

FRDM-KL27Z User's Guide

1 Introduction

The Freescale Freedom development board is an evaluation and development tool ideal for rapid prototyping of microcontroller-based applications. The hardware design is form-factor compatible with popular third-party hardware designed to work with Arduino™ and Arduino-compatible boards.

The Freescale KL27Z Freedom board (FRDM-KL27Z) is a simple, yet sophisticated design featuring a Kinetis L series microcontroller KL27Z, a 3.3V microcontroller built on the ARM® Cortex®-M0+ core.

The Kinetis L series is the most scalable portfolio of low-power, robust, mixed signal 32-bit ARM Cortex-M0+ MCUs running up to 48 MHz in the industry. It supports power supply voltage range from 1.71V to 3.6V, ambient operating temperature ranges from -40°C to 105°C and includes up to 64 KB flash.

The FRDM-KL27Z includes the Freescale open standard embedded serial and debug adapter known as OpenSDA. This circuit offers the user several options for serial communications, flash programming and run-control debugging.

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There are also many software development tool options available to the user. Choices include Kinetis Design Studio (KDS), IAR Embedded Workbench, Keil MDK featuring the μ Vision IDE, etc.

All of these features combine to give users the freedom needed to rapidly prototype many embedded designs: a powerful microcontroller built on a very low-power core and SoC platform, easy-access to I/O with a large ecosystem of compatible hardware, a flexible programming and debug interface, and a large ecosystem of software development environments.

2 Reference documents

- OpenSDA User's Guide: A guide for users of the OpenSDA embedded circuit
- KL27 Sub-Family Reference Manual: A reference manual for KL27 sub-family devices
- Arduino Overview: A guide to the Arduino platform
- Arduino Uno: A guide to Arduino Uno revision

3 Getting started

Refer to the FRDM-KL27Z *Quick Start Package* for step-by-step instructions for getting started with the freedom board. See the "Jump Start Your Design" section at freescale.com/FRDM-KL27Z for the *Quick Start Package* and software lab guides.

4 FRDM-KL27Z hardware overview

The FRDM-KL27Z hardware is a Freescale Freedom development board assembled with the following features:

- Kinetis L series KL27 family MCU MKL27Z64VLH4 in an 64 LQFP package
- On-board serial and debug adapter (OpenSDA)
- I/O headers for easy access to MCU I/O pins
- Freescale inertial sensor, MMA8451Q, Magnetometer MAG3110
- Capacitive touch slider
- Reset pushbutton
- NMI and LLWU buttons
- RGB LED
- Infrared communication
- Thermistor sensor
- Supports the EEMBC ULPBench benchmark

Figure 1 shows a block diagram of the FRDM-KL27Z board.

