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RM1xx BLE Central *smart*BASIC Extensions

RM1xx Series

Document version 1.0

REVISION HISTORY

Version	Date	Notes	Approver
1.0	27 Jan 2017	Initial version	Jonathan Kaye
1.1	11 Oct 2017	Updates for latest stack	Jonathan Kaye

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1 INTRODUCTION

1.1 Documentation Overview

This RM1xx Extension Functionality user guide provides detailed information on RM1xx-specific *smart*BASIC extensions which provide a high level managed interface to the underlying LoRa device and Bluetooth stack in order to manage the following:

- GATT table – Services, characteristics, descriptors, advert reports
- GATT server/client operation
- BLE Advertisments and connections
- BLE security and bonding
- Attribute encoding and decoding
- Power management
- Wireless status
- Events related to the above

This document deals specifically with the *smart*BASIC APIs relating to the BLE Central functionality contained in the RM1xx series of modules. For details of LoRaMAC, BLE Peripheral or core APIs, please refer to one of the following documents:

- RM1xx LoRaMAC Extensions Guide (LoRa functions)
- RM1xx BLE Peripheral Extensions Guide (peripheral BLE functions for the RM186_PE or RM191_PE modules)
- *smart*BASIC Core Reference Guide (common functions across all *smart*BASIC modules)

All the above documents are found in the documentation tab of the RM1xx product page: http://www.lairdtech.com/products/rm1xx-lora-modules

1.2 What Does a LoRa/BLE Module Contain?

Laird's *smart*BASIC-based LoRa/BLE modules are designed to provide a complete wireless processing solution and contain 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 GPIO and ADC
- Wired communication interfaces such as UART, I2C, and SPI
- A *smart*BASIC run-time engine
- Program-accessible flash memory which contains a robust flash file system exposing a conventional file system and a database for storing user configuration data
- Voltage regulators and brown-out detectors

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

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

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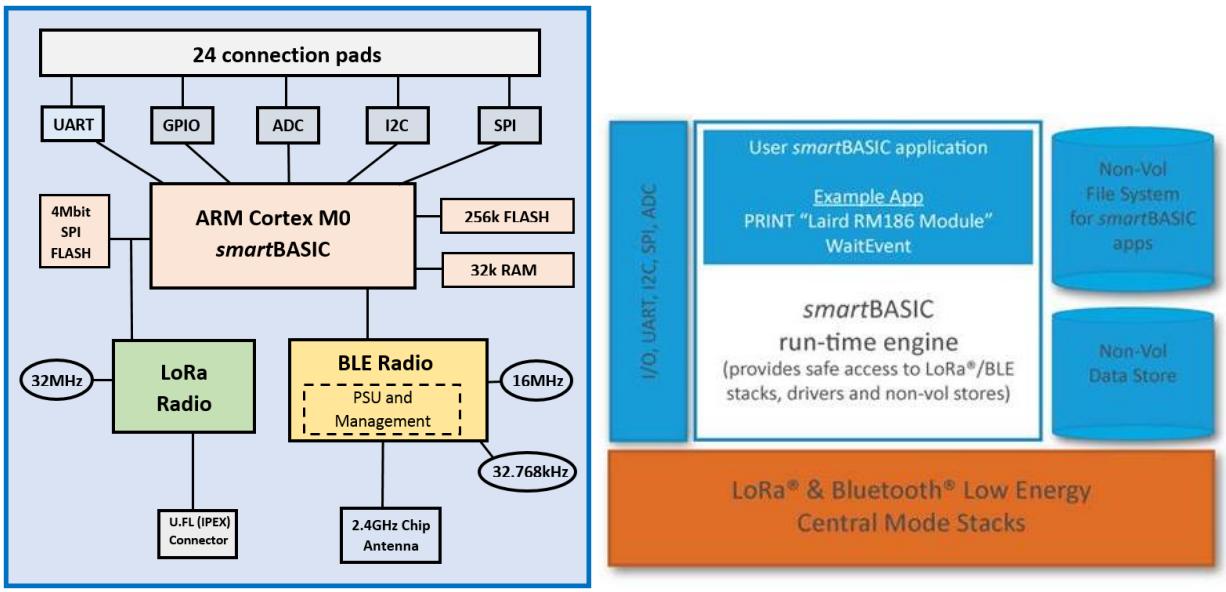

Figure 1: RM1xx smartBASIC module block diagram

2 Interactive Mode Commands

Interactive mode commands allow a host processor or terminal emulator to interrogate and control the operation of a *smart*BASIC-based module. Many of these emulate the functionality of AT commands. Others add extra functionality for controlling the filing system and compilation process.

Syntax Unlike commands for AT modems, a space character must be inserted between AT, the command, and subsequent parameters. This allows the *smart*BASIC tokeniser to distinguish efficiently between AT commands and other tokens or variables starting with the letters **AT**.

```
'Example:
AT I 3
```

The response to every Interactive mode command has the following form:

<linefeed character> response text <carriage return>

This format simplifies the parsing within the host processor. The response may be one or multiple lines. Where more than one line is returned, the last line has one of the following formats:

<lf>00<cr> for a successful outcome, or

<lf>01<tab> hex number <tab> optional verbose explanation <cr> for failure.

Note: In the case of the 01 response, the **<tab>optional_verbose_explanation** is missing in resource constrained platforms like the RM1xx modules. The *verbose explanation* is a constant string and since there are over 1000 error codes, these verbose strings can occupy more than 10 kilobytes of flash memory.

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The hex number in the response is the error result code consisting of two digits which can be used to help investigate the problem causing the failure. Rather than provide a list of all the error codes in this manual, you can use UWTerminal to obtain a verbose description of an error when it is not provided on a platform.

To get the verbose description, click the BASIC tab (in UWTerminal) and, if the error value is hhhh, enter the command ER 0xhhhh and note the 0x prefix to hhhh. This is illustrated in Figure 2.

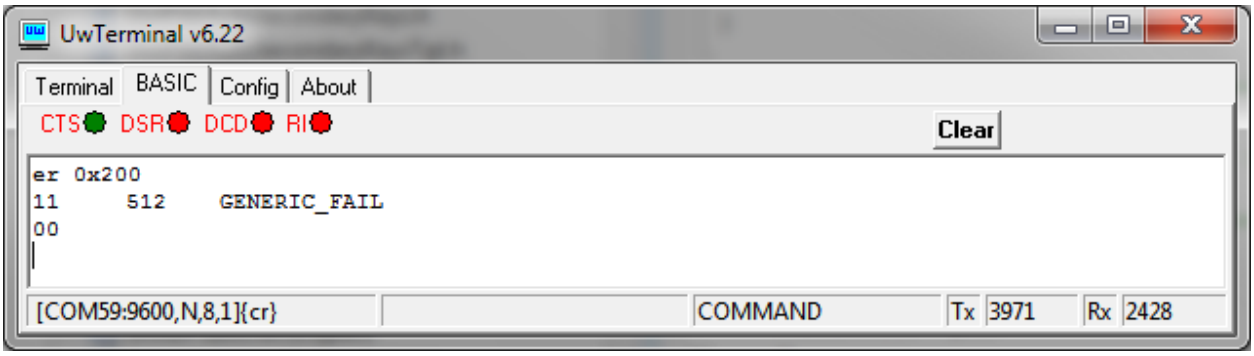

Figure 2: Optional verbose explanation

You can also obtain a verbose description of an error by highlighting the error value, right-clicking, and selecting **Lookup Selected ErrorCode** in the Terminal window.

If you get the text UNKNOWN RESULT CODE 0xHHHH, please contact Laird for the latest version of UWterminal.

2.1 AT I

Provided to give compatibility with the AT command set of Laird's standard Bluetooth modules.

AT I num

COMMAND

Returns	\n10\tMM\tInformation\r \n00\r Where \n = linefeed character 0x0A \t = horizontal tab character 0x09 MM = a *number* (see below) Information = sting consisting of information requested associated with MM \r = carriage return character 0x0D
Arguments	
num	Integer Constant – A number in the range 0 to 65,535. Currently defined numbers are:

0	Name of device
3	Version number of the module firmware
4	MAC address in the form TT AAAAAAAAAAAA
5	Chipset name
6	Flash File System size stats (data segment): Total/Free/Deleted

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	7	Flash File System size stats (FAT segment) : Total/Free/Deleted
	12	Last error code
	13	Language hash value
	16	NvRecord Memory Store stats: Total/Free/Deleted
	25	Production loaded DevEui. See LoRa Documentation for more details
	30	Temperature Sensor calibration offset
	31	Room temperature Freqency Error
	33	BASIC core version number
	601	Flash File System: Data Segment: Total Space
	602	Flash File System: Data Segment: Free Space
	603	Flash File System: Data Segment: Deleted Space
	604	Flash File System: FAT Segment: Total Space
	605	Flash File System: FAT Segment: Free Space
	606	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…1999	See SYSINFO() function definition
	2000…2999	See SYSINFO() function definition
Interactive Command	Yes	

Any other number currently returns the manufacturer's name.

For ATi4, the TT in the response is the type of address as follows:

00	Public IEEE format address
01	Random static address (default as shipped)
02	Random Private Resolvable (used with bonded devices) – **not currently available**
03	Random Private Non-Resolvable (used for reconnections) – **not currently available**

Note: Please refer to the Bluetooth specification for a further description of the types.

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  2.0.1.2
00
AT I 4
10  4  01 D31A920731B0
```

AT i is a core command.

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The information returned by this Interactive command can also be useful from within a running application and so a built-in function called SYSINFO(cmdId) can be used to return exactly the same information and cmdid is the same value as used in the list above.

2.2 AT+CFGEX

COMMAND

AT+CFGEX is used to set a non-volatile configuration key with a string. The syntax of this command is defined in the *smart*BASIC Core Functionality Manual.

The following configuration key IDs are specific to the RM1xx module.

Key ID	Definition	Notes
1009	ChannelsMask	Sets the ChannelsMask. Only valid for the RM191. See the Setting RM191 ChannelsMask section below
1010	AppEui	Application Identifier – 8 Bytes/16 Hex Characters
1011	DevEui	End Device Identifier – 8 Bytes/16 Hex Characters
1012	AppKey	Application Key – 16 Bytes/32 Hex Characters
1013	NwkSKey	Network Session Key – 16 Bytes/32 Hex Characters
1014	AppSKey	Application Session Key – 16 Bytes/32 Hex Characters
1015	DevAddr	End device Address – 8-character Hex string

The at+cfgex command returns an invalid key error (7312) if an invalid Key id is entered or the length of the entered string is incorrect for that specific Key id.

The new config value is only available for use after a system reset.

Note: The NwkSKey, AppSKey, and AppKey values are write-only. These values cannot be read back using the **at+cfgex xxxx?** command.

Prior to firmware versions 17/18.4.1.0 the Key Ids in the table above were in the range of 1000 – 1005 instead of the new range of 1010-1015.

2.3 AT&F

COMMAND

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

AT&F integermask

Returns	OK if file successfully erased.
Arguments ***Integermask***	Integer corresponding to a bit mask or the "*" character
Interactive Command	Yes

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The mask is an additive integer mask, with the following meaning:

0x0000xxxx	See core user manual
0x00010000	Erase the BLE bonding database
*	Erases all data segments

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 0x10000  'delete the BLE bonding database (AT+BTD* also does it)
AT&F *        'delete all data segments
```

AT&F is a core command with extensions.

2.4 AT + BTD *

COMMAND

Deletes the bonded device database from the flash.

AT + BTD*

Returns	\n00\r
Arguments	None
Interactive Command	Yes

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

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

```
'Examples:
AT+BTD*
```

AT+BTD* is an extension command.

2.5 AT + MAC 12 hex digit mac address

COMMAND

This is a command that is successful one time as it writes an IEEE MAC address to non-volatile memory. This address is then used instead of the random static MAC address that comes preprogrammed in the module.

Notes: If the module has an invalid licence then this address is not visible.
If the address 000000000000 is written then it is treated as invalid and prevents a new address from being entered.

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AT + MAC "12 hex digits"

Returns	\n00\r or \n01 192A\r Where the error code 192A is NVO_NVWORM_EXISTS. This means that an IEEE MAC address already exists, which can be read using the command AT I 24.
Arguments	A string delimited by "" which shall be a valid 12 hex digit MAC address that is written to non-volatile memory.
Interactive Command	Yes

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

Note: The module self-reboots if the write is successful. Subsequent invocations of this command generate an error.

```
'Examples:
AT+MAC "008098010203"
```

AT+MAC is an extension command

2.6 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
Interactive Command	Yes

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.

```
'Examples:
AT+BLX
```

AT+BLX is an extension command.

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3 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 next chapter.

3.1 Result Codes

Some of these built-in routines are subroutines and some are functions. Functions always return a value and, for some of these functions the value returned is a result code, indicating success or failure in executing that function. A failure may not necessarily result in a run-time error (see GetLastError() and ResetLastError()), but may lead to an unexpected output.

Being able to see the cause of a failure helps with the debugging process. If you declare an integer variable such as **rc** and set its value to your function call, after the function is executed you can print **rc** and see the result code. For this to be useful, it must be in hexadecimal form; prefix your result code variable with INTEGER.H' when printing it. You can also save some memory by printing the return value from the function directly without the use of a variable.

```
//Example :: ResultCodes.sb (See in RM1xxCodeSnippets.zip)
 DIM cB,nItems,rc,s$

 rc=CircBufItems(cB,nItems)
 PRINT INTEGER.H'rc

 PRINT "\n";       //New line

 //Printing return value directly
 PRINT INTEGER.H'CircBufItems(cB,nItems)

 //To remove the leading zeros
 SPRINT #s$, INTEGER.H'CircBufItems(cB,nItems)
 StrShiftLeft(s$,4) : PRINT s$
```

Highlight the last four characters of the result code in UwTerminal and select **Lookup Selected ErrorCode** (Figure 3).

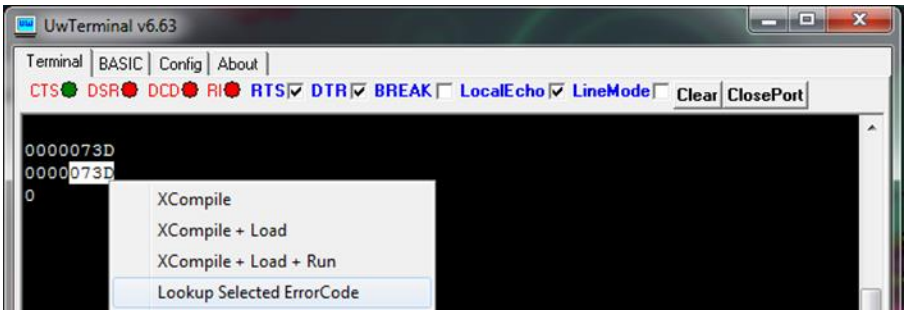

Figure 3: Lookup Selected ErrorCode

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Expected Output:

```
//smartBASIC Error Code: 073D -> "RUN_INV_CIRCBUF_HANDLE"
```

3.2 Information Routines

3.2.1 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 ***varId***	*byVal* varId *AS INTEGER* An integer ID which is used to determine which information is to be returned as described below.

ID	Definition
0	Device ID. For the RM1xx module, the value is 0x42460600
3	Version number of the module firmware. For example, W.X.Y.Z is returned as a 32-bit value made up as follows: **(W<<26) + (X<<20) + (Y<<6) + (Z)** where Y is the build number and Z is the sub-build number
33	BASIC core version number
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
1003	Maximum baudrate
1004	Maximum STRING size

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1005	1: Run-time only implementation 3: Compiler included
2000	Reason for reset: 8: Self-reset due to Flash Erase 9: ATZ 10: Self-reset due to *smart*BASIC app invoking function RESET()
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
2014	Total number of transmission buffers for sending attribute NOTIFIES
2015	Number of transmission buffers for sending attribute NOTIFIES – free
2016	Radio activity of the baseband. A bit mask as follows: Bit 0: Advertising Bit 1: Connected as slave Bit 2: Initiating Bit 3: Scanning Bit 4: Connected as master
2018	Returns the TX power while pairing in progress (see also 2008)
2019	Default ring buffer length for notify/indicates in GATT client manager (see BleGattcOpen function)
2020	Maximum ring buffer length for notify/indicates in GATT client manager (see BleGattcOpen function)
2021	Stack tide mark in percent. Values near 100 are not good
2022	Stack size
2023	Initial Heap size
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 trusted device database classed as *Rolling*
2043	Number of devices in trusted device database that can *Persist*
2100	Connect Scan interval (in milliseconds) used when connecting

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2101	Connect Scan window (in milliseconds) used when connecting
2102	Connect slave latency in outgoing connection request
2105	Multi-Link Connection Interval periodicity in milliseconds
2150	Scan Interval (in milliseconds) used when connecting
2151	Scan Window (in milliseconds) used when connecting
2152	Type of scanning: Active or Passive
0x8000 to 0x81FF	Content of FICR register in the Nordic nrf51 chipset. In the nrf51 datasheet, in the FICR section, all the FICR registers are listed in a table with each register identified by an offset. 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.

Interactive Command	No

```
//Example :: SysInfo.sb (See in RM1xxCodeSnippets.zip)
PRINT "\nSysInfo 1000 = ";SYSINFO(1000) // BASIC compiler HASH value
PRINT "\nSysInfo 2003 = ";SYSINFO(2003) // Number of timers
PRINT "\nSysInfo 0x8010 = ";SYSINFO(0x8010) // Code memory page size from FICR
```

Expected Output (For RM1xx):

```
SysInfo 1000  = 1315489536
SysInfo 2003  = 8
SysInfo 0x8010 = 1024
```

SYSINFO is a core language function.

3.2.2 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. 4 — The Bluetooth address of the module. 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.

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14	A random public address unique to this module. May be the same value as in 4 above unless AT+MAC was used to set an IEEE MAC address. 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.

Interactive Command	No

```
//Example :: SysInfo.sb (See in RM1xxCodeSnippets.zip)
PRINT "\nSysInfo$(4) = ";SYSINFO$(4) // address of module
PRINT "\nSysInfo$(14) = ";SYSINFO$(14) // public random address
PRINT "\nSysInfo$(0) = ";SYSINFO$(0)
```

Expected Output:

```
SysInfo$(4)  = \01\FA\84\D7H\D9\03
SysInfo$(14) = \01\FA\84\D7H\D9\03
SysInfo$(0)  =
```

SYSINFO$ is a core language function.

3.3 UART (Universal Asynchronous Receive Transmit)

3.3.1 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)

stOptions

byVal stOptions AS STRING
This string (can be a constant) MUST be exactly 5 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 (Not Available) ▪ **E** – Even (Not Available)
2	Databits: 8
3	Stopbits: 1

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4	Flow Control: ▪ **N** – None ▪ **H** – CTS/RTS hardware ▪ **X** – Xon/Xof (Not Available)

3.3.2 UartCloseEx

```
//Example :: UartCloseEx.sb (See in Firmware Zip file)
 DIM rc1
 DIM rc2

 UartClose()
 rc1 = UartOpen(9600,0,0,"CN81H")     //open as DTE at 300 baudrate, odd parity
                     //8 databits, 1 stopbits, cts/rts flow control
 PRINT "Laird"

 IF UartCloseEx(1)!=0 THEN
   PRINT "\nData in at least one buffer. Uart Port not closed"
 ELSE
   rc1 = UartOpen(9600,0,0,"CN81H")  //open as DTE at 300 baudrate, odd parity
   PRINT "\nUart Port was closed"
 ENDIF
```

Expected Output:

```
Laird
Data in at least one buffer. Uart Port not closed
```

UARTCLOSEEX is a core function.

3.3.3 UartSetRTS

The RM1xx module does not offer the capability to control the RTS pin as the underlying hardware does not allow it. The function exists to enable porting of applications from platforms where an app has invoked it.

3.3.4 UartBREAK

The RM1xx module does not offer the capability to send a BREAK signal.

If this feature is required, then the best way to expedite it is to put UART_TX and an I/O pin configured as an output through an AND gate.

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For normal operation the general purpose output pin is set to logic high which means the output of the AND gate follows the state of the UART_TX pin.

When a BREAK is to be sent, the general purpose pin is set to logic high which means the output of the AND gate is low and remains low regardless of the state of the UART_TX pin.

3.4 I2C – Two Wire Interface (TWI)

The RM1xx can only be configured as an I2C master with the additional constraint that it be the only master on the bus and only 7-bit slave addressing is supported.

3.5 SPI Interface

The RM1xx module can only be configured as a SPI master.

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4 Core Extensions Built-in Routines

4.1 Miscellaneous Routines

4.1.1 AssertRM1xx

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 RM1xx module. This ensures that apps for other modules are not mistakenly loaded into the RM1xx.

ASSERTRM1xx ()

Returns	Not Applicable as it is a subroutine
Arguments	**None**
Interactive Command	No

```
AssertRM1xx()//Ensure loading on RM1xx only
```

ASSERTRM1xx is an extension subroutine.

4.2 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 range of modules. However, some are dependent on the actual I/O availability of each module.

