



ConnectCore 8X

System-on-module

Hardware Reference Manual -- Preliminary

Revision history—90002295

Revision	Date	Description
1P	December 2018	Initial release
2P	January 2019	Added backdrive caution.
3P	May 2019	Updated entire manual, including entire MCA section, some pin data, block diagram, and assembly information.
4P	March 2020	Added North American certifications; added power consumption section; updated frequency value, variants nformation, and some graphics; updated MCA to trademarked name.
5P	May 2020	Added operating temperature statement.
6P	June 2020	Added Canada, Europe, and Japan certifications; added FCC notices; added antenna port section.

Trademarks and copyright

Digi, Digi International, and the Digi logo are trademarks or registered trademarks in the United States and other countries worldwide. All other trademarks mentioned in this document are the property of their respective owners.

© 2020 Digi International Inc. All rights reserved.

Disclaimers

Information in this document is subject to change without notice and does not represent a commitment on the part of Digi International. Digi provides this document “as is,” without warranty of any kind, expressed or implied, including, but not limited to, the implied warranties of fitness or merchantability for a particular purpose. Digi may make improvements and/or changes in this manual or in the product(s) and/or the program(s) described in this manual at any time.

Warranty

To view product warranty information, go to the following website:

www.digi.com/howtobuy/terms

Customer support

Gather support information: Before contacting Digi technical support for help, gather the following information:

- Product name and model
- Product serial number (s)
- Firmware version
- Operating system/browser (if applicable)

Logs (from time of reported issue)

Trace (if possible)

Description of issue

Steps to reproduce

Contact Digi technical support: Digi offers multiple technical support plans and service packages. Contact us at +1 952.912.3444 or visit us at www.digi.com/support.

Feedback

To provide feedback on this document, email your comments to

techcomm@digi.com

Include the document title and part number (ConnectCore® 8X System-on-Module Hardware Reference Manual -- Preliminary, 90002295 6P) in the subject line of your email.

Contents

About the ConnectCore® 8X

Features and functionality	6
Module variants	8
Block diagrams	9
ConnectCore 8X module	9
NXP i.MX 8X application processor	10
SOM revisions	10
Identify the SOC revision of your SOM	10

The ConnectCore 8X System-on-module

Power interfaces	12
Reference power architecture scheme	12
System-on-module power rails distribution	13
Electrical characteristics	16
System power-up sequence	19
RTC power and coin cell charger	19
Bootstrap	20
Wireless interfaces	21
WLAN IEEE 802.11a/b/g/n/ac	21
Bluetooth	28
PCI Express	28
Antenna ports	30
CryptoAuthentication device	31
The Digi Microcontroller Assist™ hardware	31
Reset control	32
IOs	33
Watchdog	36
Real-time clock	36
Pulse width modulation	36
Power management	37
MCA firmware update	40

IOMUX

Module pinout	42
IOMUX table	43
Extended LGA version	61

Module specifications

Power consumption	98
Power consumption use cases	98
Complex power consumption use cases	98
Results	99
Environmental specifications	100

Assembly instructions

Moisture sensitivity and shelf life	102
Mounting	102
Coplanarity	102
Solder paste print	102
Stencil	102
SMT pick and place	103
SMT process parameter reference	103
Reflow profile	103

Regulatory information and certifications

United States FCC	106
Labeling requirements	106
Maximum power and frequency specifications (FCC)	106
FCC notices	107
FCC-approved antennas	108
RF exposure	110
Operating frequency	110
Europe	110
CE mark	110
OEM labeling requirements	110
CE labeling requirements	111
Declarations of Conformity	111
Approved antennas	111
Canada (IC)	112
Canadian Notice	112
Labeling requirements	112
Transmitters with detachable antennas	112
RF exposure	113
Approved antennas	113
Japan	113
Approval Label (MIC Marking)	114

About the ConnectCore® 8X

The ConnectCore 8X is a secure and extremely cost-effective connected System-on-Module platform. Its innovative Digi SMTplus™ (patent-pending) surface mount form factor allows you to choose simplified design integration leveraging proven and easy-to-use edge-castellated SMT technology, or a versatile LGA option for ultimate design flexibility with access to virtually all interfaces.

Built on the NXP i.MX 8X application processor, the module is the intelligent communication engine for today's secure connected devices. It integrates dual-Ethernet and pre-certified dual-band Wi-Fi (802.11a/b/g/n/ac) with dual mode Bluetooth 5.0 connectivity.

Features and functionality

The ConnectCore 8X System-on-module is based on the i.MX 8X processor from NXP. This processor offers a number of interfaces, some of them multiplexed and not available simultaneously. The module has the following features:

- i.MX 8X dual/quad Arm Cortex-A35 and single Cortex-M4F cores:
 - Cortex-A35 cores operate up to 1.0 GHz and support Arm virtualization extensions.
 - Cortex-M4F core operates up to 266 MHz.
 - AArch64 for 64-bit support.
 - AArch32 for backward compatibility with Armv7.
- System Control Unit (SCU):
 - Power control, clocks, and reset.
 - Boot ROMs.
 - PMIC interface.
 - Resource Domain Controller.
- Graphics Processing Unit (GPU):
 - 4x Vec4 shaders with 16 execution units.
 - Supports OpenGL 3.0, 2.0; OpenGL ES 3.1, 3.0, 2.0 and 1.1; OpenCL 1.2 FP and 1.1; OpenVG 1.1; and Vulkan.
 - High-performance 2D Blit Engine.
- Video Processing Unit (VPU):
 - H.265 decode (4Kp30).
 - H.264 decode (1080p60).
 - VP6/VP8 decode (1080p60).
 - MPEG-2 decode (1080p60).
 - MPEG4, H263, Sorenson Spark decode (1080p).
 - RealVideo decode (1080p).
 - JPEG dec (64Kx64K image size).
 - H.264 encode (1080p30).

- Up to 4 GB, 32-bit LPDDR4-1200 memory.
- 16 GB, 8-bit eMMC memory. Higher density available depending on product variant.
- NXP PF8100 Power Management IC (PMIC):
 - 7x DC/DC buck converters.
 - 4x LDO regulators.
 - OTP (one-time-programmable) memory.
 - Coin cell charger.
- CryptoAuthentication device.
- Security accelerators:
 - Enhanced High Assurance Boot (HAB) secure and encrypted boot.
 - Random Number Generator with a high-quality entropy source generator and NIST certifiable HMAC-based DRBG.
 - RSA up to 4096, Elliptic Curve up to 1023.
 - AES-128/192/256, DES, 3DES, ARC4, MD5, SHA-1, SHA-224/256/384/512.
 - Dedicated Security Controller for Flashless SHE and HSM support, Trustzone, RTIC.
 - Built-in ECDSA/DSA protocol support.
 - 10x tamper pins: up to 5 active or 10 passive.
 - Voltage and temperature tamper detection to help prevent against side-channel style attacks.
 - 64 kB Secure RAM (can be erased via tamper detection).
- 2x2 MIMO IEEE802.11 a/b/g/n/ac.
- Bluetooth 5.0.
- Debug interfaces:
 - System JTAG controller.
 - Single Wired Debug (SWD) interface for the MCA.
- i.MX 8X interfaces:
 - PCIe 3.0 with L1 substate support. In wireless modules, this interface is used by the Wireless MAC and is not available for general purposes.
 - 1x USBOTG 3.0 with PHY - USB 3.0 can be used as USB 2.0.
 - 1x USBOTG 2.0 (with PHY).
 - 2x Gb Ethernet with AVB.
 - 3x CAN/CAN-FD.
 - Media Local Bus (MLB25/50).
 - 6x UARTs:
 - 4x UARTs, three of which support hardware flow control. (One of the UARTs with hardware flow control is used by the Bluetooth and is not available for general purposes in wireless variants.)
 - 1x UART tightly coupled with Cortex-M4F cores.
 - 1x SCU (not available for general use).
 - 10x I2C. Note that I2C ports associated with a specific PHY (e.g. MIPI DSI) can be used generally but require the PHY to be powered on even if the PHY itself is not used:

- 4x I2C: High Speed, DMA support. One of them (I2C0) is used internally in the SOM and is not available for general purposes.
 - 4x I2C: Low Speed, no DMA support.
 - 1x I2C: PMIC control (dedicated).
 - 1x I2C: Cortex M4F (dedicated).
- 4x SAI:
 - SAI0 and SAI1 are transmit/receive.
 - SAI2 and SAI3 are receive-only.
- 2x Quad SPI or 1x Octal SPI (FlexSPI).
- 1x SD 3.0 card interface.
- Displays:
 - 2x MIPI-DSI/LDVS. For LVDS, VESA and JEIDA standards supported.
 - 1x 24-bit parallel display up to WVGA.
- Cameras:
 - 1x MIPI-CSI camera with 4 lanes.
 - 1x 8-bit parallel CSI.
- 1x Enhanced Serial Audio Interface (ESAI).
- 2x ASRC (Asynchronous Sample Rate Converter).
- 1x SPDIF.
- MPEG-2 Transport Stream.
- 1x 12-bit, 6 channel ADC converter.
- 3.3 V/1.8 V GPIO.
- 4x PWM channels.
- 1x 4x4 KPP (Key Pad Port).
- 1x MQS (Medium Quality Sound).
- 4x SPI.
- Arm Cortex-M0+ Digi Microcontroller Assist™ (MCA) subsystem:
 - Cortex-M0+ core operates up to 48MHz.
 - Power and reset control.
 - Real time clock (RTC).
 - 19 general purpose I/Os (GPIOs), all IRQ capable with debouncing configuration.
 - 9 analog to digital converters (ADCs), all with comparator capabilities.
 - Watchdog.
 - Tamper detection, both digital and analog.
 - 8 bytes of non volatile storage (NVRAM).
 - 3 UARTs, with optional hardware handshake.
 - 10 pulse width modulators (PWMs).

