AirPrime EM919X/EM7690

Product Technical Specification

SIERRA WIRELESS®

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Due to the nature of wireless communications, transmission and reception of data can never be guaranteed. Data may be delayed, corrupted (i.e., have errors) or be totally lost. Although significant delays or losses of data are rare when wireless devices such as the Sierra Wireless modem are used in a normal manner with a well-constructed network, the Sierra Wireless modem should not be used in situations where failure to transmit or receive data could result in damage of any kind to the user or any other party, including but not limited to personal injury, death, or loss of property. Sierra Wireless accepts no responsibility for damages of any kind resulting from delays or errors in data transmitted or received using the Sierra Wireless modem, or for failure of the Sierra Wireless modem to transmit or receive such data.

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Document History

Version	Date	Updates
0.1-Draft	October 17, 2019	Preliminary release
0.2-Draft	November 15, 2019	Updated pinouts, RF and connectors, mechanical drawings, and thermal notes, some power consumptions changed to TBD
0.3-Draft	November 29, 2019	Cleaned up a few pinout descriptions, updated module control signals, added notes for optional signals, removed band of n8, updated 5G UL modulation, added preliminary CA and EN-DC tables
0.4-Draft	March 6, 2020	Updated M.2 pinout to have both USB3.1 and PCIe signals, added PCIE_DIS for interface selection, updated M.2 port configuration, added 3 VCC pins, added ANT_CTRLx pins, changed to use MHF7S connectors, added figures of USB3, specified maximum sink current for WWAN_LED#, updated supported NR bands and bandwidth in 4.6, updated typical conducted Rx sensitivities in 4.7, updated 5G NR data rates, updated MIMO support descriptions, added notes for CA/EN-DC, updated power state transition trigger levels, removed GNSS features of 10Hz and SBAS, added production testing with reference document.
0.5-Draft	May 12, 2020	Corrected some data rates in Table 1-1, updated system block diagram, added VCC peak and continuous current spec, updated RESET# timing, updated PCIe/USB descriptions and power on/off timing diagrams and parameters, updated mmWave IF ports assignment, updated GNSS specifications, updated power consumption data, updated MHF7S part numbers, added mmWave guidelines reference document, removed intra-band EN-DC on n41.
0.6-Draft	June 24, 2020	Changed to EM919X/EM7690 to include EM9190, EM9191 and EM7690. Updated power consumption, updated RESET timing, added ESDC compliance, updated RF sensitivity, updated DPR of SAR backoff control, updated mechanical drawings, added weight information, updated antenna gain and collocated radio transmitter specifications, updated FCC ID and IC, added FCC compliance standards.
0.7-Draft	July 31, 2020	Added variants information, specified EM9191 data rate, added bands n7, n8, n12, n20, n25, n38, n40, n48 and B43 support in future release, clarified RF power class and B41 standalone HPUE, updated bandwidth support for some bands, updated some NR conducted Rx sensitivity, added some notes for PCIe interface, added non-sleep mode standby power consumption, updated mechanical and environmental specifications, updated mechanical drawings, updated CA and EN-DC tables, added a few reference documents.
0.8-Draft	August 27, 2020	Updated EM9191 variant information, updated EM9191 DL throughput, updated n41 DL MIMO, added 42C for Intra-band ULCA, updated B71 bandwidth support, added a note for B46 Conducted Rx Sensitivity, updated Tx Power Control and moved to section 3.7, updated power supply/consumption spec for EM9190, EM9191 and EM7690 respectively, updated CA and EN-DC tables based on updated EM9191 capability, updated a few reference documents.
1	October 30, 2020	Removed USB2.0 backward-compatible references Updated resistor value – Figure 3-7 Recommended Wireless Disable Connection Updated 3.6.6 PCIE_DIS – Interface Selection Updated Table 5-1 Averaged Standby DC Power Consumption Added test data footnote – Table 5-2 Averaged Call Mode DC Power Consumption Added footnote – Table 5-5 Power State Transition Trigger Levels Updated PLA_S2# signal details – Figure 5-2 Power On/Off Timing for PCIe Port, and Table 5-6 PCIe Timing
2	November 04, 2020	Updated Table 5-1 Averaged Standby DC Power Consumption Updated Figure 7-5 Unit Product Marking Example

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1. Introduction

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The Sierra Wireless EM919X/EM7690 Embedded Module series includes variants of EM9190, EM9191 and EM7690. EM919X will represent EM9190 and EM9191 in this document.

EM919X/EM7690 is an M.2 module with FirstNet-ready (B14 LTE). It provides 5G NR Sub-6G, 5G mmWave, 4G LTE advanced Pro, 3G (HSPA+, UMTS) subject to variants, and GNSS connectivity for a wide range of devices and purposes including business, personal, portable computing and communication devices, IoT devices, M2M applications and industrial use cases.

EM919X/EM7690 Embedded Modules are available in a variety of region-specific and function-specific SKUs, including 5G NR Sub-6G and mmWave-capable variant (EM9190), 5G NR Sub-6G variant (EM9191), and LTE Cat-20 variant (EM7690). Refer to Table 1-1 for detailed RF capabilities supported by each variant, refer to Carrier Aggregation and EN-DC for more details about band combination.

Table 1-1 Variants Information

Variant	LTE Only		FR1 NSA EN-DC		FR2 NSA EN-DC	
	Layer	DLCA	LTE	NR	LTE	NR
EM9190	20 Layers	7CC	20 Layers	100 MHz TDD, 20MHz FDD	8 Layers	800 MHz[1]
					20 Layers[1]	400 MHz
EM9191	20 Layers	7CC	12 Layers	100 MHz TDD, 20MHz FDD	Not Support	
			16 Layers[1]	60 MHz TDD, 20MHz FDD		
EM7690	20 Layers	7CC	Not Support		Not Support	

1. Supported with a future firmware update.

1.1. Supported RF Bands

The modem supports data operation on 5G NR, 4G LTE and 3G networks over the bands described in Table 1-2. For detailed combinations of LTE carrier aggregation (CA) and NR EN-DC, refer to Carrier Aggregation and EN-DC.

Table 1-2 RF Band Support

Technology	Bands		Data Rates[4]
5G	mmWave[1]	n257, n258, n260, n261	Downlink (DL): • 20 layers LTE[5] + mmWave (400MHz BW, 64QAM, 2x2): ~5.38Gbps @ 98.75% duty cycle. • 8 layers LTE + mmWave (800MHz[5] BW, 64QAM, 2x2): ~7.53Gbps @ 98.75% duty cycle. Uplink (UL): • 2 layers LTE + mmWave (200MHz BW, 64QAM, 2x2): ~1.60Gbps @ 98.4% duty cycle.

Technology	Bands		Data Rates[4]
	Sub-6G[2]	n1, n2, n3, n5, n7[5], n8[5], n12[5], n20[5], n25[5], n28, n38[5], n40[5], n41, n48[5], n66, n71, n77, n78, n79	EM9190 Downlink (DL): • 20 layers LTE + TDD (100MHz BW, 256QAM, 4x4): ~4.14Gbps @ 95% duty cycle • 20 layers LTE + FDD (20MHz BW, 256QAM, 4x4): ~2.44Gbps EM9191 Downlink (DL): • 12 layers LTE + TDD (100MHz BW, 256QAM, 4x4): ~3.33Gbps @ 95% duty cycle • 16 layers LTE[5] + FDD (20MHz BW, 256QAM, 4x4): ~2.03Gbps Uplink (UL): • 2 layers LTE + TDD (100MHz BW, 256QAM, SISO): ~0.66Gbps @ 92.5% duty cycle • 2 layers LTE + FDD (20MHz BW, 256QAM, SISO): ~0.32Gbps
LTE	LTE	B1, B2, B3, B4, B5, B7, B8, B12, B13, B14, B17, B18, B19, B20, B25, B26, B28, B29, B30[3], B32, B34, B38, B39, B40, B41, B42, B43[5], B46[3], B48, B66, B71	• DL Cat 20: up to 20 layers • UL Cat 18: 2CC intra-band contiguous and inter-band, 256QAM • Supported BW: 1.4–20 MHz, per 3GPP specs for supported bands
3G	HSPA+/WCDMA	Bands 1, 2, 3, 4, 5, 6, 8, 9, 19	• DC-HSPA+ — Rel 10, DL 42Mbps / UL 5.76 Mbps • WCDMA — R99
GNSS	L1	GPS/QZSS L1, GLONASS G1, Galileo E1, BeiDou B1i	Standalone GNSS
	L5[6]	GPS L5, GAL E5a, QZSS L5 BDS B2a	

1. EM9190 only, IF and BB parts for mmWave support is provided, and it has to work with Qualcomm QTM525 or QTM527 chipset to implement mmWave. The QTM525/QTM527 is active antenna array with dedicate power management, RF power amplifiers and frequency converters integrated.
2. EM919X only, not supported in EM7690.
3. LTE-LAA B46. And devices can choose to operate B30 as Tx/Rx or Rx only.
4. For theoretical peak data rate with minimal overhead and maximal TDD ratio, refer to *[7] AirPrime EM919X 5G NR Peak Throughput*.
5. Supported with a future firmware update.
6. Subject to SKU configuration.

1.2. Physical Features

M.2 form factor:

- WWAN Type 3042-S3-B (in WWAN — PCIe and USB3 Port Configuration 2) with length of 52mm, as specified in *[13] PCI Express M.2™ Specification Revision 3.0, Version 1.2*.
- Conforms to M.2 form factor width specification. For complete dimensions, refer to Figure 7-2.
- 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!PCTEMP?**) must be kept below 115°C. For best performance, the internal module temperature should be kept below 100°C. Proper mounting, heat sinks, and active cooling may be required. Refer to [4] EM9190 Thermal Application Note for details.*

1.3. Application Interface Features

- PCIe or USB interface (QMI) for Linux and Android
- MBIM for Windows 10 and Linux
- AT command interface and proprietary extended AT commands, refer to *[2] AirPrime EM919X AT Command Reference* for details.
- Software Development Kits (SDK) including API (Application Program Interface) functions for Linux
- Dynamic power reduction support via software and dedicated hardware interface (DPR)
- OMADM (Open Mobile Alliance Device Management)
- FOTA (Firmware Over The Air)

Note: OMA DM and FOTA support is operator-dependent that is based on carrier requirements.

1.4. Modem Features

- 5G mmWave (EM9190), 5G Sub-6G (EM919X), 4G LTE, 3G (DC-HSPA+ / HSPA+ / HSPA / WCDMA) operation
- Multiple (up to 16) cellular packet data profiles
- Traditional modem COM port support for AT commands
- Sleep mode for minimum idle power draw
- SIM application tool kit with proactive SIM commands
- Enhanced Operator Name String (EONS)
- Mobile-originated PDP context activation / deactivation
- Support QoS QCI
- Static and Dynamic IP address. The network may assign a fixed IP address or dynamically assign one using DHCP (Dynamic Host Configuration Protocol).
- PAP and CHAP support
- PDP context type (IPv4, IPv6, or IPv4v6)
- RFC1144 TCP/IP header compression
- Public Safety 3GPP Features — 3GPP R15 (per 3GPP TS 23.203, TS 29.212): QCI values 65, 66, 69, and 70.

1.5. 5G Features

Note: 5G features are supported on EM919X only, and mmWave features are supported on EM9190 only.

- Supported Frequency Range: Both FR1 (Sub-6G) and FR2 (mmWave).
- Network Options: Option 2 for SA and Option 3/3a for NSA EN-DC.
  - SA:
    - TDD: n41[1], n78, n79
    - FDD: n1[1], n2[1], n3[1], n7[1], n25[1], n28[1], n66[1], n71[1]
  - NSA: support the EN-DC for all NR bands, refer to Carrier Aggregation and EN-DC for more detailed combinations.
- UL Modulation: 256QAM[2] for FR1 and 64QAM for FR2.

- DL Modulation: 256QAM for FR1 and 64QAM for FR2.
- UL MIMO:
  - FR1: not supported
  - FR2: 2x2 UL MIMO
- DL MIMO:
  - 2x2 DL MIMO are supported on all bands. The antenna ports for FR1 are Primary (TRx) and Diversity (DRx) ports except for n41 whose 2x2 DL MIMO is supported by MIMO1/2.
  - 4x4 DL MIMO can be supported on FR1 bands n1/2/3/7[1]/25[1]/38[1]/40[1]/41/48[1]/66/77/78/79.
- SRS fast hopping: Not supported.
- SCS:
  - FR1: FDD can only support 15KHz, and TDD can only support 30KHz.
  - FR2: 120KHz for data and sync channels, and 240KHz for sync channels only.
- BW per CC:
  - FR1: Up to 100MHz.
  - FR2: 50MHz and 100MHz

1. Supported with a future firmware update.
2. Only enabled based on particular carrier requirement.

1.6. LTE Features

- Carrier aggregation:
  - DL: Up to 7CC
  - UL: 2CC intra-band continuous and inter-band CA
- DL MIMO:
  - 2x2 DL MIMO are supported on all bands. The antenna ports are Primary (TRx) and Diversity (DRx) ports.
  - 4x4 DL MIMO can be supported on bands B1/2/3/4/7/25/30/32/34/38/39/40/41/42/43[1]/48/66.
- HPUE: B41 standalone mode.
- LAA: supported by B46.
- Modulation:
  - DL Modulation: up to 256QAM
  - UL Modulation: up to 256QAM
- CSG support (LTE Femto)
- LTE Advanced receivers (NLIC, eICIC, feICIC)
- Basic cell selection and system acquisition
  - PSS/SSS/MIB decode
  - SIB1–SIB16 decoding
- NAS/AS security procedures
  - Snow 3G/AES/ZUC security
- CQI/RI/PMI reporting
- Paging procedures
  - Paging in Idle and Connected mode
- Dedicated bearer
  - Network-initiated dedicated bearer
  - UE-initiated dedicated bearer
- Multiple PDN connections (IPv4 and IPv6 combinations), subject to operating system support.
- Connected mode intra-LTE mobility
- Idle mode intra-LTE mobility
- iRAT between LTE/3G for idle and connection release with redirection
- Detach procedure
  - Network-initiated detach with reattach required
  - Network-initiated detach followed by connection release

1. Supported with a future firmware update.

1.7. Short Message Service (SMS) Features

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

1.8. Position Location (GNSS)

- High-precision GNSS with L1+L5 (optional)
- Customizable tracking session
- Automatic tracking session on startup
- Concurrent standalone GNSS (GPS, GLONASS, Galileo, BeiDou, QZSS)
- Simultaneous fixes from two GNSS systems (e.g. GPS and GLONASS)
- Assisted GPS (A-GPS)/GLONASS SUPL2.0 with configurable aiding refresh rate
- gpsOneXTRA 2.0/3.1

1.9. Accessories

A hardware development kit is available for AirPrime M.2 modules, refer to *[3] AirPrime EM9190 Development Kit User Guide* for details. The kit contains hardware components for evaluating and developing with the module, including:

- Development board
- Cables
- Antennas
- Other accessories

For over-the-air 5G and LTE testing, ensure that an appropriate antenna is being used.

1.10. Required Connectors

Table 1-3 describes the connectors used to integrate the EM919X/EM7690 Embedded Module into your host device.

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

Connector Type	Description
RF cables — 5G NR Sub-6G/ LTE/GNSS	• Mate with M.2-spec connectors • Four connector jacks (mate with I-PEX 20448-001R-081 or equivalent)
RF cables — mmWave[2]	• Eight connector jacks (mate with I-PEX 20955-001R-13 or equivalent) • Two cables for each mmWave antenna module (up to 8 cables in total)
EDGE (67 pin)	• Slot B compatible — Per the M.2 standard (*[13] PCI Express M.2™ Specification Revision 3.0, Version 1.2*), a generic 75-pin position 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. Refer to SIM Interface for details.

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

2. EM9190 only.

1.11. Integration Requirements

Sierra Wireless provides, in the documentation suite, guidelines for successful module integration and offers integration support services as necessary.

When integrating the EM919X/EM7690 Embedded Module, the following items must be addressed:

- **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.
- **Service provisioning** — Manufacturing process
- **Software** — As discussed in Software Interface.
- **Host interface** — Compliance with interface voltage levels

2. Standards Compliance

2

The EM919X/EM7690 Embedded Module complies with the mandatory requirements described in the following standards. The exact set of requirements supported is network operator dependent.

Table 2-1 Standards Compliance

Technology	Standards
5G[1]	3GPP Release 15
LTE	3GPP Release 15
UMTS	3GPP Release 9

1. Applicable to EM919X only.

3. Electrical Specifications

The system block diagram in Figure 3-1 represents the EM919X/EM7690 module integrated into a host system. The module includes the following major interfaces to the host:

- Full_Card_Power_Off# — Input supplied to the module by the host, active-low to turn the unit off, or active-high to turn the unit on.
- W_DISABLE# — Active low input from the host to the EM919X/EM7690 disables the main RF radio.
- GPS_DISABLE# — Active low input from the host to the EM919X/EM7690 disables the GNSS radio receiver.
- WAKE_ON_WAN# — Active low output used to wake the host when specific events occur.
- RESET# — Active low input from the host used to reset the module.
- Antenna — Four LTE/Sub-6G RF connectors and eight mmWave IF connectors (EM9190 only) to support up to four mmWave antennas. For details, refer to RF Specifications.
- Dynamic power control (DPR) — Signal used to adjust Tx power to meet FCC SAR requirements. For details, refer to Tx Power Control.
- SIMs:
  - External SIM — The SIM holder/tray is mounted on the host platform.
  - Internal SIM — A SIM is mounted/embedded internal to the module.
  - Either the external or internal SIM can be active — the active SIM can be specified through configuration or software control.
- SIM detect — Internal pullup 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 — USB3.1 Gen2 interface to the host for data, control, debug and status information.
- PCIe — PCIe3.0 (PCIe2.0 backward compatible) interface to the host for data, control, debug and status information.
- PCIE_DIS — Host interface selection, high for USB, low or Hi-Z for PCIe.

The EM919X/EM7690 has three main interface areas — the host I/O connector, the LTE/Sub-6G RF connectors, and the mmWave IF (EM9190 only) connectors. Details of these interfaces are described in the sections that follow.

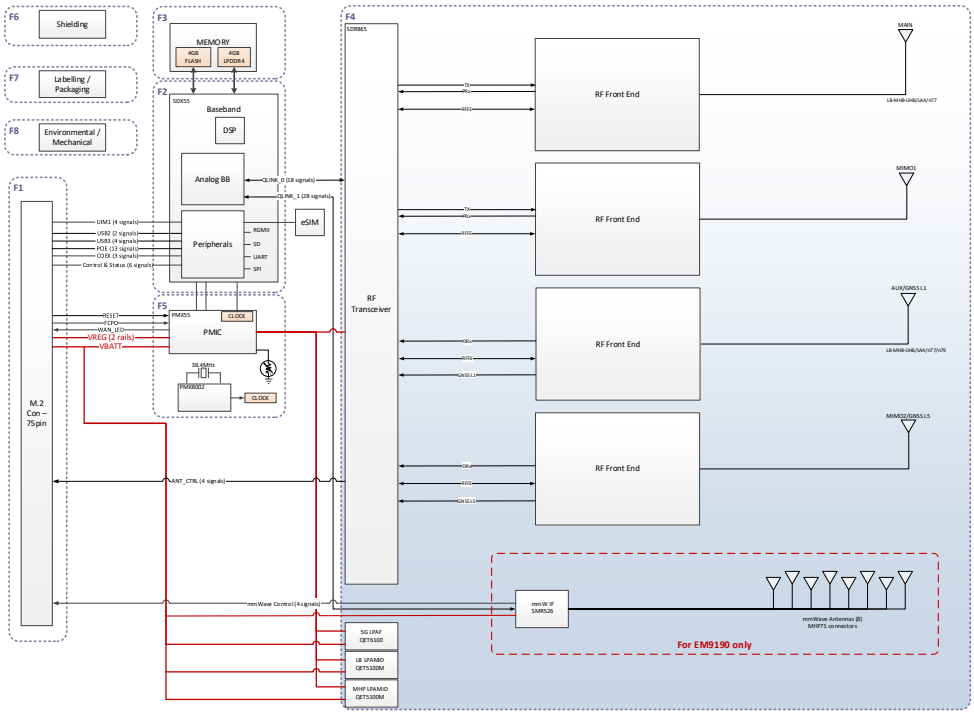


Figure 3-1 System Block Diagram

3.1. Host Interface Pin Assignments

The EM919X/EM7690 host I/O connector provides pins for power, serial communications, and control. Pin assignments are listed in Table 3-1.

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

- Table 3-2, Power Supply Requirements
- Table 3-3, USB Interfaces
- Table 3-5, SIM Interface Signals
- Table 3-6, Module Control Signals

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

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

Table 3-1 Host Interface (75-pin) Connectors-Module View [1]

Pin	Signal Name	Pin Type[2]	Description	Direction[3]	Active State	Voltage Levels (V)		
						Min	Typ	Max
1	CONFIG_3 (NC in default configuration)		Reserved — Host must not repurpose this pin.			-	-	-
2	VCC	V	Power source	Input	Power	3.135	3.3	4.4
3	GND	V	Ground	Input	Power	-	0	-
4	VCC	V	Power source	Input	Power	3.135	3.3	4.4
5	GND	V	Ground	Input	Power	-	0	-
6	Full_Card_Power_Off#	PD	Turn modem on	Input	High	1.0	-	4.4
			Turn modem off	Input	Low	-0.3	-	0.5
7	USB_D+		USB data positive	Input / Output	Differential	-	-	-
8	W_DISABLE#	PU	Wireless Disable (WWAN radio)	Input	Low	-	-	0.4
				Input	High	0.7	-	4.4
9	USB_D-		USB data negative	Input / Output	Differential	-	-	-
10	WWAN_LED#	OC	LED Driver	Output	Low	0	-	0.15
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	PCIE_DIS	PD	Host interface selection	Input	High	1.35	1.80	2.10
				Input	Low	-0.3	-	0.5
21	CONFIG_0 (GND in default configuration)	V	Reserved — Host must not repurpose this pin	Output		-	0	-

Pin	Signal Name	Pin Type[2]	Description	Direction[3]	Active State	Voltage Levels (V)		
						Min	Typ	Max
22	VBUS_SENSE	PD	USB detection	Input	High	1.6	-	5.25
23	WAKE_ON _WAN#	OC	Wake Host	Output	Low	0	-	0.1
24[5]	VCC	V	Power source	Input	Power	3.135	3.3	4.4
25	DPR		Dynamic power control	Input	High	1.17	1.80	2.10
				Input	Low	-0.3	-	0.63
26	GPS_DISABLE#	PU	Wireless Disable (GNSS radio)	Input	Low	-	-	0.4
				Input	High	0.7	-	4.4
27	GND	V	Ground	Input	Power	-	0	-
28	PLA_S2#	O	Power loss acknowledge	Output	High	1.17	1.80	2.10
					Low	-0.3	-	0.63
29	USB3_TXM		USB3 Negative Transmit Data	Output	Differential	-	-	-
30	UIM1_RESET	O	SIM Reset	Output	Low	0		0.45
					High	2.55 (3V SIM) 1.35 (1.8V SIM)	3.00 (3V SIM) 1.80 (1.8V SIM)	3.10 (3V SIM) 1.90 (1.8V SIM)
31	USB3_TXP		USB3 Positive Transmit Data	Output	Differential	-	-	-
32	UIM1_CLK	O	SIM Clock	Output	Low	0	-	0.45
					High	2.55 (3V SIM) 1.35 (1.8V SIM)	3.00 (3V SIM) 1.80 (1.8V SIM)	3.10 (3V SIM) 1.90 (1.8V SIM)
33	GND	V	Ground	Input	Power		0	
34	UIM1_DATA		SIM 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) 1.17 (1.8V SIM)	3.00 (3V SIM) 1.80 (1.8V SIM)	3.30 (3V SIM) 2.10 (1.8V SIM)
				Output	Low	0		0.40
					High	2.55 (3V SIM) 1.35 (1.8V SIM)	3.00 (3V SIM) 1.80 (1.8V SIM)	3.10 (3V SIM) 1.90 (1.8V SIM)
35	USB3_RXM		USB3 Negative Receive Data	Input	Differential	-	-	-
36	UIM1_PWR	V	SIM VCC supply	Output	Power	2.90 (3V SIM) 1.75 (1.8V SIM)	3.00 (3V SIM) 1.80 (1.8V SIM)	3.10 (3V SIM) 1.85 (1.8V SIM)
37	USB3_RXP		USB3 Positive Receive Data	Input	Differential	-	-	-

Pin	Signal Name	Pin Type[2]	Description	Direction[3]	Active State	Voltage Levels (V)		
						Min	Typ	Max
38[5]	VCC	V	Power source	Input	Power	3.135	3.3	4.4
39	GND	V	Ground	Input	Power	-	0	-
40	QTM0_PON[4]	O	mmWave antenna module Power On signal (from EM9190)	Output	High	1.35	-	1.8
				Output	Low	0	-	0.45
41	PCIE_TXM0		PCIe Negative Transmit Data0	Output	Differential	-	-	-
42	QTM1_PON[4]	O	mmWave antenna module Power On signal (from EM9190)	Output	High	1.35	-	1.8
				Output	Low	0	-	0.45
43	PCIE_TXP0		PCIe Positive Transmit Data0	Output	Differential	-	-	-
44	QTM2_PON[4]	O	mmWave antenna module Power On signal (from EM9190)	Output	High	1.35	-	1.8
				Output	Low	0	-	0.45
45	GND	V	Ground	Input	Power	-	0	-
46	QTM3_PON[4]	O	mmWave antenna module Power On signal (from EM9190)	Output	High	1.35	-	1.8
				Output	Low	0	-	0.45
47	PCIE_RXM0		PCIe Negative Receive Data0	Input	Differential	-	-	-
48	QTM_IO_1.9V[4]	V	1.904 V power supply	Output	Power	1.8	1.904	2
49	PCIE_RXP0		PCIe Positive Receive Data0	Input	Differential	-	-	-
50	PCIE_PERST_N		PCIe Reset	Input	Low	0	-	0.7
				Input	High	1.5	-	VCC
51	GND	V	Ground	Input	Power	-	0	-
52	PCIE_CLKREQ_N	OC	PCIe Clock Request	Output	Low	0	-	0.35
53	PCIE_REFCLKM		PCIe Negative Reference Clock	Input	Differential	-	-	-
54	PCIE_PEWAKE_N	OC	PCIe Wake	Output	Low	0	-	0.35
55	PCIE_REFCLKP		PCIe Positive Reference Clock	Input	Differential	-	-	-
56	NC		Reserved — Host must not repurpose this pin			-	-	-
57	GND	V	Ground	Input	Power	-	0	-
58	NC		Reserved — Host must not repurpose this pin			-	-	-
59	ANT_CTRL0		Antenna tuning control (low bands)	Output	High	1.35	-	1.8
				Output	Low	0	-	0.45
60	Reserved		Coexistence	Input	High	1.17	1.80	2.10
				Input	Low	-0.3	-	0.63
				Output	High	1.35	-	1.80
				Output	Low	0	-	0.45
61	ANT_CTRL1		Antenna tuning control (low bands)	Output	High	1.35	-	1.8
				Output	Low	0	-	0.45

Pin	Signal Name	Pin Type[2]	Description	Direction[3]	Active State	Voltage Levels (V)		
						Min	Typ	Max
62	Reserved		Coexistence	Input	High	1.17	1.80	2.10
				Input	Low	-0.3	-	0.63
				Output	High	1.35	-	1.80
				Output	Low	0	-	0.45
63	ANT_CTRL2		Antenna tuning control (low bands)	Output	High	1.35	-	1.80
				Output	Low	0	-	0.45
64	Reserved		Coexistence	Input	High	1.17	1.80	2.10
				Input	Low	-0.3	-	0.63
				Output	High	1.35	-	1.80
				Output	Low	0	-	0.45
65	ANT_CTRL3		Antenna tuning control (low bands)	Output	High	1.35	-	1.80
				Output	Low	0	-	0.45
66	SIM1_DETECT	PU	SIM indication	Input		0 V — SIM not present Open circuit — SIM present		
67	RESET#	PU	Reset module	Input	Low	-0.3	-	0.63
68[5]	VCC	V	Power source	Input	Power	3.135	3.3	4.4
69	CONFIG_1 (GND in default configuration)		Reserved — Host must not repurpose this pin	Output		-	0	-
70	VCC	V	Power source	Input	Power	3.135	3.3	4.4
71	GND	V	Ground	Input	Power		0	
72	VCC	V	Power source	Input	Power	3.135	3.3	4.4
73	GND	V	Ground	Input	Power		0	
74	VCC	V	Power source	Input	Power	3.135	3.3	4.4
75	CONFIG_2 (NC in default configuration)		Reserved — Host must not repurpose this pin.			-	-	-

1. All values are preliminary and subject to change.
2. I — Input; O — Digital output; OC — Open Collector output; PU — Digital input (internal pull up); PD — Digital input (internal pull down); V — Power or ground
3. Signal directions are from module's point of view (e.g. "Output" from module to host, "Input" to module from host.)
4. These pins are NC for EM9191/EM7690.
5. Optional to leave NC for EM9191/EM7690.

3.2. Power Supply

The host provides power to the EM919X/EM7690 through multiple power and ground pins as summarized in Table 3-2.

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 3-2 Power Supply Requirements

Name	Pins	Specification		Min	Typ	Max	Unit
VCC (3.3V)	2, 4, 24[1], 38[1], 68[1], 70, 72, 74	Voltage range		Refer to Table 3-1			
		Ripple voltage		-	-	100	mV_{pp}
			EM9190 with mmWave	-	-	5000	mA

Name	Pins	Specification		Min	Typ	Max	Unit
		Peak current	EM9190 without mmWave			3000	
			EM9191			2700	
			EM7690			2300	
		Continuous current	EM9190 with mmWave	-	-	4000	mA
			EM9190 without mmWave			2300	
			EM9191			2000	
			EM7690			1600	
GND	3, 5, 11, 27, 33, 39, 45, 51, 57, 71, 73			-	0	-	V

1. Optional to leave NC for EM9191/EM7690.

3.3. USB Interface

Note: Host support for USB 3.1 signals is required when USB is selected as host interface.

