L70 Hardware Design

GPS Module Series

Rev. L70_Hardware_Design_V2.2

Date: 2014-06-11

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

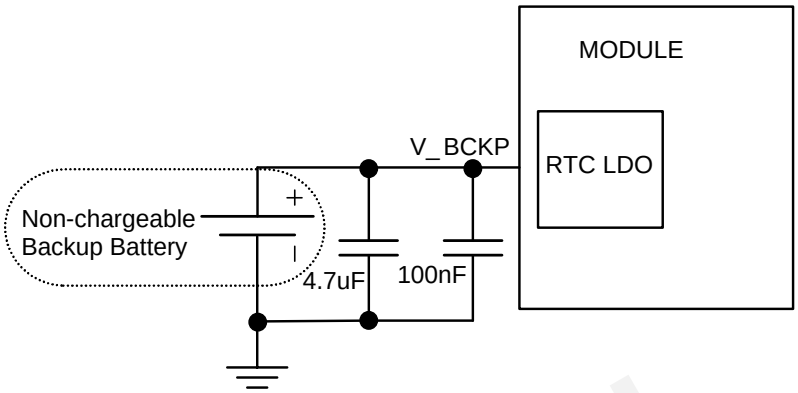


Figure 6: RTC Supply from Non-chargeable Battery

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

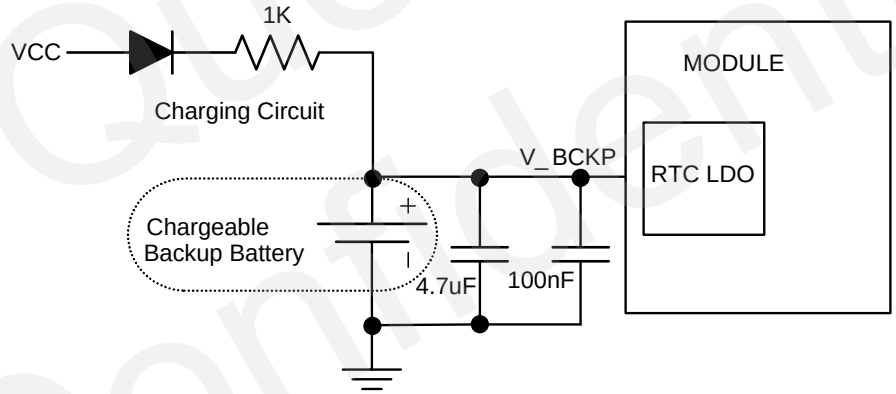


Figure 7: Reference Charging Circuit for Chargeable Battery

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.

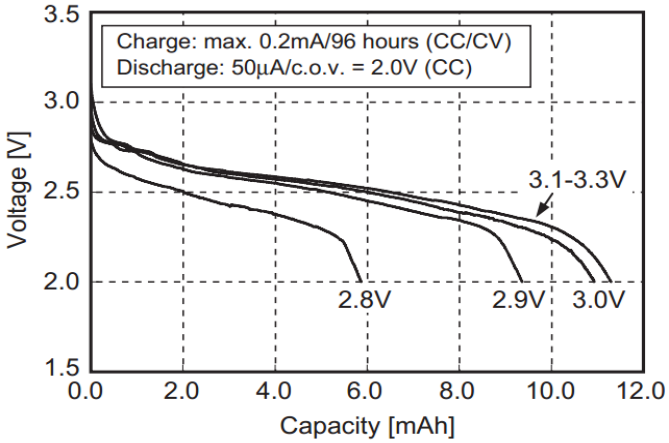


Figure 8: Seiko MS920SE Charge and Discharge Characteristics

3.4.4. Periodic Mode

Periodic mode is a power saving mode of L70 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:

$I_{periodic} = (I_{tracking} * T1 + I_{standby/backup} * T2) / (T1+T2)$ 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*T1+Istandby*T2)/(T1+T2)=(12mA*3s + 0.2mA*12s)/(3s+12s)≈2.6 (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*T1+Ibackup*T2)/(T1+T2)=(12mA*3s + 0.007mA*12s)/(3s+12s)≈2.4 (mA)

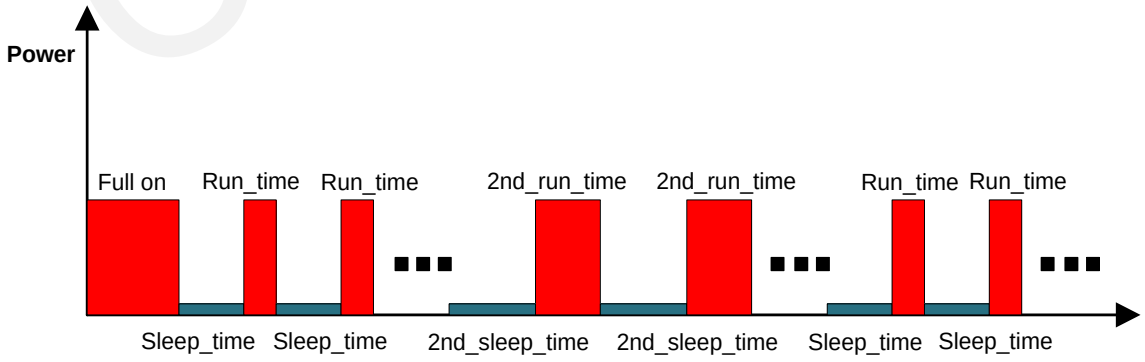


Figure 9: Periodic Mode

3.4.5. AlwaysLocate™ Mode

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

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

The positioning accuracy in AlwaysLocate™ mode will be somewhat degraded, especially in high speed. The following picture shows the rough power consumption of L70 module in different daily scenes when AlwaysLocate™ mode is enabled.

