TI Designs
Bluetooth® Smart to Wi-Fi IoT Gateway

TI Designs

TI Designs provide the foundation that you need including methodology, testing and design files to quickly evaluate and customize the system. TI Designs help *you* accelerate your time to market.

Design Resources

TIDC-BLE-TO-WIFI-IOT-GATEWAY	Tool Folder Containing Design Files
CC2650	Product Folder
CC3200	Product Folder
TPS79601	Product Folder
TPD2EUSB30	Product Folder

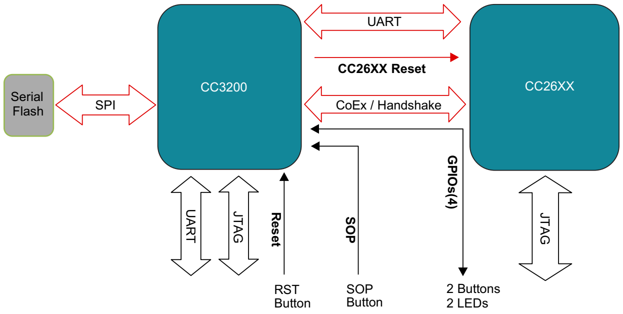
ASK Our E2E Experts
WEBENCH® Calculator Tools

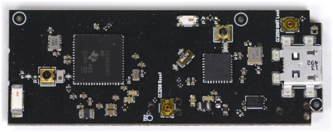
Design Features

- Connect *Bluetooth* Smart Devices To IoT Cloud
- USB Powered, Small Form Factor, Low-Power Wi-Fi Connection
- USB (Over UART) Command Interface For Configuration—Works With SensorTag
- HTTP Server and Pages For Configuration
- Single-Board *Bluetooth* Smart Wi-Fi Integrated Design
- MQTT Protocol Enabled For IoT Connectivity
- Over-The-Air (OTA) Firmware Update

Featured Applications

- Internet of Things (IoT)
- Social Alerts
- Health and Fitness
- Remote Tracking





An IMPORTANT NOTICE at the end of this TI reference design addresses authorized use, intellectual property matters and other important disclaimers and information.

SimpleLink, Code Composer Studio, Internet-on-a-Chip are trademarks of Texas Instruments.
ARM is a registered trademark of ARM Limited .
Cortex is a registered trademark of ARM Limited.
Bluetooth is a registered trademark of Bluetooth SIG, Inc.
Chrome is a registered trademark of Google Inc.
IBM is a registered trademark of IBM Corporatoin.
HyperTerminal is a registered trademark of Microsoft Corporation.
Internet Explorer is a trademark of Microsoft Inc.
Firefox is a registered trademark of Mozilla Inc.
Silabs is a trademark of Silicon Laboratories.
ZigBee is a trademark of ZigBee Alliance.
All other trademarks are the property of their respective owners.

1 Key System Specifications

Table 1. Key System Specifications

PARAMETER	SPECIFICATION	DETAILS
Wi-Fi chip	A Single-Chip Wireless MCU with integrated Wi-Fi network processor and power management subsystem	Refer to the following link: http://www.ti.com/product/cc3200
Bluetooth Smart chip	The CC2650 is a wireless MCU targeting *Bluetooth*® Smart, ZigBee™ and 6LoWPAN, and ZigBee RF4CE remote control applications	Refer to the following link: http://www.ti.com/product/cc2650
Power chip	The TPS79601 low dropout (LDO) low-power linear voltage regulator features ultralow-noise and excellent line and load transient responses in small outline, 3 × 3 VSON package	Refer to the following link: http://www.ti.com/product/tps79601/description
ESD chip	The TPD2EUSB30 are 2 channel Transient Voltage Suppressor (TVS) based Electrostatic Discharge (ESD) protection diode arrays	Refer to the following link: http://www.ti.com/product/TPD2EUSB30
Antenna	2450AT18D0100 for *Bluetooth* Smart and 2450AT42B100 for Wi-Fi. 2.4 Ghz, ceramic chip antenna	Refer to the following links: http://www.johansontechnology.com/datasheets/antennas/2450AT18D0100.pdf http://www.johansontechnology.com/datasheets/antennas/2450AT42B100.pdf
V_{IN}	Input voltage 5 V, USB powered	
V_{OUT}	Output voltage 3.3 V, powers the gateway	

1.1 Deliverables

The *Bluetooth* Smart to Wi-Fi Gateway TI design comprises the following mentioned collaterals.

1.1.1 Hardware Design Files

The hardware design files help the customer design a custom board. The package includes schematics, layout, and Gerber files.

1.1.2 Software Source

The software package contains all the gateway source files. The software is modular, which makes it easier for the developer to include a particular module.

1.1.3 Collaterals

This design guide explains the usage of the gateway.

2 System Description

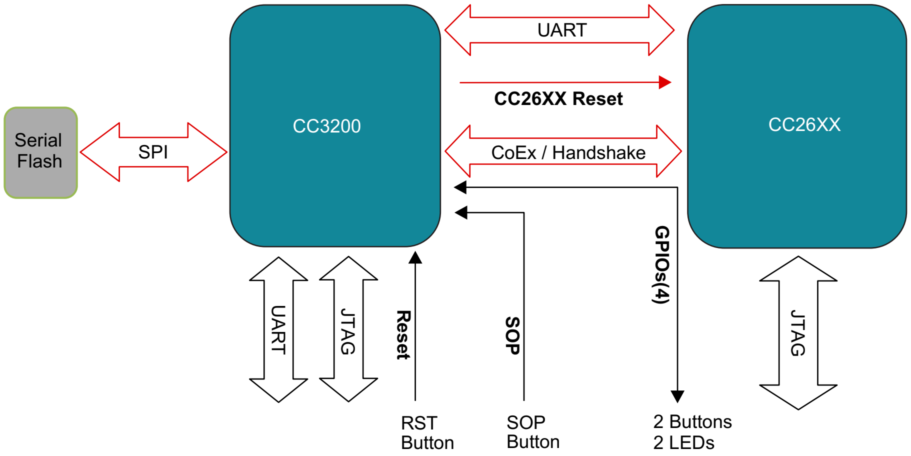


Figure 1. The Gateway Block Diagram

This *Bluetooth* Smart-to-Wi-Fi Gateway solution connects the *Bluetooth* Smart devices to the cloud over Wi-Fi. The integrated hardware solution comprises the CC3200 Wi-Fi wireless MCU and the CC2650 Wireless MCU on a single board. Customers may reuse the reference design to design their own gateway. The software and hardware design resources reduce engineering efforts, shorten time to market, and help developers and customers release their products with cloud connectivity features faster.

The CC3200 Wireless MCU is an intelligent, low-power Wi-Fi chip with an ARM® Cortex®-M4 application processor. The CC3200 contains a wireless network processor with stable and certified TCP / IP stack integrated on a single chip. The device comes with on-chip security protocols and various network application protocols (HTTP, mDNS, and others). CC3200 is the first and only chip in the world to be “Wi-Fi” certified by the Wi-Fi alliance at chip level.

The CC3200 SDK (Software Development Kit) facilitates easy development experience for the user. The CC3200 contains CCS, IAR and GCC toolchain support, app notes and extensive user guides. The SimpleLink™ APIs provide an easy and well abstracted access to the stack functionality. The SDK provides MQTT support (for IoT), OTA (Over The Air) download support, and numerous MCU examples, which reduces the development effort and thereby reduces the time to market. Extensive E2E support from TI helps the developers at every stage.

CC2650 is an ultralow-power wireless MCU capable of running multiple protocols (*Bluetooth* Smart, ZigBee, and 6LowPAN). This wireless MCU can run for years even when powered by coin-cell batteries or any energy-harvested sources.

The CC2650 platform comes ready-to-use, royalty free, and with certified wireless protocol stacks, TI RTOS, Code Composer Studio™ integrated development environment (IDE), development tools, online training, and E2E community support.

The CC3200 Wireless MCU powers the entire board and also communicates and controls the CC2650 *Bluetooth* Smart Wireless MCU over UART. With the support of its built-in Wi-Fi network processor, the CC3200 Wireless MCU ensures seamless connection with the remote cloud. The CC2650 Wireless MCU can connect to multiple *Bluetooth* Smart devices.

Two LED indicators are provided to indicate the status. Two buttons are provided to trigger various actions. A simple button is provided to switch the CC3200 to UARTLoad mode. Debugging and programming options for both CC3200 and CC2650 chips are provided by dedicated JTAG ports.

The gateway can easily be configured for the first time using the Command Line Interface (CLI). UniFlash flashes the binaries on CC3200.

A 1-MB Serial Flash (SFLASH) is provided for storing the binaries, configuration files, and http pages.

A dedicated RESET button is provided to bring the gateway out of unknown conditions during development.

2.1 CC2650—Wireless MCU

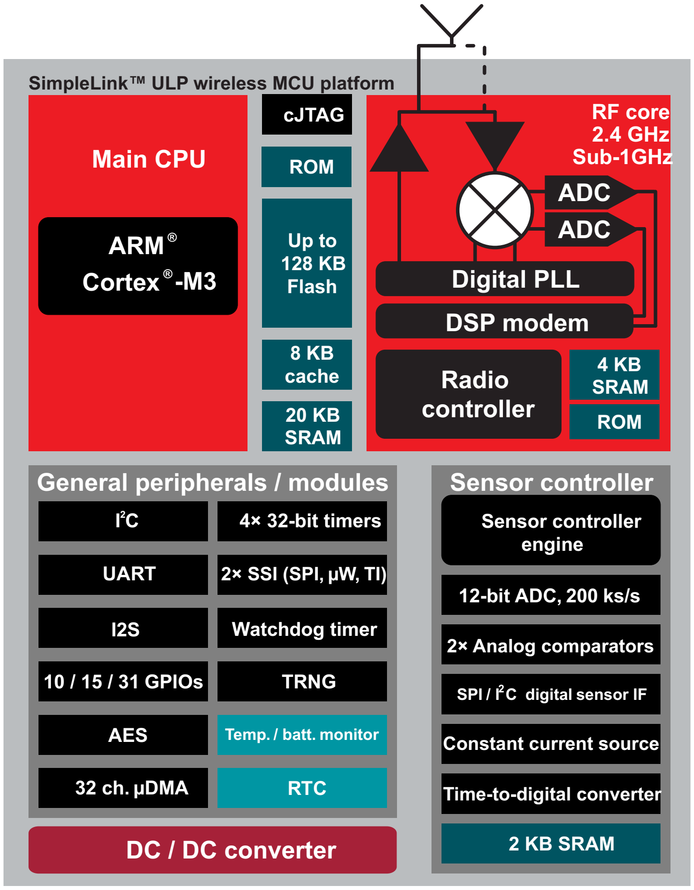


Figure 2. CC2650 Block Diagram

The CC2650 is a wireless-MCU-targeting *Bluetooth* Smart application. The device is a member of the CC26xx family of cost-effective, ultralow power, 2.4-GHz RF devices. Very low active RF current consumption and very low MCU current consumption provide excellent battery lifetime and allows operation on small-coin cell batteries and in energy-harvesting applications. The CC2650 contains a 32-bit ARM Cortex M3 running at 48-MHz as the main processor and a rich peripheral feature set. This set includes a unique ultralow-power sensor controller, which is ideal for interfacing external sensors and collecting analog and digital data autonomously while the rest of the system is in sleep mode.

CC2650 is a Network Processor in the gateway design. For more details of CC2650, see the product page.

2.2 CC3200—Wireless MCU

The CC3200 MCU subsystem contains an industry-standard ARM Cortex M4 core running at 80 MHz. The device includes a wide variety of peripherals, including a fast parallel camera interface, I^{2}S, SD / MMC, UART, SPI, I^{2}C, and four-channel ADC. The CC3200 family includes flexible embedded RAM for code and data, and ROM with an external serial flash bootloader and peripheral drivers.

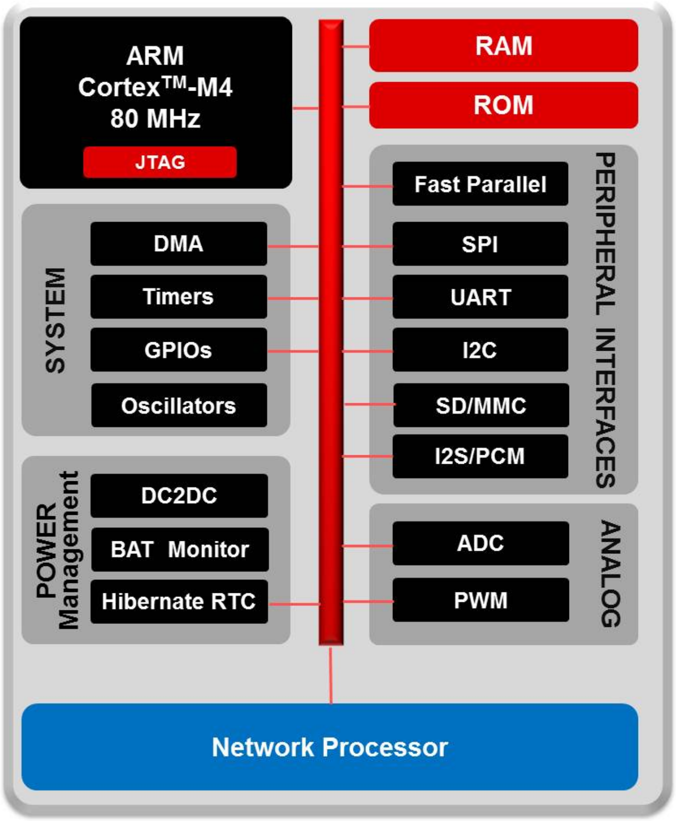


Figure 3. CC3200 Block Diagram

The Wi-Fi network processor subsystem features a Wi-Fi Internet-on-a-Chip™ and contains an additional dedicated ARM MCU that completely offloads the applications MCU. This subsystem includes an 802.11 b/g/n radio, baseband, and MAC with a powerful crypto engine for fast, secure Internet connections with 256-bit encryption. The CC3200 device supports Station, Access Point, and Wi-Fi Direct modes. The device also supports WPA2 personal and enterprise security and WPS 2.0. The Wi-Fi Internet-on-a-chip includes embedded TCP/IP and TLS/SSL stacks, HTTP server, and multiple Internet protocols.

The CC3200 is the host processor in the gateway design. For more details about CC3200, see the product page.