4.2.1 GPIO Events

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 RM1xx module, 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 RM1xx module, N can only be 0. Use GpioAssignEvent() to generate these events. See example for GpioAssignEvent()

4.2.2 GpioSetFunc

FUNCTION

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

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

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.
nFunction	***byVal nFunction AS INTEGER*** Specifies the configuration of the GPIO pin as follows: **1** DIGITAL_IN **2** DIGITAL_OUT **3** ANALOG_IN **4** ANALOG_REF (not currently available on the RM1xx module) **5** ANALOG_OUT (not currently available on the RM1xx module)
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.

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	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. For RM1xx: 10 bit adc and 2/3rd scaling 0x13: = For RM1xx: 10 bit adc, 1/3rd scaling 0x11: = For RM1xx: 10 bit adc, unity scaling 0 = Use the system default: 10-bit ADC, 2/3 scaling 0x13 = 10-bit ADC, 1/3 scaling 0x11 = 10-bit ADC, unity scaling

Note: The internal reference voltage is 1.2V with +/- 1.5% accuracy.

WARNING: This subfunc value is 'global' and once changed will apply to all ADC inputs.

Interactive Command: NO

```
//Example :: GpioSetFunc.sb (See in Firmware Zip file)
 PRINT GpioSetFunc(3,1,2)          //Digital In Gpio pin 3, weak pull up resistor
 PRINT GpioSetFunc(4,3,0)          //Analog In Gpio pin 4, default settings
 PRINT GpioSetFunc(5,1,0x12)       //internal pull up on gpio5 and wake from deep sleep
                                   //when there is transition from high to low
```

Expected Output:

```
000
```

GPIOSETFUNC is a Module function.

4.2.3 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.

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Note: This is a 'sticky' configuration; calling it affects all currently configured PWM outputs. 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 PWN 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. **Most typical value:** 0x0000 (indicates a successful operation)
Arguments	
nMinFreqHz	***byRef nMinFreqHz AS INTEGER*** On entry this variable contains the minimum frequency desired for the PWM output. On exit, if successful, it contains the actual frequency of the PWM output.
nMaxResolution	***byVal nMaxResolution INTEGER.*** This specifies the duty cycle resolution and the value to set to get a 100% duty cycle.
Interactive Command	No

```
// Example :: GpioConfigPWM() (See in Firmware Zip file)
DIM rc
DIM nFreqHz, nMaxRes
// we want a minimum frequency of 500Hz so that we can use a 100Hz low pass filter to
// create an analogue output which has a 100Hz bandwidth
nFreqHz = 500
// we want a resolution of 1:1000 in the generated analogue output
nMaxValUs = 1000
```


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```
 PRINT GpioConfigPWM(nFreqHz,nMaxRes)

 PRINT "\nThe actual frequency of the PWM output is ";nFreqHz;"\n"
 // now configure SIO2 pin as a PWM output
 PRINT GpioSetFunc(2,2,2)  //3rd parameter is subfunc == PWM output
 // Set PWM output to 0%
 GpioWrite(2,0)
 // Set PWM output to 50%
 GpioWrite(2,(nMaxRes/2))
 // Set PWM output to 100%
 GpioWrite(2,nMaxRes)    // any value >= nMaxRes will give a 100% duty cycle
 // Set PWM output to 33.333%
GpioWrite(2,(nMaxRes/3))
```

Expected Output:

```
0
The actual frequency of the PWM output is 1000
0
```

GPIOCONFIGPWM is a Module function.

4.2.4 GpioRead

FUNCTION

This routine reads the value from a SIO (special purpose I/O) pin.

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

GPIOREAD (*nSigNum*)

Returns	INTEGER, the value from the signal. If the signal number is invalid, it returns the value 0. For digital pins, the value is 0 or 1. For ADC pins it is a value in the range of 0 to M where M is the maximum 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.
Interactive Command	No

```
//Example :: GpioRead.sb (See in Firmware Zip file)
 DIM signal
```


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```
signal = GpioRead(3)
PRINT signal
```

Expected Output:

```
1
```

GPIOREAD is a Module function.

4.2.5 GpioWrite

SUBROUTINE

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

If the GPIO pin has been configured as a PWM output, then the nNewValue specifies a value in the range 0 to N where N is the maximum PWM value that generates a 100% duty cycle output (a constant high signal) and N is a value that is configured using the function GpioConfigPWM().

If the GPIO pin has been configured as a FREQUENCY output, then the nNewValue specifies the desired frequency in Hertz in the range 0 to 4000000. Setting a value of 0 makes the output a constant low value. Setting a value greater than 4000000 clips the output to a 4 MHz signal.

GPIOWRITE (nSigNum, nNewValue)

Arguments	
nSigNum	**byVal nSigNum INTEGER.** The signal number as stated in the pinout table of the module.
nNewValue	**byVal nNewValue 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 analogue – value is written to the pin If the pin is configured as a PWM – value sets the duty cycle If the pin is configured as a FREQUENCY – value sets the frequency
Interactive Command	No

```
//Example :: GpioWrite.sb (See in Firmware Zip file)
 DIM rc,dutycycle,freqHz,minFreq
 //set sio pin 1 to an output and initialise it to high
 PRINT GpioSetFunc(1,2,0);"\n"
 //set sio pin 5 to PWM output
 minFreq = 500
 PRINT GpioConfigPWM(minFreq,1024);"\n"  //set max pwm value/resolution to 1:1024
 PRINT GpioSetFunc(5,2,2);"\n"
```


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```
PRINT GpioSetFunc(6,2,3);"\n\n"          //set sio pin 6 to Frequency output


GpioWrite(18,0)                          //set pin 1 to low
GpioWrite(18,1)                          //set pin 1 to high
//Set the PWM output to 25%
GpioWrite(5,256)  //256 = 1024/4
//Set the FREQ output to 4.236 Khz
GpioWrite(6,4236)

//Note you can generate a chirp output on sio 6 by starting a timer which expires
//every 100ms and then in the timer handler call GpioWrite(6,xx) and then
//increment xx by a certain value
```

Expected Output:

```
0000
```

GPIOWRITE is a Module function.

4.2.6 GpioBindEvent

FUNCTION

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

Note: In the RM1xx module, using this function results in over 1 mA of continuous current consumption from the power supply. If power is important, use GpioAssignEvent() instead which uses other resources to expedite an event.

GPIOBINDEVENT (nEventNum, nSigNum, nPolarity)

Returns	INTEGER, a result code. **Typical value:** 0x0000 (indicates a successful operation)
Arguments	
nEventNum	**byVal nEventNum INTEGER** The GPIO event number (in the range of 0 - N) which results in the event EVGPIOCHANn being thrown to the *smart*BASIC runtime engine.
nSigNum	**byVal nSigNum INTEGER** The signal number as stated in the pinout table of the module.
nPolarity	**byVal *nPolarity* INTEGER** States the transition as follows: **0** Low to high transition **1** High to low transition

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	2	Either a low to high or high to low transition
Interactive Command	No	

```
//Example :: GpioBindEvent.sb (See in Firmware Zip file)
FUNCTION Btn0Press()
  PRINT "\nHello"
ENDFUNC 0

PRINT GpioBindEvent(0,16,1)       //Bind event 0 to high low transition on sio16
(button0)
ONEVENT EVGPIOCHAN0 CALL Btn0Press //When event 0 happens, call Btn0Press

PRINT "\nPress button 0"

WAITEVENT
```

Expected Output:

```
0
Press button 0
Hello
```

GPIOBINDEVENT is a Module function.

4.2.7 GpioUnbindEvent

FUNCTION

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

GPIOUNBINDEVENT (nEventNum)

Returns	INTEGER, a result code. **Typical value:** 0x0000 (indicates a successful operation)
Arguments	
nEventNum	byVal nEventNum INTEGER. The GPIO event number (in the range of 0 - N) which is disabled so that it no longer generates run-time events in *smart*BASIC.
Interactive Command	No

```
//Example :: GpioUnbindEvent.sb (See in Firmware Zip file)
FUNCTION Btn0Press()
```


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```
  PRINT "\nHello"
ENDFUNC 1

FUNCTION Tmr0TimedOut()
  PRINT "\nNothing happened"
ENDFUNC 0

PRINT GpioBindEvent(0,16,1);"\n"

ONEVENT EVGPIOCHAN0 CALL Btn0Press
ONEVENT EVTMR0   CALL Tmr0TimedOut

PRINT GpioUnbindEvent(0);"\n"
PRINT "\nPress button 0\n"
TimerStart(0,8000,0)

WAITEVENT
```

Expected Output:

```
0
0

Press button 0

Nothing happened
```

GPIOUNBINDEVENT is a Module function.

4.2.8 GpioAssignEvent

FUNCTION

This routine assigns an event to a level transition on a specified special I/O line configured as a digital input. Changes in the input line can invoke a handler in *smart*BASIC user code

Note: In the RM1xx, this function results in approximately 4 uA of continuous current consumption from the power supply. It is impossible to assign a polarity value which detects either level transitions.

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GPIOASSIGNEVENT (nEventNum, nSigNum, nPolarity)

Returns	INTEGER, a result code. **Typical value:** 0x0000 (indicates a successful operation)
Arguments	
nEventNum	**byVal nEventNum INTEGER.** The GPIO event number (in the range of 0 - N) which results in the event EVDETECTCHANn being thrown to the *smart*BASIC runtime engine. **Note**: A value of 0 is only valid for the RM1xx.
nSigNum	**byVal nSigNum INTEGER.** The signal number as stated in the pinout table of the module.
nPolarity	**byVal *nPolarity* INTEGER.** States the transition as follows: **0** – Low to high transition **1** – High to low transition **2** – Either a low to high or high to low transition **Note:** This is not available in the RM1xx module.
Interactive Command	No

```
//Example :: GpioAssignEvent.sb (See in Firmware Zip file)
 FUNCTION Btn0Press()
   PRINT "\nHello"
 ENDFUNC 0

 PRINT GpioAssignEvent(0,16,1)       //Assign event 0 to high low transition on sio16
(button0)
 ONEVENT EVDETECTCHAN0 CALL Btn0Press  //When event 0 is detected, call Btn0Press

 PRINT "\nPress button 0"

 WAITEVENT
```

Expected Output:

```
0
Press button 0
Hello
```

GPIOASSIGNEVENT is a Module function.

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4.2.9 GpioUnAssignEvent

FUNCTION

This routine unassigns the runtime engine event from a level transition assigned using GpioAssignEvent().

GPIOUNASSIGNEVENT (nEventNum)

Returns	INTEGER, a result code. **Typical value:** 0x0000 (indicates a successful operation)
Arguments	
nEventNum	**byVal nEventNum INTEGER.** The GPIO event number (in the range of 0 - N) which is disabled so that it no longer generates run-time events in *smart*BASIC. **Note**: A value of 0 is only valid for the RM1xx.
Interactive Command	No

```
//Example :: GpioUnAssignEvent.sb (See in Firmware Zip file)
 FUNCTION Btn0Press()
   PRINT "\nHello"
 ENDFUNC 1

 FUNCTION Tmr0TimedOut()
   PRINT "\nNothing happened"
 ENDFUNC 0

 PRINT GpioAssignEvent(0,16,1);"\n"

 ONEVENT EVDETECTCHAN0 CALL Btn0Press
 ONEVENT EVTMR0    CALL Tmr0TimedOut

 PRINT GpioUnAssignEvent(0);"\n"
 PRINT "\nPress button 0\n"
 TimerStart(0,8000,0)
 WAITEVENT
```


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Expected Output:

```
0
0


Press button 0


Nothing happened
```

GPIOUNASSIGNEVENT is a Module function.

5 BLE Extensions Built-in Routines

Bluetooth Low Energy (BLE) extensions are specific to the RM1xx *smart*BASIC BLE module and provide a high level managed interface to the underlying Bluetooth stack.

5.1 MAC Address

To address privacy concerns, there are four types of MAC addresses in a BLE device which can change as needed. For example, an iPhone regularly changes its BLE MAC address and it always exposes only its resolvable random address.

To manage this, the usual six octet MAC address is qualified on-air by a single bit which qualifies the MAC address as public or random. If public, then the format is as defined by the IEEE organization. If random, then it can be up to three types and this qualification is done using the upper two bits of the most significant byte of the random MAC address. The exact details and format of how the specification requires this to be managed is not relevant for the purpose of how BLE functionality as exposed in this module; only details on how various API functions in *smart*BASIC expect MAC addresses to be provided is described.

Where a MAC address is expected as a parameter (or provided as a response) it is always a STRING variable. This variable is seven octets long where the first octet is the address type and the other six octets are the usual MAC address in big endian format (so that most significant octet of the address is at offset 1), whether public or random.

The address type is:

0	Public
1	Random Static
2	Random Private Resolvable
3	Random Private Non-Resolvable
All other values are illegal	

For example, to specify a public address which has the MAC potion as 112233445566 then the STRING variable contains seven octets 00112233445566 and a variable can be initialized using a constant string by escaping as follows:

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DIM address	\00\11\22\33\44\55\66
Static random address	01C12233445566 (upper tow bits of MAC portion == 11)
Resolvable random address	02412233445566 (upper 2 bits of MAC portion == 01)
Non-resolvable address	03112233445566 (upper 2 bits of MAC portion == 00)

Note: The MAC 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; you will not see seven bytes, but a bit in the packet somewhere which specifies it to be public or random.

5.2 Events and Messages

5.2.1 EVBLE_CONN_TIMEOUT

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

```
//See example for BleConnect()
```

5.2.2 EVBLE_ADV_REPORT

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

```
//See example for BleScanGetAdvReport.sb
```

5.2.3 EVBLE_FAST_PAGED

This event is thrown when an advert report is received 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.sb
```

5.2.4 EVBLE_SCAN_TIMEOUT

This event is thrown when a scanning procedure initiated by the BleScanStart() function times out.

```
//See example for BleScanStart()
```

5.2.5 EVBLEMSG

BASIC application when a significant BLE-related event occurs. It does so by throwing this message (as opposed to an EVENT, which is akin to an interrupt and has no context or queue associated with it). The message contains two parameters:BASIC application when a significant BLE-related event has occurred. It does so by throwing this message (as opposed to an EVENT, which is akin to an interrupt and has no

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context or queue associated with it). The message contains two parameters:BASIC application when a significant BLE related event has occurred. It does so by throwing this message (as opposed to an EVENT, 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 is to prevent messages that are not handled from filling that queue. The list of triggers and associated context parameter are described in Table 1.

Table 1: Triggers and associated context parameters

MsgID	Description
0	A connection has been established and msgCtx is the connection handle.
1	A disconnection event and msgCtx identifies the handle.
2	Immediate Alert Service Alert. The 2nd parameter contains new alert level.
3	Link Loss Alert. The 2nd parameter contains new alert level.
4	A BLE Service Error. The 2nd parameter contains the error code.
5	Thermometer Client Characteristic Descriptor value has changed. (Indication enable state and msgCtx contains new value: 0 for disabled, 1 for enabled)
6	Thermometer measurement indication has been acknowledged.
7	Blood Pressure Client Characteristic Descriptor value has changed. (Indication enable state and msgCtx contains new value: 0 for disabled, 1 for enabled)
8	Blood Pressure measurement indication has been acknowledged.
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. msgCtx is key type.
12	Heart Rate Client Characteristic Descriptor value has changed. (Notification enable state and msgCtx contains new value: 0 for disabled, 1 for enabled)
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.
19	The supply voltage has dropped below that specified in the most recent call of SetPwrSupplyThreshMv() and msgCtx is the current voltage in millivolts.
20	The connection is no longer encrypted and msgCtx is the conn handle

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MsgID	Description
21	The device name characteristic in the GAP service of the local GATT table has been written by the remote GATT client.

Note: Message ID 13 is reserved for future use

The following is an example of how these messages can be used:

```
//Example :: EvBleMsg.sb (See in RM1xxCodeSnippets.zip)
 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
       rc = BleAuthenticate(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 Btn0Press()
```


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```
  PRINT "\nExiting..."
ENDFUNC 0

PRINT GpioSetFunc(16,1,0x12)
PRINT GpioBindEvent(0,16,0)

ONEVENT EVBLEMSG      CALL HndlrBleMsg
ONEVENT EVBLE_ADV_TIMEOUT CALL HndlrBlrAdvTimOut
ONEVENT EVGPIOCHAN0    CALL Btn0Press

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

WAITEVENT
```

Expected Output (When connection made with RM1xx):

```
Adverts Started
Press button 0 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...
```


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Expected Output (When no connection made):

```
Adverts Started
Press button 0 to exit

Advert stopped via timeout
Exiting...
```

5.2.6 EVDISCON

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

- Parameter 1 – Connection handle
- Parameter 2 – The reason for the disconnection

For example: The reason 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 can be determined and provided in this document here.

```
//Example :: EvDiscon.sb (See in RM1xxCodeSnippets.zip)
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
```


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```
// 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
```

5.2.7 EVCHARVAL

This event is thrown when a characteristic has been written to by a remote GATT client. It comes with three parameters which are the characteristic handle that was returned when the characteristic was registered using the function BleCharCommit() the Offset and Length of the data from the characteristic value.

```
//Example :: EvCharVal.sb (See in RM1xxCodeSnippets.zip)

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=BleSvcCommit(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'
```


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```
  rc=BleCharCommit(hSvc,attr$,hMyChar)

  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$,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
//=============================================================================
FUNCTION HandlerCharVal(BYVAL charHandle, BYVAL offset, BYVAL len)
  DIM s$
  IF charHandle == hMyChar THEN
```


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```
      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

 ONEVENT EVCHARVAL CALL HandlerCharVal
 ONEVENT EVBLEMSG CALL HndlrBleMsg

 IF OnStartup()==0 THEN
    rc = BleCharValueRead(hMyChar,at$)
    PRINT "\nValue of the characteristic is ";at$
    PRINT "\nSend a new value to write to the characteristic\n"
 ELSE
    PRINT "\nFailure OnStartup"
 ENDIF

 WAITEVENT

 PRINT "\nExiting..."
```

Expected Output:

```
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...
```


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5.2.8 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 :: EVCHARHVC charHandle

// See example that is provided for EVCHARCCCD
```

5.2.9 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 :: EvCharCccd.sb (See in RM1xxCodeSnippets.zip)

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

   //Commit svc with handle 'hSvcUuid'
   rc=BleSvcCommit(1,hSvcUuid,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)
```


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```
  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$,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

//=========================================================================
// Indication acknowledgement from client handler
//=========================================================================
FUNCTION HndlrCharHvc(BYVAL charHandle AS INTEGER) AS INTEGER
  IF charHandle == hMyChar THEN
    PRINT "\nGot confirmation of recent indication"
```


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

ONEVENT EVBLEMSG  CALL HndlrBleMsg
ONEVENT EVCHARHVC  CALL HndlrCharHvc
ONEVENT EVCHARCCCD CALL HndlrCharCccd
ONEVENT EVGPIOCHAN1 CALL HndlrBtn0Pr

IF OnStartup()==0 THEN
```


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```
  rc = BleCharValueRead(hMyChar,at$)
  PRINT "\nCharacteristic Value ";at$
  PRINT "\nYou can write to the CCCD characteristic."
  PRINT "\nThe RM1xx will then indicate a new characteristic value\n"
  PRINT "\nPress button 0 to exit"
ELSE
  PRINT "\nFailure OnStartup"
ENDIF

WAITEVENT

PRINT "\nExiting..."
```

5.2.10 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 was returned when the characteristic was 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 :: EvCharSccd.sb (See in RM1xxCodeSnippets.zip)

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 charMet : charMet = BleAttrMetaData(1,0,20,0,rc)
  DIM mdSccd : mdSccd = BleAttrMetadata(1,1,2,0,rc)

  //Commit svc with handle 'hSvcUuid'
  rc=BleSvcCommit(1,BleHandleUuid16(0x18EE),hSvc)
  //initialise char, read enabled, accept signed writes, broadcast capable
  rc=BleCharNew(0x03,BleHandleUuid16(1),charMet,0,mdSccd)
  //commit char initialised above, with initial value "hi" to service 'hMyChar'
```


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```
  rc=BleCharCommit(hSvc,attr$,hMyChar)
  rc=BleAdvRptInit(adRpt$,0x02,0,20)
  //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

//=============================================================================
```


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```
// 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"
    ELSE
      PRINT "\nBroadcasts have been disabled by client"
    ENDIF
  ELSE
    PRINT "\nThis is for some other characteristic"
  ENDIF
ENDFUNC 1

ONEVENT EVBLEMSG  CALL HndlrBleMsg
ONEVENT EVCHARSCCD CALL HndlrCharSccd
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 "\n--- Press button 0 to exit\n"
ELSE
  PRINT "\nFailure OnStartup"
ENDIF

WAITEVENT

PRINT "\nExiting..."
```

5.2.11 EVCHARDESC

This event is thrown when the client writes to writable descriptor of a characteristic which is not a CCCD or SCCD (CCCD and SCCD 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()

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- 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 :: EvCharDesc.sb (See in RM1xxCodeSnippets.zip)

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

  //Commit svc with handle 'hSvcUuid'
  rc=BleSvcCommit(1,BleHandleUuid16(0x18EE),hSvc)
  //initialise char, read/write enabled, accept signed writes
  rc=BleCharNew(0x4A,BleHandleUuid16(1),charMet,0,0)
  //Add another descriptor
  attr$="descr_value"
  rc=BleCharDescAdd(0x2999,attr$,BleAttrMetadata(1,1,20,0,rc))
  //commit char initialised above, with initial value "hi" to service 'hMyChar'
  attr2$="char value"
  rc=BleCharCommit(hSvc,attr2$,hMyChar)
  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$,0x18EE,0x2905,-1,-1,-1,-1)
  rc=BleAdvRptAddUuid16(scRpt$,0x2905,-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
ENDSUB
```


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```
//=========================================================================================
// 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 HndlrCharDesc(BYVAL charHandle, BYVAL hDesc) AS INTEGER
  IF charHandle == hMyChar THEN
    PRINT "\n ::Char Handle: ";charHandle
    PRINT "\n ::Descriptor Index: ";hDesc
    PRINT "\nThe new descriptor value is then read using the function
BleCharDescRead()"
```


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

ONEVENT EVBLEMSG  CALL HndlrBleMsg
ONEVENT EVCHARDESC CALL HndlrCharDesc
ONEVENT EVGPIOCHAN1 CALL HndlrBtn0Pr

OnStartup()
PRINT "\nWrite to the User Descriptor with UUID 0x2999"
PRINT "\n--- Press button 0 to exit\n"

WAITEVENT

PRINT "\nExiting..."
```

5.2.12 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 finite number of these temporary buffers and if they are exhausted, the notify function or the write_with_no_resp command will fail with a result code of 0x6803 (BLE_NO_TX_BUFFERS). Once the attribute data is transmitted over the air, given 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; the *smart*BASIC application can then 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 because those messages have to be confirmed by the client which results in a EVCHARHVC message to the *smart*BASIC application. Likewise, writes which are acknowledged also do not consume these buffers.

```
//Example :: EvNotifyBuf.sb (See in RM1xxCodeSnippets.zip)

DIM hMyChar,rc,at$,conHndl,ntfyEnabled

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


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```
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=BleSvcCommit(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$,hMyChar)
  rc=BleScanRptInit(scRpt$)
  //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"
```


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```
  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
```


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```
    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 RM1xx 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 RM1xx 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...
```

5.3 Miscellaneous Functions

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

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5.3.1 BleTxPowerSet

FUNCTION

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

The actual value is determined by scanning through the value list (4, 0, -4, -8, -12, -16, -20, -30, -55) so that the highest value in the list which is less than the desired value is set. Note that if desired value is less than
-55 then -55 is selected.

