LG69T (AM,AQ,AS) Hardware Design

GNSS Module Series

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The following safety precautions must be observed during all phases of operation, such as usage, service, or repair of any terminal or mobile incorporating the module. Manufacturers of the terminal should notify users and operating personnel of the following safety information by incorporating these guidelines into all product manuals. Otherwise, Quectel assumes no liability for customers' failure to comply with these precautions.

	Ensure that the product may be used in the country and the required environment, as well as that it conforms to the local safety and environmental regulations.
	Keep away from explosive and flammable materials. The use of electronic products in extreme power supply conditions and locations with potentially explosive atmospheres may cause fire and explosion accidents.
	The product must be powered by a stable voltage source, and the wiring shall conform to security precautions and fire prevention regulations.
	Proper ESD handling procedures must be followed throughout the mounting, handling and operation of any devices and equipment that incorporate the module to avoid ESD damages.

About the Document

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1 Product Description

1.1. Overview

The document contains three variants of LG69T module: LG69T (AM), LG69T (AQ), LG69T (AS). You can choose the dedicated type base on your requirement. These modules also support multiple global positioning and navigation systems: GPS, Galileo, BeiDou, and QZSS.

Key features:

- The LG69T (AQ), LG69T (AM), LG69T (AS) modules are dual-band, multi-constellation GNSS module and feature high-performance, high reliability positioning engine. These modules facilitate a fast and precise GNSS positioning capability.
- These modules support serial communication interface UART.
- The LG69T (AM) and LG69T (AQ) modules are support standard RTCM correction input, as well as centimeter-level navigation by using RTCM data from third-party base stations.
- The LG69T (AM) and LG69T (AS) modules are meet the automotive standard temperature from -40 °C to +85 °C, and have good stability meet the automotive application scenarios. The LG69T (AQ) module is meet the industrial standard temperature from -40 °C to +85 °C.
- The LG69T (AQ) module integrates a 6-axis IMU and supports dual-band sophisticated RTK technology and dead-reckoning (DR) algorithms to fuse the 6-axis IMU data, GNSS raw data and speed data, etc. to provide centimeter-level positioning accuracy in an open-sky environment.
- The LG69T (AQ) module integrated state-of-the-art algorithms fuse between the IMU data, GNSS measurements, wheel ticks, and vehicle dynamics models, to provide accurate positioning in areas where GNSS alone would fail.
- The LG69T (AS) module supports RTK data output as a base station.
- The embedded flash memory provides the capacity for storing user-specific configurations and future firmware updates.

All three modules are SMD type modules with a compact form factor of 22.0 mm × 17.0 mm × 3.15 mm. It can be embedded in your applications through the 102 LGA pins.

All three modules are fully compliant with the EU RoHS Directive.

1.1.1. Special Marks

Table 1: Special Marks

Mark	Definition
*	Unless otherwise specified, when an asterisk (*) is used after a function, feature, interface, pin name, command, or argument, it indicates that the function, feature, interface, pin, AT command, or argument is under development and currently not supported; and the asterisk (*) after a model indicates that the sample of such model is currently unavailable.
◆	When the symbol ◆ is used after a piece of data, it indicates that the piece of data is preliminary, unless otherwise specified.

1.2. Features

Table 2: Product Features

Features		LG69T (AM) *	LG69T (AQ) *	LG69T (AS) *
Grade	Industrial	-	●	-
	Automotive	●	-	●
Category	Standard Precision GNSS	-	-	-
	High Precision GNSS	●	●	●
	DR	-	●	-
	RTK Rover	●	●	-
	RTK Base Station	-	-	●
	Timing	-	-	-
Supply Voltage	3.0-3.6 V, Typical: 3.3 V	●	●	●
IO Voltage	Typical: VCC	●	●	●
Communication Interfaces	UART	●	●	●
	USB	-	-	-
	SPI	-	-	-

	I2C		-	-	-
	CAN		-	-	-
Integrated Features	Additional LNA		●	●	●
	Additional SAW		●	●	●
	RTC crystal		●	●	●
	TCXO oscillator		●	●	●
	6-axis IMU		-	●	-
Constellations	GPS	L1 C/A	●	●	●
		L5	●	●	●
	GLONASS	L1	-	-	-
	Galileo	E1	●	●	●
		E5a	●	●	●
	BeiDou	B1I	●	●	●
		B2a	●	●	●
	QZSS	L1 C/A	●	●	●
		L5	●	●	●
	IRNSS	L5	-	-	-
	SBAS	L1	-	-	-
Temperature Range	Operating temperature range: -40 °C to +85 °C Storage temperature range: -40 °C to +90 °C				
Physical Characteristics	Size: (22.0 ±0.20) mm × (17.0 ±0.20) mm × (3.15 ±0.20) mm Weight: Approx. 1.9 g				

NOTE

1. The LG69T (AS) module supports the RTK data output.
2. For more information about GNSS constellation configuration, see ***document [1]*** and ***[2]***.

1.3. Performance

Table 3: Product Performance

Parameter	Specification	LG69T (AM) (G2 [1] + BeiDou)	LG69T (AQ) (G2 [1] + BeiDou)	LG69T (AS) (G2 [1] + BeiDou)
Power Consumption [2]	Acquisition	TBD	TBD	TBD
	Tracking	TBD	TBD	TBD
	Backup mode	TBD	TBD	TBD
Sensitivity [3]	Acquisition	-145 dBm◆	-145 dBm◆	-145 dBm◆
	Reacquisition	-153 dBm◆	-153 dBm◆	-153 dBm◆
	Tracking	-160 dBm◆	-160 dBm◆	-160 dBm◆
TTFF [2] (without AGNSS)	Cold Start	36 s◆	36 s◆	36 s◆
	Warm Start	30 s◆	30 s◆	30 s◆
	Hot Start	3 s◆	3 s◆	3 s◆
TTFF (with AGNSS)	-	-	-	-
Horizontal Position Accuracy	Autonomous [4]	1 m◆	1 m◆	-
	RTK [5]	0.1 m + 1ppm◆	0.1 m + 1ppm◆	-
Update Rate	PVT [6]	10 Hz◆	10 Hz◆	-
	IMU Raw Data	-	100 Hz◆	-
	GNSS Raw Data	-	-	1 Hz◆
Convergence Time		TBD	TBD	-
Accuracy of 1PPS Signal [2]	Typical Accuracy	TBD	TBD	TBD
	Time Pulse Width	TBD	TBD	TBD

[1] G2 is GPS + Galileo.
[2] Room temperature, all satellites at -130 dBm.
[3] Demonstrated with a good external LNA.
[4] CEP, 50%, 24 hours static, -130 dBm, more than 6 SVs.
[5] Measured by using active high-precision antennas in an open-sky environment and within 1 km from the base station.
[6] PVT means: Position, Velocity, Time.

Velocity Accuracy [2]	Without Aid: 0.1 m/s
Acceleration Accuracy [2]	Without Aid: 0.1 m/s²
Dynamic Performance [2]	Maximum Altitude: 18000 m Maximum Velocity [7]: 515 m/s Acceleration [7]: 4g

NOTE

The sensitivity data are acquired by connecting the module to a simulator with a coaxial cable. In the sensitivity testing, a first-level LNA is used to simulate the real working environment.

1.4. Block Diagram

The following figure show three block diagrams of three modules.

The LG69T (AM), LG69T (AQ), and LG69T (AS) modules include a GNSS IC, a MCU IC, a 6-axis IMU (supported by LG69T (AQ) module), two additional LNAs, two additional SAWs, flash memory, two diplexers, a TCXO and three XTALs. The diplexers integrate two band-pass filters, which can improve the out-of-band rejection. Consequently, the LNAs will have less chance to produce in-band interference in challenging environments, which ensures enhanced performance in a jamming environment.

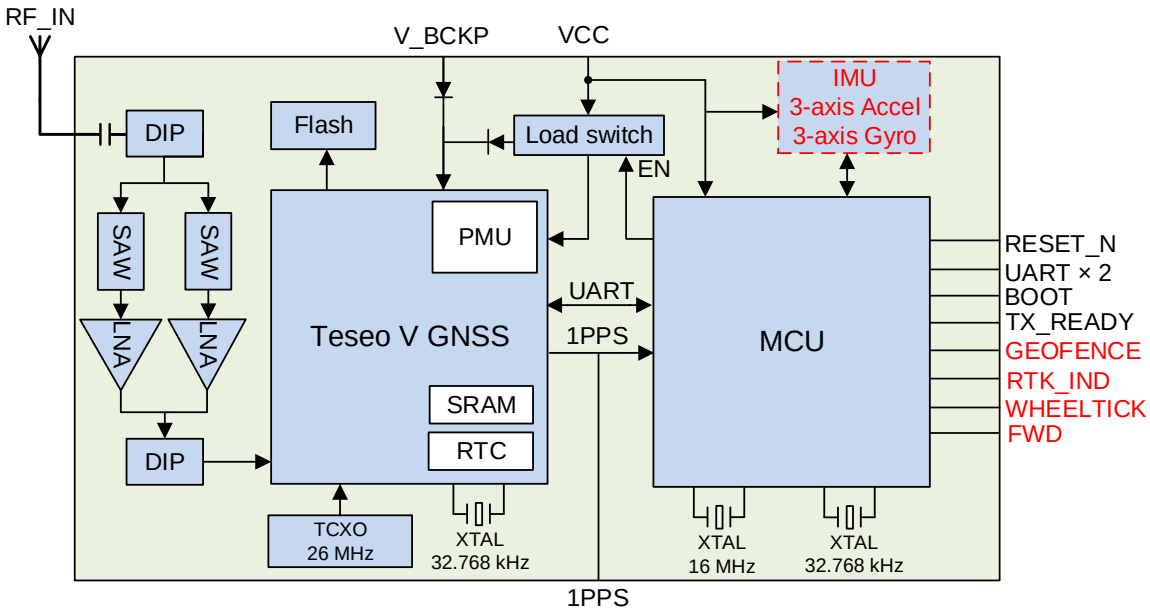


Figure 1: LG69T (AM), LG69T (AQ) and LG69T (AS) Block Diagram

[7] ITAR limits.

The LG69T (AM) and LG69T (AQ) modules support GEOFENCE and RTK_IND. Only the LG69T (AQ) module supports 6-axis IMU, FWD and WHEELTICK. LG69T (AS) does not support the red part in the block diagram

1.5. GNSS Constellations

The Quectel LG69T (AM), LG69T (AQ) and LG69T (AS) modules are a dual-band GNSS receiver that can receive and track GPS, Galileo, BeiDou, and QZSS signals.

1.5.1. GPS

These modules are designed to receive and track GPS L1 C/A and L5 signals centered at 1575.42 MHz and 1176.45 MHz.

1.5.2. Galileo

These modules are designed to receive and track Galileo E1 and E5a signals centered at 1575.42 MHz and 1176.45 MHz.

1.5.3. BeiDou

These modules are designed to receive and track BeiDou B1I and B2a signals centered at 1561.098 MHz and 1176.45 MHz. The ability to receive and track BeiDou signals in conjunction with GPS results in higher coverage, improved reliability, and better accuracy.

1.5.4. QZSS

The Quasi-Zenith Satellite System (QZSS) is a regional navigation satellite system that transmit signals compatible with the GPS L1 C/A, L1C, L2C, and L5 signals for the Pacific region covering Japan and Australia. These modules can detect and track QZSS L1 C/A and L5 signals concurrently with GPS signals, leading to better availability especially under challenging conditions, i.e., in urban canyons.

