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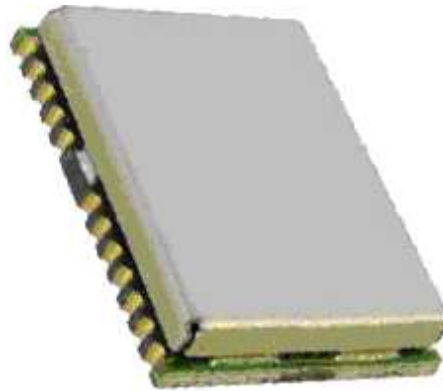
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GPS Receiver

Low-Power High-Performance and Low-Cost 65 Channel SMD GPS Module



Data Sheet

Version 1.4

Abstract

Technical data sheet describing the cost effective, high-performance GPS1513R based series of ultra high sensitive GPS modules.

The GPS1513R is a GPS module that is sensitive to *electrostatic dis-charge* (ESD). Please handle with appropriate care.

The Acceptability of Electronic Assemblies of the GPS1513R has been under IPC-A-610D specification.



Version History

Rev.	Date	Description
1.1	10-12-08	Initial Draft – preliminary information
1.2	01-20-09	Preliminary
1.3	15-04-09	Minor corrections
1.4	15-08-09	Application note

Note

Flash version supports the features;

1. Binary code (Configuration command programmable)
2. Selectable NMEA output data sentences
3. Selectable Serial Port Settings. (4800/9600/38400/115200bps. Default : 9600)
4. Selectable update rate (1 / 2 / 4 / 5 / 8 / 10 Hz update rate (ROM version only supports 1Hz default))
5. Firmware upgrade

1 Functional Description

1.1 Introduction

The GPS-1513R is a small form factor GPS module solution intended for a broad range of Original Equipment Manufacturer (OEM) products, where fast and easy system integration and minimal development risk is required.

The GPS-1513R GPS receiver's -161dBm tracking sensitivity allows continuous position coverage in nearly all application environments. Its high performance search engine is capable of testing 8,000,000 time-frequency hypotheses per second, offering industry-leading signal acquisition and TTFF speed.

The receiver is optimized for applications requiring high performance, low power, and low cost; suitable for a wide range of OEM configurations including mobile phone, PND, asset tracking, and vehicle navigation products.

The very small 13mm x 15.8mm form factor and the SMT pads allow standard surface mount device pick-and-place process in fully automated assembly process; enabling high-volume, very cost-efficient production.

1.2 Features

- 65 Channel GPS L1 C/A Code
- Perform 8 million time-frequency hypothesis testing per second
- Open sky hot start 1 sec
- Open sky cold start 29 sec
- Signal detection better than -161dBm
- Multipath detection and suppression
- Accuracy 2.5m CEP
- Maximum update rate 10Hz
- Tracking current ~23mA
- Supports active and passive antenna

1.3 Applications

- Automotive and Marine Navigation
- Automotive Navigator Tracking
- Emergency Locator
- Geographic Surveying
- Personal Positioning
- Sporting and Recreation

2 Characteristics

2.1 General Specification

Parameter	Specification
Receiver Type	65 Channels GPS L1 frequency, C/A Code
Time-To-First-Fix	Cold Start (Autonomous) 29s (Average, under open sky) Warm Start (Autonomous) 28s (Average, under open sky) Hot Start (Autonomous) 1s (Average, under open sky)
Sensitivity	Tracking & Navigation -161 dBm Reacquisition -158 dBm Cold Start (Autonomous) -148 dBm
Accuracy	Autonomous 2.5 m CEP Velocity 0.1 m/sec (without aid) Time 300 ns
Update Rate	Supports 1 / 2 / 4 / 5 / 8 / 10 Hz update rate (1Hz default)
Velocity Accuracy	0.1m/s
Heading Accuracy	0.5 degrees
Dynamics	4 G (39.2 m/sec)
Operational Limits	Velocity 515 m/s (1000 knots) Altitude <18000 meters (COCOM limit, either may be exceeded but not both)
Serial Interface	3.3V LVTTTL level
Datum User definable	Default WGS-84 User definable
Input Voltage	3.3V DC +/-10%
Input Current	~23mA tracking
Dimension	15.8mm L x 13mm W x2.8mm H
Weight	2g

