Freescale Semiconductor, Inc.
User's Guide

Freedom Board for Kinetis K22F Hardware (FRDM-K22F)

User's Guide

1   Introduction

The Freescale Freedom development platform is a set of software and hardware tools for evaluation and development. It is ideal for rapid prototyping of microcontroller-based applications. The Freescale Freedom K22 hardware, FRDM-K22F, is a simple yet sophisticated design featuring a Kinetis K series microcontroller built on the ARM® Cortex®-M4 core which features a floating point unit (FPU).

FRDM-K22F can be used to evaluate the K22FN512, K22FN256, and K22FN128 Kinetis K series devices. The FRDM-K22F board features the MK22FN512VLH12 MCU, which boasts a maximum operation frequency of 120 MHz, 512 KB of flash, a 128 KB RAM, a full-speed USB controller with available crystal-less operation, and analog and digital peripherals. The FRDM-K22F hardware is form-factor compatible with the Arduino™ R3 pin layout, providing a broad range of expansion board options. The onboard interface includes a six-axis digital accelerometer and magnetometer, an RGB LED, and sufficient footprint to add an optional Bluetooth module (for use over UART), an RF module (for use over SPI), and an SDHC slot (for use over SPI).

Contents

freescale™

The FRDM-K22F platform features OpenSDAv2, the Freescale open-source hardware embedded serial and debug adapter running an open-source bootloader. This circuit offers several options for serial communication, flash programming, and run-control debugging. OpenSDAv2 is an mbed™ HDK-compatible debug interface preloaded with the open-source CMSIS-DAP Interface firmware (mbed interface) for rapid prototyping and product development, with a focus on connected Internet of Things devices.

2   FRDM-K22F Hardware Overview

The features of the FRDM-K22F hardware are as follows:

- MK22FN512VLH12 MCU—120 MHz, 512 KB flash memory, 128 KB RAM, low-power, and crystal-less USB in 64 LQFP package)
- Dual role USB interface with USB connector
- RGB LED
- FXOS8700CQ—accelerometer and magnetometer
- Two user push buttons
- Flexible power supply option—OpenSDAv2 USB, K22F USB, or external source
- Easy access to MCU input/output through Arduino R3 compatible I/O connectors
- Programmable OpenSDAv2 debug circuit supporting the CMSIS-DAP interface software that provides:
  — Mass storage device (MSD) flash programming interface
  — CMSIS-DAP debug interface over a USB HID connection providing run-control debugging and compatibility with IDE tools
  — Virtual serial port interface
- Optional microSD card slot for operation over SPI
- Optional header for add-on RF module: nRF24L01+ Nordic 2.4 GHz radio
- Optional header for add-on Bluetooth module: JY-MCU BT board V1.05 BT

Figure 1 shows the block diagram of the FRDM-K22F design. The primary components and their placement on the hardware assembly are explained in Figure 2.

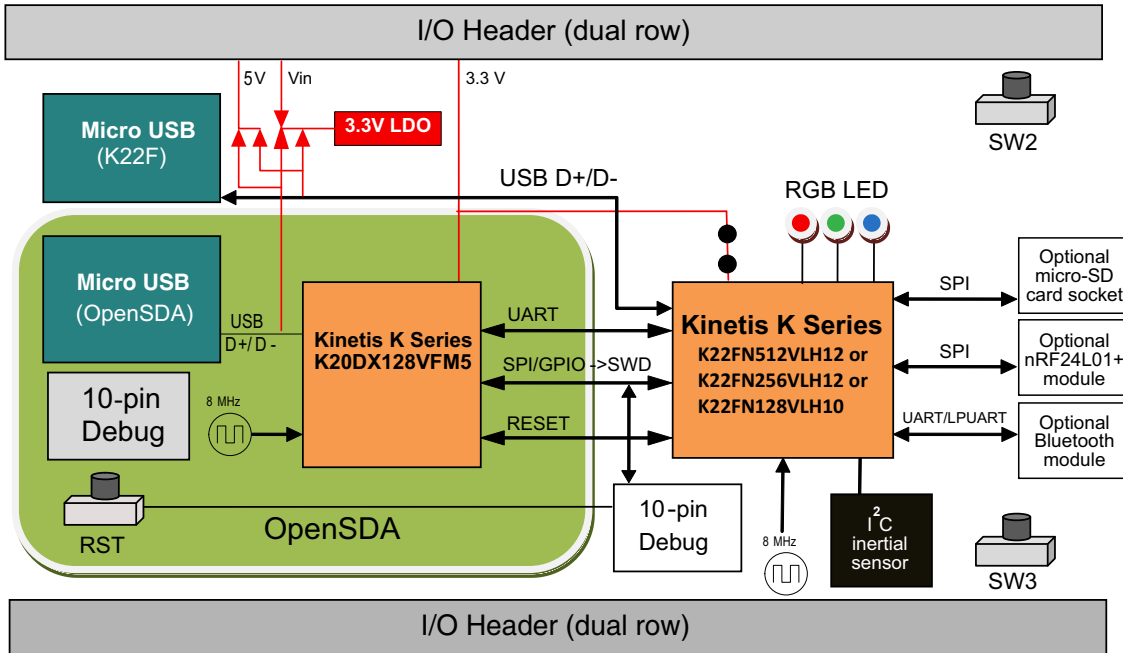**Figure 1. FRDM-K22F block diagram**
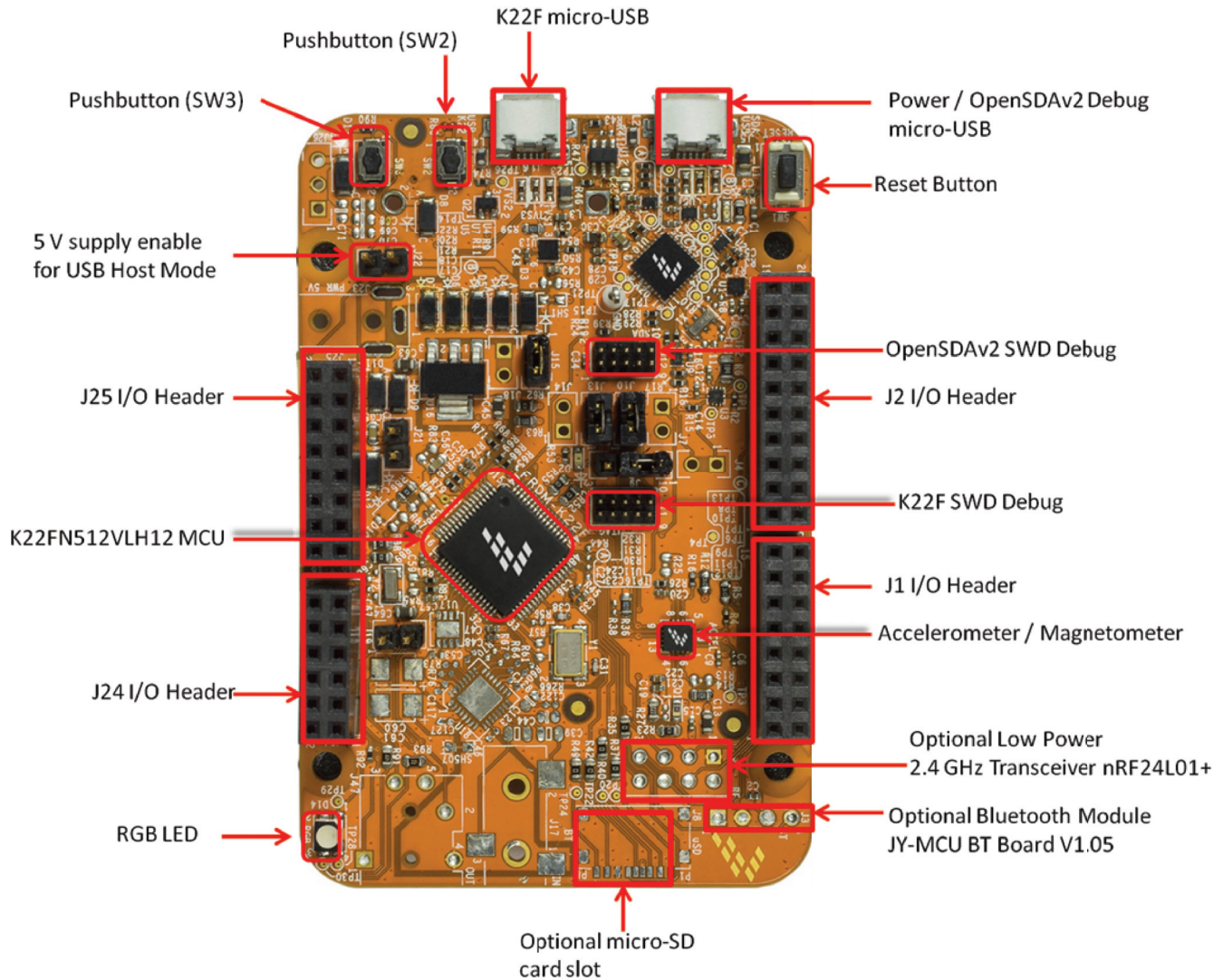
Figure 2. FRDM-K22F primary component placement

