LC86G Series Hardware Design

GNSS Module Series

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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

Document Information	
Title	**LC86G Series Hardware Design**
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Revision History

Version	Date	Description
-	2022-07-04	Creation of the document
1.0	2022-11-29	First official release
1.1	2023-06-09	1. Updated pins 8 and 11 from RESERVED to AADET_N and EX_ANT, respectively. 2. Added the number of concurrent GNSS (*Table 2*). 3. The updates in table 3 are as follows (*Table 3)*: Added the power data for LC86G series; Updated the power consumption of acquisition and tracking, warm start of TTFF (without AGNSS) and the accuracy of 1PPS signal for LC86G series; Updated the power consumption of Backup mode for LC86G (AB); Updated the cold start of TTFF (without AGNSS) for LC86G (LA). 4. Added the DC characteristics of all pins (*Table 6*). 5. Updated the block diagram (*Figure 1*). 6. Updated the supported baud rates of UART interface (*Chapter 4.1.1.1*). 7. Added the description and reference designs for external active antenna and passive antenna (*Chapter 5.3*). 8. Updated the supply current (*Table 26*, *Table 27* and *Table 28*).

Version	Date	Description
		9. Updated the ESD protection measures (*Chapter 6.4*). 10. Updated the carrier tape dimensions (*Chapter 8.1.1*). 11. Added the module mounting direction (*Chapter 8.1.3*).

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1 Product Description

1.1. Overview

The LC86G series module supports multiple global positioning and navigation systems: GPS, GLONASS, Galileo, BDS, QZSS. The module also supports SBAS (including WAAS, EGNOS, MSAS and GAGAN) and AGNSS functions. The LC86G series comprises three variants: LC86G (AA), LC86G (AB), and LC86G (LA).

Key features:

- Single-band, multi-constellation GNSS modules featuring a high-performance, high reliability positioning engine, which facilitates fast and precise GNSS positioning.
- Supported serial communication interface: UART.
- Supported advanced power saving mode: Backup mode.
- Embedded low-power algorithms make the modules suitable for different application scenarios.
- EASY technology facilitates achieving a faster Time to First Fix (TTFF) in either hot or warm start.
- Capacity for storing user-specific configurations and future firmware updates through the embedded flash memory.
- LC86G (AA) has an integrated antenna on top with the dimension of 14.9 × 14.9 × 4 mm and can track GPS + Galileo + BDS by default.
- LC86G (AB) has an integrated antenna on top with the dimension of 14.9 × 14.9 × 4 mm and can track GPS + GLONASS + Galileo by default.
- LC86G (LA) has an integrated antenna on top with the dimension of 18.4 × 18.4 × 4 mm and can track GPS + GLONASS + Galileo + BDS + QZSS by default.

LC86G (LA) form factor is 18.4 × 18.4 × 6.95 mm while the LC86G (AA) and the LC86G (AB) form factors are 16.0 × 16.0 × 6.95 mm. They can be embedded into your application through 12 LCC and 24 LGA pins.

The LC86G series modules are fully compliant with the EU RoHS Directive.

NOTE

The LC86G (AA), LC86G (AB), and LC86G (LA) variants will be hereinafter referred to as “the module/modules” collectively, or individually as “LC86G (AA)”, “LC86G (AB)”, and “LC86G (LA)” to indicate the differences between them.

1.1.1. Special Mark

Table 1: Special Mark

Mark	Definition
●	A function or technology is supported by the module(s).

1.2. Features

Table 2: Product Features

Features		LC86G (AA)	LC86G (AB)	LC86G (LA)
Grade	Industrial	●	●	●
	Automotive	-	-	-
Category	Standard Precision GNSS	●	●	●
	High Precision GNSS	-	-	-
	DR	-	-	-
	RTK	-	-	-
	Timing	-	-	-
VCC Voltage	2.55–3.6 V, Typ. 3.3 V	●	●	●
V_BCKP Voltage	1.65–3.6 V, Typ. 3.3 V	●	●	●
I/O Voltage	Following VCC	●	●	●
Communication Interfaces	UART	●	●	●
	SPI	-	-	-
	I2C	-	-	-
	CAN	-	-	-
	USB	-	-	-
Integrated Features	Additional LNA	●	●	●
	Additional Filter	●	●	●
	RTC Crystal	●	●	●

Features			LC86G (AA)	LC86G (AB)	LC86G (LA)
	TCXO Oscillator		●	●	●
	6-axis IMU		-	-	-
Constellations and Frequency Bands	Number of Concurrent GNSS		3 + QZSS	3 + QZSS	4 + QZSS
	GPS	L1 C/A	●	●	●
		L5	-	-	-
		L2C	-	-	-
	GLONASS	L1	-	●	●
		L2	-	-	-
	Galileo	E1	●	●	●
		E5a	-	-	-
		E5b	-	-	-
	BDS	B1I	●	-	●
		B1C	*	-	●
		B2a	-	-	-
		B2I	-	-	-
	QZSS	L1 C/A	●	●	●
		L5	-	-	-
		L2C	-	-	-
	NavIC	L5	-	-	-
	SBAS	L1	●	●	●
Temperature Range	Operating temperature range: -40 °C to +85 °C Storage temperature range: -40 °C to +90 °C				
Physical Characteristics	LC86G (AA) LC86G (AB)	Size: (16.0 ±0.2) mm × (16.0 ±0.2) mm × (6.95 ±0.30) mm Weight: Approx. 5.9 g			
	LC86G (LA)	Size: (18.4 ±0.2) mm × (18.4 ±0.2) mm × (6.95 ±0.30) mm Weight: Approx. 8.0 g			

NOTE

For more information about GNSS constellation configuration, see *document [1] protocol specification*.

1.3. Performance

Table 3: Product Performance

Parameter	Specification	LC86G (AA)	LC86G (AB)	LC86G (LA)
Power Consumption [1]		GPS + Galileo + BDS	GPS + GLONASS + Galileo	GPS + GLONASS + Galileo + BDS + QZSS
	Acquisition	30 mA (99 mW)	33 mA (108.9 mW)	34 mA (112.2 mW)
	Tracking	30 mA (99 mW)	33 mA (108.9 mW)	34 mA (112.2 mW)
	Backup Mode [2]	13 µA (42.9 µW)	13 µA (42.9 µW)	13 µA (42.9 µW)
Sensitivity [3]		GPS + Galileo + BDS	GPS + GLONASS + Galileo	GPS + GLONASS + Galileo + BDS + QZSS
	Acquisition	-147 dBm	-147 dBm	-147 dBm
	Reacquisition	-160 dBm	-160 dBm	-160 dBm
	Tracking	-166 dBm	-166 dBm	-166 dBm
TTFF [1] (without AGNSS)	Cold Start	30 s	30 s	30 s
	Warm Start	28 s	28 s	25 s
	Hot Start	1 s	1 s	1 s
TTFF [4]	Cold Start	12 s	12 s	12 s

[1] Room temperature, all satellites at -130 dBm.
[2] It refers to the first way mentioned in *Chapter 3.3.3 Backup Mode*.
[3] Conducted sensitivity without patch antenna.
[4] Open-sky, active high-precision GNSS antenna.

Parameter	Specification	LC86G (AA)	LC86G (AB)	LC86G (LA)
(with EASY)	Warm Start	2 s	2 s	2 s
	Hot Start	1 s	1 s	1 s
TTFF [4] (with Flash EPO)	Cold Start	5 s	5 s	5 s
Horizontal Position Accuracy [5]		1.5 m	1.5 m	1.5 m
Update Rate		1 Hz (Default), Max. 10 Hz	1 Hz (Default), Max. 10 Hz	1 Hz (Default), Max. 10 Hz
Accuracy of 1PPS Signal [1]	RMS	11 ns	11 ns	11 ns
	3σ	33 ns	32 ns	33 ns
Velocity Accuracy [1]	Without Aid	0.1 m/s	0.1 m/s	0.1 m/s
Acceleration Accuracy [1]	Without Aid	0.1 m/s²	0.1 m/s²	0.1 m/s²
Dynamic Performance [1]	Maximum Altitude	10000 m	10000 m	10000 m
	Maximum Velocity	490 m/s	490 m/s	490 m/s
	Maximum Acceleration	4g	4g	4g

[5] CEP, 50 %, 24 hours static, -130 dBm, more than 6 SVs.

1.4. Block Diagram

A block diagram of the module, which includes a front-end section consisting of an LNA and a SAW filter, and a GNSS IC section consisting of a GNSS engine and internal PMU is illustrated below.

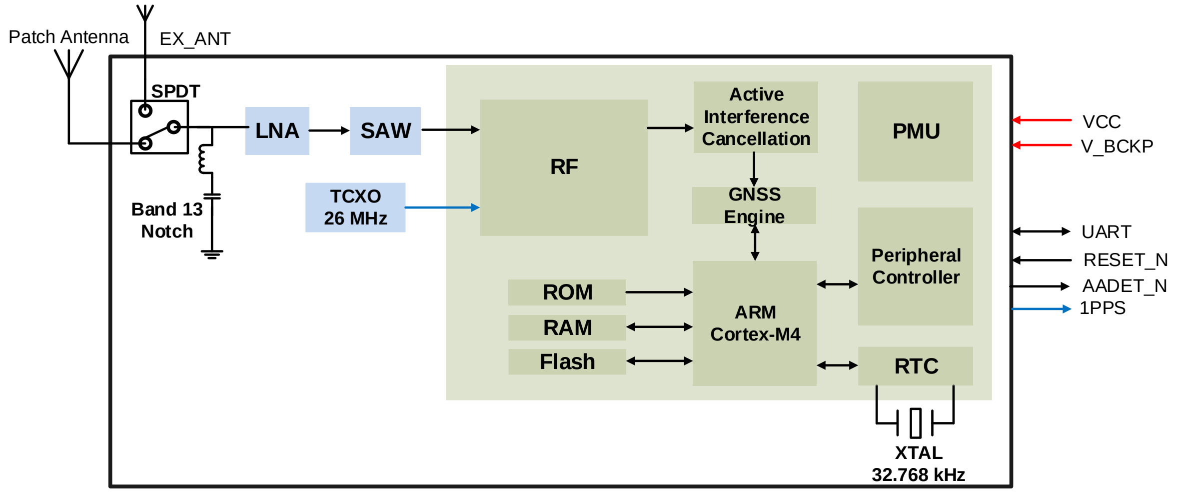


Figure 1: Block Diagram

1.5. GNSS Constellations and Frequency Bands

The module is a single-band concurrent GNSS receiver that can receive and track multiple GNSS systems. Due to the RF front-end architecture, five GNSS constellations can be received: GPS, GLONASS, Galileo, BDS, and QZSS, plus SBAS satellites. If low power consumption is a key factor, then the module can be configured for a subset of GNSS constellations.

QZSS is a regional navigation satellite system that transmits signals compatible with the GPS L1 C/A, L1C, L2C, and L5 signals for the Pacific region covering Japan and Australia. The module can detect and track QZSS L1 C/A signal concurrently with GPS signal, leading to better availability especially under challenging conditions, e.g., in urban canyons.

Table 4: GNSS Constellations and Frequency Bands

System	Signals		
	LC86G (AA)	LC86G (AB)	LC86G (LA)
GPS	L1 C/A: 1575.42 MHz	L1 C/A: 1575.42 MHz	L1 C/A: 1575.42 MHz
GLONASS	-	L1: 1602 MHz + K × 562.5 kHz K= (-7 to +6, integer)	L1: 1602 MHz + K × 562.5 kHz K= (-7 to +6, integer)
Galileo	E1: 1575.42 MHz	E1: 1575.42 MHz	E1: 1575.42 MHz
BDS	B1I: 1561.098 MHz B1C*: 1575.42 MHz	-	B1I: 1561.098 MHz B1C: 1575.42 MHz
QZSS	L1 C/A: 1575.42 MHz	L1 C/A: 1575.42 MHz	L1 C/A: 1575.42 MHz

1.6. Augmentation System

1.6.1. SBAS

The module supports the reception of SBAS signals. By augmenting primary GNSS constellations with additional satellite-broadcast messages, the system improves the accuracy and reliability of GNSS information by correcting signal measurement errors and providing information about signal accuracy, integrity, continuity, and availability. SBAS transmits signals for ranging or distance measurement, thus further improving availability. Supported SBAS systems: WAAS, EGNOS, MSAS and GAGAN.

1.7. AGNSS

The module supports the AGNSS feature that significantly reduces the module's TTFF, especially under lower signal conditions. To implement the AGNSS feature, the module should get the assistance data including the current time and rough position. For more information, see *document [2] AGNSS application note*.

1.7.1. EASY

The module supports the EASY technology to improve TTFF. To achieve that goal, the EASY technology provides ancillary information, such as ephemeris and almanac.

The EASY technology works as an embedded software to accelerate TTFF by predicting satellite navigation messages from the received ephemeris. After receiving the broadcast ephemeris for the first time, the module automatically calculates and predicts the orbit information up to subsequent 3 days, and saves the predicted information in the internal memory. The module will use the information for positioning if there is not enough information from satellites, resulting in improved positioning and TTFF.

The EASY function reduces TTFF to 2 s in a warm start. In this case, the backup domain should still be valid. To obtain enough broadcast ephemeris information from GNSS satellites after fixing the position, the GNSS module should keep tracking the information for at least 5 minutes in strong-signal environments.

The EASY function is enabled by default, and it is disabled by **$PAIR490** command. For more information about commands, see *document [1] protocol specification*.

1.7.2. EPO

The module features a leading AGNSS technology called EPO, which assists the receiver to reduce the TTFF for up to 14 days. For more information about EPO, see *document [2] AGNSS application note*.

1.8. Multi-tone AIC

The module features a function called multi-tone active interference cancellation (AIC) to decrease harmonic distortion of RF signals from Wi-Fi, Bluetooth, and 2G, 3G, 4G, and 5G networks.

Up to 12 AIC tones embedded in the module provide effective narrow-band interference and jamming elimination. Thus, the GNSS signal could be demodulated from the jammed signal, which can ensure better navigation quality.

