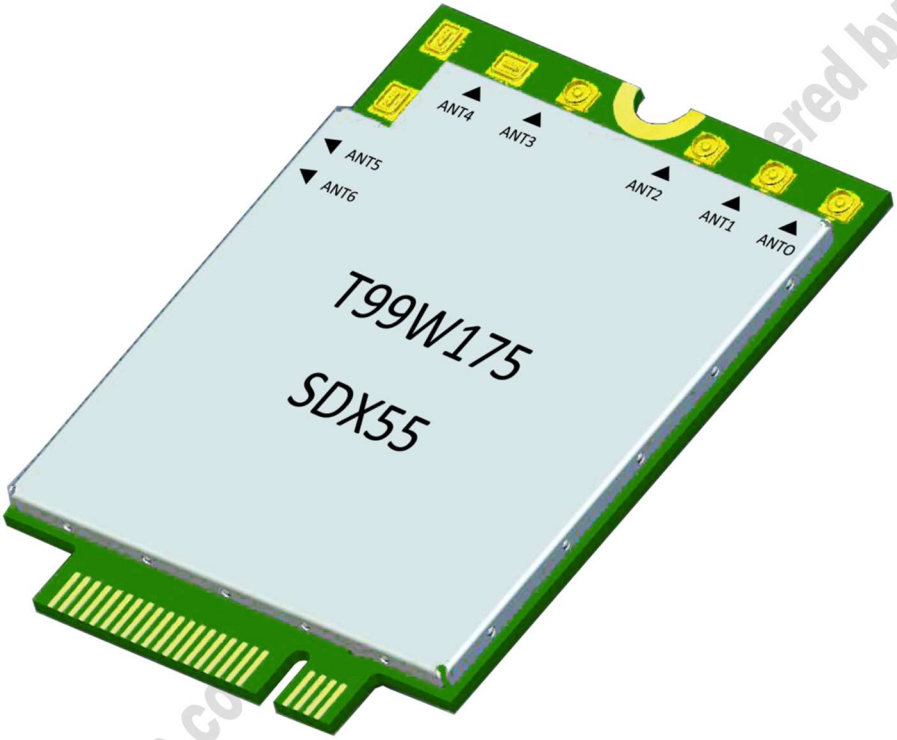
5GNR/ LTE-Advanced PCI Express M.2 Module (Sub 6G, mmWave, LTE, UMTS)

Engineering Requirements Specification



Project code: T99W175.0x
Solution: SDX55+SDR865+SMR526
SKU: WW-1-5G

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1. General Description

T99W175 is designed to enable wireless data connectivity for notebook computer or any other device compatible with the PCI Express M.2 Specification 3042 type Key B slot. T99W175 is the data card solution that delivers wireless wide-area network (WWAN) connectivity for the 5GNR (Sub 6G/ mmWave), LTE, UMTS (HSDPA/HSUPA/HSPA+DC-HSPA+) and GPS/Glonass/ Beidou/ Galileo protocols in one hardware configuration.

SKU		WW-1-5G / T99W175
Carrier Support		NA: AT&T, Verizon, Sprint WW: Vodafone, Swisscom, Telefonica-O2 EU: Deutsche Telekom, Swisscom APAC: Telstra, Optus, Docomo, KDDI, Softbank China: CMCC/CUCC/CTCC * Carrier engagement based on real business agreement
QCT Solution		SDX55+SDR865+SMR526+PMX55
5G	FR1 (Sub 6G)	LB: n5/8/12/20/28/71; MB: n1/2/3/66; HB: n7/38/41/77/78/79
	FR2 (mmWave)	n257/258/260/261 (UL 2X2+4CC or 1X1+8CC)
	4x4 MIMO	n1/2/3/66/7/38/41/77/78/79
	UE Capability	UL (TBD); DL(TBD)
4G	Support Band	LB: B26(5/18/19)/8/12(17)/13/14/20/28/29/71 MB: B1/2(25)/3/4(66)/32 HB: B7/30/34/38/39/40/41/42/48
	4x4 MIMO	B1/25(2)/3/66(4)/7/30/40/41(38)/42/48
	LAA	B46 (DL only)
	LTE Cat.	ue-CategoryUL 13 (UL: 150Mbps) + ue-CategoryDL 20 (DL: 2Gbps); 7xDL CA, 3xUL CA (Intra-band), 5xDL CA+4X4 MIMO (Up to Cat20)
3G	WCDMA	HSPA+ Rel8 (DL/UL: up to 42/11 Mbps)
	Support Band	B1/2/4/5(6/19)/8/9
GNSS		Dual-Frequency GNSS: L1: GPS/Glonass/Beidou/Galileo, L5: GPS/Beidou/Galileo
eSIM		Dual SIM with eSIM on board (eSIM is option), Dual SIM Single Active (DSSA)
Interface		PCIe3.0
Form factor		3042 PCIe M.2 Key.B

1.1 System Main Feature

Feature	Description
Physical	PCI express M.2 module, size 3042, Key.B,75Pin golden finger
Electrical	Single VCC supply (3.135V~3.63V)
Dimension	Dimensions (L × W × H): 42 mm × 30 mm × 2.6 mm, maximum height=2.75mm (add 0.15mm tolerance)
Shielding design	Shield case on board design, no additional shielding requirement
Weight	Approximately ~8g
USIM	Off-board USIM connector supported on Host through USIM1; e-SIM embedded on Module through USIM2
Operating Bands	WCDMA/HSDPA/HSUPA/HSPA+ operating bands: Band 1: 1920 to 1980 MHz (UL), 2110 to 2170 MHz (DL) Band 2: 1850 to 1910 MHz (UL), 1930 to 1990 MHz (DL) Band 4: 1710 to 1755 MHz (UL), 2110 to 2155 MHz (DL) Band 5: 824 to 849 MHz (UL), 869 to 894 MHz (DL) Band 6: 830 to 840 MHz (UL), 875 to 885 MHz (DL) Band 8: 880 to 915 MHz (UL), 925 to 960 MHz (DL) Band 9: 1750 to 1785 MHz (UL), 1845to 1880 MHz (DL) Band 19: 830 to 845 MHz (UL), 875 to 890 MHz (DL)
	LTE FDD/TDD operating bands: Band 1: 1920 to 1980 MHz (UL), 2110 to 2170 MHz (DL) Band 2: 1850 to 1910 MHz (UL), 1930 to 1990 MHz (DL) Band 3: 1710 to 1785 MHz (UL), 1805 to 1880 MHz (DL) Band 4: 1710 to 1755 MHz (UL), 2110 to 2155 MHz (DL) Band 5: 824 to 849 MHz (UL), 869 to 894 MHz (DL) Band 7: 2500 to 2570 MHz (UL), 2620 to 2690 MHz (DL) Band 8: 880 to 915 MHz (UL), 925 to 960 MHz (DL) Band 12: 699 to 716 MHz (UL), 729 to 746 MHz (DL) Band 13: 777 to 787 MHz (UL), 746 to 756 MHz (DL) Band 14: 788 to 798 MHz (UL), 758 to 768 MHz (DL) Band 17: 704 to 716 MHz (UL), 734 to 746 MHz (DL) Band 18: 815 to 830 MHz (UL), 860 to 875 MHz (DL) Band 19: 830 to 845 MHz (UL), 875 to 890 MHz (DL) Band 20: 832 to 862 MHz (UL), 791 to 821 MHz (DL) Band 25: 1850 to 1915 MHz (UL), 1930 to 1995 MHz (DL) Band 26: 814 to 849 MHz (UL), 859 to 894 MHz (DL) Band 28: 703 to 748 MHz (UL), 758 to 803 MHz (DL) Band 29: 717 to 728 MHz (DL) Band 30: 2305 to 2315 MHz (UL) 2350 to 2360 MHz (DL) Band 32: 1452 to 1496 MHz (DL) Band 34: 2010 to 2025 MHz (UL/DL) Band 38: 2570 to 2620 MHz (UL/DL) Band 39: 1880 to 1920 MHz (UL/DL) Band 40: 2300 to 2400 MHz (UL/DL) Band 41: 2496 to 2690 MHz (UL/DL) Band 66: 1710 to 1800 MHz (UL), 2110 to 2200 MHz (DL) Band 71: 663 to 698 MHz (UL), 617 to 652 MHz (DL)

Operating Bands	LTE 3.5G Band 42: 3400 to 3600 MHZ (UL/DL) Band 48: 3550 to 3700 MHZ (UL/DL)
	LAA Band 46: 5150 to 5925 MHZ (DL)
	5GNR Sub 6GHZ n1: 1920 to 1980 MHz (UL), 2110 to 2170 MHz (DL) n2: 1850 to 1910 MHz (UL), 1930 to 1990 MHz (DL) n3: 1710 to 1785 MHz (UL), 1805 to 1880 MHz (DL) n5: 824 to 849 MHz (UL), 869 to 894 MHz (DL) n7: 2500 to 2570 MHz (UL), 2620 to 2690 MHz (DL) n8: 880 to 915 MHz (UL), 925 to 960 MHz (DL) n12: 699 to 716 MHz (UL), 729 to 746 MHz (DL) n20: 832 to 862 MHz (UL), 791 to 821 MHz (DL) n28: 703 to 748 MHz (UL), 758 to 803 MHz (DL) n38: 2570 to 2620 MHz (UL/DL) n41: 2496 to 2690 MHz (UL/DL) n66: 1710 to 1800 MHz (UL), 2110 to 2200 MHz (DL) n71: 663 to 698 MHz (UL), 617 to 652 MHz (DL) n77: 3300 to 4200 MHz (UL/DL) n78: 3300 to 3800 MHz (UL/DL) n79: 4400 to 5000 MHz (UL/DL)
	5GNR mmWave n257: 26500 to 29500 MHz (UL/DL) n258: 24250 to 27500 MHz (UL/DL) n260: 37000 to 40000 MHz (UL/DL) n261: 27500 to 28350 MHz (UL/DL)
Diversity/2nd Rx	All UMTS operating bands All LTE operating bands
4x4 MIMO Rx	LTE-B1/25(2)/3/66(4)/7/30/40/41(38)/42/48 5GNR-n1/2/3/66/7/38/41/77/78/79
GNSS	GPS: L1 (1575.42MHz); L5 (1176MHz) GLONASS: L1 (1602MHz) BeidouB1(1561.098MHz) Galileo E1 (1575.42); E5a (1176MHz)
USIM Voltage	Support 1.8V and 2.85V, and auto detects follow SIM card type
Antenna connectors	ANT0: Support all 5GNR Sub 6G& LTE& UMTS bands ANT1: Support 5GNR Sub 6G& LTE M/H/UHB& UMTS bands and GPS L5 simultaneously ANT2: Support 5GNR Sub 6G& LTE M/H/UHB& UMTS bands ANT3: Support all 5GNR Sub 6G& LTE& UMTS bands and GPS L1 simultaneously ANT4/5/6: Support mmWave IF

Throughput	WCDMA CS: DL 64 kbps /UL 64 kbps WCDMA PS: DL 384 kbps /UL 384 kbps HSPA+:DL 21.6 Mbps /UL 5.76 Mbps DC-HSPA+: DL 42 Mbps/UL 5.76 Mbps LTE Cat20: DL:2Gbps/UL 150 Mbps 5GNR Sub 6G: DL: TBD/UL (TBD) 5GNR mmWave: DL: TBD/UL (TBD)

5GNR Air Interface

- 3GPP Rel15 5G NR sub-6&mmWave
  mmWave
- mmWave IF chip with integrated QLink in the 14 nm process and pairing with QTM525 to support the 3GPP Release 15 5G-NR mmWave standard
- 64 QAM uplink/downlink in mmWaveTDD
- Supports mmWave bands: n257 (28 GHz), n258 (26 GHz), n260 (39 GHz), and n261 (28 GHz)
  Sub-6G
- Modulation UL: 256 QAM; DL: 256 QAM
- Waveform UL: CP-OFDM and DFT-S-OFDM; DL: CP-OFDM
- Sub-Carrier Spacing (SCS): 15 KHz, 30 KHz
- Duplex mode: FDD and TDD
- Operation mode: Standalone mode (SA) and Non-Standalone mode (NSA)
- CA capability: DLCA
- MIMODL: 4 × 4 MIMO;
- EN-DC: LTE and NR sub-6 GHz dual connectivity

