Z-Stack Lighting
Sample Application User's Guide

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Revision	Description	Date
1.0	Initial release.	12/18/2012
1.1	Updated button descriptions in Table 2.	03/08/2013
1.2	Updated release.	10/25/2013

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1 Introduction

ZigBee Light Link (ZLL) is one of the public application profiles released for the ZigBee 2012-Pro specification. It is aimed at consumer lighting market allowing a novice user to wirelessly setup and control consumer lighting products.

Z-Stack Lighting Sample Application is the optimal starting point to build your own ZLL application on top of Texas Instruments' Z-Stack (www.ti.com/z-stack).

ZigBee Light Link wiki: http://processors.wiki.ti.com/index.php/Category:ZigBee_Light_Link

1.1 Scope

This document describes how to use the Z-Stack Lighting Sample Application and discusses its theory of operation. For a more general description of ZigBee Light Link, reader is referred to the Zigbee Light Link specification available from www.zigbee.org.

IAR Project **SampleApp.eww** supports following applications

a. SampleRemote: A remote for controlling color, dimmable or simple on/off lights.
b. SampleLight: A color light.
c. SampleBridge: Host Interface application running on Linux/Windows PC can be used to connect to CC253x running SampleBridge App

1.2 Definitions, Abbreviations, Acronyms

Term	Definition
ZLL	ZigBee Light Link
ZLLRC	ZLL Remote Control
Hue	Hue is the placement on the Color hue wheel, where 0 is the red area, third of range is in the green and two-thirds are in the blue
Sat	Saturation value shifts every color from white, through tint up to pure color
Level	Level controls the luminance of the light

2 Setup

2.1 Required Software Tools

Software tools needed to evaluate this sample application:

a. IAR Embedded Workbench for 8051 (CC2530)

   http://www.iar.com/Products/IAR-Embedded-Workbench/8051/

   Install 30-day time limited full version

b. SmartRF Flash Programmer Tool (includes USB drivers for the SmartRF05EB board)

   http://www.ti.com/tool/flash-programmer

c. SmartRF Studio. It includes Ubiqua USB dongle driver and other necessary software

   www.ti.com/smartrfstudio.

d. Ubiqua Protocol Analyzer from Ubilogix (*www.ubilogix.com*) or other type of network analyzer that can support ZigBee Light Link profile decodes.

2.2 Supported Hardware Platforms

2.2.1 SmartRF05EB boards with CC2530EM

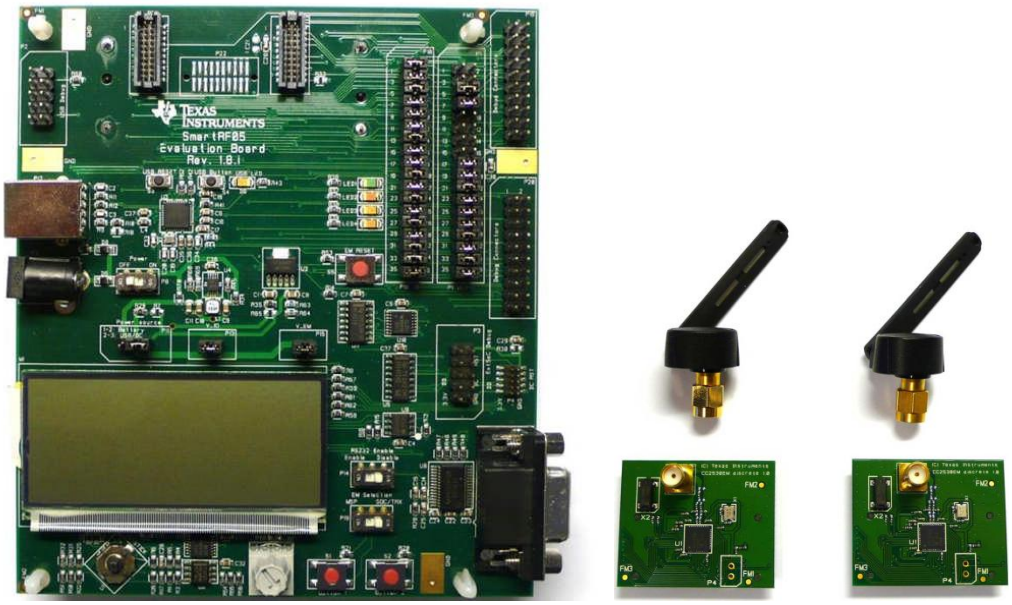


Figure 1: SmartRF05 Evaluation boards

SampleRemote, SampleLight and SampleBridge builds are supported for the SmartRF05EB + CC2530EM HW platform. SampleLight: Level, XY Color, hue and saturation are displayed on the LCD. LED1 indicates light being on/off. Table 1: SampleLight Functionalities Mapping on the SmartRF05 Board. Table 2 shows SampleRemote functionalities mapping on the SmartRF05 Board.

