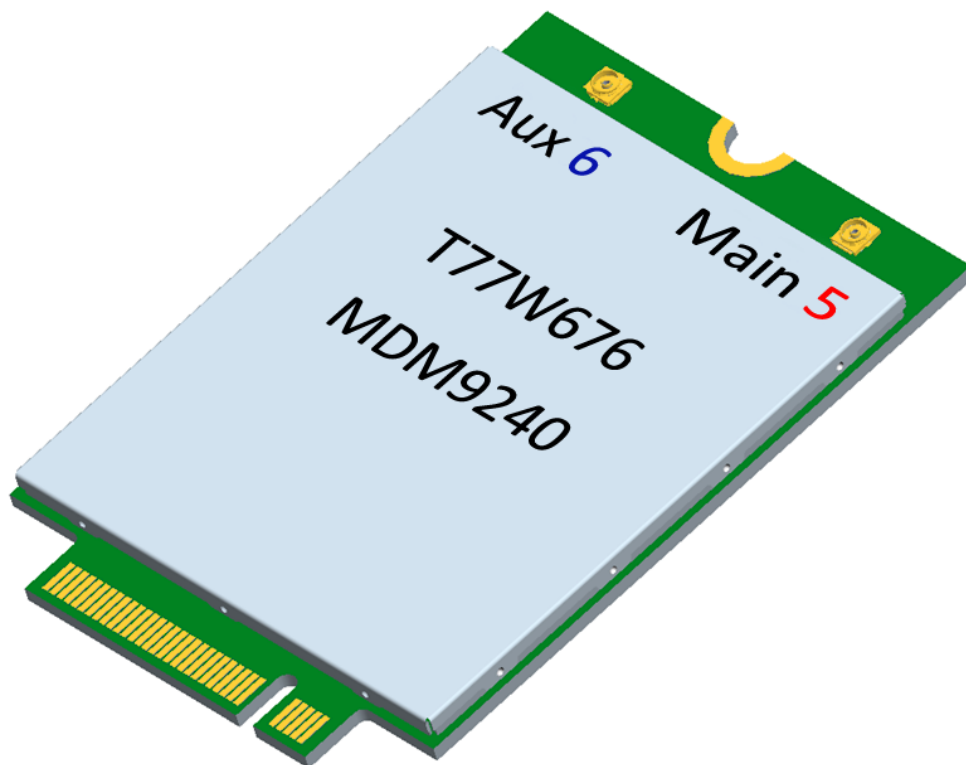# LTE-Advanced PCI Express M.2 Module (LTE, UMTS)

Engineering Requirements Specification

Project code: T77W676.00
Solution: MDM9240+WTR3925+WTR4905
SKU: WW-3-S3

FOXCONN® COMPANY CONFIDENTIAL

Reviewers

Department	Name	Signature	Review Dates	
			* Plan	** Results
Project Manager	Choro.Chung			
Project Leader	Ai-ning Song			
Hardware Engineer	Yannie.Zhang			

Modification History

Rev	Date	Originator	Comment
D1.0	2016/12/13	Yannie.Zhang	Initial release for customer discussion and carrier engagement, will update it after hardware design frozen.
D1.1	2016/12/27	Yannie.Zhang	Change the module picture and remark 1.8V MIPI.
D1.2	2017/2/24	Yannie.Zhang	Update RF performance follow EVT design
D1.3	2017/05/10	Yannie.Zhang	Upadte CA Combination.
D1.4	2017/08/02	Yannie.Zhang	Update LTE B5 power's spec.

CONTENTS

1. General Description

T77W676.00 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. T77W676.00 is the data card solution that delivers wireless wide-area network (WWAN) connectivity for the LTE, UMTS (HSDPA/HSUPA/HSPA+/DC-HSPA+) and GPS/Glonass/Beidou protocols in one hardware configuration.

SKU		WW-3-S3 / T77W676
Carrier Support		NA: AT&T, Verizon, Sprint WW: Vodafone, Orange, Telefonica-O2 EU: Deutsche Telekom, Swisscom APAC: Telstra, Optus, Docomo, KDDI China: CMCC/CUCC/CTCC * Carrier engagement based on real business agreement
QCT Solution		MDM9240+WTR3925+WTR4905+PMD9645
4G	FDD	FDD / TDD
	Support Band	B2/4/5/7/12/13/17/25/26/30/38/41/66
	Carrier Aggregation	2CCs&3CCs DL CA, 2X2MIMO, Up to inter-band 3CCs DL
	Cat (DL/UL Mbps)	Up to Cat11 @20MHz+20MHz+20MHz 3CCs DL CA
3G	WCDMA	HSPA+ Rel8 (DL/UL: up to 42/11 Mbps)
	Support Band	Band4
GNSS		GPS/GLONASS/Beidou
Interface		USB2.0, USB3.0
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~4.4V follow M.2 standard)
Dimension	Dimensions (L × W × H): 42 mm × 30 mm × 2.3 mm, maximum height=2.38mm (add PCB tolerance=0.08mm)
Shielding design	Shield case on board design, no additional shielding requirement
Weight	Approximately ~6g
USIM	Off-board USIM connector supported

Operating Bands	WCDMA/HSDPA/HSUPA/HSPA+ operating bands:
	   Band 4: 1710 to 1755 MHz (UL), 2110 to 2155 MHz (DL)
	
	LTE FDD operating bands:
	   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 7: 2500 to 2570 MHz (UL), 2620 to 2690 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 17: 704 to 716 MHz (UL), 734 to 746 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 30: 2305 to 2315 MHz (UL) 2350 to 2360 MHz (DL)
	   Band 38: 2570 to 2620 MHz (UL/DL)
	   Band 41: 2496 to 2690 MHz (UL/DL)
	   Band 66: 1710 to 1800 MHz (UL), 2110 to 2200 MHz (DL)

Diversity/2nd Rx	All UMTS operating bands All LTE operating bands
GNSS	GPS: L1 (1575.42MHz) GLONASS: L1 (1602MHz) Beidou (1561.098MHz)
USIM Voltage	Support 1.8V and 2.85V, and auto detects follow SIM card type
Antenna connectors	MAIN and AUX(supports Diversity and GPS simultaneously)
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 Cat4: DL:150 Mbps/UL 50 Mbps LTE Cat6: DL:300 Mbps/UL 50 Mbps LTE Cat9: DL:450 Mbps/UL 50 Mbps LTE Cat11: DL:585 Mbps/UL 50 Mbps

LTE air interface

LTE Rel11

- FDD: up to 585 Mbps downlink, 50 Mbps uplink
- Up to 20MHz+20MHz+20MHz Inter-band or Intra-band 3DL CA
- Support 256QAM in DL, 16QAM in UL (64QAM software upgradable)
- Support TDD+FDD CA (3GPP Rel12 feature)
- 1.4 to 20 MHz RF bandwidth
- Support downlink 4X2 MIMO
- IPv6, QoS

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

  Uplink 16 QAM: up to 5.76 Mbps
- R8 DC-HSPA+

  Downlink dual carrier with 64 QAM (SISO); up to 42 Mbps
- IPv6

GNSS

- Customizable tracking session
  - Automatic tracking session on startup
  - Concurrent standalone GPS, GLONASS and BeiDou
  - gpsOneXTRA with GPS + GLONASS + BeiDou support

