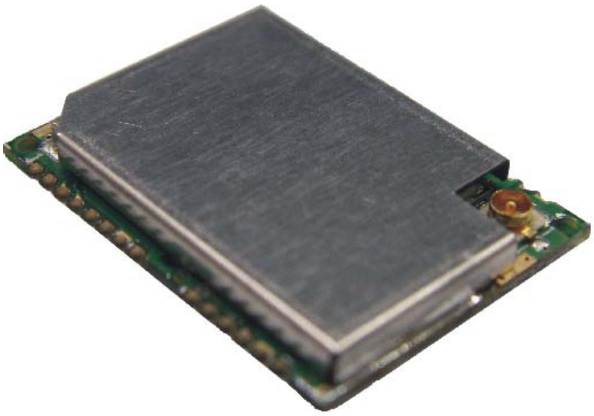
GPS Engine Board Manual

S-91

SiRF StarⅢ

V 1.0



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1. Introduction

1.1 Overview

The **Dagama** S-91 is a tiny, low-power, ultra-high performance, easy to use SMT mountable GPS receiver module based on SiRF's latest third generation single chip. Its small size/low power consumption/high performance enables the adoption of small handheld applications such as personal navigation device, PDA, GPS watch, personal locator etc. Its SMT design allows automatic pick and place assembly process. Additional convenient features of S-91 make it the best choice of GPS application. In addition to the active and passive antenna support via pin RF_IN, an on-board I-PEX connector to GPS antenna eliminates the complex performance tuning process. Just plug an antenna to the I-PEX connector and the solution is ready for use. It reduces the development efforts and shortens the development time. For active antenna applications, the built-in antenna surveillance not only reports the anomaly of short circuit (accidental events) and open circuit (malicious cut of antenna) but also protects the device. Not only the built-in software power saving mechanism, it also supports hardware power saving via pin PWR_CTRL to fully cut off the power supply of S-91.

1.2 Main Features

Not only handheld but also any other GPS applications can share the following major features of S-91.

★ Full implementation of ultra-high performance SiRFstarIII single chip architecture

★ High tracking sensitivity of -159dBm

★ Low power consumption of 40mA at full tracking

★ Ultra-small size of 17 (W) x 22.4 (L) x 2.4 (H) (mm)

★ Additional hardware power saving control pin

★ Active and passive antenna support via pin RF_IN

★ Additional I-PEX connector eliminates the efforts of RF performance tuning

★ Backup power supply pin for hot/warm starts and better performance

★ Embedded ARM7 CPU is available for external applications

★ SMT automatic pick and place assembly support to reduce production cost

★ Firmware upgradeable for future potential performance enhancements

★ Fully shielded for EMC protection

★ Active antenna surveillance and protection (optional)

1.3. Technical Specifications

1.3.1. Electrical Characteristics

◆ GPS receiver type	20 channels, L1 frequency, C/A code
◆ Horizontal Position Accuracy	< 2.5m (Autonomous) < 2.0m (WAAS) (50% 24hr static, -130dBm)
◆ Velocity Accuracy	<0.01 m/s (speed) <0.01° (heading) (50%@30m/s)
◆ Time accuracy	1µs or less
◆ TTFF (Time to First Fix) (50%, -130dBm, autonomous)	Hot Start: 1s Warm Start: 35s Cold Start: 42s
◆ Sensitivity (Autonomous)	Tracking: –159dBm Acquisition: -142dBm (-142dBm 28dB-Hz with 4dB noise figure)
◆ Measurement data output	Update time: 1 second NMEA output protocol: V.3.00 Baud rate: 4800 (default), 9600, 19200, 38400, 57600 bps (8-N-1) Datum: WGS-84 Default: GGA, GSA, RMC, VTG at 1Hz and GSV at 1/5Hz Other options: GLL, ZDA, or SiRF binary
◆ Max. Altitude	<18,000 m
◆ Max. Velocity	<1,852 km/hr
◆ SBAS Support	WAAS, EGNOS

◆ Dynamics <4g

◆ Power consumption 40mA, continuous tracking mode

◆ Power supply 3.3V

◆ Dimension single side 17.0(W) x 22.4(L) x 2.4(H) mm

◆ Operating temperature range -40 °C to +85 °C

◆ Storage temperature range -45 °C to +100 °C

1.4 Protocols

Both NMEA and SiRF binary protocols could be supported via serial UART I/O port – RXA/TXA. The default supported protocol is NMEA protocol.

1. Serial communication channel
   i. No parity, 8-data bit, 1-stop bit (N-8-1)
   ii. User selectable baud rate among 4800, 9600, 19200, 38400, and 57600 (default 4800) bps.
2. NMEA 0183 Version 3.00 ASCII output
   i. Default GGA (1 sec), GSA (1 sec), GSV (5 sec), RMC (1 sec), VTG (1 sec)
   ii. Optional GLL, ZDA

1.5 Programming Resources

The GPS receiver is embedded an internal ARM7 SOC. Its programming resources are available through the use of SDK from SiRF. Following are its related programming resources:

◆ 50-MHz ARM7TDMI processor

◆ 1 Mb SRAM

◆ 4 Mb flash memory

Please note that the receiver itself will use part of above resources.

