# UM12262

## FRDM-IMX91 Board User Manual

Rev. 3.0 — 22 April 2025 User manual

**Document information**

| Information | Content |
|---|---|
| Keywords | i.MX 91, FRDM-IMX91, UM12262 |
| Abstract | The FRDM i.MX 91 development board (FRDM-IMX91 board) is a low-cost platform designed to show the most commonly used features of the i.MX 91 applications processor in a small and low-cost package. |

# 1 FRDM-IMX91 overview

The FRDM i.MX 91 development board (FRDM-IMX91 board) is a low-cost platform designed to show the most commonly used features of the i.MX 91 Applications Processor in a small and low-cost package. The FRDM-IMX91 board is an entry-level development board, which helps developers to get familiar with the processor before investing a large amount of resources in more specific designs.

This document includes system setup and configurations, and provides detailed information on the overall design and usage of the FRDM board from a hardware system perspective.

## 1.1 Block diagram

Figure 1 shows the FRDM-IMX91 block diagram.

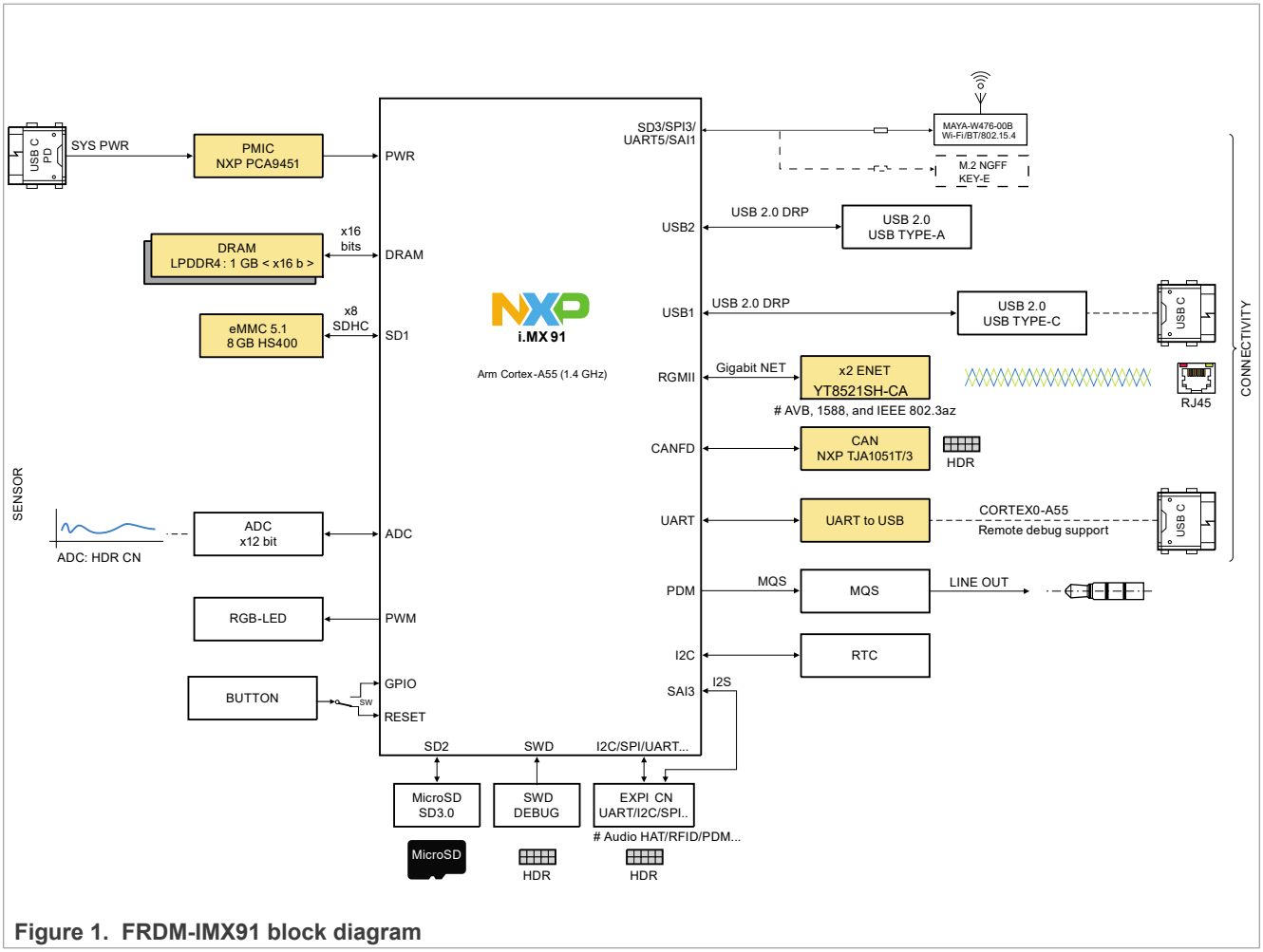



**Figure 1. FRDM-IMX91 block diagram**

## 1.2 Board features

Table 1 lists the features of FRDM-IMX91.

**Table 1. FRDM-IMX91 features**

| Board feature | Target processor feature used | Description |
|---|---|---|
| Applications processor | | The i.MX 91 applications processor features a single Arm Cortex-A55 core speeding up to 1.4 GHz.<br>***Note: For** more detail on the i.MX 91 processor, see the i.MX 91 Applications Processor Reference Manual.* |
| USB interface | USB2.0 high-speed host and device controller | • x1 USB 2.0 Type C connector<br>• x1 USB 2.0 Type A connector |
| DRAM memory | DRAM controller and PHY | 1 GB LPDDR4 (Nanya NT6AN512M16AV-J1) |
| Mass storage | uSDHC | • 8 GB eMMC5.1 (FEMDRM008G-58A39)<br>• MicroSD card connector (SD3.0 supported) |
| Boot configuration | | • Default boot mode is single boot from the eMMC device<br>• Board also supports SD card boot |
| Display interface | Parallel display | Parallel display support |
| Ethernet interface | Two ENET controllers | • 10/100/1000 Mbit/s RGMII Ethernet with one RJ45 connector (P3) supporting TSN and connected with external PHY, YT8521<br>• 10/100/1000 Mbit/s RGMII Ethernet with one RJ45 connector (P4) connected with external PHY, YT8521 |
| I/O expanders | CAN, I2C/I3C, analog-to-digital converter (ADC) | One 10-pin 2x5 2.54 mm connector P12 provides:<br>• One high-speed CAN transceiver TJA1051GT/3 connection<br>• 3-pin header for I2C/I3C expansion<br>• Two-channel ADC support |
| Tri-radio module | SDIO, UART, SPI, SAI | U-blox MAYA-W476-00B module supporting Wi-Fi 6, Bluetooth Low Energy 5.4, and 802.15.4 |
| M.2 interface | USB, SDIO, SAI, UART, I2C, and GPIO | One M.2/NGFF Key E mini card 75-pin connector, P8, supporting USB, SDIO, SAI, UART, I2C, and Vendor-defined SPI interfaces<br>***Note: By** default, these signals are connected with the onboard tri-radio module, however, to use this M.2 slot, you must rework resistors (see Table 15 ).* |
| Audio | MQS | MQS support |
| Debug interface | | • USB2.0 Type-C connector (P16) with USB-to-UART device, CH342F. CH342F provides two COM ports:<br>– First COM port is used for Cortex A55 system debug<br>– Second COM port is reserved<br>• Serial wire debug (SWD), P14 |
| EXPI | | One 2x20-pin EXPI for I2S, UART, I2C, and GPIO expansion |
| Power | | • One USB 2.0 Type-C connector for power delivery only<br>• PCA9451AHNYPMIC<br>• Discrete DCDC/LDO |
| PCB | | FRDM-IMX91: 105 mm × 65 mm, 10-layer |
| Orderable part number | | FRDM-IMX91 |

## 1.3 Board kit contents

Table 2 lists the items included in the FRDM-IMX91 board kit.

**Table 2. Board kit contents**

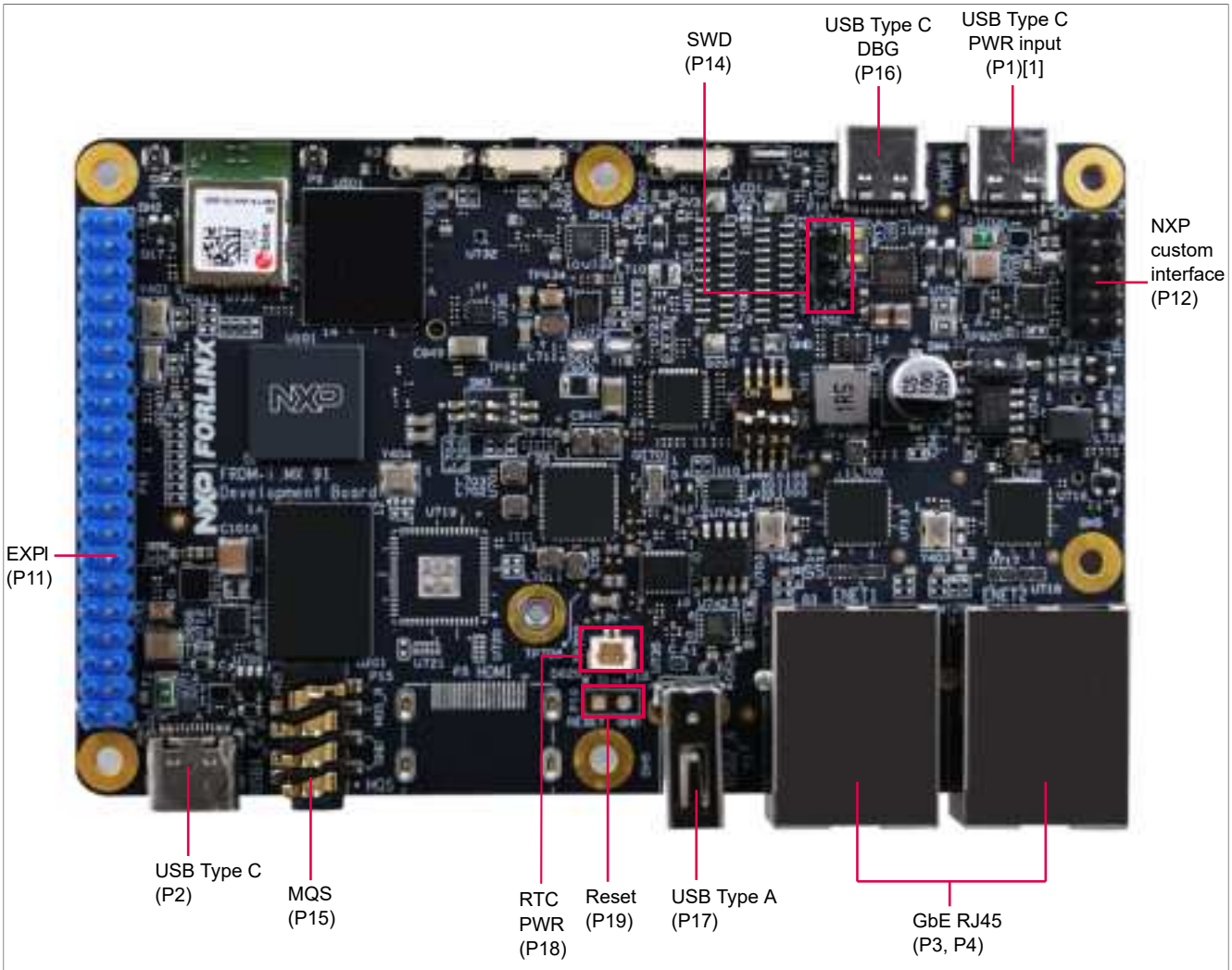
| Item description | Quantity |
|---|---|
| FRDM-IMX91 board | 1 |
| USB 2.0 Type-C Male to Type-A Male assembly cable | 2 |
| FRDM-IMX91 Quick Start Guide | 1 |

