L76-LB Hardware Design

GNSS Module Series

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About the Document

Revision History

Version	Date	Author	Description
1.0	2019-05-10	Jaden XIANG/ Gene LI	Initial
1.1	2020-07-08	Ronnie HU/ Phil GAO	1. Added the description of L76-LB with 1.8 V I/O voltage. 2. Enabled GPS+GLONASS. 3. Added TTFF, sensitivity and power consumption values of the module while working with GPS+GLONASS. 4. Removed the description of AlwaysLocate™. 5. Added the description of GLP mode (Chapter 3.4.5). 6. Completed the description of EPO (Chapter 3.9). 7. Removed the reference design of passive antenna with an external LNA. 8. Updated storage conditions of the module (Chapter 7.1). 9. Updated the recommended stencil thickness and the recommended thermal profile parameters (Chapter 7.2).
1.2	2020-11-27	Ronnie HU	1. Distinguished the module of different I/O voltage designs by the rule below: ● **L76-LB**: the standard I/O voltage variant, with 2.7–2.9 V I/O voltage. ● **L76-LB (L)**: the low I/O voltage variant, with 1.7–1.9 V I/O voltage. 2. Added DC characteristics of STANDBY for L76-LB (L). 3. Added the note for conformal coating (Chapter 7.2).

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1 Introduction

This document provides information on the interface specifications, electrical and mechanical details, as well as other related information of Quectel L76-LB GNSS module. To facilitate application designs, it also includes some reference designs. This document, coupled with application notes and user guides, makes it easy to design applications with the L76-LB 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 incorporating Quectel GNSS module. Manufacturers of the terminal should notify users and operating personnel of the following safety information by incorporating these guidelines into all manuals of 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, and the wiring shall conform to security precautions and fire prevention regulations.
	Proper ESD handling procedures must be followed throughout the mounting, handling and operation of any application that incorporates the module to avoid ESD damages.

2 Product Concept

The L76-LB module supports multiple positioning and navigation systems, such as GPS, GLONASS, BeiDou, SBAS (including WAAS, EGNOS, MSAS and GAGAN) and QZSS, as well as AGNSS functions. Designed with an embedded LNA, the module achieves high sensitivity, high accuracy, and fast GNSS signal acquisition and tracking.

Key features:

- The embedded flash memory that provides capacity for storing user-specific configurations and allows for future updates
- Multiple power-saving modes, such as Periodic, Standby and Backup
- The embedded low-power algorithms that are suitable for different application scenarios
- EASY™ autonomous AGNSS technology supported, which can collect and process all internal auxiliary information including GNSS time, calendar, the latest position, and so on, so that the module can achieve fast first fix in hot/warm start

The L76-LB module supports different I/O voltages to meet different application demands, and is thus classified into the following two product variants.

- **L76-LB**, the standard I/O voltage variant, has **2.7–2.9 V** I/O voltage.
- **L76-LB (L)**, the low I/O voltage variant, has **1.7–1.9 V** I/O voltage.

Both product variants belong to an SMD type and have a compact profile (10.1 mm × 9.7 mm × 2.5 mm). The module can be embedded in your applications through the 18 LCC pins. It provides all the necessary hardware interfaces for connection with the main PCB.

The module is fully compliant with the EU RoHS directive.

2.1. Specifications

The technical specifications of the module are listed in the following table.

Table 1: Specifications

Features	Details			
GNSS Constellation Configuration	● Default configuration [1]: GPS+GLONASS or GPS+BeiDou ● For more details about the GNSS constellation configuration, refer to ***document [1]***.			
Receiver Type	● GPS L1 C/A (1574.397–1576.443 MHz) ● GLONASS L1 (1598.0625–1605.375 MHz) ● BeiDou B1I (1559.052–1563.144 MHz)			
Power Supply [2]	● Supply voltage: 2.8–4.3 V ● Typical: 3.3 V			
Power Consumption [3] (-130 dBm, VCC = 3.3 V)		**GPS**	**GPS + GLONASS**	**GPS + BeiDou**
	Acquisition (mA)	23	31	32
	Tracking (mA)	20	27	28
	Standby (mA)	0.6	0.6	0.6
	Backup (μA)	8	8	8
	The module's peak current may rush up to 45 mA (typ.)			
Sensitivity		**GPS**	**GPS + GLONASS**	**GPS + BeiDou**
	Acquisition (dBm)	-149	-149	-149
	Reacquisition (dBm)	-161	-161	-161
	Tracking (dBm)	-167	-167	-167
Time-to-First-Fix (without AGNSS)		**GPS**	**GPS + GLONASS**	**GPS + BeiDou**
	Cold Start (s)	34	32	34
	Warm Start (s)	27	28	32
	Hot Start (s)	2	1	2
Time-to-First-Fix (EASY™ Enabled)		**GPS**	**GPS + GLONASS**	**GPS + BeiDou**
	Cold Start (s)	12	15	14
	Warm Start (s)	5	8	9
	Hot Start (s)	2	1	1
Time-to-First-Fix (EPO-Enabled)		**GPS**	**GPS + GLONASS**	**GPS + BeiDou**
	Cold Start (s)	6	8	4

	Warm Start (s)	4	6	2
	Hot Start (s)	2	2	1
Horizontal Position Accuracy (Autonomous) [4]	● < 2.5 m			
Update Rate	● 1 Hz by default, maximum up to 10 Hz			
Accuracy of 1PPS Signal	● Typical accuracy < 100 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: 18000 m ● Maximum Velocity: 515 m/s ● Acceleration: 4 g			
UART Interface	● UART port: TXD1 and RXD1 ● Baud rate: 9600 bps to 921600 bps, 9600 bps by default ● Used for NMEA sentences output, PMTK/PQ commands input and firmware upgrade			
I2C Interface [5]	● Supports fast mode, with a bit rate up to 400 kbps ● Supports 7-bit address ● Operates in a slave mode ● Outputs NMEA data by default, and it can also receive PMTK/PQ commands by an I2C bus			
Temperature Range	● Operating temperature range: -40 °C to +85 °C ● Storage temperature range: -40 °C to +90 °C			
Physical Characteristics	● Size: (10.1 ±0.15) mm × (9.7 ±0.15) mm × (2.5 ±0.20) mm ● Weight: Approx. 0.5 g			

NOTES

1. [1] For more specific information on the default GNSS constellation and the corresponding firmware version, contact Quectel Technical Support.
2. [2] L76-LB and L76-LB (L) have the same power supply voltage range.
3. [3] The power consumption data are tested when QZSS and SBAS are disabled.
   - The power supply of the integrated LNA inside L76-LB will be cut off automatically once the module enters the standby or backup mode.
   - The current consumption of VCC_RF is not reckoned in the values above.
   - Test conditions for the current consumption in the tracking mode:
     In cold start: 15 minutes after the first fix.
     In hot start: 15 seconds after the first fix.
4. [4] CEP, 50%, 2 hours static, -130 dBm, > 6 SVs.

5. [5)] The I2C interface is supported only on firmware versions ending with “SC”. In other firmware versions, I2C_SDA and I2C_SCL pins are used for RTCM data input. When the I2C interface is supported, NEAM data should be outputted via an I2C interface rather than the UART interface; otherwise, there may be NEAM data loss.

2.2. Block Diagram

The following figure shows a block diagram of the L76-LB module. It consists of a single-chip GNSS IC (RF/Baseband parts included), an LNA, a SAW filter, a TCXO, and a crystal oscillator.

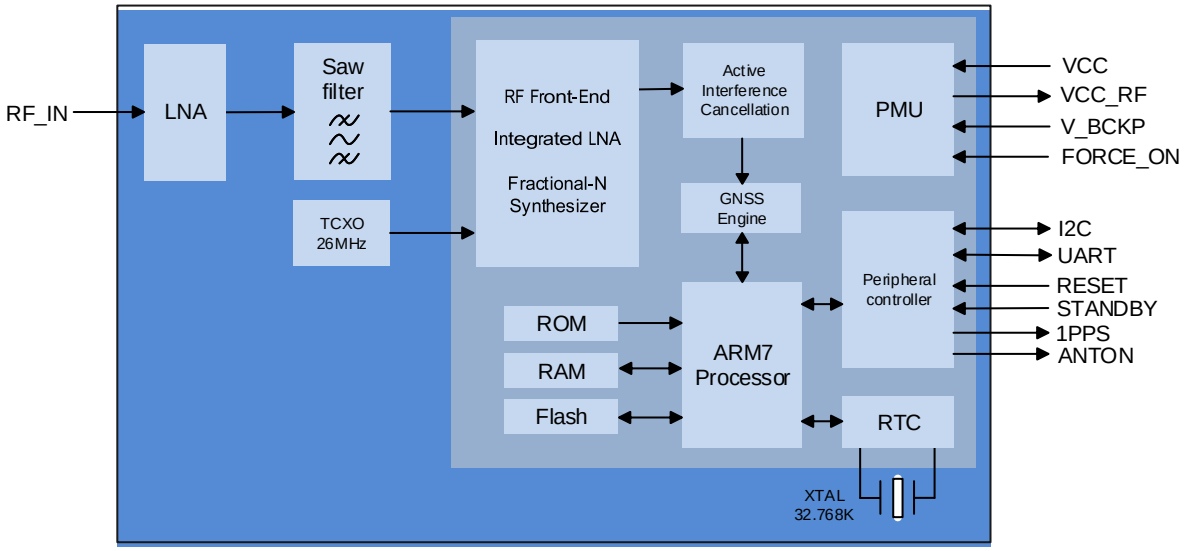

Figure 1: Block Diagram

2.3. Supported Protocols

The supported protocols are given in the following table.

