L86 Hardware Design

GNSS Module Series

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Quectel Wireless Solutions Co., Ltd.
Building 5, Shanghai Business Park Phase III (Area B), No.1016 Tianlin Road, Minhang District, Shanghai, China 200233
Tel: +86 21 5108 6236
Email: info@quectel.com

Or our local office. For more information, please visit:
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About the Document

Revision History

Version	Date	Author	Description
1.0	2014-09-04	King HAO	Initial
1.1	2015-11-09	Neil WU	1. Added the description of PPS VS. NMEA. 2. Added note for the position of pin 1. 3. Modified current consumption of backup mode. 4. Modified the PCB design guide.
1.2	2016-04-22	Neil WU	Modified the PCB design guide.
1.3	2020-04-29	Andy ZHAO	1. Updated the description about the backup mode in Chapter 3.4.3. 2. Added the information about the power-on sequence of the module in Chapter 3.5. 3. Updated the module thickness in Chapter 6.1, VCC and V_BCKP voltage ranges in Chapter 3.2.

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1 Introduction

This document defines and specifies L86 GNSS module. Hardware interfaces, external application reference circuits, mechanical size and air interface of L86 module are described in this document.

This document helps customers quickly understand the interface specifications, as well as electrical and mechanical details of L86 module. Other documents such as L86 software application notes and user guides are also provided for customers, so that the customers can use L86 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 L86 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 Description

2.1. General Description

L86 GNSS module equipped with an embedded patch antenna (18.4 mm × 18.4 mm × 4 mm) and LNA brings high performance of MTK positioning engine to the industrial applications. With a small-footprint leadless package, the L86 GPS module makes it possible to implement the top level of sensitivity, accuracy and TTFF in the industry with the minimum power consumption. An embedded flash memory can be used to store useful navigation data and perform updates in the future.

The L86 module is integrated with advanced features such as EASY, AIC, LOCUS, AlwaysLocate™ and Antenna Supervisor. These features can help shorten TTFF, improve sensitivity, reduce power consumption and detect antenna status in GNSS system. The module supports various positioning, navigation and industrial applications such as autonomous GPS, GLONASS, SBAS (including WAAS, EGNOS, MSAS, and GAGAN), QZSS, and AGPS.

By using the L86 module equipped with the embedded patch antenna and LNA, the design of the device can be simplified and the costs of the device can be reduced. Moreover, in addition to an automatic antenna switching function with which switching between an external active antenna and the internal patch antenna can be implemented, the L86 module also supports external active antenna detection and short circuit protection. The detection result and notification of different external active antenna statuses will be included in the NMEA message consisting of external active antenna connection, open circuit for antenna and antenna short-circuit. In this way, a host can query the external active antenna status in a timely and convenient manner.

As the key feature of the L86 module, the EASY technology is one type of AGPS. Being capable of obtaining and processing all internal aiding information such as GPS time, Ephemeris and Last Position, the GNSS module provides a very short TTFF at a hot or warm start.

The L86 module is an SMD type module with a compact 18.4 mm × 18.4 mm × 6.95 mm form factor. The module can be built in applications by using the 12 pins at 2.54 mm pitch spacing. The L86 module provides necessary hardware interfaces for connections to the main PCB.

The module is fully compliant to EU RoHS regulations.

2.2. Key Features

Table 1: Key Features

Features	Implementation
GNSS	● GPS + GLONASS
Power Supply	● Supply voltage: 2.8 V to 4.3 V, typ. 3.3 V
Power Consumption	● Acquisition: 26 mA @ VCC = V_BCKP = 3.3 V (GPS) ● Tracking: 22 mA @ VCC = V_BCKP = 3.3 V (GPS) ● Acquisition: 30 mA @ VCC = V_BCKP = 3.3 V (GPS+GLONASS) ● Tracking: 26 mA @ VCC = V_BCKP = 3.3 V (GPS+GLONASS) ● Standby: 1 mA @ VCC = V_BCKP = 3.3 V ● Backup: 7 μA @ V_BCKP = 3.3 V
Receiver Type	● GPS L1 1575.42 MHz C/A Code ● GLONASS L1 1598.0625–1605.375 MHz C/A Code
Sensitivity	● Acquisition: –149 dBm ● Re-acquisition: –161 dBm ● Tracking: –167 dBm
TTFF (EASY enabled)	● Cold start: typ. 15 s @ –130 dBm ● Warm start: typ. 5 s @ –130 dBm ● Hot start: typ. 1 s @ –130 dBm
TTFF (EASY disabled)	● Cold start (Autonomous): typ. 35 s @ –130 dBm ● Warm start (Autonomous): typ. 30 s @ –130 dBm ● Hot start (Autonomous): typ. 1 s @ –130 dBm
Horizontal Position Accuracy (Autonomous)	● < 2.5 m CEP @ –130 dBm
Max Update Rate	● Up to 10 Hz, 1 Hz by default
Accuracy of 1PPS Signal	● Typical accuracy: ±10 ns ● Time pulse width 100 ms
Velocity Accuracy	● Without aid: 0.1 m/s
Acceleration Accuracy	● Without aid: 0.1 m/s²
Dynamic Performance	● Maximum altitude: 18,000 m ● Maximum velocity: 515 m/s ● Acceleration: 4 G
UART Port	● UART Port: TXD1 and RXD1 ● Supports baud rate from 4800 bps to 115200 bps, where the default setting is 9600 bps. ● UART port is used for NMEA output, MTK proprietary commands

	input and firmware upgrade
Temperature Range	● Normal operation: –40 °C to +85 °C ● Storage temperature: –45 °C to +125 °C
Physical Characteristics	● Size: 18.4 ±0.15 mm × 18.4 ±0.15 mm × 6.95 ±0.1 mm ● Weight: Approx. 7.6 g

NOTES

1. The power consumption is measured in open sky with internal patch antenna. Meanwhile, EASY, AIC and SBAS are enabled.
2. If the external active antenna is used, VCC pin will supply power for external active antenna. The typical additional current consumption is about 10 mA @ 3.3 V.
3. The performance of external active antenna is similar to that of internal patch antenna expect for power consumption.
4. For more details about current consumption of backup mode, please refer to ***Chapter 3.4.3***.

2.3. Block Diagram

The following figure shows a block diagram of L86 module. It consists of a single chip GNSS IC which includes the RF part and Baseband part, a SPDT, a patch antenna, a LNA, a SAW filter, a TCXO, a crystal oscillator, and short protection and antenna detection circuit for active antenna.

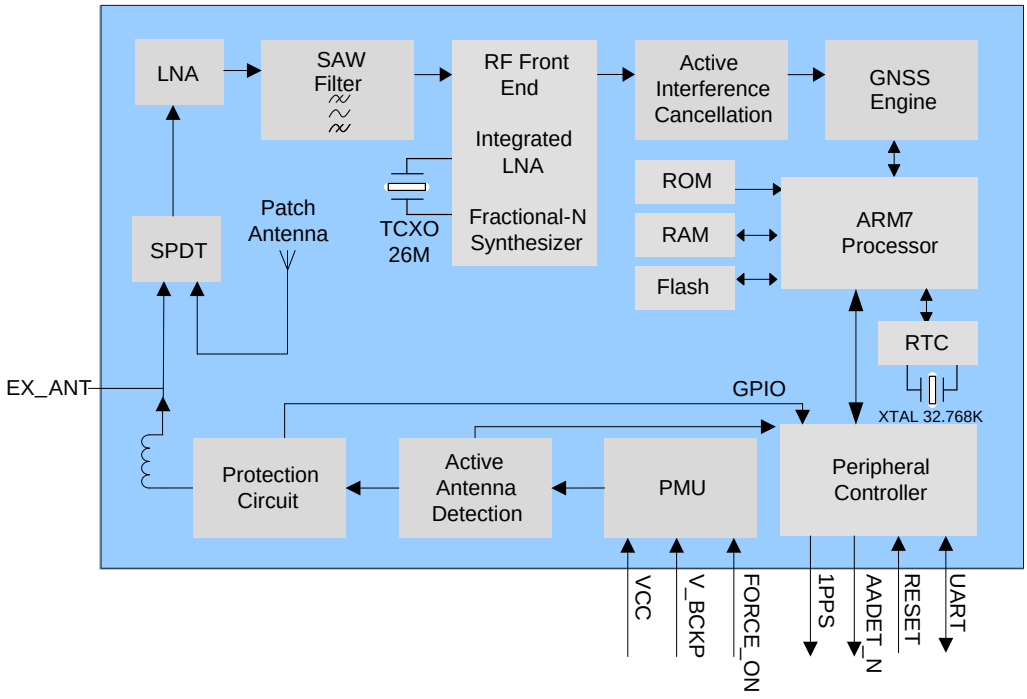

Figure 1: Block Diagram

2.4. Evaluation Board

To help customers apply L86 module to applications of the customers, Quectel provides an Evaluation Board (EVB) with micro USB serial cable and other peripherals to test the module.

For more details, please refer to the ***document [1]***.

2.5. Supported Protocols

Table 2: Supported Protocols

Protocol	Type
NMEA	Output, ASCII, 0183, 4.0
PMTK	Input, MTK proprietary protocol

NOTE

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

3 Application

The module is equipped with 12 LCC pins with 2.54 mm pitch that are connected to customer applications. Interfaces of the pins are described in details in the following chapters.

