

LC86L Hardware Design

GNSS Module Series

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About the Document

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1 Introduction

This document specifies Quectel LC86L GNSS module specifications. Hardware interfaces, external application reference circuits, mechanical size and air interface of the module are described in this document.

This document helps customers quickly understand the interface specifications, as well as electrical and mechanical details of LC86L module. Other documents such as LC86L software application notes and user guides are also provided for customers, so that the customers can use LC86L module to design and set up applications quickly.

1.1. Safety Information

The following safety precautions must be observed during all phases of operation, such as usage, service or repair of any terminal incorporating Quectel LC86L module. Manufacturers of the terminal should notify users and operating personnel of the following safety information by incorporating these guidelines into all manuals supplied with the product. If not so, Quectel assumes no liability for customers' failure to comply with these precautions.



Ensure the use of the product conforms to the local safety and environment regulations, and is allowed in the country and the environment required.



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 application that incorporates the module to avoid ESD damages.

2 Product Concept

2.1. General Description

LC86L supports various navigation bands and features, including GPS, BeiDou, GLONASS, SBAS (including WAAS, EGNOS, GAGAN and MSAS), QZSS, DGPS (RTCM) and AGPS. Designed with an embedded LNA, the module realizes high sensitivity, high accuracy, fast GNSS signal acquisition and tracking.

Key features of LC86L:

- The embedded flash memory provides capacity for storing user-specific configurations and allows for future updates.
- Support multiple power-saving modes such as Periodic, Standby and Backup, and the embedded low-power algorithms suitable for different application scenarios.
- EASY™ autonomous AGPS technology is supported, which can collect and process all internal auxiliary information including GNSS time, calendar, the latest position and so on, so that the module can achieve fast first fix in hot/warm start.
- Support active antenna detection and antenna short-circuit protection. The antenna status is reported in the NMEA message, so the host can query the antenna status timely and conveniently.

LC86L 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 customers' applications through the 12 LCC pins. It provides necessary hardware interfaces for connection with the main PCB.

The module is fully compliant to EU RoHS regulations.

2.2. Key Features

Table 1: Key Features

Features	Description
GNSS Type	<ul style="list-style-type: none"> ● Default configuration: GPS + GLONASS or GPS + BeiDou ● For more details about the GNSS constellation configuration, please refer to document [1].
Receiver Type	<ul style="list-style-type: none"> ● GPS L1 C/A: 1574.397–1576.443 MHz ● GLONASS L1: 1597.781–1605.656 MHz ● BeiDou B1 C/A: 1559.052–1563.144 MHz
Power Supply	<ul style="list-style-type: none"> ● Supply voltage: 2.8–4.3 V ● Typical: 3.3 V
Power Consumption ¹⁾	<p>GPS:</p> <ul style="list-style-type: none"> ● Acquisition: 26.8 mA @ -130 dBm, VCC = 3.3 V ● Tracking: 22.8 mA @ -130 dBm, VCC = 3.3 V ● Standby: 1.4 mA @ VCC = 3.3 V ● Backup: 6 µA @ V_BCKP = 3.3 V <p>GPS + GLONASS:</p> <ul style="list-style-type: none"> ● Acquisition: 31.8 mA @ -130 dBm, VCC = 3.3 V ● Tracking: 31.5 mA @ -130 dBm, VCC = 3.3 V ● Standby: 1.4 mA @ VCC = 3.3 V ● Backup: 6 µA @ V_BCKP = 3.3 V <p>GPS + BeiDou:</p> <ul style="list-style-type: none"> ● Acquisition: TBD @ -130 dBm, VCC = 3.3 V ● Tracking: TBD @ -130 dBm, VCC = 3.3 V ● Standby: 1.4 mA @ VCC = 3.3 V ● Backup: 6 µA @ V_BCKP = 3.3 V
Sensitivity	<ul style="list-style-type: none"> ● Acquisition: -148 dBm ● Reacquisition: -159 dBm ● Tracking: -165 dBm
Time-to-First-Fix (EASY Enabled)	<ul style="list-style-type: none"> ● Cold Start: < 15 s (average) @ -130 dBm ● Warm Start: < 5 s (average) @ -130 dBm ● Hot Start: < 1 s @ -130 dBm
Time-to-First-Fix (EASY Disabled)	<ul style="list-style-type: none"> ● Cold Start (Autonomous): < 35 s (average) @ -130 dBm ● Warm Start (Autonomous): < 30 s (average) @ -130 dBm ● Hot Start (Autonomous): < 1 s @ -130 dBm
Horizontal Position Accuracy (Autonomous)	<ul style="list-style-type: none"> ● < 2.5 m CEP @ -130 dBm
Update Rate	<ul style="list-style-type: none"> ● 1 Hz by default, maximum up to 10 Hz

Accuracy of 1PPS Signal	<ul style="list-style-type: none"> ● Typical accuracy < 100 ns ● Time pulse width: 100 ms
Velocity Accuracy	<ul style="list-style-type: none"> ● Without aid: < 0.1 m/s
Acceleration Accuracy	<ul style="list-style-type: none"> ● Without aid: < 0.1 m/s²
Dynamic Performance	<ul style="list-style-type: none"> ● Maximum Altitude: 18000 m ● Maximum Velocity: 515 m/s ● Acceleration: 4G
UART Interface	<ul style="list-style-type: none"> ● UART port: UART_TX and UART_RX ● Baud rate: 9600 bps to 921600 bps, 9600 bps by default ● Used for NMEA sentences output, PMTK/PQ commands input and firmware upgrade
Temperature Range	<ul style="list-style-type: none"> ● Operation temperature range: -40 °C to +85 °C ● Storage temperature range: -40 °C to +90 °C
Physical Characteristics	<ul style="list-style-type: none"> ● Size: (16.0 ± 0.15) mm × (16.0 ± 0.15) mm × (6.95 ± 0.20) mm ● Weight: Approx. 6 g

NOTES

- 1) The power consumption values are measured with instruments on the condition that the module uses the internal patch antenna only, and EASY, AIC and SBAS are disabled.
If an external active antenna is used, VCC pin will supply power for the external antenna, and then the current consumption of the module will increase by about 11 mA @ VCC = 3.3 V.
Using an external active antenna increases power consumption, but does not cause any compromising on performance.
2. The module supports either GPS + GLONASS or GPS + BeiDou configurations by default.

2.3. Block Diagram

The following figure shows a block diagram of LC86L module. It consists of a single chip GNSS IC which includes the RF section, the baseband section, a SPDT, a patch antenna, a LNA, a SAW filter, a TCXO, a crystal oscillator, an active antenna short-circuit protection circuit and an active antenna detection circuit.

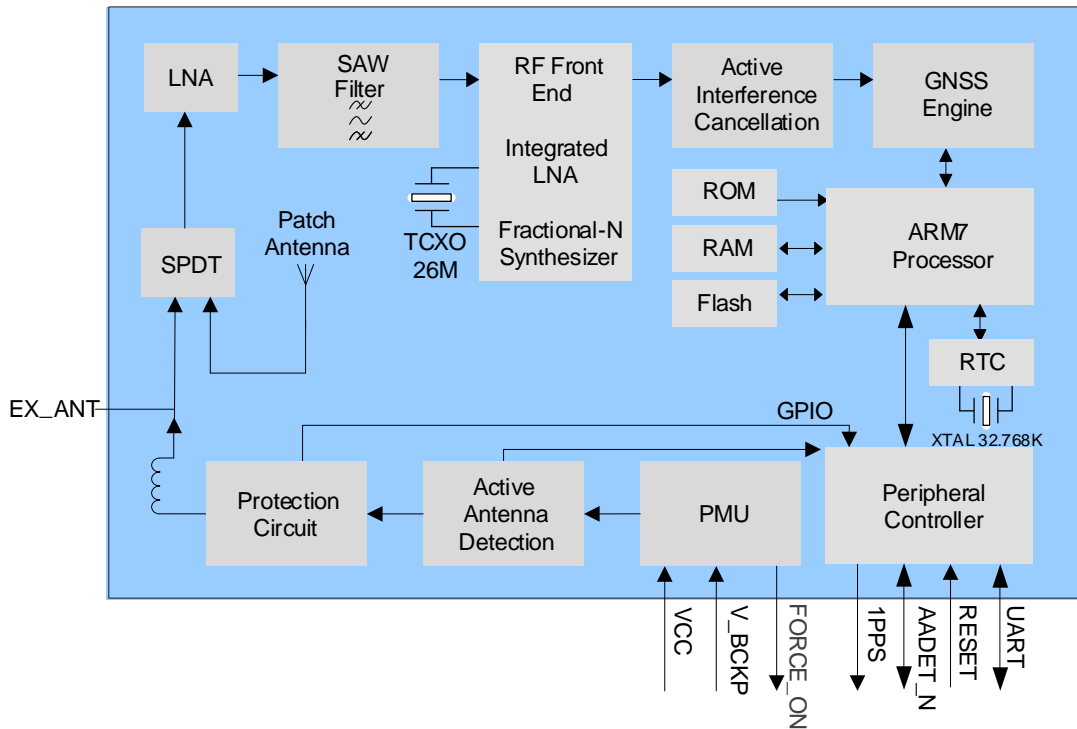


Figure 1: Block Diagram

2.4. Supported Protocols

Table 2: Supported Protocols

Protocol	Type
NMEA	Output, ASCII, 0183, 4.10
PMTK	Input/Output, MTK proprietary protocol
PQ	Input/Output, Quectel proprietary protocol

NOTES

1. Please refer to **document [1]** for details of NMEA standard protocol and MTK proprietary protocol.
2. Please refer to **document [5]** for details of Quectel proprietary protocol.

2.5. Evaluation Board

In order to facilitate application design with LC86L module, Quectel supplies the evaluation board (LC86L EVB), micro-USB cable, active antenna and other peripherals to test the module. For more details, please refer to **document [2]**.

3 Application Functions and Interfaces

The module is equipped with 12 LCC pins at 2.54 mm pitch spacing for connection with application platforms.

3.1. Pin Assignment



Figure 2: Pin Assignment

3.2. Pin Definition

Table 1: I/O Parameters Definition

Type	Description
AI	Analog Input
AO	Analog Output
DI	Digital Input
DO	Digital Output
IO	Bidirectional
PI	Power Input
PO	Power Output

Table 3: Pin Description

Power Supply					
Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
VCC	4	PI	Main power supply	V _{max} = 4.3 V V _{min} = 2.8 V V _{nom} = 3.3 V	Assure the maximum current capability of power supply no less than 100 mA.
V_BCKP	5	PI	Backup power supply	V _{max} = 4.3 V V _{min} = 2.0 V V _{nom} = 3.3 V	Supply power for RTC domain. V_BCKP can be powered directly by a battery or connected to VCC.
Reset					
Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
RESET_N	10	DI	Reset the module	V _{ILmin} = -0.3 V V _{ILmax} = 0.7 V V _{IHmin} = 2.1 V V _{IHmax} = 3.1 V	Active low. If unused, keep this pin open or connect it to VCC.

UART Interface

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
RXD	1	DI	Receive data	$V_{ILmin} = -0.3\text{ V}$ $V_{ILmax} = 0.7\text{ V}$ $V_{IHmin} = 2.1\text{ V}$ $V_{IHmax} = 3.1\text{ V}$	
TXD	2	DO	Transmit data	$V_{OLmin} = -0.3\text{ V}$ $V_{OLmax} = 0.4\text{ V}$ $V_{OHmin} = 2.4\text{ V}$ $V_{OHmax} = 3.1\text{ V}$	

RF Interface

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
EX_ANT	11	AI	External active antenna RF input		If unused, keep this pin open. 50 Ω impedance control.

