

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

5G WWAN Module

Engineering Requirements Specification



Project code: T99W696
Solution: SDX61+SDR435
SKU: WW-4-5G

1. General Description

T99W696 is designed to enable wireless data connectivity for notebook computer or any other device compatible with the PCI Express M.2 Specification 3052 type Key B slot. T99W696 is the data card solution that delivers wireless wide-area network (WWAN) connectivity for the 5G NR (Sub 6G only), LTE, UMTS (HSDPA/HSUPA/HSPA+DC-HSPA+) and GPS/Glonass/ Beidou/ Galileo protocols in one hardware configuration.

SKU		WW-3-5G / T99W696
Carrier Support		NA: AT&T, Verizon, T-Mobile WW: Vodafone, Swisscom, Telefonica-O2 EU: Deutsche Telekom, Swisscom APAC: Telstra, Optus, Docomo, KDDI, Softbank * Carrier engagement based on real business agreement
QCT Solution		SDX61+SDR435+PMX65
5G	FR1 (Sub 6G)	LB: n5/8/12/13/14/18/20/26/28/29/71 MB: n1/2(25)/3/66/ HB: n7/30/38/40/41/48/77/78/79
	4x4 DL MIMO	n1/2/3/7/25/30/38/40/41/48/66/77/78/79
	2x2 UL MIMO	n41/77/78/79
	SRS	n41/77/78/79; 1T4R@NSA; 2T4R@SA
	PC2&PC1.5	n41/77/78/79
4G	Support Band	LB: B26(5/18/19)/8/12(17)/13/14/20/28/29/71 MB: B1/2(25)/3/4(66)/32 HB: B7/30/34/38/39/40/41/42/43/48
	4x4 DL MIMO	B1/2/3/4/7/25/30/34/38/39/40/41/42/43/48/66
	LAA	Not support
	LTE Cat.	ue-CategoryUL 18 (UL: 211Mbps) + ue-CategoryDL 16 (DL: 1Gbps). Selected 4x4 @4X4 MIMO; 2xUL CA
3G	WCDMA	HSPA+ Rel8 (DL/UL: up to 42/5.76 Mbps)
	Support Band	B1/2/4/5/8
GNSS		GNSS: L1: GPS/Glonass/Beidou/Galileo
eSIM		Dual SIM with eSIM on board, Dual SIM and single active (DSSA)
Interface		PCIe Gen3 1 Lane
Form factor		3052 PCIe M.2 Key.B

1.1 System Main Feature

Feature	Description
Physical	PCI express M.2 module, size 3052, Key.B, 75Pin golden finger
Electrical	Single VCC supply (3.135V~3.63V)
Dimension	Dimensions (L × W × H): 52 mm × 30 mm × 2.3 mm, maximum height=2.45mm (add 0.15mm tolerance)
Shielding design	Shield case on board design, no additional shielding requirement
Weight	Approximately ~8g
USIM	Off-board USIM connector supported on Host through USIM1. e-SIM embedded on Module through USIM2
Operating Bands	WCDMA/HSDPA/HSUPA/HSPA+ operating bands: Band 1: 1920 to 1980 MHz (UL), 2110 to 2170 MHz (DL) Band 2: 1850 to 1910 MHz (UL), 1930 to 1990 MHz (DL) Band 4: 1710 to 1755 MHz (UL), 2110 to 2155 MHz (DL) Band 5: 824 to 849 MHz (UL), 869 to 894 MHz (DL) Band 8: 880 to 915 MHz (UL), 925 to 960 MHz (DL)
	LTE FDD/TDD operating bands: Band 1: 1920 to 1980 MHz (UL), 2110 to 2170 MHz (DL) Band 2: 1850 to 1910 MHz (UL), 1930 to 1990 MHz (DL) Band 3: 1710 to 1785 MHz (UL), 1805 to 1880 MHz (DL) Band 4: 1710 to 1755 MHz (UL), 2110 to 2155 MHz (DL) Band 5: 824 to 849 MHz (UL), 869 to 894 MHz (DL) Band 7: 2500 to 2570 MHz (UL), 2620 to 2690 MHz (DL) Band 8: 880 to 915 MHz (UL), 925 to 960 MHz (DL) Band 12: 699 to 716 MHz (UL), 729 to 746 MHz (DL) Band 13: 777 to 787 MHz (UL), 746 to 756 MHz (DL) Band 14: 788 to 798 MHz (UL), 758 to 768 MHz (DL) Band 17: 704 to 716 MHz (UL), 734 to 746 MHz (DL) Band 18: 815 to 830 MHz (UL), 860 to 875 MHz (DL) Band 19: 830 to 845 MHz (UL), 875 to 890 MHz (DL) Band 20: 832 to 862 MHz (UL), 791 to 821 MHz (DL) Band 25: 1850 to 1915 MHz (UL), 1930 to 1995 MHz (DL) Band 26: 814 to 849 MHz (UL), 859 to 894 MHz (DL) Band 28: 703 to 748 MHz (UL), 758 to 803 MHz (DL) Band 29: 717 to 728 MHz (DL) Band 30: 2305 to 2315 MHz (UL) 2350 to 2360 MHz (DL) Band 32: 1452 to 1496 MHz (DL) Band 34: 2010 to 2025 MHz (UL/DL) Band 38: 2570 to 2620 MHz (UL/DL) Band 39: 1880 to 1920 MHz (UL/DL) Band 40: 2300 to 2400 MHz (UL/DL) Band 41: 2496 to 2690 MHz (UL/DL) Band 66: 1710 to 1800 MHz (UL), 2110 to 2200 MHz (DL) Band 71: 663 to 698 MHz (UL), 617 to 652 MHz (DL)

