Re-imagining Cellular IoT Solutions

Cavli C10GS
LTE CAT 1/4 Module
Integrated eSIM

Hardware Manual
External Release Version 2.2

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VERSION HISTORY

Version	Edit	Date
1.0	• Initial Version	01/12/2021
1.2	• Contents of UART section updated • USB section updated • Side view dimension edited	24/02/2022
1.3	• Changed pin 73 • Reel structure update • Updated SPQ to 450 pcs/reel	02/03/2022
1.4	• Changed Template to the latest format	14/07/2022
1.5	• Updated Power characteristics • Updated reference circuits ○ Main antenna matching circuit ○ GNSS active antenna matching circuit ○ GNSS passive antenna matching circuit ○ USB connection design circuit diagram updated ○ Coplanar Antenna • Updated GNSS constellation support details • Added notes on USB connection design	27/09/2022
1.6	• Updated LTE Bands • Updated Network Protocols • Updated typical current consumption • Updated USIM Voltage • Updated Main and Passive antenna matching circuit	04/11/2022
1.7	• Changed Temperature Range and Network Protocols	20/02/2023
1.8	• GNSS Performance figures updated	02/03/2023
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2.0	• Updated FCC warnings	01/08/2023
2.1	• Added EU Declaration of Conformity(DoC)	11/08/2023
2.2	• Updated data in Chapter 9 • Merged EU DoC and FCC warnings	21/08/2023

1 Introduction

This document is the Hardware Manual of Cavli Wireless solution product C10GS Smart Module, which describes the hardware composition and functional features of the module, the definition and usage of the application interface, and the electrical performance and mechanical properties of the module. This document and the other application documents combined will enable users to develop end devices with Cavli Modules.

2 Module Overview

2.1 Module introduction

C10GS module which integrates application processing subsystem, communication subsystem, multimedia and connectivity peripherals to enable single chip 4G LTE feature phone solution.

The C10GS communication subsystem integrates LTE CAT 1/4 and RF transceiver to cover 1/2/3/4/5/6/8/10/18/19/20/25/26/40/66 bands for worldwide roaming. LTE CAT 1/4 is compliant with 3GPP E-UTRA Release 9.

The application subsystem runs on dual ARM11 processor with integrated peripherals for connectivity and multimedia.

The C10GS module can be used in the following applications:

- ✓ Vehicle telematics
- ✓ Asset tracking
- ✓ Fleet management
- ✓ Smart city and smart home applications
- ✓ Connected retail applications- point of sale devices, automated teller machines, vending machines etc
- ✓ Industrial IoT - gateways, remote control & monitoring systems

2.2 Module characteristics

Table 2-1 Key Features

Characteristics		Description
Physical characteristics		37mm x 21.8mmx 2.8mm
Fixed way		LGA package, patch mount
Operating Voltage		3.6V - 4.5V Typical Voltage 3.8V
Application processor		ARM11 with 400MHz clock with 32KB I-Cache,32KB D-Cache and 16KB Data TCM for each CPU
Application interface	USIM card interface	Supports 1.8V, supports hot swap function
	USB interface	• USB2.0 (High-Speed) (only supports slave mode), data transfer rate up to 480Mbps • For AT commands, data transfer, software debugging and software upgrades
	Inside UART interface	• UART1 for DM and AT interfacing (921600bps only) • UART2 for interfacing (default 115200bps) • UART3 for User interfacing. • The baud rate is up to 921600bps.
	PCM interface	• For audio, external codec chip • Supports 8-bit A-law, U-law and 16-bit linear encoding formats • Support short frame mode • Support main mode
	SDIO interface	• Compliant with SDIO 3.0 protocol • Comply with IEEE 802.11 standard
	I2C interface	• Compliant with I2C bus protocol • High speed mode supports 3.3Mbps rate
	Network indication	• WWAN_STATE network status indication • STATUS Module status
	GPIO	• 13 GPIO interface
	Ethernet Interface	• RGMII interface

	GNSS	• GPS, GLONASS, BEIDOU, Galileo, QZSS, SBAS
	SPI Interface	• Standard SPI interface
Frequency band		LTEBANDS: 1/2/3/4/5/6/8/10/18/19/20/25/26/40/66
Data service		• FDD/TDD LTE CAT 1/4 • Peak DL 10Mbps/ UL 5Mbps (CAT 1) • Peak DL 150Mbps / UL 50Mbps (CAT 4)
AT command		• Support for standard AT instruction sets (Hayes 3GPP TS 27.007 and 27.005) • Specific AT query C10GS AT command set
Network protocol		Supports • TCP/TCPS • UDP • HTTPS • MQTT/MQTTS • FTP/FTPS • PPP • SNMP and its TLS • Web Socket (WS) and its TLS
Antenna interface		• MAIN x 1 • GNSS × 1 • Characteristic impedance 50 Ω
Virtual network card		Supports USB virtual network card
Temperature range		• Normal working temperature - 20℃ to +70℃ • Limit working temperature - 30℃ to +85℃ • Storage temperature: -50℃ to +TBD
Humidity		RH5%～RH95%
Module function distinction		**S** on the model number represents the single mode

NOTE

- When the temperature is in the range of −40°C to −30°C or +75°C to +85°C, some RF specifications of the C10GS module may not meet the 3GPP standards.

2.3 Module function

C10GS/C10GS-G Module mainly consists of the following circuit units:

- ✓ RF Band SAW Duplex array
- ✓ Multi-Band PA
- ✓ Interfaces
- ✓ Memory unit

The functional block diagram of the C10GS module is shown below：

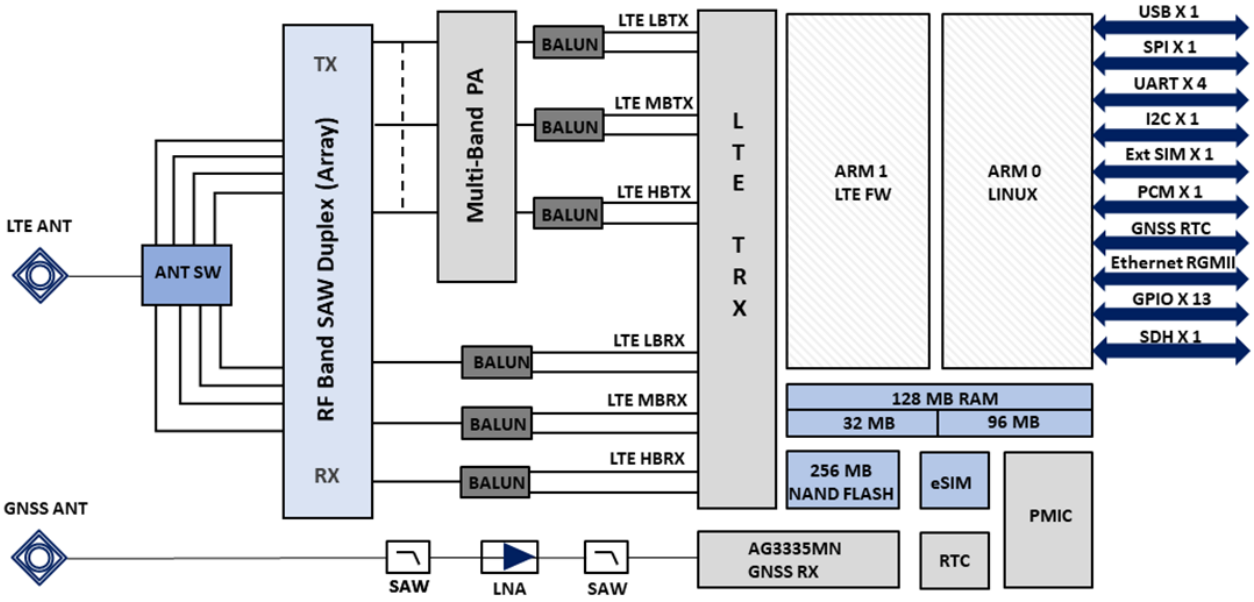


Figure 1 C10GS Functional Block Diagram

2.4 Module working mode

Table 2-2 work mode

Working mode	Description
Turn off the machine	In the case of shutdown, the module is fully powered off.
Flight Mode	The module closes the module RF circuit, unable to interact with the network.
Dormancy	The module closes most functions, and it will synchronize with the network.
Ideal state	Turn on the machine and register the network successfully, in the idle state
Data transmission	The module is in working state and has data interaction with the network.

3 Interface application description

3.1 Chapter overview

This chapter mainly describes the interface definition and application of this module. It contains the following sections:

- ✓ Module interface
- ✓ Power interface
- ✓ Switching machine reset mode
- ✓ USB interface
- ✓ UART interface
- ✓ USIM interface
- ✓ GPIO Interface
- ✓ Network status indicator interface
- ✓ PCM digital voice interface
- ✓ I2C bus
- ✓ SDIO interface
- ✓ Antenna
- ✓ Control interface
- ✓ Ethernet interface
- ✓ GNSS interface
- ✓ JTAG interface
- ✓ SPI interface

3.2 Module interface

3.2.1 C10GS Pin layout

C10GS pins are assigned as follows：

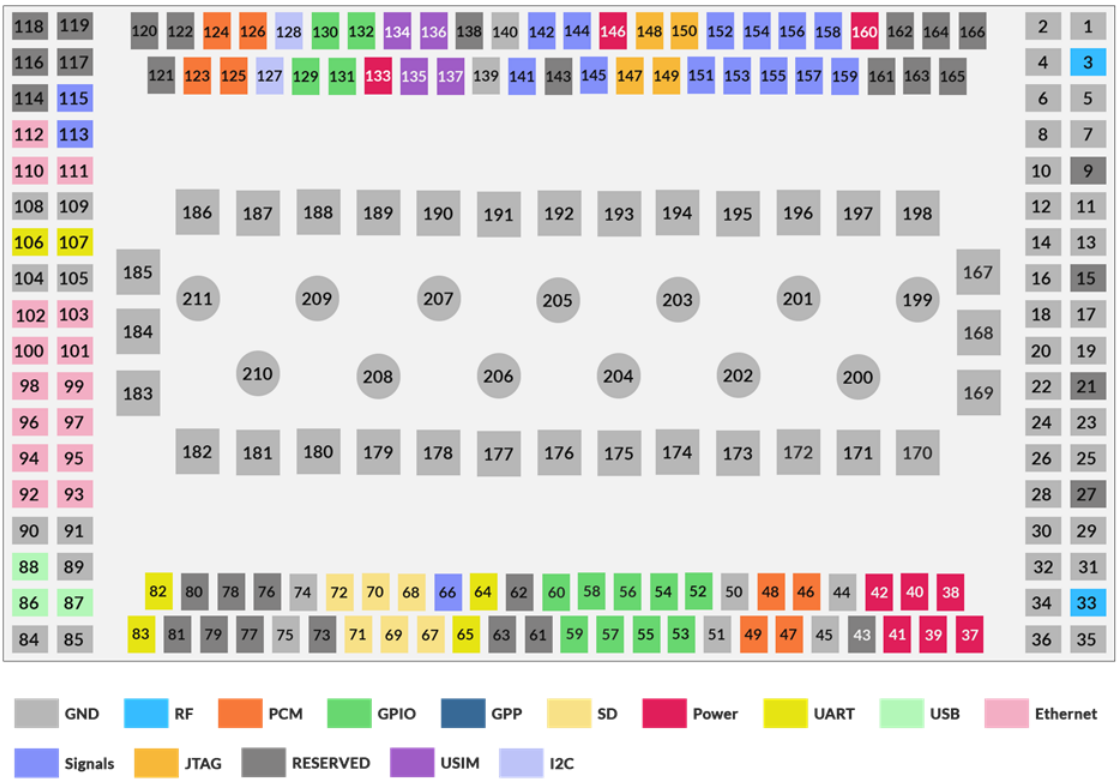


Figure 2 C10GS module Interface definition

NOTE

- All RESERVED and unused pin feet need to be left floating

3.2.2 C10GS pin interface

The C10GS module has the LGA interface. The module interface definition is shown in the following table:

Table 3-1 Pin name

Pin No.	Pin name	Pin No.	Pin name
1	GND	2	GND
3	LTE_MAIN	4	GND
5	GND	6	GND
7	GND	8	GND
9	RESERVED	10	GND
11	GND	12	GND
13	GND	14	GND
15	RESERVED	16	GND
17	GND	18	GND
19	GND	20	GND
21	RESERVED	22	GND
23	GND	24	GND
25	GND	26	GND
27	RESERVED	28	GND
29	GND	30	GND
31	GND	32	GND
33	GNSS_L1	34	GND
35	GND	36	GND
37	VCC1	38	VCC2
39	VCC3	40	VCC4

41	VCC5	42	VCC6
43	RESERVED	44	GND
45	GND	46	PCM_SYNC
47	PCM_DIN	48	PCM_DOUT
49	PCM_CLK	50	GND
51	GND	52	GPIO01
53	GPIO02	54	GPIO03
55	GPIO04	56	GPIO09
57	GPIO10	58	GPIO11
59	GPIO12	60	GPIO13
61	RESERVED	62	RESERVED
63	RESERVED	64	UART3_RX
65	UART3_TX	66	RESERVED
67	SDH_D0	68	SDH_D1
69	SDH_D2	70	SDH_D3
71	SDH_CLK	72	SDH_CMD
73	VDD_SDIO	74	GND
75	GND	76	RESERVED
77	RESERVED	78	RESERVED
79	RESERVED	80	RESERVED
81	RESERVED	82	UART1_RX
83	UART1_TX	84	GND
85	GND	86	USB_DP
87	USB_VBUS	88	USB_DN
89	GND	90	GND

91	GND	**92**	RGMII_TXD0
93	RGMII_TXD1	**94**	RGMII_TXD2
95	RGMII_TXD3	**96**	RGMII_RXD0
97	RGMII_RXD1	**98**	RGMII_RXD2
99	RGMII_RXD3	**100**	PHY2MAC_125MHZ
101	RGMII_TCTL	**102**	RGMII_TCLK
103	RGMII_MDC	**104**	GND
105	GND	**106**	UART2_RX
107	UART2_TX	**108**	GND
109	GND	**110**	RGMII_MDIO
111	RGMII_RCLK	**112**	RGMII_RCTL
113	STATUS	**114**	RESERVED
115	FLIGHT_MODE	**116**	RESERVED
117	RESERVED	**118**	RESERVED
119	RESERVED	**120**	RESERVED
121	RESERVED	**122**	RESERVED
123	SPI_CS	**124**	SPI_MOSI
125	SPI_MISO	**126**	SPI_SCLK
127	I2C_SCL	**128**	I2C_SDA
129	GPIO05	**130**	GPIO06
131	GPIO07	**132**	GPIO08
133	USIM_VCC	**134**	USIM_DATA
135	USIM_CLK	**136**	USIM_RESET
137	USIM_DETECT	**138**	RESERVED
139	GND	**140**	GND

141	WWAN_STATE	142	POWER_ON
143	RESERVED	144	WAKEUP_IN
145	RESET	146	VREF
147	JTAG_TCK	148	JTAG_TMS
149	JTAG_TDI	150	JTAG_TDO
151	GEO_FENCE	152	JAM_IND
153	1PPS	154	3D_FIX
155	RTCM_TXD	156	RTCM_RXD
157	GNSS_RESET	158	GNSS_TXD
159	GNSS_RXD	160	GNSS_VRTC
161	RESERVED	162	RESERVED
163	RESERVED	164	RESERVED
165	RESERVED	166	RESERVED
167	GND	168	GND
169	GND	170	GND
171	GND	172	GND
173	GND	174	GND
175	GND	176	GND
177	GND	178	GND
179	GND	180	GND
181	GND	182	GND
183	GND	184	GND
185	GND	186	GND
187	GND	188	GND
189	GND	190	GND

191	GND	**192**	GND
193	GND	**194**	GND
195	GND	**196**	GND
197	GND	**198**	GND
199	GND	**200**	GND
201	GND	**202**	GND
203	GND	**204**	GND
205	GND	**206**	GND
207	GND	**208**	GND
209	GND	**210**	GND
211	GND		

Table 3-2 IO parameter definition

Pin Type	Full Form
IO	Two-way input and output
PI	power input
PO	Power Output
AI	Analog input
AO	Analog output
DI	Digital input
DO	Digital output

NOTE

- The module typically has an IO port level of 1.8V (in addition to the SIM, the SIM card port level supports 1.8V).
- This module defines the RESERVED pin as a reserved pin. It is recommended to be suspended and must not be used

3.3 Power interface

The C10GS module power interface consists of three parts:

- ✓ VCC1, VCC2, VCC3, VCC4, VCC5 and VCC6 are the module working power supply
- ✓ GNSS_VRTC is the RTC power
- ✓ USIM_VCC is the working power supply for SIM card

3.3.1 Power supply design

The power interface of the C10GS module is as follows:

Table 3-3 Power pin definitions

Power supply							
Pin No.	Definition	IO	Description	Remarks	Min	Typical	Max
37	VCC1	DI	Module input voltage	Input voltage 3.6~4.5V	3.6V	3.8V	4.5V
38	VCC2	DI	Module input voltage	Input voltage 3.6~4.5V	3.6V	3.8V	4.5V
39	VCC3	DI	Module input voltage	Input voltage 3.6~4.5V	3.6V	3.8V	4.5V
40	VCC4	DI	Module input voltage	Input voltage 3.6~4.5V	3.6V	3.8V	4.5V

41	VCC5	DI	Module input voltage	Input voltage 3.6~4.5V	3.6V	3.8V	4.5V
42	VCC6	DI	Module input voltage	Input voltage 3.6~4.5V	3.6V	3.8V	4.5V
133	USIM_VCC	PO	SIM card power supply		0	1.8V/ 2.85V	1.98/ 3.3V
146	VREF	PO	Reference voltage	Output voltage 1.8V		1.8V	

The C10GS module is powered by a single power supply and the module provides six power supply pins. The power supply range is from 3.6V to 4.5V. It is recommended to use 3.8V/1.1A power supply. If the module's operating voltage drop causes the VCC supply voltage to be too low or the supply current is insufficient, the module may shut down or restart. Therefore, in order to reduce the power fluctuation of the module when working, it is necessary to use a low-ESR value of the voltage regulator capacitor, the power pin and the ground pin should be connected and can provide sufficient power supply capability.

