AN12659

NXP quad motor-control development platform HW overview

Rev. 1.0 — 31 March 2020 Application note

582710

Document information

Information	Content
Keywords	NXP quad motor-control development platform, multi-motor applications.
Abstract	This document presents the NXP quad motor-control development platform hardware, prepared to reduce the development effort and time to market of multi-motor applications. It describes the NXP quad motor-control development platform modular architecture and provides a detailed hardware description of the different components.

Revision history

Revision history

Revision number	Date	Description
1.0	2020-03-31	First version.

Abbreviations

Table 1. Abbreviations

Acronym	Description
MCU	Microcontroller Unit
PHY	Physical layer
NFC	Near Field Communication
LDO	Low-Dropout Regulator
SWD	Serial Wire Debug
JTAG	Joint Test Action Group
PCB	Printed Circuit Board
XIP	eXecute In Place
QSPI	Quad Serial Peripheral Interface
LCD	Liquid-Crystal Display
CAN	Controller Area Network
UART	Universal Asynchronous Receiver-Transmitter
SDHC	Secure Digital Host Controller
SNVS	Secure Non-Volatile Storage
PMSM	Permanent Magnet Synchronous Motor
BLDC	Brushless DC Motor

1 NXP quad motor-control development platform architecture

The NXP quad motor-control development platform is a cost-effective platform to allow rapid development of multi-motor control applications. It is based on NXP's i.MX RT1050 crossover processor, able to operate up to four motors and able to address the increased need for cost-constrained, centralized motor-control systems.

The NXP quad motor-control development platform uses a modular architecture. It is supported by dedicated motor-control software libraries and NXP FreeMaster real-time debugger. It exhibits a flexible design consisting of a *daughter board*, a *digital board* and a *power stage board* as illustrated in Figure 1.

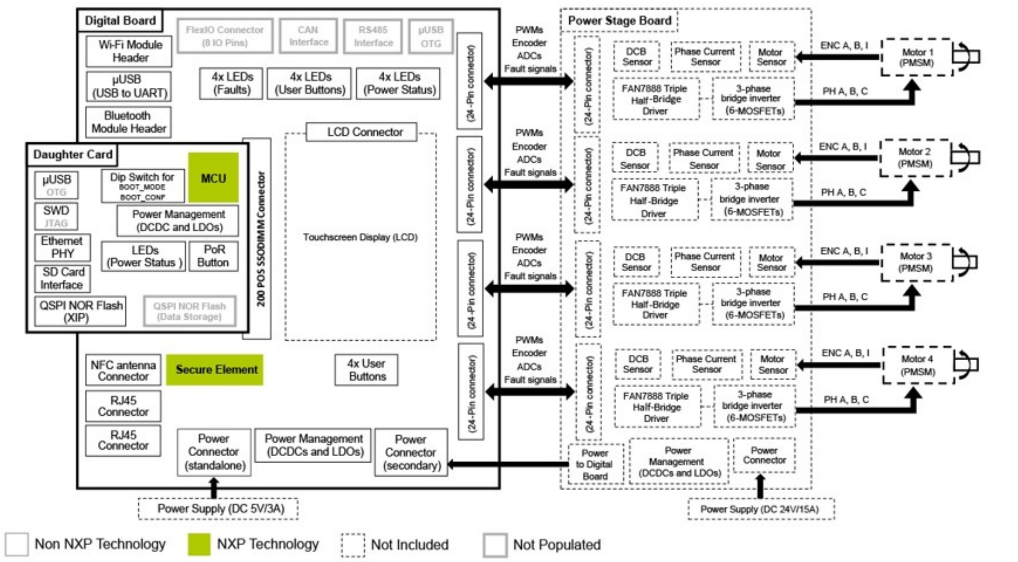

Figure 1. NXP quad motor-control development platform architecture

The *daughter board* embeds an i.MX RT1050 crossover processor and is the core of this motor-control reference design. It is based on a 528 MHz ARM Cortex-M7 core and comes with high-speed communication and peripheral interfaces, advanced graphics support for industrial HMI and sensor interfaces. As a result, the i.MX RT1050 crossover processor provides a high level of integration in sophisticated automation and multi-motor applications.

The *digital board* works as an external platform to prototype your next multi-motor control application. It includes the headers and the footprints required to easily plug-in widely used industrial communication and peripheral interfaces supported by the i.MX RT1050 crossover processor. It also provides the connectors that expose the control signals for the four motor devices.

The *power stage board* supports the control and connection of up to four PMSM or BLDC motors. It includes the power management unit, provides the motor-control capabilities, such as rotational or linear motion and comes with motor connectors built in. The PCB of the *power stage board* is not delivered, but its design files are made available as part of the NXP quad motor-control development platform.

2 Daughter board hardware description

The daughter board provides the application processor within the NXP quad motor-control development platform architecture. It is based on a single i.MX RT1050 crossover processor able to control four motors simultaneously and qualified for industrial products. The i.MX RT1050 crossover processor features relevant for motor-control functions include:

- Arm® Cortex®-M7 core operating at up to 528MHz.
- 32kbyte L1 instruction cache and 32kbyte L1 data cache.
- Up to 512kbyte on-chip RAM
- Four flexible FlexPWM interfaces.
- Multiple output hardware triggers at each PWM cycle
- Two 12-bit ADCs with 16 input channels.
- Four Quad timers.
- Four 32-bit periodic interrupt timers.
- Two 32-bit general-purpose timers.
- Four quadrature encoders/decoders.
- Four analogue comparators with 6-bit DAC
- Junction temperature range of -40 to 105 ºC.

The i.MX RT1050 crossover processor also provides various external memory interfaces, including SDRAM, RAW NAND FLASH, NOR FLASH, SD/eMMC, Quad SPI. It also includes a wide range of other interfaces for connecting peripherals, such as WLAN, Bluetooth™, GPS, camera sensors, and rich multimedia features, including an LCD display. Refer to the product website for more information about i.MX RT1050 crossover processor.

The daughter board includes an SODIMM 200 connector (Edge connector) where the i.MX RT1050 crossover processor communication and peripheral interfaces are routed to. In order to facilitate motor-control applications, the Edge connector has been designed so that analog signals and motor control signals (PWM, ENC, FAULT), and other communication signals (ethernet, CAN, serial com, LCD etc.) are isolated.

Figure 2 is a picture of the daughter board PCB front side with the placement of its main components highlighted.

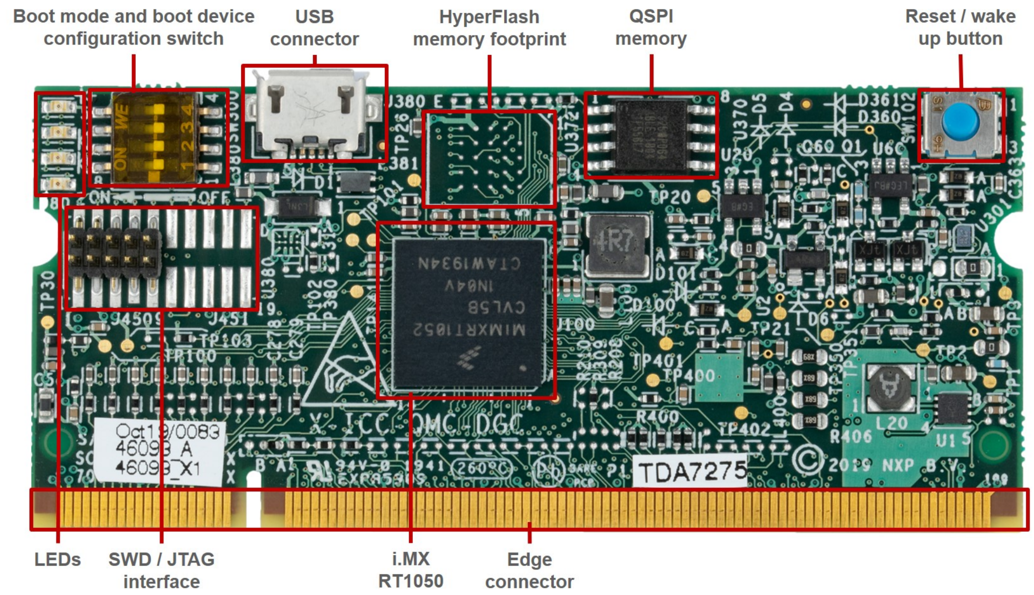

Figure 2. Daughter board PCB - Front side

Figure 2 is a picture of the daughter board PCB back side with the placement of its main components highlighted.

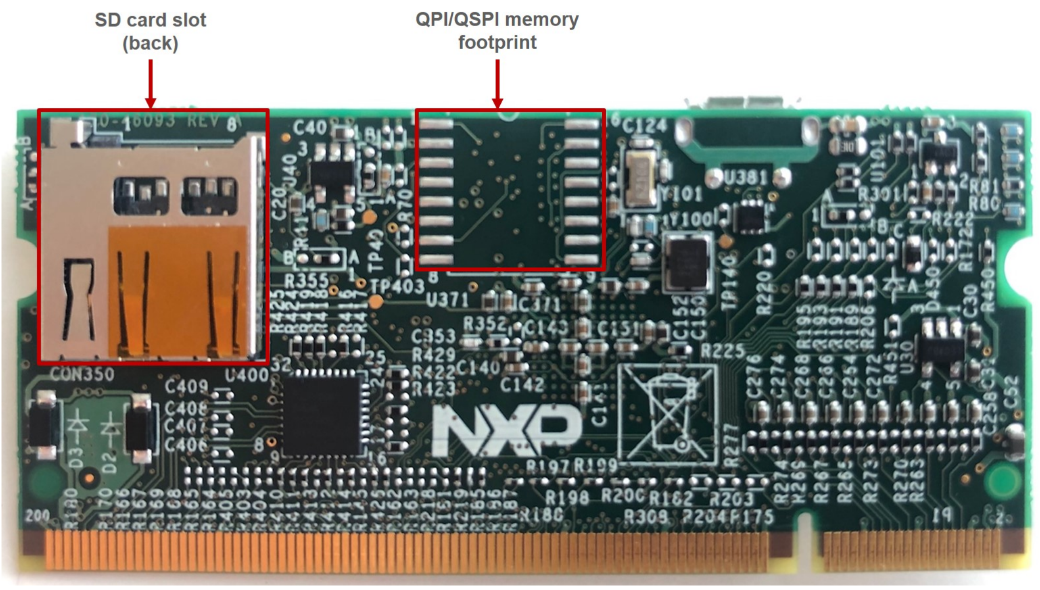

Figure 3. Daughter board PCB - Back side

The daughter board design files are available at www.nxp.com/quadmotorcontrol.

