NAVMAN

Jupiter 30 / 20
GPS receiver module

Integrator's Manual

Related documents

•Jupiter Series Development kit guide
 LA000645

• Navman NMEA reference manual
 MN000315

• SiRF Binary Protocol reference manual

SiRF
Powered

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1.0 Introduction

The Navman Jupiter 30 and Jupiter 20 series of GPS receiver modules are complete GPS receivers designed for surface mount assembly (SMT) integration. The modules provide a simple, cost effective GPS solution for application designers. Application integration will vary primarily with respect to antenna system design and EMI protective circuitry.

The Jupiter 30 is the successor to the established Jupiter 20, sharing the same form factor (25.4 x 25.4 mm) and electrical compatibility. This provides a low risk migration path for existing users, offering greater sensitivity, lower power consumption and a faster fix.

Fundamental operation requires a 3.3 VDC power supply, approximate current of 80 mA (Jupiter 30) or 100 mA (Jupiter 20), GPS antenna system interface, relevant EMI protection, and the design and layout of a custom PCB.

This document outlines the following design considerations and provides recommended solutions:

Hardware application information
This section introduces the system interface and provides the following physical specifications:

  a. electrical connections (SMT pad interface)

  b. mounting (PCB pad layout dimensions)

  c. manufacturing recommendations

  d. application circuit interface

It also discusses the fundamental considerations when designing for RF, and presents the antenna system design overview. This covers the following topics:

  a. PCB layout

  b. antenna system design choices

Software application information
This section provides answers to some common questions that may not have been covered in the above topics.

A sample solution is presented and discussed for example purposes only. Due to the nature and complexity of GPS signals, it is recommended that application integrators adhere to the design considerations and criteria described in this document.

2.0 Hardware application information

The modules provide 30 Surface Mount pads for electrical connections. The sections that follow introduce the physical and relative functional specifications for application integration.

Note: The electrical connections can carry very low level GPS signals at 1.57542 GHz. The layout must be designed appropriately with consideration of the frequencies involved.

2.1 Electrical connections (SMT pad interface)

Details of the module connector configuration are shown in Table 2-1.

Pin No.	Name	Type	Description
1	PWRIN	P	main power input (3.3 V)
2	GND	P	ground
3	BOOT	I	serial boot (high for serial boot, low or open circuit for normal operation)
4	RXA	I	CMOS level asynchronous input for UART A
5	TXA	O	CMOS level asynchronous output for UART A
6	TXB	O	CMOS level asynchronous output for UART B
7	RXB	I	CMOS level asynchronous input for UART B
8	pin 8 multi-functional (see table 2-2)		
9	RF_ON	O	output to indicate whether the RF section is enabled (active high)
10	GND	P	ground
11	GND	P	ground
12	GND	P	ground
13	GND	P	ground
14	GND	P	ground
15	GND	P	ground
16	GND	P	ground
17	RF_IN	I	RF input
18	GND	P	ground
19	ACTIVE_PWR	P	active power input, 70 mA current limit supply to this pin
20	VCC_RF	O	RF Power (+2.85 V) supply output
21	V_BATT	P	backup battery input
22	NRESET	I	external reset (active low), voltage on PIN 22 NRESET must not exceed PWRIN at all times
23	GPS_FIX	O	GPS fix indication (active low)
24	pins 24-28 multi-functional (see table 2-2)		
25			
26			
27			
28			
29	1PPS	O	1 pulse per second output
30	GND	P	ground

Table 2-1: Jupiter 30 and Jupiter 20 Module pin functions

Pin	Jupiter 30			Jupiter 20		
	GPIO	Name and Description	GPIO	Standard & XTrac name	DR function	
24	13	reserved	6	GPIO (SDO)	not connected	
25	4	reserved	5	GPIO (SDI)	ADC DOut	
26	–	WAKEUP push-to-fix wakeup (active on +ve edge)	7	GPIO (SCK)	ADC Clk	
27	15	ANT_OC antenna open circuit sensor input (active high)	15	ANT_OC	FWD/REV fwd/rev input (low=forward, high=reverse)	
28	1	ANT_CTRL active antenna control output	1	ANT_CTRL	WHEEL_TICKS wheel tick input	
8	14	NANT_SC antenna short circuit sensor input (active low)	3	NANT_SC	GYRO_IN gyro input (analogue 0–5V)	

Table 2-2: Summary of pin multi-functionality

GPIO

Note that the Jupiter 20 D (Dead Reckoning) does not support the active antenna supervisory functionality and associated proprietary NMEA status messaging (see section 3.7).

SPI (Jupiter 20 only)

The Jupiter 20 (GSW2) and Jupiter 20 S (XTrac) do not support the SPI. These pins function only as user GPIOs.

The SPI on the Jupiter 20 D is used to control an internal ADC, which interfaces to an external gyro.

Implementation of the SPI for any other alternative function requires an SDK (Software Development Kit) from SiRF.

2.2 Physical dimensions

The physical dimensions of the Jupiter 30 and Jupiter 20 modules are identical:

length: 25.4 mm ± 0.1 mm
width: 25.4 mm ± 0.1 mm
thickness: 3.0 mm max
weight: 4.0 g max

2.3 Manufacturing process recommendations

2.3.1 Reflow recommendations

For lead based solder pastes, the maximum reflow temperature is 225 °C for 10 seconds. For lead-free solder pastes, the maximum reflow temperature is 265 °C for 10 seconds. Refer to Figure 2-1.

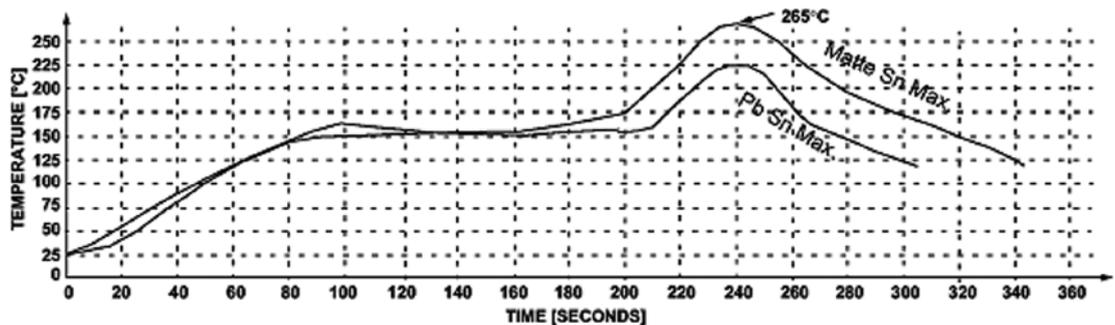**Figure 2-1: Lead-free and tin/lead reflow profile recommendation**

2.3.2 Connection pad material

The 30 surface mount connection pads have a base metal of copper with a gold flash finish. This is suitable for a lead free manufacturing process.