1.6. RTK

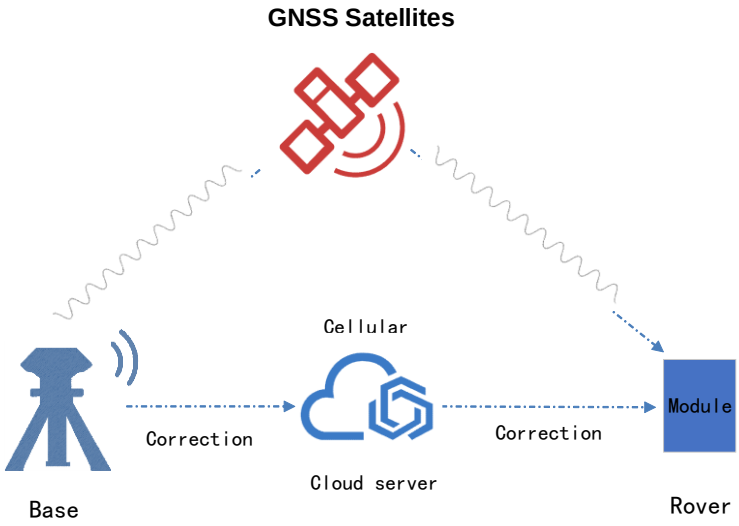


Figure 2: RTK Operation Process

1.6.1. RTK Rover

The Quectel LG69T (AM) and LG69T (AQ) modules support RTK functionality as rovers.

Before supporting the RTK navigation technique, these modules need to receive the RTK correction messages via its UART port. RTK correction messages can be delivered either using a cellular module or other terrestrial network technology. In default configuration, these modules will attempt to achieve the best positioning accuracy based on the correction data that it receives. When these modules receive an input stream of RTCM messages, they will enter RTK float mode. Once it fixes carrier phase ambiguities, these modules enter the RTK fixed mode.

These modules may be expected to achieve sub-meter level accuracy only when it is in RTK fixed mode.

It will typically take less than 60 s before the rover has been able to solve the carrier ambiguities and go from RTK float mode to RTK fixed mode. The length of this time period is referred to as the convergence time.

1.6.2. RTK Base Station

The Quectel LG69T (AS) module supports RTK data output as base station.

The LG69T (AS) module supports static mode, and the receiver mode flag can be set as "fixed mode" through corresponding commands. The module can be set to use the previously measured coordinates of base station antenna position. If this coordinate has the best effect, this method can ensure that rover achieves the best accuracy.

The LG69T (AS) module can self survey in its coordinates in situations without using other methods to measure the base station antenna. When this mode is adopted, the user provides accuracy constraints and the shortest observation time. The receiver will estimate its average position. When the accuracy and observation meet the conditions, it will start running in static mode and output the configured RTCM reference station messages.

1.7. Dead Reckoning Function

Only the Quectel LG69T (AQ) module supports DR function. Dead Reckoning is the process of estimating the module's current position based on the last position obtained from GNSS, speed, heading sensor data, etc. With this combined 6-axis IMU inputs, the system plots the navigation trace when the satellite signals are partially or completely blocked while satellite signals provide updates and correction for 6-axis IMU drift. With this technology, the system obtains continuous and high-accuracy positioning in environments such as tunnels and urban canyons.

2 Pin Assignment

The Quectel LG69T (AM), LG69T (AQ), and LG69T (AS) modules are equipped with 102 pins by which the modules can be mounted on your PCB.

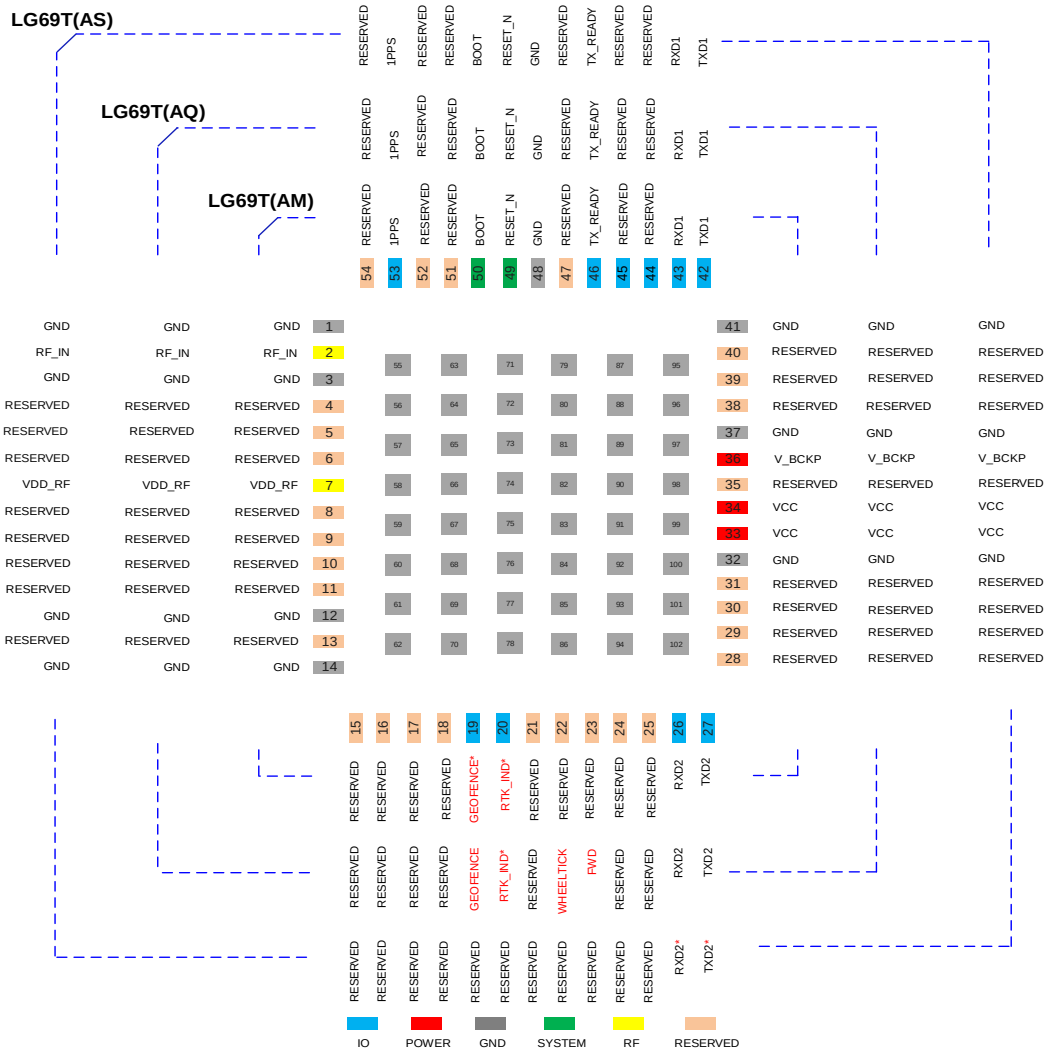


Figure 3: Pin Assignment

Table 4: I/O Parameter Definition

Type	Description
AI	Analog Input
DI	Digital Input
DO	Digital Output
DIO	Digital Input/Output
PI	Power Input
PO	Power Output

Table 5: Pinout

Function	Name	No.	I/O	Description	Remarks
Power	VCC	33, 34	PI	Main power supply	Provides clean and steady voltage.
	V_BCKP	36	PI	Backup power supply for backup domain	V_BCKP must be connected to power supply for startup, and it should be always powered if hot (warm) start is needed.
IO	GEOFENCE	19	DO	Indicates geofence status	For LG69T (AM) and LG69T (AQ) modules, the pin is GEOFENCE. Once the pin is activated, the receiver continuously compares its current position to the preset geofence area. For LG69T (AS) module, the pin is RESERVED. If unused, leave the pin N/C (not connected).
	RTK_IND *	20	DO	Indicates RTK status	For LG69T (AM) and LG69T (AQ) modules, the pin is RTK_IND and set high at startup. For LG69T (AS) module, the pin is RESERVED. If unused, leave the pin N/C (not connected).
	FWD *	23	DI	Forward/Backward direction	For LG69T (AQ) module, these pins are FWD and WHEELTICK. For LG69T (AM) and LG69T (AS), these

	WHEELTICK *	22	DI	Odometer/Wheel-tick signal input	pins are RESERVED. If unused, leave the pin N/C (not connected).
	TXD2	27	DO	Transmits data 2	For LG69T (AM) and LG69T (AQ) modules, UART2 is used for correction UART input by default, and can also be configured as NMEA output or raw data output. For LG69T (AS) module, UART2 can be configured as RTCM messages output.
	RXD2	26	DI	Receives data 2	
	TXD1	42	DO	Transmits data 1	For LG69T (AM) and LG69T (AQ) modules, the UART1 interface is used for standard NMEA messages output, PQTM commands input and output, RTK data input or raw data output, and firmware upgrade. For LG69T (AS) module, the UART1 is used for RTCM messages output, PQTM commands input and output, RTK data output.
	RXD1	43	DI	Receives data 1	
	TX_READY	46	DO	Informs external devices to receive data when buffer transmission is full interface	If unused, leave the pin N/C (not connected).
	1PPS	53	DO	One pulse per second	Synchronized on rising edge, and the pulse width is 100 ms. If unused, leave the pin N/C (not connected).
ANT	RF_IN	2	AI	GNSS antenna interface	50 Ω characteristic impedance.
	VDD_RF	7	PO	Power supply for external RF components	VDD_RF = VCC, the output current capacity depends on VCC. Typically used to supply power for an external active antenna or the LNA. If unused, leave the pin N/C (not connected).
System	RESET_N	49	DI	Resets the module	Active low.
	BOOT	50	DI	Controls module startup mode	Pulled down internally by default. While keeping the pin floating during startup, the module will enter Normal working mode. While keeping the pin at high level for about 50 ms during

					startup, the module will enter Boot download mode.
GND	GND	1, 3, 12, 14, 32, 37, 41, 48, 55-102	-	Ground	Assures a good GND connection to all GND pins of the module, preferably with a large ground plane.
RESERVED	RESERVED	4-6, 8-11, 13, 15-25, 28-31, 35, 38-40, 44, 45, 47, 51, 52, 54	-	Reserved	For LG69T (AM) and LG69T (AQ) modules, pin 19 is GEOFENCE and pin 20 is RTK_IND. For LG69T (AQ) module, pin 22 is WHEELTICK and pin 23 is FWD. These pins must be left floating and cannot be connected to power or GND.

NOTE

Leave RESERVED and unused pins N/C (not connected).

3 Power Management

The Quectel LG69T (AM), LG69T (AQ), and LG69T (AS) modules provide a power optimized architecture with built-in autonomous energy saving capabilities to minimize power consumption at any given time. These receivers can be used in two operating modes: Backup mode for best power consumption, and Continuous mode for best performance.

3.1. Power Unit

VCC is the supply voltage pin of the module. It supplies power for the PMU which in turn supplies power for the entire system. The load current of the VCC pin varies according to VCC voltage level, processor load, and satellite acquisition. It is important to supply sufficient current and make sure the power supply is clean and stable.

The V_BCKP pin supplies power for the backup domain. To achieve quick startup and improve TTFF, the backup domain power supply should be valid during the interval. SRAM memory also belongs to the backup domain. If the VCC is not valid, the V_BCKP supplies power for SRAM memory that contains all the necessary GNSS data and some of the user configuration variables.

VDD_RF is an output pin, which has the equal voltage the VCC input. In Continuous mode, VDD_RF supplies power for the external active antenna or the LNA.

