Cordio™ BT4 Radio IP
WH000

# Customer Evaluation and Demonstration Kit User's Guide

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# Cordio™ BT4 Radio IP, Customer Evaluation and Demonstration Kit User's Guide



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## Change history

| Issue | Date | Release note part version |
|---|---|---|
| 0.1 | Feb 2015 | Original Sunrise Micro Release |
| 1.0 | Jan 2016 | ARM Release r2p3-00eac0 |
| 2.0 | April 2016 | Modified Sections 5.2 and 5.3 to add power profile picture, modified 3v measurement test point instructions. |
| 3.0 | 26 Jun 16 | Released at r2p3-07rel0 |
| 4.0 | 29 Aug 16 | Released at r3p0-00rel0 |

# 1 Contents

# 1 KIT CONTENTS

## 1.1 Contents

The CORDIO™ BT4 Evaluation and Development Kit contains the following items:

- ARM Cordio BT4 Module (P/N: Cordio BT4 Module BD)
- ARM Customer Evaluation Base Board (P/N: BT4-GEN2-EVAL)
- USB power cable
- USB to UART cable
- Whip Antenna
- Batteries: 3V Lithium Coin cell, 1.5V AAA Alkaline, and 1.2V Zinc/Air Button
- USB FLASH Drive:
    - Customer Evaluation and Demonstration Board User's Guides
    - Board Schematics
    - Radio Control Tool Utility and User's Guide
    - Android Demo Application
    - Bluetooth Qualification Certificates
    - RF PHY Test Report
    - Product Marketing Literature
    - Cordio BT4 Technical Summary

## 1.2 Default Jumper and Switch Positions

The CORDIO Evaluation Board should ship with the jumpers and switches in the following positions. More information about their configuration can be found in Sections 3.3 – 3.5.

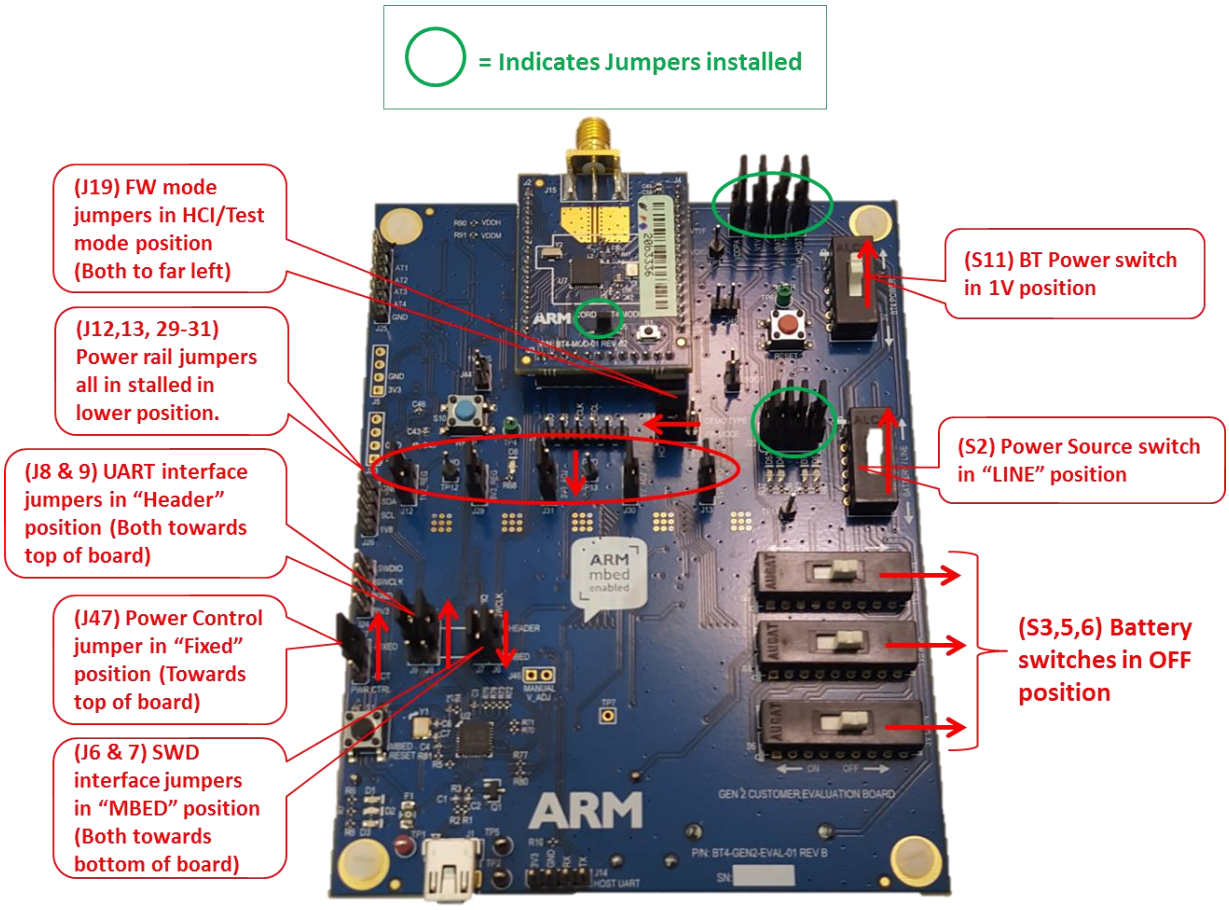



***Figure 1.2 – Default Jumper and Switch Positions***

# 2 DESCRIPTION

## 2.1 Overview

The Cordio BT4 Module and Customer Evaluation Base Board is based upon the CORDIO™ BT4 Development SoC which is a low power, 40 pin 5 x5 mm QFN that contains the BT4 Radio IP plus an ARM Cortex M0+™ host MCU.

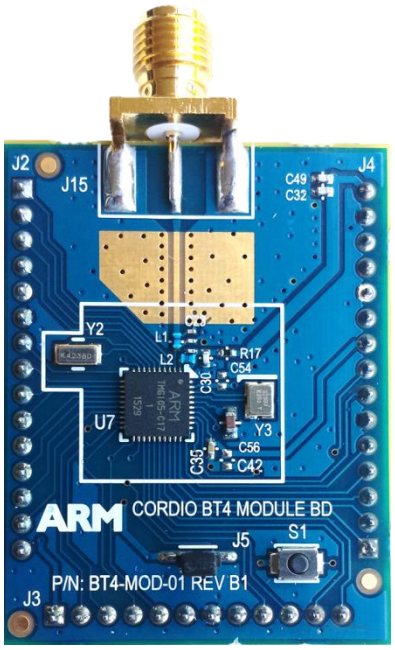



***Figure 2.1 – Cordio BT4 Module***

The BT4 Development SoC in on 42 pin Module which contains the necessary discrete RF components around the BT4 radio IP block within the SoC, the SoC's External EEPROM and a Reset Button. The majority of pins of the SoC are various voltage rails and I/O signals that are taken directly to the pins on the module. This modular approach is taken to easily upgrade to future Cordio products.

The Customer Evaluation Base Board or "Eval Board" is a platform for the Module to plug into which enables the evaluation of BT4 Radio Hard Macro's RF performance and the low power consumption characteristics. Supported by a Bluetooth Smart® protocol stack from ARM®, the evaluation platform supports the choice of either a test FW mode or an operational / demo FW mode.

Schematics and Bill of Materials for both boards can be found in the *Cordio BT4 Module and Eval board Schematics* document included on the USB thumb drive provided in the Evaluation kit.

The platform can be powered from either an external 5v supply (Bench supply or USB cable) or from one of three different types of batteries.

The board is mbed enabled allowing the user to utilize mbed tools and example source code as well as Keil tools to develop custom FW for their ARM Cortex based SoC while it is still in development. It also supports drag-n-drop FW programming of the Module.

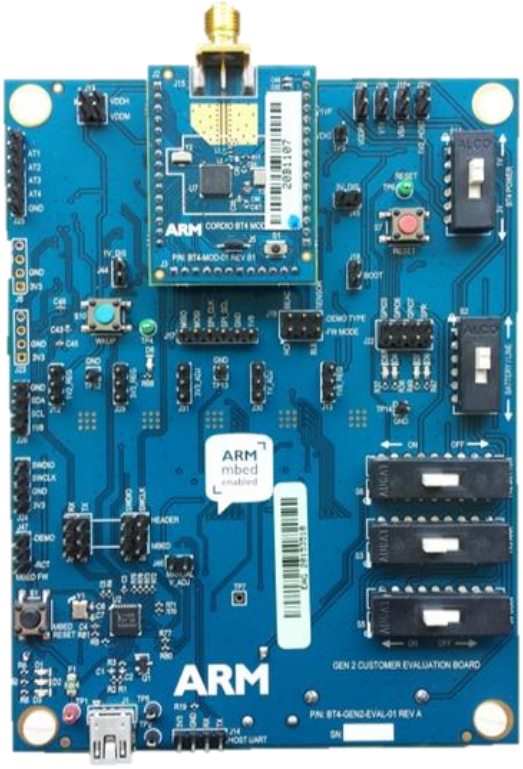



***Figure 2.1a – Gen 2, BT4 Eval Board, Top Side***

***Figure 2.1b – Gen 2 BT4 Eval Board, Bottom Side***

## 2.2 Features

- Based upon ARM Cordio BT4 Development SoC
  - BT4 Radio IP Block with an ARM Cortex M0$^{+}$ Host MCU
- Includes full Bluetooth Smart protocol stack
- Selectable Power Sources:
  - 5 Volt (USB or Bench supply), 3v CR2032 Lithium Coin Battery, 1.5v AAA Alkaline, 1.2v Zinc/Air Hearing Aid Battery
- Current measure test points on all power rails to radio IP block and Host MCU
- Radio Control Tool: Tx and Rx evaluation via DTM HCI commands
- SMA jack / Whip antenna
- Board Usages:
  - RF Evaluation: (conductive or radiated)
  - Power consumption evaluation
  - Demo Modes: Temperature & Gyro sensors / UriBeacon mode
  - Development of Host MCU Firmware/Applications:
    - mbed enabled: On-line IDE with C/C++ compiler toolchain, SDK/open-source libraries, developers collaborative forum, Keil tools. Supports drag and drop MCU programing.

