



OOBE Demo Guide

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1. Introduction

The ble_zigbee_light_prov Application is an excellent demonstration of one of the many real-world Multiprotocol (BLE and Zigbee) applications involving provisioning of Zigbee node over a BLE link and monitoring and control of lights using both the BLE and Zigbee link simultaneously. Users can choose to experience only the BLE or Zigbee or Multiprotocol (BLE + Zigbee) features of the demo. This demo application is pre-programmed into the WBZ451 module of the curiosity board.

This Application brings several BLE, Zigbee and Multiprotocol (BLE + Zigbee) concepts to practice.

1. [BLE](#)
 - a. Advertisement and BLE Connection
 - b. Transparent Profile and Service (Microchip proprietary)
2. [Zigbee](#)
 - a. Network Steering and Binding
 - b. Lights On/off, Level and Scene control clusters implementations
3. [Multiprotocol](#)
 - a. Simultaneous Operation of BLE and Zigbee protocols
 - b. Arbitration between Application, BT link stack, ZB link stack via FreeRTOS and HW control

2. BLE Demo Experience

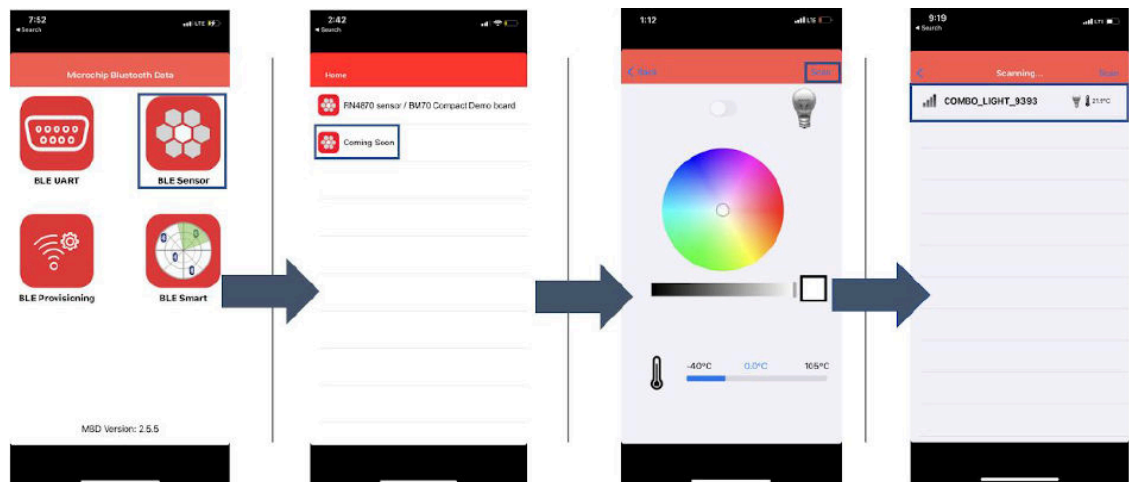
The demo consists of the WBZ451 Curiosity board with accompanying ble_zigbee_light_prov Firmware, the Microchip Bluetooth Data (MBD) Smartphone App. The MBD app has the capability to scan for BLE Advertisements from WBZ451 module and to establish a connection.

Scan operation monitors temperature sensor and status of RGB LED (on or off). Establishing a BLE connection with WBZ451 module enables users to control the RGB status (on or off) as well as intensity and color of the RGB LED using slide controls.

BLE Sensor App Demo

1. Install the Microchip Bluetooth Data (MBD) Smartphone App
 - a. iOS/Android users can search for “Microchip Bluetooth Data” App in App Store and install
 - b. Enable Bluetooth on the Smartphone
2. Launch the MBD Smartphone App
3. Supply power to WBZ451 Curiosity Board
 - a. Connect a USB cable to the kit or a 4.2V Li-ion/Li-Po Battery. For more information refer to the Power Supply section of the PIC32CX-BZ25 and WBZ451 Curiosity Board User's Guide.
 - b. The user-programmable blue LED starts blinking on the Curiosity Board when the board is in advertisement mode.
4. Monitor RGB LED state and Temperature
 - a. WBZ451 Curiosity Board starts in advertisement mode to advertise its presence on a smartphone and to allow access to RGB LED on/off state and temperature sensor data.
 - b. Navigate through the Smartphone App as shown in the following figure to access the advertisement information.

Figure 2-1.



5. Control RGB LED state on/off as well as intensity and color
 - a. Click the device that shows up after initiating a scan to establish a connection with WBZ451 module.
 - b. The user programmable blue LED becomes solid once connection is established between the smartphone and WBZ451 module



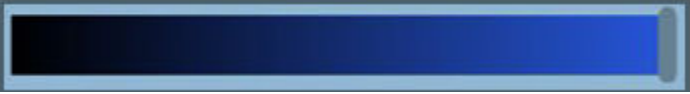

- c.  Controls the RGB LED state on/off.
- d.  Controls the color of RGB LED when the LED is "on".
- e.  Controls the intensity of RGB LED when the LED is "on".
- f.  Additional information

Figure 2-2.



6. Disconnecting the WBZ451 module from the Microchip Bluetooth Data App
 - a. Press the reset button on WBZ451 Curiosity Board
 - b. Initiating a "Scan" on Smartphone App

Upon successful disconnection, the WBZ451 module starts in Advertisement Mode.

