Linx TECHNOLOGIES

F4 Series
GPS Receiver Module
Data Guide

Wireless made simple®

Warning: Some customers may want Linx radio frequency ("RF") products to control machinery or devices remotely, including machinery or devices that can cause death, bodily injuries, and/or property damage if improperly or inadvertently triggered, particularly in industrial settings or other applications implicating life-safety concerns ("Life and Property Safety Situations").

NO OEM LINX REMOTE CONTROL OR FUNCTION MODULE SHOULD EVER BE USED IN LIFE AND PROPERTY SAFETY SITUATIONS. No OEM Linx Remote Control or Function Module should be modified for Life and Property Safety Situations. Such modification cannot provide sufficient safety and will void the product's regulatory certification and warranty.

Customers may use our (non-Function) Modules, Antenna and Connectors as part of other systems in Life Safety Situations, but only with necessary and industry appropriate redundancies and in compliance with applicable safety standards, including without limitation, ANSI and NFPA standards. It is solely the responsibility of any Linx customer who uses one or more of these products to incorporate appropriate redundancies and safety standards for the Life and Property Safety Situation application.

Do not use this or any Linx product to trigger an action directly from the data line or RSSI lines without a protocol or encoder/ decoder to validate the data. Without validation, any signal from another unrelated transmitter in the environment received by the module could inadvertently trigger the action.

All RF products are susceptible to RF interference that can prevent communication. RF products without frequency agility or hopping implemented are more subject to interference. This module does not have a frequency hopping protocol built in.

Do not use any Linx product over the limits in this data guide. Excessive voltage or extended operation at the maximum voltage could cause product failure. Exceeding the reflow temperature profile could cause product failure which is not immediately evident.

Do not make any physical or electrical modifications to any Linx product. This will void the warranty and regulatory and UL certifications and may cause product failure which is not immediately evident.

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Warning: This product incorporates numerous static-sensitive components. Always wear an ESD wrist strap and observe proper ESD handling procedures when working with this device. Failure to observe this precaution may result in module damage or failure.

F4 Series GPS Receiver

Data Guide

Description

The F4 Series GPS receiver module is a self-contained high-performance GPS receiver. Based on the SiRFstar IV chipset, it provides exceptional sensitivity, even in dense foliage and urban canyons. The module's very low power consumption helps maximize runtimes in battery powered applications. The F4 Series receiver can acquire and track up to 48 satellites simultaneously in just seconds, even at the lowest signal levels. Housed in a compact reflow-compatible SMD package, the receiver requires no programming or additional RF components (except an antenna) to form a complete GPS solution. Five GPIOs are easily configured through simple serial commands. These features along with the module's standard NMEA data output make the F4 Series easy to integrate, even by engineers without previous RF or GPS experience.

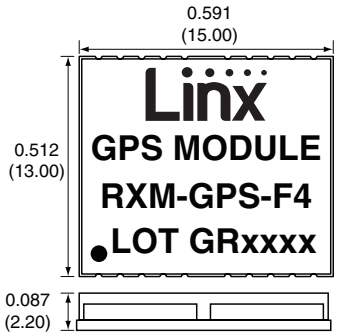


Figure 1: Package Dimensions

Features

- SiRF Star IV chipset
- Built-in jammer remover
- High sensitivity (-160dBm)
- 48 channels
- Fast TTFF at low signal levels
- 5 user definable GPIOs
- CGEE allows 3-day prediction
- No programming necessary
- No external RF components needed (except an antenna)
- No production tuning
- Direct serial interface
- Power down feature
- Compact surface-mount package
- Manual or reflow compatible

Applications

- Positioning and Navigation
- Location and Tracking
- Security/Loss-Prevention
- Surveying
- Logistics
- Fleet Management

Ordering Information

Ordering Information	
Part Number	**Description**
RXM-GPS-F4-x	F4 Series GPS Receiver Module
MDEV-GPS-F4	F4 Series GPS Receiver Master Development System

x = “T” for Tape and Reel, “B” for Bulk
Reels are 1,000 pieces
Quantities less than 1,000 pieces are supplied in bulk

Figure 2: Ordering Information

Electrical Specifications

F4 Series GPS Receiver Specifications						
Parameter	**Symbol**	**Min.**	**Typ.**	**Max.**	**Units**	**Notes**
Power Supply						
Operating Voltage	V_{CC}	1.71	1.8	1.89	VDC	
Supply Current	I_{CC}					
Peak				130	mA	1
Acquisition			46		mA	1
Tracking			27.5		mA	1
Hibernate			20		µA	1
Ready-to-Start			9		µA	2
Output Low Voltage	V_{OL}			0.4	VDC	
Output High Voltage	V_{OH}	0.75*VCC		VCC	VDC	
Output Low Current	I_{OL}		2.0		mA	
Output High Current	I_{OH}		2.0		mA	
Input Low Voltage	V_{IL}	–0.4		0.45	VDC	
Input High Voltage	V_{IH}	07*VCC		3.6	VDC	
Input Capacitance	C_{IN}		5		pF	
Load Capacitance	C_{LOAD}			8	pF	
LNA Section						
Input Power	P_{IN}			18	dB	
Antenna Port						
RF Impedance	R_{IN}		50		Ω	
Environmental						
Operating Temperature		–30		85	ºC	
Storage Temperature		–40		85	ºC	

Receiver Section						
Receiver Sensitivity						
Tracking			–160		dBm	
Navigation			–157		dBm	
Cold Start			–145		dBm	
Acquisition Time						
Hot Start (Open Sky)				1	s	
Hot Start (Indoor)				15	s	
Cold Start			32		s	
Cold Start, CGEE			15		s	
Position Accuracy						
Autonomous			3		m	
SBAS			2.5		m	
Altitude				18,000	m	
Velocity				515	m/s	
Chipset	SiRF Star IV, GSD4e-9411					
Frequency	L1 1575.42MHz, C/A Code					
Channels	48					
Update Rate	1Hz default, up to 5Hz					
Protocol Support	NMEA 0183 ver 3.0, SiRF Binary					

1. VCC = 1.8V
2. Initial state after power is applied

Figure 3: Electrical Specifications

Absolute Maximum Ratings

Absolute Maximum Ratings				
Supply Voltage V_{CC}	+1.95			VDC
I/O Pin Voltage	+3.6			VDC
Operating Temperature	–40	to	+85	ºC
Storage Temperature	–40	to	+85	ºC
Soldering Temperature	+225°C for 10 seconds			

Exceeding any of the limits of this section may lead to permanent damage to the device. Furthermore, extended operation at these maximum ratings may reduce the life of this device.

Figure 4: Absolute Maximum Ratings

Pin Assignments

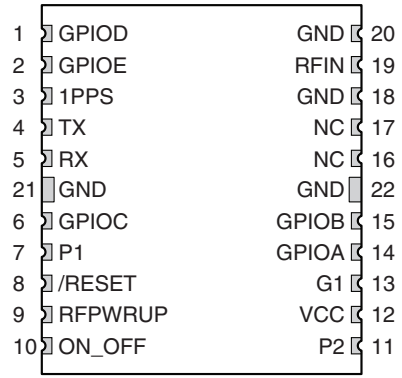


Figure 5: F4 Series GPS Receiver Pin Assignments (Top View)

Pin Descriptions

Pin Descriptions			
Pin Number	**Name**	**I/O**	**Description**
1	GPIOD	I/O	General Purpose I/O. 3.6V tolerant.
2	GPIOE	I/O	General Purpose I/O. 3.6V tolerant.
3	1PPS	O	1 Pulse Per Second. 1.8V level.
4	TX	O	Serial output (default NMEA)
5	RX	I	Serial input (default NMEA). 3.6V tolerant.
6	GPIOC	I/O	General Purpose I/O. 3.6V tolerant.
7, 11	P1, P2	I	Pull to 1.8V VCC through 2.2k resistors.
8	/RESET	I	Reset Input. Active low with an internal pull-up. Internal reset is preferred; external reset will clear all RAM. 3.6V tolerant.
9	RFPWRUP	O	Power State Indicator
10	ON_OFF	I	Power Control Pin. Internal 10k pull-down resistor. 3.6V tolerant.
12	VCC	P	Supply Voltage
13	G1	I	Pull to GND through a 100k resistor.
14	GPIOA	I/O	General Purpose I/O. 3.6V tolerant.
15	GPIOB	I/O	General Purpose I/O. 3.6V tolerant.
16, 17	NC	–	No electrical connection.
18, 20, 21, 22	GND	P	Ground
19	RFIN	I	GPS RF signal input

Figure 6: F4 Series GPS Receiver Pin Descriptions

A Brief Overview of GPS

The Global Positioning System (GPS) is a U.S.-owned utility that freely and continuously provides positioning, navigation, and timing (PNT) information. Originally created by the U.S. Department of Defense for military applications, the system was made available without charge to civilians in the early 1980s. The global positioning system consists of a nominal constellation of 24 satellites orbiting the earth at about 12,000 nautical miles in height. The pattern and spacing of the satellites allow at least four to be visible above the horizon from any point on the Earth. Each satellite transmits low power radio signals which contain three different bits of information; a pseudorandom code identifying the satellite, ephemeris data which contains the current date and time as well as the satellite's health, and the almanac data which tells where each satellite should be at any time throughout the day.