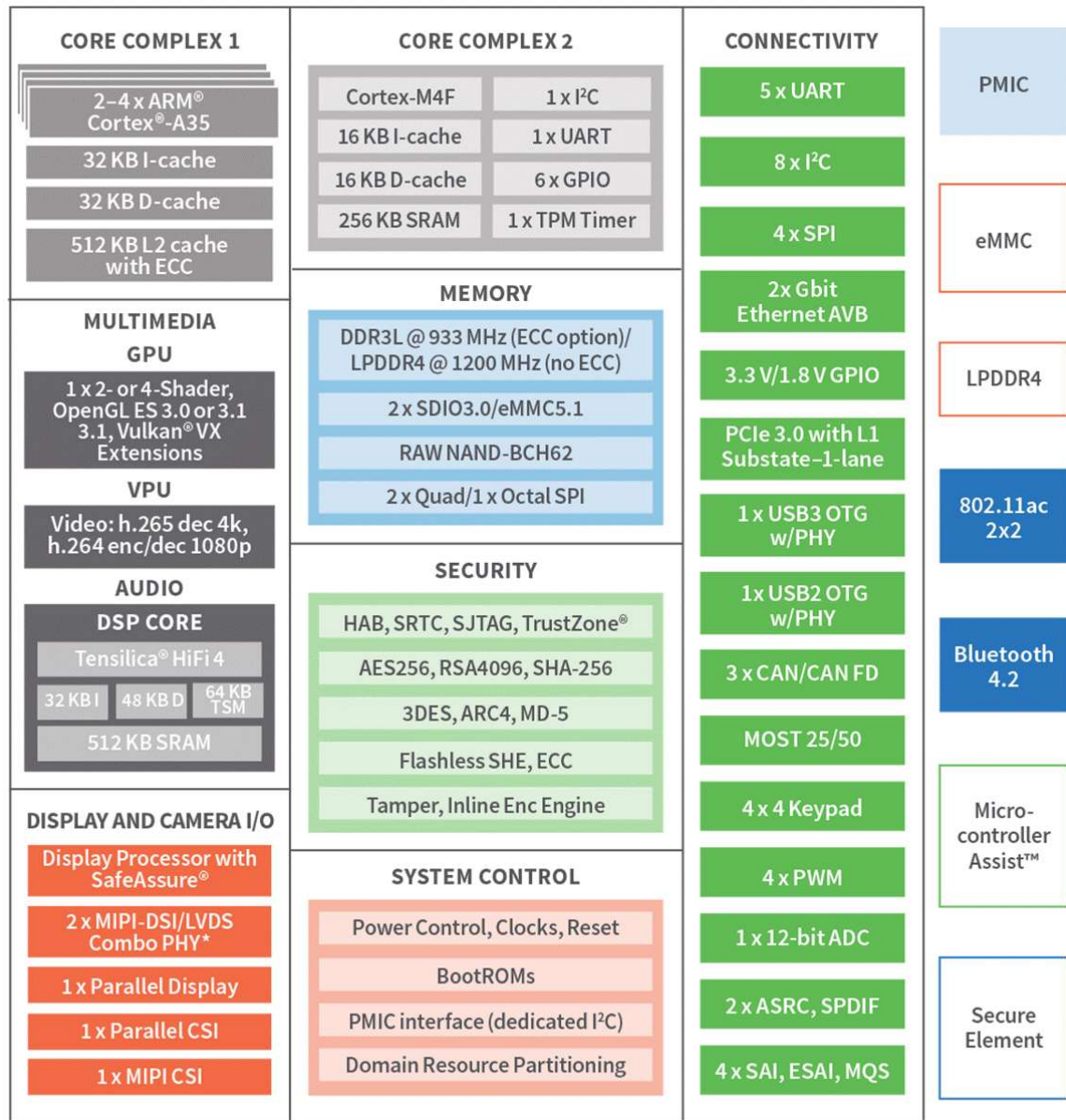
Module variants

See the full list of variants in the [ConnectCore 8X documentation portal](#).

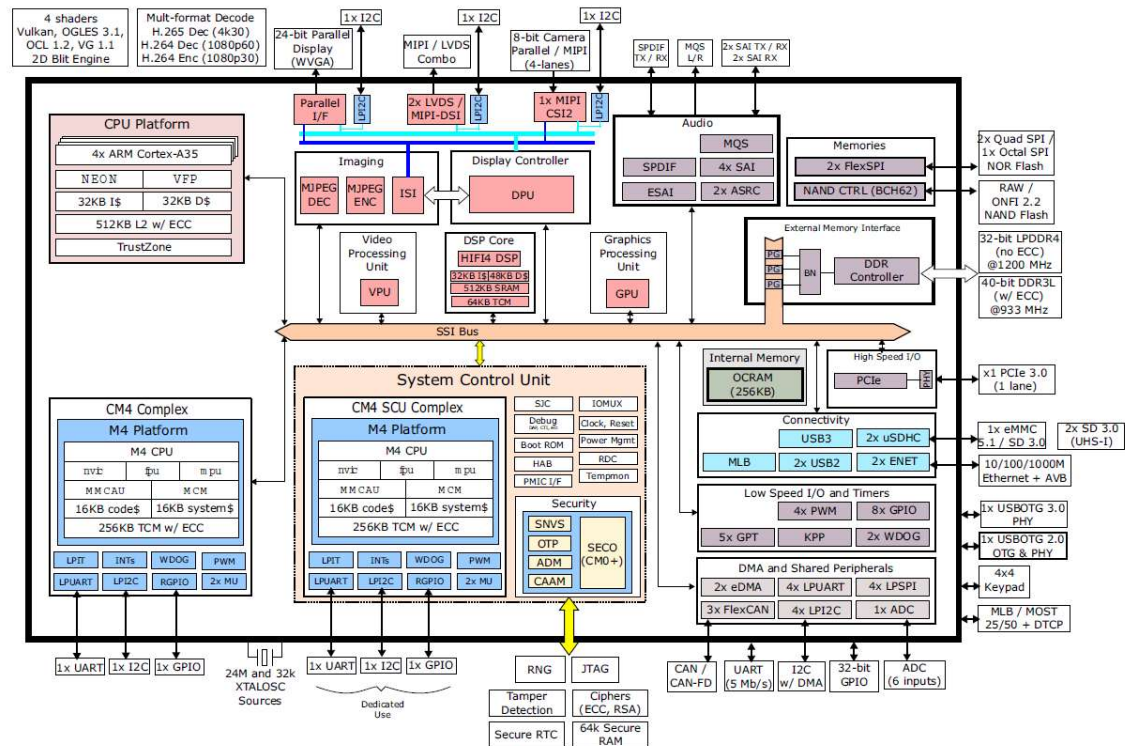
Block diagrams

The following figures show block diagrams of the ConnectCore 8X module and of the NXP i.MX 8X application processor.

ConnectCore 8X module



NXP i.MX 8X application processor



SOM revisions

The ConnectCore 8X SOM uses an NXP i.MX8X system-on-chip (SOC). NXP released two revisions of the system-on-chip (SOC) silicon:

- Revision **B0**
- Revision **C0**

On the **C0** revision of the i.MX8X, NXP fixed most of the errata that were reported on B0. For a full list of fixes, see [NXP Application Note AN12770](#).

Identify the SOC revision of your SOM

The label on the ConnectCore 8X SOM looks like this:



The red circle denotes Digi's revision of the ConnectCore 8X SOM. The following table correlates the ConnectCore 8X SOM revision with the i.MX8X SOC revision:

SOM revision	Description	i.MX8X SOC revision
1P, 2P, ...	Pre-production series	B0
A, B, ...	Mass production series	C0

Note See the [SOC revisions](#) section of the ConnectCore 8X software documentation portal for more information.