Under the premise of ensuring that the VCC power supply is sufficient, one 22uF tantalum capacitor can be connected in parallel with the power input, 10uF in parallel, two 0.1uF capacitor (eliminating clock and digital signal interference) and 33nF (eliminating low frequency RF interference) ceramic capacitors.

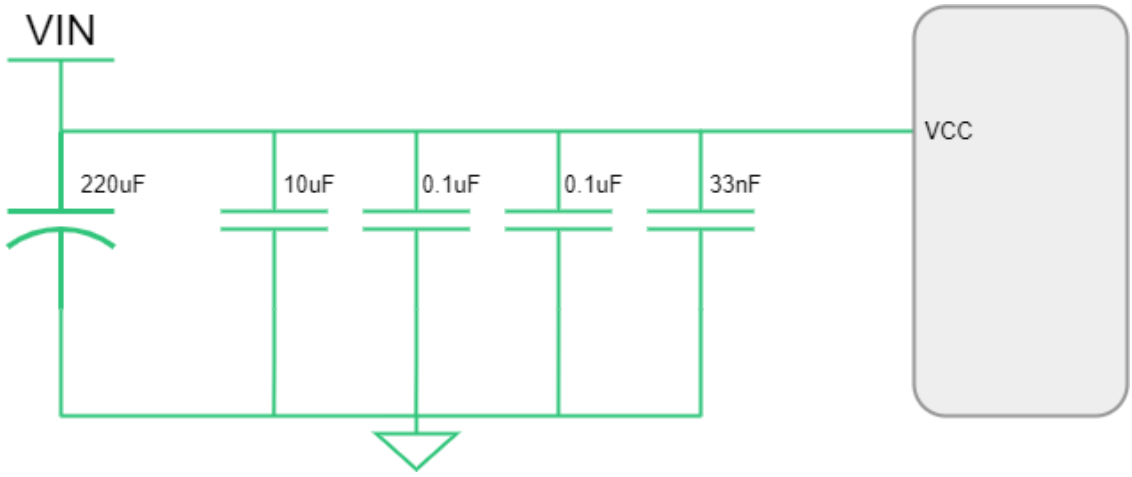


Figure 3 VCC power supply

3.3.2 Power reference circuit

In actual design, the power circuit can be designed using a switching DC power supply or a linear LDO power supply, and then the PMOS transistor is used to control the power supply input so that the power supply can be completely cut off. Both design circuits need to supply enough current. Specific reference to the following circuit design:

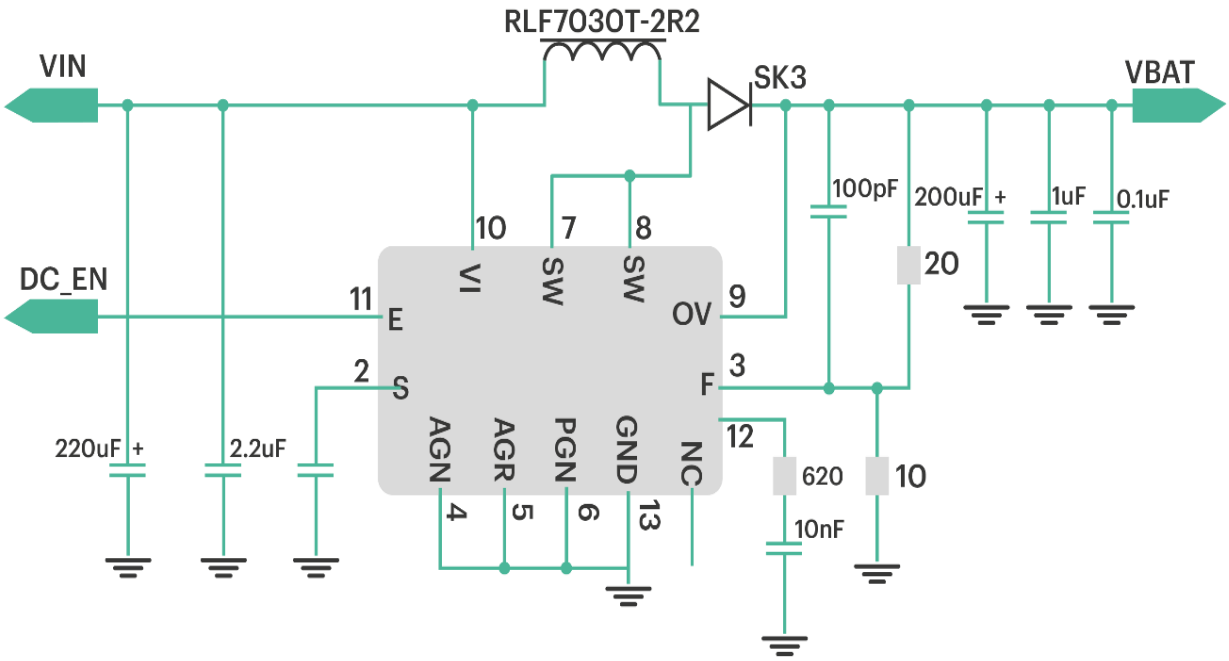


Figure 4 DC switching power supply reference circuit

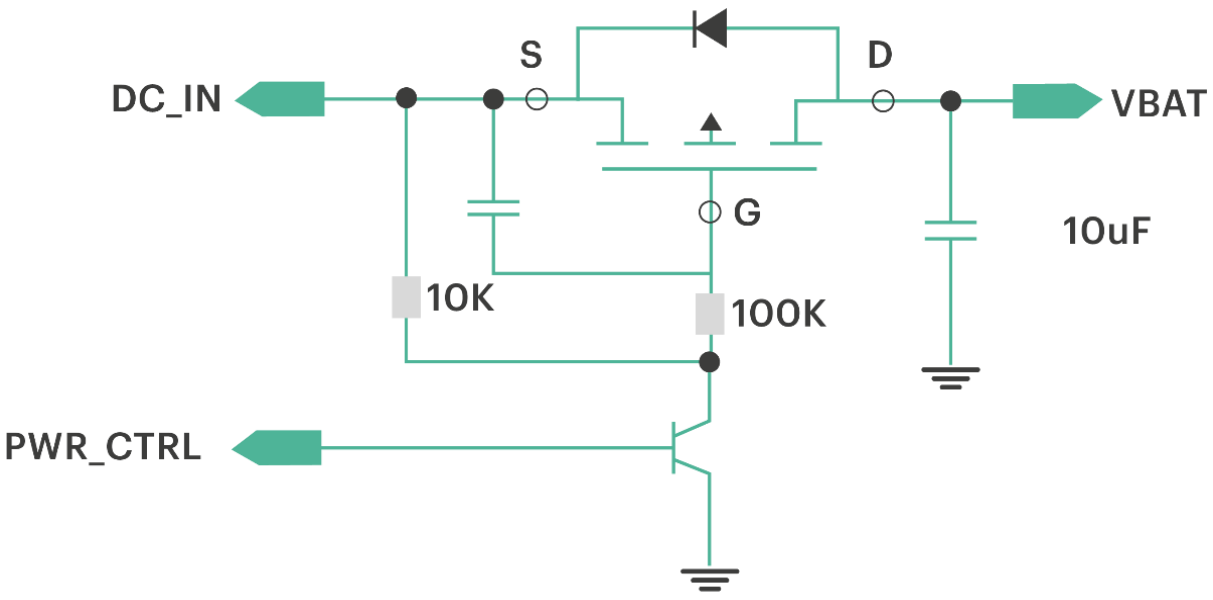


Figure 5 PMOS tube control power switch reference circuit

NOTE

- To prevent damage to the module from surges and over voltages, it is recommended to connect a 5.1V/500mW Zener diode to the VCC pin of the module.
- It is recommended to add 3 ceramic capacitors (33pF, 10pF, 100nF) to the power pin input and place them near the VCC pin.
- The minimum operating voltage of the module is 3.6V. Data transmission or calls will generate a current of more than 2, thus a ripple voltage drop will occur on the power supply voltage. Therefore, the actual supply voltage must not be lower than 3.6V.
- Due to the large current consumption of the module power pins, it is recommended that the PCB traces be as short as possible. Minimize the equivalent impedance of the VCC trace.

3.3.3 VREF 1.8 voltage output

The C10GS module outputs 1.8V through VREF for internal digital circuitry. This voltage is the logic level voltage of the module. After normal power-on, the 146th pin will output 1.8V and the current load will be 50mA. The external master can read the voltage of VREF to determine if the module is powered on. VREF can also be used as an external power supply, such as a level shifting chip, but maximum load should be within 50mA.

3.4 Switching machine reset mode

3.4.1 Turn ON Module

The 142th pin of the C10GS module is POWER_ON pin. The module can be powered on by pulling down POWER_ON active low for at least 500ms. The user can check whether the module is powered on by querying the high and low levels of the VREF pin.

Table 3-4 Switch pin definition

Pin No.	Signal name	I/O	High value	Description
142	POWER_ON	PI		Power on

It is recommended to use the open-collector drive circuit to control the POWER_ON, which can be released after the base level is pulled for 500ms, and the module is powered on.

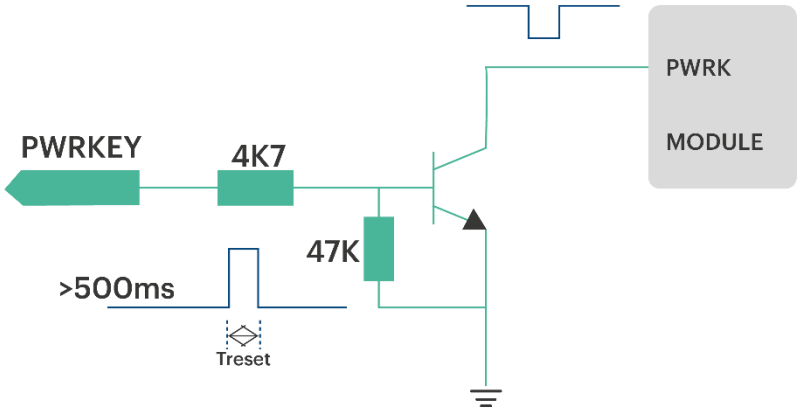


Figure 6 Power-on reference circuit

Switching machine design can also be done with buttons, button accessories need to be placed with a TVS tube for ESD protection.

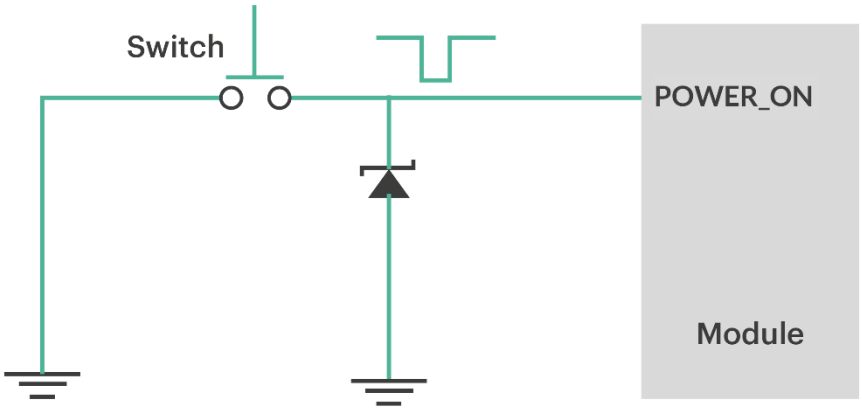


Figure 7 Power-on reference circuit-2

3.4.2 Reset control

The C10GS module Pin 145 is a reset pin. The application detects that the module is abnormal. When the software does not respond, the module can be reset. Pull the pin low for 100-450ms to reset the module. The RESET pin is sensitive to interference. A 10nF to 0.1uF capacitor can be installed near the signal for signal filtering. Keep away from RF interference signals when routing.

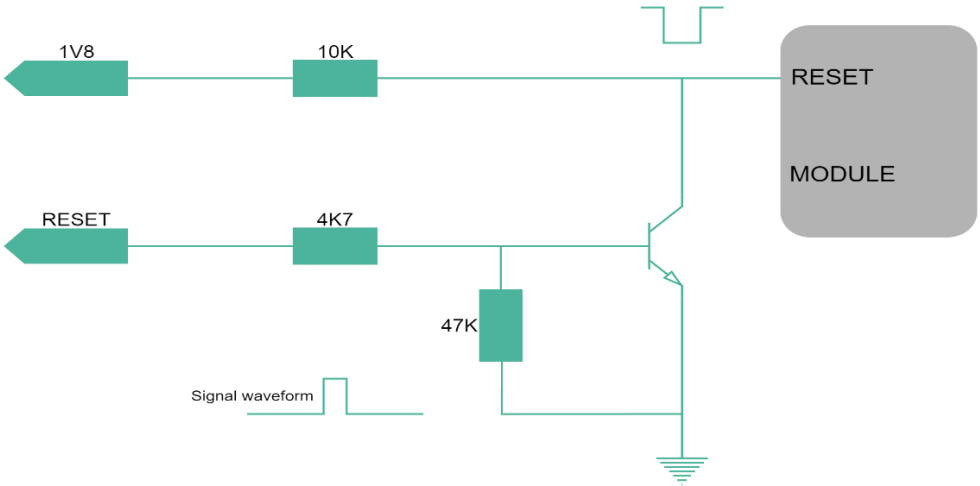


Figure 8 Reset reference circuit

Table 3-5 RESET pin parameters

Symbol	Description	Min	Typical	Max	Unit
Treset	Low level pulse width	150	200	450	ms
VIH	RESET input high level voltage	1.4	1.8	2.1	V
VIL	RESET input low level voltage	-0.3	0	0.8	V

The C10GS module supports AT command reset, and the AT command is `AT+TRB` to restart the module. Detailed instructions can be found in the C10GS AT Command Set Manual.