The AIC function is enabled by default, and it can be disabled with **$PAIR074** command. For more information about the command, see *document [1] protocol specification*.

1.9. Firmware Upgrade

The module is delivered with preprogrammed firmware. Quectel may release firmware versions that contain bug fixes or performance optimizations. It’s highly important to implement a firmware upgrade mechanism in your system. A firmware upgrade is the process of transferring a binary file image to the receiver and storing it in the non-volatile flash. For more information, see *document [3] firmware upgrade guide*.

2 Pin Assignment

The module is equipped with 36 pins (12 LCC pins and 24 LGA pins) by which it can be mounted on your PCB.

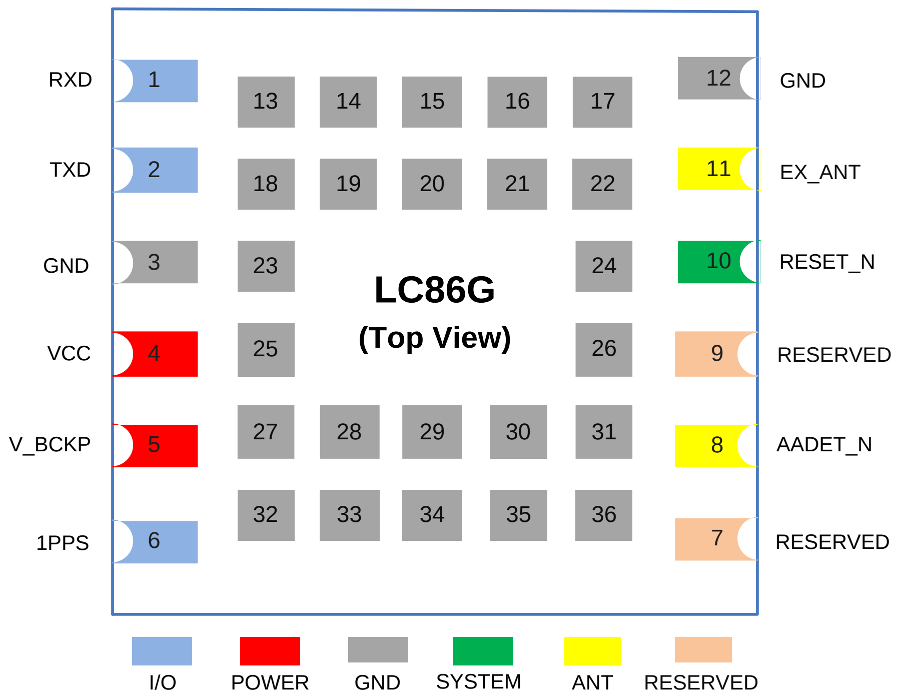


Figure 2: Pin Assignment

Table 5: I/O Parameter Definition

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

Table 6: Pin Description

Function	Name	No.	I/O	Description	DC Characteristics	Remarks
Power	VCC	4	PI	Main power supply	$V_I$min = 2.55 V $V_I$nom = 3.3 V $V_I$max = 3.6 V	Requires clean and steady voltage.
	V_BCKP	5	PI	Backup power supply for backup domain	$V_I$min = 1.65 V $V_I$nom = 3.3 V $V_I$max = 3.6 V	V_BCKP must be connected to power supply for startup, and it should always be powered if hot (warm) start is needed.
I/O	TXD	2	DO	Transmits data	V_{OL}max = 0.4 V V_{OH}min = 2.4 V	The UART interface supports RTCM and standard NMEA messages, PAIR and PQTM messages and firmware upgrade.
	RXD	1	DI	Receives data	V_{IL}min = -0.3 V V_{IL}max = 0.8 V V_{IH}min = 2 V V_{IH}max = VCC + 0.3 V	
	1PPS	6	DO	One pulse per second	V_{OL}max = 0.4 V V_{OH}min = 2.4 V	Synchronized on rising edge. If unused, leave the pin N/C (not connected).
	AADET_N	8	DO	Active antenna open circuit status indication	V_{OL}max = 0.7 V V_{OH}min = 2.4 V	If unused, leave the pin N/C.
Antenna	EX_ANT	11	AI	External antenna input interface	-	50 Ω characteristic impedance. If unused, keep this pin N/C.
System	RESET_N	10	DI	Resets the module	V_{IL}min = -0.3 V V_{IL}max = 0.45 V V_{IH}min = 1.8 V V_{IH}max = 3.6 V	Active low.
GND	GND	3, 12–36	-	Ground	-	Ensure a good GND connection to all module GND pins, preferably with a large ground plane.
RESERVED	RESERVED	7, 9	-	Reserved	-	These pins must be left floating and cannot be connected to power or GND.

NOTE

Leave RESERVED and unused pins N/C.

3 Power Management

The module features an optimized power architecture with built-in autonomous energy saving capabilities to minimize power consumption at any given time. The receiver can be used in two operating modes: Backup mode for optimum power consumption, and Continuous mode for optimum performance.

3.1. Power Unit

VCC is the supply voltage pin of the module. It supplies the PMU which in turn supplies 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 the backup domain, which includes RTC and RAM. To achieve quick startup and improve TTFF, the backup domain power supply should be valid at all times during the Backup mode. If the VCC is not valid, the V_BCKP supplies RAM that contains all the necessary GNSS data and some of the user configuration variables.

The module's internal power supply is shown below:

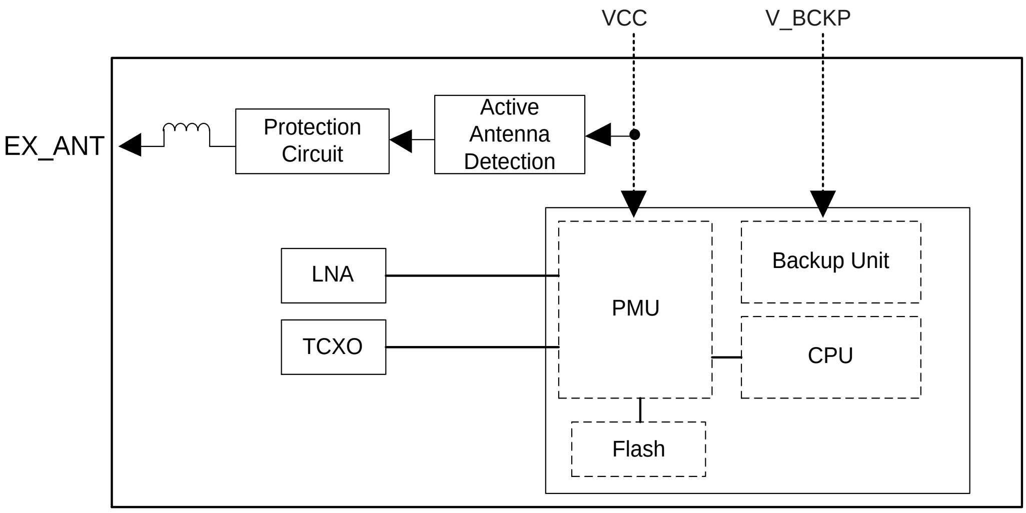


Figure 3: Internal Power Supply

3.2. Power Supply

3.2.1. VCC

The VCC is the supply voltage pin that supplies BB and RF.

Module power consumption may vary by several orders of magnitude, especially when a power saving mode is enabled. Therefore, it is important for the power supply to be able to sustain peak power for a short time, ensuring that the load current does not exceed the rated value. When the module starts up or switches from the Backup mode to the Continuous mode, VCC 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 mode, it is important for the LDO at the power supply or module input to be able to provide sufficient current when the module is switched from Backup mode to Continuous mode. An LDO with a high PSRR should be chosen for optimum performance. In addition, a TVS, and a combination of a 10 μF, a 100 nF, and a 33 pF decoupling capacitor should be added near the VCC pin. The minimum value capacitor should be the closest to the VCC pin.

It is not recommended to use a switching DC-DC converter.

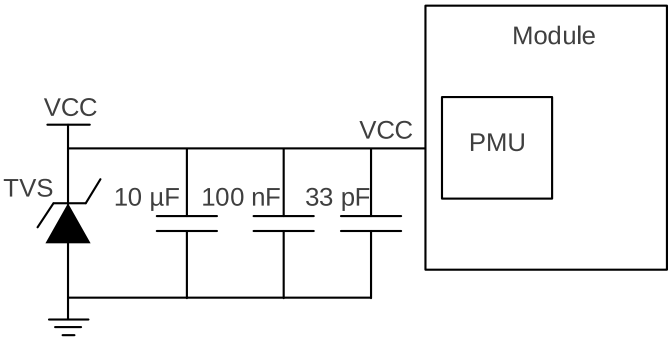


Figure 4: VCC Input Reference Circuit

NOTE

Ensure the module VCC is controlled by MCU to save power, or restart the module when it enters an abnormal state.

3.2.2. V_BCKP

The V_BCKP pin supplies power for the backup 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 always be 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 external rechargeable battery, which requires an external charging circuit. It is recommended to place the battery with 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 backup domain.

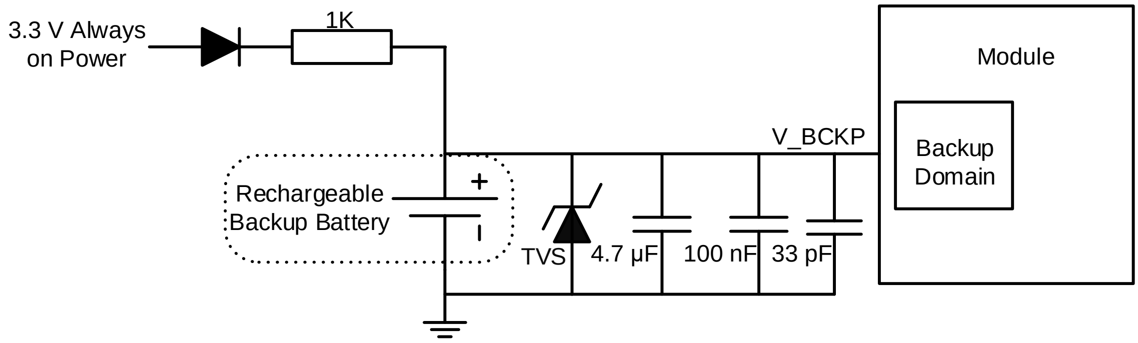


Figure 5: Reference Power Supply Circuit with Rechargeable Backup Battery

V_BCKP can also be powered by a 3.7 V lithium battery. It is recommended to use MCU to control the enable pin of LDO via MCU, as shown below.

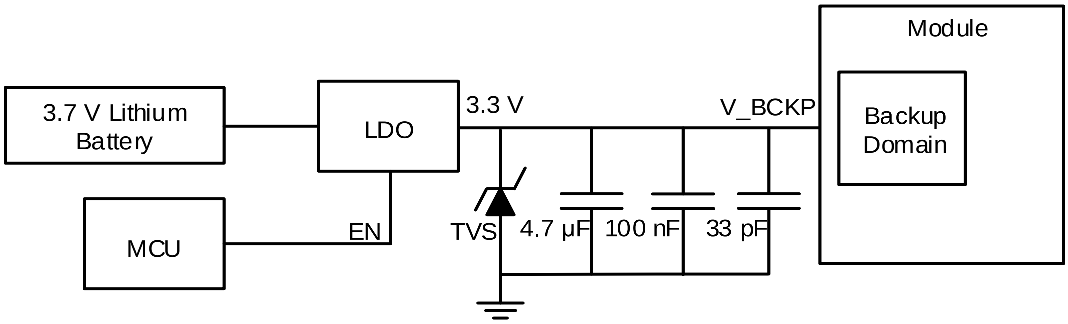


Figure 6: Reference Power Supply Circuit with 3.7 V Lithium Battery

NOTE

1. Connect the V_BCKP pin to VCC when backup supply voltage is unavailable.
2. Since the module cannot work normally when the non-rechargeable battery is depleted, it is recommended to use a rechargeable battery or 3.7 V lithium battery.
3. If V_BCKP is below the minimum recommended operating voltage, the module cannot work normally.
4. To limit the charging current and maintain the performance of the rechargeable battery, it is

necessary to select 1 kΩ current-limiting resistor. The required specific resistance depends on the battery chosen for your application.

5. It is recommended to control the V_BCKP of the module via MCU to restart the module if the module enters an abnormal state.

3.3. Power Modes

3.3.1. Feature Comparison

The module features supported in different modes are listed in the table below.

Table 7: Feature Comparison in Different Power Modes

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

3.3.2. Continuous Mode

If VCC and V_BCKP are powered on, the module automatically enters the Continuous mode that comprises acquisition mode and tracking mode. In acquisition mode, the module starts to search for satellites and to determine visible satellites, coarse frequency, as well as the code phase of satellite signals. Once 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 supports a Backup mode to reduce power consumption. Only backup domain is active in Backup mode and it keeps track of time. There are three ways to enter/exit Backup mode with different power consumption.

The first way (the power consumption: 13 µA):

- Enter Backup mode:
  1. Send the **$PAIR650,0*25** command to shut down internal main power supply in sequence.
  2. Cut off the power supply to the VCC pin and keep V_BCKP powered.

- Exit Backup mode:
  1. Restore VCC power supply.
  2. Drive the RESET_N low for at least 100 ms.

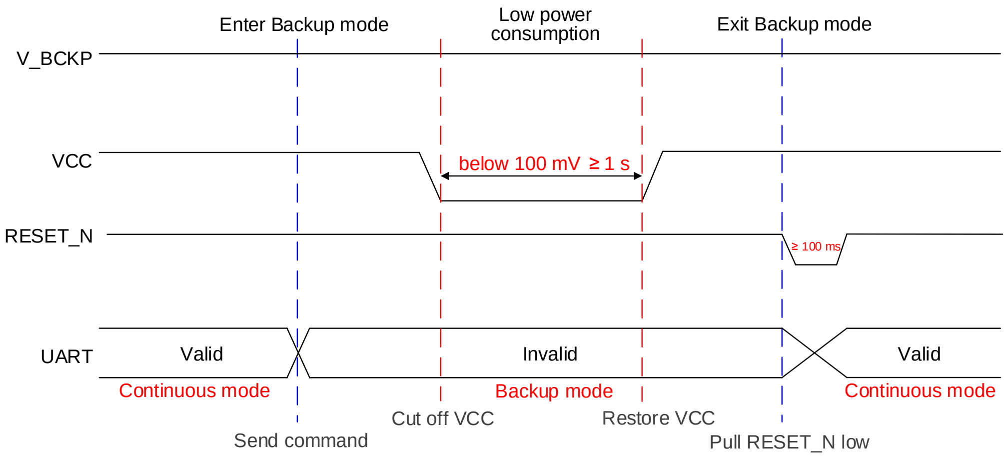


Figure 7: Enter/Exit Backup Mode Sequence 1

The second way (the power consumption: 35 µA):

- Enter Backup mode: Send the **$PAIR650,0*25** command to shut down internal main power supply in sequence.

