L80 Hardware Design

GPS Module Series

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About the document

History

Revision	Date	Author	Description
V1.0	2013-07-25	Tony GAO	Initial

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1 Introduction

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

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

2 Description

2.1. General Description

L80 GPS module with an embedded patch antenna (15mmx15mmx4mm) 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 lead-free 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 with many advanced features including EASY, AIC, LOCUS, AlwaysLocate^{TM} and Antenna Advisor. These features are beneficial to accelerate TTFF, improve sensitivity, save consumption and detect antenna status for GPS system. The module supports various location, 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.

L80 module is a SMD type module with the compact 16mm x 16mm x 6.45mm form factor, which can be embedded in your applications through the 12-pin pads with 2.54mm pitch. It provides necessary hardware interfaces between the module and main board.

The module is fully ROHS compliant to EU regulation.

2.2. Key Features

Table 1: Module Key Features

Feature	Implementation
Power Supply	• Supply Voltage: 2.8V ~ 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 <15ns (Time service is not supported) • 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 Maximum • 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 x 16±0.15 x 6.45±0.1mm • Weight: Approx. 6.0g

> **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 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.
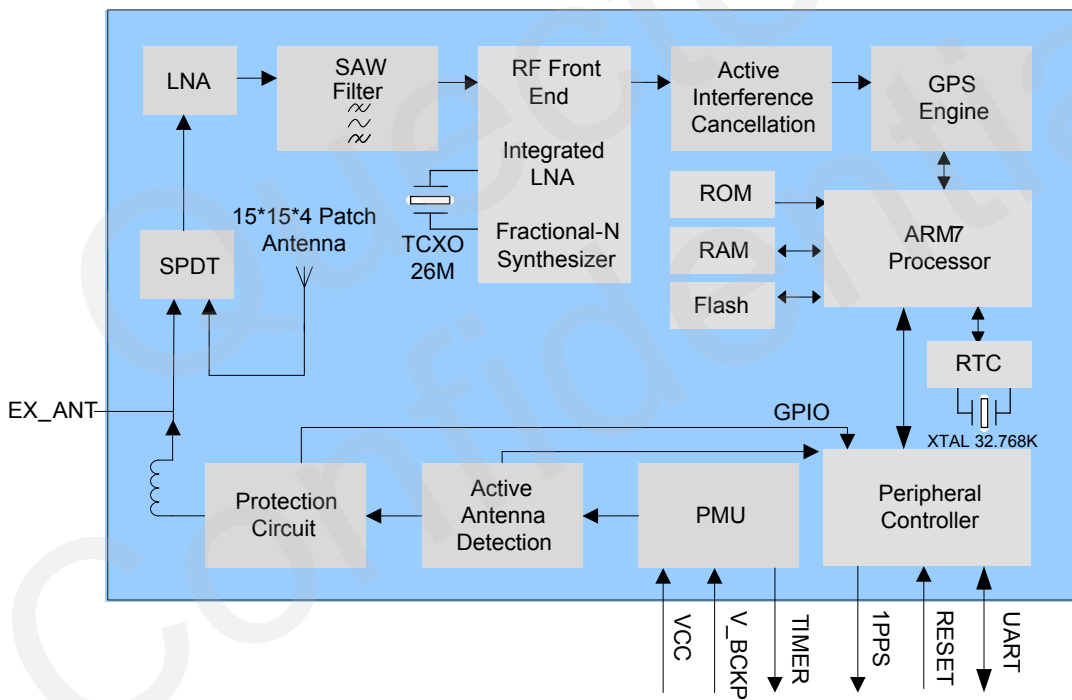
Figure 1: Block Diagram

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. The Protocols Module Supports

Table 2: The Protocols Supported by the Module

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

NOTE

Please refer to *document [2]* about 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 these pads 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=2.8V Vnom=3.3V	Supply current of no less than 100mA.
V_BCKP	5	I	Backup power supply	Vmax=4.3V Vmin=1.5V	Supply power for RTC domain .The V_BCKP pin

				Vnom=3.3V	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=2.4V VOHmax= 3.1V	It belongs to RTC domain. If unused, keep this pin open or connect to Ground externally.

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: 54 mV (RMS) max @ f = 0… 3MHz and 15 mV (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 as red line in the following figure, belongs to RTC domain and can be used to control the power switch on/off. For more details about TIMER function, please refer to *chapter 3.4.3.*
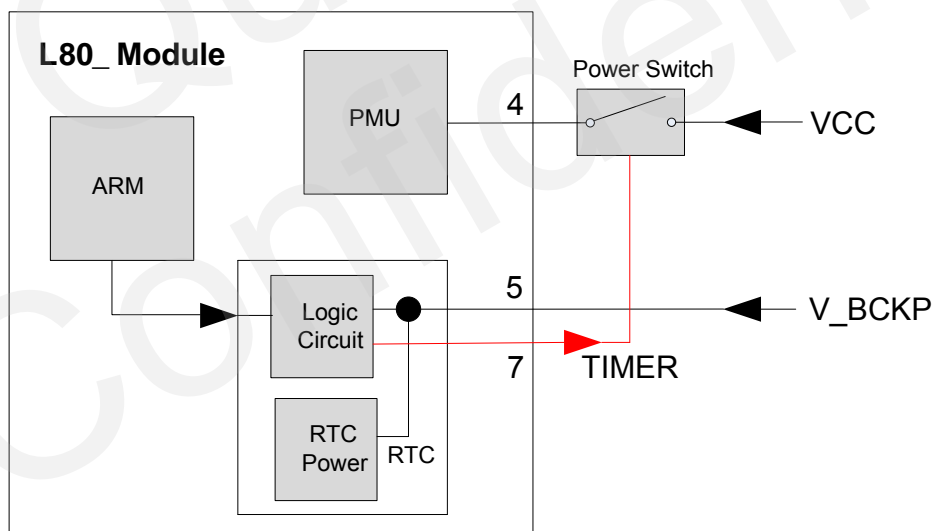
Figure 3: Internal Power Construction

Here, we list some power solutions for L80 module, the reference design is shown as below.