3. ZigBee Demo Experience

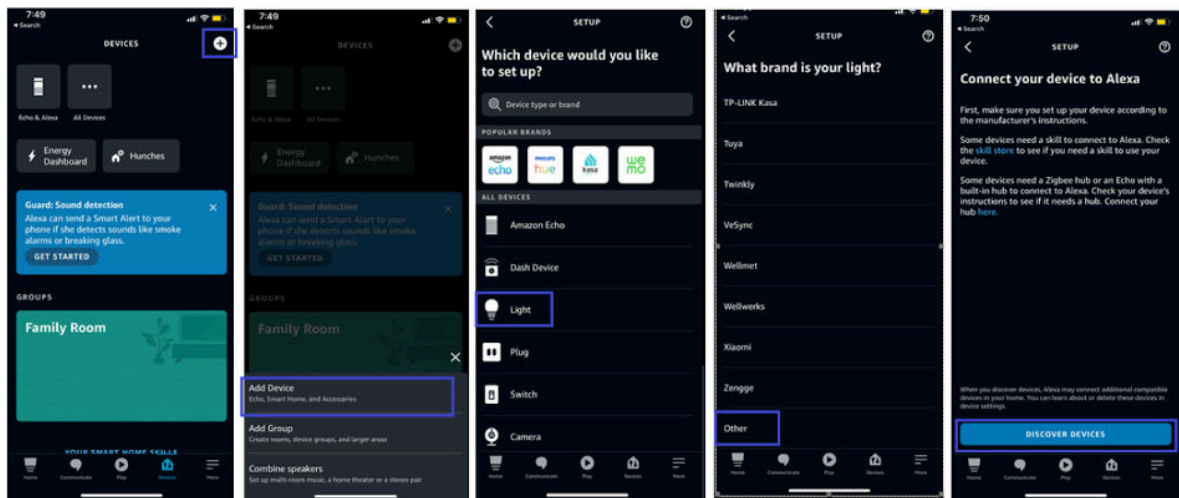
The demo consists of the WBZ451 Curiosity board with accompanying ble_zigbee_light_prov (Zigbee Router/Zigbee Lights) Firmware, the Amazon Echo or Combined Interface firmware. The Amazon Echo or Combined Interface firmware plays the role of Zigbee Coordinator. The Coordinator, upon reset, creates a Zigbee network (Network Forming) and enables permit join for 3 minutes (Network Steering). The Router upon reset sends beacon requests looking for any existing network. If a network is found (beacon received from Zigbee Coordinator), the router will join (Network Steering) the existing network. To experience the Out of Box demo, users need to reset (factory new) the Zigbee Coordinator first followed by a reset (factory new) on the Zigbee Router. After a successful connection between the Zigbee Coordinator and the router, the router starts sending attributes to the coordinator. The Coordinator can control the router's Light On/Off, level, and color.

Demo of Zigbee Lights with Amazon Echo as Coordinator

1. Supply power to the WBZ451 Curiosity Board by connecting a USB cable to the kit (PC to WBZ451 Curiosity Board).
2. Discovering Zigbee Lights (Using Voice Commands or the Alexa App)
 - a. Voice Commands
 - i. Ask Alexa to discover your device. Say "Discover my devices."
 - b. Alexa App
 - i. From the menu, select "Add Device."
 - ii. Select the type of smart home device "Light" and select other.
 - iii. Initiate Discover Devices

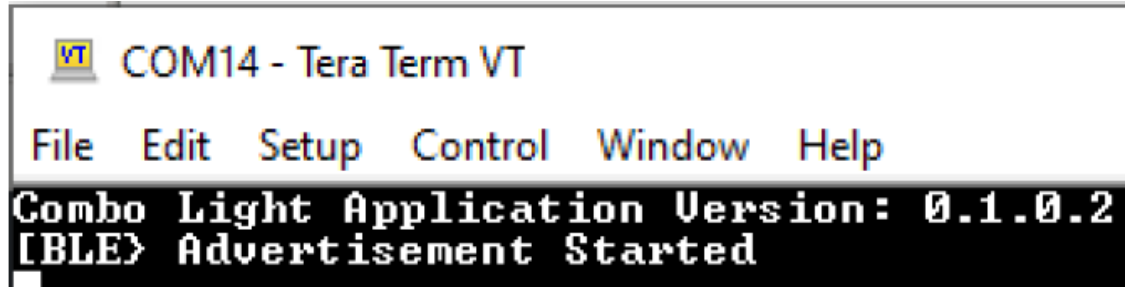
Note: Echo/Alexa is in discovery mode for 45 secs. Devices (Lights/other) wanting to join Echo should initiate joining/connecting procedure within this time limit for a successful join

Figure 3-1.



3. Connecting Zigbee Lights (Router) to Echo (Coordinator)
 - a. Issue Reset to factory new by pressing and holding the SW2 button for 10 second.
 - b. Users can view the data logs for a better understanding of the demo experience. To view the logs -> Open a terminal emulator like TeraTerm with the following settings (Speed: 115200, Data: 8-bit, Parity: none, Stop bits: 1 bit, Flow control: none, LF+CR for tx and rx, echo enabled (Use of TeraTerm is not mandatory to experience the demo). The following message will be printed

Figure 3-2.



- c. To initiate a connection, the user needs to press and hold the SW2 button for 5 secs
 - i. Router finds the network and joins.

Figure 3-3.

```

Zigbee Device Initialized: Type Help for Commands
Commissioning Procedure Started - 180 Seconds
Commissioning Sequence: Formation->Steering->Find & Bind->
Network Established
Steering: Success
Network Search: Complete: Joined to a Network
Joined to: Address 0x0000 MACID 0x0000000000000000 ExtendedPANID 0x000000000000
0bee
Attribute operation response received: status = 0x00
Attribute operation response received: status = 0x00

```

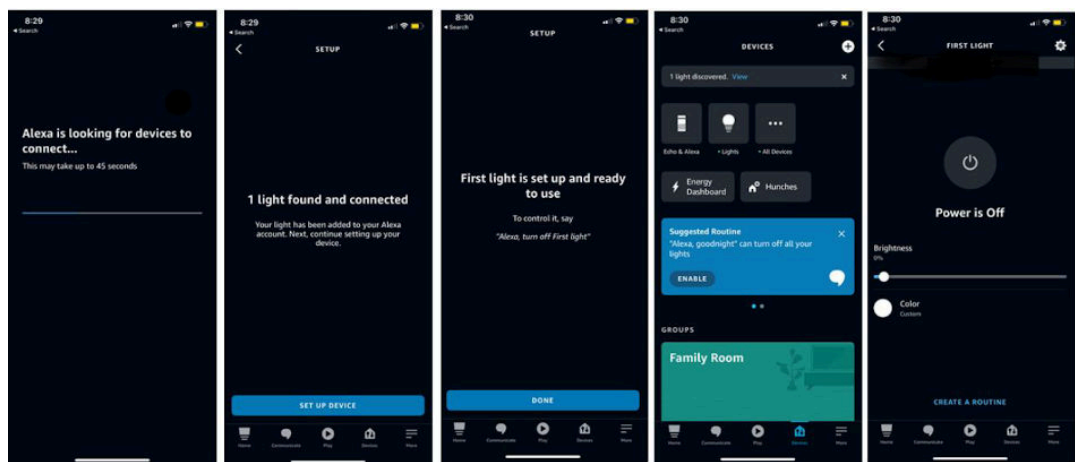
Note 1: Reset to factory new (using SW2 button press) will erase the Zigbee connection state stored prior to reset and bring up the device as a factory new device.