3.1. Pin Assignment

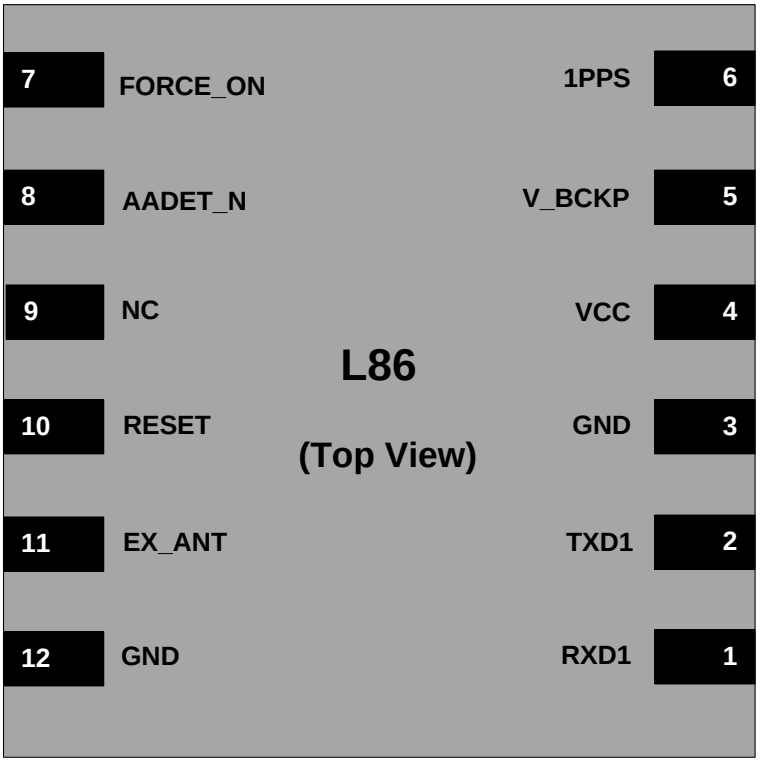

Figure 2: Pin Assignment

3.2. Pin Definition

Table 3: Pin Description

Power Supply					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
VCC	4	I	Main power supply	Vmax = 4.3 V Vmin = 2.8 V Vnom = 3.3 V	Supply current no less than 100 mA.
V_BCKP	5	I	Backup power supply	Vmax = 4.3 V Vmin = 2 V Vnom = 3.3 V	Supply power for RTC domain. The V_BCKP pin can be directly powered by battery or connected to VCC.
Reset					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
RESET	10	I	System reset	V_{IL}min = –0.3 V V_{IL}max = 0.7 V V_{IH}min = 2.1 V V_{IH}max = 3.1 V	Low level active. If unused, keep this pin open or connect it to VCC.
UART Port					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
RXD1	1	I	Receive data	V_{IL}min = –0.3 V V_{IL}max = 0.7 V V_{IH}min = 2.1 V V_{IH}max = 3.1 V	
TXD1	2	O	Transmit data	V_{OL}max = 0.42 V V_{OH}min = 2.4 V V_{OH}nom = 2.8 V	
RF Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
EX_ANT	11	I	External active antenna RF input	Characteristic impedance of 50 Ω	If unused, keep this pin open.
Other Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
1PPS	6	O	One pulse per	V_{OL}max = 0.42 V	Synchronized at rising edge,

			second	VOHmin = 2.4 V VOHnom = 2.8 V	the pulse width is 100 ms. If unused, keep this pin open.
FORCE_ON	7	I	Logic high will force module to be waked up from backup mode	VILmin = –0.3 V VILmax = 0.7 V VIHmin = 2.1 V VIHmax = 3.1 V	Keep this pin open or pulled low before entering into backup mode. It belongs to RTC domain. If unused, keep this pin open.
AADET_N	8	O	Active antenna detection	VOLmax = 0.7 V VOHmin = 1.3 V	If unused, keep this pin open. Refer to ***Chapter 4.3***.

3.3. Power Supply

VCC pin supplies power for BB, RF, I/O, LNA, short protection and antenna detection circuit. The load current of VCC varies according to the VCC level, processor load, the number of tracked satellites and the rate of satellite re-acquisition. Using external active antenna will consume an additional current about 10 mA from our module. It is important to supply sufficient current and make the power clean and stable. The decouple combination of 10 μF and 100 nF capacitor is recommended nearby VCC pin.

The V_BCKP pin supplies power for RTC domain. It should be valid when powering on the module. The voltage of RTC domain ranges from 2 V 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 GNSS information for quick start-up and a small amount of user configuration variables. For more details about Backup, refer to ***Chapter 3.4.3***.

The module's internal power 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 & 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 → backup).
- Based on the step above, FORCE_ON logic high can turn off the switch (backup → full on).

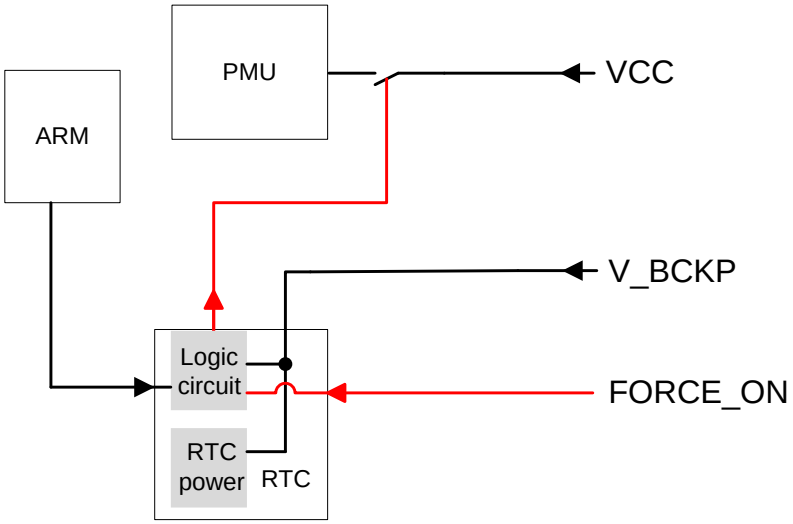

Figure 3: Internal Power Construction

NOTES

1. VCC does not supply power for RTC domain in L86 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 L86 module supports EASY technology and improves TTFF after next restart.
2. 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 V to 0.5 V).
3. It's strongly recommended to use external LDOs without output discharge function to keep long output voltage drop-down period.
4. Please refer to ***document [3]*** for more details of GNSS module power supply.

3.4. Operating Modes

The table below briefly illustrates the relationship among different operating modes of L86 module.

Table 4: Module State Switch

Current Mode	Next Mode				
	Backup	**Standby**	**Full on**	**Periodic**	**AlwaysLocate™**
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
AlwaysLocate™	N/A	N/A	Refer to ***Chapter 3.4.5***	N/A	N/A

NOTE

For more details about MTK proprietary protocol, please refer to ***document [2]***.

3.4.1. Full on Mode

Full on mode includes tracking mode and acquisition mode. Acquisition mode is defined as the mode in which the module starts searching satellites and determining the visible satellites, coarse carrier frequency and code phase of satellite signals. When the acquisition is completed, it switches to tracking mode automatically. Tracking mode is defined as the mode in which the module keeps tracking satellites and demodulates the navigation data from the specific satellites.

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

Table 5: Default Configurations

Item	Configuration	Comment
Baud Rate	9600 bps	
Protocol	NMEA	RMC, VTG, GGA, GSA, GSV, GLL and GPTXT (MTK proprietary protocol)
Update Rate	1 Hz	
SBAS	Enable	
AIC	Enable	
LOCUS	Disable	

EASY	Enable	EASY will be disabled automatically when update rate exceeds 1 Hz.
GNSS	GPS + GLONASS	

3.4.2. Standby Mode

Standby mode is a low-power-consumption mode. In 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 L86 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 GPS time, Ephemeris, Last Position, etc., resulting to the fastest possible TTFF in either Hot or Warm start. The typical standby current consumption in this way is about 1 mA @ VCC = 3.3V.

NOTE

When the external active antenna is used, an additional current about 10 mA will be consumed because the VCC still supplies power for external active antenna in standby mode.

3.4.3. Backup Mode

Less power is consumed in the backup mode compared with that consumed in the standby mode. In this mode, the module stops acquiring and tracking satellites. UART is not accessible. But the backed-up memory in RTC domain which contains all the necessary GNSS information for quick start-up and a small amount of user configuration variables is alive. Due to the backed-up memory, EASY technology is available.

There are two methods of entering backup mode and returning to full-on mode:

- Sending command "$PMTK225,4*2F" (used to turn on the switch as indicated with the red line in Figure 3) to enter backup mode permanently. The only way to wake up the module is to pull FORCE_ON to high (which turns off the switch in Figure 3). The typical current required in this way to enter backup mode can be 840 μA.
- Cutting off the power supply of the VCC pin and keeping the V_BCKP pin powered on, so that the module enters backup mode from the full-on mode. Provided that the VCC pin is powered on, the module will return to the 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 μA. 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 following timing diagram indicates that the module enters backup mode after being powered on.

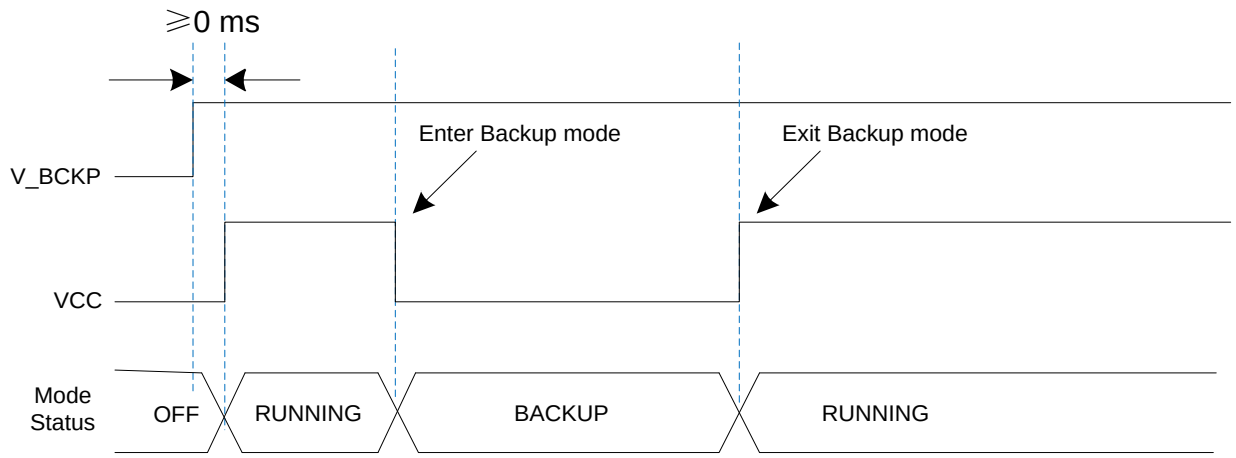

Figure 4: Backup Mode Sequence Diagram

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 antenna supervisor 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.

The V_BCKP pin can be directly powered by an external capacitor or battery (rechargeable or non-chargeable). Please refer to the following figure for RTC backup reference design.