LTE Air Interface

LTE Rel15

- 20 layers and 2 Gbps downlink (DL) throughput – 4 × 4 MIMO across 5x CA
- 150 Mbps uplink (UL) throughput – 40 MHz ULCA and 256 QAM
- LAA (Licensed assist access) across 80 MHz
- CA capability:
  DLCA
    Inter-band DLCA
    Intra band contiguous CA
    Intra band non contiguous
  ULCA
    Inter band ULCA (Depend on Customer requirements)
    Intra band contiguous CA

- Modulation UL: 256 QAM; DL: 256 QAM
- 4 × 2 MIMO 7x CA (R15)
- 4 × 4 MIMO 5x CA (R15)
- FDD + TDD CA

WCDMA/HSPA Air Interface

- R99:
  All modes and data rates for WCDMA FDD
- R5 HSDPA
  PS data speeds up to 7.2 Mbps on the downlink
- R6 HSUPA
  E-DCH data rates of up to 5.76 Mbps for 2 ms TTI (UE category 6) uplink
- R7 HSPA+
  Downlink 64 QAM SISO: up to 21 Mbps
  Downlink 16 QAM 2X2 MIMO: up to 28 Mbps
- R8 DC-HSPA+
  Downlink dual carrier with 64 QAM (SISO); up to 42 Mbps

GNSS

- GPS, GLONASS, Galileo, and BeiDou support
- Two GNSS paths to support simultaneous L1 and /L5
- Customizable tracking session
  - Automatic tracking session on startup
  - Concurrent standalone GPS, GLONASS , BeiDou and Galileo
  - gpsOneXTRA with GPS + GLONASS + BeiDou+ Galileo support

1.2 EUTRANR- Dual Connectivity & Carrier Aggregation Combination

TBD

1.3 System Block Diagram

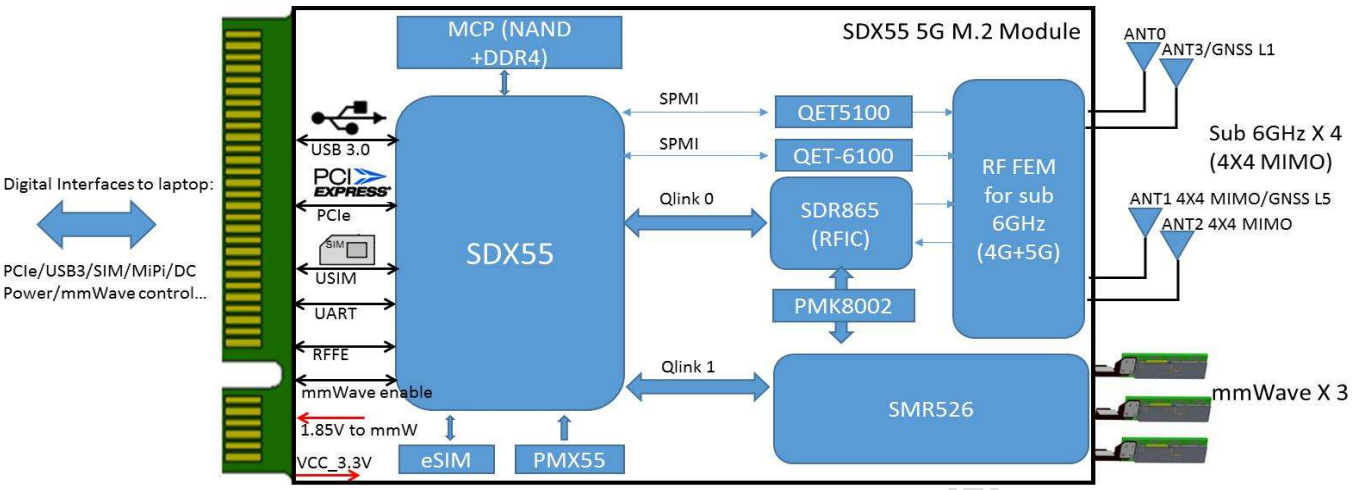


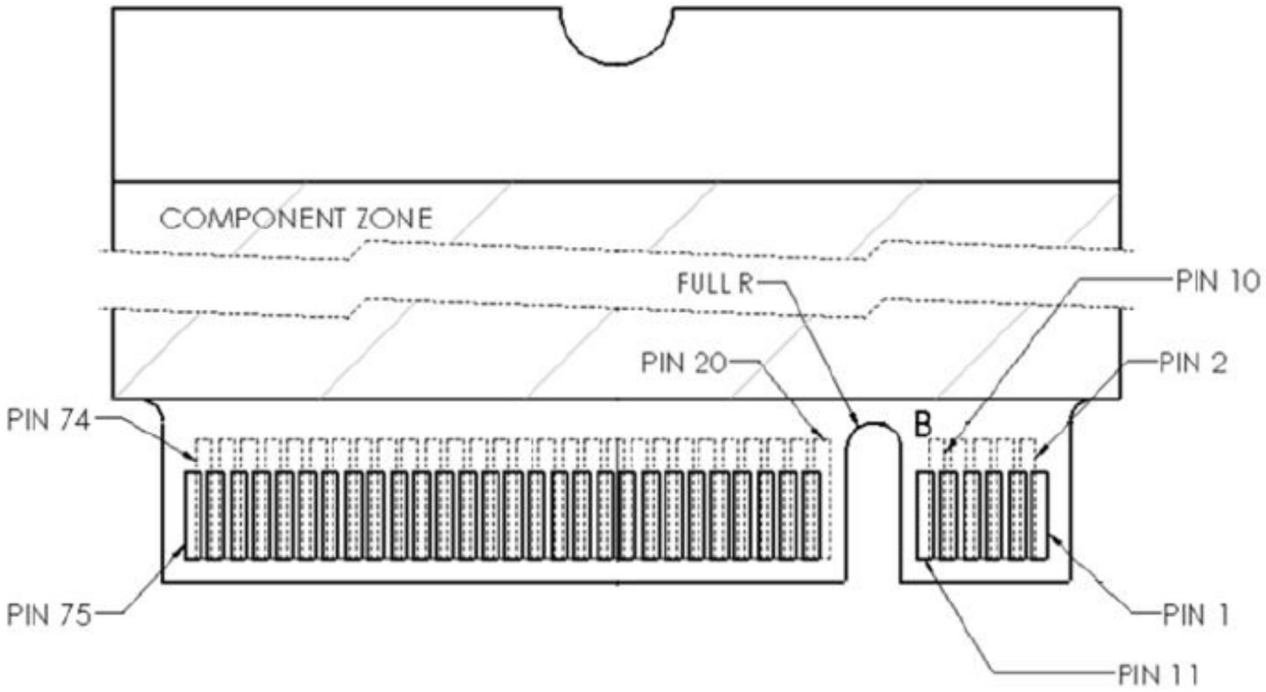
Figure 1-1 System block diagram

Chipsets: SDX55+SDR865+SMR526+PMX55

1.4 Pin definition

Golden finger Pin sequence

Figure 1-2 shows the sequence of pins on the 75-pin signal interface of M.2 3042Key.B.



1.4.2 Pin definition

Table 1-1 M.2 Pin definition

			CONFIG_2 (GND)	75	
74	3.3V		GND	73	
72	3.3V		GND	71	
70	3.3V		CONFIG_1 (GND)	69	
68	GPIO (I/0) (0/1.8V)		RESET# (I)(0/1.8V)	67	
66	SIM DETECT_1 (I)		mmWave_1P85	65	1.Pin59~63 for mmWave antenna enable 2.Pin65 for mmWave power (1.85V)
64	COEX_TXD (O)(0/1.8V)	Dual layout 3GPIOs and UART I/F for LTE / Wi-Fi coexistence	mmWave_Enable_3	63	
62	COEX_RXD(I)(0/1.8V)		mmWave_Enable_2	61	
60	LAA_n79_Tx_EN (O)	WWAN output to WLAN	mmWave_Enable_1	59	
58	MIPI_CLK (0/1.8V)	For external tunable antenna (MIPI)	GND	57	
56	MIPI_DATA (0/1.8V)		REFCLKP	55	
54	PEWAKE# (IO)(0/3.3V)		REFCLKN	53	
52	CLKREQ# (IO)(0/3.3V)		GND	51	
50	PERST# (I)(0/3.3V)		PERp0	49	
48	Not connect(Reserve as UIM_2-PWR (O)	USIM_2 for on board eSIM and reserve for external 2nd USIM	PERn0	47	
46	Not connect(Reserve for UIM_2-RESET (O)		GND	45	
44	Not connect(Reserve for UIM_2-CLK (O)		PETp0	43	
42	Not connect(Reserve for UIM_2-DATA (IO)		PETn0	41	
40	Not connect(Reserve for SIM DETECT_2 (I)		GND	39	
38	WLAN_Tx_EN (I)	WLAN output to WWAN	PERp1	37	Reserve for PCIe lane2 Rx+/-
36	UIM_1-PWR (O)	USIM_1 connect to external SIM socket	PERn1	35	
34	UIM_1-DATA (IO)		GND	33	
32	UIM_1-CLK (O)		PETp1	31	Reserve for PCIe lane2 Tx+/-
30	UIM_1-RESET (O)		PETn1	29	
28	DPR_2 (I)(0/1.8V)	2nd SAR detect	GND	27	
26	GPIO_10 - W_DISABLE2# (I) (0/3.3.V)	3.3V I/O	DPR_1 (I)(0/1.8V)	25	1st DPR detect
24	ANT_TUNER_POWER (1.8V)	Antenna tuner power (1.8V)	GPIO_11 - WoWWAN # (O)(0/1.8V)	23	
22	ANT_TUNER_CONFIG(I)(0/1.8V)	Antenna tuner mode control	CONFIG_0 (NC)	21	
20	Not connect		Module Key	13~19	
12~18	Module Key		GND	11	
10	GPIO_9 - LED#1 (O)(Open drain)		USB_D-	9	
8	W_DISABLE1# (I)(0/3.3V)	3.3V I/O	USB_D+	7	
6	FULL_CARD_POWER_OFF# (I)(0/3.3V)	3.3V I/O	GND	5	
4	3.3V		GND	3	
2	3.3V		CONFIG_3 (NC)	1	

Notes: Foxconn will provide one excel file to explain the PCIe M.2 Pin connection after project award.

1.5 Platform connection design

1.5.1 Configuration Pins

The M.2 module provides 4 configuration pins. T99W175 is configured as WWAN-PCIe-2, refer to PCIe M.2_Rev 1.2

Item	Module configuration decodes				Module type	Port configuration
Config	Config_0	Config_1	Config_2	Config_3	WWAN-PCIe	2
Pin No.	21	69	75	1		
State	NC	GND	GND	NC		

1.5.2 Power and ground

(1) Power Rail Parameters

Parameter	Min	Type	Max	Units
Operating voltage	3.135	3.3	3.63	Vdc

The operating voltage was defined as 3.135V~3.63V.

(2) 3.135 V is the minimum voltage supplied to WWAN M.2 card by the host platform, and VCC must never be under 3.135 V in any case. As our experiment, if we set the VCC=3.0V, the M.2 card will power off possibly when M.2 card working at +23dBm continue mode.

(3) The WWAN M.2 module provides 5 power pins and 11 Ground pins. To ensure that the WWAN module works normally, all the pins must be connected.

1.5.3 Full_Card_Power_Off

The WWANM.2 module can be controlled to power on/off by the Full_Card_Power_Ofpin.

Item	State	M.2 card state
1	Low	Powers off, it's internally pulled down by 100K ohm resistor
2	High	Powers on, it is 3.3V tolerant but can be driven by either 1.8V or 3.3V GPIO.

