



# 5GNR/ LTE-Advanced LGA Module (Sub 6G, LTE)

## Engineering Requirements Specification



Project code: T99W651.00  
Solution: SDX72+SDR875  
SKU: ATT



## 1. General Description

Part Number: T99W651.00; Description: 5G LGA module

The T99W651 is a wireless transceiver module solution that provides wireless wide Area network (WWAN) connectivity for 5G NR (Sub 6G), LTE protocols in one hardware configuration.

SKU	SDX72 (5G R17) ATT	
QCT Solution	SDX72-0+SDR875+PMX75+PMK75	
4G/5G Carrier Support	AT&T	
WWAN	5G (FR1)	n2, n5, n14, n30, n66, n77
	4G	B2, B5, B12, B14, B29, B30, B46(optional*), B66
	4X4 DL MIMO	2, 30, 66, 77
	2X2 UL MIMO	n77
	8Rx DL	n77(optional*)
	Power Class	PC3; PC2& PC1.5 for n77
	5G Sub6 Tput	UL 900Mbps/DL 4.14Gbps
	LTE Cat	ue-CategoryUL 18 (UL: 211Mbps) + ue-CategoryDL 20 (DL: 2Gbps);
Memory Configuration	Discrete Memory 2G Bytes LPDDR4x +8G Bytes eMMC ;	
SIM	DSSA	
Interface	USB3.1 Gen2,PCIe Gen4/ PCIe Gen3,I2S,I2C,MIPI,SPI,UART,GPIO,PCM,USXGMII	
Antenna	5G Sub6/LTE*4 (DL 4x4 MIMO); 8Rx*4(optional*);LAA*2(optional*)	
Form Factor	48 x 48 x 2.9 mm, LGA module	

\*Base SKU not include optional feature

## 1.1 System Main Feature

Feature	Description
Physical	LGA module, 404 LGA Pin
Electrical	Single VCC supply (3.135V~4.4V)
Dimension	Dimensions (L × W × H): 48 mm × 48 mm × 2.90 mm
Shielding design	Shield case on board design, no additional shielding requirement
Weight	TBD
(U)SIM	Support off-board (U)SIM connectors on the host via (U)SIM1/(U)SIM2;
Operating Bands	LTE FDD operating bands: Band 2: 1850 to 1910 MHz (UL), 1930 to 1990 MHz (DL) Band 5: 824 to 849 MHz (UL), 869 to 894 MHz (DL) Band 12: 699 to 716 MHz (UL), 729 to 746 MHz (DL) Band 14: 788 to 798 MHz (UL), 758 to 768 MHz (DL) Band 29: 717 to 728 MHz (DL) Band 30: 2305 to 2315 MHz (UL) 2350 to 2360 MHz (DL) Band 66: 1710 to 1800 MHz (UL), 2110 to 2200 MHz (DL) Band 46: 5150 to 5925 MHz (DL) (optional*)
	5G NR Sub 6GHz n2: 1850 to 1910 MHz (UL), 1930 to 1990 MHz (DL) n5: 824 to 849 MHz (UL), 869 to 894 MHz (DL) n14: 788 to 798 MHz (UL), 758 to 768 MHz (DL) n30: 2305 to 2315 MHz (UL) 2350 to 2360 MHz (DL) n66: 1710 to 1800 MHz (UL), 2110 to 2200 MHz (DL) n77: 3300 to 4200 MHz (UL/DL)
Diversity/2 <sup>nd</sup> RX	All operating bands
4x4 MIMO Rx	LTE-B2/66/30 5G NR-n2/66/30/77
(U)SIM Voltage	Support 1.8V and 2.85V, and auto detects follow SIM card type
Throughput	LTE Cat16: ue-CategoryUL 18 (UL: 211Mbps) + ue-CategoryDL 20 (DL: 2Gbps); 5G NR Sub 6G: UL 900Mbps/DL 4.14Gbps

### 5G NR Air Interface

- 3GPP Rel17 5G NR sub-6
- 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
- MIMO DL: 4 × 4 MIMO
- MIMO UL: 2 × 2 MIMO
- EN-DC: LTE and NR sub-6 GHz dual connectivity



