QUECTEL

L26-P&L26-T
Hardware Design

GNSS Module Series

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	Ensure that the product may be used in the country and the required environment, as well as that it conforms to the local safety and environmental regulations.
	Keep away from explosive and flammable materials. The use of electronic products in extreme power supply conditions and locations with potentially explosive atmospheres may cause fire and explosion accidents.
	The product must be powered by a stable voltage source, and the wiring shall conform to security precautions and fire prevention regulations.
	Proper ESD handling procedures must be followed throughout the mounting, handling and operation of any devices and equipment that incorporate the module to avoid ESD damages.

About the Document

Document Information	
Title	**L26-P&L26-T Hardware Design**
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Revision History

Version	Date	Description
-	2019-11-09	Creation of the document
1.0	2019-11-09	First official release
1.1	2022-05-25	1. Completely reorganized the structure of the document, including but not limited to the adding of chapters 1.5, 1.6, 1.7, 1.8, 1.9, 3.1, 3.2.2, 3.3, 3.4, 3.5, 4.1.4, 4.2.1, 5.1.2, 5.2, 6.3, and 9. 2. Selected pin names have been updated to agree with a common naming convention across Quectel GNSS modules. The pins have the same physical hardware but with updated names. Pin 1: from WAKE_UP to WAKEUP Pin 3: from TIMEPULSE to 1PPS Pin 9: from VCC_RF to VDD_RF Pin 16: from ANT2 to ANT_DET2 Pin 17: from ANT1 to ANT_DET1 Pin 20: from UART_TX to TXD Pin 21: from UART_RX to RXD 3. Updated the product features of L26-P/L26-T (Table 1). 4. Updated the product performance of L26-P/L26-T (Table 2). 5. Updated pin assignment and pin description (Chapter 2). 6. Updated descriptions of the UART interface (Chapter 4.1.1).

	7. Added a note to WI (Chapter 4.1.2). 8. Updated descriptions of RESET_N (Chapter 4.2.2). 9. Updated descriptions of BOOT (Chapter 4.2.3). 10. Updated recommended antenna specifications (Chapter 5.1.1). 11. Updated reference designs for active and passive antennas (Chapter 5.1.3). 12. Changed the maximum supply voltage of VCC and V_BCKP from 4.8 V to 3.6 V and added the minimum and maximum storage temperature (Table 9). 13. Updated the recommended operating conditions (Table 10). 14. Updated information on ESD protection (Chapter 6.4). 15. Updated dimensional tolerances to ±0.20 mm (Chapter 7). 16. Updated the module packaging, storage requirements, the recommended reflow soldering thermal profile and relevant parameters, and added notes on conformal coating, ultrasonic technology, and the SMT process (Chapter 8).

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1 Product Description

1.1. Overview

Quectel L26-P/L26-T module supports multiple global positioning and navigation systems: GPS, GLONASS, Galileo, BDS, and QZSS. The module also supports SBAS (including WAAS, EGNOS, MSAS, and GAGAN) and AGNSS functions.

Key features:

- L26-P/L26-T is a single-band, multi-constellation GNSS module, and features high-performance, high reliability positioning engine.
- L26-P module integrates a 6-axis IMU and can output GNSS raw data concurrently with the sensor raw data. Combined with Quectel's 4G modules, RTK, and DR (dead reckoning) algorithm, the module can provide outstanding positioning accuracy at centimeter-level under the open sky.
- L26-T module features high precision timing in demanding applications worldwide.
- L26-T module supports the output of multi-GNSS raw data.
- L26-P/L26-T module supports serial communication interface UART.
- The built-in LNA ensures better performance in weak signal areas.

Quectel L26-P/L26-T module is an SMD type module with a compact form factor of 12.2 mm × 16.0 mm × 2.3 mm. The module can be embedded in your applications through 24 LCC pins.

The module is fully compliant with the *EU RoHS Directive*.

1.2. Features

Table 1: Product Features

Features			L26-T	L26-P
Grade	Industrial		●	●
	Automotive		-	-
Category	Standard Precision GNSS		●	●
	High Precision GNSS		-	-
	DR		-	●
	RTK		-	-
	Timing		●	-
VCC Voltage	3.0–3.6 V, Typ. 3.3 V		●	●
V_BCKP Voltage	2.0–3.6 V, Typ. 3.3 V		●	●
IO Voltage	Typ. 3.3 V		●	●
Communication Interfaces	UART		●	●
	USB		-	-
	SPI		-	-
	I2C		-	-
	CAN		-	-
Integrated Features	Additional LNA		●	●
	Additional Filter		●	●
	RTC Crystal		●	●
	TCXO Oscillator		●	●
	6-axis IMU		-	●
Constellations	GPS	L1 C/A	●	●
		L5	-	-

	GLONASS	L1	●	●
	Galileo	E1	●	●
		E5a	-	-
	BDS	B1I	●	●
		B2a	-	-
	QZSS	L1 C/A	●	●
		L5	-	-
	IRNSS	L5	-	-
	SBAS	L1	●	●
Temperature Range	Operating temperature range: -40 °C to +85 °C Storage temperature range: -40 °C to +90 °C			
Physical Characteristics	Size: (12.2 ±0.15) mm × (16.0 ±0.15) mm × (2.3 ±0.20) mm Weight: Approx. 0.9 g			

NOTE

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

1.3. Performance

Table 2: Product Performance

Parameter	Specification	L26-T	L26-P
Power Consumption [1]		GPS + GLONASS + Galileo	GPS + BDS
	Acquisition	71 mA	73 mA
	Tracking	67 mA	62 mA
	Standby mode	1.7 mA	1.7 mA

[1] Room temperature, all satellites at -130 dBm.

	Backup mode [2]	8 μA	8 μA
Sensitivity	Acquisition	-147 dBm	-147 dBm
	Reacquisition	-154 dBm	-154 dBm
	Tracking	-162 dBm	-162 dBm
TTFF [1] (without AGNSS)	Cold Start	32 s	32 s
	Warm Start	25 s	25 s
	Hot Start	2 s	2 s
TTFF [3] (with AGNSS)	Cold Start	13 s	13 s
Horizontal Position Accuracy [4]		1.5 m	1.5 m
Update Rate		1 Hz (Max. 10 Hz)	1 Hz
Accuracy of 1PPS Signal [1]		Typ. < 6.8 ns @ 1σ	Typ. 100 ns
Velocity Accuracy [1]		Without Aid: 0.1 m/s	
Acceleration Accuracy [1]		Without Aid: 0.1 m/s²	
Dynamic Performance [1]		Maximum Altitude: 18000 m Maximum Velocity: 515 m/s Maximum Acceleration: 4g	

1.4. Block Diagram

The block diagram of the module that includes a GNSS IC, a 6-axis IMU (only supported by L26-P), an additional LNA, an additional SAW filter, a TCXO, and an XTAL is presented below.

[2] To enter the Backup mode, you must strictly follow the steps in ***Chapter 3.3.4***, otherwise the current consumption may reach mA level.
[3] Open-sky, active high precision GNSS antenna.
[4] CEP, 50%, 24 hours static, -130 dBm, more than 6 SVs.

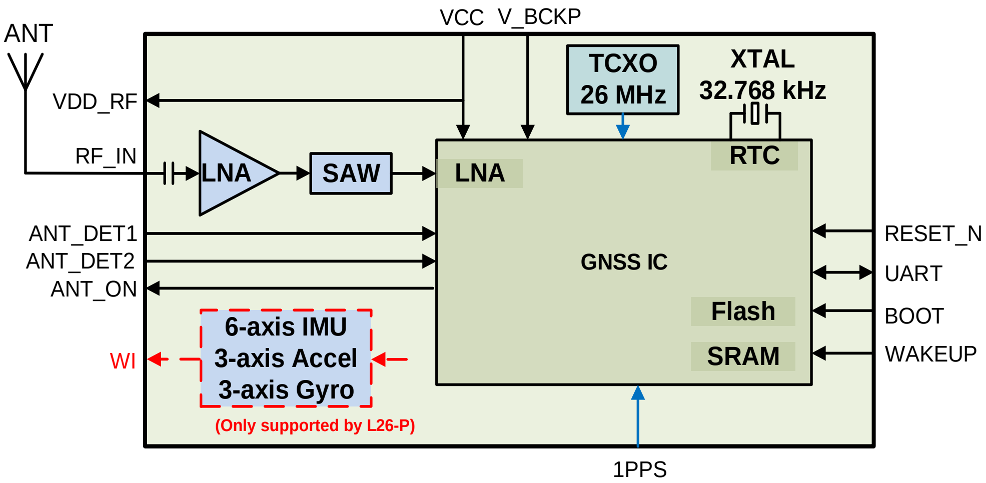


Figure 1: Block Diagram

1.5. GNSS Constellations

Quectel L26-P/L26-T module is a single-band GNSS receiver that can receive and track GPS, GLONASS, Galileo, BDS, and QZSS signals.

1.5.1. GPS

L26-P/L26-T module is designed to receive and track GPS L1 C/A signal centered at 1575.42 MHz.

1.5.2. GLONASS

L26-P/L26-T module is designed to receive and track GLONASS L1 signal in the frequency range from 1598.0625 to 1605.375 MHz.

1.5.3. Galileo

L26-P/L26-T module is designed to receive and track Galileo E1 signal centered at 1575.42 MHz.

1.5.4. BDS

L26-P/L26-T module is designed to receive and track BDS B1I signal centered at 1561.098 MHz. The ability to receive and track BDS signal in conjunction with GPS signal makes for higher coverage, improved reliability, and better accuracy.

1.5.5. QZSS

Quasi-Zenith Satellite System (QZSS) is a regional navigation satellite system that transmits signals compatible with the GPS L1 C/A, L1C, L2C, and L5 signals for the Pacific region covering Japan and Australia. L26-P/L26-T module can detect and track QZSS L1 C/A signal in conjunction with GPS signal, leading to better availability especially under challenging conditions, e.g, in urban canyons.

1.6. Augmentation System

1.6.1. SBAS

L26-P/L26-T module supports SBAS signal reception. By augmenting primary GNSS constellations with additional satellite-broadcast messages, the system improves the accuracy and reliability of GNSS information by correcting signal measurement errors and providing information about signal accuracy, integrity, continuity, and availability. SBAS transmits signals for ranging or distance measurement, thus further improving availability. Supported SBAS systems: WAAS, EGNOS, MSAS, and GAGAN.

1.7. AGNSS

L26-P/L26-T module supports AGNSS feature that significantly reduces the module's TTFF, especially under lower signal conditions. To implement the AGNSS feature, the module should get the assistance data including the current time and rough position. For more information, see ***document [2]***.

1.8. Dead Reckoning Function

L26-P module supports the Dead Reckoning (DR), which is the process of estimating the module's current position based on the last position obtained from GNSS, speed, heading sensor data, etc. With the combined 6-axis IMU inputs, the system plots the navigation trace when the satellite signals are partially or completely blocked while satellite signals provide updates and corrections for the 6-axis IMU drift. With this technology, the system achieves continuous and high-accuracy positioning in environments such as tunnels and urban canyons.