A GPS receiver receives and times the signals sent by multiple satellites and calculates the distance to each satellite. If the position of each satellite is known, the receiver can use triangulation to determine its position anywhere on the earth. The receiver uses four satellites to solve for four unknowns; latitude, longitude, altitude, and time. If any of these factors is already known to the system, an accurate position (fix) can be obtained with fewer satellites in view. Tracking more satellites improves calculation accuracy. In essence, the GPS system provides a unique address for every square meter on the planet.

A faster Time To First Fix (TTFF) is also possible if the satellite information is already stored in the receiver. If the receiver knows some of this information, then it can accurately predict its position before acquiring an updated position fix. For example, aircraft or marine navigation equipment may have other means of determining altitude, so the GPS receiver would only have to lock on to three satellites and calculate three equations to provide the first position fix after power-up.

Client Generated Extended Ephemeris (CGEE)

CGEE is a type of assisted GPS (AGPS) where the receiver uses the ephemeris data broadcast by the satellites to calculate models of each visible satellite's future location. This allows the receiver to store up to 3 days worth of ephemeris data and results in faster TTFF.

Time To First Fix (TTFF)

TTFF is often broken down into three parts:

Cold: A cold start is when the receiver has no accurate knowledge of its position or time. This happens when the receiver's internal Real Time Clock (RTC) has not been running or it has no valid ephemeris or almanac data. In a cold start, the receiver takes 35 to 40 seconds to acquire its position.

Warm or Normal: A typical warm start is when the receiver has valid almanac and time data and has not significantly moved since its last valid position calculation. This happens when the receiver has been shut down for more than 2 hours, but still has its last position, time, and almanac saved in memory, and its RTC has been running. The receiver can predict the location of the current visible satellites and its location; however, it needs to wait for an ephemeris broadcast (every 30 seconds) before it can accurately calculate its position.

Hot or Standby: A hot start is when the receiver has valid ephemeris, time, and almanac data. This happens when the receiver has been shut down for less than 2 hours and has the necessary data stored in memory with the RTC running. In a hot start, the receiver takes 1 second to acquire its position. The time to calculate a fix in this state is sometimes referred to as Time to Subsequent Fix or TTSF.

Module Description

The F4 Series GPS Receiver module is based on the SiRFstarIV chipset, which consumes less power than competitive products while providing exceptional performance even in dense foliage and urban canyons. No external RF components are needed other than an antenna. The simple serial interface and industry standard NMEA protocol make integration of the F4 Series receiver into an end product extremely straightforward.

The module's high-performance RF architecture allows it to receive GPS signals that are as low as –160dBm. The F4 Series can track up to 48 satellites at the same time. Once locked onto the visible satellites, the receiver calculates the range to the satellites and determines its position and the precise time. It then outputs the data through a standard serial port using several standard NMEA protocol formats.

The GPS core handles all of the necessary initialization, tracking, and calculations autonomously, so no programming is required. The RF section is optimized for low level signals, and requires no production tuning.

Power Supply Requirements

The module requires a clean, well-regulated power source. While it is preferable to power the unit from a battery, it can operate from a power supply as long as noise is less than 20mV. Power supply noise can significantly affect the receiver's sensitivity, therefore providing clean power to the module should be a high priority during design. Bypass capacitors should be placed as close as possible to the module. The values should be adjusted depending on the amount and type of noise present on the supply line.

The 1PPS Output

The 1PPS line outputs 1 pulse per second on the rising edge of the GPS second when the receiver has an over-solved navigation solution from five or more satellites. The pulse has a duration of 200ms with the rising edge on the GPS second. This line is low until the receiver acquires an over-solved navigation solution (a lock on more than 4 satellites). The GPS second is based on the atomic clocks in the GPS satellites, which are monitored and set to Universal Time master clocks. This output and the time calculated from the GPS satellite transmissions can be used as a clock feature in an end product.

Antenna Considerations

The F4 Series module is designed to utilize a wide variety of external antennas, but care must be taken in antenna selection to ensure optimum performance. For example, a handheld device may be used in many varying orientations so an antenna element with a wide and uniform pattern may yield better overall performance than an antenna element with high gain and a correspondingly narrower beam. Conversely, an antenna mounted in a fixed and predictable manner may benefit from pattern and gain characteristics suited to that application. Evaluating multiple antenna solutions in real-world situations is a good way to rapidly assess which will best meet the needs of your application.

For GPS, the antenna should have good right hand circular polarization characteristics (RHCP) to match the polarization of the GPS signals. Ceramic patches are the most commonly used style of antenna, but there are many different shapes, sizes and styles of antennas available. Regardless of the construction, they will generally be either passive or active types. Passive antennas are simply an antenna tuned to the correct frequency. Active antennas add a Low Noise Amplifier (LNA) after the antenna and before the module to amplify the weak GPS satellite signals.

For active antennas, a 300 ohm ferrite bead can be used to connect the the RFIN line to an external supply for the antenna. This bead prevents the RF from getting into the power supply, but allows the DC voltage onto the RF trace to feed into the antenna. A series capacitor inside the module prevents this DC voltage from affecting the bias on the module's internal LNA.

Maintaining a 50 ohm path between the module and antenna is critical. Errors in layout can significantly impact the module's performance. Please review the layout guidelines elsewhere in this guide carefully to become more familiar with these considerations.

Power Control

The F4 Series GPS Receiver module offers four power control modes: Full Power, Adaptive Trickle Power, Push-to-Fix and Hibernate. In Full Power mode the module is fully active and and continuously tracking. Measurements are of the highest quality and are continuously output by the module. This is the highest current consumption state.

In Adaptive Trickle Power mode, the receiver powers on at full power to acquire and track satellites and obtain satellite data. It then powers off the RF stage and only uses its processor (CPU) to determine a position fix. Once the fix is obtained, the receiver goes into Hibernate mode. After a user-defined period of time, the receiver wakes up to track the satellites for a user-defined period of time, updates its position using the CPU only, and then resumes standby. The initial acquisition time is variable, depending on whether it is a cold start or assisted, but a maximum acquisition time is definable. This cycling of power is ideal for battery-powered applications since it significantly reduces the amount of power consumed by the receiver while still providing similar performance to the full power mode.

Push-to-Fix mode is for applications that require infrequent position reporting. The module stays in Hibernate mode until either the ON_OFF line is triggered or a user-defined time period has expired. The Push-to-Fix Period is set by a serial command and can be between 10 seconds and two hours. An edge on the ON-OFF line triggers an immediate position fix. When the module wakes up it acquires a new position fix and outputs the NMEA messages before going back into Hibernate mode.

Hibernate mode is the lowest power setting. The tracking and processor blocks are powered down, but the RTC is still running and the memory blocks are still powered, enabling a hot start.

The module switches between these states by toggling the ON_OFF line. The ON_OFF line must go high for at least 100ms to trigger the change of state and must remain low for at least 100ms to reset the edge detector.

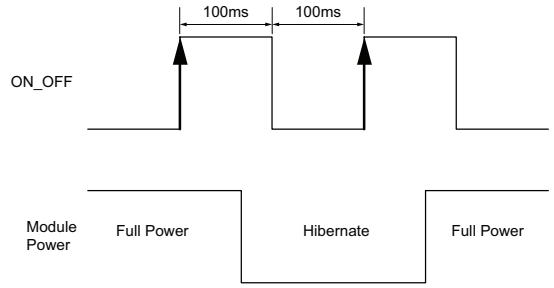


Figure 7: F4 Series GPS Receiver Power Control

If the module is in Full Power mode, a pulse on the ON_OFF line initiates an orderly shutdown into Hibernate mode. If the module is in Hibernate mode, a pulse transistions the module into Full Power Mode. If the module is in Push-to-fix mode a pulse initiates a single push-to-fix cycle. If the module is in Adaptive Trickle Power mode, a pulse initiates one Trickle Power cycle.