- Exit Backup mode: Drive the RESET_N low for at least 100 ms.

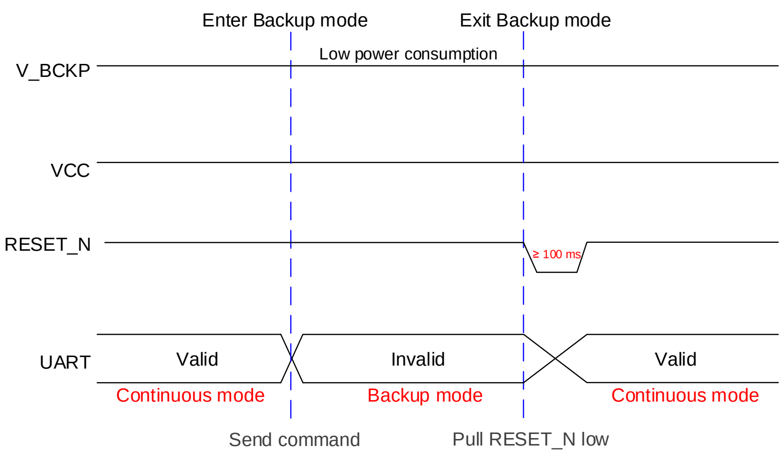


Figure 8: Enter/Exit Backup Mode Sequence 2

For details of the relevant software command, see document [1] protocol specification.

The third way (the power consumption: 30 μA):

- Enter Backup mode: Cut off the power supply to the VCC pin and keep V_BCKP powered.
- Exit Backup mode: Restore VCC power supply.

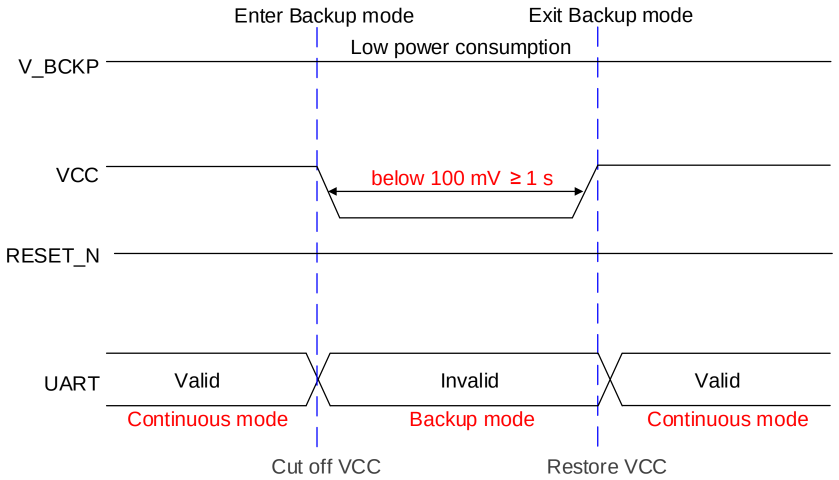


Figure 9: Enter/Exit Backup Mode Sequence 3

NOTE

1. The **$PAIR650,0*25** command must be sent to shut down internal main power supply for the first and second ways; to ensure hot (warm) start of the module at the next startup, the V_BCKP must be kept powered.
2. Ensure a stable V_BCKP voltage without a rush or drop when the VCC is switched on or off.

3.4. Power-up Sequence

Once the VCC and V_BCKP are 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 the VCC or before it.

Ensure that the VCC and V_BCKP have no rush or drop during rising time, and then keep them stable. The recommended ripple is < 50 mV.

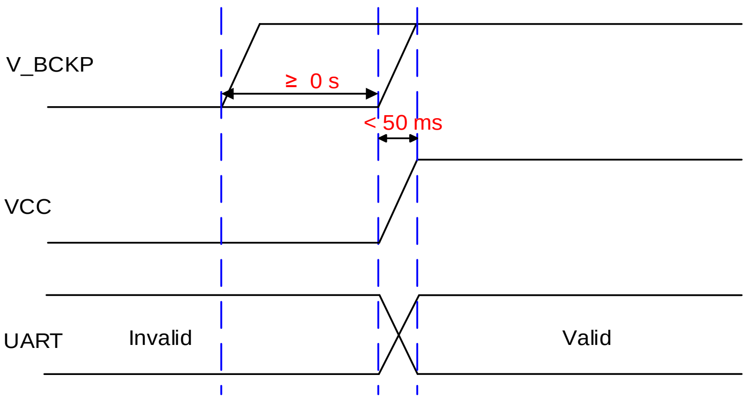


Figure 10: Power-up Sequence

3.5. Power-down Sequence

Once the VCC and V_BCKP are shut down, the module turns off automatically and the voltage should drop quickly within less than 50 ms.

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

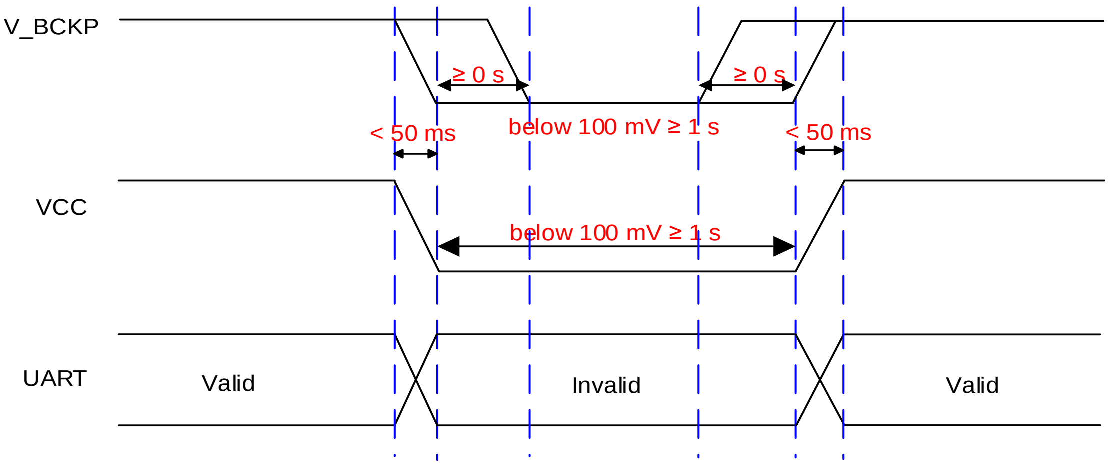


Figure 11: Power-down and Power-on Restart Sequence

4 Application Interfaces

4.1. I/O Pins

4.1.1. Communication Interface

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

4.1.1.1.UART Interface

The module has one UART interface with the following features:

- Supports RTCM and standard NMEA messages, PAIR and PQTM messages and firmware upgrade.
- Supported baud rates: 9600, 19200, 38400, 57600, 115200, 230400, 460800, and 921600 bps.
- Hardware flow control and synchronous operation are not supported.

For more information, see *document [1] protocol specification*.

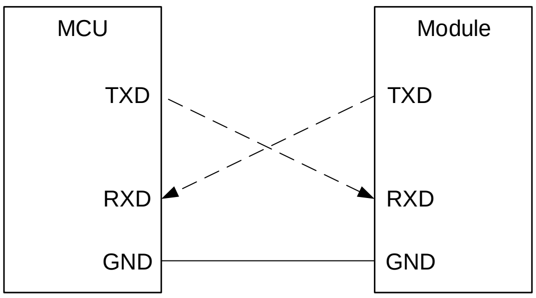


Figure 12: UART Interface Reference Design

A reference design is shown in the figure above. For more information, see *document [4] reference design*.

NOTE

1. UART interface default settings may vary depending on software version. See the relevant software versions for details.
2. If the I/O voltage of MCU is not matched with the module, a level-shifting circuit must be selected.

4.1.2. AADET_N

The AADET_N pin is used to indicate the open circuit status of an external active antenna.

When the external active antenna is not connected to EX_ANT pin or has poor contact with the antenna feed point, the AADET_N pin keeps outputting high-level signal. When a good connection to the active antenna is achieved, the pin changes to low level. When the module is connected to the external passive antenna, the AADET_N pin should always be kept low.

NOTE

External active antenna is only available when the voltage of AADET_N pin is less than or equal to 0.7 V.

4.1.3. 1PPS

The 1PPS can be used for time pulse signals, it generates a one pulse per second periodic signal, synchronized to GNSS time grid with intervals. Maintaining high accuracy of 1PPS requires visible satellites in an open sky environment and powered VCC. See *Table 3: Product Performance* for details about pulse accuracy.

4.2. System Pin

4.2.1. RESET_N

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

By default, the RESET_N pin is pulled up internally to 1.8 V with a 10 kΩ resistor, thus no external pull-up circuit is allowed for this pin.

The reference circuit as shown below is recommended to control the RESET_N pin.

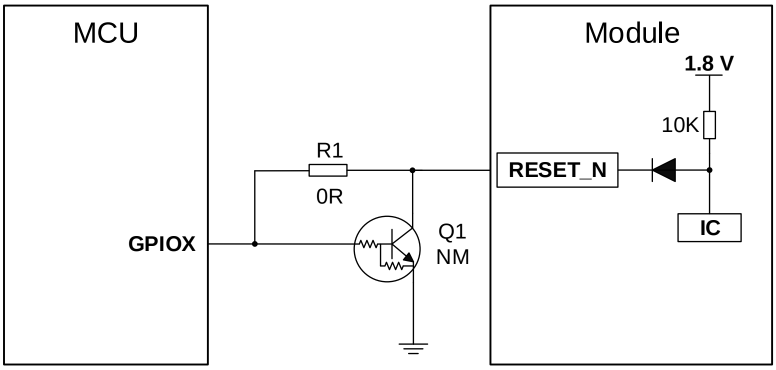


Figure 13: Reference Compatible Circuit for Module Reset

The following figure shows the reset sequence of the module.

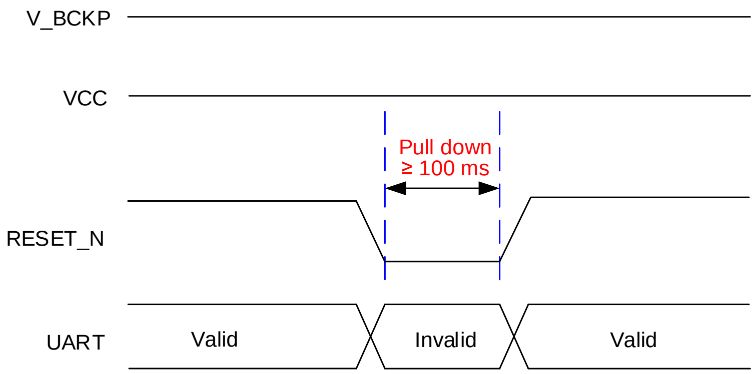


Figure 14: Reset Sequence

NOTE

1. The *Figure 13: Reference Compatible Circuit for Module Reset* is the compatible circuit scheme of RESET_N. The corresponding circuit can be selected according to your demands (mounting either R1 or Q1).
2. RESET_N must be connected so that it can be used to reset the module if the module enters an abnormal state.

5 Design

LC86G is a series of ultra-compact modules with an embedded 18.4 mm × 18.4 mm × 4.0 mm or 14.9 mm × 14.9 mm × 4.0 mm patch antenna. In addition, an LNA is embedded for better performance and the module can also work with an external passive or active antenna. The PCB layout of the modules and the overall environment of the equipment have a great impact on the achievable C/N_0 value. For more information on the RF layout, see *document [5] RF layout application note*.

5.1. C/N_0 Conception

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:

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

The "Power of GNSS signal" is GNSS signal level. In practical environment, the signal level at the earth's 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:

$$\text{NF} = 10 \log \text{F (dB)}$$

"F" is the noise figure of receiver system:

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

"F1" is the first stage noise figure; "G1" is the first stage gain, etc. This formula indicates that the LNA with enough gain can compensate for the noise figure behind the LNA. In this case, "System NF" depends mainly on the noise figure of components and traces before the first stage LNA plus noise figure of the LNA itself.

5.2. Integrated Patch Antenna

The quality of the GNSS antenna is crucial to the overall sensitivity of the GNSS system.

5.2.1. 14.9 mm × 14.9 mm × 4.0 mm Patch Antenna of LC86G (AA)

The LC86G (AA) module has a 14.9 mm × 14.9 mm × 4.0 mm high-performance patch antenna that supports GPS + Galileo + BDS constellations by default. The specifications of the antenna are given in following table.

Table 8: LC86G (AA) Antenna Specification with 30 mm × 30 mm Ground Plane

<table>
<tr><th>Antenna Type</th><th>Parameter</th><th>Specification</th><th>Notes</th></tr>
<tr><td rowspan="8">Patch Antenna</td><td>Size</td><td>14.9 mm × 14.9 mm × 4.0 mm</td><td>-</td></tr>
<tr><td>Frequency Range for Receiver</td><td>1559–1586 MHz</td><td>-</td></tr>
<tr><td>Impendence</td><td>50 Ω</td><td>-</td></tr>
<tr><td>Bandwidth</td><td>27 MHz</td><td>-</td></tr>
<tr><td>Frequency Temperature Coefficient (TF)</td><td>0 ±20 ppm/°C</td><td>-40 °C to +85 °C</td></tr>
<tr><td>Polarization</td><td>RHCP</td><td>Right-hand Circular Polarization</td></tr>
<tr><td>Gain at Zenith</td><td>> -0.9 dBi</td><td rowspan="2">Center Frequency</td></tr>
<tr><td>VSWR</td><td>≤ 2.0</td></tr>
</table>

The figure and tables below show antenna performance in different PCB ground planes and different positions (A: PCB center, B: PCB corner, C: PCB edge middle).