LTE Air Interface

LTE Rel17

- 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

## 2. RF specifications

### 2.1 Antenna Design

#### 2.1.1 Antenna specification

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

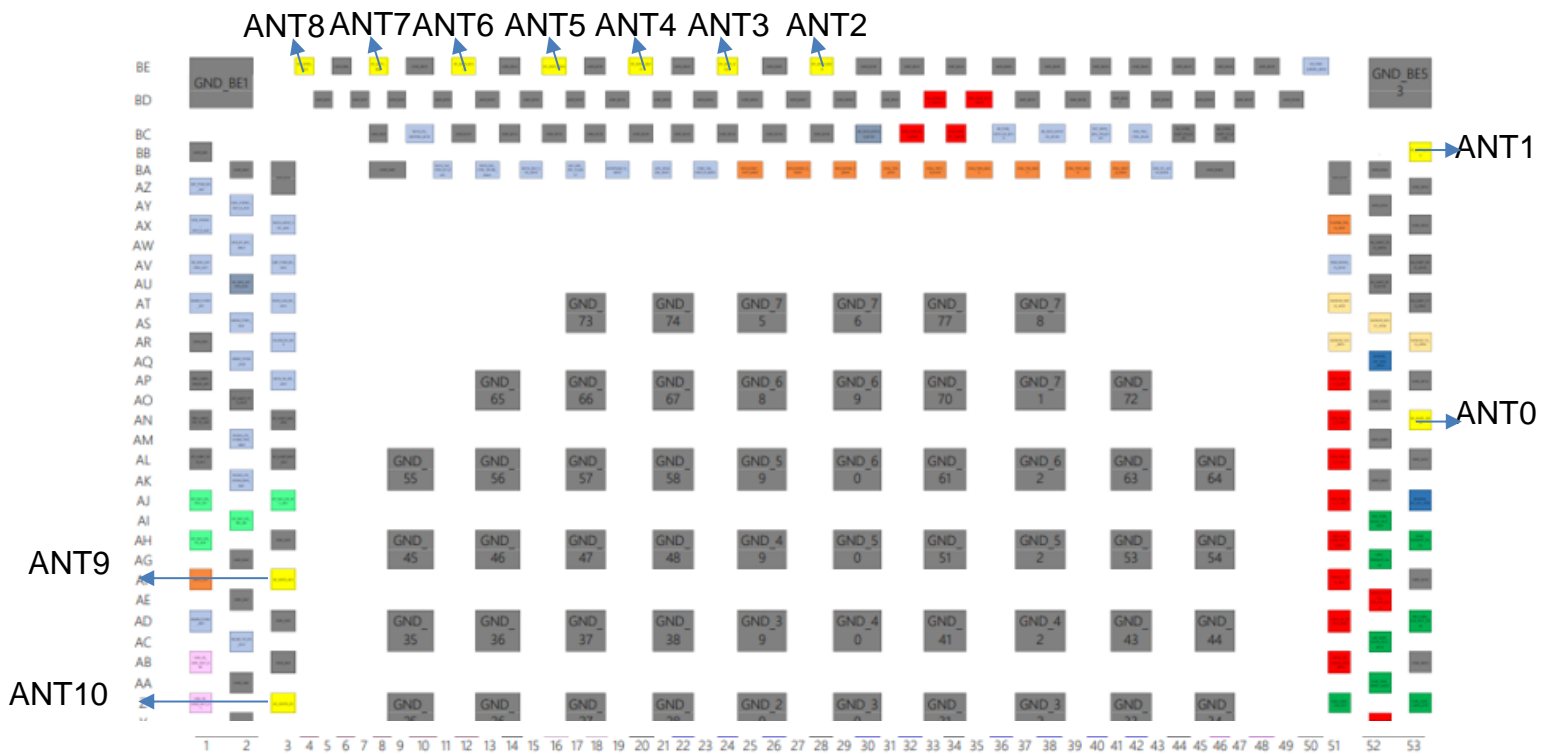
Table 2-1 LTE& 5GNR Sub 6G antenna specifications