Table 2: Supported Protocols

Protocol	Description
NMEA	ASCII, 0183, 4.10
PMTK	MTK’s proprietary protocol

PQ	Quectel's proprietary protocol

NOTES

1. For details of supported protocols, refer to ***document [1]***.
2. For details of Quectel's proprietary protocol, refer to ***document [2]***.

2.4. Evaluation Board

In order to facilitate application design with the module, Quectel supplies the evaluation board, a micro-USB cable, an active antenna, and other required peripherals to test the module. For more details, refer to ***document [3]***.

3 Application Interfaces

L76-LB is equipped with 18 LCC pins through which the module can be mounted to the motherboard of any terminal.

3.1. Pin Assignment

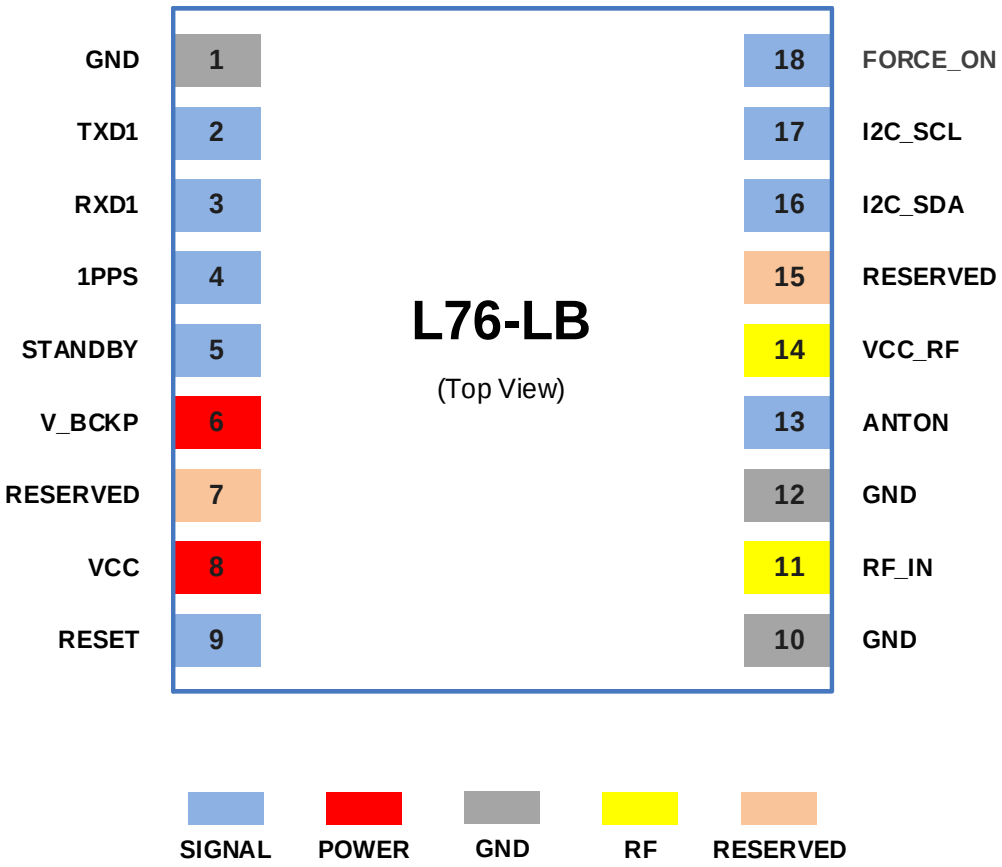

Figure 2: Pin Assignment

3.2. Pin Description

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	8	PI	Main power supply	Vmax = 4.3 V Vmin = 2.8 V Vnorm = 3.3 V	Make sure that the maximum current capability of power supply is no less than 100 mA.
V_BCKP	6	PI	Backup power supply	Vmax = 4.5 V Vmin = 1.5 V Vnorm = 3.3 V I_{V_BCKP} = 8 μA in the backup mode	Supply power for RTC domain when VCC is powered off.
Reset					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
RESET	9	DI	Resets the module	**L76-LB:** V_{IL}min = -0.3 V V_{IL}max = 0.7 V V_{IH}min = 2.1 V V_{IH}max = 3.1 V	Active low. If unused, keep this pin open.

				L76-LB (L): V_{IL}min = -0.3 V V_{IL}max = 0.45 V V_{IH}min =1.35 V V_{IH}max = 2.1 V	
UART Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
RXD1	3	DI	Receives data from TXD of DTE	**L76-LB:** V_{IL}min = -0.3 V V_{IL}max = 0.7 V V_{IH}min = 2.1 V V_{IH}max = 3.1 V **L76-LB (L):** V_{IL}min = -0.3 V V_{IL}max = 0.45 V V_{IH}min =1.35 V V_{IH}max = 2.1 V	The UART port is used for NMEA sentences output, PMTK/PQ commands input and firmware upgrade. If I2C is supported, do not use UART for NMEA sentences output. Instead, use the I2C interface.
TXD1	2	DO	Transmits data to RXD of DTE	**L76-LB:** V_{OL}max = 0.42 V V_{OH}min = 2.4 V V_{OH}norm = 2.8 V **L76-LB (L):** V_{OL}max = 0.27 V V_{OH}min = 1.53 V V_{OH}norm = 1.8 V	
I2C Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
I2C_SDA	16	IO	I2C	**L76-LB:** V_{IL}min = -0.3 V V_{IL}max = 0.7 V V_{IH}min = 2.1 V V_{IH}max = 3.1 V V_{OL}max = 0.42 V V_{OH}min = 2.4 V V_{OH}norm = 2.8 V **L76-LB (L):** V_{IL}min = -0.3 V V_{IL}max = 0.45 V	The I2C interface is used for NMEA sentences output by default. The module can also receive PMTK/PQ commands by an I2C bus.
I2C_SCL	17	IO	I2C serial clock		The pins can be used for RTCM data input when the I2C function is not supported. The I2C interface is

				V_{IH}min =1.35 V V_{IH}max = 2.1 V V_{OL}max = 0.27 V V_{OH}min = 1.53 V V_{OH}norm = 1.8 V	supported only on firmware versions ending with “SC”. In other firmware versions, I2C_SDA and I2C_SCL pins are used for RTCM data input. If unused, keep these pins open.
RF Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
VCC_RF	14	PO	Supply power for external RF components	Vmax = 4.3 V Vmin = 2.8 V Vnorm = 3.3 V	Typically used to supply power for an external LNA or active antenna. If unused, keep this pin open. VCC_RF≈ VCC
RF_IN	11	AI	RF signal input		Characteristic impedance is 50 Ω.
Other Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
ANTON	13	AO	Used for external LNA control and active antenna power control in power save modes	V_{OL}max = 0.42 V V_{OH}min = 2.4 V V_{OH}norm = 2.8 V	If unused, keep this pin open.
STANDBY	5	DI	Enter/exit standby mode	**L76-LB:** V_{IL}min = -0.3 V V_{IL}max = 0.7 V V_{IH}min = 2.1 V V_{IH}max = 3.1 V **L76-LB (L):** V_{IL}min = -0.3 V V_{IL}max = 0.45 V V_{IH}min =1.35 V V_{IH}max = 2.1 V	It is pulled up internally and it is edge-triggered. If unused, keep this pin open.

1PPS	4	DO	One pulse per second	**L76-LB:** V_{OL}max = 0.42 V V_{OH}min = 2.4 V V_{OH}norm = 2.8 V **L76-LB (L):** V_{OL}max = 0.27 V V_{OH}min = 1.53 V V_{OH}norm = 1.8 V	Synchronized at rising edge, with the pulse width of 100 ms. If unused, keep this pin open.
FORCE_ON	18	DI	Forces the module to wake up from the backup mode	**L76-LB:** V_{IL}min = -0.3 V V_{IL}max = 0.7 V V_{IH}min = 2.1 V V_{IH}max = 3.1 V **L76-LB (L):** V_{IL}min = -0.3 V V_{IL}max = 0.45 V V_{IH}min =1.35 V V_{IH}max = 2.1 V	Active high. Keep this pin open or pulled low before entering into the backup mode. It belongs to the RTC domain. If unused, keep this pin open.
GND	1, 10, 12		Ground		
RESERVED	7, 15				Keep these pins open.

