

User Guide

BL654 and BL654PA *smartBASIC* Extensions

Release 29.4.6.0

This guide pertains to BL654 and BL654PA specific smartBASIC functions and routines. For information on functions and routines that apply to all smartBASIC modules, see the [smartBASIC Core Manual](#).

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1 INTRODUCTION

This user guide provides detailed information on BL654- and BL654PA-specific *smartBASIC* extensions which provide a high-level managed interface to the underlying Bluetooth stack in order to manage the following:

- Perform GAP functionality such as scanning, advertising, and connections
- Perform GATT server functionality
- Perform GATT client functionality
- Perform pairing, bonding, and security manager functions
- Manage Tx power functionality
- Attribute encoding and decoding
- Perform NFC related functionality
- Events related to the above

1.1 Differences Between BL654 and BL654PA

The BL654PA is a physically longer variant of the BL654 to accommodate an external PA (power amplifier) and LNA (low noise amplifier) to increase the transmit power and link budget. The PA and LNA are controlled using two GPIO pins (SIO_34 and SIO_36) which means those two pins are no longer available for use via *smartBASIC*. Any attempt to use them in a *smartBASIC* app results in failure.

From a firmware perspective, the two variants are loaded with exactly the same firmware image at production. On the BL654PA hardware, a non-volatile memory location is updated with a signature which is used to alter the behavior.

If the MCU is chip-erased and the firmware is reloaded, then the power amplifier will not be driven by the GPIO resulting in very low transmit power.

To enable PA functionality in a BL654PA module, the command **AT+PALNA** must be entered so that the appropriate run-time signature exists for the firmware to operate correctly.

The command **AT I 2** returns **BL654** or **BL654PA** so it is always possible to determine the variant type. Be aware that **AT I 0** always returns BL654.

The BL654PA FW implements the following logic to pass FCC, IC, and other regulatory testing.

PHY	TX power	High Bandwidth Setting (AT+CFG 214)	Maximum Allowed Packet Length (AT+CFG 216)
1 Mbps	18 dBm only	0	200 bytes
2 Mbps	18 dBm only	0	200 bytes
1 Mbps	18 dBm only	1	27 bytes
2 Mbps	18 dBm only	1	27 bytes
1 Mbps	14 dBm, 6 dBm, 0 dBm, -6 dBm, -26 dBm	1	251 bytes
2 Mbps	14 dBm, 6 dBm, 0 dBm, -6 dBm, -26 dBm	1	251 bytes

Whilst the coded PHY 125 kbps is set to maximum 14 dBm to pass FCC, IC TX Power Spectral Density.

Coded PHY	TX power	High Bandwidth Setting (AT+CFG 214)	Maximum Allowed Packet Length (AT+CFG 216)
125 kbps	14 dBm, 6 dBm, 0 dBm, -6 dBm, -26 dBm	1	251 bytes

In addition, the **BleChannelMap** is set for all 37 channels (cannot be reduced from this default).

1.2 What Does a BLE Module Contain?

Our *smart*BASIC-based BLE modules are designed to provide a complete wireless processing solution. Each contains the following:

- A highly-integrated radio with an integrated antenna (external antenna options are also available)
- BLE Physical and Link layer
- Higher level stack
- Multiple SIO and ADC
- Wired communication interfaces such as UART, I2C, and SPI
- A *smart*BASIC run-time engine
- Program accessible flash memory – Contains a robust flash file system exposing a conventional file system and a database for storing user configuration data

For simple end devices, these modules can replace an embedded processing system.

The following block diagram (Figure 1) illustrates the structure of the BLE *smart*BASIC module from a hardware perspective on the left and a firmware/software perspective on the right.

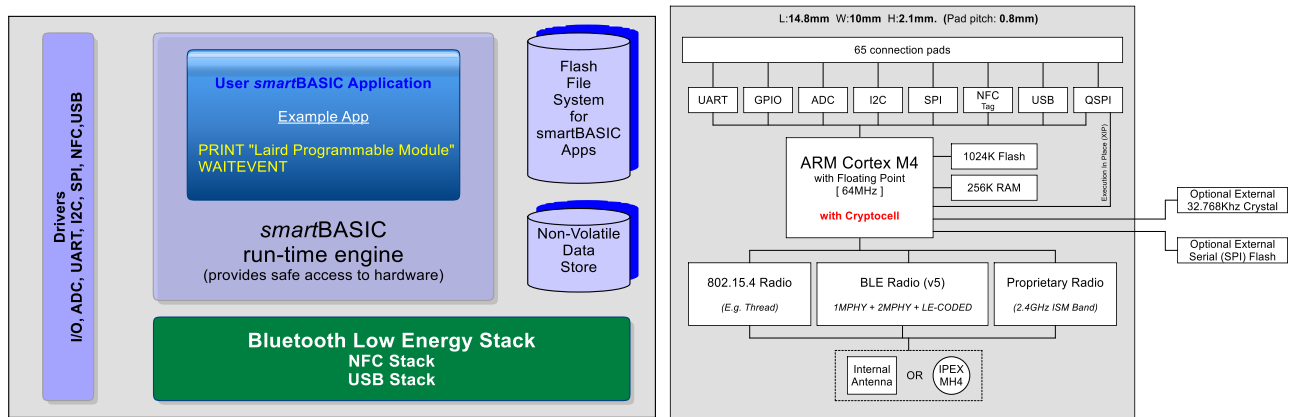


Figure 1: Bluetooth *smart*BASIC module block diagram

2 MODULE CONFIGURATION

There are many features of the module that cannot be modified programmatically which relate to interactive mode operation or alter the behaviour of the *smart*BASIC runtime engine. These configuration objects are stored in non-volatile flash and are retained until the flash file system is erased via AT&F* or AT&F 1.

To write to these objects, which are identified by a positive integer number, the module must be in interactive mode and you must use the AT+CFG command. To read current values of these objects, use the AT+CFG command, described [here](#).

Predefined configuration objects are as listed under details of the AT+CFG command.

3 INTERACTIVE MODE COMMANDS

Below are some BL654-specific AT commands.

3.1.1 AT I or AT I or AT IX

COMMAND

Provides compatibility with the AT command set of Laird's standard Bluetooth modules.

Note: *ATIX* results in any integer values being displayed in hexadecimal.

AT I num

Returns \n10\tMM\tInformation\r
 \n00\r

Where

\n = linefeed character 0x0A
\t = horizontal tab character 0x09
MM = a *number* (see below)
Information = string consisting of information requested associated with MM
\r = carriage return character 0x0D

Arguments

num Integer Constant
A number in the range of 0 to 65,535. Currently defined numbers are:

0	Device Name
1	BLE Stack Build Number
2	Device Variant. For example, BL654 or BL654PA
3	Version number of module firmware
4	Bluetooth Address
5	Chipset ID
6	File System Flash Segment Statistics
14	Static Random BLE address
16	NvRecords Flash Segment Statistics
24	If AT+MAC used to set IEEE address, then that mac address
26	BLE Bonding database segment
33	smartBASIC core version number
36	Config Keys Flash Segment Statistics
44	Current random BLE address
2080	Module startup time
2081	Get time in milliseconds since reset (overflows as 32-bit counter)
2083	Get High Voltage mode as follows: 0: Normal mode 1: High Voltage Mode
7001	Toolchain used to build firmware
0x8000+n	Read the content of the FICR register whose address is 0x10000000+n
0x9000+n	Read the content of the UICR register whose address is 0x10001000+n

0xC0FE	Displays the licence
0xC12C	CRC of most recent file downloaded since reset - volatile

Interactive Command Yes

This is an Interactive mode command and **must** be terminated by a carriage return for it to be processed.

Example:

```
AT i 3
10 3 28.6.1.2
00
AT I 4
10 4 01 D31A920731B0
```

3.1.2 AT+CFG

COMMAND

AT+CFG is used to set a non-volatile configuration key. Configuration keys are comparable to S registers in modems. Their values are kept over a power cycle but are deleted if the AT&F* command is used to clear the file system.

Unless otherwise stated, if a config key value is changed then a reset is required for it to take effect.

The “num *value*” syntax is used to set a new value and the “num ?” syntax is used to query the current value. When the value is read the syntax of the response is:

```
27 0xhhhhhhhhh (dddd)
```

...where 0xhhhhhhhhh is an eight hexdigit number which is 0 padded at the left and dddd is the decimal signed value.

AT+CFG num value or AT+CFG num ?

Returns	If the config key is successfully updated or read, the response is \n00\r.
Arguments:	
num	Integer Constant The ID of the required configuration key. All of the configuration keys are stored as an array of 16-bit words.
value	Integer_constant This is the new value for the configuration key and the syntax allows decimal, octal, hexadecimal, or binary values.

This is an Interactive mode command and must be terminated by a carriage return for it to be processed.

The following Configuration Key IDs are defined.

ID	Definition
40	Maximum size of local simple variables
41	Maximum size of local complex variables
42	Maximum depth of nested user-defined functions and subroutines
43	The size of stack for storing user functions' simple variables
44	The size of stack for storing user functions' complex variables
45	The size of the message argument queue length
100	Enable/Disable Virtual Serial Port Service when in interactive mode. Valid values are:
0x0000	Disable
0x0001	Enable
0x81nn	Enable ONLY if Signal Pin nn on module is HIGH

ID	Definition	
	0xC1nn	Enable ONLY if Signal Pin nn on module is LOW
	ELSE	Disable
101	In Virtual Serial Port Service, select either to use INDICATE or NOTIFY to send data to client.	
	0	Prefer Notify
	ELSE	Prefer Indicate
	This is a preference and the actual value is forced by the property of the TX characteristic of the service.	
102	Advert interval in milliseconds when advertising for connections in interactive mode and AT Parse mode. Valid values: 20 to 10240 milliseconds	
103	Advert timeout in milliseconds when advertising for connections in interactive mode and AT Parse mode. Valid values: 0 to 16383 seconds, where 0 means forever.	
104	Data transfer is managed in the Virtual Serial Port service manager. When sending data using NOTIFIES, the underlying stack uses transmission buffers of which there is a finite number. This specifies the number of transmissions to leave unused when sending a lot of data and allows other services to send notifies without having to wait for them. The total number of transmission buffers can be determined by calling SYSINFO(2014) or in interactive mode submitting the command ATi 2014	
105	When in interactive mode and connected for virtual serial port services, this is the minimum connection interval in milliseconds to be negotiated with the master. Valid values: 0 to 4000 ms. If a value of less than 8 is specified, then the minimum value of 7.5 is selected.	
106	When in interactive mode and connected for virtual serial port services, this is the maximum connection interval in milliseconds to be negotiated with the master. Valid values: 0 to 4000 ms. Note: If a value of less the minimum specified in 105, then it is forced to the value in 105 plus 2 milliseconds.	
107	When in interactive mode and connected for virtual serial port services, this is the connection supervision timeout in milliseconds to be negotiated with the master. Valid range: 0 to 32000. Note: If the value is less than the value in 106, then a value double the one in 106 is used.	
108	When in interactive mode and connected for virtual serial port services, this is the slave latency to be negotiated with the master. An adjusted value is used if this value times the value in 106 is greater than the supervision timeout in 107	
109	When in interactive mode and connected for virtual serial port services, this is the Tx power used for adverts and connections. The main reason for setting a low value is to ensure that in production, if <i>smart</i> BASIC applications are downloaded over the air, limited range allows many stations to be used to program devices.	
110	If Virtual Serial Port Service is enabled in interactive mode (see 100), this specifies the size of the transmit ring buffer in the managed layer sitting above the service characteristic FIFO register. Valid range: 32 to 256	
111	If Virtual Serial Port Service is enabled in interactive mode (see 100), this specifies the size of the receive ring buffer in the managed layer sitting above the service characteristic fifo register. Valid range: 32 to 256	
112	If set to 1, then the service UUID for the virtual serial port is as per Nordic's implementation and any other value is per Laird's modified service. See more details of the service definition here . VSP can also be configured using a \$autorun\$ application which does not have a waitevent statement so will exit as soon as the VSP is configured.	

ID	Definition
113	This is the advert interval in milliseconds when advertising for connections in interactive mode and UART bridge mode. VSP can also be configured using a \$autorun\$ application which does not have a waitevent statement so will exit as soon as the VSP is configured. Valid values: 0 to 16383 seconds, where 0 means forever.
114	This is the advert timeout in milliseconds when advertising for connections in interactive mode and UART bridge mode. VSP can also be configured using a \$autorun\$ application which does not have a waitevent statement so will exit as soon as the VSP is configured. Valid values: 0 to 16383 seconds. 0 disables the timer (makes it continuous)
115	This is used to specify the UART baudrate when Virtual Serial Mode Service is active and UART bridge mode is enabled. VSP can also be configured using a \$autorun\$ application which does not have a waitevent statement so will exit as soon as the VSP is configured. Valid values: 1200, 2400, 4800, 9600, 14400, 19200, 28800, 38400, 57600, 76800, 115200, 230400, 250000, 460800, 921600, 1000000. Note: If an invalid value is entered, then the default value of 9600 is used.
116	In VSP/UART bridge mode, this value specifies the latency in milliseconds for data arriving via the UART and transferring to VSP and then onward on-air. This mechanism ensures that the underlying bridging algorithm waits for up to this amount of time before deciding that no more data is going to arrive to fill a BLE packet and so flushes the data onwards. Note: Given that the largest packet size takes 20 bytes, if more than 20 bytes arrive then the latency timer is overridden and the data is immediately sent.
120	Check if implemented on this platform and if implemented:- This contains a bitmask. Bits 0 to 7 specify a gpio number in the range 0 to 255 and Bit 8 signifies the assert level for Autorun app to be launched on startup. For example, if you want sio pin number 40, when high, to allow \$autorun\$ app to be launched on startup, then set the value of this config key to 0x128.
200	Maximum number of 128-bit, Vendor Specific UUID bases to allocate
204	Gatt Table : Attribute table size in bytes. The size must be a multiple of 4
205	Max number of connections acting as a peripheral (Can be up to 1)
206	Max number of connections acting as a central (Can be up to 16) Note: In order to configure the device to be able to have eight connections as central, CFG 205 should be set to 0, otherwise the device auto-adjusts to have seven connections as central and one as peripheral.
207	Max number of SMP instances for all connections acting as a central. We recommend that this is left to 1 as the stack reserves memory for its use which is only used occasionally
208	Include the Service Changed characteristic in the Attribute Table (default is included)
209	Security manager is placed in debug mode to use the SIG defined debug key for LE Secure Connections pairing
210	Low Frequency Clock Configuration The BL654 module does not have an onboard 32.768Khz low frequency crystal and that clock is derived from an RC oscillator which is calibrated against the high frequency 32MHz crystal on a periodic basis. However, the user has access to the relevant pins (SIO0 and SIO1) to fit the 32K crystal externally. This register is used to configure the LF clock source to be either one or the other or even for autodetection.

ID	Definition																											
Note: Autodetection means there is a startup delay from reset of up to half a second as opposed to about 1 to 2 milliseconds. This should be factored into any battery life calculations.																												
This configuration register is a bitmask consisting of : ~~~~~ <table><thead><tr><th>Bits</th><th>Len</th><th>Description</th></tr></thead><tbody><tr><td>0..7</td><td>(8)</td><td>Calibration Time Interval in 1/4 second units</td></tr><tr><td>8..15</td><td>(8)</td><td>How often (in number of calibration intervals) the RC oscillator shall be calibrated if the temperature hasn't changed.</td></tr><tr><td>16..26</td><td>(10)</td><td>Crystal accuracy in ppm (0..1024ppm)</td></tr><tr><td>27..29</td><td>(3)</td><td>Reserved for future use (set to 0)</td></tr><tr><td>30..31</td><td>(2)</td><td>LF Clock Source : 00 - Autodetect</td></tr><tr><td></td><td></td><td>01 - RC Oscillator with Calibration against HF Clock</td></tr><tr><td></td><td></td><td>10 - Crystal</td></tr><tr><td></td><td></td><td>11 - Synthesized from HF Clock (Very power inefficient)</td></tr></tbody></table>		Bits	Len	Description	0..7	(8)	Calibration Time Interval in 1/4 second units	8..15	(8)	How often (in number of calibration intervals) the RC oscillator shall be calibrated if the temperature hasn't changed.	16..26	(10)	Crystal accuracy in ppm (0..1024ppm)	27..29	(3)	Reserved for future use (set to 0)	30..31	(2)	LF Clock Source : 00 - Autodetect			01 - RC Oscillator with Calibration against HF Clock			10 - Crystal			11 - Synthesized from HF Clock (Very power inefficient)
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Note: If bits 30-31 is 10 then bits 0-15 are ignored; likewise, if 30-31 is 01 then bits 16..26 are ignored.																												
The command AT I 2082 or from an application SYSINFO(2082) returns the actual parameters installed at the instance. For example, if autodetection is specified (bits 31..31 == 00) then the value returned is either 01, 10, or 11. And similarly for the other parameters, if invalid values were entered.																												
211	Maximum ATT_MTU size. Possible values are 23 – 247 Bytes.																											
212	Maximum Attribute data length. Possible values are 20 – 244 Bytes.																											
213	Use EVCHARVALUE and EVATTRNOTIFYEX instead of the default EVCHARVAL and EVATTRNOTIFY respectively. These former events include all parameters in the event, including the string data, and therefore provide improved throughputs. For more information, see EVCHARVALUE and EVATTRNOTIFYEX.																											
214	0 – Medium bandwidth (three packets per connection interval) is used on all connections. 1 – High bandwidth (six packets per connection interval) is used on the FIRST connection. Other connections have medium bandwidth.																											
Note: When high bandwidth is used, the maximum number of connections that a device can have are reduced from eight to six.																												
216	Maximum packet length a module can use (this is not the same as the current packet length). Possible values are 27-251. By default this is set to 251.																											
518	The default UART TX ring buffer length.																											
519	The default UART RX ring buffer length.																											
520	The baudrate to use for command mode on power up. This setting is inherited by the \$autorun\$ application if a print happens before an explicit uartopen inside that application.																											
Note: These values revert to factory default values if the flash file system is deleted using the AT & F * interactive command.																												

3.1.3 AT+CFGEX

COMMAND

AT+CFGEX is used to set a non-volatile string configuration key. Configuration keys are comparable to S registers in modems. Their values are kept over a power cycle but are deleted if the AT&F* command is used to clear the file system.

Unless otherwise stated, if a config key value is changed, a reset is required for it to take effect.

The *num value* syntax is used to set a new value and the *num ?* syntax is used to query the current value. When the value is read, the syntax of the response is:

```
27 string
...where string is the current value of the configuration key.
```

AT+CFGEX num value or AT+CFGEX num ?

Returns	If the config key is successfully updated or read, the response is \n00\r.
Arguments:	
num	Integer Constant The ID of the required configuration key. All of the configuration keys are stored as an array of 16-bit words.
value	String_constant This is the new string value for the configuration key.

This is an Interactive mode command and must be terminated by a carriage return for it to be processed.

The following Configuration Key IDs are defined.

ID	Definition
117	VSP advertisement name, the name of the device which will be seen by scanning devices when the module is in VSP mode (can be between 1-31 bytes in length). Default value is: LAIRD BL654

Note: These values revert to factory default values if the flash file system is deleted using the AT & F * interactive command.

3.1.4 AT+BTD *

COMMAND

Deletes the bonded device database from the flash.

AT+BTD*

Returns	\n00\r
Arguments	None

This is an Interactive Mode command and must be terminated by a carriage return for it to be processed.

Note: The module self-reboots so that the bonding manager context is also reset.

Example:

```
AT+BTD*
```

3.1.5 AT+BLX

COMMAND

This command is used to stop all radio activity (adverts or connections) when in interactive mode. It is particularly useful when the virtual serial port is enabled while in interactive mode.

AT+BLX

Returns	\n00\r
Arguments:	None

This is an Interactive Mode command and MUST be terminated by a carriage return for it to be processed.

Example

```
AT+BLX
```

3.1.6 AT&F

COMMAND

AT&F provides facilities for erasing various portions of the module's non-volatile memory.

AT&F integermask

Returns	OK if flash is successfully erased
Arguments	
Integermask	Integer corresponding to a bit mask or the * character

The mask is an additive integer mask with the following acceptable values:

0x0000xxxx	Also see core user guide
1	Erases flash file system
0x100	Erase the system config keys' flash segment (AT+CFG)
0x10000	Erase the BLE bonding manager
0x10 or 0x40000	Erase the NvRecords flash segment
*	Erases all data segments
Else	Not applicable to current modules

If an asterisk is used in place of a number, then the module is configured back to the factory default state by erasing all flash file segments.

This is an Interactive Mode command and MUST be terminated by a carriage return for it to be processed.

```
AT&F 1      'delete the file system
AT&F 16     'delete the user config keys
AT&F *      'delete all data segments
```

3.1.7 AT+PROTECT

COMMAND

This command is used to enable readback protection of the flash. For this command to be issued correctly, the readback protection flag should first be enabled using AT+PROTECT "E" followed by setting the protection using AT+PROTECT "S".

WARNING: Enabling readback protection is a one time only command. Exiting this mode completely erases the firmware and requires the use of an nrfjprog command to be issued through the JTAG interface. Once erased, a new license for the module is needed. While this mode is enabled, firmware upgrade can only be carried out over UART. **Do not** enable readback protection unless absolutely necessary.

Note: To make note of the license, keep a copy of the response to the command AT I 14 and AT I 0xC0FE.

AT+PROTECT "Char"

Returns 00 for successful execution.

Arguments:

A character which could be one of the following values:

"Char"

- E – Enable the readback protection flag.
- D – Disable the readback protection flag.
- S – Set readback protection on the module. This is an irreversible command.

This is an Interactive mode command and must be terminated by a carriage return for it to be processed.

3.1.8 AT+REGOUT0

COMMAND

This command is used to enable external circuitry to be supplied from the VDD pin and set the external output/supply voltage value. This command can only be performed once and the module must be reset (using SIO_18, ATZ, reset(0), or UART BREAK) for the new value to take effect.

AT+REGOUT0 nValue

Returns 00 for successful execution.

Arguments:

nValue

- 0: 1.8v
- 1: 2.1v
- 2: 2.4v
- 3: 2.7v
- 4: 3.0v
- 5: 3.3v

This is an Interactive mode command and must be terminated by a carriage return for it to be processed.

4 CORE LANGUAGE BUILT-IN ROUTINES

Core language built-in routines are present in every implementation of *smart*BASIC. These routines provide the basic programming functionality. They are augmented with target-specific routines for different platforms which are described in the extension manual for each target platform.

All the core functionality is described in the Laird *smart*BASIC Core Functionality Guide. This document is available from the [BL654 product page](#) on the Laird website. Additional information is also available from our Laird Embedded Wireless Solutions Support Center at <http://ews-support.lairdtech.com>.

Some functions have small behavioral differences from the core functionality. These are listed in the sections below.

4.1 Information Routines

4.1.1 SYSINFO

FUNCTION

Returns an informational integer value depending on the value of `varId` argument.

SYSINFO (`varId`)

Returns	INTEGER. Value of information corresponding to integer ID requested.																														
Exceptions	- Local Stack Frame Underflow - Local Stack Frame Overflow																														
Arguments:	byVal <code>varId</code> AS INTEGER An integer ID which is used to determine which information is to be returned as described below.																														
	<table> <tr> <td>0</td><td>Device ID. Each platform type has a unique identifier.</td></tr> <tr> <td>3</td><td>Module firmware version number Example: W.X.Y.Z is returned as a 32-bit value made up as follows: (W<<24) + (X<<18) + (Y<<6) + (Z) where W is the platform and will always be 29 for the BL654 and X is changed whenever 3rd party libraries are changed. In this case the Nordic Softdevice and Y is the build number and Z is the sub-build number. Note you can check the Softdevice build number in command mode by submitting the command AT I 1</td></tr> <tr> <td>33</td><td>BASIC core version number Example: A.B is returned as a 32 bit value made up as follows: (A<<8) + (B) and note the string "A.B" is returned via command mode command AT I 33</td></tr> <tr> <td>601</td><td>Flash File System: Data Segment: Total Space</td></tr> <tr> <td>602</td><td>Flash File System: Data Segment: Free Space</td></tr> <tr> <td>603</td><td>Flash File System: Data Segment: Deleted Space</td></tr> <tr> <td>611</td><td>Flash File System: FAT Segment: Total Space</td></tr> <tr> <td>612</td><td>Flash File System: FAT Segment: Free Space</td></tr> <tr> <td>613</td><td>Flash File System: FAT Segment: Deleted Space</td></tr> <tr> <td>631</td><td>NvRecord Memory Store Segment: Total Space</td></tr> <tr> <td>632</td><td>NvRecord Memory Store Segment: Free Space</td></tr> <tr> <td>633</td><td>NvRecord Memory Store Segment: Deleted Space</td></tr> <tr> <td>1000</td><td>BASIC compiler HASH value as a 32 bit decimal value</td></tr> <tr> <td>1001</td><td>How RAND() generates values: 0 for PRNG and 1 for hardware assist</td></tr> <tr> <td>1002</td><td>Minimum baudrate</td></tr> </table>	0	Device ID. Each platform type has a unique identifier.	3	Module firmware version number Example: W.X.Y.Z is returned as a 32-bit value made up as follows: (W<<24) + (X<<18) + (Y<<6) + (Z) where W is the platform and will always be 29 for the BL654 and X is changed whenever 3 rd party libraries are changed. In this case the Nordic Softdevice and Y is the build number and Z is the sub-build number. Note you can check the Softdevice build number in command mode by submitting the command AT I 1	33	BASIC core version number Example: A.B is returned as a 32 bit value made up as follows: (A<<8) + (B) and note the string "A.B" is returned via command mode command AT I 33	601	Flash File System: Data Segment: Total Space	602	Flash File System: Data Segment: Free Space	603	Flash File System: Data Segment: Deleted Space	611	Flash File System: FAT Segment: Total Space	612	Flash File System: FAT Segment: Free Space	613	Flash File System: FAT Segment: Deleted Space	631	NvRecord Memory Store Segment: Total Space	632	NvRecord Memory Store Segment: Free Space	633	NvRecord Memory Store Segment: Deleted Space	1000	BASIC compiler HASH value as a 32 bit decimal value	1001	How RAND() generates values: 0 for PRNG and 1 for hardware assist	1002	Minimum baudrate
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1002	Minimum baudrate																														

1003	Maximum baudrate
1004	Maximum STRING size
1005	Is 1 for run-time only implementation, 3 for compiler included
1010	Module Type
2000	Reset Reason 8 : Self-Reset due to Flash Erase 9 : ATZ 10 : Self-Reset due to smart BASIC app invoking function RESET()
2001	Cause of last reset. This is a bit mask where the bits are defined as follows: Bit 0: Reset from pin-reset Bit 1: Reset from watchdog Bit 2: Reset from soft reset Bit 3: Reset from CPU lockup Bit 16: Reset due to wake up from System OFF mode when wakeup is triggered from GPIO Bit 19: Reset due to wake up from System OFF mode by NFC field detect
2002	Timer resolution in microseconds
2003	Number of timers available in a smart BASIC Application
2004	Tick timer resolution in microseconds
2005	LMP Version number for BT 4.0 spec
2006	LMP Sub Version number
2007	Chipset Company ID allocated by BT SIG
2008	Returns the current TX power setting (see also 2018)
2009	Number of devices in trusted device database
2010	Number of devices in trusted device database with IRK
2011	Number of devices in trusted device database with CSRK
2012	Max number of devices that can be stored in trusted device database
2013	Maximum length of a GATT Table attribute in this implementation
2016	Radio activity of the baseband and the BT allocation is as follows:- 0 – advertising 1 – connected as slave 2 – Initiating a connection 3 – scanning for adverts 4 – connected as master
2018	Returns the TX power while pairing in progress (see also 2008)
2021	Stack tide mark in percent. Values near 100 are not good.
2022	Stack size
2023	Initial Heap size
2024	The chipset temperature in tenth of a centigrade. For example, 23.4 is returned as 234
2025	Current used heap memory. Note: This is the total of all used blocks. It is entirely possible to get a MALLOC_FAIL even though this indicates there is enough memory for your need because there may not be a block large enough to accommodate the request. Although smartBASIC does not directly expose malloc/free, they are used extensively in STRING variable operations.
2026	Supply voltage in millivolts
2040	Max number of devices that can be stored in trusted device database
2041	Number of devices in trusted device database
2042	Number of devices in the rolling device database
2043	Maximum number of devices that can be stored in the rolling device Database
2044	Returns a 16 bit hash of the current state of the Gatt Table Schema
2050	Will be 0 if NFC pins are disabled and 1 if enabled

2051	Maximum number of NDEF messages that can be created simultaneously
2052	Maximum size of an NDEF message in bytes
	Bootloader variant
2060	0: Legacy 1: Secure Bootloader
2080	The startup time from reset to just before the autorun application is launched in milliseconds
2081	The current tick count in milliseconds
	This is a bitmask value
2082	The actual Low Frequency Clock configuration submitted to the softdevice. See AT+CFG 210 description for details about the 4 bit fields in the 32 bits
	Get High Voltage Mode as follows:-
2083	0: Normal mode 1: High Voltage Mode
2100	Connect Scan Interval used when connecting, in milliseconds
2101	Connect Scan Window used when connecting, in milliseconds
2102	Connect Slave Latency default value in connection requests
2105	Connect Multi-Link Connection Interval periodicity in milliseconds
2150	Scan Interval used when scanning in milliseconds
2151	Scan Window used when scanning in milliseconds
2152	Scan Type Active or Passive (0=Passive, 1=Active)
2203	Advert Channel Mask
0x8000 – 0x87FF	Content of FICR register in the Nordic nrf52840 chipset. In the nrf52840 datasheet, in the FICR section, all the FICR registers are listed in a table with each register identified by an offset, so for example, to read the Code memory page size which is at offset 0x010, call SYSINFO(0x8010) or in interactive mode use AT I 0x8010.
0x9000 – 0x9800	Content of UICR register in the Nordic nrf52 chipset. In the nrf52840 datasheet, in the UICR section, all the UICR registers are listed in a table with each register identified by an offset, so for example, to read the NFC pins functionality which is at offset 0x20C, call SYSINFO(0x920C) or in interactive mode use AT I 0x920C.

Example:

```
// Example :: SysInfo.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

PRINT "\nSysInfo 601    = ";SYSINFO(601)    // Flash File System: Total Space (Data Segment)
PRINT "\nSysInfo 2102   = ";SYSINFO(2102)   // Default connect slave latency
PRINT "\nSysInfo 1002 = ";SYSINFO(1002)    // Minimum UART baud rate
```

Expected Output:

```
SysInfo 601    = 49152
SysInfo 2102   = 0
SysInfo 1002 = 1200
```

4.1.2 SYSINFO\$

FUNCTION

Returns an informational string value depending on the value of `varId` argument.

SYSINFO\$ (varId)

Returns	STRING. Value of information corresponding to integer ID requested.
Exceptions	- Local Stack Frame Underflow - Local Stack Frame Overflow
Arguments:	
varId	byVal varId AS INTEGER
	An integer ID which is used to determine which information is to be returned as described below.
	The Bluetooth address of the module.
4	It is seven bytes long. First byte is 00 for IEEE public address and 01 for random public address. Next six bytes are the address.
	A random public address unique to this module. May be the same value as in 4 above unless an IEEE Bluetooth address is set.
14	It is seven bytes long. First byte is 00 for IEEE public address and 01 for random public address. Next six bytes are the address.

Example:

```
// Example :: SysInfo$.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM s$
s$= SYSINFO$(4)
PRINT "\nSysInfo$(4) = ";STRHEXIZE$(s$) // address of module
s$= SYSINFO$(14)
PRINT "\nSysInfo$(14) = ";SYSINFO$(s$) // public random address
s$= SYSINFO$(0)
PRINT "\nSysInfo$(0) = ";SYSINFO$(s$)
```

Expected Output:

```
SysInfo$(4)    = 000016A4B75403
SysInfo$(14)   = 01E2B56986B2E6
SysInfo$(0)    =
```

4.2 UART Interface

4.2.1 UartOpen

FUNCTION

This function is used to open the main default UART peripheral using the parameters specified.

See core manual for further details.

UARTOPEN (baudrate, txbuflen, rxbuflen, stOptions)

byVal stOptions AS STRING

This string (can be a constant) MUST be a minimum five characters long where each character is used to specify further comms parameters as follows.

Character Offset:

stOptions	0	DTE/DCE role request: ▪ T – DTE ▪ C – DCE
	1	Parity: ▪ N – None ▪ O – Odd (Not Available) ▪ E – Even (Not Available)
	2	Databits: 8
	3	Stopbits: 1
	4	Flow Control: ▪ N – None ▪ H – CTS/RTS hardware ▪ X – Xon/Xof (Not Available)
	5	SIO pin for RTS (\FF for default pin)
	6	SIO pin for TX (\FF for default pin)
	7	SIO pin for CTS (\FF for default pin)
	8	SIO pin for RX (\FF for default pin)
	9	Behaviour when detected a UART_BREAK 0=Enter Deep Sleep 1=No Action 2= Send EVUARTBREAK event to smartBASIC application
	10	0 = The event EVUARTCTS is not sent to the smartBASIC application !0 = The event EVUARTCTS is sent to the smartBASIC application

The following baud rates are supported: 2400, 4800, 9600, 14400, 19200, 28800, 38400, 57600, 76800, 115200, 230400, 250000, 460800, 921600 and 1000000 baud.

4.2.2 UartSetRTS

The BL654 module does not offer the capability to control the RTS pin as the underlying hardware does not allow it.

4.2.3 UartBREAK

The BL654 module does not offer the capability to send a BREAK signal.

4.3 Auxiliary UART (Universal Asynchronous Receive Transmit)

This section describes all the events and routines used to interact with the Auxilliary UART peripheral available on the module. Depending on the platform, at a minimum, the UART consists of a transmit, a receive, a CTS (Clear To Send) and RTS (Ready to Send) line. The CTS and RTS lines are used for hardware handshaking to ensure that buffers do not overrun.

If there is a need for the following low bandwidth status and control lines found on many peripherals, then the user is able to create those using the GPIO lines of the module and interface with those control/status lines using *smart*BASIC code.

Output	DTR	Data	Terminal	Ready
Input	DSR	Data	Set	Ready
Output/Input	DCD	Data	Carrier	Detect
Output/Input	RI	Ring Indicate		

The lines DCD and RI are marked as Output or Input because it is possible, unlike a device like a PC where they are always inputs and modems where they are always outputs, to configure the pins to be either so that the device can adopt a DTE (Data Terminal Equipment) or DCE (Data Communications Equipment) role.

Note: DCD and RI have to be BOTH outputs or BOTH inputs; one cannot be an output and the other an input.

4.3.1 Auxilliary UART Events

In addition to the routines for manipulating the Auxilliary UART interface, when data arrives via the receive line it is stored locally in an underlying ring buffer and then an event is generated.

Similarly, when the transmit buffer is emptied, events are thrown from the underlying drivers so that user *smart*BASIC code in handlers can perform user defined actions.

The following is a detailed list of all events generated by the UART subsystem which can be handled by user code.

EVAUXRX	This event is generated when one or more new characters have arrived and have been stored in the local ring buffer.
EVAUXTXEMPTY	This event is generated when the last character is transferred from the local transmit ring buffer to the hardware shift register.
EVAUXCTS	This event , when enabled, reports CTS changes. Use AuxInfo(7) to determine the current state of the CTS input line. See AuxInfo() for more details

```
// Example :: EVAUXRX.sb
DIM rc
FUNCTION HndlrAuxRx()
    PRINT "\nData has arrived\r"
ENDFUNC 1          //remain blocked in WAITEVENT

FUNCTION Btn0Pressed()
ENDFUNC 0

rc = GPIOBindEvent(0,16,1)
PRINT "\nPress Button 0 to exit this application \n"

ONEVENT EVAUXRX      CALL HndlrAuxRx
ONEVENT EVGPIOCHAN0  CALL Btn0Pressed

WAITEVENT            //wait for rx, tx and modem status events
PRINT "Exiting..."
```

Expected Output:



Note: If you type unknown commands, an E007 error displays in UwTerminal.

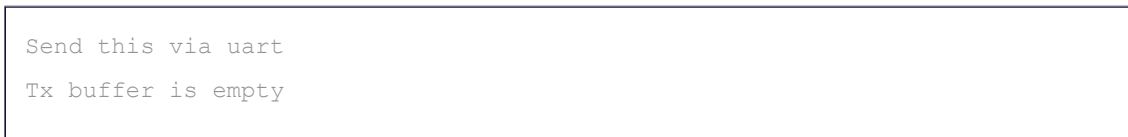
```
// Example :: EVAUXTXEMPTY.sb
FUNCTION HndlrUartTxEty()
    PRINT "\nTx buffer is empty"
ENDFUNC 0

ONEVENT EVAUXTXEMPTY CALL HndlrAuxTxEty

PRINT "\nSend this via uart"

WAITEVENT
```

Expected Output:



4.3.2 AUXOpen

Note: If communicating with a Mac OS X device, the baud rate cannot be set above 230400 due to Mac having no support for these baud rates.

FUNCTION

This function is used to open the main default UART peripheral using the parameters specified.

If the UART is already open, then this function fails. To prevent this, call [AuxClose\(\)](#) or [AuxCloseEx\(\)](#) before calling this function.

If this function is used to alter the communications parameters, like say the baudrate and the application exits to interactive mode, then those settings are inherited by the interactive mode parser. Hence this is the only way to alter the communications parameters for Interactive mode.

While the Auxilliary UART is open, if a BREAK is sent to the module, then it forces the module into deep sleep mode as long as BREAK is asserted. As soon as BREAK is deasserted, the module wakes up through a reset as if it had been power cycled.

AUXOPEN (baudrate,txbuflen,rxbuflen,stOptions)

	INTEGER Indicates success of command:	
Returns:	0	Opened successfully
	0x5208	Invalid baudrate
	0x5209	Invalid parity
	0x520A	Invalid databits
	0x520B	Invalid stopbits
	0x520C	Cannot be DTE (because DCD and RI cannot be inputs)
	0x520D	Cannot be DCE (because DCD and RI cannot be outputs)
	0x520E	Invalid flow control request
	0x520F	Invalid DTE/DCE role request
	0x5210	Invalid length of stOptions parameter (must be five characters)
	0x5211	Invalid Tx buffer length
	0x5212	Invalid Rx buffer length
Exceptions	- Local Stack Frame Underflow - Local Stack Frame Overflow	
Arguments:		
baudrate	byVal baudrate AS INTEGER The baudrate for the UART. Note that, the higher the baudrate, the more power is drawn from the supply pins. AT I 1002 or SYSINFO(1002) returns the minimum valid baudrate AT I 1003 or SYSINFO(1003) returns the maximum valid baudrate	
txbuflen	byVal txbuflen AS INTEGER Set the transmit ring buffer size to this value. If set to 0 then a default value is used by the underlying driver	
Rxbuflen	byVal rxbuflen AS INTEGER Set the receive ring buffer size to this value. If set to 0 then a default value is used by the underlying driver	
stOptions	byVal stOptions AS STRING This string (can be a constant) MUST be a minimum of five characters long where each character is used to specify further comms parameters as follows. Character Offset:	
	0	DTE/DCE role request: - T – DTE - C – DCE
	1	Parity: - N – None - O – Odd - E – Even
	2	Databits: 5, 6, 7, 8, or 9
	3	Stopbits: 1 or 2
	4	Flow Control: - N – None - H – CTS/RTS hardware - X – Xon/Xof (may not be available, see extension manual)
	5	SIO pin to use for RTS
	6	SIO pin to use for TX

7	SIO pin to use for CTS
8	SIO pin to use for RX
9	Behaviour when detected a AUX_BREAK 0=Enter Deep Sleep 1=No Action 2= Send EVAUXTBREAK event to smartBASIC application
10	0 = The event EVAUXCTS is not sent to the smartBASIC application !0 = The event EVAUXCTS is sent to the smartBASIC application

Interactive Command NO

Note: There are further restrictions on the options based on the hardware as for example a PC implementation cannot be configured as a DCE role. Likewise, many microcontroller UART peripherals are not capable of 5 bits per character – but a PC is.

Note: In DTE equipment DCD and RI are inputs, while in DCE they are outputs.

4.3.3 AUXClose

FUNCTION

This subroutine is used to close the auxilliary UART port which had been opened with AUXOPEN.

When this subroutine is invoked, the receive and transmit buffers are both flushed. If there is any data in either of these buffers when the UART is closed, it will be lost. This is because the execution of AUXCLOSE takes a very short amount of time, while the transfer of data from the buffers takes much longer.

AUXCLOSE()

Exceptions

- Local Stack Frame Underflow
- Local Stack Frame Overflow

Arguments None

4.3.4 AUXCloseEx

FUNCTION

This function is used to close the Auxillary UART port which had been opened with AUXOPEN depending on the flag mask in the input parameter.

Please see *UartClose()* for more details.

AUXCLOSEEX(nFlags)

Returns INTEGER
An integer result code. The most typical value is 0x0000, which indicates a successful operation. If 0x5231 is returned it implies one of the buffers was not empty so not closed.

Exceptions

- Local Stack Frame Underflow
- Local Stack Frame Overflow

Arguments

nFlags *byVal nFlags AS INTEGER*
If Bit 0 is set, then only close if both rx and tx buffers are empty. Setting this bit to 0 has the same effect as *UartClose()* routine.
Bits 1 to 31 are for future use and must be set to 0.

4.3.5 AUXInfo

FUNCTION

This function is used to query information about the Auxilliary UART, such as buffer lengths, whether the port is already open or how many bytes are waiting in the receive buffer to be read.

AUXINFO (ifold)

Returns	INTEGER The value associated with the type of uart information requested																		
Exceptions	- Local Stack Frame Underflow - Local Stack Frame Overflow																		
Arguments	byVal ifold AS INTEGER This specifies the type of UART information requested as follows if the UART is open: <table> <tr> <td>0</td><td>1 – The port is open 0 – The port is closed</td></tr> </table> The following specify the type of uart information when the port is open: <table> <tr> <td>1</td><td>Receive ring buffer capacity</td></tr> <tr> <td>2</td><td>Transmit ring buffer capacity</td></tr> <tr> <td>3</td><td>Number of bytes waiting to be read from receive ring buffer</td></tr> <tr> <td>4</td><td>Free space available in transmit ring buffer</td></tr> <tr> <td>5</td><td>Number of bytes still waiting to be sent in transmit buffer</td></tr> <tr> <td>6</td><td>Total number of bytes waiting in rx and tx buffer</td></tr> <tr> <td>7</td><td>Get status of CTS input</td></tr> <tr> <td>8</td><td>Count of how many times CTS has changed. Value from 0 to 0xFFFF and the count wraps to 0 after 0xFFFF</td></tr> </table> If the AUX interface is closed, 0 is always returned regardless of the value of <i>ifold</i>. Note: AUXINFO(0) always returns the open/close state of the AUX interface.	0	1 – The port is open 0 – The port is closed	1	Receive ring buffer capacity	2	Transmit ring buffer capacity	3	Number of bytes waiting to be read from receive ring buffer	4	Free space available in transmit ring buffer	5	Number of bytes still waiting to be sent in transmit buffer	6	Total number of bytes waiting in rx and tx buffer	7	Get status of CTS input	8	Count of how many times CTS has changed. Value from 0 to 0xFFFF and the count wraps to 0 after 0xFFFF
0	1 – The port is open 0 – The port is closed																		
1	Receive ring buffer capacity																		
2	Transmit ring buffer capacity																		
3	Number of bytes waiting to be read from receive ring buffer																		
4	Free space available in transmit ring buffer																		
5	Number of bytes still waiting to be sent in transmit buffer																		
6	Total number of bytes waiting in rx and tx buffer																		
7	Get status of CTS input																		
8	Count of how many times CTS has changed. Value from 0 to 0xFFFF and the count wraps to 0 after 0xFFFF																		

4.3.6 AUXWrite

FUNCTION

This function is used to transmit a string of characters from the auxilliary uart interface

AUXWRITE (strMsg)

Returns	INTEGER 0 to N : Actual number of bytes successfully written to the local transmit ring buffer
Exceptions	- Local Stack Frame Underflow - Local Stack Frame Overflow - UART has not been opened using UARTOPEN (or auto-opened with PRINT statement)
Arguments	byRef strMsg AS STRING The array of bytes to be sent. STRLEN(strMsg) bytes are written to the local transmit ring buffer. If STRLEN(strMsg) and the return value are not the same, this implies the transmit buffer did not have enough space to accommodate the data. If the return value does not match the length of the original string, then use STRSHIFTLEFT function to drop the data from the string, so that subsequent calls to this function only retries with data which was not placed in the output ring

	buffer.
Interactive Command	NO

Note: **strMsg** cannot be a string constant (e.g. “the cat”); it must be a string variable. If you must use a const string, first save it to a temp string variable and then pass it to the function.

4.3.7 AUXRead

FUNCTION

This function is used to read the content of the receive buffer of the Auxilliary uart port and **append** it to the string variable supplied.

AUXREAD(strMsg)

Returns	INTEGER 0 to N : The total length of the string variable – not just what got appended. This means the caller does not need to call strlen() function to determine how many bytes in the string that need to be processed.
Exceptions	- Local Stack Frame Underflow - Local Stack Frame Overflow - Uart has not been opened using UARTOPENxxx
Arguments	
strMsg	byRef strMsg AS STRING The content of the receive buffer is appended to this string.
Interactive Command	NO

Note: **strMsg** cannot be a string constant (e.g. “the cat”); they must be a string variable. If you must use a const string, first save it to a temp string variable and then pass it to the function.

4.3.8 AUXReadN

FUNCTION

This function is used to read the content of the receive buffer of the Auxilliary uart port and **append** it to the string variable supplied but it ensures that the string is not longer than nMaxLen.

AUXREADN(strMsg, nMaxLen)

Returns	INTEGER 0 to N : The total length of the string variable – not just what got appended. This means the caller does not need to call strlen() function to determine how many bytes in the string that need to be processed.
Exceptions	- Local Stack Frame Underflow - Local Stack Frame Overflow - Uart has not been opened using UARTOPENxxx
Arguments	
strMsg	byRef strMsg AS STRING The content of the receive buffer is appended to this string.
nMaxLen	byval nMaxLen AS INTEGER The output string strMsg is never longer than this value unless on entry the string was already longer . If a value less than 1 is specified, it is clipped to 1 and if > that 0xFFFF it is clipped to 0xFFFF.

Interactive Command	NO

Note: **strMsg** cannot be a string constant (e.g. "the cat"); they must be a string variable. If you must use a const string, first save it to a temp string variable and then pass it to the function.

4.3.9 AUXReadMatch

FUNCTION

This function is used to read the content of the underlying receive ring buffer of the Auxilliary uart port and **append** it to the string variable supplied, up to and including the first instance of the specified matching characters (up to a sequence of 3 characters) OR the end of the ring buffer.

This function is very useful when interfacing with a peer which sends messages terminated by a constant character such as a carriage return (0x0D) or the dual character sequence (0x0D 0x0A). In that case, in the handler, if the return value is greater than 0, it implies a terminated message arrived and so can be processed further.

AUXREADMATCH(strMsg , chr)

Returns	INTEGER Indicates the presence of the match character in strMsg as follows: 0 – Data may have been appended to the string, but no matching character. 1 to N – The total length of the string variable up to and including the match chr .
	Note: When 0 is returned you can use STRLEN(strMsg) to determine the length of data stored in the string. On some platforms with low amount of RAM resources, the underlying code may decide to leave the data in the receive buffer rather than transfer it to the string.
Exceptions	- Local Stack Frame Underflow - Local Stack Frame Overflow - Uart has not been opened using UARTOPEN
Arguments	
strMsg	<i>byRef strMsg AS STRING</i> The content of the receive buffer gets appended to this string up to and including the match character.
Chrs	<i>byVal chrs AS INTEGER</i> The characters to match in the receive buffer; for example, the carriage returns character 0x0D, or 0x0A0D. For 0x0A0D, it will mean the string <CR><LF> because an integer constant is specified in little endien format. The most significant byte MUST be 0x00 as it is taken as the NULL terminator for the string that is cast from this 4 byte integer value.
Interactive Command	NO

Note: **strMsg** cannot be a string constant (e.g. "the cat"); they must be a string variable. If you must use a const string, first save it to a temp string variable and then pass it to the function.

4.3.10 AUXFlush

SUBROUTINE

This subroutine is used to flush either or both receive and transmit ring buffers of the Auxilliary uart port.

This is useful when, for example, you have a character terminated messaging system and the peer sends a very long message and the input buffer fills up. In that case, there is no more space for an incoming termination character and the RTS

handshaking line would have been asserted so the message system stalls. A flush of the receive buffer is the best approach to recover from that situation.

Note: Execution of AUXFLUSH is much quicker than the time taken to transmit data to/from the buffers

AUXFLUSH(bitMask)

Exceptions	- Local Stack Frame Underflow - Local Stack Frame Overflow - Uart has not been opened using UARTOPEN						
Arguments							
	<i>byVal bitMask AS INTEGER</i> This bit mask is used to choose which ring buffer to flush. <table> <tr> <th>Bit</th><th>Description</th></tr> <tr> <td>0</td><td>Set to flush the Rx buffer</td></tr> <tr> <td>1</td><td>Set to flush the Tx buffer</td></tr> </table>	Bit	Description	0	Set to flush the Rx buffer	1	Set to flush the Tx buffer
Bit	Description						
0	Set to flush the Rx buffer						
1	Set to flush the Tx buffer						
Interactive Command	NO						

4.3.11 AUXGetCTS

FUNCTION

This function is used to read the current state of the CTS status input line of the Auxilliary Uart port

If the device does not expose a CTS input line, then this function returns a value that signifies an asserted line.

AUXGETCTS()

Returns	INTEGER Indicates the status of the CTS line: 0 : CTS line is NOT asserted 1 : CTS line is asserted
Exceptions	- Local Stack Frame Underflow - Local Stack Frame Overflow - Uart has not been opened using UARTOPEN
Arguments	None
Interactive Command	NO

4.3.12 AUXSetRTS

The BL654 module does not offer the capability to control the RTS pin as the underlying hardware does not allow it.

4.3.13 AUXBreak

The BL654 module does not offer the capability to send a BREAK signal from the Auxilliary uart port

4.4 I2C – Two Wire Interface (TWI)

The BL654 can be only be configured as an I2C master if it is the only master on the bus and only 7-bit slave addressing is supported. Refer to the core user guide for API details.

When the I2C interface is opened using `I2cOpen()` or `I2cOpenEx()`, it takes a frequency parameter for the clock line. Valid values are 100KHz, 250KHz and 400KHz.

Note `I2cOpenEx()` allows for SCL and SDA to be routed to other gpio pins.

4.5 SPI Interface

The BL654 module can be configured as both SPI master and SPI slave. The section below describes the SPI slave API. See core user guide for SPI master API.

4.6 SPI Slave Interface

This section describes all the events and routines used to interact with the SPI Slave peripheral that is available on the module. For successful SPI operations, the remote SPI master's CS, MISO, MOSI, and SCK should be connected directly to the module's CS, MISO, MOSI and SCK pins (respectively). The module's 4 SPI Slave pins can be configured using the `SpiSlaveConfig()` function, which by default are 11 (CS), 17 (MISO), 18 (MOSI), and 19 (SCK). Special purpose pins such as `nAutorun` (13) and `nReset` (22) cannot be configured for SPI Slave operations.

On the BL654, the SPI Slave peripheral supports the following frequencies:- 125KHz, 250KHz, 500KHz, 1MHz, 2MHz, 4MHz, and 8MHz. These frequencies are set by the SPI master and cannot be configured by the SPI Slave.

4.6.1 Events and Messages

4.6.1.1 *EVSPISLAVETXR*

This event is thrown when an SPI slave transaction has been completed and the SPI slave Tx/Rx buffers have been updated. The event comes with the following parameters:

nTxAmount – The amount of data that was read (clocked out) by the remote SPI master.

nRxAmount – The amount of data that was written by the remote SPI master into the SPI slave Rx buffer.

4.6.1.2 *EVSPISLAVERXBUFFERFULL*

This event is thrown when the SPI slave Rx buffer is full and as a result some data written by the remote SPI master might've been dropped. The event contains the following parameters:-

nRxAmountDropped – The amount of data that was written from the remote SPI master but dropped due to the buffer being full.

4.6.1.3 *EVSPISLAVETXBUFFEREMPTY*

This event is thrown when the SPI slave Tx buffer has been emptied due to an SPI master reading out the Tx data from the SPI slave Tx buffer. The handler for this event contains no parameters.

4.6.2 SpiSlaveConfig

FUNCTION

This function is used to update the configuration options of the SPI slave peripheral. If the SPI slave peripheral is already open, then these values will not take effect until the peripheral is closed and then opened again.

SPI_SLAVE_CONFIG(*nConfigId*, *nValue*)

Returns	INTEGER, a result code. Typical value: 0x0000 - The Tx buffer has been updated successfully 0x5260 - Invalid configuration index	
Arguments:		
<i>nConfigId</i>	byVal nConfigId AS INTEGER. The configuration ID, possible values are:-	
	0	SPI Slave Chip Select (CS) pin – default 28
	1	SPI Slave Master In Slave Out (MISO) pin – default 29
	2	SPI Slave Master Out Slave In (MOSI) pin – default 30
	3	SPI Slave Clock (SCK) pin – default 31
	4	SPI Slave Tx buffer size in bytes – (Possible values: 16-255, default 255)
	5	SPI Slave Rx buffer size in bytes – (Possible values: 16-255, default 255)
	6	SPI Slave Mode:-
	Mode	CPOL CPHA
	0	0 0
	1	0 1
	2	1 0
	3	1 1
<i>nValue</i>	byVal nValue AS INTEGER The value to be assigned to the configuration ID.	

Example:

```
// Example :: SpiSlaveConfig.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples
dim rc, nHandle

// Configure SPI Slave peripheral Tx buffer before opening
rc = SpiSlaveConfig(4, 100)
if rc == 0 then
    print "\nSPI slave tx buffer size configured"
else
    print "\nFailed to configure SPI slave tx buffer with error code ";integer.h' rc
endif

// Open SPI Slave Peripheral
rc = SpiSlaveOpen(nHandle)
if rc == 0 then
    print "\nOpened SPI Slave peripheral with handle = ";integer.h' nHandle
else
    print "\nFailed to open SPI Slave peripheral"
endif

WaitEvent
```

Expected Output:

```
SPI slave tx buffer size configured
Opened SPI Slave peripheral with handle = 9ABCDEF0
```

4.6.3 SpiSlaveOpen

FUNCTION

This function is used to open a slave SPI peripheral in half duplex mode using the preconfigured SPI Slave values. The parameters (GPIO pins, buffer sizes, mode, etc) are inherited from the SpiSlaveConfig() function. The default parameters on the BL654 are:

SPI Slave CS Pin	28
SPI Slave MOSI Pin	29
SPI Slave MISO Pin	30
SPI Slave SCK Pin	31
SPI Slave Tx Buffer Size (in bytes)	255
SPI Slave Rx Buffer Size (in bytes)	255
SPI Slave Mode	0 (CPOL = 0, CPHL = 0)

In order to change these parameters, the SPI slave peripheral should be closed before SpiSlaveConfig() is used. After all the parameters have been successfully configured, SpiSlaveOpen can be called again at which point the new values will take effect.

SPI_SLAVE_OPEN(nHandle)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
nHandle	byRef nHandle AS INTEGER. When calling this function, a variable should be given which on return will contain the handle of the opened SPI Slave peripheral if the function is successful.

Example:

```
// Example :: SpiSlaveOpen.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples
dim rc, nHandle

// Open SPI Slave Peripherhal
rc = SpiSlaveOpen(nHandle)
if rc == 0 then
    print "\nOpened SPI Slave peripheral with handle = ";integer.h' nHandle
else
    print "\nFailed to open SPI Slave peripheral"
endif

WaitEvent
```

Expected Output:

```
Opened SPI Slave peripheral with handle = 9ABCDEF0
```

4.6.4 SpiSlaveClose

FUNCTION

This function is used to close the spi slave peripheral with the given handle.

SPISLAVECLOSE(nHandle)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
nHandle	byRef nHandle AS INTEGER. Handle of the SPI slave interface to close. On return, this will contain an invalid handle indicating that the SPI Slave peripheral has been successfully closed.

Example:

```
// Example :: SpiSlaveClose.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples
dim rc, nHandle

// Open SPI Slave Peripherhal
rc = SpiSlaveOpen(nHandle)
if rc == 0 then
    print "\nOpened SPI Slave peripheral with handle = ";integer.h' nHandle

    rc = SpiSlaveClose(nHandle)
    if rc == 0 then
        print "\nSPI Slave successfully closed"
    endif
endif
WaitEvent
```

Expected Output:

```
Opened SPI Slave peripheral with handle = 9ABCDEF0
SPI Slave successfully closed
```

4.6.5 SpiSlaveTxBufferWrite

FUNCTION

This function is used to write the content of a string to the SPI slave Tx buffer. **This written data is only stored in the buffer and not sent to the SPI master until the SPI master selects the SPI slave chip and clock out the data from the buffer.** When the SPI master selects the chip and clocks out the data, the buffer becomes inaccessible by the app until the SPI master operation is complete.

SPISLAVETXBUFFERWRITE(nHandle, strWr\$)

Returns	INTEGER, a result code. Typical value: 0x0000 The Tx buffer has been updated successfully 0x5206 Tx Buffer full 0x521D Resource busy (e.g. the buffer is being accessed by the remote SPI master) 0x5220 Invalid handle 0x5222 Invalid wite length (e.g. the given string is larger than the Tx buffer size)
Arguments:	
nHandle	byVal nHandle AS INTEGER. Handle of the SPI slave interface to write to.
strWr\$	byRef strWr\$ AS STRING Reference to a string variable to write to the SPI slave Tx buffer.

Example:

```
// Example :: SpiSlaveTxBufferWrite.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples
dim rc, nHandle
dim st$ : st$ = "SPI Slave Data"

// Open SPI Slave Peripherhal
rc = SpiSlaveOpen(nHandle)
if rc == 0 then
    // Try writing data to the buffer
    rc = SpiSlaveTxBufferWrite(nHandle, st$)
    if rc == 0 then
        print "\nSPI Slave buffer updated with written data"
    else
        print "\nFailed to write SPI Slave data with error code ";integer.h' rc
    endif
endif

WaitEvent
```

Expected Output:

```
SPI Slave buffer updated with written data
```

4.6.6 SpiSlaveRxBufferRead

FUNCTION

This function is used to read the contents of the SPI slave Rx buffer. The data in the Rx buffer would have been placed by the remote SPI master in an earlier transaction. **This Rx buffer can only be accessed if the SPI slave is not selected by the remote SPI master and there is no ongoing SPI operation.** The data that is read is then removed from the buffer in order to make room for more SPI master write operations.

If data is received from the remote SPI master and the Rx buffer is full, the event EVSPISLAVERXBUFFERFULL is thrown with the amount of data that was dropped.

SPISLAVERXBUFFERREAD(nHandle, nLength, strRd\$)

Returns	INTEGER, a result code. Typical value: 0x0000 The Rx buffer has been read successfully 0x5220 Invalid handle 0x5223 Invalid read length (e.g. the given length is larger than the Rx buffer)
Arguments:	
nHandle	byRef nHandle AS INTEGER. Handle of the SPI slave interface to close. On return, this will contain an invalid handle indicating that the SPI Slave peripheral has been successfully closed.
nLength	byRef nLength AS INTEGER Number of bytes to read from the Rx buffer. On return, this value will contain the number of data bytes that was read.
strRd\$	ByRef strRd\$ AS STRING On return, this variable will contain the string data that was read from the SPI slave Rx buffer.

Example:

```
// Example :: SpiSlaveRxBufferRead.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples
dim rc, nHandle, st$
dim nLen : nLen = 30 // Try to read 30 bytes of data

// Open SPI Slave Peripheral
rc = SpiSlaveOpen(nHandle)
if rc == 0 then
    // Try reading data from SPI slave buffer
    rc = SpiSlaveRxBufferRead(nHandle, nLen, st$)
    if rc == 0 then
        if nLen > 0 then
            print "\nSPI slave Data read: "; st$
        else
            print "\nNo SPI slave data read"
        endif
    else
        print "\nFailed to read SPI Slave data with error code ";integer.h' rc
    endif
endif

WaitEvent
```

Expected Output:

```
No SPI slave data read
```

4.7 QSPI

The BL654 can interact with a QSPI memory to read/write data for data logging or other purposes. For successful QSPI operations, the remote QSPI memory's CS, DIO0, DIO1, DIO2, DIO3 and SCK should be connected directly to the module's CS, DIO0, DIO1, DIO2, DIO3 and SCK pins (respectively). The QSPI memory can operate in various modes including fast read, dual-read output, dual-read input/output, quad-read output, quad-read input/output, page program, dual page program output, quad page program output and quad page input/output and has support for deep power-down mode and 24/32-bit addressing modes.

4.7.1 Events and Messages

4.7.1.1 EVQSPIERASED

This event is thrown when a QSPI full-chip erase operation has completed either successfully or unsuccessfully, note that this will only be called when a full-chip erase is used, a sector/page erase will not use this event. The event comes with the following parameters:-

nHandle – The handle of the QSPI interface on which the erase was performed.

nStatus – The status of the full-chip erase procedure in hex which can be:

Status	Functionality
0x0000	Full-chip erase process completed successfully
0x5270	Full-chip erase process failed.
0x5271	Full-chip erased aborted by forced reset

4.7.2 QSPIOpen

FUNCTION

This function is used to open the QSPI interface with the settings configured through the QSPIConfigSet function.

QSPIOPEN(nHandle)

Returns	INTEGER, a result code.
Typical value:	
	0x0000 The QSPI interface has been successfully opened
	0x0211 Invalid configuration parameter
	0x5207 QSPI device already open
	0x521D Resource not available
	0x5225 Invalid frequency
	0x5266 QSPI device not detected
	0x5274 Invalid pin configuration

Arguments:

nHandle	byRef nHandle AS INTEGER On return, this will contain a handle to the QSPI interface, if opened successfully.

Example:

```
// Example :: QSPI.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples
dim rc
dim qspihandle
dim tmpval
dim Manufacturer, MemoryType, MemoryDensity
dim data$

sub AssertRC(rc, tag)
    if rc!=0 then
        print "Failed with ";integer.h' rc;" at tag ";tag;"\n"
    endif
endsub

function QSPITest()
    rc = QSPIConfigGet(6, tmpval)
    AssertRC(rc, 0)
    if (rc != 0) then
        exitfunc 0
    endif
    print "Default drive strength is: ";tmpval;"\r\n"

    rc = QSPIConfigSet(6, 1)
    AssertRC(rc, 1)
    if (rc != 0) then
        exitfunc 0
    endif
    print "Changed drive strength to: 1\r\n"

    rc = QSPIConfigGet(6, tmpval)
    AssertRC(rc, 2)
    if (rc != 0) then
        exitfunc 0
    endif
    print "Drive strength is now: ";tmpval;"\r\n"
```

```
rc = QSPiOpen(qspihandle)
AssertRC(rc, 3)
if (rc != 0) then
    exitfunc 0
endif
print "Opened QSPI interface, handle: ";qspihandle;"\r\n"

rc = QSPiConfigSet(6, 0)
AssertRC(rc, 4)
if (rc != 0) then
    exitfunc 0
endif
print "Changed volatile drive strength configuration to: 0\r\n"

rc = QSPiActiveConfigGet(qspihandle, 6, tmpval)
AssertRC(rc, 5)
if (rc != 0) then
    exitfunc 0
endif
print "Drive strength on handle ";qspihandle;" is: ";tmpval;"\r\n"

rc = QSPiSetPowerMode(qspihandle, 1)
AssertRC(rc, 6)
if (rc != 0) then
    exitfunc 0
endif
print "Entered high performance mode\r\n"

rc = QSPiErase(qspihandle, 0, 0)
AssertRC(rc, 7)
if (rc != 0) then
    exitfunc 0
endif
print "Erased 4KB sector at 0x0\r\n"

data$ = "test data ab"
rc = QSPiWrite(qspihandle, data$, 0x4)
AssertRC(rc, 8)
if (rc != 0) then
    exitfunc 0
endif
print "Wrote '";data$;"' to 0x4\r\n"

data$ = ""
rc = QSPiRead(qspihandle, data$, 0x4, 12)
AssertRC(rc, 9)
if (rc != 0) then
    exitfunc 0
endif
print "Read '";data$;"' from 0x4\r\n"

rc = QSPiInfo(qspihandle, Manufacturer, MemoryType, MemoryDensity)
AssertRC(rc, 7)
if (rc != 0) then
    exitfunc 0
endif
print "QSPI memory manufacturer ID: ";Manufacturer;" memory type: ";MemoryType;" density: ";MemoryDensity;"\r\n"

rc = QSPiMemorySize(qspihandle, 6, tmpval)
AssertRC(rc, 7)
if (rc != 0) then
```



```
        exitfunc 0
    endif
    print "QSPI memory size: ";tmpval;"KB\r\n"

    rc = QSPIDPMSet(qspihandle, 1)
    AssertRC(rc, 7)
    if (rc != 0) then
        exitfunc 0
    endif
    print "Entered DPM\r\n"

    tmpval = QSPIIsDPM(qspihandle)
    print "DPM mode: ";tmpval;"\r\n"

    tmpval = QSPIIsBusy(qspihandle)
    print "Busy (with erase): ";tmpval;"\r\n"

    rc = QSPIDPMSet(qspihandle, 0)
    AssertRC(rc, 7)
    if (rc != 0) then
        exitfunc 0
    endif
    print "Exited DPM\r\n"

    tmpval = QSPIIsDPM(qspihandle)
    print "DPM mode: ";tmpval;"\r\n"

    rc = QSPIReset(qspihandle, 0, 1)
    AssertRC(rc, 7)
    if (rc != 0) then
        exitfunc 0
    endif
    print "Reset QSPI chip keeping configuration\r\n"

    rc = QSPIClose(qspihandle)
    AssertRC(rc, 3)
    if (rc != 0) then
        exitfunc 0
    endif
    print "QSPI handle ";qspihandle;" closed.\r\n"
endfunc 1

print "QSPI example, ensure SB4, SB5, SB6, SB7, SB10 and SB11 are soldered before
running.\r\n\r\n"
rc = QSPITest()
```

Expected Output:

```
QSPI example, ensure SB4, SB5, SB6, SB7, SB10 and SB11 are soldered before running.

Default drive strength is: 0
Changed drive strength to: 1
Drive strength is now: 1
Opened QSPI interface, handle: -1698897952
Changed volatile drive strength configuration to: 0
Drive strength on handle -1698897952 is: 1
Entered high performance mode
Erased 4KB sector at 0x0
Wrote 'test data ab' to 0x4
Read 'test data ab' from 0x4
QSPI memory manufacturer ID: 194, memory type: 40, density: 19
QSPI memory size: 512KB
```

```
Entered DPM
DPM mode: 1
Busy (with erase): 0
Exited DPM
DPM mode: 0
Reset QSPI chip keeping configuration
QSPI handle -1698897952 closed.
```

4.7.3 QSPIClose

FUNCTION

This function is used to close a previously opened QSPI interface and free the pins for other functionality. Note that if the QSPI memory is busy with a full-chip erase then closing the interface will fail, use the QSPIReset function to reset the memory whilst a full-chip erase is active to allow closing it.

QSPICLOSE(nHandle)

Returns INTEGER, a result code.

Typical value:

- 0x0000 The QSPI interface has been successfully closed
- 0x5201 QSPI not open
- 0x5220 Invalid handle
- 0x526C QSPI busy with full-chip erase

Arguments:

nHandle **byVal nHandle AS INTEGER**
Handle of the QSPI interface to close. On return, this will contain an invalid handle indicating that the QSPI peripheral has been successfully closed.

4.7.4 QSPIConfigSet

FUNCTION

This function is used to set the configuration options before opening the QSPI interface. Note that changing these configuration options after opening the QSPI interface will have no effect.

QSPICONFIGSET(nIndex, nValue)

Returns INTEGER, a result code.

Typical value:

- 0x0000 The volatile configuration option has been updated successfully
- 0x0209 Invalid configuration index
- 0x0211 Invalid configuration parameter
- 0x5227 Pin configuration cannot be changed

Arguments:

nIndex **byVal nIndex AS INTEGER**
Index of the configuration which is as follows:

6	Drive strength (0 = standard, 1 = high)
7	Frequency in Hz (2M, 3.2M, 4M, 6.4M, 8M, 16M or 32M)
8	QSPI clock mode (0 = clock starts with level 0, 3 = clock starts with level 1)
9	QSPI read mode (0 = Single data line (FAST_READ, op-code 0x0b), 1 = Dual data line (READ2O, op-code 0x3B), 2 = Dual data line (READ2IO, op-code 0xBB), 3 = Quad data line (READ4O, op-code 0x6B), 4 = Quad data line (READ4IO, op-code 0xEB))

10	QSPI write mode (1 = Dual data line (PP2O, op-code 0xA2), 2 = Quad data line (PP4O, op-code 0x32), 3 = Quad data line (PP4IO, op-code 0x38))
11	RX delay (in 15.625ns periods)
12	Clock delay (in 62.5ns periods)
13	Force-enable QSPI mode on open (0 = do not change QSPI mode, 1 = enable QSPI enable bit when interface is opened)
14	Power mode on open (0 = do not change power mode, 1 = set to ultra-low power mode when interface is opened, 2 = set to high performance mode when interface is opened)
15	Dummy cycles on open (0 = do not change dummy cycles, 1 = set to 0 when interface is opened, 2 = set to 1 when interface is opened)
16	Page size (256 bytes or 512 bytes)
17	Enable DPM (0 = DPM functionality disabled, 1 = DPM functionality enabled)
18	DPM enter duration (in 16us periods)
19	DPM exit duration (in 16us periods)
20	Address type (24-bit or 32-bit)
21	32-bit address op-code
22	32-bit address byte 0
23	32-bit address byte 1
24	Extended address mode (0 = do not send any instruction, 1 = send op-code, 2 = send op-code and byte 0, 3 = send op-code and byte 0 and byte 1)
25	Extended address WIP wait (0 = do not wait for write, 1 = wait for write complete)
26	Extended address write enable (0 = do not enable writing, 1 = enable writing)
27	XIP offset
nValue	byVal nValue AS INTEGER Value to set.

See example for [QSPiOpen](#).

4.7.5 QSPIConfigGet

FUNCTION

This function is used to query the volatile configuration options of the QSPI interface, note that this will not get the configuration options of an opened interface, to query that use the QSPIActiveConfigGet function.

QSPICONFIGGET(*nIndex*, *nValue*)

Returns	INTEGER, a result code. Typical value: 0x0000 Configuration returned successfully 0x0213 Invalid index
Arguments:	
<i>nIndex</i>	byVal <i>nIndex</i> AS INTEGER Index of the configuration which is as follows:
6	Drive strength (0 = standard, 1 = high)
7	Frequency in Hz (2M, 3.2M, 4M, 6.4M, 8M, 16M or 32M)
8	QSPI clock mode (0 = clock starts with level 0, 3 = clock starts with level 1)
9	QSPI read mode (0 = Single data line (FAST_READ, op-code 0x0b), 1 = Dual data line (READ2O, op-code 0x3B), 2 = Dual data line (READ2IO, op-code 0xBB), 3 = Quad data line (READ4O, op-code 0x6B), 4 = Quad data line (READ4IO, op-code 0xEB))
10	QSPI write mode (1 = Dual data line (PP2O, op-code 0xA2), 2 = Quad data line (PP4O, op-code 0x32), 3 = Quad data line (PP4IO, op-code 0x38))
11	RX delay (in 15.625ns periods)
12	Clock delay (in 62.5ns periods)
13	Force-enable QSPI mode on open (0 = do not change QSPI mode, 1 = enable QSPI enable bit when interface is opened)
14	Power mode on open (0 = do not change power mode, 1 = set to ultra-low power mode when interface is opened, 2 = set to high performance mode when interface is opened)
15	Dummy cycles on open (0 = do not change dummy cycles, 1 = set to 0 when interface is opened, 2 = set to 1 when interface is opened)
16	Page size (256 bytes or 512 bytes)
17	Enable DPM (0 = DPM functionality disabled, 1 = DPM functionality enabled)
18	DPM enter duration (in 16us periods)
19	DPM exit duration (in 16us periods)
20	Address type (24-bit or 32-bit)
21	32-bit address op-code
22	32-bit address byte 0
23	32-bit address byte 1
24	Extended address mode (0 = do not send any instruction, 1 = send op-code, 2 = send op-code and byte 0, 3 = send op-code and byte 0 and byte 1)
25	Extended address WIP wait (0 = do not wait for write, 1 = wait for write complete)
26	Extended address write enable (0 = do not enable writing, 1 = enable writing)
27	XIP offset
<i>nValue</i>	byRef <i>nValue</i> AS INTEGER On return, this variable will contain the volatile configuration value.

See example for [QSPIOpen](#).

4.7.6 QSPIActiveConfigGet

FUNCTION

This function is used to query a configuration option of an open QSPI interface.

QSPIACTIVECONFIGGET(nHandle, nIndex, nValue)

Returns	INTEGER, a result code. Typical value: 0x0000 Configuration returned successfully 0x0213 Invalid index 0x5220 Invalid handle
Arguments:	
nHandle	byVal nHandle AS INTEGER Handle of the QSPI interface to use.
nIndex	byVal nIndex AS INTEGER Number of bytes to read from the Rx buffer. On return, this value will contain the number of data bytes that was read.
	0 Clock SIO
	1 Chip select SIO
	2 IO0 SIO
	3 IO1 SIO
	4 IO2 SIO
	5 IO3 SIO
	6 Drive strength (0 = standard, 1 = high)
	7 Frequency in Hz
	8 QSPI clock mode (0 = clock starts with level 0, 3 = clock starts with level 1)
	9 QSPI read mode (0 = Single data line (FAST_READ, op-code 0x0b), 1 = Dual data line (READ2O, op-code 0x3B), 2 = Dual data line (READ2IO, op-code 0xBB), 3 = Quad data line (READ4O, op-code 0x6B), 4 = Quad data line (READ4IO, op-code 0xEB))
	10 QSPI write mode (1 = Dual data line (PP2O, op-code 0xA2), 2 = Quad data line (PP4O, op-code 0x32), 3 = Quad data line (PP4IO, op-code 0x38))
	11 RX delay (in 15.625ns periods)
	12 Clock delay (in 62.5ns periods)
	16 Page size
	17 Enable DPM (0 = DPM functionality disabled, 1 = DPM functionality enabled)
	18 DPM enter duration (in 16us periods)
	19 DPM exit duration (in 16us periods)
	20 Address type
	21 32-bit address op-code
	22 32-bit address byte 0
	23 32-bit address byte 1
	24 Extended address mode (0 = do not send any instruction, 1 = send op-code, 2 = send op-code and byte 0, 3 = send op-code and byte 0 and byte 1)

	25	Extended address WIP wait
	26	Extended address write enable
	27	XIP offset
	28	Current mode (0 = ultra-low power mode, 1 = high performance mode)
nValue	ByRef nValue AS INTEGER On return, this variable will contain the configuration value from the QSPI interface.	

See example for [QSPIOpen](#).

4.7.7 QSPIWrite

FUNCTION

This function is used to write data to the QSPI memory at a particular offset. Note that both the offset and data length must be a multiple of 4, and the page being written to must be erased prior to writing to it using the QSPIErase function.

QSPIWRITE(nHandle, strWr\$, nOffset)

Returns	INTEGER, a result code. Typical value: 0x0000 Data written successfully 0x5201 QSPI interface not open 0x5267 QSPI device timeout 0x5268 String size limit reached 0x526a Supplied offset is not valid 0x526b Supplied length is not valid 0x526c QSPI device busy with full-chip erase 0x5275 DPM mode is currently active
Arguments:	
nHandle	byVal nHandle AS INTEGER Handle of the QSPI interface to use.
strWr\$	byRef strWr\$ AS STRING Data to write to the QSPI memory. Must be a multiple of 4 bytes in length.
nOffset	ByVal nOffset AS INTEGER Offset of the QSPI memory in which to write the data to. Must be a multiple of 4.

See example for [QSPIOpen](#).

4.7.8 QSPIRead

FUNCTION

This function is used to read data from the QSPI memory. Note that both the offset and data length must be a multiple of 4.

QSPIREAD(nHandle, strRd\$, nOffset, nLength)

Returns	INTEGER, a result code. Typical value: 0x0000 Data read successfully 0x5201 QSPI interface not open 0x5267 QSPI device timeout 0x5268 String size limit reached 0x526a Supplied offset is not valid 0x526b Supplied length is not valid 0x526c QSPI device busy with full-chip erase 0x5275 DPM mode is currently active
Arguments:	
nHandle	byVal nHandle AS INTEGER Handle of the QSPI interface to use.
strRd\$	byRef strRd\$ AS INTEGER On success, this variable will contain the data read from the QSPI memory.
nOffset	ByVal nOffset AS INTEGER Offset of the QSPI memory in which to write the data to. Must be a multiple of 4.
nLength	ByVal nLength AS INTEGER Number of bytes to read from the QSPI memory. Must be a multiple of 4.

See example for [QSPIOpen](#).

4.7.9 QSPIErase

FUNCTION

This function is used to erase data from the QSPI memory. After starting a full-chip erase, the [EVQSPIERASED](#) event must be waited for before performing any other actions.

QSPIERASE(nHandle, nType, nOffset)

Returns	INTEGER, a result code. Typical value: 0x0000 Erase completed successfully 0x5201 QSPI interface not open 0x5267 QSPI device timeout 0x526a Supplied offset is not valid 0x526c QSPI device busy with full-chip erase 0x526d Specified erase type is not valid 0x526e Full-chip erase has started (wait for EVQSPIERASED event) 0x526f Timeout occurred whilst starting erase process 0x5275 DPM mode is currently active
Arguments:	
nHandle	byVal nHandle AS INTEGER Handle of the QSPI interface to use.

nType	byVal nType AS INTEGER The type of erase to perform which must be one of: <table> <tr> <td>0</td><td>4KB sector erase</td></tr> <tr> <td>1</td><td>64KB sector erase</td></tr> <tr> <td>2</td><td>Full-chip erase</td></tr> </table>	0	4KB sector erase	1	64KB sector erase	2	Full-chip erase
0	4KB sector erase						
1	64KB sector erase						
2	Full-chip erase						
nOffset	byVal nOffset AS INTEGER The offset of the QSPI memory to start the erase process at, must be at a 4KB boundary for a 4KB sector erase, must be at a 64KB boundary for a 64KB sector erase, must be 0 for a full-chip erase.						

See example for [QSPIOpen](#).

4.7.10 QSPICustomCommand

FUNCTION

This function is used to send a custom command to the QSPI memory and read the response.

QSPICUSTOMCOMMAND(nHandle, strWr\$, strRd\$, nIO2Level, nIO3Level, nEnableWrite, nWaitWIP)

Returns	INTEGER, a result code. Typical value: 0x0000 Custom command executed successfully 0x5201 QSPI interface not open 0x526c QSPI device busy with full-chip erase 0x5273 Custom command too long
Arguments:	
nHandle	byVal nHandle AS INTEGER Handle of the QSPI interface to use.
strWr\$	byRef strWr\$ AS INTEGER String which contains op-code and data to write (maximum 7 bytes)
strRd\$	ByRef strRd\$ AS STRING On return, this variable will contain the string data that was read from QSPI memory.
nIO2Level	byVal nIO2Level AS INTEGER The logic level of the IO2 pin (0 = low, 1 = high)
nIO3Level	byVal nIO3Level AS INTEGER The logic level of the IO2 pin (0 = low, 1 = high)
nEnableWrite	byVal nEnableWrite AS INTEGER If to enable writing before executing the command (0 = do not enable writing, 1 = enable writing)
nWaitWIP	byVal nWaitWIP AS INTEGER If to wait for the write to complete (0 = do not wait, 1 = wait for the write to complete)

Example:

```
// Example :: QSPI_Custom.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples
dim rc
dim qspihandle
dim wr$, rd$

sub AssertRC(rc, tag)
    if rc!=0 then
        print "Failed with ";integer.h' rc;" at tag ";tag;"\n"
    endif
endsub

function QSPICustomTest()
    rc = QSPIOpen(qspihandle)
    AssertRC(rc, 0)
    if (rc != 0) then
        exitfunc 0
    endif
    print "Opened QSPI interface, handle: ";qspihandle;"\r\n"

    //This op-code, 0x9f, is the RDID (read identification) command
    wr$ = "\9f\00\00\00"
    rc = QSpiCustomCommand(qspihandle, wr$, rd$, 1, 1, 0, 0)
    AssertRC(rc, 1)
    if (rc != 0) then
        exitfunc 0
    endif
    print "Custom command sent: ";strhexize$(wr$);", got: ";strhexize$(rd$);"\r\n"

    rc = QSPIClose(qspihandle)
    AssertRC(rc, 2)
    if (rc != 0) then
        exitfunc 0
    endif
    print "QSPI handle ";qspihandle;" closed.\r\n"
endfunc 1

print "QSPI custom command example, ensure SB4, SB5, SB6, SB7, SB10 and SB11 are soldered
before running.\r\n\r\n"
rc = QSPICustomTest()
```

Expected Output:

```
QSPI custom command example, ensure SB4, SB5, SB6, SB7, SB10 and SB11 are soldered before
running.

Opened QSPI interface, handle: -1698897952
Custom command sent: 9F000000, got: C22813
QSPI handle -1698897952 closed.
```

4.7.11 QSPISetPowerMode

FUNCTION

This function is used to change the power mode of the QSPI memory to either ultra-low power mode or high performance mode.

QSPISETPOWERMODE(nHandle, nPowerMode)

Returns	INTEGER, a result code. Typical value: 0x0000 QSPI power mode set successfully 0x5201 QSPI interface not open 0x526c QSPI device busy with full-chip erase 0x5272 Supplied power mode is not valid 0x5275 QSPI chip is in DPM mode	
Arguments:		
nHandle	byVal nHandle AS INTEGER Handle of the QSPI interface to use.	
nPowerMode	byVal nPowerMode AS INTEGER Power mode to set which can be:	
	Mode	Functionality
	0	Ultra power-save mode
	1	High performance mode

See example for [QSPISetPowerMode](#).

4.7.12 QSPIInfo

FUNCTION

This function is used to query the QSPI memory and retrieve details about it.

QSPIINFO(nHandle, nManufacturerID, nMemoryType, nMemoryDensity)

Returns	INTEGER, a result code. Typical value: 0x0000 QSPI information returned successfully 0x5201 QSPI interface not open 0x526c QSPI device busy with full-chip erase 0x5275 QSPI chip is in DPM mode
Arguments:	
<i>nHandle</i>	byVal nHandle AS INTEGER Handle of the QSPI interface to use.
<i>nManufacturerID</i>	byRef nManufacturerID AS INTEGER On return, this variable will contain the manufacturer ID of the QSPI chip.
<i>nMemoryType</i>	ByRef nMemoryType AS INTEGER On return, this variable will contain the memory type of the QSPI chip.
<i>nMemoryDensity</i>	ByRef nMemoryDensity AS INTEGER On return, this variable will contain the memory density of the QSPI chip.

See example for [QSPIInfo](#).

4.7.13 QSPIMemorySize

FUNCTION

This function is used to query the QSPI memory and retrieve the size of the memory in the desired format.

QSPIMEMORYSIZE(nHandle, nFormat, nSize)

Returns	INTEGER, a result code. Typical value: 0x0000 QSPI memory size returned successfully 0x0211 Invalid format specified 0x5201 QSPI interface not open 0x526c QSPI device busy with full-chip erase 0x5275 QSPI chip is in DPM mode														
Arguments:															
nHandle	byVal nHandle AS INTEGER Handle of the QSPI interface to use.														
nFormat	byVal nFormat AS INTEGER Format of the memory size to return which can be: <table> <tr> <th>Format</th><th>Functionality</th></tr> <tr> <td>0</td><td>Bits</td></tr> <tr> <td>1</td><td>Kilobits</td></tr> <tr> <td>2</td><td>Megabits</td></tr> <tr> <td>5</td><td>Bytes</td></tr> <tr> <td>6</td><td>KiloBytes</td></tr> <tr> <td>7</td><td>MegaBytes</td></tr> </table>	Format	Functionality	0	Bits	1	Kilobits	2	Megabits	5	Bytes	6	KiloBytes	7	MegaBytes
Format	Functionality														
0	Bits														
1	Kilobits														
2	Megabits														
5	Bytes														
6	KiloBytes														
7	MegaBytes														
nSize	ByRef nSize AS INTEGER On return, this variable will contain the size of the QSPI memory in the format specified.														

See example for [QSPIOpen](#).

4.7.14 QSPISBusy

FUNCTION

This function is used to check if the QSPI memory is busy with a full-chip erase.

QSPISBUSY(nHandle)

Returns	INTEGER, if the memory is busy with an erase. Typical value: 0x0000 QSPI memory is not busy with full-chip erase or is not open. 0x0001 QSPI memory is busy with full-chip erase.
Arguments:	
nHandle	byRef nHandle AS INTEGER. Handle of the QSPI interface to use.

See example for [QSPIOpen](#).

4.7.15 QSPIDPMSet

FUNCTION

This function is used to enter or exit deep power-down mode.

QSPIDPMSET(nHandle, nDPM)

Returns	INTEGER, a result code. Typical value: 0x0000 QSPI memory entered/exited DPM successfully 0x0211 Invalid format specified 0x5201 QSPI interface not open 0x526c QSPI device busy with full-chip erase 0x5276 QSPI interface was not opened with DPM support enabled		
Arguments:			
nHandle	byVal nHandle AS INTEGER. Handle of the QSPI interface to use.		
nDPM	byVal nDPM AS INTEGER If the QSPI memory should enter or exit DPM mode which can be:		
	Mode	Functionality	
	0	Exit DPM	
	1	Enter DPM	

See example for [QSPIDPMSet](#).

4.7.16 QSPIIsDPM

FUNCTION

This function is used to check if the QSPI memory is in deep power-down mode.

QSPIIsDPM(nHandle)

Returns	INTEGER, if the QSPI memory is in DPM mode. Typical value: 0x0000 QSPI memory is not in DPM mode or interface is not open. 0x0001 QSPI memory is in DPM mode.
Arguments:	
<i>nHandle</i>	byRef nHandle AS INTEGER. Handle of the QSPI interface to use.

See example for [QSPIIsDPM](#).

4.7.17 QSPIReset

FUNCTION

This function is used to reset a QSPI memory.

QSPIRESET(nHandle, nType, nReapplyConfig)

Returns	INTEGER, a result code. Typical value: 0x0000 QSPI memory reset successfully 0x0211 Invalid type specified 0x5201 QSPI interface not open 0x526c QSPI device busy with full-chip erase 0x5275 QSPI chip is in DPM mode	
Arguments:		
nHandle	byVal nHandle AS INTEGER Handle of the QSPI interface to use.	
nType	byVal nType AS INTEGER This specifies if the QSPI reset should be forced regardless if the chip is busy with an erase and can be:	
	Type	Functionality
	0	Normal (will not reset if full-chip erase is active)
	1	Force (will reset if full-chip erase is active, this may lead to data corruption)
nReapplyConfig	ByVal nReapplyConfig AS INTEGER This controls if the volatile QSPI configuration should be re-applied after resetting the memory and can be:	
	Mode	Functionality
	0	Do not re-apply configuration after reset
	1	Re-apply configuration after reset (power mode and dummy cycles)

See example for [QSPIOpen](#).

4.8 Input/Output Interface Routines

I/O and interface commands allow access to the physical interface pins and ports of the *smart*BASIC modules. Most of these commands are applicable to the entire range of modules. However, some are dependent on the actual I/O availability of each module.

There are 48 SIO (Special I/O) pins available on the BL654. All of these pins can be configured to provide additional types of functionality. However, some of the pins have set functionality that should never be changed.