1.2 Carrier aggregation combination

1.2.1. Refer to Qualcomm documents 80-NR113-650, Rev.E, Published: 03-16-2016.
Remark: T77W676 hardware design can support follow CA combination, but the Final CA combinations plan depends on carrier engagement and Qualcomm software design.
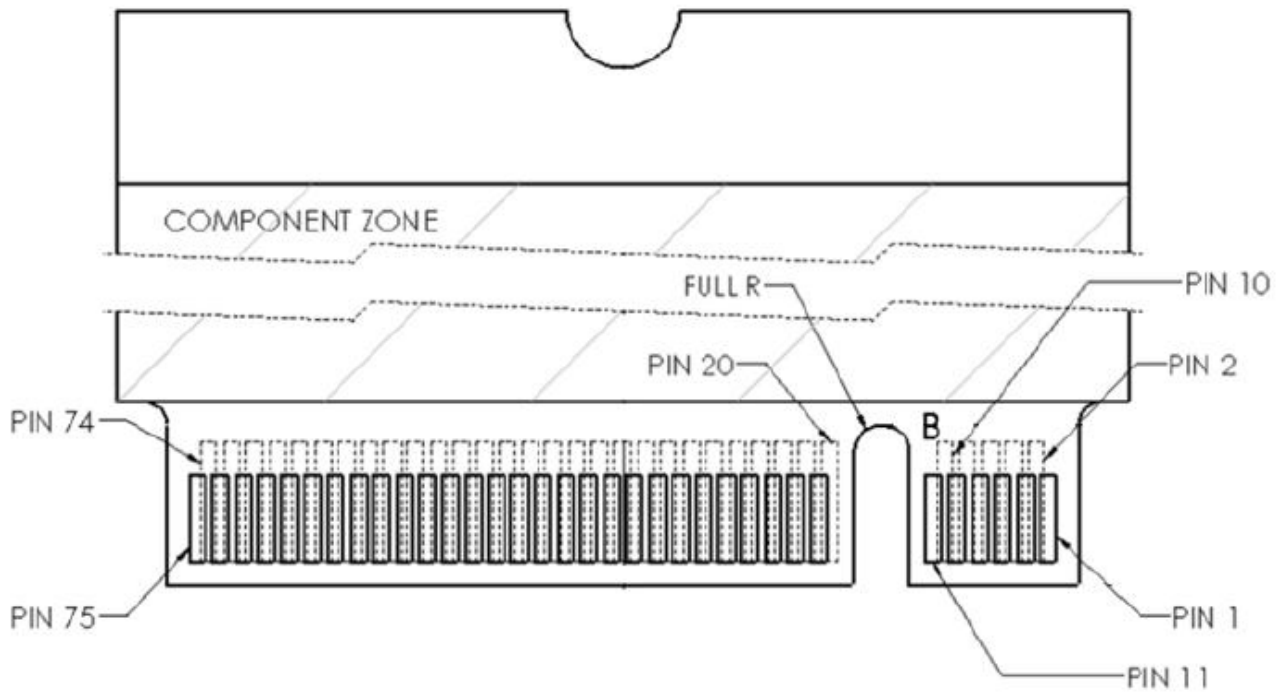1.2.2. Qualcomm MDM9240 support 3CA+256QAM(up to Cat11) and partial Rel12 (FDD+TDD CA) which is mandatory for AU/JP/China carriers.

Region	Carriers	2CCs DL CA Combinations	3CCs DL CA Combinations
NA	AT&T, VZW, Sprint, TMO, Canada	B2 + B2, B2 + B4, B2 + B5, B2 + B12, B2 + B13, B2 + B17, B2 + B29, B2 + B30, B4 + B4, B4 + B5, B4 + B7, B4 + B12, B4 + B13, B4 + B17, B4 + B29, B4 + B30, B5 + B30, B12 + B12, B12 + B30, B25 + B25, B25 + B26, B25 + B41, B26 + B41, B29 + B30, B41 + B41, B2+B66, B5+B66, B12+B66, B13+B66, B66+B66, B29+B66	B2 + B2 + B12, B2 + B2 + B13, B2 + B4 + B5, B2 + B4 + B12, B2 + B4 + B13, B2 + B4 + B29, B2 + B5 + B30, B2 + B12 + B12, B2 + B12 + B30, B2 + B29 + B30, B4 + B4 + B5, B4 + B4 + B12, B4 +B4 +B13, B4 + B5 + B30, B4 + B12 + B12, B4 + B12 + B30, B4 + B29 + B30, B25 + B26 + B41, B25 + B41 + B41, B26 + B41 + B41, B41 + B41 + B41 B13+B66+B2, B12+B66+B66, B13+B66+B66, B5+B66+B2, B5+B66+B66, B66+B66+B2, B66+B66+B66
Korea	SKT,KT, LGU+	B1 + B5, B3 + B5, B3 + B8, B5 + B7	B1 + B3 + B5, B1 + B3 + B8, B1 + B5 + B7, B1 + B7 + B28, B3 + B7 + B8
JP	KDDI, DCM, SBM	B1 + B3, B1 + B8, B1 + B18, B1 + B19, B1 + B26, B3 + B19, B19 + B21, B41 + B41	B1 + B3 + B19, B1 + B3 + B28, B1 + B41 + B41, B41 + B41 + B41
EU	Various	B1 + B20, B3 + B3, B3 + B7, B3 + B20, B3 + B38, B7 + B7, B7 + B8, B7 + B20, B38 + B38	B1 + B3 + B20, B1 + B7 + B20, B3 + B3 + B7, B3 + B3 + B20, B3 + B7 + B20, B3 + B7 + B7, B3 + B20 + B38, B3 + B38 + B38
China	CMCC, CTCC, CUCC	B1 + B3, B1 + B26, B3 + B26, B3 + B40, B39 + B39, B39 + B41, B40 + B40, B41 + B41	B1 + B3 + B3, B1 + B3 + B26, B1 + B3 + B41, B3 + B40 + B40, B39 + B39 + B41, B39 + B41 + B41, B40 + B40 + B40, B41 + B41 + B41
AU/SEA/LA	Telstra /Optus	B1 + B3, B1 + B7, B1 + B28, B3 + B8, B3 + B28, B5 + B7, B5 + B40, B7 + B8, B7 + B28	B3 + B3 + B8, B3 + B7 + B7, B3 + B7 + B28, B7 + B7 + B28, B3 + B40 + B40, B28 + B40 + B40, B40 + B40 + B40

1.3 Pin definition

1.3.1 Golden finger Pin sequence

Figure 1-2 shows the sequence of pins on the 75-pin signal interface of M.2 3042 Key.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	SUSCLK(32kHz) (I)(0/3.3V)	Not connect in T77W676	RESET# (I)(0/1.8V)	67	
66	SIM DETECT (I)		ANTCTL3 (O)(0/1.8V)	65	
64	COEX_TXD (O)(0/1.8V)	Dual layout 3GPIOs and UART I/F for LTE / Wi-Fi coexistence	ANTCTL2 (O)(0/1.8V)	63	
62	COEX_RXD(I)(0/1.8V)		ANTCTL1 (O)(0/1.8V)	61	
60	COEX3(I/O)(0/1.8V)		ANTCTL0 (O)(0/1.8V)	59	
58	MIPI_DATA (0/1.8V)	For external tunable antenna (MiPi)	GND	57	
56	MIPI_CLK (0/1.8V)		REFCLKP	55	Reserved, but SW disable in default
54	PEWAKE# (IO)(0/3.3V)	Reserved, but SW disable in default	REFCLKN	53	Reserved, but SW disable in default
52	CLKREQ# (IO)(0/3.3V)	Reserved, but SW disable in default	GND	51	
50	PERST# (I)(0/3.3V)	Reserved, but SW disable in default	PERp0	49	Reserved, but SW disable in default
48	GPIO_4 - TX_BLANKING (0/1.8V*)		PERn0	47	Reserved, but SW disable in default
46	GPIO_3 - SYSCLK (0/1.8V*)	Not connect in Foxconn design	GND	45	
44	GPIO_2 - GNSS_IRQ (0/1.8V*)	Reserved	PETp0	43	Reserved, but SW disable in default
42	GPIO_1 - GNSS_SDA(0/1.8V*)	Reserved	PETn0	41	Reserved, but SW disable in default
40	GPIO_0 - GNSS_SCL (0/1.8V*)	Reserved	GND	39	
38	Not connect		USB3.0- Rx+	37	
36	UIM- PWR (O)		USB3.0- Rx-	35	
34	UIM- DATA (IO)		GND	33	
32	UIM- CLK (O)		USB3.0- Tx+	31	
30	UIM- RESET (O)		USB3.0- Tx-	29	
28	GPIO_8 - AUDIO_3 (IO) (0/1.8V)		GND	27	
26	GPIO_10 - W_DISABLE2# (I) (0/3.3.V)	3.3V I/O	DPR (I)(0/3.3V)	25	3.3V I/O
24	GPIO_7 - AUDIO_2 (IO) (0/1.8V)		GPIO_11 - WoWWAN# (O)(0/1.8V)	23	
22	GPIO_6 - AUDIO_1 (IO)(0/1.8V)		CONFIG_0 (GND)	21	
20	GPIO_5 - AUDIO_0 (IO)(0/1.8V)		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 (N/C)	1	

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

1.4 Platform connection design

1.5.1 Configuration Pins

The M.2 module provides 4 configuration pins. T77W676 is configured as WWAN-USB3.0 0, refer to PCIe M.2_Rev 1.1.