Note 2: Reset (SW1 button press) will not clear the Zigbee connection state prior to reset.

Note 3: After a successful/unsuccessful join process, users can also initiate the reset to factory new by entering the command 'resetToFN' over UART

Note 4: When using more than 1 WBZ451 Zigbee Light, users need to reprogram the new kit with different a mac ID.

Figure 3-4.



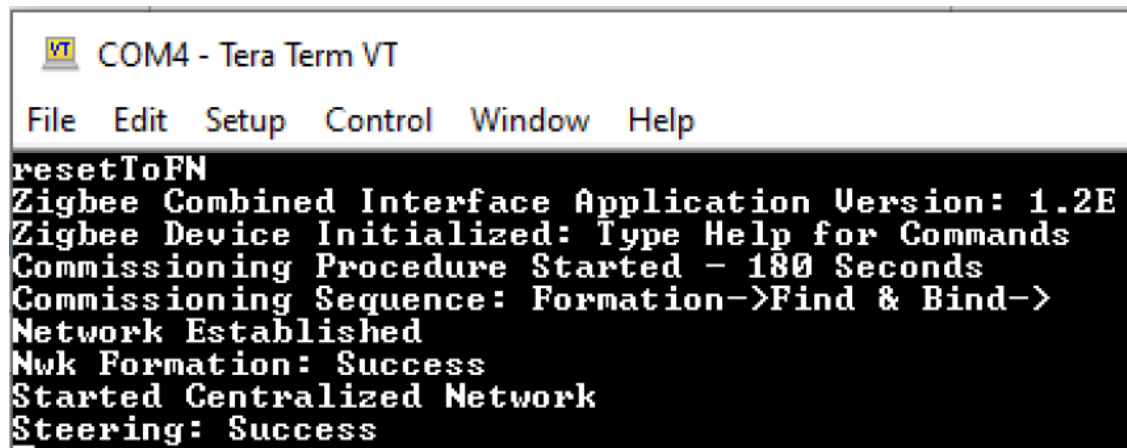
- 4. Control the on/off state of RGB LEDs.
 - a. Voice commands
 - i. Ask Alexa, "Alexa, turn on first light" to change status of RGB LED from off to on
 - ii. Ask Alexa, "Alexa, Dim first light" to reduce the brightness.
 - iii. Ask Alexa, "Alexa, Turn my first light green" to change the color.
 - b. Alexa App

- i. select First Light in “Lights” and control

Setup – Zigbee Coordinator (Combined Interface)-Network Creation and Steering

1. Supply Power: Connect a USB cable to the WBZ451 Curiosity Board (zigbee_combined_interface)
2. Open a terminal emulator like TeraTerm with the following settings for both the WBZ451 Curiosity boards. USB Serial Device COMxx (Speed: 115200, Data: 8-bit, Parity: none, Stop bits: 1 bit, Flow control: none, LF+CR for tx and rx, echo enabled)
3. Reset the board to factory new (use either step 3.a or 3.b)
 - a. using button (SW2), press and hold SW2 button for 10 secs.
 - b. send “resetToFN” to Coordinator over UART

Figure 3-5.



The screenshot shows a terminal window titled "COM4 - Tera Term VT". The menu bar includes File, Edit, Setup, Control, Window, and Help. The terminal output displays the following text:

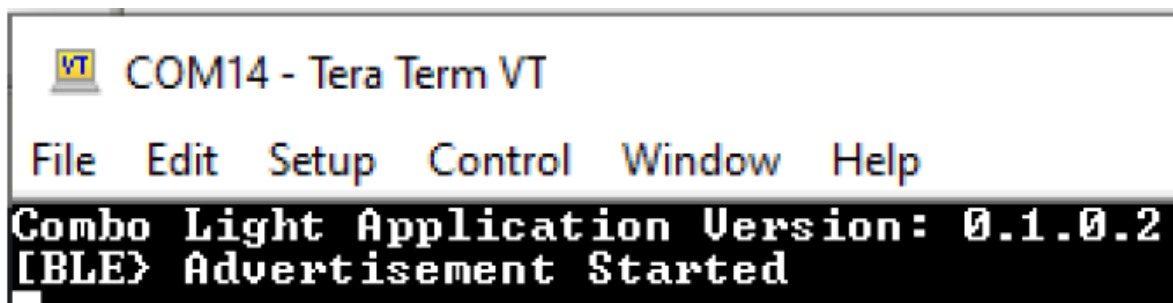
```
resetToFN
Zigbee Combined Interface Application Version: 1.2E
Zigbee Device Initialized: Type Help for Commands
Commissioning Procedure Started - 180 Seconds
Commissioning Sequence: Formation->Find & Bind->
Network Established
Nwk Formation: Success
Started Centralized Network
Steering: Success
```

Note: Combined Interface will have permit join enabled for 180 secs after a successful creation of centralized network. Devices (Lights/other) wishing to join the combined interface must initiate the joining/connecting procedure within this time limit in order for the join to be successful.

Zigbee Router (Lights) Setup – Connecting Zigbee Lights to the Network

1. Supply Power: Connect a USB cable to the WBZ451 Curiosity Board (PC to Board).
2. Issue Reset to factory new by pressing and holding the SW2 button for 10 seconds.
3. Users can view the data logs for a better understanding of the demo experience. To view the logs -> Open a terminal emulator like TeraTerm with the following settings (Speed: 115200, Data: 8-bit, Parity: none, stop bits: 1 bit, Flow control: none, LF+CR for tx and rx, echo enabled). The following message will be printed

Figure 3-6.



