L80 Hardware Design

GPS Module Series

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About the Document

History

Revision	Date	Author	Description
1.0	2013-07-25	Tony GAO	Initial
1.1	2013-08-10	Tony GAO	1. Modified the voltage range of VCC pin. 2. Added AADET_N pin in Figure 1 Block Diagram, and the description of it in Table 3. 3. Modified the description about power supply in *chapter 3.3*. 4. Optimized the mechanical dimensions about the height in Figure 18. 5. Modified the structure of *chapter 4*. 6. Added content in *chapter 4.3* about how to judge the antenna status via AADET_N pin.
1.2	2014-06-11	Tony GAO	1. Modified the input power at EX_ANT. 2. Updated packaging information.
1.3	2015-11-09	Neil WU	1. Added the description of FLP mode. 2. Added the description of PPS VS. NMEA. 3. Added note for the position of pin 1. 4. Modified the PCB design guide.
1.4	2016-04-22	Neil WU	Modified the PCB design guide.

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1 Introduction

This document defines and specifies L80 GPS module. It describes hardware interfaces, external application reference circuits, mechanical size and air interface of L80 module.

This document can help you quickly understand the interface specifications, as well as electrical and mechanical details of L80 module. Other documents such as L80 software application notes and user guide are also provided for you. These documents ensure you can use L80 module to design and set up applications quickly.

2 Description

2.1. General Description

L80 GPS module with an embedded patch antenna (15mm × 15mm × 4mm) and LNA brings high performance of MTK positioning engine to the industrial applications. It is able to achieve the industry's highest level of sensitivity, accuracy and TTFF with the lowest power consumption in a small-footprint leadless package. With 66 search channels and 22 simultaneous tracking channels, it acquires and tracks satellites in the shortest time even at indoor signal level. The embedded flash memory provides capacity for users to store some useful navigation data and allows for future updates.

L80 module combines many advanced features including EASY, AIC, LOCUS, AlwaysLocate[TM], FLP, Antenna Supervisor and so on. These features are beneficial to accelerate TTFF, improve sensitivity, save consumption and detect antenna status for GPS system. The module supports various positioning, navigation and industrial applications including autonomous GPS, SBAS (including WAAS, EGNOS, MSAS, and GAGAN), QZSS, and AGPS.

L80 simplifies the device's design and cost because of embedded Patch Antenna and LNA. Furthermore, L80 not only supports automatic antenna switching function which can achieve switching between external active antenna and internal patch antenna, but also supports external active antenna detection and short protection. The detection and notification of different external active antenna status will be shown in the NMEA message including external active antenna connection, open circuit for antenna and antenna shortage. So host can query the external active antenna status timely and conveniently.

EASY technology as the key feature of L80 is one kind of AGPS. Capable of collecting and processing all internal aiding information like GPS time, Ephemeris, Last Position, etc., the GPS module delivers a very short TTFF in either Hot or Warm start.

L80 module is a SMD type module with the compact 16mm × 16mm × 6.45mm form factor. It can be embedded in your applications through the 12-pin pads with 2.54mm pitch. It provides necessary hardware interfaces for connection with the main PCB.

The module is fully RoHS compliant to EU regulation.

2.2. Key Features

Table 1: Key Features

Features	Implementation
Power Supply	● Supply voltage: 3.0V~4.3V Typical: 3.3V
Power Consumption	● Acquisition: 25mA @VCC=V_BCKP=3.3V ● Tracking: 20mA @VCC=V_BCKP=3.3V ● Standby: 1.0mA @VCC=V_BCKP=3.3V ● Backup: 7uA @V_BCKP=3.3V
Receiver Type	● GPS L1 1575.42MHz C/A Code ● 66 search channels, 22 simultaneous tracking channels
Sensitivity	● Acquisition: -148dBm ● Re-acquisition: -160dBm ● Tracking: -165dBm
TTFF (EASY enabled)	● Cold start: 15s typ. @-130dBm ● Warm start: 5s typ. @-130dBm ● Hot start: 1s typ. @-130dBm
TTFF (EASY disabled)	● Cold start (Autonomous): 35s typ. @-130dBm ● Warm start (Autonomous): 30s typ. @-130dBm ● Hot start (Autonomous): 1s typ. @-130dBm
Horizontal Position Accuracy (Autonomous)	● <2.5m CEP @-130dBm
Max Update Rate	● Up to 10Hz,1Hz by default
Accuracy of 1PPS Signal	● Typical accuracy: ±10ns ● Time pulse width 100ms
Velocity Accuracy	● Without aid: 0.1m/s
Acceleration Accuracy	● Without aid: 0.1m/s²
Dynamic Performance	● Maximum altitude: 18,000m ● Maximum velocity: 515m/s ● Acceleration: 4G
UART Port	● UART Port: TXD1 and RXD1 ● Supports baud rate from 4800bps to 115200bps, 9600bps by default ● UART port is used for NMEA output, MTK proprietary commands input and firmware upgrade
Temperature Range	● Normal operation: -40°C ~ +85°C ● Storage temperature: -45°C ~ +125°C
Physical Characteristics	● Size: 16±0.15 × 16±0.15 × 6.45±0.1mm ● Weight: Approx. 6.0g

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NOTES

1. The power consumption is measured in the open sky with internal patch antenna. Meanwhile, EASY, AIC and SBAS are enabled.
2. If the external active antenna is used, VCC pin will supply power for external active antenna. The typical additional current consumption is about 11mA @3.3V.
3. The performance of external active antenna is similar to that of internal patch antenna expect for power consumption.

2.3. Block Diagram

The following figure shows a block diagram of L80 module. It consists of a single chip GPS IC which includes the RF part and Baseband part, a SPDT, a patch antenna, a LNA, a SAW filter, a TCXO, a crystal oscillator, short protection and antenna detection circuit for active antenna.
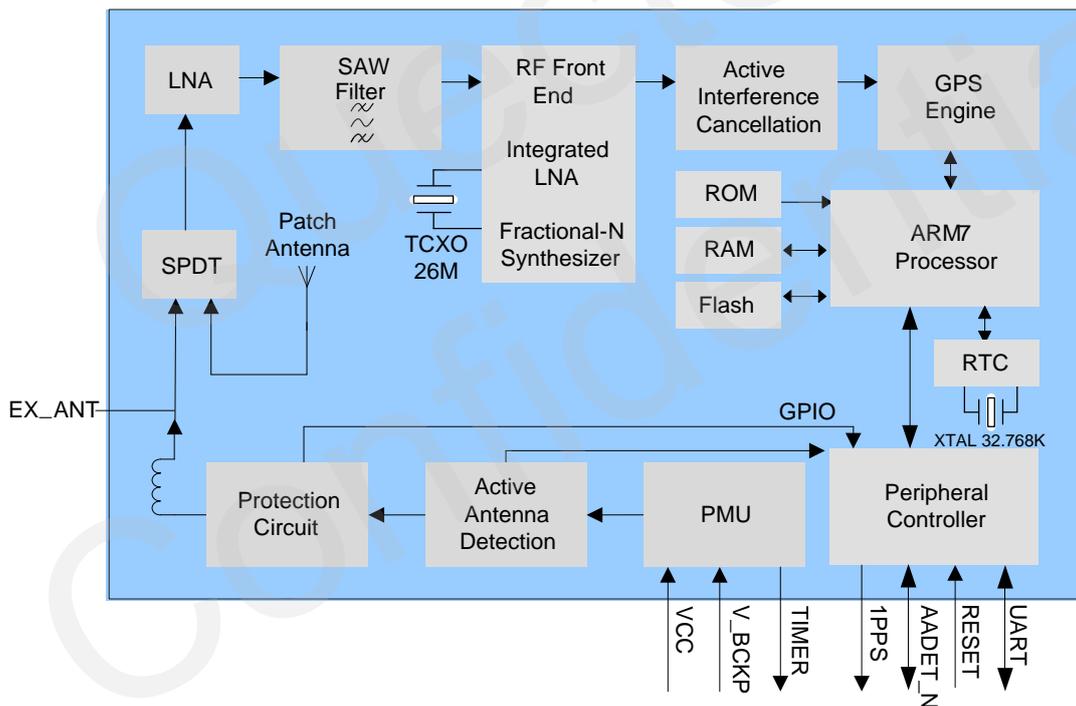
Figure 1: Block Diagram

2.4. Evaluation Board

In order to help you use L80 module on your applications, Quectel supplies an Evaluation Board (EVB) with micro USB serial cable and other peripherals to test the module.

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

2.5. Protocols Supported by the Module

Table 2: Protocols Supported by the Module

Protocol	Type
NMEA	Output, ASCII, 0183, 3.01
PMTK	Input, MTK proprietary protocol

NOTE

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

3 Application

The module is equipped with a 12-pin 2.54mm pitch SMT pad that connects to your application platform. Sub-interfaces included in the pad are described in details in the following chapters.

3.1. Pin Assignment
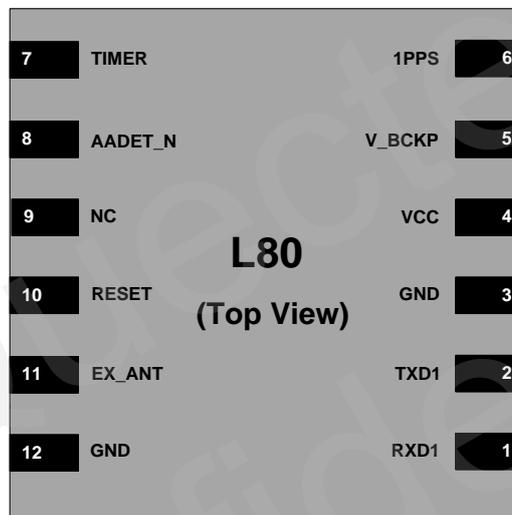
Figure 2: Pin Assignment

3.2. Pin Definition

Table 3: Pin Description

Power Supply					
Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
VCC	4	I	Main power supply	Vmax=4.3V Vmin=3.0V Vnom=3.3V	Supply current not less than 100mA.
V_BCKP	5	I	Backup power	Vmax=4.3V	Supply power for RTC

| | | | supply | Vmin=1.5V
Vnom=3.3V | domain. The V_BCKP pin can be directly supplied power by battery or connect it to VCC. |

Reset

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
RESET	10	I	System reset	VILmin=-0.3V VILmax=0.8V VIHmin=2.0V VIHmax=3.6V	Low level active. If unused, keep this pin open or connect it to VCC.