Table 1: GPS-1513R general specification

*: GPGGA, GPGSA, GPGSV, GPRMC, GPVTG are default output message

2.2 Block Diagram

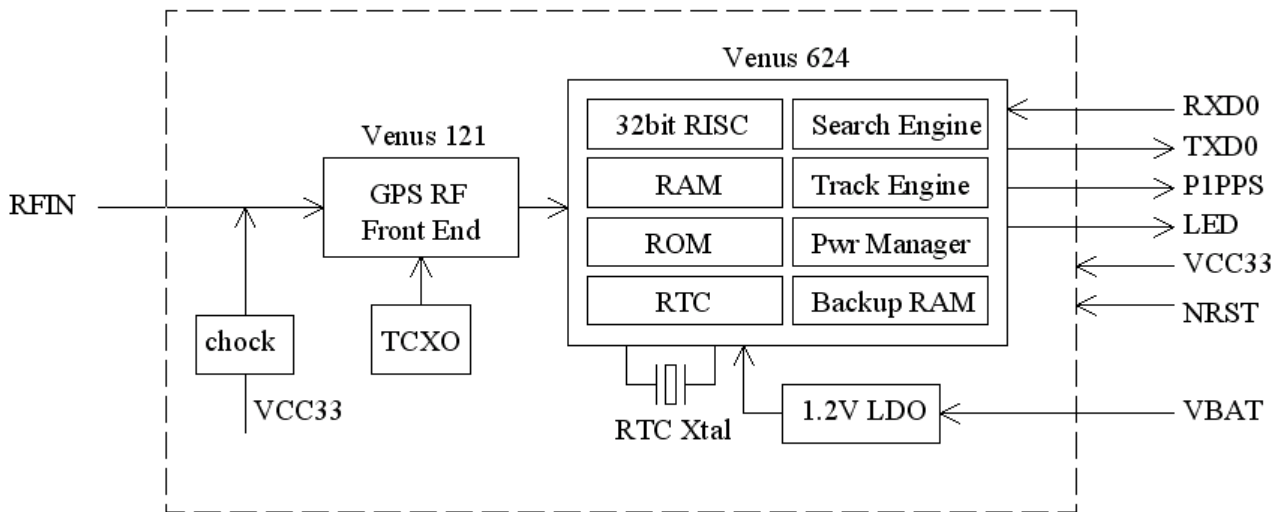


Figure 1: GPS-1513R Hardware Block Schematic

The GPS-1513R is a high performance GPS receiver in a compact surface mount package. It is based on the Venus 6 positioning technology, providing exceptional signal acquisition performance, and continuous operation even in dense foliage and urban canyons. The module includes internal SAW filter and high performance integrated LNA, works with both active and passive antenna. The simple UART serial interface and the standard NMEA-0183 protocol make using GPS-1513R very easy and straightforward.

The GPS-1513R performs all the necessary system initialization, satellite signal acquisition & tracking, data demodulation, and calculation of navigation solution autonomously. The position, velocity, time information in NMEA format is generated at user selectable update rate of 1 / 2 / 4 / 5 / 8 / 10 Hz.

2.2 Serial Port Settings

The default configuration within the standard GPS firmware is:

- Standard configuration of serial port:
- Supporting 4800/9600 baud rate (Default Value : 9600), 8 data bits, no parity, 1 stop bit, no flow control

2.3 Improved TTFF

In order to improve the TTFF (Time To First Fix), The system designer has to supply the power from the system to the Pin 5 V-bat to support the RTC with a back-up power when no system power is available.

2.4 Communication Specifications

Item	Description
Interface	Full duplex serial interface
Bit rate	4800/9600/38400/115200bps (Optional, Default 9600),
Start bit	1bit
Stop bit	1bit
Data bit	8bit
Parity	None
Transmission data	SACII NMEA0183 Ver:3.01
Update rate	1Hz
Output sentence	GGA/GSA/GSV/RMC/VTG (typ)

Table 2: Communication specifications

2.5 Multi-path Mitigation

Multipath refers to the existence of signals reflected from objects in the vicinity of a receiver's antenna that corrupt the direct line-of-sight signals from the GPS satellites, thus degrading the accuracy of both code-based and carrier phase-based measurements. Particularly difficult is close-in multipath in which the reflected secondary signals arrive only slightly later (within about 100 nanoseconds) than does the direct-path signal, having been reflected from objects only a short distance from the receiver antenna.

GPS-1513R deploys the advanced multi-path detection and suppression algorithm to reduce multipath errors, the GPS signals themselves can be designed to provide inherent resistance to multipath errors.

2.6 ELECTRICAL SPECIFICATIONS

Parameter	Minimum	Maximum	Condition
Supply Voltage (VCC33)	-0.5	3.6	Volt
Backup Battery Voltage (VBAT)	-0.5	3.6	Volt
Input Pin Voltage	-0.5	VCC+0.5	Volt
Input Power at RFIN		+5	dBm
Storage Temperature	-55	+100	degC

Table 4: Absolute Maximum Ratings

OPERATING CONDITIONS

Parameter	Min	Typ	Max	Unit
Supply Voltage (VCC33)	3	3.3	3.6	Volt
Acquisition Current (enhanced mode, exclude active antenna current)			75	mA
Acquisition Current (low power mode, exclude active antenna current)			55	mA
Tracking Current (exclude active antenna current)		28		mA
Backup Voltage (VBAT)	1.5		6	Volt
Backup Current (VCC33 voltage applied)			1.5	mA
Backup Current (VCC33 voltage off)			10	uA
Output Low Voltage			0.4	Volt
Output HIGH Voltage	2.4			Volt
Input LOW Voltage			0.8	Volt
Input HIGH Voltage	2			Volt
Input LOW Current	-10		10	uA
Input HIGH Current	-10		10	uA
RF Input Impedance (RFIN)		50		Ohm

Table 3: Operating Conditions

2.7 Antenna Consideration

A numbers of important properties of GNSS antennas affect functionality and performance, including;

- Frequency coverage
- Gain pattern
- Circular polarization
- Multipath suppression
- Phase Center
- Impact on receiver sensitivity
- Interference handling

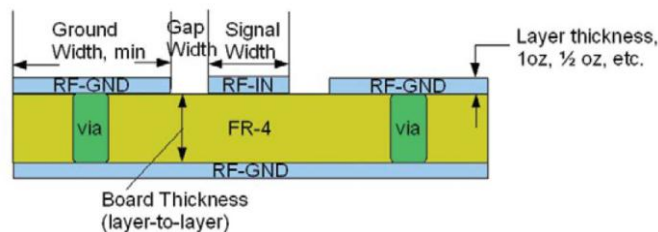
The GPS-1513R is designed to use with a wide variety of active and passive antennas, but care must be taken during antenna selection to ensure optimum signal reception performance. There are many choices of antenna configurations; the best choice is often a tradeoff between size, gain, bandwidth and cost. The best way is to test multiple antenna solutions in the configuration of the final system to determine which provides the best overall performance.