## 1.4 Board pictures

Figure 2 shows the top-side view of the FRDM-IMX91 board.


**Figure 2. FRDM-IMX91 top-side view**

Figure 3 shows the connectors available on the top side of the FRDM-IMX91 board.




[1] - USB Type C PWR input (P1) shown in the figure is the only power supply port, and must always be supplied for system running.

**Figure 3. FRDM-IMX91 connectors**

Figure 4 shows the onboard switches, buttons, and LEDs available on the FRDM-IMX91 board.

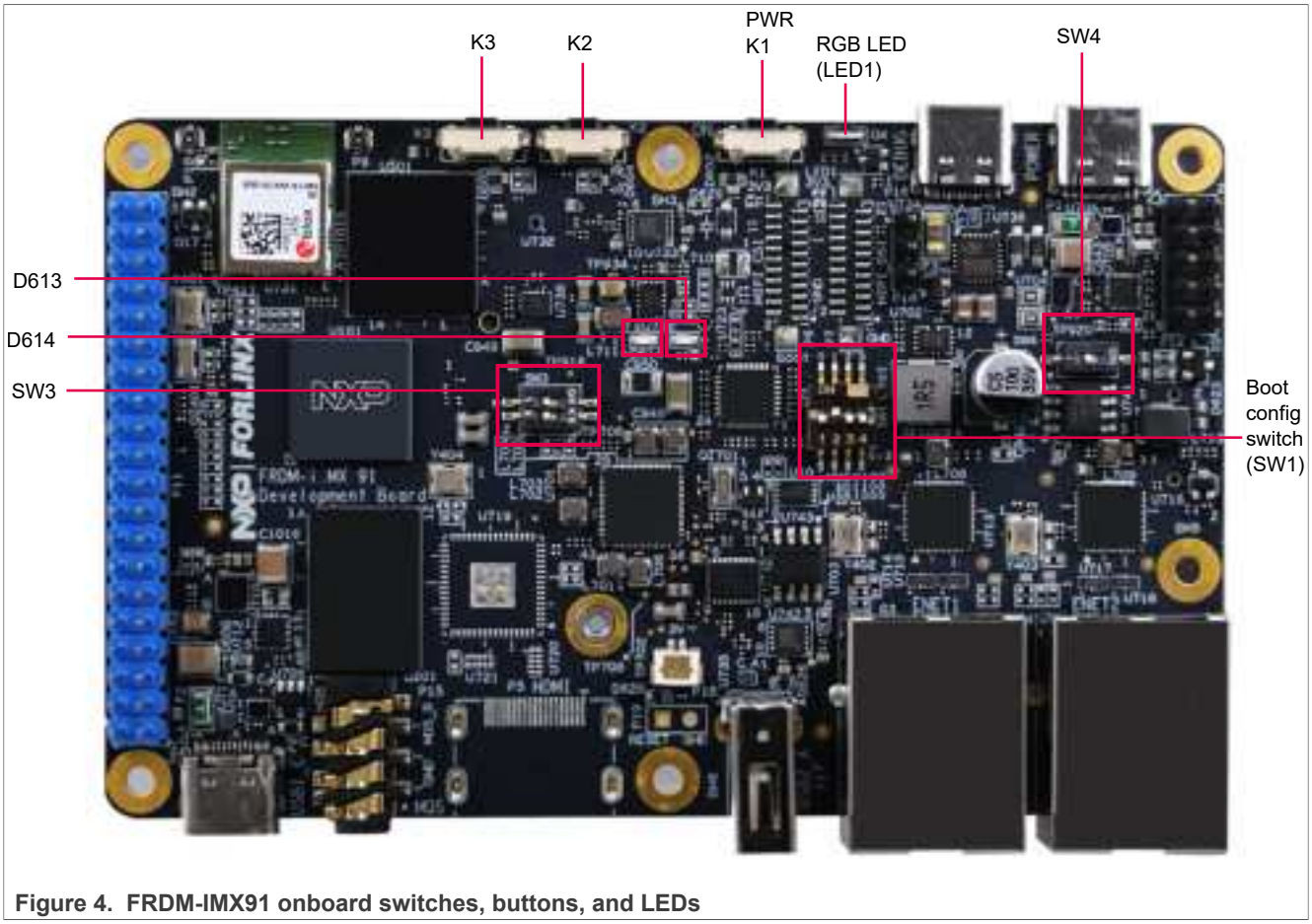



**Figure 4. FRDM-IMX91 onboard switches, buttons, and LEDs**

Figure 5 shows the bottom-side view, and also highlights the connectors available at the bottom side of the FRDM-IMX91 board.

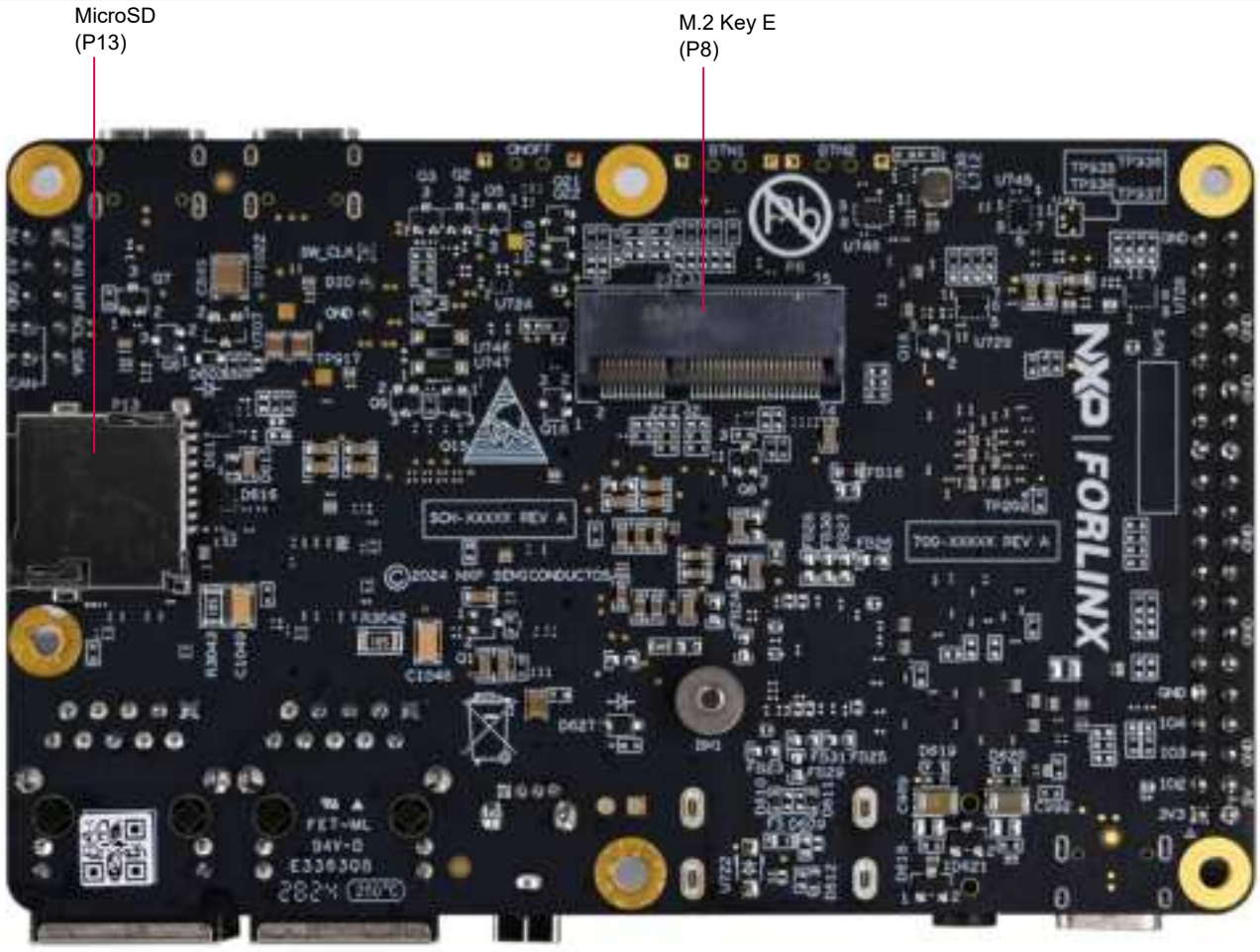



**Figure 5. FRDM-IMX91 bottom-side view**

## 1.5 Connectors

See Figure 3 and Figure 5 for connectors position on the board. Table 3 describes the FRDM-IMX91 board connectors.

