RSR GNSS Transcoder

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RSR GNSS Transcoder™ User Manual

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1 Introduction

1.1 Overview

The Jackson Labs Technologies, Inc. RSR GNSS Transcoder™ is a miniature, fully self-contained, real-time, full-constellation, 10-channel GPS simulator. It can be used as an independent GPS L1 RF source just like any other industry-standard GPS simulator, or be connected to an external Position/Velocity/Navigation/Timing (PVT/PNT) source to transcode a standard NMEA PVT/PNT message stream and 1PPS signals into an equivalent GPS RF signal without requiring the use of any external equipment such as a PC.

The JLT RSR GNSS Transcoder™ defines a unique new product category in the GNSS market, allowing embedded retrofit of any GPS receiver to modern signal standards by converting standard positioning data formats into a legacy L1 GPS RF signal. The transcoding process is performed in real time using embedded next-generation JLT-designed GPS simulator technology, providing legacy receivers with access to standards such as Inertial Navigation System (INS), Satelles/Iridium, SAASM, M-Code, Glonass, Galileo, BeiDou, QZSS, or any other current or emerging GNSS signal. Data originating from non-GNSS NMEA sources such as Inertial Navigation System components can also be transcoded. Optionally, long-duration holdover capabilities may be added to legacy GPS equipment with the optional internal Cesium-based Chip Scale Atomic Clock (CSAC) technology. The JLT RSR GNSS Transcoder™ can receive an optional external 1PPS reference input and encode this externally-supplied timing reference into the GPS RF signal with nanoseconds level accuracy. This allows it to act as a GPS "RF Modulator" add-on for timing equipment such as PTP/1588 units or Atomic clock references.

The RSR GNSS Transcoder™ has a miniature form factor (1.6 x 2.3 x 0.5 inches or 4 x 6 x 1.3 cm for the non-CSAC version) with minimal power consumption (<1.1W w/o CSAC typically). No external equipment other than a power source is required. Its self-contained real-time hardware simulation capabilities set it apart from competitive GPS/GNSS simulators that either require an external computer for signal processing and control, or are based on passive record-and-playback technology that is highly inflexible.

Applications of the RSR GNSS Transcoder™ include:

- Adding enhanced holdover capabilities to mission-critical receivers in both mobile and stationary data-center environments

- Relaying assured position/velocity/time (PVT) data from a single SAASM-keyed RSR Puck to multiple GB-GRAM, MicroGRAM, and DAGR receivers, eliminating numerous rekeying operations

- Retrofitting legacy GPS receivers for INS, Galileo, Glonass, BeiDou, SBAS, M-code, or SAASM capability

- Adding "RF Modulator" capability to a host of Position, Navigation, and Timing equipment such as NTP/PTP/1588 units, Atomic clocks, GPS Distribution devices such as the D3 DAGR, or Satelles/Iridium(tm) receivers

All of these applications may be realized simply by replacing the target receiver's existing GPS antenna with the RSR GNSS Transcoder™ and connecting a suitable GNSS receiver, IMU/INS, or other navigation data source to the transcoder's USB or RS-232 serial data port. When equipped with the optional integrated CSAC, the RSR GNSS Transcoder™ can also be used as a simple coax-connected time-transfer device, and can even act as a wireless pseudolite transmitter in relevance to specifications such as IS-GPS-250A.

The output signal from the RSR GNSS Transcoder™ is compatible with virtually any legacy GPS receiver, including military GPS receivers such as GB-GRAM, MicroGRAM, and DAGR. This sets it apart as competitive high-end GPS simulators are typically not compatible with these legacy military receivers due to subtle errors in their GPS simulation software.

In addition to its many navigation-related applications, the RSR GNSS Transcoder™ can encode an externally-provided or internally-generated one pulse per second (1PPS) signal with typically better than 5ns accuracy, and is thus suitable for testing and calibration of GPS-disciplined oscillator (GPSDO) timing products as well as adding RF Modulator capability to typical timing devices such as PTP/1588 slaves. The RSR GNSS Transcoder™ is capable of locking its internal timebase to an externally-provided 1PPS reference, as well as providing external access to CMOS-level 10MHz and 1PPS outputs from its internal timebase. A built-in 9-degrees-of-freedom (9-DOF) Inertial Navigation System (INS) is provided to support advanced future capabilities such as interpolation of externally-provided 1-Hz position fixes to 10 Hz, and to provide PNT capability during short-term interruptions to the external GNSS reference receiver.

Figure 1.1   RSR GNSS Transcoder™ PCB module (TCXO version)

The RSR GNSS Transcoder™ module includes two power supply inputs that may be used separately or simultaneously. The unit can operate from its built-in mini-B USB connector (2.7V to 5.5V range, 5V nominal), or from a 7V to 36V DC power supply. It can accept PVT fixes over its RS-232 or USB serial ports via its built-in NMEA parsing capability, in addition to accepting PVT fixes via standard SCPI commands. Simulation motion control commands can be stored in internal EEPROM and used to automatically start a dynamic simulation scenario with full autonomy from any external control requirements. Front-end GNSS receivers can be connected via the RS-232 serial port. Auto-detection and auto-configuration of uBlox and Rockwell Collins GPS receivers such as the MicroGRAM, RSR Puck, and GB-GRAM and various Novatel receivers is supported, along with civilian-grade uBlox 5th- through 8th-generation and later GNSS receiver product lines.

The SimCon Windows application, freely available on the Jackson Labs website, enables easy GPS simulation configuration and control of all features of the RSR GNSS Transcoder™. SimCon's Terminal window allows direct monitoring and transmission of SCPI command traffic, while the Controls window displays the available SCPI commands in each category and provides assistance with commands and queries. The Display window allows you to view various aspects of the simulation and hardware state, including motion preview and simulation maps, satellite ground tracks, satellite vehicle data, and simulator performance graphs. The Motion window provides an easy-to-use interface to design and edit motion simulations. Finally, the Health window provides indicators for the RSR GNSS Transcoder's™ continuous health-monitoring features. The SimCon application is described in detail in Chapter 4.

Additionally, the RSR GNSS Transcoder™ integrates a complete Jackson Labs Technologies, Inc. CSAC-capable GPSDO module which allows automatic disciplining of either the internal high-stability TCXO or the optional internal CSAC oscillator to an external 1PPS reference using battle-proven JLT disciplining algorithms.

1.2 Operating Principles

The RSR GNSS Transcoder™ is based on a next-generation full-constellation real-time GPS simulator. The unit includes an ARM Cortex main processor that handles communications, calculations, and oscillator disciplining, as well as a high-performance FPGA that implements RF signal generation for up to 10 concurrent GPS channels. Tight coupling between the processor, the FPGA, and the timing reference allows real-time encoding of PVT/PNT data into a GPS L1 C/A code RF signal.

In operation, baseband signals in I/Q format representing the individual GPS channels are summed digitally and RF modulated using a TX DAC at the GPS L1 frequency of 1575.42 MHz, taking advantage of sample clock aliasing to avoid the need to generate a high-level RF carrier signal internally. Traditional GNSS simulators that rely on generation and subsequent attenuation of a much-stronger signal must include bulky and costly shielding due to the extremely low power levels of the desired output signal, often well below -120 dBm. In the RSR GNSS Transcoder™, the low-level RF signals used internally can be filtered and attenuated both effectively and economically without adding size, weight, or power consumption to the package. The resulting output power level is user-controllable over ~20 dB of range.

Prior to the output jack, an internal RF splitter feeds a portion of the simulated GPS signal to an on-board 8th-generation GNSS receiver which provides signal monitoring and calibration capabilities. The output signal then undergoes final filtering, exiting the transcoder via a resistive pad which includes a 186-ohm DC resistance to ground to simulate a typical GPS antenna load from the perspective of the external target GNSS receiver. The RSR GNSS Transcoder™'s RF output is

compatible with external GPS-provided antenna voltages up to 6V. Care must be taken to avoid supplying antenna voltages higher than 6V to the RF SMA connector.

The RSR GNSS Transcoder™ includes circuitry to time-stamp an external 1PPS reference signal to better than +/-2.8ns typically, as well as circuitry to discipline its internal high-stability TCXO or optional CSAC oscillator from this external 1PPS reference signal. It also includes a regulated 5.4V power supply circuit to provide power to an external GNSS receiver. Additional features include a USB port for optional PC-based configuration and control, and a 9-DOF inertial measurement unit.

1.3 General Safety Precautions

The following general safety precautions must be observed during all phases of operation of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Jackson Labs Technologies, Inc. assumes no liability for the customer's failure to comply with these requirements.

1.3.1 Legacy GPS Receiver Compatibility

JLT strives to achieve the greatest possible degree of compatibility with legacy GPS receivers. If any incompatibilities are encountered with specific receiver models, please report these to support@jackson-labs.com.

1.3.2 Use an approved Antenna Lightning Protector

The use of an approved and properly-grounded antenna lightning protector on the GNSS antenna connected to any external GNSS receiver used with the RSR GNSS Transcoder™ is required to prevent damage, injury or death in case of a lightning strike.

1.3.3 Transmission of synthesized GPS RF signals

It is illegal to transmit simulated/synthesized GPS RF signals. The RF output of the RSR GNSS Transcoder™ must not be fed to a transmitting antenna. It is intended only to be directly coupled into the RF input of a GPS receiver using shielded coax cables. The RF output must not be amplified or re-transmitted in any way without approval from the appropriate government authorities.

1.3.4 Grounding

To avoid damaging the sensitive electronic components in the RSR GNSS Transcoder™, always make sure to discharge any built-up electrostatic charge to a good ground source, such as the power supply ground. This should be done before handling the circuit board or anything connected to it such as an external receiver's GNSS antenna.

1.3.5 Power Connections

When connecting DC power to the device, make sure to follow the polarity indicated in table Table 3.2.

1.3.6 Environmental Conditions

This instrument is intended for indoor use with a properly-installed GNSS Antenna Lightning Protector. It is designed to operate at a maximum relative non-condensing humidity of 95% and at altitudes of up to 50,000 meters. Refer to the specifications for the DC voltage requirements and ambient operating temperature range.

2 RSR GNSS Transcoder™ Quick-Start Instructions

2.1 Introduction

The RSR GNSS Transcoder™ supports various hardware connections and configuration options. This chapter focuses on a basic hardware setup and simulation configuration, allowing you to start using the RSR GNSS Transcoder as a simulator in minutes. Chapter 3 provides a more detailed description of the available setup and configuration options, and Chapter 6 provides a command reference for the supported SCPI command set.

Configuring the RSR GNSS Transcoder™ as a simulator requires a USB connection to a computer for power and communications and an RF connection to the target GPS receiver. Configuration and status commands are sent through a virtual COM port associated with the USB connection to the RSR GNSS Transcoder™.

2.2 Power and Control Setup

The power and control connection to the RSR GNSS Transcoder™ is made with a USB cable between the USB mini-B port on the RSR GNSS Transcoder™ and a computer. The location of the USB mini-B port is labeled in Figure 2.1. Power may be provided externally or via the USB connection itself. See Section 3.2.1 for more details on the USB connection power requirements.

When the USB cable is connected for the first time, Windows will try to locate and install the drivers. For Windows 8.1 and previous versions, it may be necessary to download the SiLabs CP2104 drivers from the Silicon Labs website (www.silabs.com). A revised SiLabs Linux driver that fully supports GPSD and NTP is available on the JLT website as well, and will need to be used if the 1PPS output feature of the internal TCXO or CSAC is to be used for optional GPSD/NTP functionality. Windows

10 with an Internet connection will typically automatically download and install the drivers. Please note the COM port number that is assigned when the driver is installed.

The virtual COM port provided by the SiLabs driver is used to communicate with the RSR GNSS Transcoder™'s SCPI command interface. If a standalone terminal program is used, it should be configured for 115200 baud, no parity, 8 data bits and 1 stop bit, with no flow control. Standard freeware terminal programs such as Tera Term Pro or HyperTerm are available online for newer versions of Windows, or the unit can be used with the SimCon or GPSCon software applications available at no charge on the support page of the JLT website. Once a connection is established in the terminal software, the RSR GNSS Transcoder™ should respond to pressing the Enter key by returning the SCPI> command prompt.

Figure 2.1   Minimum connections to the RSR GNSS Transcoder™ PCB

2.3 Connecting to a Target GPS Receiver's Antenna Input

The RF output from the RSR GNSS Transcoder connects directly to the antenna input on the target GPS receiver. The SMA GPS L1 RF connector is labeled in Figure 2.1. In addition to an RF output, this connection also provides a 186-ohm DC load for the antenna output voltage from the target GPS receiver. Many receivers require an antenna current to operate properly. **PLEASE NOTE: If the target receiver's antenna output voltage is higher than 6V, a DC block is required between the RSR GNSS Transcoder™'s RF output and the target receiver's antenna input. For example, an external DC block must be used with the Symmetricom/Microsemi XLI reference, as it outputs 12V DC which would damage the internal 186-ohm DC termination resistor.** Use an appropriate RF cable to connect the SMA RF output to the antenna input of the target receiver, and add a DC block as necessary.

2.4 Simulation Control

This section describes the low-level SCPI commands needed to set up, initiate, and stop a fixed-position simulation at a specified location and start time. These commands may be entered at the SCPI command prompt in the terminal program described in section 2.2 . Each command is terminated with a carriage-return character (Enter key). **Please note, however, that the SimCon utility available for download at the Jackson Labs Technologies, Inc. website provides greatly-improved ease of access to these and other features of the RSR GNSS Transcoder. With SimCon, many users will not need to run a separate terminal program or enter SCPI commands directly. Refer to Chapter 4 for more information about downloading and running SimCon.**

For manual START/STOP simulation control, set the simulation mode to manual:

    SIM:MODE MANUAL

To set the fixed position of the simulation enter the command:

    SIM:POS:LLH lat,lon,height

where lat and lon are latitude and longitude in decimal degrees and height is in meters above the GPS ellipsoid (not Mean Sea Level height). Any combination of lat/long/height parameters may be provided; for example, to change only the simulated height, enter:

    SIM:POS:LLH ,,height

The simulated time can also be specified manually. This means the GPS receiver will indicate the start time and date as soon as the simulation commences. This allows simulating any time/date in the future or past as required. (Note, however, that it may be necessary to perform a cold start operation on the receiver if the simulation time/date differs substantially from the receiver's last-known PNT fix.)

To set the assigned start time, set the time mode to *Assigned* mode:

    SIM:TIME:MODE ASSIGNED

Next, set the assigned start time and date with the commands:

    SIM:TIME:START:TIME hh,mm,ss.sss

and

    SIM:TIME:START:DATE yyyy,mm,dd

Finally, start the simulation with the command:

SIM:COMMAND START

The simulation will start immediately after the Enter key has been received. The GPS receiver should indicate the selected time/date after acquisition of the simulated signal, typically within less than a minute.

The simulation will run indefinitely or until stopped with the command:

SIM:COMMAND STOP

The RF output power of the simulated GPS signal can be controlled with the command

OUT:POW -xxx

where xxx is the desired power level in dBm. The "dBm" abbreviation does not have to be entered; it is assumed. Available power levels range from approximately -105 to -125 dBm.

2.5 Simulating to Rockwell Collins DAGR with Battery Power

With the RSR GNSS Transcoder™ still connected for SCPI port control as described above, set the Simulation mode to Simulation with the following command:

SIM:MODE SIM

SAASM GPS receivers like the DAGR may require the anti-spoofing flag in the GPS navigation message to be set to 1. This is configured on the RSR GNSS Transcoder™ by sending the command:

SIM:SV:ASFLAG 1

In Simulation mode, the RSR GNSS Transcoder™ will start simulating on power up using the previously assigned start time, start date and fixed position as described in Section 2.4 . Because a computer is not required to start the simulation, the Simulation mode is useful for battery-operated testing or demonstrations as described in this section.

Figure 2.2 shows the setup for simulating GPS L1 signals to a Rockwell Collins DAGR. The RSR GNSS Transcoder™ is powered by the USB port with a 5V USB power bank. When the power bank is connected, the simulation will start as indicated by the PWR/XT LED blinking at 5Hz. The RF output from the RSR GNSS Transcoder™ is connected to the external antenna input on the DAGR. The DAGR uses the 186-ohm DC termination resistor in the RSR GNSS Transcoder™ to detect the presence of an external antenna or simulator in this case.