Other Interfaces

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
1PPS	6	DO	One pulse per second	$V_{OLmin} = -0.3\text{ V}$ $V_{OLmax} = 0.4\text{ V}$ $V_{OHmin} = 2.4\text{ V}$ $V_{OHmax} = 3.1\text{ V}$	Synchronized at rising edge and the pulse width is 100 ms. If unused, keep this pin open.
FORCE_ON	7	DI	Logic high will wake up the module from backup mode	$V_{ILmin} = -0.3\text{ V}$ $V_{ILmax} = 0.5\text{ V}$ $V_{IHmin} = 0.7\text{ V}$ $V_{IHmax} = 3.6\text{ V}$	Keep this pin open or pulled low before entering backup mode. It belongs to RTC domain. If unused, keep this pin open.
AADET_N	8	DO	Active antenna detection	$V_{OLmax} = 0.7\text{ V}$ $V_{OHmin} = 1.3\text{ V}$	If unused, keep this pin open. Refer to Chapter 4.3 for details.

NOTE

Please keep all reserved and unused pins open.

3.3. Power Supply

VCC supplies power for baseband, RF, I/O, LNA, active antenna short-circuit protection and active antenna detection circuits. The load current of VCC varies according to the VCC voltage level, processor load, the number of tracked satellites and the rate of satellite re-acquisition. Using an external active antenna will consume additional 11 mA. Therefore, it is important to supply sufficient current and ensure that the power is clean and stable. It is recommended to choose an LDO with a minimum output current of 100 mA as the power supply, and add a 10 μ F and a 100 nF decoupling capacitor combination as well as a TVS near the VCC pin.

V_BCKP supplies power for RTC domain. It should be valid when the module is powered on. The voltage of RTC domain ranges from 2.0 to 4.3 V. In order to achieve a better TTFF, RTC domain should be valid all the time. It can supply power for SRAM memory in RTC domain which contains all the necessary GPS information for quick start-up and a small amount of user configuration variables.

3.3.1. Internal Power-System Construction

The module's internal power-system construction is shown below.

VCC supplies power for PMU, and V_BCKP supplies power for RTC domain. FORCE_ON signal highlighted in red in the following figure belongs to RTC domain and can be used to turn on/off the switch. The following actions will turn on or off the switch:

- The switch will be turned off by default when VCC and V_BCKP is supplying power.
- Based on the step above, FORCE_ON open or low and sending PMTK command can turn on the switch (full on \rightarrow backup).
- Based on the step above, FORCE_ON logic high can turn off the switch (backup \rightarrow full on).

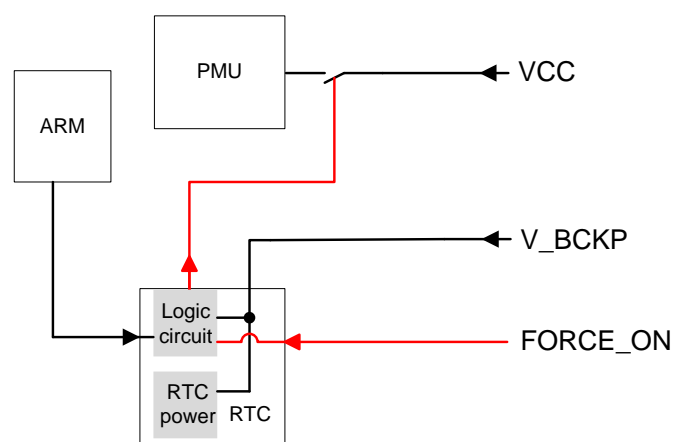


Figure 3: Internal Power-System Construction

A power supply solution for LC86L is provided below.

The simplest power circuit for LC86L module is 3.3 V power source connected to VCC pin and V_BCKP pin of the module directly. In this case, once the module is powered on, the full cold start will be implemented.

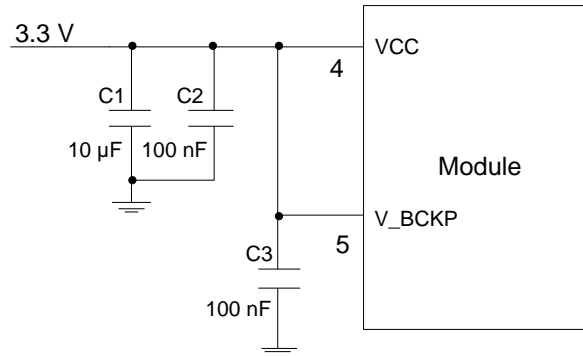


Figure 4: Reference Design of Power Supply

NOTES

1. If the design mentioned above is applied to a power supply circuit, LC86L module does not support EASY technology and backup mode.
2. VCC does not supply power for RTC domain in LC86L module, so the V_BCKP pin must be powered externally. Furthermore, it is strongly recommended to power V_BCKP through a backup battery, which can ensure LC86L module supports EASY technology and improves TTFF after next restart.
3. Please choose one voltage source without built-in output high speed discharge function, and confirm the voltage drop down curve to keep long output voltage drop down period. Meanwhile, make sure the output voltage drop time is greater than 100 ms (from 2.7 to 0.5 V).
4. It's strongly recommended to use external LDOs without output discharge function to keep long output voltage drop-down period.

3.4. Operating Modes

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

Table 4: Module Operating Modes

	Full on	Standby	Backup	Periodic	GLP
Antenna detection	●			○	●
PPS	●			○	●
RF	●			○	●
NMEA output	●			○	●
Acquiring & Tracking	●			○	●
Power consumption	High	Low	Low	Medium	Medium
Position accuracy	High	Low	Low	Low	Medium

NOTES

- = supported
- = supported in full on periodic mode

Table 5: Operating Mode Switching

Current Mode	Next Mode				
	Backup	Standby	Full on	Periodic	GLP
Backup	N/A	N/A	Refer to Chapter 3.4.3	N/A	N/A
Standby	N/A	N/A	Send any data via UART	N/A	N/A
Full on	Refer to Chapter 3.4.3	PMTK161	N/A	Refer to Chapter 3.4.4	Refer to Chapter 3.4.5
Periodic	N/A	N/A	Refer to Chapter 3.4.4	N/A	N/A
GLP	N/A	N/A	Refer to Chapter 3.4.5	N/A	N/A

3.4.1. Full on Mode

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

When the combination of VCC and V_BCKP is valid, the module will enter into full on mode automatically and follow the default configurations as below. For more details, refer to **Chapter 3.3** about internal power-system construction. PMTK commands may be used to change the configurations to satisfy requirements.

Table 6: Default Configurations

Item	Configuration	Comment
GNSS	GPS+GLONASS	<p>The following PMTK commands can be used to switch among multiple positioning systems:</p> <ul style="list-style-type: none"> ● \$PMTK353,1,0,0,0,0*2A: search GPS satellites only ● \$PMTK353,1,1,0,0,0*2B: search GPS and GLONASS satellites ● \$PMTK353,1,0,0,0,1*2B: search GPS and BeiDou satellites
Baud Rate	9600 bps	
Protocol	NMEA	RMC, VTG, GGA, GSA, GSV, GLL and TXT
Update Rate	1 Hz	
SBAS	Enabled	
AIC	Enabled	
LOCUS	Disabled	
EASY Technology	Enabled	When update rate exceeds 1 Hz, EASY will be disabled automatically.

3.4.2. Standby Mode

Standby mode is a low-power-consumption mode. In the standby mode, the internal core and I/O power domain are still active, but RF and TCXO are powered off, and the module stops satellite search and navigation. UART is still accessible through PMTK commands or any other data, but there is no NMEA messages output.

Sending PMTK command **\$PMTK161,0*28** will make LC86L module enter standby mode. Sending any data via UART can wake the module up. When the module exits from standby mode, it will use all internal aiding information like GNSS time, ephemeris, last position, etc. to ensure the fastest possible TTFF in either hot or warm start. The typical standby current consumption in this way is about 1.4 mA @ VCC = 3.3 V.

NOTE

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

3.4.3. Backup Mode

The power consumption in backup mode is lower than that in standby mode. In backup mode, the module stops acquiring and tracking satellites. UART is not accessible. But the SRAM memory in RTC domain which contains all the necessary GNSS information for quick start-up and a small amount of user configuration variables is active. Due to the SRAM memory, EASY technology is available. The current consumption in this mode is about 6 μ A @ VCC = 3.3 V.

There are two ways to enter/exit backup mode.

- Sending **\$PMTK225,4*2F** command makes the module enter backup mode. In such a case, the only way to wake up the module is by pulling FORCE_ON pin high.
- Cutting off the power supply of VCC while keeping V_BCKP powered, the module will enter backup mode. As soon as the VCC power supply is restored, the module enters full on mode immediately.

The specific operation steps of entering backup mode in the second way are as follows:

1. Supply power to the VCC pin later than the V_BCKP pin, where the module is working normally.
2. Cut off the power supply for the VCC pin, so that the module enters backup mode, where the current measured at V_BCKP pin is the current in backup mode.

The typical current value in the backup mode is 7 μ A. If customers directly supply power to the V_BCKP pin in the shutdown state without performing the foregoing steps, the module will enter an unstable state and the current will exceed the nominal value.

The timing diagram indicating that the module enters backup mode after being powered on is as follows:

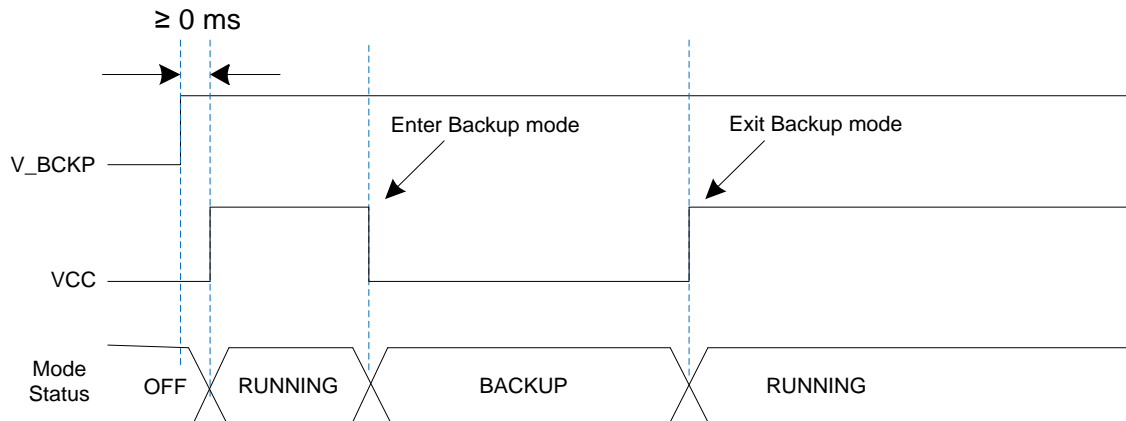


Figure 5: Backup Mode Sequence Diagram

NOTES

1. Keep FORCE_ON pin open or low before the module enters backup mode. Otherwise, the backup mode will be unavailable.
2. The two different methods of entering the backup mode have great impact on current consumption. Because the active antenna detection circuit is powered by VCC, the current consumption in the method of sending commands is larger than that in the method of cutting off VCC and keeping V_BCKP alive.

As the main power supply for V_BCKP pin is battery. The V_BCKP pin can be powered by an external capacitor and a rechargeable or non-rechargeable battery. A reference design of RTC backup power supply is illustrated below.

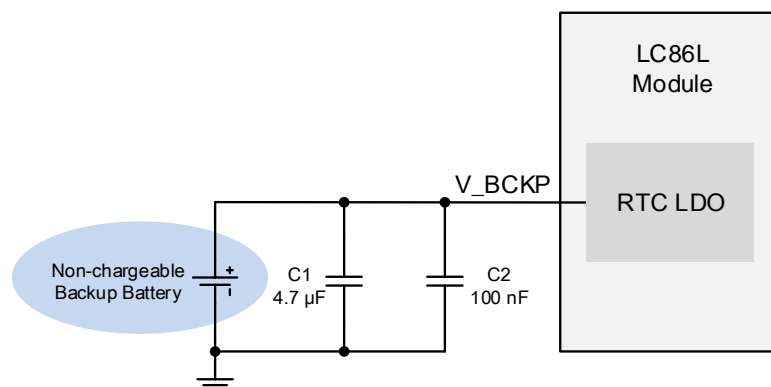


Figure 6: RTC Backup Power Supply (Non-chargeable Battery)

V_BCKP does not support battery charging function, therefore it is necessary to add an external charging circuit when a rechargeable battery is applied. A reference circuit is provided below.

