

# LC86L Hardware Design

## GNSS Module Series

Version: 1.0

Date: 2020-09-18

Status: Released



**Our aim is to provide customers with timely and comprehensive service. For any assistance, please contact our company headquarters:**

**Quectel Wireless Solutions Co., Ltd.**

Building 5, Shanghai Business Park Phase III (Area B), No.1016 Tianlin Road, Minhang District, Shanghai 200233, China

Tel: +86 21 5108 6236

Email: [info@quectel.com](mailto:info@quectel.com)

**Or our local office. For more information, please visit:**

<http://www.quectel.com/support/sales.htm>.

**For technical support, or to report documentation errors, please visit:**

<http://www.quectel.com/support/technical.htm>

Or email to [support@quectel.com](mailto:support@quectel.com).

## **General Notes**

Quectel offers the information as a service to its customers. The information provided is based upon customers' requirements. Quectel makes every effort to ensure the quality of the information it makes available. Quectel does not make any warranty as to the information contained herein, and does not accept any liability for any injury, loss or damage of any kind incurred by use of or reliance upon the information. All information supplied herein is subject to change without prior notice.

## **Disclaimer**

While Quectel has made efforts to ensure that the functions and features under development are free from errors, it is possible that these functions and features could contain errors, inaccuracies and omissions. Unless otherwise provided by valid agreement, Quectel makes no warranties of any kind, implied or express, with respect to the use of features and functions under development. To the maximum extent permitted by law, Quectel excludes all liability for any loss or damage suffered in connection with the use of the functions and features under development, regardless of whether such loss or damage may have been foreseeable.

## **Duty of Confidentiality**

The Receiving Party shall keep confidential all documentation and information provided by Quectel, except when the specific permission has been granted by Quectel. The Receiving Party shall not access or use Quectel's documentation and information for any purpose except as expressly provided herein. Furthermore, the Receiving Party shall not disclose any of the Quectel's documentation and information to any third party without the prior written consent by Quectel. For any noncompliance to the above requirements, unauthorized use, or other illegal or malicious use of the documentation and information, Quectel will reserve the right to take legal action.

## Copyright

The information contained here is proprietary technical information of Quectel Wireless Solutions Co., Ltd. Transmitting, reproducing, disseminating and editing this document as well as using the content without permission are forbidden. Offenders will be held liable for payment of damages. All rights are reserved in the event of a patent grant or registration of a utility model or design.

***Copyright © Quectel Wireless Solutions Co., Ltd. 2020. All rights reserved.***

# About the Document

## Revision History

Version	Date	Author	Description
1.0	2020-09-18	Ronnie HU/ Keith ZHANG	Initial

---

## Contents

<b>About the Document</b> .....	<b>3</b>
<b>Contents</b> .....	<b>4</b>
<b>Table Index</b> .....	<b>6</b>
<b>Figure Index</b> .....	<b>7</b>
<b>1 Introduction</b> .....	<b>8</b>
1.1. Safety Information.....	8
<b>2 Product Concept</b> .....	<b>9</b>
2.1. Specifications.....	10
2.2. Block Diagram.....	11
2.3. Supported Protocols.....	12
2.4. Evaluation Board.....	13
<b>3 Application Functions and Interfaces</b> .....	<b>14</b>
3.1. Pin Assignment.....	14
3.2. Pin Definition.....	15
3.3. Power Supply.....	17
3.3.1. Internal Power-System Construction.....	17
3.4. Operating Modes.....	18
3.4.1. Full-On Mode.....	19
3.4.2. Standby Mode.....	20
3.4.3. Backup Mode.....	21
3.4.4. Periodic Mode.....	23
3.4.5. GLP Mode.....	25
3.5. Power-On.....	26
3.6. Reset.....	27
3.7. UART Interface.....	28
3.8. EASY™ Autonomous AGNSS Technology.....	29
3.9. EPO Offline AGNSS Technology.....	29
3.10. Multi-Tone AIC.....	30
3.11. LOCUS.....	31
3.12. PPS vs. NMEA.....	32
<b>4 Built-in Antennas and External Antenna Interfaces</b> .....	<b>33</b>
4.1. Internal Patch Antenna.....	33
4.1.1. PCB Design Guide.....	33
4.1.2. GPS + GLONASS Patch Antenna.....	36
4.1.3. GPS + BeiDou Patch Antenna.....	37
4.2. External Active Antenna.....	38
4.3. External Active Antenna Status Indicator.....	39
4.3.1. GPTXT Sentence.....	39
4.3.2. AADET_N Pin.....	40

<b>5</b>	<b>Electrical, Reliability and Radio Characteristics .....</b>	<b>42</b>
5.1.	Absolute Maximum Ratings .....	42
5.2.	Operating Conditions .....	43
5.3.	Electrostatic Discharge .....	43
<b>6</b>	<b>Mechanical Dimensions .....</b>	<b>44</b>
6.1.	Mechanical Dimensions .....	44
6.2.	Recommended Footprint .....	46
6.3.	Top and Bottom Views .....	47
<b>7</b>	<b>Storage, Manufacturing and Packaging .....</b>	<b>48</b>
7.1.	Storage .....	48
7.2.	Manufacturing and Soldering .....	49
7.3.	Packaging .....	50
<b>8</b>	<b>Appendix A References.....</b>	<b>52</b>

## Table Index

Table 1: Specifications.....	10
Table 2: Supported Protocols.....	12
Table 3: I/O Parameters Definition.....	15
Table 4: Pin Description.....	15
Table 5: Feature Comparison in Different Operation Modes.....	18
Table 6: Operation Mode Switching.....	19
Table 7: Default Configurations.....	20
Table 8: Entering/Exiting Backup Mode.....	21
Table 9: PMTK Command Format.....	23
Table 10: Pin Definition of UART Interface.....	28
Table 11: Recommended Parameters of Thermal Profile.....	50
Table 12: Packaging Specifications.....	51
Table 13: Related Documents.....	52
Table 14: Terms and Abbreviations.....	52

## Figure Index

Figure 1: Block Diagram.....	12
Figure 2: Pin Assignment .....	14
Figure 3: Internal Power-System Construction .....	18
Figure 4: Backup Mode Sequence Diagram.....	22
Figure 5: RTC Backup Power Supply (Non-Chargeable Battery).....	22
Figure 6: RTC Backup Power Supply (Rechargeable Battery).....	23
Figure 7: Periodic Mode .....	25
Figure 8: Power-On Timing .....	26
Figure 9: Reference Reset Circuit Using OC Circuit .....	27
Figure 10: Restart Timing.....	27
Figure 11: Connection of UART Interface .....	28
Figure 12: Anti-Jamming Performance by AIC.....	31
Figure 13: PPS vs. NMEA Timing .....	32
Figure 14: Recommended Distance Between the Module and Motherboard Edges .....	33
Figure 15: Recommended Treatment for the Feed Point of the Patch Antenna .....	34
Figure 16: Recommended Ground Plane .....	34
Figure 17: Recommended Distance between Module and Tall Metal Components.....	35
Figure 18: Recommended Placement of GNSS Module .....	35
Figure 19: GPS + GLONASS Patch Antenna Test Results (with Ground Plane of 100 mm x 60 mm) ....	37
Figure 20: GPS + BeiDou Patch Antenna Test Result with Ground Plane of 100 mm x 60 mm .....	38
Figure 21: Reference Design for Active Antenna.....	38
Figure 22: Patch Antenna Status Description in GPSTXT .....	40
Figure 23: Top and Side Dimensions .....	44
Figure 24: Bottom View Dimensions .....	45
Figure 25: Recommended Footprint .....	46
Figure 26: Top View of the Module.....	47
Figure 27: Bottom View of the Module.....	47
Figure 28: Recommended Thermal Profile for Reflow Soldering .....	49
Figure 29: Tape and Reel Specifications.....	51



# 1 Introduction

This document provides information on the interface specifications, as well as electrical and mechanical details of the LC86L module. Consult this document to learn about the hardware interfaces, external application reference circuits, mechanical size and air interface of the module.

This document, coupled with application notes and user guides, makes it easy to design applications with the LC86L module.

## 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 containing 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. Otherwise, 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 to be used in the country and in the required environment.



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, while the wiring must comply with 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

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

The LC86L module is classified into two product variants based on the two default GNSS configurations:

- **LC86L (A)**, supporting GPS + GLONASS
- **LC86L (B)**, supporting GPS + BeiDou

### Key features:

- Embedded flash memory that provides capacity for storing user-specific configurations and allows for future updates
- Multiple power-saving modes, such as periodic, standby, backup and GLP
- Embedded low-power algorithms suitable for different application scenarios
- EASY™ autonomous AGNSS technology, which can collect and process all internal auxiliary information including GNSS time, calendar, and the latest position, so that the module can achieve a fast first fix in hot/warm start
- Active antenna detection and short-circuit protection

Note that the antenna status is reported through the NMEA message, so the host can query the antenna status in a convenient and timely manner. The 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 provides all the necessary hardware interfaces for connection with the main PCB.

The module is also fully compliant with EU RoHS regulations.

## 2.1. Specifications

Table 1: Specifications

Features	Description																				
GNSS Type	<ul style="list-style-type: none"> <li>● Default configuration: GPS + GLONASS or GPS + BeiDou</li> <li>● For more details about the GNSS constellation configuration, refer to <b>document [1]</b>.</li> </ul>																				
Receiver Type	<ul style="list-style-type: none"> <li>● GPS L1 C/A: 1574.397–1576.443 MHz</li> <li>● GLONASS L1: 1597.781–1605.656 MHz</li> <li>● BeiDou B1 C/A: 1559.052–1563.144 MHz</li> </ul>																				
Power Supply	<ul style="list-style-type: none"> <li>● Supply voltage: 2.8–4.3 V</li> <li>● Typical: 3.3 V</li> </ul>																				
Power Consumption <sup>1)</sup>	<table border="1"> <thead> <tr> <th></th> <th>GPS</th> <th>GPS + GLONASS</th> <th>GPS + BeiDou</th> </tr> </thead> <tbody> <tr> <td>Acquisition (mA)</td> <td>27</td> <td>32</td> <td>33</td> </tr> <tr> <td>Tracking (mA)</td> <td>23</td> <td>31</td> <td>30</td> </tr> <tr> <td>Standby (mA)</td> <td>1.8</td> <td>1.8</td> <td>1.8</td> </tr> <tr> <td>Backup (µA)</td> <td>6</td> <td>6</td> <td>6</td> </tr> </tbody> </table>		GPS	GPS + GLONASS	GPS + BeiDou	Acquisition (mA)	27	32	33	Tracking (mA)	23	31	30	Standby (mA)	1.8	1.8	1.8	Backup (µA)	6	6	6
		GPS	GPS + GLONASS	GPS + BeiDou																	
	Acquisition (mA)	27	32	33																	
	Tracking (mA)	23	31	30																	
Standby (mA)	1.8	1.8	1.8																		
Backup (µA)	6	6	6																		
Sensitivity	<ul style="list-style-type: none"> <li>● Acquisition: -148 dBm</li> <li>● Reacquisition: -161 dBm</li> <li>● Tracking: -166 dBm</li> </ul>																				
Time-to-First-Fix (EASY™ Enabled)	<ul style="list-style-type: none"> <li>● Cold Start: &lt; 15 s (average) @ -130 dBm</li> <li>● Warm Start: &lt; 5 s (average) @ -130 dBm</li> <li>● Hot Start: &lt; 2 s @ -130 dBm</li> </ul>																				
Time-to-First-Fix (EASY™ Disabled)	<ul style="list-style-type: none"> <li>● Cold Start (Autonomous): &lt; 35 s (average) @ -130 dBm</li> <li>● Warm Start (Autonomous): &lt; 30 s (average) @ -130 dBm</li> <li>● Hot Start (Autonomous): &lt; 2 s @ -130 dBm</li> </ul>																				
Horizontal Position Accuracy (Autonomous)	<ul style="list-style-type: none"> <li>● &lt; 2.5 m CEP @ -130 dBm</li> </ul>																				
Update Rate	<ul style="list-style-type: none"> <li>● 1 Hz by default, max. up to 10 Hz</li> </ul>																				
Accuracy of 1PPS Signal	<ul style="list-style-type: none"> <li>● Typical accuracy &lt; 100 ns</li> <li>● Time pulse width: 100 ms</li> </ul>																				
Velocity Accuracy	<ul style="list-style-type: none"> <li>● Without aid: &lt; 0.1 m/s</li> </ul>																				
Acceleration Accuracy	<ul style="list-style-type: none"> <li>● Without aid: &lt; 0.1 m/s<sup>2</sup></li> </ul>																				