**Table 3. FRDM-IMX91 connectors**

| Part identifier | Connector type | Description | Reference section |
|---|---|---|---|
| P1, P2, P16 | USB 2.0 Type C | USB connector | Section 2.16.2 |
| P3, P4 | RJ45 jack | Ethernet connectors | Section 2.14 |
| P9 (DNP) | U.FL connector | RF antenna connector | Section 2.11 |
| P10 (DNP) | U.FL connector | RF antenna connector | Section 2.11 |
| P8 | 75-pin connector | M.2 socket KEY-E | Section 2.10 |
| P11 | 2x20-pin connector | EXPI | Section 2.15 |
| P12 | 2x5-pin connector | I/O connector | Section 2.4 |
| P13 | MicroSD push- push connector | MicroSD 3.0 | Section 2.8 |
| P14 | 1x3-pin 2.54 mm connector | SWD connector | Section 2.16.1 |

**Table 3. FRDM-IMX91 connectors***...continued*

| Part identifier | Connector type | Description | Reference section |
|---|---|---|---|
| P15 | 3.5 mm headphone jack | MQS connector | Section 2.6 |
| P17 | USB 2.0 Type A | USB connector | Section 2.13 |
| P18 | JST_SH_2P | RTC battery connector | For detail, see the board schematic |

## 1.6 Push buttons

Figure 4 shows the push buttons available on the board.

Table 4 describes the push buttons available on FRDM-IMX91.

**Table 4. FRDM-IMX91 push buttons**

| Part identifier | Switch name | Description |
|---|---|---|
| K1 | Power button | The i.MX 91 applications processor supports the use of a button input signal to request main SoC power state changes (that is, ON or OFF) from the PMIC.<br>The ON/OFF button is connected to the ONOFF pin of the i.MX 91 processor.<br>• In the ON state:<br>– If the ON/OFF button is held longer than the debounce time, the power off interrupt is generated.<br>– If the button is held longer than the defined max timeout (approx. 5 s), the state will transit from ON to OFF, and send PMIC_ON_ REQ signal to turn off the powers of PMIC.<br>• In the OFF state:<br>– If the ON/OFF button is held longer than the OFF-to-ON time, the state will transit from OFF to ON, and send PMIC_ON_REQ signal to turn on the powers of PMIC. |
| K2 | User button | The User button is kept for customized use cases. |
| K3 | Reset / User button | By default, K3 is connected with SYS_nRST and used as a reset function. To use K3 as a customized function, remove the R3061 resistor and install the R2612 resistor. |

## 1.7 DIP switch

The following DIP switches are used on the FRDM-IMX91 board.

- 4-bit DIP switch – SW1
- 2-bit DIP switch – SW3
- 1-bit DIP switch – SW4

If a DIP switch pin is:

- OFF – pin value is 0
- ON – pin value is 1

The following list describes the description and configuration of the DIP switches available on the board.

- SW1 – Provides control for boot mode configuration. For detail, see Section 2.5.
- SW3 – Provides control for enabling or disabling the CAN interface signals, CAN_TXD (GPIO_IO25) and CAN_RXD (GPIO_IO27), on the board.

**Table 5. SW3 configuration**

| Switch | Signal | Description |
|---|---|---|
| SW3[1] | CAN_TXD (GPIO_IO25) | – ON (default setting): Enables CAN_TXD signal<br>– OFF: Disables CAN_TXD signal |
| SW3[2] | CAN_RXD (GPIO_IO27) | – ON (default setting): Enables CAN_RXD signal<br>– OFF: Disables CAN_RXD signal |

- SW4 – Provides control for enabling or disabling the CAN split termination RC filter.

**Table 6. SW4 configuration**

| Switch | Signal | Description |
|---|---|---|
| SW4[1] | | – ON (default setting): Enables RC termination filter (62 Ω + 56 pF) and configures CAN bus for normal operation.<br>– OFF: Disables RC termination filter for test mode. |

## 1.8 LEDs

The FRDM-IMX91 board has light-emitting diodes (LEDs) to monitor system functions, such as power-on and board faults. The information collected from LEDs can be used for debugging purposes.

Figure 4 shows the LEDs available on the board.

Table 7 describes the FRDM-IMX91 LEDs.

**Table 7. FRDM-IMX91 LEDs**

| Part identifier | LED color | LED name | Description (When LED is ON) |
|---|---|---|---|
| D601 | Red | PWR LED | Indicates 3.3 V power-on status. When 3.3 V is available on board, the D601 LED turns ON. |
| LED1 | Red / Green / Blue | RGB_LED | User application LEDs. Each of these LEDs can be controlled through a user application.<br>• Red LED connects to target MPU pin GPIO_IO13<br>• Green LED connects to target MPU pin GPIO_IO04<br>• Blue LED connects to target MPU pin GPIO_IO12 |
| D613 | GREEN | LED_GREEN | D613 ON – WLAN status indicator. When ON, indicates that the WLAN connection is established. |
| D614 | ORANGE | LED_ORANGE | D614 ON – Bluetooth status indicator. When ON, indicates that the Bluetooth connection is established. |

# 2 FRDM-IMX91 functional description

This chapter describes the features and functions of the FRDM-IMX91 board.

***Note:*** *For details of the i.MX 91 MPU features, see i.MX 91 Applications Processor Reference Manual.*

The chapter is divided into the following sections:

- Section "Processor"
- Section "Power supply"

- Section "Clocks"
- Section "I2C interface"
- Section "Boot mode and boot device configuration"
- Section "PDM interface"
- Section "LPDDR4 DRAM memory"
- Section "SD card interface"
- Section "eMMC memory"
- Section "M.2 interface"
- Section "CAN interface"
- Section "USB interface"
- Section "Ethernet"
- Section "EXPI connector"
- Section "Debug interface"
- Section "Board errata"

## 2.1 Processor

The i.MX 91 applications processor includes single Arm Cortex-A55 processors with speeds up to 1.4 GHz. Robust control networks are possible via the CAN-FD interface. Also, dual 1 Gbit/s Ethernet controllers, one supporting time sensitive networking (TSN), drive gateway applications with low latency.

The i.MX 91 is useful for applications such as:

- Smart home
- Building control
- Contactless HMI
- Commercial
- Healthcare
- Industrial

Each processor provides a 16-bit LPDDR4 memory interface and other interfaces for connecting peripherals, such as WLAN, Bluetooth, USB2.0, uSDHC, Ethernet, CAN, and multisensors.

For more detailed information about the processor, see the *i.MX 91 data sheet* and *i.MX 91 Applications Processor Reference Manual* at https://www.nxp.com/imx91.

## 2.2 Power supply

The primary power supply to the FRDM-IMX91 board is VBUS_IN (12 V - 20 V) through USB Type-C PD connector (P1).

Three DC buck switching regulators are used:

- MP8759GD (U702) switches VBUS_IN supply to SYS_5V (5 V) power supply, which is input power supply for PCA9451AHNY PMIC (U701) and other devices on board.
- MP2147GD (U726) switches VDD_5V supply to VPCIe_3V3 (3.3 V / 4 A) for M.2 / NGFF module (P8).
- MP1605C (U730) switches VPCIe_3V3 supply to VEXT_1V8 (3.3 V / 500 mA) for onboard tri-radio module MAYA-W476-00B (U731).

Figure 6 shows the FRDM-IMX91 power supply block diagram.

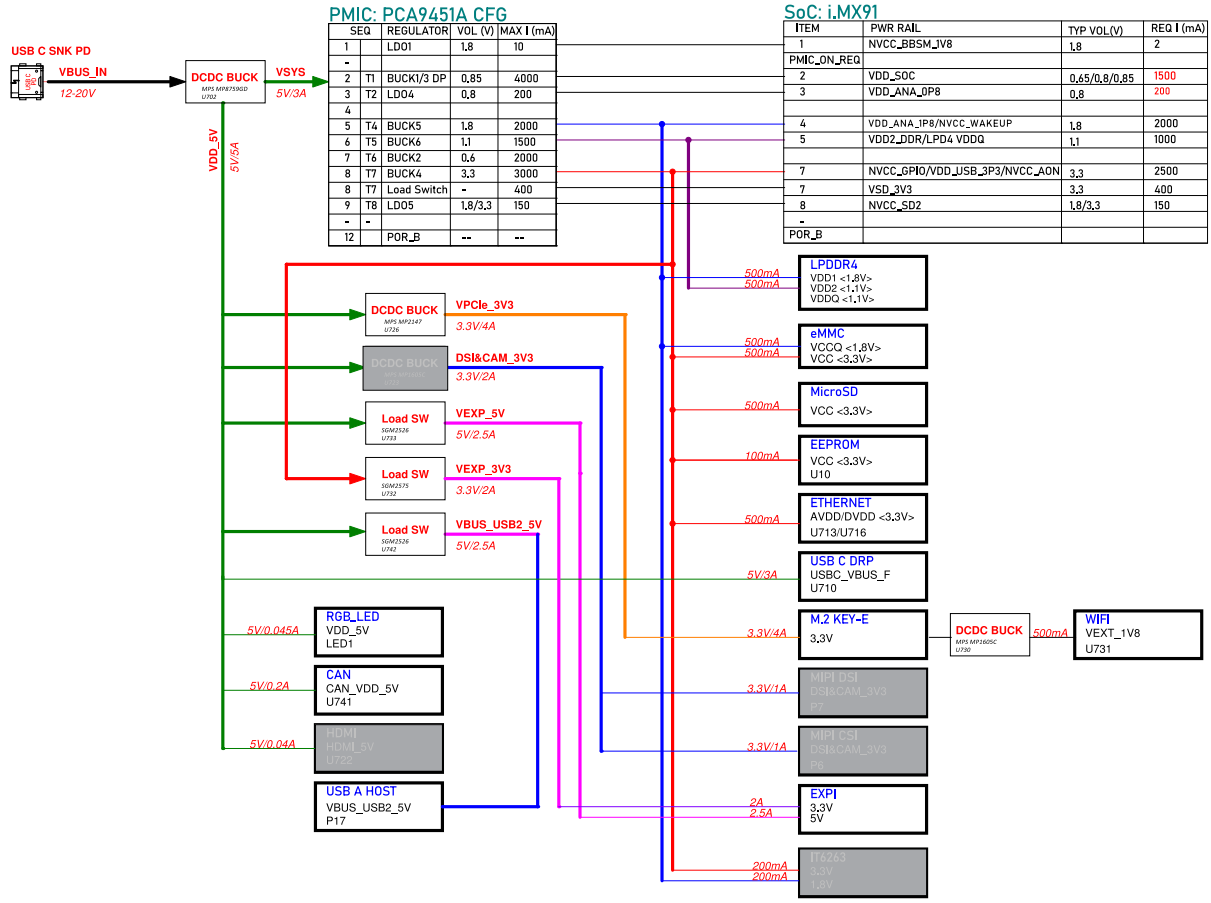



**Figure 6. FRDM-IMX91 power supply**

Table 8 describes different power sources available on the board.