Module Power-up Sequence

The module requires a specific sequence to power up and begin normal operation. When power is first applied the module enters a “ready-to-start” state while the Real Time Clock (RTC) starts up and settles. It awaits a pulse on the ON_OFF line to enter Full Power Mode.

The RTC start time is variable, so the host needs to either monitor the RFPWRUP line for a high pulse or wait for at least one second before pulsing the ON_OFF line. An example flowchart is shown in Figure 8.

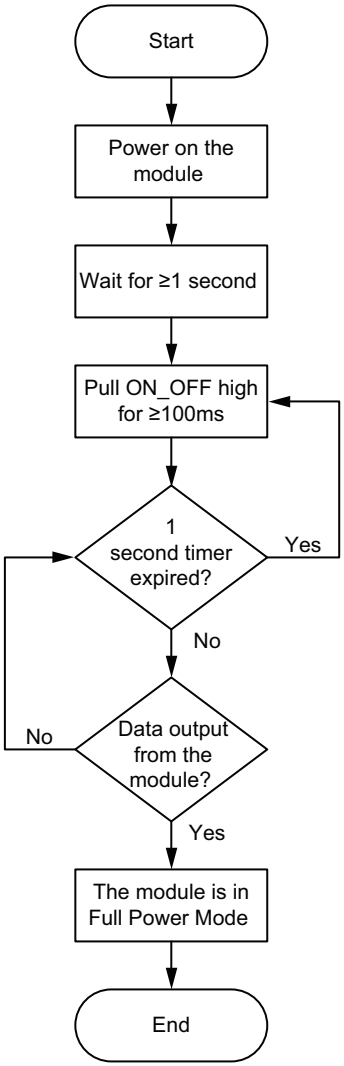


Figure 8: F4 Series GPS Receiver Power Power-up Sequence

Module Power-down Sequence

The module requires a controlled power-down sequence. Uncontrolled removal of power while the module is operating carries the risk of data corruption. The consequences of this corruption range from longer TTFF to complete system failure. The appropriate procedure to remove power is shown in Figure 9.

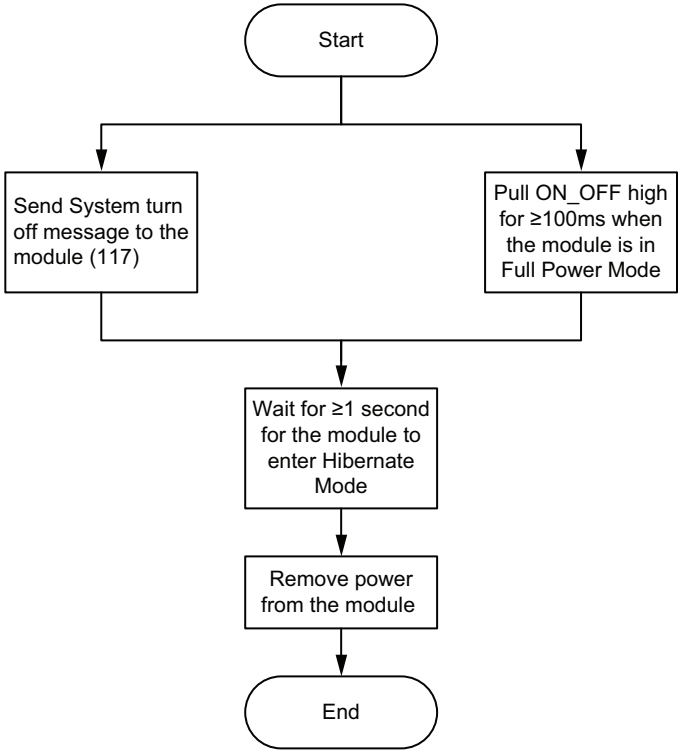


Figure 9: F4 Series GPS Receiver Power Power-down Sequence

Slow Start Time

The most critical factors in start time are current ephemeris data, signal strength and sky view. The ephemeris data describes the path of each satellite as they orbit the earth. This is used to calculate the position of a satellite at a particular time. This data is only usable for a short period of time, so if it has been more than a few hours since the last fix or if the location has significantly changed (a few hundred miles), then the receiver may need to wait for a new ephemeris transmission before a position can be calculated. The GPS satellites transmit the ephemeris data every 30 seconds. Transmissions with a low signal strength may not be received correctly or be corrupted by ambient noise. The view of the sky is important because the more satellites the receiver can see, the faster the fix and the more accurate the position will be when the fix is obtained.

If the receiver is in a very poor location, such as inside a building, urban canyon, or dense foliage, then the time to first fix can be slowed. In very poor locations with poor signal strength and a limited view of the sky with outdated ephemeris data, this could be on the order of several minutes. In the worst cases, the receiver may need to receive almanac data, which describes the health and course data for every satellite in the constellation. This data is transmitted every 15 minutes. If a lock is taking a long time, try to find a location with a better view of the sky and fewer obstructions. Once locked, it is easier for the receiver to maintain the position fix.

Protocols

Linx GPS modules use the SiRFstar IV chipset. This chipset allows two protocols to be used, NMEA-0183 and SiRF Binary. Switching between the two is handled using a single serial command. The NMEA protocol uses ASCII characters for the input and output messages and provides the most common features of GPS development in a small command set. The SiRF Binary protocol uses BYTE data types and allows more detailed control over the GPS receiver and its functionality using a much larger command set. Although both protocols have selectable baud rates, it's recommended that SiRF Binary use 115,200bps. For a detailed description of the SiRF Binary protocol, see the SiRF Binary Protocol Reference Manual, available from SiRF Technology, Inc.

> Note: Although SiRF Binary protocol may be used with the module, Linx only offers tech support for the NMEA protocol.

Interfacing with NMEA Messages

Linx modules default to the NMEA protocol. Output messages are sent from the receiver on the TX pin and input messages are sent to the receiver on the RX pin. By default, output messages are sent once every second. Details of each message are described in the following sections.

The NMEA message format is as follows: <Message-ID + Data Payload + Checksum + End Sequence>. The serial data structure defaults to 9,600bps, 8 data bits, 1 start bit, 2 stop bits, and no parity. Each message starts with a $ character and ends with a <CR> <LF>. All fields within each message are separated by a comma. The checksum follows the * character and is the last two characters, not including the <CR> <LF>. It consists of two hex digits representing the exclusive OR (XOR) of all characters between, but not including, the $ and * characters. When reading NMEA output messages, if a field has no value assigned to it, the comma will still be placed following the previous comma. For example, {,04,,,,,2.0,} shows four empty fields between values 04 and 2.0. When writing NMEA input messages, all fields are required, none are optional. An empty field will invalidate the message and it will be ignored.

Reading NMEA output messages:

- Initialize a serial interface to match the serial data structure of the GPS receiver.
- Read the NMEA data from the TX pin into a receive buffer.
- Separate it into six buffers, one for each message type. Use the characters ($) and <CR> <LF> as end points for each message.
- For each message, calculate the checksum as mentioned above to compare with the received checksum.
- Parse the data from each message using commas as field separators.
- Update the application with the parsed field values.
- Clear the receive buffer and be ready for the next set of messages.

Writing NMEA input messages:

- Initialize a serial interface to match the serial data structure of the GPS receiver.
- Assemble the message to be sent with the calculated checksum.
- Transmit the message to the receiver on the RX pin.

NMEA Output Messages

The following sections outline the data structures of the NMEA messages that are supported by the module. By default, the NMEA commands are output at 9,600bps, 8 data bits, no parity 1 start bit and 2 stop bits.

