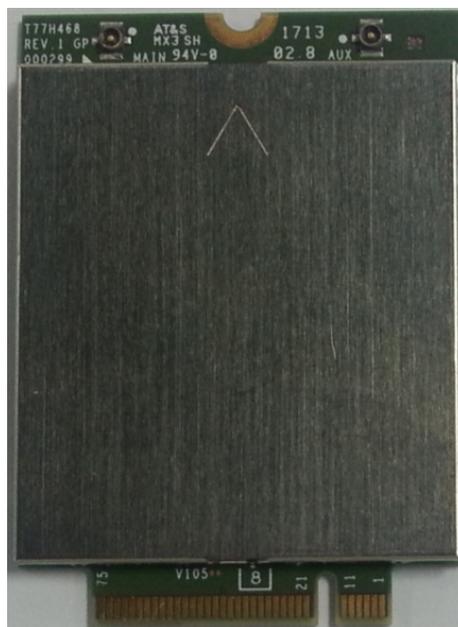


# 3GPP Long Term Evolution Cat3 PCI Express M.2 Module

## User Manual



Project code: T77H468  
Solution: MDM9615+WTR1605L  
SKU: NA-1-S3

**Reviewers**

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**Modification History**

Rev	Date	Originator	Comment
D0.1	2013/01/04	Ai-ning	Initial release
D1.1	2013/03/06	Ai-ning	Update to MDM9615 version (S2 version)
D2.0	2013/04/13	Ai-ning	Update to MDM9615 NA SKU
D3.0	2013/06/26	Ai-ning	Update system connection

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1. General Description

T77H468 is designed to enable wireless data connectivity for notebook computer or any other device compatible with the PCI Express M.2 Specification 3042 type slot. T77H468 is the data card solution that delivers wireless wide-area network (WWAN) connectivity for the LTE, UMTS (HSDPA/HSUPA/HSPA+/DC-HSPA+), CDMA 1X/CDMA EV-DOa/ CDMA EVDO-rB, GSM/GPRS/EDGE and GPS/Glonass protocols in one hardware configuration.

WTR1605L	SKU NA-1-S3			
	G	C	W	L
	QUAD BAND	BC 0,1	Band 1,2,4, 5,8	Band 2,4,5,13,17,25
TX_LB1				17
TX_LB2	850/900			
TX_LB3				13
TX_LB4		0	5,8	5, 8r
TX_MB1			4	4
TX_MB2	1800/1900			
TX_MB3		1	1,2	1r, 2,25
TX_MB4				
TX_HB				
PRX_LB1				13,17
PRX_LB2	850/900		8	
PRX_LB3		0	5	5
PRX_MB1	1800/1900			
PRX_MB2		1	2	2
PRX_MB3			1	
PRX_HB			4	4
DRX_LB1		0	5,8	5
DRX_LB2				17
DRX_LB3				13
DRX_MB		1	2	2,25
DRX_HB			1,4	4

1.1 System Main Feature

Feature	Description
Physical	PCI express M.2 module, size 3042, 75Pin golden finger
Electrical	Single VCC supply (3.3V+/-5% 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 6.2g
USIM	Off-board USIM connector supported
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 8: 880 to 915 MHz (UL), 925 to 960 MHz (DL)
	GSM operating bands: GSM850: 824 to 849 MHz (UL), 869 to 894 MHz (DL) E-GSM900: 880 to 915 MHz (UL), 925 to 960 MHz (DL) DCS1800: 1710 to 1785 MHz (UL), 1805 to 1880 MHz (DL) PCS1900: 1850 to 1910 MHz (UL), 1930 to 1990 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 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)
	CDMA 1X/CDMA EV-DOrB operating bands: BC0: 824 to 849 MHz (UL), 869 to 894 MHz (DL) BC1: 1850 to 1910 MHz (UL), 1930 to 1990 MHz (DL)
Diversity/2nd Rx	All WCDMA/HSDPA/HSUPA/HSPA+ operating bands All CDMA 1X/CDMA EVDO operating bands All LTE operating bands
GNSS	GPS: L1 (1575.42MHz) GLONASS: L1 (1602MHz)
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	GPRS: DL 85.6 kbps /UL 85.6 kbps EDGE: DL 236.8 kbps/UL 236.8 kbps 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 CDMA 1x: DL 153.6 kbps/UL 153.6 kbps EVDO Rev.A: DL 3.1 Mbps /UL 1.8 Mbps EVDO Rev.B: DL 14.7 Mbps/UL 5.4 Mbps LTE FDD : DL:100 Mbps/UL 50 Mbps @20M BW cat3
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LTE air interface

LTE R9, Cat3, 20MHz BW (FDD: up to 100 Mbps downlink, 50 Mbps uplink)

- FDD: up to 100 Mbps downlink, 50 Mbps uplink
- 1.4 to 20 MHz RF bandwidth
- 1X2 MISO (1Tx and 2Rx for two downlinks simultaneously)
- 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; up to 21 Mbps  
1X2 MISO (1Tx and 2Rx for two downlinks simultaneously)  
2Rx with 16 QAM; up to 28 Mbps  
Uplink 16 QAM; up to 5.76 Mbps
- R8 DC-HSPA+  
Downlink dual carrier with 64 QAM; up to 42 Mbps

CDMA air interface

- 1x  
153.6 kbps forward link, 153.6 kbps reverse link
- 1xEV-DO r0  
High-speed peak data rates – 2.4 Mbps forward link; 153 kbps reverse link
- 1xEV-DO rA  
High-speed peak data rates – 3.1 Mbps forward link; 1.8 Mbps reverse link

- 1xEV-DO<sub>r</sub>B  
High-speed peak data rates – 14.7 Mbps forward link; 5.4 Mbps reverse link

#### GSM / GPRS / EDGE air interface

- R99  
Circuit-switched data: 9.6 k; 14.4 k
- GPRS  
Packet-switched data:  
DTM (simple class A) operation  
Multi-slot class 12 data services  
CS schemes – CS1, CS2, CS3, and CS4  
GEA1, GEA2, and GEA3 ciphering  
Maximum of four Rx timeslots per frame
- EDGE  
E2 power class for 8 PSK  
DTM (simple class A), multislot class 12  
Downlink coding schemes – CS 1-4, MCS 1-9  
Uplink coding schemes – CS 1-4, MCS 1-9  
BEP reporting  
SRB loopback and test mode B  
8-bit and 11-bit RACH  
PBCCH support  
One-phase/two-phase access procedures  
Link adaptation and IR  
NACC, extended UL TBF

#### GNSS

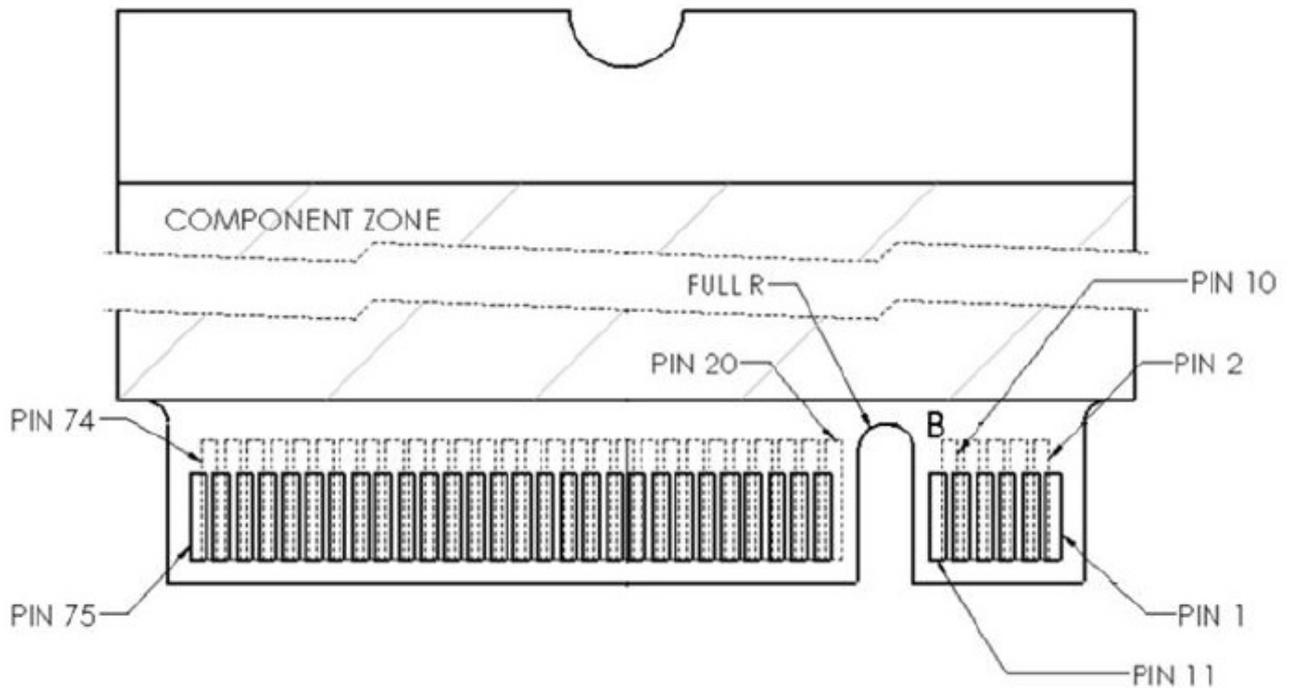
- GPS  
Standalone, MS-A, MS-B, and XTRA GPS
- Glonass  
GLONASS standalone mode  
GLONASS capability increases the number of satellites available to the positioning engine, resulting in an expanded area of coverage over traditional GPS receivers



