GCT450 LTE450 MINIPCIE MODULE

Hardware Design Guide

Title	GCT450 LTE450 MiniPCIe Module Hardware Design Guide
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Revision History

Revision	Date	Description of Major Changes
1.0	2017/06/08	Initial Release
1.1	2018/03/16	Add GCT450 series module description
1.2	2019/02/28	Add Wi-Fi and Ethernet feature support as optional
1.3	2019/07/10	Update some descriptions
1.4	2020/4/10	Update the Packaging information

Content

1 Introduction

This document describes the specification and function of GCT450 series module in detail, and provides application design reference. With the help of this document, users can quickly understand module interface specifications, electrical and mechanical characteristics of GCT450 series quickly, and design application products based on the GCT450 series module easily.

GCT450 series module is a wireless communication module by MiniPCIe package (PCI Express Mini Card Form Factor,Type F2), which supports both LTE FDD and LTE TDD mode. It can be widely used in various products and devices for providing data services, such as Routers,laptops, vehicle terminals and other electrical equipment.

GCT450 series module has variant HW configurations as shown on Chapter 1.4, and the customer can select the appropriate model according to the sales region or operator.

1.1 Product View

FIGURE 1 MODULE TOP VIEW

1.2 Key Features

TABLE 1 KEY FEATURES

Feature	Description
Package	51 mm × 30 mm × 4.5 mm 52 pins MiniPCIe package
Power Supply	Supply Voltage 3.3V-4.2V Typical supply voltage 3.8V
Frequency Bands	LTE FDD B1/B3/B7/B8/B20/B28/31/72/40
Speed Rate	LTE FDD: Max 50Mbps (UL), Max 150Mbps (DL)

Protocol	TCP/UDP/PPP/FTP/HTTP/NTP/PING PAP (Password Authentication Protocol) and CHAP (Challenge Handshake Authentication Protocol)
SIM	Support USIM/SIM card: 1.8V, 3.0V
UART	UART interface: 3-wire UART interface For AT command transfer and data transfer The baud rate is up to 3000000bps and the default is 115200bps.
USB	Compliant with USB 2.0 specification (slave only) Used for commanding communication, data transfer, software debugging, and firmware upgrade
Antenna	Including main antenna (ANT_MAIN), Rx diversity antenna (ANT_DIV)
Network Indication	Use NET_MODE and NET_STATUS to indicate network connectivity status
Temperature Range	Operation temperature range: -30°C ~ +70°C Extended temperature range: -40°C ~ +85°C
RoHS	All components are fully compliant with EU RoHS standards

1.3 Advanced Features

Below features are HW optional, please contact with our sales team to get more details.

The default FW does not support these features.

TABLE 2 ADVANCED FEATURES

Feature	Description
Ethernet	On board 10/100Mbps IEEE 802.3/802.3u compliant Fast Ethernet transceiver Standard 4 lines to connect with the external transformer to simplify the design Auto Negotiation and Auto MDI/MDIX
SDIO	SDIO 3.0 Interface, Standard 6 lines interface External Wi-Fi chipset supporting for 802.11 b/g/n
PCM	For audio use, an external Codec chip is required. Supports 8-bit A-law, u-law and 16-bit linear encoding formats
ADC	Supports 1-channel 12-bits ADC, voltage input range: 0.3V~VBAT

1.4 Module Selection

The frequency bands supported by GCT450 series module are shown below:

TABLE 3 MODULE VARIANT

Network	GCT450EU	GCT450RU	GCT450ID	GCT450BR
LTE FDD	B3/7/20/31/72	B3/7/20/31	B1/3/B8/B31	B3/7/28/31
LTE TDD	N/A	B40	B40	N/A
LTE RX Diversity	Support	Support	Support	Support

2 Interface Application

2.1 Interface Overview

The following figure shows a block diagram of GCT450 and illustrates the major functional parts

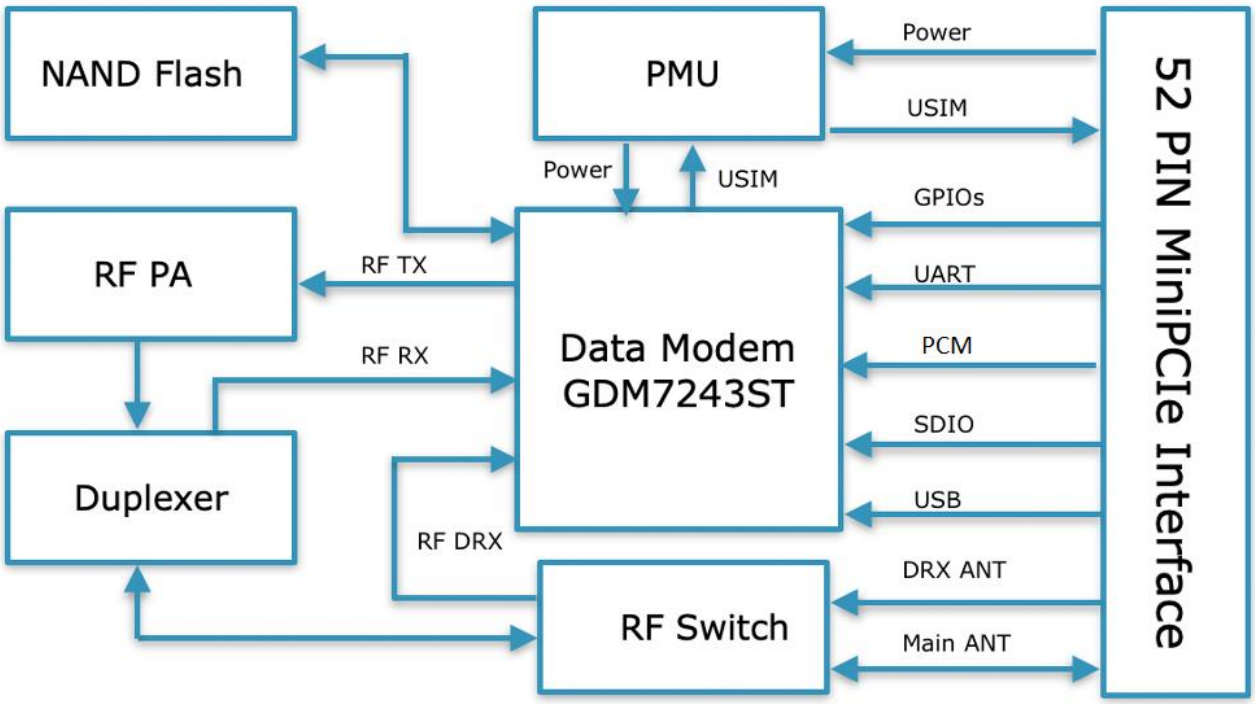


FIGURE 2 MODULE INTERFACE

2.2 Power Supply

TABLE 4 POWER SUPPLY

Name	Pin No.	I/O	Description	Remarks
VBAT	2,24,39,41,52	PI	Module power supply	3.3V-4.2V,Typical 3.8V The power supply must be able to supply 2.0A

GND	4,9,15,18,21,26, 27,29,34,35,37, 40,43,50	PI	Ground

The power supply range of the GCT450 module is 3.3V~4.2V, and the typical value is 3.8V. When data is transmitted, the instantaneous high-power emission will form a current peak of up to 2A, which will cause large ripple of VBAT, such as instantaneous voltage drop. The VBAT supply voltage is too low and the module will shut down. In order to ensure the normal operation of the module, it is required to have sufficient power supply capability for the power supply, and it is necessary to ensure that the input voltage is not lower than 3.3V.

In order to reduce the voltage drop, a low-ESR 100uF filter capacitor is required, and three ceramic capacitors (100nF, 33pF, 10pF) are added to the VBAT pins, respectively, and the capacitor needs to be placed close to the VBAT pins. When the external power supply is connected to the module, VBAT pins need to be star-shaped. The VBAT trace width should not be less than 2mm. In principle, the longer the VBAT trace, the wider the line width.

In order to ensure the stability of the power supply, it is recommended to add a 5.1V, Zener diode with a power of 0.5W or more at the front end of the power supply.

