



R4 Series
GPS Receiver Module
Data Guide

Wireless made simple®

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R4 Series GPS Receiver

Data Guide



Description

The R4 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. With over 200,000 effective correlators, the R4 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. The module's standard NMEA data output makes the R4 Series easy to integrate, even by engineers without previous RF or GPS experience.

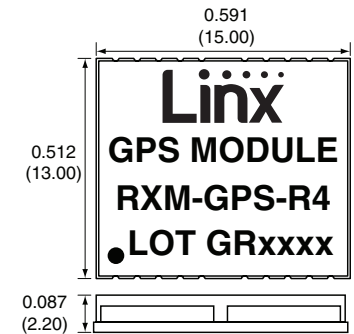


Figure 1: Package Dimensions

Features

- SiRF Star IV chipset
- Built-in jammer remover
- High sensitivity (-160dBm)
- 48 channels
- Fast TTFF at low signal levels
- Battery-backed SRAM
- 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

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.

Ordering Information

| Ordering Information | |
|----------------------|--|
| Part Number | Description |
| RXM-GPS-R4-x | R4 Series GPS Receiver Module |
| MDEV-GPS-R4 | R4 Series GPS Receiver Master Development System |
| EVM-GPS-R4 | R4 Series GPS Receiver Evaluation Module |

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

Absolute Maximum Ratings

| Absolute Maximum Ratings | | | | |
|------------------------------|-----------------------|----|-----|-----|
| Supply Voltage V_{CC} | +4.3 | | | VDC |
| Input Battery Backup Voltage | +7.0 | | | VDC |
| Operating Temperature | -40 | to | +85 | °C |
| Storage Temperature | -40 | to | +85 | °C |
| 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 3: Absolute Maximum Ratings

Electrical Specifications

| R4 Series GPS Receiver Specifications | | | | | | |
|---------------------------------------|-----------|------|------|------|-------|-------|
| Parameter | Symbol | Min. | Typ. | Max. | Units | Notes |
| Power Supply | | | | | | |
| Operating Voltage | V_{CC} | 3.0 | 3.3 | 3.6 | VDC | |
| Supply Current | I_{CC} | | | | | |
| Peak | | | | 122 | mA | 1 |
| Acquisition | | | 56 | | mA | 1 |
| Tracking | | | 33 | | mA | 1 |
| Hibernate | | | 0.43 | | mA | 1 |
| Backup Battery Voltage | V_{BAT} | 2.0 | | 6.0 | VDC | |
| Backup Battery Current | I_{BAT} | | 660 | 830 | µA | 2 |
| VOUT Output Voltage | V_{OUT} | | VCC | | | 3 |
| Output Low Voltage | V_{OL} | | | 0.4 | VDC | |

| | | | | | |
|----------------------|--------------------------------|---------|------|--------|-----|
| Output High Voltage | V_{OH} | | | | |
| TX Pin | | 0.7*VCC | VCC | VCC | VDC |
| 1.8V Level Pin | | 1.2 | 1.8 | 1.85 | VDC |
| Output Low Current | I_{OL} | | 2.0 | | mA |
| Output High Current | I_{OH} | | | | |
| TX Pin | | | 0.05 | | mA |
| 1.8V Level Pin | | | 2.0 | | mA |
| Input Low Voltage | V_{IL} | -0.4 | | 0.45 | VDC |
| Input High Voltage | V_{IH} | 1.3 | | 3.6 | VDC |
| LNA Section | | | | | |
| Input Power | P_{IN} | | | 18 | dB |
| 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 | | | 2.5 | | m |
| SBAS | | | 2.5 | | m |
| Altitude | | | | 18,000 | m |
| Velocity | | | | 515 | m/s |
| Chipset | SiRF Star IV, GSD4e ROM | | | | |
| 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 | | | | |
| Antenna Port | | | | | |
| RF Impedance | R_{IN} | | 50 | | Ω |

1. $V_{CC} = 3.3V$, without active antenna
2. $V_{CC} = 0V$
3. VOUT current is directly sourced from VCC.