The module's internal power supply is shown below:

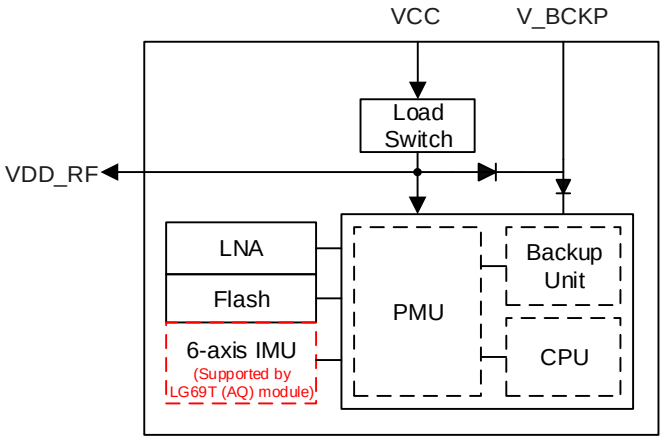


Figure 4: Internal Power Supply

3.2. Power Supply

3.2.1. VCC

The VCC is the supply voltage pin. The VCC pin supplies power for BB, RF, 6-axis IMU (supported by LG69T (AQ) module).

Module power consumption may vary by several orders of magnitude, especially when power saving mode is enabled. Therefore, it is important that the power supply can sustain peak power for a short time, ensuring that the load current does not exceed the rated value. When the module startup or switches from Backup mode to Continuous mode, it must charge the internal capacitors in the core domain. In some cases, this can lead to a significant current drain.

For low-power applications using power saving modes, it is important that the LDO at the power supply or module input can provide the current. An LDO with a high PSRR should be chosen for good performance. In addition, a TVS, and a combination of a 47 µF, 100 nF and a 33 pF decoupling capacitor network should be added near the VCC pin. The lowest value capacitor should be the closest to module pins.

An LDO voltage regulator with a fast discharge is recommended as the power supply. This can ensure a quick voltage drop when the VCC power is cut.

It is not recommended to use a switching DC-DC power supply.

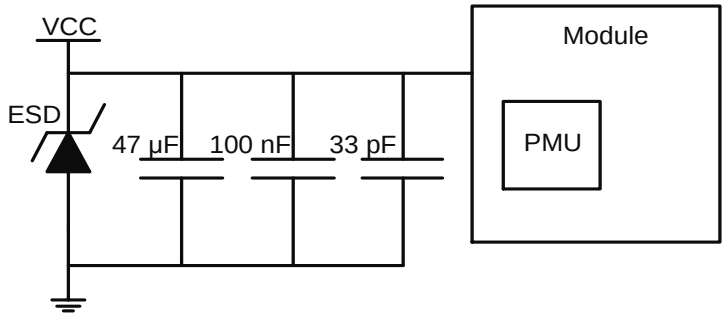


Figure 5: VCC Input Reference Circuit

3.2.2. V_BCKP

The V_BCKP pin supplies power for the V_BCKP domain. Use of valid time and GNSS orbit data at startup, allows GNSS hot (warm) start. V_BCKP must be connected to power supply for startup, and it should be always powered if hot (warm) start is needed.

If there is a constant power supply in your system, it can be used to provide a suitable voltage to power V_BCKP.

V_BCKP can be powered by an automotive battery or a DC-DC. It is recommended to place a TVS, and a combination of a 4.7 μF, a 100 nF and a 33 pF capacitor near the V_BCKP pin. The figure below illustrates the reference design for powering the V_BCKP domain with an automotive battery.

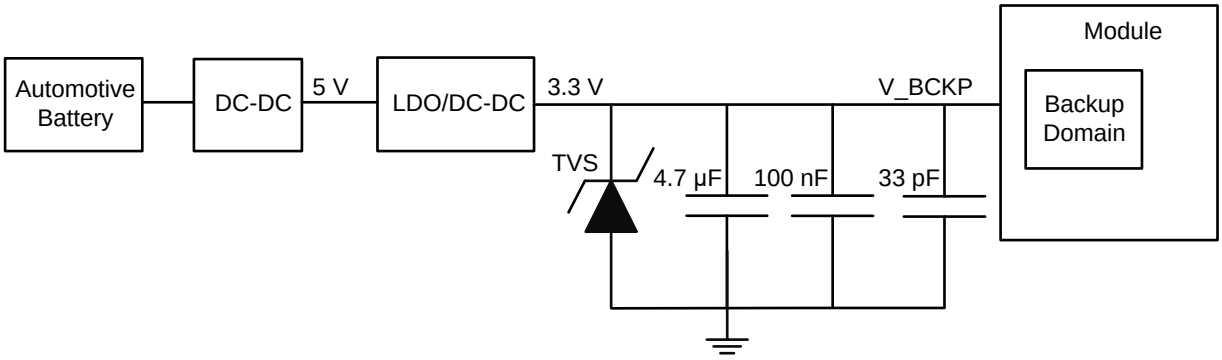


Figure 6: LG69T (AM) Reference Charging Circuit for an Automotive Battery

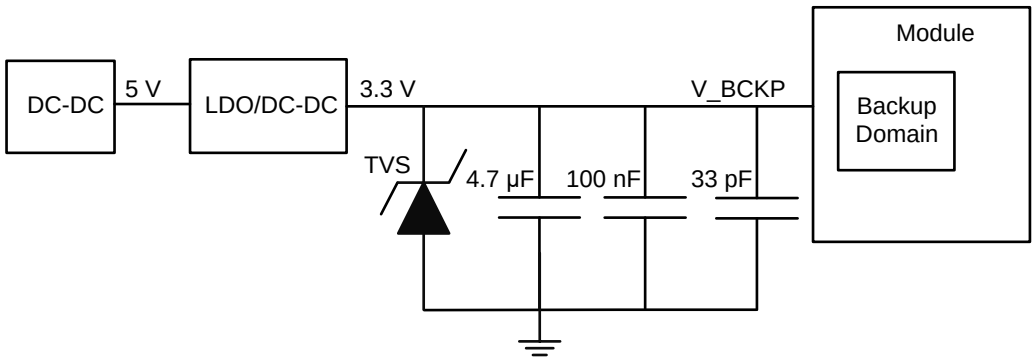


Figure 7: LG69T (AQ) and LG69T (AS) Reference Charging Circuit for a DC-DC

If V_BCKP is powered by a rechargeable battery, it is necessary to implement an external charging circuit for the battery. A reference charging circuit is illustrated below.

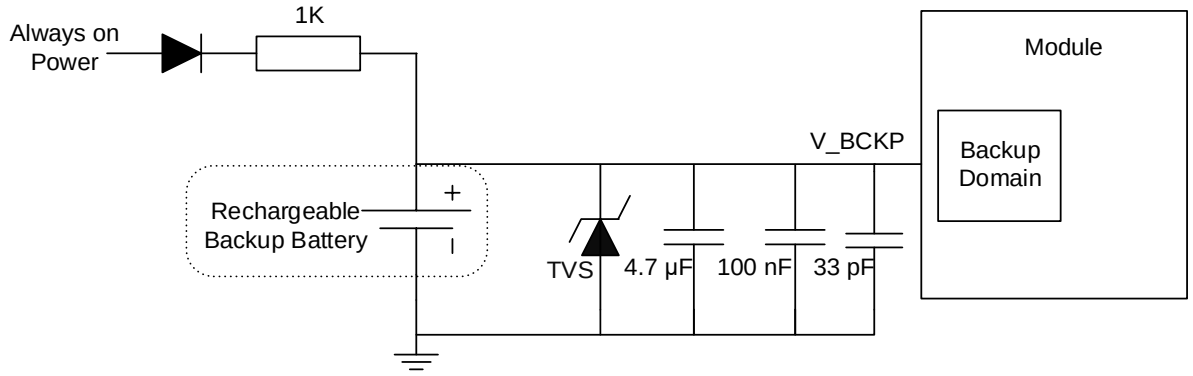


Figure 8: Reference Charging Circuit for a Rechargeable Battery

NOTE

1. V_BCKP cannot be below the spec value, otherwise the module cannot work normally.
2. A suitable resistor should be chosen according to the charging current of the battery.

3.3. Power Mode

3.3.1. Feature Comparison

The table below illustrates the supported features/functions of the module in different modes.

Table 6: Feature Comparison in Different Power Modes

Features	Continuous	Backup
NMEA from UART	●	-
1PPS	●	-
RF	●	-
Acquisition & Tracking	●	-
Power Consumption	High	Low
Position Accuracy	High	-

3.3.2. Continuous Mode

If VCC is powered on, the module automatically enters Continuous mode that comprises acquisition mode and tracking mode. In acquisition mode, the module starts to search satellites, and to determine visible satellites, coarse frequency, as well as the code phase of satellite signals. When the acquisition is completed, the module automatically switches to tracking mode. In tracking mode, the module tracks satellites and demodulates the navigation data from specific satellites.

3.3.3. Backup Mode

For power-sensitive applications, the module receiver provides a Backup mode to reduce power consumption. Only V_BCKP domain is active in Backup mode and it keep track of time. The approach to entering/exiting Backup mode is as shown below:

- Enter Backup mode: Cut off the power supply of VCC for at least 1 s and keep V_BCKP powered.
- Exit Backup mode: Restore the VCC power supply, the module exits Backup mode.

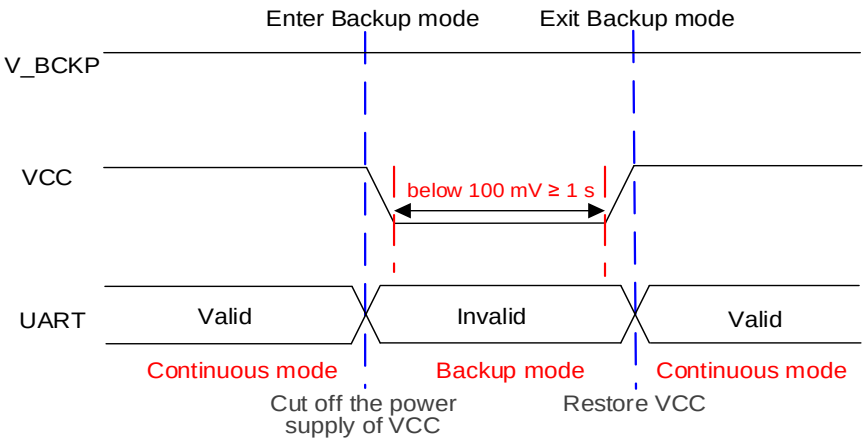


Figure 9: Enter/Exit from Backup Mode Sequence

3.4. Power-Up Sequence

Once the VCC is powered up, the module starts up automatically and the voltage should rise rapidly in less than 50 ms.

To ensure the correct power-up sequence, the backup unit should start up no later than the PMU. Hence, the V_BCKP must be powered simultaneously with or before the VCC.

Ensure that the VCC has no rush or drop during rising time, and then keep the voltage stable. The

recommended ripple is < 50 mV.

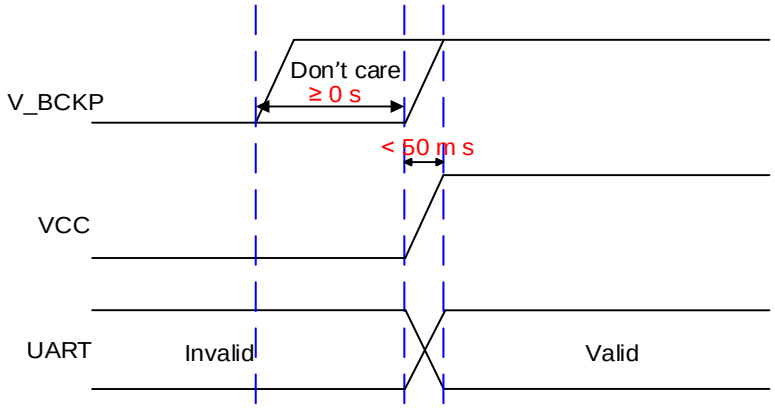


Figure 10: Power-Up Sequence

3.5. Power-Down Sequence

Once the VCC is shut down, voltage should drop quickly with a drop time of less than 50 ms. It is recommended to use a voltage regulator that supports fast discharge.