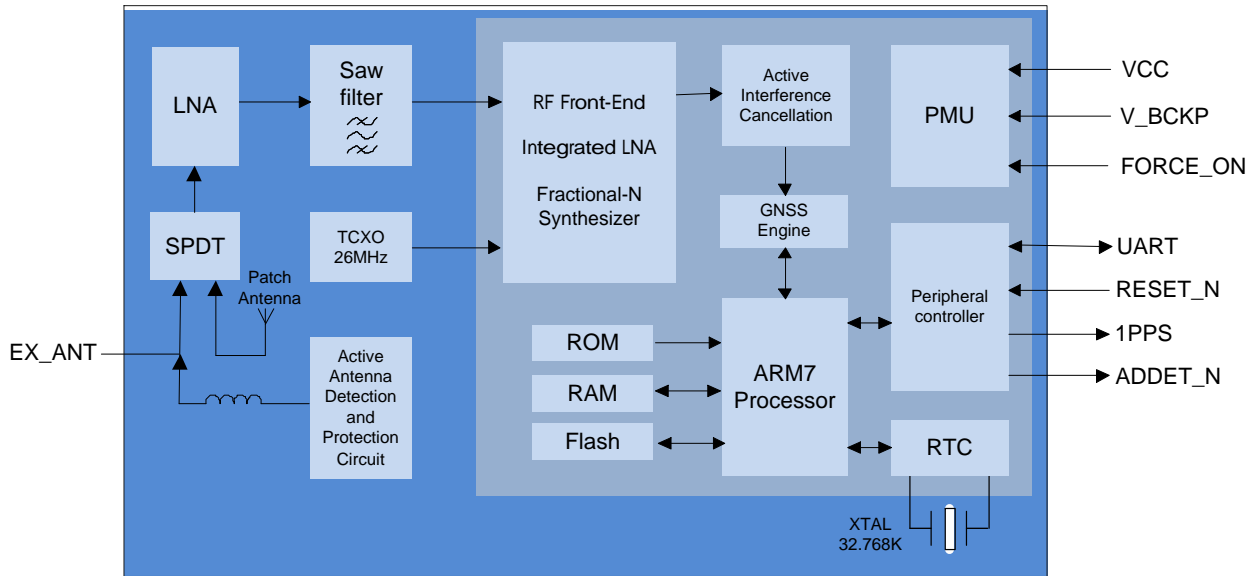
Dynamic Performance	<ul style="list-style-type: none"> <li>● Maximum Altitude: 18000 m</li> <li>● Maximum Velocity: 515 m/s</li> <li>● Acceleration: 4 g</li> </ul>
UART Interface	<ul style="list-style-type: none"> <li>● UART port: TXD and RXD</li> <li>● Baud rate: 9600 bps to 921600 bps, 9600 bps by default</li> <li>● Used for NMEA sentences output, PMTK/PQ commands input and firmware upgrade</li> </ul>
Temperature Range	<ul style="list-style-type: none"> <li>● Operation temperature range: -40 °C to +85 °C</li> <li>● Storage temperature range: -40 °C to +90 °C</li> </ul>
Physical Characteristics	<ul style="list-style-type: none"> <li>● Size: (16.0 ±0.15) mm × (16.0 ±0.15) mm × (6.95 ±0.20) mm</li> <li>● Weight: Approx. 6 g</li> </ul>

## NOTES

- 1) The power consumption values are measured when the module is using the internal patch antenna only, and while EASY™, AIC and SBAS are disabled.  
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.
2. The module supports either GPS + GLONASS or GPS + BeiDou configurations by default.

## 2.2. Block Diagram

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



**Figure 1: Block Diagram**

## 2.3. Supported Protocols

**Table 2: Supported Protocols**

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

### NOTES

1. For details of NMEA standard protocol and MTK proprietary protocols, see **document [1]**.
2. For details of Quectel's proprietary protocol, see **document [2]**.

## 2.4. Evaluation Board

In order to facilitate application design with the LC86L module, Quectel supplies the evaluation board (LC86L EVB), a micro-USB cable, an active antenna and other peripherals needed for testing the module. For more details, see **document [3]**.

# 3 Application Functions and Interfaces

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

## 3.1. Pin Assignment

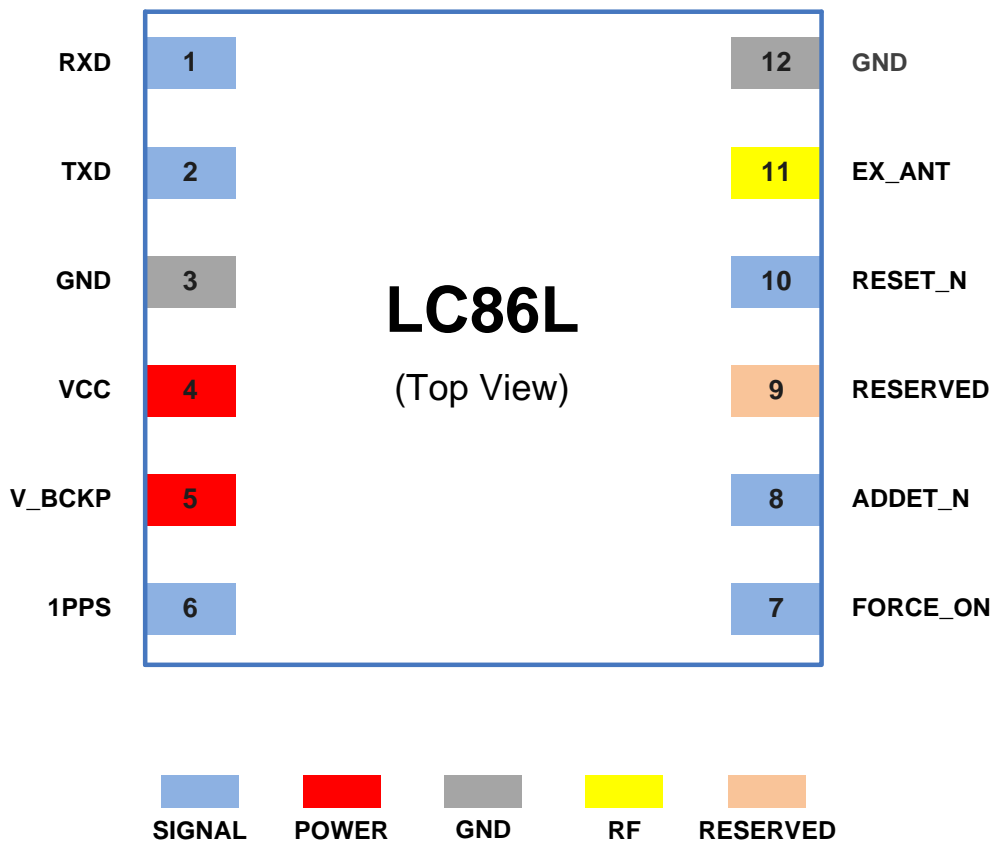


Figure 2: Pin Assignment

## 3.2. Pin Definition

**Table 3: 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 4: Pin Description**

Power Supply					
Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
VCC	4	PI	Main power supply	V <sub>max</sub> = 4.3 V V <sub>min</sub> = 2.8 V V <sub>nom</sub> = 3.3 V	Make sure that the maximum current capability of power supply is no less than 100 mA.
V_BCKP	5	PI	Backup power supply	V <sub>max</sub> = 4.3 V V <sub>min</sub> = 1.5 V V <sub>nom</sub> = 3.3 V	Supply power for the RTC domain. V_BCKP can be powered directly by a battery or when connected to VCC.
Reset					
Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
RESET_N	10	DI	Resets the module	V <sub>ILmin</sub> = -0.3 V V <sub>ILmax</sub> = 0.7 V V <sub>IHmin</sub> = 2.1 V V <sub>IHmax</sub> = 3.1 V	Active low. If unused, keep this pin open.



### UART Interface

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
RXD	1	DI	Receives data	$V_{ILmin} = -0.3\text{ V}$ $V_{ILmax} = 0.7\text{ V}$ $V_{IHmin} = 2.1\text{ V}$ $V_{IHmax} = 3.1\text{ V}$	The UART port is used for NMEA sentences output, PMTK/PQ commands input and firmware upgrade.
TXD	2	DO	Transmits 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 $\Omega$ 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, with the pulse width of 100 ms. If unused, keep this pin open.
FORCE_ON	7	DI	When pulled high, forces the module to wake up from the 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 the backup mode. The FORCE_ON pin belongs to RTC domain. If unused, keep this pin open.
AADET_N	8	DO	Active antenna status indication	$V_{OLmax} = 0.7\text{ V}$ $V_{OHmin} = 1.3\text{ V}$	If unused, keep this pin open. Refer to <b>Chapter 4.3</b> for details.
GND	3, 12		Ground		
RESERVED	9		Reserved		Keep this pin open.

**NOTE**

Keep all reserved and unused pins open.

### 3.3. Power Supply

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 VCC varies according to the VCC voltage level, processor load, the number of tracked satellites and the rate of satellite re-acquisition. The usage of 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<sup>1)</sup> with a minimum output current of 100 mA as the power supply. Also, add a 10  $\mu$ F and a 100 nF decoupling capacitor combination as well as a TVS near the VCC pin.

The V\_BCKP pin supplies power for the RTC domain. The pin should be valid when the module is powered on. The voltage of RTC domain ranges from 1.5 to 4.3 V. In order to achieve a better TTFF, the RTC domain should be valid all the time. In the RTC domain, the V\_BCKP can supply power for SRAM memory that contains all the necessary GNSS 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 in the figure below.

- The VCC supplies power for PMU, while V\_BCKP supplies power for the RTC domain.
- FORCE\_ON belongs to the RTC domain.
- The PMU is designed with an integrated switch that is used to control the PMU power supply status.

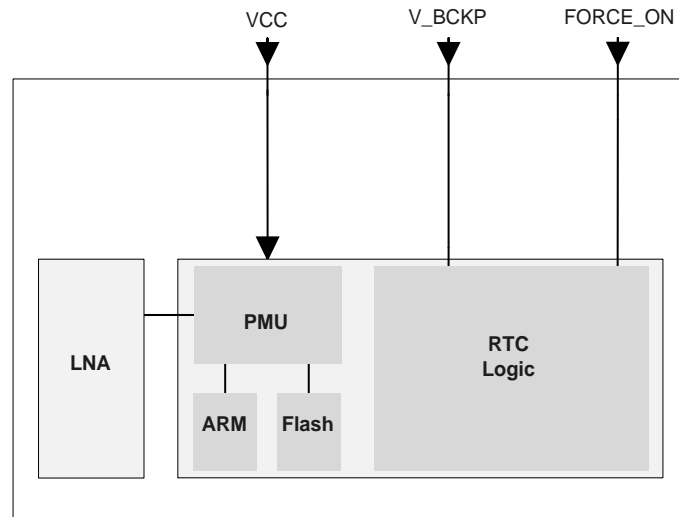


Figure 3: Internal Power-System Construction

#### NOTES

1. 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.
2. <sup>1)</sup> 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).