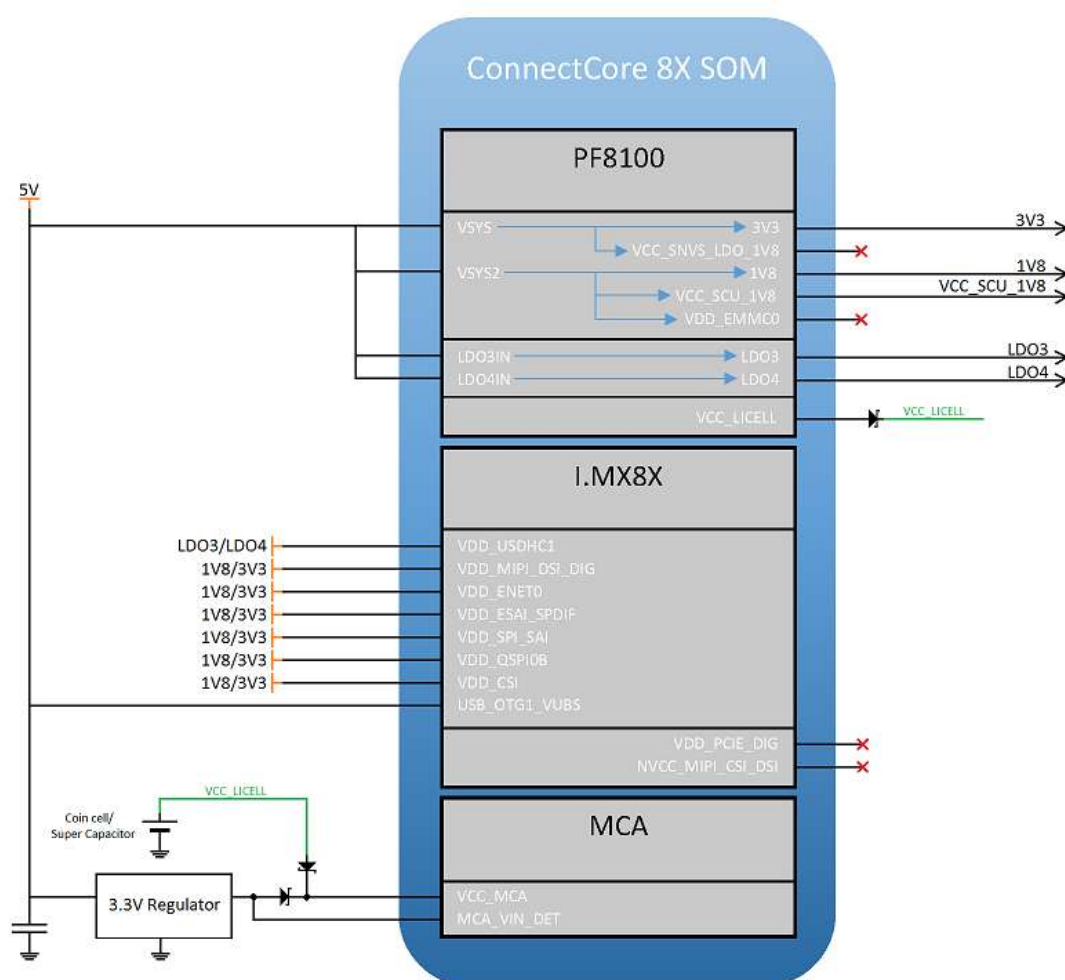
The ConnectCore 8X System-on-module

This section describes the functionality of the ConnectCore 8X System-on-module.

Power interfaces

Reference power architecture scheme

The following diagram represents the full power architecture distribution of the ConnectCore 8X module in a typical application with the coin cell charger functionality supported:



System-on-module power rails distribution

The ConnectCore 8X requires three primary power supply inputs: VSYS, VSYS2, and VCC_MCA:

- VSYS and VSYS2 are the input power supplies to the on-module NXP PF8100 Power Management IC (PMIC), as well as to most of its regulators. Some PMIC regulators are internally dedicated to powering the module, while others power external circuitry.
- VCC_MCA is the input power supply of the on-module Digi Microcontroller Assist.

Two additional linear dropout regulators (LDO3 and LDO4), which have a dedicated input power line, are available to power carrier board external circuitry. These additional regulators are not mandatory.

The following table summarizes the PMIC regulators of the ConnectCore 8X SOM:

PMIC regulator	SoM power rail name	Input power supply	Internally used	Externally available	Comments
SW1	-	VSYS2	YES	NO	
SW2	-	VSYS2	YES	NO	
SW3	-	VSYS2	YES	NO	
SW4	-	VSYS2	YES	NO	
SW5	-	VSYS2	YES	NO	
SW6	1V8	VSYS2	YES	YES	General purpose 1.8V power rail for external circuitry. Also used internally in the SOM.
SW7	3V3	VSYS	YES	YES	General purpose 3.3V power rail for external circuitry. Also used internally in the SOM.
LDO1	VCC_SCU_1V8	VSYS2	YES	YES	Power supply for the i.MX 8X System Control Unit (SCU). Digi recommends not using this power rail externally unless otherwise noted.
LDO2	VDD_EMMC0	VSYS2	YES	YES	Used for powering the internal eMMC0 memory. Digi recommends not using this power rail externally unless otherwise noted.
LDO3	LDO3	LDO3IN	NO	YES	
LDO4	LDO4	LDO4IN	NO	YES	

PMIC regulator	SoM power rail name	Input power supply	Internally used	Externally available	Comments
VSNVS	VCC_SNVS_LDO_1V8	VSYS / VCC_LICELL	YES	YES	An always-on power domain of the CPU that powers some core functionality of the SOM. Do not use this power rail externally.

Note VCC_LICELL is the input power for the PMIC VSNVS regulator, which is normally used to power the CPU in low-power mode (RTC). This pin also supports coin cell charger functionality for Li-ion rechargeable batteries or supercapacitors. However, RTC mode in the ConnectCore 8X is supported by the ConnectCore 8X MCA, not by the i.MX 8X. Therefore, in order to supply the RTC of the system, do not use VCC_LICELL as an input power rail. Instead, follow the configuration explained in [RTC power and coin cell charger](#).

In addition to the input power supplies of the PMIC, other power domains of the SOM must also be set externally. This allows power management flexibility so you can adapt the input voltage of the different interfaces. The following table lists the input power rails that must be powered externally to the SOM together with the devices/power domains they power:

Input rail	Device being powered	Internal power domains being powered	Description
VCC_MCA	Digi Microcontroller Assist	Full device	Input power supply for the ConnectCore 8X MCA. This power domain is mandatory.

Input rail	Device being powered	Internal power domains being powered	Description
VDD_USDHC1	i.MX 8X CPU	VDD_USDHC1_1P8_3P3	Input power supply for the USDHC1 interface. This interface is typically connected to a microSD socket, which also allows booting from the microSD card. Digi recommends that this power domain be connected to a flexible power supply (LDO3/4) so it can work at its highest speed by adjusting input voltage level.
VDD_MIPI_DSI_DIG	i.MX 8X CPU	VDD_MIPI_DSI_DIG_1P8_3P3	Input power supply for DSI0 and DSI1 dedicated GPIOs and I2C buses.
VDD_ENET0	i.MX 8X CPU	■ VDD_ENET0_VSELECT_1P8_2P5_3P3 ■ VDD_ENET0_1P8_2P5_3P3 ■ VDD_ENET_MDIO_1P8_3P3	Input power supply for the ENET0 interface, including the MDIO bus. Because all ENET0-related CPU blocks are powered from the same power rail, 2.5V configuration is not available. (The MDIO bus does not work at this voltage.)

Input rail	Device being powered	Internal power domains being powered	Description
VDD_ESAI_SPDIF	i.MX 8X CPU	VDD_ESAI_SPDIF_1P8_2P5_3P3	Input power supply for ESAI0 and SPDIF0 interfaces.
VDD_SPI_SAI	i.MX 8X CPU	VDD_SPI_SAI_1P8_3P3	Input power supply for SAI0, SAI1, SPI0 and SPI2 interfaces.
VDD_QSPI0B	i.MX 8X CPU	VDD_QSPI0B_1P8_3P3	Input power supply for QSPI0B interface.
VDD_CSI	i.MX 8X CPU	■ VDD_TMPR_CSI_1P8_3P3 ■ VDD_CSI_1P8_3P3	Input power supply for CSI interface.
USB_OTG1_VBUS	i.MX 8X CPU	USB_OTG1_VBUS	Input power supply for the USB1 interface VBUS.

Two additional power domains of the CPU are connected to the module LGA pads:

- VDD_PCIE_DIG
- NVCC_MIPI_CSI_DSI

These power domains are powered internally in the SOM and must not be connected to external circuitry unless otherwise noted.

Electrical characteristics

Input power rails

The following table lists the electrical specifications of all input power rails for the ConnectCore 8X:

Device	SOM power rail	Input voltage (V)		
		Minimum	Typical	Maximum
PMIC	VSYS	TBD (2.7)	-	5.5
	VSYS2	TBD (3.0)	-	5.5

Device	SOM power rail		Input voltage (V)		
			Minimum	Typical	Maximum
	LDO3IN		2.5 ¹	-	5.5
	LDO4IN		2.5 ¹	-	5.5
MCA	VCC_MCA		2.4	-	3.6
CPU	VDD_USDHC1 VDD_MIPI_DSI_DIG VDD_ENET0 VDD_SPI_SAI VDD_QSPI0B VDD_CSI	1.8 V mode	1.65	1.8	1.95
		3.3 V mode	3.00	3.30	3.60
		1.8 V mode	1.65	1.8	3.60
	VDD_ESAI_SPDIF	2.5 V mode	2.40	2.50	2.60
		3.3 V mode	3.00	3.30	3.60
	USB_OTG1_VBUS		4.4	-	5.5

¹When VLDOx is greater than 2.5V, minimum input voltage for the LDOs will be the nominal output voltage plus 0.25V.