2.1 Daughter board power supply and power management unit

The daughter board 5V supply voltage is provided either through the USB connector for standalone functionality or by the power supply of the digital board coming from the Edge connector. The power management unit includes a DC/DC converter (5 V to 3.3V), and two LDOs of 3.3V and 1.8V output voltage respectively.

Note: *This USB connector can also be used for serial download mode and allows to download the application (bootable) image without the need of debug interface.*

The i.MX RT1050 crossover processor external flash memory is powered by the 1.8V output LDO by default, but can be changed to the DCDC_3V3 voltage moving the resistor R70 to position B. Table 2 describes flash memory supply voltage based on R70 position.

Table 2. Flash memory VDD based on R70 position

R70 position	Voltage
A	1.8V (default)
B	3.3V

Figure 4 shows the placement of R70 in the daughter board PCB.

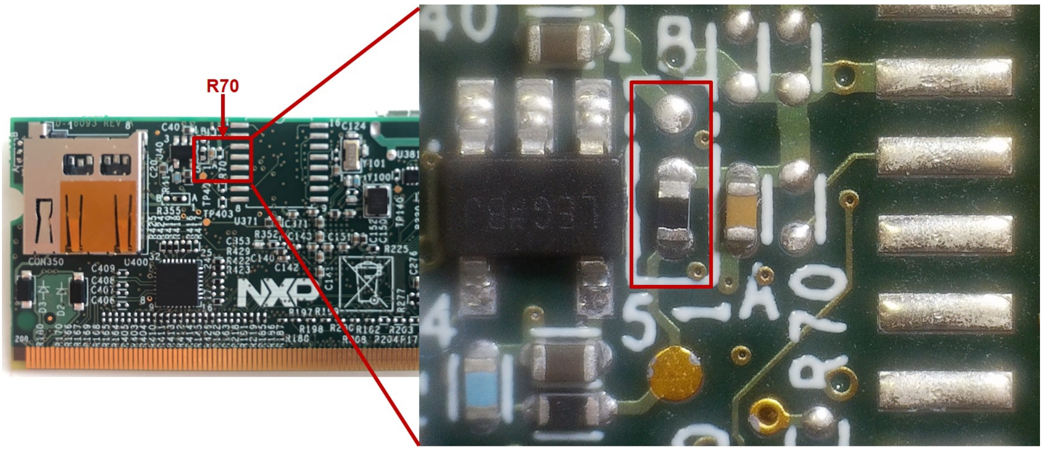

Figure 4. R70 placement in daughter board PCB

The SD card interface is powered by the 3.3 V DC/DC supply voltage by default, but can be changed via firmware to the 1.8V output LDO using the VDD_SDHC_SEL GPIO as shown in Table 3.

Table 3. SD card interface power supply based on VDD_SDHC_SEL_GPIO value

VDD_SDHC_SEL GPIO	Voltage
0	3.3V
1	1.8V

The i.MX RT1050 crossover processor VDD_SNVS (supply input voltage to Secure Non-Volatile Storage and Real Time Clock) is powered by the DCDC_3V3 by default, but can be changed to 3V replacing the resistor R21 value as shown in Table 4

Table 4. SNVS power supply based on R20 and R21 resistor values

Voltage	Resistors
3.3V (default)	R20: 102k
	R21: 18.2k

Voltage	Resistors
3.0V	R20: 102k
	R21: 20.5k

Figure 5 shows the placement of R20 and R21 in the daughter board PCB.

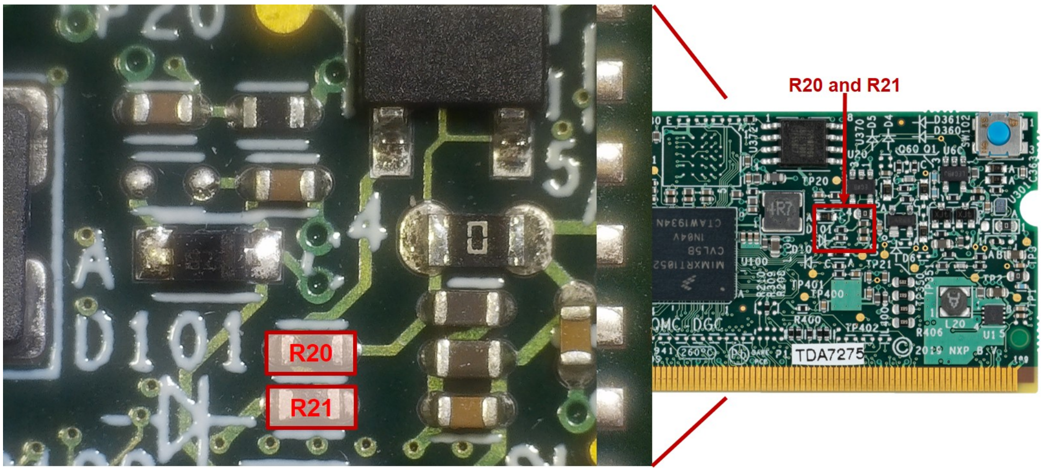

Figure 5. R20 and R21 placement in daughter board PCB

2.2 Daughter board LEDs

The four LEDs in the daughter board (D80, D81, D82, D83) are indicators of the active power supply domains:

- LED D80 turns red when the daughter board is reset.
- LED D81 turns green when the daughter board identifies the 5V power supply on board.
- LED D82 turns green when the 3V3 output LDO is active and represents the analog part power supply identification.
- LED D83 turns green when the DCDC_3V3 is active and represents the primary 3.3V power supply identification.

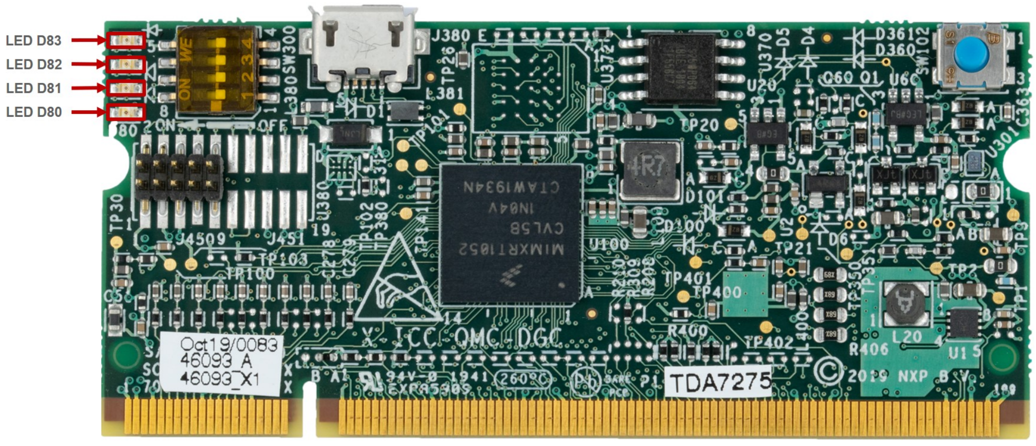

Figure 6. Daughter board LEDs placement

2.3 Daughter board reset / wake-up button

The daughter board includes one push button as shown in Figure 7.

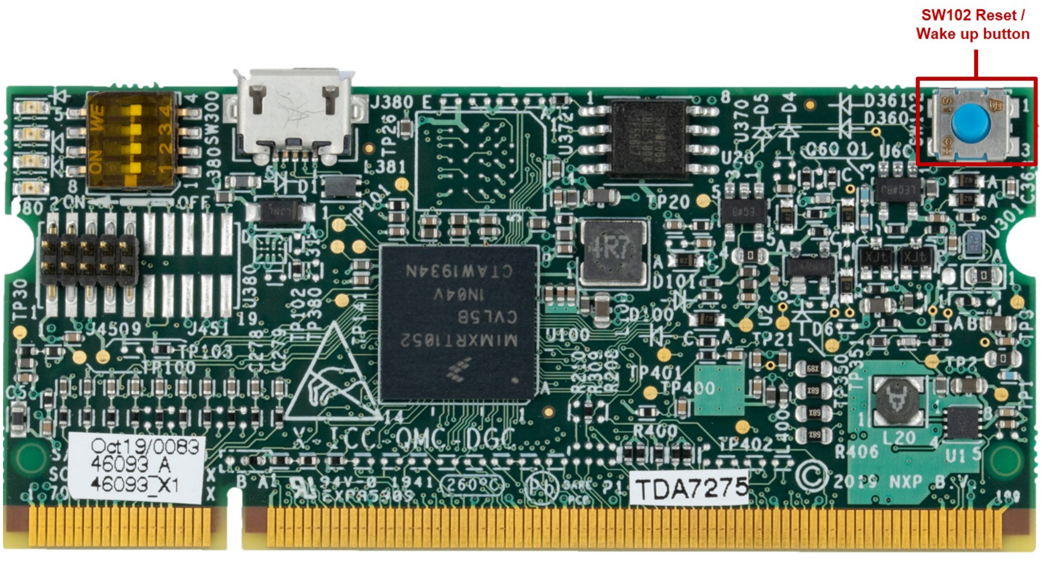

Figure 7. SW102 reset / wake-up button placement

The SW102 button is used to reset the i.MX RT1050 crossover processor by default, but can be changed to wake-up the i.MX RT1050 crossover processor by moving the resistor R110 to position B. Figure 8 indicates the placement of R110 resistor in the daughter board PCB.

