NXP Semiconductors
User's Guide

Document Number: KW01RCDUG
Rev. 0, 10/2016

Sub-GHz RC Dimmer Using IEEE 802.15.4

1. Introduction

This document explains the features and usage of the Sub-GHz Remote Control Dimmer reference design, which uses the KW01 device. It does not contain software or hardware descriptions.

See the Board User's Guide or Design Guide for hardware and software descriptions.

2. Audience

This manual is intended for any person interested in understanding the functionality of the Sub-GHz RC Dimmer reference design

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Contents

3. Overview of Reference Design

The Sub-GHz Remote Control Dimmer reference design demonstrates the functionality of the MKW01Z128 MCU working in a custom IEEE 802.15.4 star network. This reference design is focused on a home automation application where the user is able to control various devices connected into a network using the KW01-RCD-RD board as a remote control.

The controlled device is a bulb simulated in a graphical user interface (GUI).

KW01-RCD-RD is a custom hardware configured as a low power IEEE 802.15.4 end device, which establishes communication with a USB-KW019032 board configured as the IEEE 802.15.4 coordinator device that is in charge of creating the network and managing associations of all the devices on it.

Multiple USB-KW019032 IEEE 802.15.4 routers can establish connection with the USB-KW019032 coordinator and, therefore, creating a star network. This custom star network is configured to support a maximum of four routers.

Each bulb in the network is simulated with a GUI and it establishes connection to its corresponding USB-KW019032 device through the Freescale Serial Communication Interface (FSCI) which is a custom protocol to interface with the 802.15.4 SW stack.

Sub-GHz technology has some advantages over other wireless technologies such less data traffic in its respective ISM band. Sub-GHz RC Dimmer and remaining devices, coordinator, routers, and end node are configured to work on the 915MHz ISM band, in the Americas region.

The following figure shows a general block diagram of the system implementation.

