LC86L Hardware Design

GNSS Module Series

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Status: Released

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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	
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Revision History

Version	Date	Description
1.0	2020-09-18	Creation of the document
1.1	2020-12-04	Corrected the indication for pin 1 position in Figures 23 to 26.
1.2	2021-07-30	1. Added LC86L (C). 2. Completely reorganized the structure of the document. 3. Updated the name of pin 7 from FORCE_ON to WAKEUP. 4. Updated the Table 2 (Chapter 1.3). 5. Added description about GNSS Constellations and Augmentation System (Chapter 1.5 and1.6). 6. Updated the Figure 3 and Table 4 (Chapter 2). 7. Updated the description of Power-Up Sequence (Chapter 3.4). 8. Added Power-Down Sequence (Chapter 3.5). 9. Updated the description of the 1PPS pin (Chapter 4.1.4). 10. Updated the description of the RESET_N pin (Chapter 4.2). 11. Updated the recommended footprint (Figure 15). 12. Updated the external active antenna reference design (Figure 16). 13. Added Chapter 5.2.2 and 5.4. 14. Added the description of integrated patch antenna (Chapter

	5.3). 15. Updated the NOTES about module storage (Chapter 8.2). 16. Updated the recommended peak reflow temperature and the reflow time in reflow zone (Chapter 8.3). 17. Added Chapter 9. 18. Updated the appendix (Chapter 10).

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1 Product Description

1.1. Overview

The Quectel LC86L module supports multiple global positioning and navigation systems: BeiDou, GPS, Galileo (Only for LC86L (C)), GLONASS, and QZSS. The module also supports SBAS (including WAAS, EGNOS, MSAS and GAGAN) and AGNSS functions. The default constellation configuration of LC86L (A) and LC86L (C) is GPS + GLONASS + QZSS [1], and the default constellation configuration of LC86L (B) is GPS + BeiDou + QZSS.

Key features:

- The LC86L module is a single-band, multi-constellation GNSS module and features a high-performance and high reliability positioning engine. This module facilitates a fast and precise GNSS positioning capability.
- The module supports serial communication interface UART.
- The embedded flash memory provides the capacity for storing user-specific configurations and future firmware updates.
- The module supports multiple power-saving modes, such as periodic, standby, backup and GLP.
- Embedded low-power algorithms suitable for different application scenarios.
- The module supports EASY™ autonomous AGNSS technology, which can collect and process all internal auxiliary information including GNSS time, calendar, and the latest position. Consequently the module can achieve a fast first fix in hot/warm start.
- The module supports active antenna detection and short-circuit protection.
- The antenna status is reported through the NMEA message, so the host can query the antenna status in a convenient and timely manner.

The Quectel LC86L module is an SMD type module with a compact form factor of 16.0 mm × 16.0 mm × 6.95 mm. It can be embedded in your applications through the 12 LCC pins.

The module is fully compliant with the EU RoHS Directive.

[1] When the LC86L(C) supports the configuration as GPS + GLONASS + Galileo + QZSS, the minimum baud rate should be set to 19200 bps.

1.2. Features

Table 1: Product Features

Features			LC86L (A)	LC86L (B)	LC86L (C)
Grade	Industrial		●	●	●
	Automotive		-	-	-
Category	Standard Precision GNSS		●	●	●
	High Precision GNSS		-	-	-
	DR		-	-	-
	RTK		-	-	-
	Timing		-	-	-
Supply	2.8–4.3 V, Typical: 3.3 V		●	●	●
I/O	Typical: 2.8 V		●	●	●
Communication Interfaces	UART		●	●	●
	SPI		-	-	-
	I2C		-	-	-
Features	Additional LNA		●	●	●
	Additional SAW		●	●	●
	RTC crystal		●	●	●
	TCXO oscillator		●	●	●
	6-axis IMU		-	-	-
Constellations	GPS/QZSS	L1 C/A	●	●	●
		L5	-	-	-
	Galileo	E1	-	-	●
		E5a	-	-	-

	BeiDou	B1I	●	●	●
		B2a	-	-	-
	GLONASS	L1	●	●	●
	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: (16.0 ±0.15) mm × (16.0 ±0.15) mm × (6.95 ±0.20) mm Weight: Approx. 6.0 g				

NOTE

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

1.3. Performance

Table 2: Product Performance

Parameter		Specification	LC86L (A)	LC86L (B)	LC86L (C)
Power Consumption [2]	GPS + GLONASS	Acquisition	32 mA	-	32 mA
		Tracking	31 mA	-	30 mA
		Standby mode	1.8 mA	-	1.8 mA
		Backup mode	6 μA	-	7 μA
	GPS + BeiDou	Acquisition	-	33 mA	-
		Tracking	-	30 mA	-
		Standby mode	-	1.8 mA	-
		Backup mode	-	6 μA	-
Sensitivity [3]		Acquisition	-148 dBm	-148 dBm	-148 dBm

[2] The power consumption values are measured when the module is using the internal patch antenna only, and while EASY™, AIC and SBAS are disabled. All satellites at -130 dBm, except Galileo at -122 dBm.

[3] Room temperature, demonstrated with good LNA.

	Reacquisition	-161 dBm	-161 dBm	-162 dBm
	Tracking	-166 dBm	-166 dBm	-166 dBm
TTFF [4] (without AGNSS)	Cold Start	35 s	35 s	35 s
	Warm Start	30 s	30 s	30 s
	Hot Start	2 s	2 s	2 s
TTFF (with AGNSS)	Cold Start	15 s	15 s	15 s
	Warm Start	5 s	5 s	5 s
	Hot Start	2 s	2 s	2 s
Horizontal Position Accuracy [5]	2.5 m			
Update Rate	1 Hz (max. 10 Hz)			
Accuracy of 1PPS Signal	Typical accuracy: 100 ns Time pulse width: 100 ms			
Velocity Accuracy [4]	Without aid: 0.1 m/s			
Acceleration Accuracy [4]	Without aid: 0.1 m/s²			
Dynamic Performance [4]	Maximum Altitude: 10000 m Maximum Velocity: 515 m/s Acceleration: 4g			

NOTE

When an external active antenna is used, VCC pin supplies power for the external antenna, so the current consumption of the module increases by about 11 mA @ VCC = 3.3 V. Although using an external active antenna increases the overall power consumption, it does not decrease the module's performance.

1.4. Block Diagram

The following figure shows a block diagram of the module. The module includes a single-chip GNSS IC with a RF section, the baseband section, a SPDT, a patch antenna, an additional LNA, an additional SAW filter, a TCXO, a crystal oscillator, a detection and protection circuit for active antenna.

[4] All satellites at -130 dBm, except Galileo at -122 dBm.

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

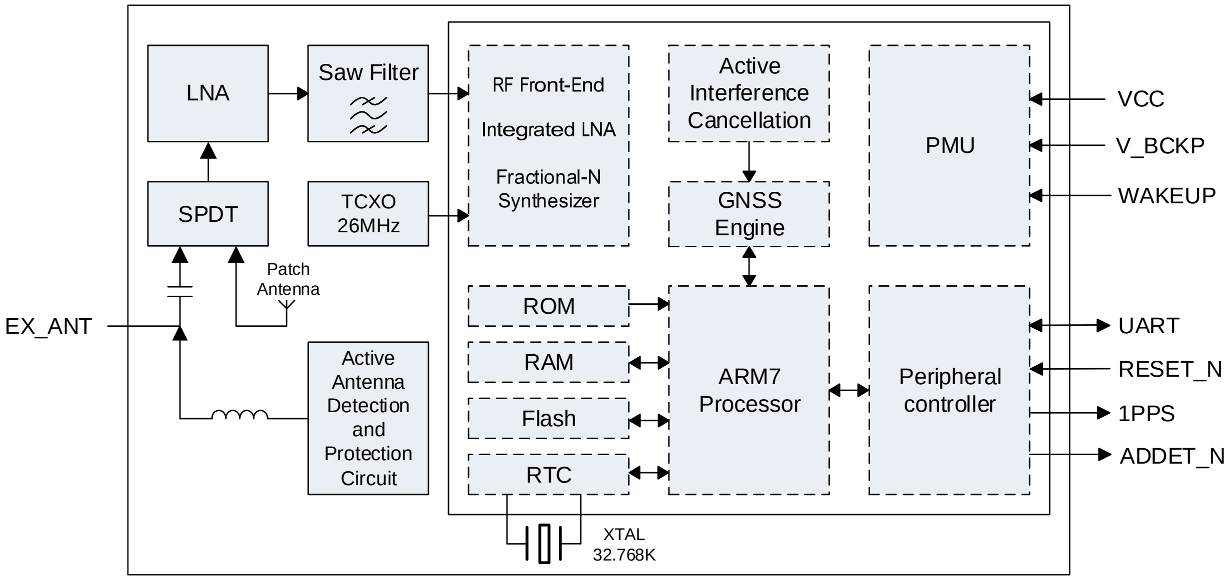

Figure 1: Block Diagram

1.5. GNSS Constellations

The Quectel LC86L module is a single-band GNSS receiver that can receive and track GPS, BeiDou, GLONASS, Galileo (Only for LC86L (C)), and QZSS signals.

1.5.1. GPS

The module is designed to receive and track GPS L1 C/A signals (1574.397–1576.443 MHz) provided by GPS.

1.5.2. BeiDou

The module is designed to receive and track BeiDou B1I signals (1559.052–1563.144 MHz) provided by the BeiDou Navigation Satellite System. The ability to receive and track BeiDou signals in conjunction with GPS results in higher coverage, improved reliability, and better accuracy.

1.5.3. GLONASS

The module is designed to receive and track GLONASS L1 signals (1597.781–1605.656 MHz) provided by GLONASS.

1.5.4. Galileo

The module is designed to receive and track Galileo E1 (Only for LC86L (C)) signals (1573.374–1577.466 MHz) provided by Galileo.

1.5.5. QZSS

The Quasi-Zenith Satellite System (QZSS) is a regional navigation satellite system that transmits additional GPS L1 C/A signals for the Pacific region covering Japan and Australia. The Quectel LC86L module can detect and track these signals concurrently with GPS signals, resulting in better availability especially under challenged conditions, e.g., in urban canyons.

1.6. Augmentation System

1.6.1. SBAS

The Quectel LC86L module supports SBAS (satellite-based augmentation system) broadcast signal reception, and GNSS data are complemented by additional regional or wide area GNSS enhancement data. The system enhances the data through satellite broadcasting, and the data can be used in GNSS receivers to improve the accuracy of the results. SBAS satellites can also be used as additional signals for range or distance measurement, further improving availability. Supported SBAS systems include WAAS, EGNOS, MSAS and GAGAN.

1.7. AGNSS

The module supports AGNSS feature that significantly reduces the module’s Time to First Fix (TTFF), especially under lower signal conditions. To implement AGNSS feature, the module should get the assistance data including the current time, rough position, and LTO data.