For example, setting 1000 results in +4; -3 results in -4; -100 results in -55.

At any time SYSINFO(2008) returns the actual transmit power setting. Or, when in command mode, use the command AT I 2008.

BLETXPOWERSET (nTxPower)

Returns	INTEGER, a result code. Typical value: 0x0000 (indicates a successful operation)
Arguments	
nTxPower	byVal nTxPower AS INTEGER. Specifies the new transmit power in dBm units to be used for all subsequent Pairing packets. The actual value is determined by scanning through the value list (4, 0, -4, -8, -12, -16, -20, -30, -55) so that the highest value in the list which is less than the desired value is set. Note that if desired value is less than -55 then -55 is selected.
Interactive Command	No

```
//Example :: BleTxPowerSet.sb (See in RM1xxCodeSnippets.zip)
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)
```


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```
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= -30
Tx power : desired= -45           actual= -55
Tx power : desired= -1000         actual= -55
```

BLETXPOWERSET is an extension function.

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.

The actual value is determined by scanning through the value list (4, 0, -4, -8, -12, -16, -20, -30, -55) so that the highest value in the list which is less than the desired value is set. Note that if desired value is less than -55, then -55 is selected.

For example, setting 1000 results in +4; -3 results in -4; -100 results in -55.

At any time SYSINFO(2008) returns the actual transmit power setting. Or, when in command mode, use the command AT I 2008.

BLETXPWRWHILEPAIRING (nTxPower)

Returns	INTEGER, a result code. **Typical value:** 0x0000 (indicates a successful operation)
Arguments	
nTxPower	byVal nTxPower AS INTEGER. Specifies the new transmit power in dBm units to be used for all subsequent Tx packets. The actual value is determined by scanning through the value list (4, 0, -4, -8, -12, -16, -20, -30, -55) so that the highest value in the list which is less than the desired value is set. Note that if desired value is less than -55 then -55 is selected.
Interactive Command	No

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```
//Example :: BleTxPwrWhilePairing.sb (See in RM1xxCodeSnippets.zip)
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= 4
Tx power while pairing: desired= 8       actual= 4
Tx power while pairing: desired= 2       actual= 0
Tx power while pairing: desired= -10     actual= -12
Tx power while pairing: desired= -25     actual= -30
Tx power while pairing: desired= -45     actual= -55
Tx power while pairing: desired= -1000   actual= -55
```

BLETXPOWERSET is an extension function.

5.3.3 BleConfigDcDc

SUBROUTINE

This routine is used to configure the DC to DC converter to one of three states: OFF, ON, or AUTOMATIC

Note: Until a future revision when the chipset vendor has fixed a hardware issue at the silicon level, this function does not function as stated and any *nNewState* value are interpreted as OFF.

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BLECONFIGDCDCnNewState (nNewState)

Returns	None
Arguments	
nNewState	**byVal *nNewState* AS INTEGER.** Configure the internal DC to DC converter as follows: 0 Off 2 Auto All other values On
Interactive Command	No

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

BLECONFIGDCDC is an extension function.

5.4 Advertising Functions

Note: The RM1xx module is NOT capable of being a peripheral device and so, although the functions described below exist, most return an error. They only function as described in the RM1xx module, or in the future in a module with a combined central and peripheral stack.

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:

- First field – One octet in length and contains the number of octets that follow it that belong to that record
- Second field – One octet and is a tag value which identifies the type of payload that starts at the next octet. Hence the payload data is **length – 1**.

A special NULL AD record consists of only one field – the length field when it contains just 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 has 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

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.

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

If the Advert packet type (nAdvType) is specified as 1 (ADV_DIRECT_HIGH_DUTY_CYCLE) 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 milliseconds.

If the Advert packet type (nAdvType) is specified as 4 (ADV_DIRECT_LOW_DUTY_CYCLE) then the peerAddr$ string must not be empty and should be a valid address. When advertising with this packet type, the timeout is as per the interval and timeout values specified.

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.

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

Returns	INTEGER, a result code. **Typical value:** 0x0000 (indicates a successful operation) If a 0x6A01 resultcode is received, it implies 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 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	
nAdvType	**byVal *nAdvType* AS INTEGER.** Specifies the advertisement type as follows:

0	ADV_IND – Invites connection requests
1	ADV_DIRECT_HIGH_DUTY_CYCLE – Invites connection from addressed device using high duty cycle timing. nAdvInternal and nAdvTimeout are ignored and interval is set to 3.75ms and Timeout to 1.28 seconds as per the specification. See ADV_DIRECT_LOW_DUTY_CYCLE for an alternative.
2	ADV_SCAN – Invites scan requests for more advert data
3	ADV_NONCONN – Does not accept connections and/or active scans
4	ADV_DIRECT_LOW_DUTY_CYCLE – Invites connection from addressed device using low duty cycle timing using nAdvInternal and nAdvTimeout specified

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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 (such as \00\11\22\33\44\55\66), where the first octet is the address type and the rest of the 6 octets is the usual MAC address in big endian format (so that 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. **Interval range:** Between 20 and 10240 milliseconds.
nAdvTimeout	**byVal nAdvTimeout AS INTEGER.** The time after which the module stops advertising (in milliseconds). **Value range:** Between 0 and 16383000 milliseconds (rounded up to the nearest one seconds or 1000 milliseconds). A value of 0 means disable the timeout, but note that if limited advert modes was specified in BleAdvRptInit() then the timeout is capped to 180000 milliseconds as per the Bluetooth Specification. When the advert type specified is ADV_DIRECT_IND, the timeout is automatically set to 1280 milliseconds as per the Bluetooth Specification. **Warning:** To save power, do not set this to (e.g.) 100 milliseconds.
nFilterPolicy	**byVal *nFilterPolicy* AS INTEGER.** Specifies the filter policy for the whitelist consisting of all bonded masters as follows: 0 – Disable whitelist 1 – Filter scan request; allow connection request from any 2 – Filter connection request; allow scan request from any 3 – Filter scan request and connection request If the filter policy is not 0, the whitelist is enabled and filled with all the addresses of all the devices in the trusted device database.
Interactive Command	No

```
//Example :: BleAdvertStart.sb
 DIM addr$ : addr$=""

 FUNCTION HndlrBlrAdvTimOut()
  PRINT "\nAdvert stopped via timeout"
```


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```
  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
RM1xx'"
 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
RM1xx’


Advert stopped via timeout
Exiting...
```

BLEADVERTSTART is an extension function.

5.4.2 BleAdvertStop

FUNCTION

Note: The function is not available in the RM1xx module and always returns an error.

This function causes the BLE module to stop advertising.

BLEADVERTSTOP ()

Returns	INTEGER, a result code. Most typical value – 0x0000, indicating a successful operation.
Arguments	None

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Interactive Command	No

```
//Example :: BleAdvertStop.sb (See in RM1xxCodeSnippets.zip)
 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(16,1,2)
 rc = GpioBindEvent(0,16,1)

 ONEVENT EVBLE_ADV_TIMEOUT CALL HndlrBlrAdvTimOut
 ONEVENT EVGPIOCHAN0    CALL Btn0Press

 WAITEVENT
```


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Expected Output:

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


Advertising Stopped
Exiting...
```

BLEADVERTSTOP is an extension function.

5.4.3 BleAdvRptInit

FUNCTION

Note: The function is not available in the RM1xx module and always returns an error.

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

This report is for use with advertisement packets.

BLEADVRPTINIT (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 is forced to 1 and bits 3 and 4 are forced to 0. Bits 3 to 7 are reserved for future use by the BT SIG and must be set to 0. **Note:** If a whitelist is enabled in the BleAdvertStart() function then both Limited and General Discoverability flags MUST be 0 as per the BT 4.0 specification (Volume 3, Sections 9.2.3.2 and 9.2.4.2)
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 0 then the device name is not included.
Interactive Command	No

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```
//Example :: BleAdvRptInit.sb (See in RM1xxCodeSnippets.zip)
 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
```

BLEADVRPTINIT is an extension function.

5.4.4 BleScanRptInit

FUNCTION

Note: The function is not available in the RM1xx module and will always return an error.

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

This report is for use with SCAN_RESPONSE packets.

BLESCANRPTINIT (scanRpt)

Returns	INTEGER, a result code. Most typical value – 0x0000, indicating a successful operation.
Arguments	
scanRpt	**byRef *scanRpt* AS STRING.** This contains a scan report.
Interactive Command	No

```
//Example :: BleScanRptInit.sb (See in RM1xxCodeSnippets.zip)
 DIM scnRpt$ : scnRpt$=""

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


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Expected Output:

```
Scan report initialised
```

BLESCANRPTINIT is an extension function.

5.4.5 BleAdvRptAddUuid16

FUNCTION

Note: The function is not available in the RM1xx module and always returns an error.

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.

BLEADVRPTADDUUID16 (AdvRpt$, nUuid1, nUuid2, nUuid3, nUuid4, nUuid5, nUuid6)

Returns	INTEGER, a result code. Most typical value – 0x0000, indicating a successful operation.
Arguments	
AdvRpt$	**byRef *AdvRpt AS* STRING**. The advert report onto which the 16-bit UUIDs AD record is added.
Uuid1	***byVal uuid1 AS INTEGER*** UUID in the range 0 to FFFF, if value is outside that range it is ignored. Set the value to -1 to have it ignored and then all further UUID arguments are also ignored.
Uuid2	***byVal uuid2 AS INTEGER*** UUID in the range 0 to FFFF, if value is outside that range it is ignored. Set the value to -1 to have it ignored and then all further UUID arguments are also ignored.
Uuid3	***byVal uuid3 AS INTEGER*** UUID in the range 0 to FFFF, if value is outside that range it is ignored. Set the value to -1 to have it ignored and then all further UUID arguments are also ignored.
Uuid4	***byVal uuid4 AS INTEGER*** UUID in the range 0 to FFFF, if value is outside that range it is ignored. Set the value to -1 to have it ignored and then all further UUID arguments are also ignored.
Uuid5	***byVal uuid5 AS INTEGER*** UUID in the range 0 to FFFF, if value is outside that range it is ignored. Set the value to -1 to have it ignored and then all further UUID arguments are also ignored.
Uuid6	***byVal uuid6 AS INTEGER*** UUID in the range 0 to FFFF, if value is outside that range it is ignored. Set the value to -1 to have it ignored and then all further UUID arguments are also ignored.
Interactive Command	No

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```
//Example :: BleAdvAddUuid16.sb (See in RM1xxCodeSnippets.zip)
 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
```

BLEADVRPTADDUUID16 is an extension function.

5.4.6 BleAdvRptAddUuid128

FUNCTION

Note: The function is not available in the RM1xx module and always returns an error.

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. Most typical value – 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.

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nUuidHandle	***byVal nUuidHandle AS INTEGER*** This is handle to a 128-bit UUID which was obtained using say the function BleHandleUuid128() or some other function which returns one, like BleHandleUuid128 ()
Interactive Command	No

```
DiM tx$,scRpt$,adRpt$,addr$
Dim uuid$
Dim hUuidCustom

scRpt$=""
PRINT BleScanRptInit(scRpt$)

uuid$ = "ced9d91366924a1287d56f2764762b2a"
uuid$ = StrDehexize$(uuid$)
hUuidCustom = BleHandleUuid128(uuid$)

//Advertise the service 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)

WAITEVENT
```

Expected Output:

```
00000
```

BLEADVRPTADDUUID128 is an extension function.

5.4.7 BleAdvRptAppendAD

FUNCTION

Note: The function is not available in the RM1xx module always returns an error.

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.

BLEADVRPTAPPENDAD (advRpt$, nTag, stData$)

Returns	INTEGER, a result code. Most typical value – 0x0000, indicating a successful operation.
Arguments	
advRpt$	**byRef *AdvRpt AS* STRING**. The advert report onto which the AD record is to be appended.

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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.
Interactive Command	No

```
//Example :: BleAdvRptAppendAD.sb (See in RM1xxCodeSnippets.zip)
 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
```

BLEADVRPTAPPENDAD is an extension function

5.4.8 BleAdvRptsCommit

FUNCTION

Note: The function is not available in the RM1xx module and will always return an error.

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 and in that case this call has no effect.

The advertisements do not occur until they are started using BleAdvertStart() function.

BLEADVRPTSCOMMIT (advRpt$, scanRpt$)

Returns	INTEGER, a result code. Most typical value – 0x0000, indicating a successful operation.
Arguments	
advRpt$	**byRef *advRpt* AS STRING.** The most recent advert report.

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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.
Interactive Command	No

```
//Example :: BleAdvRptsCommit.sb (See in RM1xxCodeSnippets.zip)
 DIM advRpt$ : advRpt$=""
 DIM scRpt$ : scRpt$=""
 DIM discovMode : discovMode = 0
 DIM advApprnce : advApprnce = 1
 DIM maxDevName : maxDevName = 10

 PRINT BleAdvRptInit(advRpt$, discovMode, advApprnce, maxDevName)
 PRINT BleAdvRptAddUuid16(advRpt$, 0x180F,0x180A, -1, -1, -1, -1)
 PRINT BleAdvRptsCommit(advRpt$, scRpt$)

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

Expected Output:

```
000
```

BLEADVRPTSCOMMIT is an extension function.

5.5 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 is explicitly instructed to abort or stop.

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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. The user app must install a handler for that event which stops the scan procedure and immediately start a connection procedure.

For more information about adverts see the section "Advertising Functions"

5.5.1 BleScanStart

FUNCTION

This function is used to start a scan for adverts which may result in at least one of these events being thrown:

EVBLE_SCAN_TIMEOUT	End of scanning
EVBLE_ADV_REPORT	Advert report received
EVBLE_FAST_PAGED	Peripheral inviting connection to this module

The event EVBLE_ADV_REPORT is 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.

The event EVBLE_FAST_PAGED is 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 values: Scan Interval – 80 milliseconds Scan Window – 40 milliseconds
Scan Window	
Scan Type	Default: Active

Active scanning means that for each advert received, if it is of type ADV_IND or ADV_DISCOVER_IND then 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.

These values for these default parameters can be changed prior to invoking this function by calling the function BleScanConfig() appropriately.

There can be situations where there are many peripherals advertising and it may desirable to save power by not having to process all the adverts that are received. For this situation, this function takes a filter parameter which enables an opaque object to be presented to the baseband which contains a whitelist

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of MAC addresses. This means that only addresses that match those in the object get transferred to upper layers for further processing. This opaque object consisting of whitelisted mac addresses is created and modified using the functions BleWhiteListCreate(), BleWhiteListAddAddr(), and BleWhiteListAddIrk().

Note: **IRK** stands for Identity Resolving Key.

Finally, 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. When that happens, you can 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, it is recommend starting the scan and then immediately calling BleScanStop().

BLESCANSTART (scanTimeoutMs, nFilterHandle)

Returns	INTEGER, a result code. Most typical value – 0x0000, indicating a successful operation.
Arguments	
scanTimeoutMs	**byVAL *scanTimeoutMs* AS INTEGER.** The length milliseconds the scan for adverts lasts. If it times out, then the event EVBLE_SCAN_TIMEOUT is thrown to the *smart*BASIC application. Valid range – 0 to 65535000 milliseconds (about 18 hours). If 0 is supplied, it will not start a timer and scanning can only be stopped by calling either BleScanAbort() or Ble ScanStop().
nFilterHandle	**byVAL nFilterHandle AS INTEGER** This must be 0 to specify no filtering of adverts, otherwise it will be a value returned by BleWhiteListCreate() and subsequently updated by BleWhiteListAddAddr() and/or BleWhiteListAddIrk(). When non-zero, only devices with matching address (or resolvable address corresponding to the IRK) result in a EVBLE_ADV_REPORT event to the *smart*BASIC application.
Interactive Command	No

```
//Example :: BleScanStart.sb (See in RM1xxCodeSnippets.zip)
 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
```


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```
'//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
```

BLESCANSTART is an extension function.

5.5.2 BleScanAbort

FUNCTION

This function is used to cancel an ongoing scan for adverts which has not timed out. It takes no parameters since 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:

Bit 0	Set if advertising is in progress (not possible with the RM1xx)
Bit 1	Set if there is already a connection in the peripheral role (not possible with the RM1xx)
Bit 2	Set if there is a current connection attempt ongoing
Bit 3	Set when scanning
Bit 4	Set if there is already a connection to a peripheral

Note: There is also BleScanStop() which also cancels an ongoing scan. The difference is that, by calling BleScanAbort(), the memory that was allocated from the 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. Most typical value – 0x0000, indicating a successful operation.
Arguments	None
Interactive Command	No

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```
//Example :: BleScanAbort.sb (See in RM1xxCodeSnippets.zip)
 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
```

BLESCANABORT is an extension function.

5.5.3 BleScanStop

FUNCTION

This function is used to cancel an ongoing scan for adverts which has not timed out. It takes no parameters since 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:

Bit 0	Set if advertising is in progress (not possible with the RM1xx)

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Bit 1	Set if there is already a connection in the peripheral role (not possible with the RM1xx)
Bit 2	Set if there is a current connection attempt ongoing
Bit 3	Set when scanning
Bit 4	Set if there is already a connection to a peripheral

Note: There is also BleScanAbort() which also cancels an ongoing scan. The difference is that, by calling BleScanStop(), the memory that was allocated from the 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. Most typical value – 0x0000, indicating a successful operation.
Arguments	None
Interactive Command	No

```
//Example :: BleScanStop.sb (See in RM1xxCodeSnippets.zip)
 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 "\nStop scanning. Freeing up allocated memory"
   rc = BleScanStop()
   IF SysInfo(2016) == 0 THEN
     PRINT "\nScan stopped"
```


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```
    ENDIF
 ENDIF
```

Expected Output:

```
Scanning
Stop scanning. Freeing up allocated memory
Scan stopped
```

BLESCANSTOP is an extension function.

5.5.4 BleScanFlush

FUNCTION

This function is used to flush the buffer that contains advert reports that are currently in the internal cache waiting to be read by the function BleScanGetAdvReport().

When scanning is initiated using BleScanStart() the internal cache is automatically flushed so no need to call this function prior to starting a scan.

BLESCANFLUSH ()

Returns	INTEGER, a result code. Most typical value – 0x0000, indicating a successful operation.
Arguments	None
Interactive Command	No

```
DIM rc

 '//Flush the advert report cache
 rc = BleScanFlush()
```

BLESCANFLUSH is an extension function.

5.5.5 BleScanConfig

FUNCTION

This function is used to modify the default parameters that are used when initiating a scan operation using BleScanStart().

The following lists the default parameters and their settings:

Scan Interval	80 milliseconds
Scan Window	40 milliseconds
Scan Type (Active/Passive)	Active

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Minimum Reports in the 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. Most typical value – 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 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.
Interactive Command	No

```
//Example :: BleScanConfig.sb (See in RM1xxCodeSnippets.zip)
 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:"
```


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```
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
```

BLESCANCONFIG is an extension function.