# 3 HARDWARE

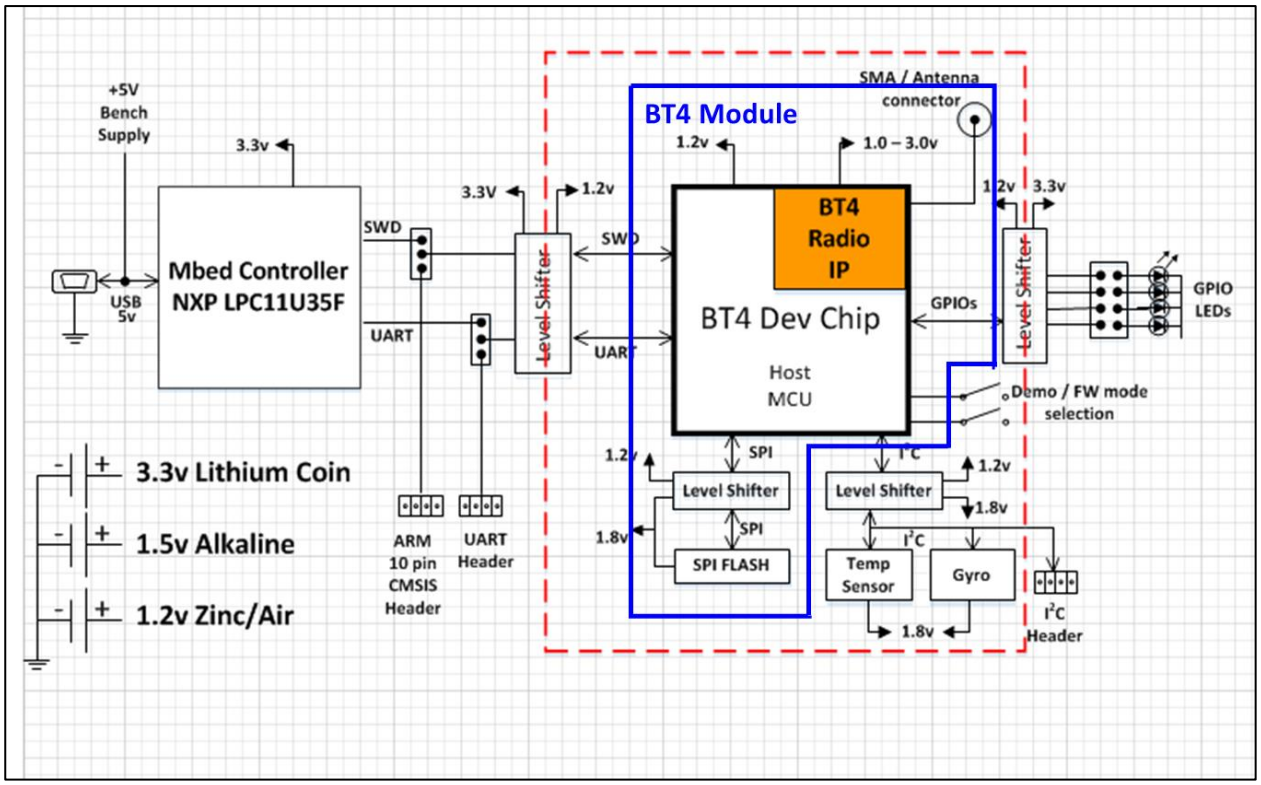



***Figure 3.1 - BT4 Customer Evaluation Board – Block Diagram***

## 3.1 Block Diagram

The ARM Cordio BT4 Radio IP can be run in either a 1 volt or 3 volt mode/domain. The Cortex M0$^+$ Host processor and its memories within the SoC are run at 1.2 volts. Level shifters are provided on all I/O buses to take the SPI and I2C interfaces to 1.8 Volts and the UART and Serial Wire Debug lines to 3.3v. A separate mbed controller from NXP runs at 3.3v and provides mbed development tools and drag-n-drop programming of the FW for the BT4 Development SoC.

The entire block diagram is power-up when run in 5 volt line powered mode. Components within the red rectangle are powered in any one of the three battery modes at 1.2 volts. The BT4 IP block is powered at either 1.0 or 3.3 volts depending on the S11 switch setting.

## 3.2 Power Selection and Switches

The BT4 Customer Eval board can be powered by either an external 5v supply or from 1 of 3 on-board batteries.

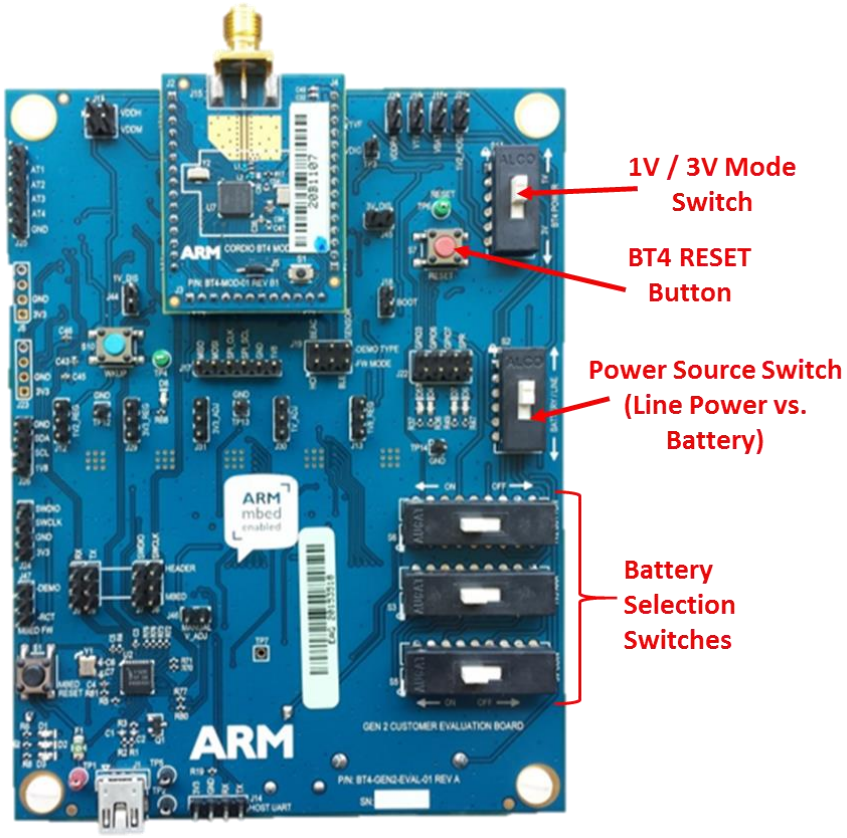



***Figure 3.2 - BT4 Customer Eval Board – Switch Descriptions***

### 3.2.1 5 Volt External Supply:

An external 5 volt line supply can be provided either via the provided USB cable or via a 5v Bench supply attached to TP1 and TP2 on the bottom left corner of the board. To select this power mode, slide the “Power Mode Switch”, located along the center right edge of the board, to the “Line” position (towards the top of the board).

If “Line” mode is selected, the position of the 3 Battery selection slide switches on the lower right side of the board do not matter. We recommend all 3 of these switches be slid to the right (towards the edge of the board) in the “OFF” positions so that the batteries are not drained due to powering their respective on-board voltage regulators.

### 3.2.2 Battery Supplies

The Eval board may be powered by one of three on-board batteries. First, the “Power Mode Switch” along the center right edge of the board must be slid towards the bottom of the board in the “Battery” position (towards the 3 battery slide switches).

You may now select one of three batteries to power the board via the 3 Battery switches along the right lower side of the board.

- 3.3V Lithium Coin cell
- 1.5 V AAA Alkaline cell
- 1.2V Zinc/Air Button battery

A given battery is selected by sliding a switch to the “ON” position (towards the center of the board).

PLEASE NOTE: **Only one battery switch may be ON at any time**. To prevent multiple power sources being applied at the same time, if two or more of the 3 battery switches are “ON” at the same time, all 3 battery sources will be disabled.

When the board is not in use, or is being transported, place all 3 battery switches in the “OFF” position (towards the edge of the board) to conserve battery life. Simply placing the main Power Mode Switch in the “Line” position does not disable the batteries from powering their respective regulators.

### 3.2.3 1v / 3V Mode Switch

The Cordio BT4 IP block can be powered via either a 1 volt or 3 volt rail. Switch S11, labeled as “BT4 Power” on the top right corner of the board, selects what power mode the BT4 IP block will be run in.

The 1 volt mode can be selected regardless if the board is being powered by line power or any one of the 3 different battery supplies.

The 3 volt mode is only valid when powering the board via 5v line power or by the 3.3v Lithium battery. 3 volt mode is not functional when powering the board via the 1.5v AAA or 1.2 Zinc/Air batteries.

**PLEASE NOTE: DO NOT SWITCH POWER MODES WHEN POWER IS SUPPLIED TO THE BOARD AS THIS MAY PERMENTANTLY DAMAGE THE SOC. Always power-down the board prior to moving this switch position!**

### 3.2.4 Power Domains

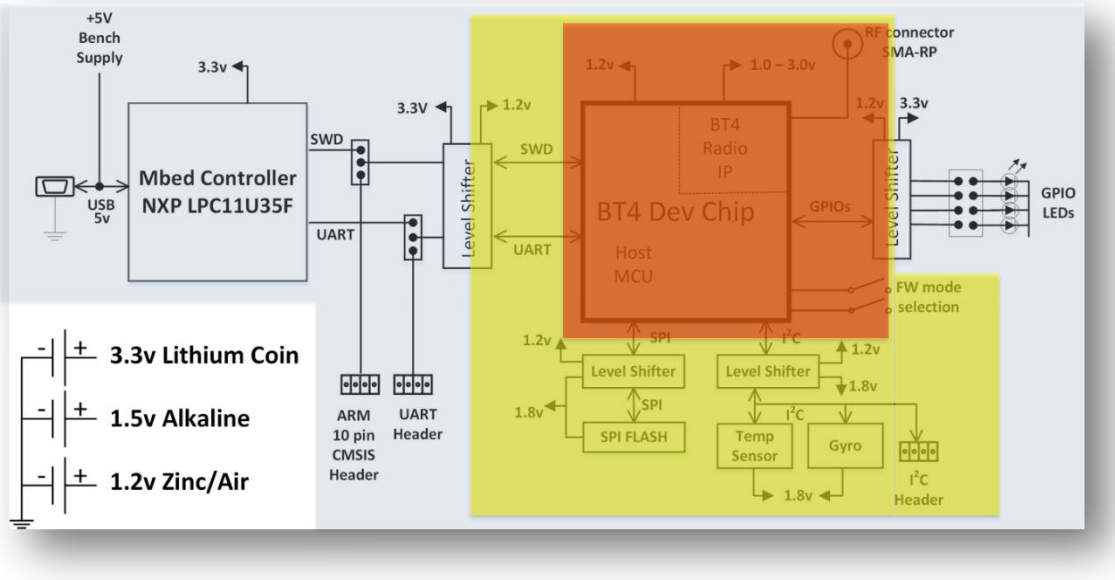



***Figure 3.2.3 - Block Diagram – Power Domains***

All circuitry on the board is powered up when the board is run in “Line” mode on an external 5 volt supply as shown by the grey shaded areas above. You MUST run in 5 volt mode to utilize the mbed controller or external interfaces such as the Host UART during RF testing or FW programing.