Ceramic patch antenna is low-cost and provides good sensitivity. 50-ohm output ceramic patch antenna can be connected directly to RF input of the module. Usually the antenna and GPS-1513R are mounted on opposite side of the PCB to reduce possibility of picking up digital noise. To improve signal reception performance, use larger ground plane under the patch antenna If possible; larger the ground plane, larger the overall antenna gain. The center frequency of the ceramic patch antenna changes with ground plane size. For optimal operation, center frequency needs to be 1575MHz when mounted on the PCB. It is usual to ask the ceramic patch antenna vendor to select or tune a patch antenna that best matches the customer PCB.

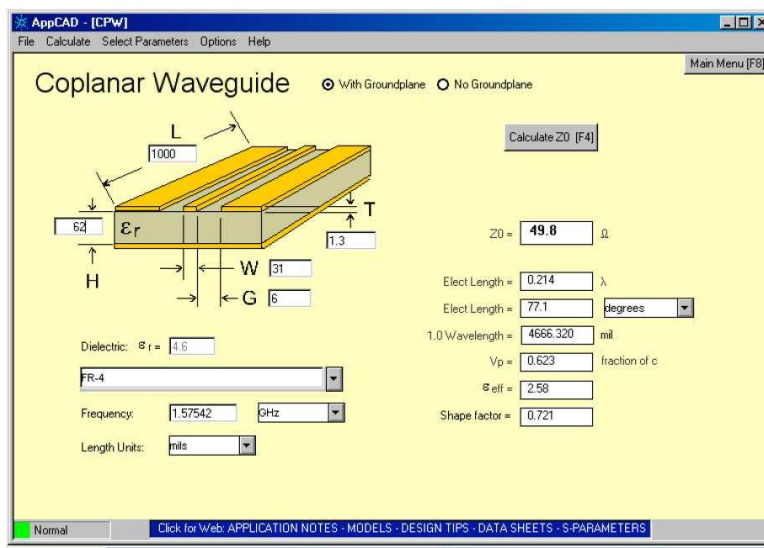
Active antenna is essentially a passive antenna with built-in LNA and a coaxial cable to connect the antenna to the module. It has the flexibility of being located remotely from the module, but requires antenna power. Active antenna usually costs more than passive patch antenna, but the performance in low signal environments is usually better. When using active antenna, an external bias choke inductor is used to provide DC bias for the active antenna. Active antenna with gain up to 30dB and noise figure less than 2dB can be used with GPS-1513R.

Chip antenna is often desired for its small size. Matching element of the chip antenna needs to be designed-in according to the chip antenna datasheet. If application doesn't have a large ground plane as shown in the datasheet for the measured performance spec condition, testing will be needed to determine if it can provide acceptable performance with the smaller sized application PCB.

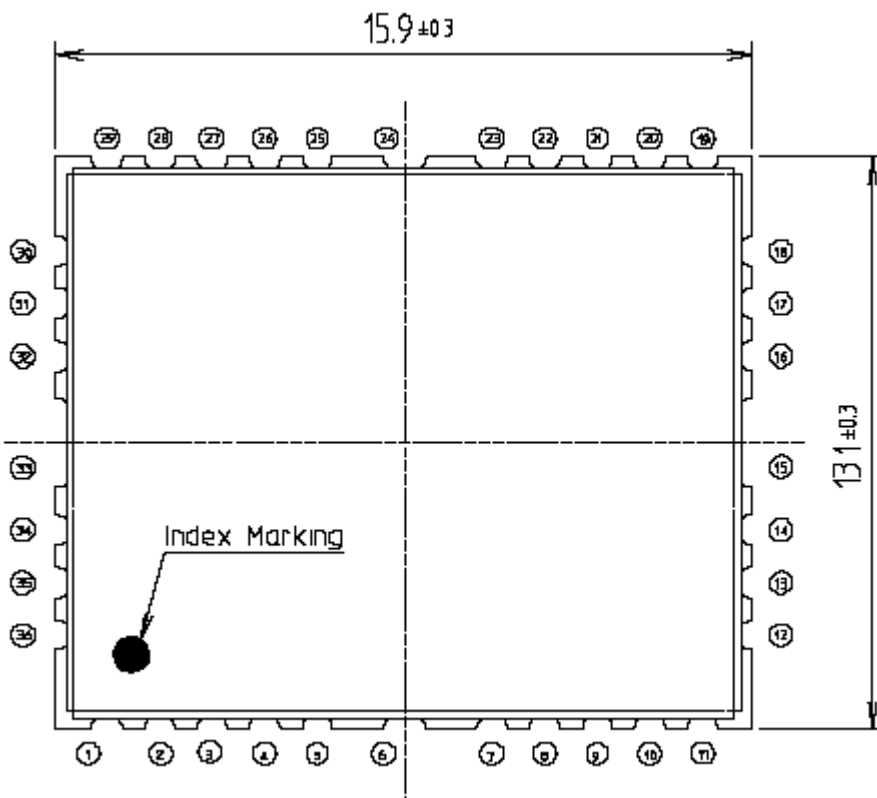
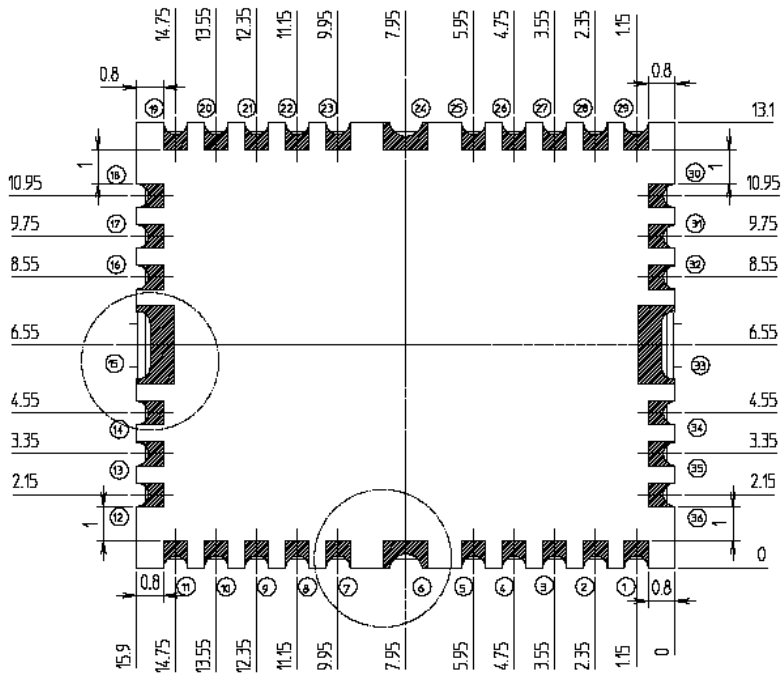
The signal path from antenna to RF input of GPS-1513R is the most critical part of application design. The goal is to provide optimal 50-ohm match between a 50Ω antenna and the module 50-ohm RF input for maximum power transfer. The 50-ohm grounded coplanar wave guide, consisting of the RF input signal with RF ground on either sides and a RF ground underneath, is a good choice for efficiency.



