

R41Z Evaluation Kit User Guide

The **R41Z Evaluation Kit** from Rigado allows for stand-alone use of the **R41Z Module** featuring the NXP MKW41Z RF System-on-Chip (SoC).

This guide provides setup instructions for starting development and describes the hardware functionality of the **R41Z Evaluation Kit** that can facilitate development of your project.



1. Overview

The R41Z Evaluation Kit provides a great starting point for almost any Bluetooth Smart (4.2 Low Energy) or Thread project. All features of the R41Z module are accessible from the evaluation board. A simple USB connection provides power and OpenSDA V2.1 based debugging. Four user buttons (two conventional and two capacitive) are available, as well as an RGB LED, reset button, combination acceleration/magnetometer sensor, and an external 4Mbit flash module. Arduino form factor headers provide access to 16 GPIO and 6 analog inputs. This allows for easy use of Rigado R41Z Shields and many existing Arduino shields. Current sense resistors allow for measuring current into the R41Z module and into the shield.

1.1 Key Features

- R41Z Thread + Bluetooth Module
- On-board programming and debug (OpenSDA v2.1)
- Virtual COM port over USB
- Pin-for-pin compatible with projects created for the NXP FRDM-KW41Z board
- Buttons and LEDs for user interaction
- 3-axis combination accelerometer and magnetometer, I²C interface
- 4Mbit Flash, SPI interface
- Provision for IR LED
- 32.768kHz crystal
- CR2032 battery holder
- Supports all DC-DC modes of the R41Z module
- Adjustable output regulator simplifies development

Table of Contents

1.	OVERVIEW	1
1.1	KEY FEATURES	1
2.	USEFUL TOOLS.....	4
3.	HARDWARE KIT	4
4.	APPLICATION FIRMWARE DEVELOPMENT	5
4.1	SET UP TOOLCHAIN	5
5.	HARDWARE DESCRIPTION	8
5.1	POWER	9
5.1.1	R41Z POWER MODES.....	10
5.1.2	POWER CONFIGURATION SWITCH.....	11
5.1.3	DC-DC MODE SELECTION	11
5.1.4	MEASURING POWER CONSUMPTION.....	14
5.2	DEBUG INTERFACE	15
5.2.1	OPENSDA INTERFACE	15
5.2.2	RESET BUTTON	15
5.2.3	EXTERNAL DEBUG HEADER	16
5.3	PERIPHERALS	17
5.3.1	EXPANSION HEADERS	17
5.3.2	IR LED PROVISION	17
5.3.3	USER LEDs	18
5.3.4	THERMISTOR	19
5.3.5	USER BUTTONS.....	19
5.3.6	SPI FLASH.....	20
5.3.7	I ² C ACCELERATION/MAGNETOMETER SENSOR	21
5.4	R41Z MODULE	22
5.4.1	32.768KHZ OSCILLATOR	22
6.	LIFE SUPPORT POLICY	23
7.	DOCUMENT HISTORY	23
8.	RELATED DOCUMENTS	23

Table of Figures

FIGURE 1 - USEFUL DEVELOPMENT TOOLS	4
FIGURE 2 - R41Z EVALUATION BOARD (TOP VIEW).....	4
FIGURE 3 - EVALUATION BOARD LAYOUT	8
FIGURE 4 - SCHEMATIC: POWER SUPPLY.....	9
FIGURE 5 - R41Z POWER MODES	10
FIGURE 6 - POWER CONFIGURATION SWITCH	11
FIGURE 7 - POWER CONFIGURATION SWITCH OPTIONS.....	11
FIGURE 8 - POWER CONFIGURATION JUMPERS (DEFAULT).....	12
FIGURE 9 - DC-DC MODE SELECTION.....	12
FIGURE 10 - POWER CONFIGURATION JUMPERS (BOOST MODE)	13
FIGURE 11 - SCHEMATIC: CURRENT MEASUREMENT HEADERS	14
FIGURE 12 - SCHEMATIC: RESET BUTTON	15
FIGURE 13 - EXTERNAL DEBUGGER HEADER PINOUT	16
FIGURE 14 - EXPANSION HEADER PINOUT	17
FIGURE 15 - SCHEMATIC: IR LED	18
FIGURE 16 - SCHEMATIC: USER LEDs.....	18
FIGURE 17 - SCHEMATIC: THERMISTOR AND ADC MODE SELECTION	19
FIGURE 18 - SCHEMATIC: USER BUTTONS.....	19
FIGURE 19 - SPI PORT SIGNALS.....	20
FIGURE 20 - SCHEMATIC: SPI FLASH	20
FIGURE 21 - COMBO SENSOR ADDRESSES.....	21
FIGURE 22 - I2C SENSOR SIGNALS	21
FIGURE 23 - SCHEMATIC: I2C COMBO SENSOR.....	21
FIGURE 24 - SCHEMATIC: 32kHz OSCILLATOR	22

2. Useful Tools

Below is a list of tools that aid development with the R41Z Thread+Bluetooth module. Not all tools will be required depending on which software suite is used.

Tool	Description
NXP MKW41Z Connectivity Software	A set of example projects designed to demonstrate Bluetooth and Thread applications and provide a solid base for starting new projects. Available from the NXP website (login required).
NXP Kinetic Design Studio	A development environment based on the Eclipse IDE and designed for applications involving NXP’s Kinetic line of microcontrollers, including the MKW41Z. Available from NXP at nxp.com/kds
NXP Kinetic SDK V2.0	A collection of sample drivers and applications for NXP Kinetic microcontrollers. Note that the SDK is built using the NXP website for the specific microcontroller or development board being used. The R41Z Evaluation Board has been designed to be SDK compatible with the NXP FRDM-KW41Z board. Included in the MKW41Z connectivity software.
Segger J-Link Software	Software and documentation pack for connecting to the OpenSDA debug interface. Available from Segger at segger.com/jlink-software.html

Figure 1 - Useful Development Tools

3. Hardware Kit

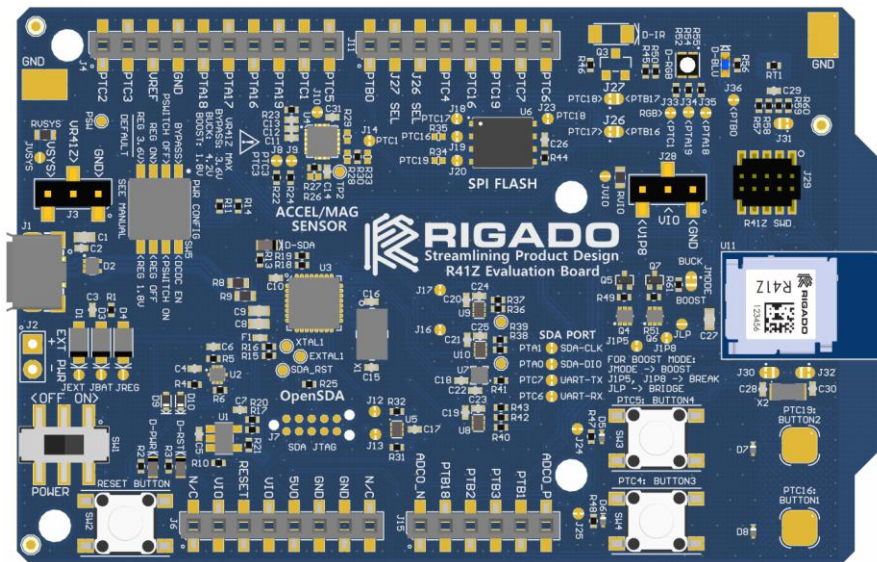


Figure 2 - R41Z Evaluation Board (Top View)

R41Z-EVAL:

- 1x R41Z Evaluation Board
- 1x Micro-USB Cable
- 1x Quick Start Guide
- 1x Regulatory Notice

4. Application Firmware Development

This section walks through how to set up and program the R41Z Evaluation Kit with an example application.