2.3 *TPS79601—Power IC*

The TPS796 family of low-dropout (LDO), low-power linear voltage regulators features high power-supply rejection ratio (PSRR), ultralow-noise, fast startup, and excellent line and load transient responses in small-outline, 3 × 3 VSON, SOT223-6, and TO-263 packages. Each device in the family is stable with a small, 1-μF ceramic capacitor on the output. The family uses an advanced, proprietary BiCMOS fabrication process to yield extremely low dropout voltages (for example, 250 mV at 1 A). Each device achieves fast start-up times.

For more details of TPS79601, see the product page.

2.4 *TPD2EUSB30 ESD Protection Diode*

The TPD2EUSB30 is a 2-channel Transient-Voltage-Suppressor (TVS)-based Electrostatic-Discharge (ESD)-protection diode array. The TPDxEUSB30/A devices are rated to dissipate ESD strikes at the maximum level specified in the IEC 61000-4-2 international standard (Contact). These devices also offer 5-A (8 / 20 μs) peak pulse current ratings per IEC 61000-4-5 (Surge) specification.

For more details of TPD2EUSB30, see the product page.

3 System Design Theory

The *Bluetooth* Smart-to-Wi-Fi IoT gateway aims at addressing the problem statement “How can the data on a *Bluetooth* Smart device be available over the internet or on a Wi-Fi enabled device”

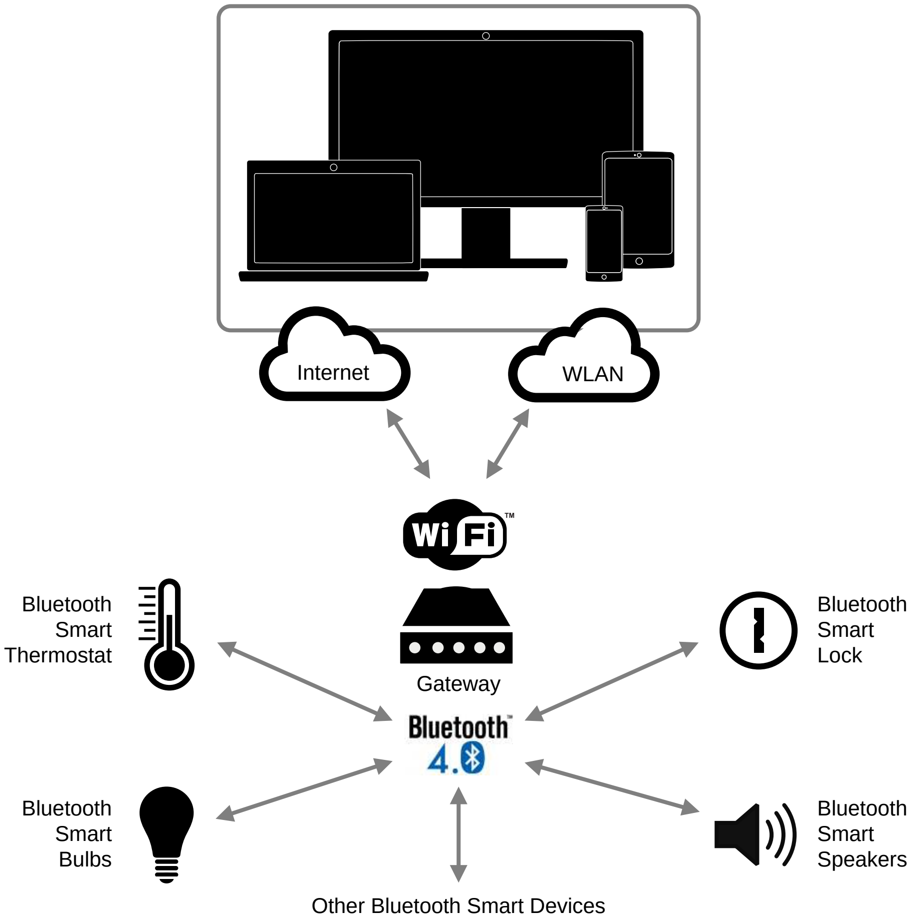


Figure 4. Gateway System

SensorTag is one of TI’s most popular designs. The *Bluetooth* Smart-enabled version is usually limited to using a phone or tablet as a gateway, which limits the use in more infrastructure-oriented applications as the phone may not always be present. Given the emergence of the Internet of Things (IoT), these devices should be connected to the Internet or a private LAN seamlessly (that is, without changing the software or design of the existing SensorTag modules).

3.1 Architecture

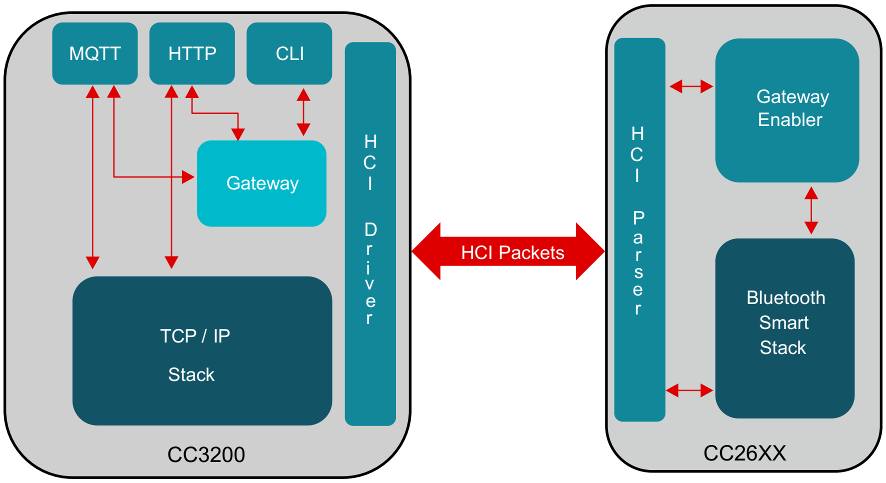


Figure 5. Software Architecture

The CC3200 Wireless MCU acts as a master and controls the CC26XX *Bluetooth* Smart Wireless MCU. The Gateway enabler application on the CC26XX brings out the *Bluetooth* Smart stack functionalities over the host controller interface (HCI) commands.

The application runs on the CC3200 and contains the following modules:

- Gateway module (central and database)
- TCP / IP stack (network processor)
- HTTP server and pages
- IoT stack (MQTT client stack—IBM)
- Host HCI layer
- Utilities such as CLI and JSON parser
- Over-the-air (OTA) and serial boot loader (SBL) module

3.2 Working Principle

The software is a multitask architecture. The initialization sequence spawns the tasks and executes various module-initialization functions.

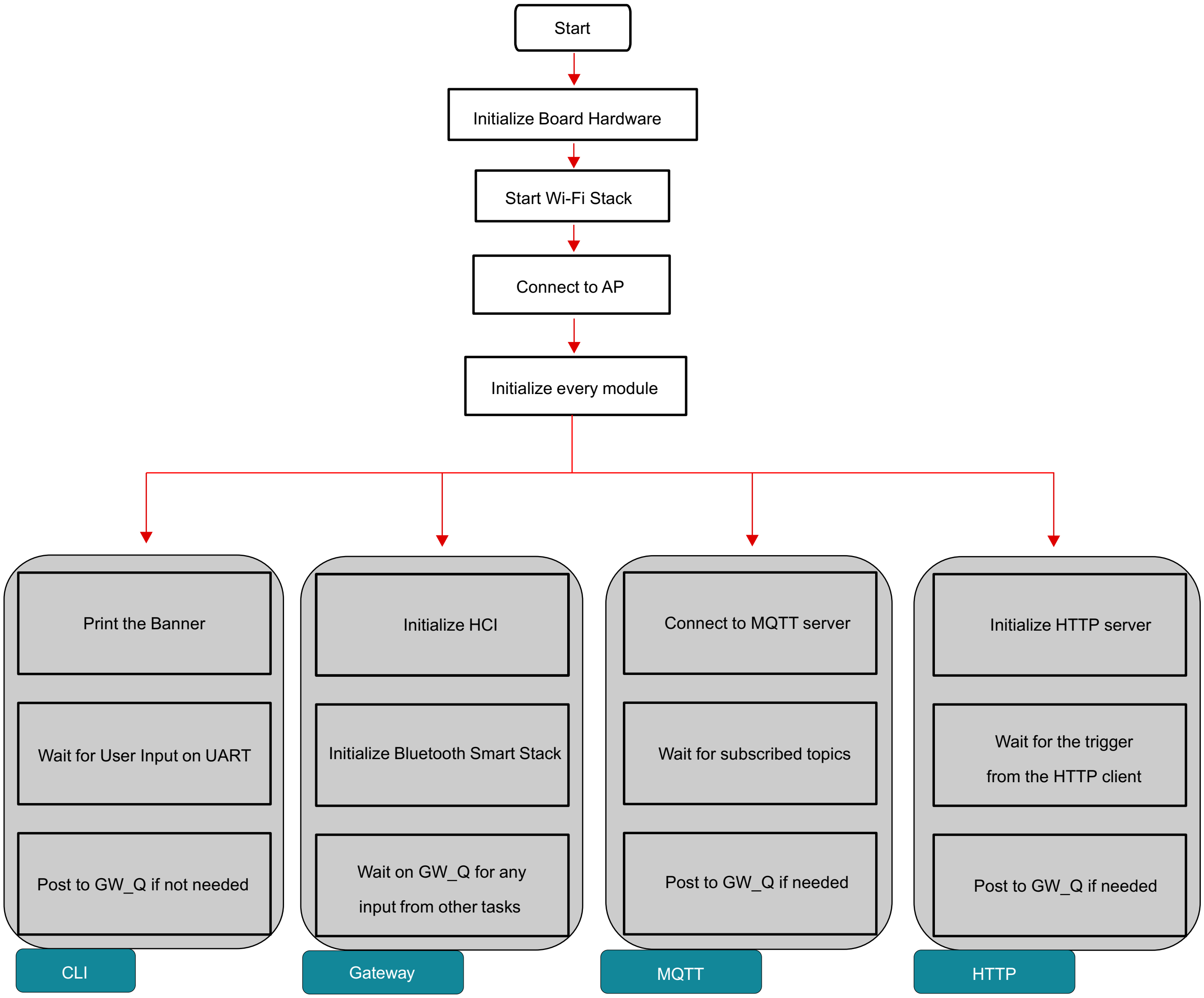

Start
Initialize Board Hardware
Start Wi-Fi Stack
Connect to AP
Initialize every module
Print the Banner
Wait for User Input on UART
Post to GW_Q if not needed
CLI
Initialize HCI
Initialize Bluetooth Smart Stack
Wait on GW_Q for any input from other tasks
Gateway
Connect to MQTT server
Wait for subscribed topics
Post to GW_Q if needed
MQTT
Initialize HTTP server
Wait for the trigger from the HTTP client
Post to GW_Q if needed
HTTP

Figure 6. Initialization Sequence on CC3200 MCU

When configured, the gateway acts as a data pipe between the *Bluetooth* Smart devices and the monitoring entity (on Wi-Fi). No special configuration or code change is needed on the *Bluetooth* Smart device to remote it to the gateway.

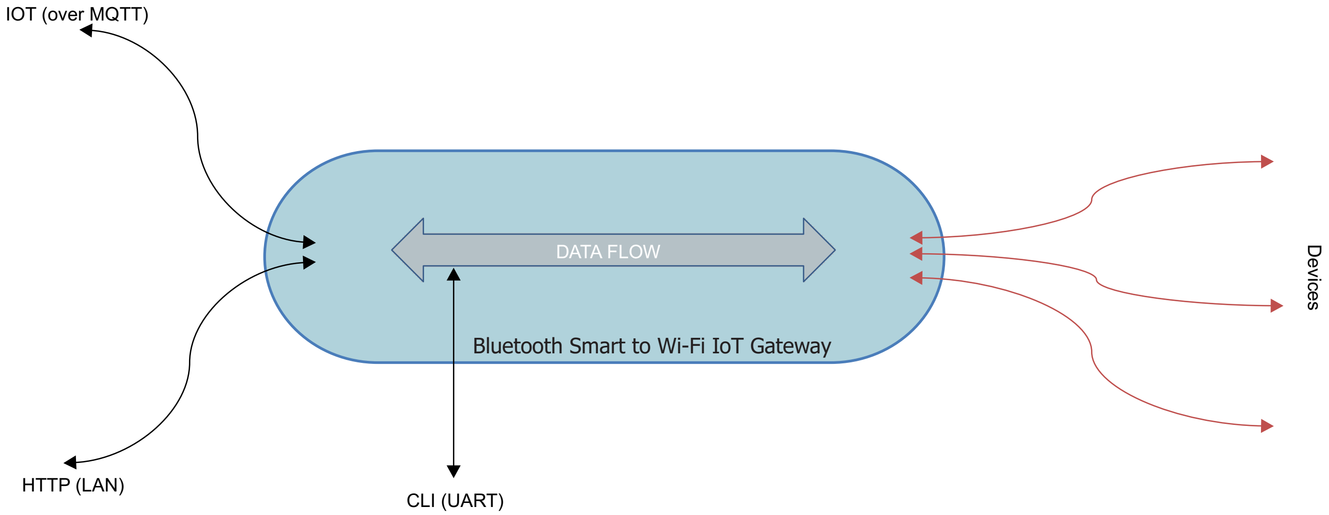


Figure 7. Data Flow

The gateway setup comprises of WLAN connection and *Bluetooth* Smart device connection. When the setup is complete, you can monitor the characteristics of the device over MQTT, HTTP, or CLI. With the software architecture, users can easily remove a particular entity from the binary (to reduce the size).

OTA download functionality is also present in the gateway. OTA can update the binary and also the Gateway Enabler binary.

4 Getting Started Hardware

The primary feature of the gateway is to make the characteristics of a connected *Bluetooth* Smart device available on the cloud (IoT using MQTT). The gateway can be controlled over a local LAN using HTTP pages.

Starting the gateway hardware is an easy process. To power on the gateway, connect it to a PC or a wall-mount USB adapter through the USB cable provided in the package. Connecting the gateway to a PC provides access to the command line interface on a terminal (TeraTerm or HyperTerminal®), which aids in controlling or monitoring the gateway. When connected, press the RESET button to start the gateway.