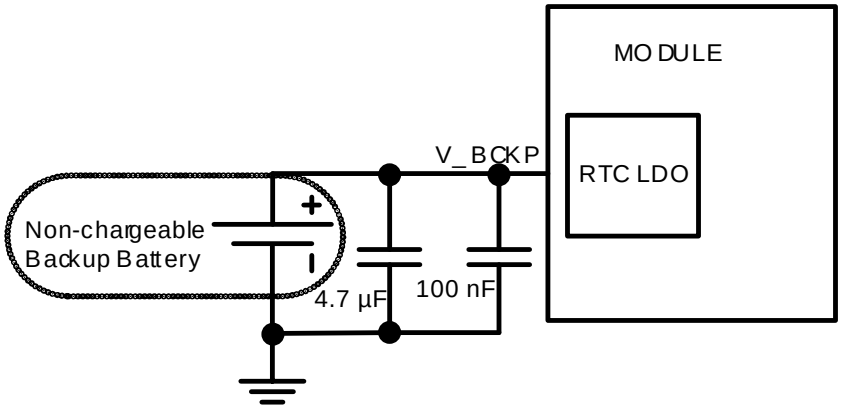

Figure 5: RTC Supply from Non-chargeable Battery

The V_BCKP pin does not support charging function for rechargeable battery. It is necessary to add an external charging circuit for rechargeable batteries.

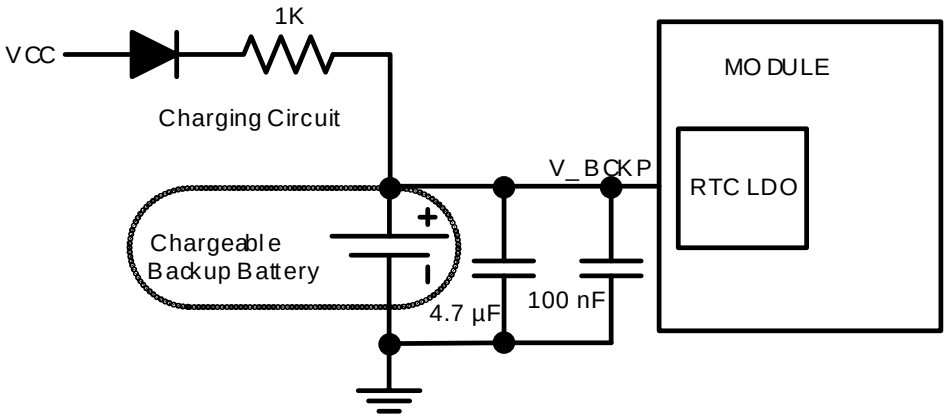

Figure 6: Reference Charging Circuit for Chargeable Battery

Coin-type rechargeable capacitor from Seiko (http://www.sii.co.jp/en/) can be used and Schottky diode from ON Semiconductor (http://www.onsemi.com/) is recommended to be used here for its low voltage drop.

3.4.4. Periodic Mode

Periodic mode is a mode of switching between the full on mode and standby/backup mode periodically to reduce power consumption. It contains periodic standby mode and periodic backup mode.

The format of the command which enables the module to enter periodic mode is as follows:

Table 6: PMTK Command Format

Format: $PMTK225,<Type>,<Run_time>,<Sleep_time>,<2nd_run_time>,<2nd_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	Full on mode period (ms)
Sleep_time	Decimal	Standby/Backup mode period (ms)
2nd_run_time	Decimal	Full on mode period (ms) for extended acquisition in case module's acquisition fails during the **Run_time**
2nd_sleep_time	Decimal	Standby/Backup mode period (ms) for extended sleep in case module's acquisition fails during the **Run_time**
Checksum	Hexadecimal	Hexadecimal checksum

Example

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

Sending "$PMTK225,0*2B" in any time will make the module enter full on mode from periodic standby mode.

Pulling FORCE_ON high and sending "$PMTK225,0*2B" immediately will make the module enter full on mode from periodic backup mode.

Sending "$PMTK225,0*2B" in **Run_time** or **2nd_run_time** will also make the module enter full on mode from periodic backup mode, but it is hard to operate and not recommended.

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 you send PMTK command, the module will be in the full on mode firstly. After several minutes, the module will enter the periodic mode and follow the parameters set by you. 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**.

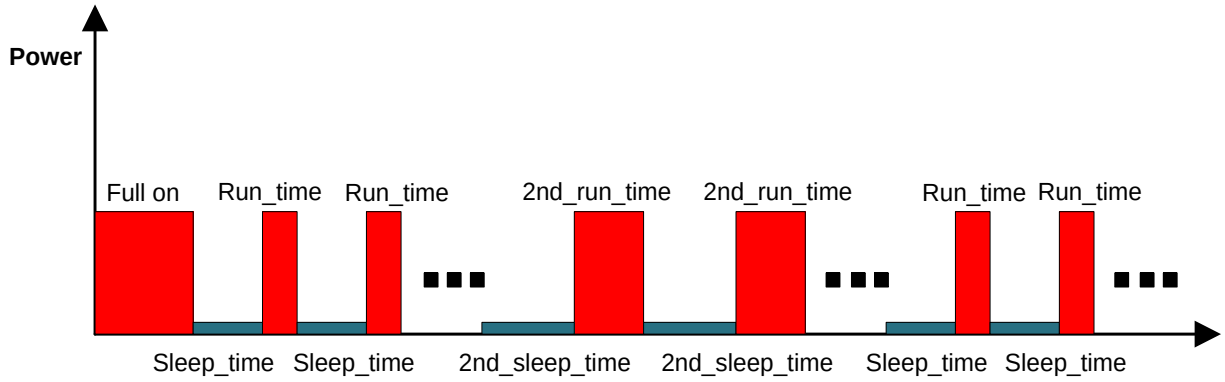

Figure 7: Periodic Mode

Please ensure the module is in the tracking state before entering into periodic mode. Otherwise, the module will have a risk of failure to track the satellites. If GNSS module is located in weak signal environment, it is better to set a longer **2nd_run_time** to ensure the success of reacquisition.

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

$I_{periodic} = (I_{tracking} \times T1 + I_{standby/backup} \times T2) / (T1 + T2)$
(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 based on GPS&GLONASS. The average current consumption is calculated as below:
$I_{periodic} = (I_{tracking} \times T1 + I_{standby} \times T2) / (T1 + T2) = (26\ mA \times 3\ s + 1\ mA \times 12\ s) / (3\ s + 12\ s) = 6\ (mA)$

PMTK225,1,3000,12000,18000,72000*16 for periodic mode with 3s in tracking mode and 12s in backup mode based on GPS&GLONASS. The average current consumption is calculated as below:
$I_{periodic} = (I_{tracking} \times T1 + I_{backup} \times T2) / (T1 + T2) = (26\ mA \times 3\ s + 0.007\ mA \times 12\ s) / (3\ s + 12\ s) \approx 5.2\ (mA)$

3.4.5. AlwaysLocate™ Mode

AlwaysLocate™ is an intelligent power saving mode. It contains AlwaysLocate™ backup mode and AlwaysLocate™ standby mode.

AlwaysLocate™ standby mode allows the module to switch automatically between full on mode and standby mode. According to the environmental and motion conditions, the module can adaptively adjust the full on time and standby time to achieve a balance between positioning accuracy and power consumption. The returning of "$PMTK001,225,3*35" from the module in response to the sent "$PMTK225,8*23" indicates that the module accesses AlwaysLocate™ standby mode successfully. This mode will facilitate power saving. Sending "$PMTK225,0*2B" in any time will enable the module to return to the full on mode.

AlwaysLocate™ backup mode is similar to AlwaysLocate™ standby mode. The difference is that in AlwaysLocate™ backup mode, switching between full on mode and backup mode can be performed automatically. The PMTK command to enter AlwaysLocate™ backup mode is "$PMTK225,9*22". Pulling FORCE_ON high and sending "$PMTK225,0*2B" immediately will enable the module to return to the full on mode.

The positioning accuracy in AlwaysLocate™ mode will be decreased, especially at high speed. The following figure shows the power consumption of L86 module in different daily scenes when AlwaysLocate™ mode is enabled.

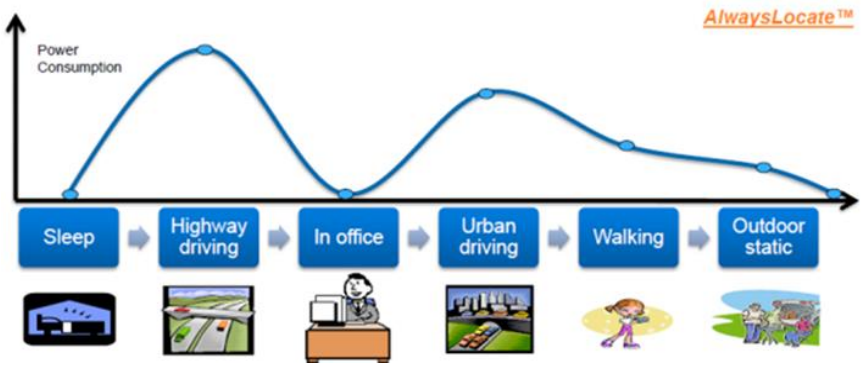

Figure 8: AlwaysLocate™ Mode

Example

The typical average consumption is about 4.0 mA in AlwaysLocate™ standby mode and 3.5 mA in AlwaysLocate™ backup mode.

NOTES

1. Power consumption is measured in GPS and GLONASS system under outdoor static mode with patch antenna. Using external active antenna will increase the power consumption.
2. Before entering into AlwaysLocate™ backup mode, please ensure FORCE_ON pin is open or low, and power supply for V_BCKP is alive.

3.5. Power on

Power is supplied to the V_BCKP pin and the VCC pin in sequence to power on the L86 module. After being powered on, the module outputs the NMEA message through the serial port. The power-on sequence diagram is shown below.

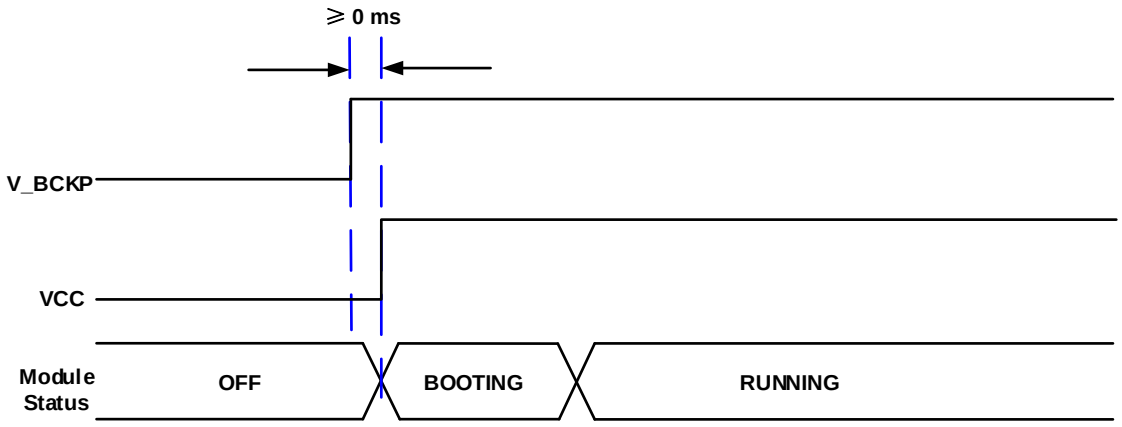

Figure 9: Power-on Timing

3.6. Reset

L86 module can be restarted by driving the RESET pin to a low level voltage for a certain time 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 short TTFF is possible. An OC driver circuit shown below is recommended to control the RESET pin.

