SC650T Hardware Design

Smart LTE Module Series

Rev: SC650T_Hardware_Design_V1.1

Date: 2019-03-01

Status: Preliminary

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About the Document

History

Revision	Date	Author	Description
1.0	2019-02-26	Arsene	Initial

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OEM/Integrators Installation Manual

Important Notice to OEM integrators

1. This module is limited to OEM installation ONLY.
2. This module is limited to installation in mobile or fixed applications, according to Part 2.1091(b).
3. The separate approval is required for all other operating configurations, including portable configurations with respect to Part 2.1093 and different antenna configurations
4. For FCC Part 15.31 (h) and (k): The host manufacturer is responsible for additional testing to verify compliance as a composite system. When testing the host device for compliance with Part 15 Subpart B, the host manufacturer is required to show compliance with Part 15 Subpart B while the transmitter module(s) are installed and operating. The modules should be transmitting and the evaluation should confirm that the module's intentional emissions are compliant (i.e. fundamental and out of band emissions). The host manufacturer must verify that there are no additional unintentional emissions other than what is permitted in Part 15 Subpart B or emissions are complaint with the transmitter(s) rule(s). The Grantee will provide guidance to the host manufacturer for Part 15 B requirements if needed.

End Product Labeling

When the module is installed in the host device, the FCC/IC ID label must be visible through a window on the final device or it must be visible when an access panel, door or cover is easily re-moved. If not, a second label must be placed on the outside of the final device that contains the following text:
Contains FCC ID: XMR2019SC650TNA ”
“Contains IC: 10224A-19SC650TNA
The FCC ID/IC ID can be used only when all FCC/IC compliance requirements are met.

In the event that these conditions cannot be met (for example certain laptop configurations or co-location with another transmitter), then the FCC/IC authorization is no longer considered valid and the FCC ID/IC ID 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/IC authorization.

Manual Information to the End User

The OEM integrator has to be aware not to provide information to the end user regarding how to install or remove this RF module in the user’s manual of the end product which integrates this module. The end user manual shall include all required regulatory information/warning as show in this manual.

Federal Communication Commission Interference Statement

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.
This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can

be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one of the following measures:
- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

Industry Canada Statement

This device complies with Industry Canada’s licence-exempt RSSs. Operation is subject to the following two conditions:
(1) This device may not cause interference; and
(2) This device must accept any interference, including interference that may cause undesired operation of the device.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes:
(1) l'appareil ne doit pas produire de brouillage, et
(2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement."

The device could automatically discontinue transmission in case of absence of information to transmit, or operational failure. Note that this is not intended to prohibit transmission of control or signaling information or the use of repetitive codes where required by the technology.

The device for operation in the band 5150–5250 MHz is only for indoor use to reduce the potential for harmful interference to co-channel mobile satellite systems; The maximum antenna gain permitted for devices in the bands 5250–5350 MHz and 5470–5725 MHz shall comply with the e.i.r.p. limit; and The maximum antenna gain permitted for devices in the band 5725–5825 MHz shall comply with the e.i.r.p. limits specified for point-to-point and non point-to-point operation as appropriate.

L'appareil peut interrompre automatiquement la transmission en cas d'absence d'informations à transmettre ou de panne opérationnelle. Notez que ceci n'est pas destiné à interdire la transmission d'informations de contrôle ou de signalisation ou l'utilisation de codes répétitifs lorsque cela est requis par la technologie.

Le dispositif utilisé dans la bande 5150-5250 MHz est réservé à une utilisation en intérieur afin de réduire le risque de brouillage préjudiciable aux systèmes mobiles par satellite dans le même canal; Le gain d'antenne maximal autorisé pour les dispositifs dans les bandes 5250-5350 MHz et 5470-5725 MHz doit être conforme à la norme e.r.p. limite; et Le gain d'antenne maximal autorisé pour les appareils de la bande 5725-5825 MHz doit être conforme à la norme e.i.r.p. les limites spécifiées pour un fonctionnement

point à point et non point à point, selon le cas
CAN ICES-3(B)/ NMB-3(B)

Radiation Exposure Statement

This equipment complies with FCC/IC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20 cm between the radiator & your body.

This radio transmitter [10224A-19SC650TNA] has been approved by Innovation, Science and Economic Development Canada to operate with the antenna types listed below, with the maximum permissible gain indicated. Antenna types not included in this list that have a gain greater than the maximum gain indicated for any type listed are strictly prohibited for use with this device.

Frequency Bands	**Antenna type**	**Maximun Gain（dBi）**
2.4G WIFI/BT	Dipole	5.38
5G WIFI	Dipole	5.05
LTE B5	Dipole	2.53
LTE B26	Dipole	3.19
LTE B2/25	Dipole	1.59
LTE B14	Dipole	4.45
LTE B4/66	Dipole	2
LTE B7	Dipole	3
LTE B12	Dipole	3.95
LTE B13	Dipole	4.45

1 Introduction

This document defines the SC650T module and describes its air interface and hardware interface which are connected with customers' applications.

This document can help customers quickly understand module interface specifications, electrical and mechanical details as well as other related information of SC650T module. Associated with application note and user guide, customers can use SC650T module to design and set up mobile applications easily.

1.1. Safety Information

The following safety precautions must be observed during all phases of operation, such as usage, service or repair of any cellular terminal or mobile incorporating SC650T module. Manufacturers of the cellular terminal should send the following safety information to users and operating personnel, and incorporate these guidelines into all manuals supplied with the product. If not so, Quectel assumes no liability for customers' failure to comply with these precautions.

	Full attention must be given to driving at all times in order to reduce the risk of an accident. Using a mobile while driving (even with a handsfree kit) causes distraction and can lead to an accident. Please comply with laws and regulations restricting the use of wireless devices while driving.
	Switch off the cellular terminal or mobile before boarding an aircraft. The operation of wireless appliances in an aircraft is forbidden to prevent interference with communication systems. If the device offers an Airplane Mode, then it should be enabled prior to boarding an aircraft. Please consult the airline staff for more restrictions on the use of wireless devices on boarding the aircraft.
	Wireless devices may cause interference on sensitive medical equipment, so please be aware of the restrictions on the use of wireless devices when in hospitals, clinics or other healthcare facilities.
	Cellular terminals or mobiles operating over radio signals and cellular network cannot be guaranteed to connect in all possible conditions (for example, with unpaid bills or with an invalid (U)SIM card). When emergent help is needed in such conditions, please remember using emergency call. In order to make or receive a call, the cellular terminal or mobile must be switched on in a service area with adequate cellular signal strength.
	The cellular terminal or mobile contains a transmitter and receiver. When it is ON, it receives and transmits radio frequency signals. RF interference can occur if it is used close to TV set, radio, computer or other electric equipment.
	In locations with potentially explosive atmospheres, obey all posted signs to turn off wireless devices such as your phone or other cellular terminals. Areas with potentially explosive atmospheres include fuelling areas, below decks on boats, fuel or chemical transfer or storage facilities, areas where the air contains chemicals or particles such as grain, dust or metal powders, etc.

2 Product Concept

2.1. General Description

SC650T is a series of Smart LTE module based on Qualcomm platform and Android operating system, and provides industrial grade performance. Its general features are listed below:

- Support worldwide LTE-FDD
- Support short-range wireless communication via Wi-Fi 802.11a/b/g/n/ac and BT4.2 LE standards
- Integrate GPS/GLONASS/BeiDou satellite positioning systems
- Support multiple audio and video codecs
- Built-in high performance Adreno™ 506 graphics processing unit
- Provide multiple audio and video input/output interfaces as well as abundant GPIO interfaces

SC650T includes models such as SC650T-NA and SC650T-EM.

The following table shows the supported frequency bands of SC650T.

Table 1: SC650T-NA Frequency Bands

Type	Frequency Bands
LTE-FDD	B2/B4/B5/B7/B12/B13/B14/B25/B26/B66
Wi-Fi 802.11a/b/g/n/ac	2402MHz~2482MHz; 5180MHz~5825MHz
BT4.2 LE	2402MHz~2480MHz
GNSS	GPS: 1575.42MHz±1.023MHz GLONASS: 1597.5MHz~1605.8MHz BeiDou: 1561.098MHz±2.046MHz

Table 2: SC650T-EM Frequency Bands

Type	Frequency Bands

LTE-FDD	B1/B3/B7/B20/B28
Wi-Fi 802.11a/b/g/n/ac	2402MHz~2482MHz; 5180MHz~5825MHz
BT4.2 LE	2402MHz~2480MHz
GNSS	GPS: 1575.42MHz±1.023MHz GLONASS: 1597.5MHz~1605.8MHz BeiDou: 1561.098MHz±2.046MHz

SC650T is an SMD type module which can be embedded into applications through its 323 pins (including 152 LCC pads and 171 LGA pads). With a compact profile of 43.0mm × 44.0mm × 2.85mm, SC650T can meet almost all requirements for M2M applications such as smart metering, smart home, security, routers, wireless POS, mobile computing devices, PDA phone, tablet PC, etc.

2.2. Key Features

The following table describes the detailed features of SC650T module.

Table 3: SC650T Key Features

Features	Details
Application Processor	**SC650T** Octa-core ARM Cortex-A53 64-bit CPU @2.0GHz (high performance) ● One quad-core with 1MB L2 cache ● One quad-core with 512KB L2 cache
Modem system	Hexagon DSP v56 core up to 850MHz 768KB L2 cache
GPU	**SC650T** Adreno™ 506 with 64-bit addressing, designed for 650MHz
Memory	16GB eMMC + 2GB LPDDR3 (default) 32GB eMMC + 4GB LPDDR3 (optional)
Operating System	Android OS 9.0
Power Supply	VBAT Supply Voltage: 3.55V~4.4V Typical 3.8V
Transmitting Power	Class 3 (23dBm±2dB) for LTE-FDD bands
LTE Features	Support 3GPP R8 Cat 4 Support 1.4 to 20MHz RF bandwidth Support Multiuser MIMO in DL direction

	● Cat 4 FDD: Max 150Mbps (DL)/Max 50Mbps (UL)
WLAN Features	2.4GHz/5GHz, support 802.11a/b/g/n/ac, maximally up to 433Mbps Support AP and STA mode
Bluetooth Features	BT4.2 LE
GNSS Features	GPS/GLONASS/BeiDou
SMS	Text and PDU mode Point-to-point MO and MT SMS cell broadcast
LCM Interfaces	Support two groups of 4-lane MIPI_DSI Support dual LCDs Support WUXGA up to (1920×1200) at 60fps
Camera Interfaces	Support two groups of 4-lane MIPI_CSI, up to 2.1Gbps per lane Support 2 cameras (4-lane + 4-lane) or 3 cameras (4-lane + 4-lane + 2-lane) up to 24MP with dual ISP
Video Codec	**SC650T** Video encoding and decoding: up to 4K @30fps, up to 1080P @60fps Wi-Fi Video: encoding up to 1080P @30fps; decoding up to 1080P @60fps
Audio Interfaces	**Audio Input:** Two analog microphone inputs, two digital microphone inputs, integrating internal bias voltage **Audio Output:** Class AB stereo headphone output Class AB earpiece differential output
Audio Codec	G711, QCELP, EVRC, EVRC-B, EVRC-WB, AMR-NB, AMR-WB, GSM-EFR, GSM-FR, GSM-HR
USB Interface	Compliant with USB 3.0 and 2.0 specifications, with transmission rates up to 5Gbps on USB 3.0 and 480Mbps on USB 2.0. Support USB OTG Used for AT command communication, data transmission, software debugging and firmware upgrade
UART Interfaces	4 UART Interfaces: UART5, UART6, UART4 and UART2 ● UART5 & UART6: 4-wire UART interface with RTS/CTS hardware flow control, baud rate up to 4Mbps ● UART4: 2-wire UART interface ● UART2: 2-wire UART interface used for debugging
Vibrator drive interface	Drive ERM vibrator
SD Card Interface	Support SD 3.0 Support SD card hot-plug
(U)SIM Interfaces	2 (U)SIM interfaces Support USIM/SIM card: 1.8V/2.95V

	Support Dual SIM Dual Standby (supported by default)
I2C Interfaces	Five I2C interfaces, used for peripherals such as TP, camera, sensor, etc.
I2S Interface	Support for I2S peripherals
Flashlight Interface	2 high current Flash and torch LED driver ● 1A for Flash mode and 300mA for torch mode by default ● 1.5A for Flash mode and 300mA for torch mode maximally
ADC Interfaces	2 general purpose ADC interfaces Support up to 15-bit sampling accuracy
SPI Interfaces	2 SPI interfaces, only support master mode ● One SPI interface used for peripheral device One SPI interface used for sensor application, such as fingerprint sensors
Charging Interface	Used for battery voltage detection, fuel gauge, battery temperature detection
Real Time Clock	Supported
Antenna Interfaces	Main antenna, Rx-diversity antenna, GNSS antenna and Wi-Fi/BT antenna interfaces
Physical Characteristics	Size: (43.0±0.15)mm × (44.0±0.15)mm × (2.85±0.2)mm Package: LCC + LGA Weight: approx. 13.0g
Temperature Range	Operating temperature range: -35°C ~ +65°C [1)] Extended temperature range: -40°C ~ +75°C [2)] Storage temperature range: -40°C ~ +90°C
Firmware Upgrade	Over USB interface
RoHS	All hardware components are fully compliant with EU RoHS directive

NOTES

1. [1)] Within operation temperature range, the module is 3GPP compliant.
2. [2)] Within extended temperature range, the module remains the ability to establish and maintain a voice, SMS, data transmission, emergency call, etc. There is no unrecoverable malfunction. There are also no effects on radio spectrum and no harm to radio network. Only one or more parameters like P_{out} might reduce in their value and exceed the specified tolerances. When the temperature returns to the normal operating temperature levels, the module will meet 3GPP specifications again.

2.3. Evaluation Board

In order to help customers develop applications with SC650T conveniently, Quectel supplies the evaluation board, USB to RS232 converter cable, USB Type-C data cable, power adapter, earphone, antenna and other peripherals to control or test the module. For more details, please refer to ***document [1]***.

3 Application Interfaces

3.1. General Description

SC650T is equipped with 323-pin 1.0mm pitch SMT pads that can be embedded into cellular application platform. The following chapters provide the detailed description of pins/interfaces listed below.

- Power supply
- VRTC interface
- Charging interface
- USB interface
- UART interfaces
- (U)SIM interfaces
- SD card interface
- GPIO interfaces
- I2C interfaces
- I2S interfaces
- SPI interfaces
- ADC interfaces
- Vibrator drive interface
- LCM interfaces
- TP (touch panel) interfaces
- Camera interfaces
- Flashlight interfaces
- Sensor interfaces
- Audio interfaces
- Emergency download interface
- LED sink driver interfaces

3.2. Pin Assignment

The following figure shows the pin assignment of SC650T module.

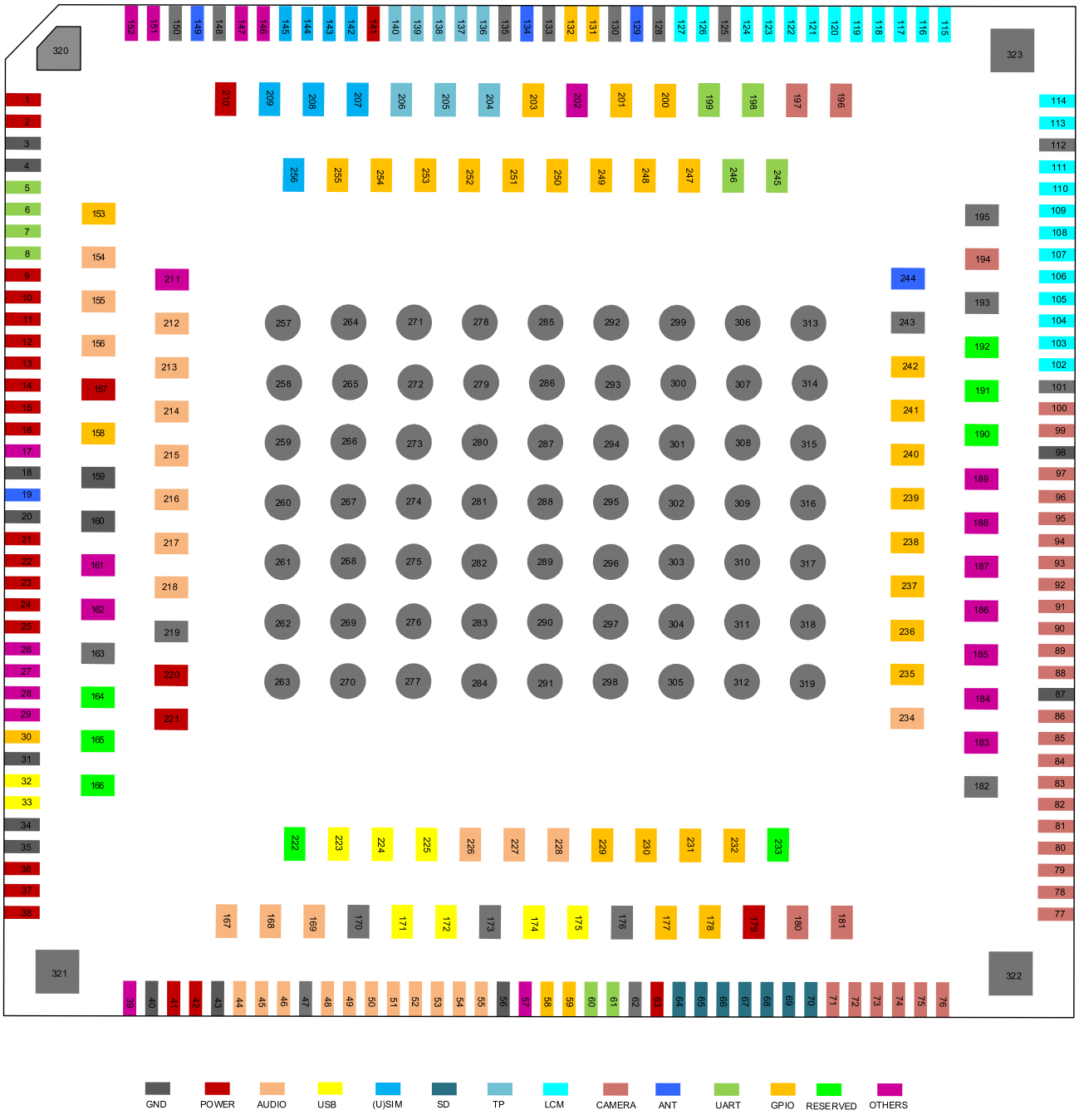


Figure 1: Pin Assignment (Top View)

3.3. Pin Description

Table 4: I/O Parameters Definition

Type	Description
IO	Bidirectional
DI	Digital input
DO	Digital output
PI	Power input
PO	Power output
AI	Analog input
AO	Analog output
OD	Open drain

The following tables show the SC650T's pin definition and electrical characteristics.

Table 5: Pin Description

Power Supply					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
VBAT	36，37，38	PI/PO	Power supply for the battery.	Vmax=4.4V Vmin=3.55V Vnorm=3.8V	It must be able to provide sufficient current up to 3.0A. It is suggested to use a TVS to increase voltage surge withstand capability.
VDD_RF	1，2	PO	Connect to external bypass capacitors to eliminate voltage fluctuation of RF part.	Vmax=4.4V Vmin=3.55V Vnorm=3.8V	Do not load externally.
VPH_PWR	220,221	PO	Power supply for the	Vmax=4.4V	Peripheral power

			module.	Vmin=3.55V Vnorm=3.8V	interface
VRTC	16	PI/PO	Power supply for internal RTC circuit	$V_O$max=3.2V V_I=2.0V~3.25V	
LDO5_1P8	9	PO	1.8V output power supply	Vnorm=1.8V $I_O$max=20mA	Power supply for external GPIO's pull up circuits and level shift circuit.
LDO10_2P8	11	PO	2.8V output power supply	Vnorm=2.8V $I_O$max=150mA	Power supply for VDD of sensors and TPs. Add a 1.0uF~4.7uF bypass capacitor if used. If unused, keep this pin open.
LDO6_1P8	10	PO	1.8V output power supply	Vnorm=1.8V $I_O$max=300mA	Power supply for I/O VDD of cameras, LCDs and sensors. Add a 1.0uF~2.2uF bypass capacitor if used. If unused, keep this pin open.
LDO17_2P85	12	PO	2.85V output power supply	Vnorm=2.85V $I_O$max=300mA	Power supply for cameras and LCDs. Add a 1.0uF~4.7uF bypass capacitor if used. If unused, keep this pin open.
LDO13_3P075	157	PO	13.125V output power supply	Vnorm=3.125V $I_O$max=150mA	Power supply for USB Add a 1.0uF~4.7uF bypass capacitor if used. If unused, keep this pin open.
LDO23_1P2	15	PO	1.2V output power supply	Vnorm=1.2V $I_O$max=600mA	Power supply for DVDD of front cameras. Add a 1.0uF~2.2uF bypass capacitor if

					used. If unused, keep this pin open.
LDO2_1P1	13	PO	1.1V output power supply	Vnorm=1.1V $I_O$max=1200mA	Power supply for DVDD of rear cameras. Add a 1.0uF~2.2uF bypass capacitor if used. If unused, keep this pin open.
LDO22_2P8	14	PO	2.8V output power supply	Vnorm=2.8V $I_O$max=150mA	Power supply for AVDD of cameras. Add a 1.0uF~4.7uF bypass capacitor if used. If unused, keep this pin open.
GND	3,4,18,20,31,34,35,40,43,47,56,62,87,98,101,112,125,128,130,133,135,148,150,159,160,163,170,173,176,182,193,195,219,243,257--323		Ground		

Audio Interfaces

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
DMIC1_DATA	45	DI	Digital microphone1 data		
DMIC1_CLK	46	DO	Digital microphone1 clock		
DMIC2_DATA	168	DI	Digital microphone2 data		
DMIC2_CLK	169	DO	Digital microphone2 clock		

MIC_BIAS1	44	AO	Microphone bias voltage	V_O=1.6V~2.85V	Dias voltage for DMIC1
MIC_BIAS2	233	AO	Microphone bias voltage	V_O=1.6V~2.85V	Dias voltage for AMIC2
MIC_BIAS3	167	AO	Microphone bias voltage	V_O=1.6V~2.85V	Dias voltage for DMIC2
LINE_OUT_3	228	AO	Audio output		
LINE_OUT_REF	227	AI	Audio output reference ground		
LINE_OUT_4	226	AO	Audio output		
AMIC1_P	218	AI	Analog microphone positive input for channel 1		
AMIC1_M	217	AI	Analog microphone negative input for channel 1		
AMIC2_P	216	AI	Analog microphone positive input for headset		
AMIC2_M	215	AI	Analog microphone negative input for headset		
EAR_P	53	AO	Earpiece positive output		
EAR_N	52	AO	Earpiece positive output		
PDM_CLK	55	AO	External audio power amplifier clock interface		
PDM_DATA	54	AO	External audio power amplifier data interface		
WSA_EN	230	DO	External audio power amplifier enable signal		
HPH_R	51	AO	Headphone right channel output		
HPH_REF	50	AI	Headphone reference ground		
HPH_L	49	AO	Headphone left channel output		

HS_DET	48	AI	Headset insertion detection		Pulled up internally.
USB Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
USB_VBUS	41，42	PI/PO	Charging power input. Power supply output for OTG device. USB/charger insertion detection.	Vmax=10V Vmin=4V Vnorm=5.0V	
USB_DM	33	IO	USB 2.0 differential data bus (minus)	USB 2.0 standard compliant	90Ω differential impedance.
USB_DP	32	IO	USB 2.0 differential data bus (plus)		
USB_SS_RX_P	171	AI	USB 3.0 differential receive (plus)	USB 3.0 standard compliant	90Ω differential impedance.
USB_SS_RX_M	172	AI	USB 3.0 differential receive (minus)		
USB_SS_TX_P	174	AO	USB 3.0 differential transmit (plus)		90Ω differential impedance.
USB_SS_TX_M	175	AO	USB 3.0 differential transmit (minus)		
USBC_CC2	223	AI/AO	USB Type-C control configuration channel 2		
USBC_CC1	224	AI/AO	USB Type-C control configuration channel 1		
CC_OUT	225	AO	USB Type-C switch control		
(U)SIM Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
USIM1_DET	145	DI	(U)SIM1 card hot-plug detection	V_{IL}max=0.63V V_{IH}min=1.17V	Active Low. Require external pull-up to 1.8V. If unused, keep this pin open. Disabled by default, and can be enabled

					through software configuration.
USIM1_RST	144	DO	(U)SIM1 card reset signal	V_{OL}max=0.4V V_{OH}min= 0.8 × USIM1_VDD	
USIM1_CLK	143	DO	(U)SIM1 card clock signal	V_{OL}max=0.4V V_{OH}min= 0.8 × USIM1_VDD	
USIM1_DATA	142	IO	(U)SIM1 card data signal	V_{IL}max= 0.2 × USIM1_VDD V_{IH}min= 0.7 × USIM1_VDD V_{OL}max=0.4V V_{OH}min= 0.8 × USIM1_VDD	
USIM1_VDD	141	PO	(U)SIM1 card power supply	**1.8V (U)SIM：** Vmax=1.85V Vmin=1.75V **2.95V (U)SIM：** Vmax=3.1V Vmin=2.8V	Either 1.8V or 2.95V (U)SIM card is supported.
USIM2_DET	256	DI	(U)SIM2 card detection	V_{IL}max=0.63V V_{IH}min=1.17V	Active Low. Need external pull-up to 1.8V. If unused, keep this pin open. Disabled by default, and can be enabled through software configuration.
USIM2_RST	207	DO	(U)SIM2 card reset signal	V_{OL}max=0.4V V_{OH}min= 0.8 × USIM2_VDD	
USIM2_CLK	208	DO	(U)SIM2 card clock signal	V_{OL}max=0.4V V_{OH}min= 0.8 × USIM2_VDD	
USIM2_DATA	209	IO	(U)SIM2 card data signal	V_{IL}max= 0.2 × USIM2_VDD V_{IH}min= 0.7 × USIM2_VDD V_{OL}max=0.4V V_{OH}min=	