2.3.3 Solder paste mask size

This should be adjusted by experimentation according to the customer's production process requirements. A 1:1 (paste mask:pad size) ratio has been found to be successful.

2.3.4 Solder paste type

The module accepts all commonly used solder pastes. The solder paste can be lead based or lead-free. If a lead-free process is introduced, factors such as circuit board thickness, fabrication complexity, assembly process compatibility, and surface finish should be taken into consideration.

2.3.5 Coating

The final PCB may be selectively coated with an acrylic resin, air/oven cured conformal coating, clear lacquer or corresponding method, which gives electrical insulation and sufficient resistance to corrosion.

2.3.6 Post reflow washing

It is recommended that a low residue solder paste is used to prevent the need for post reflow washing. If a washing process is used, an aqueous wash is not recommended due to the long drying time required and danger of contaminating the fine pitch internal components.

2.3.7 Pre-baking

The modules are delivered on a tape and reel package sealed in an airtight bag. The MSR (Moisture Sensitivity Rating) is 3, therefore they should be loaded and reflowed within 168 hours. If the modules are in ambient humidity for longer than this, a pre-baking/drying process will be required.

2.3.8 Rework

Navman recommends that rework and repair is carried out in accordance with the following guidelines:

- IPC-7711 Rework of Electronic Assemblies
- IPC-7721 Repair and Modification of Printed Boards and Electronic Assemblies

Note: Jupiter 30 and Jupiter 20 modules are covered by a 12-month warranty.

2.4 Typical application circuit

The schematic in Figure 2-2 represents a very basic application circuit, with simple interfaces to the module. It is subject to variations depending on application requirements.

Note: Refer to the Jupiter 20 Dead Reckoning Application Note (LA000433) for the Jupiter 20 D reference design.

2.4.1 Power for receiver and active antenna

The receiver power connection requires a clean 3.3 VDC. Noise on this line may affect the performance of the GPS receiver.

When an active antenna is used, the DC power is fed to it through the antenna coax. This requires the user to apply the antenna DC voltage to pad 19 of the module. A 2.7 V 25 mA supply is made available on pad 20 if the chosen antenna can accept that voltage. This supply is under the command of the TricklePower energy control.

2.4.2 Grounding

Separate AGND (Analogue Ground) and DGND (Digital Ground) grounds are shown in Figure 2-2. If this grounding method is used, the ground planes can be connected underneath the module. In some applications with very small ground planes, separate ground planes may not be required. This should be determined by the application integrator. See Section 2.5.2 for ground plane recommendations and design considerations involving the antenna input and the 50Ω microstrip connection.

2.4.3 Decoupling

The schematic in Figure 2-2 illustrates a suggested method of decoupling. These are capacitors C1 to C7. This level of decoupling may not be required in a particular application, in which case these capacitors could be omitted. Only the signal lines used in the application require decoupling.

All capacitors are highly recommended if the module will experience substantial electromagnetic interference (EMI). All low value capacitors should be as close as possible to the module pad with a short connection to the ground plane. Any data lines that have not been properly shielded are susceptible to data corruption. Refer to Table 2-3 for suggested values of decoupling relative to the function desired.
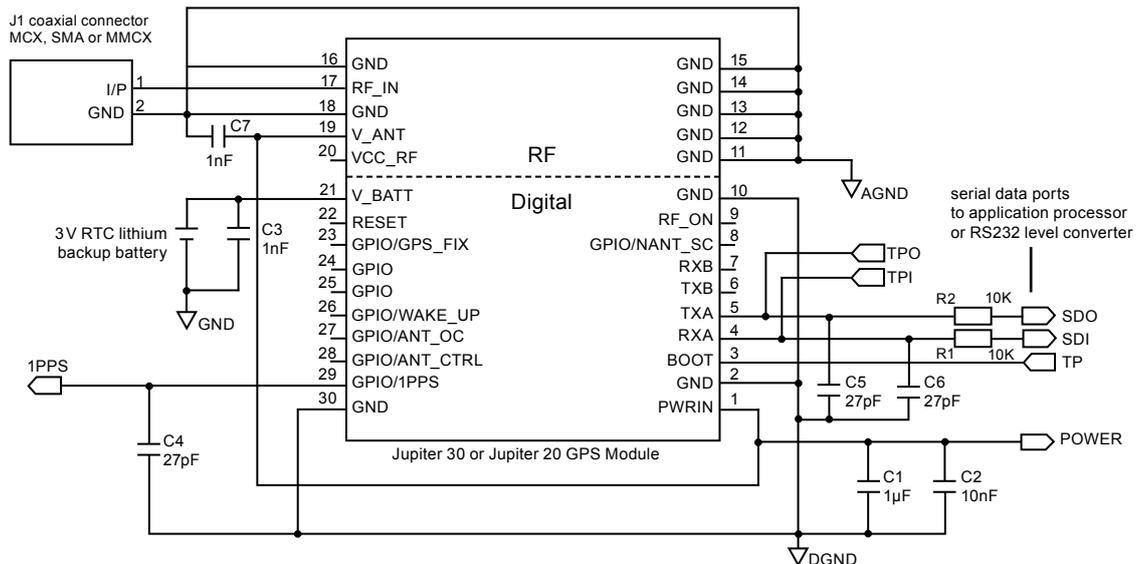
Figure 2-2: Sample application circuit

Function	Pad	Decoupling
PWRIN	1	1 µF‖1 nF
BOOT	3	27 pF
RXA	4	27 pF
TXA	5	27 pF
TXB	6	27 pF
RXB	7	27 pF
NANT_SC	8	27 pF
RF_ON	9	27 pF
ACTIVE_PWR	19	1 nF
VCC_RF	20	1 nF
V_BATT	21	1 µF‖1 nF
NRESET	22	27 pF
GPS_FIX	23	27 pF
GPIO13	24	27 pF
GPIO4	25	27 pF
WAKEUP	26	27 pF
ANT_OC	27	27 pF
ANT_CTRL	28	27 pF
1PPS	29	27 pF
Note: '‖' represents a parallel connection		

Table 2-3: Decoupling recommendations

2.4.4 Serial RS232 data level shifter

To connect the module to a PC comm. port, the serial data signals must be level shifted to RS232 levels. This has not been shown in the reference design, but many single chip RS232 level shifters are available, such as MAX3232.

Note: It is highly recommended to provide test points on the serial data lines and 'Boot' signal (pad 3), even if the application circuit does not use these signals. This will allow the user to connect to these signals if a firmware upload or new configuration is required. These test points can take the form of an unfitted 'through-hole' connector. Refer to Figure 2-2 showing test points TPO, TPI & TP.

2.4.5 External RF filter

If there is a high potential for interference (EMI) though the antenna system, an external bandpass SAW filter may be added to the antenna input connection (pad 17) which will attenuate interfering frequencies. (Many commercial active antennas have a filter so it would not be necessary to add another).

