PIC32CX-BZ2 Out-of-box Experience

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 monitor 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.

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

BLE only 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

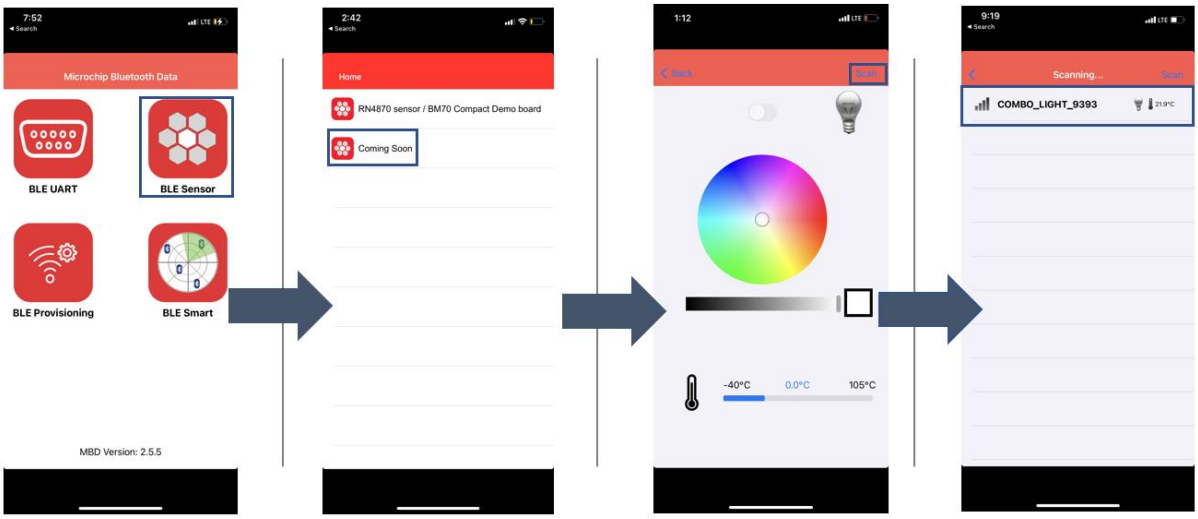
1. Install the MBD Smartphone App
   a. iOS users can search for “Microchip Bluetooth Data” App in App Store and install
   b. Android users can directly install the mbd_x_x.apk file available as part of Early Adopter Package (Smartphone App folder)
   c. Enable Bluetooth on the Smartphone
2. Launch 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 Power Supply section of the PIC32CX-BZ25 and WBZ451 Curiosity Board User's Guide

b. The user programmable blue LED starts blinking on 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 to 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



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

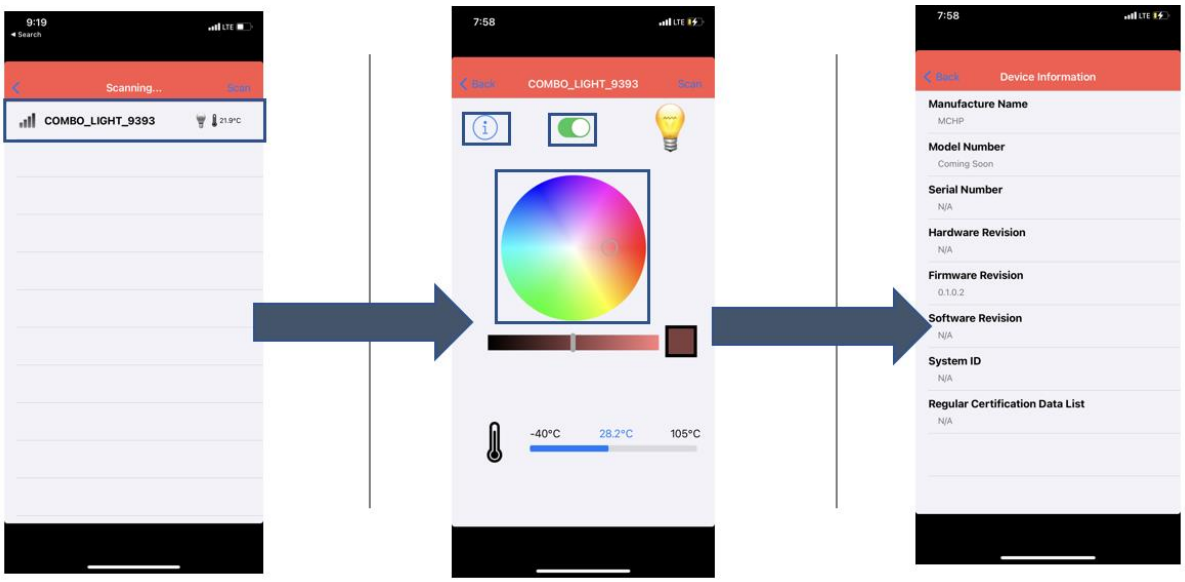
   b. User Programmable blue LED becomes solid once connection is established between the smartphone and WBZ451 module

   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”

   f.  Additional information



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

Zigbee only Demo Experience

Introduction

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 (Zigbee Coordinator) Firmware. 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), 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 Router, router starts sending attributes to the coordinator. Coordinator can control the Router - Light On/Off, level and color.