				0.8 × USIM2_VDD	
USIM2_VDD	210	PO	(U)SIM2 card power supply	**1.8V (U)SIM：** Vmax=1.85V Vmin=1.75V **2.95V (U)SIM：** Vmax=3.1V Vmin=2.8V	Either 1.8V or 2.95V (U)SIM card is supported.
UART Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
UART2_TXD	5	DO	UART2 transmit data. Debug port by default.	V_{OL}max=0.45V V_{OH}min=1.35V	1.8V power domain. If unused, keep these pins open.
UART2_RXD	6	DI	UART2 receive data. Debug port by default.	V_{IL}max=0.63V V_{IH}min=1.17V	
UART4_TXD	7	DO	UART4 transmit data	V_{OL}max=0.45V V_{OH}min=1.35V	
UART4_RXD	8	DI	UART4 receive data	V_{IL}max=0.63V V_{IH}min=1.17V	
UART5_RXD	198	DI	UART5 receive data	V_{IL}max=0.63V V_{IH}min=1.17V	
UART5_TXD	199	DO	UART5 transmit data	V_{OL}max=0.45V V_{OH}min=1.35V	
UART5_RTS	245	DO	UART5 request to send	V_{OL}max=0.45V V_{OH}min=1.35V	
UART5_CTS	246	DI	UART5 clear to send	V_{IL}max=0.63V V_{IH}min=1.17V	
UART6_RXD	61	DI	UART6 receive data	V_{IL}max=0.63V V_{IH}min=1.17V	
UART6_TXD	60	DO	UART6 transmit data	V_{OL}max=0.45V V_{OH}min=1.35V	
SD Card Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
SD_CLK	70	DO	High speed digital clock signal of SD card	**1.8V SD card：** V_{OL}max=0.45V V_{OH}min=1.4V	

				2.95V SD card: V_{OL}max=0.37V V_{OH}min=2.2V	
SD_CMD	69	IO	Command signal of SD card	**1.8V SD card:** V_{IL}max=0.58V V_{IH}min=1.27V V_{OL}max=0.45V V_{OH}min=1.4V **2.95V SD card:** V_{IL}max=0.73V V_{IH}min=1.84V V_{OL}max=0.37V V_{OH}min=2.2V	
SD_DATA0	68	IO	High speed bidirectional digital signal lines of SD card	**1.8V SD card:** V_{IL}max=0.58V V_{IH}min=1.27V V_{OL}max=0.45V V_{OH}min=1.4V **2.95V SD card:** V_{IL}max=0.73V V_{IH}min=1.84V V_{OL}max=0.37V V_{OH}min=2.2V	
SD_DATA1	67	IO			
SD_DATA2	66	IO			
SD_DATA3	65	IO			
SD_DET	64	DI	SD card insertion detection	V_{IL}max=0.63V V_{IH}min=1.17V	Active low.
SD_LDO11	63	PO	Power supply for SD card	Vnorm=2.95V $I_O$max=800mA	
SD_LDO12	179	PO	1.8V/2.95V output	Vnorm=1.8V/2.95 V $I_O$max=50mA	Power supply for SD card's pull-up circuit.
TP (Touch Panel) Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
TP0_RST	138	DO	Reset signal of touch panel (TP0)	V_{OL}max=0.45V V_{OH}min=1.35V	1.8V power domain. Active low.
TP0_INT	139	DI	Interrupt signal of touch panel (TP0)	V_{IL}max=0.63V V_{IH}min=1.17V	1.8V power domain.
TP0_I2C_SCL	140	OD	I2C clock signal of touch panel (TP0)		1.8V power domain.

TP0_I2C_SDA	206	OD	I2C data signal of touch panel (TP0)		1.8V power domain.
TP1_RST	136	DO	Reset signal of touch panel (TP1)	V_{OL}max=0.45V V_{OH}min=1.35V	1.8V power domain. Active low.
TP1_INT	137	DI	Interrupt signal of touch panel (TP1)	V_{IL}max=0.63V V_{IH}min=1.17V	1.8V power domain.
TP1_I2C_SDA	204	OD	I2C data signal of touch panel (TP1)		1.8V power domain.
TP1_I2C_SCL	205	OD	I2C clock signal of touch panel (TP1)		1.8V power domain.
LCM Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
LCD_BIAS_P	21	PO	LCD positive bias voltage.		
LCD_BIAS_N	22	AI	LCD negative bias voltage.		
WLED_EN	158	DO	LCD enable for backlight.		
WLED_PWM	30	DO	PWM signal output		
LCD0_RST	127	DO	LCD0 reset signal	V_{OL}max=0.45V V_{OH}min=1.35V	1.8V power domain. Active low.
LCD0_TE	126	DI	LCD0 tearing effect signal	V_{IL}max=0.63V V_{IH}min=1.17V	1.8V power domain.
LCD1_RST	113	DO	LCD1 reset signal	V_{OL}max=0.45V V_{OH}min=1.35V	1.8V power domain. Active low.
LCD1_TE	114	DI	LCD1 tearing effect signal	V_{IL}max=0.63V V_{IH}min=1.17V	1.8V power domain.
DSI0_CLK_N	116	AO	LCD0 MIPI clock signal (negative)		
DSI0_CLK_P	115	AO	LCD0 MIPI clock signal (positive)		
DSI0_LN0_N	118	AO	LCD0 MIPI lane 0 data signal (negative)		
DSI0_LN0_P	117	AO	LCD0 MIPI lane 0 data signal (positive)		
DSI0_LN1_N	120	AO	LCD0 MIPI lane 1 data signal (negative)		

DSI0_LN1_P	119	AO	LCD0 MIPI lane 1 data signal (positive)
DSI0_LN2_N	122	AO	LCD0 MIPI lane 2 data signal (negative)
DSI0_LN2_P	121	AO	LCD0 MIPI lane 2 data signal (positive)
DSI0_LN3_N	124	AO	LCD0 MIPI lane 3 data signal (negative)
DSI0_LN3_P	123	AO	LCD0 MIPI lane 3 data signal (positive)
DSI1_CLK_N	103	AO	LCD1 MIPI clock signal (negative)
DSI1_CLK_P	102	AO	LCD1 MIPI clock signal (positive)
DSI1_LN0_N	105	AO	LCD1 MIPI lane 0 data signal (negative)
DSI1_LN0_P	104	AO	LCD1 MIPI lane 0 data signal (positive)
DSI1_LN1_N	107	AO	LCD1 MIPI lane 1 data signal (negative)
DSI1_LN1_P	106	AO	LCD1 MIPI lane 1 data signal (positive)
DSI1_LN2_N	109	AO	LCD1 MIPI lane 2 data signal (negative)
DSI1_LN2_P	108	AO	LCD1 MIPI lane 2 data signal (positive)
DSI1_LN3_N	111	AO	LCD1 MIPI lane 3 data signal (negative)
DSI1_LN3_P	110	AO	LCD1 MIPI lane 3 data signal (positive)

Camera Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
CSI0_CLK_N	89	AI	MIPI clock signal of rear camera (negative)		
CSI0_CLK_P	88	AI	MIPI clock signal of rear camera (positive)		
CSI0_LN0_N	91	AI	MIPI lane 0 data signal of rear camera (negative)		
CSI0_LN0_P	90	AI	MIPI lane 0 data signal of rear camera (positive)		
CSI0_LN1_N	93	AI	MIPI lane 1 data signal of rear camera (negative)		
CSI0_LN1_P	92	AI	MIPI lane 1 data signal of rear camera (positive)		
CSI0_LN2_N	95	AI	MIPI lane 2 data signal of rear camera (negative)		
CSI0_LN2_P	94	AI	MIPI lane 2 data signal of rear camera (positive)		
CSI0_LN3_N	97	AI	MIPI lane 3 data signal of rear camera (negative)		
CSI0_LN3_P	96	AI	MIPI lane 3 data signal of rear camera (positive)		
CSI2_CLK_N	78	AI	MIPI clock signal of front camera (negative)		
CSI2_CLK_P	77	AI	MIPI clock signal of front camera (positive)		
CSI2_LN0_N	80	AI	MIPI lane 0 data signal of front camera (negative)		

CSI2_LN0_P	79	AI	MIPI lane 0 data signal of front camera (positive)		
CSI2_LN1_N	82	AI	MIPI lane 1 data signal of front camera (negative)		
CSI2_LN1_P	81	AI	MIPI lane 1 data signal of front camera (positive)		
CSI2_LN2_N	84	AI	MIPI lane 2 data signal of front camera (negative)		
CSI2_LN2_P	83	AI	MIPI lane 2 data signal of front camera (positive)		
CSI2_LN3_N	86	AI	MIPI lane 3 data signal of front camera (negative)		
CSI2_LN3_P	85	AI	MIPI lane 3 data signal of front camera (positive)		
MCAM_MCLK	99	DO	Master clock signal of rear camera	V_{OL}max=0.45V V_{OH}min=1.35V	1.8V power domain.
SCAM_MCLK	100	DO	Master clock signal of front camera	V_{OL}max=0.45V V_{OH}min=1.35V	1.8V power domain.
MCAM_RST	74	DO	Reset signal of rear camera	V_{OL}max=0.45V V_{OH}min=1.35V	1.8V power domain.
MCAM_PWDN	73	DO	Power down signal of rear camera	V_{OL}max=0.45V V_{OH}min=1.35V	1.8V power domain.
SCAM_RST	72	DO	Reset signal of front camera	V_{OL}max=0.45V V_{OH}min=1.35V	1.8V power domain.
SCAM_PWDN	71	DO	Power down signal of front camera	V_{OL}max=0.45V V_{OH}min=1.35V	1.8V power domain.
CAM_I2C_SCL	75	OD	I2C clock signal of camera		1.8V power domain.
CAM_I2C_SDA	76	OD	I2C data signal of camera		1.8V power domain.
DCAM_MCLK	194	DO	Master clock signal of depth camera	V_{OL}max=0.45V V_{OH}min=1.35V	
CAM4_MCLK	236	DO	Master clock signal of fourth camera	V_{OL}max=0.45V V_{OH}min=1.35V	
DCAM_RST	180	DO	Reset signal of	V_{OL}max=0.45V	

			depth camera	V_{OH}min=1.35V	
DCAM_PWDN	181	DO	Power down signal of depth camera	V_{OL}max=0.45V V_{OH}min=1.35V	
DCAM_I2C_SDA	197	OD	I2C data signal of depth camera		1.8V power domain.
DCAM_I2C_SCL	196	OD	I2C clock signal of depth camera		1.8V power domain.
Keypad Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
PWRKEY	39	DI	Turn on/off the module	V_{IL}max=0.63V V_{IH}min=1.17V	Pull-up to 1.8V internally. Active low.
VOL_UP	146	DI	Volume up	V_{IL}max=0.63V V_{IH}min=1.17V	If unused, keep this pin open.
VOL_DOWN	147	DI	Volume down	V_{IL}max=0.63V V_{IH}min=1.17V	If unused, keep this pin open.
SENSOR_I2C Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
SENSOR_I2C_SCL	131	OD	I2C clock signal of external sensors		1.8V power domain.
SENSOR_I2C_SDA	132	OD	I2C data signal of external sensors		1.8V power domain.
ADC Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
PMU_MPP2	151	AI	General purpose ADC interface		Maximum input voltage: 1.7V.
PMU_MPP4	152	AI	General purpose ADC interface		Maximum input voltage: 1.7V.
BAT_THERM	29	AI	Battery temperature detection		Internally pulled up. Externally connected to GND via a 47K NTC resistor. Maximum input voltage: 1.875V.
BAT_ID	17	AI	Battery type detection		Maximum input voltage: 1.875V.If unused, keep this pin

					open.
Charging Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
BAT_PLUS	27	AI	Differential input signal of battery voltage detection (plus)		Must be connected.
BAT_MINUS	28	AI	Differential input signal of battery voltage detection (minus)		Must be connected.
Antenna Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
ANT_MAIN	19	IO	Main antenna interface		50Ω impedance
ANT_DRX	149	AI	Diversity antenna interface		
ANT_GNSS	134	AI	GNSS antenna interface		
ANT_WIFI/BT	129	IO	Wi-Fi/BT antenna interface		
ANT_FM	244	AI	FM antenna interface		
GPIO Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
GPIO_0	248	IO	GPIO	V_{IL}max=0.63V V_{IH}min=1.17V	
GPIO_1	247	IO	GPIO		
GPIO_2	201	IO	GPIO		
GPIO_3	200	IO	GPIO		
GPIO_22	58	IO	GPIO		
GPIO_23	59	IO	GPIO		
GPIO_33	238	IO	GPIO		

GPIO_36	237	IO	GPIO	V_{OL}max=0.45V V_{OH}min=1.4V	
GPIO_42	252	IO	GPIO		Suggest as ACCL_INT
GPIO_43	253	IO	GPIO		Suggest as ALSP_INT
GPIO_44	254	IO	GPIO		Suggest as MAG_INT
GPIO_45	255	IO	GPIO		Suggest as GYRO_INT
GPIO_46	153	IO	GPIO		
GPIO_48	240	IO	GPIO		
GPIO_59	234	IO	GPIO		
GPIO_60	232	IO	GPIO		
GPIO_90	231	IO	GPIO		
GPIO_97	229	IO	GPIO		
GPIO_98	177	IO	GPIO		
GPIO_99	178	IO	GPIO		
GPIO_105	242	IO	GRFC1		GRFC is only used for RF Tuner control.
GPIO_107	241	IO	GRFC2		

SPI Interfaces

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
FP_SPI_CS0	203	DO	Chip selection signal of SPI interface		
FP_SPI_CS1	232	DO	Chip selection signal of SPI interface		
FP_SPI_CLK	250	DO	Clock signal of SPI interface		
FP_SPI_MOSI	249	DO	Master out slave in of SPI interface		
FP_SPI_MISO	251	DI	Master in salve out of SPI interface		

I2S Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
I2S_MCLK	234	DO	Master clock signal of I2S interface		
I2S_1_SCK	212	DO	Clock signal of I2S interface		
I2S_1_WS	156	DO	Channel selection signal of I2S interface		
I2S_1_D0	154	IO	Data0 signal of I2S interface		
I2S_1_D1	155	IO	Data1 signal of I2S interface		
I2S_1_D2	213	IO	Data2 signal of I2S interface		
I2S_1_D3	214	IO	Data3 signal of I2S interface		
Vibrator Drive Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
VIB_DRV	161	AO	Vibrator drive		Connected to the positive terminal of vibrator.
LED Driver Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
LED_RED	23	PO	Red LED light		The output current does not exceed 12mA
LED_GRN	24	PO	Green LED light		The output current does not exceed 12mA
LED_BLU	25	PO	Blue LED light		The output current does not exceed 12mA
Flashlight Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**

FLASH_LED1	26	AO	Flash/torch current driver output		Support flash and torch modes.
FLASH_LED2	162	AO	Flash/torch current driver output		
Emergency Download Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
USB_BOOT	57	DI	Force the module to enter into emergency download mode		Pulled up to LDO5_1P8 during power-up will force the module to enter into emergency download mode.
Other Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
GNSS_LNA_EN	202	DO	LNA enable signal		If unused, keep this pin open.
OPTION	211	DI	Choose different charging modes		Choose Micro USB or TYPE-C
JTAG Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
JTAG_PS_HOLD	183	DO	Power hold signal		
JTAG_TRST_N	184	DI	JTAG reset		
JTAG_TCLK	188	DI	JTAG clock input		
JTAG_TMS	185	DI	JTAG mode-select input		
JTAG_TDO	186	DO	JTAG data output		
JTAG_TDI	187	DI	JTAG data input		
JTAG_SRST_N	189	DI	JTAG reset for debug		
Reserved Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**

RESERVED	164,165,166,190,191,192，222	Reserved pins	Keep these pins open.

3.4. Power Supply

3.4.1. Power Supply Pins

SC650T provides 3 VBAT pins,2 VDD_RF pins and 2 VPH_PWR pins. VBAT pins are dedicated for connection with an external power supply. VDD_RF pins are designed for module's RF part, and are used to connect bypass capacitors so as to eliminate voltage fluctuation of RF part. VPH_PWR pins are designed for peripherals.

3.4.2. Decrease Voltage Drop

The power supply range of the module is from 3.55V to 4.4V, and the recommended value is 3.8V. The power supply performance, such as load capacity, voltage ripple, etc. directly influences the module's performance and stability. Under ultimate conditions, the module may have a transient peak current up to 3A. If the power supply capability is not sufficient, there will be voltage drops, and if the voltage drops below 3.1V, the module will be powered off automatically. Therefore, please make sure the input voltage will never drop below 3.1V.

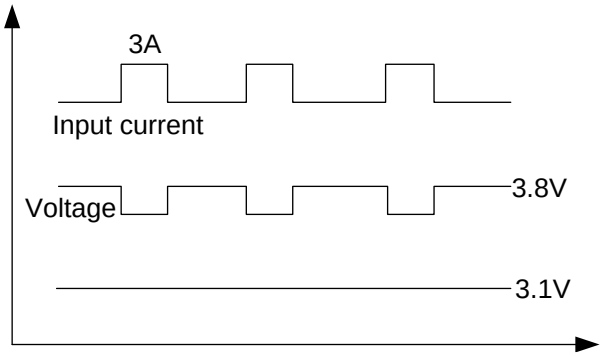


Figure 2: Voltage Drop Sample

To decrease voltage drop, a bypass capacitor of about 100μF with low ESR (ESR=0.7Ω) should be used, and a multi-layer ceramic chip capacitor (MLCC) array should also be reserved due to its ultra-low ESR. It is recommended to use three ceramic capacitors (100nF, 33pF, 10pF) for composing the MLCC array, and place these capacitors close to VBAT/VDD_RF pins. The width of VBAT trace should be no less than 3mm. In principle, the longer the VBAT trace is, the wider it will be.

In addition, in order to get a stable power source, it is suggested to use a 0.5W TVS and place it as close to the VBAT pins as possible to increase voltage surge withstand capability. The following figure shows

the structure of the power supply.

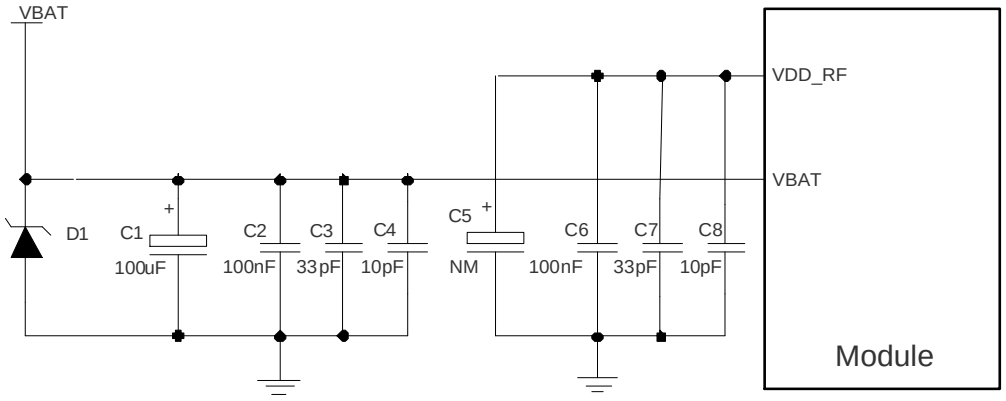


Figure 3: Star Structure of Power Supply

3.4.3. Reference Design for Power Supply

The power design for the module is very important, as the performance of module largely depends on the power source. The power supply of SC650T should be able to provide sufficient current up to 3A at least. By default, it is recommended to use a battery to supply power for SC650T. But if battery is not intended to be used, it is recommended to use a regulator for SC650T. If the voltage difference between the input and output is not too high, it is suggested to use an LDO to supply power for the module. If there is a big voltage difference between the input source and the desired output (VBAT), a buck converter is preferred to be used as the power supply.

The following figure shows a reference design for +5V input power source which adopts an LDO (MIC29502WU) from MICROCHIP. The typical output voltage is 3.8V and the maximum rated current is 5.0A.

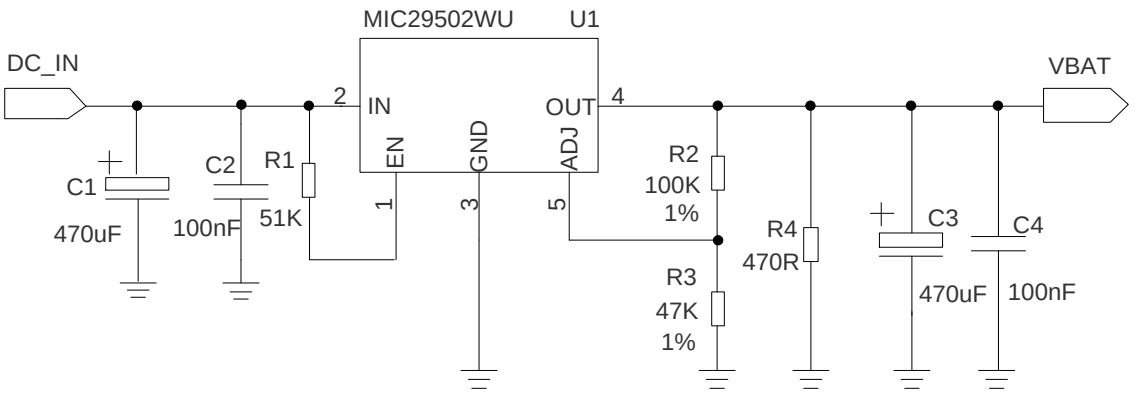


Figure 4: Reference Circuit of Power Supply

NOTES

1. It is recommended to switch off the power supply for module in abnormal state, and then switch on the power to restart the module.
2. The module supports battery charging function by default. If the above power supply design is adopted, please make sure the charging function is disabled by software, or connect VBAT to Schottky diode in series to avoid the reverse current to the power supply chip.
3. When the battery power is reduced to 0%, the system will trigger automatic shutdown, so the design of power supply should be consistent with the configuration of fuel gauge driver.

3.5. Turn on and off Scenarios

3.5.1. Turn on Module Using the PWRKEY

The module can be turned on by driving PWRKEY pin to a low level for at least 1.6s. PWRKEY pin is pulled to 1.8V internally. It is recommended to use an open drain/collector driver to control the PWRKEY. A simple reference circuit is illustrated in the following figure.

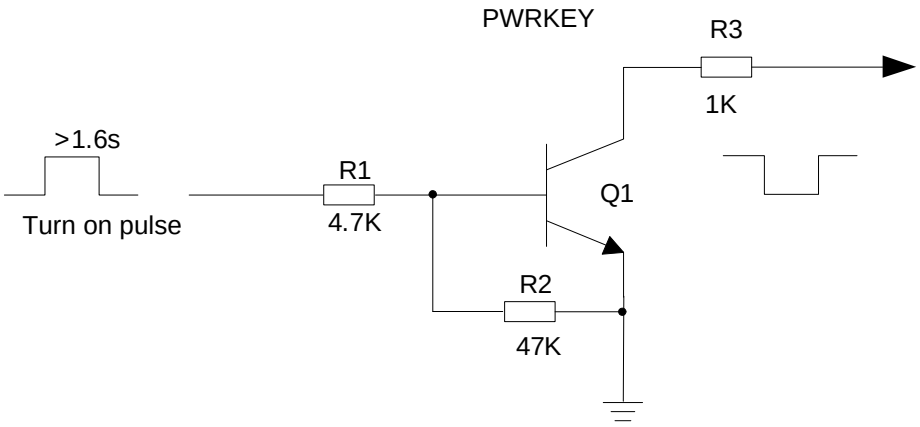


Figure 5: Turn on the Module Using Driving Circuit

Another way to control the PWRKEY is using a button directly. A TVS component is indispensable to be placed nearby the button for ESD protection. A reference circuit is shown in the following figure.