The simplest power circuit for L80 module is 3.3V power source connect to VCC pin and V_BCKP pin of the module directly. In this case, every time to restart the module, the cold start will be implemented. It doesn't support backup mode introduced in *chapter 3.4.3,* as well as EASY technology introduced in

chapter 3.7.
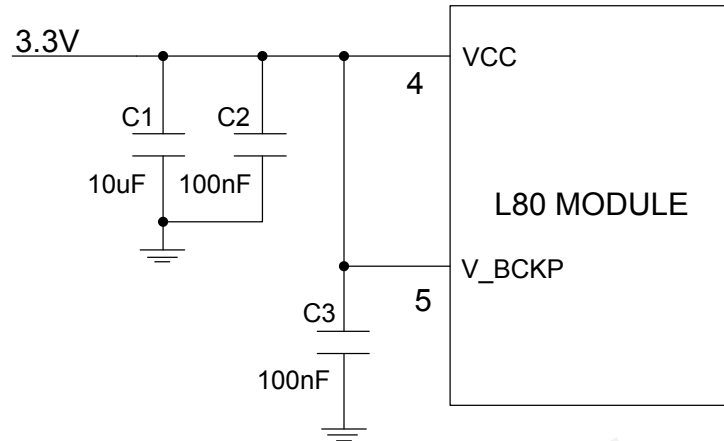
Figure 4: Reference Circuit for Power Supply

Another power solution can implement a backup battery in the condition of VCC off to maintain V_BCKP on. It will enter into backup mode and benefit TTFF in next stating module. For more details, please refer to *chapter 3.4.3.*

Power source supplies power for the VCC pin, The V_BCKP pin can be directly supplied power by an external rechargeable battery. Furthermore, it is necessary to add an external charging circuit for rechargeable battery.

Customer can apply a power switch circuit in the front VCC pin for more power saving functions when it is coordinated with TIMER pin. The detail schematic of power switch circuit is shown in Figure 6.
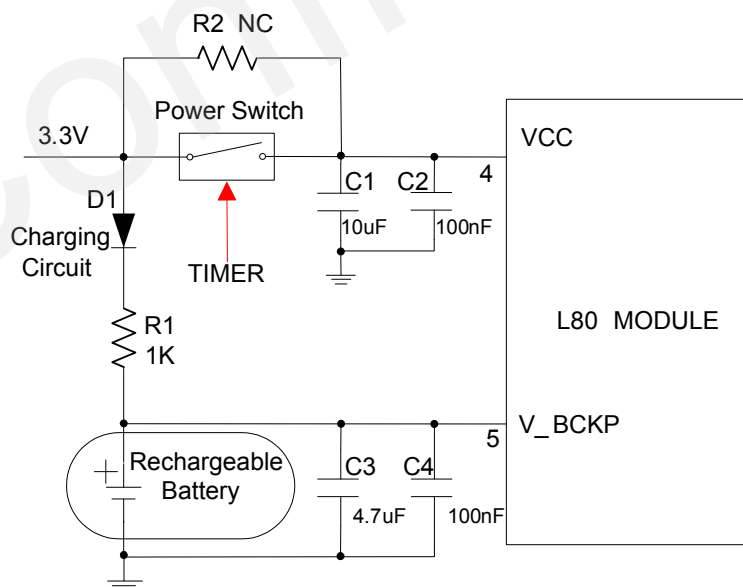
Figure 5: Reference Charging Circuit for Chargeable Battery

> **NOTE**
>
> VCC does not supply power for RTC domain in L80 module internally, so the V_BCKP pin must be powered externally

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
Backup	N/A	N/A	Refer to *chapter 3.4.3*	N/A	N/A
Standby	N/A	N/A	Send any data via UART	N/A	N/A
Full on	Refer to *chapter 3.4.3*	PMTK 161	N/A	Refer to *chapter 3.4.4*	Refer to *chapter 3.4.5*
Periodic	N/A	N/A	Refer to *chapter 3.4.4*	N/A	N/A
Always Locate	N/A	N/A	Refer to *chapter 3.4.5*	N/A	N/A

> **NOTE**
>
> Please refer to *document [2]* about MTK proprietary protocol for more details.

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 and 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 mode. In standby mode, the internal core and I/O power domain are still active, but RF and TCXO are powered off, the module stops satellites search and navigation. UART is still accessible like 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 exit from standby mode, it will use all internal aiding information like GPS time, Ephemeris, Last Position etc, resulting to a 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 supply power for external active antenna in standby mode.

3.4.3. Backup Mode

Backup mode is a lower power mode 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.
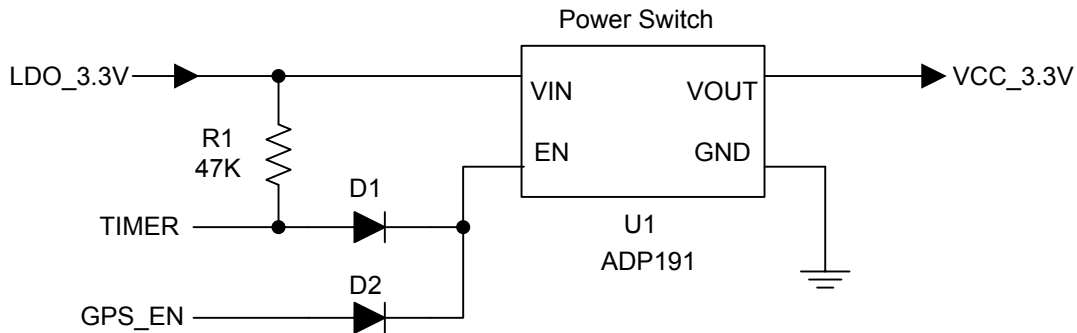
Figure 6: The External Switch Circuit for TIMER