Note: All of the pins can be configured as digital inputs or outputs, therefore these are not listed in the table below.

Exception: On the BL654PA variant, SIO 34 and 36 are not available for general use as they are used to control the external PA and LNA

Table 1: SIO pin functionality

SIO	Functionality
0	XTAL1
1	XTAL2

SIO	Functionality
2	Adc00, Vsp
3	Adc01
4	Adc02/SPIM MISO
5	UART_RTS/Adc03
6	UART_TX
7	UART_CTS
8	UART_RX
9	NFC1
10	NFC2
11	No alternate functionality
12	No alternate functionality
13	No alternate functionality
14	No alternate functionality
15	No alternate functionality
16	No alternate functionality
17	QSPI_CS
18	Reset (Cannot be used as an SIO pin)
19	QSPI_CLK
20	QSPI_DIO0
21	QSPI_DIO1
22	QSPI_DIO2
23	QSPI_DIO3
24	No alternate functionality
25	No alternate functionality
26	I2cData
27	I2cClock
28	Adc04
29	Adc05
30	Adc06
31	Adc07
32	No alternate functionality
33	No alternate functionality
34	No alternate functionality Note: Not available on the BL654PA variant
35	Autorun
36	No alternate functionality Note: Not available on the BL654PA variant
37	No alternate functionality
38	No alternate functionality

SIO	Functionality
39	No alternate functionality
40	SPIM MOSI
41	SPIM CLK
42	No alternate functionality
43	No alternate functionality
44	SPIM CS
45	No alternate functionality
46	No alternate functionality
47	No alternate functionality

Notes: Where Autorun or Vsp functionality is required, that pin can only be used for that function and cannot be changed.

Pwm option outputs a fully configurable waveform; Freq option outputs a 50:50 mark space ratio waveform.

SPIM refers to SPI Master peripheral.

4.8.1 Events and Messages

EVGPIOCHANn	Here n is from 0 to N where N is platform dependent and an event is generated when a preconfigured digital input transition occurs. The number of digital inputs that can auto-generate is hardware dependent. For the BL654, N can be 0, 1, 2, or 3. Use GpioBindEvent() to generate these events. See example for GpioBindEvent() .
EVDETECTCHANn	Here n is from 0 to N where N is platform dependent and an event is generated when a preconfigured digital input transition occurs. The number of digital inputs that can auto-generate is hardware dependent. For the BL654, N can only be 0. Use GpioAssignEvent() to generate these events.

4.8.2 GpioSetFunc

FUNCTION

This routine sets the function of the SIO pin identified by the nSigNum argument.

The module datasheet contains a pinout table which denotes SIO pins. The number designated for that special I/O pin corresponds to the nSigNum argument.

The nFunction argument denotes the required functionality. Use only supported values from [Table 1](#).

The bSubFunc argument defines the configuration of the requested function.

GPIOSETFUNC (nSigNum, nFunction, nSubFunc)

Returns INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.

Arguments:

nSigNum byVal nSigNum AS INTEGER.

The signal number as stated in the pinout table of the module.

Note: On the BL654PA variant, 34 and 36 are not available as they are used to control the external PA and LNA.

nFunction **byVal nFunction AS INTEGER.**

Specifies the configuration of the SIO pin as follows:

1 = DIGITAL_IN

2 = DIGITAL_OUT

3 = ANALOG_IN

nSubFunc **byVal nSubFunc INTEGER**

Configures the pin as follows:

If nFunction == DIGITAL_IN

Bits 0..3

0x01 Pull down resistor (weak)

0x02 Pull up resistor (weak)

0x03 Pull down resistor (strong)

0x04 Pull up resistor (strong)

Else No pull resistors

Bits 4, 5

0x10 When in deep sleep mode, awake when this pin is LOW

0x20 When in deep sleep mode, awake when this pin is HIGH

Else No effect in deep sleep mode

Bits 8..31

Must be 0s

If nFuncType == DIGITAL_OUT

Values:

0 Initial output to LOW

1 Initial output to HIGH

2 Output is PWM (Pulse Width Modulated Output). See function GpioConfigPW() for more configuration. The duty cycle is set using function GpioWrite().

3 Output is FREQUENCY. The frequency is set using function GpioWrite() where 0 switches off the output; any value in range 1..4000000 generates an output signal with 50% duty cycle with that frequency.

Bits 4..6 (output drive capacity)

0 0 = Standard; 1 = Standard

1 0 = High; 1 = Standard

2 0 = Standard; 1 = High

3 0 = High; 1 = High

4 0 = Disconnect; 1 = Standard

5 0 = Disconnect; 1 = High

6 0 = Standard; 1 = Disconnect

7 0 = High; 1 = Disconnect

If nFuncType == ANALOG_IN

0 := Use Default for system.

0	Use the system default: 10-bit ADC, 1/6 scaling
0x16	10-bit ADC, 1/6 scaling
0x15	10-bit ADC, 1/5 scaling
0x14	10-bit ADC, 1/4 scaling
0x13	10-bit ADC, 1/3 scaling
0x12	10-bit ADC, 1/2 scaling
0x11	10-bit ADC, 1/1 scaling (Unity)
0x21	10-bit ADC, 2/1 scaling
0x41	10-bit ADC, 4/1 scaling

Note: The internal reference voltage is the same as the module Vcc value with +/- 1.5% accuracy.

Example:

```
// Example :: GpioSetFunc.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

PRINT GpioSetFunc(15,1,2) //Digital In SIO 15, strong pull up resistor
PRINT GpioSetFunc(3,3,0) //Analog In SIO 3 (Temperature Sensor), default settings
PRINT GpioSetFunc(17,2,1) //SIO17 (LED0) digital out, initial output high
```

Expected Output:

```
000
```

4.8.3 GpioSetFuncEx

FUNCTION

This routine sets the function of the SIO pin identified by the nSigNum argument and provides for more enhanced configurability compared to the legacy function GpioSetFunc().

The module datasheet contains a pinout table which denotes SIO pins. The number designated for that special I/O pin corresponds to the nSigNum argument.

The nFunction argument denotes the required functionality. Use only supported values from [Table 1](#).

The bSubFunc argument defines the configuration of the requested function.

GPIOSETFUNCEX (nSigNum, nFunction, subFunc\$)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
nSigNum	byVal nSigNum AS INTEGER. The signal number as stated in the pinout table of the module. Note: On the BL654PA variant, 34 and 36 are not available as they are used to control the external PA and LNA.
nFunction	byVal nFunction AS INTEGER. Specifies the configuration of the SIO pin as follows: 1 = DIGITAL_IN 2 = DIGITAL_OUT 3 = ANALOG_IN
subFunc\$	byVal nSubFunc\$ INTEGER

If nFunction == DIGITAL_IN

subFunc\$ will be a string that has the following form: - "\Digital_In_Bitmask", where Digital_In_Bitmask bits can be as follows:

Bits 0..3

0x01	Pull down resistor (weak)

0x02	Pull up resistor (weak)

0x03	Pull down resistor (strong)

0x04	Pull up resistor (strong)

Else	No pull resistors

Bits 4, 5

0x10	When in deep sleep mode, awake when this pin is LOW

0x20	When in deep sleep mode, awake when this pin is HIGH

Else	No effect in deep sleep mode

Bits 8..31

Must be 0s	

If nFuncType == DIGITAL_OUT

subFunc\$ is a string that has the following form: \Digital_Out, where Digital_Out consists of the following:

- Bits 0-3: Values
- Bits 4-6: Drive Capacity (Only for LOW and HIGH configuration. For PWM and FREQUENCY this is always set to 0=Standard; 1=Standard)

Values:

0	Initial output to LOW

1	Initial output to HIGH

2	Output is PWM (Pulse Width Modulated Output). See function GpioConfigPW() for more configuration. The duty cycle is set using function GpioWrite().

3	Output is FREQUENCY. The frequency is set using function GpioWrite() where 0 switches off the output; any value in range 1..4000000 generates an output signal with 50% duty cycle with that frequency.

Bits 4..6 (output drive capacity)

0	0 = Standard; 1 = Standard

1	0 = High; 1 = Standard

2	0 = Standard; 1 = High

3	0 = High; 1 = High

4	0 = Disconnect; 1 = Standard

5	0 = Disconnect; 1 = High

6	0 = Standard; 1 = Disconnect

7	0 = High; 1 = Disconnect

If nFuncType == ANALOG_IN

The reference voltage for the analog to digital converter is 0.6 volts.

subFunc\$ is a string that has the following form: \Gain_hex\Resolution_hex\Acquisition_hex

If the string is empty, then default values are used. Otherwise, the values can be as follows:

Gain_hex

0	Use the system default: 10-bit ADC, 1/6 scaling
0x16	1/6 scaling
0x15	1/5 scaling
0x14	1/4 scaling
0x13	1/3 scaling
0x12	1/2 scaling
0x11	1/1 scaling (Unity)
0x21	2/1 scaling
0x41	4/1 scaling

For example, if you have a maximum analog voltage of 1.7 volts, then select a gain of 1/3 so that the maximum voltage into the convertor is $1.7 * 1/3 = 0.57$. This means it is not bigger than the reference voltage of 0.6v and it is specified in subFunc\$ so that the first byte in the string is \13

Resolution_hex

0	Use the system default: 10-bit ADC
0x08	8-bit ADC resolution
0x0A	10-bit ADC resolution
0x0C	12-bit ADC resolution

Acquisition_hex

0	Use the system default: 10 microseconds
0x03	3 microseconds
0x05	5 microseconds
0x0A	10 microseconds
0x0F	15 microseconds
0x14	20 microseconds
0x28	40 microseconds

Any other value results in this function being rejected.

For example, selecting 1/5th scaling, 12-bit resolution, and acquisition time of 20 microseconds requires that the variable subFunc\$ be initialised as \15\0C\14.

Note: The internal reference voltage is the same as the module Vcc value with +/- 1.5% accuracy.

Example:

```
// Example :: GpioSetFuncEx.sb
// https://github.com/LairdCP/BL6542-Applications/tree/master/UserGuideExamples

//Digital In SIO 15, strong pull up resistor
PRINT GpioSetFuncEx(15,1,"\02")
//Analog In SIO 3 (Temperature Sensor), default settings
PRINT GpioSetFuncEx(3,3,"")
//Analog In SIO 23, 1/6 scaling, 12-bit resolution, 3us acquisition time
PRINT GpioSetFuncEx(23,3,"\16\0C\03")
//SIO17 (LED0) digital out, initial output high
```

```
PRINT GpioSetFuncEx(17,2,"\01")
//SIO26 digital out, PWM
PRINT GpioSetFuncEx(26,2,"\02")
```

Expected Output:

```
00000
```

4.8.4 GpioConfigPwm

FUNCTION

This routine configures the PWM (Pulse Width Modulation) of all output pins when they are set as a PWM output using GpioSetFunc() function described above.

Note: This is a 'sticky' configuration; calling it affects all PWM outputs already configured. We recommend that this is called once at the beginning of your application and not changed again within the application unless all PWM outputs are deconfigured and then re-enabled after this function is called.

The PWM output is generated using 32-bit hardware timers. The timers are clocked by a 1-MHz clock source.

A PWM signal has a frequency and a duty cycle property; the frequency is set using this function and is defined by the nMaxResolution parameter. For a given nMaxResolution value, given that the timer is clocked using a 1-MHz source, the frequency of the generated signal is 1000000 divided by nMaxResolution. Hence, if nMinFreqHz is more than the 1000000/nMaxResolution, this function will fail with a non-zero value.

The nMaxResolution can also be viewed as defining the resolution of the PWM output in the sense that the duty cycle can be varied from 0 to nMaxResolution. The duty cycle of the PWM signal is modified using the GpioWrite() command.

For example, a period of 1000 generates an output frequency of 1KHz, a period of 500, and a frequency of 2KHz etc.

On exit, the function returns with the actual frequency in the nMinFreqHz parameter.

GPIOCONFIGPWM (nMinFreqHz, nMaxResolution)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
nMinFreqHz	byRef nMinFreqHz AS INTEGER. The nominal frequency of the waveform.
nMaxResolution	byVal nMaxResolution AS INTEGER. Set to same value as nMinFreqHz.

Example:

```
// Example :: GpioConfigPwm.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

dim retval
dim i
dim nFreq
dim nResolution
dim res[5] as integer

FUNCTION HandlerTimer1()
    dim TmpVal
    i=i+1
    if i==5 then
        i=0
    endif
    TmpVal = (res[i]*100/nFreq)
    PRINT "\nTimer event! PWM changed to "; TmpVal; "% duty cycle."
    GpioWrite(13,res[i])
ENDFUNC 1

i=0
nFreq=2048
nResolution=2048
res[0]=nResolution/2
res[1]=nResolution/4
res[2]=nResolution/8
res[3]=0
res[4]=nResolution

ONEVENT EVTMR1 CALL HandlerTimer1

//Configure PWM
retval = GpioConfigPWM(nFreq,nResolution)
retval = GpioSetFunc(13,2,2)

//Write the first value to the PWM out
GpioWrite(13,res[i])
PRINT "\nTimer started. PWM on 50% duty cycle."

//start a 5000 millisecond (5 second) recurring timer
TimerStart(1,5000,1)

WAITEVENT
```

Expected Output:

```
Timer started. PWM on 50% duty cycle.
Timer event! PWM changed to 25% duty cycle.
Timer event! PWM changed to 12% duty cycle.
Timer event! PWM changed to 0% duty cycle.
Timer event! PWM changed to 100% duty cycle.
```

4.8.5 GpioRead

FUNCTION

This routine reads the value from a SIO pin.

The module datasheet contains a pinout table which mentions SIO (Special I/O) pins and the number designated for that SIO pin corresponds to the `nSigNum` argument.

Note: For ADC readings, the value read has an error percentage of +/-3% for 1/6 and 1/4 gains, and +/-4% for 1/2 and 1 gains.

GPIOREAD (nSigNum)

Returns INTEGER, the value from the signal.
If the signal number is invalid, then it returns a value of 0.
For digital pins, the value is 0 or 1. For ADC pins it is a value in the range 0 to M where M is the maximum value based on the bit resolution of the analogue to digital converter.

Arguments:

nSigNum **byVal nSigNum INTEGER.**
The signal number as stated in the pinout table of the module.

Refer to the example for [GpioBindEvent](#).

Example:

```
// Example: GpioRead.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

//This example reads from temperature sensor, for it to work, a jumper needs to be placed
//on J6 between SIO 3 and TEMP SENS
#define GPIO TEMP SENS          3

dim rc, adc

//Start timer to read temperature sensor
TimerStart(0,1000,1)

//Remove resistor
rc = GpioSetFunc(GPIO TEMP SENS, 1, 2)

//Analogue in
rc = GpioSetFunc(GPIO TEMP SENS, 3, 0)

FUNCTION HandlerTimer0 ()
    //Read the ADC
    adc = GpioRead(GPIO TEMP SENS)
    PRINT "\nRaw Temperature Sensor Reading: ";adc
ENDFUNC 1

OnEvent EVTMR0 call HandlerTimer0

WAITEVENT
```

Expected output:

```
Raw Temperature Sensor Reading: 1943
Raw Temperature Sensor Reading: 1943
```

4.8.6 GpioWrite

FUNCTION

This function writes a new value to the SIO pin. If the pin number is invalid, nothing happens.

If the SIO pin is configured as a PWM output then the `nNewValue` specifies a value in the range 0 to N where N is the `nMinFreqHz` set in the `GpioConfigPwm` command. The write value controls the mark space ratio of the output waveform. A value of 0 outputs a low, a value of `nMinFreqHz` outputs a high, and a value in varies the mark space ratio. The higher the value, the longer the mark period.

As with the `GpioConfigPwm` function, the `nNewValue` is used to calculate a hardware register value. This value must be less than the register value calculated from the `GpioConfigPwm` function that is used to set the PWM output frequency. Again, be careful to avoid non-integer results or the output waveform will not be accurate.

As an indication, if you divide the PWM output frequency by the value of the register calculated in the `GpioConfigPwm` function above, that result is the minimum `nNewValue` you can enter to get a mark:space ratio. Other valid mark:space ratios are provided by integer multiples of this minimum value.

For example, with a system frequency of 40 MHz and an output PWM frequency of 5 MHz, the register value to provide the output frequency is 8. So the minimum value of `nNewValue` is 0.625 MHz and the remaining obtainable values are 4.375, 3.75, 3.125, 2.5, 1.875, and 1.25 MHz. Any other `nNewValue` entered rounds down to one of these values.

GPIOWRITE (`nSigNum`, `nNewValue`)

Returns

Arguments:

<code>nSigNum</code>	byVal <code>nSigNum</code> INTEGER. The signal number as stated in the pinout table of the module.
<code>nNewValue</code>	byVal <code>nNewValue</code> INTEGER. The value to be written to the port. If the pin is configured as digital, then 0 clears the pin and a non-zero value sets it. If the pin is configured as a PWM then this value sets the duty cycle. If the pin is configured as a FREQUENCY then this value sets the frequency.

Example:

```
// Example :: GpioWrite.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

dim rc, i1, i2
i2 = 1
i1 = 1

//-----
// For debugging
// --- rc = result code
// --- ln = line number
//-----

Sub AssertRC(rc,ln)
    if rc!=0 then
        print "\nFail :";integer.h' rc;" at tag ";ln
    endif
end
```

```
EndSub

rc=GpioSetFunc(17,2,1)
AssertRC(rc,20)

rc=GpioSetFunc(19,2,1)
AssertRC(rc,23)

function HandlerTmr0()
    i1=!i1
    GpioWrite(19,i1)
    AssertRC(rc,30)
endfunc 1

function HandlerTmr1()
    i2=!i2
    GpioWrite(17,i2)
    AssertRC(rc,42)
endfunc 1

function HandlerUartRx()
endfunc 0

TimerStart(0,500,1)
TimerStart(1,1000,1)

onevent evuartrx call HandlerUartRx
onevent evtmr0   call HandlerTmr0
onevent evtmr1   call HandlerTmr1
print "\n\nPress any key to exit"

waitevent

print "\nExiting..."
```

Expected Output:

```
Press any key to exit
Exiting...
```


4.8.7 GpioBindEvent/GpioAssignEvent

FUNCTION

This routine binds an event to a level transition on a specified SIO line configured as a digital input so that changes in the input line can invoke a handler in *smart*BASIC user code.

When this function is called on the BL654, the SIO pin specified by *nSigNum* is set up as a digital input in the underlying firmware so *GpioSetFunc()* does **not** need to be called beforehand.

If this function is used in your *smart*BASIC application, we recommend that you unbind all bound events by calling *GpioUnbindEvent()* at the end of the application. Likewise for all assigned events, *GpioUnassignEvent* should be called.

Note: In the BL654 module, an SIO pin can only be bound to one event at a time.

GPIOBINDEVENT (*nEventNum*, *nSigNum*, *nPolarity*)

GPIOASSIGNEVENT (*nEventNum*, *nSigNum*, *nPolarity*)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.						
Arguments:							
<i>nEventNum</i>	byVal <i>nEventNum</i> INTEGER. The SIO event number (in the range of 0 - N) which results in the event EVGPIOCHANn being thrown to the <i>smart</i>BASIC runtime engine.						
<i>nSigNum</i>	byVal <i>nSigNum</i> INTEGER. The signal number as stated in the pinout table of the module. Note: On the BL654PA variant, 34 and 36 are not available as they are used to control the external PA and LNA.						
<i>nPolarity</i>	byVal <i>nPolarity</i> INTEGER. States the transition as follows: <table> <tr> <td>0</td><td>Low to high transition</td></tr> <tr> <td>1</td><td>High to low transition</td></tr> <tr> <td>2</td><td>(GpioBindEvent Only) Either a low to high or high to low transition</td></tr> </table>	0	Low to high transition	1	High to low transition	2	(GpioBindEvent Only) Either a low to high or high to low transition
0	Low to high transition						
1	High to low transition						
2	(GpioBindEvent Only) Either a low to high or high to low transition						

Note: Using *GpioBindEvent* provides the capability to detect any transition. However, it results in slightly higher power consumption. If power is of importance, *GpioAssignEvent()* should be used instead as it uses other resources to expedite an event.

Example:

```
// Example :: GpioBindEvent.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

dim rc

function HandlerBtn0()
    dim i : i = GpioRead(11)

    '//if button 0 was pressed
    if i==0 then
        print "\nButton 0 Pressed"

    '//if button 0 was released
    elseif i==1 then
        print "\nButton 0 Released"
    endif
endfunc 1

function HandlerUartRx()
endfunc 0

rc= GpioBindEvent(0,11,2)           '//Bind event 0 to high or low transition on SIO11 (button
1)
if rc==0 then
    onevent evgpiochan0 call HandlerBtn0  '//When event 0 happens, call Btn0Press
    print "\nSIO11 - Button 0 is bound to event 0. Press button 0"
else
    print "\nGpioBindEvent Err: ";integer.h'rc
endif

onevent evuartrx call HandlerUartRx
print "\n\nPress any key to exit"

waitevent
rc=GpioUnbindEvent(0)
if rc==0 then
    print "\n\nEvent 0 unbound\nExiting..."
endif
```

Expected Output:

```
SIO11 - Button 0 is bound to event 0. Press button 0

Press any key to exit
Button 0 Pressed
Button 0 Released
Button 0 Pressed
Button 0 Released

Event 0 unbound
Exiting...
00
```

4.8.8 GpioUnbindEvent/GpioUnAssignEvent

FUNCTION

This routine unbinds the runtime engine event from a level transition bound using GpioBindEvent().

GPIOUNBINDEVENT (nEventNum)

GPIOUNASSIGNEVENT (nEventNum)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.

Arguments:

byVal nEventNum	INTEGER. The SIO event number (in the range of 0 - N) which is disabled so that it no longer generates run-time events in <i>smart</i> BASIC.

See example for [GpioBindEvent](#).

4.9 Miscellaneous Routines

This section describes all miscellaneous functions and subroutines.

4.9.1 ASSERTBL654

SUBROUTINE

This function's main use case is during *smart*BASIC source compilation and the presence of at least one instance of this statement ensures that the *smart*BASIC application only fully compiles without errors on a BL654 module. This ensures that apps for other modules are not mistakenly loaded into the BL654.

AssertBL654 ()

Returns	Not acceptable as it is a subroutine

Arguments:	None

Example:

```
AssertBL654()//Ensure loading on BL654 only
```

4.9.2 ERASEFILESYSTEM

FUNCTION

This function is used to erase the flash file system which contains the application that invoked this function, **if and only if**, the SIO2 input pin is held high.

Given that SIO2 is high, after erasing the file system, the module resets and reboots into command mode with the virtual serial port service enabled; the module advertises for a few seconds. See the [virtual serial port service section](#) for more details.

This facility allows the current \$autorun\$ application to be replaced with a new one.

WARNING

If this function is called from within \$autorun\$ and the SIO2 input is high, it is erased and a fresh download of the application is required which can be facilitated over the air.

ERASEFILESYSTEM (nArg)

Returns	INTEGER Indicates success of command:
	0 Successful erasure. The module reboots.
	<>0 Failure.

Exceptions	- Local Stack Frame Underflow - Local Stack Frame Overflow

Arguments:

nArg **byVal nArg AS INTEGER**

This is for future use and MUST always be set to 1. Any other value will result in a failure.

Example:

```
DIM rc
rc = EraseFileSystem(1234)
IF rc!=0 THEN
    PRINT "\nFailed to erase file system because incorrect parameter"
ENDIF
//Input SIO2 is low
rc = EraseFileSystem(1)
IF rc!=0 THEN
    PRINT "\nFailed to erase file system because SIO19 is low"
ENDIF
```

Expected Output:

```
Failed to erase file system because incorrect parameter
Failed to erase file system because SIO19 is low
00
```

5 BLE EXTENSIONS BUILT-IN ROUTINES

5.1 LE Privacy

To address privacy concerns, there are four types of Bluetooth addresses in a BLE device which can change as often as required. For example, an iPhone regularly changes its BLE Bluetooth address and it always exposes only its resolvable random address. This feature is known as LE privacy. It allows the Bluetooth address within advertising packets to be replaced with a random value that can change at different time intervals. Malicious devices are not able to track your device as it actually looks like a series of different devices.

To manage this, the usual six-octet Bluetooth address is qualified on-air by a single bit which qualifies the Bluetooth address as public or random:

- Public – The format is as defined by the IEEE organisation.
- Random – The format can be up to three types and this qualification is done using the upper two bits of the most significant byte of the random Bluetooth address.

Address types:

00	Public
01	Random Static
02	Random Private Resolvable
03	Random Private Non-Resolvable

All other values are illegal

On the BL654, the address type can be set using the function `BleSetAddressTypeEx()`. On the other hand, `Sysinfo$(4)` can be used to retrieve the Bluetooth address if it is public or random static. Due to LE privacy 1.2, if the address type is random resolvable or random non-resolvable, it cannot be retrieved by the application layer since it is fully controlled by the baseband layer.

Note: The Bluetooth address portion in *smart*BASIC is always in big endian format. If you sniff on-air packets, the same six packets appear in little endian format, hence reverse order – and you do not see seven bytes, but a bit in the packet somewhere which specifies it to be public or random.

5.1.1 BleSetAddressTypeEx

FUNCTION

This functions sets the current address type to be used by the LE radio scan/advert/connection requests. Type 2 and Type 3 can be set to be refreshed periodically.

BLESETADDRESSTYPEEX (nAddrType, nPeriodMS)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.								
Arguments:									
	byVal nAddrType AS INTEGER. Specifies the type of the LE address as follows:								
nAddrType	<table> <tr> <td>0</td><td>Public address, same as Classic.</td></tr> <tr> <td>1</td><td>Random static address, generated first boot.</td></tr> <tr> <td>2</td><td>Random address, resolvable with IRK, generated on call.</td></tr> <tr> <td>3</td><td>Random address, non resolvable, generation on call</td></tr> </table>	0	Public address, same as Classic.	1	Random static address, generated first boot.	2	Random address, resolvable with IRK, generated on call.	3	Random address, non resolvable, generation on call
0	Public address, same as Classic.								
1	Random static address, generated first boot.								
2	Random address, resolvable with IRK, generated on call.								
3	Random address, non resolvable, generation on call								
nPeriodMS	The time period for changing resolvable and non-resolvable addresses in milliseconds. If the nAddrType is 0 or 1, this parameter is ignored. Negative values result in an error being returned. A value of 0 means the address will not change.								

Example:

```
// Example: BleSetAddressTypeEx.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc, addr$
// Set the address to pulic, nPeriodMS is ignored
rc = BleSetAddressTypeEx(0,0)
addr$ = SysInfo$(4)
PRINT "\nBluetooth Address - "; StrHexize$(addr$)

// Set the address to random static, nPeriodMS is ignored
rc = BleSetAddressTypeEx(1,0)
addr$ = SysInfo$(4)
PRINT "\nBluetooth Address - "; StrHexize$(addr$)

// Set the address to be random resolvable that changes every 30 seconds
rc = BleSetAddressTypeEx(2,30000)
addr$ = SysInfo$(4)
PRINT "\nCurrent Address - "; StrHexize$(addr$)

// Set the address to be random non-resolvable that changes every 1 seconds
rc = BleSetAddressTypeEx(3,1000)
addr$ = SysInfo$(4)
PRINT "\nBluetooth Address - "; StrHexize$(addr$)
```

Expected Output:

```
Bluetooth Address - 000016A4B75201
Bluetooth Address - 01D3B61EE3F699
Bluetooth Address - 01D3B61EE3F699
Bluetooth Address - 01D3B61EE3F699
```

Note: Even though Sysinfo\$(4) returns the random static address after setting address types 2 and 3, the actual address used by the radio packets are the random resolvable and the random non-resolvable addresses respectively. The reason for this is that private addresses are only known to the baseband.

5.2 Events and Messages

5.2.1 EVBLE_ADV_TIMEOUT

This event is thrown when adverts that are started using `BleAdvertStart()` time out.

Example:

```
// Example :: EvBle_Adv_Timeout.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM peerAddr$

//handler to service an advert timeout
FUNCTION HndlrBleAdvTimOut ()
    PRINT "\nAdvert stopped via timeout"
    //DbgMsg( "\n    - could use SystemStateSet(0) to switch off" )

    //-----
    //  Switch off the system - requires a power cycle to recover
    //-----
    //  rc = SystemStateSet(0)
ENDFUNC 0

//start adverts
//rc = BleAdvertStart(0,"",100,5000,0)
IF BleAdvertStart(0,peerAddr$,100,2000,0)==0 THEN
    PRINT "\n Advert Started"
ELSE
    PRINT "\n\nAdvert not successful"
ENDIF

ONEVENT  EVBLE_ADV_TIMEOUT  CALL  HndlrBleAdvTimOut

WAITEVENT
```

Expected Output:

```
Advert Started
Advert stopped via timeout
```

5.2.2 EVBLE_CONN_TIMEOUT

This event is thrown when a BLE connection attempt initiated by the `BleConnect()` function times out.

See example for [BleConnect](#).

5.2.3 EVBLE_ADV_REPORT

This event is thrown when an advert report is received whether successfully cached or not.

See example for [BleScanGetAdvReport](#).

5.2.4 EVBLE_FAST_PAGED

This event is thrown when an advert report is received which is of type `ADV_DIRECT_IND` and the advert had a target address (`InitA` in the spec) which matches the address of this module.

See example for [BleScanGetPagerAddr](#).

5.2.5 EVBLE_SCAN_TIMEOUT

This event is thrown when a BLE scanning procedure initiated by the [BleScanStart\(\)](#) function times out.

See example for [BLESCANSTART](#).

5.2.6 EVBLEMSG

The BLE subsystem is capable of informing a *smart*BASIC application when a significant BLE-related event has occurred. It does so by throwing this message (as opposed to an `EVENTTable 20`, which is akin to an interrupt and has no context or queue associated with it).

The message contains two parameters:

- **msgID** – Identifies what event was triggered
- **msgCtx** – Conveys some context data associated with that event.

The *smart*BASIC application must register a handler function which takes two integer arguments to be able to receive and process this message.

Note: The messaging subsystem, unlike the event subsystem, has a queue associated with it and, unless that queue is full, pends all messages until they are handled. Only messages that have handlers associated with them are inserted into the queue. This prevents messages that will not get handled from filling that queue. The following table lists the triggers and associated context parameters.

MsgID	Description
0	A BLE connection is established and msgCtx is the connection handle.
1	A BLE disconnection event and msgCtx identifies the handle.
4	A BLE Service Error. The second parameter contains the error code.
9	Pairing in progress and displayed Passkey supplied in msgCtx.
10	A new bond has been successfully created.
11	Pairing in progress and authentication key requested. msgCtx is key type.
14	Connection parameters update and msgCtx is the conn handle.
15	Connection parameters update fail and msgCtx is the conn handle.
16	Connected to a bonded master and msgCtx is the conn handle.
17	A new pairing has replaced old key for the connection handle specified.
18	The connection is now encrypted and msgCtx is the conn handle.

MsgID	Description
20	The connection is no longer encrypted and msgCtx is the conn handle
21	The device name characteristic in the GAP service of the local GATT table has been written by the remote GATT client.
22	Attempt to add a new bonding to the bonding database failed
23	On a BLE connection to a bonded device, if the current GATT table schema does not match what existed at the last connection, then a GATT Service Change Indication is automatically sent and the app is informed via this event
24	On a BLE connection to a bonded device, if the current gatt table schema does not match what existed at the last connection, then a GATT Service Change Indication is automatically sent and the app is informed when the client acknowledges that indication

Note: Message ID 13 is reserved for future use.

Example:

```
// Example :: EvBleMsg.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM addr$ : addr$=""
DIM rc

//=====
// This handler is called when there is a BLE message
//=====
FUNCTION HndlrBleMsg (BYVAL nMsgId AS INTEGER, BYVAL nCtx AS INTEGER)
    SELECT nMsgId
        CASE 0
            PRINT "\nBLE Connection ";nCtx
        CASE 1
            PRINT "\nDisconnected ";nCtx;"\n"
        CASE 18
            PRINT "\nConnection ";nCtx;" is now encrypted"
        CASE 16
            PRINT "\nConnected to a bonded master"
        CASE 17
            PRINT "\nA new pairing has replaced the old key";
        CASE ELSE
            PRINT "\nUnknown Ble Msg"
    ENDSELECT
ENDFUNC 1

FUNCTION HndlrBlrAdvTimOut ()
```

```
PRINT "\nAdvert stopped via timeout"
PRINT "\nExiting..."
ENDFUNC 0

FUNCTION HndlrUartRx()
    rc=BleAdvertStop()
    PRINT "\nExiting..."
ENDFUNC 0

ONEVENT EVBLEMSG          CALL HndlrBleMsg
ONEVENT EVBLE_ADV_TIMEOUT CALL HndlrBlrAdvTimOut
ONEVENT EVUARTRX          CALL HndlrUartRx

// start adverts
IF BleAdvertStart(0,addr$,100,10000,0)==0 THEN
    PRINT "\nAdverts Started"
    PRINT "\nPress any key to exit\n"
ELSE
    PRINT "\n\nAdvertisement not successful"
ENDIF

WAITEVENT
```

Expected Output (When connection made with the module):

```
Adverts Started
Press any key to exit

BLE Connection 3634
Connected to a bonded master
Connection 3634 is now encrypted
A new pairing has replaced the old key
Disconnected 3634

Exiting...
```

Expected Output (When no connection made):

```
Adverts Started
Press any key to exit

Advert stopped via timeout
Exiting...
```

5.2.7 EVDISCON

This event is thrown when there is a BLE disconnection. It comes with two parameters:

- Connection handle
- The reason for the disconnection

The reason, for example, can be 0x08 which signifies a link connection supervision timeout which is used in the Proximity Profile.

A full list of Bluetooth HCI result codes for the reason of disconnection is provided in this document [here](#).

Example:

```
// Example :: EvDiscon.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM addr$ : addr$=""

FUNCTION HndlrBleMsg(BYVAL nMsgId AS INTEGER, BYVAL nCtx AS INTEGER)
    IF nMsgID==0 THEN
        PRINT "\nNew Connection ";nCtx
    ENDIF
ENDFUNC 1

FUNCTION Btn0Press()
    PRINT "\nExiting..."
ENDFUNC 0

FUNCTION HndlrDiscon(BYVAL hConn AS INTEGER, BYVAL nRsn AS INTEGER) AS INTEGER
    PRINT "\nConnection ";hConn;" Closed: 0x";nRsn
ENDFUNC 0

ONEVENT EVBLEMSG      CALL HndlrBleMsg
ONEVENT EVDISCON      CALL HndlrDiscon

// start adverts
IF BleAdvertStart(0,addr$,100,10000,0)==0 THEN
    PRINT "\nAdverts Started\n"
ELSE
    PRINT "\n\nAdvertisement not successful"
ENDIF

WAITEVENT
```

Expected Output:

```
Adverts Started

New Connection 2915
Connection 2915 Closed: 0x19
```

5.2.8 EVCHARVAL

This event is thrown when a characteristic is written to by a remote GATT client. It comes with three parameters:

- **Char Handle** – Characteristic handle that was returned when the characteristic was registered using the function [BleCharCommit\(\)](#)
- **Offset** – Offset
- **Length** – Length of the data from the characteristic value

5.2.9 EVCHARVALUE

This event is thrown when the remote device writes to a characteristic value. It differs from EVCHARVAL in that the event contains the parameters including the connection handle and the string data. If the write operation is performed on a characteristic that requires authorisation, then EVAUTHVAL is thrown instead and the user should then authorize and read the value.

If the event is thrown with an empty string but the length has a non-zero value, then this indicates that there was not enough memory to allocate to the event.

The event comes with the following parameters:

- **Connection Handle** – The handle of the connection that wrote to the characteristic value.
- **Char Handle** – Characteristic handle that was returned when the characteristic was registered using the function [BleCharCommit\(\)](#)
- **Offset** – The offset at which the characteristic data was written.
- **Length** – The length of the data that was written. This should be equal to `StrLen$(Data$)`, and can be used to detect if there was any data loss.
- **Data\$** – The string data that was written to the characteristic.

Example:

```
// Example :: EvCharVal.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM hMyChar,rc,at$,conHndl

//=====
// Initialise and instantiate service, characteristic, start adverts
//=====
FUNCTION OnStartup()
    DIM rc, hSvc, attr$, adRpt$, addr$, scRpt$ : attr$="Hi"

    //commit service
    rc=BleServiceNew(1, BleHandleUuid16(0x18EE), hSvc)
    //initialise char, write/read enabled, accept signed writes
    rc=BleCharNew(0x0A,BleHandleUuid16(1),BleAttrMetaData(1,1,20,0,rc),0,0)
    //commit char initialised above, with initial value "hi" to service 'hSvc'
    rc=BleCharCommit(hSvc,attr$,hMyChar)
    //commit changes to service
    rc=BleServiceCommit(hSvc)
    rc=BleScanRptInit(scRpt$)
    //Add 1 service handle to scan report
    //rc=BleAdvRptAddUuid16(scRpt$,0x18EE,-1,-1,-1,-1)
    //commit reports to GATT table - adRpt$ is empty
    rc=BleAdvRptsCommit(adRpt$,scRpt$)
    rc=BleAdvertStart(0,addr$,20,300000,0)
ENDFUNC rc

//=====
// Close connections so that we can run another app without problems
//=====
```

```

SUB CloseConnections ()
    rc=BleDisconnect(conHndl)
    rc=BleAdvertStop()
ENDSUB

//=====
// Ble event handler
//=====
FUNCTION HndlrBleMsg (BYVAL nMsgId, BYVAL nCtx)
    conHndl=nCtx
    IF nMsgID==1 THEN
        PRINT "\n\n--- Disconnected from client"
        EXITFUNC 0
    ELSEIF nMsgID==0 THEN
        PRINT "\n--- Connected to client"
    ENDIF
ENDFUNC 1

//=====
// New char value handler - Thrown when AT+CFG 213=0
//=====
FUNCTION HandlerCharVal (BYVAL charHandle, BYVAL offset, BYVAL len)
    DIM s$
    IF charHandle == hMyChar THEN
        PRINT "\n";len;" byte(s) have been written to char value attribute from offset
";offset

        rc=BleCharValueRead(hMyChar,s$)
        PRINT "\nNew Char Value: ";s$
    ENDIF
    CloseConnections()
ENDFUNC 1

//=====
// New char value handler - Thrown when AT+CFG 213=1
//=====
FUNCTION HandlerCharValue (BYVAL nConnHandle, BYVAL charHandle, BYVAL offset, BYVAL len,
BYVAL Data$)
    DIM s$
    IF charHandle == hMyChar THEN
        PRINT "\n";len;" byte(s) have been written to char value attribute from offset
";offset

        PRINT "\nData written is :";Data$ PRINT "\nData written is :";Data$;" - Connection
Handle=";integer.h' nConnHandle

        rc=BleCharValueRead(hMyChar,s$)
        PRINT "\nNew Char Value: ";s$
    ENDIF
    CloseConnections()
ENDFUNC 1

ONEVENT EVCHARVAL CALL HandlerCharVal // This event is thrown if AT+CFG 213 = 0
ONEVENT EVCHARVALUE CALL HandlerCharValue // This event is thrown if AT+CFG 213 = 1
ONEVENT EVBLEMSG CALL HndlrBleMsg

IF OnStartup()==0 THEN
    rc = BleCharValueRead(hMyChar,at$)
    PRINT "\nThe characteristic's value is ";at$
    PRINT "\nWrite a new value to the characteristic\n"
ELSE

```

```
PRINT "\nFailure OnStartup"
ENDIF

WAITEVENT

PRINT "\nExiting..."
```

Expected Output (AT+CFG 213=0):

```
The characteristic's value is Hi
Write a new value to the characteristic

--- Connected to client
5 byte(s) have been written to char value attribute from offset 0
New Char Value: Hello

--- Disconnected from client
Exiting...
```

Expected Output (AT+CFG 213=1):

```
The characteristic's value is Hi
Write a new value to the characteristic

--- Connected to client
5 byte(s) have been written to char value attribute from offset 0
Data written is :hello - Connection Handle=0001FF00

New Char Value: Hello

--- Disconnected from client
Exiting...
```

5.2.10 EVCHARHVC

This event is thrown when a value sent via an indication to a client gets acknowledged. It comes with one parameter:

- The characteristic handle that was returned when the characteristic was registered using the function [BleCharCommit\(\)](#)

Example:

```
// Example :: EVCHARHVC charHandle
// See example that is provided for EVCHARCCCD
```

5.2.11 EVCHARCCCD

This event is thrown when the client writes to the CCCD descriptor of a characteristic. It comes with two parameters:

- The characteristic handle returned when the characteristic was registered with [BleCharCommit\(\)](#)
- The new 16-bit value in the updated CCCD attribute

Example:

```
// Example :: EvCharCccd.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM hMyChar, rc, at$, conHndl

//=====
```

```
// Initialise and instantiate service, characteristic, start adverts
//=====

FUNCTION OnStartup()
    DIM rc, hSvc, metaSuccess, at$, attr$, adRpt$, addr$, scRpt$
    attr$="Hi"

    DIM svcUuid : svcUuid=0x18EE
    DIM charUuid : charUuid = BleHandleUuid16(1)
    DIM charMet : charMet = BleAttrMetadata(0,0,20,1,metaSuccess)
    DIM hSvcUuid : hSvcUuid = BleHandleUuid16(svcUuid)
    DIM mdCccd : mdCccd = BleAttrMetadata(1,1,2,0,rc) //CCCD metadata for char

    //Create service
    rc=BleServiceNew(1,hSvcUuid,hSvc)

    //initialise char, write/read enabled, accept signed writes, indicatable
    rc=BleCharNew(0x20,charUuid,charMet,mdCccd,0)

    //commit char initialised above, with initial value "hi" to service 'hMyChar'
    rc=BleCharCommit(hSvc,attr$,hMyChar)

    //commit service to GATT table
    rc=BleServiceCommit(hSvc)

    rc=BleAdvertStart(0,addr$,20,300000,0)
ENDFUNC rc

//=====
// Close connections so that we can run another app without problems
//=====

SUB CloseConnections()
    rc=BleDisconnect(conHndl)
    rc=BleAdvertStop()
    rc=GpioUnbindEvent(1)
ENDSUB

//=====
// Ble event handler
//=====

FUNCTION HndlrBleMsg(BYVAL nMsgId, BYVAL nCtx)
    conHndl=nCtx
```

```
IF nMsgID==1 THEN
    PRINT "\n\n--- Disconnected from client"
    EXITFUNC 0
ELSEIF nMsgID==0 THEN
    PRINT "\n--- Connected to client"
ENDIF
ENDFUNC 1

//=====
// Indication acknowledgement from client handler
//=====
FUNCTION HndlrCharHvc(BYVAL charHandle AS INTEGER) AS INTEGER
    IF charHandle == hMyChar THEN
        PRINT "\nGot confirmation of recent indication"
    ELSE
        PRINT "\nGot confirmation of some other indication: ";charHandle
    ENDIF
ENDFUNC 1

//=====
// Called when data received via the UART
//=====
FUNCTION HndlrUartRx() AS INTEGER
ENDFUNC 0

//=====
// CCCD descriptor written handler
//=====
FUNCTION HndlrCharCccd(BYVAL charHandle, BYVAL nVal) AS INTEGER
    DIM value$
    IF charHandle==hMyChar THEN
        IF nVal & 0x02 THEN
            PRINT "\nIndications have been enabled by client"
            value$="hello"
            IF BleCharValueIndicate(hMyChar,value$)!=0 THEN
                PRINT "\nFailed to indicate new value"
            ENDIF
        ELSE
            PRINT "\nIndications have been disabled by client"
        ENDIF
    ENDIF
```



```
ELSE
    PRINT "\nThis is for some other characteristic"
ENDIF
ENDFUNC 1

ONEVENT EVBLEMSG    CALL HndlrBleMsg
ONEVENT EVCHARHVC   CALL HndlrCharHvc
ONEVENT EVCHARCCCD  CALL HndlrCharCccd
ONEVENT EVUARTRX    CALL HndlrUartRx

IF OnStartup()==0 THEN
    rc = BleCharValueRead(hMyChar,at$)
    PRINT "\nValue of the characteristic ";hMyChar;" is: ";at$
    PRINT "\nYou can write to the CCCD characteristic."
    PRINT "\nThe BL654 will then indicate a new characteristic value\n"
    PRINT "\n--- Press any key to exit"
ELSE
    PRINT "\nFailure OnStartup"
ENDIF

WAITEVENT

CloseConnections()

PRINT "\nExiting..."
```

Expected Output:

```
Value of the characteristic 1346437121 is: Hi
You can write to the CCCD characteristic.
The BL654 will then indicate a new characteristic value

--- Press any key to exit
--- Connected to client
Indications have been enabled by client
Got confirmation of recent indication
Exiting...
```

5.2.12 EVCHARSCCD

This event is thrown when the client writes to the SCCD descriptor of a characteristic. It comes with two parameters:

- The characteristic handle that is returned when the characteristic is registered using the function `BleCharCommit()`
- The new 16-bit value in the updated SCCD attribute

The SCCD is used to manage broadcasts of characteristic values.

Example:

```
// Example :: EvCharSccd.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM hMyChar,rc,chVal$,conHndl

//=====
// Initialise and instantiate service, characteristic, start adverts
//=====

FUNCTION OnStartup()
    DIM rc, hSvc, attr$, adRpt$, addr$, scRpt$ ,rc2
    attr$="Hi"
    DIM charMet : charMet = BleAttrMetaData(1,1,20,1,rc)

    //Create service
    rc=BleServiceNew(1,BleHandleUuid16(0x18EE),hSvc)

    //initialise broadcast capable, readable, writeable
    rc=BleCharNew(0x0B,BleHandleUuid16(1),charMet,0,BleAttrMetadata(1,1,1,0,rc2))

    //commit char initialised above, with initial value "hi" to service 'hMyChar'
    rc=BleCharCommit(hSvc,attr$,hMyChar)

    //commit service to GATT table
    rc=BleServiceCommit(hSvc)

    rc=BleAdvertStart(0,addr$,20,300000,0)
ENDFUNC rc

//=====
// Close connections so that we can run another app without problems
//=====

SUB CloseConnections()
    rc=BleDisconnect(conHndl)
```

```
rc=BleAdvertStop()  
rc=GpioUnbindEvent(1)  
ENDSUB  
  
//=====  
// Broadcast characteristic value  
//=====  
FUNCTION PrepAdvReport()  
    dim adRpt$, scRpt$, svcDta$  
  
    //initialise new advert report  
    rc=BleAdvRptinit(adRpt$, 2, 0, 0)  
  
    //encode service UUID into service data string  
    rc=BleEncode16(svcDta$, 0x18EE, 0)  
  
    //append characteristic value  
    svcDta$ = svcDta$ + chVal$  
  
    //append service data to advert report  
    rc=BleAdvRptAppendAD(adRpt$, 0x16, svcDta$)  
  
    //commit new advert report, and empty scan report  
    rc=BleAdvRptsCommit(adRpt$, scRpt$)  
ENDFUNC rc  
  
//=====  
// Reset advert report  
//=====  
FUNCTION ResetAdvReport()  
    dim adRpt$, scRpt$  
  
    //initialise new advert report  
    rc=BleAdvRptinit(adRpt$, 2, 0, 20)  
  
    //commit new advert report, and empty scan report  
    rc=BleAdvRptsCommit(adRpt$, scRpt$)  
ENDFUNC rc
```

```
//=====
// Ble event handler
//=====

FUNCTION HndlrBleMsg (BYVAL nMsgId, BYVAL nCtx)
    conHndl=nCtx
    IF nMsgID==1 THEN
        PRINT "\n\n--- Disconnected from client"
        dim addr$
        rc=BleAdvertStart(0,addr$,20,300000,0)
        IF rc==0 THEN
            PRINT "\nYou should now see the new characteristic value in the advertisment
data"
        ENDIF
    ELSEIF nMsgID==0 THEN
        PRINT "\n--- Connected to client"
    ENDIF
ENDFUNC 1

//=====
// Called when data arrives via UART
//=====

FUNCTION HndlrUartRx()
ENDFUNC 0

//=====
// CCCD descriptor written handler
//=====

FUNCTION HndlrCharSccd(BYVAL charHandle, BYVAL nVal) AS INTEGER
    DIM value$
    IF charHandle==hMyChar THEN
        IF nVal & 0x01 THEN
            PRINT "\nBroadcasts have been enabled by client"
            IF PrepAdvReport()==0 THEN
                rc=BleDisconnect(conHndl)
                PRINT "\nDisconnecting..."
            ELSE
                PRINT "\nError Committing advert reports: ";integer.h'rc
            ENDIF
        ELSE
            PRINT "\nError Committing advert reports: ";integer.h'rc
        ENDIF
    ELSE
        PRINT "\nError Committing advert reports: ";integer.h'rc
    ENDIF
ENDFUNC 0
```

```
        PRINT "\nBroadcasts have been disabled by client"
    IF ResetAdvReport()==0 THEN
        PRINT "\nAdvert reports reset"
    ELSE
        PRINT "\nError Resetting advert reports: ";integer.h'rc
    ENDIF
ENDIF
ELSE
    PRINT "\nThis is for some other characteristic"
ENDIF
ENDFUNC 1

//=====
// New char value handler
//=====
FUNCTION HndlrCharVal(BYVAL charHandle, BYVAL offset, BYVAL len)
    DIM s$
    IF charHandle == hMyChar THEN
        rc=BleCharValueRead(hMyChar,chVal$)
        PRINT "\nNew Char Value: ";chVal$
    ENDIF
ENDFUNC 1

//=====
// Called after a disconnection
//=====
FUNCTION HndlrDiscon(hConn, nRsn)
    dim addr$
    rc=BleAdvertStart(0,addr$,20,300000,0)
ENDFUNC 1

ONEVENT EVBLEMSG      CALL HndlrBleMsg
ONEVENT EVCHARSCCD    CALL HndlrCharSccd
ONEVENT EVUARTRX      CALL HndlrUartRx
ONEVENT EVCHARVAL     CALL HndlrCharVal
ONEVENT EVDISCON      CALL HndlrDiscon

IF OnStartup()==0 THEN
    rc = BleCharValueRead(hMyChar,chVal$)
```

```
PRINT "\nCharacteristic Value: ";chVal$

PRINT "\nWrite a new value to the characteristic, then enable broadcasting.\nThe
module will then disconnect and broadcast the new characteristic value."

PRINT "\n--- Press any key to exit\n"

ELSE

    PRINT "\nFailure OnStartup"

ENDIF

WAITEVENT

CloseConnections()

PRINT "\nExiting..."
```

Expected Output:

```
Characteristic Value: Hi
Write a new value to the characteristic, then enable broadcasting.
The module will then disconnect and broadcast the new characteristic value.
--- Press any key to exit

--- Connected to client
New Char Value: hello
Broadcasts have been enabled by client
Disconnecting...

--- Disconnected from client
You should now see the new characteristic value in the advertisement data
Exiting...
```

5.2.13 EVCHARDESC

This event is thrown when the client writes to a writable descriptor of a characteristic which is not a CCCD or SCCD (they are catered for with their own dedicated messages). It comes with two parameters:

- The characteristic handle that was returned when the characteristic was registered using the function [BleCharCommit\(\)](#)
- An index into an opaque array of handles managed inside the characteristic handle. Both parameters are supplied as-is as the first two parameters to the function [BleCharDescRead\(\)](#).

Example:

```
// Example :: EvCharDesc.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM hMyChar,rc,at$,conHndl, hOtherDscr

//=====
// Initialise and instantiate service, characteristic, start adverts
//=====

FUNCTION OnStartup$()
    DIM rc, hSvc, at$, adRpt$, addr$, scRpt$, hOtherDscr,attr$, attr2$, rc2
```

```
attr$="Hi"
DIM charMet : charMet = BleAttrMetaData(1,0,20,0,rc)

//Commit svc with handle 'hSvcUuid'
rc=BleServiceNew(1,BleHandleUuid16(0x18EE),hSvc)
//initialise characteristic - readable
rc=BleCharNew(0x02,BleHandleUuid16(1),charMet,0,0)

//Add user descriptor - variable length
attr$="my char desc"
rc=BleCharDescUserDesc(attr$,BleAttrMetadadata(1,1,20,1,rc2))

//commit char initialised above, with initial value "char value" to service 'hSvc'
attr2$="char value"
rc=BleCharCommit(hSvc,attr2$,hMyChar)

//commit service to GATT table
rc=BleServiceCommit(hSvc)

rc=BleAdvertStart(0,addr$,20,300000,0)
ENDFUNC attr$

//=====
// Close connections so that we can run another app without problems
//=====
SUB CloseConnections()
    rc=BleDisconnect(conHndl)
    rc=BleAdvertStop()
    rc=GpioUnbindEvent(1)
ENDSUB

//=====
// Ble event handler
//=====
FUNCTION HndlrBleMsg(BYVAL nMsgId, BYVAL nCtx)
    conHndl=nCtx
    IF nMsgID==1 THEN
        PRINT "\n\n--- Disconnected from client"
        EXITFUNC 0
    ELSEIF nMsgID==0 THEN
        PRINT "\n--- Connected to client"
    ENDIF
ENDFUNC 1
```

```
//=====
// Called when data arrives via UART
//=====

FUNCTION HndlrUartRx()
ENDFUNC 0

//=====
// Client has written to writeable descriptor
//=====

FUNCTION HndlrCharDesc(BYVAL hChar AS INTEGER, BYVAL hDesc AS INTEGER) AS INTEGER
    dim duid,a$,rc
    IF hChar == hMyChar THEN
        rc = BleCharDescRead(hChar,hDesc,0,20,duid,a$)
        IF rc ==0 THEN
            PRINT "\nNew value for desriptor ";hDesc;" with uuid ";integer.h'duid;" is
";a$
        ELSE
            PRINT "\nCould not read the descriptor value"
        ENDIF
    ELSE
        PRINT "\nThis is for some other characteristic"
    ENDIF
ENDFUNC 1

ONEVENT EVBLEMSG CALL HndlrBleMsg
ONEVENT EVCHARDESC CALL HndlrCharDesc
ONEVENT EVUARTRX CALL HndlrUartRx

PRINT "\nOther Descriptor Value: ";OnStartup$()
PRINT "\nWrite a new value \n--- Press any key to exit\n"

WAITEVENT

CloseConnections()

PRINT "\nExiting..."
```

Expected Output:

```
Other Descriptor Value: my char desc
Write a new value
--- Press any key to exit

--- Connected to client
New value for desriptor 0 with uuid FE012901 is hello
```


5.2.14 EVAUTHVAL

This event is thrown **instead of EVCHARVAL** when a characteristic with read and/or write authorisation is being read or written to by a remote GATT client. It comes with three parameters:

- **Connection handle** – The connection handle of the GATT client
- **Char handle** – The characteristic handle that was returned when the characteristic was registered using the function `BleCharCommit()`
- **ReadWrite** – Will be 0x00000000 when this is a read attempt and 0x00010000 when write attempt

Call `BleAuthorizeChar()` to either grant or deny access.

If this is a write attempt and access is granted then as soon as the function `BleAuthoriseChar()` returns the new value is ready to be read using `BleCharValueRead()`.

Note: When a characteristic requires authentication and the remote device reads from it or writes to it using the `WRITE_CMD` (write without response), the event `EVAUTHVALEX` is thrown instead. The user should therefore have both `EVAUTHVAL` and `EVAUTHVALEX` events in their app and service the events appropriately. See the example below for more information.

5.2.15 EVAUTHVALEX

This event is thrown when the remote device writes to a characteristic value that requires authentication using the `WRITE_CMD` (write without response) command. You should then write the data using `BleCharValueWriteEx` at the app layer, otherwise the value is not updated. If the event is thrown with an empty string but the length has a non-zero value, this indicates that there was not enough memory to allocate to the event. The event comes with the following parameters:

- **Connection handle** – The connection handle of the GATT client
- **Char handle** – The characteristic handle that was returned when the characteristic was registered using the function `BleCharCommit()`
- **Offset** – The offset of the characteristic at which the remote is attempting to write.
- **Length** – The length of the data that the remote is attempting to write. This should be equal to `StrLen$(Data$)` and can be used to verify that no data loss has occurred.
- **Data\$** – The string data that the remote device is attempting to write.

Note: When a characteristic requires authentication and the remote device reads from it or writes to it using a normal `WRITE`, the event `EVAUTHVAL` is thrown instead. You should therefore have both `EVAUTHVAL` and `EVAUTHVALEX` events in their app and service the events appropriately. See the example below for more information.

Example:

```
// Example :: EvAuthVal.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM hMyChar, rc, at$, conHndl

//-----
// Initialise and instantiate service, characteristic, start adverts
//-----

FUNCTION OnStartup()
    DIM rc, hSvc, attr$, adRpt$, addr$, scRpt$ : attr$="Hi"

    //Commit service
    rc=BleServiceNew(1, BleHandleUuid16(0x18EE), hSvc)
    //Initialise char, write/read enabled, accept signed writes
    rc=BleCharNew(0x0A, BleHandleUuid16(1), BleAttrMetaDataex(1, 1, 20, 8, rc), 0, 0)
    //Commit char initialised above, with initial value "hi" to service 'hSvc'
```

```

rc=BleCharCommit(hSvc,attr$,hMyChar)
//Commit changes to the service
rc=BleServiceCommit(hSvc)
rc=BleScanRptInit(scRpt$)
//Add 1 service handle to scan report
//rc=BleAdvRptAddUuid16(scRpt$,hSvc,-1,-1,-1,-1)
//Commit reports to GATT table - adRpt$ is empty
rc=BleAdvRptsCommit(adRpt$,scRpt$)
rc=BleAdvertStart(0,addr$,20,300000,0)
ENDFUNC rc

//-----
// Close connections so that we can run another app without problems
//-----
SUB CloseConnections()
    rc=BleDisconnect(conHndl)
    rc=BleAdvertStop()
ENDSUB

//-----
// Ble event handler
//-----
FUNCTION HndlrBleMsg(BYVAL nMsgId, BYVAL nCtx)
    conHndl=nCtx
    IF nMsgID==1 THEN
        PRINT "\n\n--- Disconnected from client"
        EXITFUNC 0
    ELSEIF nMsgID==0 THEN
        PRINT "\n--- Connected to client"
    ENDIF
ENDFUNC 1

//-----
// AUTHVAL - The remote has written to the characteristic using WRITE (write with response)
//-----
FUNCTION HndlrAuthVal(BYVAL connHandle, BYVAL charHandle, BYVAL readWrite)
    DIM s$
    IF charHandle == hMyChar THEN
        IF readWrite!=0 THEN
            rc=BleAuthorizeChar(connHandle, charHandle, 3) //Grant access
            rc=BleCharValueRead(hMyChar,s$)
            PRINT "\nAuthenticated char written using Write with response."
            PRINT "\nNew Char Value: ";s$
        ENDIF
    ENDIF
ENDFUNC 1

//-----
// AUTHVALEX - The remote has written to the characteristic using WRITE_CMD (write without response)
//-----
FUNCTION HndlrAuthValEx(BYVAL connHandle, BYVAL charHandle, BYVAL offset, BYVAL length,
BYVAL data$ AS STRING)
    DIM s$
    IF charHandle == hMyChar THEN
        // We are OK with this connection handle, so write the characteristic
        rc = BleCharValueWriteEx(charHandle, offset, data$)
        rc=BleCharValueRead(hMyChar,s$)
        PRINT "\nAuthenticated char written using Write without response."
        PRINT "\nNew Char Value: ";s$
    ENDIF
ENDFUNC 1

```

```
//-----
// Enable synchronous event handlers
//-----
ONEVENT EVBLEMSG      CALL HndlrBleMsg
ONEVENT EVAUTHVAL     CALL HndlrAuthVal
ONEVENT EVAUTHVALEX   CALL HndlrAuthValEx

IF OnStartup()==0 THEN
    rc = BleCharValueRead(hMyChar,at$)
    PRINT "\nThe characteristic's value is ";at$
    PRINT "\nWrite a new value to the characteristic\n"
ELSE
    PRINT "\nFailure OnStartup"
ENDIF

WAITEVENT
```

Expected Output:

```
The characteristic's value is Hi
Write a new value to the characteristic
--- Connected to client
Authenticated char written using Write with response.
New Char Value: "Test"
Authenticated char written using Write without response.
New Char Value: "Test"
```

5.2.16 EVAUTHCCCD

This event is thrown **instead of EVCHARCCCD** when a CCCD descriptor of a characteristic with read and/or write authorisation is being read or written to by a remote GATT client. It comes with following three parameters:

- The connection handle of the Gatt client
- The characteristic handle returned when the characteristic was registered with [BleCharCommit\(\)](#)
- Is 0x00000000 when this is a read attempt and 0x0001HHHH when write attempt where the new 16-bit value to be written is 0xHHHH

Call `BleAuthorizeDesc()` to either grant or deny access.

If this is a write attempt and access is granted, as soon as the function `BleAuthoriseDesc()` returns, the new value 0xHHHH is assumed to be written to the descriptor.

Example:

```
// Example :: EvAuthCccd.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM hMyChar,rc,at$,conHndl

//=====
// Initialise and instantiate service, characteristic, start adverts
//=====
FUNCTION OnStartup()
    DIM rc, hSvc, metaSuccess, at$, attr$, adRpt$, addr$, scRpt$
    attr$="Hi"
    DIM svcUuid : svcUuid=0x18EE
    DIM charUuid : charUuid = BleHandleUuid16(1)
    DIM charMet : charMet = BleAttrMetaDataex(1,1,20,0,metaSuccess)
```

```

DIM hSvcUuid : hSvcUuid = BleHandleUuid16(svcUuid)
DIM mdCccd : mdCccd = BleAttrMetadatahex(1,1,2,8,rc) //CCCD metadata for char, write
auth

//Commit svc with handle 'hSvcUuid'
rc=BleServiceNew(1, BleHandleUuid16(svcUuid), hSvc)
//Initialise char, write/read enabled, accept signed writes, indicatable
rc=BleCharNew(0x6A,charUuid,charMet,mdCccd,0)
//Commit char initialised above, with initial value "hi" to service 'hMyChar'
rc=BleCharCommit(hSvc,attr$,hMyChar)
rc=BleServiceCommit(hSvc)
rc=BleScanRptInit(scRpt$)
//Add 1 service handle to scan report
rc=BleAdvRptAddUuid16(scRpt$,hSvc,-1,-1,-1,-1,-1)
//Commit reports to GATT table - adRpt$ is empty
rc=BleAdvRptsCommit(adRpt$,scRpt$)
rc=BleAdvertStart(0,addr$,20,300000,0)
rc=GpioBindEvent(1,16,1) //Channel 1, bind to low transition on GPIO pin 16
ENDFUNC rc

//=====
// Close connections so that we can run another app without problems
//=====
SUB CloseConnections()
rc=BleDisconnect(conHndl)
rc=BleAdvertStop()
rc=GpioUnbindEvent(1)
ENDSUB

//=====
// Ble event handler
//=====
FUNCTION HndlrBleMsg(BYVAL nMsgId, BYVAL nCtx)
conHndl=nCtx
IF nMsgID==1 THEN
PRINT "\n\n--- Disconnected from client"
EXITFUNC 0
ELSEIF nMsgID==0 THEN
PRINT "\n\n--- Connected to client"
ENDIF
ENDFUNC 1

//=====
// Indication acknowledgement from client handler
//=====
FUNCTION HndlrCharHvc(BYVAL charHandle AS INTEGER) AS INTEGER
IF charHandle == hMyChar THEN
PRINT "\nGot confirmation of recent indication"
ELSE
PRINT "\nGot confirmation of some other indication: ";charHandle
ENDIF
ENDFUNC 1

//=====
// Handler to service button 0 pressed
//=====
FUNCTION HndlrBtn0Pr() AS INTEGER
CloseConnections()
ENDFUNC 1

//=====
// CCCD descriptor authorisation

```

```
//=====
FUNCTION HndlrAuthCccd(BYVAL connHandle,BYVAL charHandle, BYVAL readWrite) AS INTEGER
    DIM value$

    IF charHandle==hMyChar THEN
        IF readWrite != 0x0 THEN

            rc=BleAuthorizeDesc(connHandle,charHandle, -1 ,3) //grant access
            IF readWrite == 0x10002 THEN
                PRINT "\nSending indication..."
                value$="hello"
                IF BleCharValueIndicate(hMyChar,value$)!=0 THEN
                    PRINT "\nFailed to indicate new value"
                ENDIF
            ELSE
                PRINT "\nIndications were disabled"
            ENDIF
        ENDIF
    ELSE
        PRINT "\nThis is for some other characteristic"
    ENDIF
ENDFUNC 1

ONEVENT EVBLEMSG CALL HndlrBleMsg
ONEVENT EVCHARHVC CALL HndlrCharHvc
ONEVENT EVAUTHCCCD CALL HndlrAuthCccd
ONEVENT EVGPIOCHAN1 CALL HndlrBtn0Pr

IF OnStartup()==0 THEN
    rc = BleCharValueRead(hMyChar,at$)
    PRINT "\nValue of the characteristic ";hMyChar;" is: ";at$
    PRINT "\nYou can write to the CCCD characteristic."
    PRINT "\nThe BL654 will then indicate a new characteristic value\n"
    PRINT "\n--- Press button 0 to exit"
ELSE
    PRINT "\nFailure OnStartup"
ENDIF

WAITEVENT

PRINT "\nExiting..."
```

Expected Output:

```
Value of the characteristic 1818531328 is: Hi
You can write to the CCCD characteristic.
The BL654 will then indicate a new characteristic value

--- Press button 0 to exit
--- Connected to client
Sending indication...
Got confirmation of recent indication
```

5.2.17 EVAUTHSCCD

This event is thrown **instead of EVCHARSCCD** when a SCCD descriptor of a characteristic with read and/or write authorisation is being read or written to by a remote GATT client. It comes with the following three parameters

- The connection handle of the Gatt client
- The characteristic handle returned when the characteristic was registered with [BleCharCommit\(\)](#)
- Is 0x00000000 when this is a read attempt and 0x0001HHHH when it's a write attempt where the new 16-bit value to be written is 0xHHHH

Call `BleAuthorizeDesc()` to either grant or deny access.

If this a write attempt and access is granted then as soon as the function `BleAuthoriseDesc()` returns the new value 0xHHHH is assumed to be written to the descriptor.

The SCCD is used to manage broadcasts of characteristic values.

Example:

```
// Example :: EvAuthSccd.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM hMyChar,rc,at$,conHndl

//=====
// Initialise and instantiate service, characteristic, start adverts
//=====
FUNCTION OnStartup()
    DIM rc, hSvc, at$, attr$, adRpt$, addr$, scRpt$ , rc2
    attr$="Hi"
    DIM charMet : charMet = BleAttrMetadataex(1,1,20,0,rc)

    //Commit svc with handle 'hSvcUuid'
    rc=BleServiceNew(1,BleHandleUuid16(0x18EE),hSvc)
    //Initialise char, read enabled, accept signed writes, broadcast capable
    rc=BleCharNew(0x4B,BleHandleUuid16(1),charMet,0,BleAttrMetadataex(1,1,2,8,rc2))
    //Commit char initialised above, with initial value "hi" to service 'hMyChar'
    rc=BleCharCommit(hSvc,attr$,hMyChar)
    //Commit svc
    rc=BleServiceCommit(hSvc)

    rc=BleAdvRptInit(adRpt$,0x02,0,20)
    //Add 'hSvc' and 'hMyChar' to the advert report
    rc=BleAdvRptAddUuid16(adRpt$,hSvc,hMyChar,-1,-1,-1,-1)
    //Commit reports to GATT table - adRpt$ is empty
    rc=BleAdvRptsCommit(adRpt$,scRpt$)
    rc=BleAdvertStart(0,addr$,20,300000,0)
    rc=GpioBindEvent(1,16,1) //Channel 1, bind to low transition on GPIO pin 16
ENDFUNC rc

//=====
// Close connections so that we can run another app without problems
//=====
SUB CloseConnections()
    rc=BleDisconnect(conHndl)
    rc=BleAdvertStop()
    rc=GpioUnbindEvent(1)
ENDSUB

//=====
// Ble event handler
//=====
FUNCTION HndlrBleMsg(BYVAL nMsgId, BYVAL nCtx)
    conHndl=nCtx
```

```
IF nMsgID==1 THEN
    PRINT "\n\n--- Disconnected from client"
    EXITFUNC 0
ELSEIF nMsgID==0 THEN
    PRINT "\n--- Connected to client"
ENDIF
ENDFUNC 1

//=====
//handler to service button 0 pressed
//=====
FUNCTION HndlrBtn0Pr() AS INTEGER
    CloseConnections()
ENDFUNC 1

//=====
// CCCD descriptor written handler
//=====
FUNCTION HndlrAuthSccd(BYVAL connHandle,BYVAL charHandle, BYVAL readWrite) AS INTEGER
    DIM value$

    IF charHandle==hMyChar THEN
        IF readWrite != 0x0 THEN
            rc=BleAuthorizeDesc(connHandle,charHandle, -2 ,3) //grant access
            if readWrite == 0x1000 then
                PRINT "\nBroadcasts have been disabled by client"
            ELSE
                PRINT "\nBroadcasts have been enabled by client"
            endif
        ENDIF
    ELSE
        PRINT "\nThis is for some other characteristic"
    ENDIF
ENDFUNC 1

ONEVENT EVBLEMSG CALL HndlrBleMsg
ONEVENT EVAUTHSCCD CALL HndlrAuthSccd
ONEVENT EVGPIOCHAN1 CALL HndlrBtn0Pr

IF OnStartup()==0 THEN
    rc = BleCharValueRead(hMyChar,at$)
    PRINT "\nCharacteristic Value: ";at$
    PRINT "\nYou can write to the SCCD attribute."
    PRINT "\nThe BL654 will then indicate a new characteristic value"
    PRINT "\n--- Press button 0 to exit\n"
ELSE
    PRINT "\nFailure OnStartup"
ENDIF

WAITEVENT

PRINT "\nExiting..."
```

Expected Output:

```
Characteristic Value: Hi
You can write to the SCCD attribute.
The BL654 will then indicate a new characteristic value
--- Press button 0 to exit

--- Connected to client
Broadcasts have been enabled by client
```

5.2.18 EVAUTHDESC

This event is thrown **instead of EVCHARDESC** when a writable descriptor of a characteristic with read and/or write authorisation is being read or written by a remote GATT client. It comes with the following parameters:

- The connection handle of the Gatt client
- The characteristic handle that is returned when the characteristic is registered using the function `BleCharCommit()`
- The descriptor Handle Index
- Is 0x00000000 when this is a read attempt and 0x00010000 when it is a write attempt

Call `BleAuthorizeChar()` to either grant or deny access.

The first three parameters in the event are supplied as-is as the first three parameters to the function `BleAuthizeChar()`.

If this event is for a write, as soon as the function `BleAuthorizeDesc()` returns, the descriptor contains the value and so the function `BleCharDescRead()` can be called to read it.

Example:

```
// Example :: EvAuthDesc.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM hMyChar,rc,at$,conHndl, hOtherDscr

//=====
// Initialise and instantiate service, characteristic, start adverts
//=====
FUNCTION OnStartup$()
    DIM rc, hSvc, at$, adRpt$, addr$, scRpt$, hOtherDscr,attr$, attr2$
    attr$="Hi"
    DIM charMet : charMet = BleAttrMetadata(1,1,20,0,rc)

    //Commit svc with handle 'hSvcUuid'
    rc=BleServiceNew(1,BleHandleUuid16(0x18EE),hSvc)
    //Initialise char, read/write enabled, accept signed writes
    rc=BleCharNew(0x4A,BleHandleUuid16(1),charMet,0,0)

    //Add another descriptor
    attr$="descr_value"
    rc=BleCharDescAdd(0x2905,attr$,BleAttrMetadata(1,1,20,9,rc))
    //Commit char initialised above, with initial value "hi" to service 'hMyChar'
    attr2$="char value"
    rc=BleCharCommit(hSvc,attr2$,hMyChar)
    rc=BleServiceCommit(hSvc)

    rc=BleAdvRptInit(adRpt$,0x02,0,20)
    rc=BleScanRptInit(scRpt$)
    //Get UUID handle for other descriptor
    hOtherDscr=BleHandleUuid16(0x2905)
    //Add 'hSvc','hMyChar' and the other descriptor to the advert report
    rc=BleAdvRptAddUuid16(adRpt$,hSvc,hOtherDscr,-1,-1,-1,-1)
    rc=BleAdvRptAddUuid16(scRpt$,hOtherDscr,-1,-1,-1,-1,-1)
    //Commit reports to GATT table - adRpt$ is empty
    rc=BleAdvRptsCommit(adRpt$,scRpt$)
    rc=BleAdvertStart(0,addr$,20,300000,0)
    rc=GpioBindEvent(1,16,1) //Channel 1, bind to low transition on GPIO pin 16
ENDFUNC attr$

//=====
// Close connections so that we can run another app without problems
//=====
SUB CloseConnections()
    rc=BleDisconnect(conHndl)
```



```

    rc=BleAdvertStop()
    rc=GpioUnbindEvent(1)
ENDSUB

//=====
// Ble event handler
//=====
FUNCTION HndlrBleMsg(BYVAL nMsgId, BYVAL nCtx)
    conHndl=nCtx
    IF nMsgID==1 THEN
        PRINT "\n\n--- Disconnected from client"
        EXITFUNC 0
    ELSEIF nMsgID==0 THEN
        PRINT "\n--- Connected to client"
    ENDIF
ENDFUNC 1

//=====
// Handler to service button 0 pressed
//=====
FUNCTION HndlrBtn0Pr() AS INTEGER
    CloseConnections()
ENDFUNC 1

//=====
// Client has written to writeable descriptor
//=====
FUNCTION HndlrAuthDesc(BYVAL hConn AS INTEGER, BYVAL hChar AS INTEGER, BYVAL hDesc AS
INTEGER, BYVAL rw) AS INTEGER
    dim duid,a$,rc
    IF hChar == hMyChar THEN
        rc = BleAuthorizeDesc(hConn, hChar, hDesc, 3)
        rc = BleCharDescRead(hChar,hDesc,0,512,duid,a$)
        IF rc ==0 THEN
            PRINT "\nNew value for desriptor ";hDesc;" is ";a$
        ELSE
            PRINT "\nCould not access the uuid"
        ENDIF
    ELSE
        PRINT "\nThis is for some other characteristic"
    ENDIF
ENDFUNC 1

ONEVENT EVBLEMSG CALL HndlrBleMsg
ONEVENT EVAUTHDESC CALL HndlrAuthDesc
ONEVENT EVGPIOCHAN1 CALL HndlrBtn0Pr

PRINT "\nOther Descriptor Value: ";OnStartup$()
PRINT "\nWrite a new value \n--- Press button 0 to exit\n"

WAITEVENT

PRINT "\nExiting..."

```

Expected Output:

```

Other Descriptor Value: descr_value
Write a new value
--- Press button 0 to exit

--- Connected to client
New value for desriptor 0 is cC

```

5.2.19 EVVSPRX

This event is thrown when the Virtual Serial Port service is open and data has arrived from the peer.

5.2.20 EVVSPTXEMPTY

This event is thrown when the Virtual Serial Port service is open and the last block of data in the transmit buffer is sent via a notify or indicate. See [VSP \(Virtual Serial Port\) Events](#)

5.2.21 EVCONNRSSI

This event message is thrown when rssi reporting is enabled for specific connections using the function `BleConnRssiStart()` which takes the connection handle.

It consists of a two integers payload with the following values:

- Integer 1 – The connection handle for which the rssi is being reported
- Integer 2 – The signed RSSI value in units of dBm.

5.2.22 EVNOTIFYBUF

When in a connection and attribute data is sent to the GATT client using a notify procedure (such as the function `BleCharValueNotify()`) or when a `Write_with_no_response` is sent by the GATT client to a remote server, they are stored in temporary buffers in the underlying stack. There is a finite number of these temporary buffers. If they are exhausted, the notify function or the `write_with_no_resp` command fails with a result code of 0x6803 (BLE_NO_TX_BUFFERS). Once the attribute data is transmitted over the air, if there are no acknowledges for Notify messages, the buffer is freed to be reused.

This event is thrown when at least one buffer has been freed. Because of this, the *smart*BASIC application can handle this event to retrigger the data pump for sending data using notifies or `writes_with_no_resp` commands.

Note: When sending data using Indications, this event is not thrown. Those messages must be confirmed by the client which results in a `EVCHARHVC` message to the *smart*BASIC application. Likewise, writes which are acknowledged do not consume these buffers.

Example:

```
// Example :: EvNotifyBuf.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM hMyChar,rc,at$,conHndl,ntfyEnabled

//=====
// Initialise and instantiate service, characteristic, start adverts
//=====

FUNCTION OnStartup()
    DIM rc, hSvc, at$, attr$, adRpt$, addr$, scRpt$
    attr$="Hi"
    DIM mdCccd : mdCccd = BleAttrMetadata(1,1,2,0,rc) //CCCD metadata for char

    //Commit svc with handle 'hSvc'
    rc=BleServiceNew(1, BleHandleUuid16(0x18EE), hSvc)
```

```
//initialise char, write/read enabled, accept signed writes, notifiable
rc=BleCharNew(0x12,BleHandleUuid16(1),BleAttrMetaData(1,0,20,0,rc),mdCccd,0)
//commit char initialised above, with initial value "hi" to service 'hMyChar'
rc=BleCharCommit(hSvc,attr$,hMyChar)
//commit changes to service
rc=BleServiceCommit(hSvc)
rc=BleScanRptInit(scRpt$)
//Add 1 service handle to scan report
rc=BleAdvRptAddUuid16(scRpt$,0x18EE,-1,-1,-1,-1,-1)
//commit reports to GATT table - adRpt$ is empty
rc=BleAdvRptsCommit(adRpt$,scRpt$)
rc=BleAdvertStart(0,addr$,50,0,0)

ENDFUNC rc

//=====
// Close connections so that we can run another app without problems
//=====

SUB CloseConnections()
    rc=BleDisconnect(conHndl)
    rc=BleAdvertStop()
ENDSUB

SUB SendData()
    DIM tx$, count
    IF ntfyEnabled then
        PRINT "\n--- Notifying"
        DO
            tx$="SomeData"
            rc=BleCharValueNotify(hMyChar,tx$)
            count=count+1
        UNTIL rc!=0
        PRINT "\n--- Buffer full"
        PRINT "\nNotified ";count;" times"
    ENDIF
ENDSUB

//=====
// Ble event handler
//=====
```

```
FUNCTION HndlrBleMsg (BYVAL nMsgId, BYVAL nCtx)
    conHndl=nCtx
    IF nMsgID==0 THEN
        PRINT "\n--- Connected to client"
    ELSEIF nMsgID THEN
        PRINT "\n--- Disconnected from client"
        EXITFUNC 0
    ENDIF
ENDFUNC 1

//=====
// Tx Buffer free handler
//=====

FUNCTION HndlrNtfyBuf ()
    SendData ()
ENDFUNC 0

//=====
// CCCD descriptor written handler
//=====

FUNCTION HndlrCharCccd (BYVAL charHandle, BYVAL nVal) AS INTEGER
    DIM value$,tx$
    IF charHandle==hMyChar THEN
        IF nVal THEN
            PRINT " : Notifications have been enabled by client"
            ntfyEnabled=1
            tx$="Hello"
            rc=BleCharValueNotify(hMyChar,tx$)
        ELSE
            PRINT "\nNotifications have been disabled by client"
            ntfyEnabled=0
        ENDIF
    ELSE
        PRINT "\nThis is for some other characteristic"
    ENDIF
ENDFUNC 1

ONEVENT EVNOTIFYBUF CALL HndlrNtfyBuf
ONEVENT EVBLEMSG CALL HndlrBleMsg
```

```
ONEVENT EVCHARCCCD CALL HndlrCharCccd

IF OnStartup()==0 THEN
    rc = BleCharValueRead(hMyChar,at$)
    PRINT "\nYou can connect and write to the CCCD characteristic."
    PRINT "\nThe BL654 will then send you data until buffer is full\n"
ELSE
    PRINT "\nFailure OnStartup"
ENDIF

WAITEVENT

CloseConnections()

PRINT "\nExiting..."
```

Expected Output:

```
You can connect and write to the CCCD characteristic.
The BL654 will then send you data until buffer is full

--- Connected to client
Notifications have been disabled by client : Notifications have been enabled by client
--- Notifying
--- Buffer full
Notified 1818505336 times
Exiting...
```

5.2.23 EVCONNPARAMREQ

This event is only thrown for a central role connection when a peripheral requests an update to the connection parameters via `BleSetCurConnParams()`. The user must turn manual parameter control to receive this message by using `BleConnectConfig(8,1)`. In this case, auto accept is disabled and full control is given to the user.

The event contains the following integer values:

- **nConnHandle** – The handle of the connection where the peripheral is requesting a change.
- **nMinIntUs** – The minimum acceptable connection interval in microseconds.
- **nMaxIntUs** – The maximum acceptable connection interval in microseconds.
- **nSuprToutUs** – The link supervision timeout for the connection in microseconds.
- **nSlaveLatency** – The number of connection interval polls that may be ignored.

Example:

```
//Example :: EvConnParamReq.sb

// In order to get the expected output, this application should be run against
// a peripheral device. The peripheral device should request new connection
// parameters upon connection, which in turn will trigger EVCONNPARAMREQ on
// this device.

// This is the target Bluetooth device to connect to, 7 bytes in hex
#define BTAddr "000016A4B75202"

// BLE EVENT MSG IDS
#define BLE_EVBLEMSGID_CONNECT 0 // msgCtx = connection handle
#define BLE_EVBLEMSGID_DISCONNECT 1 // msgCtx = connection handle
```

```
#define BLE_EVBLEMSGID_CONN_PARMS_UPDATE 14 //nCtx = connection handle
#define BLE_EVBLEMSGID_CONN_PARMS_UPDATE_FAIL 15 //nCtx = connection handle

DIM rc

//=====
// This handler is called when there is a BLE message
//=====
FUNCTION HndlrBleMsg (BYVAL nMsgId AS INTEGER, BYVAL nCtx AS INTEGER)
    SELECT nMsgId
        CASE BLE_EVBLEMSGID_CONNECT
            PRINT "\nBLE Connection ";integer.h' nCtx;"\n"
        CASE BLE_EVBLEMSGID_DISCONNECT
            PRINT "\nDisconnected ";nCtx;"\n"
        CASE BLE_EVBLEMSGID_CONN_PARMS_UPDATE
            // The connection parameter has been updated. Read connection parameters
            dim intrvl,sprvto,slat
            rc= BleGetCurConnParms(nCtx,intrvl,sprvto,slat)
            print "--- Param Updated \n"
            print "- interval: ";intrvl;" supervision timeout: ";sprvto;" latency: ";slat;"\n"
        CASE BLE_EVBLEMSGID_CONN_PARMS_UPDATE_FAIL
            print "--- Param Update Failed\n"
            print "- interval: ";intrvl;" supervision timeout: ";sprvto;" latency: ";slat;"\n"
        CASE ELSE
            PRINT "\nUnknown Ble Msg"
    ENDSELECT
ENDFUNC 1

//=====
// This handler is called when peripheral requests new parameter
//=====
function HandlerParamReq (BYVAL hConn AS INTEGER, BYVAL intrvlmin AS INTEGER, BYVAL intrvlmax
AS INTEGER, BYVAL sprvto AS INTEGER, BYVAL slat AS INTEGER)

    print "--- Param Request \n"
    print "- intervalmin: ";intrvlmin;" intervalmax: ";intrvlmax;" supervision
timeout: ";sprvto;" latency: ";slat;"\n"
    // Accept the peripheral's request by changing the connection's conn parameters
    rc = BleSetCurConnParms(hConn, intrvlmin, intrvlmax, sprvto, slat)

endfunc 1

//=====
// Program starts here
//=====
// Disable auto accept so that we get an event when peripheral requests
// new connection parameteres. Set to 0 to re-enable auto accept
rc = BleConnectConfig(8,1)
// Connect to peripheral
DIM addr$ : addr$ = BTAddr
addr$ = StrDehexize$(addr$)
rc = BleConnect(addr$, 5000, 7500, 7700, 500000)

//-----
// Enable synchronous event handlers
//-----
ONEVENT EVBLEMSG CALL HndlrBleMsg
ONEVENT EVCONNPARAMREQ CALL HandlerParamReq

WAITEVENT
```

Expected Output:

```
BLE Connection 0001FF00
--- Param Request
- intervalmin:45000 intervalmax:50000 supervision timeout:6000000 latency:0
--- Param Updated
- interval:50000 supervision timeout:6000000 latency:0
```

5.2.24 EVBLE_EXTADVDRIPPED

This event message is thrown when too many extended advert reports or scan responses have been received and the message queue does not have enough space to accommodate them. To mitigate this, call NVCFGKEYSET(45,n) to increase the size of the message. This configuration change will only come into effect after a reset, so call RESET() to make the change effective.

5.2.25 EVBLE_EXTADVNOEMEM

This event message is thrown when an extended advert report has been received and there is no heap space to allow for it to be packaged into a STRING variable to be thrown to the smartBASIC user application in an event. The lack of space can also apply when there is available memory but it is in smaller fragments in the free space managed by the heap.

5.2.26 EVBLE_SCAN_ABORTED

This event message is thrown when a scanning is in progress and an outgoing connection is started. Given a connection attempt requires a scanning, then any existing scanning has to be aborted for that connection phase to work. This event is to let the app know that it has been aborted so that it can be restarted when the connection fails or is successful.

5.2.27 EVBLE_EXTADV_END

This event message is thrown when an extended advert identified by the set_id parameter in the message has terminated and will also provide the reason for the termination.

It consists of a two integers payload with the following values:

- Integer 1 – Set id
- Integer 2 – Reason for termination. 0 for timeout and for positive values specifies how many adverts were sent.

5.2.28 EVBLE_EXTADV_RPT

This event message is thrown when an extended advert report is to be conveyed to the application

It consists of 3 string and 1 integer in the following order :

- String 1 – Address of the device that send the advert
- String 2 – Payload of the advert consisting of many concatenated AD elements
- Integer 1 – RSSI of the received advert
- String 3 – Metadata of the associated advert. Use BleExtRptMetadata() to extract fields

5.2.29 EVBLE_EXTSCN_RPT

This event message is thrown when an extended advert scan response is to be conveyed to the application

It consists of 3 string and 1 integer in the following order :

- String 1 – Address of the device that send the scan response
- String 2 – Payload of the advert consisting of many concatenated AD elements
- Integer 1 – RSSI of the received scan response
- String 3 – Metadata of the scan response. Use BleExtRptMetadata() to extract fields

5.2.30 EVBLE_EXTADV_RPT_INCOMPLETE

This event message is thrown when an extended advert or scan response is to be conveyed to the application which has incomplete data. Use String 3 and function `BleExtRptMetadata(metadata$,8)` to determine if it was an advert report or a scan response.

In addition, `BleExtRptMetadata(metadata$,7,)` will return the status field which will detail the reason why it is incomplete. See the description for `BleExtRptMetadata()` for more details.

It consists of 3 string and 1 integer in the following order :

- String 1 – Address of the device that send the scan response
- String 2 – Payload of the advert consisting of many concatenated AD elements
- Integer 1 – RSSI of the received scan response
- String 3 – Metadata of the scan response. Use `BleExtRptMetadata()` to extract fields

5.3 Miscellaneous Functions

This section describes all BLE-related functions that are not related to advertising, connection, security manager, or GATT.

5.3.1 BleTxPowerSet

FUNCTION

This function sets the power of all packets that are transmitted subsequently.

Although this function can accept any value, the actual transmit power is determined by the internal power table which depends on the variant of the module

The standard BL654 supports -40, -20, -16, -12, -8, -4, 0, 2, 4, 5, 6, 7, and 8 dBm.

The BL654PA variant supports -26, -6, 0, 6, 14 and 18 dBm.

Note: For LE_CODED transmissions, the transmit power is limited to +14 dBm for duty cycle requirements.