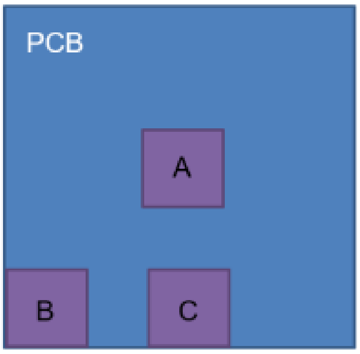


Figure 15: LC86G (AA) Different Antenna Positions (A, B, C)

Table 9: LC86G (AA) Performance with 30 mm × 30 mm Ground Plane

Parameter	A			B			C		
Frequency (MHz)	1561	1575	1602	1561	1575	1602	1561	1575	1602
VSWR	1.17	1.20	24.76	1.47	2.89	25.15	2.02	1.49	21.42
Peak RHCP Gain (dBi)	-0.83	0.59	-11.20	1.12	-0.62	-10.49	-0.41	0.95	-9.16

Table 10: LC86G (AA) Performance with 40 mm × 40 mm Ground Plane

Parameter	A			B			C		
Frequency (MHz)	1561	1575	1602	1561	1575	1602	1561	1575	1602
VSWR	1.60	1.28	21.85	1.41	2.44	23.71	2.41	1.30	19.02
Peak RHCP Gain (dBi)	-0.02	1.38	-10.45	1.92	0.13	-9.92	0.57	1.65	-9.13

Table 11: LC86G (AA) Performance with 50 mm × 50 mm Ground Plane

Parameter	A			B			C		
Frequency (MHz)	1561	1575	1602	1561	1575	1602	1561	1575	1602
VSWR	1.59	1.38	19.89	1.36	2.50	20.14	2.70	1.66	17.06
Peak RHCP Gain (dBi)	1.32	1.80	-9.20	2.54	-0.29	-9.80	1.56	2.37	-7.65

As can be seen from the above data, ground plane size has a strong impact on the overall performance of the patch antenna. The larger the planar ground, the better the peak gain. As for the layout, although the overall difference is not large, different positions of the antennas on the PCB affect the receiving and tracking of different constellation signals. You can determine the best placement according to your needs.

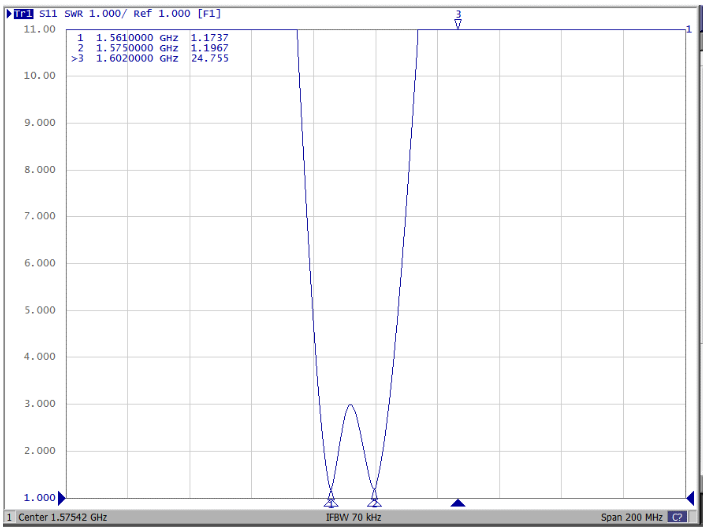


Figure 16: LC86G (AA) Patch Antenna Test Results (30 mm × 30 mm Ground Plane)

5.2.2. 14.9 mm × 14.9 mm × 4.0 mm Patch Antenna of LC86G (AB)

LC86G (AB) module has a 14.9 mm × 14.9 mm × 4.0 mm high-performance patch antenna that supports GPS + GLONASS + Galileo constellations by default. The specifications of the antenna are given in following table.

Table 12: LC86G (AB) Antenna Specification with 30 mm × 30 mm Ground Plane

Antenna Type	Parameter	Specification	Notes
Patch Antenna	Size	14.9 mm × 14.9 mm × 4.0 mm	-
	Frequency Range for Receiver	1573–1606 MHz	-
	Impendence	50 Ω	-
	Bandwidth	33 MHz	-
	Frequency Temperature Coefficient (TF)	0 ±20 ppm/°C	-40 °C to +85 °C
	Polarization	RHCP	Right-hand Circular Polarization

Antenna Type	Parameter	Specification	Notes
	Gain at Zenith	≤ 2.0 dBi	Center Frequency
	VSWR	≤ 5.5	

The figure and tables below show antenna performance in different PCB grounding planes and different positions (A: PCB center, B: PCB corner, C: PCB edge middle).

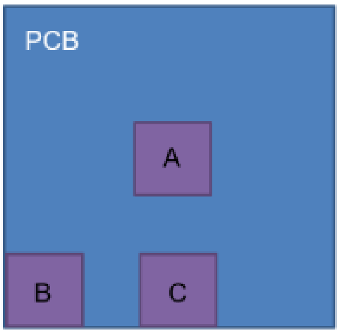


Figure 17: LC86G (AB) Different Antenna Positions (A, B, C)

Table 13: LC86G (AB) Performance with 30 mm × 30 mm Ground Plane

Parameter	A			B			C		
Frequency (MHz)	1561	1575	1602	1561	1575	1602	1561	1575	1602
VSWR	4.80	3.99	5.88	7.60	2.47	4.22	10.00	2.89	1.39
Peak RHCP Gain (dBi)	-7.90	0.30	2.10	-6.40	1.65	1.12	-8.80	0.2	1.4

Table 14: LC86G (AB) Performance with 40 mm × 40 mm Ground Plane

Parameter	A			B			C		
Frequency (MHz)	1561	1575	1602	1561	1575	1602	1561	1575	1602
VSWR	9.33	1.49	2.15	7.73	2.51	3.81	8.19	2.49	1.62
Peak RHCP Gain (dBi)	-7.09	-0.16	2.19	-4.50	0.30	-1.10	-6.50	0.50	1.10

Table 15: LC86G (AB) Performance with 50 mm × 50 mm Ground Plane

Parameter	A			B			C		
Frequency (MHz)	1561	1575	1602	1561	1575	1602	1561	1575	1602
VSWR	8.95	1.48	2.47	6.65	2.49	3.51	5.98	2.89	1.30
Peak RHCP Gain (dBi)	-10.70	-2.20	0.70	-5.10	1.20	0.40	-3.60	1.30	1.80

As can be seen from the above data, ground plane size has a strong impact on the overall performance of the patch antenna. The larger the planar ground, the better the peak gain. As for the layout, although the overall difference is not large, different positions of the antennas on the PCB affect the receiving and tracking of different constellation signals. You can determine the best placement according to your needs.

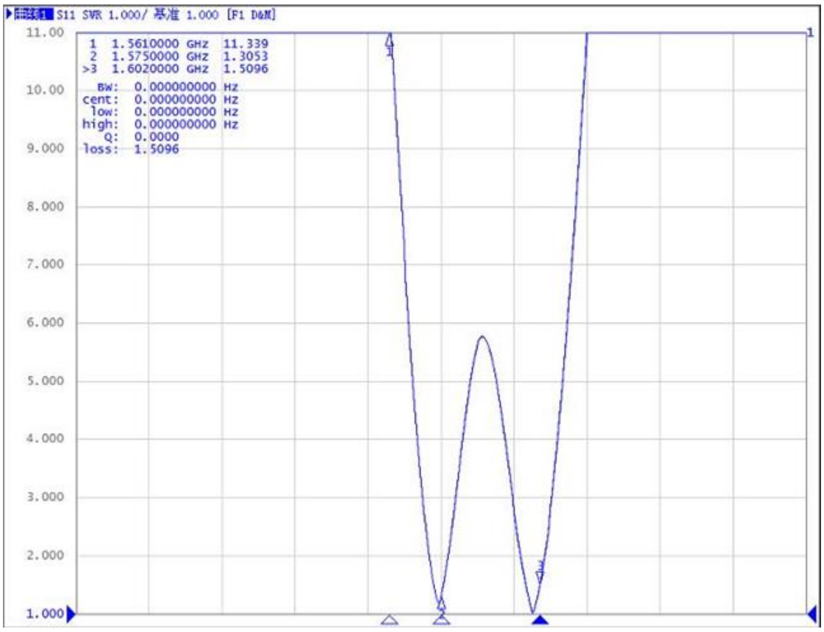


Figure 18: LC86G (AB) Patch Antenna Test Results (30 mm × 30 mm Ground Plane)

5.2.3. 18.4 mm × 18.4 mm × 4.0 mm Patch Antenna of LC86G (LA)

The LC86G (LA) module has an 18.4 mm × 18.4 mm × 4.0 mm high-performance patch antenna that supports GPS + GLONASS + Galileo + BDS + QZSS constellations by default. The specifications of the antenna are given in following table.

Table 16: LC86G (LA) Antenna Specification with 30 mm × 30 mm Ground Plane

Antenna Type	Parameter	Specification	Notes
Patch Antenna	Size	18.4 mm × 18.4 mm × 4.0 mm	-
	Frequency Range for Receiver	1559–1606 MHz	-
	Impendence	50 Ω	-
	Bandwidth	47 MHz	-
	Frequency Temperature Coefficient (TF)	0 ±20 ppm/°C	-40 °C to +85 °C
	Polarization	RHCP	Right-hand Circular Polarization
	Gain at Zenith	> -3.0 dBi	Center Frequency
	VSWR	≤ 7.0	

The figure and tables below show antenna performance in different PCB grounding planes and different positions (A: PCB center, B: PCB corner, C: PCB edge middle).

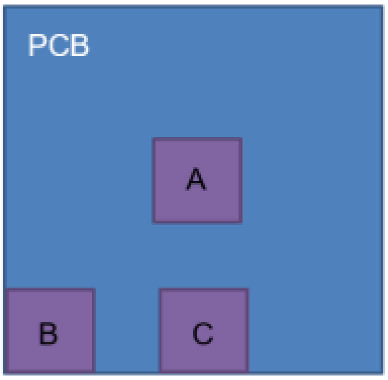


Figure 19: LC86G (LA) Different Antenna Positions (A, B, C)

Table 17: LC86G (LA) Performance 30 mm × 30 mm Ground Plane

Parameter	A			B			C		
Frequency (MHz)	1561	1575	1602	1561	1575	1602	1561	1575	1602
VSWR	3.42	3.62	6.68	1.87	2.15	8.69	1.67	4.26	6.05
Peak RHCP Gain (dBi)	-1.81	-1.19	-2.99	-1.43	0.5	-3.66	-0.38	-0.96	-1.89

Table 18: LC86G (LA) Performance with 40 mm × 40 mm Ground Plane

Parameter	A			B			C		
Frequency (MHz)	1561	1575	1602	1561	1575	1602	1561	1575	1602
VSWR	4.77	2.65	4.81	1.57	1.85	7.07	1.34	4.31	3.98
Peak RHCP Gain (dBi)	-2.25	-0.07	-1.43	0.51	2.18	-2.88	0.99	-0.35	-0.45

Table 19: LC86G (LA) Performance with 50 mm × 50 mm Ground Plane

Parameter	A			B			C		
Frequency (MHz)	1561	1575	1602	1561	1575	1602	1561	1575	1602
VSWR	4.63	2.13	3.99	1.51	1.78	6.05	1.23	4.42	2.86
Peak RHCP Gain (dBi)	-0.37	1.82	-0.25	2.13	2.88	-2.47	1.97	0.86	0.79

As can be seen from the above data, ground plane size has a strong impact on the overall performance of the patch antenna. The larger the planar ground, the better the peak gain. As for the layout, although the overall difference is not large, different positions of the antennas on the PCB affect the receiving and tracking of different constellation signals. You can determine the best placement according to your needs.

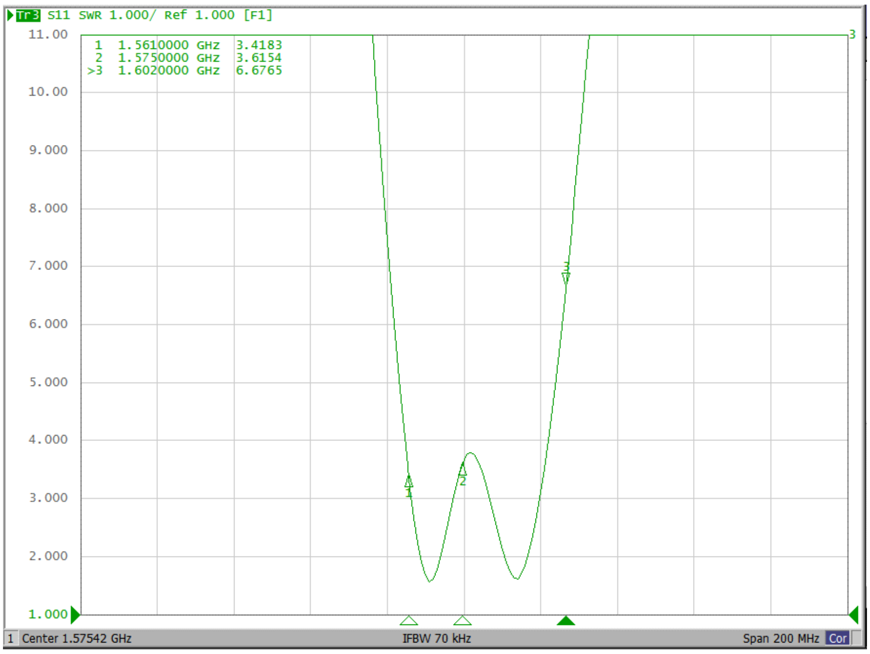


Figure 20: LC86G (LA) Patch Antenna Test Results (30 mm × 30 mm Ground Plane)

5.2.4. PCB Design Guide

Antenna radiation characteristic depends on various factors, such as the size, shape of the PCB and the dielectric constant of components nearby. In PCB design, it is recommended to follow the rules below.