The screenshot shows a terminal window titled "COM14 - Tera Term VT". The menu bar includes File, Edit, Setup, Control, Window, and Help. The terminal output displays the following text:

```
Combo Light Application Version: 0.1.0.2
[BLE] Advertisement Started
```

4. To initiate a connection, user needs to press and hold the SW2 button for 5 secs
 - a. Router finds the network and joins
 - b. Zigbee Lights (Router) will search for an existing network to join and after joining an existing network, the finding and binding of clusters will be initiated and completed

Note: Zigbee Lights(Router) will be in identifying mode and will toggle RGB LED for 3 mins after Finding and Binding is successful

Figure 3-7.

```
Zigbee Device Initialized: Type Help for Commands
Commissioning Procedure Started - 180 Seconds
Commissioning Sequence: Formation->Steering->Find & Bind->
Network Established
Steering: Success
Network Search: Complete: Joined to a Network
Joined to: Address 0x0000 MACID 0x0000000000000000bee ExtendedPANID 0x000000000000
0bee
Attribute operation response received: status = 0x00
Attribute operation response received: status = 0x00
```

Note 1: Resetting to factory new (by pressing the SW2 button) will erase the Zigbee connection state stored prior to the reset and restore the device as a factory new device.

Note 2: Reset (SW1 button press) will not clear the Zigbee connection state prior to reset.

Note 3: After a successful or unsuccessful join process, users can also initiate the reset to factory new by entering the command 'resetToFN' over UART.

Note 4: When using more than 1 WBZ451 Zigbee Lights, users need to reprogram the new kit with different mac ID.

Figure 3-8.

Zigbee Coordinator	Zigbee Router
<pre>resetToFN Zigbee Combined Interface Application Version: 1.2E Zigbee Device Initialized: Type Help for Commands Commissioning Procedure Started - 180 Seconds Commissioning Sequence: Formation->Find & Bind-> Network Established Nwk Formation: Success Started Centralized Network Steering: Success Device joined: Address 0x8185 MACID 0x000000000000aabb ExtendedPANID 0x00000000 00000000</pre>	<pre>Combo Light Application Version: 0.1.0.2 BLE Advertisement Started Zigbee Device Initialized: Type Help for Commands Commissioning Procedure Started - 180 Seconds Commissioning Sequence: Formation->Steering->Find & Bind-> Network Established Steering: Success Network Search: Complete: Joined to a Network Joined to: Address 0x0000 MACID 0x0000000000000000bee ExtendedPANID 0x000000000000 0bee Attribute operation response received: status = 0x00</pre>

Monitoring and Control Zigbee Lights (Router)

1. Obtain the Router's Network Address
 - a. To get the Network Address of Router, user should send the getNetworkAddress command (the Router should have completed the joining process). A Command should be entered in terminal window of the Zigbee Router.

Figure 3-9.

```
getNetworkAddress
8185
```

The network address is also displayed on the Zigbee Coordinator device logs.

Figure 3-10.

Zigbee Coordinator

```
resetToFN
Zigbee Combined Interface Application Version: 1.2E
Zigbee Device Initialized: Type Help for Commands
Commissioning Procedure Started - 180 Seconds
Commissioning Sequence: Formation->Find & Bind->
Network Established
Nwk Formation: Success
Started Centralized Network
Steering: Success
Device joined: Address 0x8185 MACID 0x000000000000aabb ExtendedPANID 0x000000000000
00000000
```

2. Monitor the OnOff status, level, and Color control of Zigbee lights on the Coordinator.
 - a. After a successful finding and binding, the coordinator device receives attributes automatically from the router periodically.

Figure 3-11.

```

resetToFN
Zigbee Combined Interface Application Version: 1.2E
Zigbee Device Initialized: Type Help for Commands
Commissioning Procedure Started - 180 Seconds
Commissioning Sequence: Formation->Find & Bind->
Network Established
Nwk Formation: Success
Started Centralized Network
Steering: Success
Device joined: Address 0x8185 MACID 0x000000000000aabb ExtendedPANID 0x00000000
00000bee
<-Level Control Attr Report: Value = 0x7f
<-Color Control Attr <0x0> Report: Value = 0x0
<-Color Control Attr <0x1> Report: Value = 0x7f
<-Color Control Attr <0x3> Report: Value = 0x6165
<-Level Control Attr Report: Value = 0x7f
<-Color Control Attr <0x4> Report: Value = 0x606c
<-Color Control Attr <0x7> Report: Value = 0xfa
<-Color Control Attr <0x0> Report: Value = 0x0
<-On/Off Attr Report: Value = 0x0
<-Level Control Attr Report: Value = 0x7f
<-Color Control Attr <0x1> Report: Value = 0x7f
<-Color Control Attr <0x3> Report: Value = 0x6165
<-Level Control Attr Report: Value = 0x7f

```

3. On/off control of Zigbee lights (RGB LED state)
 - a. On—Send the following command from Coordinator device over UART: **onOff -s 0x8185 0x23 -on**
 - b. Off—Send the following command from Coordinator device over UART: **onOff -s 0x8185 0x23 -off**

Note: "0x8185" is the address of the router (Light), the coordinator is trying to control.

Note: "0x23" is the zigbee endpoint of the zigbee light in control.

Coordinator (Combined Interface-left) and the router (Zigbee Lights-right)

Figure 3-12.

Zigbee Coordinator	Zigbee Router
<pre> <-On/Off Attr Report: Value = 0x0 <-Level Control Attr Report: Value = 0x7f onOff -s 0x8185 0x23 -on onOff -s 0x8185 0x23 -off <-Level Control Attr Report: Value = 0x7f </pre>	<pre> onOff Finding & Binding: Success Commissioning Procedure Complete On Off </pre>

4. Multiprotocol (BLE + ZigBee) Demo Experience

The demo consists of the WBZ451 Curiosity board with the accompanying ble_zigbee_light_prov firmware, and the Microchip Bluetooth Data (MBD) Smartphone App. Users can provision the zigbee device over BLE, control and monitor the lights and temperature using either the BLE link or Zigbee link using the MBD app and Alexa App respectively. MBD app has the capability to scan for BLE advertisements from the WBZ451 module and to establish a connection. There are multiple sub apps in the Microchip Bluetooth Data App, for showcasing the provisioning and control/monitor capabilities over BLE.

