Si4455-2WayLink-DEMO

Si4455 EZRadio® Two-Way Link Demo Kit User's Guide

1. Overview

Thank you for your interest in Silicon Laboratories Si4455 EZRadio® Two-Way Link Demo Kit. The Silicon laboratories Si4455 EZRadio Two-Way Link Demo Kit (P/N EZR-LEDK2W-XXX) contains everything you need to familiarize yourself with and evaluate the Si4455 transceiver. The kit has three versions: one for the 434 MHz band, one for the 868 MHz band, and one for the 915 MHz band. The key features of the demo kit are as follows:

- The demo boards have four LEDs to display information and four push-buttons to receive user commands.
- The provided software pack contains all the documentation and files needed to develop a user application.
- The kit supports the use of the Silicon Laboratories Integrated Development Environment (IDE) for software debugging and the use of the Keil & SDCC C compiler, assembler, and linker toolchain.
- The kit supports the use of the Wireless Development Suit (WDS) for setting radio parameters & managing application firmware.
- The demo boards come with the Si4455 range test demo application. The range test demo implements Packet Error Rate (PER) measurement. PER is a commonly-used technique for measuring the quality of RF links in wireless systems under particular conditions.

1.1. Kit Contents

Table 1. Kit Contents

Qty	Part Number	Description
	EZR-LEDK2W-434	**Si4455 EZRadio Two-Way Link Demo Kit 434 MHz**
2	4455-LED-434-PER	Si4555 RFStick 434 MHz EZRadio transceiver board
2	Toolstick_BA	Toolstick Base Adapter
2	USB-XTEN-01	USB extender cable (USBA-USBA)
4	AAA	AAA alkaline battery
	EZR-LEDK2W-868	**Si4455 EZRadio Two-Way Link Demo Kit 868 MHz**
2	4455-LED-868-PER	Si4555 RFStick 868 MHz EZRadio transceiver board
2	Toolstick_BA	Toolstick Base Adapter
2	USB-XTEN-01	USB extender cable (USBA-USBA)
4	AAA	AAA alkaline battery
	EZR-LEDK2W-915	**Si4455 EZRadio Two-Way Link Demo Kit 915 MHz**
2	4455-LED-915-PER	Si4555 RFStick 915 MHz EZRadio transceiver board
2	Toolstick_BA	Toolstick Base Adapter
2	USB-XTEN-01	USB extender cable (USBA-USBA)
4	AAA	AAA alkaline battery

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Figure 1. Si4455 RFStick 434 MHz Transceiver Board (P/N 4455-LED-434-PER)

Figure 2. Toolstick Base Adapter (P/N Toolstick_BA)

For more information on using the RFstick and the Toolstick Base Adapter together to develop your own application please refer to the “AN692: Si4355/Si4455 Programming Guide and Sample Code.”

The demo boards come with the Si4455 range test demo application; however, be sure to use the latest version of the application. The user can update the firmware on the boards using the firmware update functionality of the WDS. For more information on updating the firmware, refer to the "WDS User's Guide for EZRadio Next Generation".

2. Range Test Demo

2.1. Basics

As it was stated above range test demo is used to provide measured results on the quality of the RF link.

The demo uses two RFstick one of them as the ‘transmitter’ (TX) other as the ‘receiver’ (RX). Both RFsticks can be either transmitters or receiver.

The transmitter sends packets to the receiver repeatedly with half second interval. The packet includes address of the transmitter and number of the sent packet. The packet number increments from packet to packet.

The receiver receives the packet and checks its address. If their addresses match packet number is stored. The receiver then sends back an acknowledge packet (ACK) to the transmitter. ACK packet also includes the address and the packet number of the received packet.