NOTE: This process will erase any preloaded firmware provided by Rigado including the bootloader and demonstration firmware, if provided. To access any firmware or demo applications that may be preloaded on the R41Z evaluation kit, please contact Rigado (modules@rigado.com)

4.1 Set Up Toolchain

1. On an available iPhone or Android smartphone install the NXP Kinetis BLE Toolbox app.
2. Download and install the NXP Kinetis Design Studio (KDS) from: www.nxp.com/kds.
3. Download and install the Kinetis KW41Z Connectivity Software suite at the [NXP website](#).
 - a. From the “Software & Tools” tab of the KW41Z product page, click the download button for the Connectivity Software

NXP > Microcontrollers and Processors > ARM® Processors > Kinetis Cortex-M MCUs > W Series Wireless M0+/M4 ✉

KW41Z: Kinetis® KW41Z-2.4 GHz Dual Mode: BLE and 802.15.4 Wireless Radio Microcontroller (MCU) based on ARM® Cortex®-M0+ Core ☆

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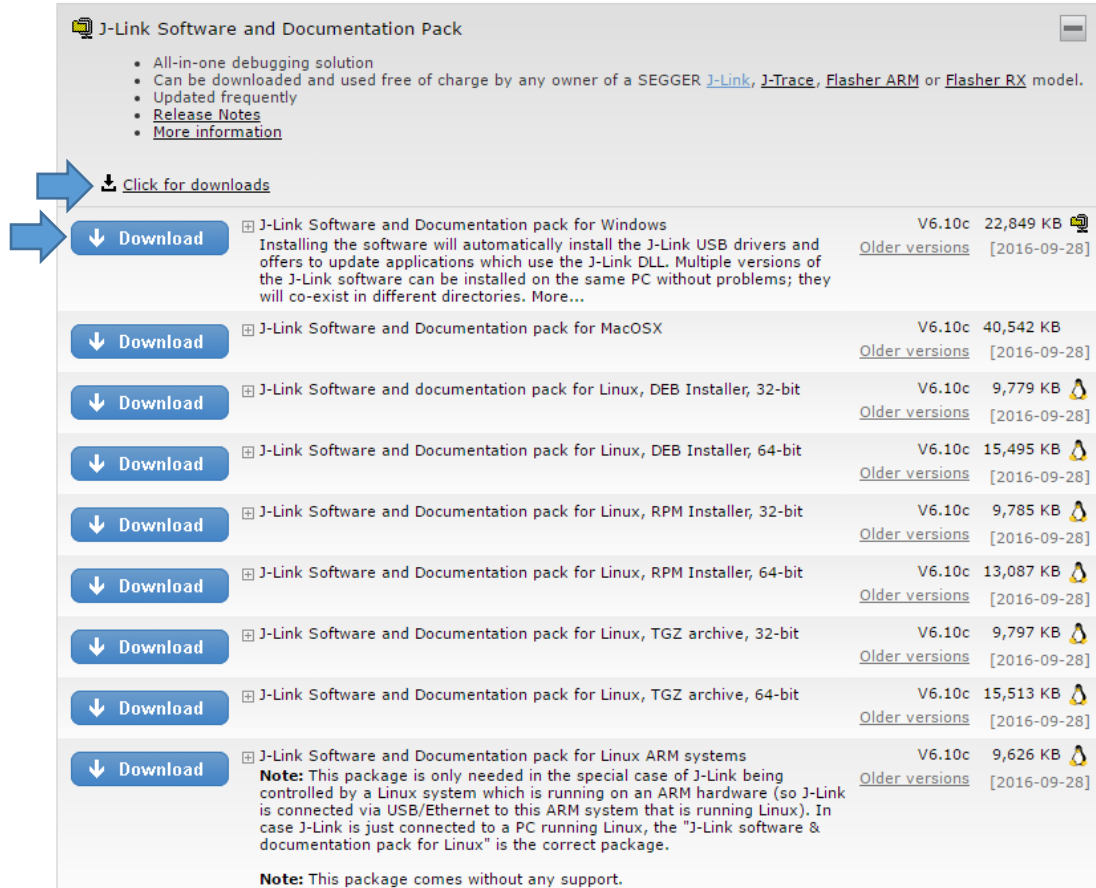
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	<p>Kinetis KW41Z Connectivity Software (REV 1.0.2) New Kinetis KW41Z Connectivity Software. Protocol Stacks exe (66.1 MB) KW41Z-CONNECTIVITY-SOFTWARE 10/11/2016</p>	Download Download Details

- b. You will need to create or login to an NXP account to continue. Once you have logged in, the download should start.
 - c. Run the downloaded executable to install the software suite. The default installation settings are acceptable in most cases.
4. Download and install The Segger J-Link package at www.segger.com/downloads/jlink

- a. At the Segger website, find the box labeled “J-Link Software and Documentation Pack”. Use the link labeled “Click for Downloads”. From the drop-down menu, select the correct package for your host operating system. For this guide, we will use the first package for Windows.



J-Link Software and Documentation Pack

- All-in-one debugging solution
- Can be downloaded and used free of charge by any owner of a SEGGER [J-Link](#), [J-Trace](#), [Flasher ARM](#) or [Flasher RX](#) model.
- Updated frequently
- [Release Notes](#)
- [More information](#)

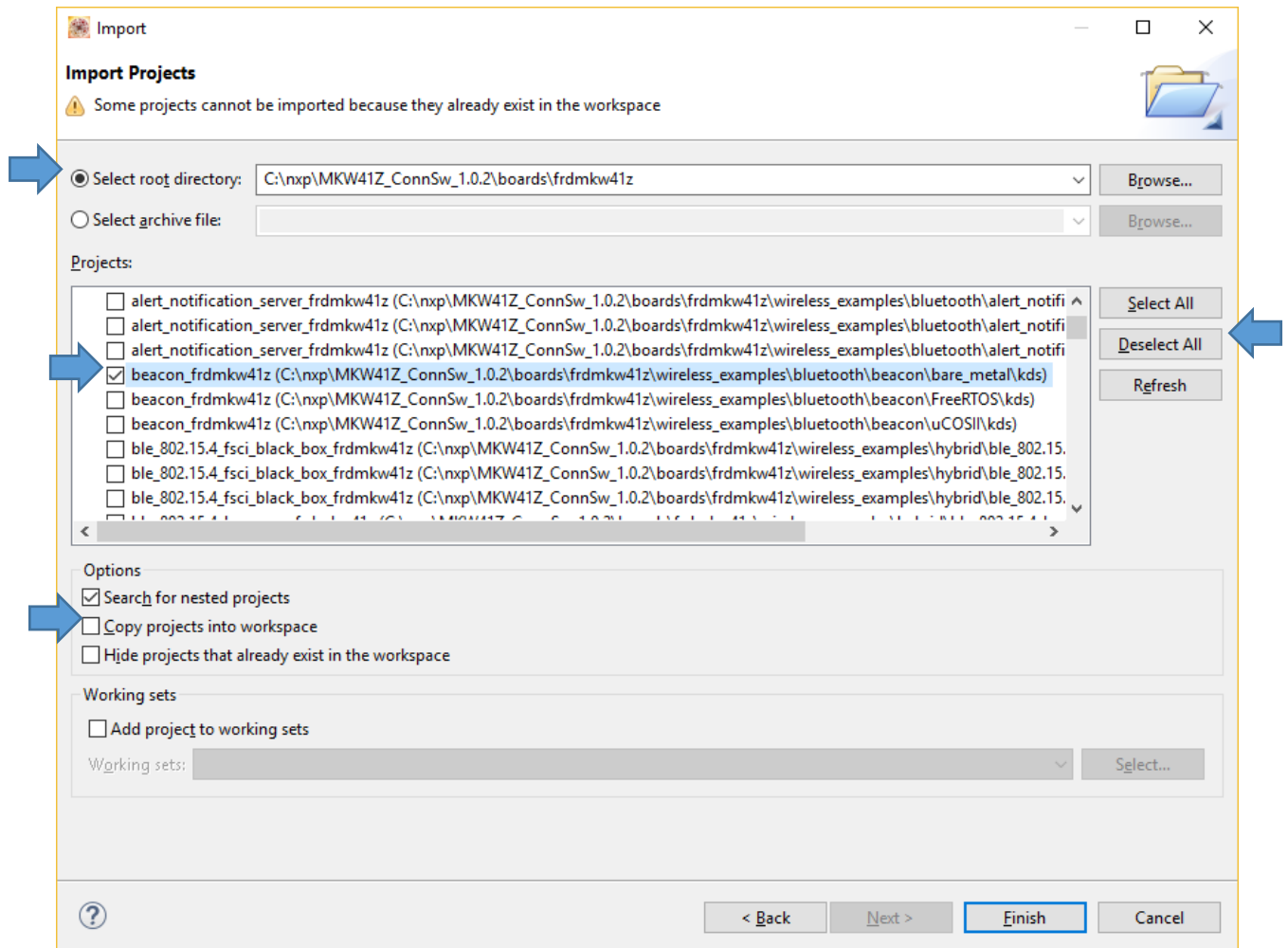
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Download	Package Name	Version	Size	Icon
Download	J-Link Software and Documentation pack for Windows Installing the software will automatically install the J-Link USB drivers and offers to update applications which use the J-Link DLL. Multiple versions of the J-Link software can be installed on the same PC without problems; they will co-exist in different directories. More...	V6.10c	22,849 KB	
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Download	J-Link Software and Documentation pack for Linux, TGZ archive, 64-bit	V6.10c	15,513 KB	
Download	J-Link Software and Documentation pack for Linux ARM systems Note: This package is only needed in the special case of J-Link being controlled by a Linux system which is running on an ARM hardware (so J-Link is connected via USB/Ethernet to this ARM system that is running Linux). In case J-Link is just connected to a PC running Linux, the "J-Link software & documentation pack for Linux" is the correct package.	V6.10c	9,626 KB	