1.7.1. EASY™

The LC86L module supports the EASY™ technology to improve TTFF and acquisition sensitivity of GNSS modules. To achieve that goal, the EASY™ technology provides assistant information, such as the ephemeris, almanac, rough last position, time, and a satellite status.

EASY™ technology works as embedded software which can accelerate TTFF by predicting satellite navigation messages from received ephemeris. The GNSS engine automatically calculates and predicts orbit information up to 3 days after first receiving the broadcast ephemeris, and then saves the predicted information into the internal memory. The GNSS engine uses the information for positioning if there is no enough information from satellites, so the function is helpful for positioning and TTFF improvement.

The EASY™ function can reduce TTFF to 5 s in warm start. In this case, RTC domain should be valid. In order to get enough broadcast ephemeris information from GPS satellites, the GPS module should receive the information for at least 5 minutes in good signal conditions after fixing the position.

For more information about the commands to enable or disable EASY™ function, see ***document [1]***.

1.7.2. EPO™

The LC86L module features a leading AGNSS technology called EPO™ (Extended Prediction Orbit). It is a free service provided by Quectel, which can improve accuracy in weak signal conditions and achieve fast TTFF. You must know the current UTC time to download the currently valid EPO files. Through EPO data downloaded from EPO servers, the function provides up to 30-day orbit predictions to speed up TTFF. For more information, see ***document [2]***.

1.8. Multi-tone AIC

The LC86L module features a function called multi-tone active interference cancellation (multi-tone AIC) to decrease harmonic distortion of RF signal from Wi-Fi, Bluetooth, and 2G, 3G, 4G, and 5G network.

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

The following figure shows anti-jamming performance by the AIC:

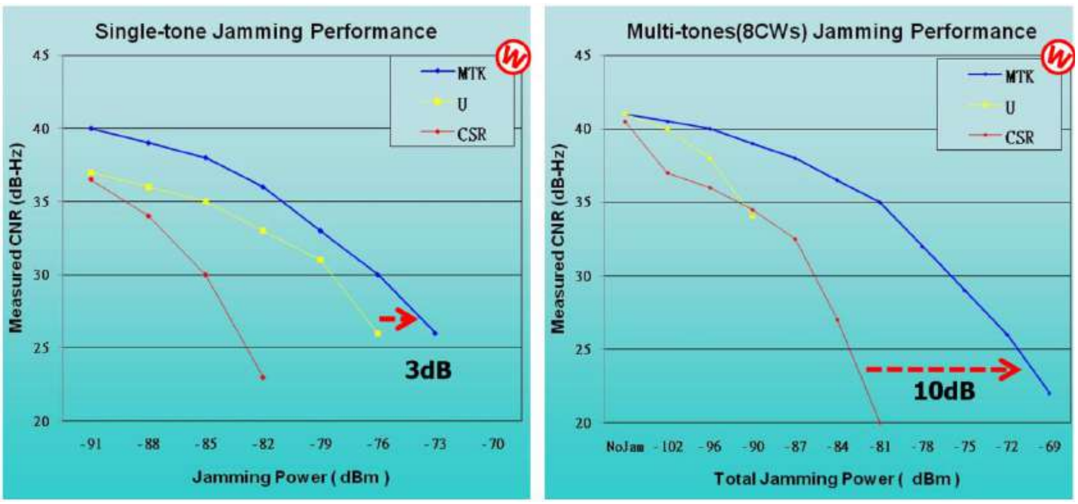

Figure 2: Anti-Jamming Performance by AIC

For more information about the commands to enable or disable AIC function, see ***document [1]***.

1.9. LOCUS

The LC86L module supports the embedded logger function called LOCUS. When this function is enabled with the command, it logs position information to the internal flash memory. Additionally, with this function, the host can enter power saving modes to reduce power consumption. As a result, the host does not receive the NMEA information all the time. LOCUS provides typically more log capacity without any added costs.

Software commands can be used to query the current state of LOCUS. For more information about the commands, see ***document [1]***.

The LOCUS log acquired by the host must be parsed via LOCUS parsing code provided by Quectel. For more details, contact Quectel Technical Supports.

2 Pin Assignment

The Quectel LC86L module is equipped with 12 LCC pins by which the module can be mounted on your PCB.

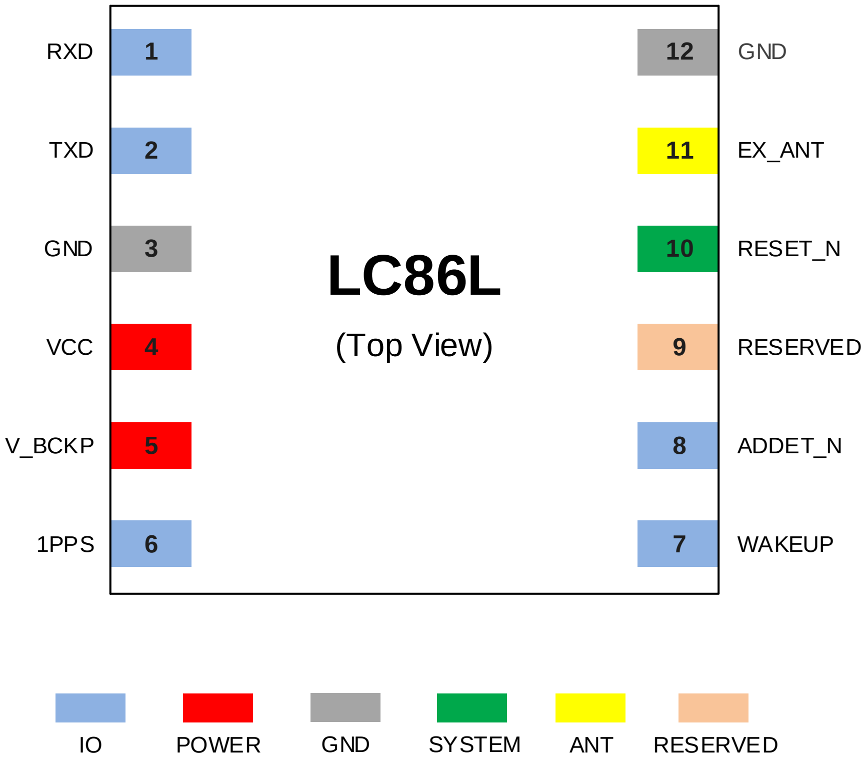

Figure 3: Pin Assignment

Table 3: I/O Parameter Definition

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

Table 4: Pinout

Function	Name	No.	I/O	Description	Remarks
Power	VCC	4	PI	Main power supply	Make sure that the maximum current capability of power supply is no less than 100 mA.
	V_BCKP	5	PI	Backup power supply for RTC domain	Supplies power for the RTC domain. V_BCKP can be powered directly by a battery or VCC.
IO	RXD	1	DI	Receives data	The UART port is used for NMEA sentences output, PMTK/PQ commands input and firmware upgrade.
	TXD	2	DO	Transmits data	
	WAKEUP	7	DI	Pulling the pin high to force the module to wake up from backup mode	Keep this pin open or pulled low before the module enters the backup mode. The pin belongs to RTC domain. If unused, leave the pin N/C (not connected).
	AADET_N	8	DO	Active antenna status indication	If unused, leave the pin N/C (not connected).
	1PPS	6	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	EX_ANT	11	AI	External antenna input interface	50 Ω characteristic impedance. If unused, leave the pin N/C (not connected).
System	RESET_N	10	DI	Resets the module	Active low.

GND	GND	3, 12	-	Ground	Assure a good GND connection to all GND pins of the module, preferably with a large ground plane.
RESERVED	RESERVED	9	-	Reserved	This pin 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 LC86L module provides a power optimized architecture with built-in autonomous energy saving capabilities to minimize power consumption at any given time. The receiver can be used in five operating modes: standby mode, periodic mode, GLP mode, backup mode for best power consumption, and continuous mode for best performance.

3.1. Power Unit

The VCC pin supplies power for a baseband, an RF, an LNA, the I/O ports as well as for the short-circuit protection and detection circuits of the active antenna. 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 RTC domain. To achieve quick startup and improve TTFF, the RTC domain power supply should be valid during the module is powered on. SRAM memory also belongs to the RTC domain. The V_BCKP supplies power for SRAM memory that contains all the necessary GNSS data and some of the user configuration variables.

The module's internal power supply is shown below:

- The VCC supplies power for PMU, while V_BCKP supplies power for the RTC domain.
- WAKEUP belongs to the RTC domain.
- The PMU is designed with an integrated switch that is used to control the PMU power supply status.

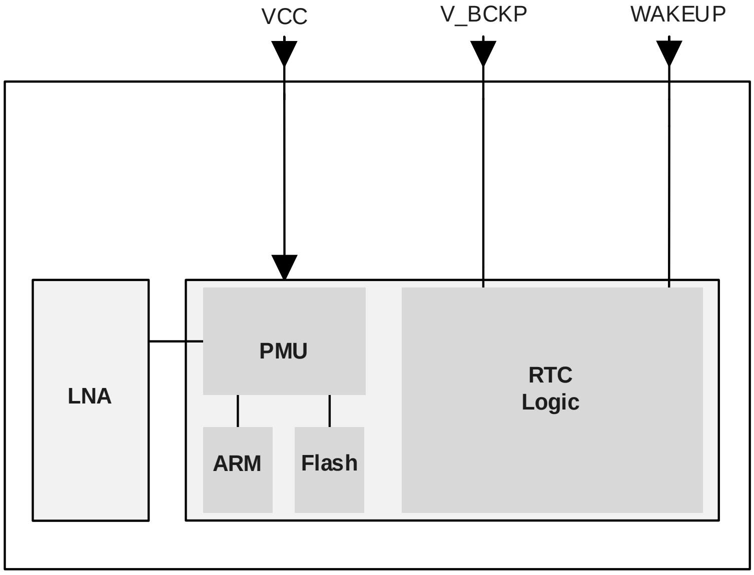

Figure 4: Internal Power Supply

NOTE

As the VCC pin does not supply power for the RTC domain in LC86L module, the V_BCKP pin must be powered externally. Furthermore, it is strongly recommended to power V_BCKP through a backup battery, which can ensure that the module supports EASY™ technology and improves TTFF after next restart.

3.2. Power Supply

3.2.1. VCC

The VCC is the supply voltage pin. The VCC pin supplies power for BB, RF, an LNA, the I/O ports as well as for the short-circuit protection and detection circuits of the active antenna. VCC pin load current varies according to VCC voltage level, processor load and satellite acquisition state.

The module's power consumption may vary in several orders of magnitude, especially when low power 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 switches from backup mode to normal operation or startup, 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 and backup modes, it is important that the LDO[6] at the

[6] Choose an external LDO without an output discharge function, to make sure the output voltage drop time is long – it should be greater than 100 ms (from 2.7 V to 0.5 V).

power supply or module input can provide the current/drain. An LDO with a high PSRR should be chosen for good performance. In addition, a TVS diode, and a combination of a 4.7 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.