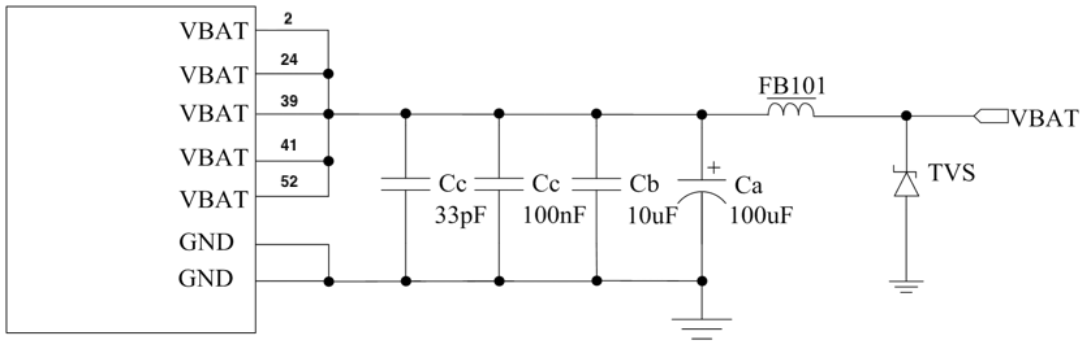


FIGURE 3 STAR STRUCTURE POWER SUPPLY

2.3 Reset

TABLE 5 RESET PIN

Pin Name	Pin No.	I/O	Description	DC	Remarks
RESET_N	22	DI	Reset Module	V_{IH}max=2.1V V_{IH}min=1.2V V_{IL}max=0.6V	

Using the RESET_N pin, the module can be reset after the pin is pulled down for 100~300ms in the normal working state of the module. The RESET_N signal is sensitive to interference, so it is recommended that the traces on the module interface board be as short as possible and must be shielded with ground surrounded. Reference circuit is as below.

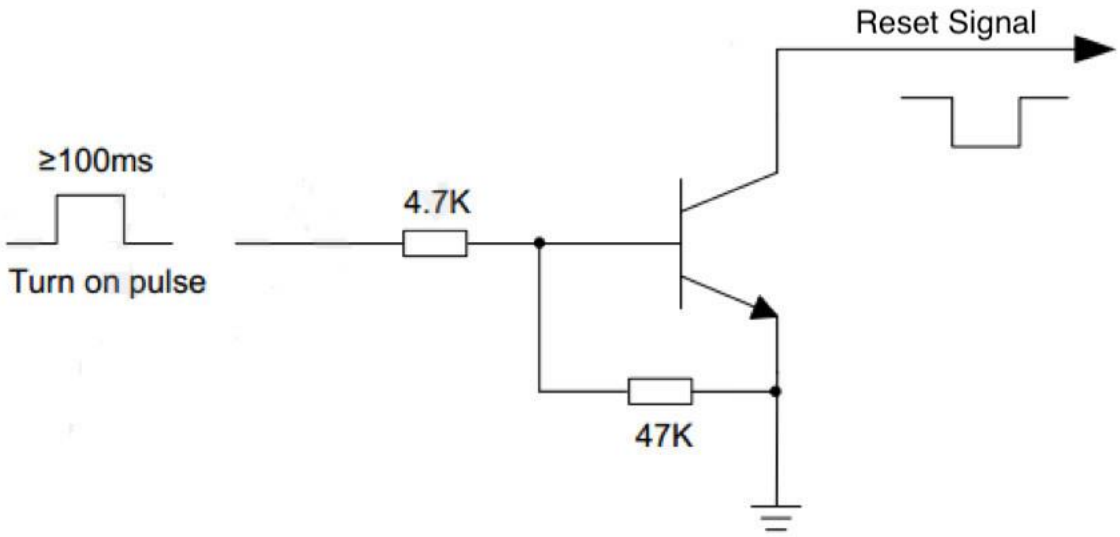


FIGURE 4 RESET CONTROL CIRCUIT

2.4 SIM Card

The SIM interface complies with the ETSI and IMT-2000 SIM card specifications and supports 1.8V and 3.0V SIM cards.

TABLE 6 SIM PIN DESCRIPTION

Name	Pin No.	I/O	Description	Remarks
SIM_VDD	8	PO	SIM card power supply	1.8V and 3.0V SIM card
SIM_DATA	10	IO	SIM card data signal	**Need to add pull-up 15K resistor to USIM_VDD**
SIM_CLK	12	DO	SIM card clock signal	
SIM_RST	14	DO	SIM card reset signal	

In the circuit design of the SIM interface, in order to ensure the good performance and reliability of the SIM card, the following principles are recommended in the circuit design:

- The SIM card holder is placed as close as possible to the module to ensure that the SIM card signal line wiring length does not exceed 150 mm.
- The SIM card signal line is routed away from the RF line and the VBAT power line.

- In order to prevent the SIM_CLK signal from interference with the USIM_DATA signal, the wiring between the two should not be too close, and the ground shield should be added between the two traces.
- Pull-up resistor on SIM_DATA help to Increase the anti-interference ability of the SIM card, and are recommended to be placed close to the holder.
- Adding a 22Ω resistor on the USIM_DATA, USIM_CLK and USIM_RST lines to suppress spurious EMI and enhance ESD protection.Suggest the resistor on the USIM_CLK line as 0Ω if no EMI issue.
- To improve the antistatic capability, add adding ESD protection diodes (junction capacitance not more than 50pF) or varistor on SIM_VDD, SIM_DATA, SIM_CLK and SIM_RST lines; and 33pF capacitors on each line to filter out LTE signal interference. The peripheral components of the SIM card should be placed as close as possible to the SIM card holder.
- The wiring between the ground of the SIM card holder and the SIM_GND of the module should be short and thick; if the GND of the customer PCB is complete, SIM_GND can also be directly connected to the GND of the PCB.

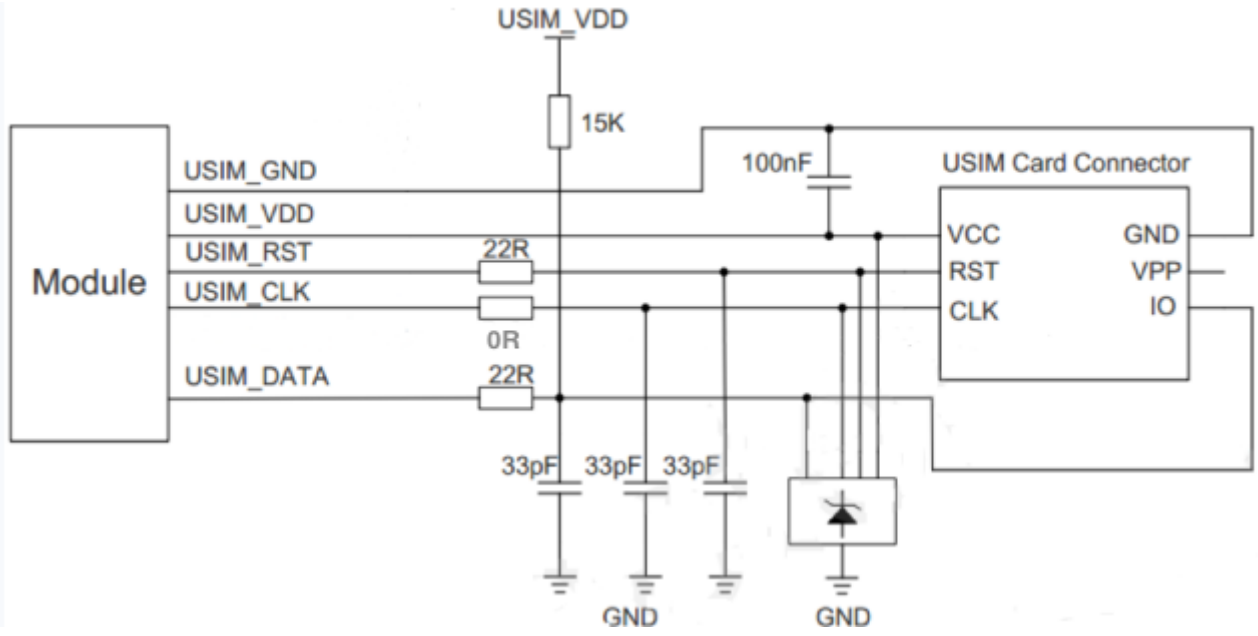


FIGURE 5 CONNECTION PIN OF THE SIM CARD

2.5 USB

The USB interface of the GCT450 module complies with the USB 2.0 specification and supports high-speed (480Mbps), full-speed (12Mbps) mode. USB interface is mainly used for AT commands, data transmission, software debugging and firmware upgrade

TABLE 7 USB PIN DESCRIPTION

Pin Name	Pin No.	I/O	Description	Remarks
USB_DP	38	IO	USB differential data signal +	Need 90Ω differential impedance
USB_DM	36	IO	USB differential data signal -	Need 90Ω differential impedance
GND	34,40		Ground	

In the circuit design of the USB interface, in order to ensure the performance of the USB, it is recommended to follow the below principles in the circuit design.

- To reduce signal interference during USB high-speed data transmission, R1 and R2 are connected in series on the USB_DM and USB_DP lines, and 0Ω is recommended for R1 and R2.
- USB_DP and USB_DM traces need to be 90Ω impedance control. Do not trace the USB lines under the crystal oscillator, oscillator, magnetic device and RF signal. It is recommended to take the inner differential trace and must be shielded with ground surrounded.
- To improve the antistatic capability, adding an ESD protection diode (with a junction capacitance of less than 3pF) to the USB_DP and USB_DM lines. Place the ESD device as close as possible to the USB interface.

