ConnectCore® 6UL

SBC Express

Hardware Reference Manual

Revision history—90001520

Revision	Date	Description
01	October 2016	Alpha release
A	June 2017	Modified regulatory and certification information as required by RED (Radio Equipment Directive); added mechanical drawings.
B	January 2020	Clarified VCC_LICELL voltage specifications.
C	October 2021	Added safety instructions and UKCA labeling requirements.
D	January 2022	Updated Bluetooth version throughout.

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Description of issue

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About the ConnectCore 6UL SBC Express

The ConnectCore 6UL SBC Express is a compact board featuring the Digi ConnectCore 6UL System-on-module (SoM). The ConnectCore 6UL System-on-module integrates an NXP i.MX6UL application processor with DDR3 and NAND flash memory, WLAN/Bluetooth, power management IC, a crypto-authentication security chip, and a Microcontroller Assist™ (MCA) for additional functionality.

The Digi ConnectCore 6UL SBC Express is a development board for evaluating the Digi ConnectCore 6UL System-on-module. The reference-design castellated edge development board enables you to explore and develop firmware before designing your own custom carrier board.

Features and functionality

- ConnectCore 6UL module
    - i.MX6UL single ARM Cortex-A7 core operating at speeds up to 528 MHz
    - 16-bit DDR3-800 memory interface with a density up to 1GB
    - 8-bit SLC NAND flash with density up to 2GB
    - IEEE 802.11 a/b/g/n/ac WLAN and Bluetooth 5 dual mode
- Power from either micro USB console connector or dedicated 5V power connector
- Boot source configuration: NAND flash, USB for recovery
- Coin-cell connector to supply the on-module real-time clock (not populated by default)
- Power and reset button
- Debug:
    - Standard IEEE 1149.1 JTAG interface
    - Single Wired Debug (SWD) interface for the Microcontroller Assist™ (MCA)
    - Serial console through USB micro AB-type connector
- Storage:
    - microSD card
    - NAND flash
- Communication:
    - 10/100 Mbps Ethernet interface
    - Two USB Host 2.0 with stacked USB A-type connector

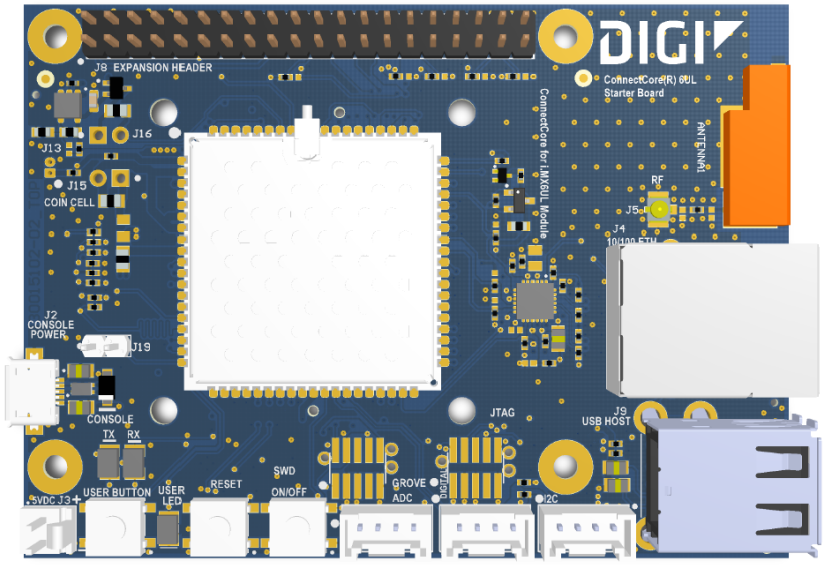
    - USB device with micro AB USB connector (shared with one USB host port)
    - SISO IEEE 802.11 a/b/g/n/ac + Bluetooth 5 dual mode interface with on-board antenna
- Expansion:
    - Expansion connector that can accommodate Raspberry PI Hat boards
    - Three Grove connectors providing digital, ADC, and I2C connectivity
- User interface:
    - One user LED
    - One user button
- Dimensions:
    - 87 mm x 63 mm

Safety instructions

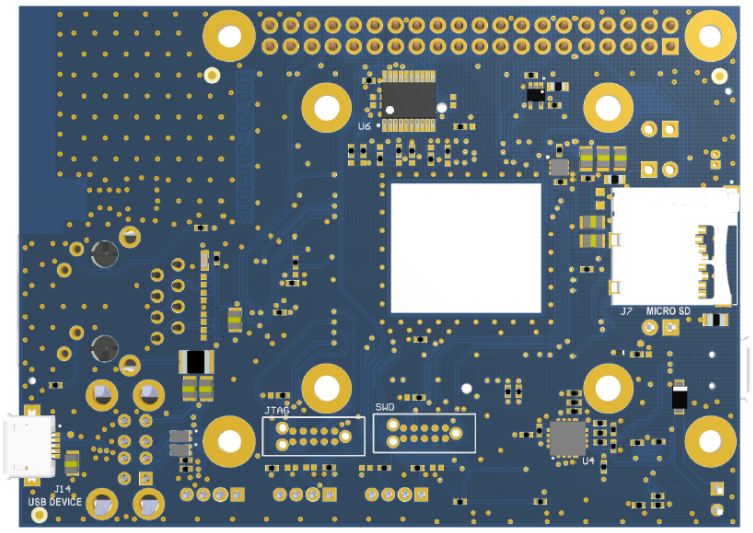
- The ConnectCore 6UL SBC Express cannot be guaranteed operation due to the radio link and so should not be used for interlocks in safety critical devices such as machines or automotive applications.
- The ConnectCore 6UL SBC Express has not been approved for use in (this list is not exhaustive):
    - nuclear applications
    - explosive or flammable atmospheres
- There are no user serviceable components inside the ConnectCore 6UL SBC Express. Do not remove the shield or modify the ConnectCore 6UL in any way. Modifications may exclude the SBC Express from any warranty and can cause the ConnectCore 6UL to operate outside of regulatory compliance for a given country, leading to the possible illegal operation of the radio.
- Use industry standard ESD protection when handling the ConnectCore 6UL SBC Express.
- Take care while handling to avoid electrical damage to the PCB and components.
- Do not expose ConnectCore 6UL SBC Express to water or moisture.
- Use this product with the antennas specified in the ConnectCore 6UL SBC Express user guides.
- The end user must be told how to remove power from the ConnectCore 6UL SBC Express or to locate the antennas 20 cm from humans or animals.