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

#### 2.1.2 Antenna location and mechanical design.

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

Figure 2-2 Antenna connector location and type



ANT	LB	MB	HB	UHB	LAA*
ANT0	RX	TRX1	TRX0	TRX1	/
ANT1	TRX0	TRX0	RX	TRX0	/
ANT2*	/	/	/	8RX	/
ANT3*	/	/	/	8RX	/
ANT4	/	RX	RX	TRX(SRS/ASDIV)	/
ANT5	/	RX	RX	TRX(SRS/ASDIV)	/
ANT6*	/	/	/	8RX	/
ANT7*	/	/	/	8RX	/
ANT8*	/	/	/	/	/
ANT9*	/	/	/	/	RX
ANT10*	/	/	/	/	RX

Remark: TRX0 is main TX ANT, TRX1 is 2nd TX ANT, only use for NSA or ULMIMO.  
Ant2,3,6,7 for 8RX as optional, Ant9,10 for LAA as optional, ANT8 for GNSS as reserved.

## 2.2 Bandwith specifications

Table 2-2-1 LTE Support Bandwidth table

Band	1.4M	3M	5M	10M	15M	20M
2	√	√	√	√	√	√
5	√	√	√	√	×	×
12	√	√	√	√	×	×
14	×	×	√	√	×	×
[29]	×	√	√	√	×	×
30	×	×	√	√	×	×
[46] (optional*)	×	×	×	√	×	√
66	√	√	√	√	√	√

Table 2-2-2 NR Support Bandwidth table

Band	Duplex	SCS (KHz)	Bandwidths
n2	FDD	15	5, 10, 15, 20, 25,30,35,40
n5	FDD	15	5, 10, 15, 20, [25]
n14	FDD	15	5, 10
n30	FDD	15	5, 10
n66	FDD	15	5, 10, 15, 20, 25, 30,35,40,45
n77	TDD	30	10, 15, 20, 25, 30, 40, 50, 60, 70, 80, 90, 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

## 2.3 Transmitting Power

Table 2-3-1 LTE Conductive Maximum transmits power (LTE BW: All)

LTE Band	3GPP Standard (dBm)	Design Spec.(dBm)		
		Max.	Typ.	Min.
2	23+/-2	24.5	23	21.5
5	23+/-2	24.5	23	21.5
12	23+/-2	24.5	23	21.5
14	23+/-2	24.5	23	21.5
30	23+/-2	24.5	23	21.5
66	23+/-2	24.5	23	21.5

Table 2-3-2 NR Conductive Maximum transmits power (NR BW: All)

5GNR Sub 6G	3GPP Standard (dBm)	Design Spec.(dBm)		
		Max.	Typ.	Min.
n2	23+/-2	24.5	23	21.5
n5	23+/-2	24.5	23	21.5
n14	23+/-2	24.5	23	21.5
n30	23+/-2	24.5	23	21.5
n66	23+/-2	24.5	23	21.5
n77(PC3)	23+2/-3	24.5	23	21.5
n77(PC2)	26+2/-3	27.5	26	24.5
n77(PC1.5)	29+2/-3	29	28	26.5

Note:

1. PC1.5 achieved by 2 Tx Chains
2. PC1.5 is defined as max=29dBm which reserve 1dB of headroom for platform antenna design to meet EIRP requirements

## FCC Compliance

### Product Feature and Specification

Product Feature & Specification	
EUT Type	5G WWAN Module
Brand Name	Foxconn
Model Name	T99W651
FCC ID	2AQ68T99W651
Wireless Technology and Frequency Range	LTE Band 2: 1850 MHz ~ 1910 MHz LTE Band 5: 824 MHz ~ 849 MHz LTE Band 12: 699 MHz ~ 716 MHz LTE Band 14: 788 MHz ~ 798 MHz LTE Band 30: 2305 MHz ~ 2315 MHz LTE Band 66: 1710 MHz ~ 1780 MHz 5G NR n2 : 1850 MHz ~ 1910 MHz 5G NR n5 : 824 MHz ~ 849 MHz 5G NR n14 : 788 MHz ~ 798 MHz 5G NR n30 : 2305 MHz ~ 2315 MHz 5G NR n66 : 1710 MHz ~ 1780 MHz 5G NR n77: 3700 MHz ~ 3980 MHz, 3450MHz ~ 3550MHz
Mode	LTE: QPSK, 16QAM, 64QAM 5G NR: DFT-s-OFDM/CP-OFDM, Pi/2 BPSK/QPSK/16QAM/64QAM