The DAGR will start to track satellites and obtain a position fix. Figure 2.2 shows the DAGR with a position fix from the RSR GNSS Transcoder™'s RF output. If no fix is obtained after one or two minutes, verify that the DAGR detects the RSR GNSS Transcoder™ as an external antenna by disconnecting the RF cable. The DAGR should display an error message that the external antenna connection is lost if the RSR GNSS Transcoder was detected correctly.

Also, because the DAGR maintains a real time clock with battery backup, it may be necessary to remove the backup battery for the DAGR to continuously track the simulated signals from the RSR GNSS Transcoder™. Removing the battery backup may be necessary to avoid lock acquisition failure due to the unexpected time/date discontinuity when simulation begins. Removing the battery backup should not be necessary in Transcoding applications.

Figure 2.2   DAGR Target Receiver with battery-powered RSR GNSS Transcoder™

3 Setup and Configuration Instructions

3.1 Introduction

The RSR GNSS Transcoder™ is a full-constellation, real-time 10-channel GPS simulator with minimal size, weight, and power consumption (SWaP) requirements. It is designed to receive NMEA traffic from an external PVT/PNT source such as a GNSS receiver via an RS-232 serial connection and to provide a transcoded L1 C/A signal to a connected GPS receiver that reflects the incoming NMEA data stream. It thus acts as an "RF Modulator" for baseband Positioning/Navigation/Timing (PNT) signals. The RSR GNSS Transcoder™ includes special embedded design features such as a PCB outline that allows direct, glue-less mating to a Rockwell Collins RSR Puck SAASM receiver. The unit can also be used with many other industry-standard GNSS receivers or as a stand-alone general-purpose GPS simulator under user control. Beyond its role as a PNT transcoder, the RSR GNSS Transcoder™ is suitable for use in R&D, manufacturing, or field test applications.

The RF output of the RSR GNSS Transcoder™ simulates the GPS signals that would normally be present in a Live-Sky GPS antenna feed. The RSR GNSS Transcoder™ includes a USB port that can provide power to the unit when an external DC power source of 7V to 36V (12V nominal) is not available. The USB port is used as a control/monitoring serial port, accessible via the SimCon application software (available on the support page at www.jackson-labs.com) or via standard terminal programs such as TeraTerm Pro.

Once powered, the RSR GNSS Transcoder™ will generate a GPS L1 C/A RF output signal that is compatible with legacy GPS receivers. Depending on configuration, the unit will either output a fixed position stored in memory, a position defined by SCPI serial commands, or a position equal to the latest NMEA input position received via the RS-232 serial input port. Through its ability to transcode NMEA sentences into GPS RF signals, the RSR GNSS Transcoder™ effectively upgrades the legacy GPS target receiver, providing compatibility with advanced standards such as Satelles/Iridium(tm), SAASM, M-Code, Glonass, Galileo, or BeiDou and even non-GNSS positioning sources such as INS modules. A secondary application is the transfer of

nanoseconds-accurate UTC timing such as PTP/1588 or Atomic Clock sources into legacy GPS equipment.

The RF output of the RSR GNSS Transcoder™ is attenuated to approximately -120 dBm per satellite, which results in Carrier to Noise (C/No) values in the 42 dB to 47 dB range on typical 8th-generation target GPS receivers. This low RF power level avoids accidental re-broadcasting of signals through faulty (leaky) antenna coax cables, and it closely imitates the signal levels that a typical industry-standard active GPS antenna with a good view of the sky would present to a GPS receiver. The RF output power level is adjustable through standard SCPI user commands for further fine-tuning ability, and the unit is optionally able to simulate various RF free-space path losses and antenna sensitivity patterns for further fidelity to live-sky signals.

To enhance the capabilities of the unit, a 9-degrees-of-freedom (9-DOF) MEMS IMU is integrated into the board. Future firmware upgrades will take advantage of the IMU to synthesize intermediate position and velocity fixes at rates up to 10 Hz. An optional Chip-Scale Atomic Clock (CSAC) is available to provide exceptional timing accuracy even during extended holdover (flywheel) events when the external GNSS receiver or 1PPS reference is not able to provide a PVT fix, and the CSAC can act as a noise-filter for noisy external 1PPS references such as GNSS receivers with excessive sawtooth or multipath errors. The RSR GNSS Transcoder™ also includes an internal GPS receiver that continuously monitors the RF output signal on the SMA connector for signal strength and PVT/PNT fix quality, and is user-queryable via the SCPI interface and the SimCon application.

3.2 Operating the Unit

The RSR GNSS Transcoder™ is designed for physical compatibility with the widest possible variety of operating environments. For example, its miniaturized form factor allows it to be mounted below a Rockwell RSR SAASM Puck to provide a highly-integrated transcoding solution. An optional IP67-rated waterproof enclosure is available for vehicle-mounted or desktop applications. In addition to transcoding applications, the RSR GNSS Transcoder™ can also be used as a stand-alone simulator unit without an external GNSS receiver. Stand-alone use with the optional CSAC installed on the unit allows time-transfer to any GPS receiver with nanoseconds level accuracy and atomic clock-grade holdover performance. Power can be applied through the USB port, or through the avionics-compatible 7V to 36V DC power port. Care must be taken to avoid surge voltages higher than 36V to be applied to the unit such as can happen when hot-plugging the unit with voltages higher than 15V due to the lead inductance, and low-ESR internal bypass capacitors. This can typically be accomplished by using a 1 Ohms or higher series damping resistor on the power line. Units manufactured after June 2018 include a 1 Ohms internal series resistor on the 7V to 36V power input for this purpose.

Please note that the unit will typically generate an RF output shortly after power is applied. The RF output connector of the unit does not need to be terminated if unused; however, it is recommended to terminate the output when unused to avoid leakage of GPS RF signals out of the coax connector.

3.2.1 USB Control and Power

The integrated mini-USB connector can be used to power the RSR GNSS Transcoder™ from external industry-standard USB battery packs, USB "wall wart" supplies, or from a PC. The allowable voltage range for USB power is 2.7V to 5.6V (5V nominal). Power consumption is low at less than 1.2W typically (TCXO variant), allowing extended operating periods with small batteries.

The RSR GNSS Transcoder™ will appear as a standard USB serial port when plugged into a PC, assuming the drivers for the integrated SiLabs CP2104 USB interface chip have been downloaded from the Silicon Labs and/or JLT website. It can then be controlled by GPSCon, SimCon, or by any standard terminal program configured for 115200 Baud, 8 data bits, no parity bit, one stop bit, and no flow control. The freeware SimCon and GPSCon Windows applications can be downloaded from www.jackson-labs.com. Typical power consumption through the USB port is approximately 1.18W at 5V, or approximately 1.35W when equipped with the CSAC option.

3.2.2 DC Power supply: 7V to 36V

An alternative way to power the unit other than through the USB port is to use the DC power input port. The RSR GNSS Transcoder™ includes a vehicle and avionics-compatible DC-DC switching power supply with noise filtering. External DC power should be applied to pin 2 of connector J4, with pin 4 grounded. The allowable voltage range on this DC power port is 7V to 36V (12V nominal). **Care must be taken to avoid surge voltages higher than 36V to be applied to the unit such as can happen when hot-plugging the unit with voltages higher than 15V due to the lead inductance, and low-ESR internal bypass capacitors. This can typically be accomplished by using a 1 Ohms or higher series damping resistor on the power line. Units manufactured after June 2018 include a 1 Ohms internal series resistor on the 7V to 36V power input for this purpose. Units manufactured before June 2018 should not be operated above 15V without at least a 1 Ohms series resistor on the power line placed close to the unit.** The USB port is diode-protected from back-feeding power from the internal DC-DC converter when an external 7V to 36V supply is provided at J4, allowing safe operation with both power sources applied at the same time. Typical current consumption of the RSR GNSS Transcoder™ at 12V is approximately 0.12A, or approximately 0.14A when equipped with the CSAC option.

3.3 Alternate Powering Supply Options

The RSR GNSS Transcoder™ module has the capability to provide power to the external GNSS receiver via pin 11 of connector J4. This pin has multiple functions, described below:

3.3.1 Powering External GNSS Receivers

The RSR GNSS Transcoder™ includes connector J4 with signals designed to interface seamlessly to an external GNSS receiver such as the Rockwell RSR SAASM Puck. It can provide power to the external GNSS receiver as well as RS-232 level serial communications and TTL/CMOS level 1PPS connections. External GNSS receivers are assumed to be compatible with a prime-power input between 2.7V and 5.5V (5V nominal).

When connecting pin 11 of J4 to the prime-power input of the Rockwell RSR Puck or other external GNSS receivers, the unit will provide either the supplied USB voltage (2.7V to 5.5V range) to the Puck, or an internally regulated 5.4V supply derived from the external 7V to 36V DC prime-power port, whichever is higher. The Rockwell Puck or other external GNSS receiver can thus be fully powered by connector J4 of the RSR GNSS Transcoder™ module and does not require any other wiring connections than those to the transcoder module.

3.3.2 Powering the RSR GNSS Transcoder™ From an External LiPo or LiIon Single-Cell Battery

While the primary use of pin J4-11 is to provide regulated power to an external GNSS receiver, pin J4-11 can alternatively be used to provide power to the RSR GNSS Transcoder™ as well as the Rockwell RSR Puck or other external GNSS receiver from a single-cell LiPo or LiIon battery. Pin 11 will then act as a low-voltage power supply for the RSR GNSS Transcoder™ itself, supporting voltages between 2.7V to 5.5V. A typical LiPo battery provides a voltage range between 4.2V (charged) and 3.7V (discharged). In this configuration, the 4.2V battery power is typically split up externally and fed to the prime-power input of the Rockwell RSR Puck as well as into pin 11 of connector J4 of the RSR GNSS Transcoder™.

Important! Neither USB power nor external power to pin J4-2 should be connected when using pin J4-11 as the prime power input to the RSR GNSS Transcoder™. If power is applied to the USB port or to the DC 7V to 36V port, the external LiPo/LiIon battery will be charged at voltages up to 5.5V. This can result in battery failure, fire, or explosion. Consequently, <u>simultaneous operation of a battery connected to J4 pin 11 and any other external power source is not allowed</u>.

Please note that neither the RSR GNSS Transcoder™ nor the Rockwell RSR Puck will automatically disconnect the battery when the LiPo minimum allowable lower-level battery voltage of 3.7V is reached. Continuing to operate the RSR GNSS Transcoder™ from a LiPo or LiIon battery below 3.7V cell voltage may damage the battery or cause a battery fire. The user **must** disconnect the battery externally before the terminal cell voltage of 3.7V is reached. External charge and control ICs are readily available that prevent under-voltage conditions on LiPo/LiIon batteries, and are strongly recommended for use in conjunction with direct battery power on any of the power input connections.

Powering the RSR GNSS Transcoder™ from a 5V supply on pin 11 of connector J4 results in the lowest overall power consumption, since the USB port has losses associated with its series protection diode and the DC 7V to 36V input has losses associated with the internal 36V to 5.4V switching regulator. Pin 11 of J4 should receive a clean, regulated 5V power input for applications that require the lowest possible overall power consumption. **To re-iterate, the USB port and DC 7V to 36V power ports must remain unconnected when pin J4-11 is used to power the unit from an external battery.**

3.4 Connecting to a Target GPS Receiver

The RSR GNSS Transcoder™ simply replaces existing GPS antenna cabling for most industry-standard target GPS receivers, and will provide a GPS L1 RF signal on the SMA output connector comparable to that available from a well-positioned GPS antenna. To the GPS receiver, the RSR GNSS Transcoder™ will simply appear to be an industry-standard active GPS antenna.

The RSR GNSS Transcoder™ uses an integrated 186-ohm resistor to ground to simulate a typical active antenna load, allowing operation with GPS receivers that require an external antenna load to function properly. Please note that the DC antenna load is compatible only with GPS receivers that output between 0V to 6V DC nominal on their antenna connector. Receivers that expect the external antenna to consume approximately 10mA to 50mA at 3.3V to 5V should work well. One example is the Rockwell Collins DAGR handheld GPS receiver. This model will not work properly if the antenna current is either too low or too high, but it will work properly with the RF output of the RSR

GNSS Transcoder™ directly connected to the SMA GPS antenna input connector of the DAGR via an SMA to SMA coax cable.

PLEASE NOTE: Some legacy systems such as the Microsemi XLI Reference use 12V DC for the GPS antenna DC output power. When used with this model, or with any other receiver that provides more than 6V at its antenna jack, an external DC block MUST be present between the RSR GNSS Transcoder™ and the target GPS receiver antenna port. Otherwise, damage due to overheating of the internal DC load may result.

The L1 GPS RF output of the RSR GNSS Transcoder™ can be adjusted between approximately -105 dBm to below -125 dBm via SCPI serial commands. These levels typically result in C/No ratios between 33 dB and 47 dB. Higher output levels allow compensation for longer antenna cable runs by compensating for RF cable losses.

3.5 Mechanical Drawing

The following figure is a mechanical drawing of the RSR GNSS Transcoder™ module.

Figure 3.1   Mechanical Drawing of RSR GNSS Transcoder™ Module

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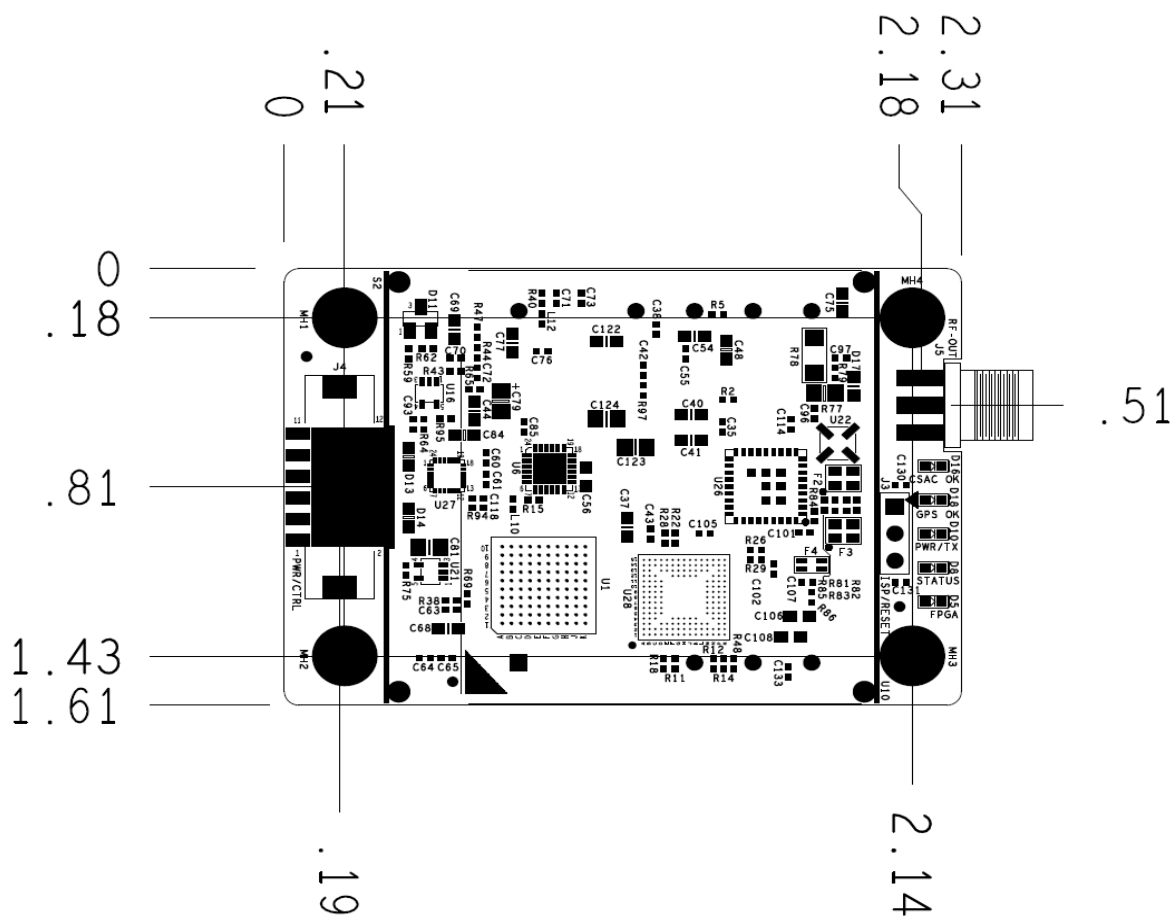
3.6 Major Features

The major connections and features of the RSR GNSS Transcoder™ are shown in Figure 3.2 and Figure 3.3.