Note: This package comes without any support.

- b. The J-Link software pack will download in the form of a ZIP file. Extract the file and run the installer application contained inside. You may use the default installations settings.
5. Connect your R41Z Evaluation Board to your host computer using the supplied USB cable. The board will enumerate as a mass storage device and a virtual COM port.
 6. Open Kinetis Design Studio and import a sample project from the Connectivity Suite.
 - a. You will be asked to create or select a workspace. You may use the default location or a working folder. For this guide, the default location is used.
 - b. Start the import process by clicking “File>Import”
 - c. In the Import window, select “Existing Projects into Workspace” under the “General” category. This should be the default selection when the Import window opens.
 - d. After selecting next, you will see a second Import Window. For “Root Directory”, select “C:\nxp\MKW41Z_ConnSw_1.x.x\boards\frdmkw41z”. A list of all example projects contained in the SDK should appear below. For a description of each project, navigate to the containing folder and open the readme file.
 - e. Press the “Deselect All” button. **Important:** Under “Options”, deselect the checkbox for “Copy projects into workspace”. Select a project to import. For this guide, we will be

importing the bare metal implementation of “beacon_frmk41z”. When you have selected a project, click “Finish”



7. Build the project by click the  button. The project should compile with no errors.
8. Download the compiled project to the R41Z Evaluation Board by pressing the  button. If asked to choose a debug profiles, select the configuration with name ending in “jlink”.
9. KDS will now switch from the “C/C++” perspective to the “Debug” perspective. In the Debug perspective, you can set breakpoints in the program, trace execution, and read register and variable contents. You can switch back to the “C/C++” perspective by using the buttons in the top right of the KDS window. Begin execution of the Beacon demo program by pressing the  button.
10. Open the Kinetis BLE Toolbox app and select the “Beacons” button. You should see the Evaluation board broadcasting.

Next Steps: Use the other BLE and Thread examples to jumpstart your application development. Sample projects demonstrating peripherals and drivers are included in the Software Suite.

5. Hardware Description

Design files for the R41Z Evaluation Kit may be found on the [Rigado website](#).

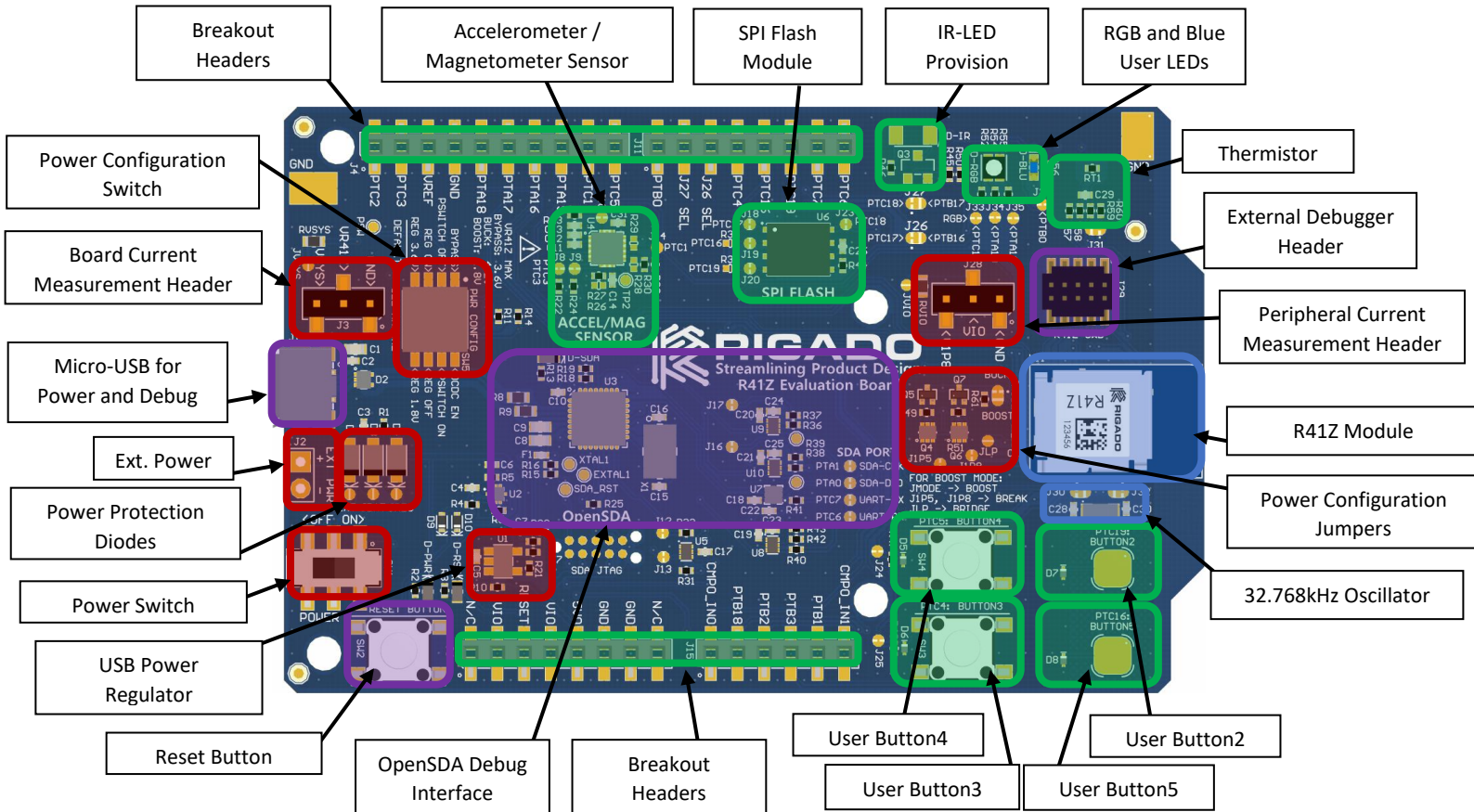


Figure 3 - Evaluation Board Layout

5.1 Power

The R41Z Evaluation Board has three possible power sources: USB, a CR2032 coin cell, and a 0.1" through-hole connector. An LDO regulator supplies regulated power to the module when the USB source is connected. The power sources are OR'd together with protection diodes to prevent reverse voltage to any supply allowing for multiple sources to be connected at the same time. For example, a coin cell battery may remain connected to the board while the USB source is connected for debugging. However, since the diodes do cause approximately a 0.3V drop in source voltage, an option to bypass the diodes via solder jumpers is available. Care should be taken to not damage the supplies or Evaluation board when the protection is by-passed.