When using an active antenna, the filter will not pass DC through to the antenna, so an alternate power source would be required if an active antenna is used. Alternatively a parallel RF choke across the filter will allow the antenna power to pass through, but choice of components is important, for example using a choke of sufficiently high self-resonant frequency. Care should also be taken not to exceed the filter maximum DC voltage.

2.5 PCB design recommendations

The modules are surface mounted devices, hence the layout of the application PCB plays an integral part in the overall performance of the finished system.

It is not difficult to design such a PCB, despite the presence of high frequency, low level radio signals. The following recommendations have been offered to allow the designer to create a design that will meet the requirements of this product.

2.5.1 Recommended PCB pad layout

The layout in Figure 2-3 shows the recommended copper pad dimensions. The solder paste mask needs to be adjusted to suit the application's reflow process, however a 1:1 (paste mask:pad size) ratio is the recommended starting point.
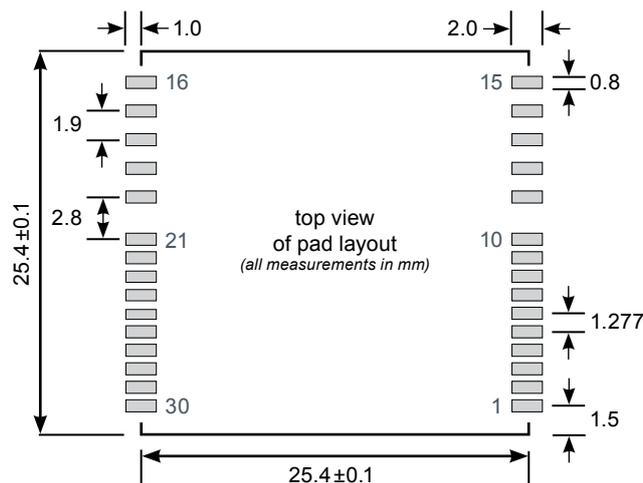
Figure 2-3: Recommended application layout dimensions

2.5.2 General recommendations

Choice of PCB stack up
In general, a two layer PCB substrate can be used, with all the RF signals on one side. Multi-layer boards can also be used. These design recommendations here only address the microstrip style of RF connection. Stripline designs can also be accommodated. However, long lengths of stripline can cause excessive signal loss and vias in the signal track should be avoided.

Ground plane design

We reccomend a complete ground plane is used under the PCB with signal tracks on the same layer as the module. We also recommend having a ground plane on both sides of the PCB underneath the module.

If the ground planes are very small, separate analogue and digital ground planes may not be required. The ground return for any signal should have a clear path back to its source and should not mix with other ground return signal paths. Hence the return path, which is the ground underneath the microstrip antenna connection, should not be shared with any digital signal or power supply return paths. Pads 16 and 18 are the RF signal Ground connections.

Decoupling components

The recommended values for power and signal decoupling are listed in Table 2-3. The placement of these components must ensure that the low value capacitors have very short tracks to the module pad, and very close vias connecting them to the ground plane. (Figure 2-4 shows a typical layout).
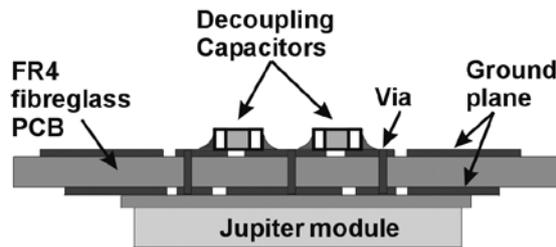

Figure 2-4: Typical module layout

Antenna connection

The PCB layout design of the antenna input connection requires appropriate selection of PCB track width, substrate material and careful attention to the layout geometry. If this overall system is not implemented correctly, the module will receive poor GPS signals and therefore provide inferior navigation data.

Figure 2-5 illustrates an example of a PCB design integrating an external active antenna connected via an MCX or SMA coaxial connector.

(Top)   (Bottom)
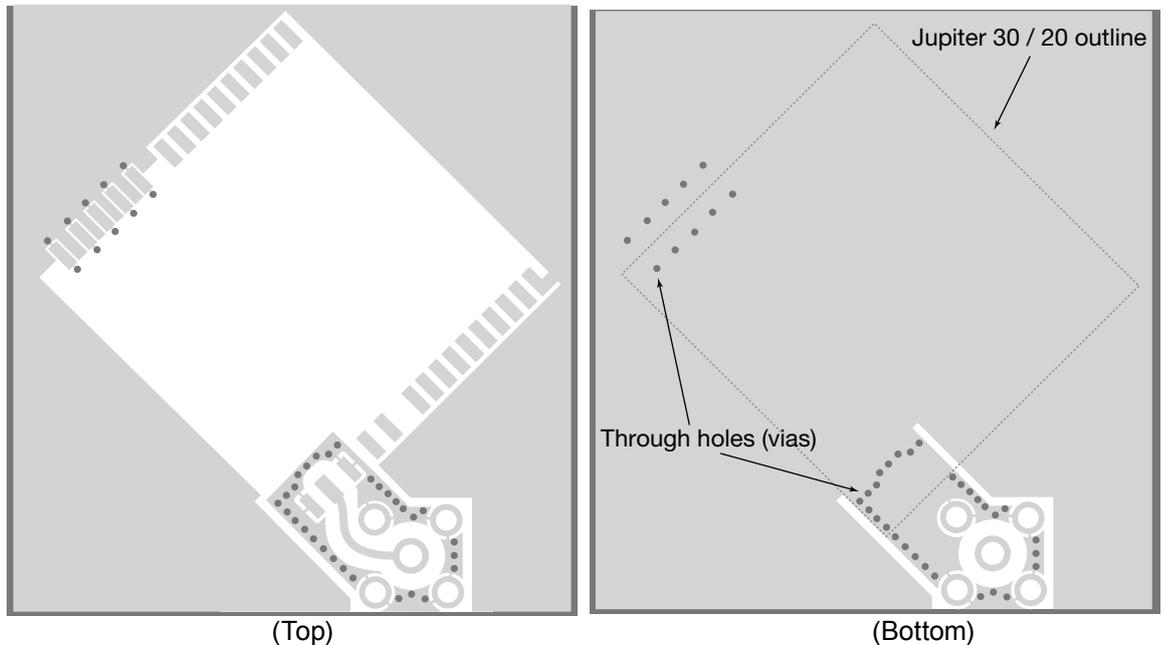
Figure 2-5: Example PCB layout for external active antenna

The modules can be used with a passive patch antenna if the connection to the antenna input is very short. It is possible to mount the patch antenna on the same PCB as the module, but to reduce the possibility of digital noise, it is recommended that the antenna be mounted on the opposite side of the board to the module.

Design of 50 ohm microstrip antenna connection

When designing the signal track from the antenna connection to the antenna input on the module, a controlled impedance microstrip with a characteristic impedance of 50 ohms must be used.