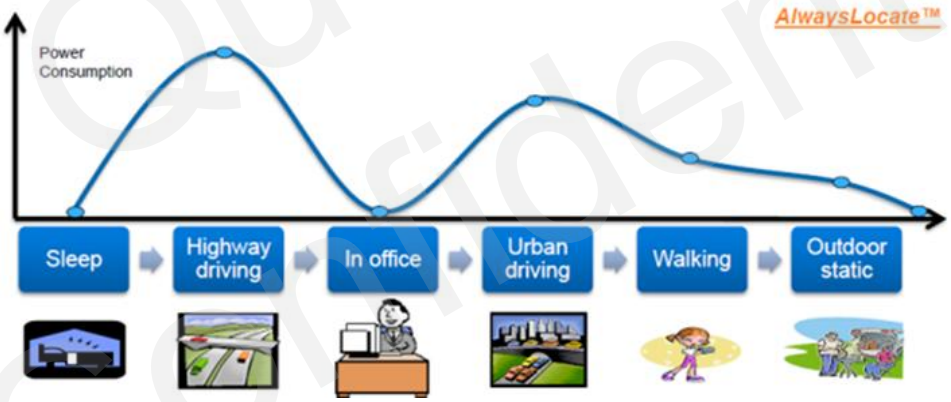


Figure 10: AlwaysLocate™ Mode

Example:
The typical average consumption is about 1.5mA in AlwaysLocate™ standby mode and 1.4mA in AlwaysLocate™ backup mode.

NOTES

1. Power consumption is measured under outdoor static mode with active antenna.
2. The same as periodic backup mode, AlwaysLocate™ 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

L70 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.

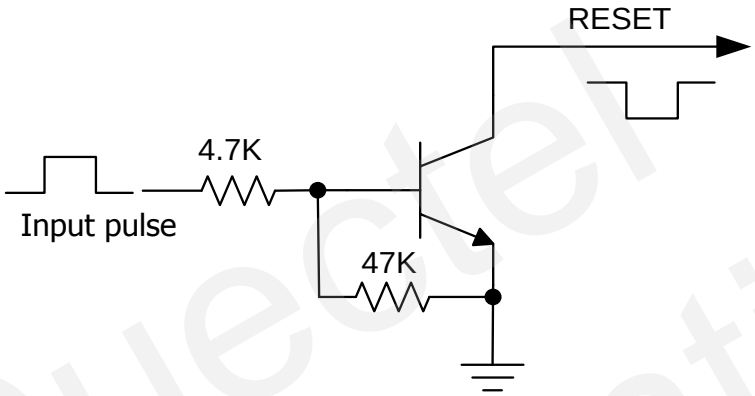


Figure 11: Reference Reset Circuit Using OC Circuit

The restart timing of L70 has been illustrated bellow.

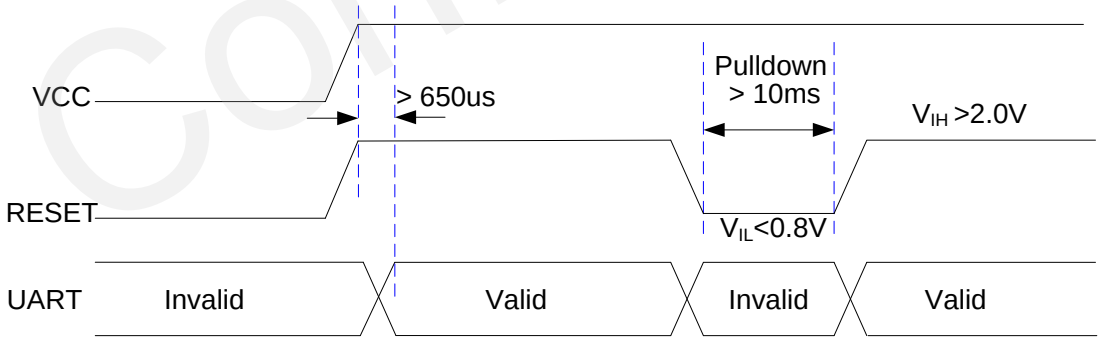


Figure 12: Restart Timing

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 Figure 13. 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