### 3.4. Operating Modes

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

Table 5: Feature Comparison in Different Operation Modes

	Full-On	Standby	Backup	Periodic	GLP
Antenna Detection	●			○	●
PPS	●			○	●
RF	●			○	●
NMEA Output	●			○	●

Acquiring & Tracking	●			○		●
Power Consumption	High	Low	Low	Medium		Medium
Positioning Accuracy	High	Low	Low	Low		Medium

### NOTES

- = supported
- = supported in the full-on periodic mode

**Table 6: Operation Mode Switching**

Current Mode	Next Mode				
	Full-On	Standby	Backup	Periodic	GLP
Full-On	/	Pull STANDBY low or send <b>PMTK161</b>	Refer to <b>Chapter 3.4.3</b>	Send <b>PMTK225</b>	Refer to <b>Chapter 3.4.5</b>
Standby	Pull STANDBY high, or send any data via UART	/	NA	N/A	N/A
Backup	Refer to <b>Chapter 3.4.3</b>	NA	/	NA	NA
Periodic	Refer to <b>Chapter 3.4.4</b>	N/A	NA	/	N/A
GLP	Refer to <b>Chapter 3.4.5</b>	N/A	NA	N/A	/

### 3.4.1. Full-On Mode

The full-on 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.

When the combination of VCC and V\_BCKP is valid, the module enters the full-on mode automatically and follows the default configurations as given below. For more details, refer to **Chapter 3.3** for the internal power-system construction. PMTK commands may be used to change the configurations in order to satisfy requirements.

**Table 7: Default Configurations**

Item	Configuration	Comment
GNSS	GPS + GLONASS <sup>1)</sup> / GPS + BeiDou <sup>2)</sup>	<p>The following PMTK commands can be used to switch among multiple positioning systems:</p> <ul style="list-style-type: none"> <li>● <b>\$PMTK353,1,0,0,0,0*2A</b>: search GPS satellites only</li> <li>● <b>\$PMTK353,1,1,0,0,0*2B</b>: search GPS and GLONASS satellites</li> <li>● <b>\$PMTK353,1,0,0,0,1*2B</b>: search GPS and BeiDou satellites</li> </ul>
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.

#### NOTES

1. <sup>1)</sup> GPS + GLONASS is used for **LC86L (A)**.
2. <sup>2)</sup> GPS + BeiDou is used for **LC86L (B)**.

### 3.4.2. Standby Mode

The 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, so the module stops satellite search and navigation. UART is still accessible through PMTK commands or any other data, but there is no NMEA message output.

Send PMTK command **\$PMTK161,0\*28** to make the LC86L module enter the standby mode. You can wake the module up by sending data via UART. When the module exits the 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. The typical standby current consumption in this way is about 1.8 mA @ VCC = 3.3 V.

**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.

### 3.4.3. 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 current consumption in this mode is about 6  $\mu$ A (VCC = 3.3 V).

**NOTE**

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

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

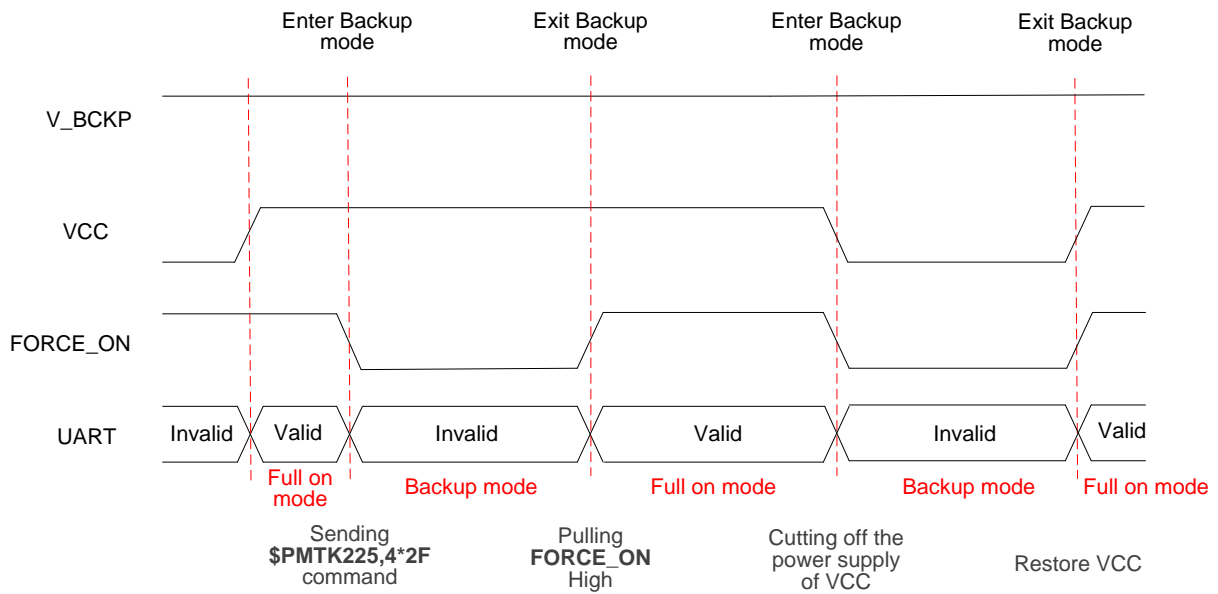
**Table 8: Entering/Exiting Backup Mode**

Option	Enter Backup Mode	Exit Backup Mode
Option 1	Send \$PMTK225,4*2F command	Pull the FORCE_ON pin high
Option 2	Cut off the power supply to the VCC while keeping the V_BCKP powered <sup>1)</sup>	Power on the VCC

**NOTE**

<sup>1)</sup> 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.

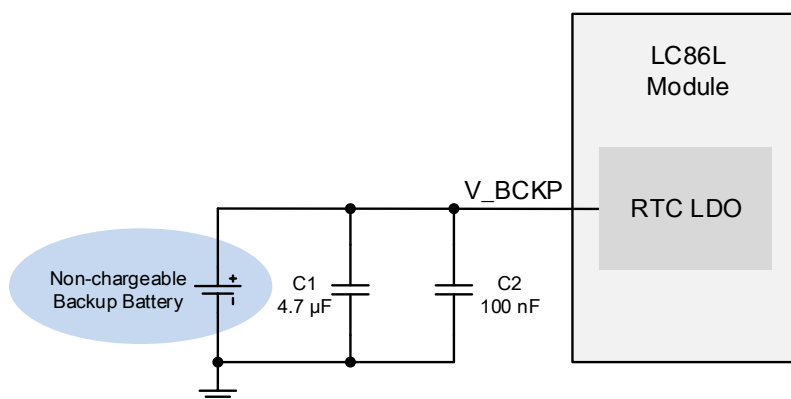
The timing diagram indicating that the module enters the backup mode after being powered on is as follows:



**Figure 4: Backup Mode Sequence Diagram**

The two different methods for entering the backup mode have significant impact on the current consumption. Because the active antenna detection circuit is powered by VCC, this means that the current consumption for entering the backup mode is greater when you send PMTK command than when you cut off VCC while keeping the V\_BCKP alive.

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



**Figure 5: RTC Backup Power Supply (Non-Chargeable Battery)**

The 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.

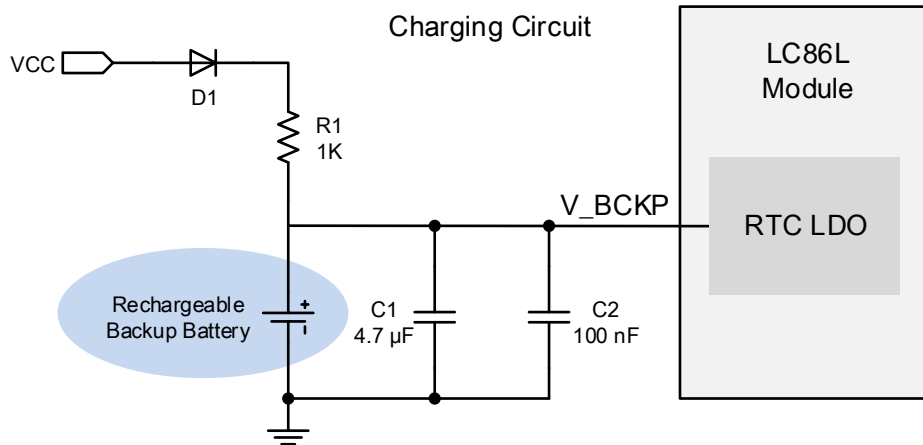


Figure 6: RTC Backup Power Supply (Rechargeable Battery)

### 3.4.4. Periodic Mode

The periodic mode achieves the balance between the positioning accuracy and power consumption, but performance is lower compared to the full-on mode. In the periodic mode, the module should be always supplied with power. In this mode, the module switches between the full-on mode and standby/backup mode periodically to reduce power consumption.

To enter the periodic mode, send the PMTK command in the format illustrated in the table below. Note that with the 'Type' parameter you specify whether you want the module to go into the periodic standby mode, or the periodic backup mode.

#### NOTE

Before entering the 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 weak signal environments, it is recommended to set a longer **Second Run Time** to ensure the success of reacquisition.

Table 9: PMTK Command Format

Parameter	Format	Description
<b>Format:</b> \$PMTK225,<Type>,<Run Time>,<Sleep Time>,<Second Run Time>,<Second Sleep Time>*<Checksum><CR><LF>		
Type	Decimal	<b>Type = 1</b> for periodic backup mode <b>Type = 2</b> for periodic standby mode
Run Time	Decimal	<b>Run Time</b> = Full-on mode period (ms)



<b>Sleep Time</b>	Decimal	<b>Sleep Time</b> = Standby/Backup mode period (ms)
<b>Second Run Time</b>	Decimal	<b>Second Run Time</b> = Full-on mode period (ms) for extended acquisition in case the module fails in acquisition during the <b>Run Time</b>
<b>Second Sleep Time</b>	Decimal	<b>Second Sleep Time</b> = Standby/Backup mode period (ms) for extended sleep in case the module fails in acquisition during the <b>Run Time</b>
<b>Checksum</b>	Hexadecimal	Hexadecimal checksum

## Example

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

To enter the full-on mode from the periodic standby mode, send the **\$PMTK225,0\*2B** command.

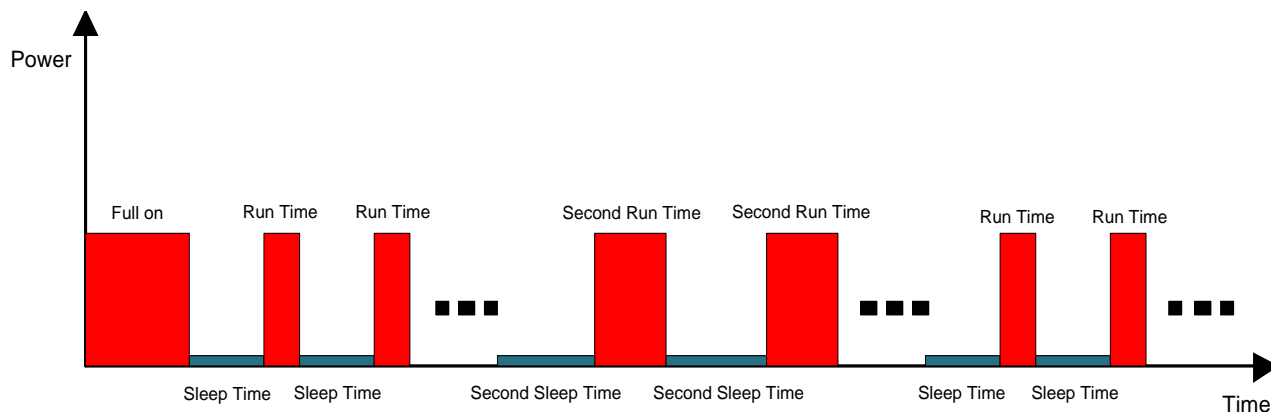
To enter the full-on mode from the periodic backup mode, first pull the FORCE\_ON pin high and then send the **\$PMTK225,0\*2B** command right away.

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

### NOTE

Before entering periodic backup mode, make sure that the FORCE\_ON pin is open or low, and that power supply for V\_BCKP is alive.