The PCB parameters that affect impedance are as follows:

1. Track width (W)

2. PCB substrate thickness (H)

3. PCB substrate permittivity (ε_r)

4. To a lesser extent, PCB copper thickness (T) and proximity of same layer ground plane.

Figure 2-6 shows a representation of the PCB microstrip and its parameters.
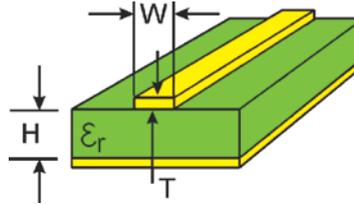

Figure 2-6: PCB microstrip dimensions

Table 2-4 shows typical track widths for an FR4 material PCB substrate (permittivity ε_r of 4.3 at 1.5 GHz) and different PCB thickness. The effect of track thickness (T) can be ignored for the short track lengths associated with this design.

Substrate material	Permittivity ε_r	Substrate thickness H (mm)	Track width W (mm)
FR4	4.3	1.6	2.0
		1.2	1.8
		1.0	1.6
		0.8	1.4
		0.6	1.2
		0.4	0.7
		0.2	0.4

Table 2-4: PCB substrate thicknesses v track width

Notes:

1. If a multi-layer PCB is used, the thickness is the distance from signal track to nearest ground plane.

2. If the antenna connection is routed under the module, the track width should be approximately halved for that section only.

It is recommended that the antenna connection PCB track should be routed around the outside of the module outline, kept on a single layer and have no bends greater than 45 degrees. It is not recommended, for production reasons, to route the track under the module.

However, if the track has to route under the module, it should have a modified track width and solder mask to avoid short circuits to the underside of the module.

To minimise signal loss and reduce the requirement for vias, it is not recommended to place the signal track on an inner layer of a multi-layer PCB.

The PCB track connection to the RF antenna input must:

• have a characteristic impedance of 50 ohm

• be as short as possible

- be interfaced to a coaxial connector if an external antenna is used

- have maximum clearance to ground on the same layer, or at least be half the substrate thickness

- be routed away from noise sources such as: switching power supplies, digital signals, oscillators and transmitters

The PCB track connection to the RF antenna input must **NOT** have:

- vias

- sharp bends

- components overlaying the track

2.6 Antenna system design choices

2.6.1 Antenna types

There are two major types of GPS antenna: passive and active. The active antenna has a built in LNA (Low Noise Amplifier) to increase the strength of the signal, and to compensate for the signal loss in a long cable connection.

The features of each type of antenna are shown in Table 2-5, comparing an externally mounted active antenna with a passive patch antenna mounted on the same PCB as the module.

Feature	Passive antenna	Active antenna
requires short cable between antenna and receiver	yes	no
consumes power	no	yes
can be mounted remote from receiver	no	yes
gives good performance in poor signal situations	no	yes
has built in additional filtering	no	yes
low cost	yes	no
requires a coaxial connector	no	yes

Table 2-5: Passive and active antenna features

2.6.2 Active antenna

An active antenna is a passive antenna with a built in LNA that requires a power supply. Active antennas are used when the antenna input is connected to the receiver through a coaxial cable (usually longer than 3 m) or any high loss transmission path. The GPS signals experience loss in the transmission path from the antenna. The loss is overcome by the antenna's LNA, which amplifies the signal before it enters the transmission path.

The amplification is also used to enhance the signal in areas of low signal. If the coaxial cable is shorter than 3 m it may experience too much gain at the receiver and degrade the performance. There are some variations as to how the antenna will receive its power but it is usually supplied through the coaxial cable via the antenna input as shown in Figure 2-7. (Refer to Table 2-6 for the recommended active antenna characteristics.)
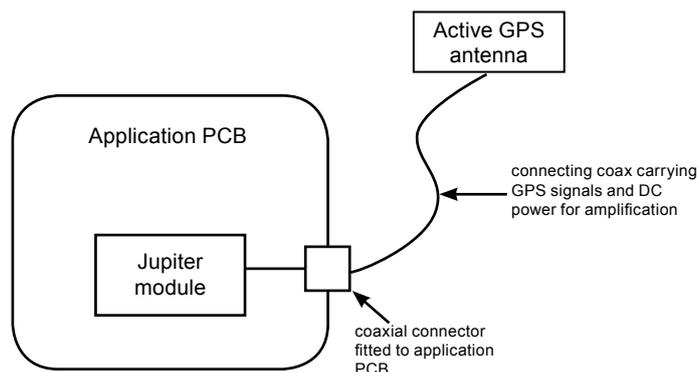

Figure 2-7: Arrangement of active antenna and application board

2.6.3 Passive antenna

A passive antenna does not require any power because it has no amplifier. This is not the best choice if signal strength is a concern, however, it may be sufficient if the signal path is kept to a minimum (usually below 300 mm). An advantage to using a passive antenna is the ability to mount directly onto the application. For best performance, a passive patch antenna should have a metal ground plane (about 80 mm in diameter) placed directly under the antenna, and it is advisable to screen the module and application circuits from the antenna. For this reason the antenna and module should not be mounted on the same side of the PCB (see Figure 2-8).
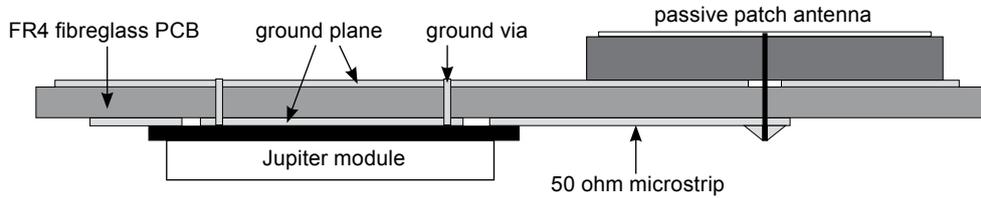

Figure 2-8: Cross section of application board with passive patch antenna

Any cover close to the antenna (called the superstrate) will cause the resonant frequency and efficiency of the antenna to drop. It is therefore recommended to keep any distance to the superstrate to a minimum of 3 mm from the top surface of the patch.

See Table 2-6 for recommended characteristics of both passive patch and active antennas for use with the Jupiter receiver.

Characteristic	Active antenna	Passive antenna
Polarisation	right-hand circular polarised	right-hand circular polarised
Receive frequency	1.57542 GHz +/- 1.023 MHz	1.57542 GHz > +/- 1.023 MHz
Power supply	3 V	–
DC current	< 10mA at 3 VDC	–
Antenna gain	–	+2 to 5 dBi with 1 dB loss (max) in connections
Total gain (includes antenna gain, LNA gain and cable loss)	≤ 26 dBi (Jupiter 20) ≤18 dBi (Jupiter 30)	–
Axial ratio	< 3 dB	< 3 dB
Output VSWR	< 2.5	–

Table 2-6: Recommended antenna characteristics

Note: GPS active and passive antenna selection must include practical TTFF tests in weak and strong outdoor environments – noting peak and average signal strength measurements. This must be done in comparison with the antenna supplied in the Development kit. Performance results and signal strength measurements must be comparable to the reference antenna supplied. Passive antenna signal strength measurements will be lower than an active antenna, but time to fix should be comparable.

