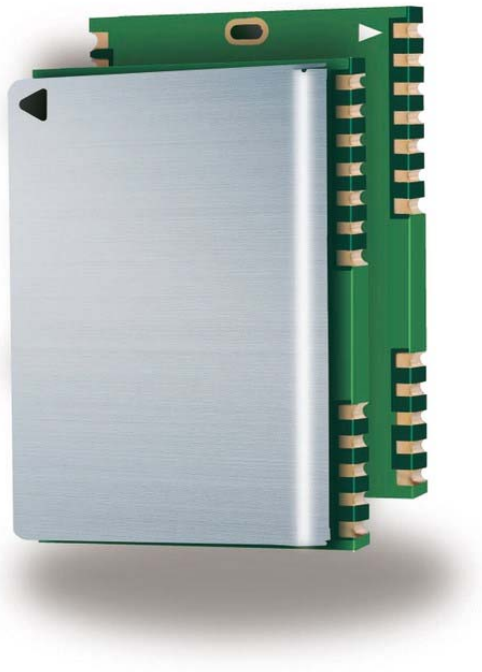
L20

Quectel GPS Engine

Hardware Design

L20_HD_V1.0



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0 Revision History

Revision	Date	Author	Description of change
1.0	2010-12-03	Crystal HE/David WEI	Initial

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1 Introduction

This document defines and specifies the L20 GPS module. It describes L20 hardware interface and its external application reference circuits, mechanical size and air interface.

This document can help customer quickly understand module interface specifications, electrical and mechanical details. With the help of this document and other application notes, customer can use L20 module to design and set up application quickly.

1.1 Related Documents

Table 1: Related documents

SN	Document name	Remark
[1]	L20_EVB _UGD	L20 EVB User Guide
[2]	L20_GPS_Protocol	L20 GPS Protocol Specification
[3]	L20_AGPS_AN	L20 A-GPS Application Note

1.2 Terms and Abbreviations

Table 2: Terms and abbreviations

Abbreviation	Description
CGEE	Client Generated Extended Ephemeris
EMC	Electromagnetic Compatibility
ESD	Electrostatic Discharge
EGNOS	European Geostationary Navigation Overlay Service
GPS	Global Positioning System
GNSS	Global Navigation Satellite System
GGA	GPS Fix Data
GLL	Geographic Position – Latitude/Longitude
GSA	GNSS DOP and Active Satellites
GSV	GNSS Satellites in View
HDOP	Horizontal Dilution of Precision
IC	Integrated Circuit
I/O	Input/Output
Kbps	Kilo Bits Per Second
LNA	Low Noise Amplifier

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MSAS	Multi-Functional Satellite Augmentation System
NMEA	National Marine Electronics Association
OSP	One Socket Protocol
PDOP	Position Dilution of Precision
RMC	Recommended Minimum Specific GNSS Data
SBAS	Satellite-based Augmentation System
SUPL	Secure User Plane Location
SAW	Surface Acoustic Wave
TBD	To Be Determined
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
ZDA	Time & Date
Inorm	Normal Current
Imax	Maximum Load Current
Vmax	Maximum Voltage Value
Vnorm	Normal 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

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2 Product Concept

L20 GPS ROM-based module enables fast acquisition and tracking with the latest SiRF Star IV technology. This module provides outstanding GPS performance in a compact form factor. Choosing an external optional EEPROM which provides capability for storing ephemeris and patch codes downloaded through UART, L20 can support either Standalone or A-GPS (CGEE function). L20 advanced jamming suppression mechanism and innovative RF architecture provides a high level of immunity for jamming, ensuring maximum GPS performance. The module supports location, navigation and industrial applications including autonomous GPS C/A, SBAS (WAAS or EGNOS), and A-GPS.

L20 is an SMD type module with the compact 16mm x 12.2mm x 2.4 mm form factor, which can be embedded in customer applications through the 24-pin pads. It provides all hardware interfaces between the module and host board.

- The UART port is used for host processor to communicate with L20.
- The I2C port operating up to 400Kbps can be used to connect an EEPROM IC to save Ephemeris data for CGEE function and storing patch codes.
- The antenna interface supports passive or active antenna.

The module is fully RoHS compliant to EU regulation.

2.1 Key Features

Table 3: Module key features

Feature	Implementation
Power supply	Single supply voltage: 2.0V – 3.6V typical : 3.0V
Power consumption (passive antenna)	● Acquisition 57mA ● Tracking 41mA
Receiver Type	● GPS L1 1575.42MHz C/A Code ● 48 search channels
Sensitivity	● Cold Start (Autonomous) -148 dBm ● Reacquisition -160 dBm ● Hot Start -160 dBm ● Tracking -163 dBm ● Navigation -160 dBm
Time-To-First-Fix	● Cold Start (Autonomous) <35s ● Warm Start (Autonomous) <35s ● Hot Start (Autonomous) <1s
Horizontal Position Accuracy	● <2.5 m CEP
Max Update Rate	● 1Hz

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Accuracy of 1PPS Signal	● Typical accuracy 61 ns ● Time pulse 200ms
Velocity Accuracy	● Without aid 0.01 m/s
Acceleration Accuracy	● Without aid 0.1 m/s²
Dynamic Performance	● Maximum altitude <18288m ● Maximum velocity 515m/s Maximum ● Acceleration 4 G
I2C Interface	● Open drain output ● Operate up to 400Kbps
UART Port	● UART Port: two lines TXD1 and RXD1 ● Support baud rate from 4800bps to 115200bps. ● UART Port is used for NMEA or OSP messages output/input
Temperature range	● Normal operation: -40°C ~ +85°C ● Storage temperature: -45°C ~ +125°C
Physical Characteristics	Size: 16±0.15 x 12.2±0.15 x 2.4±0.1mm Weight: about 1.2g

2.2 Functional Diagram

The following figure shows a block diagram of L20 module. It consists of single chip GPS IC which includes RF part and Base-band part, LNA and SAW filter.