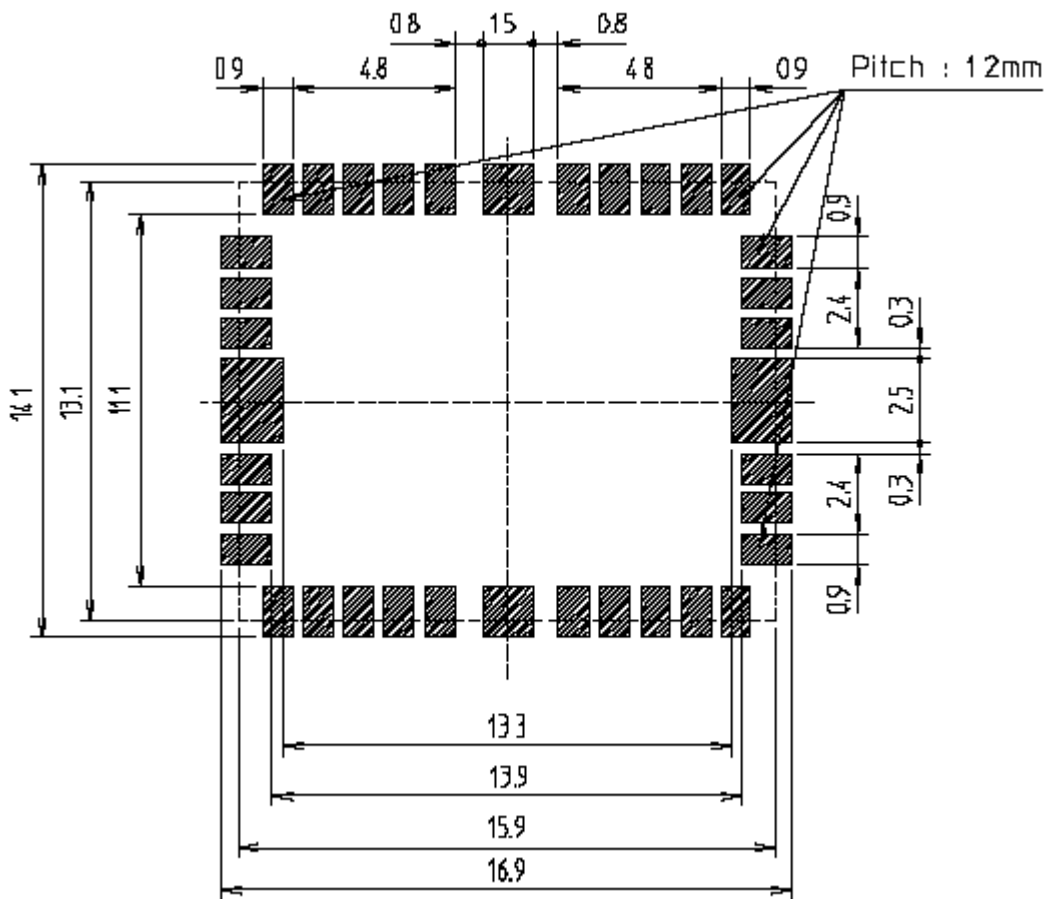
For a two-layer FR4 PCB design with 1.6mm thickness, 4.6 dielectric constant, and 1oz copper the RF-input trace should be 31mil in width, the gap to the adjacent grounds should be 6mil, and each of the RF grounds should be at least twice the width of the input signal trace (62mil). Freeware program such as AppCAD can be used to calculate values required for other configurations.