- Patch antenna feed point on the motherboard should be surrounded by the keep-out area on each layer. The diameter of the keep-out area should be at least 2.5 mm.

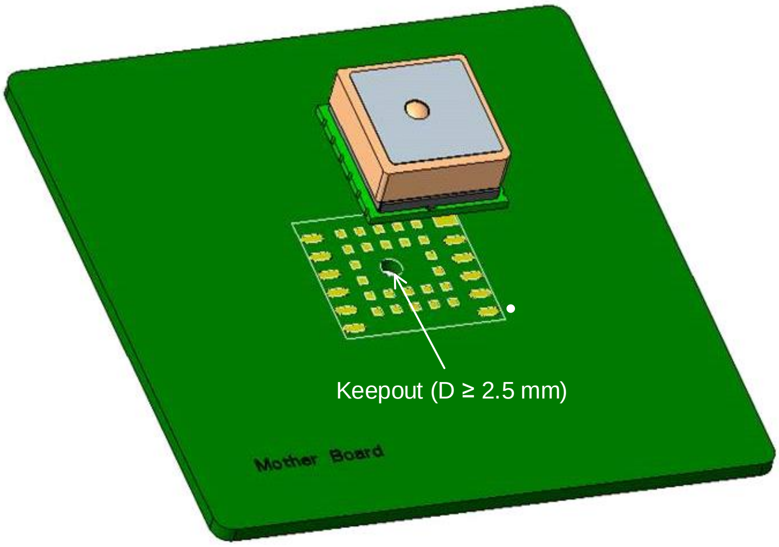


Figure 21: Recommended Treatment for Patch Antenna Feed Point

- Make sure the antenna points to the sky.
- The performance of the embedded patch antenna depends on the size of the ground plane around the module. It is recommended to design a ground plane of at least 30 mm × 30 mm as shown below. In addition, components, especially thick ones, must not be placed in the area in any case (interfering vias are not allowed either).

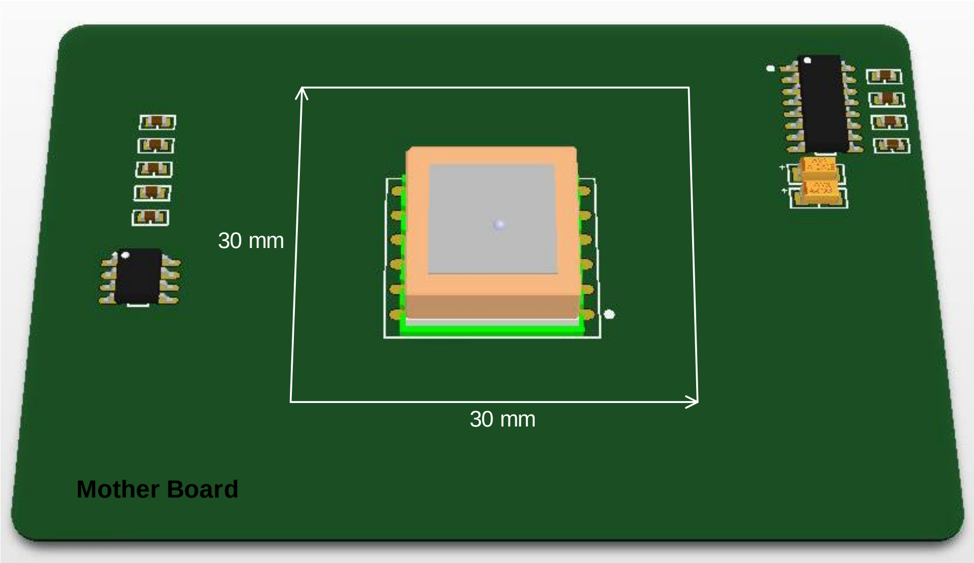


Figure 22: Recommended Ground Plane

- Keep the patch antenna at least 10 mm away from other tall metal components (height > 6 mm). Otherwise, the antenna performance will be affected.

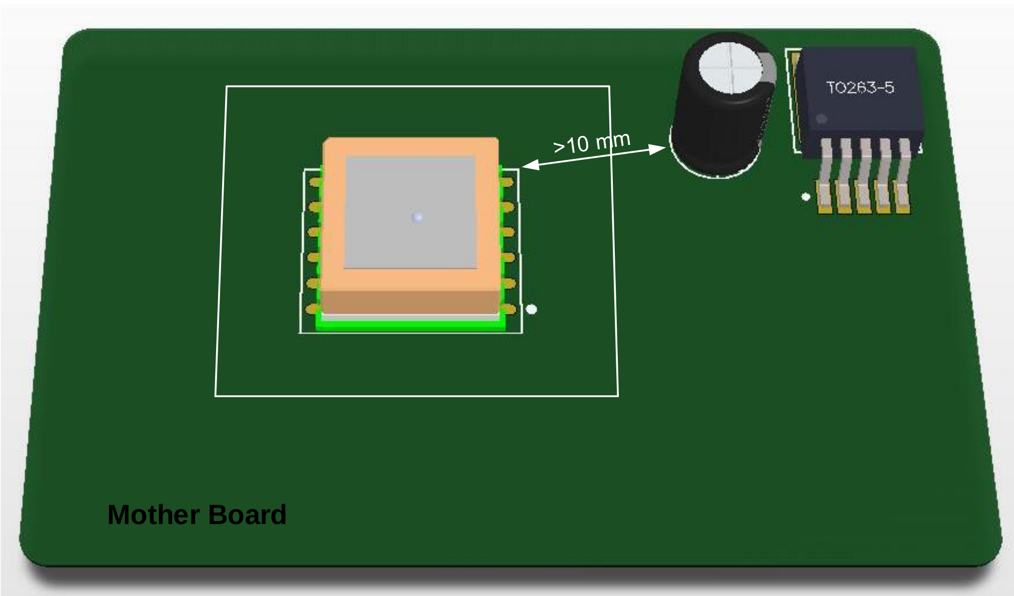


Figure 23: Recommended Distance Between Module and Tall Metal Components

- Make sure the microcontroller, crystal, LCM, camera and other high-speed components and interfaces are placed on the motherboard opposite to the module, and keep them away from the module as far as possible, preferably by placing them in a diagonal position relative to the module.

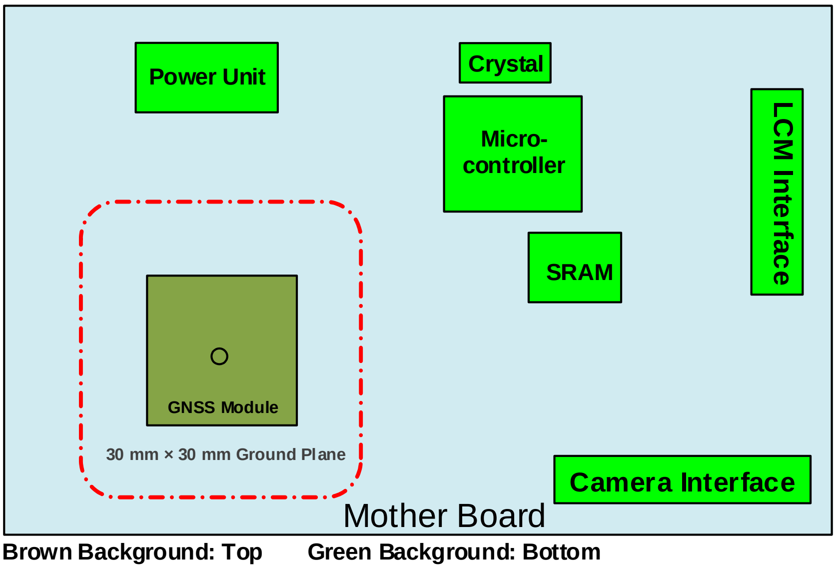


Figure 24: Recommended Placement of GNSS Module and Other Components

- Make sure interfering signals (USB, LCM, camera, crystal, etc.) are on inner layer shielded by ground plane, and keep them and their vias far away from the module.
- Make sure the RF systems such as Wi-Fi, Bluetooth, 2G, 3G, 4G and 5G are placed on the mother board opposite to the module, and keep them away from the module as far as possible, preferably by placing the RF systems in the diagonal position relative to the module.
- Keep DC-DC converter far away from the module.
- Device enclosure should be made of non-metal materials, especially for those which are around the antenna area. The minimum distance between antenna and enclosure is 3 mm.
- The RF part of the module is sensitive to temperature. Please keep it away from the heat-emitting circuit.
- It is recommended to reserve an integrated ground layer to isolate the GNSS module from other modules.

5.3. External Antenna

The LC86G series can also be connected to external passive or active antenna, and it is recommended to use an active antenna that meets the requirements.

5.3.1. External Active Antenna

The module can be connected via the EX_ANT pin to an external active antenna. The module automatically switches from integrated antenna signals to external active antenna signals through its SPDT switch after detecting the external active antenna.

5.3.1.1.External Active Antenna Specification

The recommended external active antenna specifications are given in the table below.

Table 20: Recommended Active Antenna Specification

Antenna Type	Specification
Active Antenna	Frequency Range: 1559–1606 MHz Polarization: RHCP VSWR: < 2 (Typ.) Passive Antenna Gain: > 0 dBi Active Antenna Noise Figure: < 1.5 dB Active Antenna Total Gain: < 17 dB

Select an active antenna whose power consumption falls within the range of 5 mA to 40 mA and take account of the relationship between the voltage of EX_ANT pin and the antenna power consumption, as is illustrated in the following figure.

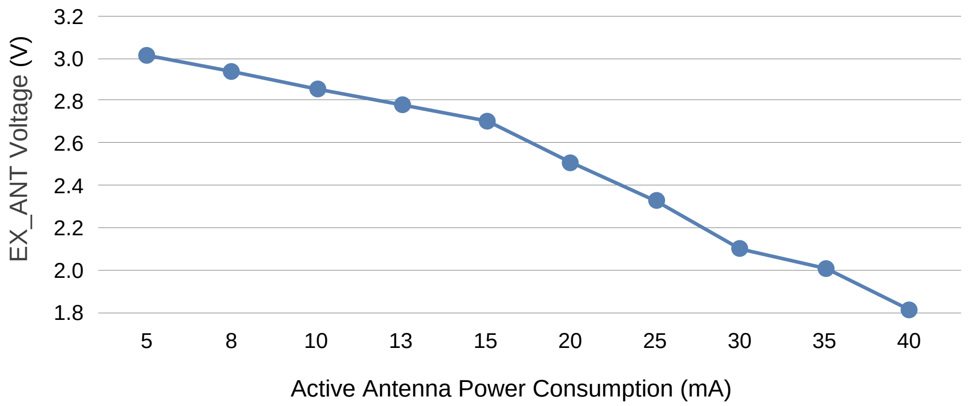


Figure 25: Relationship Between EX_ANT Voltage and Active Antenna Power Consumption

NOTE

1. For recommended antenna selection and design, see *document [6] GNSS antenna selection guidance* or contact Quectel Technical Support (support@quectel.com).

2. The total antenna gain equals the internal LNA gain minus the total insertion loss of cables and components inside the antenna.

5.3.1.2.External Active Antenna Reference Design

The EX_ANT pin is powered by VCC and supplies power to the external active antenna. To mitigate the impact of out-of-band signals on GNSS module performance in a complex electromagnetic environment around the module, you must choose the active antenna whose SAW filter is placed in front of the LNA in the internal framework. The minimum operating voltage of the selected active antenna must meet the circuit design characteristics.

The following figure is a typical reference design with active antenna.

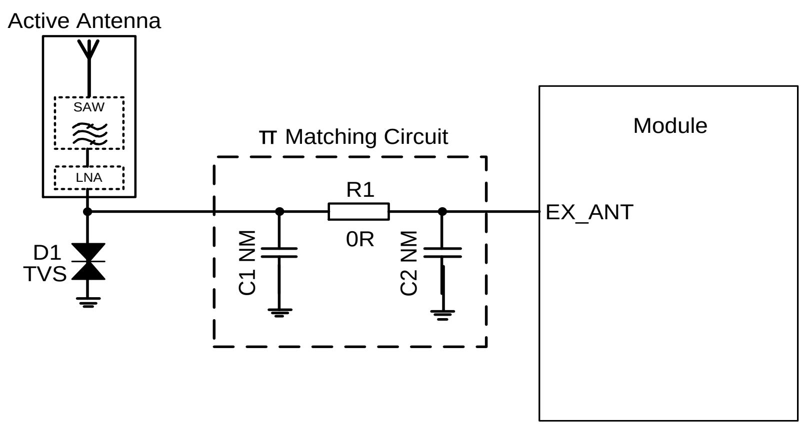


Figure 26: Active Antenna Reference Design

The C1, R1, and C2 components are reserved for matching antenna impedance. By default, R1 is 0 Ω, and C1 and C2 are not mounted. D1 is an ESD protection device to protect the RF signal input from the potential damage caused by ESD. The junction capacitance of D1 cannot be more than 0.6 pF and a transient voltage suppressor is recommended. The impedance of the RF trace line on the main PCB should be controlled to 50 Ω, and the trace length should be kept as short as possible.

5.3.1.3.External Active Antenna Status Indication

The module supports automatically switching between external active antenna and patch antenna, and the antenna short-circuit protection is enabled by default. If the external active antenna is short-circuited, the module automatically cuts off the power supply for it and switches to the integrated antenna to avoid damage. Meanwhile, you need to check the status of external active antenna via the output message **$PQTMANTENNASTATUS**, as shown below.

- If **$PQTMANTENNASTATUS,3,1,2,1*52** is output by the module, it means external active antenna is not connected or has poor contact with antenna feed point, and the integrated patch antenna is used. The connection status of external active antenna must be confirmed.

- If **$PQTMANTENNASTATUS,3,1,2,2*51** is output by the module, it means external active antenna is used.