Output power rails

The following table lists the electrical specifications of all output power rails for the ConnectCore 8X:

Device	SOM power rail	Used internally in the SOM	Output voltage (V)			Accuracy (%)			Max output current (mA) ¹	Turn-on time (us)			Turn-off time (us)		
			Min	Typ	Max	Min	Typ	Max		Min	Typ	Max	Min	Typ	Max
PMIC	SW6	1V8	-	1.80	-	-2.0	-	2.0	2500	36	160	279	-	-	-
	SW7	3V3	-	3.30	-	-2.0	-	2.0	2500	-	-	200	-	-	-
	LD01	VCC_SCU_1V8	-	1.80	-	-3.0	-	3.0	400	-	-	500	-	-	2500
	LD02	VDD_EMMC0	-	3.30	-	-3.0	-	3.0	400	-	-	500	-	-	2500
	LD03	LDO3	1.5	-	5.0	-3.0	-	3.0	400	-	-	500	-	-	2500
	LD04	LDO4	1.5	-	5.0	-3.0	-	3.0	400	-	-	500	-	-	2500
	VSNVS	VCC_LICELL (coin cell charger)	1.8	-	3.6	-3.0	-	3.0	0.060						

Note For a complete description of the electrical characteristics of the different output power rails (PMIC regulators), see the NXP PF8x00 datasheet.

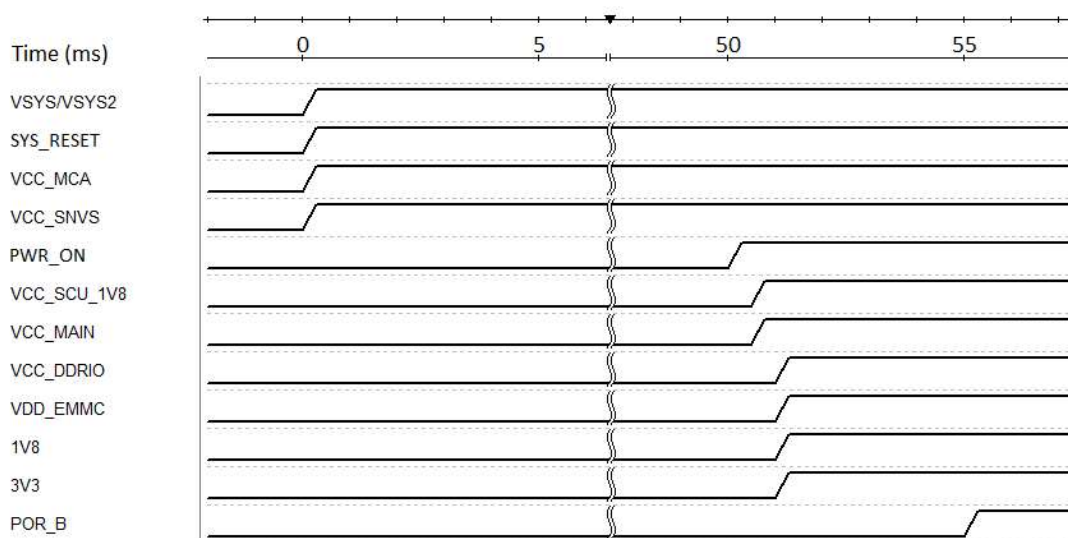
- ¹ The maximum output current involves both external and internal circuitry. For those regulators that are used internally in the SOM, the current available outside it will be lower.
- ² Turn-on time for this regulator is specified for VSW7 = 1.8 V. In the ConnectCore 8X this regulator is configured to work at 3.3V, so a higher turn-on time may be observed.

System power-up sequence

When the power supply is connected to the ConnectCore 8X module, the PMIC and the MCA are the first components to be powered up. VSYS and VSYS2 are PMIC supplies, while VCC_MCA is the Digi Microcontroller Assist input power line. The system power-up sequence is as follows:

1. The MCA starts to run as soon as it is powered up. After a certain programmable time, it will release the PWRON line of the PMIC (PMIC power on/off).
2. Once the PMIC is switched on, it starts an initialization process as determined by its OTPs. Finally the CPU reset line, which is controlled by both the PMIC and the MCA, is released.

The following time diagram shows the power-up sequence.

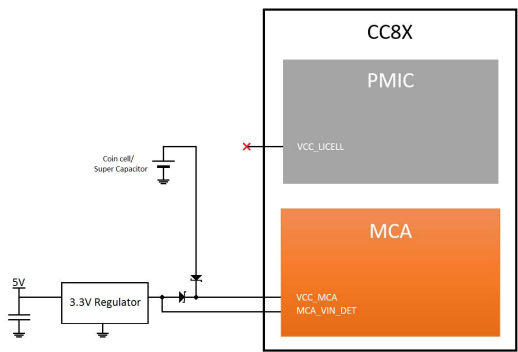


RTC power and coin cell charger

The VCC_LICELL pin supports coin cell charger functionality. This pin is also the input power supply for an always-on regulator of the PMIC (VSNVS) that feeds the low-power mode circuitry of the CPU. In the ConnectCore 8X module, the low-power modes of the system (RTC) are supported by the on-module MCA, not by the i.MX 8X CPU. Therefore, in order to reduce the static power consumption of the SOM, do not power the VSNVS regulator in low power mode. The coin cell should only power the VCC_MCA power domain through the diode configuration as shown in the following diagrams.

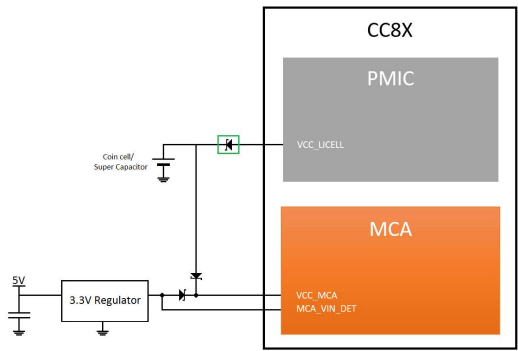
If the coin-cell charger functionality is mandatory, place a reverse diode between VCC_LICELL and the coin cell.

RTC connection without coin cell charger



RTC connection with coin cell charger

Note This hardware configuration has been validated with the Panasonic DB2J31400L diode, which has a low reverse leakage current (300nA) that is ideal for this low-power mode application.



Bootstrap

The ConnectCore 8X module can be configured to boot from different devices and interfaces as determined by the Boot ROM. The configuration of the booting process of the CPU is done through the SCU (System Control Unit) boot mode.

The BOOT_MODE is initialized by the SCU at the rising edge of POR_B, when it latched the SCU_BOOT_MODE lines. Once these lines are sampled, the subsequent state does not affect the content of the BOOT_MODE, which is tracked by the SCU.

The following table describes the eight boot modes that are supported by the ConnectCore 8X module:

BOOT_MODE [3]	BOOT_MODE [2]	BOOT_MODE [1]	BOOT_MODE [0]	Boot mode
0	0	0	0	Boot from eFuses

BOOT_MODE [3]	BOOT_MODE [2]	BOOT_MODE [1]	BOOT_MODE [0]	Boot mode
0	0	0	1	USB serial download
0	0	1	0	USDHC Boot: eMMC0
0	0	1	1	USDHC Boot: USDHC1
0	1	0	0	NAND Boot: 128 pages in Block
0	1	0	1	NAND Boot: 32 pages in Block
0	1	1	0	FlexSPI Boot: 3B read
0	1	1	1	FlexSPI Boot: Hyperflash 3.0

These BOOT_MODE lines are referred to the VCC_SCU_1V8 power domain. By default, none of them are configured inside the module. To configure the desired boot mode, they must be driven low or high in the carrier board in the following way:

- To set high level, place a 4.7K pull-up to VCC_SCU_1V8.
- To set low level, place a 100K pull-down to GND.

Wireless interfaces

The ConnectCore 8X System-on-module combines a wireless local area network (WLAN) and Bluetooth dual solution to support MIMO 2x2 IEEE802.11 a/b/g/n/ac WLAN standards and Bluetooth 5.0, enabling seamless integration of WLAN/Bluetooth and Low Energy technology.

WLAN IEEE 802.11a/b/g/n/ac

The 2.4 GHz band on the ConnectCore 8X module supports 20/40 MHz bandwidths, and the 5 GHz band supports 20/40/80 MHz bandwidths. The following sections specify the performance of the WLAN IEEE 802.11a/b/g/n/ac interface on the ConnectCore 8X module.