5.5.6 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 a 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 information that is retrieved 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. The RSSI can be used to determine the closest device, but please be aware that due to fading and reflections it is possible that a device further away could result in a higher RSSI value.

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BLESCANGETADVREPORT (periphAddr$, advData$, nDiscarded, nRssi)

Returns	INTEGER, a result code. Most typical value – 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.
Interactive Command	No

Note: This code snippet was tested with another RM1xx running the iBeacon app (see in *smart*BASIC_Sample_Apps folder) on Peripheral firmware.

```
//Example :: BleScanGetAdvReport.sb (See in RM1xxCodeSnippets.zip)
 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 periphAddr$, advData$, nDiscarded, nRssi
```


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```
  '//Read all cached advert reports
  DO
    rc=BleScanGetAdvReport(periphAddr$, advData$, nDiscarded, nRssi)
    PRINT "\n\nPeer Address: "; StrHexize$(periphAddr$)
    PRINT "\nAdvert Data: ";StrHexize$(advData$)
    PRINT "\nNo. Discarded Adverts: ";nDiscarded
    PRINT "\nRSSI: ";nRssi
  UNTIL rc!=0
  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
```

BLESCANGETADVREPORT is an extension function.

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5.5.7 BleGetADbyIndex

FUNCTION

This function is used to extract a copy of the nth (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. Most typical value – 0x0000, indicating a successful operation.
Arguments	
nIndex	**byVAL *nIndex AS* INTEGER** This is a zero based index of the AD element that is copied into the output data parameter ADval$.
rptData$	**byREF *rptData$ AS* STRING**. This parameter is a string that contains concatenated AD elements which are either constructed for an outgoing advert or received in a scan (depends on module variant)
nADTag	***byREF nADTag AS INTEGER*** When the nth index is found, the single byte tag value for that AD element is returned in this parameter
ADval$	***byREF ADval$ AS STRING*** When the nth index is found, the data excluding single byte the tag value for that AD element is returned in this parameter.
Interactive Command	No

```
//Example :: BleAdvGetADbyIndex.sb (See in RM1xxCodeSnippets.zip)
 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$ )
```


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```
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:

```
06DD1122334455 07EEAABBCCDDEEFF

First AD element with tag 0x000000DD is 1122334455
Second AD element with tag 0x000000EE is AABBCCDDEEFF
Error reading AD: 00006060
```

BLEGETADBYINDEX is an extension function.

5.5.8 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.

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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.

BLEGETADBYTAG (rptData$, nADtag, ADval$)

Returns	INTEGER, a result code. Most typical value – 0x0000, indicating a successful operation.
Arguments	
rptData$	**byREF *rptData$ AS* STRING**. This parameter is a string that contains concatenated AD elements which are either constructed for an outgoing advert or received in a scan (depends on module variant)
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.
Interactive Command	No

```
//Example :: BleAdvGetADbyIndex.sb (See in RM1xxCodeSnippets.zip)
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
```


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```
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:

```
06DD1122334455 07EEAABBCCDDEEFF

AD element with tag 0x000000DD is 1122334455
AD element with tag 0x000000EE is AABBCCDDEEFF
Error reading AD: 00006060
```

BLEGETADBYTAG is an extension function.

5.5.9 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.

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BLESCANGETPAGERADDR (periphAddr$, nRssi)

Returns	INTEGER, a result code. Most typical value – 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.
Interactive Command	No

```
//Example :: BleScanGetPagerAddr.sb (See in RM1xxCodeSnippets.zip)
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

'//Handler is called when advert is received requesting 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
```


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Expected Output:

```
Scanning
Advert received from peripheral 01D8CFCF14498D with RSSI -96
requesting a connection to this module
```

BLESCANGETPAGERADDR is an extension function.

5.6 Whitelist Management Functions

IMPORTANT! The functions in this section are still in alpha state and should not be used.

The BLE paradigm is to consume as little power as possible so that operation from whatever power source lasts as long as possible.

One way to minimize power consumption is to ensure that incoming radio packets are filtered at the baseband level so that only a subset of addresses result in upper layers being informed about those radio packets.

This subset list of addresses is referred to as a whitelist in the Bluetooth specification. When a device powers up, the whitelist is empty. It is up to the upper layers to populate that list.

This section deals with all *smart*BASIC functions that enable that whitelist to be created in an opaque object for other operations such as BleScanStart() to use and activate. The functions allow creation, addition of addresses and identity resolving keys (IRKs), and destruction of the whitelist.

An identity resolving key (IRK) is a 128-bit value that is used as a key in an AES encryption EBC algorithm along with a three-byte random number to create another three-byte value such that when they are concatenated a resolvable MAC address is created as per the Bluetooth specification. The upper two bits of this six-byte MAC address is adjusted to signify that it is a resolvable random MAC address.

The receiving device examines the upper two bits and if it signifies a resolvable address, then it takes the relevant three bytes from that address and uses an IRK that it acquired from a device through a bonding process to determine whether it is a known address. For whitelisting purposes, all of this is done by the lower layers in the baseband.

5.6.1 BleWhiteListCreate

FUNCTION

This function is used to create a whitelist which is empty but contains enough memory to hold a maximum number of MAC addresses and a maximum number of Identity Resolving Keys (IRKs).

It returns a handle to the opaque object which is then subsequently used with the other whitelisted API functions.

Note: Do **NOT** destroy this object using BleWhiteListDestroy () while the object is in use by the underlying stack. This results in unpredictable behaviour.

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BLEWHITELISTCREATE (maxMacAddr, maxIRKs)

Returns	INTEGER This is a handle that identifies the opaque object that was created. It is 0 if there was no free memory in the heap to create it. Always check for this.
Arguments	
maxMacAddr	**byVAL *maxMacAddr* AS INTEGER.** The is the maximum number of addresses that are stored in the created whitelist opaque object. Each MAC address is a seven-byte entity: six for the address and the seventh for the type. To add a key to this list, use the BleWhiteListAddAddr() function.
maxIRKs	**byVAL *maxIRKS* AS INTEGER.** The is the maximum number of identity resolving keys that are stored in the created whitelist opaque object. Each key is 16 bytes in length. To add a key to this list, use the function BleWhiteListAddIrk().
Interactive Command	No

```
//Example :: BleWhiteListCreate.sb (See in RM1xxCodeSnippets.zip)
DIM hWhiteList : hWhiteList = BleWhiteListCreate(20,10)

IF hWhiteList == 0 THEN
  PRINT "\nWhitelist not created, not enough memory"
ELSE
  PRINT "\nWhitelist created. Handle: "; rc
ENDIF
```

Expected Output:

```
Whitelist created. Handle: -1091583777
```

BLEWHITELISTCREATE is an extension function.

5.6.2 BleWhiteListAddAddr

FUNCTION

This function is used to add a mac address to a whitelist that was created using BleWhiteListCreate() and returns a resultcode.

Do not attempt to add a resolvable random address. Instead use BleWhiteListAddIrk() and add the identity resolving key for that instead.

BLEWHITELISTADDADDR (handle, madAddr$)

Returns	INTEGER, a result code. Most typical value – 0x0000, indicating a successful operation.

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Arguments	
handle	**byVAL *handle* AS INTEGER** This is a handle to the whitelist object that needs to be added to and is returned by BleWhiteListCreate().
macAddr$	**byREF *macAddr$* AS STRING** This is the mac address (seven bytes in length) to be added to the whitelist identified by the handle above.
Interactive Command	No

```
//Example :: BleWhiteListAddAddr.sb (See in RM1xxCodeSnippets.zip)
DIM rc
DIM hWhiteList : hWhiteList = BleWhiteListCreate(20,10)
DIM macAddr$ : macAddr$ = "\01\D8\CF\CF\14\49\8D"

IF hWhiteList == 0 THEN
  PRINT "\nWhitelist not created, not enough memory"
ELSE
  PRINT "\nWhitelist created. Handle: ";hWhiteList
ENDIF

rc = BleWhiteListAddAddr(hWhiteList, macAddr$)
IF rc==0 THEN
  PRINT "\nMAC Address "; StrHexize$(macAddr$);" was added to the whitelist"
ELSE
  PRINT "\nError: "; INTEGER.H'rc
ENDIF
```

Expected Output:

```
Whitelist created. Handle: -1091583780
MAC Address 01D8CFCF14498D was added to the whitelist
```

BLEWHITELISTADDADDR is an extension function.

5.6.3 BleWhiteListDestroy

SUBROUTINE

This function is used to destroy a whitelist object that was created using BleWhiteListCreate().

Note: Do NOT destroy a whitelist object while the object is in use by the underlying stack. This results in unpredictable behaviour.

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BLEWHITELISTDESTROY (handle)

Returns	None
Arguments	
handle	**byVAL *handle* AS INTEGER** This is a handle to the whitelist object that needs to be destroyed and is returned by BleWhiteListCreate().
Interactive Command	No

```
//Example :: BleWhiteListDestroy.sb (See in RM1xxCodeSnippets.zip)
DIM hWhiteList : hWhiteList = BleWhiteListCreate(20,10)

IF hWhiteList!=0 THEN
  BleWhiteListDestroy(hWhiteList)
  PRINT "\nWhitelist with handle: ";hWhiteList;" destroyed"
ENDIF
```

Expected Output:

```
Whitelist with handle: -1091583777 destroyed
```

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

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5.7.2 BleConnect

FUNCTION

This function is used to make a connection to a device in peripheral mode which is actively advertising. Note that the peripheral device MUST be advertising with either ADV_IND or ADV_DIRECT_IND type of advert to be able to successfully connect.

When the connection is complete a EVBLEMSG message with msgId = 0 and context containing the handle is thrown to the *smart*BASIC runtime engine.

If the connection times out, then the event EVBLE_CONN_TIMEOUT application.

When a connection is attempted, there are other parameters that are used and the default values for those are assumed; such as scan window, scan interval, and periodicity. The default values for these 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. Most typical value – 0x0000, indicating a successful operation.
Arguments	
periphAddr$	**byRef periphAddr$ AS STRING** This is the MAC 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 of the connection attempt. If it times out, then the event EVBLE_CONN_TIMEOUT is thrown to the *smart*BASIC application.
minConnIntUs	**byVal minConnIntUs AS INTEGER.** The minimum connection interval in microseconds.
maxConnIntUs	**byVal maxConnIntUs AS INTEGER.** The maximum connection interval in microseconds.
nSuprToutUs	**byVal nSuprToutUs AS INTEGER.** The link supervision timeout for the connection in microseconds.
Interactive Command	No

```
//Example :: BleConnect.sb (See in RM1xxCodeSnippets.zip)
DIM rc, periphAddr$

'//Scan indefinitely
rc=BleScanStart(0, 0)

IF rc==0 THEN
  PRINT "\nScanning"
```


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```
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
    PRINT "\n--- Connected to device with MAC address "; StrHexize$(periphAddr$)
    PRINT "\n--- Disconnecting now"
    rc=BleDisconnect(nCtx)
  ENDIF
ENDFUNC 1
```


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```
'//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 01D8CFCF14498D
--- Disconnecting now
```

BLECONNECT is an extension function.

5.7.3 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 connection attempt.

The value is a bit mask:

Bit 0	Set if advertising is in progress (not possible with the RM1xx)
Bit 1	Set if there is already a connection in peripheral mode (not possible with the RM1xx)
Bit 2	Set if there is current connection attempt ongoing
Bit 3	Set when scanning
Bit 4	Set if there is already a connection to a peripheral

BLECONNECTCANCEL ()

Returns	INTEGER, a result code. Most typical value – 0x0000, indicating a successful operation.
Arguments	None
Interactive Command	No

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```
//Example :: BleConnectCancel.sb (See in RM1xxCodeSnippets.zip)
 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 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 \nCancel"
   ELSE
     PRINT "\nError: "; INTEGER.H'rc
   ENDIF

   '//Cancel current connection attempt
   rc=BleConnectCancel()

   PRINT "\n--- Connection attempt cancelled"
```


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```
ENDFUNC 0

ONEVENT EVBLE_ADV_REPORT  CALL HndlrAdvRpt

WAITEVENT
```

Expected Output:

```
Scanning
--- Connecting
Cancel
--- Connection attempt cancelled
```

BLECONNECTCANCEL is an extension function.

5.7.4 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 must be shared as efficiently as possible; one scheme to put in place is to have all connections parameters being integer multiples of a 'base' value. For the purpose of this documentation and discussions with Laird, this parameter is referred to as 'multi-link connection interval periodicity'.

The default settings for these parameters are as follows:

Multi-link Connection Interval Periodicity	20 milliseconds
Scan Interval	80 milliseconds
Scan Window	40 milliseconds
Scan Latency	0

Notes:

- The Scan Window and Interval are multiple integers of the periodicity (but do not have to be) and 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, therefore reading back via SYSINFO() does not accurately return the value you set.

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BLECONNECTCONFIG (configID, configValue)

Returns	INTEGER, a result code. Most typical value – 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 Slave Latency (0..1000) 5 Multi-Link Connection Interval Periodicity (20..200) 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.
Interactive Command	No

```
//Example :: BleConnectConfig.sb (See in RM1xxCodeSnippets.zip)
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
```


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```
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
```

BLECONNECTCONFIG is an extension function.

5.7.5 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. Most typical value – 0x0000, indicating a successful operation.
Arguments	
nConnHandle	**byVal *nConnHandle* AS INTEGER.** Specifies the handle of the connection that must be disconnected.
Interactive Command	No

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```
//Example :: BleDisconnect.sb (See in RM1xxCodeSnippets.zip)
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
```

BLEDISCONNECT is an extension function.

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5.7.6 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 is thrown to the *smart*BASIC runtime engine if it was successful. If the request to change the connection parameters fails, an EVBLEMSG message with msgid = 15 is thrown to the *smart*BASIC runtime engine.

BLESETCURCONNPARMS (nConnHandle, nMinIntUs, nMaxIntUs, nSuprToutUs, nSlaveLatency)

Returns	INTEGER, a result code. Most typical value – 0x0000, indicating a successful operation.
Arguments	
nConnHandle	**byVal *nConnHandle* AS INTEGER.** Specifies the handle of the connection that must have the connection parameters changed.
nMinIntUs	**byVal *nMinIntUs* AS INTEGER.** The minimum acceptable connection interval in microseconds. Valid range is 7500 to 4000000 and it must be less than or equal to nMaxIntUs
nMaxIntUs	**byVal *nMaxIntUs* AS INTEGER.** The maximum acceptable connection interval in microseconds. Valid range is 7500 to 4000000 and it must be less than or equal to nMinIntUs
nSuprToutUs	**byVal *nSuprToutUs* AS INTEGER.** The link supervision timeout for the connection in microseconds. It should be greater than the slave latency times the actual granted connection interval.
nSlaveLatency	**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.
Interactive Command	No

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 millisecond 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 e.g. 50 msec 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 polls 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.

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```
//Example :: BleSetCurConnParms.sb (See in RM1xxCodeSnippets.zip)
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=BleGetCurconnParms(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 = BleSetCurconnParms(nCtx, 50000,75000,4000000,19)
      ENDIF
    CASE 1 //BLE_EVBLEMSGID_DISCONNECT
      PRINT "\n --- Disconnected : ",nCtx
      EXITFUNC 0
    CASE 14 //BLE_EVBLEMSGID_CONN_PARMS_UPDATE
      rc=BleGetCurconnParms(nCtx,intrvl,sprvto,slat)
      IF rc==0 THEN
        PRINT "\n\nConn Interval",intrvl
        PRINT "\nConn Supervision Timeout",sprvto
        PRINT "\nConn Slave Latency",slat
      ENDIF
    CASE 15 //BLE_EVBLEMSGID_CONN_PARMS_UPDATE_FAIL
      PRINT "\n ??? Conn Parm Negotiation FAILED"
    CASE ELSE
      PRINT "\nBle Msg",nMsgId
  ENDSELECT
ENDFUNC 1
```


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```
ONEVENT EVBLEMSG  CALL HandlerBleMsg

IF BleAdvertStart(0,addr$,25,60000,0)==0 THEN
  PRINT "\nAdverts Started\n"
  PRINT "\nMake a connection to the RM1xx"
ELSE
  PRINT "\n\nAdvertisement not successful"
ENDIF
WAITEVENT
```

Expected Output (Unsuccessful Negotiation):

```
Adverts Started

Make a connection to the RM1xx
 --- 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 RM1xx
 --- 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: First set of parameters differ depending on your central device.

BLESETCURCONNPARMS is an extension function.

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5.7.7 BleGetCurConnParms

FUNCTION

This function gets the current connection parameters for the connection identified by the connection handle. Given there are three connection parameters, the function takes three variables by reference so that the function can return the values in those variables.

BLEGETCURCONNPARMS (nConnHandle, nIntervalUs, nSuprToutUs, nSlaveLatency)

Returns	INTEGER, a result code. Most typical value – 0x0000, indicating a successful operation.
Arguments	
nConnHandle	**byVal *nConnHandle* AS INTEGER.** Specifies the handle of the connection that must have the connection parameters changed
nIntervalUs	**byRef *nIntervalUs* AS INTEGER.** The current connection interval in microseconds
nSuprToutUs	**byRef *nSuprToutUs* AS INTEGER.** The current link supervision in microseconds timeout for the connection.
nSlaveLatency	**byRef *nSlaveLatency* AS INTEGER.** This is 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.
Interactive Command	No

See previous example

BLEGETCURCONNPARMS is an extension function.

5.7.8 BleGetConnHandleFromAddr

FUNCTION

Given a seven-byte Bluetooth MAC address in Little Endian format (the first byte is the type and the second byte is the most significant byte of the six-byte MAC address) this function returns a valid connection handle in the nConnHandle argument if a connection exists and an invalid one if there isn't.

BLEGETCONNHANDLEFROMADDR (addr$, nConnHandle)

Returns	INTEGER, a result code. **Typical value:** 0x0000 (indicates a successful operation)
Arguments	
addr$	**byRef *addr$* AS STRING** This is a 7-byte string which must be a valid 7-byte mac address.
nConnHandle	**byRef *nConnHandle* AS INTEGER.** The connection handle will be returned in this argument. Will be an invalid handle value if a connection does not exist.
Interactive Command	No

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```
DIM addr$ : addr$=""
DIM rc, connHandle

addr$ = "\00\00\01\64\01\02\03"
rc = BleConnHandleFromAddr(addr$,connHandle)
PRINT "\nConnection Handle = ";integer.h' connHandle
```

Expected Output:

```
Connection Handle = 0001FF00
```

BLEGETCONNHANDLEFROMADDR is an extension function.

5.7.9 BleGetAddrFromConnHandle

FUNCTION

Given a valid connection handle, a seven byte Bluetooth MAC address in Little Endian format (the first byte is the type and the second byte is the most significant byte of the six-byte MAC address) is returned which is the Bluetooth address of the connected device.

BLEGETADDRFROMCONNHANDLE (nConnHandle, addr$)

Returns	INTEGER, a result code. **Typical value:** 0x0000 (indicates a successful operation)
Arguments	
nConnHandle	**byVal *nConnHandle* AS INTEGER.** The connection handle for the connection for which the connected device address is to be returned. Note this will be a resolvable address in the case of say iOS devices.
addr$	**byRef *addr$* AS STRING** The 7-byte string will contain a valid 7-byte mac address if the connection handle provided is for a valid connection.
Interactive Command	No

```
DIM addr$ : addr$=""
DIM rc, connHandle

connHandle = 0x0001FF00
rc = BleAddrFromConnHandle (connHandle , addr$)
PRINT "\Address = ";StrHexize$(addr$)
```


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Expected Output:

```
Address = 00000164010203
```

BLEGETADDRFROMCONNHANDLE is an extension function.

5.8 Security Manager Functions

This section describes routines which manage all aspects of BLE security such as saving, retrieving, and deleting link keys and creation of those keys using pairing and bonding procedures.

5.8.1 Events and Messages

The following security manager messages are thrown to the run-time engine using the EVBLEMSG message with msgIDs as follows:

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.

To submit a passkey, use the function BLESECMNGRPASSKEY.

5.8.2 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.

BLESECMNGRPASSKEY (connHandle, nPassKey)

Returns	INTEGER, a result code. Most typical value – 0x0000, indicating a successful operation.
Arguments	
connHandle	**byVal connHandle AS INTEGER**. This is the connection handle as received via the EVBLEMSG event with msgId set to 0.
nPassKey	**byVal *nPassKey* AS INTEGER.** This is the passkey to submit to the stack. Submit a value outside the range 0 to 999999 to reject the pairing.
Interactive Command	No

```
//Example :: BleSecMngrPasskey.sb (See in RM1xxCodeSnippets.zip)

 DIM rc, connHandle
```


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```
DIM addr$ : addr$=""

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 11
      PRINT "\n +++ Auth Key Request, type=";nCtx
      rc=BleSecMngrPassKey(connHandle,123456)
      IF rc==0 THEN //key is 123456
        PRINT "\nPasskey 123456 was used"
      ELSE
        PRINT "\nResult Code 0x";integer.h'rc
      ENDIF
    CASE ELSE
  ENDSELECT
ENDFUNC 1

ONEVENT EVBLEMSG CALL HandlerBleMsg

rc=BleSecMngrIoCap(4) //Set i/o capability - Keyboard Only (authenticated pairing)
IF BleAdvertStart(0,addr$,25,0,0)==0 THEN
  PRINT "\nAdverts Started\n"
  PRINT "\nMake a connection to the RM1xx"
ELSE
  PRINT "\n\nAdvertisement not successful"
ENDIF

WAITEVENT
```

Expected Output:

```
Adverts Started

Make a connection to the RM1xx
--- Ble Connection,        1655
 +++ Auth Key Request, type=1
Passkey 123456 was used
--- Disconnected 1655
```

BLESECMNGRPASSKEY is an extension function.