Figure 3.2   Major connections of the RSR GNSS Transcoder™ PCB Top Side
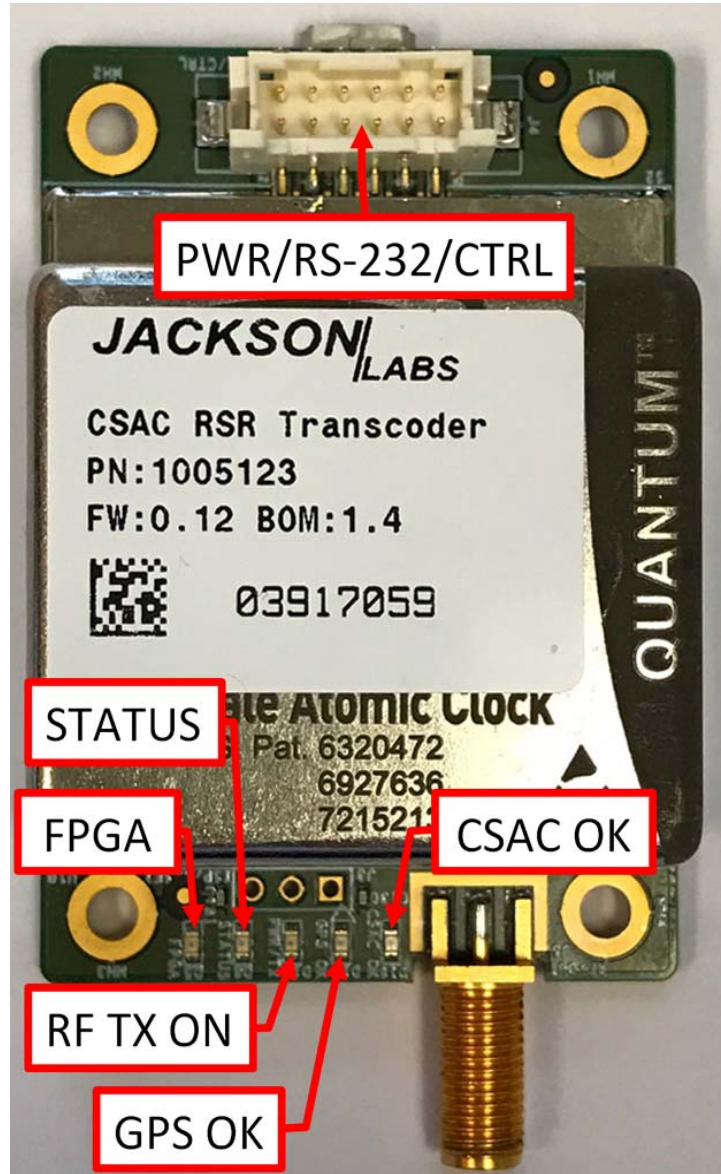
Figure 3.3   Major connections of the RSR GNSS Transcoder™ PCB Bottom Side

The RSR GNSS Transcoder™ has three major connectors: J4 for power and control of the external GNSS receiver or PVT/PNT source, 10MHz out, and 1PPS In/Out; J5, which provides the GPS L1 C/A RF output signal to the target GPS receiver; and J2 for USB power and serial control.

A secondary 3-pin connector (J3) can be used to reset the board and to place the board into In-System-Programming (ISP) mode for firmware upgrades as explained in Chapter 6. An alternate firmware upgrade method simply uses a single-button upload feature in the SimCon control application, and is highly recommended as it does not require shorting of the ISP pin on connector J3. JLT can provide source code for in-situ firmware upgrades in a customers' application environment as well upon request. Connector J3 is also used to connect an external switch which will send a Zeroize command to the Rockwell SAASM GPS receiver when pressed (grounded) during normal operation.

Figure 3.2 shows the five status LEDs available on the RSR GNSS Transcoder™ module. Table 3.1 shows the individual functionality of these status LEDs:

Table 3.1   Status LED Functionality

Ref	Name	Function	Specification
LED D5	FPGA LED	FPGA Health Status	Blinks slowly if FPGA is OK. OFF: System not initialized yet, or fault detected
LED D8	GNSS FIX OK	External NMEA Fix Status	ON: Detection of GNSS Fix in externally supplied NMEA stream (external GNSS Receiver LOCK OK). OFF: no external PVT/PNT source is detected, or source does not report a valid 3D GNSS Fix
LED D10	Power/Transmit	Transmit RF ON Indicator	10Hz blink rate: module is generating GPS L1 RF output on the SMA connector. ON: Power is on, but RF output is disabled
LED D18	Internal GPS FIX OK	1PPS Fix Status of built-in monitoring GPS receiver	Blinking at 1Hz: indicates built-in monitoring GPS receiver is sensing a good fix from the simulated GPS RF SMA connector output signal. OFF: internal GPS receiver is showing an error condition, or RF output is disabled

LED D16	CSAC OK	CSAC Built-In Self Test (BIST) Status Indicator (only on boards with CSAC option)	ON: CSAC has achieved atomic lock and is operating normally. OFF: CSAC is not present, has not yet achieved atomic lock, or is indicating a CSAC fault

3.6.1 Power/Communication Connector J4

Table 3.2 shows the signals on connector J4. This connector is a 12-pin male connector from Hirose, part number DF11C-12DP-2V-57. The use of connector J4 is optional when the board is powered and controlled via the built-in USB connector.

Table 3.2 Connector J4 pinout

Ref	Name	Function	Specification
J4-1	GNSS-RXD	NMEA Serial Output to external GNSS receiver	RS-232 level serial control port output to external GNSS receiver
J4-2	DC In 7V to 36V	Prime Power DC Input	7V to 36V DC Prime Power input, <50mV AC, <0.25A
J4-3	GNSS-TXD	Serial Control Input from external GNSS receiver	RS-232 level serial port input from external NMEA source
J4-4	GND	System Ground	Ground
J4-5	GNSS_PWR_OFF	External GNSS Power Control Output	CMOS-level Power Control output to external GNSS receiver 0V (GNSS ON) or 3.3V (GNSS OFF). Can drive 8mA. Compatible with Rockwell RSR Puck Power Control input pin. Controlled by the GPS:RESET ONCE SCPI command
J4-6	LOCK_OK	Internal Oscillator LOCK Status	3.3V indicates internal oscillator is locked to external 1PPS reference, and no events are pending. 0V indicates either oscillator is unlocked, or events are pending and can be queried with the SYNC:HEALTH? SCPI command.

J4-7	GNSS-1PPS	1PPS Reference Input from external reference or GNSS	1PPS CMOS or TTL reference input to RSR GNSS Transcoder™. 0V to 5V swing allowed, 1.6V threshold. Internally pulled to ground via 5.2K resistor.
J4-8	1PPS OUT	1PPS Output driven by internal oscillator	3.3V CMOS 1PPS output from RSR GNSS Transcoder™ derived from internal TCXO.
J4-9	ISP#, SAASM Zeroize#	Processor In System Programming pin. SAASM Zeroize input.	Pulling this pin to ground during power-on or during a Reset event will cause the processor to go into ISP mode. Alternate function is to send a Zeroize command to the externally connected SAASM GPS receiver when pulled low during normal operation. Leave floating normally.
J4-10	GND	System Ground	Ground
J4-11	+5.4V IN/OUT	Dual-purpose power pin: Power Output to external GNSS Alternatively used as high-efficiency power input from external power source	Follows USB power supply voltage for USB powered applications. Provides 5.4V output for external GNSS receiver if Prime Power input pin 2 of J4 is used. Can alternatively be used as a high-efficiency 2.7V to 5.5V Input to board if neither Prime Power nor USB power is applied.
J4-12	10MHz OUT	10MHz buffered output from internal oscillator	3.3V CMOS 10MHz buffered output from internal TCXO. Must be software-enabled via SCPI command.

3.6.2 ISP#/SAASM Zeroize and RESET# Connector J3

The following table shows the optional ISP#/RESET# connector J3 pinout. Pulling RESET# low via an open-drain transistor or via a switch to ground will cause the board to be reset. Holding ISP# low during the reset event will cause the processor to go into In-System-Programming (ISP) mode as explained in Chapter 7. Both signals should be left floating during normal operation. Two metal tweezers are commonly used to momentarily reset the board while holding the ISP pin low. This method of updating the firmware has been replaced by a simple button press in the SimCon application as explained in detail in Chapter 4.

Pin 1 of connector J3 has an alternate function as a Zeroize command input for units connected to external SAASM GPS receivers (Rockwell Collins MicroGRAM, GB-GRAM, RSR Puck, and others). Pulling this pin to ground during normal operation will cause the unit to send a SAASM Key Zeroize serial command to the externally connected SAASM GPS receiver. This pin can thus be connected to an external switch to ground, and used to initialize ISP mode, as well as an emergency zeroize button for the SAASM GPS receiver. This pin has no effect during normal operation when the unit is connected to a commercial GNSS receiver and operating normally.

Table 3.3   ISP#/Zeroize and RESET# Connector J3

Ref	Name	Function	Specification
J3-1	ISP#/Zeroize#	Places processor into In System Programming mode. Alternatively zeroizes external SAASM GPS receiver.	Leave floating during normal operation, or pull to ground during power-on or during a Reset event to enable ISP mode. Internally pulled to 3.3V. Pulling this pin low during normal operation will cause a Zeroize command to be sent to the external SAASM GPS.
J3-2	Ground	Ground	Ground
J3-3	RST#	Resets main processor and FPGA	Pull to ground momentarily to Reset the board. Leave floating during normal operation. Internally pulled to 3.3V

3.6.3 RF SMA Connector J5

Connector J5 serves a dual purpose: the simulated/synthesized L1 GPS C/A code is transmitted via SMA connector J5, and antenna DC power from the external GPS receiver is dissipated through an internal 186-ohm DC resistive load. This allows J5 to be directly connected to generic GPS Antenna input connectors on standard GPS receivers, while at the same time simulating the load presented to the receiver by a typical GPS antenna system. GPS receivers such as the Rockwell Collins DAGR GPS will use this load to sense external antenna connectivity and to automatically switch over to the external antenna connection. On some GPS receivers this load may be needed to prevent antenna fault indications.

The RF output level on connector J5 is variable from about -105 dBm to less than -125dBm via SCPI command. Various L1 frequency test tones can also be activated on connector J5 via SCPI command. These test tones are useful as jamming signals for testing, or to verify RF output power levels.

Do not feed more than 6V DC antenna voltage into connector J5 to prevent overloading of the internal load resistors. **12V antenna voltages provided by receivers such as the Microsemi/Symmetricom XLI units at their antenna inputs may damage the unit due to overheating**. When receivers that supply excessive antenna voltage are to be connected, an external RF DC block adapter rated for operation at 1.6 GHz should be used on connector J5.

3.6.4 Optional CSAC Holdover Oscillator

The RSR GNSS Transcoder™ module can be ordered with an optional Chip-Scale Atomic Clock (CSAC) holdover oscillator installed. The CSAC oscillator provides short-term-stability (STS) improvements as well as significant holdover and thermal-stability improvements compared to the standard internal TCXO, and allows the unit to provide an atomic quality time/frequency reference to the GPS simulation even in the absence of any external NMEA/GNSS or 1PPS timing references. The internal TCXO is then used as a phase-noise and spur-filter oscillator for the CSAC, as it is tightly phase-locked to the CSAC via an analog PLL. This improves the phase noise of the 10MHz output on connector J4 as well as the overall simulation signal quality.

The CSAC (as well as the TCXO on units without a CSAC) can be automatically disciplined to an external 1PPS reference source which is typically a user-supplied GNSS receiver, but could also be a PTP/1588 source or Atomic reference oscillator. When this is done, the unit will go into holdover mode automatically when the external GNSS receiver stops producing a 1PPS signal for any reason including loss of GNSS lock. Both the 1PPS output and the 10MHz output on connector J4 are generated by the internal TCXO locked to the optional CSAC, and are thus highly stable and accurate while exhibiting very low phase noise. The built-in CSAC is steered by the same algorithms used on the popular JLT CSAC GPSDO modules, providing a highly-stable atomic reference platform.

As an interesting side-note: the internally-generated 1PPS pulse and NMEA date/time information is also available to the USB port DCD interrupt pin of the serial port. This means that the RSR GNSS Transcoder™ can act as a standard PVT reference for NTP servers under Linux using the industry-standard GPSD driver.

In the event of failure of the CSAC, or when the CSAC option is not installed, the internal TCXO is automatically controlled by a 24-bit DAC and optionally disciplined to an external 1PPS reference via JLT's GPSDO disciplining algorithms. Switchover between the software-driven TCXO DAC and the analog PLL locking the TCXO to the CSAC is automatic. The built-in CSAC oscillator can also be powered-down manually through a SCPI command to reduce overall power consumption. The unit will automatically revert to TCXO-only disciplining in the event the CSAC is manually powered down or fails to operate properly for any reason.

Operation with the optional CSAC oscillator allows the unit to act as a time-transfer device to any external GPS receiver. In stable conditions the CSAC can have drift rates of less than 2us per day, allowing highly-accurate timekeeping when operating in GPS-denied environments, when generating IS-GPS-250A compatible Pseudolite signals, or in other applications that require exceptional timing performance. Accumulated phase and frequency errors associated with the CSAC can be calibrated out within minutes simply by supplying an accurate and stable 1PPS reference source to the module, with no user intervention required.

For testing and evaluation the CSAC can be manually steered (CSAC:STEER xx SCPI command), and steering values can be manually stored inside the CSAC NVRAM by issuing the CSAC:STEER:LATCH ONCE command. Please see the CSAC GPSDO user manual for additional details on the operation and monitoring capabilities of the built-in CSAC GPSDO subsystem.

3.7 Optional Cable and Enclosure Solutions

The RSR GNSS Transcoder™ can be ordered with a ruggedized IP67 waterproof machined anodized-aluminum enclosure. The unit can be operated inside the enclosure with or without the optional CSAC oscillator. The internal USB connector pins and the pins of connector J4 are brought

out of the enclosure on a water-tight DB-15 female connector, and the RF SMA output connector is available in the back of the enclosure. Four strong magnets on the bottom of the enclosure allow mounting the unit on a vehicle roof or other metal surfaces, while four mounting holes allow a more permanent mounting solution with screws or bolts.