Item	Module configuration decodes				Module type	Port configuration
Config	Config_0	Config_1	Config_2	Config_3		
Pin No.	21	69	75	1	WWAN-USB3.0	0
State	GND	GND	GND	NC		

1.5.2 Power and ground

(1) Power Rail Parameters

Parameter	Min	Type	Max	Units
Operating voltage	3.135	3.3	4.4	Vdc

The operating voltage was defined in PCIe M.2_Rev 1.1 standard as 3.135V~4.4V.

(2) 3.135 V is the minimum voltage supplied to LTE 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 LTE M.2 module provides 5 power pins and 11 Ground pins. To ensure that the LTE module works normally, all the pins must be connected.

1.5.3 Full_Card_Power_Off

The M.2 LTE module can be controlled to power on/off by the Full_Card_Power_Of pin.

| 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 USB3.0 interface

T77W676 module is compliant with USB3.0 in all modes. When two devices are connected via a USB3.0 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 1-3 USB3.0 interface.
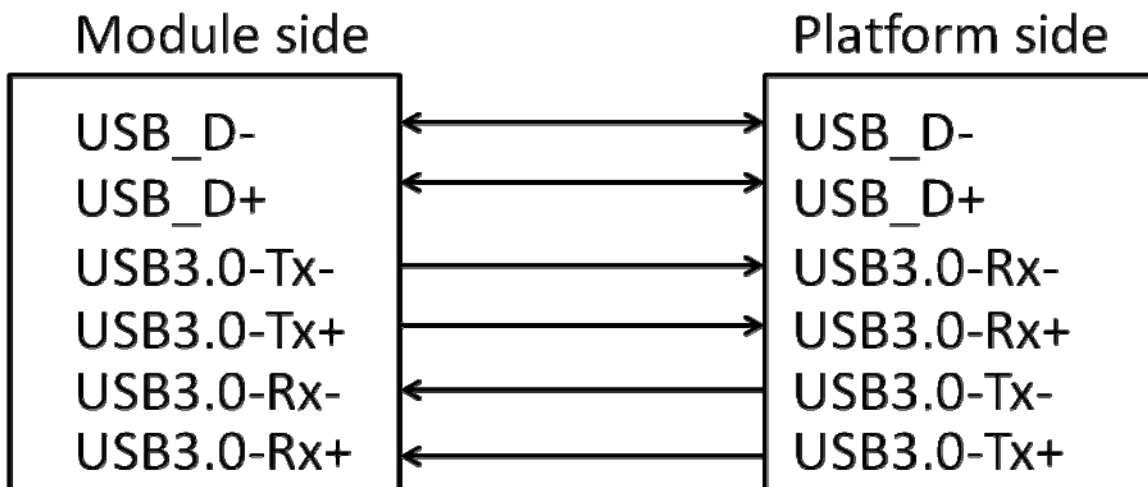
1.5.5 W_DISABLE#

This control setting is implementation-specific and represents the collective intention of the host software to manage radio operation. T77W676 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), internally pull up
W_DISABLE#2	Low	GPS Disabled (no RF operation allowed)
	High	GPS Enabled (RF operation allowed), internally pull up

Note: 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.

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
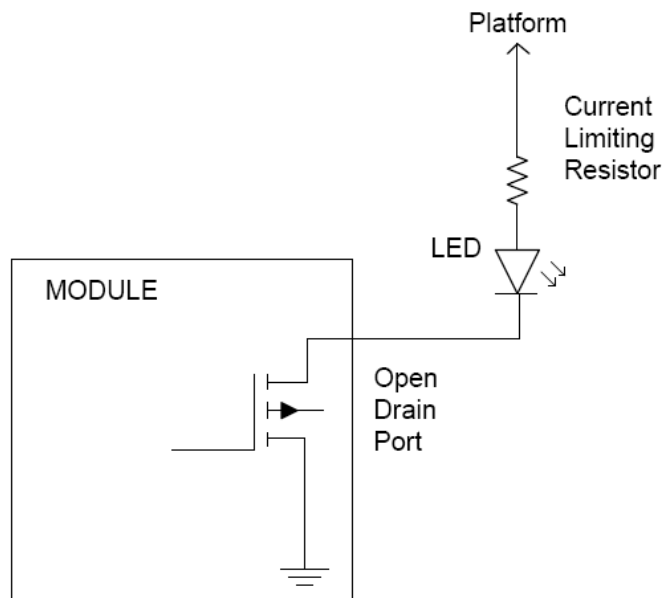
## 1.5.7 WoWWAN

The WAKE_ON_WWAN# signal is for power saving.

・LTE module always listening at very low power in idle mode

・LTE module will wake up mother board via 'WoWWAN' signal.

・The platform will power on when triggered by the LTE module.
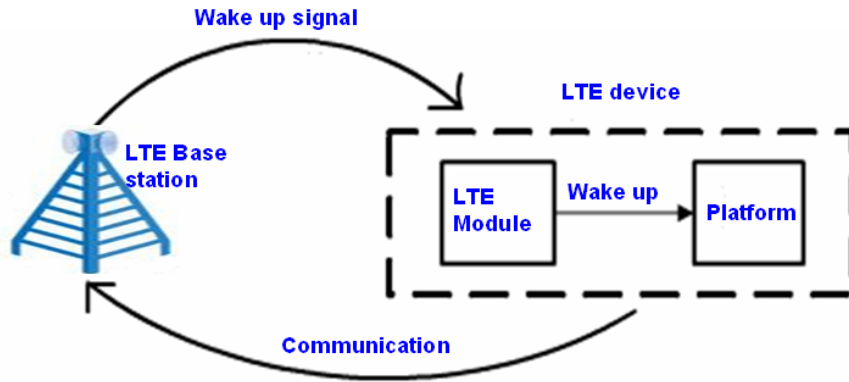
The WAKE_ON_WWAN# signal is used to wake up the host. It is open drain and should be pulled up at the host side. When the WWAN needs to wake up the host, it will output a one second low pulse, shown in Figure 1-4.
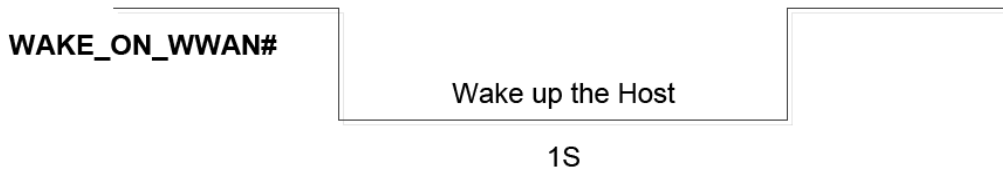
Typical Connection in Platform/System
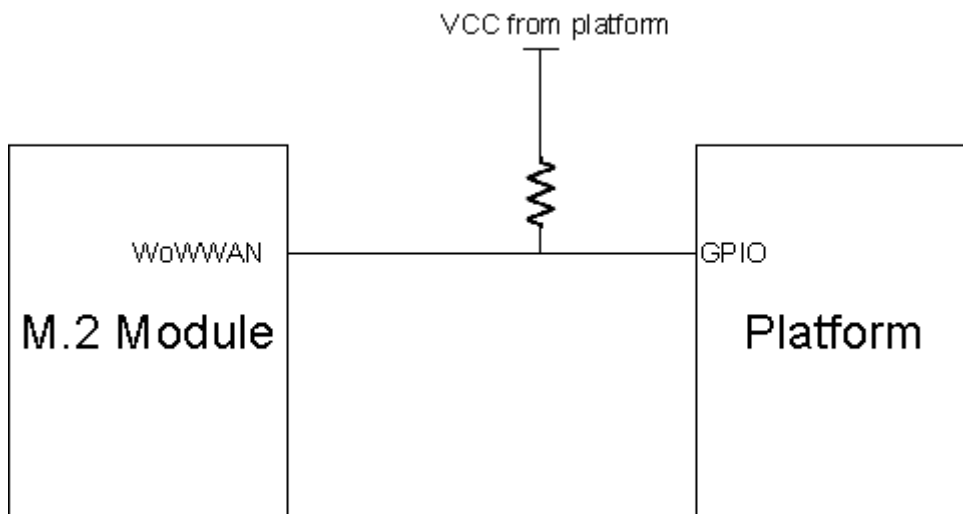
1.5.8 DPR (Dynamic Power Reduction)

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

Item	State	Definition	Interpretation
1	Low	Enable the SAR power back off.	Radio is capable of transmitting.
2	High	Disable the SAR power back off, internally pull up	Radio is incapable of transmitting.