UART Port

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
RXD1	1	I	Receive data	VILmin=-0.3V VILmax=0.8V VIHmin=2.0V VIHmax=3.6V	
TXD1	2	O	Transmit data	VOLmin=-0.3V VOLmax=0.4V VOHmin=2.4V VOHmax=3.1V	

RF Interface

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

Other Interfaces

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
1PPS	6	O	One pulse per second	VOLmin=-0.3V VOLmax=0.4V VOHmin=2.4V VOHmax=3.1V	Synchronized at rising edge, the pulse width is100ms. If unused, keep this pin open.
TIMER	7	O	An open drain output signal can be used to control GPS module main power on/off	VOLmin=-0.3V VOLmax=0.4V VOHmin=1.1V VOHmax=3.1V	It belongs to RTC domain. If unused, keep this pin open or connect to Ground externally.

AADET_N	8	I/O	Active antenna detection	VOLmax=0.7V VOHmin=1.3V	If unused, keep this pin open. Refer to ***chapter 4.3***.

3.3. Power Supply

VCC pin supplies power for BB, RF, I/O, LNA, short protection and antenna detection circuit. The load current of VCC varies according to the VCC level, processor load, the number of tracked satellites and the rate of satellite re-acquisition. Using external active antenna will consume additional 11mA from our module. So it is important to supply sufficient current and make the power clean and stable. VCC supply ripple voltage should meet the requirement: 54mV (RMS) max @f=0…3MHz and 15mV (RMS) max @f >3MHz. You should choose the LDO without built-in output high-speed discharge function to keep long output voltage drop-down period. The decouple combination of 10uF and 100nF capacitor is recommended nearby VCC pin.

The V_BCKP pin supplies power for RTC domain. It should be valid when power on the module. The voltage of RTC domain ranges from 1.5V to 4.3V. In order to achieve a better TTFF, RTC domain should be valid all the time. It can supply power for SRAM memory in RTC domain which contains all the necessary GPS information for quick start-up and a small amount of user configuration variables.

The module's internal power construction is shown as below.

VCC supplies power for PMU, and V_BCKP supplies power for RTC domain. TIMER signal highlighted in red in the following figure belongs to RTC domain and can be used to control the power switch on/off.
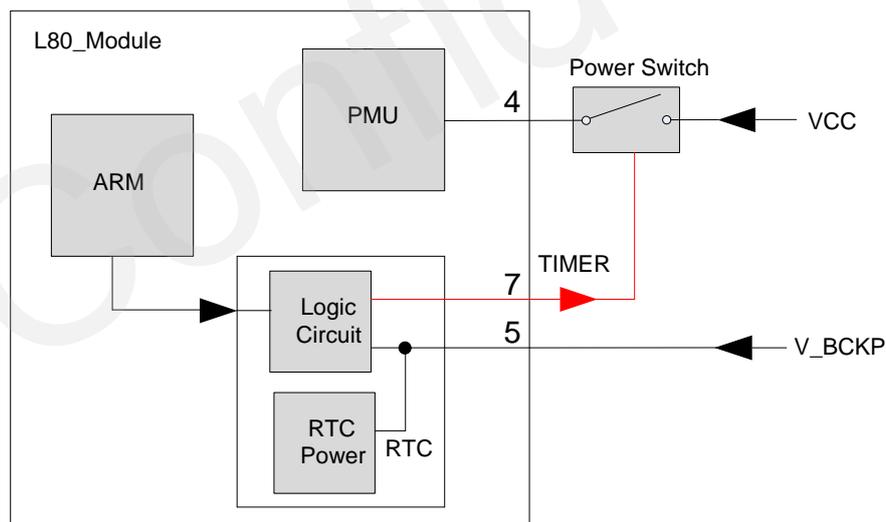
Figure 3: Internal Power Construction

Power supply solutions for L80 module are listed as the following.

The simplest power circuit for L80 module is 3.3V power source connected to VCC pin and V_BCKP pin of the module directly. In this case, once you powered on the module, the full cold start will be implemented.
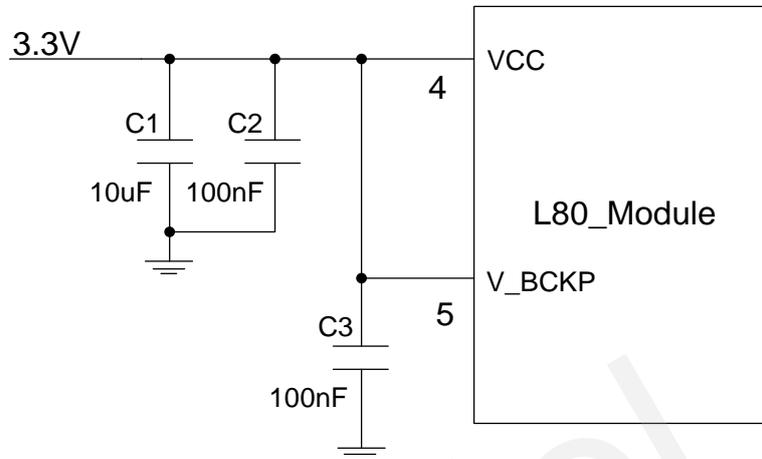
Figure 4: Reference Circuit for Power Supply

NOTE

If your power supply circuit adopts the design mentioned above, L80 module does not support EASY technology and backup mode as well as other modes related to it, e.g. AlwaysLocate[TM] backup mode.

The other way is feeding V_BCKP through a backup battery directly. The module will enter into backup mode when power source (3.3V) is cut off. Furthermore, it is necessary to add an external charging circuit for rechargeable battery. The detailed schematic (mount R2 with 0R to replace Power switch) is shown as below. Note that the capacity of backup battery should be large enough to maintain V_BCKP valid as there is no charge source when power source (3.3V) is cut off. MS621FE FL11E from Seiko is recommended. The consumption of V_BCKP is as low as 7uA in backup mode.

You can also apply a power switch circuit to replace R2 when it matches with TIMER pin. In this way, the module will not only support backup mode but also support periodic backup mode and AlwaysLocate[TM] backup mode. The schematic with power supply circuit is shown as below. As power source (3.3V) is always valid and the battery is charged continuously, the capacity of the battery can be small. The detailed schematic for power switch circuit is shown in Figure 6.

For more details about backup mode, periodic backup mode and AlwaysLocate[TM] backup mode, please refer to the related chapters.
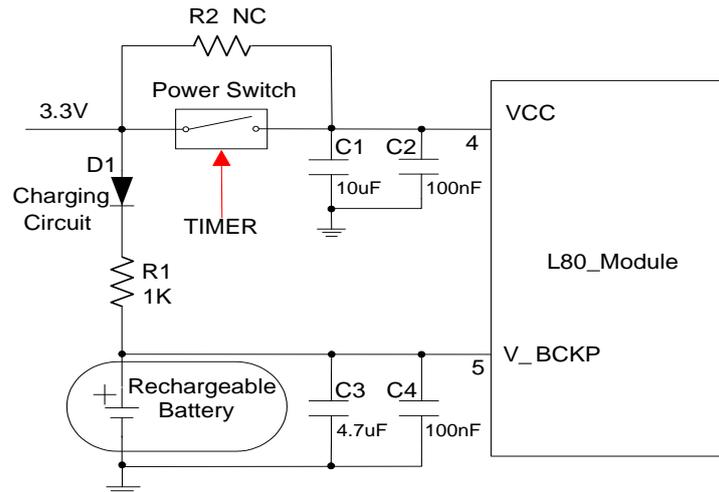
Figure 5: Reference Charging Circuit for Chargeable Battery

NOTE

VCC does not supply power for RTC domain in L80 module, so the V_BCKP pin must be powered externally. Furthermore, it is strongly recommended to supply power to V_BCKP through a backup battery, which can ensure L80 module supports EASY technology and improves TTFF after next restart. For details about TTFF, please refer to *chapter 2.2*.

3.4. Operating Modes

The table below briefly illustrates the relationship among different operating modes of L80 module.

Table 4: Module States Switch

Current Mode	Next Mode					
	Backup	**Standby**	**Full on**	**Periodic**	**AlwaysLocate**	**FLP**
Backup	N/A	N/A	Refer to *chapter 3.4.3*	N/A	N/A	N/A
Standby	N/A	N/A	Send any data via UART	N/A	N/A	N/A
Full on	Refer to *chapter 3.4.3*	PMTK161	N/A	PMTK225	PMTK225	PMTK262
Periodic	N/A	N/A	Refer to *chapter 3.4.4*	N/A	N/A	N/A

Always Locate	N/A	N/A	Refer to *chapter 3.4.5*	N/A	N/A	N/A
FLP	N/A	N/A	Refer to *chapter 3.4.6*	N/A	N/A	N/A

NOTE

Please refer to the *document [2]* for more details of MTK proprietary protocol.

3.4.1. Full on Mode

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

When the combination of VCC and V_BCKP is valid, the module will enter into full on mode automatically and follow the default configurations as below. You can refer to *chapter 3.3* about internal power construction to have a good comprehension. You can also use PMTK commands to change the configurations to satisfy your requirements.

Table 5: Default Configurations

Item	Configuration	Comment
Baud Rate	9600bps	
Protocol	NMEA	RMC, VTG, GGA, GSA, GSV, GLL and GPTXT（MTK proprietary protocol）
Update Rate	1Hz	
SBAS	Enable	
AIC	Enable	
LOCUS	Disable	
EASY	Enable	EASY will be disabled automatically when update rate exceeds 1Hz.

3.4.2. Standby Mode

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

Sending PMTK command "$PMTK161,0*28" will make L80 module enter into standby mode. Sending any data via UART can wake the module up. When the module exits from standby mode, it will use all internal aiding information like GPS time, Ephemeris, Last Position, etc., resulting to the fastest possible TTFF in either Hot or Warm start. The typical standby current consumption in this way is about 1mA @VCC=3.3V.