When a value is set, the highest transmit power that is less than or equal to the desired power is used.

`SYSINFO(2008)` and `AT+I2008` can be used to return the actual power level set.

BLETXPOWERSET (nTxPower)

Returns INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.

Arguments:

byVal nTxPower AS INTEGER.
nTxPower Specifies the new transmit power in dBm units to be used for all subsequent tx packets.
 The actual value is determined by the radios internal power table.

Example:

```
// Example :: BleTxPowerSet.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc,dp

dp=1000 : rc = BleTxPowerSet(dp)
PRINT "\nrc = ";rc
PRINT "\nTx power : desired= ";dp," actual= "; SysInfo(2008)
```



```
dp=8 : rc = BleTxPowerSet(dp)
PRINT "\nTx power : desired= ";dp," ", " actual= "; SysInfo(2008)
dp=2 : rc = BleTxPowerSet(dp)
PRINT "\nTx power : desired= ";dp," ", " actual= "; SysInfo(2008)
dp=-10 : rc = BleTxPowerSet(dp)
PRINT "\nTx power : desired= ";dp," ", " actual= "; SysInfo(2008)
dp=-25 : rc = BleTxPowerSet(dp)
PRINT "\nTx power : desired= ";dp," ", " actual= "; SysInfo(2008)
dp=-45 : rc = BleTxPowerSet(dp)
PRINT "\nTx power : desired= ";dp," ", " actual= "; SysInfo(2008)
dp=-1000 : rc = BleTxPowerSet(dp)
PRINT "\nTx power : desired= ";dp," actual= "; SysInfo(2008)
```

Expected Output:

```
rc = 0
Tx power : desired= 1000    actual= 4
Tx power : desired= 8      actual= 4
Tx power : desired= 2      actual= 0
Tx power : desired= -10    actual= -12
Tx power : desired= -25    actual= -40
Tx power : desired= -45    actual= -40
Tx power : desired= -1000  actual= -40
```

5.3.2 BleTxPwrWhilePairing

FUNCTION

This function sets the transmit power of all packets that are transmitted while a pairing is in progress. This mode of pairing is referred to as Whisper Mode Pairing. The actual value is clipped to the transmit power for normal operation which is set using BleTxPowerSet() function.

At any time SYSINFO(2018) returns the actual transmit power setting. Or when in command mode, uses the command AT I 2018.

Although this function can accept any value, the actual transmit power is determined by the internal power table which supports -40, -20, -16, -12, -8, -4, 0, 2, 4, 5, 6, 7, and 8 dBm, when a value is set the highest transmit power that is less than or equal to the desired power is used. SYSINFO(2008) and AT I 2008 returns the power level set and does not reflect the transmit power level of the radio itself.

BLETXPWRWHILEPAIRING (nTxPower)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.

Arguments:

byVal nTxPower AS INTEGER.

Specifies the new transmit power in dBm units to be used for all subsequent Tx packets while the pairing is in progress and normal power is resumed when the transaction is complete. The actual value is determined by the radios internal power table.

nTxPower

Please note that the tx power will be reduced to nTxPower for ALL connections, even on connections that there is no pairing in progress.

Example:

```
// Example :: BleTxPwrWhilePairing.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc,dp

dp=1000 : rc = BleTxPwrWhilePairing(dp)
PRINT "\nrc = ";rc
PRINT "\nTx power while pairing: desired= ";dp," actual= "; SysInfo(2018)
dp=8 : rc = BleTxPwrWhilePairing(dp)
PRINT "\nTx power while pairing: desired= ";dp," ", " actual= "; SysInfo(2018)
dp=2 : rc = BleTxPwrWhilePairing(dp)
PRINT "\nTx power while pairing: desired= ";dp," ", " actual= "; SysInfo(2018)
dp=-10 : rc = BleTxPwrWhilePairing(dp)
PRINT "\nTx power while pairing: desired= ";dp," actual= "; SysInfo(2018)
dp=-25 : rc = BleTxPwrWhilePairing(dp)
PRINT "\nTx power while pairing: desired= ";dp," actual= "; SysInfo(2018)
dp=-45 : rc = BleTxPwrWhilePairing(dp)
PRINT "\nTx power while pairing: desired= ";dp," actual= "; SysInfo(2018)
dp=-1000 : rc = BleTxPwrWhilePairing(dp)
PRINT "\nTx power while pairing: desired= ";dp," actual= "; SysInfo(2018)
```

Expected Output:

```
rc = 0
Tx power while pairing: desired= 1000 actual= 10
Tx power while pairing: desired= 8 actual= 8
Tx power while pairing: desired= 2 actual= 2
Tx power while pairing: desired= -10 actual= -10
Tx power while pairing: desired= -25 actual= -20
Tx power while pairing: desired= -45 actual= -20
Tx power while pairing: desired= -1000 actual= -20
```

5.3.3 BleConfigHfClock

SUBROUTINE

This routine is used to configure the source of the high frequency clock (HFCLK) to be either the internal RC oscillator or an external 32MHz crystal. Enabling the 32MHz crystal increases current consumption but at extreme temperatures useful when the uart is in operation otherwise the baudrate will vary outside the limit and prevent proper communication.

BLECONFIGHFCLOCK(*nClkSrc*)

Returns	None
Arguments	
<i>nClkSrc</i>	byVal <i>nClkSrc</i> AS INTEGER. Source of the High Frerquency Clock as follows:
0	Internal RC Oscillator
1	External 32MHz Crystal
Other Values	External 32MHz Crystal (but not recommended as in future it can change)

5.3.4 BleConfigDcDc

SUBROUTINE

This routine is used to configure the DC to DC converter to one of two states: ENABLED or DISABLED.

BLECONFIGDCDC (nNewState)

Returns	None				
Arguments					
nNewState	byVal nNewState AS INTEGER. Configure the internal DC to DC converter as follows:				
	<table> <tr> <td>0</td><td>Disabled</td></tr> <tr> <td>All other values</td><td>Enabled</td></tr> </table>	0	Disabled	All other values	Enabled
0	Disabled				
All other values	Enabled				

```
BleConfigDcDc(2) //Set for automatic operation
```

5.3.5 BleChannelMap

FUNCTION

This function is used to enable or disable data channel usage when in a connection. Applies to data channels 0 to 36 only.

BLECHANNELMAP (chanMap\$)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
chanMap\$	byVal chanMap\$ AS STRING. This must be a string which is exactly 5 bytes long where a bit set means enable that channel to be used and a 0 means to disable. The mapping between bits in the 5 bytes to data channels in BLE are as follows:- Bit 0 of byte index 0 : BLE channel 0 Bit 7 of byte index 0 : BLE channel 7 Bit 0 of byte index 1 : BLE channel 8 Bit 7 of byte index 1 : BLE channel 15 Bit 0 of byte index 2 : BLE channel 16 Bit 7 of byte index 2 : BLE channel 23 Bit 0 of byte index 3 : BLE channel 24 Bit 7 of byte index 3 : BLE channel 31 Bit 0 of byte index 4 : BLE channel 32 Bit 4 of byte index 4 : BLE channel 36 Bit 5 to 7 of byte index 4 are ignored.

5.4 Advertising Functions

This section describes all the advertising-related routines.

An advertisement consists of a packet of information with a header identifying it as one of four types along with an optional payload that consists of multiple advertising records, referred to as AD in the rest of this manual.

Each AD record consists of up to three fields:

- Field 1 – One octet in length and indicates the number of octets that follow it that belong to that record.
- Field 2 – One octet in length and is a tag value which identifies the type of payload that starts at the next octet. Hence the payload data is 'length – 1'.
- Field 3 – A special NULL AD record that consists of one field (the length field) when it contains only the 00 value.

The specification also allows custom AD records to be created using the Manufacturer Specific Data AD record.

Refer to the *Supplement to the Bluetooth Core Specification, Version 1, Part A* which contains the latest list of all AD records. You must register as at least an adopter, which is free, to gain access to this information. It is available at https://www.Bluetooth.org/docman/handlers/downloadaddoc.ashx?doc_id=245130

5.4.1 BleAdvertStart

FUNCTION

This function causes a BLE advertisement event as per the Bluetooth specification. An advertisement event consists of an advertising packet in each of the three advertising channels.

The type of advertisement packet is determined by the `nAdvType` argument and the data in the packet is initialised, created, and submitted by the **BLEADVRPTINIT**, **BLEADVRPTADDxxx**, and **BLEADVRPTCOMMIT** functions respectively.

If the Advert packet type (`nAdvType`) is specified as 1 (`ADV_DIRECT_IND`), then the `peerAddr$` string must not be empty and should be a valid address. When advertising with this packet type, the timeout is automatically set to 1280 ms.

When filter policy is enabled, the whitelist consisting of all bonded masters is submitted to the underlying stack so that only those bonded masters result in scan and connection requests being serviced.

Note: `nAdvTimeout` is rounded up to the nearest 1000 msec.

In order to advertise over CODED PHY (long range), `BleAdvertConfig()` should be called beforehand to set the advertising primary and secondary channels to CODED PHY. See [BleAdvertConfig\(\)](#) for more details. Furthermore, the advertising type should be set to `ADV_EXT_CONN_NONSCAN_DIRECTED`. Finally, high bandwidth should be enabled using "AT+CFG 214 1" followed by "ATZ".

Extended advertising types (6-11) are only supported as experimental features in this release.

BLEADVERTSTART (`nAdvType`, `peerAddr$`, `nAdvInterval`, `nAdvTimeout`, `nFilterPolicy`)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation. If a 0x6A01 resultcode is received, it implies a whitelist has been enabled but the Flags AD in the advertising report is set for Limited and/or General Discoverability. The solution is to resubmit a new advert report which is made up so that the <code>nFlags</code> argument to <code>BleAdvRptInit()</code> function is 0. The BT 4.0 spec disallows discoverability when a whitelist is enabled during advertisement. See Volume 3, Sections 9.2.3.2 and 9.2.4.2.							
Arguments:	byVal nAdvType AS INTEGER. Specifies the advertisement type as follows: <table> <tr> <td>0</td><td>ADV_IND</td><td>Invites connection requests</td></tr> <tr> <td>1</td><td>ADV_DIRECT_IND</td><td>Invites connection from addressed device.</td></tr> </table>		0	ADV_IND	Invites connection requests	1	ADV_DIRECT_IND	Invites connection from addressed device.
0	ADV_IND	Invites connection requests						
1	ADV_DIRECT_IND	Invites connection from addressed device.						

			nAdvertTimeout must be <= 1280ms because nAdvInterval is ignored and will advertise at a rate of every 3.75milliseconds which means this type of advert is not power efficient and will impact battery life. See ADV_DIRECT_LOW_DUTYCYCLE_IND for a more power efficient alternative.
	2	ADV_SCAN_IND	Invites scan request for more advert data
	3	ADV_NONCONN_IND	Does not accept connections/active scans
	4	ADV_DIRECT_LOW_DUTYCYCLE_IND	Invites connection from addressed device. No limit on nAdvertTimeout as the advertising interval is as per nAdvInterval, like a normal advert but with the payload being the target address. See ADV_DIRECT_IND for an alternative.
	5	Unused	
	6	ADV_EXT_CONN_NONSCAN	Invites connection requests over the secondary advertising channel. This advertising type can be used for CODED PHY connections.
	7	ADV_EXT_CONN_NONSCAN_DIRECTED	Invites connection from addressed devices over the secondary advertising channel. This advertising type can be used for CODED PHY connections.
	8	ADV_EXT_NONCONN_SCAN	Invites scan requests over the secondary advertising channel.
	9	ADV_EXT_NONCONN_SCAN_DIRECTED	Invites scan requests from addressed devices over the secondary advertising channel.
	10	ADV_EXT_NONCONN_NONSCAN	Undirected nonconnectable nonscannable advertising using extended advertising packets.
	11	ADV_EXT_NONCONN_NONSCAN_DIRECTED	Directed nonconnectable nonscannable advertising using extended advertising packets.
peerAddr\$	byRef peerAddr\$ AS STRING		
	It can be an empty string that is omitted if the advertisement type is not ADV_DIRECT_IND. This is only required when nAdvType == 1. When not empty, a valid address string is exactly seven octets long (for example: \00\11\22\33\44\55\66) where the first octet is the address type and the rest of the six octets is the usual Bluetooth address in big endian format (so the most significant octet of the address is at offset 1), whether public or random.		
	0	Public	
	1	Random Static	
	2	Random Private Resolvable	
	3	Random Private Non-Resolvable	
	All other values are illegal.		
nAdvInterval	byVal nAdvInterval AS INTEGER.		
	The interval between two advertisement events (in milliseconds).		
	An advertisement event consists of a total of three packets being transmitted in the three advertising channels.		
	Valid range is between 20 and 10240 milliseconds.		

<i>nAdvTimeout</i>	byVal <i>nAdvTimeout</i> AS INTEGER. The time after which the module stops advertising (in milliseconds). The range of this value is between 0 and 16383000 milliseconds and is rounded up to the nearest 1 seconds (1000ms). A value of 0 means disable the timeout, but note that if limited advert modes was specified in BleAdvRptInit() then this function fails. When the advert type specified is ADV_DIRECT_IND , the timeout is automatically set to 1280 ms as per the Bluetooth Specification. WARNING: To save power, do not mistakenly set this to e.g. 100ms.										
<i>nFilterPolicy</i>	byVal <i>nFilterPolicy</i> AS INTEGER. Specifies the filter policy for the whitelist as follows: <table border="1"> <tr> <td>0</td><td>Disable whitelist</td></tr> <tr> <td>1</td><td>Filter Policy – Filter scan request; allow connection request from any</td></tr> <tr> <td>2</td><td>Filter Policy – Filter connection request; allow scan request from any</td></tr> <tr> <td>3</td><td>Filter scan request and connection request</td></tr> <tr> <td>hhh</td><td>A whitelist handle (for more details see section “Whitelist Management Functions”)</td></tr> </table> If the filter policy is not 0, but 1,2 or 3 the whitelist is enabled and filled with first 8 addresses and 8 identity resolving keys of devices in the trusted device database. Given the database can accommodate more devices please note that if more than 8 devices exist than a partial whitelist is activated. To cater for that limitation, a whitelist can be manually created using the API described in the section “Whitelist Management Functions” and the handle returned from a manually created list can be supplied for this parameter	0	Disable whitelist	1	Filter Policy – Filter scan request; allow connection request from any	2	Filter Policy – Filter connection request; allow scan request from any	3	Filter scan request and connection request	hhh	A whitelist handle (for more details see section “ Whitelist Management Functions ”)
0	Disable whitelist										
1	Filter Policy – Filter scan request; allow connection request from any										
2	Filter Policy – Filter connection request; allow scan request from any										
3	Filter scan request and connection request										
hhh	A whitelist handle (for more details see section “ Whitelist Management Functions ”)										

Example:

```
// Example :: BleAdvertStart.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM addr$ : addr$=""

FUNCTION HndlrBlrAdvTimOut()
    PRINT "\nAdvert stopped via timeout"
    PRINT "\nExiting..."
ENDFUNC 0

//The advertising interval is set to 25 milliseconds. The module will stop
//advertising after 60000 ms (1 minute)
IF BleAdvertStart(0,addr$,25,60000,0)==0 THEN
    PRINT "\nAdverts Started"
    PRINT "\nIf you search for Bluetooth devices on your device, you should see 'Laird
BL654'"
ELSE
    PRINT "\n\nAdvertisement not successful"
ENDIF

ONEVENT EVBLE_ADV_TIMEOUT CALL HndlrBlrAdvTimOut

WAITEVENT
```

Expected Output:

```
Adverts Started

If you search for Bluetooth devices on your device, you should see 'Laird BL654'

Advert stopped via timeout
Exiting...
```

5.4.2 BleAdvertStop

FUNCTION

This function causes the BLE module to stop advertising.

BLEADVERTSTOP ()

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments	None

Example:

```
// Example :: BleAdvertStop.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM addr$ : addr$=""
DIM rc

FUNCTION HndlrBlrAdvTimOut()
    PRINT "\nAdvert stopped via timeout"
    PRINT "\nExiting..."
ENDFUNC 0

FUNCTION Btn0Press()
    IF BleAdvertStop()==0 THEN
        PRINT "\nAdvertising Stopped"
    ELSE
        PRINT "\n\nAdvertising failed to stop"
    ENDIF

    PRINT "\nExiting..."
ENDFUNC 0

IF BleAdvertStart(0,addr$,25,60000,0)==0 THEN
    PRINT "\nAdverts Started. Press button 0 to stop.\n"
ELSE
    PRINT "\n\nAdvertisement not successful"
ENDIF

rc = GpioSetFunc(11,1,2)
rc = GpioBindEvent(0,11,1)

ONEVENT EVBLE_ADV_TIMEOUT CALL HndlrBlrAdvTimOut
ONEVENT EVGPIOCHAN0 CALL Btn0Press

WAITEVENT
```

Expected Output:

```
Adverts Started. Press button 0 to stop.

Advertising Stopped
Exiting...
```

5.4.3 BleAdvertConfig

FUNCTION

This function is used to modify the default parameters that are used when initiating an advertise operation using [BleAdvertStart\(\)](#).

The following lists the default values for the parameters:

Advert Channel Mask	Bit field detailing the channels to advertise on.

Note: Set channel mask Bit 0 to enable advert channel 0, Bit 1 to enable advert channel 1, and Bit 2 to enable advert channel 2.

BLEADVERTCONFIG (configID, configValue)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.	
Arguments:		
configID	byVal configID AS INTEGER. This identifies the value to update as follows:	
	0	Unused
	1	Unused
	2	Unused
	3	Advert Channel Mask. Set t 0 to enable channel 37, bit 1 to enable channel 38, and bit 2 to enable channel 39
	4	Primary PHY to advertise on. Possible values are:- 1 - 1MPHY 4 - CODED PHY All other values are invalid
	5	Secondary PHY to advertisie on. Possible values are:- 1 - 1MPHY 4 - CODED PHY All other values are invalid
	For all other configID values the function returns an error.	
configValue	byVal configValue AS INTEGER. This contains the new value to set in the parameters indentedified by configID.	

5.4.4 BleAdvRptInit

FUNCTION

This function is used to create and initialise an advert report with a minimal set of ADs (advertising records) and store it the string specified. It is not advertised until BLEADVRSPTSCOMMIT is called.

This report is for use with advertisement packets.

BLEADVRSPTINIT (advRpt\$, nFlagsAD, nAdvAppearance, nMaxDevName)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.	
Arguments:		
advRpt\$	byRef advRpt\$ AS STRING. This contains an advertisement report.	
nFlagsAD	byVal nFlagsAD AS INTEGER. Specifies the flags AD bits where bit 0 is set for limited discoverability and bit 1 is set for general discoverability. Bit 2 will be forced to 1 and bits 3 & 4 will be forced to 0. Bits 3 to 7 are reserved for future use by the BT SIG and must be set to 0.	
nAdvAppearance	byVal nAdvAppearance AS INTEGER. Determines whether the appearance advert should be added or omitted as follows:	
	0	Omit appearance advert
	1	Add appearance advert as specified in the GAP service which is supplied via the BleGapSvcInit() function
nMaxDevName	byVal nMaxDevName AS INTEGER. The n leftmost characters of the device name specified in the GAP service. If this value is set to zero (0) then the device name is not included.	

Example:

```
// Example :: BleAdvRptInit.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM advRpt$ : advRpt$=""
DIM discovMode : discovMode=0
DIM advAppearance : advAppearance = 1
DIM maxDevName : maxDevName = 10

IF BleAdvRptInit(advRpt$, discovMode, advAppearance, maxDevName)==0 THEN
    PRINT "\nAdvert report initialised"
ENDIF
```

Expected Output:

Advert report initialised

5.4.5 BleScanRptInit

FUNCTION

This function is used to create and initialise a scan report which will be sent in a SCAN_RSP message. It will not be used until BLEADVPTSCOMMIT is called.

This report is for use with SCAN_RESPONSE packets.

BLESCANRPTINIT (scanRpt)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
scanRpt	byRef scanRpt AS STRING. This contains a scan report.

Example:

```
// Example :: BleScanRptInit.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM scnRpt$ : scnRpt$=""

IF BleScanRptInit(scnRpt$)==0 THEN
    PRINT "\nScan report initialised"
ENDIF
```

Expected Output:

```
Scan report initialised
```

5.4.6 BleAdvRptGetSpace

FUNCTION

This function returns the free space in the advert advRpt\$.

BLEADVPTGETSPACE(advRpt)

Returns	INTEGER, the free space in bytes.
Arguments:	
advRpt\$	byRef advRpt\$ AS STRING. This contains an advert/scan report.

Example:

```
// Example :: BleAdvRptGetSpace.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

dim rc, s$, dn$
rc=BleScanRptInit(s$)
dn$ = BleGetDeviceName$()

//Add device name to scan report
rc=BleAdvRptAppendAD(s$,0x09,dn$)

print "\nFree space in scan report: "; BleAdvRptGetSpace(s$); " bytes"
```

Expected Output:

```
Free space in scan report: 18 bytes
```

5.4.7 BleExtAdvRptGetSpace

See description in section “Extended Adverts Functions” [here](#).

5.4.8 BleAdvRptAddUuid16

FUNCTION

This function is used to add a 16 bit UUID service list AD (Advertising record) to the advert report. This consists of all the 16 bit service UUIDs that the device supports as a server. Up to 6 16 bit UUIDs can be added.

BLEADVRPTADDUUID16 (*advRpt\$, nUuid1, nUuid2, nUuid3, nUuid4, nUuid5, nUuid6*)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
AdvRpt\$	byRef AdvRpt AS STRING. The advert report onto which the 16-bit uuids AD record is added.
nUuid1	byVal uuid1 AS INTEGER UUID in the range 0 to FFFF; if the value is outside that range, it is ignored. Set the value to -1 to have it ignored and then all further UUID arguments will also be ignored.
nUuid2	byVal uuid2 AS INTEGER UUID in the range 0 to FFFF; if the value is outside that range, it is ignored. Set the value to -1 to have it ignored and then all further UUID arguments will also be ignored.
nUuid3	byVal uuid3 AS INTEGER UUID in the range 0 to FFFF; if the value is outside that range, it is ignored. Set the value to -1 to have it ignored and then all further UUID arguments will also be ignored.
nUuid4	byVal uuid4 AS INTEGER UUID in the range 0 to FFFF; if the value is outside that range, it is ignored. Set the value to -1 to have it ignored and then all further UUID arguments will also be ignored.
nUuid5	byVal uuid5 AS INTEGER UUID in the range 0 to FFFF; if the value is outside that range, it is ignored. Set the value to -1 to have it ignored and then all further UUID arguments will also be ignored.
nUuid6	byVal uuid6 AS INTEGER UUID in the range 0 to FFFF; if the value is outside that range, it is ignored. Set the value to -1 to have it ignored and then all further UUID arguments will also be ignored.

Example:

```
// Example :: BleAdvAddUuid16.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM advRpt$, rc
DIM discovMode : discovMode=0
DIM advAppearance : advAppearance = 1
DIM maxDevName : maxDevName = 10

rc = BleAdvRptInit(advRpt$, discovMode, advAppearance, maxDevName)

//BatteryService = 0x180F
//DeviceInfoService = 0x180A
```

```
IF BleAdvRptAddUuid16(advRpt$, 0x180F, 0x180A, -1, -1, -1, -1) == 0 THEN
    PRINT "\nUUID Service List AD added"
ENDIF

//Only the battery and device information services are included in the advert report
```

Expected Output:

```
UUID Service List AD added
```

5.4.9 BleAdvRptAddUuid128

FUNCTION

This function is used to add a 128 bit UUID service list AD (Advertising record) to the advert report specified. Given that an advert can have a maximum of only 31 bytes, it is not possible to have a full UUID list unless there is only one to advertise.

BLEADVRPTADDUUID128 (advRpt, nUuidHandle)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
advRpt	byRef AdvRpt AS STRING. The advert report into which the 128-bit UUID AD record is to be added.
nUuidHandle	byVal nUuidHandle AS INTEGER This is handle to a 128-bit UUID which was obtained using a function such as BleHandleUuid128() or some other function which returns one.

Example:

```
// Example :: BleAdvAddUuid128.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM uuid$ , hUuidCustom
DIM tx$, scRpt$, adRpt$, addr$, hndl
scRpt$ = ""
PRINT BleScanRptInit(scRpt$)

//create a custom uuid for my ble widget
uuid$ = "ced9d91366924a1287d56f2764762b2a"
uuid$ = StrDehexize$(uuid$)
hUuidCustom = BleHandleUuid128(uuid$)

//Advertise the 128 bit uuid in a scan report
PRINT BleAdvRptAddUuid128(scRpt$, hUuidCustom)
adRpt$ = ""
PRINT BleAdvRptsCommit(adRpt$, scRpt$)
```

```
addr$="" //because we are not doing a DIRECT advert
PRINT BleAdvertStart(0,addr$,20,30000,0)
```

Expected Output:

```
00000
```

5.4.10 BleAdvRptAppendAD

FUNCTION

This function adds an arbitrary AD (Advertising record) field to the advert report. An AD element consists of a LEN:TAG:DATA construct where TAG can be any value from 0 to 255 and DATA is a sequence of octets.

BLEADVAPTAPPENDAD (advRpt, nTag, stData\$)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
AdvRpt	byRef AdvRpt AS STRING. The advert report onto which the AD record is to be appended.
nTag	byVal nTag AS INTEGER nTag should be in the range 0 to FF and is the TAG field for the record.
stData\$	byRef stData\$ AS STRING This is an octet string which can be 0 bytes long. The maximum length is governed by the space available in AdvRpt, a maximum of 31 bytes long.

Example:

```
// Example :: BleAdvRptAppendAD.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM scnRpt$,ad$
ad$="\01\02\03\04"

PRINT BleScanRptInit(scnRpt$)

IF BleAdvRptAppendAD(scnRpt$,0x31,ad$)==0 THEN //6 bytes will be used up in the report
    PRINT "\nAD with data '"&ad$&"' was appended to the advert report"
ENDIF
```

Expected Output:

```
0
AD with data '\01\02\03\04' was appended to the advert report
```

5.4.11 BleExtAdvRptAppendAD

See description in section “Extended Adverts Functions” [here](#).

5.4.12 BleAdvRptsCommit

FUNCTION

This function is used to commit one or both advert reports. If the string is empty then that report type is not updated. Both strings can be empty. In that case, this call will have no effect.

The advertisements will not happen until they are started using BleAdvertStart() function.

BLEADVPTS_COMMIT (advRpt, scanRpt)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
advRpt	byRef advRpt AS STRING. The most recent advert report.
scanRpt	byRef scanRpt AS STRING. The most recent scan report.

Note: If any one of the two strings is not valid then the call will be aborted without updating the other report even if this other report is valid.

Tip: You can commit advert reports to update your advertisement data **while advertising**.

Example:

```
// Example :: BleAdvRptsCommit.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM advRpt$ : advRpt$=""
DIM scRpt$ : scRpt$=""

DIM discovMode : discovMode = 0
DIM advApprnce : advApprnce = 1
DIM maxDevName : maxDevName = 10

PRINT BleAdvRptInit(advRpt$, discovMode, advApprnce, maxDevName)
PRINT BleAdvRptAddUuidl6(advRpt$, 0x180F,0x180A, -1, -1, -1, -1)
PRINT BleAdvRptsCommit(advRpt$, scRpt$)

// Only the advert report will be updated.
```

Expected Output:

000

5.5 Extended Adverts Functions

This section describes all the extended adverts related routines, including ones for scanning and connecting which is an enhancement that was introduced in the v5.0 specification.

This enhancement allows for the advertising payload to be greater than 31 and in addition the use of all 40 channels and PHYs of 1M, 2M and LE_CODED.

As a recap, the specification labels the 40 channels from 0 to 39 and in the 4.x specification channels 37,38 and 39 were dedicated as advertisement channels and they were always sent at 1M PHY as that was the only one possible.

In v5.0, advertisement channels 37,38 and 39 are now qualified as 'Primary Advertising Channels' and channels 0 to 36 which were used exclusively for data in connections, they are now qualified as 'Secondary Advertising Channels'.

In extended adverts, the adverts sent in the primary channels are still limited to a payload of not more than 31 bytes and only those on secondary channels can have larger than 31 bytes.

Each advert packet sent on a secondary channel can now have up to 255 bytes of payload (concatenated AD elements) and the specification allows for chaining up to 6 of those 255 byte packets so that up to 1650 bytes as a single object can be broadcast. However, field experience has shown that reliability of receiving all those chained packets is not 100% and so many stack vendors do not offer the chaining capability and so each advert can only have up to 255 bytes of payload. On that basis, the Laird module also limits it to 255 bytes.

When extended adverts are sent, a newly created **primary** channel advert, called ADV_EXT_IND, is used with a special payload that has a pointer to the advert that is subsequently sent on the **secondary** channel. That pointer object contains the following information:-

- Time offset to the start of the packet in one of the secondary channels.
- The PHY that the advert will be sent out on, which will be one of 1M, 2M or LE_CODED
- Then channel number which will be in the range 0 to 36

Also note that for earlier specifications, the adverts on channels 37,38,39 were **always** sent on 1M PHY because that was the only PHY available. Given that v5.x has introduced new PHYs, it is now possible to send the ADV_EXT_IND (which only go out on primary channels) on LE_CODED, and that is to allow long range connections to be established. That is logical because when the two peers are far apart, normal 1M PHY adverts are not going to reach the master device for it to initiate connections.

An advert or scan response payload consists of multiple advertising records, referred to as AD in the rest of this manual.

Each AD record consists of up to three fields:

- Field 1 – One octet in length and indicates the number of octets that follow it that belong to that record.
- Field 2 – One octet in length and is a tag value which identifies the type of payload that starts at the next octet. Hence the payload data is 'length – 1'.
- Field 3 – A special NULL AD record that consists of one field (the length field) when it contains only the 00 value.

The specification also allows custom AD records to be created using the Manufacturer Specific Data AD record.

Refer to the *Supplement to the Bluetooth Core Specification, Version 1, Part A* which contains the latest list of all AD records. You must register as at least an adopter, which is free, to gain access to this information. It is available at https://www.Bluetooth.org/docman/handlers/downloaddoc.ashx?doc_id=245130

In the 'legacy' adverts smartBASIC api functions have been provided that allow AD elements to be appended to the advert or scan response payload. Those functions are BleAdvRptInit(), BleScanRptInit(), BleAdvRptAddUuid16(), BleAdvRptAddUuid128() and BleAdvRptAppendAD() and they can still be used for extended adverts. However, if the report will exceed 31 bytes then it will fail. Once that happens a new function called BleExtAdvRptAppendAD() has been added that will allow any AD element to be appended to an advert string and that new function will fail when the total length will exceed 255 bytes.

The rest of this section will describe the new functions that have been added to facilitate extended adverts. In addition the following events have been added which are described in an earlier section and can be navigated to by clicking them.

1. [EVBLE_EXTADVDRIPPED](#)
2. [EVBLE_EXTADVNOMEM](#)
3. [EVBLE_SCAN_ABORTED](#)
4. [EVBLE_EXTADV_END](#)
5. [EVBLE_EXTADV_RPT](#)

6. `EVBLE_EXTSCN_RPT`
7. `EVBLE_EXTADV_RPT_INCOMPLETE`

To summarise, to start extended adverts the smartBASIC application will make the following function calls in the sequence specified:-

1. `BleAdvSetCreate()`
2. `BleAdvSetNewData()`
3. `BleAdvSetStart()`

and once adverts are started `BleAdvSetNewData()` can be called as often as required to change the data that is currently being advertised.

To stop adverts, call the following:-

1. `BleAdvSetStop()`

To scan for adverts, call the following, to stop use the existing function to do so and to preprocess advert reports or scan responses that are received register handlers for events `EVBLE_EXTADV_RPT`, `EVBLE_EXTSCN_RPT` and `EVBLE_EXTADV_RPT_INCOMPLETE`. This scanning will also result in 'legacy' adverts being received which are processed in the same way that has always existed, that is, by registering for the event `EVBLE_ADV_REPORT`.

1. `BleScanStartEx()`

To make connections, use the following function which will allow for making a long range connections. In fact it is recommended that this new function should always be used as the existing function `BleConnect()` may be deprecated:-

2. `BleConnectExtended()`

5.5.1 BleAdvSetCreate

FUNCTION

This function is used to create a new advertising set identified by the **nSetId** parameter which is a value in the range 0 to N where N is function of the firmware build. The set identified by nSetId value of 0 is always available and at runtime use `NvCfgKeyGet(217)` to obtain the maximum sets that can be created.

Think of a set as the definition of an advertising object and when multiple are defined they can all be advertised simultaneously in an interleaved manner so that it facilitates the transmission of say iBeacons and Eddystone beacons. Note that at the time when this was written the underlying stack only allows up to 1 set to be created and reused as often as desired.

If the **nAdvProperties** argument is specified with bit 2 set (directed), then the `peerAddr$` string must not be empty and should be a valid address.

When filter policy is enabled, the whitelist consisting of all bonded masters is submitted to the underlying stack so that only those bonded masters result in scan and connection requests being serviced.

BLEADVSETCREATE (nSetId, nAdvProperties, nPriSecPhy, nFilterPolicy, peerAddr\$, chanMask\$)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.	
Arguments:		
nSetId	byVal nSetId AS INTEGER. A value in the range 0 to N where N is the value returned by command AT+CFG 127?	
nAdvProperties	byVal nAdvProperties AS INTEGER. Specifies a bitmask as follows:	
	Bit	Description
	0	Set for Connectable, clear for Unconnectable
	1	Set for Scannable, clear for Unscannable. <i>Note when extended bit 3 is set, bits 0 and 1 cannot both be 1</i>
	2	Set for Directed and clear for Undirected
	3	Set for Extended and clear for 4.x adverts
	4..7	Reserved for future use, set to 0
	8	Set for High latency and clear for low latency when the directed bit 2 is set and will be

		ignored if extended bit 3 is set
	9	Set to omit advertisers address from all extended advert pdus so that it is anonymous
	10	Set to include the TX_POWER info field in the CEAP payload of extended adverts. <i>See specification for more details</i>
	11..31	<i>Reserved for future use, set to 0</i>
nPriSecPhy	byVal nPriSecPhy AS INTEGER. Bitmask to set Primary and Secondary PHYs bit 0 : Primary Phy - Clear for 1MPHY and Set for LE_CODED - When set, Bit 3 (Extended) in nAdvProperties overridden as always set bit 123 : Secondary Phy 321 - 000 == Same Phy as Primary Phy - 001 == 1MPHY - 010 == 2MPHY - 011 == LECODED - 100 to 111 is reserved for future use	
nFilterPolicy	byVal nFilterPolicy AS INTEGER. A handle that will have been created using BleWhiteListCreate() that specifies the peer addresses that will be whitelisted.	
peerAddr\$	byRef peerAddr\$ AS STRING It can be an empty string that is omitted if the advertisement type is not ADV_DIRECT_IND. This is only required when nAdvType == 1. When not empty, a valid address string is exactly seven octets long (for example: \00\11\22\33\44\55\66) where the first octet is the address type and the rest of the six octets is the usual Bluetooth address in big endian format (so the most significant octet of the address is at offset 1), whether public or random.	
	0	Public
	1	Random Static
	2	Random Private Resolvable
	3	Random Private Non-Resolvable
	All other values are illegal.	
chanMask\$	byVal chanMask\$ AS STRING This is a string that will be exactly 0 or 5 bytes long that has 40 bits that map to the 40 channels available in BLE. If a bit is 1 then the corresponding channel is not allowed. Bit 0 of the first byte is channel 0 and bit 7 of the 5 th byte is channel 39. At least one but corresponding to channels 37,38 and 39 must be clear. <i>See specification v5.0, Vol 6, Part B, Section 1.4.1</i>	

5.5.2 BleAdvSetNewData

FUNCTION

This function is used to attach advert and/or scan response data to the data set specified. If adverts are currently being transmitted for the set specified they need to be stopped and the data will automatically be updated in the next adverts sent.

This function assumes that the set specified has already been created using BleAdvSetCreate() and if not will return an appropriate error code.

BLEADVSETNEWDATA (nSetId, advData\$, scanData\$)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
nSetId	byVal nSetId AS INTEGER.

	A value in the range 0 to N where N is the value returned by command AT+CFG 127?
advData\$	byRef advData\$ AS STRING. Contains concatenated AD elements to be transmitted. The string will have been created with either BleAdvRptInit() or BleScanRptInit(). The latter when the advert is unconnectable so that it is created with no AD elements. Depending on the type of advert, the length of the advert cannot be greater than 31 or 238 or 255. 31 limit when nAdvProperties bit 3 is clear 238 limit when nAdvProperties bit 0 is set and bit 3 is set 255 limit when nAdvProperties bit 0 is clear and bit 3 is set
scanData\$	byRef scanData\$ AS STRING. Contains concatenated AD elements to be transmitted. The string will have been created with either BleScanRptInit(). Depending on the type of advert, the length of the advert cannot be greater than 0, 31 or 255. 0 when nAdvProperties bit 1 is clear 31 limit when nAdvProperties bit 3 is clear 255 limit when nAdvProperties bit 3

5.5.3 BleAdvSetStart

FUNCTION

This function is used to start adverts for the advertising set specified using interval and duration parameters specified.

If the **nAdvMaxCount** is non-zero then when that many adverts are sent, advertising will be automatically stopped regardless of the value of the **nAdvDuration** parameter.

If **nAdvMaxCount** is zero and **nAdvDuration** is also 0 then advertising will not automatically stopped until either BleAdvSetStop() with the same nSetID or BleAdvertStop() is called.

BLEADVSETSTART (nSetId, nAdvInterval, nAdvDuration, nAdvMaxCount, nAuxOffset)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation. If a 0x6A01 resultcode is received, it implies a whitelist has been enabled but the Flags AD in the advertising report is set for Limited and/or General Discoverability. The solution is to resubmit a new advert report which is made up so that the nFlags argument to BleAdvRptInit() function is 0. The BT spec disallows discoverability when a whitelist is enabled during advertisement.
Arguments:	
nSetId	byVal nSetId AS INTEGER. A value in the range 0 to N where N is the value returned by command AT+CFG 127?
nAdvInterval	byVal nAdvInterval AS INTEGER. The interval between two advertisement events (in milliseconds). Valid range is between 20 and 10240 milliseconds.
nAdvDuration	byVal nAdvTimeout AS INTEGER. The time after which the module stops advertising (in milliseconds). The range of this value is between 0 and 16383000 milliseconds and is rounded up to the nearest 1 seconds (1000ms). A value of 0 means disable the timeout
nAdvMaxCount	byVal nAdvMaxCount AS INTEGER. This is a value in the range 0 to 255 When non-zero, then advertising will automatically stop when this many adverts are sent. The event EVBLE_EXTADV_END will be received with the reason set to the number of adverts sent.
nAuxOffset	byVal nAuxOffset AS INTEGER. This is reserved for future use and must always be set to 0 which signifies the use of stack default value which is around 4 milliseconds. No assumptions should be made on this value as the default value is subject to change by the stack vendor.

5.5.4 BleAdvSetStop

FUNCTION

This function is used to stop adverts for the advertising set specified.

BLEADVSETSTOP (nSetId)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
nSetId	byVal nSetId AS INTEGER. A value in the range 0 to N where N is the value returned by command AT+CFG 127?

5.5.5 BleScanStartEx

FUNCTION

This function is used to start a scan for adverts which may result in at least one of the following events being thrown:

EVBLE_SCAN_TIMEOUT	End of scanning
EVBLE_ADV_REPORT	Advert report received
EVBLE_FAST_PAGED	Peripheral inviting a connection to this module
EVBLE_EXTADVDRIPPED	Event message queue full and extended advert arrived
EVBLE_EXTADVNOEMEM	Extended advert or scan response arrived and malloc failed
EVBLE_EXTADV_RPT	Received an extended advert report
EVBLE_EXTSCN_RPT	Received an extended scan response
EVBLE_EXTADV_RPT_INCOMPLETE	Received and extended advert report or scan response which has incomplete data payload

- **EVBLE_ADV_REPORT** – Received when an advert has been successfully cached in a ring buffer. The handler should call the function BleScanGetAdvReport() repeatedly to read all the advert reports that have been cached until the cache is empty, otherwise there is a risk that advert reports will be discarded. The output parameter nDiscarded returns the number of discarded reports, if any.
- **EVBLE_FAST_PAGED** – Received when a peripheral has sent an advert with the address of this module. The handler should stop scanning using BleScanStop() and then initiate a connection using BleConnect().
- **EVBLE_EXTADV_RPT_INCOMPLETE** is received when an advert report or scan response is received when the data is incomplete. This can happen for example when an advertiser has sent an advert or scan response which is greater than 255 bytes by sending chained packets. The underlying code in this buffer does not provide a buffer larger than 255 bytes for the data to be stored in and so it has to be reported as incomplete.

There are two parameters used when initiating a scan that are configurable using BleScanConfig(), otherwise default values are used:

- Scan Interval – Specify the duty cycle for listening for adverts. Default value: 80 milliseconds.
- Scan Window – Specify the duty cycle for listening for adverts. Default value: 40 milliseconds.

The values for these default parameters can be changed prior to invoking this function by calling the function BleScanConfig() appropriately.

Scanning can be stopped at any time by calling BleScanStop() or by starting a connection.

Note: Be aware that scanning is a memory intensive operation and so heap memory is used to manage a cache for legacy adverts. If the heap is fragmented, it is likely this function will fail with an appropriate resultcode returned. If that happens, call reset() and then attempt the scan start again. The memory that is allocated to manage this scan process is NOT released when the scanning times out. To force release of that memory, we recommend that you start the scan and then immediately call BleScanStop().

BLESCANSTARTEX(scanTimeoutMs, nPriPhyScan, chanMask\$, nFilterHandle)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
scanTimeoutMs	byVAL scanTimeoutMs AS INTEGER. The length of time in milliseconds the scan for adverts lasts. If the timer times out then the event EVBLE_SCAN_TIMEOUT is thrown to the <i>smart</i>BASIC application. Valid range is 0 to 65535000 milliseconds (about 18 hours). If 0 is supplied, a timer is not started and scanning can only be stopped by calling either BleScanAbort() or Ble ScanStop().
nPriPhyScan	byVAL nPriPhyScan AS INTEGER Bit Mask to specify the PHY to scan on in the primary channels and whether passive or active scanning as follows Note: At least one bit MUST be set. - Bit 0: Scan on 1MPHY - Bit 1: Scan on LE_CODED - Bit 2: Set for Extended Scanning (If Bit 1 set, then this is overridden and always set) - Bit 3: Set for Passive Scanning and clear for Active Scanning <i>Note when Bit 2 is clear and bit 1 is not set, then the scanning is as per legacy scanning which would if BleScanStart() was called.</i>
chanMask\$	byVal chanMask\$ AS STRING This is a string that will be exactly 0 or 5 bytes long that has 40 bits that map to the 40 channels available in BLE. If a bit is 1 then the corresponding channel is not allowed. Bit 0 of the first byte is channel 0 and bit 7 of the 5th byte is channel 39. At least one but corresponding to channels 37,38 and 39 must be clear. <i>See specification v5.0, Vol 6, Part B, Section 1.4.1</i>
nFilterHandle	byVal nFilterPolicy AS INTEGER. A handle that will have been created using BleWhiteListCreate() that specifies the peer addresses that will be whitelisted.

5.5.6 BleExtRptMetadata

FUNCTION

This function is used to extract information from the metaData\$ string parameter that is sent in the following events:-

EVBLE_EXTADV_RPT	Received an extended advert report
EVBLE_EXTSCN_RPT	Received an extended scan response
EVBLE_EXTADV_RPT_INCOMPLETE	Received an extended advert report or scan response which has incomplete data payload

BLEEXTRPTMETADATA (metaData\$, nInfold)

Returns	INTEGER, the value of the information field. It will be 0x80000000 if the metaData\$ string is of the wrong length. It will be 0x80000001 if the metaData\$ string is invalid due to not having correct magic header.
Arguments:	
metaData\$	byRef metaData\$ as STRING The metaData\$ string that arrived in one of the events listed above.
nInfold	byVal nInfold AS INTEGER. The information extracted is as per the list below. 1 : Set_id 2 : data_id

	3 : primary phy 4 : secondary phy 5 : channel_index 6 : tx_power (This field is set to 127 if the report does not contain the TxPower field) 7 : Status (0=Complete 1=INCOMPLETE_MORE_DATA - More data to be received 2=INCOMPLETE_TRUNCATED - Buffer size insufficient to receive more 3=INCOMPLETE_MISSED - Failed to receive the remaining data 8 : Packet type: 0 for Advert Report and 1 for Scan Response All other id values will return 0.

5.5.7 BleConnectExtended

FUNCTION

This function is used to make normal or long range connections to a device in peripheral mode which is actively advertising using filtering.

When the connection is complete, a EVBLEMSG message with msgId = 0 and context containing the handle are thrown to the *smart*BASIC runtime engine.

If the connection times out, then the event EVBLE_CONN_TIMEOUT is thrown to the *smart*BASIC application.

When a connection is attempted, there are other parameters that are used and the default values for those are assumed; for example, scan window, scan interval, and periodicity. The default values for those can be changed using the BleConnectConfig() function. At any time, the current settings can be obtained via the SYSINFO() command.

BLECONNECTEXTENDED(peerAddr\$, connTimeoutMs, minConnIntUs, maxConnIntUs, nSuprToutUs, nLongRange, hFilter)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
peerAddr\$	byRef peerAddr\$ AS STRING The Bluetooth address of the device to connect to which MUST be properly formatted and is exactly seven bytes long.
connTimeoutMs	byVal connTimeoutMs AS INTEGER. The length of time in milliseconds that the connection attempt lasts. If the timer times out then the event EVBLE_CONN_TIMEOUT is thrown to the <i>smart</i> BASIC application.
minConnIntUs	byVal minConnIntUs AS INTEGER. The minimum connection interval in microseconds. Valid range is between 7500 and 4000000 microseconds.
maxConnIntUs	byVal maxConnIntUs AS INTEGER. The maximum connection interval in microseconds. Valid range is between 7500 and 4000000 microseconds
nSuprToutUs	byVal nSuprToutUs AS INTEGER. The link supervision timeout for the connection in microseconds.
nLongRange	byVal nLongRange AS INTEGER. Set to 0 for normal 1MPHY connections and 1 for long range connections off LE_CODED adverts sent by the peer
hFilter	byVal hFilter AS INTEGER. A handle that will have been created using BleWhiteListCreate() that specifies the peer addresses that will be whitelisted.

5.5.8 BleExtAdvRptAppendAD

FUNCTION

This function adds an arbitrary AD (Advertising record) field to the advert or scan report. An AD element consists of a LEN:TAG:DATA construct where TAG can be any value from 0 to 255 and DATA is a sequence of octets.

This function is the only one that is able to add an AD element to a report when adding it will extend the report beyond 31 bytes. It will not succeed if the report will result in it being over 255 bytes long.

Use function BleExtAdvGetSpace() to determine current available space in advRpt\$ string.

BLEEXTADVVRTAPPENDAD (advRpt\$, nTag, stData\$)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
AdvRpt\$	byRef AdvRpt\$ AS STRING. The advert report onto which the AD record is to be appended.
nTag	byVal nTag AS INTEGER nTag should be in the range 0 to FF and is the TAG field for the record.
stData\$	byRef stData\$ AS STRING This is an octet string which can be 0 bytes long. The maximum length is governed by the space available in AdvRpt, a maximum of 255 bytes long.

5.5.9 BleExtAdvRptAddUuid16

FUNCTION

This function is used to add a 16 bit UUID service list AD (Advertising record) to the extended advert report. This consists of all the 16 bit service UUIDs that the device supports as a server. Up to six 16 bit UUIDs can be added.

BLEEXTADVVRTADDUUID16 (advRpt\$, nUuid1, nUuid2, nUuid3, nUuid4, nUuid5, nUuid6)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
AdvRpt\$	byRef AdvRpt AS STRING. The advert report onto which the 16-bit uuids AD record is added.
nUuid1	byVal uuid1 AS INTEGER UUID in the range 0 to FFFF; if the value is outside that range, it is ignored.
nUuid2	byVal uuid2 AS INTEGER UUID in the range 0 to FFFF; if the value is outside that range, it is ignored. Set the value to -1 to have it ignored and then all further UUID arguments will also be ignored.
nUuid3	byVal uuid3 AS INTEGER UUID in the range 0 to FFFF; if the value is outside that range, it is ignored. Set the value to -1 to have it ignored and then all further UUID arguments will also be ignored.
nUuid4	byVal uuid4 AS INTEGER UUID in the range 0 to FFFF; if the value is outside that range, it is ignored. Set the value to -1 to have it ignored and then all further UUID arguments will also be ignored.
nUuid5	byVal uuid5 AS INTEGER UUID in the range 0 to FFFF; if the value is outside that range, it is ignored. Set the value to -1 to have it ignored and then all further UUID arguments will also be ignored.
nUuid6	byVal uuid6 AS INTEGER UUID in the range 0 to FFFF; if the value is outside that range, it is ignored. Set the value to -1 to have it ignored and then all further UUID arguments will also be ignored.

5.5.10 BleExtAdvRptAddUuid128

FUNCTION

This function is used to add a 128 bit UUID service list AD (Advertising record) to the extended advert report. This consists of all the 128 bit service UUIDs that the device supports as a server. Up to six 128 bit UUIDs can be added. If there isn't enough space to add an element with all the UUID's specified then the AD element tag will be the incomplete list variant which has the value 0x06 instead of 0x07 which denotes the fact that all UUIDs fitted.

The function takes UUID **handles** that will have been obtained using functions like BleHandleUuid128() and BleHandleUuidSibling().

BLEEXTADVRPTADDUUID128 (advRpt\$, hUuid1, hUuid2, hUuid3, hUuid4, hUuid5, hUuid6)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
AdvRpt\$	byRef AdvRpt AS STRING. The advert report onto which the 128-bit uuids AD record is added.
hUuid1	byVal hUuid1 AS INTEGER UUID handle that will have been obtained using BleHandleUuid128() or BleHandleUuidSibling().
hUuid2	byVal hUuid2 AS INTEGER UUID handle that will have been obtained using BleHandleUuid128() or BleHandleUuidSibling(). Set the value to 0 to have it ignored and then all further UUID handle arguments will also be ignored.
hUuid3	byVal hUuid3 AS INTEGER UUID handle that will have been obtained using BleHandleUuid128() or BleHandleUuidSibling(). Set the value to 0 to have it ignored and then all further UUID handle arguments will also be ignored.
hUuid4	byVal hUuid4 AS INTEGER UUID handle that will have been obtained using BleHandleUuid128() or BleHandleUuidSibling(). Set the value to 0 to have it ignored and then all further UUID handle arguments will also be ignored.
hUuid5	byVal hUuid5 AS INTEGER UUID handle that will have been obtained using BleHandleUuid128() or BleHandleUuidSibling(). Set the value to 0 to have it ignored and then all further UUID handle arguments will also be ignored.
hUuid6	byVal hUuid6 AS INTEGER UUID handle that will have been obtained using BleHandleUuid128() or BleHandleUuidSibling(). Set the value to 0 to have it ignored and then all further UUID handle arguments will also be ignored.

5.5.11 BleExtAdvRptGetSpace

FUNCTION

This function returns the free space in the extended advert advRpt\$.

BLEEXTADVRPTGETSPACE(advRpt)

Returns	INTEGER, the free space in bytes.
Arguments:	
advRpt\$	byRef advRpt\$ AS STRING. This contains an advert/scan report.

5.6 Scanning Functions

When a peripheral advertises, the advert packet consists type of advert, address, RSSI, and some user data information.

A central role device enters scanning mode to receive these advert packets from any device that is advertising.

For each advert that is received, the data is cached in a ring buffer, if space exists, and the EVBLE_ADV_REPORT event is thrown to the *smart*BASIC application so that it can invoke the function BleScanGetAdvReport() to read it.

The scan procedure ends when it times out (timeout parameter is supplied when scanning is initiated) or when explicitly instructed to abort or stop.

Note: While scanning for a long period of time, it is possible that a peripheral device is advertising for a connection to it using the ADV_DIRECT_IND advert type. When this happens, it is good practice for the central device to stop scanning and initiate the connection. To cater for this specific scenario, which would normally require the central device to look out for that advert type and the self address, the EVBLE_FAST_PAGED event is thrown to the application. This means that all the user app needs to do is to install a handler for that event which stops the scan procedure and immediately starts a connection procedure.

For more information about adverts see the section [Advertising Functions](#).

5.6.1 BleScanStart

FUNCTION

This function is used to start a scan for adverts which may result in at least one of the following events being thrown:

EVBLE_SCAN_TIMEOUT	End of scanning
EVBLE_ADV_REPORT	Advert report received
EVBLE_FAST_PAGED	Peripheral inviting a connection to this module

- **EVBLE_ADV_REPORT** – Received when an advert has been successfully cached in a ring buffer. The handler should call the function BleScanGetAdvReport() repeatedly to read all the advert reports that have been cached until the cache is empty, otherwise there is a risk that advert reports will be discarded. The output parameter nDiscarded returns the number of discarded reports, if any.
- **EVBLE_FAST_PAGED** – Received when a peripheral has sent an advert with the address of this module. The handler should stop scanning using BleScanStop() and then initiate a connection using BleConnect().

There are three parameters used when initiating a scan that are configurable using BleScanConfig(), otherwise default values are used:

- Scan Interval – Specify the duty cycle for listening for adverts. Default value: 80 milliseconds.
- Scan Window – Specify the duty cycle for listening for adverts. Default value: 40 milliseconds.
- Scan Type – Default scan type: Active

Active scanning means that for each advert received (if it is ADV_IND or ADV_DISCOVER_IND) a SCAN_REQ is sent to the advertising device so that the data in the scan response can be appended to the data that has already been received for the advert.

The values for these default parameters can be changed prior to invoking this function by calling the function BleScanConfig() appropriately.

Note: Be aware that scanning is a memory intensive operation and so heap memory is used to manage a cache. If the heap is fragmented, it is likely this function will fail with an appropriate resultcode returned. If that happens, call reset() and then attempt the scan start again. The memory that is allocated to manage this scan process is NOT released when the scanning times out. To force release of that memory, we recommend that you start the scan and then immediately call BleScanStop().

Connections may not be established during a scan operation. If a continued scan is required, stop the scan or let it timeout, connect, then restart the scan.

In order to scan for devices over the CODED PHY medium (long range), BleScanConfig() should be called beforehand to configure the device with this capability. See [BleScanConfig\(\)](#) for more information. Furthermore, high bandwidth should be enabled using “AT+CFG 214 1” followed by “ATZ”.

BLESCANSTART (scanTimeoutMs, nFilterHandle)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
scanTimeoutMs	byVAL scanTimeoutMs AS INTEGER. The length of time in milliseconds the scan for adverts lasts. If the timer times out then the event EVBLE_SCAN_TIMEOUT is thrown to the <i>smart</i> BASIC application. Valid range is 0 to 65535000 milliseconds (about 18 hours). If 0 is supplied, a timer is not started and scanning can only be stopped by calling either BleScanAbort() or Ble ScanStop().
nFilterHandle	byVAL nFilterHandle AS INTEGER This must be zero (0) to specify no filtering of adverts. Note: In this current firmware version, this is only a placeholder.

Example:

```
// Example:: BleScanStart.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc

'//Scan for 20 seconds with no filtering
rc = BleScanStart(20000, 0)

IF rc==0 THEN
    PRINT "\nScanning"
ELSE
    PRINT "\nError: "; INTEGER.H'rc
ENDIF

'//This handler will be called when scanning times out
FUNCTION HndlrScanTO()
    PRINT "\nScan timeout"
ENDFUNC 0

ONEVENT EVBLE_SCAN_TIMEOUT CALL HndlrScanTO

WAITEVENT
```

Expected Output:

```
Scanning
Scan timeout
```

5.6.2 BleScanStartEx

See description in section “Extended Adverts Functions” [here](#).

5.6.3 BleScanAbort

FUNCTION

This function is used to cancel an ongoing scan for adverts which has not timed out. It takes no parameters as there can only be one scan in progress.

Use the value returned by SYSINFO(2016) to determine if there is an ongoing scan operation in progress. The value is a bit mask where:

- **bit 0** is set if advertising is in progress
- **bit 1** is set if there is already a connection in a peripheral role
- **bit 2** is set if there is a current ongoing connection attempt
- **bit 3** is set when scanning
- **bit 4** is set if there is already a connection to a peripheral

There is also BleScanStop() which cancels an ongoing scan. The difference is that, by calling BleScanAbort(), the memory that was allocated from heap by BleScanStart() is not released back to the heap. The scan manager retains it for the next scan operation.

BLESCANABORT ()

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments	None

Example:

```
// Example :: BleScanAbort.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc, startTick

'//Scan for 20 seconds with no filtering
rc = BleScanStart(20000, 0)

IF rc==0 THEN
    PRINT "\nScanning"
ELSE
    PRINT "\nError: "; INTEGER.H'rc
ENDIF

'//Wait 2 seconds before aborting scan
startTick = GetTickCount()
WHILE GetTickSince(startTick) < 2000
ENDWHILE

'//If scan in progress, abort
IF SysInfo(2016) == 0x08 THEN
    PRINT "\nAborting scan"
    rc = BleScanAbort()
```

```
IF SysInfo(2016) == 0 THEN
    PRINT "\nScan aborted"
ENDIF
ENDIF
```

Expected Output:

```
Scanning
Aborting scan
Scan aborted
```

5.6.4 BleScanStop

FUNCTION

This function is used to cancel an ongoing scan for adverts which has not timed out. It takes no parameters, as there can only be one scan in progress.

Use the value returned by SYSINFO(2016) to determine if there is an ongoing scan operation in progress. The value is a bit mask where:

- **bit 0** is set if advertising is in progress
- **bit 1** is set if there is already a connection in a peripheral role
- **bit 2** is set if there is a current ongoing connection attempt
- **bit 3** is set when scanning
- **bit 4** is set if there is already a connection to a peripheral

There is also BleScanAbort() which cancels an ongoing scan. The difference is that, by calling BleScanStop(), the memory that was allocated from heap by BleScanStart() is released back to the heap. The scan manager must reallocate the memory if BleScanStart() is called again.

BLESCANSTOP ()

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments	None

Example:

```
// Example :: BleScanStop.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc, startTick

'//Scan for 20 seconds with no filtering
rc = BleScanStart(20000, 0)

IF rc==0 THEN
    PRINT "\nScanning"
ELSE
    PRINT "\nError: "; INTEGER.H'rc
ENDIF

'//Wait 2 seconds before aborting scan
```

```
startTick = GetTickCount()
WHILE GetTickCount(startTick) < 2000
ENDWHILE

'//If scan in progress, abort
IF SysInfo(2016) == 0x08 THEN
    PRINT "\nStop scanning. Freeing up allocated memory"
    rc = BleScanStop()
    IF SysInfo(2016) == 0 THEN
        PRINT "\nScan stopped"
    ENDIF
ENDIF
ENDIF
```

Expected Output:

```
Scanning
Stop scanning. Freeing up allocated memory
Scan stopped
```

5.6.5 BleScanFlush

FUNCTION

This function is used to flush the ring buffer which stores incoming adverts which are later read.

BLESCANFLUSH ()

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments	None

Example:

```
// Example :: BleScanFlush.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc, startTick

'//Scan for 20 seconds with no filtering
rc = BleScanStart(20000, 0)

IF rc==0 THEN
    PRINT "\nScanning"
ELSE
    PRINT "\nError: "; INTEGER.H'rc
ENDIF

'//Wait 2 seconds before aborting scan
startTick = GetTickCount()
```

```

WHILE GetTickSince(startTick) < 2000
ENDWHILE

'//If scan in progress, abort
IF SysInfo(2016) == 0x08 THEN
    PRINT "\nAborting scan"
    rc = BleScanAbort()
    IF SysInfo(2016) == 0 THEN
        PRINT "\nScan aborted"
    ENDIF
ENDIF

'//Free up memory
rc = BleScanFlush()
IF (rc == 0) THEN
    PRINT "\nScan results flushed."
ENDIF
ENDIF

```

Expected Output:

```

Scanning
Aborting scan
Scan aborted
Scan results flushed.

```

5.6.6 BleScanConfig

FUNCTION

This function is used to modify the default parameters that are used when initiating a scan operation using BleScanStart().

The following are the default values for the parameters:

Scan Interval	80 milliseconds
Scan Window	40 milliseconds
Scan Type (Active/Passive)	Active
Minimum Reports in Cache	4

Note: The default Scan Window and Interval give a 50% duty cycle. The 50% duty cycle attempts to ensure that connection events for existing connections are missed as infrequently as possible.

BLESCANCONFIG (configID, configValue)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.		
Arguments:			
configID	byVal configID AS INTEGER.		
	This identifies the value to update as follows:		
	0	Scan Interval in milliseconds (range 0..10240)	
	1	Scan Window in milliseconds (range 0..10240)	

	2	Scan Type (0=Passive, 1=Active)
	3	Advert Report Cache Size
	4	Scan PHYs. Possible values are:- 1 - 1MPHY 4 - CODED PHY All other values are invalid
	5	Extended advertising. Possible values are:- 0 - Only return legacy advertising packets 1 - Return both legacy and extended advertising packets (required for CODED adverts)
	For all other configID values the function returns an error.	
configValue	byVal configValue AS INTEGER. This contains the new value to set in the parameters identified by configID.	

Example:

```
// Example :: BleScanConfig.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc, startTick

PRINT "\nScan Interval: "; SysInfo(2150)    //get current scan interval
PRINT "\nScan Window: "; SysInfo(2151)    //get current scan window
PRINT "\nScan Type: ";
IF SysInfo(2152)==0 THEN                  //get current scan type
    PRINT "Passive"
ELSE
    PRINT "Active"
ENDIF
PRINT "\nReport Cache Size: "; SysInfo(2153) //get report cache size

PRINT "\n\nSetting new parameters..."
rc = BleScanConfig(0, 100)                //set scan interval to 100
rc = BleScanConfig(1, 50)                  //set scan window to 50
rc = BleScanConfig(2, 0)                   //set scan type to passive
rc = BleScanConfig(3, 3)                   //set report cache size

PRINT "\n\n--- New Parameters:"
PRINT "\nScan Interval: "; SysInfo(2150)    //get current scan interval
PRINT "\nScan Window: "; SysInfo(2151)    //get current scan window
PRINT "\nScan Type: ";
IF SysInfo(2152)==0 THEN                  //get current scan type
    PRINT "Passive"
ELSE
```

```
PRINT "Active"
ENDIF
PRINT "\nReport Cache Size: "; SysInfo(2153) //get report cache size
```

Expected Output:

```
Scan Interval: 80
Scan Window: 40
Scan Type: Active
Report Cache Size: 4

Setting new parameters..

--- New Parameters:
Scan Interval: 100
Scan Window: 50
Scan Type: Passive
Report Cache Size: 3
```

5.6.7 BleScanGetAdvReport

FUNCTION

When a scan is in progress after having called BleScanStart() for each advert report, the information is cached in a queue buffer and an EVBLE_ADV_REPORT event is thrown to the *smart*BASIC application.

This function is used by the *smart*BASIC application to extract it from the queue for further processing in the handler for the EVBLE_ADV_REPORT event.

The retrieved information consists of the address of the peripheral that sent the advert, the data payload, the number of adverts (all, not just from that peripheral) that have been discarded since the last time this function was called and the RSSI value for that packet.

Note: The RSSI can be used to determine the closest device. However, due to fading and reflections, it is possible that a device further away could result in a higher RSSI value.

BLESCANGETADVREPORT (periphAddr\$, advData\$, nDiscarded, nRssi)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
periphAddr\$	byREF periphAddr\$ AS STRING On return, this parameter is updated with the address of the peripheral that sent the advert.
advData\$	byREF advData\$ AS STRING On return, this parameter is updated with the data payload of the advert which consists of multiple AD elements.
nDiscarded	byREF nDiscarded AS INTEGER On return, this parameter is updated with the number of adverts that were discarded because there was no space in the internal queue.
nRssi	byREF nRssi AS INTEGER On return, this parameter is updated with the RSSI as reported by the stack for that advert. Note: This is NOT a value that is sent by the peripheral but a value that is calculated by the receiver in this module.

Note: This code snippet was tested with another BL654 running the iBeacon app (see in smartBASIC_Sample_Apps folder) on peripheral firmware.

Example:

```
// Example :: BleScanGetAdvReport.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc

'//Scan for 20 seconds with no filtering
rc = BleScanStart(5000, 0)

IF rc==0 THEN
    PRINT "\nScanning"
ELSE
    PRINT "\nError: "; INTEGER.H'rc
ENDIF

'//This handler will be called when scanning times out
FUNCTION HndlrScanTO()
    PRINT "\nScan timeout"
ENDFUNC 0

'//This handler will be called when an advert is received
FUNCTION HndlrAdvRpt()
    DIM periphAddr$, advData$, nDiscarded, nRssi

    '//Read all cached advert reports
    rc=BleScanGetAdvReport(periphAddr$, advData$, nDiscarded, nRssi)
    WHILE (rc == 0)
        PRINT "\n\nPeer Address: "; StrHexize$(periphAddr$)
        PRINT "\nAdvert Data: ";StrHexize$(advData$)
        PRINT "\nNo. Discarded Adverts: ";nDiscarded
        PRINT "\nRSSI: ";nRssi
        rc=BleScanGetAdvReport(periphAddr$, advData$, nDiscarded, nRssi)
    ENDWHILE

    PRINT "\n\n --- No more adverts in cache"
ENDFUNC 1

ONEVENT EVBLE_SCAN_TIMEOUT CALL HndlrScanTO
ONEVENT EVBLE_ADV_REPORT   CALL HndlrAdvRpt
WAITEVENT
```


Expected Output:

```
Scanning

Peer Address: 01D8CFCF14498D
Advert Data: 0201061AFF4C000215E2C56DB5DFFB48D2B060D0F5A71096E012345678C4
No. Discarded Adverts: 0
RSSI: -97

Peer Address: 01D8CFCF14498D
Advert Data: 0201061AFF4C000215E2C56DB5DFFB48D2B060D0F5A71096E012345678C4
No. Discarded Adverts: 0
RSSI: -97

--- No more adverts in cache

Peer Address: 01D8CFCF14498D
Advert Data: 0201061AFF4C000215E2C56DB5DFFB48D2B060D0F5A71096E012345678C4
No. Discarded Adverts: 0
RSSI: -92

Peer Address: 01D8CFCF14498D
Advert Data: 0201061AFF4C000215E2C56DB5DFFB48D2B060D0F5A71096E012345678C4
No. Discarded Adverts: 0
RSSI: -92

--- No more adverts in cache
Scan timeout
```

5.6.8 BleScanGetAdvReportEx

When a scan is in progress after having called `BleScanStart()` for each advert report, the information is cached in a queue buffer and an `EVBLE_ADV_REPORT` event is thrown to the *smart*BASIC application.

This function is used by the *smart*BASIC application to extract it from the queue for further processing in the handler for the `EVBLE_ADV_REPORT` event.

The retrieved information consists of the address of the peripheral that sent the advert, the data payload, the number of adverts (all, not just from that peripheral) that have been discarded since the last time this function was called and the RSSI value for that packet, in addition to the advert type and the channel number on which the advert was received.

BLESCANGETADVREPORTEX (nAdvertType, periphAddr\$, advData\$, nDiscarded, nRssi, nChannel)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.		
Arguments:			
nAdvertType	byREF nAdvertType AS STRING		
	On return, this parameter will contain the type of the advert that was read. Possible values are as follows:-		
	0	ADV_IND	Invites connection requests
	1	ADV_DIRECT_IND	Invites connection from addressed device
	2	ADV_SCAN_IND	Invites scan request for more advert data
	3	ADV_NONCONN_IND	Does not accept connections/active scans
periphAddr\$	byREF periphAddr\$ AS STRING		
	On return, this parameter is updated with the address of the peripheral that sent the advert.		
advData\$	byREF advData \$ AS STRING		
	On return, this parameter is updated with the data payload of the advert which consists of multiple AD elements.		

<i>nDiscarded</i>	byREF nDiscarded AS INTEGER On return, this parameter is updated with the number of adverts that were discarded because there was no space in the internal queue.
<i>nRssi</i>	byREF nRssi AS INTEGER On return, this parameter is updated with the RSSI as reported by the stack for that advert. Note: This is NOT a value that is sent by the peripheral but a value that is calculated by the receiver in this module.
<i>nChannel</i>	byREF nChannel AS INTEGER On return, this parameter is set to the channel on which the advert has arrived. Valid values are 0, 1, or 2 corresponding to channels 37,38 and 39 respectively.

```
//Example :: BleScanGetAdvReportEx.sb
DIM rc

'//Scan for 5 seconds with no filtering
rc = BleScanStart(5000, 0)

IF rc==0 THEN
    PRINT "\nScanning"
ELSE
    PRINT "\nError: "; INTEGER.H'rc
ENDIF

'//This handler will be called when scanning times out
FUNCTION HndlrScanTO()
    PRINT "\nScan timeout"
ENDFUNC 0

'//This handler will be called when an advert is received
FUNCTION HndlrAdvRpt()
    DIM nAdvType, periphAddr$, advData$, nDiscarded, nRssi, nChannel

    '//Read all cached advert reports
    rc=BleScanGetAdvReportEx(nAdvType, periphAddr$, advData$, nDiscarded, nRssi, nChannel)
    WHILE (rc == 0)
        PRINT "\n\nAdvert Type: "; nAdvType
        PRINT "\nPeer Address: "; StrHexize$(periphAddr$)
        PRINT "\nAdvert Data: "; StrHexize$(advData$)
        PRINT "\nNo. Discarded Adverts: ";nDiscarded
        PRINT "\nRSSI: ";nRssi
        PRINT "\nChannel: ";nChannel
        rc=BleScanGetAdvReportEx(nAdvType, periphAddr$, advData$, nDiscarded, nRssi, nChannel)
    ENDWHILE

    PRINT "\n\n --- No more adverts in cache"
ENDFUNC 1

ONEVENT EVBLE_SCAN_TIMEOUT CALL HndlrScanTO
ONEVENT EVBLE_ADV_REPORT   CALL HndlrAdvRpt

WAITEVENT
```

Scanning

Advert Type: 2
Peer Address: 01CDBD40C5A79A
Advert Data: 0201061AFF4C000215E2C56DB5DFFB48D2B060D0F5A71096E012345678C40409526F6E

```
No. Discarded Adverts: 0
RSSI: -81
Channel: 1

--- No more adverts in cache
Scan timeout
00
```

5.6.9 BleGetADbyIndex

FUNCTION

This function is used to extract a copy of the *n*th (zero based) advertising data (AD) element from a string which is assumed to contain the data portion of an advert report, incoming or outgoing.

Note: If the last AD element is malformed then it is treated as not existing. For example, it is malformed if the length byte for that AD element suggests that more data bytes are required than actually exist in the report string.

BLEGETADBYINDEX (*nIndex*, *rptData\$*, *nADtag*, *ADval\$*)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
<i>nIndex</i>	byVAL <i>nIndex</i> AS INTEGER This is a zero-based index of the AD element that is copied into the output data parameter <i>ADval\$</i> .
<i>rptData\$</i>	byREF <i>rptData\$</i> AS STRING. This parameter is a string that contains concatenated AD elements which were either constructed for an outgoing advert or were received in a scan.
<i>nADtag</i>	byREF <i>nADtag</i> AS INTEGER When the <i>n</i> th index is found, the single byte tag value for that AD element is returned in this parameter.
<i>ADval\$</i>	byREF <i>ADval\$</i> AS STRING When the <i>n</i> th index is found, the data excluding single byte the tag value for that AD element is returned in this parameter.

Example:

```
// Example :: BleGetADbyIndex.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc, ad1$, ad2$, fullAD$, nADtag, ADval$

'//AD with length = 6 bytes, tag = 0xDD
ad1$="\06\DD\11\22\33\44\55"

'//AD with length = 7 bytes, tag = 0xDA
ad2$="\07\EE\AA\BB\CC\DD\EE\FF"

fullAD$ = ad1$ + ad2$

PRINT "\n\n"; Strhexize$(fullAD$); "\n"
```

```
rc=BleGetADbyIndex(0, fullAD$ , nADTag, ADval$ )
IF rc==0 THEN
    PRINT "\nFirst AD element with tag 0x"; INTEGER.H'nADTag ;" is ";StrHexize$(ADval$)
ELSE
    PRINT "\nError reading AD: " ;INTEGER.H'rc
ENDIF

rc=BleGetADbyIndex(1, fullAD$ , nADTag, ADval$)
IF rc==0 THEN
    PRINT "\nSecond AD element with tag 0x"; INTEGER.H'nADTag ;" is ";StrHexize$(ADval$)
ELSE
    PRINT "\nError reading AD: "; INTEGER.H'rc
ENDIF

'//Will fail because there are only 2 AD elements
rc=BleGetADbyIndex(2, fullAD$ , nADTag, ADval$)
IF rc==0 THEN
    PRINT "\nThird AD element with tag 0x"; INTEGER.H'nADTag ;" is ";StrHexize$(ADval$)
ELSE
    PRINT "\nError reading AD: "; INTEGER.H'rc
ENDIF
```

Expected Output:

06DD112233445507EEAABBCCDDEEFF

First AD element with tag 0x000000DD is 1122334455
Second AD element with tag 0x000000EE is AABBCCDDEEFF
Error reading AD: 00006060

5.6.10 BleGetADbyTag

FUNCTION

This function is used to extract a copy of the first advertising data (AD) element that has the tag byte specified from a string which is assumed to contain the data portion of an advert report, incoming or outgoing. If multiple instances of that AD tag type are suspected, then use the function BleGetADbyIndex to extract.

Note: If the last AD element is malformed, then it is treated as nonexistent. For example, it is malformed if the length byte for that AD element suggests that more data bytes are required than actually exist in the report string.

BLEGETADBYTAG (rptData\$, nADtag, ADval\$)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
rptData\$	byREF rptData\$ AS STRING. This parameter is a string that contains concatenated AD elements which were either constructed for an outgoing advert or were received in a scan.
nADtag	byVAL nADtag AS INTEGER This parameter specifies the single byte tag value for the AD element that is to returned in the ADval\$ parameter. Only the first instance can be catered for. If multiple instances are suspected, then use BleAdvADbyIndex() to extract it.
ADval\$	byREF ADval\$ AS STRING When the nth index is found, the data excluding single byte the tag value for that AT element is returned in this parameter.

Example:

```
// Example :: BleGetADbyTag.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc, ad1$, ad2$, fullAD$, nADtag, ADval$

'//AD with length = 6 bytes, tag = 0xDD
ad1$="\06\DD\11\22\33\44\55"

'//AD with length = 7 bytes, tag = 0xDA
ad2$="\07\EE\AA\BB\CC\DD\EE\FF"

fullAD$ = ad1$ + ad2$
PRINT "\n\n"; Strhexize$(fullAD$);"\n"

nADtag = 0xDD
rc=BleGetADbyTag(fullAD$ , nADtag, ADval$ )
IF rc=0 THEN
    PRINT "\nAD element with tag 0x"; INTEGER.H'nADtag ;" is ";StrHexize$(ADval$)
```

```
ELSE
    PRINT "\nError reading AD: " ; INTEGER.H'rc
ENDIF

nADTag = 0xEE
rc=BleGetADbyTag(fullAD$ , nADTag, ADval$)
IF rc==0 THEN
    PRINT "\nAD element with tag 0x"; INTEGER.H'nADTag ;" is ";StrHexize$(ADval$)
ELSE
    PRINT "\nError reading AD: "; INTEGER.H'rc
ENDIF

nADTAG = 0xFF
'//Will fail because no AD exists in 'fullAD$' with the tag 'FF'
rc=BleGetADbyTag(fullAD$ , nADTag, ADval$)
IF rc==0 THEN
    PRINT "\nAD element with tag 0x"; INTEGER.H'nADTag ;" is ";StrHexize$(ADval$)
ELSE
    PRINT "\nError reading AD: "; INTEGER.H'rc
ENDIF
```

Expected Output:

```
06DD112233445507EEAABBCCDDEEFF
AD element with tag 0x000000DD is 1122334455
AD element with tag 0x000000EE is AABBCCDDEEFF
Error reading AD: 00006060
```

5.6.11 BleScanGetPagerAddr

FUNCTION

When a scan is in progress after calling BleScanStart(), an EVBLE_FAST_PAGED event is thrown whenever an ADV_DIRECT_IND advert is received with the address of this module, requesting a connection to it.

This function returns the address of the peripheral requesting a connection and the RSSI. It should be used in the handler of the EVBLE_FAST_PAGED event to get the peripheral's address. Scanning should then be stopped using either BleScanAbort() or BleScanStop(). You can then use the address supplied by this function to connect to the peripheral using BleConnect() if that is the desired use case. The Bluetooth specification does NOT mandate a connection.

BLESCANGETPAGERADDR (periphAddr\$, nRssi)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
periphAddr\$	byREF periphAddr\$ AS STRING On return, this parameter is updated with the address of the peripheral that sent the advert.
nRssi	byREF nRssi AS INTEGER On return, this parameter is updated with the RSSI as reported by the stack for that advert. Note: This is NOT a value that is sent by the peripheral but a value that is calculated by the receiver in this module.

Example:

```
// Example :: BleScanGetPagerAddr.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc

'//Scan for 20 seconds with no filtering
rc = BleScanStart(10000, 0)

IF rc==0 THEN
    PRINT "\nScanning"
ELSE
    PRINT "\nError: "; INTEGER.H'rc
ENDIF

'//This handler will be called when scanning times out
FUNCTION HndlrScanTO()
    PRINT "\nScan timeout"
ENDFUNC 0

'//This handler will be called when an advert is received requesting a connection to this
```

```

module
FUNCTION HndlrFastPaged()
    DIM periphAddr$, nRssi
    rc = BleScanGetPagerAddr(periphAddr$, nRssi)
    PRINT "\nAdvert received from peripheral "; StrHexize$(periphAddr$); " with RSSI
";nRssi
    PRINT "\nrequesting a connection to this module"
    rc = BleScanStop()
ENDFUNC 0

ONEVENT EVBLE_SCAN_TIMEOUT CALL HndlrScanTO
ONEVENT EVBLE_FAST_PAGED   CALL HndlrFastPaged

WAITEVENT

```

Expected Output:

```

Scanning
Advert received from peripheral 01D8CFCF14498D with RSSI -96
requesting a connection to this module

```

5.7 Connection Functions

This section describes all the connection manager-related routines.

The Bluetooth specification stipulates that a peripheral cannot initiate a connection but can perform disconnections. Only Central Role devices are allowed to connect when an appropriate advertising packet is received from a peripheral.

5.7.1 Events and Messages

See also [Events and Messages](#) for BLE-related messages that are thrown to the application when there is a connection or disconnection. The relevant message IDs are (0), (1), (14), (15), (16), (17), (18) and (20):

MsgId	Description
0	There is a connection and the context parameter contains the connection handle.
1	There is a disconnection and the context parameter contains the connection handle.
14	New connection parameters for connection associated with connection handle.
15	Request for new connection parameters failed for connection handle supplied.
16	The connection is to a bonded master
17	The bonding has been updated with a new long term key
18	The connection is encrypted
20	The connection is no longer encrypted

5.7.2 BleConnect

FUNCTION

This function is used to make a connection to a device in peripheral mode which is actively advertising.

Note: The peripheral device **MUST** be advertising with either ADV_IND or ADV_DIRECT_IND type of advert to be able to successfully connect.

In the case of multiple connections, it is recommended that this function is not called in quick succession so that the underlying stack is given time to complete the setup of the new connection before moving on to establish a new connection. Calling this function in quick succession may cause newly established connections to be dropped.

In order to perform connections over CODED PHY (long range), BleConnectConfig() should be called beforehand to set the connection PHYs to CODED PHY and enable extended connection. See [BleConnectConfig\(\)](#) for more details. Furthermore, high bandwidth should be enabled using "AT+CFG 214 1" followed by "ATZ".

When the connection is complete, a EVBLEMSG message with msgId = 0 and context containing the handle are thrown to the *smart*BASIC runtime engine.

If the connection times out, then the event EVBLE_CONN_TIMEOUT is thrown to the *smart*BASIC application.

When a connection is attempted, there are other parameters that are used and the default values for those are assumed; for example, scan window, scan interval, and periodicity. The default values for those can be changed using the BleConnectConfig() function. At any time, the current settings can be obtained via the SYSINFO() command.

BLECONNECT (periphAddr\$, connTimeoutMs, minConnIntUs, maxConnIntUs, nSuprToutUs)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
periphAddr\$	byRef periphAddr\$ AS STRING The Bluetooth address of the device to connect to which MUST be properly formatted and is exactly seven bytes long.
connTimeoutMs	byVal connTimeoutMs AS INTEGER. The length of time in milliseconds that the connection attempt lasts. If the timer times out then the event EVBLE_CONN_TIMEOUT is thrown to the <i>smart</i> BASIC application.
minConnIntUs	byVal minConnIntUs AS INTEGER. The minimum connection interval in microseconds. Valid range is between 7500 and 4000000 microseconds.
maxConnIntUs	byVal maxConnIntUs AS INTEGER. The maximum connection interval in microseconds. Valid range is between 7500 and 4000000 microseconds
nSuprToutUs	byVal nSuprToutUs AS INTEGER. The link supervision timeout for the connection in microseconds.

Example:

```
// Example :: BleConnect.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc, periphAddr$
```

```
'//Scan indefinitely
rc=BleScanStart(0, 0)

IF rc==0 THEN
    PRINT "\nScanning"
ELSE
    PRINT "\nError: "; INTEGER.H'rc
ENDIF

'//This handler will be called when an advert is received
FUNCTION HndlrAdvRpt()
    DIM advData$, nDiscarded, nRssi

    '//Read an advert report and connect to the sender
    rc=BleScanGetAdvReport(periphAddr$, advData$, nDiscarded, nRssi)
    rc=BleScanStop()

    '//Connect to device with Bluetooth address obtained above with 5s connection timeout,
    '//20ms min connection interval, 75 max, 5 second supervision timeout.
    rc=BleConnect(periphAddr$, 5000, 20000, 75000, 5000000)
    IF rc==0 THEN
        PRINT "\n--- Connecting"
    ELSE
        PRINT "\nError: "; INTEGER.H'rc
    ENDIF
ENDFUNC 1

'//This handler will be called in the event of a connection timeout
FUNCTION HndlrConnTO()
    PRINT "\n--- Connection timeout"
    rc=BleScanStart(0, 0)
ENDFUNC 1

'//This handler will be called when there is a BLE message
FUNCTION HndlrBleMsg(nMsgId, nCtx)
    IF nMsgId == 0 THEN
        PRINT "\n--- Connected to device with Bluetooth address "; StrHexize$(periphAddr$)
        PRINT "\n--- Disconnecting now"
        rc=BleDisconnect(nCtx)
    ENDIF
ENDFUNC
```

```

ENDIF
ENDFUNC 1

'//This handler will be called when a disconnection happens
FUNCTION HndlrDiscon(nCtx, nRsn)
ENDFUNC 0

ONEVENT EVBLEMSG          CALL HndlrBleMsg
ONEVENT EVDISCON          CALL HndlrDiscon
ONEVENT EVBLE_ADV_REPORT  CALL HndlrAdvRpt
ONEVENT EVBLE_CONN_TIMEOUT CALL HndlrConnTO

WAITEVENT

```

Expected Output:

```

Scanning
--- Connecting
--- Connected to device with Bluetooth address 01D8CFCF14498D
--- Disconnecting now

```

5.7.3 BleConnectExtended

See description in section “Extended Adverts Functions” [here](#).

5.7.4 BleConnectCancel

FUNCTION

This function is used to cancel an ongoing connection attempt which has not timed out. It takes no parameters as there can only be one attempt in progress.

Use the value returned by SYSINFO(2016) to determine if there is an ongoing scan operation in progress. The value is a bit mask where:

- **bit 0** is set if advertising is in progress
- **bit 1** is set if there is already a connection in a peripheral role
- **bit 2** is set if there is a current ongoing connection attempt
- **bit 3** is set when scanning
- **bit 4** is set if there is already a connection to a peripheral

BLECONNECTCANCEL ()

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments	None

Example:

```

// Example :: BleConnectCancel.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc, periphAddr$

```

```
    '//Scan indefinitely
rc=BleScanStart(0, 0)

IF rc==0 THEN
    PRINT "\nScanning"
ELSE
    PRINT "\nError: "; INTEGER.H'rc
ENDIF

'//This handler will be called when an advert is received
FUNCTION HndlrAdvRpt()
    DIM advData$, nDiscarded, nRssi

    '//Read an advert report and connect to the sender
    rc=BleScanGetAdvReport(periphAddr$, advData$, nDiscarded, nRssi)
    rc=BleScanStop()

    '//Wait until module stops scanning
    WHILE SysInfo(2016)==8
    ENDWHILE

    '//Connect to device with Bluetooth address obtained above with 5s connection timeout,
    '//20ms min connection interval, 75 max, 5 second supervision timeout.
    rc=BleConnect(periphAddr$, 5000, 20000, 75000, 5000000)
    IF rc==0 THEN
        PRINT "\n--- Connecting \nCancel"
    ELSE
        PRINT "\nError: "; INTEGER.H'rc
    ENDIF

    '//Cancel current connection attempt
    rc=BleConnectCancel()

    PRINT "\n--- Connection attempt cancelled"
ENDFUNC 0

ONEVENT EVBLE_ADV_REPORT    CALL HndlrAdvRpt
WAITEVENT
```

Expected Output:

```
Scanning
--- Connecting
Cancel
--- Connection attempt cancelled
```

5.7.5 BleConnectConfig

FUNCTION

This function is used to modify the default parameters that are used when attempting a connection using `BleConnect()`. At any time they can be read by adding the `configID` to 2100 and then passing that value to `SYSINFO()`.

When connecting, the central device must scan for adverts and then, when the particular peer address is encountered, it can send the connection message to that peripheral.

Therefore, a connection attempt requires the underlying stack API to be supplied with a scan interval and scan window. In addition, when multiple connections are in place, the radio has to be shared as efficiently as possible; one potential scheme is to have all connection parameters being integer multiples of a 'base' value. For the purpose of this documentation, this parameter is referred to as *multi-link connection interval periodicity*.

The following are the default settings for these parameters:

Multi-link Connection Interval Periodicity	20 milliseconds
Scan Interval	80 milliseconds
Scan Window	40 milliseconds
Slave Latency	0

Notes: The Scan Window and Interval are multiple integers of the periodicity (although not required to be). The scanning has a 50% duty cycle. The 50% duty cycle attempts to ensure that connection events for existing connections are missed as infrequently as possible.

The Scan Window and Interval are internally stored in units of 0.625 milliseconds slots so reading back via `SYSINFO()` does not accurately return the value you set.

BLECONNECTCONFIG (`configID`, `configValue`)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.

Arguments:

configID	byVal configID AS INTEGER.	
	The following are the values to update:	
	0	Scan interval in milliseconds (range 0..10240)
	1	Scan Window in milliseconds (range 0..10240)
	2	Slave Latency (0..1000)
	5	Multi-Link Connection Interval Periodicity (20..200)
	8	Turn manual control for connection parameter update. See EvConnParamReq for more details.
	9	Action to take when a PHY change request is received from remote device as follows:- 0: Automatically accept incoming PHY change request from remote device. This is the default operation. 1: Throw an event to the smartBASIC app to allow the user to accept or reject incoming PHY change request. The event thrown is <code>EVBLE_PHY_REQUEST</code> . See LE 2M PHY for more information.

	10	BLE PHY to perform the connection on. Possible values are:- 1 - 1MPHY 4 - CODED PHY All other values are invalid
	11	Extended Connection. Possible values are:- 0 - Connect to device sending out legacy adverts 1 - Connect to device sending out legacy or extended adverts
	For all other configID values, the function returns an error.	
configValue	byVal configValue AS INTEGER. This contains the new value to set in the parameters indentified by configID.	