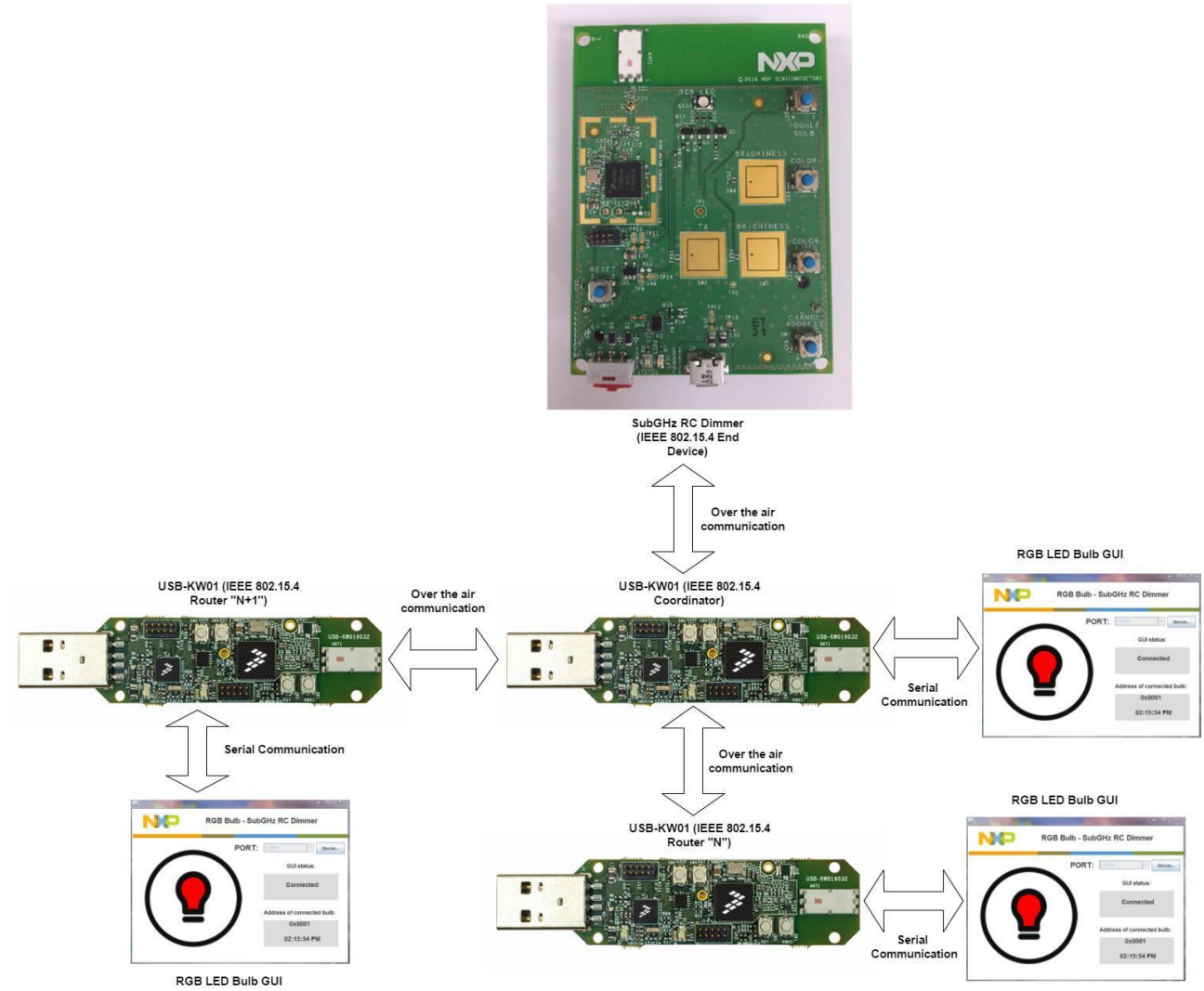

Figure 1. Sub-GHz RC dimmer star network

3.1. Get to know the Sub-GHz RC Dimmer reference design

The following figure highlights the most relevant parts of the hardware.

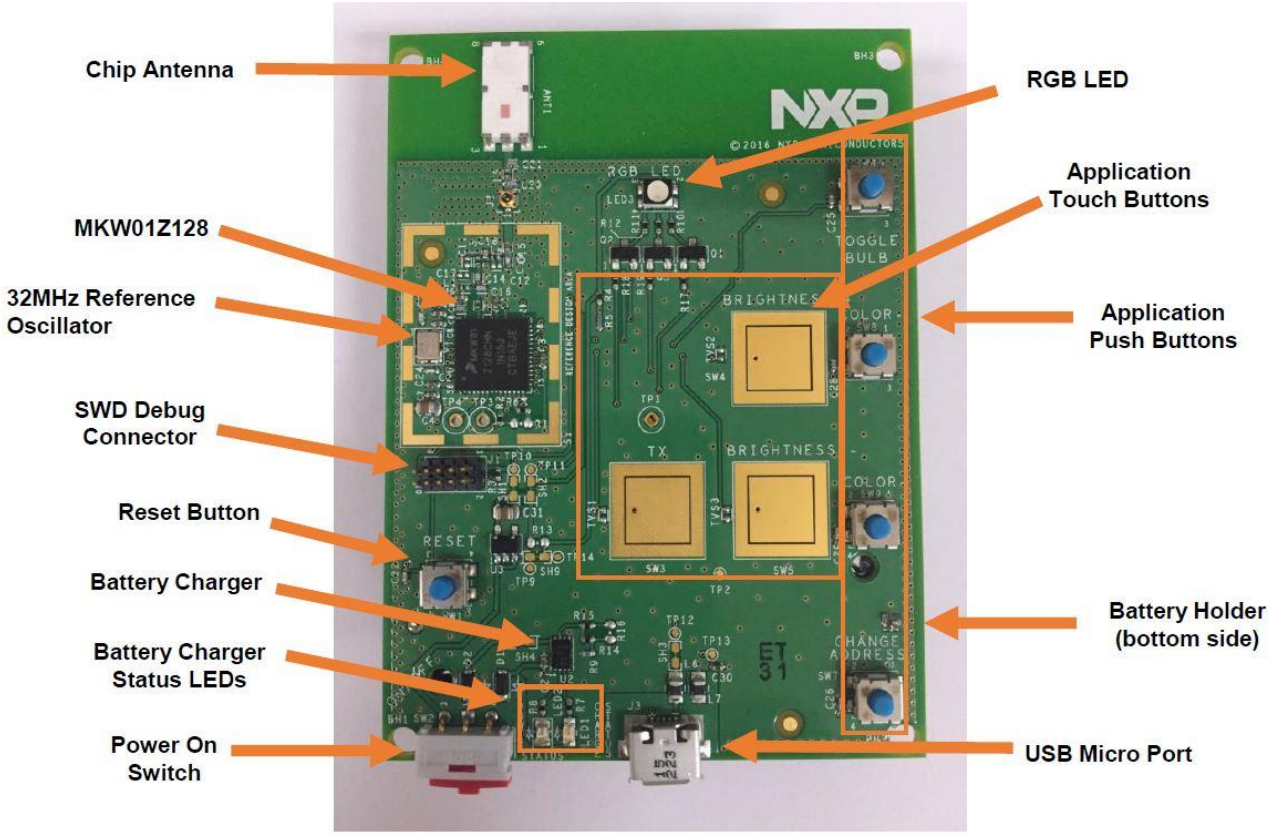

Figure 2. KW01-RCD-RD components

4. Set Up

This chapter describes how to set up the Sub-GHz RC Dimmer reference design.

4.1. Powering Sub-GHz RC Dimmer

The KW01-RCD-RD development platform can be powered using a 3.7 V 1200 mAh rechargeable lithium battery as shown in the following figure.

Figure 3. Powering the board using a battery

The KW01-RCD-RD also supports an external power supply via micro-USB port in case as shown in the following figure. The green LED will turn on indicating power presence in the USB micro port.