NOTE

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

3.4.3. Backup Mode

Backup mode consumes lower power than standby mode. In this mode, only the backup supply V_BCKP is powered on while the main supply VCC is switched off by host or the TIMER signal of L80. In order to enter into backup mode autonomously via the TIMER pin, an external switch circuit is necessary. The following figure has shown a typical reference design about the switch circuit for TIMER.
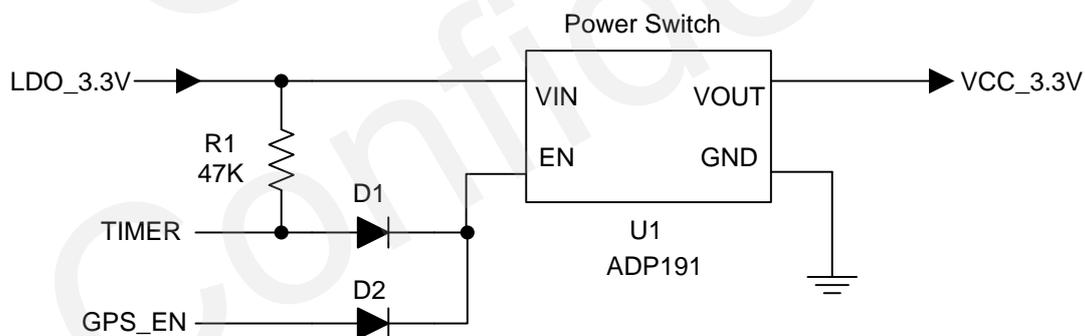
Figure 6: The External Switch Circuit for TIMER

NOTES

1. U1 is an integrated power switch component. The part number ADP191 is recommended. U1 also can be replaced by discrete components. Please refer to the **document [3]** for more details.
2. TIMER pin also can be used to control the EN pin of a LDO.

3. TIMER and GPS_EN signals form an "OR" logic via the Schottky diodes D1 and D2. GPS_EN is a GPIO signal coming from the host.

4. TIMER is an open drain output signal. When TIMER pin is used, please pull it high by using an external resistor. R1 is the pull-up resistor for TIMER signal.

Keeping GPS_EN signal low and sending PMTK command"$PMTK225,4*2F" will make L80 module enter into backup mode forever. When this command is executed successfully, TIMER signal will be pulled down to close the power switch, so L80 module can go into backup mode as the main power VCC is cut off. For this case, pulling the GPS_EN signal high by host is the only way to wake the module up.

In backup mode, L80 module stops to acquire and track satellites. UART is not accessible. But the backed-up memory in RTC domain which contains all the necessary GPS information for quick start-up and a small amount of user configuration variables is alive. Due to the backed-up memory, EASY technology is available. The typical consumption in backup mode can be as low as 7uA.

As the main power supply for V_BCKP pin is battery. Coin-type rechargeable capacitor such as MS920SE from Seiko can be used and Schottky diode such as RB520S30T1G from ON Semiconductor is recommended to be used here for its low voltage drop.
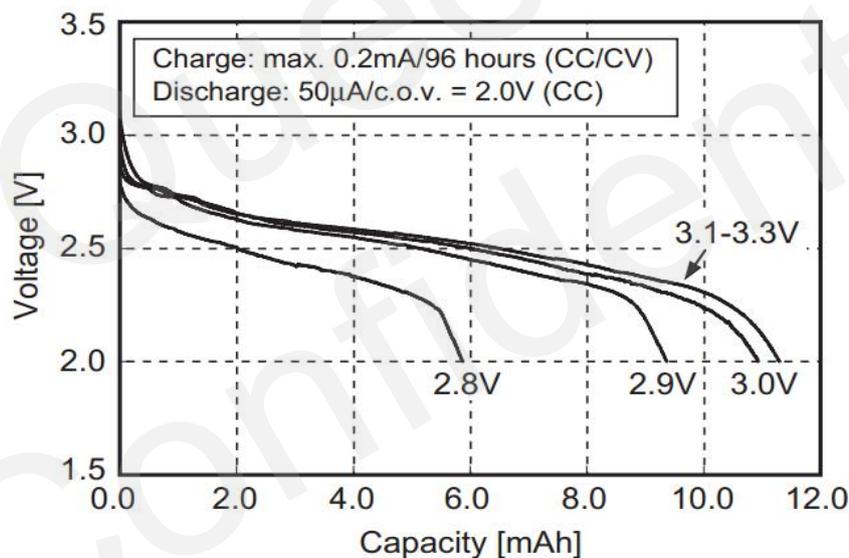
Figure 7: Seiko MS920SE Charge and Discharge Characteristics

3.4.4. Periodic Mode

Periodic mode is a power saving mode of L80 that can control the full on mode and standby/backup mode periodically to reduce power consumption. It contains periodic standby mode and periodic backup mode.

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

Table 6: PMTK Command Format

Format: $PMTK225,<Type>,<Run_time>,<Sleep_time>,<2nd_run_time>,<2nd_sleep_time>*<checksum><CR><LF>		
Parameter	**Format**	**Description**
Type	Decimal	**Type=1** for Periodic Backup Mode **Type=2** for Periodic Standby Mode
Run_time	Decimal	Full on mode period (ms)
Sleep_time	Decimal	Standby/Backup mode period (ms)
2nd_run_time	Decimal	Full on mode period (ms) for extended acquisition in case GPS module's acquisition fails during the **Run_time**
2nd_sleep_time	Decimal	Standby/Backup mode period (ms) for extended sleep in case GPS module's acquisition fails during the **Run_time**
Checksum	Hexadecimal	Hexadecimal checksum

Example

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

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

Sending "$PMTK225,0*2B" just in **Run_time** or **2nd_run_time** can make the module enter into full on mode from periodic backup mode.

NOTES

1. The precondition is that the external switch circuit supports periodic backup mode. For details, please refer to *chapter 3.4.3.*
2. Before entering into periodic backup mode, please ensure the GPS_EN signal is low and power supply for V_BCKP is alive.

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

Please ensure the module is in the tracking state before entering into periodic mode. Otherwise, the

module will have a risk of failure to track the satellites. If GPS module is located in weak signal environment, it is better to set a longer **2nd_run_time** to ensure the success of re-acquisition.

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

$I_{periodic}= (I_{tracking}\times T1 + I_{standby/backup}\times T2)/(T1+T2)$ T1: **Run_time**, T2: **Sleep_time**

Example

PMTK225,2,3000,12000,18000,72000*15 for periodic mode with 3s in tracking mode and 12s in standby mode. The average current consumption is calculated below:
$I_{periodic}= (I_{tracking}\times T1 + I_{standby}\times T2)/(T1+T2) = (20mA\times 3s + 1mA\times 12s)/(3s+12s) \approx 4.8 (mA)$

PMTK225,1,3000,12000,18000,72000*16 for periodic mode with 3s in tracking mode and 12s in backup mode. The average current consumption is calculated below:
$I_{periodic}= (I_{tracking}\times T1 + I_{backup}\times T2)/(T1+T2) = (20mA\times 3s + 0.007mA\times 12s)/(3s+12s) \approx 4.0 (mA)$
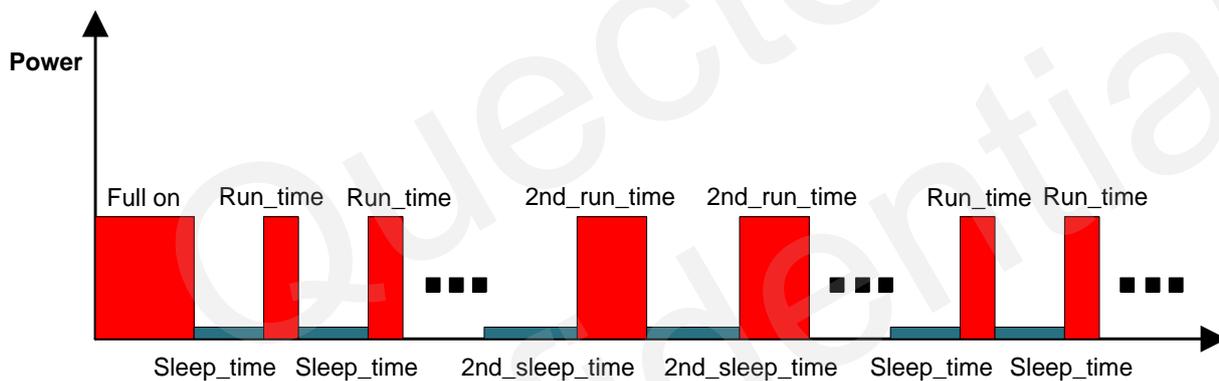
Figure 8: Periodic Mode

3.4.5. AlwaysLocate^{TM} Mode

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

AlwaysLocate^{TM} standby mode allows the module to switch automatically between full on mode and standby mode. According to the environmental and motion conditions, the module can adaptively adjust the full on time and standby time to achieve a balance between positioning accuracy and power consumption. Sending "$PMTK225,8*23" and the module returning: "$PMTK001,225,3*35" means the module accesses AlwaysLocate^{TM} standby mode successfully. It will benefit power saving in this mode. Sending "$PMTK225,0*2B" in any time will make the module back to full on mode.

AlwaysLocate^{TM} backup mode is similar to AlwaysLocate^{TM} standby mode. The difference is that

AlwaysLocate^{TM} backup mode can switch between full on mode and backup mode automatically. The PMTK command to enter into AlwaysLocate^{TM} backup mode is "$PMTK225,9*22".The module can exit from AlwaysLocate^{TM} backup mode by command "$PMTK225,0*2B" sent just after the module has been waked up from previous backup cycle.