1.9. Firmware Upgrade

Quectel L26-P/L26-T module is delivered with preprogrammed firmware. Quectel may release firmware versions that contain bug fixes or performance optimizations. It is highly important to implement a firmware upgrade mechanism in your system. A firmware upgrade is the process of transferring a binary file image to the receiver and storing it in non-volatile flash. For more information, see ***document [3]***.

2 Pin Assignment

2.1. Pin Assignment

Quectel L26-P/L26-T module is equipped with 24 LCC pins by which the module can be mounted on your PCB.

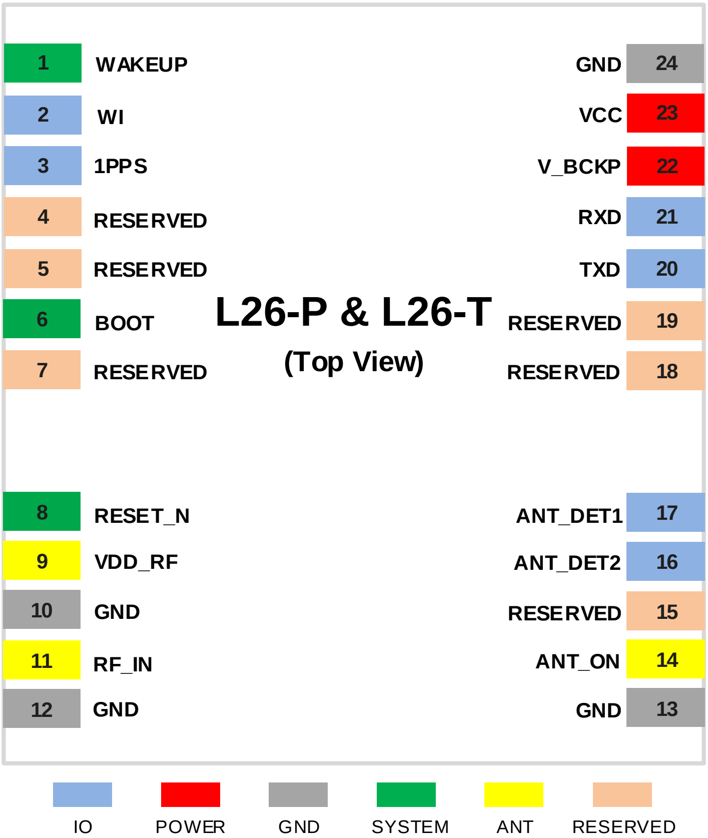


Figure 2: Pin Assignment

NOTE

Pin 2 is RESERVED for L26-T and WI for L26-P.

2.2. Pin Description

Table 3: I/O Parameter Definition

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

Table 4: Pin Description

Function	Name	No.	I/O	Description	Remarks
Power	VCC	23	PI	Main power supply	Supplies clean and steady voltage.
	V_BCKP	22	PI	Backup power supply for backup domain	V_BCKP must be connected to power supply for startup, and it should always be powered if hot (warm) start is needed.
IO	TXD	20	DO	Transmits data	The UART interface is used for standard NMEA message output, PSTM command input/output, and firmware upgrade.
	RXD	21	DI	Receives data	
	ANT_DET2	16	AI	External active antenna detection 2	If unused, leave the pin N/C (not connected).
	ANT_DET1	17	AI	External active antenna detection 1	
	WI	2	DO	Warning indicator	VCC must be valid to ensure the output of interrupt signal. L26-T does not support this feature.
	1PPS	3	DO	One pulse per second	Synchronized on the rising edge. If unused, leave the pin N/C.
Antenna	VDD_RF	9	PO	Power supply for external RF components	VDD_RF = VCC, the output current capacity depends on VCC. Typically used to supply power for an external active antenna or LNA. In the Backup mode, VDD_RF is turned off.

					If unused, leave the pin N/C.
	RF_IN	11	AI	GNSS antenna interface	50 Ω characteristic impedance.
	ANT_ON	14	DO	Power control for active antenna with antenna detection or an external LNA	If unused, leave the pin N/C.
System	WAKEUP	1	DI	Wakes up the module from the Standby mode	Keep this pin at a low voltage level in the Continuous mode. It is pulled down internally with a 47 kΩ resistor. Drive the pin to a high voltage level for at least 10 ms to exit the Standby mode. If unused, leave the pin N/C.
	RESET_N	8	DI	Resets the module	Active low. Do not reserve any pull-up circuit for this pin.
	BOOT	6	DI	Controls module startup mode	Pulled down internally by default. By keeping the pin floating during startup, the module enters the Normal operating mode. By keeping the pin at a high voltage level for about 50 ms during startup, the module enters the Boot download mode.
GND	GND	10, 12, 13, 24	-	Ground	Ensure a good GND connection to all GND pins of the module, preferably with a large ground plane.
RESERVED	RESERVED	2, 4, 5, 7, 15, 18, 19	-	Reserved	These pins must be left floating and cannot be connected to power or GND.

NOTE

1. Pin 2 is RESERVED for L26-T and WI for L26-P.
2. Leave RESERVED and unused pins N/C.

3 Power Management

Quectel L26-P/L26-T module features a power optimized architecture with built-in autonomous energy saving capabilities to minimize power consumption at any given time. The receiver can be used in three operating modes: Standby and Backup modes for optimum power consumption, and Continuous mode for optimum performance.

3.1. Power Unit

VCC is the supply voltage pin of the module. The load current of the VCC pin varies according to VCC voltage level, processor load, and satellite acquisition. It is important to supply sufficient current and make sure the power supply is clean and stable.

The V_BCKP pin supplies the backup domain, which includes RTC and SRAM. To achieve quick startup and improve TTFF, the backup domain power supply should be valid during the interval. If the VCC is invalid, the V_BCKP supplies the SRAM that contains all the necessary GNSS data and some of the user configuration variables.

VDD_RF is an output pin equal in voltage to the VCC input. In the Continuous mode, VDD_RF supplies the external active antenna or LNA. Only in the Backup mode, VDD_RF is turned off.

The module's internal power supply is shown below:

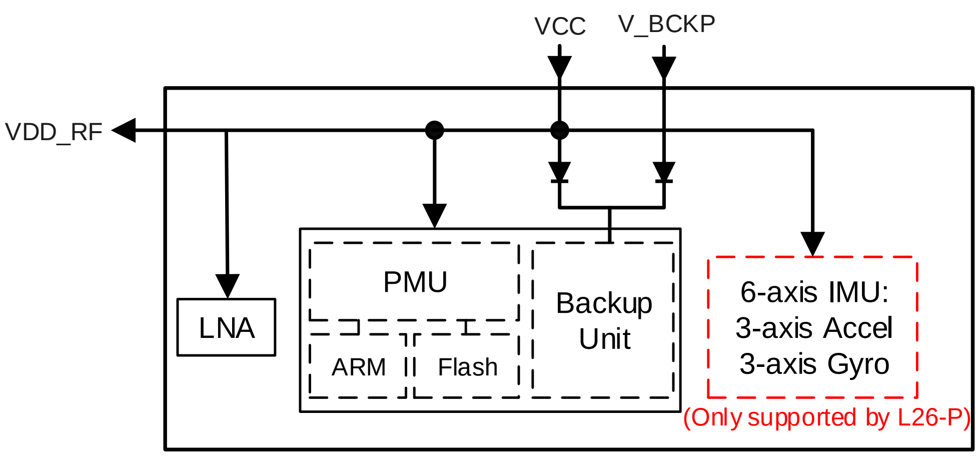


Figure 3: Internal Power Supply

3.2. Power Supply

3.2.1. VCC

VCC is the supply voltage pin that supplies the BB, RF, and 6-axis IMU (only supported by the L26-P module).

Module power consumption may vary by several orders of magnitude, especially when power saving modes are enabled. Therefore, it is important for the power supply to be able to sustain peak power for a short time, ensuring that the load current does not exceed the rated value. When the module starts up or switches from the Backup mode to the Continuous mode, VCC must charge the internal capacitors in the core domain. In some cases, this can lead to a significant current drain.

For low-power applications using power saving modes, it is important that the LDO at the power supply or module input can provide sufficient current. An LDO with a high PSRR should be chosen for optimum performance. In addition, a TVS, and a combination of a 10 μF, a 100 nF, and a 33 pF decoupling capacitor network should be added near the VCC pin. The lowest value capacitor should be the closest to module pins.

A fast discharging LDO voltage regulator is recommended to ensure a quick voltage drop when the VCC power is removed.

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

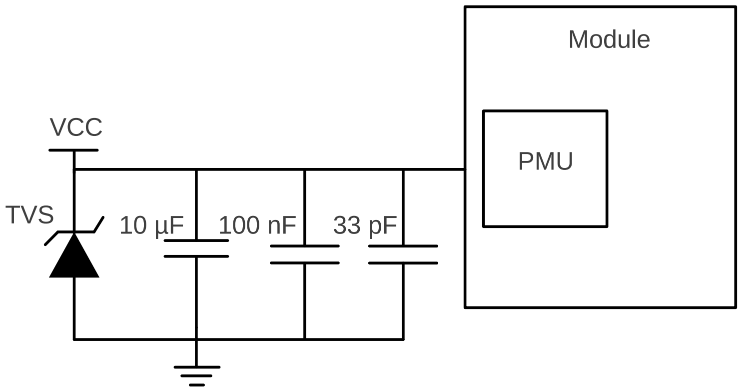


Figure 4: VCC Input Reference Circuit

NOTE

It is recommended to control the module VCC via MCU to save power, or restart the module when it enters an abnormal state.

3.2.2. V_BCKP

The V_BCKP pin supplies the backup domain. Use of valid time and GNSS orbit data at startup allows GNSS hot (warm) start. V_BCKP must be connected to power supply for startup, and it should be always powered if hot (warm) start is needed.

If there is a constant power supply in your system, it can be used to provide a suitable voltage to power V_BCKP.

V_BCKP can be directly powered by an external rechargeable battery. It is recommended to place a battery with a TVS and a combination of a 4.7 µF, a 100 nF, and a 33 pF capacitor near the V_BCKP pin. A reference design for powering the backup domain with a rechargeable battery is illustrated below.