The USB interface reference circuit is as follows:

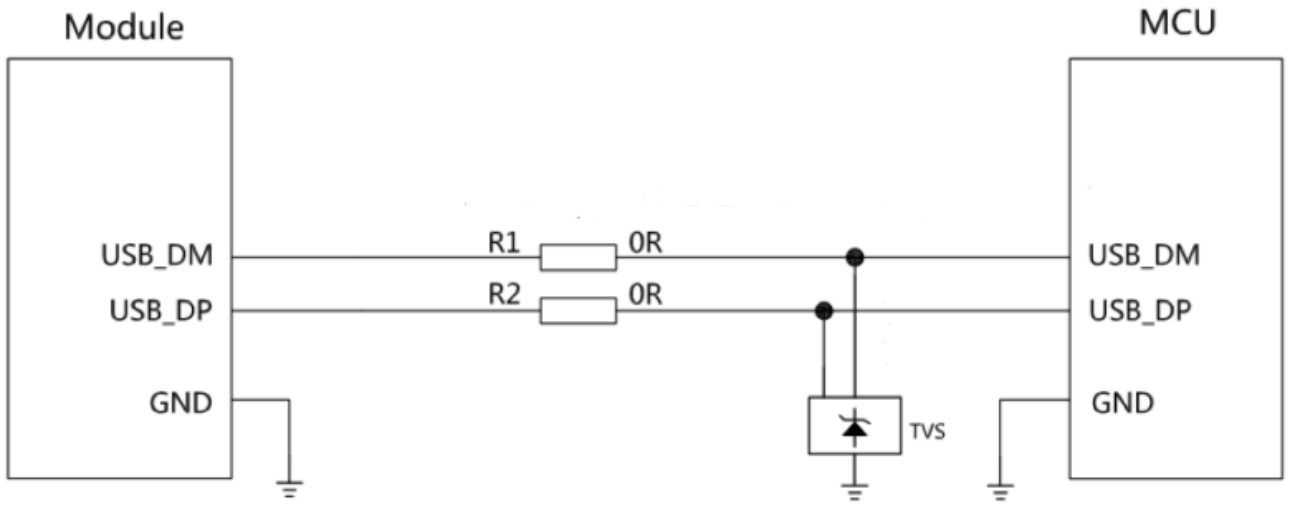


FIGURE 6 USB INTERFACE REFERENCE CIRCUIT

2.6 UART

The module provides one UART interfaces which supports: 9600, 19200, 38400, 57600, 115200 bps baud rate (see AT Command Manual for details); Default baud rate

is 115200 bps. This UART interface can be used for data transmission and AT command communication.

TABLE 8 MAIN UART PIN

Pin Name	Pin No.	I/O	Description	Remarks
UART_RXD	32	DI	Module receives data	1.8V power domain ; stay vacant if unused
UART_TXD	30	DO	Module sends data	1.8V power domain ; stay vacant if unused

TABLE 9 SERIAL LOGIC LEVEL

Parameter	MIN	MAX	Unit
V_{IL}	-0.3	0.6	V
V_{IH}	1.2	1.8	V
V_{OL}	0	0.45	V
V_{OH}	1.35	1.8	V

The serial port level of the GCT450 module is 1.8V. If the client host system level is 3.3V, you need to add a level shifter to the serial port connection between the module and the host. It is recommended to use TI's TXB0104PWR. The following figure shows the reference circuit design using a level shifting chip:

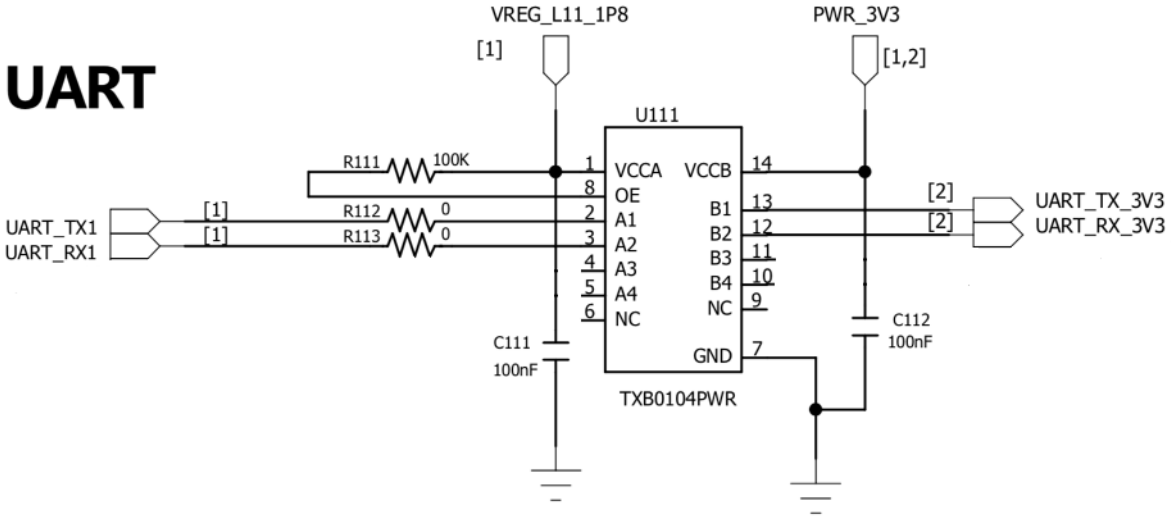


FIGURE 7 UART REFERENCE CIRCUIT

Remarks:

TXB0104PWR requires VCCA to be less than or equal to VCCB

2.7 Network Status Indication

The network indication pins NET_MODE and NET_STATUS can be used to drive the network status indication. Different mode status indicators flash to indicate different network status.

TABLE 10 NETWORK STATUS PIN

Pin Name	Pin No.	I/O	Description	Remark
NET_MODE	42	OD	Indicates the network registration status of the module	3.3V,Need external pull-up;stay vacant if unused
NET_STATUS	44	OD	Indicates the network operating status of the module	3.3V,Need external pull-up;stay vacant if unused

TABLE 11 NETWORK STATUS INDICATION PIN WORK STATUS

Pin Name	Pin Work Status	Indication Network Status
NET_MODE	Low Level	Register LTE network status
	High Level	Others
NET_STATUS	Slow flash (1s high / 1s low)	Search network status
	Always Low Level	Standby mode
	Fast flash (125ms high / 125ms low)	Data transmission mode

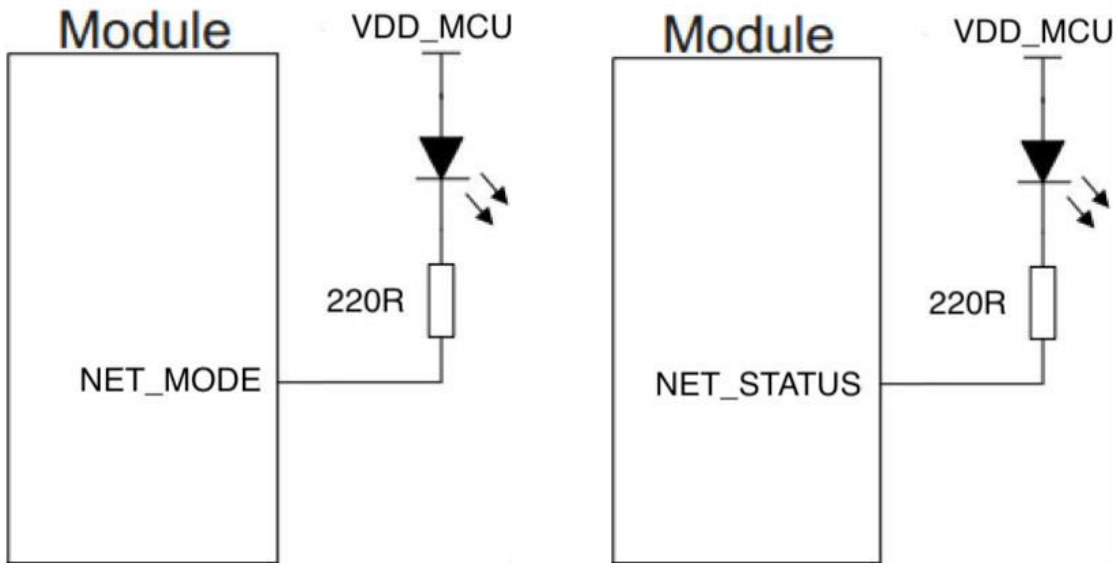


FIGURE 8 NETWORK STATUS INDICATION REFERENCE CIRCUIT

2.8 STATUS

The STATUS pin is used to indicate the operating status of the module and is an open drain output. When the module is powered on normally, it will output a low level. This pin can be connected to the GPIO or LED indicator with the device pulled up.

TABLE 12 STATUS PIN

Pin Name	Pin No.	I/O	Description	Remark
STATUS	46	OD	Indicates the working status of the module	3.3V,Need external pull-up;stay vacant if unused

The following figure shows two different STATUS reference circuit designs, which can be selected according to the application requirements.