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5.8.3 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. Most typical value – 0x0000, indicating a successful operation.
Arguments	
nMinKeysize	**byVal *nMinKeysize* 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.
Interactive Command	No

```
//Example :: BleSecMngrKeySizes.sb (See in RM1xxCodeSnippets.zip)
PRINT BleSecMngrKeySizes(8,15)
```

Expected Output:

```
0
```

BLESECMNGRKEYSIZES is an extension function.

5.8.4 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 related to Simple Secure Pairing as 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 4.0 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.

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BLESECMNGRIOCAP (nIoCap)

Returns	INTEGER, a result code. Most typical value – 0x0000, indicating a successful operation.
Arguments	
nIoCap	**byVal *nIoCap AS* INTEGER**. The user I/O capability for all subsequent pairings. 0 – None. Also known as Just Works (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 with Display (authenticated pairing)
Interactive Command	No

```
//Example :: BleSecMngrIoCap.sb (See in RM1xxCodeSnippets.zip)
PRINT BleSecMngrIoCap(1)
```

Expected Output:

```
0
```

BLESECMNGRIOCAP is an extension function.

5.8.5 BleSecMngrBondReq

FUNCTION

This function is used to enable or disable bonding when pairing.

Note: This function will be deprecated in future releases. It is recommended to invoke this function, with the parameter set to 0, before calling BleAuthenticate().

BLESECMNGRBONDREQ (nBondReq)

Returns	INTEGER, a result code. Most typical value – 0x0000, indicating a successful operation.
Arguments	
nBondReq	**byVal *nBondReq AS* INTEGER**. 0 Disable 1 Enable
Interactive Command	No

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```
//Example :: BleSecMngrBondReq.sb (See in RM1xxCodeSnippets.zip)
IF BleSecMngrBondReq(0)==0 THEN
  PRINT "\nBonding disabled"
ENDIF
```

Expected Output:

```
Bonding disabled
```

BLESECMNGRBONDREQ is an extension function.

5.8.6 BlePair

FUNCTION

This routine is used to start a pairing procedure with the peer. It will result in various EVBLEMSG events, such as:

BLE_EVBLEMSGID_NEW_BOND	messageId = 10
BLE_EVBLEMSGID_AUTH_KEY_REQUEST	messageId = 11
BLE_EVBLEMSGID_UPDATED_BOND	messageId = 17
BLE_EVBLEMSGID_ENCRYPTED	messageId = 18

If the pairing fails for any reason, then the connection is dropped.

BLEPAIR (nAppConnHandle, nPairType)

Returns	INTEGER, a result code. **Typical value:** 0x0000 (indicates a successful operation)	
Arguments		
nAppConnHandle	**byVal *nAppConnHandle*** AS INTEGER. This is the connection handle for the device that should be paired.	
nPairType	0	Bonding is not performed therefore the connection enters encryption but keys are not exchanged for future use.
	1	Bonding id forced (phase 3 of the pairing procedure as described in the Bluetooth specification) which means any exchanged keys are stored in the bonding manager database.
	Not 0 or 1	The type of bonding is dictated by the default setting which is set by the function BleSecMngrBondReq.
Interactive Command	No	

See example for BleDisconnect:

```
Change  "rc = BlePair(nCtx)" to  "PRINT BlePair(nCtx)"
```

BLEPAIR is an extension function.

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5.8.7 BleAuthenticate

FUNCTION

This function is internally the same as BlePair(), see details of that function, and exists for legacy reasons only.

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 been 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. Although, 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 and like most specifications are concise and difficult to understand. What follows is an attempt to familiarize the reader with those concepts using the perspective of the *smart*BASIC programming environment.

To help understand the terms services and characteristics 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 descriptor as color of the pot, whether it has a lid, whether the lid has a lock or whether it has a handle or a spout, etc. For a full list of these descriptors, see the Bluetooth SIG website. 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.

To wrap up the loose analogy, think of service as just a carrier bag to hold a group of related characteristics together where the printing on the carrier bag is a UUID. You will find that 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 differentiation 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 just an offset plus a base 128 bit UUID defined and reserved by the Bluetooth SIG) and custom service or characteristics **shall** have the full 128 bit UUID. The logic behind this is that when you come across a 16 bit UUID, it implies that a specification is 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 requirement for a central register is important to understand, in the sense that if a custom service or characteristic needs to be created, the developer can use any publicly available UUID (sometimes also known as GUID) generation utility.

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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.

Note that Laird does not warrant or 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 does intend to create custom services and/or characteristics then it is recommended that a single UUID is generated and be 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 are 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 has published a specification which defines that service or characteristic and there is a requirement that any device claiming to support them SHALL have approval to prove 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 just the provider and implementer.

A service is an abstraction of some collectivized functionality which, if broken down further into smaller components, would cease to provide the intended behavior. A couple of 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 like for example Systolic Pressure, Diastolic Pressure, Pulse Rate, and many more. Likewise, a Heart Rate service also has a collection which includes entities such as the Pulse Rate and Body Sensor Location.

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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 then it is defined and described in a similar fashion, so that 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, stated above, of a single long 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 recommendation is just for ease of maintenance.

Finally, having prepared a background to services and characteristics, the rest of this introduction will focus 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 has been described as a carrier bag that groups related characteristics together and a characteristic is just 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) needs to see those carrier bags to determine the groupings and once it has identified the pots it will only need 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' will be returned and is referred to as a char_handle. The developer will then need to keep those handles to be able to read and write and generally interact with that particular 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.

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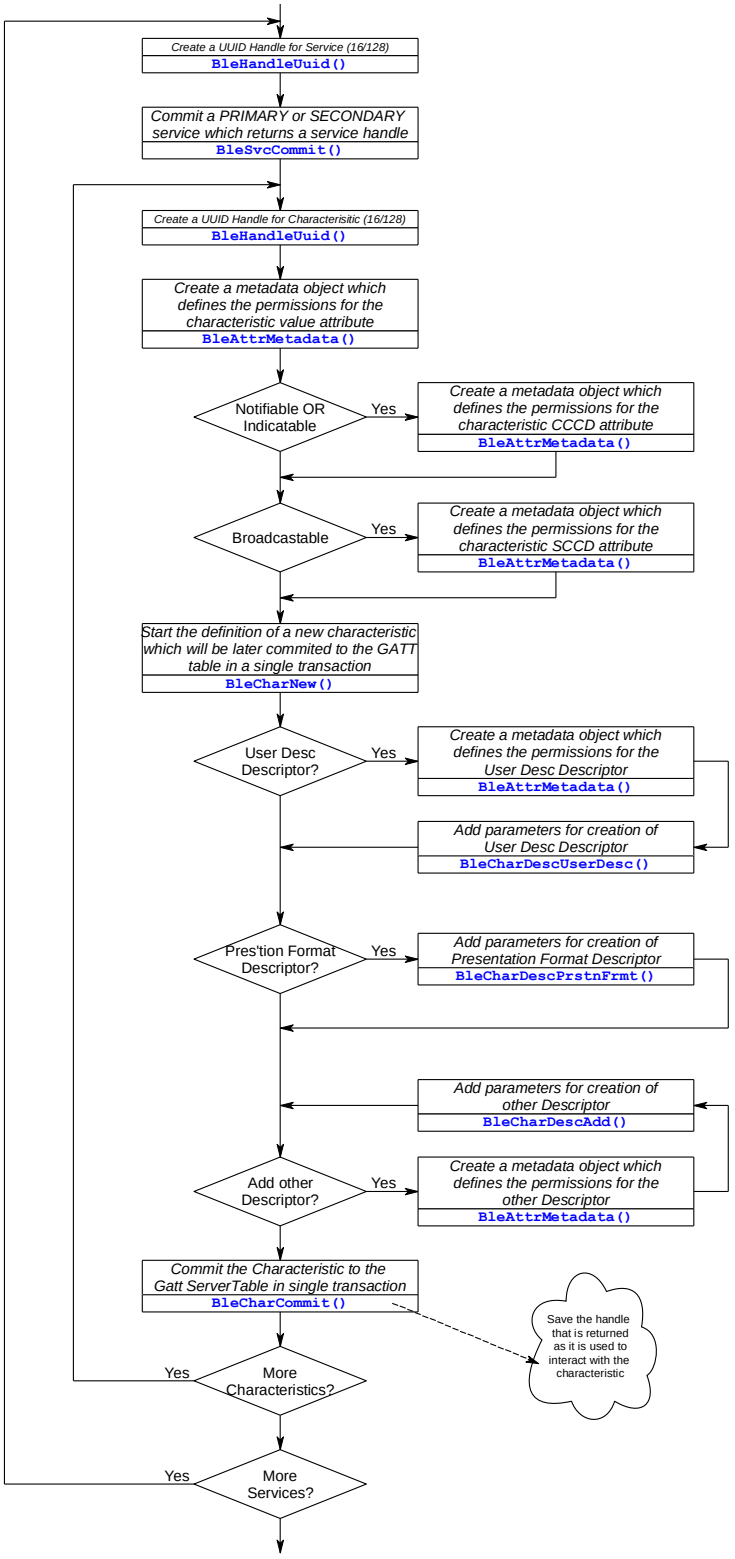
Therefore, from the *smart*BASIC app developer's **logical** perspective a GATT table looks nothing like the table that is presented in most BLE literature. Instead the GATT table is purely and simply just a collection of char_handles that reference the characteristics (data containers) which have been registered with the underlying GATT table in the BLE stack.

A particular char_handle is in turn 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 will get 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.



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```
//Example :: ServicesAndCharacteristics.sb (See in RM1xxCodeSnippets.zip)

//=========================================================================
//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
//notifyable
//=========================================================================

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 = BleSvcCommit(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
```


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```
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)

//---Register Service 2 (can now reuse the service handle)
hUuidS2 = BleHandleUuid16(0x1856)
rc = BleSvcCommit(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)
//===The 2 services are now visible in the gatt table.
//---------------------------------------------------------------------------
// 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
```


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```
  DIM attr$
  IF hChar == hChar11 THEN
   rc = BleCharValueRead(hChar11,attr$)
   print "Svc1/Char1 has been writen with = ";attr$

  ENDIF
 ENDFUNC 1

 //enable characteristic value write handler
 OnEvent EVCHARVAL     call HandlerCharVal

 WAITEVENT
```

Assuming there is a connection and notify has been enabled then 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 then 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.

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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 need to be registered, this one must only be initialized as the underlying BLE stack unconditionally registers it when starting up.

The GAP service contains five characteristics as listed at the following website:
http://developer.bluetooth.org/gatt/services/Pages/ServiceViewer.aspx?u=org.bluetooth.service.generic_access.xml

A central only role module will never be a peripheral so the 'Peripheral Preferred Connection Parameters' characteristic, which is optional will not be exist and so the last four parameters of this function are ignored and exist only to maintain compatibility with the RM1xx firmware. In future when 4.1 compatible firmware is available it will make sense again.

BLEGAPSVCINIT (deviceName, nameWritable, nAppearance, nMinConnInterval, nMaxConnInterval, nSupervisionTout, nSlaveLatency)

Returns	INTEGER, a result code. Most typical value – 0x0000, indicating a successful operation.
Arguments	
deviceName	**byRef *deviceName* AS STRING** The name of the device (e.g. 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. It is recommended 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** This parameter is ignored in this module. The preferred minimum connection interval, updates the 'Peripheral Preferred Connection Parameters' characteristic of the GAP service. Range is between 7500 and

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	4000000 microseconds (rounded to the nearest 1250 microseconds). This must be smaller than nMaxConnInterval.
nMaxConnInterval	**byVal *nMaxConnInterval* AS INTEGER** This parameter is ignored in this module. 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.
nSupervisionTimeout	**byVal *nSupervisionTimeout* AS INTEGER** This parameter is ignored in this module. 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).
nSlaveLatency	**byVal *nSlaveLatency* AS INTEGER** This parameter is ignored in this module. 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
Interactive Command	No

```
//Example :: BleGapSvcInit.sb (See in RM1xxCodeSnippets.zip)

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
```


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Expected Output:

```
Success
```

BLEGAPSVCINIT is an extension function.

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 can 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
Interactive Command	No

```
//Example :: BleGetDeviceName$.sb (See in RM1xxCodeSnippets.zip)

DIM rc,dvcNme$,nmeWrtble,apprnce,MinConnInt,MaxConnInt,ConnSupTO,sL

PRINT "\n --- DevName : "; BleGetDeviceName$()

// Changing device name manually
dvcNme$= "My RM1xx"
nmeWrtble = 0
apprnce = 768
MinConnInt = 500000
MaxConnInt = 1000000
ConnSupTO = 4000000
sL = 0

rc = BleGapSvcInit(dvcNme$,nmeWrtble,apprnce,MinConnInt,MaxConnInt,ConnSupTO,sL)
PRINT "\n --- New DevName : "; BleGetDeviceName$()
```


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Expected Output:

```
--- DevName : LAIRD RM1xx
--- New DevName : My RM1xx
```

BLEGETDEVICENAME$ is an extension function.

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 RM1xx: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$, pnpId$)

FUNCTION

Returns	INTEGER, a result code. Most typical value – 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$* AS STRING** The device system ID as defined in the specifications. Can be set empty to omit submission. Otherwise it shall be a string exactly 8 octets long, where: Byte 0..4 – Manufacturer Identifier Byte 5..7 – Organisationally Unique Identifier For the special case of the string being exactly one character long and containing @, the system ID is created from the MAC address if (and only if) an IEEE public address is set. If the address is the random static variety, this characteristic is omitted.
regDataList$	**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.

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pnpId$	byVal *pnpId$* 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)
Interactive Command	No

```
//Example :: BleSvcRegDevInfo.sb (See in RM1xxCodeSnippets.zip)

 DIM rc,manfNme$,mdlNum$,srlNum$,hwRev$,swRev$,sysId$,regDtaLst$,pnpId$

 manfNme$ = "Laird Technologies"
 mdlNum$ = "RM1xx"
 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
```

BLESVCREGDEVINFO is an extension function.

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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 (16byte) 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 shall be treated by the developer as an opaque entity and no further logic shall be based on the bit content, apart from all 0s which represents 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 will be treated as an offset into the Bluetooth SIG 128-bit base UUID.
Interactive Command	No

```
//Example :: BleHandleUuid16.sb (See in RM1xxCodeSnippets.zip)
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)
```

BLEHANDLEUUID16 is an extension function.

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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 (two byte) offset into a new 128-bit base UUID.

The base UUID is basically 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.

Please ensure that you use a 16 byte UUID that has been generated using a random number generator with sufficient entropy to minimize duplication, as stated in an earlier section and that the first byte of the array is the most significant byte of the UUID.

BLEHANDLEUUID128stUuid (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 – that is, big endian format.
Interactive Command	No

```
//Example :: BleHandleUuid128.sb (See in RM1xxCodeSnippets.zip)
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)
```


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```
// and an offset = 0xd913
```

Expected Output:

```
Handle for custom Uuid is FC03D913 (-66856685)
```

BLEHANDLEUUID128 is an extension function.

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 0s 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 BleHandleUui16() or BleHandleUuid128().
nUuid16	**byVal *nUuid16* AS INTEGER** A UUID value in the range 0 t0 65535 which will be treated as an offset into the 128-bit base UUID referenced by nUuidHandle.
Interactive Command	No

```
//Example :: BleHandleUuidSibling.sb (See in RM1xxCodeSnippets.zip)
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;")"
```


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```
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)
```

BLEHANDLEUUIDSIBLING is an extension function.

5.9.8 BleSvcCommit

This function is now deprecated. Use BleServiceNew() & BleServiceCommt() instead.

5.9.9 BleServiceNew

FUNCTION

As explained in an earlier section, a service in the context of a GATT table is just 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 shall 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 is precreated using one of these functions: BleHandleUuid16(), BleHandleUuid128(), or BleHandleUuidSibling().

Note that 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

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itself is just 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 BleSvcCommit() 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. Most typical value – 0x0000, indicating a successful operation.
Arguments	
nSvcType	**byVal *nSvcType* AS INTEGER** This will be 0 for a SECONDARY service and 1 for a PRIMARY service and all other values are reserved for future use and will result in this function failing with an appropriate result code.
nUuidHandle	**byVal *nUuidHandle* 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 will have been pre-created using one of the three functions: BleHandleUuid16(), BleHandleUuid128() or BleHandleUuidSibling()
hService	**byRef hService AS INTEGER** If the Service attribute is created in the GATT table then this will contain 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.
Interactive Command	No

```
//Example :: BleServiceNew.sb (See in RM1xxCodeSnippets.zip)

#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
```


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```
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
```

BLESERVICENEW is an extension function.

5.9.10 BleServiceCommit

This function in the RM1xx is a dummy function and does not do anything. However, for portability to other Laird 4.0 compatible modules, always invoke this function after the last descriptor of the last characteristic of a service has been committed to the GATT server.

BLESERVICECOMMIT (hService)

Returns	INTEGER, a result code. Most typical value – 0x0000, indicating a successful operation.

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Arguments	
hService	**byVal hService AS INTEGER** This handle will have been returned from BleServiceNew()
Interactive Command	No

5.9.11 BleSvcAddIncludeSvc

FUNCTION

Note: This function is currently not available for use on the RM1xx.

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 and the only difference is that when a GATT client queries a device for all services it does not get any 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. Hence 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.

Further note that if a service has INCLUDED services, then they are 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 is present before any characteristic attributes within a particular service group declaration.

BleSvcAddIncludeSvc (hService)

Returns	INTEGER, a result code. Most typical value – 0x0000, indicating a successful operation.
Arguments	
hService	**byVal hService AS INTEGER** This argument will contain a handle that was previously created using the function BleSvcCommit()
Interactive Command	No

```
//Example :: BleSvcAddIncludeSvc.sb (See in RM1xxCodeSnippets.zip)
```


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```
#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 = BleSvcCommit(BLE_SERVICE_SECONDARY,BleHandleUuid16(0x180F),hBatSvc)
rc = BleCharNew(3,BleHandleUuid16(0x2A1C),charMet,0,0)
rc = BleCharCommit(hBatSvc, s$ ,hBatChar)

//------------------------------------------------------------------------
//Create a Health Thermometer PRIMARY service attribure which has a uuid of 0x1809
//------------------------------------------------------------------------
DIM hHtsSvc  //composite handle for hts primary service

rc = BleSvcCommit(BLE_SERVICE_PRIMARY,BleHandleUuid16(0x1809),hHtsSvc)

//Have to add includes before any characteristics are committed
PRINT INTEGER.h'BleSvcAddIncludeSvc(hBatSvc)
```

BleSvcAddIncludeSvc is an extension function.

5.9.12 BleAttrMetadata

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 are added.

This function allows a 32-bit integer to be created (an opaque object) which defines those properties and is then submitted along with other information to add the attribute to the GATT table.

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When adding a service attribute (not the whole service, in this 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 two 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 must be able to enable or disable it. This is done through a Characteristic Descriptor, another attribute. The attribute also needs 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 (CCCD). 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 be capable of broadcasting its value data in advertisements. For the GATT client to be able to control this, there is 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 (SCCD). 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 behavior, a separate API function is also supplied to add that to the GATT table and when setting up a metadata object must be supplied.

In a nutshell, think of a metadata object as a note to define how an attribute behaves and the GATT table manager needs that before it is added. Some attributes have those 'notes' specified by the BT specification and so the GATT table manager does not need to be provided with any, but the rest require it.

This function helps write that metadata.

BLEATTRMETADATA (nReadRights, nWriteRights, nMaxDataLen, fIsVariableLen, 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 MITM protection
4	Signed with MITM protection (not available)
5	Signed with MITM protection (not available)

Note: In early releases of the firmware, 4 and 5 are not available.