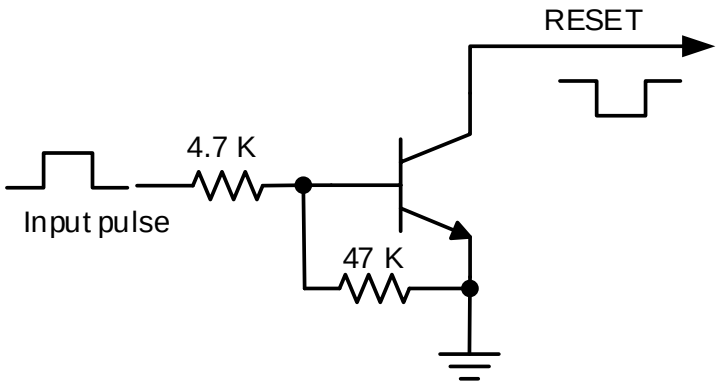

Figure 10: Reference Reset Circuit Using OC Circuit

The restart timing of L86 module is illustrated below.

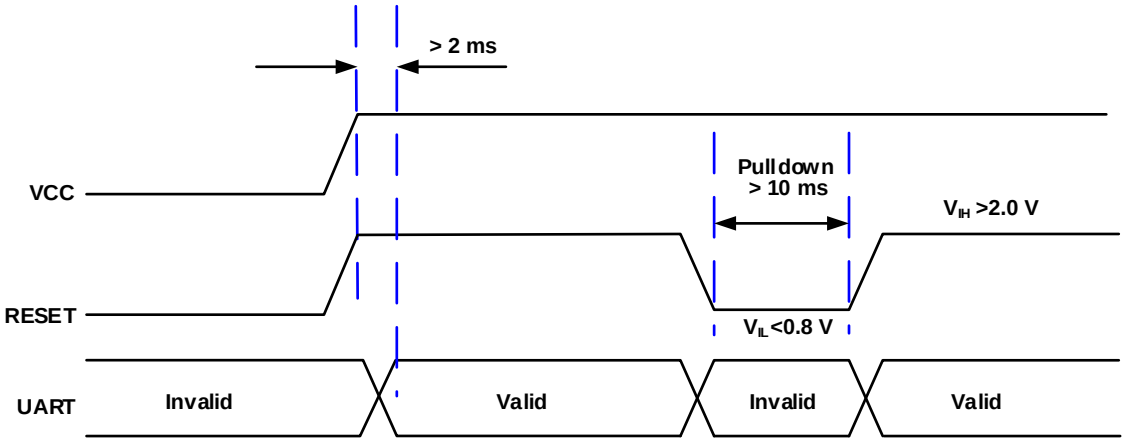

Figure 11: Restart Timing

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 rate from 4800 bps to 115200 bps.

UART port:

- TXD1: Send data to the RXD signal line of DTE.
- RXD1: Receive data from the TXD signal line of DTE.

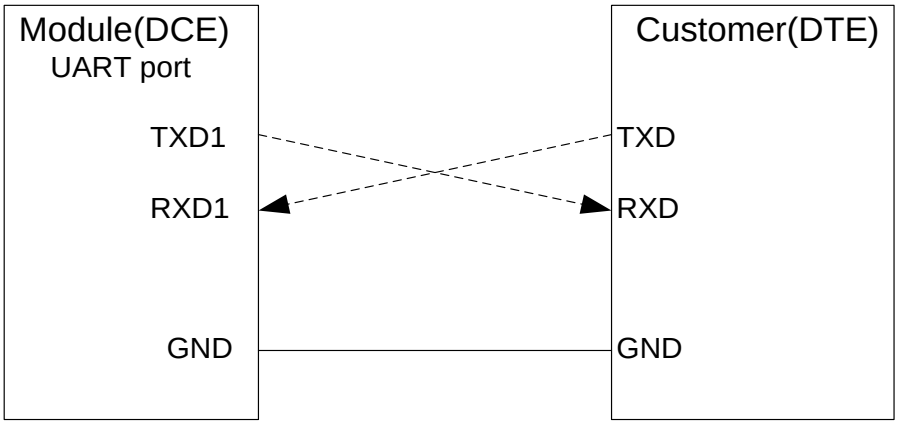

Figure 12: Connection of Serial Interfaces

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 (MTK proprietary protocol).
- UART port supports the following data rates:
  4800 bps, 9600 bps, 14400 bps, 19200 bps, 38400 bps, 57600 bps, 115200 bps.
  The default setting is 9600 bps, 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.

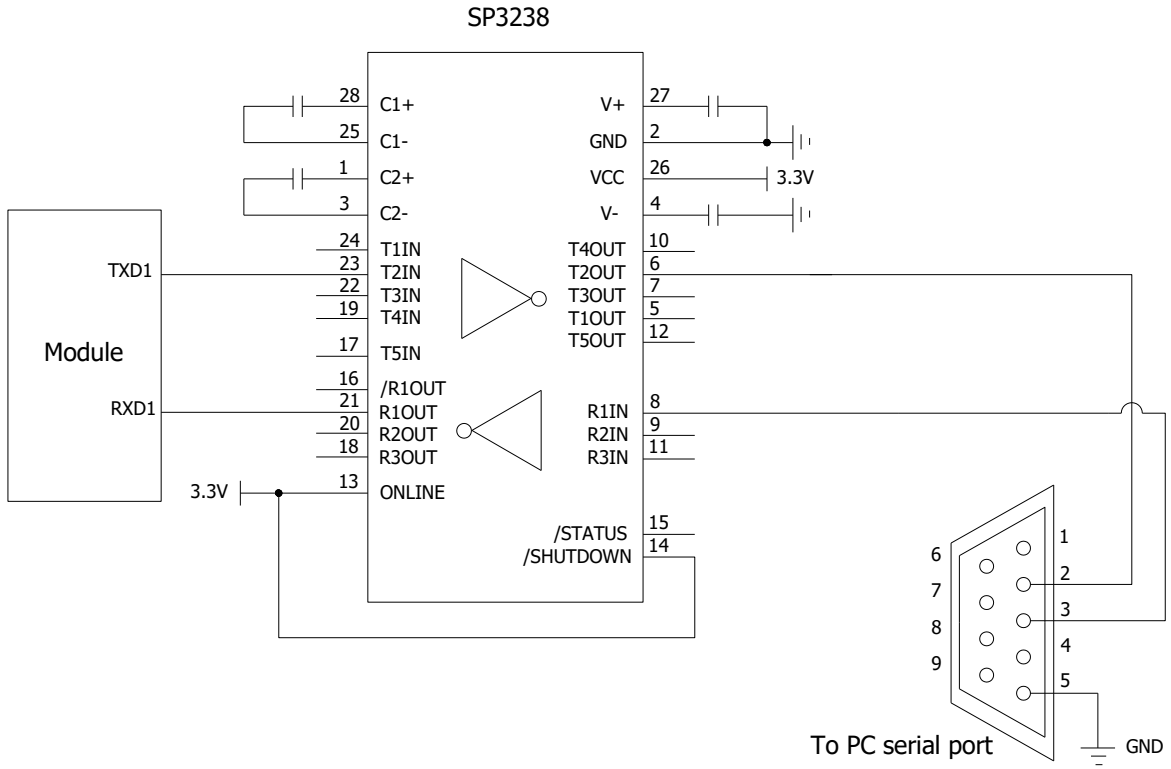

Figure 13: RS-232 Level Shift Circuit

NOTE

As GNSS module outputs more data than a single GPS system. The default output NMEA types running in 4800 bps baud rate and 1 Hz update rate will lose data. The solution to this issue in 4800 bps baud rate and 1 Hz update rate is to decrease the output NMEA types. 9600 bps baud rate is enough to transmit GNSS NMEA in default settings and it is thus recommended.

3.8. EASY Technology

EASY technology works as embedded software which can accelerate TTFF by predicting satellite navigation messages from received ephemeris. The GNSS 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. GNSS 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 5 seconds in warm start. In this case, RTC domain should be valid. In order to get enough broadcast ephemeris information from GPS satellites, the GNSS 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 [2].***

3.9. Multi-tone AIC

L86 module provides an advanced technology called multi-tone AIC (Active Interference Cancellation) to reject RF interference which comes from other active components on the main board.

Up to 12 multi-tone AIC embedded in the module can provide effective narrow-band interference and jamming elimination. The GNSS signal could be recovered from the jammed signal, which can ensure better navigation quality. AIC is enabled by default, closing it will save about 1 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

L86 module supports the embedded logger function called LOCUS. It can log position information to the internal flash memory automatically when this function is enabled by sending PMTK command “$PMTK185, 0*22”. Due to this function, the host can enter the sleep mode to reduce power consumption and does not need to keep receiving the NMEA information all the time. The module can provide a log capacity of more than 16 hours.

The detailed procedures of this function are illustrated bellow:

- The module has fixed the position (only 3D_fixed is available);
- Sending PMTK command “$PMTK184,1*22” to erase internal flash;
- Sending PMTK command “$PMTK185,0*22” to start log;
- Module logs the basic information (UTC time, latitude, longitude and height) every 15 seconds to internal flash memory;
- Stop logging the information by sending “$PMTK185,1*23”;
- Host can get the data from the module via UART by sending“$PMTK622,1*29”.