**Table 8. FRDM-IMX91 power supply devices**

| Part identifier designator | Manufacturing part number | Part manufacturer | Power supply | Specifications | Description |
|---|---|---|---|---|---|
| U702 | MP8759GD | Monolithic Power Systems Inc. | • DCDC_5V<br>• VSYS_5V | • 5 V at 8 A | Supplies power to:<br>• PMIC PCA9451AHNY (U701)<br>• NX20P3483UK USB PD and Type-C switches (U710)<br>• DC buck MP2147GD (U726) for VPCIe_3V3<br>• Load switch SGM2526 (U733) for VRPi_5V<br>• Load switch SGM2526 (U742) for VBUS_USB2_5V |
| U726 | MP2147GD | Monolithic Power Systems Inc. | VPCIe_3V3 | 3.3 V at 3 A | • Input supply for switch-mode converter MP1605C (U730)<br>• Supply for onboard tri-radio module u-blox MAYA-W476-00 B (U731) |

**Table 8. FRDM-IMX91 power supply devices*...continued***

| Part identifier designator | Manufacturing part number | Part manufacturer | Power supply | Specifications | Description |
|---|---|---|---|---|---|
| U730 | MP1605C | Monolithic Power Systems Inc. | VEXT_1V8 | 1.8 V at 500 mA | Supplies power to onboard tri-radio u-blox MAYA-W476-00B module |
| U701 | PCA9451AHNY | NXP Semiconductors | BUCK2: LPD4/x_VDDQ_0V6 | • 0.6 V at 2000 mA | Supplies power to VDDQ_DDR power supply for CPU DRAM PHY I/O (LPDDR4) |
| | | | BUCK1/3: VDD_SOC_0V8[1][2] | • VOL (V): 0.85<br>• Typ VOL (V): Dynamic voltage scaling (DVS)<br>***Note:*** *Refer to SoC data sheet.* | VDD_SOC, power supply for SoC logic and Arm core |
| | | | BUCK4:<br>• VDD_3V3 | 3.3 V at 3000 mA | Supplies power to:<br>• NVCC_GPIO, power supply for GPIO when it is in 3.3 V mode<br>• VDD_USB_3P3 pin for USB PHY power<br>• eMMC 5.1 device<br>• MicroSD<br>• EEPROM<br>• Ethernet ports (P3 and P4)<br>• I2C IO expander PCAL6524 HEAZ (U725, I2C address: 0x22)<br>Power source for:<br>• ENET1_DVDD3 and ENET1_AVDD3 supplies |
| | | | BUCK5:<br>• VDD_1V8 | 1.8 V at 2000 mA | Supplies to:<br>• LPD4/x_VDD1<br>• eMMC 5.1 device<br>• VDD_ANA_1P8, analog core supply voltage<br>• NVCC_WAKEUP, digital I/O supply |
| | | | BUCK6:<br>• LPD4/x_VDD2_1V1 | 1.1 V at 2000 mA | Supplies to:<br>• VDD2_DDR, DDR PHY supply voltage |
| | | | LDO1: NVCC_BBSM_ 1V8 | 1.8 V at 10 mA | NVCC BBSM I/O supply |
| | | | LDO4: VDD_ANA_0 P8 | 0.8 V at 200 mA | Analog core supply voltage |
| | | | LDO5: NVCC_SD | 1.8 V / 3.3 V | MicroSD card |
| | | | Load switch: VSD_3V3 | 3.3 V | MicroSD card |

**Table 8. FRDM-IMX91 power supply devices***...continued*

| Part identifier designator | Manufacturing part number | Part manufacturer | Power supply | Specifications | Description |
|---|---|---|---|---|---|
| U703 | FDS4435 (Power Trench MOSFET) | SG MICRO CORP | VDD_5V | 5 V / 2.5 A | Supplies to:<br>• 10-pin dual-row header (P12)<br>• CAN transceiver through CAN_VDD_5V<br>• RGB LED<br>Power source for:<br>• VPCIe_3V3<br>• VRPi_5V<br>• VBUS_USB2_5V |
| U732 | SGM2525 (Load switch) | SG MICRO CORP | VRPi_3V3 | 3.3 V at 2.5 A | • 2x20-pin EXPI connector (P11) |
| U733 | SGM2525 (Load switch) | SG MICRO CORP | VRPi_5V | 5 V at 2.5 A | • 2x20-pin EXPI connector (P11) |
| U737 | TLV76033DBZR (Voltage regulator) | Texas Instruments | VCC_3V3_DEBUG | 3.3 V | Supplies to 4-bit voltage-level translator used for USB-to-dual UART debug interface |
| U742 | SGM2526 (Load switch) | SG MICRO CORP | VBUS_USB2_5V | 5 V / 2.5 A | Supplies to USB2.0 Type-A Host |

[1] BUCK1 and BUCK3 are configured as dual phase mode.
[2] PCA9451 BUCK1/3 dual phase default output voltage is 0.85 V.

For further details on the power sequence needed by the i.MX 91, see section "Power sequence" in the *i.MX 91 Reference Manual*.

## 2.3 Clocks

FRDM-IMX91 provides all the clocks required for the processor and peripheral interfaces. Table 9 summarizes the specifications of each clock and the component that provides it.

**Table 9. FRDM-IMX91 clocks**

| Part identifier | Clock generator | Clock | Specifications | Destination |
|---|---|---|---|---|
| Y401 | Crystal oscillator | XTALI_24M<br>XTALO_24M | Frequency: 24 MHz | Target processor |
| QZ401 | Crystal oscillator | XTALI_32K<br>XTALO_32K | Frequency: 32.768 kHz | NVCC_BBSM block of target processor |
| QZ701 | Crystal oscillator | XIN_32K<br>XOUT_32K | Frequency: 32.768 kHz | PCA9451AHNY PMIC |
| Y402 | Crystal oscillator | PHY1_XTAL_I<br>PHY1_XTAL_O | Frequency: 25 MHz | Ethernet RMII PHY1 |
| Y403 | Crystal oscillator | PHY2_XTAL_I<br>PHY2_XTAL_O | Frequency: 25 MHz | Ethernet RMII PHY2 |

## 2.4 I2C interface

The i.MX 91 processor supports a low-power inter-integrated circuit (I2C) module that supports an efficient interface to an I2C-bus as a master. The I2C provides a method of communication between a number of devices available on the FRDM-IMX91 board.

One 10-pin 2x5 2.54 mm connector P12 is provided on the board to support I2C, CAN, and ADC connections. The developers can use the port for some specific application development.

Table 10 explains the I2C, CAN, and ADC header, P12, pinout.

**Table 10. 10-pin 2x5 2.54mm I2C, CAN, and ADC header (P12) pinout**

| Pin | Signal name | Description |
|---|---|---|
| 1 | VDD_3V3 | 3.3 V power supply |
| 2 | VDD_5V | 5 V power supply |
| 3 | ADC_IN0 | ADC input channel 0 |
| 4 | ADC_IN1 | ADC input channel 1 |
| 5 | I3C_INT | I2C/I3C interrupt signal |
| 6 | GND | Ground |
| 7 | I3C_SCL | I2C/I3C SCL signal |
| 8 | CAN_H | CAN transceiver high signal |
| 9 | I3C_SDA | I2C/I3C SDA signal |
| 10 | CAN_L | CAN transceiver low signal |

Table 11 describes the I2C devices and their I2C addresses (7-bit) on the board.

**Table 11. I2C devices**

| Part identifier | Device | I2C address (7-bit) | Port | Speed | Voltage | Description |
|---|---|---|---|---|---|---|
| U748 | PCAL6408AHK | 0x20 (0b'0100000x) | MX-I2C1 | 1 MHz Fm+ | 3.3 V | I/O expander for IRQ / OUTPUT |
| U701 | PCA9451AHNY | 0x25 (0b'0100101x) | MX-I2C2 | 1 MHz Fm+ | 3.3 V | PMIC |
| U725 | PCAL6524HEAZ | 0x22 (0b'01000[10]x) | MX-I2C2 | 1 MHz Fm+ | 3.3 V | IO expander for IRQ/ OUTPUT |
| U10 | FT24C256A | 0x50 (0b'1010000x) | MX-I2C2 | 1 MHz Fm+ | 3.3 V | EEPROM |
| U705 | PTN5110NHQZ | 0x52 (0b'10100[10]x) | MX-I2C3 | 1 MHz Fm+ | 3.3 V | USB Type-C Power Delivery PHY |
| U712 | PTN5110NHQZ | 0x50 (0b'10100[00]x) | MX-I2C3 | 1 MHz Fm+ | 3.3 V | USB Type-C Power Delivery PHY |
| U710 | NX20P3483UK | 0x71 (0b'11100[01]x) | MX-I2C3 | 1 MHz Fm+ | 3.3 V | USB load switch |
| U740 | PCF2131 | 0x 53 (0b'110101[0]x) | MX-I2C3 | 400 kHz Fm | 3.3 V | External RTC |

## 2.5 Boot mode and boot device configuration

The i.MX 91 processor offers multiple boot configurations, selectable by SW1 on the FRDM-IMX91 board. In addition, the i.MX 91 can download a program image from a USB connection when configured in serial download mode. The four dedicated BOOT MODE pins are used to select the various boot modes.