- If **$PQTMANTENNASTATUS,3,3,2,1*50** is output by the module, it means external active antenna is short-circuited and the integrated patch antenna has been used automatically. When the short-circuit problem is solved, power supply will be automatically restored to the external antenna.

For more information, see *document [1] protocol specification*.

Table 21: External Active Antenna Status Indication

Message	External Active Antenna Status	Integrated Patch Antenna Status	Attention
$PQTMANTENNASTATUS,3,1,2,1*52	Unused	Working	Make sure that the external active antenna is connected if you need to use it
$PQTMANTENNASTATUS,3,1,2,2*51	Working	Unused	-
$PQTMANTENNASTATUS,3,3,2,1*50	Short-circuited	Working	Please confirm the reason(s) for the short-circuit of the external active antenna.

5.3.2. External Passive Antenna

5.3.2.1. External Passive Antenna Specification

The module can also be connected via the EX_ANT pin to an external passive antenna. The recommended external passive antenna specifications are given in the table below.

Table 22: Recommended Passive Antenna Specification

Antenna Type	Specification
Passive Antenna	Frequency Range: 1559–1606 MHz Polarization: RHCP VSWR: < 2 (Typ.) Passive Antenna Gain: > 0 dBi

5.3.2.2. External Passive Antenna Reference Design

When the EX_ANT pin is connected to an external passive antenna, the module cannot automatically switch the RF path to the external passive antenna. You can switch to the external passive antenna by the two ways shown below:

- Send the **$PQTMCFGANTENNA,W,0,2*7C** command. After successfully sending the command, the **$PQTMCFGANTENNA,OK*2D** message will be returned, indicating the successful switch to the external passive antenna. At this time, send **$PQTMSAVEPAR*5A** to save the configuration and keep the AADET_N pin unconnected.
- Connect the AADET_N pin to the ground with a 500 Ω resistor without sending any command. The reference design is shown below.

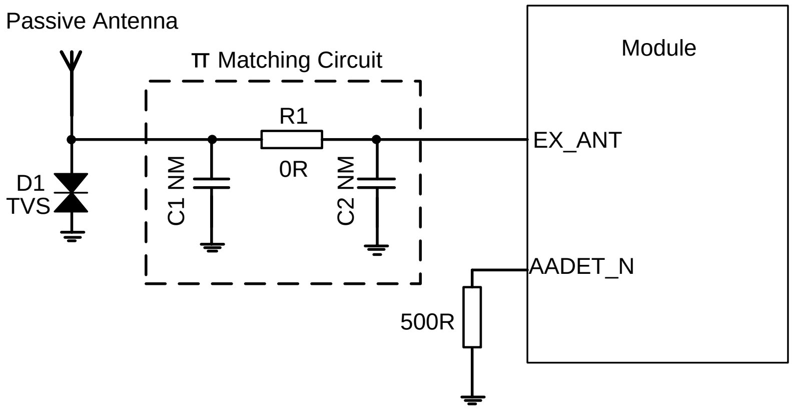


Figure 27: Passive Antenna Reference Design

The C1, R1, and C2 components are reserved for matching antenna impedance. By default, R1 is 0 Ω, and C1 and C2 are not mounted. D1 is an ESD protection device to protect the RF signal input from the potential damage caused by ESD. The junction capacitance of D1 cannot be more than 0.6 pF and a transient voltage suppressor is recommended. The impedance of the RF trace line on the main PCB should be controlled to 50 Ω, and the trace length should be kept as short as possible.

5.4. Co-existence with Cellular Systems

Since GNSS signals are usually very weak, a GNSS receiver could be vulnerable to environmental interference. 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, or of about 26 dBm at 5G bands. Therefore, coexistence with cellular systems must be optimized to avoid significant deterioration of the GNSS performance.

In a complex communication environment, interference may be caused by in-band and out-of-band signals as described in this chapter.

Suggestions are also provided for decreasing the impact of interference signals that will ensure the interference immunity of a GNSS receiver.

5.4.1. In-band Interference

In-band interference refers to the signal whose frequency is within or near the operating frequency range of a GNSS signal. For example, GPS L1 is centered at 1575.42 MHz with a bandwidth of 2.046 MHz. As shown in the figure below, the frequency of the interfering signal is within the GPS operation band, and the power of the interfering signal is higher than the power value of the received GPS signal.

See the following figure for more details.

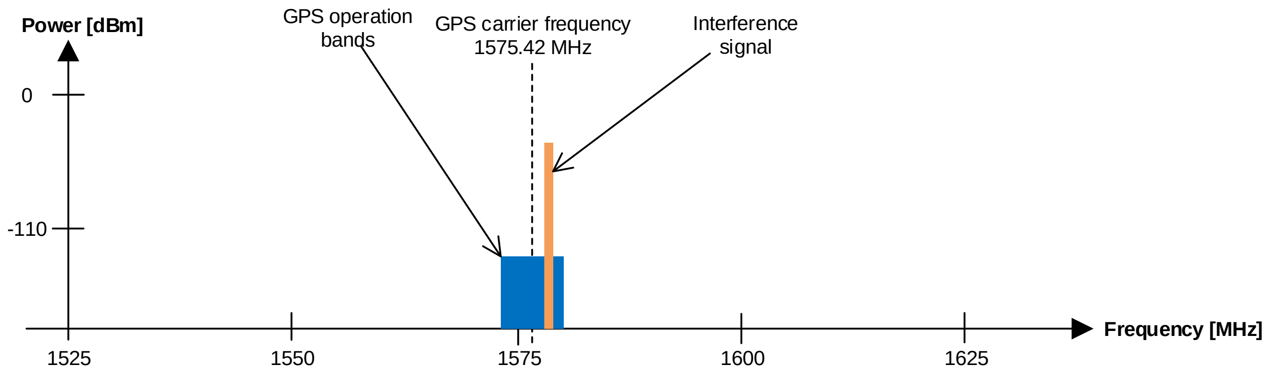


Figure 28: In-band Interference on GPS L1

In-band interferences are most commonly caused by:

- Harmonics, 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 23: 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
Band 1	n78	F2 (3500 MHz) - F1 (1925 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	-	2 × F1 (786.9 MHz)	IMD2 = 1573.8 MHz

5.4.2. Out-of-band Interference

Strong signals transmitted by other communication systems can cause a GNSS receiver saturation, thus greatly deteriorating its performance, as illustrated in the following figure. In practical applications, common strong interference signals originate from wireless communication modules, such as GSM, 3G, LTE, 5G, Wi-Fi and Bluetooth.

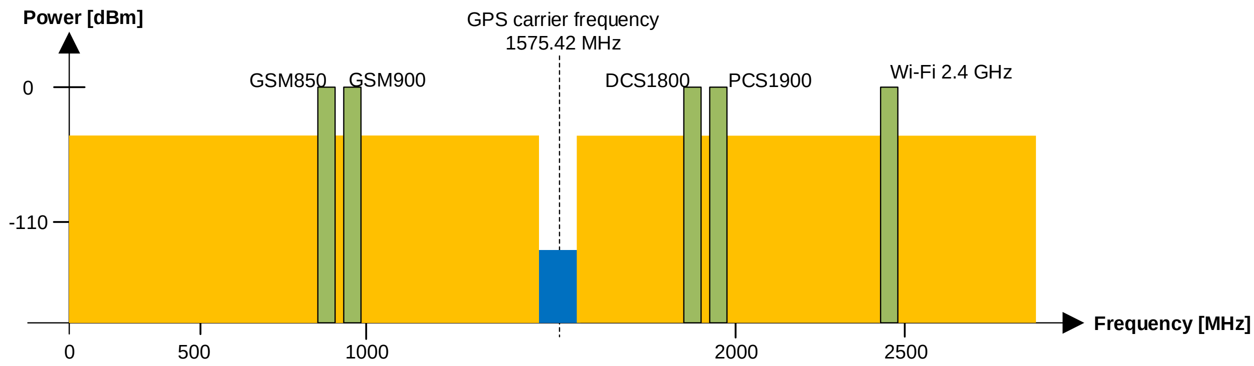


Figure 29: Out-of-band Interference on GPS L1

5.4.3. Ensuring Interference Immunity

There are several recommended strategies 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, 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 the potential interference path. A complex communication system usually contains 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.

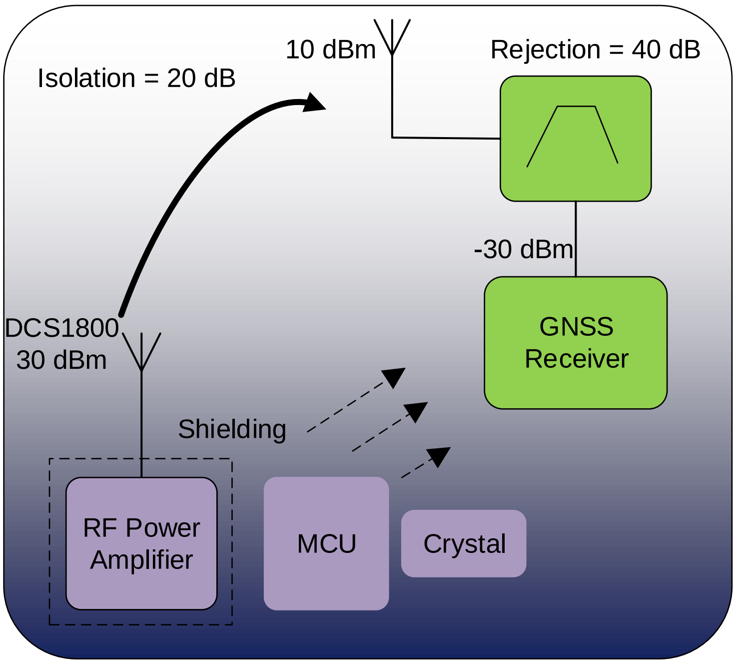


Figure 30: Interference Source and Its Path

5.5. Recommended Footprint

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

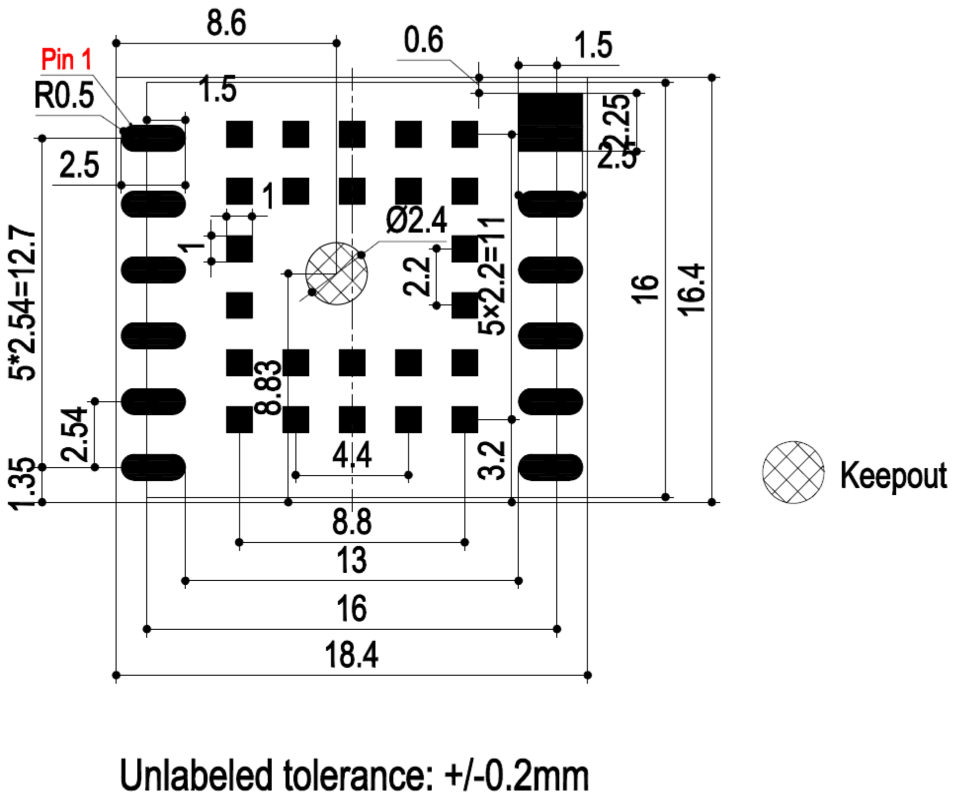


Figure 31: Recommended Footprint

NOTE

Keep at least 3 mm between the module and other components on the motherboard to improve soldering quality and maintenance convenience.

6 Electrical Specification

6.1. Absolute Maximum Ratings

Absolute maximum ratings for power supply and voltage on digital pins of the Quectel LC86G series modules are listed in table below.

Table 24: Absolute Maximum Ratings

Parameter	Description	Min.	Max.	Unit
VCC	Power Supply Voltage	-0.3	3.63	V
V_BCKP	Backup Supply Voltage	0	3.63	V
V_{IN}_IO	Input Voltage at I/O Pins	-0.3	3.63	V
P_{EX_ANT}	Input Power at EX_ANT	-	0	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 specification validity.

Table 25: Recommended Operating Conditions

Parameter	Description	Min.	Typ.	Max.	Unit
VCC	Power Supply Voltage	2.55	3.3	3.6	V
V_BCKP	Backup Supply Voltage	1.65	3.3	3.6	V
IO_Domain	Digital I/O Pin Voltage Domain	-	VCC	-	V
V_{IL}	Digital I/O Pin Low-Level Input Voltage	-0.3	-	0.8	V
V_{IH}	Digital I/O Pin High-Level Input Voltage	2	-	VCC + 0.3	V
V_{OL}	Digital I/O Pin Low-Level Output Voltage	-	-	0.4	V
V_{OH}	Digital I/O Pin High-Level Output Voltage	2.4	-	-	V
RESET_N	Low-Level Input Voltage	-0.3	-	0.45	V
	High-Level Input Voltage	1.8	-	3.6	V
EX_ANT	EX_ANT Output Voltage	1.8	-	3	V
I_{EX_ANT}	EX_ANT Output Current	-	-	40	mA
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. Digital I/O Pin refers to all digital pins specified in *Table 6: Pin Description* except RESET_N.

