Z-Stack 3.0 Sample Application User's Guide

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Revision	Description	Date
1.0	Initial release.	06/12/2013
1.1	Added Sample Applications after HA 1.2 implementation. Added clarification of help display.	11/25/2013
1.2	Cleanup for Z-Stack Home 1.2.1 release.	07/03/2014
1.3	Added CC2630/CC2650 and SensorTag sample application description.	02/20/2015
1.4	Removed HeatingCooling and SensorTag sample applications. Removed all references to the ZLight target of SampleLight CC2530. Added new Sample Applications user interface description. Added Quick Start section.	10/08/2016

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1 Introduction

ZigBee 3.0 provides seamless interoperability among the widest range of smart devices and gives consumers and businesses access to innovative products and services that will work together seamlessly to enhance everyday life. ZigBee networks can scale from 2 to 500 nodes, and can be easily installed by any consumer, ranging from novice users to IoT professionals. Installation concepts are simple and uniform across multiple OEM vendors.

ZigBee is primarily focused on sporadic real-time control of devices. In general, a ZigBee network is typically quiet, but when a user performs an action like pressing a button, they would expect to see the result of that button press quickly propagate across the network. More information can be found in www.zigbee.org, and in the official ZigBee Specification document [1] by the ZigBee alliance.

The Z-Stack 3.0 Sample applications (part of the Z-Stack 3.0 installer) are the optimal starting point to build your own ZigBee application on top of Texas Instruments Z-Stack (www.ti.com/z-stack). Please refer to the Quick Start section of this document for simplified instructions to get the sample applications up and running.

1.1 Scope

This document describes how to use Z-Stack 3.0 Sample Applications and discusses their theory of operation. For a thorough description and specification of these ZigBee Applications, the reader shall refer to the ZigBee Lightning and Occupancy Device Specification document [1] (in case of the Z3-ready Light and Switch applications) and ZigBee Home Automation specification [7] (for the other sample applications). Both documents are available on www.zigbee.org. For an in-depth description of Z-Stack in general and the Z-Stack 3.0 Sample Applications in particular, please refer to the *Z-Stack 3.0 Developer's Guide* [4]. This document is available as part of the Z-Stack 3.0 package, and provides a good reference, e.g. for changing Z-Stack configuration parameters such as channel and the network PAN ID to use.

For guidelines on how to create your own application based on the included Sample Applications, please also refer to *Z-Stack 3.0 Developer's Guide [4]*.

Seven sample applications are included in the Z-Stack 3.0 installer: SampleDoorLock, SampleDoorLockController, SampleLight, SampleSwitch, SampleTemperatureSensor SampleThermostat, and GenericApp. Each of them supports Coordinator, Router and End Device configurations when used with CC253x platforms. The Sample Switch also contains multiple build configurations that support OTA. For further details regarding the use of OTA, please refer to *Z-Stack OTA Upgrade User's Guide [5]*.

Unless specifically mentioned otherwise, the guidelines in this document refer to the CC2538 SoC, although similar approaches can be used for the other platforms.

1.2 Sample Projects

The following sample projects are supported:

a. **SampleLight / SampleSwitch**

SampleLight: A light that can be turned on/off locally or remotely. It also supports moving the level of the dimmable light by enabling the optional ZCL_LEVEL_CTRL flag.

SampleSwitch: A switch that acts as a remote controller to turn a light on/off or moves the level up/down in the case of a dimmable light.

b. **SampleDoorLock / SampleDoorLockControlle**r

SampleDoorLock: A door lock that can be locked/unlocked locally or remotely with ability to change master PIN.

SampleDoorLockController: A controller that locks/unlocks the door lock device based on user PIN input.

c. **SampleTemperatureSensor / SampleThermostat**

SampleTemperatureSensor: Sends current temperature reading to the thermostat.

SampleThermostat: A unit that receives temperature information from the Temperature Sensor.

d. **GenericApp**

This is a template application that does not includes any example functionality and it is a good starting point to develop your own application without the overhead of a sample application. The application only registers the Basic and Identify clusters at endpoint 0x08. Other cluster functionalities must be added to meet the product specific behavior.

1.3 Definitions

Term	Definition
BDB	Base Device Behavior
BB	Battery Board
CRC	Cyclic Redundancy Check
IoT	Internet of Things
PIN	Personal Identification Number
LED	Light Emitting Diode
LCD	Liquid Crystal Display
ZC	ZigBee Coordinator
ZCL	ZigBee Cluster Library
ZED	ZigBee End Device
ZHA	ZigBee Home Automation
ZR	ZigBee Router
NVM	Non Volatile Memory
TCLK	Trust Center Link Key
FN	Factory New

Table 1: Definitions.

1.4 Applicable Documents

[1] ZigBee document 15-0014-05 ZigBee Lighting & Occupancy Device Specification Version 1.0.

[2] ZigBee document 07-5123 ZigBee Cluster Library Specification Rev. 6.

[3] ZigBee document 13-0402-13 Base Device Behavior Specification Version 1.0.

[4] Texas Instruments document SWRA176, Z-Stack Developer's Guide.

[5] Texas Instruments document SWRA353, Z-Stack OTA Upgrade User's Guide.

[6] ZigBee document 05-3474-21 ZigBee Specification R21.

[7] ZigBee document 05-3520-29 ZigBee Home Automation Specification.

2 Setup

2.1 Required Software Tools

Software tools needed to evaluate sample application/s:

a. IAR Embedded Workbench, provides a tool for compiling, linking, debugging and loading applications on the target device.

   EW8051 version 9.30.1 (for CC2530)
   http://www.iar.com/Products/IAR-Embedded-Workbench/#!?architecture=8051

   EWARM version 7.70.1.11486 (for CC2538)
   http://www.iar.com/Products/IAR-Embedded-Workbench/#!?architecture=ARM

b. SmartRF Flash Programmer 2 Tool - for SmartRF06EB+CC2538EM and or SmartRF Flash Programmer Tool - for SmartRF05EB+CC2530EM. These can be found here:
   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*), the TI sniffer software (*www.ti.com/tool/packet-sniffer)* or other type of network analyzer that supports ZigBee 3.0 Specification decoding. Ubiqua requires using the CC2531 USB Dongle to capture the network traffic.

2.2 Supported Hardware Platforms

2.2.1 SmartRF06EB boards with CC2538EM

Figure 1: SmartRF06EB with CC2538EM

There are three ways to power SmartRF06EB; batteries, USB bus and external power supply. Power source can be selected using the power source selection switch (S502), seen below in **Figure 2**. Main power supply switch (S501) cuts power to the SmartRF06EB. **For Flashing and Debugging**: Make sure USB cable is connected to the PC. Consult **Table 2**, **Figure 3**, **Figure 4** for Button and LED Positions:

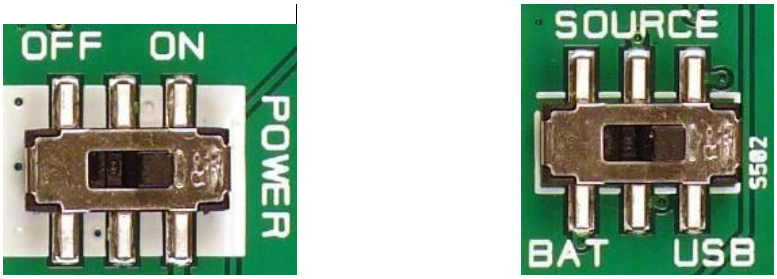


Figure 2: S501 and S502

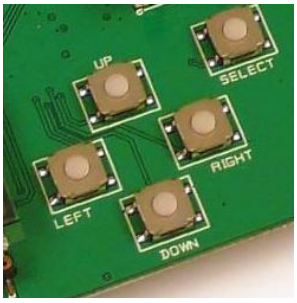


Figure 3: Button Positions

	Button
SW1	UP
SW2	RIGHT
SW3	DOWN
SW4	LEFT
SW5	SELECT

Table 2: SmartRF06 Key Positions

Figure 4: SmartRF06 LED Positions

2.2.2 SmartRF05EB/BB boards with CC2530EM

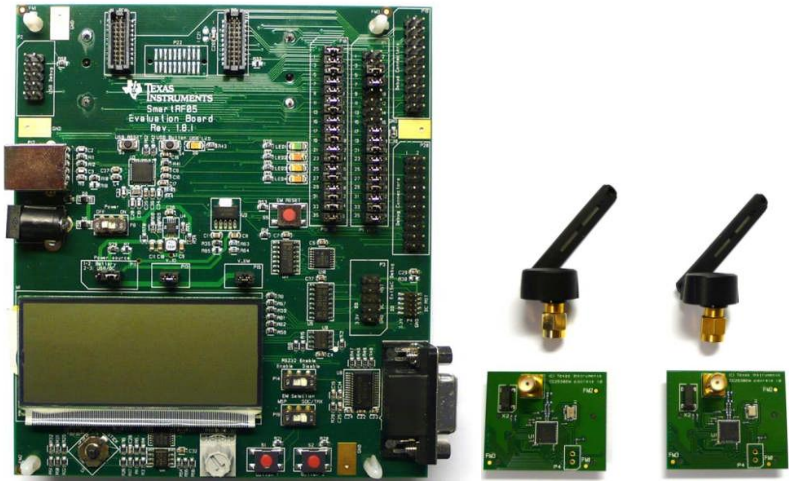


Figure 5: SmartRF05 Evaluation Board, Two CC2530EM Evaluation Modules and Antennas

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 to the PC.