The device supports a USB3.1 Gen2 interface for communication between the host and module.

The interfaces comply with the *[14] Universal Serial Bus Specification, Rev 2.0* and *[15] Universal Serial Bus Specification, Rev 3.1* (subject to limitations described below), and the host device must be designed to the same standards.

Table 3-3 USB Interfaces

Name	Pin	Description
USB_D+	7	Data positive
USB_D-	9	Data negative
VBUS_SENSE	22	USB detection
USB3_TXM[1]	29	Transmit data negative
USB3_TXP[1]	31	Transmit data positive
USB3_RXM[1]	35	Receive data negative
USB3_RXP[1]	37	Receive data positive

1. Signal directions (Tx/Rx) are from module's point of view.

Note: USB cannot be identified until VBUS_SENSE is connected.

3.3.1. Host-side Recommendation

Note: When designing the host device, careful PCB layout practices must be followed.

Sierra Wireless recommends the host platform include series capacitors on the USB3 Rx signals (no capacitors required for the Tx signals), as shown below.

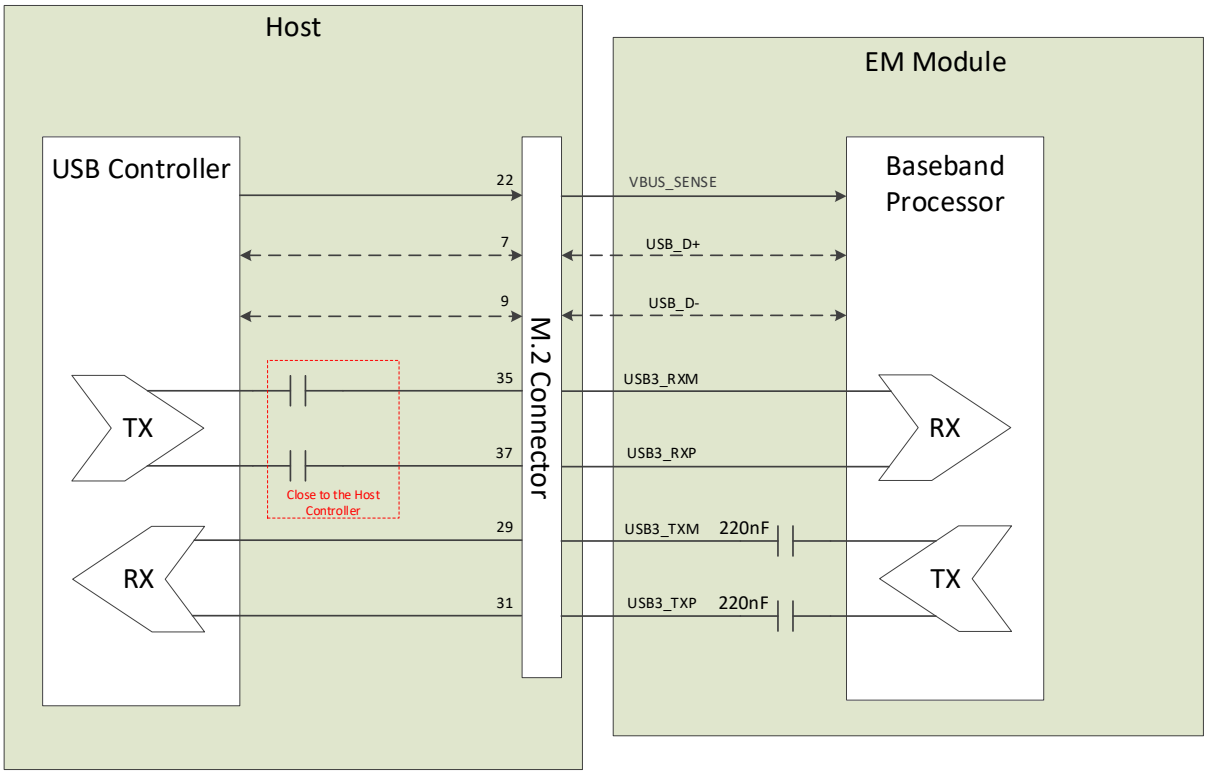


Figure 3-2 Recommended Schematic for USB Signals

3.4. PCIe Interface

Note: Host support for PCIe 3.0 signals is required when PCIe is selected as host interface.

The device supports a PCIe interface for communication between the host and module.

The PCIe interface complies with the PCI Express® Card Electromechanical Specification Revision 3.0 (2.0 backward compatible), and the host device must be designed to the same standards.

Table 3-4 PCIe Interface

	Name	Pin	Description
PCIe	PCIE_TXM0[1]	41	PCIe Negative Transmit Data0
	PCIE_TXP0[1]	43	PCIe Positive Transmit Data0
	PCIE_RXM0[1]	47	PCIe Negative Receive Data0
	PCIE_RXP0[1]	49	PCIe Positive Receive Data0
	PCIE_PERST_N	50	PCIe Reset
	PCIE_CLKREQ_N	52	PCIe Clock Request
	PCIE_REFCLKM	53	PCIe Negative Reference Clock
	PCIE_PEWAKE_N	54	PCIe Wake
	PCIE_REFCLKP	55	PCIe Positive Reference Clock

1. Signal directions (Tx/Rx) are from module's point of view.

Note: EM919X/EM7690 supports Active State Power Management (ASPM) L1 and L0s (PCIE_CLKREQ_N is required to support Clock Power Management in ASPM L1).

EM919X/EM7690 doesn't have Optimized Buffer Flush/Fill (OBFF) support, PCIE_PEWAKE_N is optional to be used to implement link wake-up functionality.

3.4.1. Host-side Recommendation

Note: When designing the host device, careful PCB layout practices must be followed.

Sierra Wireless recommends the host platform include series capacitors on the PCIe Rx signals (no capacitors required for the Tx signals). Also, pull-ups are recommended on the PCIE_PEWAKE_N and PCIE_CLKREQ_N signals, as shown below.

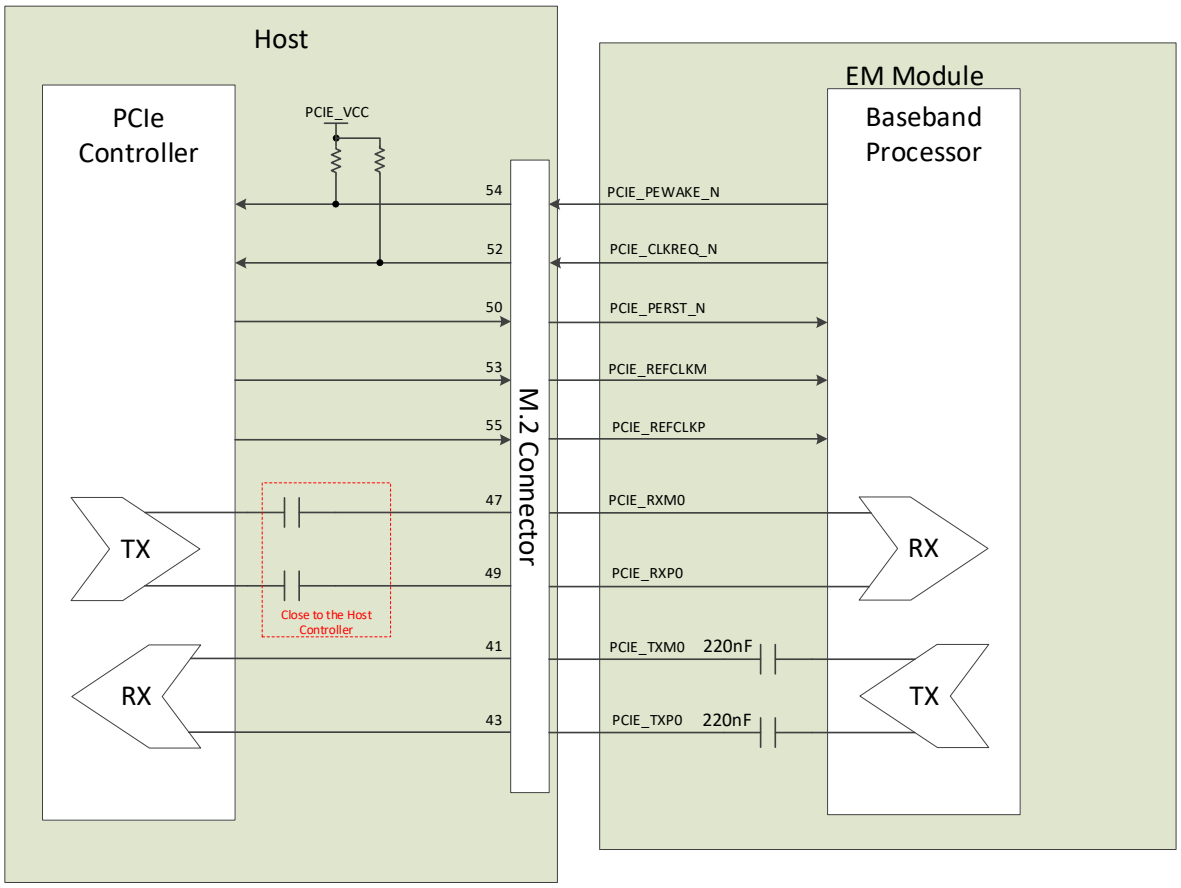


Figure 3-3 Recommended Schematic for PCIe Signals

3.5. SIM Interface

Note: Host support for SIM interface signals is required.

The module supports one external SIM (Subscriber Identity Module) (1.8 V or 3 V). The SIM hold information for a unique account, allowing users to optimize their use of each account on multiple devices.

The module may also include an M2M- or consumer-eUICC embedded SIM (SKU dependent).

The SIM pins (Table 3-5) provide the connections necessary to interface to SIM sockets located on the host device as shown in Figure 3-4. Voltage levels over this interface comply with 3GPP standards.

The types of SIM connectors used depend on how the host device exposes the SIM sockets.

Table 3-5 SIM Interface Signals

SIM	Name	Pin	Description	SIM Contact[1]	Notes
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

1. Refer to Figure 3-5 for SIM card contacts.

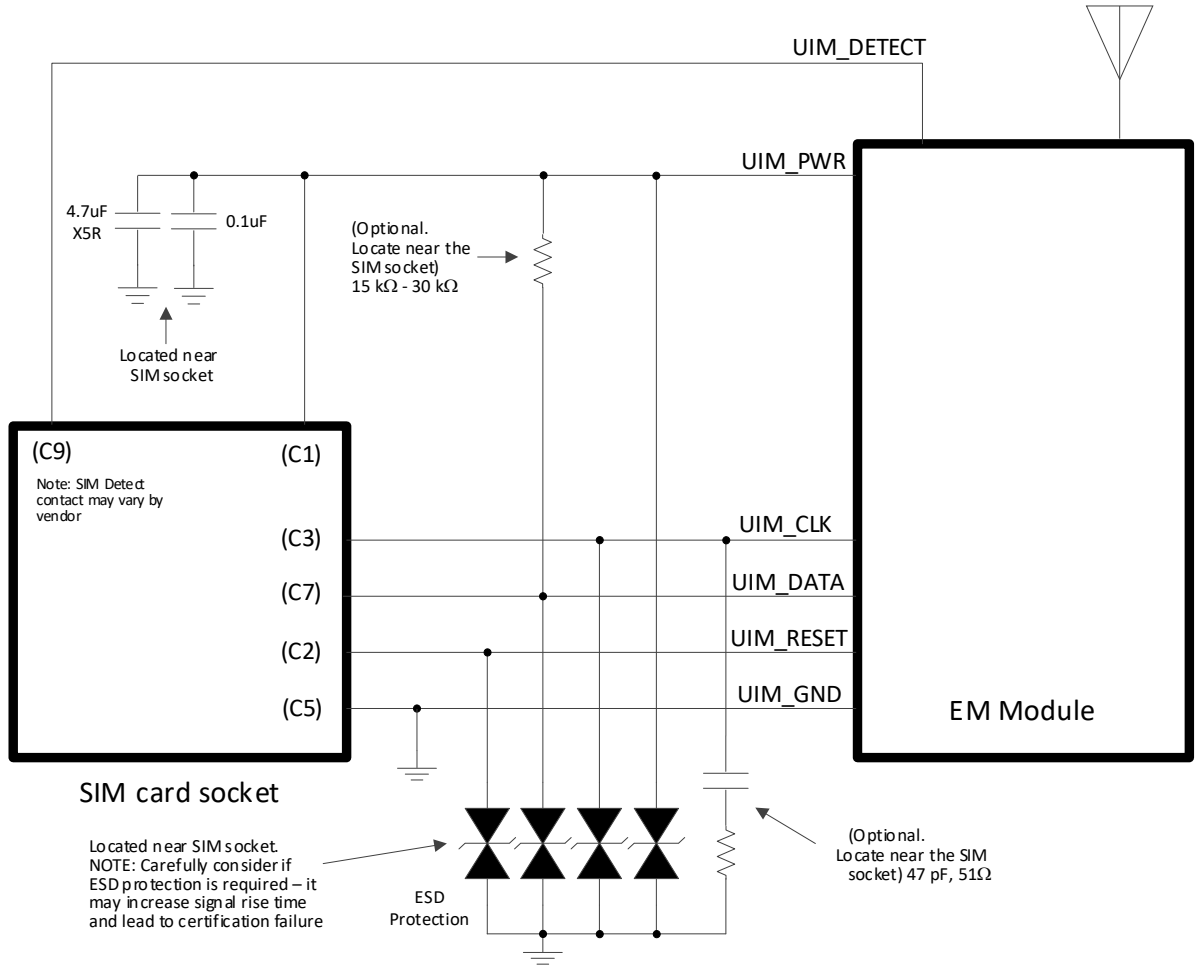


Figure 3-4 SIM Application Interface

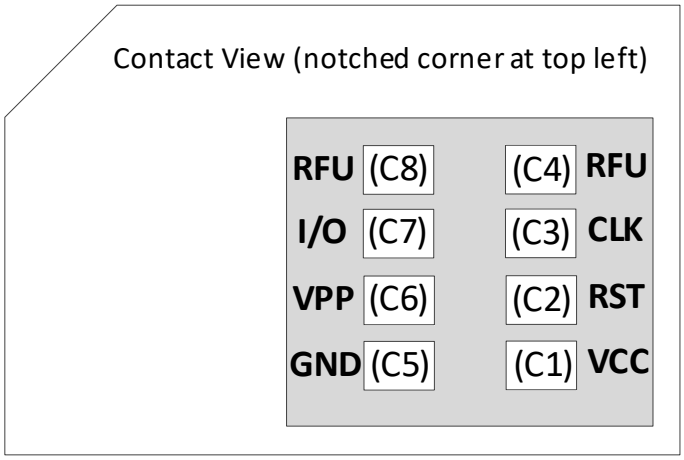


Figure 3-5 SIM Card Contacts (Contact View)

3.5.1. 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 1Ω 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 device 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.
- Avoid routing the clock and data lines (UIM1_CLK/UIM1_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). 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 (UIM1_DATA/UIM1_PWR) to optimize the signal rise time.
- VCC line should be decoupled close to the SIM socket.
- SIM is specified to run up to 5 MHz (SIM clock rate). Take note of this speed in the placement and routing of the SIM signals and connectors.
- You must decide whether additional ESD protection is required for your product, as it is dependent on the application, 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) 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 lines (UIM1_CLK) at the SIM sockets to reduce EMI and increase signal integrity is recommended if the trace length between the SIM socket and module is long — 47 pF and 50Ω resistor are recommended.
- Test your first prototype host hardware with a Comprion IT^3 SIM test device at a suitable testing facility.

3.6. Control Interface (Signals)

The EM919X/EM7690 provides signals for:

- Waking the host when specific events occur
- Host control of the module's radios
- Host control of module power
- Module status indication to host
- Host interface selection

Note: Host support for Full_Card_Power_Off# is required, and support for other signals in Table 3-6 is optional.

These signals are summarized in Table 3-6 and paragraphs that follow.

Table 3-6 Module Control Signals

Name	Pin	Description	Type[1]
Full_Card_Power_Off#	6	On/off signal	PD
W_DISABLE#	8	Wireless disable (Main RF)	PU
WWAN_LED#	10	LED Driver	OC
PCIE_DIS	20	Host interface selection	PD
WAKE_ON_WAN#	23	Wake host	O
GPS_DISABLE#	26	Wireless disable (GNSS)	PU
PLA_S2#	28	Power loss acknowledge	O
RESET#	67	Reset module	PU

1. O — Digital pin Output; OC — Open Collector output; PD — Digital pin Input, internal pull down; PU — Digital pin Input, internal pull up

3.6.1. WAKE_ON_WAN# - Wake Host

Note: Host support for WAKE_ON_WAN# is optional.

The EM919X/EM7690 uses WAKE_ON_WAN# to wake the host when specific events occur.

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

Refer to Figure 3-6 for a recommended implementation.

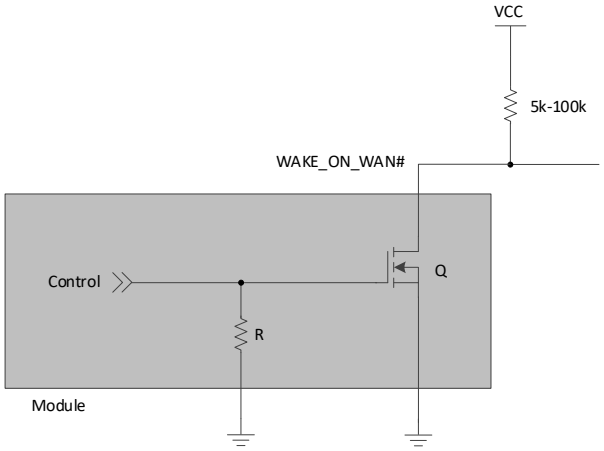


Figure 3-6 Recommended WAKE_ON_WAN# Connection

3.6.2. W_DISABLE# (WWAN Disable) and GPS_DISABLE# (GNSS Disable)

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

The host device uses W_DISABLE# to enable/disable the WWAN or radio modem, and GPS_DISABLE# to enable/disable GNSS functionality.

Letting these signals float high allows the module to operate normally. These pins have 100 kΩ pull-up resistors. Refer to Figure 3-7 for a recommended implementation.

When integrating with your host device, 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 or floating to keep it on.
- If the host never needs to assert this power state control to the module, leave this signal unconnected from the host interface.

Table 3-7 W_DISABLE# / GPS_DISABLE# Usage

Name	Pin	Description/Notes
W_DISABLE#	8	Enable/disable the WWAN or radio modem[1]. When disabled, the modem cannot transmit or receive. • Leave as not connected or drive HIGH to keep the modem always on. • Drive LOW to turn the modem off.
GPS_DISABLE#	26	Enable/disable GNSS functionality[1] • Leave as not connected or drive HIGH to enable GNSS functionality. • Drive LOW to disable GNSS functionality. • For details on enabling / disabling GNSS functionality, refer to AT!CUSTOM="GPSENABLE" command in *[2] AirPrime EM919X AT Command Reference*.

1. Sierra Wireless recommends that the host implement an open collector driver where a Low signal turns off the modem or disables GNSS functionality, and a high signal turns on the modem or enables GNSS functionality.

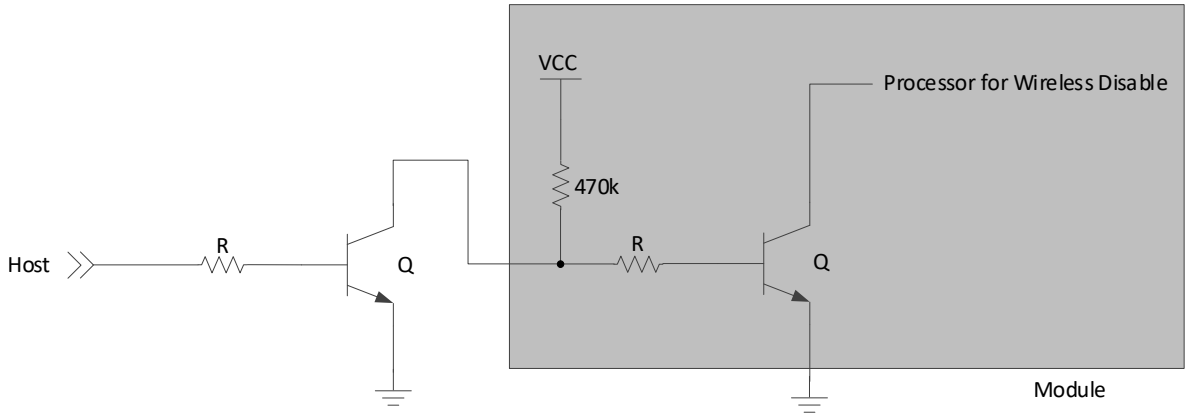


Figure 3-7 Recommended Wireless Disable Connection

3.6.3. Full_Card_Power_Off# and RESET#

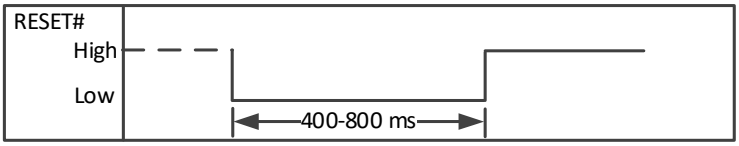
Note: Host support for Full_Card_Power_Off# is required, and support for RESET# is optional.

Full_Card_Power_Off# and RESET# are inputs to the module that the host uses as described in Table 3-8.

Table 3-8 Full_Card_Power_Off# and RESET# Usage

Name	Pin	Description/Notes

Full_Card_Power_Off#	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 signal high (10–20 kΩ for 1.8V, 75–100 kΩ for VCC rail). Note that a larger-value resistor will reduce leakage current.
		• To power off the module, refer to Required Shutdown Sequence.

RESET#	67	Reset the module. • Signal is optional. The module will operate correctly if the pin is left disconnected on the host. • To reset the module, pulse the RESET# pin with a logic low signal for 400 ms (min) to 800 ms (max) — if the signal is held low for more than 800 ms, the reset cycle restarts, and if it is held low through several cycles, the module will not fully boot. Otherwise, leave the signal floating or high impedance (the module will remain operational because the module has a pull-up resistor to an internal reference 1.8V voltage in place).  • The signal requires an open collector input from the host. • This is a “hard” reset, which should be used only if the host cannot communicate with the module via the PCIe or USB port. (If the port is not working, the module may have locked up or crashed.) **Caution:** *RESET# should not be driven or pulled to a logic high level by the host, as this may cause damage to the module.*

3.6.4. PLA_S2# (Power Loss Acknowledge)

Note: Host support for PLA_S2# is optional but highly recommended.

The PLA signal is intended to provide indication to the host platform that the power loss protection operation in module has been completed so that power may be safely removed.

For timing details, refer to Timing.

3.6.5. WWAN_LED# - LED Output

Note: Host support for WWAN_LED# is optional.

The configuration for the LED shown in Figure 3-8 is customizable. WWAN_LED# supports up to 10mA current sink. Contact your Sierra Wireless account representative for details.

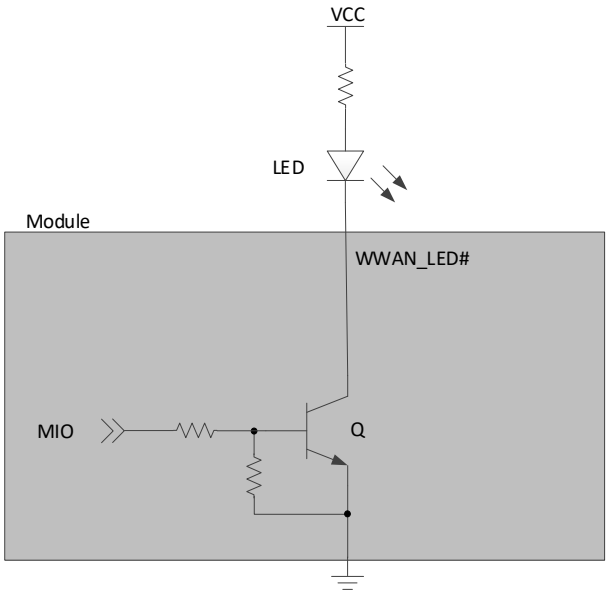


Figure 3-8 Recommended LED Connection

3.6.6. PCIE_DIS – Interface Selection

Note: Host support for PCIE_DIS is optional.

PCIE_DIS signal is provided for host interface selection:

- PCIe single lane interface – Leave signal unconnected or tie to GND
- USB interface – Drive signal high (1.8V)

Switching Interfaces

Typically, a host application will configure the module for use with only one of these interfaces (i.e. the application will be designed to use either PCIe or USB, but not both.

However, if an application must be able to switch between interfaces (e.g. a development kit that will be used to test both interfaces), the module must be power-cycled or reset to do the switch, because the interfaces are mutually-exclusive.

For example, if PCIE_DIS is high when the module boots, the USB interface will be active. To switch from USB to PCIe interface:

1. While the module is on, set PCIE_DIS low.
   At this point, the module continues to use the USB interface.
2. While keeping PCIE_DIS low, power cycle the module.
   When the module boots, it will use the PCIe interface.

(Follow the same basic process to switch from PCIe to USB – drive PCIe_DIS high, then power cycle the module.)

3.7. Tx Power Control

The module's Tx power limit may be controlled using either SAR backoff AT commands, defined in *[2] AirPrime EM919X AT Command Reference*, or the DPR (Dynamic Power Control) signal. Use the GPIOSARENABLE parameter for **!CUSTOM** to choose the method:

- AT commands:
  - !SARSTATE — set (or report) the current SAR backoff state (override the default state). This change in state is non-persistent across power cycles.

- Dynamic power control:
  - The module's firmware monitors DPR (pin 25) with logic as detailed in Table 3-9 and adjusts the RF Tx power appropriately with Smart Transmit feature, refer to *[9] AirPrime EM919X-EM7690 Non-mmWave Smart Transmit* in detail.

Table 3-9 DPR Logic

!SARINTGPIOMODE[1]	DPR Internal Pull	DPR Pin
0 (default)	Pull up	High[2]
		Low (Active)
1	Pull down	Low
		High (Active)

1. A customization (**!SARINTGPIOMODE**) is available to invert the DPR logic.
2. The host can implement an open collector drive for the DPR pin (if a 1.8V-compatible drive is not available).

3.8. mmWave Power Control

Note: For EM9190 only. Host support for mmWave power control signals is optional.

The EM9190 provides five output signals (listed in Table 3-10) that are used to power on/off the mmWave antenna modules attached to the mmWave IF connectors.

Table 3-10 mmWave Antenna Control Signals

Name	Pin	Description
QTM0_PON	40	Power control (on/off) signals for mmWave antennas attached to the module's mmWave connector.
QTM1_PON	42	
QTM2_PON	44	
QTM3_PON	46	
QTM_IO_1.9V	48	1.904 V power supply, current limit is 500mA.

4. RF Specifications

The EM919X/EM7690 includes four MHF4 RF connectors for use with host-supplied antennas. And EM9190 includes eight MHF7S connectors for use with up to four mmWave antenna modules (2 connectors per antenna module):

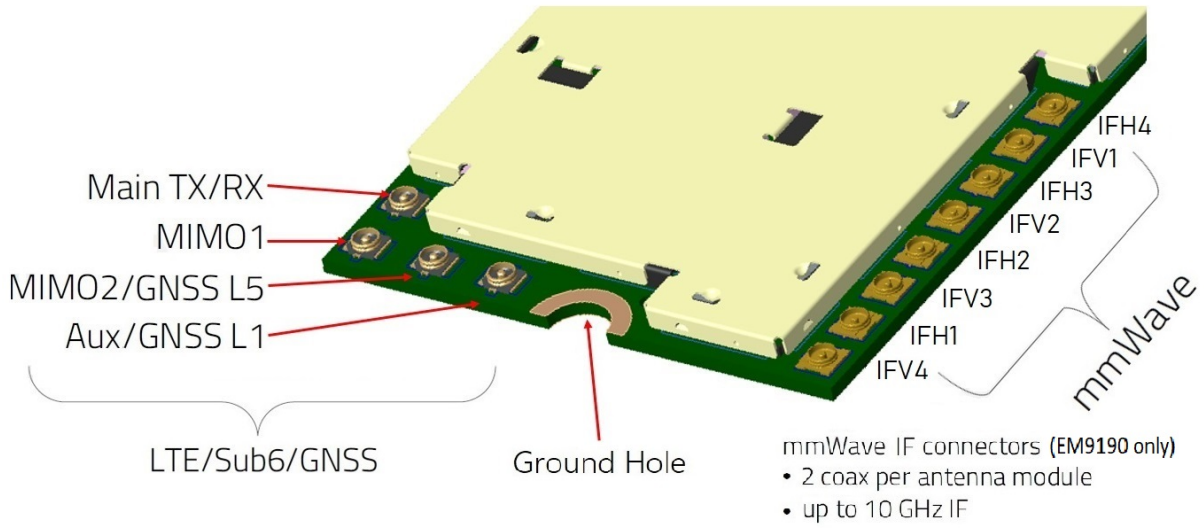


Figure 4-1 Module Connectors Include Image with Spacing Info

Note: The mmWave IF connectors are only mounted on EM9190.

- LTE/Sub-6G/GNSS connectors:
  - Main: Primary Tx/PRx path for 3G/4G/5G (except for n41)
  - Auxiliary: Diversity Rx (except for n41) and GNSS L1
  - MIMO1: MIMO1 Rx Path and n41 TRx
  - MIMO2: MIMO2 Rx Path and n41 DRx and GNSS L5
- mmWave connectors:
  - Eight connectors — Up to four mmWave antenna modules (QTM525 or QTM527) can connect to EM9190, two connectors as a pair (H/V) for each. The module does not have integrated antennas.
  - Refer to Table 4-1 for each pair of coaxial connections. For low-power usage, if not all 4 QTM525 modules are equipped, integration sequence from QTM0 to QTM3 is recommended, leave unused connectors NC (Contact Sierra Wireless as the RFC has to be updated to reflect the number of QTMs). Note that for high-power usage, it's not recommended to leave any QTM527 NC as it will violate 3GPP EIRP compliance for PC1.

