Low Power Modes
BL654PA Module

Application Note   *v1.0*

1   INTRODUCTION

The BL654PA 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 document demonstrates how to load a *smart*BASIC application in order to test the power consumption of the two low power modes: Standby Doze and Deep Sleep.

2   REQUIREMENTS

- Laird DVK-BL654PA (455-00022 or 455-00023)
- Micro USB to USB (Type-A) Cable – Provided with the devkit
- UwTerminalX v1.10a or later (found at https://github.com/LairdCP/UwTerminalX)
- *lp.low.power.deep.sleep.sb* application (found in the BL654PA GitHub repository)
- Current measuring digital multimeter (DMM) to measure current at J7 (VDD pin) and J9 (VDD_HV pin)

3 DEVELOPMENT KIT SETUP

To set up the DVK-BL654PA 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 and only valid position)
   - CR2033/VCC_3V3/1V8 switch (SW6) – In position VCC_3V3/1V8 (default and only valid position)
   - Switch SW7 is in middle position for Normal Voltage mode operation (default)
   - Jumper J7 removed, cut solderbridge SB1 and DMM inserted to measure current taken by VDD pin in Normal Voltage mode. Make sure jumper J9 is fitted
   - Jumper J9 removed, cut solderbridge SB13 and DMM inserted to measure current taken by VDD_HV pin in Normal Voltage mode. Make sure jumper J7 is fitted
   - Jumper J26, J37, J45, J39 removed 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 (and then to J9) on the development kit (Figure 1).

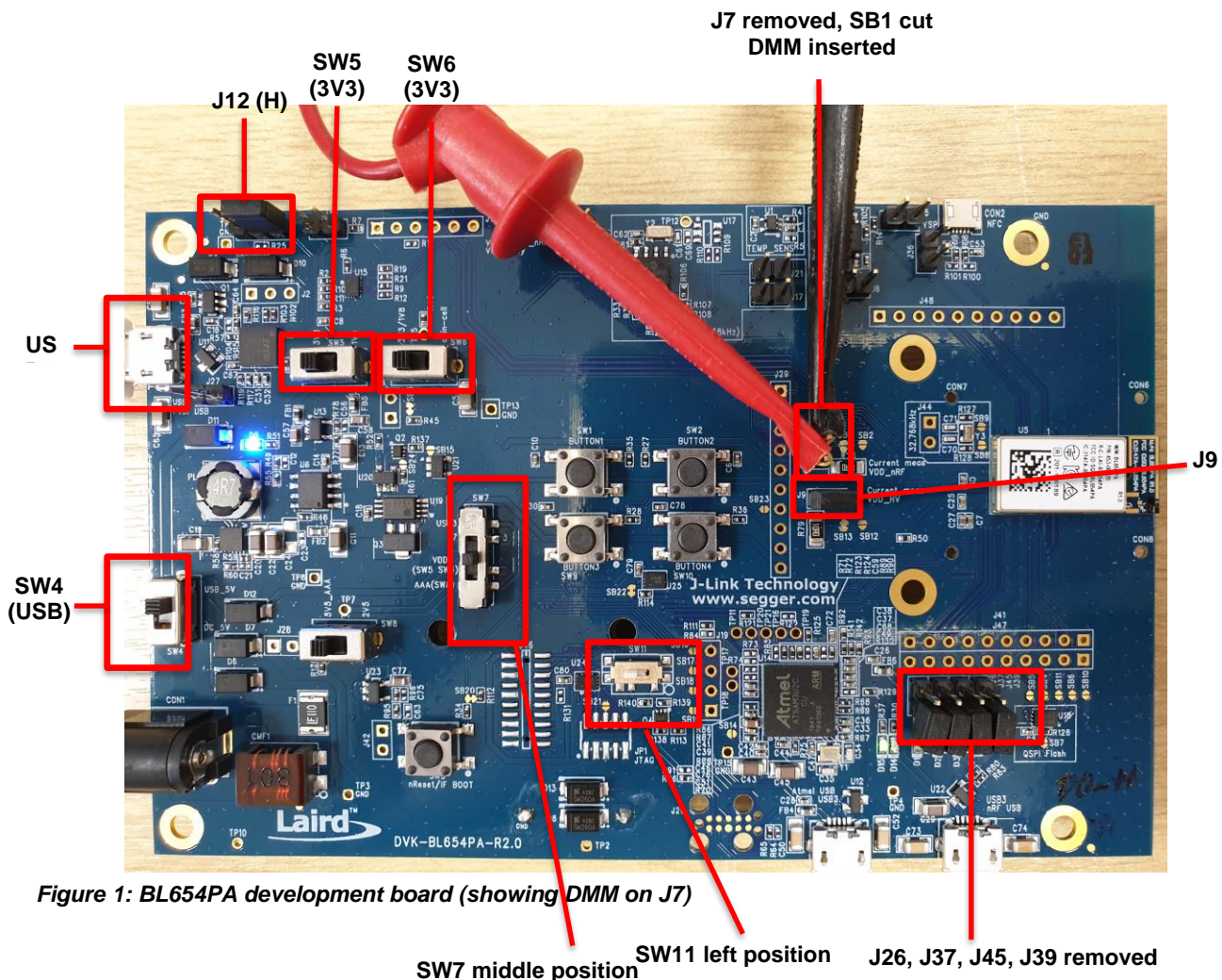**Note:** After the test is complete, remember to replace the jumper on J7 and J9.