The yellow shaded area indicates what blocks are active in either 3V Lithium battery or 1.5V AAA Alkaline battery modes. These Battery modes support both the Sensor Demo and the Beacon demo. You cannot utilize test modes (see Section 6) via the Host UART port while in Battery mode unless you are also hooked up to an external 5v supply.

In 1.2v Zinc/Air battery mode, only the BT4 SoC is powered up as shown by the orange shaded area. This allows the user to run the Beacon demo where no additional I/O is active. Unlike a production SOC, the BT4 Demonstration SoC relies on external SPI FLASH to store its firmware. This 1.8v FLASH is powered via the 1.5V AAA battery during boot while the BT4 SoC is powered by the 1.2v Zinc/Air battery. Therefore, a 1.5V AAA battery must be installed on the board (but 1.5 volt switch off) for Boot purposes when running in 1.2v mode. (Depending on your board revision, the additional 1.8volt Gyro and Temperature sensors maybe active in 1.2v mode. These sensors are also powered by the 1.5V AAA battery).

The table below shows the operational usage modes that are available in each of the 4 power source options.

| | | Customer Eval Board - Usage Mode | | | | |
|---|---|---|---|---|---|---|
| | | Radio Evaluation/ Power Consumption (w RCT) | FW Development, Keil Tools | MEMS Sensor Demo (Temp, Gyro) | Beacon Demo | GPIOs |
| Power Source | VBUS (5V Bench | Y | Y | Y | Y | 3.3v |
| | 3.3V Coin | N | N | Y | Y | N |
| | 1.5V AAA | N | N | Y | Y | N |
| | 1.2v Zinc/Air | N | N | Y | Y | N |

***Table 3.2.3 - Power Source vs. Operation Mode***

## 3.3 Jumpers

The following section provides a description of various jumpers and their function:

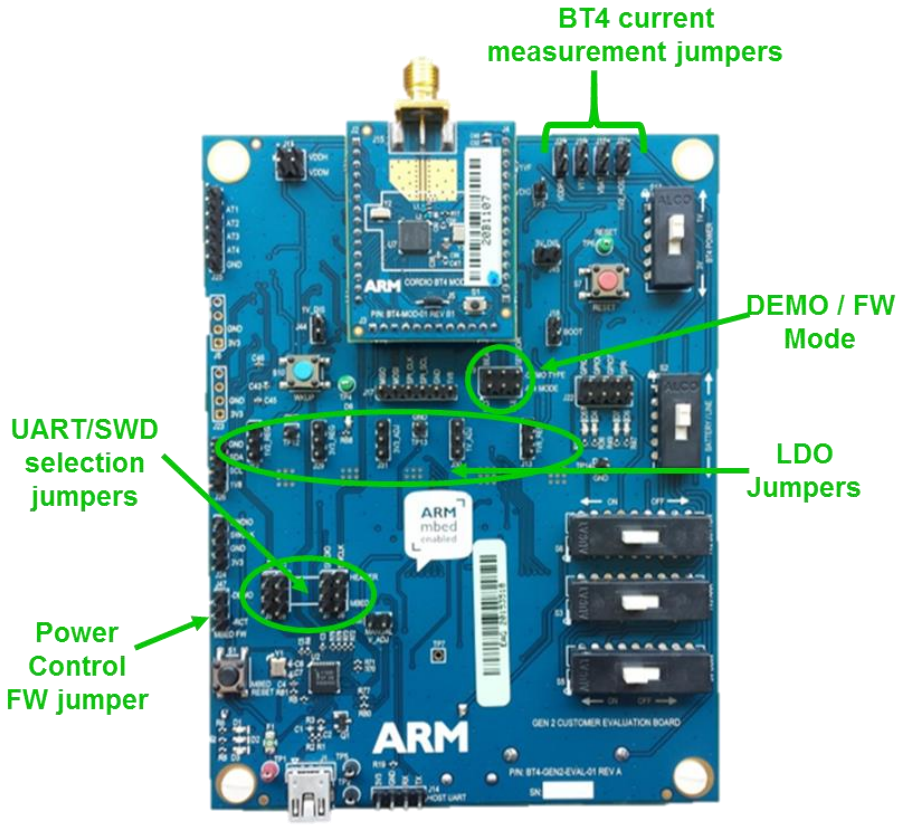



***Figure 3.3 - BT4 Customer Eval Board – Jumper Descriptions***

### 3.3.1 Power Control FW Jumper

J47 located along the lower left edge of the board determines how the on-board power regulators are controlled. The on-board LDO regulators for both the 1.0 and 3.3 volt power rails can be either fixed to these levels – OR – these regulators can supply a variable voltage level if under the control of the Radio Control Tool (RCT) as described in Section 6.1.

**The jumper on J47 should be placed in the upper "FIXED" position when the board is operating in Battery power mode or when the board is in 5v Line Power mode but is NOT under RCT control. This will pre-set the 1 volt and 3 volt rails to a fixed 1.0 and 3.3 volts respectively.**

**The lower position marked "RCT" should only be selected when a) The J19 FW jumpers are configured to HCI or "Test" mode (Section 4), b) the board is being powered in 5 volt Line Power mode and c) when the board is attached to a PC via both the USB to USB cable and the USB to UART cable and is under the control of the Radio Control Tool or "RCT".**

The RCT has the ability to adjust both the 1 volt and 3 volt power rails to the BT4 Radio IP block within the SoC for various power consumption tests. Setting of the voltage level on either power rail is done by the RCT user interface.

### 3.3.2 Current Measurement Jumpers:

The four "BT4 Current Measurement Jumpers" across the top of the board must ALWAYS be installed regardless of what power source is chosen. These four jumpers are on power pins of the BT4 SoC and are made available to measure the current draw on various parts of the BT4 Radio IP as well as the Host MCU. Below is the list of these jumpers, the voltage rail name and a brief description. A more detailed explanation of current measurement is provided in Section 5.

| Jumper | Signal Name | Description |
|---|---|---|
| J20 | VDDPA | This line powers the PA within the BT4 Radio IP block. In 1v mode, it is tied to V1V and VBAT on the board but may be monitored independently on J20. Power to VDDPA is provided internally to the IP block when it is run in 3v mode. |
| J16 | V1V | This is the main power rail to the BT4 IP block in 1V mode. It is tied to VBAT and VDDPA on the board but can be monitored independently at J16.<br>In 3 volt mode, 1V1 is generated as an output of the 3V regulator. |
| J15 | VBAT | VBAT is tied to V1V and VDDPA when the BT4 IP is run 1v mode. In 3 volt mode, VBAT is the main supply rail to the BT4 Radio IP Block of the SoC. |
| J21 | 1V2_HOST | This provides power to the Cortex M0+ Host MCU and its memories within the BT4 Eval SoC. This rail does not power the BT4 Radio IP Block and should not be figured into the Radio IP power consumption. |

***Table 3.3.1 - BT4 SoC Voltage Rails – Current Measurement Pins***

### 3.3.3 LDO Jumpers:

When the board is powered by an external 5 volt power supply, 5 LDO's generate the required on-board voltage supplies. These 5 "LDO jumpers" (J12, 13, 29, 30, & 31) are all required to be installed if the board is powered whether by an external 5V supply or through USB. (Population of these jumpers may be present in Battery Power Mode but have no relevance). These jumpers are provided to measure current consumption or provide a tap for an external power source for voltage margining. The relevant jumpers related to measuring current consumption by the BT Radio IP Block is 1V_ADJ (J30) and 3V_ADJ (J31) as the other three LDO's power additional devices on the board. Below is a description of what each voltage rail powers on the board.

| Jumper | Signal Name | Description |
|---|---|---|
| J12 | 1V2_REG | This power rails provides 1.2v to the Host MCU inside of the BT4 SoC. It powers the internal memories of the SoC as well as the I/O interfaces. External to the BT4 SoC, 1.2v is applied to the low side of several level shifters. |
| J13 | 1V8_REG | 1V8 is primarily provide to supply power to the SPI FLASH memory for the BT4 SoC as well as the on-board Gyro and Temperature sensors and an I2C header to add off board sensors or peripherals. |
| J29 | 3V3_REG | 3V3 is primarily provided to power the Mbed controller as well as to provide 3.3V for I/O such as the BT4 Host UART, GPIOs and SWD interfaces. |
| J30 | 1V_ADJ | 1V_ADJ is provided to power the BT4 Radio IP block inside of the BT4 SoC when it is run in 1v mode. The voltage is preset to 1.0 volts when the Radio Control Tool (RCT) is not being used. Under RCT control, the voltage line can be varied from 1.0 volts to 1.65 volts. |
| J31 | 3V_ADJ | 3V_ADJ is provided to power the BT4 Radio IP block inside of the BT4 SoC when it is run in 3v mode. The voltage is preset to 3.3 volts when the Radio Control Tool (RCT) is not being used. Under RCT control, the voltage line can be varied from 1.6 volts to 3.6 volts. |

***Table 3.3.2 - LDO Power Jumpers***

### 3.3.4 UART/SWD Jumpers:

The four UART/SWD Jumpers (J6-9) allow the BT4 SoC's Host UART and Serial Wire Debug (SWD) interfaces to be switched between the mbed controller and connector headers for external communications.