3   FRDM-K22F Hardware Description
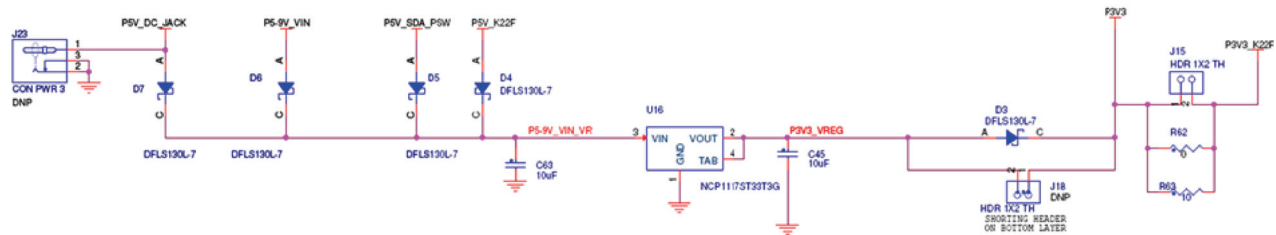
3.1   Power supply

There are multiple power supply options on the FRDM-K22F board. It can be powered from either of the USB connectors, the VIN pin on the I/O header, DC jack (optional; not populated), or an off board 1.71–3.6 V supply from the 3.3 V pin on the I/O header. The USB, DC jack, and VIN supplies are regulated onboard using a 3.3 V linear regulator to produce the main power supply. A direct voltage supply to the K22F MCU is also available via J15. Table 1 provides the operational details and requirements for the power supplies.

Table 1. FRDM-K22F power requirements

Supply Source	Valid Range	OpenSDAv2 Operational?	Regulated Onboard?
OpenSDAvs USB	5 V	Yes	Yes
K22F USB	5 V	No	Yes
P5-9V_VIN pin	5 V–9 V	No	Yes
3.3 V header (J15)	1.71 V–3.6 V	No	No
DC jack (not populated)	5 V–9 V	No	Yes

NOTE

The OpenSDAv2 circuit is only operational when a USB cable is connected and supplies power to the OpenSDAv2 USB. However, protection circuitry is in place to enable multiple sources to be powered at once.

Figure 3. Power supply schematic

Table 2. FRDM-K22F power supplies

Power Supply Name	Description
P5-9V_VIN	Power supply from the VIN pin of the I/O headers (J25 pin 16). A Schottky diode provides back-drive protection.
DC_JACK	Power supplied from the DC Jack (J23; not populated). A Schottky diode provides back-drive protection.
P3V3_VREG	Regulated 3.3 V supply. Sources power to the P3V3 supply rail through a back-drive protection Schottky diode[1].
P3V3_K22F	K22F MCU voltage supply. Header J15 provides a convenient means for energy consumption measurements[2].
P3V3_SDA	OpenSDAv2 circuit voltage supply.
P5V_USB	Nominal 5 V supplied to the I/O headers (J25 pin10).

[1] By default, the linear regulator (U16) is a 3.3 V output regulator. This is a common footprint that enables the user to modify the assembly to use an alternative device, such as a 1.8 V output regulator. The K22F microcontroller has an operating range of 1.71 V to 3.6 V.