### FCC Maximum Antenna Gain

Based on FCC 47 CFR §1.1307, the analysis concludes that this product when transmitting in standalone within a host device, is compliant with the FCC RF exposure requirements in mobile exposure condition, provided the conducted power and antenna gain do not exceed the limits for each given frequency band per wireless technology as follow table:

	Mode	Maximum Transmit Power Level (dBm)	Maximum Allowed Peak Gain (dBi)
LTE	LTE Band 2	24.50	8.5
	LTE Band 5	24.50	6.6
	LTE Band 12	24.50	6.1
	LTE Band 14	24.50	6.4
	LTE Band 30	24.50	8.5
	LTE Band 66	24.50	5.5
FR1	5G NR n2	24.50	8.5
	5G NR n5	24.50	6.6
	5G NR n14	24.50	6.4
	5G NR n30	24.50	8.5
	5G NR n66	24.50	5.5
	5G NR n77 PC3	24.50	5.5
	5G NR n77 PC2	27.50	2.5
	5G NR n77 PC1.5	29.00	1.0



**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:**

The product complies with the 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 module is intended for OEM integrator only. Per FCC KDB 996369 D03 OEM Manual v01 guidance, the following conditions must be strictly followed when using this certified module:

## KDB 996369 D03 OEM Manual v01 rule sections:

### 2.2 List of applicable FCC rules

This module has been tested for compliance to FCC Part 22, 24, 27, 90.

### 2.3 Summarize the specific operational use conditions

The module is tested for standalone module RF exposure use condition. Any other usage condition such as co-location with other transmitter(s) or being used in a portable condition will need a separate reassessment through a class II permissive change application or new certification.

### 2.4 Limited module procedures

Not applicable.

### 2.5 Trace antenna designs

The host product manufacturer should follow the antenna trace design as below. Any deviation(s) from the defined parameters of the antenna trace must notify the module grantee to change the antenna trace design. In this case, a Class II permissive change application is required to be filed by the grantee, or the host manufacturer can take responsibility through the change in FCC ID (new application) procedure followed by a Class II permissive change application.

## **T99W651 LGA Module Ant Traces Design**



#### ANT 0

Traces length: **19.9mm**

Traces width: **0.36mm**

PCB thickness: **1.6mm**

Trace copper foil: **1.2oz**

Dielectric constant: **4.3 (3.8 under external layers)**

ANT connector: **UFL\_SUNRIDGE\_MCBG(W)-ST-00TS, UFL\_ABC TAIWAN\_HS2013RFCNLA**  
or **UFL\_ABC TAIWAN\_AM4-2001-000-3**

Extra RF switch for ANT switching :

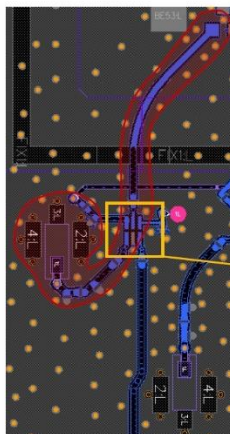
**0.4dB** max @ 600 – 1000MHz

**0.4dB** max @ 1000 – 2000MHz

**0.45dB** max @ 2000 – 2700MHz

**0.45dB** max @ 3400 – 3800MHz

**0.65dB** max @ 4900 – 6000MHz



#### ANT 1

Traces length: **16.6mm**

Traces width: **0.36mm**

PCB thickness: **1.6mm**

Trace copper foil: **1.2oz**

Dielectric constant: **4.3 (3.8 under external layers)**

ANT connector: **UFL\_SUNRIDGE\_MCBG(W)-ST-00TS, UFL\_ABC TAIWAN\_HS2013RFCNLA**  
or **UFL\_ABC TAIWAN\_AM4-2001-000-3**