6.3. Supply Current Requirement

The following table lists the supply current values of the total system that may be applied. Actual power requirements may vary depending on processor load, external circuits, firmware version, the number of tracked satellites, signal strength, startup type, test time, and conditions.

Table 26: Supply Current for LC86G (AA)

Parameter	Description	Condition	$I_{Typ.}$ [6]	I_{PEAK} [6]
I_{VCC} [7]	Current at VCC	Acquisition	30 mA	50 mA
		Tracking	30 mA	50 mA
I_{V_BCKP} [8]	Current at V_BCKP	Continuous mode	127 µA	180 µA
		Backup mode [9]	13 µA	42 µA

Table 27: Supply Current for LC86G (AB)

Parameter	Description	Condition	$I_{Typ.}$ [6]	I_{PEAK} [6]
I_{VCC} [7]	Current at VCC	Acquisition	33 mA	50 mA
		Tracking	33 mA	50 mA
I_{V_BCKP} [8]	Current at V_BCKP	Continuous mode	128 µA	180 µA
		Backup mode [9]	13 µA	40 µA

Table 28: Supply Current for LC86G (LA)

Parameter	Description	Condition	$I_{Typ.}$ [6]	I_{PEAK} [6]
I_{VCC} [7]	Current at VCC	Acquisition	34 mA	56 mA
		Tracking	34 mA	56 mA
I_{V_BCKP} [8]	Current at V_BCKP	Continuous mode	123 µA	175 µA
		Backup mode [9]	13 µA	44 µA

[6] Room temperature, measurements are taken with typical voltage.
[7] Used to determine maximum current capability of power supply.
[8] Used to determine required battery current capability.
[9] It refers to the first way mentioned in *Chapter 3.3.3 Backup Mode*.

6.4. ESD Protection

Static electricity occurs naturally and it may damage the module. Therefore, applying proper ESD countermeasures and handling methods is imperative. For example, wear anti-static gloves during the development, production, assembly, and testing of the module; add ESD protection components to the ESD sensitive interfaces and points in the product design.

Measures to ensure protection against ESD damage when handling the module:

- When mounting the module onto a motherboard, make sure to connect the GND first, and then the EX_ANT pin.
- When handling the EX_ANT pin, do not come into contact with any charged capacitors or materials that may easily generate or store charges (such as patch antenna, coaxial cable, and soldering iron).
- When soldering the EX_ANT 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

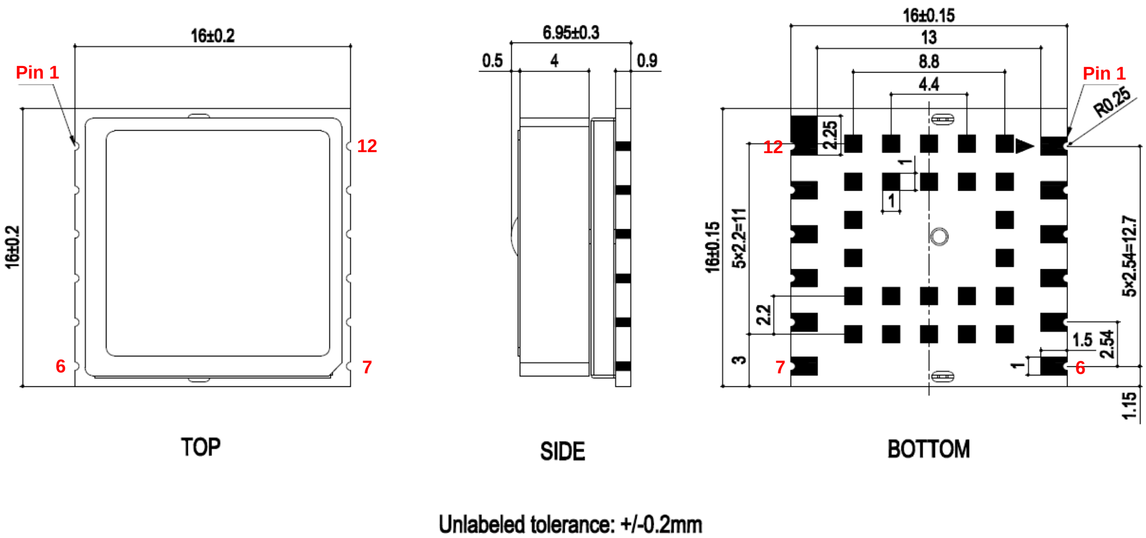


Figure 32: Top, Side and Bottom View Dimensions for LC86G (AA, AB)

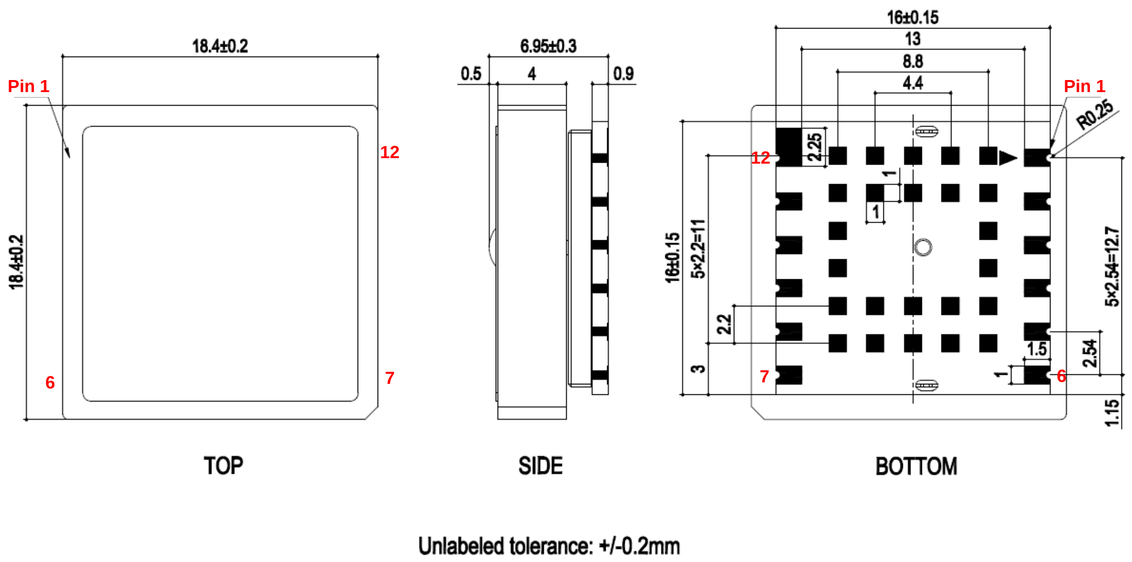


Figure 33: Top, Side and Bottom View Dimensions for LC86G (LA)

NOTE

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

7.2. Top and Bottom Views

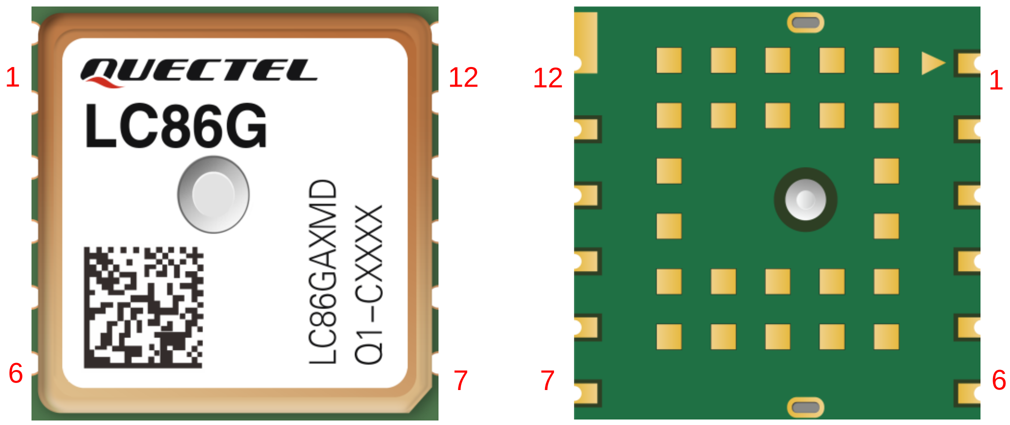


Figure 34: Top and Bottom Module Views for LC86G (AA, AB)

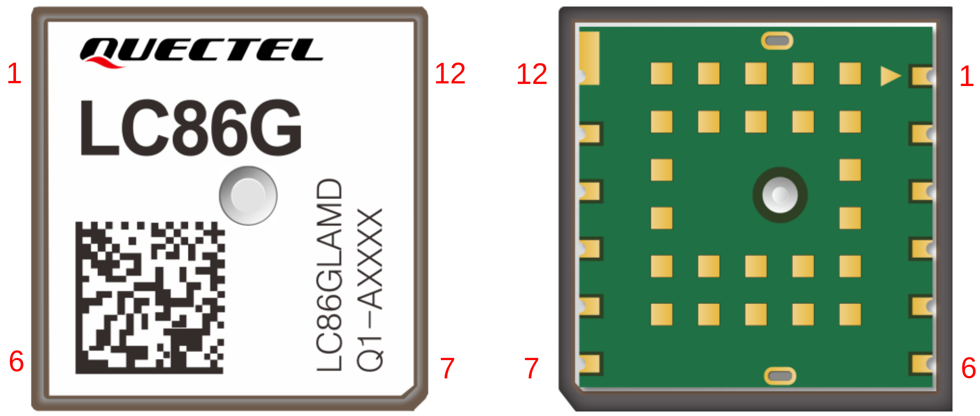


Figure 35: Top and Bottom Module Views for LC86G (LA)

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.

8 Product Handling

8.1. Packaging

This chapter describes only the key parameters and process of packaging. All figures below are for reference only. The appearance and structure of packaging materials are subject to the delivery.

The module adopts carrier tape packaging and the details are as follows.

8.1.1. Carrier Tape

Carrier tape dimensions are detailed below:

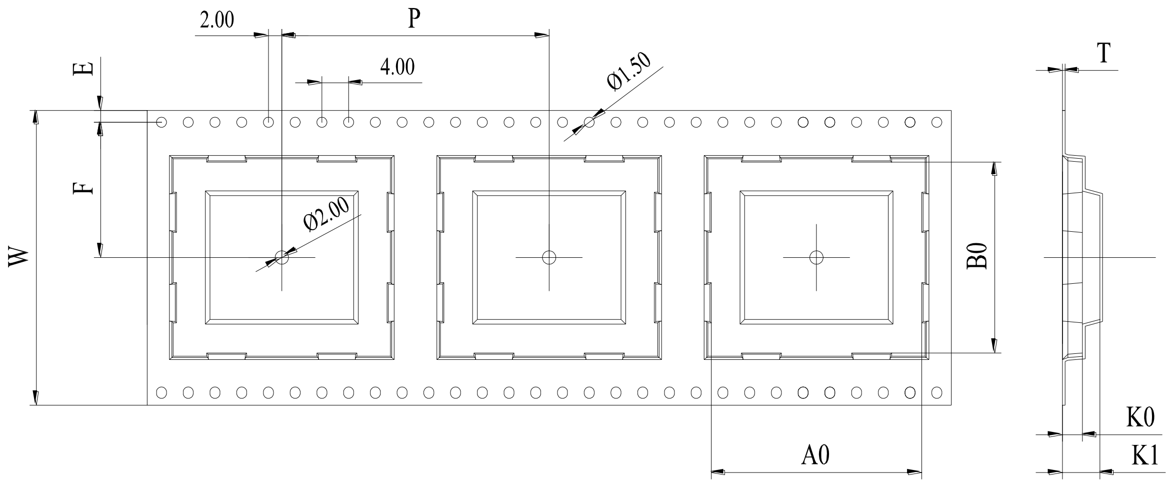


Figure 36: Carrier Tape Dimension Drawing

Table 29: Carrier Tape Dimension Table for LC86G (AA, AB) (Unit: mm)

W	P	T	A0	B0	K0	K1	F	E
32	24	0.4	16.6	16.4	7.2	8	14.2	1.75

Table 30: Carrier Tape Dimension Table for LC86G (LA) (Unit: mm)

W	P	T	A0	B0	K0	K1	F	E
32	24	0.4	16.5	16.7	7.2	8.2	14.2	1.75

8.1.2. Plastic Reel

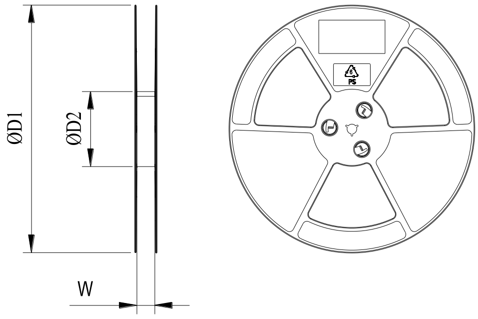


Figure 37: Plastic Reel Dimension Drawing

Table 31: Plastic Reel Dimension Table (Unit: mm)