The positioning accuracy in AlwaysLocate^{TM} mode will be somewhat degraded, especially in high speed. The following picture shows the rough power consumption of L80 module in different daily scenes when AlwaysLocate^{TM} mode is enabled.
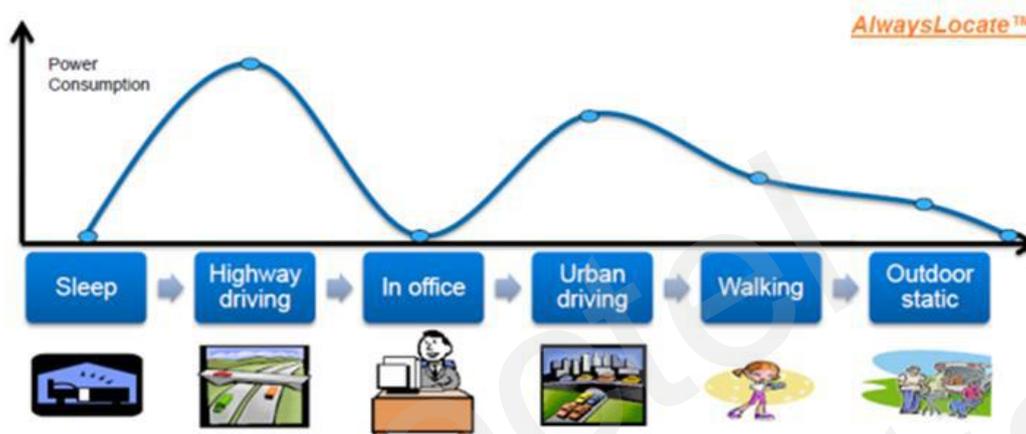
Figure 9: AlwaysLocate^{TM} Mode

Example

The typical average consumption is about 3.5mA in AlwaysLocate^{TM} standby mode and 3.0mA in AlwaysLocate^{TM} backup mode.

NOTES

1. Power consumption is measured under outdoor static mode with patch antenna. Using external active antenna will increase the power consumption.
2. Before entering into periodic backup mode, please ensure the GPS_EN signal is low and power supply for V_BCKP is alive.

3.4.6. FLP Mode

The Fitness Low Power (FLP) feature provides low power GPS solution for fitness application. FLP is a duty cycle concept to achieve low power target. It is specifically designed for walking/running/cycling applications.

FLP function is disabled by default. You can enable FLP by SDK or PMTK command. Sending "$PMTK262,1*29" will enable FLP function, and wait until L80 module gets a valid fix. Then wait at least 60s for L80 to enter FLP mode. FLP function will be disabled after sending "$PMTK262,0*28". For more

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details, please refer to the *document [4]*.

Table 7: Average Current for FLP Mode and Tracking Mode of L80

Scenario	In FLP Mode (mA)	In Tracking Mode (mA)
Static	11.3	20
Walking	10.9	20
Running	10.7	20
Driving	11.4	20

NOTES

1. The EASY and FLP function cannot work at the same time. When you enable FLP by SDK or PMTK command, the EASY function will be disabled automatically.
2. SBAS data downloading will be influenced by FLP function. It is suggested that you should disable the SBAS while enabling FLP mode.
3. The power consumption is measured in the open sky under different states of motion.
4. The current is the average of multiple measurements.

3.5. Reset

L80 module can be restarted by driving the RESET to a low level voltage for a certain time and then releasing it. This operation will reset the digital part of the GPS receiver. Note that Non-Volatile Backup RAM content is not cleared and thus fast TTFF is possible. An OC driver circuit shown as below is recommended to control the RESET.
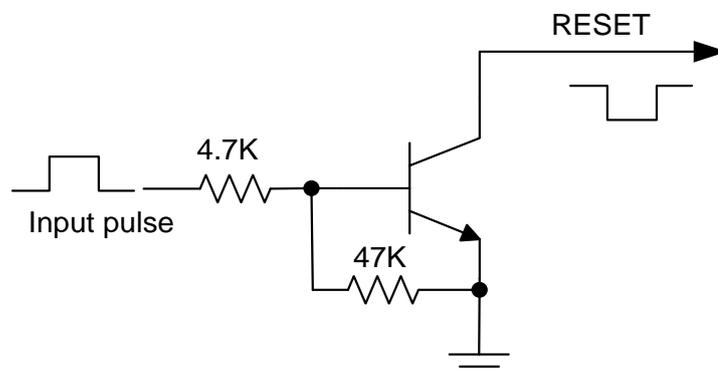
Figure 10: Reference Reset Circuit Using OC Circuit

The restart timing of L80 has been illustrated bellow.
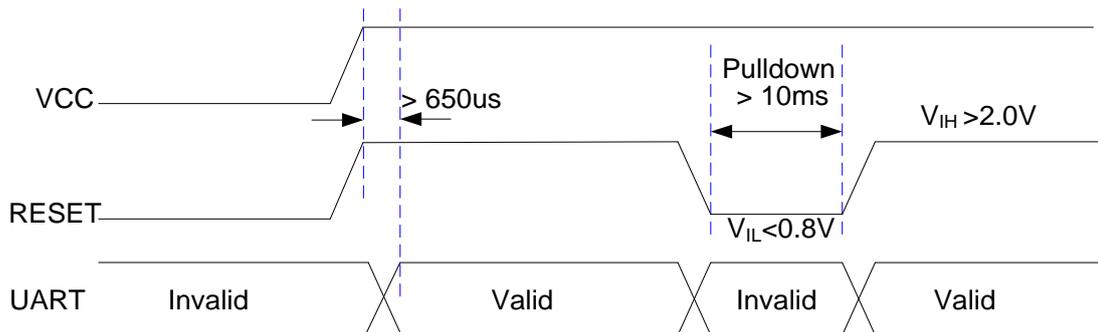
Figure 11: Restart Timing

3.6. UART Interface

The module provides one universal asynchronous receiver& transmitter serial port. The module is designed as DCE (Data Communication Equipment), following the traditional DCE-DTE (Data Terminal Equipment) connection. The module and the client (DTE) are connected through the signals shown in the following figure. It supports data baud-rate from 4800bps to 115200bps.

UART port:

● TXD1: Send data to the RXD signal line of DTE.
● RXD1: Receive data from the TXD signal line of DTE.
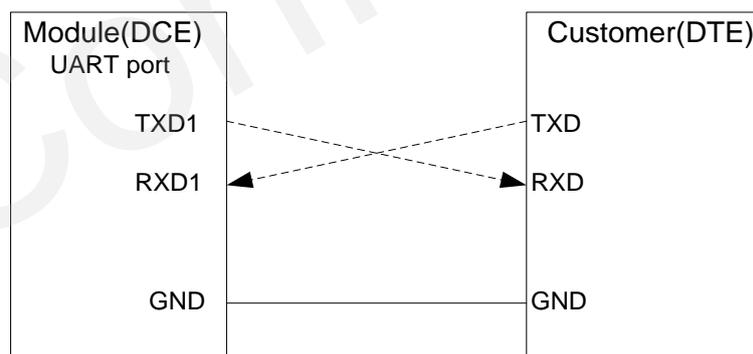
Figure 12: Connection of Serial Interfaces

This UART port has the following features:

● UART port can be used for firmware upgrade, NMEA output and PMTK proprietary commands input.

- The default output NMEA type setting is RMC, VTG, GGA, GSA, GSV, GLL and GPTXT (MTK proprietary protocol).
- UART port supports the following data rates:
  4800, 9600, 14400, 19200, 38400, 57600, 115200bps.
  The default setting is 9600bps, 8 bits, no parity bit, 1 stop bit.
- Hardware flow control and synchronous operation are not supported.

The UART port does not support the RS-232 level but only CMOS level. If the module's UART port is connected to the UART port of a computer, it is necessary to add a level shift circuit between the module and the computer. Please refer to the following figure.
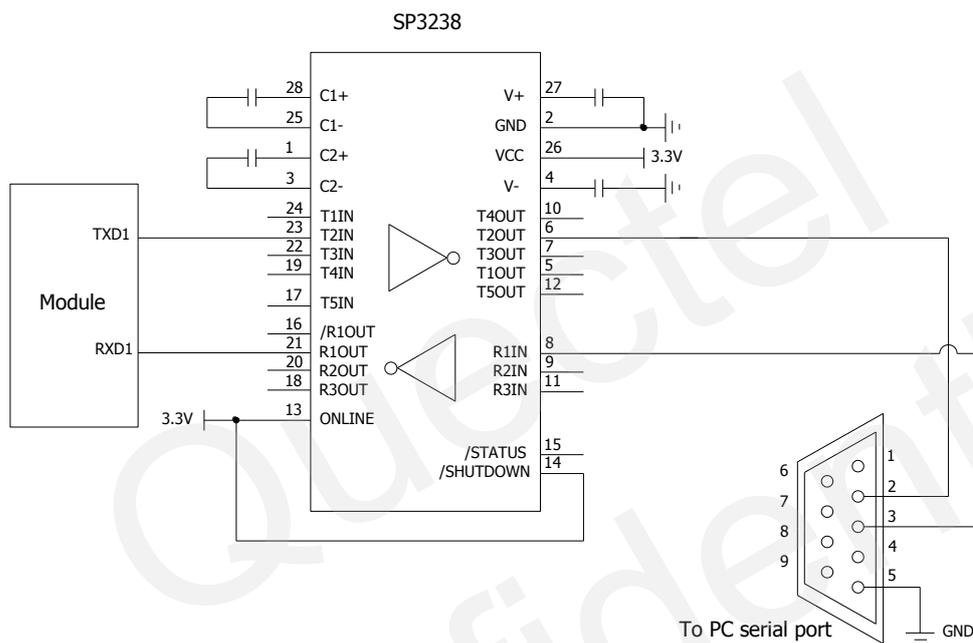
Figure 13: RS-232 Level Shift Circuit

3.7. EASY Technology

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

The EASY function can reduce TTFF to 5s in warm start. In this case, RTC domain should be valid. In order to get enough broadcast ephemeris information from GPS satellites, the GPS module should receive the information for at least 5 minutes in good signal conditions after fixing the position.

EASY function is enabled by default. Command "$PMTK869,1,0*34" can be used to disable EASY. For more details, please refer to the *document [2].*

3.8. Multi-tone AIC

L80 module provides an advanced technology called multi-tone AIC (Active Interference Cancellation) to reject RF interference which comes from other active components on the main board.

Up to 12 multi-tone AIC embedded in the module can provide effective narrow-band interference and jamming elimination. The GPS signal could be recovered from the jammed signal, which can ensure better navigation quality. AIC is enabled by default, closing it will save about 1mA @VCC=3.3V consumption. The following commands can be used to set AIC.

