Low Power Modes

BL653 Module

Application Note *v1.0*

1 INTRODUCTION

The BL653 module has three power modes:

- **Run** – The normal operation of the module when the application is running and not waiting for events.
- **Standby Doze** – The module is placed in Standby Doze when there are no pending events and the *smart*BASIC application reaches the WAITEVENT statement. The module wakes from Standby Doze if any registered event is triggered.
- **Deep Sleep** – Deep Sleep is the lowest power mode and the module can only exit it through a system reset. It is achieved through the *smart*BASIC function *SystemStateSet(0).*

This guide demonstrates how to load a smartBASIC application in order to test the power consumption of the two low power modes: Standby Doze and Deep Sleep.

2 REQUIREMENTS

- Laird DVK-BL653 (453-00039-K1 or 453-00041-K1)
- Micro USB to USB (Type-A) Cable – provided with devkit
- UwTerminalX v1.10a or later (found at https://github.com/LairdCP/UwTerminalX)
- *lp.low.power.deep.sleep.sb* application (found in the BL653 GitHub repository)
- Current measuring digital multimeter (DMM)

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3 DEVELOPMENT KIT SETUP

To set up the DVK-BL653 development kit, complete the following steps:

1. Configure the board to the following settings (shown in Figure 1)
   - DC/USB power source switch (SW4) – in position USB (default)
   - VCC_1V8/VCC_3V3 switch (SW5) – in position VCC_3V3 (default)
   - CR2033/VCC_3V3/1V8 switch (SW6) – in position VCC_3V3/1V8 (default)
   - Switch SW7 is in middle position for Normal Voltage mode operation (default)
   - Jumper J7 removed, cut solderbridge SB1
   - Optionally, remover jumper J26, J37, J45, J39 to disconnect LED's D1, D2, D3, D4
   - SW11 in left position
2. To measure the current consumption of the module, connect the current measuring DMM to J7 on the development kit (Figure 1).

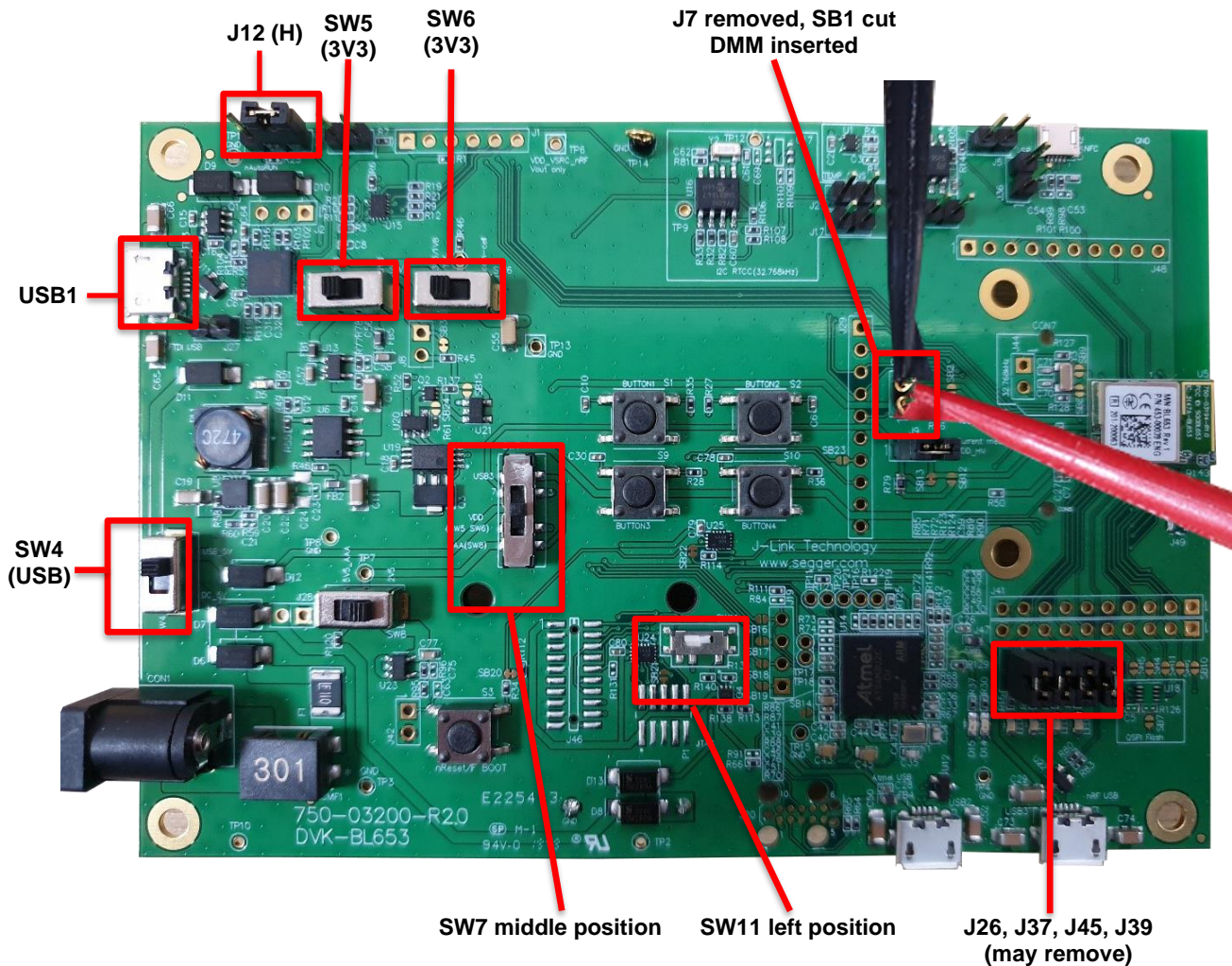**Note:** After the test is complete, remember to replace the jumper on J7.