### 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.



#### 1.3.2 Pin definition

Table 1-1 M.2 Pin definition

No.	M.2 Pin name	I/O	Description	Platform connection
1	CONFIG_3	O	Connected to Ground internally.	Refer to section '1.4.1 Configuration Pins'
2	3.3V	PI	Power supply (3.3V+/-5%)	Refer to section '1.4.2 Power and ground'
3	GND	PI	Ground	Refer to section '1.4.2 Power and ground'
4	3.3V	PI	Power supply (3.3V+/-5%)	Refer to section '1.4.2 Power and ground'
5	GND	PI	Ground	Refer to section '1.4.2 Power and ground'
6	Full_Card_Power_Off (0/1.8V)	I	When it is Low, M.2 card powers off. When it is High, M.2 card powers on. Pull down on card, should be tolerant of 3.3V	Refer to section '1.4.3 Full_Card_Power_Off'

7	USB_D+	IO	USB Data+ defined in the USB 2.0 Specification.	Refer to section '1.4.4 USB interface'
8	W_DISABLE#1 (0/3.3V)	I	Active low signal used by the host to turn on/off radio operation. When it is Low, radio off. When it is High, radio on.	Refer to section '1.4.5 W_DISABLE#'
9	USB_D-	IO	USB Data- defined in the USB 2.0 Specification.	Refer to section '1.4.4 USB interface'
10	LED#1	O	Active low signal, used to allow the M.2 card to provide status indicators via LED devices that will be provided by the system.	Refer to section '1.4.6 LED Indication'
11	GND	PI	Ground	Refer to section '1.4.2 Power and ground'
12~19	Notch	-	Notch	
20	AUDIO_0	-	Don't need to connect to platform; Connect to MDM9xxx PRIM_PCM_CLK	Reserve for future extension, please contact with us if need to use these Pins
21	CONFIG_0	O	Not connect internally.	Refer to section '1.4.1 Configuration Pins'
22	AUDIO_1	-	Don't need to connect to platform; Connect to MDM9xxx PRIM_PCM_SYNC	Reserve for future extension, please contact with us if need to use these Pins
23	WoWWAN (0/1.8V)	O	WWAN to wake up the host, It is active low.	Refer to section '1.4.7 WoWWAN'
24	AUDIO_2	-	Don't need to connect to platform; Connect to MDM9xxx PRIM_PCM_DIN	Reserve for future extension, please contact with us if need to use these Pins
25	DPR (0/1.8V)	I	Hardware pin for BodySAR Detection H: No TX power backoff (default) L: TX power backoff	Refer to '1.4.8 DPR'
26	W_Disable2	I	GPS disable: H: Turn on GPS/GLONASS (default) L: Turn off GPS/GLONASS	Refer to section '1.4.5 W_DISABLE#'
27	GND	PI	Ground	Refer to section '1.4.2 Power and ground'
28	AUDIO_3	-	Don't need to connect to platform;	Reserve for future extension, please contact

			Connect to MDM9xxx PRIM_PCM_DOUT	with us if need to use these Pins
29	SSIC-TxN	-	Don't need to connect to platform; Connect to MDM9xxx SPI_MOSI	Reserve for future extension, please contact with us if need to use these Pins
30	UIM-RESET	O	UIM-RESET	Refer to section '1.4.9 USIM'
31	SSIC-TxP	-	Don't need to connect to platform; Connect to MDM9xxx SPI_MISO	Reserve for future extension, please contact with us if need to use these Pins
32	UIM-CLK	O	UIM-CLK	Refer to section '1.4.9 USIM'
33	GND	PI	Ground	Refer to section '1.4.2 Power and ground'
34	UIM-DATA	IO	UIM-DATA	Refer to section '1.4.9 USIM'
35	SSIC-RxN	-	Don't need to connect to platform; Connect to MDM9xxx SPI_CS_N	Reserve for future extension, please contact with us if need to use these Pins
36	UIM-PWR	O	UIM-PWR	Refer to section '1.4.9 USIM'
37	SSIC-RxP	-	Don't need to connect to platform; Connect to MDM9xxx SPI_CLK	Reserve for future extension, please contact with us if need to use these Pins
38	N/C	-	Not connect	N/A for WWAN
39	GND	PI	Ground	Refer to section '1.4.2 Power and ground'
40	GNSS_SCL (0/1.8V*)	IO	I2C_CLK, Don't need to connect to platform	Reserve for future extension, please contact with us if need to use these Pins
41	NC	-	Don't need to connect to platform; Connect to MDM9xxx UART_CTS_N	Reserve for future extension, please contact with us if need to use these Pins
42	GNSS_SDA (0/1.8V*)	IO	I2C_DATA, Don't need to connect to platform	Reserve for future extension, please contact with us if need to use these Pins
43	NC	-	Don't need to connect to platform; Connect to MDM9xxx UART_RFR_N	Reserve for future extension, please contact with us if need to use these Pins
44	GNSS_IRQ (0/1.8V*)	IO	I2C_IRQ, Don't need to	Reserve for future

			connect to platform	extension, please contact with us if need to use these Pins
45	GND	PI	Ground	Refer to section '1.4.2 Power and ground'
46	SYSCLK (0/1.8V*)	IO	Don't need to connect to platform; Connect to PMIC XO	Reserve for future extension, please contact with us if need to use these Pins
47	NC	-	Don't need to connect to platform; Connect to MDM9xxx MDM_UART_TX	Reserve for future extension, please contact with us if need to use these Pins
48	TX_BLANKING	-	Don't need to connect to platform;	Reserve for future extension, please contact with us if need to use these Pins
49	NC	-	Don't need to connect to platform; Connect to MDM9xxx MDM_UART_RX	Reserve for future extension, please contact with us if need to use these Pins
50	NC	-	Not connect	N/A for WWAN
51	GND	PI	Ground	Refer to section '1.4.2 Power and ground'
52	NC	-	Not connect	N/A for WWAN
53	NC	-	Not connect	N/A for WWAN
54	NC	-	Don't need to connect to platform; Connect to MDM9xxx GPIO# internally	Foxconn use internally to separate different SKus
55	NC	-	Not connect	N/A for WWAN
56	NC	-	Don't need to connect to platform; Connect to MDM9xxx GPIO# internally	Foxconn use internally to separate different SKus
57	GND	PI	Ground	Refer to section '1.4.2 Power and ground'
58	NC	-	Don't need to connect to platform; Connect to MDM9xxx GPIO# internally	Foxconn use internally to separate different SKus
59	ANTCTL0 (0/1.8V)	O	Tunable antenna control signal, bit 0	Refer to section '1.4.10 Antenna Control'
60	COEX3 (0/1.8V)	-	For LTE/WLAN co-existence; LTE_WLAN_PRIORITY	Refer to section '1.4.11 Coexistence'
61	ANTCTL1 (0/1.8V)	O	Tunable antenna control signal, bit 1	Refer to section '1.4.10 Antenna Control'

62	COEX2 (0/1.8V)	-	For LTE/WLAN co-existence; LTE_FRAME_SYNC	Refer to section '1.4.11 Coexistence'
63	ANTCTL2 (0/1.8V)	O	Tunable antenna control signal, bit 2	Refer to section '1.4.10 Antenna Control'
64	COEX1 (0/1.8V)	-	For LTE/WLAN co-existence; LTE_ACTIVE	Refer to section '1.4.11 Coexistence'
65	ANTCTL3 (0/1.8V)	O	Tunable antenna control signal, bit 3	Refer to section '1.4.10 Antenna Control'
66	SIM Detect	I	SIM_SWP	Refer to section '1.4.9 USIM'
67	Reset# (0/1.8V)	I	System reset	Refer to section '1.4.12 RESET#'
68	SUSCLK(32kHz) (0/3.3V)	I	Reserve	Qualcomm MDM9xxx solution don't need external SUSCLK
69	CONFIG_1	O	Connected to Ground internally.	Refer to section '1.4.1 Configuration Pins '
70	3.3Vaux	PI	Power supply (3.3V+/-5%)	Refer to section '1.4.2 Power and ground'
71	GND	PI	Ground	Refer to section '1.4.2 Power and ground'
72	3.3Vaux	PI	Power supply (3.3V+/-5%)	Refer to section '1.4.2 Power and ground'
73	GND	PI	Ground	Refer to section '1.4.2 Power and ground'
74	3.3Vaux	PI	Power supply (3.3V+/-5%)	Refer to section '1.4.2 Power and ground'
75	CONFIG_2	O	Connected to Ground internally.	Refer to section '1.4.1 Configuration Pins '

1.4 Platform connection design

1.4.1 Configuration Pins

The M.2 module provides 4 configuration pins. T77H468 is configured as WWAN-SSIC 0, refer to PCIe M.2\_Rev0.7a.

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

1.4.2 Power and ground

(1) Power Rail Parameters

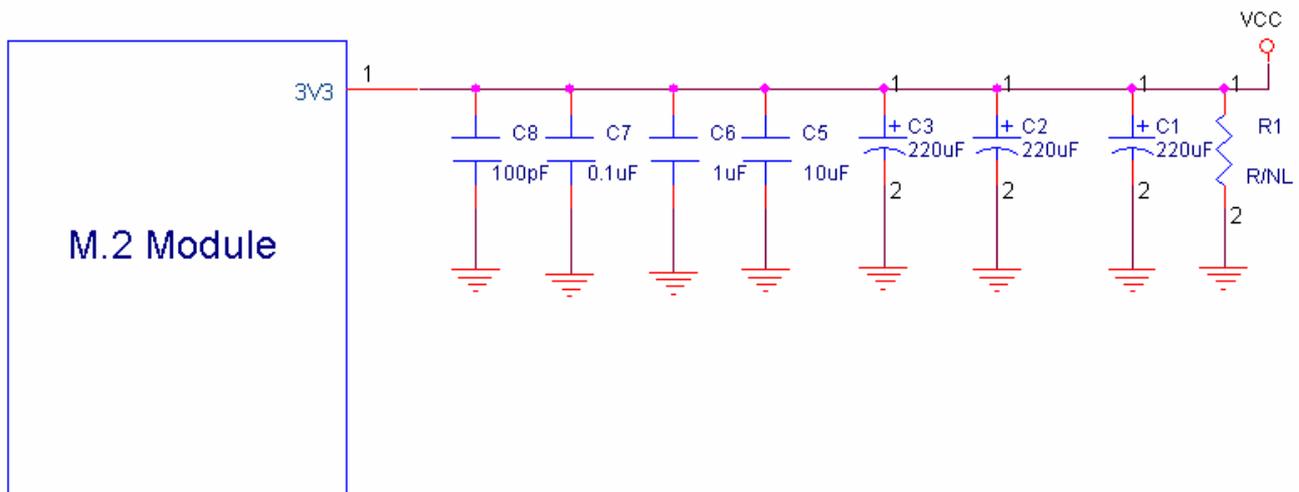
Parameter	Min	Type	Max	Units
Operating voltage	3.135	3.3	3.465	Vdc

The operating voltage was defined in PCIe M.2\_Rev0.7a standard as 3.3V+/-5%.