Placement

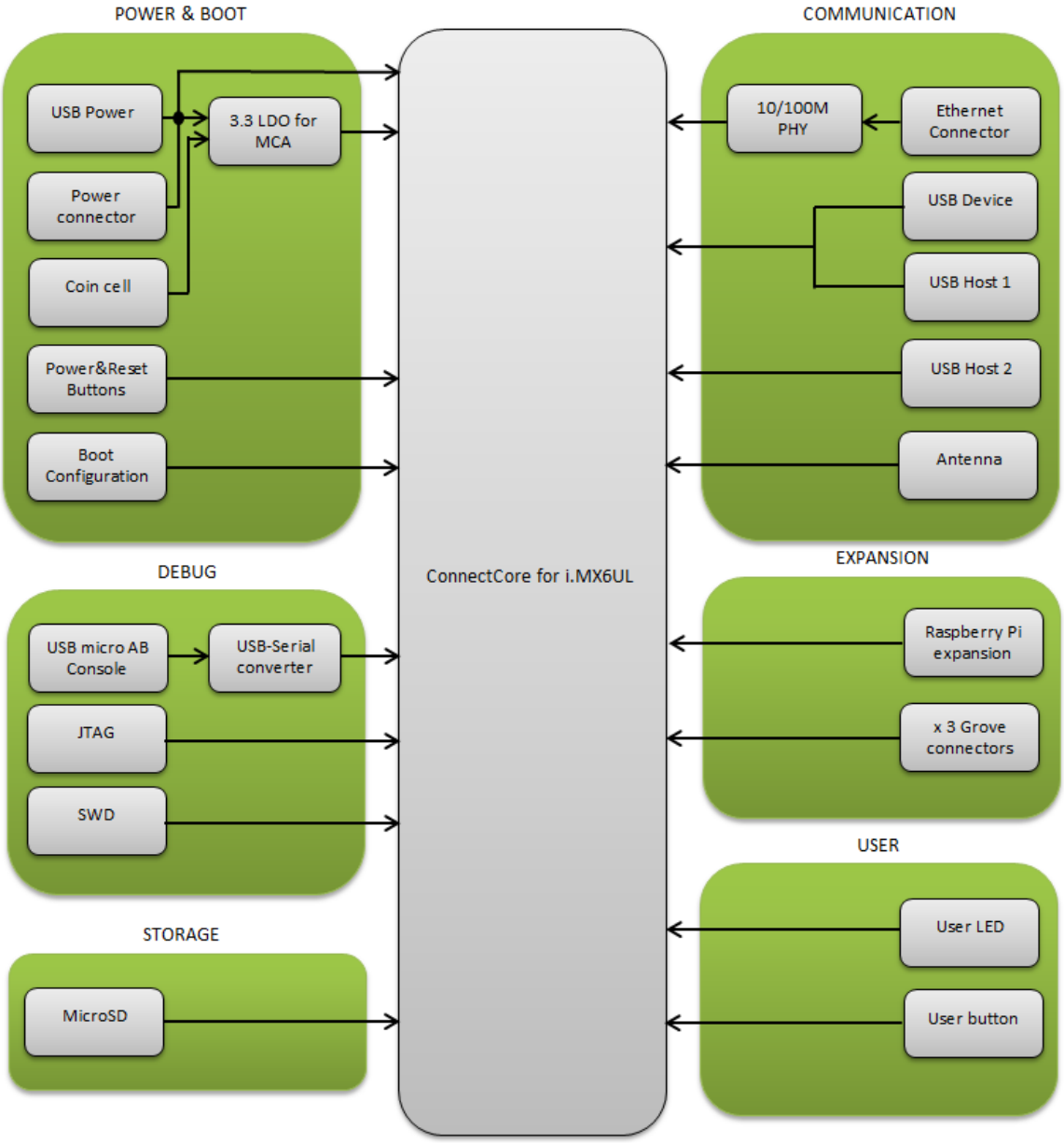
Top view



Bottom view

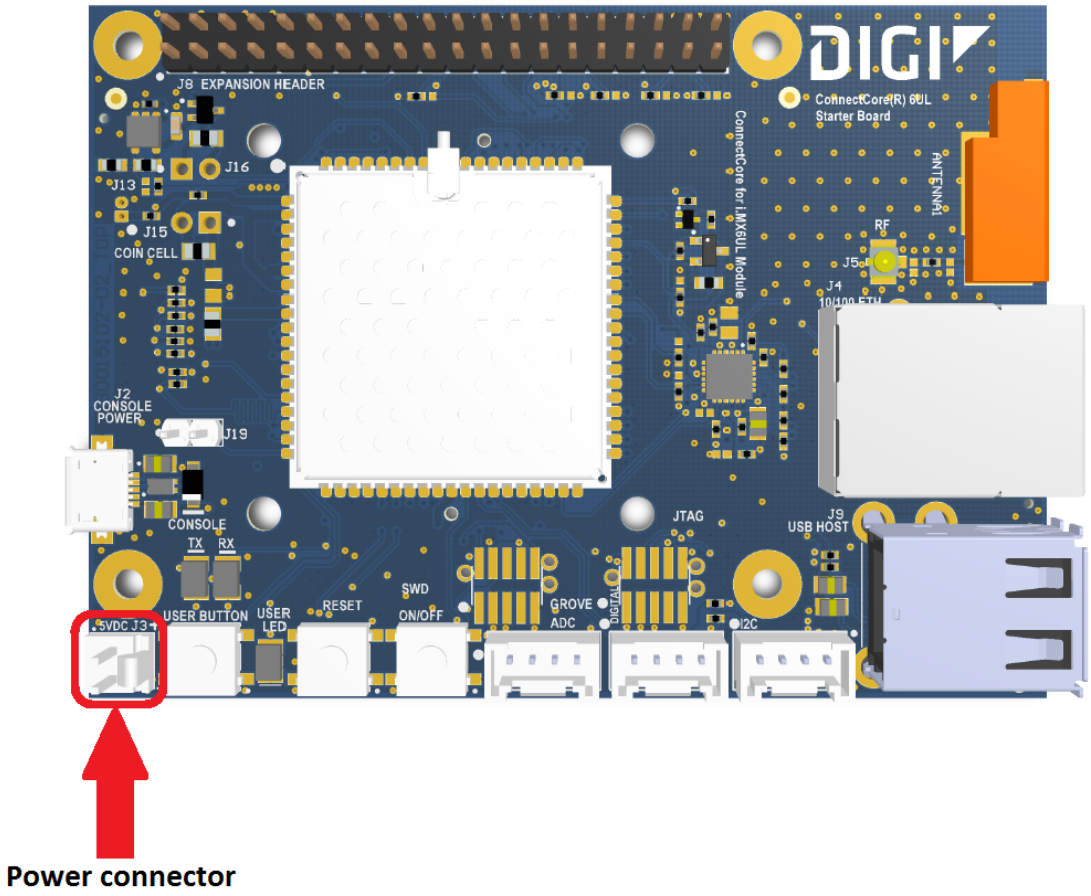


Block diagram



Interfaces

Power connector



A 5V power connector provides power to the ConnectCore 6UL SBC Express. A 2-pin, 2.54 mm pitch, latched vertical connector offers a power rail to the whole system (the board plus the ConnectCore 6UL module.) You can also power the board from the USB console port.

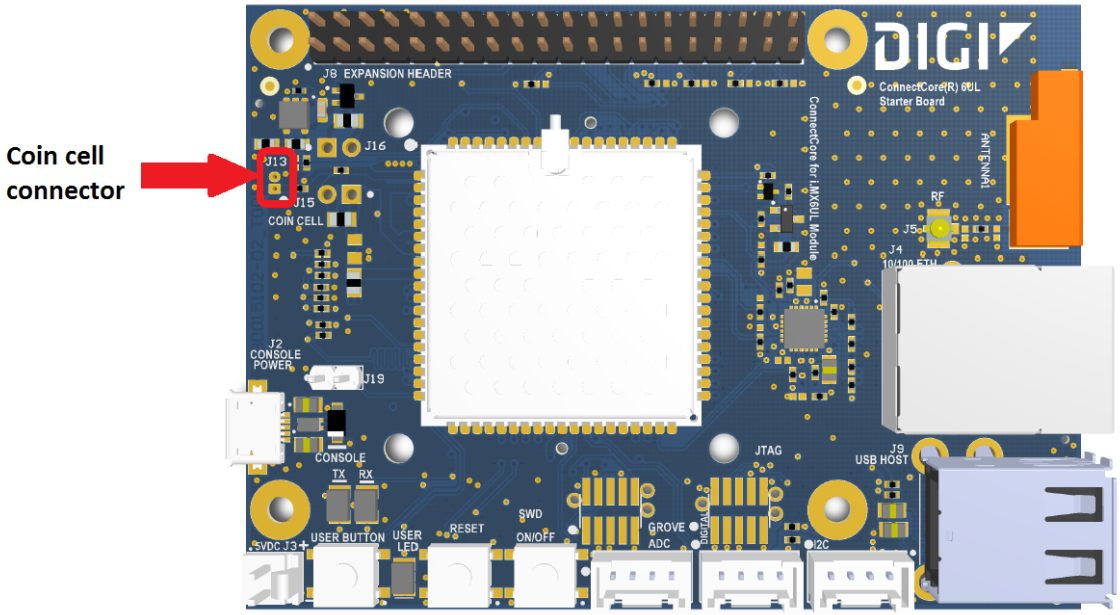
The following table shows the pinout of the power connector:

Pin	Signal name	Description
1	VIN	5V power supply line
2	GND	

For more information about power supply limitations see Supply voltages.

Note J3 5V power connector manufacturing part number: TE Connectivity 640456-2

Coin cell connector



The ConnectCore 6UL SBC Express can be assembled with a 2-pin, 1.25 mm pitch straight connector that powers the real-time clock (RTC) interface with an external coin cell or supercapacitor when the main supply is off. When the main power supply rail is connected, it powers the RTC. You can supply the RTC with a primary Lithium cell (non-rechargeable), a secondary Lithium cell (rechargeable), or a supercap.

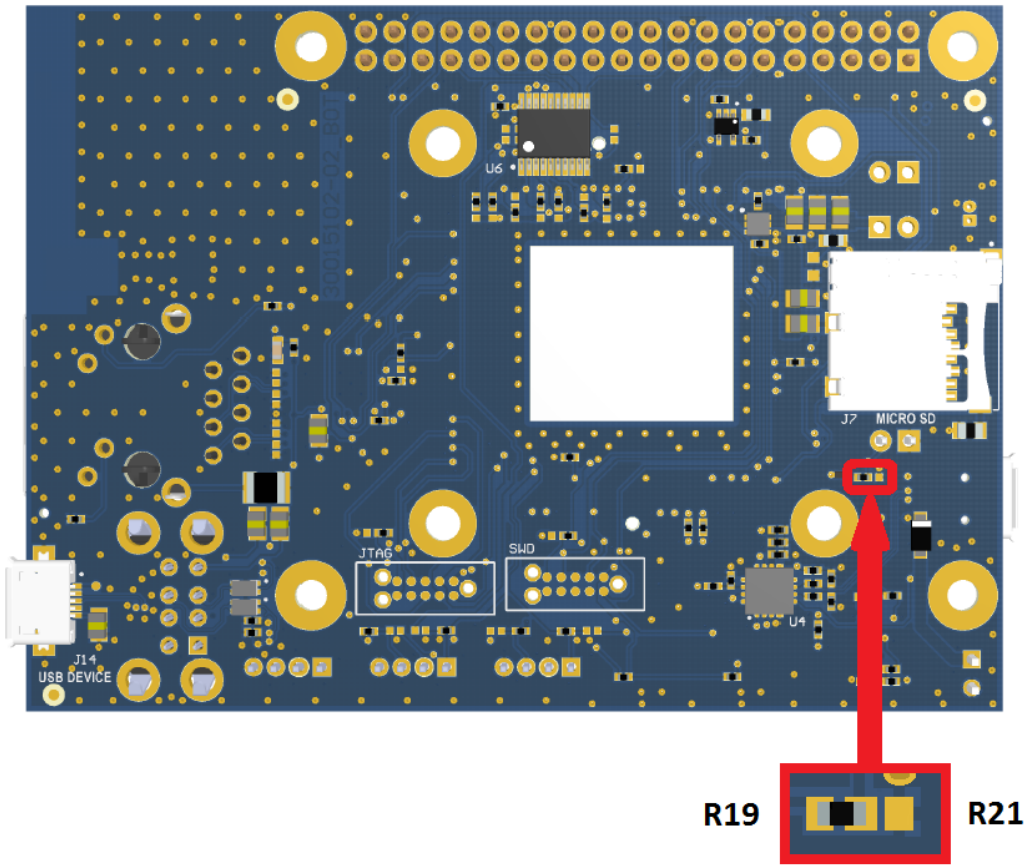
Note The voltage range of the coin cell supply must be between 1.8 - 3.3 V.

The following table shows the pinout of the coin cell connector:

Pin	Signal name	Description
1	VCC_LICELL	Power supply for RTC
2	GND	

Note J13 Coin cell connector manufacturing part number: MOLEX 53047-0210

Boot mode

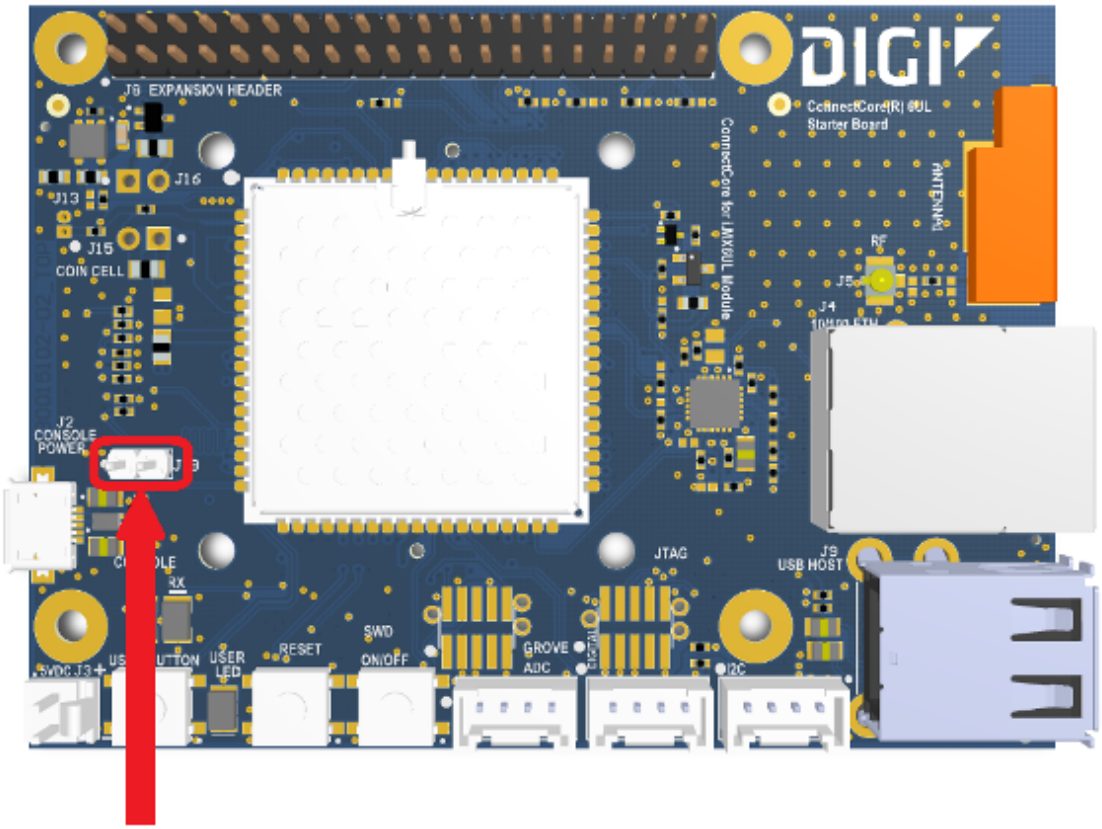


By default, the ConnectCore 6UL module boots from internal board settings, allowing it to boot from internal NAND memory. For advanced functionality, the ConnectCore 6UL SBC Express provides two resistors to configure the SOM boot mode.