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nWriteRights	**byVal *nWriteRights* AS INTEGER** This specifies the write 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 MITM protection 4 – Signed with MITM protection (not available) 5 – Signed with MITM protection (not available) **Note:** In early releases of the firmware, 4 and 5 are not available.
nMaxDataLen	**byVal *nMaxDataLen* 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. At the time of writing, the limit is 20 bytes.
fIsVariableLen	**byVal *fIsVariableLen* AS INTEGER** Set this to non-zero only if you want the attribute to automatically shorten its length according to the number of bytes written by the client. For example, if the initial length is two and the client writes one byte, then if this is 0, only the first byte is updated and the rest remains unchanged. If this parameter is set to one, then when a single byte is written the attribute shortens its length to accommodate. If the client tries to write more bytes than the initial maximum length, then the client receives an error response.
resCode	**byRef resCode AS INTEGER** This variable will be updated with result code which will be 0 if a metadata object was successfully returned by this call. Any other value implies a metadata object did not get created.
Interactive Command	No

```
//Example :: BleAttrMetadata.sb (See in RM1xxCodeSnippets.zip)

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
```


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```
mdVal=BleAttrMetadata(17,0,20,0,rc)
//There is a CCCD and SCCD in this characteristic
mdCccd=BleAttrMetadata(1,2,2,0,rc)
mdSccd=BleAttrMetadata(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
```

BLEATTRMETADATA is an extension function.

5.9.13 BleCharNew

FUNCTION

When a characteristic is to be added to a GATT table, multiple attribute 'objects' must be precreated. After they are all 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. Most typical value – 0x0000, indicating a successful operation.
Arguments	
nCharProps	**byVal *nCharProps* 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:

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 response
3	Can be written
4	Can be notifiable (CCCD descriptor must be present)

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	5	Can be indicatable (CCCD descriptor must be present)
	6	Can accept signed writes
	7	Reliable writes
nUuidHandle	**byVal *nUuidHandle* 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()	
mdVal	**byVal *mdVal* AS INTEGER** This is the mandatory metadata that is used to define the properties of the Value attribute that is created in the characteristic and is pre-created using the help of the function BleAttrMetadata().	
mdCccd	**byVal *mdCccd* 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 nCharProps specifies that the characteristic is notifiable or indicatable and this value contains 0, this function aborts with an appropriate result code.	
mdSccd	**byVal *mdSccd* 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 nCharProps specifies that the characteristic is broadcastable and this value contains 0, this function aborts with an appropriate resultcode.	
Interactive Command	No	

```
// Example :: BleCharNew.sb (See in RM1xxCodeSnippets.zip)
DIM rc
DIM charUuid : charUuid = BleHandleUuid16(2)     //Characteristic's UUID
DIM mdVal : mdVal = BleAttrMetadata(1,0,20,0,rc)  //Metadata for value attribute
DIM mdCccd : mdCccd = BleAttrMetadata(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"
```


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```
ELSE
  PRINT "\nFailed"
ENDIF
```

Expected Output:

```
New Characteristic created
```

BLECHARNEW is an extension function.

5.9.14 BleCharDescUserDesc

FUNCTION

This function adds an optional User Description descriptor to a characteristic and can only be called after BleCharNew() has started 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 to be so. 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. Most typical value – 0x0000, indicating a successful operation.
Arguments	
userDesc$	**byRef *userDesc$* AS STRING** The user description string with which to initialise 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 BleAttrMetadata(). If the write rights are set to one 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.
Interactive Command	No

```
//Example :: BleCharDescUserDesc.sb (See in RM1xxCodeSnippets.zip)
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
```


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```
//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
```

BLECHARDESCUSERDESC is an extension function.

5.9.15 BleCharDescPrstnFrmt

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. Most typical value – 0x0000, indicating a successful operation.
Arguments	
nFormat	**byVal *nFormat* AS INTEGER** Valid range 0 to 255.

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	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. At the time of writing, the enumeration list is as follows:

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** Valid range -128 to 127. 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: *actual value = Characteristic Value * 10 to the power of nExponent.*
nUnit	**byVal *nUnit* AS INTEGER** Valid range 0 to 65535. 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
nNameSpace	**byVal *nNameSpace* AS INTEGER** Valid range 0 to 255. 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
nNSdesc	**byVal *nNSdesc* AS INTEGER** Valid range 0 to 65535. This value is a description of the organisation specified by nNameSpace.
Interactive Command	No

```
//Example :: BleCharDescPrstnFrmt.sb (See in RM1xxCodeSnippets.zip)

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
```


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```
//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
```

BLECHARDESCPRSTNFRMT is an extension function.

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5.9.16 BleCharDescAdd

Note: This function has a bug for firmware versions prior to 1.4.X.Y.

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. Most typical value – 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 0x2908, 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 will be 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 one or greater, then the attribute is marked as writable and so the client is to modify the attribute value.
Interactive Command	No

```
//Example :: BleCharDescAdd.sb (See in RM1xxCodeSnippets.zip)

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
```


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```
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
```

BLECHARDESCADD is an extension function.

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5.9.17 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 is 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.

Please note that in reality, 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. Most typical value – 0x0000, indicating a successful operation.
Arguments	
hService	**byVal hService AS INTEGER** This is the handle of the service that this characteristic belongs to, 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 so 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 *smart*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 which characteristic the message is intended for. See event messages: EVCHARHVC, EVCHARVAL, EVCHARCCCD, EVCHARSCCD, EVCHARDESC.
Interactive Command	No

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```
// Example :: BleCharCommit.sb (See in RM1xxCodeSnippets.zip)

#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=BleSvcCommit(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

//the characteristic will now be visible in the GATT table
//and is refrenced by 'hHtsMeas' for subsequent calls
```


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Expected Output:

```
Characteristic Committed
```

BLECHARCOMMIT is an extension function.

5.9.18 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 is 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 and so this function is most often accessed from the handler that services that event.

BLECHARVALUEREAD (charHandle, attr$)

Returns	INTEGER, a result code. Most typical value – 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.
Interactive Command	No

```
//Example :: BleCharValueRead.sb (See in RM1xxCodeSnippets.zip)

DIM hMyChar,rc, conHndl

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

  //commit service
  rc=BleSvcCommit(1,BleHandleUuid16(0x18EE),hSvc)
  //initialise char, write/read enabled, accept signed writes
```


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```
    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$,hMyChar)
    //initialise scan report
    rc=BleScanRptInit(scRpt$)
    //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 connnection handle
  //=========================================================================
  FUNCTION HndlrBleMsg(BYVAL nMsgId, BYVAL nCtn)
    conHndl=nCtn
  ENDFUNC 1


  IF OnStartup()==0 THEN
    DIM at$ : rc = BleCharValueRead(hMyChar,at$)
```


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```
   PRINT "\nCharacteristic value attribute: ";at$;"\nConnect to RM1xx 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 RM1xx and send a new value

New characteristic value: Laird
Exiting...
```

BLECHARVALUEREAD is an extension function.

5.9.19 BleCharValueWrite

Note: For firmware versions prior to 1.4.x.x, the module must be in a connection for this function to work.

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. Most typical value – 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.

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Interactive Command	No

```
//Example :: BleCharValueWrite.sb (See in RM1xxCodeSnippets.zip)

 DIM hMyChar,rc

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

   //commit service
   rc=BleSvcCommit(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)
 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$)
   IF BleCharValueWrite(hMyChar,t$)==0 THEN
     PRINT "\nNew characteristic value: ";t$
   ELSE
     PRINT "\nFailed to write new characteristic value"
   ENDIF
```


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```
ENDFUNC 0

IF OnStartup()==0 THEN
  DIM at$ : rc = BleCharValueRead(hMyChar,at$)
  PRINT "\nCharacteristic value attribute: ";at$;"\nSend 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...
```

BLECHARVALUEWRITE is an extension function.

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. Most typical value – 0x0000, indicating a successful operation.

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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 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.
Interactive Command	No

```
//Example :: BleCharValueNotify.sb (See in RM1xxCodeSnippets.zip)

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=BleSvcCommit(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$,hMyChar)
  rc=BleScanRptInit(scRpt$)
  //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
```


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```
//=========================================================================
// 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
```


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```
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 RM1xx will then notify your device of 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 RM1xx 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...
```

BLECHARVALUENOTIFY is an extension function.

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().

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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. Most typical value – 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 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.
Interactive Command	No

```
//Example :: BleCharValueIndicate.sb (See in RM1xxCodeSnippets.zip)

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=BleSvcCommit(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$,hMyChar)
  rc=BleScanRptInit(scRpt$)
  //Add 1 service handle to scan report
  rc=BleAdvRptAddUuid16(scRpt$,0x18EE,-1,-1,-1,-1,-1)
  //commit reports to GATT table - adRpt$ is empty
```


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```
  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
```


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```
  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 RM1xx will then indicate a new characteristic value\n"
ELSE
  PRINT "\nFailure OnStartup"
ENDIF


WAITEVENT

rc=BleDisconnect(conHndl)
rc=BleAdvertStop()
PRINT "\nExiting..."
```


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Expected Output:

```
Characteristic Value: Hi
You can connect and write to the CCCD characteristic.
The RM1xx 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...
```

BLECHARVALUEINDICATE is an extension function.

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. Most typical value – 0x0000, indicating a successful operation.
Arguments	
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 is 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 applicable UUID handle of the descriptor.

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attr$	**byRef attr$ AS STRING** On exit this string variable contains the new value from the characteristic descriptor.
Interactive Command	No

```
//Example :: BleCharDescRead.sb (See in RM1xxCodeSnippets.zip)
 DIM rc,conHndl,hMyChar
 //---------------------------------------------------------------------------
 //Create some PRIMARY service attribure which has a uuid of 0x18FF
 //---------------------------------------------------------------------------
 SUB OnStartup()
   DIM hSvc,attr$,scRpt$,adRpt$,addr$
   rc=BleSvcCommit(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$="You can change this"
   rc=BleCharDescAdd(0x2999,s$,BleAttrMetadata(1,1,20,1,rc))

   //commit characteristic
   attr$="\00" //no initial alert
   rc = BleCharCommit(hSvc,attr$,hMyChar)
   rc=BleScanRptInit(scRpt$)
   //Add 1 char handle to scan report
   rc=BleAdvRptAddUuid16(scRpt$,hMyChar,-1,-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
```


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```
//=========================================================================
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..."
```


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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...
```

BLECHARDESCREAD is an extension function.

5.10 GATT Client Functions

This section describes all functions related to GATT client capability which enables interaction with GATT servers at the other end of the BLE connection. The Bluetooth Specification 4.0 and newer allows for a device to be a GATT server and/or GATT client simultaneously and the fact that a peripheral mode device accepts a connection and in all use cases has a GATT server table does not preclude it from interacting with a GATT table in the central role device which is connected to it.

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 and the best way is to see it as a table consisting of many rows and three visible columns (handle, type, value) and at least one more column which is not visible but the 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.

Basically, a table should be scanned from top to bottom and the specification stipulates that the 16-bit handle field contains values in the range 1 to 65535 and are in ascending order and 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, the next row will contain the value for that characteristic and then after that there may be 0 or more descriptors.

This means each characteristic shall consist 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

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Handle	Type	Value	Comments
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
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
0x00111	0x2906	Value (valid range)	Descriptor 4 (Range)

A color highlighted example of a GATT server table is shown above which shows there are three services (at handles 0x0001,0x0008 and 0x000B) because there are three rows where the Type = 0x2803 and 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, you can see 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, see characteristic at row with handle = 0x0004 which has the mandatory value row and then 2 descriptors.

The Bluetooth specification allows for multiple instances of the same service or characteristics or descriptors and they are differentiated by the unique handle. Hence when a handle is known there is no ambiguity.

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Each GATT server table will allocate 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 one and another with some other arbitrary random value. The specification DOES however stipulate that once the handle values are allocated they be 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 and of their handles, so 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.

In a nutshell, the table scanning process will reveal characteristic handles (as handles of handles) and these are then 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 encapsulated approach is to ensure 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 will be delivered asynchronously as an event for which a handler will have to be specified in the user *smart*BASIC application.

The rest of this chapter describes all the GATT client commands, responses and events in detail 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. Due to the connection intervals being vastly slower than the speed of the CPU, responses can arrive many tens of milliseconds after the procedure was triggered, which 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 shall be dropped as no further Gatt Client transaction can be initiated.

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5.10.1.1 EVATTRWRITE event message

This event message is thrown if BleGattcWrite() returns a success. The message contains the following three 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.

0x0000	Success
0x0001	Unknown or not applicable status
0x0100	ATT Error: Invalid Error Code
0x0101	ATT Error: Invalid Attribute Handle
0x0102	ATT Error: Read not permitted
0x0103	ATT Error: Write not permitted
0x0104	ATT Error: Used in ATT as Invalid PDU
0x0105	ATT Error: Authenticated link required
0x0106	ATT Error: Used in ATT as Request Not Supported
0x0107	ATT Error: Offset specified was past the end of the attribute
0x0108	ATT Error: Used in ATT as Insufficient Authorisation
0x0109	ATT Error: Used in ATT as Prepare Queue Full
0x010A	ATT Error: Used in ATT as Attribute not found
0x010B	ATT Error: Attribute cannot be read or written using read/write blob requests
0x010C	ATT Error: Encryption key size used is insufficient
0x010D	ATT Error: Invalid value size
0x010E	ATT Error: Very unlikely error
0x010F	ATT Error: Encrypted link required
0x0110	ATT Error: Attribute type is not a supported grouping attribute
0x0111	ATT Error: Encrypted link required
0x0112	ATT Error: Reserved for Future Use range #1 begin
0x017F	ATT Error: Reserved for Future Use range #1 end
0x0180	ATT Error: Application range begin
0x019F	ATT Error: Application range end
0x01A0	ATT Error: Reserved for Future Use range #2 begin
0x01DF	ATT Error: Reserved for Future Use range #2 end
0x01E0	ATT Error: Reserved for Future Use range #3 begin
0x01FC	ATT Error: Reserved for Future Use range #3 end

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0x01FD	ATT Common Profile and Service Error: Client Characteristic Configuration Descriptor (CCCD) improperly configured
0x01FE	ATT Common Profile and Service Error: Procedure Already in Progress
0x01FF	ATT Common Profile and Service Error: Out of Range

5.10.1.2 EVGATTCTOUT event message

This event message is thrown if a GATT Client transaction takes longer than 30 seconds. It contains the following INTEGER parameter

- Connection Handle

```
//Example :: EVGATTCTOUT.sb (See in RM1xxCodeSnippets.zip)
//

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
```


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```
  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
. . .
. . .
```

5.10.2 BleGattcOpen

FUNCTION

This function is used to initialize 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 and given that a majority of RM1xx use cases do not use it, the sacrifice of 300 bytes, which is nearly 15% of the available memory, is not worth the permanent allocation of memory.

There are various buffers that need to be created that are needed for scanning a remote GATT table which are of fixed size. There is however, one buffer which can be configured by the *smart*BASIC apps developer and that is the ring buffer that is used to store incoming notifiable and indicatable characteristics. At the

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time of writing this user manual the default minimum size is 64 unless a bigger one is desired and in that case the input parameter to this function specifies that size. A maximum of 2048 bytes is allowed, but that can result in unreliable operation as the *smart*BASIC runtime engine is starved of memory very quickly.

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 I 2019 and 2020 respectively.

Note: When the ring buffer for the notifiable and indicatable characteristics is full, then any new messages are discarded and 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 and any existing GATT client operations are not interrupted.

It is recommended that this function NOT be called when in a connection.

BLEGATTCOPEN (nNotifyBufLen, nFlags)

Returns	INTEGER, a result code. Most typical value – 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 buffer is full then the Handle Value confirmation will only be sent when BleGattcNotifyRead() is called to read the ring buffer. Bit 1..31 : Reserved for future use and must be set to 0s
Interactive Command	No

```
 //Example :: BleGattcOpen.sb (See in RM1xxCodeSnippets.zip)
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)
```


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```
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
```

BLEGATTCOPEN is an extension function.

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 is not called when in a connection.

BLEGATTCCLOSE ()

Arguments	None
Interactive Command	No

```
//Example :: BleGattcClose.sb (See in RM1xxCodeSnippets.zip)

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"
```


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Expected Output:

```
Gatt Client is now open
Gatt Client is now closed
Gatt Client is closed - was safe to call when already closed
```

BLEGATTCCLOSE is an extension subroutine.

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 and 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 100s of milliseconds, and 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.

5.10.4.1 EVDISCPRIMSVC message

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 more services were discovered because the end of the table was reached, then all parameters contain 0 except for the Connection Handle.

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 results 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
```


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```
       Else Process information then
     call BleDiscServiceNext()
         if BleDiscServiceNext() not OK then scan complete

Call BleDiscServiceFirst()
If BleDiscServiceFirst() ok then Wait for EVDISCPRIMSVC
```

BLEDISCSERVICEFIRST (connHandle, startAttrHandle, uuidHandle)

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 *smart*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 has the connection handle.
startAttrHandle	**byVal *startAttrHandle* AS INTEGER** This is the attribute handle from where the scan for primary services starts 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 is generated either by BleHandleUuid16() or BleHandleUuid128() or BleHandleUuidSibling().

BLEDISCSERVICENEXT (nConnHandle)

Calling this assumes that BleDiscServiceFirst () has been 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 *smart*BASIC runtime engine containing the results. A non-zero return value implies an EVDISCPRIMSVC message is not thrown.
Arguments	
nConnHandle	**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 has the connection handle.
Interactive Command	No

```
//Example :: BleDiscServiceFirst.Next.sb (See in RM1xxCodeSnippets.zip)
//
//Remote server has 5 prim services with 16 bit uuid and 3 with 128 bit uuids
```


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```
// 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"
```


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```
    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

//============================================================================
// EVDISCPRIMSVC event handler
//============================================================================
FUNCTION HandlerPrimSvc(cHndl,svcUuid,sHndl,eHndl) AS INTEGER
  PRINT "\nEVDISCPRIMSVC :"
  PRINT " cHndl=";cHndl
```


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```
  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 EVDISCPRIMSVC   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"
```


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```
ENDIF

WAITEVENT
PRINT "\nExiting..."
```

Expected Output:

```
Advertising, and Gatt Client is open

- Connected, so scan remote Gatt Table for ALL services
EVDISCPRIMSVC : cHndl=2804 svcUuid=FE01FE01 sHndl=1 eHndl=3
EVDISCPRIMSVC : cHndl=2804 svcUuid=FC033344 sHndl=4 eHndl=6
EVDISCPRIMSVC : cHndl=2804 svcUuid=FE01DEAD sHndl=7 eHndl=9
EVDISCPRIMSVC : cHndl=2804 svcUuid=FB04BEEF sHndl=10 eHndl=12
EVDISCPRIMSVC : cHndl=2804 svcUuid=FC033344 sHndl=13 eHndl=15
EVDISCPRIMSVC : cHndl=2804 svcUuid=FE01DEAD sHndl=16 eHndl=18
EVDISCPRIMSVC : cHndl=2804 svcUuid=FE01FE03 sHndl=19 eHndl=21
EVDISCPRIMSVC : cHndl=2804 svcUuid=FE01DEAD sHndl=22 eHndl=24
EVDISCPRIMSVC : cHndl=2804 svcUuid=00000000 sHndl=0 eHndl=0
Scan complete
Scan for service with uuid = 0xDEAD
EVDISCPRIMSVC : cHndl=2804 svcUuid=FE01DEAD sHndl=7 eHndl=9
EVDISCPRIMSVC : cHndl=2804 svcUuid=FE01DEAD sHndl=16 eHndl=18
EVDISCPRIMSVC : 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...
```

BLEDISCSERVICEFIRST and BLEDISCSERVICENEXT are both extension functions.

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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 be registered as the discovered characteristics information is passed back in that message be registered as the discovered characteristics information is passed back in that message be registered as the discovered characteristics information is passed back in that message be registered as the discovered characteristics information is passed back in that message.

A generic or UUID-based scan can be initiated. The former scans for all characteristics and the latter 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 instead it is known that a GATT table has a specific service and a specific characteristic, then a more efficient method for locating details of that characteristic is to use the function BleGattcFindChar() which 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 100s of milliseconds, and 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.

5.10.5.1 EVDISCCHAR event message

This event message is thrown if either BleDiscCharFirst() or BleDiscCharNext() returns a success. The message contains five 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 0 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

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Bit 7	Set if RELIABLE_WRITE is enabled
Bit 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 will always be 0.

BLEDISCCHARFIRST (nConnHandle, charUuidHandle, startAttrHandle, endAttrHandle)

A typical pseudo code for discovering characteristic involves first calling BleDiscCharFirst() with information obtained from a primary services scan and then waiting for the EVDISCCHAR event message and depending on the information returned in that message calling BleDiscCharNext() which 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. Typical value – 0x0000, indicating a successful operation and it means an EVDISCCHAR event message is thrown by the *smart*BASIC runtime engine containing the results. A non-zero return value implies an EVDISCCHAR message is not thrown.
Arguments	
nConnHandle	**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 will have been returned in the EVBLEMSG event message with msgId == 0 and msgCtx will have been 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 will have been generated either by BleHandleUuid16() or BleHandleUuid128() or BleHandleUuidSibling().
startAttrHandle	**byVal *startAttrHandle* AS INTEGER** This is the attribute handle from where the scan for characteristic will be started and will have been 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 will have been acquired by doing a primary services scan, which returns the start and end handles of services.
Interactive Command	No

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BLEDISCCHARNEXT (nConnHandle)

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. Most typical value – 0x0000, indicating a successful operation and it means an EVDISCCHAR event message is thrown by the *smart*BASIC runtime engine containing the results. A non-zero return value implies an EVDISCCHAR message is not thrown.
Arguments	
nConnHandle	**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 will have been returned in the EVBLEMSG event message with msgId == 0 and msgCtx will have been the connection handle.
Interactive Command	No

```
//Example :: BleDiscCharFirst.Next.sb (See in RM1xxCodeSnippets.zip)
//
//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
//============================================================================
```


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```
// 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 characeristic 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
```


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```
        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
    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
```


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```
  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 EVDISCPRIMSVC   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..."
```


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Expected Output:

```
Advertising, and Gatt Client is open

- Connected, so scan remote Gatt Table for first service
- and a characeristic scan will be initiated in the event
EVDISCPRIMSVC : 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...
```

BLEDISCCHARFIRST and BLEDISCCHARNEXT are both extension functions.