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

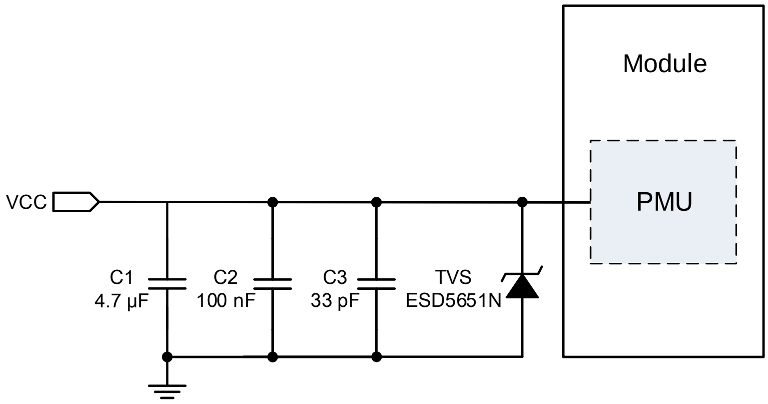

Figure 5: VCC Input Reference Circuit

3.2.2. V_BCKP

The V_BCKP pin supplies power for the RTC domain. If the VCC pin fails to power the module, the V_BCKP pin supplies power for the real-time clock (RTC) and RAM. Use of valid time and GNSS orbit data at startup allows GNSS hot (warm) start. If no backup power is connected, the module performs a cold start at power up.

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 directly powered by an external battery (rechargeable or non-rechargeable). It is recommended to place a battery with the 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 RTC domain with a non-rechargeable battery.

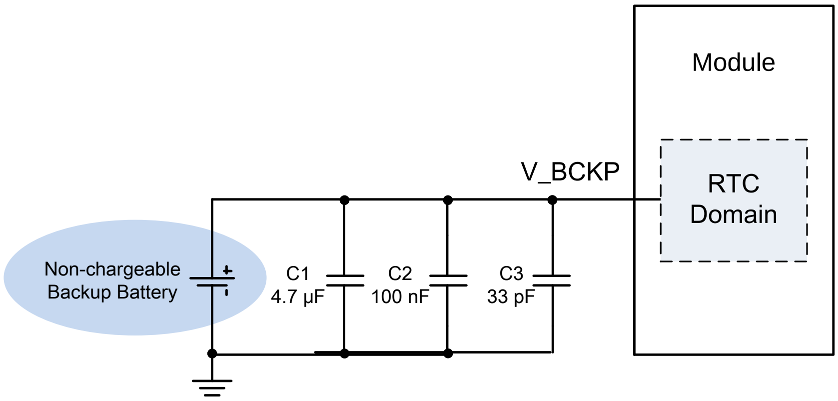

Figure 6: RTC Powered by Non-Rechargeable Battery

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

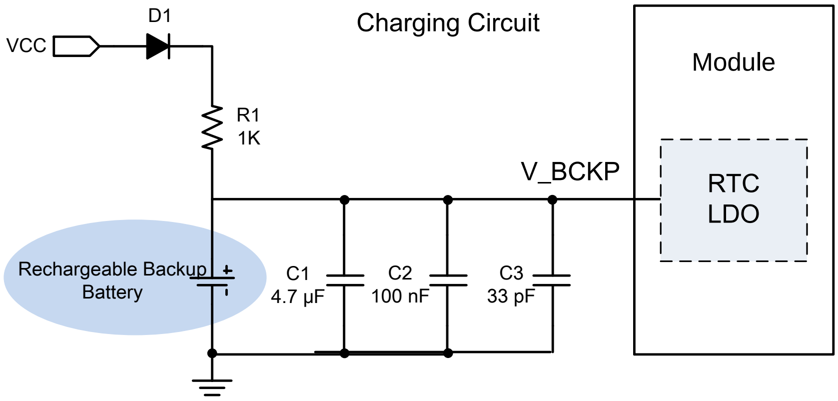

Figure 7: Reference Charging Circuit for a Rechargeable Battery

3.3. Power Mode

The table below illustrates the relationship among different operation modes of the LC86L module.

3.3.1. Operation Modes

Table 5: Feature Comparison in Different Operation Modes

Features	Continuous	Standby	Backup	Periodic	GLP
Antenna Detection	●	-	-	O	●
1PPS	●	-	-	O	●
RF	●	-	-	O	●
NMEA Output	●	-	-	O	●
Acquiring & Tracking	●	-	-	O	●
Power Consumption	High	Low	Low	Medium	Medium
Positioning Accuracy	High	Low	Low	Low	Medium

NOTE

● = supported
O = supported in the continuous periodic mode

3.3.2. Continuous Mode

The continuous mode comprises the acquisition mode and tracking mode. In acquisition mode, the module starts to search satellites, and to determine the visible satellites, coarse carrier frequency as well as the code phase of satellite signals. When the acquisition is completed, the module automatically switches to the tracking mode. In the tracking mode, the module tracks satellites and demodulates the navigation data from specific satellites.

3.3.3. Standby Mode

The standby mode is a low-power consumption mode. In standby mode, the internal core and I/O power domain are still active, RF and TCXO are powered down, the module stops satellite search and navigation. UART can still be accessed through commands or any other data while there is no NMEA message output.

For more information about the command that makes the module enter standby mode, see ***document [1]***. You can wake up the module by sending data via UART. When the module exits standby mode, it uses all internal aiding information, such as GNSS time, ephemeris, last position, etc. to ensure the fastest possible TTFF in either hot or warm start.

NOTE

When an external active antenna is used in the standby mode, an additional 11 mA is consumed because the VCC still supplies it with power.

3.3.4. Backup Mode

The power consumption in the backup mode is lower than that in the standby mode. In the backup mode, the module stops acquiring and tracking satellites. The module's UART is not accessible. But the SRAM memory in RTC domain is active, which contains all the necessary GNSS information for a quick start-up and a small amount of user configuration variables. Due to the SRAM memory, EASY™ technology is available.

The following two different methods for entering backup mode have significant impact on the current consumption. The active antenna detection circuit is powered by VCC, which means that the current consumption for entering backup mode with software command is greater than that when you cut off VCC and keep the V_BCKP active. For more information about the command that makes the module enter backup mode, see ***document [1]***.

Two ways to enter/exit the backup mode are as shown in the table below:

Table 6: Enter/Exit Backup Mode

Option	Enter Backup Mode	Exit Backup Mode
Option 1	Send a command	Pull the WAKEUP pin high
Option 2	Cut off the power supply to the VCC while keeping the V_BCKP powered [7]	Power on the VCC

The timing diagram indicating that the module enters the backup mode after being powered on is as shown in the figure below:

[7] If you supply power directly to the V_BCKP pin in the shutdown state, the module will not enter the backup mode and the current will exceed the nominal value in backup mode.

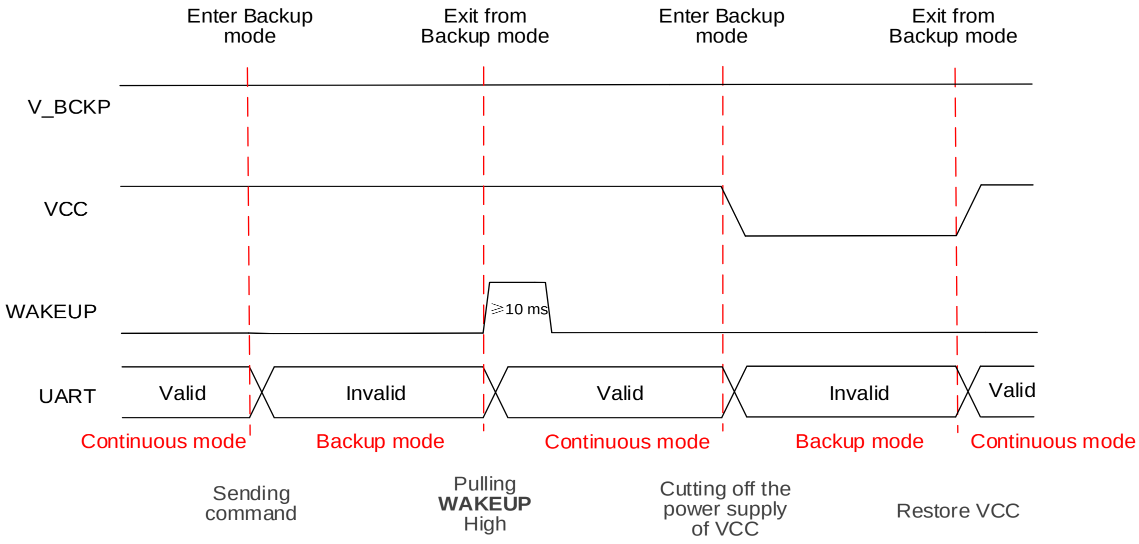

Figure 8: Backup Mode Sequence

NOTE

Keep the WAKEUP pin open or low before the module enters the backup mode. Otherwise, the backup mode is unavailable.

3.3.5. Periodic Mode

The periodic mode achieves the balance between the positioning accuracy and power consumption, but performance is lower compared to continuous mode. In periodic mode, the module should be always supplied with power. In this mode, the module switches between continuous mode and standby/backup mode periodically to reduce power consumption. For more information about the commands for entering or exiting the periodic mode, see ***document [1]***.

The following figure illustrates the operation of periodic mode. After sending the PMTK command for entering periodic mode, the module first enters continuous mode and remains in it for several minutes. Afterwards, the module enters periodic mode, following the parameters set in the PMTK command. If the module fails to fix the position in **Run Time**, it is automatically switched to **Second Run Time** and **Second Sleep Time**. As long as it manages to fix the position again, the module will return to **Run Time** and **Sleep Time**.

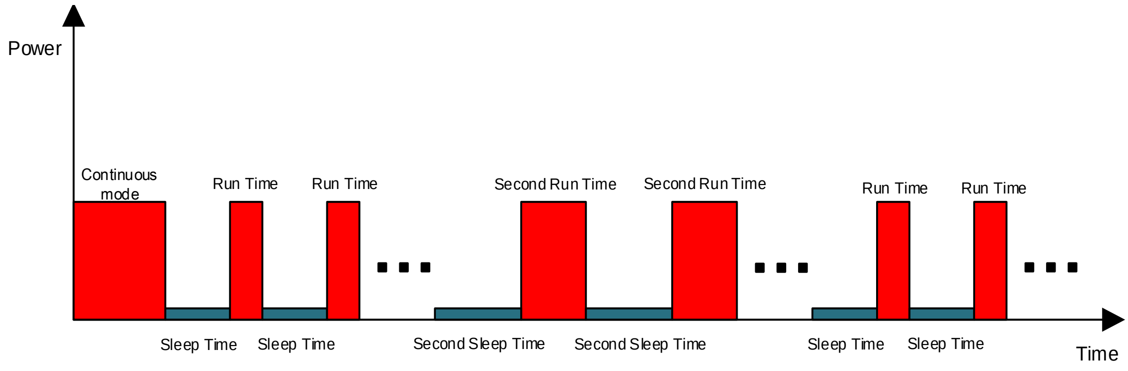

Figure 9: Periodic Mode

The average current value can be calculated with the following formula:

$I_{periodic} = (I_{tracking} \times T1 + I_{standby/backup} \times T2)/ (T1 + T2)$
T1 = Run Time, T2 = Sleep Time

NOTE

1. Before entering periodic mode, make sure the module is in the tracking mode; otherwise, there will be a risk of satellite-tracking failure. If the module operates in a weak signal environment, it is recommended to set a longer **Second Run Time** to ensure the success of reacquisition.
2. Before entering the periodic backup mode, make sure that the WAKEUP pin is open or low, and that V_BCKP is supplied with power.