GGA – Global Positioning System Fixed Data

Figure 10 contains the values for the following example:

*$GPGGA,053740.000,2503.6319,N,12136.0099,E,1,08,1.1,63.8,M,15.2,M,,0000*64*

Global Positioning System Fixed Data Example			
Name	**Example**	**Units**	**Description**
Message ID	$GPGGA		GGA protocol header
UTC Time	053740.000		hhmmss.sss
Latitude	2503.6319		ddmm.mmmm
N/S Indicator	N		N=north or S=south
Longitude	12136.0099		dddmm.mmmm
E/W Indicator	E		E=east or W=west
Position Fix Indicator	1		See Figure 11
Satellites Used	08		Range 0 to 12.
HDOP	1.1		Horizontal Dilution of Precision
MSL Altitude	63.8	meters	
Units	M	meters	
Geoid Separation	15.2	meters	
Units	M	meters	
Age of Diff. Corr.		second	Null fields when DGPS is not used
Diff. Ref. Station	0000		
Checksum	*64		
<CR> <LF>			End of message termination

Figure 10: Global Positioning System Fixed Data Example

Position Indicator Values	
Value	**Description**
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

Figure 11: Position Indicator Values

GLL – Geographic Position – Latitude / Longitude

Figure 12 contains the values for the following example:

*$GPGLL,2503.6319,N,12136.0099,E,053740.000,A,A*52*

Geographic Position – Latitude / Longitude Example			
Name	**Example**	**Units**	**Description**
Message ID	$GPGLL		GLL protocol header
Latitude	2503.6319		ddmm.mmmm
N/S Indicator	N		N=north or S=south
Longitude	12136.0099		dddmm.mmmm
E/W Indicator	E		E=east or W=west
UTC Time	053740.000		hhmmss.sss
Status	A		A=data valid or V=data not valid
Mode	A		A=autonomous, D=DGPS, N=Data not valid
Checksum	*52		
<CR> <LF>			End of message termination

Figure 12: Geographic Position – Latitude / Longitude Example

GSA – GPS DOP and Active Satellites

Figure 13 contains the values for the following example:

*$GPGSA,A,3,24,07,17,11,28,08,20,04,,,,,2.0,1.1,1.7*35*

GPS DOP and Active Satellites Example			
Name	**Example**	**Units**	**Description**
Message ID	$GPGSA		GSA protocol header
Mode 1	A		See Figure 14
Mode 2	3		1=No fix, 2=2D, 3=3D
ID of satellite used	24		Sv on Channel 1
ID of satellite used	07		Sv on Channel 2
...			...
ID of satellite used			Sv on Channel 12
PDOP	2.0		Position Dilution of Precision
HDOP	1.1		Horizontal Dilution of Precision
VDOP	1.7		Vertical Dilution of Precision
Checksum	*35		
<CR> <LF>			End of message termination

Figure 13: GPS DOP and Active Satellites Exampl

Mode 1 Values	
Value	**Description**
M	Manual – forced to operate in 2D or 3D mode
A	Automatic – allowed to automatically switch 2D/3D

Figure 14: Mode 1 Values

GSV – GPS Satellites in View

Figure 15 contains the values for the following example:

*$GPGSV,3,1,12,28,81,285,42,24,67,302,46,31,54,354,,20,51,077,46*73*

*$GPGSV,3,2,12,17,41,328,45,07,32,315,45,04,31,250,40,11,25,046,41*75*

*$GPGSV,3,3,12,08,22,214,38,27,08,190,16,19,05,092,33,23,04,127,*7B*

GPS Satellites in View Example			
Name	**Example**	**Units**	**Description**
Message ID	$GPGSV		GSV protocol header
Total number of messages[1]	3		Range 1 to 3
Message number[1]	1		Range 1 to 3
Satellites in view	12		
Satellite ID	28		Channel 1 (Range 01 to 196)
Elevation	81	degrees	Channel 1 (Range 00 to 90)
Azimuth	285	degrees	Channel 1 (Range 000 to 359)
SNR (C/No)	42	dB-Hz	Channel 1 (Range 00 to 99, null when not tracking)
Satellite ID	20		Channel 4 (Range 01 to 32)
Elevation	51	degrees	Channel 4 (Range 00 to 90)
Azimuth	077	degrees	Channel 4 (Range 00 to 359)
SNR (C/No)	46	dB-Hz	Channel 4 (Range 00 to 99, null when not tracking.
Checksum	*73		
<CR> <LF>			End of message termination

1. Depending on the number of satellites tracked, multiple messages of GSV data may be required.

Figure 15: GPS Satellites in View Example

RMC – Recommended Minimum Specific GPS Data

Figure 16 contains the values for the following example:

*$GPRMC,053740.000,A,2503.6319,N,12136.0099,E,2.69,79.65,100106,,,A*53*

Recommended Minimum Specific GPS Data Example			
Name	**Example**	**Units**	**Description**
Message ID	$GPRMC		RMC protocol header
UTC Time	053740.000		hhmmss.sss
Status	A		A=data valid or V=data not valid
Latitude	2503.6319		ddmm.mmmm
N/S Indicator	N		N=north or S=south
Longitude	12136.0099		dddmm.mmmm
E/W Indicator	E		E=east or W=west
Speed over ground	2.69	knots	TRUE
Course over ground	79.65	degrees	
Date	100106		ddmmyy
Magnetic Variation		degrees	Not available, null field
Variation Sense			E=east or W=west (not shown)
Mode	A		A=autonomous, D=DGPS, N= Data not valid
Checksum	*53		
<CR> <LF>			End of message termination

Figure 16: Recommended Minimum Specific GPS Data Example

VTG – Course Over Ground and Ground Speed

Figure 17 contains the values for the following example:

*$GPVTG,79.65,T,,M,2.69,N,5.0,K,A*38*

Course Over Ground and Ground Speed Example			
Name	**Example**	**Units**	**Description**
Message ID	$GPVTG		VTG protocol header
Course over ground	79.65	degrees	Measured heading
Reference	T		TRUE
Course over ground		degrees	Measured heading (N/A, null field)
Reference	M		Magnetic
Speed over ground	2.69	knots	Measured speed
Units	N		Knots
Speed over ground	5.0	km/hr	Measured speed
Units	K		Kilometer per hour
Mode	A		A=autonomous, D=DGPS, N= Data not valid
Checksum	*38		
<CR> <LF>			End of message termination

Figure 17: Course Over Ground and Ground Speed Example

NMEA Input Messages

The following outlines the serial commands input into the module for configuration. By default, the commands are input at 9,600bps, 8 data bits, no parity, 1 start bit and 2 stop bits.

Serial Data Structure		
Name	**Example**	**Description**
Start Sequence	$PSRF	
Message ID	<MID>	Message Identifier consisting of three numeric characters. Input messages begin at MID 100.
Payload	DATA	Message specific data.
Checksum	CKSUM	CKSUM is a two-hex character checksum as defined in the NMEA specification, NMEA-0183 Standard for Interfacing Marine Electronic Devices. Checksums are required on all input messages.
End Sequence	<CR> <LF>	Each message must be terminated using Carriage Return (CR) Line Feed (LF) (\r\n, 0x0D0A) to cause the receiver to process the input message. They are not printable ASCII characters, so are omitted from the examples.

Figure 18: Serial Data Structure

All fields in all proprietary NMEA messages are required; none are optional. All NMEA messages are comma delimited. Figure 19 outlines the message identifiers supported by the module.

Message ID Values		
Name	**MID**	**Description**
SetSerialPort	100	Set serial port parameters and protocol
NavigationInitialization	101	Reset the modules
Query/Rate Control	103	Query standard NMEA message and/or set output rate
LLANavigationInitialization	104	Reset the modules
Development Data On/Off	105	Development Data messages On/Off
System Turn Off	117	Performs an orderly shut down of the module and switches into hibernation mode
PowerManagement	200	Sets the power performance of the receiver
FirmwareVersion	201	Query the firmware version
StaticNavigation	202	Sets static navigation On/Off
SetIO	211	Sets the I/O lines to an input or output
ReadInput	212	Reads the state of the inputs lines
WriteOutput	213	Writes the state of an output line

Query	214	Get configuration and last state of all GPIOs
Query	215	Get configuration and current state of all GPIOs

Figure 19: Message ID Values

100 – SetSerialPort

This command message is used to set the protocol (SiRF binary or NMEA) and/or the communication parameters (baud rate). Generally, this command is used to switch the module back to SiRF binary protocol mode where a more extensive command message set is available. When a valid message is received, the parameters are stored in battery-backed SRAM and the receiver restarts using the saved parameters.

Figure 20 contains the values for the following example:
Switch to SiRF binary protocol at 9600,8,N,1
*$PSRF100,0,9600,8,1,0*0C*

SetSerialPort Example

Name	Example	Description
Message ID	$PSRF100	PSRF100 protocol header
Protocol	0	0=SiRF binary, 1=NMEA
Baud	9600	4800, 9600, 19200, 38400, 57600, 115200
DataBits	8	8[1]
StopBits	1	0, 1[1]
Parity	0	0=None, 1=Odd, 2=Even[1]
Checksum	*0C	
<CR> <LF>		End of message termination

1. SiRF protocol is only valid for 8 data bits, 1 stop bit and no parity.
2. Default settings are NMEA protocol using 9,600 baud, 8 data bits, 2 stop bits and no parity.