Zigbee Lights Demo with Amazon Echo as Coordinator

1. Supply power to WBZ451 Curiosity Board by connecting a USB cable to the kit (PC to WBZ451 Curiosity Board)
2. Discovery of Zigbee Lights
    a. Voice Commands

i. Ask Alexa to discover your device. Say “Discover my devices”.

or

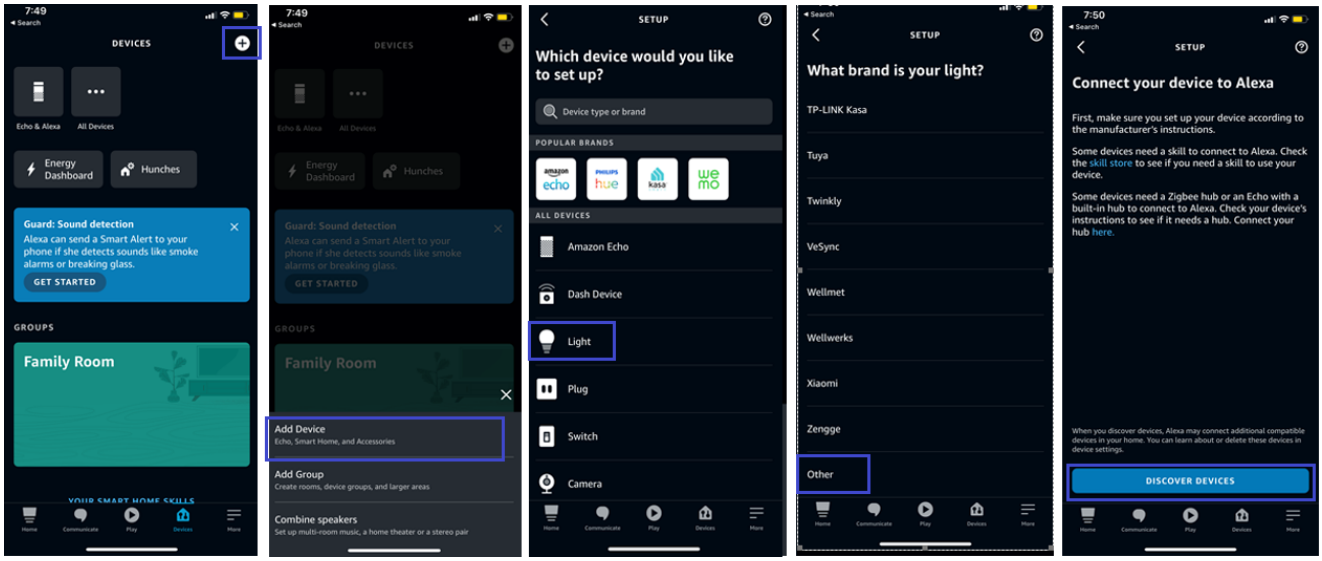
b. Alexa App

i. From the menu, select the 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

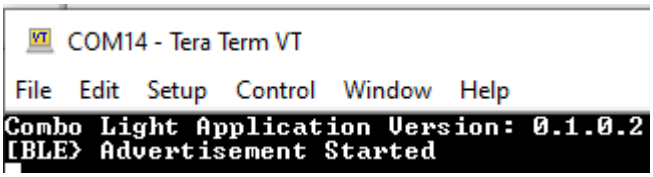


3. Connecting Zigbee Lights (Router) to Echo (Coordinator)

a. Issue Reset to factory new, using button (SW2), press and hold SW2 button for 10 secs.

Users can view the data logs for better understanding of the demo experience. To view the logs -> Open 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)