Figure 2: SmartRF05 Joystick on SmartRF05EB

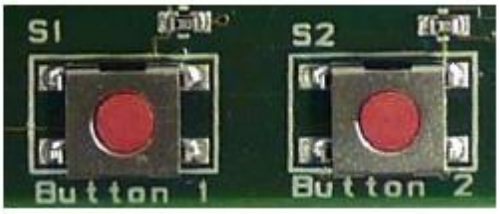


Figure 3: SmartRF05 Buttons on SmartRF05EB

SampleLight

Joystick	Functionality	Comment
Right	Reset to Factory New	
Left	Display NWK key	
Up	Start Classical Commissioning	
Down	Toggle PermitJoin State	Sets permit join option for 60 seconds

Table 1: SampleLight Functionalities Mapping on the SmartRF05 Board

SampleRemote

Joystick	Functionality	Comment
Right	Reset to Factory New	
Left	Touch-link	
Up	Send On command	To currently selected target
Down	Send Off command	To currently selected target
Center	Add Target to Group	Default is Group 1
Button 1(S1) + Right	Select Next target	From previously touch-linked target list
Button 1(S1)+ Left	Select Previous target	From previously touch-linked target list
Button 1(S1) + Up	Send level step up command	+25
Button 1 (S1)+ Down	Send level step down command	-25
Button 1 (S1) + Center	Start Classical Commissioning	

Table 2: SampleRemote Functionalities Mapping on the SmartRF05 Board

2.2.2 CC2530 ZLL Remote Control (ZLLRC)

ZLL Remote Control button mapping is shown below

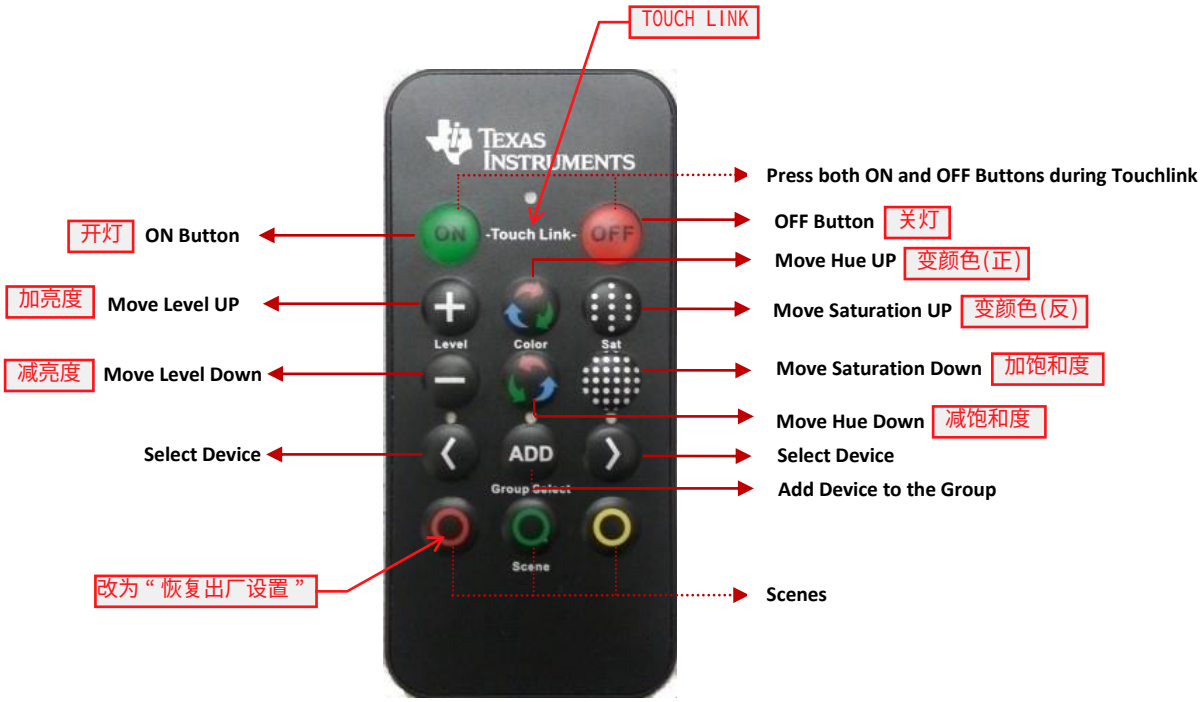


Figure 4: ZLL Remote Control

2.2.3 CC2530 Z-Light2

This HW platform can only be used as a SampleLight.