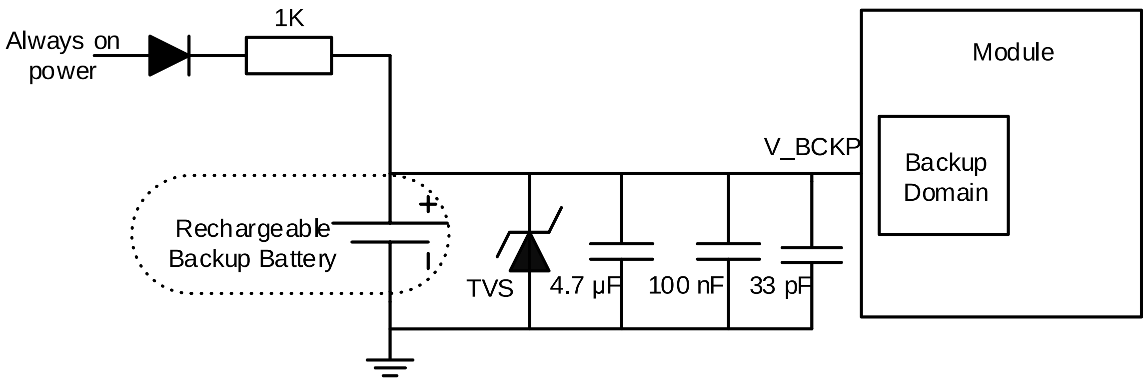


Figure 5: Reference Charging Circuit for a Rechargeable Battery

NOTE

1. If V_BCKP is below the specified value, the module cannot work normally.
2. A suitable resistor should be chosen according to the charging current of the battery.
3. It is recommended to control the module V_BCKP via MCU to restart the module when it enters an abnormal state.

3.3. Power Modes

3.3.1. Feature Comparison

The module features/functions supported in different modes are listed in the table below.

Table 5: Feature Comparison in Different Power Modes

Features	Continuous	Standby	Backup
NMEA from UART	●	-	-
1PPS	●	-	-
RF	●	-	-
Acquisition & Tracking	●	-	-
Power Consumption	High	Low	Low
Position Accuracy	High	-	-

3.3.2. Continuous Mode

If VCC is powered on, the module automatically enters the Continuous mode that comprises acquisition mode and tracking mode. In acquisition mode, the module starts to search satellites, and to determine visible satellites, coarse frequency, as well as the code phase of satellite signals. Once the acquisition is completed, the module automatically switches to tracking mode. In tracking mode, the module tracks satellites and demodulates the navigation data from specific satellites.

3.3.3. Standby Mode

The Standby mode is a power saving mode. In this mode, the internal core, IO power domain, and RF are powered off. UART is not accessible, and the module stops acquiring and tracking satellites. However, the 6-axis IMU (only supported by the L26-P module) and backup domain are still active.

There is one way to enter and two ways to exit the Standby mode.

- Enter the Standby mode:
  Send the software command. For more information about the command, see ***document [1]***.

- Exit the Standby mode:
  - Drive WAKEUP pin to high voltage level for at least 10 ms to trigger an interrupt wakeup; **OR**
  - Wait for the software command to be executed.

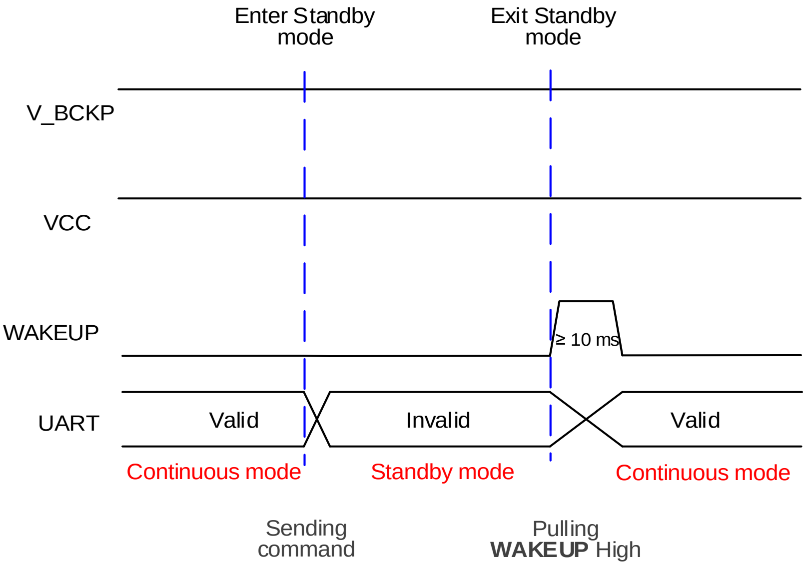


Figure 6: Sequence for Entering/Exiting Standby Mode

NOTE

Before running the command to enter the Standby mode, ensure that the WAKEUP pin is not pulled up, otherwise the module will enter an indeterminate state.

3.3.4. Backup Mode

For power-sensitive applications, the L26-P/L26-T module supports a Backup mode to reduce power consumption. Only the backup domain is active in the Backup mode and it keeps track of time.

- Enter the Backup mode:
  1. Send the software command to shut down the internal main power supply in sequence. For more information, see ***document [1]***.
  2. Cut off the power supply to the VCC pin and keep the V_BCKP powered.

- Exit the Backup mode:
  1. Restore VCC.
  2. Pull up the WAKEUP pin for at least 10 ms.

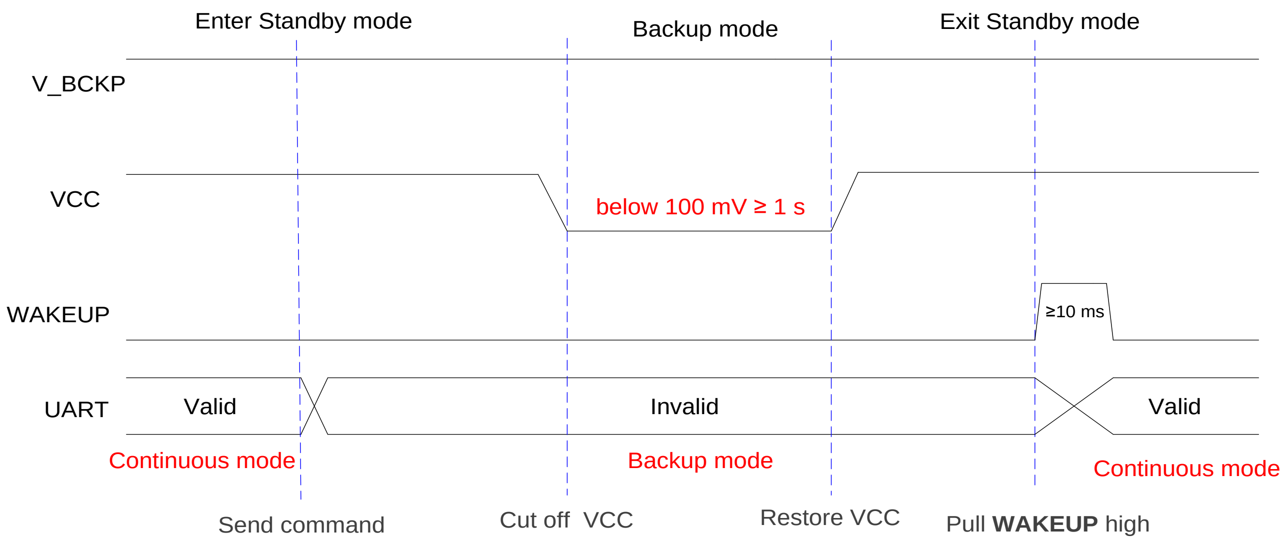


Figure 7: Sequence for Entering/Exiting Backup Mode

NOTE

1. After restoring VCC, the WAKEUP pin must be pulled up for at least 10 ms to exit the Standby mode. Otherwise, the UART will be inaccessible.
2. Ensure a stable V_BCKP voltage, without rush or drop when the VCC is switched on or off.
3. The software command must be sent; to ensure a hot (warm) start at the module's next startup, the V_BCKP must be kept powered.

3.4. Power-up Sequence

Once the VCC is powered up, the L26-P/L26-T module starts up automatically and the voltage should rise rapidly in less than 50 ms.

To ensure the correct power-up sequence, the backup unit should start up no later than the PMU. Hence, the V_BCKP must be powered before or simultaneously with the VCC.

Ensure that the VCC has no rush or drop during rising time, and then keep it stable. The recommended ripple is < 50 mV.

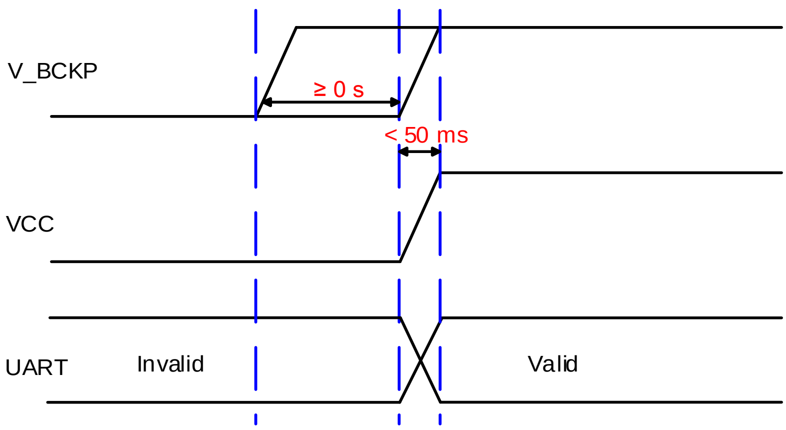


Figure 8: Power-up Sequence

3.5. Power-down Sequence

Once the VCC is shut down, voltage should drop quickly in less than 50 ms. It is recommended to use a voltage regulator that supports fast discharging.

To avoid abnormal voltage conditions, if VCC falls below the minimum specified value, the system must initiate a power-on restart by lowering VCC to less than 100 mV for at least 1 s.

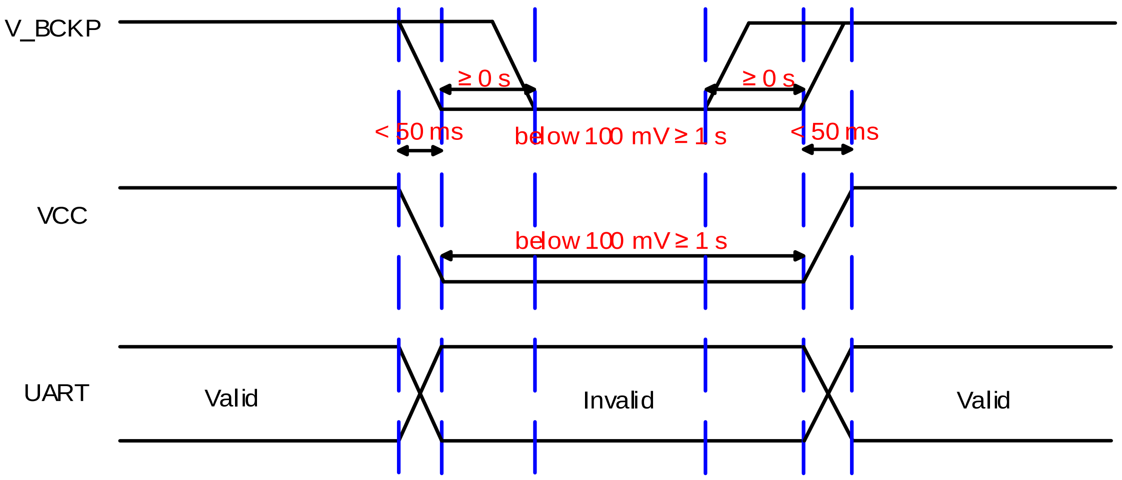


Figure 9: Power-down and Power-on Restart Sequence

4 Application Interfaces

4.1. IO Pins

4.1.1. Communication Interface

The following interface can be used for data reception and transmission.