[2] The P3V3_K22F rail is connected with two resistors, R62 and R63. To measure the energy consumption of the K22F MCU, the trace between J15 pins 1 and 2 must be first cut. A current probe or shunt resistor and voltage meter can then be applied to measure the energy consumption on these rails.

3.2   Serial and Debug Adapter version 2 (OpenSDAv2)

OpenSDAv2 is a serial and debug adapter circuit which includes an open-source hardware design, an open-source bootloader, and debug interface software. It bridges serial and debug communications between a USB host and an embedded target processor as shown in Figure 4. The hardware circuit is based on a Freescale Kinetis K20 family microcontroller (MCU) with 128 KB of embedded flash and an integrated USB controller. OpenSDAv2 comes preloaded with the CMSIS-DAP bootloader—an open-source mass storage device (MSD) bootloader, and the CMSIS-DAP interface firmware (a.k.a. mbed interface), which provides an MSD flash programming interface, a virtual serial port interface, and a CMSIS-DAP debug protocol interface. For more information on the OpenSDAv2 software, see mbed.org and https://github.com/mbedmicro/CMSIS-DAP.
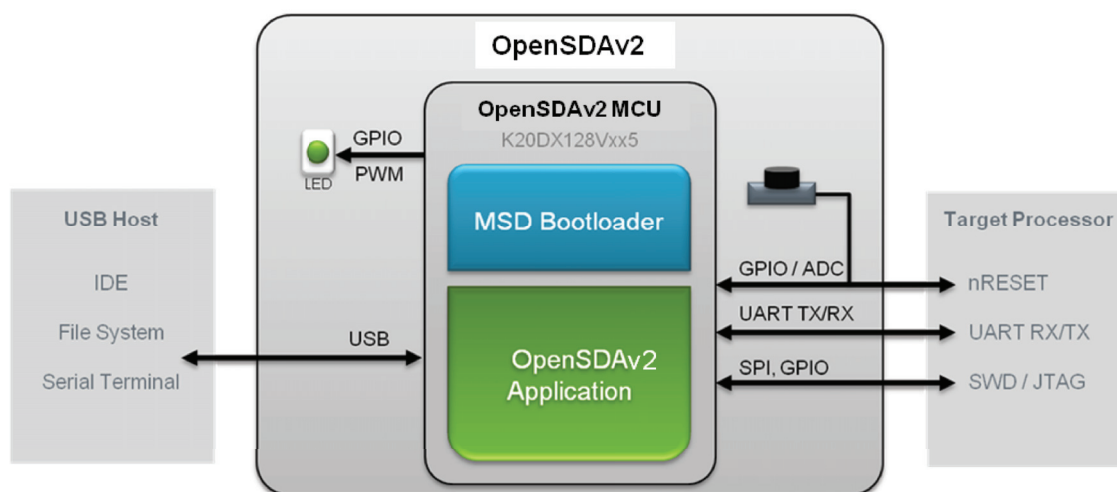

Figure 4. OpenSDA high-level block diagram

OpenSDAv2 is managed by a Kinetis K20 MCU built on the ARM Cortex-M4 core. The OpenSDAv2 circuit includes a status LED (D1) and a push button (SW1). The push button asserts the Reset signal to the K22F target MCU. It can also be used to place the OpenSDAv2 circuit into bootloader mode. SPI and GPIO signals provide an interface to either the SWD debug port or the K20. Additionally, signal connections are available to implement a UART serial channel. The OpenSDAv2 circuit receives power when the USB connector J5 is plugged into a USB host.

3.2.1   Debug interface

Signals with SPI and GPIO capability are used to connect directly to the SWD of the K22F. These signals are also brought out to a standard 10-pin (0.05") Cortex debug connector (J11). It is possible to isolate the K22F MCU from the OpenSDAv2 circuit and use J11 to connect to an off-board MCU. To accomplish this, cut the trace on the bottom side of the PCB that connects J7 pin 2 to J11 pin 4. This will disconnect the SWD_CLK pin to the K22F so that it will not interfere with communication to an off-board MCU connected to J7.
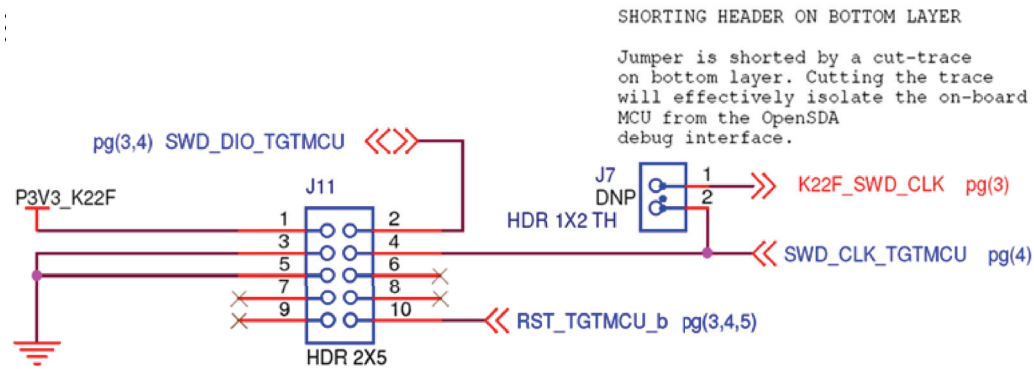
Figure 5. SWD debug connector

The J11 header is populated by default. A mating cable, such as a Samtec FFSD IDC cable, can then be used to connect from the OpenSDAv2 of the FRDM-K22F to an off-board SWD connector.

3.2.2   Virtual serial port

A serial port connection is available between the OpenSDAv2 MCU and pins PTE0 and PTE1 of the K22F.

4   Microcontroller

The FRDM-K22F features the MK22FN512VLH12 MCU. This 120 MHz microcontroller is part of the Kinetis K2x family and is implemented in a 64 LQFP package. The FRDM-K22F board also supports the MK22FN256 and MK22FN128 MCUs. Table 3 describes some of the features of the MK22FN512VLH12 MCU that is populated on this board.