NOTE

Keep all reserved and unused pins open.

3.3. Power Supply

VCC supplies power for BB, RF and RTC domains. The load current of VCC pin varies according to the VCC voltage level, processor load and satellite acquisition. After power-up and during GNSS acquisition, the typical VCC peak current is 45 mA, so it is important to supply sufficient current and make sure the power is clean and stable. It is recommended to choose an LDO with a minimum output current of 100 mA as the power supply. Also, add as a TVS, a 10 µF and a 100 nF decoupling capacitor combination near the VCC pin.

The V_BCKP pin supplies power for the RTC domain. A cell battery with the combination of a 4.7 µF and a 100 nF capacitor is recommended to be placed nearby V_BCKP pin. The voltage of the RTC domain ranges from 1.5 V to 4.5 V. In order to achieve better Time to First Fix (TTFF), the RTC domain should be

valid all the time so as to supply power for SRAM memory which contains all the necessary GNSS information for a quick start-up and a small amount of user configuration variables.

3.3.1. Internal Power-System Construction

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

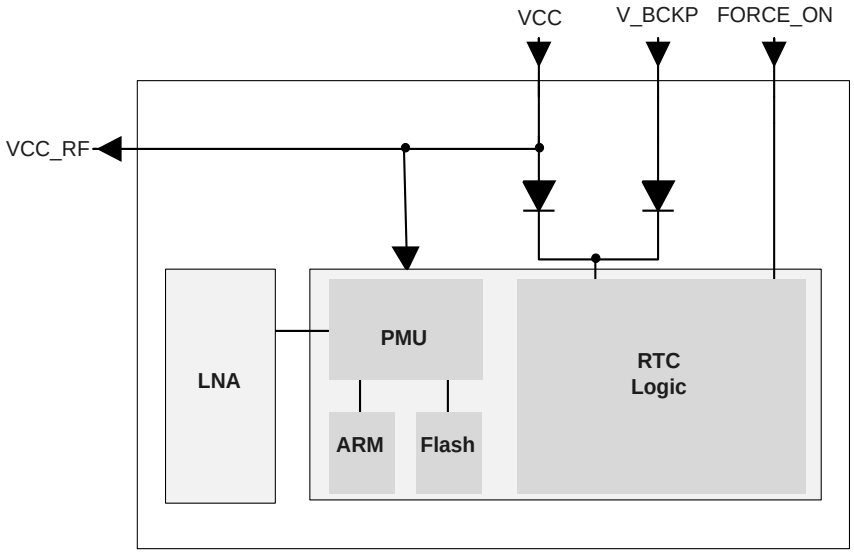

Figure 3: Internal Power-System Construction

- VCC supplies power not only for PMU but also for VCC_RF and RTC domains, while V_BCKP supplies power for the RTC domain only.
- The two diodes in the above figure form an OR gate to supply power for the RTC domain. The FORCE_ON pin belongs to the RTC domain.
- The PMU is designed with an integrated switch that is used to control the PMU power supply status.

3.4. Operation Modes

The table below briefly illustrates the supported features/functions of the module in different modes, and the switching between the modes.

Table 5: Feature Comparison in Different Operation Modes

Features	Full-On	Standby	Backup	Periodic	GLP
Antenna Detection	●	●	/	○	●
1PPS	●	/	/	○	●
RF	●	/	/	○	●
NMEA from UART	●	(Supports PMTK commands)	/	○	●
Acquisition & Tracking	●	/	/	○	●
Power Consumption	High	Low	Low	Medium	Medium
Position Accuracy	High	/	/	Low	Medium

NOTES

- ● supported
- ○ supported only in the periodic full-on mode

Table 6: Operation Mode Switching

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

3.4.1. Full-On Mode

The full-on mode comprises the acquisition mode and tracking mode. In the acquisition mode, the module starts to search for 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.

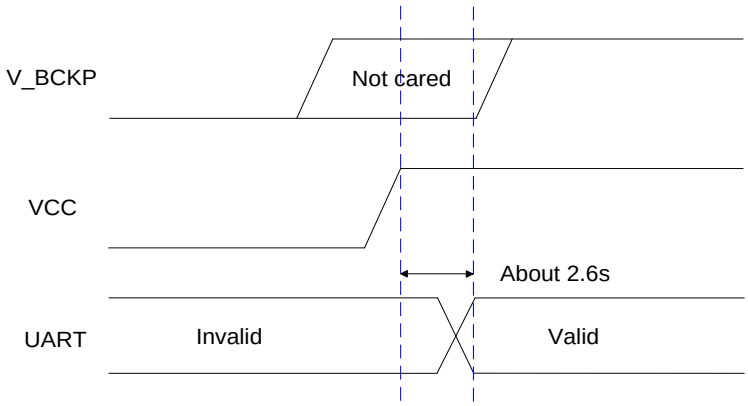

Figure 4: Full-On Mode Timing

As long as the VCC power supply is valid, the module will enter the full-on mode automatically and follow the default configurations as detailed below. For better comprehension, refer to ***Chapter 3.3*** for more details about the internal power supply system construction of the module.

Table 7: Default Configurations

Item	Configuration	Comment
GNSS	GPS+GLONASS or GPS+BeiDou	The following PMTK commands can be used to switch between different positioning systems: ● **$PMTK353,1,0,0,0,0*2A**: GPS satellites only ● **$PMTK353,1,1,0,0,0*2B**: GPS and GLONASS satellites ● **$PMTK353,1,0,0,0,1*2B**: GPS and BeiDou satellites
Baud Rate	9600 bps	-
Protocol	NMEA	RMC, VTG, GGA, GSA, GSV, GLL and TXT
Update Rate	1 Hz	-
SBAS	Enabled	-
AIC	Enabled	-

LOCUS	Disabled	-
EASY™ Technology	Enabled	When update rate exceeds 1 Hz, EASY™ is disabled automatically.
I2C	Disabled	The pins can be used for RTCM data input.

After power-up, the module's peak current may rush up to 45 mA (VCC = 3.3 V) and last for a few seconds. Then the current consumption will be reduced to the average values provided in ***Table 1***.

The module remains in the acquisition mode for several minutes before switching to the tracking mode automatically. The current consumption in the tracking mode is lower. For more details, refer to ***Table 1***.

NOTE

The L76-LB module supports the following output types of NMEA messages:

- RMC: Recommended Minimum Specific GNSS Data
- VTG: Course Over Ground and Ground Speed
- GGA: Global Positioning System Fix Data
- GSA: GNSS DOP and Active Satellites
- GSV: GNSS Satellites in View
- GLL: Geographic Position - Latitude and Longitude
- TXT: Text Transmission

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

3.4.2. Standby Mode

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

There are two ways to enter/exit the standby mode:

- **Through the STANDBY pin**:

  Pulling STANDBY pin low forces the module to enter the standby mode and pulling it high makes the module return to the full-on mode again. Note that pulling the STANDBY pin to the ground causes an extra current consumption of about 0.1 mA (VCC = 3.3 V).

- **Through a PMTK command**:

  The module enters the standby mode after sending the PMTK command: **$PMTK161,0*28**. Sending any data via UART will make the module exit the standby mode. When the module exits the standby mode, it will use all internal assistance information, such as GNSS time, ephemeris and last position,

to ensure the fastest possible TTFF in hot/warm start.

In the standby mode, the module consumes a current of about 0.6 mA (VCC = 3.3 V).

NOTES

1. The STANDBY pin is an edge-triggered pin. It is recommended to configure the host's GPIO for STANDBY control to input before power on, so as to avoid entering the standby mode unexpectedly when starting the module. After the module is powered on, the GPIO can be reset to output.
2. If the STANDBY pin is unused, keep it open.

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 8 μA (VCC = 3.3 V).