Modulation and data rates

The following tables list modulation values for the ConnectCore 8X module, which supports the following WLAN standards:

Mode	Modulation & coding	Rate
802.11b	DBPSK	1 Mbps
	DQPSK	2 Mbps
	CCK	5.5 Mbps
	CCK	11 Mbps

Mode	Modulation & coding	Rate
802.11g	BPSK-1/2	6 Mbps
	BPSK-3/4	9 Mbps
	QPSK-1/2	12 Mbps
	QPSK-3/4	18 Mbps
	16QAM-1/2	24 Mbps
	16QAM-3/4	36 Mbps
	64QAM-2/3	48 Mbps
	64QAM-3/4	54 Mbps
802.11n	BPSK-1/2	MCS0
	QPSK-1/2	MCS1
	QPSK-3/4	MCS2
	16QAM-1/2	MCS3
	16QAM-3/4	MCS4
	64QAM-2/3	MCS5
	64QAM-3/4	MCS6
	64QAM-5/6	MCS7
802.11ac	BPSK-1/2	MCS0
	QPSK-1/2	MCS1
	QPSK-3/4	MCS2
	16QAM-1/2	MCS3
	16QAM-3/4	MCS4
	64QAM-2/3	MCS5
	64QAM-3/4	MCS6
	64QAM-5/6	MCS7
	256QAM-3/4	MCS8
	256QAM-5/6	MCS9

Datarates

The following table lists the Tx throughput gains from MIMO:

VHT MCS index	Modulation type	Coding rate	Data rate (Mbps)					
			20 MHz channel		40 MHz channel		80 MHz channel	
			800 ns GI	400 ns GI	800 ns GI	400 ns GI	800 ns GI	400 ns GI
One spacial stream (requires 1 Tx antenna)								
0	BPSK	1/2	6.5	7.2	13.5	15	29.3	32.5
1	QPSK	1/2	13	14.4	27	30	58.5	65
2	QPSK	3/4	19.5	21.7	40.5	45	87.8	97.5
3	16-QAM	1/2	26	28.9	54	60	117	130
4	16-QAM	3/4	39	43.3	81	90	175.5	195
5	64-QAM	2/3	52	57.8	108	120	234	260
6	64-QAM	3/4	58.5	65	121.5	135	263.3	292.5
7	64-QAM	5/6	65	72.2	135	150	292.5	325
8	256-QAM	3/4	78	86.7	162	180	351	390
9	256-QAM	5/6	-	-	180	200	390	433.3
Two spatial streams (requires 2 Tx antennas)								
0	BPSK	1/2	13	14.4	27	30	58.5	65
1	QPSK	1/2	26	28.9	54	60	117	130
2	QPSK	3/4	39	43.3	81	90	175.5	195
3	16-QAM	1/2	52	57.8	108	120	234	260
4	16-QAM	3/4	78	86.7	162	180	351	390
5	64-QAM	2/3	104	115.6	216	240	468	520
6	64-QAM	3/4	117	130	243	270	526.5	585
7	64-QAM	5/6	130	144.4	270	300	585	650
8	256-QAM	3/4	156	173.3	324	360	702	780
9	256-QAM	5/6	-	-	360	400	780	866.7

RF channels

The ConnectCore 8X module supports the following frequency bands:

RF band	Ch. BW	Ch. spacing	Channel number (Center freq. MHz)
2.4 GHz	20 MHz	5 MHz	1(2412), 2(2417), 3(2422), 4(2427), 5(2432), 6(2437), 7(2442), 8(2447), 9(2452), 10(2457), 11(2462), 12(2467), 13(2472), 14(2484)
	40 MHz	5 MHz	3(2422), 6(2437), 9(2452)
5 GHz	20 MHz	20 MHz	36(5180), 40(5200), 44(5220), 48(5240), 52(5260), 56(5280), 60(5300), 64(5320), 100(5500), 104(5520), 108(5540), 112(5560), 116(5580), 120(5600), 124(5620), 128(5640), 132(5660), 136(5680), 140(5700), 144(5720), 149(5745), 153(5765), 157(5785), 161(5805), 165(5825)
	40 MHz	40 MHz	38(5190), 46(5230), 54(5270), 62(5310), 102(5510), 110(5550), 118(5590), 126(5630), 134(5670), 142(5710), 151(5755), 159(5795)
	80 MHz	80 MHz	42(5210), 58(5290), 106(5530), 122(5610), 138(5690), 155(5775)

Note Dependent upon regulatory bodies.

2.4 GHz band channels (20 MHz BW)

Channel #	Center frequency (MHz)	EUROPE (ETSI)	US (FCC)	Canada (ISED)	JAPAN
1	2412	✓	✓	✓	✓
2	2417	✓	✓	✓	✓
3	2422	✓	✓	✓	✓
4	2427	✓	✓	✓	✓
5	2432	✓	✓	✓	✓
6	2437	✓	✓	✓	✓
7	2442	✓	✓	✓	✓
8	2447	✓	✓	✓	✓
9	2452	✓	✓	✓	✓
10	2457	✓	✓	✓	✓
11	2462	✓	✓	✓	✓
12	2467	✓	No	No	✓
13	2472	✓	No	No	✓
14	2484	No	No	No	802.11b only

5 GHz band channels (20 MHz BW)

Channel #	Center frequency (MHz)	EUROPE (ETSI)	US (FCC)	Canada (ISED)	JAPAN
36	5180	Indoors	✓	✓	✓
40	5200	Indoors	✓	✓	✓
44	5220	Indoors	✓	✓	✓
48	5240	Indoors	✓	✓	✓
52	5260	Indoors / DFS / TPC	DFS	DFS	DFS / TPC
56	5280	Indoors / DFS / TPC	DFS	DFS	DFS / TPC
60	5300	Indoors / DFS / TPC	DFS	DFS	DFS / TPC
64	5320	Indoors / DFS / TPC	DFS	DFS	DFS / TPC
100	5500	DFS / TPC	DFS	DFS	DFS / TPC
104	5520	DFS / TPC	DFS	DFS	DFS / TPC
108	5540	DFS / TPC	DFS	DFS	DFS / TPC
112	5560	DFS / TPC	DFS	DFS	DFS / TPC
116	5580	DFS / TPC	DFS	DFS	DFS / TPC
120	5600	DFS / TPC	DFS	No Access	DFS / TPC
124	5620	DFS / TPC	DFS	No Access	DFS / TPC
128	5640	DFS / TPC	DFS	No Access	DFS / TPC
132	5660	DFS / TPC	DFS	DFS	DFS / TPC
136	5680	DFS / TPC	DFS	DFS	DFS / TPC
140	5700	DFS / TPC	DFS	DFS	DFS / TPC
144	5720	No Access	DFS	DFS	DFS / TPC
149	5745	SRD	✓	✓	No Access
153	5765	SRD	✓	✓	No Access
157	5785	SRD	✓	✓	No Access

Channel #	Center frequency (MHz)	EUROPE (ETSI)	US (FCC)	Canada (ISED)	JAPAN
161	5805	SRD	✓	✓	No Access
165	5825	SRD	✓	✓	No Access

Note

DFS = Dynamic Frequency Selection

TPC = Transmit Power Control

SRD = Short Range Devices

See [Regulatory information](#) for further details about available RF channels and their maximum transmit power.

Receive sensitivity

The following table lists typical receive sensitivity values for the ConnectCore 8X module.

Mode		802.11b		802.11ga		802.11n		802.11ac		
Modulation		DBPSK	CCK	BPSK-1/2	64QAM-3/4	BPSK-1/2	64QAM-5/6	BPSK-1/2	64QAM-5/6	256QAM-5/6
		1 Mbps	11 Mbps	6 Mbps	54 Mbps	MCS0	MCS7	MCS0	MCS7	MCS9
2.4 GHz	HT20	-90	-88	-90	-75	-82	-64	-82	-64	-
	HT40	-	-	-	-	-79	-61	-79	-61	-54
5 GHz	HT20	-	-	-90	-75	-82	-64	-82	-64	-
	HT40	-	-	-	-	-79	-61	-79	-61	-54
	HT80	-	-	-	-	-	-	-76	-58	-51

Note Specification is subject to change.

Transmit power

The following tables list the maximum transmit power values for the ConnectCore 8X module. The values corresponds to the power configured for each antenna individually, so in MIMO applications total output power will be the sum of both antennas.

FCC			
RF band	Channel BW	Standard	Output power (dBm)
2.4 GHz	20 MHz	802.11b	13.5
	20 MHz	802.11g	17
	20 MHz	802.11n	18
	40 MHz	802.11n	12
5 GHz	20 MHz	802.11a	13
	20 MHz	802.11n	12
	20 MHz	802.11ac	12
	40 MHz	802.11n	12
	40 MHz	802.11ac	12
	80 MHz	802.11ac	11

CE			
RF band	Channel BW	Standard	Output power (dBm)
2.4 GHz	20 MHz	802.11b	9
	20 MHz	802.11g	10
	20 MHz	802.11n	10.5
	40 MHz	802.11n	10
5 GHz	20 MHz	802.11a	13
	20 MHz	802.11n	12
	20 MHz	802.11ac	12
	40 MHz	802.11n	12
	40 MHz	802.11ac	12
	80 MHz	802.11ac	11

TELEC			
RF band	Channel BW	Standard	Output power (dBm)
2.4 Gz	20 MHz	802.11b	10.5
	20 MHz	802.11g	15
	20 MHz	802.11n	15.5
	40 MHz	802.11n	15
5 GHz	20 MHz	802.11a	13
	20 MHz	802.11n	12
	20 MHz	802.11ac	12
	40 MHz	802.11n	12
	40 MHz	802.11ac	12
	80 MHz	802.11ac	11

Note The tables list the maximum output power for each standard, regulatory domain and bandwidth channel. Output power may be lower depending on the channel and modulation.