1.6 Antenna

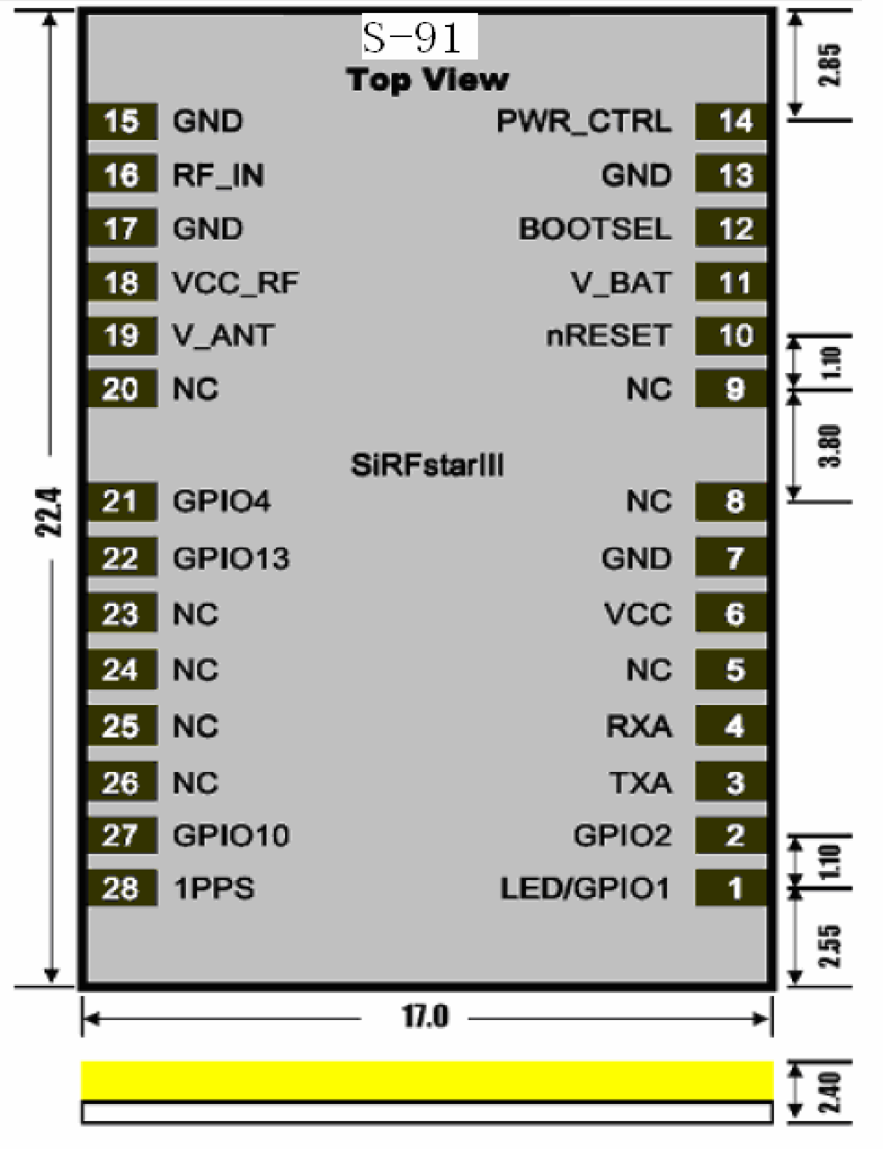
Antenna Type	Passive or active antenna via pin RF_IN, or External antenna via I-PEX connector	
Active Antenna Recommendation	Minimum gain	18d B
	Maximum noise figure	1.5dB

Antenna Supply	Using VCC_RF or external power source	
Antenna Supervisor	Short circuit detection	Built-in
	Short circuit protection	Built-in
	Short circuit report via GPIO	Built-in
	Short circuit report via NMEA	Built-in
	Open circuit detection	Built-in
	Open circuit report via GPIO	Built-in
	Open circuit report via NMEA	Built-in

2 Hardware Interface

2.1 PCB Dimension

The dimension of S-91 is 17 mm (W) x 22.4 mm (L) x 2.4 mm (H).



2.2 Pin Assignment

28-pin Interface

Pin	Name	Function	I/O
1	LED/GPIO1	LED display for position fixing status or General Purpose I/O control pin 1. Default for LED indication: Always "High" before position is fixed; Alternating "High" "Low" if position has fixed.	Output or I/O
2	GPIO2	General Purpose I/O control pin 2	-
3	TXA	Port A serial data output (from GPS); N-8-1, NMEA v3.00 output	Output
4	RXA	Port A serial data input (to GPS); N-8-1, accepts commands from external applications, e.g. SiRFDemo.	Input
5	NC	No connection	-
6	VCC	Main power supply of 3.3 ± 0.3VDC. 3.3VDC is the standard suggestion. This power is also used to keep the power of clock and fixing data.	Input
7	GND	Ground	Input
8	NC	No connection	-
9	NC	No connection	-
10	nRESET	Engine board reset input signal, active low, at least 250ms. This pin could be connected to a micro-processor's GPIO pin to control the reset of the engine board. A low signal of 250ms will reset it and re-start the acquisition process again. It may be left open if it is not used.	Input
11	V_BAT	2.0~3.6VDC backup battery connection for RTC and internal RAM - This pin is the source of the backup power supply. It allows the time and fixing data to be kept while the main power (VCC) is cut off. The time and fixing data could be used to help reduce the time to first fix (TTFF). - A power source could be connected to this pin directly. It inputs the power to keep clock and fixing data.	Power Input or Output

