Modules

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Product Technical Specification

EM8695

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Sierra Wireless

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Contact Information

Sales information and technical support, including warranty and returns	Web: sierrawireless.com/company/contact-us/ Global toll-free number: 1-877-687-7795 6:00 am to 5:00 pm PST
Corporate and product information	Web: sierrawireless.com

Revision History

For revision history details, see Appendix H: Revision History on page 82.

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1: Introduction

The Semtech EM8695 Embedded Module is a FirstNet-ready (B14 LTE) M.2 module that provides 5G Sub-6 (FR1) SA (standalone), LTE and GNSS connectivity for notebooks, ultrabooks, tablet computers, and M2M applications over several radio frequency bands.

1.1 Supported RF bands

The module, based on Qualcomm's SDX35 baseband processor, supports data operation on 5G Sub-6 and LTE networks over the bands described in Table 1-1.

Table 1-1: Supported RF Bands

RAT	Bands																															
	1	2	3	4	5	7	8	12	13	14	17	18	19	20	25	26	28	30	34	38	39	40	41	42	43	48	66	70	71	77	78	79	106
5G Sub-6[a]	F	F	F	–	F	F	F	F	F	F	–	F	–	F	F	F	F	F	–	T	–	T	T	–	–	T	F	F	F	T	T	T	–
LTE[b]	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	T	T	T	T	T	T	T	T	F	F	F	–	–	–	F

a. (5G Sub-6) Downlink MIMO support (2x2, 4x2) F=FDD; T=TDD
Data rates: Downlink (256QAM=223 Mbps), Uplink (256QAM=123 Mbps)
b. (LTE) Downlink MIMO support (2x2, 4x2) F=FDD; T=TDD
Data rates: Downlink (Cat 4, 256QAM=200 Mbps), Uplink (Cat 4, 256QAM=105 Mbps)

Table 1-2: GNSS Frequency Support

Supported GNSS Bands	Satellite System Bands within GNSS Bands			
	GPS / QZSS	GLONASS	Galileo	BeiDou
L1	L1 (1575.42 MHz)	G1 (1602 MHz)	E1 (1575.42 MHz)	B1C (1575.420_Mhz)[a] B1I (1561.098 MHz)
L5[b]	L5 (1176.45 MHz)	–	E5a (1176.45 MHz)	B2a (1176.45 MHz)

a. BeiDou B1C is a BDS-3 signal that is compatible with GPS L1 and Galileo E1.
b. The GNSS L1 signal (L1 / E1 / B1I) is required for decoding the GNSS L5 signal (L5 / E5a / B2a).

1.2 Mechanical Features

- M.2 form factor:
  - WWAN Type 3042-S3-B (in Socket 2 Port Configuration 2) with length of 42 mm, as specified in *[6] PCI Express NGFF (M.2) Specification Revision 5.1*.
  - Conforms to M.2 form factor width specification. For more details, see Figure 6-1 on page 56.
  - Input voltage per M.2 specification

Note: Any variations from the M.2 specification are detailed in this document.

- Ambient operating temperature range with appropriate heatsinking:
  - Class A (3GPP compliant): -30°C to +70°C
  - Class B (operational, non-3GPP compliant): -40°C to +85°C (reduced operating parameters required)

Important: *The internal module temperature (reported by AT!PATEMP?) must be kept below 108°C. For best performance, the internal module temperature should be kept below 100°C. Proper mounting, heat sinks, and active cooling may be required, depending on the integrated application.*

1.3 Host Interface Features

Operating system support

- Windows 10, Windows 11
- Linux (MBPL)
- Android (MBPA)

To obtain the appropriate operating system-specific mobile broadband package (MBP), contact your Sierra Wireless representative.

USB Interface

- USB 2.0 High-Speed — Maximum 16 USB endpoints (8 in/8 out)
- USB device power state support — D0, D2
- USB network interface — MBIM, QMI
- USB GNSS interface — Windows location sensor driver, AT GNSS commands, and QMI interface
- USB serial port — Modem AT command set (3GPP TS 27.007), plus Sierra Wireless proprietary extended AT commands (*[1] EM8695 AT Command Reference (Doc# 41114815)*)
- Debug interface — Diagnostics Monitor (DM) port that generates serial port logs used for debugging
- Configurable USB composite interface — Enable/disable specific interfaces via AT or QMI commands

1.4 Modem Features

- 5G NR-Light (Reduced capability) Sub-6 GHz and LTE Cat 4 operation
- Multiple (up to 16) cellular packet data profiles
- SIM Toolkit and Proactive SIM commands
- Enhanced Operator Name String (EONS)
- Mobile-originated PDP context activation/deactivation
- Quality of Service (QoS) and QCI support
- IP address support: Static, Dynamic
- Authentication protocols: PAP and CHAP support
- PDP context types: IPv4, IPv6, IPv4v6

- Header compression — Implements RFC1144 for TCP/IP header compression, optimizing data transmission by reducing header size
- Secure boot (see Security Considerations)
- Public Safety and 3GPP compliance — Complies with 3GPP Release 12
- Emergency Alert systems support:
    - CMAS (Federal Commercial Mobile Alert System)
    - ETWS (Earthquake and Tsunami Warning System)
- Multiple PDN connections

1.5 5G Sub-6 Features

- Supported frequency ranges — FR1
- Supports NR SA 20 MHz 1CC
- Network option: Standalone (SA) Option 2
- Release-17 RedCap:
    - Dedicated RedCap bandwidth part (BWP) with NCD-SSB
    - RACH with initial RedCap BWP
    - TDD (Release-17 RedCap only);
      FDD (Release-17 RedCap, with fallback to Release-16/Release-15 if cellular network does not support Release-17 RedCap)
- Modulation schemes:
    - Uplink (UL): QPSK, 16 QAM, 64 QAM, 256 QAM
    - Downlink (DL): QPSK, 16 QAM, 64 QAM, 256 QAM
- Network slicing

1.6 LTE Features

- LTE Advanced receivers
- Basic cell selection and system acquisition
    - PSS/SSS/MIB decode
    - SIB1–SIB16 decoding
- NAS/AS security procedures
- Modulation schemes:
    - Uplink (UL): QPSK, 16 QAM, 64 QAM, 256 QAM
    - Downlink (DL): QPSK, 16 QAM, 64 QAM, 256 QAM
- CQI/RI/PMI reporting
- Paging procedures
    - Paging in Idle and Connected mode
- Dedicated bearer management:
    - Network-initiated dedicated bearer
    - UE-initiated dedicated bearer
- Connected Mode Intra-LTE Mobility
- Idle Mode Intra-LTE Mobility
- Detach procedure:
    - Network-initiated detach with reattach required
    - Network-initiated detach followed by connection release

1.7 Short Message Service (SMS) Features

- Mobile-originated and mobile-terminated SMS over IMS
- Mobile-originated and mobile-terminated SMS over SGs
- Wake on SMS

1.8 Position Location (GNSS)

- High-precision GNSS with L1 plus optional L5
- Customizable tracking sessions
- Automatic tracking session on startup
- Concurrent standalone GNSS support: GPS, GLONASS, Galileo, BeiDou
- Regional Navigation Satellite System (RNSS) support: QZSS, NavIC
- Assisted GPS (A-GPS) SUPL1.0
- Assisted GPS/GLONASS SUPL2.0
- gpsOneXTRA 3.1 (GPS+GLO+BDS+GAL+QZSS) with XTRA Client 3.5

1.9 Supporting Documents

Several additional documents describe module design, usage, integration, and other features. See References on page 74.

1.10 Accessories

A hardware development kit (part #6001173) is available for Semtech M.2 modules. The kit contains hardware components for evaluating and developing with the module, including:

- Development board
- Cables
- Antennas
- Other accessories

For details, refer to *[2] AirPrime EM Series USB3.0 (M.2) Development Kit User Guide (Doc# 5303013)*.

For over-the-air LTE testing, ensure that suitable antennas are used.

1.11 Required Connectors

Table 1-3 describes the connectors used to integrate the EM8695 Embedded Module into your host device.

Table 1-3: Required Host-Module Connectors[a]

Connector type	Description
RF cables — LTE/GNSS	▪ Mate with M.2-spec connectors ▪ Three connector jacks (mate with I-PEX 20448-001R-081 or equivalent)

Table 1-3: Required Host-Module Connectors[a] (Continued)

Connector type	Description
M.2 (Slot B-compatible) 67-pin edge connector	▪ Slot B compatible — Per the M.2 standard (*[6] PCI Express NGFF (M.2) Specification Revision 5.1*), a generic M.2 Slot B-compatible edge connector on the motherboard uses a mechanical key to mate with the 67-pin notched module connector. ▪ Manufacturers include LOTES (part #APCI0018-P001A01), Kyocera, JAE, Tyco, and Longwell.
SIM	▪ Industry-standard connector. See SIM Interface on page 26 for details.

a. Manufacturers / part numbers are for reference only and are subject to change. Choose connectors that are appropriate for your own design.

1.12 Integration Guidance

When integrating the EM8695 Embedded Module, the following items, if applicable, must be considered:

- **Mounting** — Effect on temperature, shock, and vibration performance
- **Power supply** — Impact on battery drain and possible RF interference
- **Antenna location and type** — Impact on RF performance
- **Regulatory approvals** — As discussed in Regulatory Compliance and Industry Certifications on page 59.
- **Service provisioning** — Manufacturing process
- **Software** — As discussed in Software on page 54.
- **Host interface** — Compliance with interface voltage levels

1.13 Security Considerations

EM8695 modules incorporate the following permanently enabled features to enhance device security:

- Secure Boot — Ensures only firmware images signed by Sierra Wireless can be loaded and run on EM8695 modules; unauthorized code cannot be running on the module.

  Specifically, Secure Boot applies to the following firmware components: system bootloader, carrier configuration, and firmware.
- Secure Debug — Disable debug features such as RAM dump collection and JTAG.

2: Electrical Specifications

The system block and RF block diagrams in Figure 2-1 on page 16 and Figure 2-2 on page 16 represent the EM8695 module integrated into a host system.

The module includes the following interfaces to the host:

- Full_Card_Power_Off_N—Active-low input from the host—Low turns the module off, high turns the module on.
- W_DISABLE_N—Active low input from the host—Low disables the main RF radio.
- GPS_DISABLE_N—Active low input from the host—Low disables the GNSS radio receiver.
- WAKE_ON_WAN_N—Active low output to the host—Low wakes the host when specific events occur.
- WWAN_LED_N—Active low LED drive signal provides an indication of WAN radio ON state.
- RESET_N—Active low input from the host—Low resets the module.
- Antenna—Three 5G Sub-6/LTE RF connectors (Main (Rx/Tx), Auxiliary (diversity), and dedicated GNSS (GNSS L1/L5, supporting passive GNSS antennas). For GNSS L1/L5 support, see Table 1-2 on page 10.

  For additional details, see RF Specifications on page 34.
- Antenna control signals: ANT_CTRL0, ANT_CTRL1—External GPIO antenna tuner interface signals
- Dynamic power control (DPR)—Signal used to adjust Tx power to meet FCC SAR requirements. For details, see Tx Power Control on page 53.).
- Dual SIM— Supported through the interface connector. The SIM cavities/connectors must be placed on the host device for this feature. Supports Dual SIM Single Standby (DSSS).
- SIM detect—Internal pull-up on the module detects whether a SIM is present or not:
  - If a SIM is not inserted, the pin must be shorted to ground.
  - If a SIM is present, the pin will be an open circuit.
- USB—USB 2.0 interface to the host for data, control, and status information.

The EM8695 module has two main interface areas—the host I/O connector and the RF ports. Details of these interfaces are described in the sections that follow.

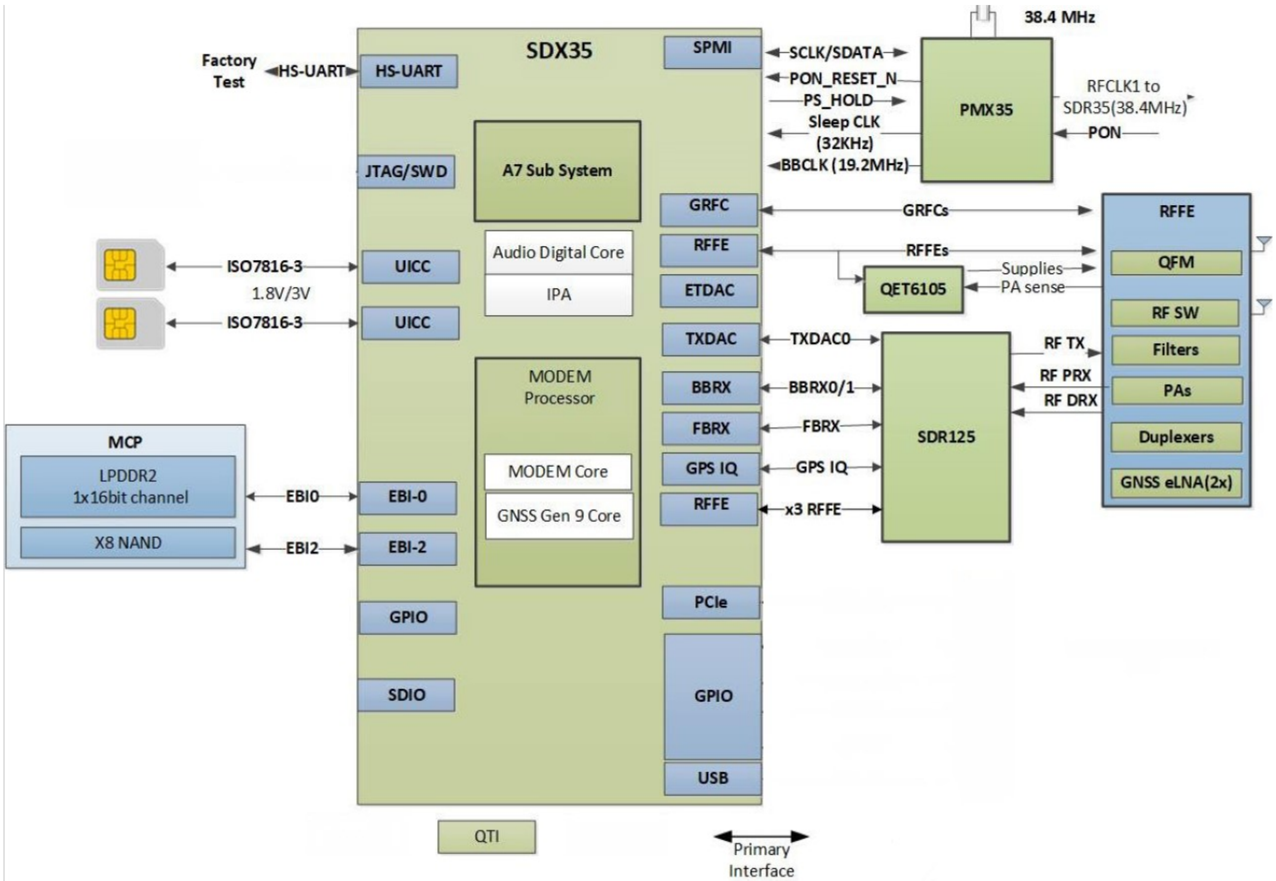
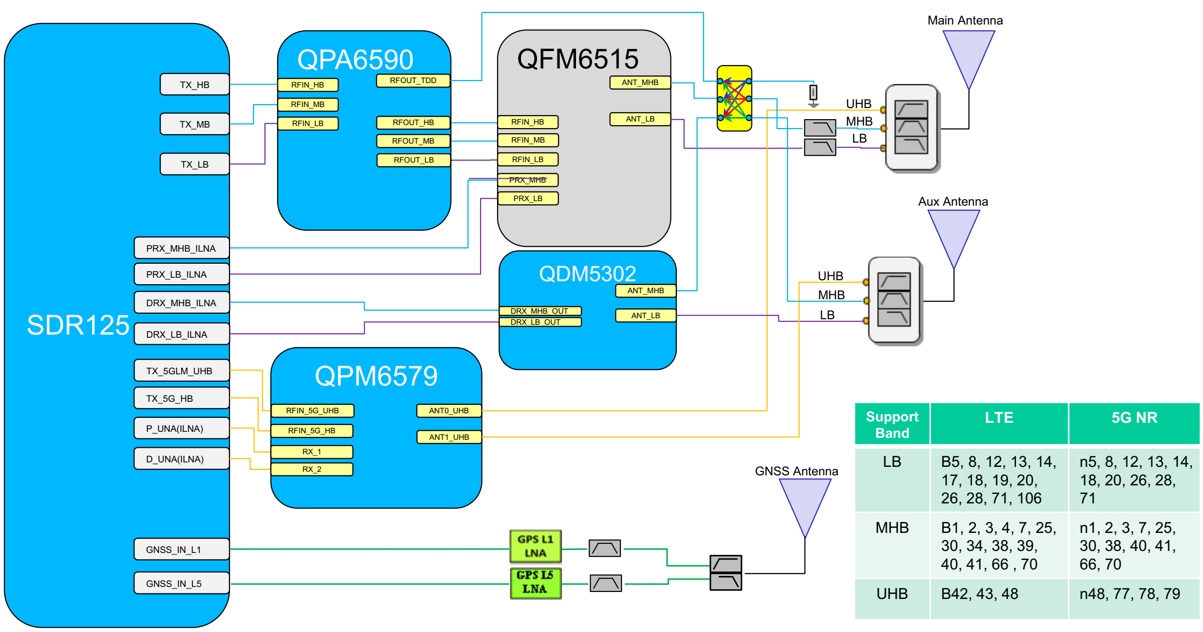


Figure 2-1: System Block Diagram



Support Band	LTE	5G NR
LB	B5, 8, 12, 13, 14, 17, 18, 19, 20, 26, 28, 71, 106	n5, 8, 12, 13, 14, 18, 20, 26, 28, 71
MHB	B1, 2, 3, 4, 7, 25, 30, 34, 38, 39, 40, 41, 66 , 70	n1, 2, 3, 7, 25, 30, 38, 40, 41, 66, 70
UHB	B42, 43, 48	n48, 77, 78, 79

Figure 2-2: RF Block Diagram

2.1 M.2 (Host) Interface Pin Assignments

The EM8695 module's host I/O connector provides pins for power, serial communications, and control. Pin assignments are listed in Table 2-1.

Refer to the following tables for pin details based on interface types:

- Table 2-3, Power and Ground Specifications, on page 25
- Table 2-4, USB Interface, on page 26
- Table 2-5, SIM Interface Signals, on page 27
- Table 2-6, Module Control Signals, on page 30

Note: On any given interface (USB, SIM, etc.), leave unused inputs and outputs as no-connects.

Note: The host should not drive any signals to the module until > 100 ms from the start of the power-on sequence.