The following message will be printed



b. To initiate a connection, user needs to press and hold the SW2 button for 5 secs

   i. Router finds the network and joins

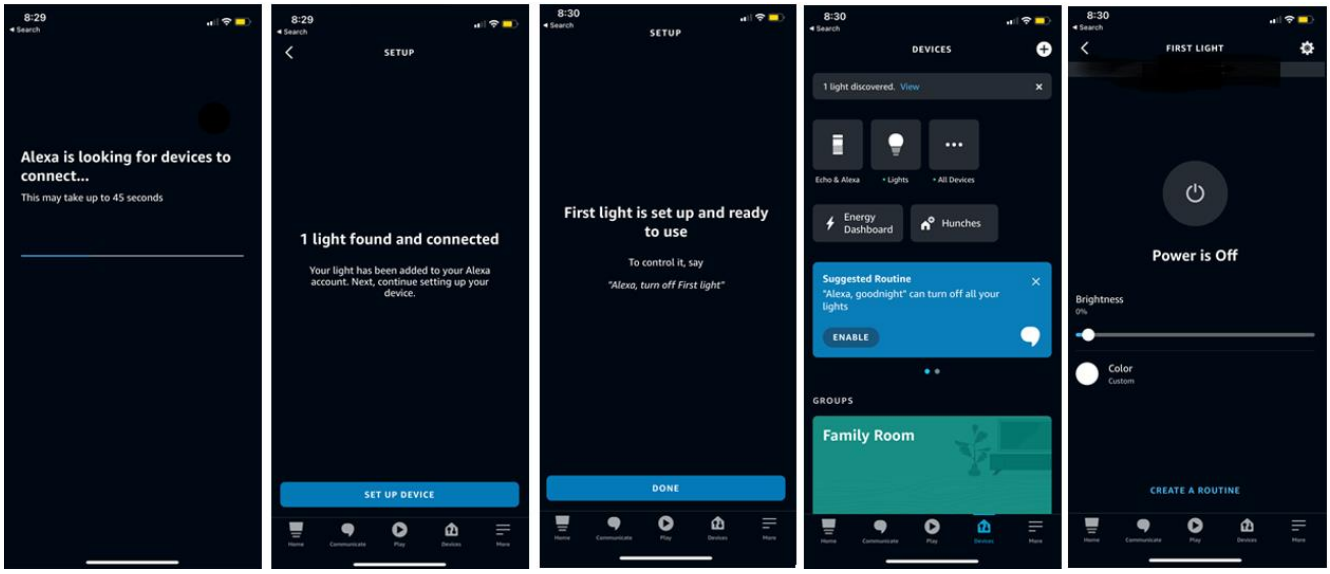
```
Zigbee Device Initialized: Type Help for Commands
Commissioning Procedure Started - 180 Seconds
Commissioning Sequence: Formation->Steering->Find & Bind->
Network Established
Steering: Success
Network Search: Complete: Joined to a Network
Joined to: Address 0x0000  MACID 0x0000000000000bee ExtendedPANID 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 Lights, users need to reprogram the new kit with different mac ID.



4. Control RGB LED state on/off

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.

or

b. Alexa App

   i. select First Light in “Lights” and control

Zigbee Lights Demo with another WBZ451 Curiosity Board as Coordinator

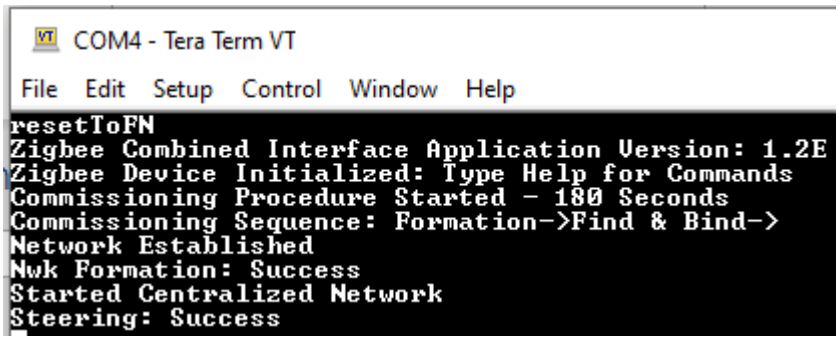
This section assumes users have a WBZ451 Curiosity board programmed with the zigbee_combined_interface application example

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 terminal emulator like Teraterm with 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
   - using button (SW2), press and hold SW2 button for 10 secs.

     or

   - send “resetToFN” to Coordinator over UART



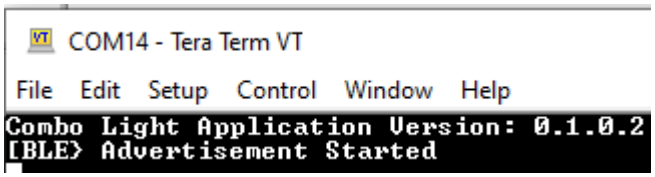
Note: Combined Interface will have permit join enabled for 180 secs after a successful creation of centralized network, Devices (Lights/other) wanting to join the combined interface should initiate joining/connecting procedure within this time limit for a successful join

Setup – Zigbee Router (Lights) – Connecting Zigbee Lights to network

1. Supply Power - Connect a USB cable to the WBZ451 Curiosity Board (PC to Board).
2. Issue Reset to factory new, using button (SW2), press and hold SW2 button for 10 secs.

   Users can view the data logs for better understanding of the demo experience. To view the logs -> Open 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

   The following message will be printed



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

```
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 0x0000000000000bee 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 Lights, users need to reprogram the new kit with different mac ID.

