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Application Note Rev. 1, 5/2019

Freedom FRDM-KV11Z Development Board User's Guide

1. Introduction

The Freedom development board is a set of software and hardware tools for evaluation and development. It is ideal for rapid prototyping of microcontroller-based applications. The Freedom KV11 hardware, FRDMKV11Z, is a simple, yet sophisticated design featuring a Kinetis V series microcontroller, built on the ARM® Cortex®-M0+ core, and a perfect solution for BLDC and PMSM motor control applications. FRDM-KV11Z can be used to evaluate the KV1x Kinetis V series devices. It is based on the MKV11Z128VLF7 microcontroller, running up to 75MHz with hardware square root and divide capability and featuring dual 16-bit analog-to-digital controllers (ADCs) sampling at up to 1.2 mega samples per second (MS/s) in 12-bit mode, multiple motor control timers, 128KB of flash and 16KB of RAM memories and CAN interface. It is supported by a comprehensive enablement suite from NXP and its third-party resources including reference designs, software libraries, and motor configuration tools. The FRDM-KV10Z hardware is form-factor compatible with the Arduino® R3 pin layout, providing a broad range of expansion board options. Board embeds a 6-axis digital sensor, combining accelerometer and magnetometer, an analog thermistor, a RGB LED and two user push-buttons. The FRDMKV11Z platform includes the OpenSDA, the NXP open-source hardware for embedded serial and debug adapter, programmed with an open-source bootloader. This circuit offers several options for serial communication, flash programming, and run-control

Contents

debugging. OpenSDA software is from P&E Micro debug interface firmware for rapid prototyping and product development.

2. FRDM-KV11Z Hardware Overview

The features of the FRDM-KV11Z hardware are as follows:

- MKV11Z128VLF7P MCU (75 MHz with hardware square root and divide, 128 KB flash and 16 KB RAM memory, dual 16-bit ADCs and motor control timers, CAN, 48 LQFP package).
- Triple role USB interface with micro-B USB connector
- RGB LED
- FXOS8700CQ – Accelerometer and magnetometer
- Two user push buttons
- Flexible power supply option – OpenSDA USB, and Arduino header and 5 V power input
- Easy access to MCU I/Os through Arduino R3-compatible and proprietary headers
- Programmable OpenSDAv2.1 debug circuit programmed with the CMSIS-DAP Interface application that provides:
  - Mass storage device (MSD) flash programming, over a driver free USB connection.
  - P&E Micro debug interface providing run-control debugging for ARM® IDE toolchains.
  - Virtual serial port interface.

Figure 1 shows the block diagram of the FRDM-KV11Z design:

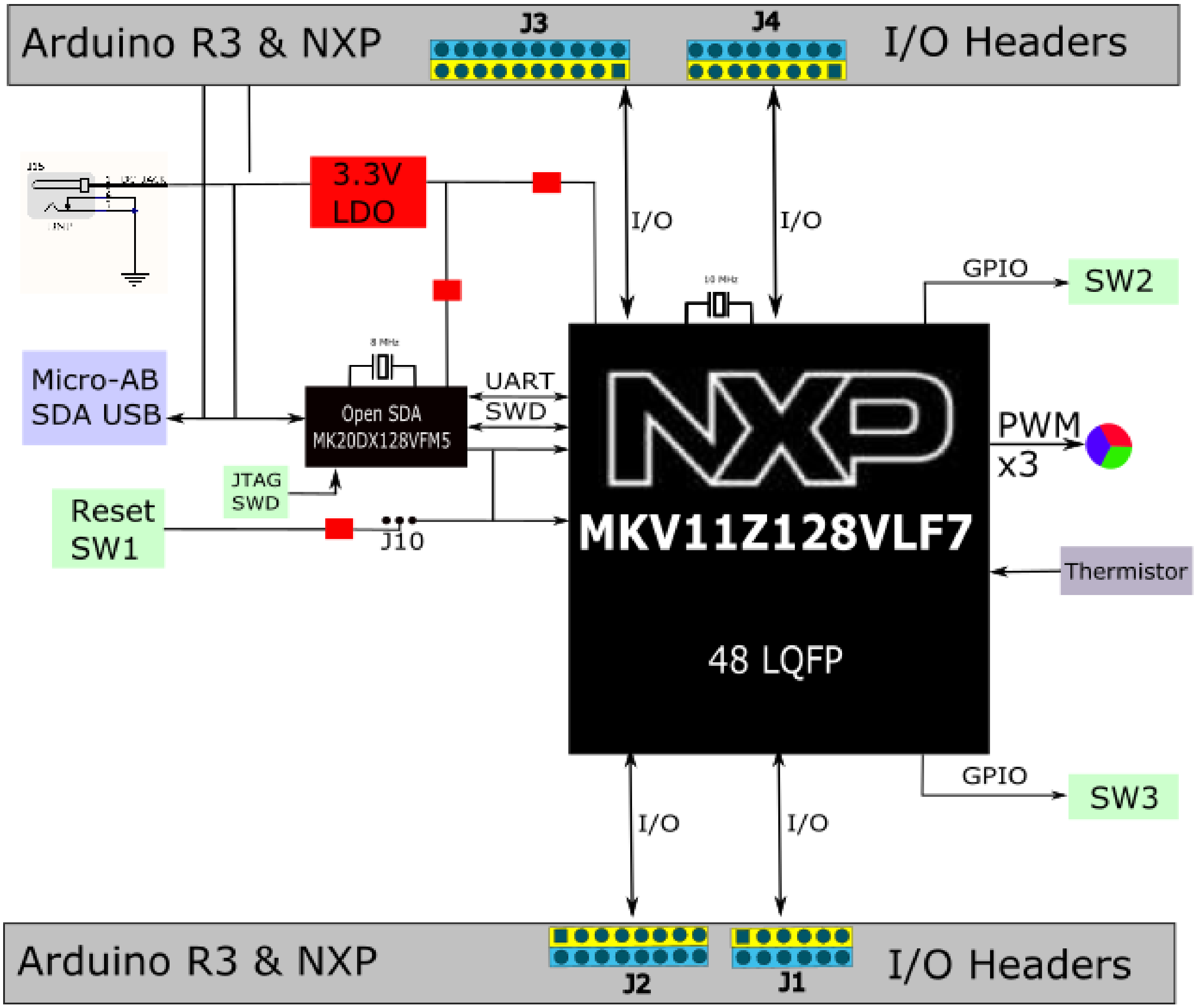

Figure 1. FRDM-KV11Z block diagram

The primary components and their placement on the hardware assembly are explained in the below figure:

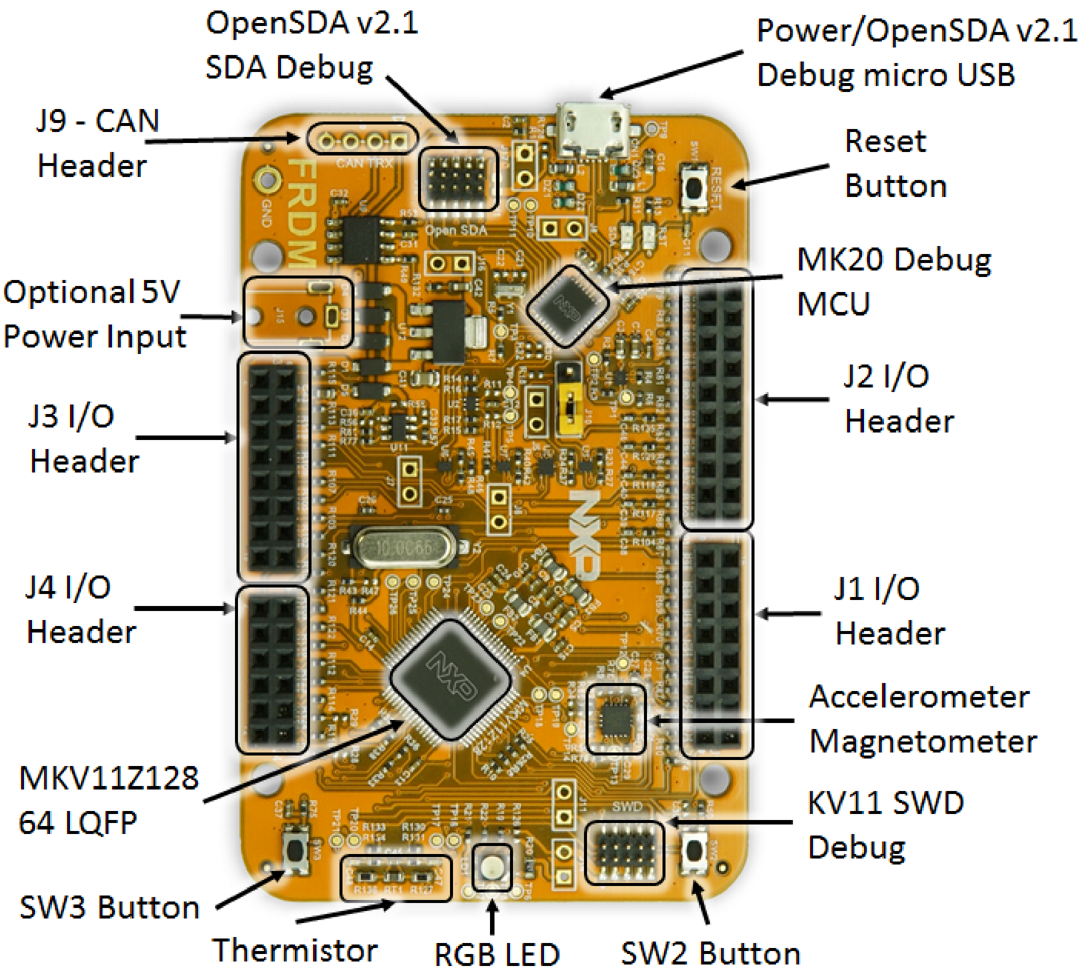

Figure 2. FRDM-KV11 callout

3. FRDM-KV11Z Hardware Description

Power supply

There are multiple power supply options on the FRDM-KV11Z. It can be powered from either of the USB connectors, the VIN pin on the J3 header, the DC Jack (not populated), or an off-board 1.71 V–3.6 V supply from the 3.3 V pin on the J14 header. The USB OpenSDA and the DC jack are regulated onboard using a 3.3 V DC-to-DC linear regulator to produce the main power supply. The voltage of the J14 and J3 header inputs are not regulated and will provide direct power-supply to the KV11Z microcontroller.

When attached to either the FRDM-MC-LVBLDC or the FRDM-MC-LVPMSM 3.3 V voltage is supplied from the motor control power board through the J3 header. The table below provides the operational details and requirements for the power supplies.

Table 1. **Power Supply sources**

Supply source	Valid range	OpenSDA operational	Regulated onboard
OpenSDA USB	5V	Yes	Yes
V_{IN} pin (J3 Header)	1.71 – 3.6 V	Yes	No
3.3V Header(J14)	1.71 – 3.6 V	No	No
DC- Jack (not populated) J15	5-9 V	Yes	Yes

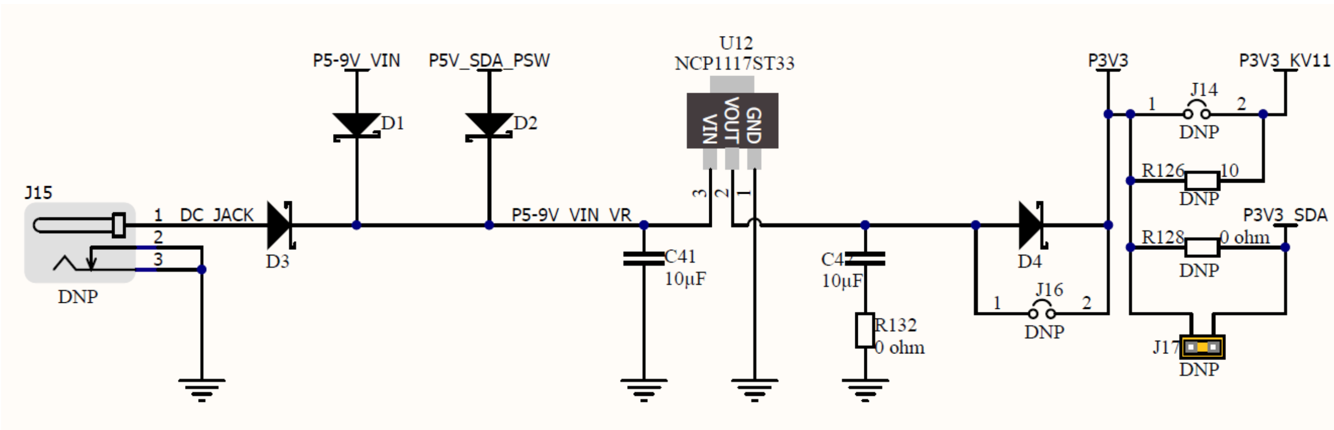

Figure 3. Power supply Regulation

Measuring MCU current

Cut trace jumper J14 is provided to isolate the power supplied to the KV11 MCU. To measure the current consumed by the MCU you can cut the trace on J14 and place a milliamp measuring DMM across the J14 header pins. Alternatively, you can populate the 10 Ohm R126 and place a voltage measuring DMM across the J14 header pins. The current will be = to the V/R126 value.