3.3.6. GLP Mode

GLP (GNSS Low Power) mode is an optimized solution for wearable fitness and tracking devices. It reduces power consumption through disabling high accuracy positioning.

In GLP mode, the module has good positioning performance while operating in walking and running scenarios. In a challenged environment, the module automatically switches to the operation in continuous mode to maintain good accuracy. Therefore, the module can still achieve maximum performance with the lowest power consumption.

In static scenarios, the average current consumption in GLP mode drops to about 15 mA, which is about 50% lower than the power consumption in continuous mode. In dynamic scenarios, power consumption may increase slightly.

For more information about the commands for entering or exiting GLP mode, see ***document [1]***.

NOTE

1. Set all the necessary commands before the module enters GLP mode. If you need to send commands, exit the GLP mode first.
2. Before the module enters GLP mode, set the baud rate to 115200 bps and the frequency to 1 Hz.
3. When the module enters GLP mode, 1PPS function is disabled.
4. When GLP mode is enabled, the SBAS function cannot be used.
5. In highly dynamic scenarios, the positioning accuracy of the module in GLP mode decreases slightly.
6. To keep good positioning accuracy, the module automatically returns to the continuous mode in complex environment.

3.4. Power-Up Sequence

When VCC is powered up, the module starts up automatically.

To ensure correct power-up sequence, the RTC logic should start up before the PMU. So, the V_BCKP must be supplied with power at the same time or before the VCC.

Ensure that the VCC has no rush or drop during rising time, and keep the voltage stable. The recommend ripple is < 100 mV.

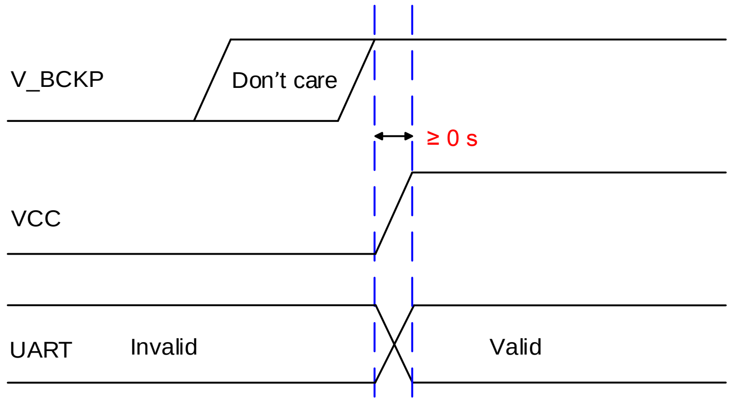

Figure 10: Power-Up Sequence

3.5. Power-Down Sequence

When 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 a specified minimum value, the system must initiate a power-on reset by lowering VCC to less than 100 mV for at least 100 ms.

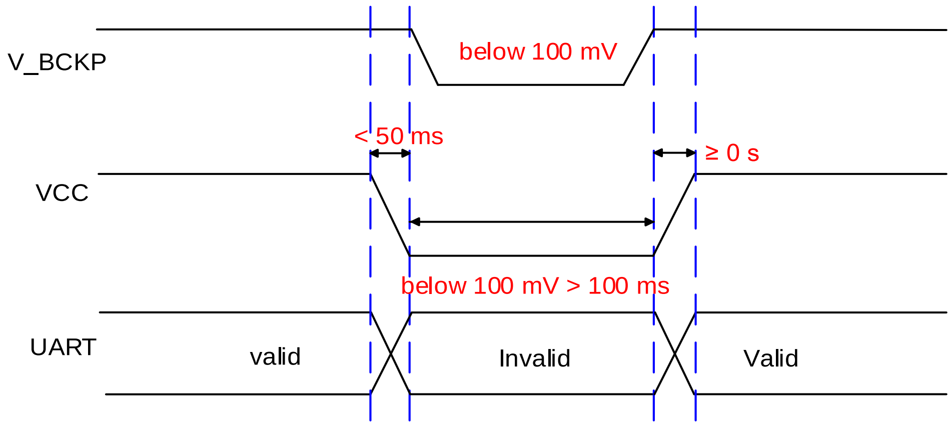

Figure 11: Power-Down Sequence

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 provides one UART interface. The UART port has the following features:

- Support for NMEA data transmission, PMTK/PQ commands input and firmware upgrading.
- Default output type of NMEA sentences: RMC, VTG, GGA, GSA, GSV, GLL, and TXT.
- Supported baud rates: 9600, 14400, 19200, 38400, 57600, 115200, 230400, 460800, 921600 bps.
- Default settings: 9600 bps (LC86L (A) and LC86L (C)), 115200 bps (LC86L (B)), 8 bits, no parity bit, 1 stop bit.
- Hardware flow control and synchronous operation are not supported.

Reference design is shown the figure below.

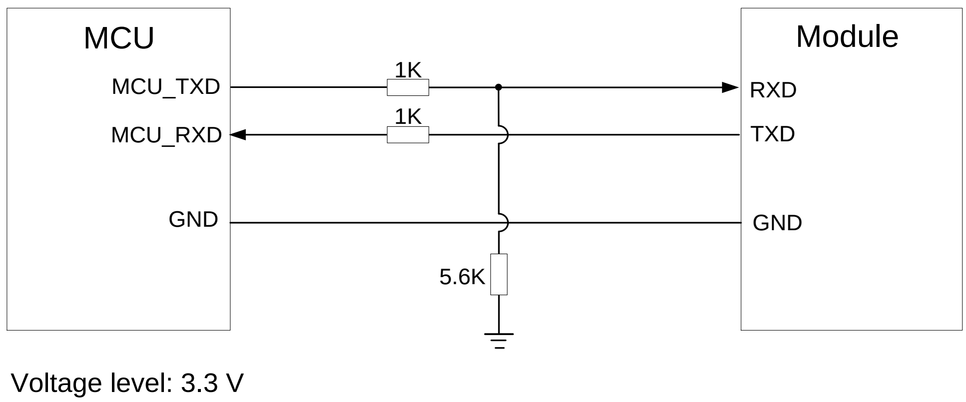

Figure 12: UART Interface Reference Design

NOTE

If the IO voltage of MCU is not matched with module, a level shifter must be selected.

4.1.2. WAKEUP

The WAKEUP pin belongs to RTC domain. Keep this pin open or pulled low before entering the backup mode. When the pin is pulled high, the module is forced to wake up from the backup mode.

4.1.3. AADET_N

The AADET_N pin can be used to indicate the status of an external active antenna.

- When the external active antenna is not connected to the EX_ANT pin or has a poor contact with the antenna's feeding point, the AADET_N pin will keep a high level to indicate the absence of the active antenna.
- The AADET_N pin will change to a low level when the active antenna is connected well.

Table 7: AADET_N – Antenna Status

AADET_N Level	Ext. Active Antenna Status	Inner Patch Antenna Status	Comment
Low	Working	Unused	
High	Short	Working	AADET_N checks the status of the external active antenna if it is used.
	Unused	Working	

The LC86L module supports automatic antenna switching function. The GPTXT sentence can be used to identify the status of external active antenna. For more information, see ***document [1]***.

NOTE

1. The active antenna is only available when the voltage of AADET_N is less than or equal to 0.7 V.
2. Because antenna short protection is enabled by default, the LC86L module will automatically switch to integrated patch antenna in case that external active antenna is short-circuited, which will avoid damage to LC86L module. Meanwhile, you need to check the status of external active antenna.

4.1.4. 1PPS

The 1PPS output generates one pulse per second trains synchronized with a GPS or UTC time grid with intervals configurable over a wide range of frequencies. The accuracy is < 100 ns. Thus, it may be used as a low frequency time synchronization pulse or as a high frequency reference signal.

4.2. System Pin

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.

RESET_N is internally pulled up to 2.8 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.

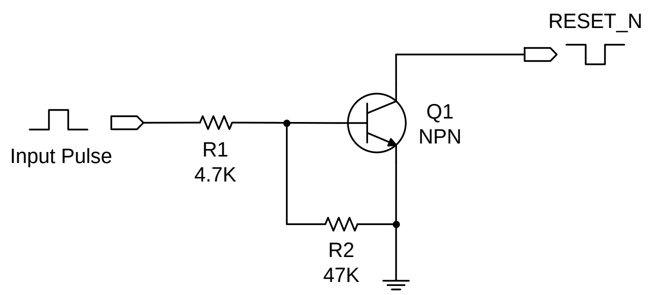

Figure 13: Reference OC Circuit for Module Reset

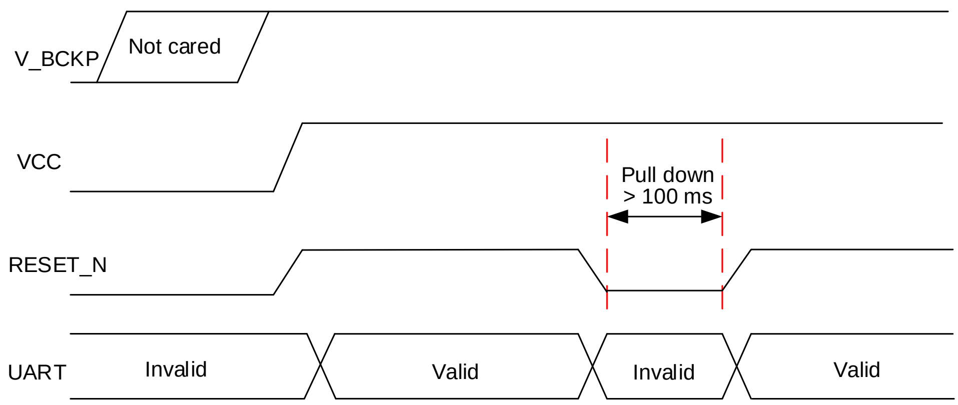

Figure 14: Reset Sequence

NOTE

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

5 Design

5.1. Recommended Footprint

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

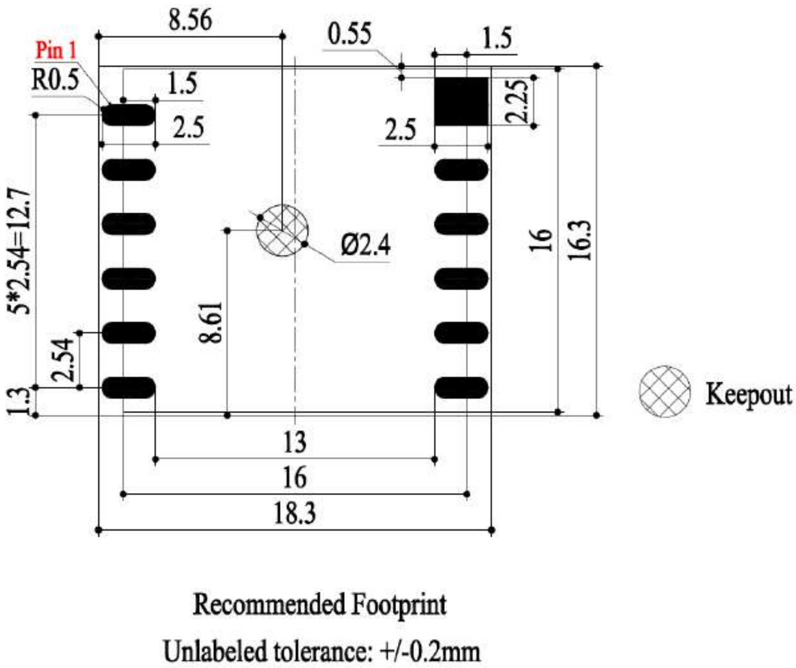

Figure 15: Recommended Footprint

NOTE

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

5.2. External Antenna Design

5.2.1. External Antenna Specification

The Quectel LC86L module can be connected to a dedicated passive or active single-band GNSS antenna to receive GPS, Galileo (Only for LC86L (C)), GLONASS, BeiDou and QZSS satellite signals.