Table 4-1 mmWave Port Assignment

QTM	P_ON	QTM525 IF port <-> mmWave IF connector		QTM527 IF port <-> mmWave IF connector	
		IF1	IF2	IF1	IF2
QTM0	QTM0_PON	QTM0_H <-> IFH1	QTM0_V <-> IFV4	QTM0_H <-> IFH1	QTM0_V <-> IFV4
QTM1	QTM1_PON	QTM1_H <-> IFH4	QTM1_V <-> IFV1	QTM1_H <-> IFH2	QTM1_V <-> IFV3
QTM2	QTM2_PON	QTM2_H <-> IFH2	QTM2_V <-> IFV3	QTM2_H <-> IFH3	QTM2_V <-> IFV2
QTM3	QTM3_PON	QTM3_H <-> IFH3	QTM3_V <-> IFV2	QTM3_H <-> IFH4	QTM3_V <-> IFV1

Note: To ensure the best mmWave performance, refer to [6] EM9190 mmWave Design Guidelines.

4.1. RF Connections

When attaching antennas to the module:

- LTE/Sub-6G /GNSS connectors:
  - Use RF plug connectors that are compatible with the following RF receptacle connectors: I-PEX (20449-001E (MHF4)).
  - Match coaxial connections between the module and the antenna to 50Ω.
  - Minimize RF cable losses to the antenna; the recommended maximum cable loss for antenna cabling is 0.5 dB.
- mmWave connectors (EM9190 only):
  - Use RF plug connectors that are compatible with the following RF receptacle connectors: I-PEX (20956-001E-01 (MHF7S)).
  - Refer to mmWave Antennas for mmWave antenna module tips.
- To ensure best thermal performance, use the ground hole (if possible) to attach (ground) the device to a metal chassis.

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

4.1.1. Shielding

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

4.2. Sub-6G Antennas and Cabling

When selecting the Sub-6G antennas and cables, it is critical to RF performance to match antenna gain and cable loss.

Note: There is no explicit list of antennas required in the application. The PWB-6-60-RSMAP Wide Band 4G/5G Terminal Paddle Antenna has been verified as a reference. For detailed electrical performance criteria, refer to Antenna Specification.

Choosing the Correct Sub-6G Antenna and Cabling

When matching antennas and cabling:

- The antenna (and associated circuitry) should have a nominal impedance of 50Ω 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.

Designing Custom Sub-6G 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.
- If multiple modules will be installed on the same platform, you may want to develop separate antennas for maximum performance.

Determining the Sub-6G 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 applications, the placement of the antenna is still very important — if the host device 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 50Ω 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. Refer to Interference from Other Wireless Devices.

Disabling the Auxiliary (Diversity) Antenna

Certification testing of a device with an integrated EM919X/EM7690 may require the module's main and diversity antennas to be tested separately.

To facilitate this testing, receive diversity can be enabled/disabled using AT commands:

- **!RXDEN** — used to enable/disable diversity for single-cell call (no carrier aggregation).

Note: 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 *[2] AirPrime EM919X AT Command Reference*.

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

4.3. 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 ground hole shown in Figure 4-1.
- 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.

4.4. Interference and Sensitivity

Several 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) and radiated sensitivity measurement (Radiated Sensitivity Measurement).

Note: The EM919X/EM7690 is based on ZIF (Zero Intermediate Frequency) technologies. When performing EMC (Electromagnetic Compatibility) tests, there are no IF (Intermediate Frequency) components from the module to consider.

4.4.1. 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.

4.4.2. 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

4.4.3. Device-generated RF Interference

The module can cause interference with other devices. Wireless devices such as AirPrime 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.

4.4.4. 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 sources of interference. The drawback is 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 the components of the host device (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.

4.4.5. Radiated Spurious Emissions (RSE)

When designing an antenna for use with AirPrime embedded modules, the host device with an AirPrime 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 50Ω emissions baseline. (AirPrime embedded modules meet the 50Ω conducted emissions requirement.)

4.5. 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 Sierra Wireless or you can use your own OTA test chamber for in-house testing.

4.5.1. Sierra Wireless' Sensitivity Testing and Desensitization Investigation

Although AirPrime embedded modules are designed to meet network operator requirements for receiver performance, they are still susceptible to various performance inhibitors.

As part of the Engineering Services package, Sierra Wireless offers modem OTA sensitivity testing and desensitization (desense) investigation. For more information, contact your account manager or the Sales Desk (refer to Contact Information).

Note: Sierra Wireless has the capability to measure TIS (Total Isotropic Sensitivity) and TRP (Total Radiated Power) according to CTIA's published test procedure.

4.5.2. Sensitivity vs. Frequency

Sensitivity definitions for supported RATs:

- UMTS bands — sensitivity is defined as the input power level in dBm that produces a BER (Bit Error Rate) of 0.1%. Sensitivity should be measured at all UMTS frequencies across each band.
- LTE bands — sensitivity is defined as the RF level at which throughput is 95% of maximum.
- 5G NR Sub-6G bands (EM919X only) — sensitivity is defined as RF level at which throughput is 95% of maximum.

4.6. Supported Frequencies

The EM919X/EM7690 supports:

- Multiple-band 5G (EM919X only) — refer to Table 4-2 (supported bands) and Table 4-6 For UL summary reference, refer to Table 4-4 for NR bandwidth support.
- Multiple-band LTE — refer to Table 4-2 (supported bands) and Table 4-3 (LTE bandwidth support).
- LTE advanced carrier aggregation:
  - Intra-band ULCA: support 3C, 7C, 41C, 42C, 48C[1].
  - Inter-band ULCA, support low band and mid-high band combination as the Table 4-5.
- Multiple-band WCDMA/HSPA/HSPA+/DC-HSPA+ — refer to Table 4-2.
- Multiple-band WCDMA receive diversity
- Inter-RAT and inter-frequency cell reselection and handover between supported frequency bands.
- GPS, GLONASS, BeiDou, Galileo, QZSS — refer to Table 4-11.

1. Supported with a future firmware update.

Table 4-2 Supported Frequency Bands, by RAT (5G/LTE/3G)

Band#	5G[1] (n<band#>)	LTE (B<band#>)	3G (Band<band#>)	Frequency (Tx)	Frequency (Rx)
1	Yes	Yes	Yes	1920–1980 MHz	2110–2170 MHz
2	Yes	Yes	Yes	1850–1910 MHz	1930–1990 MHz
3	Yes	Yes	Yes	1710–1785 MHz	1805–1880 MHz
4		Yes	Yes	1710–1755 MHz	2110–2155 MHz

Band#	5G[1] (n<band#>)	LTE (B<band#>)	3G (Band<band#>)	Frequency (Tx)	Frequency (Rx)
5	Yes	Yes	Yes	824–849 MHz	869–894 MHz
6			Yes	830–840 MHz	875–885 MHz
7	Yes[3]	Yes		2500–2570 MHz	2620–2690 MHz
8	Yes[3]	Yes	Yes	880–915 MHz	925–960 MHz
9			Yes	1749.9–1784.9 MHz	1844.9–1879.9 MHz
12	Yes[3]	Yes		699–716 MHz	729–746 MHz
13		Yes		777–787 MHz	746–756 MHz
14		Yes		788–798 MHz	758–768 MHz
17		Yes		704–716 MHz	734–746 MHz
18		Yes		815–830 MHz	860–875 MHz
19		Yes	Yes	830–845 MHz	875–890 MHz
20	Yes[3]	Yes		832–862 MHz	791–821 MHz
25	Yes[3]	Yes		1850–1915 MHz	1930–1995 MHz
26		Yes		814–849 MHz	859–894 MHz
28	Yes	Yes		703–748 MHz	758–803 MHz
29		Yes		N/A	717–728 MHz
30		Yes		2305–2315 MHz *Note: B30 Tx is disabled.*	2350–2360 MHz
32		Yes		N/A	1452–1496 MHz
34		Yes		2010–2025 MHz (TDD)	
38	Yes[3]	Yes		2570–2620 MHz (TDD)	
39		Yes		1880–1920 MHz (TDD)	
40	Yes[3]	Yes		2300–2400 MHz (TDD)	
41	Yes	Yes		2496–2690 MHz (TDD)	
42[2]		Yes		3400–3600 MHz (TDD)	
43		Yes[3]		3600-3800 MHz (TDD)	
46		Yes		N/A	5150–5925 MHz (TDD)
48[2]	Yes[3]	Yes		3550–3700 MHz (TDD)	
66	Yes	Yes		1710–1780 MHz	2110–2200 MHz
71	Yes	Yes		663–698 MHz	617–652 MHz
77	Yes			3300–4200 MHz (TDD)	
78	Yes			3300–3800 MHz (TDD)	
79	Yes			4400–5000 MHz (TDD)	
257[4]	Yes			26500–29500 MHz (TDD)	
258[4]	Yes			24250–27500 MHz (TDD)	
260[4]	Yes			37000–40000 MHz (TDD)	
261[4]	Yes			27500–28350 MHz (TDD)	

1. EM919X only.
2. B42/B48 disabled as of publication date, support pending regulatory approval.
3. Supported with a future firmware update.
4. EM9190 only.

Table 4-3 LTE Bandwidth Support[1]

Band	1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
B1			Yes	Yes	Yes	Yes
B2	Yes	Yes	Yes	Yes	Yes[2]	Yes[2]
B3	Yes	Yes	Yes	Yes	Yes[2]	Yes[2]
B4	Yes	Yes	Yes	Yes	Yes	Yes
B5	Yes	Yes	Yes	Yes[2]		
B7			Yes	Yes	Yes[3]	Yes[2,3]
B8	Yes	Yes	Yes	Yes[2]		
B12	Yes	Yes	Yes[2]	Yes[2]		
B13			Yes[2]	Yes[2]		
B14			Yes[2]	Yes[2]		
B17			Yes[2]	Yes[2]		
B18			Yes	Yes[2]	Yes[2]	
B19			Yes	Yes[2]	Yes[2]	
B20			Yes	Yes[2]	Yes[2]	Yes[2]
B25	Yes	Yes	Yes	Yes	Yes[2]	Yes[2]
B26	Yes	Yes	Yes	Yes[2]	Yes[2]	
B28		Yes	Yes	Yes[2]	Yes[2]	Yes[2,3]
B29		Yes	Yes	Yes		
B30			Yes	Yes[2]		
B32			Yes	Yes	Yes	Yes
B34			Yes	Yes	Yes	
B38			Yes	Yes	Yes[3]	Yes[3]
B39			Yes	Yes	Yes[3]	Yes[3]
B40			Yes	Yes	Yes	Yes
B41			Yes	Yes	Yes	Yes
B42[4]			Yes	Yes	Yes	Yes
B43[5]			Yes	Yes	Yes	Yes
B46				Yes		Yes
B48[4]			Yes	Yes	Yes	Yes
B66	Yes	Yes	Yes	Yes	Yes	Yes
B71			Yes	Yes[2]	Yes[2]	Yes[2]

1. Table contents are derived from 3GPP TS 36.521-1 v15.5.0, table 5.4.2.1-1.

2. Bandwidth for which a relaxation of the specified UE receiver sensitivity requirement (Clause 7.3 of 3GPP TS 36.521-1 v15.5.0) is allowed.

3. 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 v15.5.0).

4. B42/B48 disabled as of publication date, support pending regulatory approval.

5. Supported with a future firmware update.

Table 4-4 NR Bandwidth Support[1,2,3]

Band	5 MHz	10 MHz	15 MHz	20 MHz	25 MHz	30 MHz	40 MHz	50 MHz	60 MHz	80 MHz	90 MHz	100 MHz
n1	Yes	Yes	Yes	Yes		Yes[4]	Yes[4]					
n2	Yes	Yes	Yes	Yes								
n3	Yes	Yes	Yes	Yes								
n5	Yes	Yes	Yes	Yes								
n7[6]	Yes	Yes	Yes	Yes								
n8[6]	Yes	Yes	Yes	Yes								
n12[6]	Yes	Yes	Yes									
n20[6]	Yes	Yes	Yes	Yes								
n25[6]	Yes	Yes	Yes	Yes								
n28	Yes	Yes	Yes	Yes		Yes[4]						
n38[6]				Yes								
n40[6]							Yes			Yes		
n41				Yes			Yes	Yes[5]	Yes	Yes	Yes[5]	Yes
n48[6]				Yes			Yes					
n66	Yes	Yes	Yes	Yes								
n71	Yes	Yes	Yes	Yes								
n77												Yes
n78				Yes			Yes	Yes	Yes	Yes	Yes	Yes
n79												Yes

1. For EM919X only. The table contents are derived from 3GPP TS 38.521-1 v15.3.0, table 5.3.5-1.
2. For FR1 Sub-6G bands, NR TDD Bands (n41/77/78/79), only SCS 30KHz is supported, and for other FDD bands, only SCS 15KHz is supported.
3. For FR2 mmWave bands, only 50MHz and 100MHz bandwidth is supported.
4. This UE channel bandwidth is not 3GPP defined, and it is only supported at SA mode.
5. This UE channel bandwidth is set to off by default.
6. Supported with a future firmware update.

Table 4-5 LTE Inter-band ULCA Summary[1]

Low Bands \ Mid-High Bands	B1	B2	B3	B4	B7	B66
B5	Yes	Yes	Yes	Yes	Yes	Yes
B8	Yes		Yes		Yes	
B12		Yes		Yes		Yes
B13		Yes		Yes		Yes
B18	Yes		Yes			
B19	Yes		Yes			
B20	Yes		Yes		Yes	
B26	Yes		Yes			
B28	Yes		Yes		Yes	

1. This table is only for ULCA Tx combination summary, for more detailed band combination, refer to Carrier Aggregation and EN-DC.

Table 4-6 NR UL Combination of EN-DC[1]

NR Bands		Inter-band EN-DC (4G LTE Anchor's Tx)		
		Low Band 4G	Mid Band 4G	High Band 4G
FR1	n1	B8, B20		
	n2	B5, B12		
	n3	B8, B20, B28		
	n5		B1, B2, B3, B66	B7, B30
	n7[2]	B20, B28, B5, B12		
	n8[2]		B1, B3, B7	
	n12[2]		B2, B66	
	n20[2]		B1, B3, B7	
	n25[2]	B12		
	n28		B1, B3	B7
	n38[2]	B20, B5, B12, B71		
	n40[2]	B8, B28		
	n41		B2, B3, B4, B25	
	n48[2]	B13	B66	
	n66	B5, B12, B13, B14, B71		
	n71		B2, B66	B7
	n77	B8, B18, B28	B1, B3	B41
	n78	B5, B8, B12, B18, B19, B20, B28	B1, B3, B2, B66	B7, B38, B41
	n79	B19	B1, B3, B39	B41

1. For EM919X only. This table is only for NR EN-DC Tx combination summary, for more detailed band combination, refer to Carrier Aggregation and EN-DC.

2. Supported with a future firmware update.

4.7. Conducted Rx Sensitivity/Tx Power

Table 4-7 Typical Conducted Rx Sensitivity — NR Bands[1]

Band	Duplex Mode	SCS (KHz)	BW (MHz)	Rx Sensitivity (dBm)[2]				Worst Case[3]	
				PRx	DRx	PRx+DRx	4 Rx	Antenna Port	Requirement (dBm)
n1	FDD	15	20	-95.5	-94	-97	-100	4 Rx	-95.8
n2	FDD	15	20	-95	-94	-97	-100.5	4 Rx	-93.8
n3	FDD	15	20	-94.5	-94	-97	-100.5	4 Rx	-92.8
n5	FDD	15	20	-95.5	-97	-100	NA	2 Rx	-90.1
n28	FDD	15	20	-95	-97	-99	NA	2 Rx	-90.1
n41	TDD	30	20	-96	-95	-98.5	-100.5	4 Rx	-94
n66	FDD	15	20	-93.5	-93.5	-96	-99	4 Rx	-95.3
n71	FDD	15	20	-96.5	-97.5	-100	NA	2 Rx	-85.3
n77	TDD	30	100	-86.5	-87.5	-89	-91.5	4 Rx	-86.8
n78	TDD	30	40	-91	-92	-94	-96.5	4 Rx	-90.9
n79	TDD	30	100	-85.5	-85.5	-88	-89.5	4 Rx	-86.8

1. EM919X only.

2. The typical result is at room temperature and based on Lab test result and Call box only at 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.

3. Per 3GPP specification.

Table 4-8 Typical Conducted Rx (Receive) Sensitivity — LTE Bands at 10MHz BW

LTE Bands	Typical Conducted Rx Sensitivity (dBm)[1,2]				Worst Case[3]
	PRx	DRx	PRx+DRx	4 Rx	PRx+DRx (dBm)
B1	-98.5	-98	-102	-104.5	-96.3
B2	-99.5	-98.5	-101.5	-103.5	-94.3
B3	-98.5	-98	-100.5	-103.5	-93.3
B4	-99	-99	-101	-104	-96.3
B5	-100	-100	-103	-	-94.3
B7	-97	-96	-100	-102.5	-94.3
B8	-100	-100	-103	-	-93.3
B12	-100.5	-101	-104	-	-93.3
B13	-101	-101	-103.5	-	-93.3
B14	-101	-101	-103.5	-	-93.3
B17	-100.5	-101.5	-104	-	-93.3
B18	-100.5	-101	-103.5	-	-96.3
B19	-100.5	-100.5	-103	-	-96.3
B20	-100.5	-100.5	-103.5	-	-93.3
B25	-98	-97.5	-100.5	-103	-92.8
B26	-99	-100.5	-102.5	-	-93.8
B28	-100.5	-100.5	-103.5	-	-94.8
B29[4]	-100.5	-101	-103.5	-	-93.3
B30	-99	-99	-101.5	-103	-95.3
B32[4]	-100	-100	-102.5	-105	-96.5
B34	-98.5	-97.5	-101	-104	-96.3
B38	-97	-97	-100	-103	-96.3
B39	-98	-98	-101	-103.5	-96.3
B40	-97	-97	-100	-102.5	-96.3
B41	-97	-97	-100	-102.5	-94.3
B42[5]	-98	-98.5	-101	-103.5	-95.0
B46[6]	-94	-94.5	-96.5	-	-90
B48[5]	-98.5	-98.5	-101	-103.5	-95.3
B66	-99	-99	-101.5	-104	-95.8
B71	-101	-101	-103.5	-	-93.5

1. 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.

2. The typical result is at room temperature and based on Lab test result and Call box only at a shielded test environment, and the test is based on standalone mode only.

3. Per 3GPP specification.

4. This band is SDL (Rx only) band, and the typical result is based on certain 2DL CA case such as B2+B29, B2+B46, B20+B32.

5. B42/B48 disabled as of publication date, support pending regulatory approval.

6. B46 is based on 20MHz BW as most of combination for B46 LAA is 20MHz BW only.

Table 4-9 Conducted Rx (Receive) Sensitivity — UMTS Bands

UMTS Bands		Conducted Rx Sensitivity (dBm)		
		Primary (Typical)[1]	Secondary (Typical)[1]	Primary/Secondary (Worst Case)[2]
Band 1	0.1% BER 12.2 kbps	-110	-110	-106.7
Band 2		-110	-109	-104.7
Band 3		-109.5	-109.5	-103.7
Band 4		-110	-109.5	-106.7
Band 5		-111	-112.5	-104.7
Band 6		-111	-112.5	-106.7
Band 8		-111	-112.5	-103.7
Band 9		-109.5	-109.5	-105.7
Band 19		-111	-112.5	-106.7

1. The typical result is at room temperature and based on Lab test result and Call box only at a shielded test environment.
2. Per 3GPP specification.

Table 4-10 Conducted Maximum Output Tx (Transmit) Power Tolerances

Bands	Conducted Tx Power[1]	Notes
5G		
FR1 Sub-6G Bands	+23 dBm ± 1.5 dB	Power Class 3 and EM919X only
LTE		
LTE all bands	+23 dBm ± 1 dB	Power Class 3
B41 HPUE	+25 dBm ± 1 dB	Power Class 2 for B41 standalone mode only
UMTS		
All bands (12.2kbps)	+23.5 dBm ± 1 dB	Connectorized (Power Class 3)

1. The Tx Power is based on no MPR configuration as 3GPP defined. For the configuration which needs MPR or additional MPR, refer to 3GPP for the power reduction.

4.8. GNSS Specifications

Note: For detailed electrical performance criteria, refer to Recommended GNSS Antenna Specifications.

Table 4-11 GNSS Specifications

Parameter/Feature	Description
Satellite channels	Support all in-view satellites (L1 + L5) for simultaneous tracking
TTFF[1]	Hot start: ≤1 s Warm start: ≤20 s Cold start: ≤28 s
Accuracy[1]	Horizontal: < 2 m (50%); < 4 m (95%) Altitude: < 2 m (50%); < 4 m (95%) Velocity: < 0.2 m/s

Parameter/Feature	Description
Sensitivity[2]	Tracking[3]: • GPS: -160 dBm • GLONASS: -158 dBm Reacquisition[4]: • GPS: -157 dBm • GLONASS: -156 dBm Cold start (autonomous) acquisition[4]: • GPS: -148 dBm • GLONASS: -140 dBm Hot start acquisition[4]: • GPS: -155 dBm • GLONASS: -147 dBm
Operational Limits	Altitude <6000 m or velocity <100 m/s (Either limit may be exceeded, but not both.)

1. TTFF (without AGNSS) and accuracy are measured under open sky conditions with signal strength of -135 dBm.

2. The performance is tested in conducted mode with GNSS signal simulator under room temperature and without external GNSS LNAs as the module includes internal LNAs for both L1 and L5.

3. Tracking sensitivity is the lowest GNSS signal strength in which the device can still detect in-view satellites and get fixed at least 50% of the times when in sequential tracking mode.

4. Acquisition sensitivity is the lowest GNSS signal strength in which the device can still detect in-view satellites and get fixed at least 50% of the times.

5. Power

5

5.1. Power Consumption

Note: The power consumption data are measured with typical use cases of EM9190 for reference, refer to [8] AirPrime EM9190 Current Consumption Application Note for details.

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

Table 5-1 Averaged Standby DC Power Consumption[1]

Signal	Description	Band[2]	Current[3]			Notes/Configuration
			Typ	Max	Unit	
VCC	**Standby Current Consumption (Sleep Mode[4])**					
	5G	NR bands	2.7	-	mA	DRX cycle = 1.28s
	LTE	LTE bands	2.7	-	mA	DRX cycle = 1.28s
	HSPA / WCDMA	UMTS bands	2.6	-	mA	DRX cycle = 2.56s
	Standby Current Consumption[5] (Non-Sleep Mode[4])					
	5G	NR bands	31.6	-	mA	DRX cycle = 1.28s
	LTE	LTE bands	31.9	-	mA	DRX cycle = 1.28s
	HSPA / WCDMA	UMTS bands	30.7	-	mA	DRX cycle = 2.56s
	Low Power Mode (LPM)/Offline Mode[5] (Sleep Mode[4])					
	RF disabled, but module is operational		1.9	-	mA	
	Low Power Mode (LPM)/Offline Mode[5] (Non-Sleep Mode[4])					
	RF disabled, but module is operational		28.4	-	mA	
	Leakage Current					
	Module powered off — Full_Card_Power_Off# is Low, and VCC is supplied		70	120	µA	

1. Preliminary, subject to change.
2. For supported bands, refer to Table 4-2 (Supported Frequency Bands), by RAT (5G/LTE/3G).
3. Measured at 25ºC/nominal 3.3 V voltage.
4. Assume PCIe and USB are fully suspended during measurements.
5. 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 5-2 Averaged Call Mode DC Power Consumption

Mode	Description	Tx Power	Current[1,2] (mA)	Configuration[3]	Bands
3G	3G Data Call, max RF power	23dBm	800	HSDPA DL 7.2 Mbps	B1
LTE	LTE FDD DL 5CA 4x4 / UL 2CA	0dBm	905	DL 2000Mbps / UL 200Mbps; FDD, 20MHz/CC, DL: 5CC, 4x4 MIMO, 256QAM, RB=100, MCS=27; UL: 2CC, 256QAM	1A + 3C + 7C
		20dBm	1120		
	LTE FDD DL 5CA 4x4 / UL 2CA, max RF power	23dBm	1435	DL 2000 Mbps / UL 1Mbps; FDD, 20MHz/CC, DL: 5CC, 4x4 MIMO, 256QAM, RB=100, MCS=27; UL: 2CC, QPSK	
Sub-6 NSA	PDCCH 1CC, no data	-	410	DL/UL 0Gbps; Sub-6 100 MHz /CC, 4Rx, RB=0; LTE no data	1A + n78
	Sub-6 DL / UL 1CC	0dBm	660	DL 1600 Mbps / UL 95Mbps; Sub-6 100MHz/CC, DL: duty cycle ~ 80%, 1CC, 4×4 MIMO, -50dBm, 256QAM, RB=273, MCS=27; UL: SISO, 256QAM, RB=273, MCS=27; LTE no data	
Sub-6 EN-DC	LTE 5CC + Sub-6 DL / UL 1CC	0dBm	1360	DL 3600 Mbps/200Mbps. Sub-6 100 MHz/CC, DL/UL duty cycle ~80/20, Rx: 1CC, 4 ×4 MIMO, -50dBm, 256QAM, RB=273, MCS=27; Tx: SISO, 256QAM; LTE: DL 5CC, 4×4 MIMO,20 MHz/CC, 256 QAM, RB=100, MCS=27; Tx: 256QAM	1A + 3C + 7C + n78
		20dBm	1780		
	LTE 5CC + Sub-6 DL / UL 1CC, max RF power	23dBm	2030	DL 3600 Mbps/UL 1 Mbps. Sub-6 100 MHz/CC, DL/UL duty cycle ~80/20, Rx: 1CC, 4 ×4 MIMO, -50dBm, 256QAM, RB=273, MCS=27; Tx: SISO, QPSK; LTE: DL 5CC, 4 ×4 MIMO,20 MHz/CC, 256 QAM, RB=100, MCS=27; Tx: SISO QPSK	
mmWave EN-DC	LTE 4CC + mmWave DL 8CC, max RF power	TBD	TBD	TBD	TBD

1. Measured at 25ºC/nominal 3.3 V voltage.
2. Test data does not include current consumption of data transfer between module and host — the additional current increase is less than 100 mA in the worst case.
3. The measurement is using the EM919X/EM7690 development kit with a heatsink, refer to *[4] EM9190 Thermal Application Note* for details.

Table 5-3 Miscellaneous DC Power Consumption

Signal	Description	Current/Voltage				Description
		Min	Typ	Max	Unit	
VCC	USB active current	-	30	-	mA	High-speed USB connection, but no data transmission, CL = 50 pF on D+ and D- signals. RF is disabled.
	PCIe active current	-	53	-	mA	PCIe connection, but no data transmission. RF is disabled.

Signal	Description		Current/Voltage				Description
			Min	Typ	Max	Unit	
	Inrush current		-	-	3.0	A	• Assume power supply turn-on time> 100µs • Dependent on host power supply rise time.
	Peak current	EM9190 with mmWave	-	-	5.0	A	• Across all bands, all temperature ranges • 3.3V supply
		EM9190 without mmWave	-	-	3.0	A	
		EM9191	-	-	2.7	A	
		EM7690	-	-	2.3	A	

5.2. Module Power States

The module has five power states, as described in Table 5-4.

Table 5-4 Module Power States

State	Details	Host Is Powered	Host Interface Active	RF Enabled

Normal (Default State)	• Module is active
	• Default state. Occurs when VCC is first applied, Full_Card_Power_Off# is deasserted (pulled high), and W_DISABLE# 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
		✓	✓	✓

Low Power (Airplane Mode)	• Module is active
	• Module enters this state:
	  ◦ Under host interface control:
	  ◦ Host issues AT+CFUN=0 (*[1] AT Command Set for User Equipment (UE) (Release 6)*), or
	  ◦ Host asserts W_DISABLE#, after AT!PCOFFEN=0 has been issued.
	  ◦ Automatically, when critical temperature or voltage trigger limits have been reached)
		✓	✓	-

Sleep	• Normal state of module between calls or data connections • Module cycles between wake (polling the network) and sleep, at network provider-determined interval.	✓	-	-

State	Details	Host Is Powered	Host Interface Active	RF Enabled
Off	• Host keeps module powered off by asserting Full_Card_Power_Off# (signal pulled low or left floating) • Module draws minimal current • Refer to Full_Card_Power_Off# and RESET# for more information.	✓	-	-
Disconnected	Host power source is disconnected from the module and all voltages associated with the module are at 0 V.	-	-	-

5.2.1. 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. (Refer to Table 5-5 for trigger details and Figure 5-1 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 5-5 Power State Transition Trigger Levels

Transition	Voltage		Temperature[1]		Notes
	Trigger	V	Trigger	°C	
Normal to Low Power	VOLT_HI_CRIT	4.6	TEMP_LO_CRIT	-45	RF activity suspended
	VOLT_LO_CRIT	2.9	TEMP_HI_CRIT	118	
Low Power to Normal	VOLT_HI_NORM	4.4	TEMP_NORM_LO	-30	RF activity resumed
Low Power to Normal Or Remain in Normal (Remove warnings)	VOLT_LO_NORM	3.135	TEMP_HI_NORM	100	
Normal (Issue warning)	VOLT_LO_WARN	3.135	TEMP_HI_WARN	100	In the TEMP_HI_WARN state, the module may have reduced performance (Class B temperature range).
Power off/on (Host-initiated)	-	-	-	-	Power off recommended when supply voltage or module operating temperature is critically low or high.