Operating Bands	LTE 3.5G Band 42: 3400 to 3600 MHz (UL/DL) Band 43: 3600 to 3800 MHz (UL/DL) Band 48: 3550 to 3700 MHz (UL/DL)
	5G NR Sub 6GHz n1: 1920 to 1980 MHz (UL), 2110 to 2170 MHz (DL) n2: 1850 to 1910 MHz (UL), 1930 to 1990 MHz (DL) n3: 1710 to 1785 MHz (UL), 1805 to 1880 MHz (DL) n5: 824 to 849 MHz (UL), 869 to 894 MHz (DL) n7: 2500 to 2570 MHz (UL), 2620 to 2690 MHz (DL) n8: 880 to 915 MHz (UL), 925 to 960 MHz (DL) n12: 699 to 716 MHz (UL), 729 to 746 MHz (DL) n13: 777 to 787 MHz (UL), 746 to 756 MHz (DL) n14: 788 to 798 MHz (UL), 758 to 768 MHz (DL) n18: 815 to 830 MHz (UL), 860 to 875 MHz (DL) n20: 832 to 862 MHz (UL), 791 to 821 MHz (DL) n25: 1850 to 1915 MHz (UL), 1930 to 1995 MHz (DL) n26: 814 to 849 MHz (UL), 859 to 894 MHz (DL) n28: 703 to 748 MHz (UL), 758 to 803 MHz (DL) n29: 717 to 728 MHz (DL) n30: 2305 to 2315 MHz (UL) 2350 to 2360 MHz (DL) n38: 2570 to 2620 MHz (UL/DL) n40: 2300 to 2400 MHz (UL/DL) n41: 2496 to 2690 MHz (UL/DL) n48: 3550 to 3700 MHz (UL/DL) n66: 1710 to 1800 MHz (UL), 2110 to 2200 MHz (DL) n71: 663 to 698 MHz (UL), 617 to 652 MHz (DL) n77: 3300 to 4200 MHz (UL/DL) n78: 3300 to 3800 MHz (UL/DL) n79: 4400 to 5000 MHz (UL/DL)
Diversity/2nd Rx	All operating bands
4x4 MIMO Rx	LTE: B1/2/3/4/7/25/30/34/38/39/40/41/42/43/48/66 5G NR: n1/2/3/7/25/30/38/40/41/48/66/77/78/79
GNSS	GPS: L1 (1575.42MHz) GLONASS: G1 (1602MHz) BeidouB1(1561.098MHz) Galileo E1 (1575.42)
USIM Voltage	Support 1.8V and 2.85V, and auto detects follow SIM card type
Antenna connectors	ANT0: Support all 5G NR Sub 6G& LTE& UMTS bands. ANT1: Support 5G NR Sub 6G& LTE M/H/UHB& UMTS MB ANT2: Support 5G NR Sub 6G& LTE M/H/UHB& UMTS MB ANT3: Support all 5G NR Sub 6G& LTE& UMTS bands and GPS L1 simultaneously

Throughput	HSPA+: DL 21.6 Mbps /UL 5.76 Mbps DC-HSPA+: DL 42 Mbps/UL 5.76 Mbps LTE Cat16: DL:1Gbps/UL 211 Mbps 5G NR Sub 6G: DL: 2.5Gbps/UL 900Mbps
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5G NR Air Interface

- 3GPP Rel16
- Modulation UL: 256 QAM; DL: 256 QAM
- Waveform UL: CP-OFDM and DFT-S-OFDM; DL: CP-OFDM
- Sub-Carrier Spacing (SCS): 15 KHz, 30 KHz
- Duplex mode: FDD and TDD
- Operation mode: Standalone mode (SA) and Non-Standalone mode (NSA)
- CA capability: DLCA&ULCA
- MIMO DL: 4 × 4 MIMO
- MIMO UL: 2 x 2 MIMO
- EN-DC: LTE and NR sub-6 GHz dual connectivity