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 **document [3]** for more details.
2. TIMER pin also can be used to control the EN pin of a LDO, please refer to **document [3]** for more details.
3. TIMER and GPS_EN signals form an "OR" logic via the Schottky diodes D1 and D2. GPS_EN is a GPIO signal comes 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 Semiconductoris recommended to be used here for its low voltage drop.
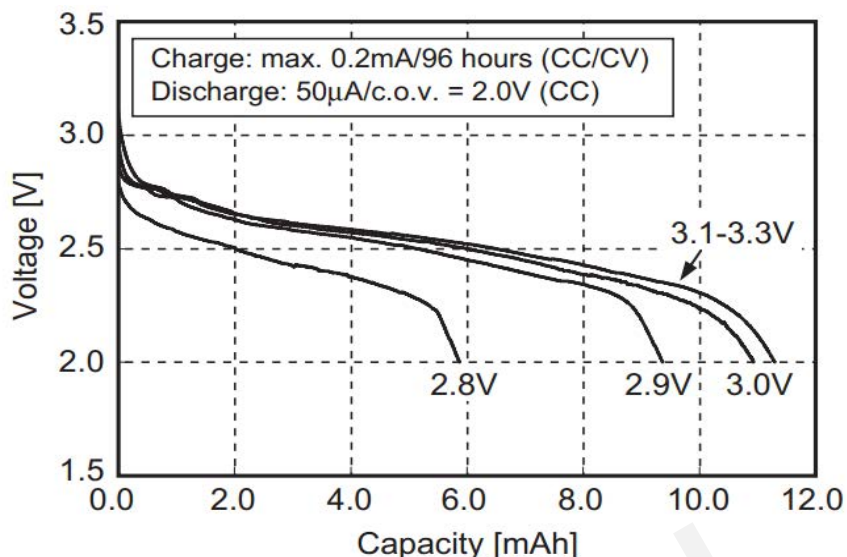
Figure 7: Seiko MS920SE Charge and Discharge Characteristics

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 enters 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 period (ms)
Sleep_time	Decimal	Standby/Backup period (ms)
2nd_run_time	Decimal	Full on period (ms) for extended acquisition in case GPS module acquisition fails during the **Run_time**
2nd_sleep_time	Decimal	Standby/Backup period (ms) for extended sleep in case GPS module 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 to full on mode from periodic standby mode.

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

NOTES

1. Periodic backup mode needs the external switch circuit to support, 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 the 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:
$I_{periodic}=(I_{tracking}\times T1+I_{standby}\times T2)/(T1+T2)=(20mA\times 3s + 1mA\times 12s)/(3s+12s)\approx4.8 (mA)$

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:
$I_{periodic}=(I_{tracking}\times T1+I_{backup}\times T2)/(T1+T2)=(20mA\times 3s + 0.007mA\times 12s)/(3s+12s)\approx4.0 (mA)$
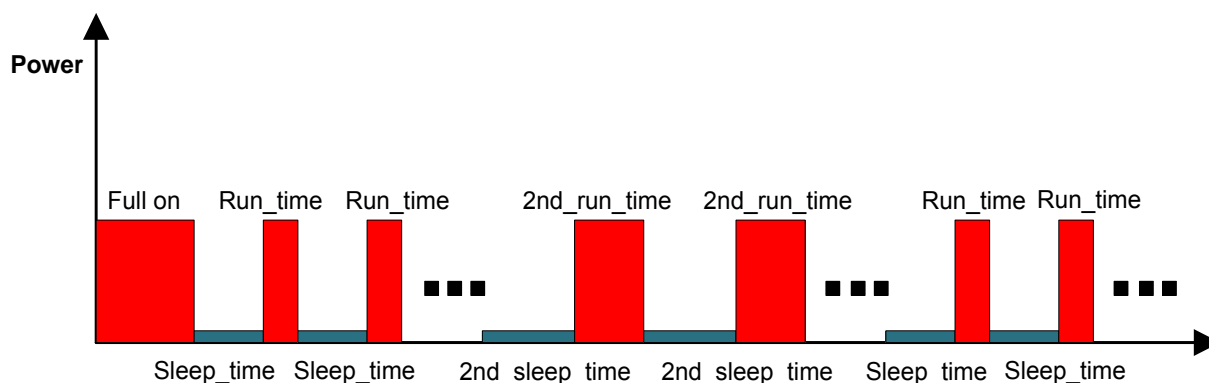
Figure 8: Periodic Mode

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 supports 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 switches automatically between full on mode and backup mode. 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.
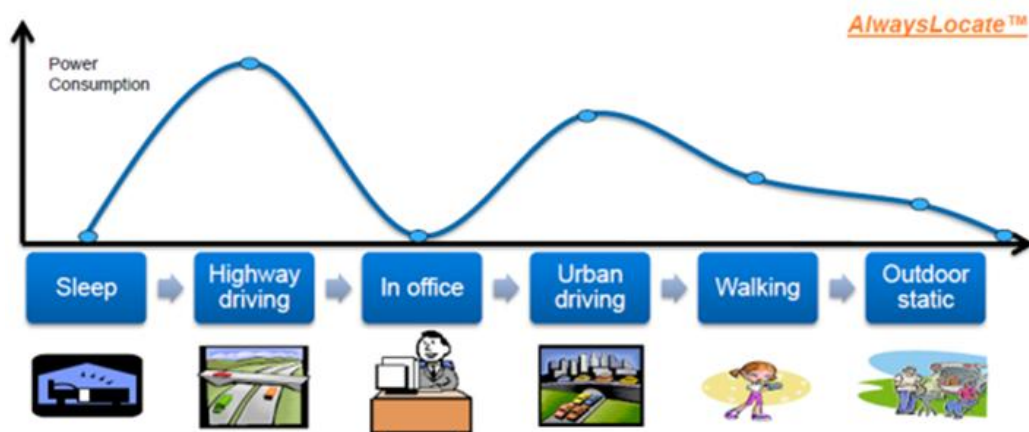
Figure 9: AlwaysLocate^{TM} Mode

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. The same as periodic backup mode, AlwaysLocate^{TM} backup mode also needs the external switch circuit to support, please refer to *chapter 3.4.3*.
3. Before entering into periodic backup mode, please ensure the GPS_EN signal is low and power supply for V_BCKP is alive.