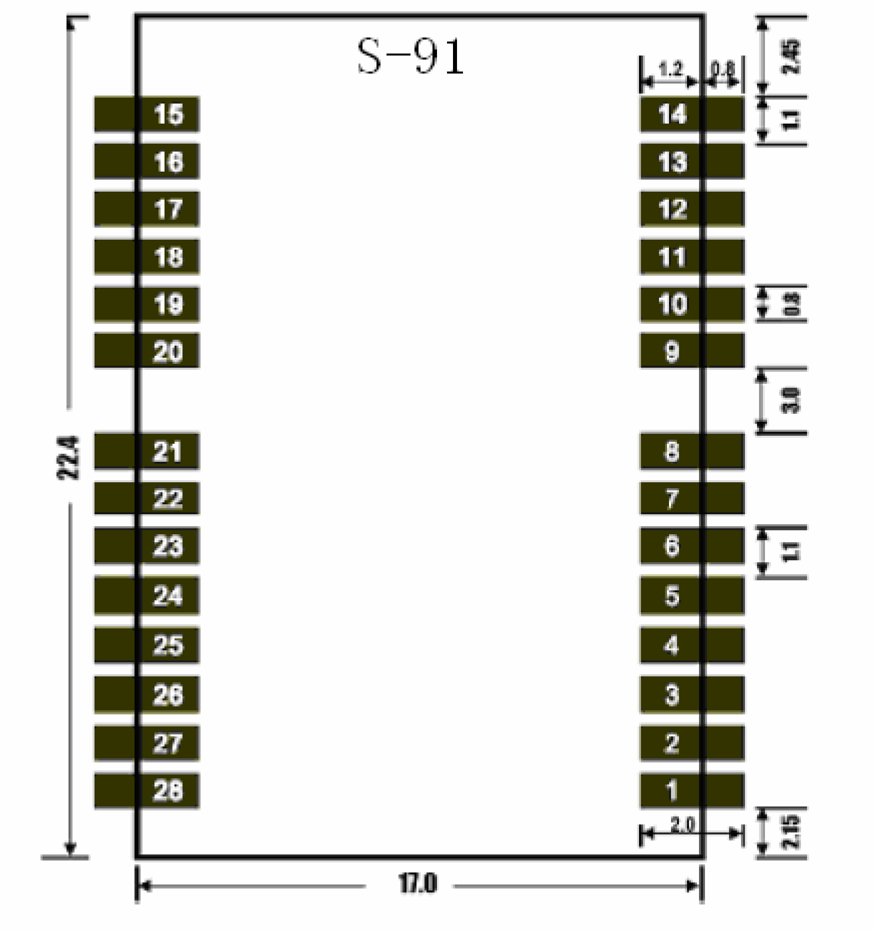
		- If connect a battery to this pin directly, then the built-in charging circuit will charge the battery automatically using the main power and thus this is an output pin. When the main power is off, the battery power is used to keep clock and the fixing data. In this case this is a power input.	
12	BOOTSEL	Firmware upgrade selection pin. "NC" for normal run (internal pull-low); "High" for firmware upgrade. Leave this pin open if the firmware upgrade is not needed.	Input
13	GND	Ground	Input
14	PWR_CTRL	Hardware controlled power saving pin. If this function is used, it is usually connected to a GPIO pin of a micro-processor. "Low" for normal run; "NC": turn off VCC for power saving (internal pull-high) Tie this pin to "Low" if it is not used.	Input
15	GND	Ground	Input
16	RF_IN	GPS signal from antenna; 50 Ohms @ 1.57542GHz Either active or passive antenna signal could be connected to this pin. **Please do not connect this pin if choose to connect antenna module to the I-PEX connector**.	Input
17	GND	Ground	Input
18	VCC_RF	VCC antenna power supply option. **Leave it open if this pin is not used.** This pin outputs the same DC voltage level as VCC (pin 6). If this voltage level is compatible to external active antenna, it could be used to power the antenna. In this case, connect VCC_RF to V_ANT. If external power source is preferred, leave this pin open.	Output
19	V_ANT	Active antenna power supply. **Leave it open if a passive antenna is used.** For active antenna, an antenna power supply is needed. This supply could be from either external power source or from the built-in power VCC_RF depending on the working	Input

		power requirement of active antenna. **The antenna power source should be well-regulated** (Vpp of noise should be less than 50mV) so that the receiver could have best performance.	
20	NC	No connection	-
21	GPIO4	General Purpose I/O control pin 4	I/O
22	GPIO13	General Purpose I/O control pin 13	I/O
23	NC	No connection	-
24	NC	No connection	-
25	NC	No connection	-
26	NC	No connection	-
27	GPIO10	General Purpose I/O control pin 10	I/O
28	1PPS	1 Pulse Per Second signal output. The rising edge of1PPS pulse synchronized to GPS second with precision of better than 1 micro-second, pulse width of 1 micro-second.	Output

2.3 Layout Suggestion

Following is the pad layout recommendation data:

Layout Recommendation Unit : mm



2.4 Power Saving

S-91 supports various kinds of power saving mechanisms – Trickle Power,Adaptive Trickle Power, Push To Fix, and power switch. The first three kinds of power saving mechanisms are implemented in software and the power switch mechanism is implemented in hardware.

2.4.1 Power Saving of Trickle Power

The trickle power saving mechanism is achieved by switching off and on CPU and RF at a fixed time interval. The biggest time interval to report a position is 10 seconds. The on and off ratio is configurable. This feature is useful for applications that need to report position regularly while power saving is significant. This feature is done by firmware automatically if this feature is enabled. The standard firmware does not turn on this feature. It could be customized by request of MOQ.

2.4.2 Power Saving of Adaptive Trickle Power

The adaptive trickle power saving mechanism is basically the same as trickle power saving mechanism with difference that it would not turn the power off if the signal quality is not good enough for tracking. Thus, it keeps both benefits of performance and power saving intelligently. This feature is done by firmware automatically if this feature is enabled. The standard firmware does not turn on this feature. It could be customized by request of MOQ.

2.4.3 Power Saving of Push To Fix

The Push To Fix power saving mechanism will not report position data until a specified time interval expires or triggered by external event. Typically, to keep the up to date position data, it would wake up to collect ephemeris and almanac data every 30 minutes. The time interval is also configurable. This mechanism is especially useful for applications that need position data only on demand. This feature is done by firmware automatically if this feature is enabled. The standard firmware does not turn on this feature. It could be customized by request of MOQ.

2.4.4 Power Saving of Power Switch

The Power Switch power saving mechanism will turn off not only the CPU and RF but also the whole engine board. The power saving is controlled by the external application via the control pin (PWR_CTRL; pin 14). The engine board will be off if PWR_CTRL pin is not connected (internal pull-high). It would be on if the pin is low.

The designer has full control of the power supply status of the engine board.

The power saving is also more complete. Applications such as AVL may prefer to turn it off while the car engine is off and turn it on while the engine is ignited. Handheld applications such as PMP navigator may prefer to stop GPS while it just wants movie watching. There might be similar demand for different applications. This mechanism is achieved by hardware and external control of pin PWR_CTRL is required if this mechanism is used. Tie it to low if the mechanism is not used.