LTE Air Interface

LTE Rel16

- CA capability:
 - DLCA
 - Inter-band DLCA
 - Intra band contiguous CA
 - Intra band noncontiguous
 - ULCA
 - Inter band ULCA (Depend on Customer requirements)
 - Intra band contiguous CA
- Modulation UL: 256 QAM; DL: 256 QAM
- MIMO DL: 4 × 4 MIMO

WCDMA/HSPA Air Interface

- R99:
 - All modes and data rates for WCDMA FDD
- R5 HSDPA
 - PS data speeds up to 7.2 Mbps on the downlink
- R6 HSUPA
 - E-DCH data rates of up to 5.76 Mbps for 2 ms TTI (UE category 6) uplink
- R7 HSPA+



Downlink 64 QAM SISO: up to 21 Mbps

Downlink 16 QAM 2X2 MIMO: up to 28 Mbps

- R8 DC-HSPA+

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

GNSS

- GPS, GLONASS, Galileo, and BeiDou support L1
- Customizable tracking session
 - Automatic tracking session on startup
 - Concurrent standalone GPS, GLONASS, BeiDou and Galileo
 - gpsOneXTRA with GPS + GLONASS + BeiDou+ Galileo support

2 Power consumption

Test condition	Estimated Power Range (Typical)	Estimated Power Range (Max.)	Remark
WCDMA (Tx=23.5dBm)	<1000 mA	<1200 mA	
LTE (Tx=23dBm)	<1000 mA	<1200 mA	
LTE DLCA mode 4x4, Tx=23dBm	<1500 mA	<1800 mA	
NR SA, Tx=23dBm	<1000 mA	<1200 mA	
5G NR Sub-6 DLCA mode 4x4, NR Tx=23dBm	<1500 mA	<1800 mA	
5G NR Sub-6 ENDC mode 4x4, LTE&NR Tx=23dBm	<1700 mA	<2000 mA	
5G NR Sub-6 ULCA mode 2x2, NR Tx0=20dBm, Tx1=20dBm	<1500 mA	<1800 mA	
GNSS tracking	<150 mA	<300 mA	
Connected Standby	<5mA		
Radio Off	<3mA		

3 Antenna Design

3.1 Antenna specification

T99W696 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 1.2 standard. The antenna elements are typically integrated into the notebook/ultra-book /tablet and connected to T99W696 module via flexible RF coaxial cables. T99W696 provides four RF connectors (MHF4 type). The four RF connectors include for 5GNR Sub 6G& LTE primary transmitter/receiver port, diversity receiver and 4x4 MIMO receiver port.

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

Table 3-1 LTE& 5GNR Sub 6G antenna specifications

Parameter	Min.	Typ.	Max.	Units	Notes
Cable loss	/	/	0.5	dB	Maximum loss to antenna
Impedance	/	50	/	Ohm	Antenna load impedance
VSWR	/	/	3:1	/	Maximum allowed VSWR of antenna
Isolation	20	/	/	dB	For all antenna each other
Isolation	23	/	/	dB	For PC1.5, between ANT0 and ANT2

4. Electrical Specification

4.1 Recommended operating conditions.

Table 4-1 Recommended operating conditions.

Parameter	Min	Type	Max	Units
Storage temperature	-40	+25	+85	°C
Recommend operating temperature. (3GPP compliant) (*1)	-30	+25	+70	°C
Extendable (with limited performance) Temperature measure on T99W696 module (*2)	-40		+85	°C
Shutdown temperature (HW protection)			+100	°C
Operating voltage	3.135	3.3	3.63	Vdc

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

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

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

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

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

Operating T99W696 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.

5. RF performance specifications

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

5.1 RF maximum TX power specifications

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

LTE Band	3GPP Standard (dBm)	Design Spec.(dBm)		
		Max.	Typ.	Min.
1	23+/-2	24	23	22
2	23+/-2	24	23	22
3	23+/-2	24	23	22
4	23+/-2	24	23	22
5	23+/-2	24.5	23.5	22.5
7	23+/-2	24	23	22
8	23+/-2	24.5	23.5	22.5
12	23+/-2	24.5	23.5	22.5
13	23+/-2	24.5	23.5	22.5
14	23+/-2	24.5	23.5	22.5
17	23+/-2	24.5	23.5	22.5
18	23+/-2	24.5	23.5	22.5
19	23+/-2	24.5	23.5	22.5
20	23+/-2	24.5	23.5	22.5
25	23+/-2	24	23	22
26	23+/-2	24.5	23.5	22.5
28	23+2/-2.5	24.5	23.5	22.5
30	23+/-2	23	22	21
34	23+/-2	24	23	22
38	23+/-2	24	23	22
39	23+/-2	24	23	22
40	23+/-2	24	23	22
41	23+/-2	24	23	22
41(HPUE)	26+2/-3	27	26	24
42	23+2/-3	24	23	22
43	23+2/-3	24	23	22
48	23+2/-3	22	21	20.3
66	23+/-2	24	23	22
71	23+2/-2.5	24.5	23.5	22.5