Example:

```
// Example :: BleConnectConfig.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc, startTick

SUB GetParms ()
    //get default scan interval for connecting
    PRINT "\nConn Scan Interval: "; SysInfo(2100); "ms"
    //get default scan window for connecting
    PRINT "\nConn Scan Window: "; SysInfo(2101); "ms"
    //get default slave latency for connecting
    PRINT "\nConn slave latency: "; SysInfo(2102)
    //get current multi-link connection interval periodicity
    PRINT "\nML Conn Interval Periodicity: "; SysInfo(2105); "ms"
ENDSUB

PRINT "\n\n--- Current Parameters:"
GetParms ()

PRINT "\n\nSetting new parameters..."
rc = BleConnectConfig(0, 60)           //set scan interval to 60
rc = BleConnectConfig(1, 13)           //set scan window to 13 (will round to 12)
rc = BleConnectConfig(2, 3)            //set slave latency to 1
rc = BleConnectConfig(5, 30)           //set ML connection interval periodicity to 30
PRINT "\n"; integer.h'rc

PRINT "\n\n--- New Parameters:"
GetParms ()
```

Expected Output:

```
--- Current Parameters:
Conn Scan Interval: 80ms
Conn Scan Window: 40ms
Conn slave latency: 0
ML Conn Interval Periodicity: 20ms

Setting new parameters...

--- New Parameters:
Conn Scan Interval: 60ms
Conn Scan Window: 12ms
Conn slave latency: 3
ML Conn Interval Periodicity: 30ms
```

5.7.6 BleDisconnect

FUNCTION

This function causes an existing connection identified by a handle to be disconnected from the peer.

When the disconnection is complete, a EVBLEMSG message with msgId = 1 and context containing the handle is thrown to the *smart*BASIC runtime engine.

BLEDISCONNECT (nConnHandle)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation
Arguments:	
nConnHandle	byVal nConnHandle AS INTEGER. Specifies the handle of the connection that must be disconnected.

Example:

```
// Example :: BleDisconnect.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM addr$ : addr$=""
DIM rc

FUNCTION HndlrBleMsg (BYVAL nMsgId AS INTEGER, BYVAL nCtx AS INTEGER)
    SELECT nMsgId
        CASE 0
            PRINT "\nNew Connection ";nCtx
            rc = BleAuthenticate(nCtx)
            PRINT BleDisconnect(nCtx)
        CASE 1
            PRINT "\nDisconnected ";nCtx;"\n"
            EXITFUNC 0
    ENDSELECT
ENDFUNC 1
```

```
ONEVENT  EVBLEMSG          CALL HndlrBleMsg

IF BleAdvertStart(0,addr$,100,30000,0)==0 THEN
    PRINT "\nAdverts Started\n"
ELSE
    PRINT "\n\nAdvertisement not successful"
ENDIF

WAITEVENT
```

Expected Output:

```
Adverts Started

New Connection 35800
Disconnected 3580
```

5.7.7 BleSetCurConnParms

FUNCTION

This function triggers an existing connection identified by a handle to have new connection parameters. For example: interval, slave latency, and link supervision timeout.

When the request is complete, a EVBLEMSG message with msgId = 14 and context containing the handle are thrown to the *smart*BASIC runtime engine if it is successful. If the request to change the connection parameters fails, an EVBLEMSG message with msgId = 15 is thrown to the *smart*BASIC runtime engine.

BLESETCURCONNPARGS (*nConnHandle*, *nMinIntUs*, *nMaxIntUs*, *nSuprToutUs*, *nSlaveLatency*)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
<i>nConnHandle</i>	byVal nConnHandle AS INTEGER. Specifies the handle of the connection that must have the connection parameters changed.
<i>nMinIntUs</i>	byVal nMinIntUs AS INTEGER. The minimum acceptable connection interval in microseconds.
<i>nMaxIntUs</i>	byVal nMaxIntUs AS INTEGER. The maximum acceptable connection interval in microseconds.
<i>nSuprToutUs</i>	byVal nSuprToutUs AS INTEGER. The link supervision timeout for the connection in microseconds. It should be greater than the slave latency times that granted the connection interval.
<i>nSlaveLatency</i>	byVal nSlaveLatency AS INTEGER. The number of connection interval polls that the peripheral may ignore. This times the connection interval shall not be greater than the link supervision timeout.

Note: Slave latency is a mechanism that reduces power usage in a peripheral device and maintains short latency. Generally, a slave reduces power usage by setting the largest connection interval possible. This means the latency is equivalent to that connection interval. To mitigate this, the peripheral can greatly reduce the connection interval and then have a non-zero slave latency.

For example, a keyboard could set the connection interval to 1000 msec and slave latency to 0. In this case, key presses are reported to the central device once per second, a poor user experience. Instead, the connection interval can be set to 50 msec, for example, and slave latency to 19. If there are no key presses, the power use is the same as before because $((19+1) * 50)$ equals 1000. When a key is pressed, the peripheral knows that the central device will poll within 50 msec, so it can send that keypress with a latency of 50 msec. A connection interval of 50 and slave latency of 19 means the slave is allowed to NOT acknowledge a poll for up to 19 poll messages from the central device.

Example:

```
// Example :: BleSetCurConnParams.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc
DIM addr$ : addr$=""

FUNCTION HandlerBleMsg (BYVAL nMsgId AS INTEGER, BYVAL nCtx AS INTEGER) AS INTEGER
    DIM intrvl, sprvTo, slat

    SELECT nMsgId
        CASE 0 //BLE_EVBLEMSGID_CONNECT
            PRINT "\n --- New Connection : ", nCtx
            rc=BleGetCurconnParams (nCtx, intrvl, sprvto, slat)
            IF rc==0 THEN
                PRINT "\nConn Interval", "", intrvl
                PRINT "\nConn Supervision Timeout", sprvto
                PRINT "\nConn Slave Latency", "", slat
                PRINT "\n\nRequest new parameters"
                //request connection interval in range 50ms to 75ms and link
                //supervision timeout of 4seconds with a slave latency of 19
                rc = BleSetCurconnParams (nCtx, 50000, 75000, 4000000, 19)
            ENDIF
        CASE 1 //BLE_EVBLEMSGID_DISCONNECT
            PRINT "\n --- Disconnected : ", nCtx
            EXITFUNC 0
        CASE 14 //BLE_EVBLEMSGID_CONN_PARAMS_UPDATE
            rc=BleGetCurconnParams (nCtx, intrvl, sprvto, slat)
            IF rc==0 THEN
                PRINT "\n\nConn Interval", intrvl
                PRINT "\nConn Supervision Timeout", sprvto
                PRINT "\nConn Slave Latency", slat
            ENDIF
    END SELECT
END FUNCTION
```

```
CASE 15 //BLE_EVBLEMSGID_CONN_PARMS_UPDATE_FAIL
    PRINT "\n ??? Conn Parm Negotiation FAILED"
CASE ELSE
    PRINT "\nBle Msg",nMsgId
ENDSELECT
ENDFUNC 1

ONEVENT EVBLEMSG    CALL HandlerBleMsg

IF BleAdvertStart(0,addr$,25,60000,0)==0 THEN
    PRINT "\nAdverts Started\n"
    PRINT "\nMake a connection to the BL654"
ELSE
    PRINT "\n\nAdvertisement not successful"
ENDIF

WAITEVENT
```

Expected Output (Unsuccessful Negotiation):

```
Adverts Started

Make a connection to the BL654
--- New Connection : 1352
Conn Interval                7500
Conn Supervision Timeout    7000000
Conn Slave Latency          0

Request new parameters
??? Conn Parm Negotiation FAILED
--- Disconnected : 1352
```

Expected Output (Successful Negotiation):

```
Adverts Started

Make a connection to the BL654
--- New Connection : 134
Conn Interval                30000
Conn Supervision Timeout    720000
Conn Slave Latency          0

Request new parameters

New conn Interval            75000
New conn Supervision Timeout 4000000
New conn Slave Latency       19
--- Disconnected : 134
```

Note: The first set of parameters differ depending on your central device.

5.7.8 BleGetCurConnParms

FUNCTION

This function gets the current connection parameters for the connection identified by the connection handle. Given there are 3 connection parameters, the function takes three variables by reference so that the function can return the values in those variables.

BLEGETCURCONNPAMS (*nConnHandle*, *nIntervalUs*, *nSuprToutUs*, *nSlaveLatency*)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
<i>nConnHandle</i>	byVal <i>nConnHandle</i> AS INTEGER. Specifies the handle of the connection to read the connection parameters of
<i>nIntervalUs</i>	byRef <i>nIntervalUs</i> AS INTEGER. The current connection interval in microseconds
<i>nSuprToutUs</i>	byRef <i>nSuprToutUs</i> AS INTEGER. The current link supervision timeout in microseconds for the connection.
<i>nSlaveLatency</i>	byRef <i>nSlaveLatency</i> AS INTEGER. The current number of connection interval polls that the peripheral may ignore. This value multiplied by the connection interval will not be greater than the link supervision timeout. Note: See Note on Slave Latency .

See previous example.

5.7.9 BleConnMgrUpdCfg

FUNCTION

This function is used to initialise the connection manager for slave/peripheral role.

BLECONNMGRRUPDCFG (*nConnUpdateFirstDelay*, *nConnUpdateNextDelay*, *nConnUpdateMaxRetry*)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
<i>nConnUpdateFirstDelay</i>	byVal <i>nConnUpdateFirstDelay</i> AS INTEGER. In milliseconds 100 to 32000
<i>nConnUpdateNextDelay</i>	BYVAL <i>nConnUpdateNextDelay</i> AS INTEGER In milliseconds 100 to 32000
<i>nConnUpdateMaxRetry</i>	BYVAL <i>nConnUpdateMaxRetry</i> AS INTEGER In number of retries

Example:

```
dim rc
#define CONN_UPD_FIRST_DELAY 500
#define CONN_UPD_NEXT_DELAY 800
#define CONN_UPD_MAX_RETRY 800

rc=BleConnMgrUpdCfg(CONN_UPD_FIRST_DELAY, CONN_UPD_NEXT_DELAY, CONN_UPD_MAX_RETRY)
```

```
if rc == 0 then
    print "\nConnection manager successfully initialised"
else
    print "\nError: ";integer.h'rc
endif
```

Expected Output:

```
Connection manager successfully initialised
```

5.7.10 BleGetConnHandleFromAddr

FUNCTION

This function is used to get the connection handle from a specified Bluetooth address.

BLEGETCONNHANDLEFROMADDR (BtAddrBE\$, nConnHandle)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
BtAddrBE\$	byRef BtAddrBE\$ AS STRING. The Bluetooth address of the connected remote device.
nConnHandle	byRef nConnHandle AS INTEGER. Returned connection handle.

Example:

```
// Example :: BleGetConnHandleFromAddr.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc, periphAddr$

'//Scan indefinitely
rc=BleScanStart(0, 0)

IF rc==0 THEN
    PRINT "\nScanning"
ELSE
    PRINT "\nError: "; INTEGER.H'rc
ENDIF

'//This handler will be called when an advert is received
FUNCTION HndlrAdvRpt()
    DIM advData$, nDiscarded, nRssi

    '//Read an advert report and connect to the sender
    rc=BleScanGetAdvReport(periphAddr$, advData$, nDiscarded, nRssi)
    rc=BleScanStop()
```

```
    '//Connect to device with MAC address obtained above with 5s connection timeout,  
    '//20ms min connection interval, 75 max, 5 second supervision timeout.  
    rc=BleConnect(periphAddr$, 5000, 20000, 75000, 5000000)  
    IF rc==0 THEN  
        PRINT "\n--- Connecting"  
    ELSE  
        PRINT "\nError: "; INTEGER.H'rc  
    ENDIF  
ENDFUNC 1  
  
    '//This handler will be called in the event of a connection timeout  
FUNCTION HndlrConnTO()  
    PRINT "\n--- Connection timeout"  
    rc=BleScanStart(0, 0)  
ENDFUNC 1  
  
    '//This handler will be called when there is a BLE message  
FUNCTION HndlrBleMsg(nMsgId, nCtx)  
    IF nMsgId == 0 THEN  
        dim h  
        rc=BleGetConnHandleFromAddr(periphAddr$, h)  
        PRINT "\n--- Connected to device with MAC address "; StrHexize$(periphAddr$);"  
Handle: ";h  
        PRINT "\n--- Disconnecting now"  
        rc=BleDisconnect(nCtx)  
    ENDIF  
ENDFUNC 1  
  
    '//This handler will be called when a disconnection happens  
FUNCTION HndlrDiscon(nCtx, nRsn)  
ENDFUNC 0  
  
ONEVENT EVBLEMSG          CALL HndlrBleMsg  
ONEVENT EVDISCON          CALL HndlrDiscon  
ONEVENT EVBLE_ADV_REPORT  CALL HndlrAdvRpt  
ONEVENT EVBLE_CONN_TIMEOUT CALL HndlrConnTO  
  
WAITEVENT
```

Expected Output:

```
Scanning  
--- Connecting  
--- Connected to device with MAC address 000016A4093A64 Handle: 261888  
--- Disconnecting now  
00
```

5.7.11 BleGetAddrFromConnHandle

FUNCTION

This function is used to get the Bluetooth address of a device from a connection handle.

BLEGETADDRFROMCONNHANDLE (nConnHandle, BtAddrBE\$)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
nConnHandle	byRef nConnHandle AS INTEGER. Connection handle from which to get Bluetooth address
BtAddrBE\$	byRef BtAddrBE\$ AS STRING. Returned Bluetooth address.

Example:

```
// Example :: BleGetAddrFromConnHandle.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc, periphAddr$

'//Scan indefinitely
rc=BleScanStart(0, 0)

IF rc==0 THEN
    PRINT "\nScanning"
ELSE
    PRINT "\nError: "; INTEGER.H'rc
ENDIF

'//This handler will be called when an advert is received
FUNCTION HndlrAdvRpt()
    DIM advData$, nDiscarded, nRssi

    '//Read an advert report and connect to the sender
    rc=BleScanGetAdvReport(periphAddr$, advData$, nDiscarded, nRssi)
    rc=BleScanStop()

    '//Connect to device with MAC address obtained above with 5s connection timeout,
    '//20ms min connection interval, 75 max, 5 second supervision timeout.
    rc=BleConnect(periphAddr$, 5000, 20000, 75000, 5000000)
    IF rc==0 THEN
        PRINT "\n--- Connecting"
    ELSE
        PRINT "\nError: "; INTEGER.H'rc
    ENDIF
ENDFUNCTION
```

```
ENDIF
ENDFUNC 1

'//This handler will be called in the event of a connection timeout
FUNCTION HndlrConnTO()
    PRINT "\n--- Connection timeout"
    rc=BleScanStart(0, 0)
ENDFUNC 1

'//This handler will be called when there is a BLE message
FUNCTION HndlrBleMsg(nMsgId, nCtx)
    IF nMsgId == 0 THEN
        dim addr$
        rc=BleGetAddrFromConnHandle(nCtx, addr$)
        PRINT "\n--- Connected to device with MAC address "; StrHexize$(addr$)
        PRINT "\n--- Disconnecting now"
        rc=BleDisconnect(nCtx)
    ENDIF
ENDFUNC 1

'//This handler will be called when a disconnection happens
FUNCTION HndlrDiscon(nCtx, nRsn)
ENDFUNC 0

ONEVENT EVBLEMSG          CALL HndlrBleMsg
ONEVENT EVDISCON          CALL HndlrDiscon
ONEVENT EVBLE_ADV_REPORT  CALL HndlrAdvRpt
ONEVENT EVBLE_CONN_TIMEOUT CALL HndlrConnTO

WAITEVENT
```

Expected Output:

```
Scanning
--- Connecting
--- Connected to device with MAC address 000016A4093A64
--- Disconnecting now
00
```

5.7.12 BleConnRssiStart

FUNCTION

This function is used to enable RSSI reporting for a particular connection. Given an RSSI value is generated for every connection event, this can result in a flood of events which will result in increased power consumption as the CPU will need to be in active mode for longer to process them. To mitigate this, this function also takes a threshold dBm value and a skipcount to reduce and manage these events.

The threshold dBm parameter ensures that a report is only generated if the change in detected RSSI value is greater or less than the most reported value by this amount and the skipcount is how many times this condition has to occur for the event to be thrown to the application.

BLECONNRSSISTART (nConnHandle, nThresholdDbm, nSkipCount)

Returns	INTEGER, a result code. Typical value: 0x0000 (indicates a successful operation)
Arguments	
nConnHandle	byVal nConnHandle AS INTEGER. Specifies the handle of the connection for which rssi reporting is to be enabled
nThresholdDbm	byVal nThresholdDbm AS INTEGER. The minimum change in dBm before triggering the EVCONNRSSI event
nSkipCount	byRef nSkipCount AS INTEGER. The number of RSSI samples with a change of nThresholdDbm or more before triggering the EVCONNRSSI event

Example:

```
// Example :: BleConnRssiStart.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc, conHndl
DIM addr$ : addr$=""

//=====
// Initialise
//=====

FUNCTION OnStartup()
    rc=BleAdvertStart(0, addr$, 50, 0, 0)
ENDFUNC rc

//=====
// Ble event handler
//=====

FUNCTION HndlrBleMsg(BYVAL nMsgId, BYVAL nCtx)
    conHndl=nCtx
    IF nMsgID==1 THEN
        PRINT "\n\n--- Disconnected from client"
        EXITFUNC 0
    ELSEIF nMsgID==0 THEN
```



```

        PRINT "\n--- Connected to client"
        rc=BleConnRssiStart(conHndl,4,10)
    ENDIF
ENDFUNC 1
//=====
// Connection related RSSI events
//=====
FUNCTION HndlrConnRssi(BYVAL charHandle, BYVAL rssi) AS INTEGER
    PRINT "\nRSSI=";rssi;" for connection "; integer.h' charHandle
    IF rssi < -80 then
        //too far away so stop monitoring the rssi (this is just an example)
        //in reality use some other reason to stop
        rc=BleConnRssiStop(conHndl)
    ENDIF
ENDFUNC 1
//=====
//=====
ONEVENT EVBLEMSG      CALL HndlrBleMsg
ONEVENT EVCONNRSSI    CALL HndlrConnRssi

IF OnStartup() !=0 THEN
    PRINT "\nFailure OnStartup"
ENDIF

//Wait for events
WAITEVENT

```

5.7.13 BleConnRssiStop

FUNCTION

This function is used to disable RSSI reporting for a particular connection which was enabled using the function BleConnRssiStart described above.

On disconnection, reporting will automatically stop.

BLECONNRSSISTOP (nConnHandle)

Returns	INTEGER, a result code. Typical value: 0x0000 (indicates a successful operation)
Arguments	
nConnHandle	byVal nConnHandle AS INTEGER. Specifies the handle of the connection for which rssi reporting is to be enabled

For example, see description of BleConnRssiStart() above.

5.8 Whitelist Management Functions

This section describes routines which are used to manage whitelists.

A whitelist is a list of Bluetooth addresses and Identity Resolving Keys (IRKs) which the baseband radio will use to gate incoming packets upwards to the stack as they are received.

If the whitelist is active, then any radio packet whose source Bluetooth address is not in the list will be rejected. However, note that in BLE for privacy reasons, resolvable Bluetooth addresses can be used and so the address will not match with one in the list and so for that type of address the list of Identity Resolving Keys in the whitelist is also consulted to see if the resolvable address is a trusted device.

A trusted device by definition will have supplied its IRK key when the pairing and bonding happened in the past.

Hence treat this group of functions as a means of creating, maintaining and destroying that list of addresses and IRKs.

The operation that enables whitelisting is the function that starts advertising, scanning. And extended connection So refer to the functions [BleAdvertStart\(\)](#), [BleScanStart\(\)](#) and [BleConnectExtended\(\)](#)

5.8.1 BleWhitelistCreate

FUNCTION

This function is used to create a new whitelist to which addresses and identity resolving keys can be added using [BleWhitelistAddAddr\(\)](#) or [BleWhitelistAddIndex\(\)](#).

BLEWHITELISTCREATE (*hWlist*, *nMaxAddrs*, *nMaxIrks*, *nPktFilterMask*)

Returns	INTEGER, a result code. Typical value: 0x0000 indicates a successful operation 0x605E indicates too many whitelists already created.
Arguments	
<i>hWlist</i>	byRef <i>hWlist</i> AS INTEGER. If an empty whitelist is successfully created then this will be updated with a valid handle. If not then this will contain -1 (0xFFFFFFFF)
<i>nMaxAddrs</i>	byVal <i>nMaxAddrs</i> AS INTEGER. Maximum addresses that will be stored in this whitelist
<i>nMaxIrks</i>	byVal <i>nMaxIrks</i> AS INTEGER. Maximum Identity Resolving Keys (IRKs) that will be stored in this whitelist
<i>nPktFilterMask</i>	byVal <i>nPktFilterMask</i> AS INTEGER. This is a bit mask which specifies what type of incoming packets this list will apply to, as follows: ▪ Bit 0 : Set to 1 for Scan Request packets ▪ Bit 1 : Set to 1 for Connection Request packets ▪ Bit 2 : Set to 1 for Advert Report Packets ▪ Bits 3 to 31 : reserved for future use Note: If all bits are 0, then a default mask of 7 is used for the BL654.

Example:

```
// Example :: BleWhitelist.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc,conHndl,hWlist, val
DIM addr$ : addr$=""

//=====
//=====

sub AssertRC (byval tag as integer)
    if rc!=0 then
        print "\nFailed with ";integer.h' rc;" at tag ";tag
    endif
endsub

//=====
// Ble event handler
//=====

FUNCTION HndlrBleMsg (BYVAL nMsgId, BYVAL nCtx)
    conHndl=nCtx
    IF nMsgID==1 THEN
        PRINT "\n\n--- Disconnected from client"
        EXITFUNC 0
    ELSEIF nMsgID==0 THEN
        PRINT "\n--- Connected to client"
    ENDIF
ENDFUNC 1

//=====
// This handler is called when there is an advert report waiting to be read
//=====

function HandlerAdvRpt () as integer
    dim ad$,dta$,ndisc,rsi
    rc = BleScanGetAdvReport (ad$,dta$,ndisc,rsi)
    while rc==0
        print "\nADV: ";strhexize$(ad$); " ";strhexize$(dta$); " ";ndisc; " ";rsi
        rc = BleScanGetAdvReport (ad$,dta$,ndisc,rsi)
    endwhile
endfunc 1
```

```
//=====
// This handler is called when there is an advert report waiting to be read
//=====
sub WhiteListInit()
    //set invalid whitelist handle
    hWlist=-1

    //now check maximum whitelists that can be defined and for that valid handle
    //is not required
    rc=BleWhiteListInfo(hWlist,0, val) //get max number of whitelists allows
    AssertRC(100)
    print "\n Max allowed whitelists = "; val

    //create a whitelist
    rc=BleWhitelistCreate(hWlist,8,8,0)
    IF rc==0 THEN
        //Add address we want to specifically look for
        addr$="000016A40B1623"
        rc=BleWhitelistAddAddr(hWlist,addr$)
        AssertRC(110)
        //Made a mistake so clear it
        rc=BleWhitelistClear(hWlist)
        AssertRC(120)
        //now add the correct address
        addr$="000016A40B1642"
        rc=BleWhitelistAddAddr(hWlist,addr$)
        AssertRC(130)
        //now add first one in the trusted database
        rc=BleWhitelistAddIndex(hWlist,0)
        AssertRC(140)
        //Change the filter property from default used in the create function
        //so that connection requests are disallowed
        rc=BleWhitelistSetFilter(hWlist,1)
        AssertRC(150)
        //now check the whitelist by interrogating the whitelist handle
        rc=BleWhiteListInfo(hWlist,101, val) //get current number of mac addresses
        AssertRC(160)
        print "\n Current number of addresses = "; val
    ENDIF
```

```
endsub

//=====
//=====

ONEVENT  EVBLEMSG          CALL HndlrBleMsg
OnEvent  EVBLE_ADV_REPORT  CALL HandlerAdvRpt

//Initiliase a whitelist
WhiteListInit()

//start adverts with whitelisting
addr$=""
rc=BleAdvertStart(0,addr$,50,0,hWlist)
AssertRC(910)

//Wait for events
WAITEVENT

//destroy the whitelist
BleWhitelistDestroy(hWlist)
```

5.8.2 BleWhitelistDestroy

FUNCTION

This function is used to destroy an existing whitelist identified by a valid handle previously returned from `BleWhitelistCreate()` so that new addresses and Identity Resolving Keys (IRKs) can be added. This function completely destroys the whitelist of the given handle, and a new one will need to be created if necessary (using `BleWhitelistCreate`).

BLEWHITELISTDESTROY (hWlist)

Returns	INTEGER, a result code. Typical value: 0x0000 (indicates a successful operation)
Arguments	
hWlist	byRef hWlist AS INTEGER. This is the handle of the whitelist and is passed as a reference so that on exit it will have an invalid handle value so cannot be used inadvertently. The handle will have been returned by <code>BleWhitelistCreate()</code>

For example, see description of `BleWhitelistCreate()` above.

5.8.3 BleWhitelistClear

FUNCTION

This function is used to clear an existing whitelist identified by a valid handle previously returned from BleWhitelistCreate() so that new addresses and Identity Resolving Keys (IRKs) can be added. The handle of the whitelist is still valid so data can be added to the whitelist without having to call BleWhitelistCreate again.

BLEWHITELISTCLEAR (hWlist)

Returns	INTEGER, a result code. Typical value: 0x0000 (indicates a successful operation)
Arguments	
hWlist	byVal hWlist AS INTEGER. This is the handle of the whitelist to clear and will have been returned by BleWhitelistCreate()

For example, see description of [BleWhitelistCreate\(\)](#) above.

5.8.4 BleWhitelistSetFilter

FUNCTION

This function is used to change the filter policy mask associated with the whitelist object identified by the handle.

BLEWHITELISTSETFILTER (hWlist, nPktFilterMask)

Returns	INTEGER, a result code. Typical value: 0x0000 (indicates a successful operation)
Arguments	
hWlist	byRef hWlist AS INTEGER. This is the handle of the whitelist and will have been returned by BleWhitelistCreate()
nPktFilterMask	byVal nPktFilterMask AS INTEGER. This is a bit mask which specifies what type of incoming packets this list will apply to, as follows: ▪ Bit 0 : Set to 1 for Scan Request packets ▪ Bit 1 : Set to 1 for Connection Request packets ▪ Bit 2 : Set to 1 for Advert Report Packets ▪ Bits 3 to 31 : reserved for future use Note: If all bits are 0, then a default mask of 7 is used for the BL654.

For example, see description of [BleWhitelistCreate\(\)](#) above.

5.8.5 BleWhitelistAddAddr

FUNCTION

This function is used to add a 7 byte BT address to the whitelist identified by the handle supplied. The function will automatically check if the BT address is trusted by interrogating the trusted device database and if it is, then the address stored there along with the IRK is added instead of the address supplied. This means that in smartphones with Android and iOS (which make heavy use of resolvable addresses) there is seamless and hassle free integration.

BLEWHITELISTADDADDR (hWlist, addr\$)

Returns	INTEGER, a result code. Typical value: 0x0000 (indicates a successful operation)
Arguments	
hWlist	byVal hWlist AS INTEGER. This is the handle of the whitelist and will have been returned by BleWhitelistCreate()
addr\$	byRef addr\$ AS STRING. This is the address that is to be added to the whitelist. It will be checked for presence in trusted device database and if trusted, the IRK will also be added automatically to the whitelist

For example, see description of [BleWhitelistCreate\(\)](#) above.

5.8.6 BleWhitelistAddIndex

FUNCTION

This function is used to add the Nth indexed device in the trusted device database to the whitelist identified by the handle supplied. If that Nth record exists in the database then the Identity Resolving Key will also be added automatically.

BLEWHITELISTADDINDEX (hWlist, nIndex)

Returns	INTEGER, a result code. Typical value: 0x0000 (indicates a successful operation)
Arguments	
hWlist	byVal hWlist AS INTEGER. This is the handle of the whitelist and will have been returned by BleWhitelistCreate()
nIndex	byVal nIndex AS INTEGER. This is the Nth index (zero based) of the record in the trusted device database to add to the whitelist. The IRK will also be added automatically to the whitelist. The index is the same entity per the function BleBondMngrGetInfo()

For example, see description of [BleWhitelistCreate\(\)](#) above.

5.8.7 BleWhitelistInfo

FUNCTION

This function is used to return information about the whitelist provided. This may be invalid for certain *nInfoID* values, as that is information about the whitelist manager in general.

BLEWHITELISTINFO (*hWlist*, *nInfoID*, *nValue*)

Returns	INTEGER, a result code. Typical value: 0x0000 (indicates a successful operation)
Arguments	
<i>hWlist</i>	byVal <i>hWlist</i> AS INTEGER. This is the handle of the whitelist and will have been returned by <i>BleWhitelistCreate()</i>
<i>nInfoID</i>	byVal <i>nInfoID</i> AS INTEGER. This is ID of the information to be returned as follows: 0 : maximum number of whitelists (<i>hWlist</i> is ignored) 1 : maximum number of Bluetooth addresses (<i>hWlist</i> is ignored) 2 : maximum number of IRKs (<i>hWlist</i> is ignored) 101 : current number of addresses added 102 : current number of IRKs added Note: For 101 and 102, the values will be cleared to 0 if <i>BleWhitelistClear()</i> is called.
<i>nValue</i>	byRef <i>nValue</i> AS INTEGER. The information value is returned in this variable

For example, see description of *BleWhitelistCreate()* above.

5.9 GATT Server Functions

This section describes all functions related to creating and managing services that collectively define a GATT table from a GATT server role perspective. These functions allow the developer to create any service that has is described and adopted by the Bluetooth SIG or any custom service that implements some custom unique functionality, within resource constraints such as the limited RAM and FLASH memory that is exist in the module.

A GATT table is a collection of adopted or custom services which, in turn, are a collection of adopted or custom characteristics. By definition, an adopted service cannot contain custom characteristics but the reverse is possible where a custom service can include both adopted and custom characteristics.

Descriptions of services and characteristics are available in the Bluetooth Specification v4.0 or newer. Because these descriptions are concise and difficult to understand, the following section attempts to familiarise you with these concepts using the *smart*BASIC programming environment perspective.

To help understand service and characteristic better, think of a characteristic as a container (or a pot) of data where the pot comes with space to store the data and a set of properties that are officially called Descriptors in the BT spec. In the pot analogy, think of a descriptor as the color of the pot, whether it has a lid, whether the lid has a lock, whether it has a handle or a spout, etc. For a full list of these descriptors online, see <http://developer.bluetooth.org/GATT/descriptors/Pages/DescriptorsHomePage.aspx> . These descriptors are assigned 16-bit UUIDs (value 0x29xx) and are referenced in some of the *smart*BASIC API functions if you decide to add those to your characteristic definition.

You can consider a service as a carrier bag to hold a group of related characteristics together where the printing on the carrier bag is a UUID. From a *smart*BASIC developer's perspective, a set of characteristics is what you need to manage and the concept of service is only required at GATT table creation time.

A GATT table can have many services, each containing one or more characteristics. The difference between services and characteristics is expedited using an identification number called a UUID (Universally Unique Identifier) which is a 128-bit (16-byte) number. Adopted services or characteristics have a 16-bit (2-byte) shorthand identifier (which is an offset plus a base 128-bit UUID defined and reserved by the Bluetooth SIG); custom service or characteristics have the full 128-bit UUID. The logic behind this is that a 16-bit UUID implies that a specification has been published by the Bluetooth SIG whereas using a 128-bit UUID does NOT require any central authority to maintain a register of those UUIDs or specifications describing them.

The lack of the requirement for a central register is important to understand in the sense that, if a custom service or characteristic must be created, the developer can use any publicly available UUID (sometimes also known as GUID) generation utility.

These utilities use entropy from the real world to generate a 128-bit random number that has an extremely low probability to be the same as that generated by someone else at the same time or in the past or future.

As an example, at the time of writing this document, the following website <http://www.guidgenerator.com/online-guid-generator.aspx> offers an immediate UUID generation service, although it uses the term GUID. From the GUID Generator website:

How unique is a GUID?

128-bits is big enough and the generation algorithm is unique enough that if 1,000,000,000 GUIDs per second were generated for 1 year the probability of a duplicate would be only 50%. Or if every human on Earth generated 600,000,000 GUIDs there would only be a 50% probability of a duplicate.

This extremely low probability of generating the same UUID is why there is no need for a central register maintained by the Bluetooth SIG for custom UUIDs.

Please note that Laird does not guarantee that the UUID generated by this website or any other utility is unique. It is left to the judgement of the developer whether to use it or not.

Note: If the developer intends to create custom services and/or characteristics then it is recommended that a single UUID is generated and used from then on as a 128-bit (16 byte) company/developer unique base along with a 16-bit (2-byte) offset, in the same manner as the Bluetooth SIG.

This allows up to 65536 custom services and characteristics to be created, with the added advantage that it is easier to maintain a list of 16-bit integers.

The main reason for avoiding more than one long UUID is to keep RAM usage down given that 16 bytes of RAM is used to store a long UUID. *smart* BASIC functions have been provided to manage these custom 2-byte UUIDs along with their 16-byte base UUIDs.

In this document, when a service or characteristic is described as adopted, it implies that the Bluetooth SIG published a specification which defines that service or characteristic and there is a requirement that any device claiming to support them has proof that the functionality has been tested and verified to behave as per that specification.

Currently there is no requirement for custom service and/or characteristics to have any approval. By definition, interoperability is restricted to the provider and implementer.

A service is an abstraction of some collectivised functionality which, if broken down further, would cease to provide the intended behaviour. Two examples in the BLE domain that have been adopted by the Bluetooth SIG are Blood Pressure Service and Heart Rate Service. Each have sub-components that map to characteristics.

Blood pressure is defined by a collection of data entities such as Systolic Pressure, Diastolic Pressure, and Pulse Rate. Likewise, a Heart Rate service has a collection which includes entities such as the Pulse Rate and Body Sensor Location.

A list of all the adopted services is at: <http://developer.Bluetooth.org/GATT/services/Pages/ServicesHome.aspx>. Laird recommends that, if you decide to create a custom service, it should be defined and described in a similar fashion; your goal should be to get the Bluetooth SIG to adopt it for everyone to use in an interoperable manner.

These services are also assigned 16-bit UUIDs (value 0x18xx) and are referenced in some of the *smart* BASIC API functions described in this section.

Services, as described above, are a collection of one or more characteristics. A list of all adopted characteristics is found at: <http://developer.Bluetooth.org/GATT/characteristics/Pages/CharacteristicsHome.aspx>. You should note that these descriptors are also assigned 16-bit UUIDs (value 0x2Axx) and are referenced in some of the API functions described in this section. Custom characteristics have 128-bit (16-byte) UUIDs and API functions are provided to handle those.

Note: If you intend to create a custom service or characteristic and adopt the recommendation of a single 16-byte base UUID so that the service can be identified using a 2-byte UUID, then allocate a 16-bit value which is not going to

coincide with any adopted values to minimise confusion. Selecting a similar value is possible and legal given that the base UUID is different.

The remainder of this introduction focuses on the specifics of how to create and manage a GATT table from a perspective of the *smart*BASIC API functions in the module.

Recall that a service was described as a carrier bag that groups related characteristics together and a characteristic is a data container (pot). Therefore, a remote GATT client looking at the server which is presented in your GATT table, sees multiple carrier bags each containing one or more pots of data.

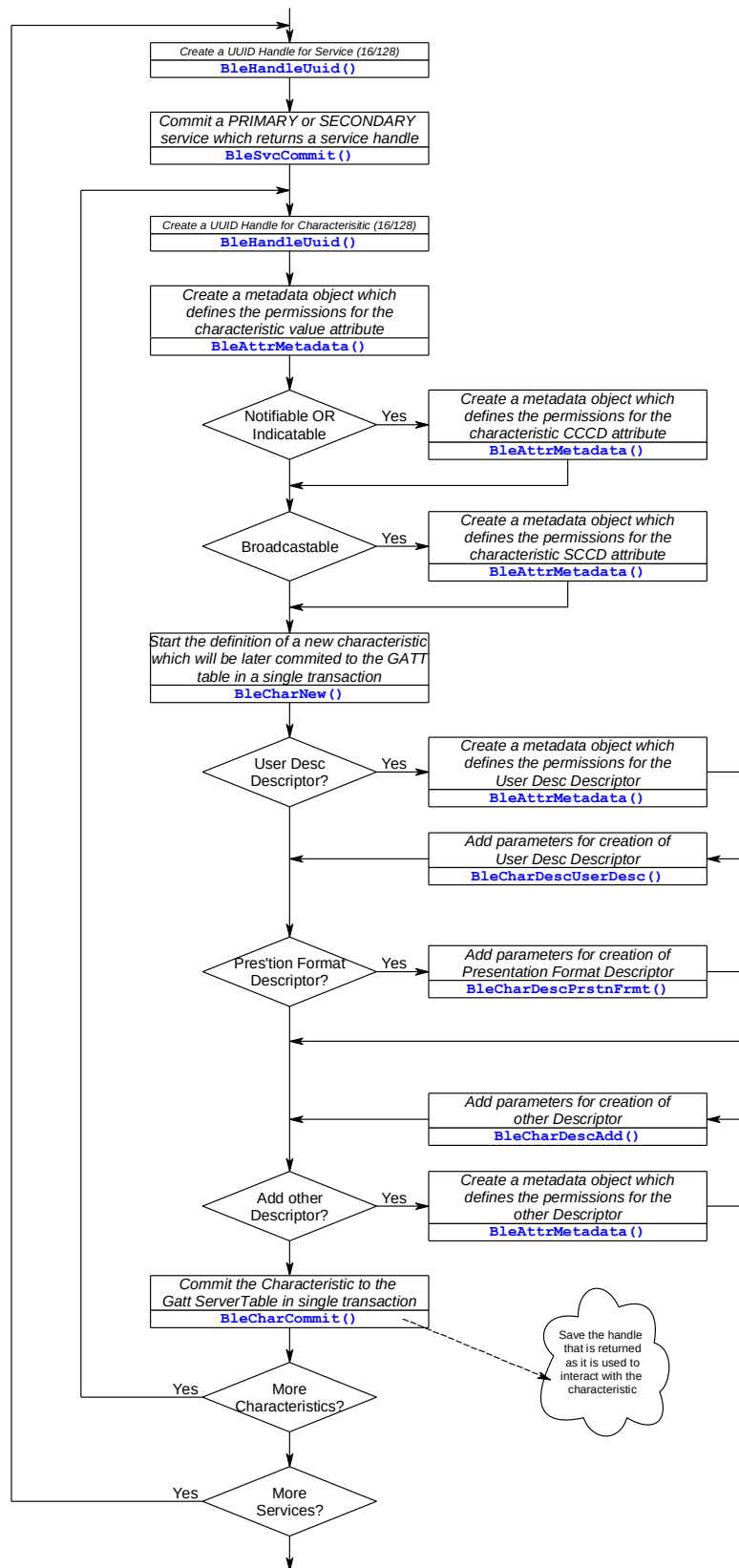
The GATT client (remote end of the wireless connection) must see those carrier bags to determine the groupings and, once it has identified the pots, it only needs to keep a list of references to the pots it is interested in. Once that list is made at the client end, it can 'throw away the carrier bag'.

Similarly in the module, once the GATT table is created and after each service is fully populated with one or more characteristics, there is no need to keep that 'carrier bag'. However, as each characteristic is 'placed in the carrier bag' using the appropriate *smart*BASIC API function, a receipt is returned and is referred to as a `char_handle`. The developer must then keep those handles to be able to interact with that characteristic. The handle does not care whether the characteristic is adopted or custom because, from then on the firmware managing it behind the scenes in *smart*BASIC does not care.

From the *smart*BASIC application developer's logical perspective, a GATT table looks nothing like the table that is presented in most BLE literature. Instead, the GATT table is simply a collection of `char_handles` that reference the characteristics (data containers) which have been registered with the underlying GATT table in the BLE stack.

A particular `char_handle` is used to make something happen to the referenced characteristic (data container) using a *smart* BASIC function and conversely, if data is written into that characteristic (data container) by a remote GATT client, then an event is thrown in the form of a message, into the *smart* BASIC runtime engine which is processed **if and only if** a handler function has been registered by the apps developer using the `ONEVENT` statement.

With this simple model in mind, an overview of how the *smart* BASIC functions are used to register services and characteristics is illustrated in the flowchart on the right and sample code follows on the next page.



Example:

```
// Example :: ServicesAndCharacteristics.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

//=====
//Register two Services in the GATT Table. Service 1 with 2 Characteristics and
//Service 2 with 1 characteristic. This implies a total of 3 characteristics to
//manage.
//The characteristic 2 in Service 1 will not be readable or writable but only
//indicatable
//The characteristic 1 in Service 2 will not be readable or writable but only
//notifiable
//=====

DIM rc      //result code
DIM hSvc     //service handle
DIM mdAttr
DIM mdCccd
DIM mdSccd
DIM chProp
DIM attr$

DIM hChar11 // handles for characteristic 1 of Service 1
DIM hChar21 // handles for characteristic 2 of Service 1
DIM hChar12 // handles for characteristic 1 of Service 2

DIM hUuidS1 // handles for uuid of Service 1
DIM hUuidS2 // handles for uuid of Service 2
DIM hUuidC11 // handles for uuid of characteristic 1 in Service 1
DIM hUuidC12 // handles for uuid of characteristic 2 in Service 1
DIM hUuidC21 // handles for uuid of characteristic 1 in Service 2

//---Register Service 1
hUuidS1 = BleHandleUuid16(0x180D)
rc = BleServiceNew(BLE_SERVICE_PRIMARY, hUuidS1, hSvc)

//---Register Characteristic 1 in Service 1
mdAttr = BleAttrMetadata(BLE_ATTR_ACCESS_OPEN,BLE_ATTR_ACCESS_OPEN,10,0,rc)
mdCccd = BLE_CHAR_METADATA_ATTR_NOT_PRESENT
```

```
mdSccd = BLE_CHAR_METADATA_ATTR_NOT_PRESENT
chProp = BLE_CHAR_PROPERTIES_READ + BLE_CHAR_PROPERTIES_WRITE
hUuidC11 = BleHandleUuid16(0x2A37)
rc = BleCharNew(chProp, hUuidC11,mdAttr,mdCccd,mdSccd)
rc = BleCharCommit(shHrs,hrs$,hChar11)

//---Register Characteristic 2 in Service 1
mdAttr = BleAttrMetadata(BLE_ATTR_ACCESS_OPEN,BLE_ATTR_ACCESS_OPEN,10,0,rc)
mdCccd = BleAttrMetadata(BLE_ATTR_ACCESS_OPEN,BLE_ATTR_ACCESS_OPEN,2,0,rc)
mdSccd = BLE_CHAR_METADATA_ATTR_NOT_PRESENT
chProp = BLE_CHAR_PROPERTIES_INDICATE
hUuidC12 = BleHandleUuid16(0x2A39)
rc = BleCharNew(chProp, hUuidC12,mdAttr,mdCccd,mdSccd)
attr$="\00\00"
rc = BleCharCommit(hSvc,attr$,hChar21)
rc = BleServiceCommit(hSvc)

//---Register Service 2 (can now reuse the service handle)
hUuidS2 = BleHandleUuid16(0x1856)
rc = BleServiceNew(BLE_SERVICE_PRIMARY, hUuidS2, hSvc)

//---Register Characteristic 1 in Service 2
mdAttr = BleAttrMetadata(BLE_ATTR_ACCESS_NONE,BLE_ATTR_ACCESS_NONE,10,0,rc)
mdCccd = BleAttrMetadata(BLE_ATTR_ACCESS_OPEN,BLE_ATTR_ACCESS_OPEN,2,0,rc)
mdSccd = BLE_CHAR_METADATA_ATTR_NOT_PRESENT
chProp = BLE_CHAR_PROPERTIES_NOTIFY
hUuidC21 = BleHandleUuid16(0x2A54)
rc = BleCharNew(chProp, hUuidC21,mdAttr,mdCccd,mdSccd)
attr$="\00\00\00\00"
rc = BleCharCommit(hSvc,attr$,hChar12)
rc = BleServiceCommit(hSvc)
//===The 2 services are now visible in the gatt table
```

Writes into a characteristic from a remote client are detected and processed as follows:

```
//-----
// To deal with writes from a GATT client into characteristic 1 of Service 1
// which has the handle hChar11
//-----

// This handler is called when there is a EVCHARVAL message
```

```
FUNCTION HandlerCharVal (BYVAL hChar AS INTEGER) AS INTEGER
    DIM attr$
    IF hChar == hChar11 THEN
        rc = BleCharValueRead(hChar11,attr$)
        print "Svc1/Char1 has been written with = ";attr$

    ENDIF
ENDFUNC 1
```

```
//enable characteristic value write handler
OnEvent EVCHARVAL          call HandlerCharVal
```

WAITEVENT

Assuming there is a connection and notify has been enabled, a value notification is expedited as follows:

```
//-----
// Notify a value for characteristic 1 in service 2
//-----
attr$="somevalue"
rc = BleCharValueNotify(hChar12,attr$)
```

Assuming there is a connection and indicate has been enabled, a value indication is expedited as follows:

```
//-----
// indicate a value for characteristic 2 in service 1
//-----
```

// This handler is called when there is a EVCHARHVC message

```
FUNCTION HandlerCharHvc (BYVAL hChar AS INTEGER) AS INTEGER
    IF hChar == hChar12 THEN
        PRINT "Svc1/Char2 indicate has been confirmed"
    ENDIF
ENDFUNC 1
```

```
//enable characteristic value indication confirm handler
```

```
OnEvent EVCHARHVC          CALL HandlerCharHvc
```

```
attr$="somevalue"
rc = BleCharValueIndicate(hChar12,attr$)
```

The rest of this section details all the *smart*BASIC functions that help create that framework.

5.9.1 Events and Messages

See also [Events and Messages](#) for the messages that are thrown to the application which are related to the generic characteristics API. The relevant messages are those that start with EVCHARxxx.

5.9.2 BleGapSvcInit

FUNCTION

This function updates the GAP service, which is mandatory for all approved devices to expose, with the information provided. If it is not called before adverts are started, default values are exposed. Given this is a mandatory service, unlike other services which must be registered, this one must only be initialised as the underlying BLE stack unconditionally registers it when starting up.

The GAP service contains five characteristics as listed at the following site:

http://developer.bluetooth.org/GATT/services/Pages/ServiceViewer.aspx?u=org.Bluetooth.service.generic_access.xml

BLEGAPSVINIT (deviceName, nameWritable, nAppearance, nMinConnInterval, nMaxConnInterval, nSupervisionTout, nSlaveLatency)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation
Arguments:	
deviceName	byRef deviceName AS STRING The name of the device (such as Laird_Thermometer) to store in the Device Name characteristic of the GAP service. Note: When an advert report is created using BLEADVRPTINIT(), this field is read from the service and an attempt is made to append it in the Device Name AD. If the name is too long, that function fails to initialise the advert report and a default name is transmitted. We recommend that the device name submitted in this call be as short as possible.
nameWritable	byVal nameWritable AS INTEGER If non-zero, the peer device is allowed to write the device name. Some profiles allow this to be made optional.
nAppearance	byVal nAppearance AS INTEGER Field lists the external appearance of the device and updates the Appearance characteristic of the GAP service. Possible values: org.Bluetooth.characteristic.gap.appearance
nMinConnInterval	byVal nMinConnInterval AS INTEGER The preferred minimum connection interval, updates the 'Peripheral Preferred Connection Parameters' characteristic of the GAP service. Range is between 7500 and 4000000 microseconds (rounded to the nearest 1250 microseconds). This must be smaller than nMaxConnInterval.
nMaxConnInterval	byVal nMaxConnInterval AS INTEGER The preferred maximum connection interval, updates the 'Peripheral Preferred Connection Parameters' characteristic of the GAP service. Range is between 7500 and 4000000 microseconds (rounded to the nearest 1250 microseconds). This must be larger than nMinConnInterval.

<i>nSupervisionTimeout</i>	byVal nSupervisionTimeout AS INTEGER The preferred link supervision timeout and updates the 'Peripheral Preferred Connection Parameters' characteristic of the GAP service. Range is between 100000 to 32000000 microseconds (rounded to the nearest 10000 microseconds).
<i>nSlaveLatency</i>	byVal nSlaveLatency AS INTEGER The preferred slave latency is the number of communication intervals that a slave may ignore without losing the connection and updates the 'Peripheral Preferred Connection Parameters' characteristic of the GAP service. This value must be smaller than (nSupervisionTimeout/ nMaxConnInterval) -1. i.e. $nSlaveLatency < (nSupervisionTimeout / nMaxConnInterval) - 1$

Example:

```
// Example :: BleGapSvcInit.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc,dvcNme$,nmeWrtble,apprnce,MinConnInt,MaxConnInt,ConnSupTO,sL,s$

dvcNme$= "Laird_TS"
nmeWrtble = 0           //Device name will not be writable by peer
apprnce = 768           //The device will appear as a Generic Thermometer
MinConnInt = 500000     //Minimum acceptable connection interval is 0.5 seconds
MaxConnInt = 1000000    //Maximum acceptable connection interval is 1 second
ConnSupTO = 4000000     //Connection supervisory timeout is 4 seconds
sL = 0                  //Slave latency--number of conn events that can be missed

rc=BleGapSvcInit(dvcNme$,nmeWrtble,apprnce,MinConnInt,MaxConnInt,ConnSupTO,sL)

IF !rc THEN
    PRINT "\nSuccess"
ELSE
    PRINT "\nFailed 0x"; INTEGER.H'rc    //Print result code as 4 hex digits
ENDIF
```

Expected Output:

```
Success
```


5.9.3 BleGetDeviceName\$

FUNCTION

This function reads the device name characteristic value from the local GATT table. This value is the same as that supplied in BleGapSvcInit() if the 'nameWritable' parameter was 0, otherwise it may be different.

EVBLEMSG event is thrown with 'msgid' == 21 when the GATT client writes a new value and is the best time to call this function.

BLEGETDEVICENAME\$ ()

Returns	STRING, the current device name in the local GATT table. It is the same as that supplied in BleGapSvcInit() if the 'nameWritable' parameter was 0, otherwise it can be different. EVBLEMSG event is thrown with 'msgid' == 21 when the GATT client writes a new value.
Arguments	None

Example:

```
// Example :: BleGetDeviceName$.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc,dvcNme$,nmeWrtble,apprnce,MinConnInt,MaxConnInt,ConnSupTO,sL

PRINT "\n --- DevName : "; BleGetDeviceName$()

// Changing device name manually
dvcNme$= "My BL654"
nmeWrtble = 0
apprnce = 768
MinConnInt = 500000
MaxConnInt = 1000000
ConnSupTO = 4000000
sL = 0

rc = BleGapSvcInit(dvcNme$,nmeWrtble,apprnce,MinConnInt,MaxConnInt,ConnSupTO,sL)
PRINT "\n --- New DevName : "; BleGetDeviceName$()
```

Expected Output:

```
--- DevName : LAIRD BL654
--- New DevName : My BL654
```

5.9.4 BleSvcRegDevInfo

FUNCTION

This function is used to register the Device Information service with the GATT server. The Device Information service contains nine characteristics as listed at the following website:

http://developer.bluetooth.org/GATT/services/Pages/ServiceViewer.aspx?u=org.Bluetooth.service.device_information.xml

The firmware revision string is always set to **BL654:vW.X.Y.Z** where W,X,Y,Z are as per the revision information which is returned to the command AT I 4.

BLESVCREGDEVINFO (*manfName\$, modelNum\$, serialNum\$, hwRev\$, swRev\$, sysId\$, regDataList\$, pnpld\$*)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
manfName\$	byVal manfName\$ AS STRING The device manufacturer. Can be set empty to omit submission.
modelNum\$	byVal modelNum\$ AS STRING The device model number. Can be set empty to omit submission.
serialNum\$	byVal serialNum\$ AS STRING The device serial number. Can be set empty to omit submission.
hwRev\$	byVal hwRev\$ AS STRING The device hardware revision string. Can be set empty to omit submission.
swRev\$	byVal swRev\$ AS STRING The device software revision string. Can be set empty to omit submission.
sysId\$	byVal sysId\$ AS STRING The device system ID as defined in the specifications. Can be set empty to omit submission. Otherwise it shall be a string exactly eight octets long, where: Byte 0..4 := Manufacturer Identifier Byte 5..7 := Organisationally Unique Identifier If the string is one character long and contains @, the system ID is created from the Bluetooth address if (and only if) an IEEE public address is set. If the address is the random static variety, this characteristic is omitted.
regDataList\$	byVal regDataList\$ AS STRING The device's regulatory certification data list as defined in the specification. It can be set as an empty string to omit submission.
pnpld\$	byVal pnpld\$ AS STRING The device's plug and play ID as defined in the specification. Can be set empty to omit submission. Otherwise, it shall be exactly 7 octets long, where: ▪ Byte 0 := Vendor Id Source ▪ Byte 1,2 := Vendor Id (Byte 1 is LSB) ▪ Byte 3,4 := Product Id (Byte 3 is LSB) ▪ Byte 5,6 := Product Version (Byte 5 is LSB)

Example:

```
// Example :: BleSvcRegDevInfo.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc,manfNme$,mdlNum$,srlNum$,hwRev$,swRev$,sysId$,regDtaLst$,pnpId$

manfNme$ = "Laird Technologies"
mdlNum$ = "BL654"
srlNum$ = "" //empty to omit submission
hwRev$ = "1.0"
swRev$ = "1.0"
sysId$ = "" //empty to omit submission
regDtaLst$ = "" //empty to omit submission
pnpId$ = "" //empty to omit submission

rc=BleSvcRegDevInfo(manfNme$,mdlNum$,srlNum$,hwRev$,swRev$,sysId$,regDtaLst$,pnpId$)

IF !rc THEN
    PRINT "\nSuccess"
ELSE
    PRINT "\nFailed 0x"; INTEGER.H'rc
ENDIF
```

Expected Output:

```
Success
```

5.9.5 BleHandleUuid16

FUNCTION

This function takes an integer in the range 0 to 65535 and converts it into a 32-bit integer handle that associates the integer as an offset into the Bluetooth SIG 128-bit (16-byte) base UUID which is used for all adopted services, characteristics, and descriptors.

If the input value is not in the valid range, then an invalid handle (0) is returned.

The returned handle is treated by the developer as an opaque entity and no further logic is based on the bit content, apart from all zeros which represent an invalid UUID handle.

BLEHANDLEUUID16 (nUuid16)

Returns	INTEGER, a nonzero handle shorthand for the UUID. Zero is an invalid UUID handle
Arguments:	
nUuid16	byVal nUuid16 AS INTEGER nUuid16 is first bitwise ANDed with 0xFFFF and the result is treated as an offset into the Bluetooth SIG 128 bit base UUID

Example:

```
// Example :: BleHandleUuid16.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM uuid
DIM hUuidHRS

uuid = 0x180D //this is UUID for Heart Rate Service
hUuidHRS = BleHandleUuid16(uuid)
IF hUuidHRS == 0 THEN
    PRINT "\nFailed to create a handle"
ELSE
    PRINT "Handle for HRS Uuid is "; integer.h' hUuidHRS; "(";hUuidHRS;" )"
ENDIF
```

Expected Output:

```
Handle for HRS Uuid is FE01180D (-33482739)
```

5.9.6 BleHandleUuid128

FUNCTION

This function takes a 16-byte string and converts it into a 32-bit integer handle. The handle consists of a 16-bit (2-byte) offset into a new 128-bit base UUID.

The base UUID is created by taking the 16-byte input string and setting bytes 12 and 13 to zero after extracting those bytes and storing them in the handle object. The handle also contains an index into an array of these 16-byte base UUIDs which are managed opaquely in the underlying stack.

The returned handle shall be treated by the developer as an opaque entity and no further logic shall be based on the bit content. However, note that a string of zeroes represents an invalid UUID handle.

Note: Ensure that you use a 16-byte UUID that has been generated using a random number generator with sufficient entropy to minimise duplication and that the first byte of the array is the most significant byte of the UUID.

BLEHANDLEUUID128 (stUuid\$)

Returns	INTEGER, A handle representing the shorthand UUID. If zero, which is an invalid UUID handle, there is either no spare RAM memory to save the 16-byte base or more than 253 custom base UUIDs have been registered.
Arguments:	
stUuid\$	byRef stUuid\$ AS STRING Any 16-byte string that was generated using a UUID generation utility that has enough entropy to ensure that it is random. The first byte of the string is the MSB of the UUID (big endian format).

Example:

```
//Example :: BleHandleUuid128.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples
```

```
DIM uuid$, hUuidCustom

//create a custom uuid for my ble widget
uuid$ = "ced9d91366924a1287d56f2764762b2a"
uuid$ = StrDehexize$(uuid$)
hUuidCustom = BleHandleUuid128(uuid$)
IF hUuidCustom == 0 THEN
    PRINT "\nFailed to create a handle"
ELSE
    PRINT "Handle for custom Uuid is ";integer.h' hUuidCustom; "(";hUuidCustom;" "
ENDIF

// hUuidCustom now references an object which points to
// a base uuid = ced9d91366924a1287d56f2747622b2a (note 0's in byte position 2/3)
// and an offset = 0xd913
```

Expected Output:

```
Handle for custom Uuid is FC03D913 (-66856685)
```

5.9.7 BleHandleUuidSibling

FUNCTION

This function takes an integer in the range 0 to 65535 along with a UUID handle which had been previously created using BleHandleUuid16() or BleHandleUuid128() to create a new UUID handle. This handle references the same 128 base UUID as the one referenced by the UUID handle supplied as the input parameter.

The returned handle shall be treated by the developer as an opaque entity and no further logic shall be based on the bit content, apart from all zeroes (which represents an invalid UUID handle).

BLEHANDLEUUIDSIBLING (nUuidHandle, nUuid16)

Returns	INTEGER, a handle representing the shorthand UUID and can be zero which is an invalid UUID handle, if nUuidHandle is an invalid handle in the first place.
Arguments:	
nUuidHandle	byVal nUuidHandle AS INTEGER A handle that was previously created using either BleHandleUuid16() or BleHandleUuid128().
nUuid16	byVal nUuid16 AS INTEGER A UUID value in the range 0 to 65535 which is treated as an offset into the 128-bit base UUID referenced by nUuidHandle.

Example:

```
// Example :: BleHandleUuidSibling.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples
DIM uuid$, hUuid1, hUuid2 //hUuid2 will have the same base uuid as hUuid1

//create a custom uuid for my ble widget
uuid$ = "ced9d91366924a1287d56f2764762b2a"
```

```

uuid$ = StrDehexize$(uuid$)
hUuid1 = BleHandleUuid128(uuid$)
IF hUuid1 == 0 THEN
    PRINT "\nFailed to create a handle"
ELSE
    PRINT "Handle for custom Uuid is ";integer.h' hUuid1;"(";hUuid1;") "
ENDIF
// hUuid1 now references an object which points to
// a base uuid = ced9000066924a1287d56f2747622b2a (note 0's in byte position 2/3)
// and an offset = 0xd913

hUuid2 = BleHandleUuidSibling(hUuid1,0x1234)
IF hUuid2 == 0 THEN
    PRINT "\nFailed to create a handle"
ELSE
    PRINT "\nHandle for custom sibling Uuid is ";integer.h'hUuid2;"(";hUuid2;") "
ENDIF
// hUuid2 now references an object which also points to
// the base uuid = ced9000066924a1287d56f2700004762 (note 0's in byte position 2/3)
// and has the offset = 0x1234

```

Expected Output:

```

Handle for custom Uuid is FC03D913 (-66856685)
Handle for custom sibling Uuid is FC031234 (-66907596)

```

5.9.8 BleServiceNew

FUNCTION

As explained in [GATT Server Functions](#), a service in the context of a GATT table is a collection of related characteristics. This function is used to inform the underlying GATT table manager that one or more related characteristics are going to be created and installed in the GATT table and that, until the next call of this function, they will be associated with the service handle that it provides upon return of this call.

Under the hood, this call results in a single attribute being installed in the GATT table with a type signifying a PRIMARY or a SECONDARY service. The value for this attribute is the UUID that identifies this service and in turn have been precreated using one of the functions: `BleHandleUuid16()`, `BleHandleUuid128()`, or `BleHandleUuidSibling()`.

Note: When a GATT client queries a GATT server for services over a BLE connection, it only receives a list of PRIMARY services. SECONDARY services are a mechanism for multiple PRIMARY services to reference single instances of shared characteristics that are collected in a SECONDARY service. This referencing is expedited within the definition of a service using the concept of INCLUDED SERVICE which is an attribute that is grouped with the PRIMARY service definition. An Included Service is expedited using the function `BleSvcAddIncludeSvc()` which is described immediately after this function.

This function now replaces `BleSvcCom()` and marks the beginning of a service definition in the GATT server table. When the last descriptor of the last characteristic has been registered the service definition should be terminated by calling `BleServiceCommit()`.

BLESERVICENEW (*nSvcType*, *nUuidHandle*, *hService*)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
<i>nSvcType</i>	byVal <i>nSvcType</i> AS INTEGER This is zero for a SECONDARY service and 1 for a PRIMARY service. All other values are reserved for future use and result in this function failing with an appropriate result code.
<i>nUuidHandle</i>	byVal <i>nUuidHandle</i> AS INTEGER This is a handle to a 16-bit or 128-bit UUID that identifies the type of service function provided by all the characteristics collected under it. It has been pre-created using one of the three functions: BleHandleUuid16(), BleHandleUuid128(), or BleHandleUuidSibling().
<i>hService</i>	byRef <i>hService</i> AS INTEGER If the service attribute is created in the GATT table, then this contains a composite handle which references the actual attribute handle. This is then subsequently used when adding characteristics to the GATT table. If the function fails to install the service attribute for any reason, this variable will contain 0 and the returned result code will be non-zero.

Example:

```
// Example :: BleServiceNew.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

#DEFINE BLE_SERVICE_SECONDARY          0
#DEFINE BLE_SERVICE_PRIMARY            1
//-----

//Create a Health Thermometer PRIMARY service attribute which has a uuid of 0x1809
//-----

DIM hHtsSvc      //composite handle for hts primary service
DIM hUuidHT : hUuidHT = BleHandleUuid16(0x1809)      //HT Svc UUID Handle

IF BleServiceNew(BLE_SERVICE_PRIMARY,hUuidHT,hHtsSvc)==0 THEN
    PRINT "\nHealth Thermometer Service attribute written to GATT table"
    PRINT "\nUUID Handle value: ";hUuidHT
    PRINT "\nService Attribute Handle value: ";hHtsSvc
ELSE
    PRINT "\nService Commit Failed"
ENDIF

//-----

//Create a Battery PRIMARY service attribute which has a uuid of 0x180F
//-----

DIM hBatSvc      //composite handle for battery primary service
                  //or we could have reused nHtsSvc
DIM hUuidBatt : hUuidBatt = BleHandleUuid16(0x180F)      //Batt Svc UUID Handle
```

```
IF BleServiceNew(BLE_SERVICE_PRIMARY,hUuidBatt,hBatSvc)==0 THEN
    PRINT "\n\nBattery Service attribute written to GATT table"
    PRINT "\nUUID Handle value: ";hUuidBatt
    PRINT "\nService Attribute Handle value: ";hBatSvc
ELSE
    PRINT "\nService Commit Failed"
ENDIF
```

Expected Output:

```
Health Thermometer Service attribute written to GATT table
UUID Handle value: -33482743
Service Attribute Handle value: 16

Battery Service attribute written to GATT table
UUID Handle value: -33482737
Service Attribute Handle value: 17
```

5.9.9 BleServiceCommit

This function in the BL654 is used to commit a defined service using `BleServiceNew()` to the GATT table and should be called after the last characteristic/description has been created/committed for that service.

BLESERVICECOMMIT (hService)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
hService	byVal hService AS INTEGER This handle is returned from <code>BleServiceNew()</code> .

See example for `BleCharCommit()`.

5.9.10 BleSvcAddIncludeSvc

FUNCTION

Note: This function is currently not available for use on this module

This function is used to add a reference to a service within another service. This is usually, but not necessarily, a SECONDARY service which is virtually identical to a PRIMARY service from the GATT server perspective. The only difference is that, when a GATT client queries a device for all services, it does not receive mention of SECONDARY services.

When a GATT client encounters an INCLUDED SERVICE object when querying a particular service it performs a sub-procedure to get handles to all the characteristics that are part of that INCLUDED service.

This mechanism is provided to allow for a single set of characteristics to be shared by multiple primary services. This is most relevant if a characteristic is defined so that it can have only one instance in a GATT table but needs to be offered in multiple PRIMARY services. A typical implementation, where a characteristic is part of many PRIMARY services, installs that characteristic in a SECONDARY service (see `BleSvcCommit()`) and then uses the function defined in this section to add it to all the PRIMARY services that want to have that characteristic as part of their group.

It is possible to include a service which is also a PRIMARY or SECONDARY service, which in turn can include further PRIMARY or SECONDARY services. The only restriction to nested includes is that there cannot be recursion.

Note: If a service has INCLUDED services, then they is installed in the GATT table immediately after a service is created using BleSvcCommit() and before BleCharCommit(). The BT 4.0 specification mandates that any 'included service' attribute be present before any characteristic attributes within a particular service group declaration.

BleSvcAddIncludeSvc (hService)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation
Arguments:	
hService	byVal hService AS INTEGER This argument contains a handle that was previously created using the function BleSvcCommit().

Example:

```
// Example :: BleSvcAddIncludeSvc.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

#define BLE_SERVICE_SECONDARY          0
#define BLE_SERVICE_PRIMARY            1

//-----
//Create a Battery SECONDARY service attribure which has a uuid of 0x180F
//-----

dim hBatSvc      //composite handle for batteru primary service
dim rc           //or we could have reused nHtsSvc
dim metaSuccess

DIM charMet : charMet = BleAttrMetaData(1,1,10,1,metaSuccess)
DIM s$ : s$ = "Hello"      //initial value of char in Battery Service
DIM hBatChar

rc = BleServiceNew(BLE_SERVICE_SECONDARY, BleHandleUuid16(0x180F), hBatSvc)
rc = BleCharNew(3,BleHandleUuid16(0x2A1C),charMet,0,0)
rc = BleCharCommit(hBatSvc, s$,hBatChar)
rc = BleServiceCommit(hBatSvc)

//-----
//Create a Health Thermometer PRIMARY service attribure which has a uuid of 0x1809
//-----

DIM hHtsSvc      //composite handle for hts primary service

rc = BleServiceNew(BLE_SERVICE_PRIMARY, BleHandleUuid16(0x1809), hHtsSvc)
rc = BleServiceCommit(hHtsSvc)

//Have to add includes before any characteristics are committed
PRINT INTEGER.h'BleSvcAddIncludeSvc(hBatSvc)
```

5.9.11 BleAttrMetadataEx

FUNCTION

A GATT Table is an array of attributes which are grouped into Characteristics which in turn are further grouped into Services. Each attribute consists of a data value which can be anything from 1 to 512 bytes long according to the specification and properties such as read and write permissions, authentication and security properties. When Services and Characteristics are added to a GATT server table, multiple attributes with appropriate data and properties get added.

This function allows a 32 bit integer to be created, which is an opaque object, which defines those properties and is then submitted along with other information to add the attribute to the GATT table.

When adding a Service attribute (not the whole service, in this present context), the properties are defined in the BT specification so that it is open for reads without any security requirements but cannot be written and always has the same data content structure. This implies that a metadata object does NOT need to be created.

However, when adding Characteristics, which consists of a minimum of 2 attributes, one similar in function as the aforementioned Service attribute and the other the actual data container, then properties for the value attribute must be specified. Here, 'properties' refers to properties for the attribute, not properties for the Characteristic container as a whole. These also exist and must be specified, but that is done in a different manner as explained later.

For example, the value attribute must be specified for read/write permission and whether it needs security and authentication to be accessed.

If the Characteristic is capable of notification and indication, the client implicitly must be able to enable or disable that. This is done through a Characteristic Descriptor which is also another attribute. The attribute will also need to have a metadata supplied when the Characteristic is created and registered in the GATT table. This attribute, if it exists, is called a Client Characteristic Configuration Descriptor or CCCD for short. A CCCD always has two bytes of data and currently only two bits are used as on/off settings for notification and indication.

A Characteristic can also optionally be capable of broadcasting its value data in advertisements. For the GATT client to be able to control this, there is yet another type of Characteristic Descriptor which also needs a metadata object to be supplied when the Characteristic is created and registered in the GATT table. This attribute, if it exists, is called a Server Characteristic Configuration Descriptor or SCCD for short. A SCCD always has two bytes of data and currently only one bit is used as on/off settings for broadcasts.

Finally if the Characteristic has other Descriptors to qualify its behaviour, a separate API function is also supplied to add that to the GATT table and when setting up a metadata object will also need to be supplied.

In a nutshell, think of a metadata object as a note to define how an attribute will behave and the GATT table manager will need that before it is added. Some attributes have those 'notes' specified by the BT specification and so the GATT table manager will not need to be provided with any, but the rest require it.

This function helps write that metadata.

BLEATTRMETADATAEX (nReadRights, nWriteRights, nMaxDataLen, nFlags, resCode)

Returns	INTEGER, a 32-bit opaque data object to be used in subsequent calls when adding Characteristics to a GATT table.	
Arguments:		
nReadRights	byVal nReadRights AS INTEGER	
	This specifies the read rights and shall have one of the following values:	
	0	No access
	1	Open
	2	Encrypted with No Man-In-The-Middle (MITM) protection
	3	Encrypted with Man-In-The-Middle (MITM) protection
	4	Signed with No Man-In-The-Middle (MITM) protection (not available)
	5	Signed with Man-In-The-Middle (MITM) protection (not available)

<i>nWriteRights</i>	byVal <i>nWriteRights</i> AS INTEGER This specifies the write rights and shall have one of the following values: <table border="1"> <tr><td>0</td><td>No access</td></tr> <tr><td>1</td><td>Open</td></tr> <tr><td>2</td><td>Encrypted with No Man-In-The-Middle (MITM) protection</td></tr> <tr><td>3</td><td>Encrypted with Man-In-The-Middle (MITM) protection</td></tr> <tr><td>4</td><td>Signed with No Man-In-The-Middle (MITM) protection (not available)</td></tr> <tr><td>5</td><td>Signed with Man-In-The-Middle (MITM) protection (not available)</td></tr> </table>	0	No access	1	Open	2	Encrypted with No Man-In-The-Middle (MITM) protection	3	Encrypted with Man-In-The-Middle (MITM) protection	4	Signed with No Man-In-The-Middle (MITM) protection (not available)	5	Signed with Man-In-The-Middle (MITM) protection (not available)
0	No access												
1	Open												
2	Encrypted with No Man-In-The-Middle (MITM) protection												
3	Encrypted with Man-In-The-Middle (MITM) protection												
4	Signed with No Man-In-The-Middle (MITM) protection (not available)												
5	Signed with Man-In-The-Middle (MITM) protection (not available)												
<i>nMaxDataLen</i>	byVal <i>nMaxDataLen</i> AS INTEGER This specifies the maximum data length of the VALUE attribute. Range is from 1 to 512 bytes according to the BT specification; the stack implemented in the module may limit it for early versions.												
<i>nFlags</i>	byVal <i>nFlags</i> AS INTEGER This is a bit mask where the bits are defined as follows: - Bit 0: Set this to 1 only if you want the attribute to automatically shorten it's length according to the number of bytes written by the client. For example, if the initial length is 2 and the client writes only 1 byte, then if this is 0, then only the first byte gets updated and the rest remain unchanged. If this parameter is set to 1, then when a single byte is written the attribute will shorten it's length to accommodate. If the client tries to write more bytes than the initial maximum length, then the client will get an error response. - Bit 1: Set this to 1 to ensure that the memory for the attribute is allocated from User space (and hence less memory available for smartBASIC) so that a larger gatt table can be created. This bit is ignored for all attributes other than for characteristic value. - Bit 2: Set this to 1 to require authorisation for reads. When an attempt to read is made by the client then one of the events EVAUTHVAL, EVAUTHCCCD, EVAUTHSCCD or EVAUTHDESC is thrown to the app and in the handler for that event, either BleAuthorizeChar() or BleAuthorizeDesc() is called with appropriate parameters to grant or deny access. - Bit 3: Set this to 1 to require authorisation for writes. When an attempt to write is made by the client then one of the events EVAUTHVAL, EVAUTHCCCD, EVAUTHSCCD or EVAUTHDESC is thrown to the app and in the handler for that event, either BleAuthorizeChar() or BleAuthorizeDesc() is called with appropriate parameters to grant or deny access.												
<i>resCode</i>	byRef <i>resCode</i> AS INTEGER This variable is updated with a result code which is 0 if a metadata object was successfully returned by this call. Any other value implies a metadata object did not get created.												

Example:

```
// Example :: BleAttrMetadata.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM mdVal    //metadata for value attribute of Characteristic
DIM mdCccd   //metadata for CCCD attribute of Characteristic
DIM mdSccd   //metadata for SCCD attribute of Characteristic
DIM rc
```

```
//++++  
// Create the metadata for the value attribute in the characteristic  
// and Heart Rate attribute has variable length  
//++++  
  
//There is always a Value attribute in a characteristic  
mdVal=BleAttrMetadataEx(17,0,20,0,rc)  
//There is a CCCD and SCCD in this characteristic  
mdCccd=BleAttrMetadataEx(1,2,2,0,rc)  
mdSccd=BleAttrMetadataEx(0,0,2,0,rc)  
  
//Create the Characteristic object  
IF BleCharNew(3,BleHandleUuid16(0x2A1C),mdVal,mdCccd,mdSccd)==0 THEN  
    PRINT "\nSuccess"  
ELSE  
    PRINT "\nFailed"  
ENDIF
```

Expected Output:

Success

5.9.12 BleCharNew

FUNCTION

When a characteristic is to be added to a GATT table, multiple attribute objects must be precreated. After they are created successfully, they are committed to the GATT table in a single atomic transaction.

This function is the first function that is called to start the process of creating those multiple attribute objects. It is used to select the characteristic properties (which are distinct and different from attribute properties), the UUID to be allocated for it and then up to three metadata objects for the value attribute, and CCCD/SCCD Descriptors respectively.

BLECHARNEW (*nCharProps*, *nUuidHandle*, *mdVal*, *mdCccd*, *mdSccd*)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.																		
Arguments:																			
<i>nCharProps</i>	byVal <i>nCharProps</i> AS INTEGER This variable contains a bit mask to specify the following high level properties for the characteristic that is added to the GATT table: <table> <tr> <th>Bit</th><th>Description</th></tr> <tr> <td>0</td><td>Broadcast capable (SCCD descriptor must be present)</td></tr> <tr> <td>1</td><td>Can be read by the client</td></tr> <tr> <td>2</td><td>Can be written by the client without a response</td></tr> <tr> <td>3</td><td>Can be written</td></tr> <tr> <td>4</td><td>Can be notifiable (CCCD descriptor must be present)</td></tr> <tr> <td>5</td><td>Can be indicatable (CCCD descriptor must be present)</td></tr> <tr> <td>6</td><td>Can accept signed writes</td></tr> <tr> <td>7</td><td>Reliable writes</td></tr> </table>	Bit	Description	0	Broadcast capable (SCCD descriptor must be present)	1	Can be read by the client	2	Can be written by the client without a response	3	Can be written	4	Can be notifiable (CCCD descriptor must be present)	5	Can be indicatable (CCCD descriptor must be present)	6	Can accept signed writes	7	Reliable writes
Bit	Description																		
0	Broadcast capable (SCCD descriptor must be present)																		
1	Can be read by the client																		
2	Can be written by the client without a response																		
3	Can be written																		
4	Can be notifiable (CCCD descriptor must be present)																		
5	Can be indicatable (CCCD descriptor must be present)																		
6	Can accept signed writes																		
7	Reliable writes																		
<i>nUuidHandle</i>	byVal <i>nUuidHandle</i> AS INTEGER This specifies the UUID that is allocated to the characteristic, either 16 or 128 bits. This variable is a handle, pre-created using one of the following functions: BleHandleUuid16(), BleHandleUuid128(), BleHandleUuidSibling().																		
<i>mdVal</i>	byVal <i>mdVal</i> AS INTEGER This is the mandatory metadata used to define the properties of the Value attribute that is created in the characteristic and is pre-created with help from function BleAttrMetadata().																		
<i>mdCccd</i>	byVal <i>mdCccd</i> AS INTEGER This is an optional metadata that is used to define the properties of the CCCD descriptor attribute that is created in the characteristic and is pre-created using the help of the function BleAttrMetadata() or set to 0 if CCCD is not to be created. If <i>nCharProps</i> specifies that the characteristic is notifiable or indicatable and this value contains 0, this function will treat the descriptor so that read and write access is open.																		
<i>mdSccd</i>	byVal <i>mdSccd</i> AS INTEGER This is an optional metadata that is used to define the properties of the SCCD descriptor attribute that is created in the characteristic and is pre-created using the help of the function BleAttrMetadata() or set to 0 if SCCD is not to be created. If <i>nCharProps</i> specifies that the characteristic is broadcastable and this value contains 0, this function will treat the descriptor so that read and write access is open.																		

Example:

```
// Example :: BleCharNew.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc

DIM charUuid : charUuid = BleHandleUuid16(2)           //Characteristic's UUID
DIM mdVal : mdVal = BleAttrMetadataEx(1,0,20,0,rc)      //Metadata for value attribute
DIM mdCccd : mdCccd = BleAttrMetadataEx(1,1,2,0,rc)    //Metadata for CCCD attribute of
Characteristic

//=====
// Create a new char:
// --- Indicatable, not Broadcastable (so mdCccd is included, but not mdSccd)
// --- Can be read, not written (shown in mdVal as well)
//=====
IF BleCharNew(0x22,charUuid,mdVal,mdCccd,0)==0 THEN
    PRINT "\nNew Characteristic created"
ELSE
    PRINT "\nFailed"
ENDIF
```

Expected Output:

```
New Characteristic created
```

5.9.13 BleCharDescUserDesc

FUNCTION

This function adds an optional User Description Descriptor to a Characteristic and can only be called after `BleCharNew()` starts the process of describing a new characteristic.

The BT 4.0 specification describes the User Description Descriptor as “.. a UTF-8 string of variable size that is a textual description of the characteristic value.” It further stipulates that this attribute is optionally writable and so a metadata argument exists to configure it as such. The metadata automatically updates the Writable Auxiliaries properties flag for the characteristic. This is why that flag bit is NOT specified for the `nCharProps` argument to the `BleCharNew()` function.

BLECHARDESCUSERDESC (userDesc\$, mdUser)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
userDesc\$	byRef userDesc\$ AS STRING The user description string with which to initialize the descriptor. If the length of the string exceeds the maximum length of an attribute then this function aborts with an error result code.
mdUser	byVal mdUser AS INTEGER This is a mandatory metadata that defines the properties of the User Description Descriptor attribute created in the characteristic and pre-created using the help of <code>BleAttrMetadata()</code> . If the write rights are set to 1 or greater, the attribute is marked as writable and the client is able to provide a user description that overwrites the one provided in this call.

Example:

```
// Example :: BleCharDescUserDesc.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc, metaSuccess, usrDesc$ : usrDesc$="A description"
DIM charUuid : charUuid = BleHandleUuid16(1)
DIM charMet : charMet = BleAttrMetadata(1,1,20,0,metaSuccess)
DIM mdUsrDsc : mdUsrDsc = BleAttrMetadata(1,1,20,0,metaSuccess)
DIM mdSccd : mdSccd = BleAttrMetadata(1,1,2,0,rc) //CCCD metadata for char

//initialise char, write/read enabled, accept signed writes, indicatable
rc=BleCharNew(0x4B,charUuid,charMet,0,mdSccd)
rc=BleCharDescUserDesc(usrDesc$,mdUsrDsc)

IF rc==0 THEN
    PRINT "\nChar created and User Description '";usrDesc$;"' added"
ELSE
    PRINT "\nFailed"
ENDIF
```

Expected Output:

```
Char created and User Description 'A description' added
```

5.9.14 BleCharDescPrstnFmt

FUNCTION

This function adds an optional Presentation Format Descriptor to a characteristic and can only be called after BleCharNew() has started the process of describing a new characteristic. It adds the descriptor to the GATT table with open read permission and no write access, which means a metadata parameter is not required.

The BT 4.0 specification states that one or more presentation format descriptors can occur in a characteristic and that if more than one, then an Aggregate Format description is also included.

The book *Bluetooth Low Energy: The Developer's Handbook* by Robin Heydon, says the following on the subject of the Presentation Format Descriptor:

“One of the goals for the Generic Attribute Profile was to enable generic clients. A generic client is defined as a device that can read the values of a characteristic and display them to the user without understanding what they mean.

...

The most important aspect that denotes if a characteristic can be used by a generic client is the Characteristic Presentation Format descriptor. If this exists, it's possible for the generic client to display its value, and it is safe to read this value.”

BLECHARDESCPRSTNFRMT (nFormat, nExponent, nUnit, nNameSpace, nNSdesc)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.			
Arguments:				
nFormat	byVal nFormat AS INTEGER Valid range 0 to 255. The format specifies how the data in the Value attribute is structured. A list of valid values for this argument is found at http://developer.Bluetooth.org/GATT/Pages/FormatTypes.aspx and the enumeration is described in the BT 4.0 spec, section 3.3.3.5.2. The following is the enumeration list at the time of writing:			
	0x00	RFU	0x01	boolean
	0x02	2bit	0x03	nibble
	0x04	uint8	0x05	uint12
	0x06	uint16	0x07	uint24
	0x08	uint32	0x09	uint48
	0x0A	uint64	0x0B	uint128
	0x0C	sint8	0x0D	sint12
	0x0E	sint16	0x0F	sint24
	0x10	sint32	0x11	sint48
	0x12	sint64	0x13	sint128
	0x14	float32	0x15	float64
	0x16	SFLOAT	0x17	FLOAT
	0x18	duint16	0x19	utf8s
	0x1A	utf16s	0x1B	struct
	0x1C-0xFF	RFU		
nExponent	byVal nExponent AS INTEGER This value is used with integer data types given by the enumeration in nFormat to further qualify the value so that the actual value is: <i>actual value = Characteristic Value * 10 to the power of nExponent.</i> Valid range -128 to 127			
nUnit	byVal nUnit AS INTEGER This value is a 16-bit UUID used as an enumeration to specify the units which are listed in the Assigned Numbers document published by the Bluetooth SIG, found at: http://developer.Bluetooth.org/GATT/units/Pages/default.aspx Valid range 0 to 65535.			
nNameSpace	byVal nNameSpace AS INTEGER The value identifies the organization, defined in the Assigned Numbers document published by the Bluetooth SIG, found at: https://developer.Bluetooth.org/GATT/Pages/GATTNamespaceDescriptors.aspx Valid range 0 to 255.			
nNSdesc	byVal nNSdesc AS INTEGER This value is a description of the organisation specified by nNameSpace. Valid range 0 to 65535.			

Example:

```
// Example :: BleCharDescPrstnFrmt.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc, metaSuccess, usrDesc$ : usrDesc$="A description"

DIM charUuid : charUuid = BleHandleUuid16(1)
```



```
DIM charMet : charMet = BleAttrMetaData(1,1,20,0,metaSuccess)
DIM mdUsrDsc : mdUsrDsc = BleAttrMetaData(1,1,20,0,metaSuccess)
DIM mdSccd : mdSccd = BleAttrMetadata(1,1,2,0,rc)    //CCCD metadata for char

//initialise char, write/read enabled, accept signed writes, indicatable
rc=BleCharNew(0x4B,charUuid,charMet,0,mdSccd)
rc=BleCharDescUserDesc(usrDesc$,mdUsrDsc)

IF rc==0 THEN
    PRINT "\nChar created and User Description '";usrDesc$;"' added"
ELSE
    PRINT "\nFailed"
ENDIF

// ~ ~ ~
// other optional descriptors
// ~ ~ ~

// 16 bit signed integer = 0x0E
// exponent = 2
// unit = 0x271A ( amount concentration (mole per cubic metre) )
// namespace = 0x01 == Bluetooth SIG
// description = 0x0000 == unknown
IF BleCharDescPrstnFrmt(0x0E,2,0x271A,0x01,0x0000)==0 THEN
    PRINT "\nPresentation Format Descriptor added"
ELSE
    PRINT "\nPresentation Format Descriptor not added"
ENDIF
```

Expected Output:

```
Char created and User Description 'A description' added
Presentation Format Descriptor added
```

5.9.15 BleCharDescAdd

FUNCTION

This function is used to add any Characteristic Descriptor as long as its UUID is not in the range 0x2900 to 0x2904 inclusive, as they are treated specially using dedicated API functions. For example, 0x2904 is the Presentation Format Descriptor and it is catered for by the API function BleCharDescPrstnFrmt().

Since this function allows existing /future defined Descriptors to be added that may or may not have write access or require security requirements, a metadata object must be supplied allowing that to be configured.

BLECHARDESCADD (nUuid16, attr\$, mdDesc)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
nUuid16	byVal nUuid16 AS INTEGER This is a value in the range 0x2905 to 0x2999 Note: This is the actual UUID value, NOT the handle. The highest value at the time of writing is 0x290E, defined for the Report Reference Descriptor. See http://developer.Bluetooth.org/GATT/descriptors/Pages/DescriptorsHomePage.aspx for a list of Descriptors defined and adopted by the Bluetooth SIG.
attr\$	byRef attr\$ AS STRING This is the data that is saved in the Descriptor's attribute
mdDesc	byVal n AS INTEGER This is mandatory metadata that is used to define the properties of the Descriptor attribute that is created in the Characteristic and was pre-created using the help of the function BleAttrMetadata(). If the write rights are set to 1 or greater, then the attribute is marked as writable and the client is able to modify the attribute value.

Example:

```
// Example :: BleCharDescAdd.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc, metaSuccess, usrDesc$ : usrDesc$="A description"
DIM charUuid : charUuid = BleHandleUuid16(1)
DIM charMet : charMet = BleAttrMetadata(1,1,20,0,metaSuccess)
DIM mdUsrDsc : mdUsrDsc = charMet
DIM mdSccd : mdSccd = charMet

//initialise char, write/read enabled, accept signed writes, indicatable
rc=BleCharNew(0x4B,charUuid,charMet,0,mdSccd)
rc=BleCharDescUserDesc(usrDesc$,mdUsrDsc)
rc=BleCharDescPrstnFrmt(0x0E,2,0x271A,0x01,0x0000)

// ~ ~ ~
// other descriptors
// ~ ~ ~
```

```
//++++
//Add the other Descriptor 0x29XX -- first one
//++++
DIM mdChrDsc : mdChrDsc = BleAttrMetadata(1,0,20,0,metaSuccess)
DIM attr$ : attr$="some_value1"
rc=BleCharDescAdd(0x2905,attr$,mdChrDsc)

//++++
//Add the other Descriptor 0x29XX -- second one
//++++
attr$="some_value2"
rc=rc+BleCharDescAdd(0x2906,attr$,mdChrDsc)

//++++
//Add the other Descriptor 0x29XX -- last one
//++++
attr$="some_value3"
rc=rc+BleCharDescAdd(0x2907,attr$,mdChrDsc)

IF rc==0 THEN
    PRINT "\nOther descriptors added successfully"
ELSE
    PRINT "\nFailed"
ENDIF
```

Expected Output:

```
Other descriptors added successfully
```

5.9.16 BleCharCommit

FUNCTION

This function commits a characteristic which was prepared by calling BleCharNew() and optionally BleCharDescUserDesc(), BleCharDescPrstnFrmt() or BleCharDescAdd().

It is an instruction to the GATT table manager that all relevant attributes that make up the characteristic should appear in the GATT table in a single atomic transaction. If it successfully created, a single composite characteristic handle is returned which should not be confused with GATT table attribute handles. If the Characteristic was not accepted then this function returns a non-zero result code which conveys the reason and the handle argument that is returned has a special invalid handle of 0.