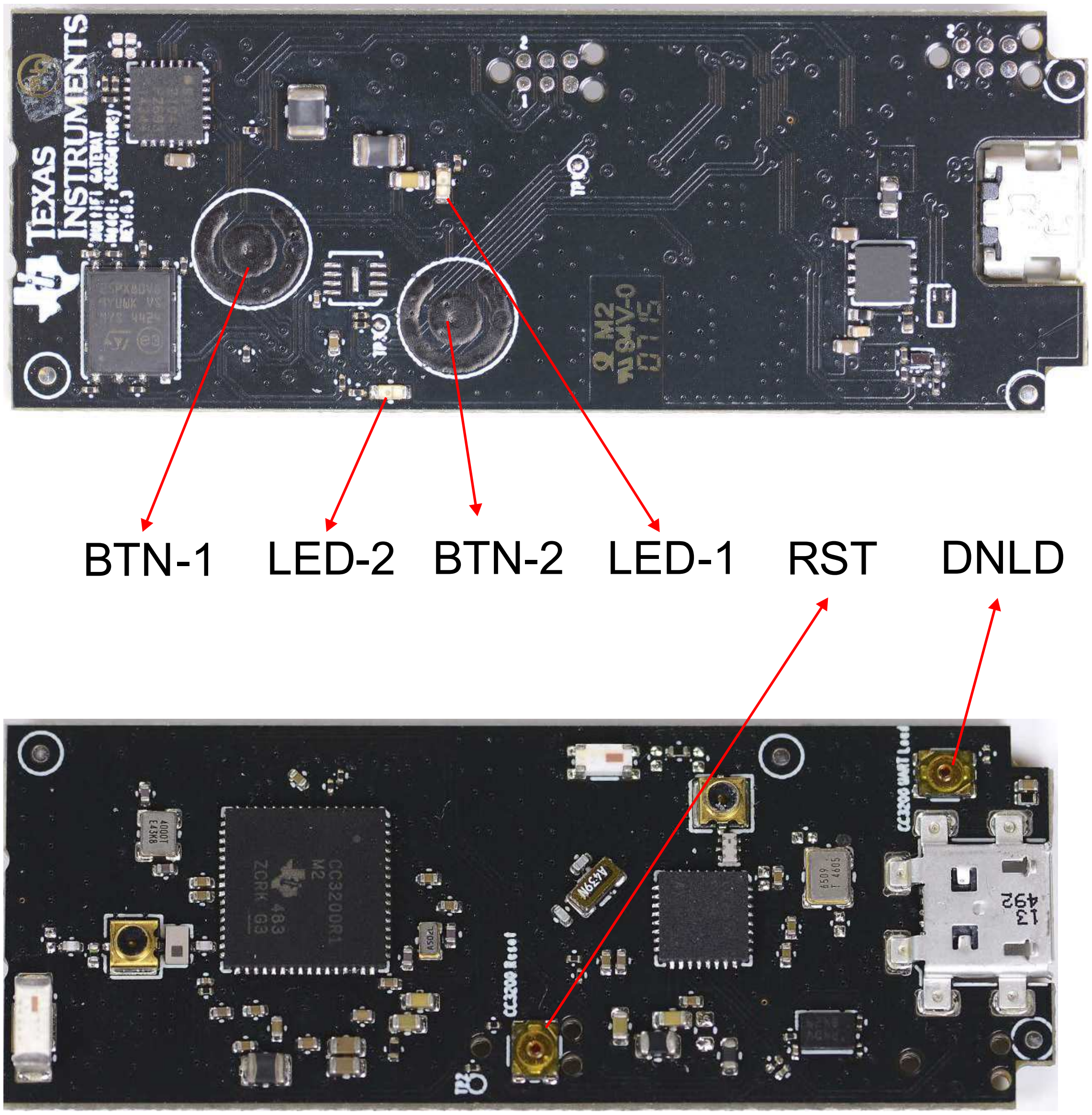


Figure 8. Board Details

4.1 Push Buttons and LEDs

Table 2. Button Description

REFERENCE	USAGE	COMMENTS
RST	Reset	This button is used to reset the gateway
DNLD	UartLoad	This button, when pressed along with RST, puts the CC3200 in UARTLOAD mode. This mode updates the firmware
BTN-1	Scan	This button is used to trigger the scan for *Bluetooth* Smart devices
BTN-2	Over The Air (OTA) trigger	This button triggers the OTA download of binaries

Table 3. LED Description

REFERENCE	INDICATION	COMMENTS
LED-1 (*Bluetooth* Smart status indicator)	OFF	*Bluetooth* Smart stack is UP
	ON	*Bluetooth* Smart stack Initialization in progress
	SLOW BLINK (1 per sec)	Scanning in progress
	FAST BLINK (2 per sec)	System Fatal ERROR
LED-2 (Wi-Fi status indicator)	OFF	AP connection success
	ON	AP connection failure
	SLOW BLINK (1 per sec)	SmartConfig in progress
	FAST BLINK (2 per sec)	System Fatal ERROR

4.2 Prerequisites

1. *Bluetooth* Smart to Wi-Fi IoT gateway hardware
2. Micro-USB cable
3. Access point with internet uplink available. The gateway must be connected to this access point.
4. Laptop or PC
   - Connected to the Internet for MQTT (Internet)
   - Connected to the same AP as the gateway for HTTP (LAN)
5. SensorTag (at least one) with default pre-programmed software
   - CC26XX SensorTag

4.3 Setup

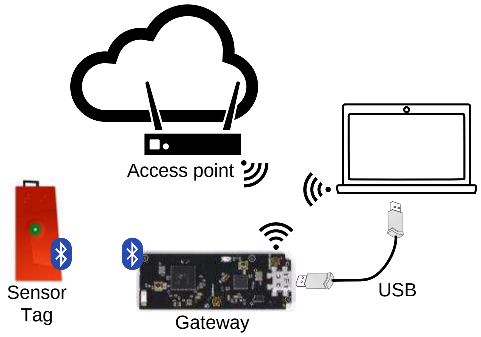


Figure 9. Setup Diagram

4.3.1 Laptop / PC Installations

- Download and install UniFlash (to flash CC3200 binaries and service pack) from the link here: http://www.ti.com/tool/uniflash
- Download and install TeraTerm: http://download.cnet.com/Tera-Term/3000-20432_4-75766675.html
- Download and install the latest Silabs™ virtual COM port driver for the CP2104 USB bridge IC (based on the OS) from the link here: http://www.silabs.com/products/mcu/Pages/USBtoUARTBridgeVCPDrivers.aspx.
  - The gateway COM ports appear in the device manager of the PC as Silicon Labs Standard COM CP210x USB to UART Bridge: Enhanced COM Port
- Download and install the latest CC3200 SDK and service packs from the link here: http://www.ti.com/tool/cc3200sdk

4.3.2 Access Point (AP) Configuration

Configure the access point in Open or WPA mode. If the AP is configured in WPA mode, write down the security key.

4.3.3 Steps

A typical usage of the gateway contains following steps:

1. Install the mentioned software on the laptop or PC
2. Connect the gateway to the laptop or PC using the USB cable
3. Configure the access point either in Open or WPA mode
4. Reset/Power on the gateway by pressing the Reset button
5. Connect the gateway to a Wi-Fi access point
6. Connect the gateway to SensorTag (using CLI or MQTT or HTTP)
7. View, read, and write the capabilities of the SensorTag (using CLI or MQTT or HTTP)

5 Getting Started Firmware

Download and install the binary package from TIDC-BLE-TO-WIFI-IOT-GATEWAY.

5.1 Flashing the Binaries

The binary package contains these files:

- blefi.bin—The *Bluetooth* Smart to Wi-Fi IoT Gateway application that runs on CC320
- CC26xx.bin (gateway-enabler)—This application runs on CC2650.
- HTTP pages
- CC2650 SensorTag.sch [Schema files]
- Blefi.usf file (UniFlash Configuration file)

Follow these steps when using BleFi for the first time.

1. Format the BleFi SFLASH
2. Download the Network Processor Service Pack
3. Download the binaries (open BleFi.usf and click program)

The TI UniFlash tool is used to format and download the gateway SFLASH. Refer to the UniFlash for more details.

5.1.1 SFLASH Formatting

Follow these steps:

1. Connect the gateway to laptop or PC equipped with UniFlash.
2. Change the COM PORT to the desired port number.
3. Press Format on the UniFlash tool.
4. Keep the DNLD button pressed and toggle the RST button on the gateway.
5. The previous procedure triggers the bootloader mode in CC3200, and the format should start.
6. The Successful Format message should appear on UniFlash.

5.1.2 Service Pack Download

The servicepack_1.0.0.1.2 service pack is provided through CC31xx_CC32xx_ServicePack-1.0.0.1.2-windows-installer.exe downloadable from http://www.ti.com/tool/cc3200sdk or http://www.ti.com/tool/cc3100sdk.

1. Download and install the service pack version servicepack_1.0.0.1.2.bin on a laptop or PC.
2. Connect the gateway to a laptop or a PC where UniFlash is installed.
3. Change the COM PORT to the desired port number.
4. Press Service Pack Programming on UniFlash tool.
5. Point to the path of the service pack binary in your computer.
6. Gateway—Keep DNLD button pressed and toggle the RST button.
7. The above procedure triggers the bootloader mode in CC3200, and the service pack programming should start.
8. The Successful message should appear on UniFlash.

5.1.3 Binary Download

1. Connect the gateway to a laptop or PC where UniFlash is installed.
2. Go to the folder where the binary package is present.
3. Double click on the blefi.usf file—This opens UniFlash.
4. Change the COM PORT to Desired Port Number
5. Press Program on UniFlash Tool.
6. Gateway—Keep DNLD button pressed and toggle the RST button.
7. The previous procedure triggers the bootloader mode in CC3200 and the download should start.
8. The Successful Download message should appear on UniFlash.

5.2 Building Source Code

This section describes the steps involved in building the blefi.bin, which executes on the CC3200 and the cc26xx.bin, which then executes on the CC2650.

5.2.1 Source Build (for CC3200 MCU)

1. Install Code Composer Studio IDE from the link here.
2. Install the gateway installer.
3. By default, the package installs to the c:\ti folder.
4. Open Code Composer Studio and the following projects from the BleFi package.
   - blefi
   - cli
   - gateway
   - mqtt_app
   - npi
   - oslib
   - schema
   - ti_rtos_config
   - json
   - mqtt
   - ota
   - simplelink

5. Build these projects in sequence:
   - ti_rtos_config
   - oslib
   - simplelink
   - ota
   - mqtt
   - json
   - schema
   - npi
   - gateway
   - cli
   - mqtt_app
   - blefi
6. Upon successful build, the blefi.bin will be found in the blefi/ccs/Release folder.

5.2.2 CC26xx Source Build (gw_enabler) Using CCS

1. Download BLE SDKv2.1 from http://www.ti.com/ble-stack.
2. Install CCS as in section 2.5.3 of *CC2640 Bluetooth low energy Software Developer's Guide* (SWRU393).
3. Change the Radio settings in bleUserConfig.h in
   C:\ti\simplelink\ble_cc26xx_2_01_00_44423\Projects\ble\ICall\Include\bleUserConfig.h.
   #elif defined(CC2650EM_5XD) || defined(CC2650EM_4XD)
   #define RF_FE_MODE_AND_BIAS (RF_FE_DIFFERENTIAL |
   RF_FE_INT_BIAS)
   #elif defined(CC2650EM_4XS)
4. Change RAM boundary address in Linker Configuration file in
   C:\ti\simplelink\ble_cc26xx_2_01_00_44423\Projects\ble\HostTest\CC26xx\CCS\Config\CCSLinkerDefines.cmd --define=ICALL_RAM0_ADDR=0.
5. Open CCS and import the HostTestApp project (both HostTest and HostTestStack) as described in*CC2640 Bluetooth low energy Software Developer's Guide* (SWRU393) in section 2.5.3.
6. Check the Copy Project files to workspace option.
7. In CCS, open the Project Properties for the Application.
8. Change the board type in the last line of the Include Options under the CCS Build at
   workspace_v6_1\HostTest\FlashROM
   "${TI_RTOS_DRIVERS_BASE}/ti/boards/SRF06EB/CC2650EM_5XD.
9. Select Projects->Build All options to build both the projects.
10. Find the HostTest.hex file under $CCS_WORKSPACE$\workspace_v6_1\HostTest\FlashROM.
11. Find the HostTestStack.hex under $CCS_WORKSPACE$\workspace_v6_1\HostTestStack\FlashROM.
12. Refer to Section 5.2.4 to merge the hex files and to convert them into cc26xx.bin.

5.2.3 CC26xx Source Build (gw-enabler) Using IAR

1. Install the IAR IDE from the link.
2. Install the latest CC26xx SDK from the link.
3. Open HostTest project from the IAR IDE, choose CC2650 App, right click on the project name → options → C/C++ Compiler, select “Preprocessor” tab, and make below changes.
4. In “Additional include directories” section, make the following changes:
   (a) Remove $TI_RTOS_DRIVERS_BASE$\ti\boards\SRF06EB\CC2650EM_7ID
   (b) Add $TI_RTOS_DRIVERS_BASE$\ti\boards\SRF06EB\CC2650EM_5XD
5. In “Defined Symbols” section, make below changes, add the preprocessor CC2650EM_5XD
6. Make changes to the “bleUserConfig.h”, found in the location of the installed SDK. The file can be found at C:\ti\simplelink\ble_cc26xx_2_XX_XX\Projects\ble\ICall\Include
7. In ble_cc26xx_2_XX_XX\Projects\ble\ICall\Include\bleUserConfig.h Change
   #define RF_FE_MODE_AND_BIAS (RF_FE_DIFFERENTIAL | RF_FE_EXT_BIAS)
   To
   #define RF_FE_MODE_AND_BIAS (RF_FE_DIFFERENTIAL | RF_FE_INT_BIAS)
8. Compile the “Host Test App” Project (both application and stack). Two hex files are generated for application and stack.
9. Refer Section 5.2.4 to merge the hex files and convert them into cc26xx.bin.

5.2.4 Merging the Hex Files to CC26xx.bin

To create the binary file in the following procedure, a USB cable, SmartRF06 board, and a CC2650EM board are required.

1. Connect the SmartRF06+CC2650EM board to a PC where Flash Programmer 2 is installed using the USB cable.
2. Open Flash Programmer 2.
3. Connect to the SmartRF06+CC2650EM board.
4. Perform Mass erase.
5. Program Stack hex image.
6. Program App hex image.
7. Navigate to Edit tab of the Flash Programmer.
8. Read the entire flash contents.
9. Navigate to 0x1ffd8
10. Change the contents of 0x1ffd8, 0x1ffd9, 0x1ffda, and 0x1ffdb to c5, 03, fe, and c5, respectively (for the Serial Bootloader).
11. Click the write button.
12. Click Save to File button.
13. Save as cc6xx.bin.

