Re-imagining Cellular IoT Solutions

Cavli CQ16
LTE Cat 1 bis Module

Hardware Manual

External Release Version 1.2

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Table of Contents

Table of Figures

VERSION HISTORY

Version	Edit	Date (DD/MM/YYY)
1.0	• Initial Version	28/11/2024
1.1	• Removed GRFC Pins	23/01/2025
1.2	• Updated Pin Layout and Assignment Details • Added power consumption characteristics	25/04/2025

1 Introduction

This document is the **Hardware Manual** of the Cavli Wireless solution product **CQ16 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

This hardware manual provides detailed information on CQ16, a series of advanced LTE Cat 1bis modules designed specifically for space constrained IoT applications. These modules offer a cost-effective and power-efficient solution, making them ideal for OEMs transitioning from legacy 2G and 3G technologies to LTE.

Key features of the CQ16 series include:

- 3GPP Rel 14 Cat 1bis Compliance: Ensures compatibility with the latest LTE standards and offers near Cat 1 speed.
- Enhanced Power Saving Modes: Optimizes battery life for extended device operation using PSM modes like Sleep, Hibernate and eDRx.
- Global Connectivity: Supports various regions and countries through different variants.
- Cloud-Based Management: Enables seamless global deployment and management via Cavli Hubble.

This manual will guide you through the hardware specifications, pinouts, interface details, and best practices for integrating the CQ16 module into your IoT devices. By understanding the intricacies of this powerful module, you can effectively leverage its capabilities to create innovative and reliable IoT solutions.

NOTE

- **EU** - Europe
- **I.N** - India
- **NA** - North America
- **AN** - Australia & New Zealand

2.2 Module Characteristics

Table 2.1 Key Features

Characteristics		Description
Physical Characteristics		17.7 x 15.8 x 2.5 mm,1.53 ± .01 g
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
	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 ✓ 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	✓ NET_STATUS network status indication ✓ STATUS Module status
	GPIO	✓ 3 GPIO Interfaces
	SPI	✓ Standard SPI interface
	SWD	✓ Standard SWD interface (2 Lines)

Frequency Band	**LTE BANDS:** EU: 1/ 3/ 7/ 8/ 20/ 28 IN: 1/ 3/ 5/ 8/ 40/ 41 NA: 2/ 4/ 5/ 12/ 13/ 25/ 66 AN: 1/ 3/ 5/ 8/ 18/ 19/ 26/ 28
Data Network	✓ FDD/TDD LTE CAT 1bis ✓ Peak DL 10Mbps/ UL 5Mbps (CAT 1bis)
AT Command	✓ Support for standard AT instruction sets (Hayes 3GPP TS 27.007 and 27.005) ✓ Specific AT Query CQ16 AT command set
Network Protocol	**TCP(S)/HTTP(S)/MQTT(S)/UDP/PPP** TLS versions supported as well
Antenna Interface	✓ MAIN x 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%

2.3 Module Function

CQ16 Module mainly consists of the following circuit units:

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

The functional block diagram of the CQ16 module is shown below：

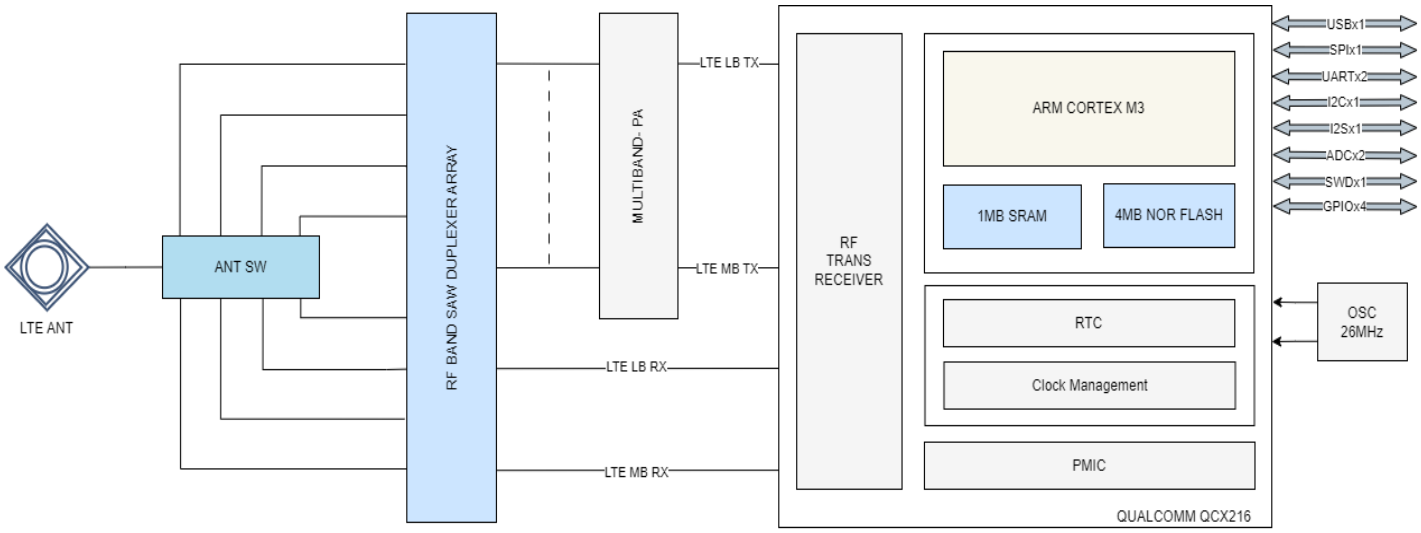


Figure 1: CQ16 Functional Block Diagram

2.4 Module Working Mode

Table 1.2 work 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

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
- SPI Interface

3.2 Module Interface

3.2.1 CQ16 Pin Layout

CQ16 pins are assigned as follows：

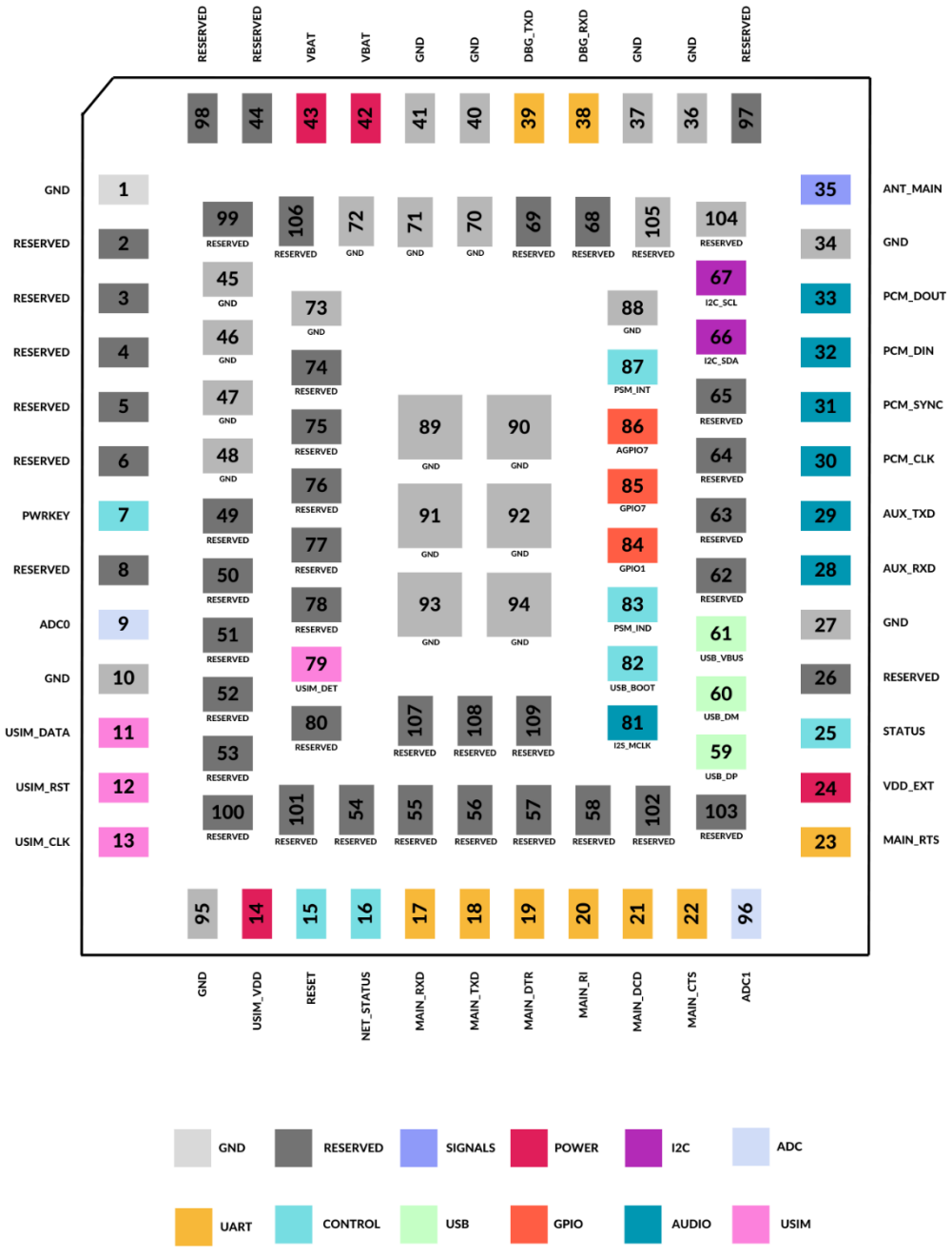


Figure 2: CQ16 module Interface definition (top view)

3.2.2 CQ16 Pin Interface

The CQ16 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	1.8	2.8	3.2
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 CQ16 PIN Assignment

The CQ16 pin names are mentioned as follows.

Table 3.5 Pin Name

Pin No.	Pin name	IO Type	Voltage definition	Pin Description	Comments
1	GND	GND	-	Ground Pin	-
2	RESERVED	-	-	Do not connect	-
3	RESERVED	-	-	Do not connect	-
4	RESERVED	-	-	Do not connect	-
5	RESERVED	-	-	Do not connect	-
6	RESERVED	-	-	Do not connect	-
7	PWRKEY	DI	-	Power Key	
8	RESERVED	-	-	Do not connect	-
9	ADC0	AI	P3	Analog to digital converter interface	-
10	GND	GND	-	Ground Pin	-
11	USIM_DATA	DIO	P5	External SIM card IO	-
12	USIM_RST	DIO	P5	External SIM card reset	-
13	USIM_CLK	DIO	P5	External SIM clock	-
14	USIM_VDD	PO	P5	External SIM power	-
15	RESET	DI	A1	System reset	-
16	NET_STATUS	DO	P2	Network status indication	-
17	MAIN_RXD	DI	P2	AT UART Receive data	-
18	MAIN_TXD	DO	P2	AT UART Transmit data	-
19	MAIN_DTR	DO	P2	Data terminal Ready	-
20	MAIN_RI	AIO	P2	AT UART Ringing	-

				indication	
21	MAIN_DCD	DI	P2	AT UART Data carrier detect	-
22	MAIN_CTS	DO	P2	AT UART Clear to send	-
23	MAIN_RTS	DI	P2	AT UART Request to send	-
24	VDD_EXT	PO	P2	1.8V output LDO	-
25	STATUS	DO	-	Module power on status indication	-
26	RESERVED	-	-	Do not connect	-
27	GND	GND	-	Ground Pin	-
28	AUX_RXD	DI	P2	Auxiliary UART Receive Data	-
29	AUX_TXD	DO	P2	Auxiliary UART Transmit Data	-
30	PCM_CLK	IO	P4	PCM Clock	-
31	PCM_SYNC	IO	P4	PCM Data frame synchronization signal	-
32	PCM_DIN	DI	P4	PCM Data Input	-
33	PCM_DOUT	DO	P4	PCM Data output	-
34	GND	GND	-	Ground Pin	-
35	ANT_MAIN	RF_IO	-	LTE Main antenna Pin	50 Ohm impedance
36	GND	GND	-	Ground Pin	-
37	GND	GND	-	Ground Pin	-
38	DBG_RXD	DI	P2	Debug UART Receive Data	-
39	DBG_TXD	DO	P2	Debug UART send Data	-
40	GND	GND	-	Ground Pin	-
41	GND	GND	-	Ground Pin	-

42	VBAT	PI	VB	Input Power	-
43	VBAT	PI	VB	Input Power	-
44	RESERVED	-	-	Do not connect	-
45	GND	GND	-	Ground Pin	-
46	GND	GND	-	Ground Pin	-
47	GND	GND	-	Ground Pin	-
48	GND	GND	-	Ground Pin	-
49	RESERVED	-	-	Do not connect	-
50	RESERVED	-	-	Do not connect	-
51	RESERVED	-	-	Do not connect	-
52	RESERVED	-	-	Do not connect	-
53	RESERVED	-	-	Do not connect	-
54	RESERVED	-	-	Do not connect	-
55	RESERVED	-	-	Do not connect	-
56	RESERVED	-	-	Do not connect	-
57	RESERVED	-	-	Do not connect	-
58	RESERVED	-	-	Do not connect	-
59	USB_DP	AIO	P6	Differential input/output signal of USB +	-
60	USB_DM	AIO	P6	Differential input/output signal -	-
61	USB_VBUS	DI	-	-	-
62	RESERVED	-	-	Do not connect	-
63	RESERVED	-	-	Do not connect	-
64	RESERVED	-	-	Do not connect	-
65	RESERVED	-	-	Do not connect	-

66	I2C_SDA	DIO	P2	I2C Serial data	-
67	I2C_SCL	DO	P2	I2C Serial Clock	-
68	RESERVED	-	-	Do not connect	-
69	RESERVED	-	-	Do not connect	-
70	GND	GND	-	Ground Pin	-
71	GND	GND	-	Ground Pin	-
72	GND	GND	-	Ground Pin	-
73	GND	GND	-	Ground Pin	-
74	RESERVED	-	-	Do not connect	-
75	RESERVED	-	-	Do not connect	-
76	RESERVED	-	-	Do not connect	-
77	RESERVED	-	-	Do not connect	-
78	RESERVED	-	-	Do not connect	-
79	USIM_DET	DI	P5	SIM detect Pin	-
80	RESERVED	-	-	Do not connect	-
81	I2S_MCLK	DIO	P2	I2S Master Clock	-
82	USB_BOOT	DI	P2	Boot Config Pin	-
83	PSM_IND	DI	-	Put into Flight Mode	-
84	GPIO1	DIO	P2	Configurable IO	-
85	GPIO7	DIO	P2	Configurable IO	-
86	AGPIO7	DI	A1	Always on GPIO	-
87	PSM_INT	DI	P2	Wake Up interrupt	-
88	GND	GND	-	Ground Pin	-
89	GND	GND	-	Ground Pin	-
90	GND	GND	-	Ground Pin	-