The raw data which host gets has to be parsed via LOCUS parser 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 7: Status of the Antenna

Status of the Antenna	EXT/Patch	NMEA Message
External Active Antenna is not Inserted	Patch	OPEN
External Active Antenna is Inserted and Worked Normally	EXT	OK
External Active Antenna is Inserted but Short-circuited	Patch	SHORT

3.12. PPS VS. NMEA

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

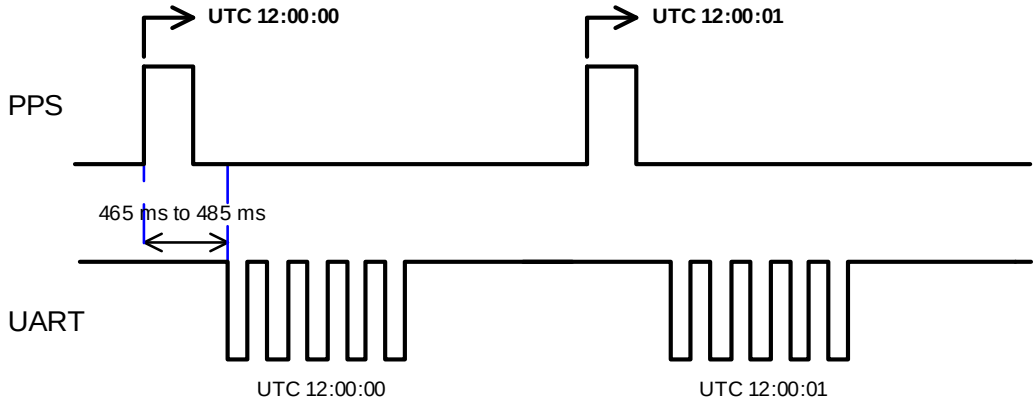

Figure 14: PPS VS. NMEA Timing

This feature only supports 1 Hz NMEA output and baud rate at 14400–115200 bps. At baud rate of 9600 and 4800 bps, it only supports RMC NMEA sentence. Because at low baud rate, per second transmission may exceed one second if there are many NMEA sentences output. This function can be enabled by sending “$PMTK255,1*2D”, and the function can be disabled by sending “$PMTK255,0*2C”.

4 Antenna Interfaces

L86 GNSS module supports both GPS and GLONASS systems. The LNA is embedded for better performance. It is an ultra-compact module with embedded 18.4 mm × 18.4 mm × 4.0 mm patch antenna. In addition, L86 module 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. 18.4×18.4×4 Patch Antenna

The quality of the embedded GNSS antenna is crucial to the overall sensitivity of the GNSS system. L86 module offers an on-module patch antenna. An 18.4 mm × 18.4 mm × 4.0 mm high-performance patch antenna is chosen for reducing product size. This antenna is specially designed for satellite reception applications, and it has excellent stability and sensitivity to consistently provide high signal reception efficiency. The specification of the antenna used by L86 module is described in following table.

Table 8: Antenna Specification for L86 Module with Ground Plane 100 mm × 60 mm

Antenna Type	Parameter	Specification	Notes
Patch Antenna	Size	18.4 mm × 18.4 mm × 4.0 mm	
	Range of Receiving Frequency	GPS: 1575.42 ±1.023 MHz GLONASS: 1598.0625–1605.375 MHz	
	Impendence	50 Ω	
	Bandwidth	10 MHz minimum	Return Loss ≤ –10 dB
	Frequency Temperature Coefficient (TF)	0 ±20 ppm/°C	–40 °C to +85 °C
	Polarization	RHCP	Right Hand Circular Polarization
	Gain at Zenith	Typ. 4.0 dBi	Centre frequency
	VSWR	Max. 1.5	

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.

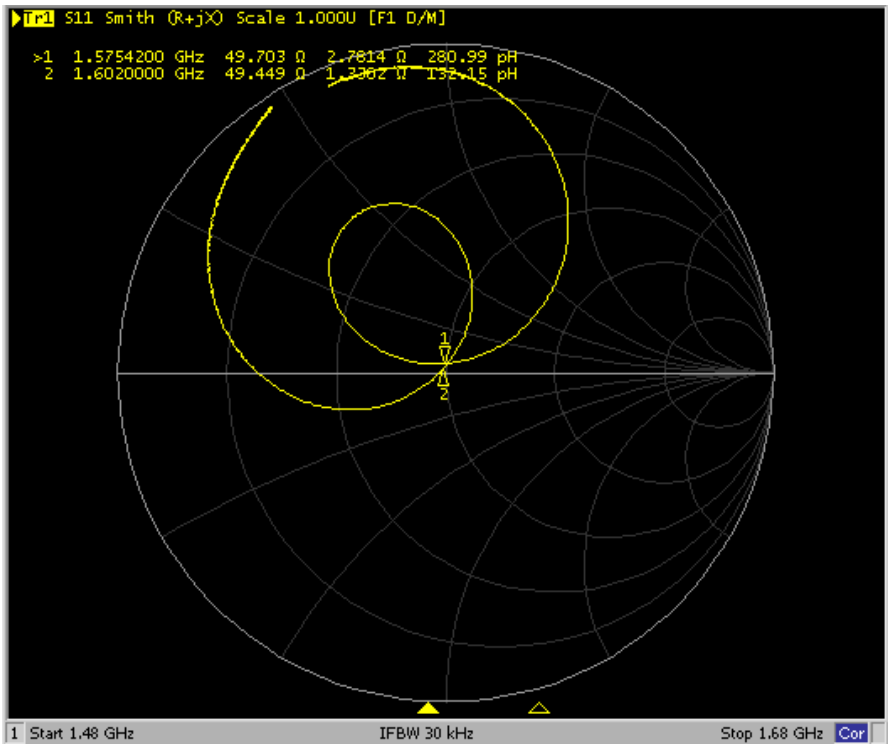

Figure 15: Matching Map of Patch Antenna

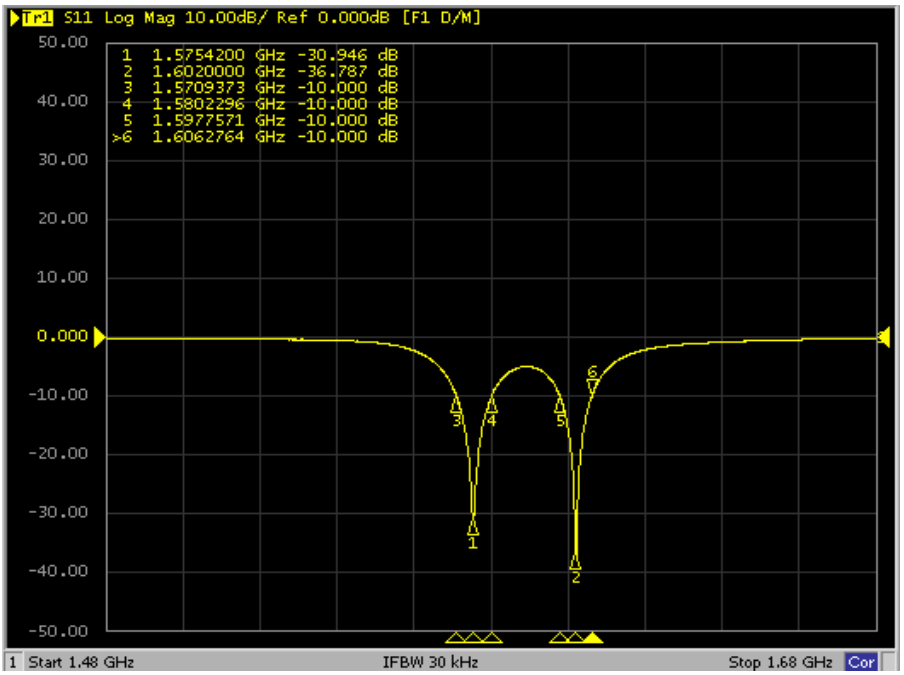

Figure 16: S11 Parameters of Patch Antenna

4.1.2. PCB Design Guide

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

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

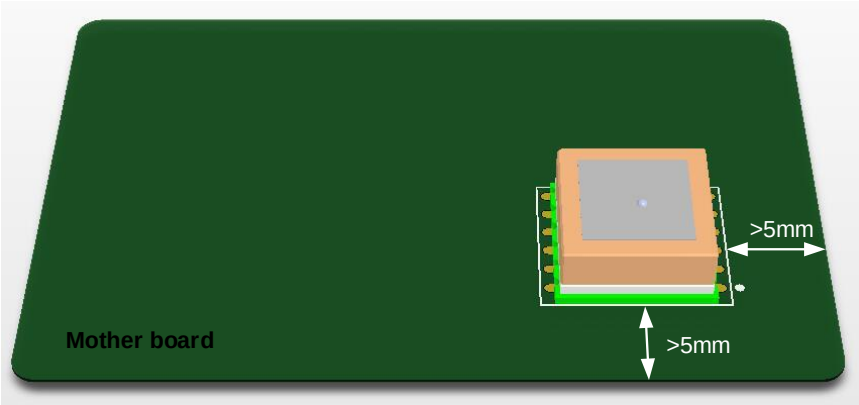

Figure 17: Recommended Distance between Module and Motherboard Edges

- 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 be not less than 2.5 mm.