If necessary, the LDO regulator can be disabled to allow for USB based debugging while powering the R41Z from either an external source or a coin cell. Since the R41Z can accept a wide range of power options, the LDO regulator can be adjusted to simulate some sources. For details on these options, see Power Configuration Switch section later in this document.

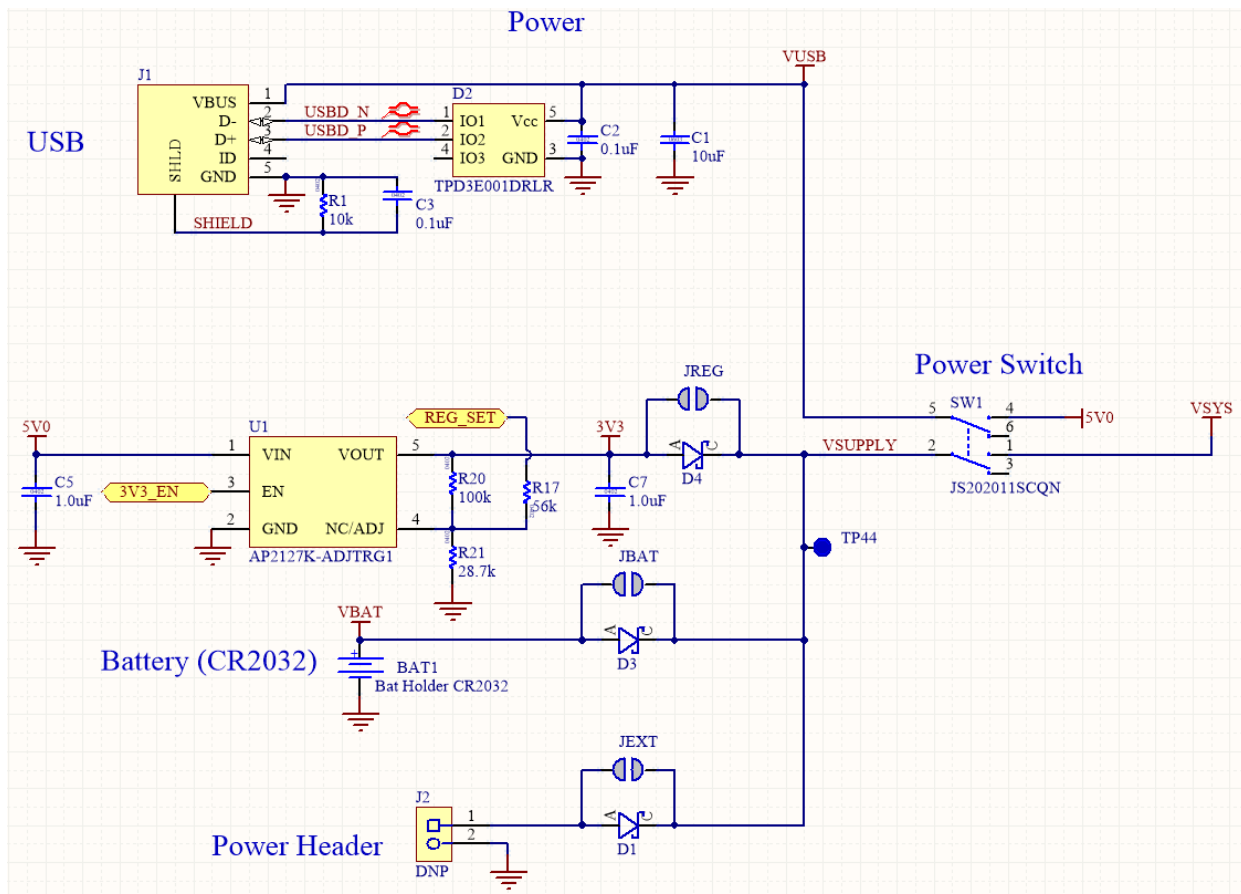


Figure 4 - Schematic: Power Supply

5.1.1 R41Z Power Modes

The Rigado R41Z module contains a DC-DC converter that allows it operate in a variety of power environments. The R41Z Evaluation board supports the operating modes summarized below:

R41Z DC-DC Converter Modes			
Mode	Input Voltage	Output Voltage	Usage Notes
Bypass	1.71V – 3.6V	N/A	DC-DC Converter is bypassed: Input voltage directly supplies all internal module power rails. Suitable for larger or non-battery powered applications that have steady, regulated 3.3V or 1.8V power rails that power multiple devices. Since the DC-DC converter is bypassed in this mode, the R41Z cannot provide regulated power to other devices.
Buck	1.8V – 4.2V	1.8V – 3.0V ¹	DC-DC Converter operates in buck mode. Internal power rails are sourced and regulated by the R41Z module. An externally available power rail (V1P8) allows the R41Z to supply regulated power to other peripheral devices. Suitable for small applications powered directly from a lithium ion battery ² . If total power consumption is low, the R41Z module can provide a regulated power rail to supply other devices.
Boost	0.9V – 1.8V	1.8V – 3.0V ¹	DC-DC Converter operates if boost mode. Internal power rails are sourced and regulated by the R41Z module. An externally available power rail (V1P8) allows the R41Z to supply regulated power to other peripheral devices. Suitable for small applications powered directly from a low voltage battery ² (For example, alkaline or NiMH). If total power consumption is low, the R41Z module can provide a regulated power rail to supply other devices.
Note 1: Output voltage is user adjustable in Buck and Boost mode. Defaults to 1.8V at Power On Reset. In Buck mode, output voltage cannot be greater than input voltage.			
Note 2: The R41Z does not include automatic battery management. Applications powered from batteries must include battery management and protection features implemented with additional hardware and/or software.			

Figure 5 - R41Z Power Modes

5.1.2 Power Configuration Switch

The power configuration switch enables easy adjustment of most power settings on the R41Z Evaluation Board.