The recommended connections as below

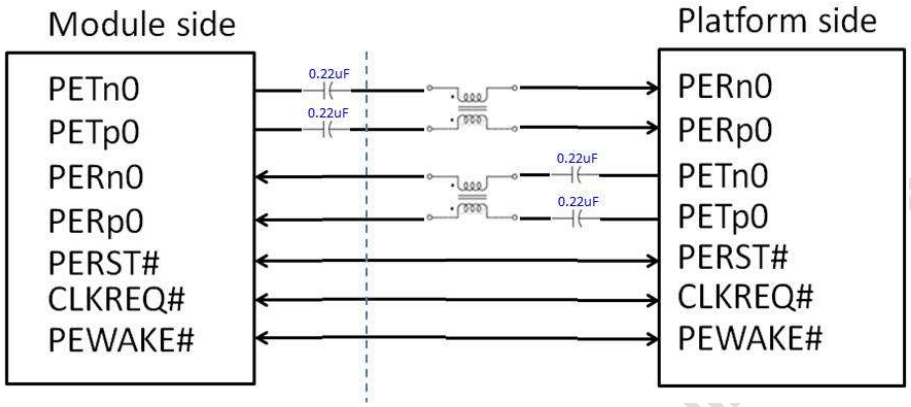
1.5.4 PCIe interface

T99W175 module is compliant with PCIe in all modes. When two devices are connected via a PCIe interface, one of the devices must act as a host, and the other device must act as a peripheral. The host is responsible for initiating and controlling traffic on the bus.

Figure 1-3PCIe interface

1. Reserve choke on all the PCIe signals in platform for noise reduction
2. Place 0.22uF capacitor on platform side PCIe Tx path for noise reduction
3. Place 0.22uF capacitor on module side PCIe Tx path for noise reduction

Notes: All the above components should be covered by shielding cover.



Remark:

PCIe configuration the module supports

Win10: MBIM, GNSS

Linux: DIAG, RmNet, Modem, NMEA

1.5.5 W_DISABLE#

This control setting is implementation-specific and represents the collective intention of the host software to manage radio operation. T99W175 provides a hardware pin (W_DISABLE#) to disable or enable the radio. Besides, the radio can also be enabled or disabled through software AT commands.

Item	State	Function (WWAN state)
W_DISABLE#1	Low	WWAN Disabled (no RF operation allowed)
	High	WWAN Enabled (RF operation allowed)
W_DISABLE#2	Low	GPS Disabled (no RF operation allowed)
	High	GPS Enabled (RF operation allowed)

Note: 1. W_Disable# is connected to configurable GPIO pin from PMIC, which can support either 3.3V VIO or 1.8V VIO. The default configuration is 3.3V VIO with interrupt function (low active); 1.8V will not disable RF function.

Please reserve external pull up 3.3V with 10K on W_DISABLE#1&W_DISABLE#1 for issue debug

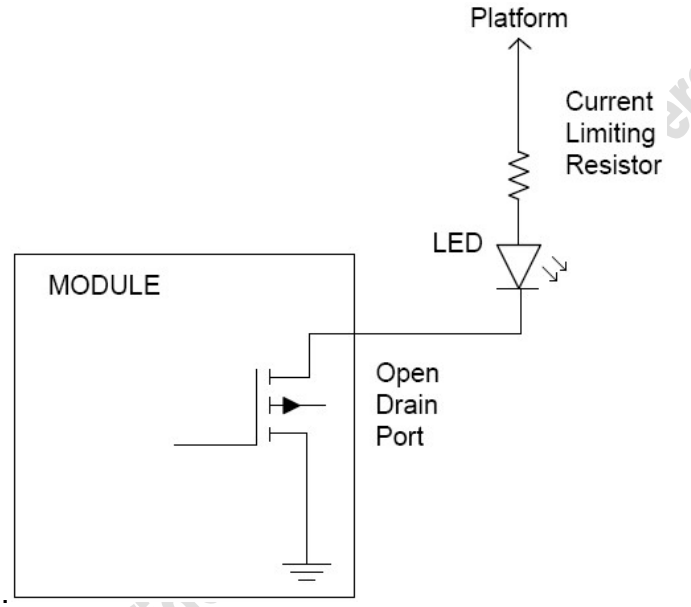
1.5.6 LED Indication

The LED signal is provided to enable wireless communication add-in cards to provide status indications to users via system provided indicators

(1) State of the LED# pin

Item	State	Definition	Interpretation
1	Low	The LED is emitting light.	Radio is capable of transmitting.
2	High	The LED is emitting no light.	Radio is incapable of transmitting.

(2) Typical LED Connection in Platform/System



1.5.7 DPR (Dynamic Power Reduction)

The optional DPR signal is used by wireless devices to assist in meeting regulatory SAR (Specific Absorption Rate) requirements for RF exposure. The signal is provided by a host system proximity sensor to the wireless device to provide an input trigger causing a reduction in the radio transmit output power.

The required value of the power reduction will vary between different host systems and is left to the host platform OEM and card vendor to determine, along with the specific implementation details. The assertion and de-assertion of DPR is asynchronous to any system clock. All transients resulting from the proximity sensor need to be de-bounced by system circuitry.

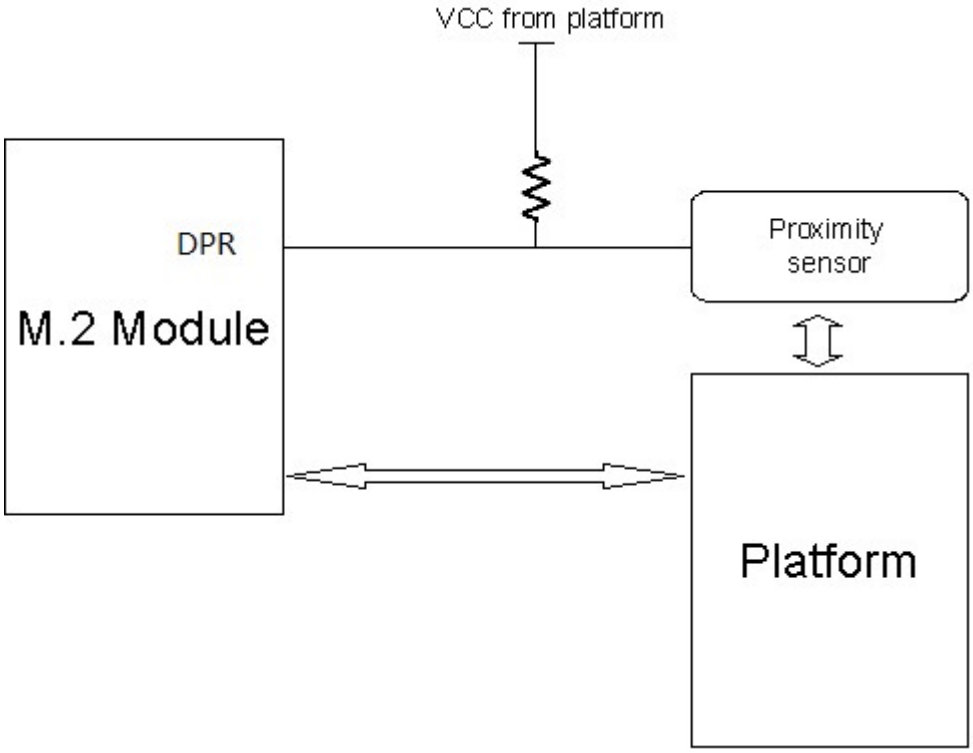
(1) State of the DPR

Design Pin 25 for DPR detection and reserved the 2nd DPR on Pin 28 to meet EN-DC multiple Tx requirement

Item	State	Definition
1	Low	Enable the SAR power back off.
2	High	Disable the SAR power back off, internally pull up

Note: DPR_1& 2 are connected to configurable GPIO pin from PMIC and Modem, which can support 1.8V VIO with interrupt function (low active)

(2) Typical Connection in Platform/System



(3) DPR table by different Platform requirement

Refer the detail DPR table base on different platform requirement and implement into FW setting

(Waiting customer provide)

Remark:

a. The platform (system) side needs design a proximity sensor connects to platform system side, while the sensor be triggered then pull low the DPR pin to enable SAR power back off mechanism

b. After DPR pin becomes low level, you can set the MAX TX power by AT commands.

c. If DPR2 not use please put as NC

1.5.8 USIM

The UIM contains parameters necessary for the WWAN device's operation in a wireless wide area network radio environment. The UIM signals are described in the following paragraphs for M.2 add-in cards that support the off-card UIM interface.

(1) 2 USIM interface

Design 2 USIM interface on M.2 connector; USIM _1 (Pin 30/32/34/36/66) dedicate for

external USIM socket; USIM_2 connect to on board e-SIM chip; Put Pin 40/42/44/46/48 as NC and reserved for 2nd external USIM socket

(2) USIM card socket

It is recommended to take electrostatic discharge (ESD) protection measures near the USIM card socket. The USIM socket should be placed near the NGFF interface (<100 mm), because a long circuit may impact signal quality.

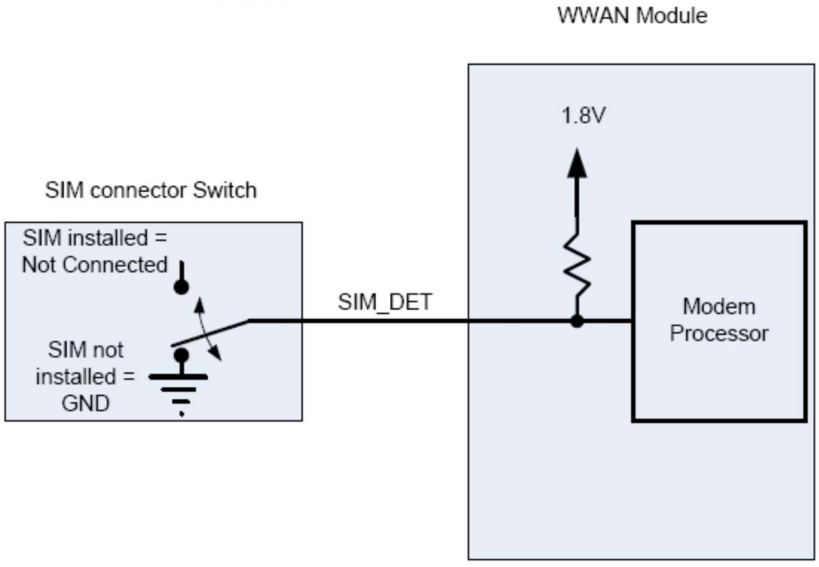
(3) UIM-PWR

UIM_PWR power supply can supply 1.8 V and 2.85 V power to UIM card and auto detects follow SIM card type

(4) SIM Detect

This signal is used to detect the insertion and removal of a SIM device in the SIM socket. With a Normal Short SIM Card connector, PUSH-PUSH type, the detect switch is normally shorted to ground when no SIM card is inserted. When the SIM is inserted, the SIM_DETECT will transition from logic 0 to logic 1 state. The rising edge will indicate insertion of the SIM card. When the SIM is pulled out, the SIM_DETECT will transition from logic1 to logic 0. This falling edge will indicate the pulling out of the SIM card. The M.2 module monitoring this signal will treat the rising/falling edge or the actual logic state as an interrupt, that when triggered, the module will act accordingly.

The UIM_PWR from the PRODUCT shall be turned ON 2 seconds after UIM_DETECT pin is asserted to HIGH. This is to ensure the power is not turned ON earlier before SIM card to be seated well.



(5) eSIM support

Build in eUICC is a product specifically designed for embedded UICC applications. It combines traditional smart card security with a more form factor at close as possible to the chip size, a chip-scale package (CSP), it supports Secure Element with the highest security

level (EAL5+ and EMVCo certified hardware) and fully compatible with the ISO/IEC 7816-3 standard (T=0, T=1) and a single-wire protocol (SWP) interface for communication
The detail implementation and requirement needs be engaged and discussed with customer

1.5.9 Antenna Control

T99W175 also provides MIPI interface (VIO=1.8V) for external antenna tuner application. The function is under development for customization. M.2 pin.56 (MIPI_DATA), Pin58(MIPI_CLK) M.2 pin24 (antenna tuner Power) are provided to allow for the implementation of antenna tuner solutions with variable capacitors. We will provide a tool to fill MIPI registers in ODM factory to enable antenna tuner support on specific platforms.