3.5 USB interface

The C10GS module USB interface supports USB2.0 high-speed protocol, supports slave mode, and does not support USB charging mode. USB input and output traces must comply with the USB2.0 feature. The input power supply of USB_VBUS is 3.3 - 5V. The USB interface is used to update the firmware of the module. It is recommended to use USB interface for the firmware update. The USB interface is defined as follows ：

Table 3-6 USB interface pin definition

Pin No.	Signal name	I/O	Description
87	USB_VBUS	PI	USB detection
88	USB_DN	IO	USB differential signal -
86	USB_DP	IO	USB differential signal +

The module acts as a USB slave device and supports USB sleep and wake-up mechanisms. USB interface application reference circuit is as follows ：

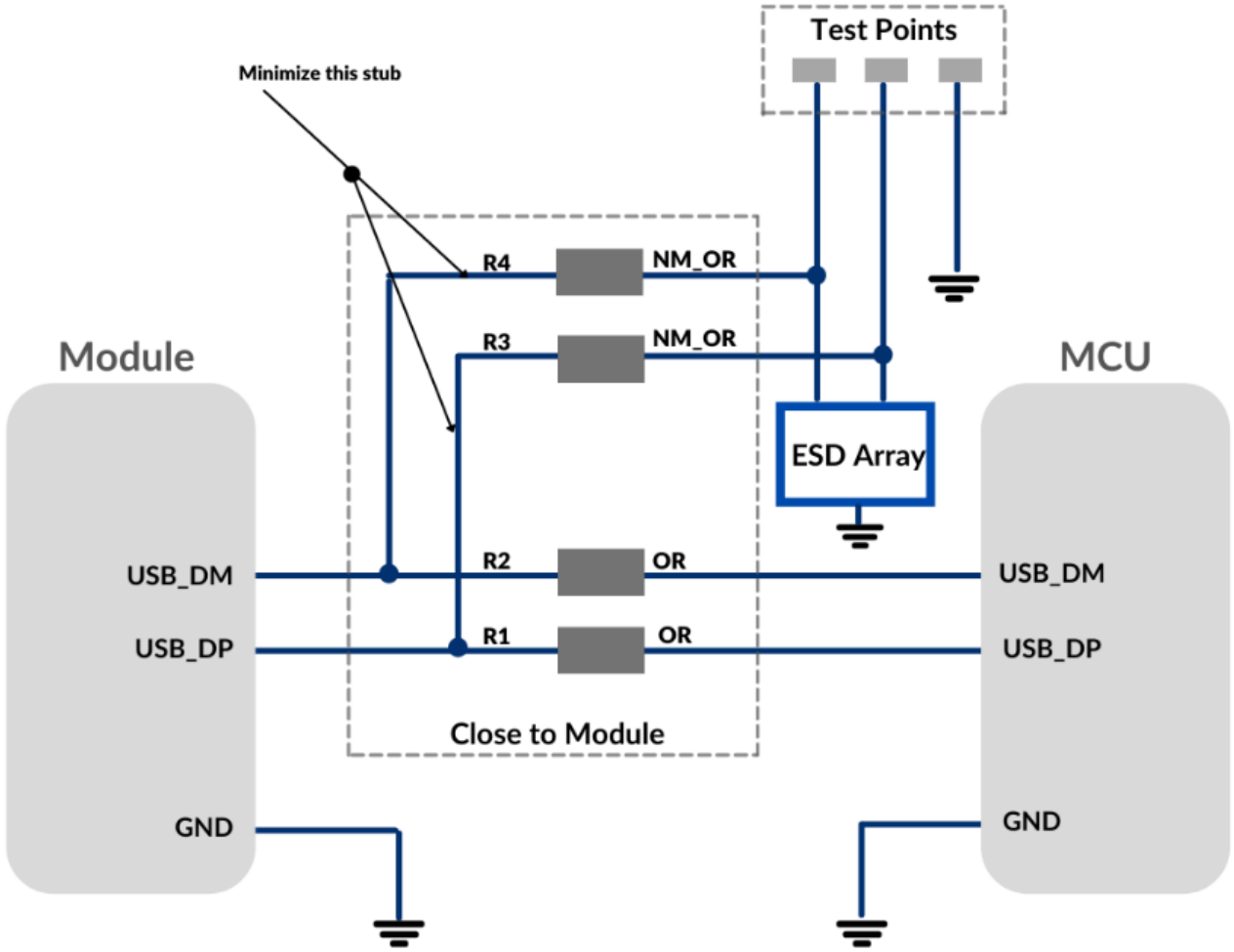


Figure 9 USB connection design circuit diagram

NOTE

- R1 or R2 is required to have a resistance of 16R
- The USB interface supports high-speed (480Mbps) and full-speed (12Mbps) modes, so the trace design needs to strictly follow the USB2.0 protocol requirements, pay attention to the protection of the data line, differential trace, control impedance is 90Ω.
- In order to improve the antistatic performance of the USB interface, it is recommended to add an ESD protection device on the data line. The equivalent capacitance of the protection device is less than 2pF.
- The USB interface bus supply voltage is provided internally by the module and does not need to be externally supplied. At the same time, since the USB interface of the module does not provide USB bus power, the module can only be used as a slave device of the USB bus device.

3.6 UART interface

The C10GS module provides three sets of UART interfaces. Main serial port and auxiliary serial ports, serial port level is 1.8V.

3.6.1 UART1 serial port

The pins 82 and 83 of the module are UART1 serial port pins. UART1 serial interface can be used as DM port of the module to debug and configure the module. The pins are defined as follows：

Table 3-7 UART1 serial port pin definition

Pin No.	Signal name	I/O	Description	Parameter	Level value (V)			Remark
					min	typical	max	
82	UART1_RX	DI	Data reception	VIH	1.3	1.8	1.9	
				VIL	-0.3		0.6	
83	UART1_TX	DO	Data transmission	VOH	1.3	1.8	1.9	
				VOL	0		0.45	

3.6.2 UART2 serial port

The serial port can realize AT interactive instructions, print program log information, and interact with peripheral data and firmware update.

The module's serial port baud rate can be set:

- ✓ 4800, 9600, 19200, 38400, 57600, 115200, 230400, 460800, 921600bps baud rate.

The default baud rate is 115200bps.

The UART interface is defined as follows：+

Table 3-8 UART2 serial port signal definition

Pin No.	Signal name	I/O	Description	Parameter	Level value (V)			Remarks
					min	typical	max	
106	UART2_RX	DI	Master data reception	VIH	1.3	1.8	1.9	1.8V voltage domain
				VIL	-0.3		0.6	
107	UART2_TX	DO	Master data transmission	VOH	1.3	1.8	1.9	1.8V voltage domain
				VOL	0		0.84	
				VIL	-0.3		0.6	

3.6.3 Serial port application circuit

If you need to use a 2-wire serial port, you can refer to the following serial port design:

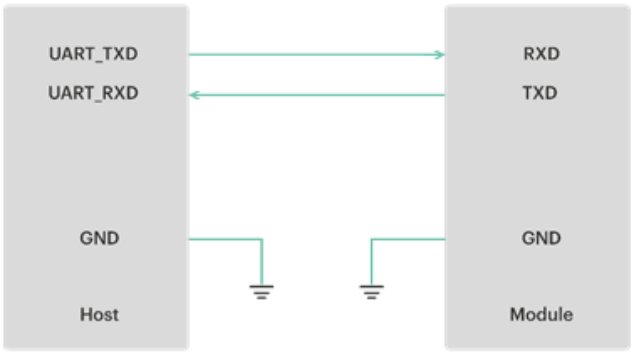


Figure 10 Two Wire UART communication

The serial port of the module is TTL 1.8V level. If the serial port needs to be connected with the MCU of 3.3V level, it needs to externally add a level conversion chip to achieve level matching. The chip connection method can refer to the following circuit:

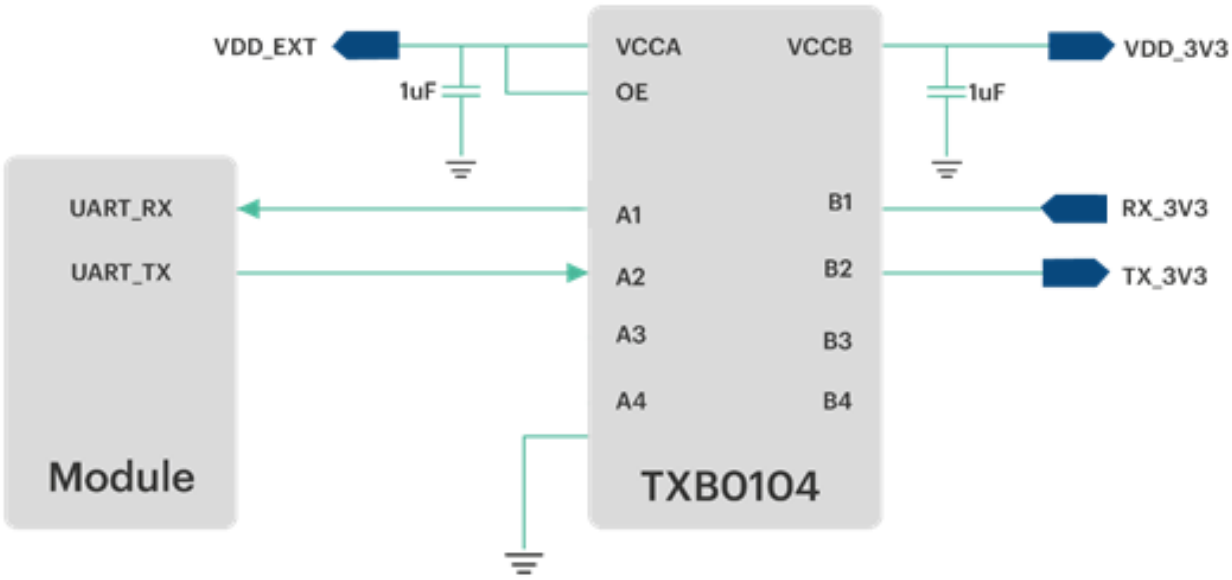


Figure 11 Level conversion chip circuit

3.6.4 UART3 serial port

The pins 64 and 65 of the module are UART3 serial port pins. UART3 serial interface can be used to interact with peripheral devices. The pins are defined as follows:

Table 3-9 UART3 serial port pin definition

Pin No.	Signal name	I/O	Description	Parameter	Level value (V)			Remark
					min	typical	max	
64	UART3_RX	DI	Data reception	VIH	1.3	1.8	1.9	
				VIL	-0.3		0.6	
65	UART3_TX	DO	Data transmission	VOH	1.3	1.8	1.9	
				VOL	0		0.45	

3.7 USIM interface

The C10GS module provides a USIM card interface compatible with the ISO 7816-3 standard. The USIM card power supply is provided by the module's internal power manager and supports 1.8V.

Table 3-10 SIM card signal definition

USIM interface				
Pin No.	**Definition**	**I/O**	**Functional description**	**Remarks**
133	USIM_VCC	PO	SIM card power supply	
134	USIM_DATA	IO	SIM card bus data	Internal 10K pull-up resistance
135	USIM_CLK	DO	SIM card clock output	Far away from the source of interference
136	USIM_RESET	DO	SIM card reset output	Far away from the source of interference
137	USIM_DETECT	DI	SIM card hot plug detection	Internal level has been pulled up

3.7.1 USIM card reference circuit

The C10GS module does not come with a USIM card slot. Users need to design a USIM card slot on their own interface board.
The USIM card interface reference circuit is as follows

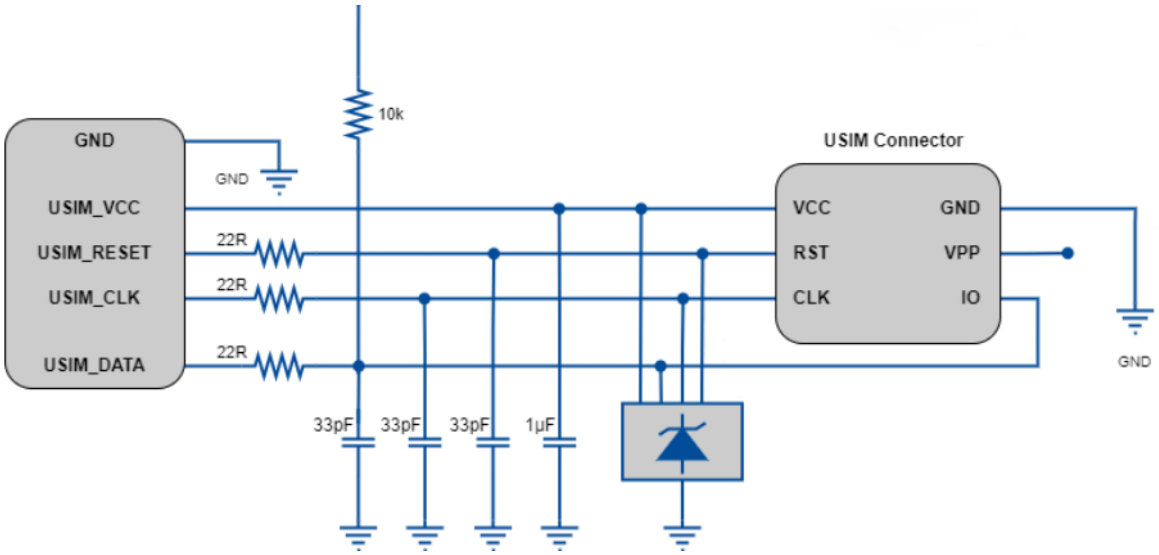


Figure 12 USIM design circuit diagram

NOTE

- The USIM interface cable is recommended to use ONSEMI's SMF15C device for ESD protection. The peripheral circuit components should be placed close to the card holder. The SIM card holder is close to the module layout.
- The USIM card circuit is susceptible to radio frequency interference and does not recognize or drop the card. Therefore, the card slot should be placed as far as possible from the RF radiation of the antenna. The card trace should be as far away as possible from the RF, power supply and high-speed signal lines.
- The USIM_DATA has been internally pulled up to VREF through a 10K resistor, and no external pull-up is required.
- USIM_DETECT is the USIM card insertion or non-insertion detection pin. It is high by default. The SIM card status can be detected by this PIN during hot plug application
- To avoid transient voltage overload, the USIM interface requires a 22R resistor in series with each other on the signal line path.
- The ground of the USIM deck and the ground of the module should maintain good connectivity.

3.8 General purpose GPIO interface

The C10GS module contains thirteen general purpose control signals. The interface is defined as follows:

Table 3-11 General GPIO Pin Definitions

Pin No.	Definition	I/O	Functional description
52	GPIO01	IO	General purpose pin 1
53	GPIO02	IO	General purpose pin 2
54	GPIO03	IO	General purpose pin 3
55	GPIO04	IO	General purpose pin 4
56	GPIO09	IO	General purpose pin 9
57	GPIO10	IO	General purpose pin 10
58	GPIO11	IO	General purpose pin 11

59	GPIO12	IO	General purpose pin 12
60	GPIO13	IO	General purpose pin 13
129	GPIO05	IO	General purpose pin 5
130	GPIO06	IO	General purpose pin 6
131	GPIO07	IO	General purpose pin 7
132	GPIO08	IO	General purpose pin 8

3.9 Network status indication interface

The C10GS module provides one GPIO pins to indicate module status.

Table 3-12 definition of network indicator lamp

Pin No.	Signal name	I/O	Description
141	WWAN_STATE	DO	Network indication

Table 3-13 Network indicator state

Pin	Signal state
Module is not run or module is not registered	Low
Module registration to network successful	High

LED network indicator light reference design chart is as follows:

Figure 13 Circuit diagram of network indicator

NOTE

- The resistance value in the circuit diagram of the network indicator can be adjusted according to the LED lamp parameters.
- The brightness of the network indicator can be adjusted by adjusting the current limiting resistor R, which can be adjusted to a maximum of 40 mA.

3.10 PCM digital voice interface

C10GS module provides a set of PCM audio interfaces supporting 8-bit A-rate, U-rate and 16-bit linear short frame encoding formats with PCM_SYNC of 8 kHz and PCM_CLK of 2048 kHz.