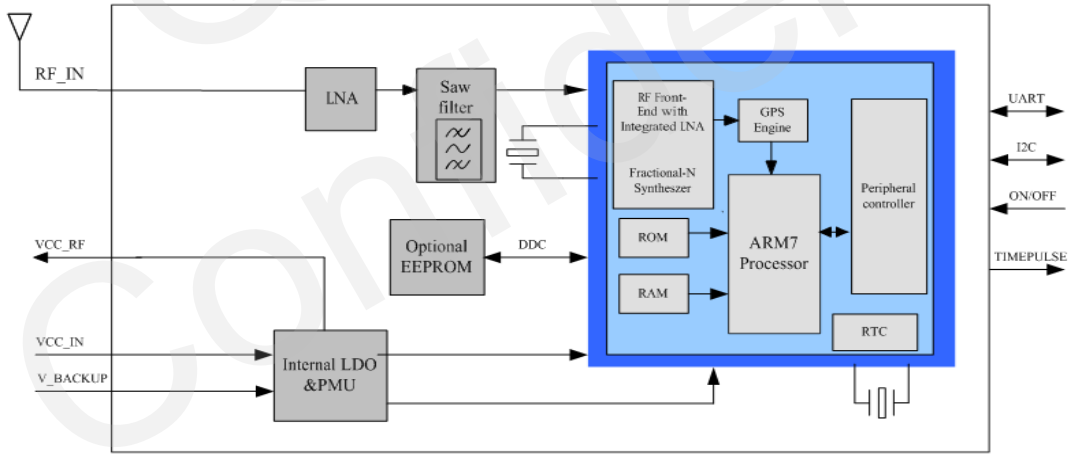

Figure 1: Module functional diagram

2.3 Evaluation Board

In order to help customer to develop applications with L20 module, Quectel supplies an Evaluation Board (EVB) with appropriate power supply, RS-232 serial cable, active antenna and the module.

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

2.4 Assisted GPS

By supplying aiding information like ephemeris, almanac, rough last position and time and satellite status, A-GPS can help improve GPS receiver TTFF and the acquisition sensitivity.

L20 uses one kind of A-GPS called CGEE provided by SiRF to achieve quick positioning. Up to three days EE (extended ephemeris) data can be saved in an EEPROM via the I2C interface.

For more details, please refer to *document [3].*

2.5 Protocol

The module supports standard NMEA-0183 protocol and the One Socket Protocol, OSP, which is the binary protocol interface that enables customer device host processor to access all SiRF GPS chip products of the SiRF Star IV family and beyond. The module is capable of supporting the following NMEA formats: ***GGA, GSA, GLL, GSV, RMC, and VTG.***

Table 4: The module supported protocols

Protocol	Type
NMEA	Input/output, ASCII, 0183, 3.01
OSP	Input/output, OSP protocol

Note: Please refer to document [2] about NMEA standard protocol and SiRF private protocol.

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3 Application Interface

The module is equipped with a 24-pin 1.1mm pitch SMT pad that connects to host application platform. Sub-interfaces included in these pads are described in details in the following chapters:

- Power management *(refer to Chapter 3.3)*
- UART interface *(refer to Chapter 3.4.1)*
- I2C interface (*refer to Chapter 3.4.2*)

Electrical and mechanical characteristics of the SMT pad are specified in *Chapter 5 & Chapter 6.*

3.1 Pin Description

Table 5: Pin description

Power Supply				
PIN NAME	**I/O**	**DESCRIPTION**	**DC CHARACTERISTICS**	**COMMENT**
VCC	I	Supply voltage	Vmax= 3.6V Vmin=2.0V Vnorm=3.0V	Supply current for no less than 100mA.
V_BCKP	I	Backup voltage supply	Vmax=3.6V Vmin=2.0V Vnorm=3.0V	Power supply for RTC when VCC is not applied for the system.
VCC_RF	O	Output voltage RF section	Vmax=3.6V Vmin=2.0V Vnorm=3.0V Imax=50mA	Usually supply for external active antenna, if the supply voltage is suitable for that active antenna. VCC_RF=VCC. If unused, keep this pin open.
General purpose input/output				
PIN NAME	**I/O**	**DESCRIPTION**	**DC CHARACTERISTICS**	**COMMENT**
ON_OFF(1)	I	Power control pin	VILmin=-0.4V VILmax=0.45V VIHmin=0.7xVCC VIHmax=3.6V	Applying a pulse which consists of a rising edge and high level that persists for at least 1ms onto the ON_OFF pin can switch operating mode between hibernate and full-on.

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				If unused, keep this pin open.
TIMEPULSE(1)	O	Time pulse	VOLmin=-0.3V VOLmax=0.4V VOHmin=0.75xVCC	1 pulse per second (1PPS). Synchronized at rising edge, pulse length 200ms. If unused, keep this pin open.
Serial Interface				
PIN NAME	**I/O**	**DESCRIPTION**	**DC CHARACTERISTICS**	**COMMENT**
SDA2	I/O	Serial data input/output	VOLmax=0.4V VOHmin=0.75xVCC VILmin=-0.4V VILmax=0.45V VIHmin=0.7xVCC VIHmax=3.6V	If unused, keep this pin open
SCL2	O	Serial clock output	VOLmax=0.4V VOHmin=0.75xVCC	If unused, keep this pin open
RXD1	I	Receive data	VILmin=-0.4V VILmax=0.45V VIHmin=0.7xVCC VIHmax=3.6V	If unused, keep this pin open.
TXD1	O	Transmit data	VOLmax=0.4V VOHmin=0.75xVCC	If unused, keep this pin open.
RF interface				
PIN NAME	**I/O**	**DESCRIPTION**	**DC CHARACTERISTICS**	**COMMENT**
RF_IN	I	GPS signal input	Impedance of 50Ω	Refer to Chapter 4

(1)These pins will only be enabled after loading a specific patch from external EEPROM for L20. The patch is downloaded from PC to L20 and then stored into the EEPROM through the I2C interface.