(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 when M.2 card working at +23dBm continue mode.

(3) Whenever the M.2 module works at 2G mode, the module transmits at the maximum power (like +33dBm), the transient peak current may reach to 2.5 A.

We recommended design the VCC supply of host as below:



Remark: When the system power restarts, reserve R1 to discharge power.

(4) 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.

1.4.3 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.

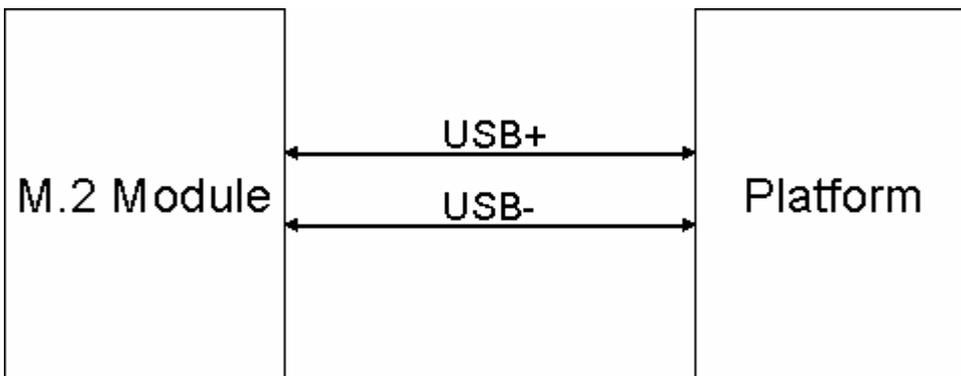
The recommended connections as below



1.4.4 USB interface

T77H468 module is compliant with USB2.0 in all three modes (Low speed, Full speed, and high speed). When two devices are connected via a USB 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 1-4-4 USB2.0 interface



### 1.4.5 W\_DISABLE#

This control setting is implementation-specific and represents the collective intention of the host software to manage radio operation. T77H468 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

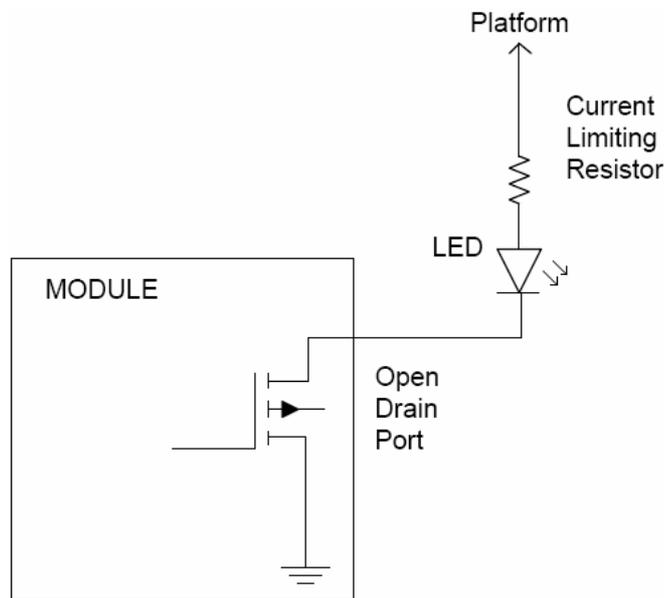
### 1.4.6 LED Indication

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.

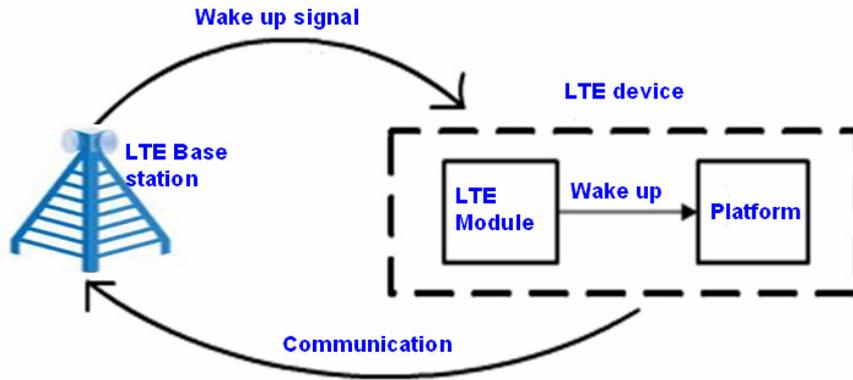
#### (2) Typical LED Connection in Platform/System



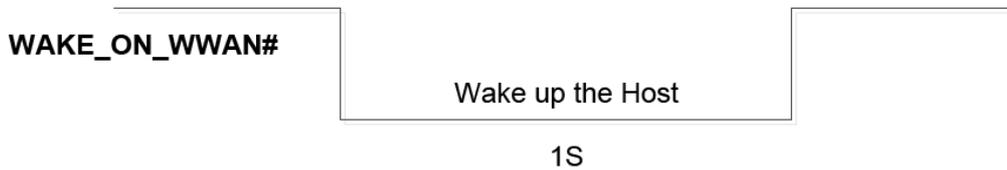
### 1.4.7 WoWWAN

The WAKE\_ON\_WWAN# signal is for power saving.

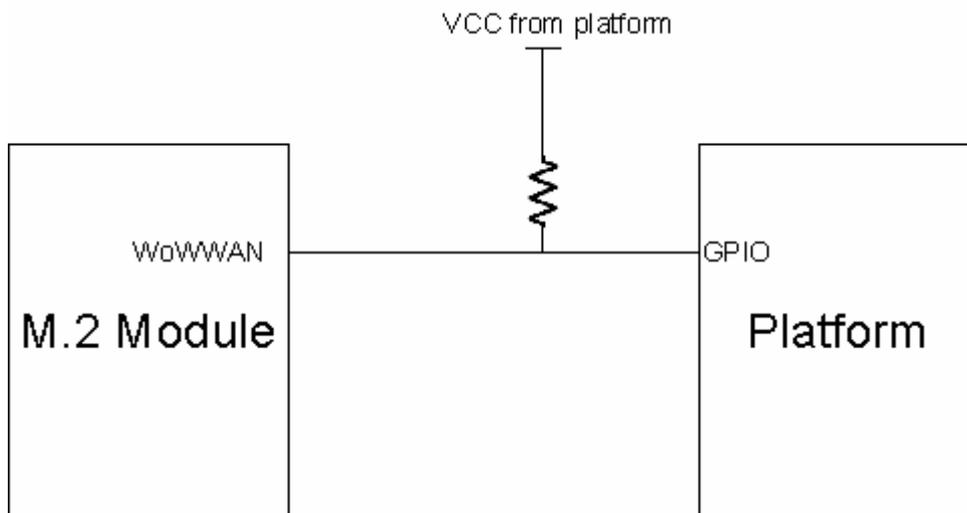
- LTE module always listening at very low power in idle mode
- LTE module will wake up mother board via 'WoWWAN' signal.
- The platform will power on when triggered by the LTE module.



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 1-4-6.



Typical Connection in Platform/System



1.4.8 DPR (Dynamic Power Reduction)

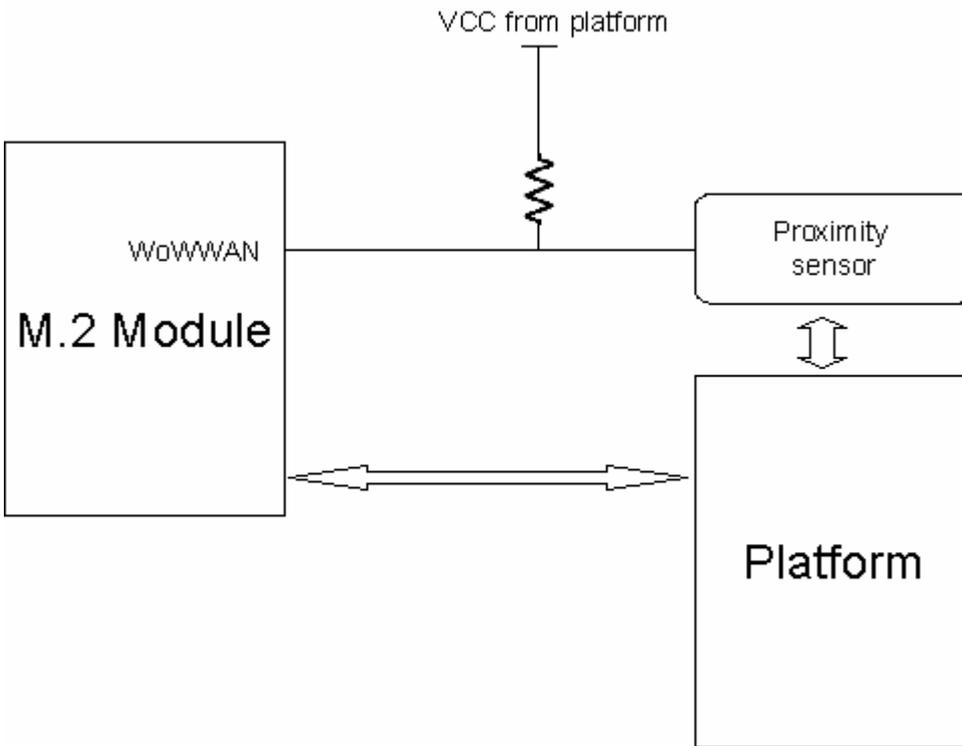
The optional DPR signal is used by wireless devices to assist in meeting regulatory SAR (Specific Absorption Rate) requirements for RF exposure. The signal is provided by a host system proximity sensor to the wireless device to provide an input trigger causing a reduction in the radio transmit output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

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.