Enable AIC function: "$PMTK 286,1*23".
Disable AIC function: "$PMTK 286,0*22".

3.9. LOCUS

L80 module supports the embedded logger function called LOCUS. It can log position information to the internal flash memory automatically when this function is enabled by sending PMTK command "$PMTK185, 0*22". Due to this function, the host can go to sleep to save power consumption and does not need to receive the NMEA information all the time. The module can provide a log capacity of more than 16 hours.

The detail procedures of this function are illustrated bellow:

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

The raw data which host gets has to be parsed via LOCUS parser code provided by Quectel. For more details, please contact Quectel technical supports.

3.10. Antenna Supervisor

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

Table 8: Status of the Antenna

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

3.11. PPS VS. NMEA

Pulse per Second (PPS) VS. NMEA can be used in time service. The latency range of the beginning of UART Tx is between 170ms and 180ms, and behind the rising edge of PPS.
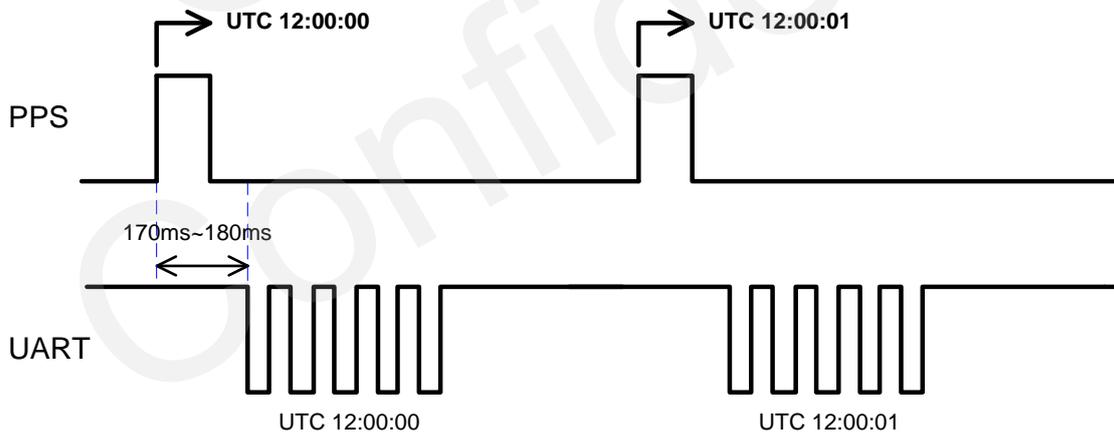
Figure 14: PPS VS. NMEA Timing

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

4 Antenna Interfaces

L80 module receives L1 band signal from GPS satellites at a nominal frequency of 1575.42MHz. The LNA is embedded for better performance. It is an ultra-compact module with embedded 15.0 × 15.0 × 4.0mm patch antenna. In addition, L80 can also support external active antenna, and the RF signal is obtained from the EX_ANT pin. Both internal patch signal and external active antenna signal are intelligently switched through SPDT.

4.1. Internal Patch Antenna

4.1.1. 15×15×4 Patch Antenna

The quality of the embedded GPS antenna is crucial to the overall sensitivity of the GPS system. L80 offers an on-module patch antenna. A 15.0 × 15.0 × 4.0mm high-performance patch antenna is chosen for reducing product size. This antenna is specially designed for satellite reception applications, and it has excellent stability and sensitivity to consistently provide high signal reception efficiency. The specification of the antenna used by L80 is described in following table.

Table 9: Antenna Specification for L80 Module with Ground Plane 100mm × 60mm

Antenna Type	Parameter	Specification	Notes
Patch Antenna	Size	15.0 × 15.0 × 4.0mm	
	Range of receiving Frequency	1575.42MHz±1.023MHz	
	Impendence	50 Ohm	
	Band Width	10MHz minimum	Return Loss ≤ -10dB
	Frequency Temperature Coefficient (TF)	0±20ppm/°C	-40°C~+85°C
	Polarization	RHCP	Right Hand Circular Polarization
	Gain at Zenith	3.4dBi typ.	Centre frequency
	VSWR	1.5 max	
	Axial ratio	3 dB max	

The test result of the antenna is shown as the following figure. This embedded GPS antenna provides good radiation efficiency, right hand circular polarization and optimized radiation pattern. The antenna is insensitive to surroundings and has high tolerance against frequency shifts.
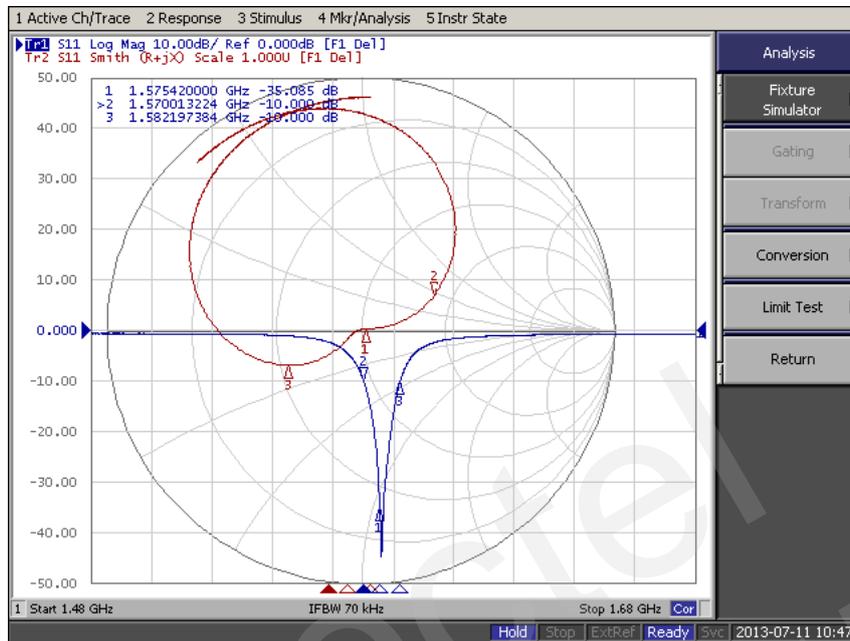
Figure 15: Patch Antenna Test Result with Ground Plane 100mm × 60mm

4.1.2. PCB Design Guide

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

- Keep the module at least 5mm away from the nearest edge of the mother board, that is, it is better to be placed in the center of the mother board.
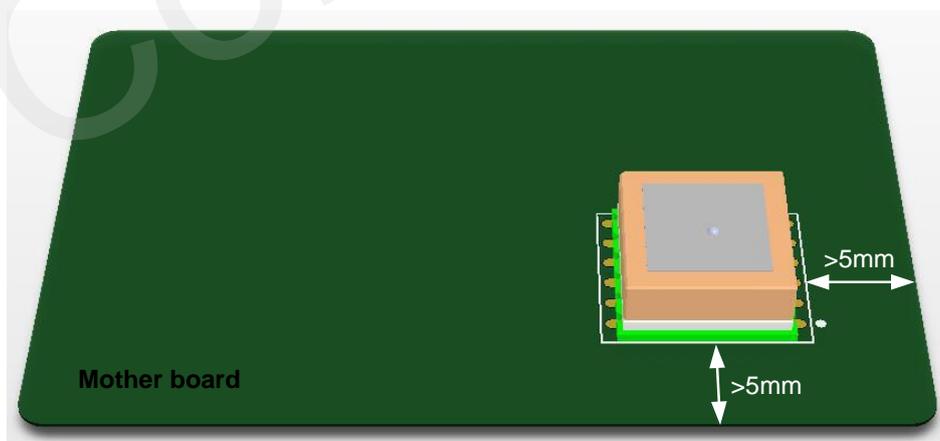
Figure 16: Recommended Distance between Module and Mother Board Edges

- The position on the mother board corresponding to the feed point of the patch antenna should be kept out on each layer, and the diameter of the keepout area should be not less than 2.5mm.
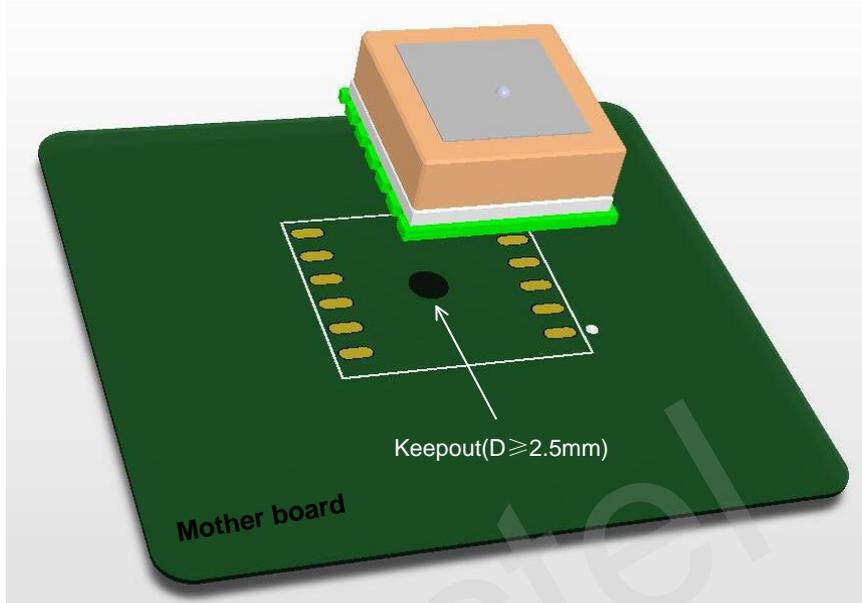
Figure 17: Recommended Treatment for the Feed Point of the Patch Antenna