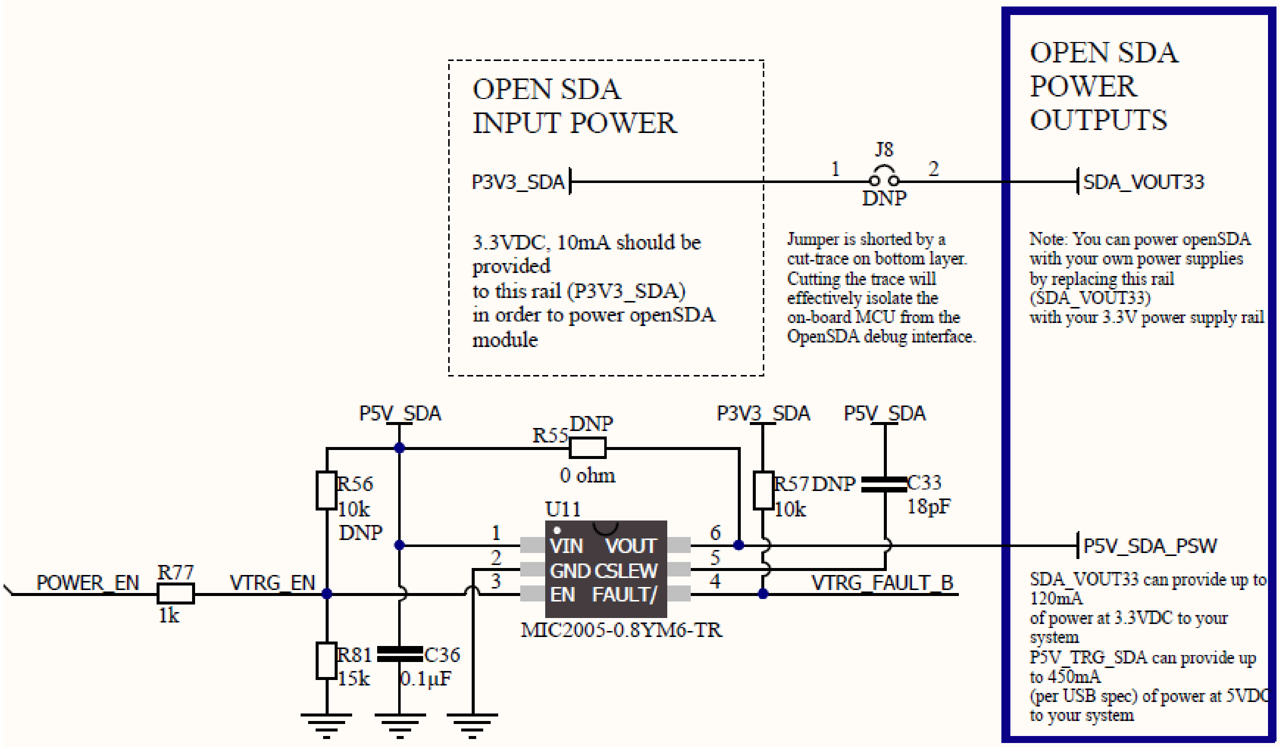

Figure 4. OpenSDA and Power Switch

Debug interface

There are two debug interface options provided: the on-board OpenSDA circuit and an external ARM Cortex JTAG connector. The ARM Cortex SWD connector (J19) is a standard 2x10-pin connector that provides an external debugger cable access to the SWD interface of the KV311Z128VLH7P. Alternatively, the on-board OpenSDA debug interface can be used to access the debug interface of the KV311Z128VLH7P.

OpenSDA

An on-board K20DX128VFM5- based OpenSDA circuit provides a SWD debug interface to the KV311Z128VLH7P. A standard USB-A male to micro-B male cable (provided) can be used for debugging via the USB connector (CN1).

The OpenSDA interface also provides a USB to serial bridge. Drivers for the OpenSDA interface are provided in the IDE you use. Updated Windows drivers and more utilities can be found online at http://www.pemicro.com/opensda.

Cortex debug connector

The Cortex Debug connector is a 20-pin (0.05") connector providing access to the SWD signals available on the KV11 device. If the OpenSDA is powered and J13 is used cutting the trace on J11 header will insure signal integrity. The pinout and KV11 pin connections to the debug connector (J13) are shown figure below. The signal RST_TGTMCU_B is tied to the KV11 RESET_b pin.

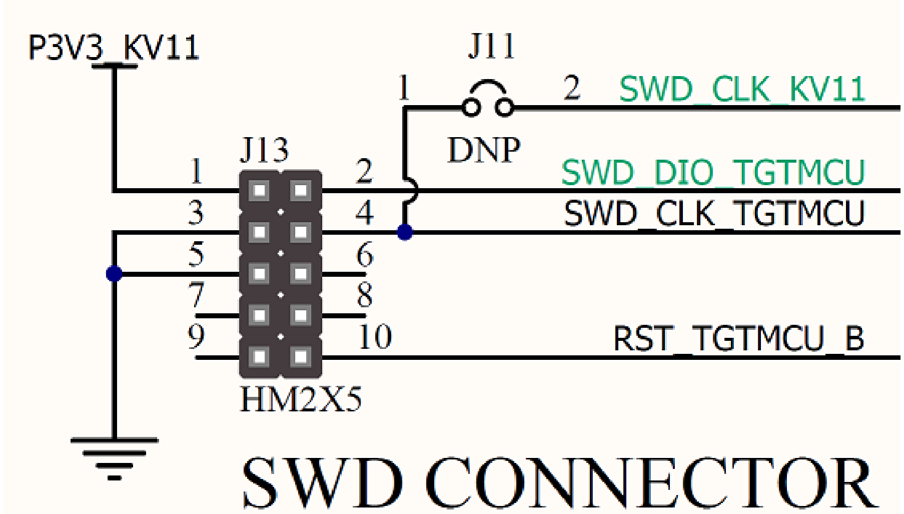

Figure 5. Cortex debug connector

Virtual mass storage device programming

A mass storage device is enumerated in a Windows base machine when you attach the FRDM-KV11 with a USB cable to the Windows computer USB connector.

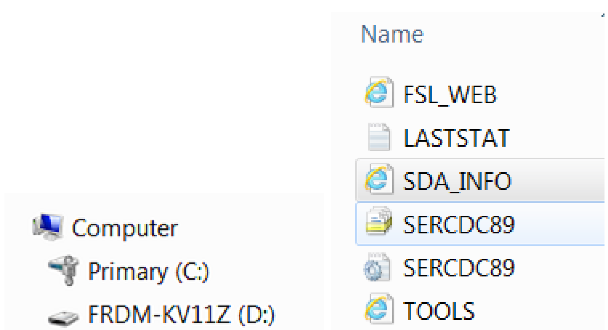

Figure 6. Flash programming MSD and SDA_INFO

To program the KV11 MCU flash drag and drop a binary or SRECORD file compiled for the Kinetis KV11 MCU on to the FRDM-KV11Z virtual MSD device. If you open the SDA_INFO file on the FRDM-KV11 MSD you will be able to determine the versions of the firmware on your OpenSDA debugger.