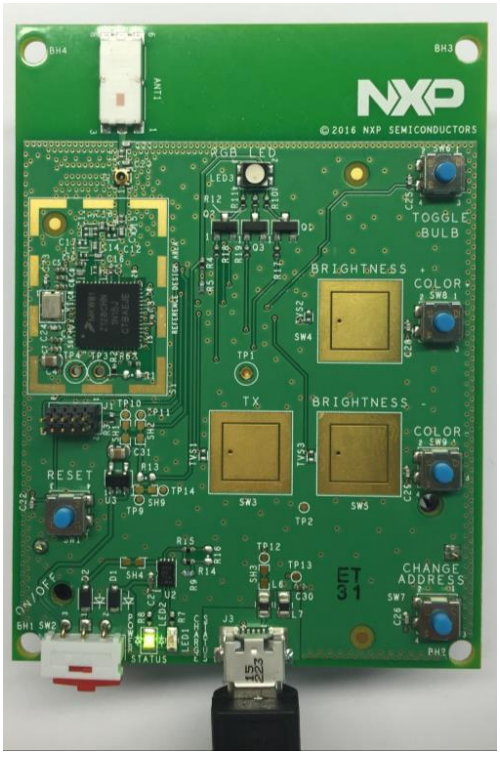

Figure 4. Powering the board using a USB micro port

To recharge the battery, it needs to be inserted into the battery holder and USB connected to a computer or wall plug-in (not included). The green LED (LED2) will turn on indicating power presence in the

USB micro port, and the red LED (LED1) will turn on when charge is complete, as shown in the following figure.

Figure 5. Battery is fully charged

4.2. IEEE 802.15.4 network creation

Use the power on switch SW2 to switch on the board. The RGB LED (LED3) in KW01-RCD-RD will start flashing indicating that it is searching for a coordinator to establish a connection. The IEEE 802.15.4 coordinator device must be powered on, as well as the IEEE 802315.4 router devices to create the network. The RGB LED will stop flashing after the board establishes a connection with the coordinator. The coordinator and routers are all USB-KW019032 boards, but with different firmware loaded.

Connect the coordinator USB-KW019032 to a PC. The blue LED (D12) will start blinking indicating the coordinator is creating the network, it will stop once the connection is established.

The RGB LED in the KW01-RCD-RD board will turn off indicating that it is associated to the coordinator.

Finally, you must connect the desired number of USB-KW019032 router devices to the PC, each following USB-KW019032 will be counted as one router. The blue LED (D12) on each USB-KW019032 router will start blinking indicating the board is searching for the coordinator, it will stop blinking after the router is associated with the coordinator.

The following figure shows the coordinator, end device, and four routers associated in a IEEE 802.15.4 network.

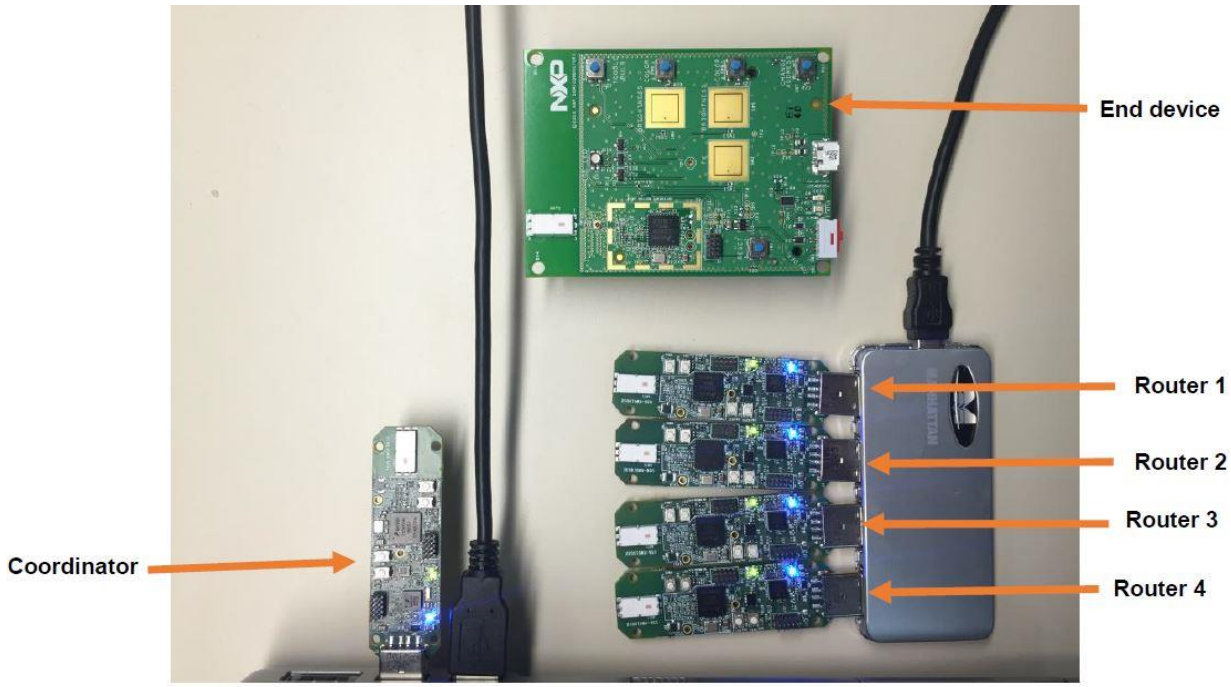

Figure 6. IEEE 802.15.4 devices connected

The coordinator short address is always 1. When the first router associates with the coordinator, this is assigned to the short address 2, the next router is 3, and so on successively with all other connected routers. The following table shows the short address of the RGB bulb devices in the network.