3. Mechanical Characteristics



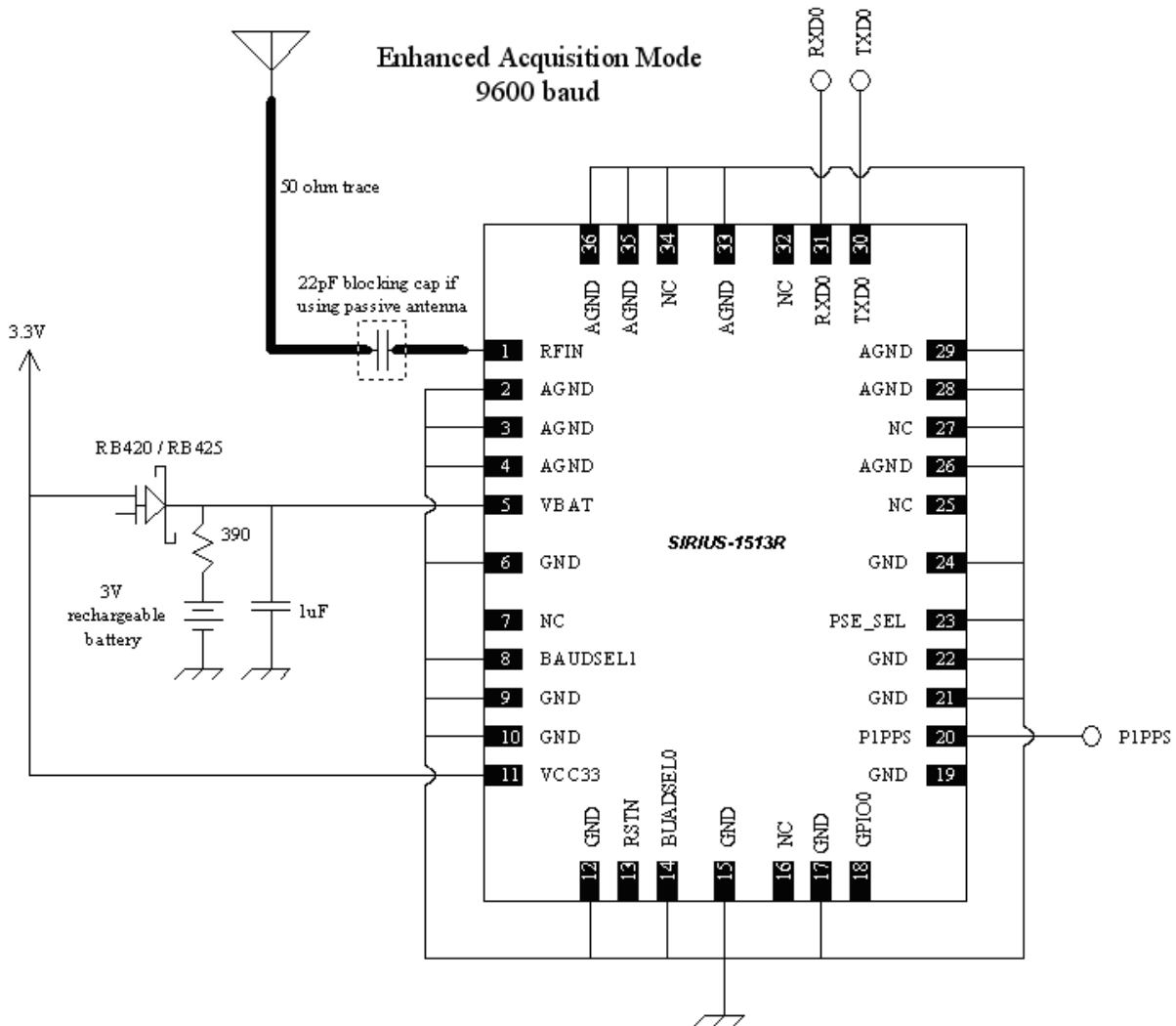
4. RECOMMENDED PCB FOOTPRINT



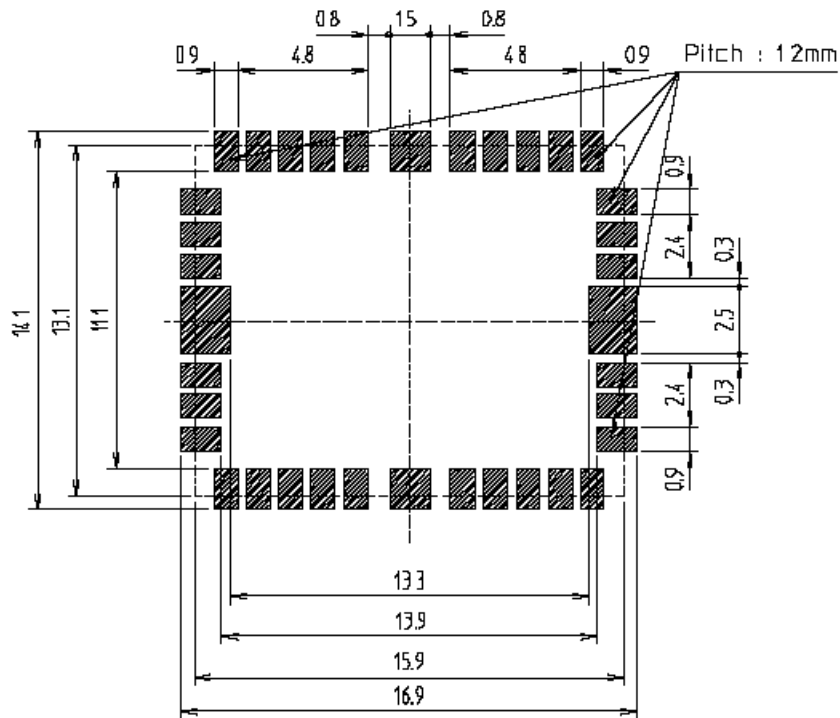
5. PINOUT DESCRIPTION

Pin No.	Name	Description
1	RFIN	GPS RF input, connect to antenna
2	AGND	Analog Ground
3	AGND	Analog Ground
4	AGND	Analog Ground
5	VBAT	Backup supply voltage for RTC and backup memory, minimum 1.5V
6	GND	Digital ground
7	NC	No connection
8	BaudSel1	Hardware baud rate selection input, used with BaudSel0. BaudSel[1:0] = 00 for 9600 baud, 01 for 4800 baud, 10 for 38400 baud, 11 for 115200 baud 3.3V LVTTTL
9	GND	Digital Ground
10	GND	Digital Ground
11	VCC33	Main 3.3V supply input
12	GND	Digital Ground
13	RSTN	External active-low reset input. Only needed when power supply rise time is very slow.
14	BaudSel0	Hardware baud rate selection input, used with BaudSel1 3.3V LVTTTL
15	GND	Digital ground
16	NC	No connection
17	GND	Digital Ground
18	LED	GPS status indicator. Active low.
19	GND	Digital Ground
20	P1PPS	1 pulse per second time mark
21	GND	Digital Ground
22	GND	Digital Ground
23	PSE_SEL	Search engine mode selection 1: low power acquisition mode 0: enhanced acquisition mode 3.3V LVTTTL
24	GND	Digital ground
25	NC	No connection
26	AGND	Analog Ground
27	NC	No connection
28	AGND	Analog Ground
29	AGND	Analog Ground
30	TXD0	UART output, 3.3V LVTTTL
31	RXD0	UART input, 3.3V LVTTTL
32	NC	No connection
33	AGND	Analog ground