2.6.4 Jupiter module used as a GPS sensor

The adapter board reference design shows how a Jupiter GPS receiver module can be used with an external active antenna via a coax connector. The same design can be used with a passive patch antenna on the same PCB. It follows the general arrangement described in Section 2.6.3. The module is placed such that the connection between the antenna and the antenna input pad is as short as possible. Also note the PCB should have a complete ground plane on the patch side of the board. This serves as the ground plane required by the antenna.

The serial data from the module must be connected to a local host processor, and care should be taken such that noise from these devices cannot enter the signal path or GPS antenna. It is recommended that all digital devices are placed on the opposite side of the board to that of the antenna.

2.6.5 DC supply protection for an active antenna

Antenna DC supply current limit

When the Jupiter receiver is used with an external active antenna, the DC supply in the coax cable is vulnerable to over-current if a fault occurs in the antenna or its cable gets crushed, for example in a car door.

> **WARNING**
>
> **It is important to note that the module antenna power feed does not have internal current limiting. Damage can occur if unlimited current is permitted to flow through the module antenna power feed components.**

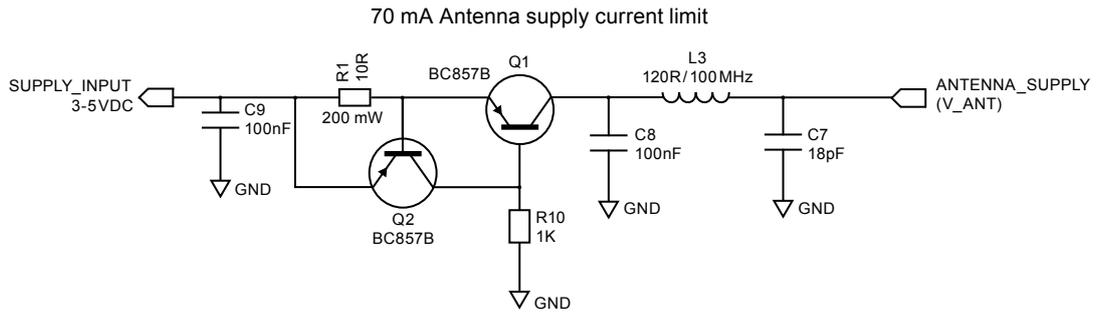The circuit shown in Figure 2-9 will provide over-current protection.

Figure 2-9: Simple current limiter circuit

Transistor Q1 serves as a series pass transistor. Q2 is used to sense the current in the antenna circuit, turning off Q1 if the voltage across the current sense resistor R1 exceeds 0.6 V. This circuit does not turn off the supply to the antenna, but merely limits it to a safe value. With the components shown the supply will be limited to approximately 70 mA.

Other options are available to provide this function. MAXIM can supply a current trip IC that will turn off the load if a preset supply current is exceeded. The part number for this is MAX4785. The circuit is shown in Figure 2-10.
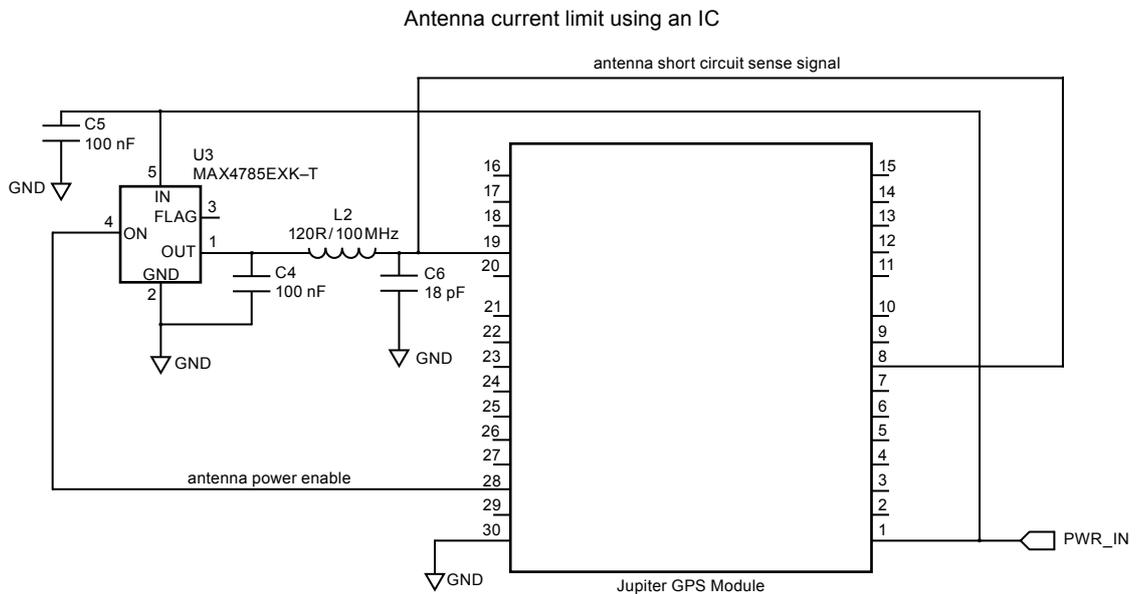

Figure 2-10: Active current limit using an IC

Electro-resistive fuses can be used to protect the supply over-current. These are available from Bourns, Vitromon and other manufacturers.

Antenna short/open sense inputs and control output

The Jupiter receiver has a digital input to provide signalling when an antenna fault has occurred. These functions are shared with the Jupiter 30 GPIO pads as shown in Table 2-7.

Antenna sense functions	Jupiter GPIO function
ANT_CTRL	GPIO1 (ON=High)
ANT_OC	GPIO15 (Active High)
NANT_SC	GPIO3 (Active Low)

Table 2-7: Antenna sense and control functions

The reference design shown in figure 2-11 is indicative of an open-circuit switchover threshold of approximately 3 mA. This maybe too high for some low-power antennae and can be adjusted by changing the following resistor values – R7 to 12Ω and R3 to 2K2Ω. This results in an open-circuit switchover threshold of approximately 2 mA.

The over current circuit consisting of Q1 and Q2 is the same as the simple current limit circuit shown in Figure 2-9, providing a 70 mA current limit.

In addition, this design has the following features:

1. Q4-A and Q4-B form a low current sensor, thus providing a signal to indicate when the antenna has become disconnected or open circuit. It is not mandatory to use a matched pair of transistors, as shown in this design, but it will provide consistent results over a wide temperature range.

2. Q3 provides a method for the receiver to turn off the active antenna supply in the event of a fault occurring. This is a latched condition in the software and can be restored by issuing a reset or power down.