Table 1. Device's short address

Device name	Short address
Coordinator	1
Router 1	2
Router 2	3
Router 3	4
Router 4	5

Routers send keep alive message every time period to indicate the coordinator they continue alive. When a router is disconnected from the network, the coordinator will detect that there are not keep alive messages and it will delete the router from the neighbors table. Once the router is reconnected, the coordinator will add this device again to the neighbors table.

4.3. GUI connection

Open an RGB Bulb – Sub-GHz RC Dimmer GUI for each USB-KW019032 (coordinator and routers) connected in the network. Select the appropriated port and click on "connect" button in each GUI. The following figure shows the GUI in disconnection state and Figure 8 shows the GUI in connection state.

Now you are ready to start using the application.

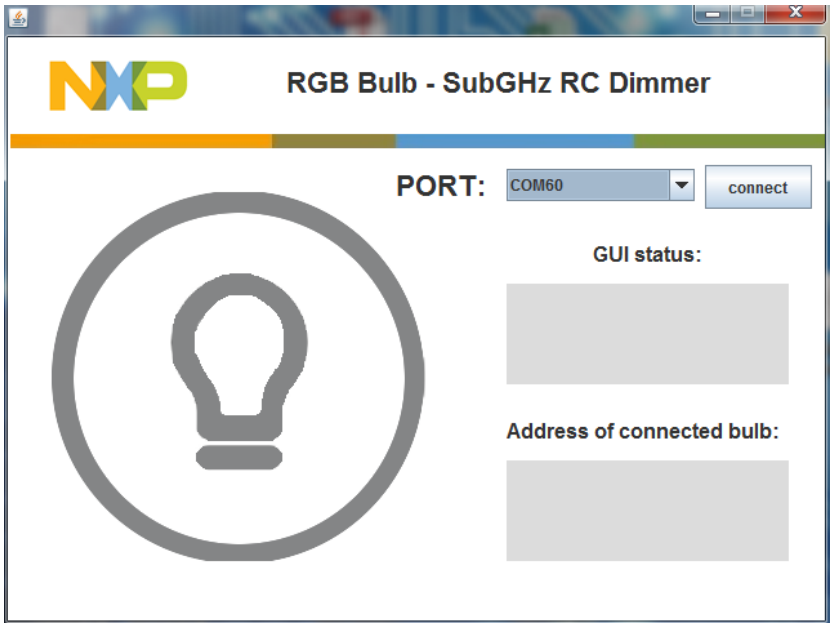

Figure 7. RGB Bulb GUI disconnection state

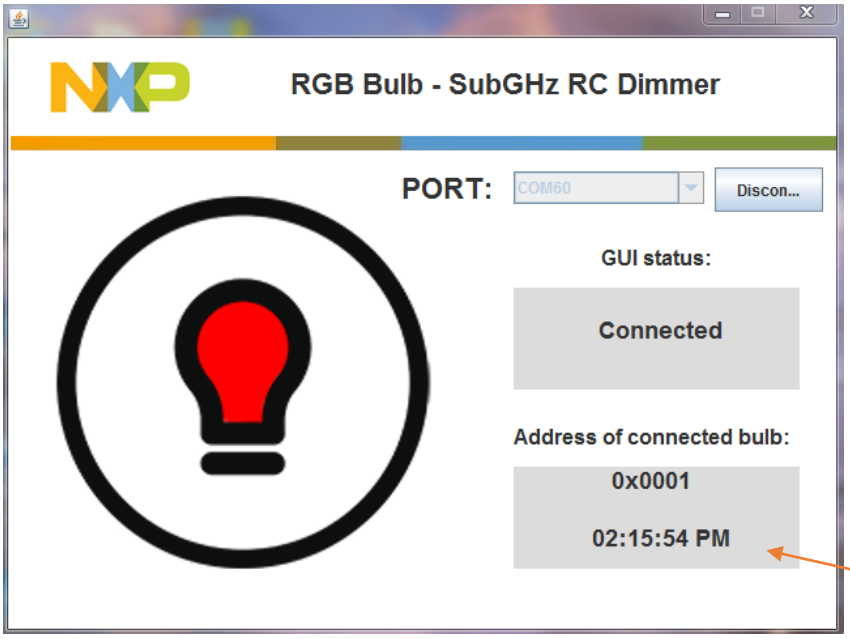

Figure 8. RGB Bulb GUI connection state

5. Functional Description

This chapter describes the functionality of the Sub-GHz RC Dimmer.

5.1. Low power

The KW01-RCD-RD development platform is programmed to go into low power mode (LLS) after one minute of inactivity. Red color in RGB LED will blink indicating the board is entering in low power mode as shown in the following figure.