91	GND	GND	-	Ground Pin	-
92	GND	GND	-	Ground Pin	-
93	GND	GND	-	Ground Pin	-
94	GND	GND	-	Ground Pin	-
95	GND	GND	-	Ground Pin	-
96	ADC1	AI	P3	Analog to Digital Converter Interface	
97	RESERVED	-	-	Do not connect	-
98	RESERVED	-	-	Do not connect	-
99	RESERVED	-	-	Do not connect	-
100	RESERVED	-	-	Do not connect	-
101	RESERVED	-	-	Do not connect	-
102	RESERVED	-	-	Do not connect	-
103	RESERVED	-	-	Do not connect	-
104	RESERVED	-	-	Do not connect	-
105	RESERVED	-	-	Do not connect	-
106	RESERVED	-	-	Do not connect	-
107	RESERVED	-	-	Do not connect	-
108	RESERVED	-	-	Do not connect	-
109	RESERVED	-	-	Do not connect	-

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 CQ16 module power interface consists of three parts:

- ✓ **VBAT** is the module working power supply.
- ✓ **USIM_VDD** is the working power supply for SIM card

3.3.1 Power Supply Design

The power interface of the CQ16 module is as follows:

Table 3.5 Power pin definitions

Power supply							
Pin No.	**Definition**	**IO**	**Description**	**Remarks**	**V_Min**	**V_Typ**	**V_Max**
42, 43	VBAT	PI	Module input voltage	-	3.1V	3.8V	4.5V
14	USIM_VDD	PO	External SIM card power supply	Output voltage 1.8/3	1.75/2.95	1.8/3	1.85/3.05
24	VDD_EXT	PO	1.8V output LDO / Reference Voltage	Output voltage 1.8V	1.75	1.8	1.85
1, 10, 27, 34, 36, 37, 40, 41, 45, 46, 47, 48, 70, 71, 72, 73, 88, 89, 90, 91, 92, 93, 94, 95	GND	-	Ground	-	-	0	-

The CQ16 module can be powered by a single power supply mode.

- 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** line width should be within 1mm.

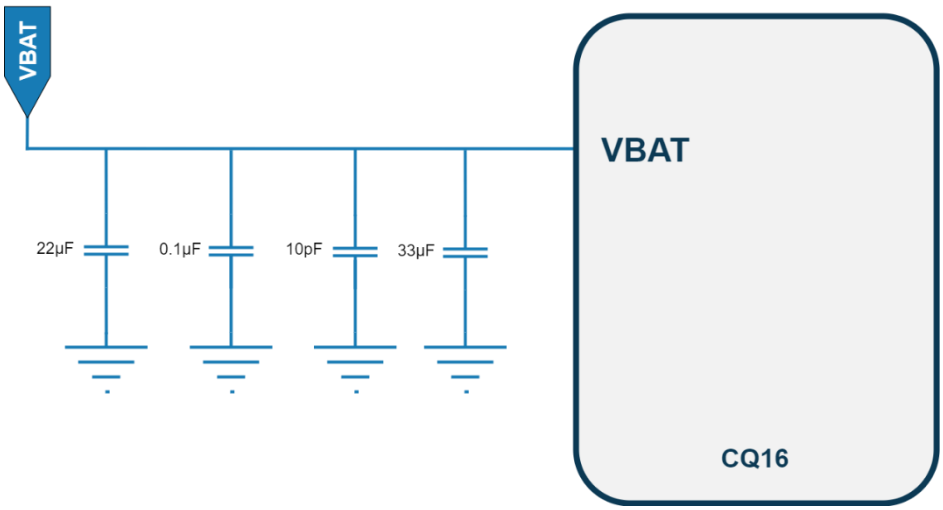


Figure 3: VBAT power supply

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.

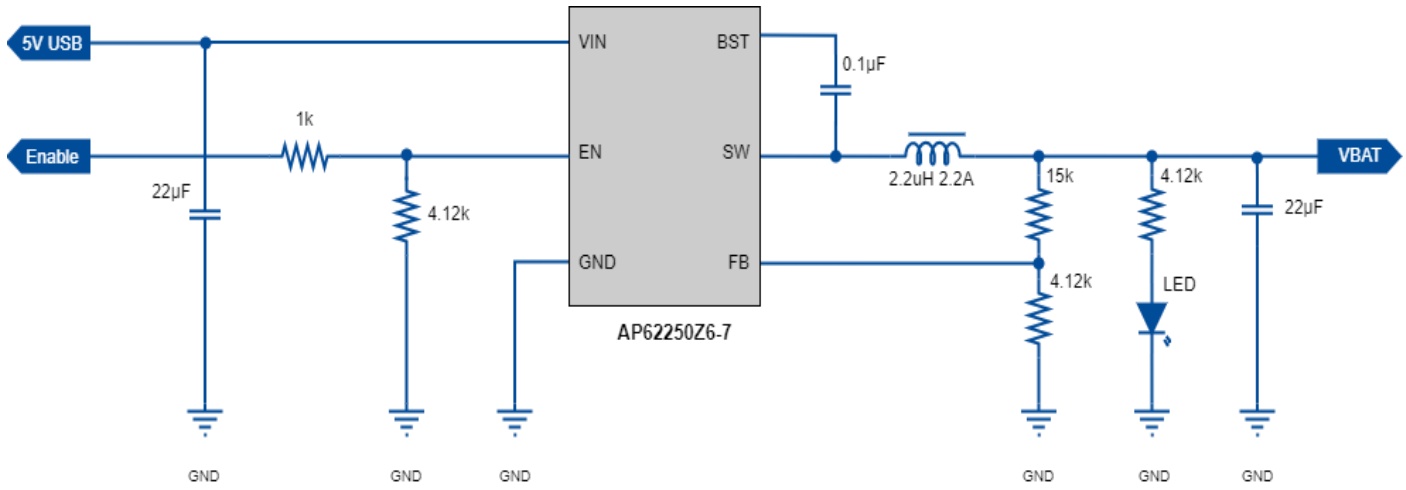


Figure 4: Buck converter reference circuit

3.3.3 VDD_EXT 1.8 Voltage Output

The CQ16 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 24th 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
24	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 7th pin of the CQ16 module is Power on pin. The module can be powered on by pulling down the POWERKEY 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
7	PWRKEY	DI	Power key

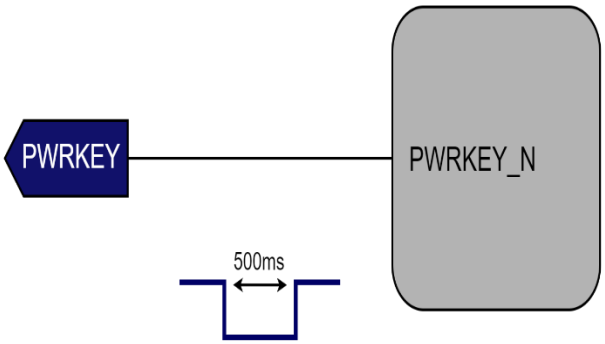


Figure 5: Power-on reference circuit

NOTE

- ✓ If you want to enable automatic boot up for the CQ16, connect the PWRKEY 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 CQ16 module's 15th pin 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.