5.3 WLAN Connection

The gateway must be connected to a Wi-Fi Access Point (AP), which has cloud connectivity, to realize the IoT functionality. This Wi-Fi connection can also be used for HTTP configuration.

CC3200 maintains Wi-Fi Profiles, which helps in automatic connections to an AP during the boot up. The user should not need to make an AP connection in every power cycle.

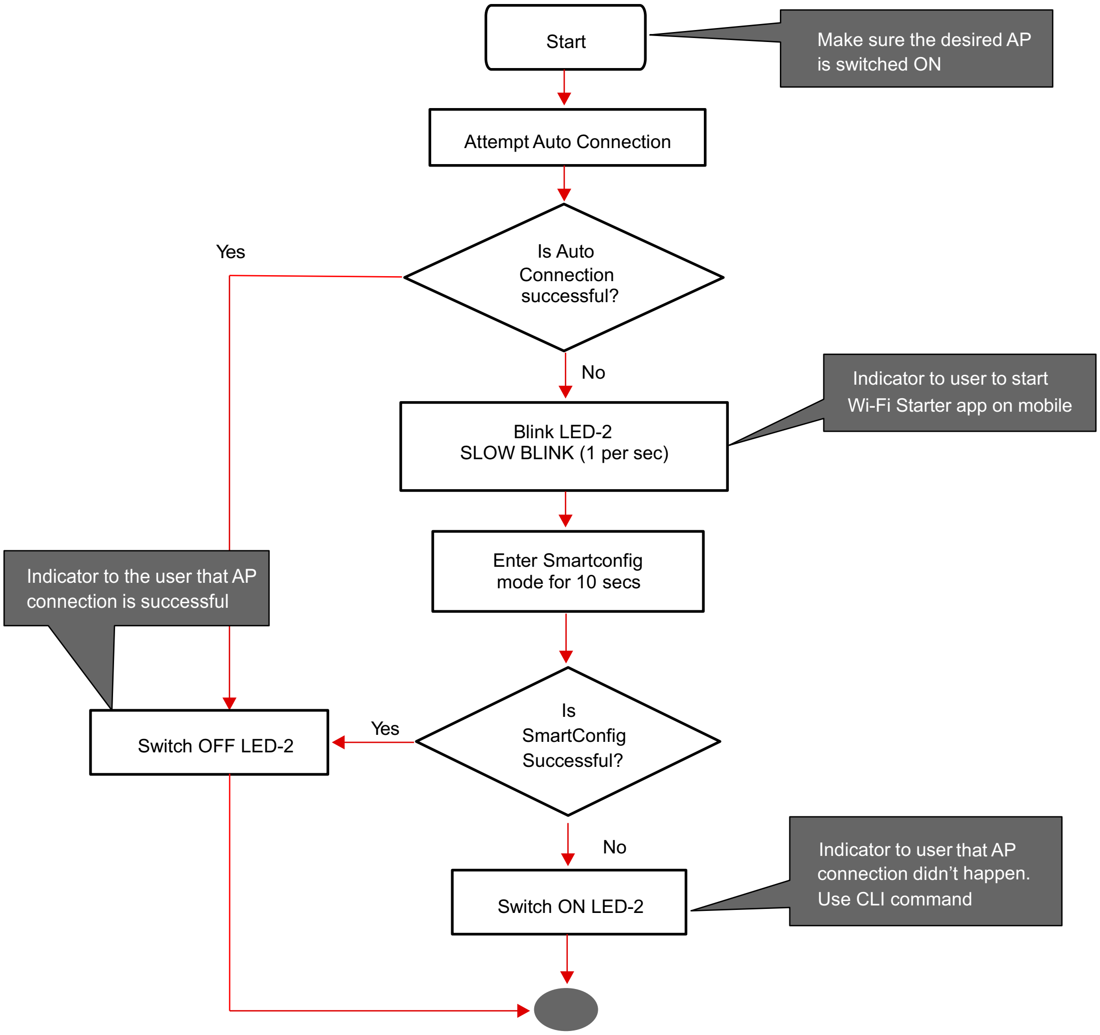

Start
Make sure the desired AP is switched ON
Attempt Auto Connection
Is Auto Connection successful?
Yes
No
Blink LED-2 SLOW BLINK (1 per sec)
Indicator to user to start Wi-Fi Starter app on mobile
Enter Smartconfig mode for 10 secs
Indicator to the user that AP connection is successful
Is SmartConfig Successful?
Yes
Switch OFF LED-2
No
Switch ON LED-2
Indicator to user that AP connection didn't happen. Use CLI command

Figure 10. WLAN Connection Process During Initialization

The AP connection may not be successful during the bootup due to one of these reasons:

- No WLAN profile present
- AP not switched on before the gatewayis reset
- The Smartconfig application was not available or was not successful

Post initialization, use the CLI command (wlan_connect; refer to Section 6.1) to connect to the AP. Ensure the AP is on while using this command. Upon successful connection, this configuration is stored as a WLAN profile. During subsequent power-cycles, this profile is checked if an auto connection is possible.

5.4 *Bluetooth* Smart Device Connection

A *Bluetooth* Smart device can be connected to the gateway using various UI commands (Refer to Section 6). When connected, the device is paired with the gateway, and the subsequent power cycle of the gateway does not need a UI command to be entered for connection.

NOTE: Only Just Works bonding is supported, and no Passkey support is present while connecting to *Bluetooth* Smart devices.

The CLI commands to connect to a *Bluetooth* Smart device are scan and linke. Scan is used to scan the devices that are advertising in the vicinity of BleFi. Linke connects to a desired device. The parameter of the linke command is the <scan id>.

For example,

```
G:>scan

.

.

G:>linke 0
```

5.4.1 Schema File

Typically, the characteristic in a *Bluetooth* Smart device is addressed using a handle. The handle is a numeric value and is not user friendly. The schema file mechanism in gateway maps the numeric handle to a human-readable string. This string can be used while monitoring the respective characteristic or while changing the value of the characteristic.

For example, to access the temperature data of the connected *Bluetooth* Smart Device,

G:>get 0 /Temp/Data
is used instead of
G:>get 0 15
Where 15 is the handle value.

NOTE: If schema file is not present, then default strings will be mapped (Example: char1).

To avail this facility, the user must create and download a schema file to the gateway. The schema file format is a human-readable JSON format and can be generated using any JSON editor. The SensorTag schema files in the package are created using https://www.jsoneditoronline.org/.

The name of the schema file is same as the device name that it publishes while advertising. An extension .sch must be added before downloading.
Example: SensorTag.sch

5.4.1.1 Schema File Format

```
{
  "Service_1 UUID": [
    {
    "Service_1.Characteristic_1 UUID": " Service_1.Characteristic_1 Name"
    },
   {
    “Service_1.Characteristic_2 UUID": " Service_1.Characteristic_2 Name"
    },
          ....
          ....
          ....

   ],
  "Service_2 UUID": [
    {
    "Service_2.Characteristic_1 UUID": " Service_2.Characteristic_1 Name"
    },
   {
    “Service_2.Characteristic_2 UUID": " Service_2.Characteristic_2 Name"
    },
          ....
          ....
          ....
   ],

          ....
          ....
          ....

}
```

6 Gateway Usage

This section assumes that the binaries are flashed in the gateway and the WLAN connection is also successful. For more information on the setup, refer to Section 4.3.

Typical gateway usage contains

- WLAN connection
- Connection to a *Bluetooth* Smart device
- Data monitoring over MQTT/CLI/HTTP

The gateway can be controlled or monitored using the UIs (User Interfaces)

- Command Line Interface (CLI) over UART
- Message Queue Telemetry Transport (MQTT) from a remote client
- Hypertext Transfer Protocol (HTTP) from a local machine

Table 4 summarizes the various control and monitoring capabilities of the UIs.

Table 4. Gateway UI Capabillities

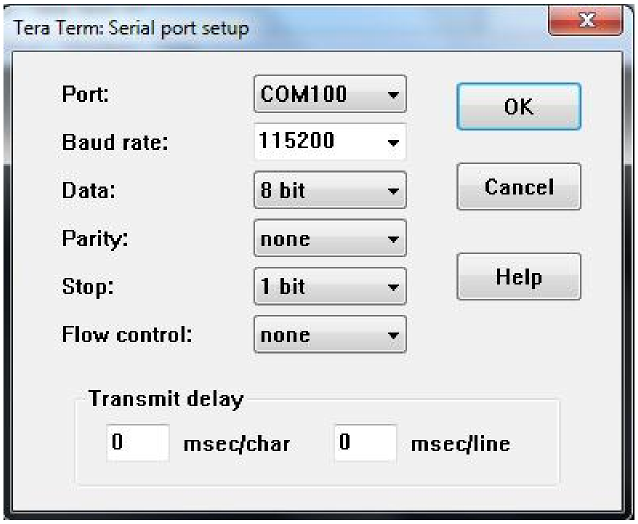
ACTION	CLI	HTTP	MQTT
WLAN Connect	√	X	X
WLAN Disconnect	√	X	X
Bluetooth Smart Device Scan	√	√	√
List *Bluetooth* Smart Devices	√	√	√
Bluetooth Device Connect	√	√	√
Bluetooth Device Disconnect	√	√	√
List *Bluetooth* Device Characteristics	√	√	√
Read *Bluetooth* Smart Device Characteristics	√	√	√
Write to *Bluetooth* Smart Device Characteristics	√	√	√
Remove Pairing Information	√	X	X
Reset MCU	√	X	X
OTA Configuration	√	X	X
Reset MQTT Client	√	X	X

6.1 CLI

The gateway can be controlled or monitored using the CLI over UART. To start CLI, open any terminal application on the laptop or PC that is connected to the gateway.

Terminal Setup:

1. In your terminal application, open the serial port Silicon Labs CP210x USB to UART bridge [COM100].
2. Setup the serial port with baud rate 115200 as shown in Figure 11.



Tera Term: Serial port setup

Port: COM100

Baud rate: 115200

Data: 8 bit

Parity: none

Stop: 1 bit

Flow control: none

Transmit delay

0 msec/char 0 msec/line

Figure 11. Serial Port Setup for CLI

The following sections describe the commands available in CLI.

6.1.1 HELP Command

```
NAME
      help

SYNOPSIS
      help

PARAMETERS
      None

DESCRIPTION
      help is used to display the CLI commands supported and their
      description.

EXAMPLES
      □  help
```

6.1.2 SCAN Command

```
NAME
      scan

SYNOPSIS
      scan

PARAMETERS
      None

DESCRIPTION
      scan is used to discover Bluetooth Smart devices which are
      advertising.

EXAMPLES
      □  scan
```

6.1.3 LIST Command

NAME

list

SYNOPSIS

list

PARAMETERS

None

DESCRIPTION

list is used to list the scanned and connected Bluetooth Smart devices.

EXAMPLES

- □ **list**

6.1.4 LINKE Command

NAME

linke

SYNOPSIS

linke [device scan id]

PARAMETERS

[device scan id] – scan Id of the scanned Bluetooth Smart device to be connected to. Please use the **list** command to find the scan ID of the device

DESCRIPTION

linke is used to connect to one of the scanned Bluetooth Smart devices.

EXAMPLES

- □ **linke 1**

6.1.5 LINKT Command

NAME

linkt

SYNOPSIS

linkt [device connection id]

PARAMETERS

[device connection id] – connection Id of the connected Bluetooth Smart device to be disconnected from. Please use the **list** command to know the connection ID of the device.

DESCRIPTION

linkt is used to disconnect from one of the connected Bluetooth Smart devices

EXAMPLES

□ **linkt 0**

6.1.6 LISTCHAR Command

NAME

listchar

SYNOPSIS

listchar [device connection id]

PARAMETERS

[device connection id] - – connection Id of the connected Bluetooth Smart device to be list the characteristics. Please use the **list** command to know the connection ID of the device.

DESCRIPTION

listchar is used to list the characteristics of one of the connected Bluetooth Smart devices.

EXAMPLES

□ **listchar 0**

6.1.7 GET Command

NAME

get

SYNOPSIS

get **[device connection id] [Charstring]**

PARAMETERS

[device connection id] – connection Id of the connected Bluetooth Smart device. Please use the **list** command to know the connection ID of the device.

[Charstring] - Name of the characteristic to be get

DESCRIPTION

get is used to read the value of the characteristic of one of the connected Bluetooth Smart devices.

EXAMPLES

□ **get 0 /Acc/Data**

□ **get 0 char18**

6.1.8 SET Command

NAME

set

SYNOPSIS

set **[device connection id] [Charstring]**
[length of value in bytes] [value]

PARAMETERS

[device connection id] – connection Id of the connected Bluetooth Smart device. Please use the **list** command to know the connection ID of the device.

[Charstring] - Name of the characteristic to be set

length of value in bytes] – length of the value to be written in bytes

[value] – value of the characteristic to be written

DESCRIPTION

set is used to write to the value of the characteristic of one of the connected Bluetooth Smart devices.

EXAMPLES

□ **set 0 /Acc/Cfg 1 1**

□ **set 0 char18 1 1**

6.1.9 WLAN_CONNECT Command

NAME

wlan_connect

SYNOPSIS

wlan_connect [ssid] {key}

DESCRIPTION

wlan_connect is used to connect to an AP. Upon successful connection, a WLAN profile will be added. BleFi can be connected to two kinds of AP

□ Open
□ WPA

The Open AP connection does not need the **key** parameter. If the **key** parameter is present, then a WPA connection will be tried.

PARAMETERS

ssid – string value, ssid of the AP that the connection has to be tried to.
key – security password for AP connection (only in case of WPA)

EXAMPLES

□ **wlan_connect open_ap_1**
□ **wlan_connect wpa_ap password123**

6.1.10 WLAN_DISCONNECT Command

NAME

wlan_disconnect

SYNOPSIS

wlan_disconnect

DESCRIPTION

wlan_disconnect is used to disconnect the WLAN connection to AP

PARAMETERS

None

EXAMPLES

□ **wlan_disconnect**

6.1.11 MQTTRST Command

```
NAME
      mqttrst

SYNOPSIS
      Mqttrst

PARAMETERS
      None

DESCRIPTION
      mqttrst is used to reset the mqtt client in blefi.

EXAMPLES
   □  mqttrst
```

6.1.12 RESET Command

```
NAME
      reset

SYNOPSIS
      reset

PARAMETERS
      None

DESCRIPTION
      reset is used to reset the blefi.

EXAMPLES
   □  reset
```

6.1.13 OTA Configuration Command

NAME

addotameta

SYNOPSIS

addotameta [metadatastring]

PARAMETERS

metadatastring – meta data string of the associated Dropbox account where the blefi OTA (Over The Air) files are stored.