The characteristic handle that is returned references an internal opaque object that is a linked list of all the attribute handles in the characteristic which by definition implies that there is a minimum of 1 (for the characteristic value attribute) and more as appropriate. For example, if the characteristic's property specified is notifiable then a single CCCD attribute also exists.

Note: In the GATT table, when a characteristic is registered, there are actually a minimum of two attribute handles, one for the Characteristic Declaration and the other for the Value. However there is no need for the *smart* BASIC apps

developer to access it, so it is not exposed. Access is not required because the characteristic was created by the application developer and so shall already know its content – which never changes once created.

BLECHARCOMMIT (hService, attr\$, charHandle)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
hService	byVal hService AS INTEGER This is the handle of the service to which the characteristic belongs, which in turn was created using the function BleSvcCommit().
attr\$	byRef attr\$ AS STRING This string contains the initial value of the value attribute in the characteristic. The content of this string is copied into the GATT table and the variable can be reused after this function returns.
charHandle	byRef charHandle AS INTEGER The composite handle for the newly created characteristic is returned in this argument. It is zero if the function fails with a non-zero result code. This handle is then used as an argument in subsequent function calls to perform read/write actions, so it is must be placed in a global <i>smart</i> BASIC variable. When a significant event occurs as a result of action by a remote client, an event message is sent to the application which can be serviced using a handler. That message contains a handle field corresponding to this composite characteristic handle. Standard procedure is to select on that value to determine for which characteristic the message is intended. See event messages: EVCHARHVC, EVCHARVAL, EVCHARCCCD, EVCHARSCCD, EVCHARDESC.

Example:

```
// Example :: BleCharCommit.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

#define BLE_SERVICE_SECONDARY 0
#define BLE_SERVICE_PRIMARY 1

DIM rc
DIM attr$,usrDesc$ : usrDesc$="A description"
DIM hHtsSvc //composite handle for hts primary service
DIM mdCharVal : mdCharVal = BleAttrMetadata(1,1,20,0,rc)
DIM mdCccd : mdCccd = BleAttrMetadata(1,1,2,0,rc)
DIM mdUsrDsc : mdUsrDsc = BleAttrMetadata(1,1,20,0,rc)
DIM hHtsMeas //composite handle for htsMeas characteristic

//-----
//Create a Health Thermometer PRIMARY service attribute which has a uuid of 0x1809
//-----
rc=BleServiceNew(BLE_SERVICE_PRIMARY, BleHandleUuid16(0x1809), hHtsSvc)
```

```
//-----
//Create the Measurement Characteristic object, add user description descriptor
//-----
rc=BleCharNew(0x2A,BleHandleUuid16(0x2A1C),mdCharVal,mdCccd,0)
rc=BleCharDescUserDesc(usrDesc$,mdUsrDsc)

//-----
//Commit the characteristics with some initial data
//-----
attr$="hello\00worl\64"
IF BleCharCommit(hHtsSvc,attr$,hHtsMeas)==0 THEN
    PRINT "\nCharacteristic Committed"
ELSE
    PRINT "\nFailed"
ENDIF
rc=BleServiceCommit(hHtsSvc)

//the characteristic will now be visible in the GATT table
//and is referenced by 'hHtsMeas' for subsequent calls
```

Expected Output:

```
Characteristic Committed
```

5.9.17 BleCharValueRead

FUNCTION

This function reads the current content of a characteristic identified by a composite handle that was previously returned by the function BleCharCommit().

In most cases a read will be performed when a GATT client writes to a characteristic value attribute. The write event is presented asynchronously to the *smart* BASIC application in the form of EVCHARVAL event. This function will most often be accessed from the handler that services that event.

BLECHARVALUEREAD (charHandle, attr\$)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
charHandle	byVal charHandle AS INTEGER This is the handle to the characteristic whose value must be read which was returned when BleCharCommit() was called.
attr\$	byRef attr\$ AS STRING This string variable contains the new value from the characteristic.

Example:

```
// Example :: BleCharValueRead.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM hMyChar,rc, conHndl

//=====
// Initialise and instantiate service, characteristic,
//=====

FUNCTION OnStartup()
    DIM rc, hSvc, scRpt$, adRpt$, addr$, attr$ : attr$="Hi"

    //commit service
    rc=BleServiceNew(1, BleHandleUuid16(0x18EE), hSvc)
    //initialise char, write/read enabled, accept signed writes
    rc=BleCharNew(0x0A,BleHandleUuid16(1),BleAttrMetaData(1,1,20,0,rc),0,0)
    //commit char initialised above, with initial value "hi" to service 'hSvc'
    rc=BleCharCommit(hSvc,attr$,hMyChar)
    //commit changes to service
    rc=BleServiceCommit(hSvc)
    //initialise scan report
    rc=BleScanRptInit(scRpt$)
    //Add 1 service handle to scan report
    rc=BleAdvRptAddUuid16(scRpt$,0x18EE,-1,-1,-1,-1,-1)
    //commit reports to GATT table - adRpt$ is empty
    rc=BleAdvRptsCommit(adRpt$,scRpt$)
    rc=BleAdvertStart(0,addr$,150,0,0)
ENDFUNC rc

//=====
// New char value handler
//=====

FUNCTION HndlrChar(BYVAL chrHndl, BYVAL offset, BYVAL len)
    dim s$
    IF chrHndl == hMyChar THEN
        PRINT "\n";len;" byte(s) have been written to char value attribute from offset
";offset

        rc=BleCharValueRead(hMyChar,s$)
```

```
        PRINT "\nNew Char Value: ";s$
    ENDIF

    rc=BleAdvertStop()
    rc=BleDisconnect(conHndl)
ENDFUNC 0

//=====
// Get the connection handle
//=====

FUNCTION HndlrBleMsg(BYVAL nMsgId, BYVAL nCtn)
    conHndl=nCtn
ENDFUNC 1

IF OnStartup()==0 THEN
    DIM at$ : rc = BleCharValueRead(hMyChar,at$)
    PRINT "\nCharacteristic value attribute: ";at$;"\nConnect to BL654 and send a new
value\n"
ELSE
    PRINT "\nFailure OnStartup"
ENDIF

ONEVENT EVCHARVAL CALL HndlrChar
ONEVENT EVBLEMSG CALL HndlrBleMsg

WAITEVENT

PRINT "\nExiting..."
```

Expected Output:

```
Characteristic value attribute: Hi
Connect to BL654 and send a new value

New characteristic value: Laird
Exiting...
```

5.9.18 BleCharValueWrite

FUNCTION

This function writes new data into the VALUE attribute of a Characteristic, which is in turn identified by a composite handle returned by the function BleCharCommit().

BLECHARVALUEWRITE (charHandle, attr\$)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
charHandle	byVal charHandle AS INTEGER This is the handle to the characteristic whose value must be updated which was returned when BleCharCommit() was called.
attr\$	byRef attr\$ AS STRING String variable, contains new value to write to the characteristic.

Example:

```
// Example :: BleCharValueWrite.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM hMyChar,rc

//=====
// Initialise and instantiate service, characteristic,
//=====
FUNCTION OnStartup()
    DIM rc, hSvc, attr$ : attr$="Hi"

    //commit service
    rc = BleServiceNew(1, BleHandleUuid16(0x18EE), hSvc)
    //initialise char, write/read enabled, accept signed writes
    rc=BleCharNew(0x4A,BleHandleUuid16(1),BleAttrMetaData(1,1,20,0,rc),0,0)
    //commit char initialised above, with initial value "hi" to service 'hSvc'
    rc=BleCharCommit(hSvc,attr$,hMyChar)
    //commit changes to service
    rc = BleServiceCommit(hSvc)
ENDFUNC rc

//=====
// Uart Rx handler - write input to characteristic
//=====
FUNCTION HndlrUartRx()
    TimerStart(0,10,0)
ENDFUNC 1

//=====
// Timer0 timeout handler
//=====
FUNCTION HndlrTmr0()
    DIM t$ : rc=UartRead(t$)
    rc = BleCharValueWrite(hMyChar,t$)
    IF rc==0 THEN
        PRINT "\nNew characteristic value: ";t$
    ELSE
        PRINT "\nFailed to write new characteristic value ";integer.h'rc;"\n"
    ENDIF
ENDFUNC 0

IF OnStartup()==0 THEN
```



```

DIM at$ : rc = BleCharValueRead(hMyChar,at$)
PRINT "\nCharacteristic value attribute: ";at$;"\nType a new value\n"
ELSE
    PRINT "\nFailure OnStartup"
ENDIF

ONEVENT EVUARTRX    CALL HndlrUartRx
ONEVENT EVTMR0      CALL HndlrTmr0

WAITEVENT

PRINT "\nExiting..."

```

Expected Output:

```

Characteristic value attribute: Hi
Send a new value
Laird

New characteristic value: Laird
Exiting...

```

5.9.19 BleCharValueWriteEx

FUNCTION

This function writes new data into the VALUE attribute of a Characteristic, which is in turn identified by a composite handle returned by the function BleCharCommit(). It differs from the original BleCharValueWrite in that the offset at which to write the data can now be specified.

BLECHARVALUEWRITEEX (charHandle, offset, attr\$)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
charHandle	byVal charHandle AS INTEGER This is the handle to the characteristic whose value must be updated which was returned when BleCharCommit() was called.
offset	byVal charHandle AS INTEGER This is the offset at which to write the characteristic value.
attr\$	byRef attr\$ AS STRING String variable, contains new value to write to the characteristic.

See example for [EVAUTHVALEX](#)

5.9.20 BleCharValueNotify

FUNCTION

If there is BLE connection, this function writes new data into the VALUE attribute of a characteristic so that it can be sent as a notification to the GATT client. The characteristic is identified by a composite handle that is returned by the function BleCharCommit().

A notification does not result in an acknowledgement from the client.

BLECHARVALUENOTIFY (charHandle, attr\$)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
charHandle	byVal charHandle AS INTEGER This is the handle to the characteristic whose value must be updated which is returned when BleCharCommit() is called.
attr\$	byRef attr\$ AS STRING String variable containing new value to write to the characteristic and then send as a notification to the client. If there is no connection, this function fails with an appropriate result code.

Example:

```
// Example :: BleCharValueNotify.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM hMyChar,rc,at$,conHndl
//=====
// Initialise and instantiate service, characteristic, start adverts
//=====
FUNCTION OnStartup()
    DIM rc, hSvc, at$, attr$, adRpt$, addr$, scRpt$
    attr$="Hi"
    DIM mdCccd : mdCccd = BleAttrMetadata(1,1,2,0,rc) //CCCD metadata for char

    //Commit svc with handle 'hSvcUuid'
    rc=BleServiceNew(1, BleHandleUuid16(0x18EE), hSvc)
    //initialise char, write/read enabled, accept signed writes, notifiable
    rc=BleCharNew(0x12,BleHandleUuid16(1),BleAttrMetadata(1,0,20,0,rc),mdCccd,0)
    //commit char initialised above, with initial value "hi" to service 'hMyChar'
    rc=BleCharCommit(hSvc,attr$,hMyChar)
    //commit changes to service
    rc=BleServiceCommit(hSvc)
    rc=BleScanRptInit(scRpt$)
    //Add 1 service handle to scan report
    rc=BleAdvRptAddUuid16(scRpt$,0x18EE,-1,-1,-1,-1,-1)
    //commit reports to GATT table - adRpt$ is empty
    rc=BleAdvRptsCommit(adRpt$,scRpt$)
    rc=BleAdvertStart(0,addr$,50,0,0)
ENDFUNC rc

//=====
// Close connections so that we can run another app without problems
//=====
SUB CloseConnections()
    rc=BleDisconnect(conHndl)
    rc=BleAdvertStop()
ENDSUB

//=====
// Ble event handler
```

```
//=====
FUNCTION HndlrBleMsg (BYVAL nMsgId, BYVAL nCtx)
    conHndl=nCtx
    IF nMsgID==1 THEN
        PRINT "\n\n--- Disconnected from client"
        EXITFUNC 0
    ELSEIF nMsgID==0 THEN
        PRINT "\n--- Connected to client"
    ENDIF
ENDFUNC 1

//=====
// CCCD descriptor written handler
//=====
FUNCTION HndlrCharCccd (BYVAL charHandle, BYVAL nVal) AS INTEGER
    DIM value$
    IF charHandle==hMyChar THEN
        PRINT "\nCCCD Val: ";nVal
        IF nVal THEN
            PRINT " : Notifications have been enabled by client"
            value$="hello"
            IF BleCharValueNotify(hMyChar,value$)!=0 THEN
                PRINT "\nFailed to notify new value :";INTEGER.H'rc
            ELSE
                PRINT "\nSuccessful notification of new value"
                EXITFUNC 0
            ENDIF
        ELSE
            PRINT " : Notifications have been disabled by client"
        ENDIF
    ELSE
        PRINT "\nThis is for some other characteristic"
    ENDIF
ENDFUNC 1

ONEVENT EVBLEMSG CALL HndlrBleMsg
ONEVENT EVCHARCCCD CALL HndlrCharCccd

IF OnStartup()==0 THEN
    rc = BleCharValueRead(hMyChar,at$)
    PRINT "\nCharacteristic Value: ";at$
    PRINT "\nYou can connect and write to the CCCD characteristic."
    PRINT "\nThe BL654 will then notify your device of a new characteristic value\n"
ELSE
    PRINT "\nFailure OnStartup"
ENDIF

WAITEVENT

CloseConnections()
PRINT "\nExiting..."
```

Expected Output:

```
Characteristic Value: Hi
You can connect and write to the CCCD characteristic.
The BL654 will then notify your device of a new characteristic value

--- Connected to client
CCCD Val: 0 : Notifications have been disabled by client
CCCD Val: 1 : Notifications have been enabled by client
Successful notification of new value
Exiting...
```

5.9.21 BleCharValueIndicate

FUNCTION

If there is BLE connection, this function is used to write new data into the VALUE attribute of a characteristic so that it can be sent as an indication to the GATT client. The characteristic is identified by a composite handle returned by the function BleCharCommit().

An indication results in an acknowledgement from the client and that is presented to the *smart*BASIC application as the EVCHARHVC event.

BLECHARVALUEINDICATE (charHandle, attr\$)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
charHandle	byVal charHandle AS INTEGER This is the handle to the characteristic whose value must be updated which is returned when BleCharCommit() was called.
attr\$	byRef attr\$ AS STRING String variable containing new value to write to the characteristic and then to send as a notification to the client. If there is no connection, this function fails with an appropriate result code.

Example:

```
// Example :: BleCharValueIndicate.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples
DIM hMyChar, rc, at$, conHndl

//=====
// Initialise and instantiate service, characteristic, start adverts
//=====
FUNCTION OnStartup()
    DIM rc, hSvc, at$, attr$, adRpt$, addr$, scRpt$
    attr$="Hi"
    DIM mdCccd : mdCccd = BleAttrMetadata(1,1,2,0,rc) //CCCD metadata for char

    //Commit svc with handle 'hSvcUuid'
    rc=BleServiceNew(1, BleHandleUuid16(0x18EE), hSvc)
    //initialise char, write/read enabled, accept signed writes, notifiable
    rc=BleCharNew(0x22,BleHandleUuid16(1),BleAttrMetaData(1,0,20,0,rc),mdCccd,0)
    //commit char initialised above, with initial value "hi" to service 'hMyChar'
    rc=BleCharCommit(hSvc,attr$,hMyChar)
    //commit changes to service
    rc=BleServiceCommit(hSvc)
    rc=BleScanRptInit(scRpt$)
    //Add 1 service handle to scan report
    rc=BleAdvRptAddUuid16(scRpt$,0x18EE,-1,-1,-1,-1,-1)
    //commit reports to GATT table - adRpt$ is empty
    rc=BleAdvRptsCommit(adRpt$,scRpt$)
    rc=BleAdvertStart(0,addr$,50,0,0)
ENDFUNC rc

//=====
// Ble event handler
//=====
FUNCTION HndlrBleMsg(BYVAL nMsgId, BYVAL nCtx)
    conHndl=nCtx
    IF nMsgID==1 THEN
        PRINT "\n\n--- Disconnected from client"
        EXITFUNC 0
    ELSEIF nMsgID==0 THEN
```

```

        PRINT "\n--- Connected to client"
    ENDIF
ENDFUNC 1

//=====
// CCCD descriptor written handler
//=====
FUNCTION HndlrCharCccd(BYVAL charHandle, BYVAL nVal)
    DIM value$
    IF charHandle==hMyChar THEN
        PRINT "\nCCCD Val: ";nVal
        IF nVal THEN
            PRINT " : Indications have been enabled by client"
            value$="hello"
            rc=BleCharValueIndicate(hMyChar,value$)
            IF rc!=0 THEN
                PRINT "\nFailed to indicate new value :";INTEGER.H'rc
            ELSE
                PRINT "\nSuccessful indication of new value"
                EXITFUNC 1
            ENDIF
        ELSE
            PRINT " : Indications have been disabled by client"
        ENDIF
    ELSE
        PRINT "\nThis is for some other characteristic"
    ENDIF
ENDFUNC 1

//=====
// Indication Acknowledgement Handler
//=====
FUNCTION HndlrChrHvc(BYVAL charHandle)
    IF charHandle == hMyChar THEN
        PRINT "\n\nGot confirmation of recent indication"
    ELSE
        PRINT "\n\nGot confirmation of some other indication: ";charHandle
    ENDIF
ENDFUNC 0

ONEVENT EVBLEMSG    CALL HndlrBleMsg
ONEVENT EVCHARCCCD  CALL HndlrCharCccd
ONEVENT EVCHARHVC   CALL HndlrChrHvc

IF OnStartup()==0 THEN
    rc = BleCharValueRead(hMyChar,at$)
    PRINT "\nCharacteristic Value: ";at$
    PRINT "\nYou can connect and write to the CCCD characteristic."
    PRINT "\nThe BL654 will then indicate a new characteristic value\n"
ELSE
    PRINT "\nFailure OnStartup"
ENDIF

WAITEVENT

rc=BleDisconnect(conHndl)
rc=BleAdvertStop()
PRINT "\nExiting..."

```

Expected Output:

```
Characteristic Value: Hi
You can connect and write to the CCCD characteristic.
The BL654 will then indicate a new characteristic value

--- Connected to client
CCCD Val: 0 : Indications have been disabled by client
CCCD Val: 2 : Indications have been enabled by client
Successful indication of new value

Got confirmation of recent indication
Exiting...
```

5.9.22 BleCharDescRead

FUNCTION

This function reads the current content of a writable Characteristic Descriptor identified by the two parameters supplied in the **EVCHARDESC** event message after a GATT client writes to it.

In most cases a local read is performed when a GATT client writes to a characteristic descriptor attribute. The write event is presented asynchronously to the *smart*BASIC application in the form of an **EVCHARDESC** event and so this function is most often accessed from the handler that services that event.

BLECHARDESCREAD (*charHandle*, *nDescHandle*, *nOffset*, *nLength*, *nDescUuidHandle*, *attr\$*)

Returns	INTEGER, a result code. The typical value is 0x0000, indicating a successful operation.
Arguments:	
charHandle	byVal charHandle AS INTEGER This is the handle to the characteristic whose descriptor must be read which is returned when BleCharCommit() is called and is been supplied in the EVCHARDESC event message.
nDescHandle	byVal nDescHandle AS INTEGER This is an index into an opaque array of descriptor handles inside the charHandle and is supplied as the second parameter in the EVCHARDESC event message.
nOffset	byVal nOffset AS INTEGER This is the offset into the descriptor attribute from which the data should be read and copied into attr\$.
nLength	byVal nLength AS INTEGER This is the number of bytes to read from the descriptor attribute from offset nOffset and copied into attr\$.
nDescUuidHandle	byRef nDescUuidHandle AS INTEGER On exit, this is updated with the uuid handle of the descriptor that got updated.
attr\$	byRef attr\$ AS STRING On exit, this string variable contains the new value from the characteristic descriptor.

Example:

```
// Example :: BleCharDescRead.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples
DIM rc, conHndl, hMyChar

//-----
//Create some PRIMARY service attribure which has a uuid of 0x18FF
//-----
SUB OnStartup()
    DIM hSvc, attr$, scRpt$, adRpt$, addr$
```

```

rc = BleServiceNew(1, BleHandleUuid16(0x18FF), hSvc)
//Add one or more characteristics
rc = BleCharNew(0x0a,BleHandleUuid16(0x2AFF),BleAttrMetadata(1,1,20,1,rc),0,0)

//Add a user description
DIM s$ : s$="You can change this"
rc=BleCharDescUserDesc(s$,BleAttrMetadata(1,1,20,0,rc))

attr$="\00" //no initial alert
rc = BleCharCommit(hSvc,attr$,hMyChar)
//Commit the service
rc = BleServiceCommit(hSvc)
rc=BleScanRptInit(scRpt$)
//Add 1 char handle to scan report
rc=BleAdvRptAddUuid16(scRpt$,0x2AFF,-1,-1,-1,-1)
//commit reports to GATT table - adRpt$ is empty
rc=BleAdvRptsCommit(adRpt$,scRpt$)
rc=BleAdvertStart(0,addr$,200,0,0)
ENDSUB

//=====
// Close connections so that we can run another app without problems
//=====
SUB CloseConnections()
    rc=BleDisconnect(conHndl)
    rc=BleAdvertStop()
ENDSUB

//=====
// Ble event handler - Just to get the connection handle
//=====
FUNCTION HndlrBleMsg(BYVAL nMsgId, BYVAL nCtx)
    conHndl=nCtx
ENDFUNC 1

//=====
// Handler to service writes to descriptors by a GATT client
//=====
FUNCTION HandlerCharDesc(BYVAL hChar AS INTEGER, BYVAL hDesc AS INTEGER)
    DIM instnc,nUuid,a$, offset,duid

    IF hChar == hMyChar THEN
        rc = BleCharDescRead(hChar,hDesc,0,20,duid,a$)
        IF rc==0 THEN
            PRINT "\nRead 20 bytes from index ";offset;" in new char value."
            PRINT "\n  ::New Descriptor Data:  ";StrHexize$(a$);
            PRINT "\n  ::Length=";StrLen(a$)
            PRINT "\n  ::Descriptor UUID  ";integer.h' duid
            EXITFUNC 0
        ELSE
            PRINT "\nCould not access the uuid"
        ENDIF
    ELSE
        PRINT "\nThis is for some other characteristic"
    ENDIF
ENDFUNC 1

//install a handler for writes to characteristic values
ONEVENT EVCHARDESC CALL HandlerCharDesc
ONEVENT EVBLEMSG CALL HndlrBleMsg

```

```
OnStartup()  
PRINT "\nWrite to the User Descriptor with UUID 0x2999"  
  
//wait for events and messages  
WAITEVENT  
  
CloseConnections()  
PRINT "\nExiting..."
```

Expected Output:

```
Write to the User Descriptor with UUID 0x2999  
Read 20 bytes from index 0 in new char value.  
  ::New Descriptor Data:  4C61697264  
  ::Length=5  
  ::Descriptor UUID    FE012999  
Exiting...
```

5.9.23 BleAuthorizeChar

FUNCTION

This function is used to grant or deny a read or write access of characteristic and is called in the handler for the event EVAUTHVAL. When the function returns and if write access was requested and granted then the characteristic value is deemed to be updated and so function BleCharValueRead() can be used to get the new value.

BLEAUTHORIZECHAR (*connHandle*, *charHandle*, *readWrite*)

Returns	INTEGER, a result code. Typical value: 0x0000 (indicates a successful operation)
Arguments	
<i>connHandle</i>	byVal <i>connHandle</i> AS INTEGER This is the connection handle of the gatt client requesting the read or write access and will have been supplied in the EVAUTHVAL message.
<i>charHandle</i>	byVal <i>charHandle</i> AS INTEGER This is the handle to the characteristic whose value must be read which was returned when BleCharCommit() was called and will have been supplied in the EVAUTHVAL event message.
<i>readWrite</i>	byVal <i>readWrite</i> AS INTEGER This will be to • 0 to deny read access • 1 to allow read access • 2 to deny write access • 3 to allow write access

```
//Example :: See description for EVAUTHVAL
```


5.9.24 BleAuthorizeDesc

FUNCTION

This function is used to grant or deny a read or write access of characteristic descriptor and is called in the handler for the three events EVAUTHCCCD, EVAUTHSCCD and EVAUTHDESC. When the function returns and if write access was requested and granted then the characteristic descriptor value is deemed to be updated and so function BleCharDescRead() can be used to get the new value of the descriptor when the event is EVAUTHDESC. For events EVAUTHCCCD and EVAUTHSCCD the event itself will have supplied the new value.

BLEAUTHORIZEDESC (*connHandle*, *charHandle*, *nDescType*, *readWrite*)

Returns	INTEGER, a result code. Typical value: 0x0000 (indicates a successful operation)
Arguments	
connHandle	byVal connHandle AS INTEGER This is the connection handle of the gatt client requesting the read or write access and will have been supplied in the EVAUTHVAL message.
charHandle	byVal charHandle AS INTEGER This is the handle to the characteristic whose descriptor must be read which was returned when BleCharCommit() was called and will have been supplied in the EVAUTHVAL event message.
nDescType	byVal nDescType AS INTEGER This is as was supplied in the EVAUTHDESC event
readWrite	byVal readWrite AS INTEGER This will be to • 0 to deny read access • 1 to allow read access • 2 to deny write access • 3 to allow write access

//Example :: See description for EVAUTHCCCD, EVAUTHSCCD or EVAUTHDESC

5.9.25 BleServiceChangedNtfy

FUNCTION

This function causes an indication of the Service Changed Characteristic of the GATT Service and specifies a start attribute handle and an end attribute handle, which the client shall mark as changed so that it can update it's cache if need be.

The EVBLEMSG event will be thrown with subevent ID set to **BLE_EVBLEMSGID_SVCCHNG_IND_CNF** when other indications can be sent.

Note that if on connection to a bonded device the CCCD CRC does not match with the current GATT table then a Service Change Indication is automatically sent to the client. Additionally, the local application is sent the event **BLE_EVBLEMSGID_SVCCHNG_IND_SENT**.

BLESERVICECHANGEDNTFY (*nConnHandle*, *nStartHandle*, *nEndHandle*)

Returns	INTEGER, a result code. Typical value: 0x0000 (indicates a successful operation)
Arguments	

<i>nConnHandle</i>	byVal <i>nConnHandle</i> AS INTEGER. Specifies the handle of the connection that must be disconnected.
<i>nStartHandle</i>	byVal <i>nStartHandle</i> AS INTEGER. Specifies the start attribute handle of GATT table that has changed. Set to 0 to mark the entire table as changed.
<i>nEndHandle</i>	byVal <i>nEndHandle</i> AS INTEGER. Specifies the end attribute handle of GATT table that has changed. Set to 0 to mark the entire table as changed.

5.10 GATT Client Functions

This section describes all functions related to GATT client capability which enables interaction with GATT servers of a connected BLE device. The Bluetooth Specification 4.0 and newer allows for a device to be a GATT server and/or GATT client simultaneously; the fact that a peripheral mode device accepts a connection and has a GATT server table does not preclude it from interacting with a GATT table in the central role device with which it is connected.

These GATT client functions allow the developer to discover services, characteristics and descriptors, read and write to characteristics and descriptors, and handle either notifications or indications.

To interact with a remote GATT server, it is important to have a good understanding of how it is constructed. It is best to see it as a table consisting of many rows and three visible columns (handle, type, value) and at least one more invisible column whose content affects access to the data column.

16 bit Handle	Type (16 or 128 bit)	Value (1 to 512 bytes)	Permissions

These rows are grouped into collections called services and characteristics. The grouping is achieved by creating a row with Type = 0x2800 or 0x2801 for services (primary and secondary respectively) and 0x2803 for characteristics.

A table should be scanned from top to bottom; the specification stipulates that the 16-bit handle field contains values in the range 1 to 65535 and SHALL be in ascending order. Gaps are allowed.

When scanning, if a row is encountered with the value 0x2800 or 0x2801 in the Type column, then it is understood as the start of a primary or secondary service which in turn contains at least one characteristic or one 'included service' which have Type=0x2803 and 0x2802 respectively.

When a row with Type = 0x2803 (a characteristic) is encountered, then the next row contains the value for that characteristic; afterwards, there may be zero or more descriptors.

This means each characteristic consists of at least two rows in the table; and if descriptors exist for that characteristic, then a single row per descriptor.

Handle	Type	Value	Comments
0x0001	0x2800	UUID of the Service	Primary Service 1 Start
0x0002	0x2803	Properties, Value Handle, Value UUID1	Characteristic 1 Start
0x0003	Value UUID1	Value : 1 to 512 bytes	Actual data
0x0004	0x2803	Properties, Value Handle, Value UUID2	Characteristic 2 Start
0x0005	Value UUID2	Value : 1 to 512 bytes	Actual data
0x0006	0x2902	Value	Descriptor 1(CCCD)
0x0007	0x2903	Value	Descriptor 2 (SCCD)
0x0008	0x2800	UUID of the Service	Primary Service 2 Start
0x0009	0x2803	Properties, Value Handle, Value UUID3	Characteristic 1 Start

Handle	Type	Value	Comments
0x000A	Value UUID3	Value : 1 to 512 bytes	Actual data
0x000B	0x2800	UUID of the Service	Primary Service 3 Start
0x000C	0x2803	Properties, Value Handle, Value UUID3	Characteristic 3 Start
0x000D	Value UUID3	Value : 1 to 512 bytes	Actual data
0x000E	0x2902	Value	Descriptor 1(CCCD)
0x000F	0x2903	Value	Descriptor 2 (SCCD)
0x0010	0x2904	Value (presentation format data)	Descriptor 3
0x0011	0x2906	Value (valid range)	Descriptor 4 (Range)

A colour highlighted example of a GATT server table is shown above. There are three **services** (at handles 0x0001, 0x0008 and 0x000B) because there are three rows where the Type = 0x2800. All rows up to the next instance of a row with Type=0x2800 or 2801 belong to that service.

In each group of rows for a service, there is one or more **characteristics** where Type=0x2803. For example the service beginning at handle 0x0008 has one characteristic which contains two rows identified by handles 0x0009 and 0x000A and the actual value for the characteristic starting at 0x0009 is in the row identified by 0x000A.

Likewise, each characteristic starts with a row with Type=0x2803 and all rows following it (up to a row with type = 0x2800/2801/2803) are considered belonging to that characteristic. For example, the characteristic at row with handle = 0x0004 has the mandatory value row and then two **descriptors**.

The Bluetooth specification allows for multiple instances of the same service or characteristics or descriptors and they are differentiated by the unique handle. This ensures no ambiguity.

Each GATT server table allocates the handle numbers, the only stipulation being that they be in ascending order (gaps are allowed). This is important to understand because two devices containing the same services and characteristic and in EXACTLY the same order may NOT allocate the same handle values, especially if one device increments handles by 1 and another with some other arbitrary random value. The specification does stipulate that once the handle values are allocated, they are fixed for all subsequent connections unless the device exposes a GATT service which allows for indications to the client that the handle order has changed and thus force it to flush its cache and rescan the GATT table.

When a connection is first established, there is no prior knowledge as to which services exist or their handles. Therefore, the GATT protocol which is used to interact with GATT servers, provides procedures that allow for the GATT table to be scanned so that the client can ascertain which services are offered. This section describes *smart*BASIC functions which encapsulate and manage those procedures to enable a *smart*BASIC application to map the table.

These helper functions have been written to help gather the handles of all the rows which contain the value type for appropriate characteristics as those are the ones that will be read or written to. The *smart*BASIC internal engine also maintains data objects so that it is possible to interact with descriptors associated with the characteristic.

Basically, the table scanning process reveals characteristic handles (as handles of handles) which are used in other GATT client related *smart*BASIC functions to interact with the table to, for example, read/write or accept and process incoming notifications and indications.

This approach ensures that the least amount of RAM resource is required to implement a GATT client and, given that these procedures operate at speeds many orders of magnitude slower compared to the speed of the CPU and energy consumption is to be kept as low as possible, the response to a command is delivered asynchronously as an event for which a handler must be specified in the user *smart*BASIC application.

The rest of this chapter details all GATT client commands, responses, and events along with example code demonstrating usage and expected output.

5.10.1 Events and Messages

The nature of GATT client operation consists of multiple queries and acting on the responses. Because the connection intervals are slower than the CPU speed, responses can arrive many tens of milliseconds after the procedure is triggered; these are delivered to an application using an event or message. Since these event/messages are tightly coupled with the appropriate commands, all but one is described when the command that triggers them is described.

The event EVGATTCTOUT is applicable for all GATT client-related functions which result in transactions over the air. The Bluetooth specification states that if an operation is initiated and is not completed within 30 seconds then the connection is dropped as no further GATT client transaction can be initiated.

5.10.1.1 EVGATTCTOUT

This event message is thrown if a GATT client transaction takes longer than 30 seconds. It contains one INTEGER parameter:

- Connection Handle

Example:

```
// Example :: EVGATTCTOUT.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc, conHndl

//=====
// Initialise and instantiate service, characteristic, start adverts
//=====
FUNCTION OnStartup()
    DIM rc, adRpt$, addr$, scRpt$
    rc=BleAdvRptInit(adRpt$, 2, 0, 10)
    IF rc==0 THEN : rc=BleScanRptInit(scRpt$) : ENDIF
    IF rc==0 THEN : rc=BleAdvRptsCommit(adRpt$,scRpt$) : ENDIF
    IF rc==0 THEN : rc=BleAdvertStart(0,addr$,50,0,0) : ENDIF
    //open the GATT client with default notify/indicate ring buffer size
    IF rc==0 THEN : rc = BleGATTcOpen(0,0) : ENDIF
ENDFUNC rc

//=====
// Ble event handler
//=====
FUNCTION HndlrBleMsg(BYVAL nMsgId, BYVAL nCtx)
    conHndl=nCtx
    IF nMsgID==1 THEN
        PRINT "\n\n- Disconnected"
        EXITFUNC 0
    ELSEIF nMsgID==0 THEN
        PRINT "\n- Connected"
    ENDIF
ENDFUNC 1

'//=====
'//=====
FUNCTION HandlerGATTcTout(cHndl) AS INTEGER
    PRINT "\nEVGATTCTOUT connHandle=";cHndl
ENDFUNC 1

//=====
// Main() equivalent
//=====
ONEVENT EVBLEMSG          CALL HndlrBleMsg
OnEvent EVGATTCTOUT       call HandlerGATTcTout

rc = OnStartup()
```

WAITEVENT

Expected Output:

```
. . .
. . .
EVGATTCTOUT connHandle=123
. . .
. . .
```

5.10.1.2 EVDISCPRIMSV

This event message is thrown if either BleDiscServiceFirst() or BleDiscServiceNext() returns a success. The message contains the following four INTEGER parameters:

- Connection Handle
- Service UUID Handle
- Start Handle of the service in the GATT table
- End Handle for the service

If no additional services were discovered because the end of the table was reached, then all parameters contain zero apart from the Connection Handle.

5.10.1.3 EVDISCCHAR

This event message is thrown if either BleDiscCharFirst() or BleDiscCharNext() returns a success. The message contains the following INTEGER parameters:

- Connection Handle
- Characteristic UUID Handle
- Characteristic properties
- Handle for the value attribute of the characteristic
- Included Service UUID Handle

If no more characteristics were discovered because the end of the table was reached, then all parameters contain zero apart from the Connection Handle.

'Characteristic Uuid Handle' contains the UUID of the characteristic and supplied as a handle.

'Characteristic Properties' contains the properties of the characteristic and is a bit mask as follows:

Bit 0	Set if BROADCAST is enabled
Bit 1	Set if READ is enabled
Bit 2	Set if WRITE_WITHOUT_RESPONSE is enabled
Bit 3	Set if WRITE is enabled
Bit 4	Set if NOTIFY is enabled
Bit 5	Set if INDICATE is enabled
Bit 6	Set if AUTHENTICATED_SIGNED_WRITE is enabled
Bit 7	Set if RELIABLE_WRITE is enabled

'Handle for the Value Attribute of the Characteristic' is the handle for the value attribute and is the value to store to keep track of important characteristics in a GATT server for later read/write operations.

'Included Service Uuid Handle' is for future use and is always 0.

5.10.1.4 EVDISCDESC

This event message is thrown if either BleDissDescFirst() or BleDiscDescNext() returns a success. The message contains the following INTEGER parameters:

- Connection Handle
- Descriptor Uuid Handle
- Handle for the Descriptor in the remote GATT Table

If no more descriptors were discovered because the end of the table was reached, then all parameters contain zero apart from the Connection Handle.

'Descriptor Uuid Handle' contains the UUID of the descriptor and is supplied as a handle.

'Handle for the Descriptor in the remote GATT Table' is the handle for the descriptor as well as the value to store to keep track of important characteristics in a GATT server for later read/write operations.

5.10.1.5 EVFINDCHAR

This event message is thrown if BleGATTcFindChar() returns a success. The message contains the following INTEGER parameters:

- Connection Handle
- Characteristic Properties
- Handle for the Value Attribute of the Characteristic
- Included Service Uuid Handle

If the specified instance of the service/characteristic is not present in the remote GATT server table, then all parameters contain zero apart from the Connection Handle.

'Characteristic Properties' contains the properties of the characteristic and is a bit mask as follows:

Bit	Description
0	Set if BROADCAST is enabled
1	Set if READ is enabled
2	Set if WRITE_WITHOUT_RESPONSE is enabled
3	Set if WRITE is enabled
4	Set if NOTIFY is enabled
5	Set if INDICATE is enabled
6	Set if AUTHENTICATED_SIGNED_WRITE is enabled
7	Set if RELIABLE_WRITE is enabled
15	Set if the characteristic has extended properties

'Handle for the Value Attribute of the Characteristic' is the handle for the value attribute and is the value to store to keep track of important characteristics in a GATT server for later read/write operations.

'Included Service Uuid Handle' is for future use and is always 0.

5.10.1.6 EVFINDDESC

This event message is thrown if BleGATTcFindDesc() returned a success. The message contains the following INTEGER parameters:

- Connection Handle
- Handle of the Descriptor

If the specified instance of the service/characteristic/descriptor is not present in the remote GATT server table, then all parameters contain zero apart from the Connection Handle.

'Handle of the Descriptor' is the handle for the descriptor and is the value to store to keep track of important descriptors in a GATT server for later read/write operations – for example, CCCDs to enable notifications and/or indications.

5.10.1.7 EVATTRREAD

This event message is thrown if `BleGattcRead()` returns a success. The message contains the following INTEGER parameters:

- Connection Handle
- Handle of the Attribute
- GATT status of the read operation

'**GATT status of the read operation**' is one of the following values, where 0 implies the read was successfully expedited and the data can be obtained by calling `BlePubGattClientReadData()`.

Hex	Dec	Description
0x0000	0	Success
0x0001	1	Unknown or not applicable status
0x0100	256	ATT Error: Invalid Error Code
0x0101	257	ATT Error: Invalid Attribute Handle
0x0102	258	ATT Error: Read not permitted
0x0103	259	ATT Error: Write not permitted
0x0104	260	ATT Error: Used in ATT as Invalid PDU
0x0105	261	ATT Error: Authenticated link required
0x0106	262	ATT Error: Used in ATT as Request Not Supported
0x0107	263	ATT Error: Offset specified was past the end of the attribute
0x0108	264	ATT Error: Used in ATT as Insufficient Authorisation
0x0109	265	ATT Error: Used in ATT as Prepare Queue Full
0x010A	266	ATT Error: Used in ATT as Attribute not found
0x010B	267	ATT Error: Attribute cannot be read or written using read/write blob requests
0x010C	268	ATT Error: Encryption key size used is insufficient
0x010D	269	ATT Error: Invalid value size
0x010E	270	ATT Error: Very unlikely error
0x010F	271	ATT Error: Encrypted link required
0x0110	272	ATT Error: Attribute type is not a supported grouping attribute
0x0111	273	ATT Error: Encrypted link required
0x0112	274	ATT Error: Reserved for Future Use range #1 begin
0x017F	383	ATT Error: Reserved for Future Use range #1 end
0x0180	384	ATT Error: Application range begin
0x019F	415	ATT Error: Application range end
0x01A0	416	ATT Error: Reserved for Future Use range #2 begin
0x01DF	479	ATT Error: Reserved for Future Use range #2 end
0x01E0	480	ATT Error: Reserved for Future Use range #3 begin
0x01FC	508	ATT Error: Reserved for Future Use range #3 end
0x01FD	509	ATT Common Profile and Service Error: Client Characteristic Config Descriptor (CCCD) improperly configured
0x01FE	510	ATT Common Profile and Service Error: Procedure Already in Progress
0x01FF	511	ATT Common Profile and Service Error: Out Of Range

5.10.1.8 EVATTRWRITE

This event message is thrown if `BleGattcWrite()` returns a success. The message contains the following INTEGER parameters:

- Connection Handle
- Handle of the Attribute
- GATT status of the write operation

'**GATT status of the write operation**' is one of the following values, where 0 implies the write was successfully expedited.

Hex	Dec	Description
0x0000	0	Success
0x0001	1	Unknown or not applicable status
0x0100	256	ATT Error: Invalid Error Code
0x0101	257	ATT Error: Invalid Attribute Handle


```

0x0102 258 ATT Error: Read not permitted
0x0103 259 ATT Error: Write not permitted
0x0104 260 ATT Error: Used in ATT as Invalid PDU
0x0105 261 ATT Error: Authenticated link required
0x0106 262 ATT Error: Used in ATT as Request Not Supported
0x0107 263 ATT Error: Offset specified was past the end of the attribute
0x0108 264 ATT Error: Used in ATT as Insufficient Authorisation
0x0109 265 ATT Error: Used in ATT as Prepare Queue Full
0x010A 266 ATT Error: Used in ATT as Attribute not found
0x010B 267 ATT Error: Attribute cannot be read or written using read/write blob requests
0x010C 268 ATT Error: Encryption key size used is insufficient
0x010D 269 ATT Error: Invalid value size
0x010E 270 ATT Error: Very unlikely error
0x010F 271 ATT Error: Encrypted link required
0x0110 272 ATT Error: Attribute type is not a supported grouping attribute
0x0111 273 ATT Error: Encrypted link required
0x0112 274 ATT Error: Reserved for Future Use range #1 begin
0x017F 383 ATT Error: Reserved for Future Use range #1 end
0x0180 384 ATT Error: Application range begin
0x019F 415 ATT Error: Application range end
0x01A0 416 ATT Error: Reserved for Future Use range #2 begin
0x01DF 479 ATT Error: Reserved for Future Use range #2 end
0x01E0 480 ATT Error: Reserved for Future Use range #3 begin
0x01FC 508 ATT Error: Reserved for Future Use range #3 end
0x01FD 509 ATT Common Profile and Service Error: Client Characteristic Config Descriptor
(CCCD)improperly configured
0x01FE 510 ATT Common Profile and Service Error:Procedure Already in Progress
0x01FF 511 ATT Common Profile and Service Error: Out Of Range

```

5.10.1.9 EVNOTIFYBUF

This event message is thrown if `BleGattWriteCmd()` returned a success. The message contains no parameters.

5.10.1.10 EVATTRNOTIFY

This event is thrown when a notification or an indication arrives from a GATT server. The event contains no parameters. Please note that if one notification/indication arrives or many, like in the case of UART events, the same event mask bit is asserted. The *smart*BASIC application is informed that it must go and service the ring buffer using the function `BleGattNotifyRead`. This event is only thrown if `at+cfg 213=0`. See [BleGattNotifyRead](#) for usage.

5.10.1.11 EVATTRNOTIFYEX

This message from the underlying BLE manager informs the app that the remote has sent characteristic notifications/indications. The difference between this event and `EVATTRNOTIFY` is that this event contains the paramers such as the connection handle and the notification data. `Data_length` and `strLen(Data$)` should be of equal length. This event is only thrown if `at+cfg 213=1`. See [BleGattNotifyRead](#) for usage.

The event comes with the following parameters:

- **Connection Handle** – The handle of the connection that wrote to the characteristic value.
- **Char Handle** – Characteristic handle for which the value is being notified.
- **Type** – 0: Invalid, 1: Notification, 2: Indication.
- **Data_Length** – The length of the data that was notified. If negative, then this value indicates the amount of data lost.
- **Data\$** - The string data that was notified from the attribute.

5.10.2 BleGattcOpen

FUNCTION

This function is used to initialise the GATT client functionality for immediate use so that appropriate buffers for caching GATT responses are created in the heap memory. About 300 bytes of RAM is required by the GATT client manager; given that a majority of BL654 use cases do not use it, the sacrifice of 300 bytes is not worth the permanent allocation of memory.

There are various buffers that are needed for scanning a remote GATT table which are of fixed size. The ring buffer can be configured by the *smart*BASIC apps developer; this buffer is used to store incoming notifiable and indicatable characteristics. At the time of writing this user guide, the default minimum size is 64 unless a bigger one is desired; in that case, the input parameter to this function specifies that size. A maximum of 2048 bytes is allowed, but this can result in unreliable operation as the *smart*BASIC runtime engine is quickly starved of memory.

Use SYSINFO(2019) to obtain the actual default size and SYSINFO(2020) to obtain the maximum allowed. The same information can be obtained in interactive mode using the commands AT+I2019 and AT+I2020 respectively.

Note: When the ring buffer for the notifiable and indicatable characteristics is full, then any new messages are discarded. Depending on the flags parameter, the indicates are or are not confirmed.

This function is safe to call when the GATT client manager is already open. However, in that case, the parameters are ignored and existing values are retained. Existing GATT client operations are not interrupted.

It is recommended that this function NOT be called when in a connection.

BLEGATTCPEN (nNotifyBufLen, nFlags)

Returns	INTEGER, a result code. The typical value is 0x0000, indicating a successful operation.
Arguments:	
nNotifyBufLen	byVal nNotifyBufLen AS INTEGER This is the size of the ring buffer used for incoming notifiable and indicatable characteristic data. Set to 0 to use the default size.
nFlags	byVal nFlags AS INTEGER Bit 0 – Set to 1 to disable automatic indication confirmations. If the buffer is full then the Handle Value Confirmation is only sent when BleGattcNotifyRead() is called to read the ring buffer. Bit 1..31 – Reserved for future use and must be set to 0s.

Example:

```
// Example :: BleGattcOpen.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples
DIM rc
//open the GATT client with default notify/indicate ring buffer size
rc = BleGattcOpen(0,0)
IF rc == 0 THEN
    PRINT "\nGATT Client is now open"
ENDIF
//open the client with default notify/indicate ring buffer size - again
rc = BleGattcOpen(128,1)
IF rc == 0 THEN
    PRINT "\nGATT Client is still open, because already open"
ENDIF
```

Expected Output:

```
GATT Client is now open
GATT Client is still open, because already open
```

5.10.3 BleGattcClose

SUBROUTINE

This function is used to close the GATT client manager and is safe to call if it is already closed.

It is recommended that this function NOT be called when in a connection.

BLEGATTCCLOSE ()

Returns	
Arguments	None

Example:

```
// Example :: BleGattcClose.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc
//open the GATT client with default notify/indicate ring buffer size
rc = BleGattcOpen(0,0)
IF rc == 0 THEN
    PRINT "\nGATT Client is now open"
ENDIF
BleGattcClose()
PRINT "\nGATT Client is now closed"
BleGattcClose()
PRINT "\nGATT Client is closed - was safe to call when already closed"
```

Expected Output:

```
GATT Client is now open
GATT Client is now closed
GATT Client is closed - was safe to call when already closed
```

5.10.4 BleDiscServiceFirst / BleDiscServiceNext

FUNCTIONS

This pair of functions is used to scan the remote GATT server for all primary services with the help of the EVDISCPRIMSVC message event. When called, a handler for the event message must be registered as the discovered primary service information is passed back in that message.

A generic or UUID-based scan can be initiated. The former scans for all primary services and the latter scans for a primary service with a particular UUID, the handle of which must be supplied and is generated by using either BleHandleUuid16() or BleHandleUuid128().

While the scan is in progress and waiting for the next piece of data from a GATT server, the module enters low power state as the WAITEVENT statement is used as normal to wait for events and messages.

Depending on the size of the remote GATT server table and the connection interval, the scan of all primary may take many hundreds of milliseconds. While this is in progress, it is safe to do other non-GATT-related operations such as servicing sensors and displays or any of the onboard peripherals.

BLEDISCSERVICEFIRST (connHandle, startAttrHandle, uuidHandle)

A typical pseudo code for discovering primary services involves first calling BleDiscServiceFirst(), then waiting for the EVDISCPRIMSVC event message and depending on the information returned in that message calling BleDiscServiceNext(), which in turn will result in another EVDISCPRIMSVC event message and typically is as follows:

```
Register a handler for the EVDISCPRIMSVC event message

On EVDISCPRIMSVC event message
    If Start/End Handle == 0 then scan is complete
```

```
Else Process information then
    call BleDiscServiceNext()
    if BleDiscServiceNext() not OK then scan complete

Call BleDiscServiceFirst()
If BleDiscServiceFirst() ok then Wait for EVDISCPRIMSVC
```

Returns	INTEGER, a result code. The typical value is 0x0000, indicating a successful operation. This means an EVDISCPRIMSVC event message is thrown by the <i>smart</i> BASIC runtime engine containing the results. A non-zero return value implies an EVDISCPRIMSVC message is NOT thrown.
Arguments:	
connHandle	byVal nConnHandle AS INTEGER This is the connection handle as returned in the on-connect event for the connection on which the remote GATT server can be accessed. This is returned in the EVBLEMSG event message with msgId == 0 and msgCtx is the connection handle.
startAttrHandle	byVal startAttrHandle AS INTEGER This is the attribute handle from where the scan for primary services will be started and you can typically set it to 0 to ensure that the entire remote GATT Server is scanned
uuidHandle	byVal uuidHandle AS INTEGER Set this to 0 if you want to scan for any service, otherwise this value will have been generated either by BleHandleUuid16() or BleHandleUuid128() or BleHandleUuidSibling().

BLEDISCSERVICENEXT (connHandle)

Calling this assumes that BleDiscServiceFirst() was called at least once to set up the internal primary services scanning state machine.

Returns	INTEGER, a result code. The typical value is 0x0000, indicating a successful operation and it means an EVDISCPRIMSVC event message is thrown by the <i>smart</i> BASIC runtime engine containing the results. A non-zero return value implies an EVDISCPRIMSVC message is not thrown.
Arguments:	
connHandle	byVal nConnHandle AS INTEGER This is the connection handle as returned in the on-connect event for the connection on which the remote GATT server can be accessed. This is returned in the EVBLEMSG event message with msgId == 0 and msgCtx is the connection handle

Example:

```
// Example :: BleDiscServiceFirst.Next.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

//
//Remote server has 5 prim services with 16 bit uuid and 3 with 128 bit uuids
// 3 of the 16 bit uuid are the same value 0xDEAD and
// 2 of the 128 bit uuids are also the same 112233445566778899AABBCCDDEEFF
//
// Server created using BleGATTcTblDiscPrimSvc.sub invoked in _OpenMcp.scr
// using Nordic Usb Dongle PC10000

DIM rc,at$,conHndl,uHndl,uuid$

//=====
// Initialise and instantiate service, characteristic, start adverts
//=====

FUNCTION OnStartup()
```

```

DIM rc, adRpt$, addr$, scRpt$
rc=BleAdvRptInit(adRpt$, 2, 0, 10)
IF rc==0 THEN : rc=BleScanRptInit(scRpt$) : ENDIF
IF rc==0 THEN : rc=BleAdvRptsCommit(adRpt$,scRpt$) : ENDIF
IF rc==0 THEN : rc=BleAdvertStart(0,addr$,50,0,0) : ENDIF
//open the GATT client with default notify/indicate ring buffer size
IF rc==0 THEN : rc = BleGattcOpen(0,0) : ENDIF
ENDFUNC rc

//=====
// Close connections so that we can run another app without problems
//=====
SUB CloseConnections()
    rc=BleDisconnect(conHndl)
    rc=BleAdvertStop()
ENDSUB

//=====
// Ble event handler
//=====
FUNCTION HndlrBleMsg (BYVAL nMsgId, BYVAL nCtx)
    DIM uu$
    conHndl=nCtx
    IF nMsgID==1 THEN
        PRINT "\n\n- Disconnected"
        EXITFUNC 0
    ELSEIF nMsgID==0 THEN

        PRINT "\n- Connected, so scan remote GATT Table for ALL services"
        rc = BleDiscServiceFirst(conHndl,0,0)
        IF rc==0 THEN
            //HandlerPrimSvc() will exit with 0 when operation is complete
            WAITEVENT

            PRINT "\nScan for service with uuid = 0xDEAD"
            uHndl = BleHandleUuid16(0xDEAD)
            rc = BleDiscServiceFirst(conHndl,0,uHndl)
            IF rc==0 THEN
                //HandlerPrimSvc() will exit with 0 when operation is complete
                WAITEVENT

                uu$ = "112233445566778899AABBCCDDEEFF00"
                PRINT "\nScan for service with custom uuid ";uu$
                uu$ = StrDehexize$(uu$)
                uHndl = BleHandleUuid128(uu$)
                rc = BleDiscServiceFirst(conHndl,0,uHndl)
                IF rc==0 THEN
                    //HandlerPrimSvc() will exit with 0 when operation is complete
                    WAITEVENT
                ENDIF
            ENDIF
        ENDIF
        CloseConnections()
    ENDIF
ENDFUNC 1

//=====
// EVDISCPRIMSV event handler
//=====
FUNCTION HandlerPrimSvc(cHndl,svcUuid,sHndl,eHndl) AS INTEGER
    PRINT "\nEVDISCPRIMSVC : "
    PRINT " cHndl=";cHndl

```

```

PRINT " svcUuid=";integer.h' svcUuid
PRINT " sHndl=";sHndl
PRINT " eHndl=";eHndl
IF sHndl == 0 THEN
    PRINT "\nScan complete"

    EXITFUNC 0
ELSE
    rc = BleDiscServiceNext(cHndl)
    IF rc != 0 THEN
        PRINT "\nScan abort"

        EXITFUNC 0
    ENDIF
ENDIF
endfunc 1

//=====
// Main() equivalent
//=====
ONEVENT  EVBLEMSG          CALL HndlrBleMsg
OnEvent  EVDISCPRIMSVCSVC  call HandlerPrimSvc

//Register base uuids with the underlying stack, otherwise the services with the
//128bit uuid's will be delivered with a uuid handle == FF000000 == UNKNOWN
uuid$ = "112233445566778899AABBCCDDEEFF00"
uuid$ = StrDehexize$(uuid$)
uHndl = BleHandleUuid128(uuid$)

uuid$ = "1122DEAD5566778899AABBCCDDBEEF00"
uuid$ = StrDehexize$(uuid$)
uHndl = BleHandleUuid128(uuid$)

IF OnStartup()==0 THEN
    PRINT "\nAdvertising, and GATT Client is open\n"
ELSE
    PRINT "\nFailure OnStartup"
ENDIF

WAITEVENT
PRINT "\nExiting..."

```

Expected Output:

```

Advertising, and GATT Client is open

- Connected, so scan remote GATT Table for ALL services
EVDISCPRIMSVCSVC : cHndl=2804 svcUuid=FE01FE01 sHndl=1 eHndl=3
EVDISCPRIMSVCSVC : cHndl=2804 svcUuid=FC033344 sHndl=4 eHndl=6
EVDISCPRIMSVCSVC : cHndl=2804 svcUuid=FE01DEAD sHndl=7 eHndl=9
EVDISCPRIMSVCSVC : cHndl=2804 svcUuid=FB04BEEF sHndl=10 eHndl=12
EVDISCPRIMSVCSVC : cHndl=2804 svcUuid=FC033344 sHndl=13 eHndl=15
EVDISCPRIMSVCSVC : cHndl=2804 svcUuid=FE01DEAD sHndl=16 eHndl=18
EVDISCPRIMSVCSVC : cHndl=2804 svcUuid=FE01FE03 sHndl=19 eHndl=21
EVDISCPRIMSVCSVC : cHndl=2804 svcUuid=FE01DEAD sHndl=22 eHndl=24
EVDISCPRIMSVCSVC : cHndl=2804 svcUuid=00000000 sHndl=0 eHndl=0
Scan complete
Scan for service with uuid = 0xDEAD
EVDISCPRIMSVCSVC : cHndl=2804 svcUuid=FE01DEAD sHndl=7 eHndl=9
EVDISCPRIMSVCSVC : cHndl=2804 svcUuid=FE01DEAD sHndl=16 eHndl=18
EVDISCPRIMSVCSVC : cHndl=2804 svcUuid=FE01DEAD sHndl=22 eHndl=65535
Scan abort

```

```
Scan for service with custom uuid 112233445566778899AABBCCDDEEFF00
EVDISCPRIMSVC : cHndl=2804 svcUuid=FC033344 sHndl=4 eHndl=6
EVDISCPRIMSVC : cHndl=2804 svcUuid=FC033344 sHndl=13 eHndl=15
EVDISCPRIMSVC : cHndl=2804 svcUuid=00000000 sHndl=0 eHndl=0
Scan complete

- Disconnected
Exiting...
```

5.10.5 BleDiscCharFirst / BleDiscCharNext

FUNCTIONS

These pair of functions are used to scan the remote GATT server for characteristics in a service with the help of the EVDISCCHAR message event. When called, a handler for the event message must be registered because the discovered characteristics information is passed back in that message.

A generic or UUID based scan can be initiated. The generic version scans for all characteristics; the UUID version scans for a characteristic with a particular UUID, the handle of which must be supplied and is generated by using either BleHandleUuid16() or BleHandleUuid128().

If a GATT table has a specific service and a specific characteristic, then it is more efficient to locate details of that characteristic by using the function BleGATTcFindChar(). This function is described later.

While the scan is in progress and waiting for the next piece of data from a GATT server, the module enters low power state as the WAITEVENT statement is used as normal to wait for events and messages.

Depending on the size of the remote GATT server table and the connection interval, the scan of all characteristics may take many hundreds of milliseconds. While this is in progress, it is safe to do other non- GATT-related operations such as servicing sensors and displays or any of the onboard peripherals.

Note: It is not currently possible to scan for characteristics in included services. This is planned for a future release.

BLEDISCCHARFIRST (connHandle, charUuidHandle, startAttrHandle, endAttrHandle)

A typical pseudo code for discovering characteristic involves first calling BleDiscCharFirst() with information obtained from a primary services scan, waiting for the EVDISCCHAR event message, and (depending on the information returned in that message) calling BleDiscCharNext(). This in turn results in another EVDISCCHAR event message and typically is as follows:

Register a handler for the EVDISCCHAR event message

On EVDISCCHAR event message

 If Char Value Handle == 0 then scan is complete

 Else Process information then

 call BleDiscCharNext()

 if BleDiscCharNext() not OK then scan complete

Call BleDiscCharFirst(--information from EVDISCPRIMSVC)

If BleDiscCharFirst() ok then Wait for EVDISCCHAR

Returns	INTEGER, a result code. The typical value is 0x0000, indicating a successful operation and it means an EVDISCCHAR event message is thrown by the <i>smart</i>BASIC runtime engine containing the results. A non-zero return value implies an EVDISCCHAR message is not thrown.
Arguments:	
<i>connHandle</i>	byVal nConnHandle AS INTEGER This is the connection handle as returned in the on-connect event for the connection on which the remote GATT server can be accessed. This is returned in the EVBLEMSG event message with msgId == 0 and msgCtx is the connection handle.

charUuidHandle	byVal charUuidHandle AS INTEGER Set this to 0 if you want to scan for any characteristic in the service, otherwise this value is generated either by BleHandleUuid16() or BleHandleUuid128() or BleHandleUuidSibling().
startAttrHandle	byVal startAttrHandle AS INTEGER This is the attribute handle from where the scan for characteristic is started and is acquired by doing a primary services scan, which returns the start and end handles of services.
endAttrHandle	byVal endAttrHandle AS INTEGER This is the end attribute handle for the scan and is acquired by doing a primary services scan, which returns the start and end handles of services.

BLEDISCCHARNEXT (connHandle)

Calling this assumes that BleDiscCharFirst() has been called at least once to set up the internal characteristics scanning state machine. It scans for the next characteristic.

Returns	INTEGER, a result code. The typical value is 0x0000, indicating a successful operation. It means an EVDISCCHAR event message is thrown by the <i>smart</i> BASIC runtime engine containing the results. A non-zero return value implies an EVDISCCHAR message is not thrown.
Arguments:	
connHandle	byVal nConnHandle AS INTEGER This is the connection handle as returned in the on-connect event for the connection on which the remote GATT server can be accessed. This is returned in the EVBLEMSG event message with msgId == 0 and msgCtx is the connection handle.

Example:

```
// Example :: BleDiscCharFirst.Next.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

//
// Remote server has 1 prim service with 16 bit uuid and 8 characteristics where
// 5 uuids are 16 bit and 3 are 128 bit
// 3 of the 16 bit uuid are the same value 0xDEAD and
// 2 of the 128 bit uuids are also the same 112233445566778899AABBCCDDEEFF
//
// Server created using BleGATTcTblDiscChar.sub invoked in _OpenMcp.scr
// using Nordic Usb Dongle PC10000

DIM rc,at$,conHndl,uHndl,uuid$,sAttr,eAttr

//=====
// Initialise and instantiate service, characteristic, start adverts
//=====
FUNCTION OnStartup()
    DIM rc, adRpt$, addr$, scRpt$
    rc=BleAdvRptInit(adRpt$, 2, 0, 10)
    IF rc==0 THEN : rc=BleScanRptInit(scRpt$) : ENDIF
    IF rc==0 THEN : rc=BleAdvRptsCommit(adRpt$,scRpt$) : ENDIF
    IF rc==0 THEN : rc=BleAdvertStart(0,addr$,50,0,0) : ENDIF
    //open the GATT client with default notify/indicate ring buffer size
    IF rc==0 THEN : rc = BleGattcOpen(0,0) : ENDIF
ENDFUNC rc

//=====
// Close connections so that we can run another app without problems
//=====
SUB CloseConnections()
    rc=BleDisconnect(conHndl)
```

```

    rc=BleAdvertStop()
ENDSUB

//=====
// Ble event handler
//=====
FUNCTION HndlrBleMsg (BYVAL nMsgId, BYVAL nCtx)
    DIM uu$
    conHndl=nCtx
    IF nMsgID==1 THEN
        PRINT "\n\n- Disconnected"
        EXITFUNC 0
    ELSEIF nMsgID==0 THEN
        PRINT "\n- Connected, so scan remote GATT Table for first service"
        PRINT "\n- and a characteristic scan will be initiated in the event"
        rc = BleDiscServiceFirst(conHndl,0,0)
        IF rc==0 THEN
            //wait for start and end handles for first primary service
            WAITEVENT
            PRINT "\n\nScan for characteristic with uuid = 0xDEAD"
            uHndl = BleHandleUuid16(0xDEAD)
            rc = BleDiscCharFirst(conHndl,uHndl,sAttr,eAttr)
            IF rc == 0 THEN
                //HandlerCharDisc() will exit with 0 when operation is complete
                WAITEVENT
                uu$ = "112233445566778899AABBCCDDEEFF00"
                PRINT "\n\nScan for service with custom uuid ";uu$
                uu$ = StrDehexize$(uu$)
                uHndl = BleHandleUuid128(uu$)
                rc = BleDiscCharFirst(conHndl,uHndl,sAttr,eAttr)
                IF rc==0 THEN
                    //HandlerCharDisc() will exit with 0 when operation is complete
                    WAITEVENT
                ENDIF
            ENDIF
        ENDIF
    ENDIF
    CloseConnections()
ENDIF
ENDFUNC 1

//=====
// EVDISCPRIMSV event handler
//=====
FUNCTION HandlerPrimSvc(cHndl,svcUuid,sHndl,eHndl) AS INTEGER
    PRINT "\nEVDISCPRIMSV : "
    PRINT " cHndl=";cHndl
    PRINT " svcUuid=";integer.h' svcUuid
    PRINT " sHndl=";sHndl
    PRINT " eHndl=";eHndl
    IF sHndl == 0 THEN
        PRINT "\nPrimary Service Scan complete"
        EXITFUNC 0
    ELSE
        PRINT "\nGot first primary service so scan for ALL characteristics"
        sAttr = sHndl
        eAttr = eHndl
        rc = BleDiscCharFirst(conHndl,0,sAttr,eAttr)
        IF rc != 0 THEN
            PRINT "\nScan characteristics failed"
            EXITFUNC 0
        ENDIF
    ENDIF
ENDIF

```



```

endfunc 1

'//=====
// EVDISCCHAR event handler
'//=====
function HandlerCharDisc(cHndl,cUuid,cProp,hVal,isUuid) as integer
    print "\nEVDISCCHAR : "
    print " cHndl=";cHndl
    print " chUuid=";integer.h' cUuid
    print " Props=";cProp
    print " valHndl=";hVal
    print " ISvcUuid=";isUuid
    IF hVal == 0 THEN
        PRINT "\nCharacteristic Scan complete"
        EXITFUNC 0
    ELSE
        rc = BleDiscCharNext(conHndl)
        IF rc != 0 THEN
            PRINT "\nCharacteristics scan abort"
            EXITFUNC 0
        ENDIF
    ENDIF
endfunc 1

'//=====
// Main() equivalent
'//=====
ONEVENT EVBLEMSG          CALL HndlrBleMsg
OnEvent EVDISCPRIMSVCS    call HandlerPrimSvc
OnEvent EVDISCCHAR        call HandlerCharDisc

//Register base uuids with the underlying stack, otherwise the services with the
//128bit uuid's will be delivered with a uuid handle == FF000000 == UNKNOWN
uuid$ = "112233445566778899AABBCCDDEEFF00"
uuid$ = StrDehexize$(uuid$)
uHndl = BleHandleUuid128(uuid$)
uuid$ = "1122DEAD5566778899AABBCCDDBEEF00"
uuid$ = StrDehexize$(uuid$)
uHndl = BleHandleUuid128(uuid$)

IF OnStartup()==0 THEN
    PRINT "\nAdvertising, and GATT Client is open\n"
ELSE
    PRINT "\nFailure OnStartup"
ENDIF
WAITEVENT
PRINT "\nExiting..."

```

Expected Output:

```

Advertising, and GATT Client is open

- Connected, so scan remote GATT Table for first service
- and a characteristic scan will be initiated in the event
EVDISCPRIMSVCS : cHndl=3549 svcUuid=FE01FE02 sHndl=1 eHndl=17
Got first primary service so scan for ALL characteristics
EVDISCCHAR : cHndl=3549 chUuid=FE01FC21 Props=2 valHndl=3 ISvcUuid=0
EVDISCCHAR : cHndl=3549 chUuid=FC033344 Props=2 valHndl=5 ISvcUuid=0
EVDISCCHAR : cHndl=3549 chUuid=FE01DEAD Props=2 valHndl=7 ISvcUuid=0
EVDISCCHAR : cHndl=3549 chUuid=FB04BEEF Props=2 valHndl=9 ISvcUuid=0
EVDISCCHAR : cHndl=3549 chUuid=FC033344 Props=2 valHndl=11 ISvcUuid=0
EVDISCCHAR : cHndl=3549 chUuid=FE01FC23 Props=2 valHndl=13 ISvcUuid=0
EVDISCCHAR : cHndl=3549 chUuid=FE01DEAD Props=2 valHndl=15 ISvcUuid=0

```

```
EVDISCCHAR : cHndl=3549 chUuid=FE01DEAD Props=2 valHndl=17 ISvcUuid=0
EVDISCCHAR : cHndl=3549 chUuid=00000000 Props=0 valHndl=0 ISvcUuid=0
Characteristic Scan complete

Scan for characteristic with uuid = 0xDEAD
EVDISCCHAR : cHndl=3549 chUuid=FE01DEAD Props=2 valHndl=7 ISvcUuid=0
EVDISCCHAR : cHndl=3549 chUuid=FE01DEAD Props=2 valHndl=15 ISvcUuid=0
EVDISCCHAR : cHndl=3549 chUuid=FE01DEAD Props=2 valHndl=17 ISvcUuid=0
EVDISCCHAR : cHndl=3549 chUuid=00000000 Props=0 valHndl=0 ISvcUuid=0
Characteristic Scan complete

Scan for service with custom uuid 112233445566778899AABBCCDDEEFF00
EVDISCCHAR : cHndl=3549 chUuid=FC033344 Props=2 valHndl=5 ISvcUuid=0
EVDISCCHAR : cHndl=3549 chUuid=FC033344 Props=2 valHndl=11 ISvcUuid=0
EVDISCCHAR : cHndl=3549 chUuid=00000000 Props=0 valHndl=0 ISvcUuid=0
Characteristic Scan complete

- Disconnected
Exiting...
```

5.10.6 BleDiscDescFirst /BleDiscDescNext

FUNCTIONS

This pair of functions is used to scan the remote GATT server for descriptors in a characteristic with the help of the EVDISCDESC message event. When called, a handler for the event message must be registered because the discovered descriptor information is passed back in that message.

A generic or UUID-based scan can be initiated. The generic version scans for all descriptors; The UUID version scans for a descriptor with a particular UUID, the handle of which must be supplied and is generated by using either BleHandleUuid16() or BleHandleUuid128().

If a GATT table has a specific service, characteristic, and a specific descriptor, then it is more efficient to locate the characteristic's details by using the function BleGATTcFindDesc(). This is described later.

While the scan is in progress and waiting for the next piece of data from a GATT server, the module enters low power state as the WAITEVENT statement is used as normal to wait for events and messages.

Depending on the size of the remote GATT server table and the connection interval, the scan of all descriptors may take many hundreds of milliseconds. While this is in progress, it is safe to do other non-GATT-related operations such as servicing sensors and displays or any of the onboard peripherals.

BLEDISCDESCFIRST (connHandle, descUuidHandle, charValHandle)

A typical pseudo code for discovering descriptors involves first calling BleDiscDescFirst() with information obtained from a characteristics scan and then waiting for the EVDISCDESC event message. Depending on the information returned in that message, calling BleDiscDescNext() results in another EVDISCDESC event message and typically is as follows:

```
Register a handler for the EVDISCDESC event message

On EVDISCDESC event message
    If Descriptor Handle == 0 then scan is complete
    Else Process information then
        call BleDiscDescNext()
        if BleDiscDescNext() not OK then scan complete

Call BleDiscDescFirst( --information from EVDISCCHAR )
If BleDiscDescFirst() ok then Wait for EVDISCDESC
```

Returns

INTEGER, a result code.

The typical value is 0x0000, indicating a successful operation and it means an EVDISCDESC event message is thrown by the *smart*BASIC runtime engine containing the results. A non-

	zero return value implies an EVDISCDESC message is not thrown.
Arguments:	
connHandle	byVal nConnHandle AS INTEGER This is the connection handle as returned in the on-connect event for the connection on which the remote GATT server can be accessed. This is returned in the EVBLEMSG event message with msgId == 0 and msgCtx is the connection handle.
descUuidHandle	byVal descUuidHandle AS INTEGER Set this to 0 if you want to scan for any descriptor in the characteristic, otherwise this value is generated either by BleHandleUuid16() or BleHandleUuid128() or BleHandleUuidSibling().
charValHandle	byVal charValHandle AS INTEGER This is the value attribute handle of the characteristic on which the descriptor scan is to be performed. It will have been acquired from an EVDISCCHAR event.

BLEDISCDESCNEXT (connHandle)

Calling this assumes that BleDiscCharFirst() has been called at least once to set up the internal characteristics scanning state machine and that BleDiscDescFirst() has been called at least once to start the descriptor discovery process.

Returns	INTEGER, a result code. The typical value is 0x0000, indicating a successful operation and it means an EVDISCDESC event message is thrown by the <i>smart</i> BASIC runtime engine containing the results. A non-zero return value implies an EVDISCDESC message is not thrown.
Arguments:	
connHandle	byVal nConnHandle AS INTEGER This is the connection handle as returned in the on-connect event for the connection on which the remote GATT server can be accessed. This is returned in the EVBLEMSG event message with msgId == 0 and msgCtx is the connection handle.

Example:

```
// Example :: BleDiscDescFirst.Next.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

//
// Remote server has 1 prim service with 16 bit uuid and 1 characteristics
// which contains 8 descriptors, that are ...
// 5 uuids are 16 bit and 3 are 128 bit
// 3 of the 16 bit uuid are the same value 0xDEAD and
// 2 of the 128 bit uuids are also the same 112233445566778899AABBCCDDEEFF
//
// Server created using BleGATTcTblDiscDesc.sub invoked in _OpenMcp.scr
// using Nordic Usb Dongle PC10000

DIM rc,at$,conHndl,uHndl,uuid$,sAttr,eAttr,cValAttr

//=====
// Initialise and instantiate service, characteristic, start adverts
//=====
FUNCTION OnStartup()
  DIM rc, adRpt$, addr$, scRpt$
  rc=BleAdvRptInit(adRpt$, 2, 0, 10)
  IF rc==0 THEN : rc=BleScanRptInit(scRpt$) : ENDIF
  IF rc==0 THEN : rc=BleAdvRptsCommit(adRpt$,scRpt$) : ENDIF
  IF rc==0 THEN : rc=BleAdvertStart(0,addr$,50,0,0) : ENDIF
  //open the GATT client with default notify/indicate ring buffer size
```

```

    IF rc==0 THEN : rc = BleGattcOpen(0,0) : ENDIF
ENDFUNC rc
//=====
// Close connections so that we can run another app without problems
//=====
SUB CloseConnections()
    rc=BleDisconnect(conHndl)
    rc=BleAdvertStop()
ENDSUB

//=====
// Ble event handler
//=====
FUNCTION HndlrBleMsg(BYVAL nMsgId, BYVAL nCtx)
    DIM uu$
    conHndl=nCtx
    IF nMsgID==1 THEN
        PRINT "\n\n- Disconnected"
        EXITFUNC 0
    ELSEIF nMsgID==0 THEN
        PRINT "\n- Connected, so scan remote GATT Table for first service"
        PRINT "\n- and a characterisc scan will be initiated in the event"
        rc = BleDiscServiceFirst(conHndl,0,0)
        IF rc==0 THEN
            //wait for start and end handles for first primary service
            WAITEVENT
            PRINT "\n\nScan for descriptors with uuid = 0xDEAD"
            uHndl = BleHandleUuid16(0xDEAD)
            rc = BleDiscDescFirst(conHndl,uHndl,cValAttr)
            IF rc == 0 THEN
                //HandlerDescDisc() will exit with 0 when operation is complete
                WAITEVENT
                uu$ = "112233445566778899AABBCCDDEEFF00"
                PRINT "\n\nScan for service with custom uuid ";uu$
                uu$ = StrDehexize$(uu$)
                uHndl = BleHandleUuid128(uu$)
                rc = BleDiscDescFirst(conHndl,uHndl,cValAttr)
                IF rc==0 THEN
                    //HandlerDescDisc() will exit with 0 when operation is complete
                    WAITEVENT
                ENDIF
            ENDIF
        ENDIF
        CloseConnections()
    ENDIF
ENDFUNC 1

//=====
// EVDISCPRIMSVC event handler
//=====
FUNCTION HandlerPrimSvc(cHndl,svcUuid,sHndl,eHndl) AS INTEGER
    PRINT "\nEVDISCPRIMSVC :"
    PRINT " cHndl=";cHndl
    PRINT " svcUuid=";integer.h' svcUuid
    PRINT " sHndl=";sHndl
    PRINT " eHndl=";eHndl
    IF sHndl == 0 THEN
        PRINT "\nPrimary Service Scan complete"
        EXITFUNC 0
    ELSE
        PRINT "\nGot first primary service so scan for ALL characteristics"
        sAttr = sHndl
    ENDIF
ENDFUNC

```

```

        eAttr = eHndl
        rc = BleDiscCharFirst(conHndl,0,sAttr,eAttr)
        IF rc != 0 THEN
            PRINT "\nScan characteristics failed"
            EXITFUNC 0
        ENDIF
    ENDIF
endfunc 1

'//=====
// EVDISCCHAR event handler
'//=====
function HandlerCharDisc(cHndl,cUuid,cProp,hVal,isUuid) as integer
    print "\nEVDISCCHAR :"
    print " cHndl=";cHndl
    print " chUuid=";integer.h' cUuid
    print " Props=";cProp
    print " valHndl=";hVal
    print " ISvcUuid=";isUuid
    IF hVal == 0 THEN
        PRINT "\nCharacteristic Scan complete"
        EXITFUNC 0
    ELSE
        PRINT "\nGot first characteristic service at handle ";hVal
        PRINT "\nScan for ALL Descs"
        cValAttr = hVal
        rc = BleDiscDescFirst(conHndl,0,cValAttr)
        IF rc != 0 THEN
            PRINT "\nScan descriptors failed"
            EXITFUNC 0
        ENDIF
    ENDIF
endfunc 1

'//=====
// EVDISCDESC event handler
'//=====
function HandlerDescDisc(cHndl,cUuid,hndl) as integer
    print "\nEVDISCDESC"
    print " cHndl=";cHndl
    print " dscUuid=";integer.h' cUuid
    print " dscHndl=";hndl
    IF hndl == 0 THEN
        PRINT "\nDescriptor Scan complete"
        EXITFUNC 0
    ELSE
        rc = BleDiscDescNext(cHndl)
        IF rc != 0 THEN
            PRINT "\nDescriptor scan abort"
            EXITFUNC 0
        ENDIF
    ENDIF
endfunc 1

//=====
// Main() equivalent
//=====
ONEVENT  EVBLEMSG          CALL HndlrBleMsg
OnEvent  EVDISCPRIMSVCSVC call HandlerPrimSvc
OnEvent  EVDISCCHAR        call HandlerCharDisc
OnEvent  EVDISCDESC        call HandlerDescDisc

```

```
//Register base uuids with the underlying stack, otherwise the services with the
//128bit uuid's will be delivered with a uuid handle == FF000000 == UNKNOWN
uuid$ = "112233445566778899AABBCCDDEEFF00"
uuid$ = StrDehexize$(uuid$)
uHndl = BleHandleUuid128(uuid$)
uuid$ = "1122DEAD5566778899AABBCCDDBEEF00"
uuid$ = StrDehexize$(uuid$)
uHndl = BleHandleUuid128(uuid$)

IF OnStartup()==0 THEN
    PRINT "\nAdvertising, and GATT Client is open\n"
ELSE
    PRINT "\nFailure OnStartup"
ENDIF

WAITEVENT
PRINT "\nExiting..."
```

Expected Output:

```
Advertising, and GATT Client is open

- Connected, so scan remote GATT Table for first service
- and a characteristic scan will be initiated in the event
EVDISCPRIMSVC : cHndl=3790 svcUuid=FE01FE02 sHndl=1 eHndl=11
Got first primary service so scan for ALL characteristics
EVDISCCHAR : cHndl=3790 chUuid=FE01FC21 Props=2 valHndl=3 ISvcUuid=0
Got first characteristic service at handle 3
Scan for ALL Descs
EVDISCDESC cHndl=3790 dscUuid=FE01FD21 dscHndl=4
EVDISCDESC cHndl=3790 dscUuid=FC033344 dscHndl=5
EVDISCDESC cHndl=3790 dscUuid=FE01DEAD dscHndl=6
EVDISCDESC cHndl=3790 dscUuid=FB04BEEF dscHndl=7
EVDISCDESC cHndl=3790 dscUuid=FC033344 dscHndl=8
EVDISCDESC cHndl=3790 dscUuid=FE01FD23 dscHndl=9
EVDISCDESC cHndl=3790 dscUuid=FE01DEAD dscHndl=10
EVDISCDESC cHndl=3790 dscUuid=FE01DEAD dscHndl=11
EVDISCDESC cHndl=3790 dscUuid=00000000 dscHndl=0
Descriptor Scan complete

Scan for descriptors with uuid = 0xDEAD
EVDISCDESC cHndl=3790 dscUuid=FE01DEAD dscHndl=6
EVDISCDESC cHndl=3790 dscUuid=FE01DEAD dscHndl=10
EVDISCDESC cHndl=3790 dscUuid=FE01DEAD dscHndl=11
EVDISCDESC cHndl=3790 dscUuid=00000000 dscHndl=0
Descriptor Scan complete

Scan for service with custom uuid 112233445566778899AABBCCDDEEFF00
EVDISCDESC cHndl=3790 dscUuid=FC033344 dscHndl=5
EVDISCDESC cHndl=3790 dscUuid=FC033344 dscHndl=8
EVDISCDESC cHndl=3790 dscUuid=00000000 dscHndl=0
Descriptor Scan complete

- Disconnected
Exiting...
```

5.10.7 BleGattcFindChar

FUNCTION

This function facilitates an efficient way of locating the details of a characteristic if the UUID is known along with the UUID of the service containing it. The results are delivered in an EVFINDCHAR event message. If the GATT server table has multiple instances of the same service/characteristic combination then this function works because, in addition to the UUID handles to be searched for, it also accepts instance parameters which are indexed from 0. This means the fourth instance of a characteristic with the same UUID in the third instance of a service with the same UUID is located with index values 3 and 2 respectively.

Given that the results are returned in an event message, a handler **must** be registered for the EVFINDCHAR event.

Depending on the size of the remote GATT server table and the connection interval, the search of the characteristic may take many hundreds of milliseconds. While this is in progress, it is safe to do other non-GATT-related operations such as servicing sensors and displays or any of the onboard peripherals.

Note: It is not currently possible to scan for characteristics in included services. This is a future enhancement.

BLEGATTCFINDCHAR (connHandle, svcUuidHndl, svcIndex, charUuidHndl, charIndex)

A typical pseudo code for finding a characteristic involves calling BleGATTcFindChar() which in turn will result in the EVFINDCHAR event message and typically is as follows:

```
Register a handler for the EVFINDCHAR event message

On EVFINDCHAR event message
    If Char Value Handle == 0 then
        Characteristic not found
    Else
        Characteristic has been found

Call BleGATTcFindChar()
If BleGATTcFindChar () ok then Wait for EVFINDCHAR
```

Returns	INTEGER, a result code. The typical value is 0x0000, indicating a successful operation and it means an EVFINDCHAR event message is thrown by the <i>smart</i>BASIC runtime engine containing the results. A non-zero return value implies an EVFINDCHAR message is not thrown.
Arguments:	
connHandle	byVal nConnHandle AS INTEGER This is the connection handle as returned in the on-connect event for the connection on which the remote GATT server can be accessed. This is returned in the EVBLEMSG event message with msgId == 0 and msgCtx is the connection handle.
svcUuidHndl	byVal svcUuidHndl AS INTEGER Set this to the service UUID handle which is generated either by BleHandleUuid16() or BleHandleUuid128() or BleHandleUuidSibling().
svcIndex	byVal svcIndex AS INTEGER This is the instance of the service to look for with the UUID handle svcUuidHndl, where 0 is the first instance, 1 is the second, and so on.
charUuidHndl	byVal charUuidHndl AS INTEGER Set this to the characteristic UUID handle which is generated either by BleHandleUuid16() or BleHandleUuid128() or BleHandleUuidSibling().
charIndex	byVal charIndex AS INTEGER This is the instance of the characteristic to look for with the UUID handle charUuidHndl, where 0 is the first instance, 1 is the second, and so on.

Example:

```
// Example :: BleGATTcFindChar.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples
//
//Remote server has 5 prim services with 16 bit uuid and 3 with 128 bit uuids
// 3 of the 16 bit uuid are the same value 0xDEAD and
// 2 of the 128 bit uuids are also the same 112233445566778899AABBCCDDEEFF
//
// Server created using BleGATTcTblFindChar.sub invoked in _OpenMcp.scr
// using Nordic Usb Dongle PC10000

DIM rc,at$,conHndl,uHndl,uuid$,sIdx,cIdx

//=====
// Initialise and instantiate service, characteristic, start adverts
//=====
FUNCTION OnStartup()
    DIM rc, adRpt$, addr$, scRpt$
    rc=BleAdvRptInit(adRpt$, 2, 0, 10)
    IF rc==0 THEN : rc=BleScanRptInit(scRpt$) : ENDIF
    IF rc==0 THEN : rc=BleAdvRptsCommit(adRpt$,scRpt$) : ENDIF
    IF rc==0 THEN : rc=BleAdvertStart(0,addr$,50,0,0) : ENDIF
    //open the GATT client with default notify/indicate ring buffer size
    IF rc==0 THEN : rc = BleGattcOpen(0,0) : ENDIF
ENDFUNC rc

//=====
// Close connections so that we can run another app without problems
//=====
SUB CloseConnections()
    rc=BleDisconnect(conHndl)
    rc=BleAdvertStop()
ENDSUB

//=====
// Ble event handler
//=====
FUNCTION HndlrBleMsg(BYVAL nMsgId, BYVAL nCtx)
```



```

DIM uu$,uHndS,uHndC
conHndl=nCtx
IF nMsgID==1 THEN
    PRINT "\n\n- Disconnected"
    EXITFUNC 0
ELSEIF nMsgID==0 THEN
    PRINT "\n- Connected, so scan remote GATT Table for an instance of char"
    uHndS = BleHandleUuid16(0xDEAD)
    uu$ = "112233445566778899AABBCCDDEEFF00"
    uu$ = StrDehexize$(uu$)
    uHndC = BleHandleUuid128(uu$)
    sIdx = 2
    cIdx = 1 //valHandle will be 32
    rc = BleGattcFindChar(conHndl,uHndS,sIdx,uHndC,cIdx)
    IF rc==0 THEN
        //BleDiscCharFirst() will exit with 0 when operation is complete
        WAITEVENT
    ENDIF
    sIdx = 1
    cIdx = 3 //does not exist
    rc = BleGattcFindChar(conHndl,uHndS,sIdx,uHndC,cIdx)
    IF rc==0 THEN
        //BleDiscCharFirst() will exit with 0 when operation is complete
        WAITEVENT
    ENDIF
    CloseConnections()
ENDIF
ENDFUNC 1

'//=====
'//=====
function HandlerFindChar(cHndl,cProp,hVal,isUuid) as integer
    print "\nEVFINDCHAR "
    print " cHndl=";cHndl
    print " Props=";cProp
    print " valHndl=";hVal
    print " ISvcUuid=";isUuid
    IF hVal == 0 THEN
        PRINT "\nDid NOT find the characteristic"
    
```

```
ELSE
    PRINT "\nFound the characteristic at handle ";hVal
    PRINT "\nSvc Idx=";sIdx;" Char Idx=";cIdx
ENDIF
endfunc 0

//=====
// Main() equivalent
//=====

ONEVENT  EVBLEMSG          CALL HndlrBleMsg
OnEvent  EVFINDCHAR        call HandlerFindChar

//Register base uuids with the underlying stack, otherwise the services with the
//128bit uuid's will be delivered with a uuid handle == FF000000 == UNKNOWN
uuid$ = "112233445566778899AABBCCDDEEFF00"
uuid$ = StrDehexize$(uuid$)
uHndl = BleHandleUuid128(uuid$)
uuid$ = "1122DEAD5566778899AABBCCDDBEEF00"
uuid$ = StrDehexize$(uuid$)
uHndl = BleHandleUuid128(uuid$)

IF OnStartup()==0 THEN
    PRINT "\nAdvertising, and GATT Client is open\n"
ELSE
    PRINT "\nFailure OnStartup"
ENDIF

WAITEVENT
PRINT "\nExiting..."
```

Expected Output:

```
Advertising, and GATT Client is open

- Connected, so scan remote GATT Table for an instance of char
EVFINDCHAR  cHndl=866 Props=2 valHndl=32 ISvcUuid=0
Found the characteristic at handle 32
Svc Idx=2 Char Idx=1
EVFINDCHAR  cHndl=866 Props=0 valHndl=0 ISvcUuid=0
Did NOT find the characteristic

- Disconnected
Exiting...
```

5.10.8 BleGattcFindDesc

FUNCTION

This function facilitates an efficient way of locating the details of a descriptor if the UUID is known along with the UUID of the service and the UUID of the characteristic containing it. The results are delivered in a EVFINDDESC event message. If the GATT server table has multiple instances of the same service/characteristic/descriptor combination then this function works because, in addition to the UUID handles to be searched for, it accepts instance parameters which are indexed from 0. This means that the second instance of a descriptor in the fourth instance of a characteristic with the same UUID in the third instance of a service with the same UUID is located with index values 1, 3, and 2 respectively.