The recommended antenna specifications are given in the table below.

Table 8: Recommended External Antenna Specifications

Antenna Type	Specifications
Passive Antenna	Frequency Range: 1559–1609 MHz Polarization: RHCP VSWR: < 2 (Typ.) Passive Antenna Gain: > 0 dBi
Active Antenna	Frequency Range: 1559–1609 MHz Polarization: RHCP VSWR: < 2 (Typ.) Active Antenna Gain: > 0 dBi Active Antenna Noise Figure: < 1.5 dB Active Antenna Total Gain: < 17 dB

NOTE

The total gain of the whole antenna is the additional LNA gain minus total insertion loss of cables and components inside the antenna.

5.2.2. External Antenna Selection Guide

Both active and passive single-band GNSS antennas can be used for the Quectel LC86L module. A passive antenna is recommended if the antenna can be placed close to the module, for instance, when the distance between the module and the antenna is less than 1 m. Otherwise, use an active antenna, since the insertion loss of RF cable can decrease the CNR of GNSS signal.

CNR 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. CNR formula is as below:

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

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 CNR of GNSS signal, a

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.

5.2.3. External Active Antenna Reference Design

The following figure is a typical reference design of an active antenna. Inside the module, the EX_ANT pin is powered by VCC and supplies power to the external active antenna.

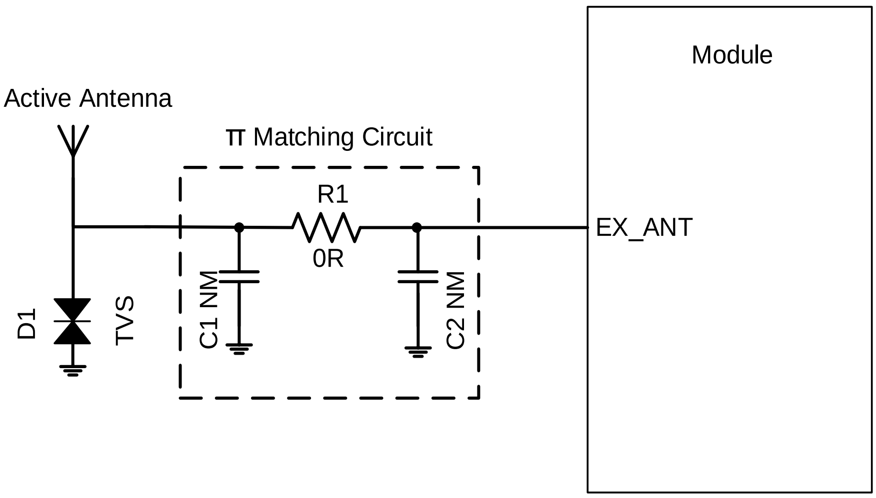

Figure 16: External Active Antenna Reference Design

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

The impedance of RF trace line in main PCB should be controlled as 50 Ω, and the trace length should be kept as short as possible.

NOTE

In order to ensure the short protection function can work effectively, please select a DC-open (DC-impedance between the SMA's inner signal needle and outside ground) GNSS active antenna. The DC-impedance can also be measured with a common and simple multimeter on few samples, and the value is generally in MΩ level.

5.3. Integrated Patch Antenna

The LNA is integrated for better performance. It is an ultra-compact module with embedded 15.0 mm × 15.0 mm × 4.0 mm patch antenna. In addition, the module can also support external active antenna, and the RF signal is obtained from the EX_ANT pin. Both integrated patch signal and external active antenna signal are intelligently switched through SPDT.

5.3.1. PCB Design Guide

The radiation characteristic of antenna depends on various factors, such as the size, shape of the PCB and the dielectric constant of components nearby. It is recommended to follow the rules listed below.

- Keep the module at least 5 mm away from the nearest edge of the Motherboard, that is, it is better to be placed in the center of the motherboard.

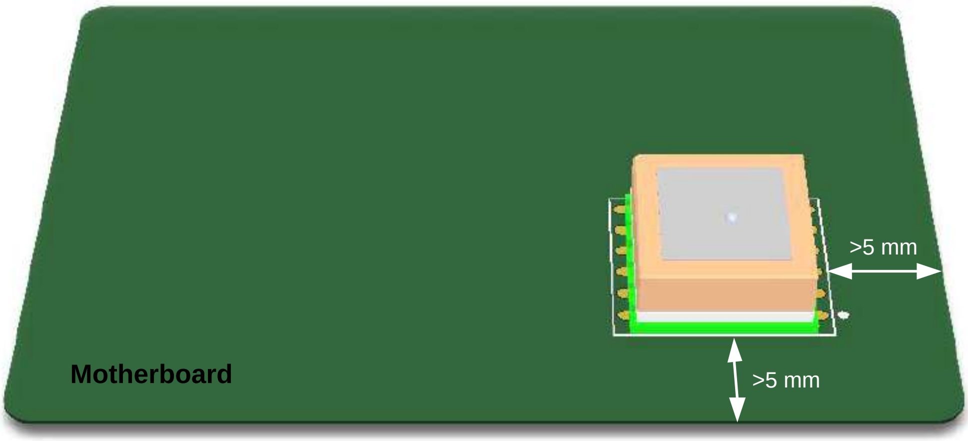

Figure 17: Recommended Distance between Module and Motherboard Edges

- Retain the position on the motherboard corresponding to the feed point of the patch antenna on each layer, ensuring that the diameter of the keepout area is not less than 2.5 mm.

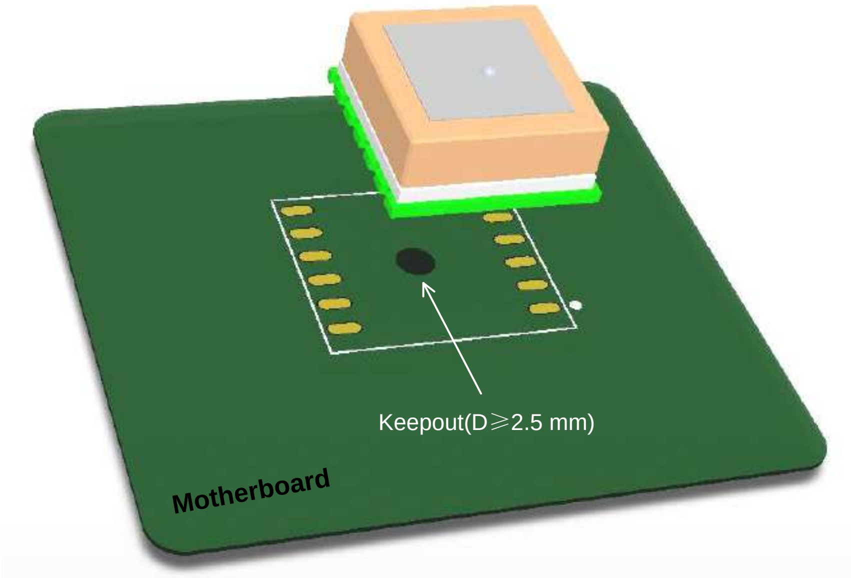

Figure 18: Recommended Treatment for the Feed Point of the Patch Antenna

- Make sure the antenna points to the sky.
- Preserve a 30 mm × 30 mm area for the ground plane, if possible. The performance of the integrated patch antenna depends on the actual size of the ground plane around the module. In addition, do not place any components, especially thick components in this area (interfering signal paths are not allowed either).

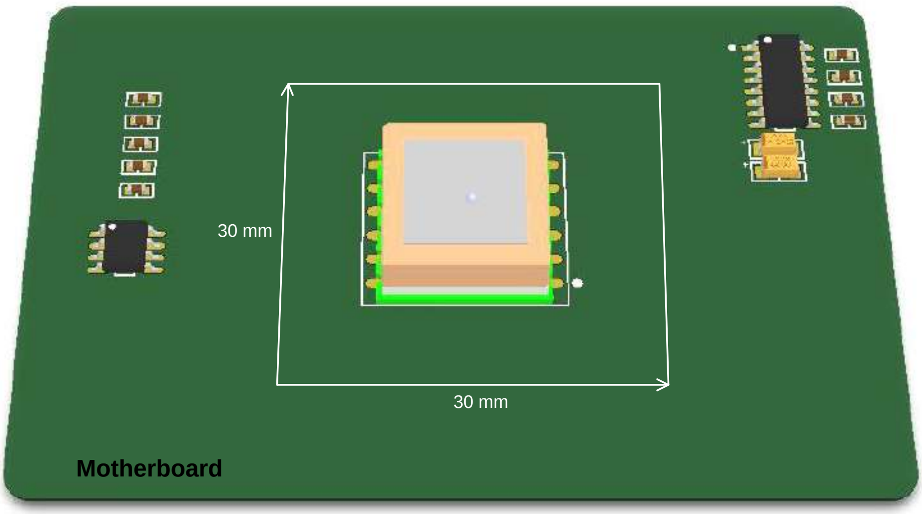

Figure 19: Recommended Ground Plane

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

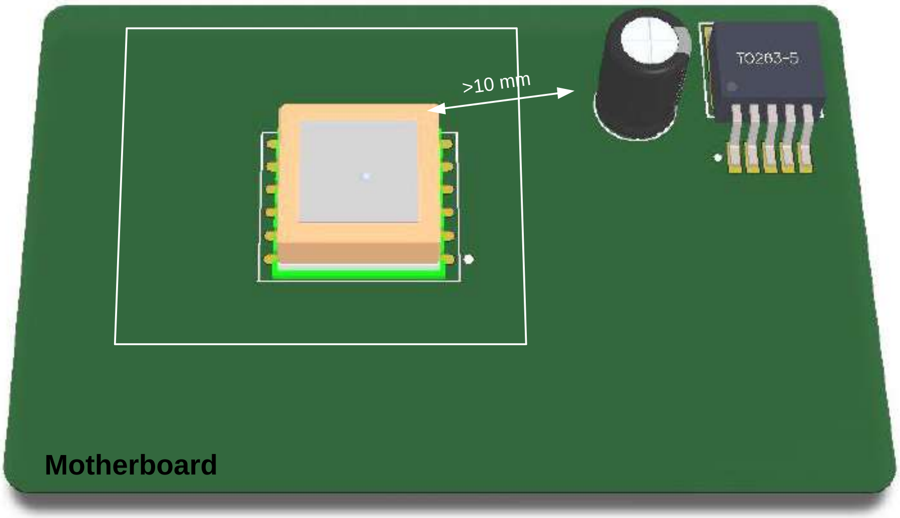

Figure 20: Recommended Distance between Module and Tall Metal Components

- Make sure the microcontroller, crystal, LCD, camera and other high-speed components and interfaces are placed on the opposite side of the module, and keep them away from the module as far as possible, for example, in the diagonal position from the module.