34	NC	No connection
35	AGND	Analog Ground
36	AGND	Analog Ground

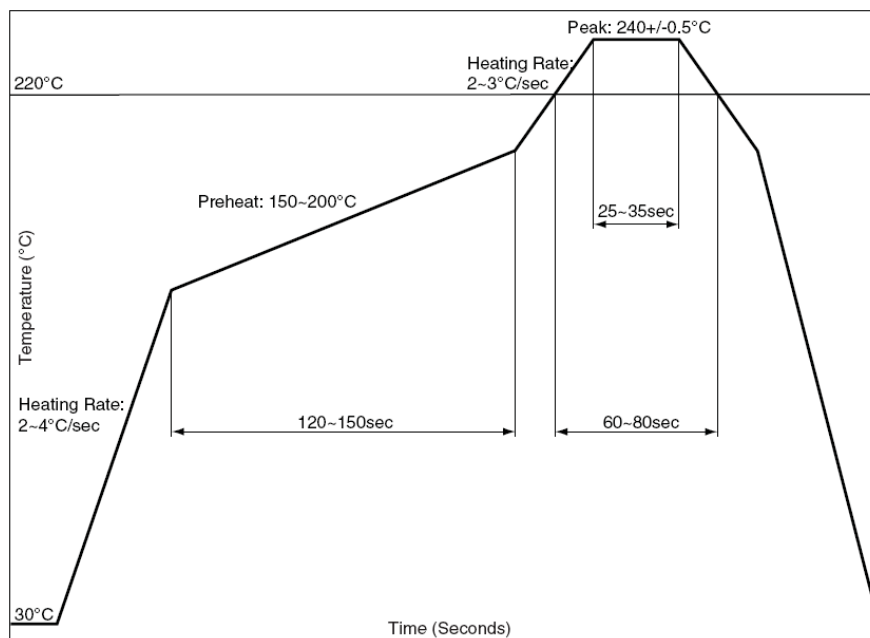
6. APPLICATION CIRCUIT



7. RECOMMENDED PCB FOOTPRINT



8. RECOMMENDED REFLOW PROFILE



The reflow profile shown above should not be exceeded, since excessive temperatures or transport times during reflow can damage the module.

Cooling temperature fall rate: max 3°C / sec

9. POWER SUPPLY REQUIREMENT

GPS-1513R requires a stable power supply, avoid ripple on VCC pin (<50mVpp). Power supply noise can affect the receiver's sensitivity. Bypass capacitors should be placed close to the module VCC33 pin, with values adjusted depending on the amount and type of noise present on the supply line.

10. BACKUP SUPPLY

The purpose of backup supply voltage pin (VBAT) is to keep the SRAM memory and the RTC powered when the module is powered down. This enables the module to have a faster time-to-first-fix when the module is powered on again. The backup current drain is less than 10µA. In normal powered on state, the internal processor access the SRAM and current drain is higher in active mode

11. 1 PPS OUTPUT

A 1 pulse per second signal (4ms HIGH duration) is generated on 1PPS pin when the receiver has 3D position fix using 4 or more satellites. The rising edge of the pulse is aligned with UTC second, with accuracy of about 300nsec. It outputs constant LOW when no position fix is available.