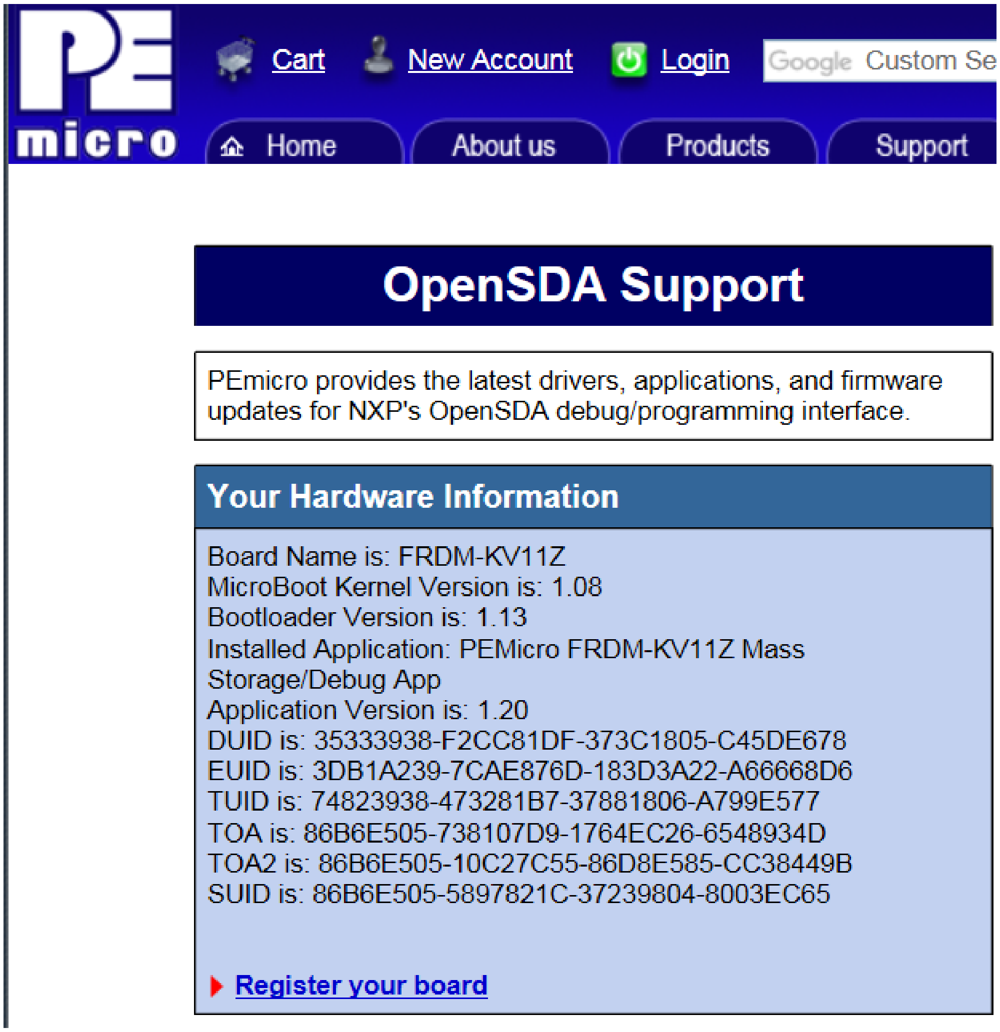

Figure 7. PEMICRO.COM OpenSDA report

3.6.1. Re-progamming the OpenSDA firmware

With header J10 jumper placed between 1-2 (default), if you hold SW1 down while plugging in the USB cable to the FRDM-KV11Z board the Bootloader Mass storage drive is enumerated.

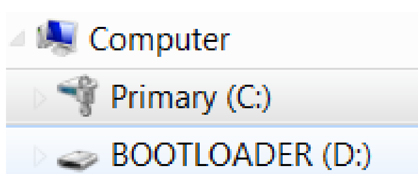

Figure 8. Bootloader MSD

Copy a new compatible OpenSDA firmware driver available from Segger at https://www.segger.com/. The version compatible with this board is “JLink_OpenSDA_V2_1.bin”

Virtual serial port

A serial port connection is available between the OpenSDA MCU and pins PTB16/UART0_RX and PTB17/UART0_TX. A voltage level translator is on-board to ensure signal integrity in case the KV11 MCU and the OpenSDA MCU are at different voltage levels. To determine which COM port number

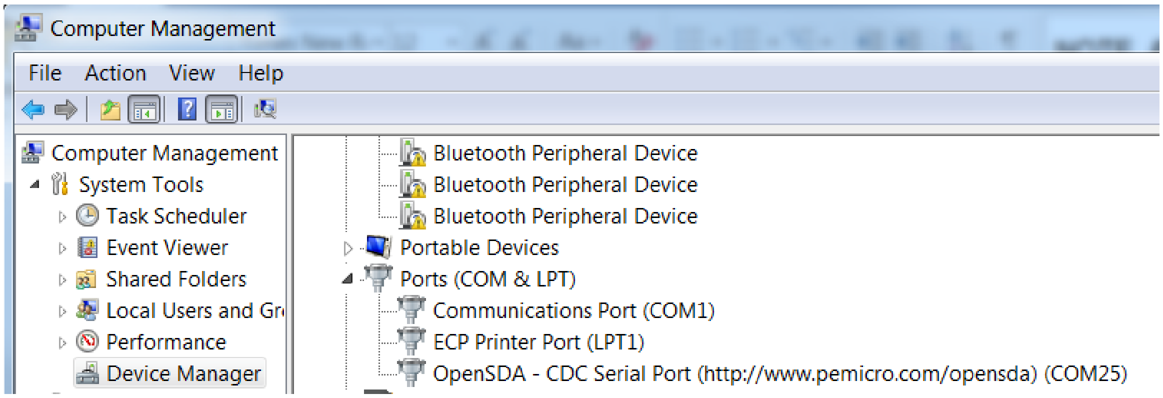

Figure 9. Determining COM number in Windows Device Manager

Open the Device Manager by right-mouse clicking on Computer and select Manage. Then select Device Manager and open the Ports (COM & LPT) drop-down.

4. Microcontroller

The Kinetis KV1x family of microcontrollers is a cost optimized solution specifically designed for motor control applications. Built upon the ARM® Cortex®-M0+ core running at 75 MHz, it is the fastest ARM Cortex-M0+ MCU in the market. With hardware square root and divide capability, it delivers a 27% increase in performance in math intensive applications versus comparable MCUs, allowing it to target BLDC as well as more computationally demanding PMSM motors. Additional features include:

- 128 KB of flash memory and optional CAN
- dual 16-bit analog-to-digital controllers with 835 ns conversion time in 12-bit mode
- Programmable delay block

Kinetis KV1x MCUs are offered in 64 LQFP, 48 LQFP, 32 LQFP and 32 QFN packages and comes with a comprehensive enablement suite from NXP and third-parties that include reference designs, software solutions and tools making motor control simple.

Table 2. **Features of MKV11Z128VLF7P**

Feature	Description
Performance	• 75 MHz ARM Cortex-M0+ core with hardware and divide hard-block. • Dual 16-bit ADCs sampling at up to 1.2 MS/s in 12-bit mode. • 10 channels of highly flexible motor control timers (PWMs) across 4 independent time bases.