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.
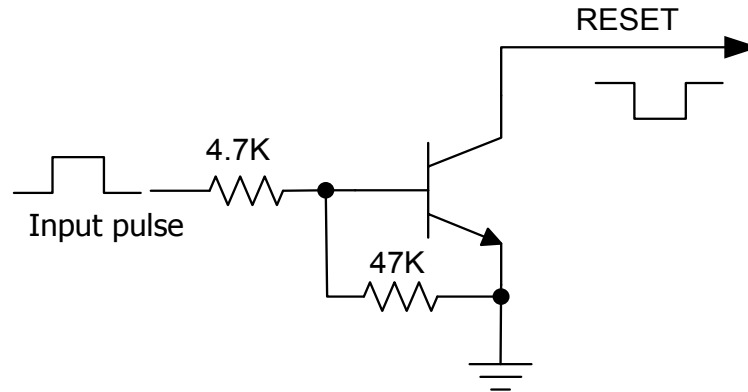
Figure 10: Reference Reset Circuit Using OC Circuit

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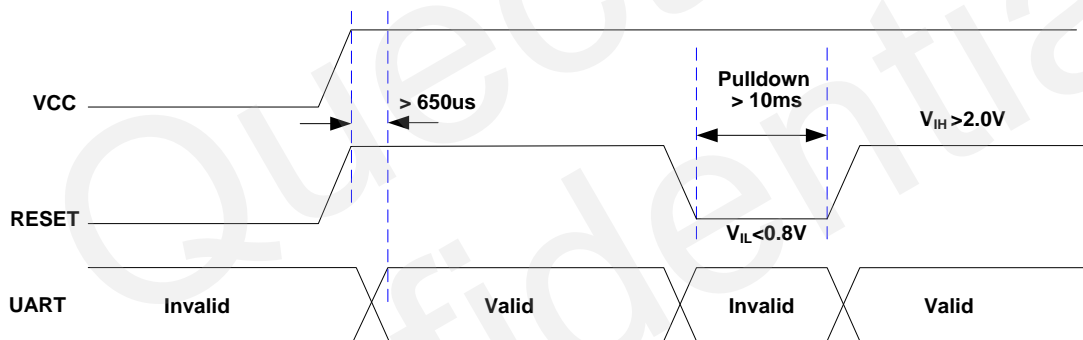
Figure 11: Restart Timing

3.6. UART Interface

The module provides one universal asynchronous receiver & transmitter serial port. The module is designed as a DCE (Data Communication Equipment), following the traditional DCE-DTE (Data Terminal Equipment) connection. The module and the client (DTE) are connected through the following signals shown as 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.
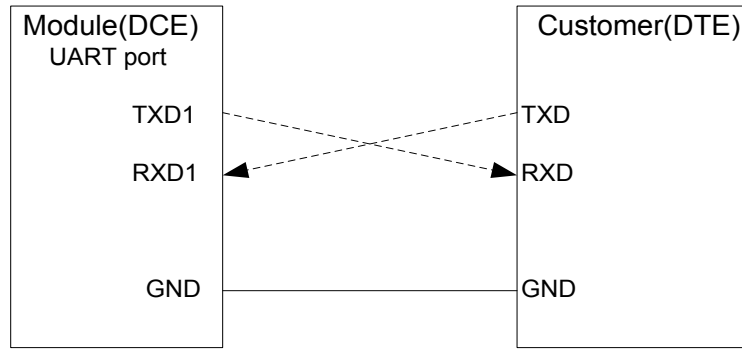
Figure 12: Connection of Serial Interfaces

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, 115200.
  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.
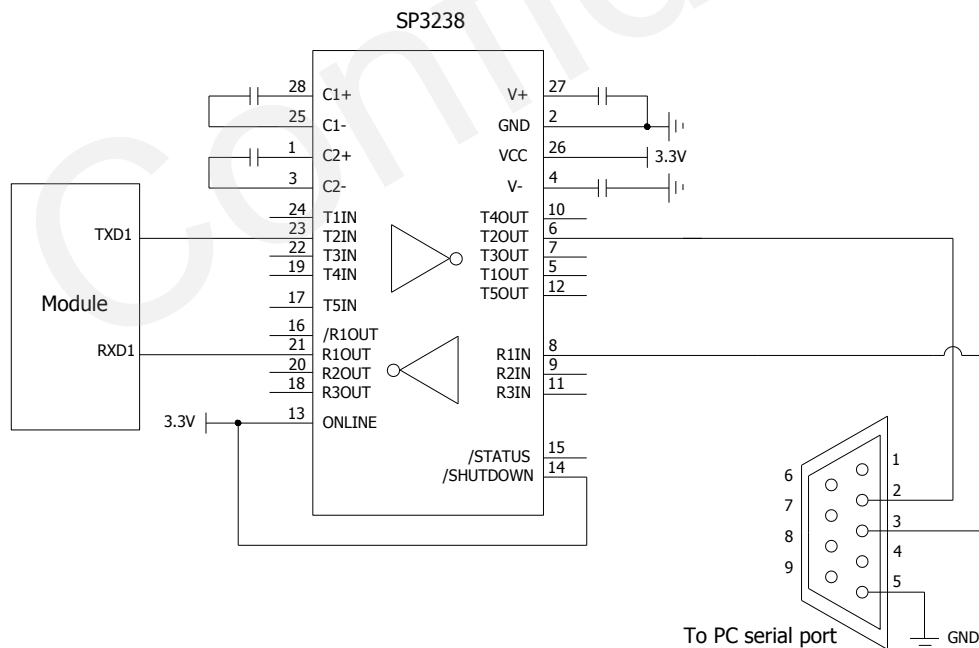
Figure 13: RS-232 Level Shift Circuit

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 saving the predicted information into the internal memory. GPS engine will use this information for positioning if no enough information from satellites, so the function will be helpful for positioning and TTFF improvement.