LED light has 4 channels mapped to Timer 1 with outputs as follows:

- Red: timer 1 channel 1
- Blue: timer 1 channel 2
- Green: timer 1 channel 3
- White: timer 1 channel 4

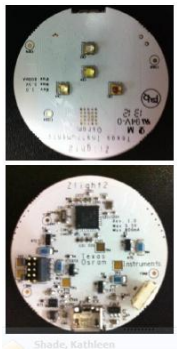


Figure 5: Z-Light2

2.2.4 CC2531 USB Dongle

CC2531 USB Dongle is a fully operational USB device that can be plugged into a PC. The dongle has 2 LEDs, two small push-buttons and connector holes that allow connection of external sensors or devices. It supports the SampleBridge App.

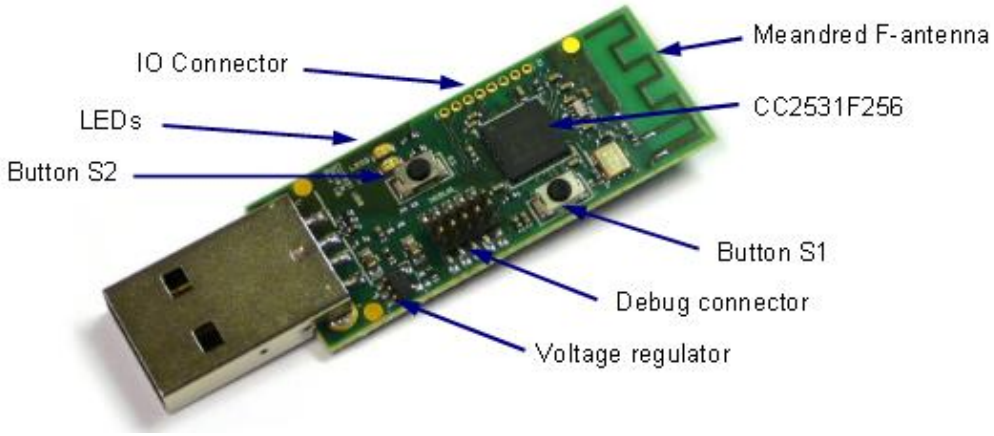


Figure 6: CC2531 USB Dongle

2.3 Hardware Setup (Powering Up and Connecting to Debugger)

2.3.1 SmartRF05EB board + CC2530EM:

Connect SmartRF05EB board to the development PC using a USB cable. There are 3 ways to supply power to the SmartRF05EB board: batteries, USB connection, or a DC power supply. To provide power from batteries, pins ***1-2*** of jumper block **P11** must be connected. Otherwise, connect pins ***2-3*** to use USB or DC. Board can be powered **ON** or **OFF** using switch **P8. For Flashing and Debugging**: Make sure USB cable is connected.

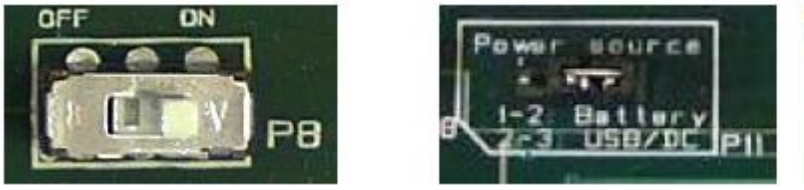


Figure 7: Power Switch and Power Source Selection

Figure 8: SmartRF board connected to PC

2.3.2 ZLL Remote Control (ZLLRC)

Insert CR2025 battery into remote control. Instructions on how to insert the battery are illustrated at the back of the remote. **For Flashing and Debugging:** Debug interface for the remote control is located at the back of the remote. Make sure CC Debug cable is inserted as shown in the figure below:

Figure 9: ZLL Remote Control connected to CC Debugger

2.3.3 Zlight-2

Zlight-2 is powered using micro USB cable. **For Flashing and Debugging**: Make sure CC Debugger is connected as shown in the figure below:

Figure 10: Z-Light2 Connected to CC Debugger

2.3.4 CC2531 USB-Dongle

CC2531 USB Dongle is powered by plugging into PC USB port. **For Flashing and Debugging**: Make sure CC Debugger is connected as shown in the figure below:

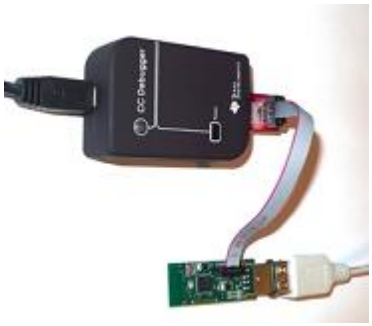


Figure 11: USB Dongle Connected to CC Debugger

3 Building, Flashing and Running the Application

3.1 Project Table

SampleApp.eww supports multiple projects/applications. Table below shows supported projects, hardware platforms and applications. Please consult the table when building project in IAR

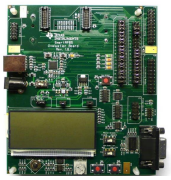
	SmartRF05EB + CC2530EM 	**USB CC2531 Dongle** 	**Z-Light2** 	**ZLL Remote (ZLLRC)** 
SampleLight	EB - Router	N/A	Zlight - Router	N/A
SampleRemote	EB – EndDevice	N/A	N/A	ZLLRC - EndDevice
SampleBridge	EB - Router	Dongle-Router	N/A	N/A