4.1.1.1. UART Interface

L26-P/L26-T module has one UART interface with the following features:

L26-P:

- Supports standard NMEA message output, PSTM command input/output, and firmware upgrade.
- Supports raw data output of 6-axis IMU.
- Supports the following baud rates: 115200, 230400, 460800, and 921600 bps.
- Hardware flow control and synchronous operation are not supported.

L26-T:

- Supports standard NMEA message output, PSTM command input/output, and firmware upgrade.
- Supports the following baud rates: 9600, 19200, 38400, 57600, 115200, 230400, 460800, and 921600 bps.
- Hardware flow control and synchronous operation are not supported.

A reference design is shown in the figure below. For more information, see ***document [4]***.

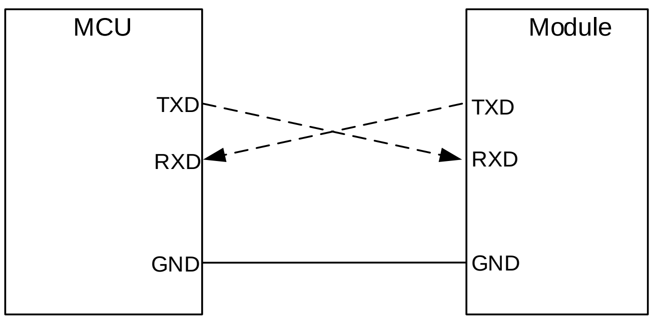


Figure 10: UART Interface Reference Design

NOTE

1. UART interface default settings vary depending on software versions. See specific software versions for details.
2. If MCU IO voltage does not match module voltage, a level-shifting circuit must be used.

4.1.2. WI

WI (only for L26-P module) signal is an interrupt output to wake up the host when the value of the 6-axis IMU is higher than the threshold value. L26-P module cannot determine what causes the vehicle tilting. It needs the MCU to judge whether the vehicle is towed or is running normally on an uphill road.

NOTE

To ensure interrupt signal output, the VCC of the module must not be powered off.

4.1.3. ANT_DET1 and ANT_DET2

ANT_DET1 and ANT_DET2 are analog input pins for detecting external active antenna status. Through an antenna detection circuit, the state of the antenna (normal/open/short) can be judged by ANT_DET1 and ANT_DET2. See ***Chapter 5.1.3.2*** for details.

4.1.4. 1PPS

The 1PPS output pin generates one pulse per second periodic signal synchronized with a GNSS time grid with intervals. The pulse accuracy of the L26-T module is < 6.8 ns @ 1σ and that of the L26-P module is < 100 ns. Thus, it may be used as a low frequency time synchronization pulse or as a high frequency reference signal. Maintaining high accuracy of 1PPS requires visible satellites in an open sky environment and powered VCC.

4.2. System Pins

4.2.1. WAKEUP

The WAKEUP pin is pulled down internally with a 47 kΩ resistor. It is used for waking up the L26-P/L26-T module from the Standby mode by being driven to a high voltage level for at least 10 ms. Keep this pin at low voltage level in the Continuous mode.

4.2.2. RESET_N

RESET_N is an input pin. L26-P/L26-T module can be reset by driving the RESET_N pin low for at least 100 ms and then releasing it.

By default, the RESET_N pin is internally pulled up to 1.0 V with a 10 kΩ resistor, thus no external pull-up circuit is allowed for this pin.

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

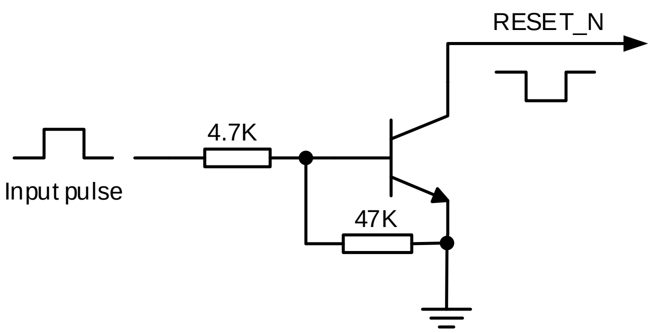


Figure 11: Reference OC Circuit for Module Reset

The following figure shows the reset timing of the module.

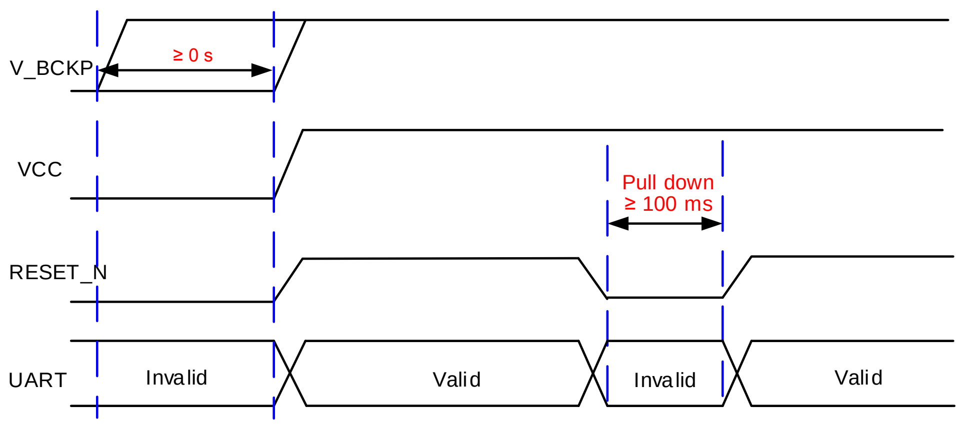


Figure 12: Reset Sequence

NOTE

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

4.2.3. BOOT

The BOOT pin can be used to set the L26-P/L26-T module to the Boot download mode. It is pulled down internally by default. For more information about the reference circuit design, see ***document [4]***.

The BOOT pin voltage level is checked automatically to identify the operating mode when the module is powered on.

Table 6: Operating Modes

Voltage Level	Operating Mode	Comment
Low	Normal	If the pin is kept floating during startup, the module enters the Normal operating mode.
High	Boot download	If the pin is kept at a high level for about 50 ms during startup, the module enters the Boot download mode.

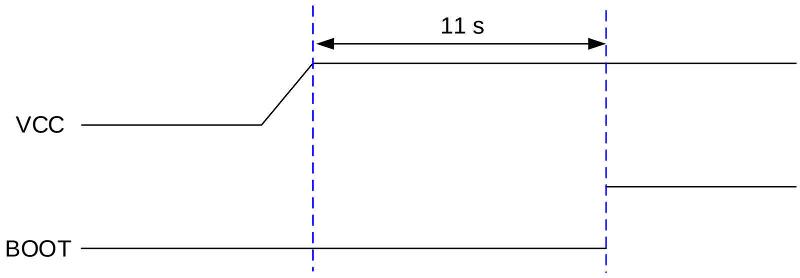


Figure 13: BOOT Pin State (Normal Operating Mode)

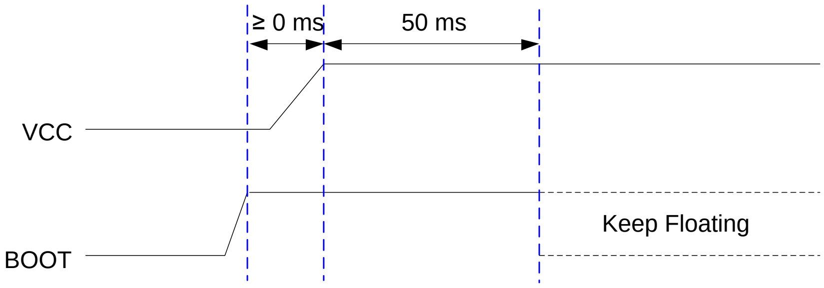


Figure 14: BOOT Pin Control Sequence (Boot Download Mode)

5 Design

This chapter explains the reference design of the RF section and recommended footprint of the module.

5.1. Antenna Design

5.1.1. Antenna Specifications

L26-P/L26-T module can be connected to a dedicated passive or active single-band GNSS antenna to receive GNSS satellite signals. The recommended antenna specifications are given in the table below.

Table 7: Recommended Antenna Specifications

Antenna Type	Specifications
Passive Antenna	Frequency Range: 1559–1606 MHz Polarization: RHCP VSWR: < 2 (Typ.) Passive Antenna Gain: > 0 dBi
Active Antenna	Frequency Range: 1559–1606 MHz Polarization: RHCP VSWR: < 2 (Typ.) Passive Antenna Gain: > 0 dBi Active Antenna Noise Figure: < 2 dB Active Antenna Total Gain: 5–20 dB

NOTE

1. Contact Quectel Technical Support for recommended antenna model(s).
2. The total gain of the whole antenna equals the internal LNA gain minus total insertion loss of cables and components inside the antenna.

5.1.2. Antenna Selection Guide

Both active and passive single-band GNSS antennas can be used for the L26-P/L26-T module. A passive antenna is recommended if the antenna can be placed close to the module, for instance, when the distance between the module and the antenna is less than 1 m. It is recommended to switch from a passive antenna to an active antenna once the loss is > 1 dB, since the insertion loss of RF cable can decrease the C/N_0 of GNSS signal. For more information about RF trace layout, see ***document [5]***.

C/N_0 is an important factor for GNSS receivers, and it is defined as the ratio of the received modulated carrier signal power to the received noise power in 1 Hz bandwidth. C/N_0 formula:

$$C/N_0 = \text{Power of GNSS signal} - \text{Thermal Noise} - \text{System NF(dB-Hz)}$$

The “Power of GNSS signal” is GNSS signal level. In practical environment, the signal level at the earth’s surface is about -130 dBm. “Thermal Noise” is -174 dBm/Hz at 290 K. To improve C/N_0 of GNSS signal, an LNA could be added to reduce “System NF”.

“System NF”, formula:

$$\mathrm{NF} = 10 \log \mathrm{F}\ (\mathrm{dB})$$

“F” is the noise factor of receiver system:

$$\mathrm{F} = \mathrm{F1} + (\mathrm{F2} - 1)/\mathrm{G1} + (\mathrm{F3} - 1)/(\mathrm{G1} \cdot \mathrm{G2}) + \cdots$$

“F1” is the first stage noise factor; “G1” is the first stage gain, etc. This formula indicates that the LNA with enough gain can compensate for the noise factor behind the LNA. In this case, “System NF” depends mainly on the noise figure of components and traces before the first stage LNA plus the noise figure of the LNA itself. This explains the need for using an active antenna, if the antenna connection cable is too long.