You can select the boot mode by configuring the resistors in one of the following combinations:

Boot mode	Resistor configuration	
	R19	R21
Boot from board settings (default)	Populated	Not populated
Boot from fuses	Not populated	Populated

Boot from USB

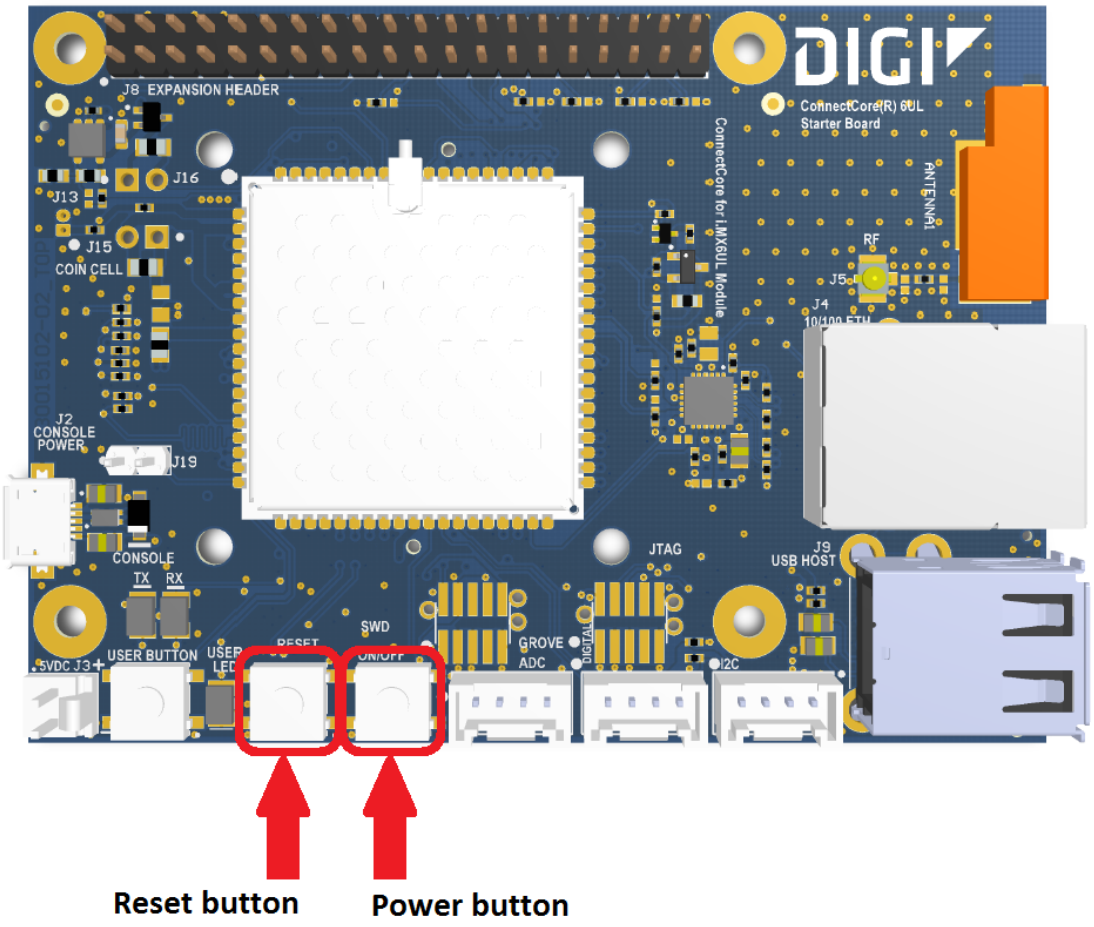


You can close the USB mode jumper on the ConnectCore 6UL SBC Express to force the i.MX6UL to boot from the source programmed in the one-time-programmable (OTP) bits. If the boot configuration OTP bits are not programmed, the CPU falls back to booting into USB debug mode.

The default state for the jumper is open, which configures the i.MX6UL to boot from board settings (boot from NAND flash). If the NAND flash doesn't contain valid firmware, the i.MX6UL also falls back to booting into USB debug mode. You can use this functionality for recovery purposes, such as if the boot loader is erased or cannot boot.

For more information about boot mode configuration, see the ConnectCore 6UL module Hardware Reference Manual.

Power and reset buttons



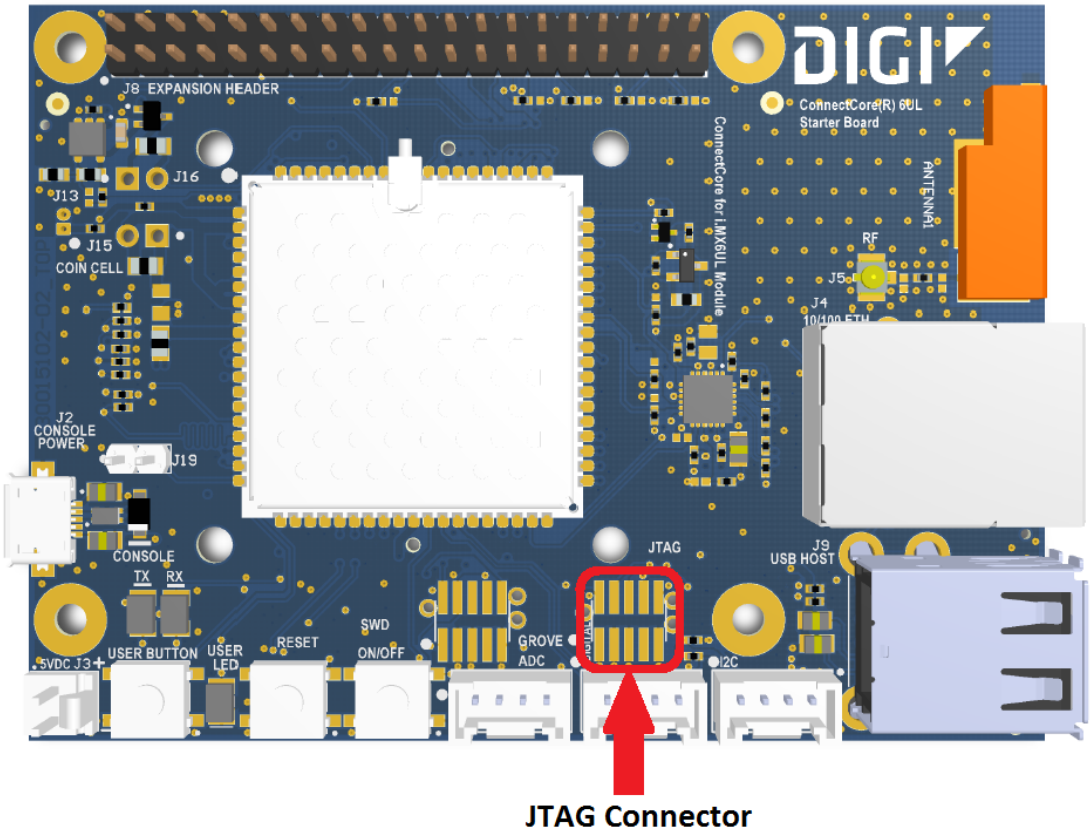
The power button on the ConnectCore 6UL SBC Express is connected to the on-module MCA, which provides the following functionality:

Board status	Power button action	Response
OFF	Short press	Power on
ON or SLEEP	Long press for 5 seconds	Power off
SLEEP	Short press	Wake up
ON	Short press	Sleep

You can also reset the ConnectCore 6UL System-on-module by pressing the **Reset** button on the ConnectCore 6UL SBC Express.

Note You can configure the duration of some power button actions. See the ConnectCore 6UL SBC Express documentation or ConnectCore 6UL SBC Pro documentation for more information.

JTAG



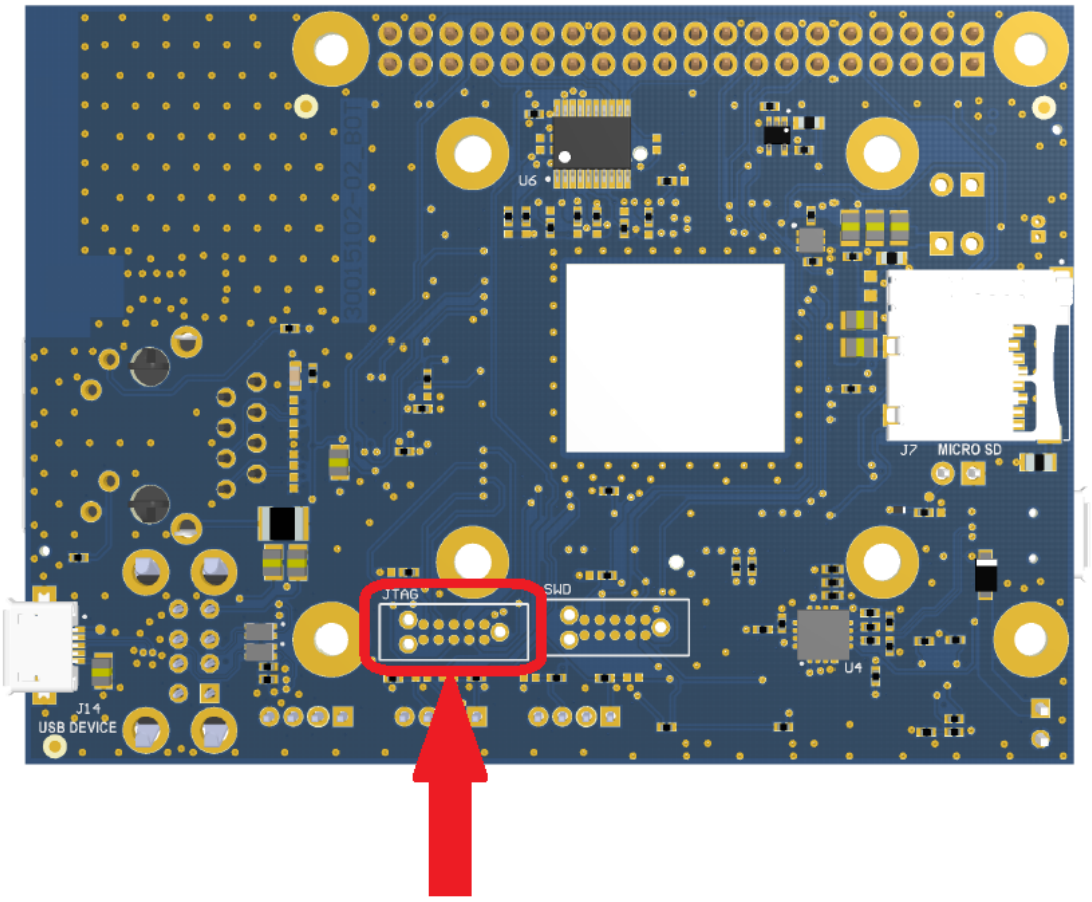
The ConnectCore 6UL SBC Express provides two options for accessing the i.MX6UL JTAG debug port. The first option is a 2x5, 1.27mm pitch pin header on the top side of the board that, by default, is not populated. The following table shows the pinout of the JTAG connector:

Pin	Signal name	Description
1	3.3V	3.3V supply voltage of the JTAG interface
2	JTAG_TMS	Test mode state signal
3	GND	
4	JTAG_TCK	Test clock signal
5	GND	
6	JTAG_TDO	Test data output signal
7	NC	

Pin	Signal name	Description
8	JTAG_TDI	Test data input signal
9	GND	
10	POR_B	CPU reset

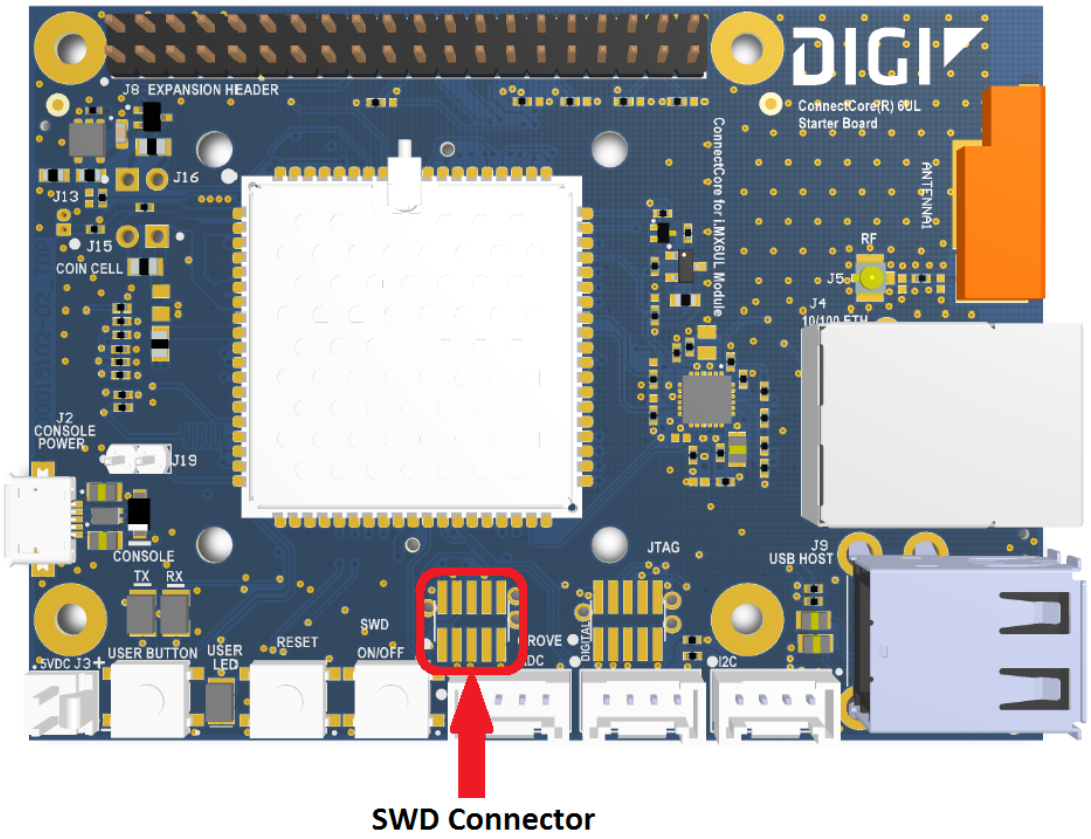
Note J17 JTAG connector manufacturing part number: SAMTEC FTSH-105-01-F-DV

The second option is the Tag Connect footprint on the bottom side of the board. This Tag Connect is compliant with the ARM 10-pin standard. The JTAG Tag Connect is highlighted in the following picture:



JTAG Tag Connect

SWD



As in the JTAG debug interface, the ConnectCore 6UL SBC Express provides two options for programming and debugging the Microcontroller Assist of the ConnectCore 6UL System-on-module.

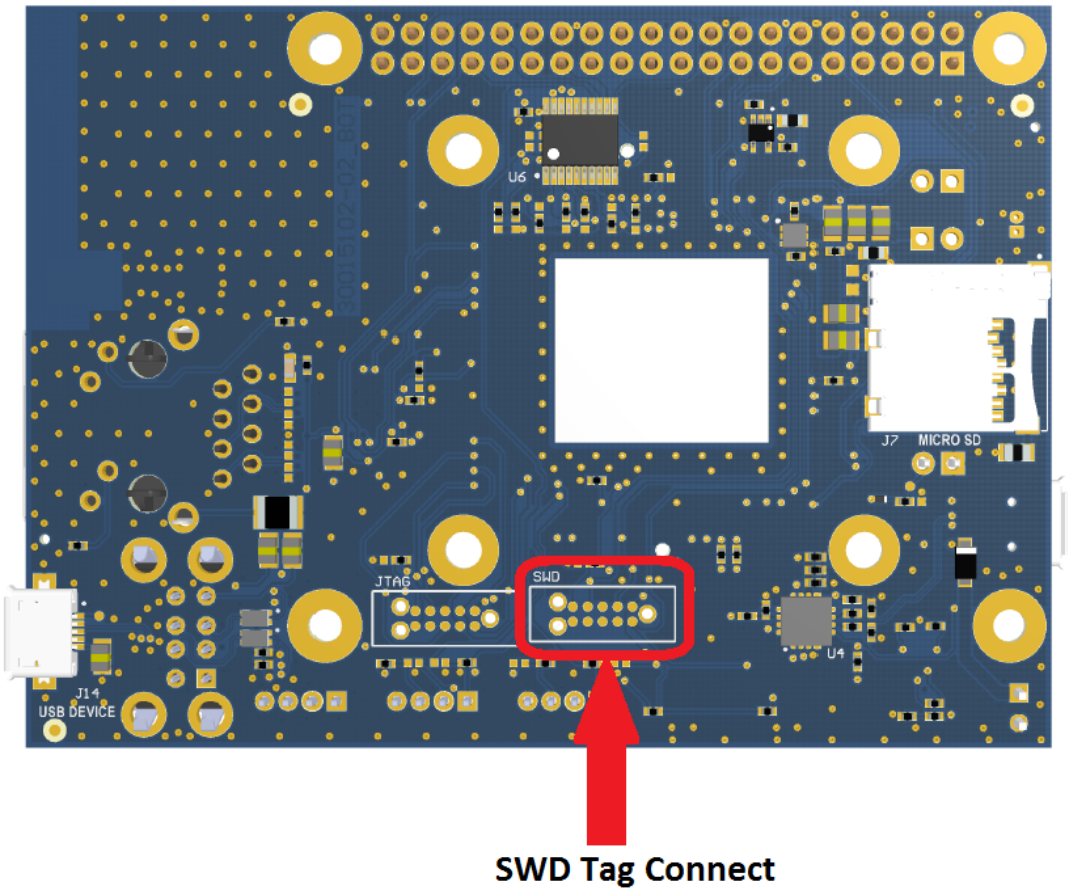
- The first option is a 2x5, 1.27 mm pitch pin header footprint on the top side of the board that, by default, is not populated. The following table shows the pinout of the SWD connector:

Pin	Signal name	Description
1	VCC_MCA	3.3V supply voltage of the MCA
2	MCA_SWD_DIO	SWD bidirectional data pin
3	GND	
4	MCA_SWD_CLK	SWD clock signal

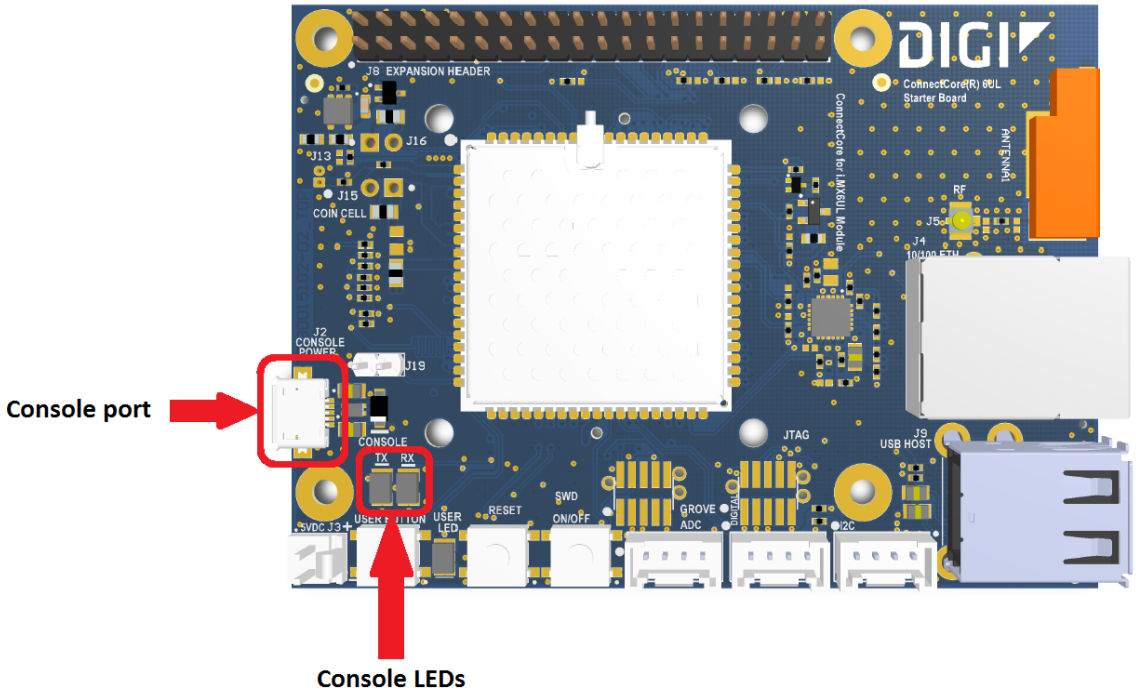
Pin	Signal name	Description
5	GND	
6	NC	
7	NC	
8	NC	
9	GND	
10	MCA_RESET_N	Reset signal for MCA

Note J18 SWD connector manufacturing part number: SAMTEC FTSH-105-01-F-DV

- The second option is the ARM 10-pin standard-compliant Tag Connect footprint on the bottom side of the board. The SWD Tag Connect is highlighted in the following picture:



Console port



The ConnectCore 6UL SBC Express uses a USB micro AB-type connector as a console port for debugging and configuration. The USB signal passes through a USB-to-serial UART bridge and generates TTL signals connected to the i.MX6UL processor. The ConnectCore 6UL module uses the UART5 port as the console port. Two LEDs on the board show console activity: one represents reception and the other represents transmission.