Table 3: SampleApp.eww Project Table

3.2 Build Steps

3.2.1 Open Project workspace

Open SampleApp.eww IAR workspace and consult section 3.1 to select application

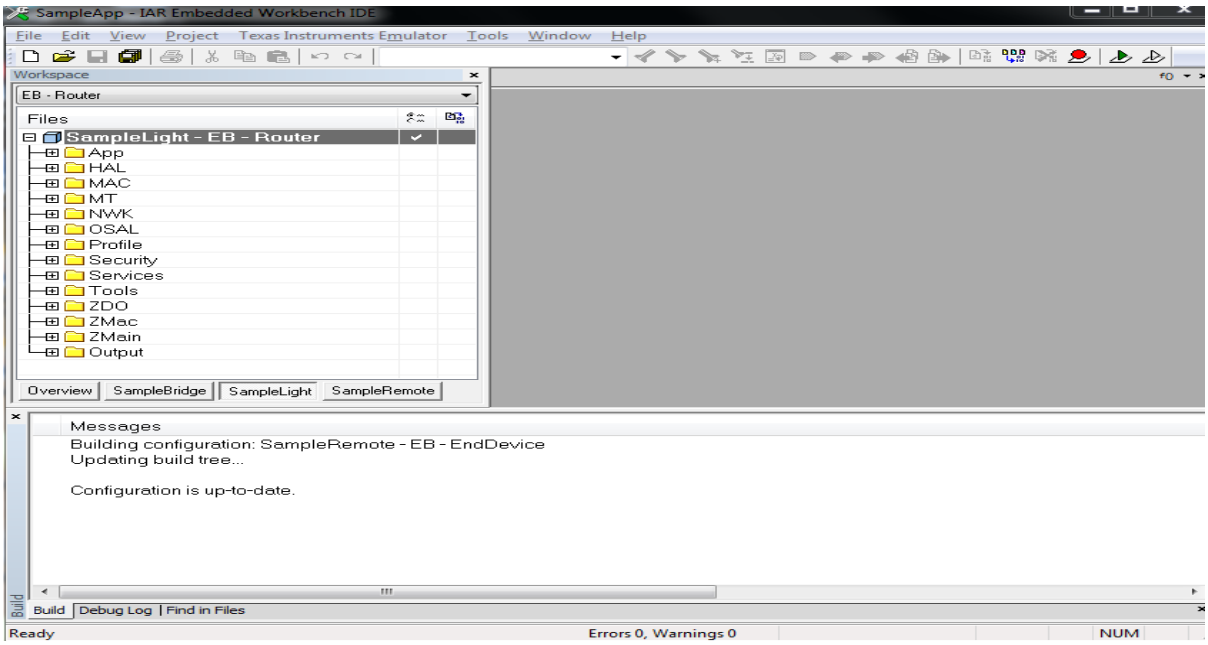


Figure 12: Open IAR Projects

3.2.2 Build Application

Pull down the Project menu and click on *Rebuild All*

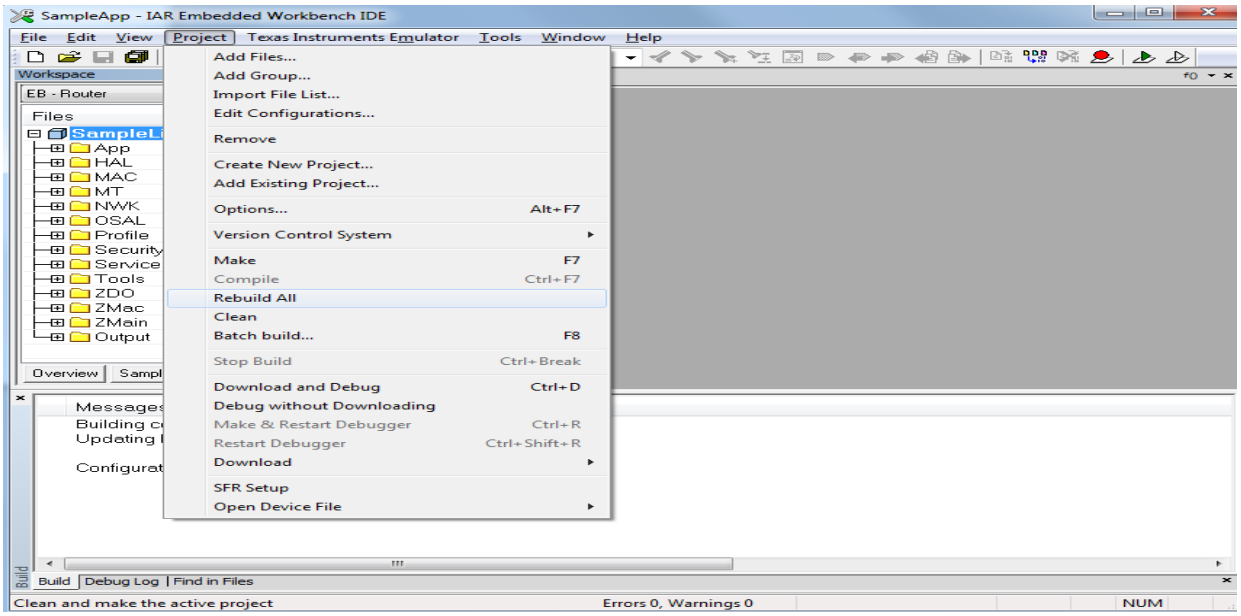


Figure 13: Build Application

3.3 Flashing and Running Image

3.3.1 Power Up and Connect Hardware

Consult section 2.3 to power up Hardware platform and connect to PC and CC Debugger.

3.3.2 Download Image

Pull down the Project menu and click on *Download and Debug*.