1. Highest junction temperature among onboard chipsets (PAs, PMIC, XO, SDX55).

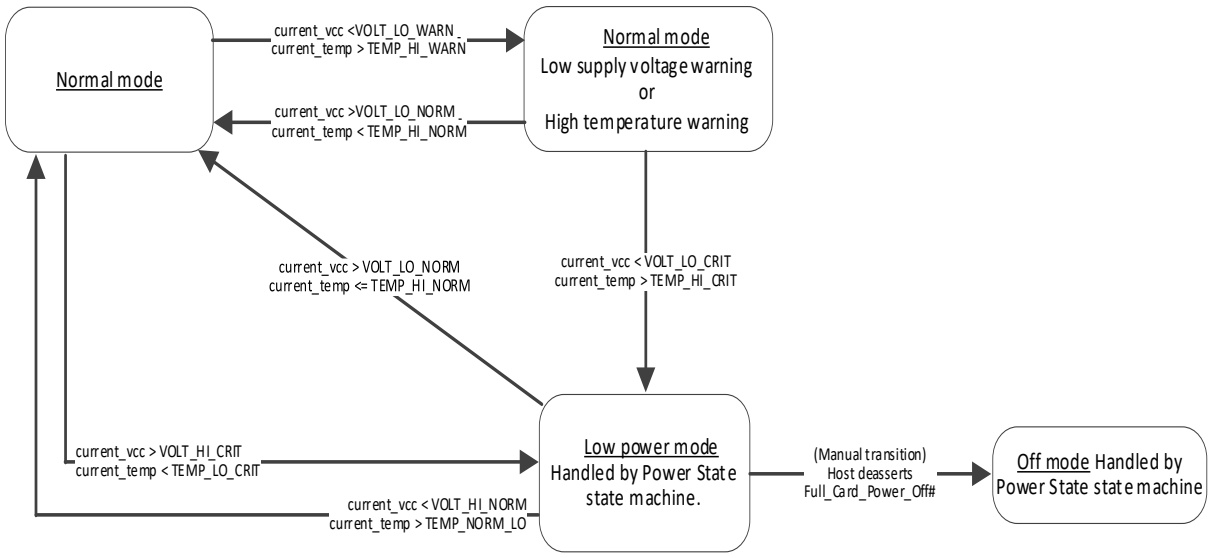


Figure 5-1 Voltage/Temperature Monitoring State Machines

5.3. Power Interface

5.3.1. Power Ramp-up

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

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

5.3.2. Timing

5.3.2.1. Power On/Off Timing for PCIe Port

Figure 5-2 describes the timing of PCIe port detection in the power-on/off sequence.

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

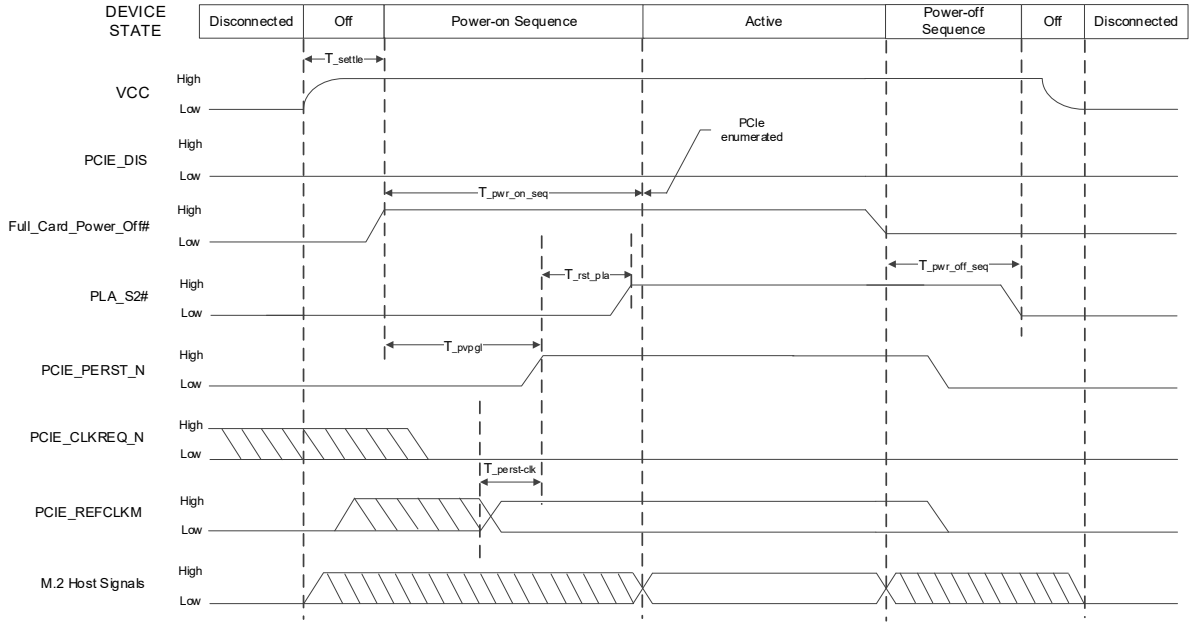


Figure 5-2 Power On/Off Timing for PCIe Port

Table 5-6 PCIe Timing

Symbol	Parameter	Minimum	Typical	Maximum	Unit
T_settle	Power on to Power Valid	-	-	-	ms
T_pvpgl[1]	Power Valid to PERST# input inactive	50	-	-	ms
T_rst_pla	PERST# high to PLA_S2# high	-	157	-	ms
T_pwr_on_seq	Power on sequence time	-	4.5	10	s
T_pwr_off_seq	Power off sequence time	-	4.5	8	s
T_perst-clk	REFCLK stable before PERST# inactive	100		-	µs

1. T_pvgpl is dependent on the host PCIe controller implementation.

Note: Power Valid when all the voltage supply rails have reached their respective Vmin. Tsettle is depending on the host power design, (i.e. a typical Adapter with a load capacitance of 330 µF and a 200 mA Soft-Start current limited ramp on the 3.3 V power rail, should settle within 5 ms.)

5.3.2.2. Power On/Off Timing for USB Port

Figure 5-3 describes the timing of USB port detection in the power-on/off sequence.

Note: Before reaching the "Active" state, signals on the host port are 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.

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

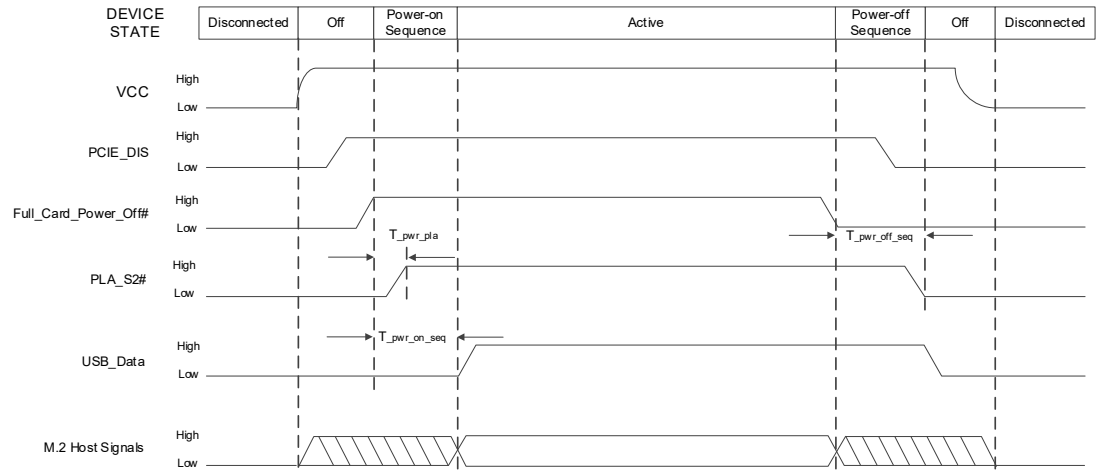


Figure 5-3 Signal Timing (Full_Card_Power_Off#, and USB Enumeration)

Table 5-7 USB Power-On / Off Timing Parameters

Symbol	Parameter	Minimum	Typical	Maximum	Unit
T pwr_on_seq	Power on sequence time	-	14.7	35	s
T_pwr_pla	Power on to PLA_S2# high	-	250	300	ms
T pwr_off_seq	Power off sequence time	-	4.5	8	s

5.3.2.3. Reset Timing

To reset the module, refer to Table 3-8 for RESET# signal usage instructions.

5.3.2.4. Required Shutdown Sequence

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

- Drive Full_Card_Power_Off# low.

Note: It triggers firmware to go through graceful power off flow which generally finishes in 8 seconds and this trigger is only effective after module boots up completely.

- Wait for PLA_S2# asserted to low.
- Remove power.

5.3.3. 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 Hz to 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.

5.3.4. SED (Smart Error Detection)

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

- Module tracks consecutive resets occurring soon after power-on.

- After a sixth consecutive reset, the module waits in boot-and-hold mode for a firmware download to resolve the power-cycle problem.

6. Software Interface

6.1. Support Tool

The EM919X/EM7690 is compatible with the following support tools from Sierra Wireless and authorized third parties:

- Firmware update utilities from Sierra Wireless
- Sierra Wireless Logger
- QXDM from QUALCOMM
- QUALCOMM Product Support Tool (QPST)
- Windows and Linux SDKs (including API and drivers)

6.2. Host Interface

The device supports the following protocols for modem communication:

- MBIM (Mobile Broadband Interface Model)
- Qualcomm QMI interface. (Please contact your Sierra Wireless account representative for QMI interface documentation.)

7. Mechanical and Environmental Specifications

7

The EM919X/EM7690 module complies with the mechanical and environmental specifications in Table 7-1. Final product conformance to these specifications depends on the OEM device implementation.

Table 7-1 Mechanical and Environmental Specifications

Parameter	Mode	Details
Ambient Temperature	Operational Class A	-30ºC to +70ºC – 3GPP compliant, with appropriate heatsinking
	Operational Class B	-40ºC to +85ºC, with appropriate heatsinking – non-3GPP compliant (reduced operating parameters required)
Humidity Text	15 minutes Idle / 15 minutes Off	Test Temperature: 85°C Relative Humidity: 85% Stress Duration: 10 days
Thermal Shock Test	Non-operational	Test Temperature: -40°C to +85°C Temperature Transition Time: < 30 seconds Dwell Time: 10 minutes Stress Duration: 300 cycles
High Temperature Operating Life Test	45 minutes Max TX / 15 minutes Idle	Temperature: 85°C Stress Duration: 20 days (480 cycles)
Low Temperature Cold Start Test	30 minutes Off / 5 minutes Idle	Test Temperature: -40°C Stress Duration: 5 days
Mechanical Shock	Non-operational	Waveform: Half sine Peak Acceleration: 30 g Shock Duration: 6 ms Number of Shock: 3 Shock direction: ±X, ±Y, ±Z Stress Duration: 1 day
Drop	Non-operational	Number of Drops: 1 drop per direction (±X, ±Y, ±Z), 6 directions – total 6 drops per module (1 round) Surface Type: Un-protected drops onto a surface that meets the test standard requirement Drop Height: 1 m Stress Duration: 1 day
Electrostatic Discharge (Refer to Electrostatic Discharge (ESD))	Operational	The LTE/Sub-6 antenna ports comply with the IEC 61000-4-2 standard: • Electrostatic Discharge Immunity: Test: Level 3 • Air Discharge: ±8 kV • Contact Discharge: ±6 kV
	Non-operational	The host connector interface (M.2) and mmWave IF ports (EM9190 only) comply with the following standard only: • minimum ±500 V Human Body Model (JESD22-A114-B)

Parameter	Mode	Details
Form Factor		M.2 Form Factor (Conforms to width specification)
Dimensions		Length: 52±0.15 mm (max, exclude de-panel burr) Width: 30±0.15 mm (max, exclude de-panel burr) Thickness: 2.38 mm (max): • Above PCB — 1.50 mm (max) • PCB — 0.88 mm (max) Weight: 9g (max)
MTBF		87.01 years Temperature: 25°C

7.1. Device Views

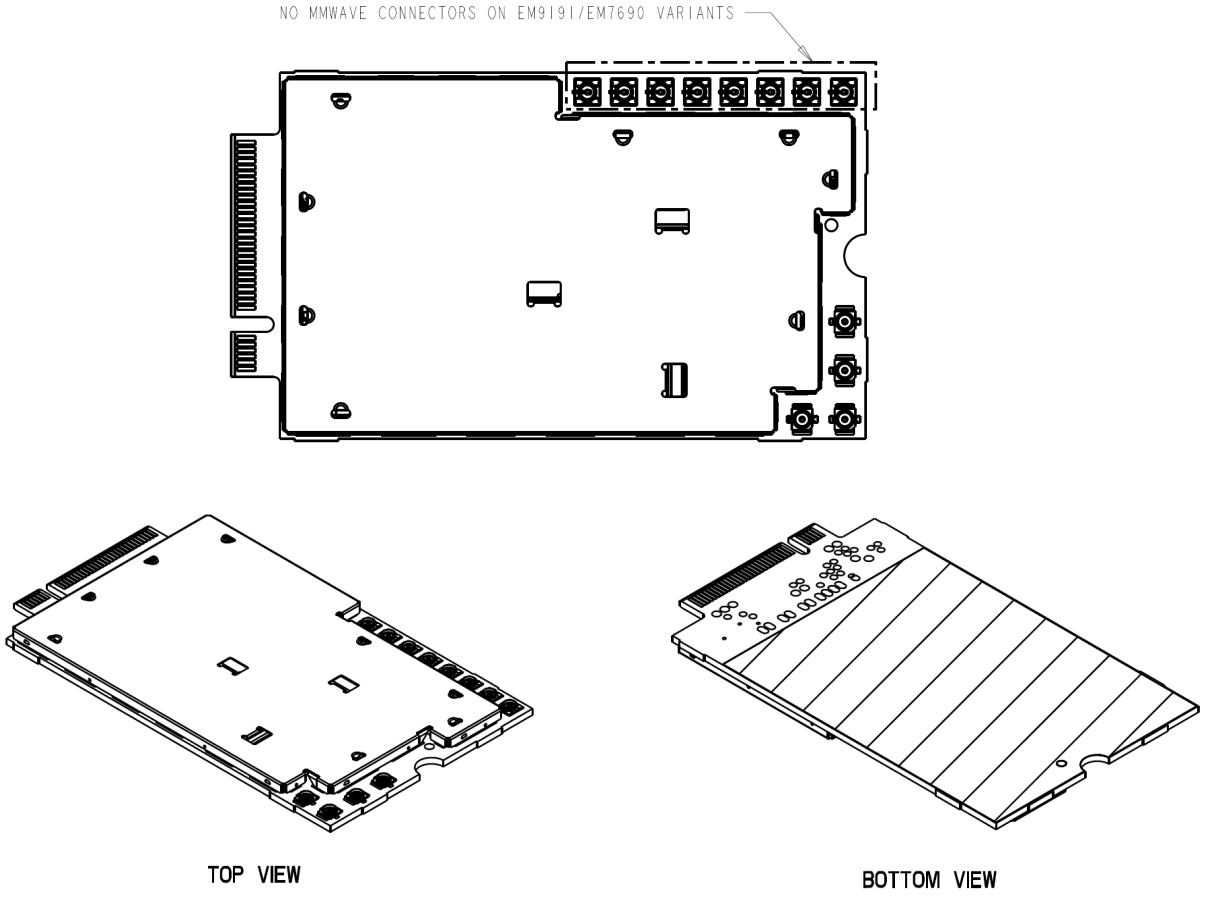


Figure 7-1 Top View and Bottom View

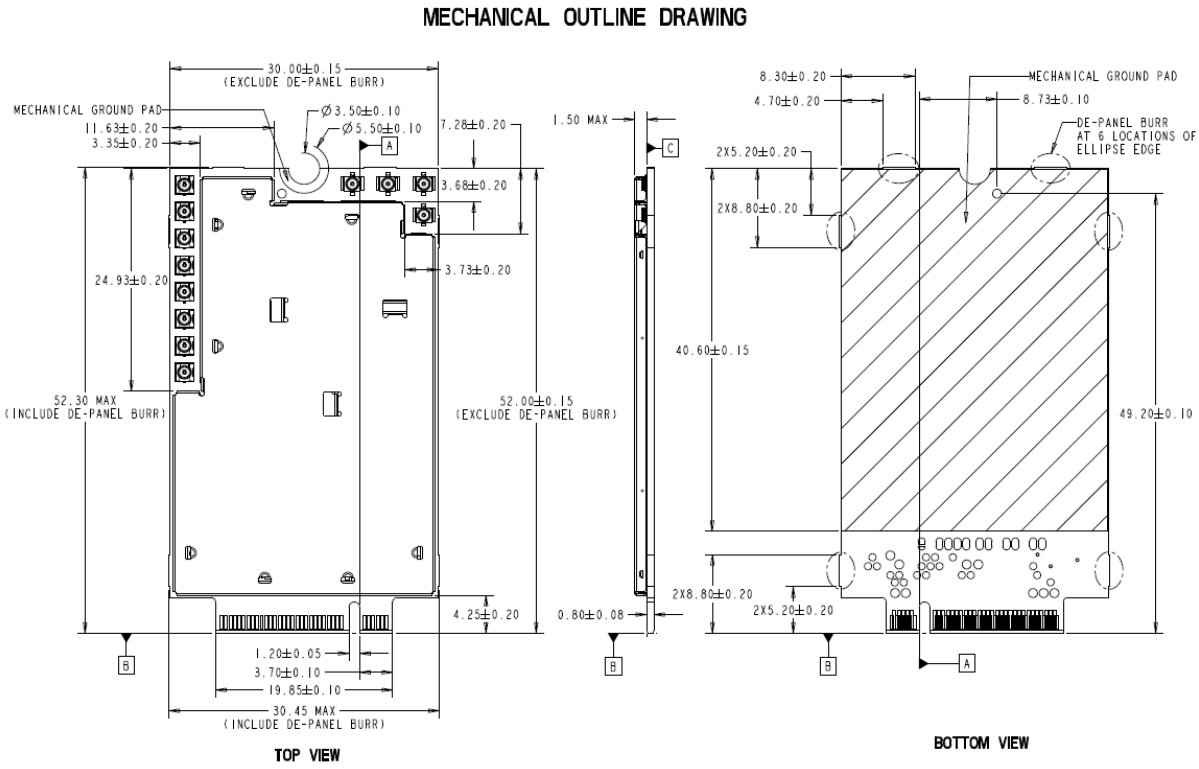


Figure 7-2 Dimensioned View of Mechanical Outline

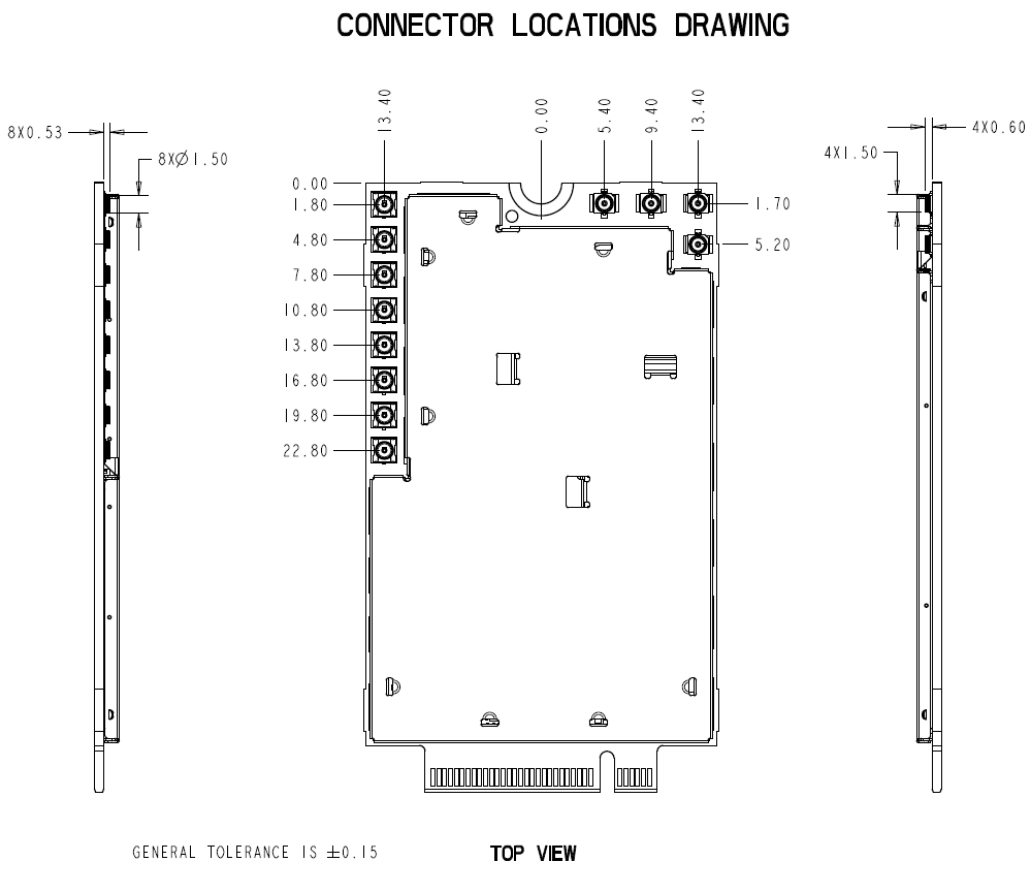


Figure 7-3 Dimensioned View of Connector Locations

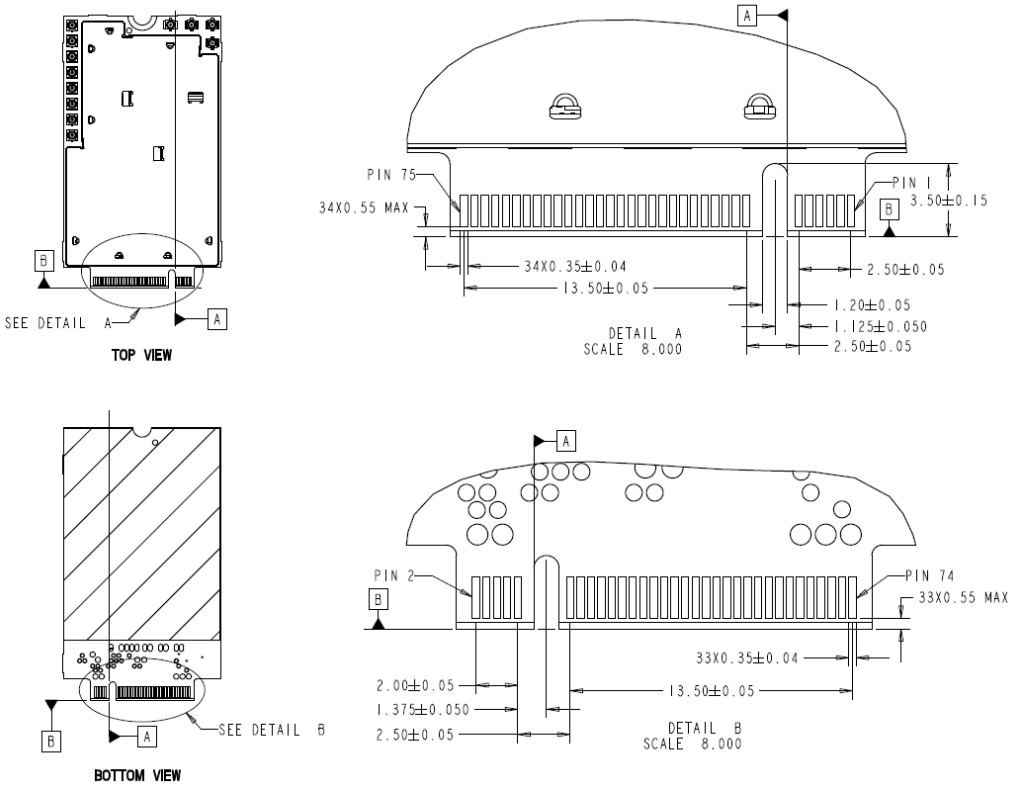


Figure 7-4 Dimensioned View of Pin-out

7.2. Product Marking (Labeling)

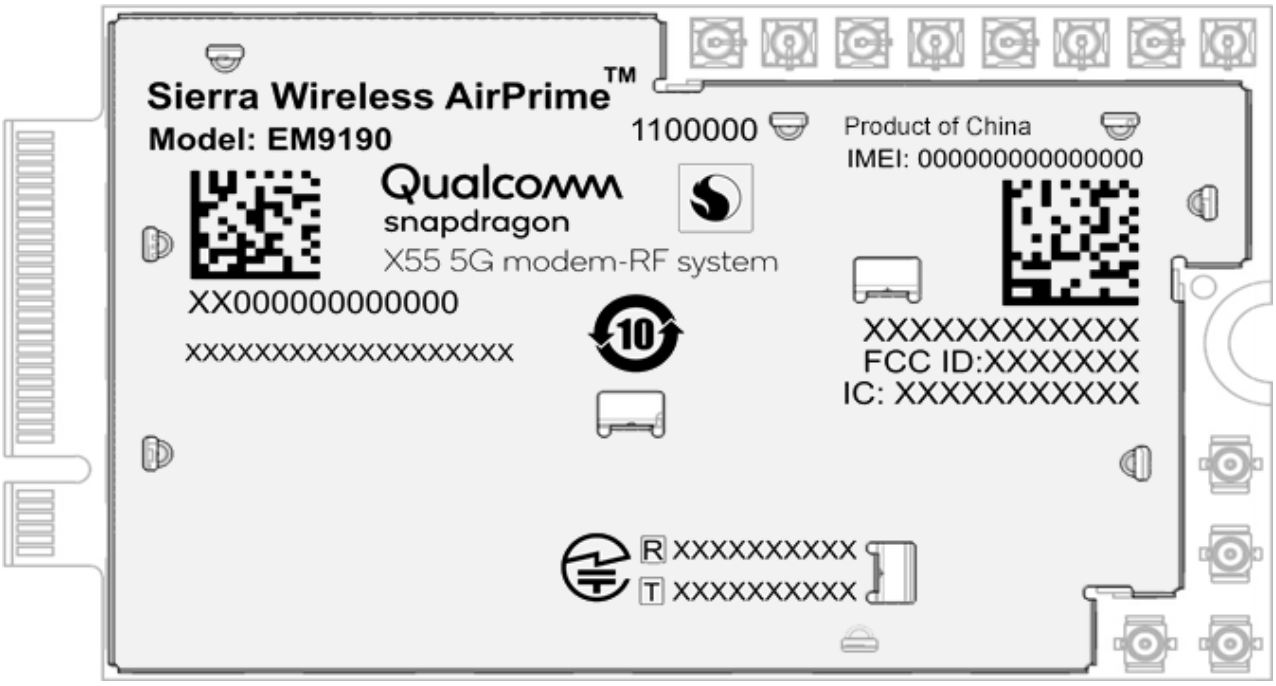


Figure 7-5 Unit Product Marking Example — Laser-etched, Typical Representation (Not to scale. Contents vary by SKU.)

Note: The mmWave IF connectors are only mounted on EM9190.

The EM919X/EM7690 product marking is laser-etched and may contain:

- Sierra Wireless 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
- CPN
- Barcodes
- Manufacture location

Note: The EM919X/EM7690 supports OEM partner-specific label requirements.

7.3. Electrostatic Discharge (ESD)

The OEM is responsible for ensuring that the EM919X/EM7690 host interface pins are not exposed to ESD during handling or normal operation. (Refer to Table 7-1 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 Sub-6 antenna ports.)

7.4. Thermal Considerations

Embedded modules can generate significant amounts of heat that must be dissipated in the host device for safety and performance reasons. Figure 7-6 and Figure 7-7 display the location of heat source.

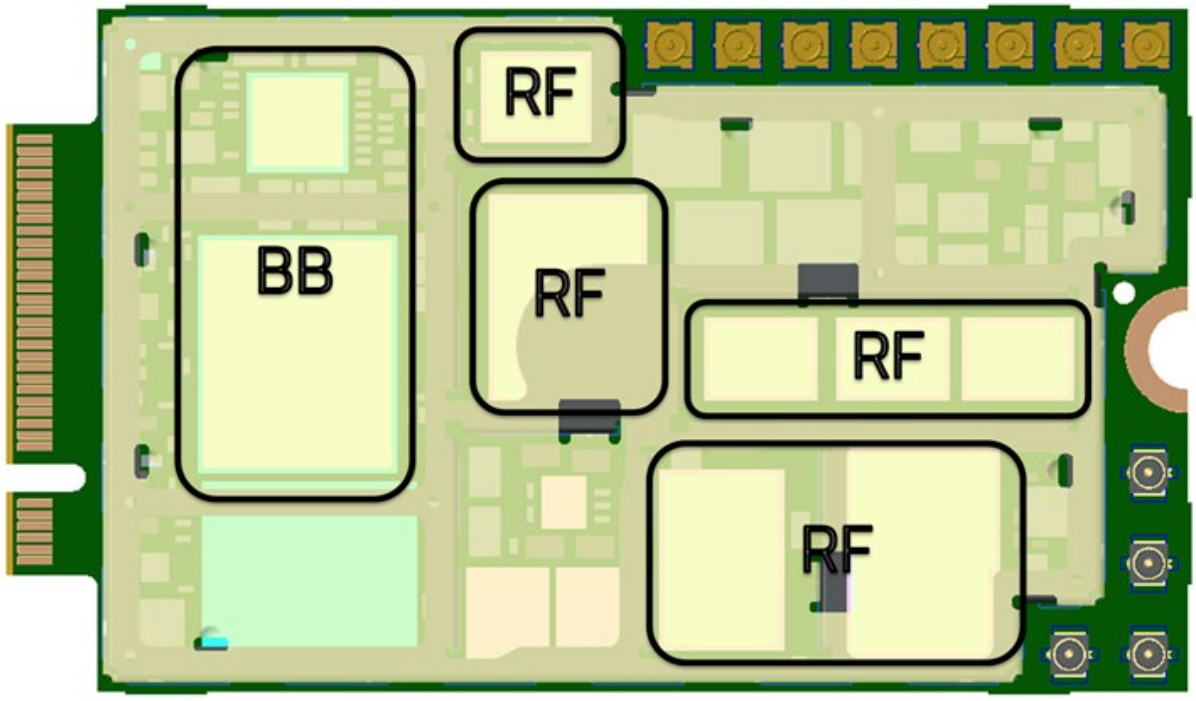


Figure 7-6 Shield Locations (Top View)

Note: The mmWave IF connectors are only mounted on EM9190.