PER can be calculated with the following equation:

$$PER = \frac{P_{TX} - P_{RX}}{P_{TX}} \times 100$$

Where:

PER is the packet error rate (%)

P_{TX} is the number of sent packets

P_{RX} is the number of received packets

The transmitter can calculate PER using the following data:

- P_{TX} is the packet counter to be included in the packet
- P_{RX} is the number of all the received acknowledge packets

The receiver can calculate PER using the following data:

- P_{TX} is the packet number included in the last received packet
- P_{RX} is the number of all received data packets

2.2. RF and Demo Parameters

This section provides information on the user parameters of the range test demo. All the parameters (excluding frequency band) can be changed in the demo through its menu system (see "2.4. Menu System of the Range Test Demo" on page 6). The following parameters are available:

- Frequency band (defined by the HW)
- Communication frequency (selected by the user)
- Node address (selected by the user)
- Modulation (selected by the user)
- Data rate (selected by the user)

Demo settings are stored in the MCU’s flash memory and restored after power on reset. Default values are loaded if no settings were previously stored in the flash.

It is also possible to define custom RF parameters for communication. Custom parameters can be stored with the Wireless Development Suit (WDS). For more information on creation and storage of custom parameters, refer to the WDS User’s guide for EZRadio Next Generation.

2.3. Frequency and Frequency Bands

The RFstick provides RF matching solutions for all supported frequency bands. Different HW solutions are required for each frequency bands. Range test demo automatically reads required frequency band information from the on board EEPROM and selects the appropriate frequency range.

Silicon Labs provides Si4455 Two-Way Link Demo Kits for the following frequency bands:

- Middle band: 425–525 MHz
- High band: 850–960 MHz

Range test demo provides four different selectable frequencies in all the supported bands. In case of custom parameters are stored the custom frequency can also be selected, but only in the defined frequency band. Table 2 lists the available frequencies.

Table 2. Available Frequencies

		Freq. band	
		Middle	**High**
Frequency Number	**0**	Custom	Custom
	1	433.92 MHz	867.84 MHz
	2	434.15 MHz	868.30 MHz
	3	458.50 MHz	917.00 MHz
	4	475.00 MHz	950.00 MHz

2.3.1. Node Address

Each node using the range test demo can select from 16 different addresses (0-15). Transmitter and receiver of the same link have to use the same addresses. It is advised to use only one link (one transmitter and one receiver) with the same address within close proximity, otherwise the different systems will disturb each other.

2.3.2. Modulation

User can select from three types of modulation:

- GFSK with high precision TX crystal (TX: 30 ppm, RX: 30 ppm)
- GFSK (TX: 150 ppm, RX: 30 ppm)
- OOK

2.3.3. Data Rate

User can select from three different data rates. In case of custom settings are stored the custom data rate can also be selected. Table 3 lists the available data rates.

Table 3. Available Data Rates

		Modulation	
		GFSK (both types)	**OOK**
Data Rate Number	**0**	Custom	Custom
	1	9.6 kbps	2.4 kbps
	2	38.4 kbps	9.6 kbps
	3	128.0 kbps	20.0 kbps

2.3.4. Custom Parameters

As it was stated above user can store custom RF parameters into the devices with WDS. One custom field is available in each node. If any of the three RF parameters (frequency, modulation, data rate) is set to custom both the other parameters are configured to be custom as well.

Notes:

- The firmware drops an error message and continues with default parameters if no custom field is stored, but custom parameter is selected.
- The firmware goes to error state if the frequency band of the custom settings mismatches with the frequency band of the device.

2.3.5. Default Demo Settings

The default demo settings are as follows:

- Frequency band: **defined by the HW**
- Frequency number:
  - Middle band: **1**
  - High band—868 MHz: **2**
  - High band—915 MHz: **4**
- Node address: **5**
- Modulation: **High precision GFSK**
- Data rate number: **1** (FSK: 9.6 kbps, OOK: 2.4 kbps)

2.4. Menu System of the Range Test Demo

Range test demo provides a light-weight menu system (using switches, push-buttons and LEDs of the RF stick) to control demo states and set parameters. The user can change the state of the demo through the menu system with push-buttons. The actual state of the demo is shown on the LEDs. Switches are used as inputs during parameter selection.