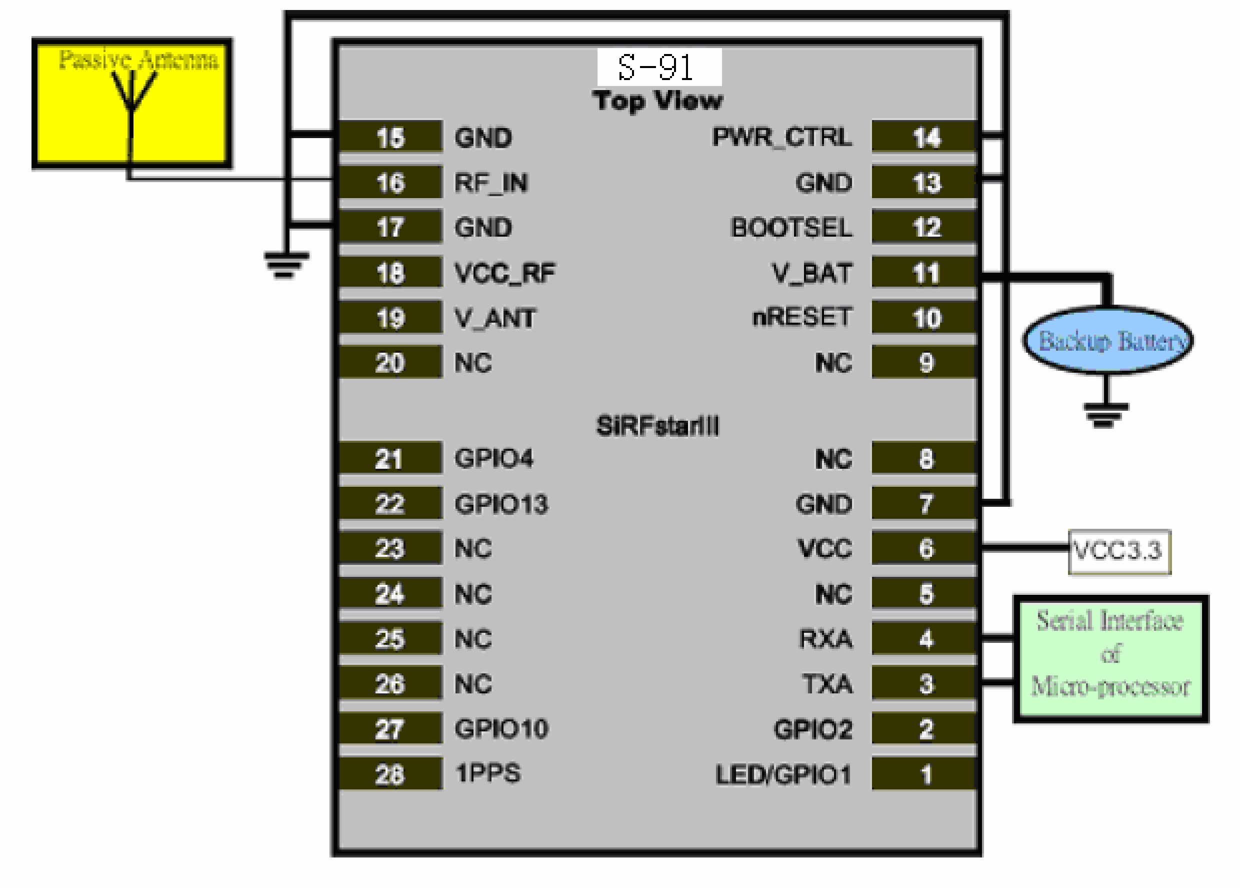
2.5 Antenna Application

2.5.1 I-PEX Antenna Connection

The easiest way to use S-91 is to connect an antenna module via the I-PEX connector -no worry of troublesome RF performance tuning. There are several options of antenna modules for different dimension and cable length. The power source for active antenna module is connected to pin 19 (V_ANT). The alternative way is to connect antenna to pin RF_IN as described in the following sections.

2.5.2 RF_IN Antenna Connection – Passive Antenna

Following figure is a simple illustration of connecting a passive antenna. The passive antenna is connected to Pin 16 (RF_IN). Please note that there is no connection to V_ANT.



In the above illustration, power control feature is not used. If this feature is used, connect PWR_CTRL to a micro-processor GPIO pin.

For backup battery connection, just connect it to the V_BAT pin is enough. It's very simple and it does not need any other external components.

2.5.3 RF_IN Antenna Connection – Active Antenna

For active antenna, a DC power supply is required. This power supply of pin 19 (V_ANT) will then be used to power the active antenna connected to pin RF_IN. Please do not connect the antenna power supply to pin RF_IN directly. The quality of antenna power affects the RF performance significantly. The peak to peak noise level should be less than 50mV.