See [Regulatory information](#) for further details about available RF channels and their maximum transmit power.

Bluetooth

The ConnectCore 8X module supports both Bluetooth and Bluetooth Low Energy protocols:

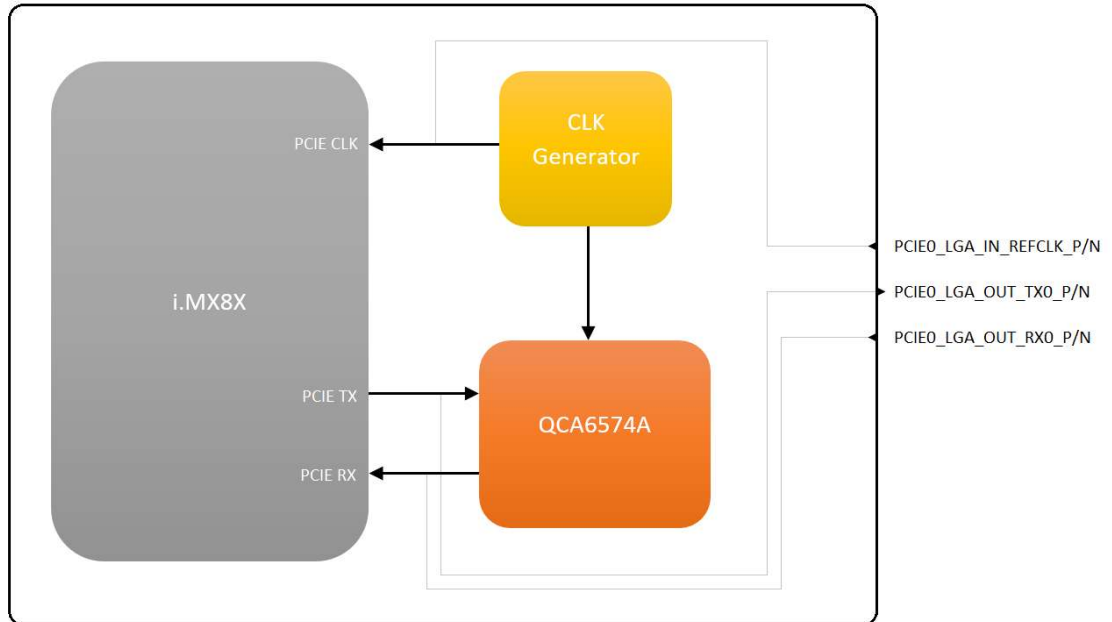
- Bluetooth 5.0; backwards compatible with Bluetooth 1.X, 2.X + Enhanced Data Rate, Bluetooth 3.X, Bluetooth 4.X, and Bluetooth class 1 and class 2 power-level transmissions
- Integrated WLAN-Bluetooth coexistence

See [Bluetooth certification](#) for more information.

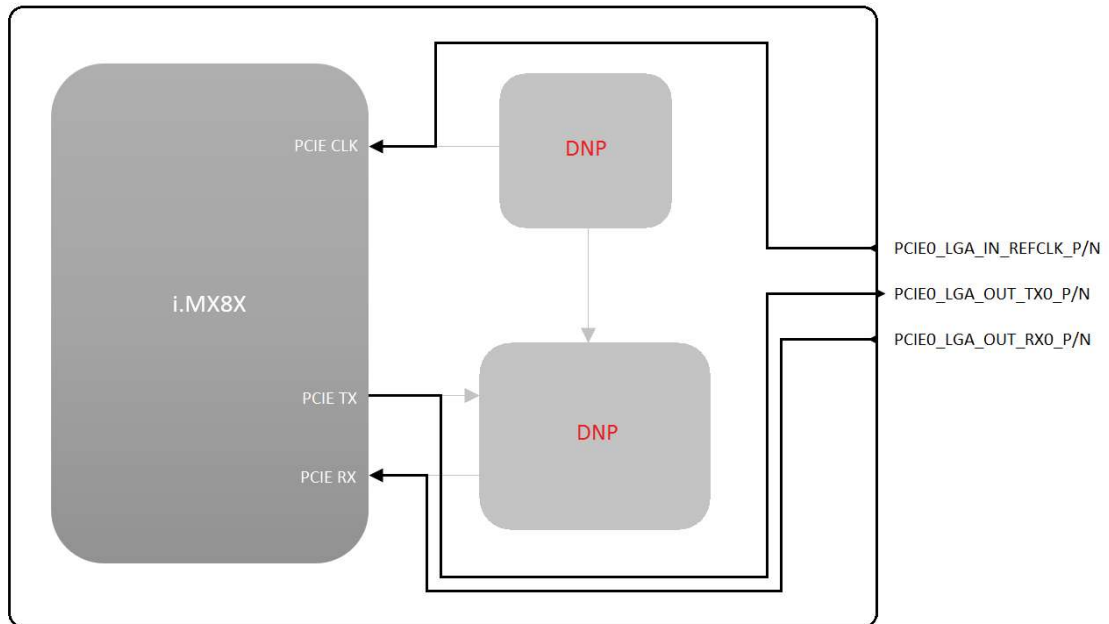
PCI Express

The ConnectCore 8X module features one PCI Express dual mode (DM) controller. This interface is not externally available in wireless variants of the SOM, since it is used by the wireless MAC. In non-wireless variants, it can be used externally. The following diagrams show the internal PCIe configuration:

Wireless variants



Non-wireless variants



The dedicated PCIe clock generator is not internally populated in the non-wireless variants, so to use the PCI Express interface it must be populated externally (see the [ConnectCore 8X SBC Pro reference design](#)).

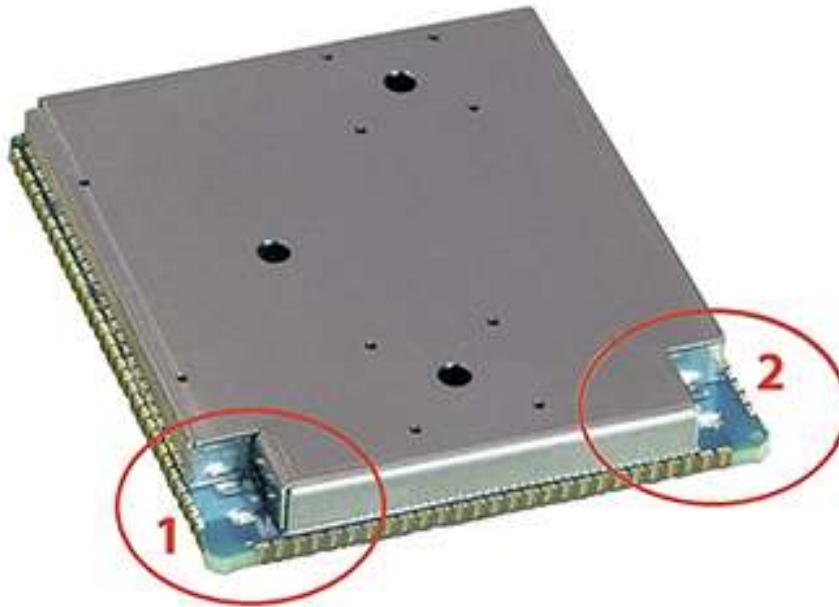
The following control lines can also be used externally in non-wireless variants:

- PCIE_LGA_OUT_CTRL0_WAKE_B
- PCIE_LGA_OUT_CTRL0_CLKREQ_B
- PCIE_LGA_OUT_CTRL0_PERST_B

Note There are other PCIe-related pads on the ConnectCore 8X module: F7, F8, F9, G20, G21, G23, G24. Leave these pins unconnected.

Antenna ports

The ConnectCore 8X module has two antenna ports:



Antenna 1 supports both WLAN 2.4&5GHz and Bluetooth, and antenna 2 only supports WLAN 2.4&5GHz.

CryptoAuthentication device

The ConnectCore 8X module includes an Atmel CryptoAuthentication Device. This is a highly secure cryptographic co-processor with secure hardware-based key storage. It includes the following features:

- Performs high-speed public key (PKI) algorithms (ECDSA and ECDH). NIST standard P256 elliptic curve support.
- SHA-256 hash algorithm with HMAC option.
- 256-bit key length.
- Storage for up to 16 keys.
- Two high-endurance monotonic counters.
- Guaranteed unique 72-bit serial number.
- Internal High-quality FIPS Random Number Generator (RNG).
- 10 Kb EEPROM memory.