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



**Figure 7: Periodic Mode**

The average current value can be calculated with 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**

The periodic mode with 3 s in the tracking mode and 12 s in the standby mode based on GPS + GLONASS (LC86L (A)). The average current consumption is calculated as follows:

$$I_{\text{periodic}} = (I_{\text{tracking}} \times T1 + I_{\text{standby}} \times T2) / (T1 + T2) = \approx 7.64 \text{ (mA)}$$

- **PMTK225,1,3000,12000,18000,72000\*16**

The periodic mode with 3 s in the tracking mode and 12 s in the backup mode based on GPS + GLONASS (LC86L (A)). The average current consumption is calculated as follows:

$$I_{\text{periodic}} = (I_{\text{tracking}} \times T1 + I_{\text{backup}} \times T2) / (T1 + T2) = \approx 6.2 \text{ (mA)}$$

### 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. The module automatically switches to the operation in the full-on mode in challenging environments to keep good accuracy. As a result, the module can still achieve maximum performance with the lowest power consumption.

The average current consumption in GLP mode is down to about 15 mA in a static scenario, which is

about 50% lower than the power consumption in the full-on mode. The power consumption may increase slightly in dynamic scenarios.

Entering/exiting the GLP mode:

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

## NOTES

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 the GLP mode, set also 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 the GLP mode is enabled, the SBAS function cannot be used.
5. In highly dynamic scenarios, the positioning accuracy of the module in the GLP mode is slightly decreased.
6. To keep good positioning accuracy, the module automatically returns to the full-on mode in complex environments.

## 3.5. Power-On

To power on the LC86L module, the user should supply power to the V\_BCKP pin earlier than to the VCC pin, or at the same time. After being powered on, the module outputs the NMEA messages through the serial port. The power-on sequence diagram is shown below.

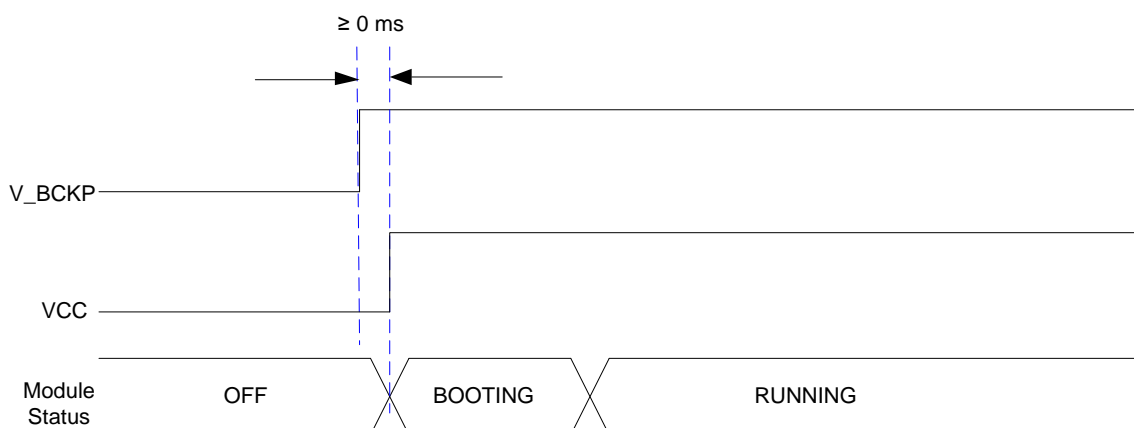
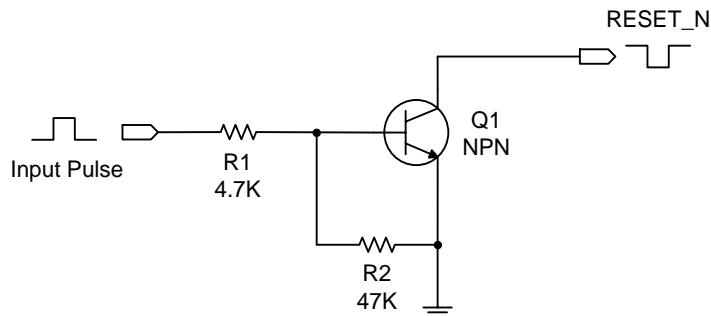


Figure 8: Power-On Timing

### 3.6. Reset

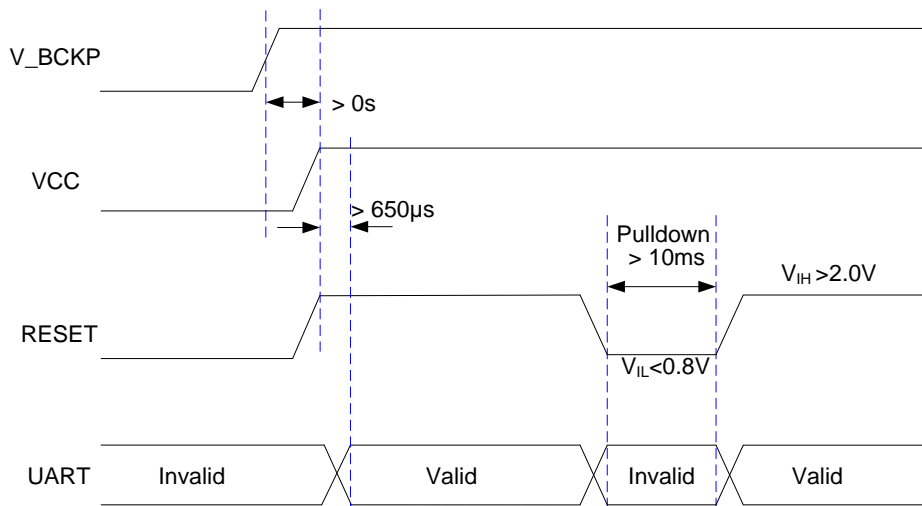
The LC86L module can be restarted by driving the RESET\_N pin low for at least 10 ms and then releasing it. This operation will reset the digital part of the GNSS receiver. It should be noted that non-volatile backup RAM is not cleared after resetting and, therefore, a short TTFB is possible.

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



**Figure 9: Reference Reset Circuit Using OC Circuit**

The reset timing of LC86L is illustrated as follows.



**Figure 10: Restart Timing**

### 3.7. UART Interface

The module provides one universal asynchronous receiver and transmitter (UART) serial port. The UART port has the following features:

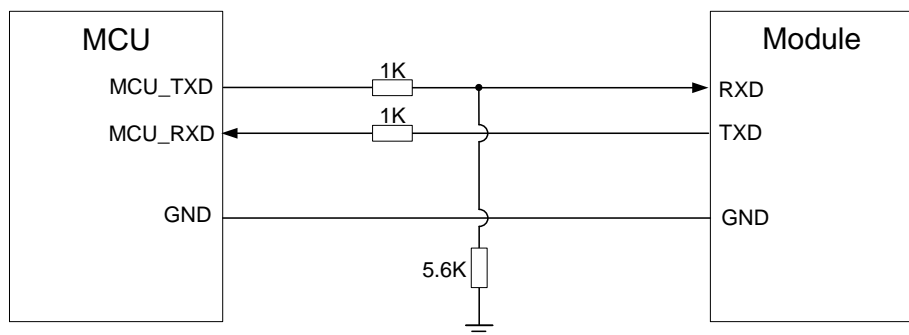
- Support for NMEA sentences output, PMTK/PQ commands input and firmware upgrade
- Default output type of NMEA sentences: RMC, VTG, GGA, GSA, GSV, GLL, and TXT
- Supported baud rates: 9600, 14400, 19200, 38400, 57600, 230400, 460800 and 921600 bps.
- The default setting is 9600 bps, 8 bits, no parity bit, 1 stop bit

Note that hardware flow control and synchronous operation are not supported. The module is designed as data communication equipment (DCE), whereas the client is operating as data terminal equipment (DTE), thus establishing the traditional DCE-DTE connection. The module (DCE) and the client (DTE) are connected through the signals shown in the following table.

**Table 10: Pin Definition of UART Interface**

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

A reference design of 3.3 V level MCU match for LC86L is shown below.



Voltage level: 3.3 V

**Figure 11: Connection of UART Interface**

### 3.8. EASY™ Autonomous AGNSS Technology

The LC86L module 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 to accelerate TTFF by predicting satellite navigation messages from received ephemeris. After receiving the broadcast ephemeris for the first time, the GNSS engine automatically calculates and predicts the orbit information up to the subsequent 3 days, and saves the predicted information to the internal memory. The GNSS engine will use the information for positioning if there are not enough information from satellites. Therefore, the function improves positioning and TTFF.

The EASY™ function reduces TTFF to 5 s in warm start. In this case, RTC domain should be valid. In order to obtain enough broadcast ephemeris information from GNSS satellites, the GNSS module should receive the information for at least 5 mins in good signal environments after fixing the position.

EASY™ function is enabled by default. To disable the function, send **\$PMTK869,1,0\*34** command. For more details, see **document [1]**.

### 3.9. EPO Offline AGNSS Technology

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. Customers 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.

The following are download URLs of EPO Files:

**Table 1: Download URLs of EPO Files**

EPO Type	GNSS Type	EPO File URL Example	File Name
Unified QEPO URL	GPS only	<a href="http://wpepodownload.mediatek.com/QGPS.DAT?vendorinfo">http://wpepodownload.mediatek.com/QGPS.DAT?vendorinfo</a>	Single name: QGPS.DAT
Unified QEPO URL	GPS+GLONASS	<a href="http://wpepodownload.mediatek.com/QG_R.DAT?vendorinfo">http://wpepodownload.mediatek.com/QG_R.DAT?vendorinfo</a>	Single name: QG_R.DAT
EPO	GPS only	<a href="http://wpepodownload.mediatek.com/EPO_GPS_3_X.DAT?vendorinfo">http://wpepodownload.mediatek.com/EPO_GPS_3_X.DAT?vendorinfo</a>	X <sup>1)</sup> = 1–10 EPO_GPS_3_1.DAT to EPO_GPS_3_10.DAT

EPO	GPS+GLONASS	<a href="http://wpepdownload.mediatek.com/EPO_GR_3_X.DAT?vendorinfo">http://wpepdownload.mediatek.com /EPO_GR_3_X.DAT?vendorinfo</a>	X <sup>1)</sup> = 1–10. EPO_GR_3_1.DAT to EPO_GR_3_10.DAT
-----	-------------	--	---

The following shows a complete URL sample:

[http://wpepdownload.mediatek.com/QGPS.DAT?vendor=AAA&project=BBB&device\\_id=CCC](http://wpepdownload.mediatek.com/QGPS.DAT?vendor=AAA&project=BBB&device_id=CCC)

- The query string starts with “?” and is separated by “&”.
- The values of “**vendor**” and “**project**” (**AAA**, **BBB** in the example) are issued by Quectel. Contact Quectel Technical Support to get the values.
- The value of “**device\_id**” (**CCC** in the example) contains two parts – one assigned by the vendor, and the other assigned by the customer. For example: if **CCC = XXX\_YYY**, the value **XXX** is provided by Quectel Technical Support, while **YYY** can be assigned by customers and it must be a unique value, such as IMEI. Each device must have a unique ID.

#### NOTE

<sup>1)</sup> Each file contains orbit predictions for 3 days. As there can be a maximum of 30 days’ predictions, there will be up to 10 files.

Slices of 30-day EPO:

\_1 for days 1 to 3,

\_2 for days 4 to 6,

...

\_10 for days 28 to 30.