Rockwell Collins makes available a cable harness upon demand to connect the Rockwell Collins RSR SAASM or M-Code puck receivers directly to the RSR GNSS Transcoder™. Legacy GPS antennae can thus simply be replaced by the Rockwell RSR Puck connected to the RSR GNSS Transcoder™ and an optional 5V (USB) or 7V to 36V (12V nominal) power source connected to the cable harness. The RF output of the unit would simply be connected to the legacy equipment's RF antenna input connector on top of the vehicle in this scenario. A USB break-out cable can be used for software upgrades and configuration. The following images show the optional RSR GNSS Transcoder™ IP-67 waterproof enclosed unit:

Figure 3.4   Optional RSR GNSS Transcoder™ IP-67 Water Proof Enclosure (front)

Figure 3.5   Optional RSR GNSS Transcoder™ IP-67 Water Proof Enclosure (back)

The following table shows the female DB-15 connector pinout of the RSR GNSS Transcoder™ Enclosure. Please see Table 3.2 for additional details on the signal functions and voltage levels for the below referenced DB-15 pins:

Table 3.4 Enclosure DB-15 Connector Pinout

Ref	Name	Function	J4/USB equivalent pin
Pin1	USB Ground	USB Signal Ground	USB Pin 5
Pin 2	USB D+	USB D+	USB Pin 3
Pin 3	USB D-	USB D-	USB Pin 2
Pin 4	USB 5V	5V Input from USB	USB Pin 1
Pin 5	Ground	5V-USB Ground	J4-4
Pin 6	ISP#/ZEROIZE	ISP#/ZEROIZE	J4-9
Pin 7	EXT 1PPS IN	1PPS Input from GPS	J4-7
Pin 8	GPS PWR OFF	Disable Ext. GPS	J4-5
Pin 9	Ext. GPS TXD	RX input	J4-3
Pin 10	Ext. GPS RXD	TX output	J4-1
Pin 11	5.5V IN/OUT	5.5V to RSR	J4-11
Pin 12	Ground	Ext GPS Ground	J4-10
Pin 13	1PPS OUTPUT	1PPS CMOS OUT	J4-8
Pin 14	Ground	Prime Power Ground	J4-4
Pin 15	Prime Power	7V to 36V input	J4-2

Please note that a standard USB cable can be adapted to DB-15 pins 1 to 4 to supply communications and power from an attached PC or other USB power source. A heavy-duty USB cable should be used to minimize voltage drop across the power and ground wires. The RSR GNSS Transcoder™ will need at least 4.5V across pins 1 and 4 of the DB-15 connector to operate properly during power-on. A momentary current in excess of 1A may flow during the power-on surge through the USB power cable, so the cable must be able to momentarily provide 1A at 4.5V or higher. Lower-quality USB cables will cause excessive voltage drop and subsequent operational failures in the module. Alternatively - or concurrently - a 7V to 36V (12V nominal) DC Prime Power supply may be connected across pins 15 (+) and 14 (-) of the DB-15 connector to supply power to the unit independently of the USB cable.

Figure 3.6   IP-67 Water Proof Enclosure Drawing
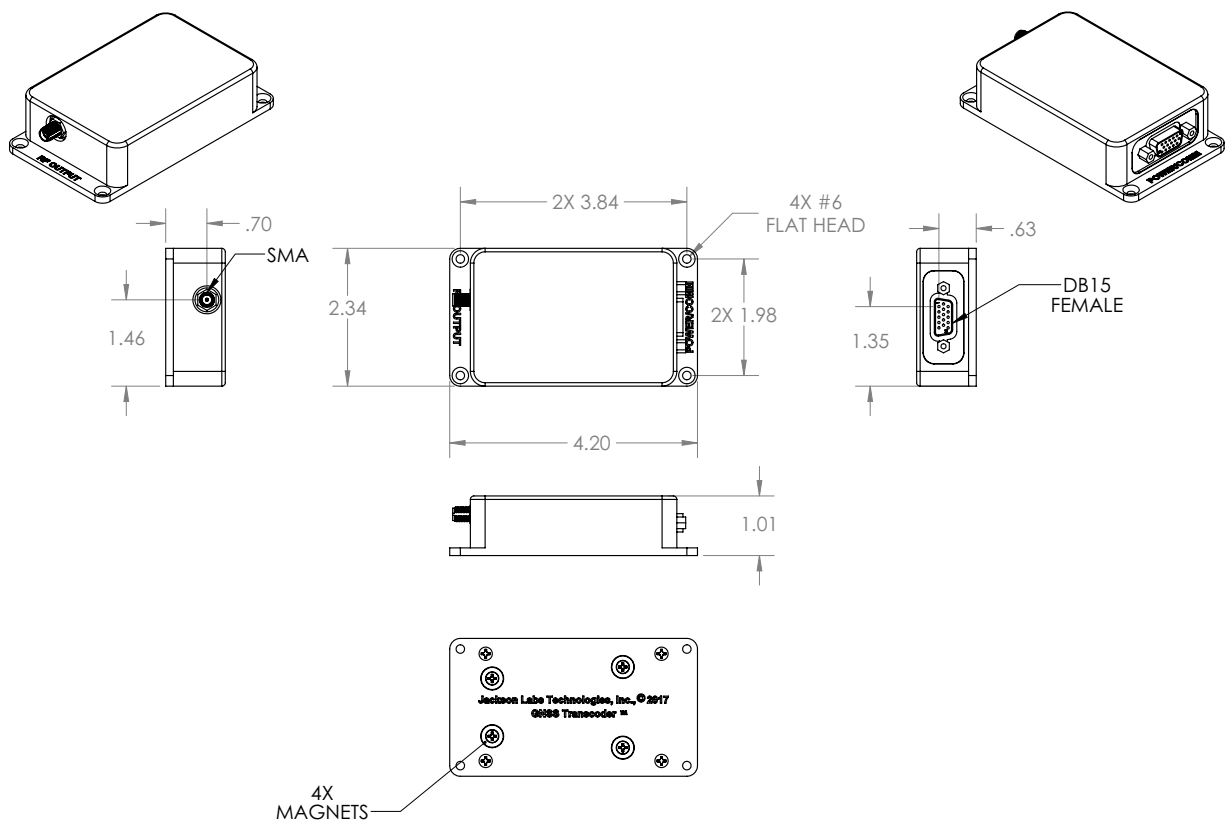
3.7.1 Compatible Water-Proof DB-15 Male Connector

The RSR GNSS Transcoder™ Enclosure is compatible with various male IP67 Water-Proof DB-15 mating connectors such as the Assman WSW Components part number A-HDS15-HOOD-WP connector, hood, and rubber seal assembly available at Digi-Key:

www.digikey.com/product-detail/en/assmann-wsw-components/A-HDS15-HOOD-WP/AE10119-ND/1089501

Any industry-standard male DB-15 ("VGA" type) connector may be used to provide power and communications to the unit; however, only waterproof connectors with matching hoods will guarantee that the signals and pins will not be exposed to damage from oxidation or dust.

3.8 Operating Modes of the RSR GNSS Transcoder™

The RSR GNSS Transcoder™ can be operated in one of three modes. It may be connected to an external GNSS or other Position/Velocity/Time (PVT) source, operated via SCPI commands sent from an external control application, or operated via manual PVT entry using a serial terminal program. The unit may also run a simulation totally autonomously, either from an internally-stored motion-vector control file or using a stationary position fix.

3.8.1 Transcoding with External PNT Source

Figure 3.1 shows a typical diagram using the RSR GNSS Transcoder™ to upgrade the legacy GPS equipment in an airplane or other vehicle with the position solution from ALT-PNT position sources. When live signals are available, legacy GPS systems can be switched to live GPS signals. But when GPS signals are jammed, the antenna connection can switch to the RF output from the RSR GNSS Transcoder™. When the RSR GNSS Transcoder™ is provided live ephemeris, almanac and UTC/ionospheric correction parameters and precise timing from a GPS receiver's 1PPS, the transition between live sky the RSR GNSS Transcoder's RF output is made with minimal disturbance to the legacy GPS systems.

Figure 3.7   Upgrading Legacy GPS Equipment
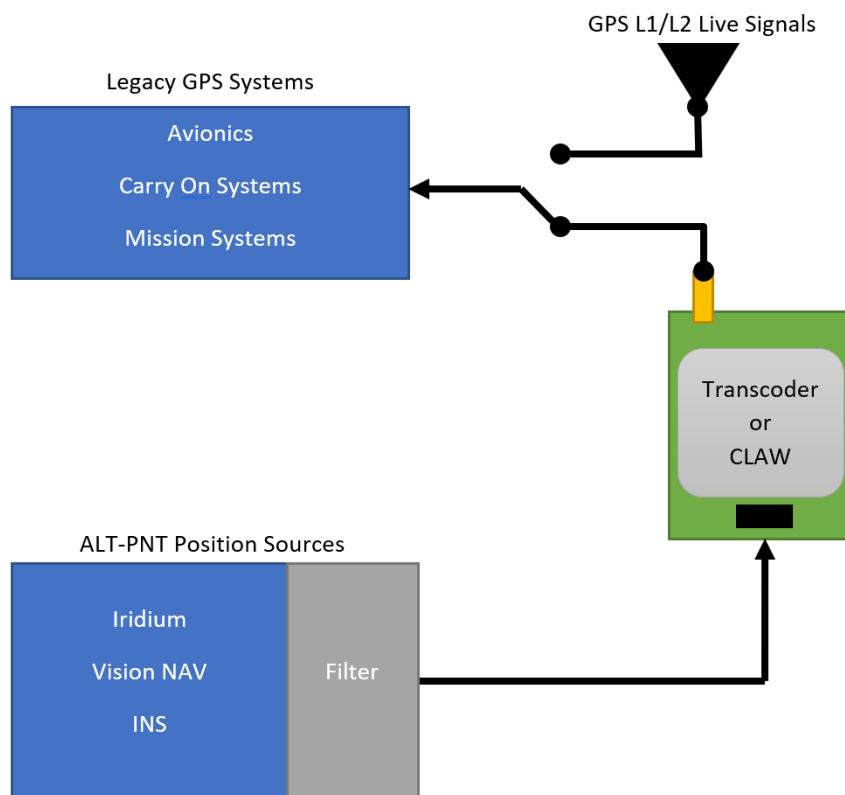
Any GNSS receiver, INS or other device capable of providing GGA and RMC sentence NMEA output at 1Hz can be used as a PVT source for transcoding. Transcoding with precise time and UTC phase transfer also requires a 1PPS signal from the transcoding receiver. When configured in transcoding mode with the SIM:MODE TRANSCODE command, the RSR GNSS Transcoder™ will pause for several seconds after power-on, and by default look for NMEA data at 9600 or 38400 baud and the presence of a 1PPS input. The baud rate can also be manually configured from 9600 to 115,200 baud with the SYSTem:COMMunicate:SERial:BAUD command as described in Section 6.13.3 . When incoming NMEA data is detected, the RSR GNSS Transcoder™ will wait for a valid position fix and a stable 1PPS output from the GNSS receiver. At that time it will enable the GPS L1 RF output and begin transcoding. The unit may also optionally be configured to transcode NMEA PVT information without an external 1PPS reference signal being present by sending the SYNC:SOUR:MODE NMEA command as described in Section 6.7.5 .. Finally, when transcoding

with an external PVT source via the RS-232 port on the 16-pin J3 connector, the GPS:PORT setting must be RS232 as described in Section 6.10.29 .

During transcoding, the RSR GNSS Transcoder™ will continue to update the position and synchronize precise timing with the 1PPS reference input until the external GNSS receiver indicates a loss of lock. The RSR GNSS Transcoder™ can operate in three different user-selectable holdover modes when the external receiver indicates a loss of GNSS fix. The holdover mode is controlled with the SIMulation:HOLDover:MODE <ON|OFF|LIMIT> command as described in Section 6.3.4 .

ON mode: This mode will cause the RF output to remain on by propagating time using either the internal high stability TCXO or optional CSAC atomic clock as a timing reference, and applying the currently selected filter mode to the transcoded position. Both clocks can be used for precise time transfer to the target receiver, with the CSAC being able to maintain precise timing for longer holdover periods. The ON mode is best used to provide timing holdover to the target GPS receiver and when guaranteed position accuracy during holdover is not required. When using the ON mode and the position filter mode is set to INS, the transcoded position continues to be updated based on a dead reckoning solution from the internal INS. The INS solution accuracy will degrade as time passes, and is only to be used as an approximate positioning reference. See Section 3.8.8 for more details on configuring the filtering mode.

JLT has devised a way to communicate fix status of the GPS simulator entirely through the RF antenna feed by attenuating certain PRN numbers. This allows a target GPS receiver to be used without any modification, while at the same time transferring information about the simulated PVT fix quality. Thus it is possible to determine if the RSR GNSS Transcoder™ is in holdover mode or receiving valid external GNSS reference fixes, for example.

The holdover indicate mode configured with the SIMulation:HOLDover:INDicate <ON | OFF> command is available to communicate to the target GPS receiver that the transcoder is operating in holdover mode. When holdover indicate mode is enabled and the RSR GNSS Transcoder™ is operating in holdover mode, the unit decreases the RF signal amplitude of the highest elevated satellite by 6 dB to indicate that the holdover state is active. This difference in signal strength can be easily distinguished in the target receiver's reported SNR numbers since the highest elevation satellite will have a reported SNR significantly below the average reported for other satellites. In most cases, the target receiver can continue to use this satellite in the PVT solution. However, the accuracy of the PVT solution may be affected due to the reduction in signal strength of one satellite.

The target system can use the information encoded in the highest elevation satellite signal strength to determine that the RSR GNSS Transcoder™ is itself in holdover mode and use the information provided by the GPS receiver with caution as necessary. For example, when the target system detects the holdover condition, it may no longer use the position information, since it is known at that time that the position is only an estimate. The system may continue to use the 1PPS phase reference provided by the target receiver for a user-determined period of time, however, based on the holdover performance of the RSR GNSS Transcoder™'s oscillator or external 1PPS reference holdover performance.

When the external GNSS receiver obtains a GPS fix, the transcoded position quickly moves within defined maximum dynamics to the new input position and the time will quickly skew to the precise time obtained by the input 1PPS. See Section 3.8.8 for the commands that control the maximum dynamics that are applied to the RF simulator output when the position has to be "jumped" from one second to the other such as would happen when the external reference GNSS receiver has reacquired a PVT fix after a longer GNSS-denied period.

OFF mode: The off mode will cause the RF output to turn off within about 4 seconds after the external GNSS receiver loses valid position data. When this happens, the target GPS receiver will also lose GPS lock. Timing holdover performance will depend only upon the characteristics of the target GPS receiver system. This mode also guarantees that the target receiver will not output invalid PVT data since it will indicate that no GPS fix is available. When the external GNSS receiver regains a GPS fix, the transcoded position will move immediately to the new input position and the time will jump to the precise time from the external 1PPS reference, or from the internal oscillator when no 1PPS reference is present. This mode is typically used only with the TCXO variant of the module, as the CSAC time and phase information would not be available to a target GPS receiver when the module goes into holdover/flywheel mode.

LIMIT mode: The LIMIT mode will cause the transcoded RF output to remain on for a defined length of time after the external GNSS receiver indicates loss of valid position data. The holdover time limit is configured using the SIMulation:HOLDover:LIMIT command as described in Section 6.3.6 . When the holdover limit has been reached the RF output turns off, causing the target receiver to lose its GPS lock. The LIMIT mode is useful when the holdover timing stability of the RSR GNSS Transcoder™ is needed for a limited time to prevent excessive timing errors from being transferred to the target receiver. When the external GNSS receiver once again indicates valid PVT data, the RSR GNSS Transcoder™'s holdover recovery behavior will be similar to the ON holdover mode if the RF output was still enabled at the time the holdover ended, or to the OFF holdover mode if the RF output had already been disabled due to reaching the holdover time threshold limit. This behavior can be loosely compared to GPS cold- and warm-start conditions.

3.8.2 Detecting and Configuring External GNSS Receiver

In addition to accepting standard NMEA input from the external GNSS receiver, the RSR GNSS Transcoder™ can also control special functions on Rockwell Collins RSR SAASM Puck and Microgram SAASM GPS receivers as well as uBlox 5 through uBlox 8 GPS/GNSS receivers through serial configuration data sent from the RS-232 port to the external GNSS receiver. The type of receiver is configured with the GPS:TYPE command as described in Section 6.10.1 . The default configuration is AUTO, causing the receiver type to be automatically queried after power-on or reset. The baud rate of the external GPS receiver is also configurable as described in Section 6.13.3 , with the default setting of AUTO which auto-detects between 9600 and 38400 baud. The following sections describe the special configuration and monitoring features available with the Rockwell and Ublox receivers.