Memories	• 128 KB flash memory (KMS indicated by P suffix uses top 8 KB of flash). • 16 KB SRAM embedded memory.
System Peripherals	• Flexible low-power modes, multiple wake-up sources. • 4-channel DMA controller. • Independent external and software watchdog monitor.
Clocks	• 32 to 40 kHz or 3-32 MHz crystal oscillator • Multipurpose clock generator with FLL (MCG)
Security and integrity modules	• Hardware CRC module. • 80-bit unique identification (ID) number per chip. • Flash access control to protect proprietary software (used by KMS protecting the top 8 Kbytes of Flash).
Analog Modules	• Two 16-bit SAR ADCs (1.2 MS/s in 12-bit mode) • One 12 bit DAC. • Two analog comparators (CPM) with 6-bit DAC
Timers	• One 8-ch motor-control/general purpose/PWM timers • Two 2-ch motor-control/general purposed timers with quadrature decoder functionality. • Periodic interrupt timers. • 16-bit low-power timer • Two Programmable delay blocks (one PDB per ADC)
Communication interfaces	• One SPI module. • Two UART modules. • One I2C: support for up to 1Mbit/s operation. • One CAN module.

5. Clock source

A 10 MHz external crystal is used for the external clock source of the KV10Z MCU.

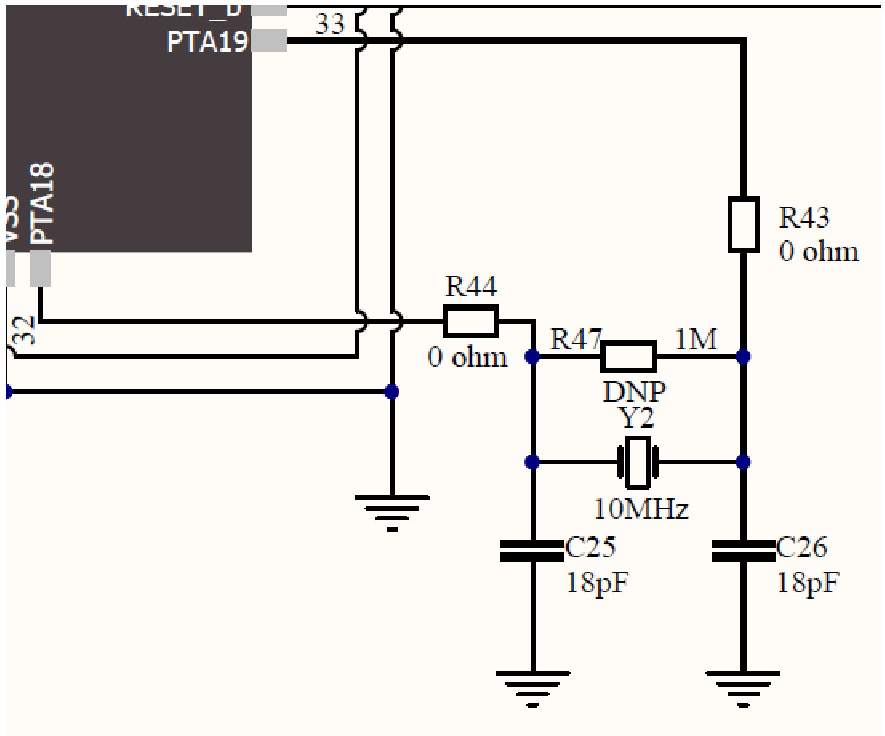

Figure 10. FRDM-KV11Z MCU clock source

To generate the max system frequency of the MCU, initialize the external clock source the OSC module, divide the input clock for the FLL in the MCG module and then multiply the FLL clock up to the 75 MHz clock frequency.

All of these settings and configurations can be managed with the MCUXpresso Clocks tool available on http://www.nxp.com/mcuxpresso.

6. Accelerometer and magnetometer

An FXOS8700CQ, 6-axis accelerometer and magnetometer sensor is interfaced through an I2C bus and two GPIO signals, as shown in the following table. By default, the I2C address is 0x1D (SA0 pull-up and SA1 pull-down).

Table 3. **Accelerometer and magnetometer signals connections**

FXOS8700CQ	KV11Z connection
SCL	PTC6/I2C0_SCL
SDA	PTC7/I2C0_SDA
INT1	PTB3
INT2	PTB2

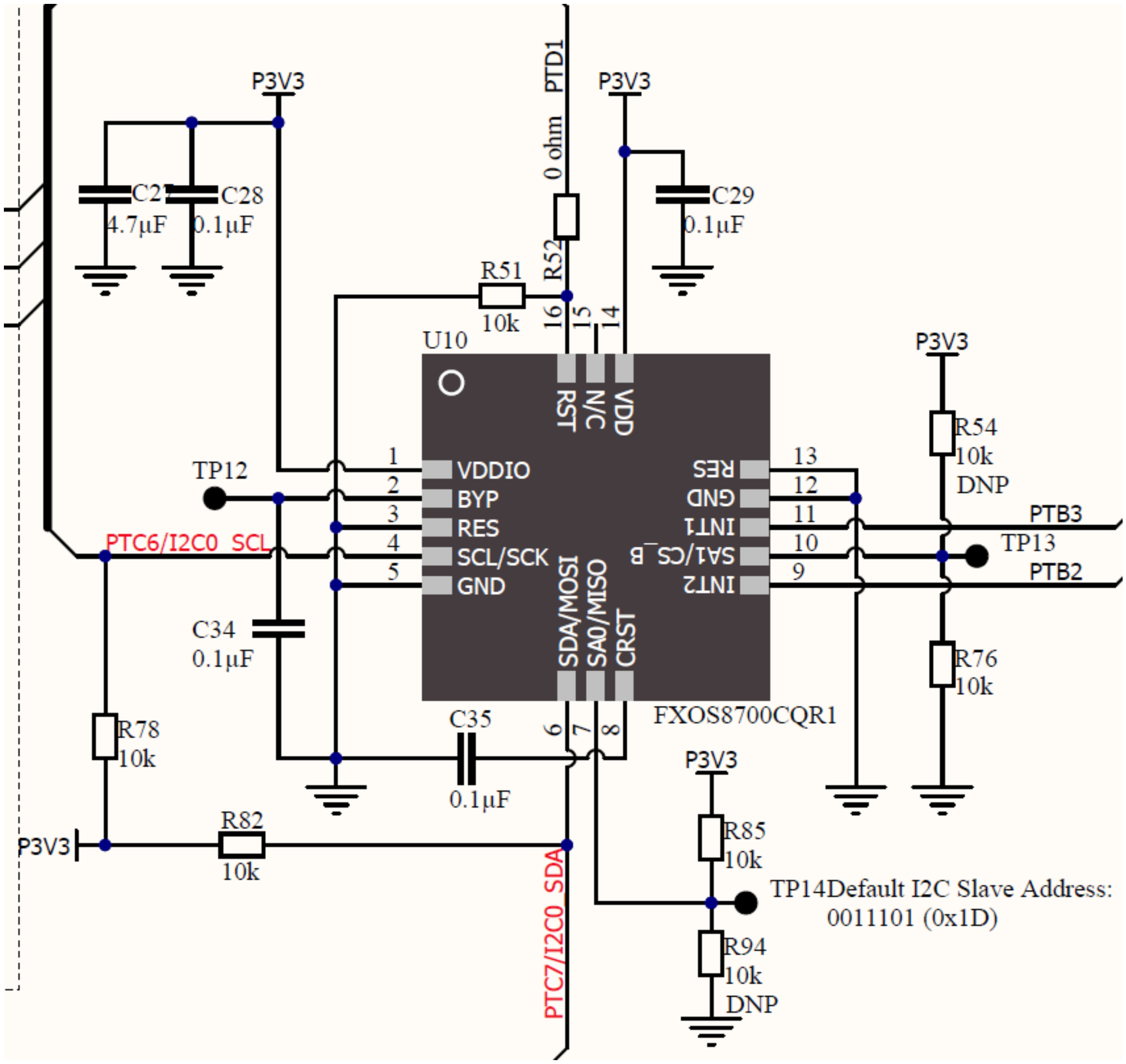

Figure 11. Accelerometer and magnetometer schematic

7. Thermistor

There is a thermistor circuit on the FRDM board. There is a thermistor RT1 provided on the board that can be used as single-ended or differential analog inputs to the KV10Z MCU.