Table 2-1: Host Interface (75-pin) Connections — Module View[a]

Pin	Signal name	Pin type[b]	Description	Direction[c]	Active state	Voltage levels (V)		
						Min	Typ	Max
1	CONFIG_3		No connect					
2	VCC[d]	V	Power source	Input	Power	3.135	3.3	4.4
3	GND	V	Ground	Input	Power	–	0	–
4	VCC[d]	V	Power source	Input	Power	3.135	3.3	4.4
5	GND	V	Ground	Input	Power	–	0	–
6	Full_Card_Power_Off_N[e]	PD	Turn modem off	Input	Low	-0.3	–	0.54
			Turn modem on	Input	High	1.26	–	3.6
7	USB_D+[e]	-	USB 2.0 HS data positive	Input/Output	Differential	–	–	–
8	W_DISABLE_N[f]	PU	Wireless Disable (WWAN radio)	Input	Low	-0.5	–	0.8
				Input	High	2.0	–	4.4
9	USB_D-[e]	-	USB 2.0 HS data negative	Input/Output	Differential	–	–	–

Table 2-1: Host Interface (75-pin) Connections — Module View[a] (Continued)

Pin	Signal name	Pin type[b]	Description	Direction[c]	Active state	Voltage levels (V)		
						Min	Typ	Max
10	WWAN_LED_N	OD	LED Driver	Output	Low	–	0	–
11	GND	V	Ground	Input	Power	–	0	–
12	Key	Notch location						
13	Key	Notch location						
14	Key	Notch location						
15	Key	Notch location						
16	Key	Notch location						
17	Key	Notch location						
18	Key	Notch location						
19	Key	Notch location						
20	NC							
21	CONFIG_0		Ground	Output	–		0	
22	NC							
23	WAKE_ON_WAN_N[e]	OD	Wake Host	Output	Low		0	
24	NC							
25	DPR	-	Dynamic power control	Input	Low	-0.3	–	0.54
				Input	High	1.26	1.80	2.1
26	GPS_DISABLE_N[f]	PU	Wireless disable (GNSS radio)	Input	Low	-0.5	–	0.8
				Input	High	2.0	–	4.4
27	GND	V	Ground	Input	Power	–	0	–
28	PLA_S2_N	O	Power loss acknowledge	Output	High	1.35	–	1.80
					Low	0	–	0.45

Table 2-1: Host Interface (75-pin) Connections — Module View[a] (Continued)

Pin	Signal name	Pin type[b]	Description	Direction[c]	Active state	Voltage levels (V)		
						Min	Typ	Max
29	NC							
30	UIM1_RESET[e]	O	SIM Reset	Output	Low	0	–	0.4
					High	2.36 (3V SIM) 1.44 (1.8V SIM)	2.95 (3V SIM) 1.80 (1.8V SIM)	3.05 (3V SIM) 1.95 (1.8V SIM)
31	NC							
32	UIM1_CLK[e]	O	SIM Clock	Output	Low	0	–	0.4
					High	2.36 (3V SIM) 1.44 (1.8V SIM)	2.95 (3V SIM) 1.80 (1.8V SIM)	3.05 (3V SIM) 1.95 (1.8V SIM)
33	GND	V	Ground	Input	Power	–	0	–
34	UIM1_DATA[e]	PU	SIM I/O pin	Input	Low	-0.30 (3V SIM) -0.30 (1.8V SIM)	–	0.60 (3V SIM) 0.35 (1.8V SIM)
					High	2.10 (3V SIM) 1.26 (1.8V SIM)	2.95 (3V SIM) 1.80 (1.8V SIM)	3.35 (3V SIM) 2.10 (1.8V SIM)
				Output	Low	0	–	0.4
					High	2.36 (3V SIM) 1.44 (1.8V SIM)	2.95 (3V SIM) 1.80 (1.8V SIM)	3.05 (3V SIM) 1.95 (1.8V SIM)
35	NC							
36	UIM1_PWR[e]	V	SIM VCC supply	Output	Power	2.7 (3V SIM) 1.65 (1.8V SIM)	2.95 (3V SIM) 1.80 (1.8V SIM)	3.05 (3V SIM) 1.95 (1.8V SIM)
37	NC							
38	NC							
39	GND	V	Ground	Input	Power	–	0	–
40	SIM_DETECT_2	PU	SIM2 indication	Input		0 V — SIM not present Open circuit — SIM present		

Table 2-1: Host Interface (75-pin) Connections — Module View[a] (Continued)

Pin	Signal name	Pin type[b]	Description	Direction[c]	Active state	Voltage levels (V)		
						Min	Typ	Max
41	NC							
42	UIM2_DATA[e]	PU	SIM2 IO pin	Input	Low	-0.30 (3V SIM) -0.30 (1.8V SIM)	–	0.60 (3V SIM) 0.35 (1.8V SIM)
					High	2.10 (3V SIM) 1.26 (1.8V SIM)	2.95 (3V SIM) 1.80 (1.8V SIM)	3.35 (3V SIM) 2.10 (1.8V SIM)
				Output	Low	0	–	0.4
					High	2.36 (3V SIM) 1.44 (1.8V SIM)	2.95 (3V SIM) 1.80 (1.8V SIM)	3.05 (3V SIM) 1.95 (1.8V SIM)
43	NC							
44	UIM2_CLK[e]	O	SIM2 Clock	Output	Low	0	–	0.4
					High	2.36 (3V SIM) 1.44 (1.8V SIM)	2.95 (3V SIM) 1.80 (1.8V SIM)	3.05 (3V SIM) 1.95 (1.8V SIM)
45	GND	V	Ground	Input	Power	–	0	–
46	UIM2_RESET_N[e]	O	SIM2 Reset	Output	Low	0	–	0.4
					High	2.36 (3V SIM) 1.44 (1.8V SIM)	2.95 (3V SIM) 1.80 (1.8V SIM)	3.05 (3V SIM) 1.95 (1.8V SIM)
47	Reserved		Reserved *Note: Leave pin floating on host side.*					
48	UIM2_PWR[e]	V	SIM2 VCC supply	Output	Power	2.7 (3V SIM) 1.65 (1.8V SIM)	2.95 (3V SIM) 1.80 (1.8V SIM)	3.05 (3V SIM) 1.95 (1.8V SIM)
49	Reserved		Reserved *Note: Leave pin floating on host side.*					
50	Reserved		Reserved *Note: Leave pin floating on host side.*					

Table 2-1: Host Interface (75-pin) Connections — Module View[a] (Continued)

Pin	Signal name	Pin type[b]	Description	Direction[c]	Active state	Voltage levels (V)		
						Min	Typ	Max
51	GND	V	Ground	Input	Power	–	0	–
52	Reserved		Reserved *Note: Leave pin floating on host side.*					
53	Reserved		Reserved *Note: Leave pin floating on host side.*					
54	Reserved		Reserved *Note: Leave pin floating on host side.*					
55	Reserved		Reserved *Note: Leave pin floating on host side.*					
56	NC							
57	GND	V	Ground	Input	Power	–	0	–
58	NC							
59	ANT_CTRL0		External GPIO antenna tuner control	Output	Low	0	–	0.45
					High	1.35	–	1.80
60	NC							
61	ANT_CTRL1		External GPIO antenna tuner control	Output	High	1.35	–	1.80
					Low	0	–	0.45
62	Reserved		Reserved *Note: Leave pin floating on host side.*					
63	NC							
64	Reserved		Reserved *Note: Leave pin floating on host side.*					
65	NC							

Table 2-1: Host Interface (75-pin) Connections — Module View[a] (Continued)

Pin	Signal name	Pin type[b]	Description	Direction[c]	Active state	Voltage levels (V)		
						Min	Typ	Max
66	SIM1_DETECT[e]	PU	SIM indication	Input		0 V — SIM not present Open circuit — SIM present		
67	RESET_N	PU	Reset module	Input	Low	-0.3	–	0.54
68	NC							
69	CONFIG_1		Ground	Output	–		0	
70	VCC[d]	V	Power source	Input	Power	3.135	3.3	4.4
71	GND	V	Ground	Input	Power	–	0	–
72	VCC[d]	V	Power source	Input	Power	3.135	3.3	4.4
73	GND	V	Ground	Input	Power	–	0	–
74	VCC[d]	V	Power source	Input	Power	3.135	3.3	4.4
75	CONFIG_2	V	No connect	Output	–	–		–

a. All values are preliminary and subject to change.
b. I — Input; O — Digital output; OC — Open Collector output; OD — Open Drain; PU — Digital input (internal pull-up); PD — Digital input (internal pull-down); V — Power or ground
c. Signal directions are from module's point of view (e.g. 'Output' from module to host, 'Input' to module from host.)
d. The host product with an embedded EM8695 module must include a VCC bypass capacitor on the VCC pins. For details, see Appendix 2.2 VCC Bypass Capacitor (Host product requirement) on page 23.
e. Required signal
f. Semtech recommends that the host implement an open collector driver where a Low signal will turn the module off or enter low power mode, and a high signal will turn the module on or leave low power mode.

2.2 VCC Bypass Capacitor (Host product requirement)

Due to characteristics of the EM8695 module's internal PA, the host product with an embedded EM8695 module must include a VCC bypass capacitor to sink the module's inrush current.

The bypass capacitor must be placed close to the VCC pins — pins 2, 3, 70, 72, 74). For details, see Figure 2-3 on page 23.

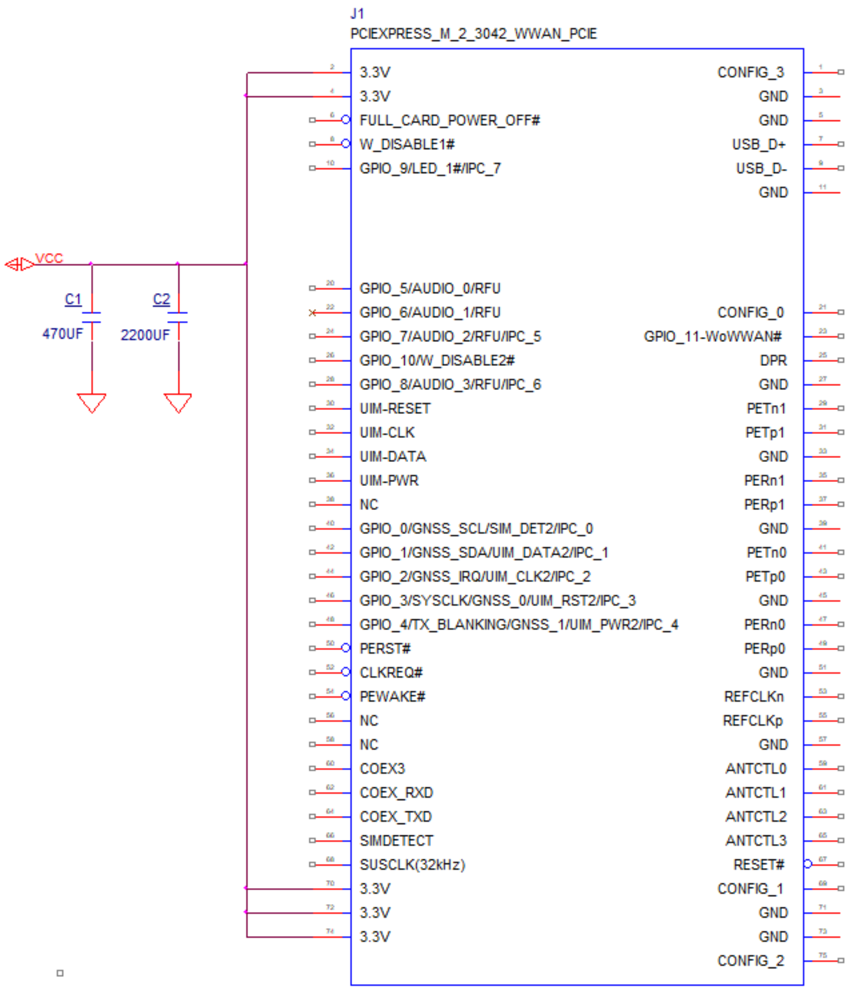


Figure 2-3: M.2 module VCC pins

Aluminum type or low ESR capacitors can lower the inrush current sink and improve EM8695 stability — Table 2-2 on page 24 describes recommended VCC bypass capacitors.

Table 2-2: Recommended VCC Bypass Capacitors

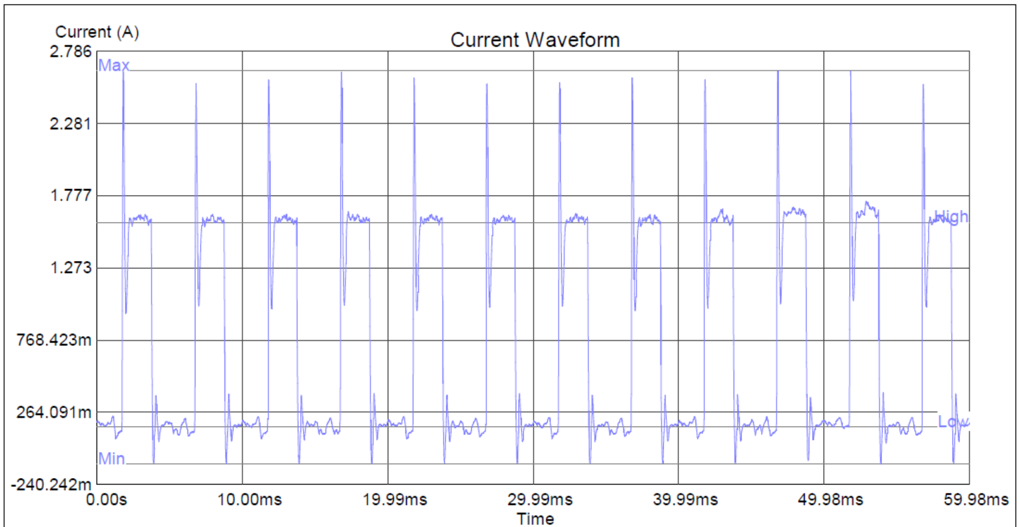
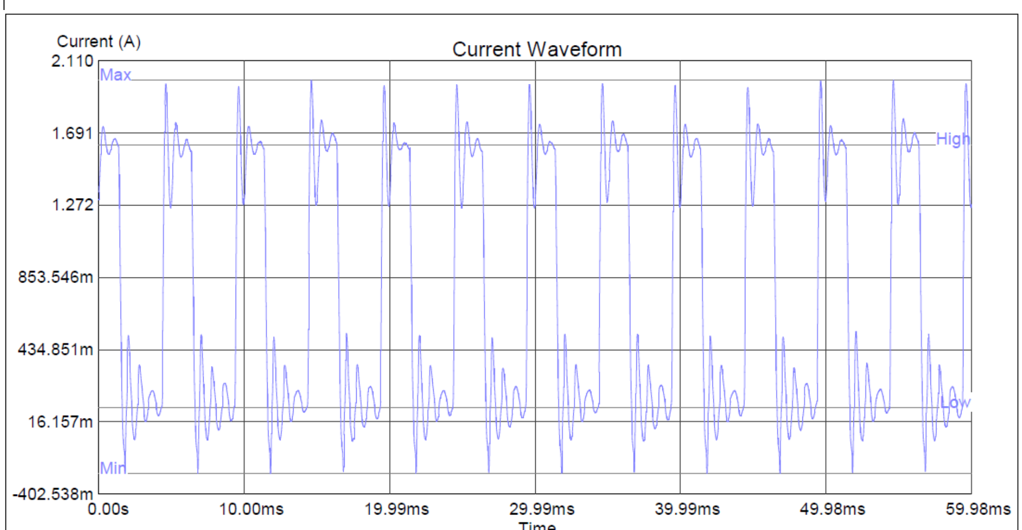
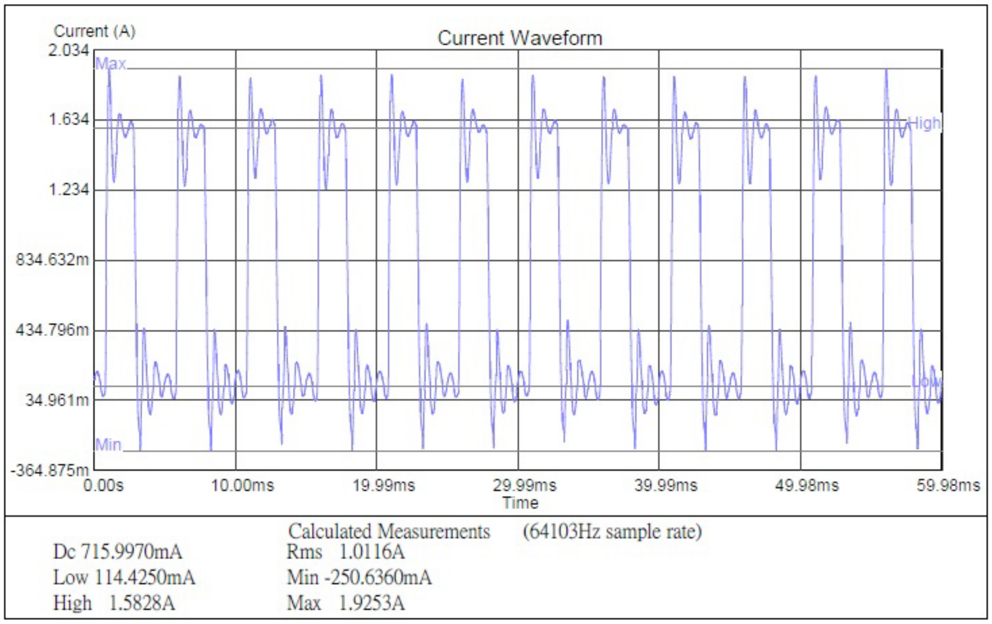
Capacitor type	Peak current	Details
470 µF aluminum capacitor	2.7 A	 Calculated Measurements (64103Hz sample rate) Dc 742.3620mA Rms 1.0361A Low 160.8070mA Min -96.1469mA High 1.5901A Max 2.6485A *Figure 2-4: Current Waveform — Peak current with 470µF aluminum capacitor*
2200 µF aluminum capacitor	2 A	 Calculated Measurements (64103Hz sample rate) Dc 728.4680mA Rms 1.0360A Low 97.3686mA Min -282.9110mA High 1.6206A Max 1.9957A *Figure 2-5: Current Waveform — Peak current with 2200µF aluminum capacitor*

Table 2-2: Recommended VCC Bypass Capacitors (Continued)

Capacitor type	Peak current	Details
470+2200 µF aluminum capacitor	1.95 A	 *Figure 2-6: Current Waveform—Peak current with 470+2200µF aluminum capacitor*

2.3 Power Supply

The host provides power to the EM8695 module through multiple power and ground pins as summarized in Table 2-3.

The host must provide safe and continuous power (via battery or a regulated power supply) at all times; the module does not have an independent power supply, or protection circuits to guard against electrical issues.

Table 2-3: Power and Ground Specifications

Name	Pins	Specification	Min	Typ	Max	Units
VCC (3.3V)	2, 4, 70, 72, 74	Voltage range	See Table 2-1			
		Ripple voltage	-	-	100	mV_{pp}
GND	3, 5, 11, 27, 33, 39, 45, 51, 57, 71, 73	-	-	0	-	V

2.4 USB High Speed Interface

Important: *Host support for USB 2.0 signals is required.*

The EM8695 module supports a USB 2.0 high speed (HS) interface for communication between the host and module.

Note: USB2.0 high speed only. USB full speed and low speed are not supported.

The USB interface complies with the *[7] Universal Serial Bus Specification, Rev 2.0* (subject to limitations described below), and the host platform must be designed to the same standards.

Table 2-4: USB Interface

	Name	Pin	Description
USB 2.0	USB_D+	7	(USB 2 High speed) Data positive
	USB_D-	9	(USB 2 High speed) Data negative

2.5 SIM Interface

Note: Host support for SIM interface signals is required.

The module supports up to two SIMs (Subscriber Identity Module) (1.8 V or 3 V) via the UIM1 and UIM2 interfaces:

- UIM1 (primary) interface—Supports an external plastic SIM.
- UIM2 (secondary) interface—Supports a second SIM. Depending on the SKU, this will be an external plastic SIM or an embedded consumer eUICC (eSIM).

Note: The UIM2 SIM type cannot be changed via software configuration.

Each SIM holds information for a unique account, allowing users to optimize their use of each account on multiple devices.

The SIM pins (Table 2-5 on page 27) provide the connections necessary to interface to external SIM sockets located on the host platform as shown in Figure 2-7 on page 28.

Voltage levels over this interface comply with 3GPP standards.

The SIM connector types used depend on how the host platform exposes the SIM sockets.

Table 2-5: SIM Interface Signals

SIM	Name	Pin	Description	SIM contact[a]	Notes
UIM1 (Primary)	UIM1_RESET	30	Reset	2	Active low SIM reset
	UIM1_CLK	32	Serial clock	3	Serial clock for SIM data
	UIM1_DATA	34	Data I/O	7	Bi-directional SIM data line
	UIM1_PWR	36	SIM voltage	1	Power supply for SIM
	SIM_DETECT	66	SIM indication	–	Input from host indicating whether SIM is present or not ▪ Grounded if no SIM is present ▪ No-connect (floating) if SIM is inserted
	UIM_GND		Ground	5	Ground reference UIM_GND is common to module ground
UIM2 (Secondary)	UIM2_RESET	46	Reset	2	Active low SIM reset
	UIM2_CLK	44	Serial clock	3	Serial clock for SIM data
	UIM2_DATA	42	Data I/O	7	Bi-directional SIM data line
	UIM2_PWR	48	SIM voltage	1	Power supply for SIM
	SIM_DETECT_2	40	SIM indication	–	Input from host indicating whether SIM is present or not ▪ Grounded if no SIM is present ▪ No-connect (floating) if SIM is inserted
	UIM2_GND		Ground	5	Ground reference UIM2_GND is common to module ground

a. See Figure 2-8 on page 28 for SIM card contacts.