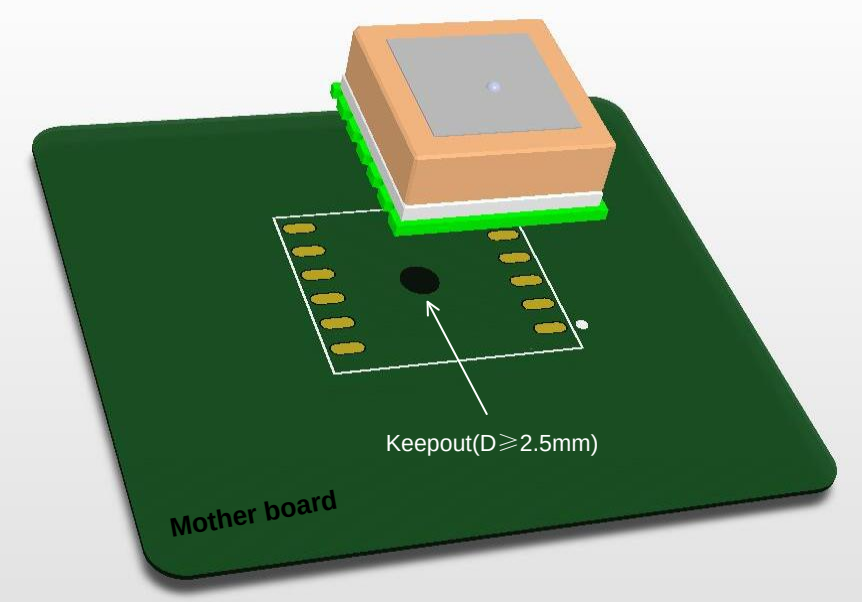

Figure 18: Recommended Treatment for the Feed Point of the Patch Antenna

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

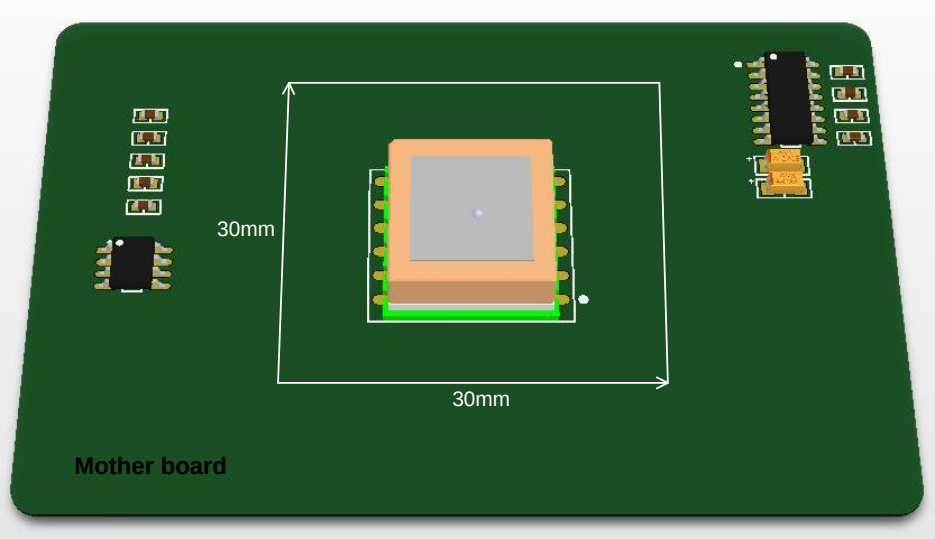

Figure 19: Recommended Ground Plane

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

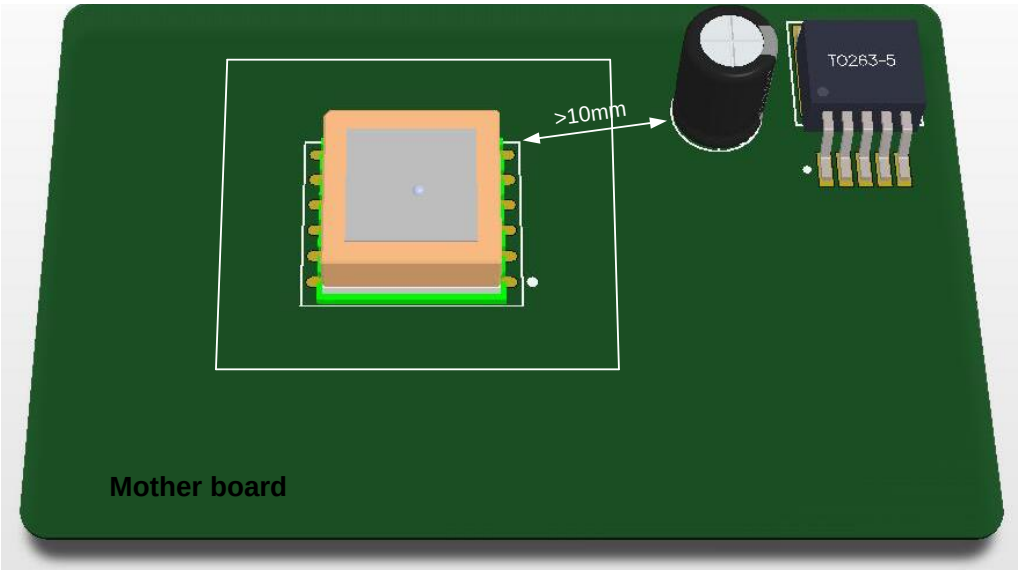

Figure 20: Recommended Distance between Module and Tall Metal Components

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

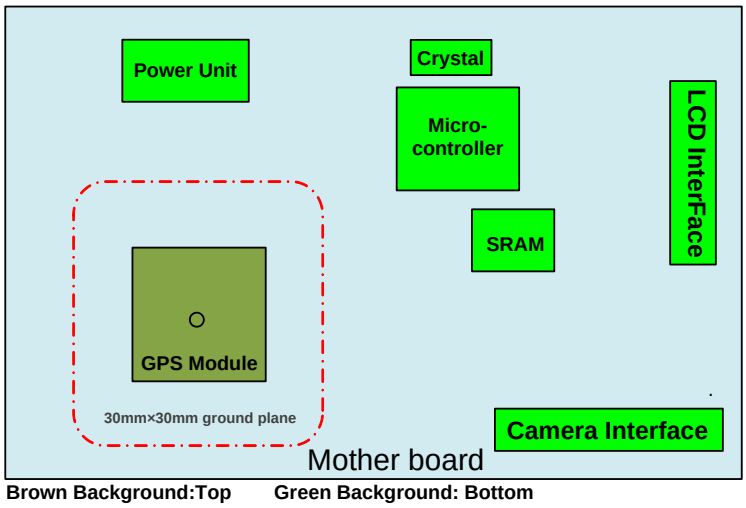

Figure 21: Recommended Placement of GNSS Module

- Make sure interfering signals (USB, LCD, Camera, Crystal, etc.) are on 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/WIFI/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.

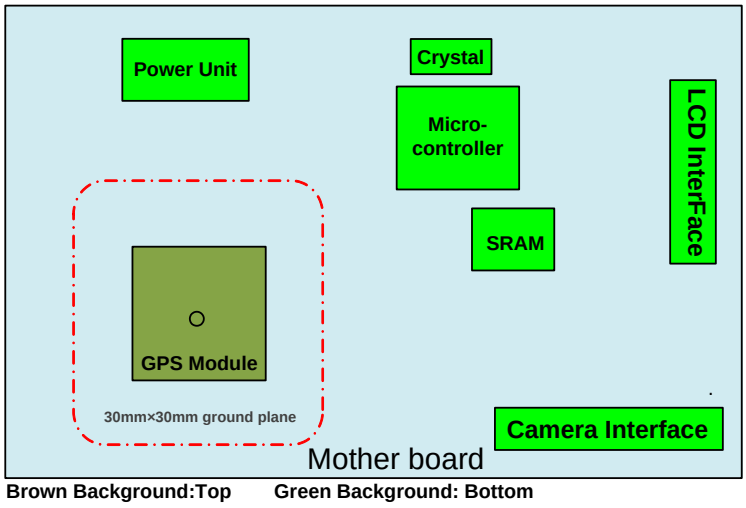

Figure 22: Recommended Placement of GNSS Module with the RF System

- Keep DCDC 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 3 mm.

- The RF part of L86 module is sensitive to temperature. Please keep them away from heat-emitting circuit.
- It is recommended to reserve an integrate ground layer to isolate the GNSS module from others.

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.

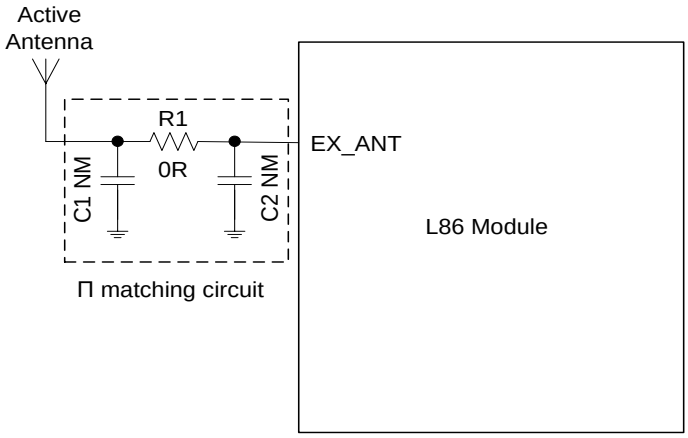

Figure 23: Reference Design for Active Antenna

C1, R1, C2 are reserved matching circuit for antenna impedance modification. By default, C1 and C2 are not mounted; R1 is 0 Ω. In this mode, R1 must not be capacitance, as current will stream through R1 to the active antenna. C1 and C2 must not be inductance or resistance to avoid short circuit.

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 9: Recommended Active Antenna Specification

Antenna Type	Specification
Active Antenna	GPS frequency: 1575.42 ±2 MHz GLONASS frequency: 1602 ±4 MHz VSWR: typ. < 2 Polarization: RHCP or Linear Noise figure: < 1.5 dB Gain (antenna): > –2 dBi Gain (embedded LNA): typ. 20 dB

	Total gain: typ. > 18 dBi

NOTE

To ensure effective short protection function, please select a DC-open (DC-impedance between the SMA's inner signal needle and outside ground) GNSS active antenna. Customers can measure the DC-impedance with a common and simple multimeter on few samples, and the value is generally in M Ω level.

4.3. Antenna Status Indicator

L86 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.

NOTE

Because antenna short protection is enabled by default, L86 module will switch to embedded patch antenna automatically in case in which external active antenna is short-circuited, which will avoid L86 module from damage. Meanwhile, you need to check the external active antenna.

Example

"OPEN" is displayed in the GPTXT sentence as below:

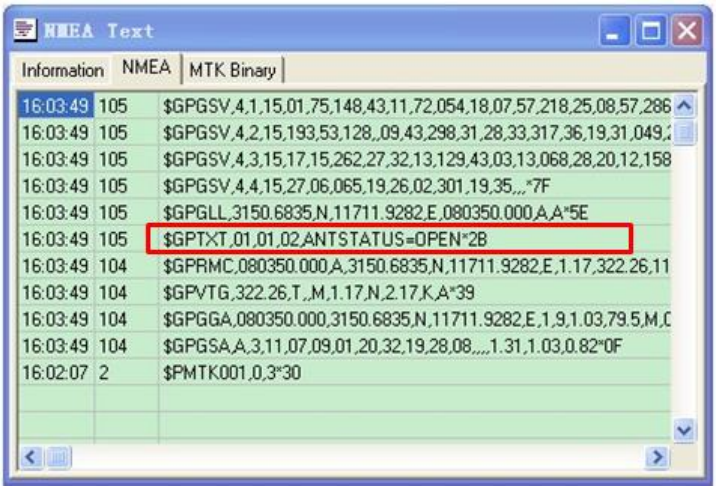

Figure 24: Active Antenna Status Description in GPTXT

Table 10: GPTXT — Status of Antenna

GPTXT Display	Ext Active Antenna Status	Inner Patch Antenna Status	Attention
OPEN	Unused	Working	You 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 absence of the active antenna. 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 11: Absolute Maximum Ratings

Parameter	Min.	Max.	Unit
Power Supply Voltage (VCC)	–0.3	4.5	V
Backup Battery Voltage (V_BCKP)	–0.3	4.5	V
Input Voltage at Digital Pins	–0.3	3.6	V
Input Power at EX_ANT		15	dBm
Storage Temperature	–45	125	°C

NOTE

When in a condition with parameters exceeding the “absolute maximum ratings”, the device may be permanently damaged. The product is not protected against overvoltage 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 12: 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	3.3	4.3	V
TOPR	Normal operating temperature		–40	25	85	°C

NOTES

1. The parameter 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

The values for current consumption are shown in the following table.