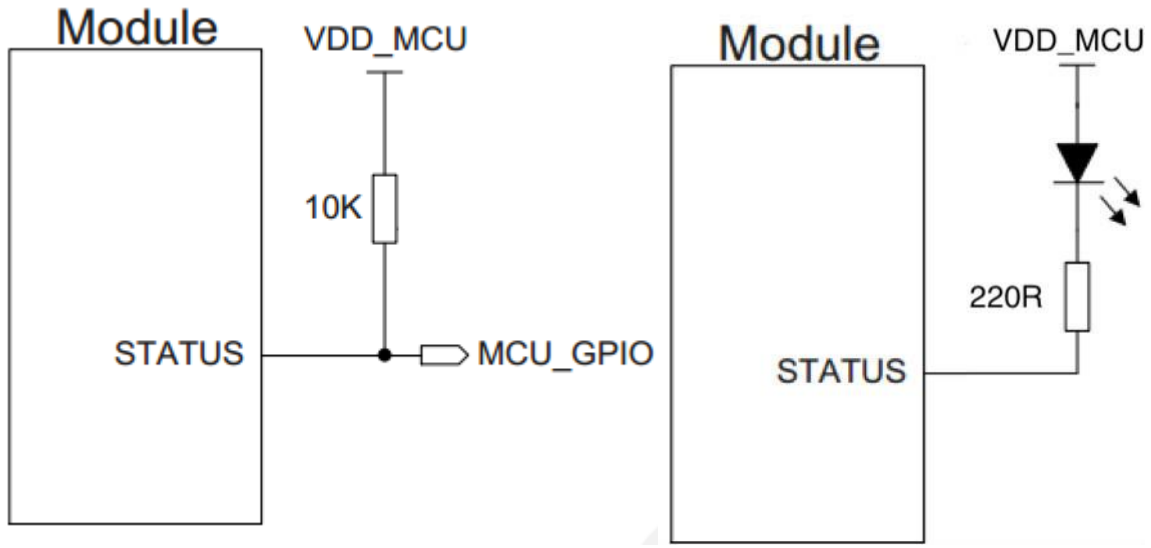


FIGURE 9 STATUS REFERENCE CIRCUIT

3 Antenna design and RF performance

The GCT450 module antenna interface consists of a main antenna, a diversity antenna. A rich antenna interface can improve the wireless access performance of the module. The antenna interface impedance value is required to reach 50 ohms.

TABLE 13 RF ANTENNA PIN

Pin Name	Pin No.	I/O	Description	Remark
ANT_MAIN	MAIN	IO	Main antenna	50Ω impedance
ANT_DIV	DIV	AI	Diversity antenna	50Ω impedance

3.1 RF Reference Circuit

The module RF U.FL connector can be connected with LTE antenna via RF cable directly. But if want to connect it with mainboard U.FL connector at first, ANT_MAIN and ANT_DIV antenna connection reference design circuit as shown below :

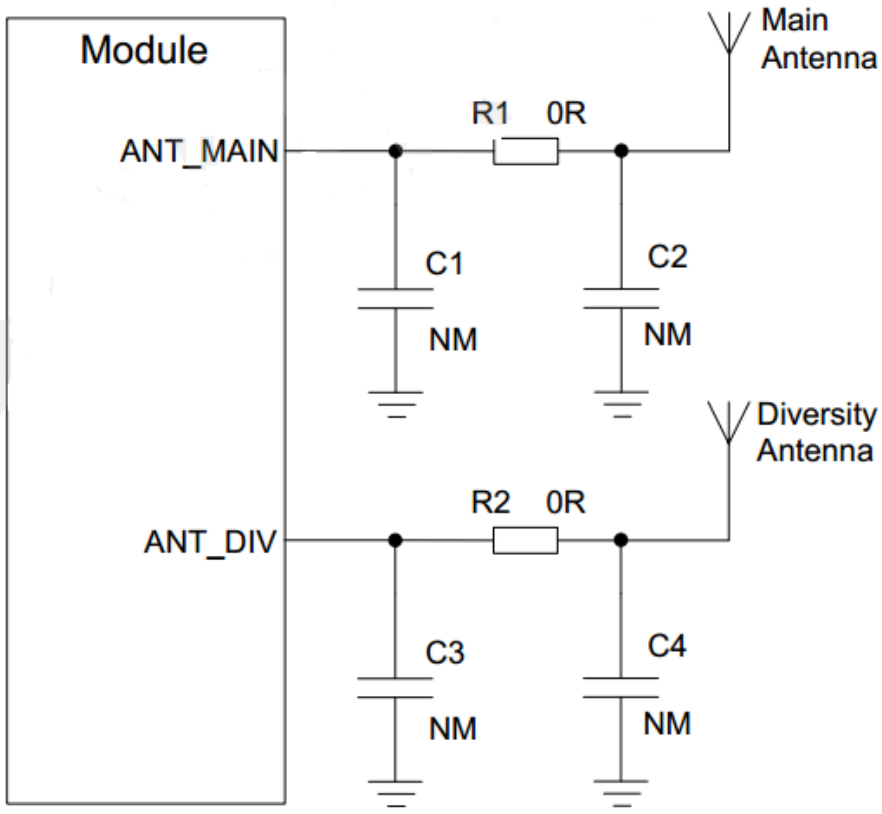


FIGURE 10 ANTENNA INTERFACE

3.2 Antenna Requirement

The requirements for the main antenna, diversity antenna are shown in the following table :

TABLE 14 ANTENNA REQUIREMENTS

Type	Requirements
LTE	VSWR : < 2
	Gain (dBi): 1
	Maximum input power (W): 50
	Input impedance (Ω): 50
	Polarization type: vertical direction
	Cable insertion loss: < 1dB (LTE B20/B28/B31/B72)
	Cable insertion loss: < 1.5dB (LTE B1/B3/B40)

3.3 RF Conductive Performance

TABLE 15 WORK FREQUENCY

LTE B1	1920MHz –1980MHz	2110MHz – 2170MHz	FDD
LTE B3	1710MHz– 1785MHz	1805MHz – 1880MHz	FDD
LTE B7	2500MHz– 2570MHz	2620 MHz–2690 MHz	FDD
LTE B8	880 MHz–915 MHz	925 MHz–960 MHz	FDD
LTE B20	832 MHz–862 MHz	791 MHz–821 MHz	FDD
LTE B28	703 MHz–748 MHz	758 MHz–803 MHz	FDD
LTE B31	452.5MHz– 457.5MHz	462.5MHz– 467.5MHz	FDD
LTE B72	451MHz– 456MHz	461MHz– 466MHz	FDD
LTE B40	2300MHz– 2400MHz	2300MHz– 2400MHz	TDD

TABLE 16 TRANSMIT POWER

Frequency	Max	Min
LTE FDD B1/B3/B7/B8/B20/28/31/72	23dBm±2dB	<-44dBm
LTE TDD B40	23dBm±2dB	<-44dBm

TABLE 17 RECEIVE SENSITIVITY

Frequency	Receive sensitivity	3GPP protocol requirements
LTE-FDD B1 (10M)	<-99dBm	<-96.3dBm
LTE-FDD B3 (10M)	<-98dBm	<-93.3dBm
LTE-FDD B7 (10M)	<-98dBm	<-94.3dBm
LTE-FDD B8 (10M)	<-98dBm	<-93.3dBm
LTE-FDD B20 (10M)	<-98dBm	<-93.3dBm
LTE-FDD B28 (10M)	<-98dBm	<-94.8dBm
LTE-FDD B31 (5M)	<-102dBm*	<-92.8dBm
LTE-FDD B72 (5M)	<-102dBm*	<-92.8dBm
LTE-TDD B40 (10M)	<-99dBm	<-96.3dBm

* GCT450 module achieves the Best RF performance for B31/B72 in 450MHz industry.

4 Electrical Characteristics

4.1 Pin Assignment

Remark :

1 : All reserved and unused pins need to be left floating.