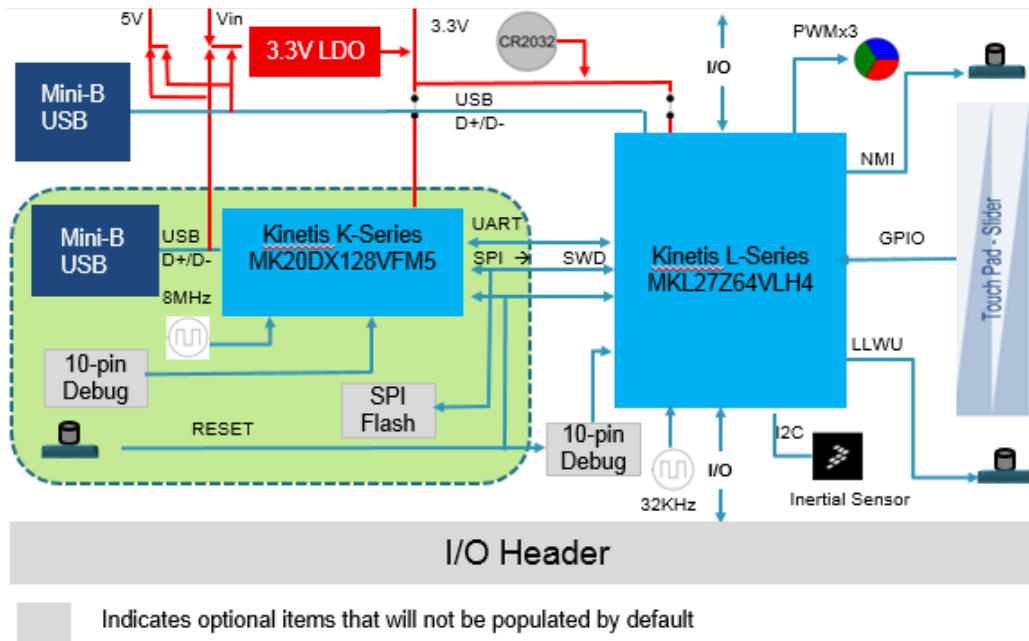


Figure 1. FRDM-KL27Z block diagram

The FRDM-KL27Z features two microcontrollers (MCUs): the target MCU and a serial and debug adapter (OpenSDA) MCU. The target MCU is a Kinetis series KL27 family device, the KL27Z64VLH4. The OpenSDA MCU is a Kinetis K series K20 family device, the K20DX128VFM5.

Features of the KL27Z64VLH4 target MCU include:

- 32-bit ARM Cortex-M0+ core
 - Up to 48 MHz operation
 - Single-cycle fast I/O access port
- Memories
 - 64 KB flash
 - 16 KB SRAM
 - 16 KB ROM with build-in bootloader
 - 32 bytes regfile
- System integration
 - 4-channel DMA controller
 - Watchdog
 - Low-leakage wakeup unit
 - SWD debug interface and Micro Trace Buffer
 - Bit Manipulation Engine
- Clocks
 - 48 MHz high accuracy internal reference clock
 - 8/2 MHz low power internal reference clock

- 32-40 kHz, or 3-32 MHz crystal oscillator
- 1 kHz LPO clock
- Analog peripherals
 - 16-bit SAR ADC with internal voltage reference, up to 17 channels
 - High-speed analog comparator containing a 6-bit DAC and programmable reference input
 - 1.2 V voltage reference (Vref)
- Communication peripherals
 - USB full-speed slave controller supporting crystal-less recovery
 - Two 16-bit SPI modules
 - One UART module supporting ISO7816
 - Two LPUART modules
 - Two I²C modules supporting up to 1 Mbit/s
 - One FlexIO module
- Timers
 - One 6-channel Timer/PWM module
 - Two 2-channel Timer/PWM modules
 - One low-power timer
 - Periodic interrupt timer
 - Real-time clock
- Security
 - 80-bit unique identification number per chip
- Human-Machine Interfaces (HMI)
 - Up to 54 general purpose input/output (GPIO)
 - GPIO interrupt
 - External input pin for LLWU in LLS and VLLSx mode

5 FRDM-KL27Z hardware description

5.1 Power supply

The FRDM-KL27Z offers a design with multiple power supply options. It can be powered from the USB connector, battery on the board, the VIN pin on the I/O header, or an off-board 1.71-3.6V supply from the 3.3V pin on the I/O header. The USB and VIN supplies are regulated on-board using a 3.3V linear regulator to produce the main power supply. The other two sources are not regulated on-board. [Figure 2](#) shows the schematic drawing for the power supply inputs and the on-board voltage regulator.