Table 5-1-2 NR Conductive Maximum transmits power (NR BW: All)

5G NR Sub 6G	3GPP Standard	Design Spec.(dBm)		
	(dBm)	Max.	Typ.	Min.
n1	23+/-2	24	23	22
n2	23+/-2	24	23	22
n3	23+/-2	24	23	22
n5	23+/-2	24.5	23.5	22.5
n7	23+/-2	24	23	22
n8	23+/-2	24.5	23.5	22.5
n12	23+/-2	24.5	23.5	22.5
n13	23+/-2	24.5	23.5	22.5
n14	23+/-2	24.5	23.5	22.5
n18	23+/-2	24.5	23.5	22.5
n20	23+/-2	24.5	23.5	22.5
n25	23+/-2	24	23	22
n26	23+/-2	24.5	23.5	22.5
n28	23+2/-2.5	24.5	23.5	22.5
n30	23+/-2	23	22	21
n38	23+/-2	24	23	22
n40	23+/-2	24	23	22
n41(PC3)	23+/-2	24	23	22
n41(PC2)	26+2/-2	27	26	24
n41(PC1.5)	29+2/-3	29	28	27
n48	23+/-2	22	21	20.3
n66	23+/-2	24	23	22
n71	23+2/-2.5	24.5	23.5	22.5
n77(PC3)	23+2/-3	24	23	22
n77(PC2)	26+2/-3	27	26	24
n77(PC1.5)	29+2/-3	29	28	27
n78(PC3)	23+2/-3	24	23	22
n78(PC2)	26+2/-3	27	26	24
n78(PC1.5)	29+2/-3	29	28	27
n79(PC3)	23+2/-3	24	23	22
n79(PC2)	26+2/-3	27	26	24
n79(PC1.5)	29+2/-3	29	28	27

Table 5-1-3 WCDMA Conductive Maximum transmits power (WCDMA BW: 5MHz)

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

8	24+1.7/-3.7	24.5	23.5	22.5
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5.2 RF min. Rx sensitivity specifications

TBD

5.3 Bandwidth specifications

Table 5-3-1 LTE Support Bandwidth table

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

Table 5-3-2 NR Support Bandwidth table

Band	Duplex	SCS (KHz)	Bandwidths
n1	FDD	15	5, 10, 15, 20, 25, 30, 40
n2	FDD	15	5, 10, 15, 20



n3	FDD	15	5, 10, 15, 20, 25, 30,35,40
n5	FDD	15	5, 10, 15, 20, [25]
n7	FDD	15	5, 10, 15, 20, 25, 30,40
n8	FDD	15	5, 10, 15, 20, [35]
n12	FDD	15	5, 10, 15
n13	FDD	15	5, 10
n14	FDD	15	5, 10
n18	FDD	15	5, 10, 15
n20	FDD	15	5, 10, 15, 20
n25	FDD	15	5, 10, 15, 20, 25, 30,35,40
n26	FDD	15	5, 10, 15, 20
n28	FDD	15	5, 10, 15, 20, 30
n29	SDL	15	5, 10
n30	FDD	15	5, 10
n38	TDD	30	10,15, 20, 30, 40
n40	TDD	30	10, 15, 20, 30, 40, 50, 60, 80, 90, 100
n41	TDD	30	10, 15, 20, 30, 40, 50, 60, 70, 80, 90, 100
n48	TDD	30	10, 20, 30, 40, [50,60,80,90,100]
n66	FDD	15	5, 10, 15, 20, 25, 30,35, 40
n71	FDD	15	5, 10, 15, 20,[25],[30],[35]
n77	TDD	30	10, 15, 20, 30, 40, 50, 60, 70, 80, 90, 100
n78	TDD	30	10, 15, 20, 30, 40, 50, 60, 70, 80, 90, 100
n79	TDD	30	40, 50, 60, 80, 100

Note:

This is the initial support bandwidth list from Qualcomm, and we will continue to update it based on Qualcomm changes.

[] Designates DL-only

<> Designates UL-only