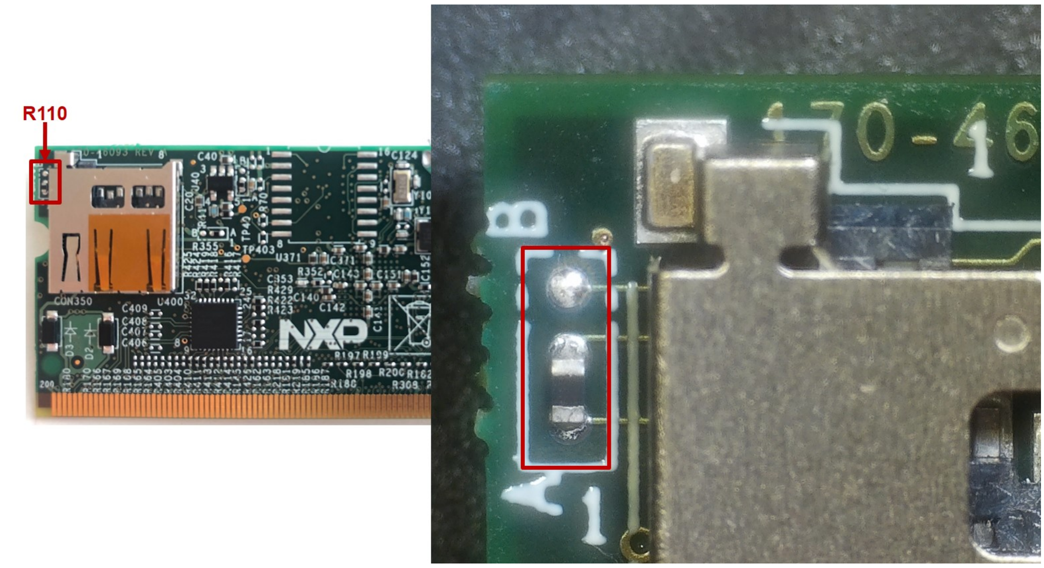

Figure 8. R110 placement in daughter board

Additionally, SW102 can be configured to also reset the Wi-Fi module, the security IC and FLEXIO modules by soldering an 0 Ohm resistor in R217, R218 and R219 pads respectively. Figure 9 indicates the placement of R217 resistor in the daughter board PCB.

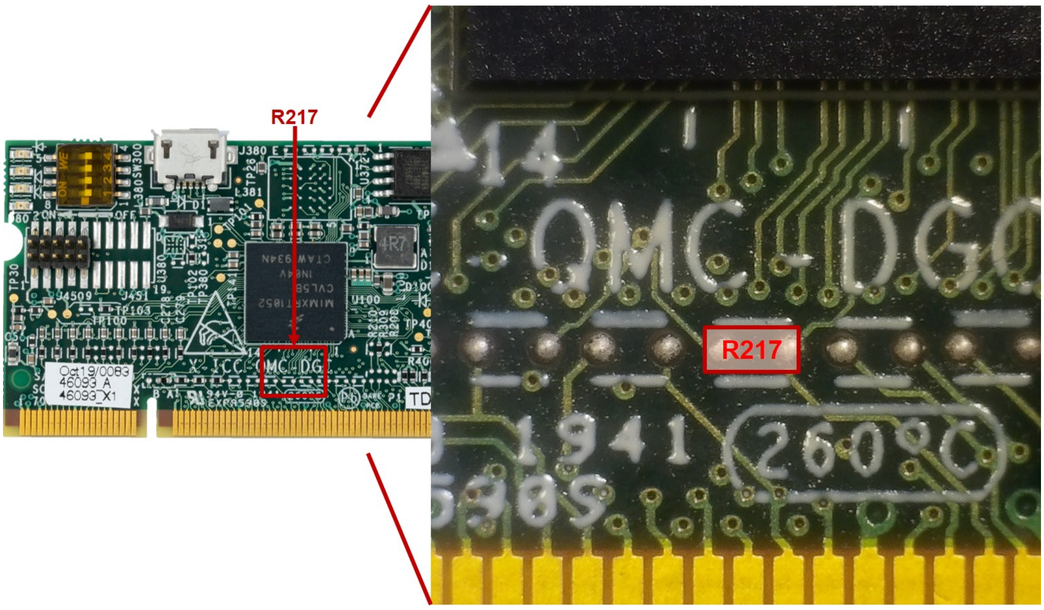

Figure 9. Enable Wi-FI module reset via SW102 button

And Figure 10 indicates the placement of R218 and R219 resistors in the daughter board PCB.

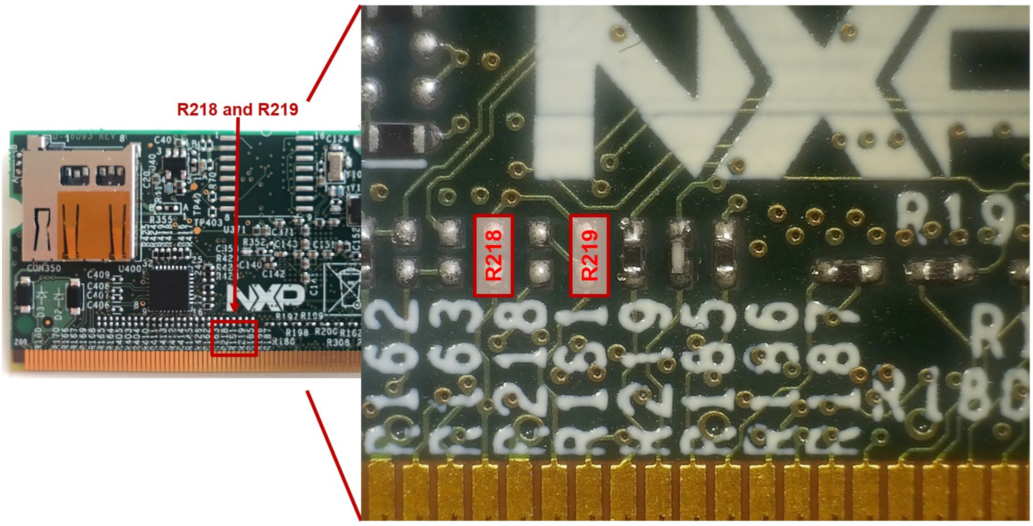

Figure 10. Enable Security IC and FLEXIO reset via SW102

2.4 External memory interface options

The i.MX RT1050 crossover processor also provides various external memory interfaces, including SDRAM, RAW NAND FLASH, NOR FLASH, SD/eMMC, Quad SP. The daughter board includes the following external memory interfaces:

1. An SD card slot in the back side of the PCB as shown in Figure 11:

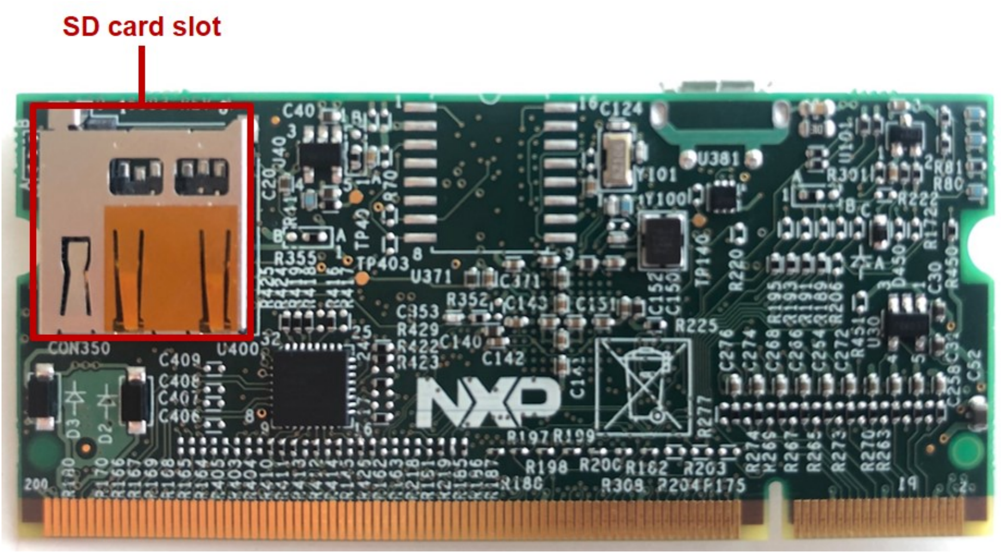

Figure 11. SD card slot on PCB

2. The footprint to connect a HyperFlash NOR Flash memory as shown in Figure 12. The HyperFLASH is a standard NOR flash with high-speed SPI interface (12 pins).

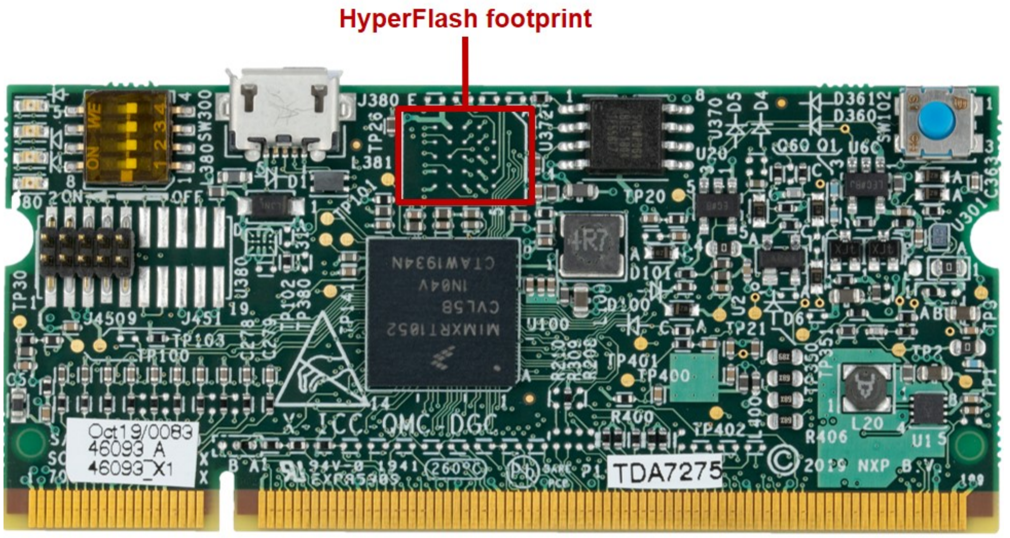

Figure 12. HyperFlash NOR Flash memory footprint on PCB

3. The footprint to connect NOR Flash 64Mb QPI/QSPI memory as shown in Figure 13. It provides the ability to work 2xQSPI memories in parallel (extension the memory size) or to have additional NV memory as data storage (data logger functionality).