Note: DPR 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 enable DPR function.

(2) Typical Connection in Platform/System
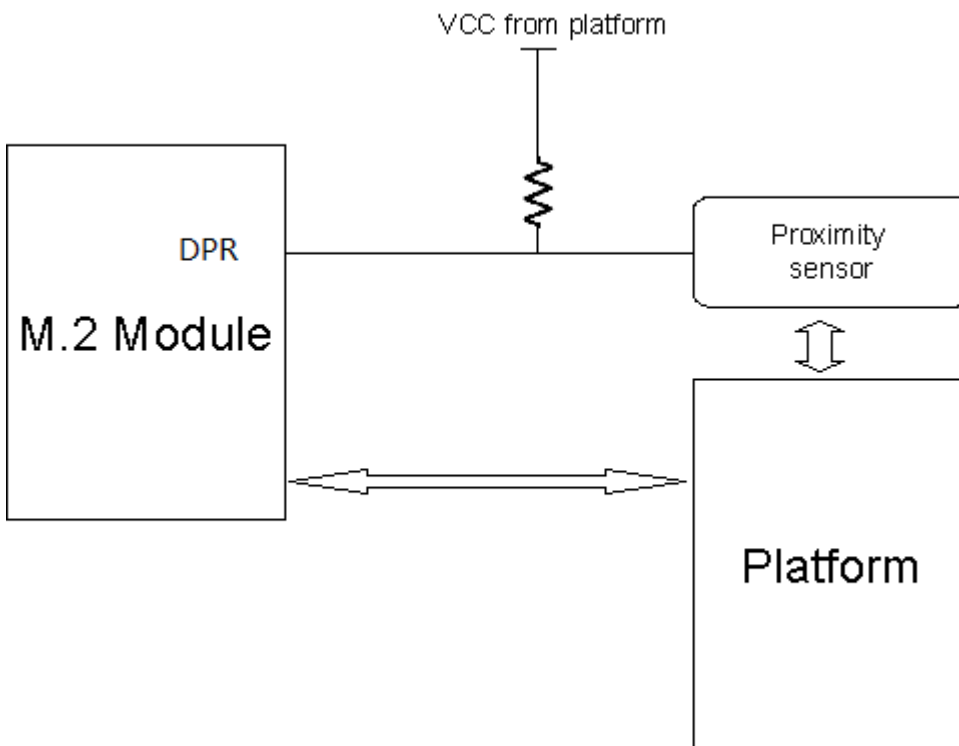
Remark:

a. The proximity sensor was controlled by the platform side.

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

1.5.9 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) 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.

(2) 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

(3) 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 indicates 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.
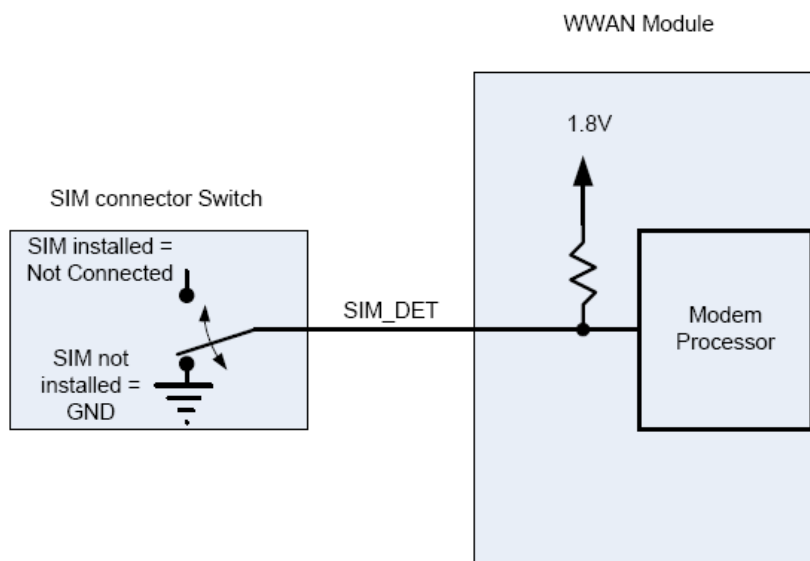
1.5.10 Antenna Control

(1).T77W676 provides GPIO control signals for external antenna tuner application. ANTCTRL (0-3) are provided to allow for the implementation of antenna tuning solutions. The number antenna control lines required will depend on the application and antenna/band requirements. We will provide a tool to fill antenna control table in ODM factory to enable antenna tuner support on specific platforms.

Foxconn general design for WWAN module with two control signals for reference only.

ANTCTL0	ANTCTL1	Frequency (MHz)	Band support
0	0	880 ~ 960	Band8 (WCDMA) + GSM900 + High Bands
0	1	791 ~ 894	Band5 (WCDMA, LTE) + GSM850 + High Bands
1	0	746 ~787	Band13 (LTE) + High Bands
1	1	704 ~746	Band17 (LTE) + High Bands

(2). T77W676 also provides MIPI interface (VIO=1.8V) for external antenna tuner application.The function is under development for customization. M.2 pin.56 (MIPI_CLK), 58 (MIPI_DATA) 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.

1.5.11 Coexistence

COEX1, COEX2 and COEX3 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.

Item	Signal name	Description
COEX1	LTE_ACTIVE (COEX_TXD)	TBD
COEX2	LTE_FRAME_SYNC (COEX_RXD)	TBD
COEX3	LTE_WLAN_PRIORITY	TBD

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.
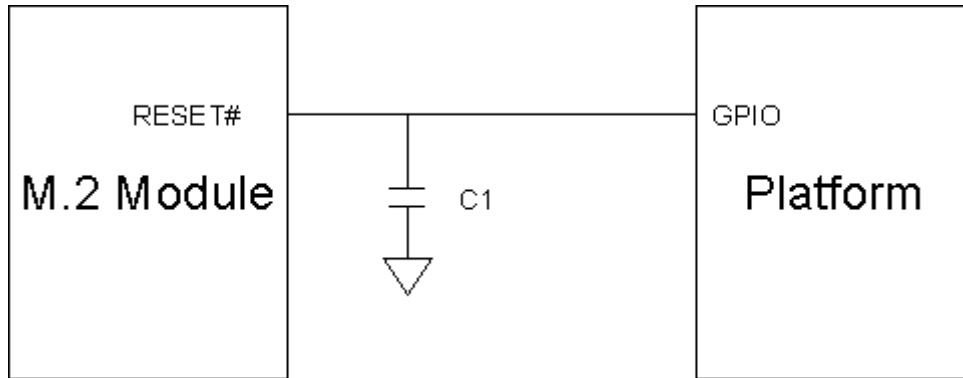
2. Hardware features

T77W676.00 consists of the following key engine components, in addition to the required front-end RF and other discrete components.