DESCRIPTION

addotameta is used to config the dropbox meta data string information used for OTA in blefi.

EXAMPLES

□ **addotameta HNFGT_m-65YJJJADDGGGBs7y8FWDvgBAbnVFzVUdhDxhVJHu7ung9dSFsc_dHO45**

6.1.14 *Bluetooth* Smart Update Command

NAME

bleupdate

SYNOPSIS

bleupdate

PARAMETERS

None

DESCRIPTION

This command is used to update the CC26xx firmware. The update takes effect after a reboot of blefi hardware.

EXAMPLES

□ **bleupdate**

6.1.15 MQTT Gateway Mode Command

```
NAME
      mqttgwmode

SYNOPSIS
      mqttgwmode mode servername

PARAMETERS
      [mode] – 0 for demo mode OR 1 for quickstart mode.
      [servername] – url or ip address of the server
DESCRIPTION
This command is used to reset the MQTT mode in quickstart or Demo mode.
In Demo mode, a server name needs to be specified.

EXAMPLES
   □  mqttgwmode 0 “192.84.45.44”
```

6.1.16 MQTT Device Mode Command

```
NAME
      mqttdevmode

SYNOPSIS
      mqttdevmode mode servername

PARAMETERS
      [mode] – 0 for demo mode OR 1 for quickstart mode.
      [servername] – url or ip address of the server
DESCRIPTION
This command is used to set the MQTT Device mode to quickstart or Demo
mode. In Demo mode, a server name needs to be specified.

EXAMPLES
   □  mqttdevmode 1
```

6.1.17 Load Default Command

```
NAME
      loaddefault

SYNOPSIS
      loaddefault

PARAMETERS
      None

DESCRIPTION
This command is used to put BleFi board in default mode.

EXAMPLES
   □  loaddefault
```

6.1.18 Auto Scan Command

```
NAME
      autoscan

SYNOPSIS
      autoscan [Time in seconds]
PARAMETERS
      Time in seconds. If less than 30, then autoscan will be disabled

DESCRIPTION
This command is used to set the autoscan duration of BleFi.

EXAMPLES
   □  autoscan 60
```

6.1.19 Display Auto-Connect List Command

```
NAME
      autoconlist

SYNOPSIS
      autoconlist
PARAMETERS
      None

DESCRIPTION
This command is used to display the list of Bluetooth Smart
devices that are privileged to autoconnect with BleFi.

EXAMPLES
   □  pairlist
```

6.1.20 Remove Auto Connection Command

```
NAME
      rmautocon

SYNOPSIS
      rmautocon
PARAMETERS
      None

DESCRIPTION
This command is used to disable the auto-connection privilege of a
previously connected BleFi device.
EXAMPLES
   □  unpair
```

6.1.21 Auto-Connect Command

```
NAME
      autocon

SYNOPSIS
      autocon
PARAMETERS
      1 or 0

DESCRIPTION
When enabled, a pre-connected Bluetooth Smart device will
automatically connect to BleFi.
This command is used to enable or disable this feature in BleFi.
EXAMPLES
   □  autocon 1
```

6.1.22 Trigger OTA Command

```
NAME
      triggerota

SYNOPSIS
      triggerota
PARAMETERS
      None

DESCRIPTION
This command is used to start the OTA process of the BleFi.
EXAMPLES
   □  triggerota
```

6.2 MQTT—Enabling IoT

MQTT (Message Queue Telemetry Transport) protocol is an extremely lightweight machine-to-machine connectivity protocol. MQTT protocol is based on the publish-and-subscribe messaging model and is designed to be used on top of TCP / IP protocol.

The key point of this protocol includes small code footprint and low network bandwidth requirements. Other features include faster response time, low power requirement, and ease of scalability. All these advantages make it an ideal candidate for communication protocol in embedded devices intended to implement IoT (internet of things) applications. More information regarding MQTT protocol can be obtained from the latest MQTT protocol specification.

A simple MQTT infrastructure contains a broker (like a central hub) connected to multiple clients, each of which has the capability of publishing on any topic (token). The broker sends the message published on any topic to all the subscribers of that topic, as shown in Figure 12.

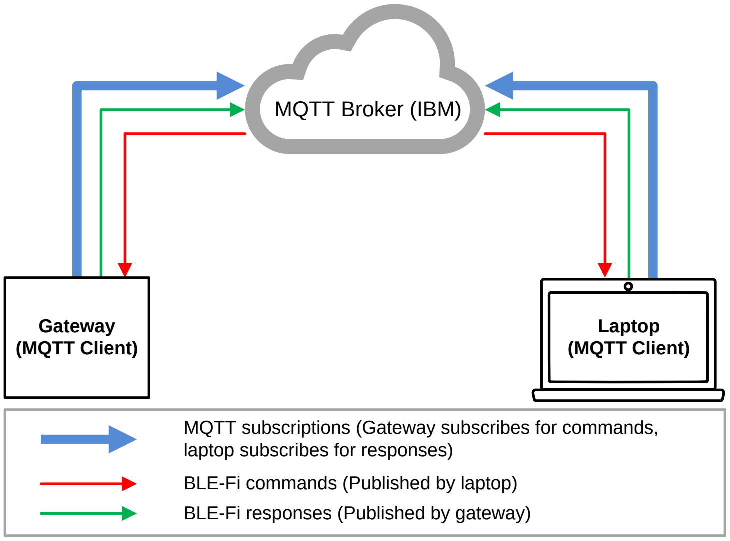

MQTT Broker (IBM)
Gateway
(MQTT Client)
Laptop
(MQTT Client)
MQTT subscriptions (Gateway subscribes for commands, laptop subscribes for responses)
BLE-Fi commands (Published by laptop)
BLE-Fi responses (Published by gateway)

Figure 12. MQTT Connection

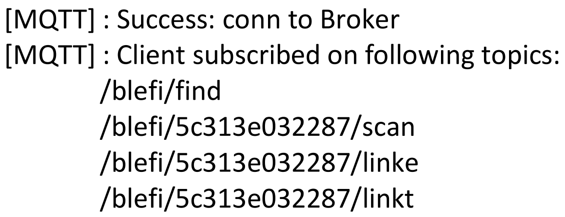
More detailed info on MQTT can be found in the following links:

- http://mqtt.org/faq
- http://processors.wiki.ti.com/index.php/CC32xx_MQTT_Client

6.2.1 Connection

The gateway should be connected to an AP (with Internet connection) for MQTT to work. Refer to Section 5.3 for more details.

The gateway connects to the IBM MQTT server during initialization. These prints on the CONSOLE (CLI) confirm the connection.



```
[MQTT] : Success: conn to Broker
[MQTT] : Client subscribed on following topics:
         /blefi/find
         /blefi/5c313e032287/scan
         /blefi/5c313e032287/linke
         /blefi/5c313e032287/linkt
```

If these prints do not appear on CONSOLE, one of the following issues may have occurred:

- Gateway-AP connection is not successful
- AP is not connected to internet
- IBM MQTT server is not responding

NOTE: The 5c313e032287 is the MAC address of the gateway. This address is just an example and will be different for different gateway devices.

6.2.2 MQTT Clients

The gateway supports two kinds of MQTT clients: a gateway client and device clients. The gateway client is created when the gateway powers up. By default, the gateway client is connected to an MQTT demo server of IBM.

The device clients are created when a CC2650 SensorTag is connected to the gateway (over *Bluetooth* Smart). There can be a maximum of 3 CC2650 SensorTag device clients. By default, the CC2650 SensorTag device clients are connected to the QuickStart server of IBM®.

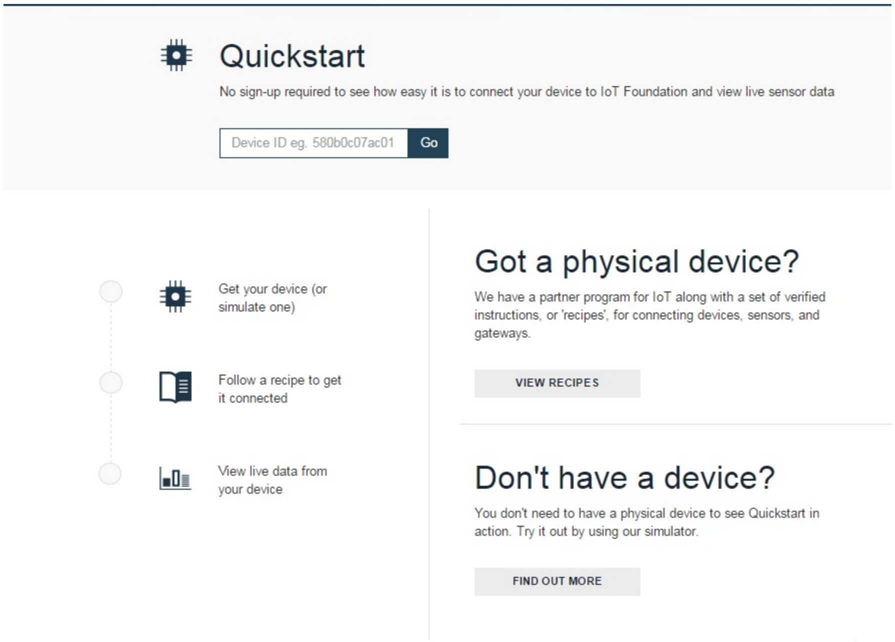
6.2.3 MQTT Device Client

Quickstart mode is enabled when CC2650 SensorTags connect to the gateway and device clients are created.

This mode provides an intuitive feel of the entire platform, with richness of live sensor data of CC26xx SensorTags connected to the gateway, being streamed and displayed on the cloud from a remote location.

Procedure:

1. Connect the CC2650 SensorTags using CLI or MQTT (Gateway client—see Section 6.2.4).
2. Open the URL http://quickstart.internetofthings.ibmcloud.com.
3. Type the BD address of the CC26xx SensorTag as the device ID, which is scanned and displayed on the CLI.
4. Click the Go button.



Quickstart

No sign-up required to see how easy it is to connect your device to IoT Foundation and view live sensor data

Get your device (or simulate one)

Follow a recipe to get it connected

View live data from your device

Got a physical device?

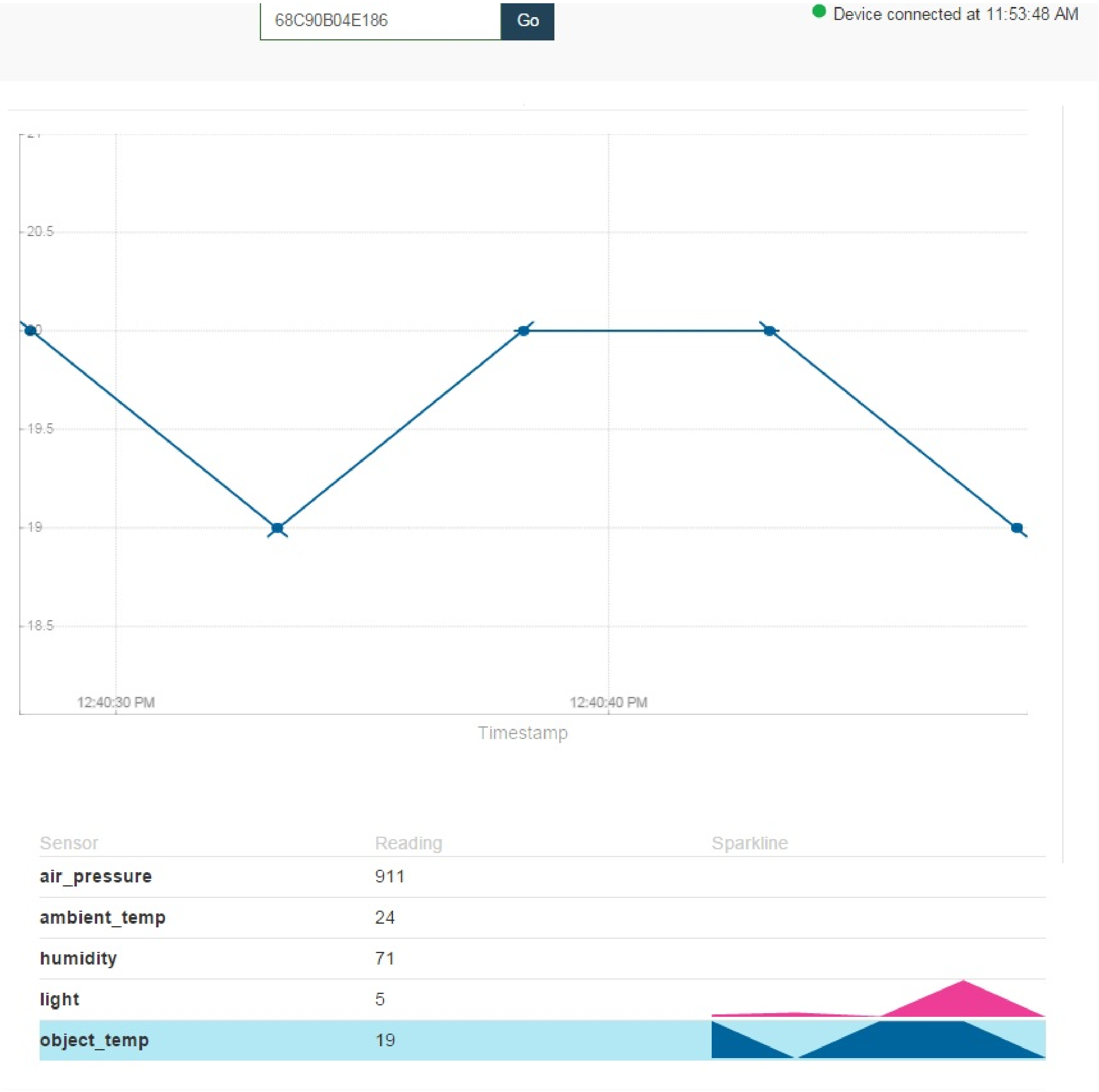
We have a partner program for IoT along with a set of verified instructions, or 'recipes', for connecting devices, sensors, and gateways.

Don't have a device?

You don't need to have a physical device to see Quickstart in action. Try it out by using our simulator.