3.2 Operating Modes

The table below briefly summarizes the various operating modes in the following chapters.

Table 6: Overview of operating modes

Mode	Function
Acquisition mode	The module starts to search satellite, determine visible satellites and coarse carrier frequency and code phase of satellite signals. When the acquisition is done, it switches to tracking mode automatically.
Tracking mode	The module refines acquisition's message, as well as keeps tracking and demodulating the navigation data from the specific satellites.
Hibernate mode	The module can be switched to hibernate mode by applying a pulse which consists of a rising edge and high level that persists for at least 1ms on the ON_OFF pin. This feature can only be enabled when a specific patch is loaded into L20.

3.3 Power Management

There are two power supply pins, VCC, V_BCKP, in L20 receiver.

3.3.1 VCC - Main Power

The main power supply is fed through the VCC pin. During operation, the current drawn by L20 GPS module can vary by some orders of magnitude. It is important that the system power supply circuitry is able to support the peak power. For this reason, the power supply must be able to provide sufficient current up to 100mA.

An LDO (Low Dropout Regulator) device is recommended for VCC.

3.3.2 V_BCKP - Backup Battery

The RTC (Real Time Clock) power supply of module can be directly provided by an external capacitor or battery (rechargeable or non-chargeable) through the V_BCKP pin, in order to achieve a better Time To First Fix (TTFF) after a power down. It can supply power for backed-up memory which contains all the necessary GPS information for quick start-up and a small amount of user configuration variables.

Note: The V_BCKP pin should be connected to a battery or a capacitor for GPS module hot start.

Table 7: Pin definition of the V_BCKP pin

Name	Pin	Function
V_BCKP	22	Backup voltage supply

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Please refer to the following figure for RTC backup:

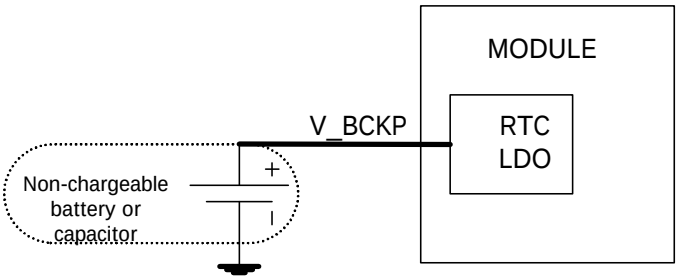

Figure 2: RTC supply from non-chargeable battery or capacitor

The V_BCKP pin does not implement charging for rechargeable battery. It is necessary to add a charging circuitry for rechargeable battery, shown as the following figure:

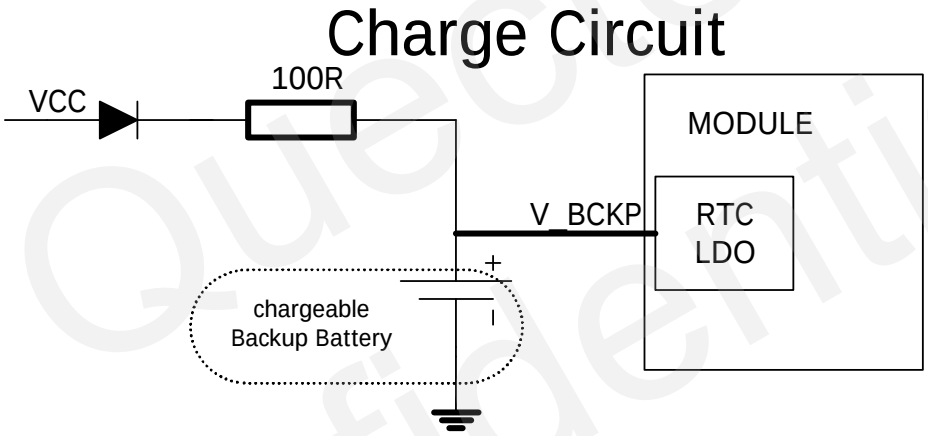

Figure 3: Reference charging circuit for chargeable battery

Coin-type Rechargeable Capacitor such as XH414H-IV01E form Seiko can be used and Schottky diode such as RB520S30T1G from ON Semiconductor is recommended to be used here for its low voltage drop.

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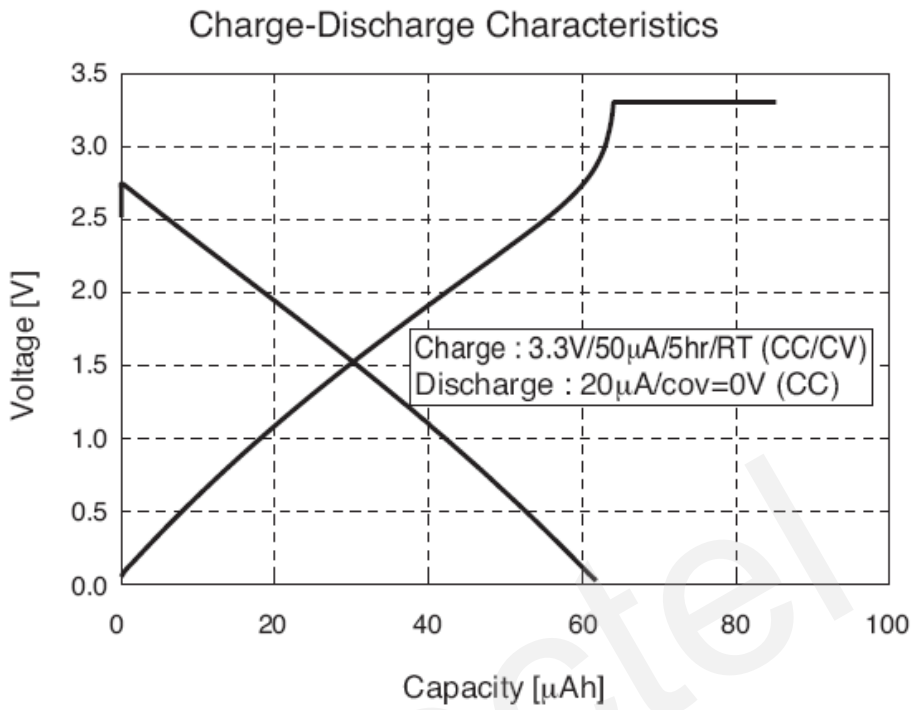

Figure 4: Seiko XH414H-IV01E charge characteristic

3.4 Communication Interface

L20 module uses UART interface to output NMEA messages or to communicate with the host processor via the OSP protocol.