Table 3. Features of the MK22FN512VLH12

Feature	Description
Ultra-low power	• 11 low-power modes with power and clock gating for optimal peripheral activity and recovery times • Full memory and analog operation down to 1.71 V for extended battery life • Low-leakage wake-up unit with up to three internal modules and 16 pins as wake-up sources in low-leakage stop (LLS) and very low-leakage stop (VLLS) modes • Low-power timer for continual system operation in reduced power states
Flash and SRAM	• 512-KB flash featuring fast access times, high reliability, and four levels of security protection • 128 KB of SRAM • No user or system intervention to complete programming and erase functions, and full operation down to 1.71 V • Flash access control to protect proprietary software • Pre-programmed Kinetis flash loader for one-time, in-system factory programming[1]
Mixed-signal capability	• High-speed 16-bit ADC with configurable resolution • Single or differential output modes for improved noise rejection • 500-ns conversion time achievable with programmable delay block triggering • Two high-speed comparators providing fast and accurate motor over-current protection by driving PWMs to a safe state • Optional analog voltage reference provides an accurate reference to analog blocks and replaces external voltage references to reduce system cost

Table 3. Features of the MK22FN512VLH12 (continued)

Feature	Description
Performance	• 120-MHz ARM Cortex-M4 core with DSP and FPU instruction set, single cycle MAC, and single instruction multiple data (SIMD) extensions • Up to 16 channel DMA for peripheral and memory servicing with reduced CPU loading and faster system throughput • Crossbar switch enables concurrent multi-master bus accesses, increasing bus bandwidth
Timing and control	• Up to four FlexTimers (FTM) with a total of 20 channels • Hardware dead-time insertion and quadrature decoding for motor control • Four-channel 32-bit periodic interrupt timer (PIT) provides time base for RTOS task scheduler, or trigger source for ADC conversion and programmable delay block

Connectivity and communications	• Full-Speed USB Device/Host/On-The-Go
	• USB low-voltage regulator[2] that supplies up to 120 mA off-chip at 3.3 volts to power external components from 5-volt input
	• Three UARTs:
	  – one UART that supports RS232 with flow control, RS485, and ISO7816
	  – two UARTs that support RS232 with flow control and RS485
	• One low-power UART (LPUART)
	• One Inter-IC Sound (I^2S) serial interface for audio system interfacing
	• Two DSPI modules and two I^2C modules

Reliability, safety and security	• Cyclic redundancy check (CRC) engine validates memory contents and communication data, increasing system reliability • Independently-clocked COP guards against clock skew or code runaway for fail-safe applications such as the IEC 60730 safety standard for household appliances • External watchdog monitor drives output pin to safe state for external components in the event that a watchdog time-out occurs

[1] The MCU populated on the FRDM-K22F comes pre-programmed with an out-of-box demo, so the flash loader is not present. To find out more information about the flash loader and how to restore it, visit freescale.com/kboot.

[2] Not available on K22FN128 devices.

5 Clocking

The Kinetis K22F MCU starts up from an internal digitally-controlled oscillator (DCO). Software can enable the main external oscillator (EXTAL0/XTAL0) if desired. The external oscillator/resonator can range from 32.768 kHz up to 32 MHz. The default external source for the MCG oscillator inputs (EXTAL) is an 8 MHz crystal.
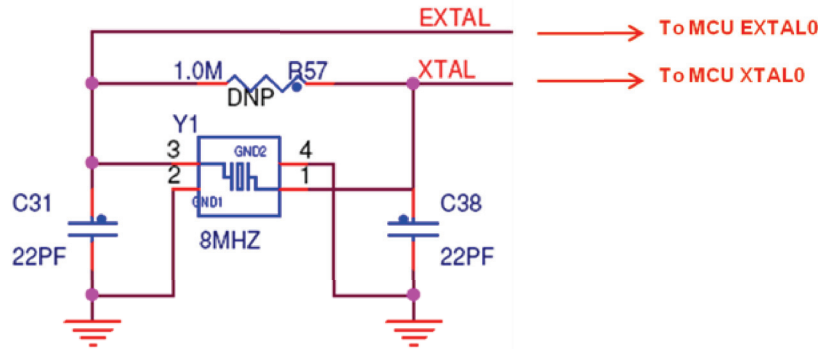
Figure 6. 8 MHz crystal clock source for MCU

Note that, unlike the MK22FN512VLH12 and MK22FN256VLH12 MCUs, the MK22FN128VLH10 MCU does not feature a Phase-Locked Loop (PLL).

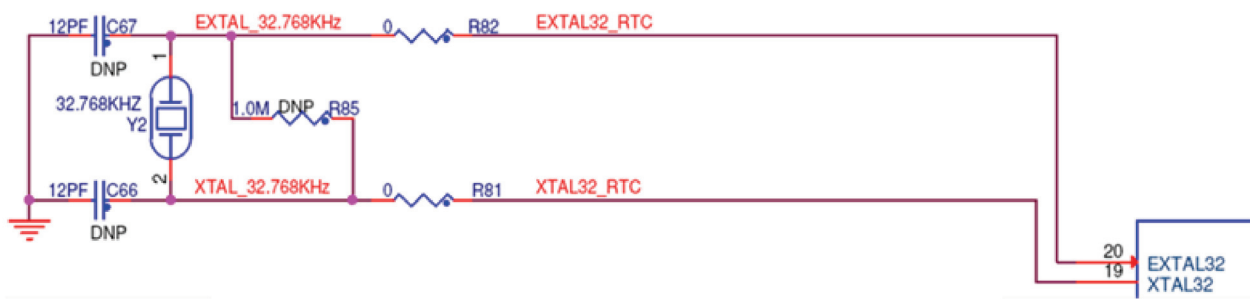By default, the 32.768 KHz crystal is connected to the K22F MCU's RTC oscillator inputs.