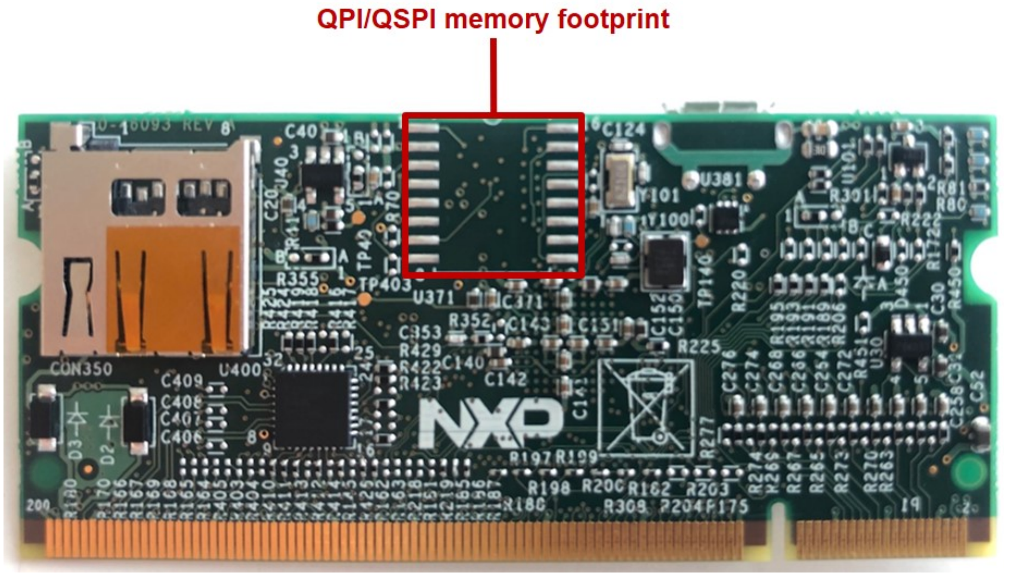

Figure 13. NOR Flash 64Mb QPI/QSPI memory footprint on PCB

2.5 Boot mode selection

The daughter board allows the selection of the internal boot or serial downloader boot modes of the i.MX RT1050 crossover processor using the two first lines on the SW300 DIP switch. Figure 14 shows the placement of SW300 DIP switch in the daughter board PCB.

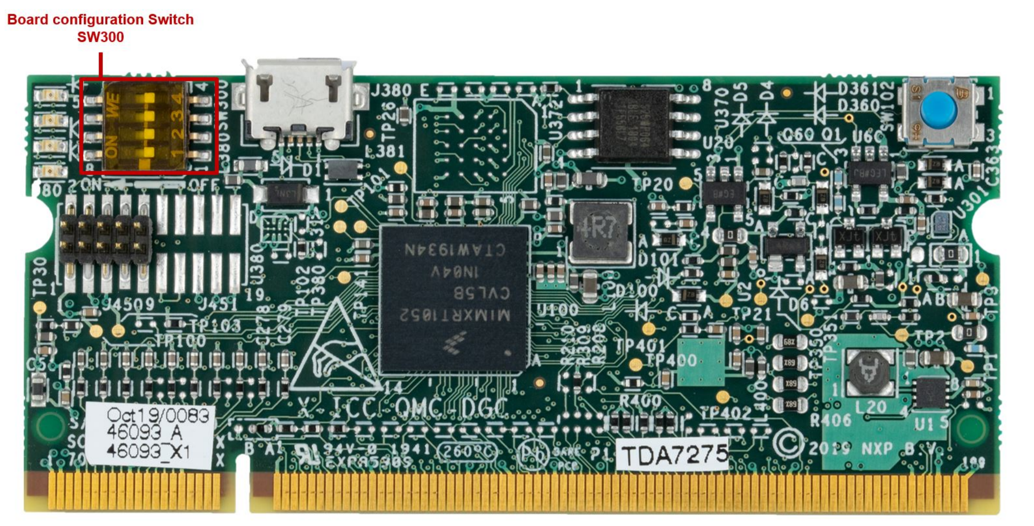

Figure 14. SW300 boot switch placement on PCB

The internal boot mode enables ROM to execute the code from boot device selected by boot configuration (selected by pins 3 and 4 of the DIP switch) . In the serial downloader mode, the MCU get into special state running from ROM code which is waiting for communication via USB1 or LPAURT1. Usually that mode is used to be able to download the application image into the boot device (QSPI flash or SD card)

Table 5 indicates the SW300 DIP switch position to enable either the internal boot or serial downloader boot mode.

Table 5. SW300 DIP switch configuration for Internal boot or serial download boot mode

Mode	SW300.1	SW300.2
Serial downloader	On	Off
Internal boot	Off	On

Note: *WARNING: Do not use any other option.*

In case the serial downloader boot mode is selected, the SW300 DIP switch also allows us to determine the type of external boot device. The daughter board allows the selection of FlexSPI or SD/MMC as boot device type. Table 6 indicates the SW300 DIP switch position to select either FlexSPI or SD/MMC as external boot device type.

Table 6. Boot device type configuration

Mode	SW300.3	SW300.4
FlexSPI	On	Off
SD 4-bit	Off	On

Note: *WARNING: Do not use any other option.*

In case the FlexSPI boot device type is selected, a serial Flash memory device (QSPI) is selected by default, but can be changed to HyperFlash by moving the position of resistor R310 to position B. Table 7 shows the serial flash boot mode configuration.

Table 7. Serial FLASH - Boot configuration

Mode	R310 position
QSPI	A (default)
HyperFLASH	B

Figure 15 indicates the placement of R310 resistor in the daughter board PCB.

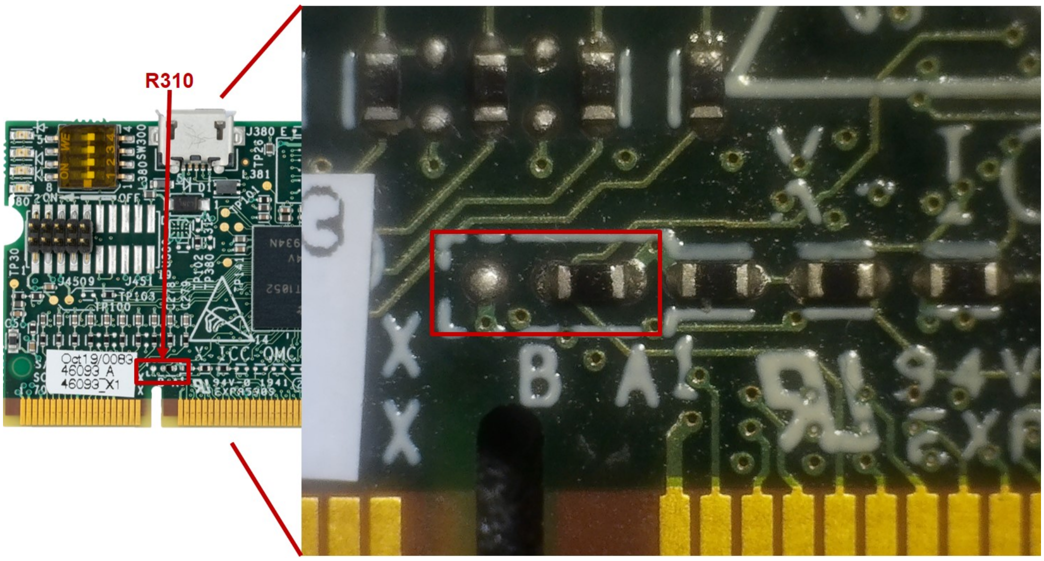

Figure 15. R310 placement in PCB

In case we want to enable the Encrypted XIP feature on Serial NOR via FlexSPI interface, we can change the resistor R301 to position B. Table 8 shows the Encrypted XIP on serial flash boot configuration.

Table 8. Encrypted XIP on serial flash - Boot configuration

Mode	R301 position
Disabled	A (default)
Enabled	B

Figure 16 indicates the placement of R301 resistor in the daughter board PCB.

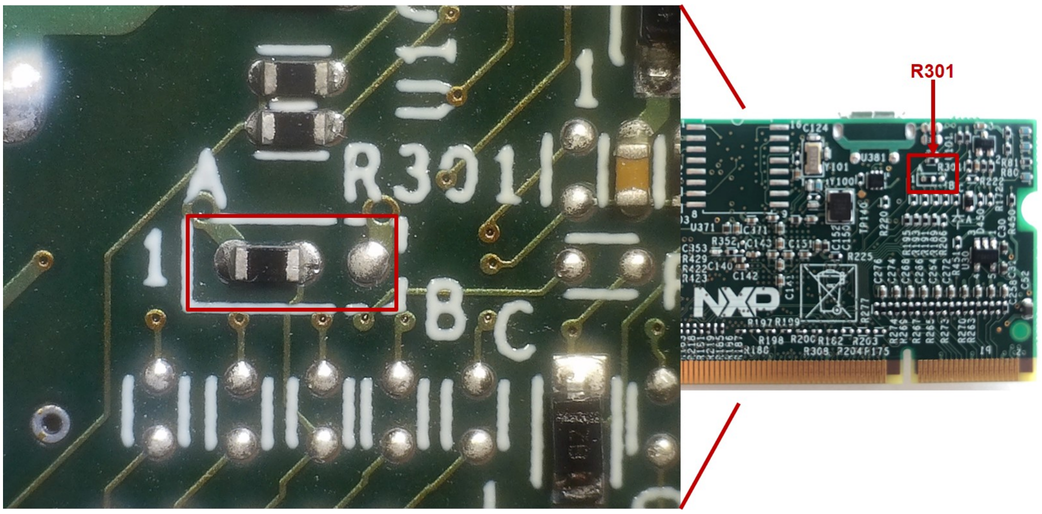

Figure 16. R301 placement in PCB

2.6 Programming interface

The daughter board supports SWD debug interface by default. In order to enable JTAG debug interface it is required to burn specific fuse on i.MX RT1050 crossover processor.Figure 17 shows the placement of the SWD / JTAG debug interface in daughter board PCB.