(2) Typical Connection in Platform/System



Remark:

- a. The proximity sensor was controlled by the platform side.
- b. After PDR pin becomes low level, you can set the MAX TX power by AT commands.

### 1.4.9 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

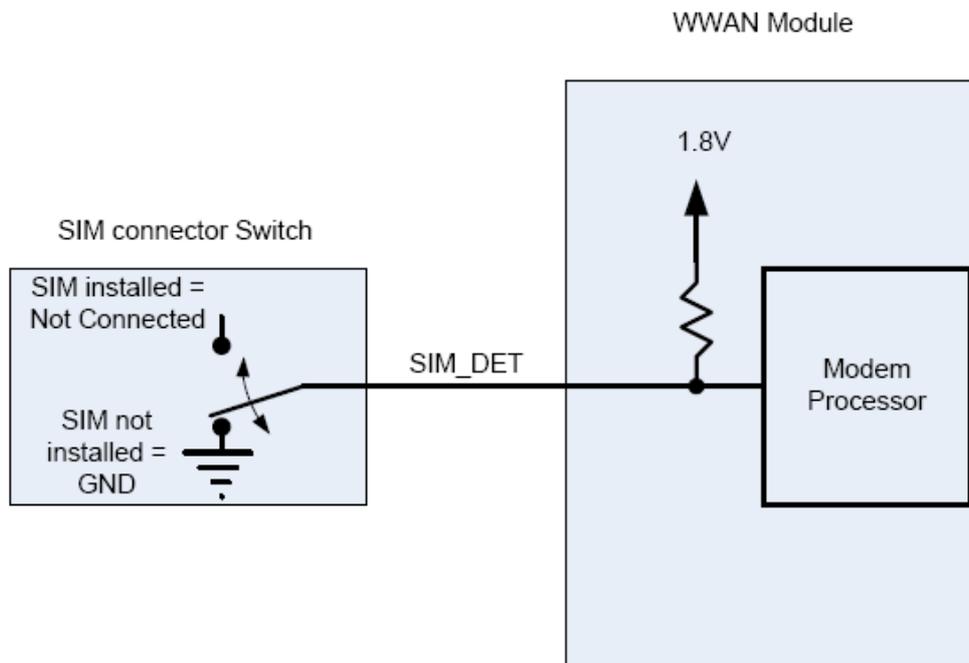
It is recommended to take electrostatic discharge (ESD) protection measures near the USIM card socket. The USIM socket should be placed near the NGFF interface (<100 mm), because a long circuit may impact signal quality.

#### (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 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.



1.4.10 Antenna Control

T77H468 provides GPIO control signals for external antenna tuner application. The function is under development for customization. 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.

An example of tuning state configuration as below.

ANTCTL0	ANTCTL1	ANTCTL2	ANTCTL3	Band support
0	0	0	0	LTE BAND XVII, XIII
0	1	0	0	LTE BAND V UMTS BAND VIII, V, GSM 850/900
1	0	0	0	LTE Band XXV, IV, II UMTS BAND IV, II, I GSM 1800/1900
1	1	0	0	
0	0	0	1	
0	1	0	1	
1	0	0	1	
1	1	0	1	
0	0	1	0	
0	1	1	0	
1	0	1	0	
1	1	1	0	
0	0	1	1	
0	1	1	1	
1	0	1	1	
1	1	1	1	

1.4.11 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).

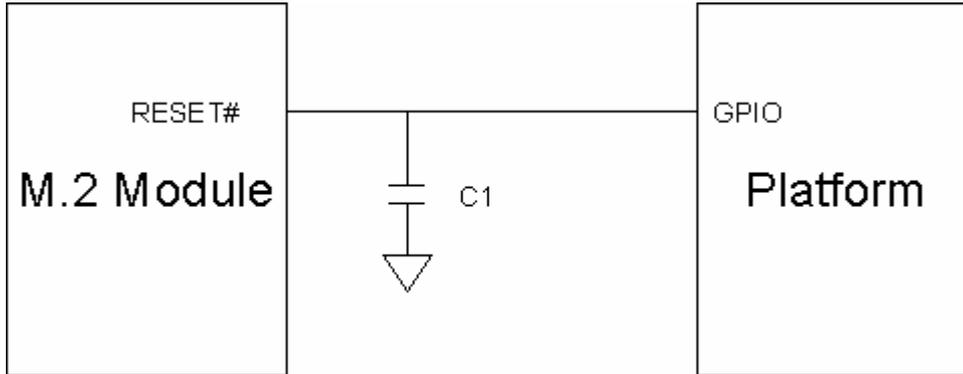
Reserve for future extension, please contact with us if need to use these Pins.

Item	Signal name	GPIO from MDM9x15	Description
COEX1	LTE_ACTIVE	GPIO_67	TBD
COEX2	LTE_FRAME_SYNC	GPIO_66	TBD
COEX3	LTE_WLAN_PRIORITY	GPIO_65	TBD

### 1.4.12 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

T77H468 consists of the following key engine components, in addition to the required front-end RF and other discrete components.

### Modem engine

- Soft Baseband: MDM-9615
- RF: WTR1605L
- Power: PM8018

### Connectivity engine

- USB: USB2.0 high-speed
- USIM: located off board
- Antenna: connectors for the off board antennas

### 2.1 Mobile Data Modem

The MDM9615 chipset solution integrates powerful digital signal processors (DXPs) into any market-proven wireless modem, offering increased processing capacity and lower power consumption. They are complete system solutions that operate on networks worldwide. The major functions of MDM9615 used on T77H468 are listed below:

#### Processor:

- Manufactured in 28nm CMOS process
- System uP (Cortex-A5+L2 cache at up to 550MHz)
- ARM7 processor for the RPM

#### Memory:

- External memory (16KB for security)
  - EBI1: 1Gb LPDDR1
- External memory
  - EBI2: 2Gb NAND flash

#### Air interface:

- WCDMA (R99, HSDPA, HSUPA, HSPA+, DC-HSPA+)
- CDMA (1x, EV-DO<sub>r0</sub>, EV-DO<sub>rA</sub>, EV-DO<sub>rB</sub>)
- LTE (R9 Cat3, FDD)
- GSM (GSM R99, GPRS, EDGE)
- GPS/Glonass

#### Advance RX operation:

- Mobile receive diversity (WCDMA, CDMA and LTE)

□ Connectivity:

- USB 2.0 HS with built-in USB PHY
- UART interface
- UIM support (dual voltage)

## 2.2 RF transceiver

The WTR1605 device is a highly integrated and versatile RF CMOS transceiver IC that can be used in multimode, multiband applications – including Rx diversity. The WTR1605 IC is the RF transceiver IC within compatible Qualcomm MDM9615 chipsets.

The WTR1605 IC integrates advanced receive and transmit features into a 4.91 × 5.47 × 0.63 mm package to simplify handset design, minimize parts count, and reduce DC power consumption. These advanced Rx/Tx features include:

- Multimode, multiband RF transceiver functions:
- GNSS receiver functions
- Fully integrated LO generation and distribution circuits to support all the RF operating band and mode combinations
- Primary, diversity, and GNSS receivers that can operate simultaneously
- Tx power detector for monitoring the transmit power levels
- The GSM receiver can share the secondary paths with CDMA, WCDMA, and LTE diversity receivers
- Qualcomm's intelligent receiver technology for CDMA modes:
- Low operating voltages that help save battery current and allows the WTR IC power to be supplied by the PMIC's switching mode power supply (SMPS) circuits for even greater power savings

## 2.3 Power management IC

T77H468 system uses the Qualcomm PM8018. Qualcomm has worked with Maxim Integrated Products Inc. to develop a custom PMIC solution for use with the T77H468 platform.

## 2.4 Antenna Design

### 2.4.1 Antenna specification

T77H468 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 0.7a, Version 1.0 standard. The antenna elements are typically integrated into the notebook/ultrabook /tablet and connected to T77H468 module via flexible RF coaxial cables. T77H468 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	/	/	2:1	/	Maximum allowed VSWR of antenna

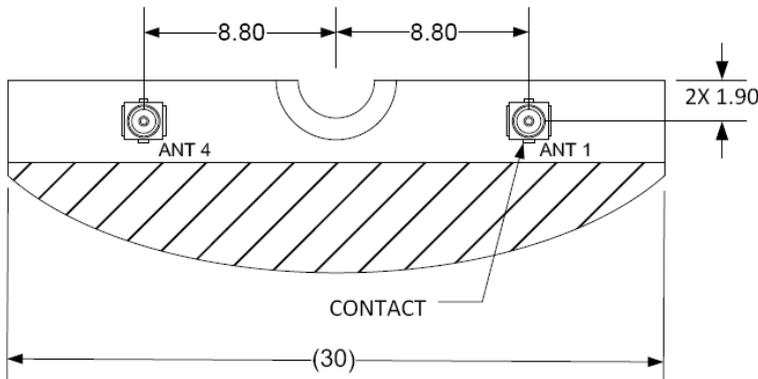
Table 2-2 Aux antenna specifications

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 <2:1
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 Aux / GPS
2	TBD
3	TBD
4	WWAN Main
5	TBD