5.1.3. Active Antenna Reference Design

5.1.3.1. Active Antenna Reference Design without Antenna Detection Function

A typical reference design of an active antenna without antenna detection is illustrated in the following figure. In this case, the antenna is powered by VDD_RF. When selecting the active antenna, it is necessary to pay attention to the operating voltage range.

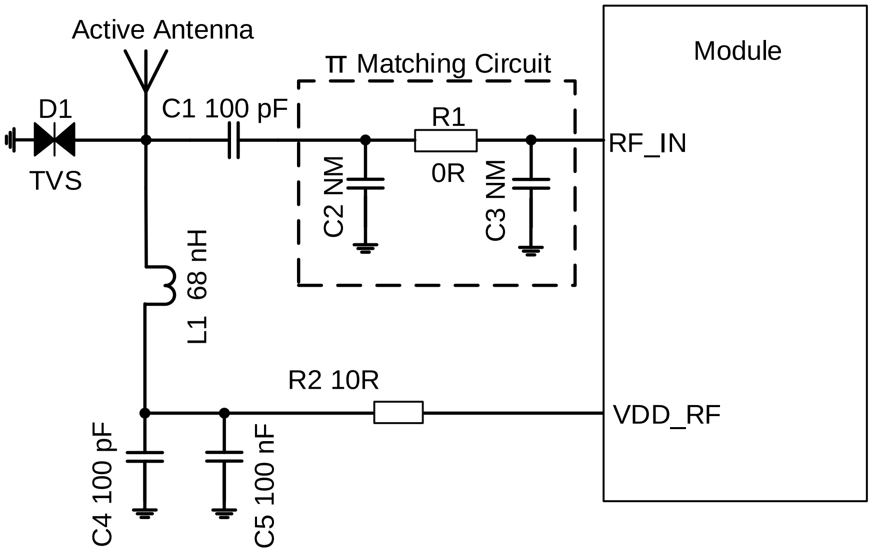


Figure 15: Active Antenna Reference Design without Antenna Detection

C2, R1, and C3 components are reserved for matching antenna impedance. By default, R1 is 0 Ω; C1 is 100 pF; C2 and C3 are not mounted. D1 is an electrostatic discharge (ESD) protection device to protect the RF signal input from the potential damage caused by ESD. The junction capacitance of D1 cannot be more than 0.6 pF and a transient voltage suppressor is recommended.

An active antenna can be powered by the VDD_RF pin. In that case, the inductor L1 is used to prevent the RF signal from leaking into the VDD_RF and to prevent noise propagation from the VDD_RF to the antenna. The L1 inductor routes the bias voltage to the active antenna without losses. Place L1, C4 and C5 close to the antenna interface and route the proximal end of L1 pad on the RF trace. The recommended value of L1 should be at least 68 nH. The R2 resistor is used to protect the module in case the active antenna is short-circuited to the ground plane.

5.1.3.2. Active Antenna Reference Design with Antenna Detection Function

The following figure is a typical reference design of an active antenna with antenna detection function.

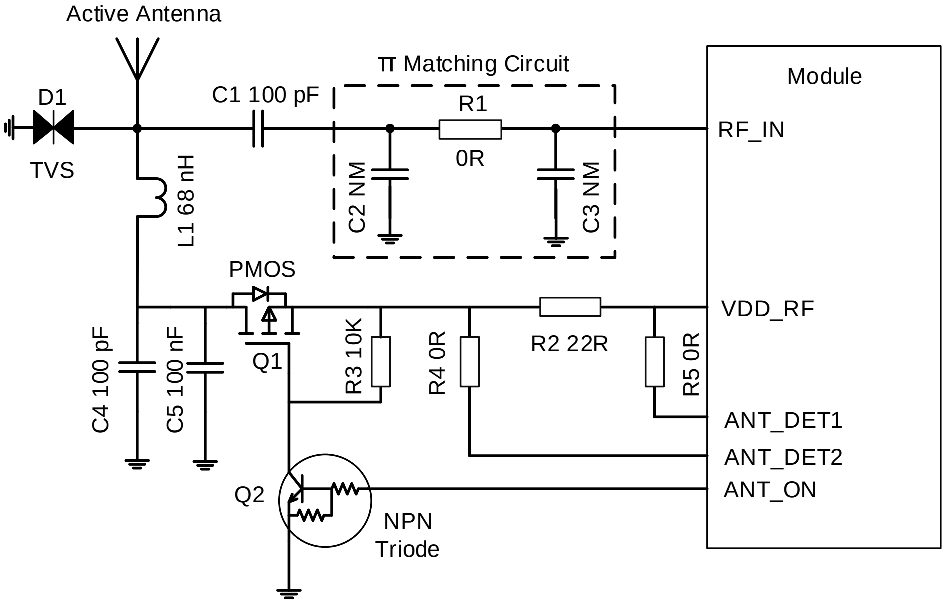


Figure 16: Active Antenna Reference Design with Antenna Detection

The L26-P/L26-T module reads the state of the antenna (normal/open/short) through the antenna detection circuit. It compares the voltages at both ends of the R2 resistor (22 Ω recommended) by two analog inputs, ANT_DET1 and ANT_DET2 pins.

The ANT_ON pin controls the power supply for the active antenna with antenna detection function. When ANT_ON is at high level, both transistors Q1 and Q2 will be switched ON and the external antenna will be powered by VDD_RF. When ANT_ON is at low level, both Q1 and Q2 will be switched off, thus disabling the external antenna. VDD_RF will be powered off automatically only in the Backup mode.

Ensure that the antenna current consumption falls within the 7–30 mA range, otherwise the active antenna may not work. The status of the antenna supervisor will be reported in an NMEA message at start-up and on each change. For more information about the NMEA message, see ***document [1]***.

5.1.4. Passive Antenna Reference Design

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

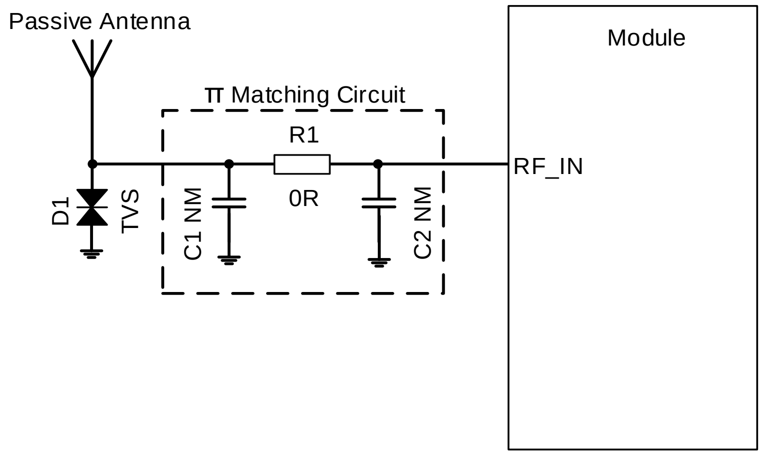


Figure 17: Passive Antenna Reference Design

C1, R1, and C2 components are reserved for matching antenna impedance. By default, R1 is 0 Ω, while C1 and C2 are not mounted. D1 is an electrostatic discharge (ESD) protection device to protect the RF route from the damage caused by ESD. The junction capacitance of D1 cannot be more than 0.6 pF and a transient voltage suppressor is recommended. RF trace impedance should be controlled to 50 Ω and the trace length should be kept as short as possible.

5.2. Coexistence with Cellular Systems

Since GNSS signals are usually very weak, a GNSS receiver could be vulnerable to environmental interference. According to 3GPP specifications, a cellular terminal should transmit a signal of up to 33 dBm at GSM bands, or of about 24 dBm at WCDMA and LTE bands. Therefore, coexistence with cellular systems must be optimized to avoid significant deterioration of the GNSS performance.

In a complex communication environment, interference signals can come from in-band and out-of-band signals. Therefore, interference can be divided into two types: in-band interference and out-of-band interference, which are both described in this chapter.

In this chapter, you can also find suggestions for decreasing the impact of interference signals that will ensure the interference immunity of a GNSS receiver.

5.2.1. In-band Interference

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

See the following figure for more details.

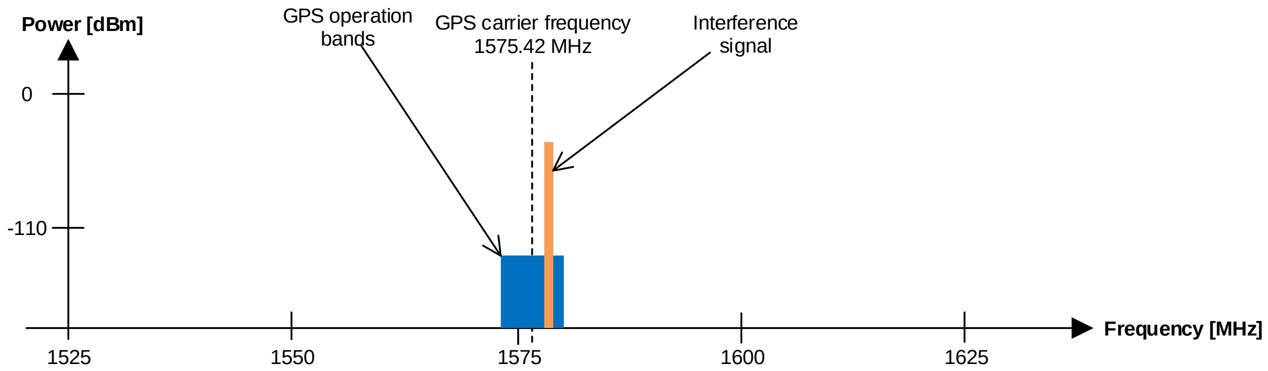


Figure 18: In-band Interference on GPS L1

The most common in-band interferences usually come from:

- Harmonics, caused by crystals, high-speed signal lines, MCUs, switch-mode power supply, etc., or
- Intermodulation from different communication systems.

Common frequency combinations are presented in the table below. The table lists some probable in-band interferences generated by two kinds of out-of-band signal intermodulations or the second harmonic of LTE Band 13.

Table 8: Intermodulation Distortion (IMD) Products

Source F1	Source F2	IM Calculation	IMD Products
GSM850/Band 5	Wi-Fi 2.4 GHz	F2 (2412 MHz) - F1 (837 MHz)	IMD2 = 1575 MHz
DCS1800/Band 3	PCS1900/Band 2	2 × F1 (1712.6 MHz) - F2 (1850.2 MHz)	IMD3 = 1575 MHz
PCS1900/Band 2	Wi-Fi 5 GHz	F2 (5280 MHz) - 2 × F1 (1852 MHz)	IMD3 = 1576 MHz
LTE Band 13	-	2 × F1 (786.9 MHz)	IMD2 = 1573.8 MHz

5.2.2. Out-of-band Interference

Strong signals transmitted by other communication systems can cause GNSS receiver saturation, thus greatly deteriorating its performance, as illustrated in the following figure.