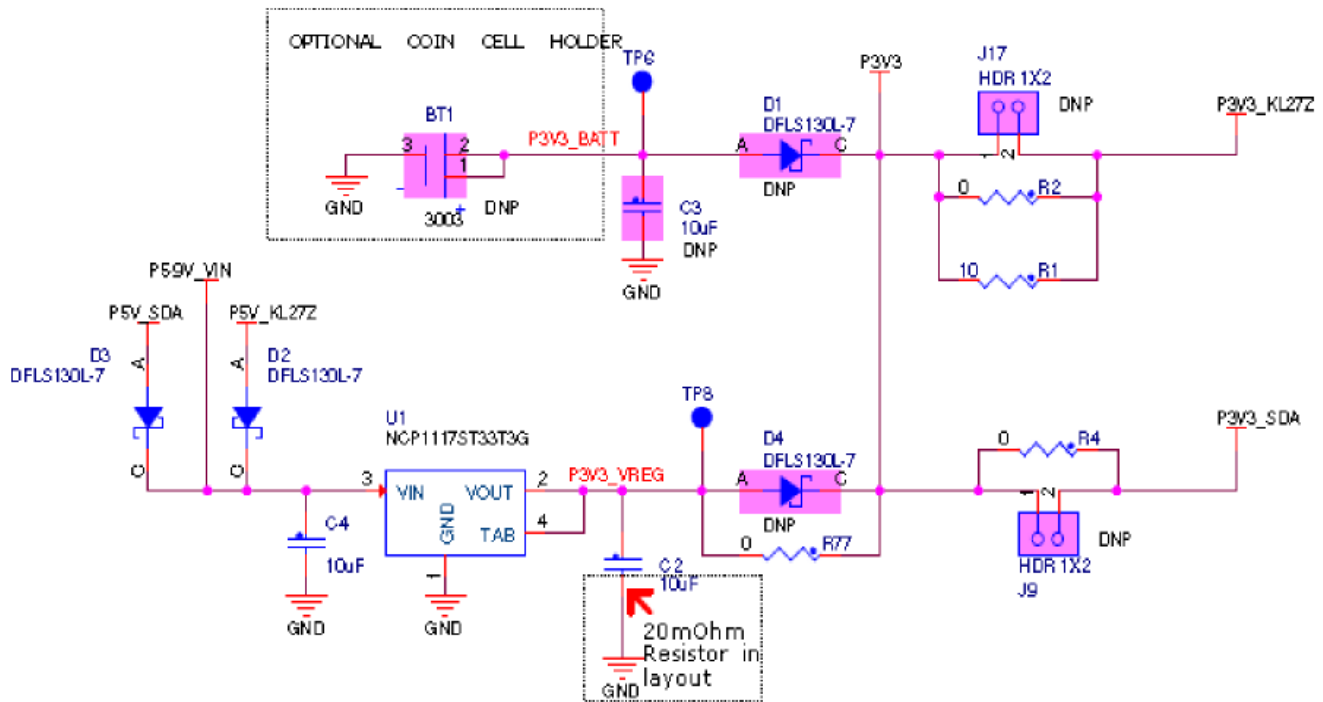


Figure 2. FRDM-KL27Z power supply

Table 1 provides the operational details and requirements for the power supplies.

Table 1. Tower supply requirements

Supply Source	Valid Range	OpenSDA Operational?	Regulated On-board?
OpenSDA USB (J13)	5V	Yes	Yes
Mini USB(J10)	5V	No	Yes
P5V0-9V0_VIN Pin on I/O header	4.3-9V	No	Yes
P3V3 Pin on I/O header	1.71-3.6V	No	No
Battery	2-3.6V	No	No

NOTE

The OpenSDA circuit is only operational when a USB cable is connected and supplying power to J13. However, the protection circuitry is in place to allow multiple sources to be powered at once.

Table 2. FRDM-KL27Z power supplies

Power Supply Name	Description
P5V0-9V0_VIN	Power supplied from the V_{IN} pin of the I/O headers (J3 pin 16).
P5V_SDA	Power supplied from the OpenSDA USB connector (J13).
P5V_KL27Z	Power supplied from the Mini USB connector (J10).

Table 2. FRDM-KL27Z power supplies

P3V3_VREG	Regulated 3.3V supply. Sources power to the P3V3 supply rail through an optional back drive protection Schottky diode.
P3V3	Main supply rail for the FRDM-KL27Z. Can be sourced from P3V3_VREG.
P3V3_KL27Z	KL27Z MCU power supply. Header J17 provides a convenient means for KL27Z energy consumption measurements.
P3V3_SDA	OpenSDA circuit power supply.