12. Environmental Conditions

Parameter		Specification
Temperature	Operating	-40°C~+85°C
	Storage	-55°C~+100°C
Humidity		5%~95%
Storage		6 months in original vacuum package.

Table 6: Environmental conditions

NMEA protocol

The serial interface protocol is based on the National Marine Electronics Association's NMEA 0183 ASCII interface specification. This standard is fully define in "NMEA 0183, Version 3.01" The standard may be obtained from NMEA, www.nmea.org

GGA-GLOBAL POSITIONING SYSTEM FIX DATA

Time, position and fix related data for a GPS receiver.

Structure:

```
$GPGGA,hhmmss.sss,ddmm.mmmm,a,dddmm.mmmm,a,x,xx,x.x,x.x,M,x.x,M,x.x,xxxx*hh<CR><LF>
```

1 2 3 4 5 6 7 8 9 10 11 12 13

Example:

```
$GPGGA,060932.448,2447.0959,N,12100.5204,E,1,08,1.1,108.7,M,,,0000*0E<CR><LF>
```

Field	Name	Example	Description
1	UTC Time	060932.448	UTC of position in hhmmss.sss format, (000000.00 ~ 235959.99)
2	Latitude	2447.0959	Latitude in ddmm.mmmm format Leading zeros transmitted
3	N/S Indicator	N	Latitude hemisphere indicator, 'N' = North, 'S' = South
4	Longitude	12100.5204	Longitude in dddmm.mmmm format Leading zeros transmitted
5	E/W Indicator	E	Longitude hemisphere indicator, 'E' = East, 'W' = West
6	GPS quality indicator	1	GPS quality indicator 0: position fix unavailable 1: valid position fix, SPS mode 2: valid position fix, differential GPS mode 3: GPS PPS Mode, fix valid 4: Real Time Kinematic. System used in RTK mode with fixed integers 5: Float RTK. Satellite system used in RTK mode. Floating integers 6: Estimated (dead reckoning) Mode 7: Manual Input Mode 8: Simulator Mode

7	Satellites Used	08	Number of satellites in use, (00 ~ 12)
8	HDOP	1.1	Horizontal dilution of precision, (00.0 ~ 99.9)
9	Altitude	108.7	mean sea level (geoid), (-9999.9 ~ 17999.9)
10	Geoid Separation		Geoid separation in meters according to WGS-84 ellipsoid (-999.9 ~ 9999.9)
11	DGPS Age		Age of DGPS data since last valid RTCM transmission in xxx format (seconds) NULL when DGPS not used
12	DGPS Station ID	0000	Differential reference station ID, 0000 ~ 1023 NULL when DGPS not used
13	Checksum	0E	

Note: The checksum field starts with a '*' and consists of 2 characters representing a hex number. The checksum is the exclusive OR of all characters between '\$' and '*'.

GLL - LATITUDE AND LONGITUDE, WITH TIME OF POSITION FIX AND STATUS

Latitude and longitude of current position, time, and status.

Structure:

\$GPGLL,ddmm.mmmm,a,dddmm.mmmm,a,hhmmss.sss,A,a*hh<CR><LF>

1 2 3 4 5 6 7 8

Example:

\$GPGLL,4250.5589,S,14718.5084,E,092204.999,A,A*2D<CR><LF>

Field	Name	Example	Description
1	Latitude	4250.5589	Latitude in ddmm.mmmm format Leading zeros transmitted
2	N/S Indicator	S	Latitude hemisphere indicator 'N' = North 'S' = South
3	Longitude	14718.5084	Longitude in dddmm.mmmm format Leading zeros transmitted
4	E/W Indicator	E	Longitude hemisphere indicator 'E' = East 'W' = West
5	UTC Time	092204.999	UTC time in hhmmss.sss format (000000.00 ~ 235959.99)
6	Status	A	Status, 'A' = Data valid, 'V' = Data not valid
7	Mode Indicator	A	Mode indicator 'N' = Data not valid 'A' = Autonomous mode 'D' = Differential mode 'E' = Estimated (dead reckoning) mode 'M' = Manual input mode 'S' = Simulator mode
8	Checksum	2D	

GSA - GPS DOP AND ACTIVE SATELLITES

GPS receiver operating mode, satellites used in the navigation solution reported by the GGA or GNS sentence and DOP values.

Structure:

```
$GPGSA,A,x,xx,xx,xx,xx,xx,xx,xx,xx,xx,xx,xx,x,x,x,x,x*hh<CR><LF>
```

1 2 3 3 3 3 3 3 3 3 3 3 3 4 5 6 7

Example:

```
$GPGSA,A,3,01,20,19,13,,,,,,,,,40.4,24.4,32.2*0A<CR><LF>
```

Field	Name	Example	Description
1	Mode	A	Mode 'M' = Manual, forced to operate in 2D or 3D mode 'A' = Automatic, allowed to automatically switch 2D/3D
2	Mode	3	Fix type 1 = Fix not available 2 = 2D 3 = 3D
3	Satellite used 1~12	01,20,19,13,,,,,,,,	Satellite ID number, 01 to 32, of satellite used in solution, up to 12 transmitted
4	PDOP	40.4	Position dilution of precision (00.0 to 99.9)
5	HDOP	24.4	Horizontal dilution of precision (00.0 to 99.9)
6	VDOP	32.2	Vertical dilution of precision (00.0 to 99.9)
7	Checksum	0A	

GSV - GPS SATELLITE IN VIEW

Numbers of satellites in view, PRN number, elevation angle, azimuth angle, and C/No. Four satellites details are transmitted per message. Additional satellite in view information is send in subsequent GSV messages.