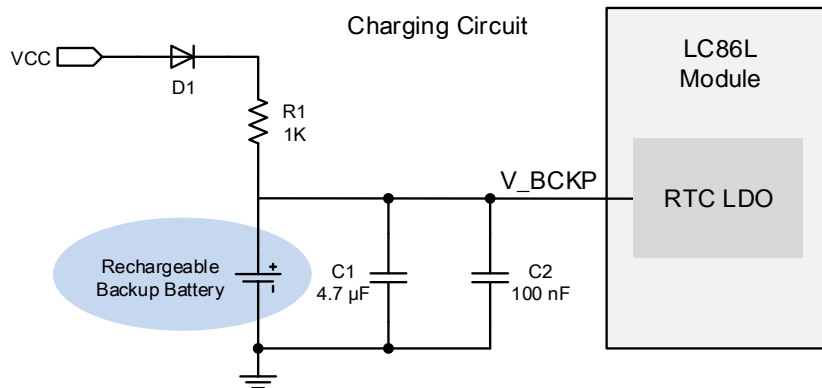


Figure 7: RTC Backup Power Supply (Rechargeable Battery)

Coin-type rechargeable capacitors from Seiko (<http://www.sii.co.jp/en/>) can be used and Schottky diodes from ON Semiconductor (<http://www.onsemi.com/>) are recommended due to their low voltage drop.

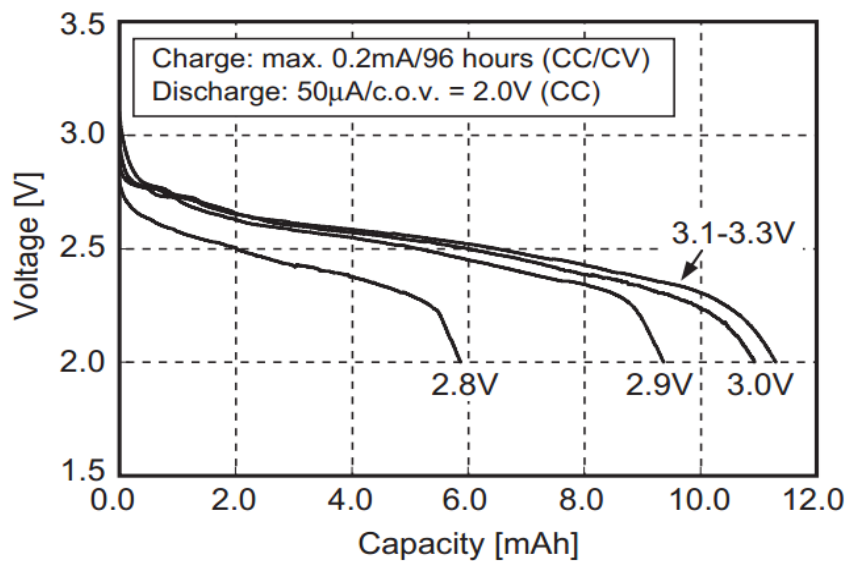


Figure 8: Seiko MS920SE Charge and Discharge Characteristics

3.4.4. Periodic Mode

Periodic Mode achieves the balance between positioning accuracy and power consumption, performance is a sacrifice compared to full on modes. In periodic mode, the module should be always supplied power and it switches between full on mode and standby/backup mode periodically to reduce power consumption. Periodic Mode contains periodic standby mode and periodic backup mode.

The command illustrated in the table below enables the module to enter periodic mode.

Table 7: PMTK Command Format

Format:		
\$PMTK225,<Type>,<Run Time>,<Sleep Time>,<Second Run Time>,<Second Sleep Time>* <Checksum><CR><LF>		
Parameter	Format	Description
Type	Decimal	Type = 1 for periodic backup mode Type = 2 for periodic standby mode
Run Time	Decimal	Run Time = Full on mode period (ms)
Sleep Time	Decimal	Sleep Time = Standby/Backup mode period (ms)
Second Run Time	Decimal	Second Run Time = Full on mode period (ms) for extended acquisition in case the module fails in acquisition during the Run Time
Second Sleep Time	Decimal	Second Sleep Time = Standby/Backup mode period (ms) for extended sleep in case the module fails in acquisition during the Run Time
Checksum	Hexadecimal	Hexadecimal checksum

Example

```
$PMTK225,2,3000,12000,18000,72000*15<CR><LF>
$PMTK225,1,3000,12000,18000,72000*16<CR><LF>
```

In periodic standby mode, sending **\$PMTK225,0*2B** at any time will make the module enter full on mode.

In periodic backup mode, pulling FORCE_ON high and sending **\$PMTK225,0*2B** immediately will make the module enter full on mode.

In periodic backup mode, sending **\$PMTK225,0*2B** in **Run Time** or **Second Run Time** will also make the module enter full on mode. However, this method is not recommended as the exact time to send the command is difficult the control.

NOTE

Before entering periodic backup mode, please ensure FORCE_ON pin is open or low, and power supply for V_BCKP is alive.

The following figure shows the operation of periodic mode. When receiving PMTK command, the module will be in the full on mode firstly. After several minutes, the module will enter into the periodic mode and follow the manually set parameters. When the module fails to fix the position in **run time**, the module will switch to **2nd_run_time** and **2nd_sleep_time** automatically. As long as the module fixes the position again, the module will return to **Run_time** and **Sleep_time**.

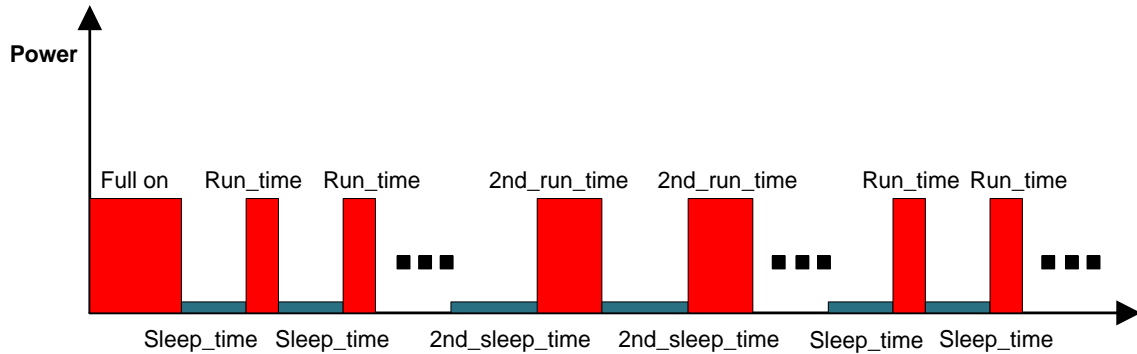


Figure 9: Periodic Mode

Please ensure that the module is in the tracking state before entering into periodic mode. Otherwise, the module will be at the risk of failure to track the satellites. If GPS module is located in weak signal environment, it is better to set a longer **2nd_run_time** to ensure the success of re-acquisition.

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

$$I_{\text{periodic}} = (I_{\text{tracking}} \times T1 + I_{\text{standby/backup}} \times T2) / (T1 + T2)$$

T1: **Run_time**, T2: **Sleep_time**

Example

PMTK225,2,3000,12000,18000,72000*15 for periodic mode with 3s in tracking mode and 12s in standby mode. The average current consumption is calculated below:

$$I_{\text{periodic}} = (I_{\text{tracking}} \times T1 + I_{\text{standby}} \times T2) / (T1 + T2) = 8.54(\text{mA})$$

PMTK225,1,3000,12000,18000,72000*16 for periodic mode with 3s in tracking mode and 12s in backup mode. The average current consumption is calculated below:

$$I_{\text{periodic}} = (I_{\text{tracking}} \times T1 + I_{\text{backup}} \times T2) / (T1 + T2) = 7.75(\text{mA})$$

3.4.5. 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 provides good positioning performance while operating in walking and running scenarios, and supports automatic dynamic duty operation switch for a balance on performance and power consumption. The module will be restored to normal mode in challenging environments to keep good accuracy, thus realizing maximum performance with the lowest power consumption.

The average current consumption in GLP mode is down to TBD mA in static scenario, which is about 50% of that in normal mode. It may increase a little bit in dynamic scenario.

GLP mode entering/exiting:

- **\$PQGLP,W,1,1*21**: The command is used to set the module into GLP mode. When **\$PQGLP,W,OK*09** is returned, it means the module has entered GLP mode successfully.
- **\$PQGLP,W,0,1*20**: The command is used to make the module exit GLP mode. When **\$PQGLP,W,OK*09** is returned, it means the module has exited GLP mode successfully

NOTES

1. It is recommended to set all the necessary commands before the module enters GLP mode. If customers need to send commands, please exit from GLP mode first.
2. When the module enters into GLP mode, 1PPS function will be disabled.
3. When the GLP mode is enabled, the SBAS will be affected.
4. In high dynamic scenario, the module will slightly decrease positioning accuracy in GLP mode.
5. The module will automatically return to the normal mode in complex environments to keep good positioning accuracy.
6. It is recommended that 115200 bps baud rate and 1 Hz frequency are set before the module enters into low power mode.

3.5. Power on

During normal powering on of the LC86L module, power is supplied to the VCC pin and the V_BCKP pin, and power is supplied to the VCC pin later than the V_BCKP pin. After being powered on, the module outputs the NMEA message through the serial port. The power-on sequence diagram is shown below.

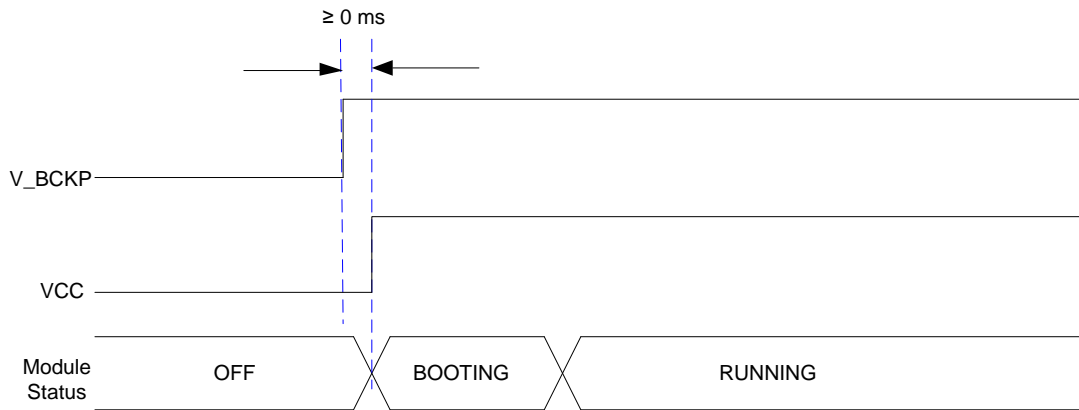


Figure 5: Power-on Timing

3.6. Reset

LC86L module can be restarted by driving RESET pin for at least 10 ms and then releasing it. This operation will reset the digital part of the GPS receiver. It should be noted that non-volatile backup RAM is not cleared after resetting and therefore a short TTFF is possible.

