Cavli C16QS
LTE CAT1.bis Module

Hardware Manual

External Release Version 5.1

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Version	Edit	Date (DD/MM/YYY)
1.0	Initial Version	13/09/2022
1.1	Updated reference circuits • VBAT power supply • LDO linear power supply • Power ON • Reset • USB connection • UART Serial port • Level conversion chip • Main Antenna matching circuit • GNSS Active antenna matching circuit • GNSS Passive antenna matching circuit • GNSS VRTC power Updated module voltage information	19/09/2022
1.2	Updated reference figures of • Power ON • Reset • GNSS active antenna • USIM reference circuit Update SPQ values in ordering information	20/09/2022
1.3	Updated the Interface Application Description	08/11/2022
1.4	Updated basic module information	28/11/2022
1.5	Updated Power Key and RESET Key reference circuits	14/12/2022
1.6	Updated the count of GPIOs from thirteen to four under Heading 3.8	20/12/2022
1.7	Updated power consumption details	18/01/2023
1.8	Updated Band List for N.A Variant	18/01/2023
1.9	Updated the tape reel capacity	20/01/2023
2.0	Updated the ordering information (NA bands)	30/01/2023
2.1	Changed GNSS bands and ADC	07/02/2023

2.2	GNSS Performance parameters updated	15/02/2023
2.3	Updated table 2-1 and 5-1 with new Temperature values Changed the reset reference circuit (Fig 6)	20/02/2023
2.4	Power Consumption characteristics (Table 5-6) updated	07/03/2023
2.5	AP_READY description updated	10/03/2023
2.6	Power supply information updated (Section 3.3.3)	03/04/2023
2.7	Tx Idle Current Consumption added	10/04/2023
2.8	NET_STATUS Pins updated	18/04/2023
2.9	Net_Status Pin description updated	24/04/2023
3.0	UART 1 Baud Rate updated	10/05/2023
3.1	Updated GNSS and UART interface Changed pin layout	15/06/2023
3.2	Updated new variants (A.N., L.N., W.W.)	11/07/2023
3.3	Updated USIM and USB reference circuits	12/07/2023
3.4	UART details updated, Device Driver information added, IN variant added, ordering information updated	31/07/2023
3.5	Added CE EU Conformity Statement	04/08/2023
3.6	Updated Functional Block diagram	24/08/2023
3.7	Changed pin layout, Bottom view to Top view	31/08/2023
3.8	Updated information related to USIM interface	05/09/2023
3.9	Updated GNSS VRTC input figure	06/09/2023
4.0	Updated Warnings and GNSS Interface note	07/09/2023
4.1	Updated Optimal Working Temperature Added FCC warnings and IC Information	18/09/2023

4.2	Changes have been made to GNSS constellation.	20/10/2023
4.3	Minor error fix	27/10/2023
4.4	Updated Operating temperature range	07/11/2023
4.5	Added pad voltage details Updated Pin interface Added new variant information Pin layout corrected	20/12/2023
4.6	CFUN and IDLE sleep power consumption updated. Pin description and comments updated. Operating temperature range updated	05/01/2024
4.7	Corrected Operating Temperature values in page no: 55	08/01/2024
4.8	Updated the WW variant Band List.	24/01/2024
4.9	Updated the power reference circuit	31/01/2024
5.0	Updated the Revised Technical Information of C16QS Updated power consumption Information	20/02/2024
5.1	Updated Power consumption values	16/04/2024

1 Introduction

This document is the **Hardware Manual** of the Cavli Wireless solution product **C16QS Smart Module**, which describes:

- ✓ The hardware composition and functional features of the module
- ✓ The definition and usage of the application interface
- ✓ 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

C16QS integrates an application processing subsystem, a communication subsystem, multimedia and connectivity peripherals to enable a single chip 4G LTE feature phone solution.

The C16QS communication subsystem integrates **LTE CAT.1bis** technology and a RF transceiver to cover 1/ 3/ 5/ 8/ 20 (**E.A**), 2 / 4/ 5/ 12/ 13/ 66(**N.A**), 1 / 3/ 5/ 8/ 18/ 19/ 26/ 28 (**A.N**), 2/ 3/ 4/ 7/ 8/ 28 (**L.A**), 1/ 2/ 3/ 4/ 5/ 7/ 8/ 12/ 18/ 19/ 20/ 25/ 26/ 28/ 40/ 41/ 66 (**W.W，B40 is disabled for NA market**),1/3/5/8/40/41(**I.N**)and 1/ 3/ 5/ 7/ 8/ 20/ 28 (**E.U**) bands for worldwide roaming.

The application subsystem runs on a single ARM Cortex M3 processor at 204MHz with integrated peripherals for connectivity and multimedia.

NOTE

- **E.A** – Europe and Asia Regions
- **N.A** – North America Region
- **A.N** – Australia, New Zealand, Taiwan and South Korea
- **L.A** – Latin America
- **W.W** – Global
- **E.U** – European Union
- **I.N** - India

2.2 Module Characteristics

Table 2.1 Key Features

Characteristics		Description
Physical Characteristics		26.5mm x 22.5mm x 2.3mm
Fixed Way		LGA package, patch mount
Operating Voltage		3.1V – 4.5V Typical Voltage 3.8 V
Application Processor		ARM Cortex M3 with a clock frequency of 204MHz.
Application Interface	USIM card	Supports 3.0V/1.8V Supports hot swap function
	USB	✓ USB2.0 (High-Speed) (only supports Slave mode) ✓ Data transfer rate up to 480Mbps
	UART	✓ UART0(2 lines), UART1(7 lines) and UART2(2 lines) ✓ AT commands and data transfer - UART1 ✓ DM data – UART0 ✓ GNSS NMEA – UART2 ✓ The baud rate is up to 3000000bps. Default is 115200bps.
	ADC	✓ 2 Analogue to Digital converter
	I2S	✓ Compliant with I2S bus protocol
	I2C	✓ Compliant with I2C bus protocol ✓ High speed mode supports 3.3Mbps rate
	Network Indication	✓ WWAN_STATE network status indication ✓ STATUS Module status
	GPIO	✓ 4 GPIO Interfaces
	GNSS	✓ GPS, BEIDOU
	SPI	✓ Standard SPI interface
	SWD	✓ Standard SWD interface (2 Lines)

Frequency Band	**LTE BANDS:** **E.A**: - 1/ 3/ 5/ 8/ 20 **N.A**: - 2/ 4/ 5/ 12/ 66 **A.N**: - 1/ 3/ 5/ 8/ 18/ 19/ 26/ 28 **L.A**: - 2/ 3/ 4/ 7/ 8/ 28 **W.W: -** 1/ 2/ 3/ 4/ 5/ 7/ 8/ 12/ 18/ 19/ 20/ 25/ 26/ 28/40/ 41/66 B40 is disabled for NA market **E.U: -** 1/ 3/ 5/ 7/ 8/ 20/ 28 **I.N: -** 1/3/5/8/41
Data Network	✓ FDD/TDD LTE CAT 1.bis ✓ Peak DL 10Mbps/ UL 5Mbps (CAT 1.bis)
AT Command	✓ Support for standard AT instruction sets (Hayes 3GPP TS 27.007 and 27.005) ✓ Specific AT Query C16QS AT command set
Network Protocol	**TCP(S)/HTTP(S)/MQTT(S)/FTP(S)/PPP** TLS versions supported as well
Antenna Interface	✓ MAIN x 1 ✓ GNSS × 1 ✓ Characteristic impedance 50 Ω
Virtual Network Card	Supports USB virtual network card
Device Drivers	✓ USB Ethernet Driver: RNDIS ✓ USB Communication Driver: CDC-ACM / COM
Temperature Range	✓ Normal working temperature: - 30℃ to +85℃ ✓ Storage temperature –45°C to +90°C
Humidity	RH5%～RH95%
Module Function Distinction	S on the model number represents the single mode

2.3 Module Function

C16QS Module mainly consists of the following circuit units:

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

The functional block diagram of the C16QS module is shown below：

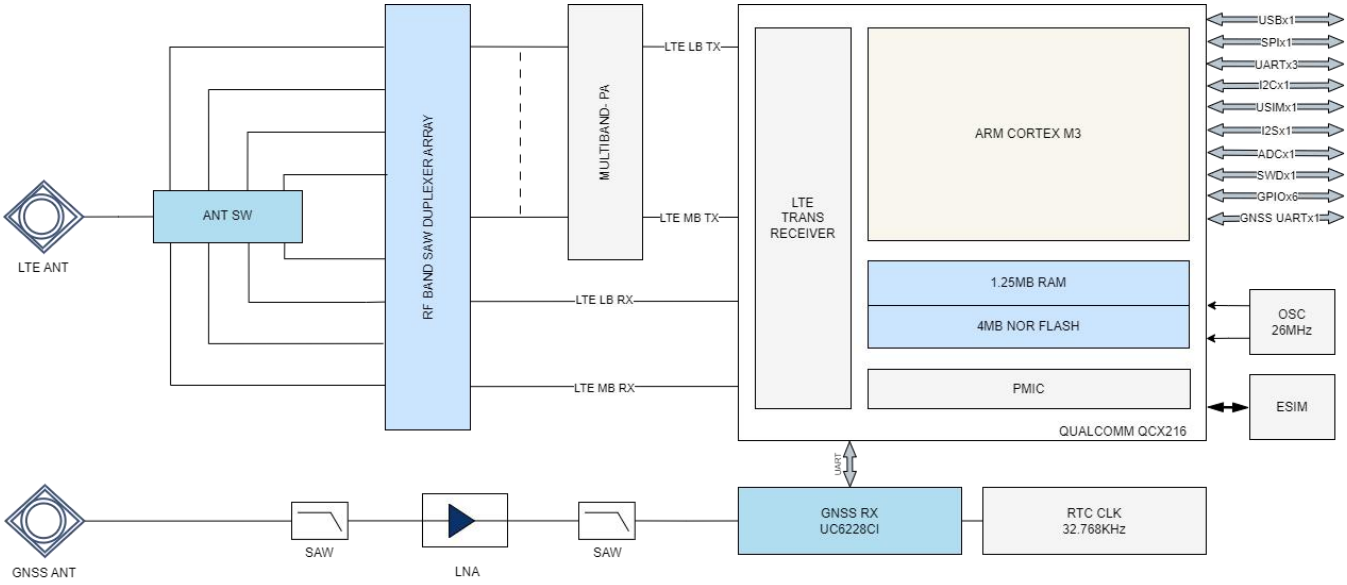


Figure 1 C16QS Functional Block Diagram

2.4 Module Working Mode

Working mode	Description
Turn off Mode	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.
Idle Mode	Turn on the machine and register the network successfully, in the idle state
Data transmission Mode	The module is in working state and has data interaction with the network.
Sleep 1	During Sleep 1 state the Static memory and retention memory will in ON state.
Sleep 2	During this State only the retention memory will be turned ON.
Hibernate	Lowest Power Saving Mode

Table 1.2 work mode

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
- I2S Interface
- I2C Bus
- SWD Interface
- Antenna
- Control Interface
- ADC Interface
- GNSS Interface
- SPI Interface

3.2 Module Interface

3.2.1 C16QS Pin Layout

C16QS pins are assigned as follows:

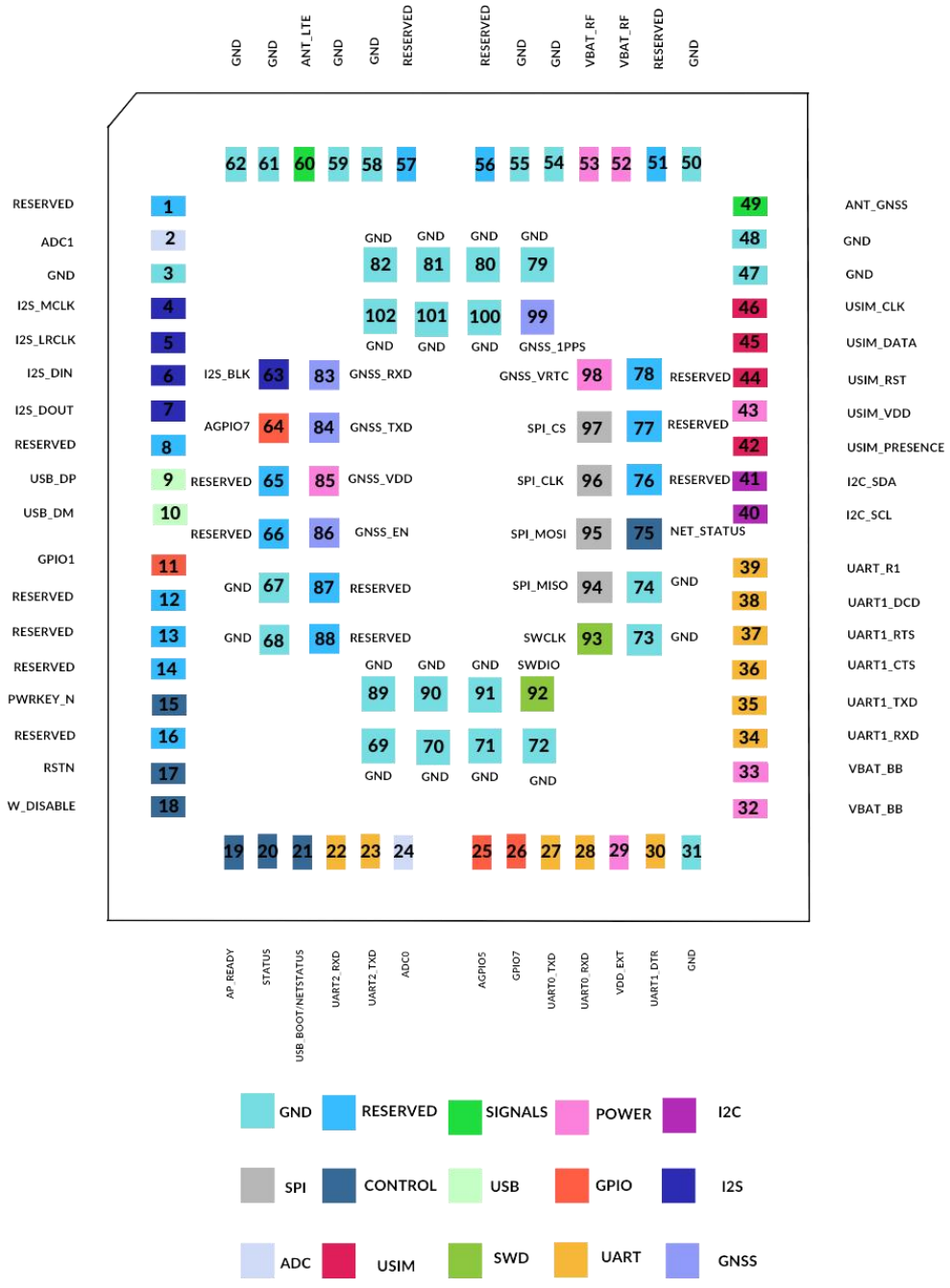


Figure 2 C16QS module Interface definition (top view)