Figure 2-2 RF connectors

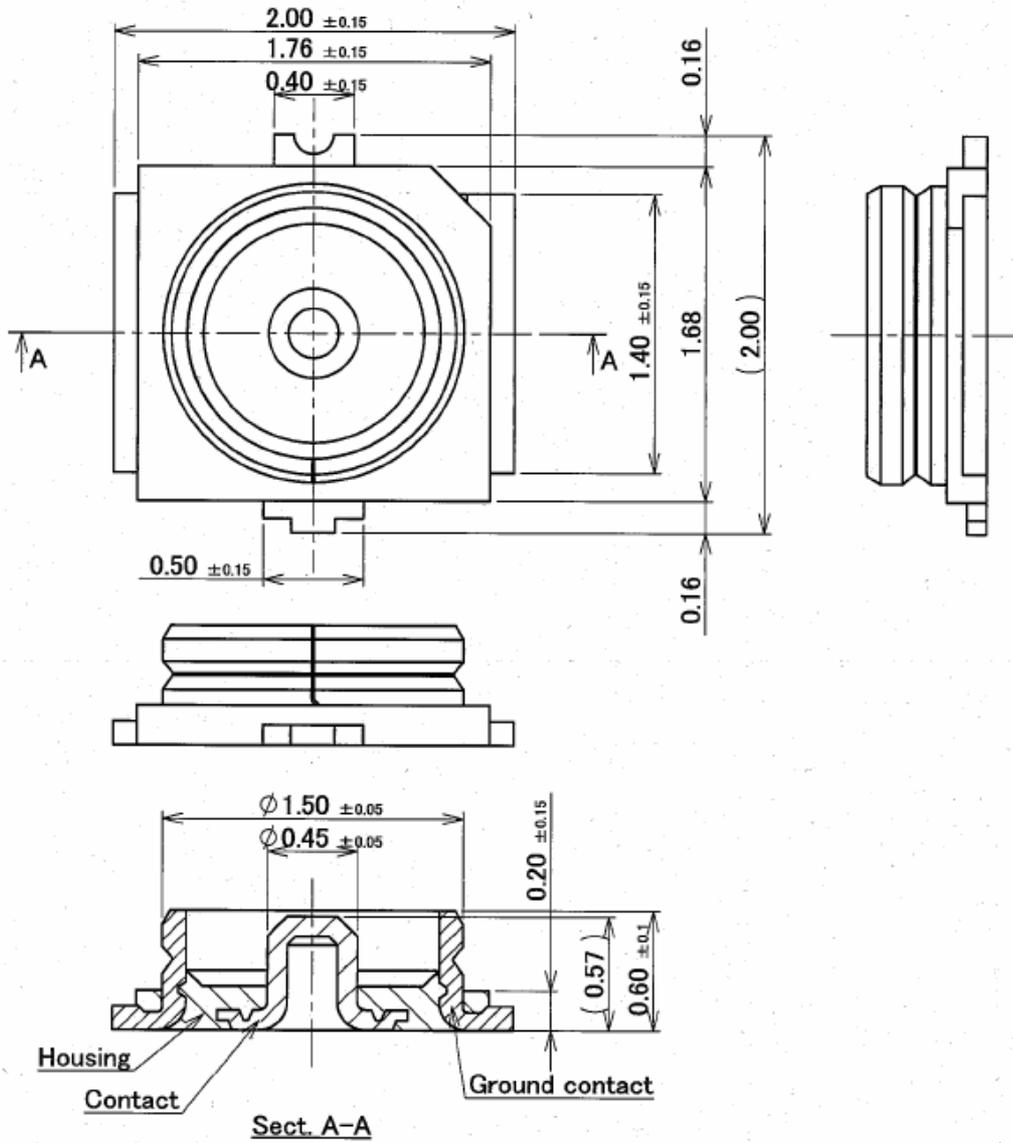
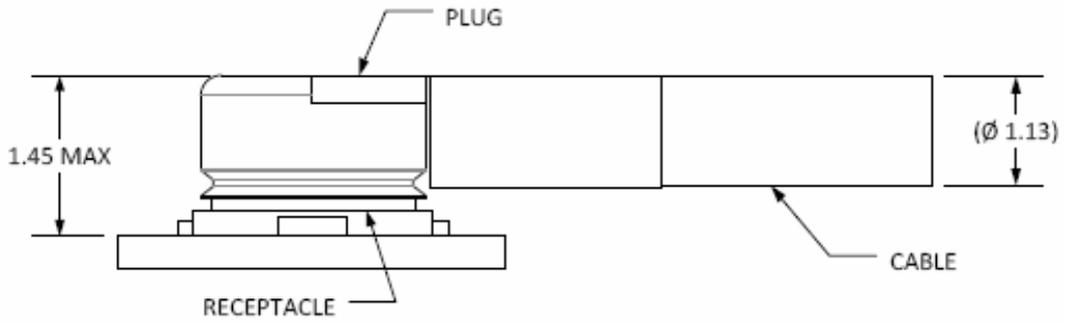
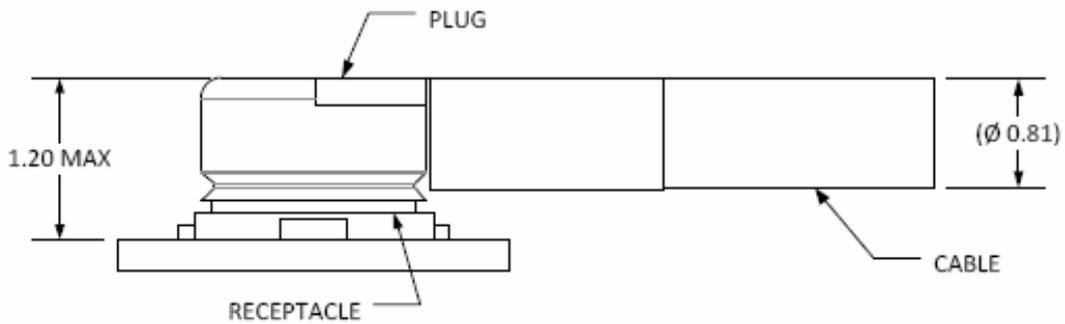


Figure 2-3 RF receptacles



**Mated Plug for Ø 1.13 mm Coax Cable**



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

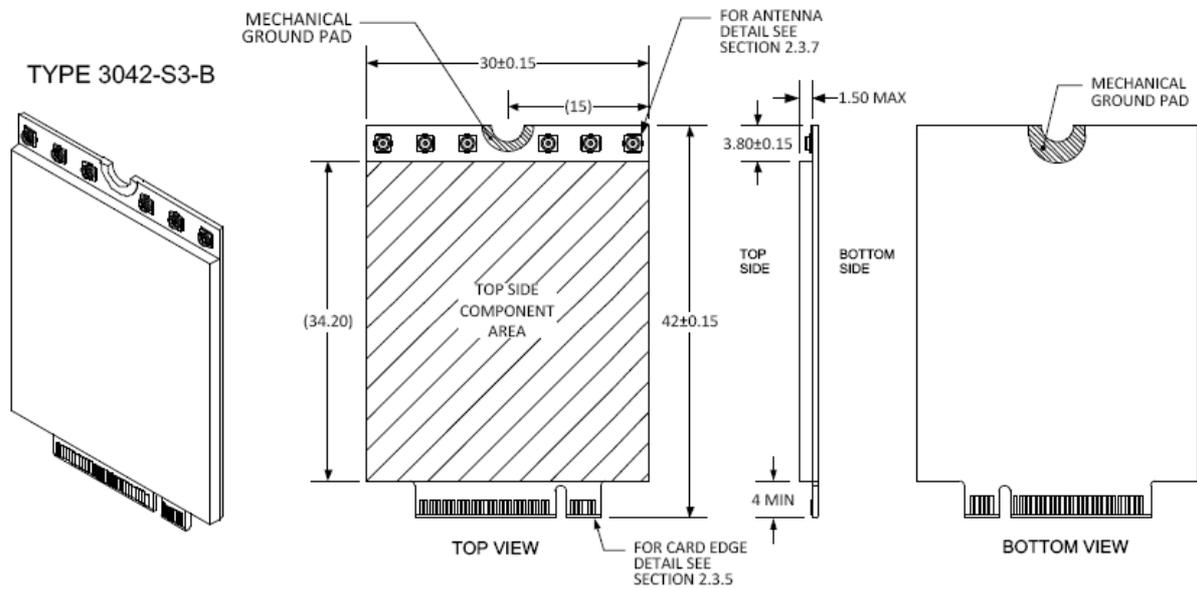
### 3. Mechanical Specifications

#### 3.1 Overview

T77H468 is compatible with the PCI Express M.2 Specification 3042 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.

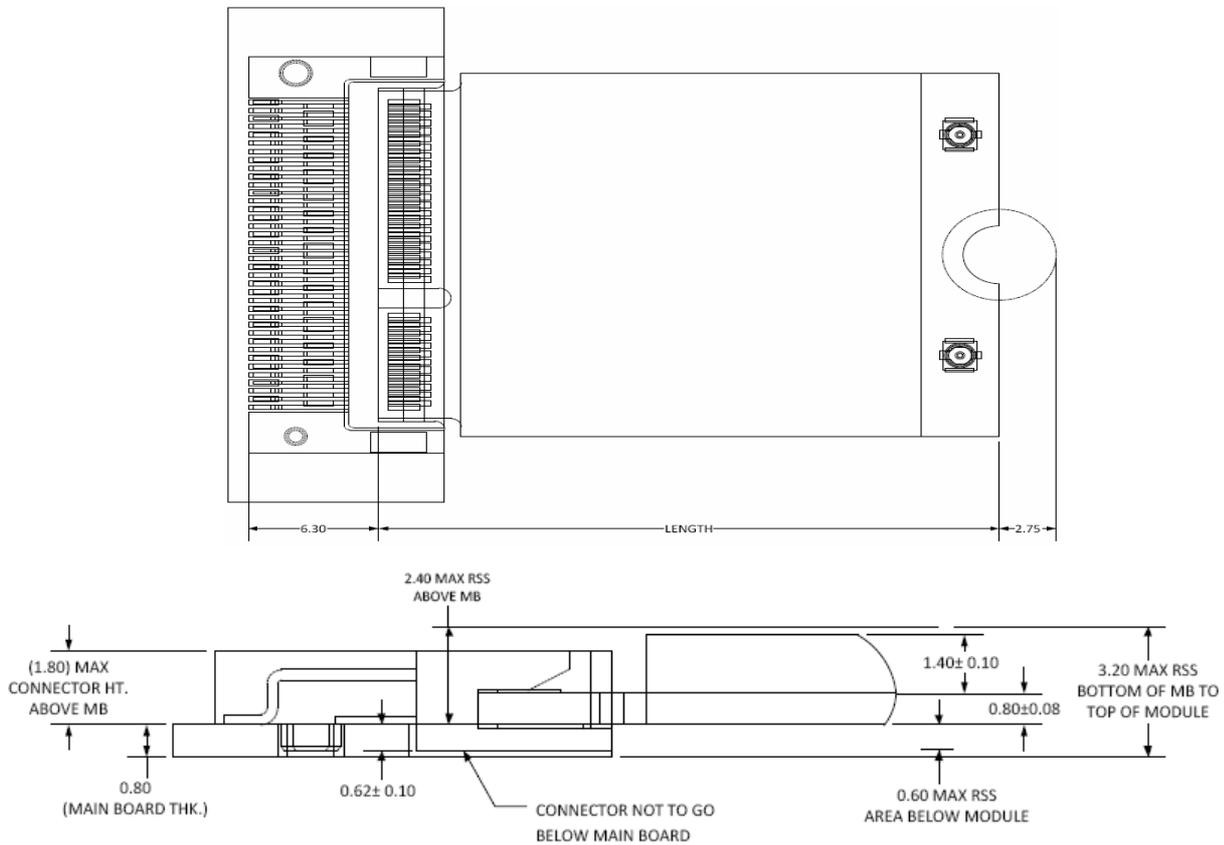
#### 3.2 Mechanical constraints

Figure 3-1 shows the mechanical constraints of T77H468 (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\_Rev0.7a standard.