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

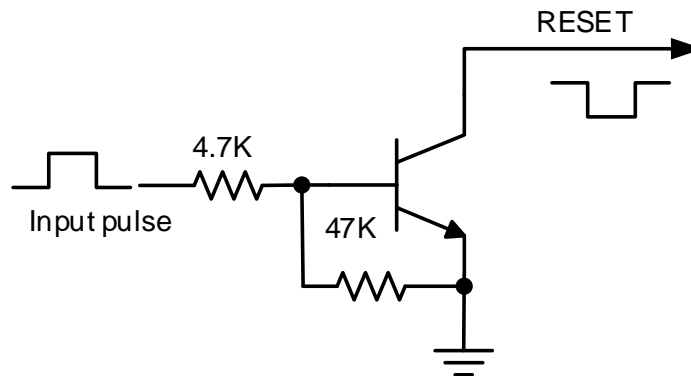


Figure 6: Reference Reset Circuit Using OC Circuit

The reset timing of LC86L is illustrated bellow.

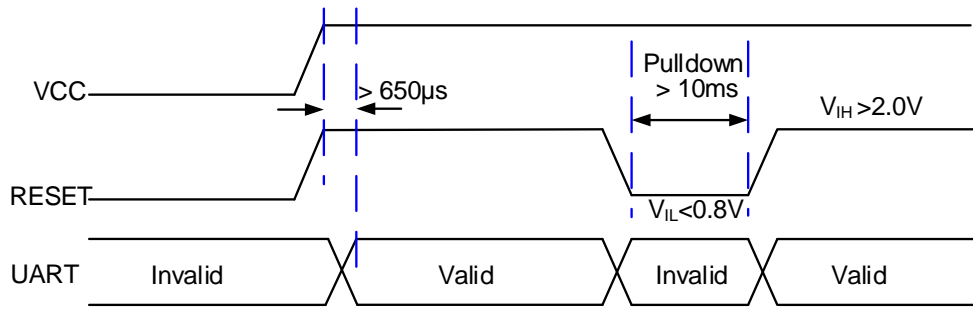


Figure 7: Restart Timing

3.7. UART Interface

The module provides one universal asynchronous receiver& transmitter serial port. The module is designed as DCE (Data Communication Equipment), following the traditional DCE-DTE (Data Terminal Equipment) connection. The module and the client (DTE) are connected through the signals shown in the following figure. It supports data baud rates from 9600 bps to 921600 bps.

Table 8: Pin Definition of UART Interface

Pin Name	Pin No.	I/O	Description	Comment
TXD	2	DO	Transmit data to the RX signal of DTE	The UART port is used for NMEA sentences output, PMTK/PQ commands input and firmware upgrade.
RXD	1	DI	Receive data from the TX signal of DTE	

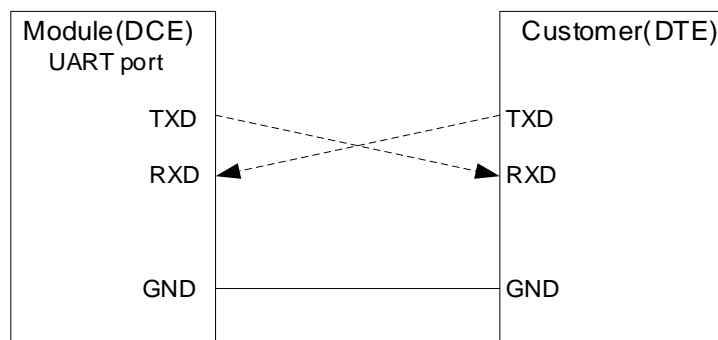


Figure 8: Connection of Serial Interfaces

This UART port has the following features:

- UART port can be used for firmware upgrade, NMEA output and PMTK proprietary commands input.
- The default output NMEA type setting is RMC, VTG, GGA, GSA, GSV, GLL and GPTXT.
- UART port supports the following baud rates:
9600, 14400, 19200, 38400, 57600, 115200, 230400, 460800, 921600 bps.
The default setting is 9600bps, 8 bits, no parity bit, 1 stop bit.
- Hardware flow control and synchronous operation are not supported.

The UART port does not support the RS-232 level but only CMOS level. If the module's UART port is connected to the UART port of a computer, it is necessary to add a level shift circuit between the module and the computer. Please refer to the following figure.

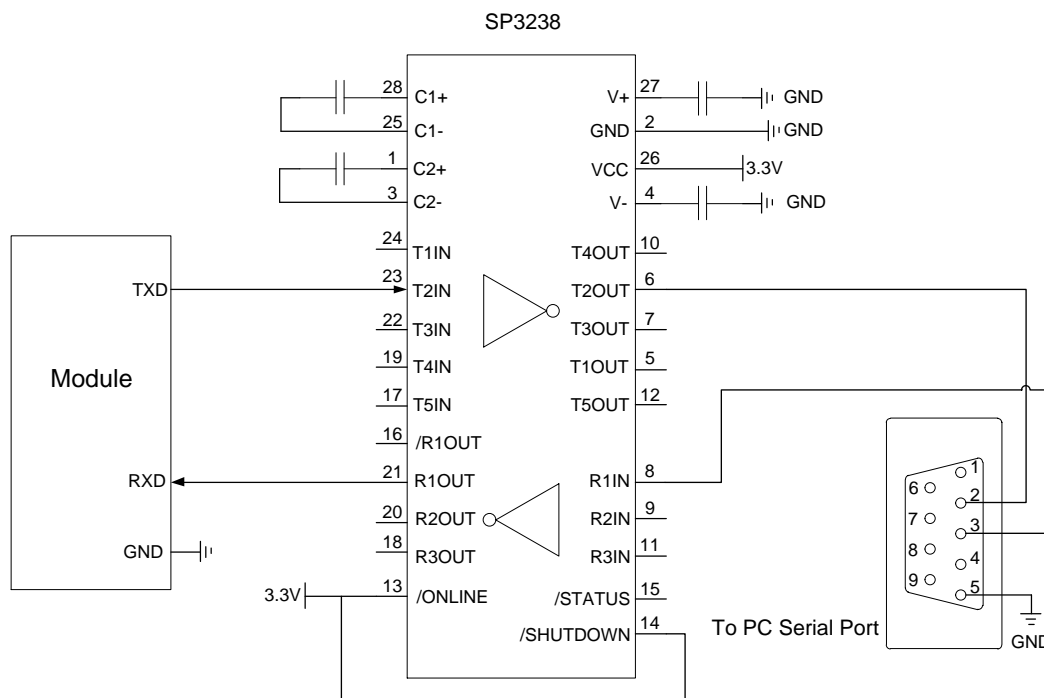


Figure 9: RS-232 Level Shift Circuit

The module provides 2.8 V UART interfaces. Another example with transistor translation circuit is shown as below. The circuit design of dotted line section can refer to the design of solid line section, in terms of both module input and output circuit designs, but please pay attention to the direction of connection.

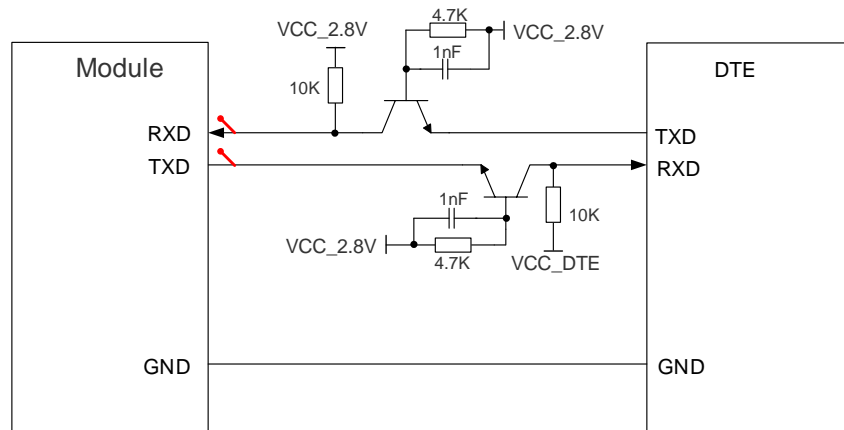


Figure 10: Reference Circuit with Transistor Circuit

3.8. EASY Technology

LC86L supports EASY™ technology which provides assistant information such as ephemeris, almanac, rough last position, time, and satellite status to improve TTFF and acquisition sensitivity of GNSS modules.

EASY technology works as embedded software which can accelerate TTFF by predicting satellite navigation messages from received ephemeris. The GPS engine will calculate and predict orbit information automatically up to 3 days after first receiving the broadcast ephemeris, and then save the predicted information into the internal memory. GPS engine will use the information for positioning if no enough information from satellites, so the function is helpful for positioning and TTFF improvement.

The EASY function can reduce TTFF to 5s 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.

EASY function is enabled by default. Command **\$PMTK869,1,0*34** can be used to disable EASY. For more details, please refer to the **document [1]**.

3.9. Single-tone AIC

LC86L module provides an advanced technology called single-tone AIC (Active Interference Cancellation) to reject RF interference which comes from other active components on the main board.

Up to 12 single-tone AIC embedded in the module can provide effective narrow-band interference and jamming elimination. The GPS signal could be recovered from the jammed signal, which can ensure better navigation quality. AIC is enabled by default, closing it will save about TBD mA @VCC = 3.3 V consumption. The following commands can be used to set AIC.

Enable AIC function: **\$PMTK 286,1*23**.

Disable AIC function: **\$PMTK 286,0*22**.

3.10. LOCUS

LC86L supports the embedded logger function called LOCUS. It can log position information to the internal flash memory automatically when this function is enabled with **\$PMTK185,0*22**. Due to this function, the host can enter sleep mode to save power consumption and does not need to receive the NMEA information all the time. The module provides a log capacity of more than 16 hours. **\$PMTK183*38** can be used to query the current state of LOCUS.

The detailed procedures of this function are illustrated below:

- The module fixes the position (only available in 3D fixed scenario).
- Send PMTK command **\$PMTK184,1*22** to erase the internal flash.
- Send PMTK command **\$PMTK185,0*22** to start logging.
- The module logs the basic information (UTC time, latitude, longitude and height) every 15 seconds to the internal flash memory.
- Stop logging the information by sending **\$PMTK185,1*23**.
- Send **\$PMTK622,1*29** command via UART to the module to get the data .

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

3.11. Antenna Supervisor

Antenna Supervisor is designed to detect different external active antenna status including external active antenna connection, open circuit for antenna and antenna short-circuited, and then notify the module. The detections and notifications of external active antenna are listed in the following table.

Table 9: External Active Antenna Status

Status of the Antenna	EXT/Patch	NMEA Message
External active antenna is not connected	Patch	OPEN
External active antenna is connected and works normally	EXT	OK
External active antenna is connected but short-circuited	Patch	SHORT

3.12. PPS VS. NMEA

Pulse per Second (PPS) VS. NMEA can be used for time service. The latency range is 465 ms and 485 ms between the beginning of UART_TX and the rising edge of PPS.

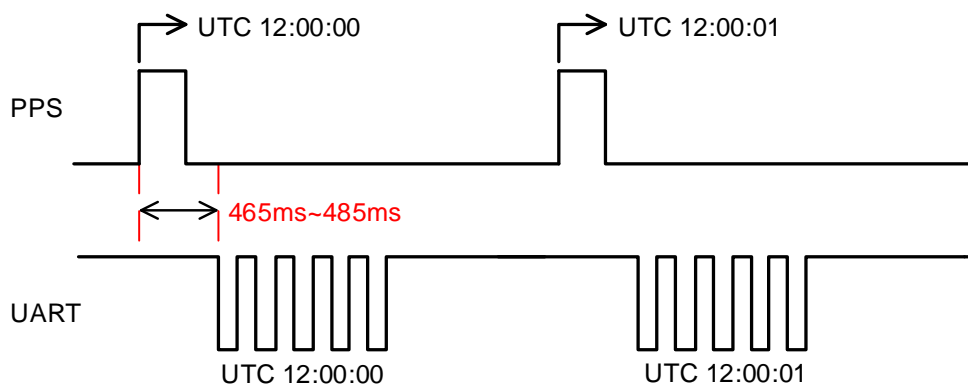


Figure 11: PPS VS. NMEA Timing

The feature only supports 1 Hz NMEA sentences output.