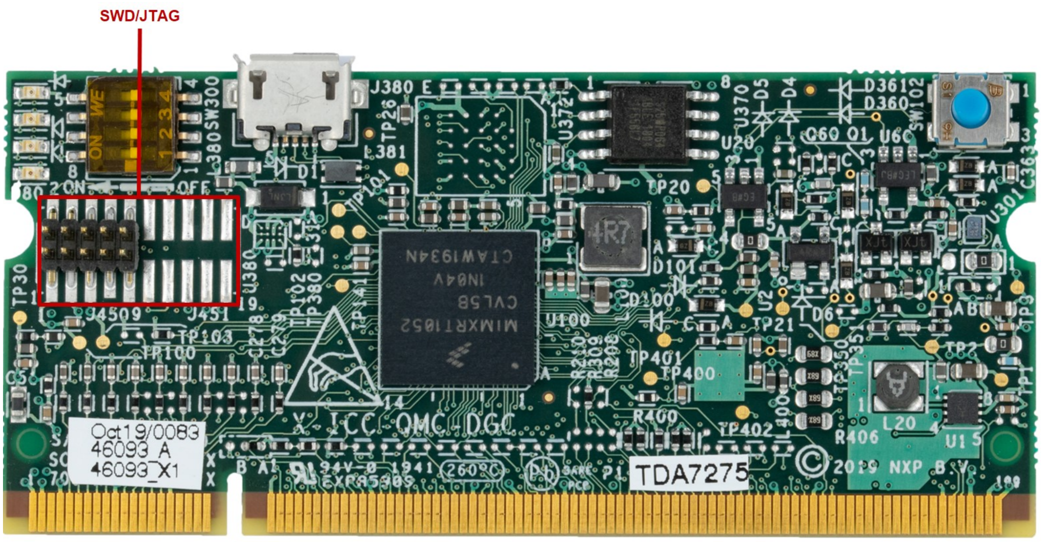

Figure 17. JTAG/SWD placement on PCB

2.7 Edge connector

The daughter board includes an Edge connector to attach it to the digital board. The i.MX RT1050 crossover processor wide range of interfaces for connecting peripherals are routed through the Edge connector to the digital board. This connector has been designed so that analog signals and motor control signals (PWM, ENC, FAULT), and other communication signals (ethernet, CAN, serial com, LCD etc.) are isolated. Figure 18 shows the location of the Edge connector on the daughter card PCB

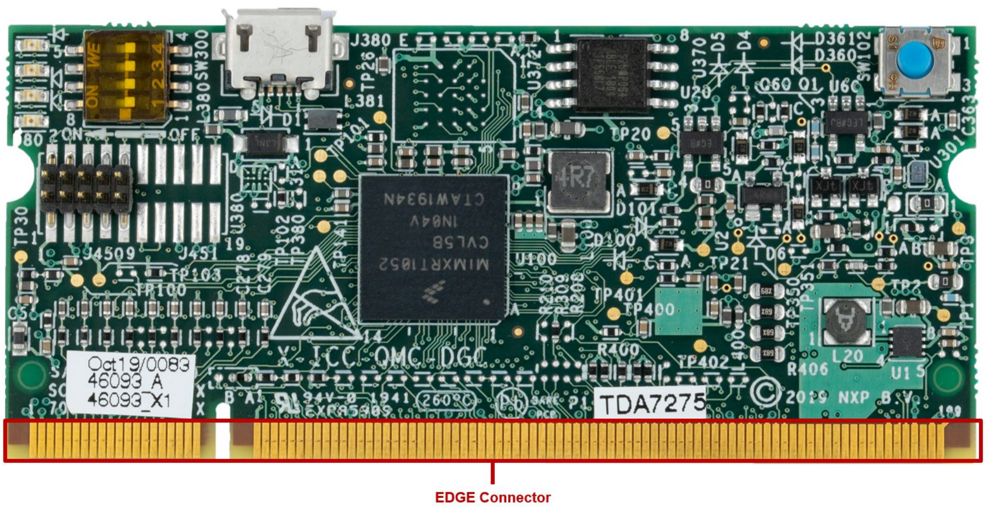

Figure 18. Edge connector placement on PCB

3 Digital board hardware description

The digital board is an expansion platform designed to help you prototype and build your multi-motor control applications faster. It is optimized for flexibility, modularity, affordability and ease of use.

The digital board provides a SODIMM 200 socket to connect a daughter board MCU, such as our daughter board based on i.MX RT1050 crossover processor. It also on-boards headers and footprints for the most important industrial connectivity protocols (e.g. PROFIBUS, CAN, PROFINET), user interfaces (e.g. LCD), security hardware (e.g. EdgeLock^{TM} SE050) and the connectors to control four motor devices (e.g. ADCs, PWMs, ENCs, faults).

The digital board design files are available at www.nxp.com/quadmotorcontrol.

3.1 Power supply and power management unit

The digital board on-boards a power ON / OFF switch (SW20). Its 5V supply voltage is provided either through the 5V/3A power connector (J20) or by the USB / serial connector (J162). Optionally, the digital board on-boards an additional micro USB type B footprint (J100), which is not placed by default. If placed, it can also be used to provide the power supply to digital board as well.

The power management unit includes DC/DC converters with 5V, 3.3V and 1.8V output voltage respectively. These DC/DC converters are enabled using the PERI_PWR_ENABLE_DELAY GPIO and are used as supply voltage for the peripherals connected to the digital board.

Figure 19 indicates the placement of the power ON / OFF switch and power supply connectors in the digital board PCB.

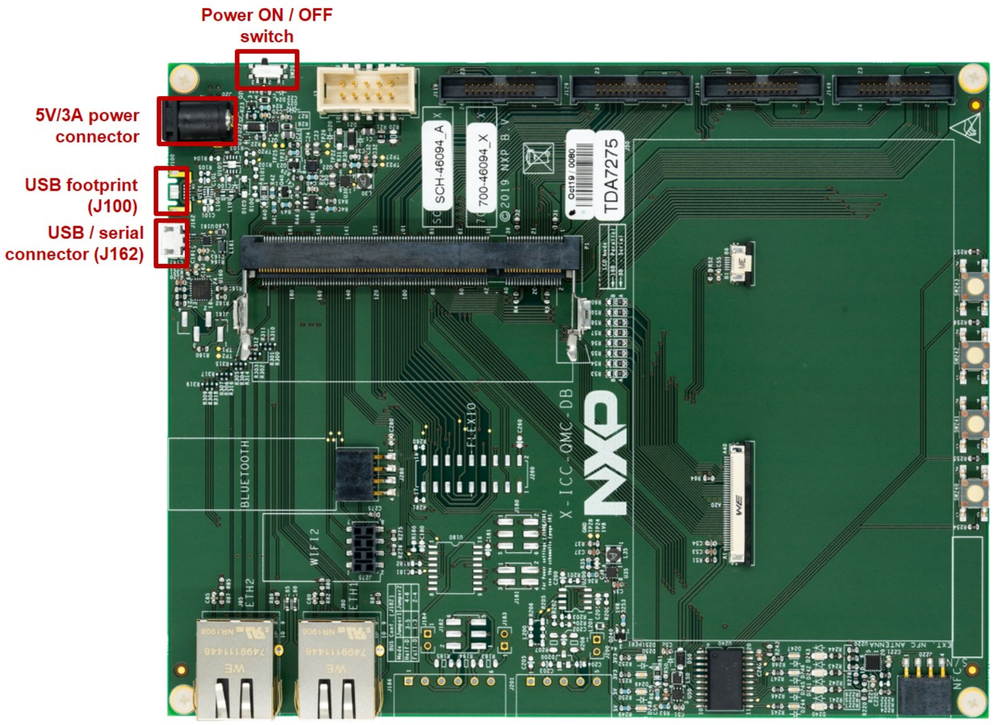

Figure 19. Power management components placement on PCB

3.2 Signal interconnection between digital board and power stage board

The digital board on-boards 4x24-pin header connector (J119, J129, J139 and J149). Each 24-pin header connector exposes the 3-phase motor currents, DC-bus voltage, DC-bus current and fault signals from the motor device connected to it. This 24-pin header also includes an interface for motor speed and position sensors control (PWMs, Encoder, ADCs, Fault signals).

Figure 20 indicates the placement of the 4x24-pin header connectors in the digital board PCB.

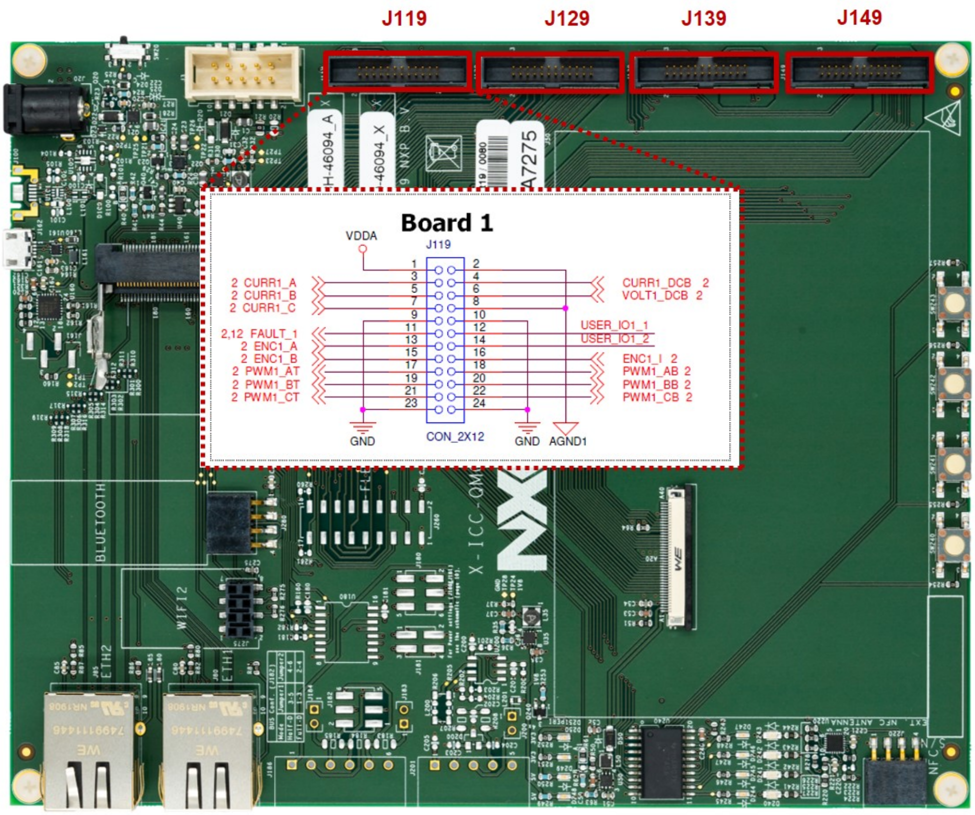

Figure 20. 4x24-pin header connector to power stage board.