Figure 6: Power Switch and Power Source Selection

Joystick (**Figure 7**) on the SmartRF05 board are used by all sample applications.

Figure 7: Joystick on SmartRF05EB REV 1.8.1

Joystick multi-position switch (5 positions) is used in the sample applications. For the sample applications, these “positions” are titled “Switches”.

	Joystick Position
SW1	UP
SW2	RIGHT
SW3	DOWN
SW4	LEFT
SW5	CENTER PRESSED

Table 3: SmartRF05 Key Positions

The board's LEDs (LED1 to LED4) are also used by the sample applications to signal some parts of the BDB process and status.

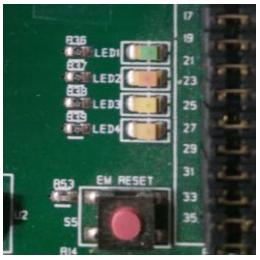


Figure 8: SmartRF05 LED Positions

2.3 ZigBee Cluster Libraries Required for Sample Applications

Sample applications use various clusters. **Table 4** identifies clusters common to all sample applications, and **Table 5** identifies clusters that are unique and mandatory to particular sample applications.

For proper operation, the following clusters are enabled in all sample applications. These are already set in the IAR Workbench preprocessor compile flags for each application:

ZCL_READ
ZCL_WRITE
ZCL_BASIC
ZCL_IDENTIFY
ZCL_GROUPS

Table 4: Clusters required across all Sample Applications.

Following table lists other mandatory clusters for each sample application. User may enable specific clusters in IAR options (**Figure 9)**. Full list is defined in f8wZCL.cfg.

Application	Mandatory Cluster
SampleLight	On/Off, Scenes, Level Control
SampleSwitch	On/Off, On/Off Switch Configuration
SampleDoorLock	DoorLock, Scenes
SampleDoorLockController	DoorLock, Scenes
SampleThermostat	Thermostat
SampleTemperatureSensor	Temperature Measurement

Table 5: Supported Mandatory Clusters.

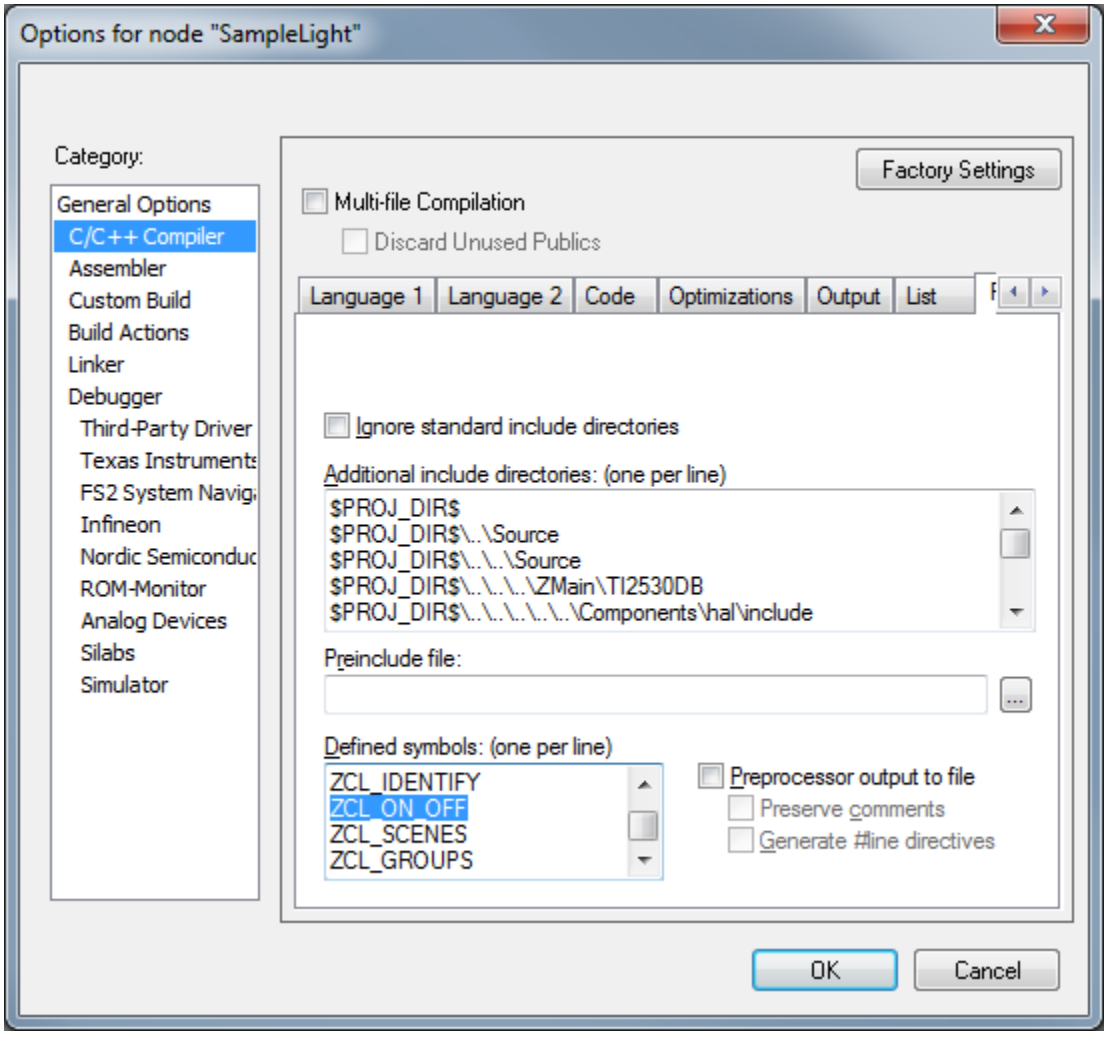


Figure 9: IAR Project Compile option to enable clusters

2.4 Sample Application User Interfaces

All the included sample applications (except Generic App) share the same menu system. Each application adds some application-specific menu items, accessible by selecting the <App Menu> item from the common menu.

The menu order was chosen to provide intuitive operation flow: First you configure the device, then you perform commissioning, and then you can perform the application-specific operations.

Figure 10 shows the common menu navigation diagram.

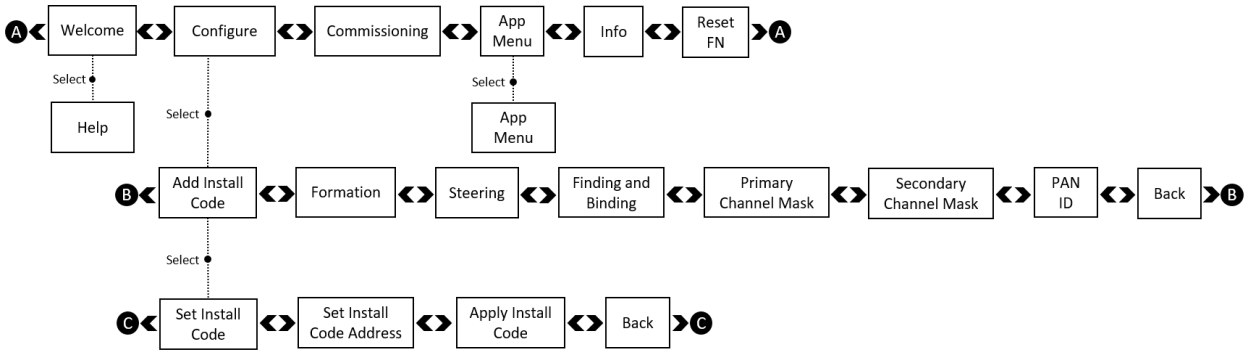


Figure 10: Common Sample Applications Screens

2.4.1 Welcome and <Help> Screens

The Welcome Screen (**Figure 11**) displays the application name and leads to the Help Screen (**Figure 12**), which outlines the generic functionality of the joystick/buttons throughout the application. The following sections describe the specific functionality of the buttons for each menu screen.