Pin No.	I/O	Description	Remark
56	I/O	MIPI Data	For external antenna tuner
58	I/O	MIPI Clock	For external antenna tuner
24	Power	VIO=1.8V	For antenna tuner power

1.5.10 Antenna Tuner Mode Switch

T99W175 provide two antenna tuner modes configure for Notebook and Tablet scenario through M.2 Pin22 (ANT_TUNER_CONFIG), and get more benefit on antenna performance

Item	Pin 22 State	Tuner Mode	Scenario
1	Low	0	For Notebook
2	High	1	For Tablet

1.5.11 Coexistence

COEX1 (Pin64), COEX2 (Pin62), LAA_n79_Tx_EN (Pin60), WLAN_Tx_EN(Pin38) are provided to allow for the implementation of wireless coexistence solutions between the radio(s) on the M.2 Card and other off-card radio(s). These other radios can be located on another M.2 Card located in the same host platform or as alternate radio implementations (for example, using a PCI Express M.2 CEM or a proprietary form-factor add-in solution). We also dual layout UART Tx/Rx with COEX1 and COEX2 for future extension, please contact with us if need to use these Pins.

Pin No.	Signal name	Description
COEX1 (Pin64)	LTE_ACTIVE (COEX_TXD)	TBD
COEX2 (Pin62)	LTE_FRAME_SYNC (COEX_RXD)	TBD

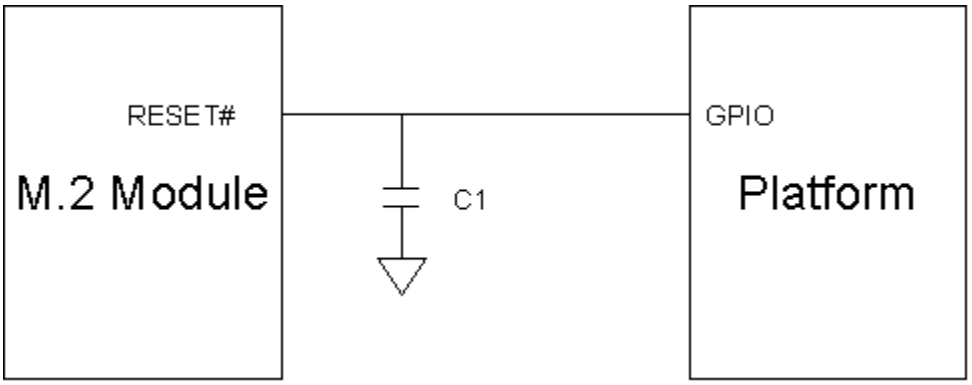
Co-existence between LAA and n79 with WiFi 5GHZ

Pin No.	Output	Input	Description
LAA_n79_Tx_EN (Pin60)	SDR865 GRFC2	WLAN 5G FEM	Avoid n79 Tx impact 5GHz Wi-Fi Rx
WLAN_Tx_EN(Pin38)	WLAN 5G Chip	LAA& n79 FEM	Avoid WLAN Tx impact n79/LAA Rx

1.5.12 RESET#

Asynchronous RESET# pin, active low. Whenever this pin is active, the modem will immediately be placed in a Power On reset condition. Care should be taken not to activate this pin unless there is a critical failure and all other methods of regaining control and/or communication with the WWAN sub-system have failed.

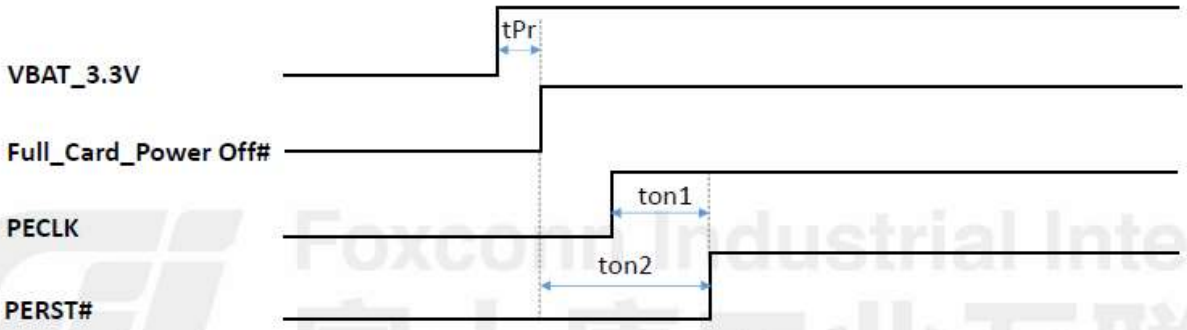
The Reset# signal is relatively sensitive; it is recommended to install one capacitor (10~100pF) near to the M.2 card pin.



1.5.13 Power off Timing Requirement

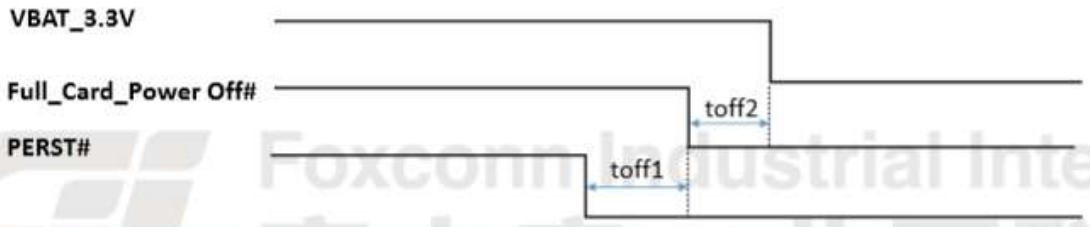
Detail refer to “SDX55 Power On& off Sequence Requirement”

(1) Power on timing requirement



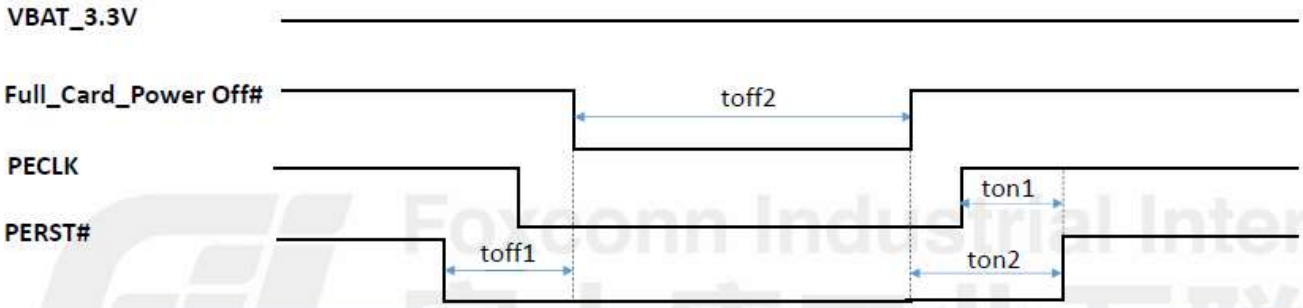
Timing	Typical	Note
tPr	10ms	3.3V power supply keep stable before Full_Card_Power_off# assert, If power supply always ready there is no tPr
ton1	150us	PCIe_CLK keep stable before PERST# inactive
ton2	150ms	PERST# should de-asserted after Full_Card_Power_Off#

(2) Power off timing requirement



Timing	Typical	Note
toff1	400ms	PERST# should de-asserted before Full_Card_Power_Off#
toff2	200ms	With MBIM driver installed, Full_Card_Power_Off# de-asserted hold time
	3s	Without MBIM driver installed, Full_Card_Power_Off# de-asserted hold time

(3) Warm boot& restart timing requirement



Timing	Typical	Note
toff1	400ms	PERST# should de-asserted before Full_Card_Power_Off#
toff2	500ms	With MBIM driver installed, Full_Card_Power_Off# de-asserted hold time
	3s	Without MBIM driver installed, Full_Card_Power_Off# de-asserted hold time
ton1	150us	PCIe_CLK keep stable before PERST# inactive
ton2	150ms	PERST# should de-asserted after Full_Card_Power_Off#

2. Hardware features

T99W175 consists of the following key engine components, in addition to the required front-end RF and other discrete components.

Modem engine

- Soft Baseband: SDX-55
- RF: SDR865
- Power: PMX55

Connectivity engine

- PCIe: PCI Express (EP and RC modes)
- USIM: located off board
- Antenna: connectors for the off-board antennas

2.1 Mobile Data Modem

The SDX55 chipset supports 5G NR standard for millimeter wave (mmW) bands and sub-6 GHz bands high-speed data capabilities over a wide range of air interface standards; the supported RF operating bands are defined by the chipset's RFICs. They are complete system solutions that operate on networks worldwide. The major functions of SDX55 used on T99W175 are listed below

❒ Processor:

- Manufactured in advanced 7 nm process - System uP (1.5 GHz ARM Cortex-A7 application processor and 1.5 GHz (Turbo) Qualcomm® Hexagon™ DSP modem processor and Cortex-M3 up to 400 MHz Hardware-based resource and power management

❒ Memory:

- External memory 4 Gb 16-bit × LPDDR4X at 1866 MHz; EBI2 for 8-bit NAND

❒ Air interface:

- WCDMA (R99, HSDPA, HSUPA, HSPA+, DC-HSPA+)
- LTE (R15 Cat20/22, FDD/TDD)
- 5GNR Rel 15 compliant
- 5GNR mmW (TDD only, 64 QAM for UL/DL)
- 5GNR sub-6 (256 QAM for UL/DL)
- GNSS supporting GPS, GLONASS, BeiDou, Galileo, and QZSS

❒ Advance RX operation:

- Mobile receive diversity (WCDMA, LTE) - 4x4 MIMO HORxD (LTE/ 5GNR Sub6G)

❒ Connectivity:

- PCI expresses (Supports Endpoint and Root Complex, Gen 3, 2 lanes)
- USB 2.0 or USB 3.1 Gen2

- QLink3.0
- SDIO 3.0
- UIM support (Two dual-voltage (1.8/2.85 V) ports)

2.2 RF transceiver

The SDR865 device is a highly integrated multimode, multiband RF CMOS transceiver IC that interfaces with the SDX55 device through QLink. The SDR865 device is the first integrated single-chip RFIC that supports 5G NR sub-6 together with legacy 2G to 4G LTE.