The BLE Scan operation helps monitor the following parameters before connection.

1. Zigbee Device Name
2. Temperature Sensor
3. RGB LED Status (on or off)

The BLE Connection operation helps monitor the following parameters

1. Zigbee Device Status
 - a. Device Type, Current Channel, Current MAC ID, Device State, SW Version, Device Name
2. Temperature Sensor
3. RGB LED Status (on or off)
4. BLE Device Information Service
 - a. Manufacturer Name, Model Number, Serial Number, Hardware Revision, Firmware Revision, Software Revision, System ID, Regular Certification Data List

BLE Connection operation helps control the following parameters

1. Zigbee Device Connection Params
 - a. Current Channel, Device Name
2. RGB LED Status (on or off), Controls the color and intensity of RGB LED when LED is “on”

When using an Amazon Echo as a Zigbee Coordinator, Alexa App helps control the following parameters

1. When the RGB LED is "on," it controls the color and intensity of the LED.

When using another WBZ451 Curiosity Board as a Zigbee Coordinator, UART commands can be used to control the following parameters

1. RGB LED Status (on or off), Controls the color and intensity of RGB LED when LED is “on”

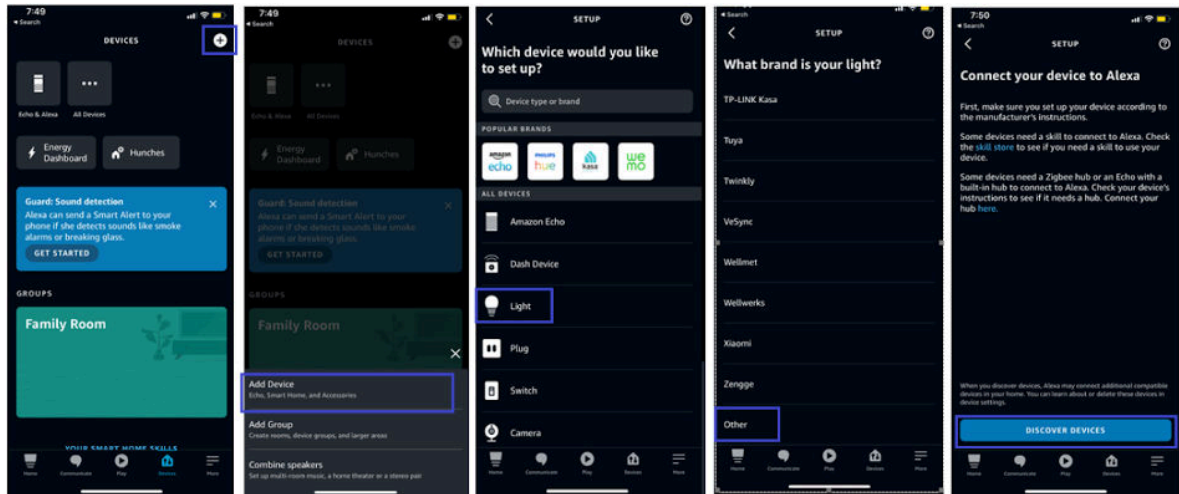
The multiprotocol demo experience starts with provisioning the Zigbee Device, then a successful zigbee connection, followed by the control/monitor of Lights over both the Zigbee and BLE links.

Multiprotocol Light Demo with Amazon Echo as Coordinator

1. Supply power to the WBZ451 Curiosity Board by connecting a USB cable to the kit (PC to WBZ451 Curiosity Board).
2. The Discovery of Zigbee Lights
 - a. Voice Commands
 - i. Ask Alexa to discover your device. Say “Discover my devices.”
 - b. Alexa App
 - i. From the menu, select "Add Device."
 - ii. Select the type of smart home device “Light” and select other.
 - iii. Initiate Discover Devices

Note: Echo/Alexa is in discovery mode for 45 secs. Devices (Lights/other) wanting to join Echo should initiate the joining/connecting procedure within this time limit for a successful join.

Figure 4-1.



Provisioning - Connecting Zigbee Lights (Router) to Coordinator (Combined Interface/Amazon Echo)

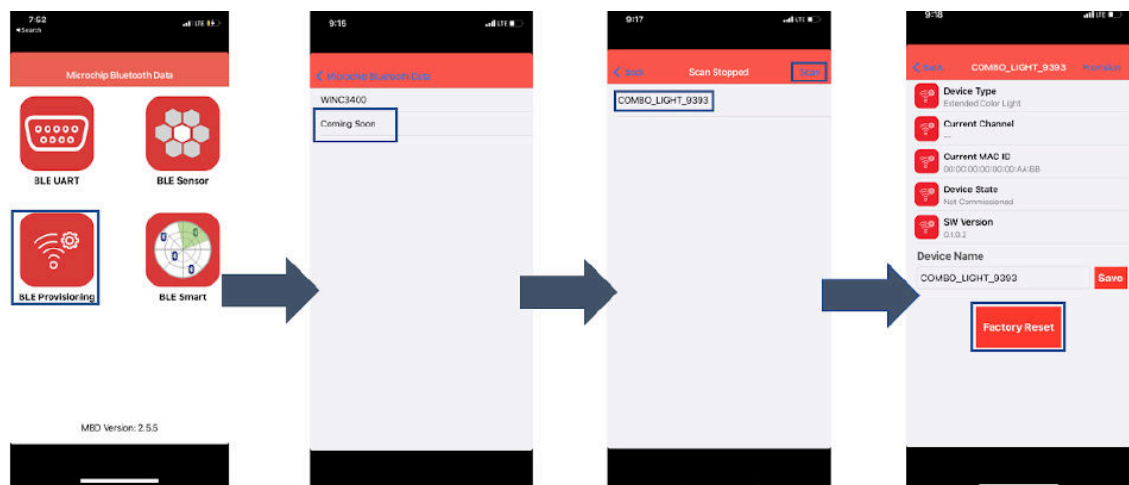
1. Issue Reset to factory new (Use either 1.a or 1.b)

- a. using button (SW2), press and hold SW2 button for 10 secs.