In the Help screen, '<', '>', '^'.'v' symbolize Left, Right, Up and Down buttons, respectively. 'OK' stands for the 'Select' button on the SmartRF06 and for pressing the joystick down towards the PCB in the SmartRF05.

Figure 11: Welcome Screen

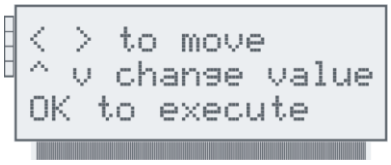


Figure 12: Help Screen

Welcome and Help Screens		
Joystick/Button	Functionality	Comment
LEFT / RIGHT	Menu navigation	Move to previous/next screen
OK	Help	Press and hold to show the help screen, release to go back to the Welcome Screen

Table 6: Welcome and Help Screens

2.4.2 <Info> Screen

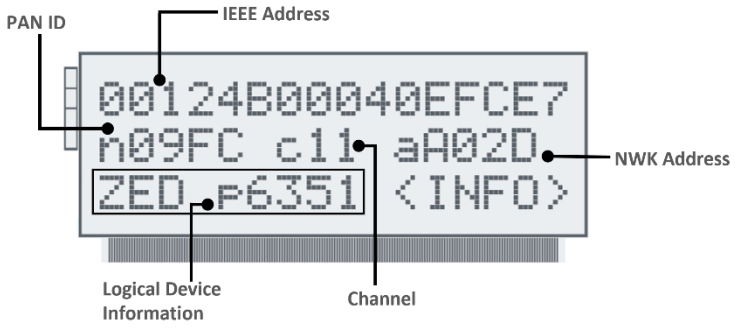


Figure 13: Info Screen Example

2.4.3 <Configure> Menu

The Configure Menu contains several submenus that allow the user to manipulate the install codes, commissioning procedures, channel masks and PAN ID. This configuration will define the device behavior during BDB commissioning procedures.

Figure 14: Configure Menu

2.4.3.1 <Add Instl Code> Menu

The Add Install Code Menu provides a user interface to set install codes. The same install code must be applied to both the Trust Center and the joining device before attempting to join. These devices will use this install code to generate the TCLK. Joining devices can only store a single install code at a time, but a Trust Center can store multiple install codes and corresponding IEEE addresses for joining devices.
Pressing OK while on this screen enters the Install-Code menu, which has two sub-screens for a TC, and one for joining devices.

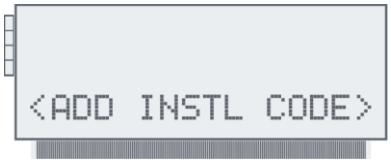


Figure 15: Add Install Code Screen

2.4.3.1.1 <Set Instl Code> Screen

The Set Install Code Screen has two modes of operation. View mode and Edit mode. In the view mode, the install code is shown in the first two LCD lines. The edit mode allows changing the

default install code to any desired value. In edit mode, the CRC of the install code is also displayed, on the left side of the third LCD line.

Figure 16: Set Install Code Screen

<Set Instl Code> Screen - view mode		
Joystick/Button	Functionality	Comment
LEFT / RIGHT	Menu navigation	Move to previous/next screen
OK	Select	Enter edit mode

Table 7: Set Install Code Screen - view mode

<Set Instl Code> Screen - edit mode		
Joystick/Button	Functionality	Comment
LEFT / RIGHT	Digit navigation	Move to previous/next digit
UP / DOWN	Value change	Increase / decrease the value of the highlighted digit
OK	Select	Save and exit mode

Table 8: Set Install Code Screen - edit mode

2.4.3.1.2 <Set I.C. Addr> Screen

The Set Install Code Address Screen is only available for a Trust Center. It has two modes of operation: In the first mode, the IEEE address to be associated with the install code entered in the previous screen is shown. The second mode allows changing this address. When a device with this IEEE address will try to join the TC, the TC will use the associated Install Code to generate a TCLK to use with this device.

Figure 17: Set Install Code Address Screen (Trust Center only)

<Set I.C. Addr> Screen - view mode		
Joystick/Button	Functionality	Comment
LEFT / RIGHT	Menu navigation	Move to previous/next screen
OK	Select	Enter edit mode

Table 9: Set Install Code Address Screen - view mode.

<Set I.C. Addr> Screen - edit mode		
Joystick/Button	Functionality	Comment
UP / DOWN	Value change	Increase / decrease the value of the highlighted digit
LEFT / RIGHT	Digit navigation	Move to previous/next digit
OK	Select	Save and exit mode

Table 10: Set Install Code Address Screen – edit mode

Apply Install Code Screen will save the last configuration done for remote nodes in the case of Trust Center, or local configuration for routers and end devices. Last status must be success to ensure the correct application of install code.

Figure 18: Apply Install Code Screen

<Aply Inst Code > Screen		
Joystick/Button	Functionality	Comment
LEFT / RIGHT	Menu navigation	Move to previous/next screen
OK	Select	Apply the install code configuration

Table 11: Apply Install Code Screen

2.4.3.2 BDB Commissioning Mode Screens

The BDB Commissioning Screens allow enabling/disabling of the top level commissioning procedures that will be performed when BDB commissioning is triggered by commissioning screen or any other means.

Figure 19: Formation Screen

Figure 20: Steering Screen

Figure 21: Finding and Binding Screen

<Nwk Formation>, <Nwk Steering>, <Findng+Bndng> Screens		
Joystick/Button	Functionality	Comment
LEFT / RIGHT	Menu navigation	Move to previous/next screen
OK	Select	Toggle enable / disable

Table 12: BDB Commissioning Mode Screens

2.4.3.3 Channel Mask Screens

Channel Mask Screens display and allow modification of the default channel configuration of the device for primary and secondary channel mask. Channels marked with * are enabled in the selected channel mask. Just press the OK button to start changing the mask.

The display numbers in the channel mask are read as follows:

```
Logical Channel  11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
                 ---------------------------------------------
Displayed Digit   1  2  3  4  5  6  7  8  9  0  1  2  3  4  5  6
```

Figure 22: Primary Channel Mask Screen

Figure 23: Secondary Channel Mask Screen

<Pri Chanl Mask>, <Sec Chanl Mask> Screens – view mode		
Joystick/Button	Functionality	Comment
LEFT / RIGHT	Menu navigation	Move to previous/next screen
OK	Select	Enter edit mode

Table 13: Channel Mask Screens – view mode.

<Pri Chanl Mask>, <Sec Chanl Mask> Screens – edit mode		
Joystick/Button	Functionality	Comment
UP / DOWN	Value change	Enable / Disable channel
LEFT / RIGHT	Channel navigation	Move to previous/next channel
OK	Select	Save and exit mode

Table 14: Channel Mask Screens – edit mode

2.4.3.4 <PAN ID> Screen

The PAN ID Screen allows changing of the default PAN ID (0xFFFF by default) to any desired value.

Figure 24: PAN ID Screen – view mode

<PAN ID> Screen – view mode		
Joystick/Button	Functionality	Comment
LEFT / RIGHT	Menu navigation	Move to previous/next screen
OK	Select	Enter edit mode

Table 15: PAN ID Screen – view mode

<PAN ID> Screen – edit mode		
Joystick/Button	Functionality	Comment
UP / DOWN	Value change	Increase / decrease the value of the highlighted digit
LEFT / RIGHT	Digit navigation	Move to previous/next digit
OK	Select	Save and exit mode

Table 16: PAN ID Screen – edit mode

2.4.4 <Commission> Screen

The Commission Screen starts the BDB top level commissioning. All enabled commissioning procedures will start running according to Base Device Behavior Specification [3] in the section 8.1.