3.8.2.1 Connecting a Rockwell Collins RSR SAASM Puck and/or MicroGRAM SAASM GPS

The RSR GNSS Transcoder™ will initialize and control externally-connected Rockwell Collins RSR SAASM Puck and MicroGRAM SAASM Receivers via the RS-232 serial port. For these receivers to communicate with the RSR GNSS Transcoder™, the NMEA protocol including input messages must be enabled manually in their configuration by Rockwell Collins by ordering the NMEA versions of these products. The Rockwell GPS receivers will have only ICD-153 interfacing enabled by default, and the NMEA capability must be configured by Rockwell Collins at their factory upon user-request. Also the 1PPS output mode should be configured to UTC during assembly-configuration of the receiver. Please contact Jackson Labs Technologies, Inc. for additional information regarding the required receiver configuration. Special features that are available with the Rockwell Collins

SAASM receivers include Y-Tracking status, keyfill status, anti-spoofing status, zeroize, 1PPS quantization error and DAGR assisted warm-start mode control and status. See Section 6.10 for details of the supported SAASM GPS relevant SCPI commands. Jackson Labs Technologies, Inc. has partnered with Rockwell Collins to create a special timing-enabled version of the internal MicroGRAM and GB-GRAM SAASM firmware. This software version has been security-approved and is only available to JLT customers. It is required to be used on the Rockwell Collins GPS SAASM receiver to achieve the best timing performance from the unit and thus recommended (but not required) on systems using the CSAC oscillator disciplining option.

3.8.2.2 Connecting a uBlox GNSS Receiver

The RSR GNSS Transcoder™ will also control products from uBlox, specifically uBlox generations 5 through 8 GPS and multi-GNSS receivers. The RSR GNSS Transcoder™ will work with both standard and fixed-position timing receiver versions of the uBlox 5 through 8. The uBlox receiver should start up at the default baud rate of 9600, and the RSR GNSS Transcoder™ will configure the baud rate of the uBlox GNSS receiver to 38400 automatically via the built-in RS-232 serial port. The RSR GNSS Transcoder™ communicates with the uBlox receivers using both the NMEA output and uBlox Binary input and output commands. The RSR GNSS Transcoder™ also configures the uBlox receiver's 1PPS output for optimum settings for the GPSDO operation of the RSR GNSS Transcoder™. The entire uBLox GNSS receiver configuration process is transparent to the user.

Special features available with the uBlox 5 through 8 GNSS receivers include a Fixed Position/ Auto Survey mode, automatic and manual dynamic Kalman filter settings, ECEF position and velocity, antenna delay setting, jamming level monitoring, concurrent GNSS reception capability (uBlox-8 and later), PPS quantization error monitoring/compensation, and 1Hz/10Hz PVT rate selection. See Section 6.10 for details on the supported SCPI commands.

3.8.3 Manually entering Lat/Long/Height Simulation Coordinates

When the RSR GNSS Transcoder™ is operating in simulator mode, it can use position information generated by a JLT-custom Motion Command Language program or from a fixed position entered through SCPI commands. The fixed position to be simulated, when entered through SCPI commands, is stored in non-volatile memory and will be retained through a power cycle. The SIMulation:POSition:LLH and SIMulation:POSition:ECEF commands are used to enter or query the current fixed position in Latitude/Longitude/Height or Earth Centered Earth Fixed (ECEF) coordinates. When the simulation is started with either manual commands (Section 6.3.2) or in simulation mode from power up (Section 6.3.3), the previously-set position will be used for the simulated position. If the fixed position is changed while the simulation is running, the simulation position will quickly move to the new position, limited only by the maximum dynamics configured in the SIMulation:POSition:FILTer SCPI commands as described starting in Section 6.3.11 . When the simulation position approaches the fixed position, the speed will reduce at the maximum acceleration rate, and the simulated position will stop at the new fixed position. This synthesized movement from the old position to the new position is done to prevent the GPS receiver filters from loosing lock during the transition.

For example, the following commands will start a fixed position simulation and then change only the altitude from 500 to 2,000 meters so that the simulated position changes to the new altitude with the specified maximum velocity and acceleration:

> SIM:MODE MANUAL
>
> SIM:POS:LLH 36,-115,500
>
> [optionally SIM:POS:LLH ,,500 if, for example, the previously-simulated latitude and longitude are to be preserved)
>
> SIM:POS:FILTER:MODE DYNA
>
> SIM:POS:FILTER:VMAX 100
>
> SIM:POS:FILTER:AMAX 0.5g
>
> SIM:COMMAND START
>
> SIM:POS:LLH ,,2000

The simulated position will now move from 500 meters and stop at the newly commanded altitude of 2,000 meters. Any additional SIM:POS:LLH commands sent cause motion with the maximum defined dynamics until the new position is reached.

3.8.4 Simulating from Internally Stored Motion Commands

The custom JLT motion command language defines a sequence of positioning commands that are stored in non-volatile memory and executed sequentially during a simulation when the simulation mode is set to SIM and the simulation position mode is set to MOTION with the "SIMulation:POSition:MODE <FIXED | MOTION>" command. This mode is typically controlled by the SimCon Windows application available for free from the Jackson Labs website. Alternatively these commands can be manually entered through the serial port as needed. The motion vectors are stored using the SIMulation:POSition:MOTION:WRITE command which causes the SCPI interface to enter command entry mode. In command entry mode, one command per line is received until an END command is received. Details on the command entry including the syntax of commands are available starting in Section 6.3.22 . The freeware SimCon application available on the support page of the JLT website and described in Chapter 4 allows auto-generation, previewing, and uploading of complex simulation scenarios and is recommended for creating simulation vector files.

The available commands include:

> Dynamics - Defines the maximum dynamics
>
> Reference - Set initial position, heading and speed
>
> Straight - Straight motion for specified duration
>
> Accelerate - Straight motion, change speed specified amount for specified duration
>
> Turn - Heading change at specified lateral acceleration
>
> Climb - Change in height at specified climb rate with start and end lateral acceleration
>
> Waypoint - Waypoint position, final heading and speed.
>
> Combined Accelerate/Turn - Specify heading change, lateral acceleration and change in speed.
>
> Combination Turn/Climb - Specify change in heading, lateral acceleration, change in height, and height rate
>
> Halt - Set final position and stop
>
> Goto - Jump to a specified motion control command number for making infinite loop simulations

End - Stop the motion simulation

3.8.5 Configuring the GPS Constellation

The default GPS constellation for simulation and transcoding is a synthesized 30-satellite constellation optimized for position and timing accuracy. In most cases, this synthesized constellation should be used, however there are cases where a specific user-selected GPS constellation needs to be simulated. In these cases, the user can provide the subframe data for either the ephemeris or almanac for each satellite.

The SIMulation:LNAV:SELect <SYNTH | USER | LIVE> command sets the source of the ephemeris and ionospheric correction data. With the USER option, the stored ephemeris and ionospheric data from the SIM:LNAV commands will be used directly in the simulation. If the validity of the ephemeris data is outside of 0 to 2 hours after the simulation time, then the RSR GNSS Transcoder™ will extrapolate the ephemeris data to provide the simulation with a current valid ephemeris set.

The SIMulation:LNAV:SELect LIVE setting selects the ephemeris, almanac and ionospheric/UTC parameters received from the external GPS receiver port in Novatel binary command format. Currently, the supported format for this data is the Novatel binary commands RAWEPHEMB, RAWALMB, and IONUTCB.

In the LIVE mode, the RSR GNSS Transcoder™ will use the best available data to generate the ephemeris and alamanc for the target receiver by generating ephemeris from provided almanac or almanac from provided ephemeris if needed. Also, once the validity of the ephemeris or almanac has expired, the RSR GNSS Transcoder™ will extrapolate the available data to generate current valid ephemeris or almanac data. Finally, if the IONUTCB data is not provided, then the settings from the SIMulation:IONosphere... and SIMulation:TIME:UTCoffset... SCPI commands will be used instead.

3.8.5.1 Uploading Almanac and Ephemerides Data

JLT provides the simnav command line utility that installs with the SimCon program files folder that allows uploading of RINEX ephemeris data to the unit. This command line utility converts the RINEX ephemeris data to the format required in the SIMulation:LNAV... commands described below.

The following command is used to provide ephemeris data:

SIMulation:LNAV:EPHemeris <prn> <subframe> <word> <data>

for up to 32 satellite PRN numbers. See Section 6.3.67 for a complete description of the required subframes and words for each PRN.

Similarly, ionospheric correction data is provided with the following command:

SIMulation:LNAV:IONosphere <subframe> <word> <data>

See Section 6.3.66 for a complete description of this command.

All of the required words in a subframe must be received together since the entire subframe is assembled in volatile memory. To store the completed subframe in non-volatile memory for use in the simulation enter the SIM:LNAV:WRITE command.

To use the simnav command line utility, first download a RINEX navigation file. NASA currently maintains an archive of RINEX navigation files including recent files that are available on their FTP site here:

ftp://cddis.gsfc.nasa.gov/gnss/data/daily/yyyy/dd/yyn/

where

yyyyis the 4-digit year,

ddd is the current day of the year, and

yy is the 2-digit year

The RINEX file is available in that folder in the following format:

brdcddd0.yyn.Z

where ddd and yy are defined above. The RSR GNSS Transcoder™ can extrapolate the provided ephemeris set to create a valid ephemeris set for the simulation epoch, but to duplicate the constellation as accurately as possible, it is best to use a RINEX navigation file with the same day as being simulated. The RINEX navigation file is in a .Z compressed format that can be extracted in Windows with WinZip, WinRAR or other compression programs. The file locations and availability of the NASA RINEX archive are current as the release of this manual, but are subject to change.

Next, copy the extracted brdcDDD0.YYn file to the SimCon installation folder (C:\Program Files\Jackson Labs\SimCon by default). Open a Command Prompt window and change directory to the SimCon installation folder. At the command prompt, enter "simnav" without any command line options to see a full list of available options.

Make sure that SimCon and other programs are disconnected to the RSR GNSS Transcoder's USB COM port. To upload the RINEX file that was downloaded, enter the following:

simnav /port:COMX /eph:brdcddd0.yyn /epoch:eph

where x is the COM port number, and ddd and yy are defined above. The simnav utility will display the commands being sent and provide status of the transfer. When the trasfer is complete, connect to the RSR GNSS Transcoder™ in SimCon and send the "SIM:LNAV:SEL USER" command to select the ephemeris data that was just uploaded and stored. The ephemeris data is stored in non-volatile memory and will still be available after a reset or power cycle.

Please note that any running simulation should be restarted for change in constellation data to take effect immediately. Also the target receiver may require a power cycle or cold start reset when the simulated constellation is changed.

3.8.6 Excluding Space Vehicles from Simulation

For most applications, all of the simulated GPS satellites should be enabled for best position and timing accuracy. However in some cases, the simulation with one or more satellites disabled is desired. The satellites can be disabled by GPS satellite PRN number using the SIMulation:SV:EXCLude command. For example, to remove SV 2 and SV 10 enter the commands:

SIM:SV:EXCL 2

SIM:SV:EXCL 10

To query the current list of excluded satellites enter the command:

SIM:SV:EXCL?

which will respond with the list of excluded satellites followed by spaces:

2 10

To re-enable removed satellites, use the SIM:SV:EXCL command with negative SV PRN numbers:

SIM:SV:EXCL -2

SIM:SV:EXCL -10

3.8.7 Satellite Elevation Mask Angle

To enable all satellites that are used by the target receiver, the elevation mask angle should be set on the RSR GNSS Transcoder™ to be equal or less than the elevation mask angle configured on the receiver. Please consult the documentation for the target receiver for its elevation mask angle settings.

The elevation mask angle on the RSR GNSS Transcoder™ causes only satellites above the specified elevation angle to be enabled and visible in the simulated RF output. To set the mask angle, use the SIMulation:SV:MASK command. For example, to specify a 10 degree mask angle use the command:

SIM:SV:MASK 10

The angle can be configured to enable satellites below the horizon with a negative mask angle (-90 to +90 degree range), however most receivers will not allow configuration of the mask angle below the horizon and the RSR GNSS Transcoder™ can simulate only up to a total of 10 satellites at any time. The number of satellites visible above the horizon rarely exceeds 10 when using a typical orbital configuration with 30 space vehicles.

3.8.8 Using the Position Filtering Capabilities

In the Fixed position and Transcoding simulation modes, position filtering on the RSR GNSS Transcoder™ is required for several reasons for proper operation of the target receiver. However, there are some occasions when position filtering should be disabled.

In the Dynamic position filtering mode the simulated position follows the input position as closely as possible, but the simulated position dynamics is limited to a defined maximum speed, acceleration and jerk. The velocity, acceleration and jerk required to move to the input position are compared with the defined maximum velocity acceleration and jerk, and limits to the movement to the next simulated position are applied so that these maximum dynamics are not exceeded. Limits are also placed on the velocity so that the simulated position will not overshoot the input position due to the acceleration and jerk limits.

Dynamic filtering is useful to match the expected dynamics of the target receiver and avoid loss of lock due to large jumps in position or velocity--both of which can result in loss of GPS satellite tracking. Dynamic filtering is also useful when simulating with fixed position mode so that the simulated position will move to the new position with limited dynamics, which is useful for creating simple dynamic simulations.

The set of commands for configuring the maximum dynamics include:

SIMulation:POSition:FILTer:VMAX

SIMulation:POSition:FILTer:AMAX

SIMulation:POSition:FILTer:JMAX

The target receiver also often has configuration options for maximum expected dynamics. In transcoding applications, the reference PVT input should be expected to have maximum dynamics because of the configuration of the PVT source and the maximum dynamics expected in the given application. So in general for transcoding applications, the dynamics should be in the order:

Application expected dynamics <= PVT source maximum dynamics

<= RSR GNSS Transcoder™ maximum dynamics <= Target receiver maximum dynamics

In the filtering OFF mode, the input transcoded position or input fixed position is applied immediately. This may be useful for some applications where it is acceptable for fixed position input to immediately jump from one position to the next. However, this can cause tracking problems and loss-of-lock conditions in the target receiver that can be difficult or impossible for the target receiver to recover from. So it is highly recommended that dynamic position filtering be enabled for most usage scenarios.

Position filtering on the RSR GNSS Transcoder™ can be configured using the following command:

SIMulation:POSition:FILTer:MODE <OFF | DYNAMIC | INS >

as described in Section 6.3.11 . The dynamics filter does not affect the simulated position when playing back motion commands, since the motion commands have built-in definitions for dynamics that override the position filtering settings.

During transcoding, the dynamic position filtering matches the input position closely while limiting the dynamics of the transcoded signal to the maximum configured dynamics. Also, the target GPS receiver follows the position provided in the transcoded signal using the dynamics model configured in the receiver. The following discussion shows typical position accuracy results from a driving test with maximum acceleration of about 0.5g and maximum velocity of about 30 m/s. The reference and target receivers were both the ublox M8 with the JLT auto-dynamics configured as described in Section 6.10.16 . The reference receiver used a patch antenna mounted on the roof of the vehicle.