Users can view the data logs for a better understanding of the demo experience. To view the logs -> Open a terminal emulator like TeraTerm with following settings (Speed: 115200, Data: 8-bit, Parity: none, stop bits: 1 bit, Flow control: none, LF+CR for tx and rx, echo enabled (Use of TeraTerm is not mandatory to experience the demo)

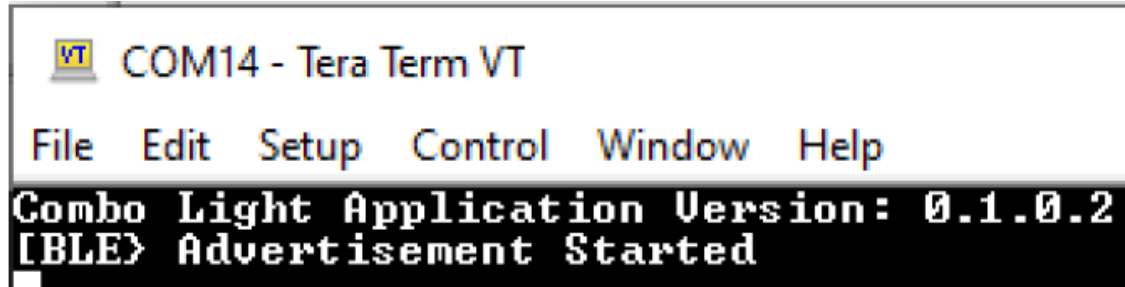
- b. Open Microchip Bluetooth Data (MBD) App, select BLE Provisioning -> Coming Soon-> COMBO_LIGHT_9393 -> Factory Reset

Figure 4-2.



The following message will be printed in the terminal window post a successful reset to factory new

Figure 4-3.



2. To scan for nearby WBZ451 devices running the Multiprotocol demo, open Microchip Bluetooth Data (MBD) App, select "BLE Provisioning" and select the "Coming Soon" option
 - a. Scan operation will find – COMBO_LIGHT_XXXX device in results, select this device
 - b. After selecting, the device status will be displayed, Users can now either change the device name or move ahead to provisioning the device keeping the device name as default

Figure 4-4.



- c. Select the "Provision" option in the MBD App to configure channel map. Channel map needs to be chosen and select commission (In channel Map select all the channels before selecting commission unless user is aware of channel on which Echo is operating on). When the commission option is selected, the device begins to search for an existing zigbee network to join. When the device joins the existing network created by Amazon Echo, a 180-second finding and binding process begins.

Note: Echo device must be in discovery mode when selecting the commission option.

- d. Upon completion of 180 seconds, the Commissioning process is completed, Users can select "ok", Device State changes from "Not Commissioned" to "Commissioned"

Figure 4-5.

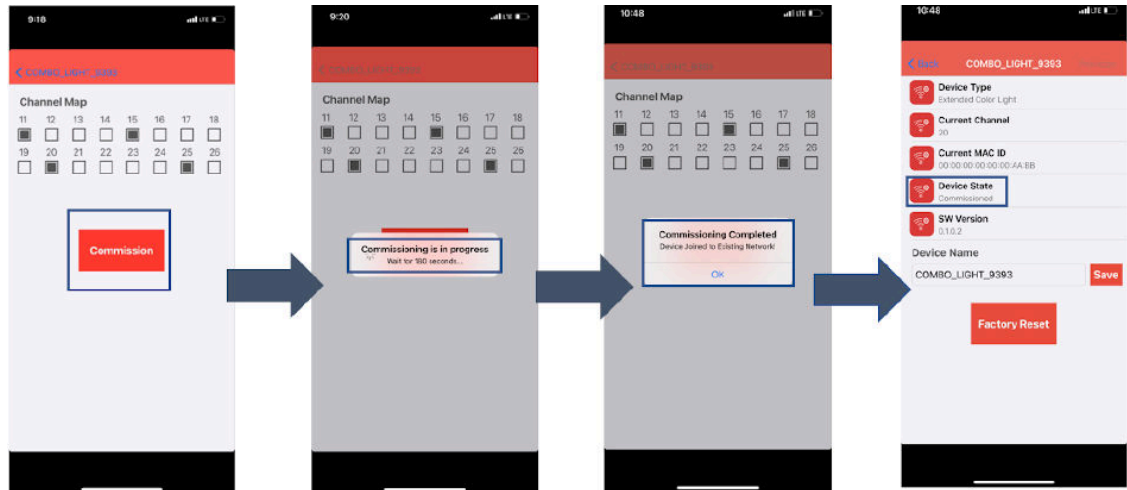


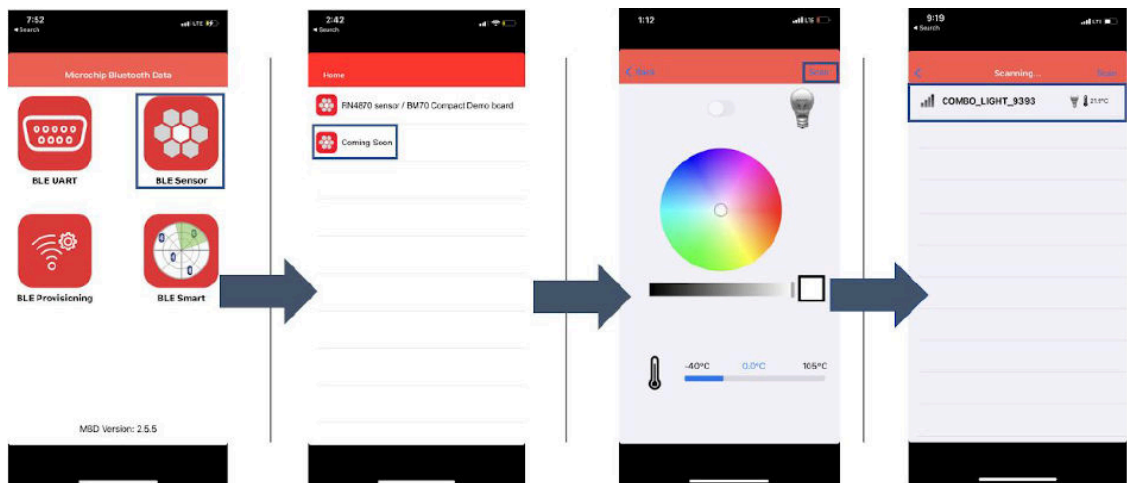
Figure 4-6.

```
Zigbee Device Initialized: Type Help for Commands
Commissioning Procedure Started - 180 Seconds
Commissioning Sequence: Formation->Steering->Find & Bind->
Network Established
Steering: Success
Network Search: Complete: Joined to a Network
Joined to: Address 0x0000 MACID 0x000000000000bee ExtendedPANID 0x000000000000
Attribute operation response received: status = 0x00
Attribute operation response received: status = 0x00
```