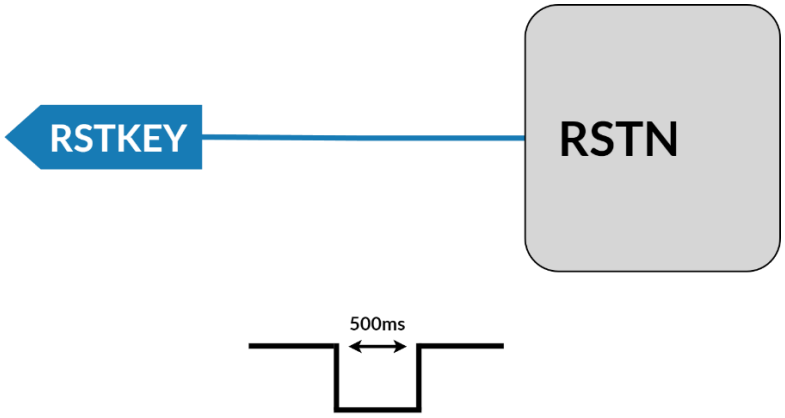


Figure 6: Reset reference circuit

Table 3.8 RESET pin parameters

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

NOTE

✓ The CQ16 module supports AT command reset, and the AT command is **AT+TRB** to restart the module. Detailed instructions can be found in the CQ16 AT Command Set Manual.

3.5 USB Interface

The CQ16 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 CQ16 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
59	USB_DP	AIO	Differential input/output signal of USB +	3.25	3.3	3.35
60	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:

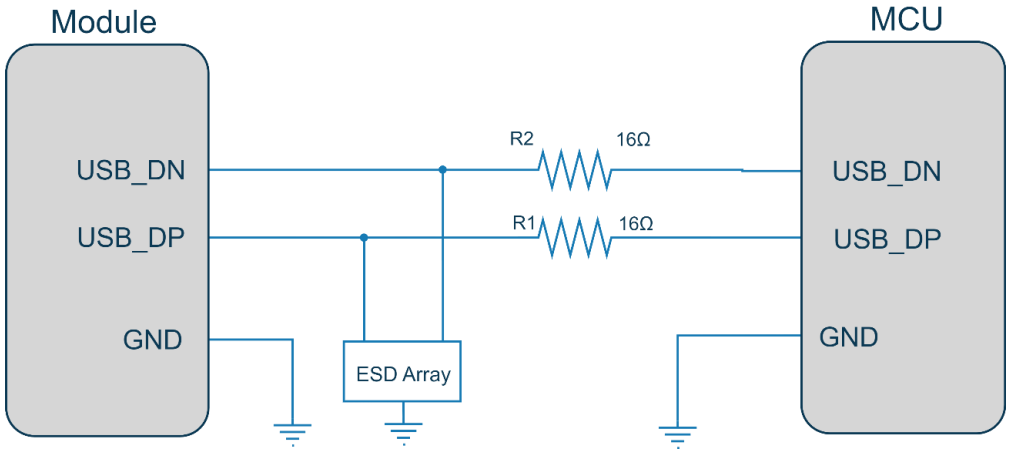


Figure 7: USB connection design circuit diagram

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 CQ16 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 – Debug UART

The pins 39 and 38 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
39	DBG_TXD	DO	UART 0 Data transmission	1.75	1.8	1.85
38	DBG_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 – Main UART

This 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
20	MAIN_RI	AIO	UART 1 Ringing indication	1.75	1.8	1.85
21	MAIN_DCD	DI	UART 1 Data carrier detect	1.75	1.8	1.85
22	MAIN_CTS	DO	UART 1 Clear to send	1.75	1.8	1.85
23	MAIN_RTS	DI	UART 1 request to send	1.75	1.8	1.85
19	MAIN_DTR	DO	UART 1 Data terminal ready	1.75	1.8	1.85
18	MAIN_TXD	DO	UART 1 Transmit data	1.75	1.8	1.85
17	MAIN_RXD	DI	UART 1 Receive data	1.75	1.8	1.85

3.6.3 UART2 Serial Port

The pins 28 and 29 of the module are UART2 serial port pins. 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
28	AUX_RXD	DI	UART 2 Data transmission	1.75	1.8	1.85
29	AUX_TXD	DO	UART 2 Data reception	1.75	1.8	1.85

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

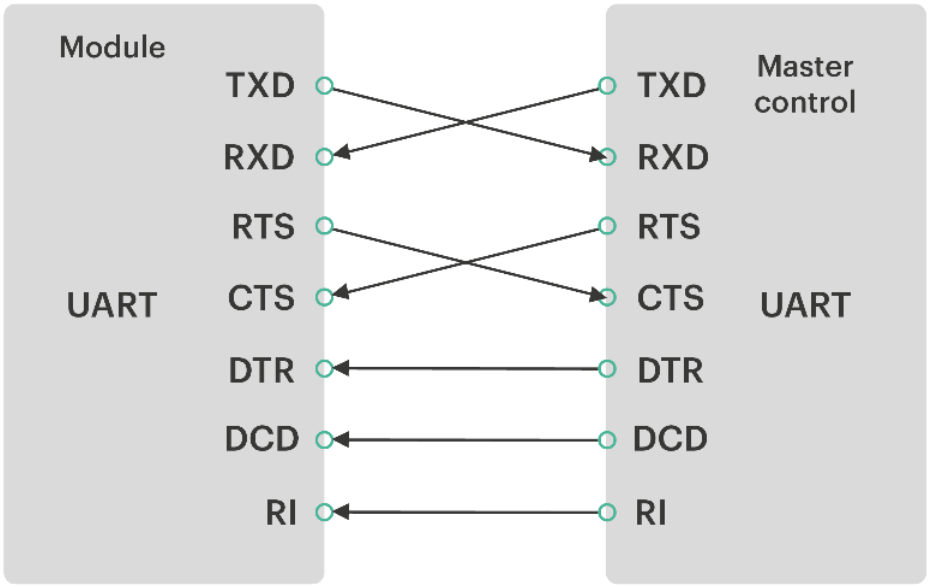


Figure 8: Full-featured serial port design

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

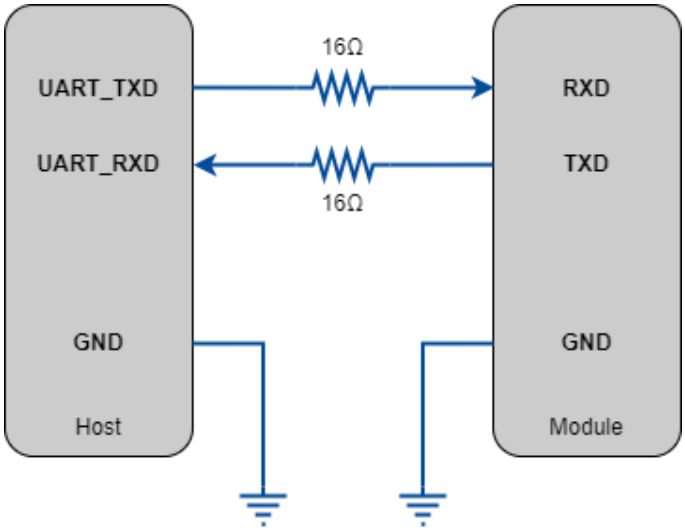


Figure 9: UART serial port design

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:

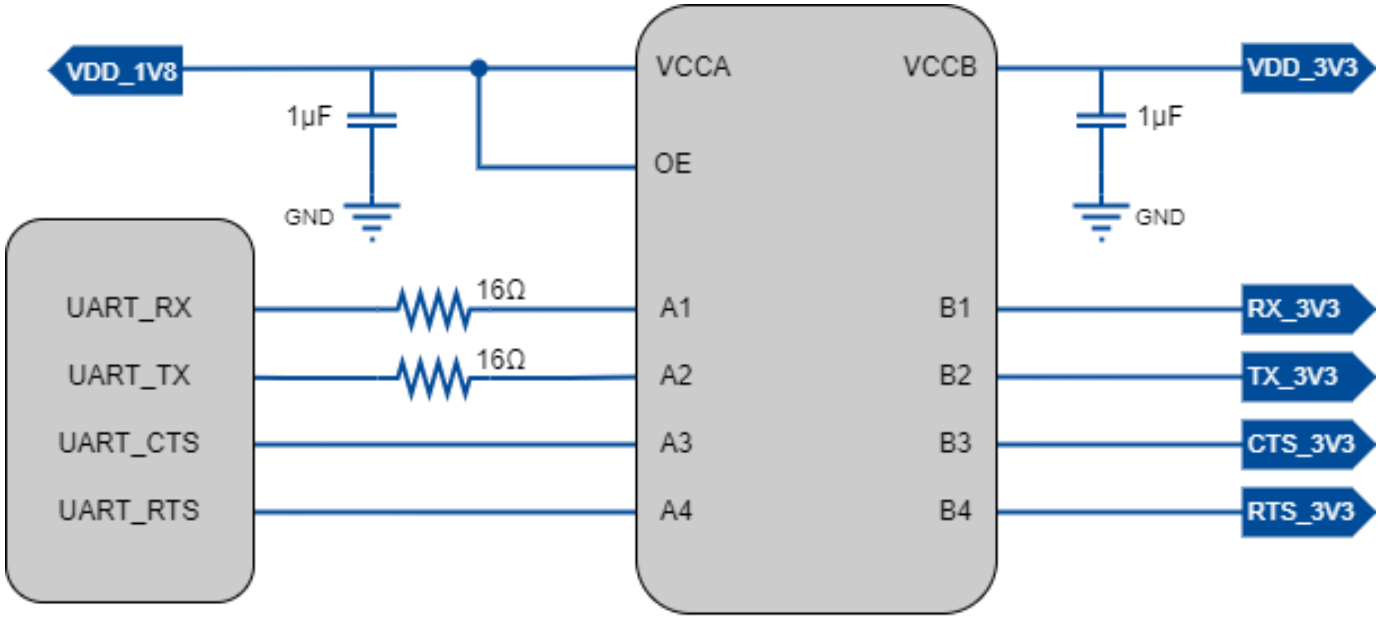


Figure 10: Level conversion chip circuit

3.7 USIM Interface

The CQ16 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
79	USIM_DET	DI	SIM detect Pin	1.75/2.95	1.8/3	1.85/3.05
14	USIM_VDD	PO	External SIM power	1.75/2.95	1.8/3	1.85/3.05
11	USIM_DATA	DIO	External SIM card IO	1.75/2.95	1.8/3	1.85/3.05
13	USIM_CLK	DIO	External SIM clock	1.75/2.95	1.8/3	1.85/3.05
12	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 CQ16 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:

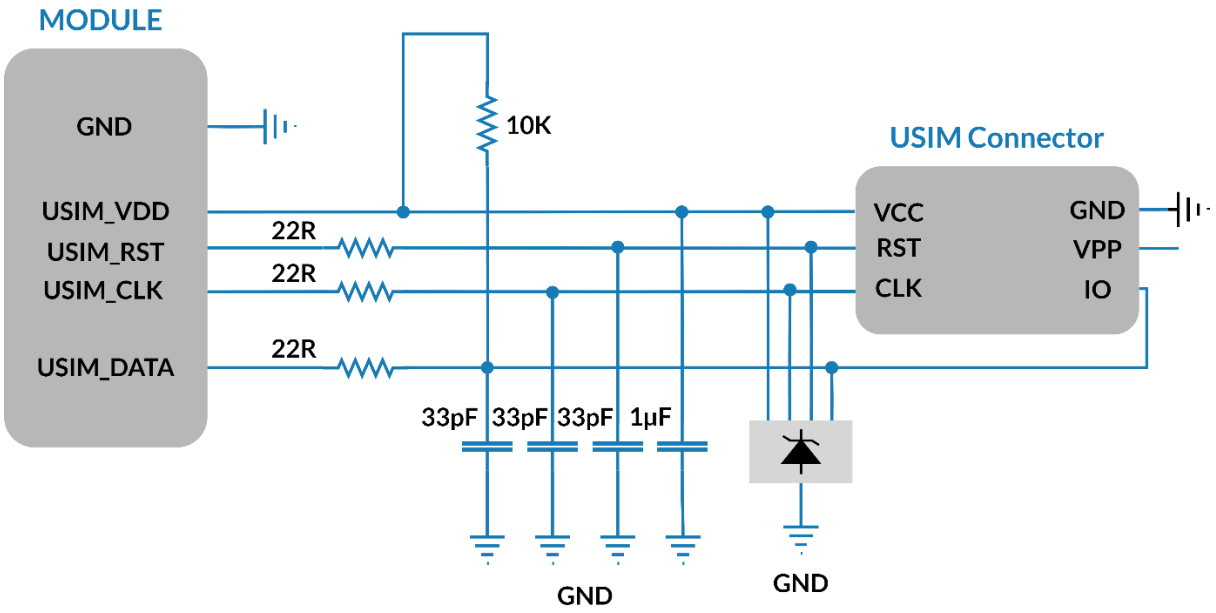


Figure 11: USIM design circuit diagram

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_DET 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 CQ16 module contains three 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
84	GPIO1	DIO	Configurable IO	1.75	1.8	1.85
85	GPIO7	DIO	Configurable IO	1.75	1.8	1.85
86	AGPIO7	AIO	Always on GPIO	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 CQ16 Module provides an open-drain GPIO signal to indicate the status of the RF communication.

3.9.1 Network Status

CQ16 provides two network status indication pins: **USB_BOOT** & **NET_STATUS** (Pins **82 & 16**). 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
82	USB_BOOT	DO	Boot USB function	1.75	1.8	1.85
16	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:

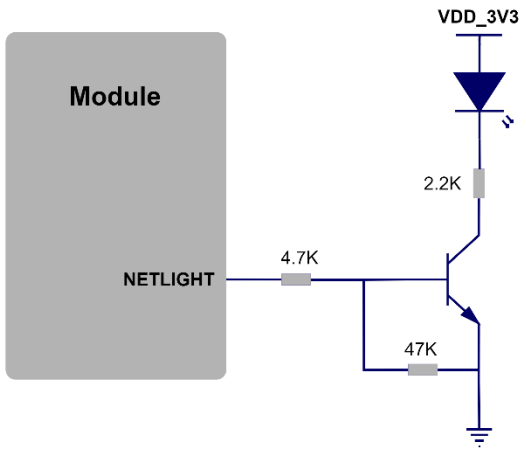


Figure 12: Net light reference circuit diagram

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
87	PSM_INT	DI	Wake up Interrupt
83	PSM_IND	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 **82** and **16**. While using one, keep the other floating.