To avoid abnormal voltage condition, if VCC falls below minimum specified value, the system must initiate a power-on restart by lowering VCC to less than 100 mV for at least 1 s.

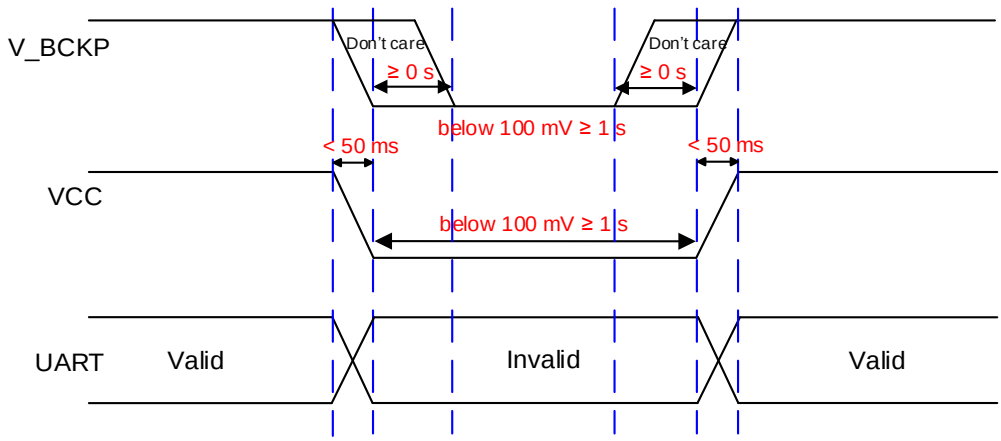


Figure 11: Power-Down and Power-on Restart Sequence

4 Application Interfaces

4.1. IO Pins

4.1.1. Communication Interfaces

The following interfaces can be used for data reception and transmission.

4.1.1.1. UART1 Interface

All three modules provide one UART1 interface with the following features:

- Supports standard NMEA messages output, PQTM commands input and output, RTK data input or raw data output, and firmware upgrade for LG69T (AM) and LG69T (AQ) module.
- Supports RTCM messages output, PQTM commands input and output, RTK data output, and firmware upgrade for LG69T (AS) module.
- Supports baud rates: 115200, 230400, 460800, and 921600 bps.
- Hardware flow control and synchronous operation are not supported.

A reference design is shown in the figure below. For more information, see ***document [3]***.

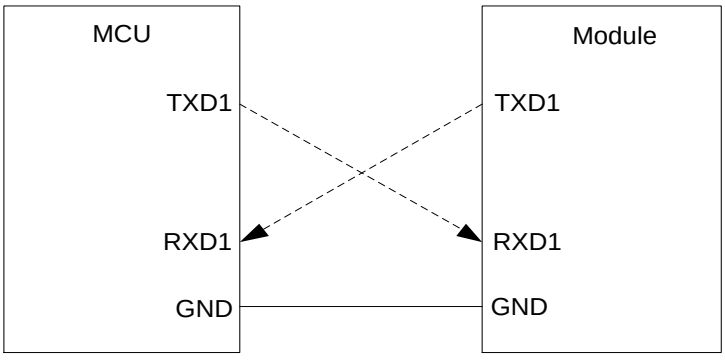


Figure 12: UART1 Interface Reference Design

NOTE

1. UART interface default settings vary depending on software version. Please see specific software versions for details.
2. If the IO voltage of MCU is not matched with module, a level shifter circuit must be selected.

4.1.1.2. UART2 Interface

All three modules provide one UART2 interface with the following features:

- Supports correction UART input by default, and can also be configured as NMEA messages output or raw data output for LG69T (AM) and LG69T (AQ) modules.
- Supports configuration as RTCM messages output for LG69T (AS) module.
- Supports baud rates: 115200, 230400, 460800, and 921600 bps.
- Hardware flow control and synchronous operation are not supported.

A reference design is shown in the figure below. For more information, see ***document [3]***.

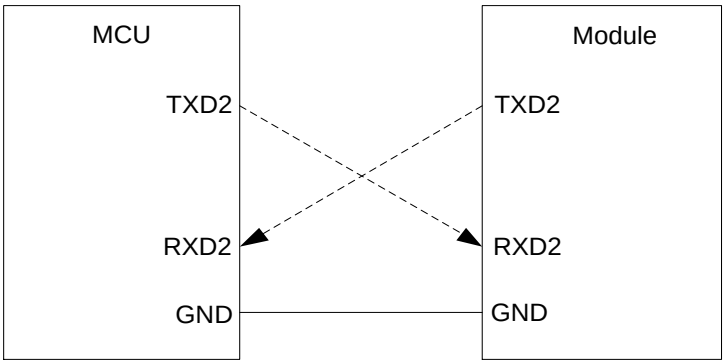


Figure 13: UART2 Interface Reference Design

NOTE

1. UART interface default settings vary depending on software version. Please see specific software versions for details.
2. If the IO voltage of MCU is not matched with module, a level shifter circuit must be selected.

4.1.2. RTK_IND *

RTK_IND is an indicator pin for RTK positioning status. This pin is set high at startup. When valid RTCM 3 messages are received, the pin switches from high to low level. The default rate is 1 Hz. The RTK_IND

pin is set to a continuous low output when the receiver is operating in RTK fixed mode.

4.1.3. FWD

The FWD pin is used to input the status signals indicating vehicle's forward/backward movement. When it is at low voltage level, the vehicle is moving forward, and when it is at high level, the vehicle is moving backward.

NOTE

Only cars need to be connected to the FWD pin, not 2-wheelers.

4.1.4. WHEELTICK

The WHEELTICK pin is used to input wheel tick pulse signals from a vehicle. It can be sampled from the wheel revolution sensors or the transmission of the vehicle. For more information about the reference circuit diagram, see ***document [3]***.

4.1.5. 1PPS

The 1PPS output pin generates one pulse per second periodic signal synchronized with a GNSS time grid with intervals. The accuracy is < TBD ns. Thus, it may be used as a low frequency time synchronization pulse or as a high frequency reference signal. To maintain the high accuracy of 1PPS, it is required to have visible satellites in an open sky environment and the VCC kept powered.

4.2. System Pins

4.2.1. RESET_N

RESET_N is an input pin. The module can be reset by driving RESET_N low for at least 100 ms and then releasing it.

The pin is internally 10 kΩ pulled up to 3.3 V by default, so no external pull-up circuit is allowed for this pin.

An OC driver circuit as shown below is recommended to control the RESET_N pin.

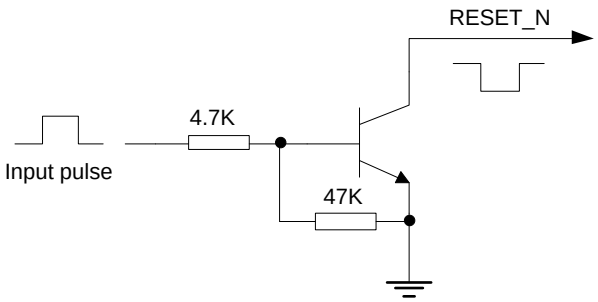


Figure 14: Reference OC Circuit for Module Reset

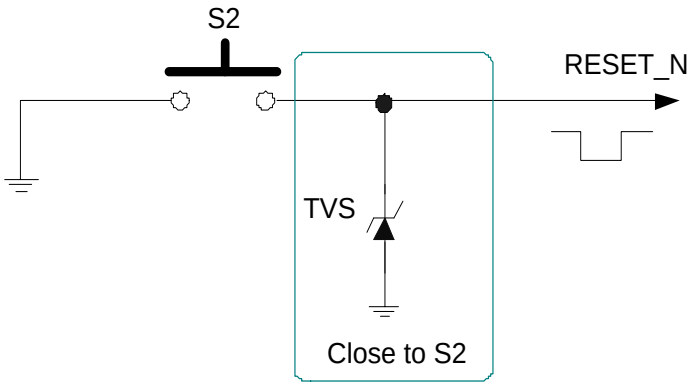


Figure 15: Reference Button Circuit for Module Reset

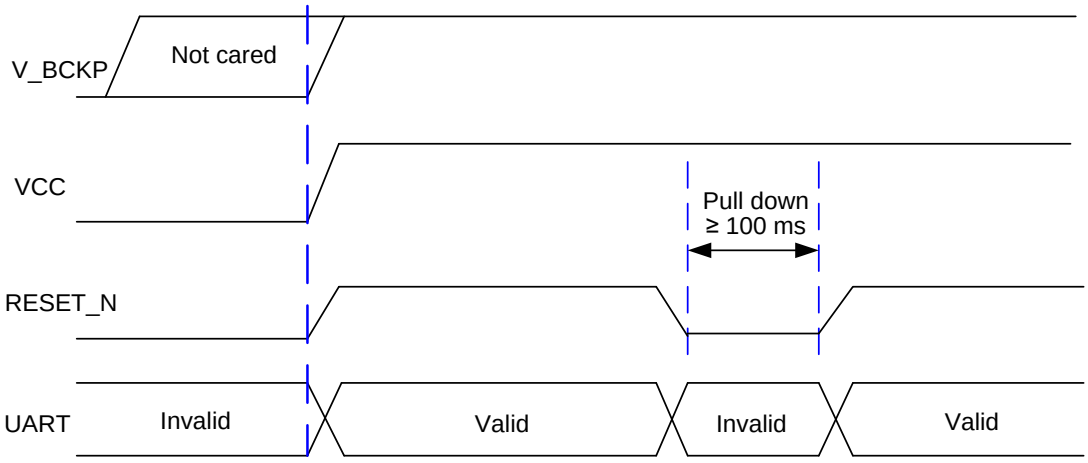


Figure 16: Reset Sequence

NOTE

Ensure RESET_N is connected so that it can be used to reset the module if the module enters an abnormal state.

4.2.2. BOOT

BOOT pin is used to put the Quectel LG69T (AM), LG69T (AQ), and LG69T (AS) modules into Boot download mode. It is pulled down internally by default. While keeping the pin floating during startup, the module enters Normal operating mode. While pulling up 100 Ω resistor to the power supply for about 50 ms during startup, the module enters Boot download mode. For more details about the reference circuit design, see ***document [3]***.

Check BOOT pin voltage level to identify its operating mode when the module is powered on.

Table 7: Operating Modes

Voltage Level	Operating Mode	Comment
Low/Floating	Normal	While keeping the pin floating during startup, the module enters Normal operating mode.
High	Boot download	While pulling up 100 Ω resistor to the power supply for about 50 ms during startup, the module enters Boot download mode.