In addition to the thermistor, there is a resistor between the thermistor and 3.3 V system power supply and another resistor between the thermistor and ground. The thermistor is a 10 K ohm part, but the associated divider chain uses different resistors. This makes the voltage across the thermistor larger or smaller, and provides the ability to try the different gain settings on the analog channels. The thermistor circuit is designed to provide useable differential inputs over the temperature range of 90˚ C to -20˚ C.

In addition to the thermistor voltage divider chain, the thermistor has a 0.1 uF capacitor in parallel.

Each analog input to the KV10Z has a 100-ohm series resistor and a 2200 pF capacitor as a low-pass filter. This helps protect the KV10Z from electrostatic discharge, and lowers the impedance of the analog signal so that it can be sampled with less noise.

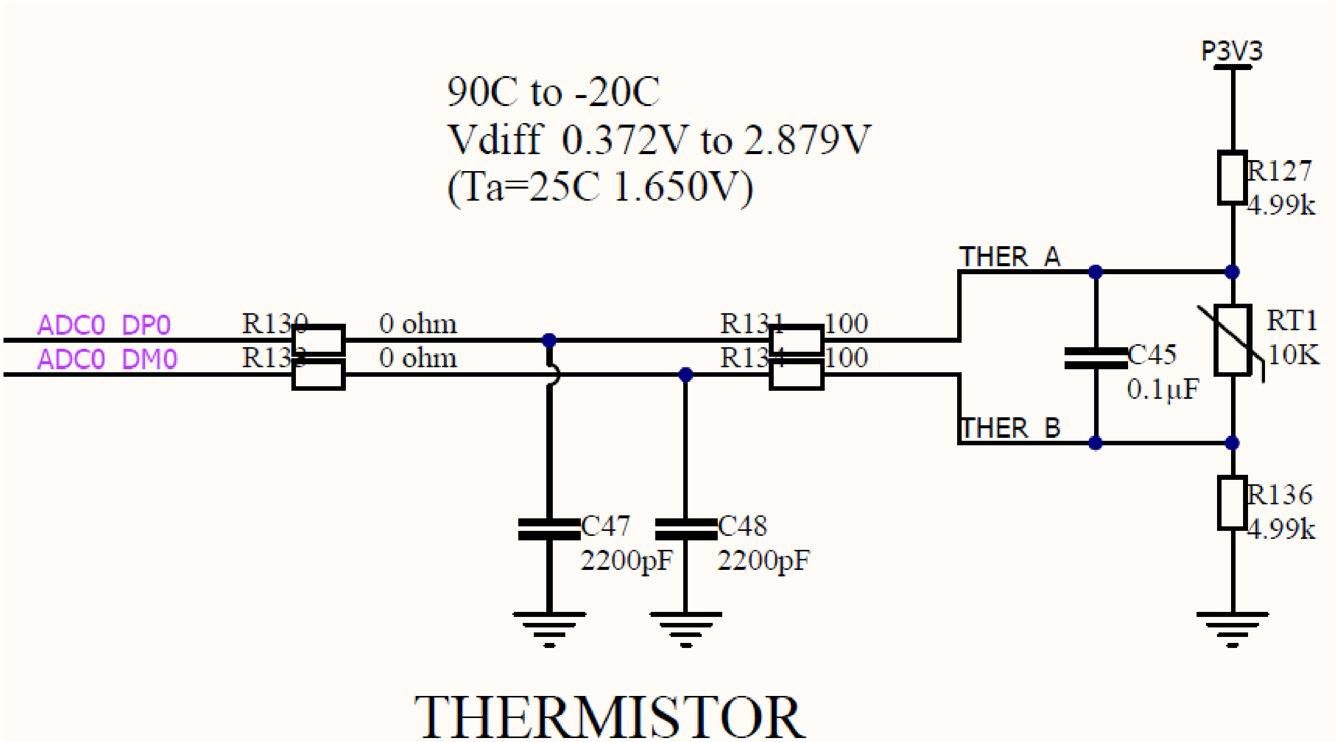

Figure 12. Thermistor circuit

8. RGB LED

RGB LED is connector through GPIO and signal connections are show in the following table.

Table 4. **LED Signal Connections**

RBG LED	KV11Z Connection
RED	PTD6
GREEN	PTE29
BLUE	PTE25

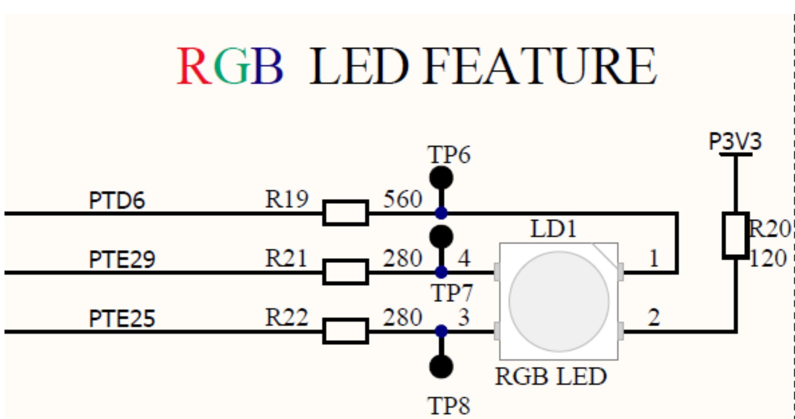

Figure 13. RGB LED circuit

9. CAN serial interface

The CAN interface signals are PTE24/CAN0_TX and PTE25/CAN0_RX. They are connected to an on-board transceiver for buffering on to header J9(not populated).