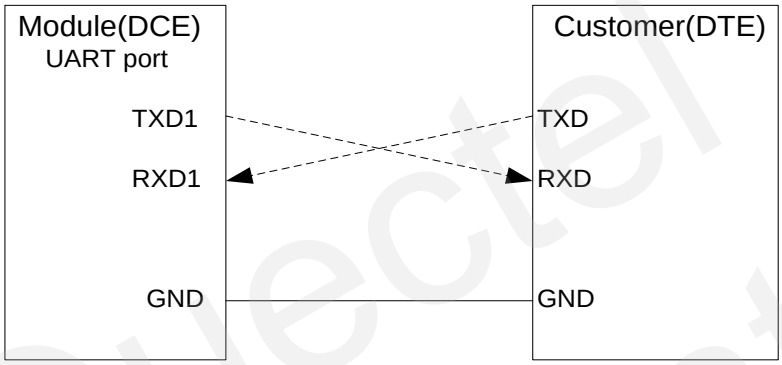


Figure 13: Connection of Serial Interfaces

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 and GLL**.
- 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.

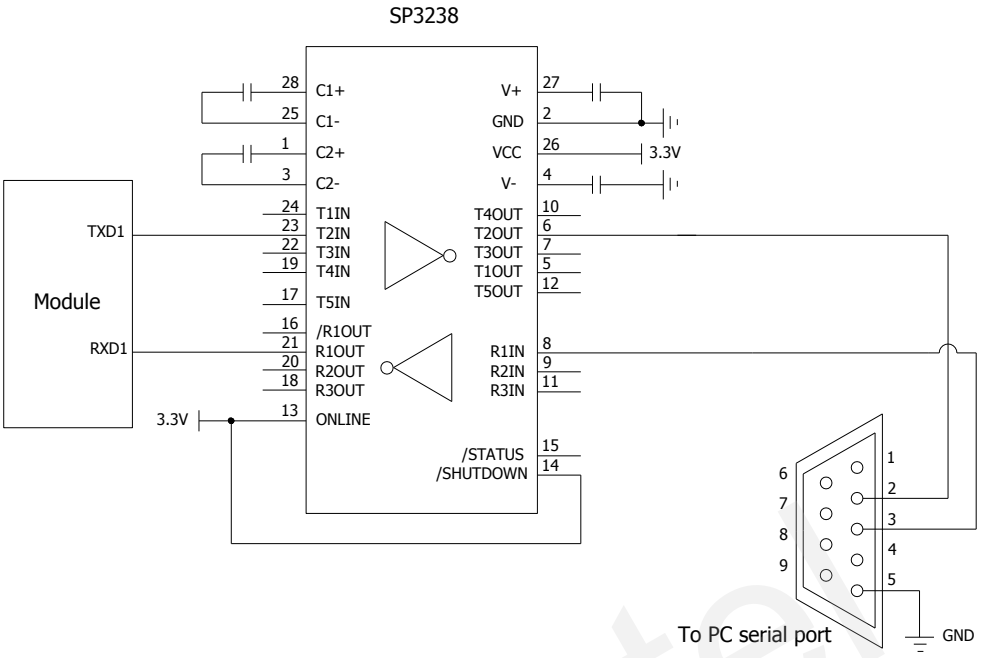


Figure 14: RS-232 Level Shift Circuit

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

L70 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. ANTON

L70 module provides a pin called ANTON which is related to module states. Its voltage level will be changed in different module states. When the module works in full on mode, this pin is a high level, while works in standby mode, backup mode as well as sleep time in periodic mode and AlwaysLocate™ mode, this pin is a low level. Based on this characteristic, ANTON pin can be used to control the power supply of active antenna or the enable pin of an external LNA to save power consumption. There is an example of this pin’s application described in ***chapter 4.2***.

3.10. LOCUS

L70 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;
- Module logs the basic information (UTC time, latitude, longitude and height) every 15 seconds to internal flash memory;
- Stop logging the information by sending “$PMTK185,1*23”;
- Host can get the data from the module via UART1 by sending “$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.

4 Antenna Interface

L70 module receives L1 band signal from GPS satellites at a nominal frequency of 1575.42MHz. The RF signal is obtained from the RF_IN pin. 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.

4.1. Antenna Specification

Table 7: Recommended Antenna Specification

Antenna Type	Specification
Passive Antenna	Center frequency: 1575.42MHz Band width: >5MHZ VSWR: <2 (Typ.) Polarization: RHCP or Linear Gain: >0dBi
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. Recommended Circuit for Antenna

Both active and passive antenna can be used for L70 module.

4.2.1. Active Antenna

4.2.1.1. Active Antenna without ANTON

The following figure is a typical reference design with active antenna. In this mode, the antenna directly power from the VCC_RF.