Figure 7 shows the boot mode selection switch.


**Figure 7. Boot mode selection switch**

Table 12 describes the SW1 values used in different boot modes.

**Table 12. Boot mode settings**

| SW1 [3:0] | BOOT_MODE[3:0] | Boot core | Boot device |
|---|---|---|---|
| 0001 | 0001 | Cortex-A55 | Serial downloader (USB) |
| 0010 | 0010 | | uSDHC1 8-bit eMMC 5.1 |
| 0011 | 0011 | | uSDHC2 4-bit SD3.0 |

On the FRDM-IMX91 board, the default boot mode is from the eMMC device. The other boot device is the microSD connector. Set SW1[3:0] as 0010 to choose uSDHC1 (eMMC) as boot device, set 0011 to choose uSDHC2 (SD), and set 0001 to enter USB serial download.

***Note:*** *For more information about the boot modes and boot device configuration, see chapter "System Boot" in the i.MX 91 Applications Processor Reference Manual.*

Figure 8 shows the connection of SW1 and i.MX 91 boot mode signals.

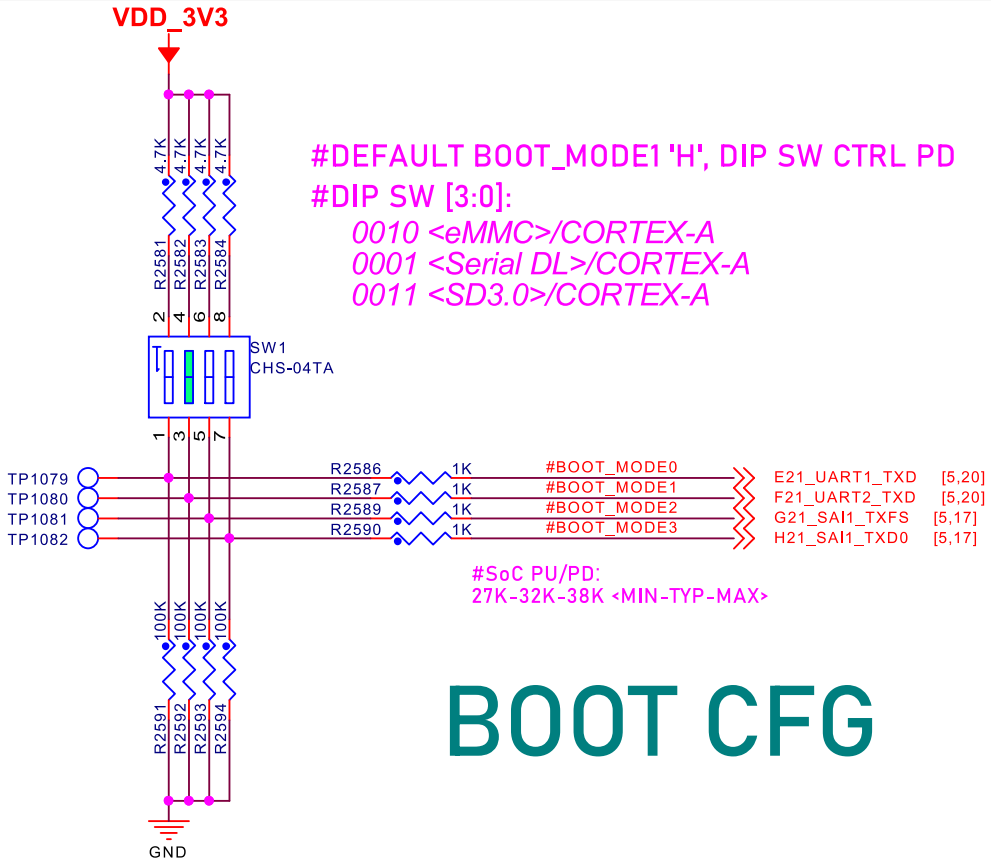



**Figure 8. Boot configuration schematic**

## 2.6 PDM interface

The pulse density modulated (PDM) microphone interface of the processor provides PDM/MQS support on the FRDM-IMX91, and it connects to a 3.5 mm audio jack (P15).

**Table 13. Audio jack**

| Part identifier | Manufacturing part number | Description |
|---|---|---|
| P15 | PJ_3536X | 3.5 mm audio jack for onboard MQS analog input / output |

## 2.7 LPDDR4 DRAM memory

The FRDM-IMX91 board features one 512 M × 16 (1 channel ×16 I/O × 1 rank) LPDDR4 SDRAM chip (NT6AN512M16AV-J1) for a total of 1 GB of RAM memory. The LPDDR4 DRAM memory is connected to the i.MX 91 DRAM controller.

The ZQ calibration resistors (R209 and R2941) used by the LPDDR4 chip are 240 Ω 1% to LPD4/x_VDDQ and the ZQ calibration resistor DRAM_ZQ used at i.MX 91 SoC side is 120 Ω 1% to GND.

In the physical layout, the LPDDR4 chip is placed at the top side of the board. The data traces are not necessarily connected to the LPDDR4 chips in sequential order. Instead, the data traces are connected as best determined by the layout and other critical traces for the ease of routing.

## 2.8 SD card interface

The target processor has three ultra secured digital host controller (uSDHC) modules for SD/eMMC interface support. The uSDHC2 interface of the i.MX 91 processor connects to the MicroSD card slot (P13) on the FRDM-IMX91 board. This connector supports one 4-bit SD3.0 MicroSD card. To select it as the boot device of the board, see Section 2.5.

## 2.9 eMMC memory

The eMMC memory (at the SOM board) is connected to the uSDHC1 interface of the i.MX 91 processor, which can support eMMC 5.1 devices. It is the default boot device of the board. Table 12 describes the boot settings.

Table 14 describes the eMMC memory device that is supported by the uSDHC1 interface.

**Table 14. Supported eMMC device**

| Part identifier | Part number | Configuration | FBGA | Manufacturer | Memory size |
|---|---|---|---|---|---|
| U501 | FEMDRM008G-58A39 | 64 Gb x1 | TFBGA-153 | FORESEE | 8 GB |

## 2.10 M.2 interface

The FRDM-IMX91 board supports the M.2/NGFF Key E mini card 75-pin connector, P8. The M.2 mini card connector supports USB, SDIO, SAI, UART, I2C, and GPIO connection. By default, these signals are connected with the onboard tri-radio MAYA-W476-00B module, however, to use this M.2 slot, the following resistors must be reworked.

**Table 15. Resistors rework for M.2 slot usage**

| Resistors DNP | Resistors install |
|---|---|
| R2808, R2809, R2812, R2819, R2820, R2821 | R2824, R2825, R2826, R2827, R2828, R2829 |
| R3023, R3024, R2958, R3028 | R2960, R2860 |
| R2854, R2855 | R2851, R2853 |
| R3038, R2870, R2871 | R3037, R2866, R2867 |
| R2796, R2798, R2800, R2802 | R2788, R2791, R2792, R2794 |
| R2797, R2799, R2801, R2805 | R2789, R2790, R2793, R2795 |
| R2832, R2834, R2836, R2838 | R2833, R2835, R2837, R2839 |

The M.2 connector can be used for Wi-Fi / Bluetooth card, IEEE 802.15.4 Radio, or 3G / 4G cards.

Table 16 describes the pinout of the M.2 mini card connector (P8).

**Table 16. M.2 mini card connector (P8) pinout**

| Pin number | M.2 mini card connector pin | Connection details |
|---|---|---|
| 2, 4, 72, 74 | 3V3_1, 3V3_2, 3V3_3, 3V3_4 | Connected to VPCIe_3V3 power supply |
| 6 | LED1 | Connected to M.2 Green LED, D613 |
| 8 | I2S_SCK | Connected to SAI1_TXC processor pin if R2788 is populated |
| 10 | I2S_WS | Connected to SAI1_TXFS processor pin if R2791 is populated |
| 12 | I2S_SD_IN | Connected to SAI1_RXD processor pin if R2794 is populated |