3. Short circuit sensing is achieved by feeding the antenna supply into the NANT_SC input. When a short circuit occurs, this line will go low.

This design provides the lowest cost solution for this function. Other designs can be created giving higher stability over a wide temperature range, using operational amplifiers.
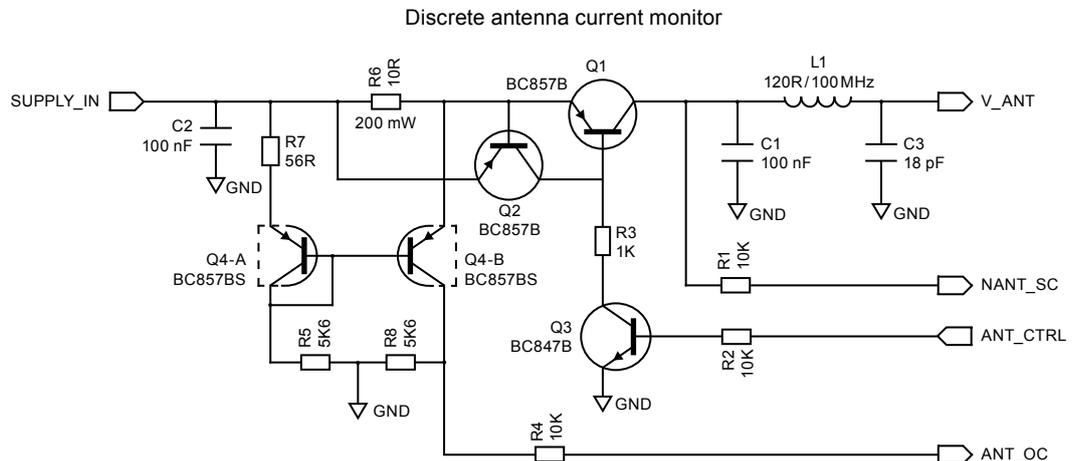
Discrete antenna current monitor

Figure 2-11: Antenna short/open circuit sensor circuit (3.3 V supply only)

2.7 Jupiter adapter printed circuit board

The module supplied in the Development kit is mounted on a carrier PCB in a method typical of a customer application. This carrier PCB illustrates and implements many of the design considerations discussed in this document.

The module is interfaced through two separate 20-pin data connectors with different header pitches. This is for development purposes and provides a simple way to evaluate the surface mount module.

The RTC (Real-Time Clock) backup supply voltage can be provided by an onboard lithium cell, or from the development unit backup supply. The adapter board carries the antenna DC supply over-current protection circuits (as shown in Figure 2-11), and a switch de-bounce IC to provide reliable reset action from the development unit.

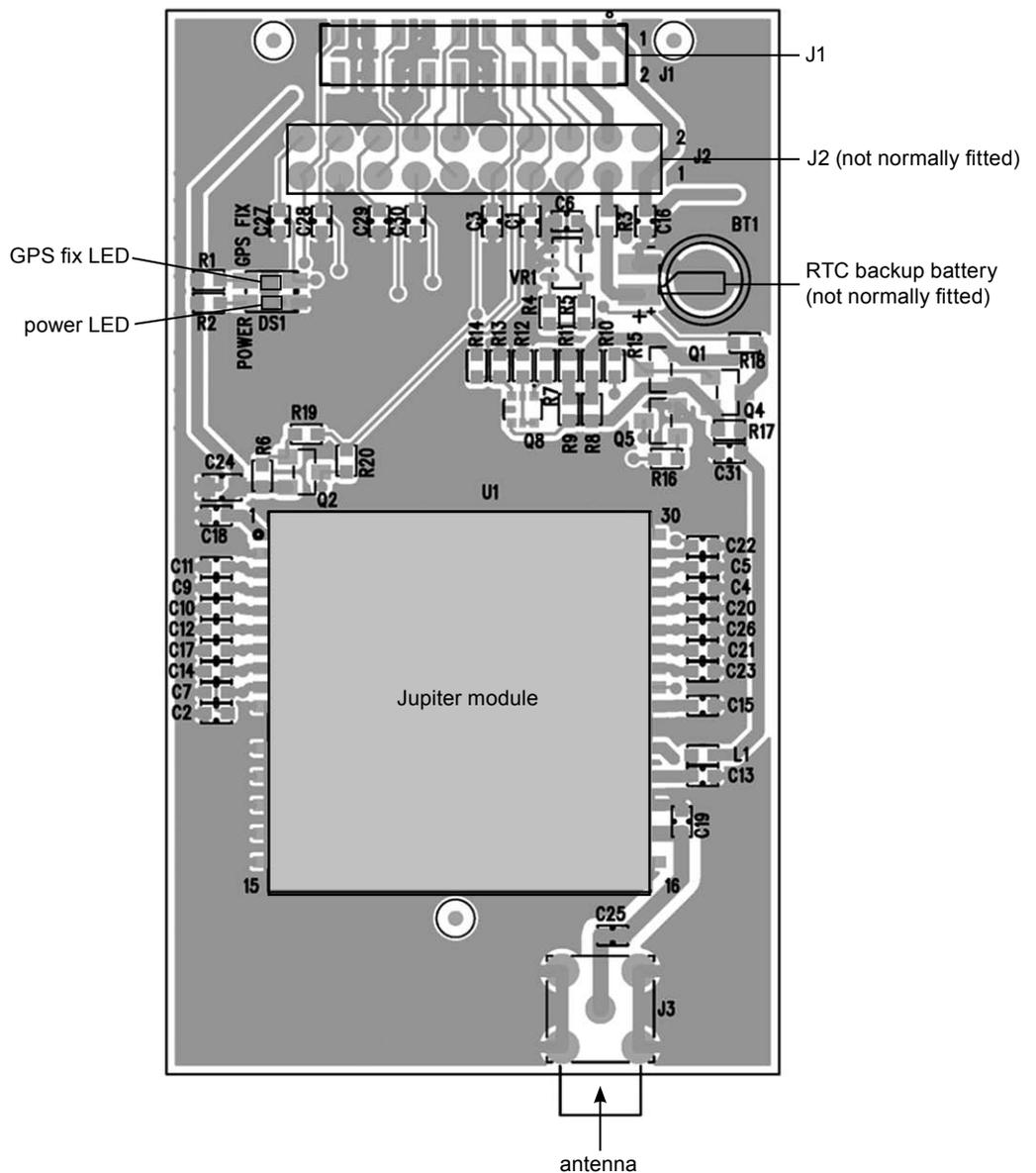Figure 2-12 shows the adapter board with the positions of the connectors and indicators.

Figure 2-12: Adapter printed circuit board

Refer to Table 2-8 for a description of the connector interfaces.