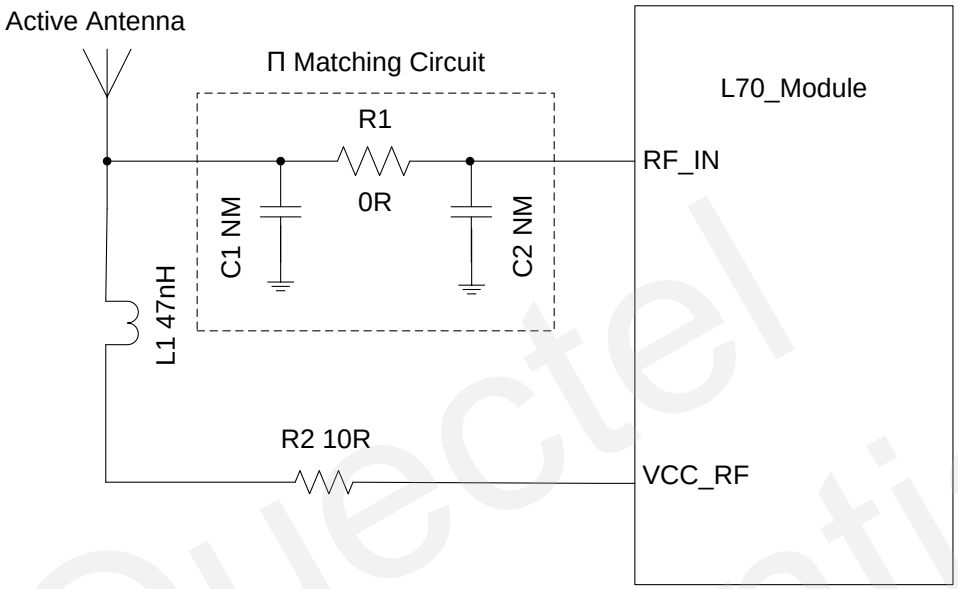


Figure 15: Reference Design with Active Antenna

C1, R1, C2 are reserved matching circuit for antenna impedance modification. By default, C1 and C2 are not mounted, R1 is 0 ohm.

L70 module provides power supply for external active antenna by VCC_RF. The voltage ranges from 2.8V to 4.3V, typical value is 3.3V. If the VCC_RF voltage does not meet the requirement for powering the active antenna, an external LDO should be used.

The inductor L1 is used to prevent the RF signal from leaking into the VCC_RF and route the bias supply to the active antenna and the recommended value of L1 is no less than 47nH. R2 can protect the whole circuit in case the active antenna is shorted to ground.

4.2.1.2. Active Antenna with ANTON

L70 module can also save power consumption by controlling the power supply of active antenna through the pin “ANTON”.

The reference circuit for active antenna with “ANTON” function is given as below.

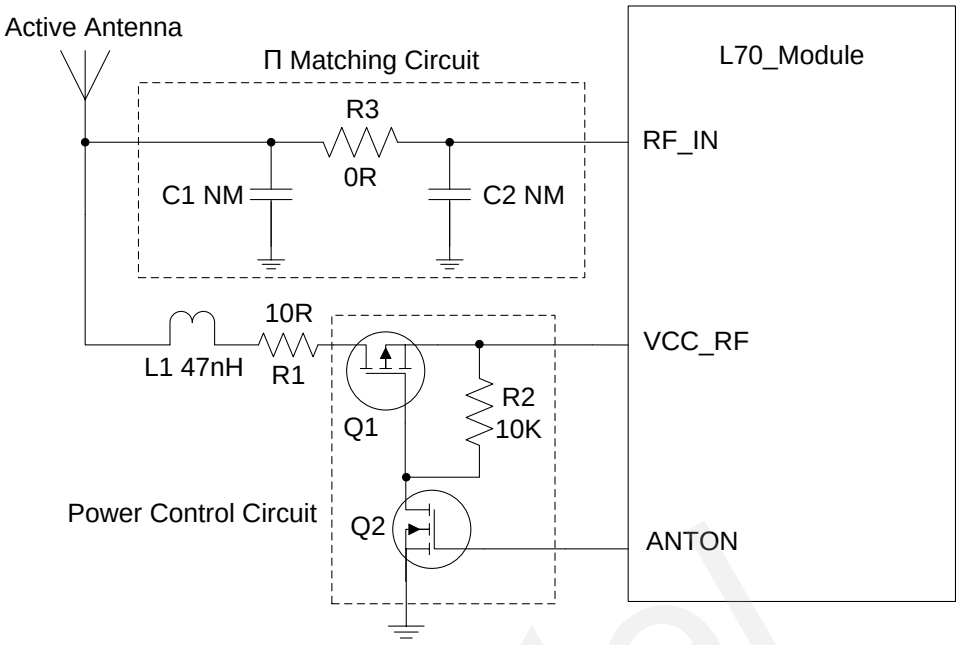


Figure 16: Reference Design for Active Antenna with ANTON

ANTON is an optional pin which can be used to control the power supply of the active antenna. When the ANTON pin is pulled down, MOSFET Q1 and Q2 are in high impedance state and the power supply for antenna is cut off. When ANTON is pulled high, it will make Q1 and Q2 in the on-state, VCC_RF will provide power supply for the active antenna. The high and low level of ANTON signal is determined by the module's states. Please refer to ***chapter 3.9*** for more details. If unused, please keep this pin open.