NOTES

J9 and J17 are not populated by default. The two pins of these headers are in parallel with 0 Ω resistors. In addition, J17 is also in parallel with a 10 Ω resistor. To measure the energy consumption of the KL27Z, either a voltmeter or an ammeter may be used. To use a voltmeter, R2 (0 Ω) must be removed before connecting the voltmeter probes to the pins of J17. Both R1 and R2 (10 Ω) must be removed to measure current with an ammeter. For the OpenSDA MCU, energy consumption can be measured by removing R4 (0 Ω) and connecting ammeter probes to the pins of J9.

5.2 Serial and debug adapter (OpenSDA)

OpenSDA is an open-standard serial and debug adapter. It bridges serial and debug communications between a USB host and an embedded target processor as shown in Figure 3. The hardware circuit is based on a Freescale Kinetis K20 family MCU with 128 KB of embedded flash and an integrated USB controller. OpenSDA features a mass storage device (MSD) bootloader, which provides a quick and easy mechanism for loading different OpenSDA Applications such as flash programmers, run-control debug interfaces, serial-to-USB converters, and more. Two or more OpenSDA applications can run simultaneously. For example, run-control debug application and serial-to-USB converter runs in parallel to provide a virtual COM communication interface while allowing code debugging via OpenSDA with just a single USB connection. These two applications are provided in a single code package. Refer to the *OpenSDA User's Guide* for more details.

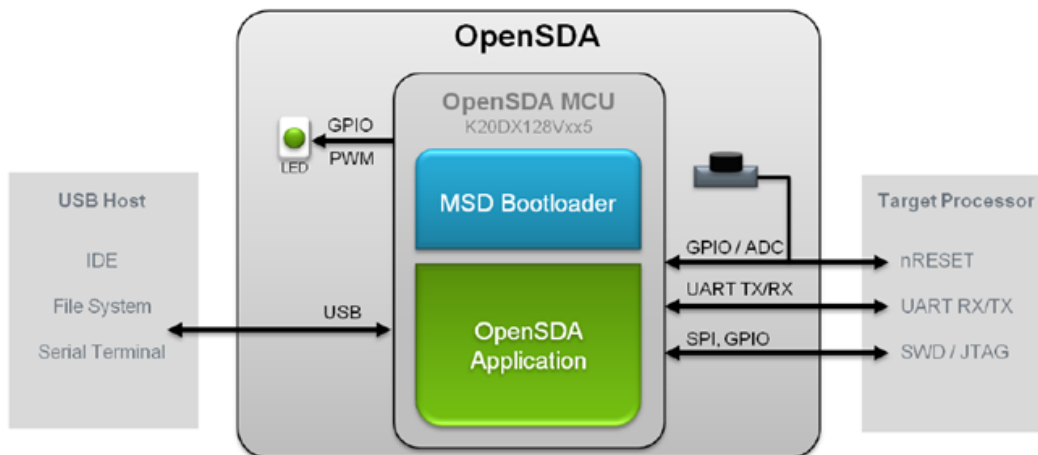


Figure 3. OpenSDA block diagram

OpenSDA is managed by a Kinetis K20 MCU built on the ARM Cortex-M4 core. The OpenSDA circuit includes a status LED (D8) and a RESET pushbutton (SW2). The pushbutton asserts the Reset signal to the KL27Z target MCU. It can also be used to place the OpenSDA circuit into Bootloader mode by holding down the RESET pushbutton while plugging the USB cable to USB connector J13. Once the OpenSDA enters bootloader mode, other OpenSDA applications such as debug app can be programmed.

SPI and GPIO signals provide an interface to the SWD debug port of the KL27Z. Additionally, signal connections are available to implement a UART serial channel. The OpenSDA circuit receives power when the USB connector J13 is plugged into a USB host.

5.3 Debugging interface

Signals with SPI and GPIO capability are used to connect directly to the SWD of the KL27Z. These signals are also brought out to a standard 10-pin (0.05") Cortex Debug connector (J11) as shown in Figure 4. It is possible to isolate the KL27Z MCU from the OpenSDA circuit and use J11 to connect to an off-board MCU. To accomplish this, cut the trace between pin1 and pin2 of J18 on bottom layer. This will disconnect the SWD_CLK pin to the KL27Z so that it will interfere with the communications to an off-board MCU connected to J11.