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 0x00000000
00000bee
```

Zigbee Router

```
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 0x000000000000bee ExtendedPANID 0x000000000000
0bee
Attribute operation response received: status = 0x00
```

1. Network Address of Router

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

    ```
    getNetworkAddress
    8185
    ```

    The network address is also displayed on Zigbee Coordinator device logs

    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 ExtendedP
    00000bee
    ```

2. Monitor the OnOff status, level and Color control of Zigbee lights on Coordinator.

    1. After a successful finding and binding, the coordinator device receives attributes automatically from the Router periodically.

```
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. Control Zigbee Lights (RGB LED state) on/off

    1. On – Send the following command from Coordinator device over UART

onOff -s 0x8185 0x23 -on

    2. 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

Coordinator (Combined interface - left) and Router (Zigbee Lights- right)

Multiprotocol (BLE + Zigbee) Demo Experience

The demo consists of the WBZ451 Curiosity board with 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 MBD app and Alexa App respectively. MBD app has the capability to scan for BLE Advertisements from 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.
BLE Scan operation helps monitors the following parameters before connection

- Zigbee Device Name
- Temperature Sensor
- RGB LED Status (on or off)

BLE Connection operation helps monitor the following parameters

- Zigbee Device Status
    - Device Type, Current Channel, Current MAC ID, Device State, SW Version, Device Name
- Temperature Sensor
- RGB LED Status (on or off)
- BLE Device Information Service
    - 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

- Zigbee Device Connection Params
    - Current Channel, Device Name
- 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 params

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

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

- 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

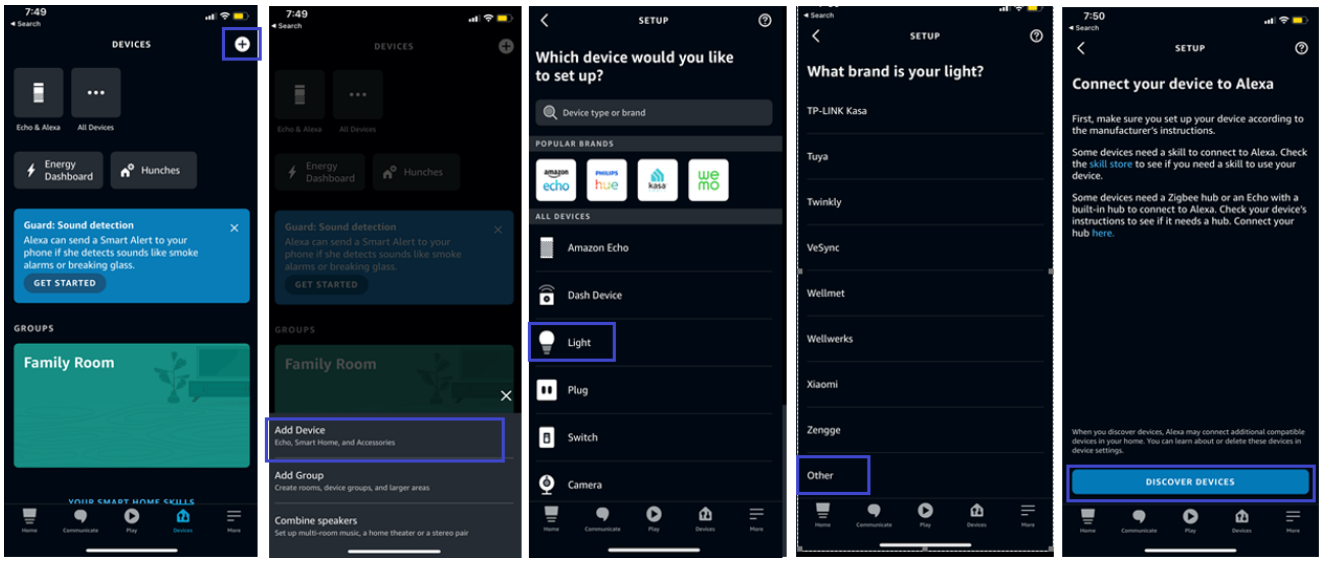
Multiprotocol Lights Demo with Amazon Echo as Coordinator

1. Supply power to WBZ451 Curiosity Board by connecting a USB cable to the kit (PC to WBZ451 Curiosity Board)
2. Discovery of Zigbee Lights
    a. Voice Commands
        i. Ask Alexa to discover your device. Say “Discover my devices”.

        or

    b. Alexa App
        i. From the menu, select the 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



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

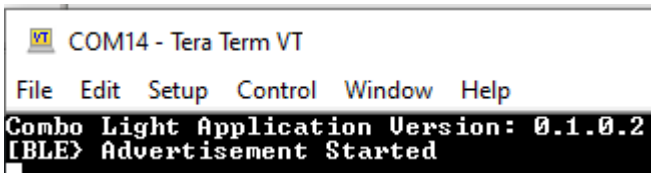
1. Issue Reset to factory new, using button (SW2), press and hold SW2 button for 10 secs.