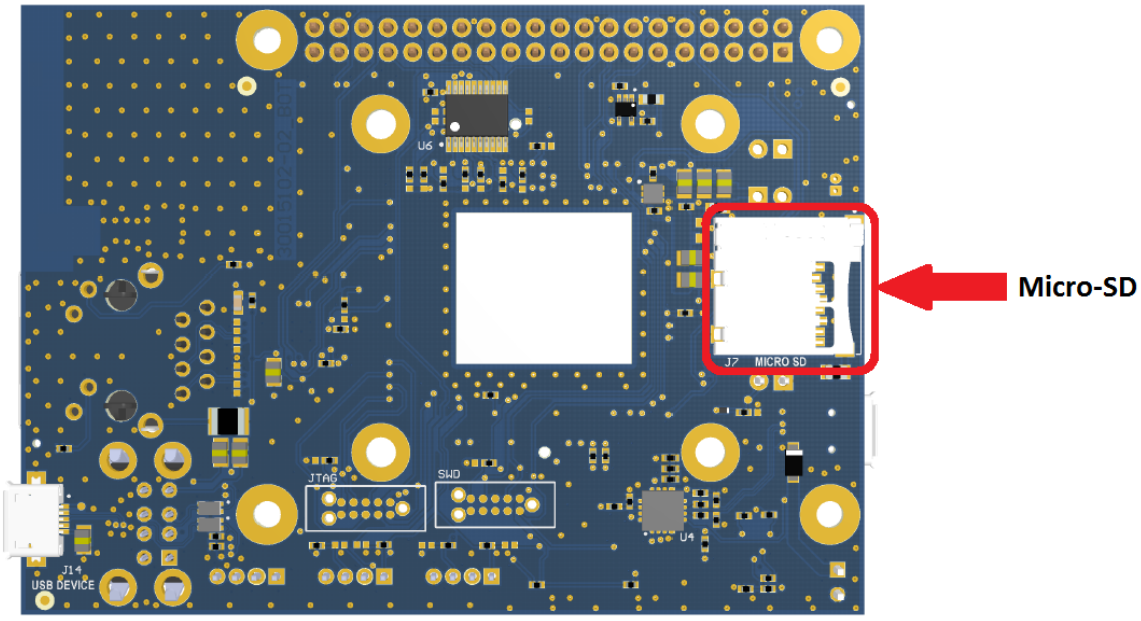
Pin	Signal name	Description
1	USB_SUPPLY	5V USB power line (connected to VIN power supply line)
2	USB_N	Differential data signal (-)
3	USB_P	Differential data signal (+)
4	NC	
5	GND	

Note The USB_SUPPLY line can be used as the main power rail of the entire system. However, its current may not be sufficient for some use cases. For more information, see Supply voltages.

Console default settings:

- **Baud rate**: 115200
- **Data**: 8 bit
- **Parity**: none
- **Stop:**1 bit
- **Flow control**: none

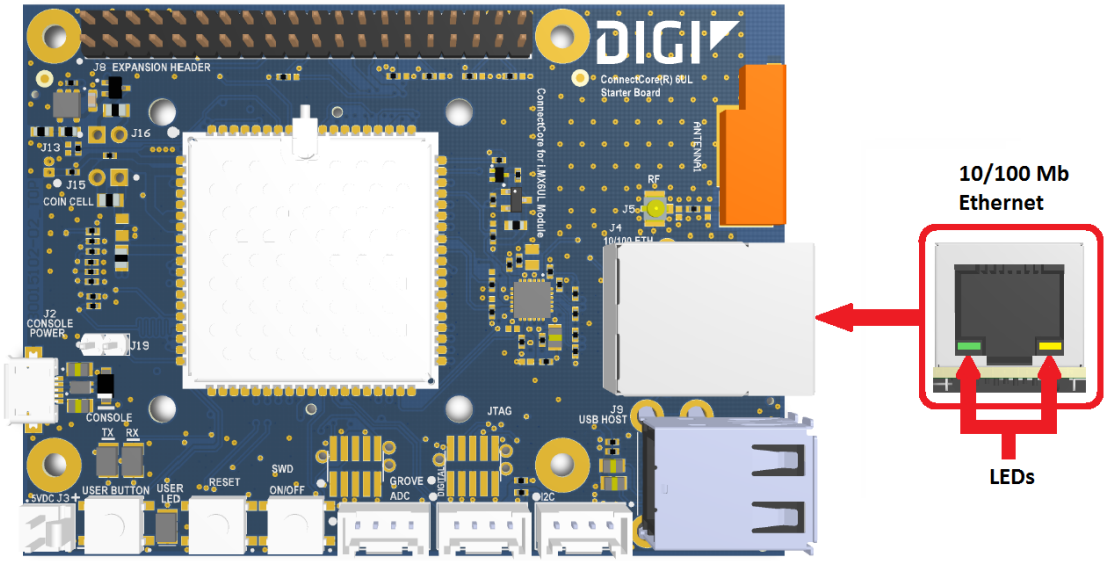
MicroSD



A microSD connector is located on the bottom of the board. This interface is connected to the USDHC2 controller of the i.MX6UL CPU. The following table shows the pinout of the microSD socket:

Pin	Signal name	Description
1	SD2_DATA2	Serial data 2
2	SD2_DATA3	Serial data 3
3	SD2_CMD	Command line
4	3V3	3.3V power line
5	SD2_CLK	Serial clock
6	GND	
7	SD2_DATA0	Serial data 0
8	SD2_DATA1	Serial data 1
9	GND	
10	GND	

10/100 Mbps Ethernet



The 10Base-T/100Base-Tx Ethernet interface uses a Microchip LAN8720Ai 10/100 Ethernet PHY.

The board includes a RJ-45 connector with integrated link/activity LEDs. The following table shows the pinout of the RJ45 connector:

Pin	Signal name	Description
1	TD+	Transmit pair data (+)
2	TD-	Transmit pair data (-)
3	RD+	Receive pair data (+)
4	CT	Center tap
5	CT	Center tap
6	RD-	Receive pair data (-)
7	NC	
8	GND	
9	LED1_P	Green LED anode
10	LED1_N	Green LED cathode
11	LED2_P	Yellow LED anode
12	LED2_N	Yellow LED cathode

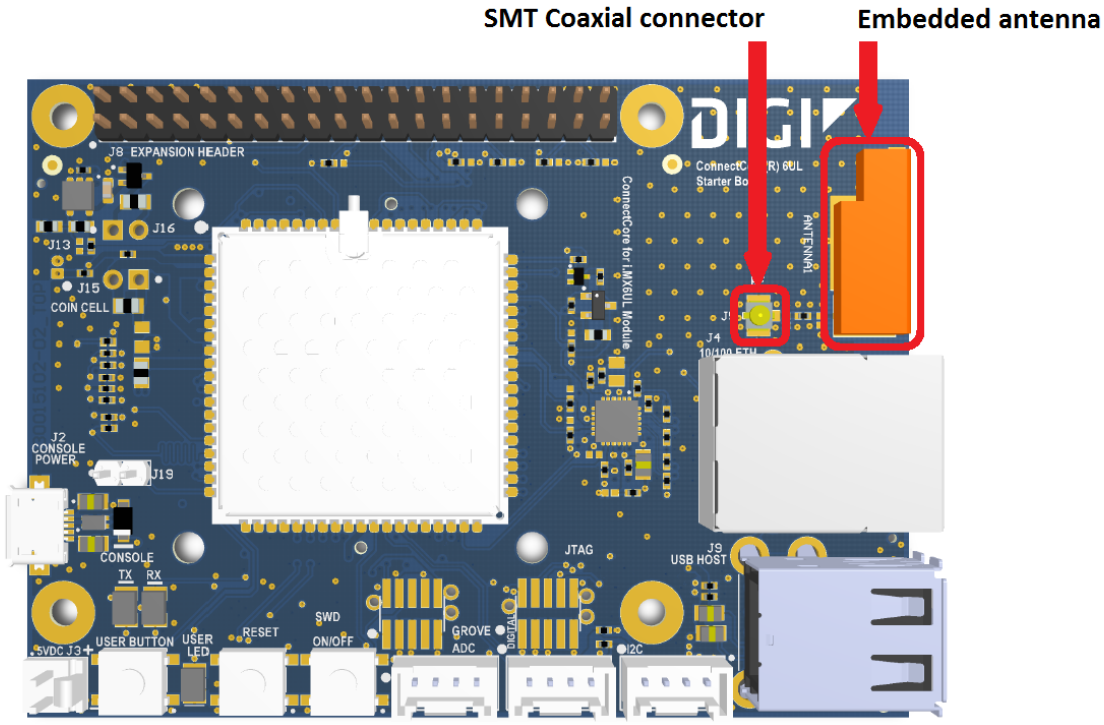
The 10/100 Ethernet PHY has two outputs to indicate the link and activity status of the port. These outputs are connected to two LEDs, integrated on the Ethernet connector. The following table shows the link/activity status indicated by the two LEDs:

Green LED	Yellow LED	Link/activity status
OFF	OFF	Link OFF
ON	OFF	10 Link/no activity
Blinking	OFF	10 Link/activity
ON	ON	100 Link/no activity
Blinking	ON	100 Link/activity

Ethernet PHY power management

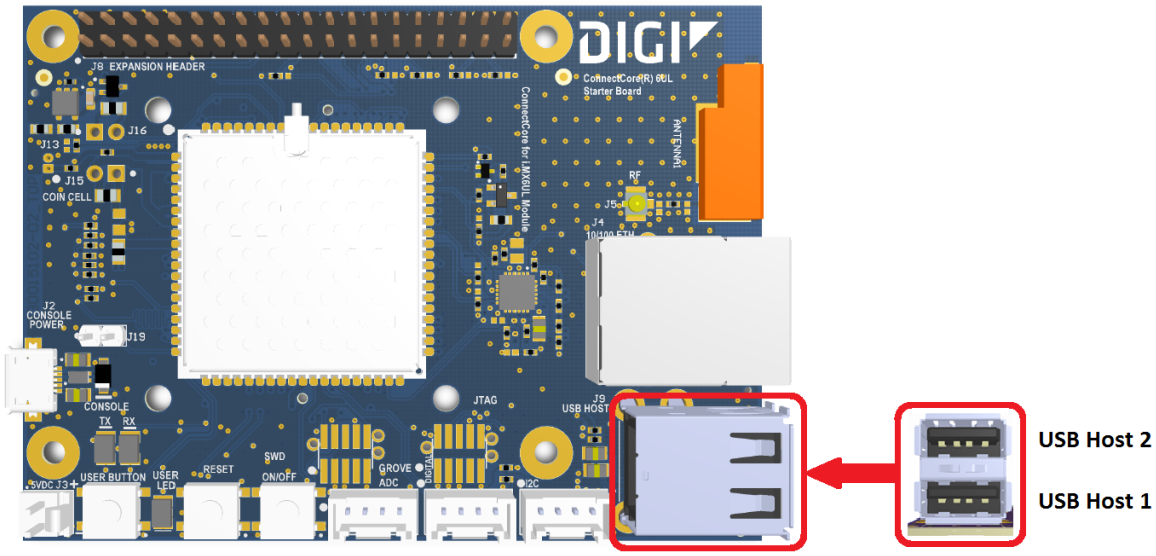
You can manage power consumption of the system by enabling or disabling Ethernet PHY power through a power switch. The dedicated GPIO connected to the power switch is GPIO3_IO02.