Figure 3.8   Detail 1 of Drive Test Path
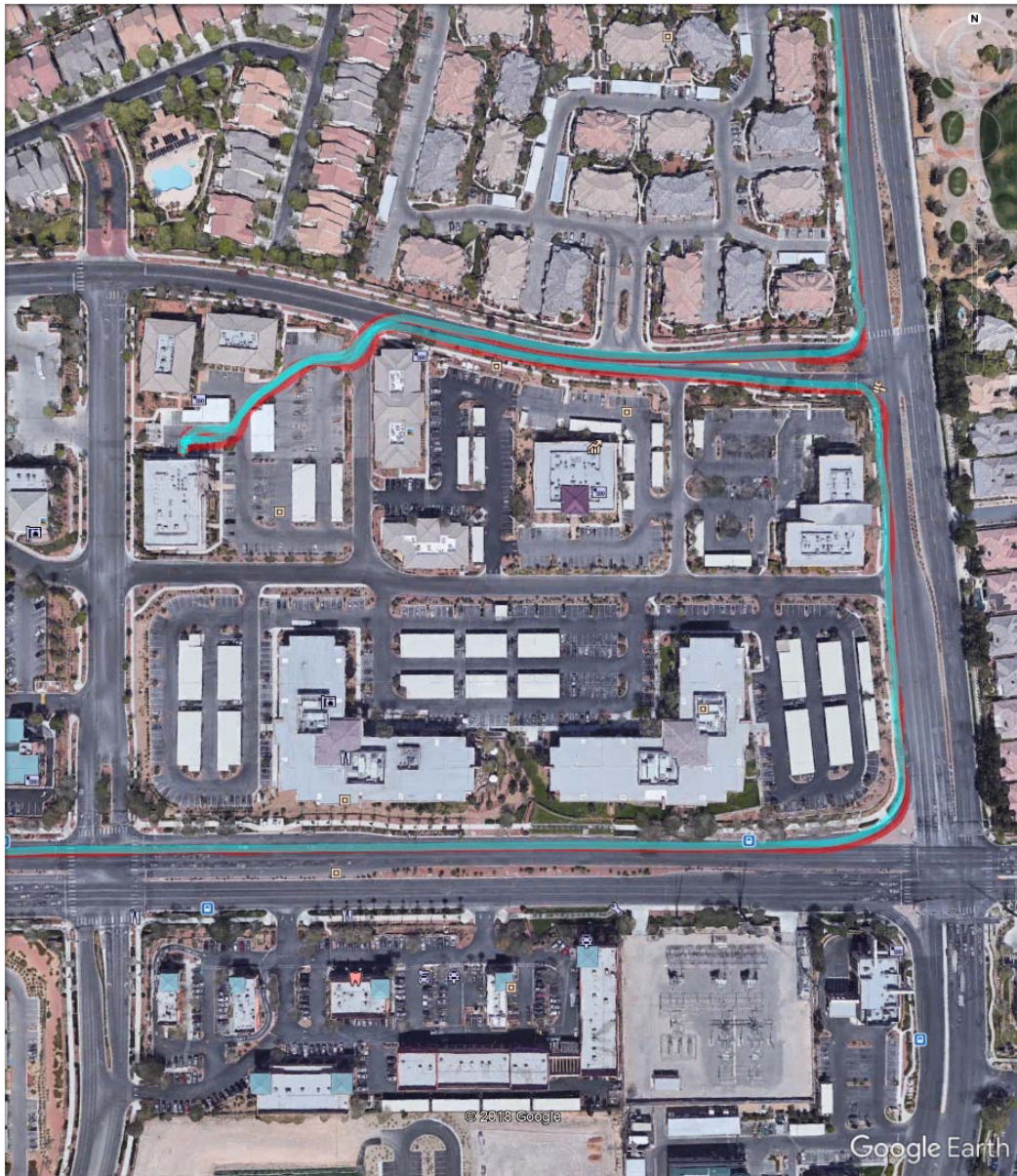
Figure 3.9   Detail 2 of Drive Test Path
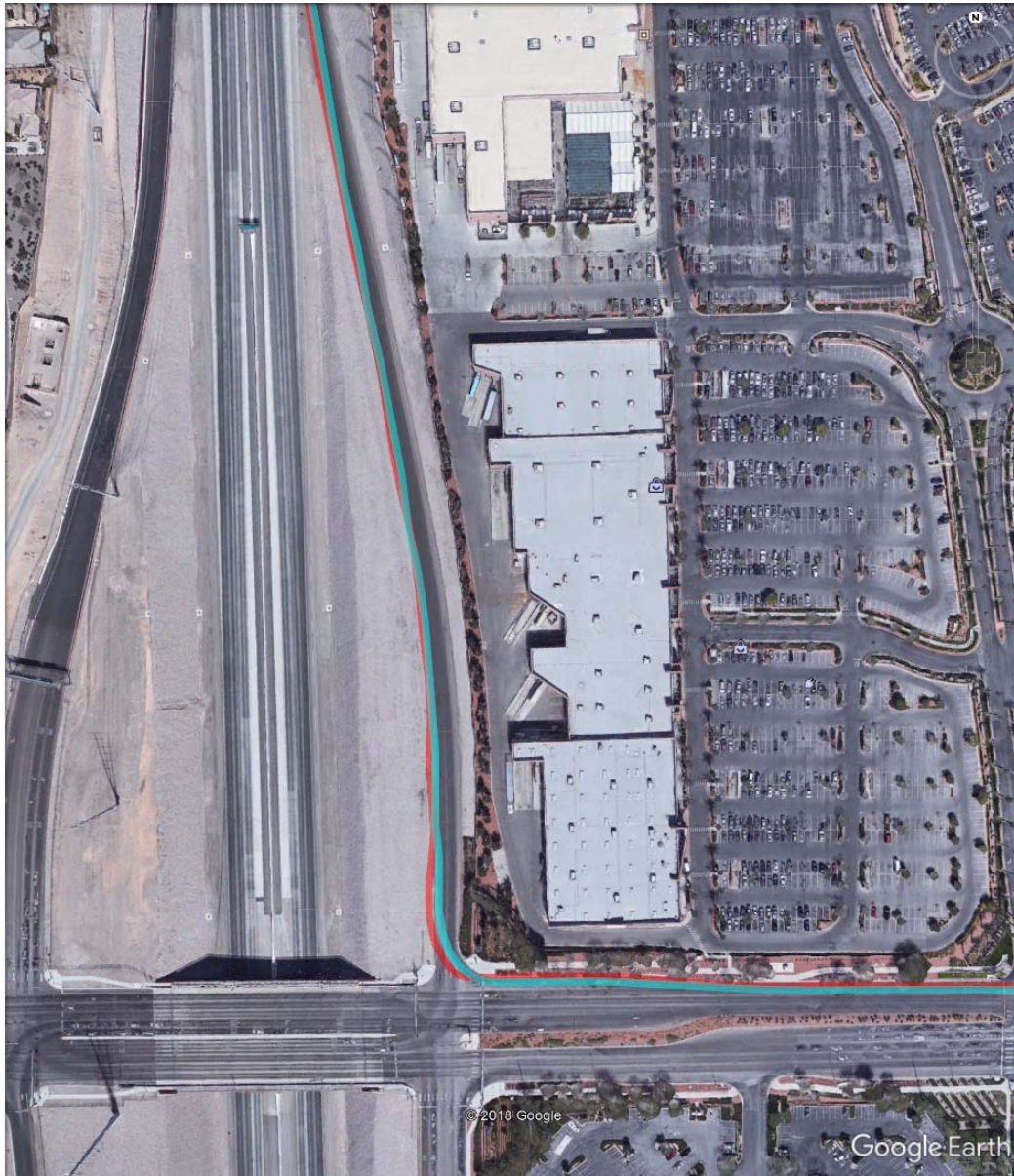
Figures 3.8 through 3.10 show the path information from the reference (cyan) and target (red) receivers. Figure 3.8 shows the path through a parking lot followed by turns on two main roads. Figure 3.9 depicts a freeway merge, and Figure 3.10 shows navigation through several traffic circles. While turning there is typically an overshoot in the target receiver's position that quickly converges on the reference receiver's path after the turn.

Figures 3.11 and 3.12 quantifies the position error between the reference and target receivers in both the along-track and cross-track directions. In Figure 3.11, the along-track (in the direction of travel) position error is plotted with speed versus time. The highest position error is typically seen during periods of the highest speed or change in speed. This is expected since the filter results in some lag during periods of acceleration. The standard deviation of the along-track position error during this test was 2.8 meters.

Figure 3.10 Detail 3 of Drive Test Path

In Figure 3.12, the cross-track (perpendicular to the direction of travel) position error is plotted with heading versus time. The highest cross-track position error is typically seen during turns or periods of changing heading. This is also seen as overshoot on the map when going into corners. The standard deviation of the cross-track position error during this test was 6.6 meters.

Figure 3.11 Along-Track Position Error and Speed vs. Time
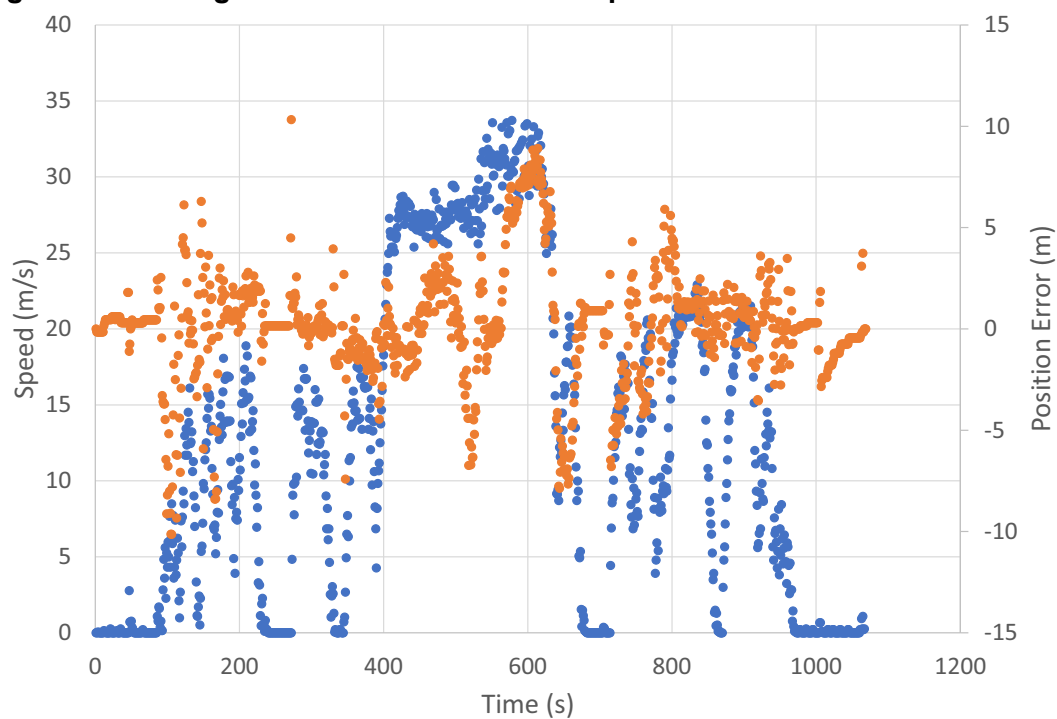
Figure 3.12 Cross-Track Position Error and Speed vs. Time
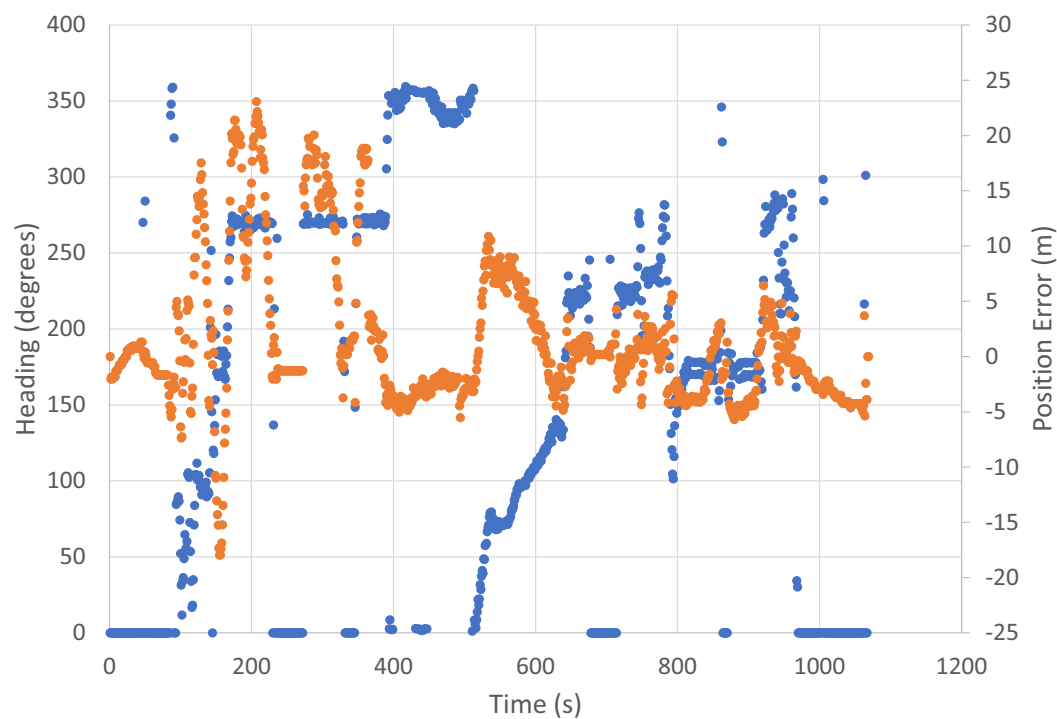
3.8.9 Adjusting the RF Output Power Level

The RF output level is typically equal for all transmitting satellites. The output power in dBm is set with the OUT:POWer command as described in Section 6.5.3 . The nominal received power for each satellite using a typical passive antenna in the real world with a clear view of the sky and the satellite in a high-noon position is about -125 dBm to -130 dBm. A higher power level can be provided by the RSR GNSS Transcoder™ to mimic the presence of an active amplified antenna system that many target GPS receivers are expecting. The controllable output power range available is typically -105 dBm to -125 dBm.

The output power command is able to compensate for either an external amplifier or external attenuators configured with the OUT:OFFset command as described in Section 6.5.4 . Any range of amplification or attenuation can be specified as an offset so that the OUT:POW command can be used to select the final, absolute RF power available to the GPS target receiver. This value also affects the controllable range with the OUT:POWer command, allowing for a wider range of control.

The following example will set the output power per satellite at -130 dBm and compensate for an external 10-dB attenuator between the RF output and the GPS target receiver:

> OUT:OFFset -10 dB
>
> OUT:POW -130 dBm

Because of the compensation for the 10-dB attenuator, the output power at the SMA connector of the RSR GNSS Transcoder™'s is offset to be 10 dB higher and thus exits the unit at -120 dBm. Note that the desired output power of -130 dBm would be outside the controllable range of -105 dBm to -125 dBm and consequently would not be achievable without the use of an external attenuator.

Likewise, the following example will set the output power to -75 dBm using an external 30-dB amplifier:

OUT:OFFset 30 dB

OUT:POW -75 dBm

The signal would exit the RF SMA connector at -105 dBm, then be amplified by the external amplifier to -75 dBm. Again, note that the desired output power of -75 dBm would be outside the controllable range without the external amplifier.

3.8.10 Enabling RF Test-Tone Output

For calibrating power levels, jamming testing, or receiver RF front-end testing, the RSR GNSS Transcoder™ can generate various digitally-synthesized RF test tones. GPS RF simulation ceases when a test tone output is enabled. The output level of the test signal is adjustable using the OUT:POWer command. The achievable test-tone output power range is about 15 dB higher than the equivalent C/A code-modulated GPS channel power.

The output test tone is configured using the command:

> OUTput:TEST <OFF | SWEEP | TONE | TWOTONE | RAND>

Where the test signal options are:

> SWEEP - Continuous wave tone that is swept over several MHz around 1575.42MHz
>
> TONE - Continuous Wave (CW) tone at 1575.42MHz
>
> TWOTONE - Two CW tones centered around 1575.42 MHz

RAND - Random noise centered around 1575.42 MHz

Normally the output tone should be set to OFF to enable GPS RF signals.

The following command is an example showing how to configure the RSR GNSS Transcoder™ as a CW jammer for mixing with another simulated or live-sky GPS signal:

OUTput:TEST TONE

Please note that transmissions in the GPS L1 band are regulated by government decree and that test tone and GPS L1 RF output from the RSR GNSS Transcoder™ should not be transmitted from a radiating antenna without permission from the FCC or other local regulating organization.

3.8.11 Configuring the simulated Time and Date

When operating in Simulation mode, the system can be configured to start the simulation using a fixed specified time. The module can also use continuous real-time data provided by a reference input PVT source. When using a fixed start time with repeated simulations, the target GPS receiver may require a manual reset or cold-start to recognized the correct simulated time, and to properly receive the GPS signals. This may happen because the target receiver does not expect the GPS time to jump backwards between simulation runs. Cell-phone GPS receivers are notorious for knowing the current UTC time and refusing to receive a time/date in the past or further out in the future without a complete cold-start of the receiver. Using the continuous time sentences from a PVT source reduces the need to cold-start the target receiver as the simulation will accurately transmit UTC time/date to the target receiver, and thus fulfill any assumptions the target receiver might have about the current time/date.

The simulation time mode is set with the SIMulation:TIME:MODE <ASSIGNed | CONTinuous | REFerence> command as detailed in Section 6.3.44 .

When using the ASSIGNed mode, the unit uses the time and date specified in the commands:

> SIMulation:TIME:START:TIME
>
> SIMulation:TIME:START:DATE

Assigning a date and time for the simulation is useful in simulating future leap-seconds, future GPS week 1023 roll-over events, or any type of date/time anomaly in the target GPS receiver.