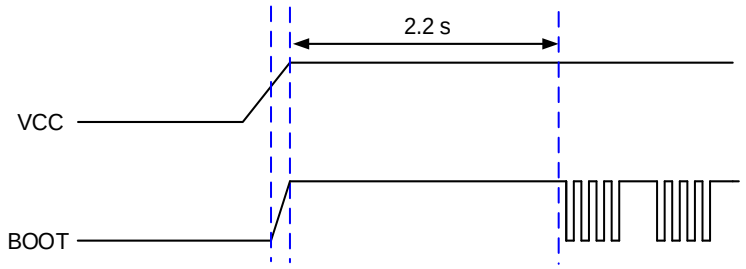


Figure 17: BOOT Pin State (Normal Operating Mode)

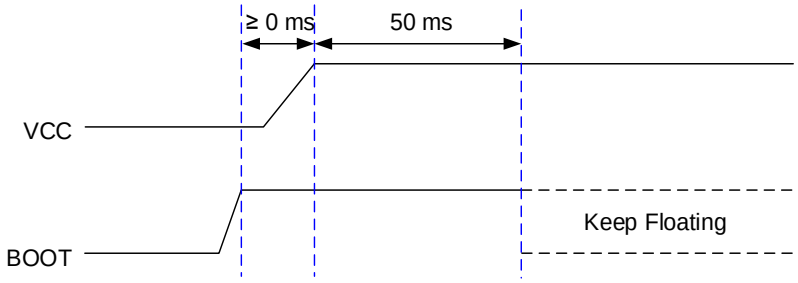


Figure 18: BOOT Pin Control State (Boot Download Mode)

5 Design

5.1. Antenna Reference Design

5.1.1. Antenna Specification

The Quectel LG69T (AM), LG69T (AQ), and LG69T (AS) modules can be connected to a dedicated active dual-band (L1 + L5) GNSS antenna to receive GPS, Galileo, BeiDou, and QZSS satellite signals. The recommended antenna specifications are given in the table below.

Table 8: Recommended Antenna Specifications

Antenna Type	Specifications
Active Antenna	Frequency Range: 1164–1189 MHz & 1559–1606 MHz Polarization: RHCP VSWR: < 2 (Typ.) Passive Antenna Gain: > 0 dBi Active Antenna Noise Figure: < 1.5 dB Active Antenna Total Gain: 7~17 dB [8] Phase Center Offset: < 20 mm [9] Phase Center Variation: < 20 mm [9] Axial Ratio: < 3 dB [9] -3 dB Beam Width: > 90° [9]

NOTE

For more information about GNSS antenna selection, see ***document [5]***.

5.1.2. Antenna Selection Guide

For LG69T (AM), LG69T (AQ), and LG69T (AS) modules, it is more recommended to use active antenna directly. When the total external gains of these modules are around 17 dB, the modules achieve the best

[8] The total gain of the whole antenna is the internal LNA gain minus total insertion loss of cables and components inside the antenna.
[9] When the LG69T (AM) and LG69T (AQ) modules use RTK algorithm, parameters recommended as above should be achieved to meet high precision positioning requirements.

reception performance. You can confirm the reception performance by checking C/N_0 values reported by the module.

C/N_0 is an important factor for GNSS receivers, and it is defined as the ratio of the received modulated carrier signal power to the received noise power in one Hz bandwidth. C/N_0 formula is as below:

$$C/N_0 = \text{Power of GNSS signal} - \text{Thermal Noise} - \text{System NF(dB-Hz)}$$

The "Power of GNSS signal" is GNSS signal level. In practical environment, the signal level at the earth surface is about -130 dBm. "Thermal Noise" is -174 dBm/Hz at 290 K. To improve C/N_0 of GNSS signal, an LNA could be added to reduce "System NF".

"System NF", formula:

$$NF = 10 \log F \, (dB)$$

"F" is the noise factor of receiver system:

$$F = F1 + (F2 - 1)/G1 + (F3 - 1)/(G1 \cdot G2) + \cdots$$

"F1" is the first stage noise factor, "G1" is the first stage gain, etc. This formula indicates that LNA with enough gain can compensate for the noise factor behind the LNA. In this case, "System NF" depends mainly on the noise figure of components and traces before first stage LNA plus noise figure of LNA itself. This explains the need for using an active antenna, if the antenna connection cable is too long.

5.1.3. Active Antenna Reference Design

The following figure is a typical reference design of an active antenna. In this case, the antenna is powered by the VDD_RF. When selecting the active antenna, it is necessary to pay attention to operating voltage range.

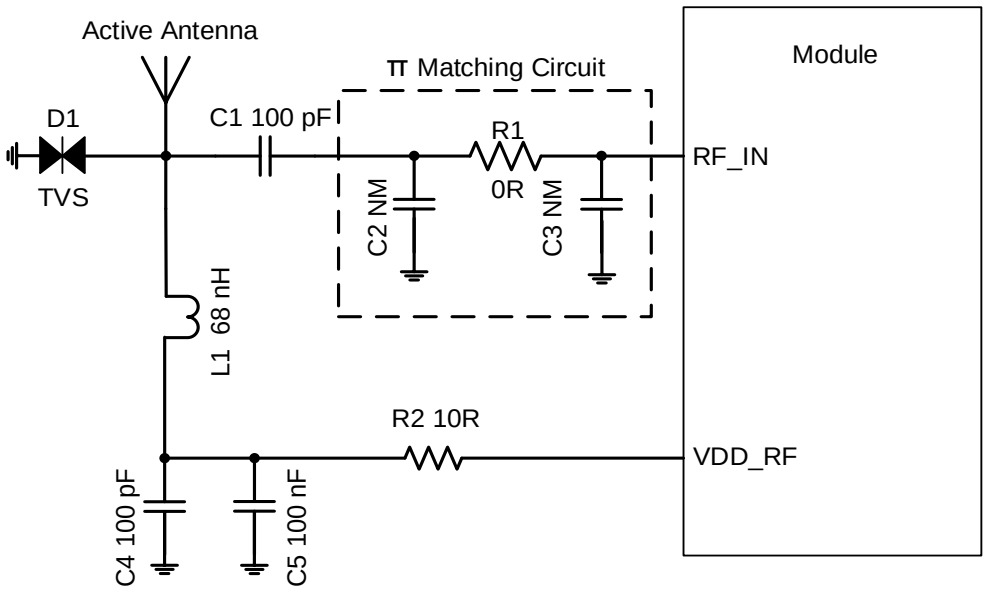


Figure 19: Active Antenna Reference Design

The components C2, R1 and C3 are reserved for matching antenna impedance. By default, R1 is 0 Ω, while C2 and C3 are not mounted; C1 is 100 pF; D1 is an electrostatic discharge (ESD) protection device to protect the RF signal input from the potential damage caused by ESD.

An active antenna can use the power supply from the VDD_RF pin. In that case, the inductor L1 is used to prevent the RF signal from leaking into the VDD_RF and to prevent noise propagation from the VDD_RF to the antenna. The L1 inductor routes the bias voltage to the active antenna without losses. The recommended value of L1 is no less than 68 nH. The resistor R2 is used to protect the module in case the active antenna is short-circuited to the ground plane. The impedance of RF trace should be controlled to 50 Ω and the trace length should be kept as short as possible. For more information, see ***document [4]***.

5.2. Coexistence with Cellular Systems

Since GNSS signals are usually very weak, a GNSS receiver could be vulnerable to the interference of the surrounding environment. According to 3GPP specifications, a cellular terminal should transmit a signal of up to 33 dBm at GSM bands, or of about 24 dBm at WCDMA and LTE bands. As a result, coexistence with cellular systems must be optimized to avoid significant deterioration of the GNSS performance.

In a complex communication environment, interference signals can come from in-band and out-of-band signals. Therefore, interference can be divided into two types: in-band interference and out-of-band interference, which are both described in this chapter.

In this chapter, you can also find suggestions for decreasing the impact of interference signals that will

ensure the interference immunity of a GNSS receiver.

5.2.1. In-Band Interference

In-band interference refers to the signal whose frequency is within or near the operating frequency range of a GNSS signal.

See the following figure for more details.

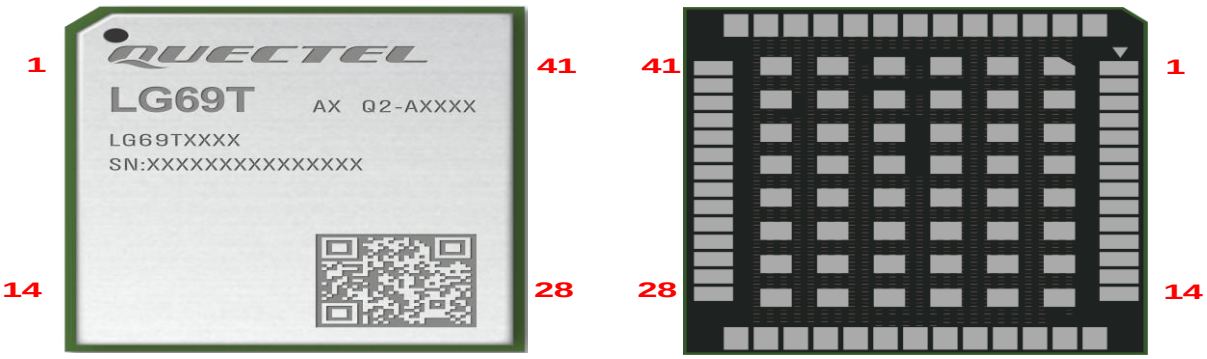


Figure 20: In-Band Interference on GPS L1

The most common in-band interferences usually come from:

- Harmonics, caused by crystals, high-speed signal lines, MCUs, switch-mode power supply etc., or
- Intermodulation from different communication systems.

Common frequency combinations are presented in the table below. The table lists some probable in-band interferences generated by two kinds of out-of-band signal intermodulation, or the second harmonic of LTE Band 13.

Table 9: Intermodulation Distortion (IMD) Products

Source F1	Source F2	IM Calculation	IMD Products
GSM850/Band 5	Wi-Fi 2.4 GHz	F2 (2412 MHz) - F1 (837 MHz)	IMD2 = 1575 MHz
DCS1800/Band 3	PCS1900/Band 2	2 × F1 (1712.6 MHz) - F2 (1850.2 MHz)	IMD3 = 1575 MHz
PCS1900/Band 2	Wi-Fi 5 GHz	F2 (5280 MHz) - 2 × F1 (1852 MHz)	IMD3 = 1576 MHz
LTE Band 13	N/A	2 × F1 (786.9 MHz)	IMD2 = 1573.8 MHz

5.2.2. Out-of-Band Interference

Strong signals transmitted by other communication systems can cause a GNSS receiver to become saturated, so that its performance is greatly deteriorated, as illustrated in the following figure.

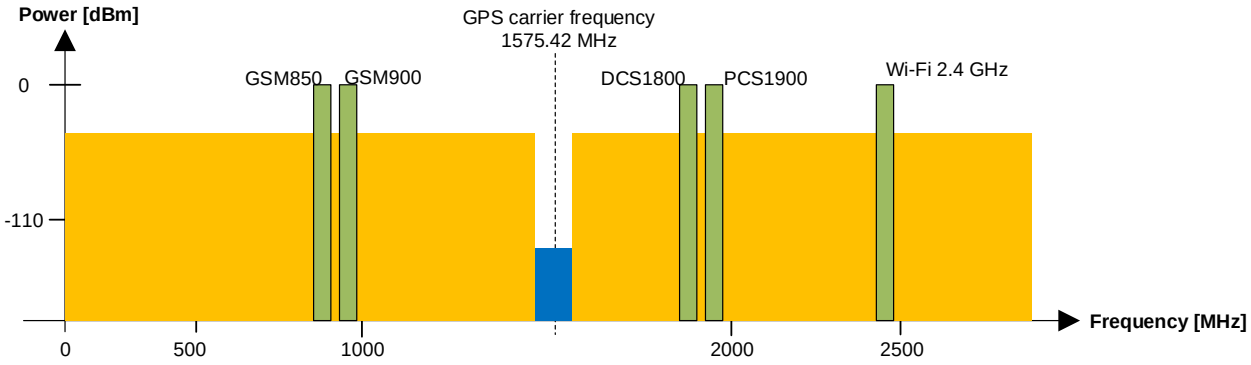


Figure 21: Out-of-Band Interference on GPS L1

5.2.3. Ensuring Interference Immunity

There are several things you can do to decrease the impact of interference signals and thus ensure the interference immunity of a GNSS receiver:

- Keep the GNSS antenna away from interference sources;
- Add a band-pass filter in front of the GNSS module;
- Use shielding and multi-layer PCB and ensure adequate grounding;
- Optimize layout and component placement of the PCB and the whole device.