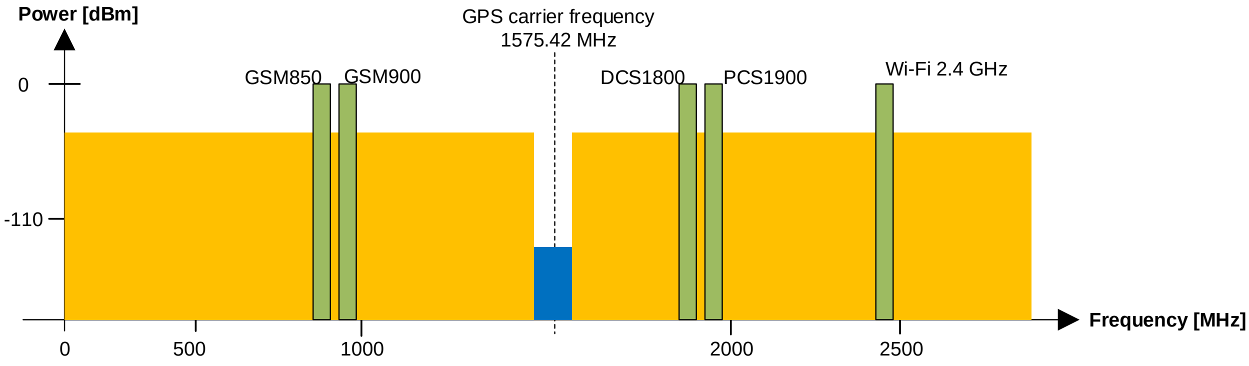


Figure 19: Out-of-band Interference on GPS L1

5.2.3. Ensuring Interference Immunity

There are several things you can do to decrease the impact of interference signals and thus ensure the interference immunity of a GNSS receiver:

- Keep the GNSS antenna away from interference sources;
- Add a band-pass filter in front of the GNSS module;
- Use shielding and multi-layer PCB and ensure adequate grounding;
- Optimize layout and component placement of the PCB and the whole device.

The following figure illustrates the interference source and its potential interference path. A complex communication system usually contains RF power amplifiers, MCUs, crystals, etc. These devices should be far away from a GNSS receiver or a GNSS module. In particular, shielding should be used to prevent strong signal interference for power amplifiers. The cellular antenna should be placed away from a GNSS receiving antenna to ensure enough isolation. Usually, a good design should provide at least a 20 dB isolation between two antennas. Take DCS1800, for example, the maximum transmitted power of DCS1800 is around 30 dBm. After a 20 dB attenuation, the signal received by the GNSS antenna will be around 10 dBm, which is still too high for a GNSS module. With a GNSS band-pass filter with around 40 dB rejection in front of the GNSS module, the out-of-band signal will be attenuated to -30 dBm.

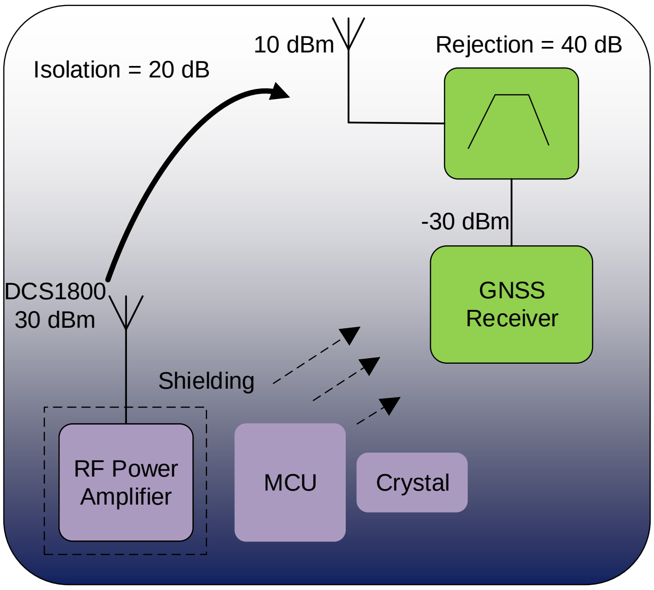


Figure 20: Interference Source and Its Path

5.3. Recommended Footprint

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

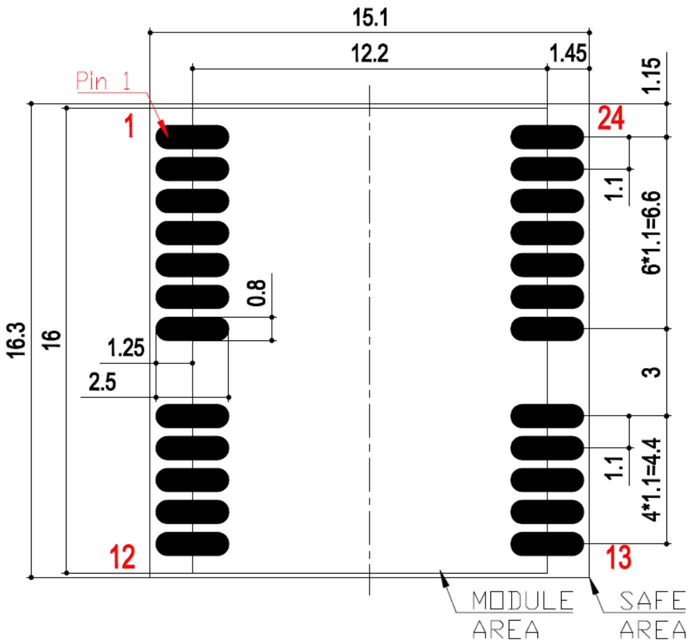


Figure 21: Recommended Footprint

NOTE

Maintain at least 3 mm keepout between the module and other components on the motherboard to improve soldering quality and maintenance convenience.

6 Electrical Specification

6.1. Absolute Maximum Ratings

Absolute maximum ratings for power supply and voltage on digital pins of the L26-P/L26-T module are listed in the table below.

Table 9: Absolute Maximum Ratings

Parameter	Description	Min.	Max.	Unit
VCC	Main Power Supply Voltage	-0.3	3.6	V
V_BCKP	Backup Supply Voltage	-0.3	3.6	V
V_{IN}_IO	Input Voltage at IO Pins	-0.2	VCC + 0.3	V
P_{RF_IN}	Input Power at RF_IN	-	15	dBm
T_storage	Storage Temperature	-40	90	°C

NOTE

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

6.2. Recommended Operating Conditions

All specifications are at an ambient temperature of +25°C. Extreme operating temperatures can significantly impact the specified values. Applications operating near the temperature limits should be tested to ensure specification validity.

Table 10: Recommended Operating Conditions

Parameter	Description	Min.	Typ.	Max.	Unit
VCC	Main Power Supply Voltage	3.0	3.3	3.6	V
V_BCKP	Backup Power Supply Voltage	2.0	3.3	3.6	V
IO_Domain	Digital IO Pin Domain Voltage	-	3.3	-	V
V_{IL}	Digital IO Pin Low-Level Input Voltage	-0.3	-	0.8	V
V_{IH}	Digital IO Pin High-Level Input Voltage	2.0	-	VCC + 0.3	V
V_{OL}	Digital IO pin Low-Level Output Voltage	-	-	0.4	V
V_{OH}	Digital IO Pin High-Level Output Voltage	VCC - 0.4	VCC - 0.2	-	V
RESET_N	Low-Level Input Voltage	-0.3	-	0.35	V
WAKEUP	High-Level Input Voltage	2.1	-	VCC	V
VDD_RF	VDD_RF Voltage	-	VCC	-	V
T_operating	Operating Temperature	-40	25	+85	°C

NOTE

1. Operation beyond the "Operating Conditions" is not recommended and extended exposure beyond the "Operating Conditions" may affect device reliability.
2. IO_Domain specifically refers to the IO pins in GPIO in ***Chapter 2***.

6.3. Supply Current Requirements

The following table lists the supply current values of the total system that may be applied. Actual power requirements may vary depending on processor load, external circuits, firmware version, the number of tracked satellites, signal strength, startup type, test time and conditions.

Table 11: Supply Current for L26-P

Parameter	Description	Condition	$I_{Typ.}$ [5]	I_{PEAK} [5]
I_{VCC} [6]	Current at VCC	Acquisition mode	73 mA	120 mA
		Tracking mode	62 mA	120 mA
		Standby mode	1.7 mA	2.4 mA
I_{V_BCKP} [7]	Current at V_BCKP	Continuous mode	120 μA	150 μA
		Standby mode	8 μA	43 μA
		Backup mode	8 μA	43 μA

Table 12: Supply Current for L26-T

Parameter	Description	Condition	$I_{Typ.}$ [5]	I_{PEAK} [5]
I_{VCC} [6]	Current at VCC	Acquisition mode	71 mA	112 mA
		Tracking mode	67 mA	112 mA
		Standby mode	1.7 mA	2.4 mA
I_{V_BCKP} [7]	Current at V_BCKP	Continuous mode	78 μA	111 μA
		Standby mode	8 μA	43 μA
		Backup mode	8 μA	43 μA

6.4. ESD Protection

Static electricity occurs naturally and it may damage the module. Therefore, applying proper ESD countermeasures and handling methods is imperative. For example, wear anti-static gloves during the development, production, assembly, and testing of the module; add ESD protective components to the ESD sensitive interfaces and points in the product design.

Measures to ensure protection against ESD damage when handling the module:

[5] Room temperature, measurements are taken with typical voltage.
[6] Used to determine the maximum current capability of power supply.
[7] Used to determine the required battery current capability.

- When mounting the module onto a motherboard, make sure to connect the GND first, and then the RF_IN pin.
- When handling the RF_IN pin, do not come into contact with any charged capacitors or materials that may easily generate or store charges (such as patch antenna, coaxial cable, and soldering iron).
- When soldering the RF_IN pin, make sure to use an ESD safe soldering iron (tip).

7 Mechanical Dimensions

This chapter describes the mechanical dimensions of the L26-P/L26-T module. All dimensions are in millimeters (mm). The dimensional tolerances are ±0.20 mm, unless otherwise specified.