3.2.2 C16QS Pin Interface

The C16QS module has the LGA interface. The module interface definition is shown in the following table:

Symbol	Description
PAD ATTRIBUTE	
AI	Analog Input
AO	Analog Output
AIO	Analog input output
B	Bidirectional digital with CMOS input
DI	Digital Input (CMOS)
DO	Digital Output (CMOS)
DIO	Digital Input/Output
H	High voltage tolerant
PI	Power Input
PO	Power Output
RF_I	Radio Frequency Input
RF_IO	Bidirectional Radio Frequency Input/Output
GND	Common ground
Pad pull details	
nppdpukp	Programmable pull resistor. The default pull direction is indicated using capital letters and is a prefix to other programmable options: NP: pdpu = default no-pull with programmable options following the colon (:) PD: nppu = default pull-down with programmable options following the colon (:) PU: nppd = default pull-up with programmable options following the colon (:)
NP	Contains no internal pull
PU	Contains an internal pull-up device
PD	Contains an internal pull-down device

3.2.3 Absolute maximum ratings

The absolute maximum ratings table reflects the stress levels that, if exceeded, may cause permanent damage to the device. No functionality is guaranteed outside the operating specifications. Functionality and reliability are only guaranteed within the operating conditions described in Operating conditions.

Table 3.2 Absolute Maximum ratings

Pin Type	V_min	V_max
VB	-0.3	4.5
A1	1.9	2.1
P2	-0.3	2
P3	-0.3	3.6
P4	1.2	1.89
P5	-0.3	4.2
P6	-0.3	3.6

3.2.4 Operating Conditions

The operating voltages are listed below.

Table 3.3 Operating Condition

Pin Type	V_min (if applicable)	V_typical	V_max (if applicable)
VB	3.1	3.8	4.5
A1	1.9	-	2.1
P2	1.75	1.8	1.85
P3	0	-	3.4
P4	1.2	1.8	1.89
P5	1.75/2.95	1.8/3	1.85/3.05
P6	3.25	3.3	3.35

3.2.4.1 Digital I/O characteristics

The Digital I/O characteristics of RESETN, AGPIO are follows;

Table 3.4 Digital I/O characteristics

Parameter	Description	Min	Typical	Max	Unit
VDD	Supply voltage	1.9	-	2.1	V
VIH	High-level input voltage	0.7 × VDD	-	–	V
VIL	Low-level input voltage	–	-	0.2 × VDD	V
VHYS	Schmitt hysteresis voltage	200	-	–	mV
IIH	Input high leakage current	–	-	0.3	μA
IIL	Input low leakage current	-10	-	–	μA
RPULL-UP	Pull-up resistance	170	-	230	kΩ
CI/O	I/O capacitance	1.5	-	2	pF

3.2.5 C16QS PIN Assignment

The C16QS pin names are mentioned as follows.

Table 3.5 Pin Name

Pin No.	Pin name	IO Type	Voltage definition	Pin Description	Comments
1	RESERVED	-	-	Do not connect	-
2	ADC1	AI	P3	Analog to digital converter interface 1	-
3	GND	GND	-	Ground Pin	-
4	I2S_MCLK	DIO	P2	I2S Master Clock	-
5	I2S_LRCK	DIO	P2	I2S Strobe Clock	-
6	I2S_DIN	DIO	P2	I2S Data in	-
7	I2S_DOUT	DIO	P2	I2S Data out	-
8	RESERVED	-	-	Do not connect	-
9	USB_DP	AIO	P6	Differential input/output signal of USB +	-
10	USB_DM	AIO	P6	Differential input/output signal -	-
11	GPIO1	DIO	P2	Configurable IO	-
12	RESERVED	-	-	Do not connect	-
13	RESERVED	-	-	Do not connect	-
14	RESERVED	-	-	Do not connect	-
15	PWRKEY_N	DI	-	Power key	
16	RESERVED	-	-	Do not connect	-
17	RSTN	DI	A1	System reset	-
18	W_DISABLE#	DI	-	Put into Flight Mode	-

19	AP_READY	DI	-	Wake up Interrupt	-
20	STATUS	DO	-	Module power on status indication	-
21	USB_BOOT	DO	-	NET_STATUS function	Same as pin 75
22	UART2_RXD	DI	P2	UART 2 Receive data	Should be left floating
23	UART2_TXD	DO	P2	UART 2 Transmit data	Should be left floating
24	ADC0	AI	P3	Analog to digital converter interface 0	-
25	AGPIO5	DI	A1	Always on GPIO	-
26	GPIO7	DIO	P2	Configurable IO	-
27	UART0_TXD	DO	P2	UART 0 Transmit data	-
28	UART0_RXD	DI	P2	UART 0 Receive data	-
29	VDD_EXT	PO	P2	1.8V output LDO	-
30	UART1_DTR	DO	P2	UART 1 Data terminal ready	-
31	GND	GND	-	Ground Pin	-
32	VBAT_BB	PI	VB	Input Power	-
33	VBAT_BB	PI	VB	Input Power	-
34	UART1_RXD	DI	P2	UART 1 Receive data	-
35	UART1_TXD	DO	P2	UART 1 Transmit data	-
36	UART1_CTS	DO	P2	UART 1 Clear to send	-
37	UART1_RTS	DI	P2	UART 1 Request to send	-
38	UART1_DCD	DI	P2	UART 1 Data carrier detect	-
39	UART1_RI	AIO	P2	UART 1 Ringing indication	-
40	I2C_SCL	DO	P2	I2C Serial Clock	-

41	I2C_SDA	DIO	P2	I2C Serial data	-
42	USIM_PRESENCE	DI	P5	SIM detect Pin	-
43	USIM_VDD	PO	P5	External SIM power	-
44	USIM_RST	DIO	P5	External SIM card reset	-
45	USIM_DATA	DIO	P5	External SIM card IO	-
46	USIM_CLK	DIO	P5	External SIM clock	-
47	GND	GND	-	Ground Pin	-
48	GND	GND	-	Ground Pin	-
49	ANT_GNSS	RF_I	-	GNSS Antenna interface Pin	50 Ohm impedance
50	GND	GND	-	Ground Pin	-
51	RESERVED	-	-	Do not connect	-
52	VBAT_RF	PI	VB	Input Power Pin	-
53	VBAT_RF	PI	VB	Input Power Pin	-
54	GND	GND	-	Ground Pin	-
55	GND	GND	-	Ground Pin	-
56	RESERVED	-	-	Do not connect	-
57	RESERVED	-	-	Do not connect	-
58	GND	GND	-	Ground Pin	-
59	GND	GND	-	Ground Pin	-
60	ANT_LTE	RF_IO	-	LTE Main antenna Pin	50 Ohm impedance
61	GND	GND	-	Ground Pin	-
62	GND	GND	-	Ground Pin	-
63	I2S_BLK	DIO	P2	I2S Bit clock	-
64	AGPIO7	DI	A1	Always on GPIO	-

65	RESERVED	-	-	Do not connect	-
66	RESERVED	-	-	Do not connect	-
67	GND	GND	-	Ground Pin	-
68	GND	GND	-	Ground Pin	-
69	GND	GND	-	Ground Pin	-
70	GND	GND	-	Ground Pin	-
71	GND	GND	-	Ground Pin	-
72	GND	GND	-	Ground Pin	-
73	GND	GND	-	Ground Pin	-
74	GND	GND	-	Ground Pin	-
75	NET_STATUS	DO	P2	Network status indication	-
76	RESERVED	-	-	Do not connect	-
77	RESERVED	-	-	Do not connect	-
78	RESERVED	-	-	Do not connect	-
79	GND	GND	-	Ground Pin	-
80	GND	GND	-	Ground Pin	-
81	GND	GND	-	Ground Pin	-
82	GND	GND	-	Ground Pin	-
83	GNSS_RXD	DI	P2	GNSS UART Reception	Should be left floating
84	GNSS_TXD	DO	P2	GNSS UART Transmission	-
85	GNSS_VDD_3V3	PI	P6	GNSS Power supply	-
86	GNSS_EN	DI	P4	Hardware enables for GNSS	-
87	RESERVED	-	-	Do not connect	-
88	RESERVED	-	-	Do not connect	-

89	GND	GND	-	Ground Pin	-
90	GND	GND	-	Ground Pin	-
91	GND	GND	-	Ground Pin	-
92	SWDIO	DIO	P2	Serial wire debug data	-
93	SWCLK	DIO	P2	Serial wire debug clock	-
94	SPI_MISO	DI	P2	Master in slave out	-
95	SPI_MOSI	DO	P2	Master out slave in	-
96	SPI_CLK	DO	P2	Serial clock	-
97	SPI_CS	DO	P2	Slave select	-
98	GNSS_VRTC_1V8	PI	P4	GNSS RTC Power supply	-
99	GNSS_1PPS	DO	P2	1PPS indicator	-
100	GND	GND	-	Ground Pin	-
101	GND	GND	-	Ground Pin	-
102	GND	GND	-	Ground Pin	-

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 and 3.0V).
- ✓ All **RESERVED** and unused pin feet need to be left floating

3.3 Power interface

The C16QS module power interface consists of three parts:

- ✓ **VBAT_BB** is the module working power supply.
- ✓ **VBAT_RF** is the module RF power supply
- ✓ **GNSS_VRTC** is the RTC power
- ✓ **USIM_VDD** is the working power supply for SIM card

3.3.1 Power Supply Design

The power interface of the C16QS module is as follows:

Table 3.5 Power pin definitions

Power supply							
Pin No.	**Definition**	**IO**	**Description**	**Remarks**	**V_Min**	**V_Typ**	**V_Max**
32, 33	VBAT_BB	PI	Module input voltage	-	3.1V	3.8V	4.5V
52, 53	VBAT_RF	PI	Module input voltage	-	3.1V	3.8V	4.5V
43	USIM_VDD	PO	External SIM card power supply	Output voltage 1.8/3	1.75/2.95	1.8/3	1.85/3.05
98	GNSS_VRTC	PI	GNSS RTC Power supply	Input voltage 1.8V	1.2	1.8	1.89
29	VDD_EXT	PO	1.8V output LDO / Reference Voltage	Output voltage 1.8V	1.75	1.8	1.85
85	GNSS_VDD_3V3	PI	GNSS Power Supply	Output Voltage 3.3V	3.25	3.3	3.35

3, 31, 47, 48, 50, 54, 55, 58, 59, 61, 62, 67-74, 79-82, 89-91, 100-102	GND	-	Ground	-	-	0	-

The C16QS module can be powered by a single power supply mode.

- The module has 4 channels of power supply, two **VBAT_BB** and two **VBAT_RF** pins.
- The module power supply range is between 3.1V – 4.5V
- It is recommended to use 3.8 V/830 mA 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, 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.
- The external power supply is connected to the module from a single voltage source and can be expanded to two sub paths with star structure.
- The **VBAT_BB** line width should be within 1mm, and the VBAT_RF line width should not be less than 2mm.
- The GNSS_VDD voltage is for powering ON GNSS IC and GNSS_EN is to start the NMEA streaming in the independent operation mode of GNSS and LTE. In normal working mode, both pins can be left floating.
- For more information, refer *C16QS GNSS Application Note.*

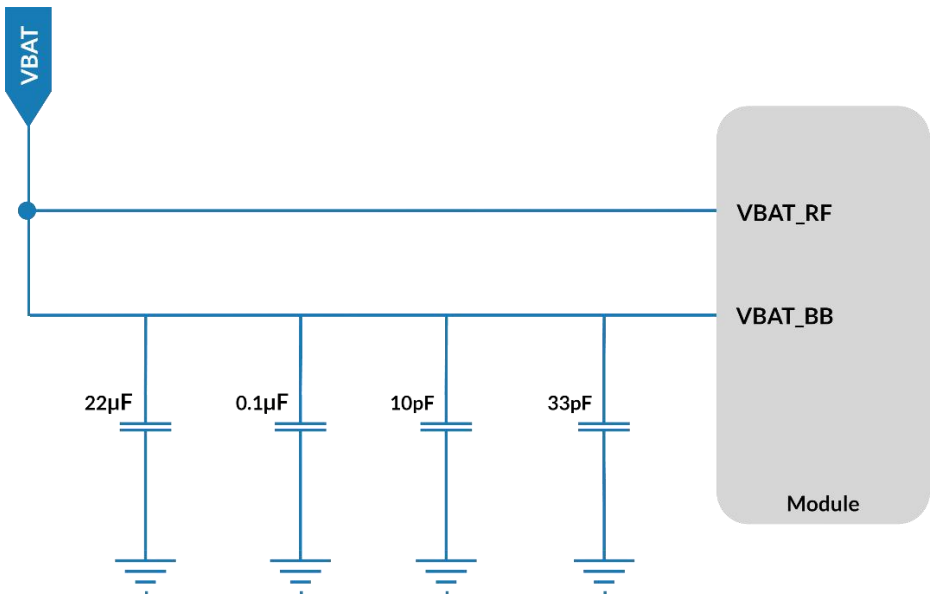


Figure 3 VBAT power supply

NOTE

✓ To ensure that the power supply is sufficient, a 10pF, 33pF, 0.1μF, 22μF ceramic capacitors can be added to the VBAT line and placed near the VBAT pin to improve the performance and stability of the system.