Modem engine

- Soft Baseband: MDM-9240
- RF: WTR3925 and WTR4905
- Power: PMD9645

Connectivity engine

- USB: USB3.0
- USIM: located off board
- Antenna: connectors for the off board antennas

2.1 Mobile Data Modem

The MDM9x40 chipset supports 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 MDM9240 used on T77W676.00 are listed below:

❒ Processor:
- Manufactured in 20nm CMOS process
- System uP (Cortex-A7 up to 1.19 GHz with 256 kB L2 cache)

❒ Memory:
- External memory
  EBI1: 2Gb LPDDR2, 32-bit LPDDR2 SDRAM at up to 518 MHz
- External memory
  EBI2: 2Gb NAND flash

❒ Air interface:
- WCDMA (R99, HSDPA, HSUPA, HSPA+, DC-HSPA+)
- LTE (R11 Cat6/9/11, FDD/TDD)
- GPS/Glonass/Beidou

❒ Advance RX operation:
- Mobile receive diversity (WCDMA, LTE)

❒ Connectivity:
- USB 3.0 with built-in USB PHY

- UART interface
- UIM support (dual voltage)

2.2 RF transceiver

In order to support 3DL CA, there are two RF transceivers in T77W676, include WTR3925 and WTR4905. WTR3925 is designed for high bands and middle bands, and WTR4905 is for low bands and GNSS. Both of them are the RF transceiver ICs within compatible Qualcomm MDM9240 chipsets.

2.2.1.1 Key features of WTR3925
- Qualcomm Technologies, Inc. (QTI) fourth-generation
- 4G/3G/2G transceiver
- First 28 nm CMOS, wafer-level package
- First single-chip LTE-carrier aggregation (CA)
- First RF transceiver to support 40 MHz CA
- Support for intraband and interband CA
- Significant increase in number of RF ports
- Dedicated feedback receiver
- Integrated GPS core – GPS/Glonass/BeiDou

2.2.1.2 Key benefits of WTR3925
- Enables a single PCB design for global platforms
- Significant power consumption and size reduction over previous generations
- > 25% current consumption savings
- > 50% direct package area savings
- LTE-A, HSPA+, UMTS, CDMA, TD-S, and GSM
- Spectrum support: 700–2700 MHz
- Supporting all newly specified and planned spectrums
- Support for 28 Rx ports and 10 Tx ports
- Reduces external components – lowers cost
- Single-ended inputs, easier PCB routing

2.2.2.1 Key features of WTR4905
- QTI fifth-generation LTE transceiver
- LTE, HSPA+, UMTS, CDMA, TD-S, and GSM
- First RF transceiver to support SAWless 2G
- Second 28 nm CMOS, wafer-level package

- Supports B28 APAC 700 MHz
- Significant increase in the number of Rx ports
- Dedicated feedback receiver
- Integrated GPS core
- GPS/GLONASS/BeiDou with no eLNA

2.2.2.2 Key benefits of WTR4905

- Smaller size (10 mm2) with more functionality
- Spectrum support: 700 – 2700 MHz
- Supports all newly specified spectrums (including B28)
- Support for eight Rx ports and five Tx ports
- Enables a single PCB design for emerging markets
- Reduces number of external switches
- No Rx SAW required for 2G bands
- Significant current consumption savings over previous generations
- > 30% for 3G talk and > 50% for 4G Cat-3
- Significant size reduction over previous generations

2.3 Power management IC

T77W676.00 system uses the Qualcomm PMD9645. The PMD9645 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 PMD9645 includes so many diverse functions, its operation is more easily understood by considering major functional blocks individually. Therefore, the PMD9645 document set is organized by the following device functionality:

- Input power management
- Output power management
- General housekeeping
- User interfaces
- IC interfaces
- Configurable pins—either multipurpose pins (MPPs) or general-purpose inputs/outputs (GPIOs)—that can be configured to function within some of the other categories

2.4 Antenna Design

2.4.1 Antenna specification
T77W676.00 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.2 Specification Revision Version 1.0 standard. The antenna elements are typically
integrated into the notebook/ultrabook /tablet and connected to T77W676.00 module via
flexible RF coaxial cables. T77W676.00 provides two RF connectors (MHF type), one for
the primary transmitter/receiver port and the other for the diversity receiver and GNSS.
To ensure stable RF performance, customer must assemble adequate antenna according to
the antenna specification.

Table 2-1 Main 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

Table 2-2 Aux antenna specifications

Parameter	
Gain	Maximum gain and uniform converge in high angle elevation and zenith. Gain in the azimuth is not desired.
Average 3D gain	>-5dBi
VSWR	Typical value <3:1
Isolation(diversity to Main)	>10dB in all related bands
Polarization	Any

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
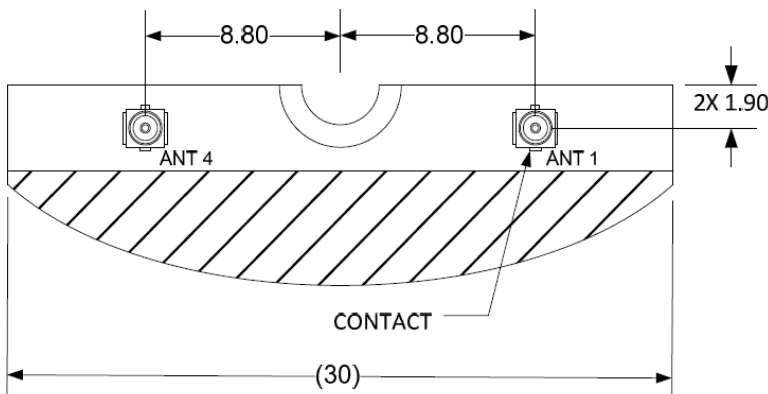
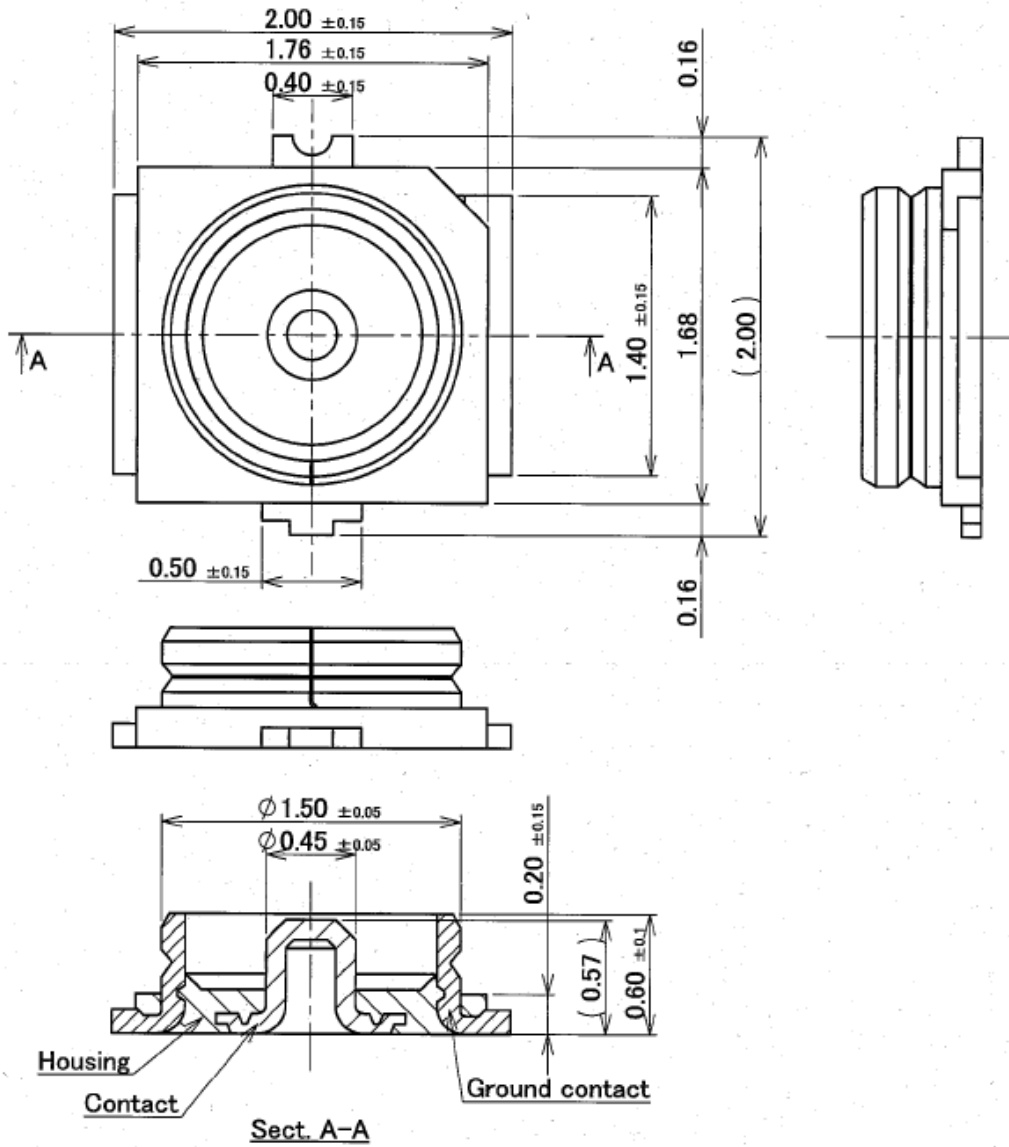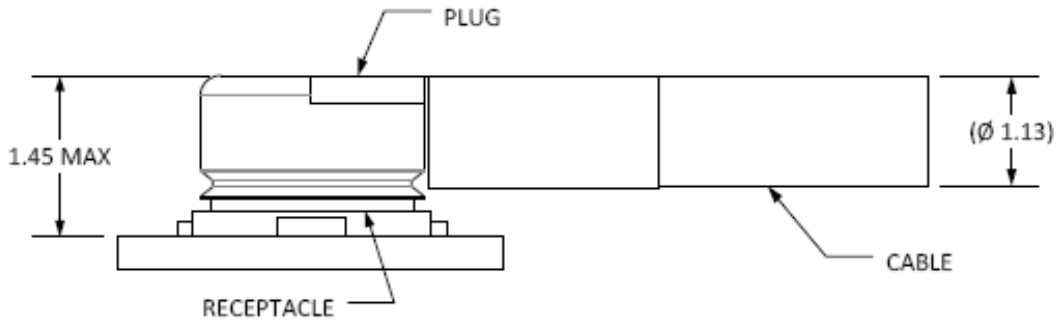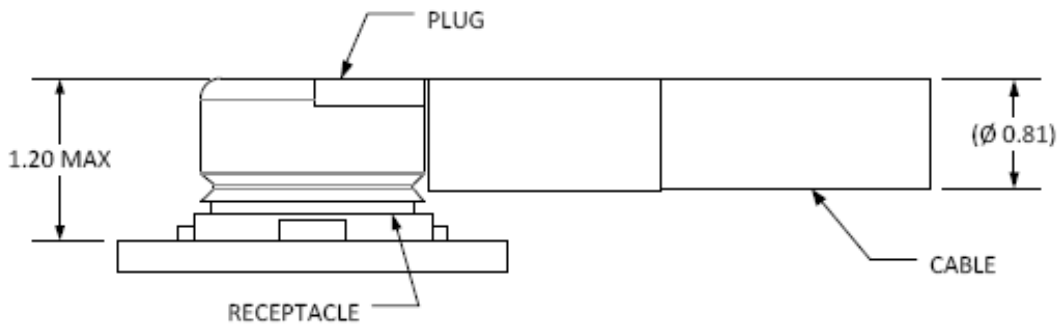| Antenna	Interface
0	TBD
1	WWAN Main
2	TBD
3	TBD
4	WWAN Aux / GPS
5	TBD