Given that the results are returned in an event message, a handler must be registered for the EVFINDDESC event.

Depending on the size of the remote GATT server table and the connection interval, the search of the characteristic may take many hundreds of milliseconds. While this is in progress, it is safe to do other non-GATT-related operations such as servicing sensors and displays or any of the onboard peripherals.

Note: It is not currently possible to scan for characteristics in included services. This planned for a future release.

BLEGATTCFINDDESC (connHndl, svcUuHndl, svcIdx, charUuHndl, charIdx, descUuHndl, descIdx)

A typical pseudo code for finding a descriptor involves calling BleGATTcFindDesc() which in turn results in the EVFINDDESC event message and typically is as follows:

```
Register a handler for the EVFINDDESC event message

On EVFINDDESC event message
    If Descriptor Handle == 0 then
        Descriptor not found
    Else
        Descriptor has been found

Call BleGATTcFindDesc()
If BleGATTcFindDesc() ok then Wait for EVFINDDESC
```

Returns	INTEGER, a result code. The typical value is 0x0000, indicating a successful operation and it means an EVFINDDESC event message is thrown by the smartBASIC runtime engine containing the results. A non-zero return value implies an EVFINDDESC message is not thrown
Arguments:	
connHndl	byVal connHndl AS INTEGER This is the connection handle as returned in the on-connect event for the connection on which the remote GATT server can be accessed. This is returned in the EVBLEMSG event message with msgId == 0 and msgCtx is the connection handle.
svcUuHndl	byVal svcUuHndl AS INTEGER Set this to the service UUID handle which is generated either by BleHandleUuid16() or BleHandleUuid128() or BleHandleUuidSibling().
svcIdx	byVal svcIdx AS INTEGER This is the instance of the service to look for with the UUID handle svcUuHndl, where 0 is the first instance, 1 is the second, and so on.
charUuHndl	byVal charUuHndl AS INTEGER Set this to the characteristic UUID handle which is generated either by BleHandleUuid16() or BleHandleUuid128() or BleHandleUuidSibling().

charIdx	byVal charIdx AS INTEGER This is the instance of the characteristic to look for with the UUID handle charUuidHndl, where 0 is the first instance, 1 is the second, and so on.
descUuHndl	byVal descUuHndl AS INTEGER Set this to the descriptor uuid handle which is generated either by BleHandleUuid16() or BleHandleUuid128() or BleHandleUuidSibling().
descIdx	byVal descIdx AS INTEGER This is the instance of the descriptor to look for with the UUID handle charUuidHndl, where 0 is the first instance, 1 is the second, and so on.

Example:

```
// Example :: BleGATTcFindDesc.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

//
//Remote server has 5 prim services with 16 bit uuid and 3 with 128 bit uuids
// 3 of the 16 bit uuid are the same value 0xDEAD and
// 2 of the 128 bit uuids are also the same 112233445566778899AABBCCDDEEFF
//
// Server created using BleGATTcTblFindDesc.sub invoked in _OpenMcp.scr
// using Nordic Usb Dongle PC10000

DIM rc,at$,conHndl,uHndl,uuid$,sIdx,cIdx,dIdx

//=====
// Initialise and instantiate service, characteristic, start adverts
//=====

FUNCTION OnStartup()
    DIM rc, adRpt$, addr$, scRpt$
    rc=BleAdvRptInit(adRpt$, 2, 0, 10)
    IF rc==0 THEN : rc=BleScanRptInit(scRpt$) : ENDIF
    IF rc==0 THEN : rc=BleAdvRptsCommit(adRpt$,scRpt$) : ENDIF
    IF rc==0 THEN : rc=BleAdvertStart(0,addr$,50,0,0) : ENDIF
    //open the GATT client with default notify/indicate ring buffer size
    IF rc==0 THEN : rc = BleGattcOpen(0,0) : ENDIF
ENDFUNC rc

//=====
// Close connections so that we can run another app without problems
//=====

SUB CloseConnections()
```

```
rc=BleDisconnect(conHndl)
rc=BleAdvertStop()
ENDSUB

//=====
// Ble event handler
//=====
FUNCTION HndlrBleMsg(BYVAL nMsgId, BYVAL nCtx)
    DIM uu$, uHndS, uHndC, uHndD
    conHndl=nCtx
    IF nMsgID==1 THEN
        PRINT "\n\n- Disconnected"
        EXITFUNC 0
    ELSEIF nMsgID==0 THEN
        PRINT "\n- Connected, so scan remote GATT Table for ALL services"
        uHndS = BleHandleUuid16(0xDEAD)
        uu$ = "112233445566778899AABBCCDDEEFF00"
        uu$ = StrDehexize$(uu$)
        uHndC = BleHandleUuid128(uu$)
        uu$ = "1122C0DE5566778899AABBCCDDEEFF00"
        uu$ = StrDehexize$(uu$)
        uHndD = BleHandleUuid128(uu$)
        sIdx = 2
        cIdx = 1
        dIdx = 1 // handle will be 37
        rc = BleGattcFindDesc(conHndl, uHndS, sIdx, uHndC, cIdx, uHndD, dIdx)
        IF rc==0 THEN
            //BleDiscCharFirst() will exit with 0 when operation is complete
            WAITEVENT
        ENDIF
        sIdx = 1
        cIdx = 3
        dIdx = 4 //does not exist
        rc = BleGattcFindDesc(conHndl, uHndS, sIdx, uHndC, cIdx, uHndD, dIdx)
        IF rc==0 THEN
            //BleDiscCharFirst() will exit with 0 when operation is complete
            WAITEVENT
        ENDIF
        CloseConnections()
```

```

ENDIF
ENDFUNC 1

'//=====
'//=====

function HandlerFindDesc(cHndl,hndl) as integer
    print "\nEVFINDDDESC "
    print " cHndl=";cHndl
    print " dscHndl=";hndl
    IF hndl == 0 THEN
        PRINT "\nDid NOT find the descriptor"
    ELSE
        PRINT "\nFound the descriptor at handle ";hndl
        PRINT "\nSvc Idx=";sIdx;" Char Idx=";cIdx;" desc Idx=";dIdx
    ENDIF
endfunc 0

//=====
// Main() equivalent
//=====

ONEVENT  EVBLEMSG          CALL HndlrBleMsg
OnEvent  EVFINDDDESC       call HandlerFindDesc

//Register base uuids with the underlying stack, otherwise the services with the
//128bit uuid's will be delivered with a uuid handle == FF000000 == UNKNOWN
uuid$ = "112233445566778899AABBCCDDEEFF00"
uuid$ = StrDehexize$(uuid$)
uHndl = BleHandleUuid128(uuid$)
uuid$ = "1122DEAD5566778899AABBCCDDBEEF00"
uuid$ = StrDehexize$(uuid$)
uHndl = BleHandleUuid128(uuid$)

IF OnStartup()==0 THEN
    PRINT "\nAdvertising, and GATT Client is open\n"
ELSE
    PRINT "\nFailure OnStartup"
ENDIF

```

```
WAITEVENT
PRINT "\nExiting..."
```

Expected Output:

```
Advertising, and GATT Client is open

- Connected, so scan remote GATT Table for ALL services
EVFINDDESC cHndl=1106 dscHndl=37
Found the descriptor at handle 37
Svc Idx=2 Char Idx=1 desc Idx=1
EVFINDDESC cHndl=1106 dscHndl=0
Did NOT find the descriptor

- Disconnected
Exiting...
```

5.10.9 BleGattcRead/BleGattcReadData

FUNCTIONS

If the handle for an attribute is known, then these functions are used to read the content of that attribute from a specified offset in the array of octets in that attribute value.

Given that the success or failure of this read operation is returned in an event message, a handler **must** be registered for the EVATTRREAD event.

Depending on the connection interval, the read of the attribute may take many hundreds of milliseconds. While this is in progress, it is safe to do other non-GATT-related operations such as servicing sensors and displays or any of the onboard peripherals.

BleGATTcRead is used to trigger the procedure and BleGattcReadData is used to read the data from the underlying cache when the EVATTRREAD event message is received with a success status.

BLEGATTREAD (connHndl, attrHndl, offset)

A typical pseudo code for reading the content of an attribute calling BleGattcRead() which in turn results in the EVATTRREAD event message and typically is as follows:

```
Register a handler for the EVATTRREAD event message

On EVATTRREAD event message
    If GATT_Status == 0 then
        BleGattcReadData() //to actually get the data
    Else
        Attribute could not be read

Call BleGattcRead()
If BleGattcRead() ok then Wait for EVATTRREAD
```

Returns	INTEGER, a result code. The typical value is 0x0000, indicating a successful operation and it means an EVATTRREAD event message is thrown by the <i>smart</i>BASIC runtime engine containing the results. A non-zero return value implies an EVATTRREAD message is not thrown.
Arguments:	
connHndl	byVal connHndl AS INTEGER This is the connection handle as returned in the on-connect event for the connection on which the remote GATT server can be accessed. This is returned in the EVBLEMSG event message with msgId == 0 and msgCtx is the connection handle.

attrHndl	byVal attrHndl AS INTEGER Set to the handle of the attribute to read. It is a value in the range 1 to 65535.
offset	byVal offset AS INTEGER This is the offset from which the data in the attribute is to be read.

BLEGATTREADDATA (connHndl, attrHndl, offset, attrData\$)

This function is used to collect the data from the underlying cache when the EVATTRREAD event message has a success GATT status code.

Returns	INTEGER, a result code. The typical value is 0x0000, indicating a successful read.
Arguments:	
connHndl	byVal connHndl AS INTEGER This is the connection handle as returned in the on-connect event for the connection on which the remote GATT server can be accessed. This is returned in the EVBLEMSG event message with msgId == 0 and msgCtx is the connection handle.
attrHndl	byRef attrHndl AS INTEGER The handle for the attribute that was read is returned in this variable. It is the same as the one supplied in BleGATTcRead, but supplied here so that the code can be stateless.
offset	byRef offset AS INTEGER The offset into the attribute data that was read is returned in this variable. It is the same as the one supplied in BleGATTcRead, but supplied here so that the code can be stateless.
attrData\$	byRef attrData\$ AS STRING The attribute data which was read is supplied in this parameter.

Example:

```
// Example :: BleGATTcRead.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

//
//Remote server has 3 prim services with 16 bit uuid. First service has one
//characteristic whose value attribute is at handle 3 and has read/write props
//
// Server created using BleGattcTblRead.sub invoked in _OpenMcp.scr
// using Nordic Usb Dongle PC10000

DIM rc,at$,conHndl,uHndl,nOff,atHndl

//=====
// Initialise and instantiate service, characteristic, start adverts
//=====

FUNCTION OnStartup()
    DIM rc, adRpt$, addr$, scRpt$
    rc=BleAdvRptInit(adRpt$, 2, 0, 10)
    IF rc==0 THEN : rc=BleScanRptInit(scRpt$) : ENDIF
```



```

    IF rc==0 THEN : rc=BleAdvRptsCommit(adRpt$,scRpt$) : ENDIF
    IF rc==0 THEN : rc=BleAdvertStart(0,addr$,50,0,0) : ENDIF
    //open the GATT client with default notify/indicate ring buffer size
    IF rc==0 THEN : rc = BleGattcOpen(0,0) : ENDIF
ENDFUNC rc

//=====
// Close connections so that we can run another app without problems
//=====

SUB CloseConnections()
    rc=BleDisconnect(conHndl)
    rc=BleAdvertStop()
ENDSUB

//=====
// Ble event handler
//=====

FUNCTION HndlrBleMsg(BYVAL nMsgId, BYVAL nCtx)
    DIM uHndA
    conHndl=nCtx
    IF nMsgID==1 THEN
        PRINT "\n\n- Disconnected"
        EXITFUNC 0
    ELSEIF nMsgID==0 THEN
        PRINT "\n- Connected, so read attribute handle 3"
        atHndl = 3
        nOff = 0
        rc=BleGattcRead(conHndl,atHndl,nOff)
        IF rc==0 THEN
            WAITEVENT
        ENDIF
        PRINT "\nread attribute handle 300 which does not exist"
        atHndl = 300
        nOff = 0
        rc=BleGattcRead(conHndl,atHndl,nOff)
        IF rc==0 THEN
            WAITEVENT
        ENDIF
        CloseConnections()
    
```

```
ENDIF
ENDFUNC 1

'//=====
'//=====

function HandlerAttrRead(cHndl,aHndl,nSts) as integer
    dim nOfst,nAhndl,at$
    print "\nEVATTRREAD "
    print " cHndl=";cHndl
    print " attrHndl=";aHndl
    print " status=";integer.h' nSts
    if nSts == 0 then
        print "\nAttribute read OK"
        rc = BleGattcReadData(cHndl,nAhndl,nOfst,at$)
        print "\nData   = ";StrHexize$(at$)
        print " Offset= ";nOfst
        print " Len=";strlen(at$)
        print "\nhandle = ";nAhndl
    else
        print "\nFailed to read attribute"
    endif
endfunc 0

//=====
// Main() equivalent
//=====

ONEVENT EVBLEMSG          CALL HndlrBleMsg
OnEvent EVATTRREAD        call HandlerAttrRead

IF OnStartup()==0 THEN
    PRINT "\nAdvertising, and GATT Client is open\n"
ELSE
    PRINT "\nFailure OnStartup"
ENDIF

WAITEVENT
PRINT "\nExiting..."
```

Expected Output:

```
Advertising, and GATT Client is open

- Connected, so read attribute handle 3
EVATTRREAD cHndl=2960 attrHndl=3 status=00000000
Attribute read OK
Data = 00000000 Offset= 0 Len=4
handle = 3
read attribute handle 300 which does not exist
EVATTRREAD cHndl=2960 attrHndl=300 status=00000101
Failed to read attribute

- Disconnected
Exiting...
```

5.10.10 BleGattcWrite

FUNCTION

If the handle for an attribute is known then this function is used to write into an attribute starting at offset 0. The acknowledgement is returned via a EVATTRWRITE event message.

Given that the success or failure of this write operation is returned in an event message, a handler **must** be registered for the EVATTRWRITE event.

Depending on the connection interval, the write to the attribute may take many hundreds of milliseconds. While this is in progress, it is safe to do other non GATT related operations such as servicing sensors and displays or any of the onboard peripherals.

BLEGATTWRITE (connHndl, attrHndl, attrData\$)

A typical pseudo code for writing to an attribute which results in the EVATTRWRITE event message and typically is as follows:

```
Register a handler for the EVATTRWRITE event message

On EVATTRWRITE event message
    If GATT_Status == 0 then
        Attribute was written successfully
    Else
        Attribute could not be written

Call BleGattcWrite()
If BleGattcWrite() ok then Wait for EVATTRWRITE
```

Returns	INTEGER, a result code. The typical value is 0x0000, indicating a successful read.
Arguments:	
connHndl	byVal connHndl AS INTEGER This is the connection handle as returned in the on-connect event for the connection on which the remote GATT server can be accessed. This is returned in the EVBLEMSG event message with msgId == 0 and msgCtx is the connection handle.
attrHndl	byVal attrHndl AS INTEGER The handle for the attribute that is to be written to.
attrData\$	byRef attrData\$ AS STRING The attribute data to write.

Example:

```
// Example :: BleGATTcWrite.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

//
//Remote server has 3 prim services with 16 bit uuid. First service has one
//characteristic whose value attribute is at handle 3 and has read/write props
//
// Server created using BleGATTcTblWrite.sub invoked in _OpenMcp.scr
// using Nordic Usb Dongle PC10000

DIM rc,at$,conHndl,uHndl,atHndl

//=====
// Initialise and instantiate service, characteristic, start adverts
//=====
FUNCTION OnStartup()
    DIM rc, adRpt$, addr$, scRpt$
    rc=BleAdvRptInit(adRpt$, 2, 0, 10)
    IF rc==0 THEN : rc=BleScanRptInit(scRpt$) : ENDIF
    IF rc==0 THEN : rc=BleAdvRptsCommit(adRpt$,scRpt$) : ENDIF
    IF rc==0 THEN : rc=BleAdvertStart(0,addr$,50,0,0) : ENDIF
    //open the GATT client with default notify/indicate ring buffer size
    IF rc==0 THEN : rc = BleGattcOpen(0,0) : ENDIF
ENDFUNC rc

//=====
// Close connections so that we can run another app without problems
//=====
SUB CloseConnections()
    rc=BleDisconnect(conHndl)
    rc=BleAdvertStop()
ENDSUB

//=====
// Ble event handler
//=====
FUNCTION HndlrBleMsg(BYVAL nMsgId, BYVAL nCtx)
```

```

DIM uHndA
conHndl=nCtx
IF nMsgID==1 THEN
    PRINT "\n\n- Disconnected"
    EXITFUNC 0
ELSEIF nMsgID==0 THEN
    PRINT "\n- Connected, so write to attribute handle 3"
    atHndl = 3
    at$="\01\02\03\04"

    rc=BleGattcWrite(conHndl,atHndl,at$)

    IF rc==0 THEN
        WAITEVENT
    ENDIF

    PRINT "\nwrite to attribute handle 300 which does not exist"
    atHndl = 300

    rc=BleGattcWrite(conHndl,atHndl,at$)

    IF rc==0 THEN
        WAITEVENT
    ENDIF

    CloseConnections()

ENDIF
ENDFUNC 1

'//=====
'//=====

function HandlerAttrWrite(cHndl,aHndl,nSts) as integer
    dim nOfst,nAhndl,at$
    print "\nEVATTRWRITE "
    print " cHndl=";cHndl
    print " attrHndl=";aHndl
    print " status=";integer.h' nSts
    if nSts == 0 then
        print "\nAttribute write OK"
    else
        print "\nFailed to write attribute"
    endif
endfunc 0

//=====

```

```
// Main() equivalent
//=====
ONEVENT  EVBLEMSG          CALL HndlrBleMsg
OnEvent  EVATTRWRITE       call HandlerAttrWrite

IF OnStartup()==0 THEN
    PRINT "\nAdvertising, and GATT Client is open\n"
ELSE
    PRINT "\nFailure OnStartup"
ENDIF

WAITEVENT
PRINT "\nExiting..."
```

Expected Output:

```
Advertising, and GATT Client is open

- Connected, so read attribute handle 3
EVATTRWRITE  cHndl=2687 attrHndl=3 status=00000000
Attribute write OK
Write to attribute handle 300 which does not exist
EVATTRWRITE  cHndl=2687 attrHndl=300 status=00000101
Failed to write attribute

- Disconnected
Exiting...
```

5.10.11 BleGattcWriteCmd

FUNCTION

If the handle for an attribute is known, then this function is used to write into an attribute at offset 0 when no acknowledgment response is expected. The signal that the command has actually been transmitted and that the remote link layer has acknowledged is by the EVNOTIFYBUF event.

Note: The acknowledgement received for the BleGattcWrite() command is from the higher level GATT layer. Do not confuse this with the link layer ACK .

All packets are acknowledged at link layer level. If a packet fails to get through, then that condition manifests as a connection drop due to the link supervision timeout.

Given that the transmission and link layer ACK of this write operation is indicated in an event message, a handler **must** be registered for the EVNOTIFYBUF event.

Depending on the connection interval, the write to the attribute may take many hundreds of milliseconds. While this is in progress, it is safe to do other non-GATT-related operations such as servicing sensors and displays or any of the onboard peripherals.

BLEGATTWRITECMD (*connHndl*, *attrHndl*, *attrData\$*)

The following is a typical pseudo code for writing to an attribute which results in the EVNOTIFYBUF event:

```
Register a handler for the EVNOTIFYBUF event message

On EVNOTIFYBUF event message
    Can now send another write command

Call BleGattcWriteCmd()
If BleGattcWrite() ok then Wait for EVNOTIFYBUF
```

Returns	INTEGER, a result code. The typical value is 0x0000, indicating a successful read.
Arguments:	
<i>connHndl</i>	byVal <i>connHndl</i> AS INTEGER This is the connection handle as returned in the on-connect event for the connection on which the remote GATT Server can be accessed. This is returned in the EVBLEMSG event message with msgId == 0 and msgCtx is the connection handle.
<i>attrHndl</i>	byVal <i>attrHndl</i> AS INTEGER The handle for the attribute that is to be written to.
<i>attrData\$</i>	byRef <i>attrData\$</i> AS STRING The attribute data to write.

Example:

```
// Example :: BleGATTcWriteCmd.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

//
//Remote server has 3 prim services with 16 bit uuid. First service has one
//characteristic whose value attribute is at handle 3 and has read/write props
//
// Server created using BleGATTcTblWriteCmd.sub invoked in _OpenMcp.scr
// using Nordic Usb Dongle PC10000

DIM rc,at$,conHndl,uHndl,atHndl

//=====
// Initialise and instantiate service, characteristic, start adverts
//=====

FUNCTION OnStartup()
    DIM rc, adRpt$, addr$, scRpt$
    rc=BleAdvRptInit(adRpt$, 2, 0, 10)
    IF rc==0 THEN : rc=BleScanRptInit(scRpt$) : ENDIF
    IF rc==0 THEN : rc=BleAdvRptsCommit(adRpt$,scRpt$) : ENDIF
    IF rc==0 THEN : rc=BleAdvertStart(0,addr$,50,0,0) : ENDIF
```

```
//open the GATT client with default notify/indicate ring buffer size
IF rc==0 THEN : rc = BleGattcOpen(0,0) : ENDIF
ENDFUNC rc

//=====
// Close connections so that we can run another app without problems
//=====
SUB CloseConnections()
    rc=BleDisconnect(conHndl)
    rc=BleAdvertStop()
ENDSUB

//=====
// Ble event handler
//=====
FUNCTION HndlrBleMsg(BYVAL nMsgId, BYVAL nCtx)
    DIM uHndA
    conHndl=nCtx
    IF nMsgID==1 THEN
        PRINT "\n\n- Disconnected"
        EXITFUNC 0
    ELSEIF nMsgID==0 THEN
        PRINT "\n- Connected, so write to attribute handle 3"
        atHndl = 3
        at$="\01\02\03\04"
        rc=BleGattcWriteCmd(conHndl,atHndl,at$)
        IF rc==0 THEN
            WAITEVENT
        ENDIF
        PRINT "\n- write again to attribute handle 3"
        atHndl = 3
        at$="\05\06\07\08"
        rc=BleGattcWriteCmd(conHndl,atHndl,at$)
        IF rc==0 THEN
            WAITEVENT
        ENDIF
        PRINT "\n- write again to attribute handle 3"
        atHndl = 3
        at$="\09\0A\0B\0C"
```



```

rc=BleGattcWriteCmd(conHndl,atHndl,at$)

IF rc==0 THEN
    WAITEVENT
ENDIF

PRINT "\nwrite to attribute handle 300 which does not exist"
atHndl = 300

rc=BleGattcWriteCmd(conHndl,atHndl,at$)

IF rc==0 THEN
    PRINT "\nEven when the attribute does not exist an event will occur"
    WAITEVENT
ENDIF

CloseConnections()

ENDIF
ENDFUNC 1

'//=====
'//=====

function HandlerNotifyBuf() as integer
    print "\nEVNOTIFYBUF Event"
endfunc 0 '//need to progress the WAITEVENT

//=====
// Main() equivalent
//=====

ONEVENT  EVBLEMSG          CALL HndlrBleMsg
OnEvent  EVNOTIFYBUF       call HandlerNotifyBuf

IF OnStartup()==0 THEN
    PRINT "\nAdvertising, and GATT Client is open\n"
ELSE
    PRINT "\nFailure OnStartup"
ENDIF

WAITEVENT
PRINT "\nExiting..."

```

Expected Output:

```
Advertising, and GATT Client is open

- Connected, so write to attribute handle 3
EVNOTIFYBUF Event
- write again to attribute handle 3
EVNOTIFYBUF Event
- write again to attribute handle 3
EVNOTIFYBUF Event
write to attribute handle 300 which does not exist
Even when the attribute does not exist an event will occur
EVNOTIFYBUF Event

- Disconnected
Exiting...
```

5.10.12 BleGattcWritePrepare

FUNCTION

The Write Prepare and Write Execute functions are used to perform the Long Write procedure. Long Writes are used when the value handle is known, but the length of the characteristic value is longer than can be sent in a single Write Request message.

BleGattcWritePrepare requests that the GATT server prepares to write the attribute value. This function can be used multiple times as long as a BleGattcWriteExecute function is used at the end to perform the full Long Write.

BLEGATTCWRITEPREPARE (*connHndl*, *attrHndl*, *offset*, *attrData\$*)

Returns	INTEGER, a result code. The typical value is 0x0000, indicating a successful read.
Arguments:	
<i>connHndl</i>	byVal <i>connHndl</i> AS INTEGER This is the connection handle as returned in the on-connect event for the connection on which the remote GATT Server can be accessed. This is returned in the EVBLEMSG event message with msgId == 0 and msgCtx is the connection handle.
<i>attrHndl</i>	byVal <i>attrHndl</i> AS INTEGER The handle for the attribute that is to be written to.
<i>offset</i>	byVal <i>attrHndl</i> AS INTEGER This is the offset at which the data in the attribute is to be written.
<i>attrData\$</i>	byRef <i>attrData\$</i> AS STRING The attribute data to write.

5.10.13 BleGattcWriteExecute

FUNCTION

The BleGattcWriteExecute function is used by the GATT client to request the server to write or cancel the write of all the values that have been prepared with the BleGattcWritePrepare function. It is used as the final step in a long write operation.

BLEGATTCWRITEEXECUTE (*connHndl*, *Flags*)

Returns	INTEGER, a result code. The typical value is 0x0000, indicating a successful read.	
Arguments:		
connHndl	byVal connHndl AS INTEGER This is the connection handle as returned in the on-connect event for the connection on which the remote GATT Server can be accessed. This is returned in the EVBLEMSG event message with msgId == 0 and msgCtx is the connection handle.	
	byVal Flags AS INTEGER	
Flags	0	Cancel all prepared writes
	1	Immediately write all pending prepared values

5.10.14 BleGattcNotifyRead

FUNCTION

A GATT server has the ability to notify or indicate the value attribute of a characteristic when enabled via the Client Characteristic Configuration Descriptor (CCCD). This means data arrives from a GATT server at any time and must be managed so that it can synchronised with the *smart*BASIC runtime engine.

Data arriving via a notification does not require GATT acknowledgements, however indications require them. This GATT client manager saves data arriving via a notification in the same ring buffer for later extraction using the command BleGattcNotifyRead(); for indications, an automatic GATT acknowledgement is sent when the data is saved in the ring buffer. This acknowledgment happens even if the data is discarded because the ring buffer is full. If the data must not be acknowledged when it is discarded on a full buffer, set the flags parameter in the BleGattcOpen() function where the GATT client manager is opened.

In the case when an ACK is NOT sent on data discard, the GATT server is throttled and no further data is notified or indicated by it until BleGattcNotifyRead() is called to extract data from the ring buffer to create space and it triggers a delayed acknowledgement.

When the GATT client manager is opened using BleGattcOpen(), it is possible to specify the size of the ring buffer. If a value of 0 is supplied, then a default size is created. SYSINFO(2019) in a *smart*BASIC application or the interactive mode command AT I 2019 returns the default size. Likewise SYSINFO(2020) or the command AT I 2020 returns the maximum size.

Data that arrives via notifications or indications get stored in the ring buffer. At the same time, a EVATTRNOTIFY event is thrown to the *smart*BASIC runtime engine. This is an event, in the same way an incoming UART receive character generates an event; that is, no data payload is attached to the event.

BLEGATTCNOTIFYREAD (*connHndl*, *attrHndl*, *attrData\$*, *discardCount*)

The following is a typical pseudo code for handling and accessing notification/indication data:

```
Register a handler for the EVATTRNOTIFY event message

On EVATTRNOTIFY event
    BleGattcNotifyRead() //to actually get the data
    Process the data

Enable notifications and/or indications via CCCD descriptors
```

Returns	INTEGER, a result code. The typical value is 0x0000, indicating data was successful read.
Arguments:	
connHndl	byRef connHndl AS INTEGER On exit, this is the connection handle of the GATT server that sent the notification or indication.
attrHndl	byRef attrHndl AS INTEGER On exit, this is the handle of the characteristic value attribute in the notification or indication.
attrData\$	byRef attrData\$ AS STRING On exit, this is the data of the characteristic value attribute in the notification or indication. It is always from offset 0 of the source attribute.
discardedCount	byRef discardedCount AS INTEGER On exit, this should contain 0. It signifies the total number of notifications or indications that got discarded because the ring buffer in the GATT client manager was full. If non-zero values are encountered, it is recommended that the ring buffer size be increased by using BleGattcClose() when the GATT client was opened using BleGattcOpen().

Example:

```
// Example :: BleGATTcNotifyRead.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples
//
// Charactersitic at handle 15 has notify (16==cccd)
// Charactersitic at handle 18 has indicate (19==cccd)

DIM rc,at$,conHndl,uHndl,atHndl

//=====
// Initialise and instantiate service, characteristic, start adverts
//=====
FUNCTION OnStartup()
    DIM rc, adRpt$, addr$, scRpt$
    rc=BleAdvRptInit(adRpt$, 2, 0, 10)
    IF rc==0 THEN : rc=BleScanRptInit(scRpt$) : ENDIF
    IF rc==0 THEN : rc=BleAdvRptsCommit(adRpt$,scRpt$) : ENDIF
    IF rc==0 THEN : rc=BleAdvertStart(0,addr$,50,0,0) : ENDIF
    //open the gatt client with default notify/indicate ring buffer size
    IF rc==0 THEN : rc = BleGattcOpen(0,0) : ENDIF
ENDFUNC rc

//=====
// Close connections so that we can run another app without problems
//=====
SUB CloseConnections()
    rc=BleDisconnect(conHndl)
    rc=BleAdvertStop()
ENDSUB

//=====
// Ble event handler
//=====
FUNCTION HndlrBleMsg(BYVAL nMsgId, BYVAL nCtx)
    conHndl=nCtx
    IF nMsgID==1 THEN
        PRINT "\n\n- Disconnected"
        EXITFUNC 0
    ELSEIF nMsgID==0 THEN
```

```

        PRINT "\n- Connected, so enable notification for char with cccd at 16"
        atHndl = 16
        at$="\01\00"
        rc=BleGattcWrite(conHndl,atHndl,at$)
        IF rc==0 THEN
            WAITEVENT
        ENDIF
        PRINT "\n- enable indication for char with cccd at 19"
        atHndl = 19
        at$="\02\00"
        rc=BleGattcWrite(conHndl,atHndl,at$)
        IF rc==0 THEN
            WAITEVENT
        ENDIF
    ENDIF
ENDFUNC 1

'//=====
'//=====
function HandlerAttrWrite(cHndl,aHndl,nSts) as integer
    dim nOfst,nAhndl,at$
    print "\nEVATTRWRITE "
    print " cHndl=";cHndl
    print " attrHndl=";aHndl
    print " status=";integer.h' nSts
    if nSts == 0 then
        print "\nAttribute write OK"
    else
        print "\nFailed to write attribute"
    endif
endfunc 0

'//=====
'// Thrown when AT+CFG 213 = 0
'//=====
function HandlerAttrNotify() as integer
    dim chndl,aHndl,att$,dsd
    print "\nEVATTRNOTIFY Event \n"
    rc=BleGattcNotifyRead(cHndl,aHndl,att$,dsd)
    print "\n  BleGattcNotifyRead()"
    if rc==0 then
        print " Connection Handle=";cHndl
        print " Characteristic Handle=";aHndl
        print " Data=";StrHexize$(att$)
        print " Discarded=";dsd
    else
        print " failed with ";integer.h' rc
    endif
endfunc 1

'//=====
'// Thrown when AT+CFG 213 = 1
'//=====
function HandlerAttrNotifyEx(BYVAL hConn, BYVAL hChar, BYVAL nType, BYVAL nLen, BYVAL
Data$) as integer

    print "\nEVATTRNOTIFYEX Event :: "
    if nType == 1 then
        print "Notification\n"
    elseif nType == 2 then
        print "Indication\n"
    endif

```

```

    print " Connection Handle=";hConn
    print " Characteristic Handle=";hChar
    print " Data=";Data$
endfunc 1

//=====
// Main() equivalent
//=====
ONEVENT EVBLEMSG          CALL HndlrBleMsg
OnEvent EVATTRWRITE       call HandlerAttrWrite
OnEvent EVATTRNOTIFY      call HandlerAttrNotify // Thrown when AT+CFG 213 = 0
OnEvent EVATTRNOTIFYEX    call HandlerAttrNotifyEx // Thrown when AT+CFG 213 = 1

IF OnStartup()==0 THEN
    PRINT "\nAdvertising, and Gatt Client is open\n"
ELSE
    PRINT "\nFailure OnStartup"
ENDIF

WAITEVENT
PRINT "\nExiting..."

```

Expected Output:

```

Advertising, and GATT Client is open

- Connected, so enable notification for char with cccd at 16
EVATTRWRITE  cHndl=877 attrHndl=16 status=00000000
Attribute write OK
- enable indication for char with cccd at 19
EVATTRWRITE  cHndl=877 attrHndl=19 status=00000000
Attribute write OK
EVATTRNOTIFY Event
    BleGATTcNotifyRead() cHndl=877 attrHndl=15 data=BAADC0DE discarded=0
EVATTRNOTIFY Event
    BleGATTcNotifyRead() cHndl=877 attrHndl=18 data=DEADBEEF discarded=0
EVATTRNOTIFY Event
    BleGATTcNotifyRead() cHndl=877 attrHndl=15 data=BAADC0DE discarded=0
EVATTRNOTIFY Event
    BleGATTcNotifyRead() cHndl=877 attrHndl=18 data=DEADBEEF discarded=0

```

5.11 Attribute Encoding Functions

Data for characteristics are stored in value attributes, arrays of bytes. Multibyte Characteristic Descriptors content is stored similarly. Those bytes are manipulated in *smart*BASIC applications using STRING variables.

The Bluetooth specification stipulates that multibyte data entities are stored in little endian format and so all data manipulation is done similarly. Little endian means that a multibyte data entity is stored so that lowest significant byte is positioned at the lowest memory address and likewise, when transported, the lowest byte is on the wire first.

This section describes all the encoding functions which allow those strings to be written in smaller bitwise subfields in a more efficient manner compared to the generic STRXXXX functions that are made available in *smart*BASIC.

Note: CCCD and SCCD descriptors are special cases; they have two bytes which are treated as 16-bit integers. This is reflected in *smart*BASIC applications so that INTEGER variables are used to manipulate those values instead of STRINGS.

5.11.1 BleEncode8

FUNCTION

This function overwrites a single byte in a string at a specified offset. If the string is not long enough, then it is extended with the new extended block uninitialized and then the byte specified is overwritten.

If the *nIndex* is such that the new string length exceeds the maximum attribute length, this function fails. The maximum attribute length can be obtained using the function `SYSINFO(n)` where *n* is 2013. The Bluetooth specification allows a length between 1 and 512.

BLEENCODE8 (*attr\$, nData, nIndex*)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
attr\$	byRef attr\$ AS STRING This argument is the string that is written to an attribute.
nData	byVal nData AS INTEGER The least significant byte of this integer is saved. The rest is ignored.
nIndex	byVal nIndex AS INTEGER This is the zero-based index into the string <i>attr\$</i> where the new data fragment is written to. If the string <i>attr\$</i> is not long enough to fit the index plus the length of the fragment, it is extended. If the extended length exceeds the maximum allowable length of an attribute (see <code>SYSINFO(2013)</code>), this function fails.

Example:

```
// Example :: BleEncode8.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc
DIM attr$

attr$="Laird"

PRINT "\nattr$=";attr$

//Remember: - 4 bytes are used to store an integer on the BL654
//write 'C' to index 2 -- '111' will be ignored
rc=BleEncode8(attr$,0x11143,2)
//write 'A' to index 0
rc=BleEncode8(attr$,0x41,0)
//write 'B' to index 1
rc=BleEncode8(attr$,0x42,1)
//write 'D' to index 3
rc=BleEncode8(attr$,0x44,3)
//write 'y' to index 7 -- attr$ will be extended
rc=BleEncode8(attr$,0x67, 7)
PRINT "\nattr$ now = ";attr$
```

Expected Output:

```
attr$=Laird
attr$ now = ABCDd\00\00g
```

5.11.2 BleEncode16

FUNCTION

This function overwrites two bytes in a string at a specified offset. If the string is not long enough, then it is extended with the new extended block uninitialized and then the bytes specified are overwritten.

If the nIndex is such that the new string length exceeds the maximum attribute length, this function fails. The maximum attribute length can be obtained using the function SYSINFO(n) where n is 2013. The Bluetooth specification allows a length between 1 and 512.

BLEENCODE16 (attr\$, nData, nIndex)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
attr\$	byRef attr\$ AS STRING This argument is the string that is written to an attribute.
nData	byVal nData AS INTEGER The two least significant bytes of this integer is saved. The rest is ignored.
nIndex	byVal nIndex AS INTEGER This is the zero based index into the string attr\$ where the new fragment of data is written. If the string attr\$ is not long enough to accommodate the index plus the length of the fragment, it is extended. If the extended length exceeds the maximum allowable length of an attribute (see SYSINFO(2013)), this function fails.

Example:

```
// Example :: BleEncode16.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc, attr$
attr$="Laird"
PRINT "\nattr$=";attr$

//write 'CD' to index 2
rc=BleEncode16(attr$,0x4443,2)
//write 'AB' to index 0 - '2222' will be ignored
rc=BleEncode16(attr$,0x22224241,0)
//write 'EF' to index 3
rc=BleEncode16(attr$,0x4645,4)

PRINT "\nattr$ now = ";attr$
```

Expected Output:

```
attr$=Laird
attr$ now = ABCDEF
```


5.11.3 BleEncode24

FUNCTION

This function overwrites three bytes in a string at a specified offset. If the string is not long enough, then it is extended with the new extended block uninitialized and then the bytes specified are overwritten.

If the `nIndex` is such that the new string length exceeds the maximum attribute length, this function fails. The maximum attribute length can be obtained using the function `SYSINFO(n)` where `n` is 2013. The Bluetooth specification allows a length between 1 and 512.

BLEENCODE24 (`attr$`, `nData`, `nIndex`)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
<code>attr\$</code>	byRef <code>attr\$</code> AS STRING This argument is the string that is written to an attribute.
<code>nData</code>	byVal <code>nData</code> AS INTEGER The three least significant bytes of this integer is saved. The rest is ignored.
<code>nIndex</code>	byVal <code>nIndex</code> AS INTEGER This is the zero based index into the string <code>attr\$</code> where the new fragment of data is written. If the string <code>attr\$</code> is not long enough to accommodate the index plus the length of the fragment, it is extended. If the extended length exceeds the maximum allowable length of an attribute (see <code>SYSINFO(2013)</code>), this function fails.

Example:

```
// Example :: BleEncode24.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc
DIM attr$ : attr$="Laird"

//write 'BCD' to index 1
rc=BleEncode24(attr$,0x444342,1)

//write 'A' to index 0
rc=BleEncode8(attr$,0x41,0)

//write 'EF' to index 4
rc=BleEncode16(attr$,0x4645,4)

PRINT "attr$=";attr$
```

Expected Output:

```
attr$=ABCDEF
```

5.11.4 BleEncode32

FUNCTION

This function overwrites four bytes in a string at a specified offset. If the string is not long enough, then it is extended with the new extended block uninitialized and then the bytes specified are overwritten.

If the *nIndex* is such that the new string length exceeds the maximum attribute length, this function fails. The maximum attribute length can be obtained using the function `SYSINFO(n)` where *n* is 2013. The Bluetooth specification allows a length between 1 and 512.

BLEENCODE32(attr\$,nData, nIndex)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
attr\$	byRef attr\$ AS STRING This argument is the string that is written to an attribute.
nData	byVal nData AS INTEGER The four bytes of this integer is saved. The rest is ignored.
nIndex	byVal nIndex AS INTEGER This is the zero based index into the string <i>attr\$</i> where the new fragment of data is written. If the string <i>attr\$</i> is not long enough to accommodate the index plus the length of the fragment, it is extended. If the extended length exceeds the maximum allowable length of an attribute (see <code>SYSINFO(2013)</code>), this function fails.

Example:

```
// Example :: BleEncode32.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc
DIM attr$ : attr$="Laird"

//write 'BCDE' to index 1
rc=BleEncode32(attr$,0x45444342,1)
//write 'A' to index 0
rc=BleEncode8(attr$,0x41,0)

PRINT "attr$=";attr$
```

Expected Output:

```
attr$=ABCDE
```

5.11.5 BleEncodeFLOAT

FUNCTION

This function overwrites four bytes in a string at a specified offset. If the string is not long enough, it is extended with the new extended block uninitialized and then the byte specified is overwritten.

If the nIndex is such that the new string length exceeds the maximum attribute length, this function fails. The maximum attribute length can be obtained using the function SYSINFO(n) where n is 2013. The Bluetooth specification allows a length between 1 and 512.

BLEENCODEFLOAT (attr\$, nMantissa, nExponent, nIndex)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.										
Arguments:											
attr\$	byRef attr\$ AS STRING This argument is the string that is written to an attribute.										
nMantissa	byVal nMantissa AS INTEGER This value must be in the range -8388600 to +8388600 or the function fails. The data is written in little endian so that the least significant byte is at the lower memory address. Note: The range is not +/- 2048 because after encoding the following 2 byte values have special meaning: <table border="1"> <tr> <td>0x007FFFFF</td><td>NaN (Not a Number)</td></tr> <tr> <td>0x00800000</td><td>NRes (Not at this resolution)</td></tr> <tr> <td>0x007FFFFE</td><td>+ INFINITY</td></tr> <tr> <td>0x00800002</td><td>- INFINITY</td></tr> <tr> <td>0x00800001</td><td>Reserved for future use</td></tr> </table>	0x007FFFFF	NaN (Not a Number)	0x00800000	NRes (Not at this resolution)	0x007FFFFE	+ INFINITY	0x00800002	- INFINITY	0x00800001	Reserved for future use
0x007FFFFF	NaN (Not a Number)										
0x00800000	NRes (Not at this resolution)										
0x007FFFFE	+ INFINITY										
0x00800002	- INFINITY										
0x00800001	Reserved for future use										
nExponent	byVal nExponent AS INTEGER This value must be in the range -128 to 127 or the function fails.										
nIndex	byVal nIndex AS INTEGER This is the zero based index into the string attr\$ where the new fragment of data is written. If the string attr\$ is not long enough to accommodate the index plus the length of the fragment, it is extended. If the extended length exceeds the maximum allowable length of an attribute (see SYSINFO(2013)), this function fails.										

Example:

```
// Example :: BleEncodeFloat.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc
DIM attr$ : attr$=""

//write 1234567 x 10^-54 as FLOAT to index 2
PRINT BleEncodeFLOAT(attr$,123456,-54,0)

//write 1234567 x 10^1000 as FLOAT to index 2 and it will fail
//because the exponent is too large, it has to be < 127
IF BleEncodeFLOAT(attr$,1234567,1000,2) !=0 THEN
    PRINT "\nFailed to encode to FLOAT"
ENDIF
```

```
//write 10000000 x 10^0 as FLOAT to index 2 and it will fail
//because the mantissa is too large, it has to be < 8388600
IF BleEncodeFLOAT(attr$,10000000,0,2) !=0 THEN
    PRINT "\nFailed to encode to FLOAT"
ENDIF
```

Expected Output:

```
0
Failed to encode to FLOAT
Failed to encode to FLOAT
```

5.11.6 BleEncodeSFLOATEx

FUNCTION

This function overwrites two bytes in a string at a specified offset as short 16-bit float value. If the string is not long enough, it is extended with the extended block uninitialized. Then the bytes are overwritten.

If the nIndex is such that the new string length exceeds the maximum attribute length, this function fails. The maximum attribute length can be obtained using the function SYSINFO(n) where n is 2013. The Bluetooth specification allows a length between 1 and 512.

BLEENCODSFLOATEx (attr\$, nData, nIndex)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
attr\$	byRef attr\$ AS STRING This argument is the string that is written to an attribute
nData	byVal nData AS INTEGER The 32 bit value is converted into a 2-byte IEEE-11073 16-bit SFLOAT consisting of a 12-bit signed mantissa and a 4-bit signed exponent. This means a signed 32-bit value always fits in such a FLOAT entity, but there is a loss in significance to 12 from 32.
nIndex	byVal nIndex AS INTEGER This is the zero-based index into the string attr\$ where the new fragment of data is written. If the string attr\$ is not long enough to accommodate the index plus the length of the fragment, it is extended. If the new length exceeds the maximum allowable length of an attribute (see SYSINFO(2013)), this function fails.

Example:

```
// Example :: BleEncodeSFloatEx.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc, mantissa, exp
DIM attr$ : attr$=""

//write 2,147,483,647 as SFLOAT to index 0
rc=BleEncodeSFloatEx(attr$,2147483647,0)
rc=BleDecodeSFloat(attr$,mantissa,exp,0)
```

```
PRINT "\nThe number stored is ";mantissa;" x 10^";exp
```

Expected Output:

```
The number stored is 214 x 10^7
```

5.11.7 BleEncodeSFLOAT

FUNCTION

This function overwrites two bytes in a string at a specified offset as short 16-bit float value. If the string is not long enough, it is extended with the new block uninitialized. Then the byte specified is overwritten.

If the `nIndex` is such that the new string length exceeds the maximum attribute length, this function fails. The maximum attribute length can be obtained using the function `SYSINFO(n)` where `n` is 2013. The Bluetooth specification allows a length between 1 and 512.

BLEENCODESFLOAT (attr\$, nMantissa, nExponent, nIndex)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.										
Arguments:											
attr\$	byRef attr\$ AS STRING This argument is the string that is written to an attribute.										
nMantissa	byVal nMantissa AS INTEGER This must be in the range -2046 to +2046 or the function fails. The data is written in little endian so the least significant byte is at the lower memory address. Note: The range is not +/- 2048 because after encoding, the following 2-byte values have special meaning: <table><tr><td>0x007FF</td><td>NaN (Not a Number)</td></tr><tr><td>0x00800</td><td>NRes (Not at this resolution)</td></tr><tr><td>0x007FE</td><td>+ INFINITY</td></tr><tr><td>0x00802</td><td>- INFINITY</td></tr><tr><td>0x00801</td><td>Reserved for future use</td></tr></table>	0x007FF	NaN (Not a Number)	0x00800	NRes (Not at this resolution)	0x007FE	+ INFINITY	0x00802	- INFINITY	0x00801	Reserved for future use
0x007FF	NaN (Not a Number)										
0x00800	NRes (Not at this resolution)										
0x007FE	+ INFINITY										
0x00802	- INFINITY										
0x00801	Reserved for future use										
nExponent	byVal nExponent AS INTEGER This value must be in the range -8 to 7 or the function fails.										
nIndex	byVal nIndex AS INTEGER This is the zero based index into the string <code>attr\$</code> where the new fragment of data is written. If the string <code>attr\$</code> is not long enough to accommodate the index plus the length of the fragment, it is extended. If the new length exceeds the maximum allowable length of an attribute (see <code>SYSINFO(2013)</code>), this function fails.										

Example:

```
// Example :: BleEncodeSFloat.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc
DIM attr$ : attr$=""
```

```
SUB Encode (BYVAL mantissa, BYVAL exp)
    IF BleEncodeSFloat(attr$,mantissa,exp,2) !=0 THEN
        PRINT "\nFailed to encode to SFLOAT"
    ELSE
        PRINT "\nSuccess"
    ENDIF
ENDSUB

Encode(1234,-4)      //1234 x 10^-4
Encode(1234,10)      //1234 x 10^10 will fail because exponent too large
Encode(10000,0)      //10000 x 10^0 will fail because mantissa too large
```

Expected Output:

```
Success
Failed to encode to SFLOAT
Failed to encode to SFLOAT
```

5.11.8 BleEncodeTIMESTAMP

FUNCTION

This function overwrites a 7-byte string into the string at a specified offset. If the string is not long enough, it is extended with the new extended block uninitialized and then the byte specified is overwritten.

The 7-byte string consists of a byte each for century, year, month, day, hour, minute and second. If (year * month) is zero, it is taken as "not noted" year and all the other fields are set zero (not noted).

For example, 5 May 2013 10:31:24 is represented as \14\0D\05\05\0A\1F\18.

If the nIndex is such that the new string length exceeds the maximum attribute length, this function fails. The maximum length of an attribute as implemented can be obtained using the function SYSINFO(n) where n is 2013. The Bluetooth specification allows a length between 1 and 512.

Note: When the attr\$ string variable is updated, the two byte year field is converted into a 16-bit integer. Hence \14\0D gets converted to \DD\07

BLEENCODETIMESTAMP (attr\$, timestamp\$, nIndex)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
attr\$	byRef attr\$ AS STRING This argument is the string that is written to an attribute.
timestamp\$	byRef timestamp\$ AS STRING This is a 7-byte string as described above. For example 5 May 2013 10:31:24 is entered \14\0D\05\05\0A\1F\18.
nIndex	byVal nIndex AS INTEGER This is the zero based index into the string attr\$ where the new fragment of data is written. If the string attr\$ is not long enough to accommodate the index plus the length of the fragment it is extended. If the new length exceeds the maximum allowable length of an attribute (see SYSINFO(2013)), this function fails.

Example:

```
// Example :: BleEncodeTimestamp.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc, ts$
DIM attr$ : attr$=""

//write the timestamp <5 May 2013 10:31:24>

ts$="\14\0D\05\05\0A\1F\18"
PRINT BleEncodeTimestamp(attr$,ts$,0)
```

Expected Output:

0

5.11.9 BleEncodeSTRING

FUNCTION

This function overwrites a substring at a specified offset with data from another substring of a string. If the destination string is not long enough, it is extended with the new block uninitialized. Then the byte is overwritten.

If the nIndex is such that the new string length exceeds the maximum attribute length, this function fails. The maximum length of an attribute as implemented can be obtained using the function SYSINFO(n) where n is 2013. The Bluetooth specification allows a length between 1 and 512.

BleEncodeSTRING (attr\$, nIndex1 str\$, nIndex2, nLen)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
attr\$	byRef attr\$ AS STRING This argument is the string is written to an attribute
nIndex1	byVal nIndex1 AS INTEGER This is the zero based index into the string attr\$ where the new fragment of data is written. If the string attr\$ is not long enough to accommodate the index plus the length of the fragment it is extended. If the new length exceeds the maximum allowable length of an attribute (see SYSINFO(2013)), this function fails.
str\$	byRef str\$ AS STRING This contains the source data which is qualified by the nIndex2 and nLen arguments that follow.
nIndex2	byVal nIndex2 AS INTEGER This is the zero based index into the string str\$ from which data is copied. No data is copied if this is negative or greater than the string.
nLen	byVal nLen AS INTEGER This specifies the number of bytes from offset nIndex2 to be copied into the destination string. It is clipped to the number of bytes left to copy after the index.

Example:

```
// Example :: BleEncodeString.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc, attr$, ts$ : ts$="Hello World"

//write "Wor" from "Hello World" to the attribute at index 2

rc=BleEncodeString(attr$,2,ts$,6,3)
```

```
PRINT attr$
```

Expected Output:

```
\00\00Wor
```

5.11.10 BleEncodeBITS

FUNCTION

This function overwrites some bits of a string at a specified bit offset with data from an integer which is treated as a bit array of length 32. If the destination string is not long enough, it is extended with the new extended block uninitialized. Then the bits specified are overwritten.

If the nIndex is such that the new string length exceeds the maximum attribute length, this function fails. The maximum length of an attribute as implemented can be obtained using the function SYSINFO(n) where n is 2013. The Bluetooth specification allows a length between 1 and 512; hence the (nDstIdx + nBitLen) cannot be greater than the maximum attribute length times eight.

BleEncodeBITS (attr\$, nDstIdx, srcBitArr, nSrcIdx, nBitLen)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
attr\$	byRef attr\$ AS STRING This is the string written to an attribute. It is treated as a bit array.
nDstIdx	byVal nDstIdx AS INTEGER This is the zero based bit index into the string attr\$, treated as a bit array, where the new fragment of data bits is written. If the string attr\$ is not long enough to accommodate the index plus the length of the fragment it is extended. If the new length exceeds the maximum allowable length of an attribute (see SYSINFO(2013)), this function fails.
srcBitArr	byVal srcBitArr AS INTEGER This contains the source data bits which is qualified by the nSrcIdx and nBitLen arguments that follow.
nSrcIdx	byVal nSrcIdx AS INTEGER This is the zero-based bit index into the bit array contained in srcBitArr from where the data bits is copied. No data is copied if this index is negative or greater than 32.
nBitLen	byVal nBitLen AS INTEGER This specifies the number of bits from offset nSrcIdx to be copied into the destination bit array represented by the string attr\$. It is clipped to the number of bits left to copy after the index nSrcIdx.

Example:

```
// Example :: BleEncodeBits.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM attr$, rc, bA: bA=b'1110100001111
rc=BleEncodeBits(attr$,20,bA,7,5) : PRINT attr$ //copy 5 bits from index 7 to attr$
```

Expected Output:

```
\00\00\A0\01
```


5.12 Attribute Decoding Functions

Data in a characteristic is stored in a value attribute, a byte array. Multibyte characteristic descriptors content is stored similarly. Those bytes are manipulated in *smart*BASIC applications using STRING variables.

Attribute data is stored in little endian format.

This section describes decoding functions that allow attribute strings to be read from smaller bitwise subfields more efficiently than the generic STRXXXX functions that are made available in *smart*BASIC.

Note: CCCD and SCCD descriptors are special cases as they are defined as having two bytes which are treated as 16-bit integers mapped to INTEGER variables in *smart*BASIC.

5.12.1 BleDecodeS8

FUNCTION

This function reads a single byte in a string at a specified offset into a 32-bit integer variable with sign extension. If the offset points beyond the end of the string, then this function fails and returns zero.

BLEDECODES8 (attr\$, nData, nIndex)

Returns	INTEGER, the number of bytes extracted from the attribute string. Can be less than the size expected if the nIndex parameter is positioned towards the end of the string.
Arguments:	
attr\$	byRef attr\$ AS STRING This references the attribute string from which the function reads.
nData	byRef nData AS INTEGER This references an integer to be updated with the 8-bit data from attr\$, after sign extension.
nIndex	byVal nIndex AS INTEGER This is the zero based index into the string attr\$ from which the data is read. If the string attr\$ is not long enough to accommodate the index plus the number of bytes to read, this function fails.

Example:

```
// Example :: BleDecodeS8.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM chrHandle,v1,svcHandle,rc
DIM mdVal : mdVal = BleAttrMetadata(1,1,50,0,rc)
DIM attr$ : attr$="\00\01\02\03\04\85\86\87\88\89"
DIM uuid : uuid = 0x1853

//create random service just for this example
rc=BleServiceNew(1, BleHandleUuid16(uuid), svcHandle)

//create char and commit as part of service committed above
rc=BleCharNew(0x07,BleHandleUuid16(0x2A1C),mdVal,0,0)
rc=BleCharCommit(svcHandle,attr$,chrHandle)
rc=BleServiceCommit(svcHandle)
```

```
rc=BleCharValueRead(chrHandle,attr$)

//read signed byte from index 2
rc=BleDecodeS8(attr$,v1,2)
PRINT "\ndata in Hex = 0x"; INTEGER.H'v1
PRINT "\ndata in Decimal = "; v1;"\n"

//read signed byte from index 6 - two's complement of -122
rc=BleDecodeS8(attr$,v1,6)
PRINT "\ndata in Hex = 0x"; INTEGER.H'v1
PRINT "\ndata in Decimal = "; v1;"\n"
```

Expected Output:

```
data in Hex = 0x00000002
data in Decimal = 2

data in Hex = 0xFFFFFFF86
data in Decimal = -122
```

5.12.2 BleDecodeU8

FUNCTION

This function reads a single byte in a string at a specified offset into a 32-bit integer variable without sign extension. If the offset points beyond the end of the string, this function fails.

BLEDECODEU8 (*attr\$, nData, nIndex*)

Returns	INTEGER, the number of bytes extracted from the attribute string. Can be less than the size expected if the nIndex parameter is positioned towards the end of the string.
Arguments:	
attr\$	byRef attr\$ AS STRING This references the attribute string from which the function reads.
nData	byRef nData AS INTEGER This references an integer to be updated with the 8-bit data from attr\$, without sign extension.
nIndex	byVal nIndex AS INTEGER This is the zero based index into the string attr\$ from which data is read. If the string attr\$ is not long enough to accommodate the index plus the number of bytes to read, this function fails.

Example:

```
// Example :: BleDecodeU8.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM chrHandle,v1,svcHandle,rc
DIM mdVal : mdVal = BleAttrMetadata(1,1,50,0,rc)
DIM attr$ : attr$="\00\01\02\03\04\85\86\87\88\89"
```

```

DIM uuid : uuid = 0x1853

rc=BleServiceNew(1, BleHandleUuid16(uuid), svcHandle)

rc=BleCharNew(0x07,BleHandleUuid16(0x2A1C),mdVal,0,0)
rc=BleCharCommit(svcHandle,attr$,chrHandle)

rc=BleServiceCommit(svcHandle)

rc=BleCharValueRead(chrHandle,attr$)

//read unsigned byte from index 2
rc=BleDecodeU8(attr$,v1,2)
PRINT "\ndata in Hex = 0x"; INTEGER.H'v1
PRINT "\ndata in Decimal = "; v1;"\n"

//read unsigned byte from index 6
rc=BleDecodeU8(attr$,v1,6)
PRINT "\ndata in Hex = 0x"; INTEGER.H'v1
PRINT "\ndata in Decimal = "; v1;"\n"

```

Expected Output:

```

data in Hex = 0x00000002
data in Decimal = 2

data in Hex = 0x00000086
data in Decimal = 134

```

5.12.3 BleDecodeS16

FUNCTION

This function reads two bytes in a string at a specified offset into a 32-bit integer variable with sign extension. If the offset points beyond the end of the string then this function fails.

BLEDECODES16 (*attr\$, nData, nIndex*)

Returns	INTEGER, the number of bytes extracted from the attribute string. Can be less than the size expected if the nIndex parameter is positioned towards the end of the string.
Arguments:	
attr\$	byRef attr\$ AS STRING This references the attribute string from which the function reads.
nData	byRef nData AS INTEGER This references an integer to be updated with the 2-byte data from attr\$, after sign extension.
nIndex	byVal nIndex AS INTEGER This is the zero based index into the string attr\$ from which data is read. If the string attr\$ is not long enough to accommodate the index plus the number of bytes to read, this function fails.

Example:

```
// Example :: BleDecodeS16.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM chrHandle,v1,svcHandle,rc
DIM mdVal : mdVal = BleAttrMetadata(1,1,50,0,rc)
DIM attr$ : attr$="\00\01\02\03\04\85\86\87\88\89"
DIM uuid : uuid = 0x1853

rc=BleServiceNew(1, BleHandleUuid16(uuid), svcHandle)

rc=BleCharNew(0x07,BleHandleUuid16(0x2A1C),mdVal,0,0)
rc=BleCharCommit(svcHandle,attr$,chrHandle)

rc=BleServiceCommit(svcHandle)

rc=BleCharValueRead(chrHandle,attr$)

//read 2 signed bytes from index 2
rc=BleDecodeS16(attr$,v1,2)
PRINT "\ndata in Hex = 0x"; INTEGER.H'v1
PRINT "\ndata in Decimal = "; v1;"\n"

//read 2 signed bytes from index 6
rc=BleDecodeS16(attr$,v1,6)
PRINT "\ndata in Hex = 0x"; INTEGER.H'v1
PRINT "\ndata in Decimal = "; v1;"\n"
```

Expected Output:

```
data in Hex = 0x00000302
data in Decimal = 770

data in Hex = 0xFFFF8786
data in Decimal = -30842
```

5.12.4 BleDecodeU16

This function reads two bytes from a string at a specified offset into a 32-bit integer variable **without** sign extension. If the offset points beyond the end of the string, then this function fails.

BLEDECODEU16 (*attr\$, nData, nIndex*)

Returns	INTEGER, the number of bytes extracted from the attribute string. Can be less than the size expected if the nIndex parameter is positioned towards the end of the string.
Arguments:	
attr\$	byRef attr\$ AS STRING This references the attribute string from which the function reads.
nData	byRef nData AS INTEGER This references an integer to be updated with the 2-byte data from attr\$, without sign extension.
nIndex	byVal nIndex AS INTEGER This is the zero based index into the string attr\$ from which data is read. If the string attr\$ is not long enough to accommodate the index plus the number of bytes to read, this function fails.

Example:

```
// Example :: BleDecodeU16.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM chrHandle,v1,svcHandle,rc
DIM mdVal : mdVal = BleAttrMetadata(1,1,50,0,rc)
DIM attr$ : attr$="\00\01\02\03\04\85\86\87\88\89"
DIM uuid : uuid = 0x1853

rc=BleServiceNew(1, BleHandleUuid16(uuid), svcHandle)

rc=BleCharNew(0x07,BleHandleUuid16(0x2A1C),mdVal,0,0)
rc=BleCharCommit(svcHandle,attr$,chrHandle)

rc=BleServiceCommit(svcHandle)

rc=BleCharValueRead(chrHandle,attr$)

//read 2 unsigned bytes from index 2
rc=BleDecodeU16(attr$,v1,2)
PRINT "\ndata in Hex = 0x"; INTEGER.H'v1
PRINT "\ndata in Decimal = "; v1;"\n"

//read 2 unsigned bytes from index 6
rc=BleDecodeU16(attr$,v1,6)
PRINT "\ndata in Hex = 0x"; INTEGER.H'v1
PRINT "\ndata in Decimal = "; v1;"\n"
```

Expected Output:

```
data in Hex = 0x00000302
data in Decimal = 770

data in Hex = 0x00008786
data in Decimal = 34694
```

5.12.5 BleDecodeS24

FUNCTION

This function reads three bytes in a string at a specified offset into a 32-bit integer variable with sign extension. If the offset points beyond the end of the string, this function fails.

BLEDECODES24 (attr\$, nData, nIndex)

Returns	INTEGER, the number of bytes extracted from the attribute string. Can be less than the size expected if the nIndex parameter is positioned towards the end of the string.
Arguments:	
attr\$	byRef attr\$ AS STRING This references the attribute string from which the function reads.
nData	byRef nData AS INTEGER This references an integer to be updated with the 3-byte data from attr\$, with sign extension.
nIndex	byVal nIndex AS INTEGER This is the zero based index into the string attr\$ from which data is read. If the string attr\$ is not long enough to accommodate the index plus the number of bytes to read, this function fails.

Example:

```
// Example :: BleDecodeS24.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM chrHandle,v1,svcHandle,rc
DIM mdVal : mdVal = BleAttrMetadata(1,1,50,0,rc)
DIM attr$ : attr$="\00\01\02\03\04\85\86\87\88\89"
DIM uuid : uuid = 0x1853

rc=BleServiceNew(1, BleHandleUuid16(uuid), svcHandle)

rc=BleCharNew(0x07,BleHandleUuid16(0x2A1C),mdVal,0,0)
rc=BleCharCommit(svcHandle,attr$,chrHandle)

rc=BleServiceCommit(svcHandle)

rc=BleCharValueRead(chrHandle,attr$)

//read 3 signed bytes from index 2
```

```
rc=BleDecodes24(attr$,v1,2)
PRINT "\ndata in Hex = 0x"; INTEGER.H'v1
PRINT "\ndata in Decimal = "; v1;"\n"

//read 3 signed bytes from index 6
rc=BleDecodes24(attr$,v1,6)
PRINT "\ndata in Hex = 0x"; INTEGER.H'v1
PRINT "\ndata in Decimal = "; v1;"\n"
```

Expected Output:

```
data in Hex = 0x00040302
data in Decimal = 262914

data in Hex = 0xFF888786
data in Decimal = -7829626
```

5.12.6 BleDecodeU24

FUNCTION

This function reads three bytes from a string at a specified offset into a 32-bit integer variable without sign extension. If the offset points beyond the end of the string, then this function fails.

BLEDECODEU24 (*attr\$, nData, nIndex*)

Returns	INTEGER, the number of bytes extracted from the attribute string. Can be less than the size expected if the nIndex parameter is positioned towards the end of the string.
Arguments:	
attr\$	byRef attr\$ AS STRING This references the attribute string from which the function reads.
nData	byRef nData AS INTEGER This references an integer to be updated with the 3-byte data from attr\$, without sign extension.
nIndex	byVal nIndex AS INTEGER This is the zero based index into the string attr\$ from which data is read. If the string attr\$ is not long enough to accommodate the index plus the number of bytes to read, this function fails.

Example:

```
// Example :: BleDecodeU24.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM chrHandle,v1,svcHandle,rc
DIM mdVal : mdVal = BleAttrMetadata(1,1,50,0,rc)
DIM attr$ : attr$="\00\01\02\03\04\85\86\87\88\89"
DIM uuid : uuid = 0x1853

rc=BleServiceNew(1, BleHandleUuid16(uuid), svcHandle)
```

```
rc=BleCharNew(0x07,BleHandleUuid16(0x2A1C),mdVal,0,0)
rc=BleCharCommit(svcHandle,attr$,chrHandle)

rc=BleServiceCommit(svcHandle)

rc=BleCharValueRead(chrHandle,attr$)

//read 3 unsigned bytes from index 2
rc=BleDecodeU24(attr$,v1,2)
PRINT "\ndata in Hex = 0x"; INTEGER.H'v1
PRINT "\ndata in Decimal = "; v1;"\n"

//read 3 unsigned bytes from index 6
rc=BleDecodeU24(attr$,v1,6)
PRINT "\ndata in Hex = 0x"; INTEGER.H'v1
PRINT "\ndata in Decimal = "; v1;"\n"
```

Expected Output:

```
data in Hex = 0x00040302
data in Decimal = 262914

data in Hex = 0x00888786
data in Decimal = 8947590
```

5.12.7 BleDecode32

FUNCTION

This function reads four bytes in a string at a specified offset into a 32-bit integer variable. If the offset points beyond the end of the string, this function fails.

BLEDECODE32 (*attr\$*, *nData*, *nIndex*)

Returns	INTEGER, the number of bytes extracted from the attribute string. Can be less than the size expected if the nIndex parameter is positioned towards the end of the string.
Arguments:	
attr\$	byRef attr\$ AS STRING This references the attribute string from which the function reads.
nData	byRef nData AS INTEGER This references an integer to be updated with the 3-byte data from attr\$, after sign extension.
nIndex	byVal nIndex AS INTEGER This is the zero based index into the string attr\$ from which data is read. If the string attr\$ is not long enough to accommodate the index plus the number of bytes to read, this function fails.

Example:

```
// Example :: BleDecode32.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM chrHandle,v1,svcHandle,rc
DIM mdVal : mdVal = BleAttrMetadata(1,1,50,0,rc)
DIM attr$ : attr$="\00\01\02\03\04\85\86\87\88\89"
DIM uuid : uuid = 0x1853

rc=BleServiceNew(1, BleHandleUuid16(uuid), svcHandle)

rc=BleCharNew(0x07,BleHandleUuid16(0x2A1C),mdVal,0,0)
rc=BleCharCommit(svcHandle,attr$,chrHandle)

rc=BleServiceCommit(svcHandle)

rc=BleCharValueRead(chrHandle,attr$)

//read 4 signed bytes from index 2
rc=BleDecode32(attr$,v1,2)
PRINT "\ndata in Hex = 0x"; INTEGER.H'v1
PRINT "\ndata in Decimal = "; v1;"\n"

//read 4 signed bytes from index 6
rc=BleDecode32(attr$,v1,6)
PRINT "\ndata in Hex = 0x"; INTEGER.H'v1
PRINT "\ndata in Decimal = "; v1;"\n"
```

Expected Output:

```
data in Hex = 0x85040302
data in Decimal = -2063334654

data in Hex = 0x89888786
data in Decimal = -1987541114
```

5.12.8 BleDecodeFLOAT

FUNCTION

This function reads four bytes in a string at a specified offset into a couple of 32-bit integer variables. The decoding results in two variables, the 24-bit signed mantissa and the 8-bit signed exponent. If the offset points beyond the end of the string, this function fails.

BLEDECODEFLOAT (attr\$, nMantissa, nExponent, nIndex)

Returns	INTEGER, the number of bytes extracted from the attribute string. Can be less than the size expected if the nIndex parameter is positioned towards the end of the string.										
Arguments:											
attr\$	byRef attr\$ AS STRING This references the attribute string from which the function reads.										
nMantissa	byRef nMantissa AS INTEGER This is updated with the 24 bit mantissa from the 4-byte object. If nExponent is 0, you must check for the following special values: <table border="1"> <tr> <td>0x007FFFFFFF</td><td>NaN (Not a Number)</td></tr> <tr> <td>0x00800000</td><td>NRes (Not at this resolution)</td></tr> <tr> <td>0x007FFFFFFE</td><td>+ INFINITY</td></tr> <tr> <td>0x00800002</td><td>- INFINITY</td></tr> <tr> <td>0x00800001</td><td>Reserved for future use</td></tr> </table>	0x007FFFFFFF	NaN (Not a Number)	0x00800000	NRes (Not at this resolution)	0x007FFFFFFE	+ INFINITY	0x00800002	- INFINITY	0x00800001	Reserved for future use
0x007FFFFFFF	NaN (Not a Number)										
0x00800000	NRes (Not at this resolution)										
0x007FFFFFFE	+ INFINITY										
0x00800002	- INFINITY										
0x00800001	Reserved for future use										
nExponent	byRef nExponent AS INTEGER This is updated with the 8-bit mantissa. If it is zero, check nMantissa for special cases as stated above.										
nIndex	byVal nIndex AS INTEGER This is the zero based index into the string attr\$ from which data is read. If the string attr\$ is not long enough to accommodate the index plus the number of bytes to read, this function fails.										

Example:

```
// Example :: BleDecodeFloat.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM chrHandle,v1,svcHandle,rc, mantissa, exp
DIM mdVal : mdVal = BleAttrMetadata(1,1,50,0,rc)
DIM attr$ : attr$="\00\01\02\03\04\85\86\87\88\89"
DIM uuid : uuid = 0x1853

rc=BleServiceNew(1, BleHandleUuid16(uuid), svcHandle)
rc=BleCharNew(0x07,BleHandleUuid16(0x2A1C),mdVal,0,0)
rc=BleCharCommit(svcHandle,attr$,chrHandle)

rc=BleServiceCommit(svcHandle)

rc=BleCharValueRead(chrHandle,attr$)
```

```
//read 4 bytes FLOAT from index 2 in the string
rc=BleDecodeFloat(attr$,mantissa,exp,2)
PRINT "\nThe number read is ";mantissa;" x 10^";exp

//read 4 bytes FLOAT from index 6 in the string
rc=BleDecodeFloat(attr$,mantissa,exp,6)
PRINT "\nThe number read is ";mantissa;"x 10^";exp
```

Expected Output:

```
The number read is 262914*10^-123
The number read is -7829626*10^-119
```

5.12.9 BleDecodeSFloat

FUNCTION

This function reads two bytes in a string at a specified offset into a couple of 32-bit integer variables. The decoding results in two variables, the 12-bit signed mantissa and the 4-bit signed exponent. If the offset points beyond the end of the string then this function fails.

BLEDECODESFloat (attr\$, nMantissa, nExponent, nIndex)

Returns	INTEGER, the number of bytes extracted from the attribute string. Can be less than the size expected if the nIndex parameter is positioned towards the end of the string.	
Arguments:		
attr\$	byRef attr\$ AS STRING This references the attribute string from which the function reads.	
nMantissa	byRef nMantissa AS INTEGER This is updated with the 12-bit mantissa from the two byte object. If the nExponent is 0, you must check for the following special values:	
	0x007FFFFFFF	NaN (Not a Number)
	0x00800000	NRes (Not at this resolution)
	0x007FFFFE	+ INFINITY
	0x00800002	- INFINITY
	0x00800001	Reserved for future use
nExponent	byRef nExponent AS INTEGER This is updated with the 4-bit mantissa. If it is zero, check the nMantissa for special cases as stated above.	
nIndex	byVal nIndex AS INTEGER This is the zero based index into the string attr\$ from which data is read. If the string attr\$ is not long enough to accommodate the index plus the number of bytes to read, this function fails.	

Example:

```
// Example :: BleDecodeSFloat.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM chrHandle,v1,svcHandle,rc, mantissa, exp
DIM mdVal : mdVal = BleAttrMetadata(1,1,50,0,rc)
```

```
DIM attr$ : attr$="\00\01\02\03\04\85\86\87\88\89"
DIM uuid : uuid = 0x1853

rc=BleServiceNew(1, BleHandleUuid16(uuid), svcHandle)

rc=BleCharNew(0x07,BleHandleUuid16(0x2A1C),mdVal,0,0)
rc=BleCharCommit(svcHandle,attr$,chrHandle)

rc=BleServiceCommit(svcHandle)

rc=BleCharValueRead(chrHandle,attr$)

//read 2 bytes FLOAT from index 2 in the string
rc=BleDecodeSFloat(attr$,mantissa,exp,2)
PRINT "\nThe number read is ";mantissa;" x 10^";exp

//read 2 bytes FLOAT from index 6 in the string
rc=BleDecodeSFloat(attr$,mantissa,exp,6)
PRINT "\nThe number read is ";mantissa;"x 10^";exp
```

Expected Output:

```
The number read is 770 x 10^0
The number read is 1926x 10^-8
```

5.12.10 BleDecodeTIMESTAMP

FUNCTION

This function reads seven bytes from string an offset into an attribute string. If the offset plus seven bytes points beyond the end of the string then this function fails.

The seven byte string consists of a byte each for century, year, month, day, hour, minute and second. If (year * month) is zero, it is taken as "not noted" year and all the other fields are set zero (not noted).

For example: 5 May 2013 10:31:24 is represented in the source as \DD\07\05\05\0A\1F\18 and the year is be translated into a century and year so that the destination string is \14\0D\05\05\0A\1F\18.

BLEDECODETIMESTAMP (attr\$, timestamp\$, nIndex)

Returns	INTEGER, the number of bytes extracted from the attribute string. Can be less than the size expected if the nIndex parameter is positioned towards the end of the string.
Arguments:	
attr\$	byRef attr\$ AS STRING This references the attribute string from which the function reads.
timestamp\$	byRef timestamp\$ AS STRING On exit this is an exact 7-byte string as described above. For example: 5 May 2013 10:31:24 is stored as \14\0D\05\05\0A\1F\18

<i>nIndex</i>	byVal <i>nIndex</i> AS INTEGER This is the zero based index into the string attr\$ from which data is read. If the string attr\$ is not long enough to accommodate the index plus the number of bytes to read, this function fails.

Example:

```
// Example :: BleDecodeTimestamp.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM chrHandle,v1,svcHandle,rc, ts$
DIM mdVal : mdVal = BleAttrMetadata(1,1,50,0,rc)
//5th May 2013, 10:31:24
DIM attr$ : attr$="\00\01\02\DD\07\05\05\0A\1F\18"
DIM uuid : uuid = 0x1853

rc=BleServiceNew(1, BleHandleUuid16(uuid), svcHandle)

rc=BleCharNew(0x07,BleHandleUuid16(0x2A1C),mdVal,0,0)
rc=BleCharCommit(svcHandle,attr$,chrHandle)

rc=BleServiceCommit(svcHandle)

rc=BleCharValueRead(chrHandle,attr$)

//read 7 byte timestamp from the index 3 in the string
rc=BleDecodeTimestamp(attr$,ts$,3)
PRINT "\nTimestamp = "; StrHexize$(ts$)
```

Expected Output:

```
Timestamp = 140D05050A1F18
```

5.12.11 BleDecodeSTRING

FUNCTION

This function reads a maximum number of bytes from an attribute string at a specified offset into a destination string. Because the output string can handle truncated bit blocks, this function does not fail.

BLEDECODESTRING (*attr\$, nIndex, dst\$, nMaxBytes*)

Returns	INTEGER, the number of bytes extracted from the attribute string. Can be less than the size expected if the nIndex parameter is positioned towards the end of the string.
Arguments:	
attr\$	byRef attr\$ AS STRING This references the attribute string from which the function reads.
nIndex	byVal nIndex AS INTEGER This is the zero based index into string attr\$ from which data is read.
dst\$	byRef dst\$ AS STRING This argument is a reference to a string that is updated with up to nMaxBytes of data from the index specified. A shorter string is returned if there are not enough bytes beyond the index.
nMaxBytes	byVal nMaxBytes AS INTEGER This specifies the maximum number of bytes to read from attr\$.

Example:

```
// Example :: BleDecodeString.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM chrHandle,v1,svcHandle,rc, ts$,decStr$
DIM mdVal : mdVal = BleAttrMetadata(1,1,50,0,rc)
//"ABCDEFGHIJ"
DIM attr$ : attr$="41\42\43\44\45\46\47\48\49\4A"
DIM uuid : uuid = 0x1853

rc=BleServiceNew(1, BleHandleUuid16(uuid), svcHandle)

rc=BleCharNew(0x07,BleHandleUuid16(0x2A1C),mdVal,0,0)
rc=BleCharCommit(svcHandle,attr$,chrHandle)

rc=BleServiceCommit(svcHandle)

rc=BleCharValueRead(chrHandle,attr$)

//read max 4 bytes from index 3 in the string
rc=BleDecodeSTRING(attr$,3,decStr$,4)
PRINT "\nd$=";decStr$
```

```
//read max 20 bytes from index 3 in the string - will be truncated
rc=BleDecodeSTRING(attr$,3,decStr$,20)
PRINT "\nd$=";decStr$

//read max 4 bytes from index 14 in the string - nothing at index 14
rc=BleDecodeSTRING(attr$,14,decStr$,4)
PRINT "\nd$=";decStr$
```

Expected Output:

```
d$=CDEF
d$=CDEFGHIJ
d$=
```

5.12.12 BleDecodeBITS

FUNCTION

This function reads bits from an attribute string at a specified offset (treated as a bit array) into a destination integer object (treated as a bit array of fixed size of 32). This implies a maximum of 32 bits can be read. Because the output bit array can handle truncated bit blocks, this function does not fail.

BLEDECODEBITS (*attr\$, nSrcIdx, dstBitArr, nDstIdx, nMaxBits*)

Returns	INTEGER, the number of bits extracted from the attribute string. Can be less than the size expected if the nSrcIdx parameter is positioned towards the end of the source string or if nDstIdx will not allow more to be copied.
Arguments:	
attr\$	byRef attr\$ AS STRING This references the attribute string from which to read, treated as a bit array. Hence a string of 10 bytes is an array of 80 bits.
nSrcIdx	byVal nSrcIdx AS INTEGER This is the zero based bit index into the string attr\$ from which data is read. For example, the third bit in the second byte is index number 10.
dstBitArr	byRef dstBitArr AS INTEGER This argument references an integer treated as an array of 32 bits into which data is copied. Only the written bits are modified.
nDstIdx	byVal nDstIdx AS INTEGER This is the zero based bit index into the bit array dstBitArr to where the data is written.
nMaxBits	byVal nMaxBits AS INTEGER This argument specifies the maximum number of bits to read from attr\$. Due to the destination being an integer variable, it cannot be greater than 32. Negative values are treated as zero.

Example:

```
// Example :: BleDecodeBits.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM chrHandle,v1,svcHandle,rc, ts$,decStr$
DIM ba : ba=0
```

```
DIM mdVal : mdVal = BleAttrMetadata(1,1,50,0,rc)
// "ABCDEFGHIJ"
DIM attr$ : attr$="41\42\43\44\45\46\47\48\49\4A"
DIM uuid : uuid = 0x1853

rc=BleServiceNew(1, BleHandleUuid16(uuid), svcHandle)

rc=BleCharNew(0x07,BleHandleUuid16(0x2A1C),mdVal,0,0)
rc=BleCharCommit(svcHandle,attr$,chrHandle)

rc=BleServiceCommit(svcHandle)

rc=BleCharValueRead(chrHandle,attr$)

//read max 14 bits from index 20 in the string to index 10
rc=BleDecodeBITS(attr$,20,ba,10,14)
PRINT "\nbit array = ", INTEGER.B' ba

//read max 14 bits from index 20 in the string to index 10
ba=0x12345678
PRINT "\n\nbit array = ",INTEGER.B' ba

rc=BleDecodeBITS(attr$,14000,ba,0,14)
PRINT "\nbit array now = ", INTEGER.B' ba
//ba will not have been modified because index 14000
//doesn't exist in attr$
```

Expected Output:

```
bit array =      00000000000100001101000000000000
bit array =      00010010001101000101011001111000
bit array now =  00010010001101000101011001111000
```


5.13 Bonding and Bonding Database Functions

5.13.1 Bonding Functions

This section describes all functions related to the pairing and bonding manager which manages trusted devices. The database stores information like the address of the trusted device along with the security keys. At the time of writing this manual a maximum of 16 devices can be stored in the database and the command AT I 2012 or at runtime SYSINFO(2012) returns the maximum number of devices that can be saved in the database

The type of information that can be stored for a trusted device is:

- The Bluetooth address of the trusted device (and it will be the non-resolvable address if the connection was originally established by the central device using its resolvable key – like iOS devices).
- A 16 byte key, eDIV and eRAND for the long term key, called LTK. Up to 2 instances of this LTK can be stored. One which is supplied by the central device and the other is the one supplied by the peripheral. This means in a connection, the device will check which role (peripheral or central) it is connected as and pick the appropriate key for subsequent encryption requests.
- The size of the long term key.
- A flag to indicate if the LTK is authenticated – Man-In-The-Middle (MITM) protection.
- A 16 byte Identity Resolving Key (IRK).
- A 16 byte Connection Signature Resolving Key (CSRK)

5.13.2 Bonding Table Types: Rolling & Persist

The bonding database contains two tables of bonds where both tables have the same structure in terms of what each record can store and from a BLE perspective are equal in meaning.

For the purpose of clarity both in this manual and in smartBASIC, one table is called the 'Rolling' table and the other is called 'Persistent' table.

When a new bonding occurs the information is ALWAYS guaranteed to be saved in the 'Rolling' table, and if it is full, then the oldest 'Rolling' bond is automatically deleted to make space for the new one.

The 'Persistent' table can only be populated by transferring a bond from the 'Rolling' table using the function BleBondingPersistKey.

Use the function BleBondingEraseKey to delete a key and the function will look for it in both tables and when found delete it. There is no need to know which table it belongs to when deleting. The database manager ensures there is only one instance of a bond and so a device cannot occur in both.

The total number of bonds in the 'Rolling' and 'Persistent' tables will always be less than or equal to the capacity of the database which is returned as explained above using AT I 2012 or SYSINFO(2012).

The number of 'Rolling' or 'Persistent' bonds (or maximum capacity) at any time can be obtained by calling the function BleBondingStats. The 'Persistent' total is the difference between the 'total' and 'rolling' variables returned by that routine.

At any time, the capacity of the 'Rolling' table is the difference between the absolute total capacity and the number of bonds in the 'Persistent' table. See the function BleBondingStats which returns information that can be used to determine this.

Bonds in the 'Rolling' table can be transferred to 'Persistent' unless the 'Persist' table is full. The capacity of the 'Persistent' table is returned by AT I 2043 or SYSINFO(2043) and at the time of writing this manual it is 12, which corresponds to 75% of the total capacity.

If a bond exists and it happens to be in the 'Persistent' table and new bonding provides new information then the record is updated.

If a bond exists and it happens to be in the 'Rolling' table and new bonding provides new information then the record is updated and in addition, the age list is updated to that the device is marked the 'youngest' in the age list.

It is expected that a smartBASIC application wanting to manage trusted device will use a combination of the functions : BleBondMngrGetInfo, BleBondingIsTrusted, BleBondingPersistKey and BleBondingEraseKey.

5.13.3 Whisper Mode Pairing

BLE provides for simple secure pairing with or without man-in-the-middle attack protection. To enhance security while a pairing is in progress the specification has provided for Out-of-Band pairing where the shared secret information is exchanged by means other than the Bluetooth connection. That mode of pairing is currently not exposed.

Laird have provided an additional mechanism for bonding using the standard inbuilt simple secure pairing which is called Whisper Mode pairing. In this mode, when a pairing is detected to be in progress, the transmit power is automatically reduced so that the 'bubble' of influence is reduced and thus a proximity based enhanced security is achieved.

To take advantage of this pairing mechanism, use the function `BleTxPwrWhilePairing()` to reduce the transmit power for the short duration that the pairing is in progress.

5.13.3.1 Events and Messages

The following bonding manager messages are thrown to the run-time engine using the `EVBLEMSG` message with the following msgIDs:

MsgId	Description
10	A new bond has been successfully created
16	The device has successfully connected to a bonded master
17	The bonding information in the bonding database have been updated
22	Adding the paired device and its information to the bonding database has failed

5.13.4 BleBondingStats

FUNCTION

This function retrieves statistics of the bonding manager which consists of the total capacity as the return value and the rolling and total bonds via the arguments. By implication, the number of persistent bonds is the difference between `nTotal` and `nRolling`.

BLEBONDINGSTATS (nRolling, nPersistent)

Returns	The total capacity of the database
Arguments:	
nRolling	byREF nRolling AS INTEGER On return, this integer contains the total number of bonds in the rolling database.
nPersistent	byREF nPersistent AS INTEGER On return, this integer contains the total number of bonds in the persistent database.

Example:

```
// Example :: BleBondingStats.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

dim rc, nRoll, nPers
print "\nBonding Manager Database Statistics:"
print "\nCapacity: ", "", BleBondingStats(nRoll, nPers)
print "\nRolling: ", "", nRoll
print "\nPersistent: ", nPers
```

Expected Output:

```
:Bonding Manager Database Statistics:
Capacity:      16
Rolling:       2
Persistent:    0
```

BLEBONDINGSTATS is a built-in function.

5.13.5 BleBondingPersistKey

FUNCTION

This function is used to make a bonding link key persistent. Its entry is moved from the rolling database to the persistent database so that it is never automatically overwritten.

BLEBONDINGPERSISTKEY (bdAddr\$)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
bdAddr\$	byREF bdAddr\$ AS STRING Bluetooth address in big endian. Must be exactly seven bytes long.

Example:

```
// Example :: BleBondingPersistKey.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

dim rc, i, j, k, adr$, inf

'//Loop through the bonding manager. Make all entries persistent
for i=0 to BleBondingStats(j,k)
    rc=BleBondMgrGetInfo(i,adr$,inf)
    if rc==0 then
        rc=BleBondingPersistKey(adr$)
        print "\n(";i;") : ";StrHexize$(adr$);" Now Persistent"
    endif
next
```

Expected Output:

```
(0) : 01F63627A60BEA Now Persistent
(1) : 01D8CFCF14498D Now Persistent
```

BLEBONDINGPERSISTKEY is a built-in function.

5.13.6 BleBondingIsTrusted

FUNCTION

This function is used to check if a device identified by the address is a trusted device which means it exists in the bonding database.

BLEBONDINGISTRUSTED (addr\$, fAsCentral, keyInfo, rollingAge, rollingCount)

Returns	INTEGER: Is 0 if not trusted, otherwise it is the length of the long term key (LTK)
Arguments	
addr\$	byRef addr\$ AS STRING This is the address of the device for which the bonding information is to be checked. If this is a resolvable address and the device is trusted, then on exit this variable is replaced with the static address that was supplied at pairing time.
fAsCentral	Set to 0 if the device is to be trusted as a peripheral and non-zero if to be trusted as central.
keyInfo	This is a bit mask with bit meanings as follows: This specifies the write rights and shall have one of the following values: Bit 0 Set if MITM is authenticated Bit 1 Set if it is a rolling bond and can be automatically deleted if the database is full and a new bonding occurs Bit 2 Set if an IRK (identity resolving key) exists Bit 3 Set if a CSRK (connection signing resolving key) exists Bit 4 Set if LTK as slave exists Bit 5 Set if LTK as master exists
rollingAge	If the value is <= 0, this is not a rolling device. 1 implies it is the newest bond, 2 implies it is the second newest bond, and so on.
rollingCount	On exit this will contain the total number of rolling bonds. This provides some context with regards to how old this device is compared to other bonds in the rolling group.