   Users can view the data logs for better understanding of the demo experience. To view the logs -> Open 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)

   Or

Open MBD App, select BLE Provisioning -> Coming Soon-> COMBO_LIGHT_9393 -> Factory Reset

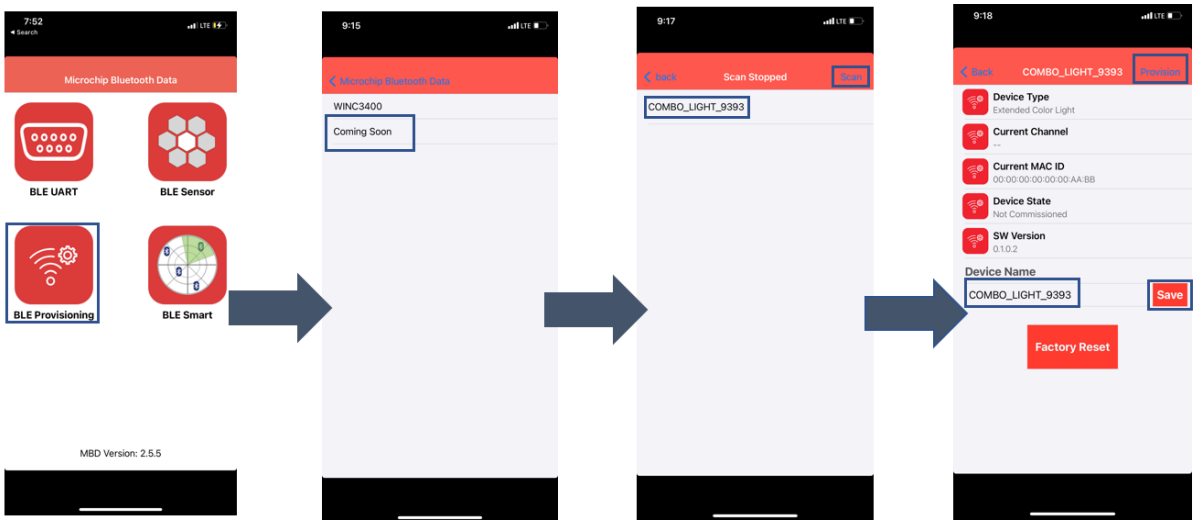
   The following message will be printed on terminal window post a successful reset to factory new



2. To scan for nearby WBZ451 devices running Multiprotocol demo, open Microchip Bluetooth Data(MBD) App, select “BLE Provisioning” and select “Coming Soon” option

   i. Scan operation will find – COMBO_LIGHT_xxxx device in results, select this device

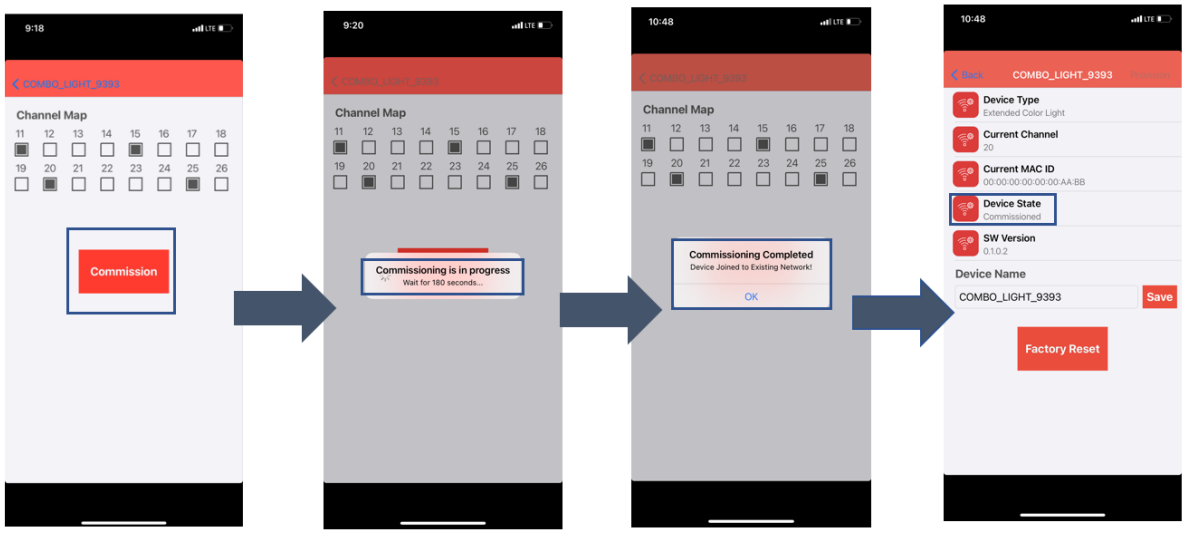
   ii. After selecting, device status will be displayed, users can now either change the device name or move ahead to provisioning the device keeping the device name as default