### 3.10. 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, 2G, 3G, 4G, and 5G.

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:

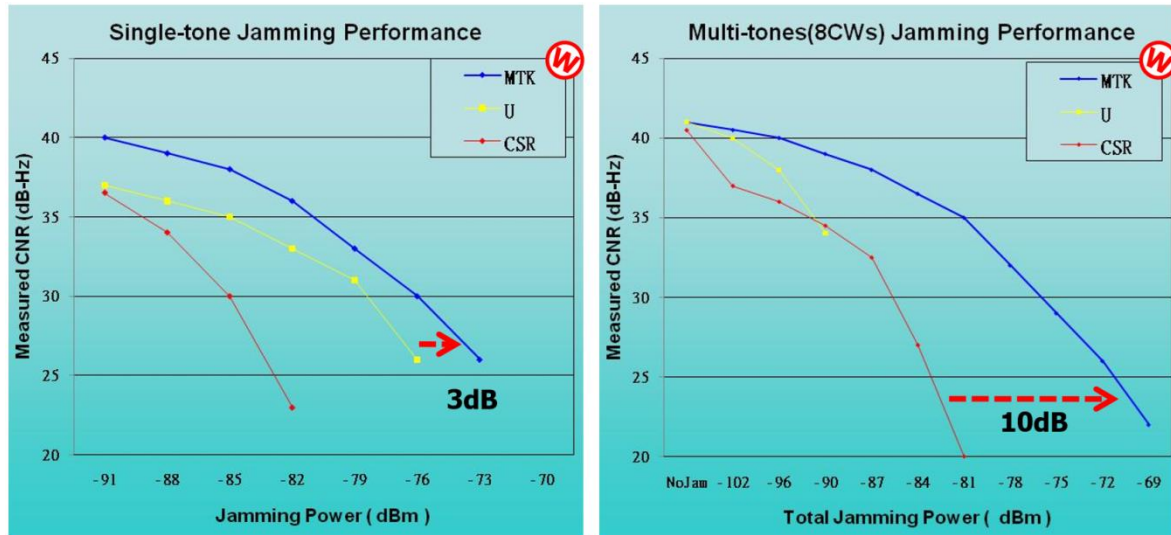


Figure 12: Anti-Jamming Performance by AIC

AIC function is enabled by default. When enabled, the AIC function increases current consumption for about 1 mA when VCC = 3.3 V. The following commands can be used to set the AIC function:

- Enable AIC function: **\$PMTK 286,1\*23**
- Disable AIC function: **\$PMTK 286,0\*22**

### 3.11. LOCUS

The LC86L module supports the embedded logger function called LOCUS. When this function is enabled with the **\$PMTK185,0\*22** command, it logs position information to the internal flash memory. Additionally, with this function, the host can enter the sleep mode to save power consumption. In that way, the host will not receive the NMEA information all the time. The module provides more than 16 hours of log capacity. The **\$PMTK183\*38** command can be used to query the current state of LOCUS.

The detailed procedures of this function are illustrated below:

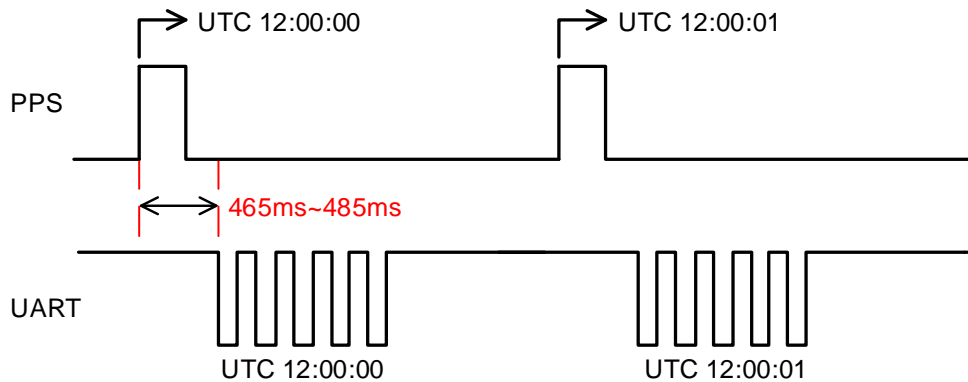
- The module fixes the position (only available in 3D fixed scenario).
- Send PMTK command **\$PMTK184,1\*22** to erase the internal flash.
- Send PMTK command **\$PMTK185,0\*22** to start logging.
- The module logs the basic information (UTC time, latitude, longitude, and height) every 15 seconds to 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, contact Quectel Technical Support.



### 3.12. PPS vs. NMEA

You can use the relationship between Pulse per Second (PPS) and NMEA for time service, as can be seen in the following figure. The latency range between the rising edge of PPS and the beginning of a NMEA sentence at the UART TXD is 465–485 ms.



**Figure 13: PPS vs. NMEA Timing**

The feature only supports 1 Hz NMEA sentence output.

Send the following PMTK commands to the module to:

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

# 4 Built-in Antennas and External Antenna Interfaces

The LC86L module supports GPS, GLONASS, BeiDou, and QZSS systems. The LNA is embedded for better performance. It is an ultra-compact module with embedded patch antenna (15.0 mm × 15.0 mm × 4.0 mm). In addition, the LC86L module can also support an external active antenna, in which case the RF signal is obtained from the EX\_ANT pin. The internal patch signal and external active antenna signal are interchanged with a SPDT switch.

## 4.1. Internal Patch Antenna

### 4.1.1. PCB Design Guide

The radiation characteristics of an antenna depend 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 or, if possible, place the module in the center of the motherboard.

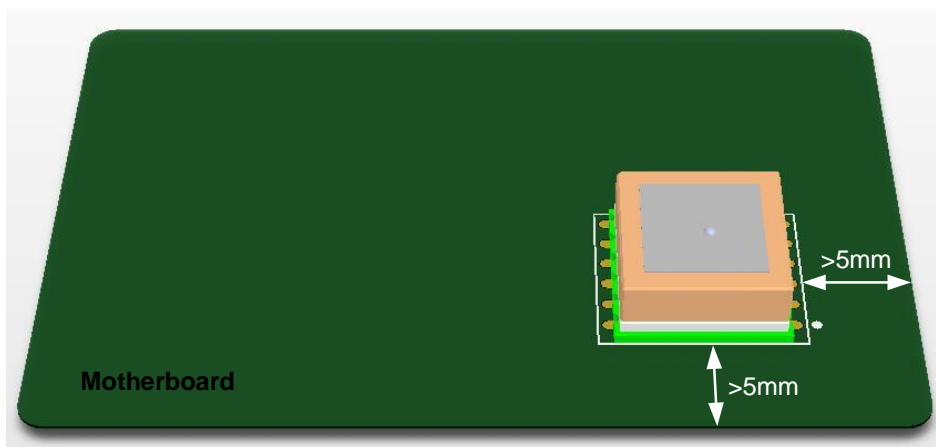
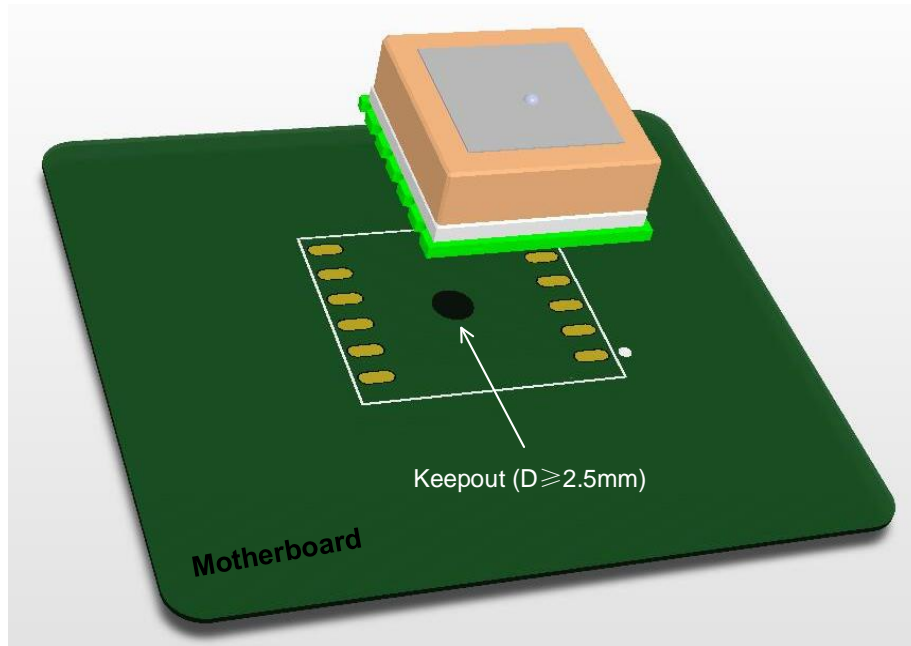


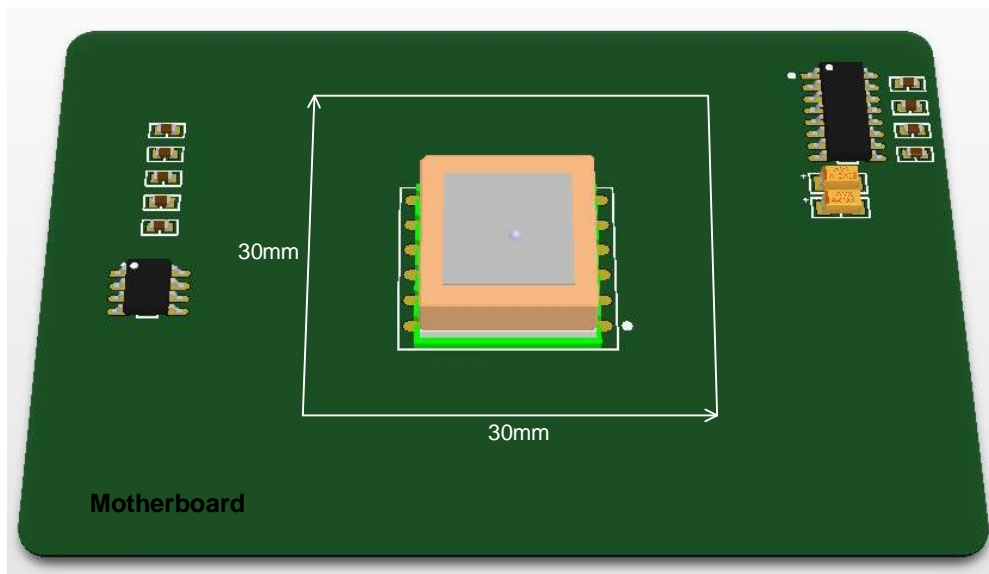
Figure 14: Recommended Distance Between the Module and Motherboard Edges

- 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.



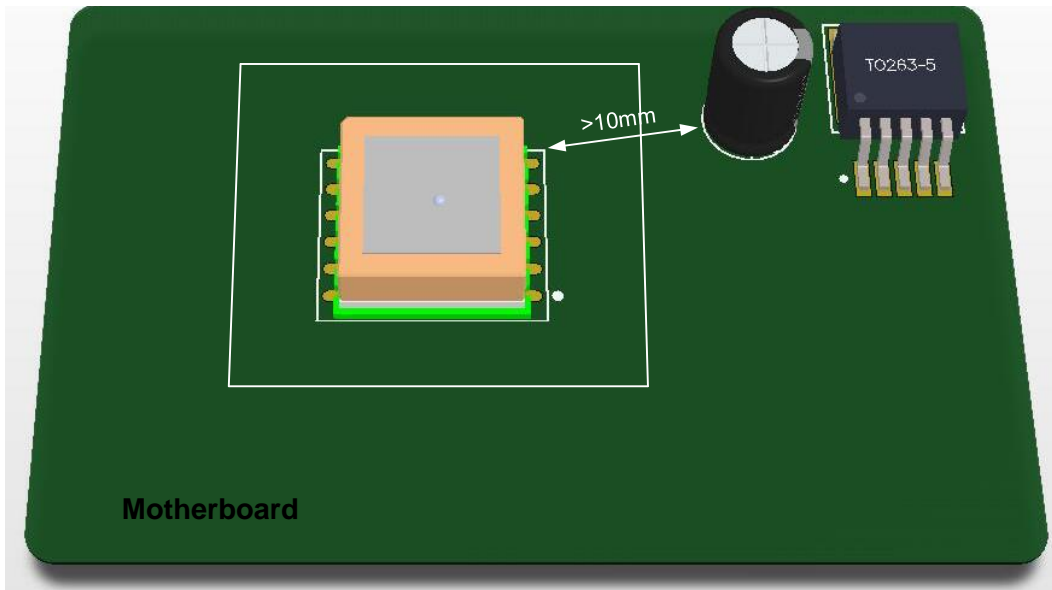
**Figure 15: Recommended Treatment for the Feed Point of the Patch Antenna**

- 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 embedded 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).