Remark:

- 2.4mm maximum above mother board
- Cut area of main board under M.2 module
- Need to add thermal pad between M.2 module and mechanical component (like material shielding) for thermal dissipation.

#### 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	-10	+25	+60	°C
Extend operating temperature	-20	+25	+75	°C
Operating voltage	3.135	3.3	3.465	Vdc

Operating T77H468 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
GSM in standby mode	<5mA
GSM (Tx=31dBm)	<500mA
WCDMA in standby mode	<5mA
WCDMA (Tx=24dBm)	<900mA
CDMA in standby mode	<5mA
CDMA (Tx=24dBm)	<900mA
LTE in standby mode	<5mA
LTE (64QAM) Tx=23 dBm	<900mA
GPS tracking	<200mA
Glomass tracking, high sensitivity	<260mA

Remark: Above specification is our target, we are working on current consumption optimization, we will update after finish current consumption measurement.

## 5. RF performance specifications

Radio performance for T77H468 is given in the following sections, including RF receiver, RF transmitter.

### 5.1 RF maximum Tx power specifications

Table 5-1 Maximum transmit power

Specification	Power class/ control level	Min.	Typ.	Max.	unit
LTE (B2)	Class 3	21	23	25	dBm
LTE (B4)	Class 3	21	23	25	dBm
LTE (B5)	Class 3	21	23	25	dBm
LTE (B13)	Class 3	21	23	25	dBm
LTE (B17)	Class 3	21	23	25	dBm
LTE (B25)	Class 3	21	23	25	dBm
WCDMA (B1)	Class 3	21	24	25	dBm
WCDMA (B2)	Class 3	21	24	25	dBm
WCDMA (B4)	Class 3	21	24	25	dBm
WCDMA (B5)	Class 3	21	24	25	dBm
WCDMA (B8)	Class 3	21	24	25	dBm
CDMA (BC0)	Class 3	23	24	30	dBm
CDMA (BC1)	Class 2	23	24	30	dBm
GSM850/900	Level 5	31	33	35	dBm
GSM1800/1900	Level 0	28	30	32	dBm
GPRS 850/900	Level 5	31	33	35	dBm
GPRS 1800/1900	Level 0	28	30	32	dBm
EDGE 850/900	Level 8	25	27	29	dBm
EDGE 1800/1900	Level 2	24	26	28	dBm

Remark:

Above table is for general application, please inform us if you have any further requirement.

5.2 RF min. Rx sensitivity specifications

Table 5-2 Conducted min. receiver sensitivity

Specification	Min.	Typ.	Max. (compliance with standard)	unit
LTE (B2)@10MHz	/	-98.5	-95	dBm
LTE (B4) @10MHz	/	-100	-97	dBm
LTE (B5) @10MHz	/	-100	-95	dBm
LTE (B13) @10MHz	/	-100	-94	dBm
LTE (B17) @10MHz	/	-100	-94	dBm
LTE (B25) @10MHz	/	-98.5	-93.5	dBm
WCDMA (B1)	/	-111	-106	dBm
WCDMA (B2)	/	-111	-104	dBm
WCDMA (B4)	/	-112	-106	dBm
WCDMA (B5)	/	-113	-104	dBm
WCDMA (B8)	/	-113	-103	dBm
CDMA (BC0)	/	-110	-105.5	dBm
CDMA (BC1)	/	-110	-105.5	dBm
GSM850/900	/	-112	-102	dBm
GSM1800/1900	/	-110	-102	dBm
GPRS 850/900 (CS1)	/	-112	-102	dBm
GPRS 1800/1900 (CS1)	/	-110	-102	dBm
EDGE 850/900 (CS5)	/	-106	-99	dBm
EDGE 1800/1900 (CS5)	/	-104	-99	dBm
GPS/GLONASS tracking sensitivity	/	-157	-152	dBm

Remark: It has 3dB margin at least refer to 3GPP standard or CDMA standard.

## 6. Software Requirements

The software includes firmware, driver, configuration file and configuration utility for LTE Card based on Qualcomm MDM9615+WTR1605L chipsets. Please refer to main features in below table.

#	Feature	Feature description
<b>1.1</b>	<b>Modem</b>	
1.1.1	LTE-FDD - Release 8	
1.1.2	LTE-FDD - Release 9 (mandatory features)	
1.1.3	DC-HSPA+ - Release 8	
1.1.4	1x Advanced	
1.1.5	EVDO Rev B	
1.1.6	eHRPD	
1.1.7	WCDMA	
1.1.8	GERAN	
1.1.9	SVLTE	
1.1.10	WCDMA/GERAN: Protocols – Rel-8: Support for E-UTRA Detection	If LTE coverage is available and if UE is able to detect the same (from a state where we didn't have any sync LTE cells), it will inform upper layers. This is spec requirement
1.1.11	LTE-eHRPD Mobility	
1.1.12	Rel8 Fast Dormancy	
1.1.13	Rel7 HSPA DTX/DRX	
1.1.14	APT - for all modes (LTE FDD/WCDMA, C2K)	
1.1.15	Peripheral attachments - WLAN for QCMobileAP and SD card	
1.1.16	Data call (Geran, WCDMA, 1X/EVDO, eHRPD and LTE)	
1.1.17	SMS (GERAN, WCDMA, 1X/EVDO, eHRPD and LTE)	
1.1.18	Data interface- QMI	QMI commands for UQCN download and selection. Add commands to manage UQCNs, set the device in Download mode.
1.1.19	Power grid /PAM table config support	
1.1.20	Support for Gobi RF configs	Support for Gobi WTR1605 configurations

1.1.21	UQCN Feature support	UQCN Feature support ,Carrier specific UQCNs implementation / UQCN generation tools
1.1.22	Configurable RRC band scan order, also add support for LTE cfigs	
1.1.23	Saving MRU/ Band scan etc. info while in suspend/resume/power-save states - WCDMA	
1.1.24	Gobi - Saving MRU/band scan info (3GPP2)	
1.1.25	Gobi - Saving MRU/band scan info (GERAN, WCDMA)	
1.1.26	Gobi - Add QMI CAT Command for terminal profile property.	Add QMI_CAT_SEND_ENVELOP_CMD_RSP. Add optional TLV in QMI_CAT_SEND_ENVELOP_CMD_RSP to report envelope response from card in raw format and corresponding status words
1.1.27	Multiple carrier support in NV	Provides the ability for a single modem image to support multiple carriers via per-carrier configuration files that are downloaded to the modem. This is a Gobi modem capability
<b>1.2</b>	<b>Modem (1X)</b>	
1.2.1	Enable complete IS-683C OTA message support	FEATURE_IS683C_OTASP makes the following messages compliant with IS683C standard: <ul style="list-style-type: none"> <li>■ Protocol Capability Response message</li> <li>■ SSPR Configuration Request/Response message</li> </ul>
1.2.2	OTASP support for all band classes	Expand the OTASP support to all the bands supported by the 3GPP2 C.S0057-B
1.2.3	Multimode: OTASP/OTAPA –Runtime Detection of OTASP Numbers	Provide capability of using custom numbers with OTASP calls via UI through Centralized Call Control support
<b>1.3</b>	<b>Modem (EVDO)</b>	
1.3.1	Dedicated Data Transfer Mode (DDTM)	Allows the user to control the 1X access at runtime when the 1xEV-DO data call is made
1.3.2	EV-DO Data Activity Based Adaptive Receive Diversity	Disable EV-DO diversity when no FL data is arriving. When data resumes, immediately bring up diversity. This saves power during the period of waiting for dormancy for applications that don't explicitly close the connect