3.4.1 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 signal (shown as Figure 5). It supports data baud-rate from 4800bps to 115200bps.

UART interface

- TXD1: Send data to the RXD signal line of DTE
- RXD1: Receive data from the TXD signal line of DTE

Table 8: Pin definition of the UART interfaces

Interface	Name	Pin	Function
UART Interface	TXD1	20	Transmit data
	RXD1	21	Receive data

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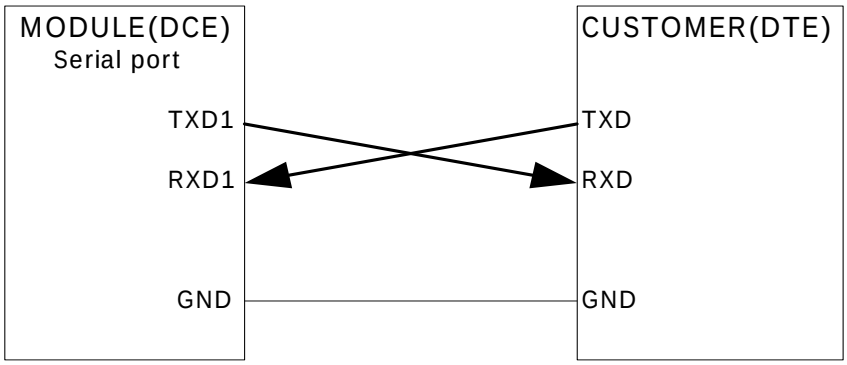

Figure 5: Connection of UART interface

This UART interface has the following features:

- The UART interface can be used to output NMEA and input & output OSP messages.
  The default output NMEA type setting is **RMC, GGA, GSA, and GSV (after successful positioning).**
- The UART interface supports the following data rates:
  4800, 9600, 14400, 19200, 28800, 38400, 57600, 115200.
  The default setting is 4800bps, 8 bits, no parity bit, 1 stop bit, no hardware flow control.
- Hardware flow control and synchronous operation are not supported.

Note: It is strongly recommended that the UART interface is used to output NMEA message to serial port of host process.

The UART interface does not support the RS-232 level. It supports only the TTL level. If the module UART interface is connected to the UART port of a computer, it is necessary to insert a level shift circuit between the module and the computer. Please refer to the following figure.

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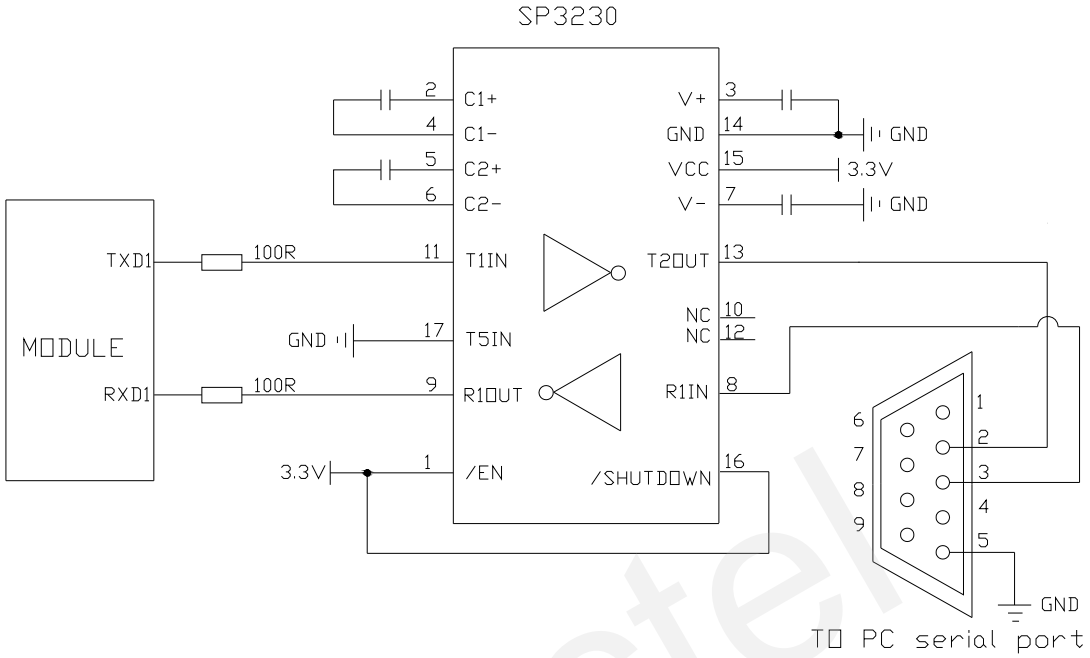

Figure 6: RS-232 level shift circuit

3.4.2 I2C Interface

L20 provides an I2C interface which can operate up to 400kbps to access an EEPROM where EE (extended ephemeris) data and updated patch code are stored.

Table 9: Pin definition of the I2C interfaces

Interface	Name	Pin	Function
I2C Interface	SDA2	18	Serial data output/input
	SCL2	19	Serial clock output

The SCL2 and SDA2 pins are open-drain output and pulled up to VCC internally by 2K resistors to satisfy the condition of maximum data rate up to 400Kbs.

3.5. Reference Design

Figure 7 is a reference design with L20 module.

The module will directly start when VCC is applied and it will automatically output NMEA messages.