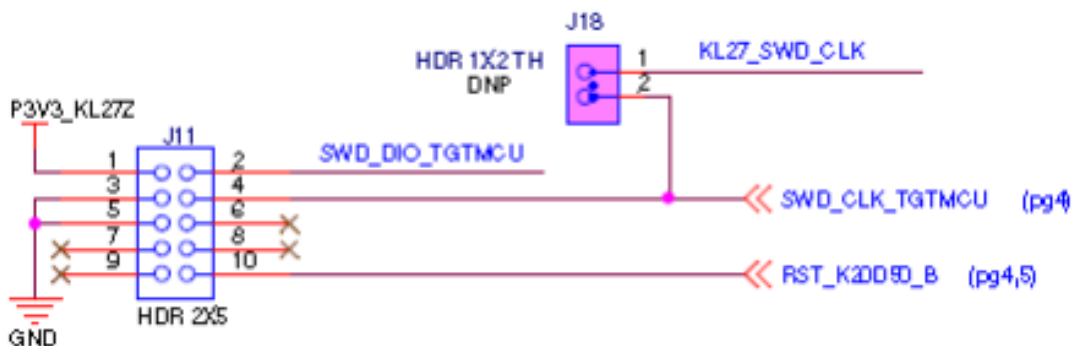


Figure 4. SWD debug connector to KL27Z

5.4 Virtual serial port

A serial port connection is available between the OpenSDA MCU and LPUART0 pin PTA1(TXD) and PTA2 (RXD) of KL27Z. Several of the default OpenSDA Applications provided by Freescale, including the MSD Flash Programmer and the P&E Debug Application, provide a USB Communications Device Class (CDC) interface that bridges serial communications between the USB host and this serial interface on the KL27Z.

5.5 Clock source

The Kinetis KL27 microcontrollers feature an on-chip oscillator compatible with input crystal: 32 to 40 KHz or 3 to 32 MHz. The KL27Z on the FRDM-KL27Z is clocked from the internal clock LIRC (2 MHz/8 MHz) or HIRC (48 MHz), and on-board 32768 Hz crystal for the RTC clock source.

5.6 Serial port

The serial port interface signals used with OpenSDA are LPUART0 pin PTA1 (TXD) and PTA2 (RXD). These signals are also connected to I/O header J1.

5.7 Reset

The RESET signal on the KL27Z is connected externally to a pushbutton, SW2. The reset button can be used to force an external reset event in the target MCU. The reset button can also be used to force the OpenSDA circuit into bootloader mode when plugging the USB cable to J13. Refer to [Section 5.2, “Serial and debug adapter \(OpenSDA\)”](#) for more details.

5.8 Debug

The sole debug interface on all Kinetis L series devices is a Serial Wire Debug (SWD) port. The primary controller of this interface on the FRDM-KL27Z is the onboard OpenSDA circuit. However, a 2x5-pin (0.05”) Cortex Debug connector, J11, provides access to the SWD signals for the KL27Z MCU. [Table 3](#) shows SWD connector signals description for KL27Z.

Table 3. ARM JTAG/SWD mini connector description

Pin	Function	Connection to KL27Z
1	VTref	P3V3_MCU
2	SWDIO/TMS	PTA3
3	GND	GND
4	SWDCLK/TCK	PTA0
5	GND	GND
6	SWO/TDO	NC
7	NC	NC
8	TDI	NC
9	NC	NC
10	RESET	PTA20

5.9 Capacitive touch slider

Two GPIO pins functioning as Touch Sense Input (TSI) signals, are connected to capacitive electrodes configured as a touch slider as shown in [Figure 5](#).