Figure 20: SetSerialPort Example

For details on the SiRF binary protocol, please refer to SiRF's Binary Protocol Reference Manual.

101 – NavigationInitialization

This command is used to initialize the receiver with the current position (in X, Y, Z coordinates), clock offset, and time, enabling a faster fix. Increased receiver sensitivity and the removal of Selective Availability (SA) have made this unneccessary. The command is retained for its ability to reset the module, but the initialization fields are no longer supported.

Figure 21 contains the values for the following example:
*$PSRF101,-2686700,-4304200,3851624,96000,497260,921,12,3*1C*

NavigationInitialization Example

Name	Example	Units	Description
Message ID	$PSRF101		PSRF101 protocol header
ECEF X	-2686700	meters	X coordinate position
ECEF Y	-4304200	meters	Y coordinate position
ECEF Z	3851624	meters	Z coordinate position
ClkOffset	96000	Hz	Clock Offset[1]
TimeOfWeek	497260	seconds	GPS Time Of Week
WeekNo	921		GPS Week Number
ChannelCount	12		Range 1 to 12
ResetCfg	3		See Figure 22
Checksum	*1F		
<CR> <LF>			End of message termination

1. Use 0 for the last saved value if available. If this is unavailable, a default value of 96000 is used.

Figure 21: NavigationInitialization Example

ResetCfg Values

Hex	Description
0x01	Hot Start – All data valid
0x02	Warm Start – Ephemeris cleared
0x04	Cold Start – Clears all data in memory
0x08	Clear Memory – Clears all data in memory and resets the receiver back to factory defaults

Figure 22: ResetCfg Values

103 – Update Rate Control

This command is used to control the output of standard NMEA messages GGA, GLL, GSA, GSV, RMC and VTG. Using this command message, standard NMEA messages may be polled once, or setup for periodic output. Checksums may also be enabled or disabled depending on the needs of the receiving program. NMEA message settings are saved in battery-backed memory for each entry when the message is accepted.

Figure 23 contains the values for the following example:

1. Query the GGA message with checksum enabled
   *$PSRF103,00,01,00,01*25*
2. Enable VTG message for a 1Hz constant output with checksum enabled
   *$PSRF103,05,00,01,01*20*
3. Disable VTG message
   *$PSRF103,05,00,00,01*21*
4. Enable 5Hz mode
   *$PSRF103,0,6,0,0*23*
5. Disable 5Hz mode
   *$PSRF103,0,7,0,0*22*

Note: When using 5Hz mode, it is recommended to disable any unused NMEA message types (see example 3) and set the serial port to maximum baud rate (see Figure 20). The rate divider takes effect only after a fix is established.

Update Rate Control Example[1]

Name	Example	Units	Description
Message ID	$PSRF103		PSRF103 protocol header
Msg	00		See Figure 24
Mode	01		0=SetRate, 1=Query, 6=Enable divider[2], 7=Disable divider
Rate[3]	00	seconds	Output: off=0, max=255
CksumEnable	01		0=Disable, 1=Enable Checksum
Checksum	*25		
<CR> <LF>			End of message termination

1. Default setting is GGA, GLL, GSA, GSV, RMC and VTG NMEA messages are enabled with checksum at a rate of 1 second.
2. Enabling the rate divider divides the rate value by 5.
3. Rate value sets the period of a single transmission. For maximum update rate (5Hz) enter a value of 1 and enable the rate divider.

Figure 23: Update Rate Control Example

MSGValues

Value	Description
0	GGA
1	GLL
2	GSA
3	GSV
4	RMC
5	VTG
6	MSS (not supported)
7	Not defined
8	ZDA
9	Not defined

Figure 24: MSG Values

104 – LLANavigationInitialization

This command is used to initialize the receiver with the current position (in lattitude, longitude and altitude coordinates), clock offset, and time, enabling a faster fix. Increased receiver sensitivity and the removal of Selective Availability (SA) have made this unneccessary. The command is retained for its ability to reset the module, but the initialization fields are no longer supported.

Figure 25 contains the values for the following example:

*$PSRF104,37.3875111,-121.97232,0,96000,237759,1946,12,1*07*

LLANavigationInitialization Example

Name	Example	Units	Description
Message ID	$PSRF104		PSRF104 protocol header
Latitude	37.3875111	degrees	Latitude position (Range 90 to –90)
Longitude	-121.97232	degrees	Longitude position (Range 180 to –180)
Altitude	0	meters	Altitude position
ClkOffset	96000	Hz	Clock Offset of the Evaluation Receiver1
TimeOfWeek	237759	seconds	GPS Time Of Week
WeekNo	1946		Extended GPS Week Number (1024 added)
ChannelCount	12		Range 1 to 12
ResetCfg	1		See Figure 26
Checksum	*07		
<CR> <LF>			End of message termination

1. Use 0 for the last saved value if available. If this is unavailable, a default value of 96000 is used.

Figure 25: NavigationInitialization Example

ResetCfg Values

Hex	Description
0x01	Hot Start – All data valid
0x02	Warm Start – Ephemeris cleared
0x04	Cold Start – Clears all data in memory
0x08	Clear Memory – Clears all data in memory and resets the receiver back to factory defaults

Figure 26: ResetCfg Values

105 – Development Data On / Off

Use this command to enable development data information if you are having trouble getting commands accepted. Invalid commands generate debug information that helps to determine the source of the command rejection. Common reasons for input command rejection are invalid checksum or parameter out of specified range.

Figure 27 below contains the values for the following example:

1. Debug On

   *$PSRF105,1*3E*

2. Debug Off

   *$PSRF105,0*3F*

Development Data On / Off Example[1]

Name	Example	Units	Description
Message ID	$PSRF105		PSRF105 protocol header
Debug	1		0=Off, 1=On
Checksum	*3E		
<CR> <LF>			End of message termination

1. Default setting is debug mode off.

Figure 27: Development Data On / Off Example

117 – System Turn Off

This message requests that the GPS receiver perform an orderly shutdown and switch to hibernate mode.

Figure 28 below contains the values for the following example:

*$PSRF117,16*0B*

System Turn Off Example

Name	Example	Units	Description
Message ID	$PSRF117		PSRF117 protocol header
Sub ID	16		16: System turn off
Checksum	*0B		
<CR> <LF>			End of message termination

Figure 28: System Turn Off Example

200 – PowerManagement

This command sets the power mode to Full Power, Adaptive Trickle Power, or Push-to-Fix mode. Figure 29 contains the values for the following example to set the receiver to Adaptive Trickle Power mode:

*$PLSC,200,2,200,3000,300000,30000*0D*

Power Management Command Example[1]			
Name	**Example**	**Units**	**Description**
MID	$PLSC,200		Message ID
Mode	2		See Figure 30
OnTime	200 (200 – 900)	ms	Must be a multiple of 100 (if not, it is rounded up to the nearest multiple of 100). Set this to 0 when Mode = 3.
LP Interval	3000 (1000 – 10000)	ms	Must be an integer value ≥1000 and ≤10000. Set this to 0 when Mode = 3.
MaxAcqTime	300000 (≥1000)	ms	When Adaptive Trickle Power is enabled, this is the maximum allowable time from the start of a power cycle to the time a valid position fix is obtained. If no fix is obtained in this time, the receiver is deactivated for up to MaxOffTime, and a hot start is commanded when the receiver reactivates. The integer must be in multiples of 1000ms. There is no upper limit.
MaxOffTime	30000 (1000 – 1800000)	ms	The longest period (in mS) for which the receiver deavtivates due to the MaxAcqTime timeout. The actual deactivated period may be less if the user-specified duty cycle (OnTime / LpInterval) can be maintained.
PushToFixPeriod	(10 – 7200)	sec	The receiver automatically awakens every Push-to-Fix period to obtain a position fix, collect ephemeris (if needed), and calibrate the real-time clock (RTC) (if needed).
Checksum	*0D		
<CR> <LF>			End of message termination

1. Default setting is full power; trickle power disabled.

Figure 29: Power Management Command Example

Mode Values	
Value	**Description**
0	Ask the receiver to send the current power mode
1	Set the receiver to Full Power mode
2	Set the receiver to Adaptive Trickle Power mode
3	Set the receiver to Push-to-Fix mode