For minimizing the current consumption, the value of resistor R2 should not be too small, and the recommended value is 10k ohm.

4.2.2. Passive Antenna

4.2.2.1. Passive Antenna without External LNA

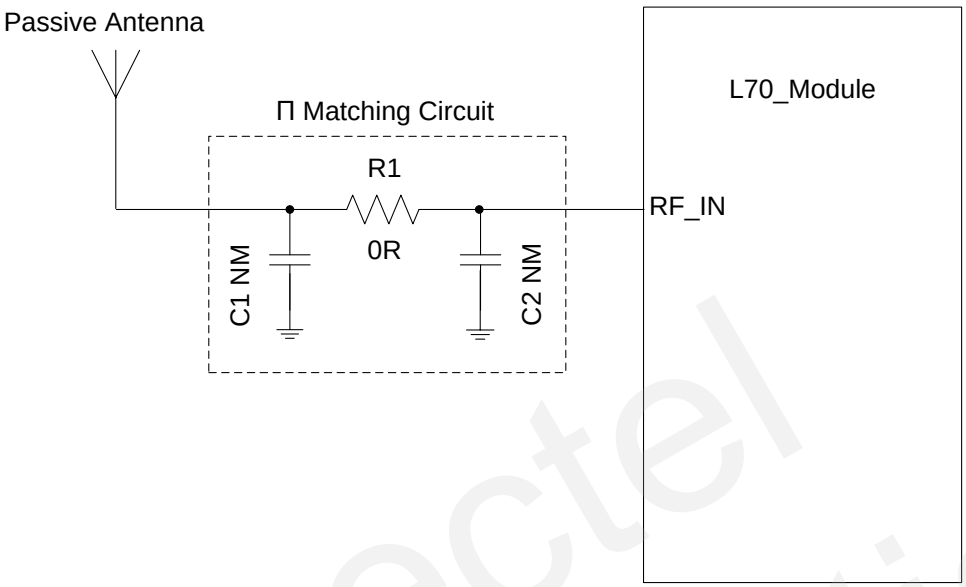


Figure 17: Reference Design with Passive Antenna

The above figure is a typical reference design with passive antenna.

C1, R1, C2 are reserved matching circuit for antenna impedance modification. By default, C1 and C2 are not mounted, R1 is 0 ohm. Impedance of RF trace should be controlled by 50 ohm and the length should be kept as short as possible.

If an external LNA is added between passive antenna and L70 module, the total sensitivity will be improved about 2dB, and the TTFF will be shorter in weak signal, which might be helpful for better performance.

4.2.2.2. Passive Antenna with External LNA

In order to improve the GPS receiver sensitivity and TTFF, an external LNA between the passive antenna and the L70 module is recommended. The reference design is shown as below.

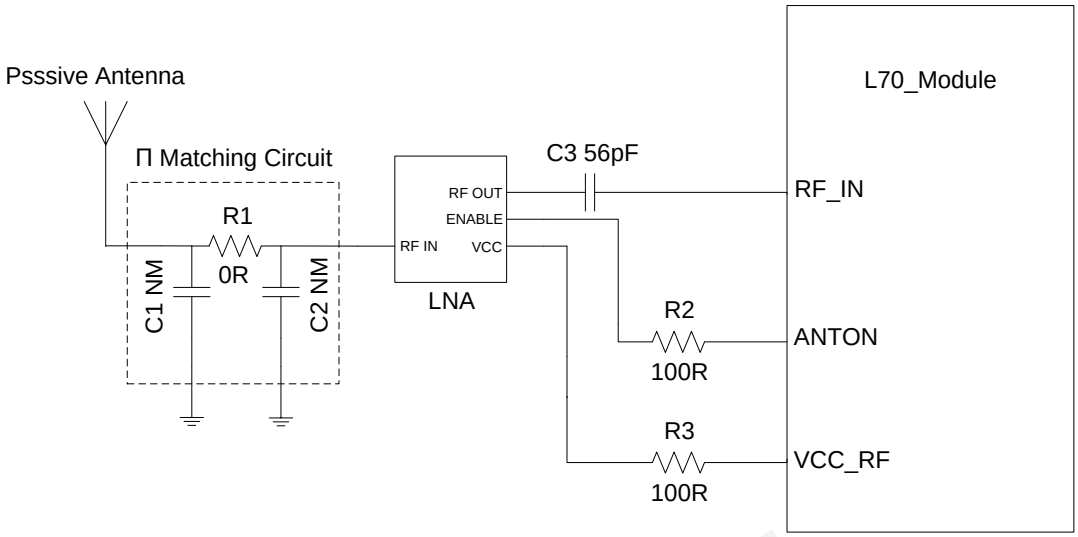


Figure 18: Reference Design for Passive Antenna with LNA

Here, C1, R1, C2 form a reserved matching circuit for passive antenna and LNA. By default, C1 and C2 are not mounted, R1 is 0 ohm. C3 is reserved for impedance matching between LNA and L70 module and the default value of C3 capacitor is 56pF which you might optimize according to the real conditions. ANTON is an optional pin which can be used to control the enable pin of the LNA.