3.3.2 Power Reference Circuit

A Buck converter can be used to design the VBAT power supply. For better understanding, refer the circuit given below.

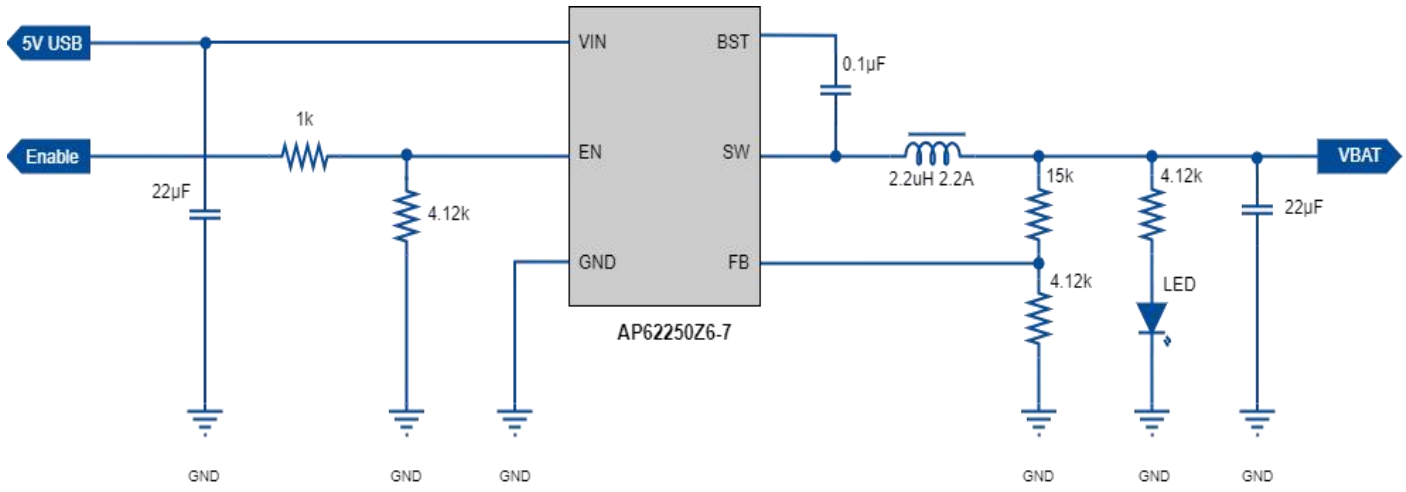


Figure 4 Buck converter reference circuit

3.3.3 VDD_EXT 1.8 Voltage Output

The C16QS module outputs 1.8V through VDD_EXT for internal digital circuitry. This voltage is the logic level voltage of the module. After normal power-on, the 29th pin will output 1.8V and the current load will be 50mA.

The external master can read the voltage of VDD_EXT to determine if the module is powered on. VDD_EXT can also be used as an external power supply, such as a level shifting chip, but maximum load should be within 50mA.

Table 3.6 VDD EXT pin definition

Pin No.	Signal name	I/O	Description	Voltage		
				V_min	V_Typical	V_max
29	VDD_EXT	PO	1.8V output LDO / Reference Voltage	1.75	1.8	1.85

3.4 Switching Machine Reset Mode

3.4.1 Turn ON Module

The 15th pin of the C16QS module is Power on pin. The module can be powered on by pulling down the POWER_KEY Low for at least 500ms. The user can check whether the module is powered on by querying the high and low levels of the VDD_EXT pin.

Table 3.7 Switch pin definition

Pin No.	Signal name	I/O	Description
15	PWRKEY_N	DI	Power key

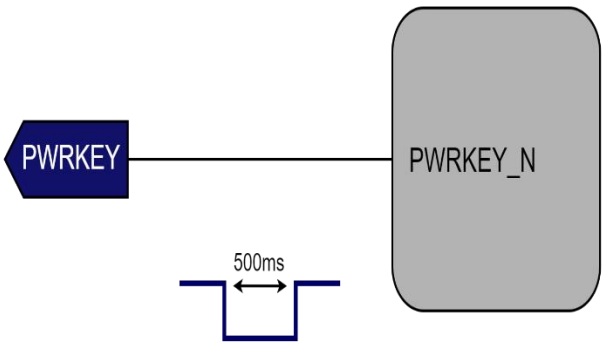


Figure 5 Power-on reference circuit

NOTE

✓ If you want to enable automatic boot up for the C16QS, connect the PWRKY_N via pull-up with a 4.7K resistor to the module's VDD_EXT. (Not from external 1.8V source)

3.4.2 Reset Control

The C16QS module Pin 17th 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 100-500ms 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.

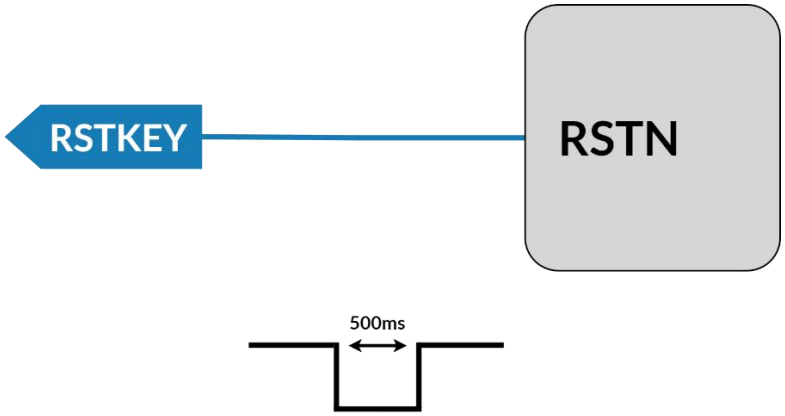


Figure 6 Reset reference circuit

Table 3.8 RESET pin parameters

Pin No.	Signal name	I/O	Description	Voltage		
				V_min	V_Typical	V_max
17	RSTN	DI	Module Reset Control	1.9	-	2.1

NOTE

✓ The C16QS module supports AT command reset, and the AT command is **AT+TRB** to restart the module. Detailed instructions can be found in the C16QS AT Command Set Manual.

3.5 USB Interface

The C16QS module USB interface supports *USB2.0* high-speed protocol, only in 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 3.3V - 5V. AT interfacing and Ethernet via USB is possible in Cavli C16QS module.

The USB interface is defined as follows:

Table 3.9 USB interface pin definition

Pin No.	Signal name	I/O	Description	Voltage		
				V_min	V_Typical	V_max
9	USB_DP	AIO	Differential input/output signal of USB +	3.25	3.3	3.35
10	USB_DM	AIO	Differential input/output signal -	3.25	3.3	3.35

The module only acts as a USB slave device and supports *USB Sleep* and *Wake-Up* mechanisms. USB interface application reference circuit is as follows：

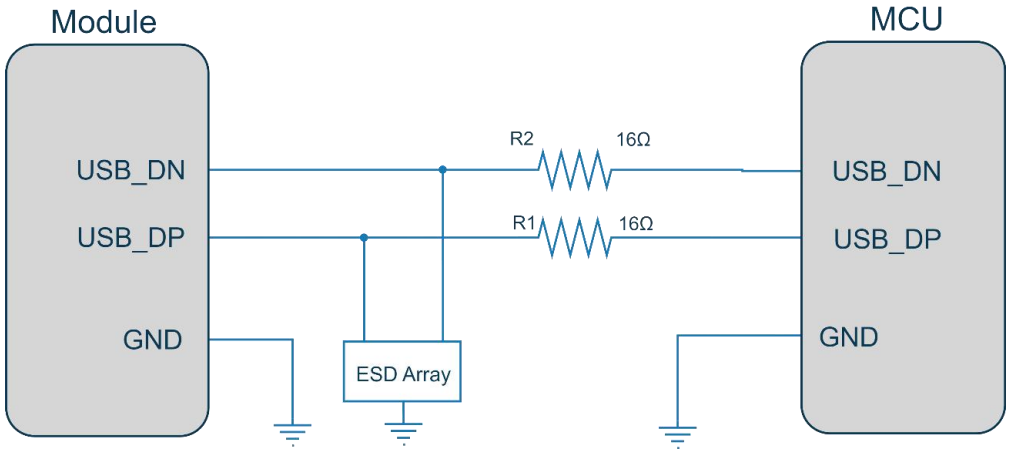


Figure 7 USB connection design circuit diagram

NOTE

- ✓ Required a resistance of 16R for R1/R2.
- ✓ 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 C16QS module provides three sets of UART interfaces. Main serial port and Auxiliary serial ports, serial port level is 1.8V.

3.6.1 UART0 Serial Port

The pins 27 and 28 of the module are UART0 serial port pins. UART0 serial interface can only be used as the debug UART of the module. The pins are defined as follows：

Table 3.10 UART0 serial port pin definition

Pin No.	Signal name	I/O	Description	Voltage		
				V_min	V_typical	V_max
27	UART0_TXD	DO	UART 0 Data transmission	1.75	1.8	1.85
28	UART0_RXD	DI	UART 0 Data reception	1.75	1.8	1.85

NOTE

✓ It is always advisable to have a test point for this UART in your design for debugging purposes.

3.6.2 UART1 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 to 600,1200,2400,4800, 9600, 19200, 38400, 57600, 115200, 230400, 460800,921600,1152000, 3000000 bps.

The default baud rate is 115200 bps and maximum baud rate is 3000000 bps

The UART interface is defined as follows：

Table 3.11 UART1 serial port signal definition

No.	Name	I/O	Description	Voltage		
				V_min	V_Typical	V_max
39	UART1_RI	AIO	UART 1 Ringing indication	1.75	1.8	1.85
38	UART1_DCD	DI	UART 1 Data carrier detect	1.75	1.8	1.85
36	UART1_CTS	DO	UART 1 Clear to send	1.75	1.8	1.85
37	UART1_RTS	DI	UART 1 request to send	1.75	1.8	1.85
30	UART1_DTR	DO	UART 1 Data terminal ready	1.75	1.8	1.85
35	UART1_TXD	DO	UART 1 Transmit data	1.75	1.8	1.85
34	UART1_RXD	DI	UART 1 Receive data	1.75	1.8	1.85

3.6.3 UART2 Serial Port

The pins 22 and 23 of the module are UART2 serial port pins. This UART is used to obtain the GNSS NMEA data. The pins are defined as follows:

Table 3.12 UART2 serial port pin definition

Pin No.	Signal name	I/O	Description	Voltage		
				V_min	V_Typical	V_max
22	UART2_RXD	DI	UART 2 Data transmission	1.75	1.8	1.85
23	UART2_TXD	DO	UART 2 Data reception	1.75	1.8	1.85

NOTE

- ✓ UART2 and GNSS UART are internally connected so while using GNSS ensure that UART 2 is kept as floating and vice versa.

3.6.4 Serial Port Application Circuit

- The serial level is 1.8V.
- The module's serial port baud rate can be set to 600 to 3000000bps baud rate and the default is 115200bps.
- The UART1 serial port can realize
  - ✓ AT interactive instructions
  - ✓ Print program log information
  - ✓ Interact with peripheral data

When users want to use the full-featured serial port, they can refer to the following connection methods

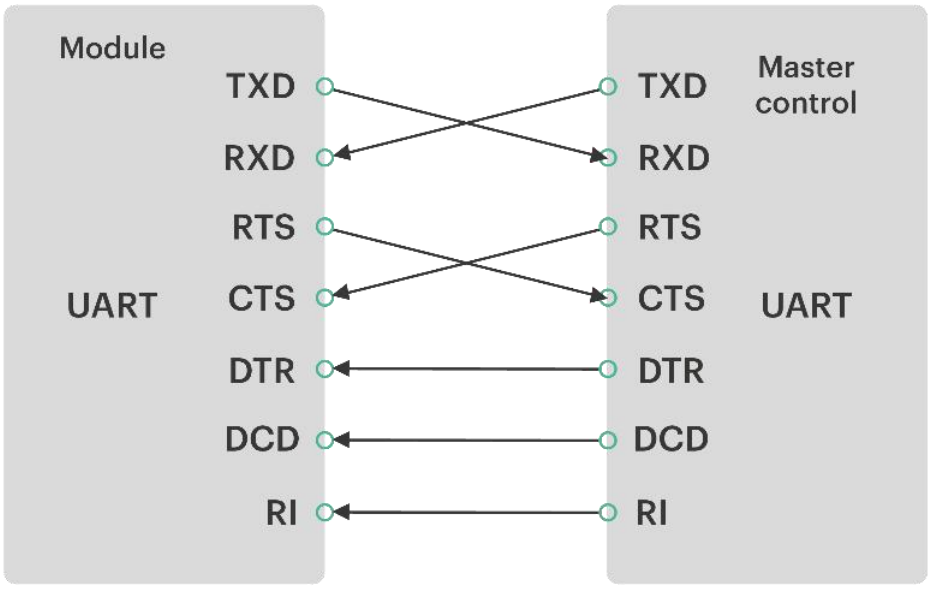


Figure 8 Full-featured serial port design

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

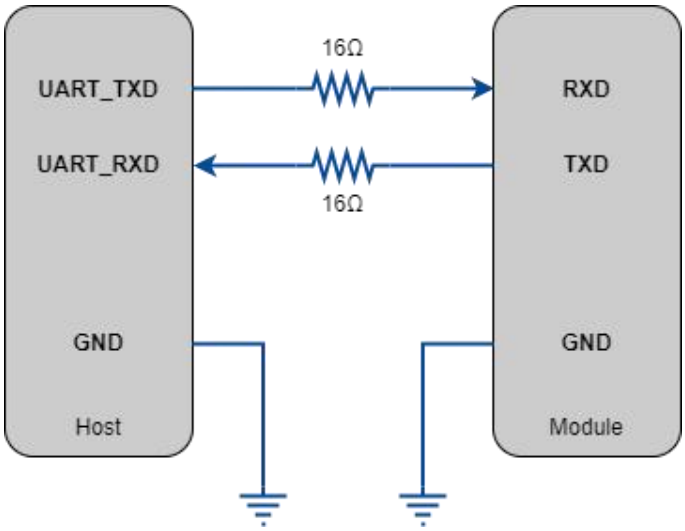


Figure 9 UART serial port design

The serial port of the module is TTL 1.8V level. If the serial port needs to be connected to the MCU of 3.3V level, it is necessary to add a level conversion chip externally to achieve level matching. Use an external 1.8V power source for VCCA. For the chip connection method, refer to the following circuit:

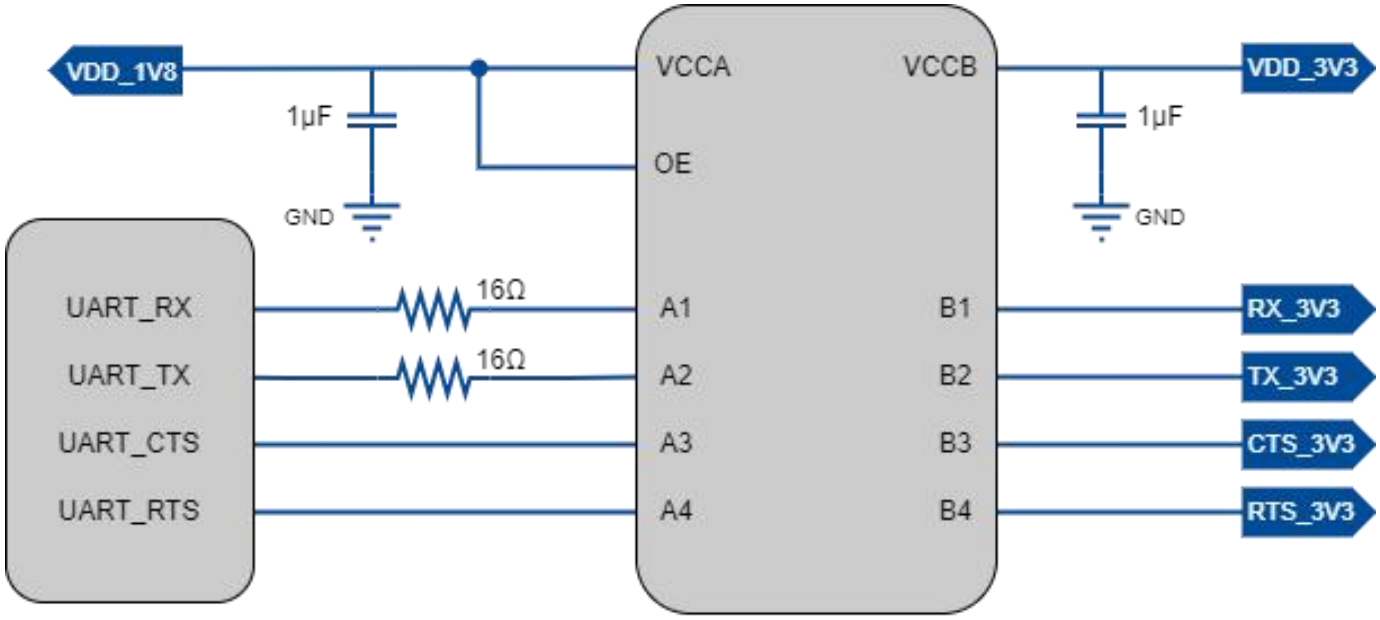


Figure 10 Level conversion chip circuit

3.7 USIM Interface

The C16QS 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/3.0V

Table 3.13 SIM card signal definition

No	Signal name	I/O	Description	Voltage		
				V_min	V_typical	V_max
42	USIM_PRESENCE	DI	SIM detect Pin	1.75/2.95	1.8/3	1.85/3.05
43	USIM_VDD	PO	External SIM power	1.75/2.95	1.8/3	1.85/3.05
45	USIM_DATA	DIO	External SIM card IO	1.75/2.95	1.8/3	1.85/3.05
46	USIM_CLK	DIO	External SIM clock	1.75/2.95	1.8/3	1.85/3.05
44	USIM_RST	DIO	External SIM card reset	1.75/2.95	1.8/3	1.85/3.05

3.7.1 USIM Card Reference Circuit

The C16QS module does not come with a USIM card slot. Users need to design a USIM card slot on their own interface board. The module supports USIM of voltages 1.8V and 2.85V.

The USIM card interface reference circuit is as follows:

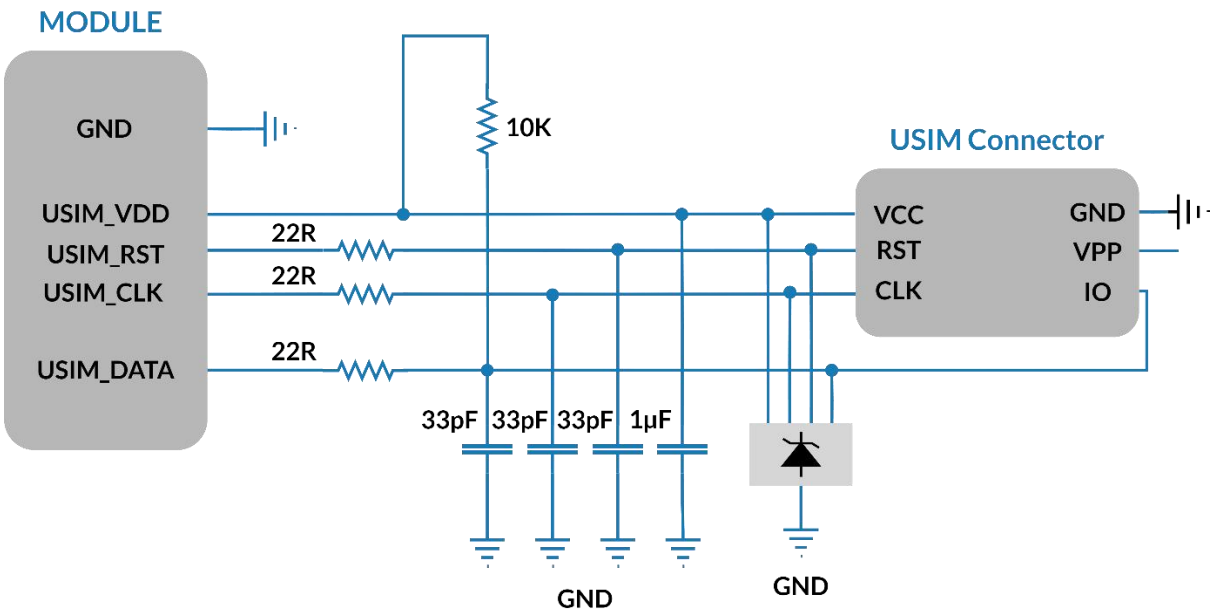


Figure 11 USIM design circuit diagram

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.
- ✓ USIM_PRESENCE is high by default. The SIM card status can be detected by this PIN during hot plug application. It is recommended to provide provision for pull-up.
- ✓ 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 C16QS module contains four general purpose control signals. The interface is defined as follows:

Table 3.14 General GPIO Pin Definitions

Pin No.	Definition	I/O	Functional description	Voltage		
				V_min	V_typical	V_max
11	GPIO1	DIO	Configurable IO	1.75	1.8	1.85
26	GPIO7	DIO	Configurable IO	1.75	1.8	1.85
25	AGPIO5	AIO	Analog configurable IO	1.9	-	2.1
64	AGPIO7	AIO	Analog configurable IO	1.9	-	2.1

NOTE

✓ Only GPIO7 is available for toggling via AT command (AT+GPSET=0/1)

3.9 Network Status Indication Interface

The C16QS module provides an open-drain GPIO signal to indicate the status of the RF communication.

3.9.1 Network Status

C16QS provides two network status indication pins: **USB_BOOT** & **NET_STATUS** (Pins **21 & 75**). These pins are used to drive a network status indication LED. Since both the pins have the same functionality, use only one and keep the other floating.

The following tables describe the pin definition and logic level changes of NETLIGHT in different network activity status.

Table 3.15 Network Indicator Pin Definition

Pin	Signal name	I/O	Description	Voltage		
				V_min	V_typical	V_max

21	NET_STATUS / USB_BOOT	DO	NET_STATUS function	1.75	1.8	1.85
75	NET_STATUS	DO	Network status indication	1.75	1.8	1.85

Table 3.16 Network Indication Status

Status	LED display status
No service	OFF
Searching for Network	Flashing
The module registers 4G network or module to register non-4G network for voice SMS and other services (Latched on to Network)	Constantly Bright

The LED network indicator reference design is as follows:

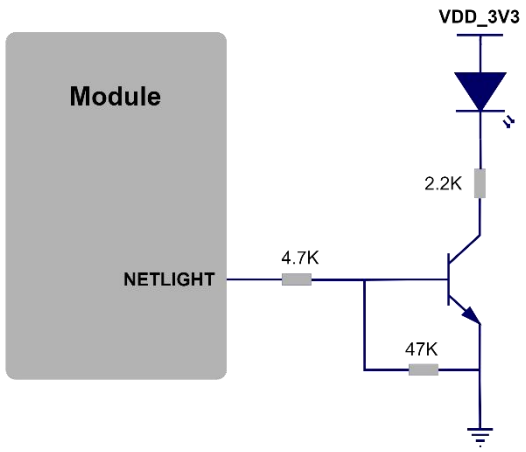


Figure 12 Net light reference circuit diagram

When the module enters flight mode, the RF function does not work and all AT commands related to RF functions will be inaccessible. This mode can be set by

- ✓ Software: **AT+CFUN=4**

Table 3.17 Network Indicator Pin Definition

Pin	Signal name	I/O	Description
19	AP_READY	DI	Wake up Interrupt
18	W_DISABLE#	DI	Put into Flight Mode

NOTE

- The brightness of the network indicator can be adjusted by adjusting the current limiting resistor, which can be adjusted to a maximum of 40 mA.
- Remember to use only one among the pins **21** and **75**. While using one, keep the other floating.

3.9.2 Module Status Indication

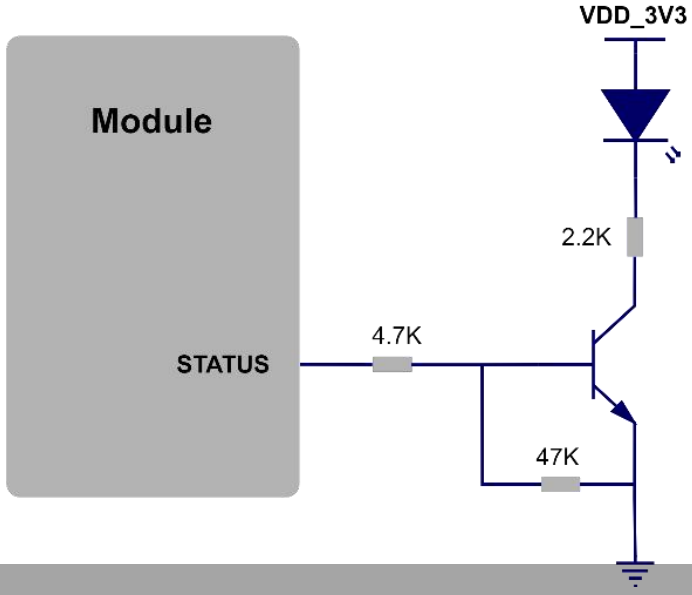
- ✓ The C16QS module provides a pin as a working status indicator for the module
- ✓ This pin can be used to connect to a GPIO or LED with pull-up
- ✓ It is used to indicate the power-on status of the module
- ✓ The drive current should be less than 0.8mA
- ✓ The STATUS pin will output a high level.

Table 3.18 Module Status Indicator Pin Definition

Pin	Signal name	I/O	Description
20	STATUS	DO	Module power on status indication

The following figure shows the STATUS reference circuit design:

Figure 13 STATUS Pin Reference Circuit



3.10 I2S Interface

C16QS module provides a set of I2S bus interface which is used for connecting digital audio devices.