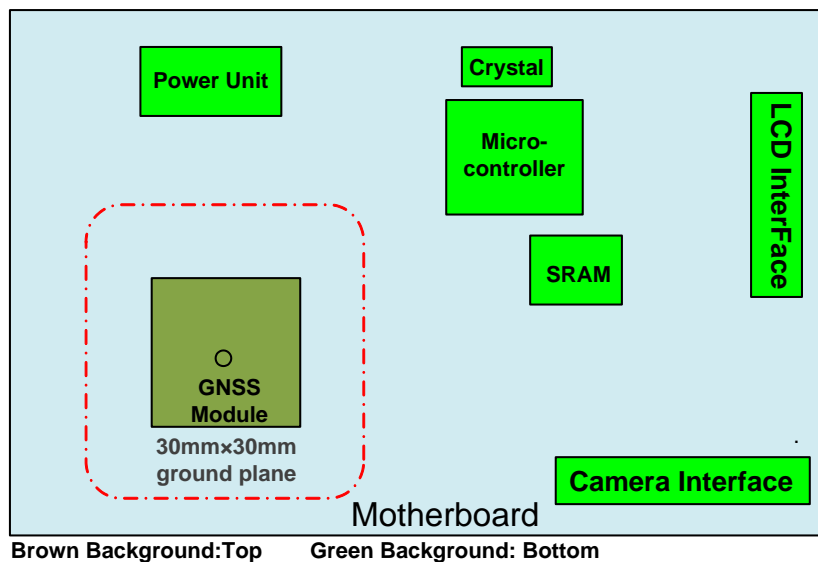
**Figure 16: Recommended Ground Plane**

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



**Figure 17: 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 18: Recommended Placement of GNSS Module**

- Make sure the interfering signals (from USB, LCD, Camera, Crystal, etc.) are in the inner layer and shielded by the ground plane; keep the interfering signals and their paths far away from the module.
- Make sure the RF system (such as Wi-Fi/BT/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.

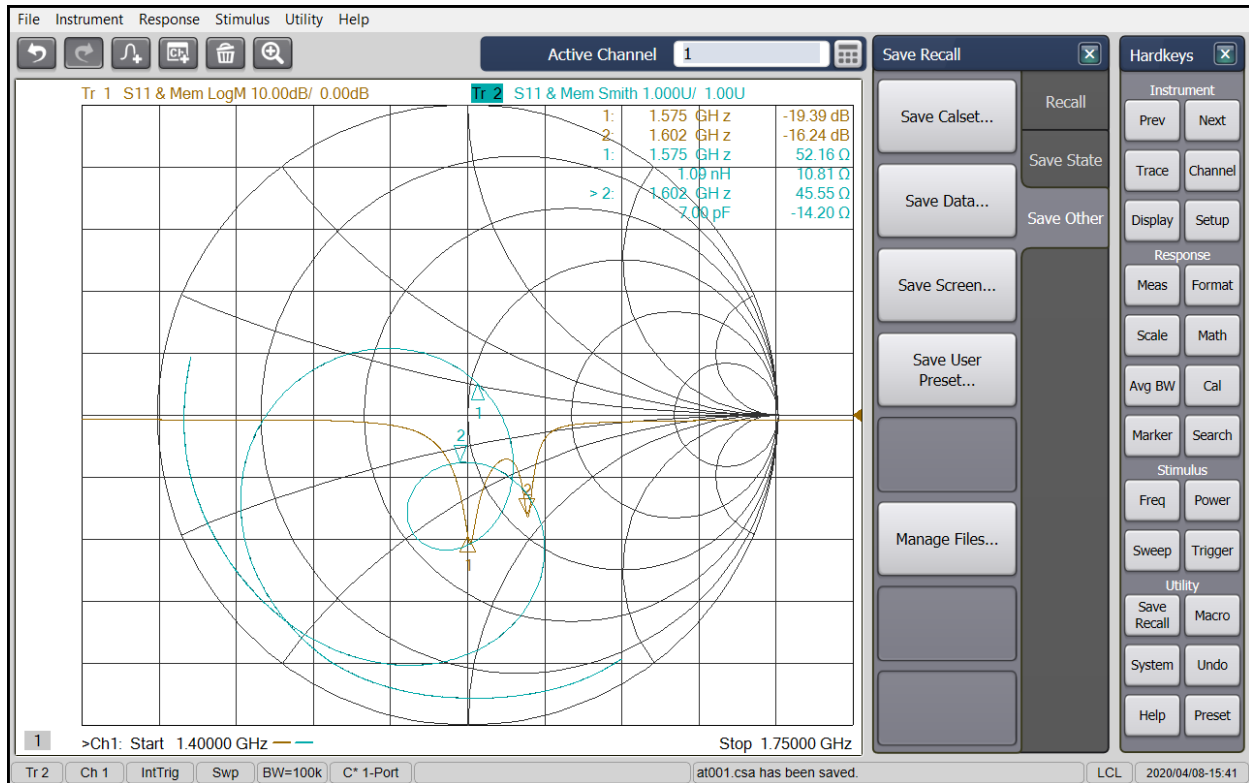
#### 4.1.2. GPS + GLONASS Patch Antenna

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

**Table 12: GPS + GLONASS 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) GLONASS L1 (1597.781–1605.656 MHz)	
Polarization	RHCP	Right-Hand Circular Polarization
Gain	GPS 0.90 dBi GLONASS 1.30 dBi	Peak Gain

The example of results for the LC86L (A) patch antenna, tested on an EVB with the ground plane of 100 mm x 60 mm, is given in the following figures. 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 19: GPS + GLONASS Patch Antenna Test Results (with Ground Plane of 100 mm × 60 mm)**

#### 4.1.3. GPS + BeiDou Patch Antenna

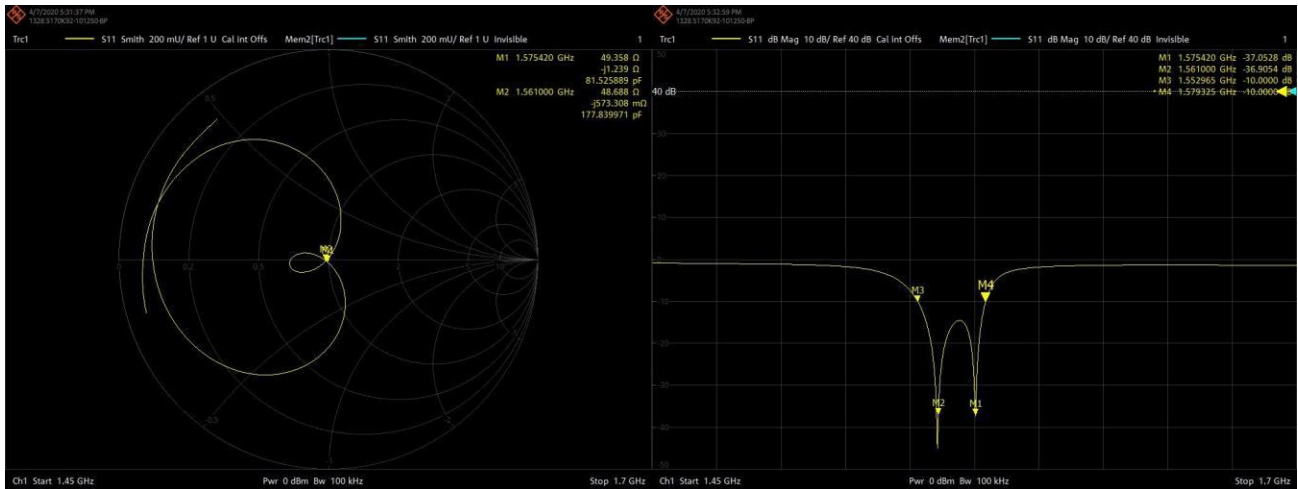
The LC86L (B) product variant is designed with a 15.0 mm × 15.0 mm × 4.0 mm high-performance patch antenna that supports GPS and BeiDou constellations by default. Its specifications are described in the following table.

**Table 13: 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 B1 C/A (1559.052–1563.144 MHz)	
Polarization	RHCP	Right-Hand Circular Polarization
Gain	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 x 60 mm, is given in the following figures. This embedded GNSS antenna provides good

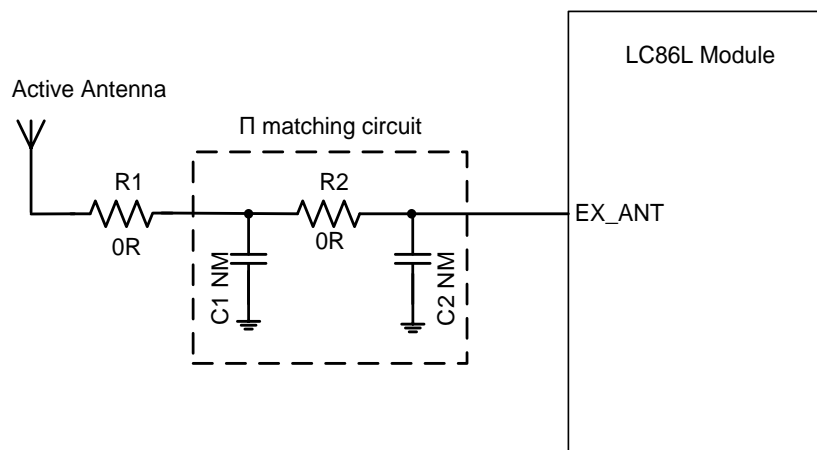
radiation efficiency, right hand circular polarization and optimized radiation pattern. The antenna is insensitive to surroundings and has high tolerance against frequency shifts.



**Figure 20: GPS + BeiDou Patch Antenna Test Result with Ground Plane of 100 mm x 60 mm**

## 4.2. External Active Antenna

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



**Figure 21: Reference Design for Active Antenna**

C1, C2, R1 and R2 are reserved matching circuits for antenna impedance modification. By default, R1 and R2 have 0 Ω impedance, while C1 and C2 are not mounted.

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

**Table 14: Recommended Antenna Specifications**

Antenna Type	Specification
L1 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**

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

## 4.3. External Active Antenna Status Indicator

### 4.3.1. GPTXT Sentence

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

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

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

If **ANTSTATUS=SHORT**, then the external active antenna is short-circuited, so the module uses the internal patch antenna.

**NOTES**

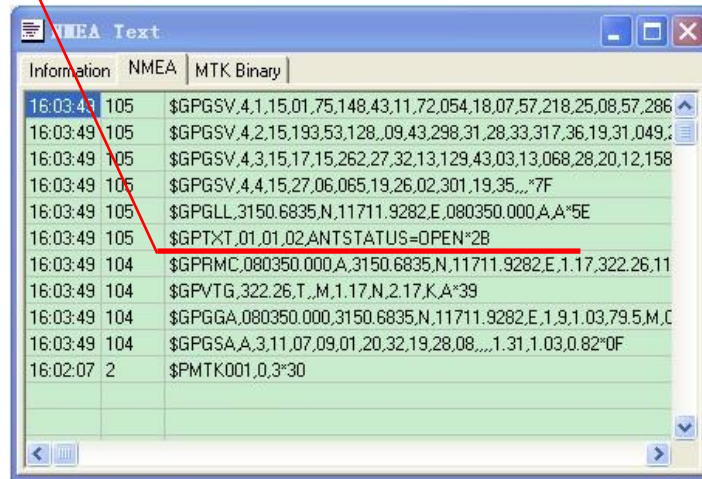
1. If you use an external active antenna and the "OPEN" is displayed in the GPTXT of NMEA sentence, double-check the connection status of the external active antenna.
2. Because the antenna short-circuit protection is enabled by default, the LC86L module will switch to the embedded patch antenna automatically in case the external active antenna is short-circuited to



avoid the damage to the module. When this happens, you should check the external active antenna.