TABLE 18 I/O DEFINITION

Serial No.	Type	Function
1	IO	Bidirectional input/output
2	DI	Digital input
3	DO	Digital output
4	PI	Power input
5	PO	Power output
6	AI	Analog input
7	AO	Analog output
8	OD	Open drain

TABLE 19 PIN FUNCTION

Pin No.	Pin Name	I/O	Function	DC Characteristic	Remark
1	Reserved		Reserved		Must stay vacant
2	VBAT	PI	Module RF power supply	Vmax=4.2V Vmin=3.3V Vnorm=3.8V	The power supply must be able to supply 2.0A
3	Reserved		Reserved		Must stay vacant
4	Ground		Ground		
5	Reserved		Reserved		Must stay vacant
6	Reserved		Reserved		Must stay vacant
7	Reserved		Reserved		Must stay vacant
8	USIM_VDD	PO	(U)SIM Card Power Supply Voltage	**1.8V(U)SIM:** Vmax=1.9V Vmin=1.7V **3.0V(U)SIM:** Vmax=3.05V Vmin=2.7V IOmax=50mA	Module automatically recognizes 1.8V or 3.0V (U) SIM card

9	Ground		Ground		
10	USIM_DATA	IO	(U)SIM Card Data Signal	**1.8V(U)SIM:** VILmax=0.6V VIHmin=1.2V VOLmax=0.45V VOHmin=1.35V **3.0V(U)SIM:** VILmax=1.0V VIHmin=1.95V VOLmax=0.45V VOHmin=2.55V	
11	Reserved		Reserved		Must stay vacant
12	USIM_CLK	DO	(U)SIM card clock signal	**1.8V(U)SIM:** VOLmax=0.45V VOHmin=1.35V **3.0V(U)SIM:** VOLmax=0.45V VOHmin=2.55V	
13	Reserved		Reserved		Must stay vacant
14	USIM_RST	DO	(U) SIM card reset signal	**1.8V(U)SIM:** VOLmax=0.45V VOHmin=1.35V **3.0V(U)SIM:** VOLmax=0.45V VOHmin=2.55V	
15	Ground		Ground		
16	Reserved		Reserved		Must stay vacant
17	Reserved		Reserved		Must stay vacant
18	Ground		Ground		
19	Reserved		Reserved		Must stay vacant
20	Reserved		Reserved		Must stay vacant
21	Ground		Ground		
22	RESET_N	DI	Reset module	VIHmax=2.1V VIHmin=1.2V VILmax=0.6V	
23	Reserved		Reserved		Must stay vacant

24	VBAT	PI	Module RF power supply	Vmax=4.2V Vmin=3.3V Vnorm=3.8V	The power supply must be able to supply 2.0A
25	Reserved		Reserved		Must stay vacant
26	Ground		Ground		
27	Ground		Ground		
28	Reserved		Reserved		Must stay vacant
29	Ground		Ground		
30	TXD	DO	Module sends data	VOLmax=0.6V VOHmin=1.2V	1.8V power domain ; stay vacant if unused.
31	Reserved		Reserved		Must stay vacant
32	RXD	DO	Module receives data	VOLmax=0.6V VOHmin=1.2V	1.8V power domain ; stay vacant if unused.
33	Reserved		Reserved		Must stay vacant
34	Ground		Ground		
35	Ground		Ground		
36	USB_DM	IO	USB differential data negative signal	Compliant with USB 2.0 specification	Requires 90Ω differential impedance
37	Ground		Ground		
38	USB_DP	IO	USB differential data positive signal	Compliant with USB 2.0 specification	Requires 90Ω differential impedance
39	VBAT	PI	Module RF power supply	Vmax=4.2V Vmin=3.3V Vnorm=3.8V	The power supply must be able to supply 2.0A
40	Ground		Ground		
41	VBAT	PI	Module RF power supply	Vmax=4.2V Vmin=3.3V Vnorm=3.8V	The power supply must be able to supply 2.0A
42	NET_MODE	OD	Indicates the network registration status of the module	VOHmin=2.0V VOLmax=0.8V	3.3V,Need external pull-up;stay vacant if unused
43	Ground		Ground		
44	NET_STATUS	OD	Indicates the network operating status of the module	VOHmin=2.0V VOLmax=0.8V	3.3V,Need external pull-up;stay vacant if unused

45	Reserved		Reserved		Must stay vacant
46	STATUS	OD	Indicates the working status of the module	VOHmin=2.0V VOLmax=0.8V	3.3V,Need external pull-up;stay vacant if unused
47	Reserved		Reserved		Must stay vacant
48	Reserved		Reserved		Must stay vacant
49	Reserved		Reserved		Must stay vacant
50	Ground		Ground		
51	Reserved		Reserved		Must stay vacant
52	VBAT	PI	Module RF power supply	Vmax=4.2V Vmin=3.3V Vnorm=3.8V	The power supply must be able to supply 2.0A

4.2 Absolute Maximum Ratings

Attention: The following limits shall not be reached in any circumstance, whether for the time being or reaching individually, otherwise it may cause permanent damage of the module!

TABLE 20 MODULE LIMIT OPERATING VOLTAGE RANGE

Name	Description	Min	Typical	Max	Unit
VBAT	The actual input voltage must be within this range	3.3	3.8	4.2	V
GPIO(1.8V)	Digital IO level	-0.3	1.8	2.0	V
GPIO(3.3V)	Digital IO level	-0.3	3.3	3.5	V
ADC	Analog to digital conversion interface	0.3		VBAT	V

4.3 Work Temperature

The module is recommended to work in the -30~+70°C environment. It is recommended that the application side consider temperature control measures under harsh environmental conditions. At the same time, the extended operating temperature range of the module is provided. Under this temperature condition, some RF indicators may exceed the standard.

TABLE 21 WORK TEMPERATURE

Name	Min	Typical	Max	Unit
Operation temperature	-30	+25	+70	℃
Extended operation temperature	-40		+85	℃

4.4 ESD Characteristics

In the module application, due to static electricity generated by static electricity of the human body and charged friction between microelectronics, discharging to the module through various means may cause certain damage to the module, so ESD protection should be taken seriously. The following table shows the ESD withstand voltage of the module pins:

TABLE 22 ESD PERFORMANCE PARAMETERS

Test point	Contact Discharge	Air Discharge	Unit
VBAT	±4	±8	kV
ANT	±4	±8	kV
Others Interface	±1	±2	kV

5 Mechanical Characteristics

5.1 Mechanical

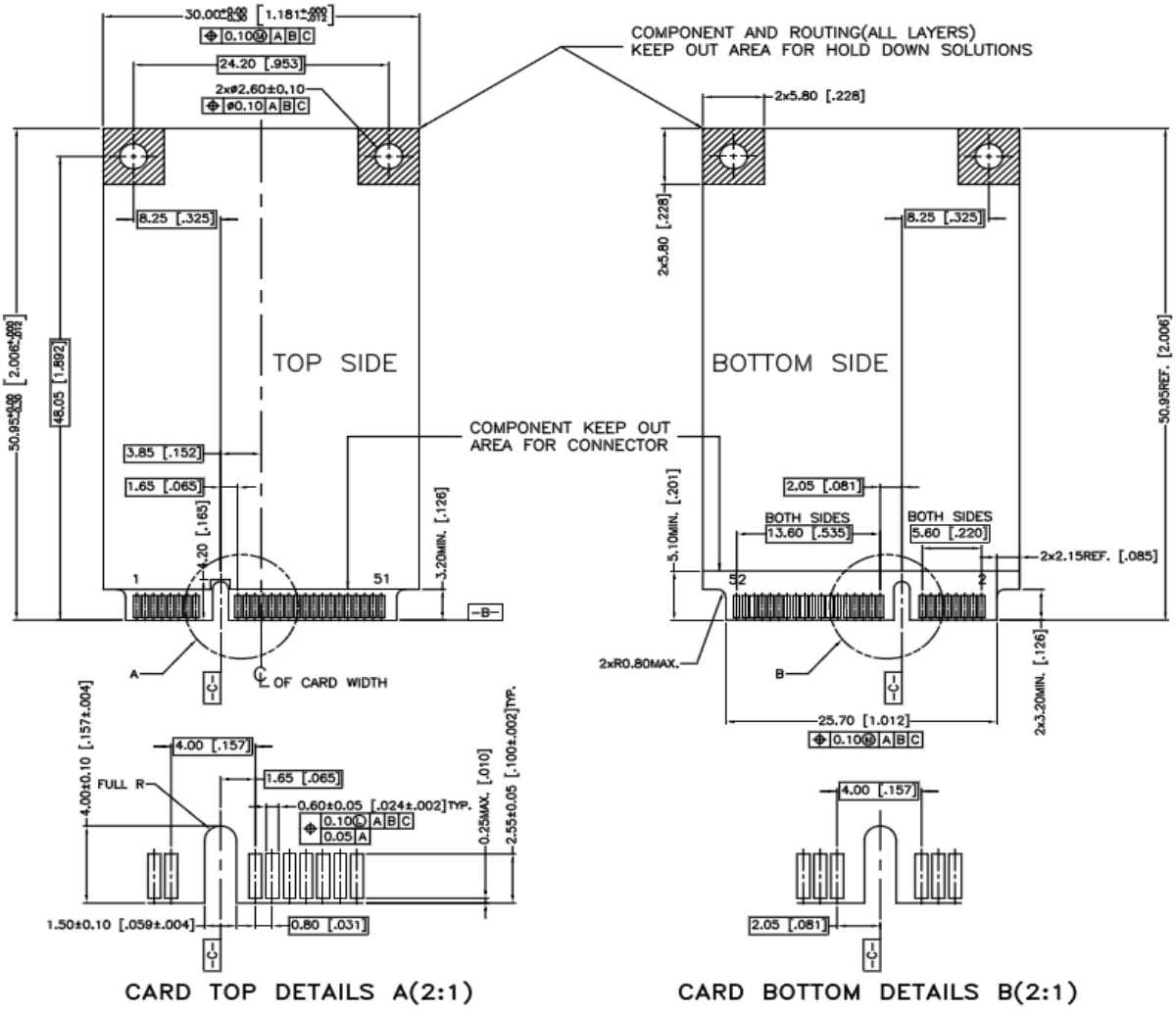
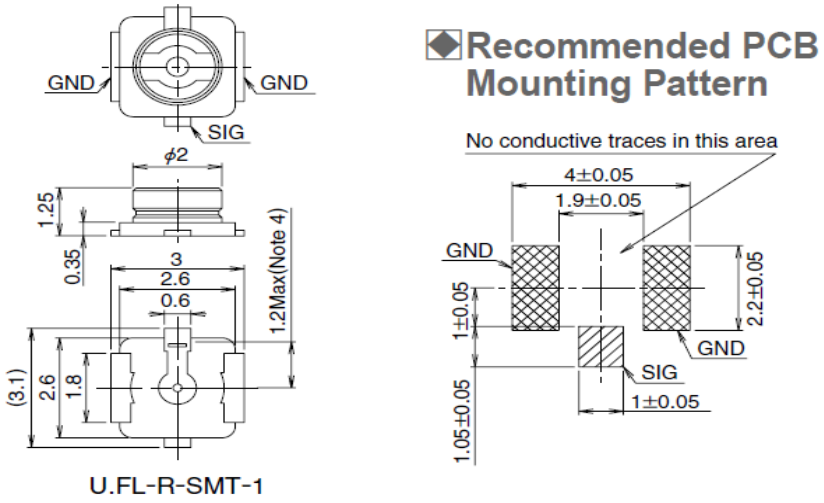