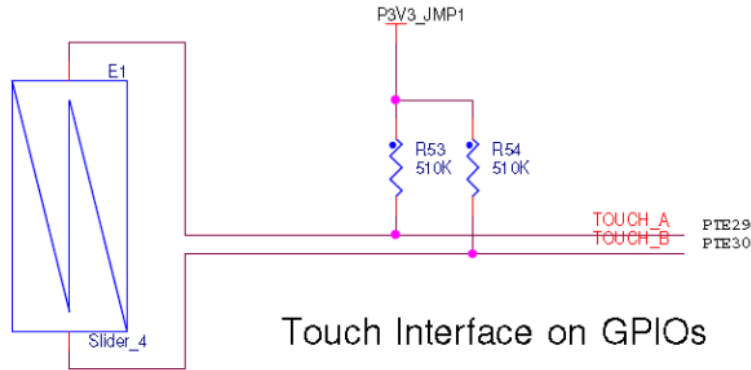


Figure 5. Touch slider connection

5.10 6-axis accelerometer and magnetometer

A Freescale MMA8451Q low-power, three-axis accelerometer is interfaced through an I²C bus and two GPIO signals as shown in Table 4. By default, the I²C address is 0x1D (SA0 pulled high).

Table 4. Accelerometer signal connections

MMA8451Q	KL27Z
SCL	PTD7
SDA	PTD6
INT1	PTC3
INT2	PTC2

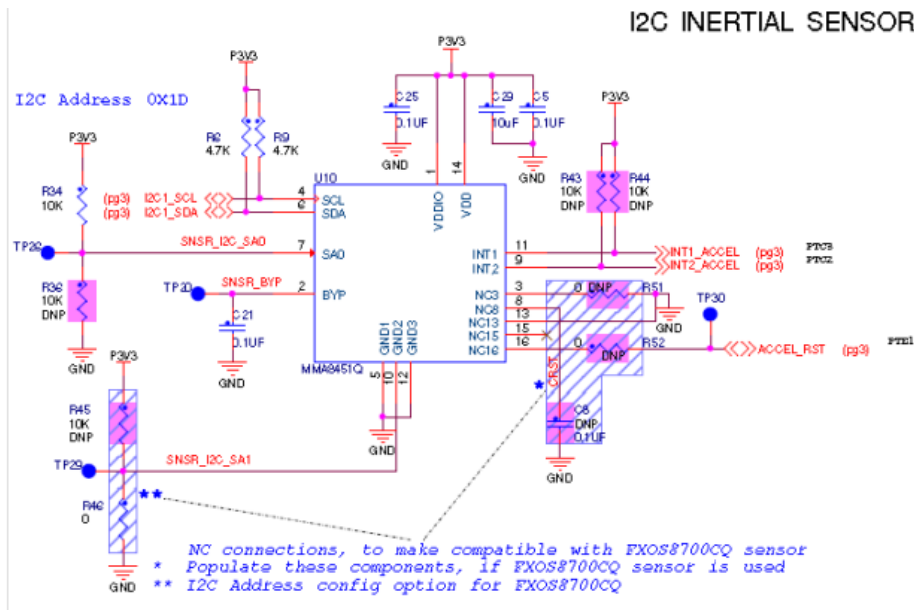


Figure 6. Accelerometer connection

This also designed to be compatible with 6-axis (FXOS8700CQ) combination of accelerometer and magnetometer sensor, if populating the U10 (FXOS8700CQ), and then keep U2 (MAG3310) DNP. Otherwise, populate U10 (MMA8451) and U2 (MAG3110).

A Freescale MAG3110 low-power, three-axis magnetometer is interfaced through an I²C bus and one GPIO signals as shown in Table 5. By default, the I²C address is 0x0E .