Embedded antenna



An embedded antenna placed on a corner of the ConnectCore 6UL SBC Express supports the wireless and Bluetooth functionality of the ConnectCore 6UL module. A surface mount coaxial connector is also connected to the PCB antenna through a 0 ohm resistor. This on-board antenna is connected to the ConnectCore 6UL module using a U.FL-to-U.FL cable.

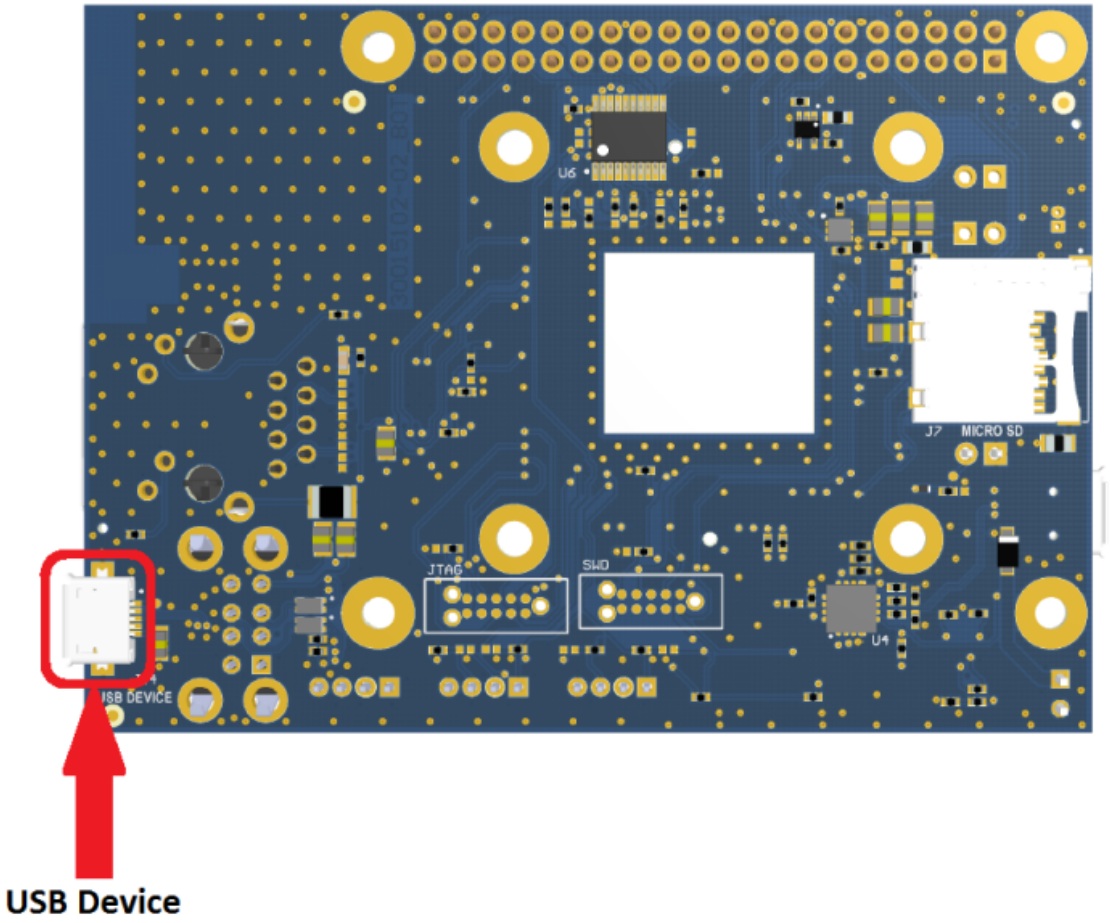
USB host



Two USB host interfaces are located on the right side of the ConnectCore 6UL SBC Express over a stackable dual USB A-type connector. Both USB hosts can operate at high, full, and low speed. The following table shows the pinout of the dual stackable USB host connector:

Pin	Signal name	Description
A1	VIN	5V power line
A2	USB_OTG2_N	USB 2 differential data signal (-)
A3	USB_OTG2_P	USB 2 differential data signal (+)
A4	GND	
B1	VIN	5V power line
B2	USB_OTG1_N	USB 1 differential data signal (-)
B3	USB_OTG1_P	USB 1 differential data signal (+)
B4	GND	

USB device

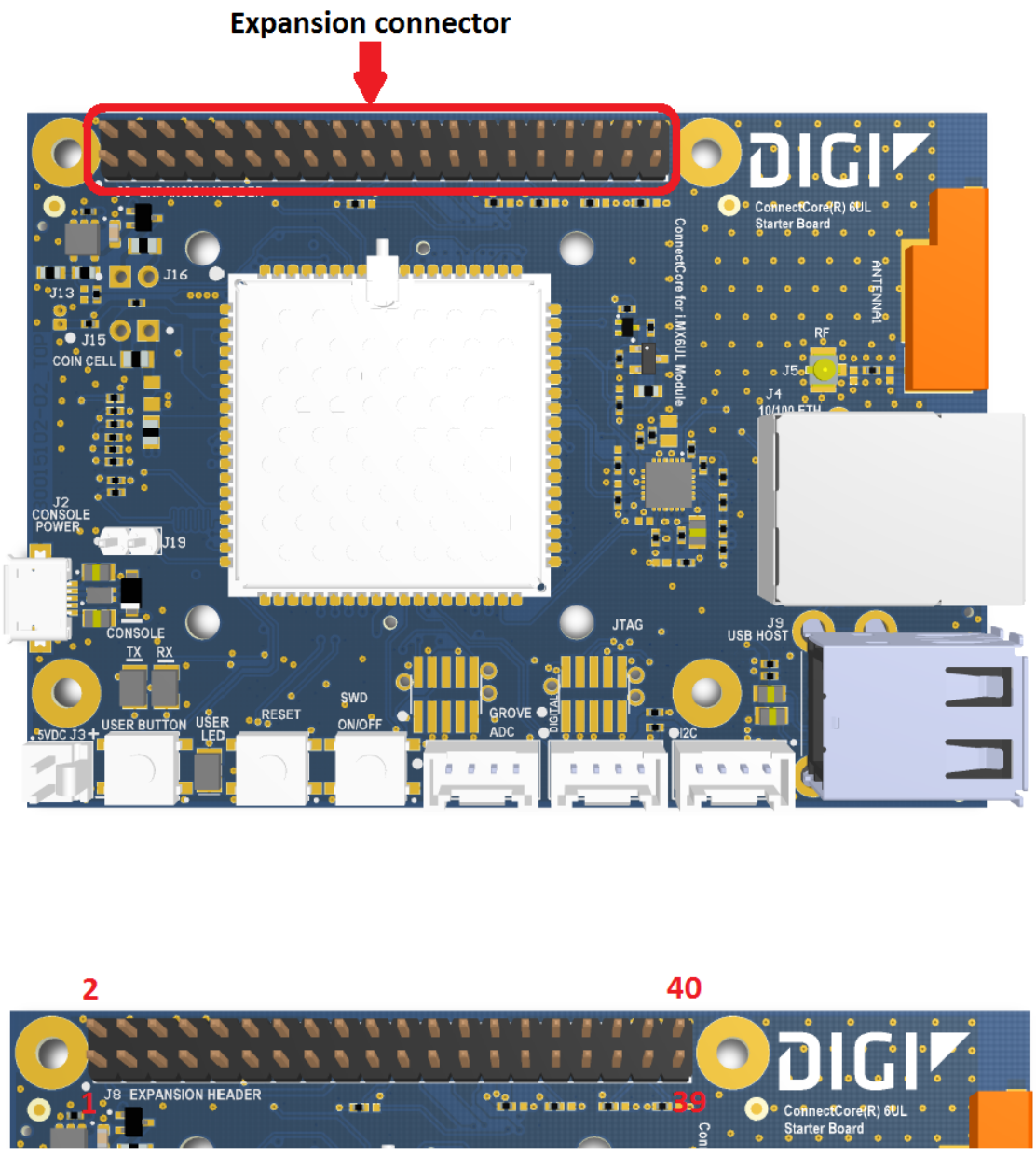


The ConnectCore 6UL SBC Express has a micro-AB type receptacle for a USB device connection. The following table shows the pinout of the USB device connector:

Pin	Signal name	Description
1	NC	
2	USB_OTG1_FIL_N	USB differential data signal (-)
3	USB_OTG1_FIL_P	USB differential data signal (+)
4	NC	
5	GND	

CAUTION! The USB device shares the USB_OTG1 instance of the i.MX6UL processor with the lower USB host port of the stacked connector. Connecting two devices to the USB_OTG1 port at the same time will cause a short circuit in the differential data pair.

Expansion connector



The ConnectCore 6UL SBC Express supports an expansion connector that mimics, as closely as possible, the Raspberry Pi HAT connector specification. This consists of a 2-row, 40-pin, 2.54 mm pitch connector which connects to most interfaces available on Raspberry Pi devices: UART, I^2C, GPIOs, ADC, PWMs, and audio. Some expansion connector signals can be configured through on-board zero-ohm resistors.

The following table shows the pinout of the expansion connector:

Pin	Signal name	Description	On-board 0 ohm serial resistor*
1	3V3	3.3V power supply line	
2	VIN	5V power supply line	
3	I2C2_SDA	i.MX6UL I2C2 bus data line	
4	VIN	5V power supply line	
5	I2C2_SCL	i.MX6UL I2C2 bus clock line	
6	GND		
7	ADC/GPIO1_4	i.MX6UL analog-to-digital converter/GPIO1_IO4	
8	UART4_TX	i.MX6UL UART4 transmitted line	
9	GND		
10	UART4_RX	i.MX6UL UART4 received line	
11	GPIO3_4	i.MX6UL GPIO3_4	
12	JTAG_TDI/GPIO1_13	i.MX6UL JTAG_TDI/GPIO1_IO13	
13	GPIO3_10_PROT	i.MX6UL GPIO3_IO10	
14	GND		
15	JTAG_MOD/GPIO1_10	i.MX6UL JTAG MOD/GPIO1_IO10	
16	JTAG_TMS/GPIO1_11	i.MX6UL JTAG TMS/GPIO1_IO11	
17	3V3	3.3V power supply line	
18	GPIO3_12_PROT	i.MX6UL GPIO3_IO12	
19	SPI3_MOSI	i.MX6UL ECSPI3 MOSI line	
20	GND		
21	SPI3_MISO	i.MX6UL ECSPI3 MISO line	
22	RASPBERRY_22	User-led GPIO, connected to i.MX6UL GPIO3_IO11	R106
		LCD_DATA8 **(default connected)**	R107
23	SPI3_SCLK	i.MX6UL ECSPI3 SCLK line	
24	SPI3_SS0	i.MX6UL ECSPI3 SS line	