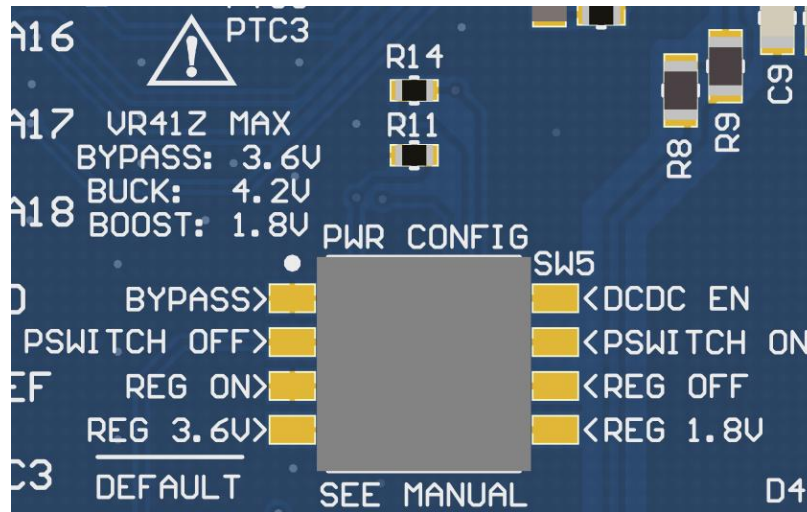


Figure 6 - Power Configuration Switch

Power Configuration Switch		
SW Position	Default	Option
1	Bypass Power Mode	DC-DC Power Mode. Buck Mode by default; Boost mode selectable with Power Configuration Jumpers. See DC-DC Mode Selection .
2	PSWITCH OFF. When in Buck Mode, the DC-DC converter will not start when power is applied. Use this option when using Bypass Mode.	PSWITCH ON. When in Buck mode, the DC-DC Converter will automatically start when power is applied. Use this option when using Boost Mode.
3	Regulator On. When USB is connected, the LDO regulator will supply power to the Evaluation Board.	Regulator Off. When USB is connected, the LDO regulator will not supply power.
4	Regulator 3.6V. When USB is connected, the LDO regulator will output 3.6V. With the reverse protection diode, 3.3V is applied to the R41Z.	Regulator 1.8V. When USB is connected, the LDO regulator will output 1.8V. With the reverse protection diode, 1.5V is applied to the R41Z. Useful for using Boost mode.

Figure 7 - Power Configuration Switch Options

5.1.3 DC-DC Mode Selection

For details regarding the electrical connections required to implement each power mode, please reference the R41Z Evaluation Board Schematic and R41Z Module Data Sheet. These documents are available online at the Rigado website.

Switching between Bypass Mode and Buck mode can easily be accomplished using the Power Configuration Switch. To use Boost Mode there are other changes that must be made via the Power Configuration Jumpers, summarized below.

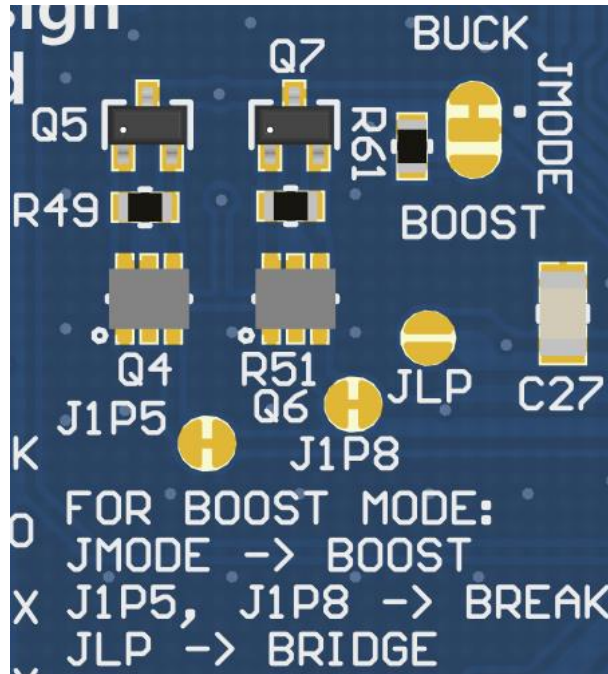


Figure 8 - Power Configuration Jumpers (Default)

The 4 jumpers used to switch between Buck and Boost DC-DC modes are labeled JMODE, JLP, J1P5, and J1P8. See the figures below for how to set these jumpers along with the correct Power Configuration Switch positions.

DC-DC Mode Selection					
Mode	PWR Config SW	JMODE	JLP	J1P5	J1P8
Bypass	Pos. 1: Bypass (Default) Pos. 2: OFF (Default) Pos. 4: REG 3.6V	Buck (Default)	Open (Default)	Closed (Default)	Closed (Default)
Buck	Pos. 1: DC-DC EN Pos. 2: Off or On* Pos. 4: REG 3.6V	Buck (Default)	Open (Default)	Closed (Default)	Closed (Default)
Boost	Pos. 1: DC-DC EN Pos. 2: On Pos. 4: REG 1.8V	Boost	Closed	Open	Open

*Note: See [Figure 7](#) for using PSWITCH in Buck mode

Figure 9 - DC-DC Mode Selection

Figure 10 below shows the Power Configuration Jumpers in Boost mode with solder jumpers across JMODE and JLP. JMODE features a white dot, highlighted by a red circle below, to indicate the default bridged connection. Do not bridge all three pads of jumper JMODE.

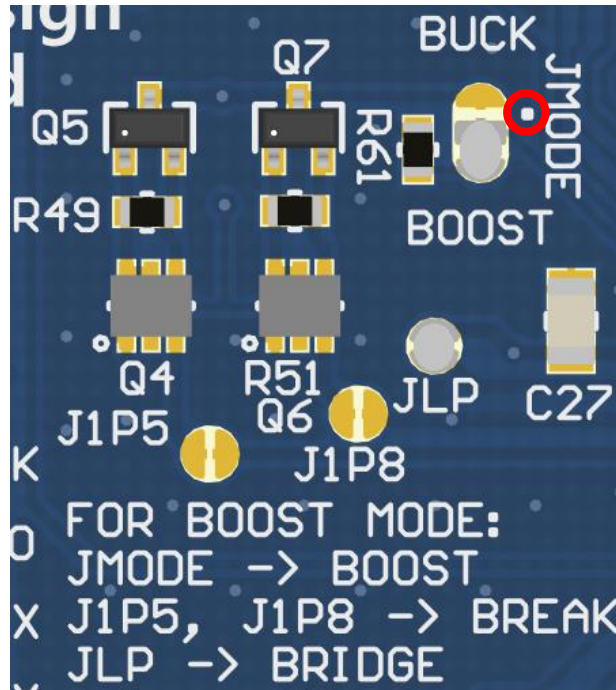


Figure 10 - Power Configuration Jumpers (Boost Mode)

5.1.4 Measuring Power Consumption

When operating the R41Z Evaluation Board in DC-DC power mode, the board power source (LDO regulator, coin cell, or external power) directly powers both the R41Z module and all onboard peripheral devices including expansion shield power. In contrast, when operating in either Buck or Boost DC-DC Mode, the R41Z module supplies regulated power to the peripheral devices and expansion shield. This makes it difficult to directly measure the power consumption of just the R41Z module. The Evaluation Board features two current measurement headers that allow direct measurement of total current and peripheral current. The current consumption of only the R41Z Module is measured by subtracting all peripheral current from the system current reading.

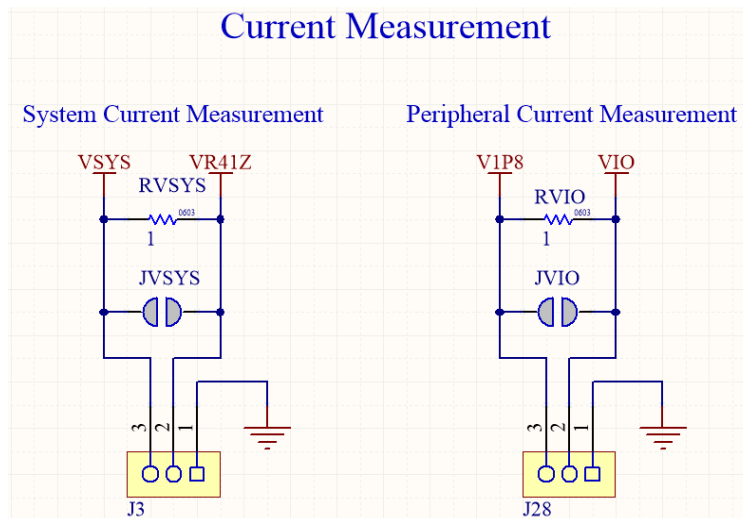


Figure 11 - Schematic: Current Measurement Headers

5.2 Debug Interface

The R41Z Evaluation Board features an OpenSDA 2.1 interface which includes a SWD connection and virtual COM port for easy programming and debugging of the R41Z module.