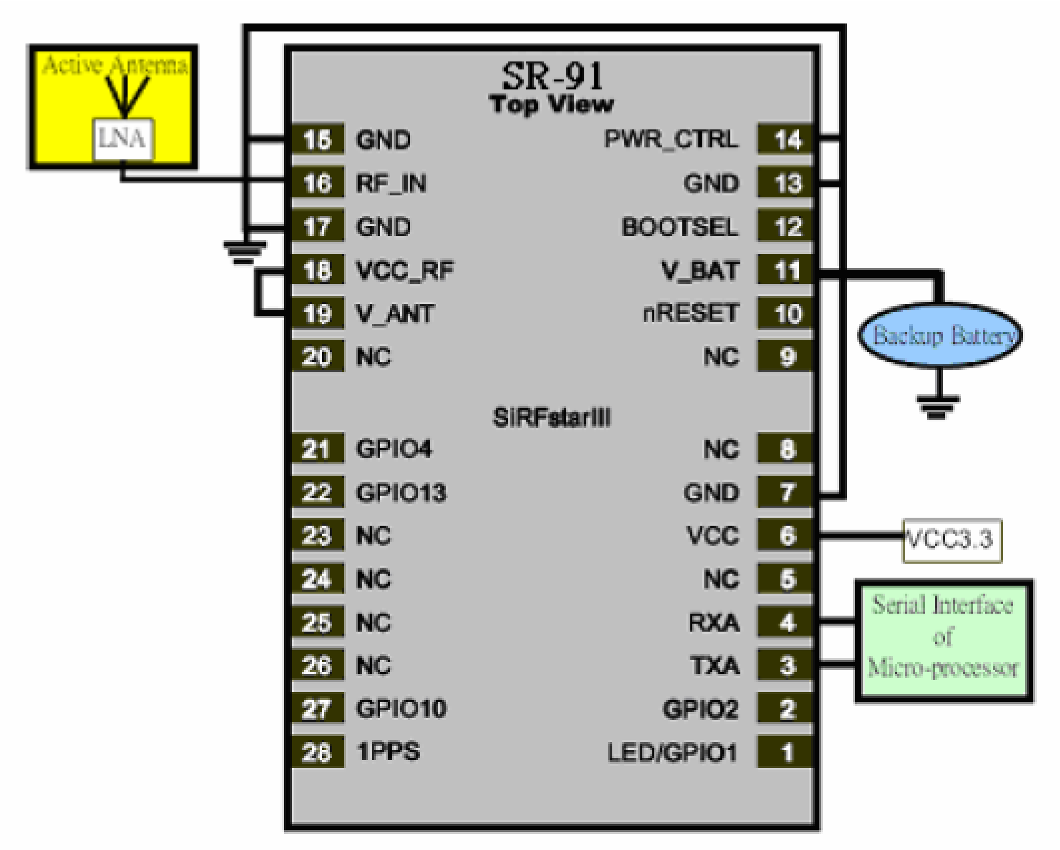
There are two power sources for V_ANT – the on-board power VCC_RF (pin 18) and external power source.

Powered by on-board VCC_RF

The main power supply of VCC (pin 6) could be used to power an active antenna. For this application, connect pin 18 (VCC_RF) to pin 19 (V_ANT) directly. To meet the stable power supply requirement, the peak to peak noise level of VCC (pin 6) should be less than 50mV. The active antenna is connected to Pin 16 (RF_IN).

Powered by External Power Source

Following figure is a simplified illustration of connecting an active antenna with external active antenna power source. The active antenna is connected to Pin 16 (RF_IN).



2.5.4 Active Antenna Status Detection and Short Circuit Protection

S-91 supports active antenna status detection without aid of external circuit. States of open circuit and short circuit could be detected. In addition, the short circuit protection circuit is also embedded inside it.

Antenna requirement for this function requires:

- voltage level to be between DC 3V~5V
- power consumption of 100mA and larger is treated as short circuit

● power consumption of 4mA and less is treated as open circuit

2.5.5 Active Antenna Status Notification

Antenna status is reported in ways of both hardware and software.

Hardware Antenna Status Notification

The antenna status is reported using pin 27 (GPIO10).