"UART/SWD jumpers" (J6-9) are located above the USB connector on the bottom left side of the board. Placing all 4 of the jumpers in their top position (marked "Header") will connect the BT4 SoC Host UART to the J5 UART header just to the right of USB connector. This is the default position that is used in most applications. This position allows serial communications with Test equipment and PCs running ARM's Radio Control Tool via J14.

**Please note that the UART supports 3.3 volt signal level.** A USB to UART cable is provided in the Kit that supports 3.3 volt signal level. **If you are connecting the Eval board to the RS-232 port of test equipment, you will need to install a signal level shifting cable or adapter!**

Placing these jumpers in the lower "mbed" position will connect the SWD and UART interfaces to the mbed controller. This is used for drag-n-drop programing of the BT4 SoC's FLASH. (See Section 9 on FW programming). This also allows support of Keil tools via the USB connector. Please visit www.mbed.org to learn more mbed tools and development community.

The Default positions for these jumpers are to have the UART jumpers (J8 & 9) to be in the top "Header" position to allow UART communicates via the J14 UART header. Counter to this, the Serial Wire Debug (SWD) jumpers (J6 & 7) should be in the lower "MBED" position to allow for FW updates and other functions as described in Section 9).

### 3.3.5 Firmware / Demo Selection Jumpers:

The J19 Firmware/Demo Selection jumpers are located just under the lower right corner of the module. There are two jumpers that determine the functionality of the board at boot time by loading the appropriate FW for either Test Mode or Demo Mode. Please see Section 4 for additional information on these FW modes.

## 3.4 Headers

The following headers are available on the BT4 Evaluation Board.

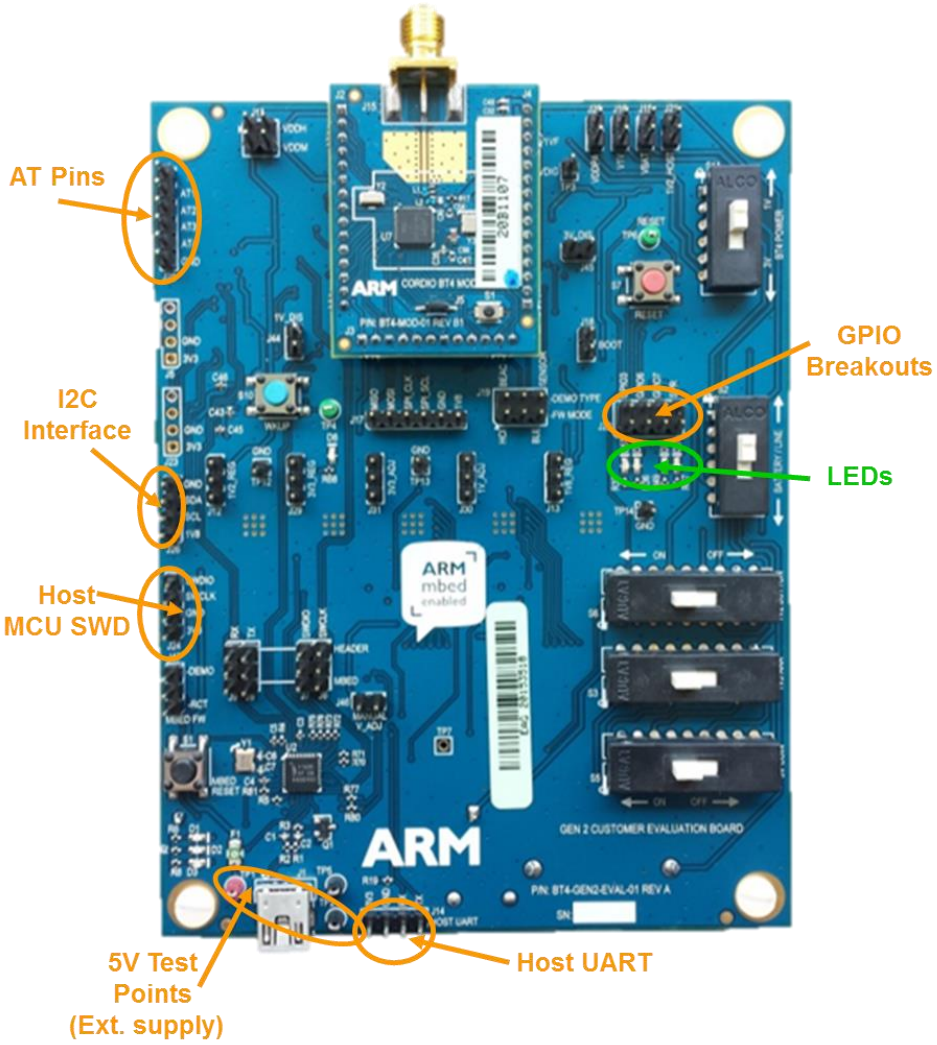



***Figure 3.4 - Header Descriptions***

### 3.4.1 J14 - Host UART:

Located on the bottom edge of the board, the Host UART port is provided to be able to communicate to the BT4 SoC and the BT4 Radio IP. The following board configuration is required:

- The board must be powered via 5 volts (external supply or USB) to be able to use this port.
- The UART Jumpers (J8 & J9) must be in the Header position (See Section 3.3.43.3.4).
- The FW mode (J19) must be set to “HCI” FW mode (See Section 4).
- The UART speed is 115200 baud, 8 bit, 1 stop, no flow control

**Please note that the UART supports 3.3 volt signal level.** A USB to UART cable is provided in the Kit that supports 3.3 volt signal level. **If you are connecting the Eval board to the RS-232 port of test equipment, you will need to install a signal level shifting cable or adapter!**

### 3.4.2 5 Volt Test Pins:

Located on the lower left corner of the board are test points TP1 (Red, +5V) and TP2 (Black, GND). These are voltage supply points to power the board from an external bench power supply.

The TP1 is tied to the same 5v input line as VBUS on the USB connector. The board is protected by a fuse for both these 5 volt input signals.

### 3.4.3 J26- $I^2C$ Pins:

This connector is located along the center left edge of the board. This connector is provided to add additional off-board I2C sensors for development and/or demonstration purposes. This 4 pin connector provides 1.8v output, Gnd, SCL (Clock) and SDA (Data) signals. The I/O signals are level shifted from the 1.2 volt MCU interface to 1.8 volts.

### 3.4.4 J22 – GPIOs (and LEDS):

J22 is located just to the left of the Line/Battery power mode slide switch along the right edge of the board. The 4 pins on the top row of this header are 4 unused GPIO pins from the BT4 SoC (Level shifted to 3.3 volts). If the user is utilizing the BT Eval Board as a firmware development platform, these lines can be programmed for specific functions/indicators. A jumper can be placed across a pair of pins on J22 to connect the GPIO to a LED for status indications.

Currently, GPIO 3 has functionality when the Eval board is in Demo mode (see Section 8.3), the other LEDs currently have no function. *Please check the LED numbers vs the GPIOs on the board schematics as the row of LEDs underneath J22 do not line up directly with the corresponding GPIO jumper label above them on older revisions of the board. This was corrected in revision C of the Evaluation board.*

### 3.4.5 J25 – AT Pins:

J25 can be found on the top left hand corner of the board. This consists of 4 Analog Test Pins. These pins are used for measurement in various trimming and calibration procedures. Further explanation on the use of these pins is beyond the scope of this document.

### 3.4.6 J24- Host Serial Wire Debug:

This header can be found along the left edge of the board. These signals are level shifted to a 3.3 volt level and are provided for debug purposes when developing custom FW on the Eval board platform. The SWD jumpers (J6 & J7) must be in the Header position to route the SWD signals to the J24 header (See Section 3.3.4).

### 3.4.7 J17 – SPI Bus

The J17 header can be found just under the BT4 module in the upper center of the board. It provides access to the SPI bus of the BT4 Development SoC for use with external devices.

## 3.5 Buttons

The figure below shows various push buttons on the Customer Evaluation Platform. This includes Reset of the BT4 Development SoC, an interrupt button labeled as “WKUP” (Wake-up) and an mbed controller reset button. The functions of these buttons are described below.

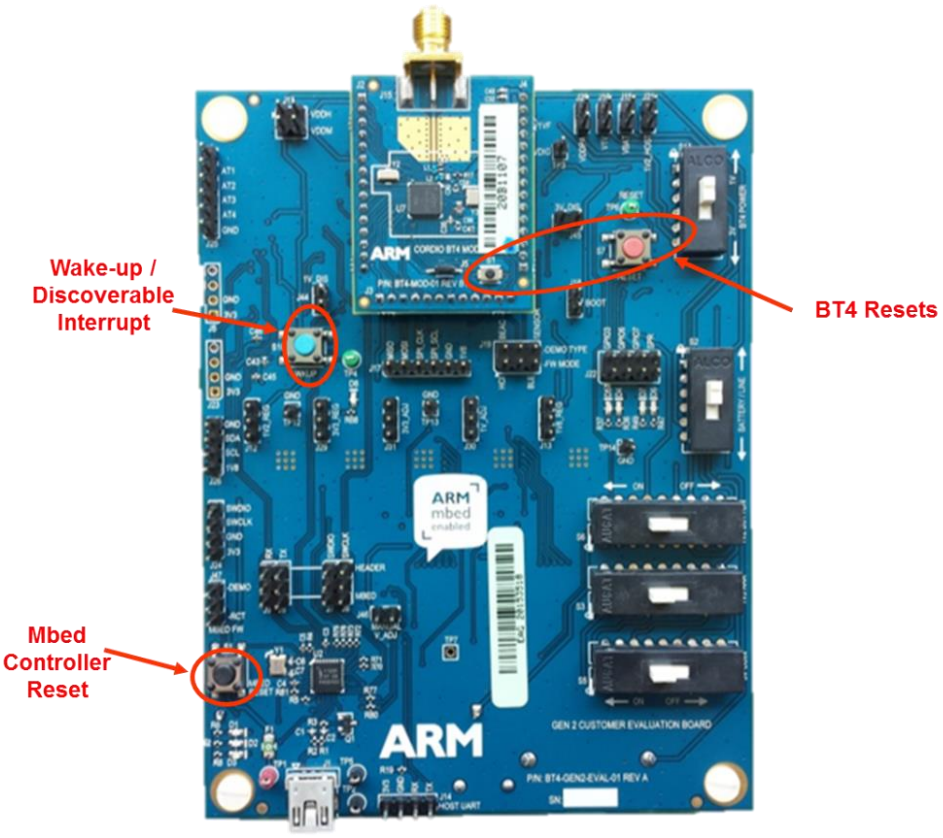



***Figure 3.5 – Push Button Locations***

### 3.5.1 BT4 Reset Buttons

The BT4 Reset buttons reset the entire BT4 Demonstration SoC which means it resets both the BT4 Radio IP block and the host MCU. This Reset button is the Red momentary push button to the right of the module.