Figure 2-2 RF connectors

Figure 2-3 RF receptacles

Mated Plug for Ø 1.13 mm Coax Cable

**Mated Plug for Ø 0.81 mm Coax Cable**

3. Mechanical Specifications

3.1 Overview

T77W676.00 is compatible with the PCI Express M.2 Specification 3042 Key.B type 75-pin card edge-type connector. Refer to Electromechanical Specification Revision 0.7a, Version 1.0 with Input Power and Voltage Tolerance ECN for more details.
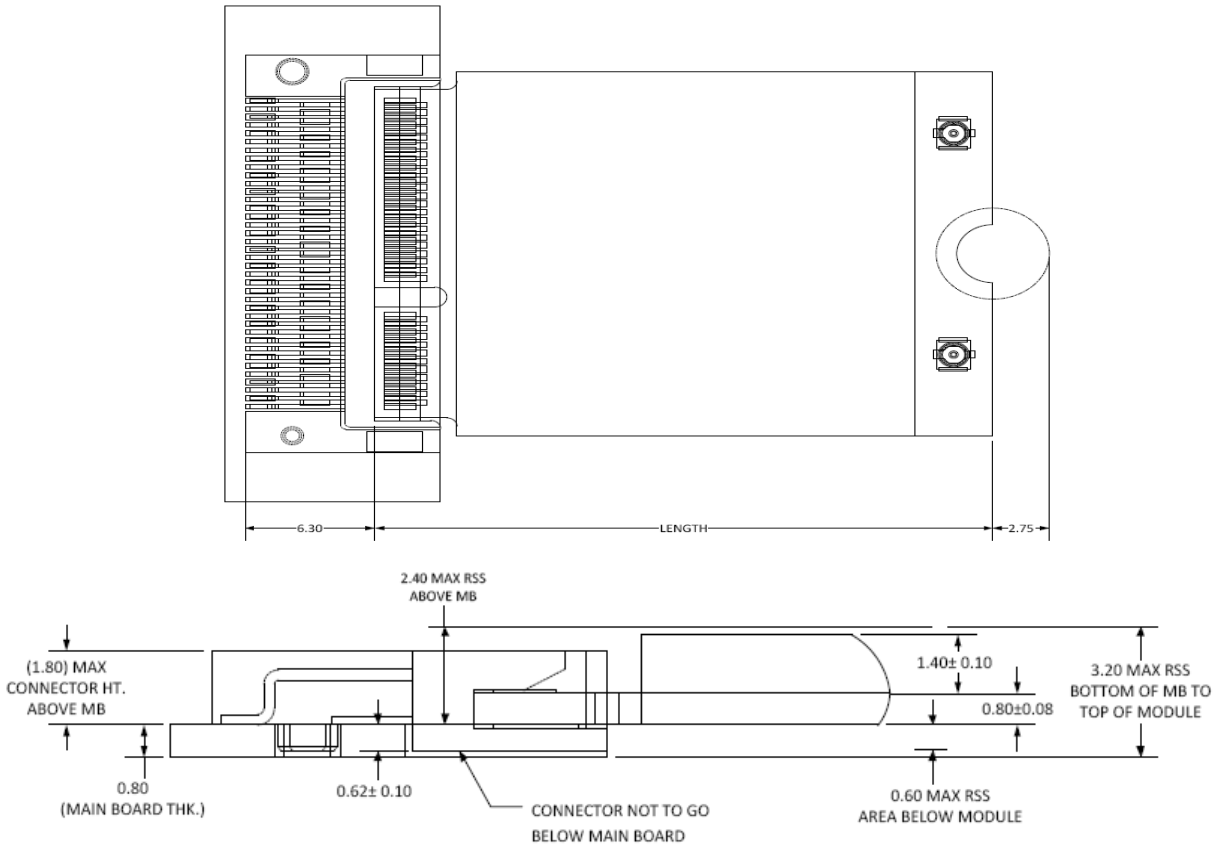
3.2 Mechanical constraints