The following abbreviations are used:

- PBx: push-button x (x: 1–4)
- SWx: switch x (x: 1–4)
- LEDx: LED x (x: 1–4)

Figure 3 shows the menu system and the available transitions.

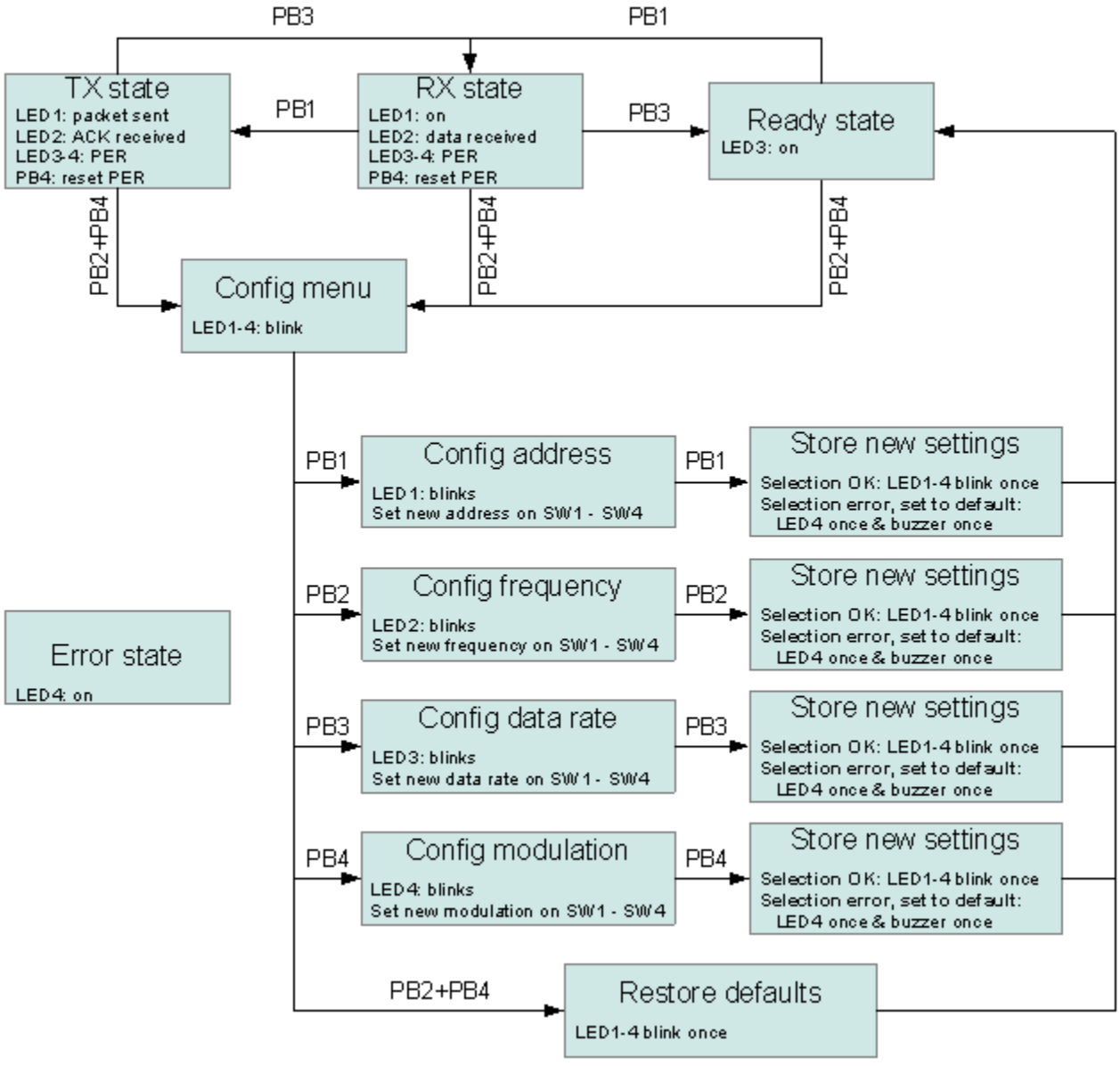

Figure 3. Range Test Demo Menu System

2.4.1. Menu States

2.4.1.1. Ready State

In Ready state the demo waits for command.