3.3 Ethernet interface

The digital board on-boards two RJ-45 Ethernet connectors. The RJ-45 physical layer transceiver is placed in the daughter board. The digital board only includes the RJ-45 socket connectors. Figure 21 indicates the placement of the RJ-45 connectors in the digital board PCB.

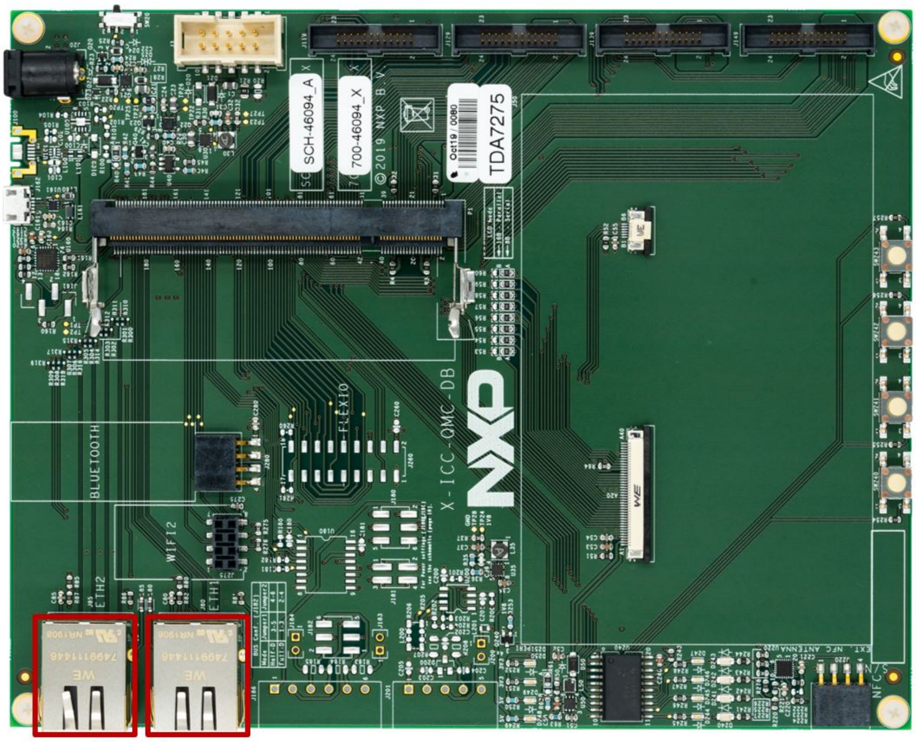

Figure 21. Ethernet connectors placement on PCB

3.4 RS-485 interface for industrial communication protocols

The digital board supports one RS-485 industrial interface with open style connector for protocols which require RS-485, such as MODBUS or PROFIBUS. The footprint is designed for ADM2484 RS-485 transceiver, but this component is not placed by default. The digital board also has footprints to place jumper connectors to configure the power supply and to set half or full duplex communication.

- J180 and J181 jumpers are used to define the power supply settings for the ADM2484 RS-485 transceiver.
- J182 jumper is used to define RS-485 interface in half or full duplex communication mode.

Figure 22 indicates the placement of the RS-485 interface footprint in the digital board PCB.

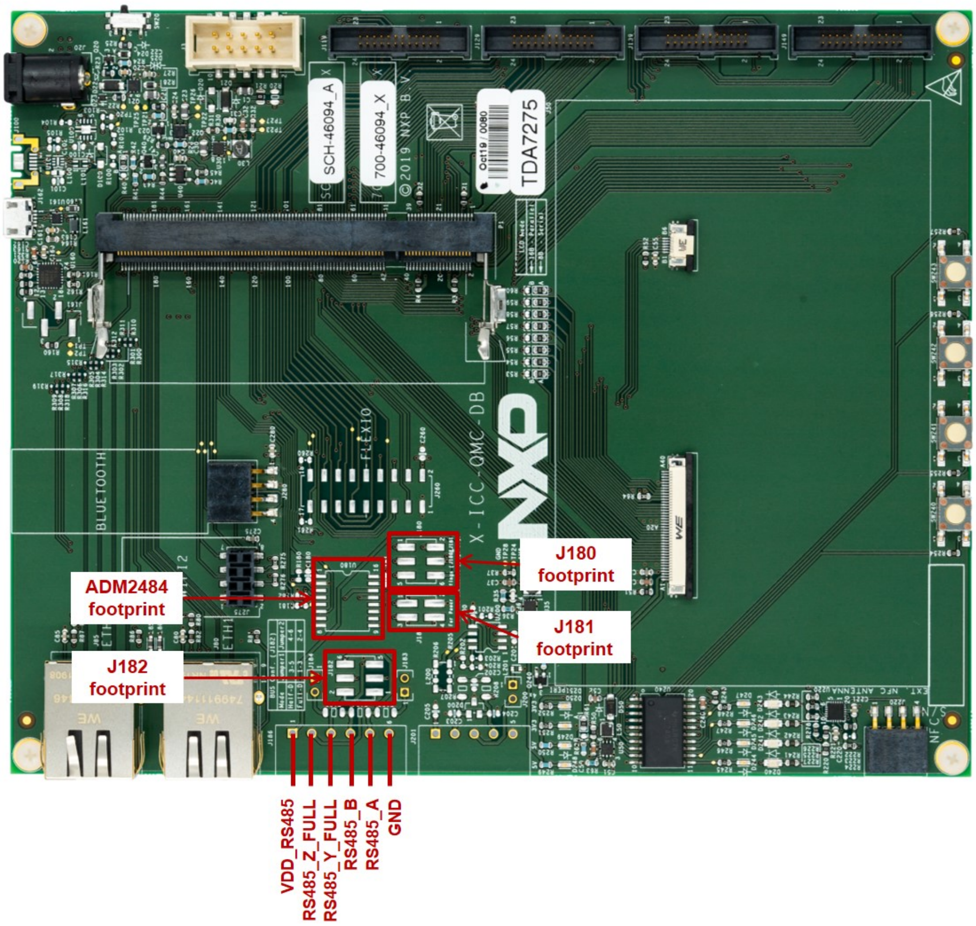

Figure 22. Industrial RS-485 footprint placement

Table 9 describes the J180 and J181 jumper configuration for the different power supply options for ADM2484:

Table 9. ADM2484 power settings

Source	J180	J181
On-Board 3.3V	Jumper 1: 1-2	Jumper 1: 1-2 Jumper 2: 3-4
On-Board 3.3V VDD to connector	Jumper 1: 1-2 Jumper 2: 5-6	Jumper 1: 1-2 Jumper 2: 3-4
On-Board 5V	Jumper 1: 3-4	Jumper 1: 1-2 Jumper 2: 3-4
On-Board 5V VDD to connector	Jumper 1: 3-4 Jumper 2: 5-6	Jumper 1: 1-2 Jumper 2: 3-4
External	Jumper 1: 5-6	Jumper 1: 3-4
External GND connected	Jumper 1: 3-4	Jumper 1: 1-2 Jumper 2: 3-4

Similarly, Table 10 describes the J182 jumper configuration to set up RS-485 interface in half duplex or full duplex mode.

Table 10. Half / Full duplex mode configuration

Mode	J182
Half-Duplex	Jumper 1: 3-5 Jumper 2: 4-6
Full-Duplex	Jumper 1: 1-3 Jumper 2: 2-4

3.5 Industrial CAN interface

The digital board supports one industrial CAN connection with open style connector. The footprint is designed for NCV7351FD13R2G CAN transceiver, but this component is not placed by default. It also includes the footprint for the data and signal line chokes for the CAN bus system.

Figure 23 indicates the placement of the CAN interface footprint in the digital board PCB.