- Enable the function: **\$PMTK255,1*2D**
- Disabled the function: **\$PMTK255,0*2C**

4 Built-in Antennas and External Antenna Interfaces

LC86L module receives L1 band signal, supports GPS, GLONASS, BeiDou, QZSS systems. The LNA is embedded for better performance. It is an ultra-compact module with embedded 15.0 × 15.0 × 4.0mm patch antenna. In addition, LC86L can also support external active antenna, and the RF signal is obtained from the EX_ANT pin. Both internal patch signal and external active antenna signal are intelligently switched through SPDT.

4.1. Internal Patch Antenna

4.1.1. 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 5mm away from the nearest edge of the Motherboard, that is, it is better to be placed in the center of the Motherboard.

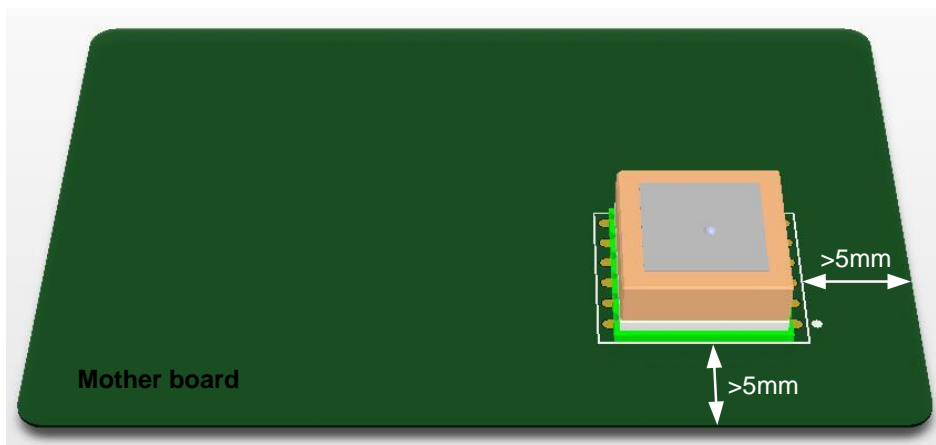


Figure 17: Recommended Distance between Module and Motherboard Edges

- The position on the Motherboard corresponding to the feed point of the patch antenna should be kept out on each layer, and the diameter of the keepout area should not be less than 2.5 mm.

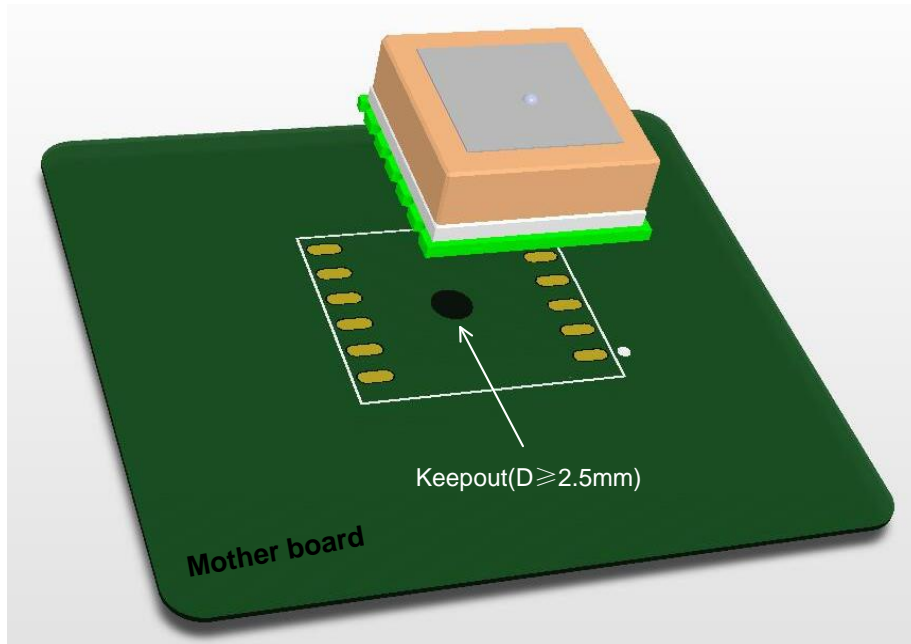


Figure 18: Recommended Treatment for the Feed Point of the Patch Antenna

- Make sure the antenna points to the sky.
- The performance of embedded patch antenna depends on the actual size of the ground plane around the module. It is recommended to design a 30mm×30mm ground plane shown below. In addition, no components especially thick components can be placed in the areas in any case (interfering vias are not allowed either).

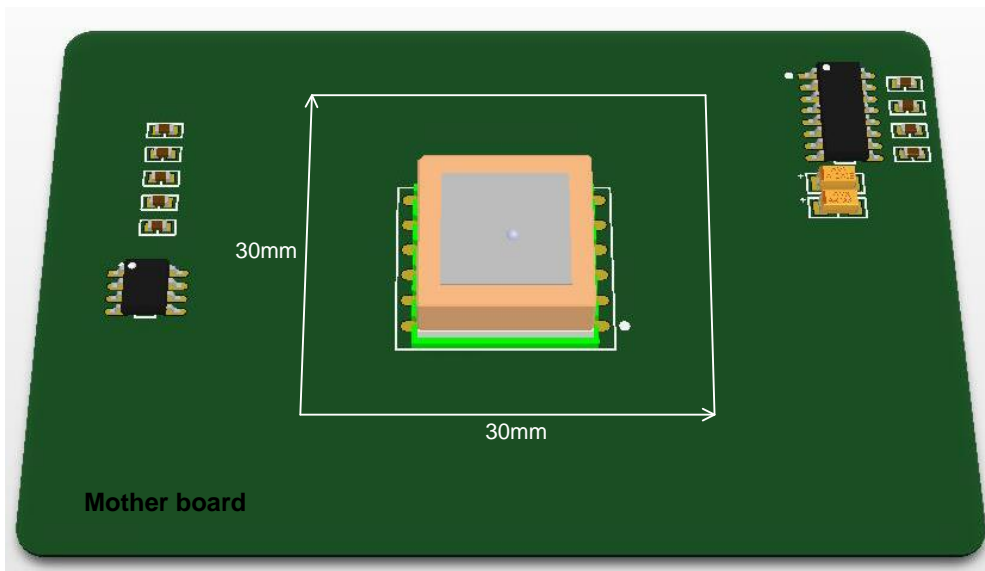


Figure 19: Recommended Ground Plane

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

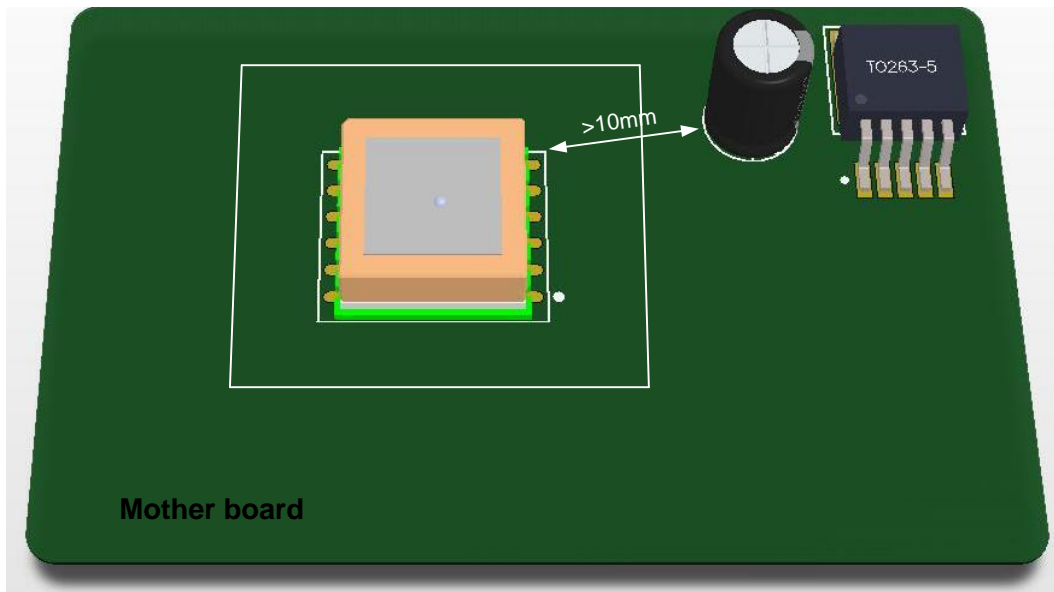


Figure 12: Recommended Distance between Module and Tall Metal Components

- 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, such as in diagonal position of the Motherboard.

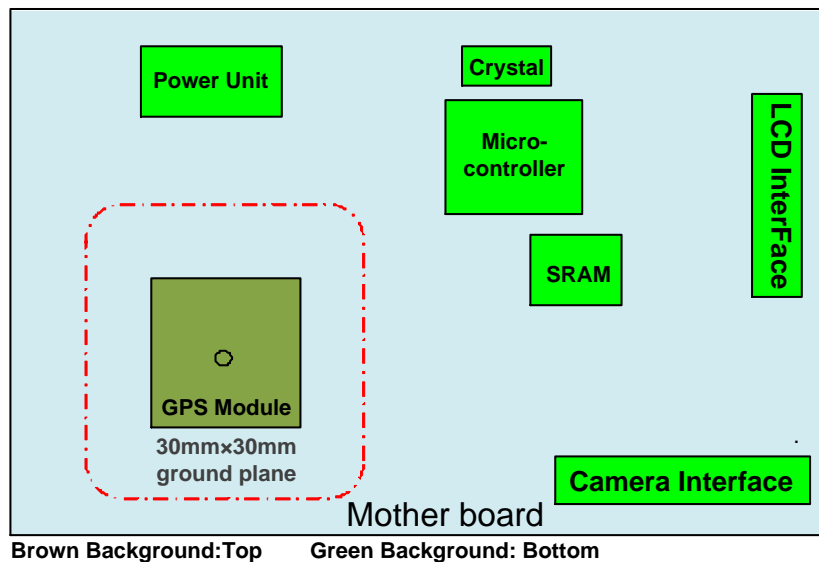


Figure 13: Recommended Placement of GNSS Module

- Make sure interfering signals (USB, LCD, Camera, Crystal, etc.) are in inner layer and shielded by ground plane, and keep them and their vias far away from the module.
- Make sure RF system such as BT/Wi-Fi/GSM is on the opposite side of the module, and keep them away from the module as far as possible, such as in diagonal position of the board.

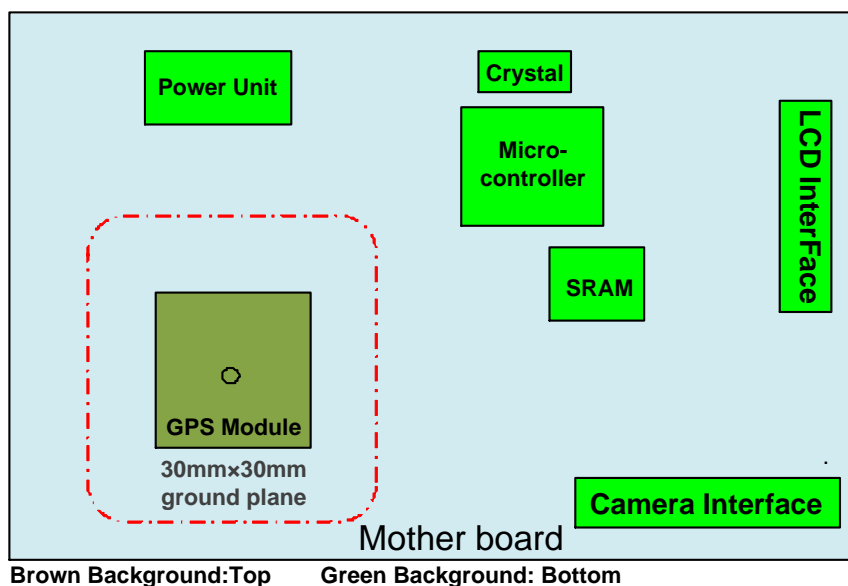


Figure 14: Recommended Placement of GNSS Module with the RF System

- Keep DC-DC far away from the module.
- Device enclosure should be made of non-metal materials especially for those which are around antenna area. The minimum distance between antenna and enclosure is 3mm.
- The RF part of GPS module is sensitive to temperature. Please keep them away from heat-emitting circuit.
- It is recommended to reserve an integrate ground layer to isolate GPS module from others.