iii. Channel map needs to be chosen and select commission, once commission option is chosen, the device starts to look for an existing zigbee network to join, upon joining the existing network created by Amazon Echo – finding and binding process is initiated which lasts for 180 secs.

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

iv. Upon completion of 180 secs, Commissioning process is completed, users can select ok, Device State changes from “Not Commissioned” to “Commissioned”



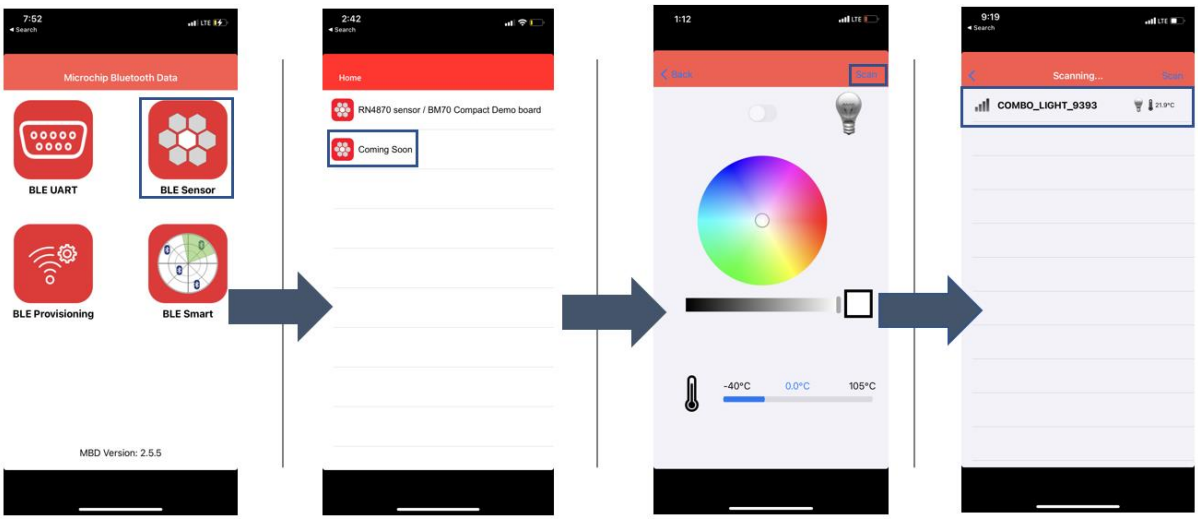

```
Zigbee Device Initialized: Type Help for Commands
Commissioning Procedure Started - 180 Seconds
Commissioning Sequence: Formation->Steering->Find & Bind->
Network Established
Steering: Success
Network Search: Complete: Joined to a Network
Joined to: Address 0x0000  MACID 0x0000000000000bee ExtendedPANID 0x000000000000
0bee