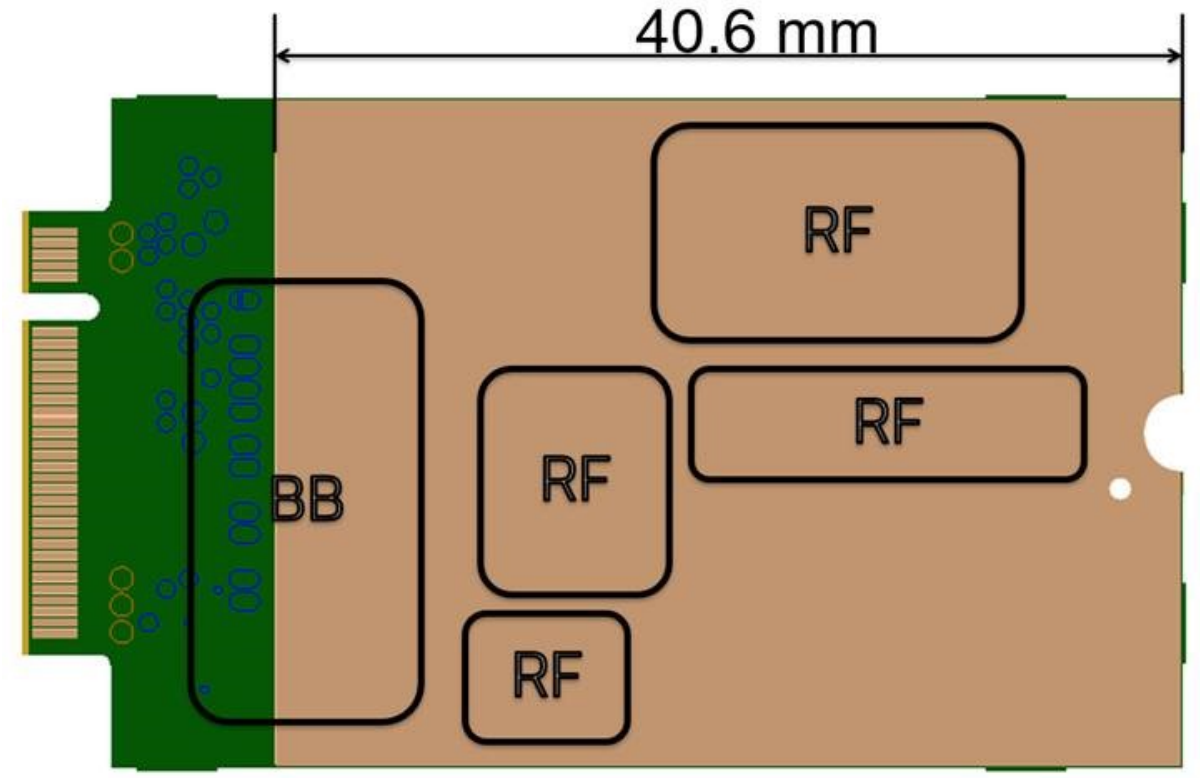


Figure 7-7 Copper Pad Location on Bottom Side of Module

Specific areas requiring heat dissipation are shown in Figure 7-7:

- RF — Bottom face of module near RF connectors. Likely to be the hottest area.
- Baseband — Bottom face of module, below the baseband area.

To enhance heat dissipation:

- It is recommended to add a heat sink that mounts the module to the main PCB or metal chassis (a thermal compound or pads must be used between the module and the heat sink).
- 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.
- You may also need active cooling to pull heat away from the module.

Note: Adequate dissipation of heat is necessary to ensure that the module functions properly. Refer to [4] EM9190 Thermal Application Note for more details.

7.5. Module Integration Testing

When testing your integration design:

- Test to your worst-case operating environment conditions (temperature and voltage)
- Test using worst-case operation
- Monitor temperature at all shield locations. Attach thermocouples to the areas indicated in Figure 7-6 (RF, Baseband).

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

8. Regulatory Compliance and Industry Certification

This 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
- The National Communications Commission (NCC) of Taiwan, Republic of China
- The Certification and Engineering Bureau of Industry Canada (IC)
- EU RED/CE
- Russia type approval certificate (FAC), FSS notification
- China CCC
- China NAL
- China SRRC
- South Korea KCC

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

- GCF
- PTCRB

Additional certifications and details on specific country approvals may be obtained upon customer request — contact your Sierra Wireless account representative for details.

Additional testing and certification may be required for the end product with an embedded EM919X/EM7690 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.

8.1. RoHS Directive Compliant

AirPrime EM919X/EM7690 modules are compliant with RoHS Directive 2011/65/EU, including directive 2015/863 amending annex II. which sets limits for the use of certain restricted hazardous substances. This directive states that electrical and electronic equipment put on the market does not contain lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB), polybrominated diphenyl ethers (PBDE), Bis (2-ethylhexyl) phthalate (DEHP), Butyl benzyl phthalate (BBP), Dibutyl phthalate (DBP) or Diisobutyl phthalate (DIBP) above threshold limits.

8.2. Important Notice

Because of the nature of wireless communications, transmission and reception of data can never be guaranteed. Data may be delayed, corrupted (i.e., have errors) or be totally lost. Although significant delays or losses of data are rare when wireless devices such as the Sierra Wireless module are used in a normal manner with a well-constructed network, the Sierra Wireless module should not be used in situations where failure to transmit or receive data could result in damage of any kind to the user or any other party, including but not limited to personal injury, death, or loss of property. Sierra Wireless and its affiliates accept no responsibility for damages of any kind resulting from delays or errors in data transmitted or received using the Sierra Wireless module, or for failure of the Sierra Wireless module to transmit or receive such data.

8.3. Safety and Hazards

Do not operate your EM919X/EM7690 module:

- In areas where blasting is in progress
- Where explosive atmospheres may be present including refueling points, fuel depots, and chemical plants
- Near medical equipment, life support equipment, or any equipment which may be susceptible to any form of radio interference. In such areas, the EM919X/EM7690 module **MUST BE POWERED OFF**. Otherwise, the EM919X/EM7690 module can transmit signals that could interfere with this equipment.

In an aircraft, the EM919X/EM7690 module **MUST BE POWERED OFF**. Otherwise, the EM919X/EM7690 module can transmit signals that could interfere with various onboard systems and may be dangerous to the operation of the aircraft or disrupt the cellular network. Use of a cellular phone in an aircraft is illegal in some jurisdictions. Failure to observe this instruction may lead to suspension or denial of cellular telephone services to the offender or legal action, or both.

Some airlines may permit the use of cellular phones while the aircraft is on the ground and the door is open. The EM919X/EM7690 module may be used normally at this time.

8.4. Important Compliance Information for the United States and Canada

The EM919X/EM7690 module, upon commercial release, will have been granted modular approval for mobile applications. Integrators may use the EM919X/EM7690 module in their final products without additional FCC/IC (Industry Canada) certification if they meet the following conditions. Otherwise, additional FCC/IC 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/IC 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 8-1.
3. The EM919X/EM7690 module may transmit simultaneously with other collocated radio transmitters within a host device, provided the following conditions are met:
   - Each collocated radio transmitter has been certified by FCC/IC 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 8-1.

Table 8-1 Antenna Gain and Collocated Radio Transmitter Specifications

Device	Operating Mode	Tx Freq Range (MHz)		Max Time-Avg Cond. Power (dBm)	Antenna Gain Limit (dBi)		EIRP Limits (dBm)
					Standalone	Collocated	
EM919X EM7690	WCDMA Band 2	1850	1910	24.5	8.5	8	32.5
	WCDMA Band 4	1710	1755	24.5	5.5	5.5	30
	WCDMA Band 5	824	849	24.5	6	5.5	30
	LTE B2	1850	1910	24	8.5	8	32
	LTE B4	1710	1755	24	5.5	5.5	29.5

Device	Operating Mode	Tx Freq Range (MHz)		Max Time-Avg Cond. Power (dBm)	Antenna Gain Limit (dBi)		EIRP Limits (dBm)
					Standalone	Collocated	
	LTE B5	824	849	24	6	5.5	29.5
	LTE B7	2500	2570	24.8	5.5	5.5	30.3
	LTE B12	699	716	24	5.5	5	29
	LTE B13	777	787	24	5.5	5	29
	LTE B14	788	798	24	5.5	5	29
	LTE B17	704	716	24	5.5	5	29
	LTE B25	1850	1915	24	8.5	8	32
	LTE B26	814	849	24	6	5.5	29.5
	LTE B30	2305	2315	24	6	6	30
	LTE B38	2570	2620	24.8	7	7	31.8
	LTE B41	2496	2690	24.8	7	7	31.8
	LTE B41-HPUE	2496	2690	26	7	7	33
	LTE B48	3550	3700	24.8	5	5	29.8
	LTE B66	1710	1780	24	5.5	5.5	29.5
	LTE B71	663	698	24	5.5	5	29
EM919X	5G NR n2	1850	1910	24	8.5	8	32
	5G NR n5	824	849	24	6	5.5	29.5
	5G NR n41	2496	2690	24.5	7	7	31
	5G NR n66	1710	1780	24	5.5	5.5	29.5
	5G NR n71	663	698	24	5.5	5	29
Collocated Transmitters	WLAN 2.4 GHz	2400	2500	20	-	5	25
	WLAN 5 GHz	5150	5850	20	-	8	28
	Bluetooth	2400	2500	17	-	5	22

Note: The FCC and IC have a strict EIRP limit in Band 30 for mobile and portable stations in order to protect adjacent satellite radio, aeronautical mobile telemetry, and deep space network operations. Mobile and portable stations must not have antenna gain exceeding 1 dBi in Band 30. Additionally, both the FCC and IC prohibit the use of external vehicle-mounted antennas for mobile and portable stations in this band.

Fixed stations may use antennas with higher gain in Band 30 due to relaxed EIRP limits. EM919X/EM7690 modules used as fixed subscriber stations in Canada or fixed customer premises equipment (CPE) stations in the United States may have an antenna gain up to 10 dBi in Band 30, however, the use of outdoor antennas or outdoor station installations are prohibited except if

professionally installed in locations that are at least 20 meters from roadways or in locations where it can be shown that the ground power level of -44 dBm per 5 MHz in the bands 2305–2315 MHz and 2350–2360 MHz or -55 dBm per 5 MHz in the bands 2315–2320 MHz and 2345–2350 MHz will not be exceeded at the nearest roadway. For the purposes of this notice, a roadway includes a highway, street, avenue, parkway, driveway, square, place, bridge, viaduct or trestle, any part of which is intended for use by the general public for the passage of vehicles.

Mobile carriers often have limits on total radiated power (TRP), which requires an efficient antenna. The end product with an embedded module must output sufficient power to meet the TRP requirement but not too much to exceed FCC/IC's EIRP limit. If you need assistance in meeting this requirement, please contact Sierra Wireless.

Airborne operations in LTE Band 48 are prohibited.

4. A label must be affixed to the outside of the end product into which the EM919X/EM7690 module is incorporated, with a statement similar to the following:

   This device contains FCC ID: N7NEM91, IC: 2417C-EM91.

5. A user manual with the end product must clearly indicate the operating requirements and conditions that must be observed to ensure compliance with current FCC/IC RF exposure guidelines.

The module is compliant with FCC 47 CFR Part 2, 22, 24, 27, 90, 96 requirements.

The end product with an embedded EM919X/EM7690 module may also need to pass the FCC Part 15 unintentional emission testing requirements and be properly authorized per FCC Part 15.

Note: If this module is intended for use in a portable device, you are responsible for separate approval to satisfy the SAR requirements of FCC Part 2.1093 and IC RSS-102.

9. Annex

9

9.1. Antenna Specification

This appendix describes recommended electrical performance criteria for Sub-6G, GNSS, and mmWave antennas used with AirPrime 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.*

9.1.1. Recommended WWAN Antenna Specifications

Table 9-1 Antenna Requirements[1]

Parameter	Requirements	Comments
Antenna System	(NR/LTE) External multi-band 4x4 DL MIMO antenna system (Ant1/Ant2/Ant3/Ant4)[2] (3G) External multi-band antenna system with diversity (Ant1/Ant2)	If Ant2 or Ant3 includes GNSS, then it must also satisfy requirements in Table 9-2.
Operating Bands — Ant1	All supporting Tx and Rx frequency bands.	
Operating Bands — Ant2/3/4	All supporting Rx frequency bands, plus GNSS frequency bands if Ant2 is used in shared Diversity/MIMO/GNSS mode.	
VSWR of Ant1 and Ant2	• < 2:1 (recommended) • < 3:1 (worst case)	On all bands including band edges
Total Radiated Efficiency	> 50% on all bands	• Measured at the RF connector. • Includes mismatch losses, losses in the matching circuit, and antenna losses, excluding cable loss. • Sierra Wireless 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	Nominally Omni-directional radiation pattern in azimuth plane.	
Envelope Correlation Coefficient between Ant	• < 0.5 on Rx bands below 960 MHz • < 0.2 on Rx bands above 1.4 GHz	

Parameter	Requirements	Comments
Mean Effective Gain of Ant1 and Ant2 (MEG1, MEG2)	≥ -3 dBi	
Ant1 and Ant2 Mean Effective Gain Imbalance | MEG1 / MEG2 |	• < 2 dB for MIMO operation • < 6 dB for diversity operation	
Maximum Antenna Gain	Must not exceed antenna gains due to RF exposure and ERP/EIRP limits, as listed in the module's FCC grant.	Refer to Important Compliance Information for the United States and Canada.
Isolation	• >10dB for all antennas at all bands frequency range. • >20dB for Ant1 and Ant4 at B41 frequency range.	• 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.
Power Handling	>1W	• 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.

1. 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) 50Ω 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, 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.

2. Ant1 - Primary, Ant2 - Secondary (Diversity/GNSS L1), Ant3 - MIMO1 Rx path and n41 TRx, Ant4 - MIMO2 Rx path, n41 DRx path and GNSS L5.

9.1.2. Recommended GNSS Antenna Specifications

Table 9-2 GNSS Antenna Requirements

Parameter	Requirements	Comments
Frequency Range	• Wide-band GNSS: 1559–1606 MHz recommended • Narrow-band GPS: 1575.42 MHz ±2 MHz minimum • Narrow-band Galileo: 1575.42 MHz ±2 MHz minimum • Narrow-band BeiDou: 1561.098 MHz ±2 MHz minimum • Narrow-band GLONASS: 1601.72 MHz ±4.2 MHz minimum • Narrow-band QZSS: 1575.42 MHz ±2 MHz minimum	

Parameter	Requirements	Comments
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.
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 ANTx for WWAN Tx	> 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.	

Note: GNSS active antenna is forbidden to use.

9.1.3. Antenna Tests

The following guidelines apply to the requirements described in Table 9-1 and Table 9-2:

- 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, connectors, and matching circuit with no more than six components, if required) have nominal impedances of 50Ω across supported frequency bands.
- All tests (except for 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 +8kV).
- 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 Sierra Wireless' engineering services. Contact your Sierra Wireless representative for assistance.

9.1.4. mmWave Antennas

Note: For EM9190 only.

The mmWave-capable EM9190 module is available in low-power (connectorized) antenna module SKU configurations or high-power (soldered down) antenna module SKU configurations. The EM9190 module can support up to four antenna modules.

Table 9-3 describes the primary mechanical and functional differences between low and high power mmWave antenna modules. For more information, refer to *[6] EM9190 mmWave Design Guidelines*.

Table 9-3 Low Power/High Power mmWave Antenna Comparison

Parameter	Low Power Modules	High Power Modules
Module Type	QTM525	QTM527
Typical Applications	Laptops Tablets Home gateways	CPE (outdoor) products
Simultaneously Active	No. Only one active at a time	Yes. All four antennas work together for additive power.
Power	23 dBm	Up to 40+ dBm
Connection Method to EM9190 Module	10-pin connectorized	Solder down
Module Footprint Area	~100 mm^2	~400 mm^2

9.1.4.1. Low Power mmWave Antenna Modules

Low-power mmWave antenna module(s) are provided by the OEM/ODM on the platform. EM9190 provides the RF IF connectors that customer can use the Coax cable to connect EM9190 from/to the antenna module as blue lines in Figure 9-1. This application may also need FPC connector at customer's mmWave antenna carrier board. For other Non-RF signals (PON, PWR, and VDC), PON and PWR are supplied from EM919X/EM7690 M.2 Interface directly, and VDC are from customer's application.

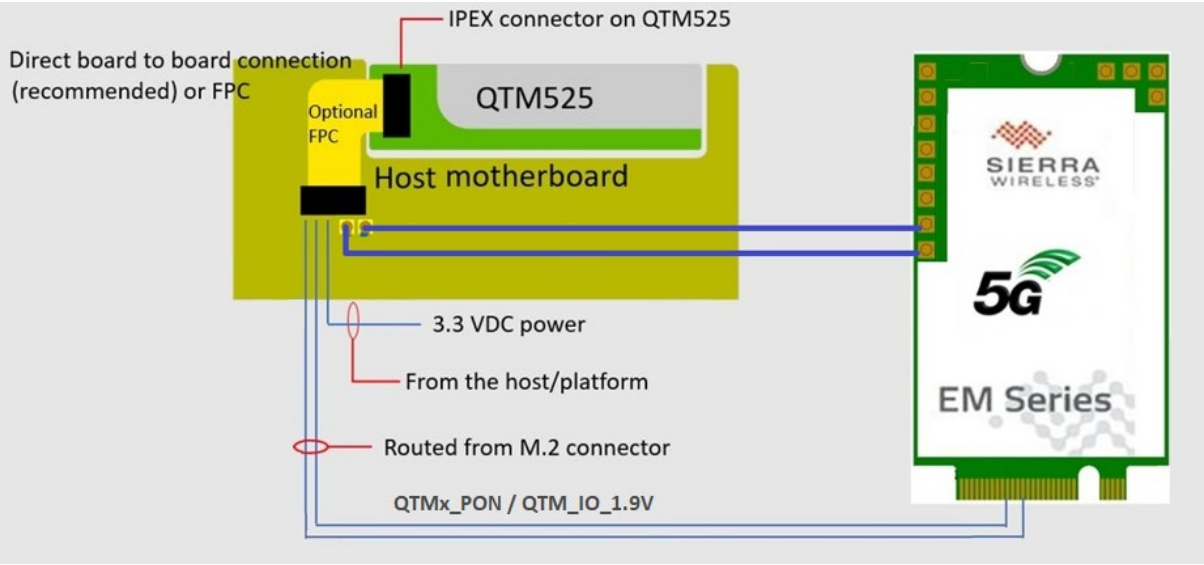


Figure 9-1 Example of Low Power mmWave Antenna Modules

9.1.4.2. High Power mmWave Antenna Modules

High power mmWave antenna modules are provided by the OEM/ODM in a 2x2 array on the platform and connect to EM9190 high-power mmWave SKUs via 8 RF COAX cables (2 per antenna module). The choice of antenna module types depends on the bands to be provided by the application.

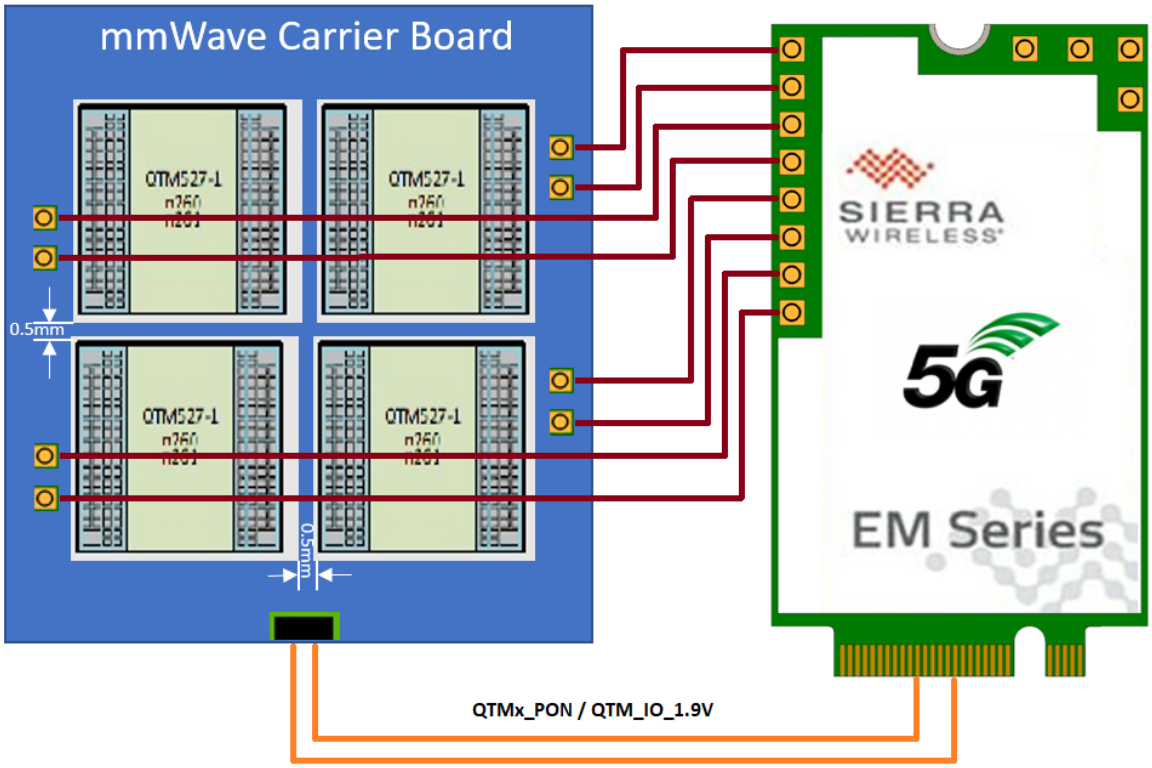


Figure 9-2 Example of High Power mmWave Antenna Modules

Each antenna module is independently powered, and multiple antenna modules can be used simultaneously for increased power.

9.2. Carrier Aggregation and EN-DC

Check detailed LTE CA combinations at LTE 2CA, LTE 3CA, LTE 4CA, LTE 5-7CA and 5G EN-DC combinations at 5G NR Sub-6G EN-DC.

Note: For TDD+FDD LTE CA, TDD is SCell only by default.

The CA and EN-DC is still under development and subject to change, some of listed CA and EN-DC may not be supported for now.

Table 9-4 LTE 2CA

CA Configuration	ULCA	4 × 4 DL MIMO
CA_12A-12A	-	-
CA_12A-25A	-	25A
CA_12A-30A	-	30A
CA_12A-46A	-	-
CA_12A-66A	12A-66A	66A
CA_12B	-	-
CA_13A-46A	-	-
CA_13A-48A	-	48A
CA_13A-66A	13A-66A	66A
CA_14A-30A	-	30A

CA Configuration	ULCA	4 × 4 DL MIMO
CA_14A-66A	-	66A
CA_18A-42A	-	42A
CA_1A-18A	1A-18A	1A
CA_1A-19A	1A-19A	1A
CA_1A-1A	-	1A-1A
CA_1A-20A	1A-20A	1A
CA_1A-26A	1A-26A	1A
CA_1A-28A	1A-28A	1A
CA_1A-32A	-	1A
CA_1A-38A	-	1A-38A
CA_1A-3A	-	1A-3A
CA_1A-40A	-	1A-40A
CA_1A-41A	-	1A-41A
CA_1A-42A	-	1A-42A
CA_1A-46A	-	1A
CA_1A-5A	1A-5A	1A
CA_1A-7A	-	1A-7A
CA_1A-8A	1A-8A	1A
CA_1C	-	1C
CA_20A-32A	-	32A
CA_20A-38A	-	38A
CA_20A-40A	-	40A
CA_20A-42A	-	42A
CA_25A-25A	-	25A-25A
CA_25A-26A	-	25A
CA_25A-41A	-	25A-41A
CA_25A-46A	-	25A
CA_26A-41A	-	41A
CA_26A-46A	-	-
CA_28A-32A	-	-
CA_28A-38A	-	38A
CA_28A-40A	-	40A
CA_28A-41A	-	41A
CA_28A-42A	-	42A
CA_28A-46A	-	-
CA_28C	-	-
CA_29A-30A	-	30A
CA_29A-66A	-	66A
CA_2A-12A	2A-12A	2A
CA_2A-13A	2A-13A	2A
CA_2A-14A	-	2A
CA_2A-17A	-	2A
CA_2A-28A	-	2A
CA_2A-29A	-	2A
CA_2A-2A	-	2A-2A
CA_2A-30A	-	2A-30A
CA_2A-46A	-	2A

CA Configuration	ULCA	4 × 4 DL MIMO
CA_2A-48A	-	2A-48A
CA_2A-4A	-	2A-4A
CA_2A-5A	2A-5A	2A
CA_2A-66A	-	2A-66A
CA_2A-71A	-	2A
CA_2A-7A	-	2A-7A
CA_2C	-	2C
CA_30A-66A	-	30A-66A
CA_38C	-	38C
CA_39A-41A	-	39A-41A
CA_39C	-	39C
CA_3A-18A	3A-18A	3A
CA_3A-19A	3A-19A	3A
CA_3A-20A	3A-20A	3A
CA_3A-26A	3A-26A	3A
CA_3A-28A	3A-28A	3A
CA_3A-32A	-	3A-32A
CA_3A-38A	-	3A-38A
CA_3A-3A	-	3A-3A
CA_3A-40A	-	3A-40A
CA_3A-41A	-	3A-41A
CA_3A-42A	-	3A-42A
CA_3A-46A	-	3A
CA_3A-5A	3A-5A	3A
CA_3A-7A	-	3A-7A
CA_3A-8A	3A-8A	3A
CA_3C	3C	3C
CA_40A-40A	-	40A-40A
CA_40C	-	40C
CA_41A-41A	-	41A-41A
CA_41A-42A	-	41A-42A
CA_41A-46A	-	41A
CA_41A-48A	-	41A-48A
CA_41C	41C	41C
CA_42A-42A	-	42A-42A
CA_42C	42C	42C
CA_46A-66A	-	66A
CA_46A-71A	-	-
CA_48A-48A	-	48A-48A
CA_48A-66A	-	48A-66A
CA_48A-71A	-	48A
CA_48C	48C	48C
CA_4A-12A	4A-12A	4A
CA_4A-13A	4A-13A	4A
CA_4A-28A	-	4A
CA_4A-29A	-	4A
CA_4A-30A	-	4A-30A

CA Configuration	ULCA	4 × 4 DL MIMO
CA_4A-46A	-	4A
CA_4A-48A	-	4A-48A
CA_4A-4A	-	4A-4A
CA_4A-5A	4A-5A	4A
CA_4A-17A	-	4A
CA_4A-71A	-	4A
CA_4A-7A	-	4A-7A
CA_5A-12A	-	-
CA_5A-25A	-	25A
CA_5A-30A	-	30A
CA_5A-38A	-	38A
CA_5A-40A	-	40A
CA_5A-41A	-	41A
CA_5A-46A	-	-
CA_5A-48A	-	48A
CA_5A-5A	-	-
CA_5A-66A	5A-66A	66A
CA_5A-7A	5A-7A	7A
CA_5B	-	-
CA_66A-66A	-	66A-66A
CA_66A-71A	-	66A
CA_66B	-	66B
CA_66C	-	66C
CA_7A-12A	-	7A
CA_7A-20A	7A-20A	7A
CA_7A-28A	7A-28A	7A
CA_7A-32A	-	7A
CA_7A-42A	-	7A-42A
CA_7A-46A	-	7A
CA_7A-66A	-	7A-66A
CA_7A-7A	-	7A-7A
CA_7A-8A	7A-8A	7A
CA_7B	-	7B
CA_7C	7C	7C
CA_8A-20A	-	.
CA_8A-32A	-	32A
CA_8A-38A	-	38A
CA_8A-39A	-	39A
CA_8A-40A	-	40A
CA_8A-41A	-	41A
CA_8A-42A	-	42A
CA_8A-46A	-	-
CA_8B	-	-
CA_7A-29A	-	7A

Table 9-5 LTE 3CA

CA Configuration	ULCA	4 × 4 DL MIMO
CA_12A-30A-66A	-	30A-66A
CA_12A-46C	-	-
CA_12A-66A-66A	12A-66A	66A-66A
CA_12A-66C	-	66C
CA_12B-66A	-	66A
CA_13A-46A-66A	-	66A
CA_13A-46C	-	-
CA_13A-48A-48A	-	48A-48A
CA_13A-48A-66A	-	48A-66A
CA_13A-48C	-	48C
CA_13A-66A-66A	13A-66A	66A-66A
CA_13A-66B	-	66B
CA_13A-66C	-	66C
CA_14A-30A-66A	-	30A-66A
CA_14A-66A-66A	-	66A-66A
CA_18A-42C	-	42C
CA_19A-42C	-	42C
CA_1A-18A-42A	1A-18A	1A-42A
CA_1A-19A-42A	1A-19A	1A-42A
CA_1A-1A-28A	-	1A-1A
CA_1A-1A-3A	-	1A-1A-3A
CA_1A-1A-5A	-	1A-1A
CA_1A-1A-7A	-	1A-1A-7A
CA_1A-20A-32A	-	1A
CA_1A-20A-42A	-	1A-42A
CA_1A-28A-42A	-	1A-42A
CA_1A-3A-18A	1A-18A, 3A-18A	1A-3A
CA_1A-3A-19A	1A-19A, 3A-19A	1A-3A
CA_1A-3A-20A	3A-20A	1A-3A
CA_1A-3A-26A	1A-26A, 3A-26A	1A-3A
CA_1A-3A-28A	1A-28A, 3A-28A	1A-3A
CA_1A-3A-32A	-	1A-3A
CA_1A-3A-38A	-	1A-3A-38A
CA_1A-3A-3A	-	1A-3A-3A
CA_1A-3A-40A	-	1A-3A-40A
CA_1A-3A-41A	-	1A-3A-41A
CA_1A-3A-42A	-	1A-3A-42A
CA_1A-3A-46A	-	1A-3A
CA_1A-3A-5A	3A-5A, 1A-5A	1A-3A
CA_1A-3A-7A	-	1A-3A-7A
CA_1A-3A-8A	1A-8A, 3A-8A	1A-3A
CA_1A-3C	3C	1A-3C
CA_1A-40C	-	1A-40C
CA_1A-41A-42A	-	1A-41A-42A
CA_1A-41C	-	1A-41C
CA_1A-42A-42A	-	1A-42A-42A