3.9.2 Module Status Indication

- ✓ The CQ16 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
25	STATUS	DO	Module power on status indication

The following figure shows the STATUS reference circuit design:

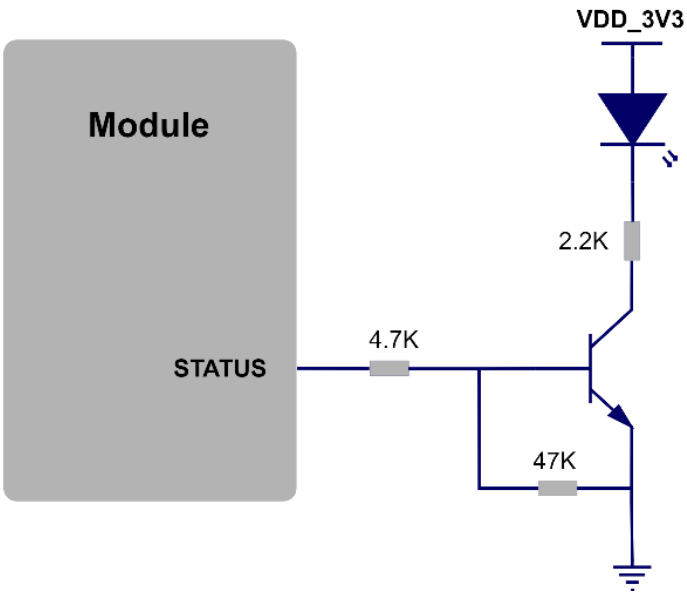


Figure 13:STATUS Pin Reference Circuit

3.10 I2S Interface

CQ16 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
33	PCM_DOUT	DIO	I2S Data out	1.75	1.8	1.85
32	PCM_DIN	DIO	I2S Data in	1.75	1.8	1.85
31	PCM_SYNC	DIO	I2S Strobe Clock	1.75	1.8	1.85
81	I2S_MCLK/ RESERVED	DIO	I2S Master Clock	1.75	1.8	1.85
30	PCM_CLK	DIO	I2S Bit Clock	1.75	1.8	1.85

3.11 I2C Bus

The CQ16 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
67	I2C_SCL	DO	I2C Serial Clock	1.75	1.8	1.85
66	I2C_SDA	DIO	I2C Serial data	1.75	1.8	1.85

The I2C reference circuit is connected as follows:

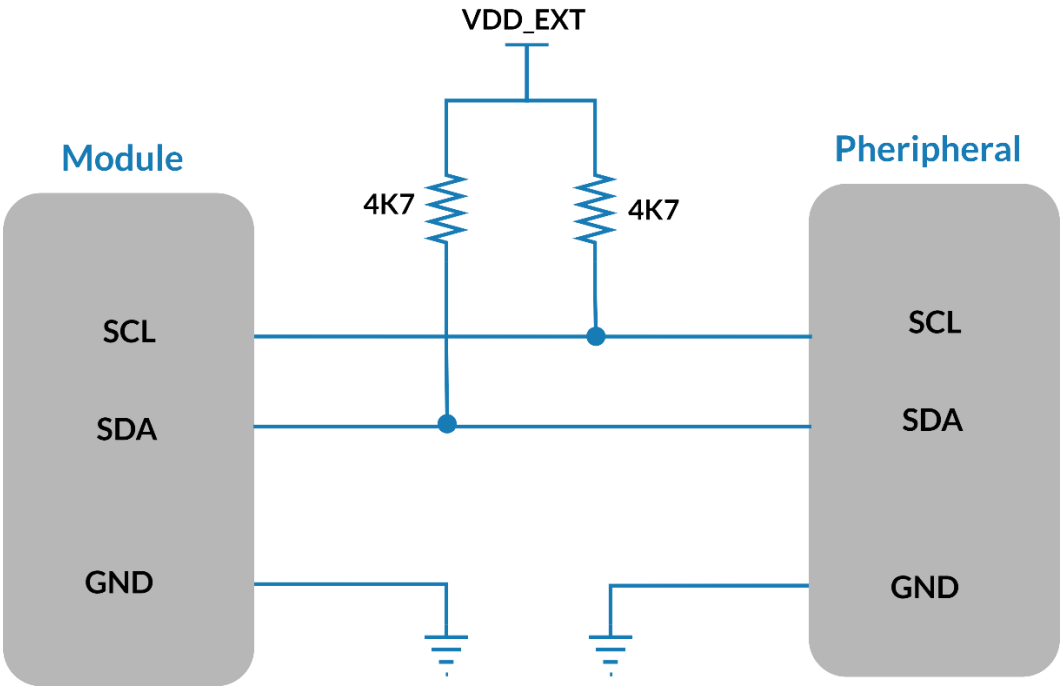


Figure 14: I2C interface reference circuit diagram

3.12 ADC Interface

The CQ16 provides one 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
96	ADC1	AIO	Analog to digital converter interface 1	0	-	3.4
9	ADC0	AIO	Analog to digital converter interface 0	0	-	3.4

3.13 Antenna

The CQ16 module provides one main set antenna interface, which is responsible for the Cat 1bis signals of the transceiver module

The impedance of the antenna interfaces are 50 ohms.

Table 3.23 Antenna interface pin definition

Pin No.	Signal Name	Description	Remarks
35	ANT_MAIN	Main antenna interface	50Ω characteristic impedance

The pin 35 of the CQ16 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：

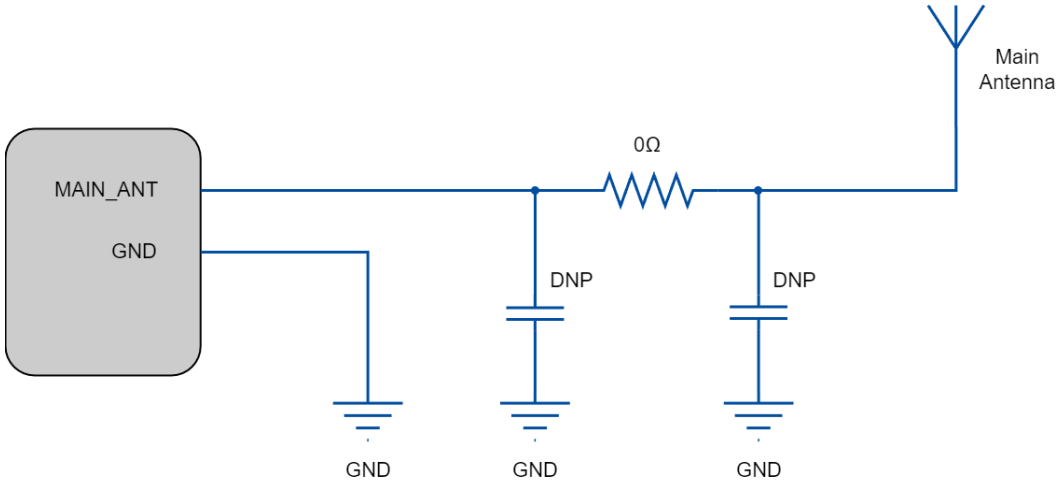


Figure 15: Main antenna matching circuit

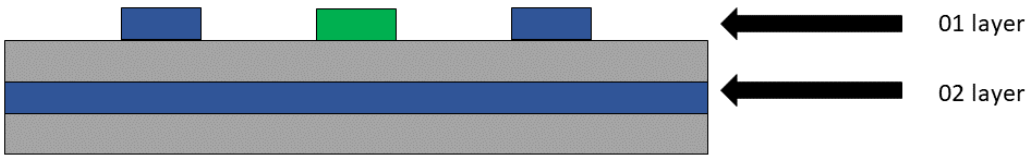
NOTE

- ✓ 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 ANT_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.