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5.10.6 BleDiscDescFirst/BleDiscDescNext

FUNCTIONS

These functions are used to scan the remote GATT server for descriptors in a characteristic with the help of the EVDISCDESC be registered as the discovered descriptor information is passed back in that. be registered as the discovered descriptor information is passed back in that. be registered as the discovered descriptor information is passed back in that.

A generic or UUID-based scan can be initiated. The former scans for all descriptors and the latter 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 a more efficient method for locating details of that characteristic is to use the function BleGattcFindDesc() which 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 100s of milliseconds, and while this is in progress it is safe to do other non-GATT related operations like for example servicing sensors and displays or any of the onboard peripherals.

5.10.6.1 EVDISCDESC event message

This event message is thrown if either BleDissDescFirst() or BleDiscDescNext() returns a success. The message contains the following three 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 0 except the Connection Handle.

'**Descriptor Uuid Handle**' contains the UUID of the descriptor and supplied as a handle.

'**Handle for the Descriptor in the remote GATT table**' is the handle for the descriptor, and also is the value to store to keep track of important characteristics in a GATT server for later read/write operations.

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 and depending on the information returned in that message calling BleDiscDescNext() which in turn will result 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()
```


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```
          if BleDiscDescNext() not OK then scan complete


Call BleDiscDescFirst( --information from EVDISCCHAR )
If BleDiscDescFirst() ok then Wait for EVDISCDESC
```

BLEDISCDESCFIRST (nConnHandle, descUuidHandle, charValHandle)

Returns	INTEGER, a result code. Most typical value – 0x0000, indicating a successful operation 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	
nConnHandle	**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 is acquired from an EVDISCCHAR event.
Interactive Command	No

BLEDISCDESCNEXT (nConnHandle)

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. Most typical value – 0x0000, indicating a successful operation 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	
nConnHandle	**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.
Interactive Command	No

```
//Example :: BleDiscDescFirst.Next.sb (See in RM1xxCodeSnippets.zip)
//
//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
```


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```
// 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 characeristic 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 descritors with uuid = 0xDEAD"
```


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```
      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
    eAttr = eHndl
    rc = BleDiscCharFirst(conHndl,0,sAttr,eAttr)
    IF rc != 0 THEN
      PRINT "\nScan characteristics failed"
      EXITFUNC 0
    ENDIF
  ENDIF
endfunc 1
'//===========================================================================
```


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```
// 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
//=============================================================================
```


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```
// Main() equivalent
//===============================================================================
ONEVENT EVBLEMSG      CALL HndlrBleMsg
OnEvent EVDISCPRIMSVC   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..."
```


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Expected Output:

```
Advertising, and Gatt Client is open

- Connected, so scan remote Gatt Table for first service
- and a characeristic 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 descritors 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...
```

BLEDISCDESCFIRST and BLEDISCDESCNEXT are both extension functions.

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5.10.7 BleGattcFindChar

FUNCTION

This function facilitates a quick and 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 EVFINDCHARrd instance of a service with the same UUID. It's 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 100s of milliseconds, and 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 will be a future enhancement.

5.10.7.1 EVFINDCHAR event message

This event message is thrown if BleGattcFindChar() returns a success. The message contains the following four 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 will contain 0 except for Connection Handle.

'**Characteristic Properties**' contains the properties of the characteristic and is a bit mask:

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
Bit 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.

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A typical pseudo code for finding a characteristic involves calling BleGattcFindChar() which in turn results 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
```

BLEGATTCFINDCHAR (nConnHandle, svcUuidHndl, svcIndex, charUuidHndl, charIndex)

Returns	INTEGER, a result code. Most typical value – 0x0000, indicating a successful operation and it means an EVFINDCHAR event message is thrown by the *smart*BASIC runtime engine containing the results. A non-zero return value implies an EVFINDCHAR message is not thrown.
Arguments	
nConnHandle	**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, etc.
charUuidHndl	**byVal *charUuidHndl* AS INTEGER** Set this to the characteristic UUID handle which are 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, etc.
Interactive Command	No

```
//Example :: BleGattcFindChar.sb (See in RM1xxCodeSnippets.zip)
//
//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
```


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```
// 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$)
```


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```
    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
```


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```
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...
```

BLEGATTCFINDCHAR is an extension function.

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5.10.8 BleGattcFindDesc

FUNCTION

This function facilitates a quick and 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 and 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; in addition to the UUID handles to be searched for, it accepts instance parameters which are indexed from 0. This means the following:

The second instance of a descriptor in the fourth instance of a characteristic in the third instance of a service (all with the same UUID) are 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 100s of milliseconds and, 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.

5.10.8.1 EVFINDDESC event message

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 will contain 0 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 CCCD's to enable notifications and/or indications.

BLEGATTCFINDDESC (nConnHandle, svcUuHndl, svcIdx, charUuHndl, charIdx, descUuHndl, descIdx)

A typical pseudo code for finding a descriptor involves calling BleGattcFindDesc() which in turn will result 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
```


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Returns	INTEGER, a result code. Most typical value – 0x0000, indicating a successful operation and it means an EVFINDDESC event message is thrown by the *smart*BASIC runtime engine containing the results. A non-zero return value implies an EVFINDDESC message is not thrown.
Arguments	
nConnHandle	**byVal *connHandle* 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 svcUuidHndl, where 0 is the first instance, 1 is the second, etc.
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, etc.
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, etc.
Interactive Command	No

```
//Example :: BleGattcFindDesc.sb (See in RM1xxCodeSnippets.zip)
//
//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

//============================================================================
```


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```
// 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
```


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```
    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 "\nEVFINDDESC "
  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 EVFINDDESC     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"
```


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```
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...
```

BLEGATTCFINDDESC is an extension function.

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.

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Depending on the connection interval, the read of the attribute may take many 100s of milliseconds, and 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.

5.10.9.1 EVATTRREAD event message

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().

0x0000	Success
0x0001	Unknown or not applicable status
0x0100	ATT Error: Invalid Error Code
0x0101	ATT Error: Invalid Attribute Handle
0x0102	ATT Error: Read not permitted
0x0103	ATT Error: Write not permitted
0x0104	ATT Error: Used in ATT as Invalid PDU
0x0105	ATT Error: Authenticated link required
0x0106	ATT Error: Used in ATT as Request Not Supported
0x0107	ATT Error: Offset specified was past the end of the attribute
0x0108	ATT Error: Used in ATT as Insufficient Authorisation
0x0109	ATT Error: Used in ATT as Prepare Queue Full
0x010A	ATT Error: Used in ATT as Attribute not found
0x010B	ATT Error: Attribute cannot be read or written using read/write blob requests
0x010C	ATT Error: Encryption key size used is insufficient
0x010D	ATT Error: Invalid value size
0x010E	ATT Error: Very unlikely error
0x010F	ATT Error: Encrypted link required
0x0110	ATT Error: Attribute type is not a supported grouping attribute
0x0111	ATT Error: Encrypted link required
0x0112	ATT Error: Reserved for Future Use range #1 begin
0x017F	ATT Error: Reserved for Future Use range #1 end
0x0180	ATT Error: Application range begin
0x019F	ATT Error: Application range end

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0x01A0	ATT Error: Reserved for Future Use range #2 begin
0x01DF	ATT Error: Reserved for Future Use range #2 end
0x01E0	ATT Error: Reserved for Future Use range #3 begin
0x01FC	ATT Error: Reserved for Future Use range #3 end
0x01FD	ATT Common Profile and Service Error: Client Characteristic Configuration Descriptor (CCCD) improperly configured
0x01FE	ATT Common Profile and Service Error: Procedure Already in Progress
0x01FF	ATT Common Profile and Service Error: Out of Range

A typical pseudo code for reading the content of an attribute calling BleGattcRead() which in turn will result in the EVATTRREAD event message and typically is as follows:

```
Register a handler for the EVATTRREAD event message

On EVATTREAD 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
```

BLEGATTCREAD (nConnHandle, attrHndl, offset)

Returns	INTEGER, a result code. Most typical value – 0x0000, indicating a successful operation and it means an EVATTRREAD event message is thrown by the *smart*BASIC runtime engine containing the results. A non-zero return value implies an EVATTRREAD message is not thrown.
Arguments	
nConnHandle	**byVal *connHandle* 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 will have been returned in the EVBLEMSG event message with msgId == 0 and msgCtx will have been the connection handle.
attrHndl	**byVal *attrHndl* AS INTEGER** Set this to the handle of the attribute to read and 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.
Interactive Command	No

BLEGATTCREADDATA (nConnHandle, 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. Most typical value – 0x0000, indicating a successful read.

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Arguments	
nConnHandle	**byVal *connHandle* 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 will have been returned in the EVBLEMSG event message with msgId == 0 and msgCtx will have been the connection handle.
attrHndl	**byVal *attrHndl* AS INTEGER** Set this to the handle of the attribute to read and 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.
attrData$	**byRef *attrData$* AS STRING** The attribute data which was read is supplied in this parameter.
Interactive Command	No

```
//Example :: BleGattcRead.sb (See in RM1xxCodeSnippets.zip)
//
//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

//============================================================================
```


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```
// 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 attibute handle 3"
    atHndl = 3
    nOff = 0
    rc=BleGattcRead(conHndl,atHndl,nOff)
    IF rc==0 THEN
      WAITEVENT
    ENDIF
    PRINT "\nread attibute 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

'//=========================================================================
'//=========================================================================
```


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```
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..."
```


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Expected Output:

```
Advertising, and Gatt Client is open

- Connected, so read attibute handle 3
EVATTRREAD cHndl=2960 attrHndl=3 status=00000000
Attribute read OK
Data  = 00000000 Offset= 0 Len=4
handle = 3
read attibute handle 300 which does not exist
EVATTRREAD cHndl=2960 attrHndl=300 status=00000101
Failed to read attribute

- Disconnected
Exiting...
```

BLEGATTCREAD and BLEGATTREADDATA are extension functions.

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 100s of milliseconds, and 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.

5.10.10.1 EVATTRWRITE event message

The EVATTRWRITE event message **WILL** be thrown if BleGattcWrite() returns a success. It is described in the Events & Message section above.

BLEGATTCWRITE (nConnHandle, attrHndl, attrData$)

A typical pseudo code for writing to an attribute which will result in the EVATTRWRITE event message and typically is as follows:

```
Register a handler for the EVATTRWRITE event message

On EVATTWRITE event message
       If Gatt_Status == 0 then
          Attribute was written successfully
       Else
          Attribute could not be written
```


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```
Call BleGattcWrite()
If BleGattcWrite() ok then Wait for EVATTRWRITE
```

Returns	INTEGER, a result code. Most typical value – 0x0000, indicating a successful read.
Arguments	
nConnHandle	**byVal n*ConnHandle* 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.
Interactive Command	No

```
//Example :: BleGattcWrite.sb (See in RM1xxCodeSnippets.zip)
//
//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
```


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```
//=========================================================================
// 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 attibute handle 3"
    atHndl = 3
    at$="\01\02\03\04"
    rc=BleGattcWrite(conHndl,atHndl,at$)
    IF rc==0 THEN
      WAITEVENT
    ENDIF
    PRINT "\nwrite to attibute handle 300 which does not exist"
    atHndl = 300
    rc=BleGattcWrite(conHndl,atHndl,at$)
    IF rc==0 THEN
      WAITEVENT
    ENDIF
    CloseConnections()
  ENDIF
ENDFUNC 1
'//=========================================================================
'//=========================================================================
```


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```
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..."
```


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Expected Output:

```
Advertising, and Gatt Client is open

- Connected, so read attibute handle 3
EVATTRWRITE cHndl=2687 attrHndl=3 status=00000000
Attribute write OK
Write to attibute handle 300 which does not exist
EVATTRWRITE cHndl=2687 attrHndl=300 status=00000101
Failed to write attribute

- Disconnected
Exiting...
```

BLEGATTCWRITE is an extension function.

5.10.11 BleGattcWriteCmd

FUNCTION

If the handle for an attribute is known, then this function is used to write into an attribute starting 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, not to be confused with the link layer ACK in this case.

All packets are acknowledged at link layer level. If a packet fails to get through then that condition will manifest 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 EVNOTIBUF event.

Depending on the connection interval, the write to the attribute may take many 100s of milliseconds, and while this is in progress it is safe to do other non GATT-related operations like for example servicing sensors and displays or any of the onboard peripherals.

5.10.11.1 EVNOTIFYBUF event

This event message is thrown if BleGattcWriteCmd() returned a success. The message contains no parameters.

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BLEGATTCWRITECMD (nConnHandle, attrHndl, attrData$)

A typical pseudo code for writing to an attribute which will result in the EVNOTIFYBUF event is as follows:

```
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. Most typical value – 0x0000, indicating a successful read.
Arguments	
nConnHandle	**byVal n*ConnHandle* 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.
Interactive Command	No

```
//Example :: BleGattcWriteCmd.sb (See in RM1xxCodeSnippets.zip)
//
//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)
```


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```
  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
```


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```
      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
```


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```
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...
```

BLEGATTCWRITECMD is an extension function.

5.10.12 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 has to be managed so that it can synchronized 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() and for indications an automatic GATT acknowledgement is sent when the data is saved in the ring buffer. This acknowledgment happens even if the data was discarded because the ring buffer was full. If, however, it is required that the data NOT be acknowledged when it is discarded on a full buffer, then 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 so no further data is notified or indicated by it until BleGattNotifyRead() is called to extract data from the ring buffer to create space and it triggers a delayed acknowledgement.

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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 and at the same time a EVATTRNOTIFY 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.

5.10.12.1 EVATTRTOTIFY event message

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 paradigm being that the *smart*BASIC application is informed that it needs to go and service the ring buffer using the function BleGattcNotifyRead.

BLEGATTCNOTIFYREAD (nConnHandle, attrHndl, attrData$, discardedCount)

A typical pseudo code for handling and accessing notification/indication data is as follows:

```
Register a handler for the EVATTRNOTIFY event message

On EVATTRNOTIRY event
  BleGattcNotifyRead() //to actually get the data
  Process the data

Enable notifications and/or indications via CCCD descriptors
```

Returns	INTEGER, a result code. Most typical value – 0x0000, indicating a successful read.
Arguments	
nConnHandle	**byVal n*ConnHandle* 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.
discardedCount	**byRef *discardedCount* AS INTEGER** On exit this should contain 0 and it signifies the total number of notifications or indications that got discarded because the ring buffer in the GATT client manager is full. If non-zero values are encountered, it is recommended that the ring buffer size be increased by using BleGattcClose() when the GATT client is opened using BleGattcOpen().
Interactive Command	No

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```
//Example :: BleGattcNotifyRead.sb (See in RM1xxCodeSnippets.zip)
//
// Server created using BleGattcTblNotifyRead.sub invoked in _OpenMcp.scr
// using Nordic Usb Dongle PC10000
//
// 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)
```


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```
  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
```


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```
'//=============================================================================
'//=============================================================================
function HandlerAttrNotify() as integer
  dim chndl,aHndl,att$,dscd
  print "\nEVATTRNOTIFY Event"
  rc=BleGattcNotifyRead(cHndl,aHndl,att$,dscd)
  print "\n BleGattcNotifyRead()"
  if rc==0 then
    print " cHndl=";cHndl
    print " attrHndl=";aHndl
    print " data=";StrHexize$(att$)
    print " discarded=";dscd
  else
    print " failed with ";integer.h' rc
  endif
endfunc 1

//=============================================================================
// Main() equivalent
//=============================================================================
ONEVENT EVBLEMSG      CALL HndlrBleMsg
OnEvent EVATTRWRITE    call HandlerAttrWrite
OnEvent EVATTRNOTIFY    call HandlerAttrNotify

IF OnStartup()==0 THEN
  PRINT "\nAdvertising, and Gatt Client is open\n"
ELSE
  PRINT "\nFailure OnStartup"
ENDIF

WAITEVENT
PRINT "\nExiting..."
```


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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
```

BLEGATTCNOTIFYREAD is an extension function.

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 communicated 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 position at the lowest memory address and likewise when transported, the lowest byte gets on the wire first.

This section describes all the encoding functions which allow those strings to be written to in smaller bytewise 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.

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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. Most typical value – 0x0000, indicating a successful operation.
Arguments	
attr$	**byRef *attr$* AS STRING** This argument is the string that is written to an attribute
nData	**byVal nData AS INTEGER** The least significant byte of this integer is saved. The rest is ignored.
nIndex	**byVal *nIndex* AS INTEGER** This is the zero-based index into the string attr$ 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.
Interactive Command	No

```
//Example :: BleEncode8.sb (See in RM1xxCodeSnippets.zip)

DIM rc
DIM attr$

attr$="Laird"

PRINT "\nattr$=";attr$

//Remember: - 4 bytes are used to store an integer on the RM1xx

//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
```


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```
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
```

BLEENCODE8 is an extension function.

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. Most typical value – 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.
Interactive Command	No

```
//Example :: BleEncode16.sb (See in RM1xxCodeSnippets.zip)
```


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```
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
```

BLEENCODE16 is an extension function.

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. Most typical value – 0x0000, indicating a successful operation.
Arguments	
attr$	**byRef *attr$* AS STRING** This argument is the string that is written to an attribute.
nData	**byVal nData AS INTEGER** The three least significant bytes of this integer is saved. The rest is ignored.
nIndex	**byVal *nIndex* AS INTEGER** This is the zero based index into the string attr$ 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.

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Interactive Command	No

```
//Example :: BleEncode24.sb (See in RM1xxCodeSnippets.zip)

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
```

BLEENCODE24 is an extension function.

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. Most typical value – 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.

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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.
Interactive Command	No

```
//Example :: BleEncode32.sb (See in RM1xxCodeSnippets.zip)

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
```

BLEENCODE32 is an extension function.

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$, nMatissa, nExponent, nIndex)

Returns	INTEGER, a result code. Most typical value – 0x0000, indicating a successful operation.
Arguments	
attr$	**byRef *attr$* AS STRING** This argument is the string that is written to an attribute.

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nMatissa	**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 that the range is not +/- 2048 because after encoding the following two byte values have special meaning: 0x07FFFFFF – NaN (Not a Number) 0x08000000 – NRes (Not at this resolution) 0x07FFFFFE – + INFINITY 0x08000002 – - INFINITY 0x08000001 – 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.
Interactive Command	No

```
//Example :: BleEncodeFloat.sb (See in RM1xxCodeSnippets.zip)

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
```


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Expected Output:

```
0
Failed to encode to FLOAT
Failed to encode to FLOAT
```

BLEENCODEFLOAT is an extension function.

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.

BLEENCODESFLOATEX (attr$, nData, nIndex)

Returns	INTEGER, a result code. Most typical value – 0x0000, indicating a successful operation.
Arguments	
attr$	**byRef *attr$* AS STRING** This argument is the string that is written to an attribute.
nData	**byVal nData AS INTEGER** The 32-bit value is converted into a 2-byte IEEE-11073 16 bit SFLOAT consisting of a 12-bit signed mantissa and a 4-bit signed exponent. This means a signed 32-bit value always fits in such a FLOAT entity, but there is loss in significance to 12 from 32.
nIndex	**byVal *nIndex* AS INTEGER** This is the zero based index into the string attr$ 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.
Interactive Command	No

```
//Example :: BleEncodeSFloatEx.sb (See in RM1xxCodeSnippets.zip)

 DIM rc, mantissa, exp
 DIM attr$ : attr$=""

 //write 2,147,483,647 as SFLOAT to index 0
 rc=BleEncodeSFloatEX(attr$,2147483647,0)
```


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```
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
```

BLEENCODESFLOAT is an extension function.