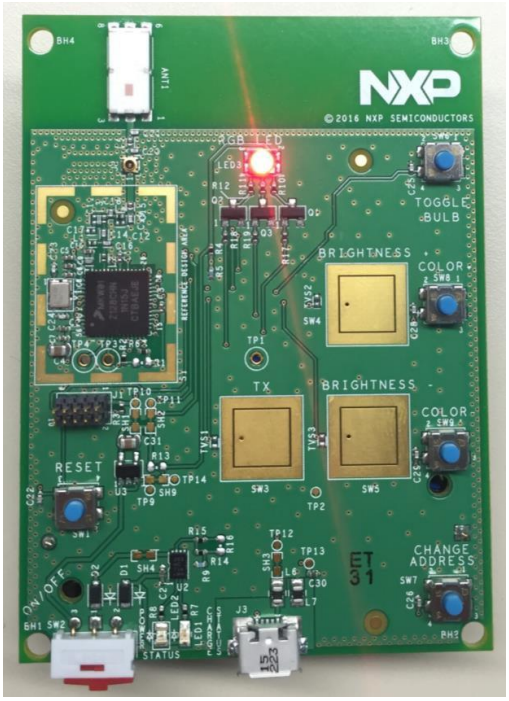

Figure 9. KW01-RCD-RD entering into low power mode by timer

The KW01-RCD-RD is also programmed to enter into low power mode by holding and releasing SW6 application's button, the red color will blink and the MWK01Z128 device will enter low power mode.

MKW01Z128 in this specific scenario is programmed to wake up from GPIO source. Press any application push button (SW6, SW7, SW8, or SW9) to exit from low power mode; Green color in RGB LED (LED3) will blink as shown in the following figure, indicating that KW01-RCD-RD is in run mode.

Figure 10. KW01-RCD-RD waking up from low power mode

If MCU current measurements are needed, cut SH1 and connect a multimeter in series. The following figure shows the power management section in the schematics, before and after making board modifications to take current measurements.

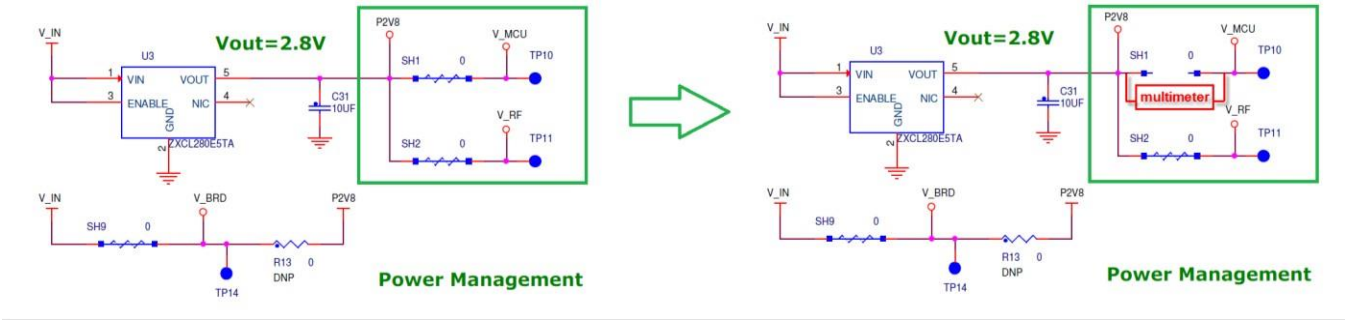

Figure 11. Modifications to take current measurements in KW01-RCD-RD

5.2. Controlling the application

The application works in two modes of operation. Mode 1 allows the user to control the network configuring static colors in the RGB Bulb GUI or mode 2 starts a color sequence in GUI.

5.2.1. Application buttons

The KW01-RCD-RD development platform contains 7 application buttons, 4 of them are push buttons and 3 touch buttons electrodes to interact with the application.

Some of these application buttons keeps same functionality in both modes of operation, but there are other application buttons that change its functionality depending on the operational mode configured. There are also functionalities that are activated with a long press in push buttons.

The following table shows a summary of the application buttons functionality in both operation modes.

Table 2. Application buttons functionality

Application button	Silkscreen	Button type	Operation mode 1	Operation mode 2
SW3	TX	Touch button	Toggle mode	Toggle mode
SW4	BRIGHTNESS +	Touch button	Increment brightness	No effect
SW5	BRIGHTNESS -	Touch button	Decrement brightness	No effect
SW6 (short press)	TOGGLE BULB	Push button	Toggle bulb	Toggle bulb
SW6 (long press)	TOGGLE BULB	Push button	Configure MCU into low power mode	Configure MCU into low power mode
SW7 (short press)	CHANGE ADDRESS	Push button	Change address	Change address
SW7 (long press)	CHANGE ADDRESS	Push button	No effect	No effect
SW8 (short press)	COLOR +	Push button	Increment color from predefined list	Increment time interval between colors
SW8 (long press)	COLOR +	Push button	Configure default values	Configure max time limit
SW9 (short press)	COLOR -	Push button	Decrement color from predefined list	Decrement time interval between colors
SW9 (long press)	COLOR -	Push button	No effect	Configure min time limit

5.2.1.1. Toggle mode “SW3”

The application touch button SW3 will toggle operation mode between mode 1 and mode 2.