Figure 1: BL653 development board

3. Connect the DVK-BL653 to your PC via the included USB-A to USB micro cable.
4. Ensure that the current measuring DMM is connected to J7 before the development kit is powered up (or else the board will not be powered).
5. Follow the on-screen prompts. Windows may prompt you to install FTDI drivers (available from the following site: http://www.ftdichip.com/FTDrivers.htm).
6. Ensure that the Windows Device Manager displays a new virtual COM port for the USB to Serial adapter.
7. Launch UwTerminalX.
8. From the Config tab in the Device drop-down menu, select *BL653* to populate the baud, parity, stop bits, data bits, and handshaking settings. If *BL653* is not selectable, set the configuration as shown in Figure 2.
9. In the Port drop-down menu, select the COM port associated with your DVK-BL653.
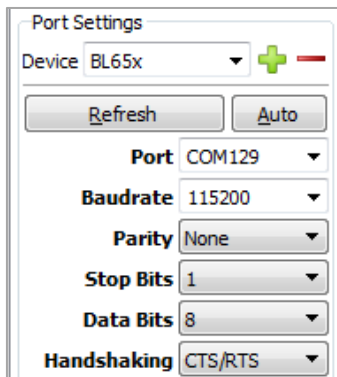

Figure 2: Setting connection parameters

10. At the top of the screen, click **OK.**
11. To return the BL653 to factory defaults, enter the command *at&f** in the Terminal tab as shown (Figure 3).

Note: If you are using a new development board with the sample application, you may need to press the reset button (SW3) to exit out of the sample application and then issue the *at&f** command to erase the file system and all non-volatile data.
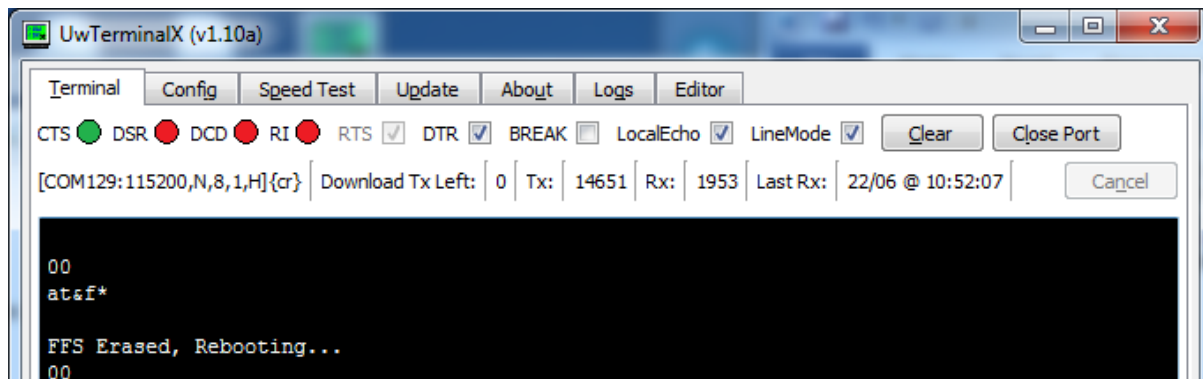

Figure 3: Return BL653 to factory default settings

4 RUNNING LOW POWER APPLICATION

The low power modes application can be downloaded and extracted from the zip file located in GitHub or saved from the GitHub raw file page:

https://github.com/LairdCP/BL653-Applications/blob/master/Applications/lp.low.power.deep.sleep.sb

Note: This application note assumes that you are familiar with loading smartBASIC applications onto the BL653 module using UwTerminalX. If not, see the application note "Loading smartBASIC Applications - BL653," available in the Documentation tab of the BL653 product page.