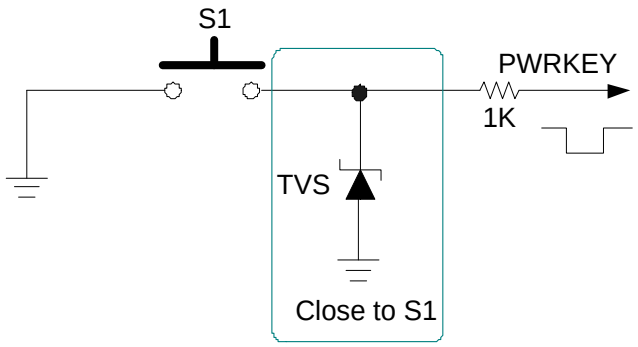


Figure 6: Turn on the Module Using Keystroke

The turning on scenario is illustrated in the following figure.

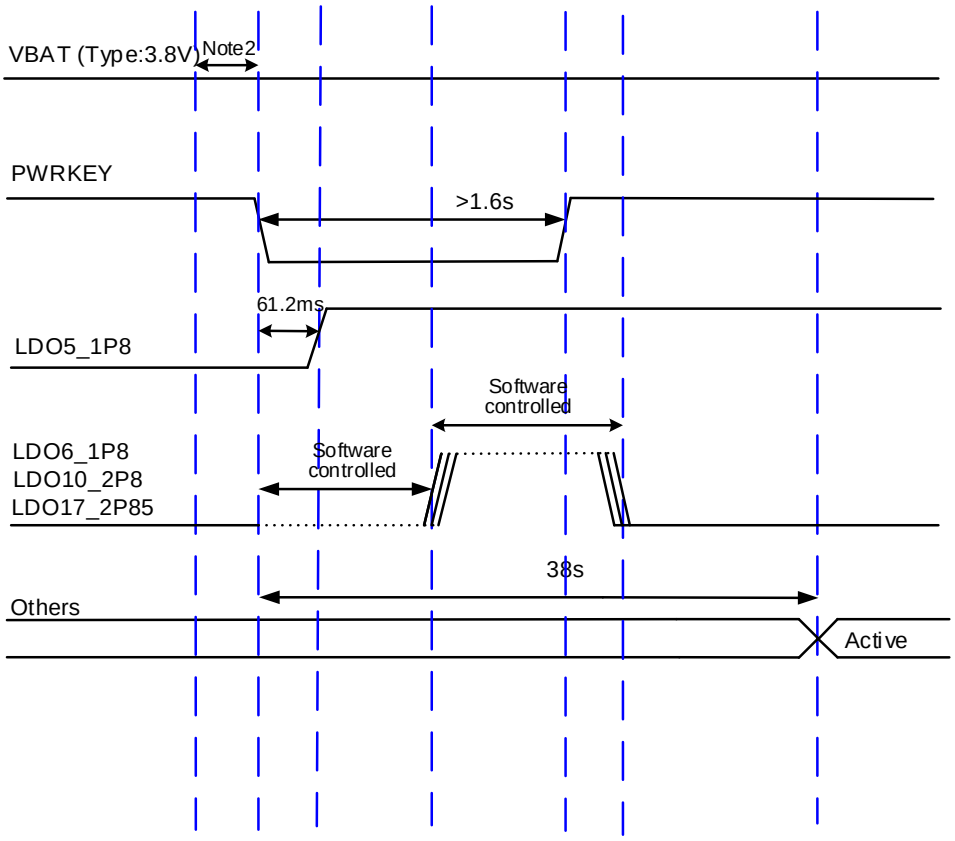


Figure 7: Timing of Turning on Module

NOTES

1. The turn-on timing might be different from the above figure when the module powers on for the first time.
2. Make sure that VBAT is stable before pulling down PWRKEY pin. The recommended time between them is no less than 30ms. PWRKEY cannot be pulled down all the time.

3.5.2. Turn off Module

Pull down PWRKEY for at least 1s, and then choose to turn off the module when the prompt window comes up.

Another way to turn off the module is to drive PWRKEY to a low level for at least 8s. The module will execute forced shutdown. The forced power-down scenario is illustrated in the following figure.

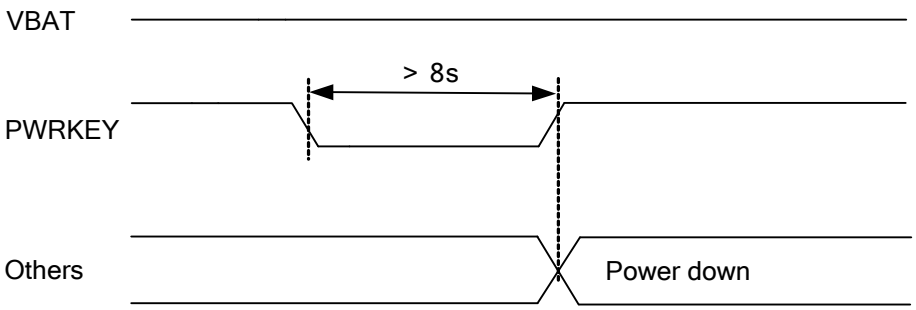


Figure 8: Timing of Turning off Module

3.6. VRTC Interface

The RTC (Real Time Clock) can be powered by an external power source through VRTC when the module is powered down and there is no power supply for the VBAT. The external power source can be rechargeable battery (such as coil cells) according to application demands. The following reference circuit design when an external battery is utilized for powering RTC.

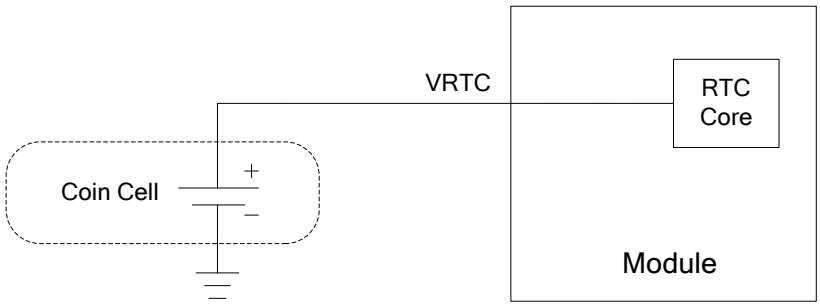


Figure 9: RTC Powered by Coin Cell

If RTC is ineffective, it can be synchronized through network after the module is powered on.

- 2.0V~3.25V input voltage range and 3.0V typical value for VRTC, when VBAT is disconnected.
- When powered by VBAT, the RTC error is 50ppm. When powered by VRTC, the RTC error is about 200ppm.
- If the rechargeable battery is used, the ESR of battery should be less than 2K, and it is recommended to use the MS621FE FL11E of SEIKO.

3.7. Power Output

SC650T supports output of regulated voltages for peripheral circuits. During application, it is recommended to use parallel capacitors (33pF and 10pF) in the circuit to suppress high frequency noise.

Table 6: Power Description

Pin Name	Default Voltage (V)	Drive Current (mA)	Idle
LDO5_1P8	1.8	20	Keep
LDO6_1P8	1.8	300	/
LDO10_2P8	2.8	150	/
LDO17_2P85	2.85	300	/
LDO13_3P075	3.125	150	/
LDO2_1P1	1.1	1200	/
LDO22_2P8	2.8	150	/
LDO23_1P2	1.2	600	/
SD_LDO12	1.8/2.95	50	/
SD_LDO11	2.95	800	/
USIM1_VDD	1.8/2.95	50	/
USIM2_VDD	1.8/2.95	50	/

3.8. Battery Charge and Management

SC650T module supports a fully programmable switch-mode Li-ion battery charge function. It can charge single-cell Li-ion and Li-polymer battery. The battery charger of SC650T module supports trickle charging, pre-charge, constant current charging and constant voltage charging modes, which optimize the charging procedure for Li-ion batteries.

- **Trickle charging:** When the battery voltage is below 2.1V, a 45mA trickle charging current is applied to the battery.
- **Pre-charge:** When the battery voltage is charged up and is between 2.1V and 3.0V (the maximum pre-charge voltage is 2.4V~3.0V programmable, 3.0V by default), the system will enter into pre-charge mode. The charging current is 250mA (100mA~250mA programmable, 250mA by default).
- **Constant current mode (CC mode):** When the battery voltage is increased to between the maximum pre-charge voltage and 4.2V (3.6V~4.5V programmable, 4.2V by default), the system will switch to CC mode. The charging current is programmable from 300mA~3000mA. The default charging current is 500mA for USB charging and 2A for adapter.
- **Constant voltage mode (CV mode):** When the battery voltage reaches the final value 4.2V, the system will switch to CV mode and the charging current will decrease gradually. When the charging current reduces to about 100mA, the charging is completed.

Table 7: Pin Definition of Charging Interface

Pin Name	Pin No.	I/O	Description	Comment
USB_VBUS	41, 42	PI/PO	Charging power input. Power supply output for OTG device. USB/charger insertion detection.	Vmax=10V Vmin=4.0V Vnorm=5.0V
VBAT	36,37, 38	PI/PO	Power supply for the module	Vmax=4.4V Vmin=3.55V Vnorm=3.8V
BAT_ID	17	AI	Battery type detection	If unused, keep this pin open.
BAT_PLUS	27	AI	Differential input signal of battery voltage detection (plus)	Must be connected.
BAT_MINUS	28	AI	Differential input signal of battery voltage detection (minus)	Must be connected.
BAT_THERM	29	AI	Battery temperature detection	Internally pulled up. Externally connected to GND via a 47K NTC resistor.

SC650T module supports battery temperature detection in the condition that the battery integrates a

thermistor (47K 1% NTC thermistor with B-constant of 4050K by default; SDNT1608X473F4050FTF of SUNLORD is recommended) and the thermistor is connected to VBAT_THERM pin. If VBAT_THERM pin is not connected, there will be malfunctions such as boot error, battery charging failure, battery level display error, etc.

A reference design for battery charging circuit is shown as below.

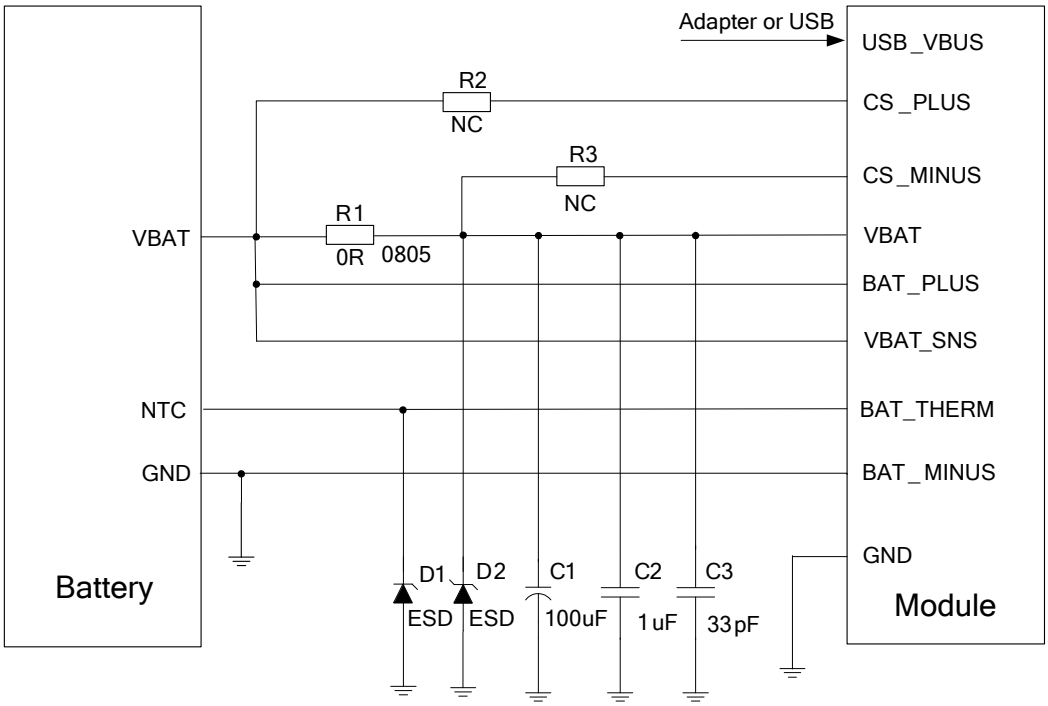


Figure 10: Reference Design for Battery Charging Circuit

SC650T offers a fuel gauge algorithm that is able to accurately estimate the battery's state by current and voltage monitor techniques. Using precise measurements of battery voltage, current, and temperature, the fuel gauge provides a dependable state of charge estimate throughout the entire life of the battery and across a broad range of operating conditions. It effectively protects the battery from over-discharging, and also allows users to estimate the battery life based on the battery level so as to timely save important data before completely power-down.

Mobile devices such as mobile phones and handheld POS systems are powered by batteries. When different batteries are utilized, the charging and discharging curve has to be modified correspondingly so as to achieve the best effect.

If thermistor is not available in the battery, or adapter is utilized for powering the module, then there is only a need for VBAT and GND connection. In this case, the system may be unable to detect the battery, which will cause power-on failure. In order to avoid this, VBAT_THERM should be connected to GND with a 47KΩ resistor. VBAT_SNS, BAT_PLUS and BAT_MINUS must be connected, otherwise there may be abnormalities in use of the module. Among them, BAT_PLUS and BAT_MINUS are used for battery level detection, and they should be routed as differential pair to ensure accuracy.

3.9. USB Interface

SC650T provides one integrated Universal Serial Bus (USB) interface which complies with the USB 3.0/2.0 specifications and supports super speed (5Gbps) on USB 3.0, high speed (480Mbps) on USB 2.0 and full speed (12Mbps) modes. The USB interface supports USB OTG function, and is used for AT command communication, data transmission, software debugging and firmware upgrade.

The following table shows the pin definition of USB interface.

Table 8: Pin Definition of USB Interface

Pin Name	Pin No.	I/O	Description	
USB_VBUS	41, 42	PI/PO	Charging power input; Power supply output for OTG device; USB/charger insertion detection.	Vmax=10V Vmin=4V Vnorm=5.0V
USB_DM	33	IO	USB 2.0 USB differential data bus (minus)	Require differential impedance of 90Ω
USB_DP	32	IO	USB 2.0 USB differential data bus (plus)	
USB_SS_RX_P	171	AI	USB 3.0 differential receive (plus)	Require differential impedance of 90Ω
USB_SS_RX_M	172	AI	USB 3.0 differential receive (minus)	
USB_SS_TX_P	174	AO	USB 3.0 differential transmit (plus)	
USB_SS_TX_M	175	AO	USB 3.0 differential transmit (minus)	
USBC_CC2	223	AI/AO	USB Type-C control configuration channel 2	
USBC_CC1	224	AI/AO	USB Type-C control configuration channel 1	Micro USB mode is USB_ID
CC_OUT	225	DO	USB Type-C switch control	

USB_VBUS can be powered by USB power or adapter. It is used for USB connection detection and power supply input for battery charging. Its input voltage ranges from 4.0V to 10.0V, and the typical value is 5.0V. SC650T module supports charging management for a single cell Li-ion battery, but varied charging parameters should be set for batteries with varied models or capacities. The maximum charging current is up to 3.0A.
The module also supports USB On-The-Go (OTG) function, through using USB_ID pin to detect whether

the OTG device is attached: when USB_ID is kept open (high level by default), SC650T is in USB slave mode; if USB_ID is connected to ground, it is in OTG mode and USB_VBUS is used to supply power for peripherals with maximum output of 5V/1A.

The following is a reference design for USB interface:

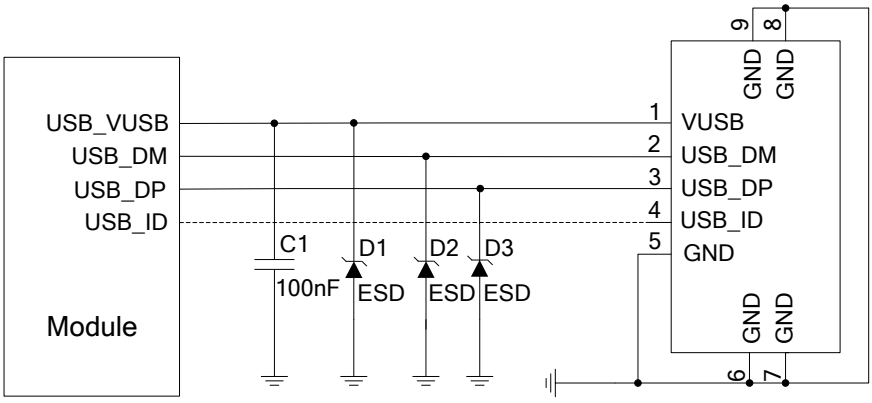


Figure 11: USB 2.0 Interface Reference Design

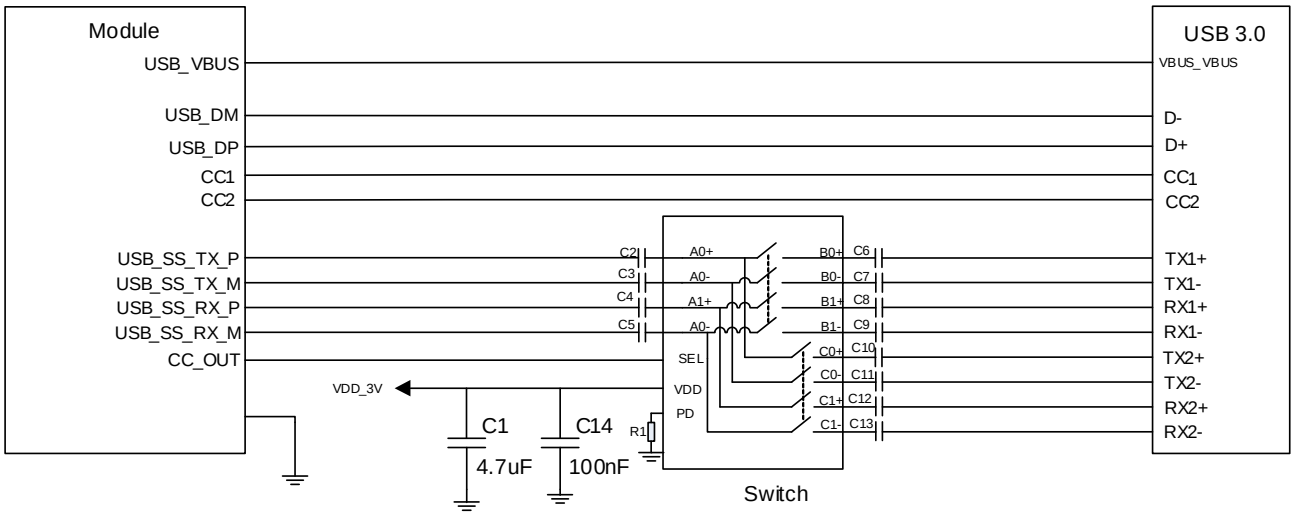


Figure 12: USB Type-C Interface Reference Design

In order to ensure USB performance, please follow the following principles while designing USB interface.

- It is important to route the USB signal traces as differential pairs with total grounding. The impedance of USB differential trace is 90Ω.
- Pay attention to the influence of junction capacitance of ESD protection devices on USB data lines. Typically, the capacitance value should be less than 2pF for USB 2.0 and less than 0.5pF for USB 3.0.
- Do not route signal traces under crystals, oscillators, magnetic devices and RF signal traces. It is

important to route the USB differential traces in inner-layer with ground shielding on not only upper and lower layers but also right and left sides.

- Keep the ESD protection devices as close as possible to the USB connector.
- Make sure the trace length difference between USB 2.0 DM/DP differential pair and that between USB 3.0 RX/TX differential pairs both do not exceed 0.7mm.

Table 9: USB Trace Length Inside the Module

Pin No.	Signal	Length (mm)	Length Difference (DP-DM)
33	USB_DM	40.02	-0.04
32	USB_DP	39.99	
171	USB_SS_RX_P	27.89	0.01
172	USB_SS_RX_M	27.90	
174	USB_SS_TX_P	21.51	0.91
175	USB_SS_TX_M	22.42	

3.10. UART Interfaces

The module provides the following four UART interfaces:

- **UART5:** 4-wire UART interface, hardware flow control supported, 1.8V power domain
- **UART6:** 2-wire UART interface,
- **UART2:** 2-wire UART interface, used for debugging
- **UART4:** 2-wire UART interface

The following table shows the pin definition of UART interfaces.

Table 10: Pin Definition of UART Interfaces

Pin Name	Pin No.	I/O	Description	Comment
UART2_TXD	5	DO	UART2 transmit data. Debug port by default.	1.8V power domain. If unused, keep these pins open.
UART2_RXD	6	DI	UART2 receive data. Debug port by default.	

UART4_TXD	7	DO	UART4 transmit data
UART4_RXD	8	DI	UART4 receive data
UART5_RXD	198	DI	UART5 receive data
UART5_TXD	199	DO	UART5 transmit data
UART5_CTS	246	DI	UART5 clear to send
UART5_RTS	245	DO	UART5 request to send
UART6_RXD	61	DI	UART6 receive data
UART6_TXD	60	DO	UART6 transmit data

UART5 is a 4-wire UART interface with 1.8V power domain. A level translator chip should be used if customers' application is equipped with a 3.3V UART interface. A level translator chip TXS0104EPWR provided by Texas Instruments is recommended.

The following figure shows a reference design.

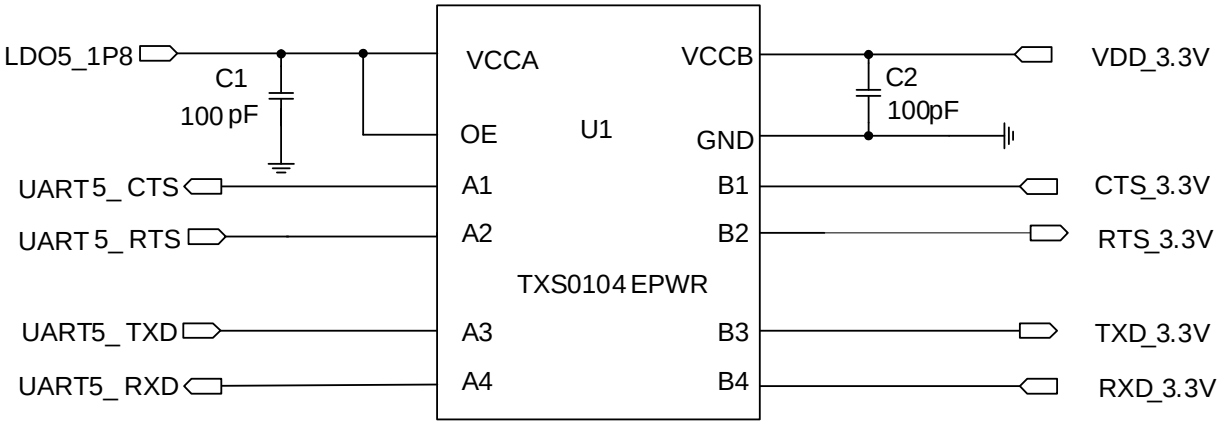


Figure 13: Reference Circuit with Level Translator Chip (for UART5)

The following figure is an example of connection between SC650T and PC. A voltage level translator and a RS-232 level translator chip are recommended to be added between the module and PC, as shown below:

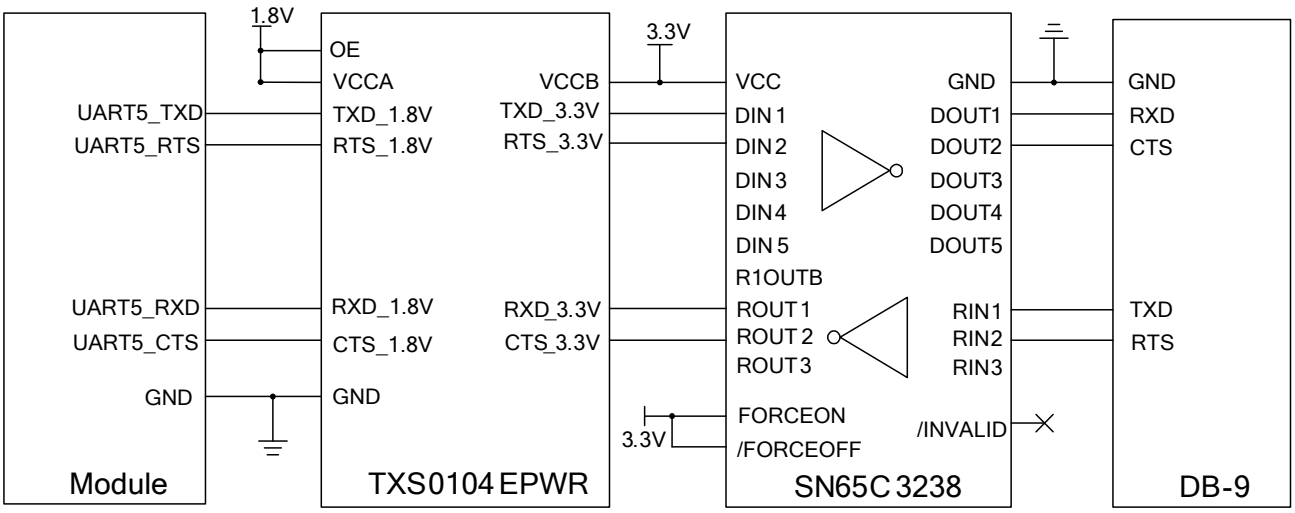


Figure 14: RS232 Level Match Circuit (for UART5)

NOTE

UART2, UART4 and UART6 are similar to UART5. Please refer to UART5 reference circuit design for UART2, UART4 and UART6's.