The following figure illustrates the interference source and its possible interference path. In a complex communication system, there are usually RF power amplifiers, MCUs, crystals, etc. These devices should be far away from a GNSS receiver, or a GNSS module. In particular, shielding should be used to prevent strong signal interference for power amplifiers. The cellular antenna should be placed away from a GNSS receiving antenna to ensure enough isolation. Usually, a good design should provide at least a 20 dB isolation between two antennas. Take DCS1800, for example, the maximum transmitted power of DCS1800 is around 30 dBm. After a 20 dB attenuation, the signal received by the GNSS antenna will be around 10 dBm, which is still too high for a GNSS module. With a GNSS band-pass filter with around 40 dB rejection in front of the GNSS module, the out-of-band signal will be attenuated to -30 dBm.

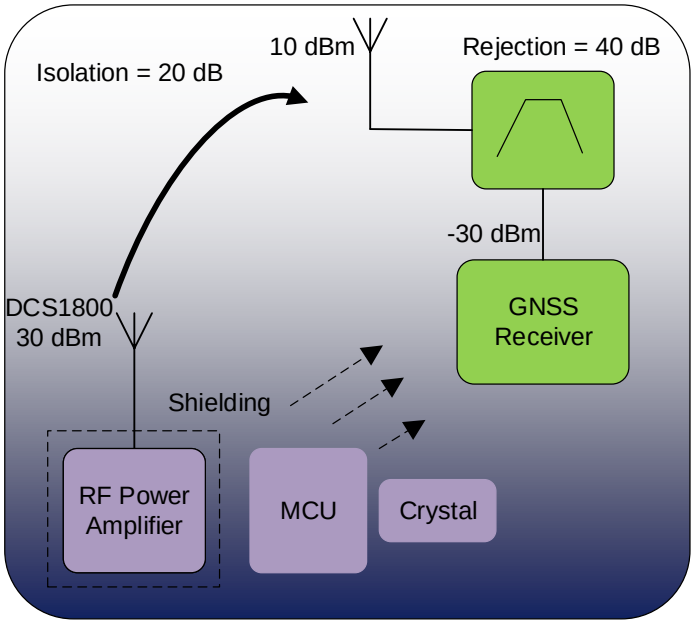


Figure 22: Interference Source and Its Path

5.3. Recommended Footprint

The figure below describes module footprint. These are recommendations, not specifications.

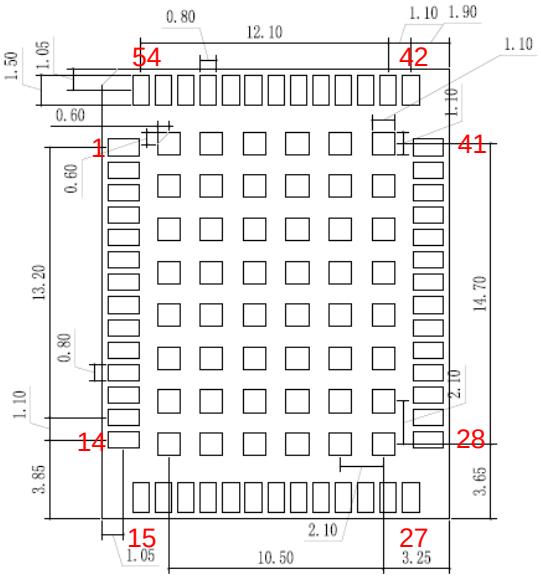


Figure 23: Recommended Footprint

NOTE

For easy maintenance, keep a distance of at least 3 mm between the module and other components on the motherboard.

5.4. Thermal Management

During the design process does not place the module near sources of heating or cooling. The receiver oscillator is sensitive to sudden changes in ambient temperature, which can adversely impact satellite signal tracking. Sources can include co-located power devices, cooling fans or thermal conduction via the PCB.

High temperature drift and air vents can affect the GNSS performance. For best performance, avoid high temperature drift and air vents near the module.

To achieve better module performance, it is recommended to comply with the following thermal management principles:

- On your PCB design, keep the module away from heating sources, especially high-power components such as the ARM processor, audio power amplifier, power supply, etc.
- To allow room for adding a heatsink when required, do not place components on the opposite side of the PCB area on which the module is mounted.
- To ensure better heat dissipation, do not apply solder mask on the opposite side of the PCB on which the module is mounted.
- The reference ground of the area on which the module is mounted should be complete, and joined to the underlying ground layers with many vias to optimize heat dissipation.
- Make sure that module ground pads and the PCB are fully connected.
- No thermal relief on ground pins.
- According to customer application demands, the heatsink can be mounted on top of the module, or on the opposite side of the PCB area on which the module is mounted, or on both sides.
- The heatsink should be designed with as many fins as possible to increase heat dissipation area. A thermal pad with high thermal conductivity should be used between the heatsink and the module/PCB.

Two different heatsink reference designs are provided below, and you can choose one or both designs according to your application structure.

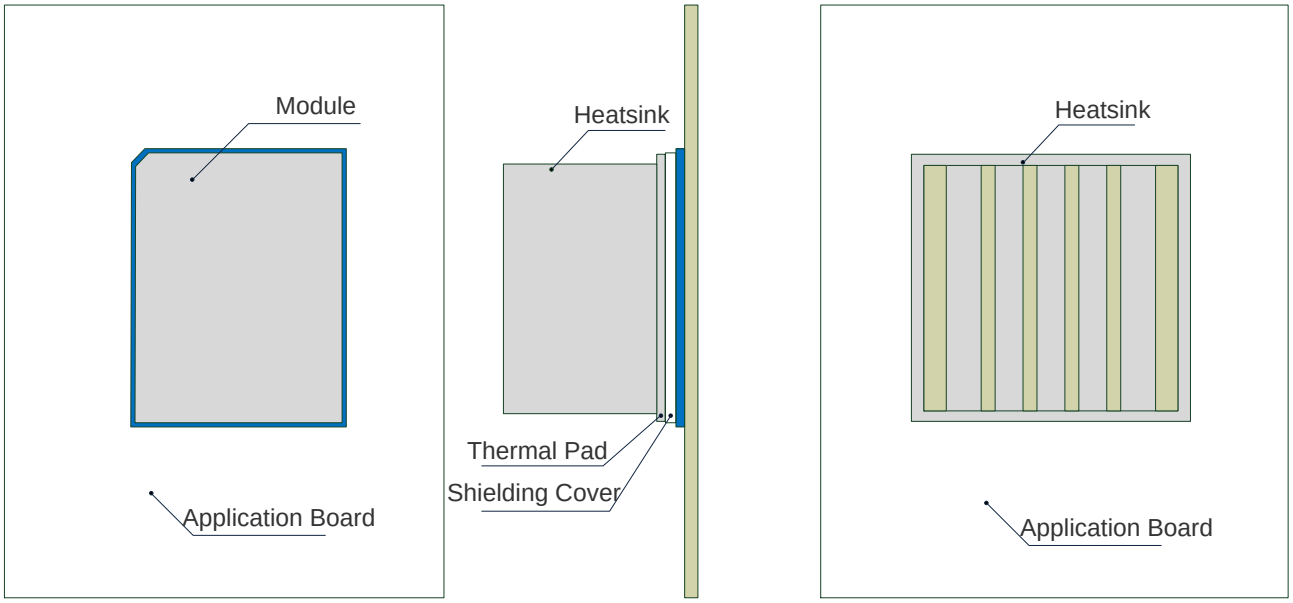


Figure 24: Recommended Heatsink Design A (Heatsink on Top of the Module)

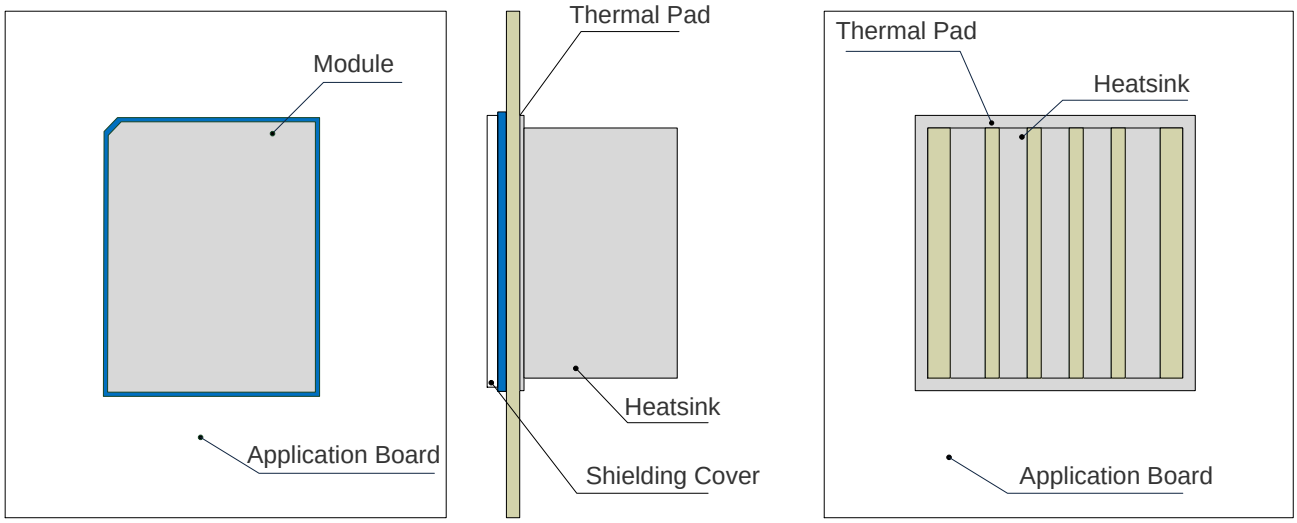


Figure 25: Referenced Heatsink Design B (Heatsink on the Backside of your PCB)

6 Electrical Specification

6.1. Absolute Maximum Ratings

Absolute maximum ratings for power supply and voltage on digital pins of the Quectel LG69T (AM), LG69T (AQ), and LG69T (AS) modules are listed in table below.

Table 10: Absolute Maximum Ratings

Parameter	Description	Min.	Max.	Unit
VCC	Main Power Supply Voltage	-0.3	3.6	V
V_BCKP	Backup Supply Voltage	-0.3	3.6	V
V_{IN}_IO	Input Voltage at IO Pins	-0.2	VCC + 0.3	V
P_{RF_IN}	Input Power at RF_IN	-	15	dBm
T_storage	Storage Temperature	-40	90	°C

NOTE

Stressing the device beyond the “Absolute Maximum Ratings” may cause permanent damage. The product is not protected against over-voltage or reversed voltage. Therefore, it is necessary to use appropriate protection diodes to keep voltage spikes within the parameters given in the table above.

6.2. Recommended Operating Conditions

All specifications are at an ambient temperature of +25 °C. Extreme operating temperatures can significantly impact the specified values. Applications operating near the temperature limits should be tested to ensure the validity of the specification.