**Table 16. M.2 mini card connector (P8) pinout***...continued*

| Pin number | M.2 mini card connector pin | Connection details |
|---|---|---|
| 14 | I2S_SD_OUT | Connected to SAI1_TXD processor pin if R2792 is populated |
| 16 | LED2 | Connected to M.2 Orange LED, D614 |
| 20 | UART_WAKE | M2_UART_nWAKE input for I/O expander (PCAL6524HEAZ, P0_3, I2C address: 0x22) if R2853 is populated |
| 22 | UART_RXD | Connected to UART5_RXD if R2835 is populated |
| 32 | UART_TXD | Connected to UART5_TXD if R2833 is populated |
| 34 | UART_CTS | Connected to UART5_CTSI if R2839 is populated |
| 36 | UART_RTS | Connected to UART5_RTSO if R2837 is populated |
| 38 | VEN_DEF1 | Connected to SPI3_MOSI if R2790 is populated |
| 40 | VEN_DEF2 | Connected to SPI3_MISO if R2795 is populated |
| 42 | VEN_DEF3 | Connected to SPI3_CLK if R2793 is populated |
| 50 | SUSCLK | Connected to PMIC_32K_OUT, generated by PCA9451AHNY PMIC |
| 52 | PERST0 | M2_nRST input for I/O expander (PCAL6524HEAZ, P2_2, I2C address: 0x22) |
| 54 | W_DISABLE2 | M2_nDIS2 input for I/O expander (PCAL6524HEAZ, P2_3, I2C address: 0x22) if R2867 is populated |
| 56 | W_DISABLE1 | M2_nDIS1 input for I/O expander (PCAL6524HEAZ, P2_4, I2C address: 0x22) if R2866 is populated |
| 58 | I2C_DATA | Connected to SDAL pin of PCA9451AHNY PMIC |
| 60 | I2C_CLK | Connected to SCLL pin of PCA9451AHNY PMIC |
| 62 | ALERT | M2_nALERT input for I/O expander (PCAL6524HEAZ, P1_2, I2C address: 0x22) if R2860 is populated |
| 3 | USB_D+ | Connected to USB2_D_P processor pin if R2806 is populated |
| 5 | USB_D- | Connected to USB2_D_N if R2807 is populated |
| 9 | SDIO_CLK | Connected to the SD3_CLK processor pin and processor interface SDHC3 if R2824 is populated |
| 11 | SDIO_CMD | Connected to the SD3_CMD processor pin and processor interface SDHC3 if R2825 is populated |
| 13 | SDIO_DATA0 | Connected to the SD3_DATA0 processor pin and processor interface SDHC3 if R2826 is populated |
| 15 | SDIO_DATA1 | Connected to the SD3_DATA1 processor pin and processor interface SDHC3 if R2827 is populated |
| 17 | SDIO_DATA2 | Connected to the SD3_DATA2 processor pin and processor interface SDHC3 if R2828 is populated |
| 19 | SDIO_DATA3 | Connected to the SD3_DATA3 processor pin and processor interface SDHC3 if R2829 is populated |
| 21 | SDIO_WAKE | Connected to the CCM_CLKO1 processor pin of NVCC_WAKEUP module if R2851 is populated |
| 23 | SDIO_RST | SD3_nRST output from I/O expander (PCAL6524HEAZ, P1_4, I2C address: 0x22) if R3037 is populated |

**Table 16. M.2 mini card connector (P8) pinout***...continued*

| Pin number | M.2 mini card connector pin | Connection details |
|---|---|---|
| 55 | PEWAKE0 | `PCIE_nWAKE` input for I/O expander (PCAL6524HEAZ, P0_2, I2C address: 0x22) if `R2868` is populated |

For further details about i.MX 91 interfaces, see *i.MX 91 Applications Processor Reference Manual*.

## 2.11 Tri-radio module interface

The FRDM-IMX91 board features a Tri-radio (Wi-Fi 6, Bluetooth Low Energy 5.4, and 802.15.4) module based on the NXP IW612 that interfaces with the SD2, UART5, SAI1, and SPI3 controller of the target processor.

**Table 17. Tri-radio module**

| Part identifier | Manufacturing part number | Description |
|---|---|---|
| U731 | MAYA-W476-00B (u-blox) | Host-based Wi-Fi 6, Bluetooth Low Energy 5.4, and 802.15.4 modules for IoT applications |

The two antenna pins (RF_ANT0 and RF_ANT1) of the module connects to U.FL connectors P9 and P10 (DNP by default). The module is supplied with VPCIe_3V3, VEXT_1V8, and VDD_1V8.

The MAYA-W476-00B module and M.2 connector share several interface lines on the FRDM-IMX91 board. Zero-ohm resistors enable signal selection between these components.

### SD3 interface

The SD3 interface lines are shared between the MAYA-W476-00B module and the M.2 connector. Zero-ohm resistors select either the MAYA-W476-00B module (default setting) or the M.2 connector.

### UART5 interface

Similarly, the UART5 interface lines are shared between the MAYA-W476-00B module and the M.2 connector. Zero-ohm resistors select either the MAYA-W476-00B module (default setting) or the M.2 connector.

### SAI1 interface

The SAI1 interface lines are shared between the MAYA-W476-00B module and the M.2 connector. Zero-ohm resistors select either the MAYA-W476-00B module (default setting) or the M.2 connector for 1.8 V translated signals, generated using the 74AVC4T3144 bidirectional voltage translator (U728).

### SPI3 interface

The SPI3 signals (CLK, MOSI, MISO, and CS0) are multiplexed with GPIO_IO[08, 09, 10, 11] signals, respectively. These SPI3 signals are shared between the MAYA-W476-00B module and the M.2 connector. Zero-ohm resistors select either the MAYA-W476-00B module (default setting) or the M.2 connector for 1.8 V translated signals, generated using the 74AVC4T3144 bidirectional voltage translator (U729).