CA Configuration	ULCA	4 × 4 DL MIMO
CA_1A-42C	-	1A-42C
CA_1A-46C	-	1A
CA_1A-5A-40A	1A-5A	1A-40A
CA_1A-5A-46A	-	1A
CA_1A-5A-7A	5A-7A, 1A-5A	1A-7A
CA_1A-7A-20A	7A-20A	1A-7A
CA_1A-7A-28A	-	1A-7A
CA_1A-7A-32A	-	1A-7A
CA_1A-7A-42A	-	1A-7A-42A
CA_1A-7A-46A	-	1A-7A
CA_1A-7A-7A	-	1A-7A-7A
CA_1A-7A-8A	-	1A-7A
CA_1A-7C	7C	1A-7C
CA_1A-8A-20A	-	1A
CA_1A-8A-38A	-	1A-38A
CA_1A-8A-40A	-	1A-40A
CA_1C-3A	-	1C-3A
CA_1C-41A	-	1C-41A
CA_1C-8A	-	1C
CA_20A-38C	-	38C
CA_20A-40C	-	40C
CA_25A-25A-25A	-	25A-25A-25A
CA_25A-25A-26A	-	25A-25A
CA_25A-25A-41A	-	25A-25A-41A
CA_25A-26A-41A	-	25A-41A
CA_25A-41C	-	25A-41C
CA_25A-46C	-	25A
CA_26A-41C	-	41C
CA_28A-40C	-	40C
CA_28A-41A-42A	-	41A-42A
CA_28A-41C	-	41C
CA_28A-42A-42A	-	42A-42A
CA_28A-42C	-	42C
CA_28A-46C	-	-
CA_29A-30A-66A	-	30A-66A
CA_29A-66A-66A	-	66A-66A
CA_2A-12A-12A	-	2A
CA_2A-12A-30A	2A-12A	2A-30A
CA_2A-12A-66A	2A-12A, 12A-66A	2A-66A
CA_2A-12B	-	2A
CA_2A-13A-46A	-	2A
CA_2A-13A-48A	-	2A-48A
CA_2A-13A-66A	13A-66A, 2A-13A	2A-66A
CA_2A-14A-30A	-	2A-30A
CA_2A-14A-66A	-	2A-66A
CA_2A-29A-30A	-	2A-30A
CA_2A-29A-66A	-	2A-66A

CA Configuration	ULCA	4 × 4 DL MIMO
CA_2A-2A-12A	2A-12A	2A-2A
CA_2A-2A-13A	2A-13A	2A-2A
CA_2A-2A-14A	-	2A-2A
CA_2A-2A-29A	-	2A-2A
CA_2A-2A-30A	-	2A-2A-30A
CA_2A-2A-46A	-	2A-2A
CA_2A-2A-4A	-	2A-2A-4A
CA_2A-2A-5A	-	2A-2A
CA_2A-2A-66A	-	2A-2A-66A
CA_2A-2A-71A	-	2A-2A
CA_2A-2A-7A	-	2A-2A-7A
CA_2A-30A-66A	-	2A-30A-66A
CA_2A-46A-46A	-	2A
CA_2A-46A-66A	-	2A-66A
CA_2A-46C	-	2A
CA_2A-48A-48A	-	2A-48A-48A
CA_2A-48A-66A	-	2A-48A-66A
CA_2A-48C	-	2A
CA_2A-4A-12A	2A-12A, 4A-12A	2A-4A
CA_2A-4A-13A	4A-13A, 2A-13A	2A-4A
CA_2A-4A-28A	-	2A-4A
CA_2A-4A-29A	-	2A-4A
CA_2A-4A-30A	-	2A-4A-30A
CA_2A-4A-4A	-	2A-4A-4A
CA_2A-4A-5A	-	2A-4A
CA_2A-4A-71A	-	2A-4A
CA_2A-4A-7A	-	2A-4A-7A
CA_2A-5A-12A	-	2A
CA_2A-5A-30A	-	2A-30A
CA_2A-5A-46A	-	2A
CA_2A-5A-48A	-	2A-48A
CA_2A-5A-66A	-	2A-66A
CA_2A-5A-7A	-	2A-7A
CA_2A-5B	-	2A
CA_2A-66A-66A	-	2A-66A-66A
CA_2A-66A-71A	-	2A-66A
CA_2A-66B	-	2A-66B
CA_2A-66C	-	2A-66C
CA_2A-7A-12A	-	2A-7A
CA_2A-7A-28A	-	2A-7A
CA_2A-7A-66A	-	2A-7A-66A
CA_2A-7A-7A	-	2A-7A-7A
CA_2A-7C	-	2A-7C
CA_2C-12A	-	2C
CA_2C-29A	-	2C
CA_2C-30A	-	2C-30A
CA_2C-5A	-	2C

CA Configuration	ULCA	4 × 4 DL MIMO
CA_2C-66A	-	2C-66A
CA_30A-66A-66A	-	30A-66A-66A
CA_39A-41C	41C	39A-41C
CA_39C-41A	-	39C-41A
CA_3A-18A-42A	3A-18A	3A-42A
CA_3A-19A-42A	3A-19A	3A-42A
CA_3A-20A-32A	3A-20A	3A-32A
CA_3A-20A-42A	-	3A-42A
CA_3A-28A-40A	-	3A-40A
CA_3A-28A-41A	-	3A-41A
CA_3A-28A-42A	-	3A-42A
CA_3A-3A-20A	-	3A-3A
CA_3A-3A-28A	-	3A-3A
CA_3A-3A-41A	-	3A-3A-41A
CA_3A-3A-46A	-	3A-3A
CA_3A-3A-5A	-	3A-3A
CA_3A-3A-7A	-	3A-3A-7A
CA_3A-3A-8A	-	3A-3A
CA_3A-40A-40A	-	3A-40A-40A
CA_3A-40C	-	3A-40C
CA_3A-41A-42A	-	3A-41A-42A
CA_3A-41C	-	3A-41C
CA_3A-42A-42A	-	3A-42A-42A
CA_3A-42C	-	3A-42C
CA_3A-46C	-	3A
CA_3A-5A-40A	3A-5A	3A-40A
CA_3A-5A-7A	5A-7A, 3A-5A	3A-7A
CA_3A-7A-20A	3A-20A, 7A-20A	3A-7A
CA_3A-7A-28A	-	3A-7A
CA_3A-7A-32A	-	3A-7A-32A
CA_3A-7A-42A	-	3A-7A-42A
CA_3A-7A-46A	-	3A-7A
CA_3A-7A-7A	-	3A-7A-7A
CA_3A-7A-8A	3A-8A	3A-7A
CA_3A-7B	-	3A-7B
CA_3A-7C	7C	3A-7C
CA_3A-8A-20A	-	3A
CA_3A-8A-32A	-	3A-32A
CA_3A-8A-38A	-	3A-38A
CA_3A-8A-40A	-	3A-40A
CA_3C-20A	3A-20A	3C
CA_3C-28A	-	3C
CA_3C-32A	-	3C
CA_3C-38A	-	3C-38A
CA_3C-40A	-	3C-40A
CA_3C-41A	-	3C-41A
CA_3C-46A	3C	3C

CA Configuration	ULCA	4 × 4 DL MIMO
CA_3C-5A	-	3C
CA_3C-7A	3C	3C-7A
CA_3C-8A	3C	3C
CA_40A-40C	-	40A-40C
CA_40A-42C	-	40A-42C
CA_40C-42A	-	40C-42A
CA_40D	-	40D
CA_41A-41A-41A	-	41A-41A
CA_41A-41C	41C	41A-41C
CA_41A-42A-42A	-	41A-42A-42A
CA_41A-42C	-	41A-42C
CA_41A-46C	-	41A
CA_41C-42A	41C	41C-42A
CA_41D	41C	41D
CA_42A-42C	-	42A-42C
CA_42D	-	42D
CA_46A-46A-66A	-	66A
CA_46A-66A-66A	-	66A-66A
CA_46A-66C	-	66C
CA_46C-66A	-	66A
CA_46C-71A	-	-
CA_48A-48A-66A	-	48A-48A-66A
CA_48A-48A-71A	-	48A-48A
CA_48A-48C	-	48A-48C
CA_48A-66A-66A	-	66A-66A
CA_48A-66B	-	48A-66B
CA_48A-66C	-	48A-66C
CA_48C-66A	-	48C-66A
CA_48C-71A	-	48C
CA_48D	-	48D
CA_4A-12A-12A	-	4A
CA_4A-12A-30A	4A-12A	4A-30A
CA_4A-12B	-	4A
CA_4A-29A-30A	-	4A, 30A, 4A-30A
CA_4A-46A-46A	-	4A
CA_4A-46C	-	4A
CA_4A-48C	-	4A-48C
CA_4A-4A-12A	4A-12A	4A-4A
CA_4A-4A-13A	4A-13A	4A-4A
CA_4A-4A-29A	-	4A-4A
CA_4A-4A-30A	-	4A-30A
CA_4A-4A-5A	-	4A-4A
CA_4A-4A-71A	-	4A-4A
CA_4A-4A-7A	-	4A-4A-7A
CA_4A-5A-12A	-	4A
CA_4A-5A-30A	-	4A-30A
CA_4A-5B	-	4A

CA Configuration	ULCA	4 × 4 DL MIMO
CA_4A-7A-12A	-	4A-7A
CA_4A-7A-28A	-	4A-7A
CA_4A-7A-7A	-	4A-7A-7A
CA_4A-7C	7C	4A-7C
CA_5A-12A-66A	-	-
CA_5A-12B	-	-
CA_5A-30A-66A	-	30A-66A
CA_5A-40A-40A	-	40A-40A
CA_5A-40C	-	40C
CA_5A-46A-66A	-	66A
CA_5A-46C	-	-
CA_5A-48A-48A	-	48A-48A
CA_5A-48C	-	48C
CA_5A-5A-66A	-	66A
CA_5A-66A-66A	-	66A-66A
CA_5A-66B	-	66B
CA_5A-66C	-	66C
CA_5A-7A-46A	-	7A
CA_5A-7A-7A	5A-7A	7A-7A
CA_5A-7C	-	7C
CA_5B-30A	-	30A
CA_5B-46A	-	-
CA_5B-66A	-	66A
CA_66A-66A-66A	-	66A-66A-66A
CA_66A-66A-71A	-	66A-66A
CA_66A-66B	-	66A-66B
CA_66A-66C	-	66A-66C
CA_66C-71A	-	66C
CA_66D	-	66D
CA_7A-12A-66A	-	7A-66A
CA_7A-12B	-	7A
CA_7A-20A-32A	7A-20A	7A
CA_7A-20A-42A	-	7A-42A
CA_7A-46C	-	7A
CA_7A-66A-66A	-	7A-66A-66A
CA_7A-7A-46A	-	7A-7A
CA_7A-7A-8A	-	7A-7A
CA_7A-8A-20A	-	7A
CA_7B-28A	-	7B
CA_7C-20A	-	7C
CA_7C-28A	7C	7C
CA_7C-46A	-	7C
CA_7C-66A	7C	7C-66A
CA_8A-39C	-	39C
CA_8A-40C	-	40C
CA_8A-41C	-	41C
CA_8A-42C	-	42C

CA Configuration	ULCA	4 × 4 DL MIMO
CA_8A-46C	-	-
CA_8B-39A	-	39A
CA_8B-41A	-	41A
CA_7A-7A-28A	-	7A-7A
CA_3A-5A-41A	-	3A-41A
CA_7A-7A-13A	-	7A-7A
CA_7A-7A-29A	7A	7A-7A
CA_7A-29A-66A	7A, 66A	7A-66A
CA_7C-29A	7C	7C
CA_7A-46A-66A	7A, 66A	7A-66A

Table 9-6 LTE 4CA

CA Configuration	ULCA	4 × 4 DL MIMO
CA_12A-30A-66A-66A	-	30A-66A-66A
CA_12A-46D	-	-
CA_12B-66A-66A	-	66A-66A
CA_13A-46C-66A	-	66A
CA_13A-46D	-	-
CA_13A-48A-48A-66A	-	48A-48A-66A
CA_13A-48A-48C	-	48A-48C
CA_13A-48A-66B	-	48A-66B
CA_13A-48A-66C	-	48A-66C
CA_13A-48C-66A	-	48C-66A
CA_13A-48D	-	48D
CA_13A-66A-66A-66A	-	66A-66A-66A
CA_13A-66A-66B	-	66A-66B
CA_13A-66A-66C	-	66A-66C
CA_13A-66D	-	66D
CA_14A-30A-66A-66A	-	30A-66A-66A
CA_14A-66A-66A-66A	-	66A-66A
CA_1A-18A-42C	-	1A-42C
CA_1A-19A-42C	1A-19A	1A-42C
CA_1A-1A-3A-28A	-	1A-1A-3A
CA_1A-1A-3A-5A	-	1A-1A-3A
CA_1A-1A-3A-7A	-	1A-1A, 1A-3A, 1A-7A, 3A-7A
CA_1A-1A-3C	3C	1A-1A, 1A-3C
CA_1A-28A-42C	-	42C
CA_1A-3A-18A-42A	1A-18A, 3A-18A	1A-3A-42A
CA_1A-3A-19A-42A	1A-19A, 3A-19A	1A-3A-42A
CA_1A-3A-20A-32A	-	1A-3A
CA_1A-3A-28A-42A	-	1A-3A-42A
CA_1A-3A-3A-20A	-	1A-3A-3A
CA_1A-3A-3A-28A	-	1A-3A-3A
CA_1A-3A-3A-7A	-	1A-3A-3A-7A
CA_1A-3A-3A-8A	-	1A-3A-3A

CA Configuration	ULCA	4 × 4 DL MIMO
CA_1A-3A-40C	-	1A-3A-40C
CA_1A-3A-41A-42A	-	1A-3A-41A-42A
CA_1A-3A-41C	-	1A-3A-41C
CA_1A-3A-42C	-	1A-3A-42C
CA_1A-3A-46C	-	1A-3A
CA_1A-3A-5A-40A	-	1A-3A-40A
CA_1A-3A-5A-7A	1A-5A, 3A-5A, 5A-7A	1A-3A-7A
CA_1A-3A-7A-20A	3A-20A, 7A-20A	1A-3A-7A
CA_1A-3A-7A-28A	-	1A-3A-7A
CA_1A-3A-7A-32A	-	1A, 3A
CA_1A-3A-7A-7A	-	1A-3A-7A, 3A-7A-7A
CA_1A-3A-7A-8A	1A-8A, 3A-8A	1A-3A-7A
CA_1A-3A-7C	7C	1A-3A-7C
CA_1A-3A-8A-20A	-	1A-3A
CA_1A-3A-8A-38A	-	1A-3A, 1A-38A, 3A-38A
CA_1A-3A-8A-40A	1A-8A, 3A-8A	1A-3A-40A
CA_1A-3C-20A	-	1A-3C
CA_1A-3C-28A	-	1A-3C
CA_1A-3C-38A	-	1A-3C
CA_1A-3C-5A	-	1A-3C
CA_1A-3C-7A	-	1A-3C-7A
CA_1A-3C-8A	3C, 1A-8A, 3A-8A	1A-3C
CA_1A-41A-42C	-	1A-41A-42C
CA_1A-41C-42A	-	1A-41C-42A
CA_1A-42D	-	1A-42D
CA_1A-46D	-	1A
CA_1A-5A-46C	-	1A
CA_1A-5A-7A-7A	-	1A-7A-7A
CA_1A-7A-20A-32A	-	1A-7A
CA_1A-7A-46C	-	1A-7A
CA_1A-7A-7A-8A	-	1A-7A-7A
CA_1A-7A-8A-20A	-	1A-7A
CA_1A-7C-20A	-	1A-7C
CA_1A-7C-28A	-	1A-7C
CA_1A-8A-40C	-	1A-40C
CA_25A-25A-41C	-	25A-25A-41C
CA_25A-26A-41C	-	25A-41C
CA_25A-41D	-	25A-41D
CA_25A-46D	-	25A
CA_28A-40D	-	40D
CA_28A-41A-42C	-	41A-42C
CA_28A-41C-42A	-	41C-42A
CA_28A-42A-42C	-	42A-42C
CA_28A-46D	-	-
CA_29A-30A-66A-66A	-	30A-66A-66A
CA_2A-12A-30A-66A	-	2A-30A-66A

CA Configuration	ULCA	4 × 4 DL MIMO
CA_2A-12A-66A-66A	-	2A-66A-66A
CA_2A-12A-66C	-	2A-66C
CA_2A-12B-66A	-	2A-66A
CA_2A-13A-46C	-	2A
CA_2A-13A-48A-48A	-	2A-48A-48A
CA_2A-13A-48A-66A	-	2A-48A-66A
CA_2A-13A-48C	-	2A-48C
CA_2A-13A-66A-66A	-	2A-66A-66A
CA_2A-13A-66B	-	2A-66B
CA_2A-13A-66C	-	2A-66C
CA_2A-14A-30A-66A	-	2A-30A-66A
CA_2A-14A-66A-66A	-	2A-66A-66A
CA_2A-29A-30A-66A	-	2A-30A-66A
CA_2A-2A-12A-12A	-	2A-2A
CA_2A-2A-12A-30A	2A-12A	2A-2A-30A
CA_2A-2A-12A-66A	-	2A-2A-66A
CA_2A-2A-12B	-	2A-2A
CA_2A-2A-13A-66A	-	2A-2A-66A
CA_2A-2A-14A-30A	-	2A-2A-30A
CA_2A-2A-14A-66A	-	2A-2A-66A
CA_2A-2A-29A-30A	-	2A-2A-30A
CA_2A-2A-30A-66A	-	2A-2A-30A-66A
CA_2A-2A-46C	-	2A-2A
CA_2A-2A-4A-12A	2A-12A, 4A-12A	2A-2A-4A
CA_2A-2A-4A-13A	4A-13A, 2A-13A	2A-2A-4A
CA_2A-2A-4A-4A	-	2A-2A-4A-4A
CA_2A-2A-4A-5A	-	2A-2A-4A
CA_2A-2A-4A-71A	-	2A-2A-4A
CA_2A-2A-5A-12A	-	-
CA_2A-2A-5A-30A	-	2A-2A-30A
CA_2A-2A-5A-66A	-	2A-2A-66A
CA_2A-2A-5B	-	2A-2A
CA_2A-2A-66A-66A	-	2A-2A-66A, 2A-66A-66A
CA_2A-2A-66A-71A	-	2A-2A-66A
CA_2A-2A-66B	-	2A-2A-66B
CA_2A-2A-66C	-	2A-2A-66C
CA_2A-2A-7A-66A	-	2A-2A-7A, 2A-2A-66A, 2A-7A-66A
CA_2A-30A-66A-66A	-	2A-30A-66A-66A
CA_2A-46A-46A-66A	-	2A-66A
CA_2A-46A-46C	-	2A
CA_2A-46C-66A	-	2A-66A
CA_2A-46D	-	2A
CA_2A-48A-48A-66A	-	2A-48A-48A-66A
CA_2A-48A-48C	-	2A-48A-48C
CA_2A-48C-66A	-	2A-48C-66A
CA_2A-48D	-	2A

CA Configuration	ULCA	4 × 4 DL MIMO
CA_2A-4A-12A-12A	-	2A-4A
CA_2A-4A-12A-30A	2A-12A, 4A-12A	2A-4A-30A
CA_2A-4A-12B	-	2A-4A
CA_2A-4A-29A-30A	-	2A-4A-30A
CA_2A-4A-4A-12A	2A-12A, 4A-12A	2A-4A-4A
CA_2A-4A-4A-5A	-	2A-4A-4A
CA_2A-4A-5A-12A	2A-12A, 4A-12A	2A-4A
CA_2A-4A-5A-30A	-	2A-4A-30A
CA_2A-4A-5B	-	2A-4A
CA_2A-4A-7A-12A	-	2A-4A-7A
CA_2A-4A-7A-7A	-	2A-4A-7A, 2A-7A-7A, 4A-7A-7A
CA_2A-4A-7C	-	2A-4A-7C
CA_2A-5A-12A-66A	-	-
CA_2A-5A-12B	-	2A
CA_2A-5A-30A-66A	-	2A-30A-66A
CA_2A-5A-46C	-	2A
CA_2A-5A-48A-48A	-	2A-48A-48A
CA_2A-5A-48A-66A	-	2A-48A-66A
CA_2A-5A-48C	-	2A-48C
CA_2A-5A-66A-66A	-	2A-66A-66A
CA_2A-5A-66B	-	2A-66B
CA_2A-5A-66C	-	2A-66C
CA_2A-5B-30A	-	2A-30A
CA_2A-5B-66A	-	2A-66A
CA_2A-66A-66A-66A	-	2A-66A-66A, 66A-66A-66A
CA_2A-66A-66A-71A	-	2A-66A-66A
CA_2A-66A-66B	-	2A-66A-66B
CA_2A-66A-66C	-	2A-66A-66C
CA_2A-66C-71A	-	2A-66C
CA_2A-66D	-	2A-66D
CA_2A-7A-12A-66A	-	2A-7A-66A
CA_2A-7A-12B	-	2A-7A
CA_2A-7A-46A-66A	-	2A-7A-66A
CA_2A-7A-46C	-	2A-7A
CA_2A-7A-66A-66A	-	2A-7A-66A, 2A-66A-66A, 7A-66A-66A
CA_2C-12A-30A	-	2C-30A
CA_2C-29A-30A	-	2C-30A
CA_2C-5A-30A	-	2C-30A
CA_2C-66A-66A	-	2C-66A-66A
CA_39A-41D	-	41D
CA_39C-41C	41C	41C
CA_3A-18A-42C	3A-18A	3A-42C
CA_3A-19A-42C	3A-19A	3A-42C
CA_3A-28A-40C	-	3A-40C
CA_3A-28A-41A-42A	-	3A-41A-42A
CA_3A-28A-41C	-	3A-41C

CA Configuration	ULCA	4 × 4 DL MIMO
CA_3A-28A-42C	-	3A-42C
CA_3A-3A-7A-20A	-	3A-3A-7A
CA_3A-3A-7A-28A	-	3A-3A-7A
CA_3A-3A-7A-7A	-	3A-3A-7A-7A
CA_3A-3A-7A-8A	-	3A-3A-7A
CA_3A-3A-7C	-	3A-3A-7C
CA_3A-40D	-	3A-40D
CA_3A-41A-42C	-	3A-41A-42C
CA_3A-41C-42A	-	3A-41C-42A
CA_3A-41D	-	3A-41D
CA_3A-42A-42C	-	3A-42A-42C
CA_3A-42D	-	3A-42D
CA_3A-46D	-	3A
CA_3A-5A-7A-7A	-	3A-7A-7A
CA_3A-7A-20A-32A	3A-20A, 7A-20A	3A-7A-32A
CA_3A-7A-46C	-	3A-7A
CA_3A-7A-7A-8A	-	3A-7A-7A
CA_3A-7A-8A-20A	-	3A-7A
CA_3A-7C-20A	-	3A-7C
CA_3A-7C-28A	7C	3A-7C
CA_3A-8A-40C	-	3A
CA_3C-40C	-	3C-40C
CA_3C-41C	-	3C-41C
CA_3C-46C	-	3C
CA_3C-7A-20A	3C, 7A-20A	3C-7A
CA_3C-7A-28A	-	3C-7A
CA_3C-7A-32A	-	3C-7A
CA_3C-7A-8A	-	3C-7A
CA_3C-7C	3C, 7C	3C-7C
CA_3C-8A-38A	-	3C-38A
CA_40C-40C	-	40C-40C
CA_40C-42C	-	40C-42C
CA_40E	-	40E
CA_41A-41A-41C	-	41A-41C
CA_41A-41D	-	41A-41D
CA_41A-42D	-	41A-42D
CA_41A-46D	-	41A
CA_41C-41C	41C	41C-41C
CA_41C-42C	41C	41C-42C
CA_41D-42A	-	41D-42A
CA_41E	41C	41E
CA_42A-42D	-	42A-42D
CA_42C-42C	-	42C-42C
CA_42E	-	42E
CA_46A-46C-66A	-	66A
CA_46A-66A-66A-66A	-	66A-66A-66A

CA Configuration	ULCA	4 × 4 DL MIMO
CA_46C-66A-66A	-	66A
CA_46D-66A	-	66A
CA_48A-48A-66A-66A	-	48A-48A-66A, 48A-66A-66A
CA_48A-48A-66B	-	48A-48A-66B
CA_48A-48A-66C	-	48A-48A-66C
CA_48A-48C-66A	-	48A-48C-66A
CA_48A-48D	-	48A-48D
CA_48A-66A-66A-66A	-	48A-66A-66A, 66A-66A-66A
CA_48C-48C	-	48C-48C
CA_48C-66A-66A	-	48C-66A-66A
CA_48C-66B	-	48C-66B
CA_48C-66C	-	48C-66C
CA_48D-66A	-	48D-66A
CA_48E	-	48E
CA_4A-13A-48C	-	-
CA_4A-46A-46C	-	4A
CA_4A-46D	-	4A
CA_4A-48A-48C	-	-
CA_4A-48D	-	4A-48D
CA_4A-4A-12A-12A	-	4A-4A
CA_4A-4A-12A-30A	4A-12A	4A-4A-30A
CA_4A-4A-12B	-	4A-4A
CA_4A-4A-29A-30A	-	4A-4A-30A
CA_4A-4A-5A-12A	-	4A-4A
CA_4A-4A-5A-30A	-	4A-4A-30A
CA_4A-4A-5B	-	4A-4A
CA_4A-5B-30A	-	4A-30A
CA_5A-30A-66A-66A	-	30A-66A-66A
CA_5A-46C-66A	-	66A
CA_5A-46D	-	-
CA_5A-48A-48A-66A	-	48A-48A-66A
CA_5A-48D	-	48D
CA_5A-5A-66A-66A	-	66A-66A
CA_5A-5A-66B	-	66B
CA_5A-5A-66C	-	66C
CA_5A-66A-66B	-	66A-66B
CA_5A-66A-66C	-	66A-66C
CA_5A-66D	-	66D
CA_5A-7A-46C	-	7A
CA_5B-30A-66A	-	30A-66A
CA_5B-66A-66A	-	66A-66A
CA_5B-66B	-	66B
CA_5B-66C	-	66C
CA_7A-12B-66A	-	7A-66A
CA_7A-46D	-	7A
CA_7A-7A-46C	-	7A-7A

CA Configuration	ULCA	4 × 4 DL MIMO
CA_7C-46C	-	7C
CA_7C-66A-66A	7C	7C-66A-66A
CA_8A-41D	-	41D
CA_8A-46D	-	-
CA_1A-7A-7A-28A	-	1A-7A-7A
CA_3A-7A-7A-28A	-	3A-7A-7A
CA_4A-5A-12B	-	4A
CA_1A-28A-40C	-	1A-40C
CA_2A-7C-66A	-	2A-7C-66A
CA_2A-48A-66A-66A	-	2A-48A-66A-66A
CA_3A-5A-40A-40A	-	3A-40A-40A
CA_7A-7A-66A-66A	-	7A-7A-66A-66A
CA_2A-2A-7A-12A	-	2A-2A-7A
CA_2A-7A-29A-66A	-	2A-7A-66A
CA_7A-7A-29A-66A	-	7A-7A-66A
CA_7C-29A-66A	-	7C-66A
CA_2A-7A-7A-13A	-	2A-7A-7A

Table 9-7 LTE 5-7CA

CA Configuration	ULCA	4 × 4 DL MIMO
CA_12A-46E	-	-
CA_13A-46D-66A	-	66A
CA_13A-46E	-	-
CA_13A-48A-48D	-	48A-48D
CA_13A-48C-48C	-	48C-48C
CA_13A-48E	-	-
CA_1A-1A-3C-7A	-	1A-1A, 1A-3C, 1A-7A, 3C-7A
CA_1A-3A-18A-42C	1A-18A, 3A-18A	1A-3A-42C
CA_1A-3A-19A-42C	1A-19A, 3A-19A	1A-3A-42C
CA_1A-3A-28A-42C	-	1A-3A-42C
CA_1A-3A-3A-42C	-	3A-3A-42C
CA_1A-3A-3A-7A-7A	-	1A-3A, 1A-7A, 3A-3A, 3A-7A, 7A-7A
CA_1A-3A-41A-42C	-	1A-3A-41A-42C
CA_1A-3A-41C-42A	-	1A-3A-41C-42A
CA_1A-3A-42D	42C	1A-3A-42D
CA_1A-3A-46D	-	1A-3A
CA_1A-3A-5A-7A-7A	1A-5A, 3A-5A, 5A-7A	1A-3A-7A-7A
CA_1A-3A-7A-20A-32A	-	1A-3A, 1A-7A, 3A-7A
CA_1A-3A-7A-20A-42A	-	1A-3A, 1A-7A, 1A-42A, 3A-7A, 3A-42A, 7A-42A
CA_1A-3A-7A-8A-20A	-	1A, 3A, 7A
CA_1A-3A-7C-28A	-	1A-3A-7C
CA_1A-3C-40C	-	1A-3C-40C
CA_1A-3C-7A-20A	-	1A-3C-7A
CA_1A-3C-7A-8A	-	1A-3C-7A
CA_1A-3C-7C	3C, 7C	1A-3C-7C