When mode 1 is selected, magenta color will blink once in the RGB LED as shown in the following figure. A static red color will be set in the RGB LED Bulb GUI when this mode is selected.

Figure 12. Mode 1 selected

When mode 2 is selected, the yellow color will blink once in RGB LED as shown in the following figure. The color sequence will start automatically in the RGB Bulb GUI after selecting this mode. The default time interval is 1 second.

Figure 13. Mode 2 selected

5.2.1.2. Change brightness “SW4” and “SW5”

The application touch button SW4 and SW5 will change RGB Bulb brightness only in mode 1. Pressing SW4 and SW5 in mode 2 will have no effect.

Every time SW4 or SW5 are pressed, the RGB LED in KW01-RCD-RD will blink red indicating that the brightness level was incremented/decremented 10%. The following figure shows a user pressing SW4 to increment the red color brightness.

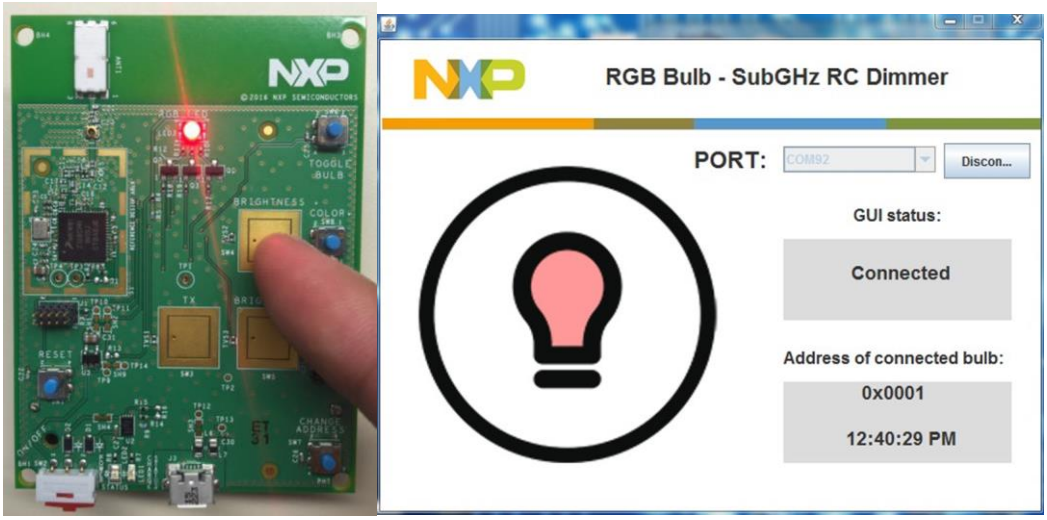

Figure 14. User incrementing red color brightness

Press SW4 several times to increment brightness and press SW5 to decrement brightness. The following figure shows the RGB Bulb brightness level changed from 0% to 100%.

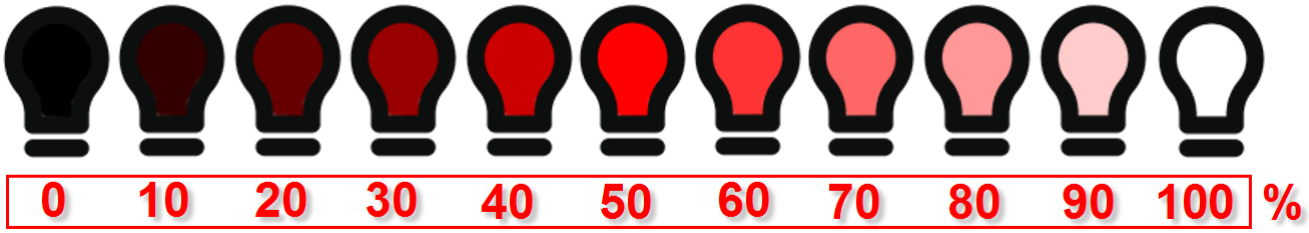

Figure 15. RGB Bulb brightness from 0% to 100%

5.2.1.3. Toggle bulb “SW6” (short press)

The application push button SW6 will toggle the RGB bulb in GUI. The RGB LED (LED3) in KW01-RCD-RD will blink its white color indicating that this button has been pressed. The following figure shows a user toggling the RGB bulb in GUI by pressing SW6.

Figure 16. User toggling RGB bulb in GUI

5.2.1.4. Change address “SW7” (short press)

The application push button SW7 changes the destination address of the messages sent by the KW01-RCD-RD. This means that the user can select which RGB bulb in the network will be controlled.

The RGB LED (LED3) in KW01-RCD-RD will blink blue the number of times of the RGB bulb device short address, for example if it toggles 3 times it means that router 2 is now being controlled (short address 3). Refer to Table 1 to see the short addresses of RGB bulb devices.

A broadcast address to control all RGB bulbs at the same time is set as the destination address in KW01-RCD-RD by pressing SW7 as the last option after controlling the last device in the network. The RGB LED in KW01-RCD-RD will perform a blue long blink indicating broadcast address is the new destination address, as shown in the following figure.