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

EASY function is enabled by default. The 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 do 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;

5

- 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's technical support team.

3.10. Antenna Advisor

Antenna Advisor is design to detect and notify the different external active antenna statuses including external active antenna detection circuit, external active antenna connection and external active antenna shortage. The detections and notifications of external active antenna are listed in the following table.

Table 7: Status of the Antenna

Status of the Antenna	EXT/Patch	NMEA Message
External active antenna is not inserted	Patch	OPEN
External active antenna is inserted and worked normally	EXT	OK
External active antenna is inserted but short-circuited	Patch	SHORT

4 Antenna Interface

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 slim 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. Recommended Circuit for Antenna

4.1.1. Internal Patch Antenna

4.1.1.1. 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 8: 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/℃	-40°C-85℃
	Polarization	RHCP	Right Hand Circular Polarization

Gain at Zenith	3.4dBi typ	
VSWR	1.5 max	Centre frequency
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.
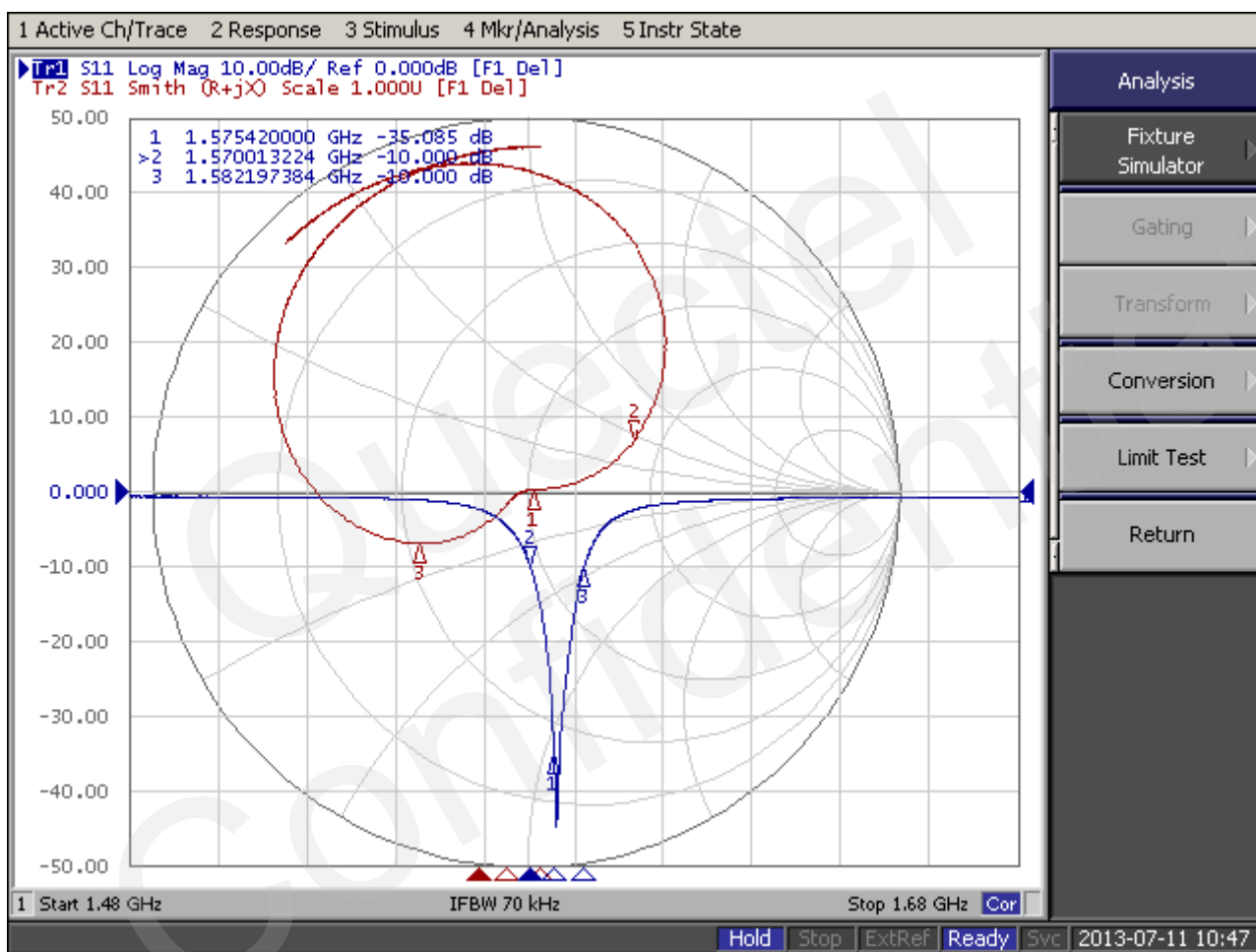
Figure 14: Patch Antenna Test Result with Ground Plane 100mm×60mm

4.1.1.2. PCB Design Guide

Radiation characteristics of antenna depend on various factors, such as the size and shape of the PCB, the dielectricconstant of components nearby. For the best performance, it is recommended to follow these rules listed as below.

Keep at least 10mm distance to the nearest edge of the mother board. It will be better for L80 to be placed in the center of the mother board.

Keep enough distance between L80 antenna and tall components, the height of which is more than 6mm, and the minimum distance (d) is 10mm.

Put L80 on the top of the main PCB, which can guarantee antenna to face to open sky and achieve good receiving performance during operation.

Device enclosure should be made of non-metal materials especially around antenna area. The minimum distance between antenna and enclosure is 1mm.

It is recommended that the mother board is bigger than 80mm×40mm for the better performance. And pour ground copper on the whole mother board.