Table 3.19 I2S pin definition

No	Signal name	I/O	Description	Voltage		
				V_min	V_typical	V_min
7	I2S_DOUT	DIO	I2S Data out	1.75	1.8	1.85
6	I2S_DIN	DIO	I2S Data in	1.75	1.8	1.85
5	I2S_LRCK	DIO	I2S Strobe Clock	1.75	1.8	1.85
4	I2S_MCLK	DIO	I2S Master Clock	1.75	1.8	1.85
63	I2S_BLK	DIO	I2S Bit Clock	1.75	1.8	1.85

3.11 I2C Bus

The C16QS 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 3.20 I2C pin definition

Pin No.	Signal name	I/O	Description	Voltage		
				V_min	V_Typical	V_max
40	I2C_SCL	DO	I2C Serial Clock	1.75	1.8	1.85

41	I2C_SDA	DIO	I2C Serial data	1.75	1.8	1.85

The I2C reference circuit is connected as follows:

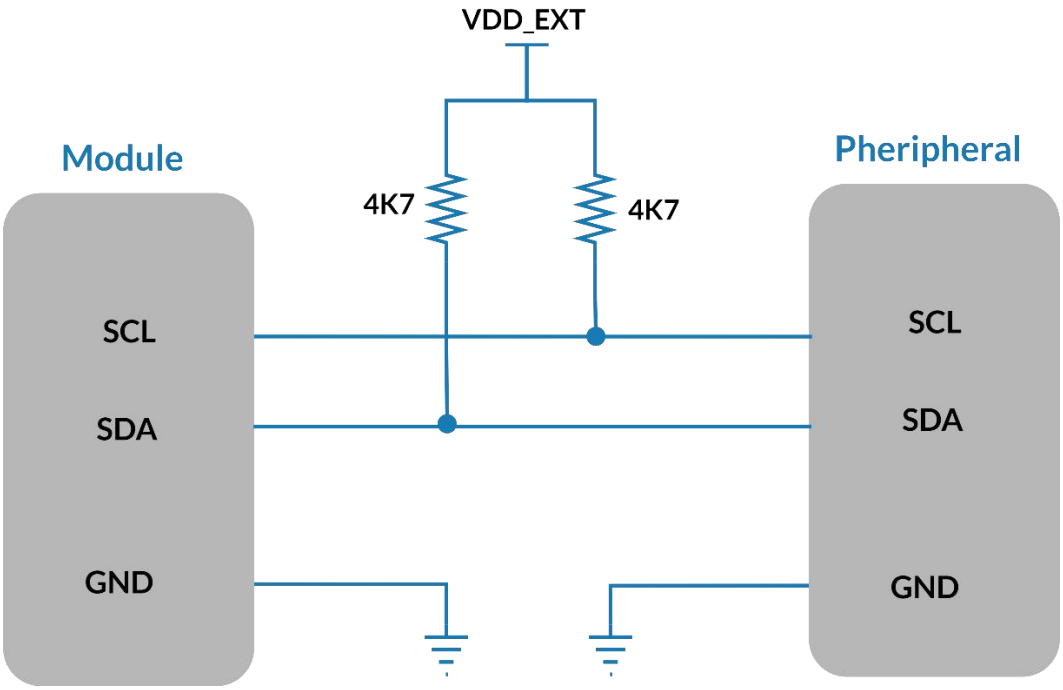


Figure 14 I2C interface reference circuit diagram

3.12 SWD Interface

C16QS module provides a 2-pin serial wire debug (SWD) interface which is an alternative to JTAG.

Pin No.	Pin name	IO	Definition	Voltage		
				V_min	V_Typical	V_max
92	SWDIO	DIO	Serial wire debug data	1.75	1.8	1.85
93	SWCLK	DIO	Serial wire debug clock	1.75	1.8	1.85

Table 3.21 SWDIO Pin Definitions

3.13 ADC Interface

The C16QS provides two analog-to-digital converter interfaces to read the voltage value.

- ✓ The ADC interface input voltage cannot exceed VBAT
- ✓ It is recommended that the ADC pin be input with a voltage divider circuit

Table 3.22 ADC Pin Definitions

Pin No.	Signal name	IO	Description	Voltage		
				V_min	V_Typical	V_max
2	ADC1	AIO	Analog to digital converter interface 1	0	-	3.4
24	ADC0	AIO	Analog to digital converter interface 0	0	-	3.4

3.14 Antenna

The C16QS module provides two antenna interfaces, one main set antenna interface, which is responsible for the CAT .1bis signals of the transceiver module, and another GNSS antenna interface.

The GNSS antenna interface is **L1.**

The impedance of the antenna interfaces are 50 ohms.

Table 3.23 Antenna interface pin definition

Pin No.	Signal Name	Description	Remarks
60	ANT_LTE	Main antenna interface	50Ω characteristic impedance
49	ANT_GNSS	GNSS L1 antenna interface	50Ω characteristic impedance

The pin 60 of the C16QS 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-ohm impedance line is taken.

Recommended circuit is shown below：

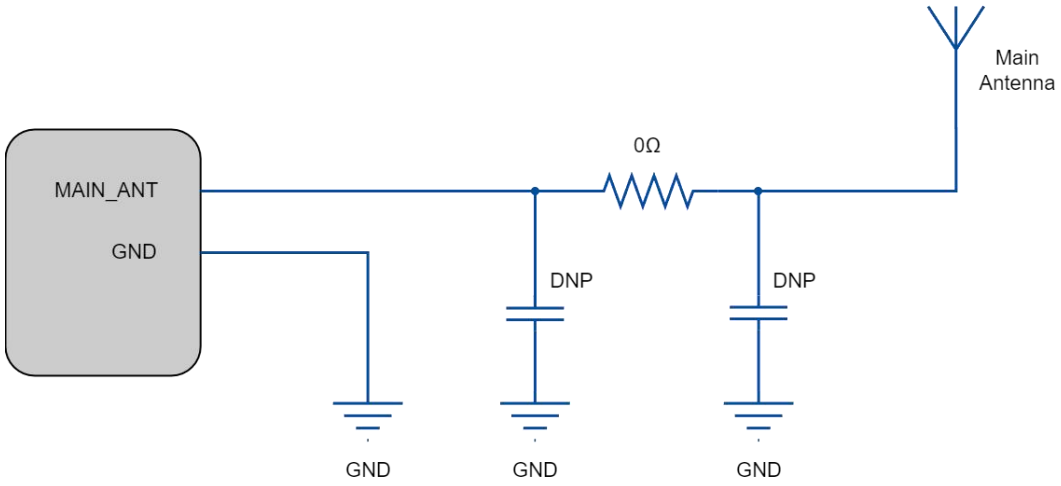


Figure 15 Main antenna matching circuit

The pin 49 of C16QS is the GNSS antenna interface.

The C16QS has a dedicated antenna **L1**, it supports GPS and BEIDOU.

In order to facilitate antenna debugging, a **π**-type matching circuit needs to be added to the motherboard and a 50-ohm impedance line is used.

NOTE

- ✓ The GNSS antenna needs to maintain a certain distance from the main antenna.
- ✓ The GNSS antenna has two antenna connection modes:
- ✓ Passive antenna mode and Active antenna mode.
- ✓ An external power supply is required while using an Active antenna, as the module cannot provide power to GNSS Active antenna.

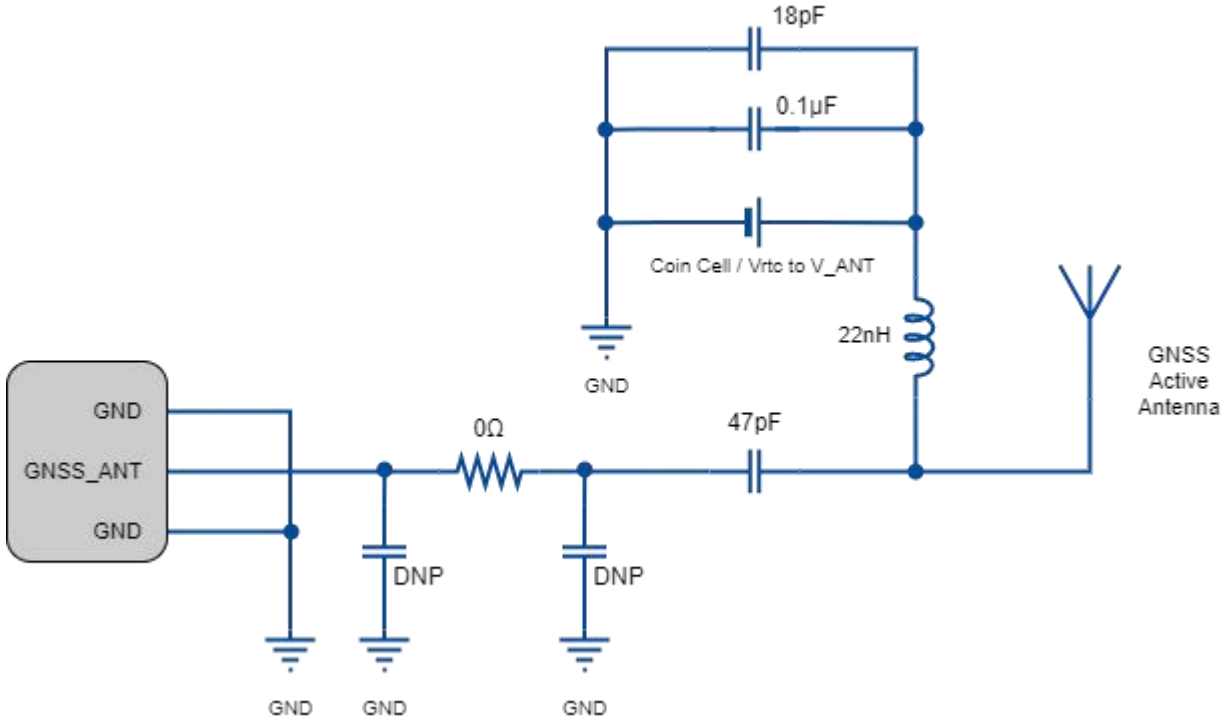


Figure 16 GNSS active antenna matching circuit

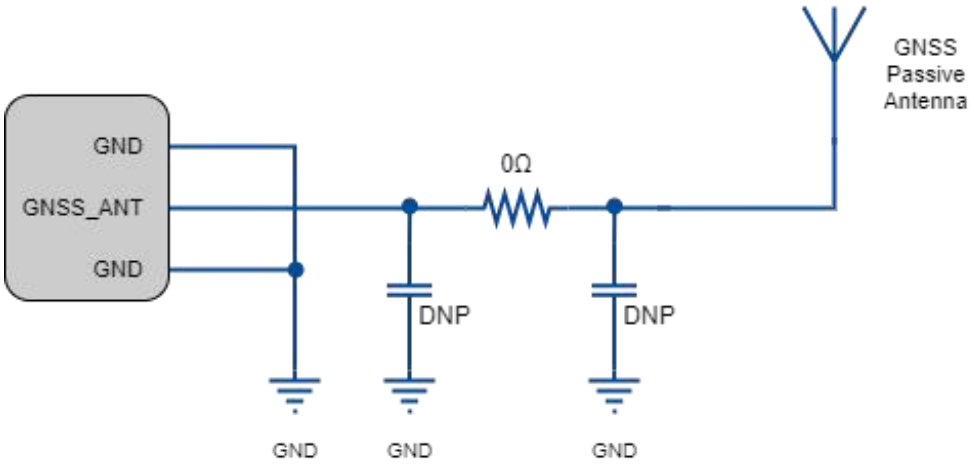


Figure 17 GNSS passive antenna matching circuit

NOTE

- ✓ An external LDO can be selected to supply power according to the active antenna requirement.
- ✓ If the module is designed with a passive antenna, then the VDD circuit is not needed.
- ✓ 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.

3.14.1 RF Trace Reference

The main set of the C16QS 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.