FIGURE 11 MODULE TOP&SIDE VIEW

5.2 Recommend RF Connector



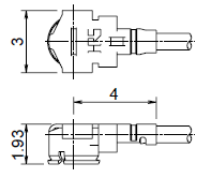
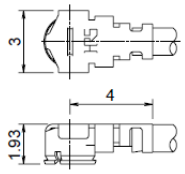
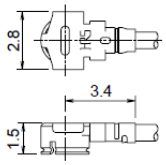
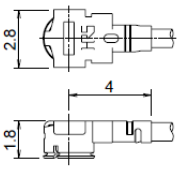
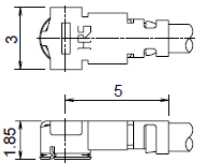
Part No.	U.FL-LP-040	U.FL-LP-066	U.FL-LP(V)-040	U.FL-LP-062	U.FL-LP-088
					
Mated Height	2.5mm Max. (2.4mm Nom.)	2.5mm Max. (2.4mm Nom.)	2.0mm Max. (1.9mm Nom.)	2.4mm Max. (2.3mm Nom.)	2.4mm Max. (2.3mm Nom.)
Applicable cable	Dia. 0.81mm Coaxial cable	Dia. 1.13mm and Dia. 1.32mm Coaxial cable	Dia. 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 12 RECOMMEND FOOTPRINT TOP VIEW

5.3 Mini PCI Express Card Connector

We recommend if there is no space (width X length), then use PCIE connector (SD-67910-001)

If there is a sufficient space, then use PCIE connector (SD-67910-001) and Latch connector (SD-480990-4000). Please visit Molex website for more information of PCIE connector.

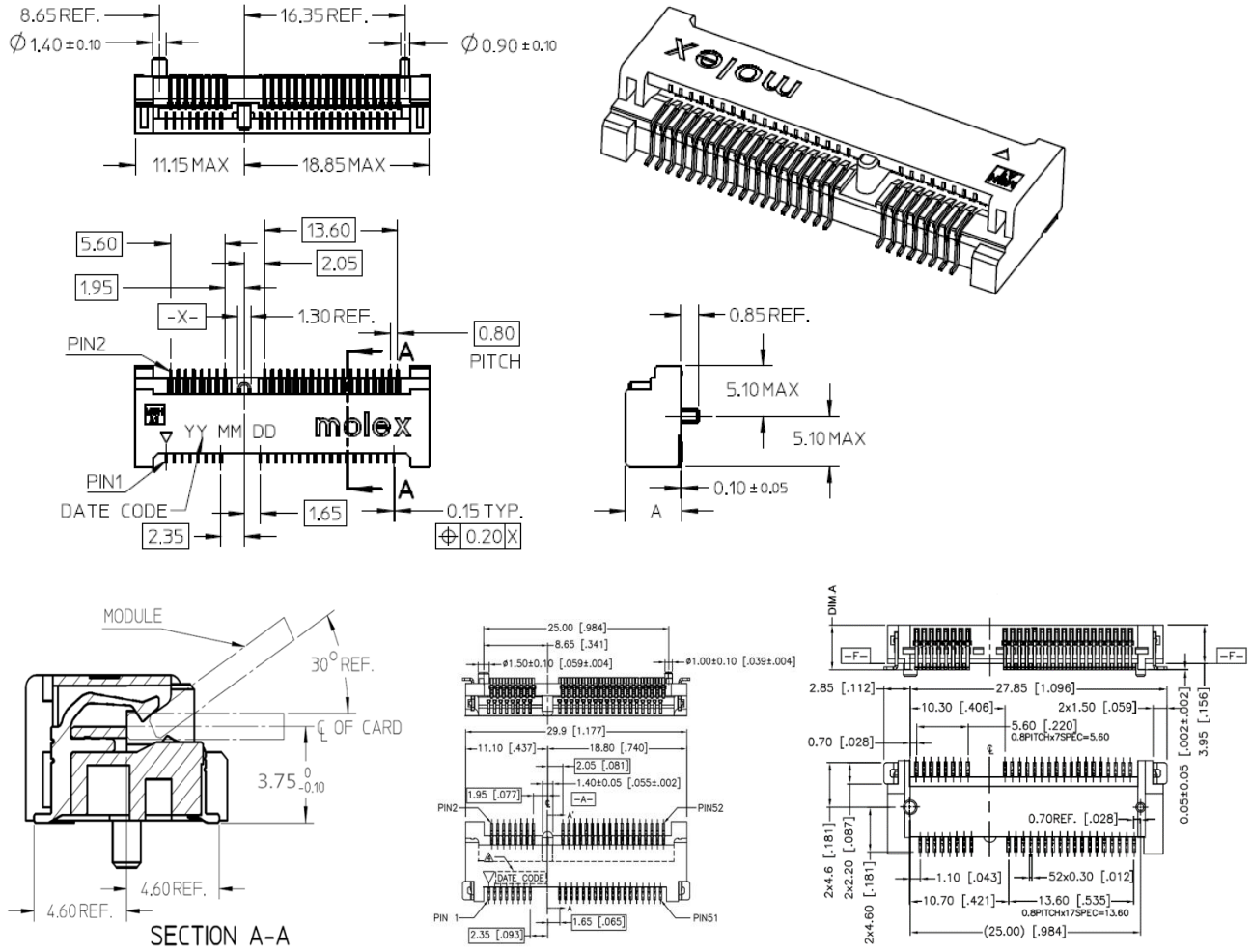
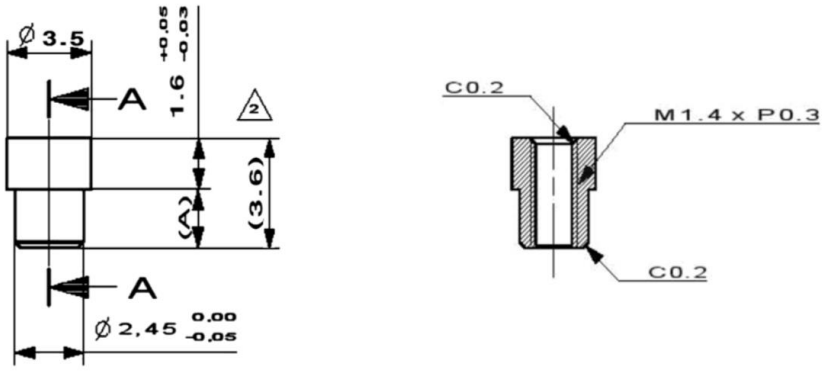