Table 13: Current Consumption

Parameter	Conditions	Min.	Typ.	Max.	Unit
I_{VCC} @ Acquisition	VCC = V_BCKP = 3.3 V (GPS)		26		mA
I_{VCC} @ Tracking	VCC = V_BCKP = 3.3 V (GPS)		22		mA
I_{VCC} @ Acquisition	VCC = V_BCKP = 3.3 V (GPS + GLONASS)		30		mA
I_{VCC} @ Tracking	VCC = V_BCKP = 3.3 V (GPS + GLONASS)		26		mA
I_{VCC} @ Standby	VCC = V_BCKP = 3.3 V		1.0		mA

I_{BCKP} @ Backup	V_BCKP = 3.3 V	7	μA

NOTES

1. The tracking current is tested in the following conditions:
   - At Cold Start, 10 minutes after First Fix.
   - At Hot Start, 15 seconds after First Fix.
2. For the backup mode current consumption test, please refer to ***Chapter 3.4.3***.

5.4. Reliability Test

Table 14: Reliability Test

Test Item	Conditions	Standard
Thermal Shock	–30 °C to +80 °C, 144 cycles	GB/T 2423.22-2002 Test Na IEC 68-2-14 Na
Damp Heat, Cyclic	+55 °C; > 90% RH 6 cycles for 144 hours	IEC 68-2-30 Db Test
Vibration Shock	5–20 Hz, 0.96 m^2/s^3; 20–500 Hz, 0.96 m^2/s^3-3 dB/oct, 1 hour/axis; no function	2423.13-1997 Test Fdb IEC 68-2-36 Fdb Test
Heat Test	85 °C, 2 hours, operational	GB/T 2423.1-2001 Ab IEC 68-2-1 Test
Cold Test	–40 °C, 2 hours, operational	GB/T 2423.1-2001 Ab IEC 68-2-1 Test
Heat Soak	90 °C, 72 hours, non-operational	GB/T 2423.2-2001 Bb IEC 68-2-2 Test B
Cold Soak	–45 °C, 72 hours, non-operational	GB/T 2423.1-2001 A IEC 68-2-1 Test

5.5. ESD Protection

L86 module is an ESD sensitive device. ESD protection precautions should be emphasized. Proper ESD handing and packaging procedures must be followed throughout the processing, handling and operation of any application. Please note that the following measures are good for ESD protection during module handling.

- Unless there is a galvanic coupling between the local GND and the PCB GND, the first point of contact shall always be between the local GND and PCB GND when handling the PCB.
- Before mounting the RF_IN pad, please make sure the GND of the module has been connected.
- Do not contact any charged capacitors or materials which can easily develop or store charges (such as patch antenna, coax cable, soldering iron) when handling with 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 of the Module

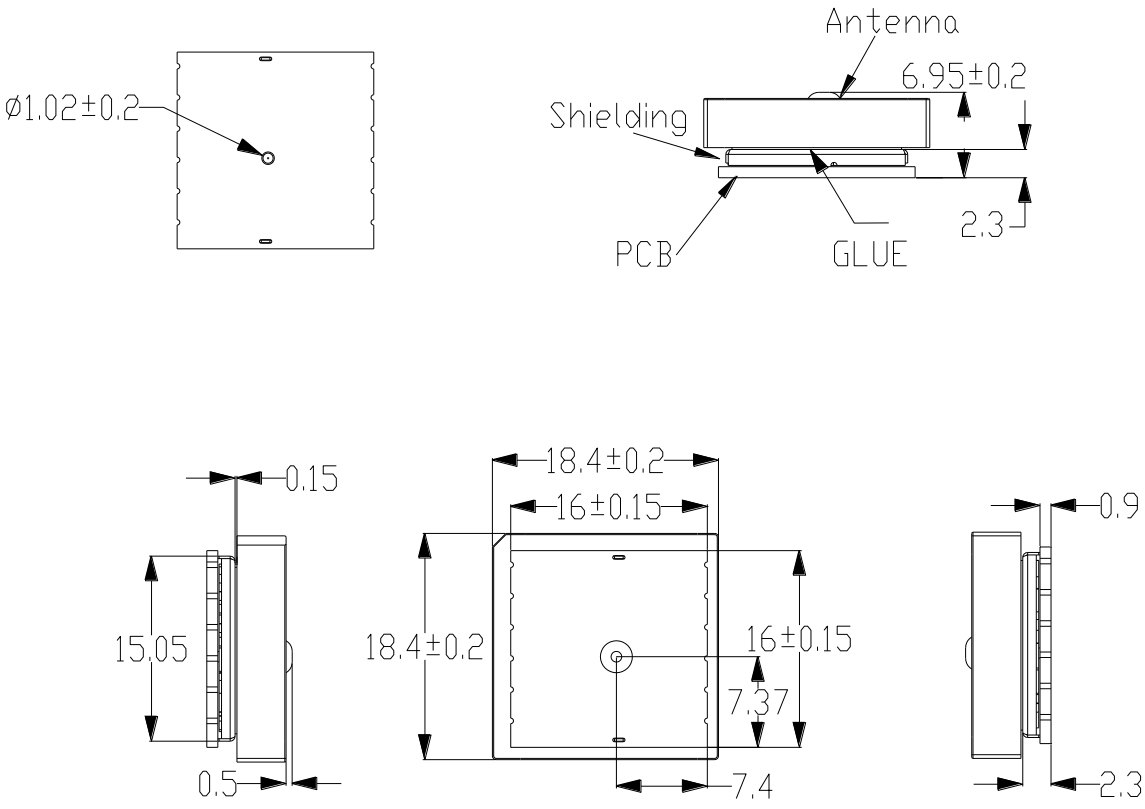

Figure 25: Mechanical Dimensions (Unit: mm)

6.2. Bottom View Dimensions and Recommended Footprint

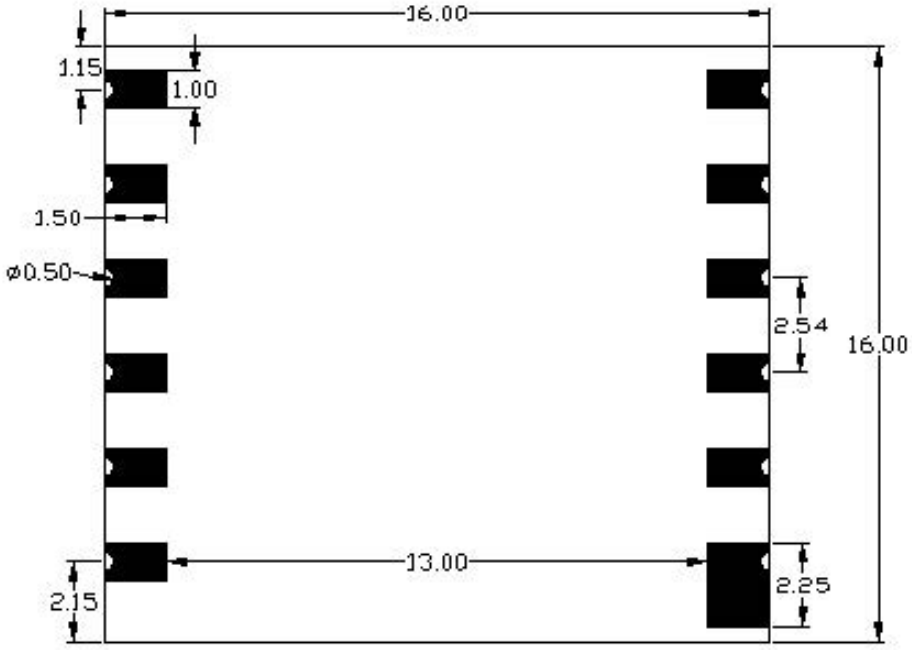

Figure 26: Bottom View Dimensions (Unit: mm)

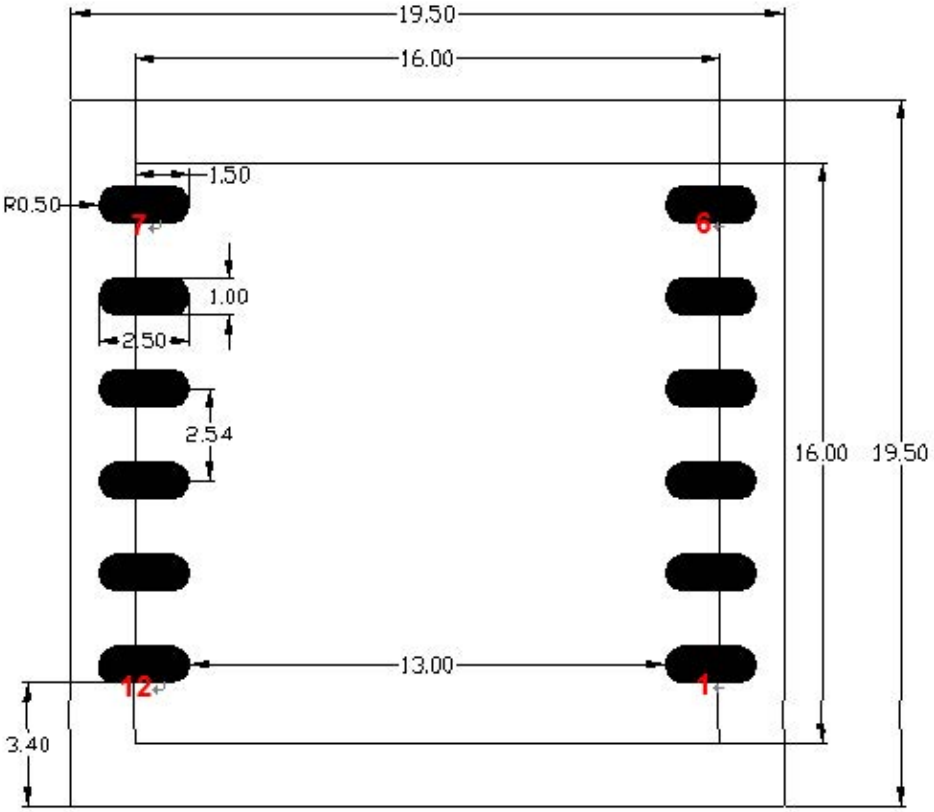

Figure 27: Recommended Footprint (Unit: mm)

NOTE

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

6.3. Top and Bottom Views of the Module

Figure 28: Top View of the Module

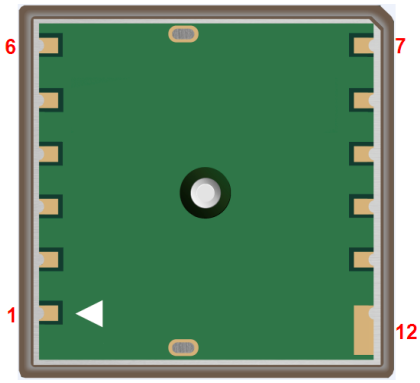

Figure 29: Bottom View of the Module

NOTES

1. The chamfer of the patch antenna does not indicate the position of pin 1.
2. These are rendering drawings of L86 module. For authentic appearance, please refer to the module from Quectel.