4.1.2. 15.0 mm × 15.0 mm × 4.0 mm Patch Antenna

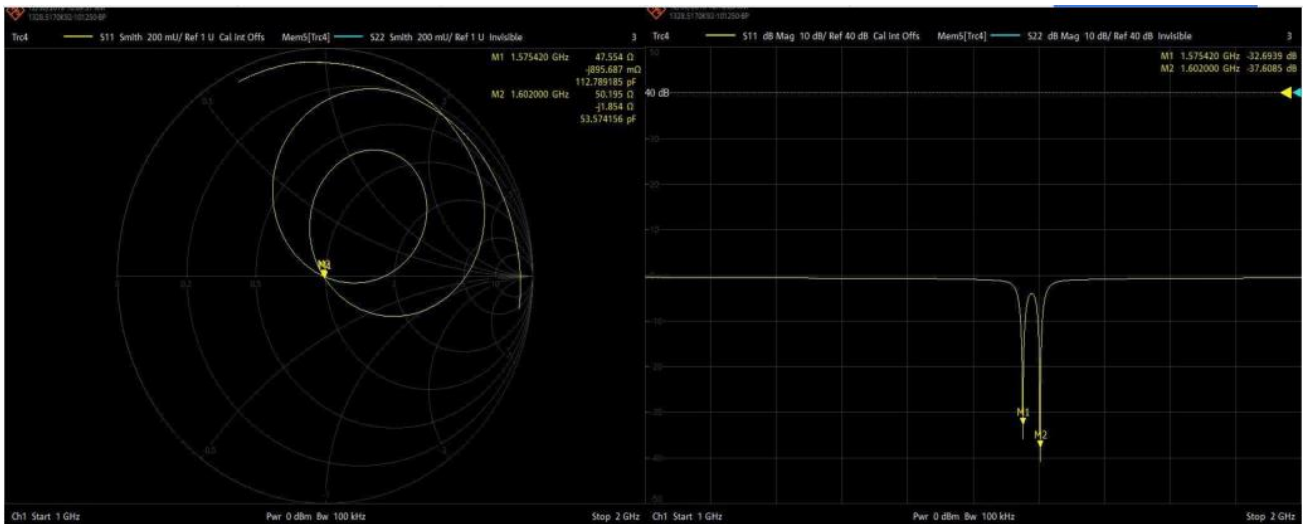
LC86L module is designed with an 15.0 mm × 15.0 mm × 4.0 mm high-performance patch antenna. Its specification is described in the following table. (Default configuration: GPS + GLONASS or GPS + BeiDou)

Table 10: Patch Antenna Specifications (with Ground Plane 100 mm × 60 mm)

Antenna Type	Parameter	Specification	Notes
Patch Antenna	Size	15.0 mm × 15.0 mm × 4.0 mm	
	Range of Receiving Frequency	GPS L1 C/A (1574.397MHz –1576.443MHz) GLONASS L1(1597.781MHz –1605.656MHz)	
	Impedence	50 Ω	

Bandwidth	10 MHz minimum	Return Loss \leq -10 dB
Frequency Temperature Coefficient (TF)	0 \pm 20 ppm/ $^{\circ}$ C	-40 $^{\circ}$ C to +85 $^{\circ}$ C
Polarization	RHCP	Right Hand Circular Polarization
Gain at Zenith	2.9 dBi typ.	Centre frequency
VSWR	1.5 max	

The test result of the antenna is shown 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.



GPS+GLONASS	Impedance (Ω)	Return Loss (dB)
1575.42	47.55-j0.89	-32.69
1602	50.19-j1.85	-37.60

Figure 15: Patch Antenna Test Result with Ground Plane 100 mm x 60 mm

4.2. External Active Antenna

The following figure is a typical reference design with active antenna. In this mode, DC on the EX_ANT pin is powered by VCC and supplies power to the external active antenna.

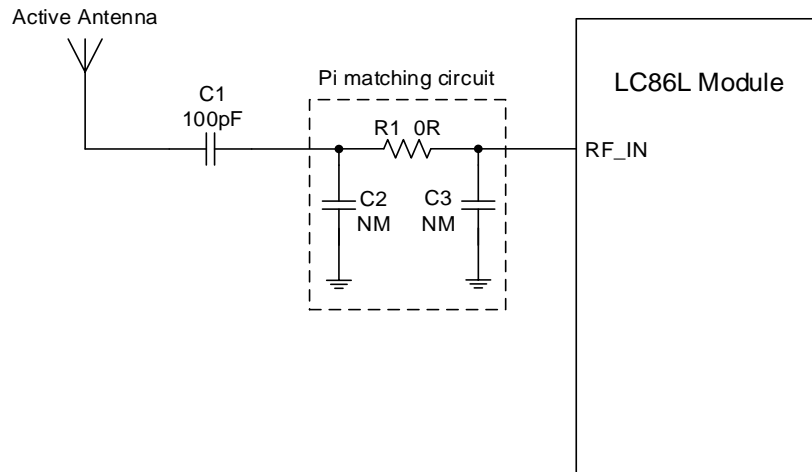


Figure 16: Reference Design for Active Antenna

C2, C3 are reserved matching circuit for antenna impedance modification. By default, C2 and C3 are not mounted; R1 is 0 Ω , C1 is 100 pF.

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.

Table 11: Recommended Active Antenna Specification

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

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) GPS active antenna. The DC-impedance can also be measured with a common and simple multimeter on few samples, and the value is generally in M Ω level.

4.3. Antenna Status Indicator

LC86L module supports automatic antenna switching function. The GPTXT sentence can be used to identify the status of external active antenna.

If **ANTSTATUS=OPEN**, it means external active antenna is not connected or has poor contact with antenna feeding point and the internal antenna is used.

If **ANTSTATUS=OK**, it means external active antenna is connected and the module will use external active antenna.

If **ANTSTATUS=SHORT**, it means active antenna is short-circuited and the internal patch antenna will be used automatically.

NOTES

1. When customers use external active antenna and the “OPEN” is displayed in the GPTXT of NMEA sentence, customers have to check the connection status of external active antenna.
2. If the external active antenna is short-circuited, the “SHORT” will be displayed in the GPTXT of NMEA sentence.
3. Because antenna short protection is enabled by default, LC86L will switch to embedded patch antenna automatically in case that external active antenna is short-circuited, which will avoid LC86L from damage. Meanwhile, customers need to check the external active antenna.

Example

“OPEN” is displayed in the GPTXT sentence below.

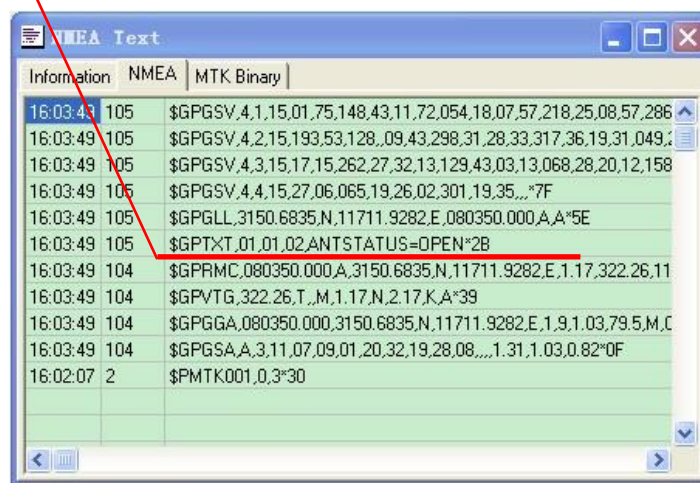


Figure 17: Patch Antenna Status Description in GPSTXT

Table 12: GPTXT - Status of Antenna

GPTXT Display	Ext Active Antenna Status	Inner Patch Antenna Status	Attention
OPEN	Unused	Working	Customers need to check the external active antenna status if the active antenna is used.
OK	Working	Unused	
SHORT	Short	Working	Please check the external active antenna

The pin “AADET_N” can also be used to indicate the status of active antenna. When active antenna is not connected to EX_ANT or has poor contact with antenna feeding point, AADET_N will keep a high level to indicate the active antenna absence. AADET_N will change to a low level when active antenna is connected well.

NOTE

Active antenna is ONLY available when the voltage of AADET_N is less than or equal to 0.7 V.

5 Electrical, Reliability and Radio Characteristics

5.1. Absolute Maximum Ratings

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

Table 13: Absolute Maximum Ratings

Parameter	Min.	Max.	Unit
Power Supply Voltage (VCC)	-0.3	4.3	V
Backup Battery Voltage (V_BCKP)	-0.3	4.3	V
Input Voltage at Digital Pins	-0.3	3.6	V
Input Power at EX_ANT		15	dBm
Storage Temperature	-45	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. Thus, it is necessary to utilize appropriate protection diodes to keep voltage spikes within the parameters given in the table above.

5.2. Operating Conditions

Table 14: Power Supply Ratings

Parameter	Description	Conditions	Min.	Typ.	Max.	Unit
VCC	Supply voltage	Voltage must stay within the min/max values, including voltage drop, ripple, and spikes.	2.8	3.3	4.3	V
I _{VCCP}	Peak supply current	VCC = 3.3 V			100	mA
V _{BCKP}	Backup voltage supply		2.0	3.3	4.3	V
T _{OPR}	Normal operating temperature		-40	25	85	°C

NOTES

1. The figure I_{VCCP} can be used to determine the maximum current capability of power supply.
2. Operation beyond the "Operating Conditions" is not recommended and extended exposure beyond the "Operating Conditions" may affect the device's reliability.

5.3. Current Consumption

Table 15: Current Consumption

Module	Conditions	Acquisition @ 3.3 V	Tracking @ 3.3 V	Standby @ 3.3 V	Backup @ V _{BCKP} = 3.3 V
	@ -130 dBm GPS	26.8 mA	22.8 mA		
LC86L	@ -130 dBm GPS+ GLONASS	31.8 mA	31.5 mA	1.4 mA	6 μA
	@ -130 dBm GPS+ BeiDou	TBD	TBD		

NOTES

Test conditions for the current consumption in tracking mode:

- In cold start: 15 minutes after the first fix.

- In hot start: 15 seconds after the first fix.

5.4. Electrostatic Discharge

LC86L module is an ESD sensitive device. ESD protection precautions should still be emphasized. Proper ESD handling and packaging procedures must be followed throughout the processing, handling and operation of any application.

Please note that the following measures are beneficial to ESD protection when LC86L is handled.

- The first contact point shall always be between the local GND and PCB GND when handling the PCB, unless there is a galvanic coupling between the local GND and the PCB GND.
- While mounting the module onto a motherboard, please make sure the GND is connected first and then the RF_IN pad.
- Do not contact any charged capacitors or materials which may easily generate or store charges (such as patch antenna, coaxial cable, soldering iron, etc.) when handling the RF_IN pad.
- To prevent electrostatic discharge from the RF input, please do not touch any exposed area of the mounted patch antenna.
- Be sure to use an ESD safe soldering iron (tip) when soldering the RF_IN pin.

6 Mechanical Dimensions

This chapter describes the mechanical dimensions of the module.