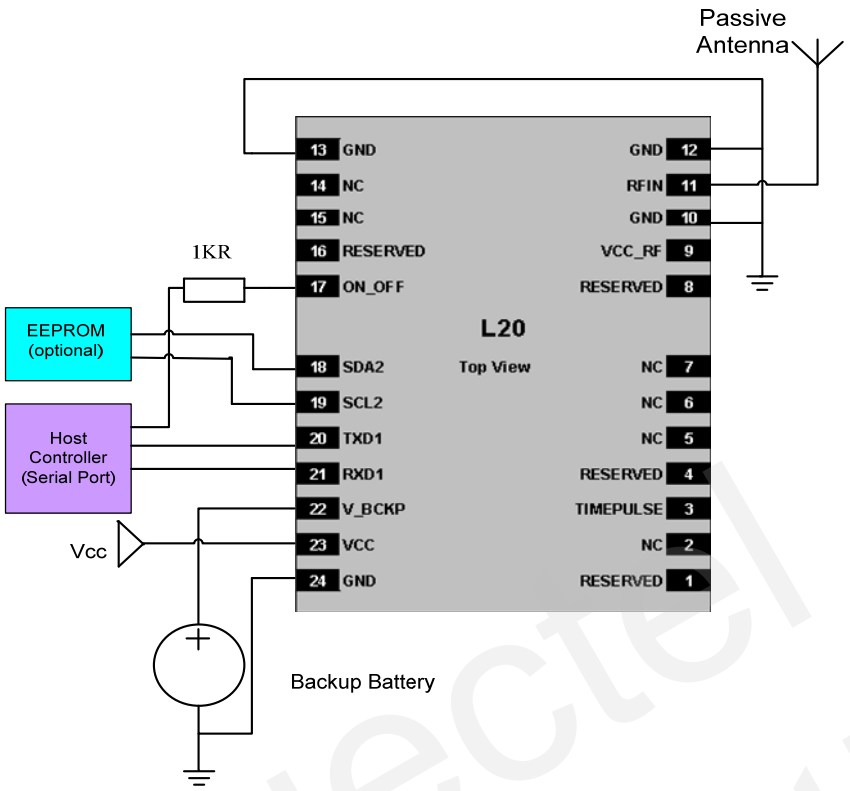

Figure 7: Reference design for L20 module

One point needs to be noticed here is that the L20's initial version of firmware, ROM 1.0, does not support the functionality of "ON_OFF" pin and "TIMEPULSE" pin. Only when a specific patch is loaded from external EEPROM, the pins' function mentioned will be enabled. Otherwise, customer can just ignore these 2 pins.

Furthermore, the new version of firmware, ROM2.0, will be released by SiRF in the second quarter 2011. The new one will support the pin definitions mentioned above.

The patch is created by SiRF and made available with descriptions of their contents and applicability. The patch is sent into L20 by PC using a specific downloading tool provided by SiRF and can be stored into an EEPROM if it is applied.

For detailed downloading procedure and how to apply patch to L20 from EEPROM when VCC is applied, please refer to document [3].

NOTE:
IF the "ON_OFF" pin is controlled by host controller, a 1KΩ resistor should be inserted between the GPIO of the controller and "ON_OFF" pin. Otherwise, the module might not properly start up.

4 Antenna Interface

L20 module receives L1 band signal from GPS satellites at a nominal frequency of 1575.42MHz. The RF signal is connected to the RF_IN pin. The input impedance of RF_IN is 50Ω.

4.1 Antenna

L20 module can be connected to passive or active antenna.

Table 10: Antenna specification for L20 module

Antenna type	Specification
Passive antenna	Center frequency: 1575.42 MHz Band Width: >20 MHz Gain: >0 dBi Polarization: RHCP or Linear
Active antenna	Center frequency: 1575.42 MHz Band Width: >5 MHz Minimum gain: 15-20dBi (compensate signal loss in RF cable) Maximum noise figure: 1.5dB Maximum gain: 50dBi Polarization: RHCP or Linear

4.2 Antenna Supply

4.2.1 Passive Antenna

Connecting a passive antenna does not require a DC bias voltage and can be connected to RF_IN pin directly. VCC_RF can be left open. It is always beneficial to reserve a passive matching network between the antenna and the RF_IN port of the module. Figure 8 is the reference design.

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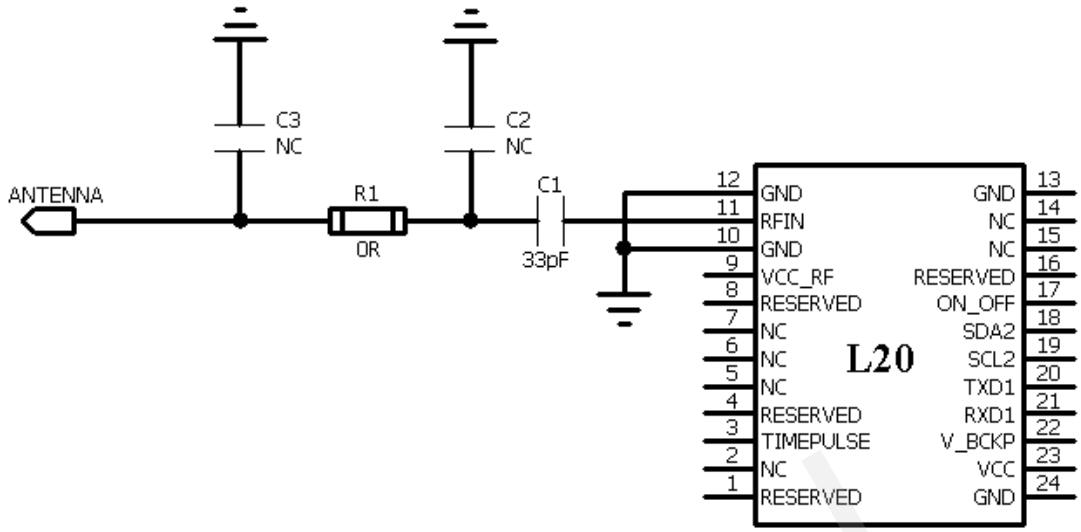

Figure 8: Reference design for passive antenna

4.2.2 Active Antenna

Active antenna, carrying an integrated low-noise amplifier, could be connected to RF_IN directly. If an active antenna is connected to RF_IN, the integrated low-noise amplifier of the antenna must be powered by a correct supply voltage. Usually, the supply voltage is fed to the antenna through the coaxial RF cable. An active antenna consumes current at 5~20mA. The inductor outside of the module prevents the RF signal from leaking into the VCC_RF pin and routes the bias supply to the active antenna.