- Make sure the antenna points to the sky.
- The performance of embedded patch antenna depends on the actual size of the ground plane around the module. It is recommended to design a 30mm×30mm ground plane as shown below. Meanwhile, do not put any components especially tall components in the areas whenever possible. (Interfering vias is not allowed either).
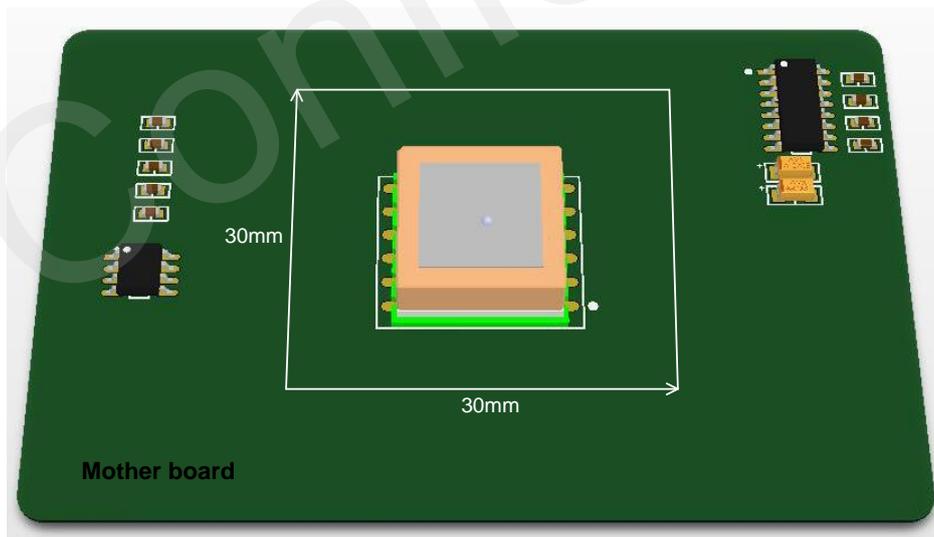
Figure 18: Recommended Ground Plane

- Keep the patch antenna at least 10mm away from other tall metal components. Otherwise, the antenna performance will be affected.
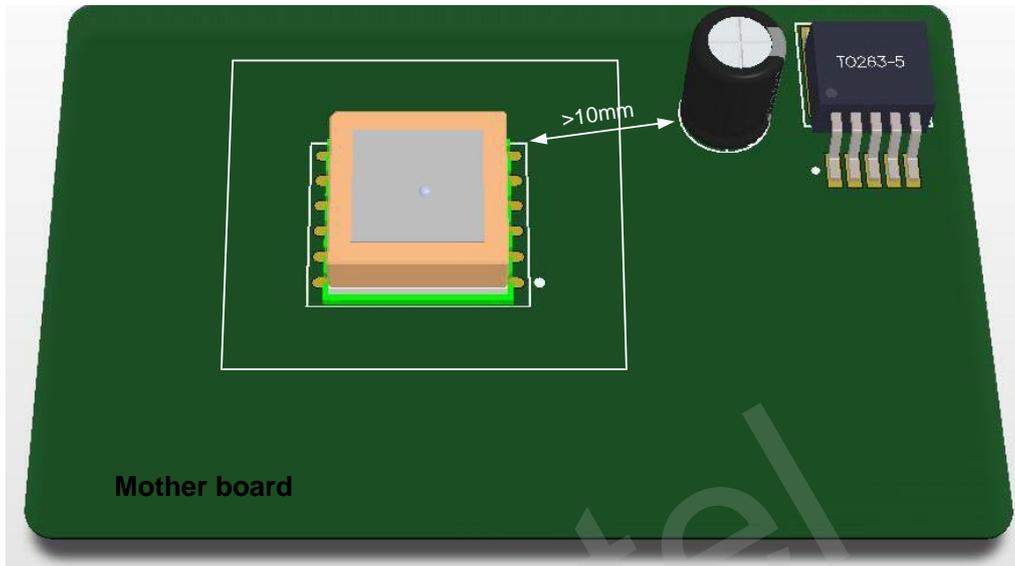
Figure 19: Recommended Distance between Module and Tall Metal Components

- Make sure the microcontroller, crystal, LCD, camera and other high speed components and interfaces are placed on the opposite side of the module, and keep them away from the module as far as possible, such as in diagonal position of the mother board.
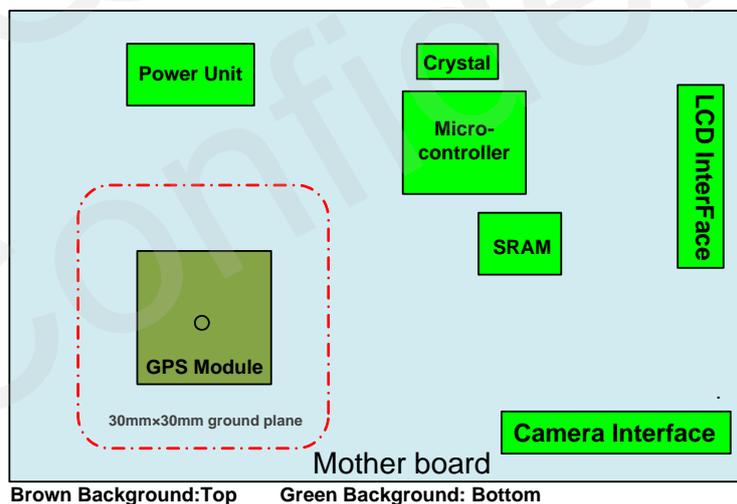
Figure 20: Recommended Placement of GNSS Module

- Make sure interfering signals (USB, LCD, Camera, Crystal, etc.) are in inner layer and shielded by ground plane, and keep them and their vias far away from the module.
- Make sure RF system such as BT/WIFI/GSM is on the opposite side of the module, and keep them away from the module as far as possible, such as in diagonal position of the board.
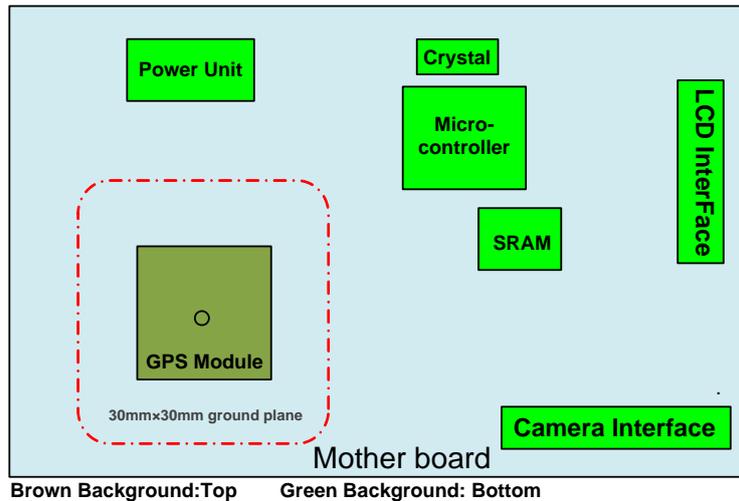
Figure 21: Recommended Placement of GNSS Module with the RF System

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

4.2. External Active Antenna

The following figure is a typical reference design with active antenna. In this mode, DC on the EX_ANT pin is powered by VCC and supplies power to the external active antenna.
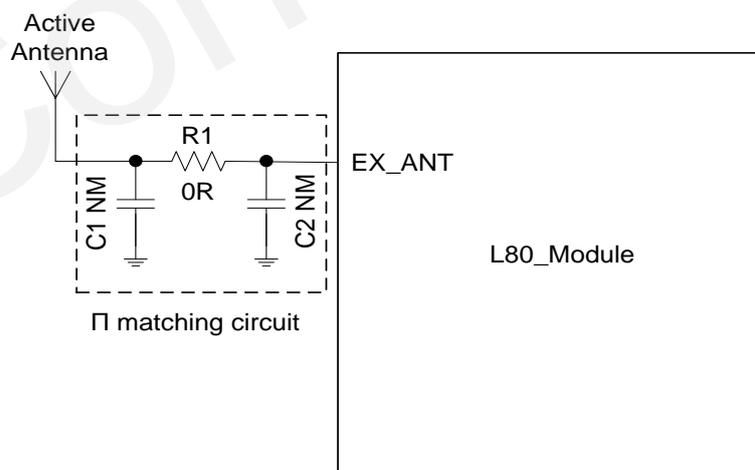
Figure 22: Reference Design for Active Antenna

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

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

Table 10: Recommended Active Antenna Specification

| Antenna Type	Specification
Active Antenna	Center frequency: 1575.42MHz Band width: >5MHZ VSWR: <2 (Typ.) Polarization: RHCP or Linear Noise figure: <1.5dB Gain (antenna): >-2dBi Gain (embedded LNA): 20dB (Typ.) Total gain: >18dBi(Typ.)

NOTE

In order to ensure the short protection function can work effectively, please select a DC-open (DC-impedance between the SMA's inner signal needle and outside ground) GPS active antenna. You can measure the DC-impedance with a common and simple multimeter on few samples, and the value is generally in M ohm level.

4.3. Antenna Status Indicator

L80 module supports automatic antenna switching function. The GPTXT sentence can be used to identify the status of external active antenna.

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

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

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

> **NOTES**
>
> 1. When you use external active antenna and the "OPEN" is displayed in the GPTXT of NMEA sentence, you have to check the connection status of external active antenna.
> 2. If the external active antenna is short-circuited, the "SHORT" will be displayed in the GPTXT of NMEA sentence.
> 3. Because antenna short protection is enabled by default, L80 will switch to embedded patch antenna automatically in case that external active antenna is short-circuited, which will avoid L80 from damage. Meanwhile, you need to check the external active antenna.