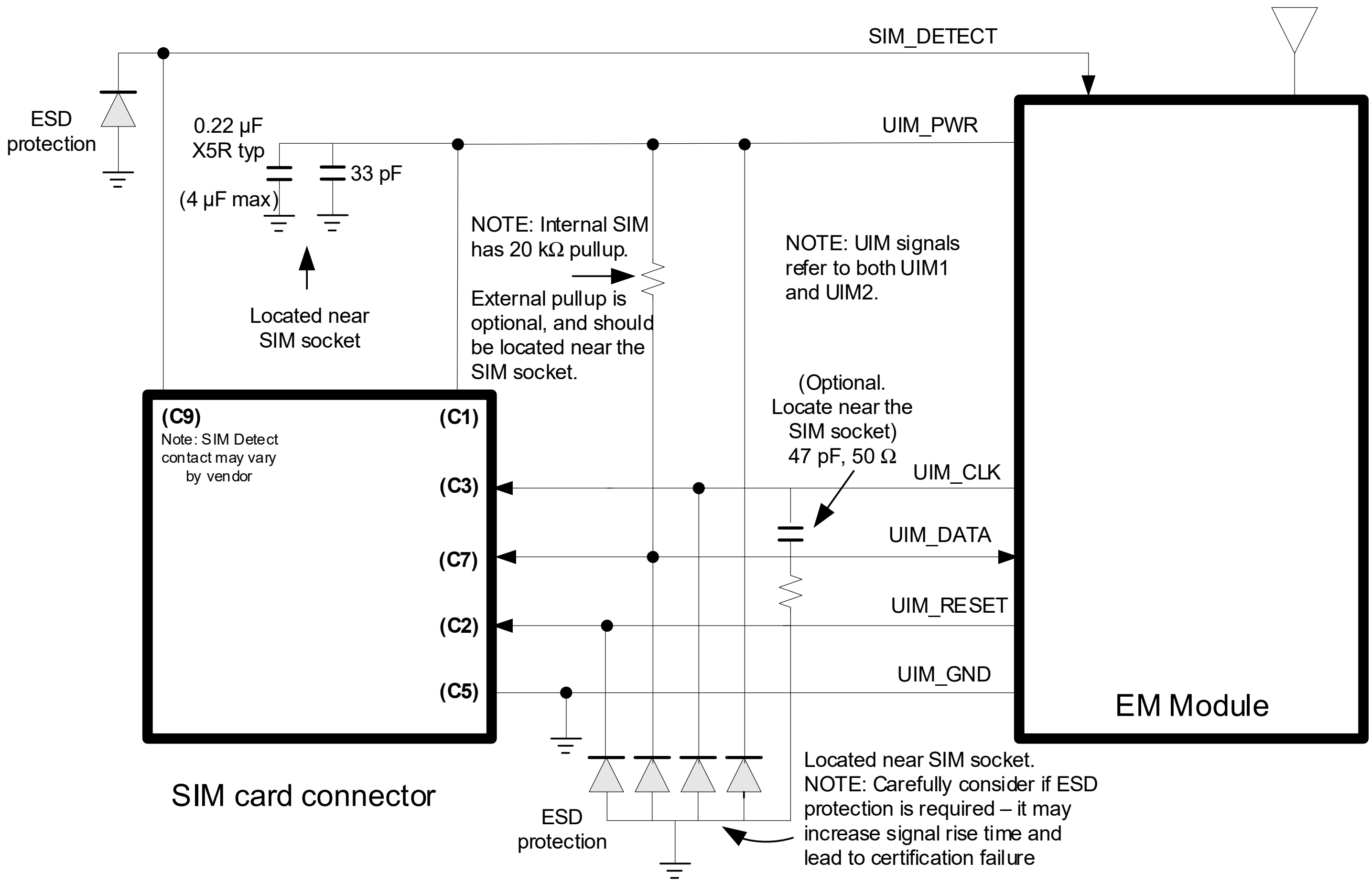


Figure 2-7: SIM Application Interface (applies to both SIM interfaces)

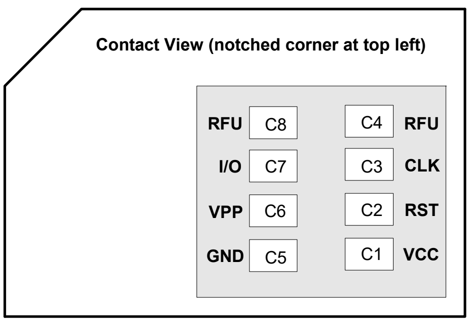


Figure 2-8: SIM Card Contacts (Contact View)

2.5.1 SIM Implementation

Note: For interface design requirements, refer to ETSI TS 102 230 V5.5.0, section 5.2.

When designing the remote SIM interface, you must make sure that SIM signal integrity is not compromised.

Some design recommendations include:

- Total impedance of the VCC and GND connections to the SIM, measured at the module connector, should be less than 1 Ω to minimize voltage drop (includes any trace impedance and lumped element components—inductors, filters, etc.).
- Position the SIM connector ≤10 cm from the module. If a longer distance is required because of the host platform design, use a shielded wire assembly—connect one end as close as possible to the SIM connector and the other end as close as possible to the module connector. The shielded assembly may help shield the SIM interface from system noise.
- Reduce crosstalk on the UIM1_DATA and UIM2_DATA lines to reduce the risk of failures during GCF approval testing.
- Avoid routing the clock and data lines for each SIM (UIM1_CLK/UIM1_DATA, UIM2_CLK/UIM2_DATA) in parallel over distances >2 cm—cross-coupling of a clock and data line pair can cause failures.
- 3GPP has stringent requirements for I/O rise time (<1 μs), signal level limits, and noise immunity—consider this carefully when developing your PCB layout.
  - Keep signal rise time <1 μs—keep SIM signals as short as possible, and keep very low capacitance traces on the data and clock signals (UIM1_CLK, UIM1_DATA, UIM2_CLK, UIM2_DATA). High capacitance increases signal rise time, potentially causing your device to fail certification tests.
- Add external pull-up resistors (15 kΩ–30 kΩ), if required, between the data and power lines for each SIM (UIM1_DATA/UIM1_PWR, UIM2_DATA/UIM2_PWR) to optimize the signal rise time.
- VCC line should be decoupled close to the SIM socket.
- Make sure that placement and routing of SIM signals and connectors supports SIM clock rates up to 5 MHz (per 3GPP specification).
- You must decide whether additional ESD protection is required for your product, as it is dependent on the platform, mechanical enclosure, and SIM connector design. The SIM pins will require additional ESD protection if they are exposed to high ESD levels (i.e., can be touched by a user).
- Putting optional decoupling capacitors on the SIM power lines (UIM1_PWR, UIM2_PWR) near the SIM sockets is recommended—the longer the trace length (impedance) from the socket to the module, the greater the capacitance requirement to meet compliance tests.
- Putting an optional series capacitor and resistor termination (to ground) on the clock line (UIM1_CLK, UIM2_CLK) at the SIM socket to reduce EMI and increase signal integrity is recommended if the trace length between the SIM socket and module is long—a 47 pF capacitor and 50 Ω resistor are recommended.
- Test your first prototype host hardware with a Comprion IT^3 SIM test device at a suitable testing facility.

2.6 Control Interface (Signals)

The EM8695 module provides signals for:

- Waking the host when specific events occur
- Host platform control of the module's radios
- Host platform control of module power
- LED driver output (i.e., module status indication to host)
- Module status indication to host

Note: Host support for Full_Card_Power_Off_N is required, and support for other signals in Table 2-6 is optional.

These signals are summarized in Table 2-6 and the subsections that follow.

Table 2-6: Module Control Signals

Name	Pin	Description	Type[a]
Full_Card_Power_Off_N	6	On/off control	PD
W_DISABLE_N	8	Wireless disable (Main RF)	PU
WWAN_LED_N	10	LED driver	OD
WAKE_ON_WAN_N	23	Wake host	OD
GPS_DISABLE_N	26	Wireless disable (GNSS)	PU
PLA_S2_N	28	Power loss acknowledge	O
RESET_N	67	Reset module	PU

a. O — Digital pin Output; OD — Open Drain output; PD — Digital pin Input, internal pull-down; PU — Digital pin Input, internal pull-up

2.6.1 WAKE_ON_WAN_N — Wake Host

Note: Host support for WAKE_ON_WAN_N is optional.

The EM8695 module uses WAKE_ON_WAN_N to wake the host when specific events occur.

The host must provide a 5 kΩ–100 kΩ pull-up resistor that considers total line capacitance (including parasitic capacitance) such that when WAKE_ON_WAN# is deasserted, the line will rise to 3.3 V (Host power rail) in 100 ns.

See Figure 2-9 for a recommended implementation.

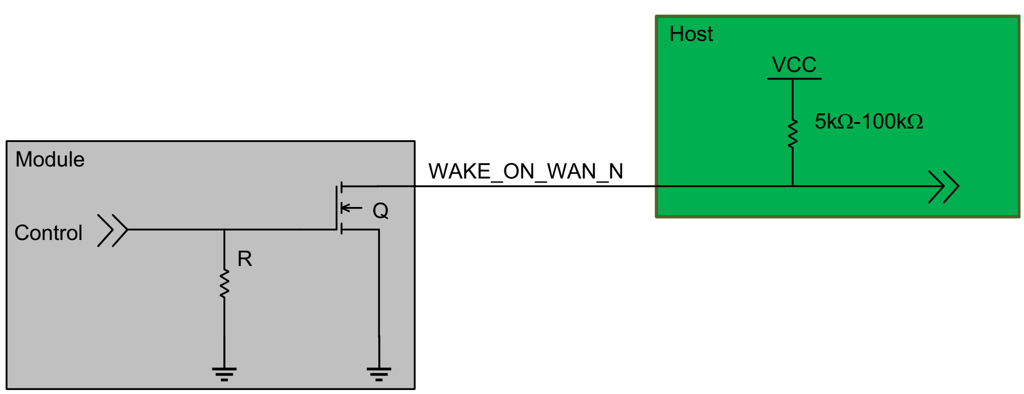


Figure 2-9: Recommended WAKE_ON_WAN_N host connection

2.6.2 W_DISABLE_N (Wireless Disable) and GPS_DISABLE_N (GNSS Disable)

Note: Host support for wireless/GNSS disable signals is optional.

The host platform can use W_DISABLE_N and GPS_DISABLE_N as follows:

- W_DISABLE_N — Control the radio state (enable / disable the WWAN or radio modem), or trigger a 'Dying Gasp' SMS when the platform is about to lose power.

Note: When the 'Dying Gasp' feature is enabled, W_DISABLE_N cannot be used to control the radio state. For details, refer to [1] EM8695 AT Command Reference (Doc# 41114815) topics for !CUSTOM="DGENABLE", !WDISABLE, and !PCINFO.

- GPS_DISABLE_N — Enable / disable GNSS functionality.

Letting these signals float high allows the module to operate normally. See Figure 2-10 for a recommended implementation.

When integrating with your host platform, keep the following in mind:

- The signal is an input to the module and should be driven LOW to turn the radio off, or HIGH to keep it on.
- If the host never needs to assert this power state control to the module, drive this signal HIGH to keep it on.

Table 2-7: W_DISABLE_N / GPS_DISABLE_N Usage

Name	Pin	Description / notes

W_DISABLE_N	8	Feature configuration (Dying Gasp)-dependent behavior:
		▪ If the Dying Gasp feature is disabled, enable / disable the WWAN or radio modem. When disabled, the modem cannot transmit or receive.
		  ▪ Keep modem always on — Drive HIGH.
		  ▪ Turn modem off — Drive LOW.
		or
		▪ If the Dying Gasp feature is enabled, trigger a 'Dying Gasp' SMS.

GPS_DISABLE_N	26	Enable / disable GNSS functionality ▪ Enable GNSS functionality — Drive HIGH. ▪ Disable GNSS functionality — Drive LOW. ▪ For details on enabling / disabling GNSS functionality, refer to the AT!CUSTOM="GPSENABLE" command in *[1] EM8695 AT Command Reference (Doc# 41114815)*.

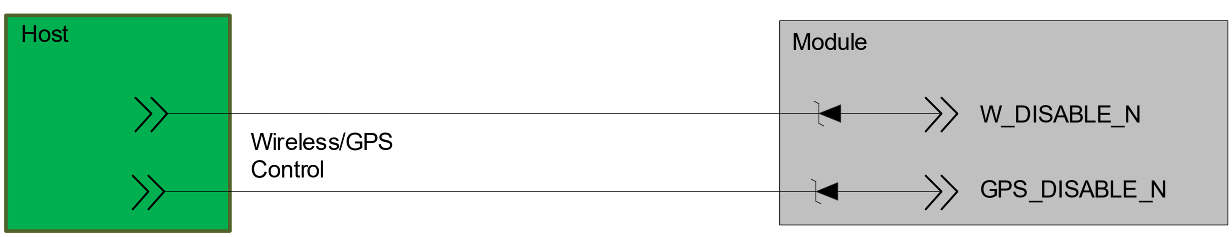


Figure 2-10: Recommended Wireless and GPS Disable Connections

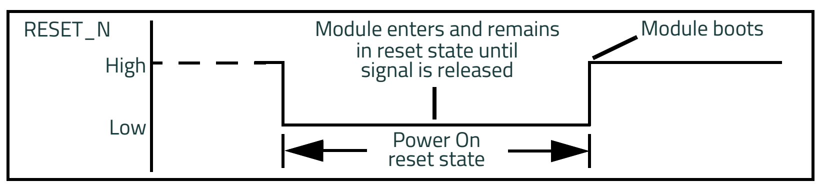
2.6.3 Full_Card_Power_Off_N and RESET_N

Note: Host support for Full_Card_Power_Off_N is required, and support for RESET_N is optional.

Full_Card_Power_Off_N and RESET_N are inputs to the module that the host uses as described in Table 2-8.

For timing details, see Power On / Off Timing for USB Port on page 51.

Table 2-8: Full_Card_Power_Off_N and RESET_N Usage

Name	Pin	Description / notes
Full_Card_Power_Off_N	6	Powers the module on / off ▪ Signal is required. ▪ Pull HIGH to keep the module on. To keep the module always on: · Tie the pin directly to a host GPIO (1.8V), or · Use an external pull-up to pull the signal high (10 kΩ–20 kΩ for 1.8V, 75 kΩ–100 kΩ for 3.6 V rail). Note that a larger-value resistor will reduce leakage current. ▪ To power off the module, see Required Shutdown Sequence on page 52.
RESET_N	67	Resets the module ▪ Signal is optional. The module will operate correctly if the pin is left disconnected on the host. If this signal is connected to the host: ▪ This is a 'hard' reset, similar to a power cycle. Hard resets should be used only if the host cannot communicate with the module USB interface and after a reasonable time-out. (If the interface is not working, the module may have locked up or crashed.) ▪ To trigger the module reset, assert the RESET_N pin with a logic low signal and then release (releasing the signal allows the module to boot).  *Note: Sierra Wireless does not recommend using RESET_N to keep the module in the reset state for an extended time period, since the module will continue to draw power while in reset state. Instead, use Full_Card_Power_Off_N to power off the module and then power it back on when needed.* **Caution:** ▪ *RESET_N should not be driven or pulled to a logic high level by the host, as this may cause damage to the module.* ▪ *Debounce of RESET_N will trigger module reset.*

2.6.4 WWAN_LED_N — LED Output

Note: WWAN_LED_N support will be available in a future release.

Note: Host support for WWAN_LED_N is optional.

The configuration for the LED shown in Figure 2-11 is customizable. The host must include a current limiting resistor on the LED for a maximum draw of 10 mA.

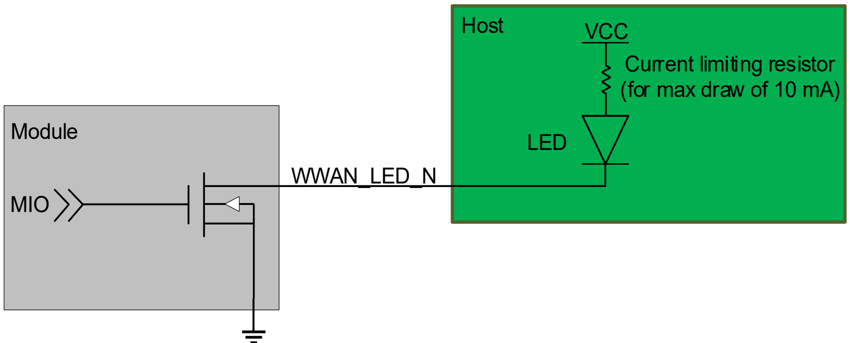


Figure 2-11: Recommended LED Connection

2.7 Antenna Control

Note: Antenna control support will be available in a future release.

Note: Host support for the antenna control signals is optional.

The EM8695 module provides two output signals (Table 2-9) that may be used for host designs that incorporate a GPIO antenna tuner. Customers can configure these signals as appropriate for the operating band(s) using the command AT!ANTSEL. (See *[1] EM8695 AT Command Reference (Doc# 41114815)* for details.)

Table 2-9: GPIO Antenna Control Signals

Name	Pin	Description
ANT_CTRL0	59	Customer-defined external switch control for tunable antennas.
ANT_CTRL1	61	Customer-defined external switch control for tunable antennas.

3: RF Specifications

Note: DRAFT RF Specifications, subject to confirmation.

The EM8695 includes three RF connectors for use with host-supplied antennas:

- Main RF connector — Tx / Rx path
- GNSS RF connector — Dedicated GNSS L1 / L5 (GPS, GLONASS, BeiDou, Galileo, QZSS, NavIC)
- Auxiliary RF connector — Diversity
- The module does not have integrated antennas.

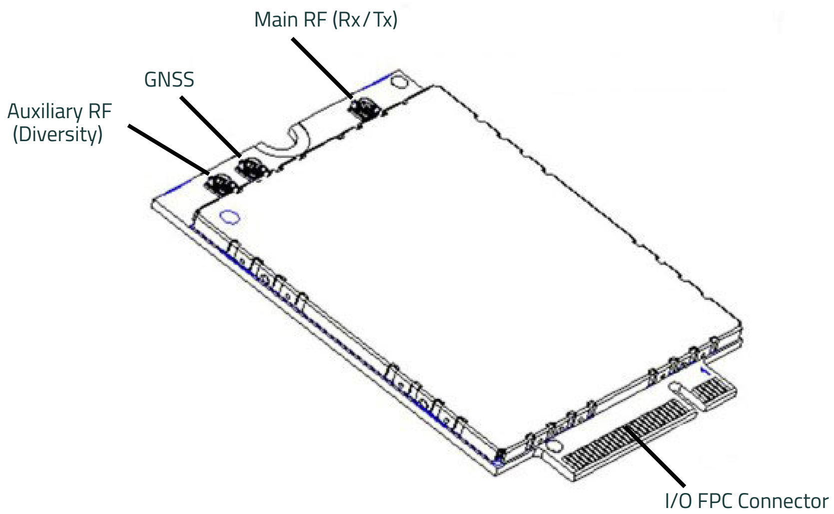


Figure 3-1: Module Connectors

3.1 RF Connections

When attaching antennas to the module:

- Use RF plug connectors that are compatible with I-PEX (20579-001E (MHF4)) RF receptacle connectors.
- Match coaxial connections between the module and the antenna to 50 Ω.
- Minimize RF cable losses to the antenna; the recommended maximum cable loss for antenna cabling is 0.5 dB.
- To ensure best thermal performance, use the mounting hole (if possible) to attach (ground) the device to a metal chassis.

Note: If the antenna connection is shorted or open, the modem will not sustain permanent damage.

3.1.1 Shielding

The module is fully shielded to protect against EMI. The shielding must not be removed.

3.2 Antennas and Cabling

When selecting the antenna and cable, it is critical to RF performance to match antenna gain and cable loss.

Note: For detailed electrical performance criteria, see *Appendix A: Antenna Specification on page 65.*

3.2.1 Choosing the Correct Antenna and Cabling

When matching antennas and cabling:

- The antenna (and associated circuitry) should have a nominal impedance of 50 Ω with a return loss of better than 10 dB across each frequency band of operation.
- The system gain value affects both radiated power and regulatory (FCC, IC, CE, etc.) test results.

3.2.2 Designing Custom Antennas

Consider the following points when designing custom antennas:

- A skilled RF engineer should do the development to ensure that the RF performance is maintained.