Figure 17. User changing KW01-RCD-RD destination address

5.2.1.5. Change color and change time interval “SW8” and “SW9” (short press)

Application push buttons SW8 and SW9 have different functionality in the different operation modes when a short press occurs.

In operation mode 1, SW8 and SW9 are used to change the RGB bulb color for a predefined color list, refer to the following table to see the predefined color list. The RGB LED in the KW01-RCD-RD board will blink indicating the color configured in RGB bulb GUI.

Table 3. Predefined color list

Color list number	Predefined color
0	Red
1	Green
2	Yellow
3	Blue
4	Magenta
5	Cyan

In operation mode 2, SW8 and SW9 are used to change time interval between colors. Use SW8 to increment time interval in 250 milliseconds steps (colors changing slower) and SW9 to decrement it (colors changing faster). The red color in the board will blink for this option.

When time interval is configured into the minimum limit value (0 seconds) or maximum limit value (1 minute), the red color in KW01-RCD-RD board will blink twice indicating these limits.

5.2.1.6. Configure MCU into low power mode “SW6” (long press)

The MKW01Z128 device will be configured into low power mode with a SW6 long press, and woken up with any application push button as described in section 5.1, Low power.

5.2.1.7. Configure default values and configure maximum time limit “SW8” (long press)

When a long press occurs in SW8 and KW01-RCD-RD is configured in operation mode 1, then HSL values in bulb GUI will be set with default values (red color at 50% brightness and saturation at 100%), the red color will blink once.

If KW01-RCD-RD is configured in operation mode 2, then the interval time of the color sequence in GUI will be set to maximum value (60 seconds), the red color will blink twice.

5.2.1.8. Configure minimum time limit “SW9” (long press)

When a long press occurs in SW9 and KW01-RCD-RD is configured in operation mode 2, then the interval time of color sequence in GUI will be set to minimum value (0 seconds), the red color will blink twice.

In operation mode 1 this option has no effect.

6. Loading Firmware

This chapter describes the firmware download process for the coordinator, router, and end devices in the Sub-GHz RC Dimmer IEEE 802.15.4 network.

6.1. USB-KW019032 coordinator and routers firmware

The USB-KW019032 includes OpenSDAv2.1 (CMSIS-DAP), a serial and debug adapter circuit that includes mass storage device functionality to load binary (.bin) files into the MKW01Z128 MCU.

Connect your USB-KW019032 to your PC, the drag and drop the desired binary file into MBED disk using the MSD capabilities of the CMSIS-DAP. The following figure shows how to load a binary file loaded into a USB-KW019032.

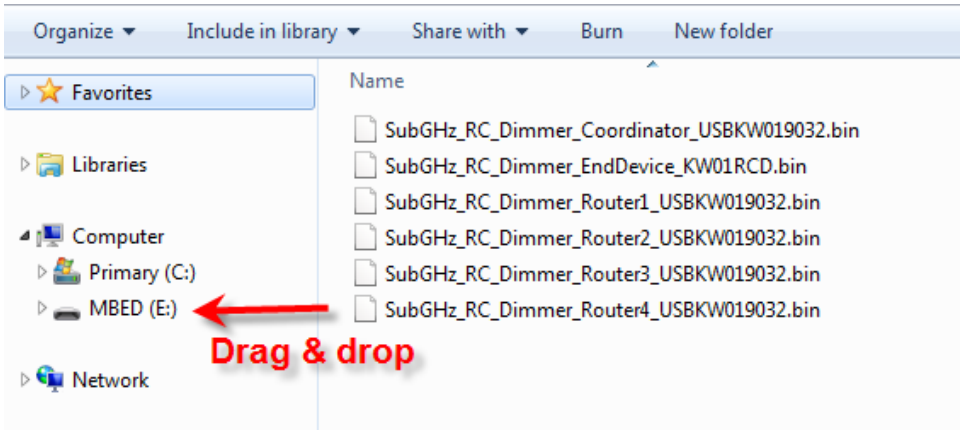

Figure 18. Loading firmware to USB-KW019032 through CMSIS-DAP's MSD capability.

6.2. KW01-RCD-RD firmware

If a firmware update is required, a new version can be downloaded using a J-link programmer.

6.2.1. Prerequisites

The following list details the required elements for the download process:

1. Download and install the latest J-Link software from www.segger.com.
2. J-Link debugger.
3. SubGHz_RC_Dimmer_EndDevice_KW01RCD.bin file with the latest firmware.

6.2.2. Download process

The following steps explain the downloading process for the firmware.

1. Copy the SubGHz_RC_Dimmer_EndDevice_KW01RCD.bin file to the J-Link software installation folder. It is typically located in C:\Program Files\SEGGER for 32-bit systems and C:\Program Files (x86)\SEGGERfor 64-bits systems.
2. Make sure the board is powered properly (see section 4.1, Powering Sub-GHz RC Dimmer).
3. Connect the J-Link debugger to the SWD header in the board as shown in the following figure.