There is also a small black Reset button in the lower right corner on the module itself. It has the same function of the Red button on the base platform board.

It is always a good idea to press either Reset button after power has been applied to the Evaluation Board.

### 3.5.2 Wake-up/Discoverable Button

The momentary Blue button located near the lower left corner of the module is an interrupt button on one of the BT4 Demonstration SoC's GPIO lines. The button has 2 functions:

1) When the Customer Eval Board is in either of the Demo modes (Beacon or Sensor), the board will be in a connectable mode for 30 seconds after power up. After that time, the board will shift into a low-power operational mode. In Beacon mode, it will continue to beacon without being connectable via the provided BT4 Browser application for configuration purposes. In Sensor mode, it will stop advertising altogether and not be discoverable/connectable by the BT4 Browser application. Pressing the Blue button will return the board to connectable mode again for 30 seconds. Once this time elapses, the board will re-enter its low-power mode.

   If jumpers on J22 are installed for the GPIO lines, the D4 LED with flash rapidly when the board is in a connectable state. After 30 seconds have expired, the LED will flash slowly. The LED will also flash slowly once it has made a wireless connection to a host device.

   **PLEASE NOTE:** Depending on which FW version is installed on the module, pressing the Blue button twice (about a second apart), may be required to place the unit into a connectable mode.

2) If the SoC has been placed in deep sleep mode, either by the Radio Control Tool or via HCI commands, this Blue button will manually wake-up the SoC from its deep sleep state. This functionality is only available in Test/HCI pass-through mode.

### 3.5.3 Mbed Reset Button

The mbed controller reset button is a Black momentary push button located in the lower left portion of the board. This is provided only for FW updates for the mbed controller and has nothing to do with the operation of the BT4 Demonstration SoC. Under normal operation, this button will not be used. If pressed, it may momentarily interrupt communication between the Customer Eval Board and the Radio Control Tool.

# 4 FW MODES

The board has the option to run Operational / Demo Firmware or Test/HCI Firmware. Within the Demo FW is the option to have the board run as either a Beacon or as a Sensor platform. Selection of the desired FW version to be loaded at power-up is done by two jumpers on J19.

Power to the board should be off prior to changing either one of these jumper settings. Upon power-up, the jumper selection will be read and the appropriate FW version will be loaded into the SoC.

The lower row determines if the board comes up in Operational / Demo mode or in the Test Mode (also known as "HCI Pass-Through" mode) that supports Direct Test Mode (DTM) commands for controlling the radio. Placing the lower jumper towards the right (green arrow) places the board in a Bluetooth Smart operational mode or "BLE" where various demos can be run. (The specific type of demo is selected by the position of the jumper on the top row of J19). Placing the jumper towards the left (yellow arrow) places the board in the Test Mode where HCI commands can be directly passed to the BT4 Radio IP via the SoC Host UART connector J14.

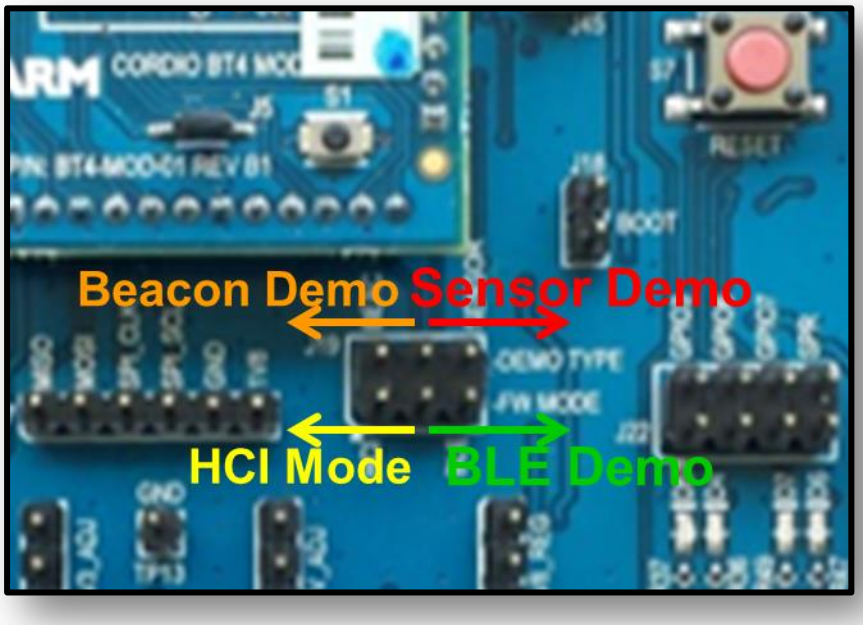



***Figure 3.3.4 - Demo/FW Jumper***

The top row of pins determine if the board powers-up as a Sensor Demo or as a Beacon Demo as shown in the picture above. (As stated previously, the lower jumper must be in the "BLE" FW position). Placing the jumper towards the left (Orange arrow) will place the board in Beacon mode whereas placing the jumper on the right side (Red arrow) places the board into Sensor mode. The position of the jumper on the top row is not relevant if the lower jumper is set to Test or "HCI" FW mode.

# 5 CURRENT MEASUREMENT

The current drain for the BT4 Radio IP can be measured independently from current required by the rest of the BT4 Demonstration SoC. Current measurement can be done while the BT4 Radio IP is running in either 1 volt or 3 volt mode.

## 5.1 Considerations

**PLEASE NOTE:** Any current meter used to measure current drain must ***not*** be set for "auto-ranging", particularly if standby current is to be measured. Many meters are poorly regulated and/or have large time constants that can cause overvoltage situations while switching ranges. This can cause permanent damage to the BT4 SoC and/or Radio IP block.

To access the appropriate current measurement points, please measure current when operating the Eval board in 5 volt Line powered mode vs. being battery powered. To ensure you are operating in this mode, check that the Power Mode switch located along the middle right edge of the board is in the "Line" position as described in section 3.2.1.

## 5.2 1 Volt Mode – Current Measurement

With the Evaluation board powered down (5 volt power removed from the board), place the 1V / 3V switch (located along the top right edge of the board) in the 1 volt mode by sliding the switch upwards. (See Section 3.2.33.2).

With power still removed from the board, remove the jumper from J30 (located just above the ARM mbed logo). Attach your desired current measuring equipment across the two lower pins of the connector as shown below. The center pin, Pin 2 on the connector, is the downstream voltage supply rail to the BT4 SoC. Pin 3 on the bottom of the J30 header of the board is the 1 volt supply coming from the LDO regulator. If a GND reference is needed, please use Pin 1 (the upper most pin on J30) or ground test point (TP13) just to the left of J30 as shown in the diagram below.

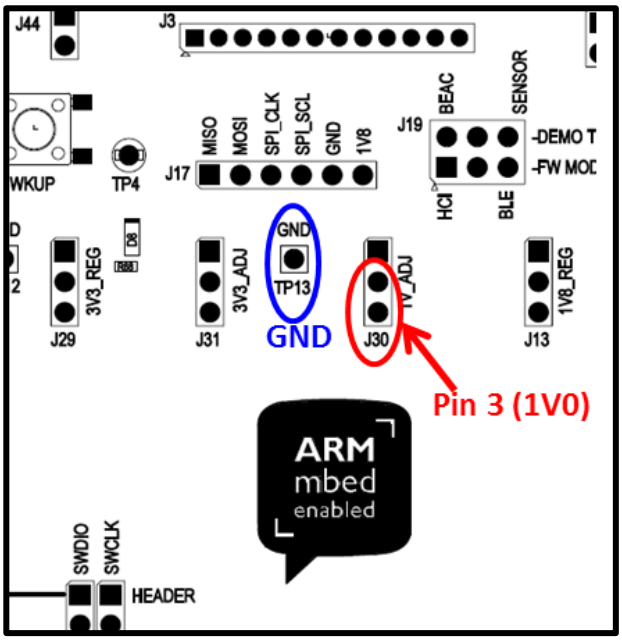



***Figure 5.2 – 1 Volt Test Point***

Attach the UART to USB cable J14 as described in Section 6.1.2. Once the desired current measurement equipment is connected to the Eval board, apply power to the board.

Use of the Radio Control Tool (RCT), Section 6, will control the Evaluation board to set the BT4 IP block into either continuous Tx, continuous Rx or into standby or sleep modes for current measurements in the desired modes of operation.The RCT can also be used to vary the regulator output from 1.0 to 1.65 volts. Please see the Radio Control Tool User's Guide for more information.

**Please also note than when using the RCT, both the USB to USB cable and the USB to UART cable must be installed between the PC and the Eval board. Note the correct position of the Power Control jumper (J47) to enable RCT control of the voltage regulator. (See Section 3.3.1).**

If you are using a current probe connected to an oscilloscope and wish to view the current drain while the Eval board is operating in a standard Bluetooth application, we recommend you place the board into "Beacon Demo" mode as described in Section 3.3.5. The power profile curve displayed on the scope should look similar to Figure 5.2b below.