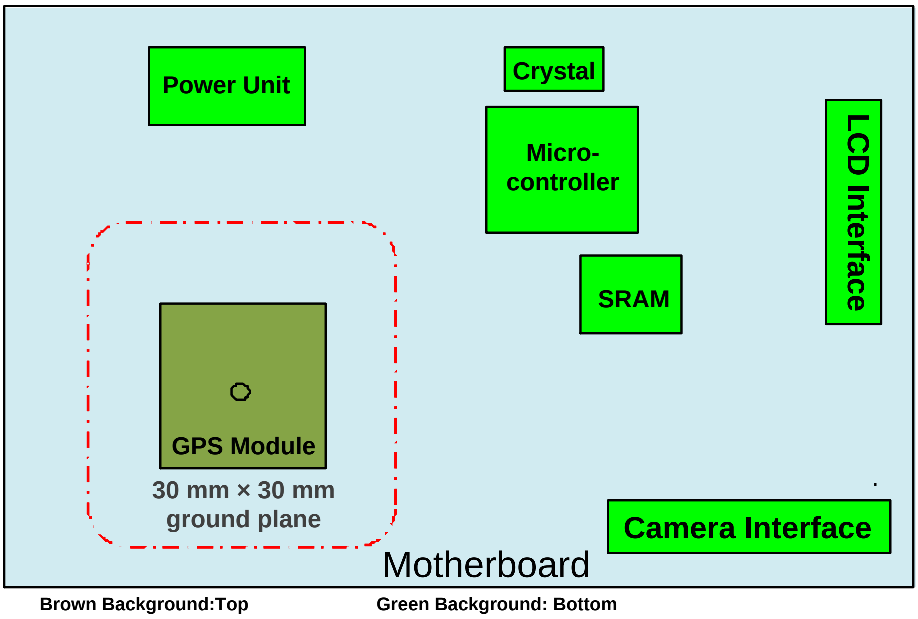

Figure 21: Recommended Placement of GNSS Module

- Make sure interfering signals (USB, LCD, Camera, Crystal, etc.) are in inner layer and shielded by ground plane, and keep the interfering signals and their paths far away from the module.
- Make sure the RF system (such as Wi-Fi/Bluetooth/2G/3G/4G/5G) is on the opposite side of the

module, and keep it away from the module as far as possible; preferably, by placing the RF system on the board in the diagonal position to the module.

- Keep the DC-DC converter far away from the module.
- Pay attention that the device enclosure is made of non-metal materials, especially those parts that are around the antenna area. Ensure that the minimum distance between the antenna and enclosure is 3 mm.
- Keep away the RF part of the GNSS module from a heat-emitting circuit, as the module is sensitive to temperature.
- Reserve an integrated ground layer to isolate the GNSS module from other components.

5.3.2. GPS + GLONASS Patch Antenna

The LC86L (A) and LC86L (C) product variants are designed with a 15.0 mm × 15.0 mm × 4.0 mm high-performance patch antenna that supports GPS + GLONASS constellations by default. The antenna specifications are described in the following table.

Table 9: GPS + GLONASS Patch Antenna Specifications (with Ground Plane 100 mm × 60 mm)

Antenna Type	Parameter	Specification	Comment
Patch Antenna	Size	15.0 mm × 15.0 mm × 4.0 mm	
	Range of Receiving Frequency	GPS L1 C/A (1574.397–1576.443 MHz) GLONASS L1 (1597.781–1605.656 MHz)	
	Polarization	RHCP	Right Hand Circular Polarization
	Gain at Zenith	GPS 0.90 dBi GLONASS 1.30 dBi	Peak Gain

The example of results for the LC86L (A) and LC86L (C) patch antenna, tested on an EVB with the ground plane of 100 mm × 60 mm, is given in the following figure. This embedded GNSS antenna provides good radiation efficiency, right-hand circular polarization, and optimized radiation pattern. The antenna is insensitive to surroundings and has a high tolerance against frequency shifts.

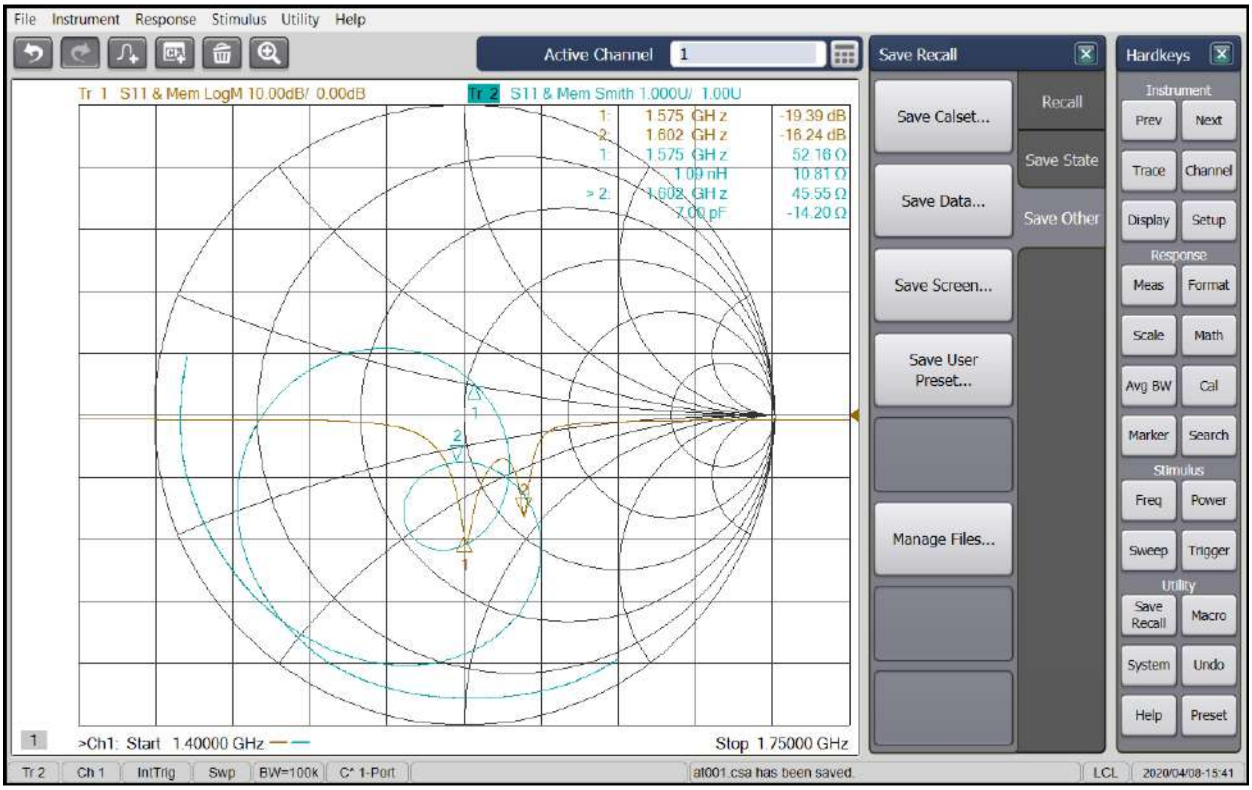

Figure 22: GPS + GLONASS Patch Antenna Test Results (with Ground Plane of 100 mm × 60 mm)

5.3.3. GPS + BeiDou Patch Antenna

The LC86L (B) product variant is designed with a 15.0 mm × 15.0 mm × 4.0 mm high-performance patch antenna that supports GPS + BeiDou constellations by default. Its specifications are described in the following table.

Table 10: GPS + BeiDou Patch Antenna Specifications (with Ground Plane of 100 mm × 60 mm)

Parameter	Specification	Comment
Size	15.0 mm × 15.0 mm × 4.0 mm	
Range of Receiving Frequency	GPS L1 C/A (1574.397–1576.443 MHz) BeiDou B1I (1559.052–1563.144 MHz)	
Polarization	RHCP	Right Hand Circular Polarization
Gain at Zenith	GPS: 3.40 dBi BeiDou: 2.65 dBi	Peak Gain

The example of the results for the LC86L (B) patch antenna, tested on an EVB with the ground plane of 100 mm × 60 mm, is given in the following figure. This embedded GNSS antenna provides good radiation efficiency, right hand circular polarization and optimized radiation pattern. The antenna is insensitive to surroundings and has high tolerance against frequency shifts.

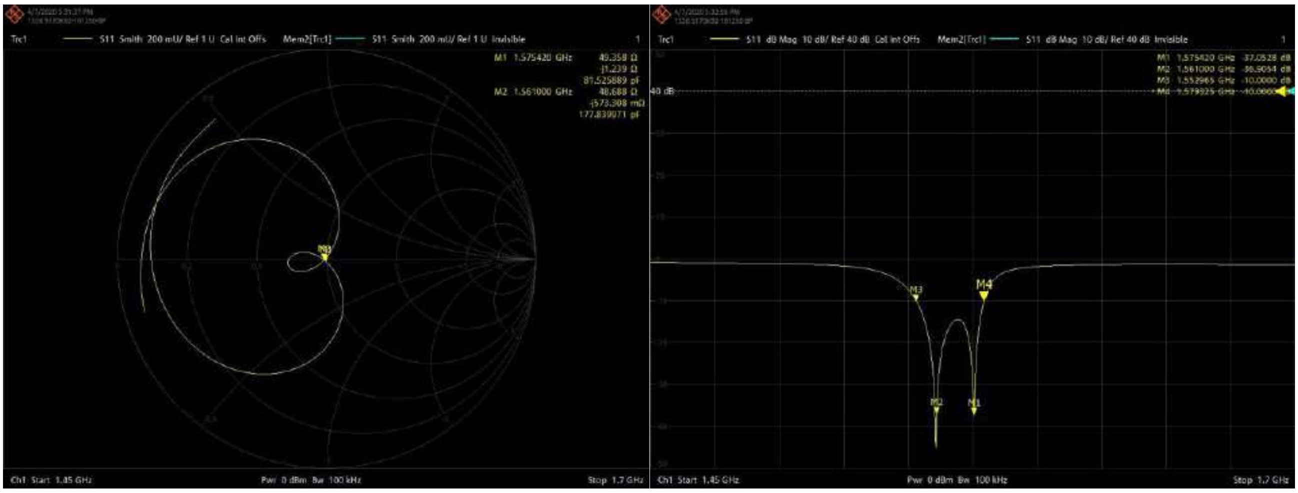

Figure 23: GPS + BeiDou Patch Antenna Test Result with Ground Plane of 100 mm × 60 mm

5.4. 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.