Jupiter function	J2 (2.54 mm pitch header) pin no.	J1 (2 mm pitch header) pin no.
V_ANT	1	1
VCC_RF	2	–
V_BATT	3	3
VDD	4	4
M_RST	5	5
GPIO/GYRO IN	6	6
GPIO/FR	7	7
BOOT	8	8
GPIO/W TICKS	9	9
RFON	10	–
GND	–	10
TXA	11	11
RXA	12	12
GPIO/SDI	13	–
GND	–	13
TXB	14	14
RXB	15	15
GPIO/SCK	16*	–
GND	17	16
GPIO/SDO	18	–
GND	–	17
GND	–	18
1PPS	19	19
GPS_FIX/GPIO	20	–

*Note: J2 Pin 16 on the adapter card is the wake-up line for push to fix mode on the Jupiter 30

Table 2-8: Connector configuration

3.0 Software application information

3.1 Normal mode operation

In normal mode of operation, the baseband processor software runs continuously, providing a navigation solution at the maximum rate of once per second. No power saving functions are applied.

If the power to the module is disrupted, the restart time can be shortened to a warm or hot start by keeping the RTC and SRAM contents valid with a backup battery on the VBATT input.

If the module has been turned off for greater than 2 hours, the unit will revert to a warm or cold start. This is caused by the stored ephemeris data becoming invalid after 4 hours.

3.2 Power management

The TricklePower mode of operation can be enabled to reduce the average power consumption. The main power is supplied to the module continuously. An internal timer wakes the processor from sleep mode. The module computes a navigation position fix, after which the processor reverts to sleep mode. The duty cycle is controlled by a user-configurable parameter.

If ephemeris data becomes outdated, the TricklePower mode will attempt to refresh the data set within every 30 minute period, or for every new satellite that comes into view.

With TricklePower set to a 20% duty cycle, a power saving of 50% can easily be achieved with minimal degradation in navigation performance.

3.2.1 Adaptive TricklePower mode

In Adaptive TricklePower mode, the processor automatically returns to full power when signal levels are below the level at which they can be tracked in TricklePower mode. This is the default behaviour when TricklePower is active. Adaptive TricklePower is always enabled on the Jupiter 30 and Jupiter 20 S (XTrac), and selectable on the Jupiter 20 standard module.

3.2.2 Push-to-Fix mode

Unlike TricklePower, the operation in this mode is not cyclic. This mode always forces the GPS software to revert to a continuous sleep mode after a navigation position fix. It will stay in sleep mode until woken by activation of the reset input (Jupiter 20) or wakeup input (Jupiter 30), and compute a fresh position.

If the ephemeris data becomes invalid or new satellites come into view, the RTC has the ability to self activate and refresh the data, thus keeping the restart TTFF very short.

This mode yields the lowest power consumption of the module, and is ideal where a battery powered application requires very few position fixes.

For further information on the TricklePower and Push-To-Fix modes refer to the Low Power Operating Modes application note (LA000513).

3.3 Serial I/O

The module can output serial data in the NMEA format or SiRF Binary format. The serial I/O protocols are defined in the Navman NMEA reference manual (MN000315) and the SiRF Binary Protocol reference manual. These describe the format of the serial data from the module, as well as the structure of the commands. Navman has provided additional functionality to the NMEA protocol as detailed in the following sections.

3.3.1 Default settings

The default protocol is NMEA, at a baud rate of 9600bps. The frame format is 8 data bits, no parity bit and 1 stop bit.

The following messages are output by default, at a rate of once per second each:

$GPGGA, $GPGLL, $GPGSA, $GPGSV, $GPRMC, $GPVTG, $GPZDA

All output messages have checksums by default.

Note: message $GPZDA is not available for Jupiter 20 S, or Jupiter 20 D.

3.3.2 NMEA input commands

All NMEA input commands are in the form:

$PSRFxxx,…[*CS] <CR> <LF>

where xxx is a decimal number between 100 and 255 (inclusive).

Note: In each case, CS represents an NMEA checksum, <CR> is carriage return, <LF> is line feed. These details are covered in the Navman NMEA reference manual MN000315.

Acknowledgements

All input commands other than the standard SiRF commands will be acknowledged with a sentence of the form:

$PTTK,…*CS

Where the arguments provided to a command are invalid, the response will be the message:

$PTTK,NACK*CS

Checksums

All input commands are accepted whether or not they include a checksum, however if a checksum is included it must be correct in order for the message to be accepted.

Incorrect checksums will result in the response:

$PTTK,CHECKSUM*CS

Unused messages

Input messages where the message ID is not between 100 and 255, or where the message ID does not correspond to a specified function, result in the response:

$PTTK,INVALID*CS

Errors

Errors in message receipt (other than checksum errors) result in the response:

$PTTK,ERROR,xx*CS

where xx is a hexadecimal error code.

Magnetic Variation (Declination)

The Jupiter 20 module calculates the magnetic variation (the Jupiter 30 does not).

Magnetic Variation fields in $GPRMC

The last two fields in the message $GPRMC are the magnetic variation. An Easterly variation should be subtracted from, or a Westerly variation added to, the true heading to give the magnetic heading (the heading given by a magnetic compass).

For example, the output might be:

$GPRMC,220137.250,A,4331.9077,S,17238.2308,E,0.075949,168.82,071004,23.1,E*4C

Standard SiRF output:

$GPRMC,220137.250,A,4331.9077,S,17238.2308,E,0.075949,168.82,071004,,*17

Magnetic Heading field in $GPVTG

The third field in the message $GPVTG is the magnetic heading (denoted by the 'M' in the following field). This is the heading that would be reported by a magnetic compass.

For example, the output might be:

$GPVTG,168.82,T,145.70,M,0.08,N,0.14,K*41

The standard SiRF output:

$GPVTG,168.82,T,,M,0.08,N,0.14,K*58

3.3.3 Altitude output

The module outputs the correct altitude and geoid separation in the $GPGGA NMEA message. Most SiRFstar-based modules output the height above the current datum (usually WGS84) ellipsoid as the altitude, contrary to the NMEA specification, and older modules omit the geoid separation. The Jupiter receiver outputs the height above mean sea level, as required by the NMEA specification.

For example, the output might be:

$GPGGA,220137.869,4331.9077,S,17238.2308,E,1,06,1.6,61.7,M,11.3,M,0.0,0000*55

Standard SiRF output (v2.3 and earlier):

$GPGGA,220137.869,4331.9077,S,17238.2308,E,1,06,1.6,72.0,M,,M,0.0,0000*6D

Or (v2.3.1 and 2.3.2):

$GPGGA,220137.869,4331.9077,S,17238.2308,E,1,06,1.6,72.0,M,11.3,M,0.0,0000*50

3.4 Navman proprietary NMEA low power mode messages

Navman has added a number of proprietary NMEA input messages to configure the TricklePower and Push-To-Fix modes.

3.4.1 Low power configuration

The following message sets the receiver to low power mode:

$PSRF151,a,bbbb,cccc[*CS] <CR> <LF>

where:

Field	Description
a	Push-To-Fix* (1=on, 0=off)
b	TricklePower duty cycle (parts per thousand)
c	TricklePower on time (milliseconds)
*Note that Push-To-Fix™ does not require fields b and c so they may be left blank	

Table 3-1: Low power modes message values

This message is the NMEA equivalent of the SiRF Binary input message ID 151.