This is the default state of the demo. The demo starts in Ready state after switched on and goes to Ready state after leaving the configuration menu. PB1 can push the demo to RX state.

State display:

- LED3 is on
- LED1-LED2 and LED4 is off by default

Option:

- PB1: switches to RX state

2.4.1.2. RX State

In RX state the node waits for incoming packets with the same node address. If packet is received it sends ACK packet and recalculates the PER.

State display:

- LED1 is on
- LED2–4 is off by default
- LED2 blinks if packet received
- LED3 & LED4 shows the actual PER (see Table 4)
- Buzzer informs about actual PER (see Table 4)

Table 4. Packet Error Rate on the LEDs and Buzzer

	LED3	LED4	Buzz
PER < 1%	off	off	off
PER > 1%	on	off	1 Hz
PER > 5%	off	on	2 Hz
PER > 20%	on	on	on

Options:

- PB1: switches to TX state
- PB3: switches to Ready state
- PB4: resets PER (only receiver's PER will be reset)
- PB2 + PB4: switches to the configuration menu

2.4.1.3. TX State

In TX state the node sends packets to the receiver repeatedly with half second timeout including the node address. After sending the packet, transmitter waits for ACK packet until the half second transmit timeout. The transmitter recalculates its PER after receiving the ACK packet or timeout occurred.

State display:

- All LEDs are off by default
- LED1 blinks if packet sent
- LED2 blinks if ACK packet received
- LED3 & LED4 shows the actual PER (see Table 3)
- Buzzer informs about actual PER (see Table 3)

Options:

- PB3: switches to RX state
- PB4: resets PER (resets both the receiver's and transmitter's PER)
- PB2 + PB4: switches to the configuration menu

2.4.1.4. Configuration Menu

The user can change demo parameters in the configuration menu.

State display:

- All LEDs blink together

Options:

- PB1: switches to address configuration menu
- PB2: switches to frequency configuration menu
- PB3: switches to data rate configuration menu
- PB4: switches to modulation configuration menu
- PB2 + PB4: restores defaults

2.4.1.5. Address Configuration Menu

The user can set new node address in this menu state.

State Display:

- LED1 blinks

Set the Configuration:

- Set the node address on the switches in binary format.
- Be aware that the direction of the switches is reversed than the bit locations in the binary number (LSB representation).
- Example: If the required node address is **10** (binary **1010**), set **SW2 & SW4 to on** and **SW1 & SW3 to off** (see Figure 4).

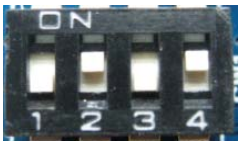

Figure 4. Address Configuration Example (10)

Options:

- PB1:
  - Stores new settings
  - **Result**: blinks all LED once
  - **Next state**: Ready state

2.4.1.6. Frequency Configuration Menu

The user can set the communication frequency in this menu state.

State Display:

- LED2 blinks

Set the Configuration:

- Set the frequency number on the switches by their frequency number:
  - **Custom**: SW1–SW4 are on
  - **Freq. num. 1**: SW1 is on, all others are off
  - **Freq. num. 2**: SW2 is on, all others are off
  - **Freq. num. 3**: SW3 is on, all others are off
  - **Freq. num. 4**: SW4 is on, all others are off
- In case of wrong selection is set or the selected frequency number is not supported (e.g., no custom frequency is stored) the default frequency of the used frequency band will be selected.