7.1. Top, Side, and Bottom View Dimensions

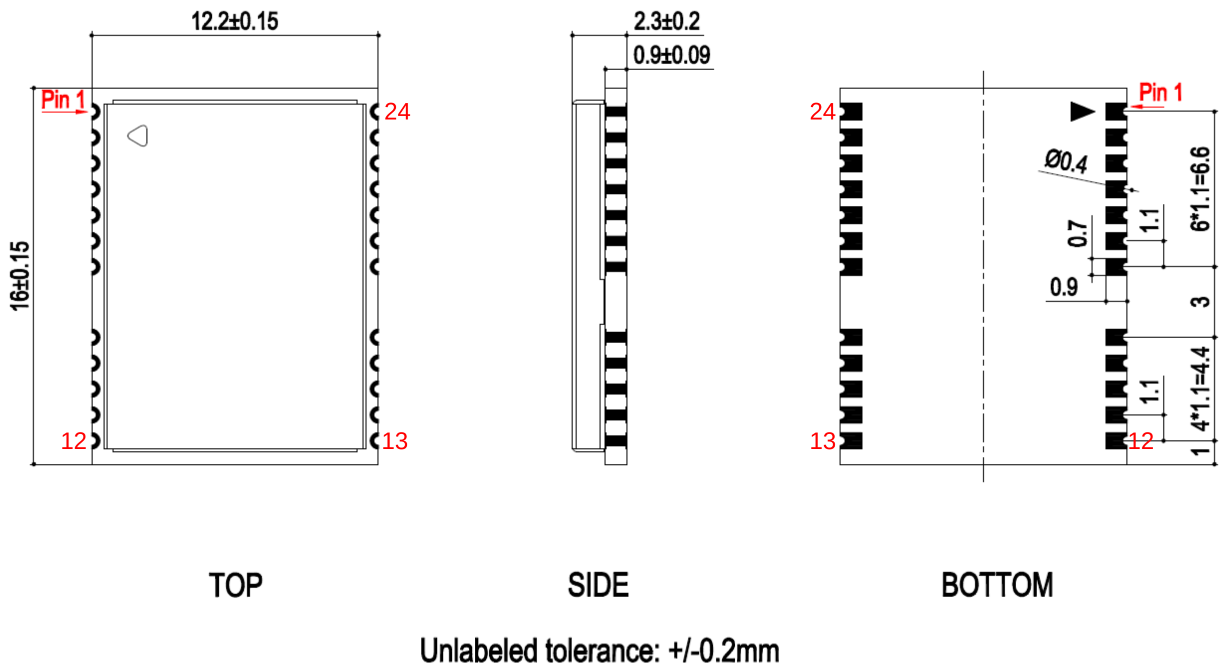


Figure 22: Top, Side, and Bottom View Dimensions

NOTE

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

7.2. Top and Bottom Views

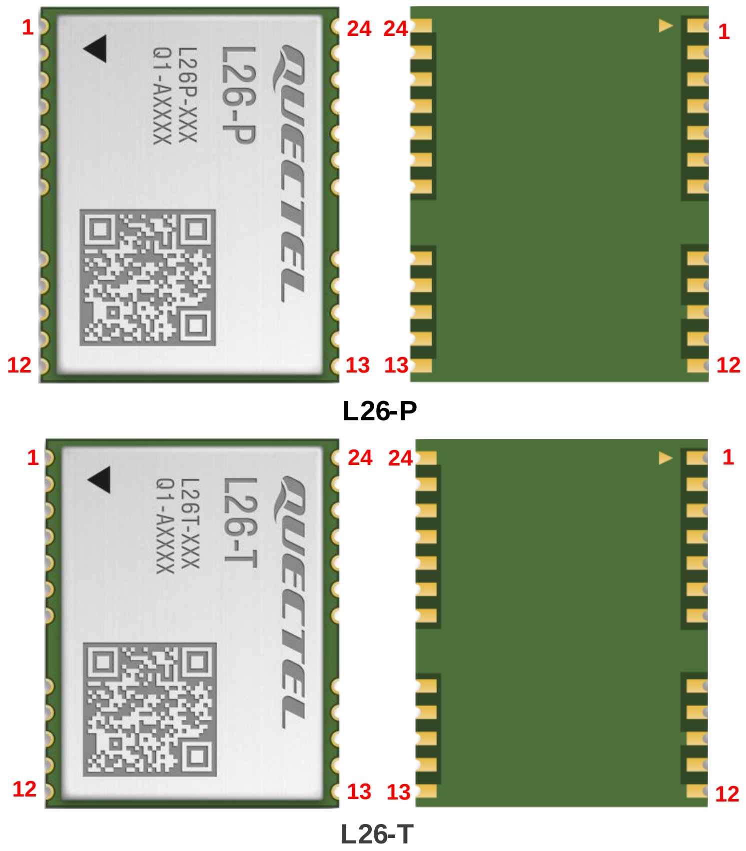


Figure 23: Top and Bottom Views

NOTE

The images above are for illustrative purposes only and may differ from the actual module. For authentic appearance and label, see the module received from Quectel.

7.3. Recommended Mounting

The following is the three-axis direction of the IMU accelerometer for the L26-P module. Please refer to the algorithm requirements for specific installation angle and direction restrictions. For more information, see ***document [1]***.

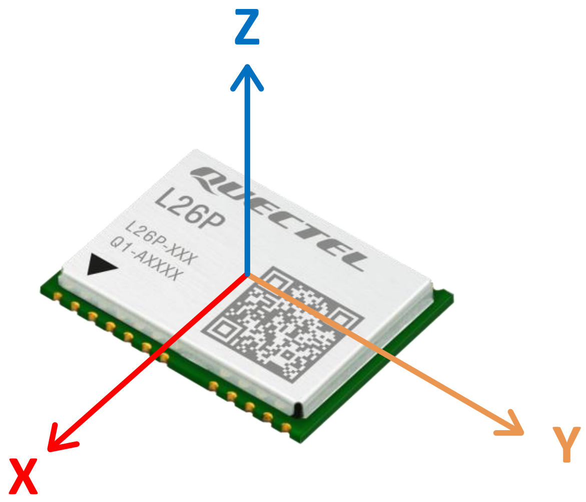


Figure 24: Axes of L26-P Module

To ensure its performance, the L26-P module must be fixed tightly on the vehicle without movement or shaking during positioning.

8 Product Handling

8.1. Packaging

This chapter describes only the key packaging parameters and the packaging process itself. All figures below are for reference only. The appearance and structure of the packaging materials are subject to the actual delivery.

The L26-P/L26-T module is packed with carrier tape packaging and the details are as follows.

8.1.1. Carrier Tape

Carrier tape dimensions are presented in the figure below:

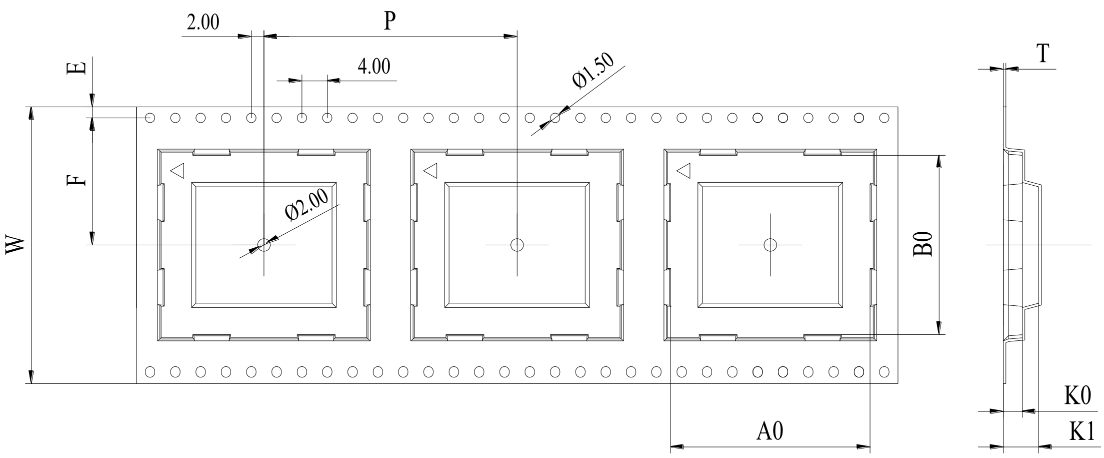


Figure 25: Carrier Tape Dimension Drawing

Table 13: Carrier Tape Dimension Table (Unit: mm)

W	P	T	A0	B0	K0	K1	F	E
32	24	0.4	12.7	16.4	2.9	7.4	14.2	1.75

8.1.2. Plastic Reel

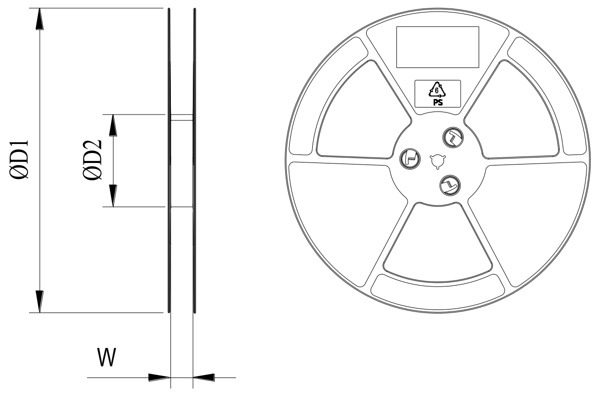
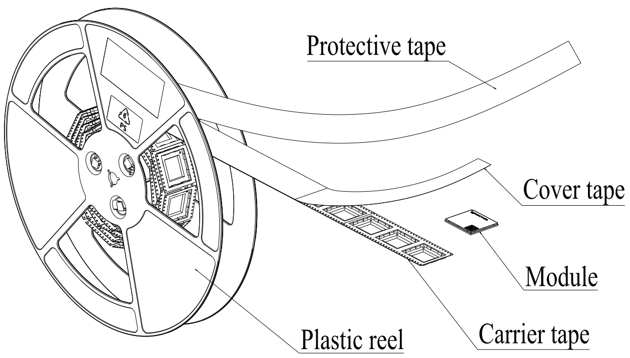


Figure 26: Plastic Reel Dimension Drawing

Table 14: Plastic Reel Dimension Table (Unit: mm)

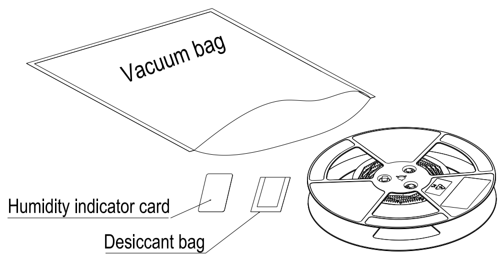
øD1	øD2	W
330	100	32.5

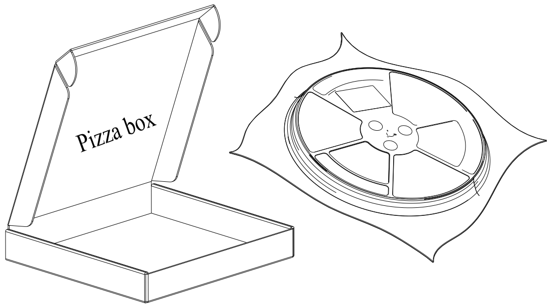
8.1.3. Packaging Process



Place the modules onto the carrier tape and use the cover tape to cover them; then wind the heat-sealed carrier tape on the plastic reel and use the protective tape for protection. One plastic reel can load 250 modules.