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. WBZ451 Curiosity Board starts in advertisement mode to advertise its presence to 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



2. 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. User Programmable blue LED becomes solid once connection is established between the smartphone and WBZ451 module

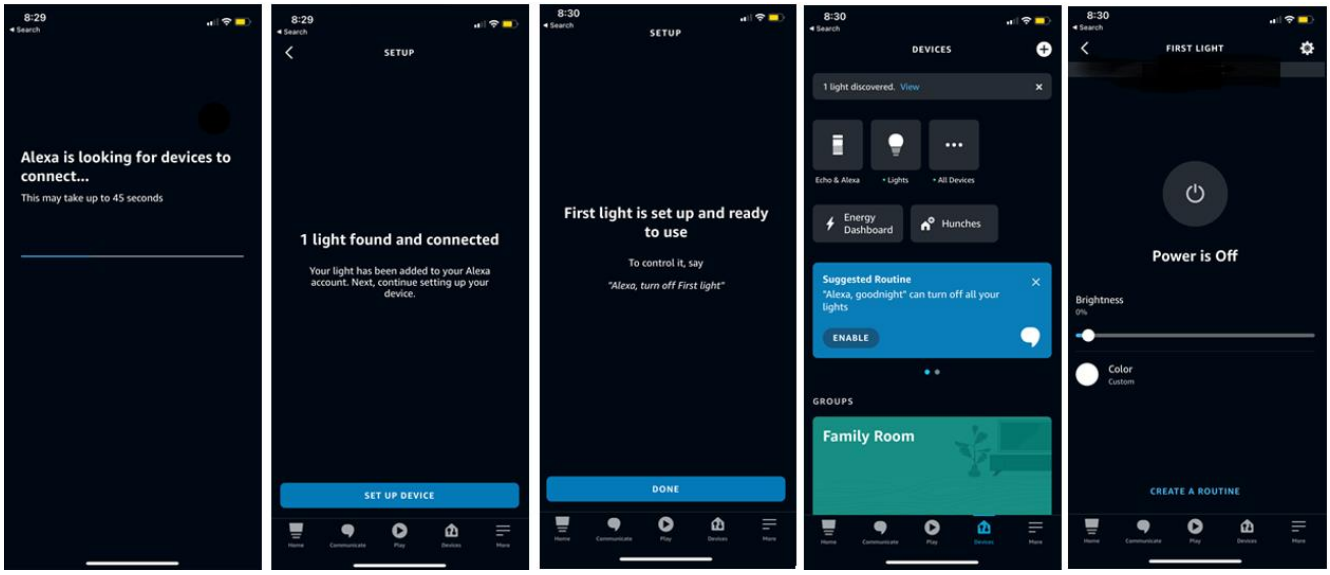
    c.  Controls the RGB LED state on/off

    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

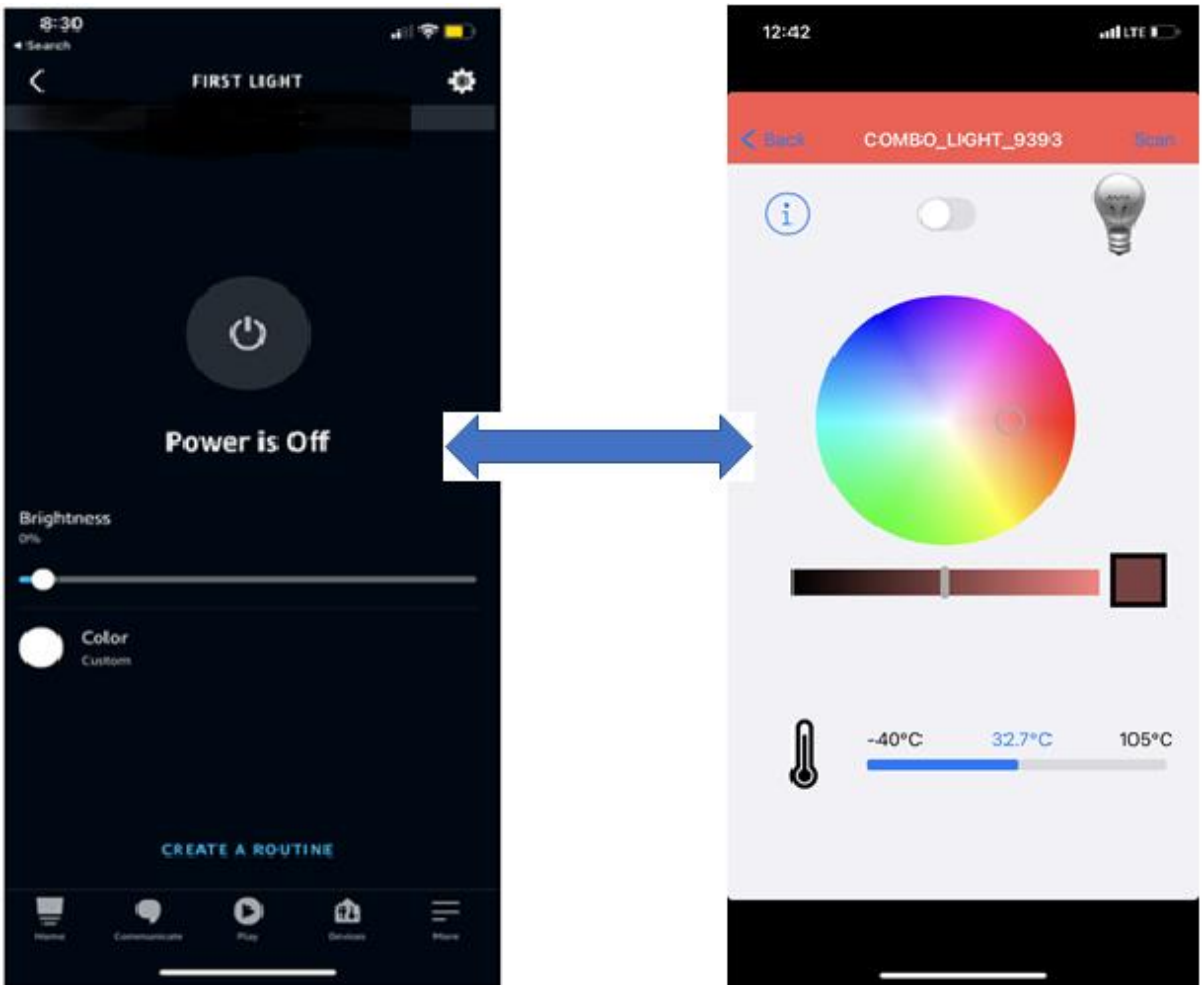
Multiprotocol Control/Monitor of Lights using Zigbee (Alexa App)



1. Control RGB LED state on/off
    a. Voice commands
        v. Ask Alexa, “Alexa Turn on first light” to change status of RGB LED from off to on
        vi. Ask Alexa, “Alexa Dim first light” to reduce the brightness.
        vii. Ask Alexa, “Alexa Turn my first light green” to change the color.

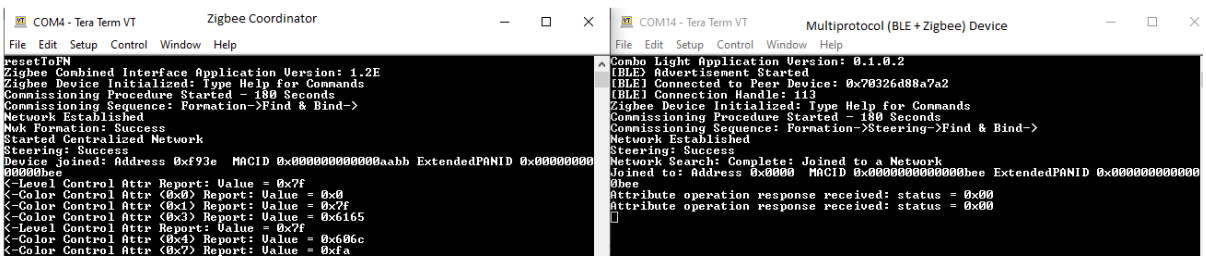
        or