The block diagram of the supply part for active antenna is shown in Figure 9.

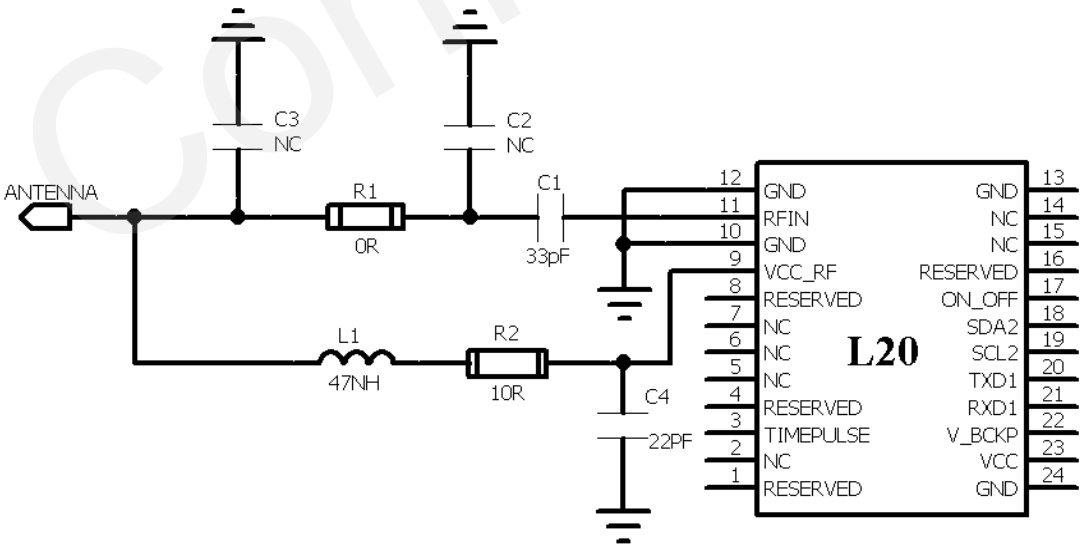

Figure 9: Reference design for active antenna with VCC_RF

The voltage of VCC_RF, which is the same as VCC, might not be suitable for the external active antenna. In this case, an external power supply should be applied. Please refer to the reference circuit shown in Figure 10.

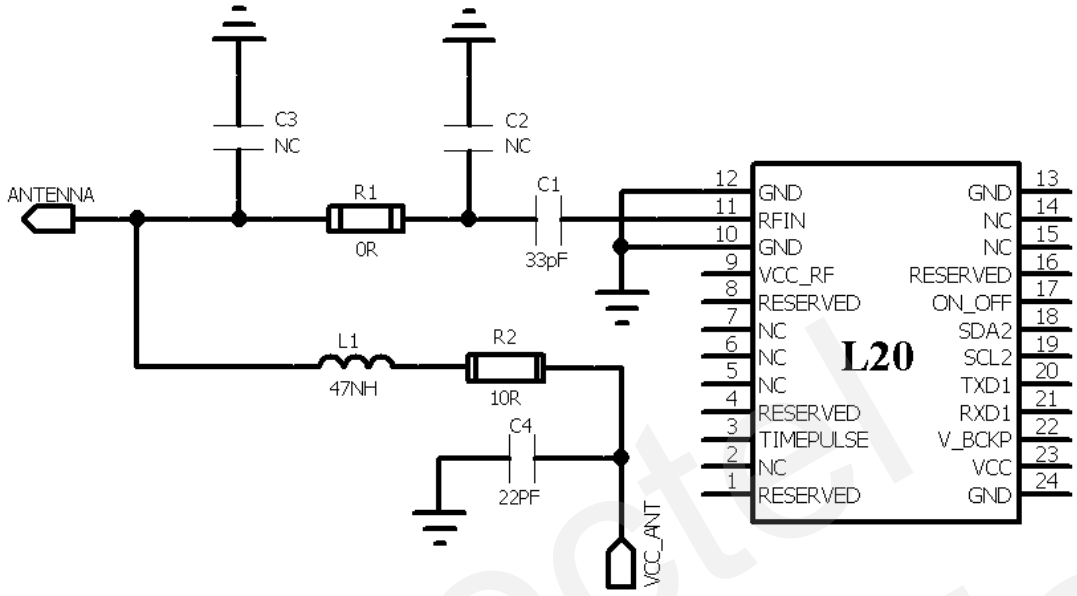

Figure 10: Reference design for active antenna with external power

Note: The rated power of resistor R2 should be chosen no less than 1 watt in case active antenna is shorted unexpectedly.

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5 Electrical, Reliability and Radio Characteristics

5.1 PIN Assignment of the Module

Table 11: L20 pin assignment

PIN No.	PIN NAME	I/O		PIN No.	PIN NAME	I/O
1	RESERVED			24	GND	
2	NC			23	VCC	I
3	TIMEPULSE	O		22	V_BCKP	I
4	RESERVED			21	RXD1	I
5	NC			20	TXD1	O
6	NC			19	SCL2	O
7	NC			18	SDA2	I/O
8	RESERVED			17	ON_OFF	I
9	VCC_RF	O		16	RESERVED	
10	GND			15	NC	
11	RF_IN	I		14	NC	
12	GND			13	GND	

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5.2 Absolute Maximum Ratings

Absolute maximum rating for power supply and voltage on digital pins of module are listed in Table 12.