High -- Either short circuit or open circuit has been detected

Low -- Normal; neither short circuit nor open circuit is detected

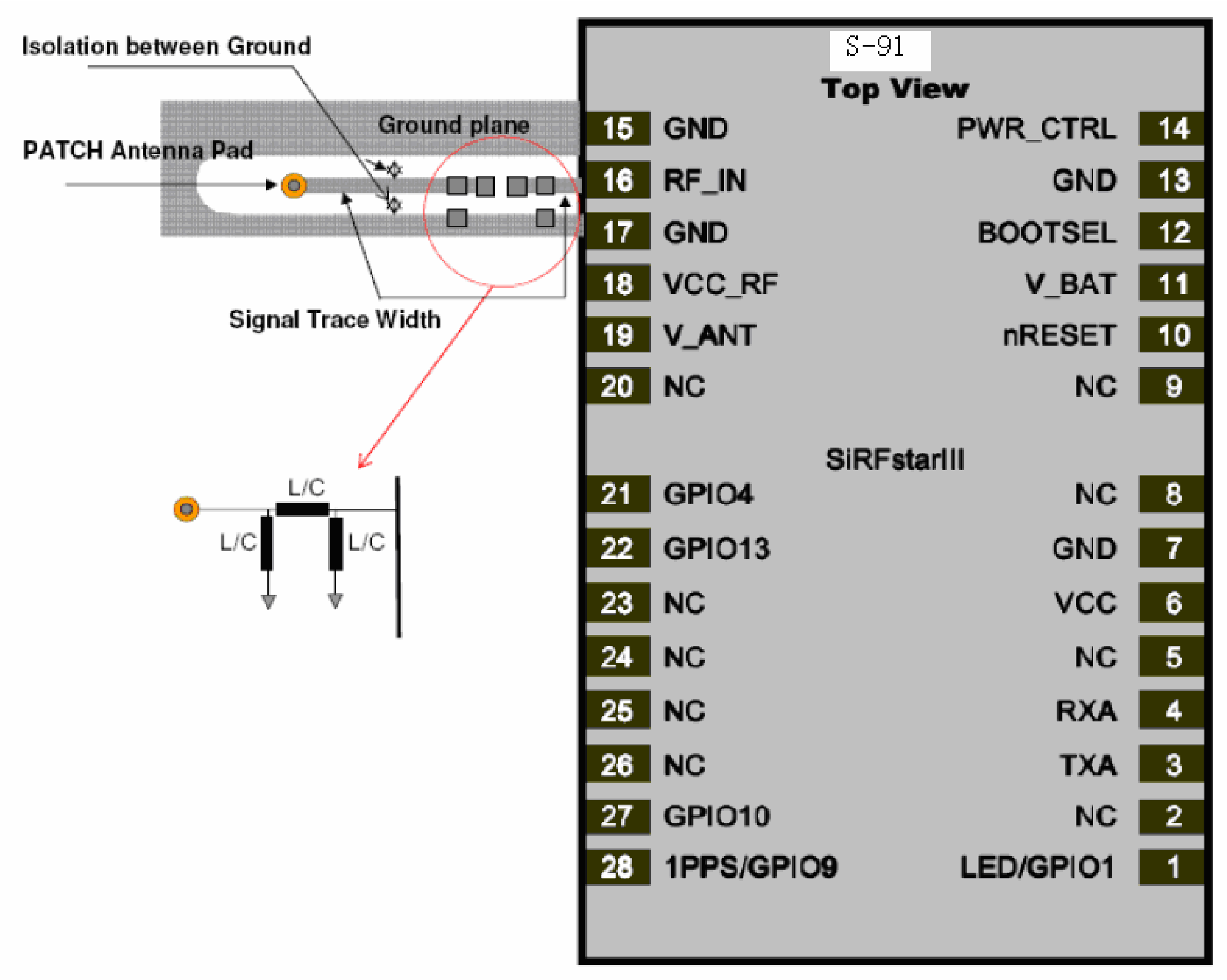
Software Antenna Status Notification

The antenna status is reported with proprietary NMEA protocol - $GPADT.

Normal condition	$GPADT,0*5A
Open circuit	$GPADT,1*5B
Short circuit	$GPADT,2*58

2.6 RF_IN Impedance Matching

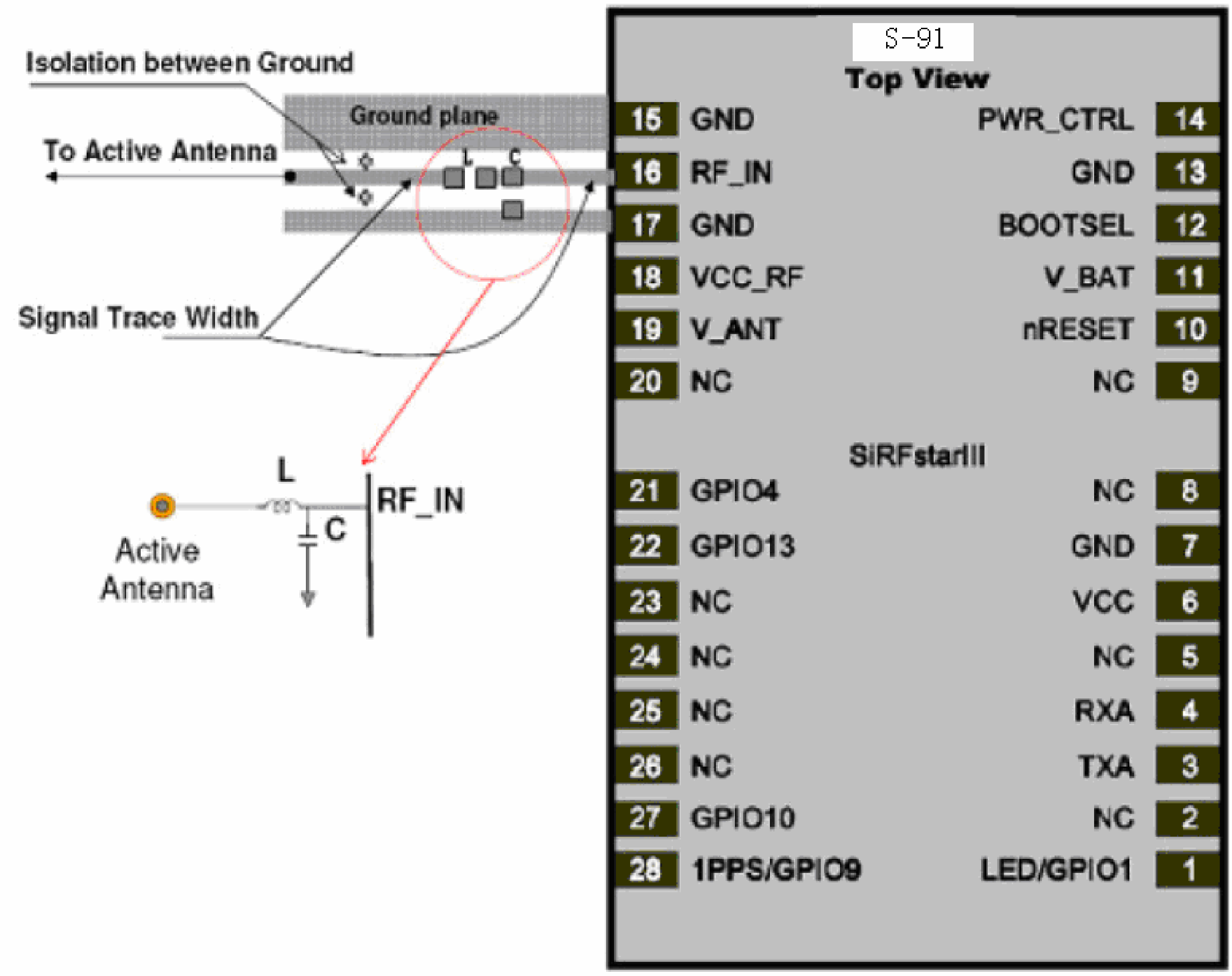
The GPS signal is delivered from antenna to S-91 via pin RF_IN. For the best delivery of GPS signal, the signal trace from antenna to pin RF_IN should be well matched to impedance of 50-ohm. Otherwise the performance would be degraded. The RF_IN impedance matching arrangement is discussed in antenna types of passive and active as following.



Above figure is an illustration of **patch** antenna layout. Following items should be considered while arranging the signal trace:

- Width of signal trace
- Isolation width between signal trace and ground
- PCB structure and thickness
- Matching network (consists of L or C) along with the signal trace and near the RF_IN side for impedance tuning.