Table 3-14 PCM pin definition

Pin No.	Signal name	I/O	Description	Parameter	Level value (V)		
					min	typical	max
47	PCM_DIN	DI	PCM data input	VIH	1.3	1.8	1.9
				VIL	-0.3		0.6
48	PCM_DOUT	DO	PCM data output	VOH	1.3	1.8	1.9
				VOL	0		0.45
46	PCM_SYNC	DO	PCM frame sync signal	VOH	1.3	1.8	1.9
				VOL	0		0.45
49	PCM_CLK	DO	PCM clock pulse	VOH	1.3	1.8	1.9
				VOL	0		0.45

Table 3-15 PCM specific parameters

Characteristic	Description
Encoding format	Linear
Data bit	16bits
Master-slave mode	Master/slave mode
PCM clock	2048kHz
PCM frame synchronization	Short frame
Data Format	MSB

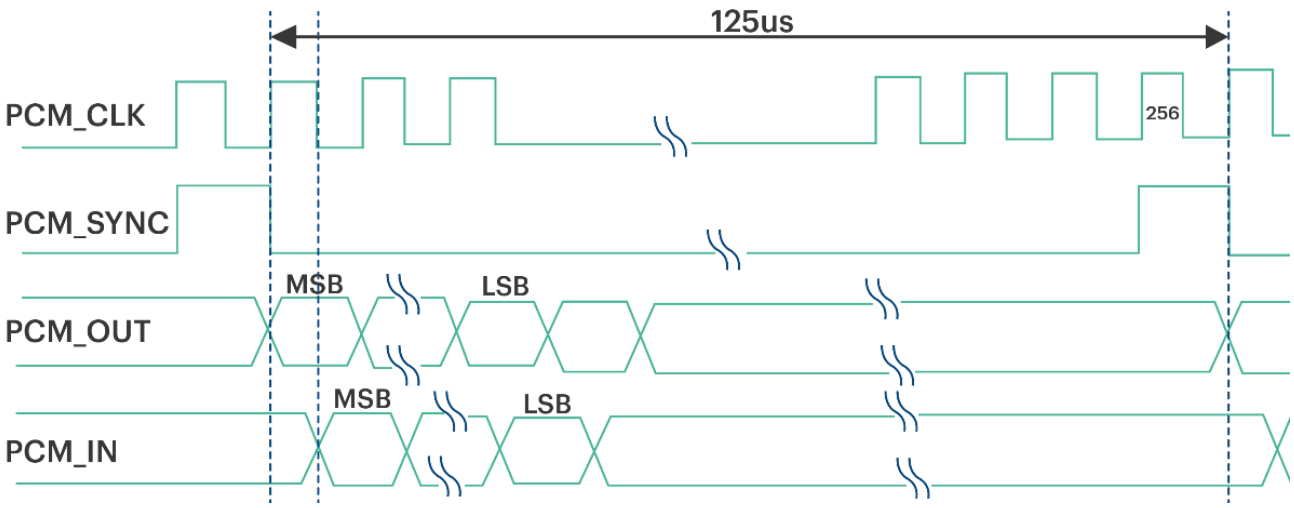


Figure 14 PCM short frame mode timing diagram

The recommended circuit for PCM to analog voice is as follows:

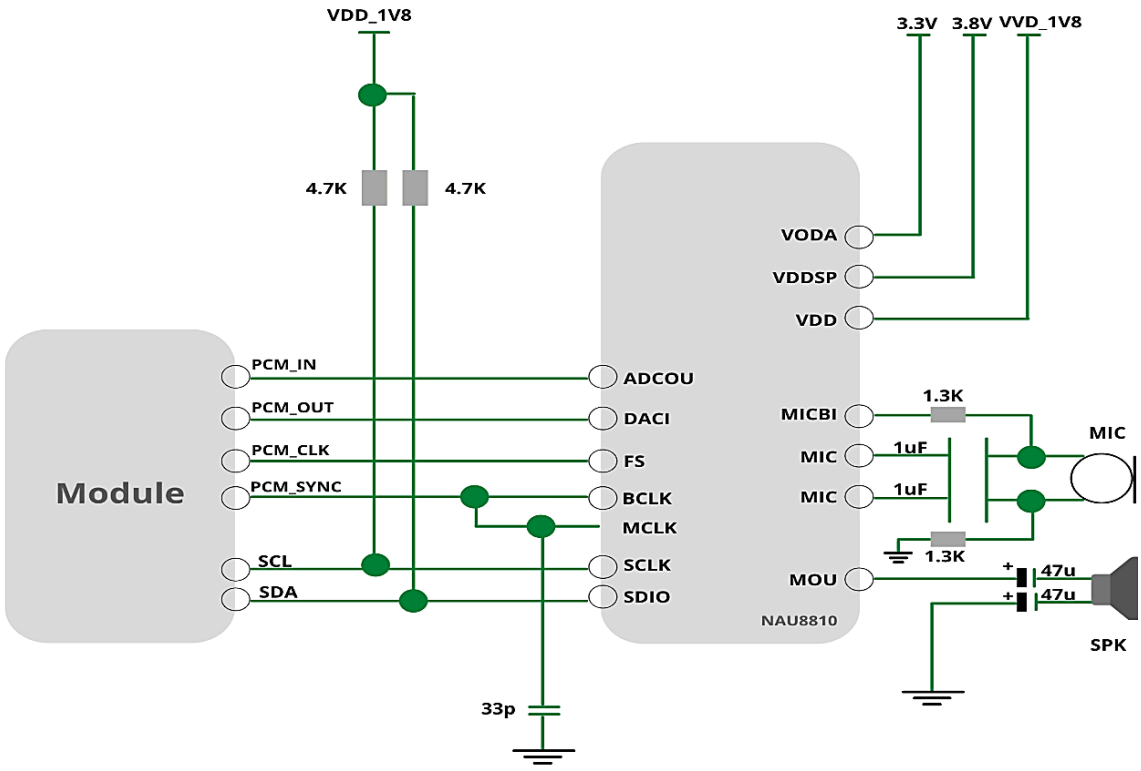


Figure 15 PCM to analog voice map

3.11 I2C bus

The C10GS module provides a set of hardware bidirectional serial buses with an I2C interface of 1.8V level, a 5.0 protocol interface, and a clock rate of 400 KHz.

Table 3-16 I2C pin definition

Pin No.	Signal name	I/O	Description	Parameter	Level value (V)		
					min	typical	max
127	I2C_SCL	DO	I2C bus clock output	VOH	1.3	1.8	1.9
				VOL	0		0.45
128	I2C_SDA	IO	I2C bus data input and output	VOH	1.3	1.8	1.9
				VOL	0		0.45
				VIH	1.3	1.8	1.9
				VIL	-0.3		0.6

The I2C reference circuit is connected as follows:

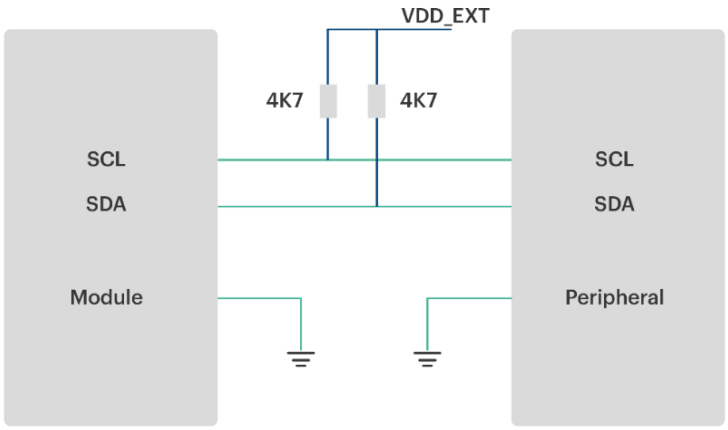


Figure 16 I2C interface reference circuit diagram

3.12 SDIO Interface

C10GS module provides a set of 4-bit SD / MMC interfaces, supports SD3.0 protocol, supports two voltage SD cards of 1.8V / 2.95V, clock frequency up to 50MHz, maximum capacity supports 32GB. Provide VREF voltage for SDIO power supply.

Table 3-17 SDIO Pin Definitions

Pin No.	Pin name	IO	Definition
67	SDH_D0	IO	SD card SDIO bus DATA2
68	SDH_D1	IO	SD card SDIO bus DATA1
69	SDH_D2	IO	SD card SDIO bus DATA0
70	SDH_D3	IO	SD card SDIO bus DATA3
71	SDH_CLK	DO	SD card SDIO bus clock
72	SDH_CMD	IO	SD card SDIO bus command
73	VDD_SDIO	DO	Reference voltage for SD Card, Bluetooth module and Wi-Fi module.

NOTE

- The SDIO bus speed is fast, and the Layout trace must conform to the SDIO3.0 specification.
- The maximum output current of the module power supply VDD_SD is 400mA.
- The reference voltage for VDD_SDIO is 3.3V, if the Bluetooth and Wi-Fi module is of 1.8V a translator is required.
- SD card clock frequency is up to 200MHZ. SDIO bus is a high-speed signal line and the characteristic impedance of the PCB design needs to be controlled at about 50 Ω.
- The length of the signal line should be less than 25mm, and the distance between the signal lines should be 2 times the line width, and the ground should be as far away as possible from other possible interference lines.
- The SDIO signal line needs a 0 Ω resistor in series to facilitate signal quality adjustment.
- In order to ensure good ESD performance, it is recommended to add a TVS tube to the SD card pin and place it near the pin.

3.13 Antenna

The C10GS module provides two antenna interfaces, one main set antenna interface, which is responsible for the CAT 1/4 signals of the transceiver module, and another GNSS antenna interface. The GNSS antenna interface is L1. The impedance of the antenna interfaces are 50 Ω.

Table 3-18 Antenna interface pin definition

Pin No.	Signal name	I/O	Description	Remarks
3	LTE_MAIN	IO	Main antenna interface	50Ω characteristic impedance
33	GNSS_L1	AI	GNSS L1 antenna interface	50Ω characteristic impedance

The pin-3 of the C10GS is the main set antenna interface. To facilitate the debugging of the antenna, a π-type matching circuit needs to be added to the main board, and a 50 Ω impedance line is taken.

The pin 33 of C10GS is the GNSS antenna interface. The C10GS has a dedicated antenna L1, it supports GPS, GLONASS, BEIDOU, QZSS, SBAS and Galileo. In order to facilitate antenna debugging, a π-type matching circuit needs to be added to the motherboard and a 50 Ω impedance line is used.

Recommended circuit is shown below：

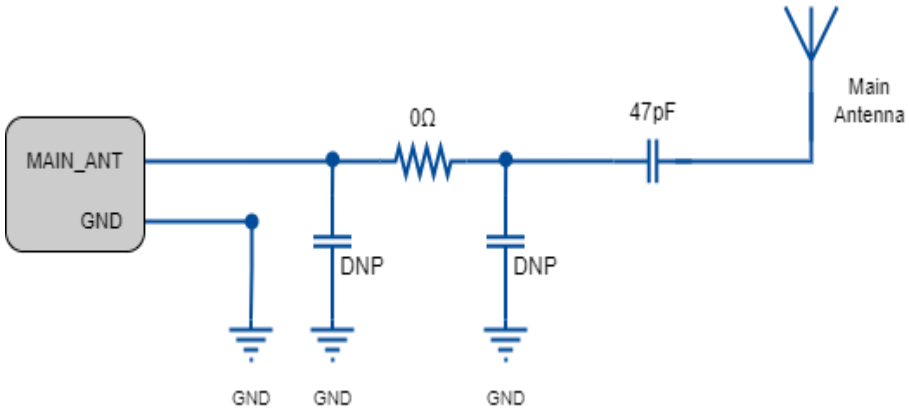


Figure 17 Main antenna matching circuit

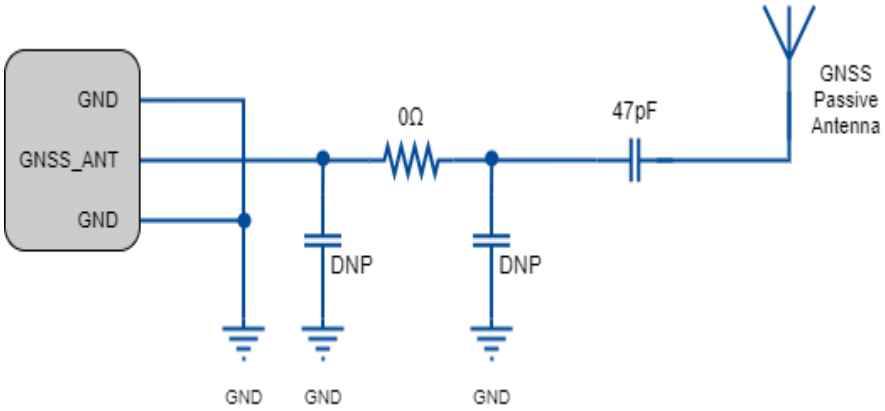


Figure 18 GNSS Passive antenna matching circuit

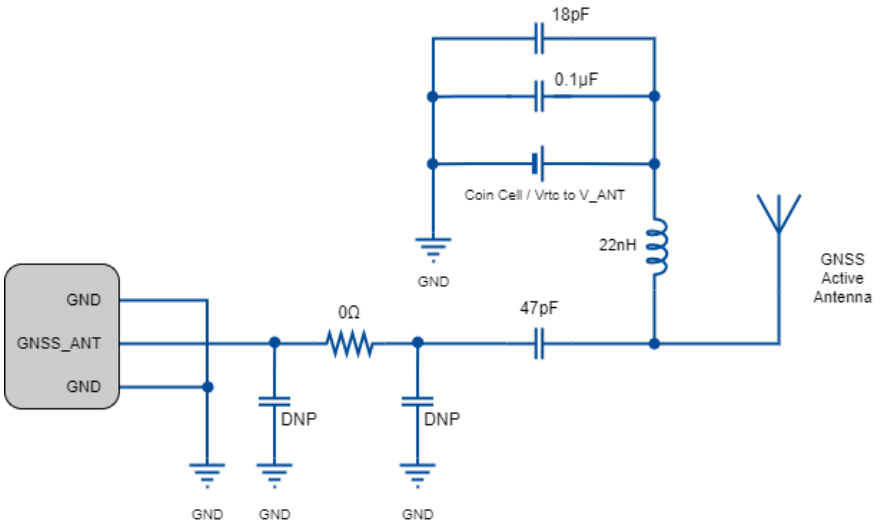


Figure 19 GNSS active antenna matching circuit

✓ The C10GS module provides two RF antenna interfaces, which are the main set antenna and the GNSS L1 antenna. The antenna interface must be a 50 Ω characteristic impedance trace.

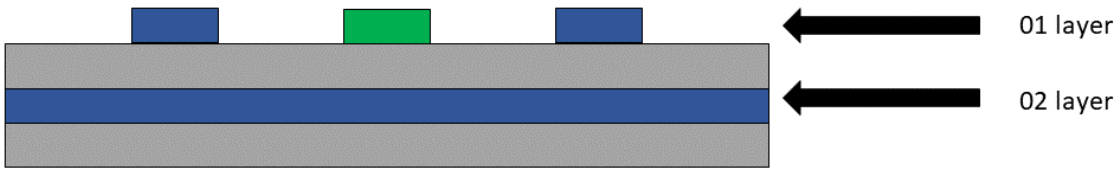
- ✓ The LTE_MAIN antenna is distributed reasonably to improve the receiving sensitivity.
- ✓ In actual use, the antenna board can be debugged and optimized according to the user's circuit board.
- ✓ Antenna impedance traces need to be away from digital signal lines, power supplies and other interference signals.

The antenna impedance traces need to be three-dimensionally packaged, and the ground holes are added on both sides of the trace to isolate.