Figure 7. 32.768 kHz crystal for RTC

6   Universal Serial Bus (USB)

The MK22FN512VLH12 MCU features a full-speed/low-speed USB module with on-the-go/host/device capability and built-in transceiver. The FRDM-K22F board routes the USB D+ and D signals from the MK22FN512VLH12 MCU directly to the onboard micro USB connector (J16).
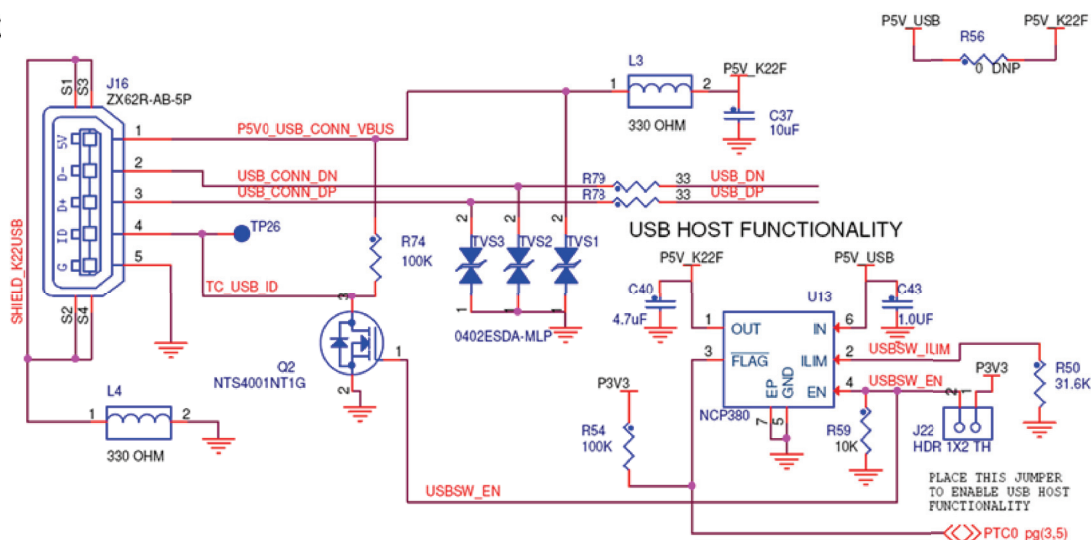
Figure 8. K22F USB port

When the FRDM-K22F board is operating in USB host mode, J22 must be shunted to supply 5 V power to VBUS (J16 pin 1). The source of 5 V power can be the OpenSDAv2 USB port (J5), pin 10 of the J25 I/O header, or P5-9V_VIN DC-DC converter of J26.
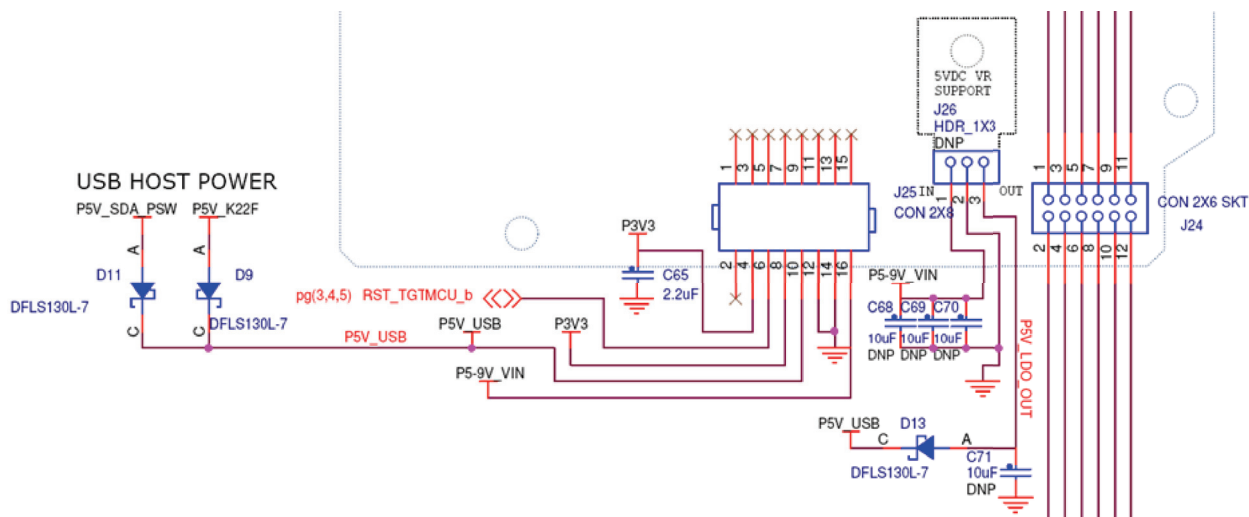
Figure 9. K22F USB port power inputs for host mode

Note that, unlike the MK22FN512xxx12 and MK22FN256xxx12 MCUs, the MK22FN128xxx10 MCU does not feature a USB voltage regulator. When evaluating the MK22FN128VLH10 device on the FRDM-K22F board, 3 V power must be applied to the USBVDD pin (which powers the USB transceiver on the MK22FN128 device) of the MCU by populating R83. See Figure 10.
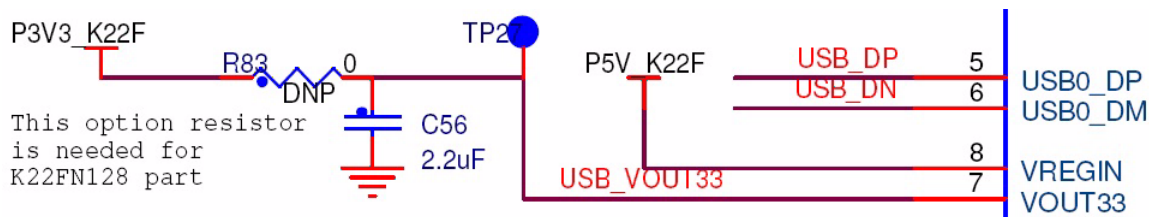
Figure 10. USB transceiver power for K22FN128 device