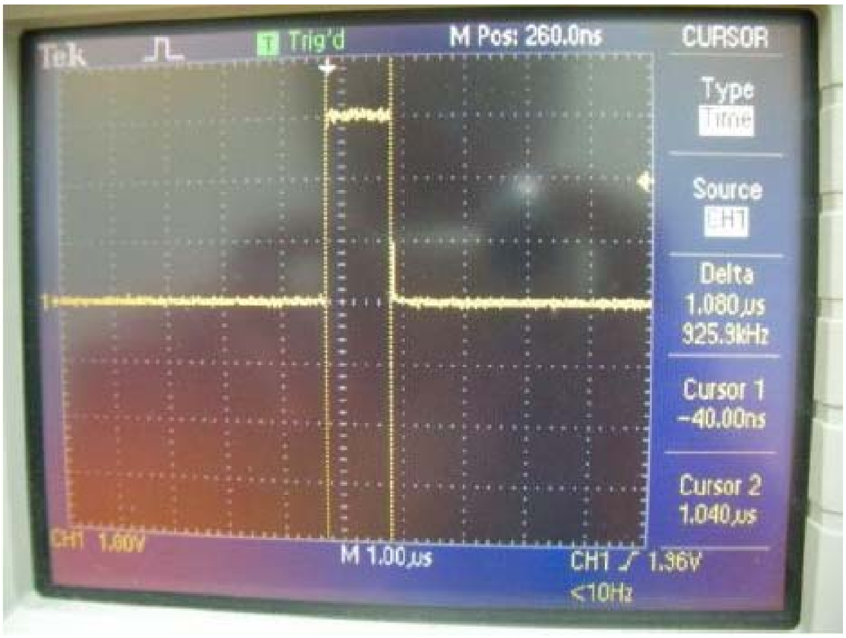
Following figure is another example of **active** antenna:



Basically, the consideration is the same as that of passive antenna. The major difference is the matching network. Please note that other kind of matching network is also possible to match it to the 50 ohms impedance.

2.7 1PPS output

The 1 pulse per second signal output is a precise reference time signal. The rising edge of 1PPS pulse is synchronized to GPS second with precision of better than 1 micro-second, pulse width of 1 micro-second.



Please note that 1PPS signal will not output until the position has been fixed. Above is the 1PPS signal taken from the screen of oscilloscope.

3 Software Interface

3.1 NMEA Output Messages

The NMEA-0183 Output Messages are shown as below:

NMEA Record	**Descriptions**
GPGGA	Global positioning system fixed data: time, position, fixed type
GPGLL	Geographic position: latitude, longitude, UTC time of position fix and status
GPGSA	GPS receiver operating mode, active satellites, and DOP values
GPGSV	GNSS satellites in view: ID number, elevation, azimuth, and SNR values
GPRMC	Recommended minimum specific GNSS data: time, date, position, course, speed
GPVTG	Course over ground and ground speed
GPZDA	PPS timing message (synchronized to PPS)

The S-91 easy to use mountable GPS engine board adopts interface protocol of National Marine Electronics Association's NMEA-0183 Version 3.00 interface specification. S-91 supports 8 types of sentences - 7 standard NMEA sentences (GPGGA, GPGLL, GPGSA, GPGSV, GPRMC, GPVTG, and GPZDA) and a proprietary sentence (GPADT).

The default output sentences are GPGGA, GPGSA, GPGSV, GPRMC, and GPVTG.

The UART communication parameters are 4800 bps, 8 data bits, 1 stop bit, and no parity. Other output sentences, baud rate, and related configurations could be requested based on MOQ.

Single message example

$GPGGA,101229.487,3723.2475,N,12158.3416,W,1,07,1.0,9.0,M, , , ,0000*3E
$GPGLL,2446.8619,N,12100.2579,E,060725.000,A,A*7E
$GPGSA,A,3,05,02,26,27,09,04,15, , , , , ,1.8,1.0,1.5*11
$GPGSV,3,1,12,07,62,081,37,16,61,333,37,01,60,166,37,25,56,053,36*74
$GPGSV,3,2,12,03,43,123,33,23,32,316,34,14,17,152,30,20,16,263,33*78
$GPGSV,3,3,12,19,17,210,29,06,08,040,,15,06,117,27,21,05,092,27*7E
$ GPRMC,151229.487,A,3723.2475,N,12148.3416,W,0.13,309.62,120598,,,A*5F
$GPVTG,,T,,M,0.00,N,0.0,K,A*13
$GPZDA,060526.000,20,06,2006,,*51
$GPADT,0*5A

3.2 GPGGA - Global Positioning System Fix Data

► Example

$GPGGA,101229.487,3723.2475,N,12158.3416,W,1,07,1.0,9.0,M, , , ,0000*3E

► Explanation

Contents	Example	Unit	Explanation
Message ID	$GPGGA		GGA protocol header
UTC Time	101229.487		hhmmss.sss hh: hour, mm: minute, ss: second
Latitude	3723.2475		ddmm.mmmm dd: degree, mm.mmmm: minute
North/South	N		N: North Latitude, S: South Latitude
Longitude	12158.3416		dddmm.mmmm dd: degree, mm.mmmm: minute
East/West	W		E: East Longitude, W: West Longitude
Position Fix Indicator	1		0: Fix not available or invalid, 1: GPS SPS Mode, fix valid, 2: Differential GPS, SPS Mode, fix valid, 3~5: Not supported,

			6: Dead Reckoning Mode, fix valid
Satellites Used	07		Number of satellites used in positioning calculation (0 to 12)
HDOP	1.0		Horizontal Dilution of Precision
MSL Altitude	9.0	meters	
Unit	M		Meters
Geoidal separation		meters	
Units	M		Meters
Age of Diff. Corr.		second	Null fields when DGPS is not used
Diff. Ref. Station ID	0000		
checksum	*3E		
<CR><LF>			End of sentence