Options:

- PB2:
  - Stores new settings
  - **Results**:
    i. Blinks all LEDs once if selection is OK.
    ii. Blinks LED4 and beeps buzzer once if the parameter had to be set to default because of an unsupported selection.
  - **Next State**: Ready state

2.4.1.7. Data Rate Configuration Menu

The user can set the communication data rate in this menu state.

State Display:

- LED3 blinks

Set the Configuration:

- Set the data rate number on the switches by their frequency number:
  - **Custom**: SW1 – SW4 are on
  - **Data rate num. 1**: SW1 is on, all others are off
  - **Data rate num. 2**: SW2 is on, all others are off
  - **Data rate num. 3**: SW3 is on, all others are off
- In case of wrong selection is set or the selected data rate number is not supported (e.g. no custom data rate is stored) the default data rate will be selected.

Options:

- PB3:
  - Stores new settings
  - **Results**:
    i. blinks all LED once if selection is OK
    ii. blinks LED4 and beeps buzzer once if parameter had to be set to default because of not supported selection
  - **Next state**: Ready state

2.4.1.8. Modulation Configuration Menu

The user can set the modulation in this menu state.

State Display:

- LED4 blinks

Set the Configuration:

- Set one of the followings on the switches:
  - **Custom**: SW1–SW4 are on
  - **High precision GFSK**: SW1 is on, all others are off
  - **GFSK**: SW2 is on, all others are off
  - **OOK**: SW3 is on, all others are off
- If the wrong selection is set or the selected data rate number is not supported (e.g., no custom data rate is stored), the default data rate (high precision GFSK) will be selected.

Options:

- PB4:
  - Stores new settings
  - **Results**:
    i. Blinks all LEDs once if selection is OK.
    ii. Blinks LED4 and beeps buzzer once if parameter had to be set to default because of an unsupported selection.
  - **Next state**: Ready state

2.4.1.9. Restore Defaults Menu

Default demo settings are restored.

- **State display**:
  - All LEDs blink once
- **Next state**:
  - Ready state

2.4.1.10. Error States

In case of critical error the demo goes to error state. Power-on-reset can reset the demo from error state. LED4 is continuously on in error state.

Critical errors:

- Frequency band of the HW mismatches with frequency band of the stored custom parameters.

2.5. How to Use the Range Test Demo

Put battery into the two RFstick devices and switch them on. Both devices will start in ready state. Select the required demo settings or start the measurements with the default or the automatically reloaded settings.

Switch one of the devices into RX and the other into TX state. Check if transmitter sends packets and receiver answers as well.

The range test could be performed inside a building if indoor propagation is tested. However it is advised to perform the test outside the building, line-of-sight to get the best possible range result. If PER>1% reset the PER on the transmitter and try to walk further in the area. It is usual that propagation conditions get better if the user goes further from a possibly shadowed area.

3. Schematics

Schematics of the RFstick boards of the kit can be seen on the following pages.
Complete manufacturing file pack with CAD/CAM files and BOMs can be found at silabs.com.