Figure 13. MQTT Device Quickstart

5. When connected, the device displays its status as “Connected” with the time.



68C90B04E186 Go

● Device connected at 11:53:48 AM

Sensor	Reading	Sparkline
air_pressure	911	
ambient_temp	24	
humidity	71	
light	5	
object_temp	19	

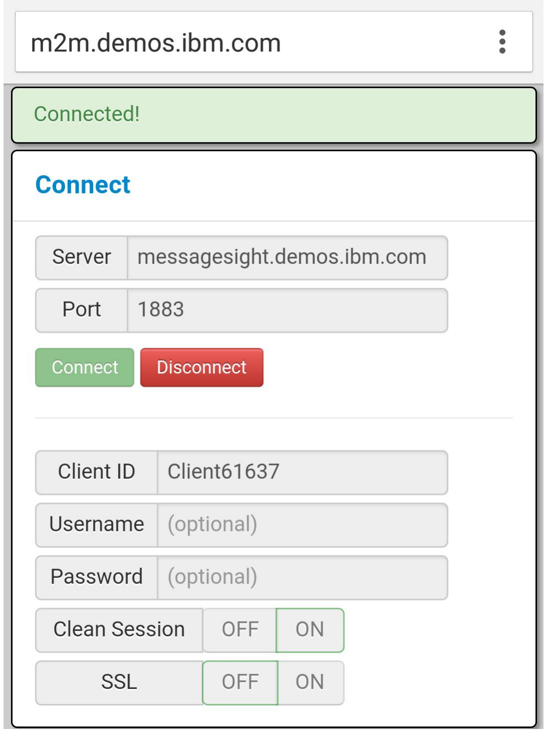
Figure 14. Device Connected

6. The device also displays live sensor data of the connected CC26xx SensorTag.

6.2.4 MQTT Gateway Client

The gateway acts as an MQTT client and connects to the messagesight.demos.ibm.com MQTT server. To access the gateway, open an MQTT client from a laptop or PC and connect to the IBM MQTT server.

1. Open an Internet browser (Chrome®, Internet Explorer™, Firefox®, or others)
2. Go to this link: http://m2m.demos.ibm.com/mqttclient/
3. Type messagesight.demos.ibm.com in the server text box and click Connect.



m2m.demos.ibm.com

Connected!

Connect

Server: messagesight.demos.ibm.com

Port: 1883

Client ID: Client61637

Username: (optional)

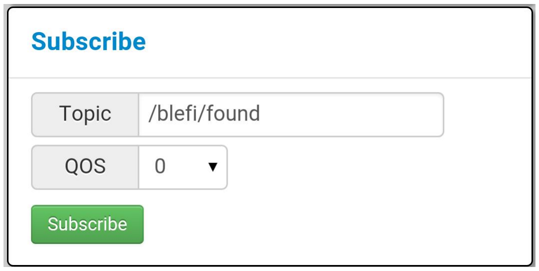
Password: (optional)

Clean Session: OFF [✓ ON]

SSL: [✓ OFF] ON

Figure 15. Remote Client Connection

4. When the connection is successful, the client can communicate with the gateway.
5. Subscribe to desired topics one by one by typing the topic name and pressing Subscribe. For the list of topics that the gateway publishes, refer to Section 6.2.6.



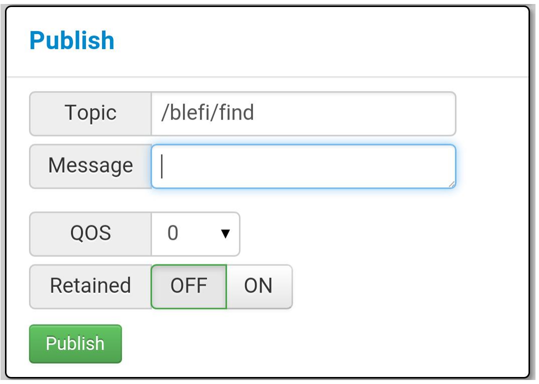
Subscribe

Topic: /blefi/found

QOS: 0 ▾

Figure 16. Remote Client Subscription

6. To send MQTT commands to the gateway, use the Publish section of the MQTT client. Enter the topic to be published and the parameter in the Message box, and press Publish. For the list of topics that the gateway responds to, refer to Section 6.2.6.



Publish

Topic: /blefi/find

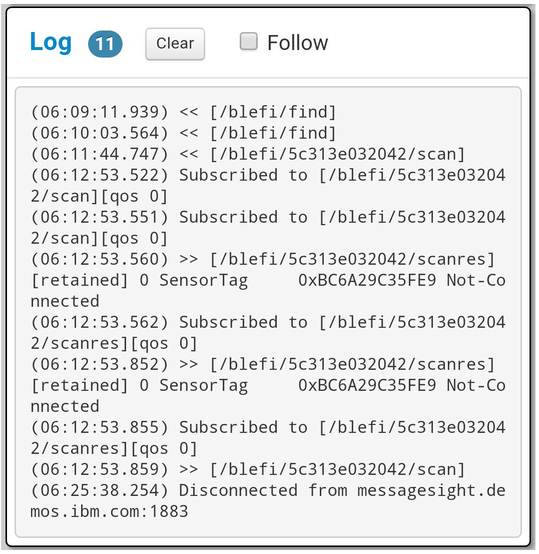
Message:

QOS: 0

Retained: OFF ON

Figure 17. Remote Client Publication

7. Once the topic is published, the gateway responds to the topic within seconds (depending on the Internet speed). The response from the gateway displays in the Log section of the MQTT client.



```
(06:09:11.939) << [/blefi/find]
(06:10:03.564) << [/blefi/find]
(06:11:44.747) << [/blefi/5c313e032042/scan]
(06:12:53.522) Subscribed to [/blefi/5c313e03204
2/scan][qos 0]
(06:12:53.551) Subscribed to [/blefi/5c313e03204
2/scan][qos 0]
(06:12:53.560) >> [/blefi/5c313e032042/scanres]
[retained] 0 SensorTag     0xBC6A29C35FE9 Not-Co
nnected
(06:12:53.562) Subscribed to [/blefi/5c313e03204
2/scanres][qos 0]
(06:12:53.852) >> [/blefi/5c313e032042/scanres]
[retained] 0 SensorTag     0xBC6A29C35FE9 Not-Co
nnected
(06:12:53.855) Subscribed to [/blefi/5c313e03204
2/scanres][qos 0]
(06:12:53.859) >> [/blefi/5c313e032042/scan]
(06:25:38.254) Disconnected from messagesight.de
mos.ibm.com:1883
```

Figure 18. Remote Client Logs

6.2.5 MQTT—Remote Access of the Gateway

MQTT works on a subscription-publish mechanism. The gateway, as an MQTT client subscribes to numerous topics. These subscribed topics act as a command to the gateway. A remote client may publish one of these topics with proper parameters as a command to the gateway. As a response to the command, the gateway publishes some topics. To receive the response, the remote client must have subscribed to these topics. The below sequence diagram depicts the working of MQTT on the gateway.

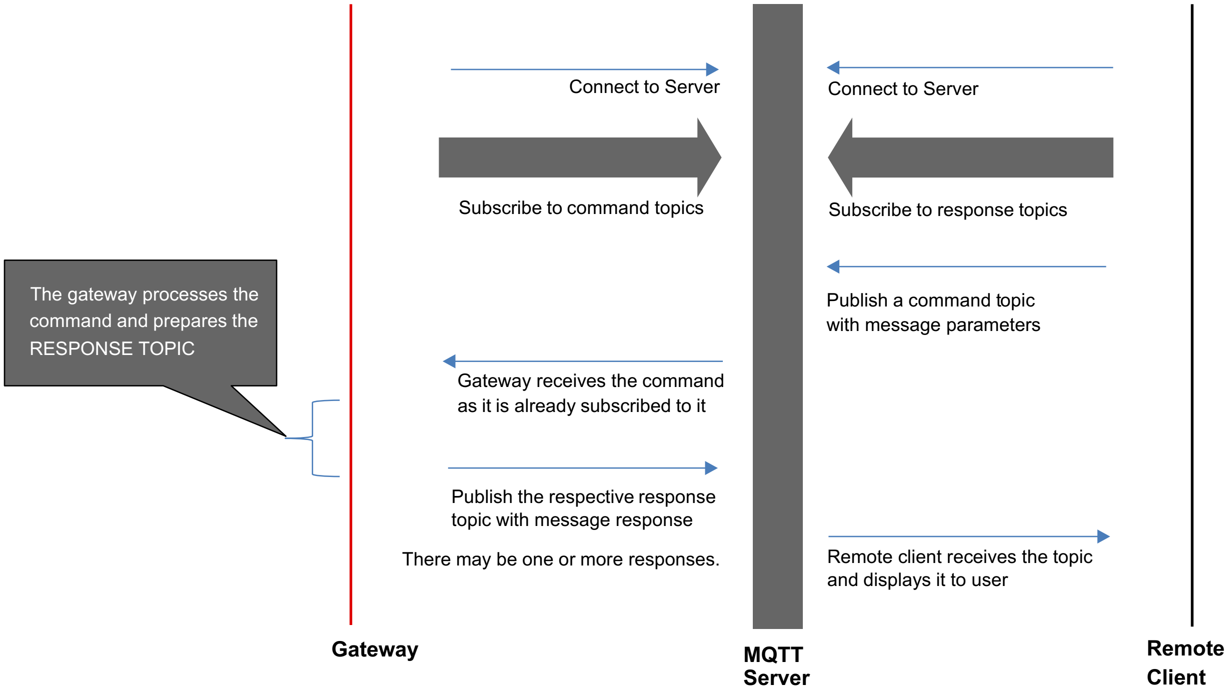

Connect to Server
Subscribe to command topics
Connect to Server
Subscribe to response topics
Publish a command topic with message parameters
The gateway processes the command and prepares the RESPONSE TOPIC
Gateway receives the command as it is already subscribed to it
Publish the respective response topic with message response
There may be one or more responses.
Remote client receives the topic and displays it to user
Gateway
MQTT Server
Remote Client

Figure 19. MQTT Sequence Diagram

The gateway maintains two different contexts while connecting to the MQTT server. From external client point of view, there is no difference while accessing the topics related to either of the contexts.

1. Gateway Context (1 number)—This context is the default context and is created during initialization. gateway context contains the topics that are related to gateway and not specific to a *Bluetooth* Smart device.
2. Device Context (0 to 3 numbers)—A device context is created when a *Bluetooth* Smart device gets connected to the gateway. The maximum number of device contexts that can be created in the gateway is three.

6.2.6 Command Topics (Available Only in Demo Mode)

The command topic is an MQTT topic subscribed by the gateway, and can be used by remote MQTT clients to command gateway.

6.2.6.1 Find the Gateway Device

TOPIC

/blefi/find

PARAMETERS

None

DESCRIPTION

This topic is used to find a BleFi device in the Cloud.

RESPONSE

To capture the response, remote client should have subscribed to **/blefi/found** before publishing the command.
BleFi responds to this command by publishing **/blefi/found** topic, with its **mac-address**. This **mac-address** is helpful in building other topics, such as scan, linke and linkt.

EXAMPLES

□ **/blefi/find**

6.2.6.2 Scan *Bluetooth* Smart Devices

TOPIC

/blefi/<mac-address>/scan

PARAMETERS

None

DESCRIPTION

This topic is used to scan the devices that are advertising in the vicinity of BleFi indicated by <mac-address>.The mac-address is found in the response to **/blefi/find**

RESPONSE

To capture the response, remote client should have subscribed to **/blefi/<mac-address>/scanres** before publishing the command.
BleFi starts a scan process to find the devices that are advertising in its vicinity.
Once the scan is complete, BleFi responds to this command by publishing **/blefi/<mac-address>/scanres** topic. The message of the response topic contains information of the Bluetooth Smart devices scanned. This command is typically followed by **/blefi/<mac-address>/linke** command.

EXAMPLES

□ **/blefi/<mac-address>/scan**

6.2.6.3 Establish Link to a *Bluetooth* Smart Device

TOPIC

/blefi/<mac-address>/linke

PARAMETERS

device-index

DESCRIPTION

This command is used to establish a link between BleFi and Bluetooth Smart device, indicated by the device-index.

RESPONSE

To capture the response, remote client should have subscribed to **/blefi/<mac-address>/linkeres** before publishing the command.
Once the link is successful, BleFi responds to this command by publishing **/blefi/<mac-address>/linkeres** topic with success indication.
Upon successful link establishment, BleFi creates a “device-context” for this device.
This command is typically followed by **/<bd-address>/list, <**bd-address> identifies the Bluetooth Smart device connected to BleFi.

EXAMPLES

- □ **/blefi/<mac-address>/linke 1**

6.2.6.4 Terminate *Bluetooth* Smart Device Link

TOPIC

/blefi/<mac-address>/linkt

PARAMETERS

device-index

DESCRIPTION

This command is used to terminate a link between BleFi and Bluetooth Smart device, indicated by the device-index.

RESPONSE

To capture the response, remote client should have subscribed to **/blefi/<mac-address>/linktres** before publishing the command.
Once the link is terminated, BleFi responds to this command by publishing **/blefi/<mac-address>/linktres** topic with success indication.
Upon termination of link, BleFi deletes the “device-context” of this device.

EXAMPLES

- □ **/blefi/<mac-address>/linkt 0**

6.2.6.5 *List Characteristics of* Bluetooth *Smart Device*

TOPIC

/<bd-address>/list

PARAMETERS

None

DESCRIPTION

This command is used to list all the characteristics of a connected Bluetooth Smart Device. The bd-address is found in the response to **/blefi/linke**

RESPONSE

To capture the response, remote client should have subscribed to **/<bd-address>/listres** before publishing the command. The response lists all the characteristics of Bluetooth Smart device. The list is an array of strings with the read/write permission enabled per characteristic. The response would be fairly lengthy. This command is typically followed by **/<bd-address>/set** or **/<bd-address>/get** command

EXAMPLES

□ **/<bd-address>/list**

6.2.6.6 *Read Value of a Characteristic*

TOPIC

/<bd-address>/get

PARAMETERS

<character string>

DESCRIPTION

This command is used to read the value of a character of the Bluetooth Smart device. The character string is found in the response to **/<bd-address>/list** command. The bd-address is found in the response to **/blefi/linke**

RESPONSE

To capture the response, remote client should have subscribed to the response to particular character (Ex: **/<bd-address>/Temp/Data)** before publishing the command. The response contains the value of the character

EXAMPLES

□ **/<bd-address>/get Temp/Data**

6.2.6.7 Write a Characteristic Value

```
TOPIC
      /<bd-address>/set

PARAMETERS
      <character string>

DESCRIPTION
      This command is used to write the value of a character of the
      Bluetooth Smart device. The character string is found in the
      response to /<bd-address>/list command. The bd-address is found
      in the response to /blefi/linke

RESPONSE
      To capture the response, remote client should have subscribed to
      /<bd-address>/setres.

EXAMPLES
      □  /<bd-address>/set Temp/Cfg 1
```

6.2.7 Response Topics (Available Only in Demo Mode)

The gateway responds to the commands from remote client by publishing the response topics. Remote clients should have subscribed to these topics before publishing the respective commands. The usage of these topics is explained in Section 6.2.6.