Example

"OPEN" is displayed in the GPTXT sentence as below
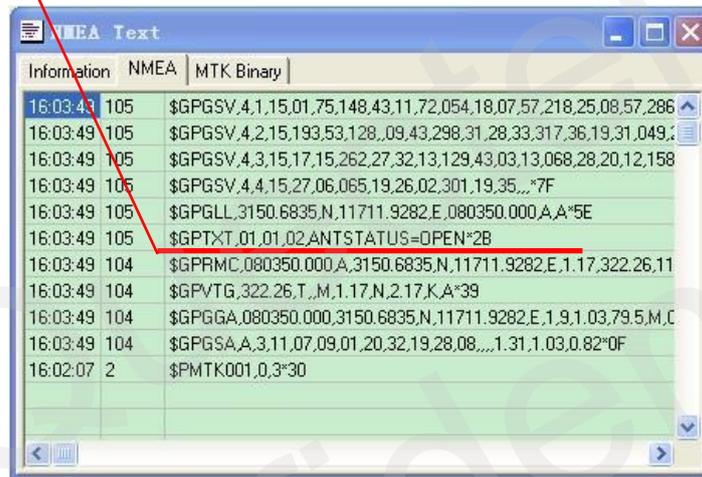
Figure 23: Patch Antenna Status Description in GPSTXT

Table 11: GPTXT - Status of Antenna

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

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

NOTE

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

---

5 Electrical, Reliability and Radio Characteristics

5.1. Absolute Maximum Ratings

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

Table 12: Absolute Maximum Ratings

Parameter	Min.	Max.	Unit
Power Supply Voltage (VCC)	-0.3	5.0	V
Backup Battery Voltage (V_BCKP)	-0.3	5.0	V
Input Voltage at Digital Pins	-0.3	3.6	V
Input Power at EX_ANT		15	dBm
Storage Temperature	-45	125	°C

NOTE

Stressing the device beyond the "Absolute Maximum Ratings" may cause permanent damage. These are stress ratings only. The product is not protected against over voltage or reversed voltage. If necessary, voltage spikes exceeding the power supply voltage specification, given in table above, must be limited to values within the specified boundaries by using appropriate protection diodes.

5.2. Operating Conditions

Table 13: Power Supply Ratings

Parameter	Description	Conditions	Min.	Typ.	Max.	Unit
VCC	Supply voltage	Voltage must stay within the min/max values, including voltage drop, ripple, and spikes.	3.0	3.3	4.3	V
I_{VCCP}	Peak supply current	VCC=3.3V			100	mA
V_BCKP	Backup voltage supply		1.5	3.3	4.3	V
TOPR	Normal operating temperature		-40	25	85	°C

NOTE

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

5.3. Current Consumption

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

Table 14: Current Consumption

Parameter	Conditions	Min.	Typ.	Max.	Unit
I_{VCC} @Acquisition	VCC=V_BCKP=3.3V		25		mA
I_{VCC} @Tracking	VCC=V_BCKP=3.3V		20		mA
I_{VCC} @Standby	VCC=V_BCKP=3.3V		1.0		mA
I_{BCKP} @Backup	V_BCKP=3.3V		7		uA

> **NOTE**
>
> The tracking current is tested in the following conditions:
> ● In Cold Start, 10 minutes after First Fix.
> ● In Hot Start, 15 seconds after First Fix.

5.4. Electrostatic Discharge

L80 module is an ESD sensitive device. ESD protection precautions should still be emphasized. Proper ESD handling and packaging procedures must be applied throughout the processing, handling and operation of any application.

The ESD bearing capability of the module is listed in the following table. Note that you should add ESD components to module pins in particular applications.

Table 15: ESD Endurance Table (Temperature: 25°C, Humidity: 45%)

Pin	Contact Discharge	Air Discharge
EX_ANT	±5KV	±10KV
Patch Antenna	±5KV	±10KV
VCC	±5KV	±10KV
UART	±3KV	±6KV
Others	±2KV	±4KV

5.5. Reliability Test

Table 16: Reliability Test

Test Item	Conditions	Standard
Thermal Shock	-30°C...+80°C, 144 cycles	GB/T 2423.22-2002 Test Na IEC 68-2-14 Na
Damp Heat, Cyclic	+55°C; >90% Rh 6 cycles for 144 hours	IEC 68-2-30 Db Test
Vibration Shock	5~20Hz, 0.96m2/s3; 20~500Hz, 0.96m2/s3-3dB/oct, 1hour/axis; no function	2423.13-1997 Test Fdb IEC 68-2-36 Fdb Test

Heat Test	85°C, 2 hours, operational	GB/T 2423.1-2001 Ab
		IEC 68-2-1 Test
Cold Test	-40°C, 2 hours, operational	GB/T 2423.1-2001 Ab
		IEC 68-2-1 Test
Heat Soak	90°C, 72 hours, non-operational	GB/T 2423.2-2001 Bb
		IEC 68-2-2 Test B
Cold Soak	-45°C, 72 hours, non-operational	GB/T 2423.1-2001 A
		IEC 68-2-1 Test

6 Mechanical Dimensions

This chapter describes the mechanical dimensions of the module.

6.1. Mechanical Dimensions of the Module
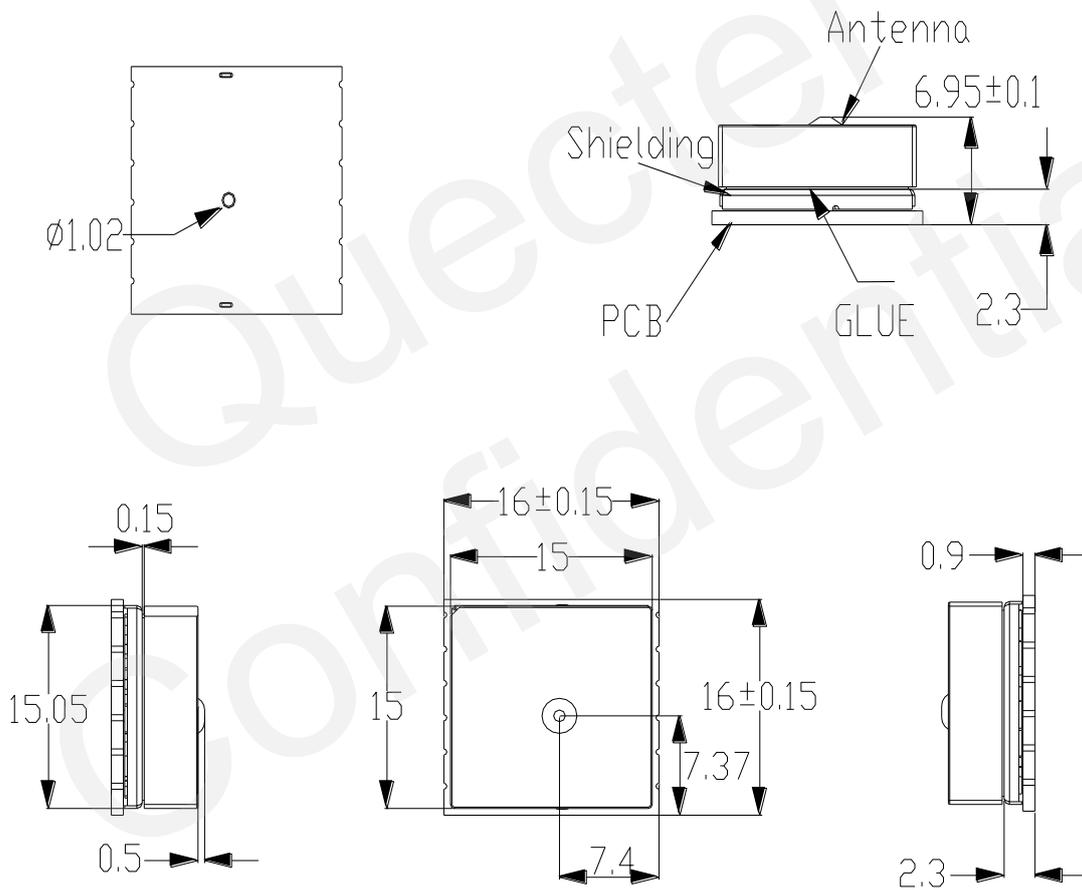
Figure 24: Mechanical Dimensions (Unit: mm)

6.2. Bottom View Dimensions and Recommended Footprint
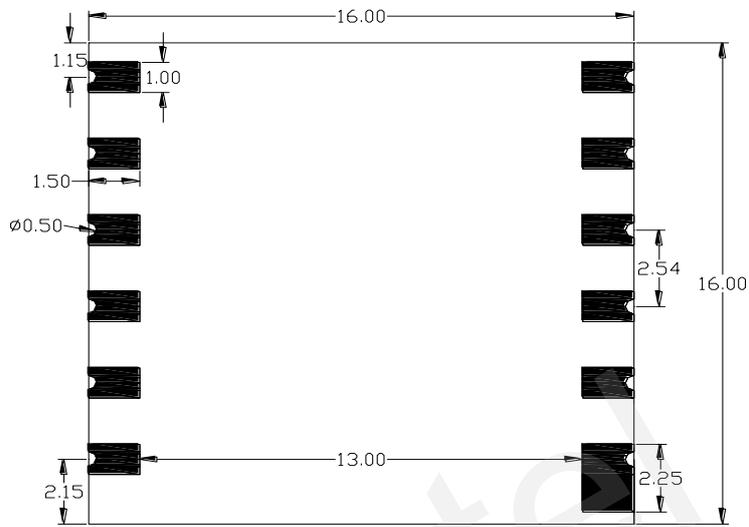

Figure 25: Bottom View Dimensions (Unit: mm)
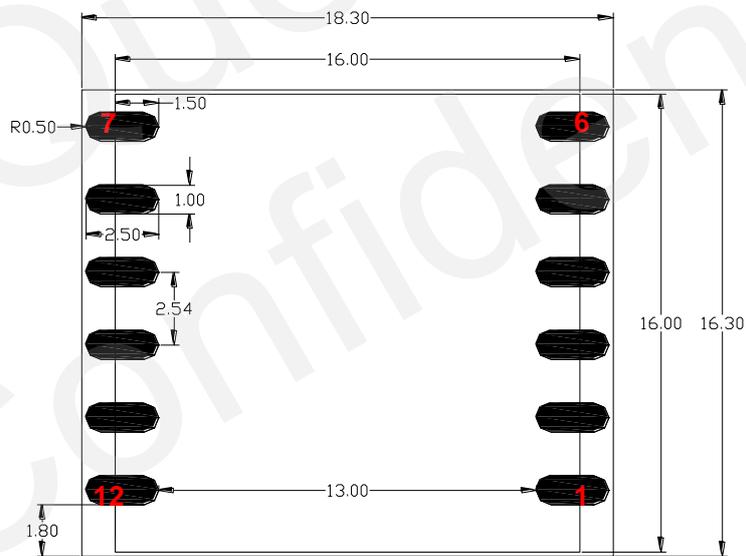
Figure 26: Recommended Footprint (Unit: mm)

> **NOTE**
>
> For easy maintenance, please keep a distance of no less than 3mm between the module and other components on host board.