2.2.1 Key features of SDR865

❒ Qualcomm Technologies, Inc. (QTI) 14 nm RF CMOS device with an integrated modem subsystem in the PSP486 (0.35 mm pitch) package
❒ Single-chip RF transceiver implementing 2G/3G/4G and 5G NR sub-6
❒ 3GPP Rel15 5G NR sub-6
❒ Uplink 256 QAM and downlink 256 QAM support for LTE
❒ Uplink 256 QAM and downlink 256 QAM support for sub-6
❒ Downlink 4 × 4 MIMO and uplink 2 × 2 UL MIMO support for Sub6G

2.2.2 Key benefits of SDR865

❒ Multimode support
- 3GPP WCDMA Rel-99, HSDPA, HSUPA, HSPA+, DC-HSPA+, and 3C-HSPA+
- 3GPP LTE FDD and TDD with CA
- TD-SCDMA
- Licensed assist access (LAA)
- 5G NR sub-6 GHz

❒ LTE CA capability
- DLCA
- Inter-band DLCA; Intra band contiguous CA; Intra band non-contiguous
- ULCA
- Inter band ULCA; Intra band contiguous CA

❒ LTE MIMO capability
- 4 × 4 DL MIMO

❒ LTE Modulation
- UL: 256 QAM; DL: 256 QAM

❒ 3GPP 5G NR standard
- Sub-6 GHz

❒ 5G Modulation
- UL: 256 QAM; DL: 256 QAM

- ❒ Waveform
  - UL: CP-OFDM and DFT-S-OFDM; DL: CP-OFDM
- ❒ Sub-Carrier Spacing (SCS)
  - 15 KHz, 30 KHz
- ❒ Duplex mode
  - FDD and TDD
- ❒ Operation mode
  - Standalone mode (SA) and Non-Standalone mode (NSA)
- ❒ CA support
  - DLCA MIMO DL: 4 × 4 MIMO; UL: 2 × 2 MIMO
- ❒ EN-DC
  - LTE and NR sub-6 GHz dual connectivity
- ❒ Transmit signal paths
  - Three Tx chains (Tx0, Tx1, Tx2)
  - 17 Tx ports (Tx0: Eight ports; Tx1: Six ports; Tx2: Three ports)
- ❒ Receiver signal paths
  - 18 single-ended PRx inputs
  - 18 single-ended DRx inputs
- ❒ GNSS Rx path
  - GPS, GLONASS, Galileo, and BeiDou support integrated in SDR865
  - Two GNSS paths to support simultaneous L1 and L2/L5
- ❒ WAN and GNSS modes
  - Simultaneous GNSS (WAN + GNSS at the same time)
  - Standalone GNSS (without WAN)
- ❒ Tx feedback Rx path
  - Feedback receiver (FBRx) circuits integrated into the SDR865 for below purposes,
  - Inner loop power control (ILPC) and CLPC
  - Tx power estimation
  - Tx factory calibration
  - Online fast autoPin and autodelay (online fast autoPin and autodelay eliminate Pin and delay characterization over temperature)

2.3 Power management IC

T99W175 system uses the Qualcomm PMX55. The PMX55 device integrates all the wireless product's power management, general housekeeping, and user interface support functions into a single mixed-signal IC. Its versatile design is suitable for any multimode, multiband product. Since the PMX55 includes so many diverse functions, its operation is more easily understood by considering major functional blocks individually. Therefore, the

PMX55 document set is organized by the following device functionality:

2.3.1 Key features of PMX55

- ❒ Five HFS510 switched-mode power supplies (SMPS) and two FTS510 SMPS
- ❒ 16 LDO linear regulators
- ❒ On-chip ADC
- ❒ Overtemperature protection
- ❒ Sleep clock and RTC with alarm
- ❒ SPMI
- ❒ 11 GPIOs

2.3.2 Key benefit of PMX55

- ❒ Miscellaneous features
  - Ultra-low-power regulator retention mode
- ❒ Switched-mode power supplies (SMPS):
  - HF-SMPS: Five; two at 4 A, one at 3 A, two at 2.5 A
  - FT-SMPS: Two; two at 4 A
- ❒ Low dropout (LDO) linear regulators
  - 16; NMOS at 1.2 A (ten), PMOS at 600 mA (three) and at 150 mA (three)
- ❒ On-chip ADC
  - Shared housekeeping (HK)
- ❒ Analog multiplexing for ADC
  - HK inputs: Many internal nodes and external inputs
  - XO input: Dedicated pin (XO_THERM)
- ❒ Overtemperature protection
  - Multistage smart thermal control
- ❒ Special-purpose clock output
  - Sleep clock
- ❒ Real-time clock
  - RTC clock circuits and alarms
- ❒ IC-level interfaces
  - Primary status and control: Two-line SPMI
  - Interrupt managers: Supported by SPMI
- ❒ Configurable I/Os
  - GPIO pins Eleven: Six low-voltage variant (1.2/1.8 V tolerant) and five medium-voltage variants (VPH tolerant); configurable as digital inputs or outputs, or special functions

2.4 Antenna Design

2.4.1 Antenna specification

T99W175 also provides connectivity for off board antennas. The antennas and their connection interface for this device satisfy the requirements specified in the PCI Express M.2SpecificationRevision Version 1.2 standard. The antenna elements are typically integrated into the notebook/ultra-book /tablet and connected to T99W175module via flexible RF coaxial cables. T99W175provides four RF connectors (MHF4 type) and three 2 in 1 mmWave IF connectors. The four RF connectors include for 5GNR Sub 6G& LTE primary transmitter/receiver port, diversity receiver and 4x4 MIMO receiver port. The three IF connector dedicated for mmWave

For LTE and 5GNR Sub 6G to ensure stable RF performance, customer must assemble adequate antenna according to the antenna specification.

Table 2-1 LTE& 5GNR Sub 6G antenna specifications

Parameter	Min.	Typ.	Max.	Units	Notes
Cable loss	/	/	0.5	dB	Maximum loss to antenna
Impedance	/	50	/	Ohm	Antenna load impedance
VSWR	/	/	3:1	/	Maximum allowed VSWR of antenna
Isolation	20	/	/	dB	For all antenna each other

Note:

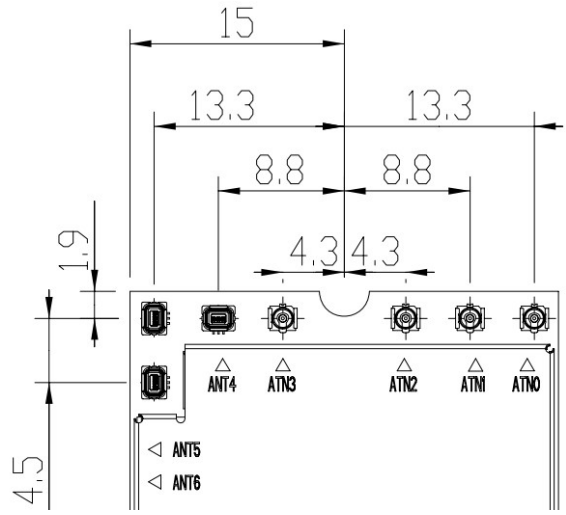
1. Antenna peak gain limit as 2.5dBi for frequency <1.5GHz and 4dBi for frequency >1.5GHz
2. For Japan regional peak gain should be limited as 2.5dBi for frequency <1.5GHz and 3dBi for frequency >1.5GHz
3. For Band 30 peak gain limit as 2.99dBi (Meet FCC certify)
4. For Band 48 peak gain limit as 0.92dBi (Meet FCC certify)

Item	Antenna Gain	Frequency range
1	<2.5dBi	<1.5GHz
2	<4dBi	>1.5GHz (Except Japan)
3	<3dBi	>1.5GHz for Japan
4	<2.99dBi	2300MHz -2690MHz(B30)
5	<0.92dBi	3550MHz -3700MHz(B48)

2.4.2 Antenna location and mechanical design.

To ensure customer has a clear knowledge of the two antennas, check below product picture.

Figure 2-1 Antenna connector location and type

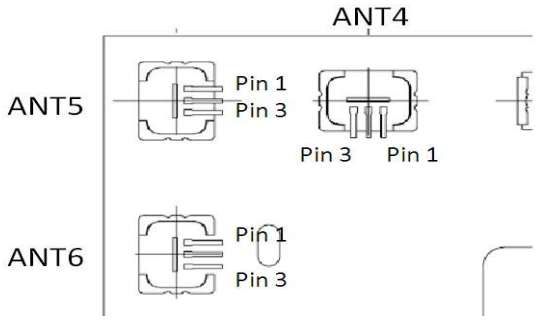


Antenna	Interface
ANT0	LTE& Sub 6G Tx/Rx
ANT1	LTE& Sub 6G Rx/GPS L5
ANT2	LTE& Sub 6G Tx/Rx
ANT3	LTE& Sub 6G Rx/GPS L1
ANT4	mmWave IF_1
ANT5	mmWave IF_2
ANT6	mmWave IF_3

Figure 2-2 LTE& Sub 6G antenna connector configure

Antenna Port	Tx	Rx
ANT0	WCDMA:B1/2/4/5/8/9/19 **LTE:** LB:B5,8,12,13,14,17,18,19,20,26,28,71 MHB:B1,2,3,4,7,25,30,34,38,39,40,41,66 **5G Sub6G:** LB:n5,8,12,20,28,71 MHB:n2,66	WCDMA:B1/2/4/5/8/9/19 **LTE:** LB:B5,8,12,13,14,17,18,19,20,26,28,29,71 MHB:B1,2,3,4,7,25,30,32,34,38,39,40,41,66 UHB:B42,48; LAA: B46 **5G Sub6G:** LB:n5,8,12,20,28,71 MHB:n1,2,3,7,38,41,66 UHB:n77,78,79
ANT1		**LTE:** MHB:B1,2,3,4,7,30,38,41,66 UHB:B42,48 **5G Sub6G:** MHB:n1,2,3,7,38,41,66 UHB:n77,78,79
ANT2	**LTE:** MHB:B1,2,3,7,66 UHB:B42,48 **5G Sub6G:** MHB:n1,2,3,7,38,41,66 UHB:n77,78,79	**LTE:** MHB:B1,2,3,4,7,30,38,41,66 UHB:B42,48 **5G Sub6G:** MHB:n1,2,3,7,38,41,66 UHB:n77,78,79
ANT3		WCDMA:B1/2/4/5/8/9/19 **LTE:** LB:B5,8,12,13,14,17,18,19,20,26,28,29,71 MHB:B1,2,3,4,7,25,30,32,34,38,39,40,41,66 UHB:B42,48; LAA: B46 **5G Sub6G:** LB:n5,8,12,20,28,71 MHB:n1,2,3,7,38,41,66 UHB:n77,78,79

Figure 2-3 mmWave IF connector configure



IF connector	ANT4	ANT6	ANT5
Pin No.	**mmWave_1**	**mmWave_3**	**mmWave_2**
1	RF_IFH1	RF_IFH4	RF_IFH2
3	RF_IFV4	RF_IFV1	RF_IFV3
mmWave Control Pin No	mmWave_Enable_1(M.2 pin59)	mmWave_Enable_2(M.2 pin61)	mmWave_Enable_3(M.2 pin63)