There are two ways to enter/exit the backup mode:

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

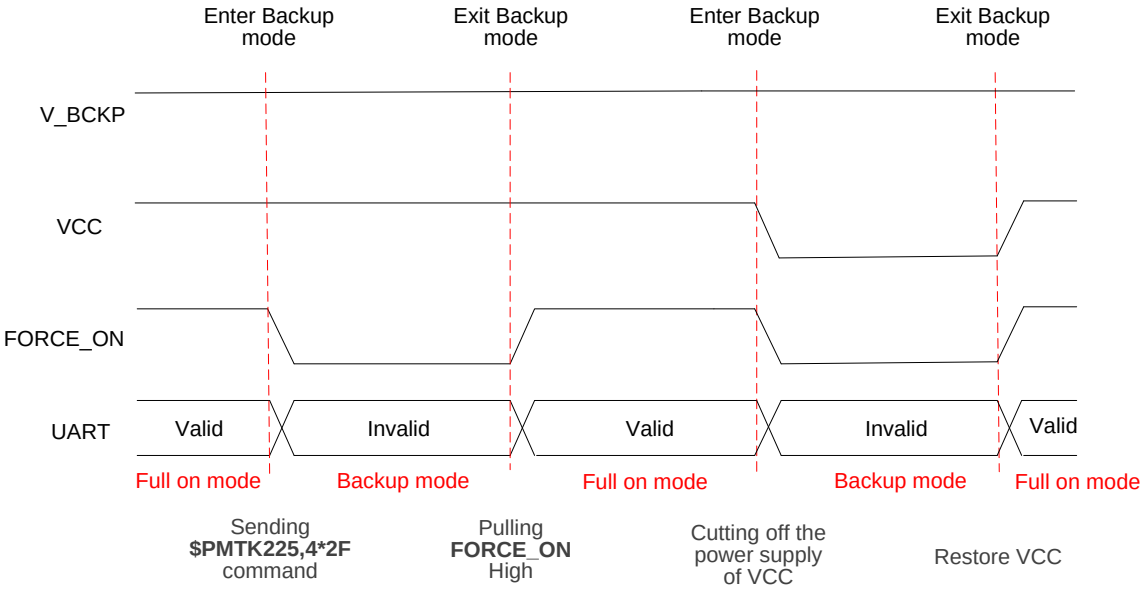

Figure 5: Timing of Entering/Exiting Backup Mode

NOTE

Before entering the backup mode, keep the FORCE_ON pin open or low; otherwise, the backup mode will be unavailable.

For details about internal power-system construction, refer to ***Chapter 3.3.1***. The power can be supplied through the V_BCKP pin with external capacitors and a rechargeable or non-chargeable battery. A reference design of the RTC backup power supply is illustrated below.

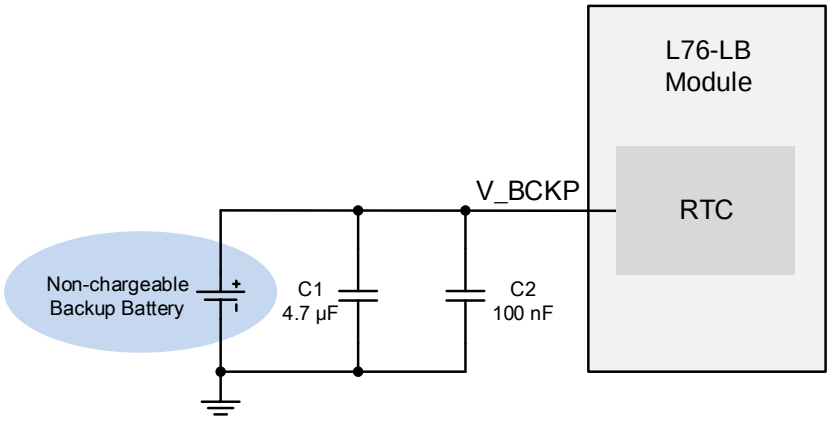

Figure 6: RTC Backup Power Supply (Non-Chargeable Battery)

The V_BCKP pin doesn't support battery charging function. Therefore, it is necessary to add a charging circuit when a rechargeable battery is applied. A reference circuit is provided below

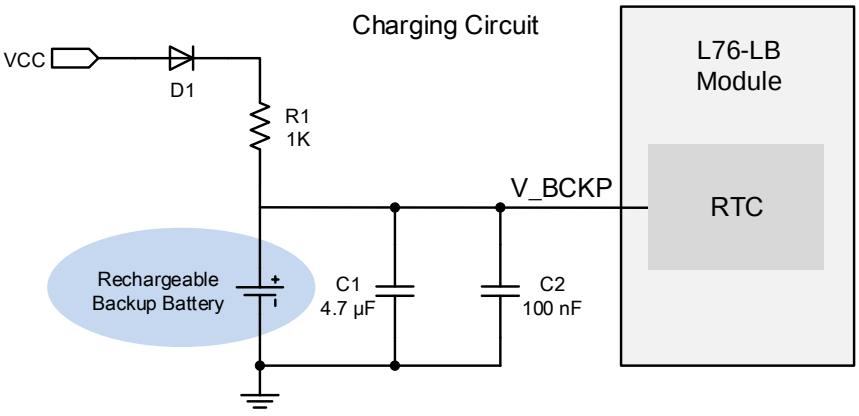

Figure 7: RTC Backup Power Supply (Rechargeable Battery)

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 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 8: PMTK Command Format

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

Example

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

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.

NOTES

1. Keep the STANDBY pin open or at high level before entering the periodic standby mode; otherwise, the periodic standby mode will be unavailable.
2. Keep the FORCE_ON pin open or at low level before entering the periodic backup mode; otherwise, the periodic backup mode will be unavailable.

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, it returns to **Run Time** and **Sleep Time**.

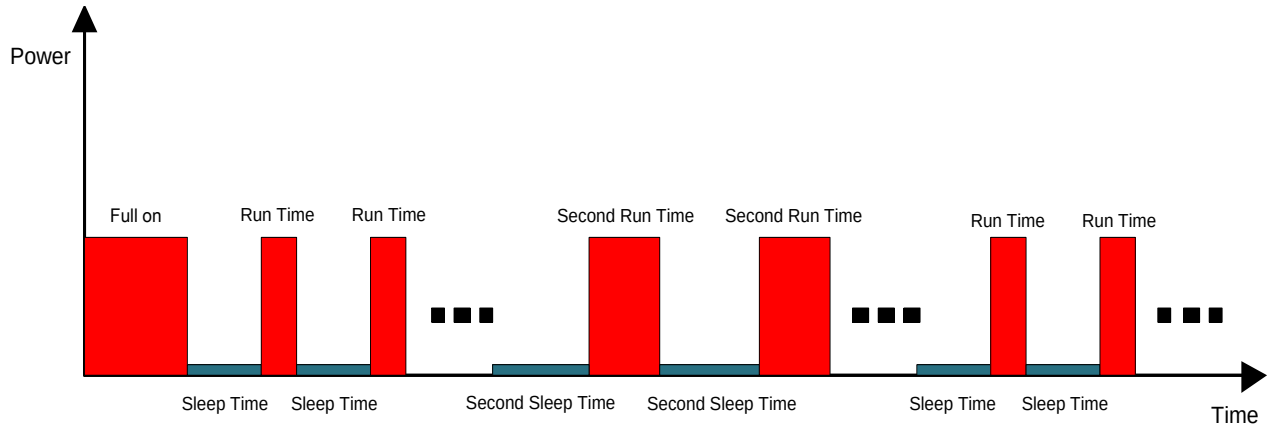

Figure 8: Periodic Mode

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

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

T1 = Run Time, T2 = Sleep Time

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. The average current consumption is calculated as follows:

$I_{periodic} = (I_{tracking} \times T1 + I_{standby} \times T2)/(T1+T2) = (27 \times 3 + 0.6 \times 12)/(3 +12) \approx 5.88$ (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. The average current consumption is calculated as follows:

$I_{periodic} = (I_{tracking} \times T1 + I_{backup} \times T2)/(T1+T2) = (27 \times 3 + 0.008 \times 12)/(3 + 12) \approx 5.41$ (mA)

3.4.5. GLP Mode

The 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 the GLP mode, the module provides good positioning performance when 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 the GLP mode is down to 13.7 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** command is returned.
- **$PQGLP,W,0,1*20**: The command is used to make the module exit the GLP mode. To mark that the module has entered the GLP mode successfully, **$PQGLP,W,OK*09** command is returned.

NOTES

1. It is recommended to set all the necessary commands before the module enters the GLP mode. If you need to send commands, exit from the GLP mode first.
2. When the module enters the GLP mode, 1PPS function is disabled.
3. When the GLP mode is enabled, the SBAS will be affected.
4. In highly dynamic scenarios, the positioning accuracy of the module in the GLP mode is slightly decreased.
5. The module automatically returns to the full-on mode in complex environments to keep good positioning accuracy.
6. It is recommended that 115200 bps baud rate and 1 Hz frequency are set before the module enters

low power mode.

3.5. Reset

You can reset the L76-LB module by driving the RESET pin low for at least 10 ms and then releasing it. Note that the resetting will force the loss of volatile RAM data, while the data in non-volatile backup RAM will not be cleared so that fast TTFF is still possible. An OC driver circuit shown below is recommended to control the RESET pin.

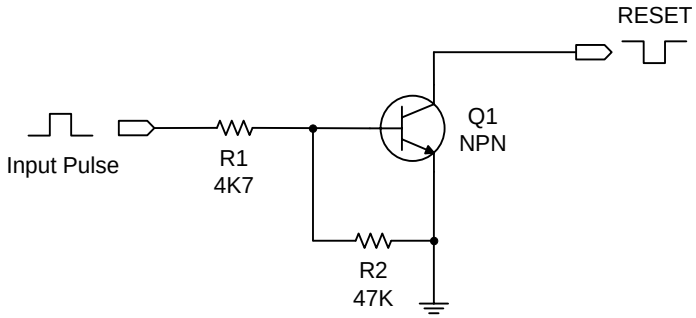

Figure 9: Reference OC Circuit for Module Reset

The following figure shows the reset timing of the L76-LB module.