Example:

```
// Example :: BleBondingIsTrusted.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc, addr$, realaddr$, Central, KeyInfo, Age, Count

addr$ = "000016A4123456"
realaddr$ = strdehexize$(addr$)

print "Address: ";addr$;"\n"
rc = BleBondingIsTrusted(realaddr$, Central, KeyInfo, Age, Count)
print "Is Trusted: ";rc;"\n"

if (rc != 0) then
  //Output details
  if (Central == 0) then
    print "Peripheral"
  elseif (Central == 1) then
    print "Central"
  endif
  print " device, keyinfo: ";integer.b'KeyInfo
  print " Age: ";Age;" Count: ";count;"\n"
endif
```

```
Address: 000016A4123456  
Is Trusted: 16  
Peripheral device, keyinfo: 0000000000000000000000000110110 Age: 1 Count: 1
```

Address: 000016A4123456
Is Trusted: 0

5.13.7 BleBondingEraseKey

BLEBONDINGERASEKEY (bdAddr\$)

Example:

```
// Example :: BleBondingEraseKey.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

dim rc, i, adr$, inf

//delete link key at index 0

rc=BleBondMgrGetInfo(0,adr$,inf)           //get the BT address

rc=BleBondingEraseKey(adr$)

if rc==0 then

    print "\nLink key for device ";StrHexize$(adr$);" erased"

else

    print "\nError erasing link key ";integer.h'rc

endif
```

```
Link key for device 01FA84D748D903 erased
```

Americas: +1-800-492-2320
Europe: +44-1628-858-940
Hong Kong: +852 2923 0610

5.13.8 BleBondingEraseAll

FUNCTION

This function is used to erase all bondings in the database.

Note: Calling this function when the connection supervision timeout is 100ms may cause a disconnection. The reason for this is that calling this function may prevent the radio sending ACK packets to the remote device within the supervision timeout. The supervision timeout is set at [BleConnect](#) or at [BleSetCurConnParams](#).

BLEBONDINGERASEALL ()

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.

Example:

```
// Example :: BleBondingEraseAll.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

dim rc

//Erase all bondings in database
rc=BleBondingEraseAll ()
if rc==0 then
    print "\nBonding database cleared"
endif
```

Expected Output:

```
Bonding database cleared
```

BLEBONDINGERASEALL is a built-in function.

5.13.9 BleBondMngrGetInfo

FUNCTION

This function retrieves the Bluetooth address and other information from the trusted device database via an index.

Note: Do not rely on a device in the database mapping to a static index. New bondings change the position in the database.

BLEBONDMNGRGETINFO (nIndex, addr\$, nExtraInfo)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
nIndex	byVal nIndex AS INTEGER This is an index into the database, less than the value returned by SYSINFO(2012).
addr\$	byRef addr\$ AS STRING On exit, if nIndex points to a valid entry in the database, this variable contains a Bluetooth address exactly seven bytes long. The first byte identifies public or private random address. The next six bytes are the address.

***nExtraInfo* byRef nExtraInfo AS INTEGER**

On exit, if nIndex points to a valid entry in the database, this variable contains a composite integer value where the lower 16 bits are for internal use and should be treated as opaque data. Bit 17 is set if the IRK (Identity Resolving Key) exists for the trusted device and bit 18 is set if the CSRK (Connection Signing Resolving Key) exists for the trusted device.

Example:

```
// Example :: BleBondMngrGetInfo.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

#define BLE_INV_INDEX          24619
DIM rc, addr$, exInfo
rc = BleBondMngrGetInfo(0,addr$,exInfo) //Extract info of device at index 0

IF rc==0 THEN
    PRINT "\nBluetooth address: ";addr$
    PRINT "\nInfo: ";exInfo
ELSEIF rc==BLE_INV_INDEX THEN
    PRINT "\nInvalid index"
ENDIF
```

Expected Output when valid entry present in database:

```
Bluetooth address: \00\BC\B1\F3x3\AB
Info: 97457
```

Expected Output with invalid index:

```
Invalid index
```

5.14 Security Manager Functions

The following is a high level overview of Bluetooth Low Energy pairing/authentication and it is encouraged that the reader access resources on the internet which give further details, like for example <https://developer.bluetooth.org/TechnologyOverview/Pages/LE-Security.aspx>

Pairing is the process of exchanging security keys between two connected devices to establish trust and authenticate the connection between the two devices. The exchanged keys can be used to encrypt the connection to safeguard against passive eavesdropping. Pairing in versions 4.0 and 4.1 of the Bluetooth core specification is exposed through Secure Simple Pairing, which is now referred to as Legacy pairing. Security is now greatly enhanced with the release of the 4.2 specification due to the introduction of the LE Secure Connections pairing model. In this model, Elliptic Curve Diffie-Hellman (ECDH) algorithm is used for the key exchange process where the two parties can compute a shared secret without exchanging it over the BLElink.

This section describes routines which manage all aspects of BLE security such as IO capabilities, Passkey exchange, OOB data, and bonding requirements.

5.14.1 Events and Messages

5.14.1.1 EVBLEMSG

The following security manager messages are thrown to the run-time engine using the EVBLEMSG message with the following msgIDs:

MsgId	Description
9	Pairing in progress and display Passkey supplied in msgCtx.
10	A new bond has been successfully created
11	Pairing in progress and authentication key requested. Type of key is in msgCtx. msgCtx is 1 for passkey_type which is a number in the range 0 to 999999 and 2 for OOB key which is a 16 byte key.
18	The connection has been successfully encrypted
20	The connection has been unencrypted
26	Authentication/pairing has failed
27	LE Secure Connections pairing has been successfully established
28	OOB data has been requested by the peer device during LE Secure Connections pairing

To submit a passkey, use the function [BLESECMNGRPASSKEY](#).

5.14.1.2 EVLESCKEYPRESS

This event message is thrown when the BL654 receives notifications that the peer device is performing keypresses during passkey entry in an LE Secure Connections pairing. This event comes with two parameters:

- Connection handle
- Keypress type

Keypress Type	Description
0	Passkey entry started
1	Passkey digit entered
2	Passkey digit erased
3	Passkey cleared
4	Passkey entry completed

See example for [BleSecMngrLescKeypressNotify](#).

5.14.1.3 EVBLE_PASSKEY

This event is thrown when there is BLE pairing in progress that requires the entry/acceptance of a passkey. The event includes the following parameters:-

- Connection handle
- The passkey that is thrown by the stack, which should then be accepted or entered by the remote device.
- Flags parameter that is reserved for future use.

Example:

```
//Example :: BleSecMngrPasskey.sb

// Definitions
#define BLE_EVBLEMSGID_CONNECT          0 // nCtx = connection handle
#define BLE_EVBLEMSGID_DISCONNECT      1 // nCtx = connection handle
#define BLE_EVBLEMSGID_NEW_BOND        10 // nCtx = connection handle
#define BLE_EVBLEMSGID_UPDATED_BOND    17 // nCtx = connection handle
#define BLE_EVBLEMSGID_ENCRYPTED        18 // nCtx = connection handle
#define BLE_EVBLEMSGID_AUTHENTICATION_FAILED 26 // nCtx = connection handle
```



```
#define BLE_EVBLEMSGID_LESC_PAIRING 27 // nCtx = connection handle

// Variable Declaration
DIM rc, connHandle
DIM addr$ : addr$=""

//-----
// Ble event handler
//-----
FUNCTION HandlerBleMsg (BYVAL nMsgId AS INTEGER, BYVAL nCtx AS INTEGER) AS INTEGER
    SELECT nMsgId
        CASE BLE_EVBLEMSGID_CONNECT
            connHandle = nCtx
            PRINT "## Ble Connection :: Handle=";integer.h' nCtx;"\n"

        CASE BLE_EVBLEMSGID_DISCONNECT
            PRINT "## Disconnected :: Handle=";integer.h' nCtx;"\n"
            EXITFUNC 0

        CASE BLE_EVBLEMSGID_ENCRYPTED
            PRINT "## Encrypted Connection :: Handle=";integer.h' nCtx;"\n"
        CASE BLE_EVBLEMSGID_NEW_BOND
            PRINT "## New Bond :: Handle=";integer.h' nCtx;"\n"
        CASE BLE_EVBLEMSGID_LESC_PAIRING
            PRINT "## LESC Pairing :: Handle=";integer.h' nCtx;"\n"
        CASE BLE_EVBLEMSGID_AUTHENTICATION_FAILED
            PRINT "## Pairing Failed :: Handle=";integer.h' nCtx;"\n"
        CASE ELSE
            // Do nothing
    ENDSELECT
ENDFUNC 1

//-----
// Pairing attempt in progress - Passkey needs to be displayed
//-----
Function HandlerBlePasskey (BYVAL nConnHandle, BYVAL nPasskey, BYVAL nFlags)
    // The following passkey should be entered by remote
    print "## Pairing Attempt :: Handle=";integer.h' nConnHandle;"\n"
    print "## Please enter the following passkey: ";nPasskey;"\n"
Endfunc 1

//-----
// Enable synchronous event handlers
//-----
ONEVENT EVBLEMSG CALL HandlerBleMsg
ONEVENT EVBLE_PASSKEY CALL HandlerBlePasskey

// Set pairing IO capability to Display.
// Remote pairing IO capability should be keyboard
rc = BleSecMngrIoCap(3)

// Start advertising
IF BleAdvertStart(0,addr$,25,60000,0)==0 THEN
    PRINT "## Adverts Started\n"
    PRINT "## Make a connection to the BL654\n"
ELSE
    PRINT "## Advertisement not successful\n"
ENDIF

WAITEVENT
```

Expected Output:

```
## Adverts Started
## Make a connection to the BL654
## Ble Connection :: Handle=0001FF00
## Pairing Attempt :: Handle=0001FF00
## Please enter the following passkey: 242652
## Encrypted Connection :: Handle=0001FF00
## LESC Pairing :: Handle=0001FF00
## New Bond :: Handle=0001FF00
```

5.14.2 BleSecMngrLescPairingPref

FUNCTION

This function is used to set LE Secure connections to be the preferred pairing model. Both devices must support LE Secure Connections in order for it to be used during pairing.

BLESECMNGRLESCPAIRINGPREF (nLescPairingPref)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
nLescPairingPref	byVal nJustWorksConf AS INTEGER. If set to 0, legacy pairing is used. If set to 1, LE Secure Connections with diffie-hellman key exchange is used as the pairing model. The default pairing model is LE Secure Connections pairing.

See example for [BlePair\(\)](#).

5.14.3 BlePair

FUNCTION

This routine is used to induce the module to pair with the peer and to specify whether to bond with the peer by storing pairing information in the bonding manager. This function is likely to be used if a write attempt to an attribute fails with a status code such as 0x105. See [EvAttrWrite](#) and [EvAttrRead](#).

BLEPAIR (hConn, nSave)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.	
Arguments:		
hConn	byRef hConn AS INTEGER. This is the connection handle provided in the EVBLEMSG(0) message which informs the stack that a connection had been established.	
nSave	byVal nSave AS INTEGER This flag sets whether or not to bond.	
	Value	Description
	0	Do not store pairing information (don't bond)
	1	Store pairing information (bond)

Example:

```
// Example :: BlePair.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

dim rc, pr$, hC, hDesc
```

```

dim s$ : s$ = "\02\00"           //value to write to cccd to enable indications

//This example app was tested with a BL654 running the health thermometer sensor sample
app which requires bonding.

//It connects, tries to read from the temperature characteristic and then initiates a
bonding procedure when it fails.

#define GATT_SERVER_ADDRESS      "\01\F6\36\27\A6\0B\EA"
#define AUTHENTICATION_REQUIRED  0x0105

#define SERVICE_UUID             0x1809
#define CHAR_UUID                0x2a1c
#define DESC_UUID                0x2902

'//-----
'// For debugging
'// --- rc = result code
'// --- ln = line number
'//-----

Sub AssertRC(rc,ln)
    if rc!=0 then
        print "\nFail :";integer.h' rc;" at tag ";ln
    endif
EndSub

'//-----
'// This handler is called when there is a significant BLE event
'//-----

function HndlrBleMsg(byval nMsgId as integer, byval nCtx as integer)
    select nMsgId
        case 0
            hC = nCtx
            print "\nConnected, Finding Temp Measurement Char"
            rc=BleGattcFindDesc(nCtx, BleHandleUuid16(SERVICE_UUID), 0,
BleHandleUuid16(CHAR_UUID), 0, BleHandleUuid16(DESC_UUID), 0)
            AssertRC(rc,35)
        case 1
            print "\n\n --- Disconnected"
        case 10
            print "\nNew bond created"
    endselect
endfunction

```

```
        print "\n\nAttempting to enable indications again"
        rc=BleGattcWrite(hC, hDesc, s$)
        AssertRC(rc,58)
    case 11
        print "\nPair request: Accepting"
        rc=BleAcceptPairing(hC,1)
        AssertRC(rc,52)
        print "\nPairing in progress"
    case 17
        print "\nNew pairing/bond has replaced old key"
    case 18
        print "\nConnection now encrypted"
    case else
    endselect
endfunc 1

'//-----
'// Called after BleGattcFindDesc returns success
'//-----

function HndlrFindDesc(hConn, hD)
    if hD==0 then
        print "\nCCCD not found"
        exitfunc 0
    endif

    hDesc = hD
    print "\nTemp Measurement Char CCCD Found. Attempting to enable indications"
    rc=BleGattcWrite(hConn, hDesc, s$)
    AssertRC(rc,58)
endfunc 1

'//-----
'// Called after BleGattcRead returns success
'//-----

function HndlrAttrWriteExit(hConn, hAttr, nSts)
endfunc 0

'//-----
'// Called after BleGattcRead returns success
```

```
'//-----  
function HndlrAttrWrite(hConn, hAttr, nSts)  
    if nSts == 0 then  
        print "\nIndications enabled"  
        print "\nDisabling indications"  
        s$ = "\00\00"  
        rc=BleGattcWrite(hC, hDesc, s$)  
        onevent evattrwrite call HndlrAttrWriteExit  
        exitfunc 1  
  
    elseif nSts == AUTHENTICATION_REQUIRED then  
        print "\n\nAuthentication required."  
        '//bond with the peer  
        rc=BlePair(hConn, 1)  
        AssertRC(rc,75)  
        print " Bonding..."  
    endif  
endfunc 1  
  
//*****  
// Equivalent to main() in C  
//*****  
rc=BleLescPairingPref(1)           //set the pairing model to be LE Secire Connections  
pairing  
rc=BleSecMngrIoCap(1)             //set io capability to Yes/No  
  
rc=BleGattcOpen(0,0)  
pr$ = GATT_SERVER_ADDRESS  
rc=BleConnect(pr$, 10000, 25, 100, 30000000)  
AssertRC(rc,91)  
  
//-----  
// Enable synchronous event handlers  
//-----  
onevent evblemsg   call HndlrBleMsg  
onevent evfinddesc call HndlrFindDesc  
onevent evattrwrite call HndlrAttrWrite  
  
waitevent  
  
print "\nExiting..."
```

Expected Output:

```
Connected, Finding Temp Measurement Char
Temp Measurement Char CCCD Found. Attempting to enable indications

Authentication required. Bonding...
Pair request: Accepting
Pairing in progress
Connection now encrypted
New bond created

Attempting to enable indications again
Indications enabled
Disabling indications
Exiting...
```

5.14.4 BleSecMngrIoCap

FUNCTION

This function sets the user I/O capability for subsequent pairings and is used to determine if the pairing is authenticated. This is described in the following whitepapers:

https://www.Bluetooth.org/docman/handlers/DownloadDoc.ashx?doc_id=86174
https://www.Bluetooth.org/docman/handlers/DownloadDoc.ashx?doc_id=86173

In addition, the *Security Manager Specification* in the core 4.2 specification Part H provides a full description. You must be registered with the Bluetooth SIG (www.Bluetooth.org) to get access to all these documents.

An authenticated pairing is deemed to be one with less than 1 in a million probability that the pairing was compromised by a MITM (Man-in-the-middle) security attack.

The valid user I/O capabilities are as described below.

BLESECMNGRIOCAP (nIoCap)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.										
Arguments:											
nIoCap	byVal nIoCap AS INTEGER. The user I/O capability for all subsequent pairings. <table> <tr> <td>0</td><td>None; also known as <i>Just Works</i> (unauthenticated pairing)</td></tr> <tr> <td>1</td><td>Display with Yes/No input capability (authenticated pairing)</td></tr> <tr> <td>2</td><td>Keyboard Only (authenticated pairing)</td></tr> <tr> <td>3</td><td>Display Only (authenticated pairing – if other end has input cap)</td></tr> <tr> <td>4</td><td>Keyboard and Display (authenticated pairing)</td></tr> </table>	0	None; also known as <i>Just Works</i> (unauthenticated pairing)	1	Display with Yes/No input capability (authenticated pairing)	2	Keyboard Only (authenticated pairing)	3	Display Only (authenticated pairing – if other end has input cap)	4	Keyboard and Display (authenticated pairing)
0	None; also known as <i>Just Works</i> (unauthenticated pairing)										
1	Display with Yes/No input capability (authenticated pairing)										
2	Keyboard Only (authenticated pairing)										
3	Display Only (authenticated pairing – if other end has input cap)										
4	Keyboard and Display (authenticated pairing)										

Example:

```
// Example :: BleSecMngrIoCap.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

PRINT BleSecMngrIoCap(1)
```

Expected Output:

```
0
```

See also examples for [BleSecMngrPasskey\(\)](#) and [BlePair\(\)](#).

5.14.5 BleAcceptPairing

FUNCTION

In legacy pairing the device can choose from Just Works, Passkey Entry, and OOB as the method of pairing depending on the input/output capabilities of the device. With Bluetooth v4.2, LE Secure connections adds the numeric comparison method to the other three. This function is used to accept or decline numeric comparison pairing.

BLEACCEPTPAIRING (nConnHandle, nAccept)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
nConnHandle	byVal nConnHandle AS INTEGER. The handle of the connection for which you are accepting or rejecting a pairing request.
nAccept	byVal nAccept AS INTEGER. Set to 0 to reject the numeric comparison pairing request, set to 1 to accept the pairing request.

See example for [BlePair\(\)](#).

5.14.6 BlePairingStaticPasskey

FUNCTION

This function pre-registers a static 6 digit passkey to the underlying stack during a pairing procedure in a future connection. It allows for a use case similar to what PIN codes provided in classic bluetooth before simple secure pairing was introduced in v2.1.

Note that the pairing still uses LESC Diffie-Hellman based exchanges but the only difference is that instead of a random number this static value is used.

Note: Repeated pairing attempts using the same preprogrammed passkey makes pairing vulnerable to MITM attacks.

Also see [BleSecMngrPasskey\(\)](#)

BLEPAIRINGSTATICPASSKEY (passKey\$)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
passKey\$	byVal passKey\$ AS STRING. The passkey to pre-register to the stack. This string shall be either empty which means use a random passkey (as specified in the specification) or a six character string consisting of only decimal digits '0' to '9'

5.14.7 BleSecMngrPasskey

FUNCTION

This function submits a passkey to the underlying stack during a pairing procedure when prompted by the EVBLEMSG with msgId set to 11. See [Events and Messages](#).

Also see [BlePairingStaticPasskey\(\)](#)

BLESECMNGRPASKEY (connHandle, nPassKey)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
connHandle	byVal connHandle AS INTEGER. The connection handle as received via the EVBLEMSG event with msgId set to 0.
nPassKey	byVal nPassKey AS INTEGER. The passkey to submit to the stack. Submit a value outside the range 0 to 999999 to reject the pairing.

Example:

```
// Example :: BleSecMngrPasskey.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc, connHandle
DIM addr$ : addr$=""
DIM i, pin$

'// Called when data arrives through the UART - PIN
FUNCTION HandlerUartRxPIN()
    i = UartReadMatch(pin$,13)
    if i !=0 then
        pin$ = StrSplitLeft$(pin$,i-1)
        if strcmp(pin$,"quit")==0 || strcmp(pin$,"exit")==0 then
            rc=BleDisconnect(connHandle)
            exitfunc 0

            elseif BleSecMngrPassKey(connHandle,StrValDec(pin$))==0 then
                print "\nPasskey: ";pin$
                OnEvent EVUARTRX disable
            endif
            pin$=""
        endif
    endif
ENDFUNC 1

FUNCTION HandlerBleMsg(BYVAL nMsgId AS INTEGER, BYVAL nCtx AS INTEGER) AS INTEGER
    SELECT nMsgId
```



```
CASE 0
    connHandle = nCtx
    PRINT "\n--- Ble Connection, ",nCtx
CASE 1
    PRINT "\n--- Disconnected ";nCtx;"\n"
    EXITFUNC 0
CASE 10
    PRINT "\n--- New bond"
CASE 11
    PRINT "\n +++ Auth Key Request, type=";nCtx
    PRINT "\nEnter the pass key and Press Enter:\n"
    onevent evuartrx call HandlerUartRxPIN
CASE 17
    print "\nNew pairing/bond has replaced old key"
CASE ELSE
ENDSELECT
ENDFUNC 1

ONEVENT EVBLEMSG CALL HandlerBleMsg

rc=BleSecMngrIoCap(2) //Set i/o capability - Keyboard Only (authenticated pairing)
IF BleAdvertStart(0,addr$,25,0,0)==0 THEN
    PRINT "\nAdverts Started\n"
    PRINT "\nPair with the module"
ELSE
    PRINT "\n\nAdvertisement not successful"
ENDIF

WAITEVENT
```

Expected Output:

```
Adverts Started

Pair with the module
--- Ble Connection,          2782
  +++ Auth Key Request, type=1
Enter the pass key and Press Enter:
904096

Passkey: 904096
--- New bond
--- Disconnected 2782
```

5.14.8 BleSecMngrLescKeypressEnable

FUNCTION

This function is used to enable keypress notifications so that during LE secure connections, when keys are entered during passkey entry pairing, notifications can be sent or received to or from the peer device therefore enhancing protection against man in the middle attacks.

BLESECMNGRLESCKEYPRESSEnable (nEnable)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
nEnable	byVal nEnable AS INTEGER. 0 to disable keypress notifications, 1 to enable keypress notifications

Example:

```
// Example :: BleSecMngrLescKeypressNotify.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

// Enable keypress notifications
rc = BLESECMNGRLESCKEYPRESSEnable(1)
if rc == 0 THEN
    PRINT "Keypress notifications enabled\n"
Endif
```

5.14.9 BleSecMngrLescKeypressNotify

FUNCTION

This function is used to send keypress notifications to the peer device during passkey entry in LE Secure Connections pairing.

BLESECMNGRLESCKEYPRESSNOTIFY (connHandle, nKeypressType)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.	
Arguments:		
connHandle	byVal connHandle AS INTEGER. This is the handle of the connection on which pairing is being performed	
nKeypressType	byRef nKeypressType AS STRING. This is the type of the keypress, and can be one of the following values:	
	0	Passkey entry started
	1	Passkey digit entered
	2	Passkey digit erased
	3	Passkey digit cleared
	4	Passkey entry completed

Example:

```
// Example :: BleSecMngrLescKeypressNotify.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

// Keypress Types
#define BLE_GAP_KP_NOT_TYPE_PASSKEY_START 0x00 // Passkey entry started.
```

```
#define BLE_GAP_KP_NOT_TYPE_PASSKEY_DIGIT_IN    0x01    // Passkey digit entered.
#define BLE_GAP_KP_NOT_TYPE_PASSKEY_DIGIT_OUT    0x02    // Passkey digit erased.
#define BLE_GAP_KP_NOT_TYPE_PASSKEY_CLEAR        0x03    // Passkey cleared.
#define BLE_GAP_KP_NOT_TYPE_PASSKEY_END          0x04    // Passkey entry completed.

// Global variable
dim rc      // Result Code
dim ghConn  // Global connection handle

//=====
// This handler is called when data has arrived at the serial port
//=====
function HandlerUartRxCmd() as integer

    dim StrKey$    // key entered

    // Now read a single character from the UART buffer
    rc = UartReadN(StrKey$, 1)

    if (strcmp(StrKey$, "\r")==0) THEN
        // Let the user know that we are done with keypresses, then send passkey
        rc = BleSecMngrLescKeypressNotify(ghConn, BLE_GAP_KP_NOT_TYPE_PASSKEY_END)
    endif

endfunc 1

'//*****
'// Equivalent to main() in C
'//*****

//-----
// Enable synchronous event handlers
//-----
OnEvent  EVUARTRX                call HandlerUartRxCmd

// Enable keypress notifications
rc = BLESECMNGRLESCKEYPRESSEnable(1)
// Set LE Secure Connections to be the preferred pairing model
rc = BLESECMNGRLESCPAIRINGPREF(1)
// Set IO capability to 2: Keyboard only
rc = BLESECMNGRIOCAP(2)

WaitEvent
```

5.14.10 BleSecMngrOOBPref

FUNCTION

This function is used to set a flag to indicate to the peer during a pairing that OOB pairing is preferred.

BLESECMNGROOBPREF(*nOobPreferred*)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
<i>nOobPreferred</i>	byVal connHandle AS INTEGER. If set to 0, OOB pairing will not have preference. If set to 1, OOB pairing will be preferred.

Example:

```
// Example :: BleSecMngrOobPref.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

dim rc
rc = BleSecMngrOobPref(1)
IF (rc == 0) THEN
    PRINT "OOB Pairing preference has been set."
ENDIF
```

Expected Output:

```
OOB Pairing preference has been set.
```

5.14.11 BleSecMngrOOBKey

FUNCTION

This function submits an OOB (Out Of Band) key to the underlying stack during a legacy pairing procedure when prompted by the EVBLEMSG with msgId set to 11 and the key type nCtx is 2, OOB. See [Events & Messages](#).

BLESECMNGROOBKEY (*connHandle*, *oobKey\$*)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
<i>connHandle</i>	byVal connHandle AS INTEGER. This is the connection handle as received via the EVBLEMSG event with msgId set to 0.
<i>oobKey\$</i>	byRef oobKey\$ AS STRING. This is the OOB key to submit to the stack. Submit a 16 byte string, or a string of a different length to reject the request.

Example:

```
// Example :: BleSecMngrOOBKey.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc, connHandle
DIM addr$ : addr$=""
DIM oob$ : oob$ = "\11\22\33\44\55\66\77\88\99\00\aa\cc\bb\dd\ee\ff"
```

```
#define OOB_KEY      2

FUNCTION HandlerBleMsg (BYVAL nMsgId AS INTEGER, BYVAL nCtx AS INTEGER) AS INTEGER
    SELECT nMsgId
        CASE 0
            connHandle = nCtx
            PRINT "\nBle Connection ",nCtx
        CASE 1
            PRINT "\nDisconnected ",nCtx;"\n"
            EXITFUNC 0
        CASE 10
            PRINT "\n--- New bond"
        CASE 11
            PRINT "\n +++ Auth Key Request, type=",nCtx
            if nCtx == OOB_KEY then
                rc=BleSecMngrOobKey(connHandle,oob$)
                print "\nOOB Key ";StrHexize$(oob$);" was used"
            endif

        CASE ELSE
            PRINT "\nUnknown Ble Msg"
    ENDSELECT
ENDFUNC 1

ONEVENT EVBLEMSG CALL HandlerBleMsg

IF BleAdvertStart(0,addr$,25,60000,0)==0 THEN
    PRINT "\nAdverts Started\n"
    PRINT "\nMake a connection to the BL654"
ELSE
    PRINT "\n\nAdvertisement not successful"
ENDIF

WAITEVENT
```

Expected Output:

```
Adverts Started

Make a connection to the BL654
Ble Connection,      1655
  +++ Auth Key Request, type=2
OOB Key 11223344556677889911AACCBBDDDEEFF was used
--- New bond
Disconnected 1655
```

5.14.12 BleSecMngrLescOwnOobDataGet

FUNCTION

This function retrieves the OOB data that should be given to the peer device. The peer device should then use this as the out of band data during LE Secure Connections pairing. The OOB data is regenerated everytime this function is called.

BLESECMNGRLESCOWNOObDATAGET (addr\$ oobHash\$, oobRand\$)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
addr\$	byRef addr\$ AS INTEGER. The Bluetooth address of the local device that should be used by the remote device during LE Secure Connections pairing
oobHash\$	byRef oobHash\$ AS STRING. The OOB hash of the local device that should be used by the remote device during LE Secure Connections pairing
oobRand\$	byRef oobRand\$ AS STRING. The OOB randomiser of the local device that should be used by the remote device during LE Secure Connections pairing

5.14.13 BleSecMngrLescPeerOobDataSet

FUNCTION

This function is used during the pairing process to send the remote OOB data via the Bluetooth link. When EVBLEMSG is received with ID 28, indicating that the remote device is requesting it's OOB data to be sent, this function should be used to send the data that was previously exchanged out of band.

BLESECMNGRLESCPEEROObDATASET (addr\$ oobHash\$, oobRand\$)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
addr\$	byRef addr\$ AS INTEGER. The Bluetooth address of the remote device that was given out of band.
oobHash\$	byRef oobHash\$ AS STRING. The OOB hash of the remote device that was given out of band.
oobRand\$	byRef oobRand\$ AS STRING. The OOB randomiser of the remote device that was given out of band.

Example:

```
// Example :: BleSecMngrLescPeerOobDataSet.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

// In this example, the OOB data is exchanged over the UART in the form
// OOB_ADDRESS OOB_HASH OOB_RAND\r
// e.g. 000016A4B75201 63F6E834009C368612724FBC3253DDE2
8311CD946F30C785DD7EA83038A5221D\r

//BLE EVENT MSG IDs
#define BLE_EVBLEMSGID_CONNECT 0 // msgCtx = connection handle
```

```
#define BLE_EVBLEMSGID_DISCONNECT 1 // msgCtx = connection handle
13
#define BLE_EVBLEMSGID_ENCRYPTED 18 // msgCtx = connection handle
#define BLE_EVBLEMSGID_AUTHENTICATION_FAILED 26 // msgCtx = connection handle
#define BLE_EVBLEMSGID_LESC_PAIRING 27 // msgCtx = connection handle
#define BLE_EVBLEMSGID_LESC_OOB_REQUEST 28 // msgCtx = connection handle

//Global defines

DIM rc, stRsp$

//=====
// This subroutine is called when Out of Band LESEC pairing is in progress
//=====
sub HandleOobReq()

    DIM OobData$, OobAddr$, OobHash$, OobRand$
    // Get our local OOB data
    rc = BleSecMngrLescOwnOobDataGet(OobAddr$, OobHash$, OobRand$)
    // Hexize the data
    OobAddr$ = StrHexize$(OobAddr$)
    OobHash$ = StrHexize$(OobHash$)
    OobRand$ = StrHexize$(OobRand$)
    // Construct a string of the retrieved data
    OobData$ = OobAddr$ + " " + OobHash$ + " " + OobRand$ + "\r"
    // Finally send the OOB data over UART
    rc = UartWrite(OobData$)
    print "Local OOB data sent over UART\n"

endsub

//=====
// This handler is called when there is a BLE message
//=====
function HandlerBleMsg(BYVAL nMsgId AS INTEGER, BYVAL nCtx AS INTEGER) as integer
    dim hz

    select nMsgId
    case BLE_EVBLEMSGID_CONNECT
        print " --- Connect: (;integer.h' nCtx;)\n"

    case BLE_EVBLEMSGID_DISCONNECT
        print " --- Disconnect: (;integer.h' nCtx;)\n"

    case BLE_EVBLEMSGID_ENCRYPTED
        print " +++ Encrypted Connection: (;integer.h' nCtx;)\n"

    case BLE_EVBLEMSGID_LESC_PAIRING
        print " +++ LESEC pairing: (;integer.h' nCtx;)\n"

    case BLE_EVBLEMSGID_LESC_OOB_REQUEST
        print " +++ LESEC OOB Request: (;integer.h' nCtx;)\n"
        HandleOobReq()

    case BLE_EVBLEMSGID_AUTHENTICATION_FAILED
        print " +++ Auth Failed: (;integer.h' nCtx;)\n"

    case else

    endselect
endfunc 1
```

```
//=====
// This handler is called when data has arrived at the serial port
//=====
function HandlerUartRx() as integer

    dim nMatch
    dim OobData$, OobAddr$, OobHash$, OobRand$
    // read UART data until carriage return and save it into stRsp$
    nMatch=UartReadMatch(stRsp$,13)
    if nMatch!=0 then
        // Get the hash and randomiser from the input string
        OobData$ = strsplitleft$(stRsp$, nMatch)
        rc = ExtractStrToken(OobData$,OobAddr$)
        rc = ExtractStrToken(OobData$,OobHash$)
        rc = ExtractStrToken(OobData$,OobRand$)

        // Dehexize the data first
        OobAddr$ = StrDeHexize$(OobAddr$)
        OobHash$ = StrDeHexize$(OobHash$)
        OobRand$ = StrDeHexize$(OobRand$)
        // Now Send the remote OOB data over the BLE link
        rc = BleSecMngrLescPeerOobDataSet(OobAddr$, OobHash$, OobRand$)
        if rc==0 THEN
            print "Remote OOB data received from UART and sent over the BLE link\n"
        endif
    endif

endfunc 1

//-----
// Enable synchronous event handlers
//-----
OnEvent EVBLEMSG          call HandlerBleMsg
OnEvent EVUARTRX          call HandlerUartRx

// Initialise LE adverts
dim addr$
rc = BleAdvertStart(0,addr$,100,30000,0)
// Enable LESC pairing
rc = BleSecMngrLescPairingPref(1)

//-----
// Wait for a synchronous event.
// An application can have multiple <WaitEvent> statements
//-----
WaitEvent
```

Expected Output:

```
--- Connect: (0001FF00)
+++ LESC OOB Request: (0001FF00)
Local OOB data sent over UART
Remote OOB data received from UART and sent over the BLE link
+++ Encrypted Connection: (0001FF00)
+++ LESC pairing: (0001FF00)
```


5.14.14 BleSecMngrKeySizes

FUNCTION

This function sets minimum and maximum long term encryption key size requirements for subsequent pairings.

If this function is not called, default values are 7 and 16 respectively. To ship your end product to a country with an export restriction, reduce nMaxKeySize to an appropriate value and ensure it is not modifiable.

BLESECMNGRKEYSIZES (nMinKeySize, nMaxKeySize)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
nMinKeysiz	byVal nMinKeysiz AS INTEGER. The minimum key size. The range of this value is from 7 to 16.
nMaxKeySize	byVal nMaxKeySize AS INTEGER. The maximum key size. The range of this value is from nMinKeySize to 16.

Example:

```
// Example :: BleSecMngrKeySizes.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

PRINT BleSecMngrKeySizes(8,15)
```

Expected Output:

0

5.14.15 BleSecMngrBondReq

FUNCTION

This function is used to enable or disable bonding when pairing. If enabled, and if your application requires pairing, a peer device only needs to pair with this module once. If disabled, the device needs to pair every time it connects to the module.

BLESECMNGRBONDREQ (nBondReq)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
nBondReq	byVal nBondReq AS INTEGER. 0 – Disable 1 – Enable

Example:

```
// Example :: BleSecMngrBondReq.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

IF BleSecMngrBondReq(0)==0 THEN
    PRINT "\nBonding disabled"
ENDIF
```

Expected Output:

Bonding disabled

5.14.16 BleEncryptConnection

FUNCTION

This function is used to encrypt a BLE connection with a device that the module has previously bonded with (the device is present in the bonding manager). The function can only be issued by the central device (i.e. the device that has initiated the connection request).

BLEENCRYPTCONNECTION (nConnHandle, nLtkMinSize, nMitmRequired)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
nConnHandle	byVal nConnHandle AS INTEGER. The handle of the connection which is obtained from an EVBLEMSG message with ID 0 indicating that a connection had been established.
nLtkMinSize	byVal nLtkMinSize AS INTEGER. The minimum long term key size which must be in the range 7-16.
nMitmRequired	byVal nMitmRequired AS INTEGER. Set to 1 if MITM protection is required, 0 if not required.

Example:

```

dim rc, pr$, hC, hDesc
#define GATT_SERVER_ADDRESS      "\01\F6\36\27\A6\0B\EA"

//This example app was tested with a BL654 running the health thermometer sensor sample
app
//which the module had previously bonded with.

'//-----
'// For debugging
'// --- rc = result code
'// --- ln = line number
'//-----

Sub AssertRC(rc,ln)
    if rc!=0 then
        print "\nFail :";integer.h' rc;" at tag ";ln
    endif
EndSub

'//-----
'// This handler is called when there is a significant BLE event
'//-----

function HndlrBleMsg(byval nMsgId as integer, byval nCtx as integer)
    select nMsgId

```

```
case 0
    hC = nCtx
    print "\nConnected"
    rc=BleEncryptConnection(hC, 16, 0)
    if rc==0 then
        print "\nEncrypting connection"
    else
        AssertRC(rc,28)
    endif
case 1
    print "\n\n --- Disconnected"
    exitfunc 0
case 10
    print "\nNew bond created"

case 11
    print "\nPair request: Accepting"
    rc=BleAcceptPairing(hC,1)
    AssertRC(rc,52)
    print "\nPairing in progress"
case 17
    print "\nNew pairing/bond has replaced old key"
case 18
    print "\nConnection now encrypted"
    rc=BleDisconnect(hC)
case else
endselect
endfunc 1

rc=BleSecMngrIoCap(0)           //set io capability to just works

pr$ = GATT_SERVER_ADDRESS
rc=BleConnect(pr$, 10000, 25, 100, 30000000)
AssertRC(rc,91)

onevent evblemsg    call HndlrBleMsg

waitevent

print "\nExiting..."
```

Expected Output:

```
Connected
Encrypting connection
Connection now encrypted

--- Disconnected
Exiting...
```

5.15 Virtual Serial Port Service – Managed

This section describes all the events and routines used to interact with a managed virtual serial port service.

“Managed” means there is a driver consisting of transmit and receive ring buffers that isolate the BLE service from the *smart*BASIC application. This in turn provides easy to use API functions.

Note: The driver makes the same assumption that the driver in a PC makes: If the on-air connection equates to the serial cable, there is no assumption that the cable is from the same source as prior to the disconnection. This is analogous to the way that a PC cannot detect such in similar cases.

The module can present a serial port service in the local GATT Table consisting of two mandatory characteristics and two optional characteristics. One mandatory characteristic is the TX FIFO and the other is the RX FIFO, both consisting of an attribute taking up to 20 bytes. Of the optional characteristics, one is the ModemIn which consists of a single byte and only bit 0 is used as a CTS type function. The other is ModemOut, also a single byte, which is notifiable only and is used to convey an RTS flag to the client.

By default, (configurable via [AT+CFG 112](#)), Laird’s serial port service is exposed with UUID’s as follows:

- The UUID of the service is: 569a**1101**-b87f-490c-92cb-11ba5ea5167c
- The UUID of the rx fifo characteristic is: 569a**2001**-b87f-490c-92cb-11ba5ea5167c
- The UUID of the tx fifo characteristic is: 569a**2000**-b87f-490c-92cb-11ba5ea5167c
- The UUID of the ModemIn characteristic is: 569a**2003**-b87f-490c-92cb-11ba5ea5167c
- The UUID of the ModemOut characteristic is: 569a**2002**-b87f-490c-92cb-11ba5ea5167c

Note: Laird’s Base 128bit UUID is 569aXXXX-b87f-490c-92cb-11ba5ea5167c where XXXX is a 16 bit offset. We recommend, to save RAM, that you create a 128 bit UUID of your own and manage the 16 bit space accordingly, akin to what the Bluetooth SIG does with their 16 bit UUIDs.

If command AT+CFG 112 1 is used to change the value of the config key 112 to 1 then Nordic’s serial port service is exposed with UUID’s as follows:

- The UUID of the service is: 6e40**0001**-b5a3-f393-e0a9-e50e24dcca9e
- The UUID of the rx fifo characteristic is: 6e40**0002**-b5a3-f393-e0a9-e50e24dcca9e
- The UUID of the tx fifo characteristic is: 6e40**0003**-b5a3-f393-e0a9-e50e24dcca9e

Note: The first byte in the UUID’s above is the most significant byte of the UUID.

The ‘rx fifo characteristic’ is for data that **comes to** the module and the ‘tx fifo characteristic’ is for data that **goes out** from the module. This means a GATT Client using this service will send data by writing into the ‘rx fifo characteristic’ and will get data from the module via a value notification.

The ‘rx fifo characteristic’ is defined with no authentication or encryption requirements, a maximum of 20 bytes value attribute. The following properties are enabled:

- WRITE
- WRITE_NO_RESPONSE

The 'tx fifo characteristic' value attribute is with no authentication or encryption requirements, a maximum of 20 bytes value attribute. The following properties are enabled:

- NOTIFY (The CCCD descriptor also requires no authentication/encryption)

The 'ModemIn characteristic' is defined with no authentication or encryption requirements, a single byte attribute. The following properties are enabled:

- WRITE
- WRITE_NO_RESPONSE

The 'ModemOut characteristic' value attribute is with no authentication or encryption requirements, a single byte attribute. The following properties are enabled:

- NOTIFY (The CCCD descriptor also requires no authentication/encryption)

For ModemIn, only bit zero is used, which is set by 1 when the client can accept data and 0 when it cannot (inverse logic of CTS in UART functionality). Bits 1 to 7 are for future use and should be set to 0.

For ModemOut, only bit zero is used which is set by 1 when the client can send data and 0 when it cannot (inverse logic of RTS in UART functionality). Bits 1 to 7 are for future use and should be set to 0.

Note: Both flags in ModemIn and ModemOut are suggestions to the peer, just as in a UART scenario. If the peer decides to ignore the suggestion and data is kept flowing, the only coping mechanism is to drop new data as soon as internal ring buffers are full.

Given that the outgoing data is **notified** to the client, the 'tx fifo characteristic' has a Client Configuration Characteristic (CCCD) which must be set to 0x0001 to allow the module to send any data waiting to be sent in the transmit ring buffer. While the CCCD value is not set for notifications, writes by the *smart* BASIC application result in data being buffered. If the buffer is full the appropriate write routine indicates how many bytes actually got absorbed by the driver. In the background, the transmit ring buffer is emptied with one or more indicate or notify messages to the client. When the last bytes from the ring buffer are sent, **EVVSPTXEMPTY** is thrown to the *smart* BASIC application so that it can write more data if it chooses.

When GATT Client sends data to the module by writing into the 'rx fifo characteristic' the managing driver will immediately save the data in the receive ring buffer if there is any space. If there is no space in the ring buffer, data is discarded. After the ring buffer is updated, event **EVVSPRX** is thrown to the *smart* BASIC runtime engine so that an application can read and process the data.

Similarly, given that ModemOut is **notified** to the client, the ModemOut characteristic has a Client Configuration Characteristic (CCCD) which must be set to 0x0001. By default, in a connection the RTS bit in ModemOut is set to 1 so that the VSP driver assumes there is buffer space in the peer to send data. The RTS flag is affected by the thresholds of 80 and 120 which means the when opening the VSP port the rxbuffer cannot be less than 128 bytes.

It is intended that in a future release it will be possible to register a 'custom' service and bind that with the virtual service manager to allow that service to function in the managed environment. This allows the application developer to interact with any GATT client implementing a serial port service, whether one currently deployed or one that the Bluetooth SIG adopts.

5.15.1 VSP Configuration

Given that VSP operation can happen in command mode the ability to configure it and save the new configuration in non-volatile memory is available. For example, in bridge mode, the baudrate of the uart can be specified to something other than the default 115200. Configuration is done using the **AT+CFG** command and refer to the section describing that command for further details. The configuration id pertinent to VSP are 100 to 116 inclusive. Additionally, the device name advertised by the VSP service can be configured using the **AT+CFGEX** command, by default the VSP name is "LAIRD BL654".

It is also possible to configure the command mode VSP by providing a \$autorun\$ application which launches after reset automatically. In this application the baudrate, GAP service, VSP Service and advertising can be configured and adverts started. Once done, given the autorun application does not have a WAITEVENT statement it falls into command mode and that VSP configuration will be operational.

A sample autorun application is as follows:

```
// *****
```

```
// Laird (c) 2015
//
// This application is meant to autorun on power up and so is named appropriately.
// It PURPOSELY does not have a WAITEVENT statement at the end and so will exit
// to command mode, where the VSP functionality will continue to operate.
//
// ++++++
// When UwTerminal downloads the app it will store it as $autorun$
// ++++++
//
//*****

//*****
// Debugging
//*****
#set $cmpif,0xFFFFFFFF //set to 0 to disable all debugging

//*****
// Definitions
//*****

//-----
// UART config
//-----
#define UARTBAUD          9600
#define UARTBUFLNRX      0 //default
#define UARTBUFLNTX      0 //default
#define UARTOPTIONS      "CN81H"

//-----
// GAP Service
//-----
//DeviceName
#define GAPDEVNAME        "autoVSP"
//DeviceName Writeable in Gap Service
#define GAPNAME_WRITEABLE 0
//Appearance in Gap Service (see BT Spec for adopted values) 512=Custom
#define GAPAPPEARANCE     512
```

```
//Minimum Connection Interval in microseconds
#define GAPMINCONNINTus          7500

//Maximum Connection Interval in microseconds
#define GAPMAXCONNINTus          50000

//Link Supervision Timeout in microseconds
#define GAPLINKSUPRVSNTOUTus     2000000

//Slave Latency
#define GAPSLAVELATENCY          0

//-----
// VSP Service
//-----
#define VSPSECURITY               1 //1=Open, 2=NO_MITM, 3=WITH_MITM

#define VSPUUIDSERVICE           "EADE1101B87f490C92CB11BA5EA5EFBE"
#define VSPUIDRX                  0x7001 //uses base of VSPUUIDSERVICE
#define VSPUIDTX                  0x7002 //uses base of VSPUUIDSERVICE
#define VSPUIDMDMIN               0x7003 //uses base of VSPUUIDSERVICE
#define VSPUIDMDMOUT              0x7004 //uses base of VSPUUIDSERVICE

#define VSPBUFLNRX                0 //default
#define VSPBUFLNTX                0 //default

//-----
// Adverts
//-----
#define ADVDISCOVERYFLAGS         2 //1=Limited,2=General,3=Both (0 do not define)
#define ADVMAXDEVICENAMELEN       10
#define ADVINTERVALms             100
#define ADVTIMEOUTms              0 //0 means infinity
#define ADVFILTERPOLICY           0

//*****
// Library Import
//*****

//*****
// Global Variable Declarations
//*****
```

```
//-----
// Misc variables
//-----

dim rc                //result code
dim hVspUuidSvc       //Contains the uuid handle of the VSP service so that it
                      //can be used to create an AD element in adverts
dim baud              //the configured baudrate

//*****
// Function and Subroutine definitions
//*****

//=====
// For debugging :: will inspect the global 'rc' variable
// --- ln = line number
//=====

#cmpif 0x01 : sub DbgAssertRC(ln as integer)
#cmpif 0x01 :   if rc!=0 then
#cmpif 0x01 :     print "\nFail :";integer.h' rc;" at tag ";ln
#cmpif 0x01 :   endif
#cmpif 0x01 : endsub

//=====
//=====

sub OpenUART()
    baud=UARTBAUD
    rc=UartOpen(baud,UARTBUFLENTX,UARTBUFLENRX,UARTOPTIONS)
    #cmpif 0x01 : DbgAssertRC(1050)
endsub

//=====
// Device Name (writable/not)
// Connection Parameters
//=====

sub ConfigServiceGAP()
    dim devicename$ : devicename$= GAPDEVNAME
```



```
rc=BleGapSvcInit (devicename$, GAPNAME_WRITEABLE, GAPAPPEARANCE, GAPMINCONNINTus, GAPMAXCONNINTus,
GAPLINKSUPRVSNTOUTus, GAPSLAVELATENCY)

    #cmpif 0x01 : DbgAssertRC(1150)
endsub

//=====
// Security :: 1=Open, 2=NO_MITM, 3=WITH_MITM
//=====

sub OpenVSP(vspSec)
    dim uuid$
    dim hVspUuidRx
    dim hVspUuidTx
    dim hVspUuidMdmIn
    dim hVspUuidMdmOut

    //create the advert & scan reports
    uuid$      = VSPUUIDSERVICE
    uuid$      = StrDehexize$(uuid$)
    hVspUuidSvc = BleHandleUuid128(uuid$)
    hVspUuidRx  = BleHandleUuidSibling(hVspUuidSvc, VSPUUIDRX)
    hVspUuidTx  = BleHandleUuidSibling(hVspUuidSvc, VSPUUIDTX)
    hVspUuidMdmIn = BleHandleUuidSibling(hVspUuidSvc, VSPUUIDMDMIN)
    hVspUuidMdmOut= BleHandleUuidSibling(hVspUuidSvc, VSPUUIDMDMOUT)

    vspSec      = (vspSec & 0x7)<<2

    //finally open the VSP

rc=BleVspOpenEx (VSPBUFLENTX, VSPBUFLENRX, vspSec, hVspUuidSvc, hVspUuidRx, hVspUuidTx, hVspUuidMdmIn, hVspUuidMdmOut)
    #cmpif 0x01 : DbgAssertRC(1410)

endsub

//=====
//=====

sub StartADVERTS()
    dim advReport$
    dim scnReport$
    dim peerAdr$ : peerAdr$=""
```

```
rc=BleAdvRptInit(advReport$,ADVDISCOVERYFLAGS,GAPAPPEARANCE,ADVMAXDEVICENAMELEN)
#cmpif 0x01 : DbgAssertRC(1530)
rc=BleScanRptInit(scnReport$)
#cmpif 0x01 : DbgAssertRC(1550)
rc=BleAdvRptAddUuid128(scnReport$,hVspUuidSvc)
#cmpif 0x01 : DbgAssertRC(1570)
rc=BleAdvRptsCommit(advReport$,scnReport$)
#cmpif 0x01 : DbgAssertRC(1590)

//finally start the adverts
rc=BleAdvertStart(0,peerAdr$,ADVINTERVALms,ADVTIMEOUTms,ADVFILTERPOLICY)
#cmpif 0x01 : DbgAssertRC(1630)
endsub

/*****
// Handler definitions
*****/

/*****
// Equivalent to main() in C
*****/

//-----
//Config and open UART
// See UARTxxx #defines above
//-----

OpenUART()

//-----
//Configure GAP Service
// See GAPxxx #defines above
//-----

ConfigServiceGAP()

//-----
//Config and open VSP
// See VSPxxx #defines above
//-----
```

```
OpenVSP (VSPSECURITY)
```

```
//-----  
//Advertising  
// See ADVxxx #defines above  
//-----  
StartADVERTS()  
  
//-----  
// PURPOSELY COMMENTED OUT AS WE WANT TO FALL INTO COMMAND MODE  
//-----  
//waitevent
```

5.15.2 Command and Bridge Mode Operation

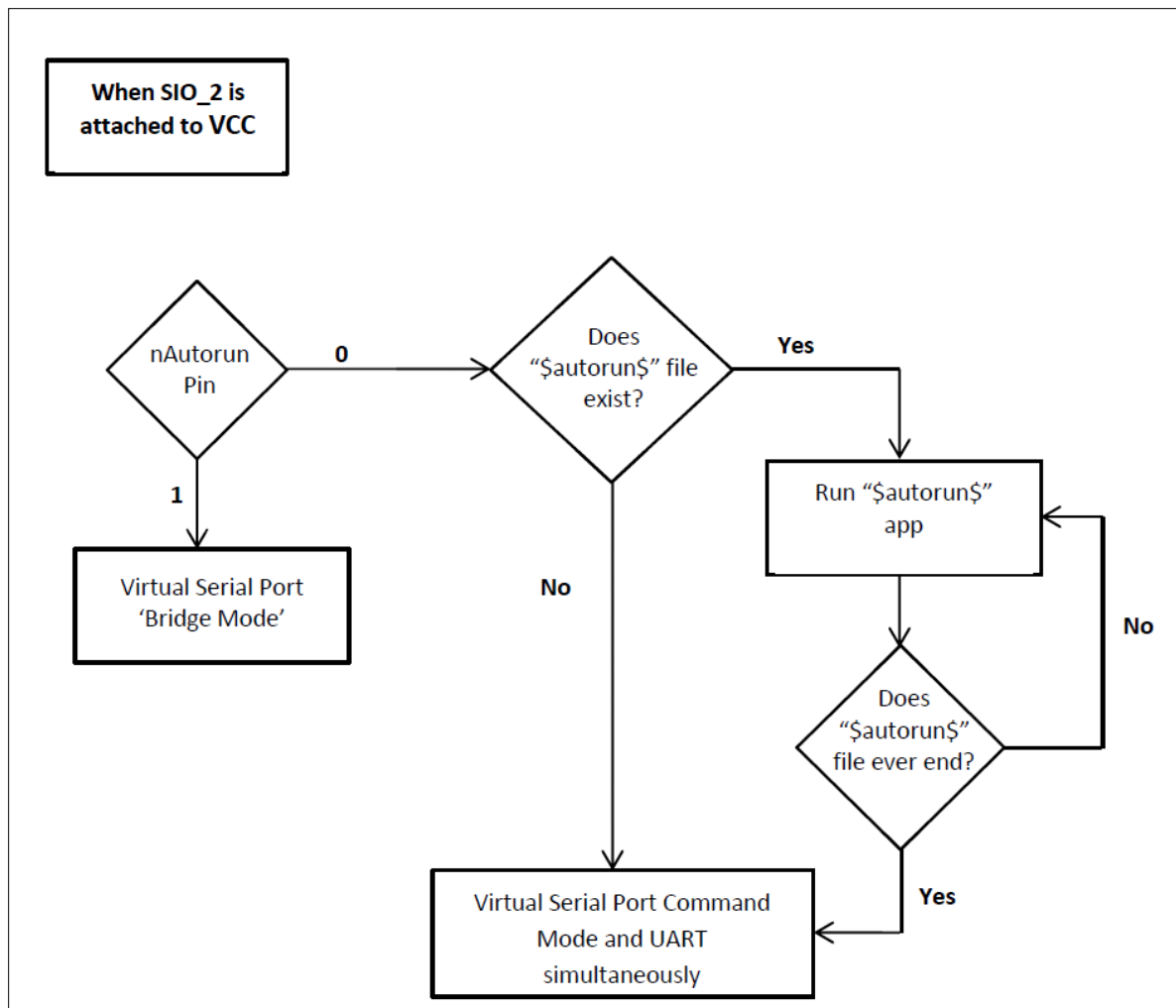
Just as the physical UART is used to interact with the module when it is not running a *smart* BASIC application, it is also possible to have *limited* interaction with the module in interactive mode. The limitation applies to NOT being able to launch *smart* BASIC applications using the AT+RUN command. If bridge mode is enabled then any incoming VSP data is retransmitted out via the UART. Conversely, any data arriving via the UART is transmitted out the VSP service. This latter functionality provides a cable replacement function.

Selection of Command or Bridge Mode is done using the nAautorun input signal. When nAautorun is low, interactive mode is enabled. When it is high, and bit 8 in the config register 100 accessed by AT+CFG 100 is set, bridge mode is selected the default value of config register 100 is 0x8102 which means by default, bridge mode is enabled if SIO2 is held high and nAautorun is high too.

The operation of VSP command and bridge mode is illustrated as per the diagrams on the following page (aknowledgments to Nicolas Mejia) .

The main purpose of interactive mode operation is to facilitate the download of an autorun *smart* BASIC application. This allows the module to be soldered into an end product without preconfiguration and then the application can be downloaded over the air once the product has been pre-tested. It is the *smart* BASIC application that is downloaded over the air, NOT the firmware. Due to this principle reason for use in production, to facilitate multiple programming stations in a locality the transmit power is limited to -12dBm. It can be changed by changing the 109 config key using the command [AT+CFG](#).

The default operation of this virtual serial port service is dependent on one of the digital input lines being pulled high externally. Consult the hardware manual for more information on the input pin number. By default it is SIO2 on the module, but it can be changed by setting the config key 100 via [AT+CFG](#).



You can interact with the BL654 over the air via the Virtual Serial Port Service using the Laird iOS or Android “BL6xx Serial” app, available free on the Apple App Store and Google Play Store respectively.

You may download smartBASIC applications onto the BL654 Over The Air using a BT900-US/BL652/BL654 devkit and a smartBASIC [application](#) from GitHub. Contact your local FAE for details.

As most of the AT commands are functional, you may obtain information such as version numbers by sending the command AT I 3 to the module over the air.

Note that the module enters interactive mode only if there is no autorun application or if the autorun application exits to interactive mode by design. Hence in normal operation where a module is expected to have an autorun application the virtual serial port service will not be registered in the GATT table.

If the application requires the virtual serial port functionality then it shall have to be registered programmatically using the functions that follow in subsequent subsections. These are easy to use high level functions such as OPEN/READ/WRITE/CLOSE.

5.15.3 VSP (Virtual Serial Port) Events

In addition to the routines for manipulating the Virtual Serial Port (VSP) service, when data arrives via the receive characteristic it is stored locally in an underlying ring buffer and then an event is generated.

Similarly when the transmit buffer is emptied, events are thrown from the underlying drivers so that user *smart* BASIC code in handlers can perform user defined actions.

The following is a list of events generated by VSP service managed code which can be handled by user code.

EVVSPRX	This event is generated when data has arrived and has been stored in the local ring buffer to be read using <code>BleVSpRead()</code> .
EVVSPTXEMPTY	This event is generated when the last byte is transmitted using the outgoing data characteristic via a notification or indication.

Use the iOS BL6xx Serial app and connect to your BL654 to test this sample app.

Example:

```
// Example :: VSpEvents.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM tx$,rc,x,scRpt$,adRpt$,addr$,hdl

//handler for data arrival
FUNCTION HandlerBleVSpRx() AS INTEGER
    //print the data that arrived
    DIM n,rx$
    n = BleVSpRead(rx$,20)
    PRINT "\nrx=";rx$
ENDFUNC 1

//handler when VSP tx buffer is empty
FUNCTION HandlerVSpTxEmpty() AS INTEGER
    IF x==0 THEN
        rc = BleVSpWrite(tx$)
        x=1
    ENDIF
ENDFUNC 1

PRINT "\nDevice name is "; BleGetDeviceName$()

//Open the VSP
rc = BleVSpOpen(128,128,0,hdl)
//Initialise a scan report
rc = BleScanRptInit(scRpt$)
//Advertise the VSP service in the scan report so
//that it can be seen by the client
```

```
rc = BleAdvRptAddUuid128(scRpt$,hdl1)
adRpt$=""
rc = BleAdvRptsCommit(adRpt$,scRpt$)
addr$="" //because we are not doing a DIRECT advert
rc = BleAdvertStart(0,addr$,20,300000,0)
//Now advertising so can be connectable

ONEVENT EVVSPRX      CALL HandlerBleVSpRx
ONEVENT EVVSPTXEMPTY CALL HandlerVSpTxEmpty

tx$="tx buffer empty"
PRINT "\nUse the iOS BL6xx Serial app to test this"

//wait for events and messages
WAITEVENT
```

5.15.4 BleVSpOpen

FUNCTION

This function opens the default VSP service using the parameters specified. The service's UUID is: 569a**1101**-b87f-490c-92cb-11ba5ea5167c

By default, ModemIn and ModemOut characteristics are registered in the GATT table with the Rx and Tx FIFO characteristics. To suppress Modem characteristics in the GATT table, set bit 1 in the nFlags parameter (value 2). If the virtual serial port is already open, this function fails.

Note that the parameters specified in the first call to this function are sticky. After calling BleVSpClose() if this function is recalled the parameters will be ignored and the internal state machine managing the VSP function will resume from a suspended state. This is because on a close, it is not possible to remove the service from the GATT table. If this is strictly required, perform a warm reset using RESET() and then action appropriately in the new incarnation. One way of detection a new incarnation could be by using NvRecordSet()/NvRecordGet() as that writes/reads to non-volatile memory.

BLEVSPOPEN (txbuflen, rxbuflen, nFlags, svcUuid)

Returns	INTEGER, indicating the success of command:	
	0	Opened successfully
	0x604D	Already open
	0x604E	Invalid Buffer Size
	0x604C	Cannot register Service in Gatt Table while BLE connected
Exceptions	- Local Stack Frame Underflow - Local Stack Frame Overflow	
Arguments		
txbuflen	byVal txbuflen AS INTEGER Set the transmit ring buffer size to this value. If set to 0, a default value is used by the underlying driver and use BleVspInfo(2) to determine the size.	
rxbuflen	byVal rxbuflen AS INTEGER Set the receive ring buffer size to this value. If set to 0, a default value is used by the underlying driver and use BleVspInfo(1) to determine the size.	
nFlags	byVal nFlags AS INTEGER This is a bit mask to customise the driver as follows:	

	Bit 0	Set to 1 to try for reliable data transfer. This uses INDICATE messages if allowed and if there is a choice. Some services only allow NOTIFY and in that case, if set to 1, it is ignored. This is deprecated – always set to 0		
	Bit 1	Set to 1 to suppress ModemIn and ModemOut characteristics		
	Bits	Security Setting for accessing characteristics		
	4	3	2	Bit Number
	0	0	0	Open
	0	0	1	Open
	0	1	0	ENCRYPTED_NO_MITM
	0	1	1	ENCRYPTED_WITH_MITM
	1	0	0	SIGNED_NO_MITM (reserved for future)
	1	0	1	SIGNED_WITH_MITM (reserved for future)
	1	1	0	ENCRYPTED_NO_MITM
	1	1	1	ENCRYPTED_NO_MITM
	Bit 5..31	Reserved for future use. Set to 0.		
svcUuid	byRef svcUuid AS INTEGER On exit, this variable is updated with a handle to the service UUID which can then be subsequently used to advertise the service in an advert report. Given that there is no BT SIG adopted Serial Port Service the UUID for the service is 128 bit, so an appropriate Advert Data element can be added to the advert or scan report using the function BleAdvRptAddUuid128() which takes a handle of that type.			
	Related Commands	BLEVSPINFO, BLEVSPCLOSE, BLEVSPWRITE, BLEVSPREAD, BLEVSPFLUSH,BLEVSPOPENEX		

Example:

```
// Example :: BleVspOpen.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM scRpt$, adRpt$, addr$, vspSvcHndl

//Close VSP if already open
IF BleVSpInfo(0) != 0 THEN
    BleVSpClose()
ENDIF

//Open VSP
IF BleVSpOpen(128,128,0,vspSvcHndl)==0 THEN
    PRINT "\nVSP service opened"
ELSE
    PRINT "\nFailed"
ENDIF
```

Expected Output:

VSP service opened

5.15.5 BleVSpOpenEx

FUNCTION

This function opens the a managed VSP service using the parameters specified. The service's UUID and UUIDs for the up to 4 characteristics can all be individually specified.

ModemIn and ModemOut characteristics are registered in the GATT table with the Rx and Tx FIFO characteristics if both UUIDMdmIn and UUIDMdmOut are not invalid (invalid handle == 0).

Note that the parameters specified in the first call to this function are sticky. After calling BleVspClose() if this function is called again then the parameters will be ignored and the internal state machine managing the VSP function will resume from a suspended state. This is because on a close, it is not possible to remove the service from the GATT table. If this is strictly required, perform a warm reset using RESET() and then action appropriately in the new incarnation. One way of detection a new incarnation could be by using NvRecordSet()/NvRecordGet() as that writes/reads to non-volatile memory.

BLEVSPOPENEX (txbuflen, rxbuflen, nFlags, hUuidSvc, hUuidRx, hUuidTx, hUuidMdmIn, hUuidMdmOut)

Returns	INTEGER, indicating the success of command:			
	0	Opened successfully		
	0x604D	Already open		
	0x604E	Invalid Buffer Size		
	0x604C	Cannot register Service in Gatt Table while BLE connected		
Exceptions	- Local Stack Frame Underflow - Local Stack Frame Overflow			
Arguments				
txbuflen	byVal txbuflen AS INTEGER Set the transmit ring buffer size to this value. If set to 0, a default value is used by the underlying driver and use BleVspInfo(2) to determine the size.			
rxbuflen	byVal rxbuflen AS INTEGER Set the receive ring buffer size to this value. If set to 0, a default value is used by the underlying driver and use BleVspInfo(1) to determine the size.			
nFlags	byVal nFlags AS INTEGER This is a bit mask to customise the driver as follows:			
	Bit 0	Set to 1 to try for reliable data transfer. This uses INDICATE messages if allowed and if there is a choice. Some services only allow NOTIFY and in that case, if set to 1, it is ignored. This is deprecated – always set to 0		
	Bit 1	This bit is ignored. See hUuidMdmln and hUuidMdmOut instead to manage.		
	Bits	Security Setting for accesing characteristics		
	4	3	2	Bit Number
	0	0	0	Open
	0	0	1	Open
	0	1	0	ENCRYPTED_NO_MITM
	0	1	1	ENCRYPTED_WITH_MITM
	1	0	0	SIGNED_NO_MITM (reserved for future)
	1	0	1	SIGNED_WITH_MITM (reserved for future)
	1	1	0	ENCRYPTED_NO_MITM
	1	1	1	ENCRYPTED_NO_MITM
	Bit 5..31	Reserved for future use. Set to 0.		
hUuidSvc	byVal hUuidSvc AS INTEGER This is the handle for the service UUID which can then be subsequently used to advertise the service in an advert report. Given that there is no BT SIG adopted Serial Port Service the UUID for the service is 128 bit, so an appropriate Advert Data element can be added to the advert or scan report using the function BleAdvRptAddUuid128() which takes a handle of that type.			
hUuidRx	byVal hUuidRx AS INTEGER This is the handle for the Rx Characteristic UUID. It cannot be an invalid handle.			
hUuidTx	byVal hUuidTx AS INTEGER This is the handle for the Tx Characteristic UUID. It cannot be an invalid handle.			

<i>hUuidMdmIn</i>	<i>byVal hUuidMdmIn AS INTEGER</i> This is the handle for the MdmIn Characteristic UUID. Can be an invalid handle (0) and in that case both modem characteristic are not registered.
<i>uUuidMdmOut</i>	<i>byVal hUuidMdmOut AS INTEGER</i> This is the handle for the MdmOut Characteristic UUID. . Can be an invalid handle (0) and in that case both modem characteristic are not registered.
Related Commands	BLEVSPINFO, BLEVSPCLOSE, BLEVSPWRITE, BLEVSPREAD, BLEVSPFLUSH, BLEVSPOPEN

```
//Example

DIM scRpt$,adRpt$,addr$,hUuidSvc,hUuidRx,hUuidTx,hUuidMdmIn,hUuidMdmOut,uuid$

uuid$ = "ced9d91366924a1287d56f2764762b2a"
uuid$ = StrDehexize$(uuid$)
hUuidSvc = BleHandleUuid128(uuid$)
hUuidRx = BleHandleUuidSibling(hUuid1,0x1234)
hUuidTx = BleHandleUuidSibling(hUuid1,0x5678)
hUuidMdmIn = BleHandleUuidSibling(hUuid1,0x9ABC)
hUuidMdmOut = BleHandleUuidSibling(hUuid1,0xDEF0)

//Open VSP
IF BleVSpOpenEx(128,128,0, hUuidSvc,hUuidRx,hUuidTx,hUuidMdmIn,hUuidMdmOut)==0 THEN
    PRINT "\nVSP service opened with non-default UUIDs"
ELSE
    PRINT "\nFailed"
ENDIF
```

Expected Output:

VSP service opened with non-default UUIDs

5.15.6 BleVSpClose

SUBROUTINE

This subroutine closes the managed virtual serial port which had been opened with BLEVSPOPEN. This routine is safe to call if it is already closed. When this subroutine is invoked both receive and transmit buffers are flushed. If there is data in either buffer when the port is closed, it will be lost.

Note that the parameters specified in the first call of BleVspOpen() are sticky. After calling this function if BleVspOpen() or BleVspOpenEx() is called again then the open parameters will be ignored and the internal state machine managing the VSP function will resume from a suspended state. This is because on a close, it is not possible to remove the service from the GATT table. If this is strictly required, perform a warm reset using RESET() and then action appropriately in the new incarnation. One way of detection a new incarnation could be by using NvRecordSet()/NvRecordGet() as that writes/reads to non-volatile memory.

BLEVSPCLOSE ()

Exceptions	- Local Stack Frame Underflow - Local Stack Frame Overflow
Arguments	None
Related Commands	BLEVSPINFO, BLEVSPOPEN, BLEVSPWRITE, BLEVSPREAD, BLEVSPFLUSH

Use the iOS "BL6xx Serial" app and connect to your BL654 to test this sample app.

Example:

```
// Example :: BleVspClose.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM tx$,rc,scRpt$,adRpt$,addr$,hdl

//handler when VSP tx buffer is empty
FUNCTION HandlerVSpTxEmpty() AS INTEGER
    PRINT "\n\nVSP tx buffer empty"
    BleVspClose()
ENDFUNC 0

PRINT "\nDevice name is "; BleGetDeviceName$()

//Open the VSP, advertise
rc = BleVSpOpen(128,128,0,hdl)
rc = BleScanRptInit(scRpt$)
rc = BleAdvRptAddUuid128(scRpt$,hdl)
adRpt$=""
rc = BleAdvRptsCommit(adRpt$,scRpt$)
addr$=""
rc = BleAdvertStart(0,addr$,20,300000,0)

//This message will send when connected to client
tx$="send this data and will close when sent"
```

```
rc = BleVSpWrite(tx$)

ONEVENT EVVSPTXEMPTY CALL HandlerVSpTxEmpty

WAITEVENT

PRINT "\nExiting..."
```

Expected Output:

```
Device name is LAIRD BL654

VSP tx buffer empty
Exiting...
```

5.15.7 BleVSpInfo

FUNCTION

This function is used to query information about the virtual serial port, such as buffer lengths, whether the port is already open or how many bytes are waiting in the receive buffer to be read.

BLEVSPINFO (infol)

Returns	INTEGER The value associated with the type of UART information requested												
Exceptions	- Local Stack Frame Underflow - Local Stack Frame Overflow												
Arguments	byVal infol AS INTEGER This specifies the information type requested as follows if the port is open: <table> <tr> <td>0</td><td>0 if closed, 1 if open, 3 if open and there is a BLE connection and 7 if the transmit fifo characteristic CCCD has been updated by the client to enable notifies or indications.</td></tr> <tr> <td>1</td><td>Receive ring buffer capacity</td></tr> <tr> <td>2</td><td>Transmit ring buffer capacity</td></tr> <tr> <td>3</td><td>Number of bytes waiting to be read from receive ring buffer</td></tr> <tr> <td>4</td><td>Free space available in transmit ring buffer</td></tr> <tr> <td>5</td><td>Tx/Rx attribute size in bytes. Valid range is 20-244, and can be configured using AT+CFG 212. See Data Packet Length Extension section for more information.</td></tr> </table>	0	0 if closed, 1 if open, 3 if open and there is a BLE connection and 7 if the transmit fifo characteristic CCCD has been updated by the client to enable notifies or indications.	1	Receive ring buffer capacity	2	Transmit ring buffer capacity	3	Number of bytes waiting to be read from receive ring buffer	4	Free space available in transmit ring buffer	5	Tx/Rx attribute size in bytes. Valid range is 20-244, and can be configured using AT+CFG 212. See Data Packet Length Extension section for more information.
0	0 if closed, 1 if open, 3 if open and there is a BLE connection and 7 if the transmit fifo characteristic CCCD has been updated by the client to enable notifies or indications.												
1	Receive ring buffer capacity												
2	Transmit ring buffer capacity												
3	Number of bytes waiting to be read from receive ring buffer												
4	Free space available in transmit ring buffer												
5	Tx/Rx attribute size in bytes. Valid range is 20-244, and can be configured using AT+CFG 212. See Data Packet Length Extension section for more information.												
Related Commands	BLEVSPOPEN, BLEVSPCLOSE, BLEVSPWRITE, BLEVSPREAD, BLEVSPFLUSH												

Example:

```
// Example :: BleVSpInfo.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM hndl, rc

//Close VSP if it is open
BleVSpClose()

rc = BleVSpOpen(128,128,0,hndl)
PRINT "\nVsp State: "; BleVSpInfo(0)
PRINT "\nRx buffer capacity: "; BleVSpInfo(1)
PRINT "\nTx buffer capacity: "; BleVSpInfo(2)
PRINT "\nBytes waiting to be read from rx buffer: "; BleVSpInfo(3)
```

```
PRINT "\nFree space in tx buffer: "; BleVSpInfo(4)
PRINT "\nTx/Rx Characteristic Size: "; BleVSpInfo(5)    // Changed using AT+CFG 212 xx
BleVSpClose()
PRINT "\nVsp State: "; BleVSpInfo(0)
```

Expected Output:

```
Vsp State: 1
Rx buffer capacity: 128
Tx buffer capacity: 128
Bytes waiting to be read from rx buffer: 0
Free space in tx buffer: 128
Tx/Rx Characteristic Size: 20
Vsp State: 0
```

5.15.8 BleVSpWrite

FUNCTION

This function is used to transmit a string of characters from the virtual serial port.

BLEVSPWRITE (strMsg)

Returns	INTEGER 0 to N : Actual number of bytes successfully written to local transmit ring buffer.
Exceptions	- Local Stack Frame Underflow - Local Stack Frame Overflow
Arguments	
strMsg	byRef strMsg AS STRING The array of bytes to be sent. STRLEN(strMsg) bytes are written to the local transmit ring buffer. If STRLEN(strMsg) and the return value are not the same, it implies that the transmit buffer did not have enough space to accommodate the data. If the return value does not match the length of the original string, use STRSHIFTLEFT function to drop the data from the string, so subsequent calls to this function only retry with data not placed in the output ring buffer. Another strategy is to wait for EVVSPTXEMPTY events, then resubmit data.
Related Commands	BLEVSPOPEN, BLEVSPCLOSE, BLEVSPINFO, BLEVSPREAD, BLEVSPFLUSH

Note: strMsg cannot be a string constant, e.g. "the cat", but must be a string variable. If you must use a const string, first save it to a temp string variable and then pass it to the function.

Use Laird Toolkit app for iOS/Android and connect to your BL654 to test this sample app.

Example:

```
// Example :: BleVSpWrite.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM tx$,rc,scRpt$,adRpt$,addr$,hdl,cnt

//handler when VSP tx buffer is empty
FUNCTION HandlerVSpTxEmpty() AS INTEGER
```

```
cnt=cnt+1
IF cnt<= 2 THEN
    tx$="then this is sent"
    rc = BleVSpWrite(tx$)
ENDIF

ENDFUNC 0

rc = BleVSpOpen(128,128,0,hndl)
rc = BleScanRptInit(scRpt$)
rc = BleAdvRptAddUuid128(scRpt$,hndl)
adRpt$=""
rc = BleAdvRptsCommit(adRpt$,scRpt$)
addr$=""
rc = BleAdvertStart(0,addr$,20,300000,0)
PRINT "\nDevice name is "; BleGetDeviceName$()

cnt=1
tx$="send this data and "
rc = BleVSpWrite(tx$)

ONEVENT EVVSPTXEMPTY CALL HandlerVSpTxEmpty

WAITEVENT

PRINT "\nExiting..."
```

Expected Output:

```
Device name is LAIRD BL654
Exiting...
```

5.15.9 BleVSpRead

FUNCTION

This function is used to read the content of the receive buffer and **copy** it to the string variable supplied.

BLEVSPREAD (strMsg, nMaxRead)

Returns	INTEGER 0 to N : The total length of the string variable. This means the caller does not need to call strlen() function to determine how many bytes in the string must be processed.
Exceptions	- Local Stack Frame Underflow - Local Stack Frame Overflow
Arguments	
strMsg	<i>byRef strMsg AS STRING</i> The content of the receive buffer is <i>copied</i> to this string.
nMaxRead	<i>byVal nMaxRead AS INTEGER</i> The maximum number of bytes to read.
Related Commands	BLEVSPOPEN, BLEVSPCLOSE, BLEVSPINFO, BLEVSPWRITE, BLEVSPFLUSH

Note: strMsg cannot be a string constant, e.g. "the cat", but must be a string variable and. If you must use a const string, first save it to a temp string variable and then pass it to the function

Use the Laird Toolkit app for iOS/Android with your BL654 to test this sample app.

Example:

```
// Example :: BleVSpRead.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM conHndl

//Only 1 global variable because its value is used in more than 1 routine
//All other variables declared locally, inside routine that they are used in.
//More efficient because these local variables only exist in memory
//when they are being used inside their respective routines

//=====
// Open VSp and start advertising
//=====

SUB OnStartup ()
    DIM rc, hndl, tx$, scRpt$, addr$, adRpt$ : adRpt$="" : addr$=""
    rc=BleVSpOpen(128,128,0,hndl)
    rc=BleScanRptInit(scRpt$)
    rc=BleAdvRptAddUuid128(scRpt$,hndl)
    rc=BleAdvRptsCommit(adRpt$,scRpt$)
    rc=BleAdvertStart(0,addr$,20,300000,0)
    PRINT "\nDevice name is "; BleGetDeviceName$()
```

```
tx$="\nSend me some text \nTo exit the app, just tell me\n"
rc = BleVSpWrite(tx$)
ENDSUB

//=====
// Close connections so that we can run another app without problems
//=====

SUB CloseConnections()
    DIM rc
    rc=BleDisconnect(conHndl)
    rc=BleAdvertStop()
    BleVspClose()
ENDSUB

//=====
// VSP Rx buffer event handler
//=====

FUNCTION HandlerVSpRx() AS INTEGER
    DIM rc, rx$, e$ : e$="exit"
    rc=BleVSpRead(rx$,20)
    PRINT "\nMessage from client: ";rx$

    //If user has typed exit
    IF StrPos(rx$,e$,0) > -1 THEN
        EXITFUNC 0
    ENDIF
ENDFUNC 1

//=====
// BLE event handler
//=====

FUNCTION HndlrBleMsg(BYVAL nMsgId, BYVAL nCtx)
    conHndl=nCtx
    IF nMsgID==1 THEN
        PRINT "\nDisconnected from client"
        EXITFUNC 0
    ENDIF
ENDFUNC 1
```

```
ONEVENT EVVSPRX CALL HandlerVSpRx
ONEVENT EVBLEMSG CALL HndlrBleMsg

OnStartup()           //Calls first subroutine declared above

WAITEVENT

CloseConnections()    //Calls second subroutine declared above
PRINT "\nExiting..."
```

Expected Output:

```
Device name is LAIRD BL654
Messgae from client: (Whatever data you send from your device)
Message from client: exit
Exiting...
```

5.15.10 BleVSpUartBridge

SUBROUTINE

This function creates a bridge between the managed Virtual Serial Port Service and the UART when both are open. Any data arriving from the VSP is automatically transferred to the UART for forward transmission. Any data arriving at the UART is sent over the air.

It should be called either when data arrives at either end or when either end indicates their transmit buffer is empty. The following events are examples: EVVSPRX, EVUARTRX, EVVSPTXEMPTY and EVUARTTXEMPTY.

Given that data can arrive over the UART a byte at a time, a latency timer specified by AT+CFG 116 command may be used to optimise the data transfer over the air. This tries to ensure that full packets are transmitted over the air. Therefore, if a single character arrives over UART, a latency timer is started. If it expires, that single character (or any more that arrive but less than 20) will be forced onwards when that timer expires.

BLEVSPUARTBRIDGE ()

Exceptions	▪ Local Stack Frame Underflow ▪ Local Stack Frame Overflow
Arguments	None
Related Commands	BLEVSPOPEN, BLEVSPCLOSE, BLEVSPINFO, BLEVSPWRITE, BLEVSPFLUSH

Example:

```
// Example :: BleVSpUartBridge.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM conHndl

//=====
// Open VSp and start advertising
//=====

SUB OnStartup()
```



```

DIM rc, hndl, tx$, scRpt$, addr$, adRpt$

rc=BleVSpOpen(128,128,0,hndl)
rc=BleScanRptInit(scRpt$)
rc=BleAdvRptAddUuid128(scRpt$,hndl)
rc=BleAdvRptsCommit(adRpt$,scRpt$)
rc=BleAdvertStart(0,addr$,20,300000,0)
rc=GpioBindEvent(1,16,1)    //Channel 1, bind to low transition on GPIO pin 16
PRINT "\nDevice name is "; BleGetDeviceName$();"\n"

tx$="\nSend me some text. \nPress button 0 to exit\n"
rc = BleVSpWrite(tx$)
ENDSUB

//=====
// Close connections so that we can run another app without problems
//=====
SUB CloseConnections()
    DIM rc
    rc=BleDisconnect(conHndl)
    rc=BleAdvertStop()
    BleVspClose()
ENDSUB

//=====
// BLE event handler - connection handle is obtained here
//=====
FUNCTION HndlrBleMsg(BYVAL nMsgId, BYVAL nCtx)
    conHndl=nCtx
    IF nMsgId==1 THEN
        PRINT "\nDisconnected from client"
        EXITFUNC 0
    ENDIF
ENDFUNC 1

//=====
//handler to service button 0 pressed
//=====
FUNCTION HndlrBtn0Pr() AS INTEGER

```

```
//just exit and stop waiting for events
ENDFUNC 0

//=====
//handler to service an rx/tx event
//=====
FUNCTION HandlerBridge() AS INTEGER
    // transfer data between VSP and UART ring buffers
    BleVspUartBridge()
ENDFUNC 1

ONEVENT EVVSPRX          CALL HandlerBridge
ONEVENT EVUARTRX         CALL HandlerBridge
ONEVENT EVVSPTXEMPTY     CALL HandlerBridge
ONEVENT EVUARTTXEMPTY    CALL HandlerBridge
ONEVENT EVBLEMSG         CALL HndlrBleMsg
ONEVENT EVGPIOCHAN1      CALL HndlrBtn0Pr

OnStartup()

WAITEVENT

CloseConnections() //Calls second subroutine declared above
PRINT "\nExiting..."
```

5.15.11 BleVSpFlush

SUBROUTINE

This subroutine flushes either or both receive and transmit ring buffers.

This is useful when, for example, you have a character terminated messaging system and the peer sends a very long message, filling the input buffer. In that case, there is no more space for an incoming termination character. A flush of the receive buffer is the best approach to recover from that situation.

BLEVSPFLUSH (bitMask)

Returns	▪ None
Arguments	
bitMask	<i>byVal bitMask AS INTEGER</i> Bit 0 is set to flush the Rx buffer. Bit 1 is set to flush the Tx buffer. Set both bits to flush both buffers.
Related Commands	BLEVSPOPEN, BLEVSPCLOSE, BLEVSPINFO, BLEVSPWRITE, BLEVSPREAD

Example:

```
// Example :: BleVSpFlush.sb
```

```
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM conHndl

//=====
// Open VSp and start advertising
//=====

SUB OnStartup()
    DIM rc, hndl, tx$, scRpt$, addr$, adRpt$ : adRpt$="" : addr$=""
    rc=BleVSpOpen(128,128,0,hndl)
    rc=BleScanRptInit(scRpt$)
    rc=BleAdvRptAddUuid128(scRpt$,hndl)
    rc=BleAdvRptsCommit(adRpt$,scRpt$)
    rc=BleAdvertStart(0,addr$,20,300000,0)
    rc=GpioBindEvent(1,16,1)    //Channel 1, bind to low transition on GPIO pin 16
    PRINT "\nDevice name is "; BleGetDeviceName$()

    tx$="\nSend me some text, I won't get it. \nTo exit the app press Button 0\n"
    rc = BleVSpWrite(tx$)
ENDSUB

//=====
// Close connections so that we can run another app without problems
//=====

SUB CloseConnections()
    DIM rc
    rc=BleDisconnect(conHndl)
    rc=BleAdvertStop()
    BleVspClose()
    BleVspFlush(3)    //Flush both buffers
ENDSUB

//=====
// VSP Rx buffer event handler
//=====

FUNCTION HandlerVSpRx() AS INTEGER
    BleVspFlush(1)
    PRINT "\nRx buffer flushed"
ENDFUNC 1

//=====
//handler to service button 0 pressed
//=====
```

```

FUNCTION HndlrBtn0Pr () AS INTEGER
    //stop waiting for events and exit app
ENDFUNC 0

//=====
// BLE event handler
//=====

FUNCTION HndlrBleMsg (BYVAL nMsgId, BYVAL nCtx)
    conHndl=nCtx
    IF nMsgID==1 THEN
        PRINT "\nDisconnected from client"
        EXITFUNC 0
    ENDIF
ENDFUNC 1

ONEVENT EVVSPRX      CALL HandlerVSPrx
ONEVENT EVBLEMSG      CALL HndlrBleMsg
ONEVENT EVGPIOCHAN1  CALL HndlrBtn0Pr

OnStartup()           //Calls first subroutine declared above

WAITEVENT

CloseConnections()    //Calls second subroutine declared above
PRINT "\nExiting..."

```

Expected Output:

```

Device name is LAIRD BL654
Rx buffer flushed
Rx buffer flushed
Exiting...

```

5.16 Data Packet Length Extension

This section describes all the events and functions used for Data Packet Length Extension and related features to achieve higher throughputs.

5.16.1 Overview

5.16.1.1 Data Packet Length Extension

One of the major additions in Bluetooth v4.2 is LE Data Packet Length Extension. This feature allows the BLE packet size to increase from 27 to 251 bytes at the link layer, thus increasing the capacity of the data channel by approximately ten times. The benefits of this include the following:

- **Higher Throughputs** – Less time is required to transfer the same amount of data compared to Bluetooth v4.1.
- **Lower power consumption** – Fewer transactions are required to transfer a given amount of data compared to Bluetooth v4.1. This reduces the time for which the radio is active.

In order to take full advantage of packet length extension, the device should also have an ATT_MTU greater than the default 23 bytes.

5.16.1.2 ATT_MTU

The attribute Maximum Transmission Unit (ATT_MTU) is the maximum size of any packet sent between a GATT client and a GATT server. It determines the maximum amount of data that can be sent over the air for GATT operations.

GATT Operation	Attribute Size	Example when ATT_MTU=23
Read	0 to (ATT_MTU-1)	The GATT client can only read 22 bytes from a GATT server's attribute data.
Write	0 to (ATT_MTU-3)	The GATT client can only write up to 20 bytes to a GATT server attribute.
Notification	0 to (ATT_MTU-3)	The GATT server can only send notifies of data up to 20 bytes long
Indications	0 to (ATT_MTU-3)	The GATT server can only send indications of data up to 20 bytes long

The MTU exchange is a subprocedure used by the GATT client to set the connection's ATT_MTU to the maximum possible value that can be supported by both devices. This means that if the ATT_MTU is set to a value larger than the default 23 bytes, larger amounts of data can be sent between the GATT server and the GATT client per transaction, therefore resulting in higher throughput. For example, when the ATT_MTU is set to 247, single read/write/notifies/indicates can be performed on attributes that are 244 bytes long.

5.16.2 CFG Keys Configuration

5.16.2.1 Maximum ATT_MTU

The maximum ATT_MTU value that the BL654 supports can be set using **AT+CFG 211 num**. Once this value is set, the BL654 should be reset (e.g. via ATZ command or a UART BREAK) for the configuration to take effect. When the *smart*BASIC application is running and if the BL654 is acting as a GATT client, the function [BleGattcAttributeMtuRequest](#) should be used to request the ATT_MTU size to change to its maximum supported value. If the BL654 is acting as a GATT server, when it receives the request it automatically responds with its maximum ATT_MTU. The connection's MTU is the minimum value between the client's and server's maximum ATT_MTU.

ID	Definition
211	Maximum ATT_MTU in bytes

Example:

```
AT+CFG 211 247
00
ATZ
00
AT+CFG 211 ?
27 0x000000F7 (247)
00
```

5.16.2.2 Maximum Attribute Data Length

In order to take full advantage of the increased ATT_MTU and packet length extension, the BL654 now supports attribute data lengths of up to 244 bytes. The maximum attribute data length is set using **AT+CFG 212 num**. The default value is 20 bytes. Once this is set, the BL654 should be reset (e.g. via ATZ command or a UART BREAK) for the configuration to take effect. At runtime, the function [BleAttrMetaDataEx](#) can then be used to create characteristic values larger than 20 bytes.