1.3.3	Rx Diversity during 1x Access	Enable 1x Rx Diversity during 1x Access if Rx Diversity for Traffic Has Been Enabled
1.3.4	1X EV-DO Rev B (with QOS for handsets)	The multi-carrier version of 1xEV-DO in which up to three carriers are supported on the forward and reverse links; QoS added for handsets
1.3.5	3 Carrier Rev B over 5x Bandwidth	3 Carrier rev B over 5x bandwidth
1.3.6	Max Bandwidth Support	Support calls where the AN assigns outer carriers that are 5.16 MHz apart
1.3.7	Rev B physical layer FL rates	Enhanced flow rates on FL
<b>1.4</b>	<b>Modem (eHRPD)</b>	
1.4.1	eHRPD: eHRPD <-> 1x handoff	Allows the mobile to move between areas of eHRPD coverage and 1x coverage (and vice-versa).
1.4.2	eHRPD: eHRPD <-> HRPD handoff	When moving from 1x/HRPD to eHRPD, AT should not send ULN. When moving back from eHRPD to HRPD, also AT should not send ULN.
<b>1.5</b>	<b>Modem (Geran)</b>	
1.5.1	GERAN 3GPP Rel-8 Spec compliance	GERAN compliant with Rel-8 spec versions
1.5.2	NACC, Ext UL TBF Rel	Network-Assisted Cell Selection for faster cell reselection and Extended UL TBF Release to extend the UL TBF and reduce the incidence of idle activity between packet transfer activities
1.2.3	PFC/PFI	Packet Flow Context/Packet Flow Identifier - Allows identity tagging of RLC blocks to identify separate QoS streams at the radio link layer
1.5.4	EDGE MSC12	Original legacy EDGE support with Multislot Class 12 capability
1.5.5	GPRS/EDGE MSC12-EDA	Extended Dynamic Allocation to permit allocation of more than two uplink timeslots for GPRS/EDGE
1.5.6	Enh DL RLC/MAC Segmentation	Permits reception of MAC control messages that exceed one radio block capacity in length
1.5.7	Enhanced Ext UL TBF	Per Ext UL TBF, with the addition that dummy block transmission is punctured for current saving purposes
1.5.8	2G PS handover	Packet-switched equivalent of CS handover to ensure faster cell change and improved throughput
1.5.9	Encryption: GEA3	New packet-switched cipher algorithm

1.5.10	WCDMA/GERAN: Band Scan – Run-time Configurable RRC Band Scan Order	Run-time configurable RRC band scan order
1.5.11	WCDMA/GERAN: Power and Network Optimizations – Frame Early Termination for Power Optimization	With pragmatic reception approach, decode partial TTI and terminate frame early to reduce power consumption
1.5.12	WCDMA/GERAN: Protocols – MRAB-Pack-1 Enhancements	These UE enhancements will reduce Multi-RAB Call Drops. The following optimizations are planned under MRAB-Pack-1: 1) Configuration of the minimum set of TFCs: Optimize the way that PS-only TFCs are selected for UL transmission in power limited conditions(2 flavors) 1-EUL) Smart application of minimum E-TFCI : Optimize utilization of Minimum E-TFCI in power limited conditions 4) MRAB Back-off: Preventing, or reducing the establishment of data connections on top of existing voice connections in power limited conditions 6) TVM Back-off : Blocking traffic volume events (Event 4a) for MRAB calls in power limited conditions
<b>1.6</b>	<b>Modem (UMTS)</b>	
1.6.1	Cat 10 HSDPA	Rel-5 Category 10 HSDPA, allowing for physical layer throughputs up to 14.4 Mbps.
1.6.2	Cat 6 HSUPA	Rel-6 Category 6 HSUPA, allowing for physical layer throughputs up to 5.76 Mbps.
1.6.3	Cat 14 HSPA+	Cat 14 HSPA+ 64-QAM HSDPA, allowing for physical layer throughputs up to 21 Mbps
1.6.4	DC-HSPA+	Dual Carrier – HSPA+, allowing for physical layer throughputs up to 42 Mbps
1.6.5	HSUPA 10ms TTI (2 Mbps)	HSUPA 10 ms TTI up to 2 Mbps in UL physical layer
1.6.6	HSUPA 2ms TTI (5.76 Mbps)	HSUPA 2ms TTI up to 5.76 Mbps in UL physical layer
1.6.7	E-FDPCH	E-FDPCH Rel-7 enhancement to the Rel-6 FDPCH (fractional DPCH) in soft handover scenarios; fractional DPCH was added in Rel-6 to optimize the consumption of downlink channelization codes - Allowing more users to share the channel
1.6.8	Enhanced L2	Support for flexible sized PDUs at RLC DL and PDU segmentation at MAC-HS level, on the HSDPA downlink to allow for higher data rates in Rel-7

1.6.9	CPC-DTX	Allows for breaks in transmission during HSUPA for power consumption benefit and UL interference reduction.
1.6.10	Q-ICE	Advanced UMTS receiver performing iterative equalization and interference cancellation in support of HSPA+
1.6.11	SCH-IC	Cancelling the interference from the synchronization channel for improved HSDPA performance
<b>1.7</b>	<b>Modem (LTE)</b>	
1.7.1	Rel-9: Mandatory LTE Features	Support for Release 9 Mandatory Features
1.7.2	Bandwidth support 1.4, 3, 5, 10, 15, 20 MHz	Per 3GPP standard
1.7.3	Standalone Security	NAS & RRC security for LTE
1.7.4	CMAS for LTE	Commercial Mobile Alert System for LTE
1.7.5	ETWS (Earthquake Tsunami Warning System) - LTE	Support for ETWS notification in LTE
1.7.6	Intra-Freq Connected mode mobility	Support for 1X2 MISO (1Tx and 2Rx for two downlinks simultaneously)
1.7.7	Intra-Freq Idle mode mobility	Support for 1X2 MISO (1Tx and 2Rx for two downlinks simultaneously)
1.7.8	Inter-Freq mobility	Mobility within LTE band/bandwidth
1.7.9	Connected mode DRX	Exercising DRX cycle while in LTE Connected mode
1.7.10	Sleep	Exercising DRX cycle while in LTE Idle mode
1.7.11	eHRPD -> LTE Idle mode reselection	Mobility from eHRPD to LTE in Idle mode based on LTE neighbor cell measurements
1.7.12	E-UTRA RRC_IDLE -> eHRPD Idle	Reselection from idle LTE to idle eHRPD
1.7.13	IRAT SON ANR	UE IRAT support for Self Organizing Networks and Automatic Neighbor Relation
1.7.14	LTE -> eHRPD (Redirections without measurement gaps - blind)	Redirections from LTE connected -> eHRPD Idle without measurements (blind redirection)
1.7.15	LTE -> eHRPD (Redirections based on measurements gaps)	Redirections from LTE connected to eHRPD idle based on measurements during gaps intervals
1.7.16	LTE -> 1x Connected mode measurements	Perform measurements on 1x side during LTE Connected mode state.
1.7.17	LTE -> 1x Redirection	Redirection from LTE connected to 1x idle
1.7.18	LTE -> 1x Reselection	Idle mode reselection from LTE idle to 1x idle
1.7.19	UMTS -> LTE Redirections (no measurements)	Redirection from UMTS to LTE (blind - no measurements)

1.7.20	UMTS -> LTE Redirections (with measurements)	Redirection from UMTS Connected mode to LTE based on LTE measurements during WCDMA Compressed mode gaps
1.7.21	GERAN -> LTE Redirections (no measurements)	Redirection from GERAN to LTE (blind - no measurements)
1.7.22	LTE <-> GERAN Idle mode mobility (cell reselection)	Idle mode reselection from LTE idle to GERAN idle
1.7.23	LTE <-> UMTS Idle mode mobility (cell reselection)	Idle mode reselection from LTE idle to UMTS idle
1.7.24	LTE -> UMTS PS Handover	UE does a PS handover under network direction from LTE to UMTS
1.7.25	LTE -> UMTS Redirections (with measurements) 2012	Redirection from LTE connected to UMTS with measurements on UMTS
1.7.26	LTE/GW Data Silent Redial for InterRAT	During inter RAT transitions between LTE and WCDMA/GPRS, data calls that are locally rejected on source RAT will be redialed by Data Services mode handler on target RAT
1.7.27	Multimode: LTE – Attach/Detach PS during Voice Call or SMS	Support disabling of PS capability during voice call/SMS and removing LTE when PS is removed (Detach) and add LTE again when PS is added (attach)
1.7.28	TDD-LTE	
<b>1.8</b>	<b>Modem (System Determination)</b>	
1.8.1	Frequency Scan and System Selection within LTE	Ability to do band scan and also power-up system selection
1.8.2	LTE BPLMN support	Support for PLMN search in background while LTE is active
1.8.3	LTE Connected mode OOS	Support System Operation mode (Online, LPM, POWER OFF, etc.) changes in LTE Connected and Idle mode
1.8.4	System Selection across LTE, UMTS, GERAN, 1x/DO	Ability to select a particular RAT based on a preferred RAT list
1.8.5	System Selection across RATs, Standalone Security, Dedicated EPS Bearer Mgmt and Dormancy	Standard LTE features
1.8.6	Support of 256 UPLMN and 256 OPLMN entries in USIM	UE can read 256 entries from each preferred list. Together, it can read a maximum of 512 PLMN entries from preferred list.

1.8.7	Multi-mode System Selection	Facilitating system selection when UE supports multiple modes
1.8.8	Multimode: System Selection – Avoiding Unnecessary Attach Requests in A 3GPP+3GPP2 Multimode UE	NAS will use a synchronous API call to check with CM whether a PLMN is ok to attach before starting attach procedure. If API returns TRUE, NAS will do the attaching and send SRV_CNF to CM. This will be a preferred system so CM won't send STOP_MODE for less preferred system. If API returns FALSE, CM_SRV_CNF with No Service
1.8.9	Carrier Specific BSR Requirements	Extensions to carrier specific set of requirements for System Selection
1.8.10	Data Services: eHRPD/LTE – Data System Determination for Multiple Radio Systems	Re-architect data call arbitration in Data Services layers to remove race conditions between various SW entities in modem and CNE
1.8.11	WCDMA/GERAN: System Selection – Prevent UE from Sending Attach Request Message Infinitely When HPLMN Reject Attach Request with Cause 14	If HPLMN rejects GPRS Registration with cause # GPRS Services Not Allowed in this PLMN (which it shouldn't as per expectation from a well-behaved network), UE keeps on attempting registration again and again on same HPLMN RA. This feature is to cover up for this network misbehavior and reattempt GPRS registration only on RA change
<b>1.9</b>	<b>Modem (Data)</b>	
1.9.1	ATCOP	
1.9.2	WCDMA/GERAN: ATCOP 3GPP – Enhancing The Interface for Manual PLMN Selection	Provide Manual PLMN Selection API between CM/NAS and ATCOP to provide the current serving status of the UE
1.9.3	IPHC	IP header compression protocol as RFC 2509
1.9.4	DHCPv4	DHCPv4 This is to support for stateless DHCPv4 protocol to get P-CSCF and DNS addresses
1.9.5	Simple IPv4	Supports IPv4 address allocation and release without IP mobility
1.9.6	Mobile IPv4	
1.9.7	4 PDNs Support over Multi-RmNet	Provides the capability to an external AP to support 4 PDNs through 4 RmNet Connections to external processor
1.9.8	Dual IP on single RmNet	UE shall support tethered RmNet to laptop data call using Dual IP on single RmNet to a single USB-end point