NOTES

1. In order to be compatible with Quectel's GNSS module, it is recommended that the part number of the LNA component is MAX2659 or SKY65602. The both LNA components can support GPS and GLONASS system. For the details about the GNSS module, please contact Quectel's technical support team.
2. The power consumption of the device will be reduced by controlling "LNA ENABLE" through the pin "ANTON" of L70. If "ANTON" function is unused, please connect the pin "LNA ENABLE" to VCC to keep LNA always on.

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 8: 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 RF_IN (P_{RF_IN})		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 9: 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	4.5	V
VCC_RF	Output voltage RF section			VCC		V
TOPR	Normal operating temperature		-40	25	85	°C

NOTES

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 device reliability.

5.3. Current Consumption

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

Table 10: The Module Current Consumption

Parameter	Conditions	Min.	Typ.	Max.	Unit
I_{VCC} @Acquisition	@VCC=3.3V		18		mA
I_{VCC} @Tracking	@VCC=3.3V		12		mA
I_{VCC} @Standby	@VCC=3.3V		200		uA
I_{BCKP} @Backup	@V_BCKP=3.3V		7		uA

NOTES

1. The VCC_RF current is not reckoned in above consumption.
2. 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

L70 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 11: The ESD Endurance Table (Temperature: 25℃, Humidity: 45%)

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

5.5. Reliability Test

Table 12: 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 Mechanics

This chapter describes the mechanical dimensions of the module.

6.1. Mechanical View of the Module

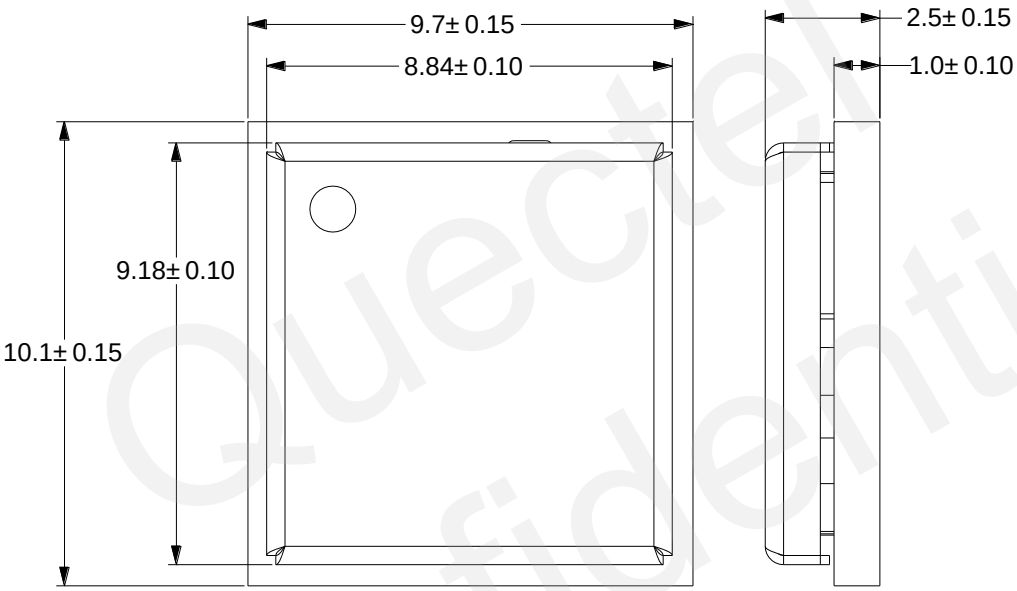


Figure 19: Top View and Side View (Unit: mm)

6.2. Bottom Dimension and Recommended Footprint

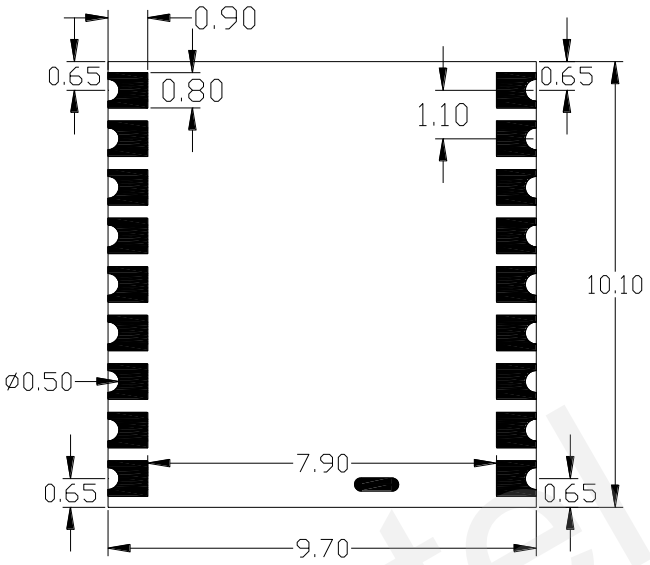


Figure 20: Bottom Dimension (Unit: mm)