7 Secure Digital Card

An optional micro secure digital (SD) card slot is supported on the FRDM-K22F. This slot, which will accept micro format SD memory cards, is connected to the SPI signals of the MCU. The SD card detect pin is an open switch that shorts with VDD when the card is inserted. Table 4 describes the SPI signal connection details of micro SD card.
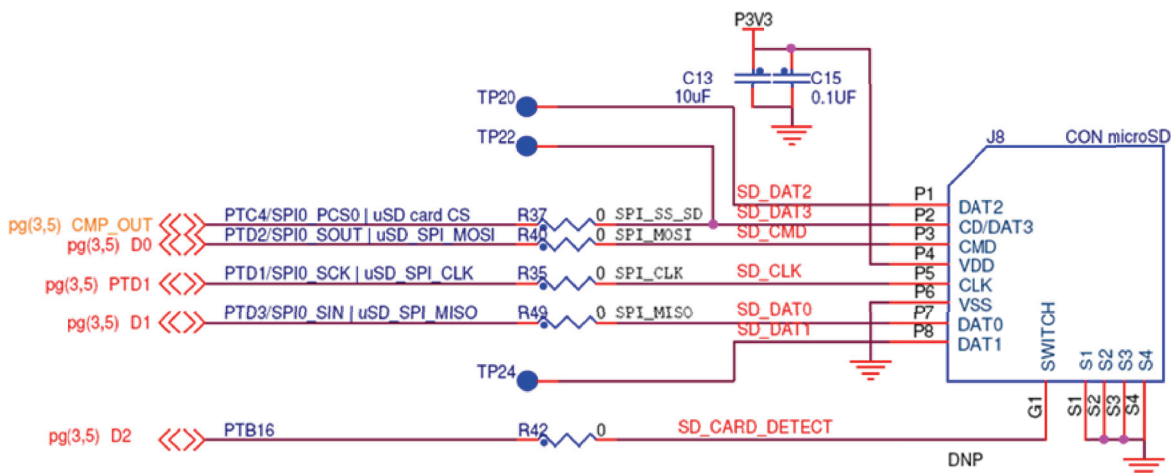

Figure 11. Micro SD interface over SPI

Table 4. Micro SD card socket connection over SPI

Pin	Function	FRDM-K22F Connection
1	DAT2	No connect
2	CD/DAT3	PTC4/LLWU_P8/**SPI0_PCS0**/UART1_TX/FTM0_CH3/FB_AD11/CMP1_OUT/LPUART0_TX
3	CMD	PTD2/LLWU_P13/ **SPI0_SOUT**/UART2_RX/FTM3_CH2/FB_AD4/LPUART0_RX/I2C0_SCL
4	VDD	3.3 V board supply (P3V3)
5	CLK	PTD1/ADC0_SEb/**SPI0_SCK**/ UART2_CTS_b/FTM3_CH1/FB_CS0_b/LPUART0_CTS_b
6	VSS	Ground
7	DAT0	PTD3/S**PI0_SIN**/UART2_TX/FTM3_CH3/FB_AD3/LPUART0_TX/I2C0_SDA
8	DAT1	No connect

Table 4. Micro SD card socket connection over SPI (continued)

Pin	Function	FRDM-K22F Connection
G1	SWITCH	**PTB16**/SPI1_SOUT/UART0_RX/FTM_CLKIN0/FB_AD17/EWM_IN
S1-S4	S1,S2,S3,S4	Shield ground

8   Accelerometer and Magnetometer

A Freescale FXOS8700CQ low-power, six-axis Xtrinsic sensor is interfaced through an I^{2}C bus and two GPIO signals, as shown in Table 5. By default, the I^{2}C address is 0x1C (pull-up on SA0 and pull-down on SA1).

Table 5. Accelerometer and magnetometer signals connection

FXOS8700Q	K22F Connection
SCL	PTB2/ADC0_SE12/**I2C0_SCL**/UART0_RTS_b/FTM0_FLT3
SDA	PTB3/ADC0_SE13/ **I2C0_SDA**/ UART0_CTS_b/FTM0_FLT0
INT1	**PTD0**/LLWU_P12/SPI0_PCS0/UART2_RTS_b/ FTM3_CH0/FB_ALE/FB_CS1_b/FB_TS_b LPUART0_RTS_b
INT2	**PTD1**/ADC0_SE5b/SPI0_SCK/UART2_CTS_b/FTM3_CH1/ FB_CS0_b/LPUART0_CTS_b
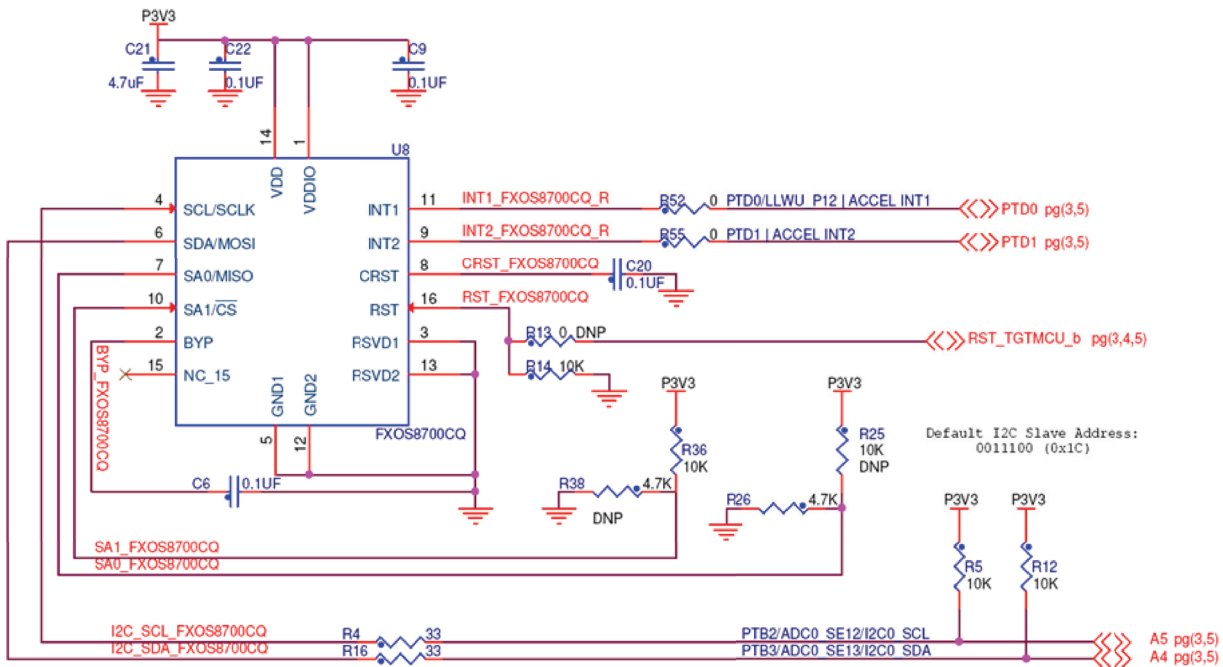
Figure 12. Accelerometer and magnetometer

9   RGB LED

An RGB LED is connected through GPIO pins. Signal connections are shown in Table 6.