1.9.9	IP only Mode/Raw IP Mode	RmNet laptop calls transfer IP packets over USB or shared memory without Ethernet framing; reduces CPU overhead and speeds up call setup times (no ARP duplicate detection)
1.9.10	Multi-RmNet Data Call	This is support multiple tethered data calls over multi-RmNet
1.9.11	DHCPv6	
1.9.12	RmNet IPv6	
1.9.13	Tethered IPv6 using DUN over USB	
<b>1.10</b>	<b>Modem (Data: EVDO)</b>	
1.10.1	RLP: 1x EVDO Rev B	This is to support Radio Link Protocol in 1xEV-DO Rev B
1.10.2	CDMA: 1X EVDO Rev B – Enhanced PA Back off for DO Rev B	Uses Tx power differential based PA back off for multi-carrier assignment, and improves a) multi-carrier coverage/throughput on FL, and b) RL data rate/throughput when multiple carriers are assigned on FL
<b>1.11</b>	<b>Modem (Data: eHRPD)</b>	
1.11.1	EAP-AKA' (prime)	Authentication protocol using AKA' (prime) over EAP transport for all air interfaces
1.11.2	eHRPD: Multiple PDN Support	Enhanced AMSS implementation to support multiple VSNCP negotiations and multiple VSNP data paths over one PPP instance for eHRPD multiple PDN connectivity; 3GPP2 eHRPD specification (X.P0057-0-EHRPD-EUTRAN)
1.11.3	eHRPD: Optimized Silent Redial and DCTM4.0	Silent Redial of data call on eHRPD system
1.11.4	Data Services: eHRPD – Ignore PDN Inactivity Timer for The Last PDN	The UE shall ignore the PDN Inactivity timer when only one PDN connection remains. Upon PDN Inactivity timer expiry, if it is the last PDN connection, the UE shall extend the timer, and shall not initiate PDN disconnection
<b>1.12</b>	<b>Modem (Data: LTE)</b>	
1.12.1	LTE: Data Call throttling	This is to prevent UE from repeatedly requesting PDN connections to the NW when it encounters a failure in either eHRPD or LTE connections
1.12.2	LTE: Default IPv4 Bearer activation at attach	Support for IPv4 data call in LTE
1.12.3	LTE: NW initiated QoS	
1.12.4	LTE: UE initiated QoS	
1.12.5	Dual IP Continuity	Dual IP continuity across LTE and eHRPD
1.12.6	IPv4/IPv6 Continuity	Dual IP continuity across LTE and eHRPD

1.12.7	LTE-eHRPD mobility: IPV4 Session Continuity	IPv4 session continuity across LTE and eHRPD
1.12.8	LTE-eHRPD mobility: IPV6 Session Continuity	IPv4 session continuity across LTE and eHRPD
1.12.9	LTE: W/G IP session Continuity	IP session continuity across LTE and W/G
1.12.10	LTE: MIMO – LTE TDD 4-Port Processing	LTE TDD 4x2 MIMO antenna configuration support (4x2 transmit diversity)
1.12.11	LTE: MBMS – LTE TDD MBSFN Awareness	Ability to ignore MBSFN symbols in LTE TDD subframes while maintaining unicast performance
1.12.12	LTE: Mobility – LTE TDD Inter-Freq Connected Mode Handover	LTE TDD inter-frequency connected mode handover with measurements covering multiple EARFCN's in the same or different bands as well as different bandwidths in the same EARFCN
1.12.13	LTE: DRX –LTE TDD Connected Mode DRX without Sleep	Improve power consumption by turning off modem/RF components during connected mode DRX periods. No Sleep support
1.12.14	LTE: DRX – LTE TDD Connected Mode DRX with Sleep	Enhanced and optimized power consumption over 1.12.13 using sleep support in Connected mode DRX periods
1.12.15	LTE: Emergency Services – LTE NAS Support for Control Plane LTE Positioning Protocol	Enable Location Positioning Protocol capabilities through NAS signaling as well as to create an API providing transport services for GPS signaling
1.12.16	Data Services – LTE-eHRPD Mobility Support of APN Class and APN Bearer in Application Profile over LTE	To support APN Bearer in Application Profile over LTE
<b>1.13</b>	<b>Modem (VoLTE)</b>	
1.13.1	LTE: VoLTE – Forking Support	Support for parallel and sequential forking in IMS VoLTE
1.13.2	LTE: QMI – VoLTE: QMI Indication for Remote Party on Hold	Indication provided when remote party places call on hold
1.13.3	LTE: VoLTE – Session Timer support on VoLTE	Session Timer Support on VoLTE/QIPCall to be implemented/tested for Phase3

1.13.4	LTE: VoLTE – VT Call Supplementary Services	Support for VT call supplementary services: 1. Call Hold/Resume 2. Call waiting a. Between two VT/VS calls b. Between VT/VS call and VOIP call c. Between VT/VS call and 1x call 3. Call conference 4. Caller id Presentation/Restriction 5. DTMF
1.13.5	LTE: VoLTE – Early Media Support	Support for early media in VoLTE
1.13.6	LTE: VoLTE – VoLTE Support in RIL, Android Telephony and QMI_VOICE	VoLTE support in RIL, Android Telephony and QMI_VOICE

The Linux features described in this chapter are:

- Device Drivers
- Modem Interface
- Linux Kernel and BSP
- Other
- Power Management
- USB
- Validated Configuration
- Development/Debug

Table 5-1 Linux features

#	Feature	Feature description
<b>2.1</b>	<b>Device Drivers</b>	
2.1.1	UART Driver	Peripheral driver for Universal Asynchronous Receiver/Transmitter
2.1.2	I2C Driver	Peripheral driver for Inter-IC bus up to 100 kbps or 400 kbps for Fast mode
2.1.3	I2S Driver	Peripheral driver for Inter-IC sound bus. I2S is an industry standard (invented by Philips) three-wire interface for streaming stereo audio between devices. Typical applications include digital audio transfer between a CPU/DSP and a DAC/ADC. The I2S core allows a Wishbone master to stream stereo audio to and from I2S capable devices.
2.1.4	SD/MMC Interface	Secure digital memory support.

2.1.5	SDIO	Secure digital input/output <ul style="list-style-type: none"> <li>■ Two controller ports</li> <li>■ Up to 48 MHz</li> <li>■ 4-bit interface</li> <li>■ Interface through Linux MMC stack</li> </ul>
2.1.6	WLAN driver	Support for wireless networking over SDIO
2.1.7	SPI Driver	Peripheral driver for Serial Peripheral Interface bus can use Data Mover and clock up to 26 MHz
2.1.8	SSBI Driver	Driver for SSBI (Single-Wire Serial Bus Interface) bus hardware cores
2.1.9	2KB, 4KB, and 8KB size pages SLC NAND x8 and x16	Flash driver support for 8-bit and 16-bit Single Level Cell (SLC) NAND devices with 2k page size
<b>2.2</b>	<b>Modem Interface</b>	
2.2.1	AT Command Support (GCF)	Support for AT commands required for GCF testing. See document 80-VR432-1 for details.
2.2.2	Dial-up Networking over USB	Support for tethered dial-up networking over USB
2.2.3	QMI	QMI is to be used by 3rd party operating systems to configure the modem data stack
2.2.4	Multimode: QMI – Add One Field to Determine if Record is Read Only or Read-Write in QMI_PBM_RECORD_READ_IND	Adding a field to know whether the record is read only or read-write in QMI_PBM_RECORD_READ_IND. This is required instead of determining through UIM for this information. This feature tells the clients if a particular phonebook is writeable or not and if not what validation is required
2.2.5	Multimode: QMI – WMS SEND RAW Async Command	Add support so raw-send and send-ack can be asynchronous
2.2.6	Data Interface: IMS – VT: Support Rm Socket Interface between AP and Modem	Provides a Rm Socket Interface between AP and Modem for VT Support
2.2.7	Modem Interfaces: QMI – Provide Number of USIM Entries per Contact	PBM support for providing the number of USIM contacts that can be associated with a contact stored on the SIM card. USIM contacts include E-mail, Additional Number, Group name and SNE
2.2.8	Multimode: Emergency Services – RAT Based ECC Number Handling	CM acquires a RAT based on ECC list for emergency call and PBM maintains ECC list per RAT and provide new API for call type resolution
2.2.9	IMS Voice Loopback Mode Support	Support loopback mode for voice packets in IMS

2.2.10	IMS – Call Failure Code & Call End Reason Provided to UI through CM	Call failure code & Call end reason provided to UI through CM
2.2.11	SIM Hotswap	Feature allows inserting or removing a SIM while the device is powered on
<b>2.3</b>	<b>Linux Kernel and BSP</b>	
2.3.1	Base Linux Kernel port	kernel version supported: 3.0
2.3.2	Secure Boot	SBL2 loads all subsystem firmware
2.3.3	Data Mover (DMOV)	Driver that interfaces with the Qualcomm Data Mover hardware.
2.3.4	Exception handler	Linux kernel handlers for A5 CPU exceptions, kernel panic, etc.
2.3.5	Watchdog	No subsystem restart, A5 watchdog bark and bite handlers, modem watchdog bite (system resets), RPM watchdog bite (system resets), restarts in Download mode based on NV flag
2.3.6	Network Stack Support	Linux network stack provides IPv4 and IPv6 support
2.3.7	RAM File System	RAM file system(s) supported for initrd
2.3.8	FAT32	FAT32 file system (for SD)
2.3.9	YAFFS2	NAND
2.3.10	FOTA	FOTA is an application used for upgrading firmware image over the air

## **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 20 cm between the radiator & your body.