Extra RF switch for ANT switching :

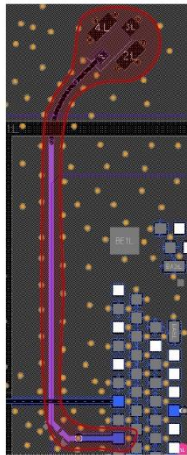
**0.4dB** max @ 600 – 1000MHz

**0.4dB** max @ 1000 – 2000MHz

**0.45dB** max @ 2000 – 2700MHz

**0.45dB** max @ 3400 – 3800MHz

**0.65dB** max @ 4900 – 6000MHz



#### ANT 4

Traces length: **33.8mm**

Traces width: **0.36mm**

PCB thickness: **1.6mm**

Trace copper foil: **1.2oz**

Dielectric constant: **4.3 (3.8 under external layers)**

ANT connector: **UFL\_SUNRIDGE\_MCBG(W)-ST-00TS, UFL\_ABC TAIWAN\_HS2013RFCNLA**  
or **UFL\_ABC TAIWAN\_AM4-2001-000-3**



#### ANT 5

Traces length: **83mm**

Traces width: **0.36mm**

PCB thickness: **1.6mm**

Trace copper foil: **1.2oz**

Dielectric constant: **4.3 (3.8 under external layers)**

ANT connector: **WUTONG\_WTTX160159B, MURATA\_MM8030-2610RJ3 or CFCN-**  
**SI30220**

## **2.6 RF exposure considerations**

The product complies with the 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. If the module is installed in a portable host, a separate SAR evaluation is required to confirm compliance with relevant FCC portable RF exposure rules.

## **2.7 Antennas**

Antennas with equal or lower gain may also be used with this module. The antenna must be installed such that 20cm can be maintained between the antenna and users. Suggests to check the Radiated Spurious Emission to make sure RSE meet FCC regulation.

## **2.8 Label and compliance information**

The final end product must be labeled in a visible area with the “Contains FCC ID: 2AQ68T99W651.” The grantee FCC ID can be used only when all FCC compliance requirements are met.”

## **2.9 Information on test modes and additional testing requirements**

This transmitter is tested in a standalone mobile RF exposure condition and any co-located or simultaneous transmission with other transmitter(s) or portable use will require a separate class II permissive change re-evaluation or new certification.



Host manufacturer shall make sure the system antenna and EIRP meet FCC regulation.

Host manufacturer shall validate on system RSE to make sure the radiated emission complies with FCC.

If there is other radio supported by the system, host manufacturer shall measure the co-location RSE to make sure comply with FCC regulation.

#### **2.10 Additional testing, Part 15 Subpart B disclaimer**

This transmitter module is tested as a subsystem and its certification does not cover the FCC Part 15 Subpart B (unintentional radiator) rule requirement applicable to the final host. The final host will still need to be reassessed for compliance to this portion of rule requirements if applicable.

As long as all conditions 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.

#### **2.11 Note EMI Considerations**

A host manufacture is recommended to use D04 Module Integration Guide recommending as "best practice" RF design engineering testing and evaluation in case non-linear interactions generate additional non-compliant limits due to module placement to host components or properties for standalone mode, reference the guidance in D04 Module Integration Guide and for simultaneous mode7; see D02 Module Q&A Question 12, which permits the host manufacturer to confirm compliance.

#### **2.12 How to make changes**

Since, only Grantees are permitted to make permissive changes, if the module will be used differently than granted, please contact Nancy Lin, the contact of Grantee, for permissive change inquiry.

**IMPORTANT NOTE:** In the event that this 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 g the end product (including the transmitter) and obtaining a separate FCC authorization.

#### **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 the 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.

#### **OEM/Host manufacturer responsibilities**

OEM/Host manufacturers are ultimately responsible for the compliance of the Host and Module. The final product must be reassessed against all the essential requirements of the FCC rule such as FCC Part 15 Subpart B before it can be placed on the US market. This includes reassessing the transmitter module for compliance with the Radio and EMF essential requirements of the FCC rules. This module must not be incorporated into any other device or system without retesting for compliance as multi-radio and combined equipment.