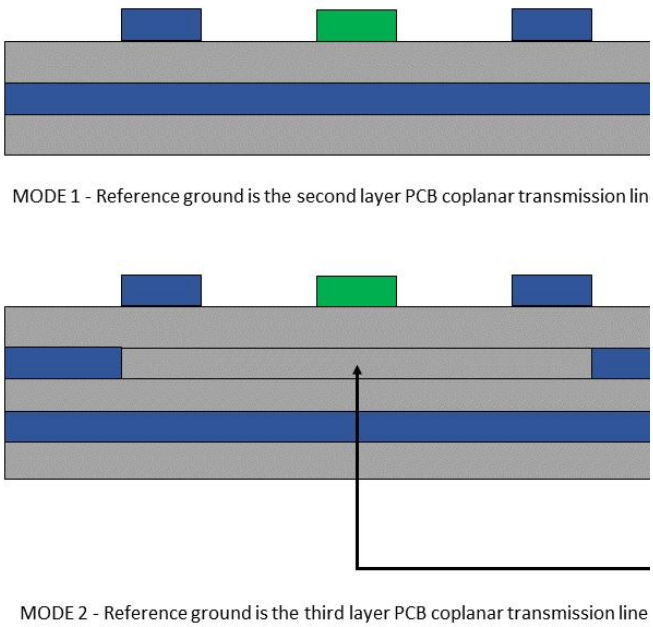


Figure 18 Coplanar antenna

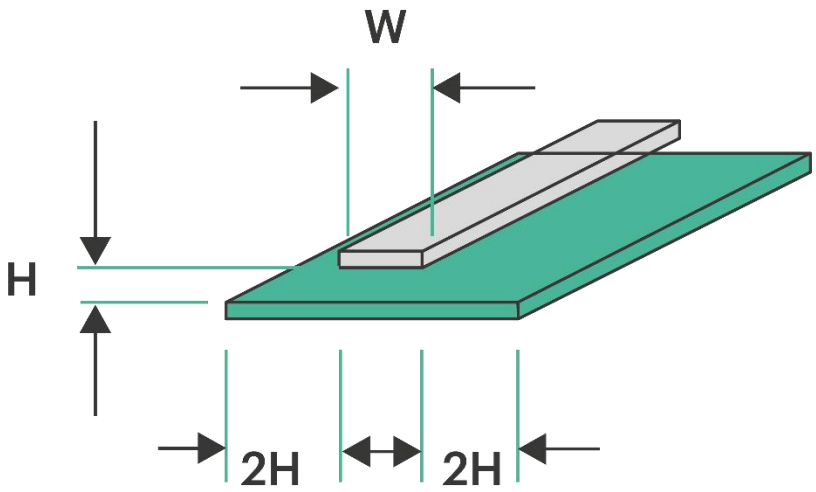


Figure 19 The complete structure of the two-layer PCB microstrip line

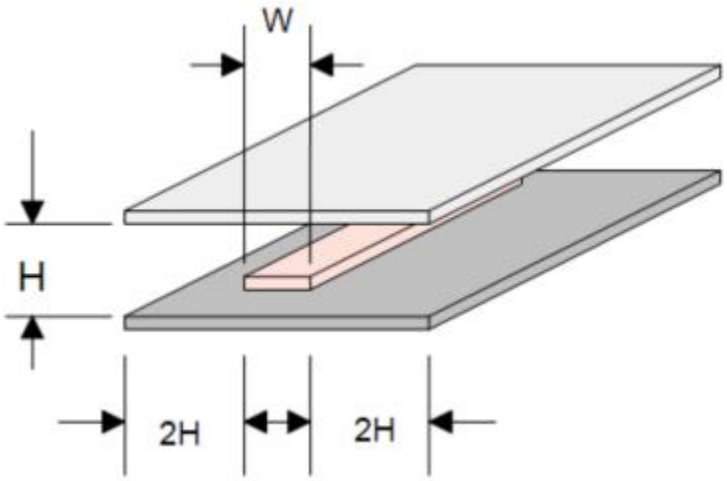


Figure 20 The complete structure of the multilayer PCB strip line

NOTE

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

3.14.2 RF Connector Size

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

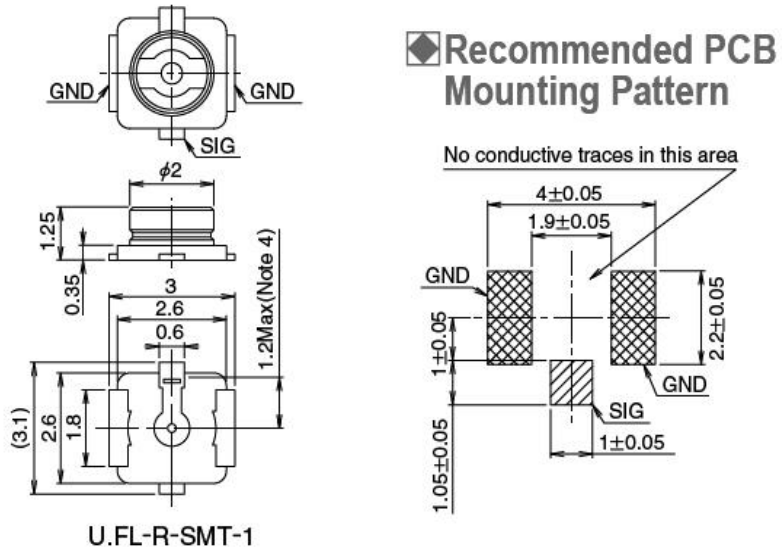


Figure 21 RF connector size chart

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

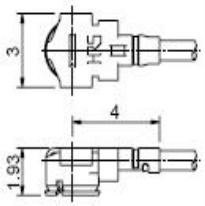
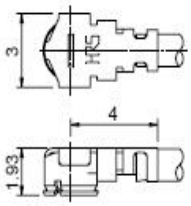
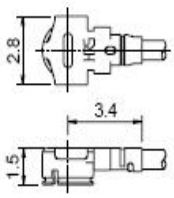
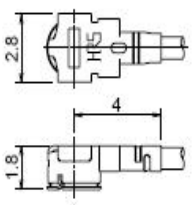
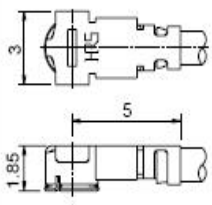
Part No.	U.FL-LP-040	U.FL-LP-066	U.FL-LP(V)-040	U.FL-LP-062	U.FL-LP-088
					
Mated Height	2.5mm Max. (2.4mm Nom.)	2.5mm Max. (2.4mm Nom.)	2.0mm Max. (1.9mm Nom.)	2.4mm Max. (2.3mm Nom.)	2.4mm Max. (2.3mm Nom.)
Applicable cable	Dia. 0.81mm Coaxial cable	Dia. 1.13mm and Dia. 1.32mm Coaxial cable	Dia. 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 22 Antenna connector matching plug diagram

Table 3.24 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

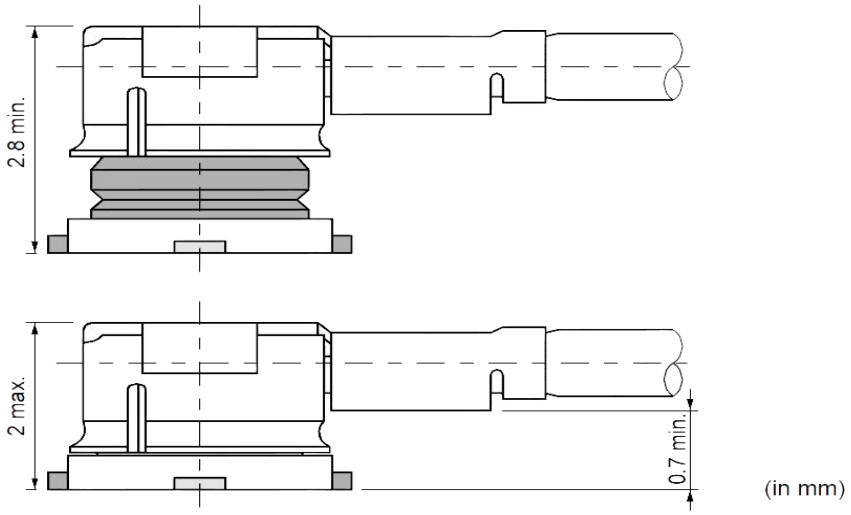


Figure 23 Matching coaxial RF line size

3.15 Control Interface

Table 3.25 Control interface pin definition

Pin No.	Signal name	I/O	Description
20	STATUS	DO	Module power on status indication
18	W_DISABLE#	DI	Put into Flight Mode

STATUS:

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

FLIGHT_MODE:

This pin is used to put the module into Flight mode and disable the RF transmission.

3.16 GNSS Interface

Multi – GNSS receiver:

- ✓ **L1** multi-band GNSS receiver
- ✓ Multi-Constellation GPS/Bei Dou
- ✓ 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

Table 3.26 GNSS interface pin definition

Pin No.	Signal name	I/O	Description	Voltage		
				V_min	V_Typical	V_max
49	ANT_GNSS	-	GNSS Antenna interface	-	-	-
99	GNSS_1PPS	DO	1PPS indicator	1.75	1.8	1.85
84	GNSS_TXD	DO	GNSS UART Transmission	1.75	1.8	1.85
85	GNSS_VDD_3V3	PI	GNSS Power supply	3.25	3.3	3.35
86	GNSS_EN	DI	Hardware enables for GNSS	1.2	1.8	1.89
83	GNSS_RXD	DI	GNSS UART Reception	1.75	1.8	1.85
98	GNSS_VRTC_1V8	PI	GNSS RTC Power Supply	1.2	1.8	1.89

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.

GNSS interface

GNNSS_TXD and GNSS_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.

Figure 24 GNSS VRTC Input

NOTE

- The recommended voltage rating of GNSS_VDD is 3.3 V.
- To enable GNSS, the voltage level of GNSS_EN should not go below 1.2V and should not exceed 1.89V.
- UART2 and GNSS UART are internally connected so while using GNSS ensure that UART 2 is kept as floating and vice versa.
- When GNSS is operating in independent mode, only GNSS_VDD needs to be supplied; VBAT is not required.
- As VBATT_RF powers the entire RF of LTE and GNSS. GNSS_VDD can power entire GNSS section
- Please refer the *C16QS GNSS Application note* for further information.

3.17 SPI Interface

Table 3.27 SPI interface pin definition

Pin No.	Signal name	I/O	Description	Voltage		
				V_min	V_Typical	V_max
97	SPI_CS	DO	Slave select	1.75	1.8	1.85
95	SPI_MOSI	DO	Master output slave input	1.75	1.8	1.85
94	SPI_MISO	DI	Master input slave output	1.75	1.8	1.85
96	SPI_CLK	DO	Serial Clock	1.75	1.8	1.85

4 Overall Technical Indicators

4.1 Chapter Overview

The C16QS 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 B7	2500MHz – 2570MHz	2620MHz – 2690MHz	FDD
LTE B8	880MHz–915MHz	925MHz–960MHz	FDD
LTE B12	699MHz - 716 MHz	729 MHz - 746 MHz	FDD
LTE B13	777MHz – 787MHz	746MHz – 756MHz	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	1930MHz – 1995 MHz	FDD

LTE B26	814 MHz - 849 MHz	859 MHz - 894 MHz	FDD
LTE B28	703 MHz - 748 MHz	758 MHz - 803 MHz	FDD
LTE B40	2300 MHz - 2400 MHz	2300 MHz - 2400 MHz	TDD
LTE B41	2496 MHz - 2690 MHz	2500 MHz - 2690 MHz	TDD
LTE B66	1710 MHz - 1780 MHz	2110 MHz - 2200 MHz	FDD

4.3 GNSS Performances

C16QS Module GNSS performance parameters:

Table 4.2 GNSS performance parameters

Features	Description
Receiving Bands	✓ GPS L1: 1575.42 MHz ✓ BD2 B1 C/A: 1561.098 MHz
Horizontal Positioning Accuracy:	< 2.0 m CEP50
Vertical Positioning accuracy	< 3.0 m CEP50
Velocity Accuracy:	Without Aid: < 0.01 m/s
TTFF@-130dBm	✓ Cold Start < 28s ✓ Hot Start ≤ 1s ✓ Reacquisition ≤ 1 s
Sensitivity:	✓ Cold Start: -147 dBm ✓ Tracking: -160 dBm ✓ Hot Start: -155 dBm ✓ Reacquisition: -158 dBm

4.4 Antenna Requirements

C16QS 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
B7 FDD	<2:1	〉-2.5dbi	〉40%	>16.5	<-88
B8 FDD	<2:1	〉-2.5dbi	〉40%	>16.5	<-88
B12 FDD	<2:1	〉-2.5dbi	〉40%	>16.5	<-88
B13 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
B28 FDD	<2:1	〉-2.5dbi	〉40%	>16.5	<-88
B40TDD	<2:1	〉-2.5dbi	〉40%	>16.5	<-88
B41 TDD	<2:1	〉-2.5dbi	〉40%	>16.5	<-88

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 C16QS module working storage temperature

Parameter	Minimum	Maximum
Normal operating temperature	-30°C	85°C
Storage temperature	-45°C	90°C

5.3 Electrostatic Property

There is no overvoltage protection inside the C16QS 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 C16QS 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 Module IO Level

The C16QS module IO levels are as follows:

Table 5.3 Electrical Characteristics of C16QS module

Parameter	Description	Minimum	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

5.5 Power Supply

The C16QS module input power requirements are as follows:

Table 5.4 C16QS module Operating Voltage

Parameter	Minimum value	Typical value	Maximum value

Input Voltage	3.1V	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.

5.6 Power Consumption Characteristics

Table 5.5 LTE power consumption

Mode	Type/band	Rx CINR @ 80dBm (dB)	Sensitivity (dBm)	Current consumption @ 23dBm and @3.7 V			
				Tx-Idle USB - connected	Tx Idle USB - Disconnected	Peak Tx @ Centre frequency	Unit
CAT 1.bis (GNSS off)	Band 1	15	-98	34	5.1	523	mA
	Band 2	15	-96	34.1	5	502	mA
	Band 3	14	-99	34.2	5.1	503	mA
	Band 4	14	-97	34.1	4.8	509	mA
	Band 5	16	-95	34	4.7	453	mA
	Band 7	TBD	TBD	TBD	TBD	TBD	mA
	Band 8	15	-96	34.2	4.8	418	mA
	Band 12	15	-96	34.3	4.8	440	mA
	Band 18	16	-98	34.2	4.8	452	mA
	Band 19	16	-98	34.2	4.7	453	mA
	Band 20	15	-96	33.9	4.6	460	mA
	Band 25	13	-96	34.2	4.7	486	mA
	Band 26	16	-97	34.1	4.7	457	mA
	Band 28	15	-97	33.9	4.6	410	mA
	Band 40	14	-98	34.2	4.6	210	mA

	Band 41	13	-98	34.1	4.7	299	mA
	Band 66	13	-98	34	4.9	532	mA
GNSS	Powering			50			mA
	Tracking			60			mA
	Fix			60			mA
GNSS off & CFUN=0				4			mA
Sleep 1				56			µA
Sleep 2				25			µA
Hibernate				11			µA
Shutdown				1			µA
Module Peak				650.88			mA

6 Structural and Mechanical Properties

6.1 Chapter Overview

- ✓ Module structural image
- ✓ Module mechanical size

6.2 Module Structural Image

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

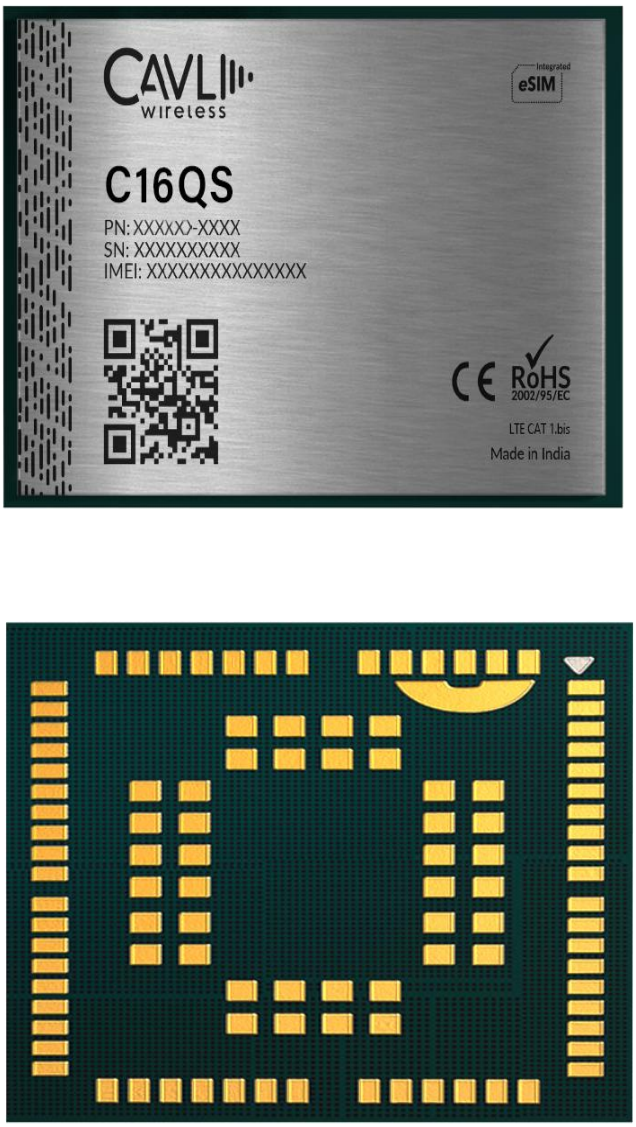


Figure 25 Top view and bottom view of the module

6.2 C16QS Module Mechanical Size

The figure below shows the bottom view size of the module:

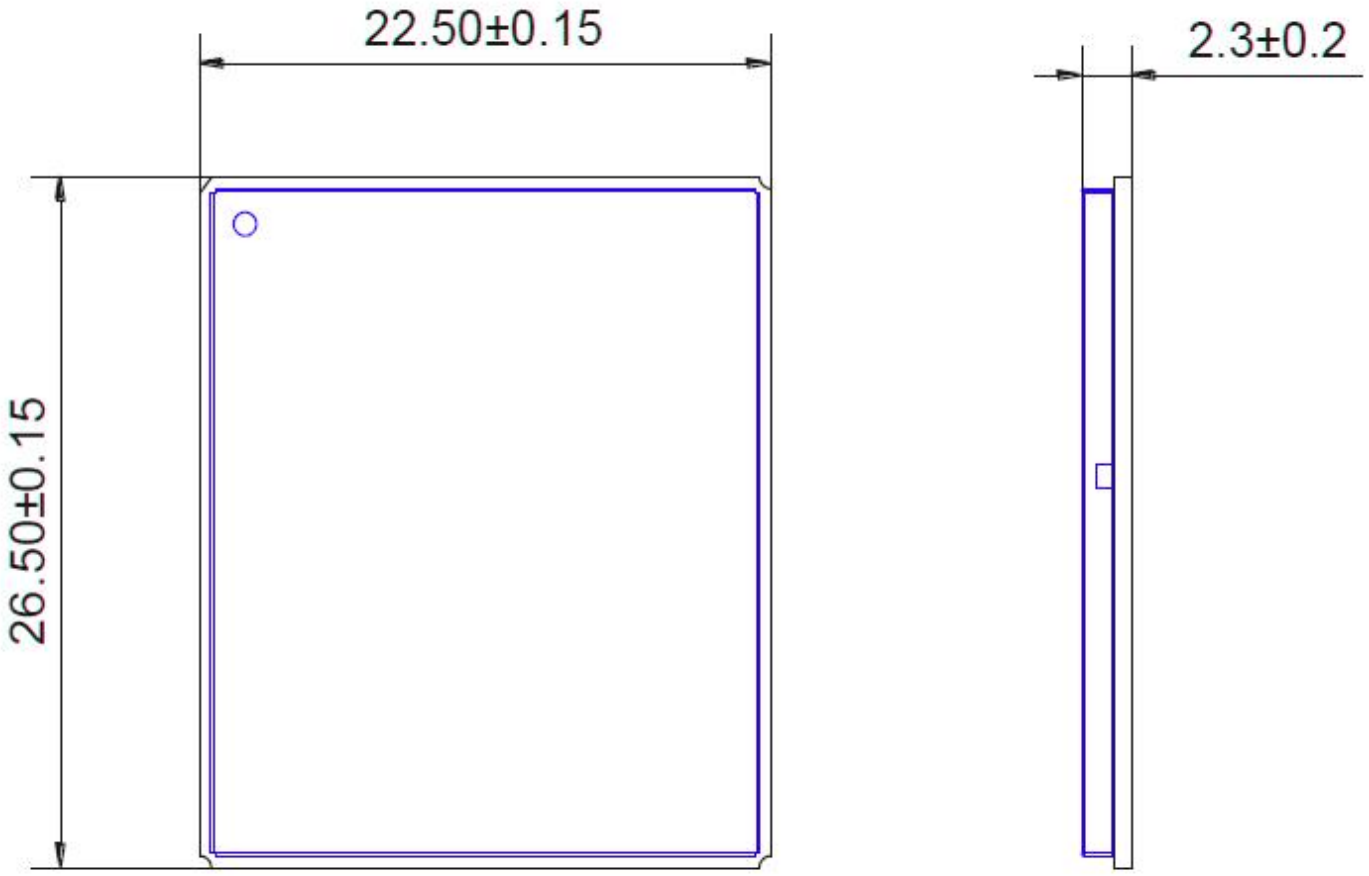


Figure 26 Front view and side view of the module (unit: mm)

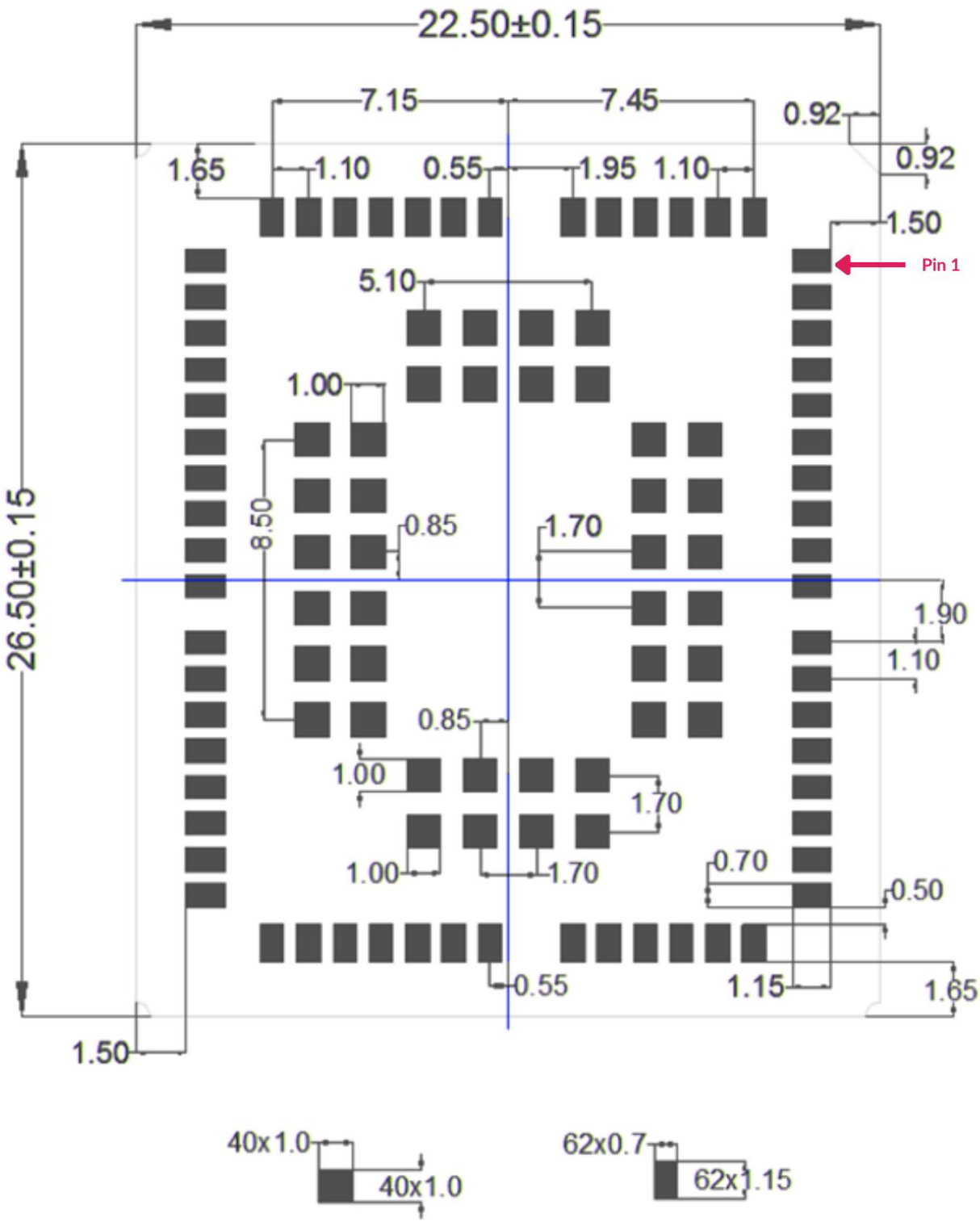


Figure 27 Bottom view of the module (unit: mm)

Module recommended footprint:

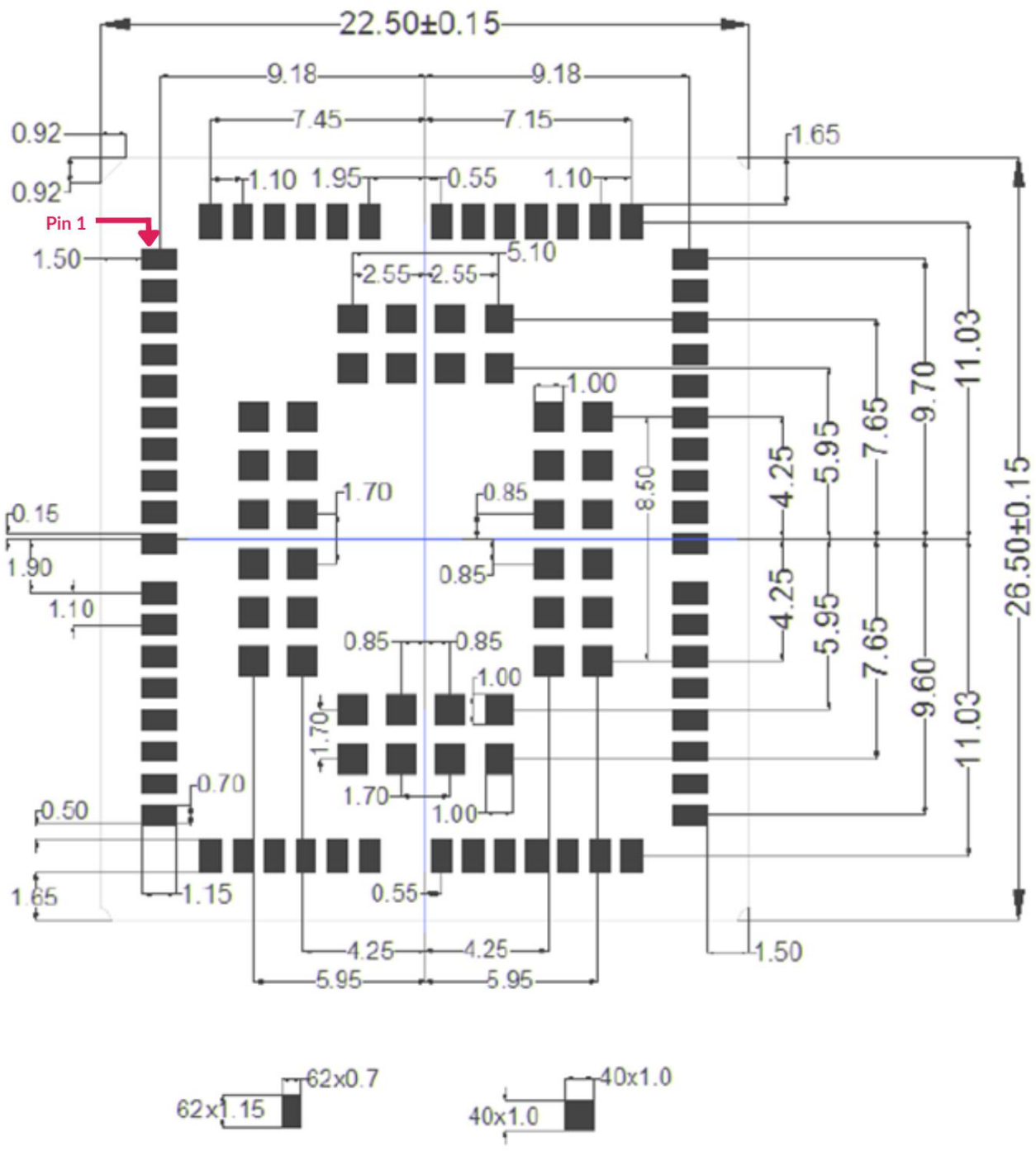


Figure 28 Recommended Footprint (Top View) (unit: mm)