Figure 30: Power Management Mode Values

The receiver outputs a response to this command. Figure 31 contains the response for the above command:

*$PLSR,200,1,2,300,1000,300000,30000*02*

Power Management Response Example			
Name	**Example**	**Units**	**Description**
MID	$PLSC,200		Message ID
Valid	1		0: command invalid, 1:command valid
Mode	2		See Figure 30
OnTime	200	ms	Displayed when mode = 2
LP Interval	3000	ms	Displayed when mode = 2
MaxAcqTime	300000	ms	Displayed when mode = 2 or 3
MaxOffTime	30000	ms	Displayed when mode = 2 or 3
PushToFixPeriod		sec	Displayed when mode = 3
Checksum	*01		
<CR> <LF>			End of message termination

Figure 31: Power Management Response Example

For some further examples of this command:

Query the power management mode
Input command: *$PLSC,200,0*0E*
Output response: *$PLSR,200,1,1*03*

Set the receiver to Full Power mode
Input command: *$PLSC,200,1*0F*
Output response: *$PLSR,200,1,1*03*

Set the receiver to Adaptive Trickle Power mode
Input command: *$PLSC,200,2,900,10000,300000,30000*34*
Output response: *$PLSR,200,1,2,900,10000,300000,30000*38*

Set the receiver to Push-to-Fix Power mode
Input command: *$PLSC,200,3,0,0,300000,30000,7200*14*
Output response: *$PLSR,200,1,3,300000,30000,7200*18*

201 – Poll Software Version

Figure 32 contains the values for the following example to poll the SiRF and Linx software versions:

*$PLSC,201*13*

Poll Software Version Command Example			
Name	**Example**	**Units**	**Description**
MID	$PLSC,201		Message ID
Checksum	*0D		
<CR> <LF>			End of message termination

Figure 32: Poll Software Version Example

Figure 33 contains the response for this command:

*$PLSR,201,1,GSD4e_4.1.2,B20121219.9600BPS.CUSTOMIO.LINX*58*

Poll Software Version Response Example			
Name	**Example**	**Units**	**Description**
MID	$PLSC,201		Message ID
Valid	1		0: command invalid, 1:command valid
SiRF	String		SiRF software version
Linx	String		Linx software version
Checksum	*01		
<CR> <LF>			End of message termination

Figure 33: Power Management Response Example

202 – StaticNavigation

This command is used to query, enable, and disable static navigation.

Figure 34 contains the values for the following example to disable static navigation:

*$PLSC,202,2*0E*

StaticNavigation Example			
Name	**Example**	**Units**	**Description**
MID	$PLSR,202		Message ID
Command	2		0: Query, 1: Enable (default), 2: Disable
Checksum	*0E		
<CR> <LF>			End of message termination

Figure 34: StaticNavigation Example

Figure 35 contains the response for the above command.

StaticNavigation Response Example			
Name	**Example**	**Units**	**Description**
MID	$PLSR,202		Message ID
Valid	1		0: command invalid; 1: command valid
Result	2		0: command failed; 1: static navigation enabled, 2: static navigation disabled
Checksum	*02		
<CR> <LF>			End of message termination

Figure 35: StaticNavigation Response Example

211 – SetIO

Figure 36 contains the values for the following example to get GPIOA as an input:

*$PLSC,211,A,0,0*7F*

SetIO Example			
Name	**Example**	**Units**	**Description**
MID	$PLSC,211		Message ID
GPIO Number	A		Number of the GPIO line to set. Only one line can be set at a time.
Direction	0		Direction: 0 = Input; 1 = Output
State	0		Set to 1 if the direction is an output; the value does not matter if the direction is an input.
Checksum	*7F		
<CR> <LF>			End of message termination

Figure 36: SetIO Example

The receiver outputs a response to this command. Figure 37 contains the response for the above command.

SetIO Response Example			
Name	**Example**	**Units**	**Description**
MID	$PLSR,211		Message ID
Valid	1		0: command invalid, 1: command valid
Checksum	*7F		
<CR> <LF>			End of message termination

Figure 37: SetIO Response Example

For some further examples of this command:

Set GPIOA as an input

Input command: *$PLSC,211,A,0,0*7F*

Output response: *$PLSR,211,1*1E*

Set GPIOA as an output, initial state low

Input command: *$PLSC,211,A,1,0*7F*

Output response: *$PLSR,211,1*1E*

NOTE

1. If the message ID is not recognized, the response will be "$PLSR,999,0,ERROR*60"
2. If the value is not allowed, the response will be "$PLSR,MID,0,ERROR*CS"
3. All GPIOs default to inputs on power-up and reset

212 – ReadInput

Figure 38 contains the values for the following example to read the state of an input:

*$PLSC,212,A*7C*

ReadInput Example			
Name	**Example**	**Units**	**Description**
MID	$PLSC,212		Message ID
GPIO Number	A		Number of the GPIO line to set. Only one line can be set at a time.
Checksum	*7C		
<CR> <LF>			End of message termination

Figure 38: ReadInput Example

The receiver outputs a response to this command. Figure 39 contains the response for the above command.

ReadInput Response Example			
Name	**Example**	**Units**	**Description**
MID	$PLSR,212		Message ID
GPIO Number	A		Number of the GPIO line to set. Only one line can be set at a time.
State	0		0 = Low; 1 = High; 2 = the referenced GPIO is not an input
Checksum	*71		
<CR> <LF>			End of message termination

Figure 39: ReadInput Response Example

For some further examples of this command:

Read that GPIOA is low

Input command: *$PLSC,212,A*7C*

Output response: *$PLSR,212,A,0*71*

Read that GPIOA is high

Input command: *$PLSC,212,A*7C*

Output response: *$PLSR,212,A,1*70*

Read that GPIOA is not an input

Input command: *$PLSC,212,A*7C*

Output response: *$PLSR,212,A,2*73*

213 – WriteOutput

Figure 40 contains the values for the following example to write the state of GPIOA to low:

*$PLSC,213,A,0*61*

WriteOutput Example			
Name	**Example**	**Units**	**Description**
MID	$PLSC,213		Message ID
GPIO Number	A		Number of the GPIO line to write. Only one line can be set at a time.
State	0		State; 0 = Low; 1 = High
Checksum	*61		
<CR> <LF>			End of message termination

Figure 40: WriteOutput Example

The receiver outputs a response to this command. Figure 41 contains the response for the above command.

WriteOutput Response Example			
Name	**Example**	**Units**	**Description**
MID	$PLSR,213		Message ID
Valid	A		0: command invalid, 1: command valid
Checksum	*1C		
<CR> <LF>			End of message termination

Figure 41: WriteOutput Response Example

For some further examples of this command:

Set GPIOA to low

Input command: *$PLSC,213,A,0*61*

Output response: *$PLSR,213,1*1C*

Set GPIOA to high

Input command: *$PLSC,213,A,1*60*

Output response: *$PLSR,213,1*1C*

GPIOA is not an output

Input command: *$PLSC,213,A,1*60*

Output response: *$PLSR,213,0*1D*

214 – Query: Get Configuration and GPIO Last State

Figure 42 contains the values for the following example to read the configuration and state of all of the GPIO lines:

*$PLSC,214*17*

Query Example			
Name	**Example**	**Units**	**Description**
MID	$PLSC,214		Message ID
Checksum	*17		
<CR> <LF>			End of message termination

Figure 42: Query Example

The receiver outputs a response to this command. Figure 43 contains the response for the above command.

WriteOutput Example			
Name	**Example**	**Units**	**Description**
MID	$PLSR,214		Message ID
Count	5		Total number of GPIOs
GPIO Number	A		GPIO Number
Configuration	0		Direction; 0 = Input; 1 = Output
Current State	0		0 = Low; 1 = High
GPIO Number	B		GPIO Number
Configuration	0		Direction; 0 = Input; 1 = Output
Current State	0		0 = Low; 1 = High
GPIO Number	C		GPIO Number
Configuration	0		Direction; 0 = Input; 1 = Output
Current State	0		0 = Low; 1 = High
GPIO Number	D		GPIO Number
Configuration	0		Direction; 0 = Input; 1 = Output
Current State	1		0 = Low; 1 = High
GPIO Number	E		GPIO Number
Configuration	0		Direction; 0 = Input; 1 = Output
Current State	0		0 = Low; 1 = High
Checksum	*73		
<CR> <LF>			End of message termination

Figure 43: Query Response Example

215 – Query: Get Configuration and GPIO Current State

Figure 44 below contains the values for the following example to read the configuration and state of all of the GPIO lines:

*$PLSC,215*16*

Query Example			
Name	**Example**	**Units**	**Description**
MID	$PLSC,215		Message ID
Checksum	*16		
<CR> <LF>			End of message termination

Figure 44: Query Example

The receiver outputs a response to this command. Figure 45 contains the response for the above command.