### Example

“OPEN” is displayed in the GPTXT sentence below.



**Figure 22: Patch Antenna Status Description in GPSTXT**

**Table 15: GPTXT – Antenna Status**

GPTXT Display	Ext. Active Antenna Status	Inner Patch Antenna Status	Attention
OPEN	Unused	Working	Check the status of the external active antenna, if it is used.
OK	Working	Unused	
SHORT	Short	Working	Check the external active antenna.

#### 4.3.2. AADET\_N Pin

The AADET\_N pin can also 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 will change to a low level when the active antenna is connected well.

Table 15: AADET\_N – Antenna Status

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

**NOTE**

The 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 16: 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. Therefore, it is necessary to use appropriate protection diodes to keep voltage spikes within the parameters given in the table above.

## 5.2. Operating Conditions

Table 17: 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 <sub>VCCP</sub>	Peak supply current	VCC = 3.3 V			100	mA
V_BCKP	Backup voltage supply		1.5	3.3	4.3	V
T <sub>OPR</sub>	Normal operating temperature		-40	25	85	°C

### NOTES

1. The I<sub>VCCP</sub> value 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. Electrostatic Discharge

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

The following measures ensure the ESD protection when LC86L is handled:

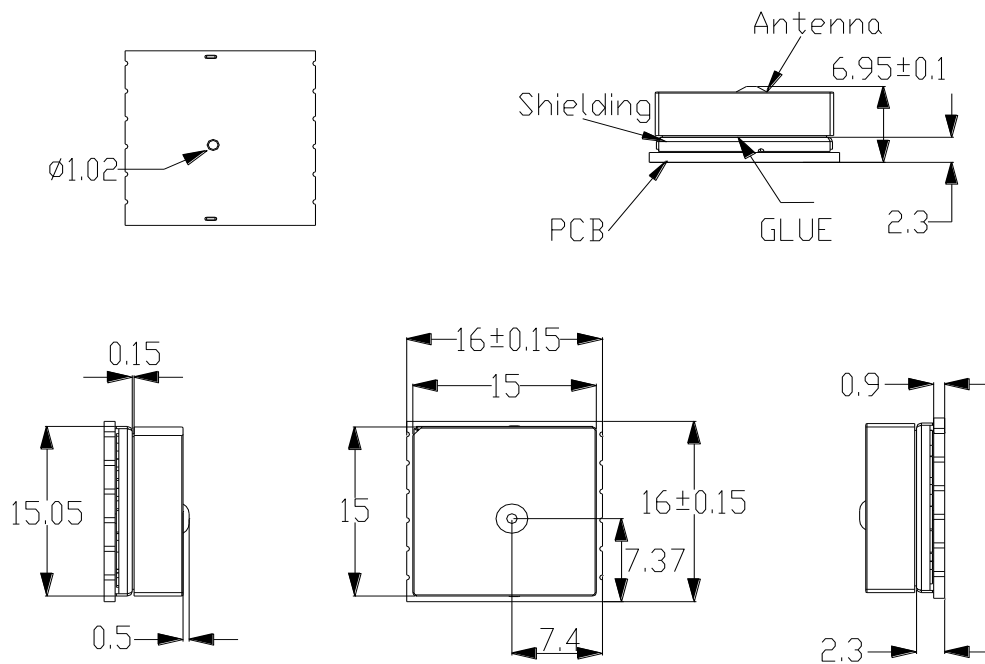
- When handling the PCB, the first contact point shall always be between the local GND and PCB GND, unless there is a galvanic coupling between the local GND and the PCB GND.
- When mounting the module onto a motherboard, make sure to first connect the GND and then the EX\_ANT pad.
- When handling the 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, or soldering iron).
- To prevent electrostatic discharge from the RF input, do not touch any exposed area of the mounted patch antenna.
- When soldering the EX\_ANT pad, make sure to use an ESD safe soldering iron (tip).

# 6 Mechanical Dimensions

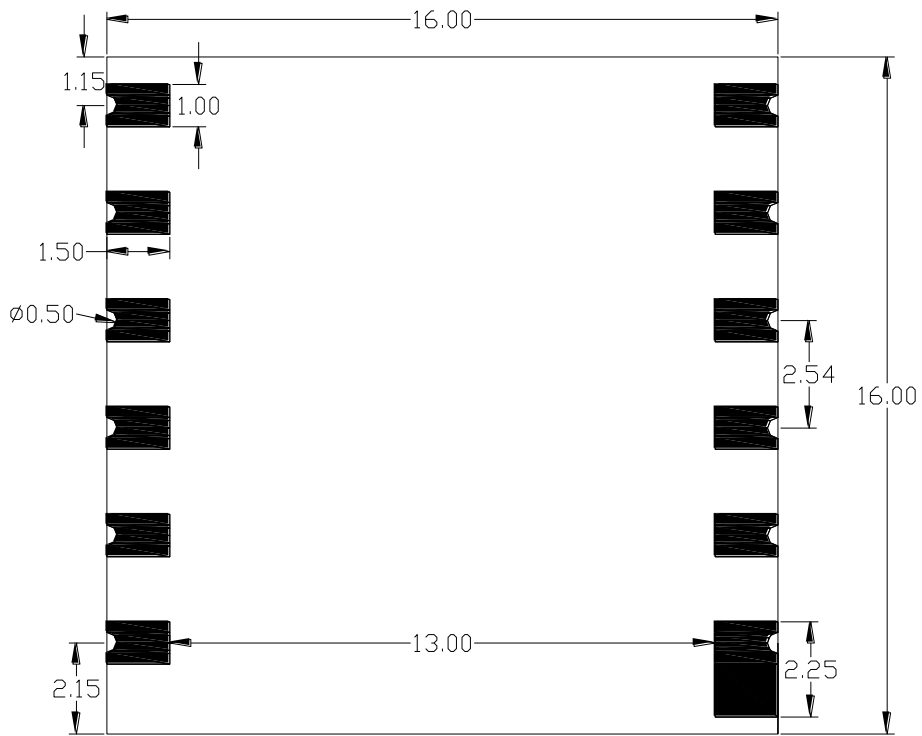
This chapter describes the mechanical dimensions of the module. The dimensional tolerances are  $\pm 0.05$  mm unless otherwise specified.

## 6.1. Mechanical Dimensions

Unit: mm



**Figure 23: Top and Side Dimensions**



**Figure 24: Bottom View Dimensions**

**NOTE**

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

## 6.2. Recommended Footprint

Unit: mm

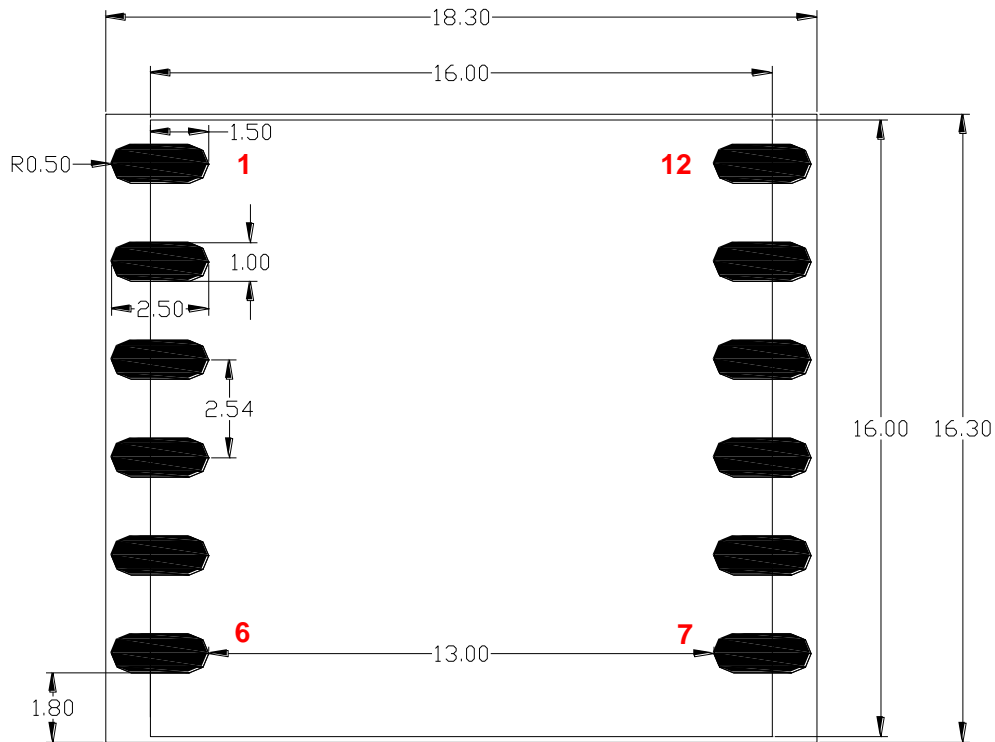


Figure 25: Recommended Footprint

### NOTE

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

### 6.3. Top and Bottom Views

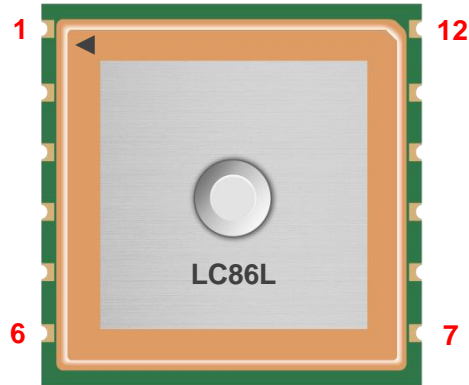


Figure 26: Top View of the Module

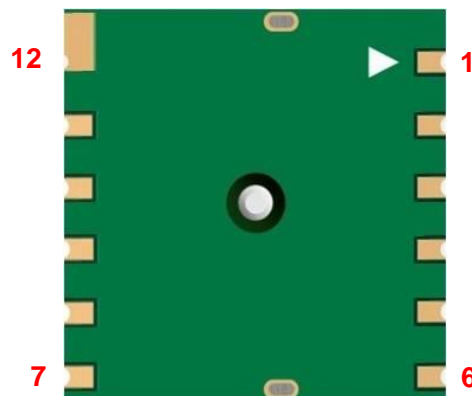


Figure 27: Bottom View of the Module

#### 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, refer to the module received from Quectel.



# 7 Storage, Manufacturing and Packaging

## 7.1. Storage

LC86L module is provided with vacuum-sealed packaging. Moisture sensitivity level (MSL) of the module is rated as 3. The storage requirements are shown below.

1. Recommended Storage Conditions: The temperature should be  $23 \pm 5$  °C and the relative humidity should be 35%–60%.
2. The storage life (in vacuum-sealed packaging) is 12 months in Recommended Storage Conditions.
3. The floor life of the module is 168<sup>1)</sup> hours in a plant where the temperature is  $23 \pm 5$  °C and relative humidity is below 60%. After the vacuum-sealed packaging is removed, the module must be processed in reflow soldering or other high-temperature operations within 168 hours. Otherwise, the module should be stored in an environment where the relative humidity is less than 10% (e.g. a drying cabinet).
4. The module should be pre-baked to avoid blistering, cracks and inner-layer separation in printed-circuit board (PCB) under the following circumstances:
  - The module is not stored in Recommended Storage Conditions;
  - Violation of the third requirement above occurs;
  - Vacuum-sealed packaging is broken, or the packaging has been removed for over 24 hours;
  - Before module repairing.
5. If needed, the pre-baking should follow the requirements below:
  - The module should be baked for 8 hours at  $120 \pm 5$  °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 a drying oven.