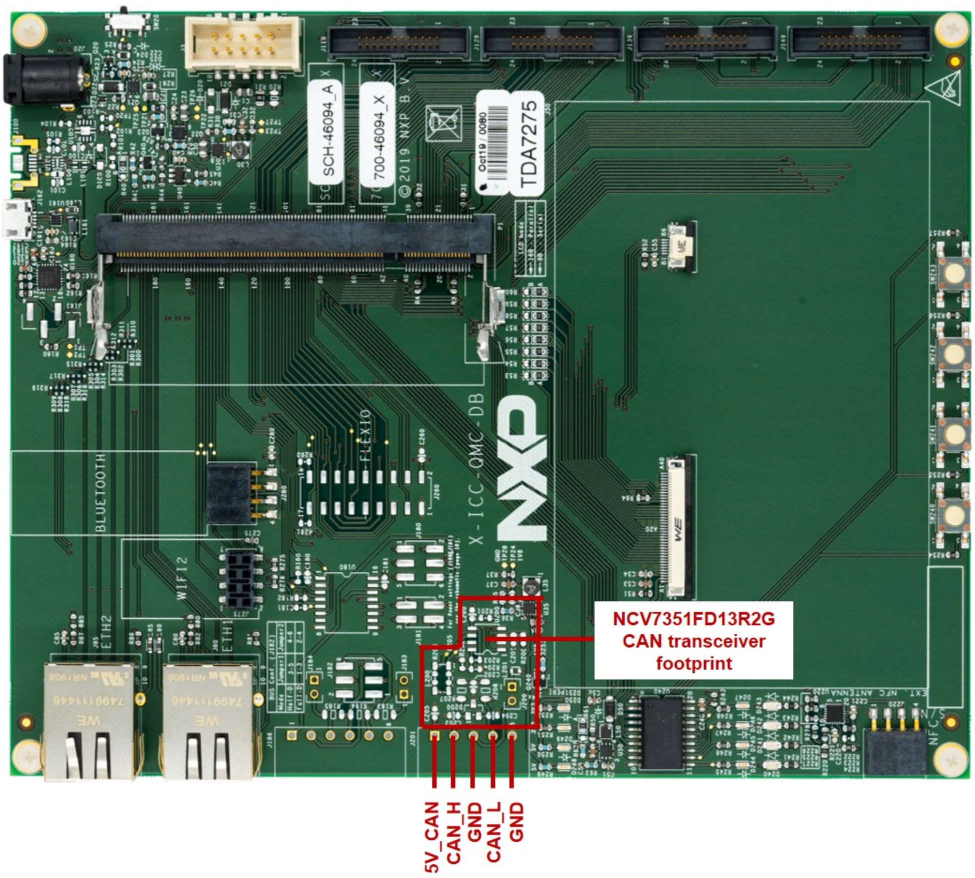

Figure 23. Industrial CAN footprint placement

3.6 Wireless module interfaces

The digital board on-boards connectors to plug-in a compatible Bluetooth module or WiFi module via UART. Figure 24 indicates the placement of the Bluetooth and WiFi modules in the digital board PCB.

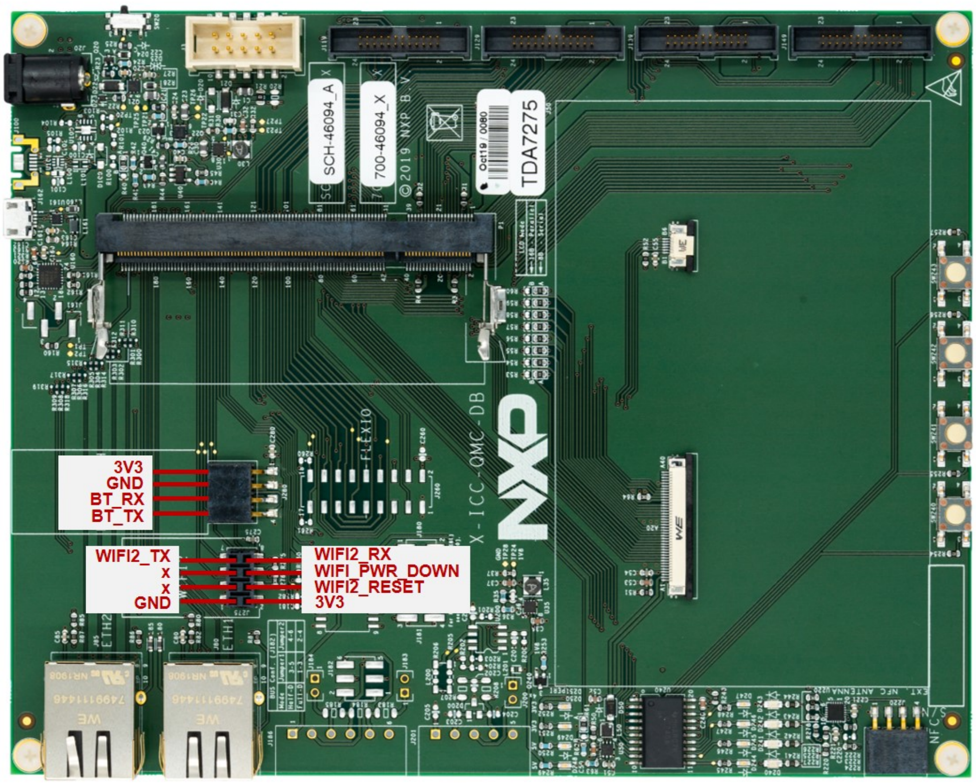

Figure 24. Bluetooth and WiFi connectors placement

3.7 Flex I/O interface

The digital board on-boards a FlexIO footprint compatible with a FlexIO header. The FlexIO interface is capable of supporting a wide range of protocols and peripherals including, but not limited to UART, I2C, SPI, I2S, camera interface, display interface, PWM waveform generation and more. Figure 25 indicates the placement of the FlexIO footprint in the digital board PCB.

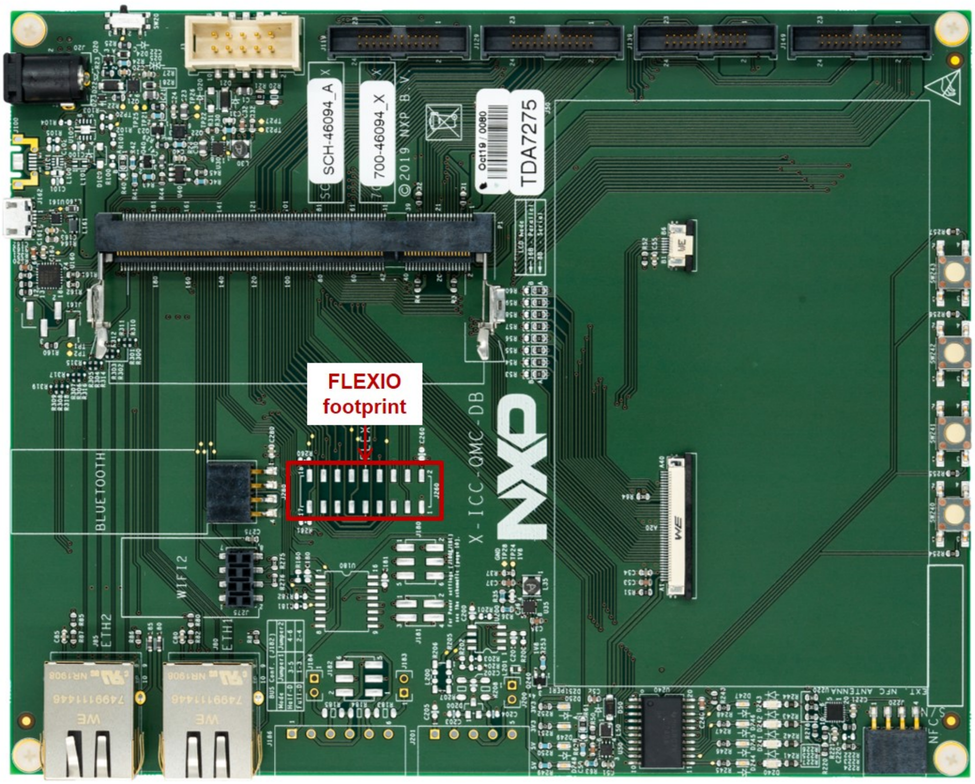

Figure 25. FlexIO footprint placement

Note: *If the LCD is connected, external devices connected to the FlexIO header may suffer conflicts between signals.*

3.8 Security hardware

The digital board on-boards an EdgeLock SE050 security IC. It is designed to provide a tamper-resistant platform to safely store keys and credentials. It allows you to safely perform cryptographic operations for security-critical communication and control functions in IoT security use cases, such as secure connection to public/private clouds, device-to-device authentication or sensor data protection, among others.

In addition, the EdgeLock SE050 supports a native contactlesss interface, providing a wireless interface to an external device like a smartphone or handheld contactless reader. The digital board supports the connection of your own dedicated NFC antenna via the J220 connector. Figure 26 indicates the placement of the EdgeLock SE050 security IC and the J220 connector in the digital board PCB.

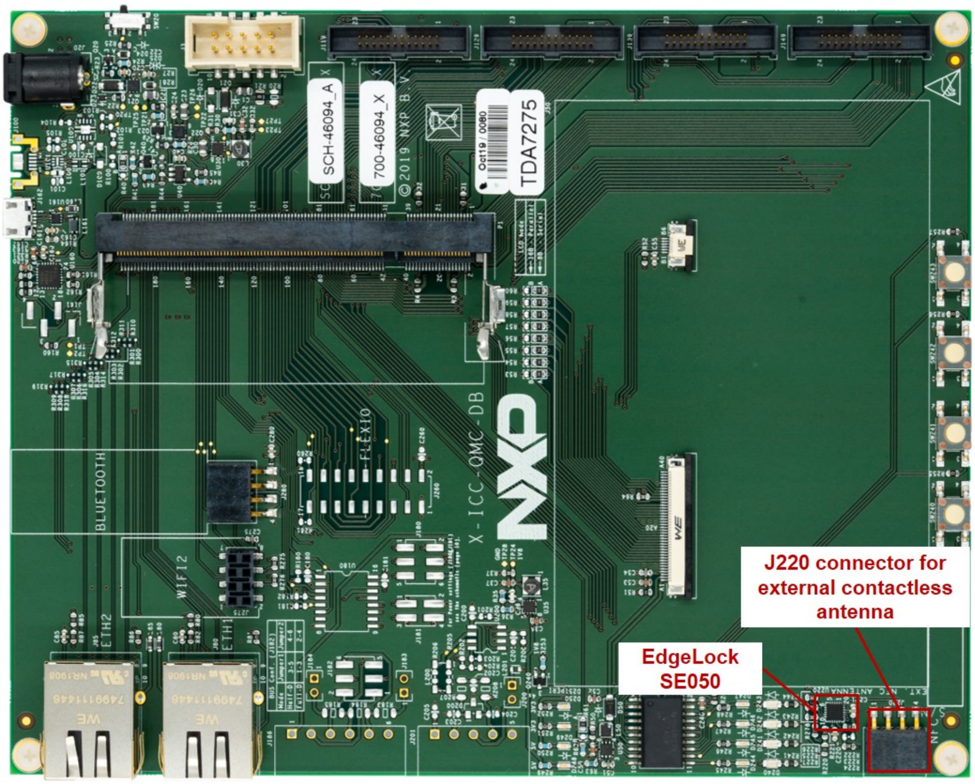

Figure 26. Security hardware placement

For more information about EdgeLock SE050 security IC, visit www.nxp.com/se050.