Here is a summary of all the response topics.

Table 5. List of MQTT Response Topics

RESPONSE TOPICS	RESPECTIVE COMMAND	COMMENTS
/blefi/found	/blefi/find	This message of this response contains <mac-addr>, which is useful to subscribe other topics
/blefi/<mac-addr>/scanres	/blefi/<mac-addr>/scan	This message contains a list of all advertising and connected devices
/blefi/<mac-addr>/linkeres	/blefi/<mac-addr>/linke	This message contains the <bd-addr>, which is useful for device-context-topic subscription
/blefi/<mac-addr>/linktres	/blefi/<mac-addr>/linkt	Response to link termination
/<bd-addr>/listres	/<bd-addr>/list	Multiple messages with array of character strings
/<bd-addr>/<char-string>	/<bd-addr>/get	Message contains the value of the character
/<bd-addr>/setres	/<bd-addr>/set	

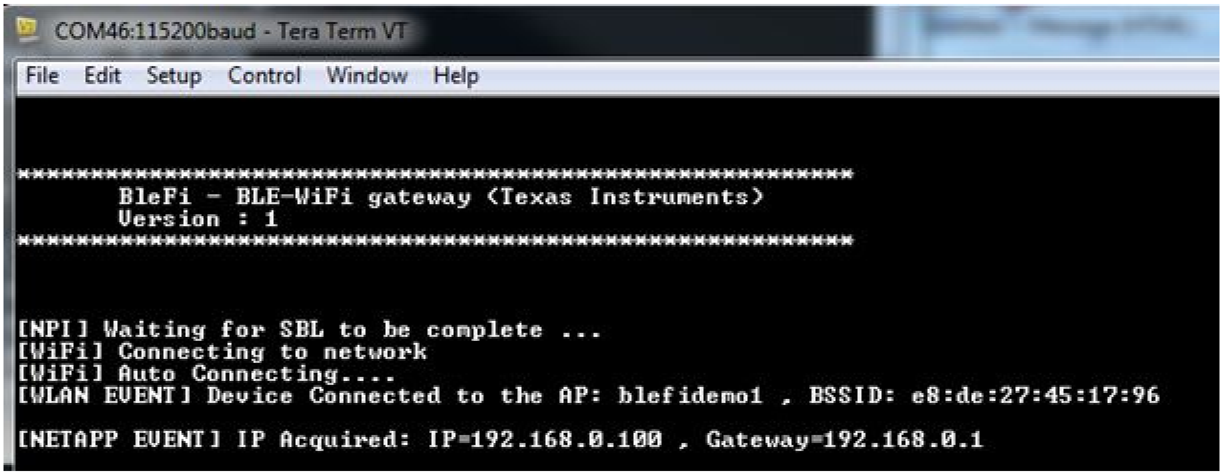
6.3 HTTP

The gateway runs an HTTP server and hosts pages. Users can interact with the device using a web browser. The HTTP pages can be used for the following purposes:

- Scanning for any available *Bluetooth* Smart device
- Establishing or terminating link with a *Bluetooth* Smart device
- Reading and writing the characteristics of the *Bluetooth* Smart device

6.3.1 *Bluetooth* Smart Dashboard

1. The HTML pages are part of the installer. These pages should be downloaded onto SFLASH of the gateway. Refer to for more information.
2. Run the gateway application. When connected to the AP, the acquired IP is displayed in the CLI as shown in Figure 20.



```
*********************************************************
       BleFi - BLE-WiFi gateway (Texas Instruments)
       Version : 1
*********************************************************


[NPI] Waiting for SBL to be complete ...
[WiFi] Connecting to network
[WiFi] Auto Connecting....
[WLAN EVENT] Device Connected to the AP: blefidemo1 , BSSID: e8:de:27:45:17:96

[NETAPP EVENT] IP Acquired: IP=192.168.0.100 , Gateway=192.168.0.1
```

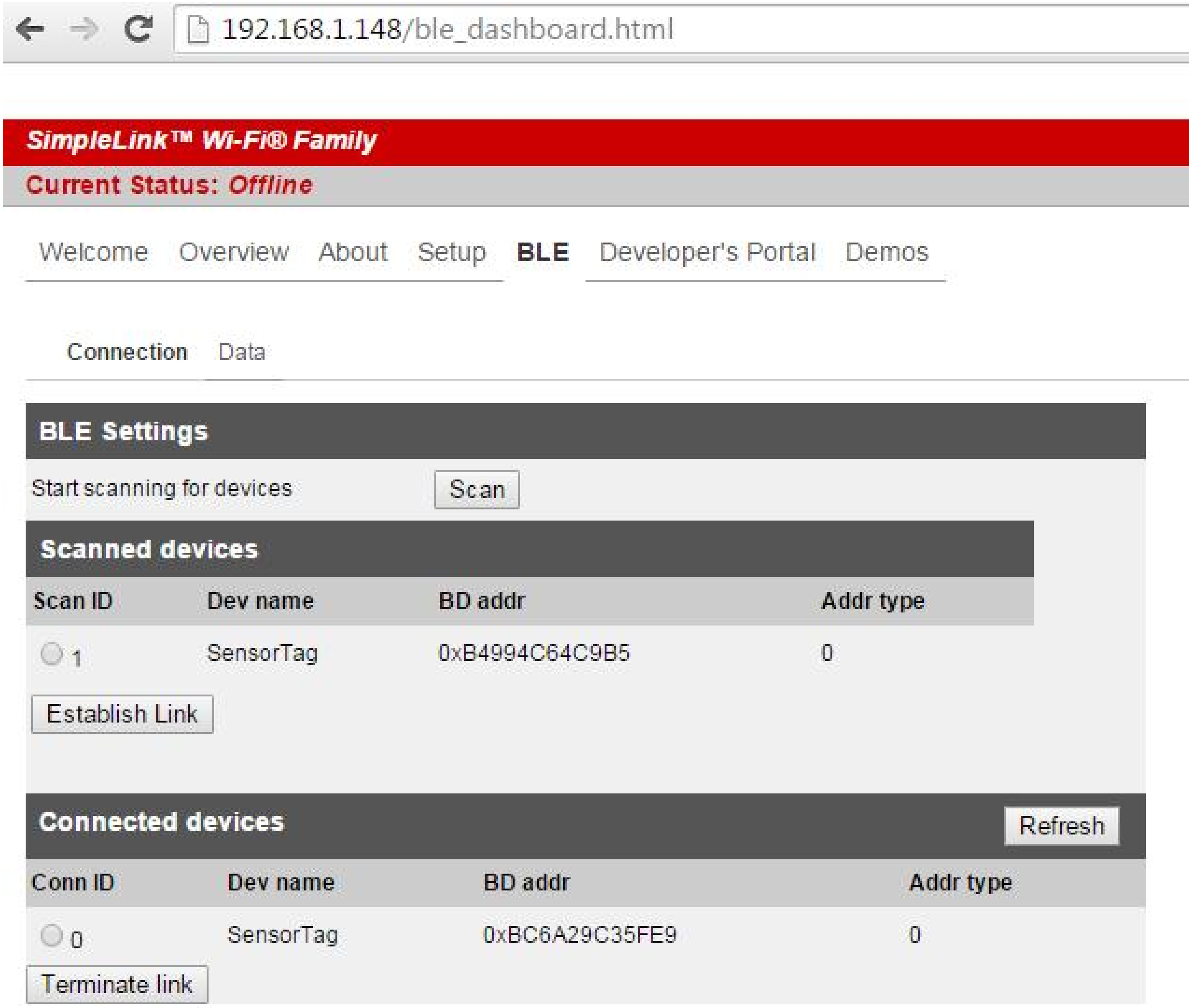
Figure 20. IP Address Displayed on CLI

3. Open the browser and type <ipaddr>/ble_dashboard.html
   - For example, type 192.168.1.100/ble_dashboard.html in browser URL field
   - Browser shows the *Bluetooth* Smart dashboard page

The *Bluetooth* Smart dashboard page contains two tabs:

- Connection—Users can scan all the advertising *Bluetooth* Smart devices in the gateway vicinity using this tab. This tab contains controls to establish and terminate link to a *Bluetooth* Smart device
- Data—This tab is used to show all the characteristics of a connected *Bluetooth* Smart device. Based on the permissions, the characteristic value can be read from or written to, using this tab

6.3.2 *Bluetooth* Smart Connection Page



Scan ID	Dev name	BD addr	Addr type
○ 1	SensorTag	0xB4994C64C9B5	0

Conn ID	Dev name	BD addr	Addr type
○ 0	SensorTag	0xBC6A29C35FE9	0

Figure 21. *Bluetooth* Smart Dashboard Page

6.3.2.1 Scanning a Bluetooth *Smart Device*

1. Select the Connection tab.
2. Press the Scan button to start scanning for available *Bluetooth* Smart devices.
3. Wait for 5 seconds for the command to be completed.
4. Press the Refresh button to show the list of scanned devices.

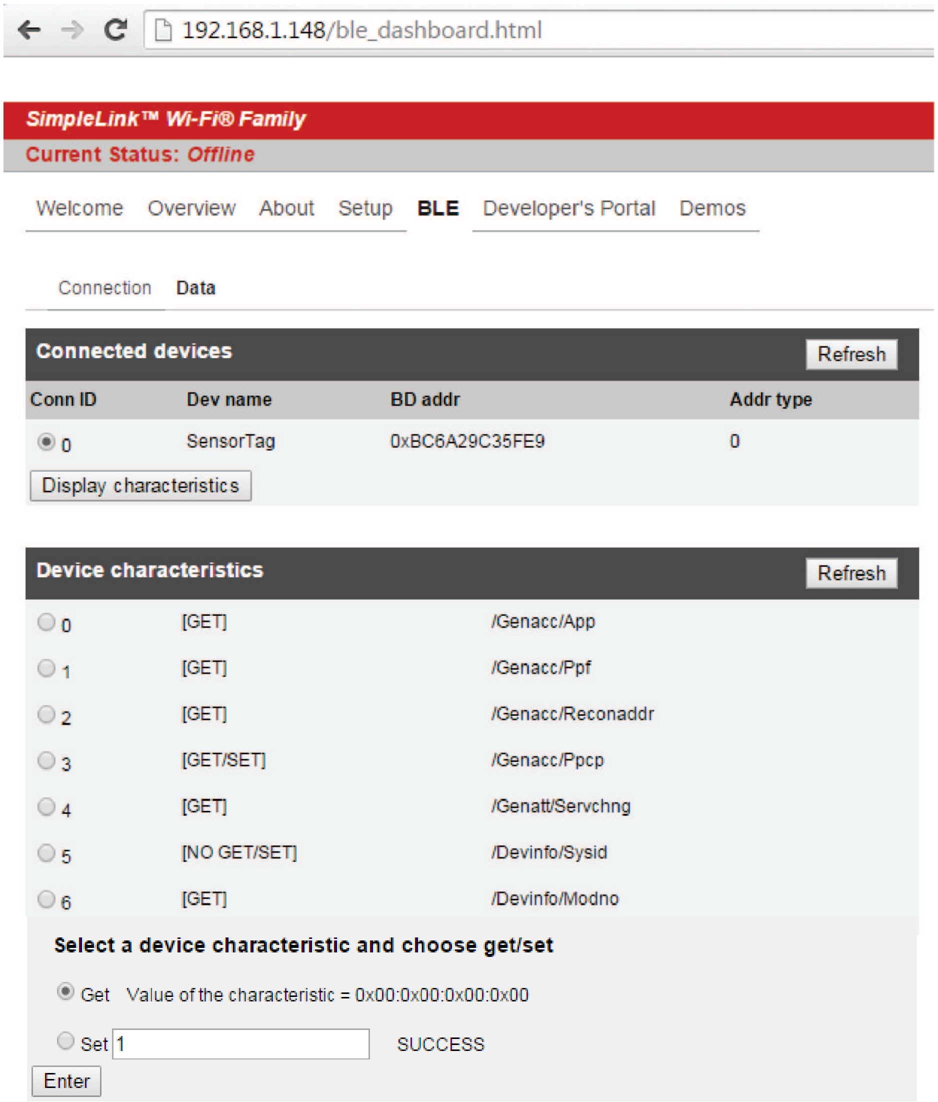
6.3.2.2 Establishing Link with a Bluetooth *Smart Device*

1. Among the list of scanned devices, Select the Radio Button of the desired Bluetooth Smart device.
2. Press the Establish Link button.
3. Wait for 5 seconds for the command to be completed.
4. Press the Refresh button to show the list of connected devices.

6.3.2.3 *Terminating Link from a* Bluetooth *Smart Device*

1. Among the list of connected devices, Select the Radio Button of the desired *Bluetooth* Smart device.
2. Press the Terminate Link button.
3. Wait for 2 seconds for the command to be completed.
4. Press Refresh button to show the updated list of connected devices.

6.3.3 *Bluetooth* Smart Data Page



192.168.1.148/ble_dashboard.html

SimpleLink™ Wi-Fi® Family

Current Status: *Offline*

Connected devices

Conn ID	Dev name	BD addr	Addr type
● 0	SensorTag	0xBC6A29C35FE9	0

Device characteristics

○ 0	[GET]	/Genacc/App
○ 1	[GET]	/Genacc/Ppf
○ 2	[GET]	/Genacc/Reconaddr
○ 3	[GET/SET]	/Genacc/Ppcp
○ 4	[GET]	/Genatt/Servchng
○ 5	[NO GET/SET]	/Devinfo/Sysid
○ 6	[GET]	/Devinfo/Modno

Select a device characteristic and choose get/set

● Get Value of the characteristic = 0x00:0x00:0x00:0x00

○ Set 1 SUCCESS

Figure 22. *Bluetooth* **Smart Data Page**

6.3.3.1 *Display Characteristics of a Connected* Bluetooth *Smart Device*

1. Select the Data tab.
2. Select the radio button of the desired *Bluetooth* Smart device from the Connected Devices table.
3. Press the Display Characteristics button to show the characteristics of the selected *Bluetooth* Smart device.