4.1 Deep Sleep Mode

To measure the deep sleep current, complete the following steps:

1. Since the application is placed into deep sleep mode through *SystemStateSet(0) smart*BASIC function, ensure that the function is not commented out in the file (Figure 4).

```
56    //************************************************************************
57    // Equivalent to main() in C
58    //************************************************************************
59
60    PRINT "To get the expected low power consumption please remove jumpers J3 and J4 on your DVK-BL652 board."
61
62    rc=gpiosetfunc(17,2,0)  //Sets LED 0 to digital out low
63    rc=gpiosetfunc(19,2,0)  //Sets LED 1 to digital out low
64    rc=gpiosetfunc(3,2,0)   //Disables the temperature sensor
65    while (uartinfo(5) > 0)
66        //Wait for the UART transmit buffer to empty
67    endwhile
68    uartclose()             //Closes the UART
69    rc=gpiosetfunc(6,2,0)   //TX - set high on default
70    rc=gpiosetfunc(5,2,0)   //RTS
71
72    //Put module into deep sleep
73    rc = SystemStateSet(0)
74
```

Figure 4: Placing module into deep sleep mode

2. Load the Low Power application:
    a. Use the right-click menu on UwTerminalX window and select **XCompile + Load**.
    b. Browse *to the lp.low.power.deep.sleep.sb* location on your computer.
3. Ensure that the application is loaded by issuing **at+dir** as shown in Figure 5.

```
00
at+dir

06    lp
00
```

Figure 5: Checking file system

4. Run the low power application by typing **at+run lp**.
5. Through the current measuring DMM, the current should fall to about 0.6 uA at 25°C temperature (Figure 6).

Note: In Deep Sleep (Nordic System OFF) and StandByDoze (Nordic System ON idle), the regulator uses refresh mode – the regulator charges up a capacitor, then turns off and turn on again when the voltage on the capacitor is below a certain value. This means that the current flows into the chip in short bursts. In Deep Sleep (Nordic System OFF), the distance between the current spikes is about 250 milliseconds. So, if the multimeter is not able to average over a long enough time, you will likely see that the value varies.

Figure 6: The current falls to about 0.6uA (600nA) at 25°C temperature when placed in deep sleep mode

Note: The only way to exit deep sleep mode is through a hardware reset. This returns the BL653 into interactive mode or runs an $autorun$ application if one exists in the file system.

4.2 Standby Doze Mode

To measure the standby doze mode current, complete the following steps:

1. The BL653 is placed into standby doze mode when the *smart*BASIC application reaches WAITEVENT and there are no pending events. To achieve this through the low power mode application, comment out the *SystemStateSet(0)* line in the *lp.low.power.deep.sleep.sb* file as shown in Figure 7.

```
62    rc=gpiosetfunc(17,2,0)  //Sets LED 0 to digital out low
63    rc=gpiosetfunc(19,2,0)  //Sets LED 1 to digital out low
64    rc=gpiosetfunc(3,2,0)   //Disables the temperature sensor
65    while (uartinfo(5) > 0)
66        //Wait for the UART transmit buffer to empty
67    endwhile
68    uartclose()             //Closes the UART
69    rc=gpiosetfunc(6,2,0)   //TX - set high on default
70    rc=gpiosetfunc(5,2,0)   //RTS
71
72    //Put module into deep sleep
73    //rc = SystemStateSet(0)
74
75    //--------------------------------------------------------------------------
76    // Wait for a synchronous event.
77    // An application can have multiple <WaitEvent> statements
78    //--------------------------------------------------------------------------
79    waitevent       //Waits for an event to happen
80
```

Figure 7: Placing module into standby doze mode

2. Reset the BL653 using the reset button (SW3).
3. Erase the flash file system using the interactive command ***at&F****.

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4. Load the Low Power application – Use the right-click menu on UwTerminalX window, select **XCompile + Load**, and browse to the *lp.low.power.deep.sleep.sb* location on your computer.

5. Run the low power application by typing *at+run "lp"*.

6. Through the current measuring DMM, the current should fall to about 2.54 uA to 2.86 uA at 25°C temperature (Figure 8).

Note: Once you're done with the current measurement, place the jumper back on J7. Otherwise the BL653 is not powered through the USB port; it is powered parasitically instead.

Figure 8: The current falls to about 2.6uA (2.54 uA to 2.86 uA is expected value) at 25°C temperature when placed in StandByDoze mode

Note: In Deep Sleep (Nordic System OFF) and StandByDoze (Nordic System ON idle) the regulator uses refresh mode, which means that the regulator charges up a capacitor, then turns off, and turn on again when the voltage on the capacitor is below a certain value. This means that the current flows into the BLE chip in short bursts. In Deep Sleep (Nordic System OFF) the distance between the current spikes is about 250 ms. So, if the multimeter is not able to average over a long enough time you will probably see that the value is varying.

5 FURTHER INFORMATION

Additional documents are also accessible from the Documentation tab in the BL653 product page.

6 REVISION HISTORY

Version	Date	Notes	Contributor(s)	Approver
1.0	31 Mar 2020	Initial Release	Raj Khatri	Jonathan Kaye

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