3.9 User interface

The digital board supports the connection of an external 16-bit TFT LCD touch screen and on-boards user LEDs and buttons. The LCD mode is used in serial 8-bit mode by default, but it can be changed to 16-bit parallel moving the R53, R54, R55, R56, R57, R58, R59 and R60 to position B. In addition, the LCD screen blacklight can be controlled through the LCD_BACKLIGHT_CTRL GPIO by default, but moving R61 resistor to position B.

The digital board includes twelve LEDs that operate in the following way:

- The LEDs D240, D241, D242 and D243 switch on while the user keeps the buttons SW240, SW241, SW2422 and SW243 pressed respectively. These buttons reach i.MX RT1050 crossover processor GPIO pins on the daughter board. As such, they could be used to interact with the LCD or other peripherals.
- The LEDs D244, D245, D246 and D427 switch on when a fault signal is triggered from motor device 1, 2, 3 and 4 respectively.
- The LEDs D248, D249, D250 and D251 switch on when the power domains are supplied. D248 is on when the 5V board voltage is supplied, D249 is on when the 5V voltage for peripherals is supplied. D250 is on when the 3V3 voltage for peripherals is supplied and D251 is on when the 1V8 voltage for peripherals is supplied.

Figure 27 indicates the placement of the LCD, LEDs and buttons in the digital board PCB.

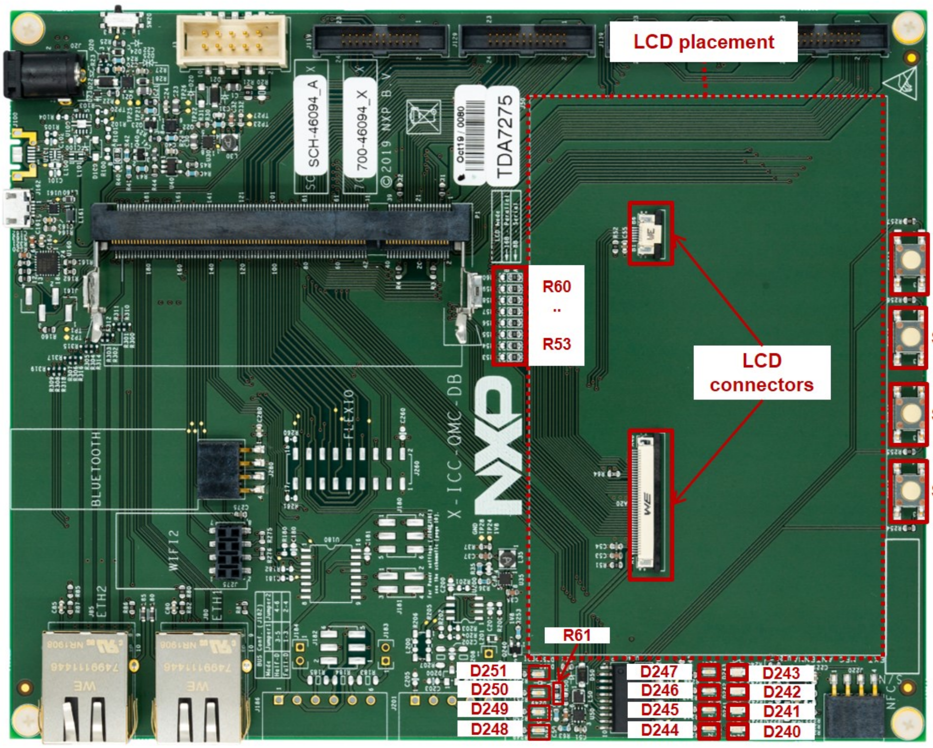

Figure 27. LCD, LEDs and buttons placement

4 Power stage board hardware description

The power stage board is a general-purpose power board able to drive up to four motors. It is designed to be a flexible platform for developing motor-control applications and it is designed to support PMSM/BLDC motor types, primarily focused on PMSM.

The power stage board design integrates: four FRDM-MC-LVPMSM compatible female connectors, 24-pin header for digital board connection (ADCs, PWMs, ENCs, faults, GPIO, power 5V and 3.3V), and a power supply connector (up to 24V/15A), among others as shown in Figure 28.

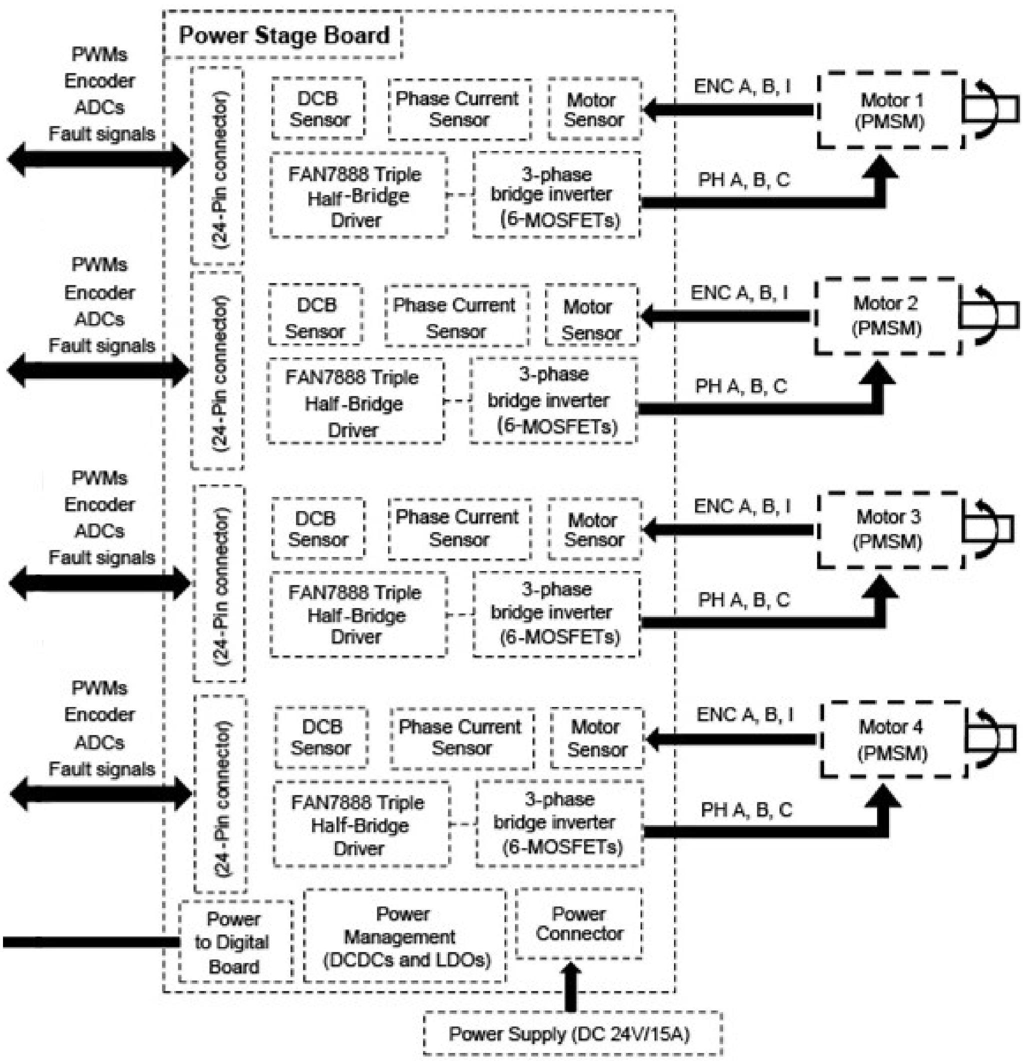

Figure 28. Power stage board diagram

Note: *The power stage board design files are available at www.nxp.com/quadmotorcontrol. The power stage board has not gone through the CE/FCC qualification process, and these design files should be considered as development designs.*

The power stage board PCB prototype is shown in Figure 29

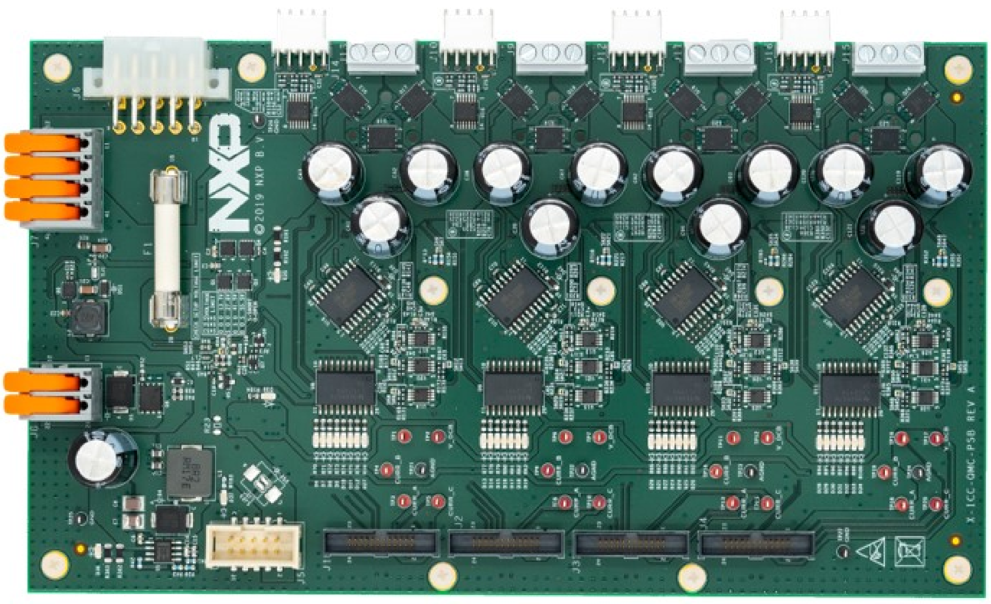

Figure 29. Power stage board PCB

5 Legal information

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Date of release: 31 March 2020
Document number: 582710