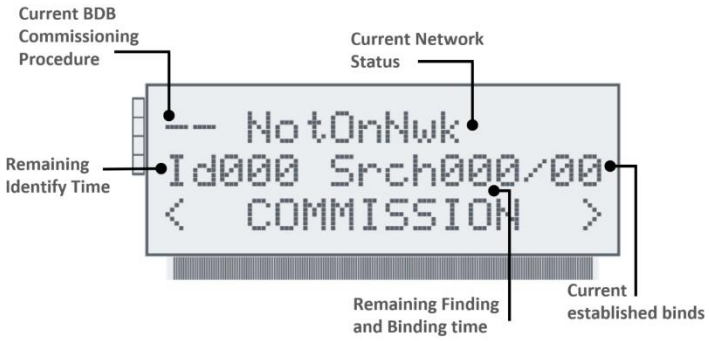


Figure 25: Commissioning Screen

The current BDB Commissioning Procedure being executed is shown in the upper right corner of the LCD as follows:

- **NS** - Network Steering.
- **NF** - Network Formation.
- **FB** - Finding and Binding.
- **PL** - Parent Lost (for end devices only).
- **--** - idle (commissioning not currently active).

The current Network status is displayed as follows:

- **NotOnNwk** - not currently connected to a network.
- **FORM** - network was formed by the current device during the latest execution of the NF method.
- **JOIN** - the current device joined an existing network during the latest execution of the NS method.
- **EXST** - the device was already connected to a network when the commissioning was started.

Joining permission state (not shown on end devices):

- **CLOSED** - the current device is closed for joining of other devices.
- **OpenXXX** - the current device is open for joining of other devices, and will close in XXX seconds.

<Commission> Screen		
Joystick/Button	Functionality	Comment
LEFT / RIGHT	Menu navigation	Move to previous/next screen
OK	Select	Start Commissioning procedure

Table 17: Commission Screen

2.4.5 <Reset to Fn> Screen

Reset to Factory New clears the devices network information and restores the NVM tables to default. The device will perform a soft reset automatically during this procedure and then display the Welcome Screen (**Figure 11**).

Figure 26: Reset to Factory New Screen

<Reset to Fn> Screen		
Joystick/Button	Functionality	Comment
LEFT / RIGHT	Menu navigation	Move to previous/next screen
OK	Select	Perform Factory New Reset

2.4.6 <Back> Screen

The Back Screen allows returning to the previous screen. When the back action is performed the upper level screen will be displayed automatically.

Figure 27: Back Screen

<Back> Screen		
Joystick/Button	Functionality	Comment
LEFT / RIGHT	Menu navigation	Move to previous/next screen
OK	Select	Back to upper menu

2.4.7 LED Usage

In order to provide input to the user about the state of the BDB process and network operation, the sample applications shared menu system uses the boards LED in the following way:

LED Usage		
LED Position	State	Comment
LED1	N/A	Used differently by the individual applications. See **section 3.2** for specific application usage
LED2	Off	Not connected to network
	Constantly on	Connected to the network as an end device
	Blinking (4 sec period, 95% duty cycle)	Connected to the network as a router
	Blinking (4 sec period, 75% duty cycle)	Connected to the network as a coordinator
LED3	Off	Device is not identifying (Finding and Binding)
	Blinking (1 sec period, 50% duty cycle)	Device is identifying
LED4	Off	Other devices cannot join through this device
	Blinking (1 sec period, 25% duty cycle)	Other devices can join using standard commissioning
	Blinking (1 sec period, 75% duty cycle)	Other devices can join using standard Touchlink (i.e. when enabled on the current device as a target)
	Constantly on	Device can join using either standard commissioning or Touchlink

Table 18: Common System Menus LED Usage

3 Using the Sample Applications

3.1 Building the Sample Applications

Devices form or join a network when BDB Top Level Commissioning is initiated for network formation or network steering, respectively. The process of building a sample application is the same for any application. The only differences are whether the device is a coordinator, router, or end device, and which ZCL clusters are included.

3.1.1 CC2530/CC2538

This step-by-step process will use the SampleLight application as an example.

- Make sure all development software tools have been installed
- Consult **section 2.2** to Power up the board.
- If Windows prompts to install a device driver, don't let it connect to Windows Update. Instead, let Windows try to find the required driver automatically. If that fails, browse to: *C:\Program Files\IAR Systems\<Embedded Workbench>\<arm\8051>\drivers\Texas Instruments* to locate the necessary files.
- Select IAR project workspace (*.eww), and open it with IAR. Select ZigBee device type configuration from the *Workspace* pull-down menu. Refer to **section 3.2** to help identify device type for each sample application. For instance, SampleLight is associated with a ZC (select **CoordinatorEB (CC2530)/Coordinator (CC2538)** from the Workspace pull-down menu).

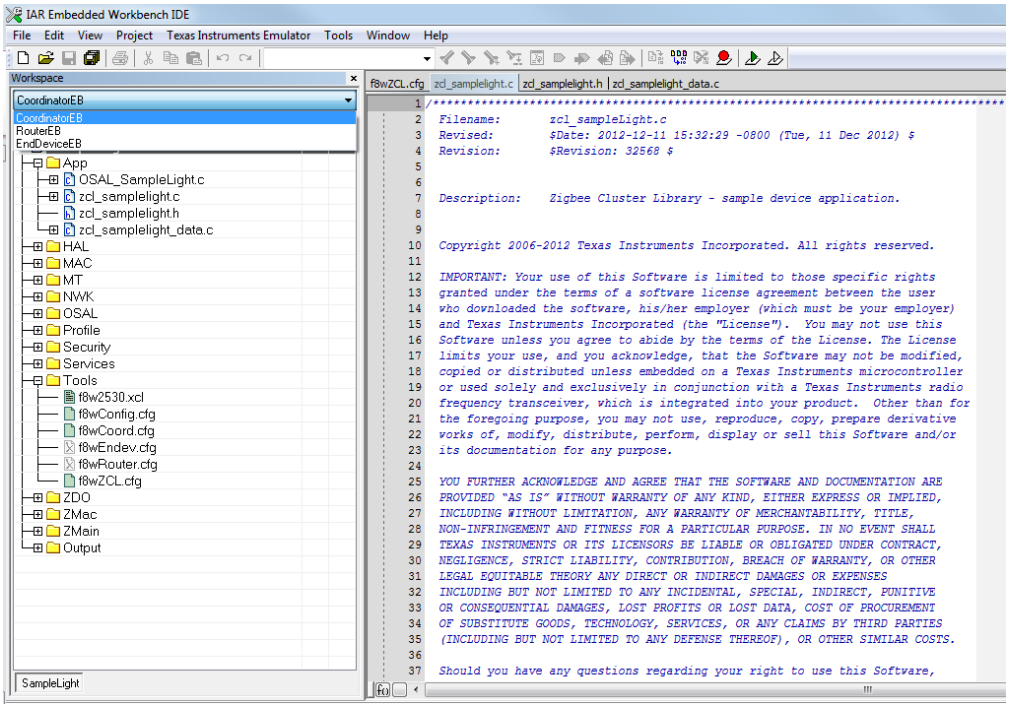


Figure 28: Selecting Correct Configuration

- Each sample application requires a different set of clusters. By default, required application clusters are enabled in IAR project options. To enable specific clusters, consult f8wZCL.cfg file and enable it in IAR compiler options (**Figure 9**)