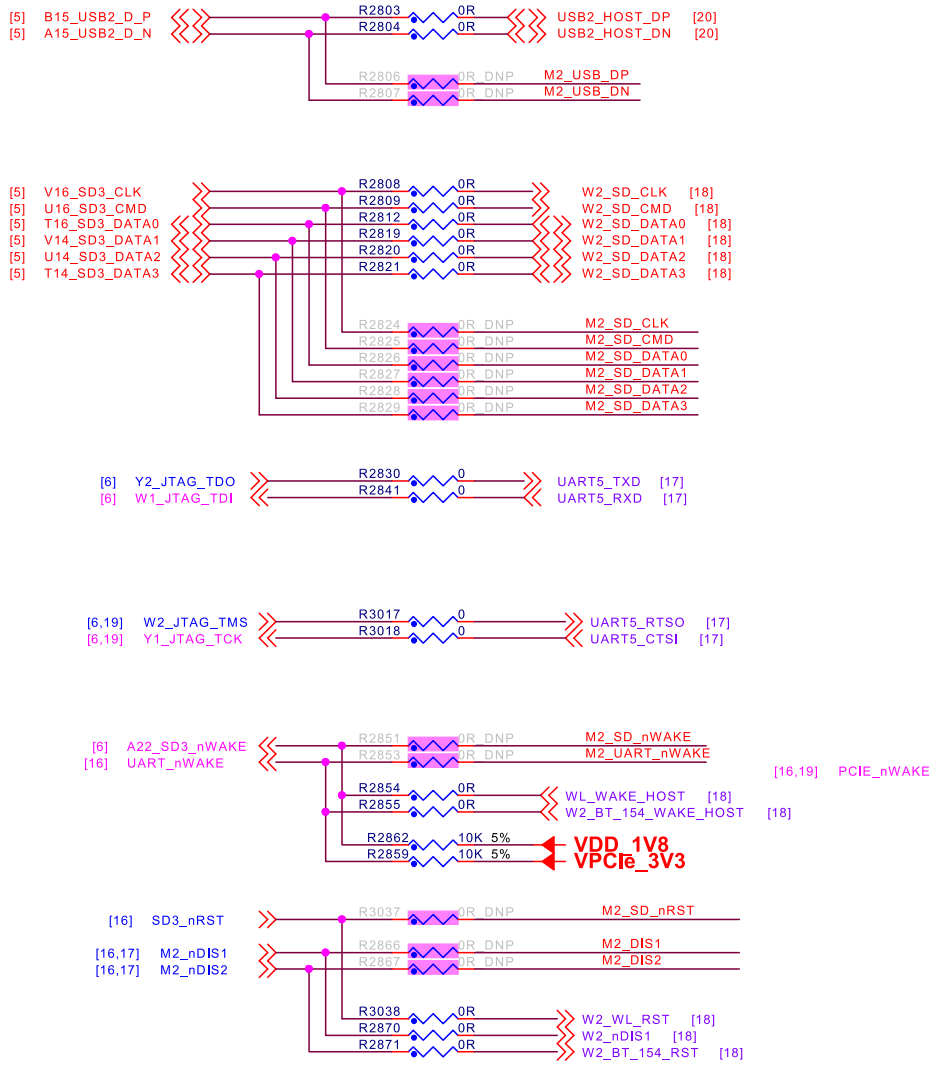



**Figure 9. Resistors configuration for SD3**

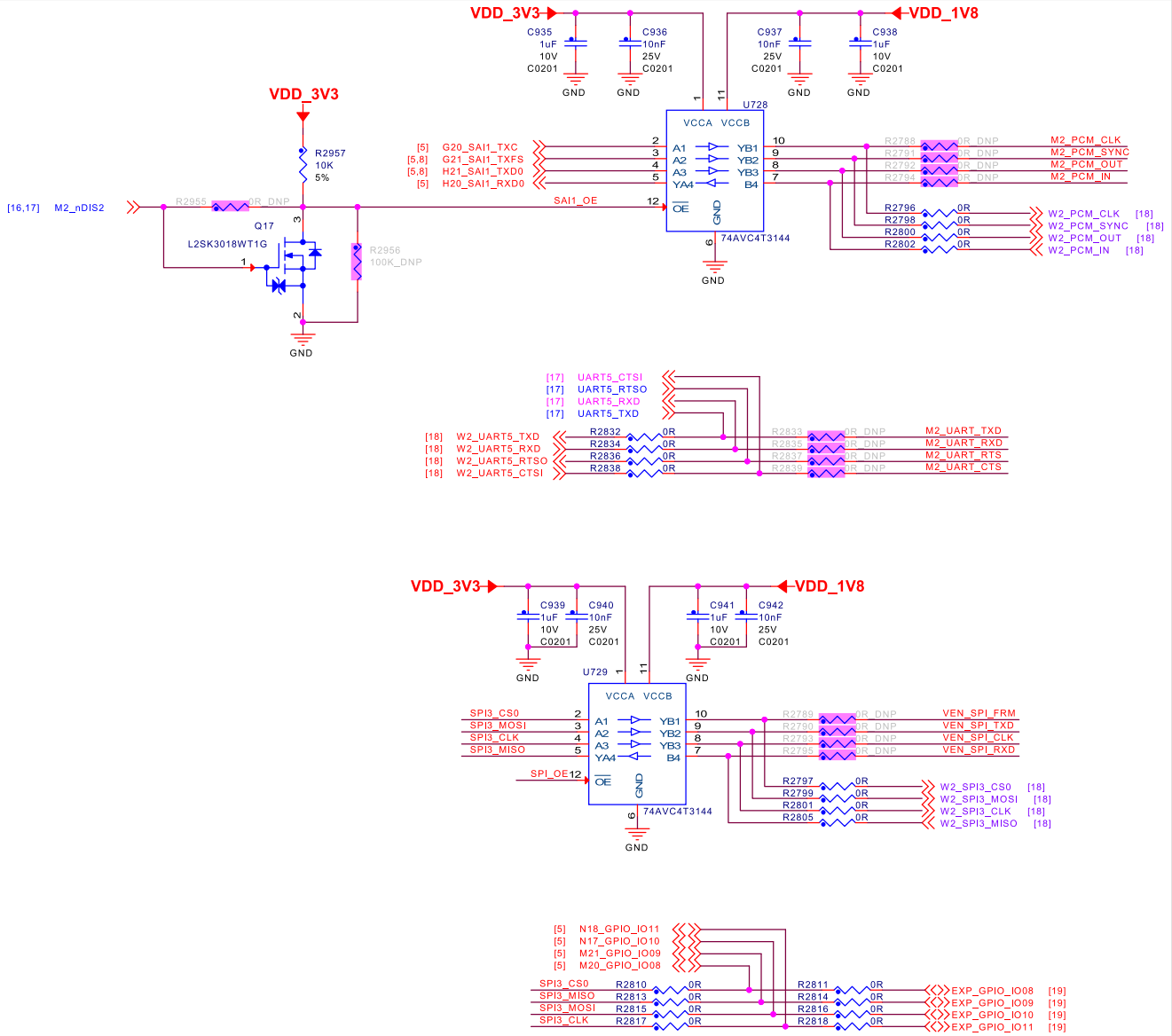



**Figure 10. Resistors configuration for SAI1, UART5, and SPI3**

## 2.12 CAN interface

The i.MX 91 processor supports a controller area network (CAN) module that is a communication controller implementing the CAN protocol according to the CAN with flexible data rate (CAN FD) protocol and the CAN 2.0B protocol specification. The processor supports two CAN FD controllers.

On the FRDM-IMX91 board, one of the controllers is connected to the high-speed CAN transceiver TJA1051T/3. The high-speed CAN transceiver drives CAN signals between the target processor and a 10-pin 2x5 2.54 mm header (P12) to its physical two-wire CAN bus.

The CAN_TXD and CAN_RXD signals are multiplexed on GPIO_IO25 and GPIO_IO27, respectively. On the board, a 2-bit DIP switch (SW3) is used to control the CAN signals. For SW3 detail, see Section 1.7. The CAN_STBY signal from the IO expander PCAL6524HEAZ (U725, P2_7, I2C address: 22) enables / disables CAN standby mode.

The CAN interface circuit includes the split termination RC filter (62Ω + 56pF) for noise rejection and signal integrity. The switch SW4 is provided for enabling/disabling the RC filter. For SW4 detail, see Section 1.7.

The HS-CAN transceiver and header are described in Table 18.

**Table 18. High-speed CAN transceiver and header**

| Part identifier | Manufacturing part number | Description |
|---|---|---|
| U741 | TJA1051T/3 | High-speed CAN transceiver. Provides an interface between a CAN protocol controller and the physical two-wire CAN bus. |
| P12 | Not applicable | 10-pin 2x5 2.54 mm connector (P12). It is connected to the CAN bus and allows external connection with the bus.<br>***Note:*** *Table 10 explains pinout for the 10-pin 2x5 2.54 mm connector P12.* |

***Note:*** *For details about TJA1051, see TJA1051 data sheet at nxp.com.*

## 2.13 USB interface

The i.MX 91 applications processor features two USB 2.0 controllers, with two integrated USB PHYs. On the FRDM-IMX91 board, one is used for the USB2.0 Type-C Port (P2) and the other is used for USB2.0 Type-A Port (P17).

Table 19 describes the USB ports available on the board.

**Table 19. USB ports**

| Part identifier | USB port type | Description |
|---|---|---|
| P2 | USB2.0 Type-C | Connects to full-speed USB host and device controller (USB 1) of target processor.<br>It can operate as a device or host. The USBC_VBUS signal controls the VBUS drive for the USB port. |
| P17 | USB2.0 Type-A | Connects to full-speed USB host and device controller (USB 2) of target processor. It can operate as a device or host. The USB2_VBUS signal controls the VBUS drive for the USB port.<br>The USB2_DP and USB2_DN signals from the USB2 controller of the target processor connect to USB2 Type A port (P17) by default. These signals can be connected to M.2 card connecter (P6) by solder/DNP R2803, R2804, R2806, R2807. |
| P1 | USB Type-C PD | It is used for power only. It does not support USB data transfer. It is the only power supply port therefore it must always be supplied for system power. |
| P16 | USB Type-C | It is used for system debug purpose. For detail, see the system debug section. |

## 2.14 Ethernet

The i.MX 91 processor supports two Gigabit Ethernet controllers (capable of simultaneous operation) with support for Energy-Efficient Ethernet (EEE), Ethernet AVB, and IEEE 1588.

The Ethernet subsystem of the board is provided by the Motorcomm YT8521SH-CA Ethernet transceivers (U713, U716) which support RGMII and connect to RJ45 connectors (P3, P4). The Ethernet transceivers (or PHYs) receive standard RGMII Ethernet signals from i.MX 91. The RJ45 connectors integrate Magnetic transformer inside, so they can be directly connected to Ethernet transceivers (or PHYs).

Each Ethernet port has a unique MAC address, which is fused into i.MX 91. The Ethernet connectors are labeled clearly on the board.

## 2.15 EXPI connector

One 2x20-pin EXPI connector (P11) is provided on the FRDM-IMX91 board to support I2S, UART, I2C, and GPIO connections. The header can be used to access various pins or to plug in accessory cards, such as the LCD display TM050RDH03-41, 8MIC-RPI-MX8 card, and MX93AUD-HAT.

The connector is shown in Figure 3.

**Table 20. P11 pin definition**

| Pin number | Net name | Pin number | Net name |
|---|---|---|---|
| 1 | VRPi_3V3 | 2 | VRPi_5V |
| 3 | GPIO_IO02 | 4 | VRPi_5V |
| 5 | GPIO_IO03 | 6 | GND |
| 7 | GPIO_IO04 | 8 | GPIO_IO14 |
| 9 | GND | 10 | GPIO_IO15 |
| 11 | GPIO_IO17 | 12 | GPIO_IO18 |
| 13 | GPIO_IO27 | 14 | GND |
| 15 | GPIO_IO22 | 16 | GPIO_IO23 |
| 17 | VRPi_3V3 | 18 | GPIO_IO24 |
| 19 | GPIO_IO10 | 20 | GND |
| 21 | GPIO_IO09 | 22 | GPIO_IO25 |
| 23 | GPIO_IO11 | 24 | GPIO_IO08 |
| 25 | GND | 26 | GPIO_IO07 |
| 27 | GPIO_IO00 | 28 | GPIO_IO01 |
| 29 | GPIO_IO05 | 30 | GND |
| 31 | GPIO_IO06 | 32 | GPIO_IO12 |
| 33 | GPIO_IO13 | 34 | GND |
| 35 | GPIO_IO19 | 36 | GPIO_IO16 |
| 37 | GPIO_IO26 | 38 | GPIO_IO20 |
| 39 | GND | 40 | GPIO_IO21 |

## 2.16 Debug interface

The FRDM-IMX91 board features two independent debug interfaces.

- Serial wire debug (SWD) header (Section 2.16.1)
- USB-to-dual UART debug port (Section 2.16.2)

### 2.16.1 SWD interface

The i.MX 91 applications processor has two serial wire debug (SWD) signals on dedicated pins, and those signals are directly connected to the standard 3-pin 2.54 mm connector P14. The two SWD signals used by the processor are:

- SWCLK (serial wire clock)
- SWDIO (serial wire data input / output)

The SWD connector P14 is shown in Figure 3.

### 2.16.2 USB debug interface

The i.MX 91 applications processor has six independent UART ports (UART1 – UART6). On the FRDM-IMX91 board, UART1 is used for Cortex-A55 core. A single chip USB to dual UART is used for the debug purpose. The part number is CH342F. You can download the driver from WCH Website.

After installing the CH342F driver, the PC / USB host enumerates two COM ports connected to the P16 connector through a USB cable:

- COM Port 1: Cortex-A55 system debugging
- COM Port 2: Reserved

You can use the following terminal tools for debugging purposes:

- Putty
- Tera Term
- Xshell
- Minicom>=2.9

To debug under Linux, make sure CH342F Linux driver is installed.

Table 21 describes the required settings.

**Table 21. Terminal setting parameters**

| | |
|---|---|
| **Data rate** | 115,200 Baud |
| **Data bits** | 8 |
| **Parity** | None |
| **Stop bits** | 1 |

The USB debug connector P16 is shown in Figure 3.

## 2.17 Board errata

No board errata.

# 3 Working with accessories

This section describes how a connection can be established between with the FRDM-IMX91 board and compatible accessory boards.

## 3.1 5-inch Tianma LCD

TM050RDH03-41 is a 5" TFT LCD display with 800x480 resolution. This industrial-grade display uses an RGB interface without a touch panel. This display module connects to the FRDM-IMX91 through the EXPI 2x20-pin connector (P11).

### 3.1.1 Connection between Tianma panel and adapter board

Figure 11 shows the FPC connection between the 5-inch Tianma LCD panel and adapter board. Insert the FPC connector with the conductive side up (stiffener side down).