## 6.3. Top and Bottom View of the Module
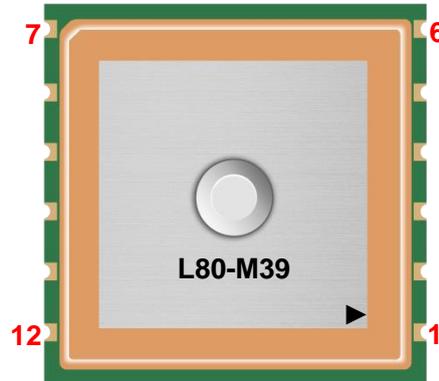

Figure 27: Top View of the Module
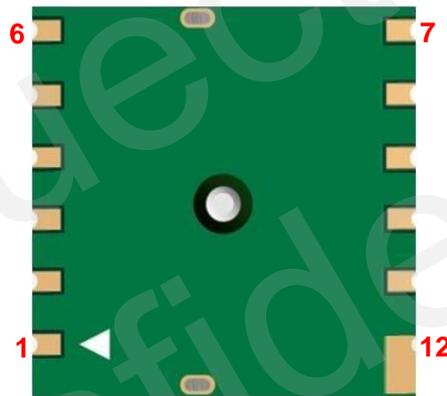
Figure 28: Bottom View of the Module

NOTES

1. The incision of the patch antenna does not indicate the position of pin 1.
2. These are design effect drawings of L80 module. For more accurate pictures, please refer to the module that you get from Quectel.

7 Manufacturing, Packaging and Ordering Information

7.1. Assembly and Soldering

L80 module is intended for SMT assembly and soldering in a Pb-free reflow process on the top side of the PCB. It is suggested that the minimum height of solder paste stencil is 100um to ensure sufficient solder volume. Pad openings of paste mask can be increased to ensure proper soldering and solder wetting over pads. It is suggested that the peak reflow temperature is 235~245ºC (for SnAg3.0Cu0.5 alloy). The absolute maximum reflow temperature is 260ºC. To avoid damage to the module when it is repeatedly heated, it is suggested that the module should be mounted after reflow soldering for the other side of PCB has been completed. Recommended reflow soldering thermal profile is shown below:
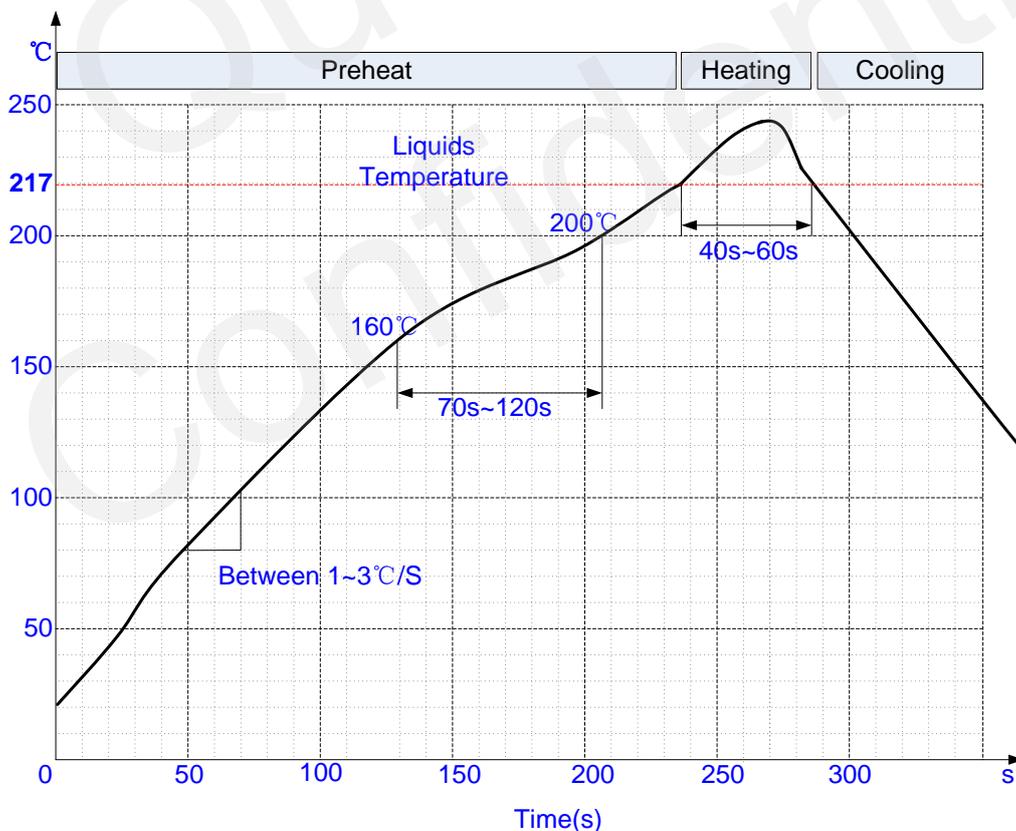

Figure 29: Recommended Reflow Soldering Thermal Profile

7.2. Moisture Sensitivity

L80 module is sensitive to moisture. To prevent L80 from permanent damage during reflow soldering, baking before reflow soldering is required in following cases:

- Humidity indicator card: One or more indicating spots are no longer blue.
- The seal is opened and the module is exposed to excessive humidity.

L80 should be baked for 192 hours at temperature 40°C+5°C/-0°C and <5% RH in low-temperature containers, or 24 hours at temperature 125°C±5°C in high-temperature containers. Care should be taken that the plastic tape is not heat resistant. L80 should be taken out from the tape before preheating; otherwise, the tape maybe damaged by high-temperature heating.

7.3. ESD Protection

L80 module is sensitive to ESD and requires special precautions when handling. Particular care must be exercised when handling patch antenna, duo to the risk of electrostatic charges.

7.4. Tape and Reel Packaging
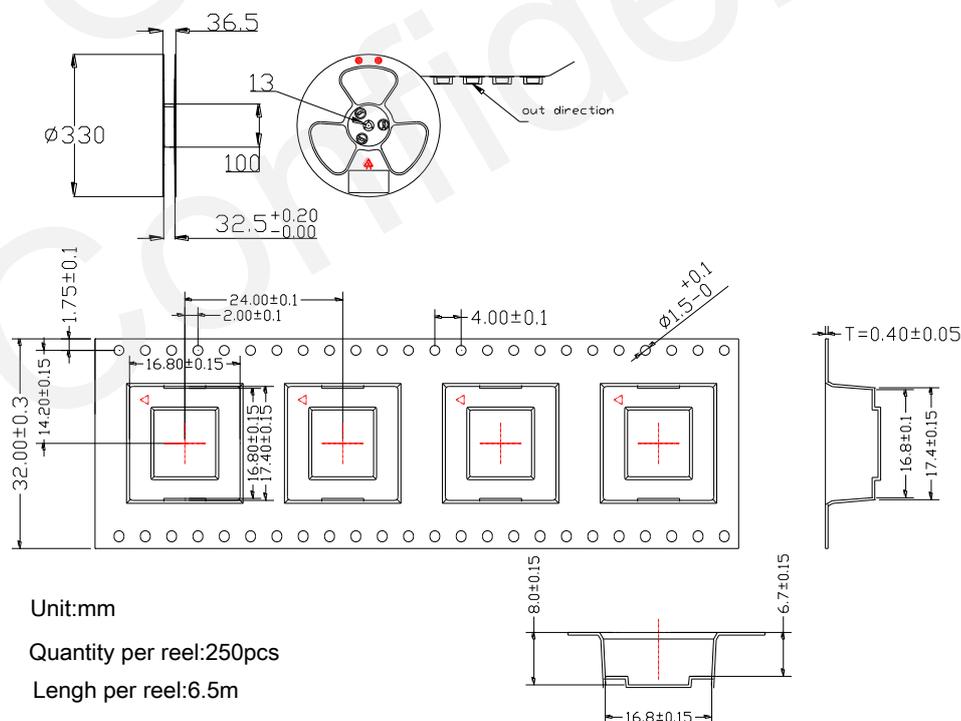
Figure 30: Tape and Reel Specifications

Table 17: Reel Packaging

Model Name	MOQ for MP	Minimum Package: 250pcs	Minimum Package x4=1000pcs
L80	250pcs	Size: 370mm × 350mm × 56mm N.W: 1.5kg G.W: 2.25kg	Size: 380mm × 250mm × 365mm N.W: 6.1kg G.W: 9.4kg

7.5. Ordering Information

Table 18: Ordering Information

Model Name	Ordering Code
L80	L80-M39

8 Appendix References

Table 19: Related Documents

SN	Document Name	Remark
[1]	Quectel_L80_EVB_User Guide	L80 EVB User Guide
[2]	Quectel_L80_GPS_Protocol_Specification	L80 GPS Protocol Specification
[3]	Quectel_L80_Reference_Design	L80 Reference Design
[4]	Quectel_GNSS_SDK_Commands_Manual	GNSS SDK Commands Manual

Table 20: Terms and Abbreviations

Abbreviation	Description
AGPS	Assisted GPS
AIC	Active Interference Cancellation
CEP	Circular Error Probable
DGPS	Differential GPS
EASY	Embedded Assist System
EGNOS	European Geostationary Navigation Overlay Service
EPO	Extended Prediction Orbit
ESD	Electrostatic Discharge
GPS	Global Positioning System
GNSS	Global Navigation Satellite System
GGA	GPS Fix Data
GLL	Geographic Position – Latitude/Longitude

GPS Module Series
L80 Hardware Design

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

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Imax	Maximum Load Current
Vmax	Maximum Voltage Value
Vnom	Nominal Voltage Value
Vmin	Minimum Voltage Value
VIHmax	Maximum Input High Level Voltage Value
VIHmin	Minimum Input High Level Voltage Value
VILmax	Maximum Input Low Level Voltage Value
VILmin	Minimum Input Low Level Voltage Value
VImax	Absolute Maximum Input Voltage Value
VImin	Absolute Minimum Input Voltage Value
VOHmax	Maximum Output High Level Voltage Value
VOHmin	Minimum Output High Level Voltage Value
VOLmax	Maximum Output Low Level Voltage Value
VOLmin	Minimum Output Low Level Voltage Value