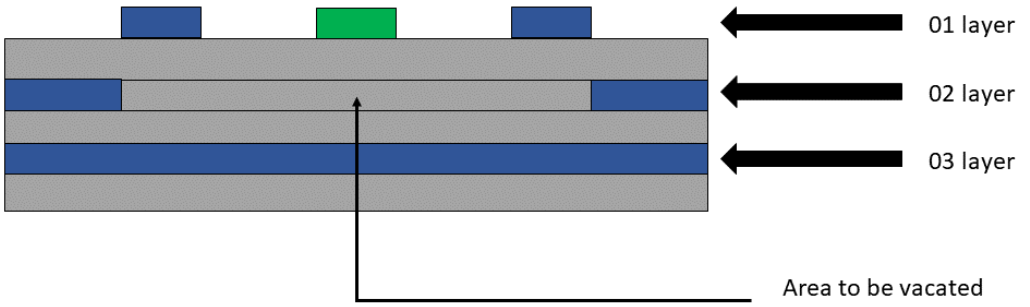
3.14.1 RF Trace Reference

The main set of the CQ16 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 16: Coplanar Antenna

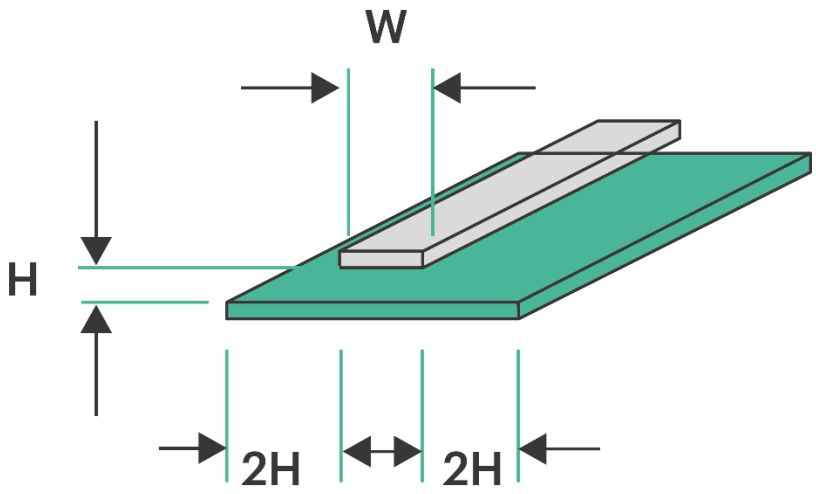


Figure 17: The complete structure of the two-layer PCB microstrip line

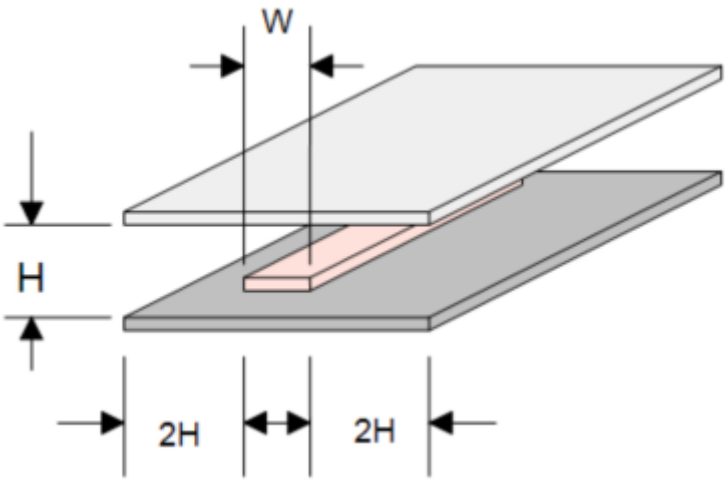


Figure 18: The complete structure of the multilayer PCB strip line

NOTE

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

3.15 Control Interface

Table 3.25 Control interface pin definition

Pin No.	Signal name	I/O	Description
25	STATUS	DO	Module power on status indication
83	PSM_IND	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.

4 Overall Technical Indicators

4.1 Chapter Overview

The CQ16 module RF overall specifications include the following sections:

- ✓ Working frequency
- ✓ 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

4.4 Antenna Requirements

CQ16 Module Antenna Design Requirements:

Table 4.2 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 CQ16 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 CQ16 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 CQ16 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 CQ16 module IO levels are as follows:

Table 5.3 Electrical Characteristics of CQ16 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 CQ16 module input power requirements are as follows:

Table 5.3 CQ16 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 5.4 CQ16 Power Consumption Table

Mode	Type/band	Rx CINR @ 80dBm (dB)	Sensitivity (dBm)	Current consumption @ 23dBm and @3.7 V			
				Typical	Tx Idle	Peak Tx @ Centre frequency	Unit
CAT 1.bis	Band 1	-	-	-	3.81	0.58	mA
	Band 3	-	-	-	3.74	486.45	mA
	Band 5	-	-	-	3.88	0.57	mA
	Band 7	-	-	-	3.87	0.58	mA
	Band 8	-	-	-	3.65	442.6	mA
	Band 28	-	-	-	3.56	0.5	mA
	Band 40	-	-	-	3.49	202.05	mA
	Band 41	-	-	-	3.71	267.5	mA
CFUN=0				3.44			mA
Sleep 1				67.75			µA

Sleep 2	41.64	µA
HIB	32.38	µA
SHUTDOWN	26.54	µA

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.