Other antennas such as BT\WIFI\GSM should be kept minimum 10mm distance far away from the embedded patch antenna in L80.
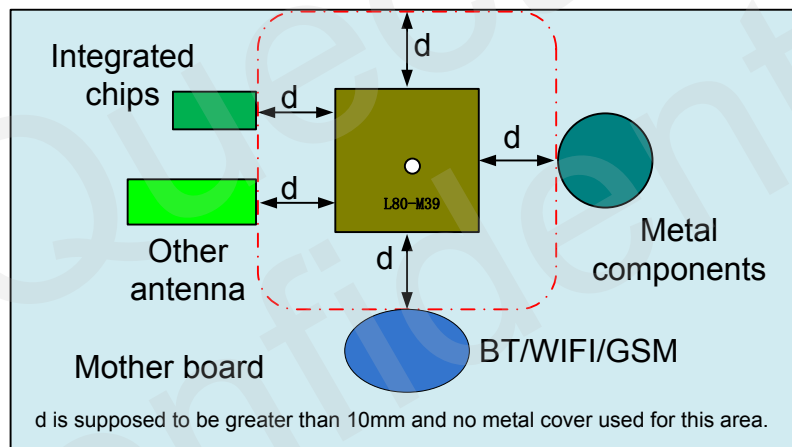
Figure 15: L80 Module Placement Guide

4.1.2. 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.
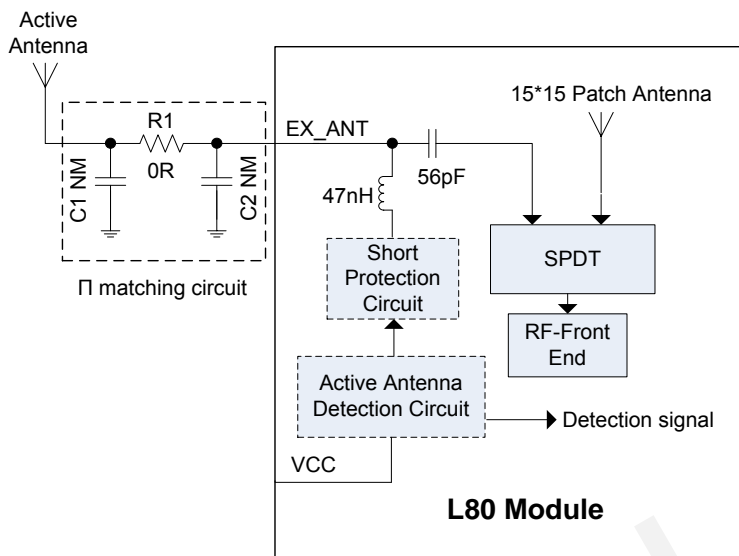
Figure 16: Reference Design for Active Antenna

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, because current should flows through R1 to the antenna. C1 and C2 must not be inductance or resistance to avoid short.

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

NOTE

L80 module provides power supply for external active antenna internally. There is about 0.3V voltage drop between VCC and external active antenna. If you want to use external active antenna, the voltage drop, VCC voltage and external active antenna operating voltage need to be considered.

Table 9: 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.)

4.2. Antenna Detection and Handling Mechanism

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 open-circuit state is dectected and the internal antenna is used at this time.

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

If **ANTSTATUS=SHORT**, it means short circuit state is dectected and the internal antenna is used.

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
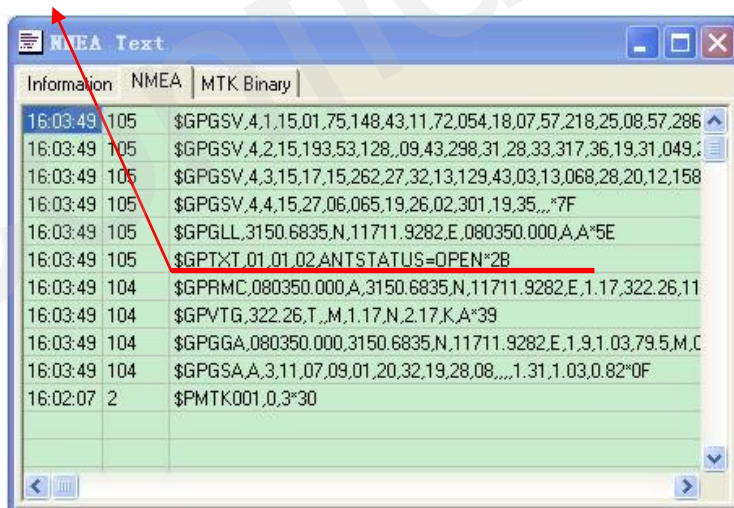
Figure 17: Patch Antenna Status Description in GPSTXT

Table 10: GPTXT - Status of Antenna

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

NOTE

L80 module only supports external active antenna and cannot use external passive antenna.

5 Electrical, Reliability and Radio Characteristics

5.1. Absolute Maximum Ratings

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

Table 11: Absolute Maximum Ratings

Parameter	Min	Max	Unit
Power supply voltage（VCC）	-0.3	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		0	dBm
Storage temperature	-45	125	℃

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 12: The Module Power Supply Ratings

Parameter	Description	Conditions	Min	Typ	Max	Unit
VCC	Supply voltage	Voltage must stay within the min/max values, including voltage drop, ripple, and spikes.	2.8	3.3	4.3	V
I_{VCCP}	Peak supply current	VCC=3.3V			100	mA
V_BCKP	Backup voltage supply		1.5	3.3	4.3	V
TOPR	Normal Operating temperature		-40	25	85	℃

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 13: The Module 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:
> - For Cold Start, 10 minutes after First Fix.
> - For Hot Start, 15 seconds after First Fix.

5.4. Electro-static Discharge

L80 module is an ESD sensitive device. ESD protection precautions should still be emphasized. Proper ESD handing and packaging procedures must be applied throughout the processing, handing 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 the particular applications.

Table 14: The ESD Endurance Table (Temperature: 25℃, Humidity: 45 %)

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

5.5. Reliability Test

Table 15: Reliability Test

Test item	Condition	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 Mechanics

This chapter describes the mechanical dimensions of the module.