CA Configuration	ULCA	4 × 4 DL MIMO
CA_1A-41C-42C	-	1A-41C-42C
CA_1A-42C-42C	-	1A-42C
CA_1A-42E	-	42E
CA_1A-46E	-	1A
CA_1A-5A-46D	-	1A
CA_1A-7A-46D	-	1A-7A
CA_25A-25A-41D	-	25A-25A-41D
CA_28A-41A-42A-42C	-	41A-42A-42C
CA_28A-41C-42C	-	41C-42C
CA_28A-42C-42C	-	42C-42C
CA_28A-46E	-	-
CA_2A-12A-30A-66A-66A	2A-12A	2A-30A-66A-66A
CA_2A-12B-66A-66A	-	2A-66A-66A
CA_2A-13A-46D	-	2A
CA_2A-13A-48A-48A-66A	-	2A-48A-48A-66A
CA_2A-13A-48A-48C	-	2A-48A-48C
CA_2A-13A-48C-66A	-	2A-48C-66A
CA_2A-13A-48D	-	2A-48D
CA_2A-13A-66A-66B	-	2A-66A-66B
CA_2A-13A-66A-66C	-	2A-66A-66C
CA_2A-13A-66D	-	2A-66D
CA_2A-14A-30A-66A-66A	-	2A-30A-66A-66A
CA_2A-14A-66A-66A-66A	-	2A-66A-66A-66A
CA_2A-2A-12A-30A-66A	2A-12A	2A-2A-30A-66A
CA_2A-2A-12A-66A-66A	2A-12A	2A-2A-66A-66A
CA_2A-2A-12B-66A	-	2A-2A-66A
CA_2A-2A-14A-30A-66A	-	2A-2A-30A-66A
CA_2A-2A-14A-66A-66A	-	2A-2A-66A-66A
CA_2A-2A-46D	-	2A-2A
CA_2A-2A-5A-12A-66A	-	2A-2A, 2A-66A
CA_2A-2A-5A-30A-66A	-	2A-2A-30A-66A
CA_2A-2A-5A-66A-66A	-	2A-2A, 2A-66A, 66A-66A
CA_2A-2A-5A-66B	-	2A-2A-66B
CA_2A-2A-5A-66C	-	2A-2A-66C
CA_2A-2A-66A-66B	-	2A-2A-66A-66B
CA_2A-2A-66A-66C	-	2A-2A-66A-66C
CA_2A-2A-7A-12A-66A	-	2A-2A, 2A-7A, 2A-66A, 7A-66A
CA_2A-46A-46C-66A	-	2A-66A
CA_2A-46A-46D	-	2A
CA_2A-46D-66A	-	-
CA_2A-46E	-	2A
CA_2A-48A-48C-66A	-	2A-48A-48C-66A
CA_2A-48A-48D	-	2A-48A-48D
CA_2A-48C-48C	-	2A-48C-48C
CA_2A-48D-66A	-	2A-66A-48D
CA_2A-48E	-	2A-48E
CA_2A-4A-5B-30A	-	2A-4A-30A

CA Configuration	ULCA	4 × 4 DL MIMO
CA_2A-5A-30A-66A-66A	-	2A-30A-66A-66A
CA_2A-5A-46D	-	2A
CA_2A-5B-30A-66A	-	2A-30A-66A
CA_2A-5B-66A-66A	-	2A-66A-66A
CA_2A-5B-66B	-	2A-66B
CA_2A-5B-66C	-	2A-66C
CA_2A-7A-12B-66A	-	2A-7A-66A
CA_2C-5B-30A	-	2C-30A
CA_39C-41D	-	41D
CA_3A-28A-40D	-	3A-40D
CA_3A-28A-41A-42C	42C	3A-41A-42C
CA_3A-28A-41C-42A	-	3A-41C-42A
CA_3A-28A-42A-42C	-	42A-42C
CA_3A-3A-42D	-	3A-3A-42D
CA_3A-3A-7A-7A-8A	-	3A-3A-7A-7A
CA_3A-40E	-	3A-40E
CA_3A-41A-42A-42C	-	41A-42A-42C
CA_3A-41C-42C	-	3A-41C-42C
CA_3A-42C-42C	-	3A-42C-42C
CA_3A-42E	-	3A-42E
CA_3A-46E	-	3A
CA_3A-7A-46D	-	3A-7A
CA_3C-46D	-	3C
CA_3C-7C-20A	-	3C-7C
CA_3C-7C-28A	-	3C-7C
CA_41A-42C-42C	-	41A-42C-42C
CA_41A-46E	-	41A
CA_41C-41D	41C	41C-41D
CA_41D-42C	-	41D, 42C
CA_46A-46D-66A	-	66A
CA_46D-66A-66A	-	66A-66A
CA_46E-66A	-	66A
CA_48A-48C-66B	-	48A-48C-66B
CA_48A-48C-66C	-	48A-48C-66C
CA_48A-48D-66A	-	48A-48D-66A
CA_48C-48C-66A	-	48C-48C-66A
CA_48C-48D	-	48C-48D
CA_48E-66A	-	48E-66A
CA_48F	-	48F
CA_4A-46A-46D	-	4A
CA_4A-46C-46C	-	-
CA_4A-48E	-	4A-48E
CA_4A-4A-5B-30A	-	4A-4A-30A
CA_5A-46D-66A	-	66A
CA_5A-46E	-	-
CA_5A-48A-48D	-	48A-48D
CA_5A-48D-66A	-	48D-66A

CA Configuration	ULCA	4 × 4 DL MIMO
CA_5A-7A-46D	-	7A
CA_5B-30A-66A-66A	-	30A-66A-66A
CA_5B-66A-66B	-	66A-66B
CA_5B-66A-66C	-	66A-66C
CA_7A-46E	-	7A
CA_7A-7A-46D	-	7A-7A
CA_7C-46D	-	7C
CA_1A-3A-3A-7A-28A	-	1A-3A-3A-7A
CA_1A-3A-3A-7C	-	1A-3A-3A-7C
CA_1A-3A-7A-7A-28A	-	1A-3A-7A-7A
CA_1A-3A-7C-20A	-	1A-3A-7C
CA_1A-3A-3A-7A-8A	-	1A-3A-3A-7A
CA_1A-3A-7A-7A-8A	-	1A-3A-7A-7A
CA_2A-7C-66A-66A	-	2A-7C-66A-66A
CA_2A-7A-7A-29A-66A	-	2A-7A-7A-66A
CA_2A-7C-29A-66A	-	2A-7C-66A
CA_1A-3A-28A-40C	-	1A-3A-40C
CA_2A-7A-7A-66A-66A	-	2A-7A-7A-66A-66A
CA_1A-3A-41C-42C	-	41C-42C, 1A-3A-41C, 1A-3A-42C
CA_1A-3C-7C-28A	-	1A-3C, 1A-7C, 3C-7C
CA_28A-41A-42C-42C	-	41A-42C, 42C-42C
CA_2A-46E-66A	-	2A-66A
CA_2A-7A-46E	-	2A-7A
CA_2A-7A-7A-46D	-	2A-7A-7A
CA_2A-7A-7A-46E	-	2A-7A-7A
CA_3A-28A-41C-42C	-	3A-41C, 3A-42C, 41C-42C
CA_3A-28A-42C-42C	-	3A-42C, 42C-42C
CA_3A-7A-32A-46D	-	3A-7A, 3A-32A, 7A-32A
CA_3A-7A-46E	-	3A-7A
CA_7A-7A-46E	-	7A-7A
CA_1A-3A-46E	-	1A-3A
CA_1A-7A-46E	-	1A-7A
CA_1A-3A-3A-7A-7A-8A	-	3A-3A-7A-7A
CA_13A-48E-66A	-	66A
CA_2A-5A-46E-66A	-	2A-66A
CA_2A-5A-46D-66A-66A	-	2A-66A-66A
CA_2A-13A-46D-66A-66A	-	2A-66A-66A
CA_5A-46E-66A-66A	-	66A-66A

Table 9-8 5G NR Sub-6G EN-DC

Sub-Category	EN-DC Combination	LTE 4x4 DL MIMO		5G-NR 4x4 DL MIMO (EM919X)	EN-DC UL (EM919X)	
		EM9190	EM9191		LTE	NR
1DL+FR1	DC_2A_n12A	2A	2A	-	2A	n12A
1DL+FR1	DC_66A_n12A	66A	66A	-	66A	n12A
1DL+FR1	DC_20A_n1A	-	-	n1A	20A	n1A
1DL+FR1	DC_8A_n1A	-	-	n1A	8A	n1A

Sub-Category	EN-DC Combination	LTE 4x4 DL MIMO		5G-NR 4x4 DL MIMO (EM919X)	EN-DC UL (EM919X)	
		EM9190	EM9191		LTE	NR
1DL+FR1	DC_3A_n20A	3A	3A	-	3A	n20A
1DL+FR1	DC_1A_n20A	1A	1A	-	1A	n20A
1DL+FR1	DC_7A_n20A	7A	7A	-	7A	n20A
1DL+FR1	DC_12A_n25A	-	-	n25A	12A	n25A
1DL+FR1	DC_1A_n28A	1A	1A	-	1A	n28A
1DL+FR1	DC_3A_n28A	3A	3A	-	3A	n28A
1DL+FR1	DC_7A_n28A	7A	7A	-	7A	n28A
1DL+FR1	DC_12A_n2A	-	-	n2A	12A	n2A
1DL+FR1	DC_5A_n2A	-	-	n2A	5A	n2A
1DL+FR1	DC_20A_n38A	-	-	n38A	20A	n38A
1DL+FR1	DC_12A_n38A	-	-	n38A	12A	n38A
1DL+FR1	DC_5A_n38A	-	-	n38A	5A	n38A
1DL+FR1	DC_71A_n38A	-	-	n38A	71A	n38A
1DL+FR1	DC_20A_n3A	-	-	n3A	20A	n3A
1DL+FR1	DC_8A_n3A	-	-	n3A	8A	n3A
1DL+FR1	DC_28A_n3A	-	-	n3A	28A	n3A
1DL+FR1	DC_8A_n40A	-	-	n40A	8A	n40A
1DL+FR1	DC_28A_n40A	-	-	n40A	28A	n40A
1DL+FR1	DC_25A_n41A	-	-	n41A	25A	n41A
1DL+FR1	DC_26A_n41A	-	-	n41A	26A	n41A
1DL+FR1	DC_3A_n41A	-	-	n41A	3A	n41A
1DL+FR1	DC_8A_n41A	-	-	n41A	8A	n41A
1DL+FR1	DC_2A_n41A	-	-	n41A	2A	n41A
1DL+FR1	DC_66A_n41A	-	-	-	66A	n41A
1DL+FR1	DC_4A_n41A	-	-	-	4A	n41A
1DL+FR1	DC_2A_n5A	2A	2A	-	2A	n5A
1DL+FR1	DC_30A_n5A	30A	30A	-	30A	n5A
1DL+FR1	DC_66A_n5A	66A	66A	-	66A	n5A
1DL+FR1	DC_1A_n5A	1A	1A	-	1A	n5A
1DL+FR1	DC_3A_n5A	3A	3A	-	3A	n5A
1DL+FR1	DC_7A_n5A	7A	7A	-	7A	n5A
1DL+FR1	DC_5A_n66A	-	-	n66A	5A	n66A
1DL+FR1	DC_12A_n66A	-	-	n66A	12A	n66A
1DL+FR1	DC_13A_n66A	-	-	n66A	13A	n66A
1DL+FR1	DC_71A_n66A	-	-	n66A	71A	n66A
1DL+FR1	DC_48A_n66A	48A	48A	n66A	48A	n66A
1DL+FR1	DC_14A_n66A	-	-	n66A	14A	n66A
1DL+FR1	DC_2A_n71A	2A	2A	-	2A	n71A
1DL+FR1	DC_66A_n71A	66A	66A	-	66A	n71A
1DL+FR1	DC_7A_n71A	7A	7A	-	7A	n71A
1DL+FR1	DC_1A_n77A	1A	1A	n77A	1A	n77A
1DL+FR1	DC_3A_n77A	3A	3A	n77A	3A	n77A
1DL+FR1	DC_28A_n77A	-	-	n77A	28A	n77A
1DL+FR1	DC_8A_n77A	-	-	n77A	8A	n77A
1DL+FR1	DC_18A_n77A	-	-	n77A	18A	n77A
1DL+FR1	DC_1A_n78A	1A	1A	n78A	1A	n78A

Sub-Category	EN-DC Combination	LTE 4x4 DL MIMO		5G-NR 4x4 DL MIMO (EM919X)	EN-DC UL (EM919X)	
		EM9190	EM9191		LTE	NR
1DL+FR1	DC_3A_n78A	3A	3A	n78A	3A	n78A
1DL+FR1	DC_7A_n78A	7A	7A	n78A	7A	n78A
1DL+FR1	DC_8A_n78A	-	-	n78A	8A	n78A
1DL+FR1	DC_20A_n78A	-	-	n78A	20A	n78A
1DL+FR1	DC_28A_n78A	-	-	n78A	28A	n78A
1DL+FR1	DC_38A_n78A	38A	38A	n78A	38A	n78A
1DL+FR1	DC_19A_n78A	-	-	n78A	19A	n78A
1DL+FR1	DC_5A_n78A	-	-	n78A	5A	n78A
1DL+FR1	DC_18A_n78A	-	-	n78A	18A	n78A
1DL+FR1	DC_40A_n78A	40A	40A	n78A	40A	n78A
1DL+FR1	DC_66A_n78A	66A	66A	n78A	66A	n78A
1DL+FR1	DC_2A_n78A	2A	2A	n78A	2A	n78A
1DL+FR1	DC_12A_n78A	-	-	n78A	12A	n78A
1DL+FR1	DC_1A_n79A	1A	1A	n79A	1A	n79A
1DL+FR1	DC_3A_n79A	3A	3A	n79A	3A	n79A
1DL+FR1	DC_19A_n79A	-	-	n79A	19A	n79A
1DL+FR1	DC_39A_n79A	39A	39A	n79A	39A	n79A
1DL+FR1	DC_41A_n79A	41A	41A	n79A	41A	n79A
1DL+FR1	DC_3A_n79A	3A	3A	n79A	3A	n79A
1DL+FR1	DC_5A_n7A	-	-	n7A	5A	n7A
1DL+FR1	DC_12A_n7A	-	-	n7A	12A	n7A
1DL+FR1	DC_20A_n7A	-	-	n7A	20A	n7A
1DL+FR1	DC_28A_n7A	-	-	n7A	28A	n7A
1DL+FR1	DC_1A_n8A	1A	1A	-	1A	n8A
1DL+FR1	DC_3A_n8A	3A	3A	-	3A	n8A
1DL+FR1	DC_7A_n8A	7A	7A	-	7A	n8A
2DL+FR1	DC_2A-66A_n12A	2A-66A	2A-66A	-	2A, 66A	n12A
2DL+FR1	DC_3A-20A_n1A	3A	3A	n1A	20A	n1A
2DL+FR1	DC_12A-66A_n25A	66A	66A	n25A	12A	n25A
2DL+FR1	DC_3C_n28A	3C	3C	-	3C	n28A
2DL+FR1	DC_1A-3A_n28A	1A-3A	1A-3A	-	1A, 3A	n28A
2DL+FR1	DC_1A-7A_n28A	1A-7A	1A-7A	-	1A, 7A	n28A
2DL+FR1	DC_3A-7A_n28A	3A-7A	3A-7A	-	3A, 7A	n28A
2DL+FR1	DC_7C_n28A	7C	7C	-	7C	n28A
2DL+FR1	DC_1A-20A_n3A	1A	1A	n3A	20A	n3A
2DL+FR1	DC_2C_n41A	-	-	n41A	-	n41A
2DL+FR1	DC_2A-66A_n41A	-	-	-	2A, 66A	n41A
2DL+FR1	DC_2A-46A_n41A	-	-	n41A	25A	n41A
2DL+FR1	DC_46A-66A_n41A	-	-	-	66A	n41A
2DL+FR1	DC_2A-2A_n41A	-	-	n41A	2A	n41A
2DL+FR1	DC_2A-4A_n41A	-	-	-	2A, 4A	n41A
2DL+FR1	DC_2A-66A_n5A	2A-66A	2A-66A	-	2A, 66A	n5A
2DL+FR1	DC_2A-2A_n5A	2A-2A	2A-2A	-	2A, 2A	n5A
2DL+FR1	DC_2A-30A_n5A	2A-30A	2A-30A	-	2A, 30A	n5A
2DL+FR1	DC_30A-66A_n5A	30A-66A	30A-66A	-	30A, 66A	n5A
2DL+FR1	DC_66A-66A_n5A	66A-66A	66A-66A	-	66A	n5A

Sub-Category	EN-DC Combination	LTE 4x4 DL MIMO		5G-NR 4x4 DL MIMO (EM919X)	EN-DC UL (EM919X)	
		EM9190	EM9191		LTE	NR
2DL+FR1	DC_1A-3A_n5A	1A-3A	1A-3A	-	1A, 3A	n5A
2DL+FR1	DC_3A-7A_n5A	3A-7A	3A-7A	-	3A, 7A	n5A
2DL+FR1	DC_7C_n5A	7C	7C	-	7C	n5A
2DL+FR1	DC_2A-48A_n5A	2A-48A	2A-48A	-	2A	n5A
2DL+FR1	DC_2A-46A_n5A	2A	2A	-	2A	n5A
2DL+FR1	DC_46A-66A_n5A	66A	66A	-	66A	n5A
2DL+FR1	DC_7A-7A_n5A	7A-7A	7A-7A	-	7A	n5A
2DL+FR1	DC_2A-7A_n5A	2A-7A	2A-7A	-	2A, 7A	n5A
2DL+FR1	DC_7A-66A_n5A	7A-66A	7A-66A	-	7A, 66A	n5A
2DL+FR1	DC_48A-66A_n5A	48A-66A	48A-66A	-	66A	n5A
2DL+FR1	DC_3C_n5A	3C	3C	-	3A	n5A
2DL+FR1	DC_1A-7A_n5A	1A-7A	1A-7A	-	1A, 7A	n5A
2DL+FR1	DC_2A-5A_n66A	2A	2A	n66A	5A	n66A
2DL+FR1	DC_2A-12A_n66A	2A	2A	n66A	12A	n66A
2DL+FR1	DC_5A-30A_n66A	30A	30A	n66A	5A	n66A
2DL+FR1	DC_5A-66A_n66A	66A	66A	n66A	5A	n66A
2DL+FR1	DC_12A-30A_n66A	30A	30A	n66A	12A	n66A
2DL+FR1	DC_12A-66A_n66A	66A	66A	n66A	12A	n66A
2DL+FR1	DC_2A-13A_n66A	2A	2A	n66A	13A	n66A
2DL+FR1	DC_13A-66A_n66A	66A	66A	n66A	13A	n66A
2DL+FR1	DC_13A-46A_n66A	-	-	-	13A	n66A
2DL+FR1	DC_66A-71A_n66A	66A	66A	n66A	71A	n66A
2DL+FR1	DC_7A-13A_n66A	7A	7A	n66A	13A	n66A
2DL+FR1	DC_13A-48A_n66A	48A	48A	n66A	13A, 48A	n66A
2DL+FR1	DC_2A-14A_n66A	2A	2A	n66A	14A	n66A
2DL+FR1	DC_5A-46A_n66A	-	-	n66A	5A	n66A
2DL+FR1	DC_5A-7A_n66A	7A	7A	n66A	5A	n66A
2DL+FR1	DC_5B_n66A	-	-	n66A	5A	n66A
2DL+FR1	DC_2A-71A_n66A	2A	2A	n66A	71A	n66A
2DL+FR1	DC_66C_n71A	66C	66C	-	66C	n71A
2DL+FR1	DC_2A-66A_n71A	2A-66A	2A-66A	-	2A, 66A	n71A
2DL+FR1	DC_2A_(n)71AA	2A	2A	-	2A	n71A
2DL+FR1	DC_66A_(n)71AA	66A	66A	-	66A	n71A
2DL+FR1	DC_2A-7A_n71A	2A-7A	2A-7A	-	2A, 7A	n71A
2DL+FR1	DC_66A-66A_n71A	66A-66A	66A-66A	-	66A	n71A
2DL+FR1	DC_2A-46A_n71A	2A	2A	-	2A	n71A
2DL+FR1	DC_46A-66A_n71A	66A	66A	-	66A	n71A
2DL+FR1	DC_2A-2A_n71A	2A-2A	2A-2A	-	2A	n71A
2DL+FR1	DC_2C_n71A	2C	2C	-		n71A
2DL+FR1	DC_7A-66A_n71A	7A-66A	7A-66A	-	7A, 66A	n71A
2DL+FR1	DC_41C_n77A	41C	41C	n77A	41C	n77A
2DL+FR1	DC_1A-3A_n77A	1A-3A	1A-3A	n77A	1A, 3A	n77A
2DL+FR1	DC_1A-28A_n77A	1A	1A	n77A	1A, 28A	n77A
2DL+FR1	DC_3A-28A_n77A	3A	3A	n77A	3A, 28A	n77A
2DL+FR1	DC_1A-8A_n77A	1A	1A	n77A	1A, 8A	n77A
2DL+FR1	DC_1A-18A_n77A	1A	1A	n77A	1A, 18A	n77A

Sub-Category	EN-DC Combination	LTE 4x4 DL MIMO		5G-NR 4x4 DL MIMO (EM919X)	EN-DC UL (EM919X)	
		EM9190	EM9191		LTE	NR
2DL+FR1	DC_1A-41A_n77A	1A-41A	1A-41A	n77A	1A, 41A	n77A
2DL+FR1	DC_3A-8A_n77A	3A	3A	n77A	3A, 8A	n77A
2DL+FR1	DC_3A-18A_n77A	3A	3A	n77A	3A, 18A	n77A
2DL+FR1	DC_3A-41A_n77A	3A-41A	3A-41A	n77A	3A	n77A
2DL+FR1	DC_1C_n78A	1C	1C	n78A	1A	n78A
2DL+FR1	DC_3C_n78A	3C	3C	n78A	3C	n78A
2DL+FR1	DC_7C_n78A	7C	7C	n78A	7C	n78A
2DL+FR1	DC_1A-3A_n78A	1A-3A	1A-3A	n78A	1A, 3A	n78A
2DL+FR1	DC_1A-7A_n78A	1A-7A	1A-7A	n78A	1A, 7A	n78A
2DL+FR1	DC_1A-8A_n78A	1A	1A	n78A	1A, 8A	n78A
2DL+FR1	DC_1A-20A_n78A	1A	1A	n78A	1A, 20A	n78A
2DL+FR1	DC_3A-3A_n78A	3A-3A	3A-3A	n78A	3A	n78A
2DL+FR1	DC_3A-7A_n78A	3A-7A	3A-7A	n78A	3A, 7A	n78A
2DL+FR1	DC_3A-8A_n78A	3A	3A	n78A	3A, 8A	n78A
2DL+FR1	DC_3A-20A_n78A	3A	3A	n78A	3A, 20A	n78A
2DL+FR1	DC_3A-28A_n78A	3A	3A	n78A	3A, 28A	n78A
2DL+FR1	DC_3A-38A_n78A	3A-38A	3A-38A	n78A	3A	n78A
2DL+FR1	DC_7A-20A_n78A	7A	7A	n78A	7A, 20A	n78A
2DL+FR1	DC_7A-28A_n78A	7A	7A	n78A	7A, 28A	n78A
2DL+FR1	DC_1A-19A_n78A	1A	1A	n78A	1A, 19A	n78A
2DL+FR1	DC_1A-28A_n78A	1A	1A	n78A	1A, 28A	n78A
2DL+FR1	DC_3A-19A_n78A	3A	3A	n78A	3A, 19A	n78A
2DL+FR1	DC_3A-28A_n78A	3A	3A	n78A	3A, 28A	n78A
2DL+FR1	DC_3A-41A_n78A	3A-41A	3A-41A	n78A	3A, 41A	n78A
2DL+FR1	DC_1A-5A_n78A	1A	1A	n78A	1A, 5A	n78A
2DL+FR1	DC_3A-5A_n78A	3A	3A	n78A	3A, 5A	n78A
2DL+FR1	DC_5A-7A_n78A	7A	7A	n78A	5A, 7A	n78A
2DL+FR1	DC_7A-7A_n78A	7A-7A	7A-7A	n78A	7A	n78A
2DL+FR1	DC_1A-18A_n78A	1A	1A	n78A	1A, 18A	n78A
2DL+FR1	DC_1A-41A_n78A	1A-41A	1A-41A	n78A	1A	n78A
2DL+FR1	DC_3A-18A_n78A	3A	3A	n78A	3A, 18A	n78A
2DL+FR1	DC_66A-66A_n78A	66A_66A	66A_66A	n78A	66A	n78A
2DL+FR1	DC_2A-7A_n78A	2A-7A	2A-7A	n78A	2A, 7A	n78A
2DL+FR1	DC_2A-66A_n78A	2A-66A	2A-66A	n78A	2A, 66A	n78A
2DL+FR1	DC_7A-66A_n78A	7A-66A	7A-66A	n78A	7A, 66A	n78A
2DL+FR1	DC_1A-3A_n79A	1A-3A	1A-3A	n79A	1A, 3A	n79A
2DL+FR1	DC_1A-19A_n79A	1A	1A	n79A	1A, 19A	n79A
2DL+FR1	DC_3A-19A_n79A	3A	3A	n79A	3A, 19A	n79A
2DL+FR1	DC_1A-3A_n8A	1A-3A	1A-3A	-	1A, 3A	n8A
2DL+FR1	DC_1A-7A_n8A	1A-7A	1A-7A	-	1A, 7A	n8A
2DL+FR1	DC_3A-7A_n8A	3A-7A	3A-7A	-	3A, 7A	n8A
3DL+FR1	DC_1A-3A-7A_n28A	1A-3A-7A	1A-3A-7A	-	1A, 3A, 7A	n28A
3DL+FR1	DC_1A-3C_n28A	1A-3C	1A-3C	-	1A, 3C	n28A
3DL+FR1	DC_1A-7C_n28A	1A-7C	1A-7C	-	1A, 7C	n28A
3DL+FR1	DC_3A-7C_n28A	3A-7C	3A-7C	-	3A, 7C	n28A
3DL+FR1	DC_3C-7A_n28A	3C-7A	3C-7A	-	3C, 7A	n28A

Sub-Category	EN-DC Combination	LTE 4x4 DL MIMO		5G-NR 4x4 DL MIMO (EM919X)	EN-DC UL (EM919X)	
		EM9190	EM9191		LTE	NR
3DL+FR1	DC_2A-46C_n41A	-	-	-	2A	n41A
3DL+FR1	DC_2A-46A-	-	-	-	2A, 66A	n41A
3DL+FR1	DC_46C-66A_n41A	-	-	-	66A	n41A
3DL+FR1	DC_2A-2A-66A_n41A	-	-	-	2A, 66A	n41A
3DL+FR1	DC_2C-66A_n41A	-	-	-	66A	n41A
3DL+FR1	DC_2A-2A-30A_n5A	2A-2A-30A	2A-2A-30A	-	2A, 30A	n5A
3DL+FR1	DC_2A-2A-66A_n5A	2A-2A-66A	2A-2A-66A	-	2A, 66A	n5A
3DL+FR1	DC_2A-30A-66A_n5A	2A-30A-66A	2A-30A-66A	-	2A, 30A, 66A	n5A
3DL+FR1	DC_2A-66A-66A_n5A	2A-66A-66A	2A-66A-66A	-	2A, 66A	n5A
3DL+FR1	DC_30A-66A-66A_n5A	30A-66A-66A	30A-66A-66A	-	30A, 66A	n5A
3DL+FR1	DC_66A-66A-66A_n5A	66A-66A-66A	66A-66A-66A	-	66A	n5A
3DL+FR1	DC_1A-7C_n5A	1A-7C	1A-7C	-	1A, 7C	n5A
3DL+FR1	DC_3A-7C_n5A	3A-7C	3A-7C	-	3A, 7C	n5A
3DL+FR1	DC_2A-46C_n5A	2A	2A	-	2A	n5A
3DL+FR1	DC_46C-66A_n5A	66A	66A	-	66A	n5A
3DL+FR1	DC_48B-66A_n5A	48B-66A	48B-66A	-	66A	n5A
3DL+FR1	DC_2A-7A-7A_n5A	2A-7A-7A	2A-7A-7A	-	2A, 7A	n5A
3DL+FR1	DC_7A-7A-66A_n5A	7A-7A-66A	7A-7A-66A	-	7A, 66A	n5A
3DL+FR1	DC_2A-7A-66A_n5A	2A-7A-66A	2A-7A-66A	-	2A, 7A, 66A	n5A
3DL+FR1	DC_7A-66A-66A_n5A	7A-66A-66A	7A-66A-66A	-	7A, 66A	n5A
3DL+FR1	DC_1A-3C_n5A	1A-3C	1A-3C	-	1A, 3A	n5A
3DL+FR1	DC_3C-7A_n5A	3C-7A	3C-7A	-	3A, 7A	n5A
3DL+FR1	DC_7C-66A_n5A	7C-66A	7C-66A	-	7A, 66A	n5A
3DL+FR1	DC_1A-3A-7A_n5A	1A-3A-7A	1A-3A-7A	-	1A, 3A, 7A	n5A
3DL+FR1	DC_66C_(n)71AA	66C	66C	-	66C	n71A
3DL+FR1	DC_2A-66C_n71A	2A-66C	2A-66C	-	2A, 66C	n71A
3DL+FR1	DC_2A-66A_(n)71AA	2A-66A	2A-66A	-	2A, 66A	n71A
3DL+FR1	DC_2A-46C_n71A	2A	2A	-	2A	n71A
3DL+FR1	DC_2A-46A-66A_n71A	2A-66A	2A-66A	-	2A, 66A	n71A
3DL+FR1	DC_46C-66A_n71A	66A	66A	-	66A	n71A
3DL+FR1	DC_2A-2A-66A_n71A	2A-2A-66A	2A-2A-66A	-	2A, 66A	n71A
3DL+FR1	DC_2C-66A_n71A	2C-66A	2C-66A	-	66A	n71A
3DL+FR1	DC_2A-7A-66A_n71A	2A-7A-66A	2A-7A-66A	-	2A, 7A, 66A	n71A
3DL+FR1	DC_2A-2A-7A_n71A	2A-2A-7A	2A-2A-7A	-	2A, 7A	n71A
3DL+FR1	DC_7A-66A-66A_n71A	7A-66A-66A	7A-66A-66A	-	7A, 66A	n71A
3DL+FR1	DC_2A-66A-66A_n71A	2A-66A-66A	2A-66A-66A	-	2A, 66A	n71A
3DL+FR1	DC_1A-3A-28A_n77A	1A-3A	1A-3A	n77A	1A, 3A, 28A	n77A
3DL+FR1	DC_1A-41C_n77A	1A-41C	1A-41C	n77A	1A, 41C	n77A
3DL+FR1	DC_3A-41C_n77A	3A-41C	3A-41C	n77A	3A, 41C	n77A
3DL+FR1	DC_28A-41C_n77A	41C	41C	n77A	28A	n77A
3DL+FR1	DC_1A-3A-8A_n77A	1A-3A	1A-3A	n77A	1A, 3A, 8A	n77A
3DL+FR1	DC_1A-3A-18A_n77A	1A-3A	1A-3A	n77A	1A, 3A, 18A	n77A
3DL+FR1	DC_1A-3A-41A_n77A	1A-3A-41A	1A-3A-41A	n77A	1A, 3A	n77A
3DL+FR1	DC_1A-3C_n78A	1A-3C	1A-3C	n78A	1A, 3C	n78A