    b. Alexa App
        viii. select First Light in “Lights” and control
2. The Light Status (on/off), light color and intensity chosen via the Voice commands/Alexa App (Zigbee link) will be relayed on to MBD App (BLE Sensor App)

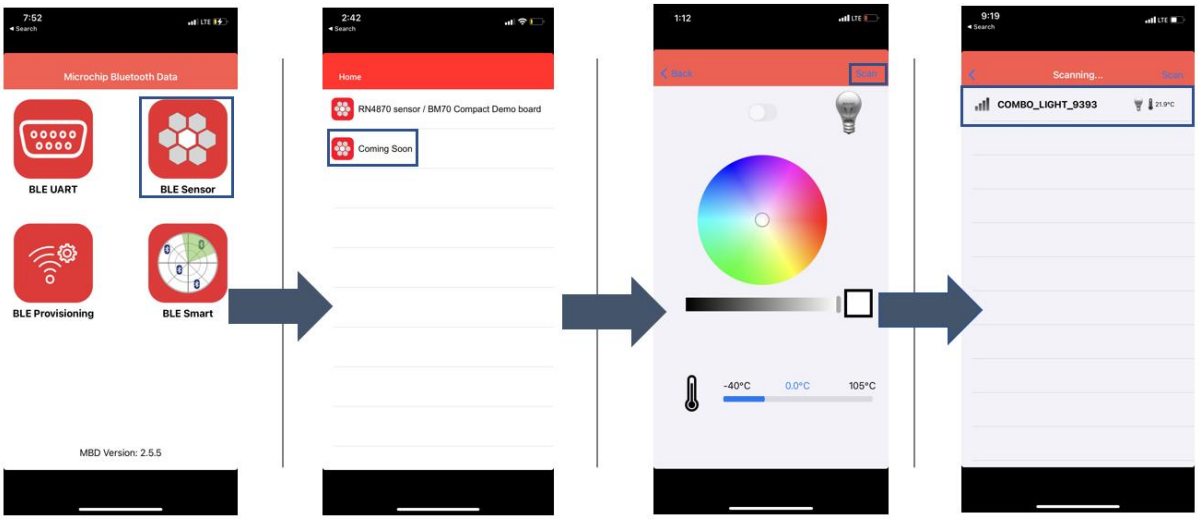


Multiprotocol Lights Demo with another WBZ451 Curiosity Board as Coordinator

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



4. Turn on light using MBD App over BLE link



a.  Set RGB LED state on

b. 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)

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

5. Turn off light using MBD App over Zigbee link

    a. Off - Send the following command from Coordinator device over UART - **onOff -s 0xf93e 0x23 -off**

    b. The Light Status (on/off), light color and intensity chosen via the Zigbee Coordinator UART commands (Zigbee link) will be relayed on to MBD App (BLE Sensor App)