Structure:

```
$GPGSV,x,x,xx,xx,xx,xxx,xx,....,xx,xx,xxx,xx *hh<CR><LF>  
  1 2 3 4 5 6 7 4 5 6 7 8
```

Example:

```
$GPGSV,3,1,09,28,81,225,41,24,66,323,44,20,48,066,43,17,45,336,41*78<CR><LF>
```

```
$GPGSV,3,2,09,07,36,321,45,04,36,257,39,11,20,050,41,08,18,208,43*77<CR><LF>
```

Field	Name	Example	Description
1	Number of message	3	Total number of GSV messages to be transmitted (1-3)
2	Sequence number	1	Sequence number of current GSV message
3	Satellites in view	09	Total number of satellites in view (00 ~ 12)
4	Satellite ID	28	Satellite ID number, GPS: 01 ~ 32, SBAS: 33 ~ 64 (33 = PRN120)
5	Elevation	81	Satellite elevation in degrees, (00 ~ 90)
6	Azimuth	225	Satellite azimuth angle in degrees, (000 ~ 359)
7	SNR	41	C/No in dB (00 ~ 99) Null when not tracking
8	Checksum	78	

RMC - RECOMMENDED MINIMUM SPECIFIC GPS/TRANSIT DATA

Time, date, position, course and speed data provided by a GNSS navigation receiver.

Structure:

```
$GPRMC,hhmmss.sss,A,dddmm.mmmm,a,dddmm.mmmm,a,x.x,x.x,ddmmyy,x.x,a*hh<CR><<LF>
```

1 2 3 4 5 6 7 8 9 10 11 12 13

Example:

```
$GPRMC,092204.999,A,4250.5589,S,14718.5084,E,0.00,89.68,211200,,A*25<CR><<LF>
```

Field	Name	Example	Description
1	UTC time	092204.999	UTC time in hhmmss.sss format (000000.00 ~ 235959.999)
2	Status	A	Status 'V' = Navigation receiver warning 'A' = Data Valid
3	Latitude	4250.5589	Latitude in dddmm.mmmm format Leading zeros transmitted
4	N/S indicator	S	Latitude hemisphere indicator 'N' = North 'S' = South
5	Longitude	14718.5084	Longitude in dddmm.mmmm format Leading zeros transmitted
6	E/W Indicator	E	Longitude hemisphere indicator 'E' = East 'W' = West
7	Speed over ground	000.0	Speed over ground in knots (000.0 ~ 999.9)
8	Course over ground	000.0	Course over ground in degrees (000.0 ~ 359.9)
9	UTC Date	211200	UTC date of position fix, ddmmyy format
10	Magnetic variation		Magnetic variation in degrees (000.0 ~ 180.0)
11	Magnetic Variation		Magnetic variation direction 'E' = East 'W' = West
12	Mode indicator	A	Mode indicator 'N' = Data not valid 'A' = Autonomous mode 'D' = Differential mode 'E' = Estimated (dead reckoning) mode 'M' = Manual input mode 'S' = Simulator mode
13	checksum	25	

VTG - COURSE OVER GROUND AND GROUND SPEED

The Actual course and speed relative to the ground.

Structure:

GPVTG,x.x,T,x.x,M,x.x,N,x.x,K,a*hh<CR><LF>

1 2 3 4 5 6

Example:

\$GPVTG,89.68,T,,M,0.00,N,0.0,K,A*5F<CR><LF>

Field	Name	Example	Description
1	Course	89.68	True course over ground in degrees (000.0 ~ 359.9)
2	Course		Magnetic course over ground in degrees (000.0 ~ 359.9)
3	Speed	0.00	Speed over ground in knots (000.0 ~ 999.9)
4	Speed	0.00	Speed over ground in kilometers per hour (0000.0 ~ 1800.0)
5	Mode	A	Mode indicator 'N' = not valid 'A' = Autonomous mode 'D' = Differential mode 'E' = Estimated (dead reckoning) mode 'M' = Manual input mode 'S' = Simulator mode
6	Checksum	5F	

ZDA- TIME AND DATE

Structure:

\$GPRMC,hhmmss.sss,dd,mm.yyyy, , ,xxx<CR><LF>

1 2 3 4 5 6 7

Example:

\$GPZDA,104548.04,25,03,2004,,*6C<CR><LF>

Field	Name	Example	Description
1	UTC time	104548.04	UTC time in hhmmss.ss format, 000000.00 ~ 235959.99
2	UTC time: day	25	UTC time day (01 ... 31)
3	UTC time: month	03	UTC time: month (01 ... 12)
4	UTC time: year	2004	UTC time: year (4 digit year)
5			Local zone hour Not being output by the receiver (NULL)
6			Local zone minutes Not being output by the receiver (NULL)
7	6C	6C	Checksum

6. Contact Information

We hope this datasheet will be helpful to the user to get the most out of the GPS module, furthermore feedback inputs about errors or mistakable verbalizations and comments or proposals to RF Solutions Ltd.. for further improvements are highly appreciated.

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