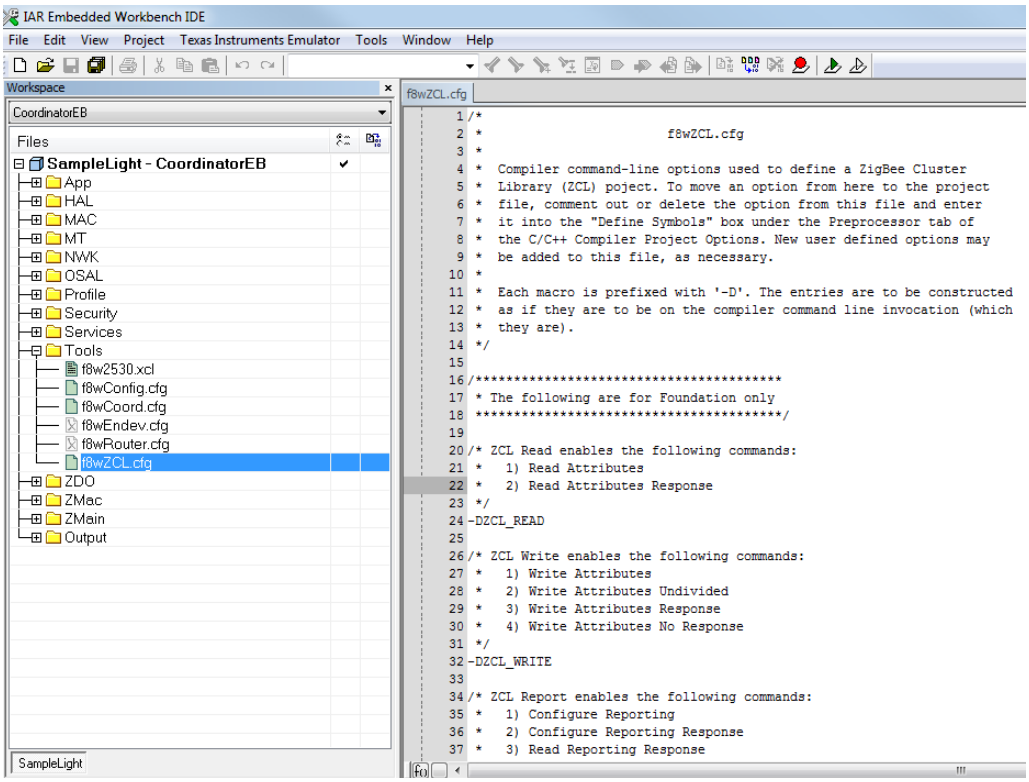


Figure 29: ZCL Cluster configuration file for reference

- Build the application by pulling down the *Project* menu and clicking on **Rebuild All**:

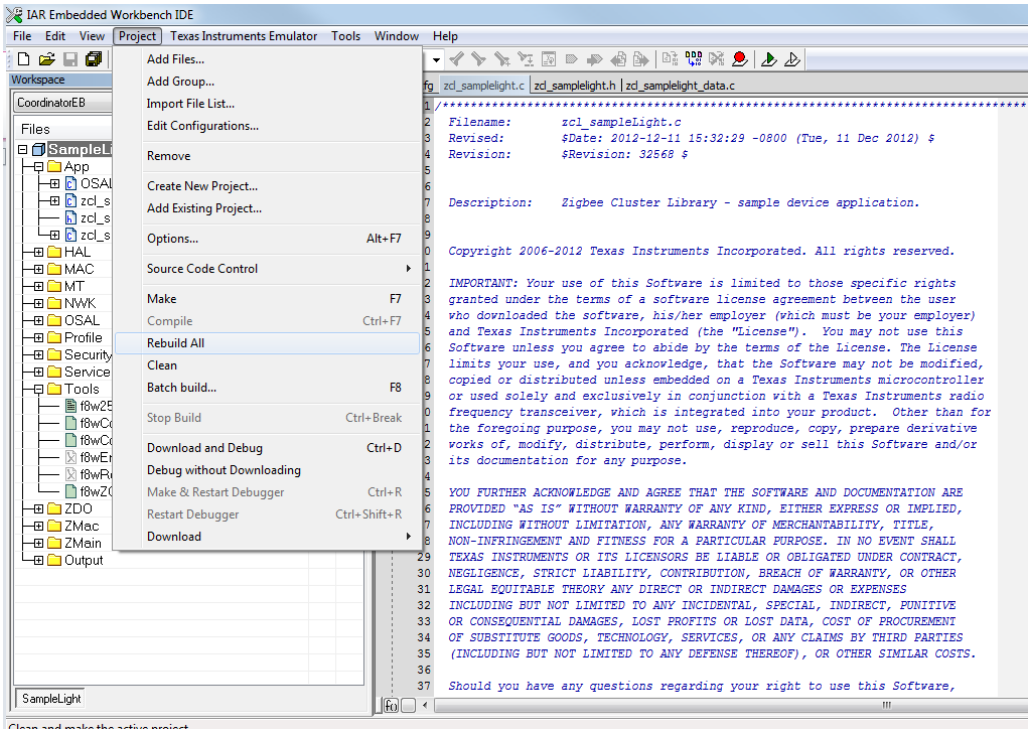


Figure 30: Building Sample Application

- In the case of CC2538, erase flash prior to programming new image:

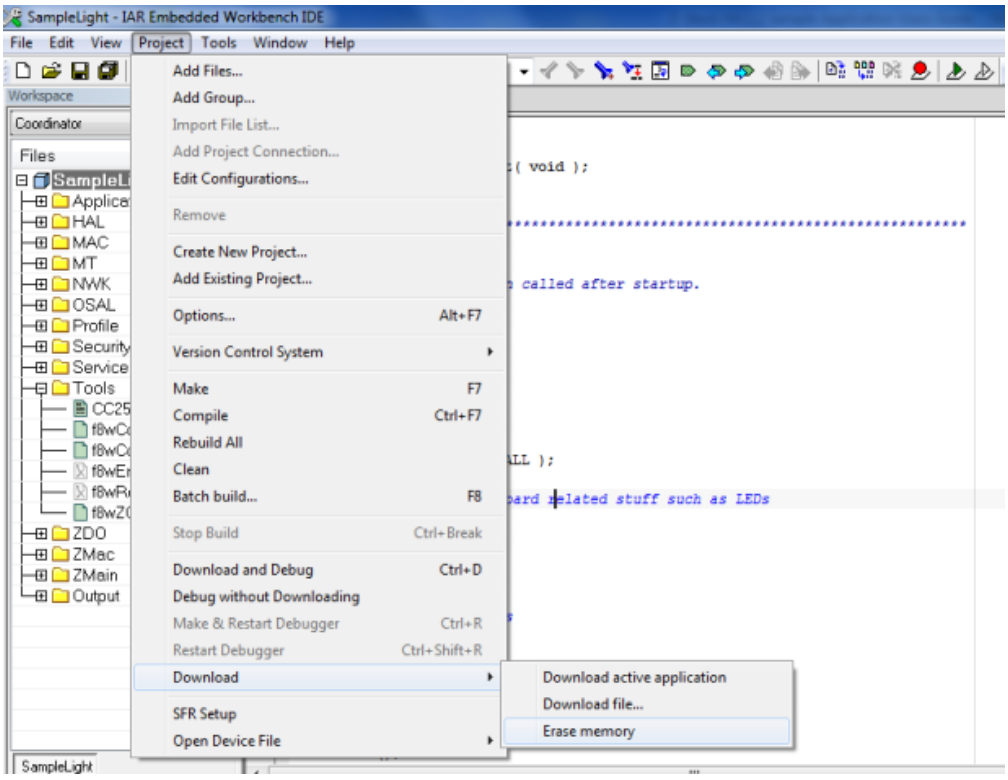


Figure 31: Erase Memory in CC2538

- Program (download) the sample application into the module by pulling down the *Project* menu and clicking on **Download and Debug**:

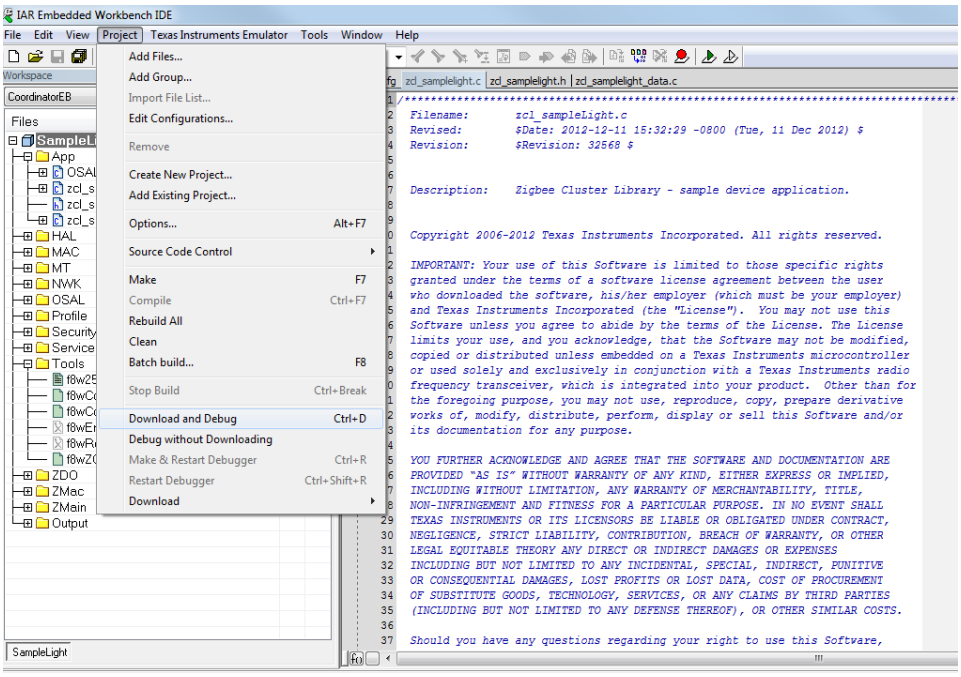


Figure 32: Downloading Sample Application

- After downloading to the CC2530EM/CC2538EM is complete, exit the debugging mode by pulling down the ***Debug*** menu and clicking on **Stop Debugging**:

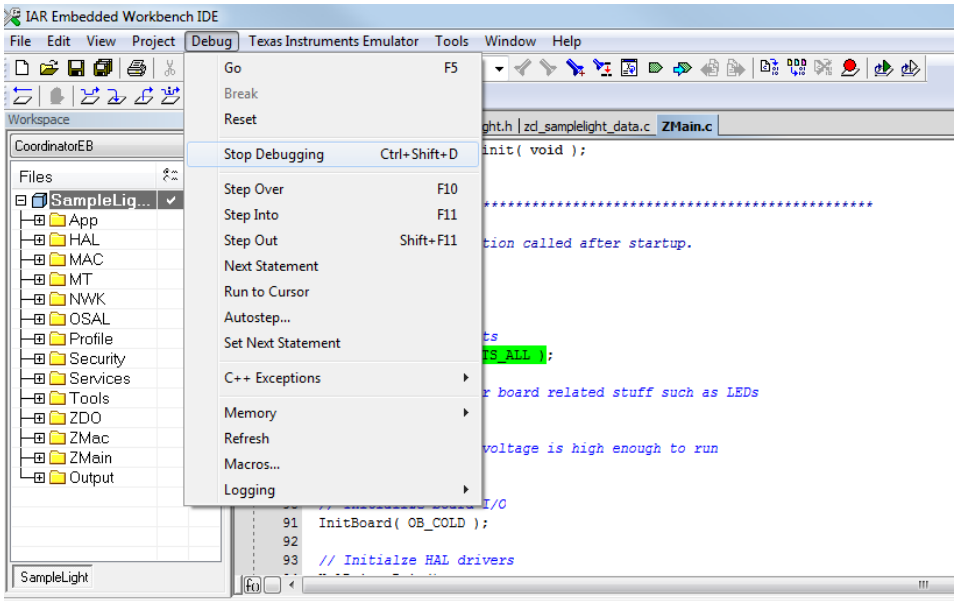


Figure 33: Stop Debugging

- Board must be reset after the code image is downloaded. Switch it off and on.

- Repeat this process for the SampleSwitch and other sample applications. Refer to **section 3.2** to verify associated applications.

3.2 Running Sample Applications

After compiling and programming the boards with their appropriate sample applications and after successful completion of commissioning procedure use these applications as follows:

3.2.1 SampleLight, SampleSwitch

ZigBee lights are usually powered from a constant power source, so they are generally configured as ZigBee Coordinators or Routers. ZigBee switches can be battery-powered devices, so they are generally configured as end devices.

The Sample Light and Sample Switch applications have the same app display functionality, only the toggle behavior changes:

Figure 34: Toggle Light Screen

- Sample Light - Toggles the local light.

- Sample Switch – Toggles all remote lights in its binding table with a unicast over-the-air message for each one of them.

<Toggle Light> Screen		
Joystick/Button	Functionality	Comment
LEFT / RIGHT	Menu navigation	Move to previous/next screen
OK	Select	Toggle local/remote light

Table 19: Toggle Light Screen

The LED usage of theses specific sample applications is as follow:

Sample Light LED usage		
LED Position	State	Comment
LED1	Off	Local or remote light is off
	Constantly On	Local or remote light is on

Table 20: Sample Light LED usage

Sample Switch LED usage		
LED Position	State	Comment
LED1	N/A	Not used in this application

Table 21: Sample Switch LED usage

3.2.2 SampleDoorLock, SampleDoorLockController

ZigBee door locks are usually powered from a constant power source, so they are generally configured as ZigBee Coordinators or Routers. ZigBee door lock controllers can be battery-powered devices, so they are generally configured as end devices.

The Sample Door Lock and Sample Door Lock Controller applications have the same app display functionality setting the PIN using the Change PIN Screen, and the way to use Toggle Lock Screen is used as follows:

- Sample Door Lock - Toggles the door lock.
- Sample Door Lock Controller - Toggles all remote door locks in its binding table with a unicast over-the-air message for each one of them.

Figure 35: Change PIN Screen

Figure 36: Toggle Lock Screen

<Change PIN> Screen		
Joystick/Button	Functionality	Comment
UP / DOWN	Value change	Increase / decrease the value of the PIN digit
LEFT / RIGHT	Menu navigation	Move to previous/next screen
OK	Select	Set new PIN digit

Table 22: Change PIN Screen.

<Toggle Lock> Screen		
Joystick/Button	Functionality	Comment
LEFT / RIGHT	Menu navigation	Move to previous/next screen
OK	Select	Toggle the local/remote door lock

Table 23: Toggle Lock Screen

The LED usage of these specific sample applications is as follow:

Sample Doorlock and Doorlock Controller LED usage		
LED Position	State	Comment
LED1	Off	Door lock state is off
	Constantly On	Door lock state is on

Table 24: Sample Doorlock and Doorlock Controller LED usage

3.2.3 SampleThermostat, SampleTemperatureSensor

Sample Thermostat

ZigBee thermostats are usually powered from a constant power source, so they are generally configured as ZigBee Coordinators or Routers. ZigBee temperature sensors can be battery-powered devices, so they are generally configured as end devices.

The Sample Thermostat allows viewing the report of current temperature of the last device that sent the over-the-air attribute report, and also allows changing the heating and cooling set point temperatures. The heating and cooling set points are the temperature values at which heating and cooling will activate, respectively.

Figure 37: Remote Temperature

<Remote Temp> Screen		
Joystick/Button	Functionality	Comment
LEFT / RIGHT	Menu navigation	Move to previous/next screen

Table 25: Remote Temperature Screen

Figure 38: Set Cooling Temperature Screen

<Set Cool Temp> Screen		
Joystick/Button	Functionality	Comment
UP / DOWN	Value change	Increase / decrease the value of the temperature cool point
LEFT / RIGHT	Menu navigation	Move to previous/next screen

Table 26: Set Cooling Temperature Screen

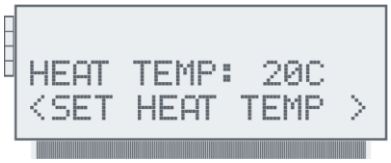


Figure 39: Set Heat Temperature Screen

<Set Heat Temp> Screen		
Joystick/Button	Functionality	Comment
UP / DOWN	Value change	Increase / decrease the value of the temperature heat point
LEFT / RIGHT	Menu navigation	Move to previous/next screen

Table 27: Set Heat Temperature Screen

The LED usage of this specific sample application is as follow:

Sample Thermostat LED usage		
LED Position	State	Comment
LED1	Off	Indicates that the cooling and heating system is currently off
	Constantly On	Indicates that the system is currently heating or cooling

Table 28: Sample Thermostat LED usage

Sample Temperature Sensor

The Sample Temperature Sensor allows viewing and changing the current temperature that the device will report to all devices in its binding table.

Figure 40: Set Local Temperature

<Set Local Temperature> Screen		
Joystick/Button	Functionality	Comment
UP / DOWN	Value change	Increase / decrease the temperature value
LEFT / RIGHT	Menu navigation	Move to previous/next screen

Table 29: Set Local Temperature Screen

The LED usage of this specific sample application is as follow:

Sample Temperature Sensor LED usage		
LED Position	State	Comment
LED1	N/A	Not used in this application

Table 30: Sample Temperature Sensor LED usage

3.3 Preserving Network Configuration

NV_RESTORE is turned on by default in CC2530 and CC2538 sample applications, so if any of the devices are power cycled, they will restore the network information stored in NVM.

3.4 Selecting the Channel of Operation

To change the channel of operation or to specify a channel mask, open the file f8wConfig.cfg within the application directory in the IAR project workspace.