Figure 3-1 shows the mechanical constraints of T77W676.00 (3042-S3-B)
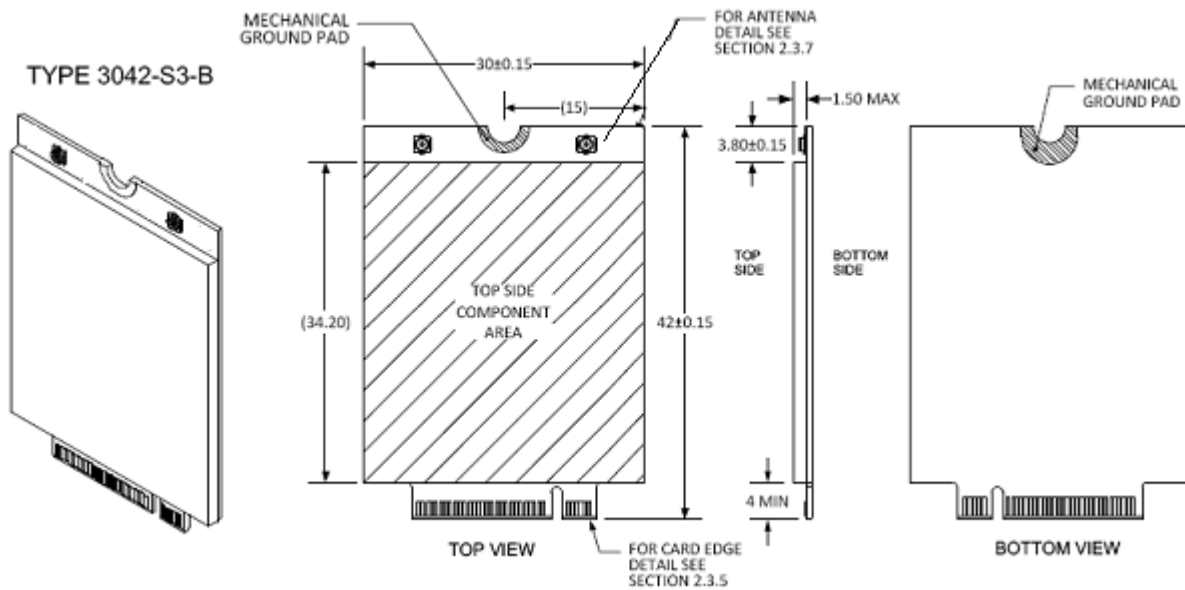
3.3 M.2 card assembly

Figure 3-2 shows Stack-up Mid-Line (In-line) Single Sided Module for 1.5 Maximum Component Height, refer to section 2.4.8.3.1 of PCIe M.2_Rev 1.1 standard.

Remark:

a. 2.4mm maximum above mother board

b. Cut area of main board under M.2 module

c. Need to add thermal pad between M.2 module and mechanical component (like material shielding) 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
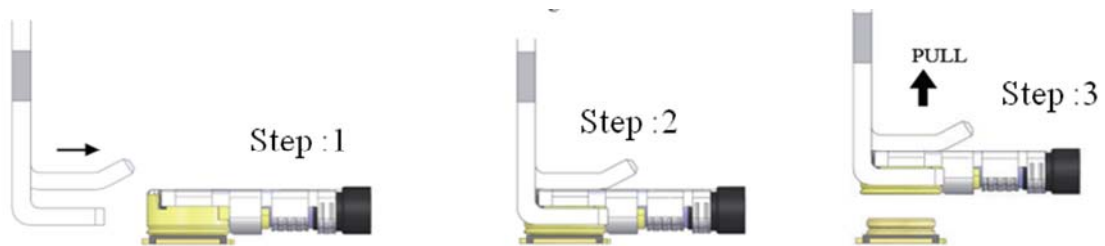
c. Pulling tool(Unit:mm)

4. Electrical Specifications

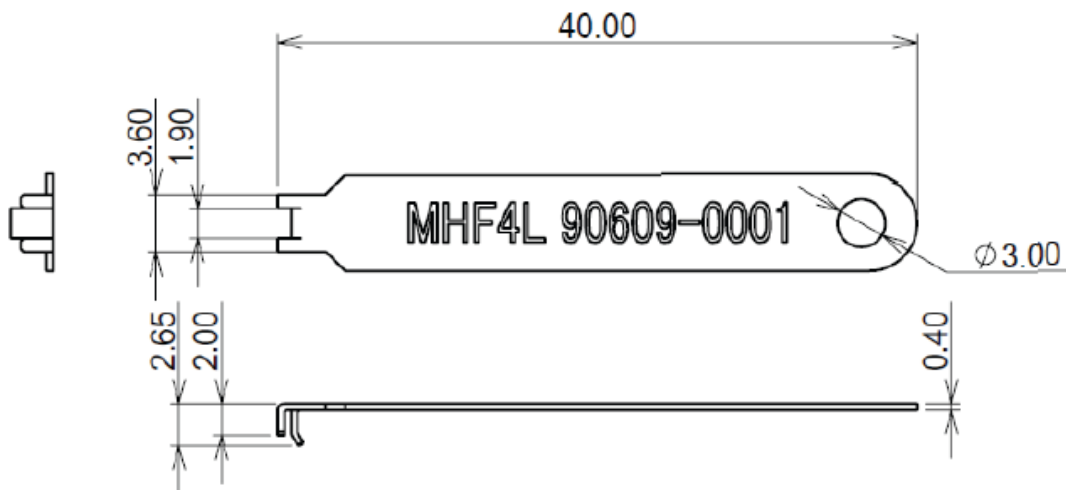### 4.1 Recommended operating conditions

Table 4-1 Recommended operating conditions

Parameter	Min	Type	Max	Units
Storage temperature	-30	+25	+85	°C
Recommend operating temperature (3GPP compliant)	-10	+25	+55	°C
Restricted operating temperature(*1) (operational, non-3GPP compliant)	-20	+25	+70	°C
Extendable (with limited performance) Temperature measure on T77W676 module(*2)	-40		+85	
Operating voltage	3.135	3.3	4.4	Vdc

(1).Restricted operation allows normal mode data transmission for limited time until automatic thermal shutdown takes effect. Within the restricted temperature range (outside the operating temperature range) the specified electrical characteristics may be in or decreased.

(2).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.

Operating T77W676.00 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 goal (Typical)	Estimated power range goal (Max.)
WCDMA in suspend mode	<5mA	
WCDMA (Tx=24dBm)	<800mA	<1500mA
LTE in suspend mode	<5mA	
LTE (16QAM) Tx=23 dBm	<900mA	<1200mA
LTE CA mode, Tx=23dBm	<1100mA	<2200mA
GPS/GNSS tracking	<150mA	<300mA
Connected standby	<3mA	
Radio Off	<3mA	

5. RF performance specifications

Radio performance for T77W676.00 is given in the following sections, including RF receiver, RF transmitter.

5.1 RF maximum Tx power &RF min. Rx sensitivity specifications

Table 5-1 Conducted Maximum transmit power & Min. receiver sensitivity (LTE BW: 10MHz)

Notes: The below test result is for reference only, we will update the Rx sensitivity after EVT build before Feb. of 2017.

Band	3GPP Standard (dBm)	MFG Spec. (dBm)	PRx (dBm)	DRx (dBm)	MIMO Combined (dBm)	3GPP,MIMO Combined (dBm)
1	23 +/-2	23 +/-1	-97.5	-97	-100	-95
2	23 +/-2	23 +/-1	-98	-97	-100	-95
3	23 +/-2	23 +/-1	-98.5	-97	-100	-94
4	23 +/-2	23 +/-1	-97	-97	-100	-97
5	23 +/-2	23 +2/-1	-99	-100	-102	-95
7	23 +/-2	23 +/-1	-98.5	-97	-100	-95
8	23 +/-2	23 +/-1	-99.5	-99.5	-102.5	-94
12	23 +/-2	23 +/-1	-99	-99	-102	-94
13	23 +/-2	23 +/-1	-99	-98.5	-101.5	-94
17	23 +/-2	23 +/-1	-99	-99	-102	-94
18	23 +/-2	23 +/-1	-99	-99	-102	-97
19	23 +/-2	23 +/-1	-99	-99	-102	-97
20	23 +/-2	23 +/-1	-99	-98.5	-101.5	-94
21	23 +/-2	23 +/-1	-98	-98	-101	-97
25	23 +/-2	23 +/-1	-98	-97	-100	-93.5
26	23 +/-2	23 +/-1	-99	-99	-102	-94.5
28	23 +/-2	23 +/-1	-98.5	-99	-101	-95.5
29	23 +/-2	23 +/-1	-98	-98	-101	-94
30	23 +/-2	23 +/-1	-97	-96.5	-100	-97
38	23 +/-2	23 +/-1	-97.5	-97	-100	-97
39	23 +/-2	23 +/-1	-98	-98	-100	-97
40	23 +/-2	23 +/-1	-97	-97	-100	-97
41	23 +/-2	23 +/-1	-97.5	-96	-99	-96
66	23 +/-2	23 +/-1	-97	-97	-100	-96.5
WCDMA	3GPP Standard (dBm)	MFG Spec. (dBm)	PRx (dBm)	DRx (dBm)	MIMO Combined (dBm)	3GPP,MIMO Combined (dBm)
1	24+1.7/-3.7	23.5+/-1	-109	-109	-112	-106.7dBm
2	24+1.7/-3.7	23.5+/-1	-109	-109	-112	-104.7dBm
4	24+1.7/-3.7	23.5+/-1	-109	-109	-112	-106.7dBm
5(6/19)	24+1.7/-3.7	23.5+/-1	-110	-110	-113	-104.7dBm
8	24+1.7/-3.7	23.5+/-1	-110	-110	-113	-103.7dBm