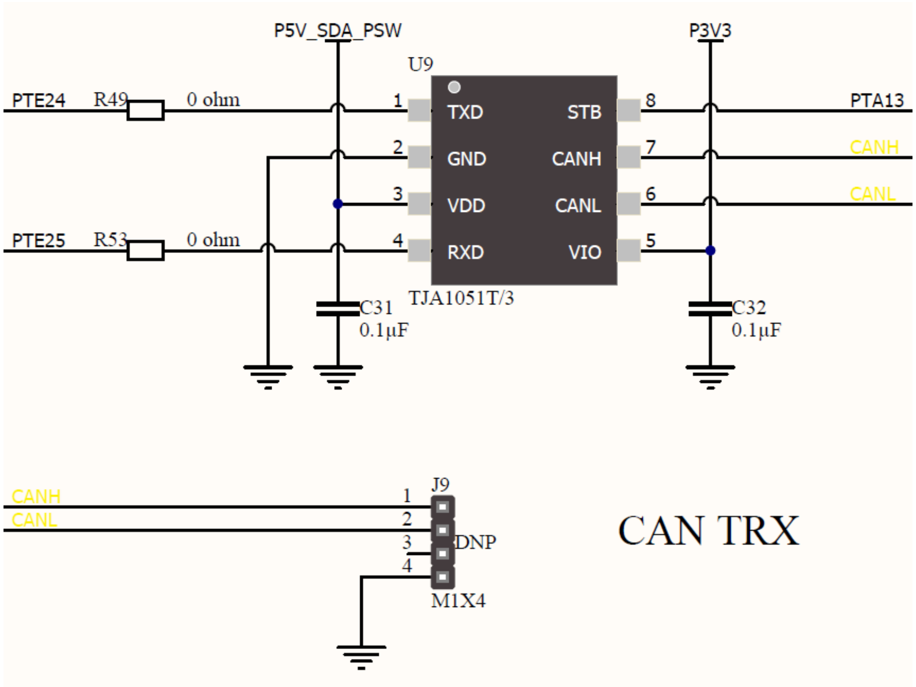

Figure 14. CAN interface circuit

10. Reset

The RESET signal is low active on all Kinetis MCUs. The KV11Z Reset signal is connected to the debug K20 MCU and a button SW1. If the J10 jumper is between 1-2 the KV11 Reset is driven by the output of the level translator. This is needed if the debug MCU and the target KV11 MCU are at different VDD levels, such as when an external 1.8 V DC VDD is provided to the KV11 MCU.

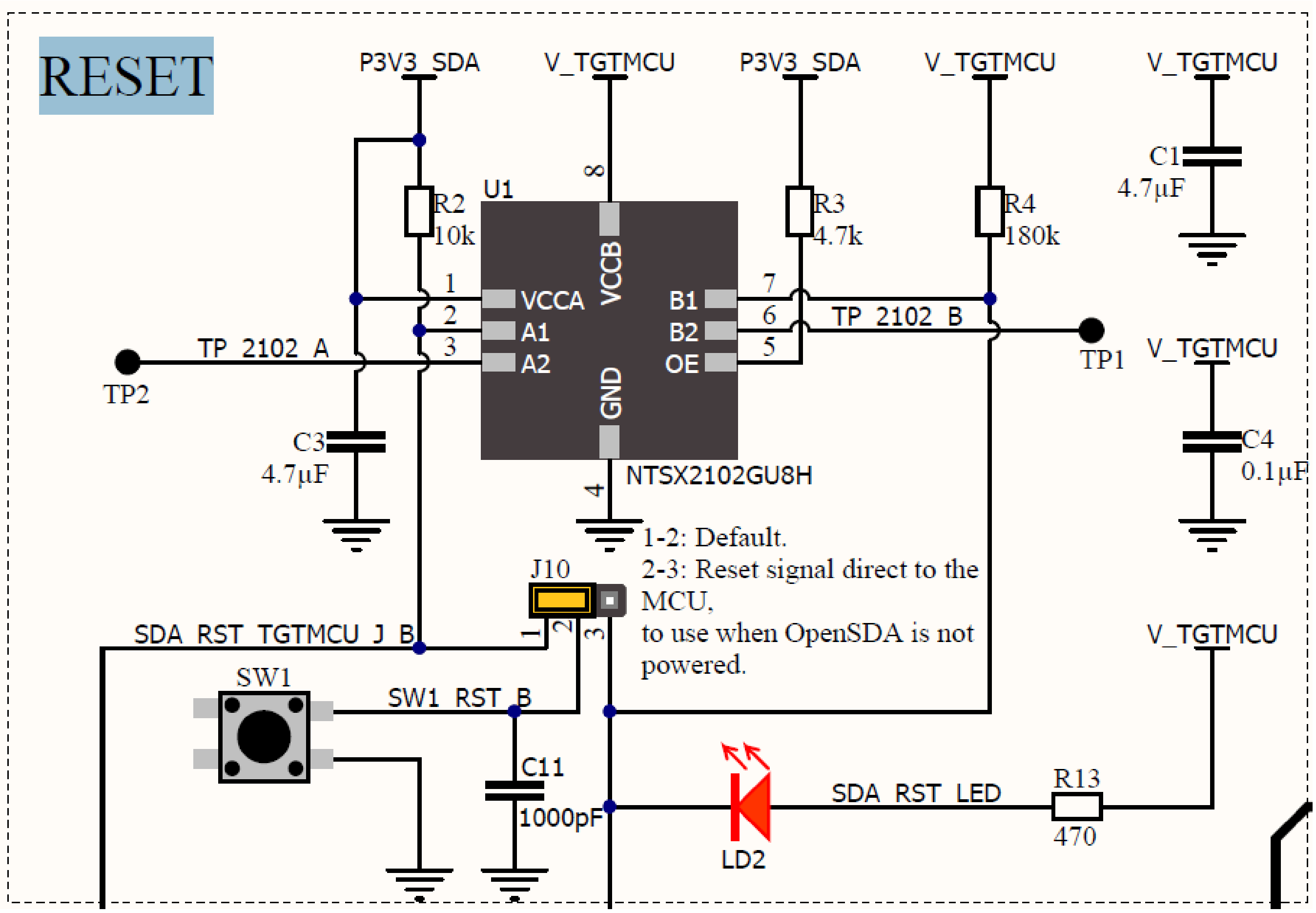

Figure 15. Reset Circuit

11. Push button switches

Two general purpose push buttons, SW2 and SW3, are available on the FRDM-KV11Z board. SW2 is connected to PTA4/NMI and SW3 is connected to PTB0. SW2 is connected by default to the NMI – Non-Maskable-Interrupt input. Care should be taken to select the function of the MCU input. If left at default the MCU will hold in the NMI interrupt function if the NMI input is low or logic 0.

Besides the general purposed input/output functions both switches can be used as low-power wake up trigger inputs.