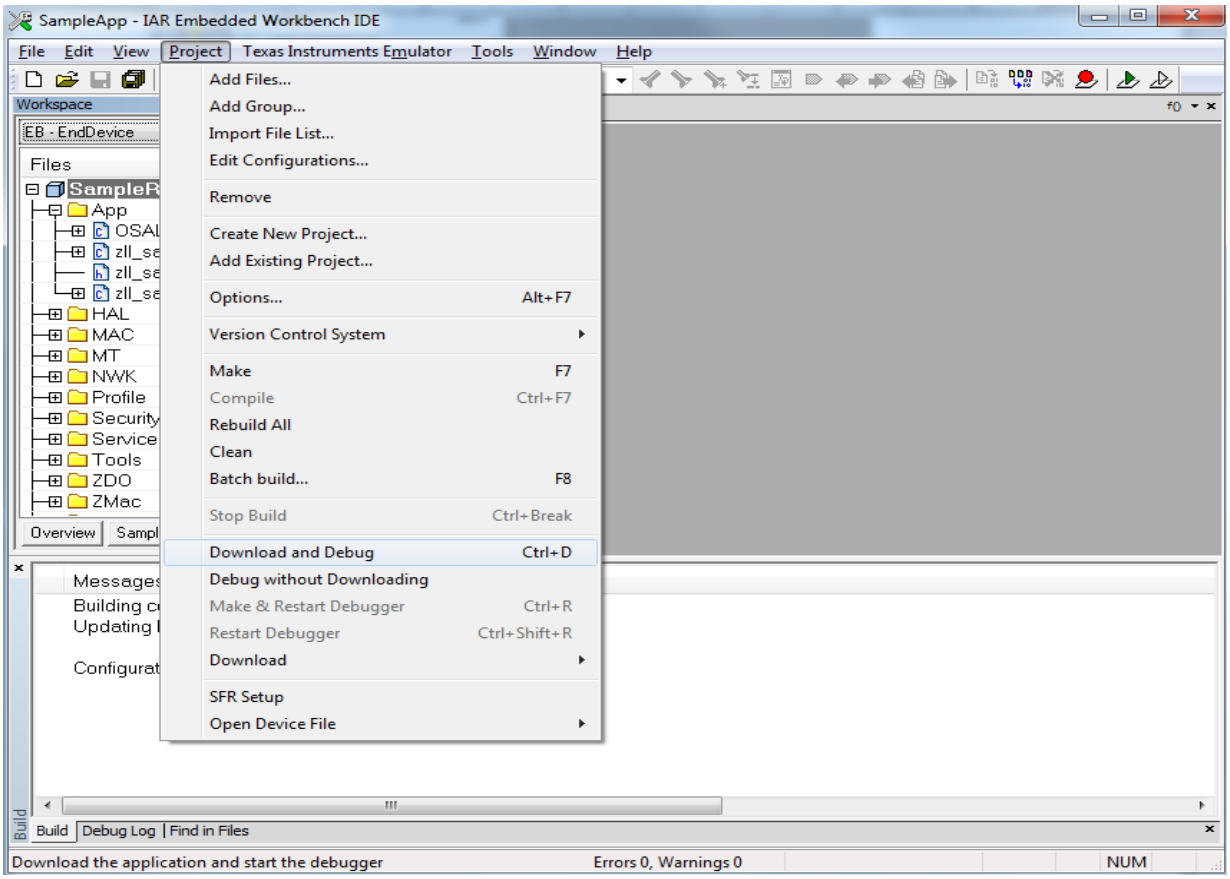


Figure 14: Download Image

Wait for download to complete

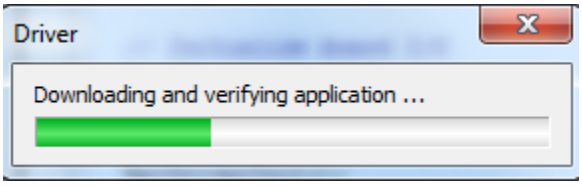


Figure 15: Wait for Download to Complete

3.3.3 Run Image

Pull down the Debug menu and click on *Go*

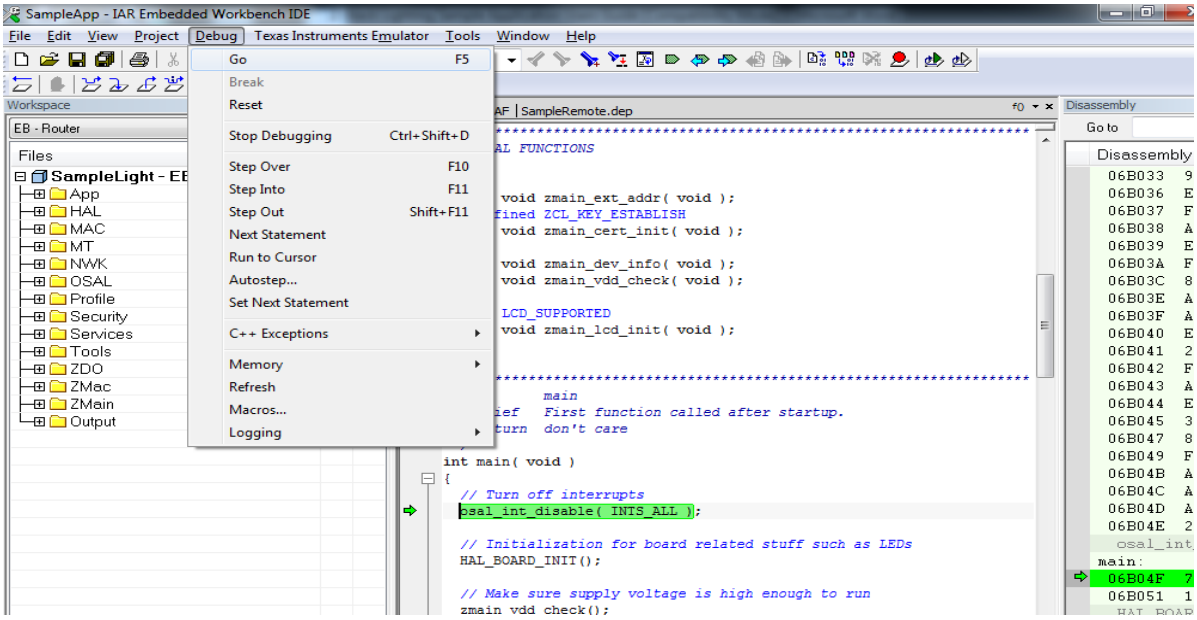


Figure 16: Click Go

After downloading is complete, exit the debugger by pulling down the Debug menu and clicking on *Stop Debugging*