5.4.1. In-Band Interference

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

See the following figure for more details.

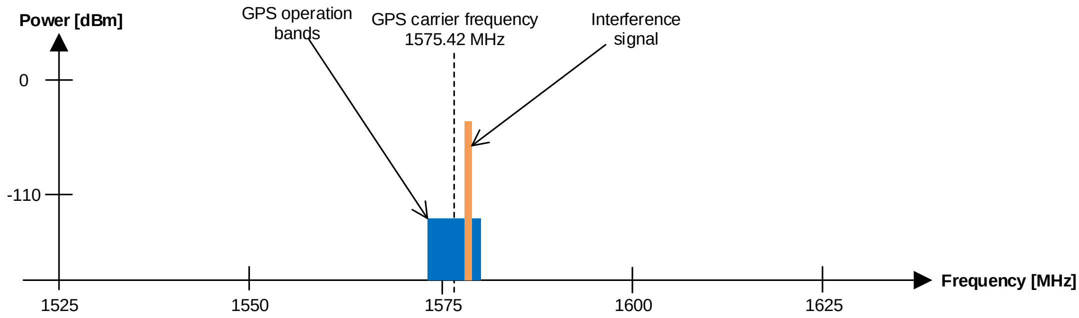

Figure 24: In-Band Interference on GPS L1

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 B13.

Table 11: Intermodulation Distortion (IMD) Products

Source F1	Source F2	IM Calculation	IMD Products
GSM850/B5	Wi-Fi 2.4 GHz	F2 (2412 MHz) - F1 (837 MHz)	IMD2 = 1575 MHz
DCS1800/B3	PCS1900/B2	2 × F1 (1712.6 MHz) - F2 (1850.2 MHz)	IMD3 = 1575 MHz
PCS1900/B2	Wi-Fi 5 GHz	F2 (5280 MHz) - 2 × F1 (1852 MHz)	IMD3 = 1576 MHz
LTE B13	N/A	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 to become saturated, so that its performance is greatly deteriorated, as illustrated in the following figure.

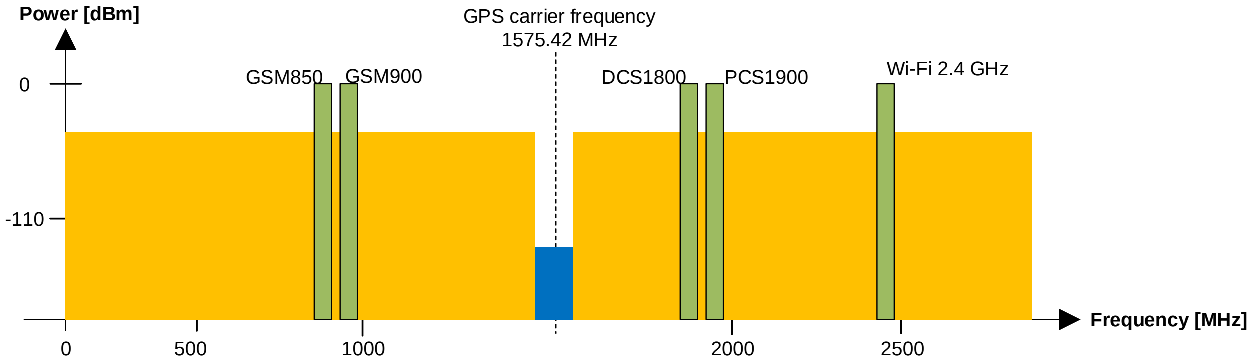

Figure 25: Out-of-Band Interference on GPS L1

5.4.3. 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.

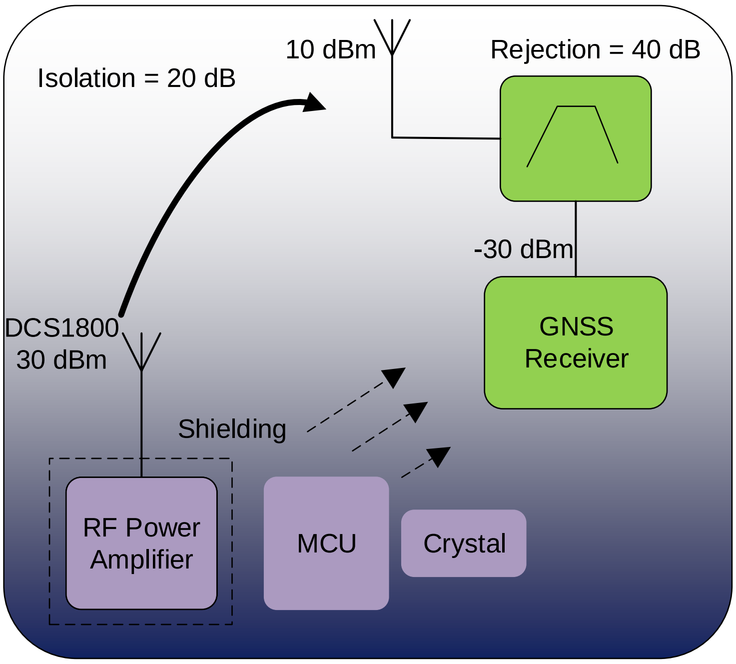

Figure 26: Interference Source and its Path

6 Electrical Specification

6.1. Absolute Maximum Ratings

Absolute maximum ratings for power supply and voltage on digital pins of the Quectel LC86L module are listed in table below.

Table 12: Absolute Maximum Ratings

Parameter	Description	Min.	Max.	Unit
VCC	Main Power Supply Voltage	-0.3	4.3	V
V_BCKP	Backup Supply Voltage	-0.3	4.3	V
V_{IN}_IO	Input Voltage at I/O Pins	-0.3	3.6	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 13: Recommended Operating Conditions

Parameter	Description	Min.	Typ.	Max.	Unit
VCC	Main Power Supply Voltage	2.8	3.3	4.3	V
V_BCKP	Backup Supply Voltage	1.5	3.3	4.3	V
IO_domain	Domain Voltage at Digital I/O Pins	-	2.8	-	V
V_{IL}	Digital I/O Pin Low-Level Input Voltage	-0.3	-	0.7	V
V_{IH}	Digital I/O Pin High-Level Input Voltage	2.1	-	3.1	V
V_{OL}	Digital I/O Pin Low-Level Output Voltage	-0.3	-	0.4	V
V_{OH}	Digital I/O Pin High-Level Output Voltage	2.4	-	3.1	V
RESET_N	Low-Level Input Voltage	-0.3	-	0.7	V
T_operating	Operating Temperature	-40	25	+85	°C

NOTE

Operation beyond the "Operating Conditions" is not recommended and extended exposure beyond the "Operating Conditions" may affect device reliability.

6.3. ESD Protection

The Quectel LC86L module is an ESD sensitive device. Therefore, proper ESD handling and packaging procedures must be applied throughout the processing, handling and operation of any application that incorporates the module.

The following measures ensure ESD protection when the module is handled:

- When mounting the module onto a motherboard, make sure to connect the GND first, and then the EX_ANT pad.
- When handling the EX_ANT 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 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 ±0.2 mm, unless otherwise specified.

7.1. Top, Side and Bottom View Dimensions

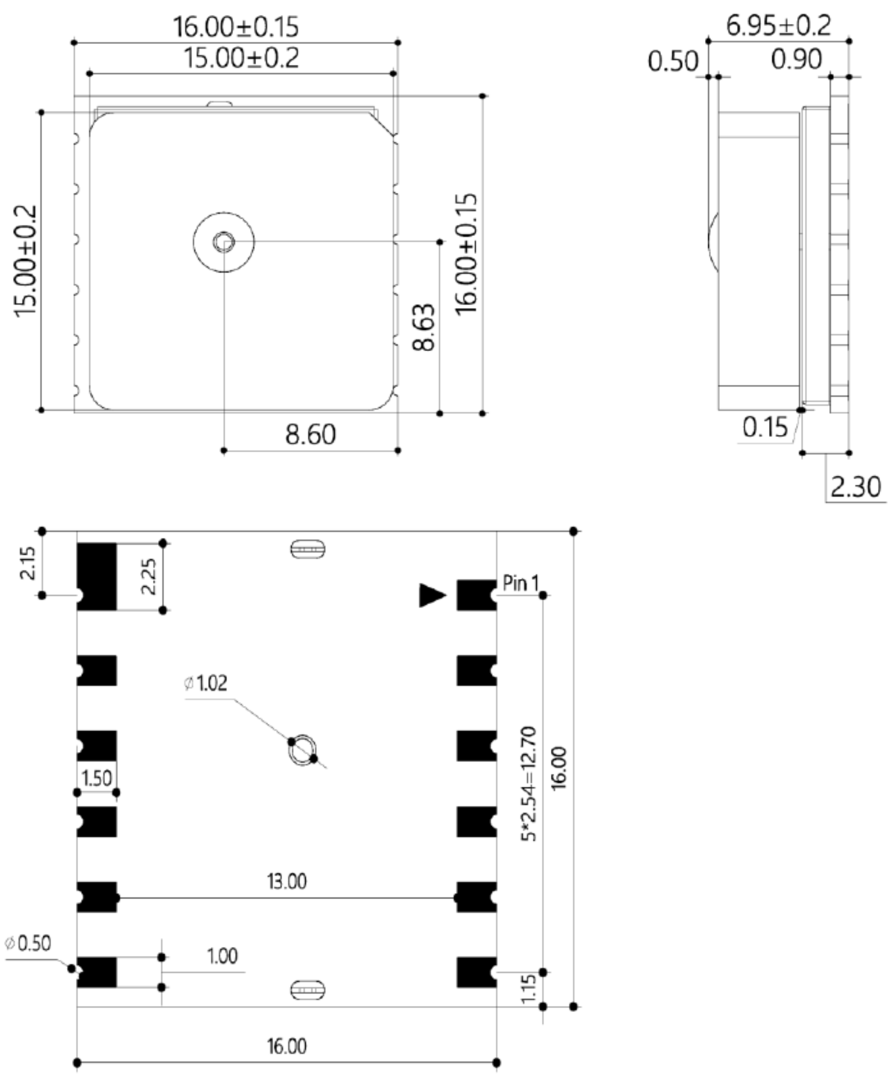

Figure 27: Top, Side and Bottom View Dimensions

NOTE

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

7.2. Top and Bottom Views

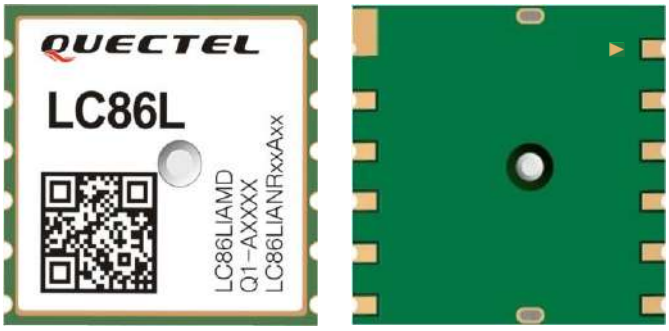

Figure 28: Top and Bottom Views

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

The Quectel LC86L module is delivered as a reeled tape, 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. Tapes

The following figure shows the position of the Quectel LC86L module when delivered in tape and the dimensions of the tape.