Pin	Signal name	Description	On-board 0 ohm serial resistor*
25	GND		
26	RASPBERRY_26	User button GPIO, connected to i.MX6UL GPIO3_IO3	R108
		LCD_DATA9 **(default connected)**	R109
27	PWM1/I2C3_SDA_PROT	i.MX6UL PWM1_OUT/CPU I2C3 Bus Data	
28	PWM2/I2C3_SCL_PROT	i.MX6UL PWM2_OUT/CPU I2C3 Clock Data	
29	RASPBERRY_29	MCA_IO0 (MCA PTB0)	R110
		GPIO5 (i.MX6UL GPIO1_IO5) **(default connected)**	R111
30	GND		
31	MCA_IO4	MCA PTA9 port	
32	PWM4_PROT	i.MX6UL PWM4_OUT	
33	GPIO3_7/PWM3_PROT	i.MX6UL GPIO3_7/i.MX6UL PWM3_OUT	
34	GND		
35	JTAG_TDO/GPIO1_12	i.MX6UL JTAG TDO/GPIO1_IO12	
36	RASPBERRY_36	i.MX6UL UART5 TX line	R83
		CSI_MCLK **(default connected)**	R104
37	RASPBERRY_37	i.MX6UL UART5 RX line	R84
		CSI_PIXCLK **(default connected)**	R105
38	JTAG_nTRST/GPIO1_15	i.MX6UL JTAG nTRST/GPIO1_IO15	
39	GND		
40	JTAG_TCK/GPIO1_14	i.MX6UL JTAG TCK line	

*Green = populated; Red = not populated

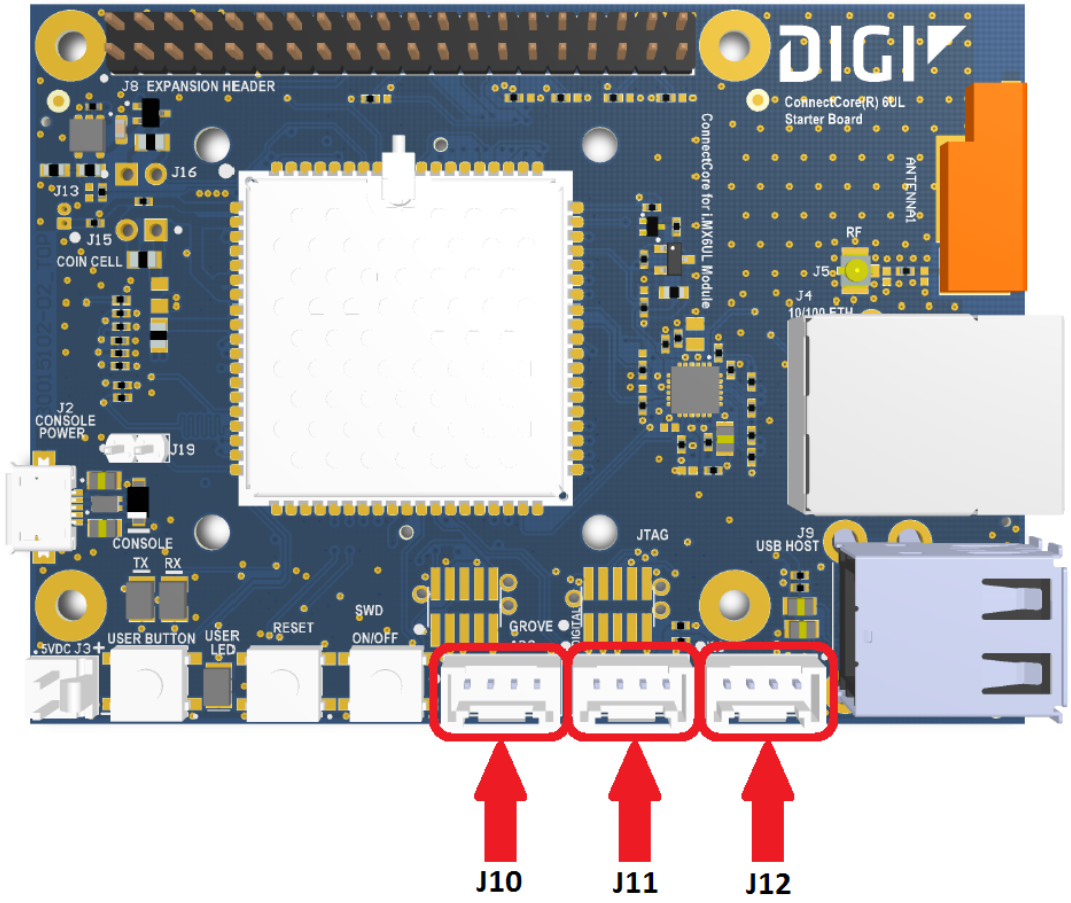
Pinout of the Raspberry Pi expansion connector

3,3V	1	2	5V
GPIO2/I2C_SDA1	3	4	5V
GPIO3/I2C_SCL1	5	6	GND
GPIO4	7	8	GPIO14/UART0_TXD
GND	9	10	GPIO15/UART0_RXD
GPIO17	11	12	GPIO18/PCM_CLK
GPIO27	13	14	GND
GPIO22	15	16	GPIO23
3,3V	17	18	GPIO24
GPIO10/SPI0_MOSI	19	20	GND
GPIO9/SPI0_MISO	21	22	GPIO25
GPIO11/SPI0_SCLK	23	24	GPIO8/SPI0_CE0_N
GND	25	26	GPIO7/SPI0_CE1_N
ID_SD/I2C_ID_EEPROM	27	28	ID_SC/I2C_ID_EEPROM
GPIO5	29	30	GND
GPIO6	31	32	GPIO12
GPIO13	33	34	GND
GPIO19	35	36	GPIO16
GPIO26	37	38	GPIO20
GND	39	40	GPIO21

5V Power
3,3V Power
Ground
General Inputs/Outputs
I2C Interface
SPI Interface
UART Interface
ID EEPROM Interface

Note Some Raspberry Pi HATs may not be compatible with the ConnectCore 6UL SBC Express. Compatibility depends on the signals used by the specific HAT.

Grove connectors



The ConnectCore 6UL SBC Express includes three Grove connectors to the i.MX6UL I2C2 bus, PWM, and ADC lines as well as on-module MCA GPIOs. Grove connectors have a standardized form factor. You can buy Grove sensors to perform a variety of functions, some of which are configurable through on-board zero-ohm resistors.

The following tables provide additional information about the Grove connectors on the ConnectCore 6UL SBC Express:

Grove connector J10 (ADC)			
Pin	**Signal name**	**Description**	**On-board 0 ohm serial resistor***
1	MCA_IO0	MCA MCA_IO0 **(default)**	R91
	ADC/GPIO1_4	i.MX6UL analog-to-digital converter/GPIO1_IO4	R92

Grove connector J10 (ADC)			
Pin	**Signal name**	**Description**	**On-board 0 ohm serial resistor***
2	NC		
3	3V3	3.3V power supply line **(default)**	R93
	VCC_MCA	On-board 3.3V regulator output	R94
4	GND		

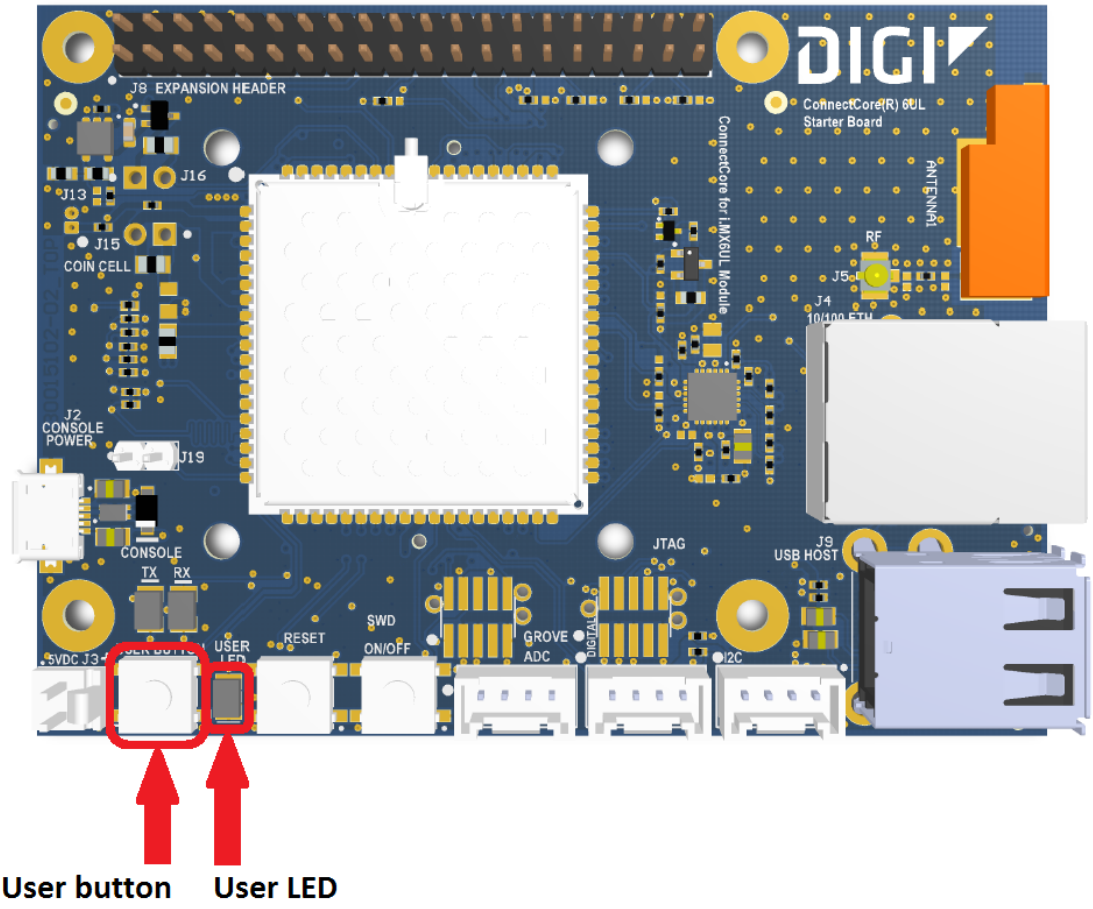
Grove connector J11 (Digital)			
Pin	**Signal name**	**Description**	**On-board zero-ohm serial resistor***
1	MCA_IO4	MCA MCA_IO4 **(default)**	R87
	PWM1_I2C3_SDA_PROT	i.MX6UL PWM1_OUT	R88
2	NC		
3	3V3	3.3V power supply line **(default)**	R89
	VCC_MCA	On-board 3.3V regulator output	R90
4	GND		

Grove connector J12 (I2C)		
Pin	**Signal name**	**Description**
1	I2C2_SCL	i.MX6UL I2C2 bus clock line, 4.7K pull-up
2	I2C2_SDA	i.MX6UL I2C2 bus data line, 4.7K pull-up
3	3V3	3.3V power supply line
4	GND	

*Green = populated; Red = not populated

Note Some Grove sensors require a 5V power supply and may not work properly with the ConnectCore 6UL SBC Express.