3.11. (U)SIM Interfaces

SC650T provides two (U)SIM interfaces which both meet ETSI and IMT-2000 requirements. Dual SIM Dual Standby is supported by default. Both 1.8V and 2.95V (U)SIM cards are supported, and the (U)SIM interfaces are powered by the dedicated low dropout regulators from SC650T module.

Table 11: Pin Definition of (U)SIM Interfaces

Pin Name	Pin No.	I/O	Description	Comment
USIM1_DET	145	DI	(U)SIM1 card detection	Active Low. Need external pull-up to 1.8V. If unused, keep this pin open. Disabled by default, and can be enabled through software configuration.
USIM1_RST	144	DO	(U)SIM1 card reset signal	
USIM1_CLK	143	DO	(U)SIM1 card clock signal	

USIM1_DATA	142	IO	(U)SIM1 card data signal	Pull up to USIM1_VDD with a 10K resistor.
USIM1_VDD	141	PO	(U)SIM1 card power supply	Either 1.8V or 2.95V (U)SIM card is supported.
USIM2_DET	256	DI	(U)SIM2 card insertion detection	Active low. Need external pull-up to 1.8V. If unused, keep this pin open. Disabled by default, and can be enabled through software configuration.
USIM2_RST	207	DO	(U)SIM2 card reset signal	
USIM2_CLK	208	DO	(U)SIM2 card clock signal	
USIM2_DATA	209	IO	(U)SIM2 card data signal	Pull-up to USIM2_VDD with a 10K resistor.
USIM2_VDD	210	PO	(U)SIM2 card power supply	Either 1.8V or 2.95V (U)SIM card is supported.

SC650T supports (U)SIM card hot-plug via the USIM_DET pin, which is disabled by default and can be enabled through software configuration. A reference circuit for (U)SIM interface with an 8-pin (U)SIM card connector is shown as below.

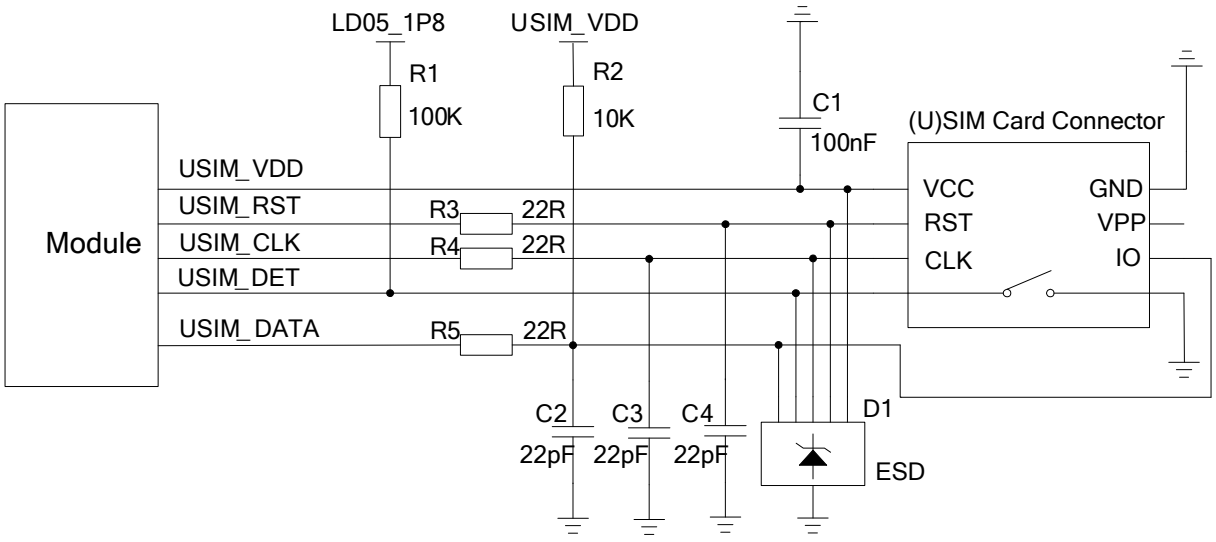


Figure 15: Reference Circuit for (U)SIM Interface with an 8-pin (U)SIM Card Connector

If there is no need to use USIM_DET, please keep it open. The following is a reference circuit for (U)SIM interface with a 6-pin (U)SIM card connector.

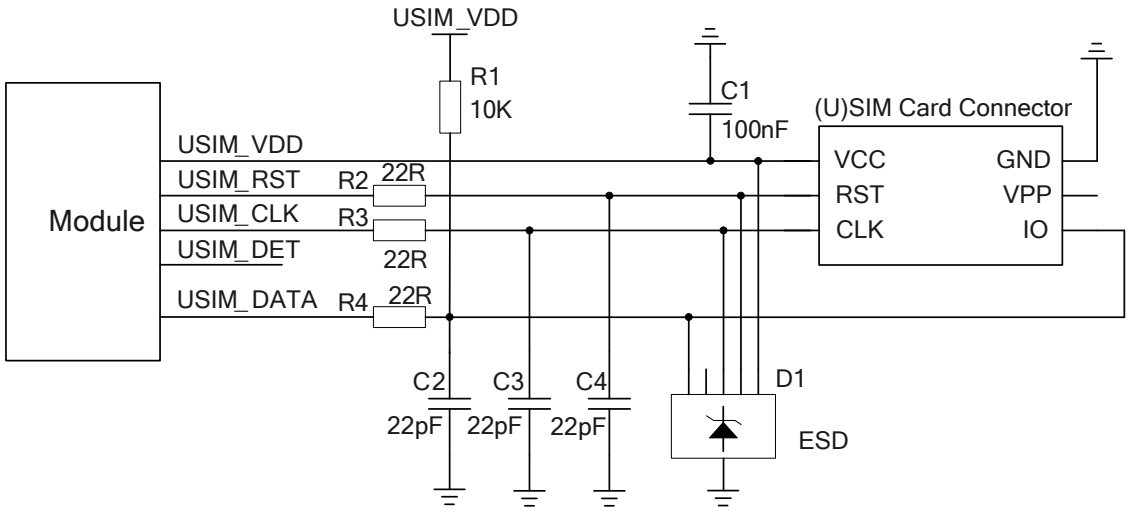


Figure 16: Reference Circuit for (U)SIM Interface with a 6-pin (U)SIM Card Connector

In order to ensure good performance and avoid damage of (U)SIM cards, please follow the criteria below in (U)SIM circuit design:

- Keep placement of (U)SIM card connector as close to the module as possible. Keep the trace length of (U)SIM card signals as less than 200mm as possible.
- Keep (U)SIM card signals away from RF and VBAT traces.
- A filter capacitor shall be reserved for USIM_VDD, and its maximum capacitance should not exceed 1uF. The capacitor should be placed near to (U)SIM card.
- To avoid cross-talk between USIM_DATA and USIM_CLK, keep them away from each other and shield them with ground. USIM_RST also needs ground protection.
- In order to offer good ESD protection, it is recommended to add a TVS diode array with parasitic capacitance not exceeding 50pF. The 22Ω resistors should be added in series between the module and (U)SIM card so as to suppress EMI spurious transmission and enhance ESD protection. Please note that the (U)SIM peripheral circuit should be close to the (U)SIM card connector.
- The 22pF capacitors should be added in parallel on USIM_DATA, USIM_VDD, USIM_CLK and USIM_RST signal lines so as to filter RF interference, and they should be placed as close to the (U)SIM card connector as possible.

3.12. SD Card Interface

SC650T module supports SD 3.0 specifications. The pin definition of the SD card interface is shown below.

Table 12: Pin Definition of SD Card Interface

Pin Name	Pin No.	I/O	Description	Comment
SD_LDO11	63	PO	Power supply for SD card	Vnorm=2.95V $I_O$max=800mA
SD_LDO12	179	PO	SD card pull-up power supply	Support 1.8V or 2.95V power supply. The maximum drive current is 50mA.
SD_CLK	70	DO	High speed digital clock signal of SD card	Control characteristic impedance as 50Ω.
SD_CMD	69	I/O	Command signal of SD card	
SD_DATA0	68	I/O	High speed bidirectional digital signal lines of SD card	
SD_DATA1	67	I/O		
SD_DATA2	66	I/O		
SD_DATA3	65	I/O		
SD_DET	64	DI	SD card insertion detection	Active low.

A reference circuit for SD card interface is shown as below.

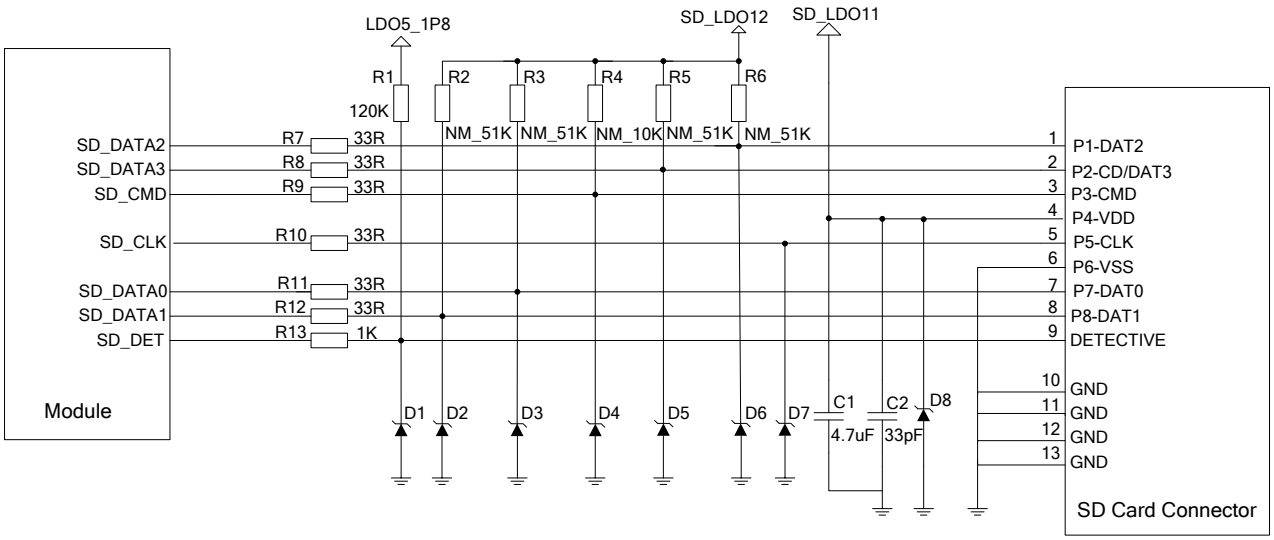


Figure 17: Reference Circuit for SD Card Interface

SD_LDO11 is a peripheral driver power supply for SD card. The maximum drive current is approx. 800mA. Because of the high drive current, it is recommended that the trace width is 0.5mm or above. In order to ensure the stability of drive power, a 4.7uF and a 33pF capacitor should be added in parallel near the SD card connector.

CMD, CLK, DATA0, DATA1, DATA2 and DATA3 are all high speed signal lines. In PCB design, please control the characteristic impedance of them as 50Ω, and do not cross them with other traces. It is recommended to route the trace on the inner layer of PCB, and keep the same trace length for CLK, CMD, DATA0, DATA1, DATA2 and DATA3. CLK additionally needs ground shielding.

Layout guidelines:

- Control impedance as 50Ω±10%, and ground shielding is required.
- The total trace length difference between CLK and other signal line traces should not exceed 1mm.

Table 13: SD Card Signal Trace Length Inside the Module

Pin No.	Signal	Length (mm)	Comment
70	SD_CLK	30.44	
69	SD_CMD	31.60	
68	SD_DATA0	31.50	
67	SD_DATA1	30.96	
66	SD_DATA2	32.70	
65	SD_DATA3	31.62	

3.13. GPIO Interfaces

SC650T has abundant GPIO interfaces with power domain of 1.8V. The pin definition is listed below.

Table 14: Pin Definition of GPIO Interfaces

Pin Name	Pin No.	GPIO	Default Status	Comment
GPIO_0	248	GPIO_0	B-PD:nppukp [1)]	
GPIO_1	247	GPIO_1	B-PD:nppukp	Wakeup [2)]
GPIO_2	201	GPIO_2	B-PD:nppukp	
GPIO_3	200	GPIO_3	B-PD:nppukp	

UART2_TXD	5	GPIO_4	B-PD:nppukp	
UART2_RXD	6	GPIO_5	B-PD:nppukp	Wakeup
TP1_I2C_SDA	204	GPIO_6	B-PD:nppukp	
TP1_I2C_SCL	205	GPIO_7	B-PD:nppukp	
TP1_RST	136	GPIO_8	B-PD:nppukp	
TP1_INT	137	GPIO_9	B-PD:nppukp	Wakeup
TP0_I2C_SDA	206	GPIO_10	B-PD:nppukp	
TP0_I2C_SCL	140	GPIO_11	B-PD:nppukp	
UART4_TXD	7	GPIO_12	B-PD:nppukp	Wakeup
UART4_RXD	8	GPIO_13	B-PD:nppukp	Wakeup
SENSOR_I2C_SDA	132	GPIO_14	B-PD:nppukp	
SENSOR_I2C_SCL	131	GPIO_15	B-PD:nppukp	
UART5_TXD	199	GPIO_16	B-PD:nppukp	
UART5_RXD	198	GPIO_17	B-PD:nppukp	Wakeup
UART5_CTS	246	GPIO_18	B-PD:nppukp	
UART5_RTS	245	GPIO_19	B-PD:nppukp	
UART6_TXD	60	GPIO_20	B-PD:nppukp	
UART6_RXD	61	GPIO_21	B-PD:nppukp	Wakeup
GPIO_22	58	GPIO_22	B-PD:nppukp	
GPIO_23	59	GPIO_23	B-PD:nppukp	
LCD0_TE	126	GPIO_24	B-PD:nppukp	
LCD1_TE	114	GPIO_25	B-PD:nppukp	Wakeup
MCAM_MCLK	99	GPIO_26	B-PD:nppukp	
SCAM_MCLK	100	GPIO_27	B-PD:nppukp	
DCAM_MCLK	194	GPIO_28	B-PD:nppukp	Wakeup

CAM_I2C_SDA	76	GPIO_29	B-PD:nppukp	
CAM_I2C_SCL	75	GPIO_30	B-PD:nppukp	
DCAM_I2C_SDA	197	GPIO_31	B-PD:nppukp	Wakeup
DCAM_I2C_SCL	196	GPIO_32	B-PD:nppukp	
GPIO_33	238	GPIO_33	B-PD:nppukp	
GPIO_36	237	GPIO_36	B-PD:nppukp	Wakeup
MCAM_PWDN	73	GPIO_39	B-PD:nppukp	
MCAM_RST	74	GPIO_40	B-PD:nppukp	
GPIO_42	252	GPIO_42	B-PD:nppukp	Wakeup
GPIO_43	253	GPIO_43	B-PD:nppukp	Wakeup
GPIO_44	254	GPIO_44	B-PD:nppukp	Wakeup
GPIO_45	255	GPIO_45	B-PD:nppukp	Wakeup
GPIO_46	153	GPIO_46	B-PD:nppukp	Wakeup
GPIO_48	240	GPIO_48	B-PD:nppukp	Wakeup
GPIO_59	235	GPIO_59	B-PD:nppukp	Wakeup
GPIO_60	239	GPIO_60	B-PD:nppukp	Wakeup
LCD0_RST	127	GPIO_61	B-PD:nppukp	Wakeup
TP0_RST	138	GPIO_64	B-PD:nppukp	
TP0_INT	139	GPIO_65	B-PD:nppukp	Wakeup
I2S_MCLK	234	GPIO_69	B-PD:nppukp	
VOL_UP	146	GPIO_85	B-PD:nppukp	Wakeup
LCD1_RST	113	GPIO_87	B-PD:nppukp	Wakeup
I2S_1_D1	155	GPIO_88	B-PD:nppukp	
FP_SPI_CS1	232	GPIO_89	B-PD:nppukp	
GPIO_90	231	GPIO_90	B-PD:nppukp	Wakeup

I2S_1_SCK	212	GPIO_91	B-PD:nppukp	Wakeup
I2S_1_WS	156	GPIO_92	B-PD:nppukp	
I2S_1_D0	154	GPIO_93	B-PD:nppukp	Wakeup
I2S_1_D2	213	GPIO_94	B-PD:nppukp	
I2S_1_D3	214	GPIO_95	B-PD:nppukp	
WSA_EN	230	GPIO_96	B-PD:nppukp	
GPIO_97	229	GPIO_97	B-PD:nppukp	Wakeup
GPIO_98	177	GPIO_98	B-PD:nppukp	
GPIO_99	178	GPIO_99	B-PD:nppukp	
GPIO_105	242	GPIO_105	B-PD:nppukp	GRFC is only used for RF Tuner control
GPIO_107	241	GPIO_107	B-PD:nppukp	
CAM4_MCLK	236	GPIO_128	B-PD:nppukp	
SCAM_RST	72	GPIO_129	B-PD:nppukp	
SCAM_PWDN [3)]	71	GPIO_130	B-PD:nppukp	
DCAM_RST	180	GPIO_131	B-PD:nppukp	Wakeup
DCAM_PWDN [3)]	181	GPIO_132	B-PD:nppukp	Wakeup
SD_DET	64	GPIO_133	B-PD:nppukp	Wakeup
FP_SPI_CLK	250	GPIO_135	B-PD:nppukp	
FP_SPI_CS0	203	GPIO_136	B-PD:nppukp	
FP_SPI_MOSI	249	GPIO_137	B-PD:nppukp	Wakeup
FP_SPI_MISO	251	GPIO_138	B-PD:nppukp	

NOTES

1. [1)] B: Bidirectional digital with CMOS input; PD: nppukp = default pulldown with programmable options following the colon (:).
2. [2)] Wakeup: interrupt pins that can wake up the system.
3. [3)] SCAM_PWDN and DCAM_PWDN cannot be pulled up when the module starts up.

4. More details about GPIO configuration, please refer to ***document [2]***.

3.14. I2C Interfaces

SC650T provides five I2C interfaces. As an open drain output, each I2C interface should be pulled up to 1.8V voltage. The SENSOR_I2C interface supports only sensors of the aDSP architecture. CAM/DCAM_I2C bus is controlled by Linux Kernel code and supports connection to video output related devices.

Table 15: Pin Definition of I2C Interfaces

Pin Name	Pin No	I/O	Description	Comment
TP0_I2C_SCL	140	OD	I2C clock signal of touch panel	Used for TP0
TP0_I2C_SDA	206	OD	I2C data signal of touch panel	
TP1_I2C_SCL	205	OD	I2C clock signal of touch panel	Used for TP1
TP1_I2C_SDA	204	OD	I2C data signal of touch panel	
CAM_I2C_SCL	75	OD	I2C clock signal of main camera	Used for main cameras
CAM_I2C_SDA	76	OD	I2C data signal of main camera	
DCAM_I2C_SCL	196	OD	I2C clock signal of front camera	Used for front cameras
DCAM_I2C_SDA	197	OD	I2C data signal of front camera	
SENSOR_I2C_SCL	131	OD	I2C clock signal for external sensor	Used for external sensors
SENSOR_I2C_SDA	132	OD	I2C data signal for external sensor	

3.15. I2S Interface

SC650T provides one I2S interface, with power domain of 1.8V .

Table 16: Pin Definition of I2S Interface

Pin Name	Pin No	I/O	Description	Comment
I2S_MCLK	234	DO	Master clock signal of I2S interface	I2S_MCLK
I2S_1_SCK	212	DO	Clock signal of I2S interface	I2S_1_SCK
I2S_1_WS	156	DO	Channel selection signal of I2S interface	I2S_1_WS
I2S_1_D0	154	IO	Data0 signal of I2S interface	I2S_1_D0
I2S_1_D1	155	IO	Data1 signal of I2S interface	I2S_1_D1
I2S_1_D2	213	IO	Data2 signal of I2S interface	I2S_1_D2
I2S_1_D3	214	IO	Data3 signal of I2S interface	I2S_1_D3

3.16. SPI Interfaces

SC650T provides two SPI interfaces which only support master mode. The two interfaces are typically applied for fingerprint identification.

Table 17: Pin Definition of SPI Interfaces

Pin Name	Pin No	I/O	Description	Comment
GPIO_22	58	DO	Chip selection signal of SPI interface	Can be multiplexed into SPI_CS.
GPIO_23	59	DO	Clock signal of SPI interface	Can be multiplexed into SPI_CLK.
UART6_TXD	60	DO	Master out slave in of SPI interface	Can be multiplexed into SPI_MOSI.
UART6_RXD	61	DI	Master in salve out of SPI interface	Can be multiplexed into SPI_MISO.
FP_SPI_CS0	203	DO	Chip selection signal of SPI interface	Used for fingerprint identification by default. Can be
FP_SPI_CS1	232	DO	Chip selection signal of SPI interface	

FP_SPI_CLK	250	DO	Clock signal of SPI interface	multiplexed into I2S interface.
FP_SPI_MOSI	249	DO	Master out slave in of SPI interface	
FP_SPI_MISO	251	DI	Master in salve out of SPI interface	

3.17. ADC Interfaces

SC650T provides two analog-to-digital converter (ADC) interfaces, and the pin definition is shown below.

Table 18: Pin Definition of ADC Interfaces

Pin Name	Pin No.	I/O	Description	Comment
PMU_MPP4	152	AI	General purpose ADC interface	Maximum input voltage: 1.7V.
PMU_MPP2	151	AI	General purpose ADC interface	Maximum input voltage: 1.7V.

The resolution of the ADC is up to 15 bits.

3.18. Vibrator Drive Interface

The pin definition of vibrator drive interface is listed below.

Table 19: Pin Definition of Vibrator Drive Interface

Pin Name	Pin No	I/O	Description	Comment
VIB_DRV	161	AO	Vibrator drive (positive)	Connected to the positive terminal of vibrator.

The Vibrator is driven by an exclusive circuit, and a reference circuit design is shown below.

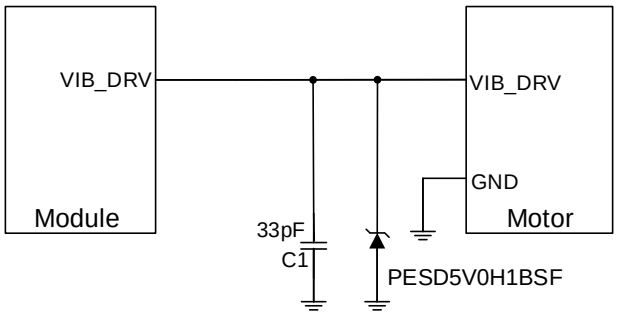


Figure 18: Reference Circuit for Vibrator Connection

3.19. LCM Interfaces

SC650T module provides two LCM interfaces, and supports dual LCDs with WUXGA (1900×1200) display. The interfaces support high speed differential data transmission, with up to eight lanes.