3.8.12 Simulating Leap Second Event

The UTC correction parameters that define the current and future leap second offset as well as fractional second offsets between GPS and UTC time are configured with the SIM:TIME:UTC... commands as detailed in Section 6.3.51 and later. The parameters that need to be set to simulate a leap second event are the start time and date as described in Section 3.8.11 , and the IS-GPS-200-defined UTC parameters DELTATLS, WNLSF, DN and DELTATLSF. The parameter DELTATLS is the current number of seconds difference between UTC and GPS time. WNLSF is the week number of the leap second event and DN is the day number (1 through 7) of the event. The actual leap second event for positive leap seconds occurs immediately after 23:59:59 on the day defined by WNLSF and DN. Finally, DELTATLSF is the final UTC offset in seconds after the leap second event. Normally the difference between DELTATLSF and DELTATLS is within ±1 second since leap second events are ±1 second. DELTATLSF and DELTATLS are equal when no leap second event is pending.

The RSR GNSS Transcoder™ also provides a simplified method of setting the UTC correction parameters with the SIM:TIME:LEAP... commands. The SIM:TIME:LEAP:ACCumulated command sets the currently accumulated UTC to GPS offset in seconds before any pending leap seconds, the SIM:TIME:LEAP:DATE command sets the date of a currently- or previously-pending leap second, and the SIM:TIME:LEAP:DURation command sets the duration of the next pending leap second.

The SIM:TIME:LEAP:DURation setting is normally 60 when no leap second event is pending, and 61 when a positive leap second event is pending or recently occurred. The SIM:TIME:LEAP:DURation setting is 59 when a negative leap second event is pending or recently occurred. However, in practice usually only positive leap second events occur.

As an example, to simulate the December 31, 2016 leap second event with the simulation beginning 30 minutes before the event, enter the following commands:

> SIM:MODE MANUAL
>
> SIM:TIME:START:TIME 23,30,00
>
> SIM:TIME:START:DATE 2016,12,31
>
> SIM:TIME:LEAP:ACC 17
>
> SIM:TIME:LEAP:DATE 2016,12,31
>
> SIM:TIME:LEAP:DUR 61
>
> SIM:COMMAND START

The simulation should be started with sufficient time for the target receiver to download the UTC correction parameters which can take up to 12.5 minutes.

Please note that the freeware application SimCon described in Chapter 4 and available on the support page of the JLT website provides pre-configured leapsecond and week 1023 rollover scenarios that can be loaded into the module and thus allow easy simulation of GPS anomalies.

3.8.13 Simulating 1023 Week Number Rollover

Using the start time- and date parameters described in Section 3.8.11 , the start time can be selected to simulate a week number rollover event that some GPS receivers have difficulty handling properly. For example, to simulate the upcoming April 6, 2019 week number rollover event, enter the following commands:

> SIM:MODE MANUAL
>
> SIM:TIME:START:TIME 23,30,00
>
> SIM:TIME:START:DATE 2019,4,6
>
> SIM:COMMAND START

The simulation will start 30 minutes before the event and continue indefinitely. You can end the simulation with the SIM:COMMAND STOP command.

Please note that the freeware application SimCon described in Chapter 4 and available on the support page of the JLT website provides pre-configured leapsecond and week 1023 rollover scenarios that can be loaded into the module and thus allow easy simulation of GPS anomalies.

3.8.14 Simulating for GPS Spoofing

The RSR GNSS Transcoder™ can generate an GPS L1 output that is synchronized to live-sky GPS signals. These live-sky and simulated signals can be combined together with a low-cost passive RF combiner/splitter so that a target receiver will start tracking the simulated signals instead of the live signals depending on relative power levels between the two signal sources. Using both user-uploaded ephemeris and ionospheric correction data as well as time synchronized from an external GPS receiver, it is possible to mix the RSR GNSS Transcoder's RF output with a live-sky GPS signal for spoofing simulations of live GPS signals. The external GPS receiver should be connected with NMEA and 1PPS input to the RSR GNSS Transcoder™. Care must be taken to avoid re-broadcasting simulated RF signals through the live sky antenna. This is usually accomplished by using passive RF combiners and GPS antennas with good rejection and isolation.

The following commands will configure the simulation mode, simulation time and the fixed (spoofed) position:

      SIM:MODE MANUAL

      SIM:TIME:MODE CONT

      SIM:POS:LLH 36,-115,500

The spoofed position in the SIM:POS:LLH command should be near the position of the antenna (within 1000 km) so that the simulated and spoofed satellites are visible at the same time. The current ephemeris and ionospheric correction data can be uploaded with the SIM:LNAV... commands described starting in Section 6.3.66 . This process could be automated if the raw subframe data were available from a receiver tracking live-sky signals.

Next, confirm that the system time has been updated with the current gps system time with the command:

      PTIME?

If the time and date lines from the query output show the current time and date then the system time is synchronized.

Finally, the source for the navigation data and the initial RF output power are set, and the simulation is started with the following commands:

      SIM:LNAV:SELect USER

      OUT:POWer -125 dBm

      SIM:COMMAND START

During the spoofing test, the output power is increased from -125 dBm with the OUT:POWer command until the output power is greater than the mixed live-sky signals. Without an external amplifier the output power can be set as high as -105 dBm. An external amplifier may be required in some cases if power levels above -105 dBm are needed.

At some point the target receiver will start tracking the spoofed signals instead of the live-sky signals and the target receiver's reported position will jump to the simulated spoofed position. Having the spoofed position very close (<100m) to the antenna position may reduce the output power required to pull the target receiver away from the live-sky signals. This behavior is very dependent on the design of the target receiver and the relevant RF power levels.

3.8.15 Monitoring the optional CSAC Oscillator

The RSR GNSS Transcoder™ with optional CSAC oscillator contains an integrated CSAC GPSDO module with the same monitoring and control features that the JLT CSAC GPSDO module provides. The following example CSAC status output is returned in response to the CSAC? query:

> RS232: OK
>
> STEER: -35
>
> STATUS: 0
>
> ALARM: 0x0000
>
> MODE: 0x0040
>
> CONTRAST: 3608
>
> LASER CURRENT: 0.98
>
> TCXO VOLTAGE: 1.549
>
> DC SIGNAL LEVEL: 1.17
>
> HEAT PACKAGE: 9.34
>
> TEMPERATURE: 38.57
>
> SN: 1607CS06361
>
> FIRMWARE REV: 1.09
>
> LIFETIME: 740
>
> POWER: ON

RSR GNSS Transcoder™ units without the optional CSAC oscillator will discipline their internal TCXO to an optional external 1PPS reference when provided. Before the CSAC achieves atomic lock, which typically takes less than 3 minutes after power-on, the system timing uses the internal TCXO as the timing and frequency reference. In the event that the CSAC GPSDO fails to obtain an atomic lock or fails during operation after obtaining atomic lock, the internal TCXO will be used for system timing instead. To enable calibration of the built-in TCXO-based GPSDO or to reduce the overall power consumption, the CSAC can also be manually disabled with the CSAC:POWer command which will power-down the internal CSAC and revert to TCXO disciplining only. The ON/OFF power status of the CSAC is output on the last line of the CSAC? query response as seen above.

3.8.16 Monitoring the External and Internal GNSS Receivers

An optional external GPS receiver can provide a PVT serial data stream to be transcoded and simulated using the 1PPS timing reference for time synchronization and internal TCXO/CSAC oscillator disciplining. This PVT data stream can be monitored using the standard GPS SCPI subsystem common to many JLT GPSDO products with commands such as SERV?, SYST:STAT?, GPS? and others. Details of each GPS command are available in Section 6.10.3 .

The RSR GNSS Transcoder™ also includes an internal GNSS receiver for monitoring the transcoded or simulated GPS RF signals for accuracy, power level, and correctness. The status of this internal GNSS receiver is monitored through the INTGPS SCPI subsystem that has many of the same commands available as the GPS SCPI subsystem. It is possible to send the 1Hz NMEA output stream

of the internal GPS monitoring receiver to the USB serial port via SCPI commands. Details of the various different INTGPS command are available starting in Section 6.11.1 .

3.8.16.1 External Rockwell Microgram and RSR Features

The RSR GNSS Transcoder™ supports special features when an external Rockwell Collins Microgram or Rockwell Collins RSR SAASM receivers with updated custom JLT firmware are connected. These features include DAGR Pass-Through mode and SAASM key-fill status monitoring.

A DAGR Pass-Through hot-start assisted mode is available when a DAGR is connected to the COM2 interface on the external Microgram or RSR. This mode allows hot-starting the MicroGRAM or RSR receiver by automatically transferring almanac, ephemeris, time, date, and position data from the external DAGR to the MicroGRAM/RSR. The DAGR Pass-Through mode can be controlled through the RSR GNSS Transcoder™'s SCPI interface. In DAGR Pass-Through mode the PVT data including the 1PPS reference from an external DAGR device is used in place of the PVT data generated by the MicroGRAM or RSR. Using a DAGR that already has a GPS fix, the SAASM HD CSAC GPSDO can immediately provide valid PVT data through the SCPI interface and discipline the CSAC oscillator.

DAGR Pass-Through mode is especially useful when the MicroGRAM or RSR receiver does not have valid almanac data, which could take up to 12.5 minutes to download from the GPS satellites before a GPS fix and valid UTC time is available. The DAGR pass-through mode is typically used when the RSR GNSS Transcoder™ is deployed in a dismounted application, and the user is sitting inside of a shielded vehicle such as a tank or troop transporter and cannot receive GNSS signals themselves. In this case the vehicle DAGR with its externally mounted antenna can provide the necessary PVT solution and navigation data to enable continuous operation and disciplining of the RSR GNSS Transcoder™ inside the vehicle for as long as the user's MicroGRAM or RSR receiver is connected to the DAGR DB-15 connector and the DAGR is receiving valid GPS fixes. The DAGR pass-through mode requires the JLT-specific Rockwell Collins NMEA firmware load on the external MicroGRAM or RSR. This firmware can be loaded only at the Rockwell Collins factory and is available only to JLT customers.

The GPS:DAGR:MODE command described in Section 6.10.37 enables and disables the DAGR Pass-Through mode. The GPS:DAGR:PVTstate? query command described in Section 6.10.40 returns the status of the DAGR Pass-Through mode.

When in DAGR Pass-Through mode, the external DAGR can also provide Hot Start data to the MicroGRAM or RSR, so the MicroGRAM or RSR can immediately obtain a GPS fix. Hot start data includes precise time, GPS almanac and ephemeris data, and current position. Once the SAASM HD CSAC GPSDO is in DAGR Pass-Through mode, a Hot-Start transfer is initiated on the DAGR's user menu.

The SAASM key, Y tracking status and key zeroizing of an external Microgram or RSR receive can also be monitored and controlled through the RSR GNSS Transcoder™'s GPS:SASTAT... commands. Details on the parameters that can be monitored and the zeroize function are available in Section 6.10.41 through Section 6.10.51 .

An externally-connected Rockwell Collins MicroGRAM or RSR SAASM receiver may also be zeroized by using pin 1 of connector J3. During normal operation, grounding pin 1 of connector J3 through an external switch will transmit a zeroize command to the externally-connected SAASM GPS receiver, and is thus useful as an emergency zeroize feature.

3.8.16.2 External Receiver Performance Monitoring

The RSR GNSS Transcoder™ includes a feature to monitor the performance of the PVT solution from a target GPS receiver. The external receiver performance monitoring feature enables applications like automatic verification of GNSS receiver accuracy on an assembly line, verification of vehicle navigation systems, automated verification of aircraft avionics GPS receivers, automated testing of GPS timing receivers or GPS Disciplined Oscillators (GPSDOs). The external receiver performance monitoring also enables automated receiver software development testing and verification.

External receiver performance monitoring provides a method to evaluate the accuracy of the PVT data produced by a receiver under fixed position or dynamic conditions as defined by a Motion Command simulation. This feature eliminates the need to separately process NMEA logs after performing a simulation and provides real-time feedback for the target receiver's performance.

To use this feature, the target receiver's NMEA serial port is connected to the RSR GNSS Transcoder's external GPS RS232 port and the target receiver's 1PPS output is connected to the RSR GNSS Transcoder's external 1PPS input. The RSR GNSS Transcoder™ is first configured to communicate with the target GPS receiver type as described in Section 3.8.2 .

Next, a fixed position or Motion Command simulation is configured and started (see Section 3.8.3 and Section 3.8.4). The simulation mode (SIM:MODE command) should be configured to SIM or MANUAL. Also the NMEA synchronization source mode should be selected with the SYNC:SOUR:MODE NMEA command to avoid using the target receiver's 1PPS for the simulation's timing reference.

When the simulation is running, the RSR GNSS Transcoder monitors the external receiver's GPRMC and GPGGA data and 1PPS input and computes the horizontal, vertical and 1PPS timing accuracy when the external receiver indicate a 3D fix. This error data is available with the following query commands:

> GPS:POSERR?
>
> GPS:VPOSERR?
>
> GPS:PPSERR?

Starting with firmware version 1.5a and later and SimCon version 1.21 and later, additional plots are available in the Performance tab of the Display Panel for monitoring the external GPS receiver including plots of the three external GPS performance monitoring queries listed above. See Section 4.9.4 for details on the Performance tab in SimCon.

4 SimCon Utility

4.1 Description

SimCon is a Windows desktop application that provides user-friendly access to the features, controls, and displays supported by the CLAW GPS Simulator™ and RSR GNSS Transcoder™ from Jackson Labs Technologies, Inc.

4.2 System Requirements

SimCon runs on PCs equipped with Windows 7 or later versions. 10 MB of free disk space, 1 GB RAM and a CPU with SSE2 support are required.

A minimum display resolution of 1280x1024 is strongly recommended. For improved performance, a 64-bit version of SimCon will automatically be installed on x64-based systems.

4.3 Installation

The latest version of SimCon is available for download from the support section of the Jackson Labs Technologies, Inc. web site:

http://www.jackson-labs.com/index.php/support

After downloading, launch the setup.exe program and follow the prompts for installation.

It is not necessary to install SimCon prior to connecting the device to your PC for the first time. SimCon communicates with the target device through a USB virtual COM port connection. In most cases, the required drivers for the Silicon Labs CP2104 UART will be downloaded automatically from Windows Update if they are not already present on your system. Should it become necessary to upgrade or reinstall the UART drivers in the future, please refer to the following URL:

https://www.silabs.com/products/development-tools/software/usb-to-uart-bridge-vcp-drivers

4.4 SimCon Overview

Upon launching SimCon for the first time, you should see a display similar to Figure 7.1 below.

Figure 4.1   SimCon Main Window
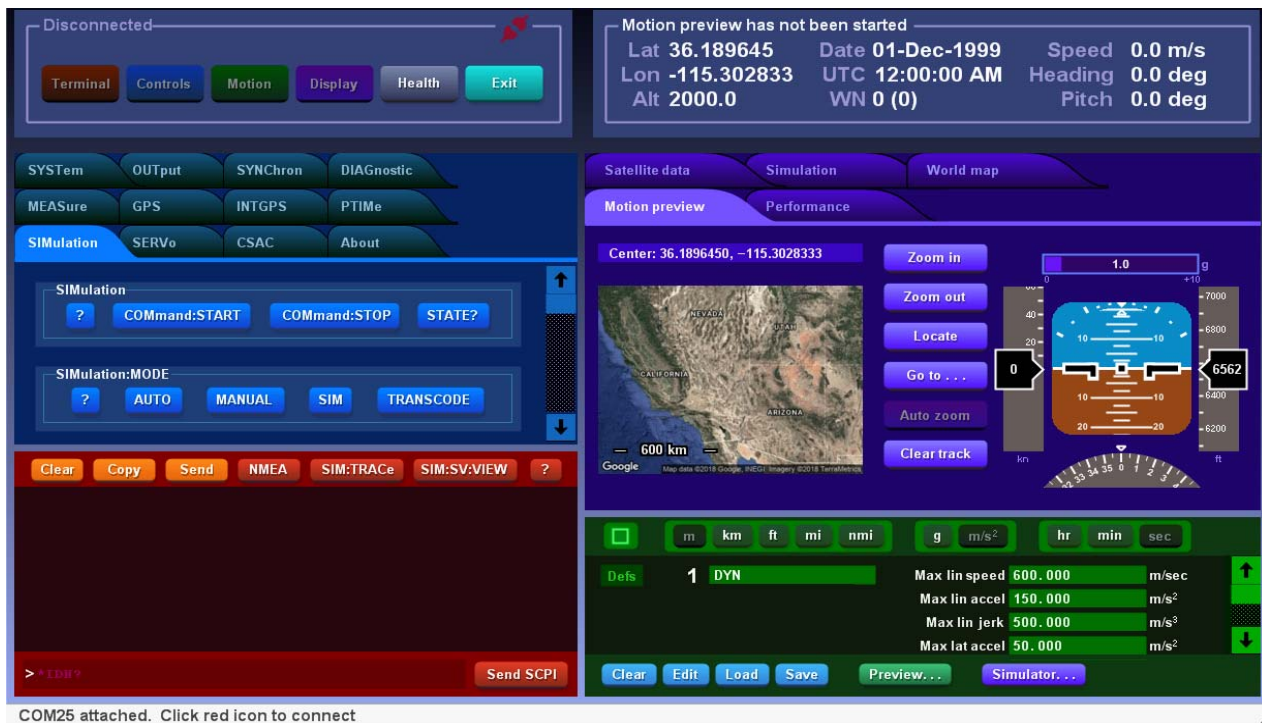
The visible controls and other elements in Figure 4.1 will be described in detail below, beginning with the two boxes called headers that are present at the top of the SimCon application window.