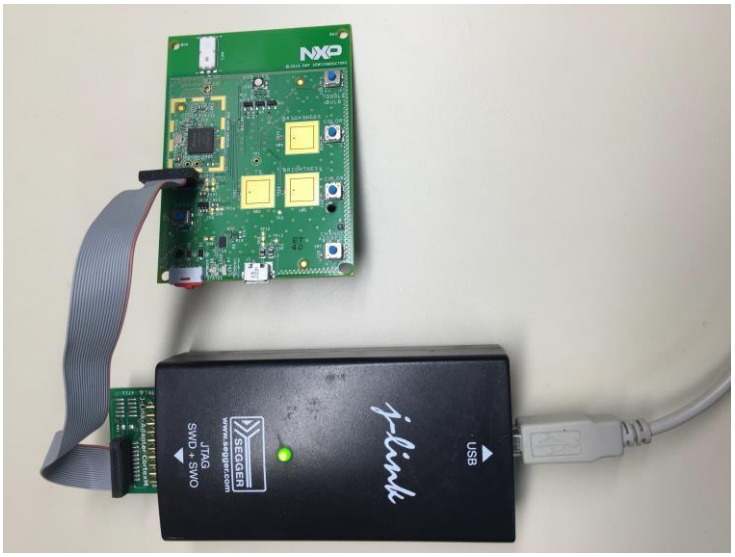

Figure 19. J-Link connection

4. Make sure that you have the J-Link debugger connected. In the J-Link software installation folder, execute the program JLink.exe. A terminal window will open (see the following figure).

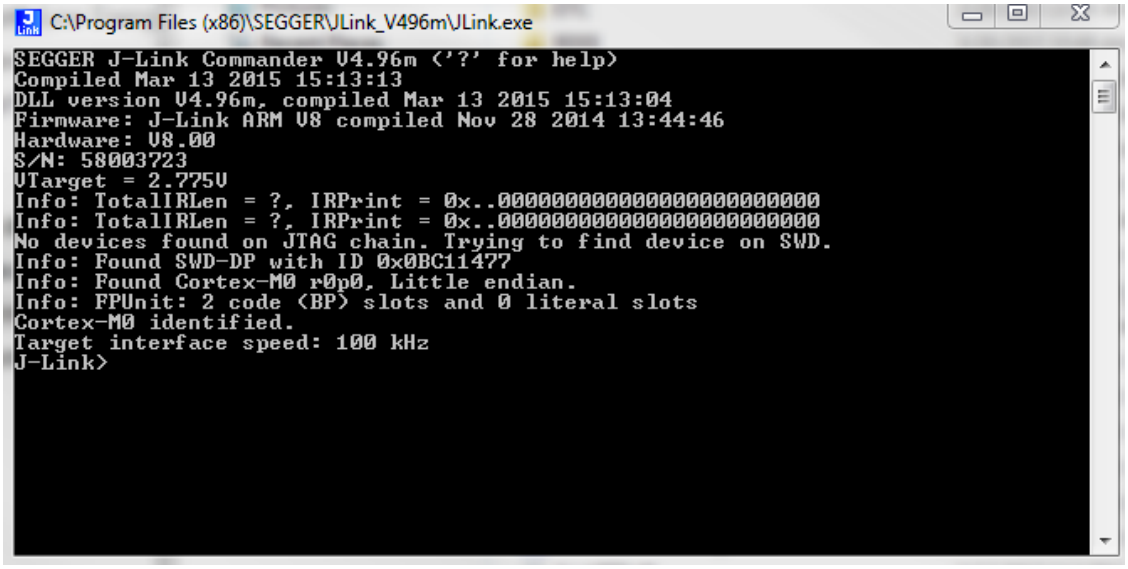

Figure 20. J-Link.exe terminal

5. Type the following instructions and press the enter key.
   - device MKW01Z128xxx4
   - loadbin SubGHz_RC_Dimmer_EndDevice_KW01RCD_us.bin 0
6. Wait for the board to flash (see the following figure).

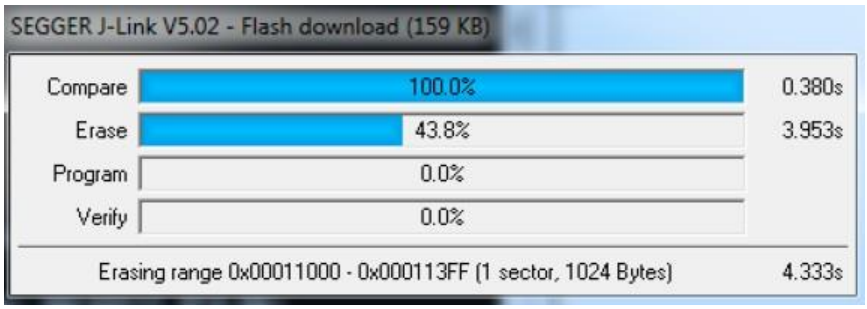

Figure 21. Board flashing

7. Power off the board and turn it on again to start using the device.

7. Revision History

Table 4. Revision history

Revision number	Date	Substantive changes
0	10/2016	Initial release

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Document Number: KW01RCDUG
Rev. 0
10/2016