Multiprotocol Control/Monitor of Lights using BLE (MBD App)

1. Monitor RGB LED state and Temperature
 - a. The WBZ451 Curiosity board begins in advertisement mode, allowing access to RGB LED on/off state and temperature sensor data and advertising its presence to a smartphone.
 - b. Navigate through the Smartphone App as shown in the following Figure to access the advertisement information

Figure 4-7.



2. Control RGB LED on/off status, as well as intensity and color.
 - a. Click the device that shows up after initiating a scan to establish a connection with the WBZ451 module

- b. The user programmable blue LED becomes solid once connection is established between the smartphone and WBZ451 module



- c. Controls the RGB LED state on/off.



- d. Controls the color of RGB LED when LED is "on".



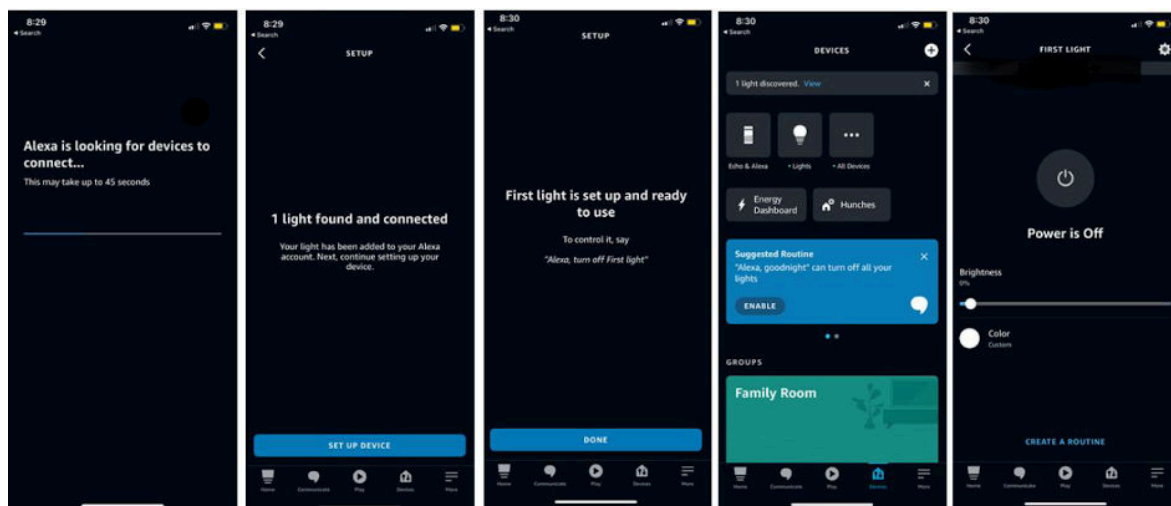
- e. Controls the intensity of RGB LED when LED is "on".

3. The light status (on/off), light color and intensity chosen via the BLE link will be relayed on to Alexa App

Multiprotocol Control/Monitor of Lights using Zigbee (Alexa App)

1. Lights Getting Found and Connected to Echo

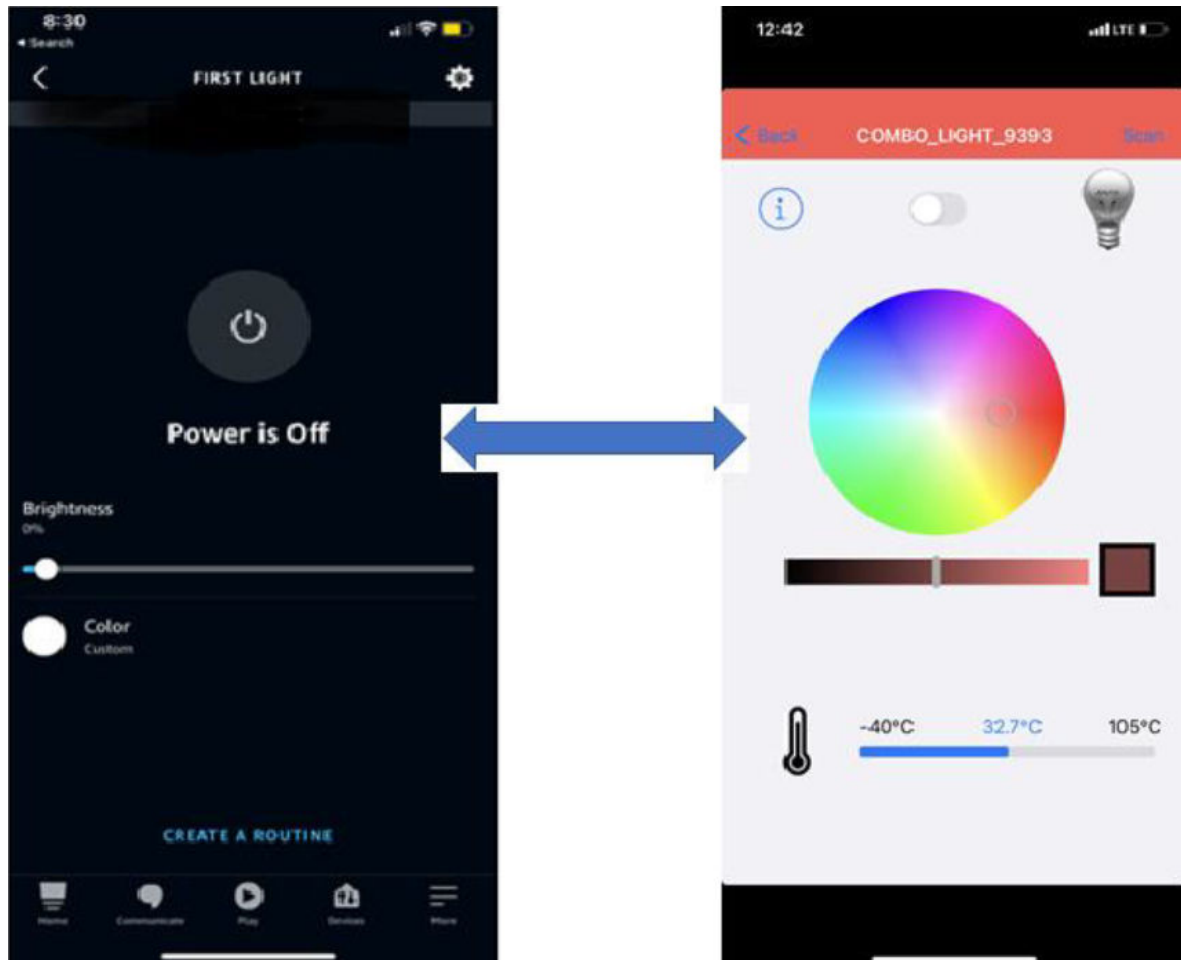
Figure 4-8.