Table 6. LED signal connection

RGB LED	K22F Connection
RED	**PTA1**/UART0_RX/FTM0_CH6/JTAG_TDI/EZP_DI
GREEN	**PTA2**/UART0_TX/ FTM0_CH7/JTAG_TDO/TRACE_SWO/EZP_DO
BLUE	**PTD5**/SPI0_PCS2/UART0_CTS_b/FTM0_CH5/FB_AD1/ EWM_OUT_b/SPI1_SCK

10 Serial Port

The primary serial port interface signals are PTE1 UART1_RX and PTE0 UART1_TX. These signals are connected to the OpenSDAv2 circuit.

11 Reset

The Reset signal on the K20 is connected externally to a push button, SW1, and also to the OpenSDAv2 circuit. The reset button can be used to force an external reset event on the target MCU. The reset button can also be used to force the OpenSDAv2 circuit into boot loader mode. For more details, see Section 3.2, "Serial and Debug Adapter version 2 (OpenSDAv2)".
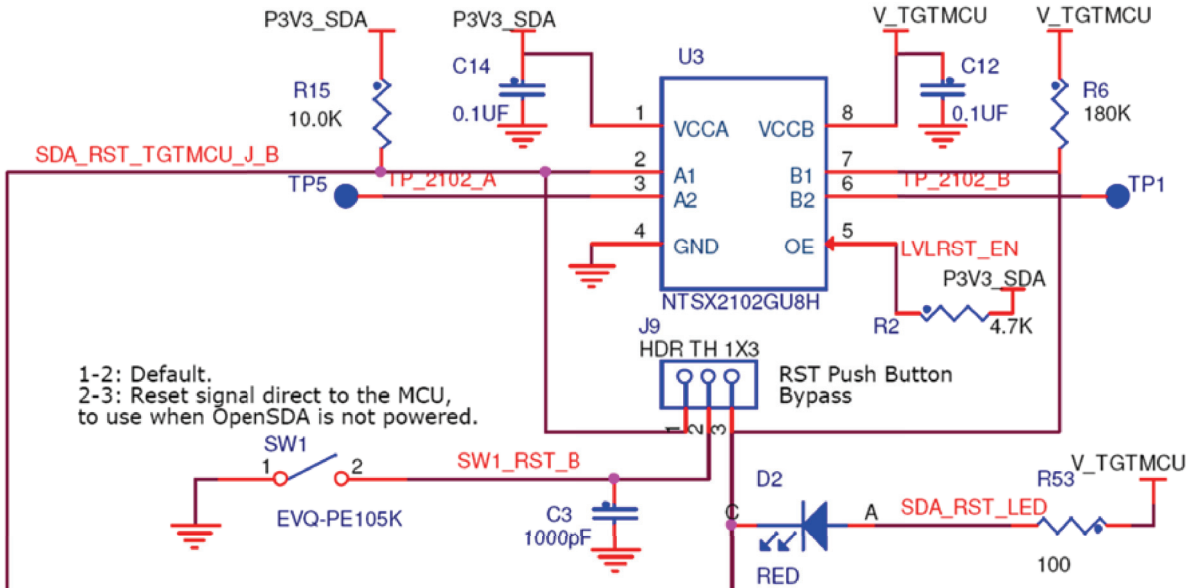
Figure 13. Reset circuit

12 Push Button Switches

Two push buttons, SW2 and SW3, are available on the FRDM-K22F board. SW2 is connected to PTC1 and SW3 is connected to PTB17. Besides the general purpose input/output functions, SW2 can be also be used as a low-leakage wakeup (LLWU) source.

Table 7. Push button switch connections

Switch	K22F Connection
SW2	**PTC1/LLWU_P6**/ADC0_SE15/SPI0_PCS3/UART1_RTS_b/FTM0_CH0/FB_AD13/ I2S0_TXD0/ LPUART0_RTS_b
SW3	**PTB17**/SPI1_SIN/UART0_TX/FTM_CLKIN1/FB_AD16/EWM_OUT_b
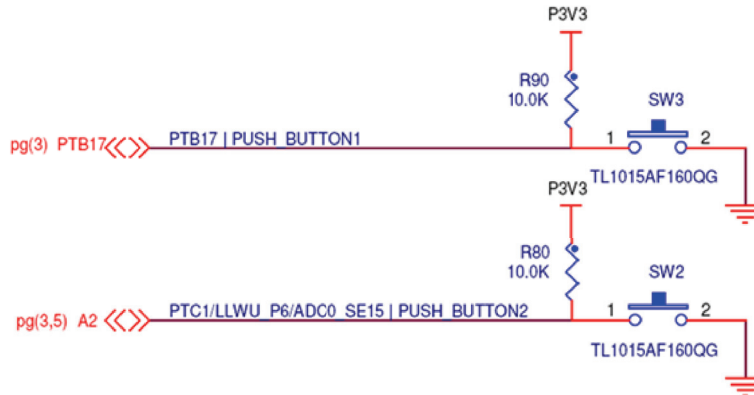
Figure 14. Push button switches

13   Debug

The debug interface on the MK22FN512VDC12 MCU is a serial wire debug (SWD) port with trace output capability. There are two debug interfaces on the FRDM-K22F: an onboard OpenSDAv2 circuit (J5) and a K22F direct SWD connection via a 10-pin header (J11). To use an external debugger, such as J-Link on J11, you may need to disconnect the OpenSDAv2 SWD circuit from the K22F by removing jumpers J13 and J10.

14   Add-On Modules

14.1   RF module

An optional header (J6) on the FRDM-K22F supports communication with a 2.4 GHz nRF24L01+ Nordic radio module over SPI. Alternatively, any SPI-based device or module can be used with this header.
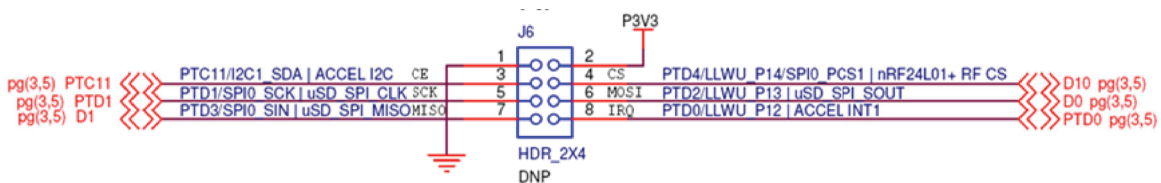
Figure 15. Optional add-on 2.4 GHz RF module

14.2   Bluetooth module

An optional header (J3) on the FRDM-K22F supports communication with an add-on Bluetooth interface, such as the JY-MCU BT V1.05 BT wireless Bluetooth module, over a UART.