3.2.3 Determining the Antenna's Location

When deciding where to put the antennas:

- Antenna location may affect RF performance. Although the module is shielded to prevent interference in most host platforms, the antenna placement is still very important — if the host platform is insufficiently shielded, high levels of broadband or spurious noise can degrade the module's performance.
- Connecting cables between the module and the antenna must have 50 Ω impedance. If the impedance of the module is mismatched, RF performance is reduced significantly.
- Antenna cables should be routed, if possible, away from noise sources (switching power supplies, LCD assemblies, etc.). If the cables are near the noise sources, the noise may be coupled into the RF cable and into the antenna. See Interference from Other Wireless Devices on page 36.

3.2.4 Disabling the Diversity Antenna

Certification testing of a device with an integrated EM8695 module may require the module's main and diversity antennas to be tested separately.

To facilitate this testing, receive diversity can be enabled / disabled using the following AT command:

- !RXDEN — Used to enable / disable diversity.

Important: *LTE networks expect modules to have more than one antenna enabled for proper operation. Therefore, customers must not commercially deploy their systems with the diversity antenna disabled.*

For details, refer to *[1] EM8695 AT Command Reference (Doc# 41114815)*.

Note: A diversity antenna is used to improve connection quality and reliability through redundancy. Because two antennas may experience difference interference effects (signal distortion, delay, etc.), when one antenna receives a degraded signal, the other may not be similarly affected.

3.3 Ground Connection

When connecting the module to system ground:

- Prevent noise leakage by establishing a very good ground connection to the module through the host connector.
- Connect to system ground using the mounting hole shown in Figure 3-1 on page 34.
- Minimize ground noise leakage into the RF.
  Depending on the host board design, noise could potentially be coupled to the module from the host board. This is mainly an issue for host designs that have signals traveling along the length of the module, or circuitry operating at both ends of the module interconnects.

3.4 Interference and Sensitivity

Interference sources can affect the module's RF performance (RF desense). Common sources include power supply noise and device-generated RF.

RF desense can be addressed through a combination of mitigation techniques (Methods to Mitigate Decreased Rx Performance on page 37) and radiated sensitivity measurement (Radiated Sensitivity Measurement on page 37).

3.4.1 Interference from Other Wireless Devices

Wireless devices operating inside the host device can cause interference that affects the module.

To determine the most suitable locations for antennas on your host device, evaluate each wireless device's radio system, considering the following:

- Any harmonics, sub-harmonics, or cross-products of signals generated by wireless devices that fall in the module's Rx range may cause spurious response, resulting in decreased Rx performance.
- The Tx power and corresponding broadband noise of other wireless devices may overload or increase the noise floor of the module's receiver, resulting in Rx desense.

The severity of this interference depends on the closeness of the other antennas to the module's antenna. To determine suitable locations for each wireless device's antenna, thoroughly evaluate your host device's design.

3.4.2 Host-generated RF Interference

All electronic computing devices generate RF interference that can negatively affect the receive sensitivity of the module.

Proximity of host electronics to the antenna in wireless devices can contribute to decreased Rx performance. Components that are most likely to cause this include:

- Microprocessor and memory
- Display panel and display drivers
- Switching-mode power supplies

3.4.3 Device-generated RF Interference

The module can cause interference with other devices. Wireless devices such as Semtech embedded modules transmit in bursts (pulse transients) for set durations (RF burst frequencies). Hearing aids and speakers convert these burst frequencies into audible frequencies, resulting in audible noise.

3.4.4 Methods to Mitigate Decreased Rx Performance

It is important to investigate sources of localized interference early in the design cycle. To reduce the effect of device-generated RF on Rx performance:

- Put the antenna as far as possible from interference sources. Note, however, that the module may be less convenient to use.
- Shield the host device. The module itself is well shielded to avoid external interference. However, the antenna cannot be shielded for obvious reasons. In most instances, it is necessary to employ shielding on host device components (such as the main processor and parallel bus) that have the highest RF emissions.
- Filter out unwanted high-order harmonic energy by using discrete filtering on low frequency lines.
- Form shielding layers around high-speed clock traces by using multi-layer PCBs.
- Route antenna cables away from noise sources.

3.4.5 Radiated Spurious Emissions (RSE)

When designing an antenna for use with Semtech embedded modules, the host device with a Semtech embedded module must satisfy any applicable standards/local regulatory bodies for radiated spurious emission (RSE) for receive-only mode and for transmit mode (transmitter is operating).

Note that antenna impedance affects radiated emissions, which must be compared against the conducted 50 Ω emissions baseline. (Semtech embedded modules meet the 50 Ω conducted emissions requirement.)

3.5 Radiated Sensitivity Measurement

A wireless host device contains many noise sources that contribute to a reduction in Rx performance.

To determine the extent of any receiver performance desensitization due to self-generated noise in the host device, over-the-air (OTA) or radiated testing is required. This testing can be performed by Semtech or you can use your own OTA test chamber for in-house testing.

3.5.1 Sensitivity vs. Frequency

Sensitivity definitions for supported RATs:

- 5G Sub-6 bands—Sensitivity is defined as the RF level at which throughput is 95% of maximum.
- LTE bands—Sensitivity is defined as the RF level at which throughput is 95% of maximum.

3.6 Supported RATs

The EM8695 module supports:

- 5G:
  - Multiple-band 5G—See Table 3-1 (supported bands) and Table 3-2 (5G NR bandwidth support).
- LTE:
  - Multiple-band LTE—See Table 3-1 (supported bands) and Table 3-3 on page 40 (LTE bandwidth support).
- inter-RAT and inter-frequency cell reselection and handover between supported frequency bands
- GNSS:
  - GPS, GLONASS, BeiDou, Galileo, QZSS—See Table 3-7 on page 44.

3.6.1 Supported Bands

Table 3-1: Supported Frequency Bands, by RAT (5G/LTE)

Band#	Mode	5G (n<band#>)	LTE (B<band#>)	Frequency (Tx)	Frequency (Rx)
1	FDD	Y	Y	1920–1980 MHz	2110–2170 MHz
2	FDD	Y	Y	1850–1910 MHz	1930–1990 MHz
3	FDD	Y	Y	1710–1785 MHz	1805–1880 MHz
4	FDD	–	Y	1710–1755 MHz	2110–2155 MHz
5	FDD	Y	Y	824–849 MHz	869–894 MHz
7	FDD	Y	Y	2500–2570 MHz	2620–2690 MHz
8	FDD	Y	Y	880–915 MHz	925–960 MHz
12	FDD	Y	Y	699–716 MHz	729–746 MHz
13	FDD	Y	Y	777–787 MHz	746–756 MHz
14	FDD	Y	Y	788–798 MHz	758–768 MHz
17	FDD	–	Y	704–716 MHz	734–746 MHz
18	FDD	Y	Y	815–830 MHz	860–875 MHz
19	FDD	–	Y	830–845 MHz	875–890 MHz
20	FDD	Y	Y	832–862 MHz	791–821 MHz
25	FDD	Y	Y	1850–1915 MHz	1930–1995 MHz
26	FDD	Y	Y	814–849 MHz	859–894 MHz
28	FDD	Y	Y	703–748 MHz	758–803 MHz
30	FDD	Y	Y	2305–2315 MHz	2350–2360 MHz
34	TDD	–	Y	2010—2025 MHz (TDD)	
38	TDD	Y	Y	2570–2620 MHz (TDD)	
39	TDD	–	Y	1880–1920 MHz (TDD)	
40	TDD	Y	Y	2300–2400 MHz (TDD)	
41	TDD	Y	Y	2496–2690 MHz (TDD)	
42	TDD	–	Y	3400–3600 MHz (TDD)	
43	TDD	–	Y	3600–3800 MHz (TDD)	
48	TDD	Y	Y	3550–3700 MHz (TDD)	
66	FDD	Y	Y	1710–1780 MHz	2110–2200 MHz
70	FDD	Y	Y	1695–1710 MHz	1995–2020 MHz
71	FDD	Y	Y	663–698 MHz	617–652 MHz
77	TDD	Y	–	3300–4200 MHz (TDD)	

Table 3-1: Supported Frequency Bands, by RAT (5G/LTE) (Continued)

Band#	Mode	5G (n<band#>)	LTE (B<band#>)	Frequency (Tx)	Frequency (Rx)
78	TDD	Y	–	3300–3800 MHz (TDD)	
79	TDD	Y	–	4400–5000 MHz (TDD)	
106	FDD	–	Y	896–901 MHz	935–940 MHz

Table 3-2: 5G NR Bandwidth Support

Band	SCS	Bandwidth (MHz)[a] (Architecture support: S — Standalone)			
		5	10	15	20
n1	15	S	S	S	S
n2	15	S	S	S	S
n3	15	S	S	S	S
n5	15	S	S	S	S
n7	15	S	S	S	S
n8	15	S	S	S	S
n12	15	S	S	S	–
n13	15	S	S	–	–
n14	15	S	S	–	–
n18	15	S	S	S	–
n20	15	S	S	S	S
n25	15	S	S	S	S
n26	15	S	S	S	S
n28	15	S	S	S	S
n30	15	S	S	–	–
n38	30	–	S	S	S
n40	30	–	S	S	S
n41	30	–	S	S	S
n48	30	–	S	S	S
n66	15	S	S	S	S
n70	15	S	S	S	–
n71	15	S	S	S	S
n77	30	–	S	S	S
n78	30	–	S	S	S
n79	30	–	S	–	S

a. Maximum supported bandwidth: 20 MHz

Table 3-3: LTE Bandwidth Support[a]

Band	1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
B1	–	–	Y	Y	Y	Y
B2	Y	Y	Y	Y	Y[b]	Y[b]
B3	Y	Y	Y	Y	Y[b]	Y[b]
B4	Y	Y	Y	Y	Y	Y
B5	Y	Y	Y	Y[b]	–	–
B7	–	–	Y	Y	Y[c]	Y[b,c]
B8	Y	Y	Y	Y[b]	–	–
B12	Y	Y	Y[b]	Y[b]	–	–
B13	–	–	Y[b]	Y[b]	–	–
B14	–	–	Y[b]	Y[b]	–	–
B17	–	–	Y[b]	Y[b]	–	–
B18	–	–	Y	Y[b]	Y[b]	–
B19	–	–	Y	Y[b]	Y[b]	–
B20	–	–	Y	Y[b]	Y[b]	Y[b]
B25	Y	Y	Y	Y	Y[b]	Y[b]
B26	Y	Y	Y	Y[b]	Y[b]	–
B28	–	Y	Y	Y[b]	Y[b]	Y[b,d]
B30	–	–	Y	Y[b]	–	–
B34	–	–	Y	Y	Y	–
B38	–	–	Y	Y	Y[c]	Y[c]
B39	–	–	Y	Y	Y[c]	Y[c]
B40	–	–	Y	Y	Y	Y
B41	–	–	Y	Y	Y	Y
B42	–	–	Y	Y	Y	Y
B43	–	–	Y	Y	Y	Y
B48	–	–	Y	Y	Y	Y
B66	–	–	Y	Y	Y	Y
B70	–	–	Y	Y	Y	–
B71	–	–	Y	Y[b]	Y[b]	Y[b,e]
B106	Y	Y	–	–	–	–

a. Table contents are derived from 3GPP TS 36.521-1 v16.9.0, table 5.4.2.1-1.
b. Bandwidth for which a relaxation of the specified UE receiver sensitivity requirement (Clause 7.3 of 3GPP TS 36.521-1 v16.9.0) is allowed.
c. Bandwidth for which uplink transmission bandwidth can be restricted by the network for some channel assignments in FDD/TDD co-existence scenarios in order to meet unwanted emissions requirements (Clause 6.6.3.2 of 3GPP TS 36.521-1 v16.9.0).
d. For 20 MHz bandwidth, the minimum requirements are specified for E-UTRA UL carrier frequencies confined to either 713–723 MHz or 728–738 MHz.
e. For 20 MHz bandwidth, the minimum requirements are specified for E-UTRA UL carrier frequencies confined to either 673–678 MHz or 683–688 MHz.

3.7 Conducted Rx Sensitivity / Tx Power

Note: Values in the following tables are preliminary, pending transceiver matching / testing. All tests were conducted under an ambient temperature of 25 °C.

Table 3-4: Typical Conducted Rx Sensitivity — NR Bands

				Typical Conducted Rx Sensitivity (dBm)[a]			Worst Case (dBm)
Band	Duplex Mode	SCS (KHz)	BW (MHz)	Main	Aux	Main+Aux	Requirement (dBm)
n1	FDD	15	20	-96.0	-97.0	-99.5	-93.7
n2	FDD	15	20	-96.5	-97.5	-100.0	-92.5
n3	FDD	15	20	-96.5	-97.5	-100.0	-91.5
n5	FDD	15	20	-96.0	-97.0	-99.5	-92.5
n7	FDD	15	20	-96.0	-96.5	-99.2	-92.5
n8	FDD	15	20	-96.5	-97.5	-100.0	-91.5
n12	FDD	15	15	-96.2	-98.5	-100.5	-92.8
n13	FDD	15	10	-95.1	-98.6	-100.2	-94.6
n14	FDD	15	10	-98.1	-98.6	-101.3	-94.6
n18	FDD	15	15	-96.8	-98.3	-100.6	-95.0
n20	FDD	15	20	-97.0	-97.0	-100.0	-91.5
n25	FDD	15	20	-96.0	-97.0	-99.5	-91.0
n26	FDD	15	20	-96.0	-97.0	-99.5	-92.0
n28	FDD	15	20	-96.5	-97.5	-100.0	-93.0
n30	FDD	15	10	-96.1	-98.0	-101.1	-96.3
n38	TDD	30	20	-96.0	-97.0	-99.5	-93.8
n40	TDD	30	20	-96.0	-97.0	-99.5	-93.8
n41	TDD	30	20	-96.0	-96.5	-99.2	-91.8
n48	TDD	30	20	-96.5	-97.5	-100.0	-92.8
n66	FDD	15	20	-96.5	-97.5	-100.0	-93.7
n70	FDD	15	15	-94.7	-97.8	-99.5	-95.0

Table 3-4: Typical Conducted Rx Sensitivity — NR Bands (Continued)

Band	Duplex Mode	SCS (KHz)	BW (MHz)	Typical Conducted Rx Sensitivity (dBm)[a]			Worst Case (dBm)
				Main	Aux	Main+Aux	Requirement (dBm)
n71	FDD	15	20	-98.0	-97.0	-100.5	-91.7
n77	TDD	30	20	-96.0	-97.0	-99.5	-92.3
n78	TDD	30	20	-97.0	-97.0	-100.0	-92.8
n79	TDD	30	20	-94.9	-91.1	-96.4	-92.8

a. Results at room temperature. Based on Lab test result and Call box only in a shielded test environment. There might be MSD for the cases which has harmonic and IMD exceptions, we guarantee better performance than the level that 3GPP defined.

Table 3-5: Typical Conducted Rx (Receive) Sensitivity — LTE Bands at 10 MHz BW[a b]

LTE bands	Conducted Rx sensitivity (dBm)[c d]			
	Main (Typ)	Aux (Typ)	SIMO (Typ)	SIMO[e] (Worst Case)
B1	-97.7	-98	-100.8	-97.0
B2	-97.2	-98.1	-100.6	-95.0
B3	-97.4	-98.8	-101.1	-94.0
B4	-97.6	-97.4	-100.5	-97.0
B5	-97.6	-99.1	-101.4	-95.0
B7	-96.4	-97	-99.7	-95.0
B8	-98.5	-96.5	-100.6	-97.0
B12	-99.6	-98.4	-102	-94.0
B13	-99.1	-99.2	-102.1	-94.0
B14	-99.2	-98.4	-101.8	-94.0
B17	-99.8	-98.7	-102.2	-94.0
B18	-98.1	-99.3	-101.7	-97.0[f]
B19	-97.7	-99.4	-101.6	-97.0
B20	-99.2	-98.2	-101.7	-94.0
B25	-97.2	-98.1	-100.6	-93.5
B26	-97.9	-99.3	-101.6	-94.5[g]
B28	-98	-98.3	-101.1	-95.5
B30	-95.3	-97.7	-99.6	-96.0
B34	-97.8	-98.5	-101.1	-97.0
B38	-96.7	-97.5	-100.1	-97.0
B39	-98.2	-98.8	-101.5	-97.0
B40	-96.8	-97.6	-100.2	-97.0

Table 3-5: Typical Conducted Rx (Receive) Sensitivity — LTE Bands at 10 MHz BW[a b] (Continued)

LTE bands	Conducted Rx sensitivity (dBm)[c d]			
	Main (Typ)	Aux (Typ)	SIMO (Typ)	SIMO[e] (Worst Case)
B41	-95.2	-96.9	-99.1	-95.0
B42	-98.2	-96.9	-100.6	-96.0
B43	-97.9	-97.3	-100.6	-96.0
B48	-98.6	-97.3	-101	-96.0
B66	-97.7	-97.4	-100.5	-96.5
B70	-95.6	-98.4	-100.2	-97.0
B71	-99.8	-99.1	-102.4	-94.2
B106[b]	-102.0	-102.0	-105.0	-99.2

a. Full RB on downlink
b. B106 BW=3 MHz
c. Sensitivity values scale with bandwidth: x_MHz_Sensitivity = 10_MHz_Sensitivity - 10*log (10 MHz/x_MHz) Note: Bandwidth support is dependent on firmware version.
d. Results at room temperature. Based on Lab test result and Call box only in a shielded test environment, and the test is based on standalone mode only.
e. Per 3GPP TS 36.521-1
f. For a UE that supports both B18 and B26, the reference sensitivity level for B26 applies for the applicably channel bandwidths.
g. The requirement is modified by -0.5 dB when the carrier frequency of the assigned E-UTRA channel bandwidth is within 865–894 MHz.

Table 3-6: Conducted Maximum Tx Power Tolerances

Bands	Conducted Tx Power[a]	Notes
5G		
n1, n2, n3, n8, n18, n20, n25, n38, n40, n41	+24 dBm ± 1.0 dB	Power Class 3
n5, n12, n13, n14, n26, n28, n66, n70, n71, n77, n78, n79	+23.5 dBm ± 1.0 dB	
n7	+23 dBm ± 1.0 dB	
n30, n48	+22 dBm ± 1.0 dB	
LTE		
B41 HPUE	+26 dBm ± 1.0 dB	Power Class 2 (HPUE)
B42[b] HPUE	+25.5 dBm ± 1.0 dB	
B1, B3, B8, B18, B19, B20, B39, B40, B41, B106	+24 dBm ± 1.0 dB	Power Class 3
B2, B4, B5, B12, B13, B14, B17, B25, B26, B28, B34, B38, B42, B43, B66, B70, B71	+23.5 dBm ± 1.0 dB	
B7	+23 dBm ± 1.0 dB	
B30	+22 dBm ± 1.0 dB	
B48	+21.5 dBm ± 1.0 dB	

a. Tx Power is based on no maximum power reduction (MPR) configuration as 3GPP defined. For configurations that require MPR or additional MPR, refer to 3GPP for the power reduction.

b. B42 HPUE is supported only during standalone operation. During non-standalone operation, PC3 is supported. ULCA is not supported.

3.8 GNSS Specifications

Note: For detailed electrical performance criteria, see Recommended GNSS Antenna Specifications on page 66.

Table 3-7: GNSS Specifications

Parameter/feature	Description
Satellite channels	Supports all in-view satellites (L1+L5) for simultaneous tracking
TTFF[a]	Hot start: 1 s Warm start: 29 s Cold start: 32 s
Accuracy	Horizontal: < 2 m (50%); < 2.8 m (90%) Altitude: < 3 m (50%); < 6 m (90%) Velocity: < 0.2 m/s
Sensitivity[b]	Tracking[c]: • GPS: -160 dBm • GLONASS: -160 dBm Acquisition[d]: • GPS: -154 dBm • GLONASS: -154 dBm
Operational Limits	Altitude < 6000 m or velocity < 100 m/s (Either limit may be exceeded, but not both.)

a. Acquisition times measured with signal strength = -135 dBm.
b. Performance is tested in conducted mode with a GNSS signal simulator under room temperature, and without external GNSS LNAs since the module includes internal LNAs for both L1 and L5.
c. Tracking sensitivity is the lowest GNSS signal level in which the device can still detect in-view satellites and get fixed at least 50% of the time when in sequential tracking mode.
d. Acquisition sensitivity is the lowest GNSS signal strength for which the device can still detect in-view satellites at least 50% of the time.

4: Power

4.1 Power Consumption

Power consumption measurements in the tables below are for the EM8695 connected to the host PC via USB.

The module does not have its own power source and depends on the host device for power. For a description of input voltage requirements, see Power Supply on page 25.