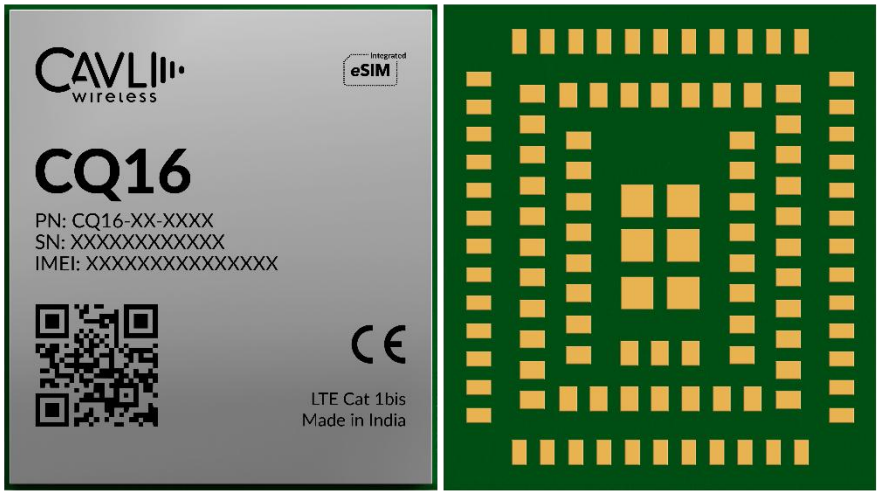


Figure 19: Top view and bottom view of the module

6.2 CQ16 Module Mechanical Size

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

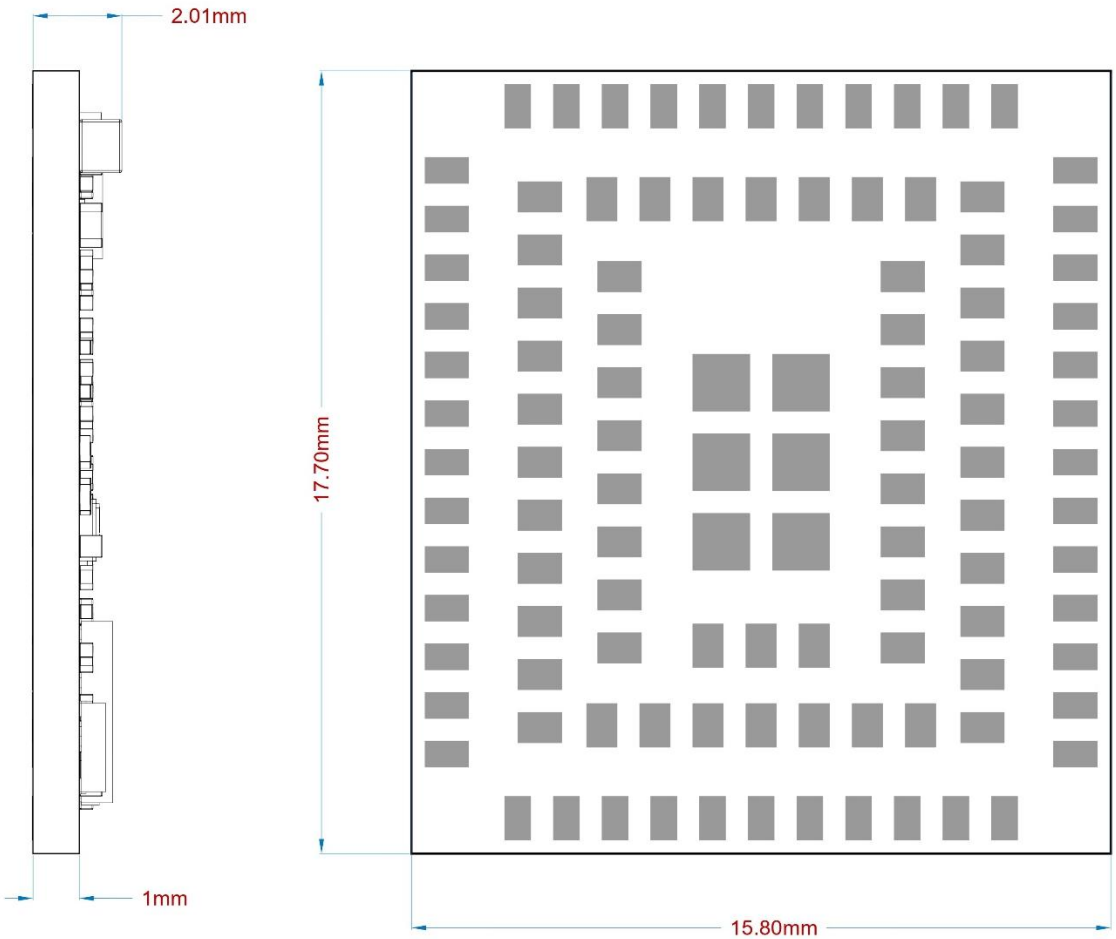


Figure 20: Front view and side view of the module (unit: mm)

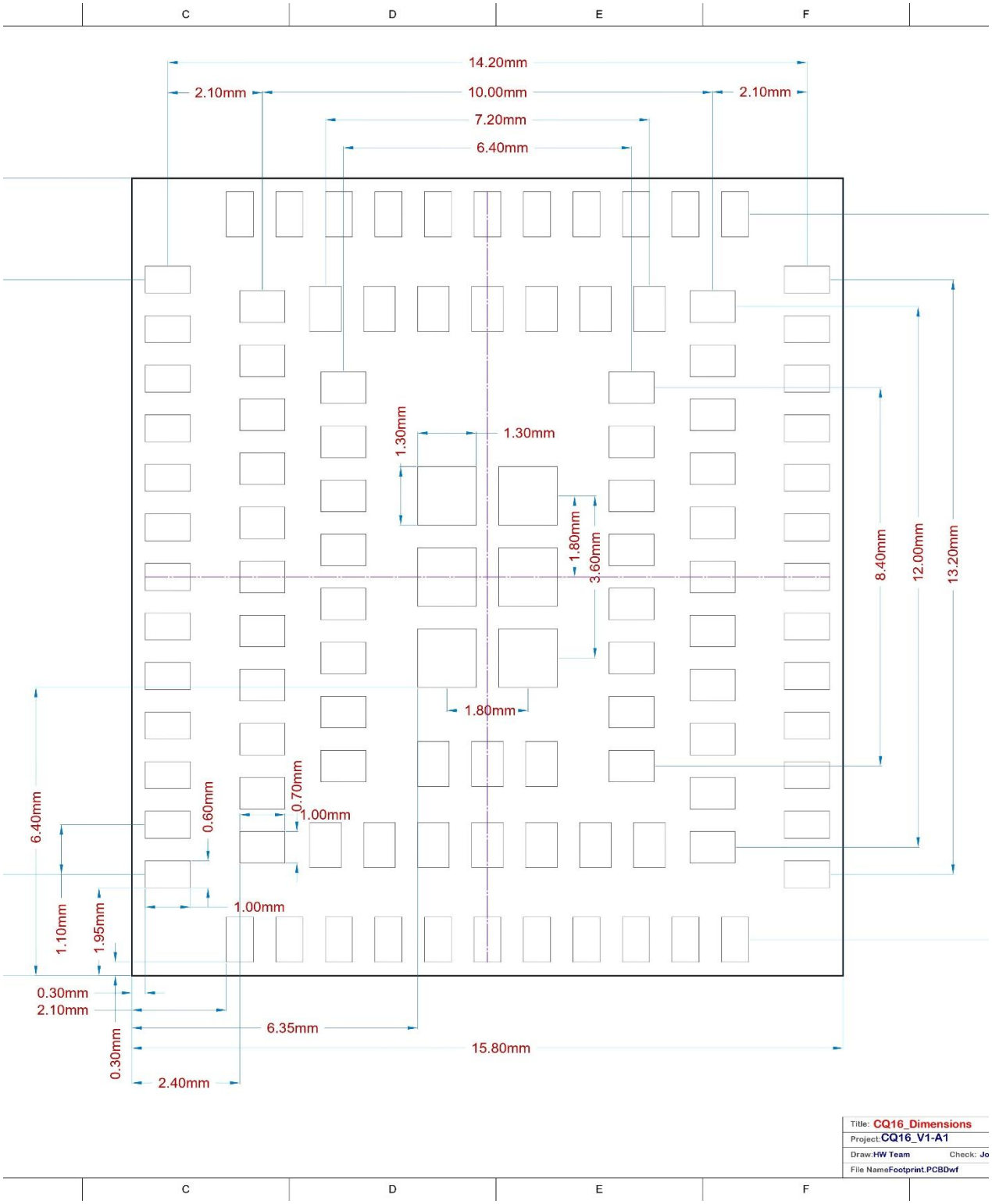


Figure 21: Bottom view of the module (unit: mm)

7 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.