Table 20: Pin Definition of LCM Interfaces

Pin Name	Pin No.	I/O	Description	Comment
LDO6_1P8	10	PO	1.8V output power supply for LCM logic circuit and DSI	
LDO17_2P85	12	PO	2.85V output power supply for LCM analog circuits	
WLED_PWM	30	DO	PWM signal output	
WLED_EN	158	DO	LCD enable for backlight.	
LCD_BIAS_P	21	PO	LCD positive bias voltage.	
LCD_BIAS_N	22	PO	LCD negative bias voltage.	
LCD0_RST	127	DO	LCD0 reset signal	Active low.
LCD0_TE	126	DI	LCD0 tearing effect signal	
LCD1_RST	113	DO	LCD1 reset signal	Active low.
LCD1_TE	114	DI	LCD1 tearing effect signal	

DSI0_CLK_N	116	AO	LCD0 MIPI clock signal (negative)
DSI0_CLK_P	115	AO	LCD0 MIPI clock signal (positive)
DSI0_LN0_N	118	AO	LCD0 MIPI lane 0 data signal (negative)
DSI0_LN0_P	117	AO	LCD0 MIPI lane 0 data signal (positive)
DSI0_LN1_N	120	AO	LCD0 MIPI lane 1 data signal (negative)
DSI0_LN1_P	119	AO	LCD0 MIPI lane 1 data signal (positive)
DSI0_LN2_N	122	AO	LCD0 MIPI lane 2 data signal (negative)
DSI0_LN2_P	121	AO	LCD0 MIPI lane 2 data signal (positive)
DSI0_LN3_N	124	AO	LCD0 MIPI lane 3 data signal (negative)
DSI0_LN3_P	123	AO	LCD0 MIPI lane 3 data signal (positive)
DSI1_CLK_N	103	AO	LCD1 MIPI clock signal (negative)
DSI1_CLK_P	102	AO	LCD1 MIPI clock signal (positive)
DSI1_LN0_N	105	AO	LCD1 MIPI lane 0 data signal (negative)
DSI1_LN0_P	104	AO	LCD1 MIPI lane 0 data signal (positive)
DSI1_LN1_N	107	AO	LCD1 MIPI lane 1 data signal (negative)
DSI1_LN1_P	106	AO	LCD1 MIPI lane 1 data signal (positive)
DSI1_LN2_N	109	AO	LCD1 MIPI lane 2 data signal (negative)
DSI1_LN2_P	108	AO	LCD1 MIPI lane 2 data signal (positive)
DSI1_LN3_N	111	AO	LCD1 MIPI lane 3 data signal (negative)
DSI1_LN3_P	110	AO	LCD1 MIPI lane 3 data signal (positive)

The following are the reference designs for LCM interfaces.

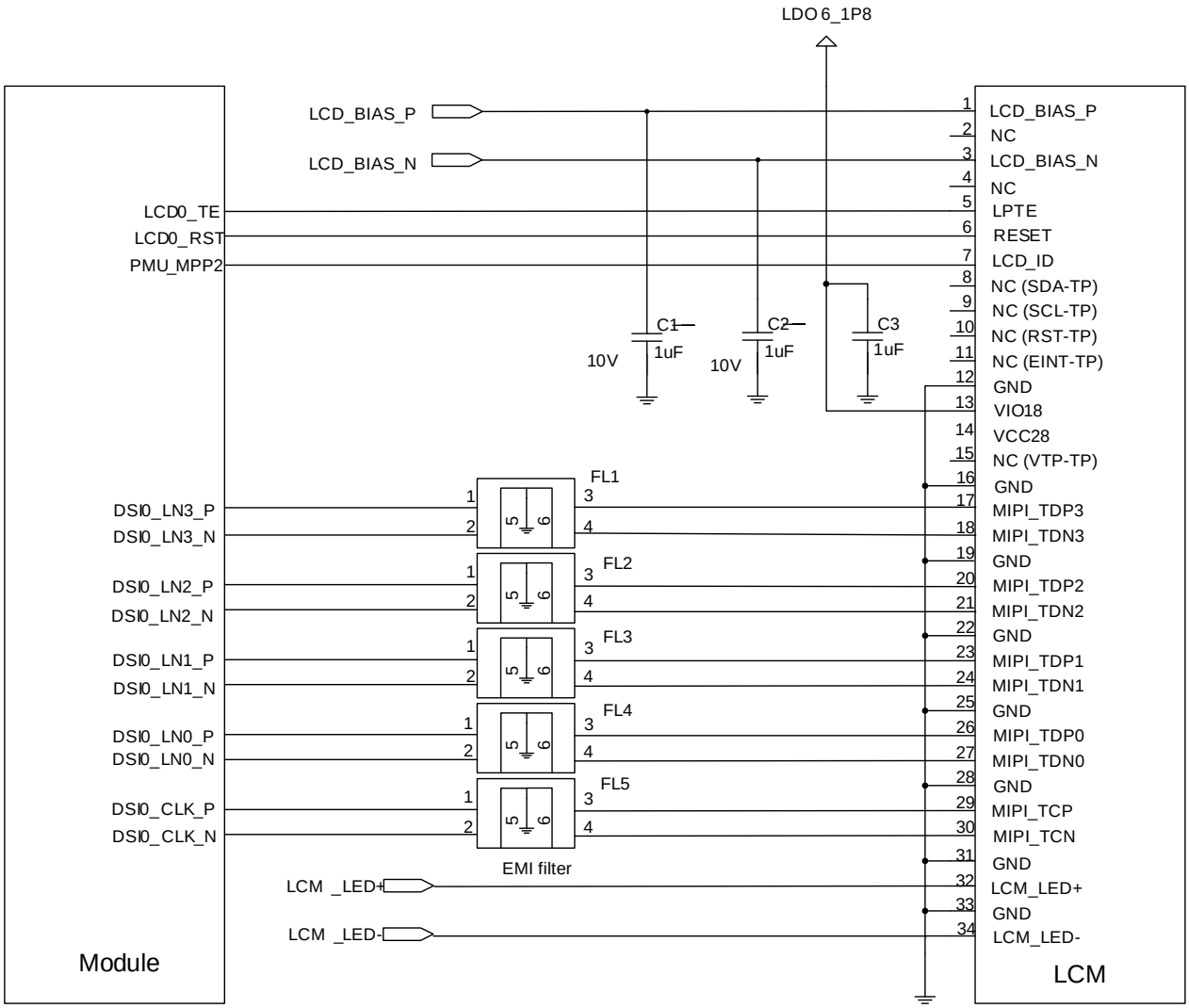


Figure 19: Reference Circuit Design for LCM0 Interface

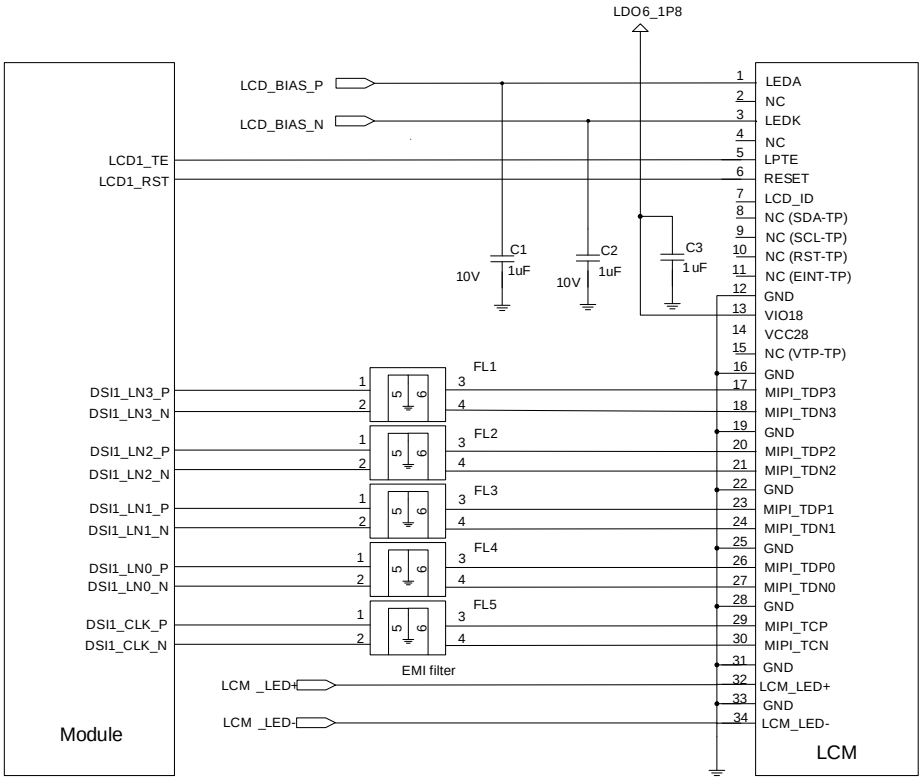


Figure 20: Reference Circuit Design for LCM1 Interface

MIPI are high speed signal lines. It is recommended that common-mode filters should be added in series near the LCM connector, so as to improve protection against electromagnetic radiation interference.

When compatible design with other displays is required, please connect the LCD_ID pin of LCM to the module's ADC pin, and please note that the output voltage of LCD_ID cannot exceed the voltage range of ADC pin.

The SC650T does not have an integrated backlight driver, and LCM requires an external backlight driver.The reference circuit of external backlight drive is shown below, where the pin WLED_PWM supports PWM output and can be used for backlight brightness adjustment.

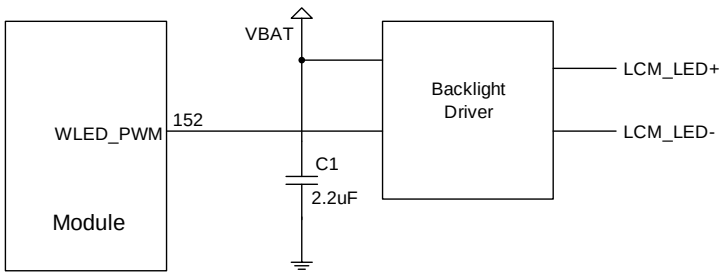


Figure 21: Reference Design of LCM External Backlight Driving Circuit

3.20. Touch Panel Interfaces

SC650T provides two I2C interfaces for connection with Touch Panel (TP), and also provides the corresponding power supply and interrupt pins. The pin definition of touch panel interfaces is illustrated below.

Table 21: Pin Definition of Touch Panel Interfaces

Pin Name	Pin No	I/O	Description	Comment
LDO10_2P8	11	PO	2.8V output power supply for TP VDD power	Vnorm=2.8V $I_O$max=150mA
LDO6_1P8	10	PO	1.8V output power supply	Pull-up power supply of I2C Vnorm=1.8V $I_O$max=300mA
TP0_INT	139	DI	Interrupt signal of touch panel (TP0)	
TP0_RST	138	DO	Reset signal of touch panel (TP0)	Active low
TP0_I2C_SCL	140	OD	I2C clock signal of touch panel (TP0)	
TP0_I2C_SDA	206	OD	I2C data signal of touch panel (TP0)	
TP1_INT	137	DI	Interrupt signal of touch panel (TP1)	
TP1_RST	136	DO	Reset signal of touch panel (TP1)	Active low
TP1_I2C_SCL	205	OD	I2C clock signal of touch panel (TP1)	
TP1_I2C_SDA	204	OD	I2C data signal of touch panel (TP1)	

A reference design for touch panel interfaces is shown below.

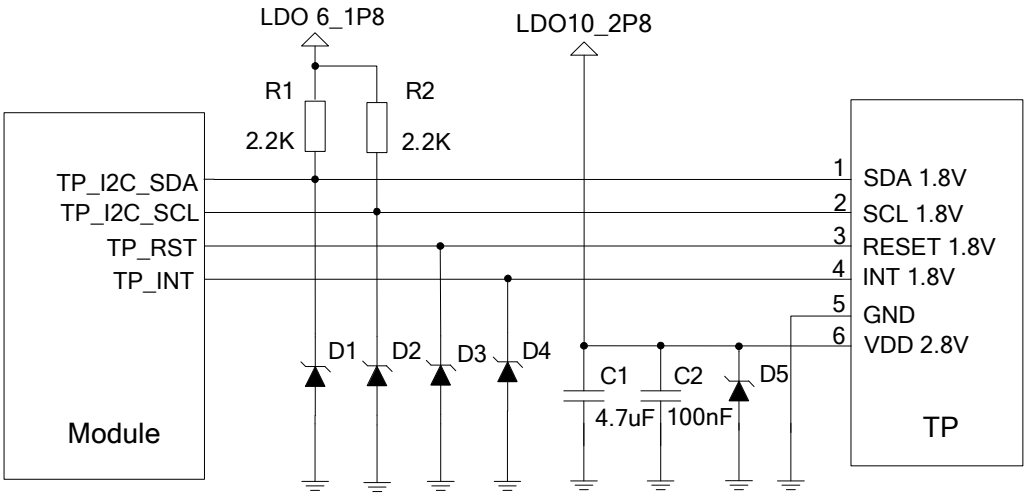


Figure 22: Reference Circuit Design for Touch Panel Interfaces

NOTE

TP is powered by LDO10_2P8 by default and LDO10_2P8 can output 150mA current. It is recommended to use an external LDO power supply if dual-TP or other applications need to be supported.

3.21. Camera Interfaces

Based on standard MIPI CSI input interface, SC650T module supports 2 cameras (4-lane + 4-lane), with maximum pixels up to 24MP. The video and photo quality are determined by various factors such as camera sensor, camera lens quality, etc.

Table 22: Pin Definition of Camera Interfaces

Pin Name	Pin No.	I/O	Description	Comment
LDO2_1P1	13	PO	1.1V output power supply for digital core circuit of rear camera	Vnorm=1.1V $I_O$max=1200mA
LDO6_1P8	10	PO	1.8V output power supply for digital I/O circuit of camera	Vnorm=1.8V $I_O$max=300mA
LDO17_2P85	12	PO	2.85V output power supply auto focus circuit	Vnorm=2.85V $I_O$max=300mA
LDO22_2P8	14	PO	2.8V output power supply for AVDD of cameras	Vnorm=2.8V $I_O$max=150mA
LDO23_1P2	15	PO	1.2V output power supply	Vnorm=1.2V

			for digital core circuit of front camera	$I_O$max=600mA
CSI0_CLK_N	89	AI	MIPI clock signal of rear camera (negative)	
CSI0_CLK_P	88	AI	MIPI clock signal of rear camera (positive)	
CSI0_LN0_N	91	AI	MIPI lane 0 data signal of rear camera (negative)	
CSI0_LN0_P	90	AI	MIPI lane 0 data signal of rear camera (positive)	
CSI0_LN1_N	93	AI	MIPI lane 1 data signal of rear camera (negative)	
CSI0_LN1_P	92	AI	MIPI lane 1 data signal of rear camera (positive)	
CSI0_LN2_N	95	AI	MIPI lane 2 data signal of rear camera (negative)	
CSI0_LN2_P	94	AI	MIPI lane 2 data signal of rear camera (positive)	
CSI0_LN3_N	97	AI	MIPI lane 3 data signal of rear camera (negative)	
CSI0_LN3_P	96	AI	MIPI lane 3 data signal of rear camera (positive)	
CSI2_CLK_N	78	AI	MIPI clock signal of front camera (negative)	
CSI2_CLK_P	77	AI	MIPI clock signal of front camera (positive)	
CSI2_LN0_N	80	AI	MIPI lane 0 data signal of front camera (negative)	
CSI2_LN0_P	79	AI	MIPI lane 0 data signal of front camera (positive)	
CSI2_LN1_N	82	AI	MIPI lane 1 data signal of front camera (negative)	
CSI2_LN1_P	81	AI	MIPI lane 1 data signal of front camera (positive)	
CSI2_LN2_N	84	AI	MIPI lane 2 data signal of front camera (negative)	
CSI2_LN2_P	83	AI	MIPI lane 2 data signal of front camera (positive)	
CSI2_LN3_N	86	AI	MIPI lane 3 data signal of front camera (negative)	
CSI2_LN3_P	85	AI	MIPI lane 3 data signal of front camera (positive)	

MCAM_MCLK	99	DO	Master clock signal of rear camera
SCAM_MCLK	100	DO	Master clock signal of front camera
MCAM_RST	74	DO	Reset signal of rear camera
MCAM_PWDN	73	DO	Power down signal of rear camera
SCAM_RST	72	DO	Reset signal of front camera
SCAM_PWDN	71	DO	Power down signal of front camera
CAM_I2C_SCL	75	OD	I2C clock signal of camera
CAM_I2C_SDA	76	OD	I2C data signal of camera
DCAM_MCLK	194	DO	Clock signal of depth camera
CAM4_MCLK	236	DO	Master clock signal of fourth camera
DCAM_RST	180	DO	Reset signal of depth camera
DCAM_PWDN	181	DO	Power down signal of depth camera
DCAM_I2C_SDA	197	OD	I2C data of depth camera
DCAM_I2C_SCL	196	OD	I2C clock of depth camera

The following is a reference circuit design for two-camera applications.

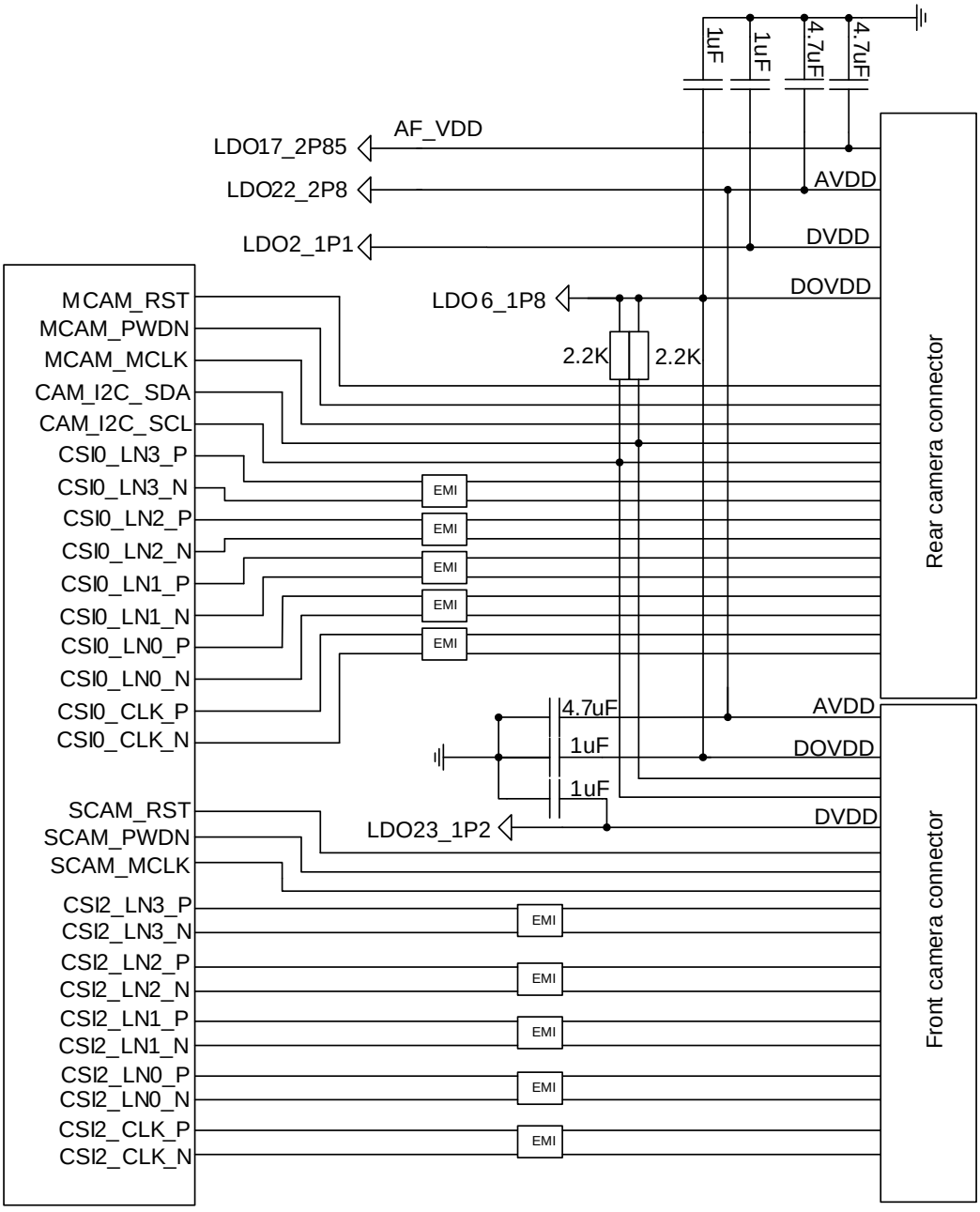


Figure 23: Reference Circuit Design for Two-Camera Applications

NOTE

CSI0 is used for rear camera, and CSI2 is used for front camera.

3.21.1.

3.21.1. Design Considerations

- Special attention should be paid to the pin definition of LCM/camera connectors. Assure the SC650T and the connectors are correctly connected.
- MIPI are high speed signal lines, supporting maximum data rate up to 2.1Gbps. The differential impedance should be controlled as 100Ω. Additionally, it is recommended to route the trace on the inner layer of PCB, and do not cross it with other traces. For the same group of DSI or CSI signals, all the MIPI traces should keep the same length. In order to avoid crosstalk, it is recommended to maintain the intra-lane spacing as trace width and the inter-lane spacing as two times of the trace width. Any cut or hole on GND reference plane under MIPI signals should be avoided.
- It is recommended to select a low capacitance TVS for ESD protection and the recommended parasitic capacitance is below 1pF.
- Route MIPI traces according to the following rules:

  a) The total trace length should not exceed 305mm;
  b) Control the differential impedance as 85Ω±10%;
  c) Control intra-lane length difference within 0.67mm;
  d) Control inter-lane length difference within 1.3mm.

Table 23: MIPI Trace Length Inside the Module

Pin No.	Pin Name	Length (mm)	Length Difference (P-N)
116	DSI0_CLK_N	21.32	0.12
115	DSI0_CLK_P	21.44	
118	DSI0_LN0_N	24.43	0.10
117	DSI0_LN0_P	24.53	
120	DSI0_LN1_N	24.42	0.36
119	DSI0_LN1_P	24.78	
122	DSI0_LN2_N	24.56	0.04
121	DSI0_LN2_P	24.60	
124	DSI0_LN3_N	28.38	0.06
123	DSI0_LN3_P	28.44	

103	DSI1_CLK_N	11.69	0.02
102	DSI1_CLK_P	11.71	
105	DSI1_LN0_N	11.46	0.09
104	DSI1_LN0_P	11.56	
107	DSI1_LN1_N	15.26	0.01
106	DSI1_LN1_P	15.27	
109	DSI1_LN2_N	15.12	-0.65
108	DSI1_LN2_P	14.47	
111	DSI1_LN3_N	16.15	-0.01
110	DSI1_LN3_P	16.14	
89	CSI0_CLK_N	17.80	0.06
88	CSI0_CLK_P	17.86	
91	CSI0_LN0_N	17.73	-0.01
90	CSI0_LN0_P	17.73	
93	CSI0_LN1_N	12.98	-0.03
92	CSI0_LN1_P	12.95	
95	CSI0_LN2_N	11.28	-0.31
94	CSI0_LN2_P	10.96	
97	CSI0_LN3_N	10.02	-0.04
96	CSI0_LN3_P	9.98	
78	CSI2_CLK_N	22.70	0.25
77	CSI2_CLK_P	22.95	
80	CSI2_LN0_N	22.14	0.26
79	CSI2_LN0_P	22.40	
82	CSI2_LN1_N	22.96	-0.42
81	CSI2_LN1_P	22.54	

84	CSI2_LN2_N	22.96	-0.01
83	CSI2_LN2_P	22.95	
86	CSI2_LN3_N	22.77	-0.36
85	CSI2_LN3_P	22.41	

3.21.2. Flashlight Interfaces

SC650T module supports 2 flash LED drivers, with maximal output current up to 1.5A in flash mode and 300mA in torch mode. The default output current is 1A in flash mode and 300mA in torch mode.

Table 24: Pin Definition of Flashlight Interfaces

Pin Name	Pin No.	I/O	Description	Comment
FLASH_LED1	26	AO	Flash/torch drive signal output	
FLASH_LED2	162	AO	Flash/torch drive signal output	

A reference circuit design is shown below.

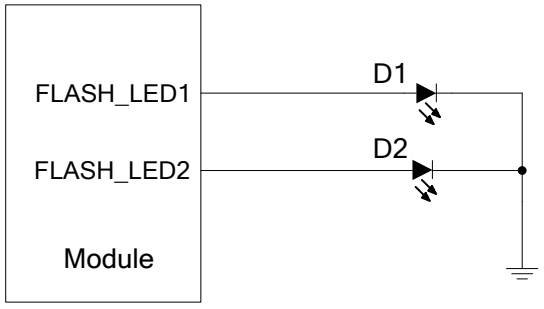


Figure 24: Reference Circuit Design for Flashlight Interfaces

3.22. Sensor Interfaces

SC650T module supports communication with sensors via I2C interface, and it supports various sensors such as acceleration sensor, gyroscopic sensor, compass, optical sensor, temperature sensor.

Table 25: Pin Definition of Sensor Interfaces

Pin Name	Pin No.	I/O	Description	Comment
SENSOR_I2C_SCL	131	OD	I2C clock signal of external sensor	
SENSOR_I2C_SDA	132	OD	I2C data signal of external sensor	
GPIO_43	253	DI	Interrupt signal of optical sensor	
GPIO_44	254	DI	Interrupt signal of direction sensor (compass)	
GPIO_42	252	DI	Interrupt signal of acceleration sensor	
GPIO_45	255	DI	Interrupt signal of gyroscopic sensor	

3.23. Audio Interfaces

SC650T module provides two analog input channels, two analog output channels and two digital input channels. The following table shows the pin definition.