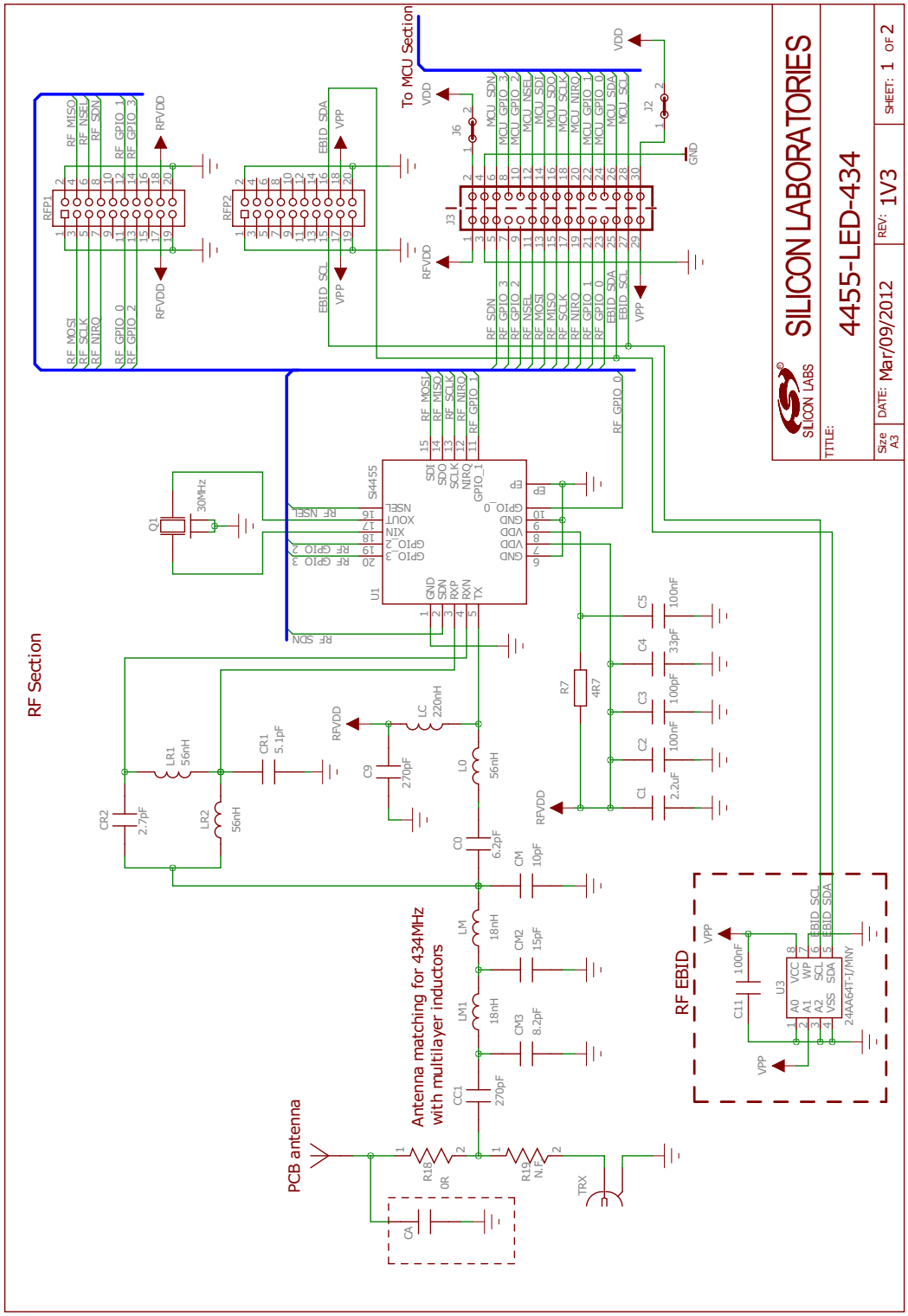

Figure 5. Si4455-LED-434 Schematic 1

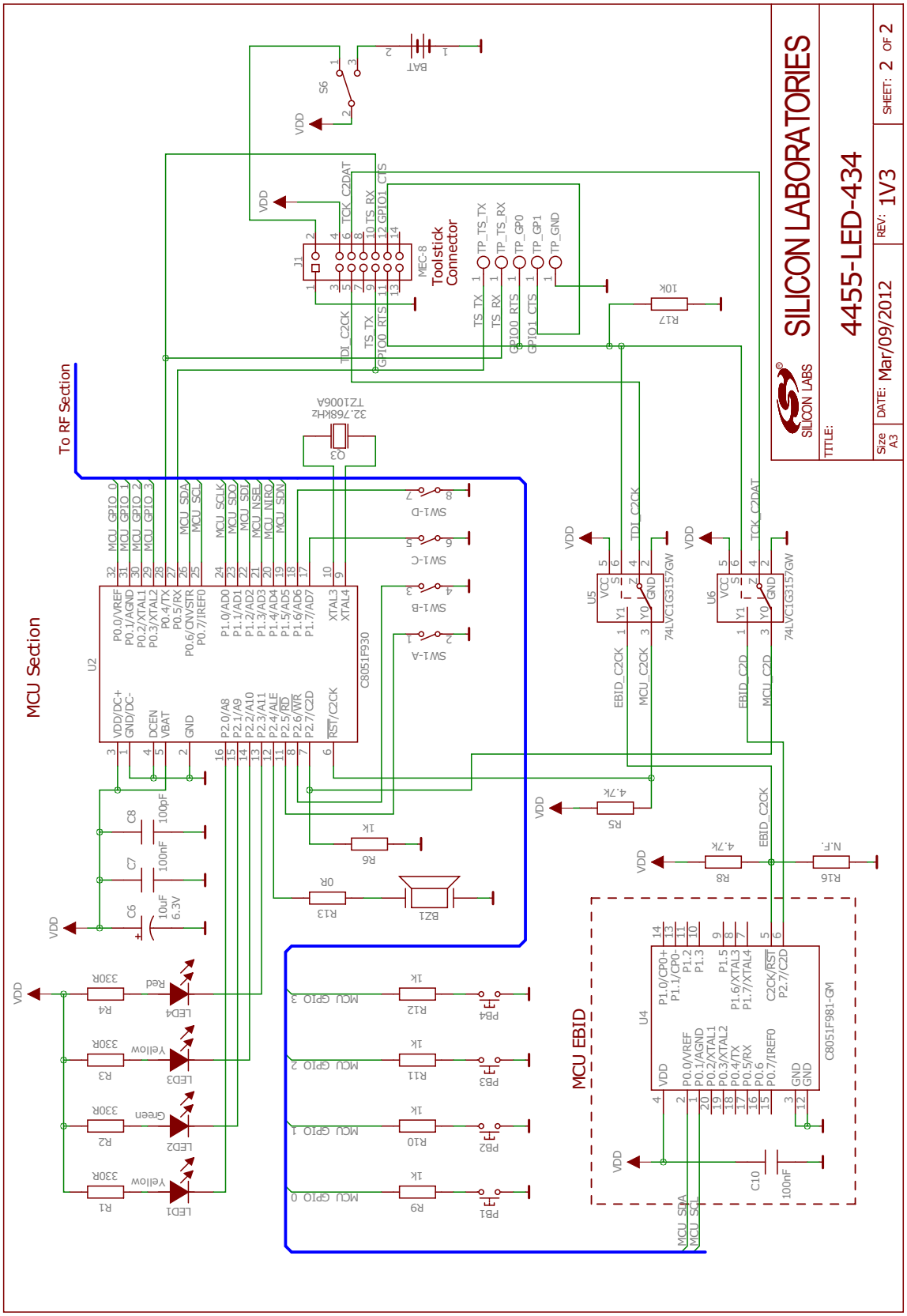

Figure 6. Si4455-LED-434 Schematic 2

DOCUMENT CHANGE LIST

Revision 0.1 to Revision 0.2

- Changed Figure 6 from RF section to MCU section.

CONTACT INFORMATION

Silicon Laboratories Inc.

400 West Cesar Chavez
Austin, TX 78701
Tel: 1+(512) 416-8500
Fax: 1+(512) 416-9669
Toll Free: 1+(877) 444-3032

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Телефон: 8 (812) 309-75-97 (многоканальный)
Факс: 8 (812) 320-03-32
Электронная почта: ocean@oceanchips.ru
Web: http://oceanchips.ru/
Адрес: 198099, г. Санкт-Петербург, ул. Калинина, д. 2, корп. 4, лит. А