Table 4-1: Averaged Standby DC Power Consumption [a]

Signal	Description	Bands[b]	Current[c]			Notes / Configuration
			Typ	Max	Unit	
VCC	**Standby current consumption (Host interface suspended[d])**					
	5G	NR bands	4.3	4.7	mA	DRX cycle = 2.56 s
	LTE	LTE bands	3.4	3.7	mA	DRX cycle = 8 (2.56 s)
	Standby current consumption[e] (Host interface active[d])					
	5G	NR bands	23.0	26.0	mA	DRX cycle = 2.56 s
	LTE	LTE bands	22.5	25.0	mA	DRX cycle = 8 (2.56 s)
	Low Power Mode (LPM) / Offline Mode[e] (Host interface suspended[d])					
	RF disabled, but module is operational		2.8	3.1	mA	
	Low Power Mode (LPM) / Offline Mode[e] (Host interface active[d])					
	RF disabled, but module is operational		21.0	24.0	mA	
	Leakage Current					
	Module powered off — Full_Card_Power_Off_N is Low, and VCC is supplied		0.31	0.37	mA	

a. Preliminary, subject to change.
b. For supported bands, see Table 3-1, Supported Frequency Bands, by RAT (5G / LTE), on page 38.
c. Measured at 25°C / nominal 3.3 V voltage.
d. Assumes USB bus is fully suspended during measurements
e. LPM and standby power consumption will increase when LEDs are enabled. To reduce power consumption, configure LEDs to remain off while in standby and LPM modes.

Table 4-2: Averaged Call Mode DC Power Consumption

Description	Tx power (dBm)	Current[a] (mA)		Notes
		Typ	Unit	
5G Sub-6	0	175	mA	
	20	1075	mA	
	24	1400	mA	
LTE	0	175	mA	
	20	760	mA	
	24	1450	mA	
	26	1300	mA	Single carrier, B41

a. Measured at 25°C / nominal 3.3 V voltage

Table 4-3: Miscellaneous DC Power Consumption

Signal	Description	Current / Voltage				Notes / Configuration
		Min	Typ	Max	Unit	
VCC	Inrush current	—	—	3.9	A	▪ Assume power supply turn-on time > 100 µs ▪ Dependent on host power supply rise time
	Peak current	1.95	2.7	3.9	A	▪ Across all bands, all temperature ranges ▪ 3.3V supply ▪ Typ 2.7 A peak current with 470 µF aluminum capacitor ▪ Min 1.95 A peak current with 470+2200 µF aluminum capacitor
	Leakage current	0.31	—	0.37	mA	▪ Module powered off · Full_Card_Power_Off_N is Low · VCC is supplied

Warning: *The maximum RF power level allowable on any RF port is +10dBm—damage may occur if this level is exceeded.*

4.2 Module Power States

Note: DRAFT Module Power States, subject to confirmation.

Table 4-4 summarizes the module's power states.

Table 4-4: Module Power States

State		Details	Host is powered	USB interface active	RF enabled

Active	Normal
	(Default)
		▪ Module is active
		▪ Default state. Occurs when VCC is first applied, Full_Card_Power_Off_N is deasserted (pulled high), and W_DISABLE_N is deasserted
		▪ Module is capable of placing/receiving calls, or establishing data connections on the wireless network
		▪ Current consumption is affected by several factors, including:
		  · Radio band being used
		  · Transmit power
		  · Receive gain settings
		  · Data rate
			Y	Y	Y

	Low power
	(Airplane mode)
		▪ Module is active
		▪ Module enters this state:
		  · Under host interface control, when:
		    · The host issues AT+CFUN=0 (*[5] AT Command Set for User Equipment (UE) (Release 6) (Doc# 3GPP TS 27.007)*),
		    or
		    · Dying Gasp is disabled (using AT!CUSTOM="DGENABLE") and the host asserts W_DISABLE_N.
		  · Automatically, when critical temperature or voltage trigger limits have been reached.
			Y	Y	N

	eDRX (Extended Discontinuous Reception)	*Note: eDRX support will be available in a future release.* ▪ eDRX mode provides a 'flexible sleep' for the modem, which significantly reduces energy consumption. For eDRX details, see Extended Discontinuous Reception (eDRX).	Y	Y	N
Off		▪ Host keeps module powered off by asserting Full_Card_Power_Off_N (signal pulled low) ▪ Module draws minimal current ▪ See Full_Card_Power_Off_N and RESET_N on page 31 for more information.	Y	N	N
Disconnected		▪ Host power source is disconnected from the module and all voltages associated with the module are at 0 V.	N	N	N

For current consumption values, see Power Consumption.

4.2.1 Power State Transitions

The module uses state machines to monitor supply voltage and operating temperature, and notifies the host when critical threshold limits are exceeded. (See Table 4-5 for trigger details and Figure 4-1 for state machine behavior.)

Power state transitions may occur:

- Automatically, when critical supply voltage or module temperature trigger levels are encountered.
- Under host control, using available AT commands in response to user choices (for example, opting to switch to airplane mode) or operating conditions.

Table 4-5: Power State Thresholds[a]

Voltage		Temperature[b]			Notes
Threshold	V	Threshold	CPU °C	PA °C	
VOLT_HI_CRIT	4.4	TEMP_HI_CRIT	115	108	Transition from Normal mode (online) to LPM (offline) when the voltage or temperature rises above the corresponding threshold value.
VOLT_HI_WARN	4.3	TEMP_HI_WARN	105	100	When the voltage or temperature is between the corresponding high warning and high critical thresholds, set a warning and remain in the current mode (Normal or LPM). Note — If the device is in Normal mode (online) and the temperature warning is set, the module performance may be reduced (Class B temperature range).
VOLT_NORM	3.3	TEMP_NORM	83	83	Operate in Normal mode (online) while the voltage and temperature are both between their corresponding high and low warning threshold values.
VOLT_LO_WARN	3.2	TEMP_LO_WARN	-28	-29	When the voltage or temperature is between the corresponding low warning and low critical thresholds, set a warning and remain in the current mode (Normal or LPM). Note — If the device is in Normal mode (online) and the temperature warning is set, the module performance may be reduced (Class B temperature range).
VOLT_LO_CRIT	3.135	TEMP_LO_CRIT	-40	-40	Transition from Normal mode (online) to LPM (offline) when the voltage or temperature drops below the corresponding threshold value.

a. Preliminary values, subject to change.
b. Highest temperature among on-board chipsets (CPU, PA).

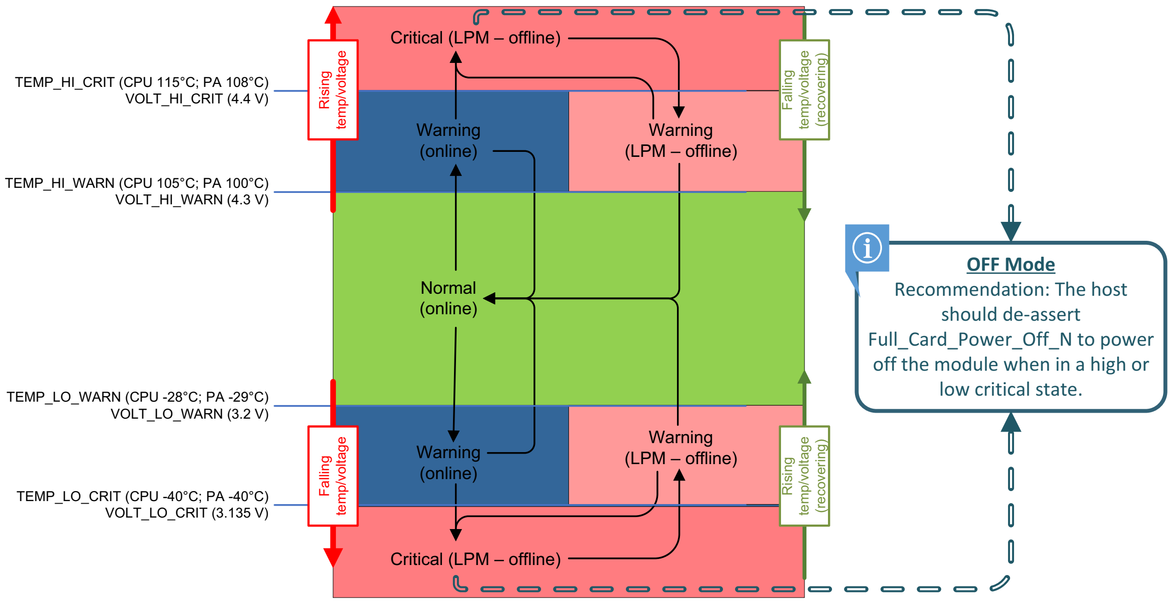


Figure 4-1: Voltage/Temperature Monitoring State Machines

4.2.2 Extended Discontinuous Reception (eDRX)

Note: eDRX support will be available in a future release.

The EM8695 supports eDRX, which is a 'flexible sleep' active mode that allows for longer sleep duration ($T_{I\text{-}eDRX}$) and a significant decrease in power consumption compared to regular DRX ($T_{I\text{-}DRX}$).

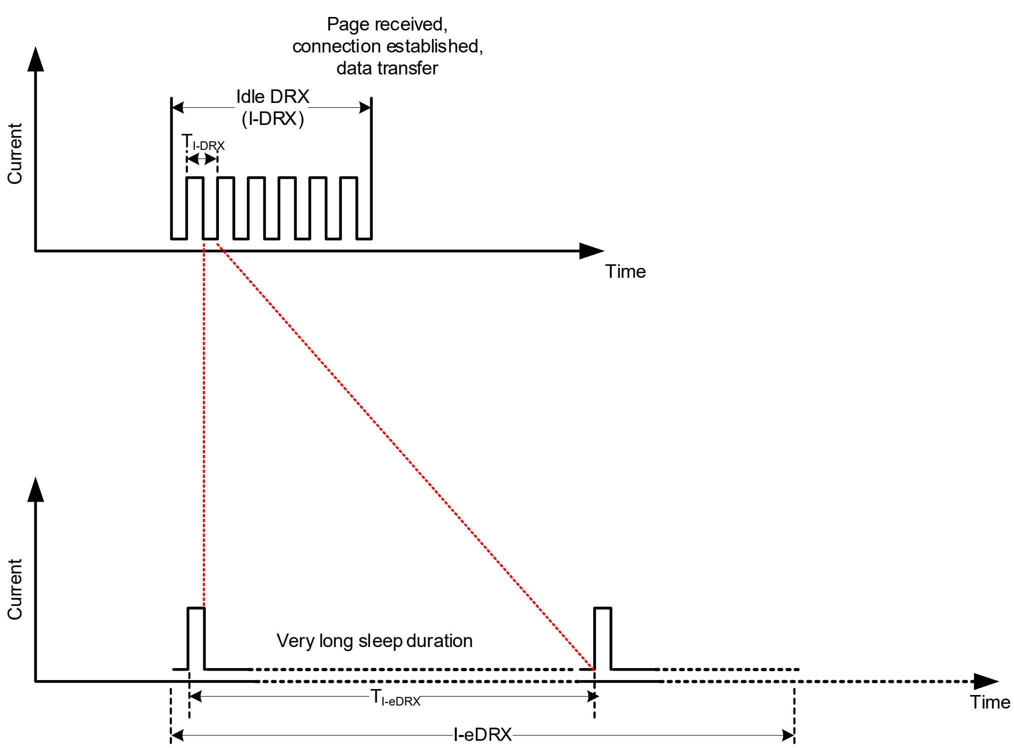


Figure 4-2: eDRX Example (Simplified)

Specifically, the EM8695 supports eDRX, which extend the DRX cycle (the paging cycle comprised of a paging window during which the module is awake and able to receive or transmit on the network, and a sleep period during which the network cannot wake the module) by increasing the sleep duration beyond the DRX maximum of 2.56 seconds:

- I-eDRX (Idle mode eDRX) — The sleep duration of the DRX cycle can be set up to 44 minutes for LTE-Cat1bis and up to 175 minutes for NR RedCap.

Note: If traffic must be transmitted when the module is in the sleep portion of the cycle, the module can initiate data/SMS/voice session immediately.

Table 4-6 describes the available methods for configuring eDRX.

Table 4-6: eDRX-Related Commands[a]

Type	Command	Description
AT	+CEDRXS	Enable/disable eDRX, and configure related settings
	+CEDRXRDP	Display current eDRX settings

a. For AT command details, refer to *[1] EM8695 AT Command Reference (Doc# 41114815)*

4.2.2.1 eDRX Process Example

- Use the AT+CEDRXS command to configure the desired eDRX behavior.
- During the network attachment process:
  - eDRX request and settings are sent to the network
  - Network responds and indicates whether eDRX is supported for the connection and may adjust the eDRX parameters.
- If eDRX is supported by the network:
  - While in active mode (connected), the sleep duration is used if supported, otherwise the regular DRX sleep duration is used.
  - While in idle mode, the I-eDRX sleep duration is used if supported, otherwise the network uses the standard LTE I-DRX value.

Important Notes

- The sleep duration must be carefully selected to match the intended use case(s) for the module. While the module is asleep, it will be unreachable by the network. The duration should provide appropriate delay-tolerance for mobile-terminated/network-originated transmissions to be received.
- Due to the extended sleep time compared to regular DRX, eDRX is not suitable for most mobile-terminated voice connections.
- Network-side store and forward is supported — Packets will be stored until the module is reachable.

4.3 Power Interface

Note: DRAFT Power Interface specifications, subject to confirmation.

4.3.1 Power Ramp-up

On initial power up, inrush current depends on the power supply rise time — turn on time > 100 µs is required for < 3 A inrush current.

The supply voltage must remain within specified tolerances while this is occurring.

If the host device cannot meet these specifications, the module may not boot properly.

4.3.2 Timing

Power On / Off Timing for USB Port

Figure 4-3 describes the timing sequence for powering the module on and off.

Note: Before reaching the "Active" state, signals on the host port are considered to be undefined and signal transitions may occur. This undefined state also applies when the module is in reset mode, during a firmware update, or during the Power-off sequence. The host must consider these undefined signal activities when designing the module interface.

Note: The host should not drive any signals to the module until > 100 ms from the start of the power-on sequence.

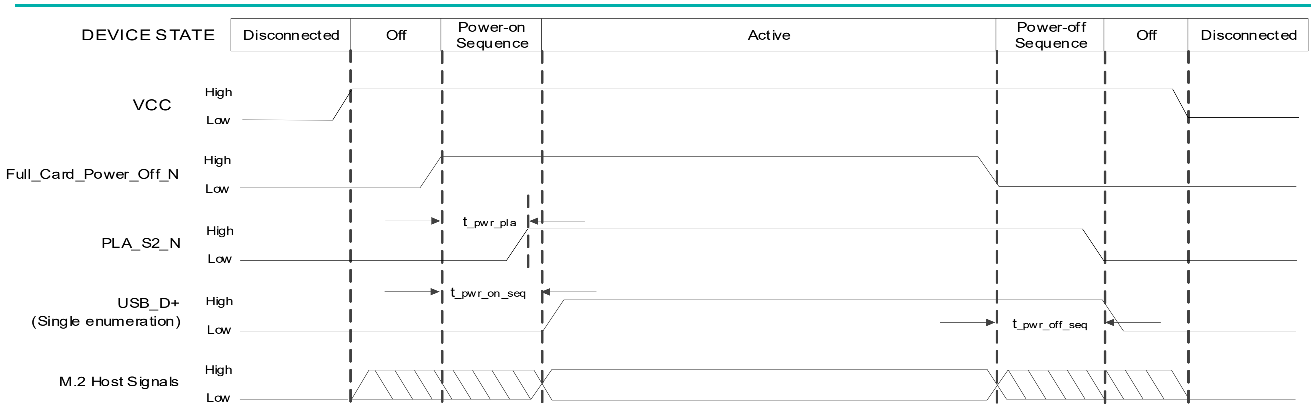


Figure 4-3: Signal Timing (Full_Card_Power_Off_N, and USB Enumeration)

Table 4-7: USB 2.0 Power-On / Off Timing Parameters

Symbol	Parameter	Min	Typ	Max	Unit
t_pwr_on_seq	Power on sequence time	22	–	24	s
t_pwr_pla	Power on to PLA_S2_N high	4	–	5	s
t_pwr_off_seq	Power off sequence time	8.5	–	10	s

USB Enumeration

The unit supports USB enumeration with the host, as shown in Figure 4-3 (hardware behavior). Enumeration starts within maximum t_pwr_on_seq seconds (Table 4-7) of power-on.

Figure 4-4 and Table 4-8 describe the software USB enumeration timing in more detail, from starting a software-initiated reset to completing the enumeration and the module being ready to receive host commands (AT and QMI):

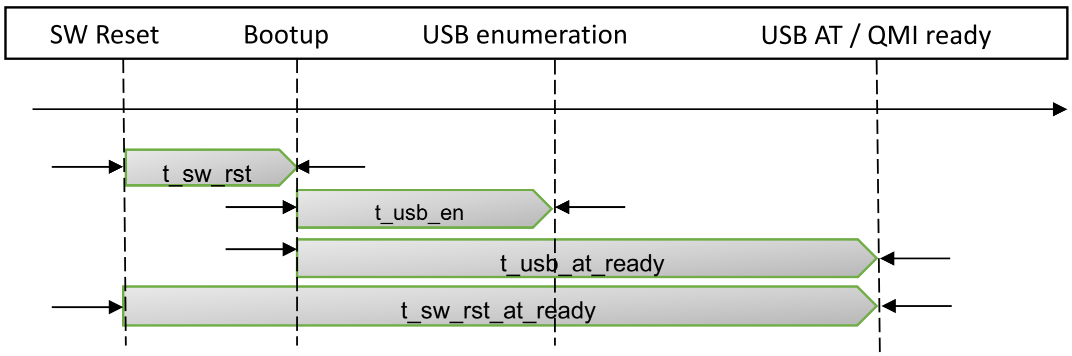


Figure 4-4: Signal Timing — USB Enumeration with Software Reset

Table 4-8: USB Enumeration with Software Reset — Timing Parameters

Symbol	Parameter	Max	Unit
t_sw_rst	Module software-initiated reset (via AT!RESET or AT!DAFTMACT)	1.5	s
t_usb_en	Boot to USB enumeration (equivalent to t_pwr_on_seq from Figure 4-3)	24	s
t_usb_at_ready	Boot to USB AT / QMI command ready	53.5	s
t_sw_rst_at_ready	Total time from SW Reset to USB AT / QMI command ready	55	s

Required Shutdown Sequence

Warning: *To avoid causing issues with the file system, follow this shutdown sequence.*

To safely power off the module:

1. Drive Full_Card_Power_Off_N low to trigger the firmware to begin the power-off sequence.
2. Wait for PLA_S2_N to become LOW. (Note: The power off process finishes within t_pwr_off_seq seconds (Table 4-7).
3. Remove power.

4.3.3 Power Supply Noise

Noise in the power supply can lead to noise in the RF signal.

The power supply ripple limit for the module is no more than 100 mVp-p, 1–100 kHz. This limit includes voltage ripple due to transmitter burst activity.

Additional decoupling capacitors can be added to the main VCC line to filter noise into the device.

4.4 SED (Smart Error Detection)

Note: DRAFT SED specifications, subject to confirmation.

The module uses a form of SED to track premature module resets.

- The module tracks consecutive resets occurring soon after power-on.
- After a fifth consecutive reset, the module waits in boot-and-hold mode for a firmware download to resolve the power-cycle problem.

4.5 Tx Power Control

The module's Tx power limit may be controlled by using the Smart Transmit method to comply with regulatory transmit power limit requirements (e.g., FCC, GCF, PTCRB).

The module's exposure scenario (Device State Index (DSI)) may be configured using either of the following methods (selected using the !CUSTOM "GPIOSARENABLE" customization):

- Configure via AT command (!SARSTATE):
  - !SARSTATE — Set (or report) the current DSI. This setting is non-persistent across power cycles.
  - The module can be set to any defined DSI.
  - For details, refer to *[1] EM8695 AT Command Reference (Doc# 41114815)*.
- Configure via the DPR (Dynamic Power Reduction) GPIO:
  - The module's firmware monitors DPR (pin 25) with logic as detailed in Table 4-9, and adjusts the RF Tx power for the indicated DSI (exposure scenario). For general details, refer to *[4] EM8695 Smart Transmit (Forthcoming)*.
  - The module can be set to DSI0 or DSI1.