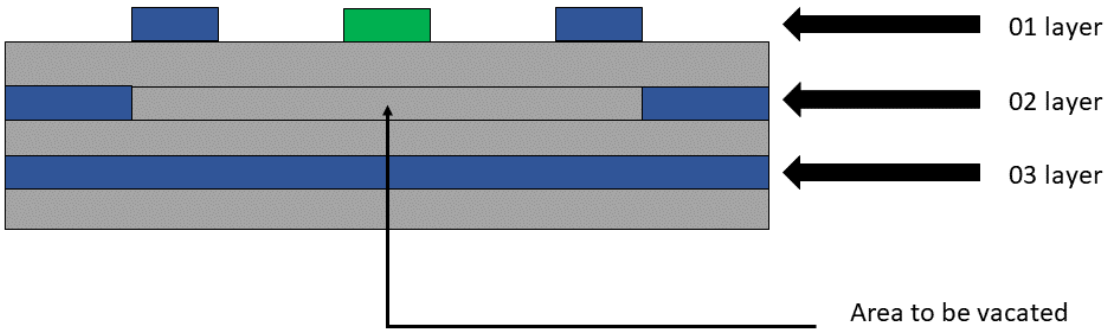
3.13.1 RF trace reference

The main set of the C10GS module are extracted by pad. The antenna pad to the antenna feed point must use microstrip lines or other types of RF traces. The characteristic impedance of the signal line should be controlled at 50Ω.

The impedance of the RF signal line is determined by the material's dielectric constant, trace width (W), ground clearance (S), and reference ground plane height (H). Therefore, the RF trace requires an impedance simulation tool to calculate the impedance of the RF trace.



MODE 1 - Reference ground is the second layer PCB coplanar transmission line structure



MODE 2 - Reference ground is the third layer PCB coplanar transmission line structure

Figure 20 Coplanar antenna

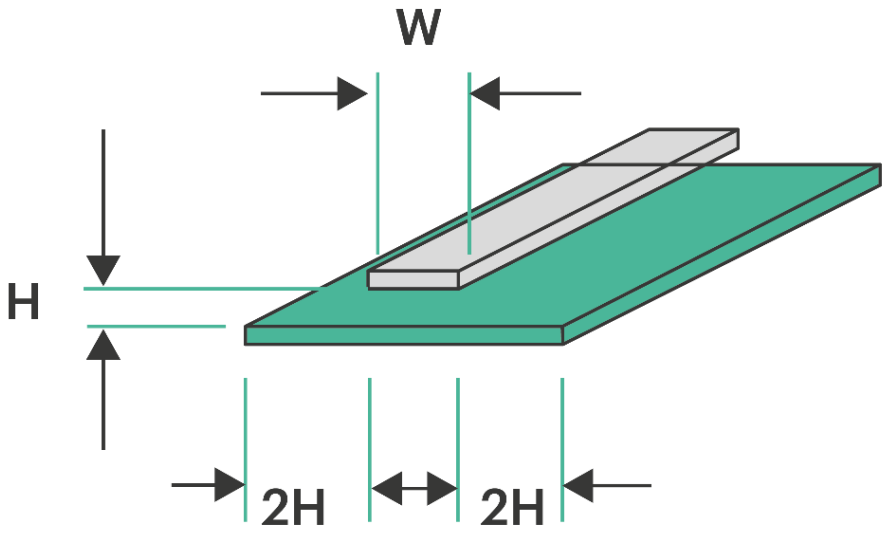


Figure 21 The complete structure of the two-layer PCB microstrip line

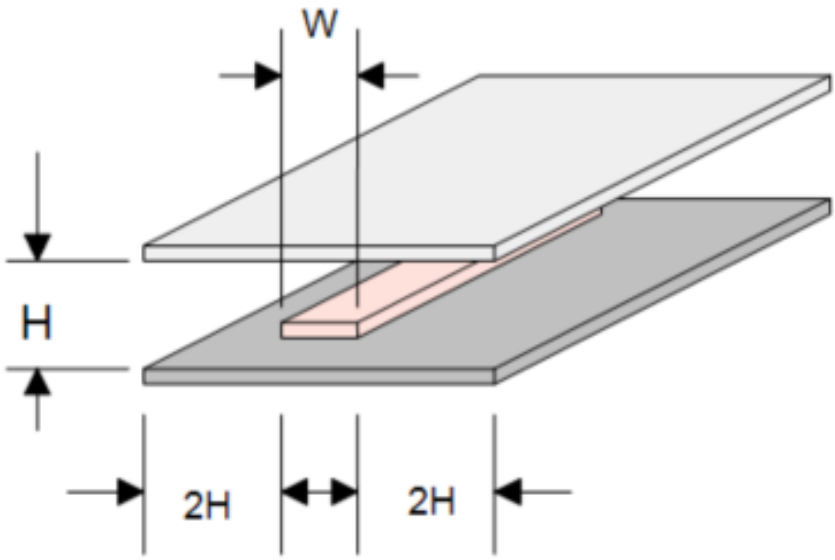


Figure 22 The complete structure of the multilayer PCB strip line

NOTE

- Since Coplanar antennas are having maximum noise immunity, it is preferred.

3.13.2 RF connector size

- ✓ If the RF connector is used, the antenna connector must use a coaxial connector with a 50 Ω characteristic impedance.
- ✓ Hirose's U.FL-R-SMT connector is recommended.

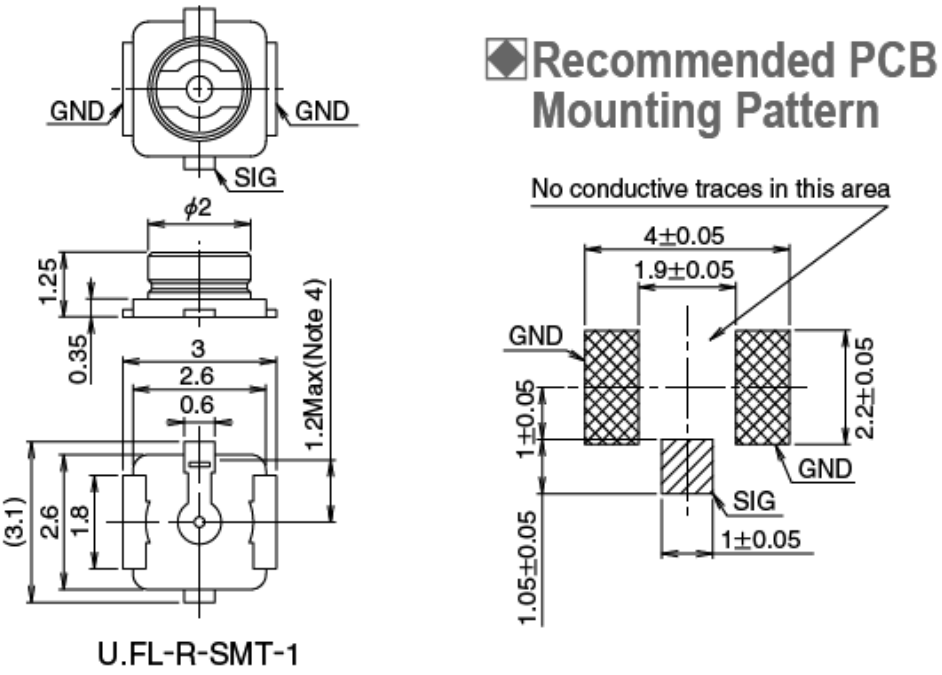


Figure 23 RF connector size chart

The RF connector plug for this connector is the U.FL-LP series from HRS.

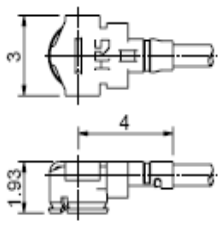
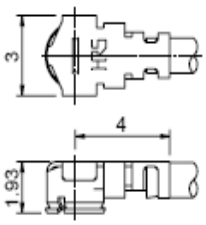
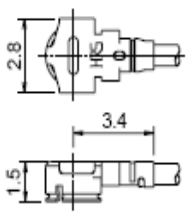
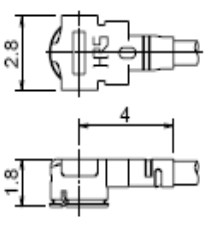
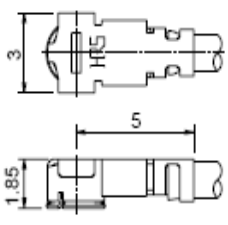
Part No.	U.FL-LP-040	U.FL-LP-066	U.FL-LP(V)-040	U.FL-LP-062	U.FL-LP-088
					
Mated Height	2.5mm Max. (2.4mm Nom.)	2.5mm Max. (2.4mm Nom.)	2.0mm Max. (1.9mm Nom.)	2.4mm Max. (2.3mm Nom.)	2.4mm Max. (2.3mm Nom.)
Applicable cable	Dia. 0.81mm Coaxial cable	Dia. 1.13mm and Dia. 1.32mm Coaxial cable	Dia. 0.81mm Coaxial cable	Dia. 1mm Coaxial cable	Dia. 1.37mm Coaxial cable
Weight (mg)	53.7	59.1	34.8	45.5	71.7
RoHS	YES				

Figure 24 Antenna connector matching plug diagram

Table 3-19 Main parameters of the RF connector

Rated condition		Environmental conditions
Frequency Range	DC to 6 GHZ	–40°C to +85°C
Characteristic impedance	50 Ω	–40°C to +85°C

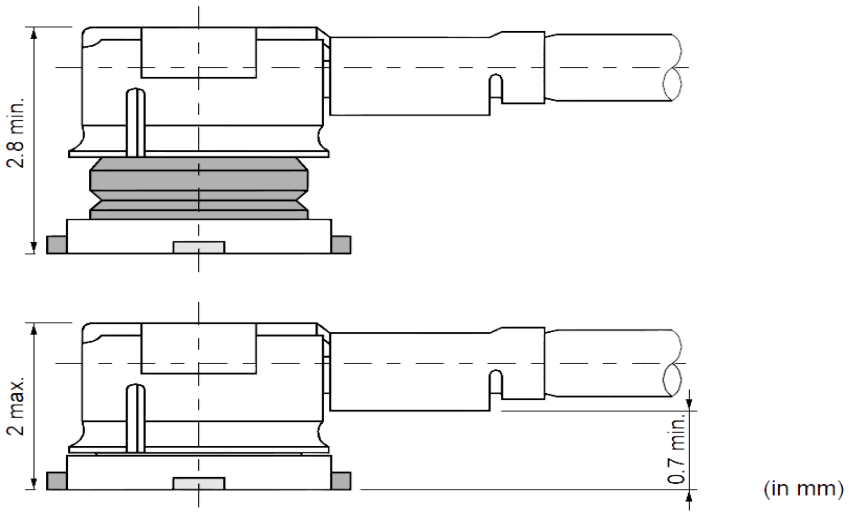


Figure 25 Matching coaxial RF line size

3.14 Control Interface

Table 3-20 Control interface pin definition

Pin No.	Signal name	I/O	Description
144	WAKEUP_IN	I	Module wake up
113	STATUS	O	Module status
115	FLIGHT_MODE	I	Module flight mode

WAKEUP_IN:

Use this WAKEUP_IN If we support sleep mode via AT command or by default it goes to sleep mode in some cases.

STATUS:

This pin is used to get the status of the module.

FLIGHT_MODE:

This pin is used to disable RF transmission.

3.15 Ethernet Interface

Table 3-21 Ethernet interface pin definition

Pin No.	Signal name	I/O	Description
92	RGMII_TXD0	DO	Transmit data to external PHY device 0
93	RGMII_TXD1	DO	Transmit data to external PHY device 1
94	RGMII_TXD2	DO	Transmit data to external PHY device 2
95	RGMII_TXD3	DO	Transmit data to external PHY device 3
96	RGMII_RXD0	DI	Receive data from external PHY device 0
97	RGMII_RXD1	DI	Receive data from external PHY device 1
98	RGMII_RXD2	DI	Receive data from external PHY device 2
99	RGMII_RXD3	DI	Receive data from external PHY device 3
100	PHY2MAC_125MHZ	DO	125MHz output clock
101	RGMII_TCTL	DO	Transmit control
102	RGMII_TCLK	DO	RGMII Transmit clock
103	RGMII_MDC	I, PU	Management data clock reference
110	RGMII_MDIO	I/O, I, PU	Management data
111	RGMII_RCLK	DO	RGMII Receive clock
112	RGMII_RCTL	DO	Receive control

3.16 GNSS Interface

Multi – GNSS receiver:

- ✓ L1 single band GNSS receiver
- ✓ Multi-Constellation GPS/GLONASS/Galileo/Bei Dou/QZSS
- ✓ Support for SBAS ranging, WAAS, EGNOS, MSAS and GAGAN
- ✓ Integrated 12 muti-tone active interference cancellers
- ✓ RTCM ready (RTCM v2.3 and v3.3)
- ✓ Indoor and outdoor multi-path detection and compensation
- ✓ 132 tracking channels

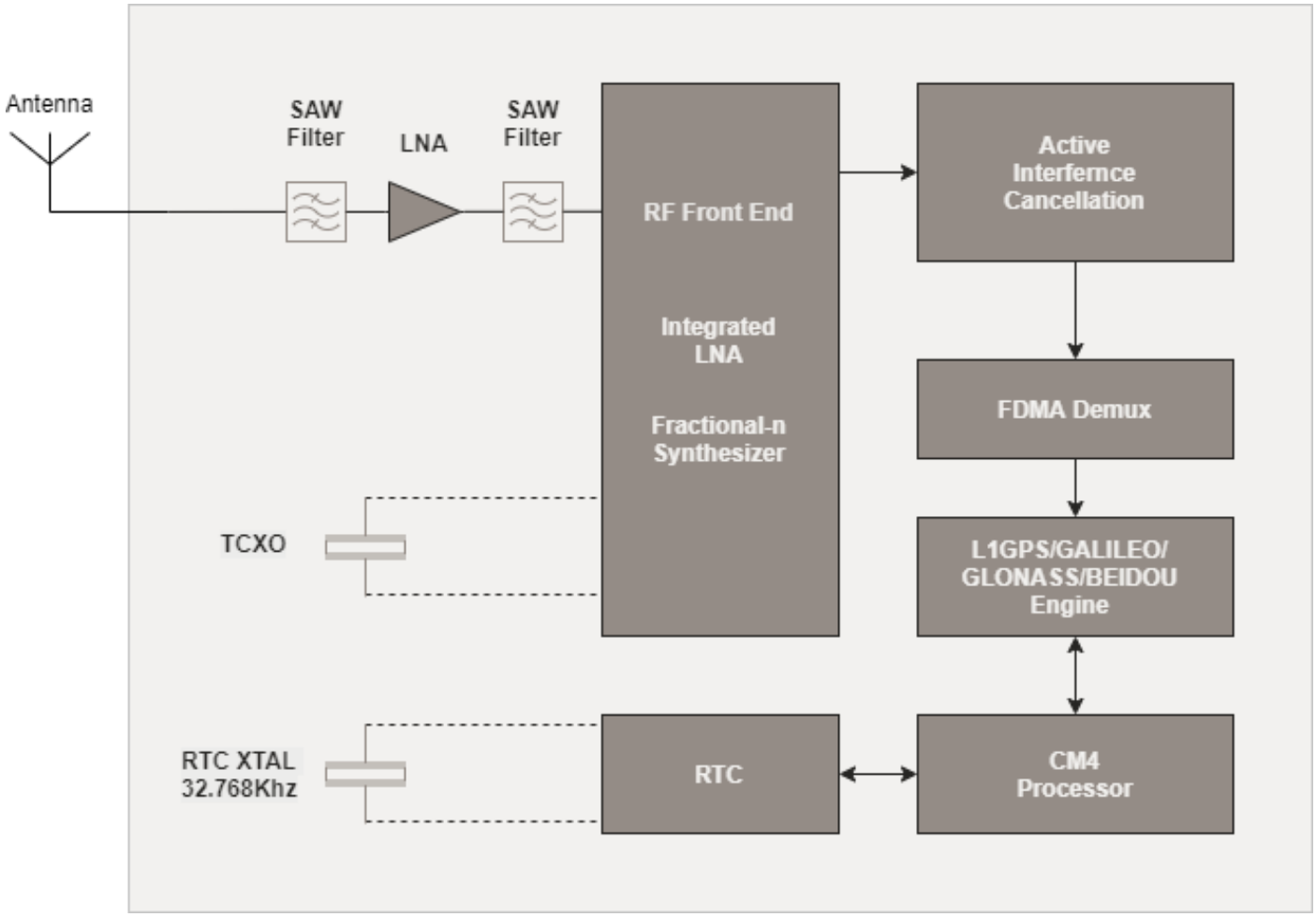


Figure 26 Multi GNSS receiver Block diagram

Table 3-22 GNSS interface pin definition

Pin No.	Signal name	I/O	Description
33	GNSS_L1	AI	GNSS L1 antenna interface
151	GEO_FENCE	O	Geo-fence boundary indicator
152	JAM_IND	O	Jamming indicator
153	1PPS	O	One pulse per second signal
154	3D_FIX_IND	O	Fix indicator
155	RTCM_TXD	O	RTCM Transmit
156	RTCM_RXD	I	RTCM Receive
157	GNSS_RESET	I	GNSS reset
158	GDBG_TXD	O	GNSS TXD
159	GDBG_RXD	I	GNSS RXD
160	GNSS_VRTC	PI	GNSS RTC Battery

1PPS:

Synchronized at rising edge, and the pulse width is 500ms. This pin must be low at start-up for normal operation. It has been pulled down internally with a 47KΩ resistor. If unused, keep this pin open.