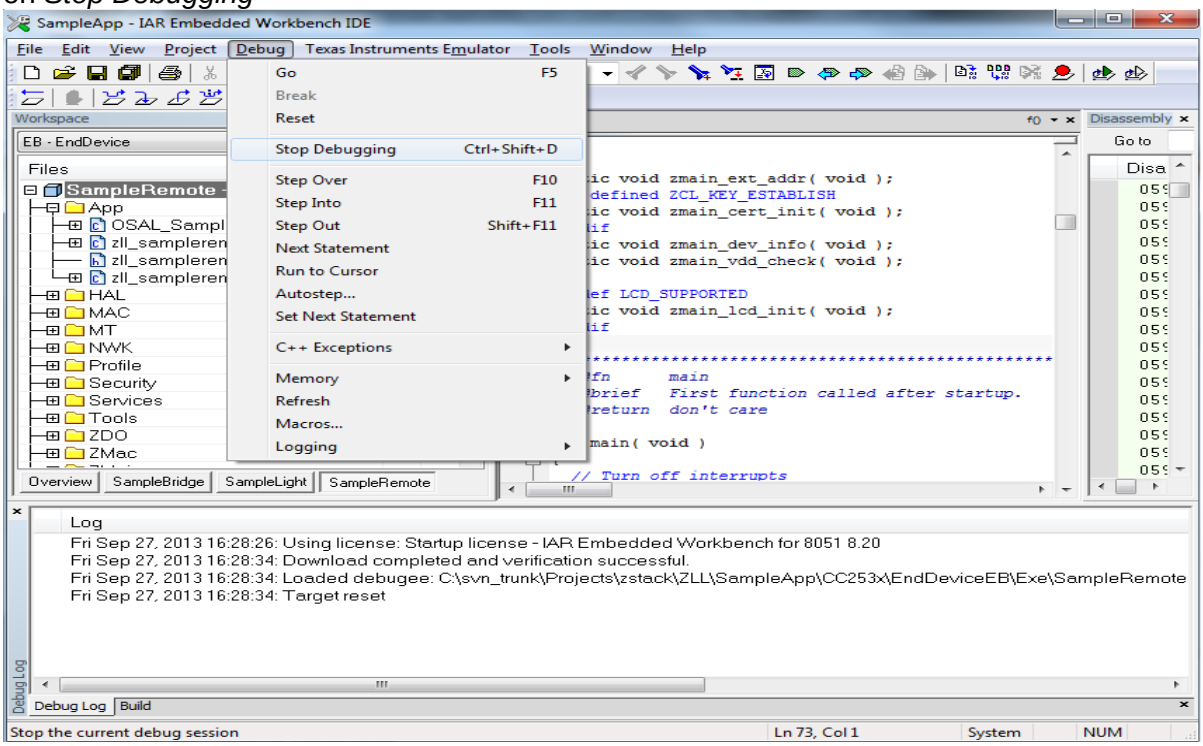
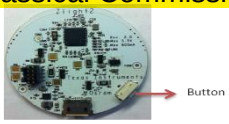


Figure 17: Stop Debugging

4 Sample Remote and Sample Light Applications

4.1 Sample Light.

- Power up the sample light. On SmartRF05 board, LCD will show “Texas Instruments” and the IEEE Address on the next line and will wait for the SampleRemote to start the touchlink procedure. On Z-Light2 board, all the LEDs will flash on power-up and will turn off. Z-Light application will then wait for the touchlink procedure
- There is a single button on the Z-Light2 board for which three functionalities have been mapped, based on the time duration the button is pressed.
  a. Pressing the button for less than 1 second: Sets the enable permit join for 60 seconds
  b. Pressing the button for >1 second and <5 seconds: Resets to factory New
  c. Pressing the button for >5 seconds: Initiates Classical Commissioning



- Compile and Flash new images (if needed). Consult section 3.