Figure 4: Figure 3: Electrical Specifications

Pin Assignments

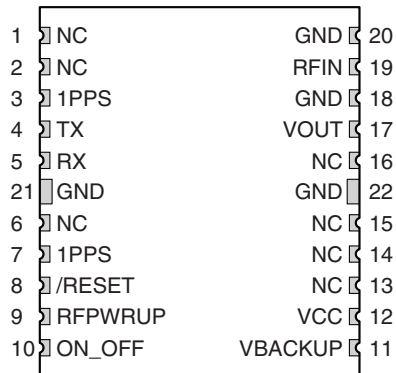


Figure 5: R4 Series GPS Receiver Pinout (Top View)

Pin Descriptions

| Pin Descriptions | | | |
|-------------------------|---------|-----|---|
| Pin Number | Name | I/O | Description |
| 1, 2, 6, 13, 14, 15, 16 | NC | - | No electrical connection. |
| 3, 7 | 1PPS | O | 1 Pulse Per Second. 1.8V level. |
| 4 | TX | O | Serial output (default NMEA) |
| 5 | RX | I | Serial input (default NMEA) |
| 8 | /RESET | I | Reset input, active low. The module has an internal power-on reset circuit so this pin can be left floating |
| 9 | RFPWRUP | O | Power State Indicator. 1.8V level. |
| 10 | ON_OFF | I | Power Control Pin. If this pin is not used, leave it floating. |
| 11 | VBACKUP | P | Backup battery supply voltage. This line must be powered to enable the module. |
| 12 | VCC | P | Supply Voltage |
| 18, 20, 21, 22 | GND | P | Ground |
| 17 | VOUT | O | VCC voltage to supply an active antenna. |
| 19 | RFIN | I | GPS RF signal input |

Figure 6: R4 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 TTTF.

Module Description

The R4 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 R4 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 R4 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.

Backup Battery

The module is designed to work with a backup battery that keeps the SRAM memory and the RTC powered when the RF section and the main GPS core are powered down. This enables the module to have a faster Time To First Fix (TTFF) when it is powered back on. The memory and clock pull about $660\mu\text{A}$. This means that a small lithium battery is sufficient to power these sections. This significantly reduces the power consumption and extends the main battery life while allowing for fast position fixes when the module is powered back on.

The backup battery must be installed for CGEE start. If the serial command is used to place the receiver into hibernate while keeping VCC powered, then the battery backup current is $15\mu\text{A}$ while the current through the VCC line is about $170\mu\text{A}$.

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 R4 Series module is designed to utilize a wide variety of external antennas. The module has a regulated power output which simplifies the use of GPS antenna styles which require external power. This allows the designer great flexibility, 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 VOUT line to the RFIN line. 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. The VOUT line is connected to the VCC line, so the voltage is the module supply voltage and the current sourcing depends on the module's power supply.

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 R4 Series GPS Receiver module offers two power control modes: Full Power and Hibernate. In Full Power mode the module is fully active and continuously tracking. Measurements are of the highest quality and are continuously output by the module. This is the highest current consumption state.

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.

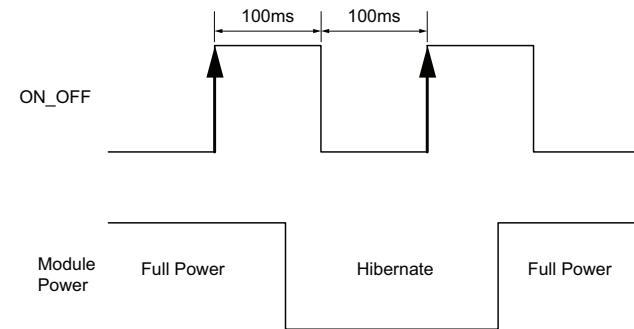


Figure 7: R4 Series GPS Receiver Power Control

If the module is in Full Power mode, a pulse on the ON_OFF line will initiate an orderly shutdown into Hibernate mode. If the module is in Hibernate mode, a pulse on the ON_OFF line will transition the module into Full Power Mode.

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 various NMEA messages that are supported by the module. By default, the commands are at 9,600bps, 8 data bits, 1 start bit, 2 stop bits, and no parity.

GGA – Global Positioning System Fixed Data

Figure 8 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 9 |
| 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 8: 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 9: Position Indicator Values

GLL – Geographic Position – Latitude / Longitude

Figure 10 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 10: Geographic Position – Latitude / Longitude Example

GSA – GPS DOP and Active Satellites

Figure 11 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 12 |
| 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 11: GPS DOP and Active Satellites Example

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

Figure 12: Mode 1 Values

GSV – GPS Satellites in View

Figure 13 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 13: GPS Satellites in View Example

RMC – Recommended Minimum Specific GPS Data

Figure 14 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 14: Recommended Minimum Specific GPS Data Example

VTG – Course Over Ground and Ground Speed

Figure 15 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 15: 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, 1 start bit, 2 stop bits, and no parity.

| 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 16: Serial Data Structure

All fields in all proprietary NMEA messages are required; none are optional. All NMEA messages are comma delimited. Figure 17 outlines the message identifiers supported by the module.

| Message ID Values | | |
|-----------------------------|-----|--|
| Name | MID | Description |
| SetSerialPort | 100 | Set PORT A 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 |

Figure 17: 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 18 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 |

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

Figure 18: 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 unnecessary. The command is retained for its ability to reset the module, but the initialization fields are no longer supported.