Place the packaged plastic reel, humidity indicator card and desiccant bag inside a vacuum bag, then vacuumize it.





Place the vacuum-packed plastic reel inside a pizza box.

Place 4 pizza boxes inside 1 carton and seal it. One carton can pack 1000 modules.

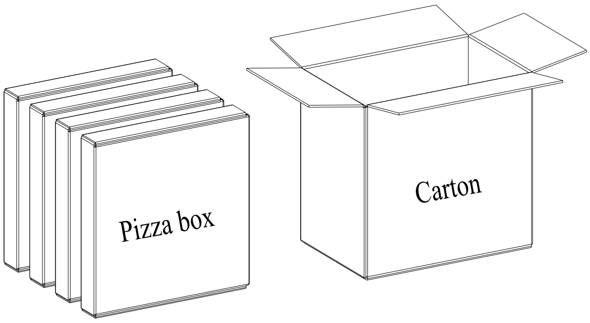


Figure 27: Packaging Process

8.2. Storage

L26-P/L26-T module is provided in the vacuum-sealed packaging. MSL of the module is rated as 3. The storage requirements are listed below.

1. Recommended Storage Condition: The temperature should be 23 ±5 °C and the relative humidity should be 35–60 %.

2. Shelf life (in vacuum-sealed packaging): 12 months in Recommended Storage Condition.

3. Floor life: 168 hours [8] in a plant where the temperature is 23 ±5 °C and relative humidity is below 60 %. After the vacuum-sealed packaging is removed, the module must 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 under Recommended Storage Condition;
   - Violation of the third requirement above;

[8] The 168 h shelf life rule is only valid when the environment conforms to *IPC/JEDEC J-STD-033*. It is recommended to start the solder reflow process within 24 hours of removing the packaging if the temperature and moisture do not conform to, or if it is not certain that they conform to *IPC/JEDEC J-STD-033*. Do not remove the packaging if the module is not ready for soldering.

- 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;
- The module must be soldered to PCB within 24 hours after the baking, otherwise it should be put in a dry environment such as a drying cabinet.

NOTE

1. To avoid blistering, layer separation and other soldering issues, extended exposure of the module to the air is forbidden.
2. Take the module out of the packaging and put it on high-temperature-resistant fixtures before baking. If shorter baking time is desired, see *IPC/JEDEC J-STD-033* for the baking procedure.
3. Pay attention to ESD protection, such as wearing anti-static gloves, when touching the module.

8.3. Manufacturing and Soldering

Push the squeegee to apply solder paste on the stencil surface, thus making the paste fill the stencil openings and then penetrate the PCB. Apply proper force on the squeegee to produce a clean stencil surface on a single pass. For more information about the stencil thickness for the module, see ***document [6]***.

The peak reflow temperature should be 235–246 ºC, with 246 ºC as the absolute maximum reflow temperature. To avoid module damage caused by repeated heating, it is strongly recommended to mount the module to the PCB only after reflow soldering the other side of the PCB. The recommended reflow soldering thermal profile (lead-free reflow soldering) and related parameters are shown in the figure and table below.

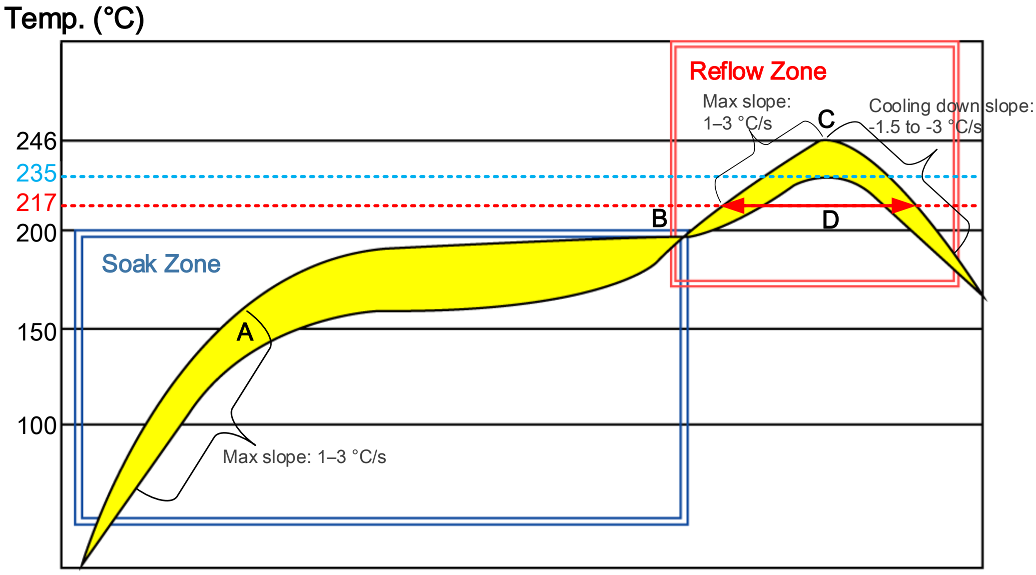


Figure 28: Recommended Reflow Soldering Thermal Profile

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	1–3 °C/s
Reflow Time (D: over 217 °C)	40–70 s
Max. Temperature	235 °C to 246 °C
Cooling Down Slope	-1.5 to -3 °C/s
Reflow Cycle	
Max. Reflow Cycle	1

NOTE

1. During manufacturing and soldering, or any other processes that may require direct contact with the

module, **NEVER** wipe the module shielding can with organic solvents, such as acetone, ethyl alcohol, isopropyl alcohol, and trichloroethylene. Otherwise, the shielding can may become rusty.

2. The module shielding can is made of cupronickel base material. The Neutral Salt Spray Test has shown that after 12 hours 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 the module requires conformal coating, **DO NOT** use any coating material that may react with the PCB or shielding cover. Prevent the coating material from entering the module shield.
4. Avoid cleaning the module with ultrasonic technology since it can damage crystals inside the module.
5. Due to SMT process complexity, please contact Quectel Technical Support before taking any action or implementing any process that you are not sure about (e.g., selective soldering, ultrasonic soldering) that is not mentioned in ***document [6]***.

9 Labelling Information

The label of the Quectel GNSS modules contains important product information. The location of the product type number is shown in the figure below.

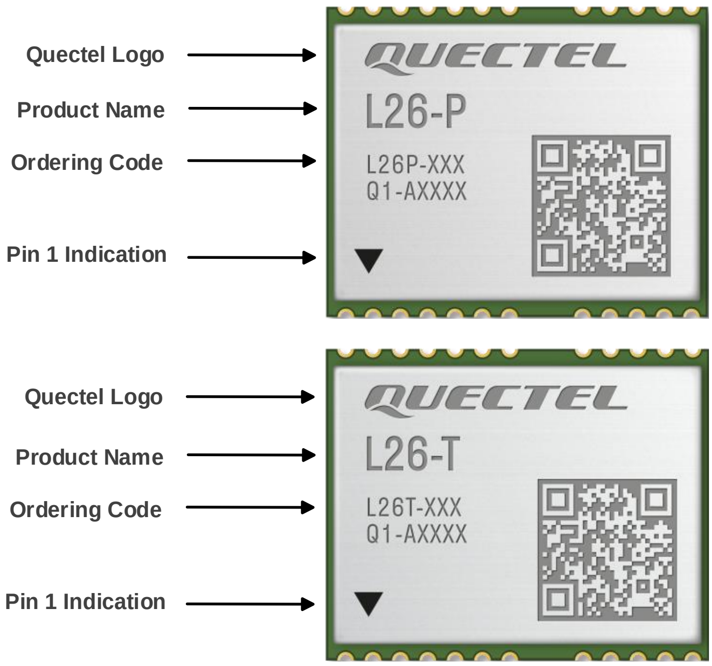


Figure 29: Labelling Information

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

10 Appendix References

Table 16: Related Documents

Document Name
[1] Quectel_L26-DR&L26-P&L26-T&LC98S_GNSS_Protocol_Specification
[2] Quectel_L89&L26-DR&L26-P&L26-T_AGNSS_Application_Note
[3] Quectel_L26-DR&L26-P&L26-T&L89&LC98S_Firmware_Upgrade_Guide
[4] Quectel_L26-T&L26-P_Reference_Design
[5] Quectel_RF_Layout_Application_Note
[6] Quectel_Module_Secondary_SMT_Application_Note

Table 17: Terms and Abbreviations

Abbreviation	Description
AGNSS	Assisted GNSS (Global Navigation Satellite System)
BB	Baseband
BDS	BeiDou Navigation Satellite System
CAN	Controller Area Network
CEP	Circular Error Probable
C/N_0	Carrier-to-noise-density Ratio
DCS1800	Digital Cellular System at 1800 MHz
DR	Dead Reckoning
EGNOS	European Geostationary Navigation Overlay Service
ESD	Electrostatic Discharge

GAGAN	GPS Aided Geo Augmented Navigation
Galileo	Galileo Satellite Navigation System (EU)
GLONASS	Global Navigation Satellite System (Russia)
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GSM	Global System for Mobile Communications
I/O	Input/Output
I2C	Inter-Integrated Circuit
IC	Integrated Circuit
IMU	Inertial Measurement Unit
I_{PEAK}	Peak Current
IRNSS	Indian Regional Navigation Satellite System
LCC	Leadless Chip Carrier (package)
LDO	Low-dropout Regulator
LNA	Low-Noise Amplifier
LTE	Long-Term Evolution
MCU	Microcontroller Unit/Microprogrammed Control Unit
MSAS	Multi-functional Satellite Augmentation System (Japan)
MSL	Moisture Sensitivity Levels
NF	Noise Figure
NMEA	NMEA (National Marine Electronics Association) 0183 Interface Standard
OC	Ordering Code/Open Connector
PCB	Printed Circuit Board
PMU	Power Management Unit
1PPS	One Pulse Per Second
PSRR	Power Supply Rejection Ratio

QR (Code)	Quick Response (Code)
QZSS	Quasi-Zenith Satellite System
RF	Radio Frequency
RHCP	Right Hand Circular Polarization
RMC	Recommended Minimum Specific GNSS Data
RoHS	Restriction of Hazardous Substances
RTC	Real-Time Clock
RTK	Real-Time Kinematic
RXD	Receive Data (Pin)
3GPP	3rd Generation Partnership Project
SAW	Surface Acoustic Wave
SBAS	Satellite-Based Augmentation System
SMD	Surface Mount Device
SMT	Surface Mount Technology
SPI	Serial Peripheral Interface
SRAM	Static Random Access Memory
SV	Satellite Vehicle
TCXO	Temperature Compensated Crystal Oscillator
TTFF	Time to First Fix
TVS	Transient Voltage Suppressor
UART	Universal Asynchronous Receiver/Transmitter
VSWR	Voltage Standing Wave Ratio
WAAS	Wide Area Augmentation System
WCDMA	Wideband Code Division Multiple Access
XTAL	External Crystal Oscillator