6.1. Mechanical View of the Module
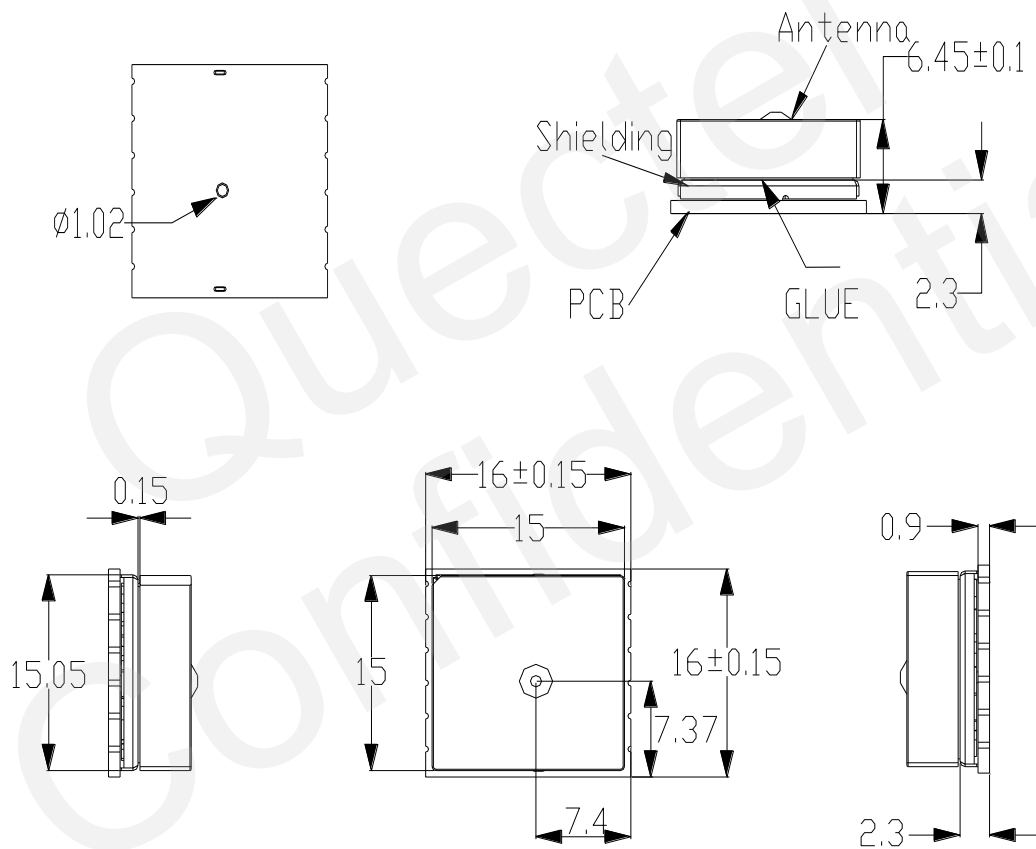
Figure 18: Mechanical View（Unit: mm）

6.2. Bottom Dimension and Recommended Footprint

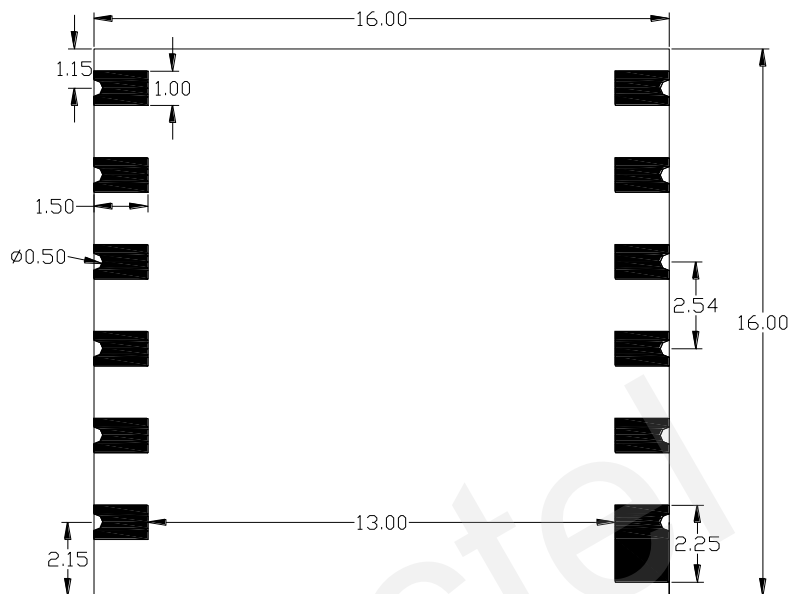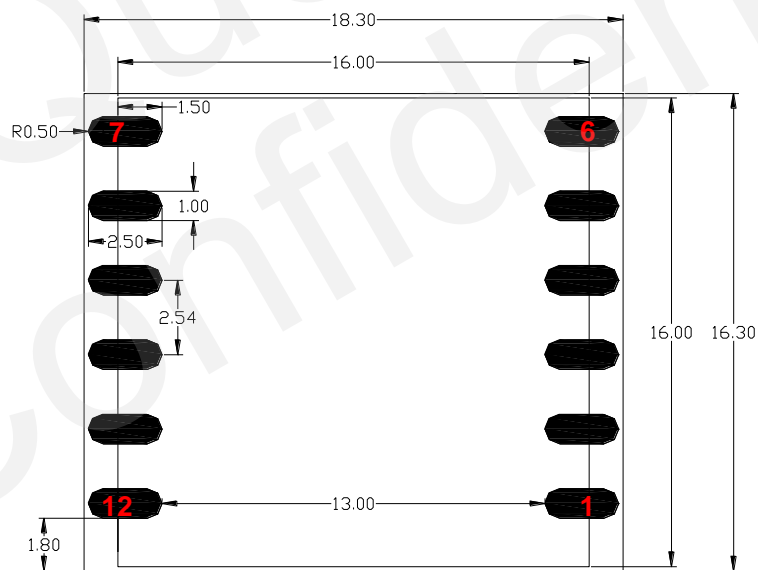**Figure 19: Bottom Dimension（Unit: mm）**