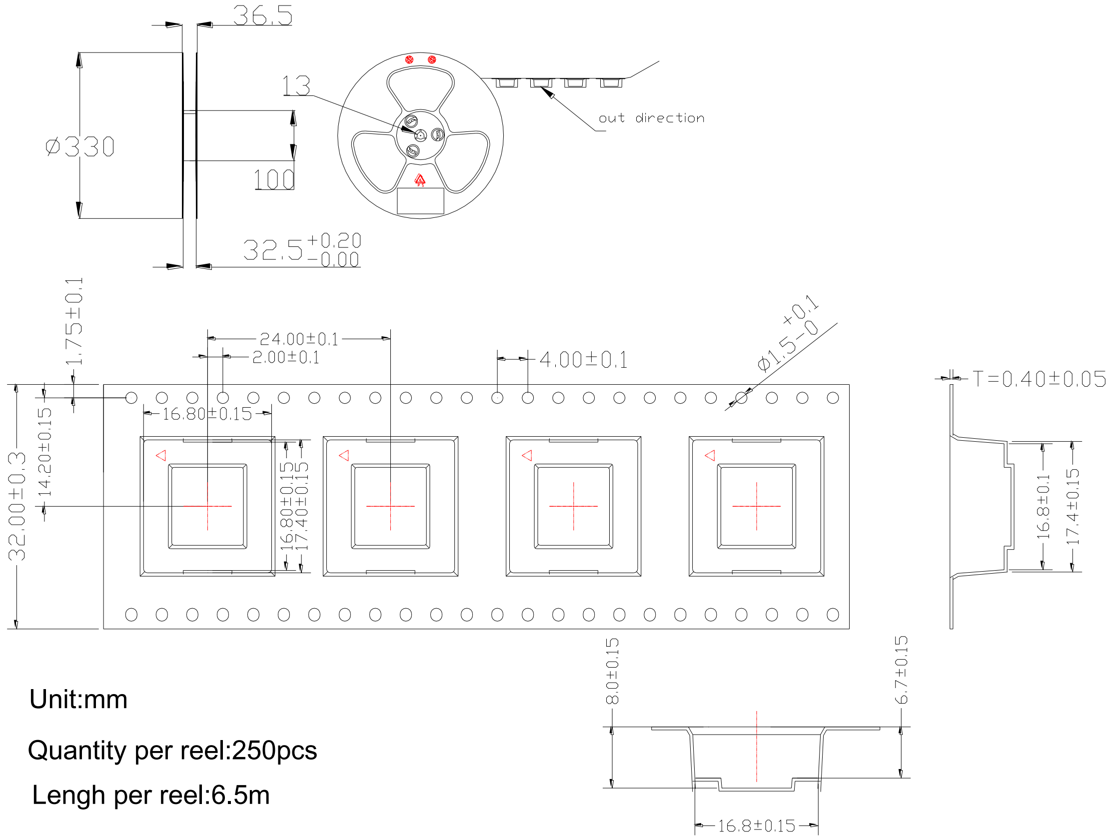

Figure 29: Tape and Reel Specifications

8.1.2. Reels

Each reel contains 250 Quectel GNSS modules. See the figure above.

Table 14: Reel Packaging

Model Name	MOQ	Minimum Package (MP): 250 pcs	Minimum Package x 4 = 1000 pcs
LC86L	250 pcs	Size: 370 mm × 350 mm × 56 mm N.W: 1.5 kg G.W: 2.25 kg	Size: 380 mm × 250 mm × 365 mm N.W: 6.1 kg G.W: 9.4 kg

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. Storage life (in the vacuum-sealed packaging) is 12 months in recommended storage conditions.

3. The floor life of the module is 168 hours [8] 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 undergo 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:

   - 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 more than 24 hours;
   - Before repairing the module.

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

[8] 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*. And do not remove the packages of tremendous modules if they are not ready for soldering.

- The module should be baked for 8 hours at 120 ±5 °C;
- All modules must be soldered to the PCB within 24 hours after the 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 out the module from the package and put it on high-temperature-resistant fixtures before baking. All modules must be soldered to PCB within 24 hours after 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 modules.

8.3. Manufacturing and Soldering

Push the squeegee to apply solder paste on the surface of stencil, 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 [4]***.

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 that the module should be mounted to the PCB only after reflow soldering of the other side of 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.

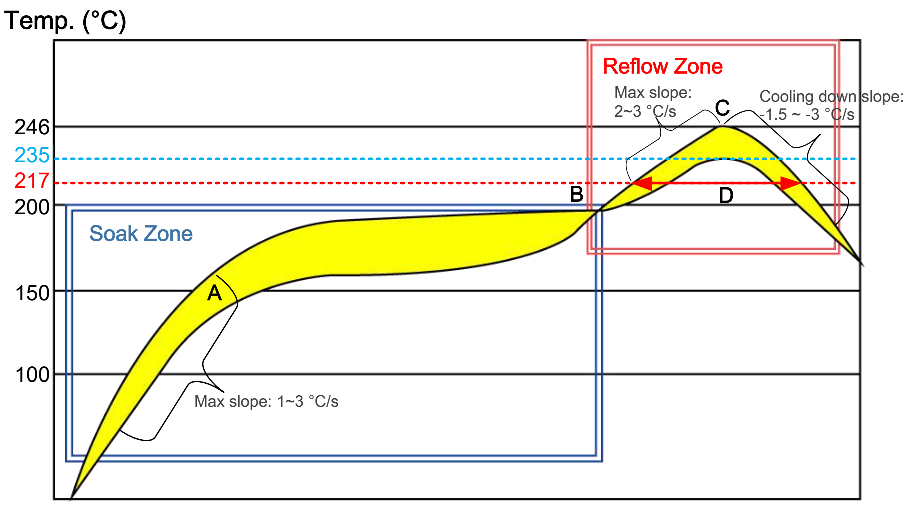

Figure 30: Recommended Reflow Soldering Thermal Profile

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 cycles	1

NOTE

1. During manufacturing and soldering, or any other processes that may contact the module directly, NEVER wipe the module label with organic solvents, such as acetone, ethyl alcohol, isopropyl alcohol, trichloroethylene, etc. Otherwise, the label information may become unclear.
2. 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 flowing into the module.

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.

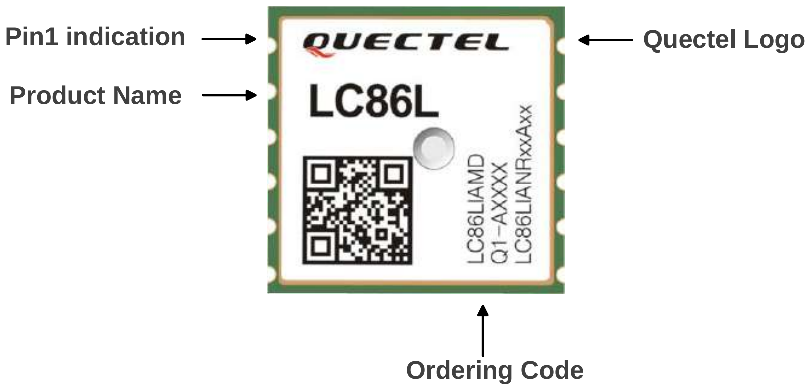

Figure 31: Labelling Information

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

10 Appendix References

Table 16: Related Documents

Document Name
[1] Quectel_L76-LB&L26-LB&LC86L_GNSS_Protocol_Specification
[2] Quectel_GNSS_Flash_EPO_Application_Note
[3] Quectel_L80&L86&LC86L_Reference_Design
[4] Quectel_Module_Secondary_SMT_Application_Note

Table 17: Terms and Abbreviations

Abbreviation	Description
AGNSS	Assisted Global Positioning System
AIC	Active Interference Cancellation
CEP	Circular Error Probable
CNR or C/N	Carrier-to-noise Ratio
CPU	Central Processing Unit
DCS1800	Digital Cellular System at 1800 MHz
DC	Direct Current
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
GLONASS	Global Navigation Satellite System
GLP	GNSS Low Power
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GSM	Global System for Mobile Communications
G.W	Gross Weight
I/O	Input /Output
IC	Integrated Circuit
IMU	Inertial Measurement Unit
kbps	Kilobits Per Second
LCC	Leadless Chip Carrier
LCD	Liquid Crystal Display
LDO	Low-dropout Regulator
LNA	Low Noise Amplifier
LTE	Long Term Evolution
LTO	Long-term Orbit
Mbps	Megabits per second
MCU	Microcontroller Unit/Microprogrammed Control Unit
MEMS	Micro-Electro-Mechanical System
MPU	Microprocessing Unit
MP	Mass Production
MSAS	Multi-functional Satellite Augmentation System
MSL	Moisture Sensitivity Levels
N.W	Net Weight

NMEA	National Marine Electronics Association
OC	Open Connector
PC	Personal Computer
PCB	Printed Circuit Board
PMU	Power Management Unit
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
RTC	Real- Time Clock
RTK	Real-Time Kinematic
RXD	Receive Data
3GPP	3rd Generation Partnership Project
SAW	Surface Acoustic Wave
SBAS	Satellite-based Augmentation System
SMA	SubMiniature version A
SMD	Surface Mount Device
SN	Serial Number
SPDT	Single Pole Double Throw
SPI	Serial Peripheral Interface
SRAM	Static Random Access Memory
TCXO	Temperature Compensated Crystal Oscillator
TTFF	Time to First Fix

TVS	Transient Voltage Suppressor
UART	Universal Asynchronous Receiver/Transmitter
UTC	Coordinated Universal Time
VSWR	Voltage Standing Wave Ratio
VTG	Course Over Ground & Ground Speed
WAAS	Wide Area Augmentation System
WCDMA	Wideband Code Division Multiple Access