øD1	øD2	W
330	100	32.5

8.1.3. Mounting Direction

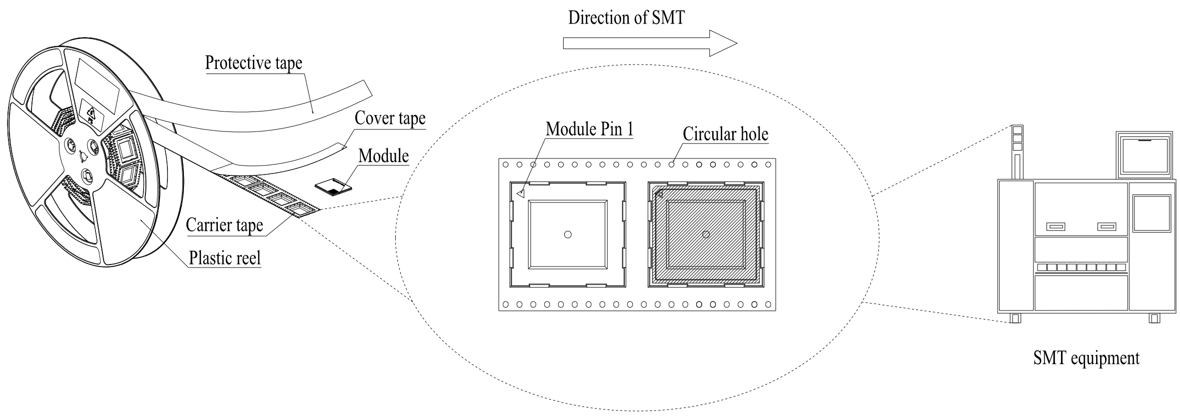
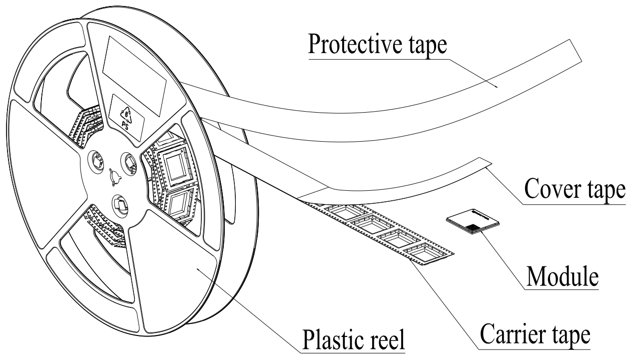


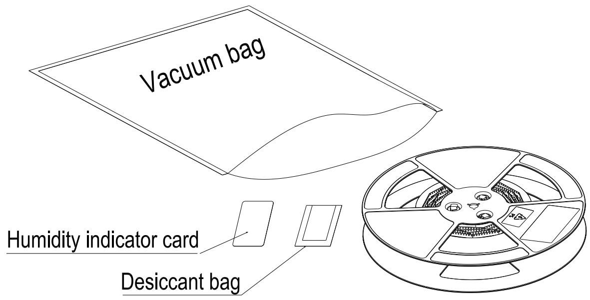
Figure 38: Mounting Direction

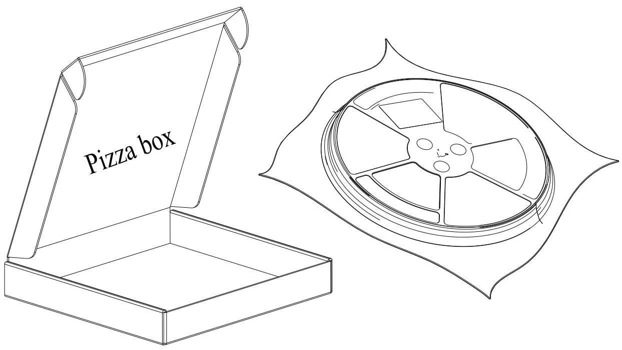
8.1.4. Packaging Process



Place the module onto the carrier tape and use the cover tape to cover it; then wind the heat-sealed carrier tape on the plastic reel and use the protective tape for protection. 1 plastic reel can load 250 modules.

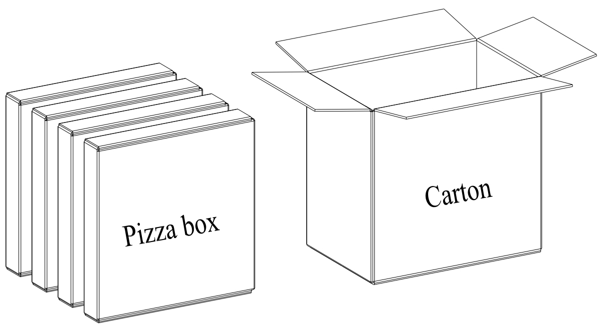
Place the packaged plastic reel, 1 humidity indicator card and 1 desiccant bag inside a vacuum bag, then vacuumize it.





Place the vacuum-packed plastic reel inside the pizza box.

Place 4 packaged pizza boxes inside 1 carton and seal it. 1 carton can pack 1000 modules.



Pizza box size (mm): 363 × 343 × 55

Carton size (mm): 380 × 250 × 365

Figure 39: Packaging Process

8.2. Storage

The module is provided in a vacuum-sealed packaging. MSL of the module is rated at 3. The storage requirements are shown below.

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

2. Shelf life (in a vacuum-sealed packaging): 12 months in Recommended Storage Condition.

3. Floor life: 168 hours [10] in a factory 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 dry 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 in Recommended Storage Condition;
   - Violation of the third requirement mentioned above;
   - Vacuum-sealed packaging is broken, or the packaging has been removed for over 24 hours;
   - 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 PCB within 24 hours after the baking, otherwise it should be put in a dry environment such as in a dry cabinet.

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 package and put it on high-temperature-resistant fixtures before baking. 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.

[10] This floor life is only applicable when the environment conforms to *IPC/JEDEC J-STD-033*. It is recommended to start the solder reflow process within 24 hours after the package is removed if the temperature and moisture do not conform to, or are not sure to conform to, *IPC/JEDEC J-STD-033*. Do not unpack the modules in large quantities until they are ready for soldering.

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 [7] module SMT application note*.

The recommended 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 recommended to mount the module to the PCB only after reflow soldering of the other side of the PCB. The recommended reflow soldering thermal profile (lead-free reflow soldering) and related parameters are shown in the figure and table below.

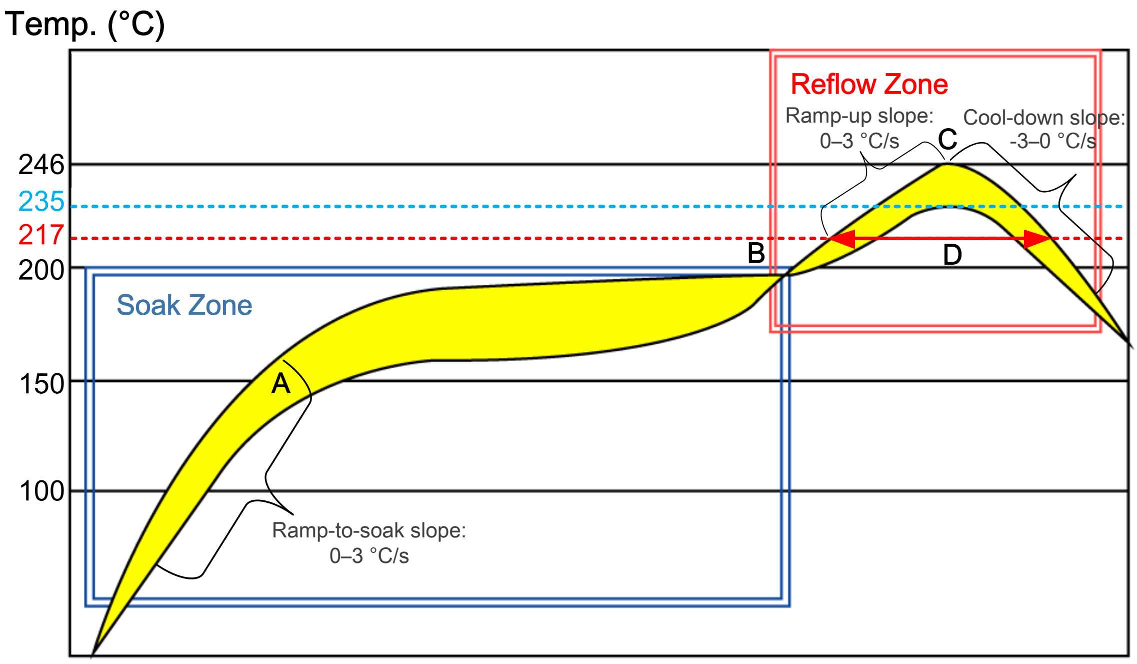


Figure 40: Recommended Reflow Soldering Thermal Profile

Table 32: Recommended Thermal Profile Parameters

Factor	Recommended Value
Soak Zone	
Ramp-to-soak Slope	0–3 °C/s
Soak Time (between A and B: 150 °C and 200 °C)	70–120 s
Reflow Zone	
Ramp-up Slope	0–3 °C/s
Reflow Time (D: over 217 °C)	40–70 s
Max. Temperature	235–246 °C
Cool-down Slope	-3–0 °C/s
Reflow Cycle	
Max. Reflow Cycle	1

NOTE

1. The above profile parameter requirements are for the measured temperature of the solder joints. Both the hottest and coldest spots of solder joints on the PCB should meet the above requirements.
2. During manufacturing and soldering, or any other process that may require direct contact with the module, **NEVER** wipe the module label with organic solvents, such as acetone, ethyl alcohol, isopropyl alcohol, and trichloroethylene. Otherwise, the label information may become unclear.
3. If a conformal coating is necessary for the module, **DO NOT** use any coating material that may react with the PCB or shielding cover. Prevent the coating material from penetrating the module shield.
4. Avoid using ultrasonic technology for module cleaning since it can damage crystals inside the module.
5. Due to SMT process complexity, contact Quectel Technical Support in advance regarding any ambiguous situation, or any process (e.g., selective soldering, ultrasonic soldering) that is not addressed in *document [7] module SMT application note*.

9 Labelling Information

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

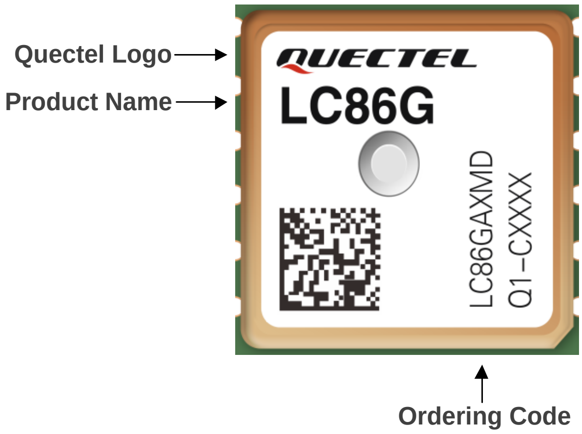


Figure 41: Labelling Information for LC86G (AA, AB)

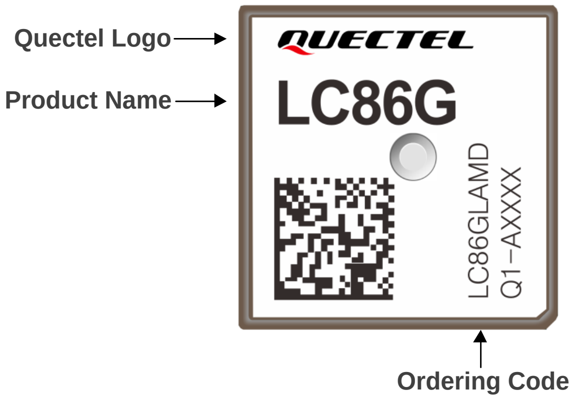


Figure 42: Labelling Information for LC86G (LA)

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 References

Table 33: Related Documents

Document Name
[1] Quectel_LC26G&LC76G&LC86G_Series_GNSS_Protocol_Specification
[2] Quectel_LC26G&LC76G&LC86G_Series_AGNSS_Application_Note
[3] Quectel_LC26G(AB)&LC76G&LC86G_Series_Firmware_Upgrade_Guide
[4] Quectel_LC86G_Series_Reference_Design
[5] Quectel_RF_Layout_Application_Note
[6] Quectel_GNSS_Antenna_Selection_Guidance
[7] Quectel_Module_SMT_Application_Note

Table 34: Terms and Abbreviations

Abbreviation	Description
1PPS	One Pulse Per Second
3GPP	3rd Generation Partnership Project
AGNSS	Assisted Global Positioning System
AIC	Active Interference Cancellation
ARM	Advanced RISC Machine
BDS	BeiDou Satellite Navigation System
bps	bit(s) per second
CEP	Circular Error Probable
C/N_0	Carrier-to-noise Ratio

Abbreviation	Description
DCS1800	Digital Cellular System at 1800 MHz
DR	Dead Reckoning
EASY	Embedded Assist System
EGNOS	European Geostationary Navigation Overlay Service
EPO	Extended Prediction Orbit
ESD	Electrostatic Discharge
GAGAN	GPS Aided Geo Augmented Navigation
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
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
MCU	Microcontroller Unit/Microprogrammed Control Unit
MSAS	Multi-functional Satellite Augmentation System (Japan)

Abbreviation	Description
MSL	Moisture Sensitivity Levels
NF	Noise Figure
NMEA	National Marine Electronics Association
OC	Open Connector
PCB	Printed Circuit Board
PI	Power Input
PMU	Power Management Unit
PQTM	Quectel Proprietary Protocol
PSRR	Power Supply Rejection Ratio
QZSS	Quasi-Zenith Satellite System
RAM	Random Access Memory
RF	Radio Frequency
RHCP	Right Hand Circular Polarization
RoHS	Restriction of Hazardous Substances
ROM	Read Only Memory
RTC	Real-Time Clock
RTCM	Radio Technical Commission for Maritime Services
RTK	Real-Time Kinematic
RXD	Receive Data
SAW	Surface Acoustic Wave
SBAS	Satellite-Based Augmentation System
SMD	Surface Mount Device
SMT	Surface Mount Technology
SPI	Serial Peripheral Interface
TCXO	Temperature Compensated Crystal Oscillator

Abbreviation	Description
T_operating	Operating Temperature
TTFF	Time to First Fix
TVS	Transient Voltage Suppressor
TXD	Transmit Data (Pin)
UART	Universal Asynchronous Receiver/Transmitter
USB	Universal Serial Bus
VCC	Supply Voltage
$V_I$max	Maximum Input Voltage
$V_I$min	Minimum Input Voltage
$V_I$nom	Normal Input Voltage
V_{IH}max	High-level Maximum Input Voltage
V_{IH}min	High-level Minimum Input Voltage
V_{IH}nom	High-level Normal Input Voltage
V_{IL}max	Low-level Maximum Input Voltage
V_{IL}min	Low-level Minimum Input Voltage
$V_O$nom	Normal Output Voltage
V_{OL}max	Low-level Maximum Output Voltage
V_{OH}min	High-level Minimum Output Voltage
VSWR	Voltage Standing Wave Ratio
WAAS	Wide Area Augmentation System
WCDMA	Wideband Code Division Multiple Access
XTAL	External Crystal Oscillator