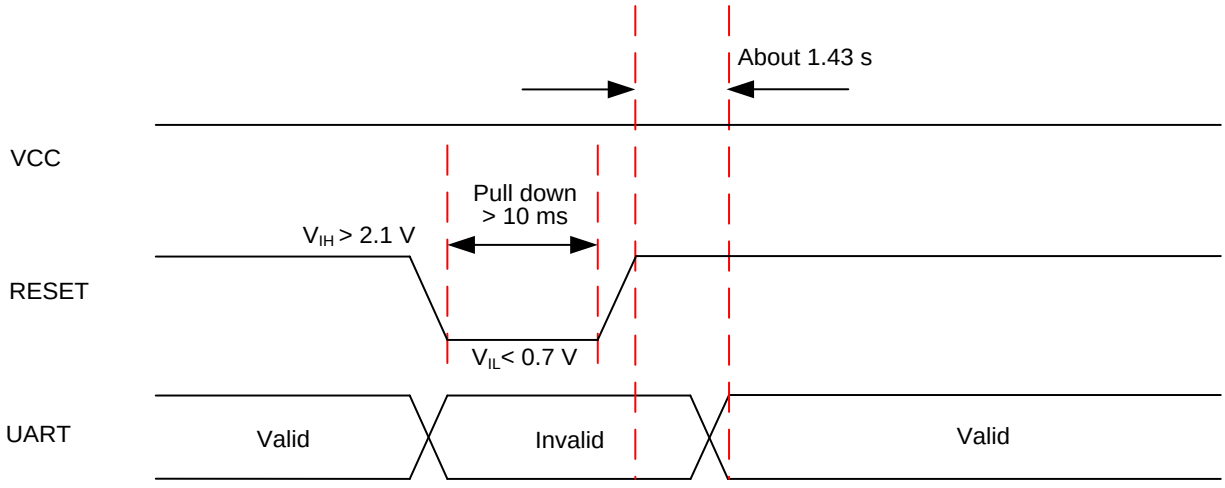

Figure 10: Reset Timing

3.6. UART Interfaces

L76-LB provides one universal asynchronous receiver and transmitter 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 9: Pin Definition of UART Interface

Pin Name	Pin No.	I/O	Description	Comment
TXD1	2	DO	Transmits data to the RX signal of DTE	The UART port is used for NMEA sentences output, PMTK/PQ commands input and firmware upgrade.
RXD1	3	DI	Receives data from the TX signal of DTE	

A reference design for the L76-LB module and MCU with 3.3 V voltage level is shown below.

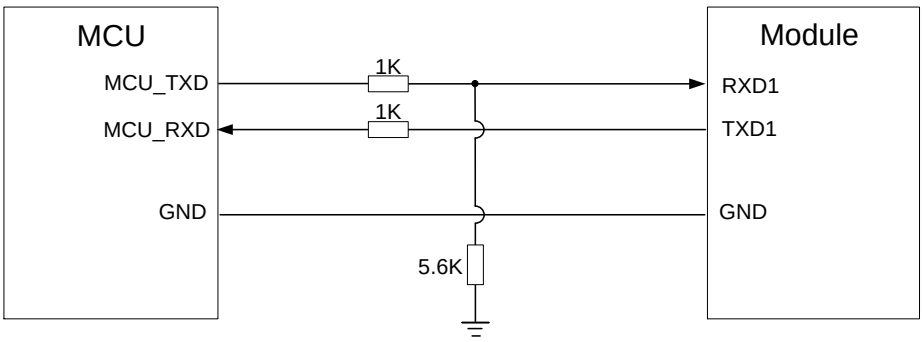

Figure 11: Reference Design of UART Interface (L76-LB Module)

A reference design for the L76-LB (L) module and MCU with 1.8 V voltage level is shown below.

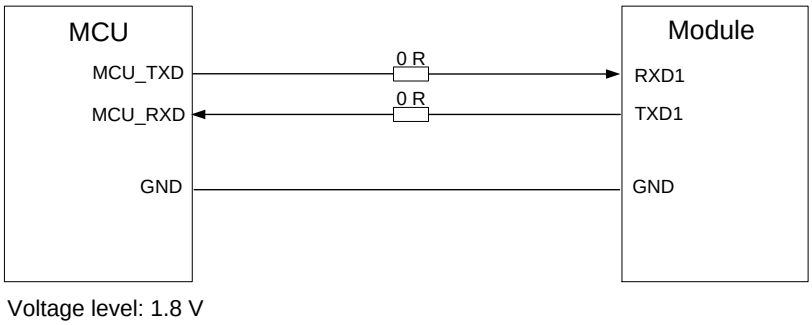

Figure 12: Reference Design of UART Interface (L76-LB (L) Module)

3.7. I2C Interface (Optional)

L76-LB provides an I2C interface with a dedicated firmware version. The interface can be used to output NMEA sentences and receive PMTK/PQ commands.

I2C interface features:

- Support for fast mode, with bit rate of up to 400 kbps
- Support for 7-bit address
- Operation in a slave mode
- Default I2C address values: 0x20 (Write), 0x21 (Read).

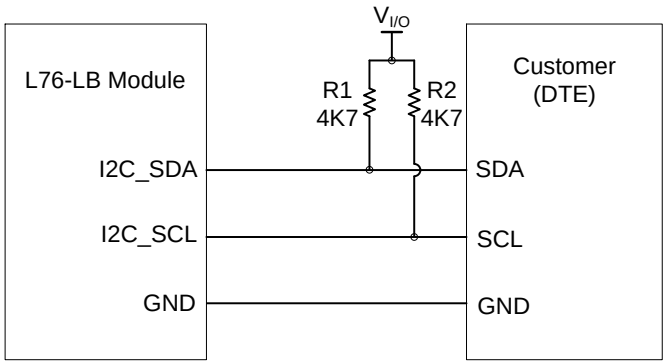

Figure 13: Reference Design of I2C Interface

NOTE

The I2C interface is supported only on firmware versions ending with “SC”. In other firmware versions, I2C_SDA and I2C_SCL pins are used for RTCM data input. When the I2C interface is supported, NMEA data should be outputted via an I2C interface rather than the UART interface; otherwise, there may be NMEA data loss.

3.8. EASY™ Autonomous AGNSS Technology

L76-LB 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 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 in the case of not enough information from satellites. Therefore, the function improves positioning and TTFF.

EASY™ function reduces TTFF to 9 s [1)] in warm start. In this case, the 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 minutes in strong-signal environments after it fixes the position.

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

NOTE

1) The average value obtained from 500 tests.

3.9. EPO Offline AGNSS Technology

L76-LB features a leading AGNSS technology called EPO (Extended Prediction Orbit). It is a free service provided by Quectel, which can achieve fast TTFF and improve accuracy in weak signal conditions. 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 10: Download URLs of EPO Files

EPO Type	GNSS Type	EPO File URL Example	File Name
Unified QEPO URL	GPS only	http://wpepodownload.mediatek.com /QGPS.DAT?vendorinfo	Single name: QGPS.DAT

Unified QEPO URL	GPS+GLONASS	http://wpepodownload.mediatek.com /QG_R.DAT?vendorinfo	Single name: QG_R.DAT
EPO	GPS only	http://wpepodownload.mediatek.com */EPO_GPS_3_X.DAT?vendorinfo*	X = 1–10 EPO_GPS_3_1.DAT to EPO_GPS_3_10.DAT
EPO	GPS+GLONASS	http://wpepodownload.mediatek.com */EPO_GR_3_X.DAT?vendorinfo*	X = 1–10. EPO_GR_3_1.DAT to EPO_GR_3_10.DAT

The following shows a complete URL sample:
http://wpepodownload.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

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

L76-LB 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:

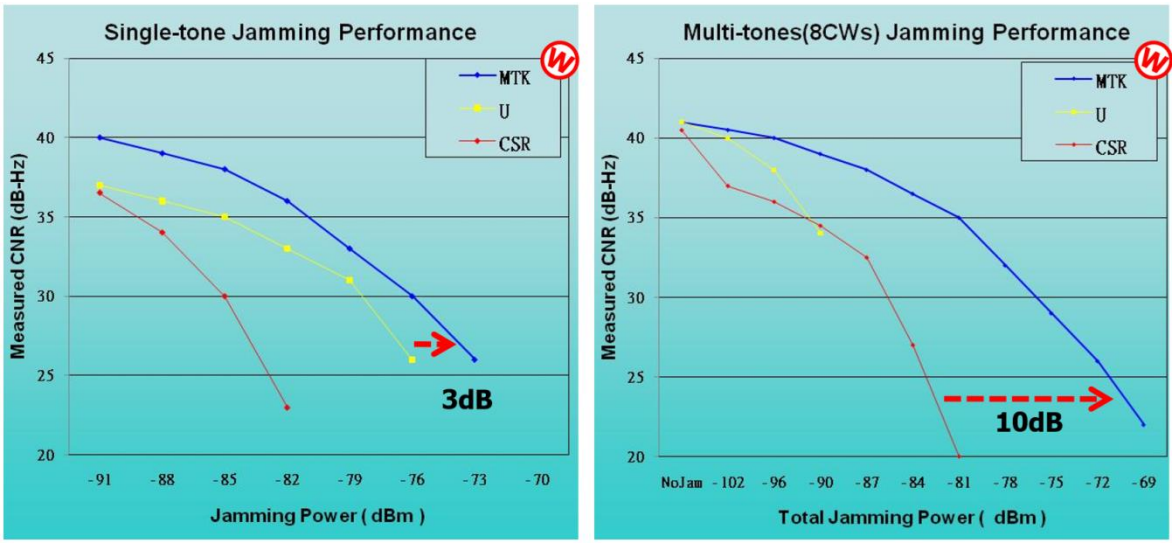

Figure 14: Anti-Jamming Performance by the AIC

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

L76-LB supports the embedded logger function called LOCUS. When this function is enabled with the **$PMTK185,0*22** command, it logs position information to the internal flash memory. Additionally, with this function, the host can enter sleep mode to save power consumption. In that way, the host won't receive the NMEA information all the time. The module provides a log capacity of more than 16 hours. The **$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 the PMTK command **$PMTK184,1*22** to erase the internal flash.
- Send the PMTK command **$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

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

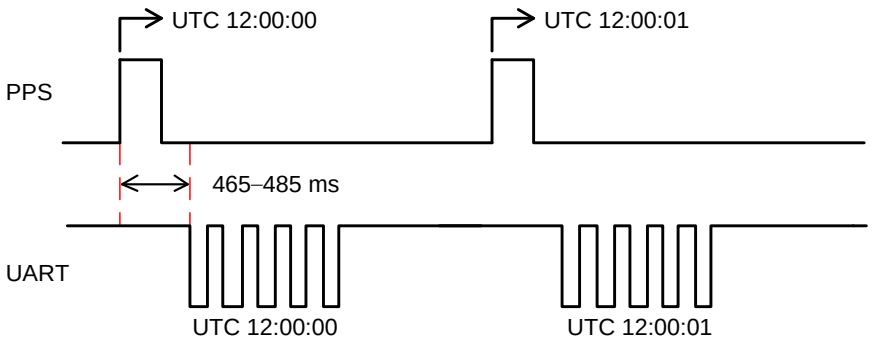

Figure 15: PPS VS. NMEA Timing

The feature only supports 1 Hz NMEA sentences output and baud rates from 14400 to 115200 bps. When the baud rate is 9600 bps, only RMC NMEA sentence output is supported.
Send the following PMTK commands to the module to:

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

4 Antenna Interfaces

L76-LB supports GPS and GLONASS systems by default. The RF signal is obtained from the RF_IN pin. The impedance of RF trace should be controlled to 50 Ω, and the trace length should be kept as short as possible.

4.1. Recommended Antenna Specifications

L76-LB receives GNSS satellite signals through an external passive or active GNSS antenna. The recommended antenna specifications are given in the following table.

Table 11: Recommended Antenna Specifications

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

NOTE

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

4.2. Reference Designs for Antenna Interface

Both active and passive GNSS antennas can be used for the L76-LB module.

4.2.1. Active Antenna without ANTON Pin

The following figure is a typical reference design of active antenna without ANTON pin.

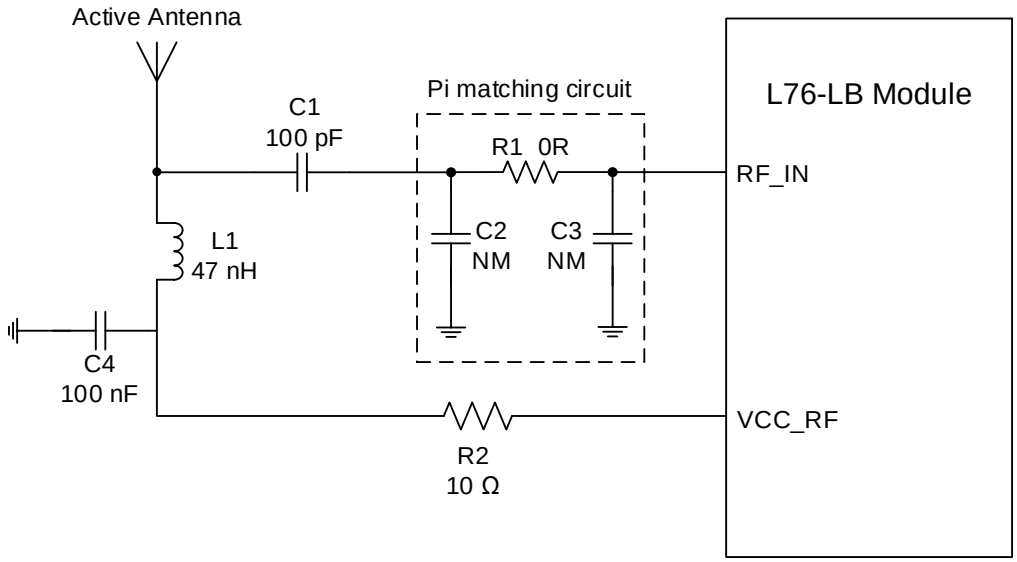

Figure 16: Reference Design of Active Antenna without ANTON Pin

R1, C2 and C3 form a reserved matching circuit for antenna impedance modification. By default, R1 is 0 Ω, while C2 and C3 are not mounted.

The module provides power supply for the external active antenna through VCC_RF. The voltage ranges from 2.8 to 4.3 V, and the typical value is 3.3 V. If the VCC_RF voltage does not meet the requirements for powering the active antenna, an external LDO should be used.

The inductor L1 is used to prevent the RF signal from leaking into the VCC_RF pin and route the bias supply to the active antenna. he recommended value of L1 is no less than 47 nH. R2 protects the whole circuit in case the active antenna is short-circuited to ground. C4 needs to be placed close to the RF path.

NOTE

R2 in the above design is a must; otherwise, the module may be damaged permanently because of the possible short-circuit of the active antenna.

4.2.2. Active Antenna with ANTON Pin

L76-LB can reduce power consumption by controlling the power supply of active antenna through the ANTON pin.

A reference circuit for active antenna with ANTON function is given as below.

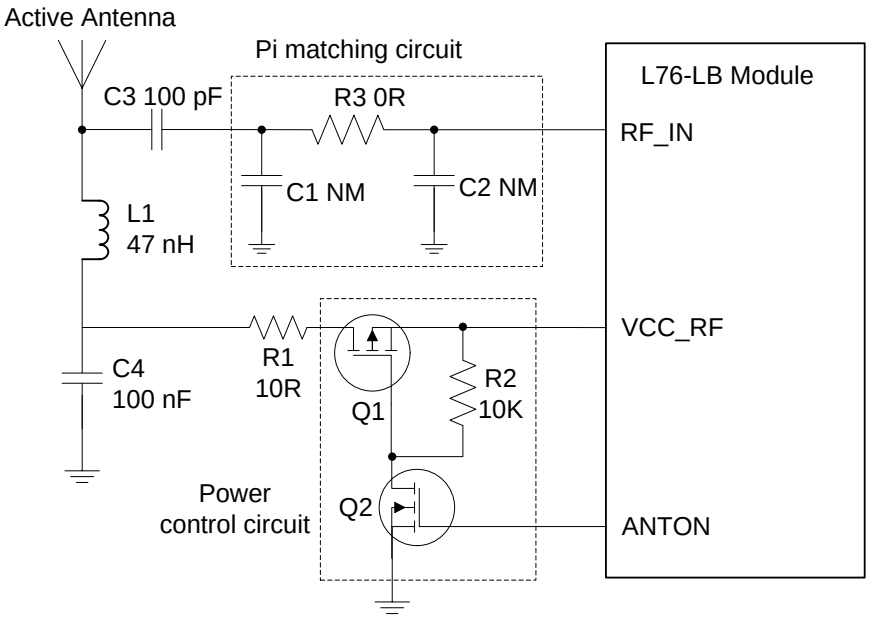

Figure 17: Reference Design of Active Antenna with ANTON Pin

ANTON is an optional function which can be used to control the power supply of an active antenna.

- When the module works in full-on mode, this pin is at high level.
- When the module works in standby mode, backup mode, or during the sleep time in periodic mode, this pin is at low level.