WriteOutput Example			
Name	**Example**	**Units**	**Description**
MID	$PLSR,215		Message ID
Count	5		Total number of GPIOs
GPIO Number	A		GPIO Number
Configuration	0		Direction; 0 = Input; 1 = Output
Current State	0		0 = Low; 1 = High
GPIO Number	B		GPIO Number
Configuration	0		Direction; 0 = Input; 1 = Output
Current State	0		0 = Low; 1 = High
GPIO Number	C		GPIO Number
Configuration	0		Direction; 0 = Input; 1 = Output
Current State	0		0 = Low; 1 = High
GPIO Number	D		GPIO Number
Configuration	0		Direction; 0 = Input; 1 = Output
Current State	1		0 = Low; 1 = High
GPIO Number	E		GPIO Number
Configuration	0		Direction; 0 = Input; 1 = Output
Current State	0		0 = Low; 1 = High
Checksum	*72		
<CR> <LF>			End of message termination

Figure 45: Query Response Example

For some further examples of this command:

Set GPIO 1 to low

Input command: *$PLSC,215*16*

Output response: *$PLSR,215,5,1,0,0,10,0,1,13,0,1,14,0,1,15,0,1*00*

Typical Applications

Figure 46 shows the R4 Series GPS receiver in a typical application using a passive antenna.

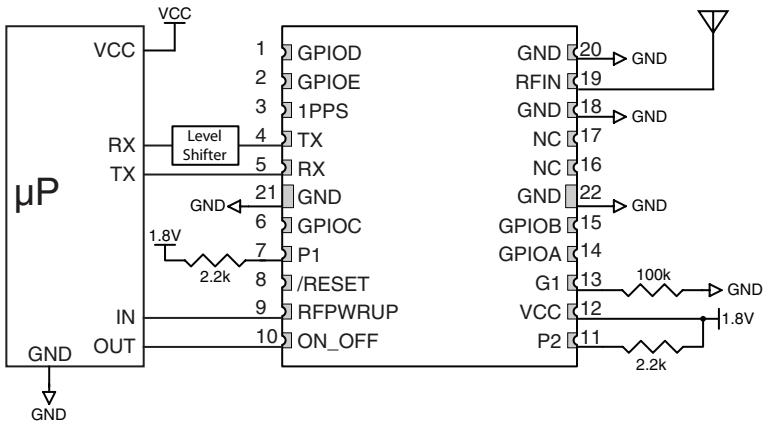


Figure 46: Circuit Using the F4 Series Module with a Passive Antenna

A microcontroller UART is connected to the receiver's UART for passing data and commands. A 3.3V coin cell battery is connected to the VBACKUP line to provide power to the module's memory when main power is turned off.

Figure 47 shows the module using an active antenna.

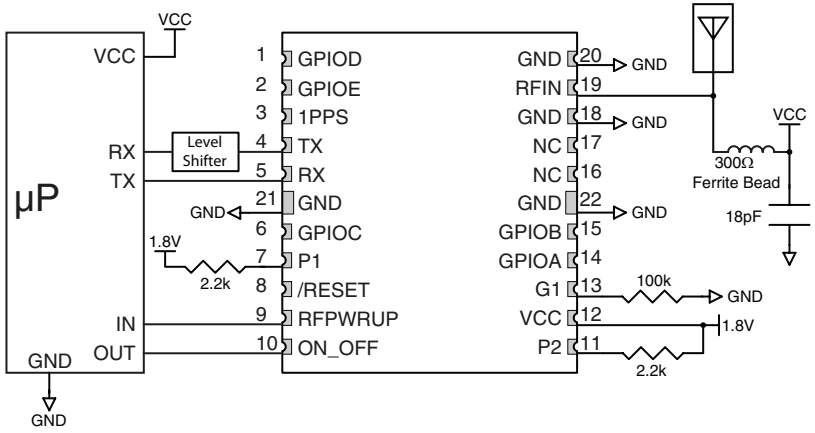


Figure 47: Circuit Using the F4 Series Module with a an Active Antenna

A 300Ω ferrite bead is used to put power from VOUT onto the antenna line to power the active antenna.

Master Development System

The F4 Series Master Development System provides all of the tools necessary to evaluate the F4 Series GPS receiver module. The system includes a fully assembled development board, an active antenna, development software and full documentation.

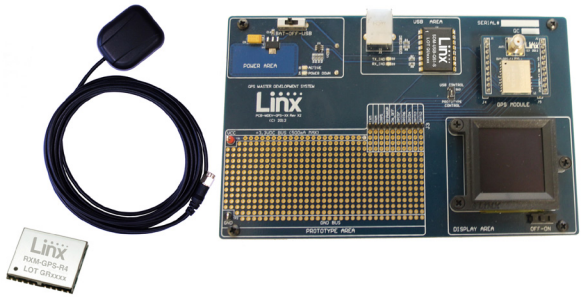


Figure 48: The F4 Series Master Development System

The development board includes a power supply, a prototyping area for custom circuit development, and an OLED display that shows the GPS data without the need for a computer. A USB interface is also included for use with a PC running custom software or the included development software.

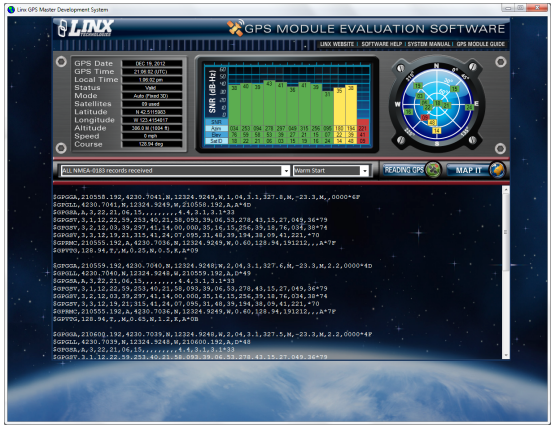


Figure 49: The F4 Series Master Development System Software

The Master Development System software enables configuration of the receiver and displays the satellite data output by the receiver. The software can select from among all of the supported NMEA protocols for display of the data.

Full documentation for the board and software is included in the development system, making integration of the module straightforward.

Board Layout Guidelines

The module's design makes integration straightforward; however, it is still critical to exercise care in PCB layout. Failure to observe good layout techniques can result in a significant degradation of the module's performance. A primary layout goal is to maintain a characteristic 50-ohm impedance throughout the path from the antenna to the module. Grounding, filtering, decoupling, routing and PCB stack-up are also important considerations for any RF design. The following section provides some basic design guidelines which may be helpful.

During prototyping, the module should be soldered to a properly laid-out circuit board. The use of prototyping or "perf" boards will result in poor performance and is strongly discouraged.

The module should, as much as reasonably possible, be isolated from other components on your PCB, especially high-frequency circuitry such as crystal oscillators, switching power supplies, and high-speed bus lines.

When possible, separate RF and digital circuits into different PCB regions. Make sure internal wiring is routed away from the module and antenna, and is secured to prevent displacement.

Do not route PCB traces directly under the module. There should not be any copper or traces under the module on the same layer as the module, just bare PCB. The underside of the module has traces and vias that could short or couple to traces on the product's circuit board.

The Pad Layout section shows a typical PCB footprint for the module. A ground plane (as large and uninterrupted as possible) should be placed on a lower layer of your PC board opposite the module. This plane is essential for creating a low impedance return for ground and consistent stripline performance.

Use care in routing the RF trace between the module and the antenna or connector. Keep the trace as short as possible. Do not pass under the module or any other component. Do not route the antenna trace on multiple PCB layers as vias will add inductance. Vias are acceptable for tying together ground layers and component grounds and should be used in multiples.

Each of the module's ground pins should have short traces tying immediately to the ground plane through a via.

Bypass caps should be low ESR ceramic types and located directly adjacent to the pin they are serving.

A 50-ohm coax should be used for connection to an external antenna. A 50-ohm transmission line, such as a microstrip, stripline or coplanar waveguide should be used for routing RF on the PCB. The Microstrip Details section provides additional information.