Table 12: Absolute maximum ratings

Parameter	Min	Max	Unit
Power supply voltage （VCC）	-0.3	6	V
Backup battery voltage (V_BCKP)	-0.3	6	V
Input voltage at digital pins	-0.5	3.6	V
	-0.5	3.6	V
VCC_RF output current (Ivccrf)	—	100	mA
Input power at RF_IN (Prfin)	—	10	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.

5.3 Operating Conditions

Table 13: 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.	2.0	3.0	3.6	V
I_{VCCP}*	Peak supply current	VCC=3.0V	—	—	70	mA
V_BCKP	Backup voltage supply		2.0	3.0	3.6	V
I_{BCKP}	Backup battery current	V_BCKP=3.0V	—	68	—	uA
VCC_RF	Output voltage RF section		—	—	VCC	V
I_{VCC_RF}	VCC_RF output current		—	—	50	mA
T_{OPR}	Normal Operating temperature		-40	25	85	°C

**** Use this figure to determine the maximum current capability of power supply.***

Note: Operation beyond the "Operating Conditions" is not recommended and extended exposure beyond the "Operating Conditions" may affect device reliability.

5.4 Current Consumption

The values for current consumption are shown in Table 14.

Table 14: The module current consumption (passive antenna)

Parameter	Condition	Min	Typ	Max	Unit
Icc Acquisition		-	57	-	mA
Icc Tracking	For Cold Start, 10 minutes after First Fix. For Hot Start, 15 seconds after First Fix.	-	41	-	mA
Hibernate			TBD		uA

5.5 Electro-Static Discharge

Although the module is fully protected against ESD strike, 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 Table 15.

Table 15: The ESD endurance table (Temperature: 25°C, Humidity: 45 %)

Pin	Contact discharge	Air discharge
Antenna port	±5KV	±10KV
VCC, GND, RF_IN	±4KV	±8KV
Others	±4KV	±8KV

5.6 Reliability Test

Table 16: Reliability test

Test term	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,0.96m^2/s^3;20~500Hz,0.96m^2/s^3-3dB/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

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		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

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6 Mechanics

This chapter describes the mechanical dimensions of the module.

6.1 Mechanical Dimensions of the Module

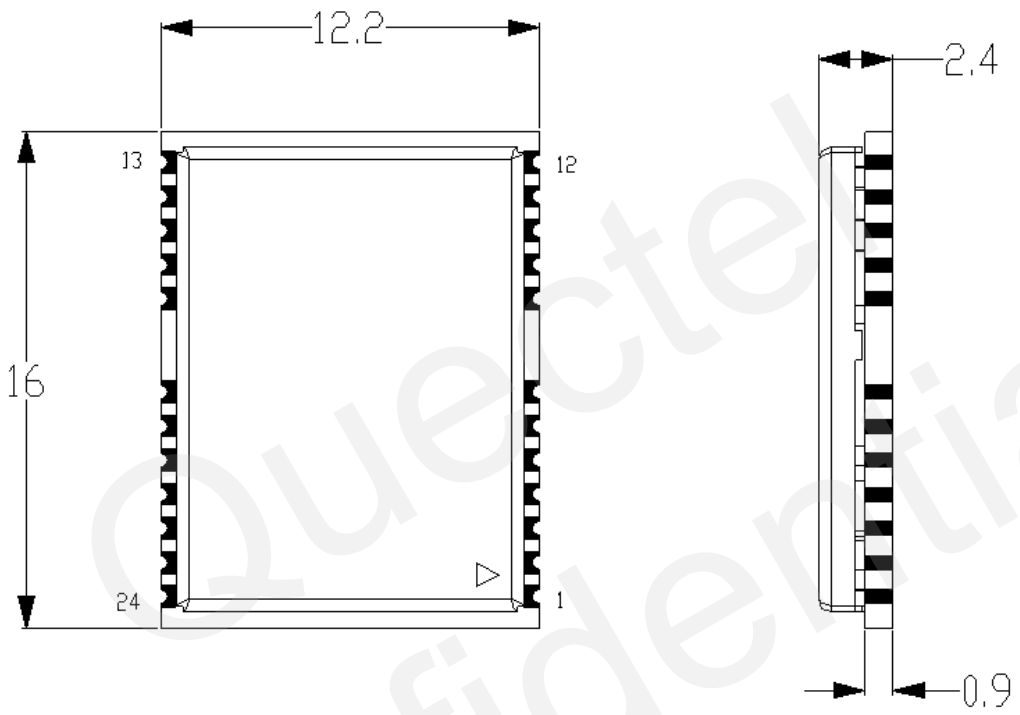

Figure 11: L20 Top view and Side dimensions（Unit:mm）

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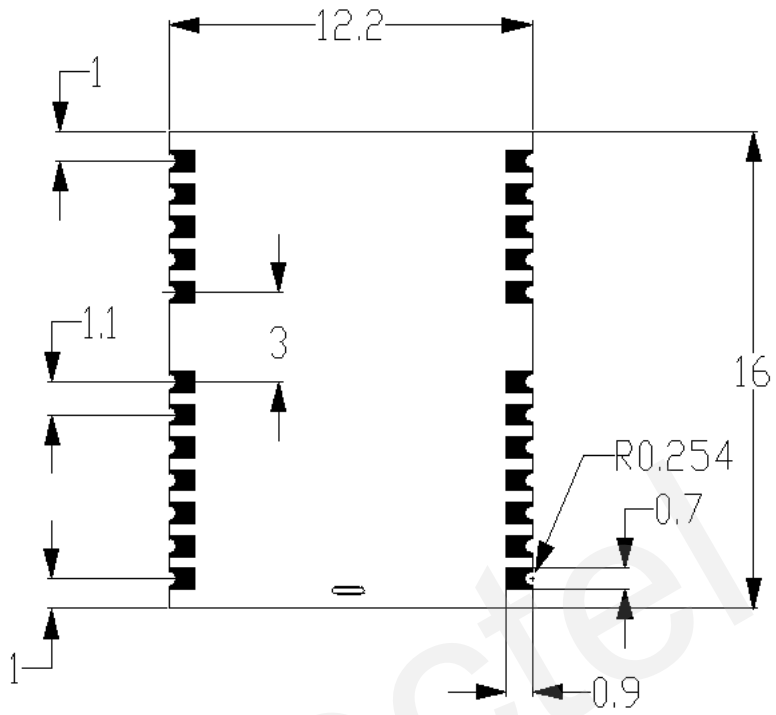