Set the channel mask by defining DEFAULT_CHANLIST appropriately. For example, here the channel mask is set to only use channel 24.

```
-DDEFAULT_CHANLIST=0x01000000  // 24 - 0x18
```

Alternatively, in bdb_interface.h the channel mask can be configured by changing the BDB_DEFAULT_PRIMARY_CHANNEL_SET definition.

```
#define BDB_DEFAULT_PRIMARY_CHANNEL_SET                    DEFAULT_CHANLIST
```

4 Trust Center Joining

The ZigBee Specification R21 [6] requires that all devices share a default Trust Center Link Key and that the network key is delivered to joining devices secured with that link key.

The Default Global Trust Center Link Key is specified in the Base Device Behavior Specification [3] as:

```
Default global Trust     =    0x5a 0x69 0x67 0x42 0x65 0x65 0x41 0x6c
Center link key (0:15)        0x6c 0x69 0x61 0x6e 0x63 0x65 0x30 0x39
```

Users can also use a link key derived from an install code to create a unique Trust Center Link Key for joining, or use a discrete pre-configured Trust Center Link Key. This key must be pre-configured in a joining node before joining through the Trust Center.

4.1 Joining directly to the Trust Center

When a device joins the network and its parent is the Trust Center, the transport key command is encrypted with the default Trust Center Link key and is sent directly by the Trust Center:

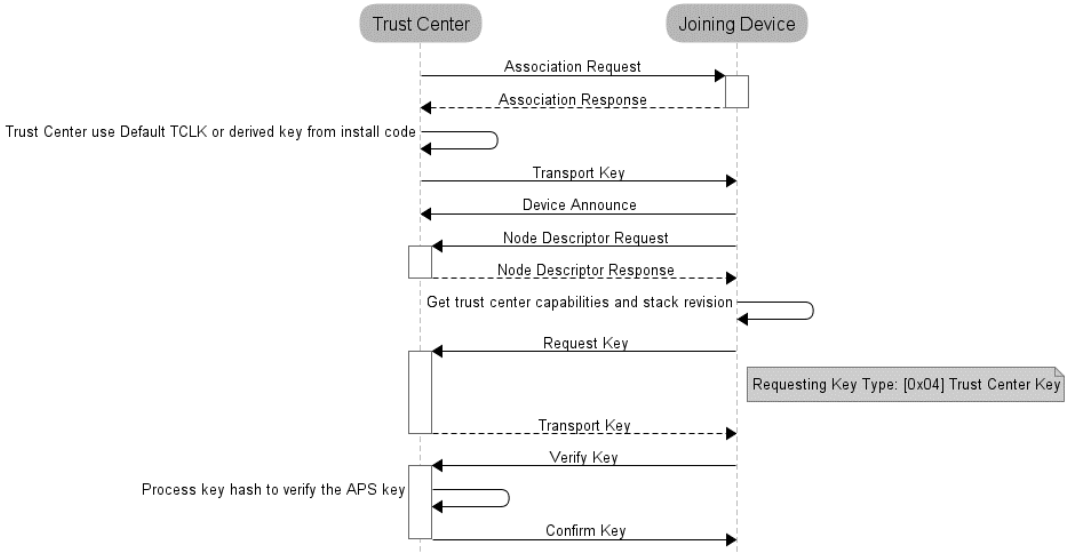


Figure 41: Joining directly to the Trust Center

4.2 Joining by intermediate Router

When a device joins the network but its parent isn't the Trust Center, the transport key command is tunneled from the Trust Center through the parent of the joining device.

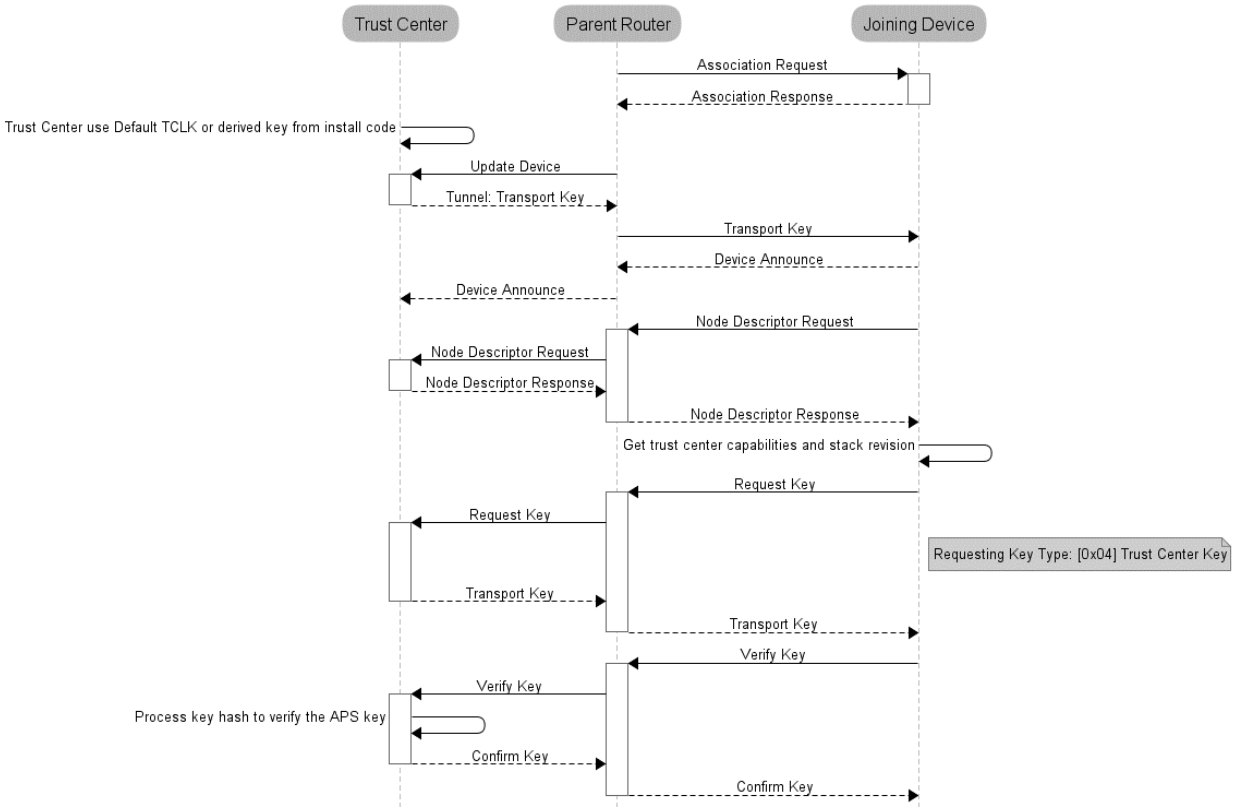


Figure 42: Joining the HA network via intermediate router

Update Device command is sent twice: once without APS encryption (Only NWK encryption is used), and once with APS encryption applied. This behavior is for backward compatibility with devices that do not support the APS encrypted Update Device command. For each of the two Update Device commands, the resulting Tunnel command is APS encrypted.

5 Distributed Joining

When a device joins to a distributed security network (no trust center), the network key will be delivered with the Distributed security global link key by the parent router device.

The Distributed security global link key is specified in the Base Device Behavior Specification [3] as:

```
Distributed Trust        =    0xd0 0xd1 0xd2 0xd3 0xd4 0xd5 0xd6 0xd7
Center link key (0:15)        0xd8 0xd9 0xda 0xdb 0xdc 0xdd 0xde 0xdf
```

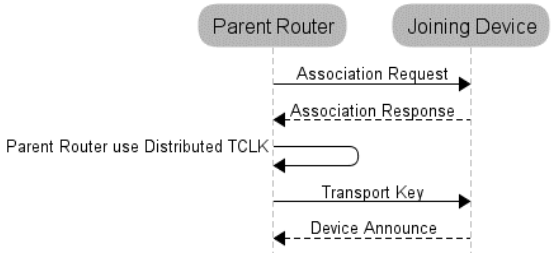


Figure 43: Joining a distributed network

6 Touchlink Joining

Touchlink commissioning is a distributed security joining that requires physical proximity and uses its own pre-configured link key. For further information refer to section 13.3.4.10.1 the ZigBee document 07-5123 ZigBee Cluster Library Specification Rev. 6 [2] and ZigBee document 13-0402-13 Base Device Behavior Specification Version 1.0. [3].