Table 4-9: DPR GPIO Logic for DSI Selection

!SARINTGPIOMODE value[a]	DPR Internal Pull	DPR Pin State	DSI
0 (Default)	Pull up (Active Low)	Low	DSI0
		High[b]	DSI1
1	Pull down (Active High)	Low	DSI1
		High	DSI0

a. Use !SARINTGPIOMODE to invert the DPR internal pull logic if required for the end product design.
b. If a 1.8 V-compatible driver is not available, the host can implement an open collector drive for the DPR pin.

5: Software

EM8695 modules support USB for the physical host interface.

The following packages (software suites) are available for use with EM8695 modules:

- Firmware update utilities
- Firmware logging and troubleshooting utilities
- Driver support package

To obtain the appropriate operating system-specific mobile broadband package (MBP), contact your Sierra Wireless representative.

6: Mechanical and Environmental Specifications

Note: DRAFT Mechanical and Environmental Specifications, subject to confirmation.

EM8695 modules comply with the mechanical and environmental specifications in Table 6-1. Final product conformance to these specifications depends on the OEM device implementation.

Table 6-1: Mechanical and Environmental Specifications

	Mode	Details
Ambient temperature	Operational Class A	-30°C to +70°C — 3GPP compliant with host application-appropriate heatsinking
	Operational Class B[a]	-40°C to +85°C, with appropriate heatsinking — non-3GPP compliant (reduced operating parameters required)
	Storage	-40°C to +85°C
High temperature	Operational	+85°C, 45 minutes transmission / 15 minutes idle, 480 hours
Low temperature	Operational	-40°C, 30 minutes off / 5 minutes idle, 120 hours
Relative humidity	Operational	85°C, 85% relative humidity for 240 hours (non-condensing)
Thermal shock	Non-operational	-40°C to +85°C, < 30 seconds transition, 10 minutes dwell, 300 cycles
Vibration	Non-operational	Tri-axial vibration, 20 Hz to 5000 Hz, 20 Grms, 10 minutes dwell
Shock	Non-operational	Half sine shock, 6 ms, 30 g, 3x each axis
Drop	Non-operational	1 m on concrete on each of six faces (module only)
Electrostatic Discharge (See Electrostatic Discharge (ESD) on page 57.)	Operational	The RF port (antenna launch and RF connector) complies with the IEC 61000-4-2 standard: ▪ Electrostatic discharge immunity: Test Level 3 ▪ Air discharge: ±8 kV
Thermal considerations		See Thermal Considerations on page 57
Form factor		M.2 Form Factor
Dimensions		Length: 42 ± 0.10 mm (max) Width: 30 ± 0.10 mm (max) Thickness: 2.38 mm (max) • Above PCB — 1.50 mm (max) • PCB — 0.88 mm (max) Weight: 6.5 g (max)

a. Class B temperature range — Pending validation

6.1 Device Views

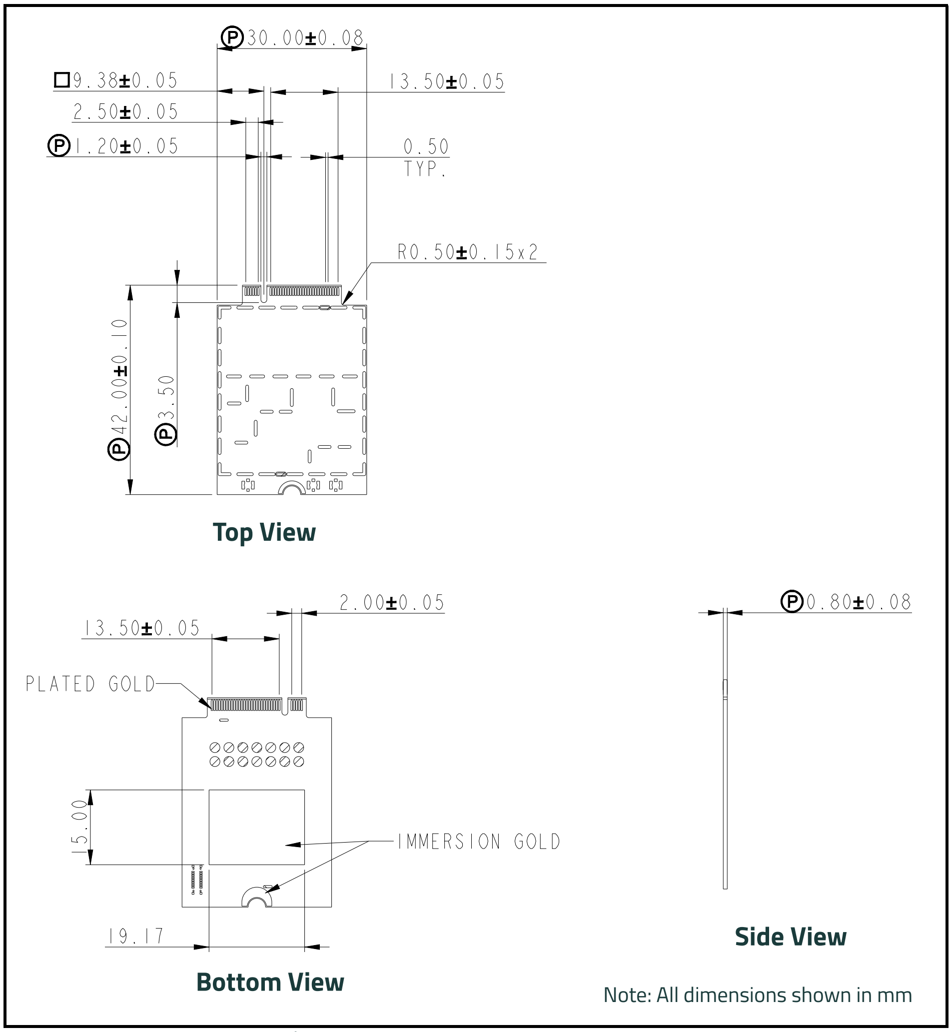


Figure 6-1: EM8695 Dimensioned Views

6.2 Product Marking

The EM8695 module's product marking is laser-etched and may contain:

- Semtech logo and product name
- IMEI number in Data Matrix barcode format
- SKU number (when required)
- Factory Serial Number (FSN) in alphanumeric format
- Manufacturing date code (incorporated into FSN)
- Licensed vendor logo
- Certification marks / details

Note: The EM8695 supports OEM partner-specific label requirements.

6.3 Electrostatic Discharge (ESD)

The OEM is responsible for ensuring that the EM8695 module's host interface pins are not exposed to ESD during handling or normal operation. (See Table 6-1 on page 55 for specifications.)

ESD protection is highly recommended for the SIM connector at the point where the contacts are exposed, and for any other signals from the host interface that would be subjected to ESD by the user of the product. (The device includes ESD protection on the antenna.)

6.4 Thermal Considerations

Embedded modules can generate significant amounts of heat that must be dissipated in the host device for safety and performance reasons. Figure 6-2 indicates specific areas that should be thermally dissipated.

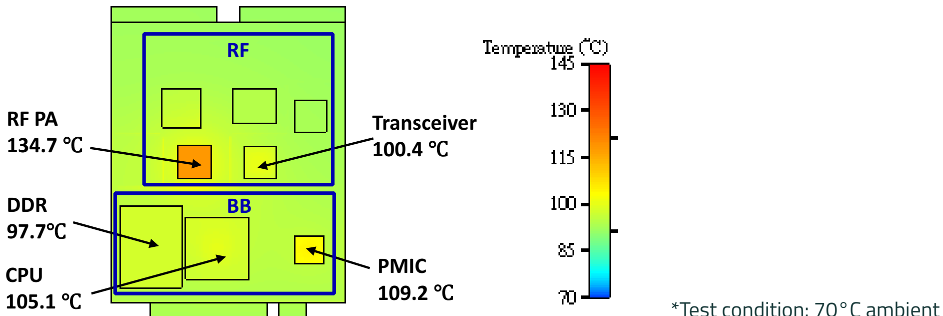


Figure 6-2: EM8695 Thermal Characteristics

The amount of thermal dissipation required depends on:

- Supply voltage—Maximum power dissipation for the module at voltage supply limits—see Table 4-2 Averaged Call Mode DC Power Consumption.
- Usage—Typical power dissipation values depend on location within the host, amount of data transferred, etc.

To enhance heat dissipation:

- Mount a heat sink on the module with a thermal pad or glue between the module and the heat sink).
- Note—Sierra Wireless recommends the host device be designed with keep-out areas around the module's exposed bottom-side testpoints and debug connector pad to prevent shorting, as indicated in Figure 6-3.

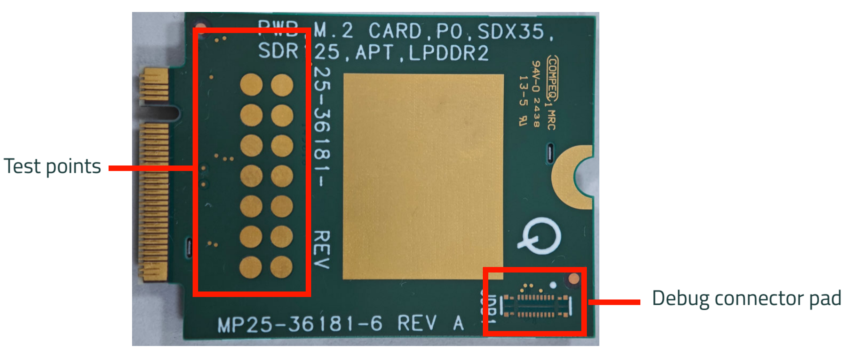


Figure 6-3: Recommended PCB Keep-out Areas

- Maximize airflow over/around the module.
- Locate the module away from other hot components.
- Module ground holes must be used to attach (ground) the device to the main PCB ground or a metal chassis.
- If possible, include active cooling to pull heat away from the module.

Note: Adequate dissipation of heat is necessary to ensure that the module functions properly.

6.5 Module Integration Testing

When testing your integration design:

- Test to your worst case operating environment conditions (ambient temperature and voltage)
- Test using worst case operation (transmitter on 100% duty cycle, maximum power)
- Monitor temperature at all shield locations.

Note: Make sure that your system design provides sufficient cooling for the module.

(For acceptance, certification, quality and production (including RF) test suggestions, see Testing on page 70.)

7: Regulatory Compliance and Industry Certifications

This chapter describes the current certification status of the EM8695 module. Certifications in other countries may be attained upon customer request—contact your Sierra Wireless account representative for details.

Additional testing and certification may be required for the host product with an embedded EM8695 module and are the responsibility of the OEM. Sierra Wireless offers professional services-based assistance to OEMs with the testing and certification process, if required.

7.1 Regulatory Compliance

The EM8695 module is designed to meet, and upon commercial release, will meet the requirements of the following regulatory bodies and regulations, where applicable:

- Federal Communications Commission (FCC) of the United States
- Innovation, Science and Economic Development Canada (ISED)
- The National Communications Commission (NCC) of Taiwan, Republic of China
- Japan Ministry of Internal Affairs and Communications (MIC)
- Radio Equipment Directive (RED) of the European Union

7.1.1 Important Compliance Information for Canada

The EM8695 module, upon commercial release, will have been granted modular approval for mobile applications under:

- IC: 2417C-EM86T

Integrators may use the EM8695 module in their host products without additional ISED certification if they meet the following conditions. Otherwise, additional ISED approvals must be obtained.

1. At least 20 cm separation distance between the antenna and the user's body must be maintained at all times.
2. To comply with ISED regulations limiting both maximum RF output power and human exposure to RF radiation, the maximum antenna gain including cable loss in a mobile-only exposure condition must not exceed the limits stipulated in Table 7-1.
3. The EM8695 module may transmit simultaneously with other collocated radio transmitters within a host product, provided the following conditions are met:
   - Each collocated radio transmitter has been certified by ISED for mobile application.
   - At least 20 cm separation distance between the antennas of the collocated transmitters and the user's body must be maintained at all times.
   - The radiated power of a collocated transmitter must not exceed the EIRP limit stipulated in Table 7-1.

Table 7-1: ISED Antenna Gain and Collocated Radio Transmitter Specifications

	RAT (LTE, FR1, Redcap NR)	Operating mode	Tx Freq Range (MHz)		Maximum Antenna Gain (dBi)	
					Standalone	Collocated
EM8695	LTE	LTE B2	1850	1910	8.0	6.0
		LTE B4	1710	1755	5.0	5.0
		LTE B5	824	849	6.0	4.0
		LTE B7	2500	2570	7.8	6.9

Table 7-1: ISED Antenna Gain and Collocated Radio Transmitter Specifications (Continued)

	RAT (LTE, FR1, Redcap NR)	Operating mode	Tx Freq Range (MHz)		Maximum Antenna Gain (dBi)	
					Standalone	Collocated
	LTE	LTE B12	699	716	6.0	3.5
		LTE B13	777	787	6.0	4.0
		LTE B14	788	798	6.0	4.0
		LTE B25	1850	1915	8.0	6.0
		LTE B26	814	849	6.0	4.0
		LTE B41_PC3	2496	2690	7.8	6.9
		LTE B41_PC2	2496	2690	5.8	4.9
		LTE B42_PC3	3450	3550	5.5	5.5
		LTE B42_PC2	3450	3550	3.5	3.5
		LTE B43	3600	3800	5.5	5.5
		LTE B48	3550	3700	7.0	7.0
		LTE B66	1710	1780	5.0	5.0
		LTE B71	663	698	5.5	3.5
	5G NR (FR1)	5G NR n2	1850	1910	8.0	6.0
		5G NR n5	824	849	6.0	4.0
		5G NR n7	2500	2570	7.8	6.9
		5G NR n12	699	716	6.0	3.5
		5G NR n13	777	787	6.0	4.0
		5G NR n14	788	798	6.0	4.0
		5G NR n25	1850	1915	8.0	6.0
		5G NR n26	814	849	6.0	4.0
		5G NR n41	2496	2690	7.8	6.9
		5G NR n48	3550	3700	7.0	7.0
		5G NR n66	1710	1780	5.0	5.0
		5G NR n70	1695	1710	5.2	5.2
		5G NR n71	663	698	5.5	3.5
		5G NR n77_PC3_27O	3700	3980	5.5	5.5
		5G NR n77_PC3_27Q	3450	3550	4.5	4.5
		5G NR n78_PC3_27O	3700	3800	5.5	5.5
		5G NR n78_PC3_27Q	3450	3550	4.5	4.5
		5G NR n79	4400	5000	TBD	TBD

Table 7-1: ISED Antenna Gain and Collocated Radio Transmitter Specifications (Continued)

	RAT (LTE, FR1, Redcap NR)	Operating mode	Tx Freq Range (MHz)		Maximum Antenna Gain (dBi)	
					Standalone	Collocated
	RedCap NR	RedCap NR n2	1850	1910	8.0	6.0
		RedCap NR n5	824	849	6.0	4.0
		RedCap NR n7	2500	2570	7.8	6.9
		RedCap NR n12	699	716	6.0	3.5
		RedCap NR n25	1850	1915	8.0	6.0
		RedCap NR n41	2496	2690	7.8	6.9
		RedCap NR n66	1710	1780	5.0	5.0
		RedCap NR n71	663	698	5.5	3.5
		RedCap NR n78_PC3_27O	3700	3800	5.5	5.5
		RedCap NR n78_PC3_27Q	3450	3550	4.5	4.5
Collocated transmitters		WLAN 2.4 GHz	2400	2500	Maximum EIRP (dBm)	
					TBD	
		WLAN 5 GHz	5150	5850	TBD	
		WLAN 6 GHz	5955	7115	TBD	
		Bluetooth	2400	2500	TBD	

4. A label must be affixed to the outside of the end product into which the EM8695 module is incorporated, with a statement similar to the following:
   - **This device contains IC: 2417C-EM86T.**
5. A user manual with the host product must clearly indicate the operating requirements and conditions that must be observed to ensure compliance with current ISED RF exposure guidelines.

Note: Host product manufacturers are responsible for the overall compliance of the host products including, where applicable, all additional equipment authorization and testing not covered by the modular approval (e.g., ISED's Interference-Causing Equipment Standards, and RF exposure requirements for host products intended for use within 20 cm of the user's body.)

7.1.2 Important Compliance Information for the United States

The EM8695 module, upon commercial release, will have been granted modular approval under:

- FCC ID: N7NEM86T

Integrators may use the EM8695 module in their host products without additional FCC certification if they meet the following conditions. Otherwise, additional FCC approvals must be obtained.

1. At least 20 cm separation distance between the antenna and the user's body must be maintained at all times.
2. To comply with FCC regulations limiting both maximum RF output power and human exposure to RF radiation, the maximum antenna gain including cable loss in a mobile-only exposure condition must not exceed the limits stipulated in Table 7-2 on page 62.

3. The EM8695 module may transmit simultaneously with other collocated radio transmitters within a host product, provided the following conditions are met:
- Each collocated radio transmitter has been certified by FCC for mobile application.
- At least 20 cm separation distance between the antennas of the collocated transmitters and the user's body must be maintained at all times.
- The radiated power of a collocated transmitter must not exceed the EIRP limit stipulated in Table 7-2.

Table 7-2: FCC Antenna Gain and Collocated Radio Transmitter Specifications

	RAT (LTE, FR1, Redcap NR)	Operating mode	Tx Freq Range (MHz)		Maximum Antenna Gain (dBi)	
					Standalone	Collocated
EM8695	LTE	LTE B2	1850	1910	8.0	6.0
		LTE B4	1710	1755	5.0	5.0
		LTE B5	824	849	6.0	4.0
		LTE B7	2500	2570	7.8	6.9
		LTE B12	699	716	6.0	3.5
		LTE B13	777	787	6.0	4.0
		LTE B14	788	798	6.0	4.0
		LTE B25	1850	1915	8.0	6.0
		LTE B26	814	849	6.0	4.0
		LTE B41_PC3	2496	2690	7.8	6.9
		LTE B41_PC2	2496	2690	5.8	4.9
		LTE B42_PC3	3450	3550	5.5	5.5
		LTE B42_PC2	3450	3550	3.5	3.5
		LTE B48*	3550	3700	0.0	0.0
		LTE B66	1710	1780	5.0	5.0
		LTE B71	663	698	5.5	3.5
		LTE B106	897.5	900.5	TBD	TBD
	5G NR (FR1)	5G NR n2	1850	1910	8.0	6.0
		5G NR n5	824	849	6.0	4.0
		5G NR n7	2500	2570	7.8	6.9
		5G NR n12	699	716	6.0	3.5
		5G NR n13	777	787	6.0	4.0
		5G NR n14	788	798	6.0	4.0

Table 7-2: FCC Antenna Gain and Collocated Radio Transmitter Specifications (Continued)

	RAT (LTE, FR1, Redcap NR)	Operating mode	Tx Freq Range (MHz)		Maximum Antenna Gain (dBi) Standalone	Collocated
	5G NR (FR1)	5G NR n25	1850	1915	8.0	6.0
		5G NR n26	814	849	6.0	4.0
		5G NR n41	2496	2690	7.8	6.9
		5G NR n48*	3550	3700	0.0	0.0
		5G NR n66	1710	1780	5.0	5.0
		5G NR n70	1695	1710	5.2	5.2
		5G NR n71	663	698	5.5	3.5
		5G NR n77_PC3_27O	3700	3980	5.5	5.5
		5G NR n77_PC3_27Q	3450	3550	4.5	4.5
		5G NR n78_PC3_27O	3700	3800	5.5	5.5
		5G NR n78_PC3_27Q	3450	3550	4.5	4.5
Collocated transmitters					Maximum EIRP (dBm)	
		WLAN 2.4 GHz	2400	2500	TBD	
		WLAN 5 GHz	5150	5850	TBD	
		WLAN 6 GHz	5955	7115	TBD	
		Bluetooth	2400	2500	TBD	

Important: *Airborne operations in LTE Band 48/5G NR n48 are prohibited.*

4. A label must be affixed to the outside of the end product into which the EM8695 module is incorporated, with a statement similar to the following:
   - **This device contains FCC ID: N7NEM86T.**
5. A user manual with the host product must clearly indicate the operating requirements and conditions that must be observed to ensure compliance with current FCC RF exposure guidelines.

Note: Host product manufacturers are responsible for the overall compliance of the host products including, where applicable, all additional equipment authorization and testing not covered by the modular approval (e.g., unintentional radiator FCC Part 15 Subpart B requirements, and RF exposure requirements for host products intended for use within 20 cm of the user's body.)