GEO_FENCE:

The GEO_FENCE signal is used for geo-fence boundary indication.

3D_FIX_IND:

The voltage level of the 3D_FIX pin can be checked to identify the working mode when the module is powered on.

JAM_IND Interface

The JAM_IND Interface is used as jammer indicator interface for the detection of any jammer which may have an impact on the device. JAM_IND pin will output a low voltage level if there is any jammer, otherwise it outputs a high voltage level.

Reset

GNSS can be reset by driving RESET to a low-level voltage.

GNSS interface

GDBG_TXD and GDBG_RXD pins are used for fetching NMEA logs.

GNSS RTC Battery

This pin is the power input of the RTC battery. The module can store the data if the GNSS_VRTC pin is supplied with 1.8 voltage.

RTCM Interface

RTCM_TXD and RTCM _RXD pins are used for RTCM interface.

3.17 JTAG interface

Table 3-23 JTAG interface pin definition

Pin No.	Signal name	I/O	Description
147	JTAG_TCK	DO	Test clock (Not for customer)
148	JTAG_TMS	DI	Test mode select (Not for customer)
149	JTAG_TDI	DI	Test data input (Not for customer)
150	JTAG_TDO	DO	Test data output (Not for customer)

3.18 SPI interface

Table 3-24 SPI interface pin definition

Pin No.	Signal name	I/O	Description
123	SPI_CS	DO	Slave select
124	SPI_MOSI	DI	Master output slave input
125	SPI_MISO	DI	Master input slave output
126	SPI_SCLK	DO	Clock

4 Overall technical indicators

4.1 Chapter overview

The C10GS module RF overall specifications include the following sections:

- ✓ Working frequency
- ✓ GNSS Performances
- ✓ Antenna requirements

4.2 Working frequency

Table 4-1 RF frequency table

Frequency band	Uplink frequency	Downstream frequency	Mode
LTE B1	1920MHz–1980MHz	2110MHz–2170MHz	FDD
LTE B2	1850MHz–1910MHz	1930MHz–1990MHz	FDD
LTE B3	1710MHz–1785MHz	1805MHz–1880MHz	FDD
LTE B4	1710MHz–1755MHz	2110MHz–2155MHz	FDD
LTE B5	824MHz–849MHz	869MHz–894MHz	FDD
LTE B6	830MHz-840MHz	875MHz-885MHz	FDD
LTE B8	880MHz–915MHz	925MHz–960MHz	FDD
LTE B10	1710MHz-1770MHz	2110MHz-2170MHz	FDD
LTE B18	815 MHz -830 MHz	860 MHz – 875 MHz	FDD
LTE B19	830 MHz – 845 MHz	875 MHz – 890 MHz	FDD
LTE B20	832MHz– 862MHz	791MHz– 821MHz	FDD
LTE B25	1850 MHz – 1915 MHz	1930 MHz – 1995 MHz	FDD
LTE B26	814 MHz – 849 MHz	859 MHz – 894 MHz	FDD
LTE B40	1880MHz– 1920MHz	1880MHz– 1920MHz	TDD
LTE B66	1710 MHz – 1780 MHz	2110 MHz – 2200 MHz	FDD

4.3 GNSS Performances

C10GS Module GNSS performance parameters:

Table 4-2 GNSS performance parameters

Features	Description
Receiving Bands	✓ GPS L1/ Galileo E1 C/A: 1575.42 MHz ✓ GLONASS L1 C/A: 1602.5625 MHz ✓ BD2 B1 C/A: 1561.098 MHz ✓ SBAS: WAAS, EGNOS, MSAS, GAGAN
Positioning Accuracy:	Autonomous: 1.5 m CEP
Timing Accuracy:	1PPS: ±10 ns
TTFF@-130dBm	✓ Cold Start <27s ✓ Hot Start <1s
Sensitivity:	✓ Acquisition: -148 dBm ✓ Tracking: -166 dBm ✓ Reacquisition: -160 dBm

4.4 Antenna requirements

C10GS Module Antenna Design Requirements:

Table 4-3 Antenna indicator requirements

Frequency band	Standing wave ratio	Antenna gain	Effectiveness	TRP	TIS
B1 FDD	<2:1	〉-2.5dbi	〉40%	>16.5	<-88
B2 FDD	<2:1	〉-2.5dbi	〉40%	>16.5	<-88
B3 FDD	<2:1	〉-2.5dbi	〉40%	>16.5	<-88
B4 FDD	<2:1	〉-2.5dbi	〉40%	>16.5	<-88
B5 FDD	<2:1	〉-2.5dbi	〉40%	>16.5	<-88
B8 FDD	<2:1	〉-2.5dbi	〉40%	>16.5	<-88

B18 FDD	<2:1	〉-2.5dbi	〉40%	>16.5	<-88
B19 FDD	<2:1	〉-2.5dbi	〉40%	>16.5	<-88
B20 FDD	<2:1	〉-2.5dbi	〉40%	>16.5	<-88
B25 FDD	<2:1	〉-2.5dbi	〉40%	>16.5	<-88
B26 FDD	<2:1	〉-2.5dbi	〉40%	>16.5	<-88
LTE B40 TDD	<2:1	〉-2.5dbi	〉40%	>16.5	<-88
LTE B66 FDD	<2:1	〉-2.5dbi	〉40%	>16.5	<-88

5 Interface electrical characteristics

5.1 Chapter overview

- ✓ Working storage temperature
- ✓ Electrostatic property
- ✓ Reliability index
- ✓ Module IO level
- ✓ Power supply
- ✓ Power consumption characteristics

5.2 Working storage temperature

Table 5-1 C10GS module working storage temperature

Parameter	Minimum value	Maximum
Normal operating temperature	-20°C	70°C
Extreme working temperature	-30°C	85°C
Storage temperature	-50°C	TBD

5.3 Electrostatic property

There is no overvoltage protection inside the C10GS module. The ESD protection is required when the module is used to ensure product quality.

ESD design recommendations:

- ✓ The USB port needs to add TVS on VDD, D+, D- for protection, and the TVS parasitic capacitance on D+/D- is <2pF;
- ✓ The module's USIM card external pin needs to be protected by TVS, and the parasitic capacitance requirement is <10pF.
- ✓ The PCB layout of the protective device should be as close as possible to the "V" line to avoid the "T" line.
- ✓ The ground plane around the module guarantees integrity and should not be split.
- ✓ ESD control of the surrounding environment and operators is required during module production, assembly and laboratory testing

Table 5-2 C10GS ESD Features

Test port	Contact discharge	Air discharge	Unit
USB interface	±4	±8	KV
USIM interface	±4	±8	KV
VBAT power supply	±4	±8	KV

5.4 Reliability index

Table 5-3 C10GS Reliability Test

Test items	Test Conditions	Guideline	Test Results
Low temperature work	Temperature: −30°C Working mode: normal work Test duration: 24 h	IEC60068-2-1	Visual inspection: TBD Function check: TBD RF indicator check: TBD
High temperature work	Temperature: 85°C Working mode: normal work Test duration: 24 h	JESD22-A108-C	Visual inspection: TBD Function check: TBD RF indicator check: TBD
Temperature cycle	High temperature: 85°C Low temperature: −30°C Working mode: normal work Test duration: 30 Cycles;1 h+1h /cycle	JESD22-A105-B	Visual inspection: TBD Function check: TBD RF indicator check: TBD
Alternating hot and humid	High temperature: 55°C Low temperature: 25°C Humidity: 95% ± 3% Working mode: normal work Test duration: 6 Cycles;12 h+12 h/cycle	JESD22-A101-B	Visual inspection: TBD Function check: TBD RF indicator check: TBD

Temperature shock	High temperature: 85°C Low temperature: −30°C Temperature change time: < 30s Working mode: no packaging, no Power on, do not boot Test duration: 100 Cycles;15 min+15 Min/cycle	JESD22-A106-B	Visual inspection: TBD Function check: TBD RF indicator check: TBD
Drop test	Height 0.8 m, 6 sides each time, dropped to the horizontal marble platform Working mode: no packaging, no Power on, do not boot	IEC60068-2-32	Visual inspection: TBD Function check: TBD RF indicator check: TBD
Drop test...	Temperature: −40°C Working mode: no packaging, no power, no boot Test duration: 24 h	JESD22-A119-C	Visual inspection: TBD Function check: TBD RF indicator check: TBD
High temperature storage	Temperature: 85°C Working mode: no packaging, no power, no boot Test duration: 24 h	JESD22-A103-C	Visual inspection: TBD Function check: TBD RF indicator check: TBD

5.5 Module IO level

The C10GS module IO levels are as follows:

Table 5-4 Electrical Characteristics of C10GS module

Parameter	Description	Minimum value	Maximum
VIH	High level input voltage	0.65* VDD_EXT	VDD_EXT+0.3V
VIL	Low level input voltage	-	0.35*VDD_EXT

VOH	High level output voltage	VDD_EXT-0.45V	VDD_EXT
VOL	Low level output voltage	0	0.45V

5.6 Power supply

The C10GS module input power requirements are as follows:

Table 5-5 C10GS module Operating Voltage

Parameter	Minimum value	Typical value	Maximum
Input voltage	3.6V	3.8V	4.5V

The power-on time of any interface of the module must not be earlier than the boot time of the module, otherwise the module may be abnormal or damaged.

5.7 Power consumption characteristics

Table 5-6 LTE power consumption

LTE Bands	Tx ON @22dBm & @ 5V (mA)	Rx CINR @-80dBm (dB)	RSSI @-80dBm (dBm)	Tx IDLE (mA)	DRX Mode	Deep Sleep Mode
B1	750mA	17.7	16.8	210mA	17mA	1.078mA
B2	752mA	17.5	15.1	210mA	17mA	1.078mA
B3	840mA	18.7	15.3	210mA	17mA	1.078mA
B4	840mA	17.6	16.2	210mA	17mA	1.078mA
B5	770mA	18.7	16.2	210mA	17mA	1.078mA
B6	TBD	TBD	TBD	210mA	17mA	1.078mA
B8	610mA	18.4	16.6	210mA	17mA	1.078mA

B10	TBD	TBD	TBD	210mA	17mA	1.078mA
B18	770mA	18.7	16.2	210mA	17mA	1.078mA
B19	770mA	18.7	16.2	210mA	17mA	1.078mA
B20	670mA	18.5	16.7	210mA	17mA	1.078mA
B25	752mA	17.5	15.1	210mA	17mA	1.078mA
B26	770mA	18.7	16.2	210mA	17mA	1.078mA
B40	470mA	18.1	18.1	210mA	17mA	1.078mA
B66	840mA	17.6	16.2	210mA	17mA	1.078mA

6 Structural and mechanical properties

6.1 C10GS module mechanical size

The figure below shows the top and bottom view of the module.

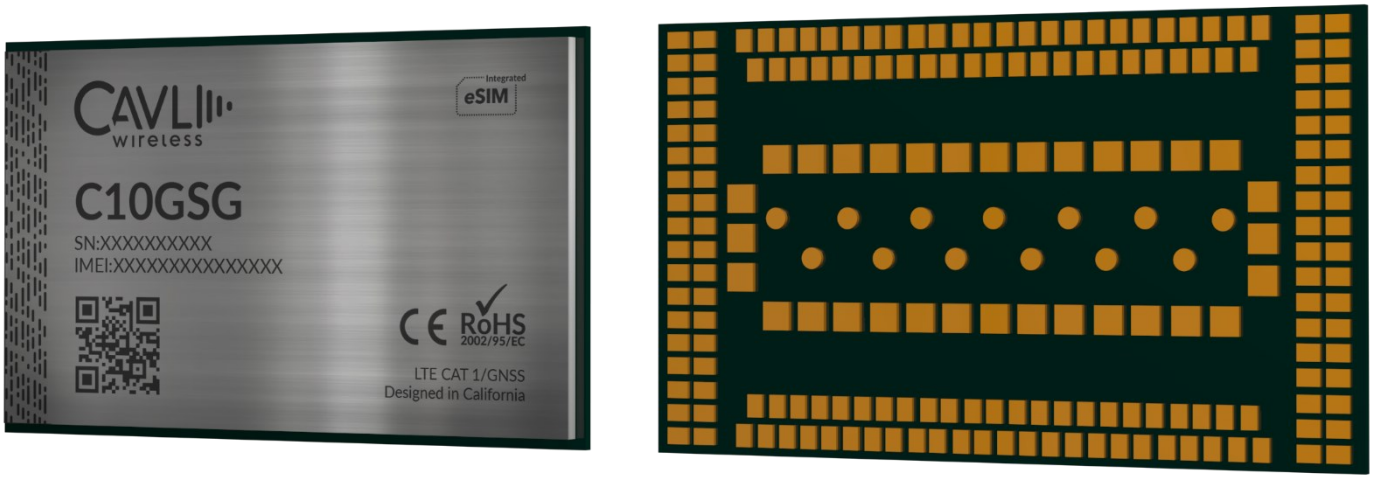


Figure 27 Top view and bottom view of the module

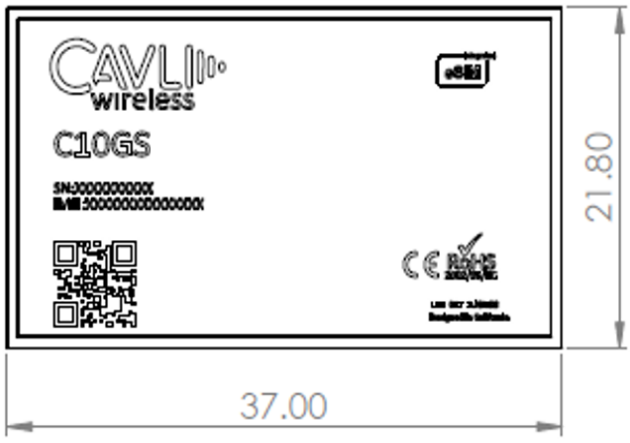


Figure 28 C10GS module dimensions

Figure 29 C10GS module side view

The mechanical dimension of C10GS is as follows:

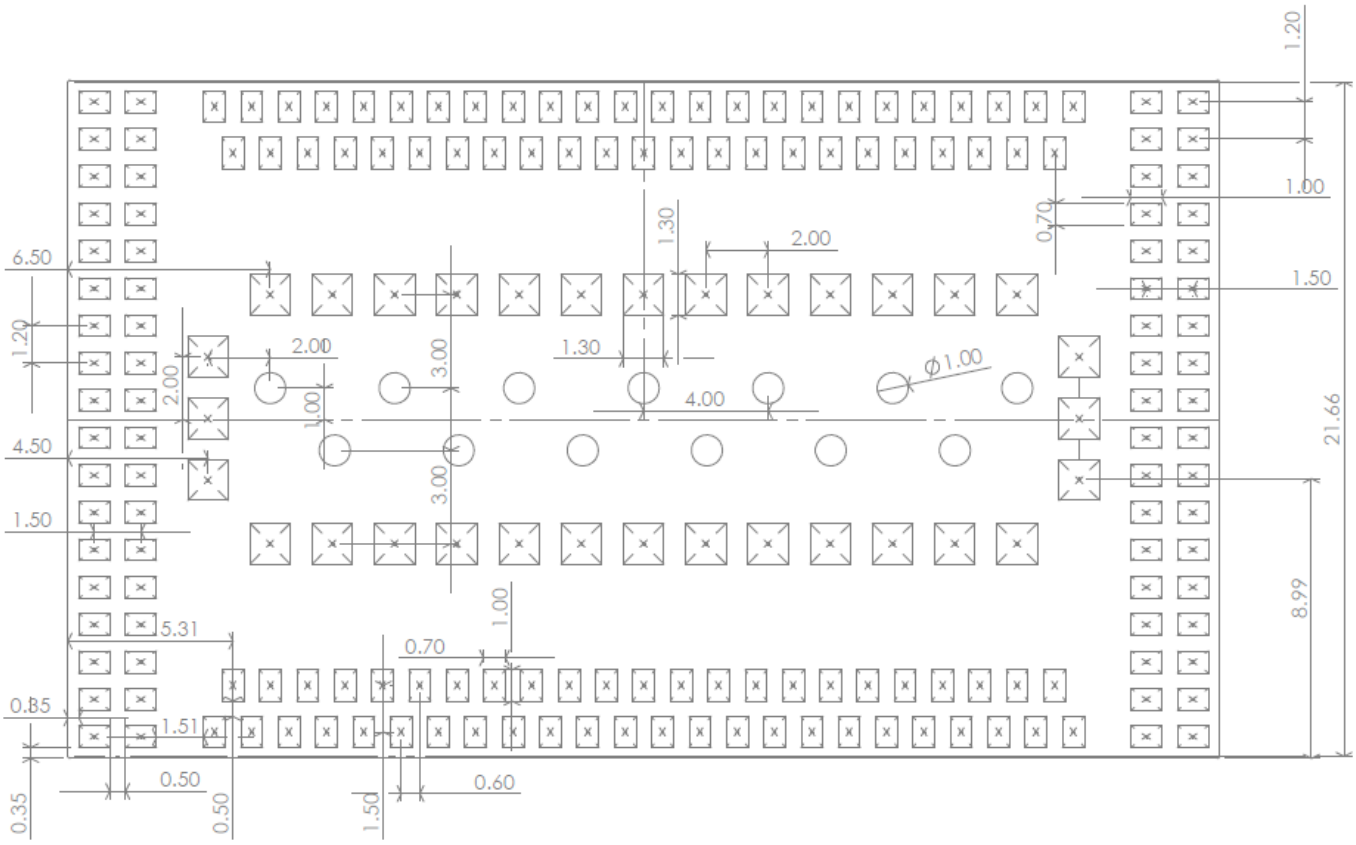


Figure 30 C10GS footprint (Top view)

7 Ordering Information

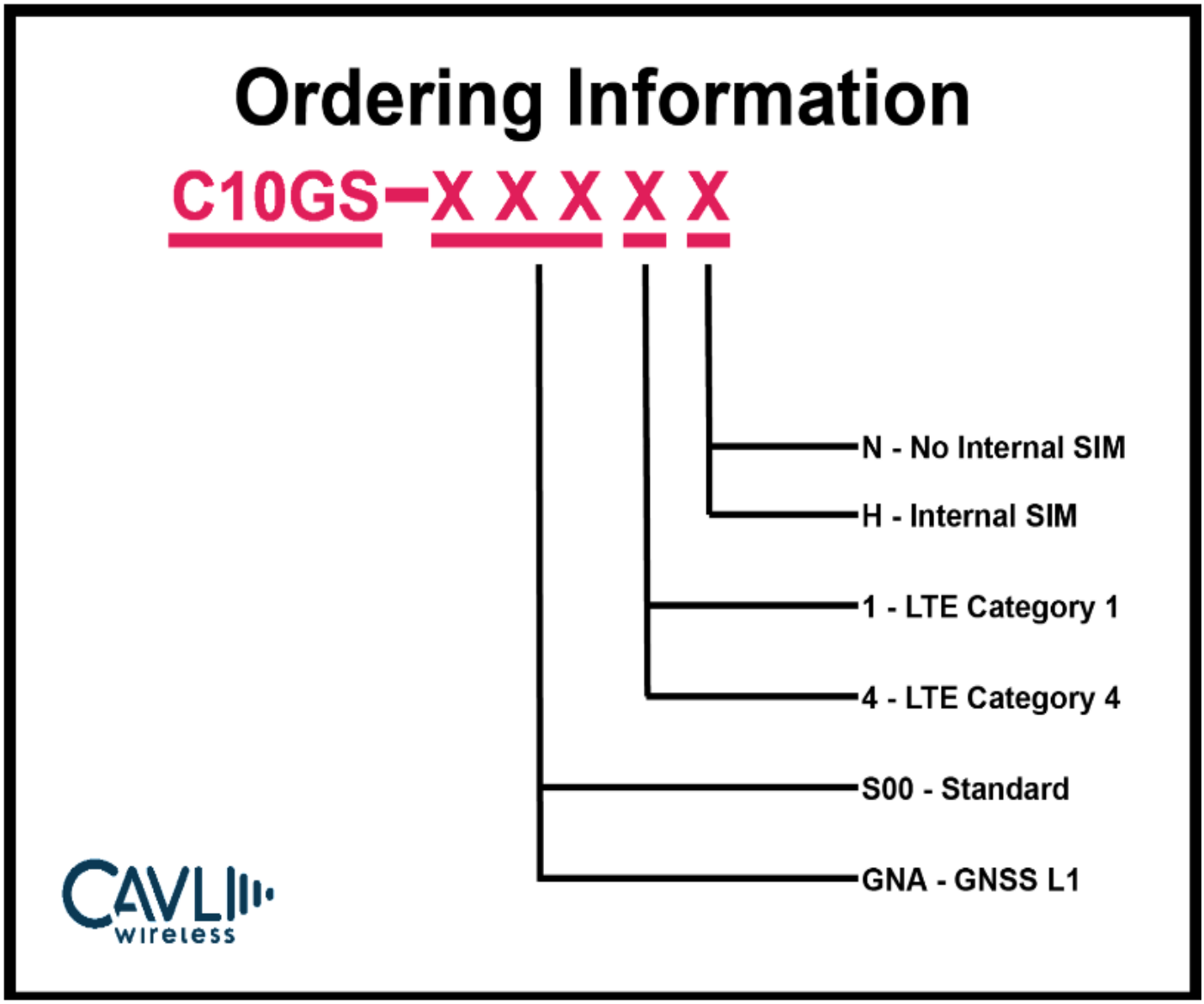


Figure 31 Ordering Information

Table 7-1 Ordering Information

Part Number	Package Type	Tape width	Tolerance	SPQ
C10GS-S001N	Tape & Reel	56mm	0.2 mm	450
C10GS-S001H	Tape & Reel	56mm	0.2 mm	450
C10GS-GNA1N	Tape & Reel	56mm	0.2 mm	450
C10GS-GNA1H	Tape & Reel	56mm	0.2 mm	450
C10GS-S004N	Tape & Reel	56mm	0.2 mm	450
C10GS-S004H	Tape & Reel	56mm	0.2 mm	450
C10GS-GNA4N	Tape & Reel	56mm	0.2 mm	450
C10GS-GNA4H	Tape & Reel	56mm	0.2 mm	450

8 Packaging and production

8.1 Chapter overview

- ✓ Module packaging and storage
- ✓ Production welding

8.2 Module packaging and storage

The C10GS module is packaged in a tape reel with a 450 pcs per reel, shipped as a tape reel sealed bag.

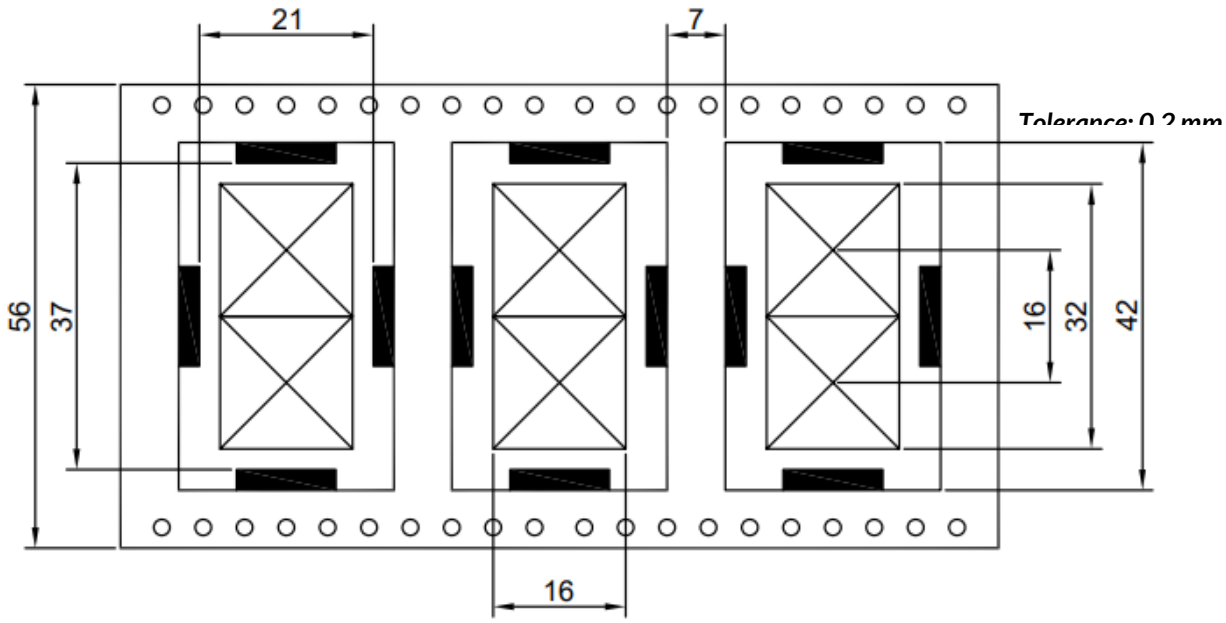


Figure 32 C10GS Tape measurements (in mm)

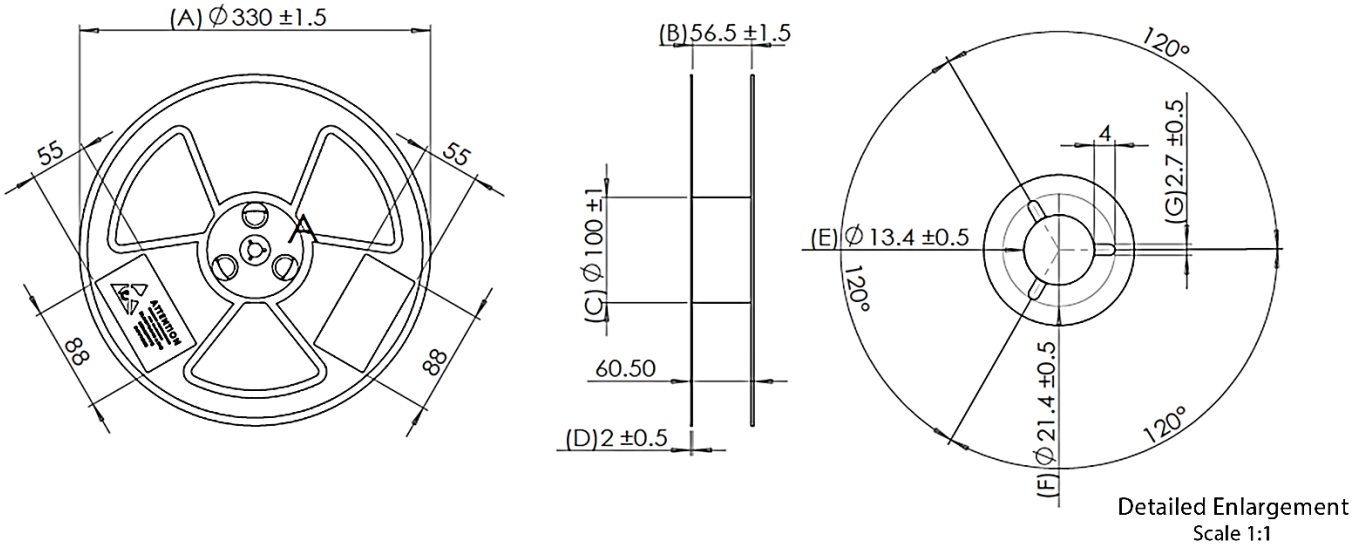


Figure 33 Reel Dimensions of C10GS (in mm)

The storage of the C10GS module is subject to the following conditions:

- ✓ The module has a moisture sensitivity rating of 3.
- ✓ When the ambient temperature is greater than 40 degrees Celsius and the air humidity is less than 90%, the module can be stored in a vacuum sealed bag for 12 months.
- ✓ When the vacuum sealed bag is opened, if the ambient temperature of the module is lower than 30 degrees Celsius and the air humidity is less than 60%, the factory can complete the patch within 72 hours, and the module can directly perform reflow soldering or other high temperature process.
- ✓ If the module is in other conditions, it needs to be baked before the patch.
- ✓ If the module needs to be baked, remove the module and bake for 48 hours at 125 degrees Celsius (allowing fluctuations of up to 5 degrees Celsius).

8.3 Production welding

The C10GS module is packaged in an anti-static tray. The SMT wire body needs to be equipped with a Tray module. It is recommended to use a reflow oven above 7 temperature zones.

- ✓ To ensure the quality of the module paste, the thickness of the stencil corresponding to the pad portion of the C10GS module is recommended to be 0.18 mm.
- ✓ The recommended reflow temperature is 235~245°C, which cannot exceed 260°C.
- ✓ When the PCB is laid out on both sides, the LGA module layout must be machined on the 2nd side.
- ✓ Avoid module falling parts, welding and welding, and poor internal welding of the module caused by the gravity of the module.

The recommended furnace temperature curve is shown below:

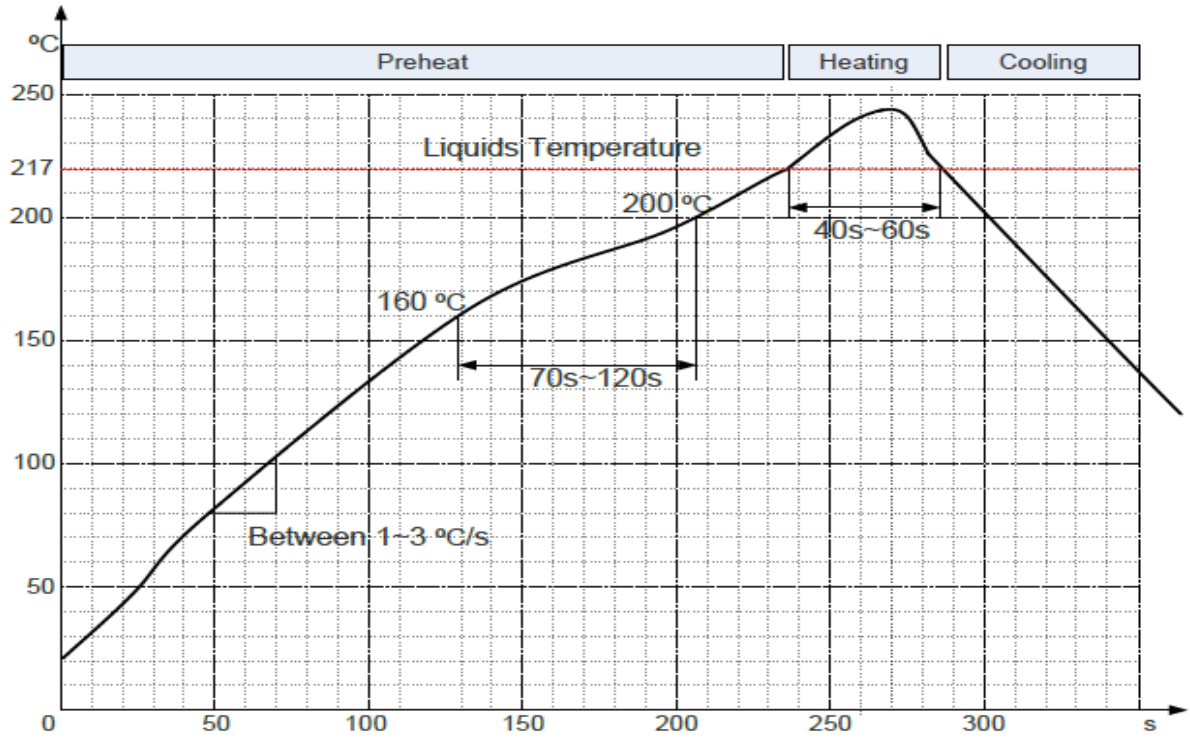


Figure 34 Reflow soldering temperature graph

Table 8-1 Reflow process parameter table

Warm zone	Time	Key parameter
Preheating zone (4℃~ 165℃)		Heating rate: 1℃/ s ~ 3℃ / s
Temperature zone (160℃～210℃)	（t1～t2）：70s ～120s	
Recirculation zone (> 217 ℃)	（t3～t4）：40s ～60s	Peak temperature: 235℃~ 245 ℃
Cooling zone		Cooling rate: 2℃/s ≤ Slope ≤ 5℃/s

9 Certificate Information & Warnings

9.1 CE EU Statement

Declaration of Conformity

Hereby, Cavli Inc declares that the equipment type LTE Cat 1 Modem, model C10GS is in compliance with Directive 2014/53/EU. Manufacturer address :

Cavli Inc.,

99 South Almaden Blvd., Suite 600, San Jose, California, 95113

Phone: 1-650-535-1150

Web: www.cavliwireless.com

The full text of the EU declaration of conformity is available at the following internet address:

https://www.cavliwireless.com/c-series/c10gs.html

9.2 IC Information

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions:

(1) this device may not cause interference, and

(2) this device must accept any interference, including interference that may cause undesired operation of the device.