Figure 20: Footprint of Recommendation（Unit: mm）

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

6.3. Top View of the Module
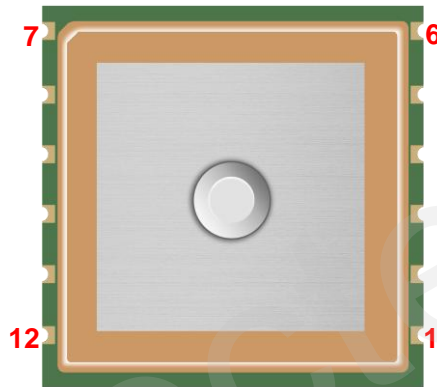
Figure 21: Top View of the Module

6.4. Bottom View of the Module
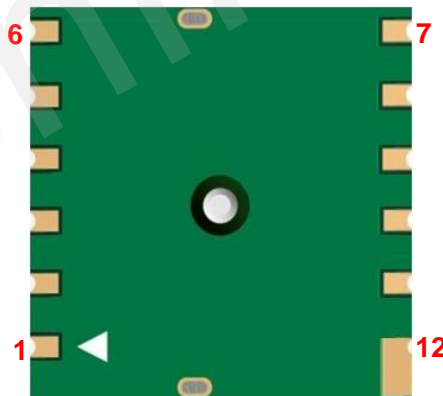
Figure 22: Bottom View of the Module

7 Manufacturing

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 peak reflow temperature is 235~245ºC (for SnAg3.0Cu0.5 alloy). Absolute max 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 the first panel has been reflowed. The following picture is the actual diagram which we have operated.
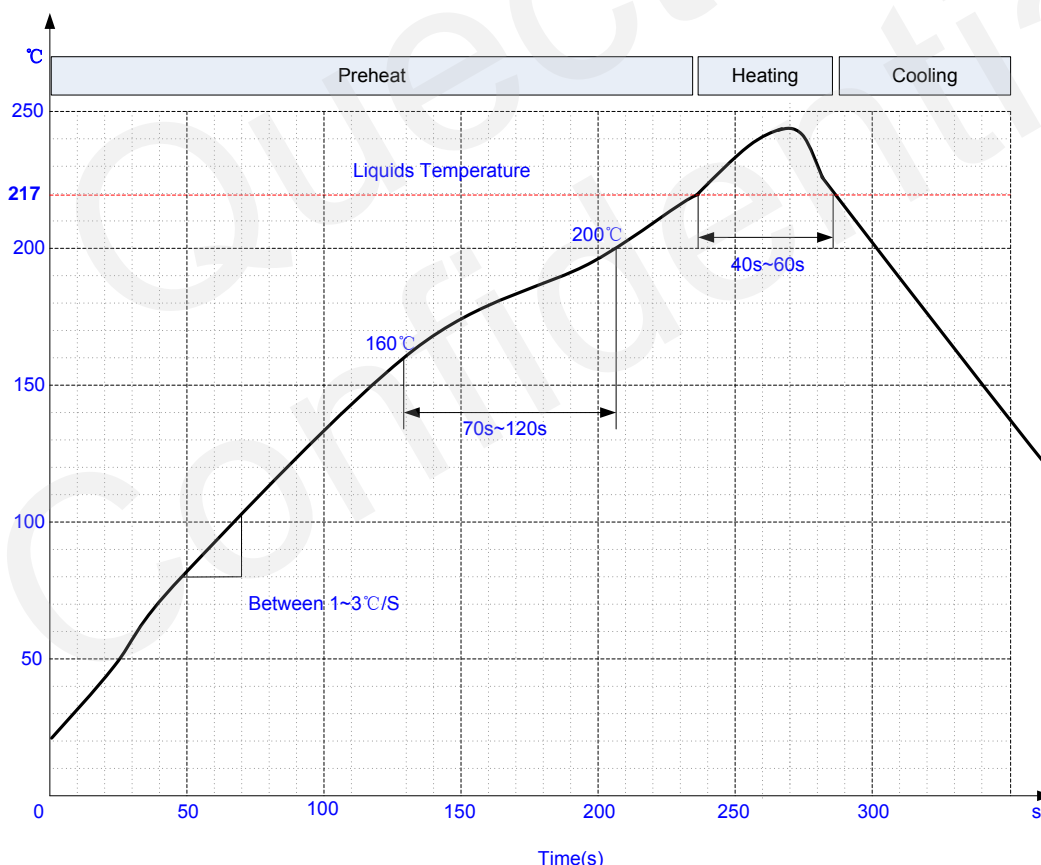
Figure 23: Ramp-soak-spike-reflow of Furnace Temperature

7.2. Moisture Sensitivity

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

- Humidity indicator card: At least one circular indicator is 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℃+5℃/-0℃ and <5% RH in low-temperature containers, or 24 hours at temperature 125℃±5 ℃ in high-temperature containers. Care should be taken that plastic tray is not heat resistant. L80 should be taken out before preheating, otherwise, the tray maybe damaged by high-temperature heating.

7.3. ESD Safe

L80 module is an ESD sensitive device and should be handled carefully.

7.4. Tape and Reel

Figure 24: Tape and Reel Specification

Table 16: Tray Packing

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 17: Ordering Information

Model Name	Ordering Code
L80	L80-M39

8 Appendix Reference

Table 18: Related Documents

SN	Document name	Remark
[1]	L80_EVB _User Guide	L80 EVB User Guide
[2]	L80_GPS_Protocol_Specification	L80 GPS Protocol Specification
[3]	L80_Reference_Design	L80 Reference Design

Table 19: Terms and Abbreviations

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

GSA	GNSS DOP and Active Satellites
GSV	GNSS Satellites in View
HDOP	Horizontal Dilution of Precision
I/O	Input /Output
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
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
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