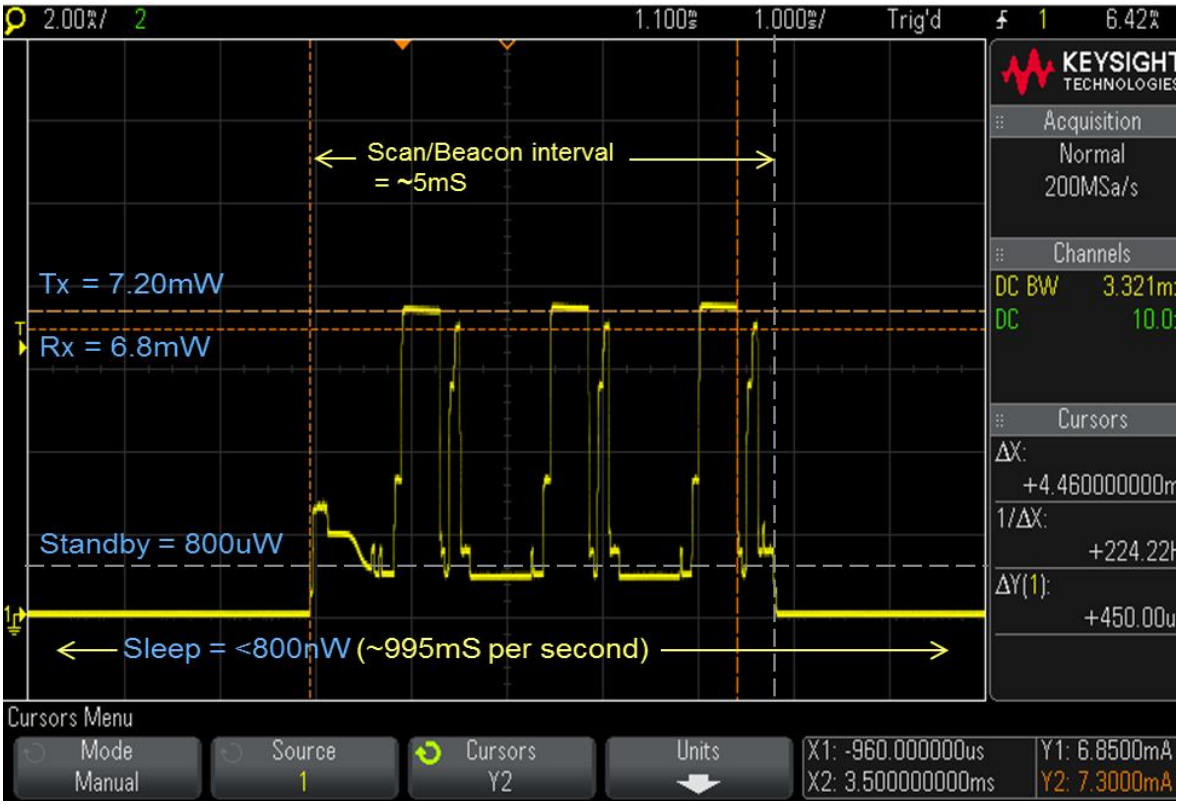



***Figure 5.2b – 1 volt Power Profile in Beacon Broadcast mode***

The diagram above shows the Eval board's power consumption in 1 volt mode while configured as a Beacon. The current beacon interval in the demo firmware is 1 second. The diagram shows the beacon coming out of deep sleep, broadcasting or "Advertising" on each of the 3 advertising channels and then going back into deep sleep mode again for the remaining 995 mSeconds. You will notice a receive scan event on each channel just after the Tx event. Tx power draining can be seen at ~7.2 mA (or 7.2mW since we are running at 1.0 volts). Rx current consumption is ~6.8mW while deep sleep is ~800nW. The average Standby current during the initial wake-up time and also between channel scans averages about 800uW. Please not that during the first 30 seconds after board power up or a reset event, you may see additional Tx and Rx pulses as the board may be trying to connect to near by Bluetooth devices. After 30 sections, the beacon will enter a "non-connectable state and you will only see these 3 Tx events. For more information on this connectable or "discoverable" stateplease refer to Section 3.5.2. This type of measurement can also be taken in 3 volt mode as described in the next section.

## 5.3 3 Volt Mode – Current Measurement

With 5 volt power removed from the board, place the 1V / 3V switch (located in the center right edge of board) in the 3 volt mode by sliding the switch downwards. (See Section 3.2.3).

With power still removed from the board, remove the jumper from J31 (located just above the ARM mbed logo). Attach your desired current measuring equipment across the two lower pins of the connector as shown below. The center pin, Pin 2 on the connector, is the downstream voltage supply rail to the BT4 SoC. Pin 3 on the bottom of the J31 header of the board is the 3.3 volt supply coming from the LDO regulator. If a GND reference is needed, please use Pin 1 (the upper most pin on J31) or ground test point (TP13) just to the right of J31 as shown in the diagram below.

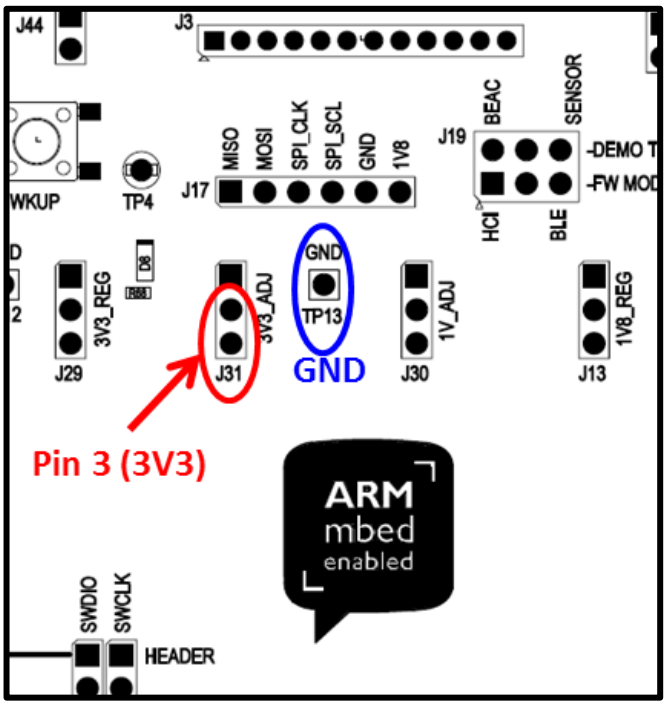



***Figure 5.3 – 3 Volt Test Point***

Once the desired current measurement equipment is connected to the Eval board, apply power to the board. Attach the UART to USB cable J14 as described in Section 6.1.2.

Use of the Radio Control Tool (RCT), Section 6, will control the Evaluation board to set the BT4 IP block into either continuous Tx, continuous Rx or into standby or sleep modes for current measurements in the desired modes of operation.

The RCT can also be used to vary the regulator output from 1.6 to 3.6 volts. Under 3 volt operation, the RCT can also control whether the on-chip 3 volt linear or 3 volt switching power regulator is used. Please see the Radio Control Tool User's Guide for more information.

**Please also note than when using the RCT, both the USB to USB cable and the USB to UART cable must be installed between the PC and the Eval board. Note the correct position of the Power Control jumper (J47) to enable RCT control of the voltage regulator. (See Section 3.3.1)**

# 6 TEST MODE

The Test Mode (also known as “HCI Pass-through” mode) allows control of the BT4 Radio IP block via the BT4 Host MCU’s UART port (J14). This allows external test devices and radio control programs (RCT) to talk directly to the Radio IP via HCI commands such as Directed Test Mode (DTM) commands per the Bluetooth specification.

This is useful in RF evaluation as well as regulatory approval tests.

The following board configuration is required:

- The board must be powered via 5 volts (USB cable) to be able to use the Host UART port.
- The UART Jumper headers (J8 & J9) must be in the Header position (See Section 3.3.4).
- The FW mode must be set to “HCI FW” (See Section 4).
- The UART speed is 115200 baud, 8 bit, 1 stop, no flow control

**Please note that the UART supports 3.3 volt signal level.** A USB to UART cable is provided in the Kit that supports 3.3 volt signal level. **If you are connecting the Eval board to the RS-232 port of test equipment such as a Bluetooth Analyzer, you will need to install a signal level shifting cable or adapter!** RS-232 to 3.3V TTL cables similar to these links can be obtained: http://techref.massmind.org/techref/io/serial/RCL1.htm or http://www.digikey.com/product-search/en/programmers-development-systems/accessories/2621524?k=MAX3232

Some bench top test equipment require an Access Address to be enterered to enable it to communicate to BLE devices via DTM commands (Direct Test Mode). The correct Access Address is 71764129.

## 6.1 Radio Control and RF Evaluation

Control of the radio for RF evaluations can be performed in a variety of methods and test configurations.

### 6.1.1 Use of Bluetooth Analyzer/Testers

Bluetooth Radio Analyzer that can control the Device Under Test (DUT) or EUT via DTM commands over UART (3.3v signaling) can talk to the BT4 Radio IP via J14 (See Section 3.4.1).

The most commonly used test equipment to complete this task is either the Rohde & Schwarz CBT32 or CMW 500. Similar test equipment is provided by other vendors as well such as Anritzu or TESCOM.
The common test set-up is depicted in the figure below. The DUT/EUT is controlled via the UART interface while RF measurements are received via a calibrated RF Coax cable, typically with an in-line 10db attenuator.

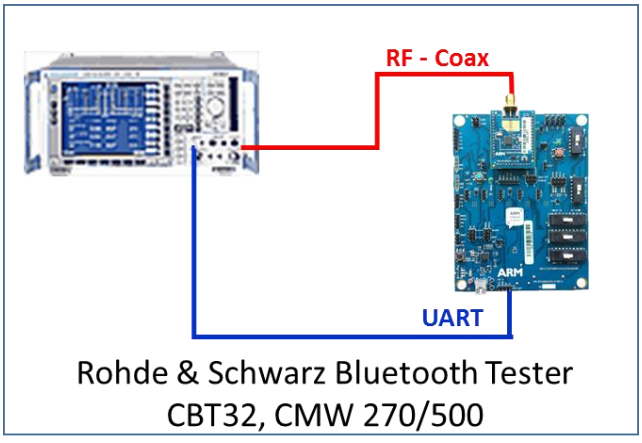



***Figure 6.1.1 – Bluetooth Analyzer Set-up***

### 6.1.2 Use of other RF Analyzers

As an alternate test method, ARM provides a Windows based Radio Control Tool, or “RCT” included in the BT4 Evaluation Kit. (See Section 6.1.3 below). The typical set-up for the RCT is depicted in the figure below. The PC is attached to the DUT (BT4 Eval Board) via a USB to UART cable as well as the USB to Mini-B USB cable, both provided in the kit. RF measurements can be made by a Spectrum Analyzer or other type of RF test equipment via an RF Coax cable.