GNSS tracking sensitivity	Design target (dBm)	Spec (dBm)			
	-159	-152			

Remark:

a. It has 3dB margin at least refer to 3GPP standard.

b. The typical value of LTE was measured as combine Rx sensitivity which was follow test setup of 3GPP standard (TS36.521 charter 7.2 and charter 7.3.5), the test setup is follow TS36.508 Annex A Figure A.3.

c. Above table is for general application, please inform us if you have any specific requirement.
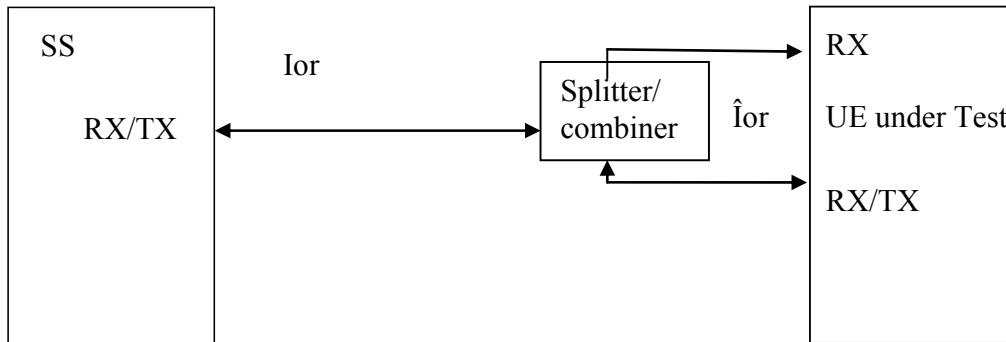
6. Host integration instructions

Install module through golden finger.

Federal Communication Commission Interference Statement

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules.   These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications.   However, there is no guarantee that interference will not occur in a particular installation.   If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that
to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

FCC Caution: Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment.

This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

Radiation Exposure Statement:

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20cm between the radiator & your body.

This device is intended only for OEM integrators under the following conditions:

This device is intended only for OEM integrators under the following conditions:

The antenna must be installed such that 20 cm is maintained between the antenna and users, and The transmitter module may not be co-located with any other transmitter or antenna.

As long as 2 conditions above are met, further underline transmitter test will not be required. However, the OEM integrator is still responsible for testing their end-product for any additional compliance requirements required with this module installed

IMPORTANT NOTE: In the event that these conditions can not be met (for example certain laptop configurations or co-location with another transmitter), then the FCC authorization is no longer considered valid and the FCC ID can not be used on the final product. In these circumstances, the OEM integrator will be responsible for re-evaluating the end product (including the transmitter) and obtaining a separate FCC authorization.

End Product Labeling

This transmitter module is authorized only for use in device where the antenna may be installed such that 20 cm may be maintained between the antenna and users. The final end product must be labeled in a visible area with the following: "Contains FCC ID: MCLT77W676". The grantee's FCC ID can be used only when all FCC compliance requirements are met.

Manual Information To the End User

The OEM integrator has to be aware not to provide information to the end user regarding how to install or remove this RF module in the user's manual of the end product which integrates this module.
The end user manual shall include all required regulatory information/warning as show in this manual.

Industry Canada statement:

This device complies with ISED's licence-exempt RSSs. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Le présent appareil est conforme aux CNR d' ISED applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) le dispositif ne doit pas produire de brouillage préjudiciable, et (2) ce dispositif doit accepter tout brouillage reçu, y compris un brouillage susceptible de provoquer un fonctionnement indésirable.

Radiation Exposure Statement:

The product comply with the Canada portable RF exposure limit set forth for an uncontrolled environment and are safe for intended operation as described in this manual. The further RF exposure reduction can be achieved if the product can be kept as far as possible from the user body or set the device to lower output power if such function is available.

Déclaration d'exposition aux radiations:

Le produit est conforme aux limites d'exposition pour les appareils portables RF pour les Etats-Unis et le Canada établies pour un environnement non contrôlé.

Le produit est sûr pour un fonctionnement tel que décrit dans ce manuel. La réduction aux expositions RF peut être augmentée si l'appareil peut être conservé aussi loin que possible du corps de l'utilisateur ou que le dispositif est réglé sur la puissance de sortie la plus faible si une telle fonction est disponible.

This device is intended only for OEM integrators under the following conditions: (For module device use)

1) The transmitter module may not be co-located with any other transmitter or antenna.

As long as **1** condition above are met, further transmitter test will not be required. However, the OEM integrator is still responsible for testing their end-product for any additional compliance requirements required with this module installed.

Cet appareil est conçu uniquement pour les intégrateurs OEM dans les conditions suivantes: (Pour utilisation de dispositif module)

1) Le module émetteur peut ne pas être coïmplanté avec un autre émetteur ou antenne.

Tant que les **1** condition ci-dessus sont remplies, des essais supplémentaires sur l'émetteur ne seront pas nécessaires. Toutefois, l'intégrateur OEM est toujours responsable des essais sur son produit final pour toutes exigences de conformité supplémentaires requis pour ce module installé.

IMPORTANT NOTE:
In the event that these conditions can not be met (for example certain laptop configurations or co-location with another transmitter), then the Canada authorization is no longer considered valid and the IC ID can not be used on the final product. In these circumstances, the OEM integrator will be responsible for re-evaluating the end product (including the transmitter) and obtaining a separate Canada authorization.

NOTE IMPORTANTE:
Dans le cas où ces conditions ne peuvent être satisfaites (par exemple pour certaines configurations d'ordinateur portable ou de certaines co-localisation avec un autre émetteur), l'autorisation du Canada n'est plus considéré comme valide et l'ID IC ne peut pas être utilisé sur le produit final. Dans ces circonstances, l'intégrateur OEM sera chargé de réévaluer le produit final (y compris l'émetteur) et l'obtention d'une autorisation distincte au Canada.

End Product Labeling

The product can be kept as far as possible from the user body or set the device to lower output power if such function is available. The final end product must be labeled in a visible area with the following: "Contains IC: 2878D-T77W676".

Plaque signalétique du produit final

L'appareil peut être conservé aussi loin que possible du corps de l'utilisateur ou que le dispositif est réglé sur la puissance de sortie la plus faible si une telle fonction est disponible. Le produit final doit être étiqueté dans un endroit visible avec l'inscription suivante: "Contient des IC: 2878D-T77W676".

Manual Information To the End User

The OEM integrator has to be aware not to provide information to the end user regarding how to install or remove this RF module in the user's manual of the end product which integrates this module.
The end user manual shall include all required regulatory information/warning as show in this manual.

Manuel d'information à l'utilisateur final

L'intégrateur OEM doit être conscient de ne pas fournir des informations à l'utilisateur final quant à la façon d'installer ou de supprimer ce module RF dans le manuel de l'utilisateur du produit final qui intègre ce module.
Le manuel de l'utilisateur final doit inclure toutes les informations réglementaires requises et avertissements comme indiqué dans ce manuel.

低功率電波輻射性電機管理辦法
本模組於取得認證後將依規定於模組本體標示審驗合格標籤。

2. 系統廠商應於平台上標示「本產品內含射頻模組：XXXyyyLPDzzzz-x」字樣。

電磁波警語標示：「減少電磁波影響，請妥適使用」。
標示方式：必須標示於設備本體適當位置及設備外包裝及使用說明書上。
「電