In some instances, a designer may wish to encapsulate or "pot" the product. There is a wide variety of potting compounds with varying dielectric properties. Since such compounds can considerably impact RF performance and the ability to rework or service the product, it is the responsibility of the designer to evaluate and qualify the impact and suitability of such materials.

Pad Layout

The pad layout diagram in Figure 50 is designed to facilitate both hand and automated assembly.

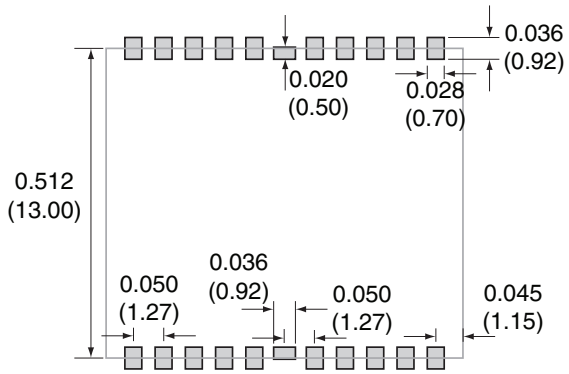
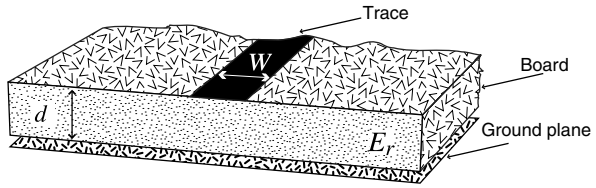


Figure 50: Recommended PCB Layout

Microstrip Details

A transmission line is a medium whereby RF energy is transferred from one place to another with minimal loss. This is a critical factor, especially in high-frequency products like Linx RF modules, because the trace leading to the module's antenna can effectively contribute to the length of the antenna, changing its resonant bandwidth. In order to minimize loss and detuning, some form of transmission line between the antenna and the module should be used, unless the antenna can be placed very close (<⅛in) to the module. One common form of transmission line is a coax cable; another is the microstrip. This term refers to a PCB trace running over a ground plane that is designed to serve as a transmission line between the module and the antenna. The width is based on the desired characteristic impedance of the line, the thickness of the PCB, and the dielectric constant of the board material. For standard 0.062" thick FR-4 board material, the trace width would be 111 mils. The correct trace width can be calculated for other widths and materials using the information below. Handy software for calculating microstrip lines is also available on the Linx website, www.linxtechnologies.com.



$$E_e = \frac{E_r+1}{2} + \frac{E_r-1}{2} \cdot \frac{1}{\sqrt{1+12d/W}}$$

$$Z_0 = \begin{cases} \frac{60}{\sqrt{E_e}} \cdot ln\left(\frac{8d}{W} + \frac{W}{4d}\right) & \text{For } \frac{W}{d} \le 1 \\ \frac{120\pi}{\sqrt{E_e} \cdot \left(\frac{W}{d} + 1.393 + 0.667 \cdot \ln\left(\frac{W}{d} + 1.444\right)\right)} & \text{For } \frac{W}{d} \ge 1 \end{cases}$$

E_r = Dielectric constant of PCB material

Figure 51: Microstrip Formulas

Example Microstrip Calculations

Dielectric Constant	Width/Height Ratio (W/d)	Effective Dielectric Constant	Characteristic Impedance (Ω)
4.80	1.8	3.59	50.0
4.00	2.0	3.07	51.0
2.55	3.0	2.12	48.0

Figure 52: Example Microstrip Calculations

Production Guidelines

The module is housed in a hybrid SMD package that supports hand and automated assembly techniques. Since the modules contain discrete components internally, the assembly procedures are critical to ensuring the reliable function of the modules. The following procedures should be reviewed with and practiced by all assembly personnel.

Hand Assembly

Pads located on the bottom of the module are the primary mounting surface (Figure 53). Since these pads are inaccessible during mounting, castellations that run up the side of the module have been provided to facilitate solder wicking to the module's underside. This allows for very quick hand soldering for prototyping and small volume production. If the recommended pad guidelines have been followed, the pads will protrude slightly past the edge of the module. Use a fine soldering tip to heat the board pad and the castellation, then introduce solder to the pad at the module's edge. The solder will wick underneath the module, providing reliable attachment. Tack one module corner first and then work around the device, taking care not to exceed the times in Figure 54.

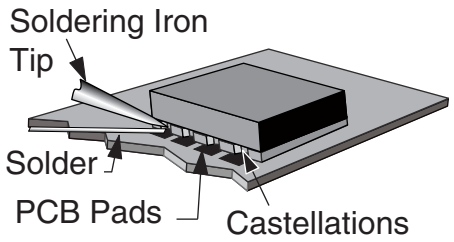


Figure 53: Soldering Technique

Warning: Pay attention to the absolute maximum solder times.

Absolute Maximum Solder Times
Hand Solder Temperature: +427ºC for 10 seconds for lead-free alloys
Reflow Oven: +240°C max (see Figure 55)

Figure 54: Absolute Maximum Solder Times

Automated Assembly

For high-volume assembly, the modules are generally auto-placed. The modules have been designed to maintain compatibility with reflow processing techniques; however, due to their hybrid nature, certain aspects of the assembly process are far more critical than for other component types. Following are brief discussions of the three primary areas where caution must be observed.

Reflow Temperature Profile

The single most critical stage in the automated assembly process is the reflow stage. The reflow profile in Figure 55 should not be exceeded because excessive temperatures or transport times during reflow will irreparably damage the modules. Assembly personnel need to pay careful attention to the oven's profile to ensure that it meets the requirements necessary to successfully reflow all components while still remaining within the limits mandated by the modules. The figure below shows the recommended reflow oven profile for the modules.

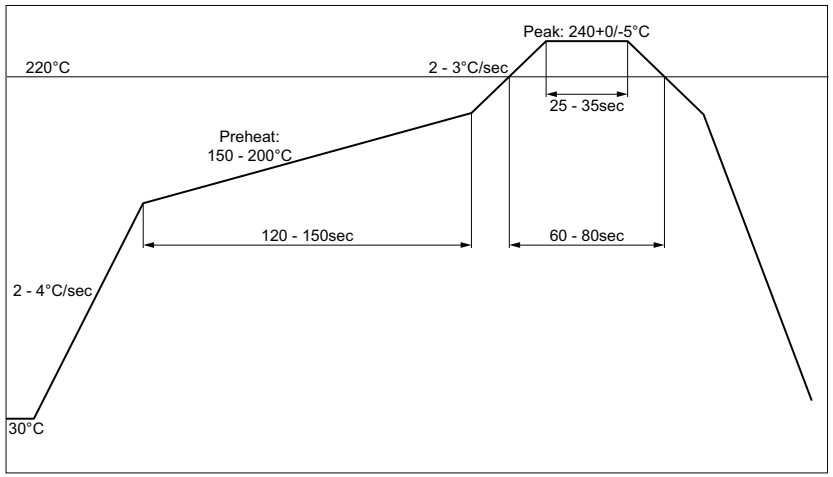


Figure 55: Maximum Reflow Profile

Shock During Reflow Transport

Since some internal module components may reflow along with the components placed on the board being assembled, it is imperative that the modules not be subjected to shock or vibration during the time solder is liquid. Should a shock be applied, some internal components could be lifted from their pads, causing the module to not function properly.

Washability

The modules are wash-resistant, but are not hermetically sealed. Linx recommends wash-free manufacturing; however, the modules can be subjected to a wash cycle provided that a drying time is allowed prior to applying electrical power to the modules. The drying time should be sufficient to allow any moisture that may have migrated into the module to evaporate, thus eliminating the potential for shorting damage during power-up or testing. If the wash contains contaminants, the performance may be adversely affected, even after drying.

Resources

Support

For technical support, product documentation, application notes, regulatory guidelines and software updates, visit www.linxtechnologies.com

RF Design Services

For customers who need help implementing Linx modules, Linx offers design services including board layout assistance, programming, certification advice and packaging design. For more complex RF solutions, Apex Wireless, a division of Linx Technologies, creates optimized designs with RF components and firmware selected for the customer's application. Call +1 800 736 6677 (+1 541 471 6256 if outside the United States) for more information.

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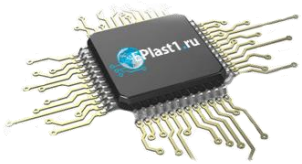
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