Table 5. Magnetometer signal connections

MMA8451Q	KL27Z
SCL	PTD7
SDA	PTD6
INT1	PTC2

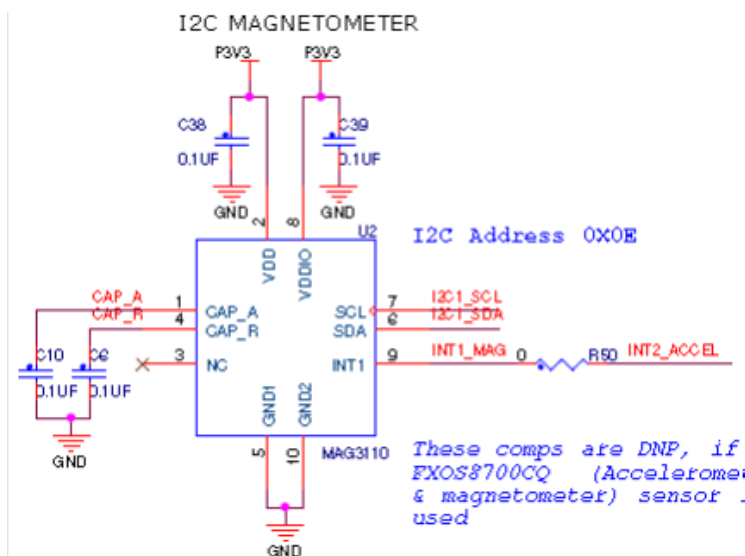


Figure 7. Magnetometer connection

5.11 RGB LED

Three PWM-capable KL27Z signals are connected to a red, green, and blue LED. The signal connections are shown in Table 6.

Table 6. RGB LED signal connections

RGB LED	KL27Z
Red Cathode	PTB18
Green Cathode	PTB19
Blue Cathode	PTA13

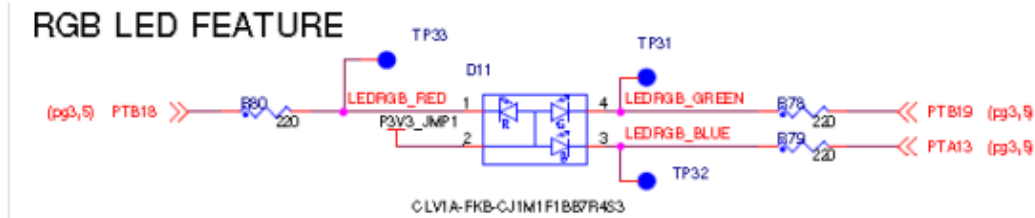


Figure 8. RGB LED connection

5.12 Input/output headers

The MKL27Z64VLH4 MCU is packaged in a 64-pin LQFP. Some pins are utilized by on-board circuitry, but many are directly connected to one of four I/O headers (J1, J2, J3 and J4).