Figure 19 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 20 |
| Checksum | *1F | | |
| <CR> <LF> | | | End of message termination |

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

Figure 19: 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 20: 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 21 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*

| Update Rate Control Example ¹ | | | |
|--|-----------|---------|---|
| Name | Example | Units | Description |
| Message ID | \$PSRF103 | | PSRF103 protocol header |
| Msg | 00 | | See Figure 22 |
| 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 21: Update Rate Control Example

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 18). The rate divider takes effect only after a fix is established

| 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 22: MSG Values

104 – LLANavigationInitialization

This command is used to initialize the receiver with the current position (in latitude, 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 unnecessary. The command is retained for its ability to reset the module, but the initialization fields are no longer supported.

Figure 23 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 24 |
| 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 23: 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 24: 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 25 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 25: 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 26 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 26: System Turn Off Example

Typical Applications

Figure 27 shows the R4 Series GPS receiver in a typical application using a passive antenna.

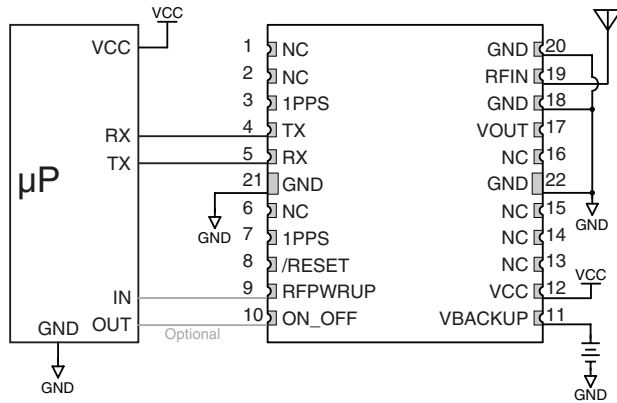


Figure 27: Circuit Using the R4 Series Module with a Passive Antenna

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 28 shows the module using an active antenna.

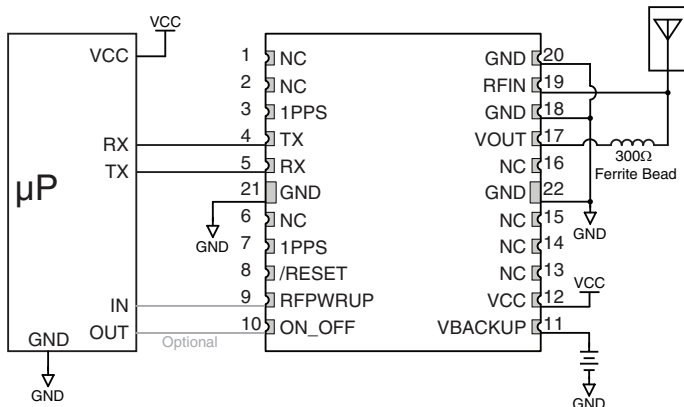


Figure 28: Circuit Using the R4 Series Module with a an Active Antenna

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

Master Development System

The R4 Series Master Development System provides all of the tools necessary to evaluate the R4 Series GPS receiver module. The system includes a fully assembled development board, an active antenna, development software and full documentation.

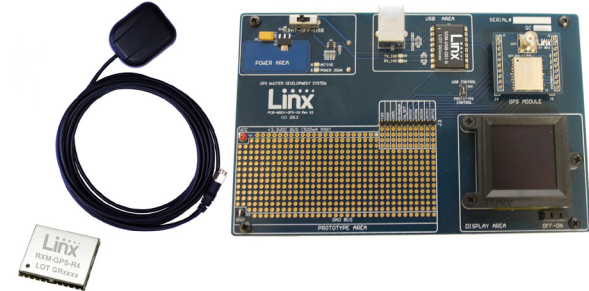


Figure 29: The R4 Series Master Development System

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.