FIGURE 13 RECOMMEND MINIPCIE CONNECTOR



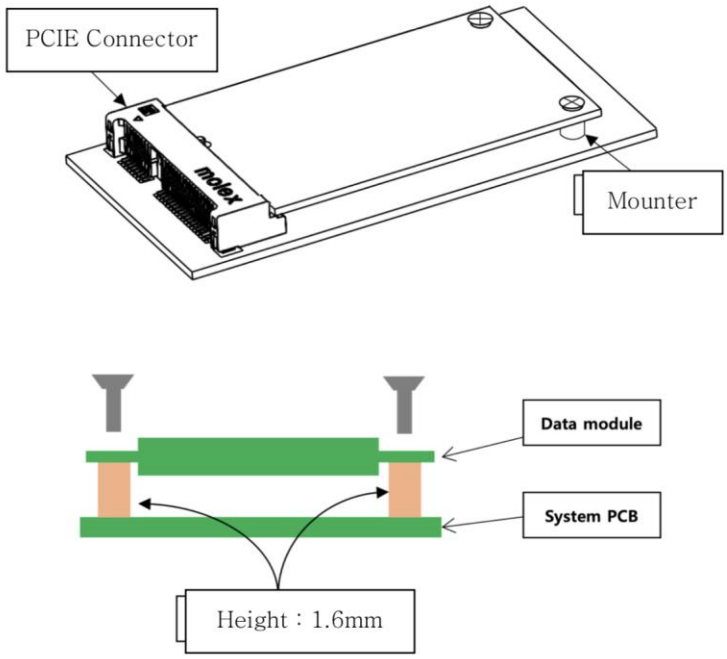
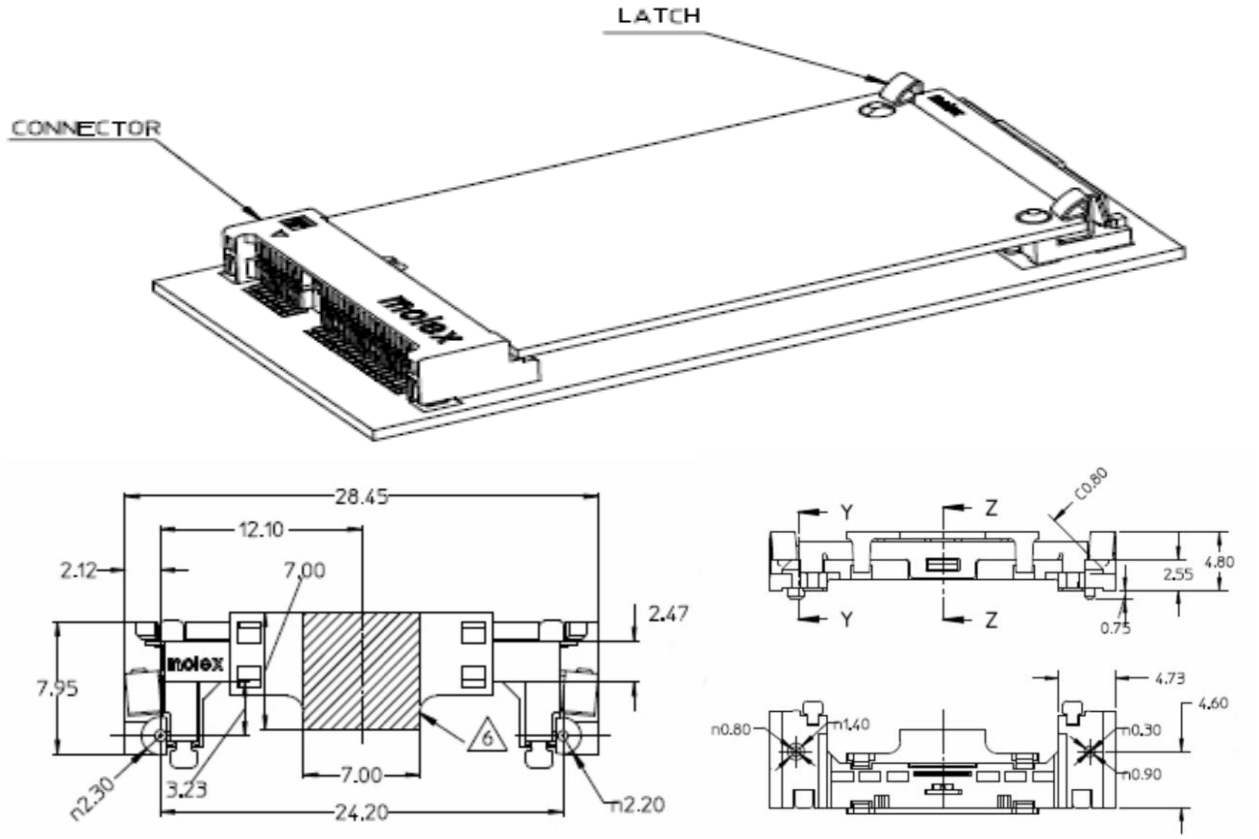