7.2 Industry Certifications

The EM8695 module complies with the mandatory requirements described in the following standards. The exact set of requirements supported is network operator-dependent.

Table 7-3: Standards Compliance

Technology	Standards
5G Sub-6	3GPP Release 17
LTE	3GPP Release 16

Upon commercial release, the following industry certifications will have been obtained, where applicable:

- GCF
- PTCRB

A: Antenna Specification

This appendix describes recommended electrical performance criteria for main path, diversity path, and GNSS antennas used with Semtech embedded modules.

The performance specifications described in this section are valid while antennas are mounted in the host device with antenna feed cables routed in their final application configuration.

Note: Antennas should be designed **before** *the industrial design is finished to make sure that the best antennas can be developed*

A.1 Recommended Main / Diversity Antenna Specifications

Table A-1: Antenna Requirements[a]

Parameter	Requirements	Comments
Antenna system	External multi-band 2×2 MIMO antenna system (Ant1 / Ant2)[b]	
Operating bands — Antenna 1	All supporting Tx and Rx frequency bands.	
Operating bands — Antenna 2	All supporting Rx frequency bands.	
VSWR of Ant1 and Ant2	▪ < 2:1 (recommended) ▪ < 3:1 (worst case)	On all bands including band edges
Total radiated efficiency of Ant1 and Ant2	> 50% on all bands	▪ Measured at the RF connector. ▪ Includes mismatch losses, losses in the matching circuit, and antenna losses, excluding cable loss. ▪ Semtech recommends using antenna efficiency as the primary parameter for evaluating the antenna system. ▪ Peak gain is not a good indication of antenna performance when integrated with a host device (the antenna does not provide omni-directional gain patterns). Peak gain can be affected by antenna size, location, design type, etc. — the antenna gain patterns remain fixed unless one or more of these parameters change.
Radiation patterns of Ant1 and Ant2	Nominally omni-directional radiation pattern in azimuth plane.	
Envelope correlation coefficient between Ant1 and Ant2	▪ < 0.5 on Rx bands below 960 MHz ▪ < 0.2 on Rx bands above 1.4 GHz	
Mean Effective Gain — Ant1 (MEG1), Ant2 (MEG2)	≥ -3 dBi	
Ant1 and Ant2 Mean Effective Gain Imbalance $\left\lvert \frac{MEG1}{MEG2} \right\rvert$	▪ < 2 dB for MIMO operation ▪ < 6 dB for diversity operation	
Maximum antenna gain	Must not exceed antenna gain limits.	See Important Compliance Information for the United States on page 61 and Important Compliance Information for Canada on page 59.

Table A-1: Antenna Requirements[a] (Continued)

Parameter	Requirements	Comments
Isolation between Ant1 and Ant2 (S21)	> 10 dB	▪ If antennas can be moved, test all positions for both antennas. ▪ Make sure all other wireless devices (Bluetooth or WLAN antennas, etc.) are turned OFF to avoid interference.
Maximum input power at antenna port	10 dBm	
Power handling	> 1 W	▪ Measure power endurance over 4 hours (estimated talk time) using a 1 W CW signal — set the CW test signal frequency to the middle of each supporting Tx band. ▪ Visually inspect device to ensure there is no damage to the antenna structure and matching components. ▪ VSWR / TIS / TRP measurements taken before and after this test must show similar results.

a. These worst-case VSWR figures for the transmitter bands may not guarantee RSE levels to be within regulatory limits. The device alone meets all regulatory emissions limits when tested into a cabled (conducted) 50 Ω system. With antenna designs with up to 2.5:1 VSWR or worse, the radiated emissions could exceed limits. The antenna system may need to be tuned in order to meet the RSE limits as the complex match between the module and antenna can cause unwanted levels of emissions. Tuning may include antenna pattern changes, phase/delay adjustment, and passive component matching. Examples of the application test limits would be included in FCC Part 22, Part 24 and Part 27,test case 4.2.2 for WCDMA (ETSI EN 301 908-1), where applicable.

b. Ant1 — Main RF (Rx / Tx), Ant2 — Auxiliary RF (Diversity / MIMO)

A.2 Recommended GNSS Antenna Specifications

Table A-2: GNSS Antenna Requirements

Parameter	Requirements	Comments
Frequency range	▪ GNSS L1: 1563–1587 MHz ▪ GNSS L5: 1164–1189 MHz ▪ GPS / QZSS L1: 1575.42 MHz ±2 MHz ▪ GPS / QZSS L5: 1176 MHz ±2 MHz ▪ Galileo E1: 1559–1591 MHz ▪ Galileo E5a: 1164–1189 MHz ▪ BeiDou B1C: 1559–1591 MHz ▪ BeiDou B1I: 1559–1563 MHz ▪ BeiDou B2a: 1166–1186 MHz ▪ GLONASS G1: 1597.5–1605.9 MHz	These ranges include a buffer zone to ensure coverage of the specific GNSS frequencies listed in Table 1-2 on page 10.
Field of view (FOV)	▪ Omni-directional in azimuth ▪ -45° to +90° in elevation	
Polarization (average Gv/Gh)	> 0 dB	Vertical linear polarization is sufficient.
Free space average gain (Gv+Gh) over FOV	> -6 dBi (preferably > -3 dBi)	Gv and Gh are measured and averaged over -45° to +90° in elevation, and ±180° in azimuth.

Table A-2: GNSS Antenna Requirements (Continued)

Parameter	Requirements	Comments
Gain	▪ Maximum gain and uniform coverage in the high elevation angle and zenith. ▪ Gain in azimuth plane is not desired.	
Average 3D gain	> -5 dBi	
Isolation between GNSS and ANT1	> 15 dB in all uplink bands and GNSS Rx bands	
Typical VSWR	< 2.5:1	
Polarization	Any other than LHCP (left-hand circular polarized) is acceptable.	

A.3 Antenna Tests

The following guidelines apply to the requirements described in Table A-1 on page 65 and Table A-2 on page 66:

- Perform electrical measurements at room temperature (+20°C to +26°C) unless otherwise specified
- For main and diversity path antennas, make sure the antennas (including contact device, coaxial cable, receptacles, and matching circuit with no more than six components, if required) have nominal impedances of 50 Ω across supported frequency bands.
- All tests (except isolation/correlation coefficient)—Test the main or diversity antenna with the other antenna terminated.
- Any metallic part of the antenna system that is exposed to the outside environment needs to meet the electrostatic discharge tests per IEC61000-4-2 (conducted discharge +8 kV).
- The functional requirements of the antenna system are tested and verified while the embedded module's antenna is integrated in the host device.

Note: Additional testing, including active performance tests, mechanical, and accelerated life tests can be discussed with Semtech's engineering services. Contact your Semtech representative for assistance.

B: Design Checklist

This chapter provides a summary of the design considerations mentioned throughout this guide. This includes items relating to the power interface, RF integration, thermal considerations, cabling issues, and so on.

Note: This is NOT an exhaustive list of design considerations. It is expected that you will employ good design practices and engineering principles in your integration.

Table B-1: Hardware Integration Design Considerations

Suggestion	Section where discussed
Component Placement	
If an ESD suppressor is not used on the host device, allow space on the SIM connector for series resistors in layout. (Up to 100 Ω may be used depending on ESD testing requirements).	SIM Implementation on page 28
Minimize RF cable losses as these affect performance values listed in product specification documents.	RF Connections on page 34
Antennas	
Match the module/antenna coax connections to 50 Ω—mismatched antenna impedance and cable loss negatively affect RF performance.	RF Connections on page 34
If installing UMTS and CDMA modules in the same device, consider using separate antennas for maximum performance.	Antennas and Cabling on page 35
Power	
Make sure the power supply can handle the maximum current specified for the module type.	Power Consumption on page 45
Limit the total impedance of VCC and GND connections to the SIM at the connector to less than 1 Ω (including any trace impedance and lumped element components—inductors, filters, etc.). All other lines must have a trace impedance less than 2 Ω.	SIM Implementation on page 28
Decouple the VCC line close to the SIM socket. The longer the trace length (impedance) from socket to module, the greater the capacitance requirement to meet compliance tests.	
PCB Signal Routing	
USB 2.0—Route the USB interface signals over 90 Ω ± 10% differential lines on the PCB.	
USB 2.0 data lines must have closely matched trace lengths (within 2 mm (15 ps). Trace lengths must be < 105 mm.	
Route USB signals using a minimum number of vias and corners to reduce reflections and impedance changes.	
USB traces should be routed away from sensitive circuits and signals. Maintain good isolation, and spacing to all adjacent signals should be at least 2 × the trace width.	
EMI / ESD	
Investigate sources of localized interference early in the design cycle.	Methods to Mitigate Decreased Rx Performance on page 37

Table B-1: Hardware Integration Design Considerations (Continued)

Suggestion	Section where discussed
Provide ESD protection for the SIM connector at the exposed contact point (in particular, the CLK, VCC, IO, DETECT and RESET_N lines).	SIM Implementation on page 28
Keep very low capacitance traces on the UIM_DATA and UIM_CLK signals.	
To minimize noise leakage, establish a very good ground connection between the module and host.	Ground Connection on page 36
Route cables away from noise sources (for example, power supplies, LCD assemblies, etc.).	Methods to Mitigate Decreased Rx Performance on page 37
Shield high RF-emitting components of the host device (for example, main processor, parallel bus, etc.).	
Use discrete filtering on low frequency lines to filter out unwanted high-order harmonic energy.	
Use multi-layer PCBs to form shielding layers around high-speed clock traces.	
For HS_USB, the ESD protection is recommended on D+ and D-. The ESD diodes used in the design should have less than 3 pF of capacitance.	
Thermal	
Test to worst case operating conditions — temperature, voltage, and operation mode (transmitter on 100% duty cycle, maximum power).	Thermal Considerations on page 57
Use appropriate techniques to reduce module temperatures (for example, airflow, heat sinks, heat-relief tape, module placement, etc.).	
Host / Modem Communication	
Make sure the host USB driver supports remote wakeup, resume, and suspend operations, and serial port emulation.	
When no valid data is being sent, do not send SOF tokens from the host (causes unnecessary power consumption).	
Windows Driver — Support Win10, Win11 for MBIM data connection Linux Driver — Support Linux kernel 4.4 and later for MBIM (cdc_mbim + libmbim) and RmNet (qmi_wwan + libqmi)	Libmbim: 1.24.8 Libqmi: 1.28.8

C: Testing

Note: All Sierra Wireless embedded modules are factory-tested to ensure they conform to published product specifications.

Developers of OEM devices integrating Sierra Wireless embedded modules should include a series of test phases in their manufacturing process to make sure their devices work properly with the embedded modules. For more information, refer to *[3] EM8695 Customer Production Test Guide (Doc# 41114988)*.

Sierra Wireless offers optional professional services-based assistance to OEMs with regulatory approvals.

D: Thermal Testing

D.1 Worst Case Testing

Semtech recommends that customers identify realistic worst-case conditions for their platforms and perform appropriate thermal testing.

For example:

- If the device has very good throughput, it is likely near a tower so will not have to transmit at maximum Tx output power.
- If the device is transmitting at maximum Tx power, it is likely not near a tower and will not reach maximum throughput rates.
- Networks usually are sharing capacity among many users, so no single user is likely to reach maximum throughput rates for any significant length of time.
- If the device is transmitting at maximum throughput, it will likely do so for a limited time to limit the amount of data usage consumed from their data plan.

Suggested realistic worst-case test conditions

Semtech suggests using a worst-case test such as shown in Table D-1.

Table D-1: Thermal Testing—Suggested Worst Case Conditions

Condition	Values	Notes
Data throughput rate	UL: 0.8 Mbps/DL: 195 Mbps	B7, H channel RB12
Tx output power	23.5 dBm	

D.2 Thermal Testing Process

To perform thermal testing of the module:

1. Mount the module in its designed location on the platform.
2. Provide the same amount of airflow as will be experienced in your platform.
3. Set up a call with the use case for the platform (throughput rate, output power, duty cycle) on the worst-case band.
4. Observe the ramp in board temperature due to the call, and confirm whether the overall system performance still meets customer requirements.
5. Use **AT!TMSTATUS?** to check the module's thermal mitigation status (refer to *[1] EM8695 AT Command Reference (Doc# 41114815)* for details).
6. Increase the platform's ambient temperature to determine the margin that exists over the desired temperature specifications as subsequent mitigation methods activate (e.g. UL data rate throttled, DL throughput throttled, Tx power reduced, Emergency Service).

E: Packaging

E.1 Standard Packaging (100-in-1)

Semtech Embedded Modules are shipped in sealed boxes. The standard packaging (see Figure E-1), contains a single tray with a capacity of 100 modules. (Note that some SKUs may have custom packaging — contact Semtech for SKU-specific details.)

In the standard packaging, Embedded Modules (M1) are inserted, system connector first, into the bottom portion (T1) of a two-part tray, all facing the same direction. This allows the top edge of each Embedded Module (M1) to contact the top of the triangular features in the top portion (T2) of the tray (Detail A).

The top and bottom portions of the tray snap together at the four connection points.

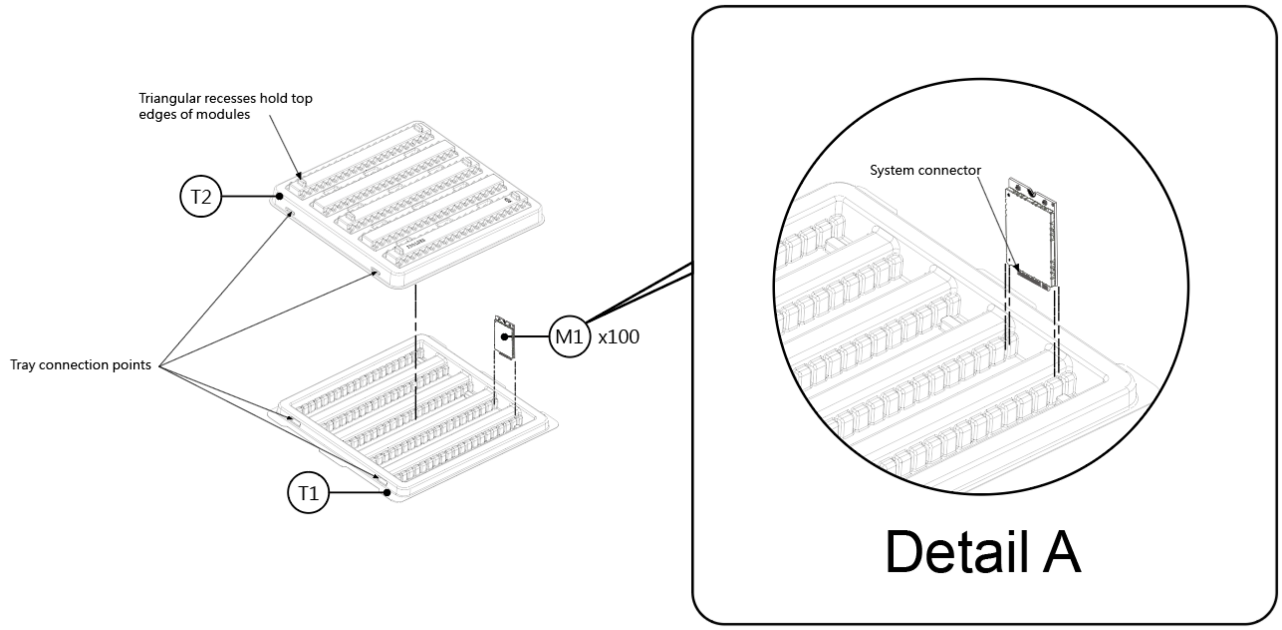


Figure E-1: Device Placement in Module Tray

The tray cover is secured to the tray base with ESD-safe tape (EP1) at the locations indicated. The tray is placed in a manufacturing box (B1). The box is sealed with a security tape (P1), and a manufacturing label (L1) is placed on the bottom-right corner of the top surface, above the security tape. If the manufacturing box is not full, a “Not Full” label (L2) will be affixed above the manufacturing label (L1).

The manufacturing box (B1) is wrapped with ≥3 layers of PE film, then a Packing Slip (PS1) will be affixed to the top left corner. (See Figure E-2.)

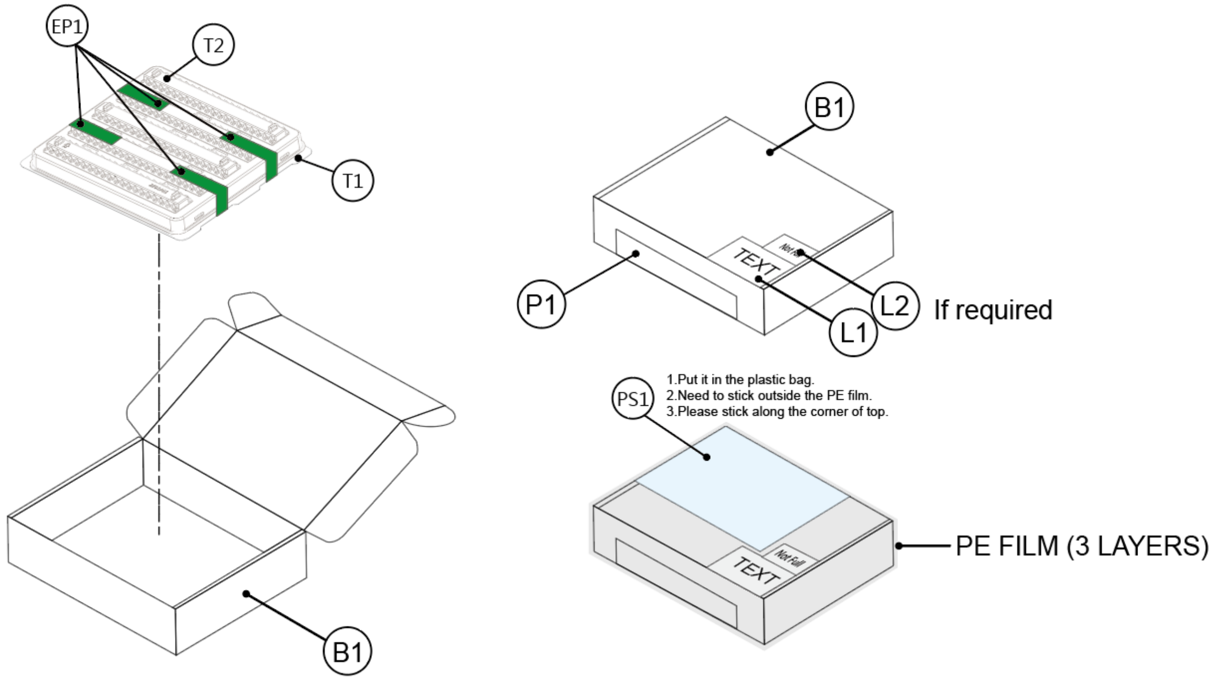


Figure E-2: Shipping Package for Manufacturing Box

E.2 500-in-1 Packaging

Five manufacturing boxes are placed in a shipping carton (B2). The carton is sealed with tape (P1) in an H-pattern covering the seams of the shipping carton. The shipping carton label (L3) is affixed to the upper right corner of the short side of the shipping carton. If the shipping carton is not full, a "Not Full" label (L2) will be affixed to the top of the carton (B2). The shipping carton (B2) is wrapped with ≥3 layers of PE film, then a Packing Slip (PS1) will be affixed to the top left corner. The shipping carton (B2) is tied with 3 plastic bands. (See Figure E-2.)