2. Control the on/off status of RGB LEDs.
 - a. Voice commands
 - i. Ask Alexa, "Alexa, Turn on first light" to change status of RGB LED from off to on
 - ii. Ask Alexa, "Alexa, Dim first light" to reduce the brightness.
 - iii. Ask Alexa, "Alexa, Turn my first light green" to change the color.
 - b. Alexa App
 - i. select First Light in "Lights" and control

- The Light Status (on/off), light color, and intensity chosen via the voice commands/Alexa App (Zigbee link) will be relayed on to the MBD App (BLE Sensor App)

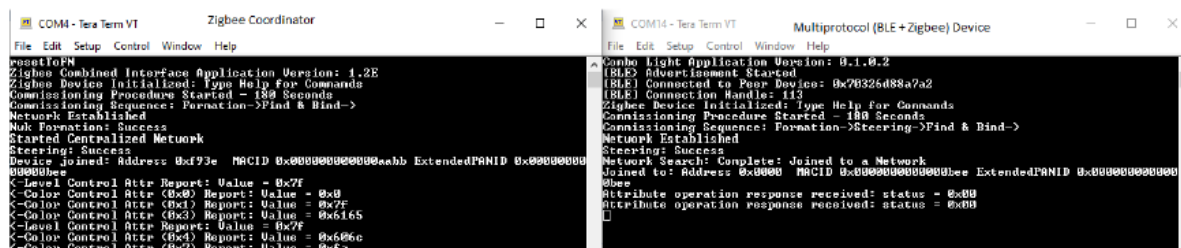
Figure 4-9.



Setup: Multiprotocol Lights Demo with another WBZ451 Curiosity Board as Coordinator

- Setup – Zigbee Coordinator (Combined Interface) - Network Creation and Steering
- BLE Provisioning - Lights to join the Zigbee network created by another WBZ451 Curiosity Board as Coordinator
- After completing steps 1 and 2, lights can be controlled by MBD App over BLE or Zigbee Commands

Figure 4-10.



- Turn on the light with the MBD App via the BLE link.

Figure 4-11.

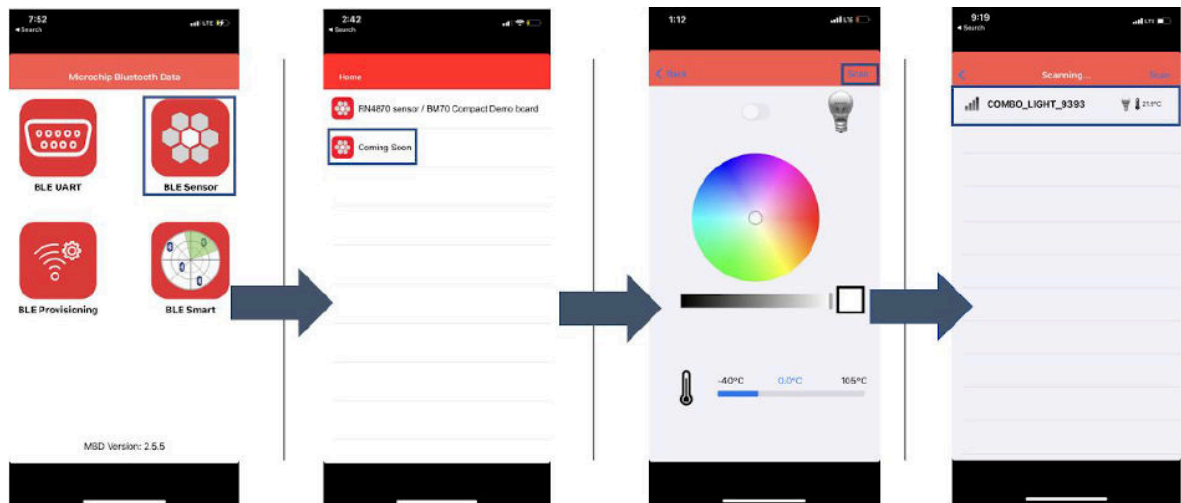


Figure 4-12.





- Turn on the RGB LEDs.
- The light status (on/off), light color, and intensity chosen via the MBD App (BLE link) will be relayed on to Multiprotocol lights (Zigbee link).

Figure 4-13.

```
Commissioning Procedure Complete
[BLE] Disconnected Handle: 113
[BLE] Advertisement Started
[BLE] Connected to Peer Device: 0x4998ee4fe949
[BLE] Connection Handle: 114
[BLE] LED ON
```

- Turn off the light with the MBD App via the Zigbee link.
 - Off-Send the following command from the Coordinator device over UART ("0xf9e" is the router address and "0x23" is the zigbee endpoint of the zigbee light in control): **onOff -s 0xf93e 0x23 -off**
 - The light status (on/off), light color, and intensity chosen via the Zigbee Coordinator UART commands (Zigbee link) will be relayed on to the MBD App (BLE Sensor App).

Figure 4-14.