System response:

$PTTK,LPSET,a,bbbb,cccc*CS

The updated values returned by the system are as described in Table 3-1.

3.4.2 Low power acquisition configuration

The following message sets the acquisition parameters of the low power mode:

$PSRF167,aaaaaa,bbbbbb,cccc,d[*CS] <CR> <LF>

where:

Field	Description
a	maximum off time (milliseconds)
b	maximum search time (milliseconds)
c	Push-To-Fix period (seconds)
d	adaptive TricklePower (1=on, 0=off)

Table 3-2: Low power acquisition input values

This message is the NMEA equivalent of the SiRF Binary input message ID 167.

System response:

$PTTK,LPACQ,aaaaaa,bbbbbb,cccc,d*CS

The updated values returned by the system are as described in Table 3-2.

3.5 Control of GPIO connections via serial commands (Jupiter 20)

Note: The information in this section does not apply to the Jupiter 30 module.

The Jupiter 20 receiver has many unused GPIO (user programmable input output) signal pads. These can be utilised in the application by introducing custom software written with the SiRF SDK (Software Development Kit) tools.

Alternatively, the receiver has an NMEA default instruction protocol that can control these IO ports through the standard serial communication ports using proprietary NMEA commands.

The GPIO lines are treated as a single 8-bit register, with the pins occupying the positions shown in Table 3-3.

Bit	Pad function	Pin
(LSB) 0	GPIO15/Fwd-Rev	27
1	GPIO1/Wheel Tick	28
2	GPIO3/Gyro In	8
3	GPIO5/SDI	25
4	GPIO6/SDO	24
5	GPIO7/SCLK	26
6	GPIO9/1PPS	29
(MSB) 7	GPIO10/GPS Fix	23

Table 3-3: Pin configuration of the GPIO lines

On the Jupiter 20 D, there is no control of GPIO15, GPIO1, GPIO3, GPIO5, GPIO6 or GPIO7, and all references to these pins are ignored.

In each of the messages described in the following sections, **x** represents a hexadecimal digit.

3.5.1 Configure port directions

$PSRF225,xx,xx[*CS] <CR> <LF>

Sets the direction of the GPIO pins. The first octet is the mask (which ports to override), the second the new direction. A zero represents an input, and a one an output. This command must be sent before attempting to manipulate or read any the specified GPIO. It also has the effect of suspending the normal port functions on the pins specified. Normal operation will resume following a hardware reset (including any use of the reset line in Push-to-Fix mode).

Response:

$PTTK,GPIO,DIR,xx,xx*CS

3.5.2 Set outputs

$PSRF226,xx[*CS] <CR> <LF>

Changes the specified outputs to high. Other outputs are not affected. There are no changes to any pins that are configured as inputs.

Response:

$PTTK,GPIO,SET,xx*CS

3.5.3 Clear outputs

$PSRF227,xx[*CS] <CR> <LF>

Changes the specified outputs to low. Other outputs are not affected. There are no changes to any pins that are configured as inputs.

Response:

$PTTK,GPIO,CLEAR,xx*CS

3.5.4 Read inputs

$PSRF228[*CS] <CR> <LF>

Returns the values on the input pins. Pins configured as outputs read as zero.

Response:

$PTTK,GPIO,READ,xx*CS

This message is sometimes output automatically.

3.6 GPS fix output

The GPS fix output is an active low output on pin 23 of the module. Whenever the unit has either a 2D or a 3D fix, this output will be low. When the unit has no fix, the output will be high. This function can be overridden and the pin used as GPIO10 using the commands described in Section 3.5. The GPS fix output function returns after a reset.

3.7 Antenna power monitor messages

The Jupiter software includes antenna monitor messages driven by the state of the antenna monitor inputs. The inputs NANT_SC (short circuit detect – active low) and ANT_OC (open circuit detect – active high) are configured as inputs, and ANT_CTRL (active antenna control) is configured as an output.

If the function of any of these pins is overridden using the procedure described in Section 3.6, then this feature is disabled. However if an antenna short circuit has occurred before any pins are overridden in this manner, the status will continue to be reported as 'short circuit' until such time as the active antenna control output is overridden.

In normal operation, the active antenna control output is high. If the short circuit detect pin goes low, the active antenna control signal will go low. This condition is latched until the user resets the module.

The active antenna control pin output is low when the receiver enters a low power mode due to TricklePower, Push-to-Fix or APM, and returns to its previous state when the receiver starts up again. No checking of the antenna current is performed while the output is low for this reason.

The antenna status output message is an NMEA message in the form:

$PTTK,ANT,d*CS

Where **d** represents any of the following numbers:

d	Description
0	normal antenna operation
1	antenna open circuit
2	antenna short circuit - antenna disabled
-1	antenna sensing disabled (due to GPIO override)

Table 3-4: Antenna status output message values

The antenna status message is output automatically in the event of a short circuit or open circuit being detected, or an open circuit condition coming to an end.

In addition, this message is output on the receipt of the NMEA input message:

$PSRF199[*CS]

The antenna status is also output as the SiRF binary message with message ID 99. It contains one byte of data, being the appropriate value from Table 3-4. This gives a payload length of 2 bytes, since the message ID is considered part of the payload.

The antenna status message is output automatically in the event of a short circuit, or open circuit being detected, or an open circuit condition coming to an end.

In addition, this message is output on the receipt of the SiRF binary message with message ID 199. The output rate of this message is also under the normal control of the SiRF Binary Query/ Rate Control input message, however this message is not output at a regular rate by default.

3.8 Custom application software

The module provides custom modification of the firmware to use available CPU processing capacities and I/O capabilities. The custom application software can be invoked internally or externally, providing the ability to dedicate the module as the host application or an external processor as the host. The module also provides the ability to communicate externally with standard or customer specific communication protocols.

The custom application software has access to the flash memory, navigation data from the GPS Navigation software, and access to various I/O lines used on the module.

This can be developed using the SiRF SDK. The SDK provides all the tools and resources necessary for custom software development. Refer to http://www.sirf.com for more information about the SDK.

4.0 Glossary and acronyms

EMI: Electromagnetic Interference

FR4 substrate: Flame Retardant type 4
The usual base material from which plated-through-hole and multi-layer printed circuit boards are constructed. The type '4' indicates woven glass reinforced epoxy resin.

GPS: Global Positioning System
A space-based radio positioning system that provides accurate position, velocity, and time data.

NMEA: National Marine Electronics Association

RF: Radio Frequency

SRAM: Static Random Access Memory

TTFF: Time-To-First-Fix
The actual time required by a GPS receiver to achieve a position solution. This specification will vary with the operating state of the receiver, the length of time since the last position fix, the location of the last position fix, and the specific receiver design.