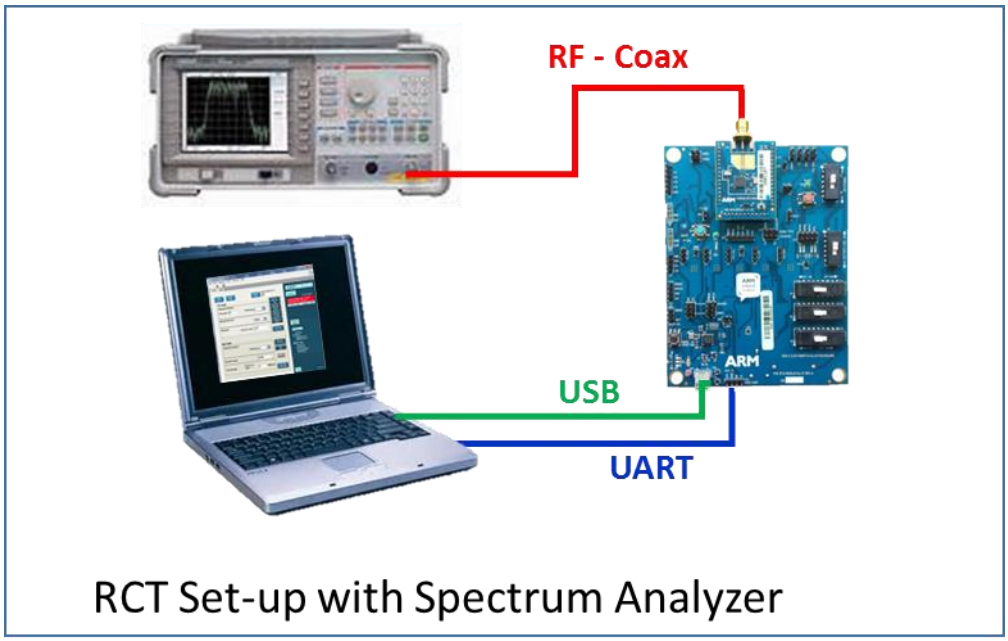



***Figure 6.1.2a – RCT Tool with RF Analyzer Set-up***

The USB to UART provided in the BT4 Evaluation kit is connected to the BT4 Eval board via the Host UART port on J14. See the pin-out of the cable in the diagram below. A Windows driver is required to be installed to use this cable. The Windows driver for this cable is included in the RCT installation file. Please also note the Jumper J8 and J9 must be configured as shown to allow communications to the J14 UART connector (Section 3.3.4).

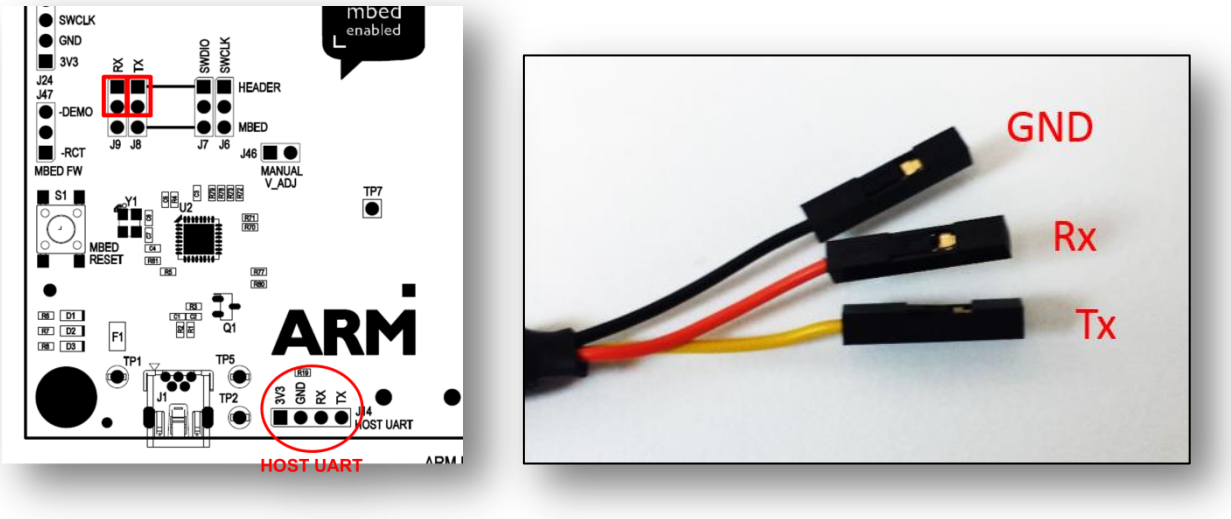



***Figure 6.1.2b -USB to UART Cable Location & Pin-Out***

### 6.1.3 ARM Radio Control Tool

ARM's Radio Control Tool (RCT) is a Windows/LabVIEW based utility that controls the BT4 Radio IP block via the BT4 Demonstration SoC's Host UART port (J14). The tool can place the Radio in either continuous transmit mode or receive mode. The desired radio channel can be selected as well as packet format and payload length. The RCT can also adjust the 1 volt and 3 volt power rails to the BT Radio IP block for current consumption measurements.

Please reference the RCT User's Guide for more detailed information.


***Figure 6.1.3 - Radio Control Tool - GUI***

### 6.1.4 Regulatory Testing

The Radio Control Tool is the primary application that can be used during regulatory testing at an accredited test lab. The RCT can place the BT4 Eval Board into the required continuous TX or RX tests on any given channel. Depending on the regional test requirements, conductive RF measurements can be made via the on-board SMA connector or radiated measurements can be made via an Antenna as depicted below. This configuration can also be used for subjective range testing as well as during functional test during final end-product manufacturing and assembly. LabVIEW source code is available upon request from ARM for manufacturing test development.

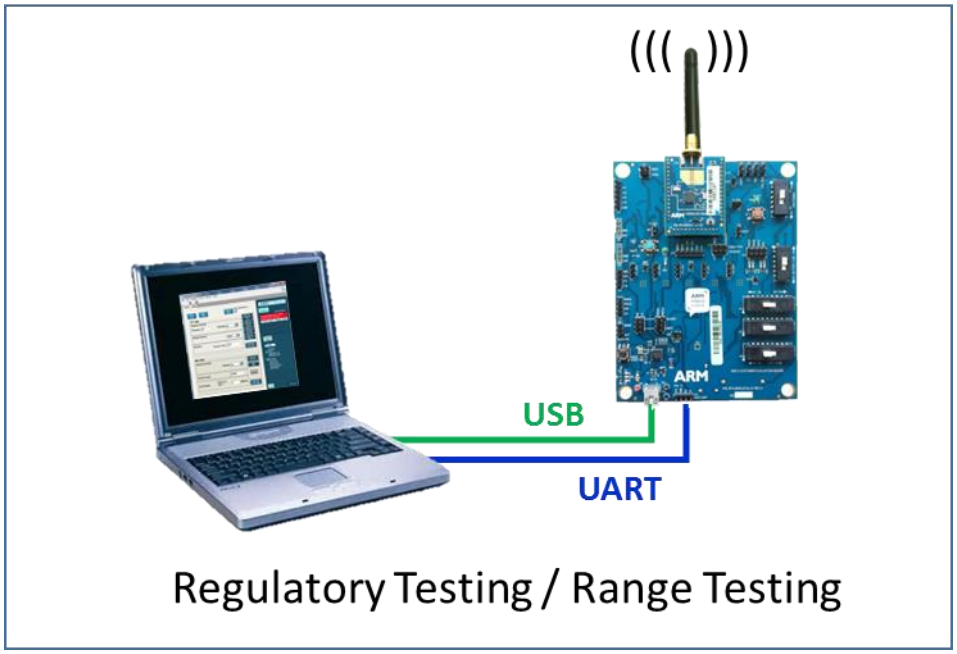



***Figure 6.1.4 – Regulatory Testing Configuration***

# 7 CMSIS DAP SUPPORT

The Eval board supports a CMSIS-DAP debug interface via an on-board mbed controller. The mbed HDK supports CMSIS-DAP, which consists of an abstraction of the Cortex Debug Access Port (DAP) command set over a driver-less USB HID connection. This provides a USB connection to the DAP that major tool vendors have started to support. It even provides the flexibility for users to write their own debugger, or debug script using the USB bindings in languages like Python.

A helpful link to get started on the mbed HDK is:

https://developer.mbed.org/handbook/CMSIS-DAP

A “Getting Started” Guide may be found at:

file:///C:/Users/chadit01/Downloads/mdk5-getting-started.pdf

Additional information as well as the required Windows serial driver needed to communicate with the Evalution board can be found at the following links:

https://developer.mbed.org/handbook/Windows-serial-configuration

https://developer.mbed.org/handbook/CMSIS-DAP-MDK

http://www2.keil.com/mdk5/install/

# 8 DEMONSTRATION MODES AND INSTRUCTIONS:

The BT4 Evaluation Board may be run in demonstration mode as either a Beacon (UriBeacon compliant) or a Sensor Platform supporting both Gyro and Temperature sensors.

## 8.1 Demo Preparation of Host Unit

### 8.1.1 Phone/Tablet Requirements:

**OS:** Android 4.4.2 or higher(*)
**Bluetooth:** Bluetooth 4.0 or higher (also known as “Bluetooth Smart Ready” or Bluetooth Low Energy-BLE)

(*) An iOS based application for Apple devises will be available later in 2016.

### 8.1.2 Android App Installation:

An Android demonstration application is included in the BT4 Evaluation Kit.

Steps for installing the Android application on a tablet or phone:

- Select the “Settings” Icon (Gear shaped Icon commonly found in apps screen or by swiping from the top of the screen downward and selecting the Gear shaped icon)
- Find the “Security” Permissions (Commonly found in the “More” tab on some versions of Android)
- Check the box next to “Unknown Sources”. This allows installation of applications from both trusted and unknown sources.
- Move the ARM application to the phone/tablet (.apk file). This is easily done by just emailing it to an account that is accessible on the phone or tablet.
- Select the App attachment on the email. It should prompt you for installation.
- The App will appear with blue radio waves and title BT4 Browser as the icon.