Sub-Category	EN-DC Combination	LTE 4x4 DL MIMO		5G-NR 4x4 DL MIMO (EM919X)	EN-DC UL (EM919X)	
		EM9190	EM9191		LTE	NR
3DL+FR1	DC_1A-7C_n78A	1A-7C	1A-7C	n78A	1A, 7C	n78A
3DL+FR1	DC_3A-7C_n78A	3A-7C	3A-7C	n78A	3A, 7C	n78A
3DL+FR1	DC_3C-7A_n78A	3C-7A	3C-7A	n78A	3C, 7A	n78A
3DL+FR1	DC_3C-20A_n78A	3C	3C	n78A	3C, 20A	n78A
3DL+FR1	DC_1A-3A-7A_n78A	1A-3A-7A	1A-3A-7A	n78A	1A, 3A, 7A	n78A
3DL+FR1	DC_1A-3A-8A_n78A	1A-3A	1A-3A	n78A	1A, 3A, 8A	n78A
3DL+FR1	DC_1A-3A-20A_n78A	1A-3A	1A-3A	n78A	1A, 3A, 20A	n78A
3DL+FR1	DC_1A-3A-28A_n78A	1A-3A	1A-3A	n78A	1A, 3A, 28A	n78A
3DL+FR1	DC_1A-7A-20A_n78A	1A-7A	1A-7A	n78A	1A, 7A, 20A	n78A
3DL+FR1	DC_1A-8A-20A_n78A	1A	1A	n78A	1A, 8A, 20A	n78A
3DL+FR1	DC_3A-7A-20A_n78A	3A-7A	3A-7A	n78A	3A, 7A, 20A	n78A
3DL+FR1	DC_3A-7A-28A_n78A	3A-7A	3A-7A	n78A	3A, 7A, 28A	n78A
3DL+FR1	DC_3A-8A-20A_n78A	3A	3A	n78A	3A, 8A, 20A	n78A
3DL+FR1	DC_1A-3A-19A_n78A	1A-3A	1A-3A	n78A	1A, 3A, 19A	n78A
3DL+FR1	DC_1A-3A-28A_n78A	1A-3A	1A-3A	n78A	1A, 3A, 28A	n78A
3DL+FR1	DC_1A-5A-7A_n78A	1A-7A	1A-7A	n78A	1A, 5A, 7A	n78A
3DL+FR1	DC_1A-7A-7A_n78A	1A-7A-7A	1A-7A-7A	n78A	1A, 7A	n78A
3DL+FR1	DC_3A-5A-7A_n78A	3A-7A	3A-7A	n78A	3A, 5A, 7A	n78A
3DL+FR1	DC_3A-7A-7A_n78A	3A-7A-7A	3A-7A-7A	n78A	3A, 7A	n78A
3DL+FR1	DC_5A-7A-7A_n78A	7A-7A	7A-7A	n78A	5A, 7A	n78A
3DL+FR1	DC_3C-8A_n78A	3C	3C	n78A	3C, 8A	n78A
3DL+FR1	DC_1A-3A-5A_n78A	1A-3A	1A-3A	n78A	1A, 3A, 5A	n78A
3DL+FR1	DC_7C-28A_n78A	7C	7C	n78A	7C, 28A	n78A
3DL+FR1	DC_1A-7A-28A_n78A	1A-7A	1A-7A	n78A	1A, 7A, 28A	n78A
3DL+FR1	DC_1A-41C_n78A	1A-41C	1A-41C	n78A	1A	n78A
3DL+FR1	DC_3A-41C_n78A	3A-41C	3A-41C	n78A	3A	n78A
3DL+FR1	DC_1A-3A-18A_n78A	1A-3A	1A-3A	n78A	1A, 3A, 18A	n78A
3DL+FR1	DC_1A-3A-41A_n78A	1A-3A-41A	1A-3A-41A	n78A	1A, 3A	n78A
3DL+FR1	DC_3C-28A_n78A	3C	3C	n78A	3C, 28A	n78A
3DL+FR1	DC_2A-7C_n78A	2A-7C	2A-7C	n78A	2A, 7C	n78A
3DL+FR1	DC_7C-66A_n78A	7C-66A	7C-66A	n78A	7C, 66A	n78A
3DL+FR1	DC_2A-7A-7A_n78A	2A-7A-7A	2A-7A-7A	n78A	2A, 7A	n78A
3DL+FR1	DC_2A-66A-66A_n78A	2A-66A-66A	2A-66A-66A	n78A	2A, 66A	n78A
3DL+FR1	DC_7A-7A-66A_n78A	7A-7A-66A	7A-7A-66A	n78A	7A, 66A	n78A
3DL+FR1	DC_7A-66A-66A_n78A	7A-66A-66A	7A-66A-66A	n78A	7A, 66A	n78A
3DL+FR1	DC_1A-3A-19A_n79A	1A-3A	1A-3A	n79A	1A, 3A, 19A	n79A
3DL+FR1	DC_1A-3A-7A_n8A	1A-3A-7A	1A-3A-7A	-	1A, 3A, 7A	n8A
4DL+FR1	DC_1A-3A-7C_n28A	1A-3A-7C	1A-3A-7C	-	1A, 3A, 7C	n28A
4DL+FR1	DC_1A-3C-7A_n28A	1A-3C-7A	1A-3C-7A	-	1A, 3C, 7A	n28A
4DL+FR1	DC_3C-7C_n28A	3C-7C	3C-7C	-	3C, 7C	n28A
4DL+FR1	DC_2A-46D_n41A	-	-	n41A	2A	n41A
4DL+FR1	DC_2A-46C-66A_n41A	-	-	-	2A, 66A	n41A
4DL+FR1	DC_46D-66A_n41A	-	-	-	66A	n41A
4DL+FR1	DC_13A-48D_n48A	48D	48D	n48A	13A	n48A

Sub-Category	EN-DC Combination	LTE 4x4 DL MIMO		5G-NR 4x4 DL MIMO (EM919X)	EN-DC UL (EM919X)	
		EM9190	EM9191		LTE	NR
4DL+FR1	DC_48D-66A_n48A	48D, 66A	48D, 66A	n48A	66A	n48A
4DL+FR1	DC_2A-2A-30A-66A_n5A	2A-2A-30A-66A	2A-2A,2A-30A,2A-66A,30A-66A	-	2A, 30A, 66A	n5A
4DL+FR1	DC_2A-2A-66A-66A_n5A	2A-2A-66A-66A	2A-2A,2A-66A,66A-66A	-	2A, 66A	n5A
4DL+FR1	DC_2A-30A-66A-66A_n5A	2A-30A-66A-66A	2A-30A,2A-66A,30A-66A,66A-66A	-	2A, 30A, 66A	n5A
4DL+FR1	DC_30A-66A-66A-66A_n5A	30A-66A-66A-66A	30A-66A,66A-66A	-	30A, 66A	n5A
4DL+FR1	DC_1A-3A-7C_n5A	1A-3A-7C	1A-3A,7C	-	1A, 3A, 7C	n5A
4DL+FR1	DC_2A-46D_n5A	2A	2A	-	2A	n5A
4DL+FR1	DC_2A-7A-7A-66A_n5A	2A-66A-7A-7A	2A-66A-7A-7A	-	2A, 66A, 7A	n5A
4DL+FR1	DC_48D-66A_n5A	48D-66A	48D-66A	-	66A	n5A
4DL+FR1	DC_46D-66A_n5A	66A	66A	-	66A	n5A
4DL+FR1	DC_7A-7A-66A-66A_n5A	7A-7A-66A-66A	7A-7A-66A-66A	-	7A, 66A	n5A
4DL+FR1	DC_2A-7A-66A-66A_n5A	2A-7A-66A-66A	2A-7A-66A-66A	-	2A, 7A, 66A	n5A
4DL+FR1	DC_2A-7C-66A_n5A	2A-7C-66A	2A-7C-66A	-	2A, 7A, 66A	n5A
4DL+FR1	DC_3C-7C_n5A	3C-7C	3C-7C	-	3A, 7A	n5A
4DL+FR1	DC_1A-3C-7A_n5A	1A-3C-7A	1A-3C-7A	-	1A, 3A, 7A	n5A
4DL+FR1	DC_7C-66A-66A_n5A	7C-66A-66A	7C-66A-66A	-	7A, 66A	n5A
4DL+FR1	DC_2A-66A-66A-66A_n5A	2A-66A-66A-66A	2A-66A-66A-66A	-	2A, 66A	n5A
4DL+FR1	DC_2A-66C_(n)71AA	2A-66C	2A-66C	-	2A, 66C	n71A
4DL+FR1	DC_2A-46D_n71A	2A	2A	-	2A	n71A
4DL+FR1	DC_2A-46C-66A_n71A	2A-66A	2A-66A	-	2A, 66A	n71A
4DL+FR1	DC_46D-66A_n71A	66A	66A	-	66A	n71A
4DL+FR1	DC_2A-2A-66A-66A_n71A	2A-2A-66A-66A	2A-2A-66A-66A	-	2A, 66A	n71A
4DL+FR1	DC_1A-3A-41C_n77A	1A-3A-41C	1A-3A,41C	n77A	1A, 3A	n77A
4DL+FR1	DC_3C-7C_n78A	3C-7C	3C,7C	n78A	3C, 7C	n78A
4DL+FR1	DC_1A-3A-7C_n78A	1A-3A-7C	1A-3A,7C	n78A	1A, 3A, 7C	n78A
4DL+FR1	DC_1A-3C-7A_n78A	1A-3C-7A	1A-7A,3C	n78A	1A, 3C, 7A	n78A
4DL+FR1	DC_1A-3C-20A_n78A	1A-3C	1A-3C	n78A	1A, 3C, 20A	n78A
4DL+FR1	DC_3C-7A-20A_n78A	3C-7A	3C-7A	n78A	3C, 7A, 20A	n78A
4DL+FR1	DC_1A-3A-7A-8A_n78A	1A-3A-7A	1A-3A-7A	n78A	1A, 3A, 7A, 8A	n78A
4DL+FR1	DC_1A-3A-7A-20A_n78A	1A-3A-7A	1A-3A,1A-7A,3A-7A	n78A	1A, 3A, 7A, 20A	n78A
4DL+FR1	DC_1A-3A-7A-28A_n78A	1A-3A-7A	1A-3A,1A-7A,3A-7A	n78A	1A, 3A, 7A, 28A	n78A
4DL+FR1	DC_1A-3A-5A-7A_n78A	1A-3A-7A	1A-3A,1A-7A,3A-7A	n78A	1A, 3A, 5A, 7A	n78A
4DL+FR1	DC_1A-3A-7A-7A_n78A	1A-3A-7A-7A	1A-3A,1A-7A,3A-7A,7A-7A	n78A	1A, 3A, 7A	n78A
4DL+FR1	DC_1A-5A-7A-7A_n78A	1A-7A-7A	1A-7A,7A-7A	n78A	1A, 5A, 7A	n78A
4DL+FR1	DC_3A-5A-7A-7A_n78A	3A-7A-7A	3A-7A,7A-7A	n78A	3A, 5A, 7A	n78A
4DL+FR1	DC_1A-3C-8A_n78A	1A-3C	1A,3C	n78A	1A, 3C, 8A	n78A
4DL+FR1	DC_3A-7C-28A_n78A	3A-7C	3A,7C	n78A	3A, 7C, 28A	n78A

Sub-Category	EN-DC Combination	LTE 4x4 DL MIMO		5G-NR 4x4 DL MIMO (EM919X)	EN-DC UL (EM919X)	
		EM9190	EM9191		LTE	NR
4DL+FR1	DC_1A-3A-41C_n78A	1A-3A-41C	1A-3A,41C	n78A	1A, 3A	n78A
4DL+FR1	DC_1A-3C-28A_n78A	1A-3C	1A,3C	n78A	1A, 3C, 28A	n78A
4DL+FR1	DC_1A-7C-28A_n78A	1A-7C	1A,7C	n78A	1A, 7C, 28A	n78A
4DL+FR1	DC_3A-3A-7A-7A_n78A	3A-3A-7A, 3A-7A-7A	3A-3A, 3A-7A,7A-7A	n78A	3A, 7A	n78A
4DL+FR1	DC_7C-66A-66A_n78A	7C-66A-66A	7C,66A-66A	n78A	7C, 66A	n78A
4DL+FR1	DC_2A-7C-66A_n78A	2A-7C-66A	2A-7C-66A	n78A	2A, 7C, 66A	n78A
4DL+FR1	DC_2A-7A-7A-66A_n78A	2A-7A-7A, 2A-7A-66A, 7A-7A-66A	2A-7A-7A, 2A-7A-66A, 7A-7A-66A	n78A	2A, 7A, 66A	n78A
4DL+FR1	DC_2A-7A-66A-66A_n78A	2A-7A-66A, 2A-66A-66A, 7A-66A-66A	2A-7A-66A, 2A-66A-66A, 7A-66A-66A	n78A	2A, 7A, 66A	n78A
4DL+FR1	DC_7A-7A-66A-66A_n78A	7A-7A-66A, 7A-66A-66A	7A-7A-66A, 7A-66A-66A	n78A	7A, 66A	n78A
4DL+FR1	DC_3C-7A-28A_n78A	3C-7A	3C,7A	n78A	3C, 7A, 28A	n78A
5DL+FR1	DC_1A-3C-7C_n28A	1A-3C-7C	1A-3C-7C	-	1A, 3C, 7C	n28A
5DL+FR1	DC_2A-46D-66A_n41A	-	-	-	2A, 66A	n41A
5DL+FR1	DC_2A-46E_n5A	2A	2A	-	2A	n5A
5DL+FR1	DC_1A-3C-7C_n5A	1A-3C-7C	1A	-	1A, 3C, 7C	n5A
5DL+FR1	DC_48E-66A_n5A	48E-66A	48E-66A	-	66A	n5A
5DL+FR1	DC_2A-2A-46D_n5A	2A-2A	2A-2A	-	2A	n5A
5DL+FR1	DC_2A-46D-66A_n5A	2A-66A	2A-66A	-	2A, 66A	n5A
5DL+FR1	DC_46D-66A-66A_n5A	66A-66A	66A-66A	-	66A	n5A
5DL+FR1	DC_46E-66A_n5A	66A	66A	-	66A	n5A
5DL+FR1	DC_2A-7A-7A-66A-66A_n5A	2A-7A-7A-66A-66A	2A-7A-7A-66A-66A	-	2A, 7A, 66A	n5A
5DL+FR1	DC_2A-7C-66A-66A_n5A	2A-7C-66A-66A	2A-7C-66A-66A	-	2A, 7A, 66A	n5A
5DL+FR1	DC_2A-46D-66A_n71A	2A-66A	2A-66A	-	2A, 66A	n71A
5DL+FR1	DC_1A-3C-7C_n78A	1A-3C-7C	1A	n78A	1A, 3C, 7C	n78A
5DL+FR1	DC_1A-3A-5A-7A-7A_n78A	1A-3A-7A-7A	1A,3A,7A	n78A	1A, 3A, 5A, 7A	n78A
5DL+FR1	DC_1A-3C-7A-28A_n78A	1A-3C-7A	1A,7A	n78A	1A, 3C, 7A, 28A	n78A
5DL+FR1	DC_1A-3A-7C-28A_n78A	1A-3A-7C	1A,3A	n78A	1A, 3A, 7C, 28A	n78A
5DL+FR1	DC_2A-7C-66A-66A_n78A	2A-7C-66A, 2A-66A-66A, 7C-66A-66A	2A-7C-66A, 2A-66A-66A, 7C-66A-66A	n78A	2A, 7C, 66A	n78A
5DL+FR1	DC_2A-7A-7A-66A-66A_n78A	2A-7A-7A, 2A-7A-66A, 2A-66A-66A, 7A-7A-66A, 7A-66A-66A	2A-7A-7A, 2A-7A-66A, 2A-66A-66A, 7A-7A-66A, 7A-66A-66A	n78A	2A, 7A, 66A	n78A
5DL+FR1	DC_3C-7C-28A_n78A	3C-7C	-	n78A	3C, 7C, 28A	n78A

Note: The EN-DC for 5G-NR FR2 (EM9190 only) depends on mmWave antenna modules in use, please contact your Sierra Wireless account representative to confirm the detailed support list.

9.3. Thermal Testing

9.3.1. Worst-case Testing

Sierra Wireless recommends that customers identify realistic worst-case conditions for their applications 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.

9.3.2. 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 application.
3. Set the platform's ambient to the higher limit of the specification and observe the junction temperature ramp (use **AT!PCTEMP?**).
4. Set up a call with the use case for the platform (throughput rate, output power, duty cycle) on the worst-case band.
5. Observe the ramp in junction temperature due to the call and confirm whether the overall system performance still meets customer requirements.
6. Use **AT!TMSTATUS?** to check the module's thermal mitigation status (refer to *[2] AirPrime EM919X AT Command Reference* for details).
7. 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 (third and second CA dropped), UL power reduced, Emergency Service).

Note: Refer to [4] EM9190 Thermal Application Note for more details.

9.4. Production Testing

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

Developers of OEM devices integrating Sierra Wireless AirPrime embedded modules should include a series of test phases in their manufacturing process to make sure that their devices work properly with the embedded modules. For more information, please refer to *[5] AirPrime EM919X Customer Production Test Mode Rev1.0*.

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

9.5. Packaging

Sierra Wireless AirPrime Embedded Modules are shipped in sealed boxes. The standard packaging (refer to Figure 9-3), contains a single tray with a capacity of 100 modules. (Note that some SKUs may have custom packaging — contact Sierra Wireless for SKU-specific details.)

In the standard packaging, Embedded Modules 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 to contact the top of the triangular features in the top portion (T2) of the tray (see Detail A).

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

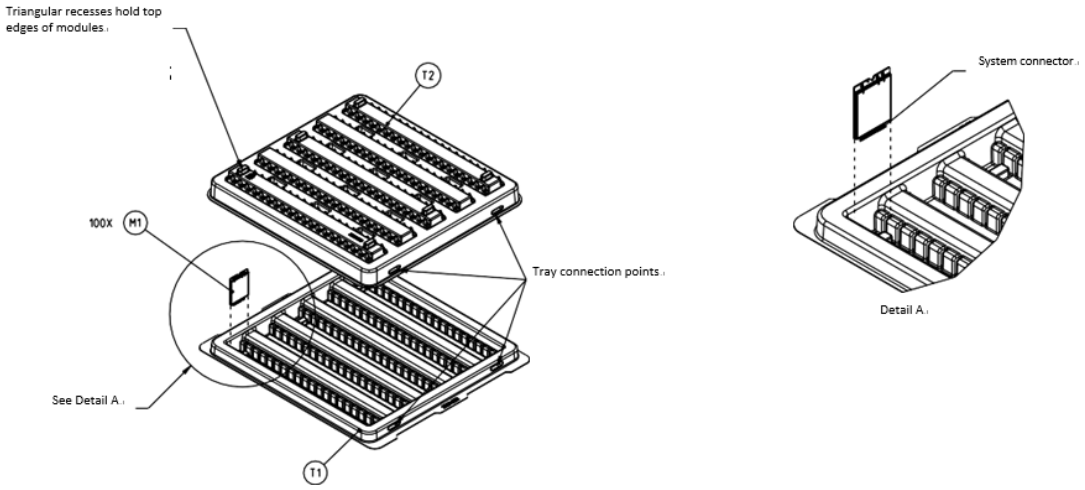


Figure 9-3 Device Placement in Module Tray

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), sealed with a security tape (P1), a manufacturing label (L3) is placed on the bottom-right corner, above the security tape, and if required a label (L4) is applied beside the manufacturing label. Refer to Figure 9-4.

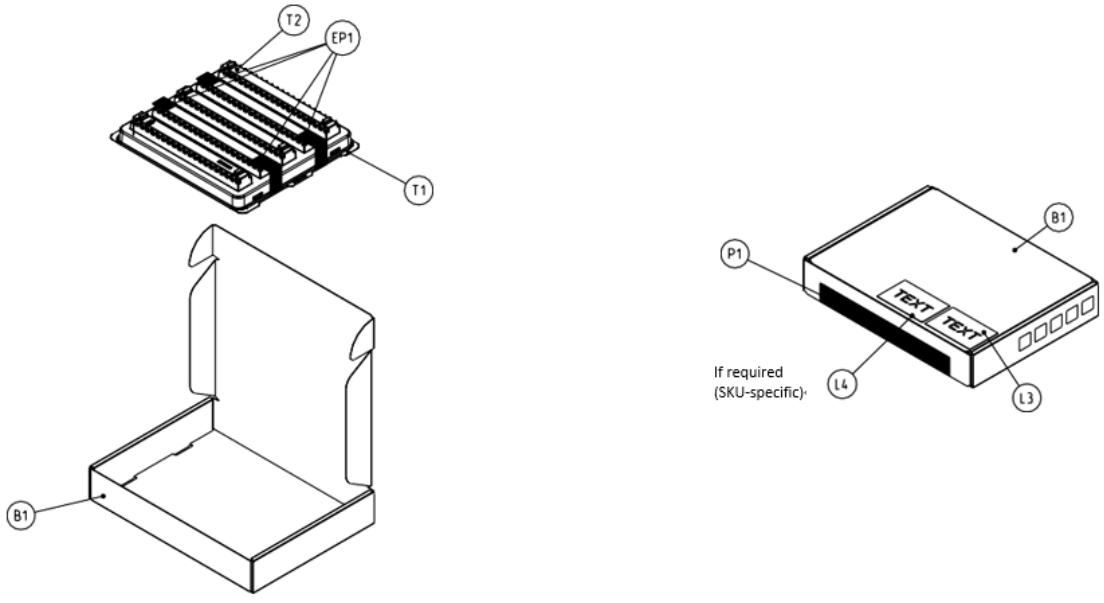


Figure 9-4 Shipping Package

9.6. 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 9-9 Hardware Integration Design Consideration

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 100Ω may be used depending on ESD testing requirements).	SIM Implementation
Minimize RF cable losses as these affect performance values listed in product specification documents.	RF Connections
Antennas	
Match the module/antenna coax connections to 50Ω mismatched antenna impedance and cable loss negatively affect RF performance.	RF Connections
If installing UMTS and CDMA modules in the same device, consider using separate antennas for maximum performance.	Sub-6G Antennas and Cabling
Power	
Make sure the power supply can handle the maximum current specified for the module type.	Power Consumption
Limit the total impedance of VCC and GND connections to the SIM at the connector to less than 1Ω (including any trace impedance and lumped element components — inductors, filters, etc.). All other lines must have a trace impedance less than 2Ω.	SIM Implementation
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 and USB3.1 — Route these signals over 90Ω differential lines on the PCB.	
PCIe 3.0 — Route the data and clock differential pairs over 90Ω differential lines on the PCB.	
I2C port — If supported, route these signals away from noise-sensitive signals on the PCB.	
PCM port — If supported, route these signals away from noise-sensitive signals on the PCB.	
EMI/ESD	
Investigate sources of localized interference early in the design cycle.	Methods to Mitigate Decreased Rx Performance
Provide ESD protection for the SIM connector at the exposed contact point (in particular, the CLK, VCC, IO, and RESET# lines).	SIM Implementation
Keep very low capacitance traces on the UIM_DATA and UIM_CLK signals.	

Suggestion	Section Where Discussed
To minimize noise leakage, establish a very good ground connection between the module and host.	Ground Connection
Route cables away from noise sources (for example, power supplies, LCD assemblies, etc.).	Methods to Mitigate Decreased Rx Performance
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.	
Thermal	
Test to worst-case operating conditions — temperature, voltage, and operation mode (transmitter on 100% duty cycle, maximum power).	Thermal Considerations
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).	

10. References

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This guide deals specifically with hardware integration issues that are unique to AirPrime embedded modules.

The Sierra Wireless documents listed below are available from www.sierrawireless.com. For additional documents describing embedded module design, usage, and integration issues, contact your Sierra Wireless account representative.

10.1. Command Documents

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

[2] AirPrime EM919X AT Command Reference (Doc# 41113480)

10.2. Other Sierra Wireless Documents

[3] AirPrime EM9190 Development Kit User Guide (Doc# 41113875)

[4] EM9190 Thermal Application Note (Doc# 2174257)

[5] AirPrime EM919X Customer Production Test Mode Rev1.0 (Doc# 41113679)

[6] EM9190 mmWave Design Guidelines (Doc# 2174276)

[7] AirPrime EM919X 5G NR Peak Throughput (Doc# 2174277)

[8] AirPrime EM9190 Current Consumption Application Note (Doc# 2174287)

[9] AirPrime EM919X-EM7690 Non-mmWave Smart Transmit (Doc# 2174291)

10.3. Industry/Other Documents

The following non-Sierra Wireless references are not included in your documentation package:

[10] FCC Regulations — Part 15 — Radio Frequency Devices

[11] IEC-61000-4-2 level 3 (Electrostatic Discharge Immunity Test)

[12] Mobile Station (MS) Conformance Specification; Part 4: Subscriber Interface Module (Doc# 3GPP TS 11.10-4)

[13] PCI Express M.2™ Specification Revision 3.0, Version 1.2

[14] Universal Serial Bus Specification, Rev 2.0

[15] Universal Serial Bus Specification, Rev 3.1

[16] JESD22-A114-B

[17] JESD22-C101

[18] MIPI Alliance Specification for RF Front-End Control Interface

11. Abbreviations

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Table 11-1 Abbreviations and Definitions

Abbreviation or Term	Definition
3GPP	3rd Generation Partnership Project
8PSK	Octagonal Phase Shift Keying
AGC	Automatic Gain Control
A-GPS	Assisted GPS
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
CQI	Channel Quality Indication
COM	Communication port
CPE	Customer-Premises Equipment
CS	Circuit-switched
CSG	Closed Subscriber Group
CW	Continuous waveform
dB	Decibel = 10 x log10 (P1/P2) *P1 is calculated power; P2 is reference power* Decibel = 20 x log10 (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
DSM	Distributed Shared Memory
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
ERP	Effective Radiated Power
ESD	Electrostatic Discharge

Abbreviation or Term	Definition
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 http://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 mini card 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)
GPS	Global Positioning System An American system that uses a series of 24 satellites in middle circular orbit to provide navigational data.
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)
LED	Light Emitting Diode. A semiconductor diode that emits visible or infrared light.
LHCP	Left-Hand Circular Polarized
LNA	Low Noise Amplifier

Abbreviation or Term	Definition
LPM	Low Power Mode
LPT	Line Print Terminal
LTE	Long Term Evolution — a high-performance air interface for cellular mobile communication systems.
MCS	Modulation and Coding Scheme
MHz	Megahertz = 10e6 Hz
MIMO	Multiple Input Multiple Output — wireless antenna technology that uses multiple antennas at both transmitter and receiver side. This improves performance.
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
OEM	Original Equipment Manufacturer — a company that manufactures a product and sells it to a reseller.
OFDMA	Orthogonal Frequency Division Multiple Access
OMADM	Open Mobile Alliance Device Management — A device management protocol.
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
PMI	Pre-coding Matrix Index
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.
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
RF	Radio Frequency
RI	Ring Indicator

Abbreviation or Term	Definition
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
SAR	Specific Absorption Rate
SBAS	Satellite-based Augmentation System
SCC	Secondary Component Carrier
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.
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).
S/N	Signal-to-noise (ratio)
SNR	Signal-to-Noise Ratio
SOF	Start of Frame — A USB function.
SSS	Secondary synchronization signal.
SUPL	Secure User Plane Location
TDD	Time Division Duplexing
TD-SCDMA	Time Division Synchronous Code Division Multiple Access
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 https://www.tiaonline.org/.
TIS	Total Isotropic Sensitivity
TRP	Total Radiated Power
UDK	Universal Development Kit (for PCI Express Mini Cards)
UE	User Equipment
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

Abbreviation or Term	Definition
USIM	Universal Subscriber Identity Module
VCC	Supply voltage
VSWR	Voltage Standing Wave Ratio
WAN	Wide Area Network
WCDMA	Wideband Code Division Multiple Access (also referred to as UMTS)
WLAN	Wireless Local Area Network
WWAS	Wide Area Augmentation System (SBAS for GPS)
ZIF	Zero Intermediate Frequency
ZUC	ZUC stream cypher