5.2.1 OpenSDA Interface

The OpenSDA hardware is separated from the R41Z target by a set of level shifters ensuring that debugging is possible regardless of the DC-DC mode used. The interface operates in a similar manner to other evaluation boards using OpenSDA. When connected to a host computer, the Evaluation board will appear as a mass storage device named “FRDM-KW41Z”. Copying binary files to this drive loads them on the R41Z Module.

The R41Z Evaluation Board ships with a Segger debug application loaded, but other OpenSDA 2.1 applications may be used. To load a new OpenSDA application, apply power to the board while holding the reset button. The Evaluation Board will appear as mass storage device named “Maintenance” onto which the OpenSDA application binary can be copied.

5.2.2 Reset Button

The reset button is primarily used to reset the R41Z module. It is also used to put the OpenSDA interface into “Maintenance” mode to allow for different Debug Applications to be loaded. The reset pin on the R41Z module and the OpenSDA I/O are connected to the reset button and isolated from each other by diodes. Unlike the standard OpenSDA implementation, a header is not needed to select which device the reset button is connected to.

When power is initially applied, the OpenSDA interface momentarily ignores any reset signal asserted by the R41Z in order to sample the state of the reset button. This is done by setting the reset line level shifter between the OpenSDA interface and the R41Z to a high impedance state.

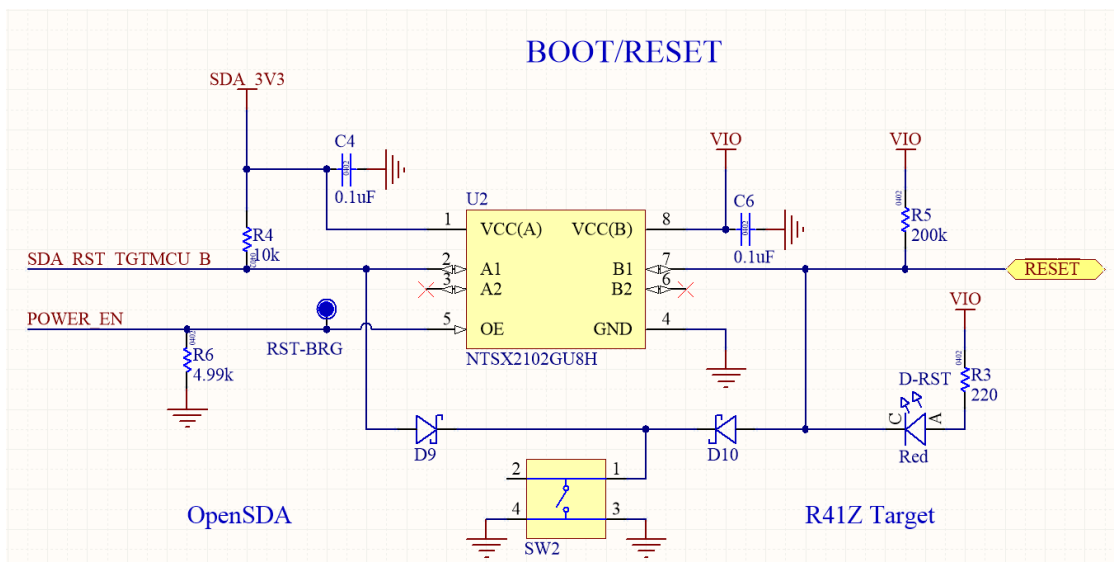


Figure 12 - Schematic: Reset Button

5.2.3 External Debug Header

In addition to the onboard OpenSDA interface, the R41Z Evaluation Board supports the use of external debuggers. A standard 10-pin SWD/JTAG header is provided with the following pinout to the target R41Z module:

SWD Header	
Pin	Usage
1	V1P8 (R41Z I/O voltage)
2	SWDIO
3	GND
4	SWCLK
5	GND
6	N/C
7	N/C
8	N/C
9	GND
10	RESET_n

Figure 13 - External Debugger Header Pinout

5.3 Peripherals

The R41Z Evaluation Board includes a set of onboard peripherals and a set of Arduino style headers. The Arduino style headers allow for additional peripherals to be added in the form of expansion shields. These headers share I/O connections to the R41Z module with the existing onboard peripherals. Jumpers are available to disconnect on-board peripherals when they interfere with expansion shield signals.

5.3.1 Expansion Headers

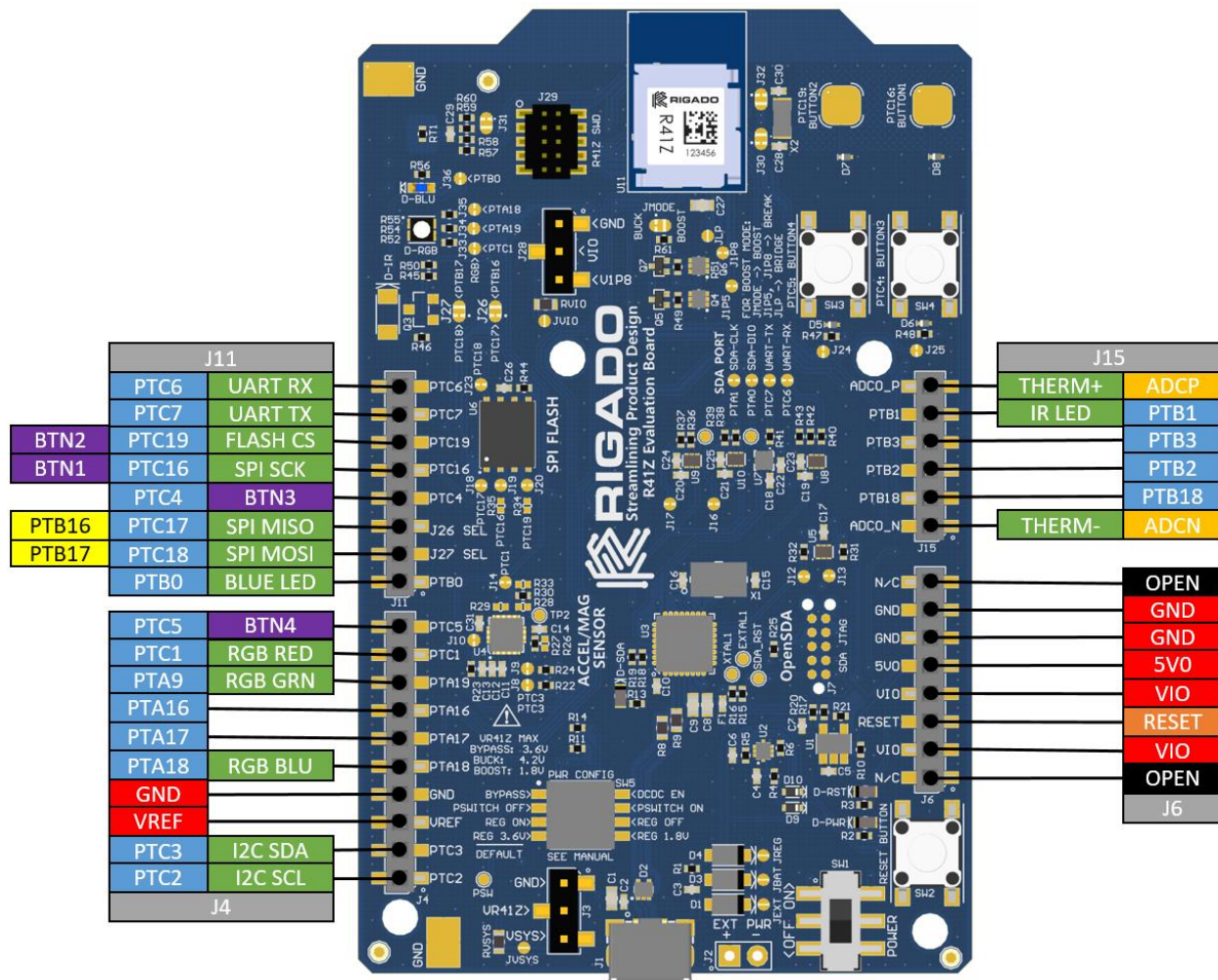


Figure 14 - Expansion Header Pinout

5.3.2 IR LED Provision

An unpopulated position for an IR LED and driver transistor exists on the Evaluation board. This enables development with the R41Z module's Carrier Modulator Transmitter (CMT) peripheral. The IR LED footprint is intended for a right angle, SMT 3317 package. The drive transistor footprint is intended for an SOT-23 NPN BJT. Resistor R45 is not provided on the board to avoid pulling down PTB1.