Based on these characteristics, ANTON can be used to control either the power supply of an active antenna or the enable pin of an external LNA in order to reduce power consumption. Refer to ***Chapter 3.2*** for the electrical characteristics of this pin.

In order to minimize the current consumption, the value of resistor R2 should not be too low, with the recommended value being 10 kΩ.

4.2.3. Passive Antenna

The following figure is a typical reference design of a passive antenna.

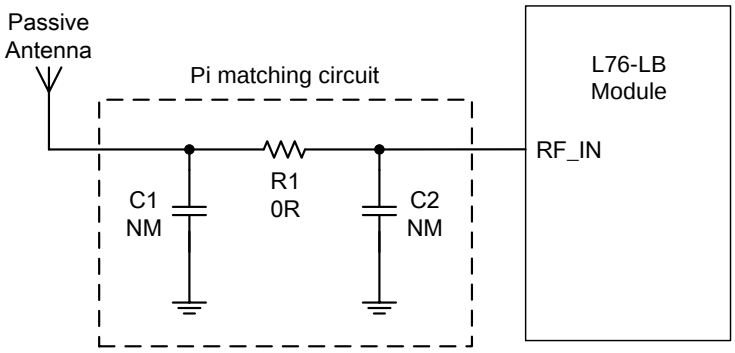

Figure 18: Reference Design of Passive Antenna

C1, C2 and R1 form a reserved matching circuit for antenna impedance modification. By default, R1 is 0 Ω, while C1 and C2 are not mounted. The impedance of RF trace should be controlled to 50 Ω and the trace length should be kept as short as possible.

5 Reliability, Electrical and Radio Characteristics

5.1. Absolute Maximum Ratings

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

Table 12: Absolute Maximum Ratings

Parameter	Min.	Max.	Unit
Power Supply Voltage (VCC)	-0.3	4.3	V
Backup Battery Voltage (V_BCKP)	-0.3	4.5	V
Input Voltage at Digital Pins	-0.2	3.1	V
Input Power at RF_IN (P_{RF_IN})		15	dBm
Storage Temperature	-40	90	°C

NOTE

Stressing the device beyond the “Absolute Maximum Ratings” may cause permanent damage. The product is not protected against over-voltage or reversed voltage. Therefore, it is necessary to utilize appropriate protection diodes to keep voltage spikes within the parameters given in the table above.

5.2. Operation Conditions

Table 13: Power Supply Ratings

Parameter	Description	Conditions	Min.	Typ.	Max.	Unit
VCC	Supply voltage	The actual input voltages must be kept between the minimum and maximum values.	2.8	3.3	4.3	V
I_{VCCP}	Peak supply current	VCC = 3.3 V			100	mA
V_BCKP	Backup voltage supply		1.5	3.3	4.5	V
T_{OPR}	Operating temperature in the full-on mode		-40	+25	+85	°C

NOTES

1. The values above can be used to determine the maximum current capability of power supply.
2. Operation beyond the "Operation Conditions" is not recommended and extended exposure beyond the "Operation Conditions" may affect device reliability.

5.3. ESD Protection

L76-LB is an ESD sensitive device. The ESD protection precautions should be emphasized. Proper ESD handling and packaging procedures must be applied throughout processing, handling and operation of any application that incorporates the module.

Please note that the following measures are beneficial to ESD protection when L76-LB is handled:

- The first contact point shall always be between the local GND and PCB GND pins when handling the PCB, unless there is a galvanic coupling between the local GND and the PCB GND.
- While mounting the module onto a motherboard, make sure to connect first the GND and then the RF_IN pad.
- When handling the RF_IN pad, do not come into contact with any charged capacitors or materials which may easily generate or store charges (such as patch antenna, coaxial cable, soldering iron, etc.).
- To prevent electrostatic discharge from the RF input, 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. All dimensions are measured in millimeter (mm), and the dimensional tolerances are ±0.05 mm unless otherwise specified.

6.1. Mechanical Dimensions

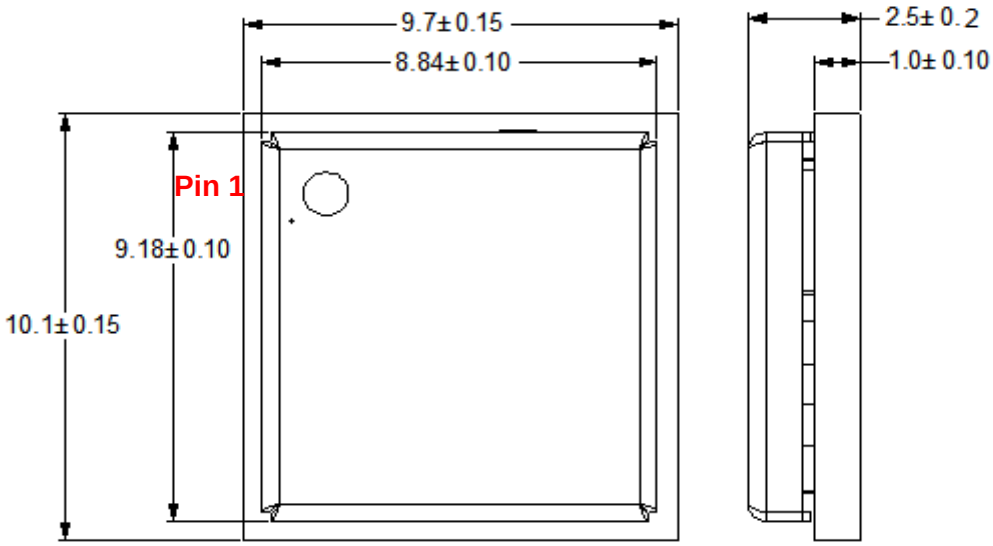

Figure 19: Top and Side Dimensions

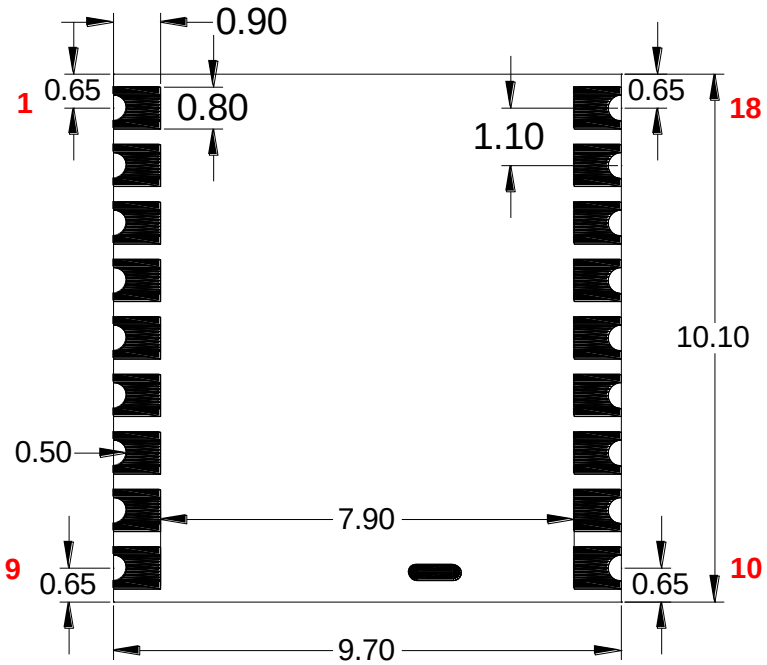

Figure 20: Bottom Dimensions

NOTE

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

6.2. Recommended Footprint

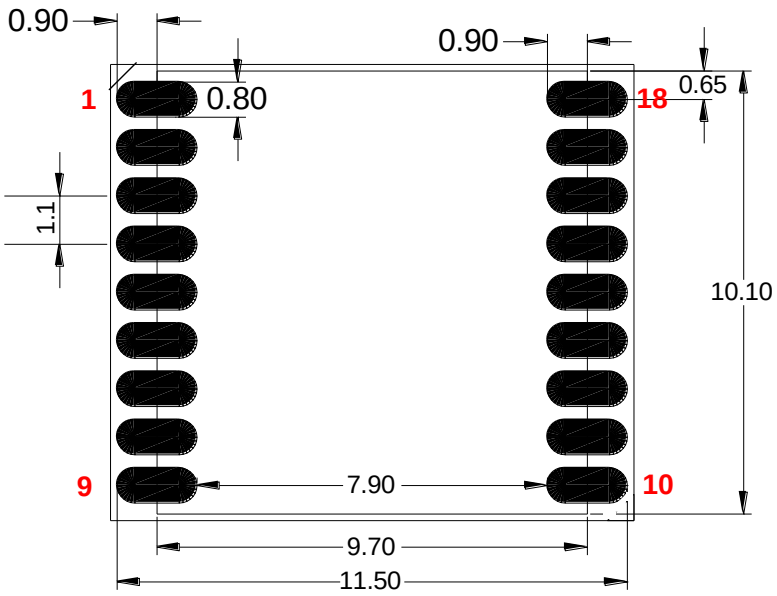

Figure 21: Recommended Footprint

NOTE

For easy maintenance of this module, it is recommended to keep a distance of no less than 3 mm between the module and other components on the motherboard.