### NOTES

1. <sup>1)</sup> This floor life is only applicable when the environment conforms to *IPC/JEDEC J-STD-033*.
2. To avoid blistering, layer separation and other soldering issues, it is forbidden to expose the

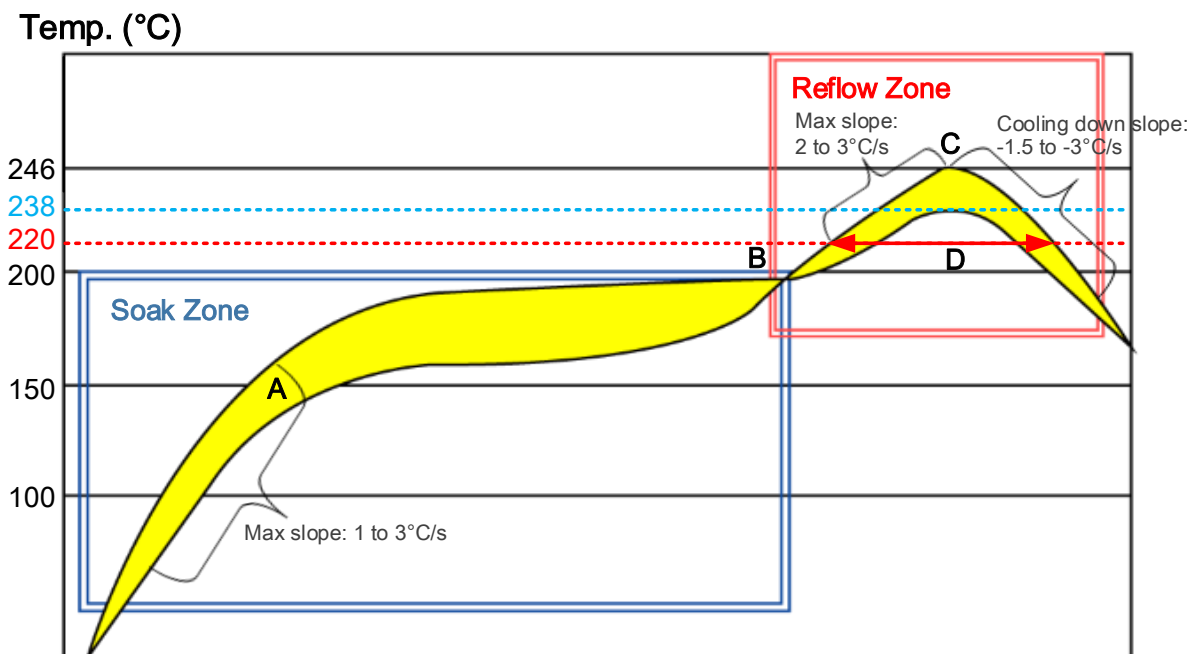
modules to the air for a long time. If the temperature and moisture do not conform to *IPC/JEDEC J-STD-033* or the relative moisture is over 60%, It is recommended to start the solder reflow process within 24 hours after the package is removed. Do not remove the module's packages if they are not ready for soldering.

3. Take the module out of the packaging and put it on high-temperature resistant fixtures before the baking. If shorter baking time is desired, 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, it is recommended that the thickness of stencil for the module is 0.15–0.18 mm. For more details, refer to **document [5]**.

The peak reflow temperature should be 238–246 °C, with 246 °C as the absolute maximum reflow temperature. To avoid damage to the module caused by repeated heating, Quectel recommends that the module should be mounted to the PCB only after the reflow soldering for the other side of PCB has been completed. The recommended thermal profile for reflow soldering (lead-free reflow soldering) and related parameters are shown in the figure and table below.



**Figure 28: Recommended Thermal Profile for Reflow Soldering**

**Table 11: Recommended Parameters of Thermal Profile**

Factor	Recommendation
<b>Soak Zone</b>	
Max Slope	1–3 °C/s
Soak Time (between A and B: 150 °C and 200 °C)	70–120 s
<b>Reflow Zone</b>	
Max Slope	2–3 °C/s
Reflow Time (D: over 220 °C)	45–70 s
Max Temperature (C)	238–246 °C
Cooling Down Slope	-1.5 to -3 °C/s
<b>Reflow Cycles</b>	
Max. Reflow Cycles	1

#### NOTES

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

### 7.3. Packaging

The modules are packaged in tape and reel carriers. One reel is 6.5 meters long and contains 250 modules. Each reel is packaged inside a vacuum-sealed bag under ESD protection. The bag should not be opened until the devices are ready to be soldered onto the application.

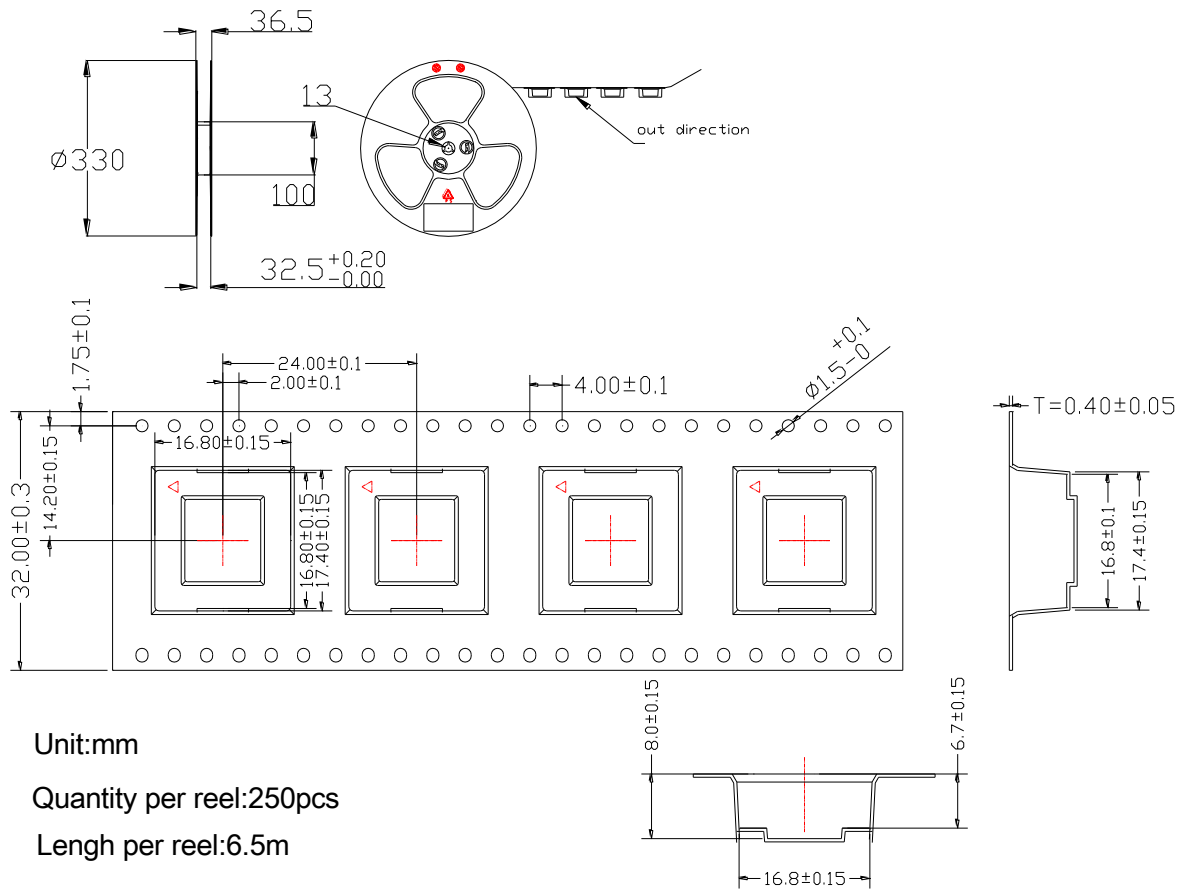


Figure 29: Tape and Reel Specifications

Table 12: Packaging Specifications

Minimum Package (pieces)	Minimum Package (MP) Specification	Minimum Package × 4 = 1000
250	Size: 370 mm × 350 mm × 56 mm Net Weight: 1.5 kg Gross Weight: 2.25 kg	Size: 380 mm × 250 mm × 365 mm Net Weight: 6.1 kg Gross Weight: 9.4 kg

# 8 Appendix A References

**Table 13: Related Documents**

SN	Document Name	Remark
[1]	Quectel_L76-LB&L26-LB&LC86L_GNSS_Protocol_Specification	GNSS Protocol Specification for LC86L, L76-LB and L26-LB Modules
[2]	Quectel_GNSS_SDK_Commands_Manual	GNSS SDK Commands Manual
[3]	Quectel_LC86L_EVB_User Guide	LC86L EVB User Guide
[4]	Quectel_L80&L86&LC86L_Reference_Design	Reference Design for LC86L, L86, and L80 Modules
[5]	Quectel_Module_Secondary_SMT_Application_Note	Secondary SMT User Guide for Quectel Modules

**Table 14: Terms and Abbreviations**

Abbreviation	Description
AGNSS	Assisted GNSS
AIC	Active Interference Cancellation
BB	Baseband
CEP	Circular Error Probable
CMOS	Complementary Metal-Oxide-Semiconductor
DCE	Data Communication Equipment
DGPS	Differential GPS
DTE	Data Terminal Equipment
EASY	Embedded Assist System
EGNOS	European Geostationary Navigation Overlay Service

---

EMC	Electromagnetic Compatibility
EPO	Extended Prediction Orbit
ESD	Electrostatic Discharge
GGA	Global Positioning System Fix Data
GLL	Geographic Position – Latitude/Longitude
GLP	GNSS Low Power
GND	Ground
GNSS	Global Navigation Satellite System
GPIO	General Purpose Input/Output
GPS	Global Positioning System
GSA	GNSS DOP and Active Satellites
GSV	GNSS Satellites in View
HDOP	Horizontal Dilution of Precision
IC	Integrated Circuit
I/O	Input/Output
Kbps	Kilo Bits Per Second
LCC	Leadless Chip Carriers
LDO	Low Dropout Regulator
LNA	Low Noise Amplifier
MCU	Microcontroller Unit
MSAS	Multi-Functional Satellite Augmentation System
MSL	Moisture Sensitivity Level
NMEA	NMEA (National Marine Electronics Association) 0183 Interface Standard
PCB	Printed Circuit Board
PDOP	Position Dilution of Precision
PMTK	MTK Proprietary Protocol

---

---

PMU	Power Management Unit
PPS	Pulse Per Second
PQ	Quectel Proprietary Protocol
PRN	Pseudo Random Noise
QZSS	Quasi-Zenith Satellite System
RF	Radio Frequency
RHCP	Right Hand Circular Polarization
RMC	Recommended Minimum Specific GNSS Data
RoHS	Restriction of Hazardous Substances
RTC	Real-Time Clock
RTCM	Radio Technical Commission for Maritime Services
SAW	Surface Acoustic Wave
SBAS	Satellite-Based Augmentation System
SMD	Surface Mount Device
SPDT	Single-Pole Double-Throw
SRAM	Static Random-Access Memory
SV	Satellite Vehicle
TCXO	Temperature Compensated Crystal Oscillator
TVS	Transient Voltage Suppressor
TXT	Text Transmission
UART	Universal Asynchronous Receiver/Transmitter
VDOP	Vertical Dilution of Precision
VSWR	Voltage Standing Wave Ratio
VTG	Course over Ground & Ground Speed
WAAS	Wide Area Augmentation System
Imax	Maximum Load Current

---

---

V <sub>max</sub>	Maximum Voltage Value
V <sub>norm</sub>	Normal Voltage Value
V <sub>min</sub>	Minimum Voltage Value
V <sub>IHmax</sub>	Maximum Input High Level Voltage Value
V <sub>IHmin</sub>	Minimum Input High Level Voltage Value
V <sub>ILmax</sub>	Maximum Input Low Level Voltage Value
V <sub>ILmin</sub>	Minimum Input Low Level Voltage Value
V <sub>Imax</sub>	Absolute Maximum Input Voltage Value
V <sub>Imin</sub>	Absolute Minimum Input Voltage Value

---