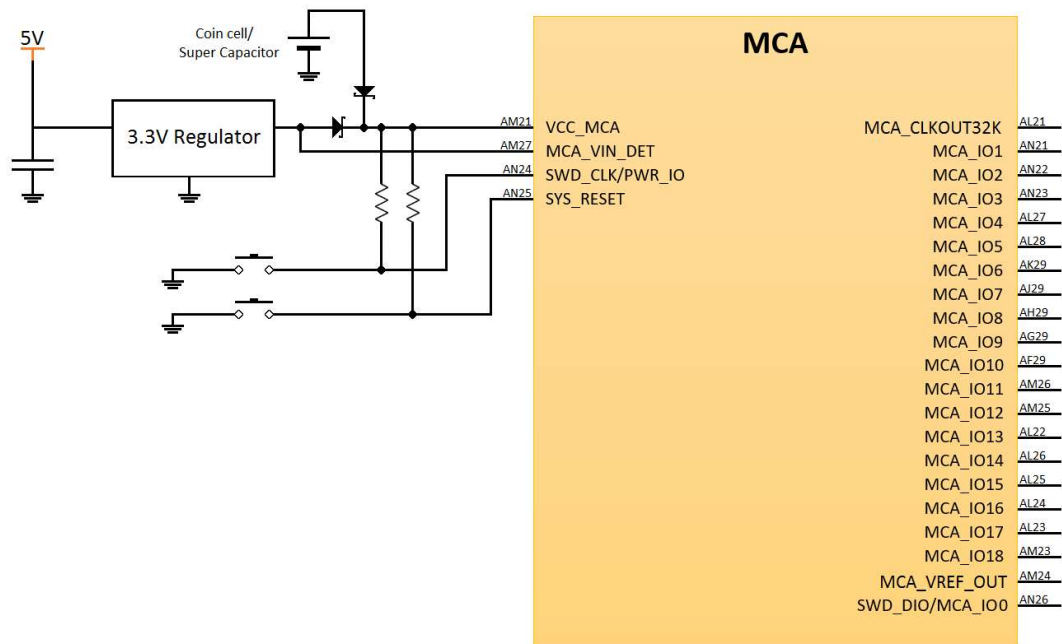
See the [software documentation](#) for information about supported cryptoauthentication features.

The Digi Microcontroller Assist™ hardware

The Digi Microcontroller Assist, or MCA, is a small microcontroller that is deeply integrated into the design of the ConnectCore 8X module. It assists the i.MX 8X processor with advanced operations related to power management, security, and system reliability. The functionality provided by the MCA includes:

- Advanced power management such as power key button, wake up sources, and PMIC control in low power.
- Peripheral extensions such as RTC, watchdog, and tamper pins.

The MCA and the i.MX 8X are connected through an I2C interface and an interrupt line. The microcontroller provides up to 19 general purpose IOs that can be configured with different modes to provide functionality such as digital input/output or ADC.



Reset control

The MCA, in cooperation with the PMIC, controls the reset line of the i.MX 8X processor. The SYS_RESET pin is the main reset input of the ConnectCore 8X module. This pin is a pseudo open-drain with an internal pull up. Asserting the SYS_RESET line low sets the MCA into reset state, and it remains in this state until the line is de-asserted.

During system initialization, the MCA performs the following actions:

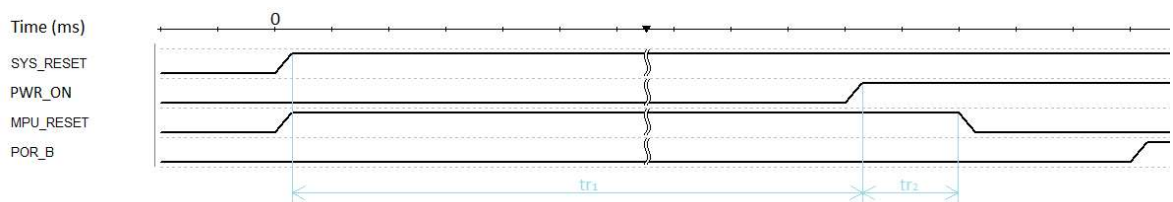
- Asserts the PMIC on/off line (SCU_PMIC_ON_REQ) low for a configurable time (0-255 ms with a default value of 50ms). This powers the PMIC off, switching off all regulated outputs of the PMIC. You can disable this power cycle by setting the timer to 0.
- Asserts the PMIC on/off line high to power the system on.
- Keeps the reset line of the CPU low for a configurable time.

- Releases the reset line of the CPU to allow starting the execution of the firmware on the i.MX 8X processor.

Note The CPU reset line is also connected to the PMIC. The PMIC won't release this line until it is switched on and the entire starting sequence is finished (a few ms after the latest regulator is turned on). This means that even if the MCA releases the reset line before the PMIC is ready, the CPU won't go out of reset.

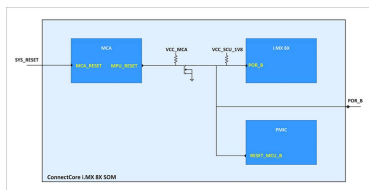
The following time diagram represents the reset sequence. Default values are as follows:

- tr_1 : 50 ms
- tr_2 : 2 ms



See [System power-up sequence](#) for more information about the power-up sequence of the ConnectCore 8X.

Reset line internal connection



IOs

The ConnectCore 8X MCA provides up to 19 configurable IOs.

Because the general purpose IOs do not incorporate internal pull-ups or pull-downs, you may have to add the components to the module carrier board.

The following table lists all available MCA IOs with their configurable capabilities:

MCA IO	Pad LGA / castellated pads	Digital I/O	IRQ capable	ADC	32KHz clock	1.2 Vref
MCA_VREF_OUT	AM24	✓	✓	✓		✓
MCA_CLKOUT32K	AL21				✓	
SWD_DIO/MCA_IO0	AN26 / 57	✓	✓			

MCA IO	Pad LGA / castellated pads	Digital I/O	IRQ capable	ADC	32KHz clock	1.2 Vref
MCA_IO1	AN21 / 52	✓	✓	✓		
MCA_IO2	AN22 / 53	✓	✓	✓		
MCA_IO3	AN23 / 54	✓	✓	✓		
MCA_IO4	AL27 / 61	✓	✓	✓		
MCA_IO5	AL28 / 62	✓	✓	✓		
MCA_IO6	AK29 / 63	✓	✓	✓		
MCA_IO7	AJ29 / 64	✓	✓	✓		
MCA_IO8	AH29 / 65	✓	✓	✓		
MCA_IO9	AG29 / 66	✓	✓			
MCA_IO10	AF29 / 67	✓	✓			
MCA_IO11	AM26	✓	✓	✓		
MCA_IO12	AM25	✓	✓	✓		
MCA_IO13	AL22	✓	✓			
MCA_IO14	AL26	✓	✓	✓		
MCA_IO15	AL25	✓	✓			
MCA_IO16	AL24	✓	✓			
MCA_IO17	AL23	✓	✓			
MCA_IO18	AM23	✓	✓	✓		

Digital IOs

All MCA IOs can be configured as digital inputs/outputs, which are powered from the VCC_MCA power rail.

The digital outputs preserve the output value set in all operating modes, except in power off and coin cell modes where the IOs are reconfigured to high impedance state to preserve power.

MCA IRQs

You can configure the MCA IOs as interrupt inputs, using the MCA software to configure the active edge of the interrupt (rising, falling, or both). The firmware provides a configurable debounce filter for each GPIO that improves noise immunity and filters rebounds on push buttons. When one or more MCA IRQs are activated, the MCA interrupts the main processor through the corresponding IRQ line, signaling the active IRQs in the IRQ status registers. The IRQ inputs can wake the system from any low power mode (suspend or power off).

See the [MCA software documentation](#) for additional information about how to configure and access the MCA IRQ lines.

Analog to digital converter

Many of the MCA IOs can be configured as Analog to digital channels. The index of the MCA ADC channels corresponds to the index of the MCA IO. This means that ADC channel 1 corresponds to the MCA_IO1, ADC channel 2 to the MCA_IO2, and so on.

The result of the ADC conversion for a given input voltage is inversely proportional to the reference voltage of the ADC. For the MCA ADCs, the reference voltage corresponds to the VCC_MCA voltage. (Note that the i.MX 8X ADCs have a different reference voltage.) The MCA ADC provides 12-bit of resolution with right-justified, unsigned format output. These ADCs are suitable for low-frequency sampling (under 10 Hz). For higher frequency sampling, Digi recommends the CPU ADC channels. You can configure the MCA ADC lines to act as an analog window comparator and generate an IRQ depending on the voltage level in the input. This feature allows applications to be notified of this event instead of needing to periodically poll the input for its value.