Figure 1: BL654PA development board (showing DMM on J7)

3. Connect the DVK-BL654PA to your PC via the included USB-A to USB micro cable.

4. Ensure that the current measuring DMM is connected to J7 (for measuring current taken by VDD pin) whilst jumper in J9 is fitted before the development kit is powered up (or else the board will not be powered).

5. Ensure that the current measuring DMM is connected to J9 (for measuring current taken by VDD_HV pin) whilst jumper in J7 is fitted before the development kit is powered up (or else the board will not be powered).

6. Follow the on-screen prompts. Windows may prompt you to install FTDI drivers (found at http://www.ftdichip.com/FTDrivers.htm).

7. Ensure that the Windows Device Manager displays a new virtual COM port for the USB to Serial adapter.

8. Launch UwTerminalX.

9. From the Config tab in the Device drop-down menu, select **BL654PA** to populate the baud, parity, stop bits, data bits, and handshaking settings. If *BL654PA* is not selectable, set the configuration as shown in Figure 2.

10. In the Port drop-down menu, select the COM port associated with your DVK-BL654PA. At the top of the screen, click **OK.**
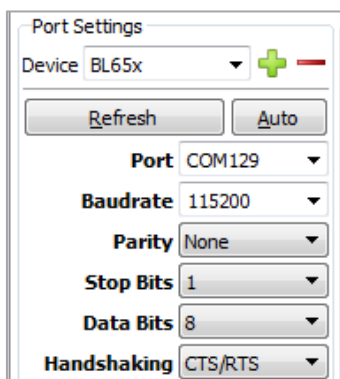

Figure 2: Setting connection parameters

11. To return the BL654PA 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.
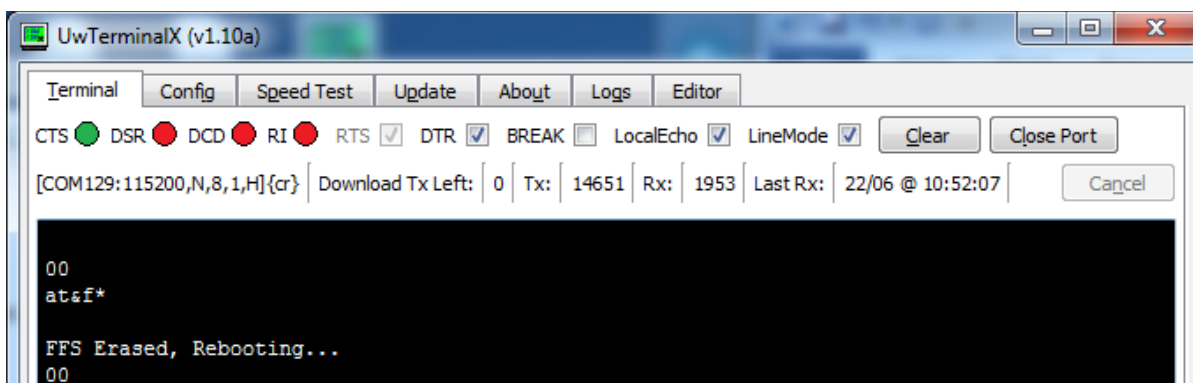