Table 26: Pin Definition of Audio Interfaces

Pin Name	Pin No.	I/O	Description	Comment
DMIC1_DATA	45	DI	Digital microphone1 data	
DMIC1_CLK	46	DO	Digital microphone1 clock	
DMIC2_DATA	168	DI	Digital microphone2 data	
DMIC2_CLK	169	DO	Digital microphone2 clock	
MIC_BIAS1	44	AO	Microphone bias voltage	Dias voltage for DMIC1
MIC_BIAS2	233	AO	Microphone bias voltage	Dias voltage for AMIC2

MIC_BIAS3	167	AO	Microphone bias voltage	Dias voltage for DMIC2
LINE_OUT_3	228	AO	Audio output	
LINE_OUT_REF	227	AI	Audio output reference ground	
LINE_OUT_4	226	AO	Audio output	
AMIC1_P	218	AI	Analog microphone positive input for channel 1	
AMIC1_M	217	AI	Analog microphone negative input for channel 1	
AMIC2_P	216	AI	Analog microphone positive input for headset	
AMIC2_M	215	AI	Analog microphone negative input for headset	
EAR_P	53	AO	Earpiece positive output	
EAR_N	52	AO	Earpiece positive output	
PDM_CLK	55	AO	External audio power amplifier clock interface	External connect to WSA8810/WSA8815
PDM_DATA	54	AO	External audio power amplifier data interface	External connect to WSA8810/WSA8815
WSA_EN	230	DO	External audio power amplifier enable signal	
HPH_R	51	AO	Headphone right channel output	
HPH_REF	50	AI	Headphone reference ground	
HPH_L	49	AO	Headphone left channel output	
HS_DET	48	AI	Headset insertion detection	Pulled up internally.

- The module offers four audio input channels, including two digital input pair and two analog input pair .
- Three MIC_BIAS output. These output voltage range of MIC_BIAS is programmable between 1.6V and 2.85V, and the maximum output current is 3mA.
- The earpiece interface uses differential output.
- The headphone interface features stereo left and right channel output, and headphone insertion detection function is supported.

3.23.1. Reference Circuit Design for Microphone Interfaces

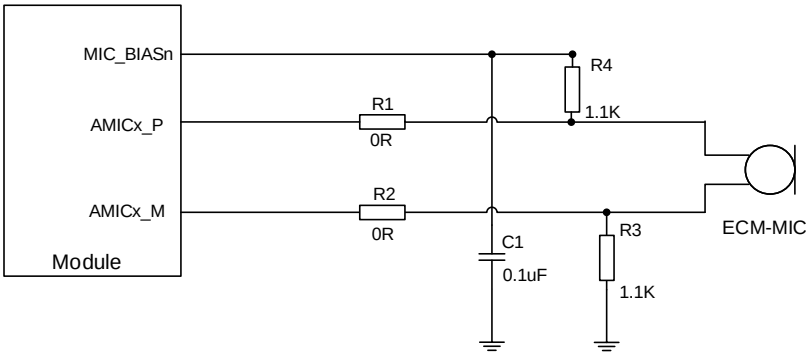


Figure 25: Reference Circuit Design for Analog ECM-type Microphone

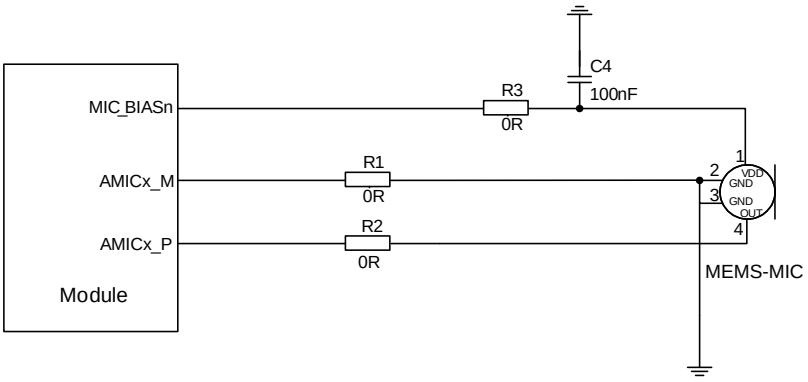


Figure 26: Reference Circuit Design for MEMS-type Microphone

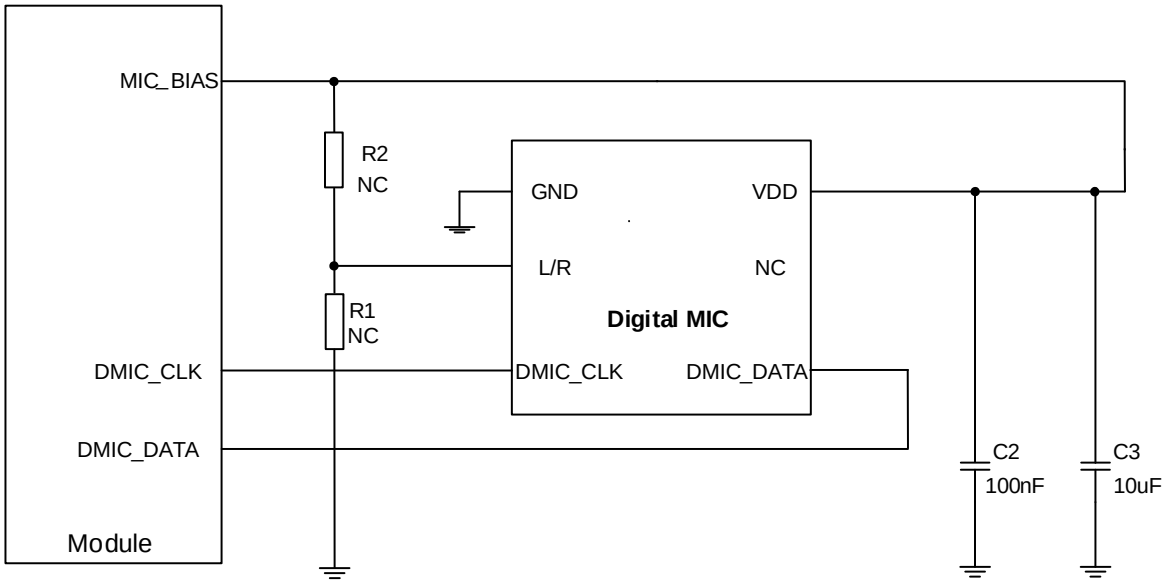


Figure 27:Reference Circuit Design for Digital Microphone

3.23.2. Reference Circuit Design for Earpiece Interface

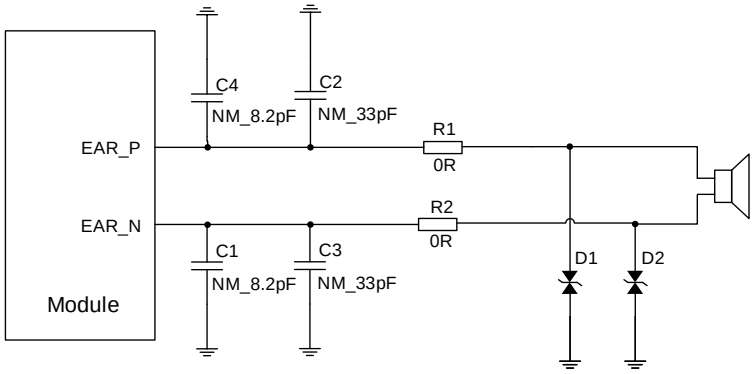


Figure 28: Reference Circuit Design for Earpiece Interface

3.23.3. Reference Circuit Design for Headphone Interface

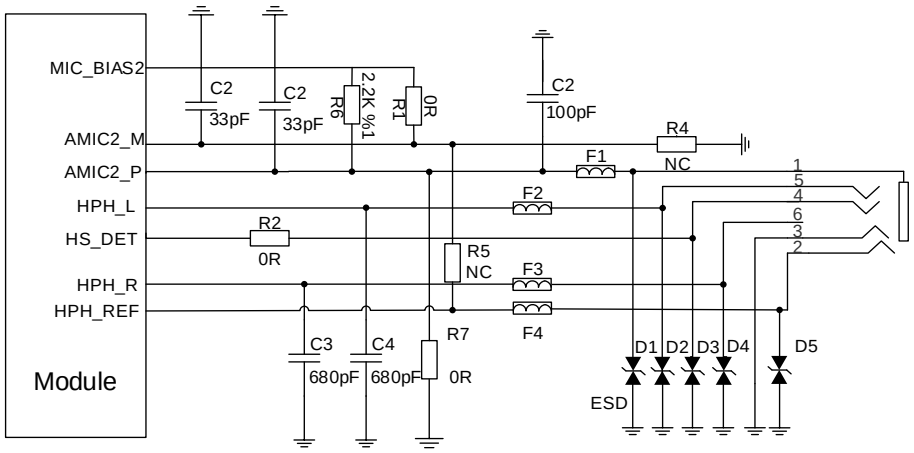


Figure 29: Reference Circuit Design for Headphone Interface

3.23.4. Reference Circuit Design for Loudspeaker Interface

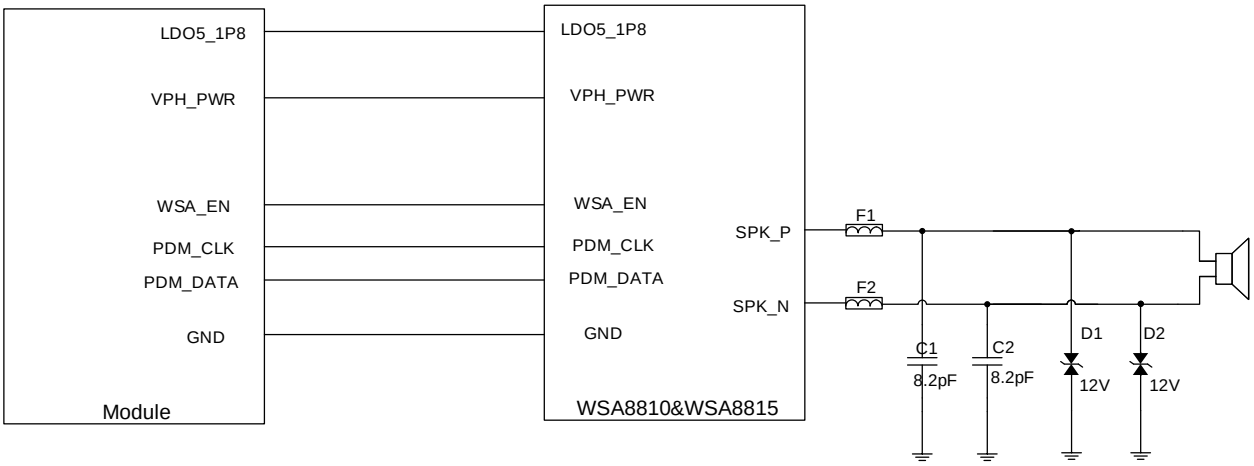


Figure 30: Reference Circuit Design for Loudspeaker Interface

3.23.5. Audio Interfaces Design Considerations

It is recommended to use the electret microphone with dual built-in capacitors (e.g. 10pF and 33pF) for filtering out RF interference, thus reducing TDD noise. The 33pF capacitor is applied for filtering out RF interference when the module is transmitting at EGSM900. Without placing this capacitor, TDD noise could be heard. The 10pF capacitor here is used for filtering out RF interference at DCS1800. Please note

that the resonant frequency point of a capacitor largely depends on the material and production technique. Therefore, customers would have to discuss with their capacitor vendors to choose the most suitable capacitor for filtering out high-frequency noises.

The severity degree of the RF interference in the voice channel during GSM transmitting largely depends on the application design. In some cases, EGSM900 TDD noise is more severe; while in other cases, DCS1800 TDD noise is more obvious. Therefore, a suitable capacitor can be selected based on the test results. Sometimes, even no RF filtering capacitor is required.

In order to decrease radio or other signal interference, RF antennas should be placed away from audio interfaces and audio traces. Power traces cannot be parallel with and also should be far away from the audio traces.

The differential audio traces must be routed according to the differential signal layout rule.

3.24. Emergency Download Interface

USB_BOOT is an emergency download interface. Pull up to LDO5_1P8 during power-up will force the module enter into emergency download mode. This is an emergency option when there are failures such as abnormal startup or operation. For convenient firmware upgrade and debugging in the future, please reverse the reference circuit design shown as below.

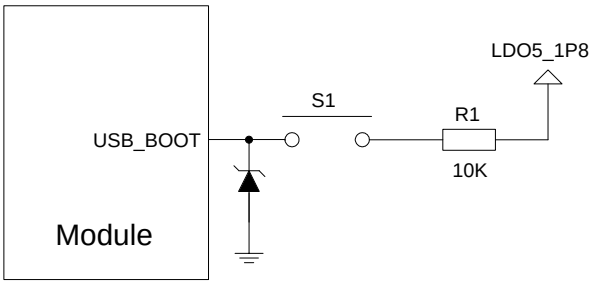


Figure 31: Reference Circuit Design for Emergency Download Interface

3.25. LED Driver Interfaces

The following is the pin definition of LED driver interfaces.

Table 27: Pin Definition of LED Driver Interfaces

Pin Name	Pin No.	I/O	Description	Comment
LED_RED	23	PO	Red LED light	The output current does not exceed 12mA
LED_GRN	24	PO	Green LED light	The output current does not exceed 12mA
LED_BLU	25	PO	Blue LED light	The output current does not exceed 12mA

A reference circuit design for LED interfaces is shown below.

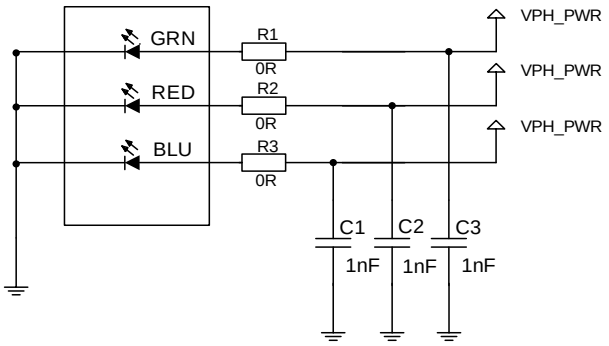


Figure 32: Reference Circuit Design for LED Interfaces

4 Wi-Fi and BT

SC650T module provides a shared antenna interface ANT_WIFI/BT for Wi-Fi and Bluetooth (BT) functions. The interface impedance is 50Ω. External antennas such as PCB antenna, sucker antenna and ceramic antenna can be connected to the module via the interface, so as to achieve Wi-Fi and BT functions.

4.1. Wi-Fi Overview

SC650T module supports 2.4GHz and 5GHz dual-band WLAN wireless communication based on IEEE 802.11a/b/g/n/ac standard protocols. The maximum data rate is up to 433Mbps.

The features are as below:

- Support Wake-on-WLAN (WoWLAN)
- Support ad hoc mode
- Support WAPI SMS4 hardware encryption
- Support AP mode
- Support Wi-Fi Direct
- Support MCS 0-7 for HT20 and HT40
- Support MCS 0-8 for VHT20
- Support MCS 0-9 for VHT40 and VHT80

4.1.1. Wi-Fi Performance

The following table lists the Wi-Fi transmitting and receiving performance of SC650T module.

Table 28: Wi-Fi Transmitting Performance

	Standard	Rate	Output Power
2.4GHz	802.11b	1Mbps	16dBm±2.5dB
	802.11b	11Mbps	16dBm±2.5dB
	802.11g	6Mbps	16dBm±2.5dB

	802.11g	54Mbps	14dBm±2.5dB
	802.11n HT20	MCS0	15dBm±2.5dB
	802.11n HT20	MCS7	13dBm±2.5dB
	802.11n HT40	MCS0	15dBm±2.5dB
	802.11n HT40	MCS7	13dBm±2.5dB
5GHz	802.11a	6Mbps	17dBm±2.5dB
	802.11a	54Mbps	16dBm±2.5dB
	802.11n HT20	MCS0	17dBm±2.5dB
	802.11n HT20	MCS7	16dBm±2.5dB
	802.11n HT40	MCS0	17dBm±2.5dB
	802.11n HT40	MCS7	16dBm±2.5dB
	802.11ac VHT20	MCS0	16dBm±2.5dB
	802.11ac VHT20	MCS8	15dBm±2.5dB
	802.11ac VHT40	MCS0	15dBm±2.5dB
	802.11ac VHT40	MCS9	14dBm±2.5dB
	802.11ac VHT80	MCS0	15dBm±2.5dB
	802.11ac VHT80	MCS9	14dBm±2.5dB

Table 29: Wi-Fi Receiving Performance

	Standard	Rate	Sensitivity
2.4GHz	802.11b	1Mbps	-97dBm
	802.11b	11Mbps	-89dBm
	802.11g	6Mbps	-91dBm
	802.11g	54Mbps	-74dBm
	802.11n HT20	MCS0	-91dBm

	802.11n HT20	MCS7	-72dBm
	802.11n HT40	MCS0	-89dBm
	802.11n HT40	MCS7	-70dBm
5GHz	802.11a	6Mbps	-92dBm
	802.11a	54Mbps	-74dBm
	802.11n HT20	MCS0	-91dBm
	802.11n HT20	MCS7	-73dBm
	802.11n HT40	MCS0	-88dBm
	802.11n HT40	MCS7	-70dBm
	802.11ac VHT20	MCS8	-68dBm
	802.11ac VHT40	MCS9	-63dBm
	802.11ac VHT80	MCS9	-59dBm

Reference specifications are listed below:

- IEEE 802.11n WLAN MAC and PHY, October 2009 + IEEE 802.11-2007 WLAN MAC and PHY, June 2007
- IEEE Std 802.11b, IEEE Std 802.11d, IEEE Std 802.11e, IEEE Std 802.11g, IEEE Std 802.11i: IEEE 802.11-2007 WLAN MAC and PHY, June 2007

4.2. BT Overview

SC650T module supports BT4.2 (BR/EDR+BLE) specifications, as well as GFSK, 8-DPSK, π/4-DQPSK modulation modes.

- Maximally support up to 7 wireless connections
- Maximally support up to 3.5 piconets at the same time
- Support one SCO or eSCO (Extended Synchronous Connection Oriented) connection

The BR/EDR channel bandwidth is 1MHz, and can accommodate 79 channels. The BLE channel bandwidth is 2MHz, and can accommodate 40 channels.

Table 30: BT Data Rate and Versions

Version	Data rate	Maximum Application	Throughput	Comment
1.2	1Mbit/s	> 80Kbit/s		
2.0+EDR	3Mbit/s	> 80Kbit/s		
3.0+HS	24Mbit/s	Reference to 3.0+HS		
4.0	24Mbit/s	Reference to 4.0 LE		

Reference specifications are listed below:

- Bluetooth Radio Frequency TSS and TP Specification 1.2/2.0/2.0 + EDR/2.1/2.1+ EDR/3.0/3.0 + HS, August 6, 2009
- Bluetooth Low Energy RF PHY Test Specification, RF-PHY.TS/4.0.0, December 15, 2009

4.2.1. BT Performance

The following table lists the BT transmitting and receiving performance of SC650T module.

Table 31: BT Transmitting and Receiving Performance

Transmitter Performance			
Packet Types	DH5	2-DH5	3-DH5
Transmitting Power	8dBm±2.5dB	8dBm±2.5dB	8dBm±2.5dB
Receiver Performance			
Packet Types	DH5	2-DH5	3-DH5
Receiving Sensitivity	-93dBm	-92dBm	-92dBm

5 GNSS

SC650T module integrates a Qualcomm IZat™ GNSS engine (Gen 8C) which supports multiple positioning and navigation systems including GPS, GLONASS and BeiDou. With an embedded LNA, the module provides greatly improved positioning accuracy.

5.1. GNSS Performance

The following table lists the GNSS performance of SC650T module in conduction mode.

Table 32: GNSS Performance

Parameter	Description	Typ.	Unit
Sensitivity (GNSS)	Cold start	-146	dBm
	Reacquisition	-157	dBm
	Tracking	-158	dBm
TTFF (GNSS)	Cold start	51	s
	Warm start	30	s
	Hot start	6	s
Static Drift (GNSS)	CEP-50	8	m

5.2. GNSS RF Design Guidelines

Bad design of antenna and layout may cause reduced GNSS receiving sensitivity, longer GNSS positioning time, or reduced positioning accuracy. In order to avoid these, please follow the design rules listed below:

- Maximize the distance between the GNSS RF part and the GPRS RF part (including trace routing and antenna layout) to avoid mutual interference.
- In user systems, GNSS RF signal lines and RF components should be placed far away from high speed circuits, switched-mode power supplies, power inductors, the clock circuit of single-chip microcomputers, etc.
- For applications with harsh electromagnetic environment or high ESD-protection requirements, it is recommended to add ESD protective diodes for the antenna interface. Only diodes with ultra-low junction capacitance such as 0.5pF can be selected. Otherwise, there will be effects on the impedance characteristic of RF circuit loop, or attenuation of bypass RF signal may be caused.
- Control the impedance of either feeder line or PCB trace as 50Ω, and keep the trace length as short as possible.
- Refer to ***Chapter 6.3*** for GNSS antenna reference circuit designs.

6 Antenna Interfaces

SC650T provides four antenna interfaces for main antenna, Rx-diversity/MIMO antenna, GNSS antenna, and Wi-Fi/BT antenna, respectively. The antenna ports have an impedance of 50Ω.

6.1. Main/Rx-diversity Antenna Interfaces

The pin definition of main/Rx-diversity antenna interfaces is shown below.

Table 33: Pin Definition of Main/Rx-diversity Antenna Interfaces

Pin Name	Pin No.	I/O	Description	Comment
ANT_MAIN	19	IO	Main antenna interface	50Ω impedance
ANT_DRX	149	AI	Diversity and MIMO antenna interface	50Ω impedance

The operating frequencies of SC650T module are listed in the following table.

Table 34: SC650T-NA Module Operating Frequencies

3GPP Band	Receive	Transmit	Unit
LTE-FDD B2	1930~1990	1850~1910	MHz
LTE-FDD B4	2110~2155	1710~1755	MHz
LTE-FDD B5	869~894	824~849	MHz
LTE-FDD B7	2620~2690	2500~2570	MHz
LTE-FDD B12	729~746	699~716	MHz
LTE-FDD B13	746~756	777~787	MHz
LTE-FDD B14	758~768	788~798	MHz

LTE-FDD B25	1930~1995	1850~1915	MHz
LTE-FDD B26	859~894	814~849	MHz
LTE-FDD B66	2110~2200	1710~1780	MHz

Table 35: SC650T-EM Module Operating Frequencies

3GPP Band	Receive	Transmit	Unit
LTE-FDD B1	2110~2170	1920~1980	MHz
LTE-FDD B3	1805~1880	1710~1785	MHz
LTE-FDD B7	2620~2690	2500~2570	MHz
LTE-FDD B20	791~821	832~862	MHz
LTE-FDD B28	758~803	703~748	MHz

6.1.1.
6.1.1.

6.1.1. Main and Rx-diversity Antenna Interfaces Reference Design

A reference circuit design for main and Rx-diversity antenna interfaces is shown as below. A π-type matching circuit should be reserved for better RF performance, and the π-type matching components (R1/C1/C2, R2/C3/C4) should be placed as close to the antennas as possible. The capacitors are not mounted by default and resistors are 0Ω.

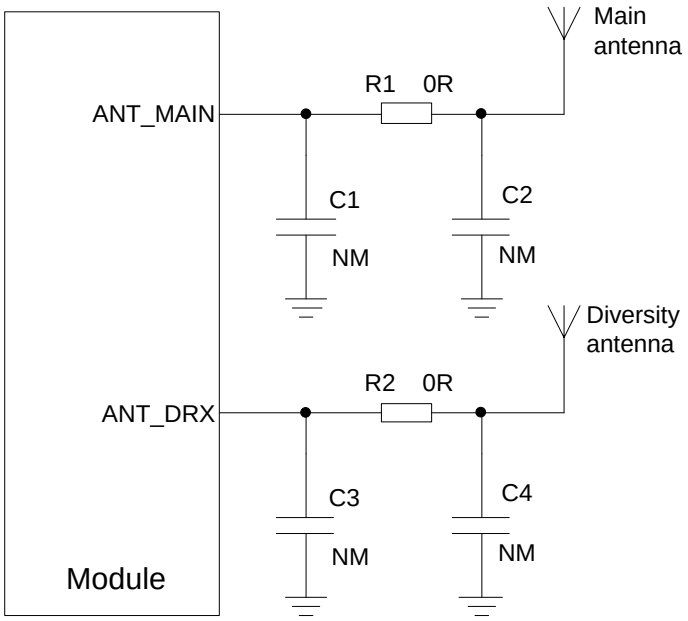


Figure 33: Reference Circuit Design for Main and Rx-diversity Antenna Interfaces

6.1.2. Reference Design of RF Layout

For user's PCB, the characteristic impedance of all RF traces should be controlled as 50Ω. The impedance of the RF traces is usually determined by the trace width (W), the materials' dielectric constant, the distance between signal layer and reference ground (H), and the clearance between RF trace and ground (S). Microstrip line or coplanar waveguide line is typically used in RF layout for characteristic impedance control. The following are reference designs of microstrip line or coplanar waveguide line with different PCB structures.