Table 11: Recommended Operating Conditions

Parameter	Description	Min.	Typ.	Max.	Unit
VCC	Main Power Supply Voltage	3.0	3.3	3.6	V
V_BCKP	Backup Supply Voltage	2.1	3.3	3.6	V
IO_Domain	Digital IO Pin Domain Voltage	-	VCC	-	V
V_{IL}	Digital IO Pin Low-Level Input Voltage	-0.3	-	0.3 × VCC	V
V_{IH}	Digital IO Pin High-Level Input Voltage	2.0	-	3.6	V
V_{OL}	Digital IO Pin Low-Level Output Voltage	-	-	0.4	V
V_{OH}	Digital IO Pin High-Level Output Voltage	VCC - 0.4	VCC	-	V
RESET_N	Low-Level Input Voltage	-0.3	-	0.3 × VCC	V
VDD_RF	VDD_RF Voltage	-	VCC	-	V
T_operating	Operating Temperature	-40	25	+85	°C

NOTE

1. Operation beyond the "Operating Conditions" is not recommended and extended exposure beyond the "Operating Conditions" may affect device reliability.
2. IO_Domain specifically refers to the IO pins in GPIO in ***Chapter 2***.

6.3. Supply Current Requirement

Table 12: Supply Current

Parameter	Description	Condition	$I_{Typ.}$ [10]	I_{PEAK} [10]
I_{VCC} [11]	Current at VCC	Acquisition	TBD	TBD
		Tracking	TBD	TBD
I_{V_BCKP} [12]	Current at V_BCKP	Continuous mode	TBD	TBD

[10] Room temperature, measurements are taken with typical voltage.
[11] Used to determine maximum current capability of power supply.
[12] Used to determine required battery current capability.

	Backup mode	TBD	TBD

6.4. ESD Protection

The Quectel LG69T (AM), LG69T (AQ), and LG69T (AS) modules are ESD sensitive devices. Therefore, proper ESD handling and packaging procedures must be applied throughout the processing, handling and operation of any application that incorporates these modules.

The following measures ensure ESD protection when these modules are handled:

- When mounting these modules onto a motherboard, make sure to connect the GND first, and then the RF_IN pad.
- When handling the RF_IN pad, do not come into contact with any charged capacitors or materials that may easily generate or store charges (such as patch antenna, coaxial cable, soldering iron, etc.).
- When soldering the RF_IN pin, make sure to use an ESD safe soldering iron (tip).

7 Mechanical Dimensions

This chapter describes the mechanical dimensions of the module. All dimensions are in millimeters (mm). The dimensional tolerances are ±0.20 mm, unless otherwise specified.

7.1. Top, Side and Bottom View Dimensions

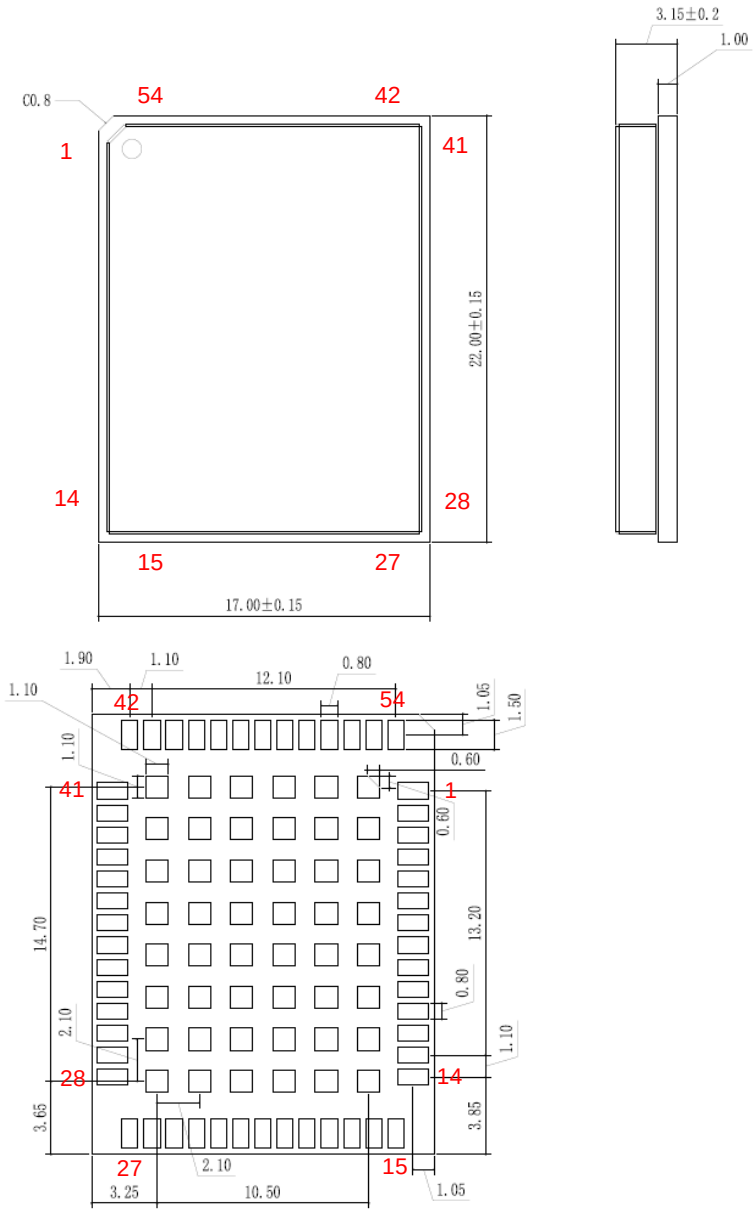


Figure 26: Top, Side and Bottom View Dimensions

NOTE

The package warpage level of the module conforms to the *JEITA ED-7306* standard.

7.2. Top and Bottom Views

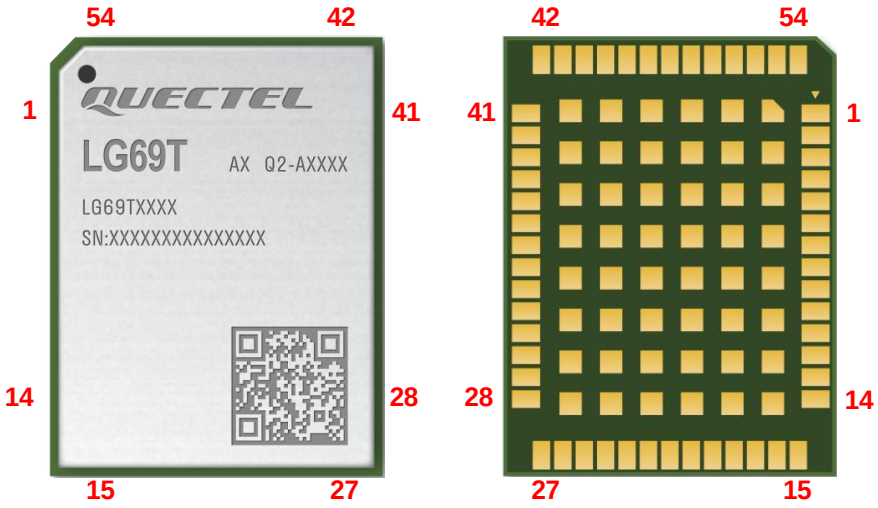


Figure 27: Top and Bottom Views of the Module

NOTE

The images above are for illustrative purposes only and may differ from the actual module. For authentic appearance and label, see the module received from Quectel.

7.3. Recommended Mounting

The LG69T (AQ) module allows for flexible installation without constraint on angle and direction. The module will automatically recognize the mounting angle deviation and compensates the deviation by algorithmic calculations.

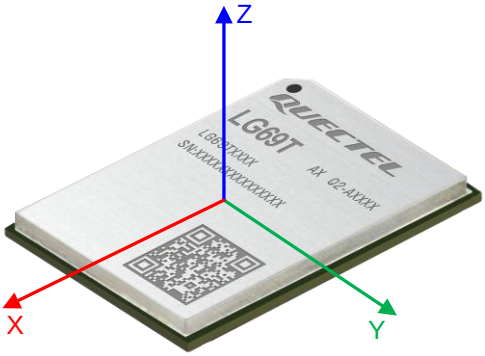


Figure 28: Axes of LG69T (AQ) Module

To ensure the performance, LG69T (AQ) module must be fixed tightly on the vehicle without movement or shaking during positioning.

8 Product Handling

8.1. Packaging

The Quectel LG69T (AM), LG69T (AQ), and LG69T (AS) modules are delivered as tape carrier package, which enables efficient production, set-up and dismantling of production batches. It is shipped in a vacuum-sealed packaging to prevent moisture intake and electrostatic discharge.

8.1.1. Carrier Tapes

Dimension details are as follow:

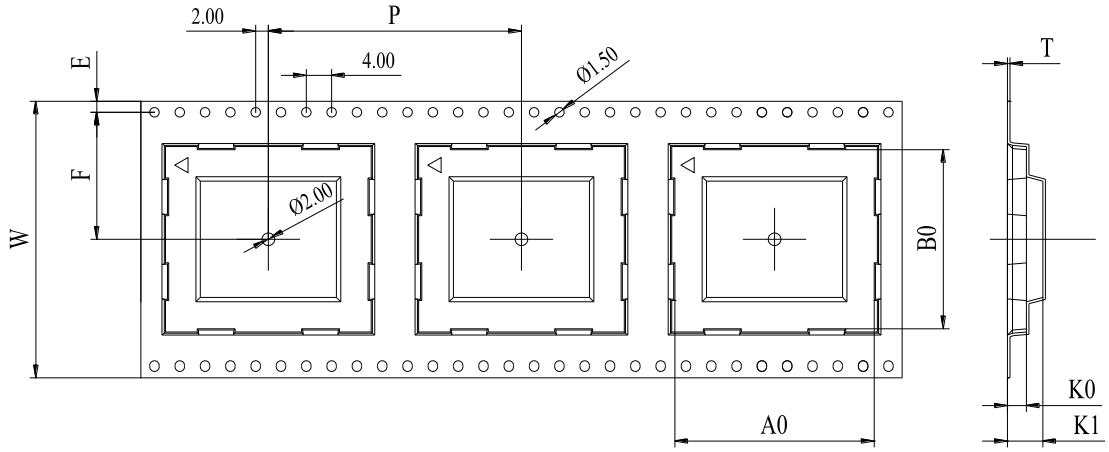


Figure 29: Carrier Tape Dimension Drawing

Table 13: Carrier Tape Dimension Table (Unit: mm)

W	P	T	A0	B0	K0	K1	F	E
44	28	0.4	17.5	22.5	3.65	8.3	20.2	1.75

8.1.2. Plastic Reels

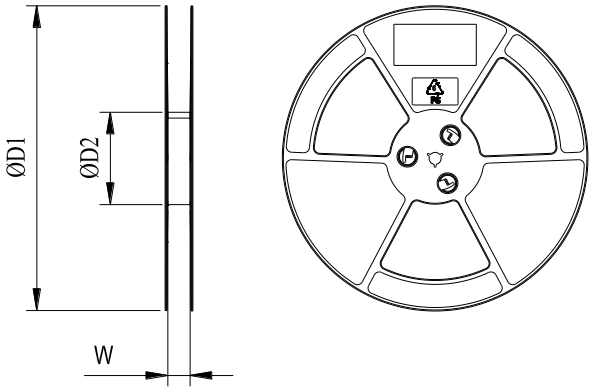
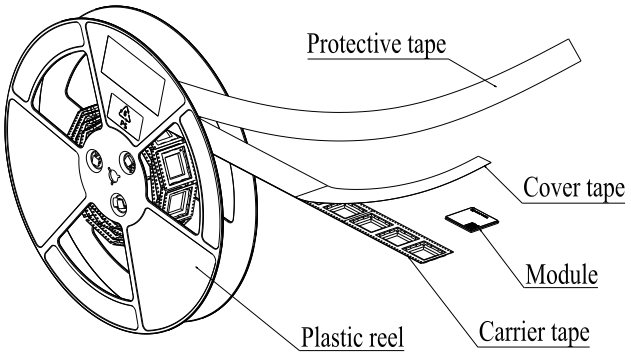