7 Manufacturing, Packaging and Ordering Information

7.1. Storage

L86 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, so that the paste fills 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 range from 0.15–0.18 mm. For more details, please refer to ***document [4]***.

It is suggested that the peak reflow temperature ranges from 238–246 ºC, and the absolute maximum reflow temperature is 246 ºC. 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.

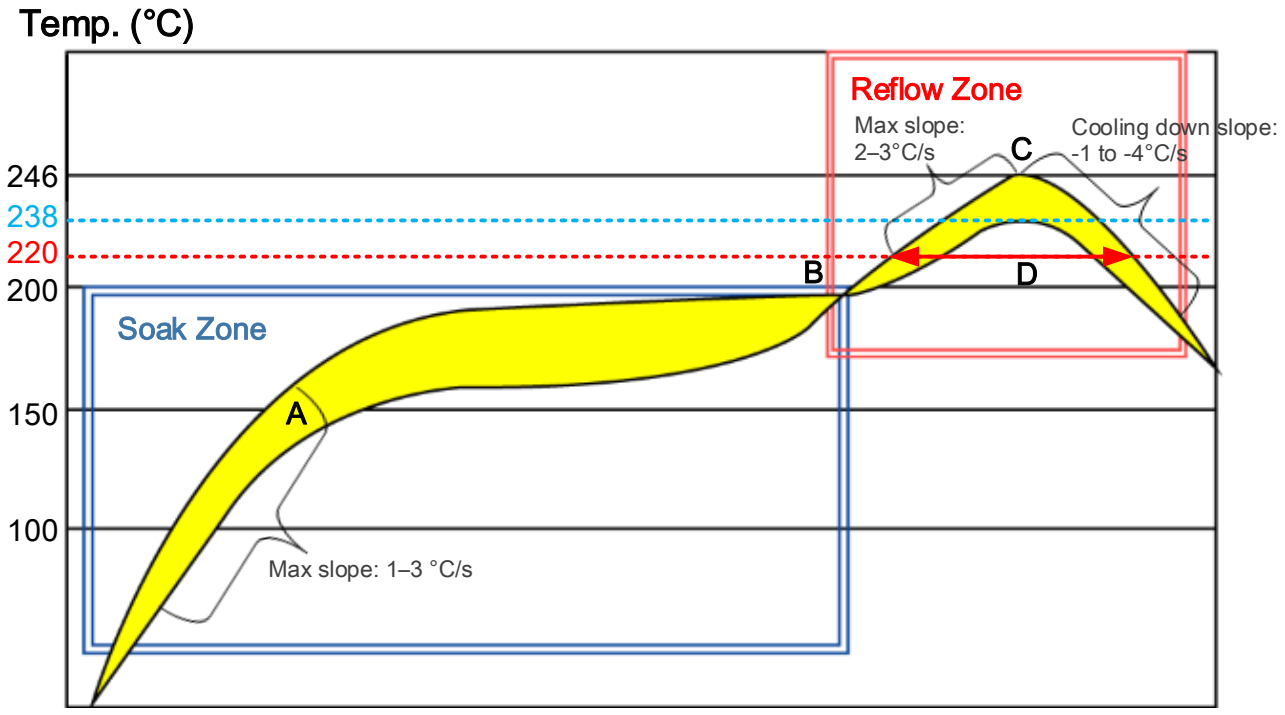

Figure 30: Recommended Reflow Soldering Thermal Profile

Table 15: Recommended Thermal Profile Parameters

Factor	Recommendation
Soak Zone	
Max slope	1–3 °C/s
Soak time (between A and B: 150°C and 200°C)	70–120 s
Reflow Zone	
Max slope	2–3 °C/s
Reflow time (D: over 220°C)	45–70 s
Max temperature	238–246 °C
Cooling down slope	-1 to -4 °C/s
Reflow Cycle	
Max reflow cycle	1

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

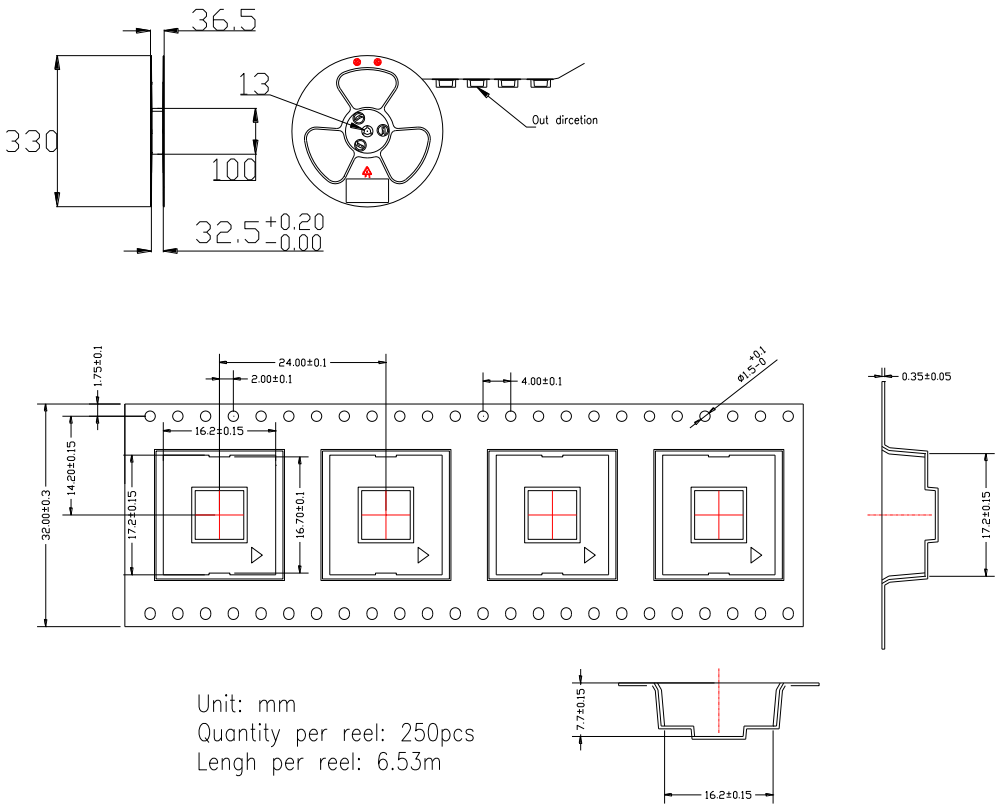

Figure 31: Tape and Reel Specifications (Unit: mm)

Table 16: Reel Packaging

Model Name	MOQ for MP	Minimum Package: 250pcs	Minimum Package x 4 = 1000 pcs
L86	250 pcs	Size: 370 mm × 350 mm × 56 mm N.W: 1.5 kg G.W: 2.25 kg	Size: 380 mm × 250 mm × 365 mm N.W: 6.1 kg G.W: 9.4 kg

7.4. Ordering Information

Table 17: Ordering Information

Model Name	Ordering Code
L86	L86-M33

8 Appendix A References

Table 18: Related Documents

SN	Document Name	Remark
[1]	Quectel_L86_EVB_User Guide	L86 EVB user guide
[2]	Quectel_L86_GNSS_Protocol_Specification	L86 GNSS protocol specification
[3]	Quectel_GNSS_Modules_with_MTK_Engine_AN	GNSS modules with MTK engine application note
[4]	Quectel_Module_Secondary_SMT_Application_Note	Secondary SMT user guide for Quectel modules

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
EPO	Extended Prediction Orbit
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
HDOP	Horizontal Dilution of Precision
I/O	Input/Output
Inom	Nominal Current
Imax	Maximum Load Current
Kbps	Kilo Bits Per Second
LNA	Low Noise Amplifier
MSAS	Multi-Functional Satellite Augmentation System
MSL	Moisture Sensitive Level
MOQ	Minimum Order Quantity
NMEA	National Marine Electronics Association
PDOP	Position Dilution of Precision
PMTK	MTK Proprietary Protocol
PPS	Pulse Per Second
PRN	Pseudo Random Noise Code
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
VDOP	Vertical Dilution of Precision

VTG	Course over Ground and Ground Speed, Horizontal Course and Horizontal Velocity
Vmax	Maximum Voltage Value
Vnom	Nominal Voltage Value
Vmin	Minimum Voltage Value
V_{IH}max	Maximum Input High Level Voltage Value
V_{IH}min	Minimum Input High Level Voltage Value
V_{IL}max	Maximum Input Low Level Voltage Value
V_{IL}min	Minimum Input Low Level Voltage Value
$V_I$max	Absolute Maximum Input Voltage Value
$V_I$min	Absolute Minimum Input Voltage Value
V_{OH}max	Maximum Output High Level Voltage Value
V_{OH}min	Minimum Output High Level Voltage Value
V_{OL}max	Maximum Output Low Level Voltage Value
V_{OL}min	Minimum Output Low Level Voltage Value
WAAS	Wide Area Augmentation System