Alternatively, any serial (SCI) module can be used with this connector. Note that the serial signals are 3 V levels and do not conform to RS-232 logic levels, so a level shifter (like a Maxim DS3232) should be used with RS-232 devices.
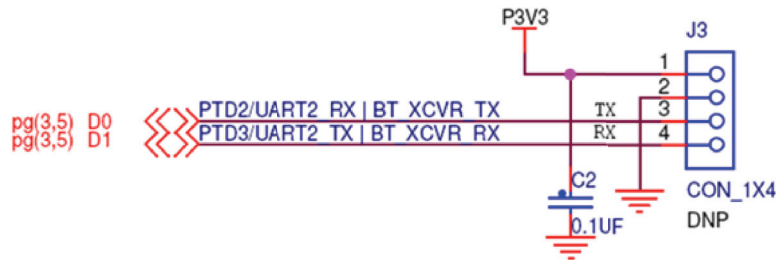

Figure 16. Optional add-on Bluetooth module

15   Input/Output Connectors

The MK22FN512VLH12 microcontroller is packaged in a 64-pin LQFP. Some pins are used in onboard circuitry, but some are directly connected to one of the four I/O headers (J1, J2, J24, and J25).

The pins on the K22F microcontroller are named for their general purpose input/output (GPIO) port pin function. For example, the first pin on Port A is referred as PTA1. The name assigned to the I/O connector pin corresponds to the GPIO pin of the K22F.
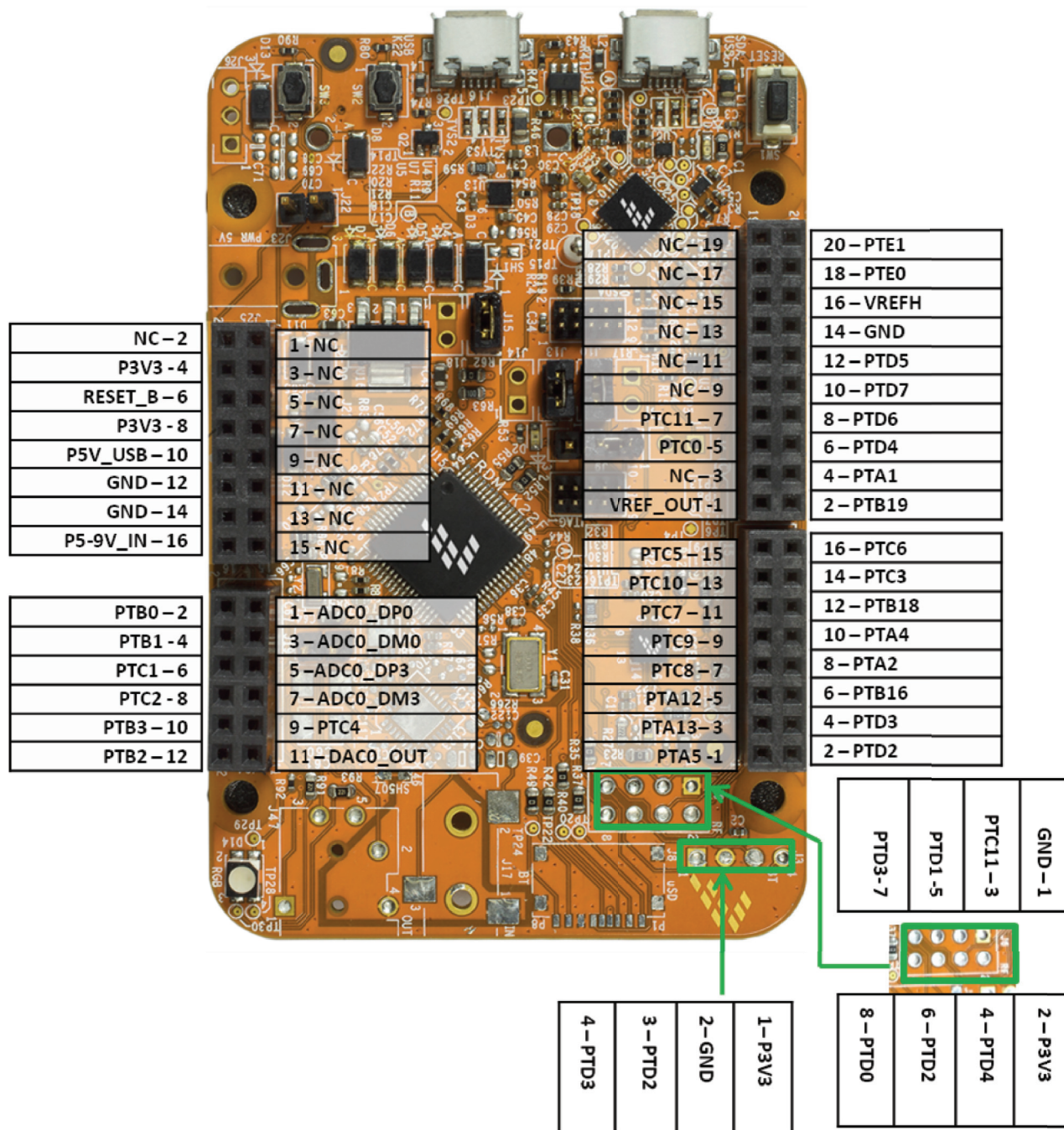
Figure 17. FRDM-K22F I/O header pinout

16 Arduino Compatibility

The I/O headers on the FRDM-K22F 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.

17   References

The following references are available on www.freescale.com/FRDM-K22F:

- *FRDM-K22F Quick Start Guide*
- *FRDM-K22F Schematic*, FRDM-K22F-SCH
- *FRDM-K22F Design Package*

The following reference is available on www.freescale.com/kboot:

- Kinetis Flashloader

18   Revision History

Table 8. Revision history

Revision Number	Date	Substantial Changes
0	07/2014	Initial release

Document Number: FRDMK22FUG
Rev. 0
07/2014