Figure 3: Return BL654PA to factory default settings

4 RUNNING LOW POWER APPLICATION

The low power modes application can be downloaded and extracted from the zip file from GitHub or saved from the GitHub raw file page:
https://github.com/LairdCP/BL654-Applications/blob/master/Applications/lp.low.power.deep.sleep.sb

Note: This application note assumes that you are familiar with loading *smart*BASIC applications onto the BL654PA module using UwTerminalX. If not, see the application note *Loading smartBASIC Applications - BL654PA*, available in the Documentation tab on the BL654PA product page of the Laird Connectivity website

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 the module into deep sleep mode

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

3. You can 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 total current measured at J7 and J9 (VDD pin +VDD_HV pin) should fall to about 2.0 uA (Figure 6).

Figure 6: Deep Sleep mode current in Normal Voltage mode (VDD pin +VDD_HV pin) is 2.13uA total (=0.79uA + 1.35uA)

Note: The only way to exit deep sleep mode is through a hardware reset. This returns the BL654PA 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 BL654PA 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 BL654PA using the reset button (SW3).

3. Erase the flash file system using the interactive command *at&F**.

4. Load the Low Power application. Use the right-click menu on the UwTerminalX window and 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 total current measured at J7 and J9 (VDD pin +VDD_HV pin) should fall to about 5.9 uA to 7.0 uA (Figure 8).

Note: Once you're done with the current measurement, place the jumper back on J7 (and J9) as otherwise the BL654PA is not powered (through the USB port) and is powered parasitically instead.
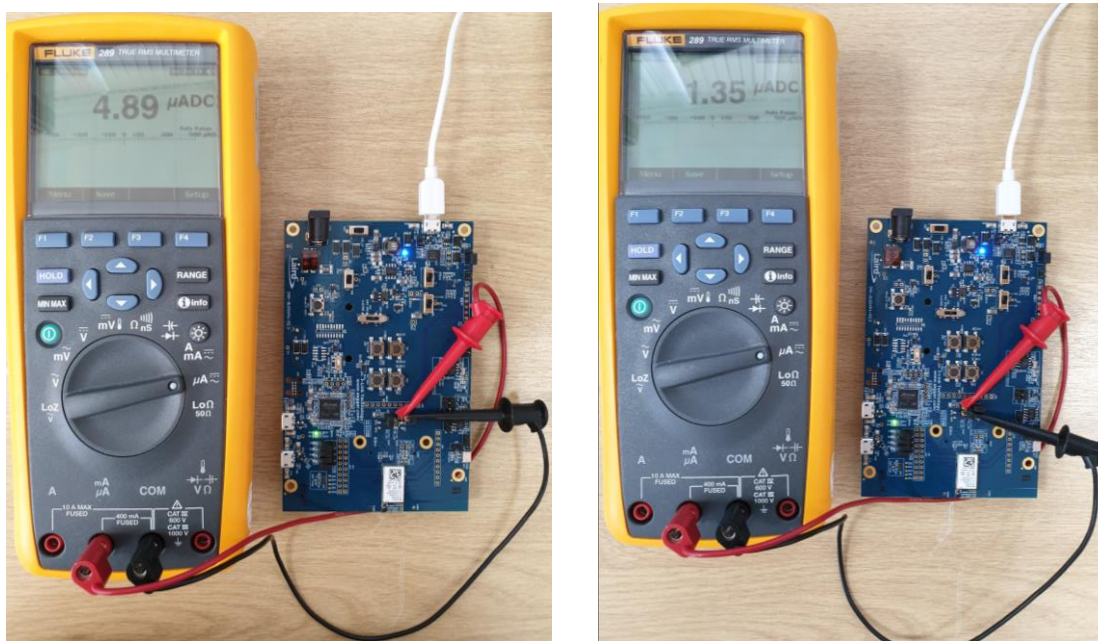

Figure 8: StandByDoze current in Normal Voltage mode (VDD pin +VDD_HV pin) is 6.24uA total (=4.89uA + 1.35uA)

5 FURTHER INFORMATION

Additional documents are also accessible from the Documentation tab on the BL654PA product page of the Laird Connectivity website

6 REVISION HISTORY

Version	Date	Notes	Contributor(s)	Approver
1.0	27 August 2019	Initial Release	Raj Khatri	Jonathan Kaye

Americas: +1-800-492-2320
Europe: +44-1628-858-940
Hong Kong: +852 2923 0610