Cet appareil est conforme avec Industrie Canada exempts de licence standard RSS (s). L'opération est soumise aux deux conditions suivantes:

(1) cet appareil ne peut causer d'interférences, et

(2) cet appareil doit accepter toute interférence, y compris les interférences qui peuvent causer un mauvais fonctionnement de l'appareil.

The end product must be labeled to display the Industry Canada certification number of the module.

Contains transmitter module IC: 3113-C10GS

Le dispositif d'accueil doivent être étiquetés pour afficher le numéro de certification d'Industrie Canada du module.

Contient module émetteur IC: 3113-C10GS

Information for OEM Integrator

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

1) The antenna must be installed such that 20 cm is maintained between the antenna and users, and

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

End product labelling

The label for end product must include “Contains IC: IC: 3113-C10GS”.

“CAUTION: Exposure to Radio Frequency Radiation.

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance of 20cm between the radiator and your body. 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 Host Marketing Name (HMN) must be indicated at any location on the exterior of the host product or product packaging or product literature, which shall be available with the host product or online.

This radio transmitter [IC: IC: 3113-C10GS] has been approved by Innovation, Science and Economic Development Canada to operate with the antenna types listed below, with the maximum permissible gain indicated. Antenna types not included in this list that have a gain greater than the maximum gain indicated for any type listed are strictly prohibited for use with this device.

Frequency Range	Manufacturer	Peak gain	Impedance	Antenna type
FDD LTE Band 1	Cavli Inc	3db	50 Ω	External
FDD LTE Band 2		3db	50 Ω	External
FDD LTE Band 3		3db	50 Ω	External
FDD LTE Band 4		3db	50 Ω	External
FDD LTE Band 5		3db	50 Ω	External
FDD LTE Band 6		3db	50 Ω	External
FDD LTE Band 8		3db	50 Ω	External
FDD LTE Band 10		3db	50 Ω	External
FDD LTE Band 18		3db	50 Ω	External
FDD LTE Band 19		3db	50 Ω	External
FDD LTE Band 20		3db	50 Ω	External

FDD LTE Band 25		3db	50 Ω	External
FDD LTE Band 26		3db	50 Ω	External
FDD LTE Band 40		3db	50 Ω	External
FDD LTE Band 66		3db	50 Ω	External

9.3 FCC Warnings

9.3.1 FCC Modular Approval Information Examples for Manual

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.
2. This device must accept any interference received, including interference that may cause undesired operation. **CAUTION:**

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

NOTE

- 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 or more 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.

9.3.2 FCC 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.

9.3.3 OEM integration instructions

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

The module must be installed in the host equipment 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. The module shall be only used with the internal on-board antenna that has been originally tested and certified with this module. External antennas are not supported. As long as these 3 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 (for example, digital device emissions, PC peripheral requirements, etc.). The end-product may need Verification testing, Declaration of Conformity testing, a Permissive Class II Change or new Certification. Please involve an FCC certification specialist in order to determine what will be exactly applicable for the end-product.

9.3.4 Validity of using the module certification

In the event that these conditions cannot be met (for example certain laptop configurations or co-location with another transmitter), then the FCC authorization for this module in combination with the host equipment is no longer considered valid and the FCC ID of the module cannot 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. In such cases, please involve a FCC certification specialist in order to determine if a Permissive Class II Change or new Certification is required.

9.3.5 Upgrade Firmware

The software provided for firmware upgrade will not be capable to affect any RF parameters as certified for the FCC for this module, in order to prevent compliance issues.

9.3.6 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: 2BB64C10GS

Information that must be placed in the end user manual:

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.

CAUTION:

Exposure to Radio Frequency Radiation.

Antenna shall be mounted in such a manner to minimize the potential for human contact during normal operation. The antenna should not be contacted during operation to avoid the possibility of exceeding the FCC radio frequency exposure limit.

9.3.7 Information that must be placed in the end user manual

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.

CAUTION: Exposure to Radio Frequency Radiation.

Antenna shall be mounted in such a manner to minimize the potential for human contact during normal operation. The antenna should not be contacted during operation to avoid the possibility of exceeding the FCC radio frequency exposure limit.

9.3.8 Requirement per KDB996369 D03

9.3.8.1 List of applicable FCC rules

List the FCC rules that are applicable to the modular transmitter. These are the rules that specifically establish the bands of operation, the power, spurious emissions, and operating fundamental frequencies. DO NOT list compliance to unintentional-radiator rules (Part 15 Subpart B) since that is not a condition of a module grant that is extended to a host manufacturer. See also Section 2.10 below concerning the need to notify host manufacturers that further testing is required.3

Explanation: This module meets the requirements of FCC part 15C(15.247). part 15E(15.407), part 22, part 24, part 27, part90.

9.3.8.2 Summarize the specific operational use conditions

Describe use conditions that are applicable to the modular transmitter, including for example any limits on antennas, etc. For example, if point-to-point antennas are used that require reduction in power or compensation for cable loss, then this information must be in the instructions. If the use condition limitations extend to professional users, then instructions must state that this information also extends to the host manufacturer's instruction manual. In addition, certain information may also be needed, such as peak gain per frequency band and minimum gain, specifically for master devices in 5 GHz DFS bands.

Explanation: The EUT has a Chip Antenna, and the antenna use a permanently attached antenna which is not replaceable.

9.3.8.3Limited module procedures

If a modular transmitter is approved as a "limited module," then the module manufacturer is responsible for approving the host environment that the limited module is used with. The manufacturer of a limited module must describe, both in the filing and in the installation instructions, the alternative means that the limited module manufacturer uses to verify that the host meets the necessary requirements to satisfy the module limiting conditions.

A limited module manufacturer has the flexibility to define its alternative method to address the conditions that limit the initial approval, such as: shielding, minimum signaling amplitude, buffered modulation/data inputs, or power supply regulation. The alternative method could include that the limited module manufacturer reviews detailed test data or host designs prior to giving the host manufacturer approval.

This limited module procedure is also applicable for RF exposure evaluation when it is necessary to

demonstrate compliance in a specific host. The module manufacturer must state how control of the product into which the modular transmitter will be installed will be maintained such that full compliance of the product is always ensured. For additional hosts other than the specific host originally granted with a limited module, a Class II permissive change is required on the module grant to register the additional host as a specific host also approved with the module.

Explanation: The module is not a limited module.

9.3.8.4 Trace antenna designs

For a modular transmitter with trace antenna designs, see the guidance in Question 11 of KDB Publication 996369 D02 FAQ – Modules for Micro-Strip Antennas and traces. The integration information shall include for the TCB review the integration instructions for the following aspects:

layout of trace design, parts list (BOM), antenna, connectors, and isolation requirements.

a. Information that includes permitted variances (e.g., trace boundary limits, thickness, length, width, shape(s),
b. dielectric constant, and impedance as applicable for each type of antenna);
c. Each design shall be considered a different type (e.g., antenna length in multiple(s) of frequency,
d. the wavelength, and antenna shape (traces in phase) can affect antenna gain and must be considered);
e. The parameters shall be provided in a manner permitting host manufacturers to design the printed circuit (PC) board layout;
f. Appropriate parts by manufacturer and specifications;
g. Test procedures for design verification; and
h. Production test procedures for ensuring compliance.

The module grantee shall provide a notice that any deviation(s) from the defined parameters of the antenna trace, as described by the instructions, require that the host product manufacturer must notify the module grantee that they wish 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.

Explanation: Yes, the module with trace antenna designs, and This manual has been shown the layout of trace design, antenna, connectors, and isolation requirements.

9.3.8.5 RF exposure considerations

It is essential for module grantees to clearly and explicitly state the RF exposure conditions that permit a host product manufacturer to use the module.

Two types of instructions are required for RF exposure information:

1. To the host product manufacturer, to define the application conditions (mobile, portable – xx cm from a person's body)
2. Additional text needed for the host product manufacturer to provide to end users in their end-product manuals. If RF exposure statements and use conditions are not provided, then the host product manufacturer is required to take responsibility of the module through a change in FCC ID (new application).

Explanation: This module complies with FCC RF radiation exposure limits set forth for an uncontrolled environment, this equipment should be installed and operated with a minimum distance of 20 centimeters between the radiator and your body." This module is designed to comply with the FCC statement, FCC ID is:

xxxxxxxxx".

9.3.8.6 Antennas

A list of antennas included in the application for certification must be provided in the instructions. For modular transmitters approved as limited modules, all applicable professional installer instructions must be included as part of the information to the host product manufacturer. The antenna list shall also identify the antenna types (monopole, PIFA, dipole, etc. (note that for example an "omni-directional antenna" is not considered to be a specific "antenna type")).
For situations where the host product manufacturer is responsible for an external connector, for example with an RF pin and antenna trace design, the integration instructions shall inform the installer that unique antenna connector must be used on the Part 15 authorized transmitters used in the host product. The module manufacturers shall provide a list of acceptable unique connectors.
Explanation: The EUT has a Chip Antenna, and the antenna use a permanently attached antenna which is unique.

9.3.8.7 Label and compliance information

Grantees are responsible for the continued compliance of their modules to the FCC rules. This includes advising host product manufacturers that they need to provide a physical or e-label stating "Contains FCC ID" with their finished product. See Guidelines for Labeling and User Information for RF Devices – KDB Publication 784748.

Explanation: The host system using this module, should have label in a visible area indicated the following texts: "Contains FCC ID: xxxxxxxxx"

9.3.8.8 Information on test modes and additional testing requirements

Additional guidance for testing host products is given in KDB Publication 996369 D04 Module Integration Guide. Test modes should take into consideration different operational conditions for a stand-alone modular transmitter in a host, as well as for multiple simultaneously transmitting modules or other transmitters in a host product.

The grantee should provide information on how to configure test modes for host product evaluation for different operational conditions for a stand-alone modular transmitter in a host, versus with multiple, simultaneously transmitting modules or other transmitters in a host.

Grantees can increase the utility of their modular transmitters by providing special means, modes, or

instructions that simulate or characterizes a connection by enabling a transmitter. This can greatly simplify a host manufacturer's determination that a module as installed in a host complies with FCC requirements.

Explanation: Top band can increase the utility of our modular transmitters by providing instructions

that simulates or characterizes a connection by enabling a transmitter.

9.3.8.9 Additional testing, Part 15 Subpart B disclaimer

The grantee should include a statement that the modular transmitter is only FCC authorized for the specific rule parts (i.e., FCC transmitter rules) listed on the grant, and that the host product manufacturer is responsible for compliance to any other FCC rules that apply to the host not covered by the modular transmitter grant of certification. If the grantee markets their product as being Part 15 Subpart B compliant (when it also contains unintentional-radiator digital circuity), then the grantee shall provide a notice stating that the final host product still requires Part 15 Subpart B compliance testing with the modular transmitter installed.

Explanation: The module without unintentional-radiator digital circuity, so the module does not require an evaluation by FCC Part 15 Subpart B. The host should be evaluated by the FCC Subpart B.

10 Appendix

10.1 Chapter overview

- ✓ Abbreviations
- ✓ Safety and precautions

10.2 Abbreviations

Table 9-1 Abbreviations

Abbreviations	Full name
3GPP	Third Generation Partnership Project
AP	Access Point
AMR	Adaptive Multi-rate
BER	Bit Error Rate
CCC	China Compulsory Certification
CDMA	Code Division Multiple Access
CE	European Conformity
CSD	Circuit Switched Data
CTS	Clear to Send
DC	Direct Current
DTR	Data Terminal Ready
DL	Down Link
DTE	Data Terminal Equipment
DRX	Discontinuous Reception
EDGE	Enhanced Data Rate for GSM Evolution

EU	European Union
EMC	Electromagnetic Compatibility
ESD	Electrostatic Discharge
FCC	Federal Communications Commission
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communication
HSDPA	High-Speed Downlink Packet Access
HSPA	Enhanced High Speed Packet Access
HSUPA	High Speed Up-link Packet Access
IMEI	International Mobile Equipment Identity
LED	Light-Emitting Diode
LTE	Long Term Evolution
NC	Not Connected
PCB	Printed Circuit Board
PCM	Pulse Code Modulation
PDU	Protocol Data Unit
PMU	Power Management Unit
PPP	Point-to-point protocol
QPSK	Quadrature Phase Shift Keying
RF	Radio Frequency
RoHS	Restriction of the Use of Certain Hazardous Substances
SMS	Short Message Service
TIS	Total Isotropic Sensitivity
TVS	Transient Voltage Suppressor
TX	Transmitting Direction

UART	Universal Asynchronous Receiver-Transmitter
UMTS	Universal Mobile Telecommunications System
USIM	Universal Subscriber Identity Module
USSD	Unstructured Supplementary Service Data
VSWR	Voltage Standing Wave Ratio
WCDMA	Wideband Code Division Multiple Access
WWAN	Wireless Wide Area Network

10.3 Safety and precautions

In order to use the wireless device safely, the terminal device informs the user of the relevant safety information:

- ✓ **Interference:** When the use of wireless devices is prohibited or the use of the device may cause interference and security of the electronic device, turn off the wireless device. Because the terminal will send and receive RF signals when it is powered on. It can interfere with TV, radio, computer or other electrical equipment.
- ✓ **Medical equipment:** In medical and health care facilities where the use of wireless devices is prohibited in the express text, please follow the regulations of the site and turn off the device. Some wireless devices may interfere with the medical device, causing the medical device to malfunction or cause errors. If interference occurs, turn off the wireless device and consult a physician.
- ✓ **Flammable and explosive areas:** In flammable and explosive areas, please turn off your wireless device and follow the relevant label instructions to avoid an explosion or fire. For example; gas stations, fuel zones, chemical products areas, chemical transportation and storage facilities, areas with explosion hazard signs, areas with “turn off radio equipment” signs, etc.
- ✓ **Traffic Safety:** Please comply with local laws or regulations in your country or region regarding the use of wireless devices when driving a vehicle.
- ✓ **Aviation Safety:** When flying, please follow the airline's regulations and regulations regarding the use of wireless devices. Before taking off, turn off the wireless device to prevent wireless signals from interfering with aircraft control signals.
- ✓ **Environmental Protection:** Please comply with local laws regarding the handling of equipment packaging materials, equipment or accessories, and support recycling operations.
- ✓ **Emergency call:** This device uses wireless signals for propagation. Therefore, there is no guarantee that the network can be connected in all situations, so in an emergency this wireless device cannot be used as the only contact method.