Figure 12: L20 Bottom dimensions（Unit:mm）

6.2 Footprint of Recommendation

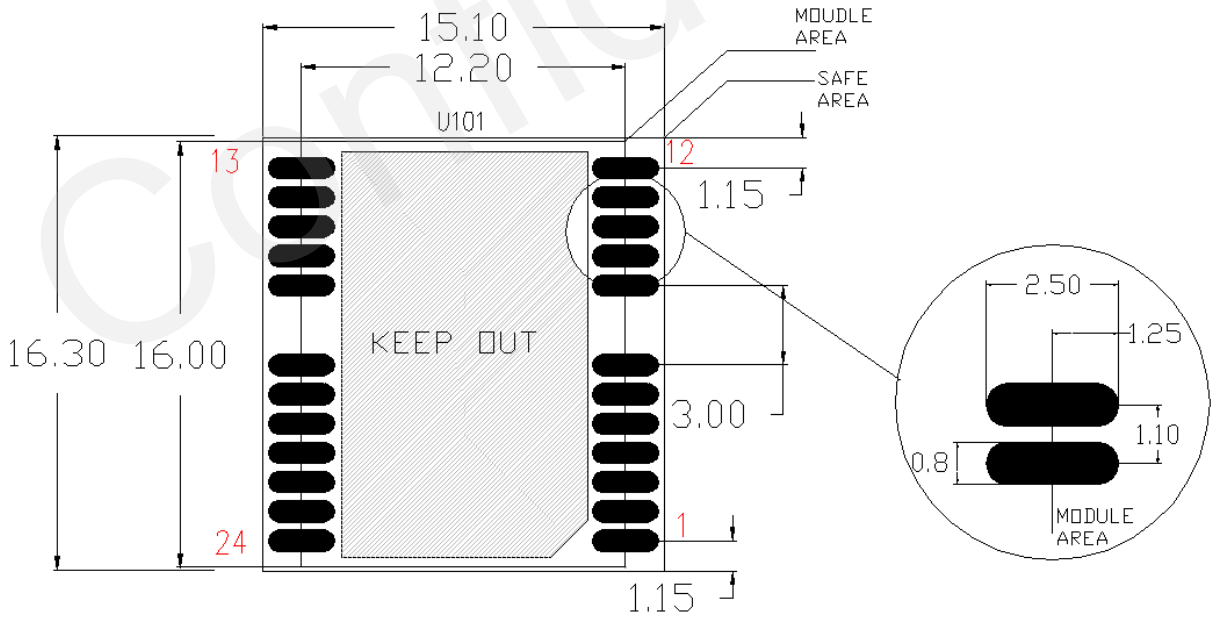

Figure 13: Footprint of recommendation（Unit:mm）

Note1：Keep out on the host board below the module and the keep-out area should be covered

by solder mask and top silk layer for isolation between the top layer of host board and the bottom layer of the module.

6.3 Top view of the module

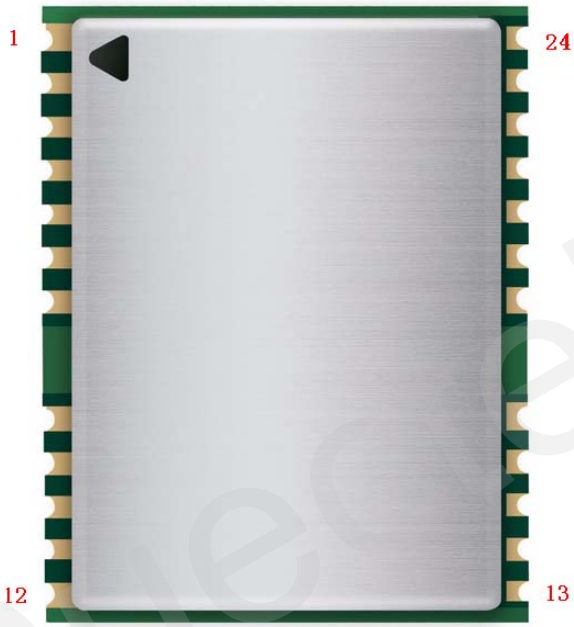

Figure 14: Top view of the module

6.4 Bottom view of the module

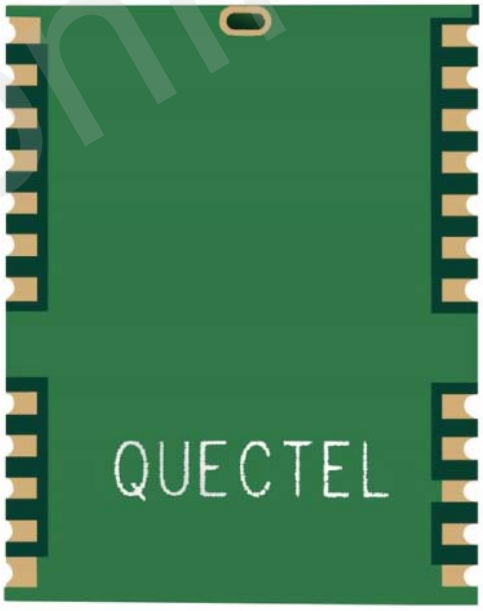

Figure 15: Bottom view of the module

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