ID	Definition
212	Maximum Attribute Data Length

Example:

```
AT+CFG 212 244
00
ATZ
00
AT+CFG 212 ?
27 0x000000F4 (244)
00
```

5.16.2.3 Maximum Packet Length

The BL654 supports a packet size of 27 bytes by default, and can be configured to support packet sizes up to 251 bytes, which is the maximum that is allowed by the Bluetooth specification. In order to increase the packet size supported by the device, the command AT+CFG 216 num should be called, where num should be in the range of 27-251 bytes long. For values less than or greater than the range, the packet length will be capped to 27 bytes or 251 bytes respectively.

Note: This function only sets the maximum packet length supported by the device. To actually change the packet length for a connection, the function [BleGattAttributeMtuRequest\(\)](#) during the connection, and the packet length requested will be 'ATT_MTU + 4'. For more information, refer to the example for [BleGattAttributeMtuRequest\(\)](#).

5.16.3 Events and Messages

5.16.3.1 EVATTRIBUTEMTU

This event is thrown when the ATT_MTU of a connection is changed. It occurs after an MTU exchange procedure has been initiated from the GATT client. The event comes with the following parameters:

- **Connection handle** – The handle of the connection for which the attribute MTU has changed.
- **Attribute MTU** – The new attribute size. This is in the range of 23-247 bytes.

For usage, see example for [BleGattAttributeMtuRequest](#).

5.16.3.2 EVPACKETLENGTH

This event message is thrown when the connection's data packet length changes. It is only thrown after a negotiation of the attribute MTU via the [BleAttributeMtuRequest smartBASIC](#) function. The event comes with the following parameters:

- **Connection handle** – The handle of the connection for which the packet length has changed.
- **Maximum Tx Octets** – The maximum number of bytes that the BL654 sends on this connection. The valid range is between 27-251 bytes.
- **Maximum Tx Time** – The maximum time that the BL654 takes to send one byte on this connection. The valid range is between 328-2120 microseconds. This value cannot be controlled by the *smartBASIC* application and is only provided for informative purposes.

- **Maximum Rx Octets** – The maximum number of bytes that the BL654 receives on this connection. The valid range is between 27-251 bytes. The default value is 27 bytes.
- **Maximum Rx Time** – The maximum time that the BL654 takes to send one byte on this connection. The valid range is between 328-2120 microseconds. This value cannot be controlled by the *smart*BASIC application and is only provided for informative purposes.

For usage, see example for [BleGattcAttributeMtuRequest](#).

5.16.4 BleGattcAttributeMtuRequest

This function is used by the GATT client to request a new attribute MTU from the remote GATT server. On the BL654, the default ATT_MTU is 23 bytes. The maximum value that the BL654 can support is 247 bytes. This can be set using the config key 211.

Note: The ATT_MTU value is set using the interactive command **AT+CFG 211 num**. This value is then always used when the BleGattcAttributeMtuRequest is called.

BLEGATTATTRIBUTEMTUREQUEST(nConnHandle)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
nConnHandle	byVal nEnable AS INTEGER. The connection handle for which the ATT_MTU should change

```
// Example :: BleGattcAttributeMtuRequest.sb

// IMPORTANT: before running this application, the ATT_MTU and maximum packet
// length are set using the interactive commands:
//
// AT+CFG 211 247 (This is to set the maximum ATT_MTU)
// AT+CFG 216 251 (This is to set the maximum packet length)
// ATZ           (This is to reset the device for value to take effect)
//
// In order to achieve an ATT_MTU larger than the default 23, the remote device
// should also have its maximum ATT_MTU set to a value greater than 23. If the
// remote device is a BL654, the same AT+CFG command should be used

//BLE EVENT MSG IDs
#define BLE_EVBLEMSGID_CONNECT 0 // msgCtx = connection handle
#define BLE_EVBLEMSGID_DISCONNECT 1 // msgCtx = connection handle

DIM rc, stRsp$, addr$

//=====
// This handler is called when there is a BLE message
//=====
function HandlerBleMsg(BYVAL nMsgId AS INTEGER, BYVAL nCtx AS INTEGER) as integer
    dim hz

    select nMsgId
    case BLE_EVBLEMSGID_CONNECT
        print " --- Connect: (;integer.h' nCtx;)"&n"
        // Upon connection, request a new attribute length. The value used will be that
        // whcih was set using 'AT+CFG 211 num' before running the program
        rc = BleGattcAttributeMtuRequest(nCtx)

    case BLE_EVBLEMSGID_DISCONNECT
        print " --- Disconnect: (;integer.h' nCtx;)"&n"
```

```
// Upon disconnection, start advertising again
rc = BleAdvertStart(0,addr$,100,0,0)

case else

endselect
endfunc 1

//=====
// This handler is called when the packet length is changed
//=====
function HandlerPacketLength(BYVAL hConn, BYVAL Tx_Octets, BYVAL Tx_Time, BYVAL
Rx_Octets, BYVAL Rx_Time)

    print "Packet Length Change: \n"
    print "Handle: ";integer.h' hConn;"\n"
    print "Tx_Octets=";Tx_Octets;" Tx_Time =";Tx_Time;"\n"
    print "Rx_Octets=";Rx_Octets;" Rx_Time =";Rx_Time;"\n"

endfunc 1

//=====
// This handler is called when there is an event that the attribute MTU has changed
//=====
function HandlerAttrMTU(BYVAL hConn AS INTEGER, BYVAL nSize AS INTEGER)

    print "Attribute MTU Changed - Handle: ";integer.h' hConn;" Size: ";nSize;"\n"

endfunc 1

//-----
// Enable synchronous event handlers
//-----
OnEvent EVBLEMSG                call HandlerBleMsg
OnEvent EVATTRIBUTEMTU          call HandlerAttrMTU
OnEvent EVPACKETLENGTH          call HandlerPacketLength

// Initialise LE routines
rc = BleAdvertStart(0,addr$,100,0,0)
// Open the gatt client. Specify the buffer size to be 251 to be able to receive
// notifications up to 244 bytes long (maximum supported by BL654 when ATT_MTU = 247)
rc = BleGattcOpen(251, 0)

//-----
// Wait for a synchronous event.
// An application can have multiple <WaitEvent> statements
//-----
WAITEVENT
```

Expected Output:

```
AT+CFG 211 247

00

AT+CFG 216 251

00
```



```
ATZ

00

AT+RUN "BleGattcAttributeMtuReq"

--- Connect: (0001FF00)
Attribute MTU Changed - Handle:0001FF00 Size:247
Packet Length Change:
Handle: 0001FF00
Tx_Octets=251 Tx_Time =2120
Rx_Octets=251 Rx_Time =2120
```

5.16.5 BleMaxPacketLengthSet

This function has been removed and replaced with the config key 216. To set the maximum packet length, either call '**AT+CFG 216 nSize**' (followed by 'ATZ' for the value to take effect), or at runtime calling `NvCfgKeySet(216, nSize)` (followed by `reset(0)` for the value to take effect).

5.16.6 BleMaxPacketLengthGet

This function is used to get the preferred maximum packet length on the BL654. The actual packet length change only occurs when when the attribute MTU for the connection is changed via the `BleGattcAttributeMtuRequest` function.

BLEMAXPACKETLENGTHSET (nSize)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
nSize	byRef nSize AS INTEGER. When the function is used, this value will contain the maximum packet length preferred by the device.

Example:

```
// Example :: BleMaxPacketLengthSet.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

// Before running the example, issue 'at+cfg 216 155' followed by 'atz'
dim rc, nSize

// Now get the maximum packet length
rc = BleMaxPacketLengthGet(nSize)
PRINT "\nThe maximum packet size is ";nSize
```

```
The maximum packet size is 155
```

5.17 LE Ping

5.17.1 Overview

The LE Ping feature can be used to verify the existence of an encrypted link with the remote device. When enabled, the BL654 sends a request to the remote device to send an encrypted packet. If a timeout occurs without the reception of a packet, an event is triggered on the BL654.

5.17.2 Events and Messages

5.17.2.1 EVBLE_PING_AUTH_TIMEOUT

This event is thrown when the ping authenticated payload timer has expired without receiving an encrypted packet. The event comes with the following parameter:-

Connection Handle – The handle of the connection for which the timeout has occurred.

For usage, see example for BlePingAuthTimeout.

5.17.3 BlePingAuthTimeout

On an encrypted connection, this function is used to monitor the time since the last reception of an encrypted packet. If the timeout is exceeded without receiving a packet, then the EVBLE_PING_AUTH_TIMEOUT is triggered. This can be used to detect if there is something wrong with the encrypted link, and therefore if the event is received, a safe action would be to disconnect.

Note: Setting nAuthTimeout to a value less than (2*Connection Interval) will always cause the EVBLE_PING_AUTH_TIMEOUT event to be triggered. The reason for this is that two connection events are required for a packet to be sent to the remote device and then sent back, therefore having nAuthTimeout smaller than (2*Connection Interval) means that the timer will always expire before the response is received from the remote device, causing the event to be triggered.

BLEPINGAUTHTIMEOUT (hConnHandle, nAuthTimeout)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
nConnHandle	byVal hConnHandle AS INTEGER. The connection handle for which the authenticated payload timer is to start.
nAuthTimeout	byVal nAuthTimeout AS INTEGER. The authentication timeout in microseconds. The range of this value is between 10000 and 480000 microseconds, and is rounded up to the nearest 10000us (10ms).

Example:

```
//Example :: BlePingAuthTimeout.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

// Set BLE_PING_TIMEOUT to a value more than (2*connection interval)
// for the feature to work. Otherwise the event will be triggered
// because two connection events are required for a packet to be
// sent back and forth.
#define BLE_PING_TIMEOUT      10000
#define BTAddr                "000016A4B75204"

// Variable declaration
```

```

DIM hndl, rc, intrvl, sprvto, slat, pingTO

//-----
// Function to handle Ble event messages
//-----
#define BLE_EVBLEMSGID_CONNECT          0    //nCtx = connection handle
#define BLE_EVBLEMSGID_DISCONNECT      1    //nCtx = connection handle
#define BLE_EVBLEMSGID_ENCRYPTED       18    //nCtx = connection handle
//-----
FUNCTION HandlerBleMsg (nMsgId, nCtx)

    select nMsgId
    case BLE_EVBLEMSGID_CONNECT
        print "## Connected!\n"
        // Read connection interval
        rc = BleGetCurConnParms(nCtx, intrvl, sprvto, slat)
        print "## Connection Interval="; intrvl; "\n"
        // Pair to the remote device
        rc = BlePair(nCtx, 0)

    case BLE_EVBLEMSGID_DISCONNECT
        print "## Disconnected!\n"

    case BLE_EVBLEMSGID_ENCRYPTED
        print "## Encrypted Connection!\n"
        // Start LE Ping Authenticated Timeout
        pingTO = BLE_PING_TIMEOUT
        rc = BlePingAuthTimeout(nCtx, pingTO)
        if rc == 0 then
            print "## Ping auth timeout enabled :: Timeout="; pingTO; "\n"
        endif

    case else
    endselect
ENDFUNC 1

//-----
// This handler is called when the LE Ping authentication has timed out
//-----
function HandlerLePingTimeout (BYVAL hConn AS INTEGER)
    print "## LE Ping Timeout : "; integer.h' hConn; "\n"
    // Disconnect as this is not safe, check timeout is more than 2*connection interval
    rc = BleDisconnect(hConn)
endfunc 1

//-----
// Enable synchronous event handlers
//-----
OnEvent EVBLEMSG          call HandlerBleMsg
OnEvent EVBLE_PING_AUTH_TIMEOUT call HandlerLePingTimeout

//Connect to remote device
DIM addr$
addr$ = BTAAddr
addr$ = StrDehexize$(addr$)
rc = BleConnect(addr$, 5000, 27000, 30000, 500000)

//-----
// Wait for a synchronous event.
//-----
WaitEvent

```

5.18 LE 2M PHY and CODED PHY

5.18.1 Events and Messages

5.18.1.1 EVBLE_PHY_REQUEST

By default, this event is not enabled and an incoming PHY change request is automatically accepted. This event is only enabled when the function [BleConnectConfig\(9, 1\)](#) is called. It is thrown when there is a request from the remote device to switch the PHY modulation. In the function handler for this event, the function [BlePhySet](#) should be used to respond with the module's PHY preferences. The event comes with the following parameters:-

Connection Handle – The handle of the connection for which there is a PHY modulation request.

BlePhyTx – The transmission PHY preference of the remote device. This will be a bitmask. Bit 0 is set for 1MPHY, Bit 1 is set for 2MPHY, and Bit 2 is set for coded PHY.

BlePhyRx – The reception PHY preference of the remote device. This will be a bitmask. Bit 0 is set for 1MPHY, Bit 1 is set for 2MPHY, and Bit 2 is set for coded PHY.

For usage, see example for [BlePhyReq](#).

5.18.1.2 EVBLE_PHY_UPDATED

This event is thrown when the PHY modulation of the underlying connection has been updated. The event contains the following parameters:-

Connection Handle – The handle of the connection for which there is a PHY modulation has been updated.

Status – The HCI status code of the operation. 0x00 indicates a successful command. 0x00 – 0xFF indicates that the command has failed. A full list of HCI status codes can be found at the end of this document.

BlePhyTx – The new value of the transmission PHY. 1 for 1MPHY, 2 for 2MPHY, 4 for coded PHY.

BlePhyRx – The new value of the transmission PHY. 1 for 1MPHY, 2 for 2MPHY, 4 for coded PHY.

For usage, see example for [BlePhyReq](#).

5.18.2 BlePhySet

This function is used to set the PHY preferences of a connection, or reply to PHY request from a remote device. When this command is initiated from the module, it triggers an EVBLE_PHY_REQUEST on the remote device, and if successful, EVBLE_PHY_UPDATED event is thrown to indicate that the PHY configuration of the connection has changed.

Note: For Coded PHY functionality, the bandwidth configuration should be set to HIGH. This is done through "AT+CFG 214 1" followed by ATZ in interactive mode, or [NvCfgKeySet\(214,1\)](#) followed by [Reset\(0\)](#) during runtime.

This function is only used to switch the PHY settings of an existing connection (e.g. from 1MPHY to CODED PHY). In order to advertise, scan or connect over CODED PHY, the functions [BleAdvertConfig\(\)](#), [BleScanConfig\(\)](#) and [BleConnectConfig\(\)](#) should be used before [BleAdvertStart\(\)](#), [BleScanStart\(\)](#) or [BleConnect\(\)](#) is called, respectively.

BLEPHYSET (hConn, nPhyTx, nPhyRx, nOptions)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments:	
hConn	byVal hConn AS INTEGER. The handle of the connection for which a PHY modulation update is taking place.
nPhyTx	byVal nPhyTx AS INTEGER. A bit field that indicates the transmission PHYs that the host prefers - Bit 0 : The host prefers to use the LE 1M transmission PHY (possibly among others). - Bit 1 : The host prefers to use the LE 2M transmission PHY (possibly among others). - Bit 2 : The host prefers to use the LE CODED transmission PHY (possibly among others).

	▪ Bit 3-7: Reserved for future use.
nPhyRx	byVal nPhyRx AS INTEGER. A bit field that indicates the reception PHYs that the host prefers ▪ Bit 0 : The host prefers to use the LE 1M reception PHY (possibly among others). ▪ Bit 1 : The host prefers to use the LE 2M reception PHY (possibly among others). ▪ Bit 2 : The host prefers to use the LE CODED transmission PHY (possibly among others). ▪ Bit 3-7: Reserved for future use.
nOptions	byVal nPhyRx AS INTEGER. This is reserved for future use and should always be set to 0.

```
//Example :: BlePhySet.sb

// Ensure that the remote device is advertising

#define BTAddr                "000016A4B75202"

// Variable declaration
DIM rc, hConn

//-----
// Function to handle Ble event messages
//-----
#define BLE_EVBLEMSGID_CONNECT          0    //nCtx = connection handle
#define BLE_EVBLEMSGID_DISCONNECT      1    //nCtx = connection handle
//-----
FUNCTION HandlerBleMsg(nMsgId, nCtx)

    select nMsgId
    case BLE_EVBLEMSGID_CONNECT
        print "## Connected!\n"
        // Upon connection, request a change to 2MPHY
        hConn = nCtx
        dim nPhyTx : nPhyTx = 2
        dim nPhyRx : nPhyRx = 2
        dim nOptions : nOptions = 0
        rc = BlePhySet(hConn, nPhyTx, nPhyRx, nOptions)

    case BLE_EVBLEMSGID_DISCONNECT
        print "## Disconnected!\n"

    case else
    endselect
ENDFUNC 1

//-----
// This handler is called when there is a connection attempt timeout
//-----
function HandlerBleConnTimOut() as integer
    print "## Connection attempt stopped via timeout\n"
endfunc 1

//-----
// This handler is called when remote is requesting a switch to a different PHY
//-----
function HandlerPhyRequest(BYVAL hConn, BYVAL PhyTx, BYVAL PhyRx)
    print "## BLE PHY REQUEST: \n"
    print "Handle: ";integer.h' hConn;"\n"
    print "PhyTx=";PhyTx;" PhyRx =" ;PhyRx;"\n"
endfunc 1
```

```
//-----  
// This handler is called when the BLE PHY is updated  
//-----  
function HandlerPhyUpdated(BYVAL hConn, BYVAL nStatus, BYVAL PhyTx, BYVAL PhyRx)  
    print "## BLE PHY CHANGED: \n"  
    print "Handle: ";integer.h' hConn;"\n"  
    print "Status: ";integer.h' nStatus;"\n"  
    print "PhyTx=";PhyTx;" PhyRx =" ;PhyRx;"\n"  
endfunc 1  
  
//-----  
// Enable synchronous event handlers  
//-----  
OnEvent EVBLEMSG                call HandlerBleMsg  
OnEvent EVBLE_CONN_TIMEOUT      call HandlerBleConnTimOut  
OnEvent EVBLE_PHY_REQUEST       call HandlerPhyRequest  
OnEvent EVBLE_PHY_UPDATED       call HandlerPhyUpdated  
  
//Connect to remote device  
DIM addr$  
addr$ = BTAddr  
addr$ = StrDehexize$(addr$)  
  
// Change default configuration so that EVBLE_PHY_REQUEST is thrown  
rc = BleConnectConfig(9, 1)  
  
rc = BleConnect(addr$, 30000, 27000, 30000, 500000)  
  
//-----  
// Wait for a synchronous event.  
//-----  
WaitEvent
```

Expected Output:

```
## Connected!  
## BLE PHY CHANGED:  
Handle: 0001FF00  
Status: 00000000  
PhyTx=2 PhyRx =2
```

6 OTHER EXTENSION BUILT-IN ROUTINES

This chapter describes non BLE-related extension routines that are not part of the core *smart*BASIC language.

6.1 Near Field Communications (NFC)

This chapter provides details of all the *smart*BASIC functions and subroutines that expose the NFC functionality and also the events that are generated when in operation.

6.1.1 Overview

This section describes all the events and routines used to interact with the NFC peripheral on the BL654 which is a passive device which means it is **not** possible to establish NFC communications between two BL654 devices. In any NFC communications, one device shall be an Active device.

On the BL654 the NFC is exposed as a Tag Type 2 **Passive** interface which means it can only offer tags to be read from an **Active** NFC reader (for example, a smartphone or an Arduino based shield).

The NFC Forum has agreed on four tag types and a good definition of those NFC Tag Types is provided at <http://www.nfc.cc/technology/nfc-tag-types> which is reproduced as follows:

- **Type 1** – Type 1 Tag is based on ISO/IEC 14443A. This tag type is read and re-write capable. The memory of the tags can be write protected. Memory size can be between 96 bytes and 2 Kbytes. Communication Speed with the tag is 106 kbit/sec. Example: Innovision Topaz
- **Type 2** – Type 2 Tag is based on ISO/IEC 14443A. This tag type is read and re-write capable. The memory of the tags can be write protected. Memory size can be between 48 bytes and 2 Kbytes. Communication Speed with the tag is 106 kbit/sec. Example: NXP Mifare Ultralight, NXP Mifare Ultralight
- **Type 3** – Type 3 Tag is based on the Japanese Industrial Standard (JIS) X 6319-4. This tag type is pre-configured at manufacture to be either read and re-writable, or read-only. Memory size can be up to 1 Mbyte. Communication Speed with the tag is 212 kbit/sec. Example: Sony Felica
- **Type 4** – Type 4 is fully compatible with the ISO/IEC 14443 (A & B) standard series. This tag type is pre-configured at manufacture to be either read and re-writable, or read-only. Memory size can be up to 32 Kbytes; For the communication with tags APDUs according to ISO 7816-4 can be used. Communication speed with the tag is 106 kbit/sec. Example: NXP DESfire, NXP SmartMX with JCOP.)

Mifare Classic is not an NFC forum compliant tag, although reading and writing of the tag is supported by most of the NFC devices as they ship with an NXP chip. The specifications for the tag types are available for free from the NFC-Forum website.

The following is a high level overview of NFC communications and it is encouraged that the reader access resources on the internet which give further details, like for example <http://www.nfc.cc/technology/nfc/>.

- The NFC physical layer is a half-duplex, bi-directional pipe with a typical datarate of 106kbps and can be 212 or 424 kbps. (The BL654 only provides a 106kbps datarate)
- The data is carried on a 13.56MHz carrier wave which is provided by one of the **active** devices in the peer to peer link. The signalling in the carrier is done using load modulation. "The term load modulation describes the influence of load changes on the initiators carrier field's amplitude"
<credit: <http://www.nfc.cc/technology/nfc/>>
- There is Active mode and Passive mode. At least one device (the initiator) has to be an active device which provides the 13.56MHz carrier wave.
- The data layer for Tags consists of NDEF messages. NDEF = NFC Data Exchange Format. Each NDEF message consists of one or more NDEF records. Each NDEF record consists of a well defined variable length header and a payload which can be anything and the NFC forum does not specify any format.
- An NDEF Record header consists of a payload length, a Type field and an optional ID Field. The Type field is used to qualify the payload so that the recipient can interpret it appropriately. The optional ID field is typically used to give a 'name' to the record which allows other records in the message to link to.

- NFC provides for three types of communications over the physical channel and they are; Reader/Writer mode, Card Emulation mode and Peer-To-Peer mode. In the context of BL654, only reader/writer mode functionality is made available and initially only passive Tags Type 2 which means Tags can be read but not written. Future enhancements to the BL654 firmware may provide Tag Type 4 (which can be read or written) but that is dependent on the chipset vendor providing an appropriate stack.

The Tag Type 2 functionality exposed in the BL654 is nicely illustrated by the following diagram, for which Laird acknowledges Nordic Semiconductor, the chipset vendor.

In the diagram the Polling device is an active device like an NFC enabled smartPhone or an Arduino with an Adafruit NFC shield.

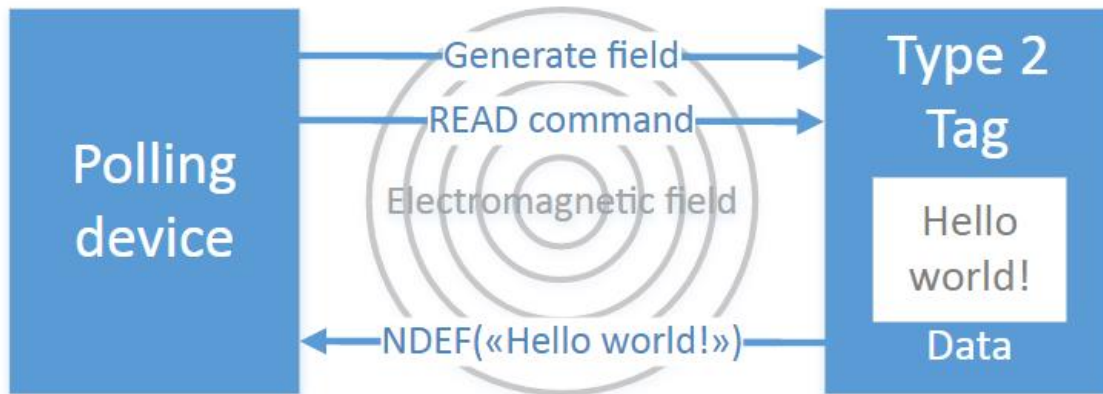


Figure 2: Simplified overview of how NFC can be used

6.1.2 NDEF Messages

NDEF is the acronym for “NFC Data Exchange Format”

NDEF **Messages**, in the context of Tags of any type, are simply an array of 1 or more NDEF **Records**.

A Tag of any type is simply an NDEF message.

Each NDEF record consists of a **header** and a **payload** both being variable length and the length of the payload in each record can be up to 2^{32} bytes long.

The header consists of:

Byte 0 : A bit mask which contains a 3 bit TNF (Type Name Format) and 5 other single bit fields. One of which specifies if the Payload length field is 1 or 4 bytes and another which specifies if the ID field in the header is present. The rest of the bits are used to specify if the record is the first, last or an in-between record in the overall NDEF message.

Byte 1 – Specifies the length of the Type field in the header which can be up to 255 bytes

Next Byte (or next 4 Bytes) – The payload length.

Next Byte – The ID Length (if the ID bit in the first byte is set)

Next N bytes – Where N is specified by Byte 1 is the the Type field

Next N Bytes – Where N is specified by the ‘ID length’ field and only if the ID bit in Byte 0 is set, used for the ID.

For full details please refer to the NFC Forum technical specification titled *NFC Data Exchange Foramt (NDEF)* and there are various resources online which have good explanations.

6.1.3 Arduino Based NFC Reader

The API presented in this section was tested using an Arduino Uno (www.arduino.cc/en/Main/ArduinoBoardUno) fitted with an Adafruit 'PN532 RFID/NFC Shield' (www.adafruit.com/products/789) and an Arduino application which is also available as-is without warranty and it can be freely modified called **NfcCli.ino**.

It is assumed that the reader is familiar with how to use an Arduino especially how to load apps into a target board. Please refer to online resources if not.

The Arduino application presents a uart based command line interface and currently has three commands :

- **openlr** – This opens the NFC interface
- **scanlr** – This forces a scan for tags and will timeout after about 5 seconds. If a tag is read, then it is interpreted and displayed in textual manner
- **closelr** – This closes the NFC interface

The command set allows for keeping the Arduino NFC antenna constantly in contact with the module's antenna and then allows the field to be enabled or disabled.

6.1.4 Sample Application 1

The following example application, for which the source available, shows how to create an NDEF message for a Tag which has two text records where the Type is "T."

```
//*****  
// Example App File : nfcl.text.tag.sb  
//  
// This application commits an NDEF message with two text tag of type 'T' with  
// a "Hello World" and "Welcome" message. Which can be read with an Arduino +  
// Adafruit NFC shield running an arduino app written by Laird which is availble  
// on request.  
//  
//*****  
  
//*****  
// Definitions  
//*****  
#define INVALID_NDEF_HANDLE      0xFFFFFFFF  
  
//*****  
// Register Error Handler as early as possible  
//*****  
sub HandlerOnErr()  
  print "\n OnErr - ";GetLastError();"\n"  
endsub  
onerror next HandlerOnErr  
  
//*****  
// Debugging resource as early as possible  
//*****  
  
//=====  
//=====  
sub AssertResCode(byval rc as integer,byval tag as integer)  
  if rc!=0 then  
    print "\nFailed with ";integer.h' rc;" at tag ";tag  
  endif  
endsub  
  
//*****  
// Global Variable Declarations  
//*****
```

```

dim rc
dim nfcHandle      //returned by NfcOpoen
dim ndefHandle     //returned by NfcNdefMsgNew

dim type$
dim id$
dim engLang$
dim payload$
dim records,memTotal,memUsed

//*****
// Initialisse Global Variable
//*****

type$="T" : id$=""
engLang$=" en"
rc=strsetchr(engLang$,strlen(engLang$),0) //prepend the language code length + UTF type

//*****
// Function and Subroutine definitions
//*****

//*****
// Handler definitions
//*****

//=====
// This handler is called when data has arrived at the serial port
#define NFC_MSGIN_NFCFIELDOFF      (2)
#define NFC_MSGIN_NFCFIELDON      (3)
#define NFC_MSGIN_NFCTAGREAD      (7)
//=====
function HandlerNfc(msgid) as integer
    print "\nEVNFC "
    select(msgid)
    case NFC_MSGIN_NFCFIELDOFF
        print "FIELD OFF"
    case NFC_MSGIN_NFCFIELDON
        print "FIELD ON"
    case NFC_MSGIN_NFCTAGREAD
        print "TAG READ"
    case else
    endselect
endfunc 1

//*****
//*****
// Equivalent to main() in C
//*****

//-----
// Enable synchronous event handlers
//-----
OnEvent EVNFC call HandlerNfc

//-----
// Initialise and then wait for events
//-----

//Enable NFC hardware interface, it already is, so will succeed
rc=NfcHardwareState(0,1)

```

```
AssertResCode(rc,20000)

//Open NFC and return the handle
rc=NfcOpen(0,"\\00",nfcHandle)
AssertResCode(rc,20005)

//Create a new NDEF message object that has a maximum size of 16 bytes
rc=NfcNdefMsgNew(32,ndefHandle)
AssertResCode(rc,20010)

//Oops, buffer will be too small do delete and create a new one
rc=NfcNdefMsgDelete(ndefHandle)
AssertResCode(rc,20012)

//Create a new NDEF message object that has a maximum size of 128 bytes
rc=NfcNdefMsgNew(128,ndefHandle)
AssertResCode(rc,20014)

//Add a NDEF Record of type "T" and message "My World" in english language code
payload$="My World"
rc=NfcNdefRecAddGeneric(ndefHandle,1,type$,id$,engLang$,INVALID_NDEF_HANDLE,payload$)
AssertResCode(rc,20020)

//Oops, changed my mind about message so reset the ndef buffer
rc=NfcNdefMsgReset(ndefHandle)
AssertResCode(rc,20022)

//Add a NDEF Record of type "T" and message "Hello World" in english language code
payload$="Hello World"
rc=NfcNdefRecAddGeneric(ndefHandle,1,type$,id$,engLang$,INVALID_NDEF_HANDLE,payload$)
AssertResCode(rc,20024)

//Add a NDEF Record of type "T" and message "Welcome" in english language code
payload$="Welcome"
rc=NfcNdefRecAddGeneric(ndefHandle,1,type$,id$,engLang$,INVALID_NDEF_HANDLE,payload$)
AssertResCode(rc,20040)

//Inspect the status of the ndef message object
rc=NfcNdefMsgGetInfo(ndefHandle,records,memTotal,memUsed)
if rc==0 then
    print "\nNDEF Info: Records=";records;" TotalMem=";memTotal;" UsedMem=";memUsed
endif

//Commit the NDEF message to the stack
rc=NfcNdefMsgCommit(nfcHandle,ndefHandle)
AssertResCode(rc,20060)

//Enable field Sense
rc=NfcFieldSense(nfcHandle,1)
AssertResCode(rc,20080)

//-----
// Wait for an event.
//-----
WaitEvent
```

The output from the Arduino reader is as follows:

```
open

OK
scan

++ NDEF MESSAGE ++
NFC Forum Type 2
UID: 5F 59 28 A2 AB C6 79

Contains (2) NDEF Records.

NDEF Record 1 (Payload Length=: 14 (0xE))
  TNF: 1
  Type: T
  03656E48656C6C6F20576F726C64      .enHello World

NDEF Record 2 (Payload Length=: 10 (0xA))
  TNF: 1
  Type: T
  03656E57656C636F6D65      .enWelcome

-- NDEF MESSAGE --
OK
```

6.1.5 Sample Application 2

The following example application, for which the source is available, shows how to create an NDEF message for a Tag which has a single record defined as a 'Simplified Tag Format for a Single Bluetooth Carrier Record' as specified in the Bluetooth SIG specification "Bluetooth Secure Simple Pairing Using NFC" dated 2014-01-09.

```
//*****
// Example App File : nfc2.text.ble.connection.handover.sb
//
// This application commits an NDEF message with a "Simplified Tag Format for a
// single Bluetooth Carrier Record" which will result in a connection and a just
// works pairing from an android device like Nexus 7 tablet.
//
// It have only been tested against a Nexus 7 (newest model)
//
//*****

//*****
// Definitions
//*****
#define INVALID_NDEF_HANDLE      0xFFFFFFFF

//*****
// Register Error Handler as early as possible
//*****
sub HandlerOnErr()
  print "\n OnErr - ";GetLastError();"\n"
endsub
onerror next HandlerOnErr

//*****
// Debugging resource as early as possible
//*****

//=====
```

```
//=====
sub AssertResCode(byval rc as integer,byval tag as integer)
    if rc!=0 then
        print "\nFailed with ";integer.h' rc;" at tag ";tag
    endif
endsub

//*****
// Global Variable Declarations
//*****

dim rc
dim nfcHandle          //returned by NfcOpoen
dim ndefHandle         //returned by NfcNdefMsgNew

dim payload$
dim records,memTotal,memUsed
dim maxdevname : maxdevname = 12
dim appearance : appearance = 0x512
dim flags : flags = 0x2
dim role : role=2
dim oobKey$ : oobKey$="" //no TK
dim devname$ : devname$="LAIRD BL654"
dim advRpt$, scnRpt$
dim peerAd$ : peerAd$=""
dim hConn : hConn=0xFFFFFFFF

//*****
// Function and Subroutine definitions
//*****

//*****
// Handler definitions
//*****

//=====
// This handler is called when data has arrived at the serial port
#define NFC_MSGIN_NFCFIELDOFF          (2)
#define NFC_MSGIN_NFCFIELDON           (3)
#define NFC_MSGIN_NFCTAGREAD           (7)
//=====
function HandlerNfc(msgid) as integer
    print "\nEVNFC "
    select(msgid)
        case NFC_MSGIN_NFCFIELDOFF
            print "FIELD OFF"
        case NFC_MSGIN_NFCFIELDON
            print "FIELD ON"
        case NFC_MSGIN_NFCTAGREAD
            print "TAG READ"
        case else
            endselect
    endfunc 1

//=====
// This handler is called when there is a BLE message
//-----
#define BLE_EVBLEMSGID_CONNECT          0
#define BLE_EVBLEMSGID_NEW_BOND         10
#define BLE_EVBLEMSGID_ENCRYPTED         18
//=====
```

```
function HandlerBleMsg (BYVAL nMsgId AS INTEGER, BYVAL nCtx AS INTEGER) as integer

    select nMsgId
    case BLE_EVBLEMSGID_CONNECT
        hConn=nCtx
        print "\n +++ Connect: (;integer.h' hConn;)"

    case BLE_EVBLEMSGID_NEW_BOND
        print "\n +++ New Bond"
        //Disable field Sense
        rc=NfcFieldSense(nfcHandle,0)
        AssertResCode(rc,20080)
        print "\n --- NFC Field OFF"

    case BLE_EVBLEMSGID_ENCRYPTED
        print "\n +++ Encrypted Connection"

    case else
    endselect
endfunc 1

//=====
// This handler is called when there is a EVDISCON message
#define ADVTYPE      0 //ADV_IND
#define ADVINTVTL    100 //advert interval in milliseconds
#define ADVTOUT      0 //no timeout
//=====
function HandlerDisconnect (BYVAL nConnH AS INTEGER, BYVAL nReas AS INTEGER) as integer
    print "\n +++ Disconnect: (;integer.h' nConnH;) reason=";nReas

    rc=BleAdvertStart (ADVTYPE,peerAd$,ADVINTVTL,ADVTOUT,0)
    AssertResCode(rc,10000)

endfunc 1

//*****
//*****
// Equivalent to main() in C
//*****

//-----
// Enable synchronous event handlers
//-----
OnEvent EVNFC      call HandlerNfc
OnEvent EVBLEMSG   call HandlerBleMsg
OnEvent EVDISCON   call HandlerDisconnect

//-----
// Initialise and then wait for events
//-----

//Open NFC and return the handle
rc=NfcOpen(0,"00",nfcHandle)
AssertResCode(rc,20005)

//Create a new NDEF message object that has a maximum size of 128 bytes
rc=NfcNdefMsgNew(128,ndefHandle)
AssertResCode(rc,20014)

//Add "Simplified Tag Format for a single Bluetooth Carrier" Record
rc=NfcNdefRecAddLeOob(ndefHandle,maxdevname,appearance,role,flags,oobKey$)
AssertResCode(rc,20020)
```

```
//Inspect the status of the ndef message object
rc=NfcNdefMsgGetInfo(ndefHandle,records,memTotal,memUsed)
if rc==0 then
    print "\n *** NDEF Info: Records=";records;" TotalMem=";memTotal;" UsedMem=";memUsed
endif

//Commit the NDEF message to the stack
rc=NfcNdefMsgCommit(nfcHandle,ndefHandle)
AssertResCode(rc,20060)

//Initialise the GAP service
rc=BleGapSvcInit(devname$,0,appearance,7500,100000,2000000,0)
AssertResCode(rc,20100)

//Initialise adverts and commit
rc=BleAdvRptInit(advRpt$,flags,appearance,maxdevname)
AssertResCode(rc,20200)
rc=BleScanRptInit(scnRpt$)
AssertResCode(rc,20210)
rc=BleAdvRptsCommit(advRpt$,scnRpt$)
AssertResCode(rc,20220)

//Start Adverts
rc=BleAdvertStart(ADVTYPE,peerAd$,ADVINTVTTL,ADVTOUT,0)
AssertResCode(rc,20300)
print "\n --- Adverts ON"

//Enable field Sense
rc=NfcFieldSense(nfcHandle,1)
AssertResCode(rc,20400)
print "\n --- NFC Field ON"

//-----
// Wait for an event.
//-----
WaitEvent
```

The output from the Arduino reader is as follows:

```
open

OK
scan

++ NDEF MESSAGE ++
NFC Forum Type 2
UID: 5F 59 28 A2 AB C6 79

Contains (1) NDEF Record.

NDEF Record 1 (Payload Length=: 32 (0x20))
  TNF: 2
  Type: application/vnd.bluetooth.le.oob
  021C02081B83160BA416000003191205 .....
  0201060C094C4149524420424C363532 .....LAIRD BL654

-- NDEF MESSAGE --
OK
```

Where the payload 021C02.... 363532 is an array of BLE Advert Data Elements which have format Len:Tag:Data. For example 021C02 implies an AD element of length 2 and tag 1C and since 1C means 'LE Role' it corresponds to the value 2 that was passed in the variable 'role' in the function call `NfcNdefRecAddLeOob()` in the sample app 2 above.

6.1.6 Wake-On-NFC

When the module is in deep sleep, it is possible to wake it up when an NFC field energises it's antenna when an active reader comes into the zone.

By default this does not happen; it only wakes up if the field sense is switched on via `NfcFieldSense()`. To do that, a 'dummy' tag needs to be committed. The following sequence is necessary to enable this feature:

1. `NfcOpen()`
2. `NfcNdefMsgNew()`
3. `NfcNdefRecAddLeOob()` or `NfcNdefRecAddGeneric()`
4. `NfcNdefMsgCommit()`
5. `NfcFieldSense()`
6. `SystemStateSet(0)`

Once `SystemStateSet()` is processed, the module enters deep sleep ***unless the reader is already energising the NFC field which will prevent deep sleep to persist.***

Please note that when the system wakes up, it is assumed that in a normal deployed scenario there will be an \$autorun\$ application so after reset your application will automatically restart. In your application you could call `SYSINFO(2001)` which will tell you what was the reason for waking up from reset. If you logically AND the result with the value `0x80000` and you end up with `0x80000`, then it implies the wakeup was due to Wake-On-NFC.

```
IF (SYSINFO(2001) & 0x80000)==0x80000 THEN
    PRINT "We woke up because of NFC"
ENDIF
```

6.1.7 Events and Messages

In addition to the routines for manipulating the NFC interface, when an active reader generates a carrier field around the module's antenna and FIELD-ON event is generated, and conversely when the carrier field collapses because the active device moves away, a FIELD-OFF event is generated. When the Tag exposed by the module is actually read, then a TAG-READ event is generated.

The following is a list of events generated by the NFC manager which can be handled by user code.

EVNFC	This is an event message with one INTEGER payload which identifies the event that happened as follows:
	2 FIELD OFF (reader carrier has collapsed)
	3 FIELD ON (reader carrier is active)
	7 TAG READ (reader has finished reading the committed NDEF message)

6.1.8 NfcHardwareState

FUNCTION

This function is used to enable or disable the NFC hardware on the device.

Note: On the BL654 the 2 pins used for the NFC antenna are multifunction so that they are either for NFC or plain GPIO. However, this is set via a non-volatile configuration register in a special region of the onchip flash. These pins are by default set for NFC functionality and have appropriate protection from over energisation from an active field. Given this is a flash register, once the NFC functionality is disabled using this function, it can only be reactivated by reloading the entire firmware using the JLINK interface. It is not possible to reset this register when firmware is uploaded using the UART interface.

NFCHARDWARESTATE (interfaceNum, newState)

Returns	INTEGER, indicating the success of command:	
	0	Opened successfully
	0x5A00	Invalid interface number
	0x5A06	Enable Fail

Exceptions	- Local Stack Frame Underflow - Local Stack Frame Overflow
Arguments	
<i>interfaceNum</i>	byVal interfaceNum AS INTEGER For platforms that have multiple NFC interfaces, this identifies the interface to enable or disable and for platforms with only one interface specify 0 for this argument
<i>newState</i>	byVal newState AS INTEGER Set to 0 to disable NFC functionality. Non-zero to enable.
Related Commands	NFCFIELDSENSE, NFCCLOSE, NFCNDEFMSGCOMMIT

Example:

```
//See subsection 'Sample Application 1'
```

6.1.9 NfcOpen

FUNCTION

This function opens the NFC interface identified by the 'interfaceNum' parameter, configure it as specified in the 'config\$' future extensible string parameter and will return a handle which is used in appropriate subsequent NFC related function calls.

The 'interfaceNum' parameter exists as in future other smartBASIC based can potentially have multiple physical NFC interfaces.

NFCOPEN (interfaceNum, config\$, nfcHandle)

Returns	INTEGER, indicating the success of command: <table><tr><td>0</td><td>Opened successfully</td></tr><tr><td>0x5A00</td><td>Invalid interface number</td></tr><tr><td>0x5A04</td><td>NFC hardware not available</td></tr></table>	0	Opened successfully	0x5A00	Invalid interface number	0x5A04	NFC hardware not available
0	Opened successfully						
0x5A00	Invalid interface number						
0x5A04	NFC hardware not available						
Exceptions	- Local Stack Frame Underflow - Local Stack Frame Overflow						
Arguments							
interfaceNum	byVal interfaceNum AS INTEGER For platforms that have multiple NFC interfaces, this identifies the interface to open and for platforms with only one interface specify 0 for this argument						
config\$	byVal config\$ AS STRING This is an extensible argument with 0 or more bytes which is used to configure the NFC interface as follows: <table><tr><td>Byte</td><td>Value</td><td>Description</td></tr><tr><td>0</td><td>0</td><td>Tag Type 2 Functionality</td></tr></table> A 0 value specifies default functionality, and more bytes will be allocated as needed to define appropriate new functionality	Byte	Value	Description	0	0	Tag Type 2 Functionality
Byte	Value	Description					
0	0	Tag Type 2 Functionality					
nfcHandle	byRef nfcHandle AS INTEGER If the function fails, then on exit this parameter is set to INVALID_HANDLE (which is 0xFFFFFFFF), and if successful a valid handle to be used in subsequent appropriate NFC related function calls.						
Related Commands	NFCFIELDSENSE, NFCCLOSE, NFCNDEFMSGCOMMIT						

Example:

```
//See subsections 'Sample Application 1' and 'Sample Application 2'
```

6.1.10 NfcClose

SUBROUTINE

This function closes the NFC interface identified by the 'nfcHandle' parameter and on exit the handle will be set to 0xFFFFFFFF so that it cannot be mistakenly used.

NFCCLOSE (nfcHandle)

Returns	None
Exceptions	- Local Stack Frame Underflow - Local Stack Frame Overflow
Arguments	
<i>nfcHandle</i>	byRef nfcHandle AS INTEGER If the function is successful then on exit this variable will be set to 0xFFFFFFFF
Related Commands	NFCFIELDSENSE, NFCOPEN, NFCNDEFMSGCOMMIT

Example:

```
//See subsection 'Sample Application 2'
```

6.1.11 NfcFieldSense

FUNCTION

This function is used when the device is in passive mode to enable or disable field sensing so that an active device can communicate with it.

NFCFIELDSENSE (nfcHandle, fNewState)

Returns	INTEGER, indicating the success of command: <table><tr><td>0</td><td>Opened successfully</td></tr><tr><td>0x020C</td><td>Invalid handle</td></tr><tr><td>0x5A03</td><td>NFC interface is not open</td></tr><tr><td>0x5AEx</td><td>An underlying stack related error</td></tr></table>	0	Opened successfully	0x020C	Invalid handle	0x5A03	NFC interface is not open	0x5AEx	An underlying stack related error
0	Opened successfully								
0x020C	Invalid handle								
0x5A03	NFC interface is not open								
0x5AEx	An underlying stack related error								
Exceptions	- Local Stack Frame Underflow - Local Stack Frame Overflow								
Arguments									
<i>nfcHandle</i>	byVal nfcHandle AS INTEGER This is the handle returned by a prior call of NfcOpen()								
<i>fNewState</i>	byVal fNewState AS INTEGER Specify 0 to disable field sensing and non-zero to enable it								
Related Commands	NFCOPEN, NFCCLOSE, NFCNDEFMSGCOMMIT								

Example:

```
//See subsections 'Sample Application 1' and 'Sample Application 2'
```

6.1.12 NfcNdefMsgNew

FUNCTION

An NDEF record can be as long as 4.2 billion bytes and since an NDEF message is an array of NDEF records the whole message can theoretically be multiples of 4.2 billion bytes.

In practice most tags only have a limited amount of memory (typically less than 32K). Most messages are less than a kilobyte in the context of the *smart*BASIC based device.

All the NDEF messages that will be created using the API exposed in this device will not be of the same length, but the memory must be persistent so that it can be delivered to a reader when required.

Therefore, this *smart*BASIC implementation, requires that the creation of an NDEF message starts with dynamically allocated memory which can be released as and when required.

This function is used to create a dynamic buffer in RAM. This buffer is of the minimum length specified by the 'maxMsgLen' parameter and is associated with a 'ndefHandle' for which a valid handle value is returned if the memory requested was successfully acquired from the underlying memory manager. There is also an absolute limit on this implementation with regards to maximum amount of memory that can be allocated and that value can be obtained via AT I 2052 command or from within a running app using SYSINFO(2052).

The 'ndefHandle' is subsequently used for various API calls to make up the full message by writing single records at a time.

Note that NDEF records are added to this buffer using various NfcNdefRecAddXXXX() functions and at any time the function NfcNdefMsgGetInfo() can be used to see how big the buffer is and how much of that is used.

NFCNDEFMSGNEW (maxMsgLen, ndefHandle)

Returns	INTEGER, indicating the success of command:	
	0	Opened successfully
	0x5A09	Invalid max memory required
	0x5A0A	Memory could not be acquired SYSINFO(2052) returns max len allowed in this system
	0x5A0B	No spare handles as available SYSINFO(2051) returns max ndef handles in this system
Exceptions	- Local Stack Frame Underflow - Local Stack Frame Overflow	
Arguments		
maxMsgLen	byVal maxMsgLen AS INTEGER This specifies the maximum expected length of the NDEF message that will be stored in the memory acquired. If, while adding a record, it does not fit, use NfcNdefMsgDelete() function to release that memory and call this function again with a larger value and try again.	
ndefHandle	byRef ndefHandle AS INTEGER If the function fails, then on exit this parameter is set to INVALID_HANDLE (which is 0xFFFFFFFF), and if successful a valid handle to be used in subsequent appropriate NDEF related function calls.	
Related Commands	NFCNDEFMSGCOMMIT, NFCNDEFDELETE, NFCDEFMSGGETINFO, NFCNDEFMSGRESET,NFCNDEFRECADDLEOOB,NFCNDEFRECADDGENERIC	

Example:

```
//See subsections 'Sample Application 1' and 'Sample Application 2'
```

6.1.13 NfcNdefMsgDelete

FUNCTION

This function is used to release the memory block associated with an `ndefHandle` that was acquired using `NfcNdefMsgNew()`.

NFCNDEFMSGDELETE (`ndefHandle`)

Returns	INTEGER, indicating the success of command:	
	0	Opened successfully
	0x5A20	Cannot be deleted as it has been committed and locked to the stack using NfcNdefMsgCommit()
	0x5A0C	The handle is not valid
Exceptions	- Local Stack Frame Underflow - Local Stack Frame Overflow	
Arguments		
<i>ndefHandle</i>	byVal ndefHandle AS INTEGER The handle of the memory block that was acquired using NfcNdefMsgNew	
Related Commands	NFCNDEFMSGCOMMIT, NFCNDEFNEW, NFCDEFMSGGETINFO, NFCNDEFMSGRESET,NFCNDEFRECADDLEOOB,NFCNDEFRECADDGENERIC	

Example:

```
//See subsections 'Sample Application 1'
```

6.1.14 NfcNdefMsgGetInfo

FUNCTION

After an NDEF message memory buffer has been acquired using `NfcNdefMsgNew()`, call this function to see how much of the memory is used after adding records.

This function is particularly useful during the *smart*BASIC app development as it allows the optimisation of memory usage after all testing has been done to then reduce the size of the buffer for final deployment.

NFCNDEFMSGGETINFO (`ndefHandle`, `records`, `memTotal`, `memUsed`)

Returns	INTEGER, indicating the success of command: 0 Opened successfully 0x5A0C The handle is not valid
Exceptions	▪ Local Stack Frame Underflow ▪ Local Stack Frame Overflow
Arguments	
ndefHandle	byRef ndefHandle AS INTEGER The handle of the memory block that was acquired using NfcNdefMsgNew.
records	byRef records AS INTEGER If the ndefHandle is valid, then on exit this will be updated with the number of records currently added to the message.
memTotal	byRef MemTotal AS INTEGER If the ndefHandle is valid, then on exit this will be updated with the total memory allocated for this message (value that was specified in NfcNdefMsgNew()) when the handle was acquired.
memUsed	byRef MemUsed AS INTEGER If the ndefHandle is valid, then on exit this will be updated with the memory that has been used in the buffer. For deployed systems, you want this to be as close to memTotal as possible to optimise memory usage.

Related Commands	NFCNDEFMSGCOMMIT, NFCNDEFDELETE, NFCDEFMSGNEW, NFCNDEFMSGRESET,NFCNDEFRECADDLEOOB,NFCNDEFRECADDGENERIC

Example:

```
//See subsections 'Sample Application 1' and 'Sample Application 2'
```

6.1.15 NfcNdefMsgReset

FUNCTION

After an ndef message has been used, this function can be used to reset the record count and memory used to 0 so that a new message with new records can be created without releasing the memory. It eliminates a heap free and malloc and so helps mitigate heap fragmentation.

NFCNDEFMSGRESET (ndefHandle)

Returns	INTEGER, indicating the success of command:	
	0	Opened successfully
	0x5A20	Cannot be deleted as it has been committed and locked to the stack using NfcNdefMsgCommit()
	0x5A0C	The handle is not valid
Exceptions	- Local Stack Frame Underflow - Local Stack Frame Overflow	
Arguments		
ndefHandle	byVal ndefHandle AS INTEGER The handle of the memory block that was acquired using NfcNdefMsgNew	
Related Commands	NFCNDEFMSGCOMMIT, NFCNDEFNEW, NFCDEFMSGGETINFO, NFCNDEFMSGDELETE, NFCNDEFRECADDLEOOB, NFCNDEFRECADDGENERIC	

Example:

```
//See subsections 'Sample Application 1'
```

6.1.16 NfcNdefRecAddLeOob

FUNCTION

This function is used to add an NDEF record to a NDEF Message.

After an NDEF message memory buffer has been acquired using NfcNdefMsgNew(), call this function to add a 'Simplified Tag Format for a Single Bluetooth Carrier Record' as specified in the Bluetooth SIG specification "Bluetooth Secure Simple Pairing Using NFC" dated 2014-01-09.

This tag is a single record in the NDEF message and will contain the following BLE AD elements (same format as in BLE adverts).

- LE Bluetooth Local Device Address
- LE Role
- Appearance
- Local Name
- (Optional) Security Manager TK Value

Please note that due to the inclusion of the local device address LE Privacy should not be enabled otherwise the NFC record will soon contain a stale address and so the smartphone/tablet will not be able to make a connection and pair.

Note: The Local Device Address and Local Name is not provided in this function call as the underlying service routine will obtain both information from the stack. With regards to the Local Name, only the maximum characters you want to

add to the record need be specified. Depending on the actual device name registered with the stack using `BleGapSvcInit()` function the appropriate AD element tag will be automatically used.

Warning:

This function adds an NDEF record as per the specification mentioned above and publishes it as a Type 2 tag. You will not be able to interact with it using any iOS devices even when the iOS device (like the iPhone 6S) has NFC which is only used for Apple Pay. With Android, you will see inconsistent behaviour between different brands and OS versions. Hence any testing you perform is best done using something like an Arduino Uno and an Adafruit NFC Shield as shown above in the context of the two sample apps.

If you wish to experiment, use the function `NfcNdefRecAddGeneric()` which will allow you to create NDEF records of any type and payload.

NFCNDEFRECADDLEOOB (ndefHandle, maxDevName, appearance, role, flags, oobKey\$)

Returns	INTEGER, indicating the success of command:	
	0	Opened successfully
	0x5A0C	The handle is not valid
	0x5A13	Invalid Device Name Length
	0x5A14	Invalid Appearance (has to be 0 .. 0xFFFF)
	0x5A15	Invalid Role
	0x5A16	Invalid OobKey (must be 0 or 16 bytes long)
	0x5A17	Invalid Flags value
	0x5A11	Inconsistent records in message (lengths don't make sense)
Exceptions	0x5AEC	Not enough space in msg buffer
	- Local Stack Frame Underflow - Local Stack Frame Overflow	
Arguments		
ndefHandle	byRef ndefHandle AS INTEGER The handle of the memory block that was acquired using NfcNdefMsgNew.	
maxDevName	byVal maxDevName AS INTEGER This specifies the maximum length of the device name to be added to the record. The appropriate AD type tag will automatically used if the length is shorter than the actual name registered using BleGapSvcInit().	
appearance	byVal appearance AS INTEGER To be consistent, this should be the same 'appearance' that was provided when BleGapSvcInit() was called. This value can be used by the phone/tablet to present an icon after it reads the NFC tag.	
role	byVal role AS INTEGER This is the BLE role that this device prefers and the value to specify is as follows: 0 Only Peripheral Supported 1 Only Central Supported 2 Both, Peripheral Preferred 3 Both, Central Preferred	
flags	byVal flags AS INTEGER This should be the same flags value as was supplied in the most recent call of the function BleAdvRptInit(). Reproduced from BleAdvRptInit() .. <i>Specifies the flags AD bits where bit 0 is set for limited discoverability and bit 1 is set for general discoverability. Bit 2 will be forced to 1 and bits 3 & 4 will be forced to 0. Bits 3 to 7 are reserved for future use by the BT SIG and must be set to 0.</i>	
oobkey\$	byRef oobKey\$ AS STRING If this string is empty then then Security Manager TK Value AD element is not added to the record. If it is exactly 16 bytes long then it will be added.	

Related Commands	NFCNDEFMSGCOMMIT, NFCNDEFDELETE, NFCDEFMSGNEW, NFCNDEFMSGRESET, NFCNDEFRECADDGENERIC, NFCNDEFMSGGETINFO

Example:

```
//See subsection 'Sample Application 2'
```

6.1.17 NfcNdefRecAddGeneric

FUNCTION

This function is used to add an NDEF record to a NDEF Message.

After an NDEF message memory buffer has been acquired using `NfcNdefMsgNew()`, call this function to add any record of your choice where you can specify the Type, ID and Payload.

The payload can even be another NDEF message, which means you can create records where the payload is an embedded NDEF record. That schema has been seen in few implementations. This is why the payload is specified using a prepend string parameter 'payload0\$', followed by a ndef handle 'ndefHandlePayload', and lastly a postpend string parameter 'payload1\$'.

It is perfectly valid for any two out of <payload0\$, ndefHandlePayload, payload1\$> to be empty strings or an invalid handle.

NFCNDEFRECADDGENERIC (ndefHandle, tnf, type\$, id\$, payload0\$, ndefHandlePayload, payload1\$)

Returns	INTEGER, indicating the success of command:	
	0	Opened successfully
	0x5A0C	Either ndefHandle or ndefHandlePayload is not valid
	0x5A18	Invalid TNF value
	0x5A12	ndefHandlePayload is valid but is empty
	0x5A11	Inconsistent records in message (lengths don't make sense)
	0x5A21	type\$ is empty
	0x5A22	type\$ is too big
	0x5A23	id\$ is too big
	0x5AEC	Not enough space in message buffer
Exceptions	- Local Stack Frame Underflow - Local Stack Frame Overflow	
Arguments		
ndefHandle	byRef ndefHandle AS INTEGER	The handle of the memory block that was acquired using NfcNdefMsgNew.
tnf	byVal tnf AS INTEGER	This can only be in the range 0 to 7 as it needs to fit in the 3 bit field of the first byte of the record.
type\$	byRef type\$ AS STRING	This is string that has to be between 1 and 255 bytes long and specifies the content of the Type field in the record header.
id\$	byRef id\$ AS STRING	This is string that has to be between 0 and 255 bytes long and specifies the content of the ID field in the record header. If the string is empty, then the ID field, which is optional, is not added to the record header.
Payload0\$	byRef payload0\$ AS STRING	This is string can be empty. If not it is added to the payload of the record.
ndefHandlePayload	byVal ndefHandlePayload AS INTEGER	This can be 0xFFFFFFFF which is designated as an invalid handle and in that is ignored. If it is not 0xFFFFFFFF and not a valid handle then this routine will exit with an error. If a valid handle, but the message buffer is empty then routine will exit with an error. Finally if the message is not empty, then it is copied in its entirety to this record (including the header, not just the payload in that message) This allows a nested mechanism and as deep as the number of ndef message handles

	that can be created. Note that once, the content of this embedded message is copied, this embedded handle message can be reset to create yet another message for embedding.
Payload1\$	byRef payload1\$ AS STRING This is string can be empty. If not it is added to the payload of the record
Related Commands	NFCNDEFMSGCOMMIT, NFCNDEFDELETE, NFCDEFMSGNEW, NFCNDEFMSGRESET, NFCNDEFRECADDLEOBB, NFCNDEFMSGGETINFO

Example:

```
//See subsections 'Sample Application 1'
```

6.1.18 NfcNdefMsgCommit

FUNCTION

After a message has been created and records added, it needs to be committed so that it can be served as a tag for an active reader to access.

This function is used to do that and if successfully committed, then the `ndefHandle` is locked and cannot be deleted or reset using the `NfcNdefMsgDelete()` or `NfcNdefMsgReset()` function respectively.

When the tag is read, an EVNFC message is thrown with context `NFC_READ`.

NFCNDEFMSGCOMMIT (`nfcHandle`, `ndefHandle`)

Returns	INTEGER, indicating the success of command: <table> <tr> <td>0</td><td>Opened successfully</td></tr> <tr> <td>0x5A0C</td><td>The handle is not valid</td></tr> </table>	0	Opened successfully	0x5A0C	The handle is not valid
0	Opened successfully				
0x5A0C	The handle is not valid				
Exceptions	- Local Stack Frame Underflow - Local Stack Frame Overflow				
Arguments					
ndefHandle	byRef ndefHandle AS INTEGER The handle that was returned by <code>NfcOpen()</code> .				
ndefHandle	byRef ndefHandle AS INTEGER The handle of the memory block that was acquired using <code>NfcNdefMsgNew</code> .				
Related Commands	NFCNDEFDELETE, NFCDEFMSGNEW, NFCNDEFMSGGETINFO, NFCNDEFMSGRESET, NFCNDEFRECADDLEOBB, NFCNDEFRECADDGENERIC				

Example:

```
//See subsections 'Sample Application 1' and 'Sample Application 2'
```


6.2 System Configuration Routines

6.2.1 SystemStateSet

FUNCTION

This function is used to alter the power state of the module as per the input parameter.

SYSTEMSTATESET (nNewState)

Returns	INTEGER, a result code. The typical value is 0x0000, indicating a successful operation.
Arguments	
nNewState	byVal nNewState AS INTEGER New state of the module as follows: 0 System OFF (Deep Sleep Mode) Note: You may also enter this state when UART is open and a BREAK condition is asserted. Deasserting BREAK makes the module resume through reset i.e. power cycle.

Example:

```
// Example :: SystemStateSet.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

//Put the module into deep sleep
PRINT "\n"; SystemStateSet(0)
```

6.3 Flash Routines

6.3.1 Overview

smartBASIC language provides high level API for accessing the flash, if **both of these requirements are met**:-

1. The external serial (SPI) flash **must** be connected to BL654 SIO_17 (SFLASH_CS), SIO_21 (SFLASH_MISO), SIO_19 (SFLASH_CLK), and SIO_20 (SFLASH_MOSI)
2. The external flash connected **must** be one of the two:-
 - 4 Mbit Macronix MX25R4035F
 - 8 Mbit Macronix MX25R8035F

The smartBASIC Flash routines can then be used for fast access using open/read/write API functions as described in the following sections.

Note: By default the BL654 devkit contains an optional SPI Flash (4 Mbit Macronix MX25R4035F) which can be used to demonstrate the Flash routines. However, the SPI flash is not connected. To connect the optional flash, solder bridges SB4, SB5, SB6, SB7, SB10, SB11 must be individually shorted.

6.3.2 FlashOpen

This function is used to open access to the flash memory in raw mode. It returns the total size of the memory accessible and the sector size.

FLASHOPEN (*totalSize*, *sectorSize*)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments	
totalSize	byRef totalSize AS INTEGER The total memory in bytes available (will be 0 if flash is not detected).
sectorSize	byRef sectorSize AS INTEGER The sector sizes in this block on memory in bytes.

Example:

```
//Example :: FlashOpen.sb
DIM rc, nTotalSize, nSectorSize
//open the flash memory in raw mode
rc = FlashOpen(nTotalSize,nSectorSize)
IF rc == 0 THEN
    PRINT "\nOpened flash successfully"
    PRINT "\nTotal Size=";nTotalSize;" Sector Size=";nSectorSize
ENDIF
```

Expected Output:

```
Opened flash successfully
Total Size=524288 Sector Size=4096
00
```

6.3.3 FlashRead

This function is used to read from the flash exposed by a previous FlashOpen() call. The number of actual bytes returned – which is the same as strlen(data\$) and will be less than or equal to nReadLen.

FLASHREAD (*nOffset*, *nReadLen*, *data\$*)

Returns	Will return the length of data\$ on exit.
Arguments	
nOffset	byVal nOffset AS INTEGER The offset to read from.
nReadLen	byVal nReadLen AS INTEGER The number of bytes to read (the maximum allowed value is 1024 bytes).
Data\$	byRef data\$ AS INTEGER The data will be read into this string.

Example:

```
//Example :: FlashRead.sb
DIM rc, nTotalSize, nSectorSize, nOffset, nReadLen, data$
//open the flash memory in raw mode
rc = FlashOpen(nTotalSize,nSectorSize)
IF rc == 0 THEN
    PRINT "\nOpened flash successfully"
ENDIF
data$ = ""
nOffset = 4088 : nReadLen = 4
rc = FlashRead(nOffset,nReadLen,data$)
PRINT "\nRead flash data: "
PRINT "\ndata=";StrHexize$(data$); " nReadLen=";nReadLen
```

Expected Output:

```
Opened flash successfully
Read flash data:
data=FFFFFFFF nReadLen=4
00
```

6.3.4 FlashWrite

This function is used to write to the bank of flash previously exposed by FlashOpen(). Please note that if the new data results in a bit reversal from 0 to 1 then the write will fail. A bit reversal from 0 to 1 can only be achieved by erasing a full sector using the function FlashErase().

FLASHWRITE (nOffset, data\$, nExitInfo)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation. If FDV_VERIFY_FAIL is returned, then nExitInfo is equal to the offset that does not verify.
Arguments	
nOffset	<i>byVal nOffset AS INTEGER</i> The offset to write to.
Data\$	<i>byRef data\$ AS INTEGER</i> The data will be written from this string
nExitInfo	<i>byVal nExitInfo AS INTEGER</i> If the return value is not 0x0000 (indicating success), then nExitInfo will contain further information about the reason of unsuccessful operation.

Example:

```
//Example :: FlashWrite.sb
DIM rc, nTotalSize, nSectorSize, nOffset, nReadLen, data$, nExitInfo
//open the flash memory in raw mode
rc = FlashOpen(nTotalSize,nSectorSize)
IF rc == 0 THEN
    PRINT "\nOpened flash successfully"
ENDIF
// Write some data
nOffset = 4088 : data$ = "ABCD"
rc = FlashWrite(nOffset,data$,nExitInfo)
IF rc == 0 THEN
    PRINT "\nWrote data to the flash successfully"
ENDIF
// clear the data$ variable before reading
data$ = ""
nOffset = 4088 : nReadLen = 4
rc = FlashRead(nOffset,nReadLen,data$)
PRINT "\nRead flash data: "
PRINT "\ndata=";data$;" nReadLen=";nReadLen
```

Expected Output:

```
Opened flash successfully
Wrote data to the flash successfully
Read flash data:
data=ABCD nReadLen=4
00
```

6.3.5 FlashErase

This function is used to erase a sector in the bank specified. The sector size in the block will have been returned in the FlashOpen function.

FLASHERASE (nOffset)

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments	
nOffset	<i>byVal nOffset AS INTEGER</i> The offset in the sector with the block to erase. Any offset in that sector will suffice.

Example:

```
//Example :: FlashErase.sb
DIM rc, nOffset, nTotalSize, nSectorSize
//open the flash memory in raw mode
rc = FlashOpen(nTotalSize,nSectorSize)
IF rc == 0 THEN
    PRINT "\nOpened flash successfully"
ENDIF
// Erase flash at offset 4088
nOffset = 4088
rc = FlashErase(nOffset)
IF rc == 0 THEN
    PRINT "\nFlash erased successfully"
ENDIF
```

Expected Output:

```
Opened flash successfully
Total Size=524288  Sector Size=4096
00
```

6.3.6 FlashClose

This subroutine is used to close access to a block of flash in raw mode.

FLASHCLOSE()

Returns	Not acceptable as it is a subroutine
Arguments:	None

Example:

```
//Example :: FlashClose.sb
DIM rc, nTotalSize, nSectorSize
//open the flash memory in raw mode
rc = FlashOpen(nTotalSize,nSectorSize)
IF rc == 0 THEN
    PRINT "\nOpened flash successfully"
ENDIF
// Close access to the flash
FlashClose()
PRINT "\nClosed flash"
```

Expected Output:

```
Opened flash successfully
Closed flash
00
```

6.4 Cryptographic Routines

6.4.1 EccGeneratePubPrvKeys

This functions is used to generate public/private keypair based on the algorithm (ECC type) provided.

ECCGENERATEPUBPRVKEYS (nEccType, privKey\$, pubKey\$)

Returns	INTEGER, a result code. The most typical values are:- 0x0000 – Keys created successfully 0x5907 – CRYPTO_ECC_TYPE_UNKNOWN (Unknown ECC type) 0x0201 – MALLOC_FAIL (not enough memory to return the keys)
Arguments	
nEccType	byVal nEccType AS INTEGER The ECC type to be used when calculating and generating the shared key. Possible values:- 0x10000 : Algorithm Curve 25519 (used in Eddystone EID)
privKey\$	byRef privKey\$ AS STRING On exit, will contain the generated private key, size as appropriate for algorithm
pubKey\$	byRef pubKey\$ AS STRING On exit, will contain the generated public key, size as appropriate for algorithm

See example for [EccCalcSharedSecret\(\)](#).

6.4.2 EccCalcSharedSecret

This function is used to create a shared scalar value which will have the same value when the remote performs an equivalent calculation with its own local private key and this side's public key.

Essentially, calling EccGeneratePubPrvKeys() twice to create two sets of private and public keys and then calling EccPubSharedSecret() twice with the private from one and public from the other will generate the same sharedSecret\$.

EECCALCSHAREDSECRET (nEccType, privKey\$, pubKey\$, sharedSecret\$)

Returns	INTEGER, a result code. The most typical values are:- 0x0000 – Keys created successfully 0x5907 – CRYPTO_ECC_TYPE_UNKNOWN (Unknown ECC type) 0x0201 – MALLOC_FAIL (not enough memory to return the keys)
Arguments	
nEccType	byVal nEccType AS INTEGER The ECC type to be used when generating the public/private keypair. Possible values:- 0x10000 : Algorithm Curve 25519 (used in Eddystone EID)
privKey\$	byRef privKey\$ AS STRING On entry contains the local private key, untouched on exit
pubKey\$	byRef pubKey\$ AS STRING On entry contains the remote public key, untouched on exit
sharedSecret\$	byRef sharedSecret\$ AS STRING On exit will contain the shared secret key

```
// Example :: EccCalcSharedSecret.sb
```

```
// Note: In real world scenarios, two devices generate their private/public
// key pair separately, then exchange the public key. Using the remote's
// public key and the own private key, the shared secret is generated, therefore
// ending with the same shared secret without exposing material that could be used to
```

```
// by a third party to decrypt in a reasonable amount of time.
// For simplicity, this example shows this process performed on one device only

dim rc, EccType : EccType = 0x10000
dim prvKey_A$, pubKey_A$, Secret_A$
dim prvKey_B$, pubKey_B$, Secret_B$

// Generate first Public/Private keypair
rc = EccGeneratePubPrvKeys(EccType, prvKey_A$, pubKey_A$)
if rc == 0 then
    PRINT "\rPrv Key A: "; strhexize$(prvKey_A$)
    PRINT "\rPub Key A: "; strhexize$(pubKey_A$)
endif

// Generate second Public/Private keypair
rc = EccGeneratePubPrvKeys(EccType, prvKey_B$, pubKey_B$)
if rc == 0 then
    PRINT "\rPrv Key B: "; strhexize$(prvKey_B$)
    PRINT "\rPub Key B: "; strhexize$(pubKey_B$)
endif

// Compute first shared secret using private key A and public key B
rc = EccCalcSharedSecret(EccType, prvKey_A$, pubKey_B$, Secret_A$)
if rc == 0 then
    PRINT "\rShared Secret 1: "; strhexize$(Secret_A$)
endif

// Compute second shared secret using private key B and public key A
rc = EccCalcSharedSecret(EccType, prvKey_B$, pubKey_A$, Secret_B$)
if rc == 0 then
    PRINT "\rShared Secret 2: "; strhexize$(Secret_B$)
endif

// Compare keys to check if they are the same
If StrCmp(Secret_A$, Secret_B$)==0 then
    PRINT "\rThe generated shared secret keys are identical"
else
    PRINT "\rThe generated shared secret keys do not match"
Endif
```

Expected Output:

```
Prv Key A: 3A803352CFBBE969C28952C9950706A7F807C3B3974B65FEFD69C15A258C56EF
Pub Key A: 92F2589A0B08F0A1ADBC42F38FFB3093823257607C5DC0F4AF9DDEF85E34030
Prv Key B: 10C9D43736EC510DE317732EF1C057954EB11FBD7800B1C6D827E63FB2657B5F
Pub Key B: 91FADCE2BD6E2FE7DF7F3251B2879753753D8F7F7D85978E2F0743DB3AE20577
Shared Secret 1: 3666BE535446B3E8A99970982EB2CE79C2501312CE2D30872DDB540A46453D23
Shared Secret 2: 3666BE535446B3E8A99970982EB2CE79C2501312CE2D30872DDB540A46453D23
The generated shared keys are identical
```

6.4.3 EccHmacSha256

This function is used to generate a HMAC-SHA256 authenticated hash of the content of data\$ using the key supplied which can be from 0 to 64 bytes in length.

ECCHMACSHA256 (key\$, data\$, hmacOut\$)

Returns	INTEGER, a result code. The most typical values are:- 0x0000 – Keys created successfully 0x0201 – MALLOC_FAIL (not enough memory to return the keys)
Arguments	
Key\$	byRef key\$ AS STRING On entry contains a key from 0 to 64 bytes long and untouched on exit
data\$	byRef data\$ AS STRING On entry contains the data to be hashed and untouched on exit
hmacOut\$	byRef hmacOut\$ AS STRING On exit will contain the hmac output, use strlen() to determine length

```
//Example :: EccHmacSha256.sb

dim rc, key$
dim data_A$, hmacOut_A$
dim data_B$, hmacOut_B$

key$ = "KEY"
data_A$ = "AAAAAB"
data_B$ = "AAAAA"

// Generate the HMAC-SHA256 for the first data
rc = EccHmacSha256(key$, data_A$, hmacOut_A$)
if rc == 0 then
    PRINT "\rHMAC of data_A: "; strhexize$(hmacOut_A$)
endif

// Generate the HMAC-SHA256 for the second data
rc = EccHmacSha256(key$, data_B$, hmacOut_B$)
if rc == 0 then
    PRINT "\rHMAC of data_A: "; strhexize$(hmacOut_B$)
endif

// Compare the HMAC-SHA256 outputs
if StrCmp(hmacOut_A$, hmacOut_B$) == 0 then
    PRINT "\rData A matches Data B"
else
    PRINT "\rData A does not match Data B"
endif
```

Expected Output:

```
HMAC of data_A: 7DB831431B6B7CDACE411C9F51CCC550EF1C20FB0812A24B7BBE12AE4332BB20
HMAC of data_A: 7DBF238349A98AB446AB8B4596E12E3729653ADA1E1A4B9ADA57C507E2021034
Data A does not match Data B
```

6.5 Watchdog Timer

6.5.1 WdtStart

FUNCTION

This function starts a watchdog timer with nResetTimeout in seconds. If the timer is not reset within nResetTimeout seconds, the module will reset.

Returns	INTEGER, a result code and the most typical values are following:- 0x0000 := Success 0x5262 := An invalid time has been provided (i.e. the value is outside the range) 0x5263:= The watchdog timer is already running
Arguments	
nResetTimeout	byVal nResetTimeout AS INTEGER The reset timeout in seconds. Valid range is between 0-131072.

```
//Example :: WdtStart
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc, nTimeout
nTimeout = 60
// Start a timer for 60 seconds
rc = WdtStart(nTimeout)
if rc == 0 then
    PRINT "Watchdog Timer started\n"
else
    PRINT "Failed to start Watchdog Timer\n"
endif

WaitEvent
```

Expected Output:

```
Watchdog Timer started
```

6.5.2 WdtReset

FUNCTION

This function resets the watchdog timer. WdtStart should be called before this function can be used.

Returns	Will return a resultcode and the most typical value is 0x0000 indicating success.
Arguments	None

```
//Example :: WdtReset
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc, nTimeout
nTimeout = 60
// Start a watchdog timer for 60 seconds
rc = WdtStart(nTimeout)

// Start a recurring normal timer to reset the watchdog timer every 55 seconds
Timerstart(1, 55000, 1)

Function HandlerTimer1()
    rc = WdtReset()
```



```

    if rc == 0 then
        print "Watchdog timer reset successfully\n"
    endif
Endfunc 1

OnEvent EVTMR1 CALL HandlerTimer1

WaitEvent

```

Expected Output:

```
Watchdog timer reset successfully
```

6.5.3 WdtIsRunning

FUNCTION

This function starts a watchdog timer with nResetTimeout in seconds. If the timer is not reset within nResetTimeout seconds, the module will reset.

Returns	Will return the following value:- 0 := Not Running 1 := Running
Arguments	None

```

//Example :: WdtIsRunning
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc, nTimeout
nTimeout = 60
// Start a timer for 60 seconds
rc = WdtStart(nTimeout)

rc = WdtIsRunning()
if rc == 1 then
    PRINT "Watchdog is running\n"
else
    PRINT "Watchdog is not running\n"
endif

WaitEvent

```

Expected Output:

```
Watchdog is running
```

Miscellaneous Routines

6.5.4 ReadPwrSupplyMv

FUNCTION

This function is used to read the power supply voltage and the value will be returned in millivolts.

Note: Due to the nrf52840's ADC accuracy, this value has a +/-3% error.

READPWRSUPPLYMV ()

Returns	INTEGER, the power supply voltage in millivolts.
Arguments	None

Example:

```
// Example :: ReadPwrSupplyMv.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

//read and print the supply voltage
PRINT "\nSupply voltage is "; ReadPwrSupplyMv(); "mV"
```

Expected Output:

```
Supply voltage is 3343mV
```

6.5.5 SetPwrSupplyThreshMv

FUNCTION

This function sets a supply voltage threshold. If the supply voltage drops below this then the BLE_EVMSG event is thrown into the run time engine with a MSG ID of BLE_EVBLEMSGID_POWER_FAILURE_WARNING (19) and the context data will be the current voltage in millivolts.

Please note that when the power supply rises above this value and then drops again, the power fail warning event will NOT be thrown again, unless this function is called explicitly again in the event handler.

In addition, if the event is enabled by calling this function AND the supply voltage is still below the threshold then all flash write and erase operations will fail silently (for example, like pairing [with bonding] will fail to retain the keys). Likewise NvRecordSet (and all other operations that involve writing to flash memory) will silently fail and nothing will be written.

6.5.5.1 Events & Messages

MsgId	Description
19	The supply voltage has dropped below the value specified as the argument to this function in the most recent call. The context data is the current reading of the supply voltage in millivolts

SETPWRSUPPLYTHRESHMV (nThreshMv)

Returns	INTEGER, 0 if the threshold is successfully set, 0x6605 if the value cannot be implemented.
Arguments	
nThreshMv	byVal nThreshMv AS INTEGER The BLE_EVMSG event is thrown to the engine if the supply voltage drops below this value. Valid values are 2100, 2300, 2500 and 2700. If 0 is supplied then low supply voltage notification is disabled which implies flash operation is no longer affected.

Example:

```
// Example :: SetPwrSupplyThreshMv.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc
DIM mv

//=====
// Handler for generic BLE messages
//=====

FUNCTION HandlerBleMsg(BYVAL nMsgId, BYVAL nCtx) AS INTEGER
    SELECT nMsgId
        CASE 19
            PRINT "\n --- Power Fail Warning ",nCtx
            //mv=ReadPwrSupplyMv()
            PRINT "\n --- Supply voltage is "; ReadPwrSupplyMv(); "mV"
        CASE ELSE
            //ignore this message
    ENDSELECT
ENDFUNC 1

//=====
// Handler to service button 0 pressed
//=====

FUNCTION HndlrBtn0Pr() AS INTEGER
    //just exit and stop waiting for events
ENDFUNC 0

ONEVENT EVBLEMSG CALL HandlerBleMsg
ONEVENT EVGPIOCHAN1 CALL HndlrBtn0Pr

rc=GpioBindEvent(1,16,1) //Channel 1, bind to low transition on GPIO pin 16
PRINT "\nSupply voltage is "; ReadPwrSupplyMv(); "mV\n"
mv=2700
rc=SetPwrSupplyThreshMv(mv)

PRINT "\nWaiting for power supply to fall below ";mv;"mV"

//wait for events and messages
WAITEVENT

PRINT "\nExiting..."
```

Expected Output:

```
Supply voltage is 3343mV

Waiting for power supply to fall below 2700mV
Exiting...
```

6.5.6 CRC16Generate

FUNCTION

This function is used to calculate the CRC16 value of a given string.

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments	
nType	byVal nType AS INTEGER The type of CRC16 checksum to generate 0 – Nordic CRC16 Other - Invalid
Data\$	byRef Data\$ AS STRING This variable should contain the string data to perform a checksum on
nCRC	byRef nCRC AS STRING Set to a variable to contain the previous checksum value and will contain an updated checksum when complete. Set to 0xffff before starting

Example:

```
// Example :: CRC16.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc
DIM nType : nType = 0
DIM Data$ : Data$ = "RandomData"
DIM nCRC16 : nCRC16 = 0

rc = CRC16Generate(nType, Data$, nCRC16)
IF rc == 0 THEN
    PRINT "\nThe computed CRC16 value is ";nCRC16
ELSE
    PRINT "\nFailed to generate CRC16 value"
ENDIF
```

6.5.7 CRC32Generate

FUNCTION

This function is used to calculate the CRC32 value of a given string.

Returns	INTEGER, a result code. The most typical value is 0x0000, indicating a successful operation.
Arguments	
nType	byVal nType AS INTEGER The type of CRC32 checksum to generate. Possible values are:- 0 – Nordic CRC32 Other - Invalid
Data\$	byRef Data\$ AS STRING This variable should contain the string data to perform a checksum on

nCRC	byRef nCRC AS STRING Set to a variable to contain the previous checksum value and will contain an updated checksum when complete. Set to 0xffff before starting

Example:

```
// Example :: CRC32.sb
// https://github.com/LairdCP/BL654-Applications/tree/master/UserGuideExamples

DIM rc
DIM nType : nType = 0
DIM Data$ : Data$ = "RandomData"
DIM nCRC32 : nCRC32 = 0

rc = CRC32Generate(nType, Data$, nCRC32)
IF rc == 0 THEN
    PRINT "\nThe computed CRC32 value is ";nCRC32
ELSE
    PRINT "\nFailed to generate CRC32 value"
ENDIF
```

7 EVENTS AND MESSAGES

*smart*BASIC is designed to be event driven, which makes it suitable for embedded platforms where it is normal to wait for something to happen and then respond.

The event handling is done synchronously, meaning the *smart*BASIC runtime engine has to process a WAITEVENT statement for any events or messages to be processed. This guarantees that *smart*BASIC never needs the complexity of locking variables and objects.

The subsystems which generate events and messages relevant to the routines described in this guide are as follows:

- BLE events and messages as described [here](#).
- Generic Characteristics events and messages as described [here](#).

8 MISCELLANEOUS

8.1 Bluetooth Result Codes

There are some operations and events that provide a single byte Bluetooth HCI result code (such as the EVDISCON message). The meaning of the result code is as per the list reproduced from the Bluetooth Specifications below. No guarantee is supplied as to its accuracy. Consult the specification for more.

Result codes in **grey** are not relevant to Bluetooth Low Energy operation.

BT_HCI_STATUS_CODE_SUCCESS	0x00
BT_HCI_STATUS_CODE_UNKNOWN_BTLE_COMMAND	0x01
BT_HCI_STATUS_CODE_UNKNOWN_CONNECTION_IDENTIFIER	0x02
BT_HCI_HARDWARE_FAILURE	0x03
BT_HCI_PAGE_TIMEOUT	0x04
BT_HCI_AUTHENTICATION_FAILURE	0x05
BT_HCI_STATUS_CODE_PIN_OR_LINKKEY_MISSING	0x06
BT_HCI_MEMORY_CAPACITY_EXCEEDED	0x07
BT_HCI_CONNECTION_TIMEOUT	0x08
BT_HCI_CONNECTION_LIMIT_EXCEEDED	0x09

BT_HCI_SYNC_CONN_LIMI_TO_A_DEVICE_EXCEEDED	0x0A
BT_HCI_ACL_COONECTION_ALREADY_EXISTS	0x0B
BT_HCI_STATUS_CODE_COMMAND_DISALLOWED	0x0C
BT_HCI_CONN_REJECTED_DUE_TO_LIMITED_RESOURCES	0x0D
BT_HCI_CONN_REJECTED_DUE_TO_SECURITY_REASONS	0x0E
BT_HCI_BT_HCI_CONN_REJECTED_DUE_TO_BD_ADDR	0x0F
BT_HCI_CONN_ACCEPT_TIMEOUT_EXCEEDED	0x10
BT_HCI_UNSUPPORTED_FEATURE_ONPARM_VALUE	0x11
BT_HCI_STATUS_CODE_INVALID_BTLE_COMMAND_PARAMETERS	0x12
BT_HCI_REMOTE_USER_TERMINATED_CONNECTION	0x13
BT_HCI_REMOTE_DEV_TERMINATION_DUE_TO_LOW_RESOURCES	0x14
BT_HCI_REMOTE_DEV_TERMINATION_DUE_TO_POWER_OFF	0x15
BT_HCI_LOCAL_HOST_TERMINATED_CONNECTION	0x16
BT_HCI_REPEATED_ATTEMPTS	0x17
BT_HCI_PAIRING_NOTALLOWED	0x18
BT_HCI_LMP_PDU	0x19
BT_HCI_UNSUPPORTED_REMOTE_FEATURE	0x1A
BT_HCI_SCO_OFFSET_REJECTED	0x1B
BT_HCI_SCO_INTERVAL_REJECTED	0x1C
BT_HCI_SCO_AIR_MODE_REJECTED	0x1D
BT_HCI_STATUS_CODE_INVALID_LMP_PARAMETERS	0x1E
BT_HCI_STATUS_CODE_UNSPECIFIED_ERROR	0x1F
BT_HCI_UNSUPPORTED_LMP_PARM_VALUE	0x20
BT_HCI_ROLE_CHANGE_NOT_ALLOWED	0x21
BT_HCI_STATUS_CODE_LMP_RESPONSE_TIMEOUT	0x22
BT_HCI_LMP_ERROR_TRANSACTION_COLLISION	0x23
BT_HCI_STATUS_CODE_LMP_PDU_NOT_ALLOWED	0x24
BT_HCI_ENCRYPTION_MODE_NOT_ALLOWED	0x25
BT_HCI_LINK_KEY_CAN_NOT_BE_CHANGED	0x26
BT_HCI_REQUESTED_QOS_NOT_SUPPORTED	0x27
BT_HCI_INSTANT_PASSED	0x28
BT_HCI_PAIRING_WITH_UNIT_KEY_UNSUPPORTED	0x29
BT_HCI_DIFFERENT_TRANSACTION_COLLISION	0x2A
BT_HCI_QOS_UNACCEPTABLE_PARAMETER	0x2C
BT_HCI_QOS_REJECTED	0x2D
BT_HCI_CHANNEL_CLASSIFICATION_UNSUPPORTED	0x2E
BT_HCI_INSUFFICIENT_SECURITY	0x2F
BT_HCI_PARAMETER_OUT_OF_MANDATORY_RANGE	0x30
BT_HCI_ROLE_SWITCH_PENDING	0x32

BT_HCI_RESERVED_SLOT_VIOLATION	0x34
BT_HCI_ROLE_SWITCH_FAILED	0x35
BT_HCI_EXTENDED_INQUIRY_RESP_TOO_LARGE	0x36
BT_HCI_SSP_NOT_SUPPORTED_BY_HOST	0x37
BT_HCI_HOST_BUSY_PAIRING	0x38
BT_HCI_CONN_REJ_DUE_TO_NO_SUITABLE_CHN_FOUND	0x39
BT_HCI_CONTROLLER_BUSY	0x3A
BT_HCI_CONN_INTERVAL_UNACCEPTABLE	0x3B
BT_HCI_DIRECTED_ADVERTISER_TIMEOUT	0x3C
BT_HCI_CONN_TERMINATED_DUE_TO_MIC_FAILURE	0x3D
BT_HCI_CONN_FAILED_TO_BE_ESTABLISHED	0x3E

9 ACKNOWLEDGEMENTS

9.1 AES Encryption

The following are required acknowledgements to address our use of open source code on the BL654 to implement AES encryption. Laird's implementation includes the following files: **aes.c** and **aes.h**.

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Issue 09/09/2006

This is an AES implementation that uses only 8-bit byte operations on the cipher state (there are options to use 32-bit types if available).

The combination of mix columns and byte substitution used here is based on that developed by Karl Malbrain. His contribution is acknowledged.

9.2 Micro-ECC

The following are required acknowledgements to address our use of open source code on the BL654 to implement Elliptic-Curve Diffie Hellman cryptography. Laird's implementation includes the following files: **uECC.c** and **uECC.h**.

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