6.1. Mechanical Dimensions

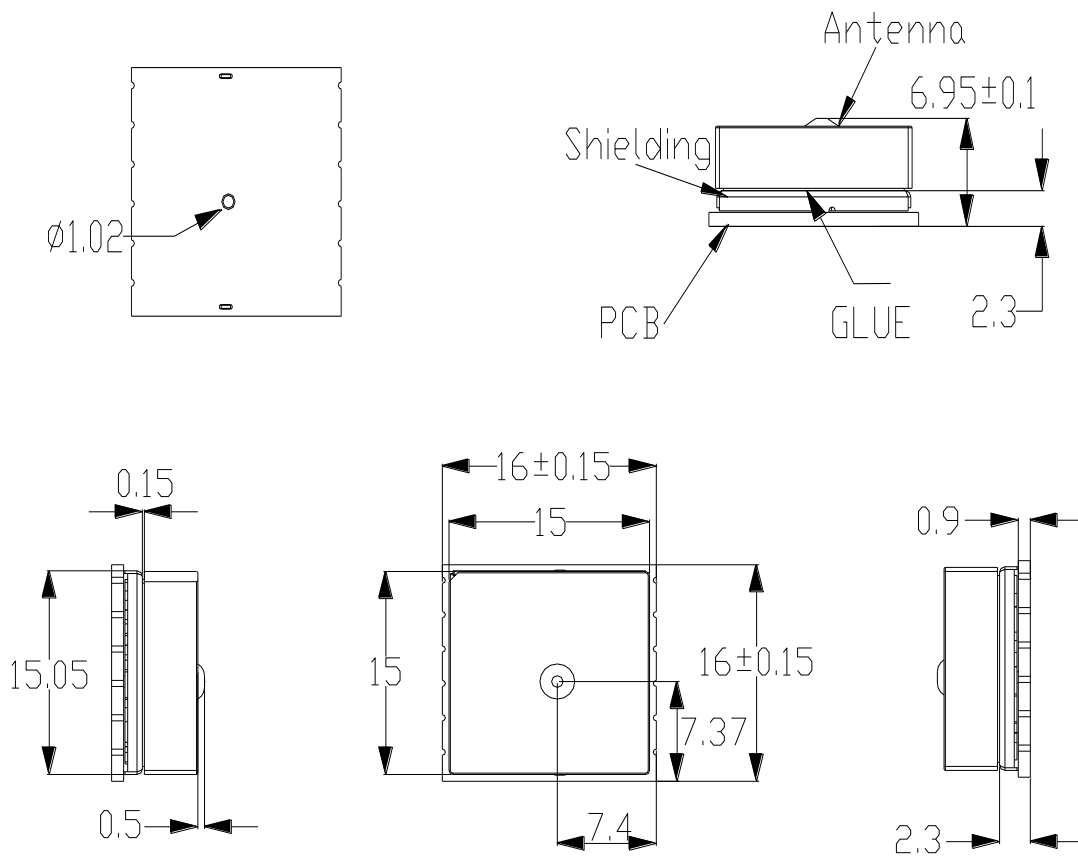


Figure 18: Top and Side Dimensions (Unit: mm)

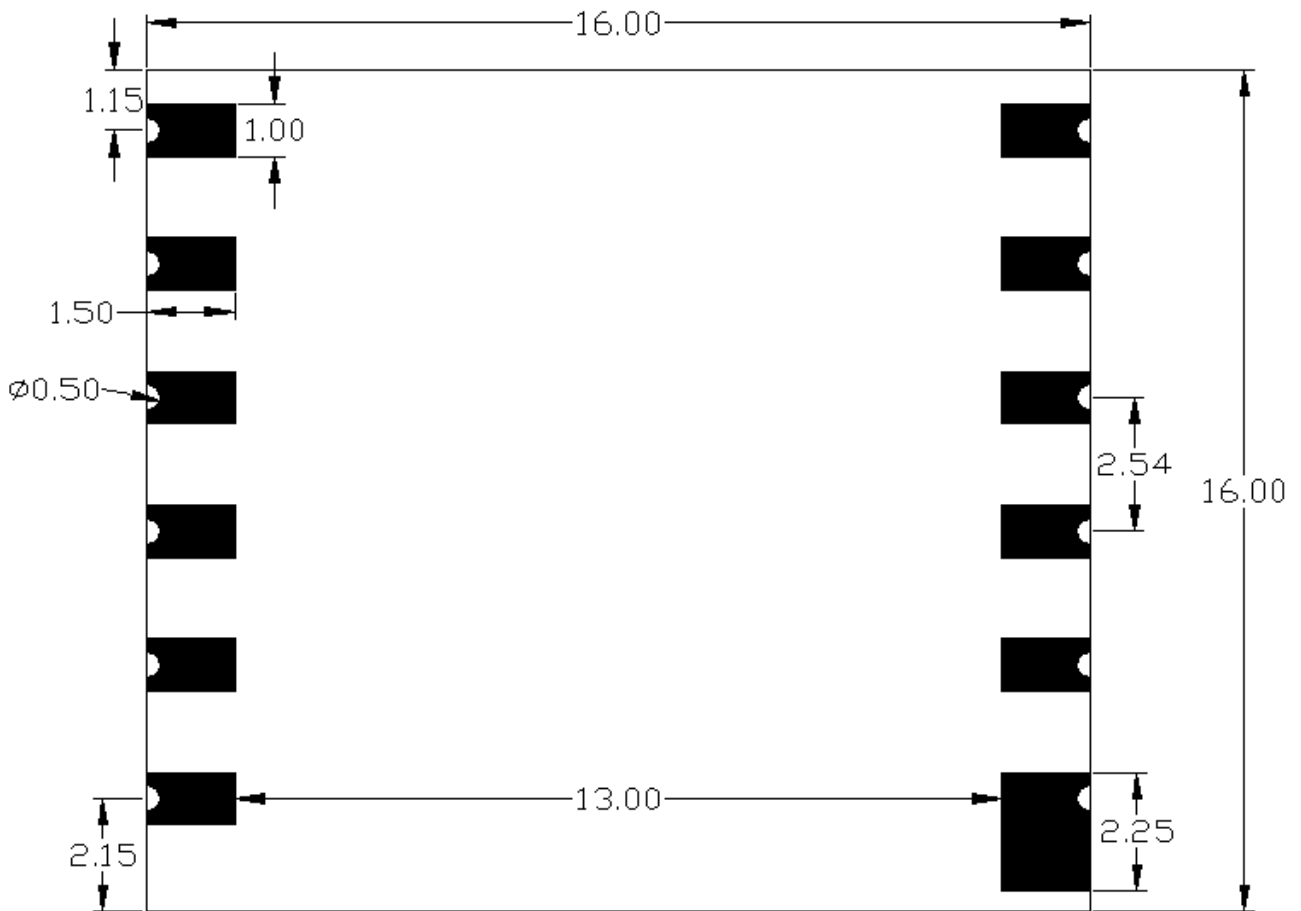


Figure 27: Bottom View Dimensions (Unit: mm)

NOTE

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

6.2. Recommended Footprint

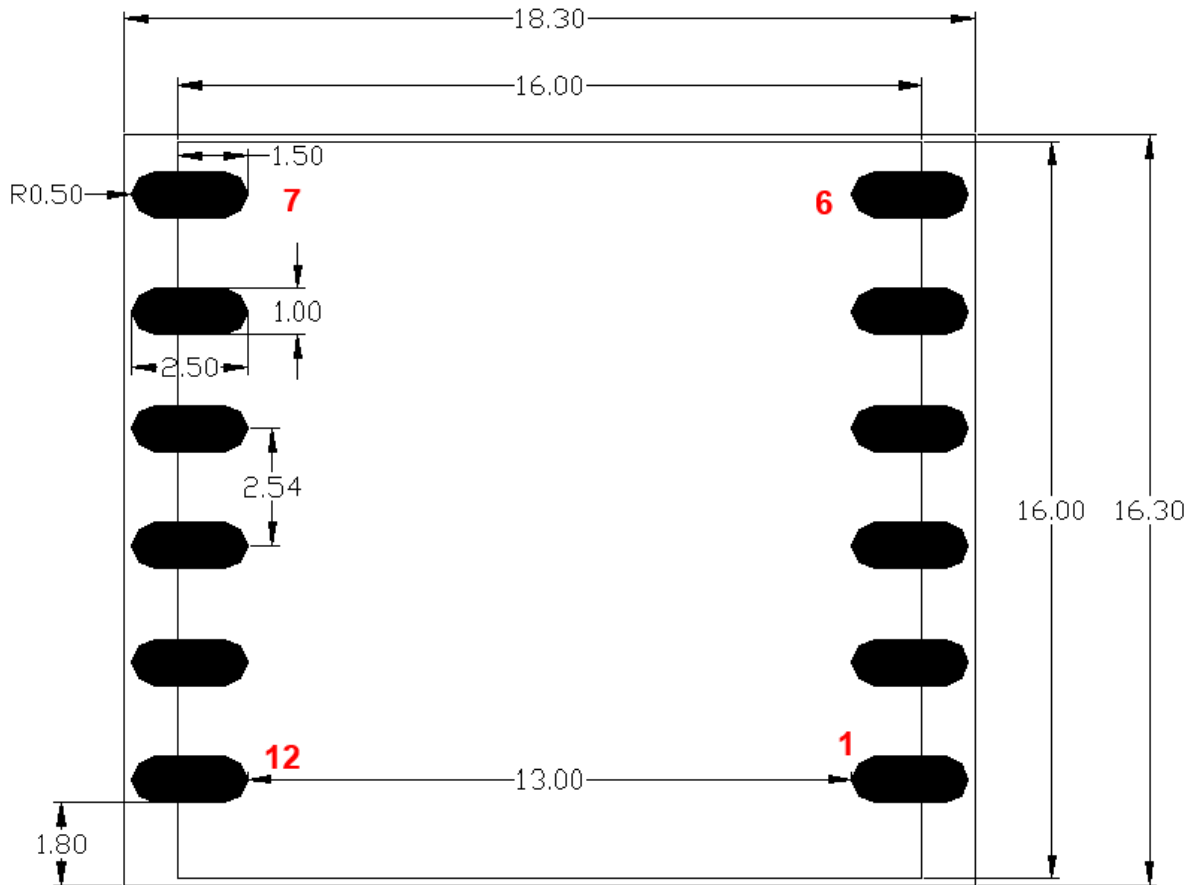


Figure 28: Recommended Footprint (Unit: mm)

NOTE

For easy maintenance, please keep a distance of no less than 3 mm between the module and other components on the motherboard.

6.3. Top and Bottom Views

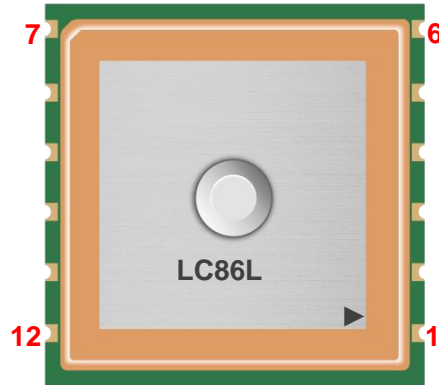


Figure 29: Top View of the Module

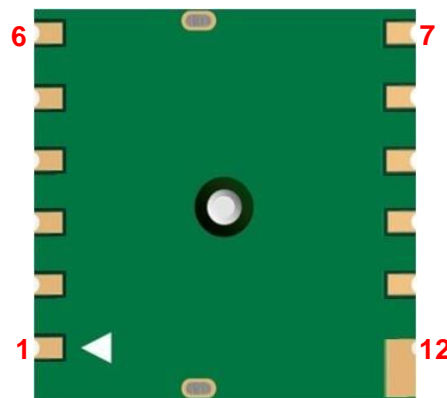


Figure 19: Bottom View of the Module

NOTES

1. The incision of the patch antenna does not indicate the position of pin 1.
2. These are renderings of LC86L module. For authentic appearance, please refer to the module received from Quectel.