Figure 2-4 MHF4 RF connectors

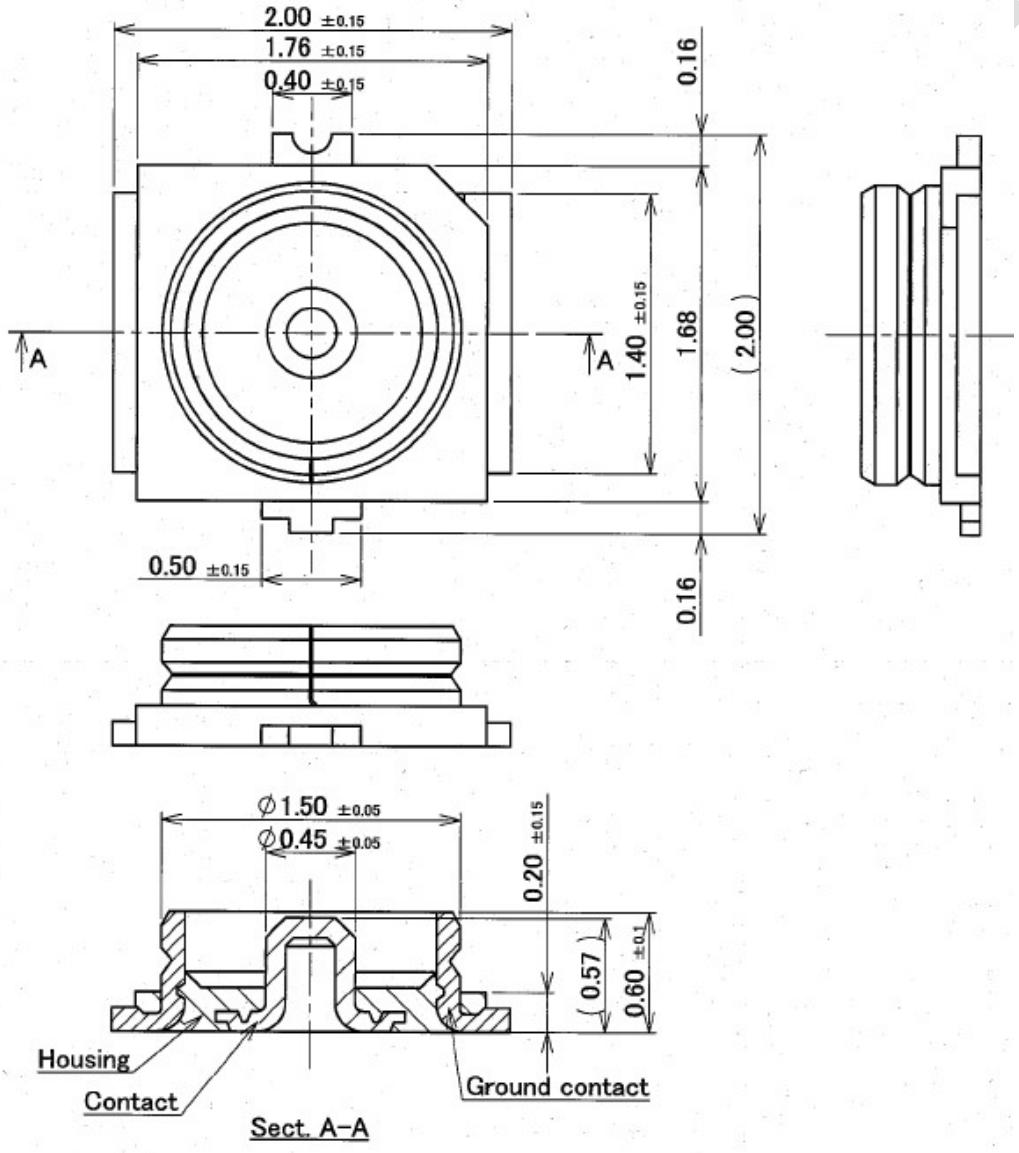
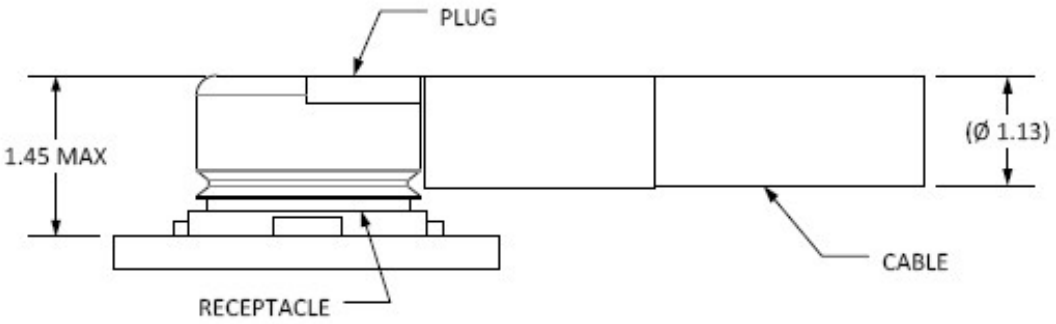
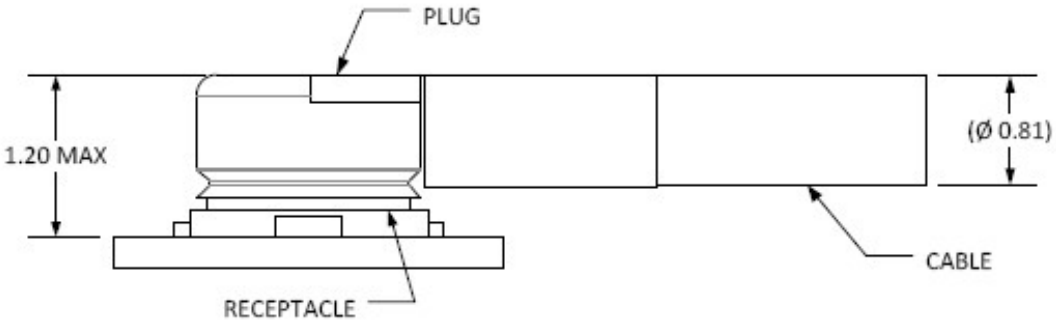


Figure 2-5 MHF4 RF receptacles

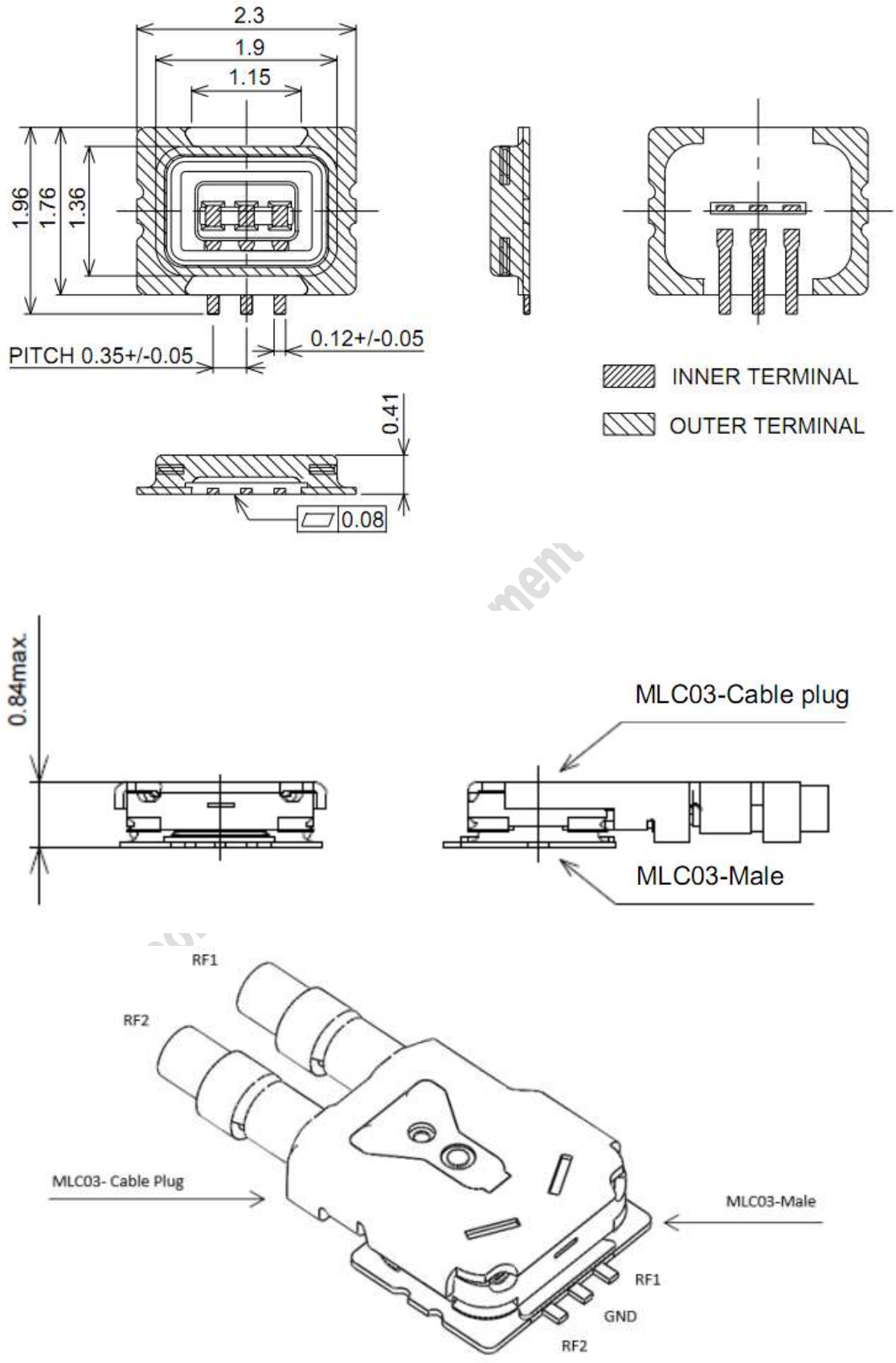


Mated Plug for Ø 1.13 mm Coax Cable



Mated Plug for Ø 0.81 mm Coax Cable

Figure 2-6 mmWave IF connector



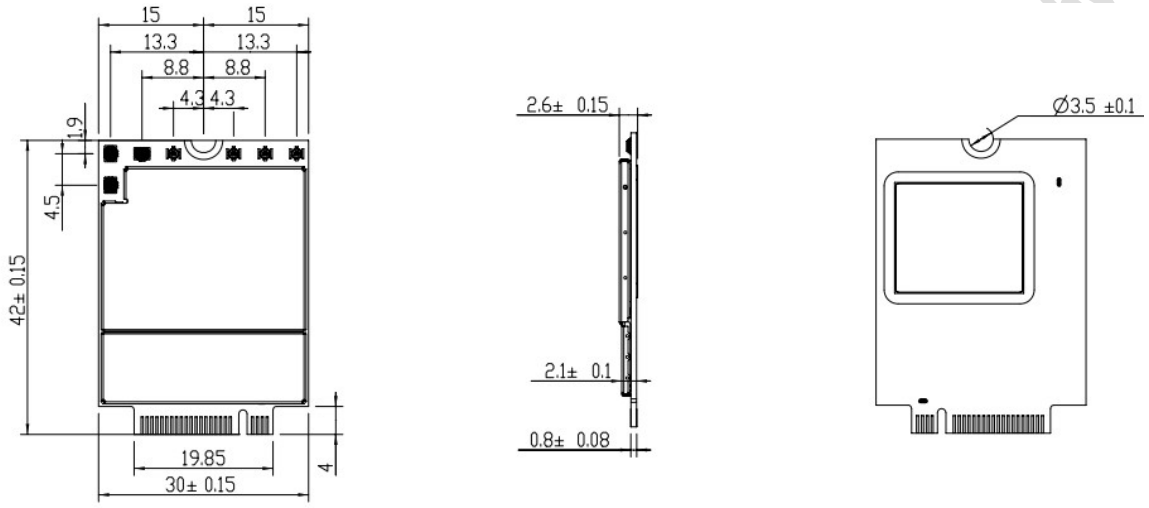
3. Mechanical Specifications

3.1 Overview

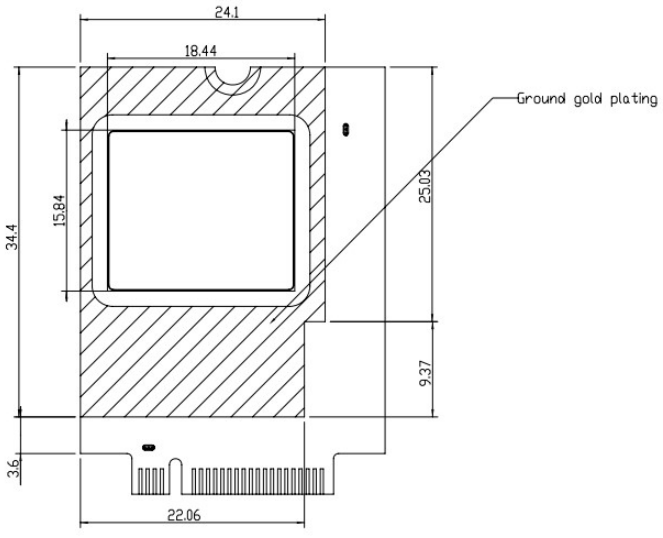
T99W175is compatible with the PCI Express M.2Specification 3042Key.B type 75-pin card edge-type connector. Refer to Electromechanical Specification Revision 1.2

3.2 Mechanical constraints

Figure 3-1 shows the mechanical constraints ofT99W175 (3042-S3-B)