Figure 30: Plastic Reel Dimension Drawing

Table 14: Plastic Reel Dimension Table (Unit: mm)

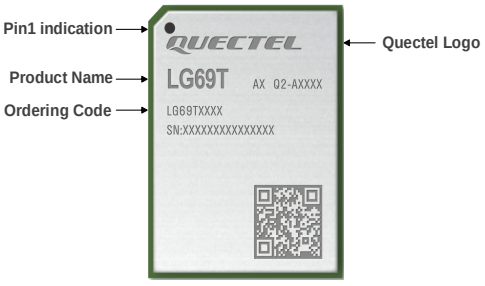
øD1	øD2	W
330	100	44.5

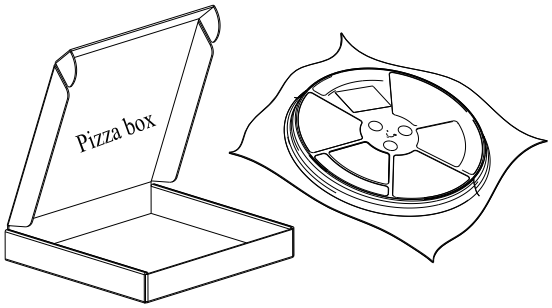
8.1.3. Packaging Process



Place the module into the carrier tape and use the cover tape to cover them; then wind the heat-sealed carrier tape to the plastic reel and use the protective tape for protection. One plastic reel can load 250 modules.

Place the packaged plastic reel, humidity indicator card and desiccant bag into a vacuum bag, then vacuumize it.





Place the vacuum-packed plastic reel into a pizza box.

Put 4 pizza boxes into 1 carton and seal it. One carton can pack 1000 modules.

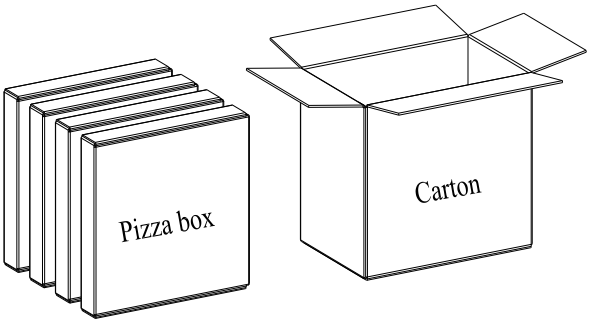


Figure 31: Packaging Process

8.2. Storage

The module is provided in the vacuum-sealed packaging. MSL of the module is rated as 3. The storage requirements are listed below.

1. Recommended storage conditions: The temperature should be 23 ±5 °C and the relative humidity should be 35–60%.

2. The storage life (in vacuum-sealed packaging) is 12 months in recommended storage conditions.

3. The shelf life of the module is 168 hours [13] in a plant where the temperature is 23 ±5 °C and relative humidity is below 60%. After the vacuum-sealed packaging is removed, the module must be processed in reflow soldering or other high-temperature operations within 168 hours. Otherwise, the module should be stored in an environment where the relative humidity is less than 10% (e.g., a drying cabinet).

4. The module should be pre-baked to avoid blistering, cracks and inner-layer separation in PCB under the following circumstances:
   - The module is not stored under recommended storage conditions;
   - Violation of the third requirement above occurs;
   - Vacuum-sealed packaging is broken, or the packaging has been removed for over 24 hours;

[13] The 168 h shelf life rule is only valid when the environment conforms to *IPC/JEDEC J-STD-033*. It is recommended to start the solder reflow process within 24 hours of removing the package if the temperature and moisture do not conform to, or it not certain that they conform to *IPC/JEDEC J-STD-033*. Do not remove the packaging if the module is not ready for soldering.

- Before module repairing.

5. If needed, the pre-baking should follow the requirements below:

- The module should be baked for 8 hours at 120 ±5 °C;
- The module must be soldered to the PCB within 24 hours of baking, otherwise they should be put in a dry environment such as a drying oven.

NOTE

1. To avoid blistering, layer separation and other soldering issues, extended exposure of the module to the air is forbidden.
2. Take the module out of the packaging and put it on high-temperature-resistant fixtures before baking. The module must be soldered to PCB within 24 hours of the baking, otherwise put them in the drying oven. If shorter baking time is desired, see *IPC/JEDEC J-STD-033* for the baking procedure.
3. Pay attention to ESD protection, such as wearing anti-static gloves, when touching the module.

8.3. Manufacturing and Soldering

Push the squeegee to apply solder paste on the stencil surface, thus making the paste fill the stencil openings and then penetrate the PCB. Apply proper force on the squeegee to produce a clean stencil surface on a single pass. For more information about the stencil thickness for the module, see ***document [6]***.

The peak reflow temperature should be 235–246 ºC, with 246 ºC as the absolute maximum reflow temperature. To avoid module damage caused by repeated heating, it is strongly recommended to mount the module to the PCB only after reflow soldering of the other side of the PCB has been completed. The recommended reflow soldering thermal profile (lead-free reflow soldering) and related parameters are shown in the figure and table below.

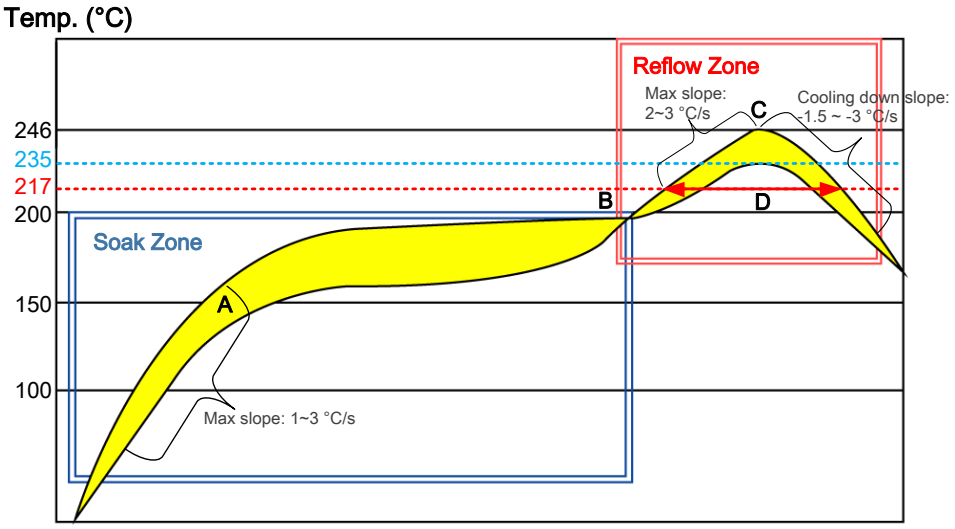


Figure 32: Recommended Reflow Soldering Thermal Profile

Table 15: Recommended Thermal Profile Parameters

Factor	Recommendation
Soak Zone	
Max. Slope	1–3 °C/s
Soak Time (Between A and B: 150 °C and 200 °C)	70–120 s
Reflow Zone	
Max. Slope	2–3 °C/s
Reflow Time (D: over 217 °C)	40–70 s
Max. Temperature	235 °C to 246 °C
Cooling Down Slope	-1.5 to -3 °C/s
Reflow Cycle	
Max. Reflow Cycle	1

NOTE

1. During manufacturing and soldering, or any other processes that may require direct contact with the module, **NEVER** wipe the module shielding can with organic solvents, such as acetone, ethyl alcohol, isopropyl alcohol, trichloroethylene, etc. Otherwise, the shielding can may become rusty.

2. The module shielding can be made of cupronickel base material. The Neutral Salt Spray Test has shown that after 12 hours the laser-engraved label information on the shielding can is still clearly identifiable and the QR code is still readable, although white rust may be found.
3. If a conformal coating is necessary for the module, **DO NOT** use any coating material that may chemically react with the PCB or shielding cover, and prevent the coating material from entering the module shield.
4. Avoid using ultrasonic technology for module cleaning since it can damage crystals inside the module.
5. Due to the complexity of the SMT process, please contact Quectel Technical Supports in advance for any situation that you are not sure about, or any process (e.g. selective soldering, ultrasonic soldering) that is not mentioned in ***document [6]***.

9 Labelling Information

The label of the Quectel GNSS modules contains important product information. The location of the product type number is shown in figure below.

Figure 33: Labelling Information

The image above is for illustrative purposes only and may differ from the actual module. For authentic appearance and label, see the module received from Quectel.

10 Appendix A References

Table 16: Related Documents

Document Name	
[1]	Quectel_LG69T(AM)_GNSS_Protocol_Specification
[2]	Quectel_LG69T(AS)_GNSS_Protocol_Specification
[3]	Quectel_LG69T(AM,AQ,AS)_Reference_Design
[4]	Quectel_RF_Layout_Application_Note
[5]	GNSS_Antenna_Selection_Guidance
[6]	Quectel_Module_Secondary_SMT_Application_Note

Table 17: Terms and Abbreviations

Abbreviation	Description
AGNSS	Assisted Global Positioning System
CEP	Circular Error Probable
C/N_0	Carrier-to-noise Ratio
DCS1800	Digital Cellular System at 1800MHz
DR	Dead Reckoning
ESD	Electrostatic Discharge
Galileo	Galileo Satellite Navigation System (EU)
GLONASS	Global Navigation Satellite System (Russian)
GNSS	Global Navigation Satellite System
GPS	Global Positioning System

GSM	Global System for Mobile Communications
I/O	Input /Output
I2C	Inter-Integrated Circuit
IC	Integrated Circuit
IMU	Inertial Measurement Unit
I_{PEAK}	Peak Current
IRNSS/NavIC	Indian Regional Navigation Satellite System
LCC	Leadless Chip Carrier (package)
LDO	Low-dropout Regulator
LGA	Land Grid Array
LNA	Low-Noise Amplifier
LTE	Long Term Evolution
Mbps	Megabits per second
MCU	Microcontroller Unit/Microprogrammed Control Unit
MSL	Moisture Sensitivity Levels
NF	Noise Factor
NMEA	National Marine Electronics Association
OC	Open Connector
PCB	Printed Circuit Board
PMU	Power Management Unit
1ppm	One Millionth of the Baseline Length
1PPS	One Pulse Per Second
PSRR	Power Supply Rejection Ratio
QR (code)	Quick Response (Code)
QZSS	Quasi-Zenith Satellite System
RF	Radio Frequency

RHCP	Right Hand Circular Polarization
RMC	Recommended Minimum Specific GNSS Data
RoHS	Restriction of Hazardous Substances
RTC	Real-Time Clock
RTCM	Radio Technical Commission for Maritime Services
RTK	Real-Time Kinematic
RXD	Receive Data
3GPP	3rd Generation Partnership Project
SAW	Surface Acoustic Wave
SBAS	Satellite-Based Augmentation System
SMD	Surface Mount Device
SMT	Surface Mount Technology
SNR	Signal-to-Noise Ratio
SPI	Serial Peripheral Interface
SRAM	Static Random Access Memory
TBD	To Be Determined
TCXO	Temperature Compensated Crystal Oscillator
TTFF	Time to First Fix
TVS	Transient Voltage Suppressor
UART	Universal Asynchronous Receiver/Transmitter
VSWR	Voltage Standing Wave Ratio
XTAL	External Crystal Oscillator