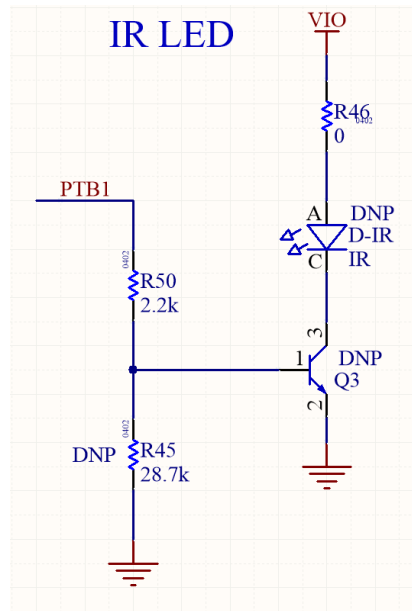


Figure 15 - Schematic: IR LED

5.3.3 User LEDs

The R41Z Evaluation Board features an RGB LED and a separate blue LED. Since the GPIO used are shared with the expansion header, solder jumpers are provided to disconnect the LEDs. The LEDs are powered directly by the R41Z module when the DCDC converter is in either Buck or Boost mode. The output voltage of the DCDC converter must be set to at least 3V for the LEDs to be readily visible.

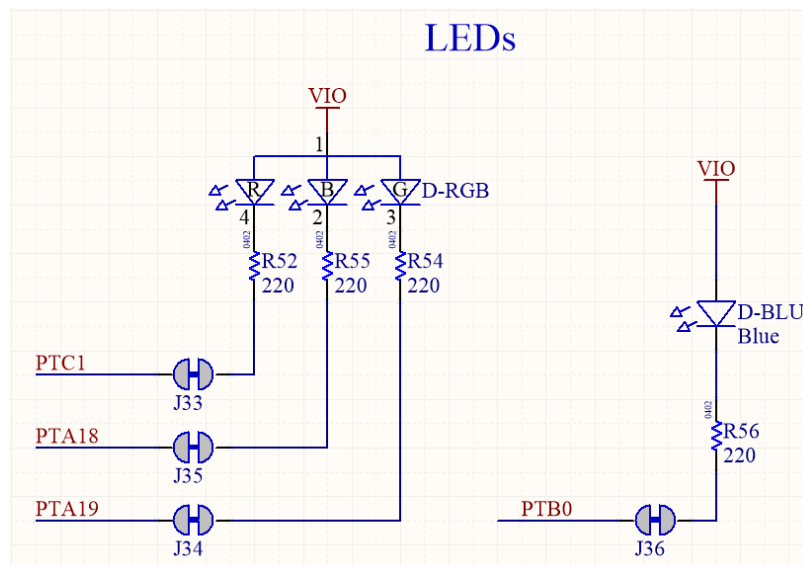


Figure 16 - Schematic: User LEDs

5.3.4 Thermistor

A thermistor circuit is provided to demonstrate the analog capabilities of the R41Z module and to aid development of applications requiring temperature measurement.

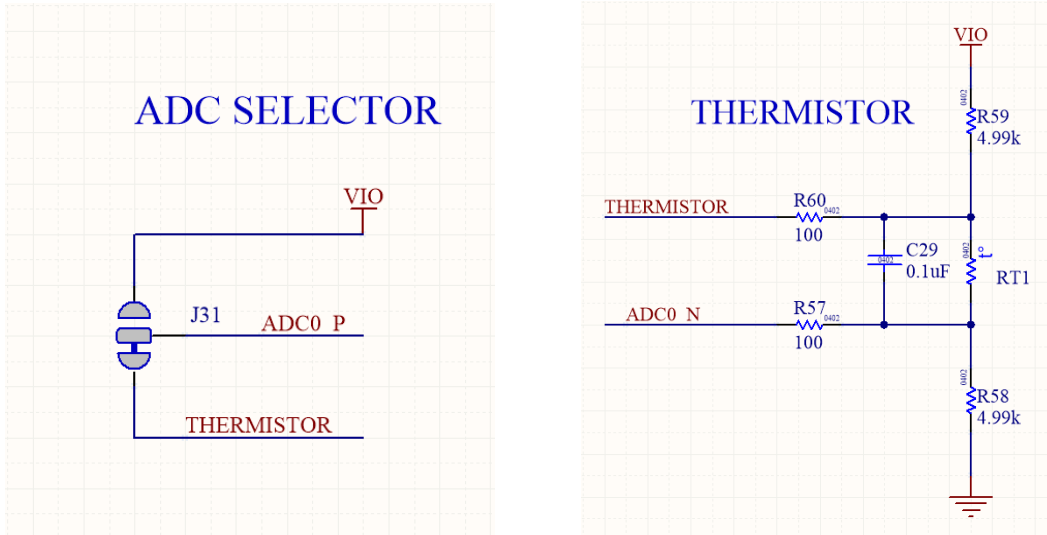


Figure 17 - Schematic: Thermistor and ADC Mode Selection

5.3.5 User Buttons

Two mechanical buttons (SW3, SW4) and two capacitive touch buttons (SW2, SW5) are provided on the Evaluation Board. The Capacitive touch buttons enable easy development of applications that make use of the R41Z's Touch Sense Input (TSI) module. Note: The TSI pads share GPIO with the SPI flash.

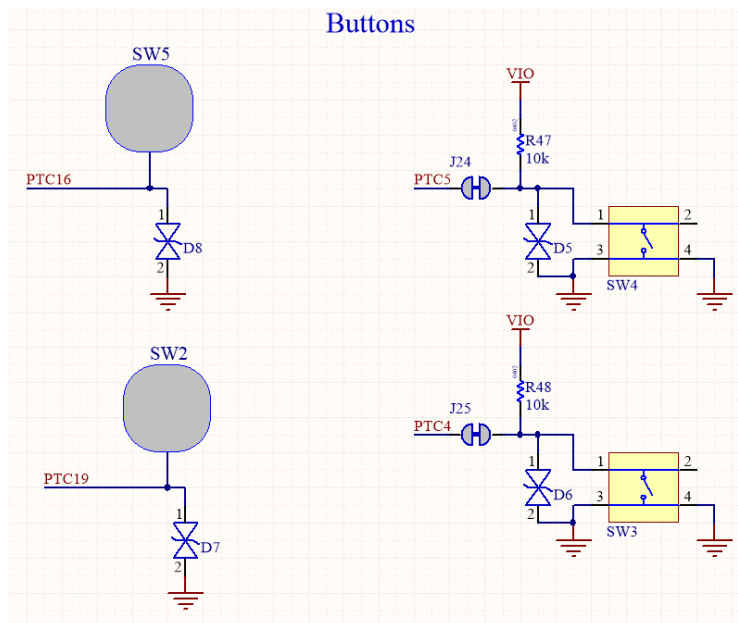


Figure 18 - Schematic: User Buttons

5.3.6 SPI Flash

To assist development of applications requiring external storage, a 4Mbit NOR flash module is provided (Adesto Tech. AT45DB041E-MHN2B-T). The flash uses an SPI interface with signals shared with the expansion headers. This allows the same SPI bus to be used with both the Flash module and one or more SPI devices on an expansion shield. Note: Since some GPIO are shared, the SPI Flash and TSI buttons cannot be used simultaneously.