**Figure 11. FPC connection between 5-inch Tianma LCD panel and adapter board**

### 3.1.2 Connection between adapter board and FRDM-IMX91

Plug 5’’ Tianma LCD to FRDM-IMX91 through the EXPI 2x20-pin connector (P11) as shown in Figure 12

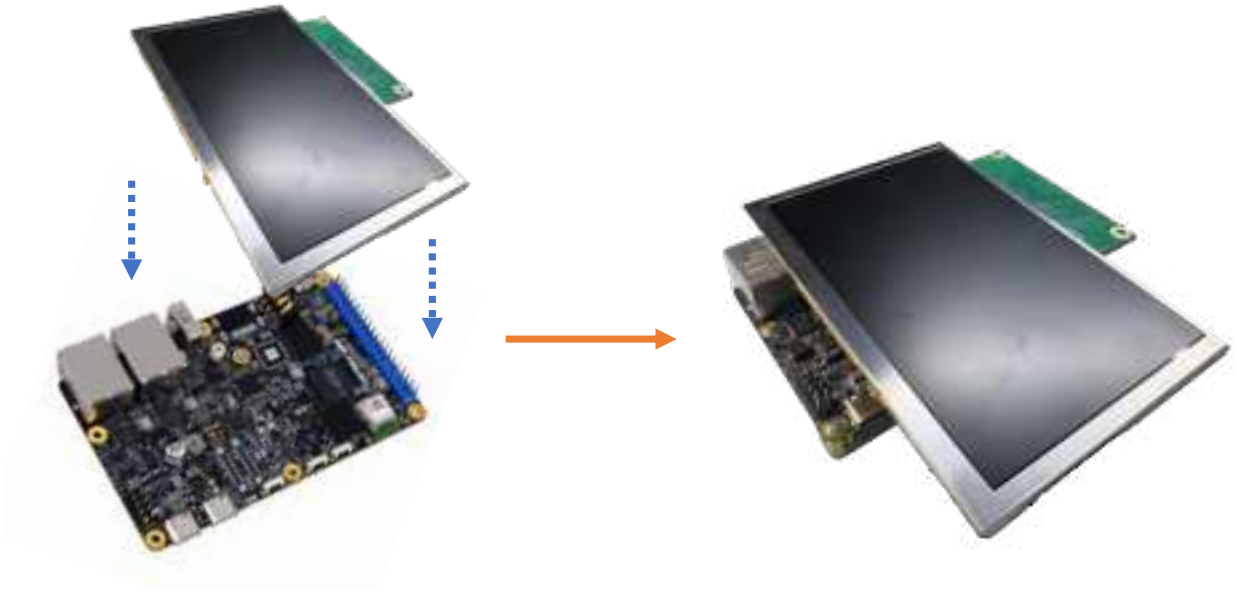


Figure 12. 5-inch Tianma LCD connection with FRDM-IMX91 through 2x20-pin EXPI connector

### 3.1.3 Software configuration update

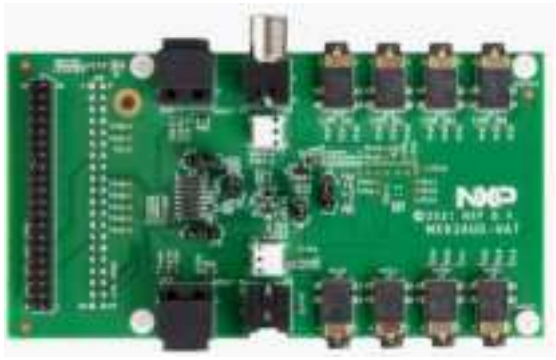
The following steps specify how to replace the default dtb with the custom dtb (imx91-11x11-frdm-tianma-wvga-panel.dtb) that supports Tianma LCD.

1. Stop at U-Boot
2. Use the below commands to replace the default dtb:

```
$setenv fdtfile imx91-11x11-frdm-tianma-wvga-panel.dtb
$saveenv
$boot
```

## 3.2 Other accessory boards

There are other accessory boards also that can work with FRDM-IMX91 through EXPI 2x20-pin interface, such as 8MIC-RPI-MX8 and MX93AUD-HAT. To use any such board, check the schematic and layout to determine the direction of the connection between FRDM-IMX91 and the accessory board in advance. Also, choose the right dtb file in the U-Boot stage.



MX93AUD-HAT

8MIC-RPI-MX8

**Figure 13. Accessory boards**

### 3.2.1 Software configuration update

- To use the MX93AUD-HAT and 8MIC-RPI-MX8 boards together or use the MX93AUD-HAT board alone, run the following commands at U-Boot to replace the default dtb:

```
$setenv fdtfile imx91-11x11-frdm-aud-hat.dtb
$saveenv
$boot
```

- To use the 8MIC-RPI-MX8 board alone, run the following commands at U-Boot to replace the default dtb:

```
$setenv fdtfile imx91-11x11-frdm-8mic.dtb
$saveenv
$boot
```

# 4 PCB information

The FRDM-IMX91 is made with standard 10-layer technology. The material is FR-4, and the PCB stack-up information is described in Table 22.

**Table 22. FRDM-IMX91 board stack up information**

| Layer | Description | Copper (mil) | Generic | Er | Dielectric thickness (mil) |
|---|---|---|---|---|---|
| 1 | TOP | 0.7+Plating | - | - | 1.3 |
| - | Dielectric | - | | | 2.61 |
| 2 | GND02 | 1.4 | - | - | - |
| - | Dielectric | - | | | 3 |
| 3 | ART03 | 1.4 | - | - | - |
| - | Dielectric | - | | | 8.8 |
| 4 | PWR04 | 1.4 | - | - | - |
| - | Dielectric | - | | | 4 |
| 5 | PWR05 | 1.4 | - | - | - |

Table 22. FRDM-IMX91 board stack up information...*continued*

| Layer | Description | Copper (mil) | Generic | Er | Dielectric thickness (mil) |
|---|---|---|---|---|---|
| - | Dielectric | - | | | 8.8 |
| 6 | ART06 | 1.4 | - | - | - |
| - | Dielectric | - | | | 4 |
| 7 | GND07 | 1.4 | - | - | - |
| - | Dielectric | - | | | 8.8 |
| 8 | ART08 | 1.4 | - | - | - |
| - | Dielectric | - | | | 3 |
| 9 | GND09 | 1.4 | - | - | - |
| - | Dielectric | - | | | 2.61 |
| 10 | BOTTOM | 0.7+Plating | - | - | 1.3 |
| Finished: | 1.6 mm | | | | |
| Designed: | 71.304 mil | | | 1.811 mm | |
| Material: | FR-4 | | | | |

# 5 European Union regulatory compliance

Table 23 is provided as per Article 10.8 of the Radio Equipment Directive 2014/53/EU.

(a) Frequency bands in which the equipment operates.

(b) The maximum RF power transmitted.

Table 23. EU regulatory compliance

| Part number | RF technology | (a) Frequency range | (b) Maximum transmitted power |
|---|---|---|---|
| FRDM-IMX91 | Bluetooth Low Energy 5.4 | 2402 MHz - 2480 MHz | 13 dBm |
| | IEEE 802.15.4 | 2405 MHz - 2480 MHz | 13 dBm |
| | Wi-Fi IEEE 802.11b/g/n/ax | 2400 MHz - 2500 MHz | 16 dBm |
| | Wi-Fi IEEE 802.11a/n/ac/ax | 4900 MHz - 5895 MHz | 18 dBm |

EUROPEAN DECLARATION OF CONFORMITY (Simplified DoC per Article 10.9 of the Radio Equipment Directive 2014/53/EU)

This apparatus, namely FRDM-IMX91 Freedom Development Platform, conforms to the Radio Equipment Directive 2014/53/EU. The full EU Declaration of Conformity for this apparatus can be found at the NXP website: FRDM-IMX91.

# 6 Acronyms

Table 24 lists and explains the acronyms and abbreviations used in this document.

Table 24. Acronyms

| Term | Description |
|---|---|
| BGA | Ball grid array |

**Table 24. Acronyms**...*continued*

| Term | Description |
|---|---|
| CAN | Controller area network |
| DNP | Do not populate |
| DRAM | Dynamic random access memory |
| DSI | Display serial interface |
| eMMC | Embedded multimedia card |
| ENET | Ethernet transceiver |
| EXPI | Expansion interface |
| FD | Flexible data rate |
| GPIO | General-purpose input/output |
| HS | High-speed |
| I2C | Inter-integrated circuit |
| I2S | Inter-IC sound |
| I3C | Improved inter-integrated circuit |
| LDO | Low dropout regulator |
| LED | Light-emitting diode |
| MISO | Master input slave output |
| MOSI | Master output slave input |
| MQS | Medium quality sound |
| NGFF | Next-generation form factor |
| PCB | Printed circuit board |
| PDM | Pulse-density modulation |
| PMIC | Power management-integrated circuit |
| PWM | Pulse width modulation |
| RGMII | Reduced gigabit media independent interface |
| SAI | Serial audio interface |
| SDIO | Secure digital I/O |
| SPI | Serial peripheral interface |
| SWD | Serial wire debug |
| TSN | Time-sensitive networking |
| UART | Universal asynchronous receiver/transmitter |
| USB | Universal serial bus |
| uSDHC | Ultra secured digital host controller |

# 7 Related documentation

Table 25 lists and explains the additional documents and resources that you can refer to for more information on the FRDM-IMX91 board. Some of the documents listed below may be available only under a nondisclosure

agreement (NDA). To request access to these documents, contact your local field applications engineer (FAE) or sales representative.

**Table 25. Related documentation**

| Document | Description | Link / how to access |
|---|---|---|
| i.MX 91 Applications Processor Reference Manual | Intended for system software and hardware developers and application programmers who want to develop products with i.MX 91 MPU | IMX91RM |
| i.MX 91 Industrial Application Processors Data Sheet | Provides information about electrical characteristics, hardware design considerations, and ordering information | IMX91IEC |
| i.MX 91 Hardware Design Guide | This document aims to help hardware engineers design and to test their i.MX 91 processor-based designs. It provides information about board layout recommendations and design checklists to ensure first-pass success and avoidance of board bring-up problems. | UG10147 |

# 8 Note about the source code in the document

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# 9 Revision history

Table 26 summarizes the revisions to this document.

**Table 26. Revision history**

| Document ID | Release date | Description |
|---|---|---|
| UM12262 v.3.0 | 22 April 2025 | Updated link in Section 5 |
| UM12262 v.2.0 | 5 March 2025 | Updated Section 5 |
| UM12262 v.1.0 | 25 February 2025 | Initial public release |

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