6.3.3.2 Read or Write Characteristic Value

1. In the Device Characteristics table, select the radio button of the characteristic to be read or written.
2. To read a characteristic, select the Get radio button and press the Enter button.
3. The characteristic value read will be displayed adjacent to the Get button.
4. To write to a characteristic value, select the Set radio button, enter the value to be written in the text box adjacent to the Set button, and press the Enter button.
5. If the write is completed successfully, the SUCCESS message is shown.

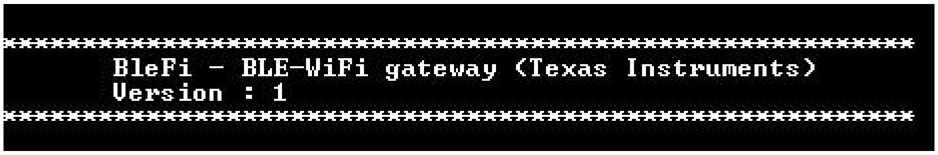
6.4 OTA

The Over-The-Air (OTA) update is the wireless delivery of new software updates and/or configurations to embedded devices and with the concept of Wireless Sensor Network and Internet of Things, OTA is an efficient way of distributing firmware updates or upgrades.

The application binary (blefi.bin) and the gateway enabler binary (cc26xx.bin) files can be updated over the air (OTA). This feature requires the user to create a Dropbox account and load the files in the account.

6.4.1 Creating a Dropbox API Application

1. Create an account with Dropbox and log in.
2. Go to https://www.dropbox.com/developers/apps/create and choose Dropbox API app.
3. Choose “Files and Datastores” and “Yes, my app only needs access to files it creates”.
4. Provide a suitable name for the app and click the Create APP button.
5. You will be redirected to Apps setting page. Scroll down to “Generated access token” and click generate. Copy and save the generated token. This token needs to be stored in the gatewayusing the “otaconfig” command in CLI.
6. Go to https://www.dropbox.com/home/Apps.
7. Click on the application name.
8. Create a new folder and name it in the following format: TI_BleFi_v<version number> (for example: TI_BleFi_v01). The version name is found on the CLI Banner.



```
***********************************************************
       BleFi - BLE-WiFi gateway (Texas Instruments)
       Version : 1
***********************************************************
```

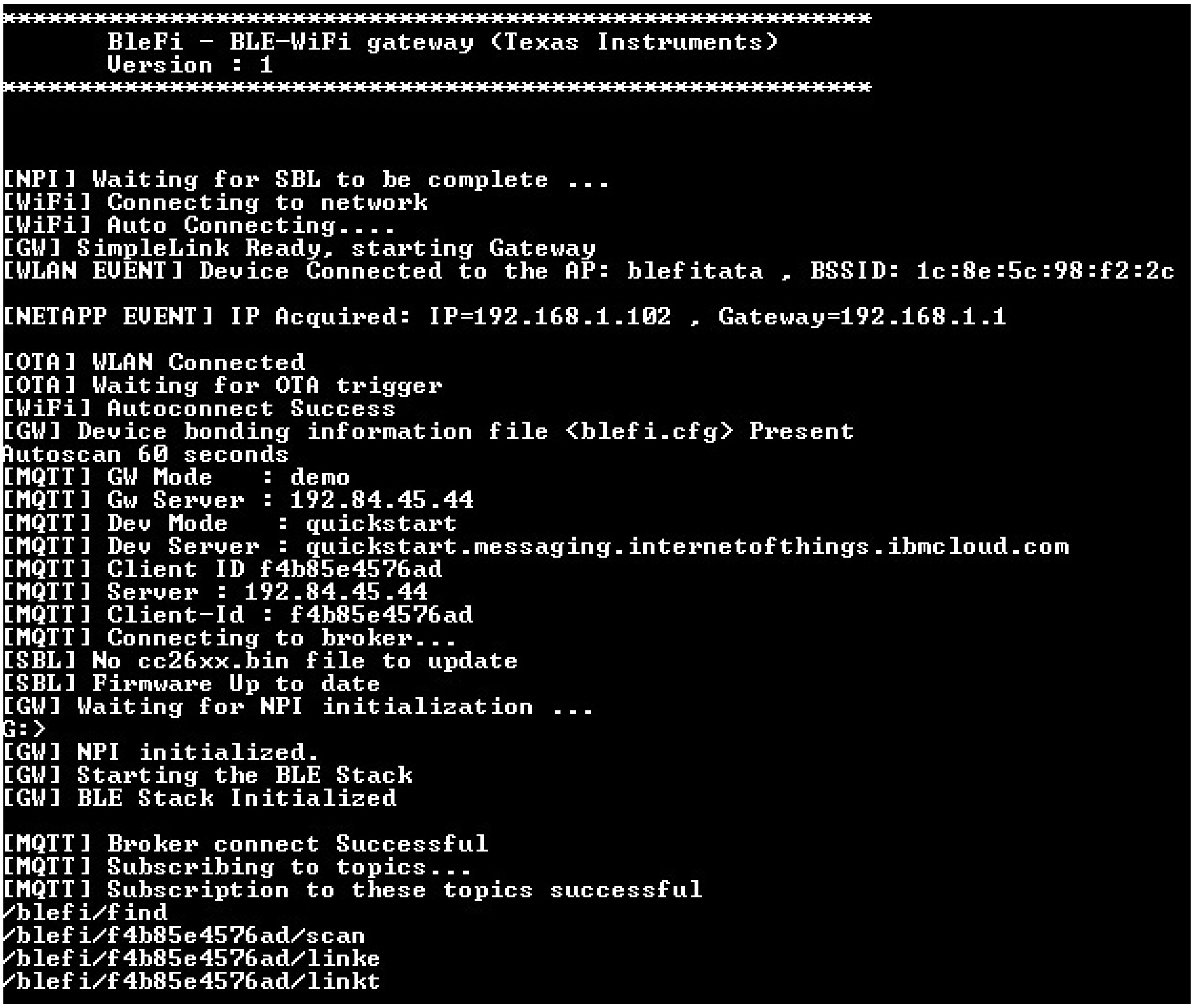
Figure 23. CLI Banner Showing Version Number

9. Rename “blefi.bin” as “f80_sys_mcuimgA.bin”. Rename “ble_gateway_enabler.bin” as “f80_cc26xx.bin” and copy these files to the newly created folder in the Dropbox account.
10. Power on the gateway, then connect to an AP (that has internet access) after initialization.
11. “Waiting for OTA Trigger” on the CONSOLE indicates that the OTA can be performed.
12. Press the BTN-1 to start the OTA process.
13. Once the OTA download is completed, the gateway restarts itself.

7 Test Data

This section describes the tests performed on the gateway.

7.1 CLI Snapshot



```
*********************************************************
       BleFi - BLE-WiFi gateway (Texas Instruments)
       Version : 1
*********************************************************



[NPI] Waiting for SBL to be complete ...
[WiFi] Connecting to network
[WiFi] Auto Connecting....
[GW] SimpleLink Ready, starting Gateway
[WLAN EVENT] Device Connected to the AP: blefitata , BSSID: 1c:8e:5c:98:f2:2c

[NETAPP EVENT] IP Acquired: IP=192.168.1.102 , Gateway=192.168.1.1

[OTA] WLAN Connected
[OTA] Waiting for OTA trigger
[WiFi] Autoconnect Success
[GW] Device bonding information file <blefi.cfg> Present
Autoscan 60 seconds
[MQTT] GW Mode   : demo
[MQTT] Gw Server : 192.84.45.44
[MQTT] Dev Mode   : quickstart
[MQTT] Dev Server : quickstart.messaging.internetofthings.ibmcloud.com
[MQTT] Client ID f4b85e4576ad
[MQTT] Server : 192.84.45.44
[MQTT] Client-Id : f4b85e4576ad
[MQTT] Connecting to broker...
[SBL] No cc26xx.bin file to update
[SBL] Firmware Up to date
[GW] Waiting for NPI initialization ...
G:>
[GW] NPI initialized.
[GW] Starting the BLE Stack
[GW] BLE Stack Initialized

[MQTT] Broker connect Successful
[MQTT] Subscribing to topics...
[MQTT] Subscription to these topics successful
/blefi/find
/blefi/f4b85e4576ad/scan
/blefi/f4b85e4576ad/linke
/blefi/f4b85e4576ad/linkt
```

Figure 24. CLI Snapshot

7.2 Module Test Matrix

Table 6. Module Test Matrix

SL NUMBER	TESTS	RESULT	COMMENTS
1	Endurance Test	PASS	48 hours, 3 Sensor tags connected. MQTT Enabled
2	MQTT	PASS	Gateway Context—Demo mode Device Context—Quickstart mode
3	CLI	PASS	All commands
4	HTML	PASS	*Bluetooth* Smart configuration pages.
5	Gateway	PASS	Data bridging between WLAN and *Bluetooth* Smart
6	*Bluetooth* Smart Central	PASS	GAP and GATT commands
7	Wi-Fi Configuration	PASS	Connecting and disconnecting from AP
8	*Bluetooth* Smart Connections	PASS	Up to three 2650 sensor tags.
9	OTA Update	PASS	Update Gateway Binary and CC26xx Binary
10	OS Functionality	PASS	TI-RTOS

8 Design Files

8.1 Schematics

To download the schematics, see the design files at TIDC-BLE-TO-WIFI-IOT-GATEWAY.

8.2 Bill of Materials

To download the bill of materials (BOM), see the design files at TIDC-BLE-TO-WIFI-IOT-GATEWAY.

8.3 Layer Plots

To download the layer plots, see the design files at TIDC-BLE-TO-WIFI-IOT-GATEWAY.

8.4 Altium Project

To download the Altium project files, see the design files at TIDC-BLE-TO-WIFI-IOT-GATEWAY.

8.5 Layout Guidelines

To download the layout guidelines, see the design files at TIDC-BLE-TO-WIFI-IOT-GATEWAY.

8.6 Gerber Files

To download the Gerber files, see the design files at TIDC-BLE-TO-WIFI-IOT-GATEWAY.

8.7 Assembly Drawings

To download the assembly drawings, see the design files at TIDC-BLE-TO-WIFI-IOT-GATEWAY.

8.8 Software Files

To download the software files, see the design files at TIDC-BLE-TO-WIFI-IOT-GATEWAY.

9 References

1. *CC3200 SimpleLink™ Wi-Fi® and Internet-of-Things solution, a Single-Chip Wireless MCU* (CC3200)
2. *SimpleLink™ multi-standard 2.4 GHz ultra-low power wireless MCU* (CC2650)
3. *Ultralow-Noise, High PSRR, Fast, RF, 1-A Low-Dropout Linear Regulators* (TPS79601)
4. *2-Channel ESD Solution for SuperSpeed USB 3.0 Interface* (TPD2EUSB30)
5. Silabs: *USB to UART Bridge* (http://www.silabs.com/products/interface/usbtouart/Pages/usb-to-uart-bridge.aspx)

10 About the Author

SREEHARSHA SRINIVAS Applications Manager, LPRF, Texas Instruments.

VIJAYSARATHY SHASTRI Applications Lead, LPRF, Texas Instruments.

Revision History

Changes from Original (July 2015) to A Revision	Page
• Changed BLE to Bluetooth Smart throughout document	2
• Changed Blefi to Gateway throughout the document	3

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

IMPORTANT NOTICE FOR TI REFERENCE DESIGNS

Texas Instruments Incorporated ("TI") reference designs are solely intended to assist designers (“Buyers”) who are developing systems that incorporate TI semiconductor products (also referred to herein as “components”). Buyer understands and agrees that Buyer remains responsible for using its independent analysis, evaluation and judgment in designing Buyer’s systems and products.

TI reference designs have been created using standard laboratory conditions and engineering practices. **TI has not conducted any testing other than that specifically described in the published documentation for a particular reference design.** TI may make corrections, enhancements, improvements and other changes to its reference designs.

Buyers are authorized to use TI reference designs with the TI component(s) identified in each particular reference design and to modify the reference design in the development of their end products. HOWEVER, NO OTHER LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE TO ANY OTHER TI INTELLECTUAL PROPERTY RIGHT, AND NO LICENSE TO ANY THIRD PARTY TECHNOLOGY OR INTELLECTUAL PROPERTY RIGHT, IS GRANTED HEREIN, including but not limited to any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services, or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

TI REFERENCE DESIGNS ARE PROVIDED "AS IS". TI MAKES NO WARRANTIES OR REPRESENTATIONS WITH REGARD TO THE REFERENCE DESIGNS OR USE OF THE REFERENCE DESIGNS, EXPRESS, IMPLIED OR STATUTORY, INCLUDING ACCURACY OR COMPLETENESS. TI DISCLAIMS ANY WARRANTY OF TITLE AND ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, QUIET ENJOYMENT, QUIET POSSESSION, AND NON-INFRINGEMENT OF ANY THIRD PARTY INTELLECTUAL PROPERTY RIGHTS WITH REGARD TO TI REFERENCE DESIGNS OR USE THEREOF. TI SHALL NOT BE LIABLE FOR AND SHALL NOT DEFEND OR INDEMNIFY BUYERS AGAINST ANY THIRD PARTY INFRINGEMENT CLAIM THAT RELATES TO OR IS BASED ON A COMBINATION OF COMPONENTS PROVIDED IN A TI REFERENCE DESIGN. IN NO EVENT SHALL TI BE LIABLE FOR ANY ACTUAL, SPECIAL, INCIDENTAL, CONSEQUENTIAL OR INDIRECT DAMAGES, HOWEVER CAUSED, ON ANY THEORY OF LIABILITY AND WHETHER OR NOT TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES, ARISING IN ANY WAY OUT OF TI REFERENCE DESIGNS OR BUYER’S USE OF TI REFERENCE DESIGNS.

TI reserves the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products are sold subject to TI’s terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI’s terms and conditions of sale of semiconductor products. Testing and other quality control techniques for TI components are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers’ products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers’ products and applications, Buyers should provide adequate design and operating safeguards.

Reproduction of significant portions of TI information in TI data books, data sheets or reference designs is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards that anticipate dangerous failures, monitor failures and their consequences, lessen the likelihood of dangerous failures and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in Buyer’s safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI’s goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed an agreement specifically governing such use.

Only those TI components that TI has specifically designated as military grade or “enhanced plastic” are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components that have ***not*** been so designated is solely at Buyer's risk, and Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265