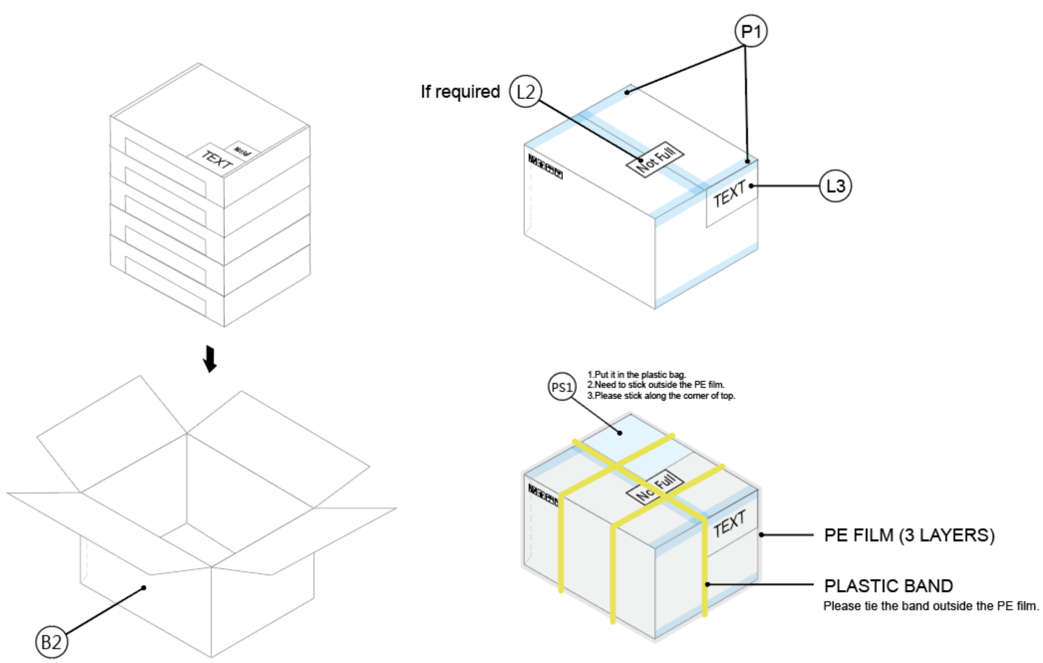


Figure E-3: Shipping Package for Shipping Carton

F: References

F.1 Semtech Documents

Semtech documents are available from source.sierrawireless.com, or on request (subject to license agreements or NDAs) from your Semtech representative.

Semtech Documents on the Source

The following documents are available from source.sierrawireless.com:

[1] EM8695 AT Command Reference (Doc# 41114815)

[2] AirPrime EM Series USB3.0 (M.2) Development Kit User Guide (Doc# 5303013)

[3] EM8695 Customer Production Test Guide (Doc# 41114988)

[4] EM8695 Smart Transmit (Forthcoming)

F.2 Industry / Other Documents

The following referenced document are not provided by Semtech:

[5] AT Command Set for User Equipment (UE) (Release 6) (Doc# 3GPP TS 27.007)

[6] PCI Express NGFF (M.2) Specification Revision 5.1

[7] Universal Serial Bus Specification, Rev 2.0

G: Abbreviations

Table G-1: Abbreviations and Definitions

Abbreviation or Term	Definition
3GPP	3rd Generation Partnership Project
8PSK	Octagonal Phase Shift Keying
A-GPS	Assisted GPS
AGC	Automatic Gain Control
API	Application Programming Interface
BeiDou	BeiDou Navigation Satellite System A Chinese system that uses a series of satellites in geostationary and middle earth orbits to provide navigational data.
BER	Bit Error Rate — A measure of receive sensitivity
BLER	Block Error Rate
Bluetooth	Wireless protocol for data exchange over short distances
CMAS	Commercial Mobile Alert System
COM	Communication port
CPE	Customer-Premises Equipment
CQI	Channel Quality Indication
CS	Circuit-switched
CSG	Closed Subscriber Group
CW	Continuous waveform
dB	Decibel = 10 x $\log_{10}$ (P1 / P2) *P1 is calculated power; P2 is reference power* Decibel = 20 x $\log_{10}$ (V1 / V2) *V1 is calculated voltage, V2 is reference voltage*
dBm	A logarithmic (base 10) measure of relative power (dB for decibels); relative to milliwatts (m). A dBm value will be 30 units (1000 times) larger (less negative) than a dBW value, because of the difference in scale (milliwatts vs. watts).
DC-HSPA+	Dual Carrier HSPA+
DCS	Digital Cellular System A cellular communication infrastructure that uses the 1.8 GHz radio spectrum.
DL	Downlink (network to mobile)
DRX	Discontinuous Reception
DSI	Device State Index (Smart Transmit exposure scenario)
DSM	Distributed Shared Memory

Table G-1: Abbreviations and Definitions (Continued)

Abbreviation or Term	Definition
DUT	Device Under Test
EGNOS	European Geostationary Navigation Overlay Service (SBAS for GPS, GLONASS, Galileo)
eICIC	Enhanced Inter-Cell Interference Coordination
EIRP	Effective (or Equivalent) Isotropic Radiated Power
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
ENDC	E-UTRAN New Radio — Dual Connectivity
EP	End Point
ERP	Effective Radiated Power
ESD	Electrostatic Discharge
FCC	Federal Communications Commission The U.S. federal agency that is responsible for interstate and foreign communications. The FCC regulates commercial and private radio spectrum management, sets rates for communications services, determines standards for equipment, and controls broadcast licensing. Consult www.fcc.gov.
FDD	Frequency Division Duplexing
FDMA	Frequency Division Multiple Access
feICIC	Further Enhanced Inter-Cell Interference Coordination
FER	Frame Error Rate — A measure of receive sensitivity.
firmware	Software stored in ROM or EEPROM; essential programs that remain even when the system is turned off. Firmware is easier to change than hardware but more permanent than software stored on disk.
FOTA	Firmware Over The Air — Technology used to download firmware upgrades directly from the service provider, over the air.
FOV	Field Of View
FPC	Flexible Printed Cable
FSN	Factory Serial Number—A unique serial number assigned to the module during manufacturing.
Galileo	A European system that uses a series of satellites in middle earth orbit to provide navigational data.
GCF	Global Certification Forum
GLONASS	Global Navigation Satellite System — A Russian system that uses a series of 24 satellites in middle circular orbit to provide navigational data.
GMSK	Gaussian Minimum Shift Keying modulation
GNSS	Global Navigation Satellite Systems (GPS, GLONASS, BeiDou, and Galileo)

Table G-1: Abbreviations and Definitions (Continued)

Abbreviation or Term	Definition
GPS	Global Positioning System An American system that uses a series of 24 satellites in middle circular orbit to provide navigational data.
HB	High Band
Host	The device into which an embedded module is integrated
HSDPA	High Speed Downlink Packet Access
HSPA+	Enhanced HSPA, as defined in 3GPP Release 7 and beyond
HSUPA	High Speed Uplink Packet Access
Hz	Hertz = 1 cycle/second
IC	Industry Canada
IF	Intermediate Frequency
IMEI	International Mobile Equipment Identity
IMS	IP Multimedia Subsystem—Architectural framework for delivering IP multimedia services.
inrush current	Peak current drawn when a device is connected or powered on
inter-RAT	Radio Access Technology
IOT	Interoperability Testing
IS	Interim Standard. After receiving industry consensus, the TIA forwards the standard to ANSI for approval.
ISIM	IMS Subscriber Identity Module (Also referred to as a SIM card)
LAA	Licensed Assisted Access
LB	Low Band
LED	Light Emitting Diode. A semiconductor diode that emits visible or infrared light.
LHCP	Left-Hand Circular Polarized
LNA	Low Noise Amplifier
LPM	Low Power Mode
LPT	Line Print Terminal
LTE	Long Term Evolution—a high-performance air interface for cellular mobile communication systems.
MB	Mid Band
MCS	Modulation and Coding Scheme
MHz	Megahertz = 10e6 Hz

Table G-1: Abbreviations and Definitions (Continued)

Abbreviation or Term	Definition
MIMO	Multiple Input Multiple Output—wireless antenna technology that uses multiple antennas at both transmitter and receiver side. This improves performance.
MPR	Maximum Power Reduction
MSAS	Multi-functional Satellite Augmentation System (SBAS for GPS)
NAS/AS	Network Access Server
NC	No Connect
NIC	Network Interface Card
NLIC	Non-Linear Interference Cancellation
NMEA	National Marine Electronics Association
NSA	5G Non-standalone architecture
ODM	Original Design Manufacturer
OEM	Original Equipment Manufacturer—a company that manufactures a product and sells it to a reseller.
OFDMA	Orthogonal Frequency Division Multiple Access
OMA DM	Open Mobile Alliance Device Management — A device management protocol.
OS	Operating System
OTA	'Over the air' (or radiated through the antenna)
PA	Power Amplifier
packet	A short, fixed-length block of data, including a header, that is transmitted as a unit in a communications network.
PCB	Printed Circuit Board
PCC	Primary Component Carrier
PCS	Personal Communication System A cellular communication infrastructure that uses the 1.9 GHz radio spectrum.
PDN	Packet Data Network
PLAN	Personal Localized Alerting Network — See CMAS
PMI	Pre-coding Matrix Index
PRX	Primary Reception
PSS	Primary synchronization signal
PST	Product Support Tools
PTCRB	PCS Type Certification Review Board
QAM	Quadrature Amplitude Modulation. This form of modulation uses amplitude, frequency, and phase to transfer data on the carrier wave.

Table G-1: Abbreviations and Definitions (Continued)

Abbreviation or Term	Definition
QCI	QoS Class Identifier
QMI	Qualcomm MSM/Modem Interface
QOS	Quality of Service
QPSK	Quadrature Phase-Shift Keying
QPST	Qualcomm Product Support Tools
QZSS	Quasi-Zenith Satellite System — Japanese system for satellite-based augmentation of GPS.
RAT	Radio Access Technology
RC	Root Complex
RF	Radio Frequency
RI	Ring Indicator
roaming	A cellular subscriber is in an area where service is obtained from a cellular service provider that is not the subscriber's provider.
RSE	Radiated Spurious Emissions
RSSI	Received Signal Strength Indication
S/N	Signal-to-noise (ratio)
SA	5G Standalone architecture
SAR	Specific Absorption Rate
SBAS	Satellite-based Augmentation System
SCC	Secondary Component Carrier
SCS	Subcarrier Spacing
SDK	Software Development Kit
SED	Smart Error Detection
Sensitivity (Audio)	Measure of lowest power signal that the receiver can measure.
Sensitivity (RF)	Measure of lowest power signal at the receiver input that can provide a prescribed BER/BLER/SNR value at the receiver output.
SG	An LTE signaling interface for SMS ("SMS over SGs")
SIB	System Information Block
SIM	Subscriber Identity Module. Also referred to as USIM or UICC.
SIMO	Single Input Multiple Output—smart antenna technology that uses a single antenna at the transmitter side and multiple antennas at the receiver side. This improves performance and security.
SISO	Single Input Single Output—antenna technology that uses a single antenna at both the transmitter side and the receiver side.

Table G-1: Abbreviations and Definitions (Continued)

Abbreviation or Term	Definition
SKU	Stock Keeping Unit—identifies an inventory item: a unique code, consisting of numbers or letters and numbers, assigned to a product by a retailer for purposes of identification and inventory control.
SMS	Short Message Service. A feature that allows users of a wireless device on a wireless network to receive or transmit short electronic alphanumeric messages (up to 160 characters, depending on the service provider).
SNR	Signal-to-Noise Ratio
SOF	Start of Frame—A USB function.
SSS	Secondary synchronization signal.
SUPL	Secure User Plane Location
TD-SCDMA	Time Division Synchronous Code Division Multiple Access
TDD	Time Division Duplexing
TIA/EIA	Telecommunications Industry Association/Electronics Industry Association. A standards setting trade organization, whose members provide communications and information technology products, systems, distribution services and professional services in the United States and around the world. Consult www.tiaonline.org.
TIS	Total Isotropic Sensitivity
TRP	Total Radiated Power
TRX	Transceiver Transmits and receives signals
UDK	Universal Development Kit (for PCI Express Mini Cards)
UE	User Equipment
UHB	Ultra-High Band
UICC	Universal Integrated Circuit Card (Also referred to as a SIM card.)
UL	Uplink (mobile to network)
UMTS	Universal Mobile Telecommunications System
USB	Universal Serial Bus
USIM	Universal Subscriber Identity Module (UMTS)
VCC	Supply voltage
VDC	Volts DC
VSWR	Voltage Standing Wave Ratio
WAN	Wide Area Network
WCDMA	Wideband Code Division Multiple Access (also referred to as UMTS)
WEA	Wireless Emergency Alerts—See CMAS

Table G-1: Abbreviations and Definitions (Continued)

Abbreviation or Term	Definition
WLAN	Wireless Local Area Network
WWAS	Wide Area Augmentation System (SBAS for GPS)
ZIF	Zero Intermediate Frequency
ZUC	ZUC stream cypher

H

H: Revision History

Revision number	Release date	Changes
0.1	February 2024	Document creation, preliminary release
1	April 2024	External release
2	July 2024	Updated band references (removed LTE B11/B21, 5G Sub-6 n53; updated LTE HPUE support Updated Table 2-1 Host Interface (75-pin) Connections — Module View (Voltage levels — pins 6, 8, 23, 25, 26, 30, 32, 34, 36, 42, 44, 46, 48; Pin names/descriptions — pins 20, 22, 24, 28, 38, 41, 43, 47, 48, 49, 59, 52, 53, 54, 55, 60, 62, 64, 68) Updated 2.5.1 WAKE_ON_WAN_N — Wake Host Updated 2.5.2 W_DISABLE_N (Wireless Disable) and GPS_DISABLE_N (GNSS Disable) Updated 2.5.4 WWAN_LED_N — LED Output Updated 2.6 Antenna Control Updated 3-6 Conducted Maximum Tx Power Tolerances (values TBD) Updated 4.2.2 Power Saving Mode (PSM) (removed usage note) Updated Figure 4-2 (PSM Cycle) Updated 4.5 Tx Power Control (resistor) Updated Table 7-1 ISED Antenna Gain and Collocated Radio Transmitter Specifications (formatting; values TBD) Updated Table 7-2 FCC Antenna Gain and Collocated Radio Transmitter Specifications (formatting; values TBD) Updated Table A-2 GNSS Antenna Requirements (Active GNSS antenna) Updated Table D-1 Thermal Testing — Suggested Worst Case Conditions (throughput rate) Updated antenna control references (ANT_CTRL only) Removed GPS references from Auxiliary antenna
3	November 2024	Updated band support throughout document — removed B68; added B30 Removed references to 5G Sub-6 HPUE and LTE B40/B41 support throughout document Updated 1.2 Mechanical Features (updated Important note — marked max temp as TBD) Updated 1.3 Host Interface Features (general update) Updated 1.4 Modem Features (general update) Updated 1.5 5G Sub-6 Features (general update) Updated 1.6 LTE Features (general update) Updated 1.8 Position Location (GNSS) (updated gpsOneXTRA version support); add NacIC) Updated 1.13 Security Considerations (general update) Updated 2.1 M.2 (Host) Interface Pin Assignments (marked signal driving delay as TBD) Updated Table 2-1, Host Interface (75-pin) Connections — Module View (Updated descriptions for pins 1, 21, 28, 69, 75) Updated 2.4 SIM Interface (general update) Updated Table 3-2, 5G NR Bandwidth Support (added n30; updated n70) Updated Table 3-3, LTE Bandwidth Support (added B30, B70) Updated Table 3-4, Typical Conducted Rx Sensitivity — NR Bands (added n30; updated all Worst Case requirement values) Updated Table 3-5, Typical Conducted Rx (Receive) Sensitivity — LTE Bands at 10 MHz BW (added B30 Worst Case value; added B70) ***(Continued on next page)***

Revision number	Release date	Changes
		(Continued from previous page) Updated Table 3-6, Conducted Maximum Tx Power Tolerances Updated Table 3-7, GNSS Specifications (updated Satellite channels; removed Protocols; set time/accuracy/sensitivity values as TBD) Updated Table 4-2, Averaged Call Mode DC Power Consumption (set LTE 26 dBm value as TBD) Updated Table 4-4, Module Power States (Removed PSM and Sleep modes, and related sections) Marked as forthcoming: 4.2.2 Extended Discontinuous Reception (eDRX) 4.5 Tx Power Control Updated 4.3.1 Power Ramp-up (marked time and current values as TBD) Updated 4.3.2 Timing (USB Enumeration — removed double enumeration example) Updated 5 Software (general update) Updated Table 6-1, Mechanical and Environmental Specifications (weight) Updated 6.3 Thermal Considerations (general update) Updated Table D-1, Thermal Testing — Suggested Worst Case Conditions (Tx output power)
4	February 2025	Updated Table 1-1, Supported RF Bands (5G Sub-6 data rates) Updated 1.2 Mechanical Features (Replaced TBD temperatures in Important note) Updated 1.3 Host Interface Features (Clarified USB endpoints description) Updated 2.1 M.2 (Host) Interface Pin Assignments (Replaced TBD timing in Important note) Added VCC Bypass Capacitor content (Updated Table 2-1, Host Interface (75-pin) Connections — Module View (footnote); added 2.2 VCC Bypass Capacitor (Host product requirement) Updated 2.6.1 WAKE_ON_WAN_N — Wake Host (added description) Marked as forthcoming: 2.7 Antenna Control Updated Table 3-4 Typical Conducted Rx Sensitivity — NR Bands (sensitivity values) Updated Table 3-5 Typical Conducted Rx (Receive) Sensitivity — LTE Bands at 10 MHz BW (sensitivity values) Updated Table 3-6 Conducted Maximum Tx Power Tolerances (bands, tolerances) Updated Table 3-7 GNSS Specifications (accuracy, sensitivity, operational limits) Updated Table 4-1 Averaged Standby DC Power Consumption (current values) Updated Table 4-2 Averaged Call Mode DC Power Consumption Updated Table 4-3 Miscellaneous DC Power Consumption (current values; inrush current note for VCC bypass capacitor) Updated Table 4-5 Power State Transition Default Trigger Levels (trigger values) Updated 4.3.1 Power Ramp-up (updated description, replaced TBD timing and current value) Updated 4.3.2 Timing (removed double USB enumeration) Updated Table 4-7 USB 2.0 Power-On/Off Timing Parameters (Single Enumeration) (timing values) Updated 4.5 Tx Power Control (replaced description) Updated Table 6-1 Mechanical and Environmental Specifications (temperature, thermal shock, dimensions) Added 6.1 Device Views Updated Figure 6-2 EM8695 Thermal Characteristics Updated 7.1 Regulatory Compliance (IC ID, FCC ID ***(Continued on next page)***

Revision number	Release date	Changes
		(Continued from previous page) Updated Table D-1, Thermal Testing—Suggested Worst Case Conditions (replaced TBD values) Updated E Packaging (Updated standard packaging details; added 500-in-1 packaging details)
5	April 2025	Updated 1.2 Mechanical Features (updated Important note AT command and values) Updated 1.5 5G Sub-6 Features (added RedCap FDD/TDD details) Updated 1.6 LTE Features (added UL modulation scheme 256 QAM) Updated 2.6.4 WWAN_LED_N—LED Output (updated resistor value) Replaced Table 4-5 Power State Transition Default Trigger Levels with Table 4-5, Power State Thresholds Replaced Figure 4-1, Voltage/Temperature Monitoring State Machines Replaced Figure 6-2, EM8695 Thermal Characteristics
6	June 2025	Added B106 support Added BeiDou B1C (Table 1-2 GNSS Frequency Support, Table A-2 GNSS Antenna Requirements) Updated Table 2-8 Full_Card_Power_Off_N and RESET_N Usage (RESET_N details) Updated Table 3-6 Conducted Maximum Tx Power Tolerances Updated Required Shutdown Sequence on page 52 Updated 6.4 Thermal Considerations (added keep-out note) Updated Table 7-1 ISED Antenna Gain and Collocated Radio Transmitter Specifications, Table 7-2 FCC Antenna Gain and Collocated Radio Transmitter Specifications
7	September 2025	Updated 1.6 LTE Features (marked LTE UL 256QAM support) Updated 3.7 Conducted Rx Sensitivity/Tx Power (added ambient temperature note) Updated Table 3-7, GNSS Specifications (updated Horizontal and Altitude accuracy) Updated Table 4-2, Averaged Call Mode DC Power Consumption (updated 24 dBm current values) Updated Figure 4-3, Signal Timing (Full_Card_Power_Off_N, and USB Enumeration) (corrected parameter name) Updated USB Enumeration (added detailed USB enumeration details—Figure 4-4, Signal Timing—USB Enumeration with Software Reset, Table 4-8, USB Enumeration with Software Reset—Timing Parameters) Updated Table 6-1, Mechanical and Environmental Specifications (updated Ambient temperature Class A note for heatsinking; updated Drop details) Updated Table 7-2, FCC Antenna Gain and Collocated Radio Transmitter Specifications (removed RedCap) Updating Table A-2, GNSS Antenna Requirements (removed active antenna)
8	October 2025	Updated Table 7-1, ISED Antenna Gain and Collocated Radio Transmitter Specifications (updated B78/n78 standalone/collocated gain values)