6.3. Top and Bottom Views

Figure 22: Top View of the Module

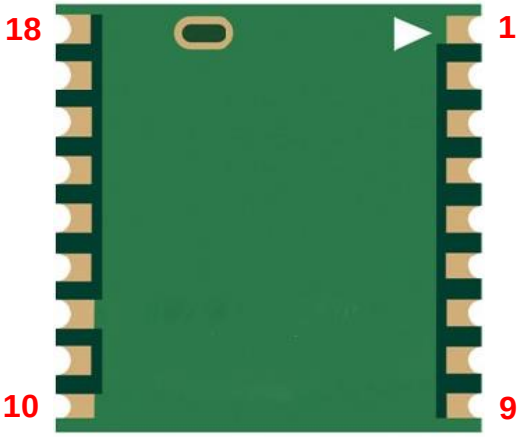

Figure 23: Bottom View of the Module

NOTE

These are renderings of the L76-LB module. For authentic appearance, refer to the module received from Quectel.

7 Storage, Manufacturing and Packaging

7.1. Storage

The 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 168 hours [1)] 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 168 hours. Otherwise, the module should be stored in an environment where the relative humidity is less than 10 % (e.g. a drying cabinet).

4. The module should be pre-baked to avoid blistering, cracks and inner-layer separation in PCB under the following circumstances:

   - 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.

NOTES

1. [1)] 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. And do not remove the packages of tremendous modules 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, the thickness of stencil for the module is recommended to be 0.15–0.18 mm. For more details, refer to ***document [5]***.

It is suggested that the peak reflow temperature is 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 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.

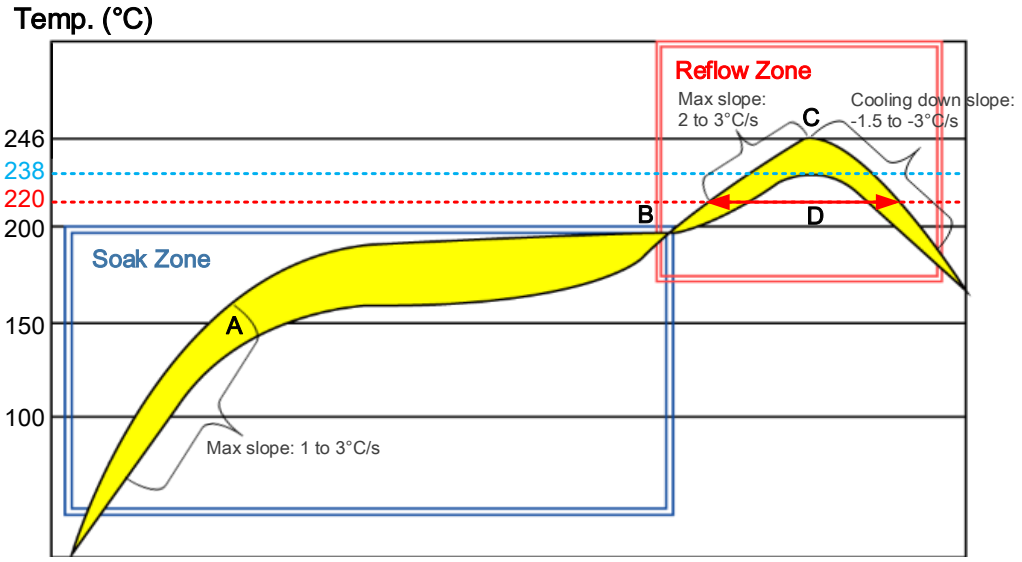

Figure 24: Recommended Thermal Profile for Reflow Soldering

Table 1: Recommended Parameters of Thermal Profile

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 (C)	238–246 °C
Cooling Down Slope	-1.5 to -3 °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.
3. If a conformal coating is necessary for the module, do NOT use any coating material that may chemically react with the PCB or shielding cover, and prevent the coating material from flowing into the module.

7.3. Tape and Reel Packaging

L76-LB is packaged in tape and reel carriers. One reel is 8.64 meters long and contains 500 modules.

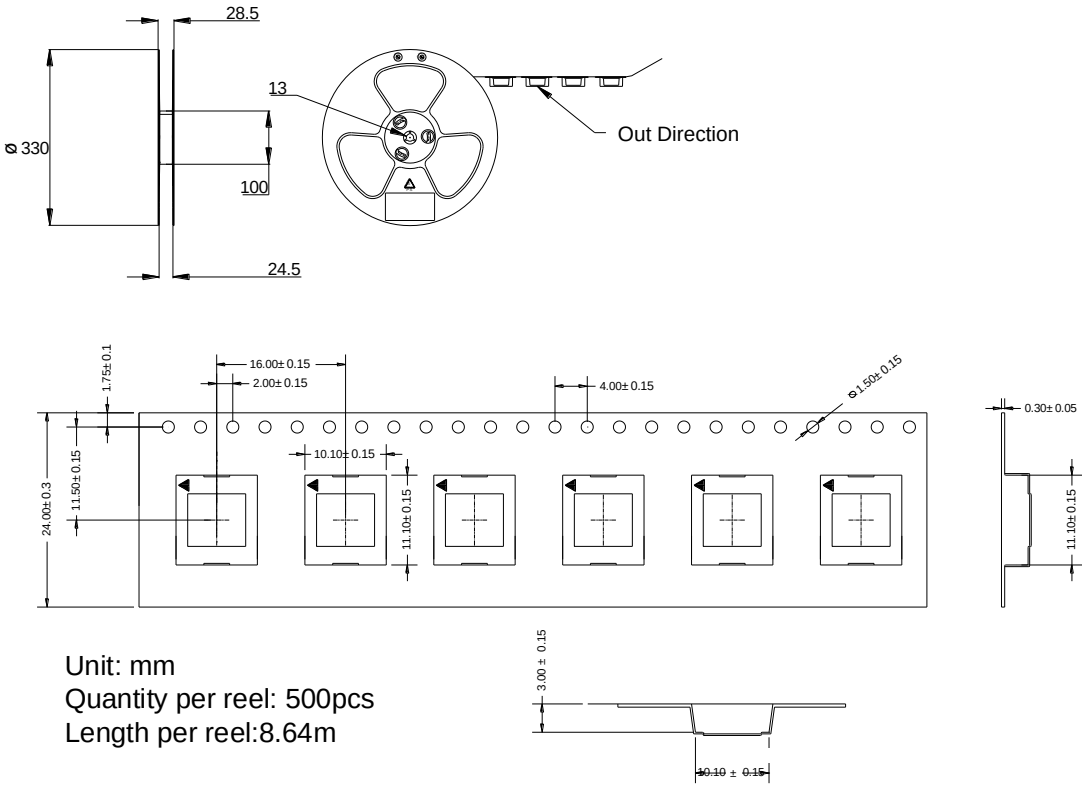

Figure 25: Tape and Reel Specifications

Table 14: Packaging Specifications

Minimum Package (pieces)	Minimum Package (MP) Specification	Minimum Package × 4 = 2000
500	Size: 370 mm × 350 mm × 56 mm Net Weight: 0.25 kg Gross Weight: 1.00 kg	Size: 380 mm × 250 mm × 365 mm Net Weight: 1.1 kg Gross Weight: 4.4 kg

8 Appendix A References

Table 15: Related Documents

SN	Document Name	Remark
[1]	Quectel_L26-LB&L76-LB&LC86L_GNSS_Protocol_Specification	GNSS Protocol Specification for L26-LB, L76-LB and LC86L
[2]	Quectel_GNSS_SDK_Commands_Manual	GNSS Module SDK Commands Manual
[3]	Quectel_L76_Series_EVB_User_Guide	L76 Series EVB User Guide
[4]	Quectel_L76-LB_Reference_Design	L76-LB Reference Design
[5]	Quectel_Module_Secondary_SMT_Application_Note	Module Secondary SMT Application Note

Table 16: 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	Electro-Static 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
MSAS	Multi-Functional Satellite Augmentation System
MSL	Moisture Sensitivity Level
NMEA	National Marine Electronics Association
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 Code
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 Mounted Device
SRAM	Static Random Access Memory
SV	Satellite Vehicle
TCXO	Temperature Compensated Crystal Oscillator
TVS	Transient Voltage Suppressor
TXT	Text Transmission
UART	Universal Asynchronous Receiver and Transmitter
VDOP	Vertical Dilution of Precision
VSWR	Voltage Standing Wave Ratio
VTG	Course over Ground and Ground Speed
WAAS	Wide Area Augmentation System
Imax	Maximum Load Current
Vmax	Maximum Voltage Value
Vnorm	Normal 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