SPI Flash	
Signal	R41Z I/O
SPI CLK	PTC16
SPI MOSI	PTC17
SPI MISO	PTC18
Flash CS_n	PTC19

Figure 19 - SPI Port Signals

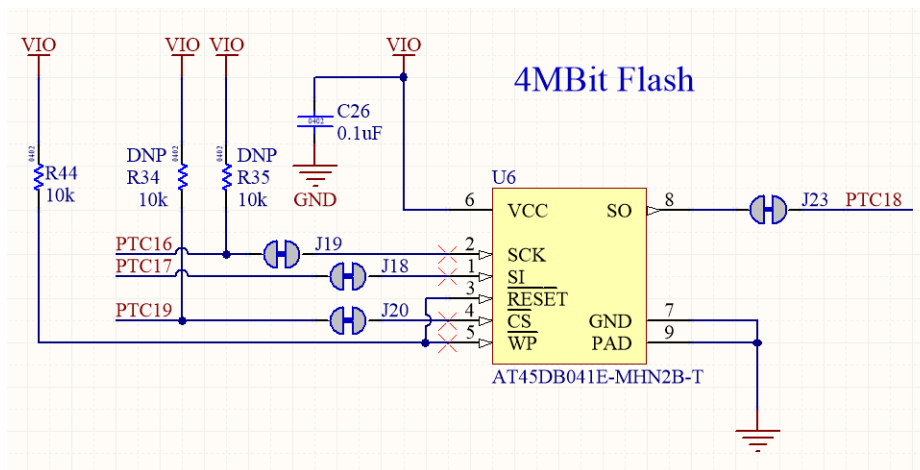


Figure 20 - Schematic: SPI Flash

5.3.7 I²C Acceleration/Magnetometer Sensor

For development of applications that require orientation and movement tracking, a combined accelerometer and magnetometer is provided (NXP FXOS8700CQR1). The sensor can support either SPI or I²C interfaces, but is used exclusively with the I²C interface on the R41Z Evaluation Board. When in I²C mode, the address of the sensor can be set using external pull-up and pull-down resistors. The signals used for the I²C bus are shared with the expansion headers.

Combo Sensor Address		
Address	SA1	SA0
0x1C	1	0
0x1D	0	1
0x1E	0	0
0x1F (Default)	1	1

Figure 21 - Combo Sensor Addresses

I2C Sensor	
Signal	R41Z I/O
Interrupt	PTC1
SCLK	PTC2
SDA	PTC3

Figure 22 - I2C Sensor Signals

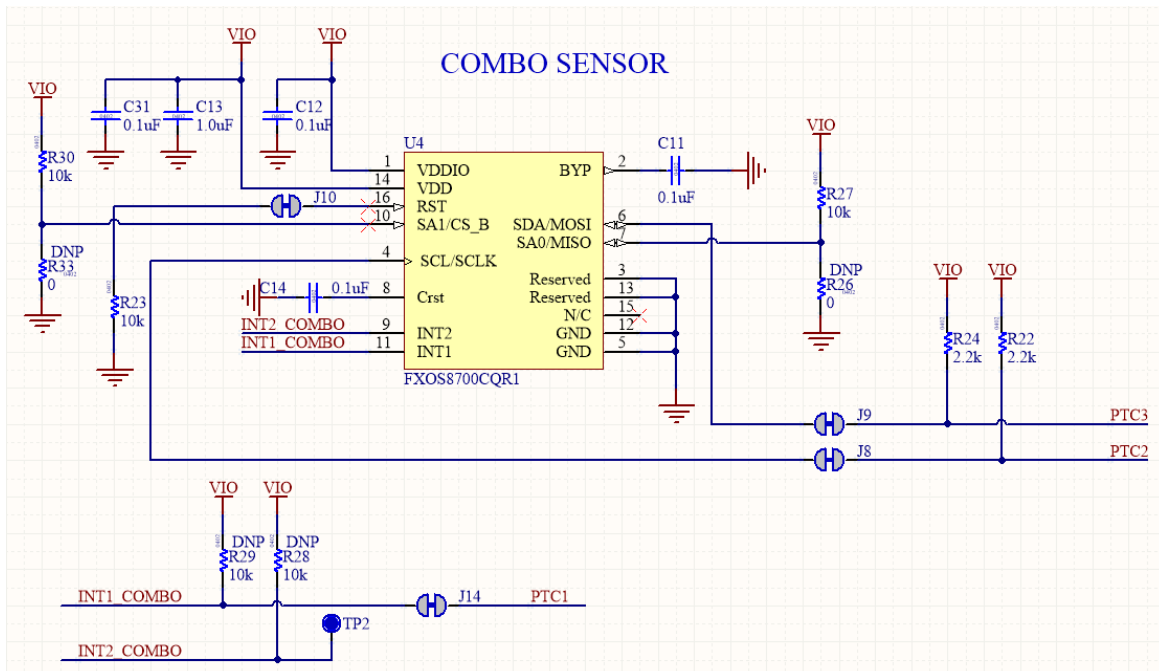


Figure 23 - Schematic: I2C Combo Sensor

5.4 R41Z Module

For details on the R41Z module, see the Rigado R41Z Data Sheet (rigado.com/r41z). The R41Z module is an industry leading Bluetooth and Thread pre-certified (pending) module with a wide range of potential applications.

5.4.1 32.768kHz Oscillator

For Low Power Timer (LPTMR) operation and to maintain high accuracy Bluetooth time keeping in low power modes, an external 32.768kHz crystal oscillator is provided. If low power modes are not needed, the external oscillator is not required. In those cases, a set of jumpers exist to connect these I/O to the expansion headers. NXP provides a [Technical Article](#) describing how to change the boot clock configuration when an external oscillator is not connected. Note: the R41Z module features programmable trim capacitors for the oscillator which can be used in place of external capacitors. However, external capacitors are provided on the R41Z Evaluation Board to simplify firmware development.

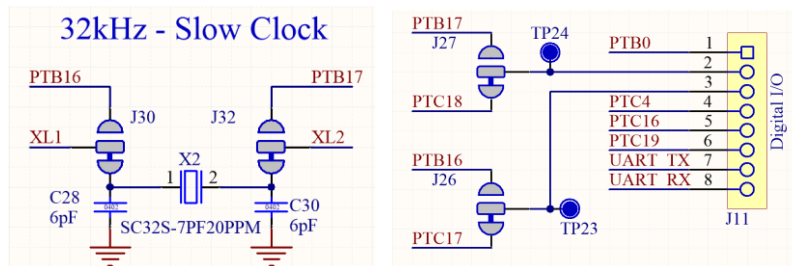


Figure 24 - Schematic: 32kHz Oscillator

6. Life Support Policy

This product is not designed to be used in a life support device or system, or in applications where there is potential for a failure or malfunction to, directly or indirectly, cause significant injury. By using this product in an application that poses these risks, such as described above, the customer is agreeing to indemnify Rigado for any damages that result.

7. Document History

Revision	Date	Changes / Notes
0.9	11/9/2016	Initial Release

8. Related Documents

Rigado Documents:

- [R41Z Module Product Brief](#)
- [R41Z Module Data Sheet](#)
- [Evaluation Kit Regulator Information](#)

NXP Documents:

- [KW41Z Fact Sheet](#)
- [NXP BLE Mobile Toolbox](#)
- [KW41Z Data Sheet](#)
- [KW41Z Reference Manual](#)
- [KW41Z Errata](#)

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