7 Storage, Manufacturing and Packaging

7.1. Storage

LC86L module is provided with vacuum-sealed packaging. MSL of the module is rated as 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. The storage life (in vacuum-sealed packaging) is 12 months in Recommended Storage Condition.
3. The floor life of the module is 24 hours in a plant where the temperature is 23 ± 5 °C and relative humidity is below 60%. After the vacuum-sealed packaging is removed, the module must be processed in reflow soldering or other high-temperature operations within 24 hours. Otherwise, the module should be stored in an environment where the relative humidity is less than 10% (e.g. a drying cabinet).
4. The module should be pre-baked to avoid blistering, cracks and inner-layer separation in PCB under the following circumstances:
 - The module is not stored in Recommended Storage Condition;
 - Violation of the third requirement above occurs;
 - 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;
 - All modules must be soldered to PCB within 24 hours after the baking, otherwise they should be put in a dry environment such as in a drying oven.

NOTE

Please take the module out of the packaging and put it on high-temperature resistant fixtures before the baking. If shorter baking time is desired, please refer to *IPC/JEDEC J-STD-033* for baking procedure.

7.2. Manufacturing and Soldering

Push the squeegee to apply the solder paste on the surface of stencil, thus making the paste fill the stencil openings and then penetrate to the PCB. The force on the squeegee should be adjusted properly so as to produce a clean stencil surface on a single pass. To ensure the module soldering quality, the thickness of stencil for the module is recommended to be 0.15–0.18 mm. For more details, please refer to **document [4]**.

It is suggested that the peak reflow temperature is 238–246 °C, and the absolute maximum reflow temperature is 246 °C. To avoid damage to the module caused by repeated heating, it is strongly recommended that the module should be mounted after reflow soldering for the other side of PCB has been completed. The recommended reflow soldering thermal profile (lead-free reflow soldering) and related parameters are shown below.

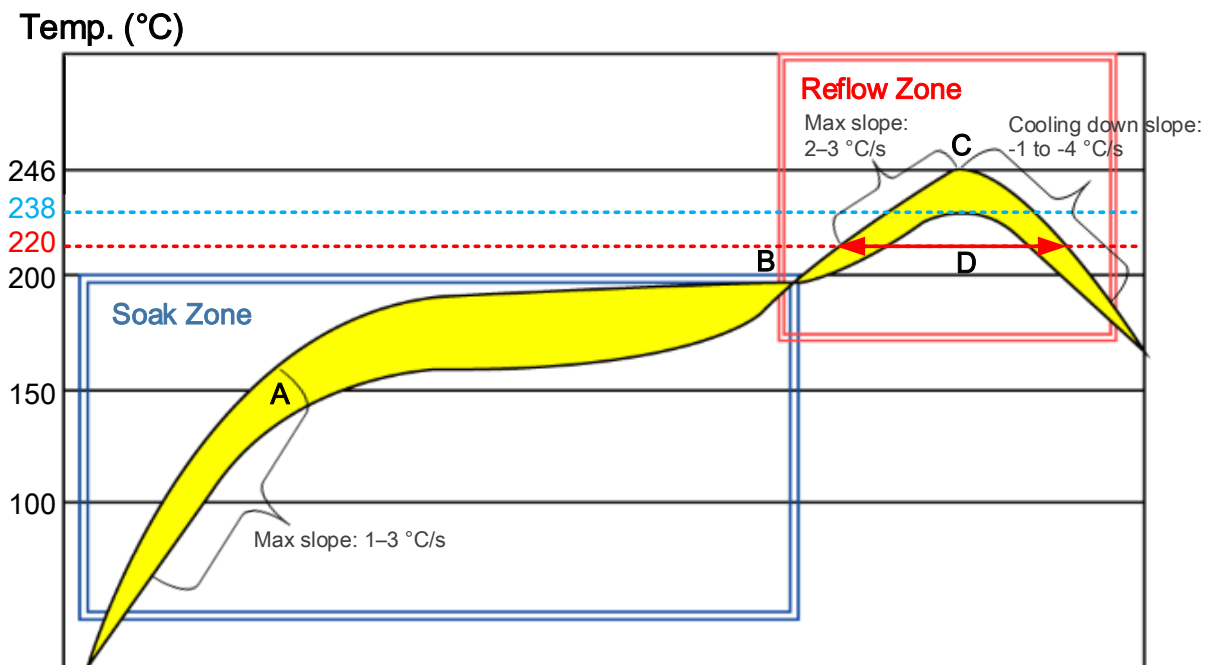


Figure 20: Recommended Reflow Soldering Thermal Profile

Table 16: 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 220 °C)	45–70 s
Max temperature	238–246 °C
Cooling down slope	-1 to -4 °C/s

Reflow Cycle

Max reflow cycle	1
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NOTES

1. During manufacturing and soldering, or any other processes that may contact the module directly, NEVER wipe the module's shielding can with organic solvents, such as acetone, ethyl alcohol, isopropyl alcohol, trichloroethylene, etc. Otherwise, the shielding can may become rusted.
2. The shielding can for the module is made of Cupro-Nickel base material. It is tested that after 12 hours' Neutral Salt Spray test, the laser engraved label information on the shielding can is still clearly identifiable and the QR code is still readable, although white rust may be found.

7.3. Packaging

The modules are stored inside a vacuum-sealed bag under ESD protection. It should not be opened until the devices are ready to be soldered onto the application.

7.3.1. Tape and Reel Packaging

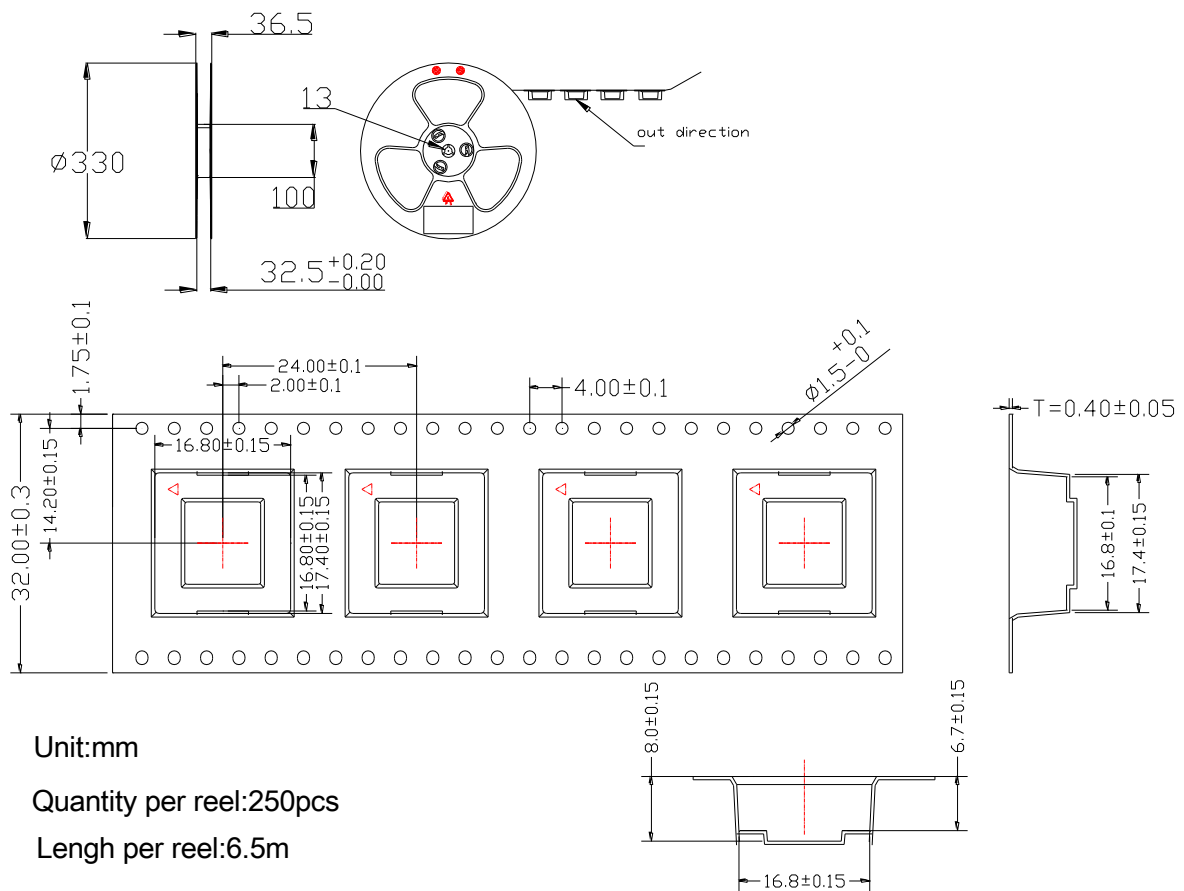


Figure 21: Tape and Reel Specifications (Unit: mm)

Table 17: Reel Packaging

Model Name	MOQ for MP	Minimum Package: 250	Minimum Package x 4 = 1000
LC86L	250	Size: 370 mm x 350 mm x 5 6mm N.W: 1.5 kg G.W: 2.25 kg	Size: 380 mm x 250 mm x 365 mm N.W: 6.1 kg G.W: 9.4 kg

8 Appendix A References

Table 18: Related Documents

SN	Document Name	Remark
[1]	Quectel_L76-LB&L26-LB&LC86L_GNSS_Protocol_Specification	LC86L, L76-LB and L26-LB GNSS protocol specification
[2]	Quectel_LC86L_EVB_User Guide	LC86L EVB user guide
[3]	Quectel_L80&L86&LC86L_Reference_Design	LC86L/L86/L80 reference design
[4]	Quectel_Module_Secondary_SMT_Application_Note	Secondary SMT user guide for Quectel modules
[5]	Quectel_GNSS_SDK_Commands_Manual	GNSS SDK Commands Manual

Table 19: Terms and Abbreviations

Abbreviation	Description
AGPS	Assisted GPS
AIC	Active Interference Cancellation
CEP	Circular Error Probable
DGPS	Differential GPS
EASY	Embedded Assist System
EGNOS	European Geostationary Navigation Overlay Service
ESD	Electrostatic Discharge
GPS	Global Positioning System
GNSS	Global Navigation Satellite System
GGA	GPS Fix Data

GLL	Geographic Position - Latitude/Longitude
GLONASS	Global Navigation Satellite System
GSA	GNSS DOP and Active Satellites
GSV	GNSS Satellites in View
I/O	Input/Output
Kbps	Kilo Bits Per Second
LNA	Low Noise Amplifier
MSAS	Multi-functional Satellite Augmentation System
MOQ	Minimum Order Quantity
NMEA	National Marine Electronics Association
PMTK	MTK Proprietary Protocol
PPS	Pulse Per Second
QZSS	Quasi-Zenith Satellite System
RHCP	Right Hand Circular Polarization
RMC	Recommended Minimum Specific GNSS Data
SBAS	Satellite-based Augmentation System
SAW	Surface Acoustic Wave
SPDT	Single-Pole Double-Throw
TTFF	Time To First Fix
UART	Universal Asynchronous Receiver & Transmitter
VTG	Course over Ground and Ground Speed, Horizontal Course and Horizontal Velocity
WAAS	Wide Area Augmentation System
Inom	Nominal Current
Imax	Maximum Load Current
Vmax	Maximum Voltage Value
Vnom	Nominal Voltage Value

V_{min}	Minimum Voltage Value
V_{IHmax}	Maximum Input High Level Voltage Value
V_{IHmin}	Minimum Input High Level Voltage Value
V_{ILmax}	Maximum Input Low Level Voltage Value
V_{ILmin}	Minimum Input Low Level Voltage Value
V_{Imax}	Absolute Maximum Input Voltage Value
V_{Imin}	Absolute Minimum Input Voltage Value
V_{OHmax}	Maximum Output High Level Voltage Value
V_{OHmin}	Minimum Output High Level Voltage Value
V_{OLmax}	Maximum Output Low Level Voltage Value
V_{OLmin}	Minimum Output Low Level Voltage Value