FIGURE 14 RECOMMEND MODULE MOUNTER



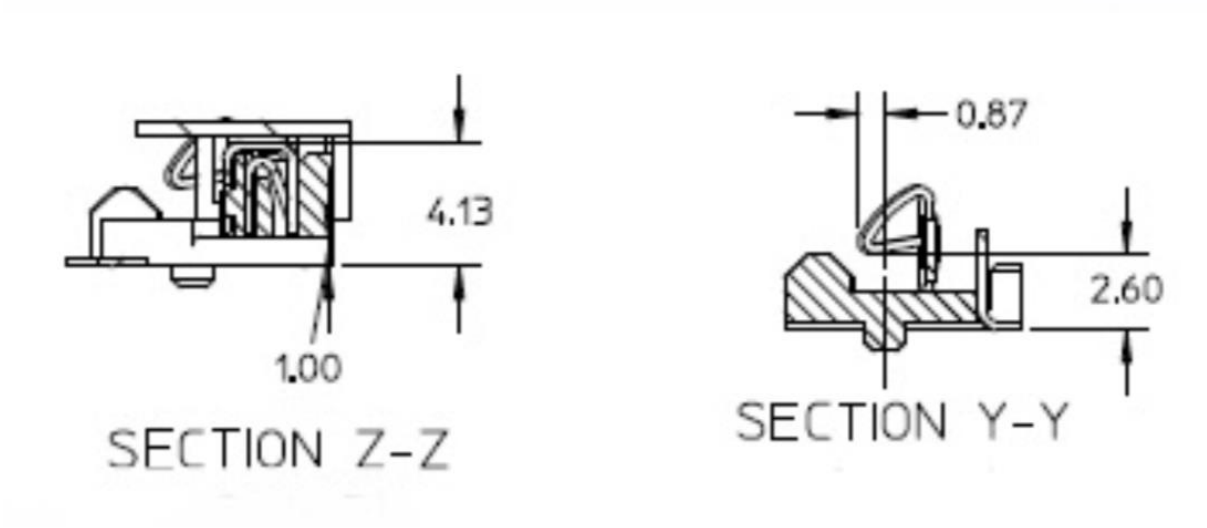


FIGURE 15 RECOMMEND MODULE LATCH

5.4 Recommended System Board Layout

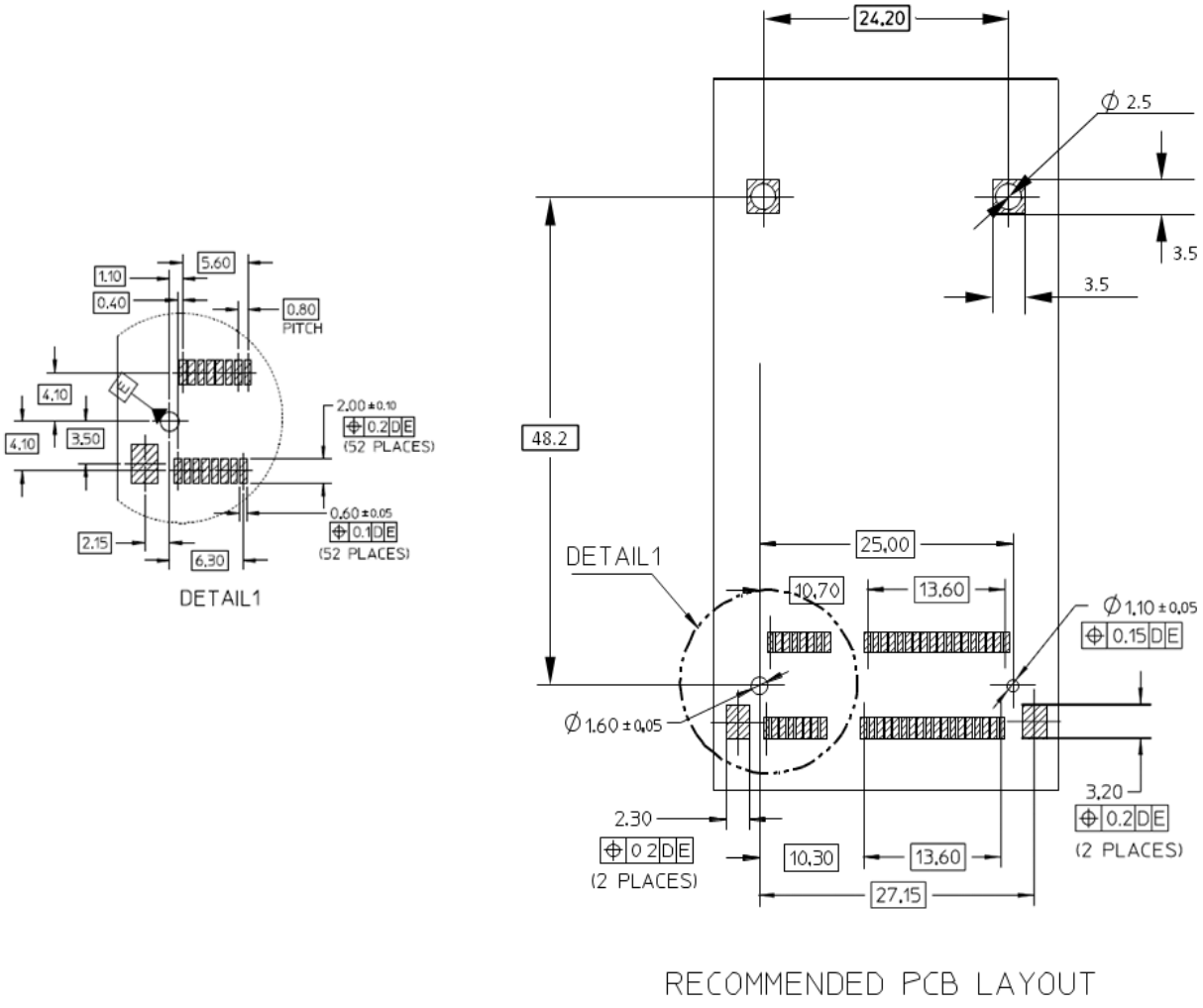


FIGURE 16 RECOMMEND PCB LAYOUT FOR MOUNTER

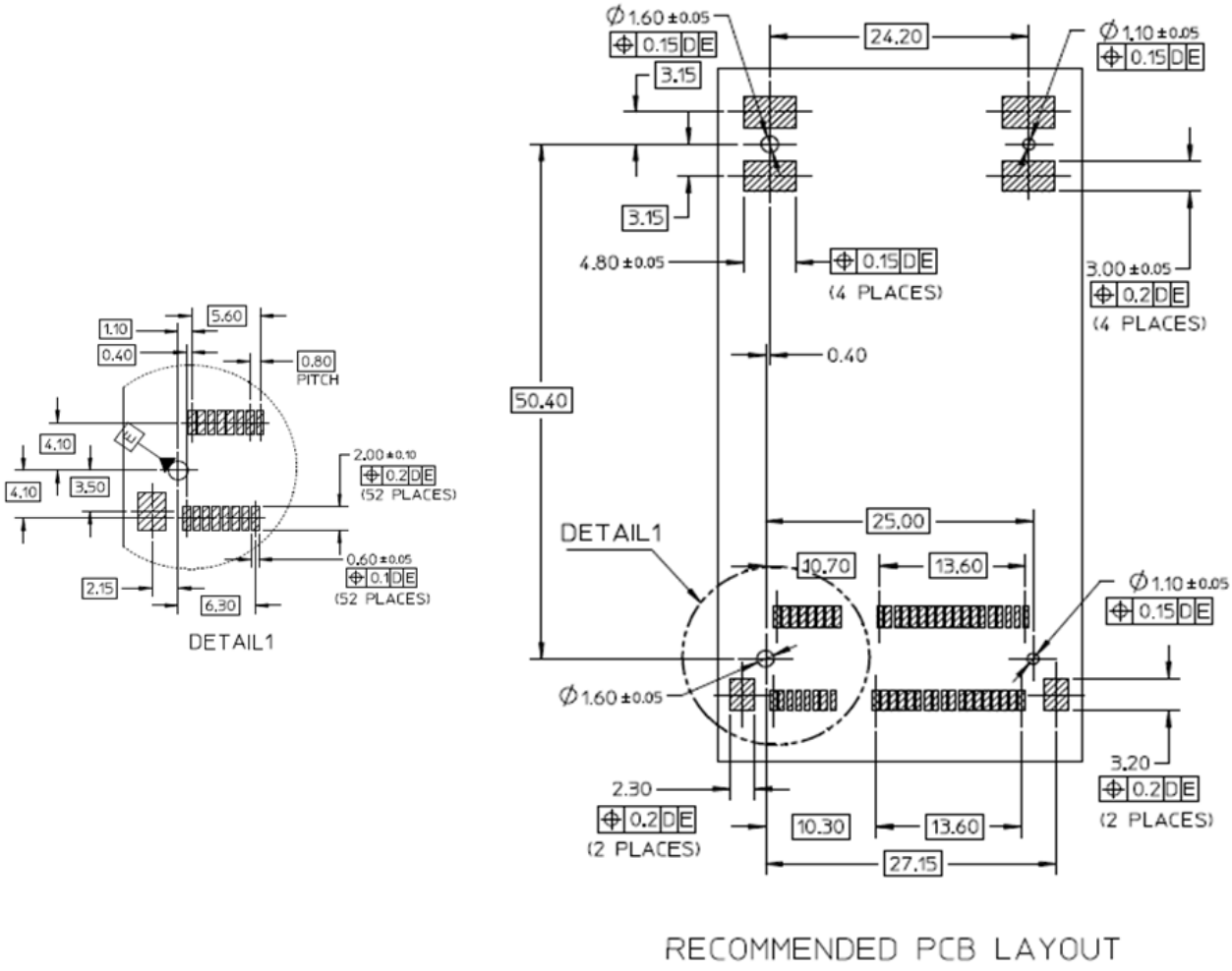


FIGURE 17 RECOMMEND PCB LAYOUT FOR LATCH

5.5 Packaging

One carton box includes 400PCS Module.There are Four small boxes inside, each small box has 10 layers*10pcs/layer=100PCS. Each small box is vacuum package.

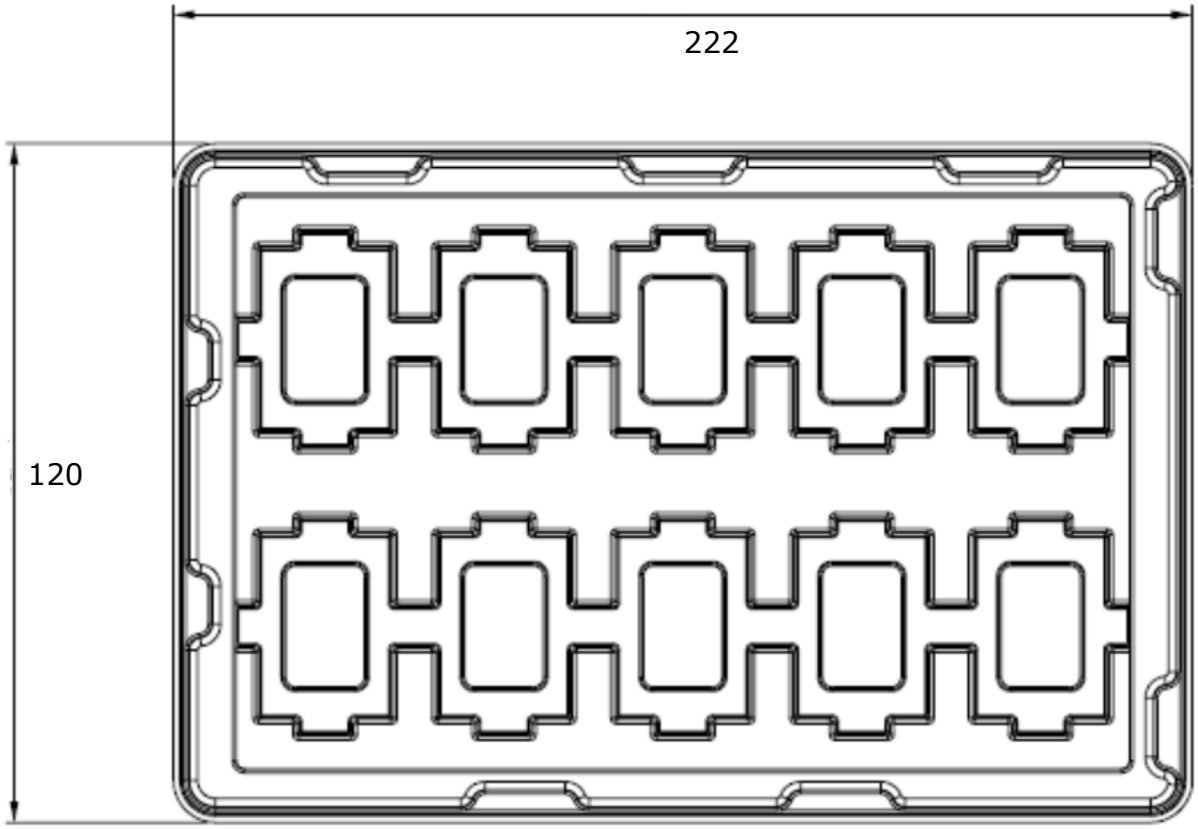


FIGURE 18 GCT450 MODULE TRAY

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