## 8.2 Demo and FW mode Jumper Selection:

Inspect the DEMO / FW mode jumpers (J19) just below the lower right corner of the module. As seen by the green arrow, ensure that the jumper on the lower row of pins is set in the “BLE” position towards the right.


***Figure 7.2 - Demo/FW Jumper***

With power to the board off (no external power cables selected and all 3 battery switches in the “OFF” position), select which demo mode the board will operate in via the jumper setting on the top row of J19. Towards the right is the Sensor demo, towards the left is the UriBeacon demo. This will determine which operation mode is loaded at boot time (or Reset).

## 8.3 Running Demos

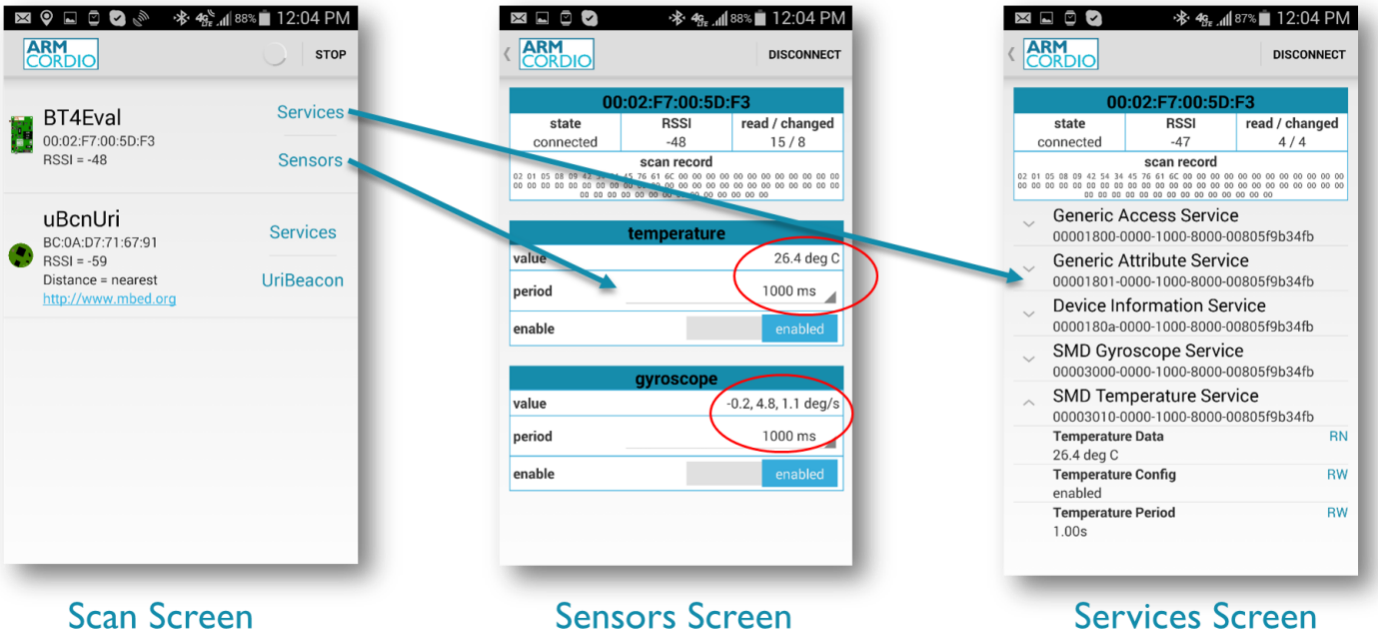
Assuming you wish to run your first demo on 5 volt/line power and with the Demo Mode jumper in its desired position, slide the “Power Mode Switch” to the “LINE” mode.

1. Open the ARM BT4 Browser Application on the phone or tablet.
    - This App is required to be used for the Sensor demonstration. It can also be used for the Beacon Demonstration but you may find that use of the Google UriBeacon App is more useful.
2. Press the Red RESET button on the Eval board for ~ 1 second and release.
3. The BT4 board should be shown in the device list.
    - In Sensor mode, the board should be shown as “BT4Eval”
    - In Beacon mode, The board should be shown as “BT4Uri”
4. If a BT4 device is not seen, toggle the STOP/SCAN on the top right corner of the App to initiate another scan. If the device is still not seen, press the Red RESET button again for 1 second and reinitiate an additional scan on the application.
5. Wirelessly connect to the board by selecting “Browse” or “Sensors”.
    - In sensor mode you can tilt or move the board to show the X, Y, Z axis values change. You can blow warm breath on the temperature sensor to change its value. (The temperature sensor and gyroscope are located on the back of the PCB (U16 and U18).
    - In Beacon mode you will see the advertising data or URL string that is being broadcasted. Depending on which version of Android app you have, you may have the ability to wirelessly connect to the beacon and change the URL in which it is broadcasting.
    - **NOTE: Please see Section 3.5.2 for a description of the use of the Blue “WKUP” push button to place the unit into connectable mode**.
    - If jumpers are installed on J22 (Section 3.4.4), the D4 LED will show the connection status in either of the two demo modes. If you do not wirelessly connect with the Eval board within 30 seconds after power-up or reset, the LED will stop blinking fast (indicating that the board is no longer connectable), and will begin to flash slowly. Press the Blue “WHUP” push button again to allow a wireless connection between the Eval board and a host device. (Pressing the blue button twice in a row, about 1 second apart) may need to be done for some FW versions).

If sensor or beacon data is not enumerated on the screen, or if the wireless connection is dropped, you can re-establish the connection by toggling on and off the Connect/Disconnect button on the top right corner of the screen.

If things work well on 5V/USB, try it in battery mode by removing the USB/5 volt cable, moving the Power mode switch to the “BATTERY” position and turning on one of the 3 battery switches. The center switch for 1.5v AAA battery is preferred. (Remember that only one Battery switch may be “ON” at any one given time). If the board does not appear in the app while it is scanning, press the Reset button for one second and re-scan.

### 8.3.1 Sensor Demo Screens:




Scan Screen Sensors Screen Services Screen

### 8.3.2 Beacon Demo Screens:


Scan Screen UriBeacon Screen Services Screen

## 8.4 Changing Between Demo Modes:

The Bluetooth specification requires the host platform (Phone or Tablet) to store information about a device whenever it connects to it. Since the ID of the BT4 Eval board does not change despite which demo mode is selected, you must clear this cached information from the tablet or phone if you wish for the board to be identified as the correct type of device (Sensor or Beacon).

1. To change demo modes, power down the board before changing the position of the Demo Mode selection jumper.
2. Clear the cached data on the phone or tablet by simply turning OFF the Bluetooth radio on the phone or Tablet. This can be accomplished by the selecting the “Settings” icon - OR - on most Android devices, you can quickly control the radios by swiping down from the top of the display to expose radio control icons.
3. Repeat the demo instructions again as described above.

If the BT4 Eval board still is shown in the app as the previous demo device type (“BT4Eval” or “BT4Uri”) and therefore does not match your jumper selection, you may have to close the app and restart it. This may require you to go into the Android Task Manager to shut down the application since it might be running in the background even though you appear to have closed it.

# 9 FW UPDATE PROCEDURE

Firmware updates may be periodically supplied by ARM. This procedure describes how to update firmware for the BT4 Demonstration SoC via the drag-n-drop programming capabilities provided by the on-board mbed controller. If you are using the BT4 Eval board as a code development platform you can use this same procedure to update the boards with your custom firmware.

Please do the following:

1. Copy the FW file to your PC's desktop
2. On the BT4 Eval board, slide the Power Mode switch UP to the "Line" position (See below)
3. Insure that both SWD jumpers (J6 & 7) that are located above the USB connector are in the "MBED" positions. (In the lower jumper position as shown).

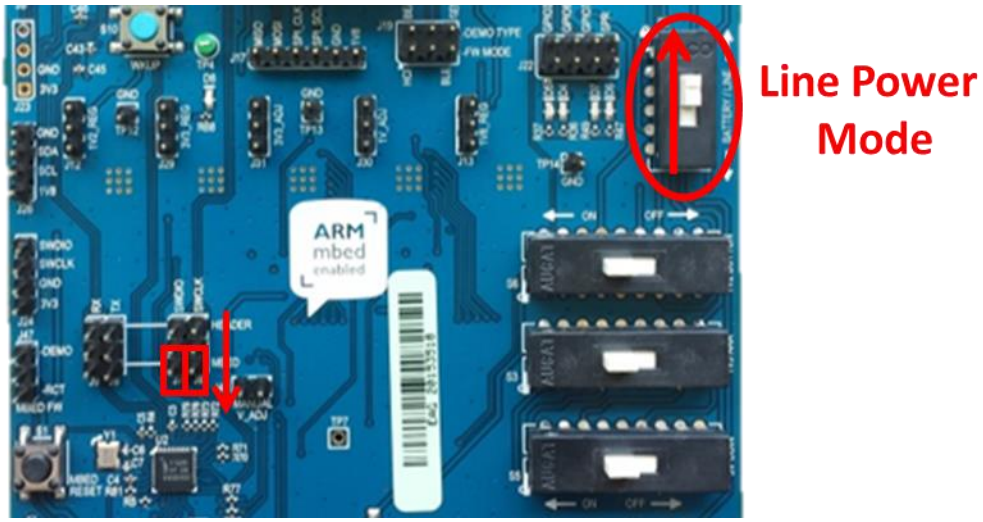



***Figure 8.0 – FW Programming Jumper/Switch Selection***

4. Plug in the USB cable to your PC and the board. The board should enumerate as a mass storage device and a window should open up on your PC. There should be a single file listed by the name of "mbed.htm". (If you have your PC configured to not support pop-up windows, you may have to select "My Computer" and open up the appropriate drive on the list provided).
5. Drag and drop the FW file from your desktop into the Mass storage window.
6. The Red LED next to the USB connector should flash quickly for about 15-20 seconds during programming. Once the programming is complete, the Red LED will stop and the drive will un-enumerate on your PC.

Firmware programing is complete at this time

Power down the board by unplugging the USB cable and plug it back in if you wish to power the board via 5 volts from the USB cable.

# 10 SCHEMATICS AND BOMS

Schematics and the Bill of Materials (BOM) for both the Cordio BT4 Module and the Customer Evaluation Base board can be found in the Evaluation Board Schematics Document which should have been provided in the Evaluation and Demonstration Kit's thumb drive.