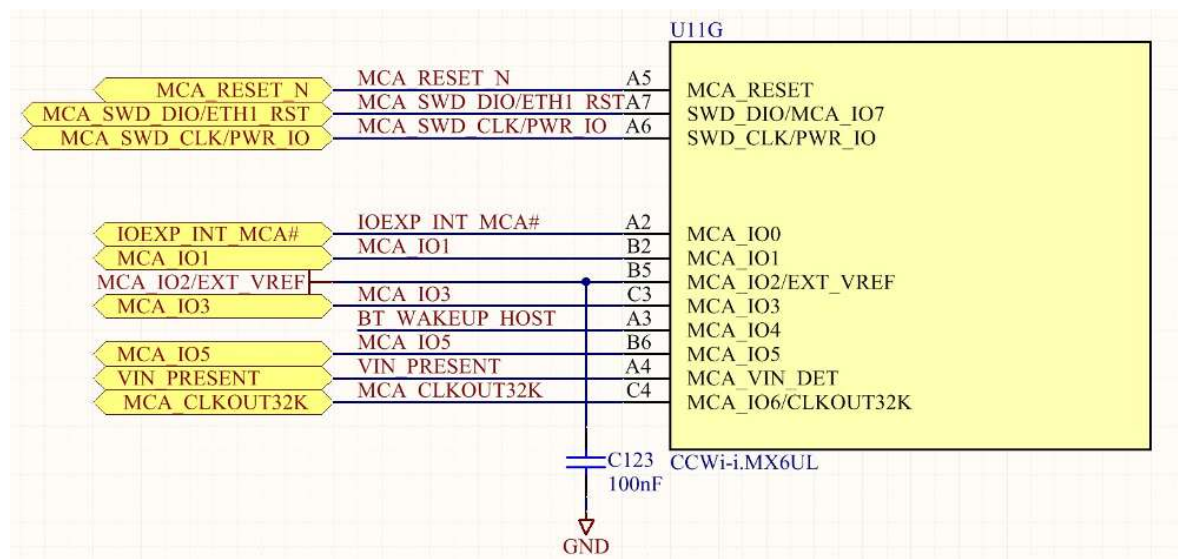
See the [MCA software documentation](#) for additional information about how to configure and access the MCA IRQ lines.

External voltage reference

The MCA_VREF_OUT pin provides an accurate voltage reference of 1.2V that can be used to provide a reference voltage for sensors and/or analog devices (such as comparators or ADCs).

The MCA_VREF_OUT pin is disabled by default. You must use software to configure the pin for external voltage reference.

See the [MCA software documentation](#) for additional information about how to control the function of this pin.



Note that the voltage reference continues normal operation in low power modes (suspend and power off). Therefore, if the voltage reference is enabled during normal operation but is not required for low power operation, Digi recommends using the software to disable it before entering low power in order to minimize the power consumption, and re-enable it when resuming normal operation.

External 32KHz clock output

The MCA_CLKOUT32K pin is a 32.768 Hz square wave output that can be used as clock input by peripherals requiring a low-frequency, high-accuracy clock.

Note The 32KHz clock output continues normal operation in low power modes (suspend and power off). Therefore, if the 32KHz clock output is enabled during normal operation but is not required for low power operation, Digi recommends using the software to disable it before entering low power in order to minimize power consumption, and re-enable it when resuming normal operation.

Watchdog

The MCA implements a watchdog timer in its firmware. The MCA watchdog resets the system, or only the i.MX 8X CPU, if the software running on the main processor fails to execute properly and does not reset the watchdog timer on time.

The main features of the MCA watchdog include:

- Configurable timeout between 1 and 255 seconds.
- Configurable to generate interrupt or system reset.
- Configurable to generate full-system reset (including the MCA itself) or CPU-only reset. Full-system reset can include a PMIC off/on, depending on the device configuration.

See the [MCA software documentation](#) for additional information about how to configure and access the watchdog timer.

Real-time clock

The MCA implements a Real-Time Clock (RTC) in its firmware. The i.MX 8X CPU internal RTCs are disabled by default because the MCA RTC is preferred due to its superior power consumption efficiency. To preserve the date during power-off, you must connect a coin cell battery following the design notes provided in [System-on-module power rails distribution](#).

The main features of the MCA RTC include:

- Date/time registers to keep the system time (backed up by the coin cell battery).
- Programmable alarm to generate an interrupt. This alarm can be used to wake the system from low power modes (suspend and power off).

See the [MCA software documentation](#) for additional information about how to configure and access the watchdog timer.

Pulse width modulation

Pulse-width modulation (PWM) is a technique that modifies the duty cycle of a pulsing signal to encode information or to control the amount of energy provided to a charge. The MCA implements pulse-width modulation in its firmware.

The MCA on the ConnectCore 8X system-on-module provides three PWM controllers. Each controller has several channels and each channel maps to one MCA IO pin:

PWM controller	Number of channels	Channel	IO
PWM0	6	0	MCA_IO0
		1	MCA_IO12
		2	MCA_IO15
		3	MCA_IO16
		4	MCA_IO17
		5	MCA_IO18
PWM1	2	0	MCA_IO5
		1	MCA_IO6
PWM2	2	0	MCA_IO7
		1	MCA_IO8

On the ConnectCore 8X:

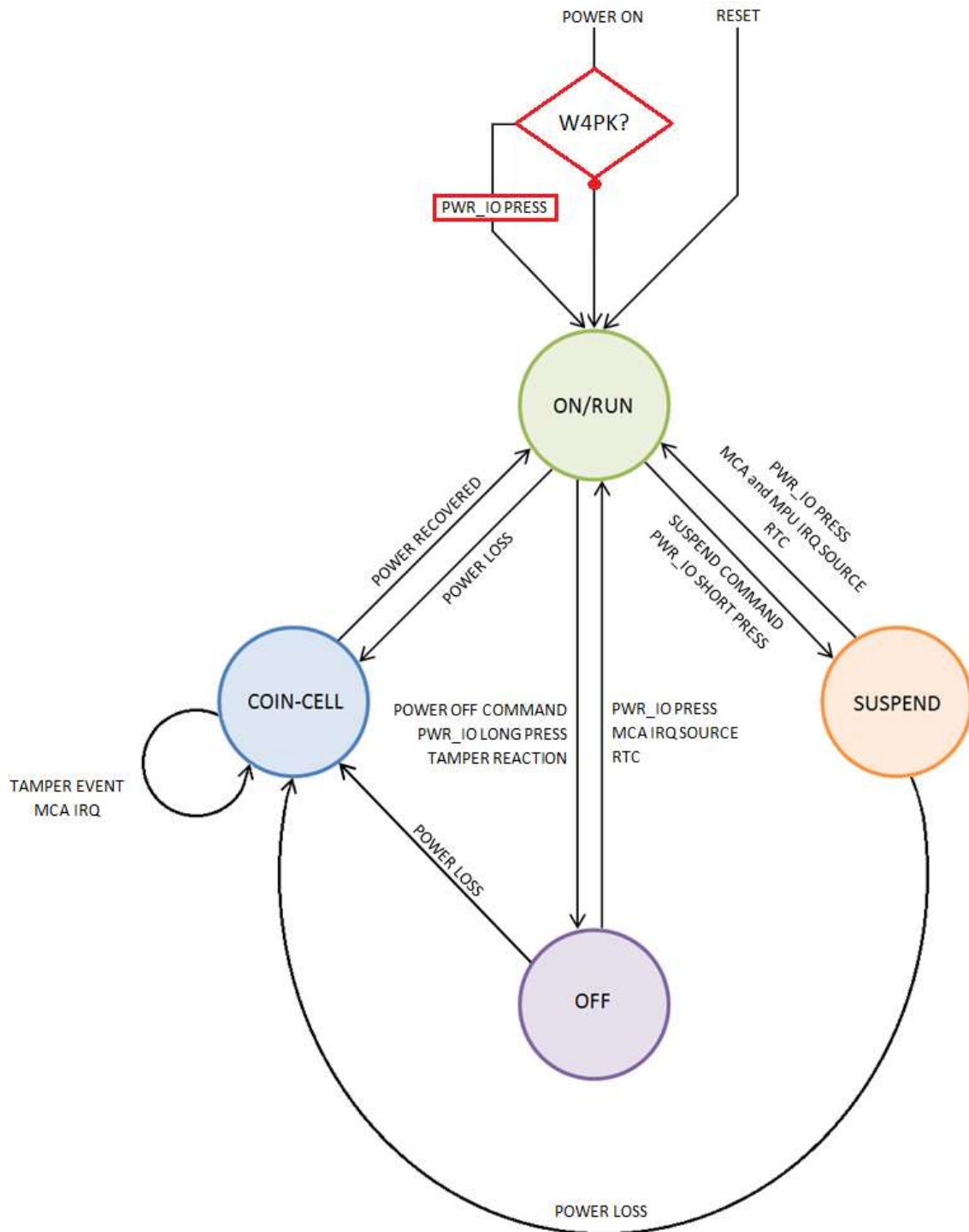
- All MCA PWM channels are available on the LGA pads.
- PWM0 channel 0 is available on the castellated pads.
- PWM1 channels 0 and 1 are available on the castellated pads.
- PWM2 channels 0 and 1 are available on the castellated pads.

Power management

The MCA plays a key role in the power management activities of the ConnectCore 8X module. In cooperation with the i.MX 8X processor, the MCA controls the power states of the PMIC and provides multiple wake up sources to transition between power modes. It also allocates dedicated signals to capture power events and indicate the system power state, allowing you to control external power sources and indicators.

Power modes

The module provides four different power operating modes: ON/RUN, OFF, SUSPEND, and COIN-CELL. The following figure shows the state diagram and the events to switch between states.



W4PK mode

You can configure boot mode using the **mca_config_tool -boot_mode** option.

If 'boot on power' (BOP) is chosen, the module will enter in ON state as soon as power is applied.