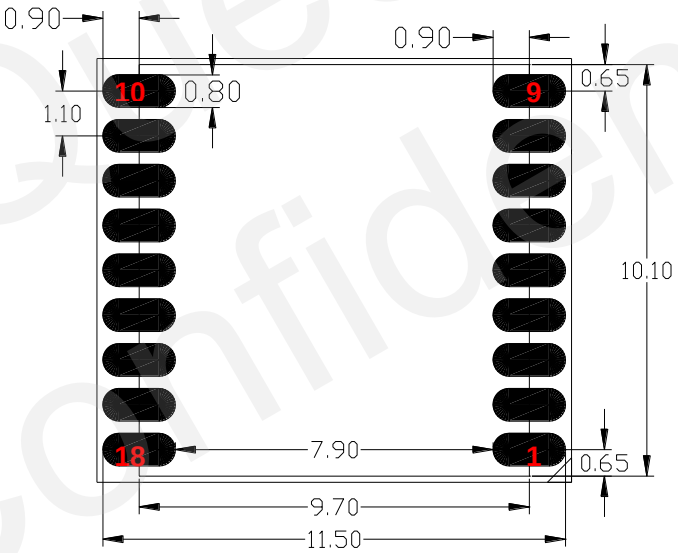


Figure 21: Footprint of Recommendation (Unit: mm)

NOTE

For easy maintenance of this module and accessing to these pads, 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

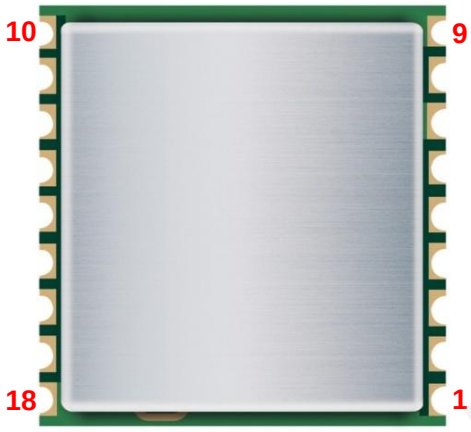


Figure 22: Top View of the Module

6.4. Bottom View of the Module

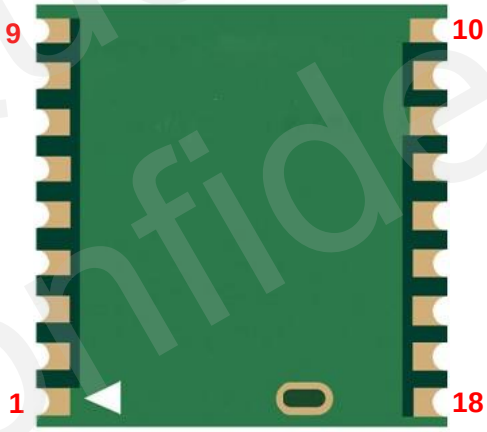


Figure 23: Bottom View of the Module

7 Manufacturing

7.1. Assembly and Soldering

L70 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 130um 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.