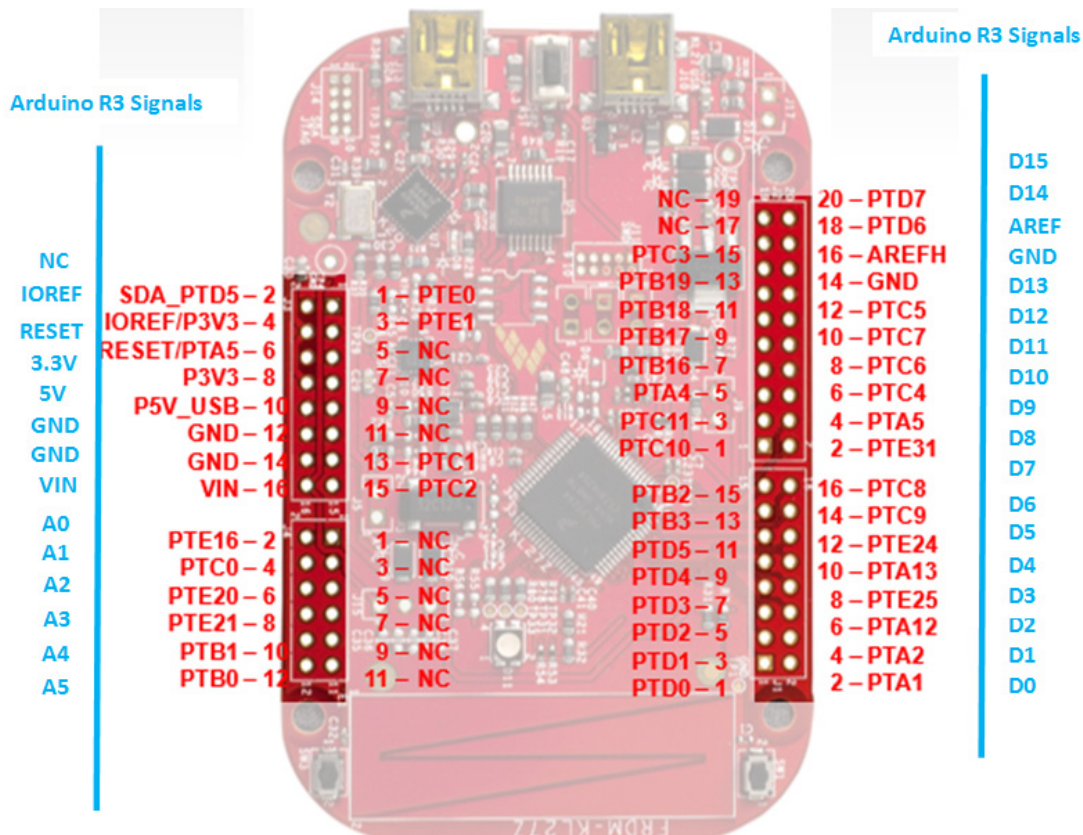


Figure 9. I/O headers

5.13 Arduino compatibility

The I/O headers on the FRDM-KL27Z are arranged to allow compatibility with peripheral boards (known as shields) that connect to Arduino and Arduino-compatible MCU boards. The pins on the headers share the same mechanical spacing and placement as the I/O headers on the Arduino Uno Revision 3 board design. See Figure 9 for compatible signals.

6 Using the FRDM-KL27Z with EEMBC ULPBench

The FRDM-KL27Z board supports the EEMBC® ULPBench benchmark. Information on this benchmark, including a description of what it is and instructions on how to obtain and use the associated EnergyMonitor hardware and software can be found at EEMBC.org.

The FRDM-KL27Z board can easily be modified to support the EEMBC ULPBench benchmark and the connection of the EEMBC EnergyMonitor v1.0.

6.1 Hardware modifications required for EnergyMonitor

The only board modifications required are to configure the board to measure current and isolate the OpenSDA MCU (refer to [Figure 2](#)).

- Add J17 and remove R1 and R2. This provides a means of powering the KL27 Kinetis MCU with the EnergyMonitor.
- Add J9 and remove R4 to isolate the OpenSDA MCU Vdd supply.
- Remove R7, R21 and R83 to isolate external current paths.
- Add a single pin header to TP4.

6.2 Programming the ULPBench device software

The ULPBench requires that the specific ULPBench profile software be loaded on the target device. This can be performed by either using the on-board OpenSDA debug/MSD interface, instruction for which can be found in the [OpenSDA User's Guide](#), or by means of an external SWD interface (J11 would need to be populated to use this method). If the default on-board interface is being used then J5, J6, J7, J9 and J17 must be placed while the code is programmed into the KL27 device. The board should be powered by means of USB connector J3 when programming the KL27. The EnergyMonitor should not be used to power the board when programming the KL27. These jumpers, along with the USB cable, must be removed when the EnergyMonitor is running to obtain the correct benchmark score.

6.3 Hardware configuration

The KL27 must be isolated from the OpenSDA MCU and any external pull up devices which may draw additional current. The hardware modifications in [Section 6.1](#), “Hardware modifications required for EnergyMonitor” must first be made. The following board jumpers must be removed:

- J9 and J17 to isolate the power supply and allow connection of the EnergyMonitor
- J5 to isolate the RESET line from the OpenSDA MCU
- J6 and J7 to isolate the SWD signals from the OpenSDA MCU
- J19 and J22 to isolate several external pull up devices
- J23 and J24 to isolate the I²C signals from the on board sensor devices
- J25 and J26 to isolate the UART signals from the OpenSDA MCU
- J27 and J28 to isolate the interrupt signals from the on board sensor devices

6.4 EnergyMonitor connections

The EnergyMonitor Vcc line should be connected to J17 pin2 and the EnergyMonitor GND line should be connected to TP4.

7 Revision history

This table provides a revision history for this document.

Table 7. Revision history

Rev. number	Date	Substantive change(s)
1	02/2015	Initial public release.

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