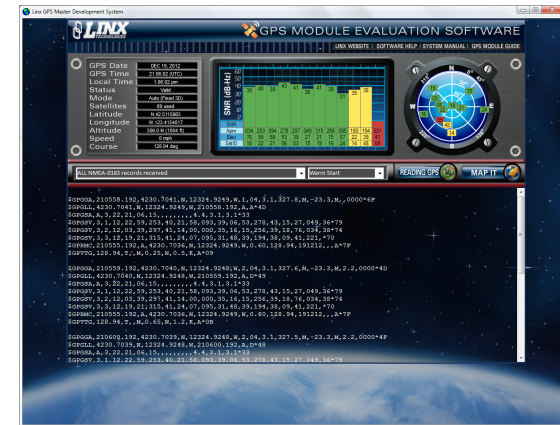


Figure 30: The R4 Series Master Development System Software

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 31 is designed to facilitate both hand and automated assembly.

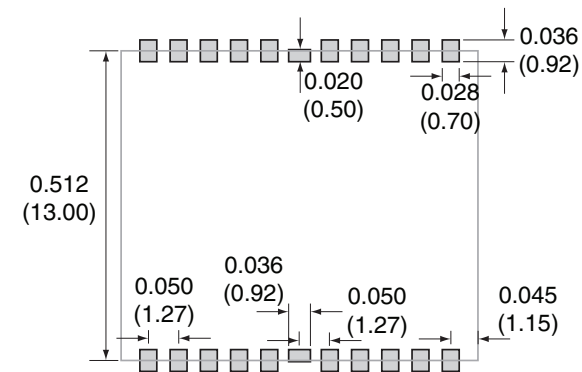
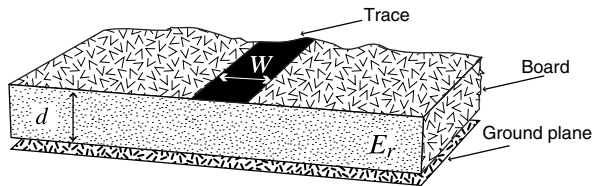


Figure 31: Recommended PCB Layout

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 (<1/8in) to the module. One common form of transmission line is a coax cable and 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 0.062in 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 in Figure 32 and examples are provided in Figure 33. Software for calculating microstrip lines is also available on the Linx website.



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

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

E_r = Dielectric constant of PCB material

Figure 32: 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 33: 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 34). 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

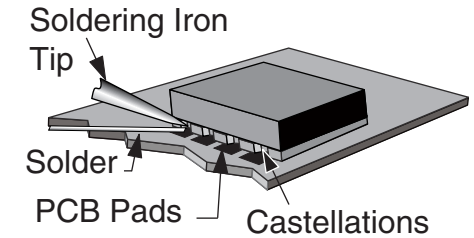


Figure 34: Soldering Technique

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 35.

Warning: Pay attention to the absolute maximum solder times.

Absolute Maximum Solder Times

Hand Solder Temperature: +427°C for 10 seconds for lead-free alloys

Reflow Oven: +240°C max (see Figure 36)

Figure 35: 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 36 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.

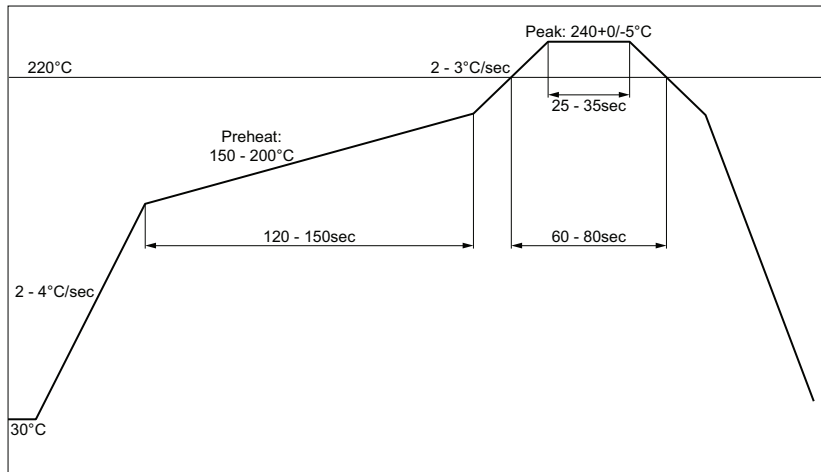


Figure 36: Maximum Reflow Temperature Profile

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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