User LED and button



The user LED and user button are located on the bottom-left corner of the board. Both LEDs are controlled with GPIO signals, which can be found in the table below:

Device	Signal
User LED (red)	GPIO3_IO11
User button	GPIO3_IO3

Specifications

Electrical specifications

Supply voltages

The ConnectCore 6UL SBC Express has three supply inputs. Two of the inputs power the whole system (the board plus the ConnectCore 6UL module) and the other one powers the RTC of the module when the main supply is not present. The following table shows the voltage range of ConnectCore 6UL SBC Express input supplies:

Signal	Description	Min	Typ	Max	Unit
VIN	Power connector input	4.6	5.0	5.5	V
USB_SUPPLY	Console type-AB micro USB power line	-	5.0	-	V
VCC_LICELL	Supply for RTC	1.8	3.0	3.6	V

Note If the voltage in the VCC_LICELL pin is higher than 3.0 V, some current drawback may occur even when the system is in “run mode”.

Note The current supply through the USB_SUPPLY power line will be limited when connected to a standard USB2.0 (0.5 A) or USB3.0 (0.9 A) interface. Under some circumstances, this current may not be enough to supply both the ConnectCore 6UL SBC Express and the ConnectCore 6UL module. In this case, Digi recommends you power the board from the power connector.

Power consumption

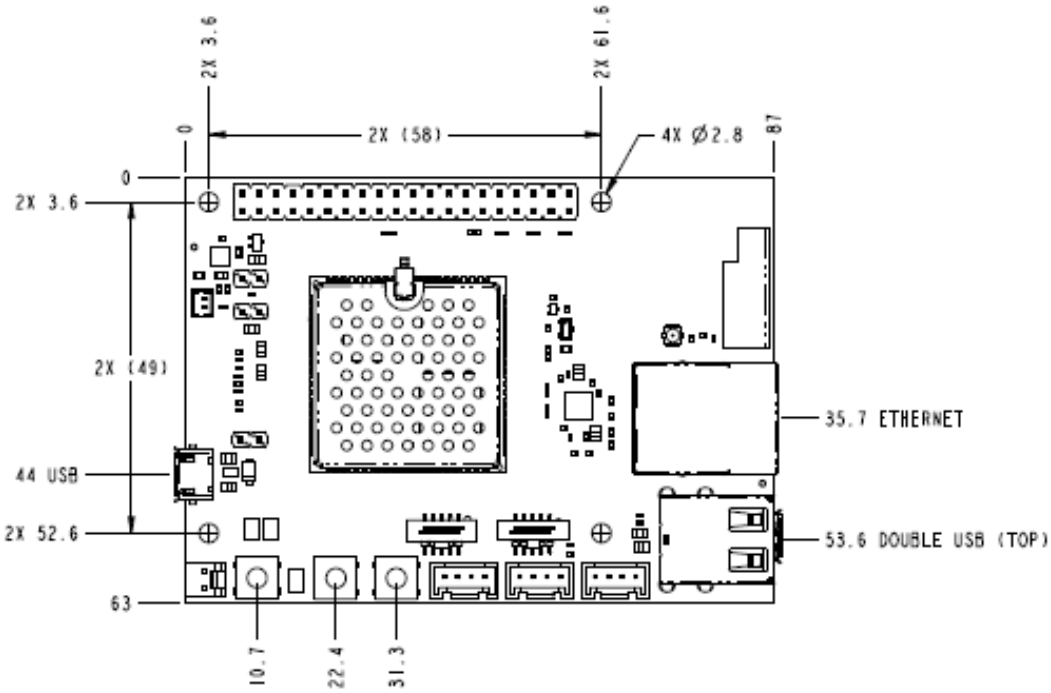
Power consumption of the ConnectCore 6UL SBC Express depends upon the use case running on the system. The board has three defined modes of operation:

Power mode	Description
Normal	Normal operating state. User interfacing with the device.
Sleep	The CPU is idle, no threads are running and most peripherals are turned off. The system can wake up according to the configured hardware wake-up source.
Power off	The PMIC and the CPU are switched off and only the RTC and the power button interfaces are enabled.

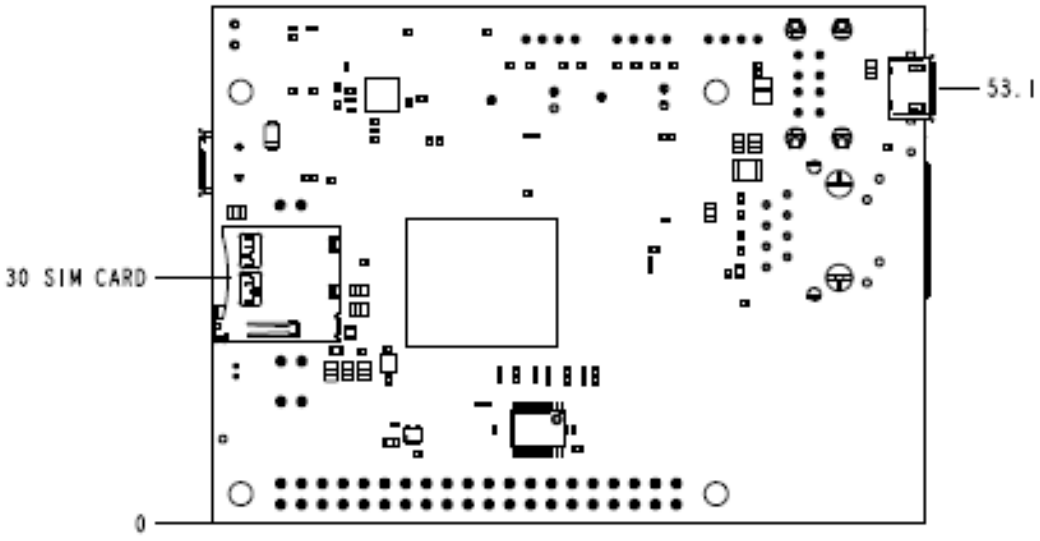
See the ConnectCore 6UL module Hardware Reference Manual for power-consumption values.

Mechanical specification

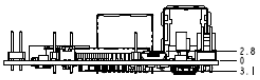
Top view

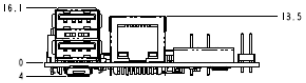


Bottom view



Profile view





Environmental specifications

This information is not currently available but will be provided in a future revision of the manual.

Regulatory information

Maximum power and frequency specifications

Note The following maximum power and frequency values are for the ConnectCore 6UL system-on-module.

Maximum power	Frequencies
63.1 mW	13 overlapping channels each 22 MHz wide and spaced at 5 MHz. Centered at 2.412 to 2.472 MHz.
31.62 mW	165 overlapping channels each 22 or 40 MHz wide and spaced at 5 MHz. Centered at 5180 to 5825 MHz.

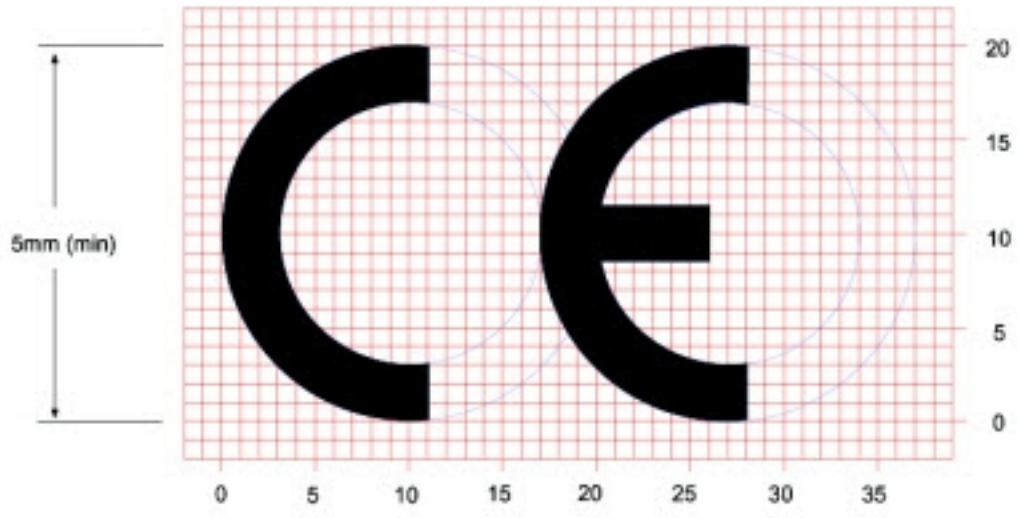
Europe and UK

CE and UKCA OEM labeling requirements

The CE and UKCA markings must be clearly visible and legible when you affix it to the product. If this is not possible, you must attach these marks to the packaging (if any) or accompanying documents.

CE labeling requirements

The “CE” marking must be affixed to a visible location on the OEM product. The following figure shows CE labeling requirements.



The CE mark shall consist of the initials “CE” taking the following form:

- If the CE marking is reduced or enlarged, the proportions given in the above graduated drawing must be respected.
- The CE marking must have a height of at least 5 mm except where this is not possible on

account of the nature of the apparatus.

- The CE marking must be affixed visibly, legibly, and indelibly.

UK Conformity Assessed (UKCA) labeling requirements

See https://www.gov.uk/guidance/using-the-ukca-marking for further details.

You must make sure that:

- if you reduce or enlarge the size of your marking, the letters forming the UKCA marking must be in proportion to the version set out below
- the UKCA marking is at least 5 mm in height – unless a different minimum dimension is specified in the relevant legislation
- the UKCA marking is easily visible, legible (from 1 January 2023 it must be permanently attached)
- the UKCA marking can take different forms (for example, the colour does not have to be solid), as long as it remains visible, legible and maintains the required proportions.

Important note

Digi customers assume full responsibility for learning and meeting the required guidelines for each country in their distribution market. Refer to the radio regulatory agency in the desired countries of operation for more information.

Declarations of Conformity

Digi has issued Declarations of Conformity for the ConnectCore 6UL SBC Express concerning emissions, EMC, and safety. For more information, see http://www.digi.com/resources/certifications.

Important note

Digi customers assume full responsibility for learning and meeting the required guidelines for each country in their distribution market. Refer to the radio regulatory agency in the desired countries of operation for more information.

CE mark

The ConnectCore 6UL SBC Express is certified for use in several European countries. For information, visit www.digi.com/resources/certifications.

If the ConnectCore 6UL SBC Express is incorporated into a product, the manufacturer must ensure compliance of the final product with articles 3.1a and 3.1b of the RE Directive (Radio Equipment Directive). A Declaration of Conformity must be issued for each of these standards and kept on file as described in the RE Directive (Radio Equipment Directive).

Furthermore, the manufacturer must maintain a copy of the ConnectCore 6UL SBC Express user manual documentation and ensure the final product does not exceed the specified power ratings, antenna specifications, and/or installation requirements as specified in the user manual. If any of these specifications are exceeded in the final product, a submission must be made to a notified body for compliance testing to all required standards.