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$, nMatissa, nExponent, nIndex)

Returns	INTEGER, a result code. Most typical value – 0x0000, indicating a successful operation.
Arguments	
attr$	**byRef *attr$* AS STRING** This argument is the string that is written to an attribute.
nMatissa	**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 that the range is not +/- 2048 because after encoding the following two byte values have special meaning:

0x07FFFFFF	NaN (Not a Number)
0x08000000	NRes (Not at this resolution)
0x07FFFFFE	+ INFINITY
0x08000002	- INFINITY
0x08000001	Reserved for future use

nExponent	**byVal n 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 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.
Interactive Command	No

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```
//Example :: BleEncodeSFloat.sb (See in RM1xxCodeSnippets.zip)

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
```

BLEENCODESFLOAT is an extension function.

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 to 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

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BLEENCODETIMESTAMP (attr$, timestamp$, nIndex)

Returns	INTEGER, a result code. Most typical value – 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$* AS STRING** This is an exactly 7-byte string as described above. For example, 5 May 2013 10:31:24 is entered \14\0D\05\05\0A\1F\18
nIndex	**byVal *nIndex* AS INTEGER** This is the zero based index into the string attr$ 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.
Interactive Command	No

```
//Example :: BleEncodeTimestamp.sb (See in RM1xxCodeSnippets.zip)

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
```

BLEENCODETIMESTAMP is an extension function.

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.

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BleEncodeSTRING (attr$, nIndex1, str$, nIndex2, nLen)

Returns	INTEGER, a result code. Most typical value – 0x0000, indicating a successful operation.
Arguments	
attr$	**byRef *attr$* AS STRING** This argument is the string that is written to an attribute
nIndex1	**byVal *nIndex1* AS INTEGER** This is the zero based index into the string attr$ 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 species 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.
Interactive Command	No

```
//Example :: BleEncodeString.sb (See in RM1xxCodeSnippets.zip)
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
```

BLEENCODESTRING is an extension function.

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)

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where n is 2013. The Bluetooth specification allows a length between 1 and 512; hence the (nDstIdx + nBitLen) cannot be greater than the max attribute length times 8.

BleEncodeBITS (attr$, nDstIdx, srcBitArr, nSrcIdx, nBitLen)

Returns	INTEGER, a result code. Most typical value – 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 are copied. No data is copied if this index is negative or greater than 32.
nBitLen	**byVal *nBitLen* AS INTEGER** This species 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.
Interactive Command	No

```
//Example :: BleEncodeBits.sb (See in RM1xxCodeSnippets.zip)
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
```

BLEENCODEBITSfunction.function.function.function.function.function.

5.12 Attribute Decoding Functions

Data in a characteristic is stored in a Value attribute, a byte array. Multibyte Characteristic Descriptors content are 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 bytewise subfields more efficiently than the generic STRXXXX functions that are made available in *smart*BASIC.

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Note: CCCD and SCCD descriptors are special cases as they are defined as having just 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 32bit 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.
Interactive Command	No

```
//Example :: BleDecodeS8.sb (See in RM1xxCodeSnippets.zip)

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=BleSvcCommit(1, BleHandleUuid16(uuid),svcHandle)

//create char and commit as part of service commited above
rc=BleCharNew(0x07,BleHandleUuid16(0x2A1C),mdVal,0,0)
rc=BleCharCommit(svcHandle,attr$,chrHandle)

rc=BleCharValueRead(chrHandle,attr$)

//read signed byte from index 2
```


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```
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 = 0xFFFFFF86
data in Decimal = -122
```

BLEDECODES8 is an extension function.

5.12.2 BleDecodeU8

FUNCTION

This function reads a single byte in a string at a specified offset into a 32bit 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.
Interactive Command	No

```
//Example :: BleDecodeU8.sb (See in RM1xxCodeSnippets.zip)
```


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```
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=BleSvcCommit(1, BleHandleUuid16(uuid),svcHandle)

rc=BleCharNew(0x07,BleHandleUuid16(0x2A1C),mdVal,0,0)
rc=BleCharCommit(svcHandle,attr$,chrHandle)

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
```

BLEDECODEU8 is an extension function.

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5.12.3 BleDecodeS16

FUNCTION

This function reads two bytes in a string at a specified offset into a 32bit 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$* AS STRING** This references the attribute string from which the function reads.
nData	**byRef nData AS INTEGER** This references an integer to be updated with the two-byte data from attr$, 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.
Interactive Command	No

```
//Example :: BleDecodeS16.sb (See in RM1xxCodeSnippets.zip)

 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=BleSvcCommit(1, BleHandleUuid16(uuid),svcHandle)

 rc=BleCharNew(0x07,BleHandleUuid16(0x2A1C),mdVal,0,0)
 rc=BleCharCommit(svcHandle,attr$,chrHandle)

 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
```


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```
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
```

BLEDECODES16 is an extension function.

5.12.4 BleDecodeU16

This function reads two bytes from a string at a specified offset into a 32bit integer variable without sign extension. If the offset points beyond the end of the string, then this function fails.

BLEDECODEU16 (attr$, nData, nIndex)

FUNCTION

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.
Interactive Command	No

```
//Example :: BleDecodeU16.sb (See in RM1xxCodeSnippets.zip)

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
```


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```
rc=BleSvcCommit(1, BleHandleUuid16(uuid),svcHandle)

rc=BleCharNew(0x07,BleHandleUuid16(0x2A1C),mdVal,0,0)
rc=BleCharCommit(svcHandle,attr$,chrHandle)

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
```

BLEDECODEU16 is an extension function.

5.12.5 BleDecodeS24

FUNCTION

This function reads three bytes in a string at a specified offset into a 32bit 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.

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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.
Interactive Command	No

```
//Example :: BleDecodeS24.sb (See in RM1xxCodeSnippets.zip)

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=BleSvcCommit(1, BleHandleUuid16(uuid),svcHandle)

rc=BleCharNew(0x07,BleHandleUuid16(0x2A1C),mdVal,0,0)
rc=BleCharCommit(svcHandle,attr$,chrHandle)

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
```

BLEDECODES24 is an extension function.

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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.
Interactive Command	No

```
//Example :: BleDecodeU24.sb (See in RM1xxCodeSnippets.zip)

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=BleSvcCommit(1, BleHandleUuid16(uuid),svcHandle)

rc=BleCharNew(0x07,BleHandleUuid16(0x2A1C),mdVal,0,0)
rc=BleCharCommit(svcHandle,attr$,chrHandle)

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
```


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```
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
```

BLEDECODEU24 is an extension function.

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	I 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.
Interactive Command	No

```
//Example :: BleDecode32.sb (See in RM1xxCodeSnippets.zip)

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=BleSvcCommit(1, BleHandleUuid16(uuid),svcHandle)
```


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```
rc=BleCharNew(0x07,BleHandleUuid16(0x2A1C),mdVal,0,0)
rc=BleCharCommit(svcHandle,attr$,chrHandle)

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
```

BLEDECODE32 is an extension function.

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$, nMatissa, 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.

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nMatissa	**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: 0x07FFFFFF – NaN (Not a Number) 0x08000000 – NRes (Not at this resolution) 0x07FFFFFE – + INFINITY 0x08000002 – - INFINITY 0x08000001 – 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.
Interactive Command	No

```
//Example :: BleDecodeFloat.sb (See in RM1xxCodeSnippets.zip)

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=BleSvcCommit(1, BleHandleUuid16(uuid),svcHandle)
rc=BleCharNew(0x07,BleHandleUuid16(0x2A1C),mdVal,0,0)
rc=BleCharCommit(svcHandle,attr$,chrHandle)

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
```


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Expected Output:

```
The number read is 262914*10^-123
The number read is -7829626*10^-119
```

BLEDECODEFLOAT is an extension function.

5.12.9 BleDecodeSFLOAT

FUNCTION

This function reads two bytes in a string at a specified offset into a couple of 32bit integer variables. The decoding results in two variables, the 12-bit signed maintissa and the 4-bit signed exponent. If the offset points beyond the end of the string, then this function fails.

BLEDECODESFLOAT (attr$, nMatissa, 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$* AS STRING** This references the attribute string from which the function reads.
nMatissa	**byRef nMantissa AS INTEGER** This is updated with the 12-bit mantissa from the 2-byte object. If nExponent is 0, you MUST check for the following special values: 0x07FFFFFF – NaN (Not a Number) 0x08000000 – NRes (Not at this resolution) 0x07FFFFFE – + INFINITY 0x08000002 – - INFINITY 0x08000001 – Reserved for future use
nExponent	**byRef nExponent AS INTEGER** This is updated with the 4-bit mantissa. If it is zero, check the nMantissa for special cases as stated above.
nIndex	**byVal *nIndex* AS INTEGER** This is the zero based index into the string attr$ 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.
Interactive Command	No

```
//Example :: BleDecodeSFloat.sb (See in RM1xxCodeSnippets.zip)

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
```


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```
rc=BleSvcCommit(1, BleHandleUuid16(uuid),svcHandle)
rc=BleCharNew(0x07,BleHandleUuid16(0x2A1C),mdVal,0,0)
rc=BleCharCommit(svcHandle,attr$,chrHandle)

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
```

BLEDECODESFLOAT is an extension function.

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 to 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 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.

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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.
Interactive Command	No

```
 //Example :: BleDecodeTimestamp.sb (See in RM1xxCodeSnippets.zip)

 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=BleSvcCommit(1, BleHandleUuid16(uuid),svcHandle)
 rc=BleCharNew(0x07,BleHandleUuid16(0x2A1C),mdVal,0,0)
 rc=BleCharCommit(svcHandle,attr$,chrHandle)

 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
```

BLEENCODETIMESTAMP is an extension function.

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. This function doesn't fail because the output string can take truncated strings.

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.

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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$.
Interactive Command	No

```
//Example :: BleDecodeString.sb (See in RM1xxCodeSnippets.zip)

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=BleSvcCommit(1, BleHandleUuid16(uuid),svcHandle)
rc=BleCharNew(0x07,BleHandleUuid16(0x2A1C),mdVal,0,0)
rc=BleCharCommit(svcHandle,attr$,chrHandle)

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$=";decStr$
```


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Expected Output:

```
d$=CDEF
d$=CDEFGHIJ
d$=
```

BLEDECODESTRING is an extension function.

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. This function doesn't fail because the output bit array can take truncated bit blocks.

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$* AS STRING** This references the attribute string from which to read, treated as a bit array. Hence a string of 10 bytes will be an array of 80 bits.
nSrcIdx	**byVal *nSrcIdx* AS INTEGER** This is the zero based bit index into the string attr$ 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 where the data is written to.
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.
Interactive Command	No

```
//Example :: BleDecodeBits.sb (See in RM1xxCodeSnippets.zip)

DIM chrHandle,v1,svcHandle,rc, ts$,decStr$
DIM ba : ba=0
DIM mdVal : mdVal = BleAttrMetadata(1,1,50,0,rc)
```


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```
//"ABCDEFGHIJ"
DIM attr$ : attr$="41\42\43\44\45\46\47\48\49\4A"
DIM uuid : uuid = 0x1853

rc=BleSvcCommit(1, BleHandleUuid16(uuid),svcHandle)
rc=BleCharNew(0x07,BleHandleUuid16(0x2A1C),mdVal,0,0)
rc=BleCharCommit(svcHandle,attr$,chrHandle)

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
```

BLEDECODEBITS is an extension function.

5.13 Pairing/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

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The type of information that can be stored for a trusted device is:

- The MAC 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)

5.13.1 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 *smart*BASIC, one table is called the 'Rolling' table and the other is called 'Persist' 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 'Persist' 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 'Persist' 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 'Persist' bonds (or maximum capacity) at any time can be obtained by calling the function BleBondingStats. The 'Persist' 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 'Persist' table. See the function BleBondingStats which returns information that can be used to determine this.

Bonds in the 'Rolling' table can be transferred to 'Persist' unless the 'Persist' table is full. The capacity of the 'Persist' 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 'Persist' 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.

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A *smart*BASIC application wanting to manage trusted device will use a combination of the functions: BleBondMngrGetInfo, BleBondingIsTrusted, BleBondingPersistKey and BleBondingEraseKey.

5.13.2 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.

Tests have shown that setting a power of -55 using BleTxPwrWhilePairing() will create a 'bubble' of about 30cm radius, outside which pairing will not succeed. This will be reduced even further if the module is in a case which affects radio transmissions.

5.13.3 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, nTotal)

Returns	INTEGER; The maximum capacity of the bonding manager
Arguments	
nRolling	**byRef nRolling AS INTEGER** On exit this will contain the number of rolling bonds in the database.
nTotal	**byRef nTotal AS INTEGER** On exit this will contain the total number of bonds in the database.
Interactive Command	No

```
//Example
DIM rolling, capacity, total
capacity = BleBondingStats(rolling,total)

PRINT "\nCapacity :";capacity
PRINT "\nRolling :";rolling
```


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```
PRINT "\nTotal   :";total
```

Expected Output:

```
Capacity : 16
Rolling : 2
Total   : 5
```

BLEBONDINGSTATS is an extension function.

5.13.4 BleBondingEraseKey

FUNCTION

This function is used to erase the bonding information for a device identified by a Bluetooth address.

If the device does not exist in the database, the function will return a success result code.

BLEBONDINGERASEKEY (addr$)

Returns	**INTEGER, a result code.** **Typical value:** 0x0000 (indicates a successful operation)
Arguments	
addr$	**byRef addr$ AS STRING** This is the address of the device for which the bonding information is to be erased
Interactive Command	No

```
//Example
DIM rc, addr$
addr$="\00\00\16\A4\12\34\56"
rc = BleBondingEraseKey(addr$)
```

BLEBONDINGERASEKey is an extension function.

5.13.5 BleBondingEraseAll

FUNCTION

This function deletes the entire trusted device database. Other values of the parameter are reserved for future use.

Note: In Interactive Mode, the command AT+BTD* can also be used to delete the database.

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BLEBONDMNGRERASEALL ()

Arguments : None	
Interactive Command	No

```
//Example :: BleBondMngrErase.sb
DIM rc
rc=BleBondMngrErase()
```

BLEBONDINGERASEALL is an extension function.

5.13.6 BleBondMngrErase

This subroutine has been deprecated and remains for old apps. New apps should use the function BleBondingEraseAll.

5.13.7 BleBondingPersistKey

FUNCTION

This function is used to mark a device in the bonding manager as persistent which means it is not automatically deleted if there is no space to store a new bonding. This device can only be delated using BleBondingEraseAll() or BleBondingEraseKey().

BLEBONDINGPERSISTKEY (addr$)

Returns	INTEGER, a result code. **Typical value:** 0x0000 (indicates a successful operation)
Arguments	
addr$	**byRef addr$ AS STRING** This is the address of the device for which the bonding information is to be marked as persistent
Interactive Command	No

```
//Example
DIM rc, addr$
addr$="\00\00\16\A4\12\34\56"
rc = BleBondingPersistKey(addr$)
```

BLEBONDINGPERISTKEY is an extension function.

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5.13.8 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.
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 then this is not a rolling device 1 implies it is the newest bond 2 implies it is the second newest bond etc.
rollingCount	On exit this will contain the total number of rolling bonds. Which give a sense of how old this device is compared to other bonds in the rolling group.
Interactive Command	No

```
//Example
DIM rc, addr$
addr$="\00\00\16\A4\12\34\56"
rc = BleBondingPersistKey(addr$)
```

BLEBONDINGISTRUSTED is an extension function.

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5.13.9 BleBondMngrGetInfo

FUNCTION

This function retrieves the MAC 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. **Typical value:** 0x0000 (indicates a successful operation)
Arguments	
nIndex	**byVal nIndex AS INTEGER** This is an index in the range 0 to 1, 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 MAC 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 bitmask where the bits indicate as follows: Bit 0.. 15 — Opaque value and no meaning is to be attached to this Bit 16 — Set if the IRK (identity resolving key) exists Bit 17 — Set if the CSRK (Connection signing resolution key) exists Bit 18 — Set if the LTK 'as slave' exists Bit 19 — Set if the LTK 'as master' exists Bit 20 — Set if this is rolling bond
Interactive Command	No

```
//Example :: BleBondMngrGetInfo.sb
#define BLE_INV_INDEX      24619
DIM rc, addr$, exInfo
rc = BleBondMngrGetInfo(0,addr$,exInfo) //Extract info of device at index 1

IF rc==0 THEN
  PRINT "\nMAC address: ";addr$
  PRINT "\nInfo: ";exInfo
ELSEIF rc==BLE_INV_INDEX  THEN
  PRINT "\nInvalid index"
ENDIF
```


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Expected Output when valid entry present in database:

```
MAC address: \00\BC\B1\F3x3\AB
Info: 97457
```

Expected Output with invalid index:

```
Invalid index
```

BLEBONDMNGRGETINFO is an extension function.

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 System Configuration Routines

6.1.1 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. Most typical value – 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.
Interactive Command	No

```
//Example :: SystemStateSet.sb (See in RM1xxCodeSnippets.zip)

 //Put the module into deep sleep
 PRINT "\n"; SystemStateSet(0)
```

SYSTEMSTATESET is an extension function.

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6.2 Miscellaneous Routines

6.2.1 ReadPwrSupplyMv

FUNCTION

This function is used to read the power supply voltage and the value will be returned in millivolts.

READPWRSUPPLYMV ()

Returns	INTEGER, the power supply voltage in millivolts.
Arguments	None
Interactive Command	No

```
//Example :: ReadPwrSupplyMv.sb (See in RM1xxCodeSnippets.zip)
//read and print the supply voltage
 PRINT "\nSupply voltage is "; ReadPwrSupplyMv();"mV"
```

Expected Output:

```
Supply voltage is 3343mV
```

READPWRSUPPLYMV is an extension function.

6.2.2 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.

6.2.2.1 Events and 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 *nThresMv* 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.
Interactive Command	No

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```
//Example :: SetPwrSupplyThreshMv.sb (See in RM1xxCodeSnippets.zip)
 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
```


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```
PRINT "\nExiting..."
```

Expected Output:

```
Supply voltage is 3343mV

Waiting for power supply to fall below 2700mV
Exiting...
```

SETPWRSUPPLYTHRESHMV is an extension function.

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.

To ensure that access to variables and resources ends up in race conditions, 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 will never need the complexity of locking variables and objects.

There are many subsystems which generate events and messages as follows:

- Timer events, which generate timer expiry events and are described here.
- Messages thrown from within the user's BASIC application as described here.
- Events related to the UART interface as described here.
- GPIO input level change events as described here.
- BLE events and messages as described here.
- Generic Characteristics events and messages as described here.

8 Module Configuration

There are many features of the module that cannot be modified programmatically which relate to interactive mode operation or alter the behavior 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 the command AT+CFG must be used which is described in detail here.

To read current values of these objects use the command AT+CFG, described here.

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

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9 MISCELLANEOUS

9.1.1 Bluetooth Result Codes

There are some operations and events that provide a single byte Bluetooth HCI result code, e.g. 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 and are unlikely to appear.

BLE_HCI_STATUS_CODE_SUCCESS	**0x00**
BLE_HCI_STATUS_CODE_UNKNOWN_BTLE_COMMAND	**0x01**
BLE_HCI_STATUS_CODE_UNKNOWN_CONNECTION_IDENTIFIER	**0x02**
BLE_HCI_HARDWARE_FAILURE	0x03
BLE_HCI_PAGE_TIMEOUT	0x04
BLE_HCI_AUTHENTICATION_FAILURE	**0x05**
BLE_HCI_STATUS_CODE_PIN_OR_KEY_MISSING	**0x06**
BLE_HCI_MEMORY_CAPACITY_EXCEEDED	**0x07**
BLE_HCI_CONNECTION_TIMEOUT	**0x08**
BLE_HCI_CONNECTION_LIMIT_EXCEEDED	0x09
BLE_HCI_SYNC_CONN_LIMI_TO_A_DEVICE_EXCEEDED	0x0A
BLE_HCI_ACL_COONECTION_ALREADY_EXISTS	0x0B
BLE_HCI_STATUS_CODE_COMMAND_DISALLOWED	**0x0C**
BLE_HCI_CONN_REJECTED_DUE_TO_LIMITED_RESOURCES	0x0D
BLE_HCI_CONN_REJECTED_DUE_TO_SECURITY_REASONS	0x0E
BLE_HCI_BLE_HCI_CONN_REJECTED_DUE_TO_BD_ADDR	0x0F
BLE_HCI_CONN_ACCEPT_TIMEOUT_EXCEEDED	0x10
BLE_HCI_UNSUPPORTED_FEATURE_ONPARM_VALUE	0x11
BLE_HCI_STATUS_CODE_INVALID_BTLE_COMMAND_PARAMETERS	**0x12**
BLE_HCI_REMOTE_USER_TERMINATED_CONNECTION	**0x13**
BLE_HCI_REMOTE_DEV_TERMINATION_DUE_TO_LOW_RESOURCES	**0x14**
BLE_HCI_REMOTE_DEV_TERMINATION_DUE_TO_POWER_OFF	**0x15**
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BLE_HCI_SCO_INTERVAL_REJECTED	0x1C

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10 ACKNOWLEDGEMENTS

The following are required acknowledgements to address our use of open source code on the RM1xx to implement AES encryption.

Laird's implementation includes the following files: **aes.c** and **aes.h**.

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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.

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