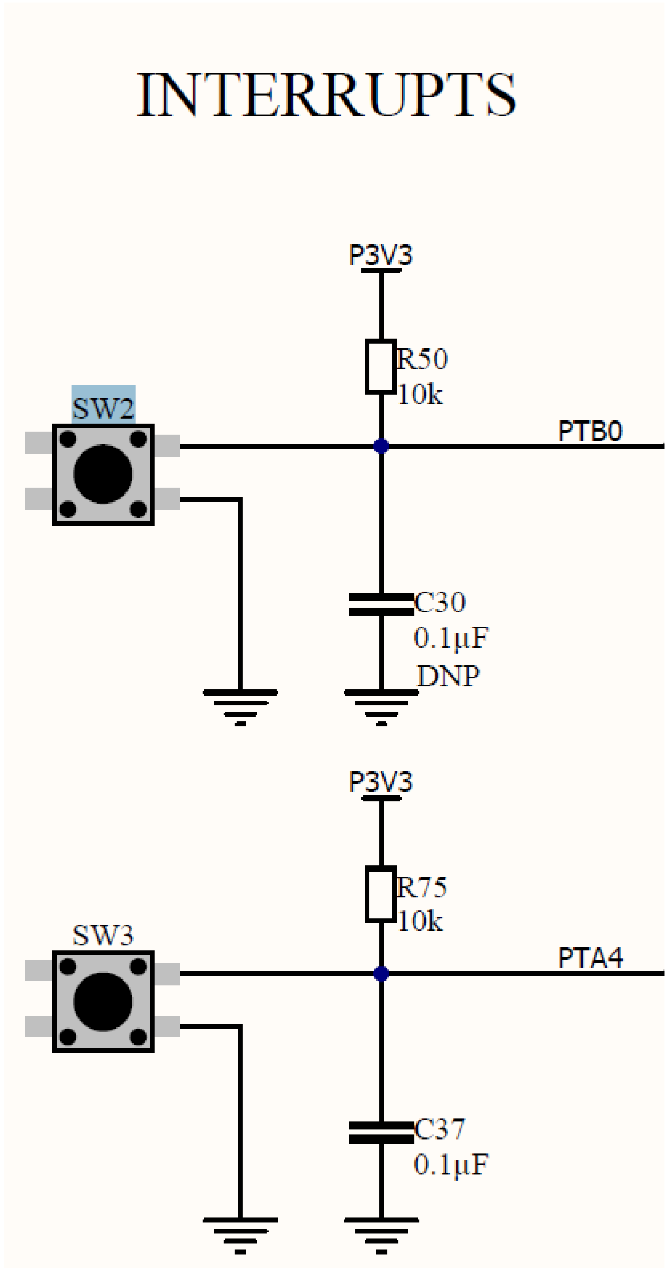

Figure 16. Switch interrupt circuit

12. Input/output connectors

The MKV11Z128VLF7 microcontroller is packaged in a 48-pin LQFP. Some pins are utilized in onboard circuitry, but some are directly connected to one of the four I/O headers.

The pins on the KV11Z microcontroller are named for their general purpose input/output port pin function. For example, the first pin on Port A is referred as PTA1. The name assigned to the I/O connector pin is same as of the KV10Z pin connected to it, if applicable.

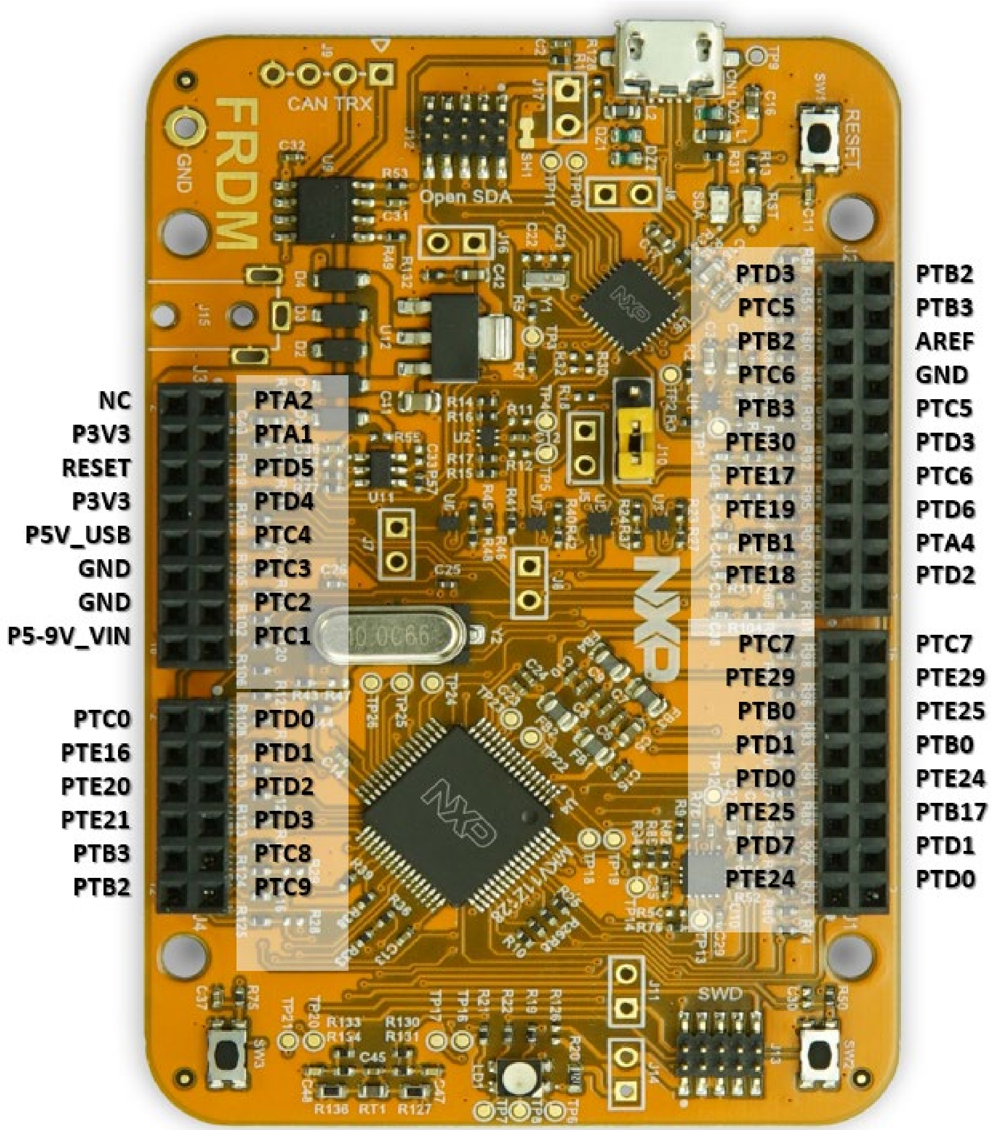

Figure 17. FRDM-KV11Z I/O header Pin-outs

13. Arduino Compatibility

The I/O headers on the FRDM-KV11Z board are arranged to enable compatibility with peripheral boards (known as shields) that connect to Arduino and Arduino-compatible microcontroller boards. The outer rows of pins (even numbered pins) on the headers, share the same mechanical spacing and placement with the I/O headers on the Arduino Revision 3 (R3) standard.

14. References

The following references are available on www.nxp.com:

- FRDMKV11ZQSG, FRDM-KV11Z Quick Start Guide
- FRDM-KV11Z Pinouts
- FRDM-KV11Z Schematic
- FRDM-KV11Z Design Package
- KV11P64M75RM KV11Z Sub family Reference Manual
- KV11P64M75- Kinetis C Series KV10 and KV11, 128/64 KB Flash Data Sheet
- MCUXpresso Software Development Kit –
- MCUXpresso IDE
- MCUXpresso Clocks Tool
- MCUXpresso Pins Tool

15. Revision history

Table 5. **Sample revision history**

Revision number	Date	Substantive changes
0	09/2017	Initial release
1	05/2019	Removed KMS references

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