1. Ground area (with gold plating) on bottom side

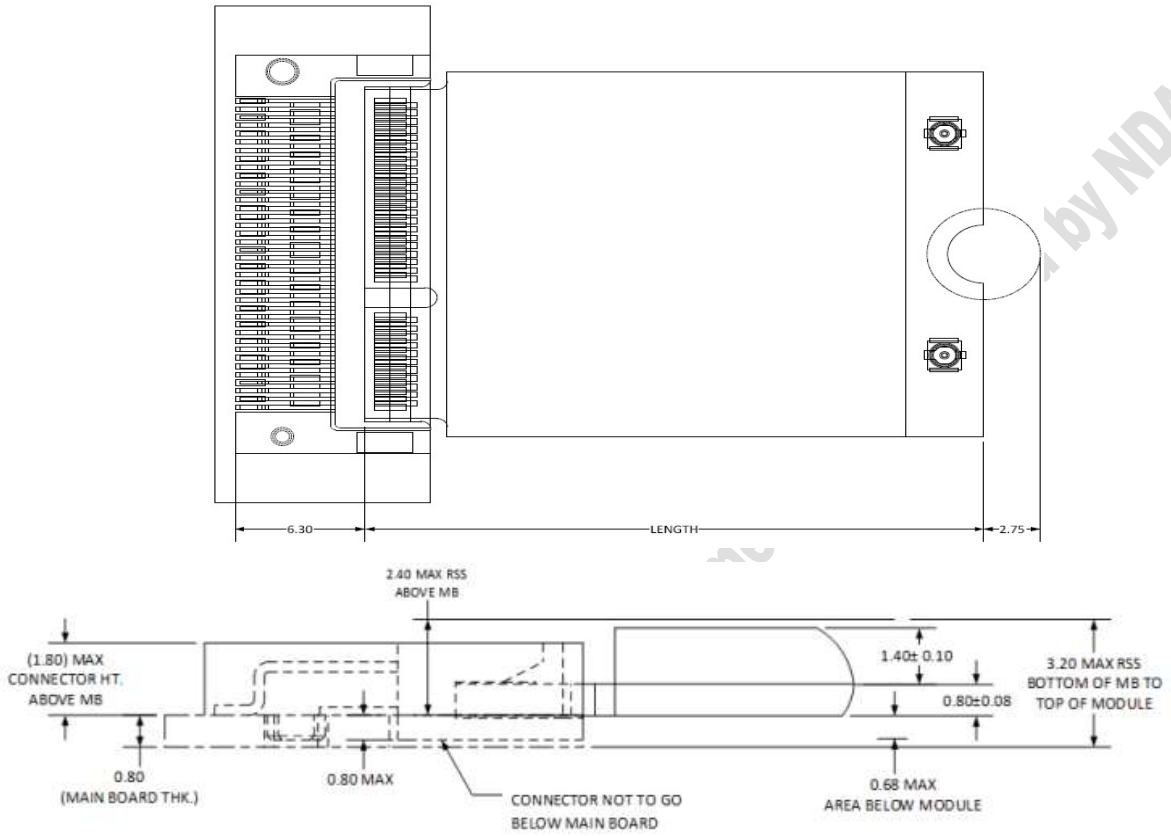


2. The recommendation extrusion pressure and force should be less than 30N between Module top and bottom side

3.3 M.2 card assembly

3.3.1 Mid-mount Connection with Single Side Module

Figure 3-2 shows Stack-up Mid-Line (In-line) Single Sided Module for 1.5Maximum Component Height; refer to section 2.4.8.3.1 of PCIe M.2_Rev 1.2 standard.

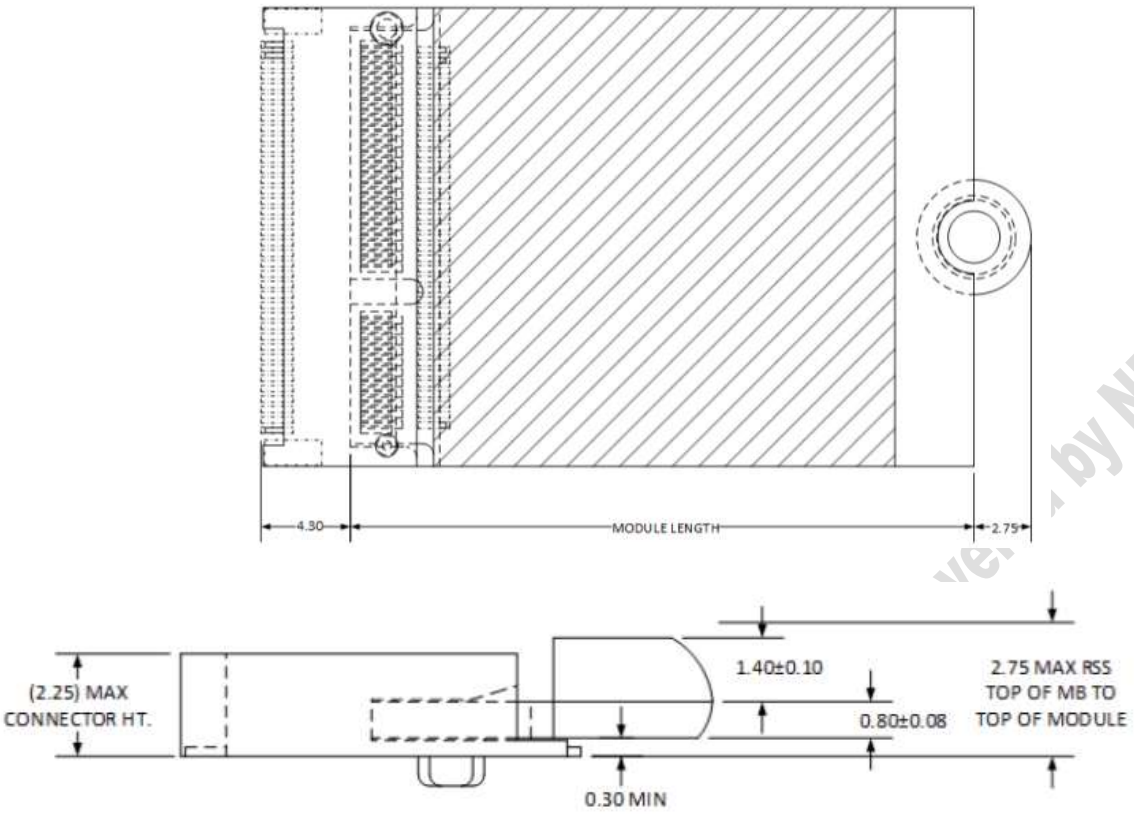


Remark:

a. 2.6mm maximum above mother board
b. Cut area of main board under M.2 module
c. Need to add thermal pad between M.2 modules with mechanical component (like material shielding) for thermal dissipation.

3.3.2 Top-mount Connection with Single Sided Module

Figure 3-4 shows Top Mount Single-sided Module for 1.5Maximum Component Height; refer to section 2.4.7.3.1 of PCIe M.2_Rev 1.2 standard.

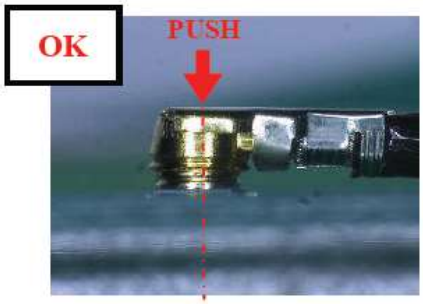


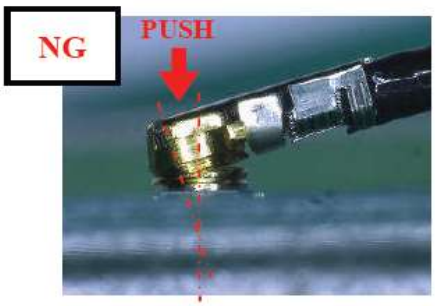
Remark:

a. 2.75mm maximum above mother board
b. Full Keep out area 30x42mm" below module which means platform do not place any components and routings below M.2 module
c. Need to add thermal pad between M.2 modules with mother board for thermal dissipation

3.4 Connector assembly

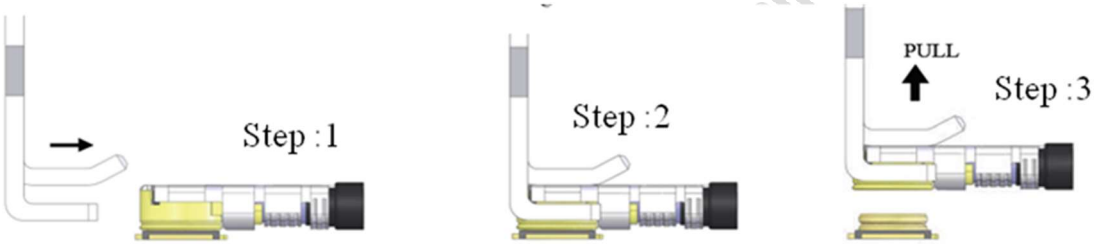
a. Mate the connector vertically as much as possible. Adjusting the mating axis of plug and receptacle. Do not slant mate.



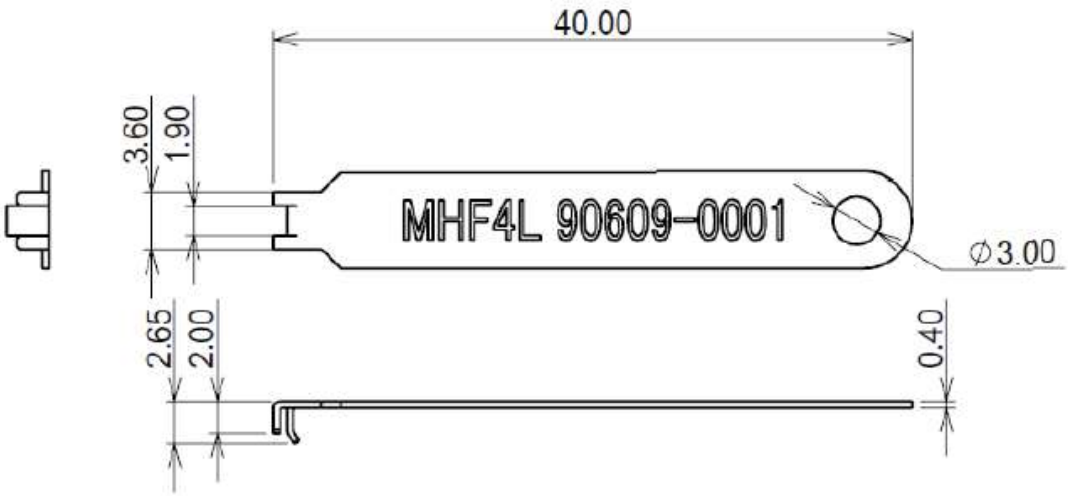


.

b. Unmating: In case of unmating by pulling tool. Use the pulling tool as the following drawing, and pull plug to vertical direction as directly as possible



c. Pulling tool (Unit:mm)



4. Electrical Specifications

4.1Recommended operating conditions

Table 4-1 Recommended operating conditions

Parameter	Min	Type	Max	Units
Storage temperature	-40	+25	+85	°C
Recommend operating temperature (3GPP compliant) (*1)	-30	+25	+70	°C
Extendable (with limited performance) Temperature measure on T99W175 module (*2)	-40		+85	°C
Operating voltage	3.135	3.3	3.63	Vdc

Note: The operating temperature reference point is board temperature on module bottom side (Ground Golding plating area)

(1) Refer application note about thermal mitigation plan (Update later)

(2). Extendable operation allows normal mode data transmission for limited time until automatic thermal shutdown takes effect. Within the extendable temperature range (outside the operating temperature range) the specified electrical characteristics may be degraded.

(3). Due to temperature measurement uncertainly, a tolerance on the stated shutdown thresholds may occur. The possible deviation is in the range of +/- 2 ℃ at the over-temperature and under-temperature limit.