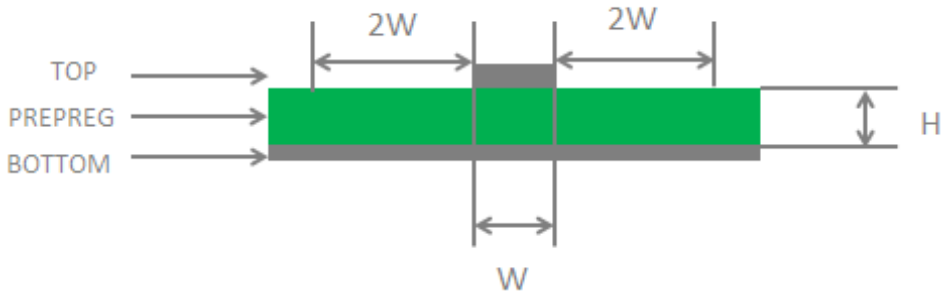


Figure 34: Microstrip Line Design on a 2-layer PCB

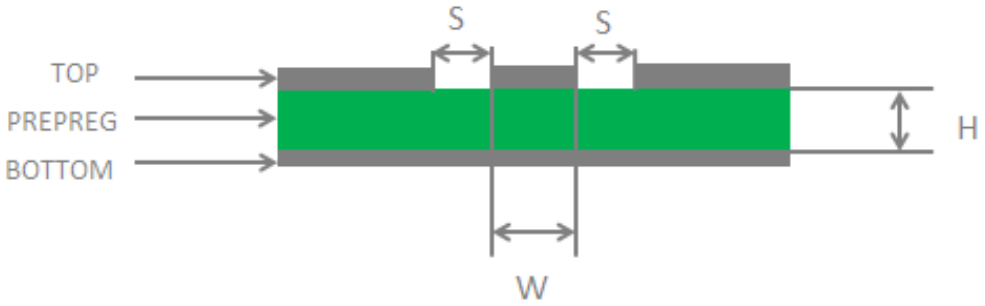


Figure 35: Coplanar Waveguide Line Design on a 2-layer PCB

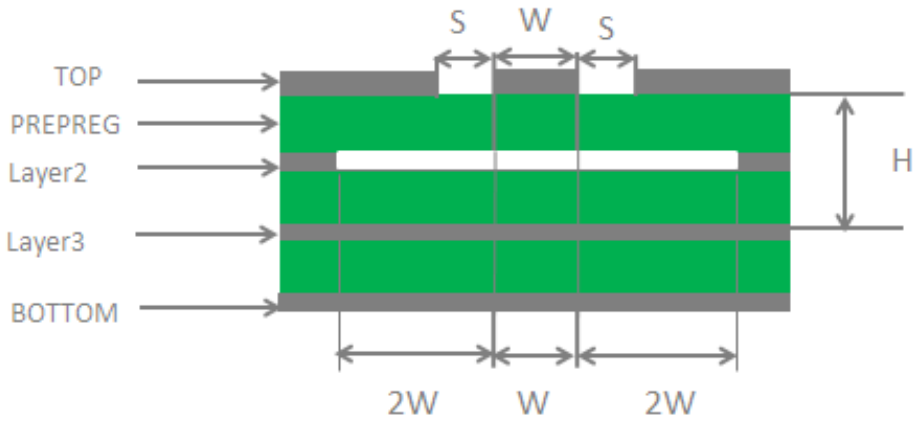


Figure 36: Coplanar Waveguide Line Design on a 4-layer PCB (Layer 3 as Reference Ground)

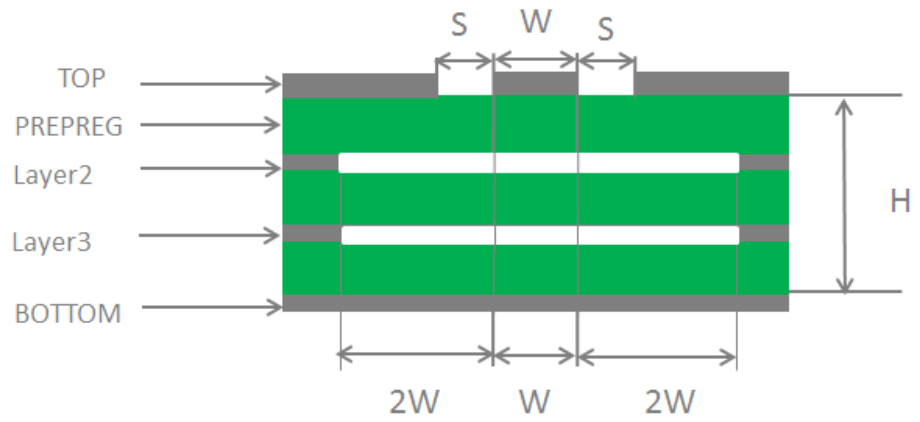


Figure 37: Coplanar Waveguide Line Design on a 4-layer PCB (Layer 4 as Reference Ground)

In order to ensure RF performance and reliability, the following principles should be complied with in RF layout design:

- Use impedance simulation tool to control the characteristic impedance of RF traces as 50Ω.
- The GND pins adjacent to RF pins should not be designed as thermal relief pads, and should be fully connected to ground.
- The distance between the RF pins and the RF connector should be as short as possible, and all the right-angle traces should be changed to curved ones.
- There should be clearance area under the signal pin of the antenna connector or solder joint.
- The reference ground of RF traces should be complete. Meanwhile, adding some ground vias around RF traces and the reference ground could help to improve RF performance. The distance between the ground vias and RF traces should be no less than two times the width of RF signal traces (2*W).

For more details about RF layout, please refer to ***document [3]***.

6.2. Wi-Fi/BT Antenna Interface

Table 36: Pin Definition of Wi-Fi/BT Antenna Interface

Pin Name	Pin No.	I/O	Description	Comment
ANT_WIFI/BT	129	IO	Wi-Fi/BT antenna interface	50Ω impedance

Table 37: Wi-Fi/BT Frequency

Type	Frequency	Unit
802.11a/b/g/n/ac	2402~2482 5180~5825	MHz
BT4.2 LE	2402~2480	MHz

A reference circuit design for Wi-Fi/BT antenna interface is shown as below. A π-type matching circuit is recommended to be reserved for better RF performance. The capacitors are not mounted by default and resistors are 0Ω.

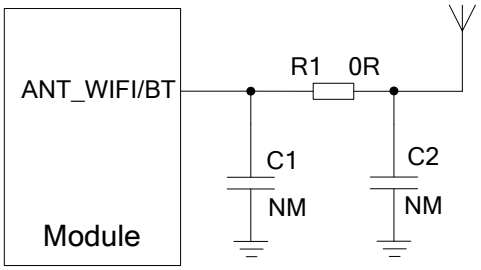


Figure 38: Reference Circuit Design for Wi-Fi/BT Antenna Interface

6.3. GNSS Antenna Interface

Table 38: Pin Definition of GNSS Antenna

Pin Name	Pin No.	I/O	Description	Comment
ANT_GNSS	134	AI	GNSS antenna Interface	50Ω impedance
GNSS_LNA_EN	202	DO	LNA enable control	For test purpose only. If unused, keep it open.

Table 39: GNSS Frequency

Type	Frequency	Unit
GPS	1575.42±1.023	MHz
GLONASS	1597.5~1605.8	MHz
BeiDou	1561.098±2.046	MHz

6.3.1. Recommended Circuit for Passive Antenna

GNSS antenna interface supports passive ceramic antennas and other types of passive antennas. A reference circuit design is given below.

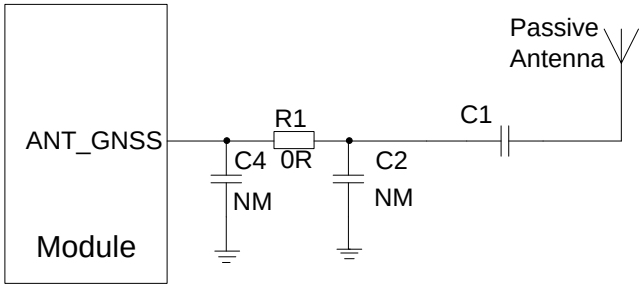


Figure 39: Reference Circuit Design for GNSS Passive Antenna

NOTE

When the passive antenna is placed far away from the module (that is, the antenna trace is long), it is recommended to add an external LNA circuit for better GNSS receiving performance, and the LNA should be placed close to the antenna.

6.3.2. Recommended Circuit for Active Antenna

The active antenna is powered by a 56nH inductor through the antenna's signal path. The common power supply voltage ranges from 3.3V to 5.0V. Although featuring low power consumption, the active antenna

still requires stable and clean power supplies. It is recommended to use high performance LDO as the power supply. A reference design of GNSS active antenna is shown below.

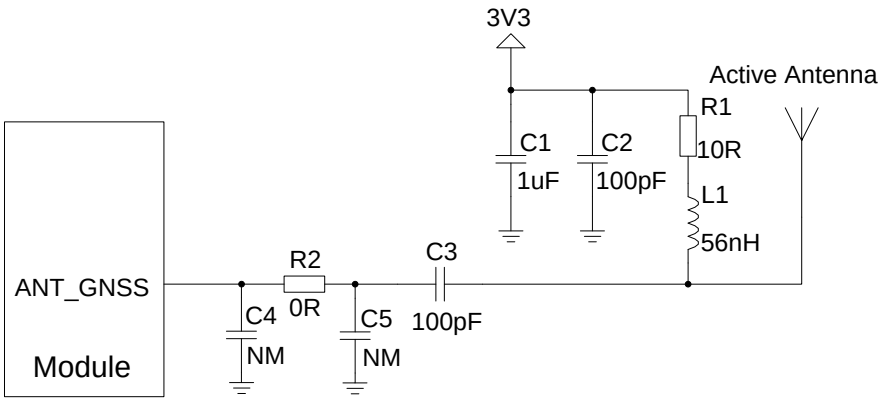


Figure 40: Reference Circuit Design for GNSS Active Antenna

6.4. Antenna Installation

6.4.1. Antenna Requirements

The following table shows the requirements on main antenna, Rx-diversity, Wi-Fi/BT antenna and GNSS antenna.

Table 40: Antenna Requirements

Antenna Type	Requirements
LTE	VSWR: ≤ 2 Gain (dBi): 1 Max Input Power (W): 50 Input Impedance (Ω): 50 Polarization Type: Vertical Cable Insertion Loss: < 1dB (LTE B5/B12/B13/B14/B20/B26/B28) Cable Insertion Loss: < 1.5dB (LTE B1/B2/B3/B4/B25/B66) Cable Insertion Loss: < 2dB (LTE B7)
Wi-Fi/BT	VSWR: ≤ 2 Gain (dBi): 1 Max Input Power (W): 50 Input Impedance (Ω): 50 Polarization Type: Vertical Cable Insertion Loss: < 1dB

GNSS [1)]	Frequency range: 1559MHz~1609MHz Polarization: RHCP or linear VSWR: < 2 (Typ.) Passive Antenna Gain: > 0dBi Active Antenna Noise Figure: < 1.5dB (Typ.) Active Antenna Gain: > -2dBi Active Antenna Embedded LNA Gain: < 17dB (Typ.) Active Antenna Total Gain: < 17dBi (Typ.)

NOTE

[1)] It is recommended to use a passive GNSS antenna when LTE B13 or B14 is supported, as the use of active antenna may generate harmonics which will affect the GNSS performance.

6.4.2. Recommended RF Connector for Antenna Installation

If RF connector is used for antenna connection, it is recommended to use the U.FL-R-SMT connector provided by HIROSE.

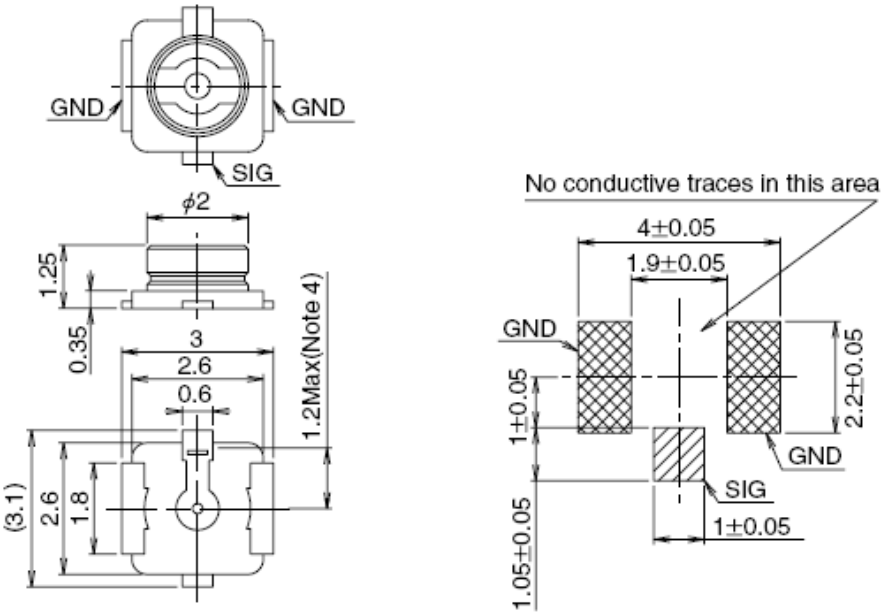


Figure 41: Dimensions of the U.FL-R-SMT Connector (Unit: mm)

U.FL-LP serial connectors listed in the following figure can be used to match the U.FL-R-SMT.

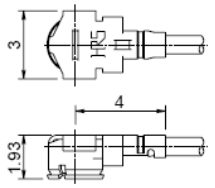
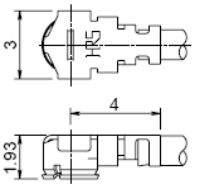
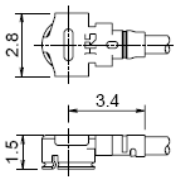
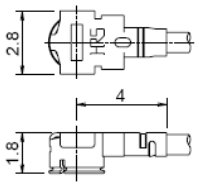
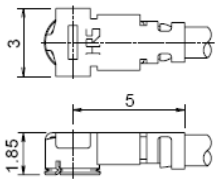
Part No.	U.FL-LP-040	U.FL-LP-066	U.FL-LP(V)-040	U.FL-LP-062	U.FL-LP-088
					
Mated Height	2.5mm Max. (2.4mm Nom.)	2.5mm Max. (2.4mm Nom.)	2.0mm Max. (1.9mm Nom.)	2.4mm Max. (2.3mm Nom.)	2.4mm Max. (2.3mm Nom.)
Applicable cable	Dia. 0.81mm Coaxial cable	Dia. 1.13mm and Dia. 1.32mm Coaxial cable	Dia. 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 42: Mechanicals of U.FL-LP Connectors

The following figure describes the space factor of mated connector.

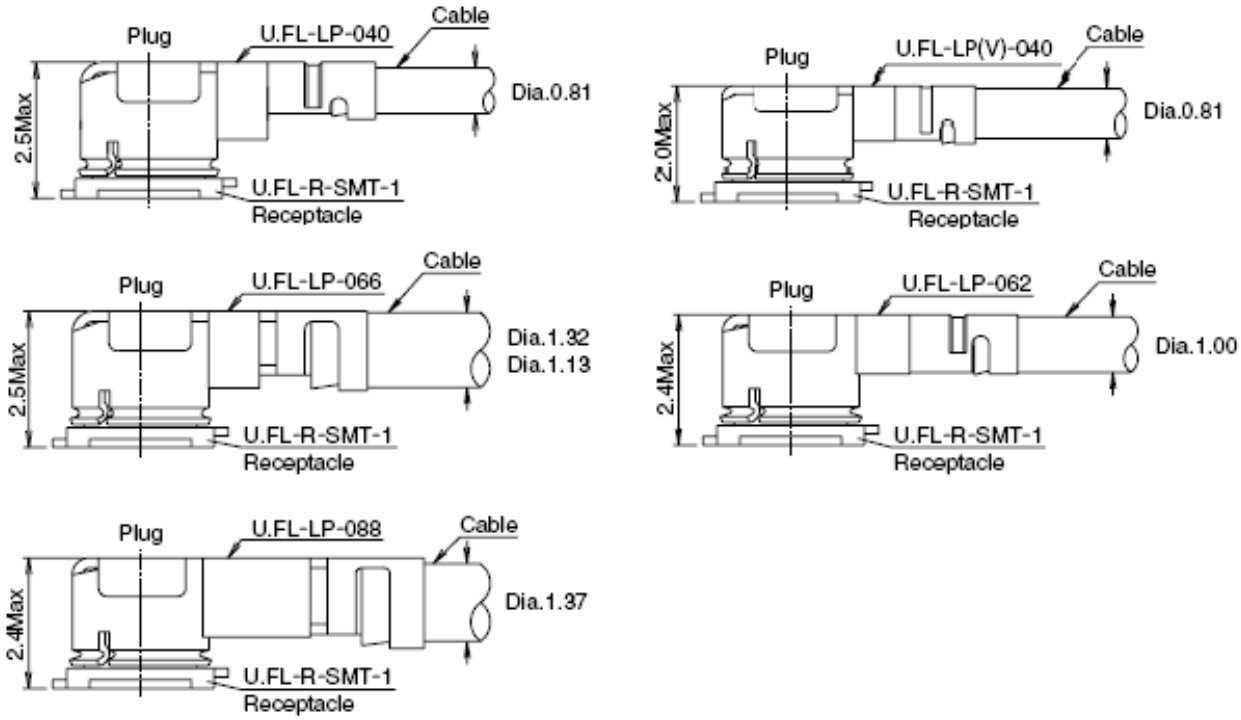


Figure 43: Space Factor of Mated Connector (Unit: mm)

For more details, please visit http://www.hirose.com.

7 Electrical, Reliability and Radio Characteristics

7.1. Absolute Maximum Ratings

Absolute maximum ratings for power supply and voltage on digital and analog pins of the module are listed in the following table.

Table 41: Absolute Maximum Ratings

Parameter	Min	Max	Unit
VBAT	-0.5	6	V
USB_VBUS	-0.5	20	V
Current on VBAT	0	3	A
Voltage on Digital Pins	-0.3	2.3	V

7.2. Power Supply Ratings

Table 42: SC650T Module Power Supply Ratings

Parameter	Description	Conditions	Min	Typ.	Max	Unit
VBAT	VBAT	The actual input voltages must stay between the minimum and maximum values.	3.55	3.8	4.4	V
USB_VBUS			4.0	5.0	10	V
VRTC	Power supply voltage of backup		2.0	3.0	3.25	V

Parameter	Description	Conditions	Min	Typ.	Max	Unit
	battery.					

7.3. Operation and Storage Temperatures

The operation and storage temperatures are listed in the following table.

Table 43: Operation and Storage Temperatures

Parameter	Min	Typ.	Max	Unit
Operating temperature range [1)]	-35	+25	+65	°C
Extended temperature range [2)]	-40		+75	°C
Storage temperature range	-40		+90	°C

NOTES

1. [1)] Within operation temperature range, the module is 3GPP compliant.
2. [2)] Within extended temperature range, the module remains the ability to establish and maintain a voice, SMS, data transmission, emergency call, etc. There is no unrecoverable malfunction. There are also no effects on radio spectrum and no harm to radio network. Only one or more parameters like P_{out} might reduce in their value and exceed the specified tolerances. When the temperature returns to the normal operating temperature levels, the module will meet 3GPP specifications again.

7.4. Current Consumption

Table 44: SC650T-NA Current Consumption

Parameter	Description	Conditions	Min	Typ.	Max	Unit
I_{VBAT}	OFF state	Power down		73		uA
	LTE-FDD supply current	Sleep (USB disconnected) @DRX=6		5.3		mA
		Sleep (USB disconnected) @DRX=8		3.5		mA
		Sleep (USB disconnected) @DRX=9		3.2		mA
	LTE data transfer	LTE-FDD B2 @max power		591		mA
		LTE-FDD B4 @max power		566		mA
		LTE-FDD B5 @max power		540		mA
		LTE-FDD B7 @max power		654		mA
		LTE-FDD B12 @max power		541		mA
		LTE-FDD B13 @max power		561		mA
		LTE-FDD B14 @max power		532		mA
		LTE-FDD B25 @max power		588		mA
		LTE-FDD B26 @max power		571		mA
		LTE-FDD B66 @max power		631		mA

Table 45: SC650T-EM Current Consumption

Parameter	Description	Conditions	Min	Typ.	Max	Unit
I_{VBAT}	OFF state	Power down		80		uA
	LTE-FDD supply current	Sleep (USB disconnected) @DRX=6		5		mA
		Sleep (USB disconnected) @DRX=8		3.2		mA
		Sleep (USB disconnected) @DRX=9		2.9		mA
	LTE data transfer	LTE-FDD B1 @max power		650		mA

	LTE-FDD B3 @max power	721	mA
	LTE-FDD B7 @max power	702	mA
	LTE-FDD B20 @max power	571	mA
	LTE-TDD B28 @max power	607	mA

7.5.

7.5. RF Output Power

The following table shows the RF output power of SC650T module.

Table 46: SC650T-NA RF Output Power

Frequency	Max	Min
LTE-FDD B2	23dBm±2dB	<-39dBm
LTE-FDD B4	23dBm±2dB	<-39dBm
LTE-FDD B5	23dBm±2dB	<-39dBm
LTE-FDD B7	23dBm±2dB	<-39dBm
LTE-FDD B12	23dBm±2dB	<-39dBm
LTE-FDD B13	23dBm±2dB	<-39dBm
LTE-FDD B14	23dBm±2dB	<-39dBm
LTE-FDD B25	23dBm±2dB	<-39dBm
LTE-FDD B26	23dBm±2dB	<-39dBm
LTE-FDD B66	23dBm±2dB	<-39dBm

Table 47: SC650T-EM RF Output Power

Frequency	Max	Min
LTE-FDD B1	23dBm±2dB	<-39dBm
LTE-FDD B3	23dBm±2dB	<-39dBm

LTE-FDD B7	23dBm±2dB	<-39dBm
LTE-FDD B20	23dBm±2dB	<-39dBm
LTE-FDD B28	23dBm±2dB	<-39dBm

7.6. RF Receiving Sensitivity

The following table shows the conducted RF receiving sensitivity of SC650T module.

Table 48: SC650T-NA RF Receiving Sensitivity x`

Frequency	Receive Sensitivity (Typ.)			3GPP (SIMO)
	Primary	Diversity	SIMO	
LTE-FDD B2 (10M)	-99.5dBm	-100.4dBm	-102.9dBm	-94.3dBm
LTE-FDD B4 (10M)	-98.7dBm	-99.6dBm	-102.3dBm	-96.3dBm
LTE-FDD B5 (10M)	-100.3dBm	-99.7dBm	-103.6dBm	-94.3dBm
LTE-FDD B7 (10M)	-96dBm	-99.2dBm	-100dBm	-94.3dBm
LTE-FDD B12 (10M)	-100dBm	-100.1dBm	-103.2dBm	-93.3dBm
LTE-FDD B13 (10M)	-98.5dBm	-100.3dBm	-102.6dBm	-93.3dBm
LTE-FDD B14 (10M)	-98.9dBm	-101dBm	-102.9dBm	-93.3dBm
LTE-FDD B25 (10M)	-99.4dBm	-100.4dBm	-102.8dBm	-92.8dBm
LTE-FDD B26 (10M)	-100.5dBm	-99.5dBm	-103.9dBm	-93.8dBm
LTE-FDD B66 (10M)	-98.3dBm	-99.4dBm	-102dBm	-95.8dBm

Table 49: SC650T-EM RF Receiving Sensitivity

Frequency	Receive Sensitivity (Typ.)			3GPP (SIMO)
	Primary	Diversity	SIMO	

LTE-FDD B1 (10M)	-99.1dBm	-99dBm	-102.3dBm	-96.3dBm
LTE-FDD B3 (10M)	-98.9dBm	-99.5dBm	-102.1dBm	-93.3dBm
LTE-FDD B7 (10M)	-98.5dBm	-98.8dBm	-101.9dBm	-94.3dBm
LTE-FDD B20 (10M)	-99.7dBm	-99.6dBm	-102.4dBm	-93.3dBm
LTE-TDD B28 (10M)	-99.8dBm	-99.4dBm	-102.2dBm	-94.8dBm

7.7.

7.7. Electrostatic Discharge

The module is not protected against electrostatic discharge (ESD) in general. Consequently, it should be subject to ESD handling precautions that are typically applied to ESD sensitive components. Proper ESD handling and packaging procedures must be applied throughout the processing, handling and operation of any application that incorporates the module.

The following table shows the electrostatic discharge characteristics of SC650T module.