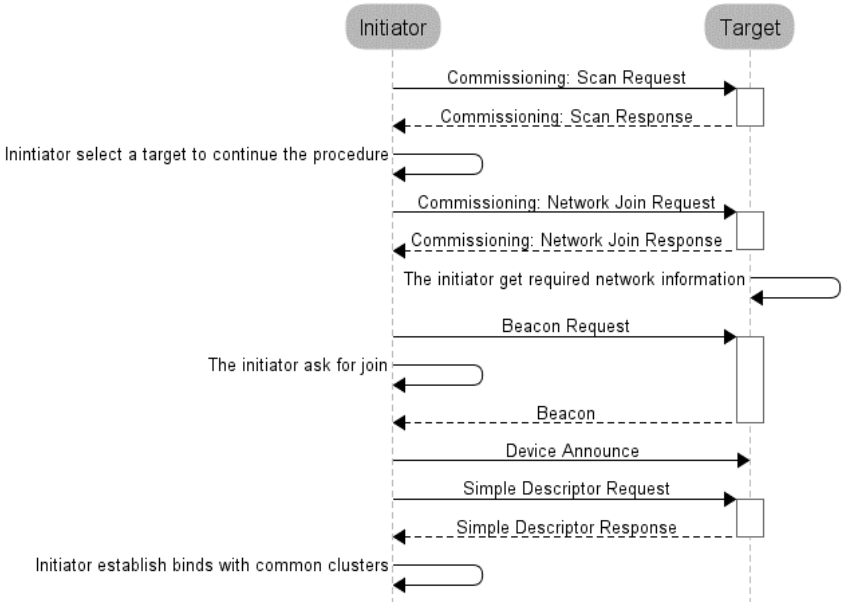


Figure 44: Joining with Touchlink commissioning (FN ZR Initiator and FN ZED Target)

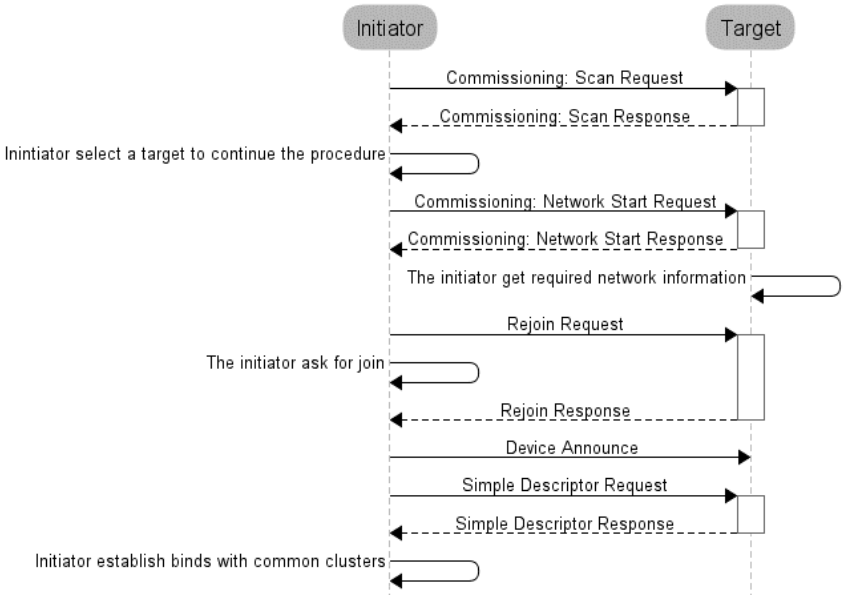


Figure 45: Joining with Touchlink commissioning (FN ZED Initiator and FN ZR Target)

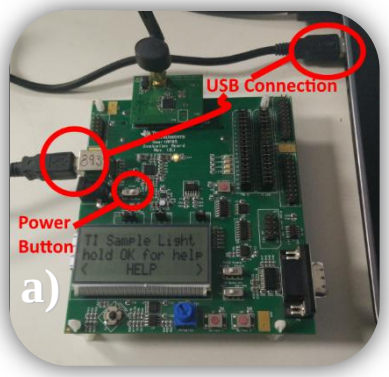
7 Quick Start Guide

This Quick Start section will focus on getting the Sample Light and Switch applications up and running on SmartRF05EB boards. The prerequisites are having two SmartRF05EB boards, two USB Type A to Type B cables, IAR Embedded Workbench for 8051, the Z-Stack 3.0 SDK installed. For this example, the Light device will be a Coordinator and the Switch device an End-Device.

1

Connect the boards

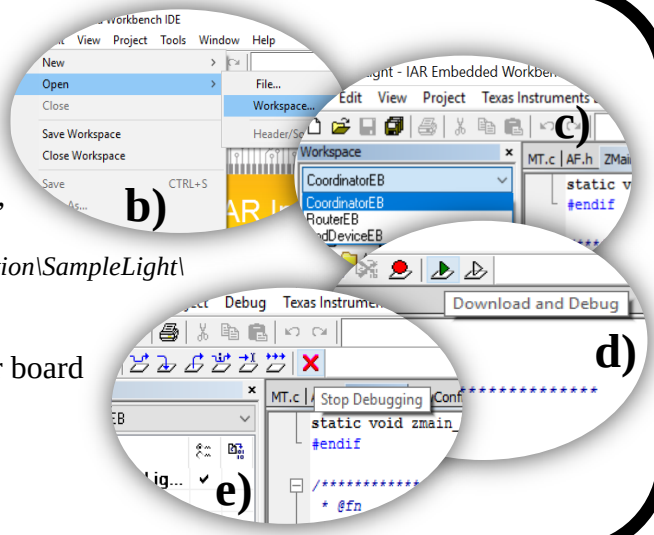
a) Connect the boards to the PC using USB cables and turn on the boards.



2

Configure a Sample Light Coordinator

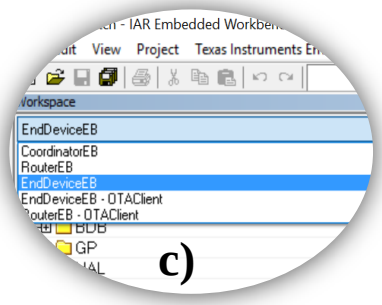
a) Open the IAR Embedded Workbench for 8051,
b) Open the SampleLight workspace located in *<Z-Stack Install Folder>\Projects\zstack\HomeAutomation\SampleLight\CC2530DB\SampleLight.eww*
c) Select the CoordinatorEB target,
d) Click on Download & Debug, select the proper board
e) Terminate Debugging



3

Configure a Sample Switch End-Device

a) Open the IAR Embedded Workbench for 8051,
b) Open the SampleSwitch workspace located in *<Z-Stack Install Folder>\Projects\zstack\HomeAutomation\SampleSwitch\CC2530DB\SampleSwitch.eww*
c) Select the EndDeviceEB target,
d) Click on Download & Debug, select the proper board
e) Terminate Debugging



4

Form network with the Coordinator

a) On the Coordinator board, move to the <Commissioning> Screen using the RIGHT button
b) Push the OK button to form a network on channel 11

5

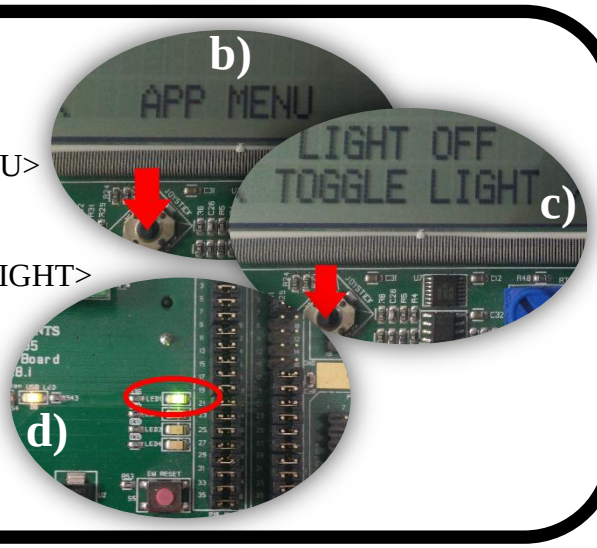
Join the End-Device board to network

a) In the End-device board, move to the <Commissioning> Screen
b) Push the OK button to join the network

6

Toggle the local light

a) On the Coordinator board, move to the <APP MENU> Screen using the RIGHT button
b) Push OK button to enter the menu
c) Press OK again multiple times on the <TOGGLE LIGHT> Screen
d) Notice that LED1 is turning on and off



7

Toggle the light remotely using the Switch

a) On the End-Device board, move to the <APP MENU> Screen using the RIGHT button
b) Push OK button to enter the menu
c) Press OK again multiple times on the <TOGGLE LIGHT> Screen
d) Notice that the Coordinator's LED1 is turning on and off