(4). Need implement thermal solution on Platform (Example add thermal pad and Vapor chamber to heat dissipated from 5G module to Platform side) would get more thermal margin and benefit then extend the operating temperature

Operating T99W175 device under conditions beyond its absolute maximum ratings (Table 4-1) may damage the device. Absolute maximum ratings are limiting values to be considered individually when all other parameters are within their specified operating ranges. Functional operation and specification compliance under any absolute maximum condition, or after exposure to any of these conditions, is not guaranteed or implied. Exposure may affect device reliability

4.2 Power consumption

Table 4-2 Radio system power consumption

Test condition	Estimated Power Range (Typical)	Estimated Power Range (Max.)	Remark
WCDMA in Suspend Mode	<3mA		
WCDMA (Tx=23.5dBm)	<900 mA	<1200 mA	
LTE in Suspend Mode	<3mA		
LTE (16QAM) Tx=23 dBm	<1000 mA	<1300 mA	
LTE 3CA mode 4x 4, Tx=23dBm	<1200 mA	<2000 mA	
LTE 5CA mode 2x 2, Tx=23dBm	<1300 mA	<2000 mA	
5G Sub 6G ENDC mode 4x 4, Tx=23dBm	<1800mA	<2500 mA	
GPS/GNSS Tracking	<150mA	<300mA	
Connected Standby	<3mA		
Radio Off	<3mA		

4.3Thermal dissipation proposal

TBD

5. RF performance specifications

Radio performance forT99W175 is given in the following sections, including RF receiver, RF transmitter.

5.1 RF maximum TX power specifications

Table 5-1 Conductive Maximum transmits power (LTE BW: 10MHz)

Notes: The below test result is for reference only; we will update the final Spec base on 1st 10k MP build CPK

LTE Band	3GPP Standard (dBm)	Design Spec.(dBm)		
		Max.	Typ.	Min.
1	23+/-2	24	23	22
2	23+/-2	24	23	22
3	23+/-2	24	23	22
4	23+/-2	24	23	22
5	23+/-2	24.5	23.5	22.5
7	23+/-2	24	23	22
8	23+/-2	24.5	23.5	22.5
12	23+/-2	24.5	23.5	22.5
13	23+/-2	24.5	23.5	22.5
14	23+/-2	24.5	23.5	22.5
17	23+/-2	24.5	23.5	22.5
18	23+/-2	24.5	23.5	22.5
19	23+/-2	24.5	23.5	22.5
20	23+/-2	24.5	23.5	22.5
25	23+/-2	24	23	22
26	23+/-2	24.5	23.5	22.5
28	23+/-2	24.5	23.5	22.5
30	23+/-2	23	22	21
34	23+/-2	24	23	22
38	23+/-2	24	23	22
39	23+/-2	24	23	22
40	23+/-2	24	23	22
41	23+/-2	24	23	22
41(HPUE)	26+2/-3	27	25.5	24
42	23+/-2	24	23	22
48	23+/-2.7	22	21	20.3
66	23+/-2	24	23	22
71	23+/-2	24.5	23.5	22.5

WCDMA Band	3GPP Standard (dBm)	Design Spec.(dBm)		
		Max.	Typ.	Min.
1	24+1.7/-3.7	24.5	23.5	22.5
2	24+1.7/-3.7	24.5	23.5	22.5
4	24+1.7/-3.7	24.5	23.5	22.5
5(6/19)	24+1.7/-3.7	24.5	23.5	22.5
8	24+1.7/-3.7	24.5	23.5	22.5
9	24+1.7/-3.7	24.5	23.5	22.5

5GNR Sub 6G	3GPP Standard (dBm)	Design Spec.(dBm)		
		Max.	Typ.	Min.
n1	23+/-2	24	23	22
n2	23+/-2	24	23	22
n3	23+/-2	24	23	22
n5	23+/-2	24	23	22
n7	23+/-2	24	23	22
n8	23+/-2	24	23	22
n12	23+/-2	24	23	22
n20	23+/-2	24	23	22
n28	23+/-2	24	23	22
n38	23+/-2	24	23	22
n41	23+/-2	24	23	22
n41(HPUE)	26+2/-3	27	25.5	24
n66	23+/-2	24	23	22
n77	23+/-2	24	23	22
n77(HPUE)	26+2/-3	27	25.5	24
n78	23+/-2	24	23	22
n78(HPUE)	26+2/-3	27	25.5	24
n79	23+/-2	24	23	22
n79(HPUE)	26+2/-3	27	25.5	24

Note: n41/n77/78/79 SA HPUE (Power Class2) support move to SA mode be available

ENDC (LTE+Sub6G)	3GPP Standard (dBm)	Sub6G Spec.(dBm)			Combine Spec. with DPS (dBm)		
		Max.	Typ.	Min.	Max.	Typ.	Min.
n1	23+/-2	24	23	22	24	23	22
n2	23+/-2	24	23	22	24	23	22
n3	23+/-2	24	23	22	24	23	22
n5	23+/-2	24	23	22	24	23	22
n7	23+/-2	24	23	22	24	23	22
n8	23+/-2	24	23	22	24	23	22
n12	23+/-2	24	23	22	24	23	22
n20	23+/-2	24	23	22	24	23	22
n28	23+/-2	24	23	22	24	23	22
n38	23+/-2	24	23	22	24	23	22

n41	23+/-2	24	23	22	24	23	22
n41 (HPUE)	26+2/-3	27	25.5	24	27	25.5	24
n66	23+/-2	24	23	22	24	23	22
n71	23+/-2	24	23	22	24	23	22
n77	23+/-2	24	23	22	24	23	22
n78	23+/-2	24	23	22	24	23	22
n78 (HPUE)	26+2/-3	27	25.5	24	27	25.5	24
n79	23+/-2	24	23	22	24	23	22
n79 (HPUE)	26+2/-3	27	25.5	24	27	25.5	24

Note: 1. LTE power follow single band Tx power Spec

2. EN-DC HPUE (Power Class2) just support “DC_B41+n41/ n41AA; DC_B39+n41; DC_B41+n79; DC_B39+n79” based on current Carrier requirement

5.2 RF min. Rx sensitivity specifications

Below is initial Spec base on DVT sample test data, will update and lock down with PVT test result

Table 5-2 Conductive Minimum Sensitivity (LTE BW: 10MHz)

Band	3GPP MIMO Combined(dBm)	Design Spec.(dBm)				
		PRx (ANT0)	DRx (ANT3)	HORx_1 (ANT1)	HORx_2 (ANT2)	MIMO Combined
1	-95	-96	-96	-97	-96	-102.5
2	-95	-96	-96	-97	-95.5	-102
3	-94	-96	-96	-96	-95.5	-102.5
4	-97	-96	-96	-97	-96	-103
5	-95	-99	-99	NA	NA	-102
7	-95	-96	-96	-96	-95.5	102.5
8	-94	-99	-99	NA	NA	-102
12	-94	-98.5	-99	NA	NA	-101.5
13	-94	-98.5	-99	NA	NA	-101.5
14	-94	-98	-99	NA	NA	-101
17	-94	-98.5	-99	NA	NA	-101.5
18	-97	-98.5	-99	NA	NA	-101.5
19	-97	-98.5	-99	NA	NA	-101.5
20	-94	-99	-99	NA	NA	-102
25	-93.5	-96	-96	-96	-95.5	-102
26	-94.5	-98.5	-99	NA	NA	-101.5
28	-95.5	-98.5	-99	NA	NA	-101.5
29	-94	-98.5	-99	NA	NA	-101.5
30	-97	-95.5	-96	-96	-96	-101
32	-97	-96	-96.5	NA	NA	-99
34	-97	-97	-97	NA	NA	-100
38	-97	-96.5	-96.5	-96.5	-96	-102.5
39	-97	-97	-97	NA	NA	-100
40	-97	-96	-96.5	-97	-96	-103
41	-96	-96	-96	-96	-95.5	-102

42	-96	-96.5	-96.5	-97	-97	-103
46	-93	-96	-95	NA	NA	-98
48	-96	-96.5	-96.5	-97	-97	-103
66	-96.5	-96	-97	-97	-97	-103
71	-94.2	-99	-99	NA	NA	-102

Band	3GPP 2x2 MIMO Combined(dBm) (Refer to 3GPP 38101-1-G30)	Design Spec.(dBm)				
		ANT0	ANT1	ANT2	ANT3	MIMO Combined
n1	-93.8	-92	-91.5	-91.5	-92	-97
n2	-91.8	-91.5	-91.5	-91.5	-91.5	-97
n3	-90.8	-91.5	-91	-91	-91.5	-96.5
n5	-86.8	-91.5	-91.5	NA	NA	-94
n7	-91.8	-90.5	-90	-90	-90.5	-95.5
n8	-85.8	-92.5	-92.5	NA	NA	-95.5
n12	-84.0	-90	-90	NA	NA	-93
n20	-89.8	-92.5	-92.5	NA	NA	-95.5
n28	-90.8	-92	-92	NA	NA	-95
n38	-94	-91.5	-91.5	-91.5	-91.5	-97.5
n41	-92	-91.5	-91.5	-91.5	-91.5	-97
n66	-93.3	-91.5	-91.5	-91	-91.5	-97
n71	-86	-92	-92	NA	NA	-95
n77	-92.4	-91.5	-92	-91.5	-92	-97.5
n78	-92.9	-92	-92	-92	-92.5	-98
n79	-89.7	-89	-90	-89	-90	-95

Note: 1. n1/ n2/ n3/ n5/ n7/ n8/ n20/ n28/ n66/ n71: SCS=15KHZ; BW=20MHZ;

2. n41/ n77/ n78: SCS=30KHZ; BW=20MHZ;

3. n79: SCS=30KHZ; BW=40MHZ

4. n12: SCS=15KHZ; BW=15MHZ

GNSS Spec.		Design target (dBm)	Spec (dBm)			
GNSS tracking sensitivity (Stand Alone)	GPS	-160	-158±2			
	GLONASS	-160	-158±2			
	BEIDOU	TBD	TBD			
	GALILEO	TBD	TBD			
AGPS tracking sensitivity		-157	-156±1			
Indoor TTFF@-145dBn	Cold start	<35s				
	Warm start	<20s				
	Hot start	<2s				

5.3 Bandwidth specifications：

Table 5-3.1 LTE Support Bandwidth table

Band	1.4M	3M	5M	10M	15M	20M
1	×	×	√	√	√	√
2	√	√	√	√	√	√
3	√	√	√	√	√	√
4	√	√	√	√	√	√
5	√	√	√	√	×	×
7	×	×	√	√	√	√
8	√	√	√	√	×	×
12	√	√	√	√	×	×
13	×	×	√	√	×	×
14	×	×	√	√	×	×
17	×	×	√	√	×	×
18	×	×	√	√	√	×
19	×	×	√	√	√	×
20	×	×	√	√	√	√
25	√	√	√	√	√	√
26	√	√	√	√	√	×
28	×	√	√	√	√	√
29	×	√	√	√	×	×
30	×	×	√	√	×	×
32	×	×	√	√	√	√
34	×	×	√	√	√	×
38	×	×	√	√	√	√
39	×	×	√	√	√	√
40	×	×	√	√	√	√
41	×	×	√	√	√	√
42	×	×	√	√	√	√
46	×	×	×	√	×	√
48	×	×	√	√	√	√
66	√	√	√	√	√	√
71	×	×	√	√	√	√

Table 5-3.2 5G Sub6G Support Bandwidth table

Band	SCS (KHz)	5M	10M	15M	20M	40M	50M	60M	80M	90M	100M
n1	15	√	√	√	√	×	×	×	×	×	×
n2	15	√	√	√	√	×	×	×	×	×	×
n3	15	√	√	√	√	×	×	×	×	×	×
n5	15	√	√	√	√	×	×	×	×	×	×
n7	15	√	√	√	√	×	×	×	×	×	×
n8	15	√	√	√	√	×	×	×	×	×	×
n12	15	√	√	√	×	×	×	×	×	×	×
n20	15	√	√	√	√	×	×	×	×	×	×
n28	15	√	√	√	√	×	×	×	×	×	×

n38	30	×	×	×	√	×	×	×	×	×	×
n41	30	×	×	×	√	√	√	√	√	√	√
n66	15	√	√	√	√	×	×	×	×	×	×
n71	15	√	√	√	√	×	×	×	×	×	×
n77	30	×	×	×	×	√	√	√	√	√	√
n78	30	×	×	×	√	√	√	√	√	√	√
n79	30	×	×	×	×	√	√	√	√	√	√