7 Ordering Information

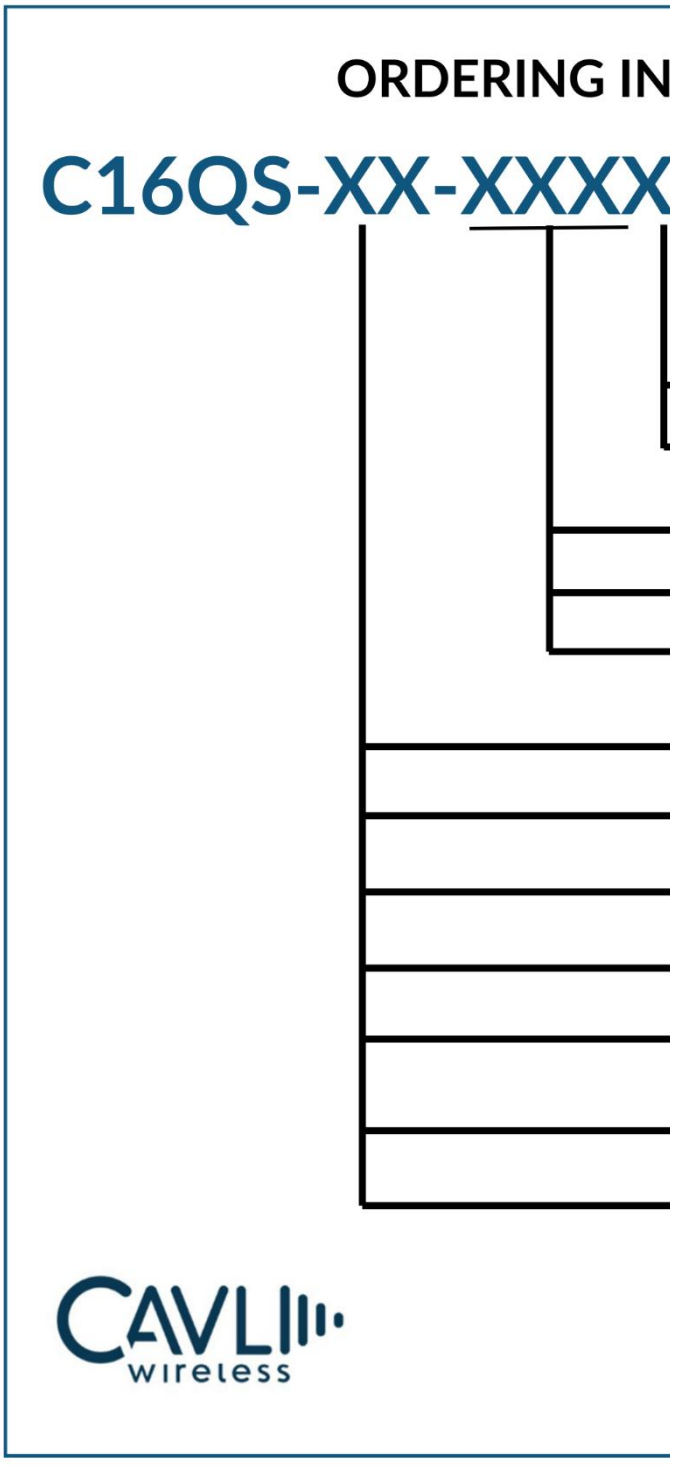


Figure 29 Ordering Information

Table 7.1 Ordering Information

Part Number	Package Type	Tape width	Tolerance	SPQ
C16QS-EA-S00N	Tape & Reel	44mm	0.2 mm	500
C16QS-EA-S00H	Tape & Reel	44mm	0.2 mm	500
C16QS-EA-GNAN	Tape & Reel	44mm	0.2 mm	500
C16QS-EA-GNAH	Tape & Reel	44mm	0.2 mm	500
C16QS-NA-S00N	Tape & Reel	44mm	0.2 mm	500
C16QS-NA-S00H	Tape & Reel	44mm	0.2 mm	500
C16QS-NA-GNAN	Tape & Reel	44mm	0.2 mm	500
C16QS-NA-GNAH	Tape & Reel	44mm	0.2 mm	500
C16QS-AN-S00N	Tape & Reel	44mm	0.2 mm	500
C16QS-AN-S00H	Tape & Reel	44mm	0.2 mm	500
C16QS-AN-GNAN	Tape & Reel	44mm	0.2 mm	500
C16QS-AN-GNAH	Tape & Reel	44mm	0.2 mm	500
C16QS-LA-S00N	Tape & Reel	44mm	0.2 mm	500
C16QS-LA-S00H	Tape & Reel	44mm	0.2 mm	500
C16QS-LA-GNAN	Tape & Reel	44mm	0.2 mm	500
C16QS-LA-GNAH	Tape & Reel	44mm	0.2 mm	500
C16QS-WW-S00N	Tape & Reel	44mm	0.2 mm	500
C16QS-WW-S00H	Tape & Reel	44mm	0.2 mm	500
C16QS-WW-GNAN	Tape & Reel	44mm	0.2 mm	500
C16QS-WW-GNAH	Tape & Reel	44mm	0.2 mm	500
C16QS-WW-GNBN	Tape & Reel	44mm	0.2 mm	500
C16QS-WW-GNBH	Tape & Reel	44mm	0.2 mm	500
C16QS-EU-S00N	Tape & Reel	44mm	0.2 mm	500

C16QS-EU-S00H	Tape & Reel	44mm	0.2 mm	500
C16QS-EU-GNAN	Tape & Reel	44mm	0.2 mm	500
C16QS-EU-GNAH	Tape & Reel	44mm	0.2 mm	500
C16QS-IN-S00N	Tape & Reel	44mm	0.2 mm	500
C16QS-IN-S00H	Tape & Reel	44mm	0.2 mm	500
C16QS-IN-GNAN	Tape & Reel	44mm	0.2 mm	500
C16QS-IN-GNAH	Tape & Reel	44mm	0.2 mm	500

8 Packaging and Production

8.1 Chapter Overview

- ✓ Module packaging and storage
- ✓ Production welding

8.2 Module Packaging and Storage

The C16QS module is packaged in a tape reel with 500 pcs per reel, shipped as a tape reel sealed bag.

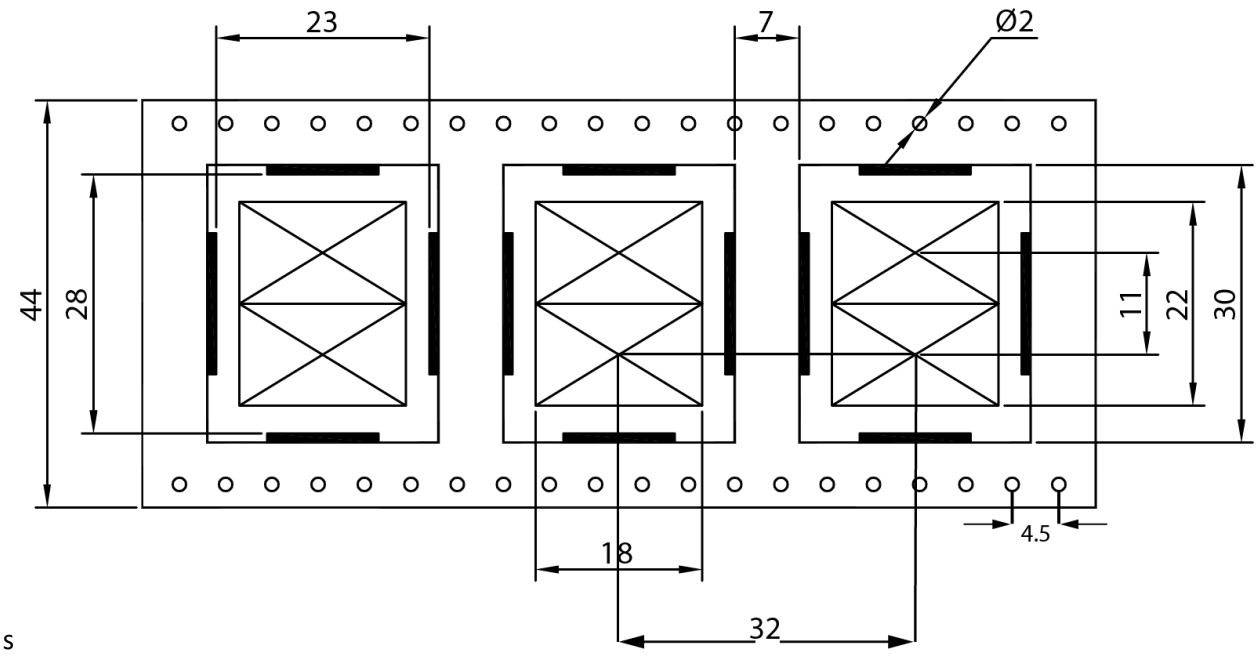


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Figure 30 C16QS Tape Measurements (in mm)

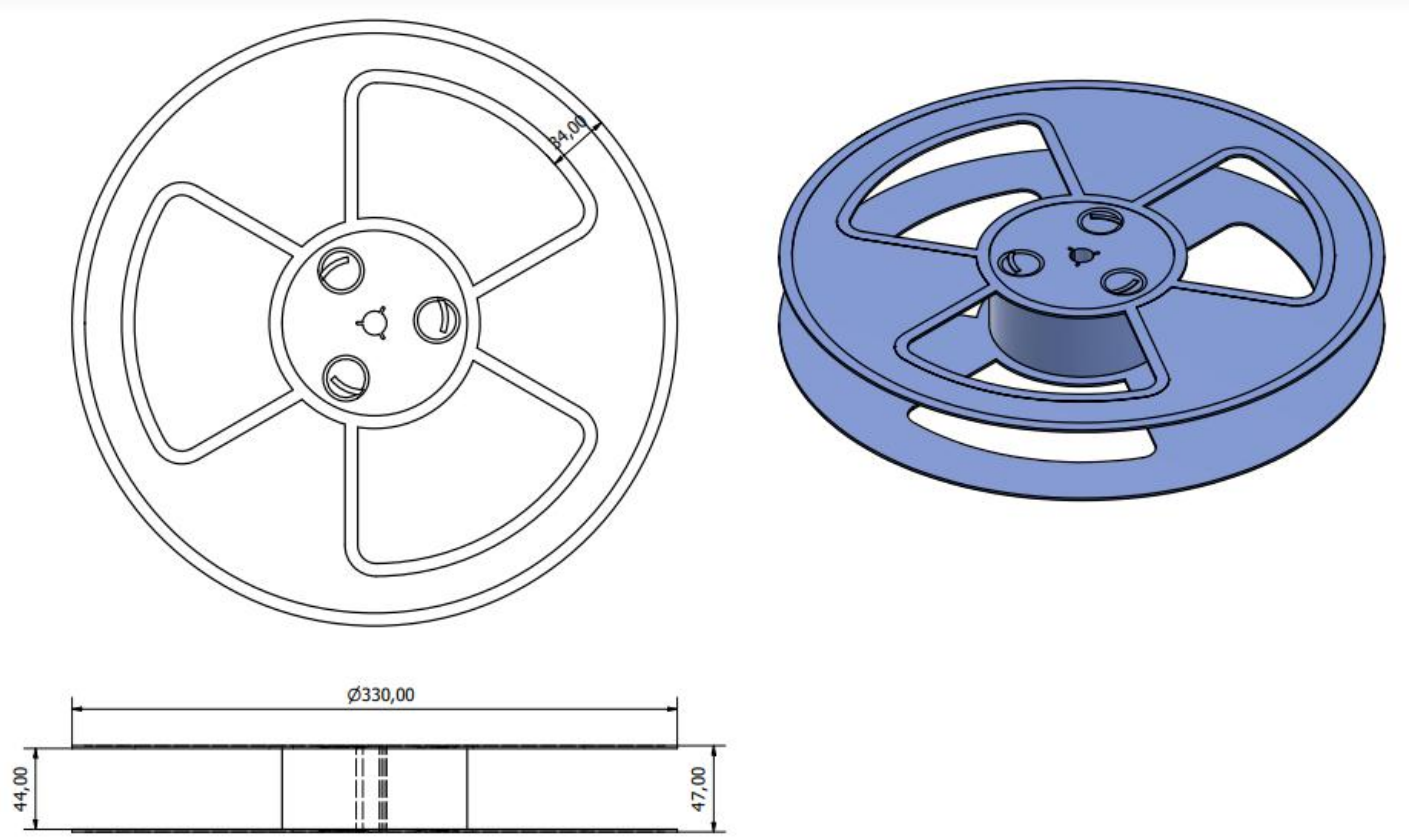

Figure 31 Reel Dimensions of C16QS (in mm)

The storage of the C16QS 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 C16QS 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 C16QSmodule 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:

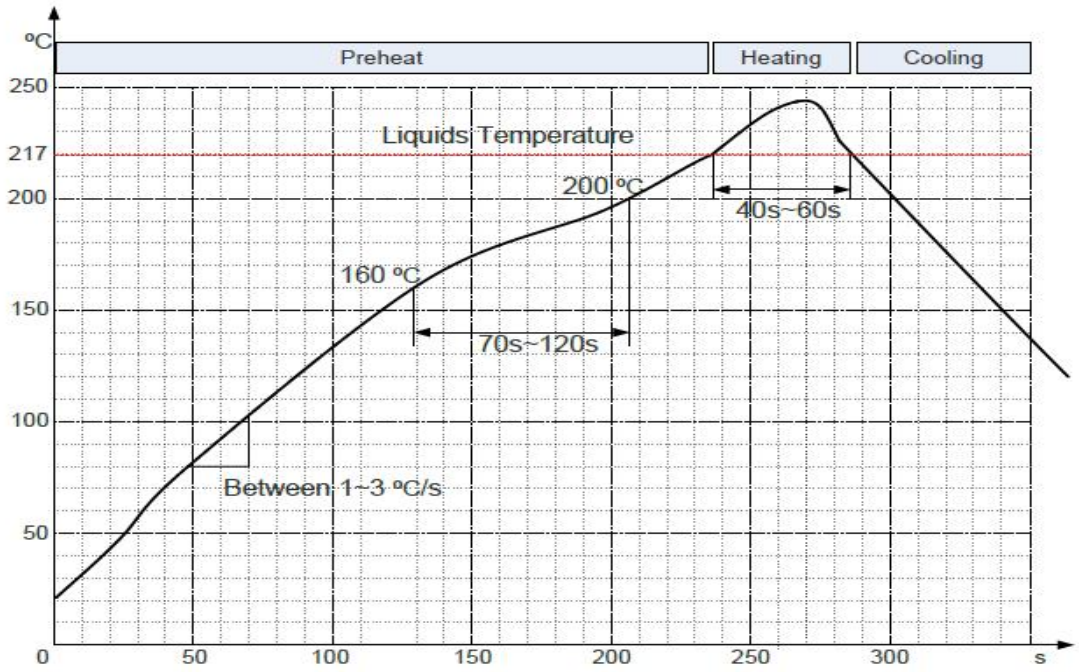

Figure 32 Reflow soldering temperature graph

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 Warnings

9.1 CE EU Conformity Statement

HEREBY, CAVLI INC DECLARES THAT THE EQUIPMENT TYPE LTE MODEM, MODELS C16QS-EA AND C16QS-AN ARE IN COMPLIANCE WITH DIRECTIVE 2014/53/EU

MANUFACTURER ADDRESS: 99 SOUTH ALMADEN BLVD., SUITE 600, SAN JOSE, CA 95113 UNITED STATES.

THE FULL TEXT OF THE EU DECLARATION OF CONFORMITY IS AVAILABLE AT THE FOLLOWING INTERNET ADDRESS:

https://www.cavliwireless.com/c-series/c16qs.html

9.2 NCC Caution

減少電磁波影響，請妥適使用

9.3 FCC Warnings

9.3.1 FCC Modular Approval Information

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.

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 a 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 : 2BB64C16QSWW”.

10 Appendix

10.1 Chapter Overview

- ✓ Abbreviations
- ✓ Safety and precautions

10.2 Abbreviations

Table 10.1 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.