4.2 SmartRF05 Remote

4.2.1 Setup

- Power up the Remote. Consult section 2.3. On SmartRF05 board, LED1 will keep blinking indicating the SampleRemote is waiting for the touchlink procedure to form a network or become part of an existing network
- Compile and Flash new images (if needed). Consult section 3.

4.2.2 Features

Consult section 2.2.1 for button mapping

- **Touchlink**: Press the joystick left to touchlink a new ZLL device. Consult section 2.2.1. A successful touch-link will cause the light to *identify*. On SmartRF05EB LED1 will toggle once.
- **Device select**: If multiple lights have been touchlinked, specific device can be select by holding SW1 and pushing joystick left or right.
- **On/Off**: To turn the light on, push the joystick up. To turn the light off, push the joystick down.
- **Level Up/Down**: To step the level up by 25 over 1s, press both button 1 and up on the joystick. To step the level down by 25 over 1s press both button 1 and down on the joystick.
- **Reset to factory new**: Push the joystick right to reset the remote. It will take about 5 seconds for the operation. You will then see LED1 start to toggle, indicating successful processing of the command

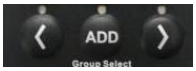
4.3 ZLL Remote Control (ZLLRC)

4.3.1 Setup

- Power up the Remote. Consult section 2.3.
- Compile and Flash new images (if needed). Consult section 3.

4.3.2 Features

- **Touchlink**: To Touchlink the remote with Z-Light2, push ON and OFF buttons simultaneously on the remote control while it is held close to the ZLight-2 (within 2 inches). You will then see LED's on the Z-Light2 Board turn on and off. Successful pairing is also indicated by a buzzer sound from the remote.

- **Device select:** If multiple lights have been Touchlinked, specific device can be selected by pressing arrow buttons on the remote 

  All devices that are Touchlinked with remote are added to the unique group. When user uses arrow buttons on remote to make device selection, specific z-light2 device will get selected and the light will flicker to indicate it is selected. Once all devices have been traversed, unique group is selected and all touchlinked devices will flicker.

- **On/Off:** To turn the light ON, press ON and to turn the light OFF, press OFF buttons respectively.
- **Level**: To move Level up/down by 20/second press Level "+"/"-" on remote. Level stops changing when key is released
- **Saturation**: To move Saturation up by 20/second press 

on remote. To move saturation down by 20/second press 

. Saturation stops changing when key is released.
- **Hue**: To move Hue up by 20/second press 

on remote. To move Hue down by 20/second press 

. Hue stops changing when key is released.

- **Groups**: There is one unique group. All Touchlinked devices get automatically added to the unique group. User can select individual device, or the group using arrow keys. Add device to a Group using "ADD" key 

and remove it by pressing "ADD" and "OFF" keys.
- **Scenes**: User can store up to 3 scenes. To Store, long press one of the three keys. To recall, press the associated key. 

- **Classic Commissioning**: It can be enabled by pressing "red" and "yellow" buttons together.
- **Reset To Factory New:** ZLL Remote can be reset to factory new state using the reset button at the back side of the remote, next to the debug port.

4.4 Multiple Remotes in the Network

In order to add another Remote to the network, the new remote being brought into the network should initially be in Factory New state. Then a touchlink should be performed between the factory new and the existing Non-Factory-New (remote currently in the network) before the new remote is used in the existing network.

5 Host Interface/Sample Bridge Application

Z-Stack Lighting project includes Host interface that allows host processors to connect to a CC253x via UART and control the ZLL (ZigBee Light Link) network using an abstract ZLL API. Host interface code runs on Linux or Windows PC. Host PC is connected to CC253x running SampleBridge application.

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5.1 SmartRF05 / CC2531 USB Dongle

SmartRF05 or USB Dongle can be used to run SampleBridge application.

5.1.1 SampleBridge Application Setup

- Consult Table 3 for devices that support SampleBridge application
- Power up the Bridge Hardware. Consult section 2.3.
- Build and Flash new images (if needed). Consult section 3.
- Setup Light as explained section 4.1.

5.1.2 Host Interface application Setup and Testing

Details on how to build and test Host interface application can be found at:
http://processors.wiki.ti.com/index.php/Category:ZigBee_Light_Link

Figure 18: SampleBridge Device connected to PC

6 Applicable Documents

6.1 Z-Stack Documents (part of the Z-Stack installer)

Installed *Documents* folder contains Z-Stack documents

6.2 Other Documents (www.zigbee.org)

1. ZigBee Alliance – ZigBee Light Light Profile Specification
2. ZigBee Alliance –ZigBee Light Light Test Specification