Table 50: ESD Characteristics (Temperature: 25°C, Humidity: 45%)

Test Points	Contact Discharge	Air Discharge	Unit
VBAT, GND	+/-5	+/-10	KV
All Antenna Interfaces	+/-5	+/-10	KV
Other Interfaces	+/-0.5	+/-1	KV

8 Mechanical Dimensions

This chapter describes the mechanical dimensions of the module. All dimensions are measured in millimeter (mm), and the tolerances for dimensions without tolerance values are ±0.05mm.

8.1. Mechanical Dimensions of the Module

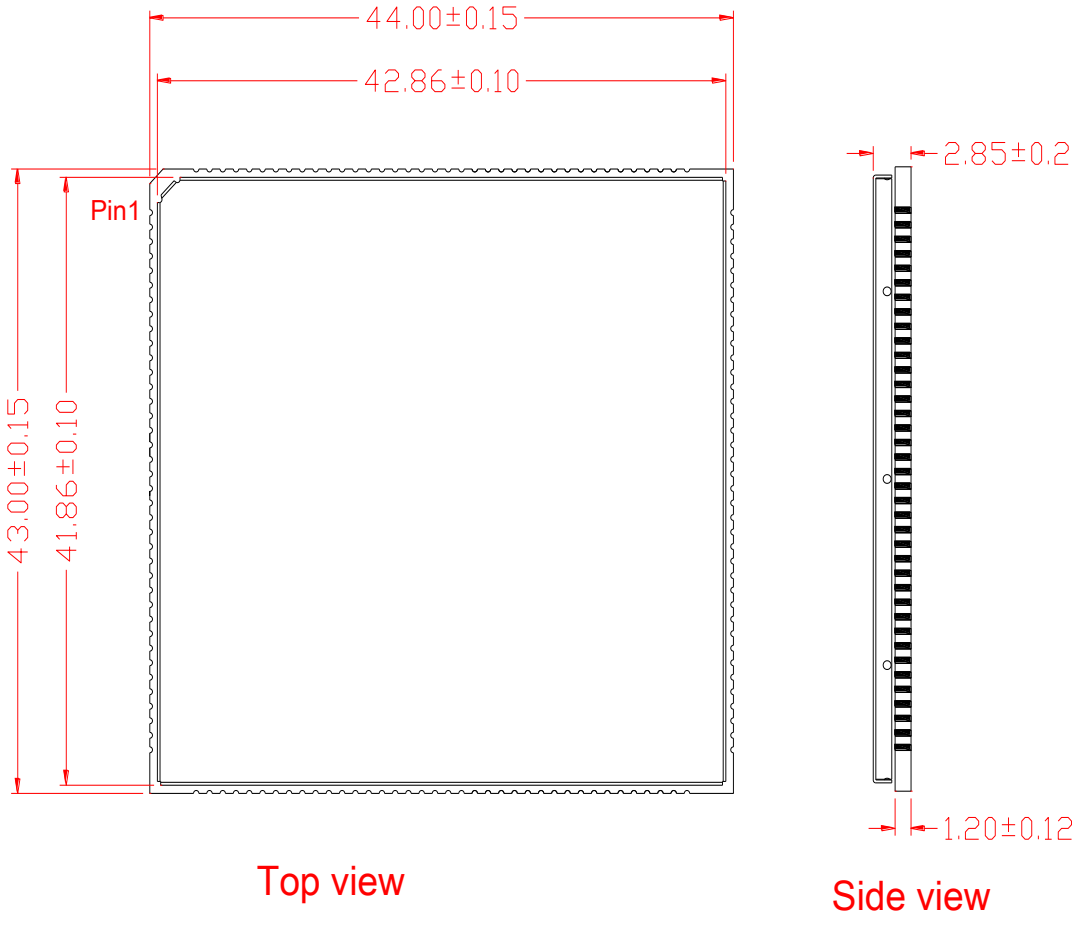


Figure 44: Module Top and Side Dimensions

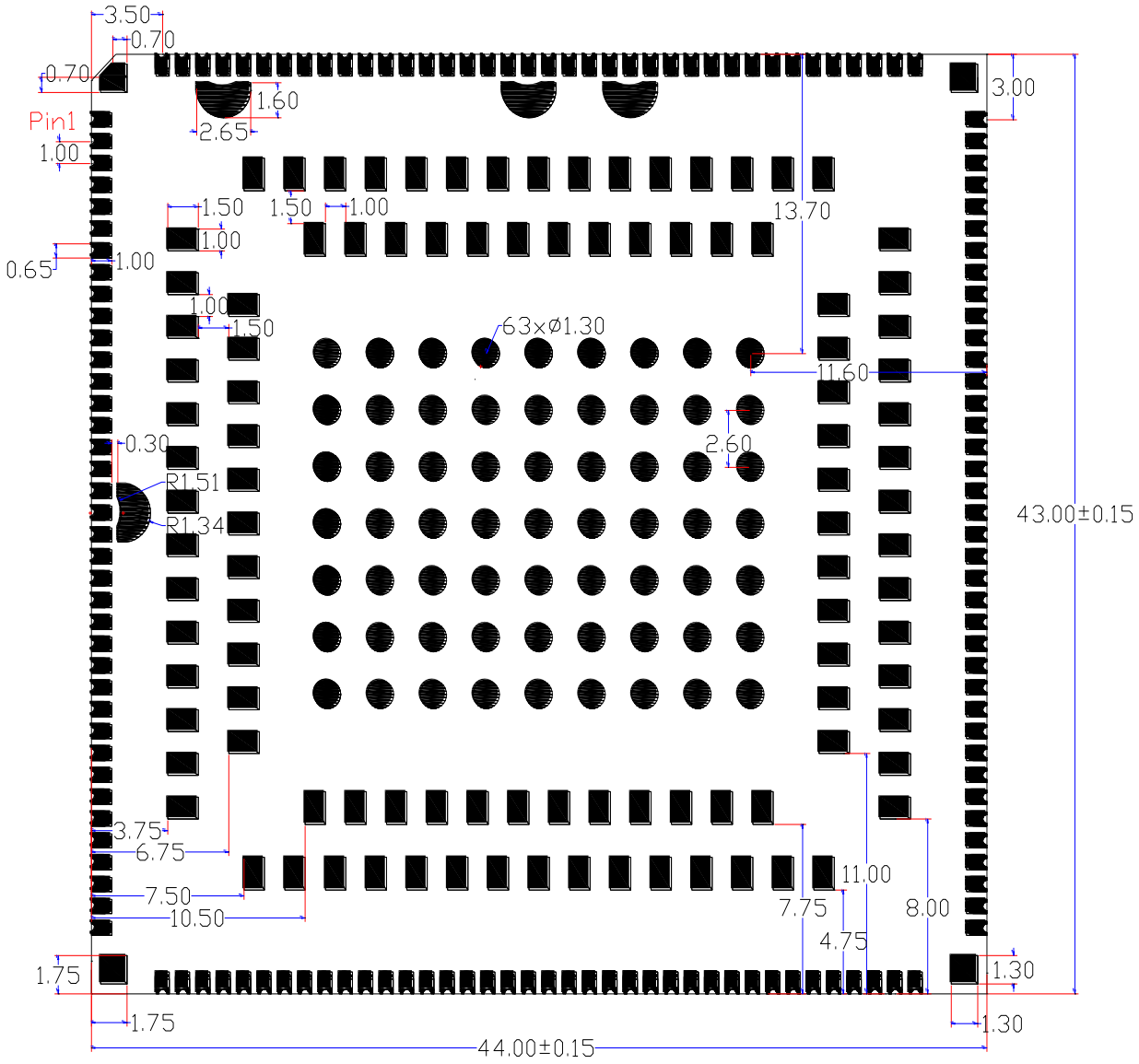


Figure 45: Module Bottom Dimensions (Top View)

8.2. Recommended Footprint

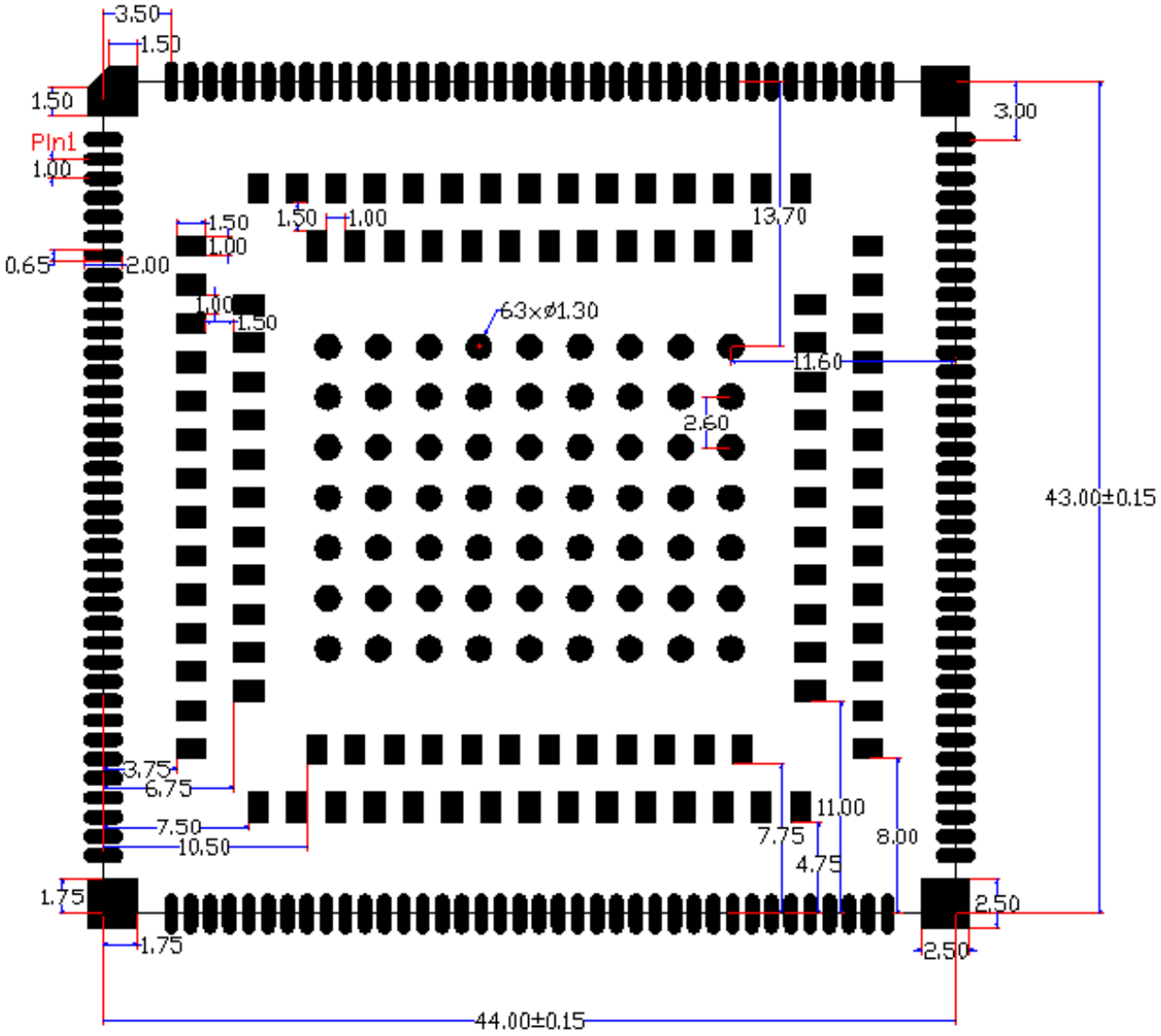


Figure 46: Recommended Footprint (Top View)

NOTES

1. For easy maintenance of the module, keep about 3mm between the module and other components on host PCB.
2. All RESERVED pins should be kept open and MUST NOT be connected to ground.

8.3. Top and Bottom View of the Module

Figure 47: Top View of the Module

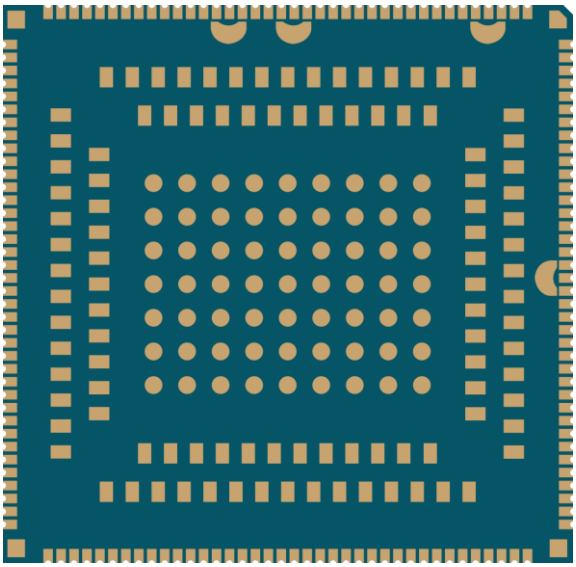


Figure 48: Bottom View of the Module

NOTE

These are renderings of SC650T module. For authentic dimension and appearance, please refer to the module that you receive from Quectel.

9 Storage, Manufacturing and Packaging

9.1. Storage

SC650T is stored in a vacuum-sealed bag. It is rated at MSL 3, and its storage restrictions are shown as below.

1. Shelf life in the vacuum-sealed bag: 12 months at <40ºC/90%RH.
2. After the vacuum-sealed bag is opened, devices that will be subjected to reflow soldering or other high temperature processes must be:
   - Mounted within 168 hours at the factory environment of ≤30ºC/60%RH.
   - Stored at <10%RH.
3. Devices require baking before mounting, if any circumstance below occurs.
   - When the ambient temperature is 23ºC±5ºC and the humidity indication card shows the humidity is >10% before opening the vacuum-sealed bag.
   - Device mounting cannot be finished within 168 hours at factory conditions of ≤30ºC/60%.
4. If baking is required, devices may be baked for 8 hours at 120ºC±5ºC.

NOTE

As the plastic package cannot be subjected to high temperature, it should be removed from devic es before high temperature (120ºC) baking. If shorter baking time is desired, please refer to *IPC/J EDECJ-STD-033* for baking procedure.

9.2. Manufacturing and Soldering

Push the squeegee to apply the solder paste on the surface of stencil, thus making the paste fill the stencil openings and then penetrate to the PCB. The force on the squeegee should be adjusted properly so as to produce a clean stencil surface on a single pass. To ensure the module soldering quality, the thickness of stencil for the module is recommended to be 0.18mm~0.20mm. It is recommended to slightly reduce the amount of solder paste for LGA pads, thus avoiding short-circuit. For more details, please refer to ***document [4]***.

It is suggested that the peak reflow temperature is 240~245ºC, and the absolute maximum reflow temperature is 245ºC. To avoid damage to the module caused by repeated heating, it is strongly recommended that the module should be mounted after reflow soldering for the other side of PCB has been completed. The recommended reflow soldering thermal profile (lead-free reflow soldering) and related parameters are shown below.

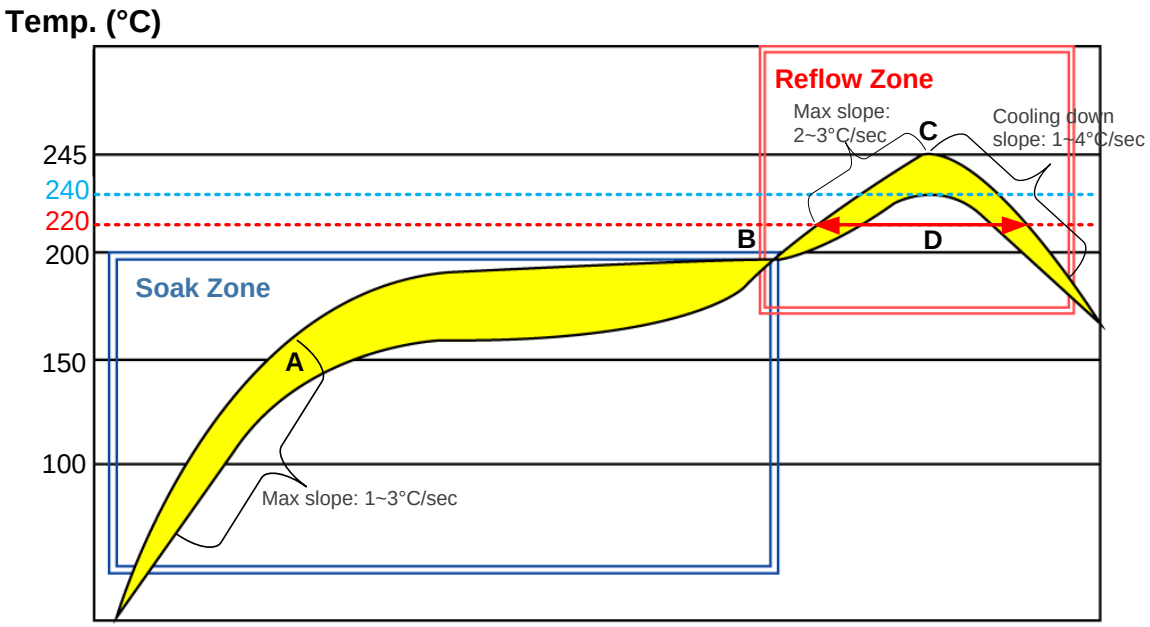


Figure 49: Recommended Reflow Soldering Thermal Profile

Table 51: Recommended Thermal Profile Parameters

Factor	Recommendation
Soak Zone	
Max slope	1 to 3°C/sec
Soak time (between A and B: 150°C and 200°C)	60 to 120 sec

Reflow Zone	
Max slope	2 to 3°C/sec
Reflow time (D: over 220°C)	40 to 60 sec
Max temperature	240°C ~ 245°C
Cooling down slope	1 to 4°C/sec
Reflow Cycle	
Max reflow cycle	1

9.3. Packaging

SC650T is packaged in tape and reel carriers. Each reel is 330mm in diameter and contains 200 modules. The following figures show the package details, measured in mm.

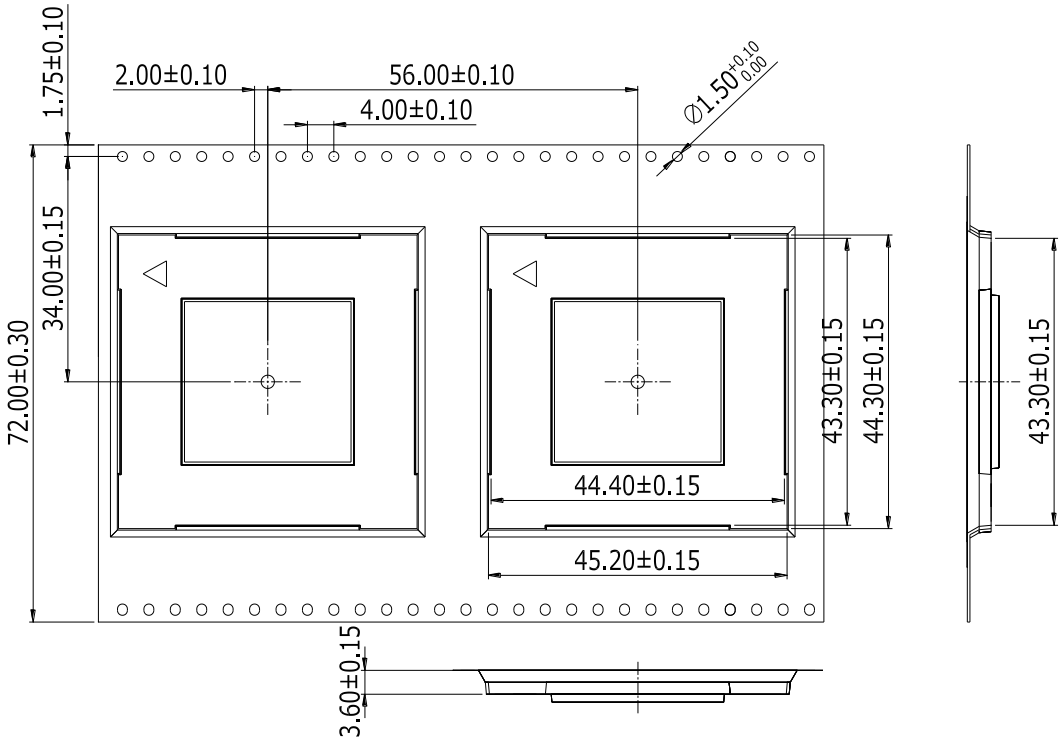


Figure 50: Tape Dimensions

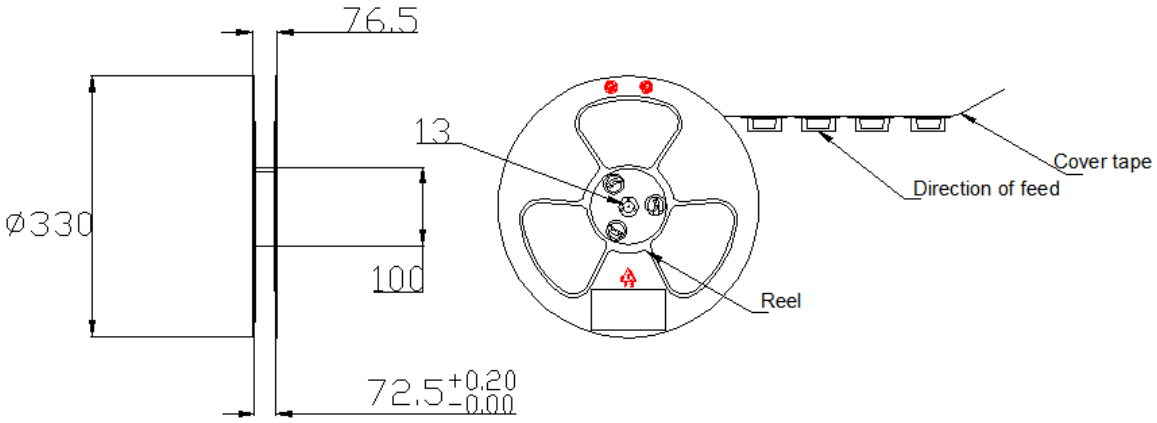


Figure 51: Reel Dimensions

Table 52: Reel Packaging

Model Name	MOQ for MP	Minimum Package: 200pcs	Minimum Package×4=800pcs
SC650T	200	Size: 398mm × 383mm × 83mm N.W: 1.92kg G.W: 3.67kg	Size: 420mm × 350mm × 405mm N.W: 8.18kg G.W: 15.18kg

10 Appendix A References

Table 53: Related Documents

SN	Document Name	Remark
[1]	Quectel_Smart_EVB-G2_User_Guide	EVB User Guide for SC650T
[2]	Quectel_SC650T_GPIO_Configuration	GPIO Configuration of SC650T
[3]	Quectel_RF_Layout_Application_Note	RF Layout Application Note
[4]	Quectel_Module_Secondary_SMT_User_Guide	Module Secondary SMT User Guide
[5]	Quectel_SC650T_Reference_Design	Reference Design for SC650T

Table 54: Terms and Abbreviations

Abbreviation	Description
ADC	Analog-to-Digital Converter
AMR	Adaptive Multi-rate
bps	Bits per Second
CS	Coding Scheme
CSD	Circuit Switched Data
CTS	Clear to Send
DRX	Discontinuous Reception
EFR	Enhanced Full Rate
ESD	Electrostatic Discharge
FR	Full Rate
GMSK	Gaussian Minimum Shift Keying

GPS	Global Positioning System
GPU	Graphics Processing Unit
HR	Half Rate
HSDPA	High Speed Down Link Packet Access
HSPA	High Speed Packet Access
I/O	Input/Output
IQ	Inphase and Quadrature
LCD	Liquid Crystal Display
LCM	LCD Module
LED	Light Emitting Diode
LNA	Low Noise Amplifier
LRA	Linear Resonant Actuator
MIPI	Mobile Industry Processor Interface
PCB	Printed Circuit Board
PDU	Protocol Data Unit
PMI	Power Management Interface
PMU	Power Management Unit
PSK	Phase Shift Keying
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keying
RF	Radio Frequency
RH	Relative Humidity
RHCP	Right Hand Circularly Polarized
RTC	Real Time Clock
Rx	Receive

SMS	Short Message Service
TE	Terminal Equipment
TX	Transmitting Direction
UART	Universal Asynchronous Receiver & Transmitter
UMTS	Universal Mobile Telecommunications System
(U)SIM	(Universal) Subscriber Identity Module
Vmax	Maximum Voltage Value
Vnorm	Normal Voltage Value
Vmin	Minimum Voltage Value
V_I	Voltage Input
V_{IH}min	Minimum Input High Level Voltage Value
V_{IL}max	Maximum Input Low Level Voltage Value
V_O	Voltage Output
V_{OH}min	Minimum Output High Level Voltage Value
V_{OL}max	Maximum Output Low Level Voltage Value
VSWR	Voltage Standing Wave Ratio