3.3 GPGLL - Geographic Position - Latitude / Longitude

► Example

$ GPGLL,2446.8619,N,12100.2579,E,060725.000,A,A*7E

► Explanation

Contents	Example	Unit	Explanation
Message ID	$GPGLL		GLL protocol header
Latitude	2446.8619		ddmm.mmmm dd: degree, mm.mmmm: minute
North/South	N		N: North Latitude, S: South Latitude
Longitude	12100.2579		dddmm.mmmm dd: degree, mm.mmmm: minute
East/West	E		E: East Longitude, W: West Longitude
UTC Time	060725.000		hhmmss.sss hh: hour, mm: minute, ss: second
Status	A		A: Data valid, V: Data invalid

Mode Indicator	A		A: Autonomous, D: DGPS, E: DR
checksum	*7E		
<CR><LF>			End of sentence

3.4 GPGSA - GNSS DOP and Active Satellites

► Example

$GPGSA,A,3,05,02,26,27,09,04,15, , , , , ,1.8,1.0,1.5*11

► Explanation

Contents	Example	Explanation
Message ID	$GPGSA	GSA protocol header
Mode 1	A	M: Manual—forced to operate in 2D or 3D mode A: 2D Automatic—allowed to automatically switch 2D/3D
Mode 2	3	1: Fix not available 2: 2D (< 4 Satellites used) 3: 3D (> 3 Satellite s used)
Satellite used in solution	05	Satellite on Channel 1
Satellite used in solution	02	Satellite on Channel 2
…		Display of quantity used (12 max)
PDOP	1.8	Position Dilution of Precision
HDOP	1.0	Horizontal Dilution of Precision
VDOP	1.5	Vertical Dilution of Precision
checksum	*11	
<CR><LF>		End of sentence

3.5 GPGSV - GNSS Satellites in View

► Example

$GPGSV,2,1,07,07,79,048,42,02,51,062,43,26,36,256,42,27,27,138,42*71

$GPGSV,2,2,07,09,23,313,42,04,19,159,41,15,12,041,42*41

► Explanation

Contents	Example	Unit	Explanation
Message ID	$GPGSV		GSV protocol header

Number of messages	2		Range 1 to 3
Message number	1		Range 1 to 3
Satellites in view	07		Number of satellites visible from receiver
Satellite ID number	07		Channel 1 (Range 1 to 32)
Elevation	79	degrees	Elevation angle of satellite as seen from receiver channel 1 (00 to 90)
Azimuth	048	degrees	Satellite azimuth as seen from receiver channel 1 (000 to 359)
SNR (C/No)	42	dBHz	Received signal level C/No from receiver channel 1 (00 to 99, null when not tracking)
…			
Satellite ID number	27		Channel 4 (Range 1 to 32)
Elevation	27	degrees	Elevation angle of satellite as seen from receiver channel 4 (00 to 90)
Azimuth	138	degrees	Satellite azimuth as seen from receiver channel 4 (000 to 359)
SNR (C/No)	42	dBHz	Received signal level C/No from receiver channel 4 (00 to 99, null when not tracking)
checksum	*71		
<CR><LF>			End of sentence

3.6 GPRMC - Recommended Minimum Specific GNSS Data

► Example

$GPRMC,151229.487,A,3723.2475,N,12148.3416,W,0.13,309.62,120598,,,A*5F

► Explanation

Contents	Example	Unit	Explanation

Message ID	$GPRMC		RMC protocol header
UTC Time	151229.487		hhmmss.sss hh: hour, mm: minute, ss: second
Status	A		A: Data valid, V: Data invalid
Latitude	3723.2475		ddmm.mmmm dd: degree, mm.mmmm: minute
North/South	N		N: North Latitude, S: South Latitude
Longitude	12148.3416		dddmm.mmmm dd: degree, mm.mmmm: minute
East/West	W		E: East Longitude, W: West Longitude
Speed over ground	0.13	knots	Receiver's speed
Course over ground	309.62	degrees	Receiver's direction of travel Moving clockwise starting at due north
Date	120598		ddmmyy dd: Day, mm: Month, yy: Year
Magnetic variation		degrees	This receiver does not support magnetic declination. All "course over ground" data are geodetic WGS84 directions.
Mode Indicator	A		A: Autonomous, D: D-GPS, N: Data not valid
checksum	*5F		A: Autonomous M: Manual D: DGPS S: Simulation E: Dead Reckoning N: Data Invalid
<CR><LF>			End of sentence

3.7 GPVTG - Course Over Ground and Ground Speed

► Example

$GPVTG,309.62,T,,M,0.18,N,0.5,K,A*0F

► Explanation

Contents	Example	Unit	Explanation
Message ID	$GPVTG		VTG protocol header
Course over ground	309.62	degrees	Receiver's direction of travel Moving clockwise starting at due north (geodetic WGS84 directions)

Reference	T		True
Course over ground	degrees		Receiver's direction of travel
Reference	M		Magnetic
Speed over ground	0.18	knots	Measured horizontal speed
Unit	N		Knots
Speed over ground	0.5	km/hr	Measured horizontal speed
Unit	K	km/hr	
Mode Indicator	A		A: Autonomous, D: DGPS, E: DR
checksum	*0F		
<CR><LF>			End of sentence

3.8 GPZDA - SiRF Timing Message

► Example

$GPZDA,181813,14,10,2006,00,00*4A

► Explanation

Contents	Example	Unit	Explanation
Message ID	$GPZDA		ZDA protocol header
UTC time	181813		Either using valid IONO/UTC or estimated from default leap seconds
Day	14		Day according to UTC time (01 to 31)
Month	10		Month according to UTC time (01 to 12)
Year	2006		Year according to UTC time (1980 to 2079)
Local zone hour	00	hour	Offset from UTC (set to 00)
Local zone minutes	00	minute	Offset from UTC (set to 00)
checksum	*4F		
<CR><LF>			End of sentence

3.9 GPADT – Antenna Detection Message

► Example

$GPADT,0*5A

► Explanation

Contents	Example	Unit	Explanation
Message ID	$GPADT		ADT protocol header
State	0		0: Normal condition

			1: Open circuit 2: Short circuit
checksum	*5A		
<CR><LF>			End of sentence