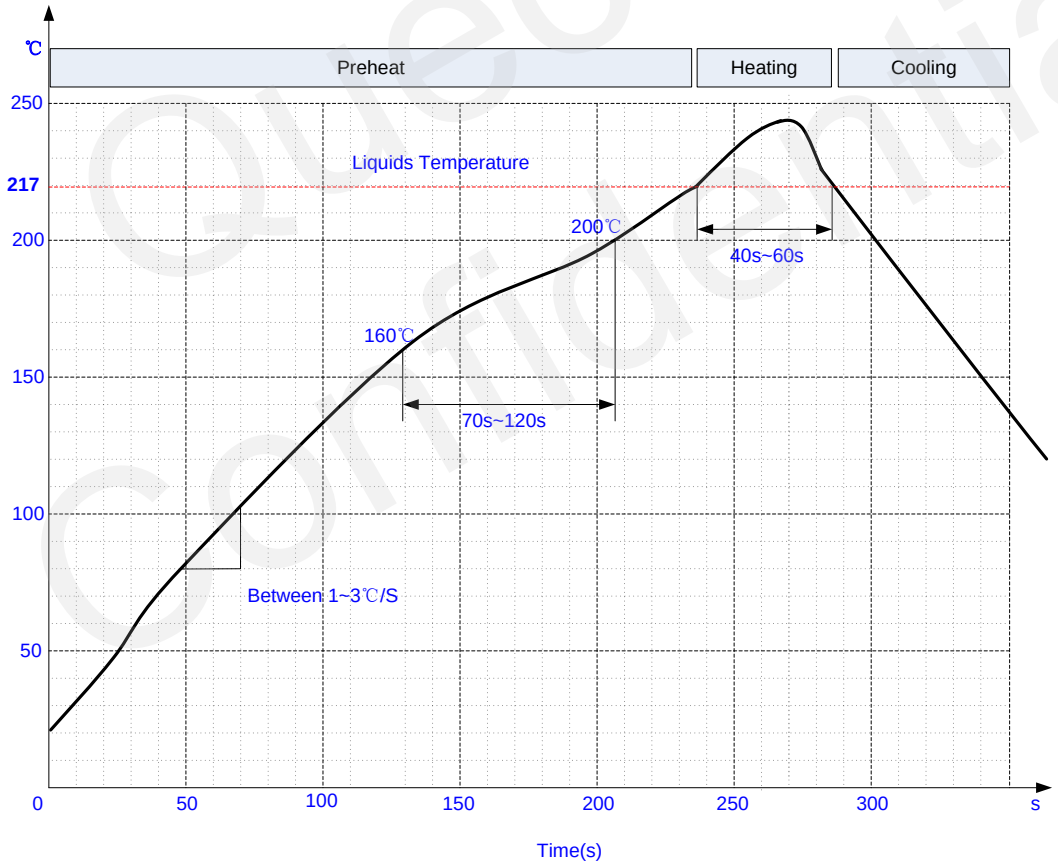


Figure 24: Ramp-soak-spike-reflow of Furnace Temperature

7.2. Moisture Sensitivity

L70 module is sensitivity to moisture absorption. To prevent L70 from permanent damage during reflow soldering, baking before reflow is required in following cases:

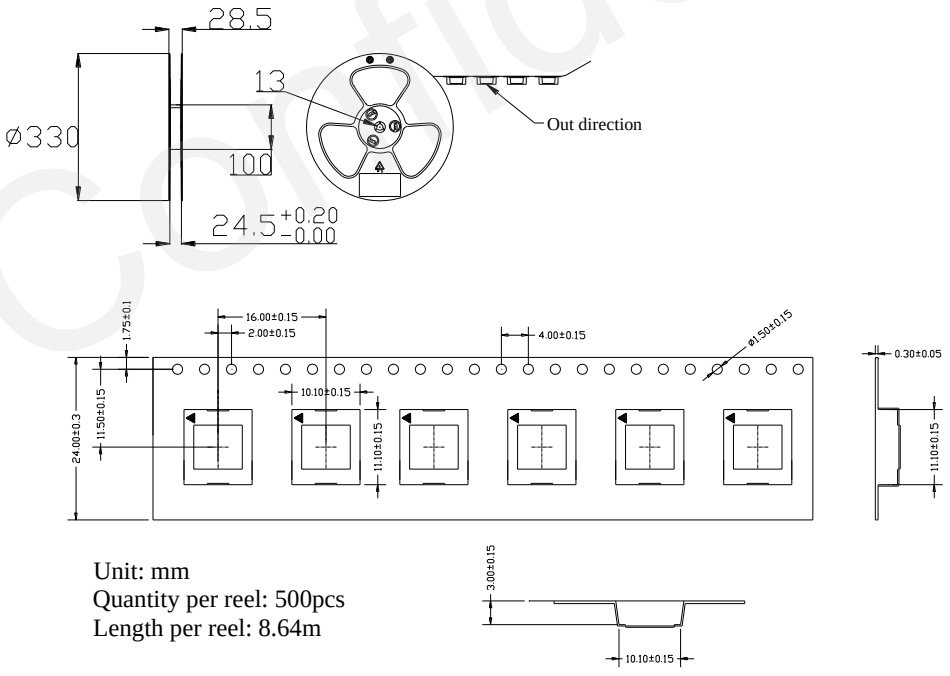
- Humidity indicator card: At least one circular indicator is no longer blue
- The seal is opened and the module is exposed to excessive humidity.

L70 should be baked for 192 hours at temperature 40ºC+5ºC/-0ºC and <5% RH in low-temperature containers, or 24 hours at temperature 125ºC±5ºC in high-temperature containers. Care should be taken that plastic tape is not heat resistant. L70 should be taken out before preheating, otherwise, the tape maybe damaged by high-temperature heating.

7.3. ESD Protection

L70 module is sensitive to ESD and requires special precautions when handling. Particular care must be exercised when handing patch antenna, duo to the risk of electrostatic charges.

7.4. Tape and Reel



Unit: mm
Quantity per reel: 500pcs
Length per reel: 8.64m

Figure 25: Tape and Reel Specification

Table 13: Reel Packing

Model Name	MOQ for MP	Minimum Package: 500pcs	Minimum Package x 4=2000pcs
L70	500pcs	Size: 370mm × 350mm × 56mm N.W: 0.25kg G.W: 1.00kg	Size: 380mm × 250mm × 365mm N.W: 1.1kg G.W: 4.4kg

7.5. Ordering Information

Table 14: Ordering Information

Model Name	Ordering Code
L70	L70B-M39

8 Appendix Reference

Table 15: Related Documents

SN	Document Name	Remark
[1]	Quectel_L70_EVB_User Guide	L70 EVB User Guide
[2]	Quectel_L70_GPS_Protocol_Specification	L70 GPS Protocol Specification
[3]	Quectel_L70&L76_Reference_Design	L70&L76 Reference Design

Table 16: 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