Using the color-coded buttons in the connection header, any desired combination of up to five different control panels can be displayed in the SimCon application window. While each control panel occupies a fixed position relative to its neighbors in the application window, the panels may be resized at any time by left-clicking on the appropriate border and dragging it to the desired position.

SimCon automatically preserves its window size and position between runs, along with the control panel selection and layout. SimCon also save and restores the connected devices as described below.

4.5 Connecting to Your Device

User interaction with SimCon typically begins in the connection header at upper left. In addition to the color-coded buttons that allow you to open and close individual control panels, the connection header displays information about the currently-connected device including its model name, COM port assignment and firmware version.

Icons appearing in the border of the connection header may be clicked to connect to a given device or disconnect from it, as shown in Figure 4.2. CLAW or RSR Transcoder devices that have been detected by SimCon but that are not currently selected for control are represented by red "unplugged" icons, while the currently-connected device, if any, is represented by a green "connected" icon.

Left-clicking the green icon that represents the current connection will disconnect SimCon from the corresponding device. Similarly, clicking on an "unplugged" icon will attempt to establish a connection to the corresponding device, breaking any existing connection first.

Note that SimCon does not automatically connect to unfamiliar devices. You must click on the appropriate "unplugged" icon to establish a connection to the desired device. In Figure 4.1, it can be seen that a device at COM25 has been recognized by SimCon at startup time, but no connection to it will be established until the red "unplugged" icon is clicked. However, if a connection is active when you exit from the SimCon application, SimCon will attempt to reconnect to the same device when the program is subsequently restarted.

As a result, there is no need to click on the green icon to disconnect manually prior to exiting from SimCon, unless you wish to prevent the program from reconnecting to the same device later. However, it's a good idea to do so before physically unplugging a device that SimCon is currently connected to.

Figure 4.2   Connection header. Two USB devices are present, with an active connection to the RSR Transcoder at COM25
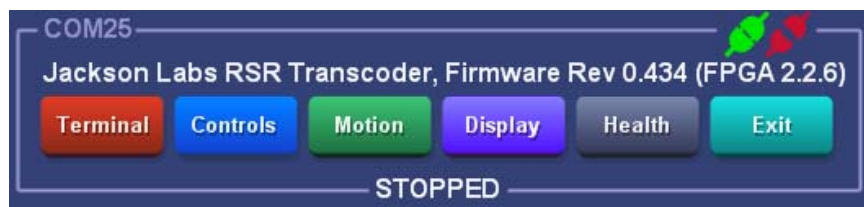
4.6 The Status Header

The information displayed in the status header at upper-right is self-evident, but its content and appearance will vary depending on context. The status header is updated continuously to reflect either the state of the hardware simulation or the state of a Motion Command Language preview operation, if one is in progress. When neither of these conditions exists, SimCon displays factory-default position and time information as a placeholder (Figure 4.3).

Figure 4.3   Default status header display
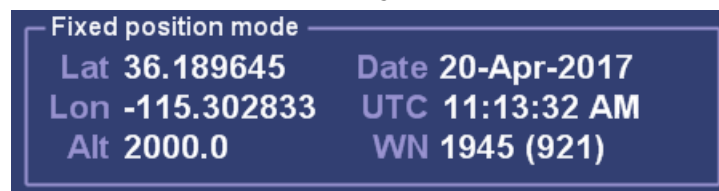
In Figure 4.4 below, additional speed, heading, and pitch fields can be seen:

Figure 4.4   Default status header display with optional speed and orientation

The speed and orientation fields always appear when the **Motion Preview** tab on the **Display** control panel is open, regardless of whether a hardware connection is active. (Further details about Motion Preview operations appear below.) They will also be present when SimCon is connected to a CLAW simulator or RSR Transcoder whose simulated position mode has been set to MOTION with the SIMulation:POSition:MODE <FIXED | MOTION> command. Along with the position and time fix information at left, the speed and orientation fields will be updated in real time to represent either the simulated vehicle state from the hardware's point of view, or the state of the Motion Command Language program that is being previewed on the host PC.

4.6.1 Shortcut Buttons

In addition to the data fields described above, a small button panel will be displayed in the status header whenever an active hardware connection exists (Figure 4.5).

Figure 4.5   Shortcut buttons in status header

These *shortcut buttons* provide convenient full-time access to functions that would otherwise need to be accessed by opening the **Motion** panel, by selecting the **SIMulation** tab in the **Controls** panel, or by entering SCPI commands manually in the **Terminal** panel.

4.6.1.1 *Fixed simulation* and *Motion simulation* buttons

The **Fixed simulation** and **Motion simulation** buttons in the status header are mutually exclusive. They serve as indicators as well as controls. When the CLAW or RSR Transcoder device is operating in FIXED mode, the **Fixed simulation** button will automatically be displayed in its selected (dark) state. The **Motion simulation** button will be in its deselected state, available for manual selection by left-clicking on it. The opposite will be true when the hardware is operating in MOTION simulation mode.
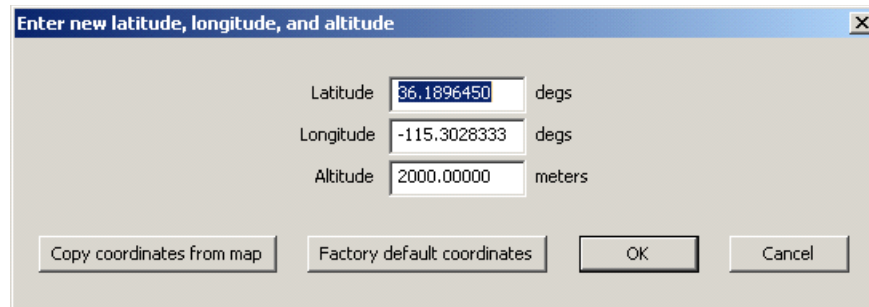
Pressing **Fixed simulation** will send the command SIMulation:POSition:MODE FIXED to the connected device to select fixed simulation mode as described in Chapter 3, while pressing **Motion simulation** will send SIMulation:POSition:MODE MOTION.

Each position mode supported by the CLAW and RSR Transcoder is associated with its own internal latitude, longitude, and altitude state. MOTION mode is set automatically when a Motion Command Language program is run on the simulator hardware, but FIXED mode must be restored manually after the motion program finishes executing if you wish to return the simulated receiver location to the fixed location specified with SIMulation:POSition:LLH. You can accomplish this by pressing the **SIM:POS:MODE FIXED** button in the **INTGPS** graph view on the **Performance** tab, the **Fixed simulation** button in the status header, or the **FIXED** button in the SIMulation:POSition:MODE box in the **Controls** panel.

4.6.1.2 *Set* button

This button will open a dialog box that allows you to enter a new position fix for use in FIXED position mode (Figure 4.6).

Figure 4.6 *Set* button dialog box

The defaults for the Latitude, Longitude, and Altitude fields will be based on the current fix information in the status header, regardless of mode. Pressing **OK** will exit the dialog and transmit the command SIMulation:POSition:LLH <lat> <lon> <alt> to the connected device, while **Cancel** will exit the dialog without altering the current fix.

The dialog's **Copy coordinates from map** button will be disabled unless the **Display** panel is open and its **Simulation** or **Motion Preview** tab is selected. When pressed, it will copy the latitude and longitude from the center of the map in the selected tab to the first two dialog fields, leaving the altitude field unaltered. Similarly, **Factory default coordinates** will write the default fix coordinates to all three fields. As with manually-entered coordinates, the coordinates obtained by clicking either of these buttons will not be sent to the hardware unless the **OK** button is pressed to exit the dialog.

Note that if the device is in MOTION position mode at the time the Set button is pressed, any changes made will take effect the next time FIXED mode is selected. The **Run** button described below will automatically set the CLAW or RSR Transcoder's position mode to MOTION if it is not already active, but pressing **Set** will not automatically change to the FIXED position mode.

4.6.1.3 *Run* button

Pressing the **Run** button will send the command SIMulation:POSition:MOTION:START 1, executing the Motion Command Language program that was most recently uploaded to the connected device. The device will automatically be set to MOTION position mode if it is not already in that mode. Assuming a valid Motion Command Language program is available for execution, the **Run** button will turn red when pressed, and its label text will change to **Stop**.

These actions are equivalent to the operation of the **Simulator... Run** button at the bottom of the **Motion** panel. If the **Simulation** tab in the **Display** panel is not already visible when the **Run** button is pressed, it will automatically be opened

4.7 The Terminal Panel

Figure 4.7   Terminal Panel

While not required for most tasks in SimCon, the **Terminal** panel is invaluable in situations where low-level command access is desired. The **Terminal** allows you to compose and transmit most of the SCPI commands described in Chapter 6. Results appear immediately without the need to disconnect the device from SimCon and launch a separate terminal program.

The **Terminal** panel also allows you to monitor the SCPI traffic associated with many of the high-level commands and queries issued by the **Controls** and **Motion** panels. In particular, you should open the **Terminal** panel before using the SCPI query buttons in **Controls** and other panels. Otherwise, the requested responses will not be seen.

Several buttons surrounding the **Terminal** text area provide access to various features described below.

4.7.1 Input field / *Send SCPI* button

After entering a SCPI command in the input field at the bottom of the **Terminal** panel, you can press the **Send SCPI** button to transmit it to the connected device, or simply press the Enter key. Up to 100 characters of text may be transmitted.

As with other text input fields in SimCon, you can use the standard Windows ctrl-C (copy) and ctrl-V (paste) keyboard shortcuts to share text strings with external applications. Additionally, the input field in the **Terminal** provides command history support. After clicking on the input field to give it the keyboard focus, you can press the up/down arrow keys to recall up to 7 of the most recently-transmitted commands.

Unlike a traditional terminal application, no text characters are actually transmitted to the connected device until either the **Send SCPI** button or the Enter key is pressed. Pressing Enter on a blank line will retransmit the last command.

4.7.2 *Clear* button

This button clears all received text from the 350-line scrolling buffer.

4.7.3 *Copy* button

This button copies all received text in the 350-line scrolling buffer to the Windows clipboard.

4.7.4 *Upload* button

The **Upload** button transmits the contents of a standard ASCII text file to the connected device. This feature is typically used to load pre-defined simulation scenarios available from JLT to simulate leap-second and week 1023 rollover events and other events stored in text files. This allows easy automatic configuration of various simulation events of interest. Various sample text files are automatically installed by SimCon and are available for loading and automatic testing when pressing the **Upload** button. Please remember to clear the target GPS receivers' Almanac (cold-start the receiver) when simulating events in the past or future. Otherwise, if the simulation date is significantly different from the date stored in the receiver's memory, the receiver may not acquire a valid GPS fix.

While it is possible to transmit Motion Command Language programs to the device with the **Upload** button, no error checking or program memory initialization is performed. The **Write** button in the **Motion** panel's **Simulator**.. control set should normally be used for this purpose instead.

The **Upload** button also allows GPGGA and GPRMC NMEA data in a text file to be sent to the RSR GNSS Transcoder™ so it can operate in the Transcode mode. An example NMEA upload file "NMEA_Transfer.txt" is automatically installed in the SimCon installation folder (C:\Program Files\Jackson Labs\SimCon by default). The start of that file includes several SCPI commands that configure the RSR GNSS Transcoder™ to accept the NMEA data and operate in Transcode mode. The "gps:port scpi" command configures the RSR GNSS Transcoder™ to accept NMEA data from the SCPI port. And the "sync:source:mode nmea" command allows the RSR GNSS Transcoder™ to operate in Transcode mode without an external 1PPS input.

NMEA sentences are received over the SCPI port using the "sim:nmea ..." command. The **Upload** feature in SimCon automatically appends the "sim:nmea" SCPI command to the NMEA data in the selected text file and synchronizes the transfer of NMEA data using the time field in the GPGGA and GPRMC sentences. The **Upload** feature requires both the GPGGA and GPRMC sentences and supports a 1Hz input rate.

4.7.5 *NMEA* button

This button toggles the display of incoming NMEA message strings, which are recognized by the presence of a '$' character at the beginning of an incoming line. These messages may originate from an external device configured for NMEA passthrough or from the internal GPS monitor receiver. They are suppressed by default in the **Terminal** window in order to avoid displaying large amounts of periodic serial traffic.

SimCon issues INTGPS:GPGGA 1 and INTGPS:GPGSV 1 commands at connection time, while other NMEA messages may be requested through the **Controls** panel. In order to view the resulting traffic in the **Terminal**, the **NMEA** button must be pressed.

4.7.6 *SIM:TRACe* button

SimCon issues a SIMulation:TRACe 1 command at connection time to obtain the time/date information necessary to update the status header. The responses arrive at one-second intervals, and are suppressed by default in the **Terminal** window in order to avoid displaying large amounts of periodic serial traffic. To view these responses, press the **SIM:TRACe** button.

4.7.7 *SIM:SV:VIEW* button

At connection time, SimCon begins issues recurring SIMulation:SV:VIEW? queries at intervals of approximately two seconds in order to obtain satellite positions and related information. The responses are suppressed by default in the **Terminal** window in order to avoid displaying large amounts of periodic serial traffic. To view these responses, press the **SIM:SV:VIEW** button.

4.8 The Controls Panel

Figure 4.8   Controls Panel

As described in Chapter 6, the CLAW and RSR Transcoder instruments support several hundred user-accessible SCPI commands and queries. The **Controls** panel shown in Figure 4.8 provides a bridge between the high-level task specific interfaces in the **Motion** and **Display** panels and the need to look up (or memorize) SCPI command syntax for manual entry in the **Terminal** panel.

The **Controls** panel is essentially a collection of individual pages that correspond to the subsystems at the topmost level of the SCPI command hierarchy.   Each supported subsystem is represented by a

page on the **Controls** panel, accessed by opening the panel and clicking on the appropriate tab. The individual SCPI commands within each subsystem are issued through labeled buttons and range-checked input fields on the corresponding page.

In addition to the SCPI subsystem tabs, the About tab provides version and copyright information for the SimCon program itself.

Refer to Chapter 6 for detailed information on the SCPI commands and queries available in the **Controls** panel. Help text is available in SimCon as well, not only for the buttons and input fields in the **Controls** panel but in almost all other contexts as well. Simply position the mouse cursor over the button or input field in question, and usage notes for the relevant control will appear in the status line at the bottom of the application window.

4.8.1 Updating firmware with the **Controls** panel

Firmware updates for the CLAW or RSR Transcoder consist of **.hex** files downloaded from the Jackson Labs website or otherwise provided by technical support personnel. To install a firmware update, select the SYSTem tab on the **Controls** panel and press the "Install firmware update" button shown in Figure 4.9 below.

Figure 4.9   Updating device firmware
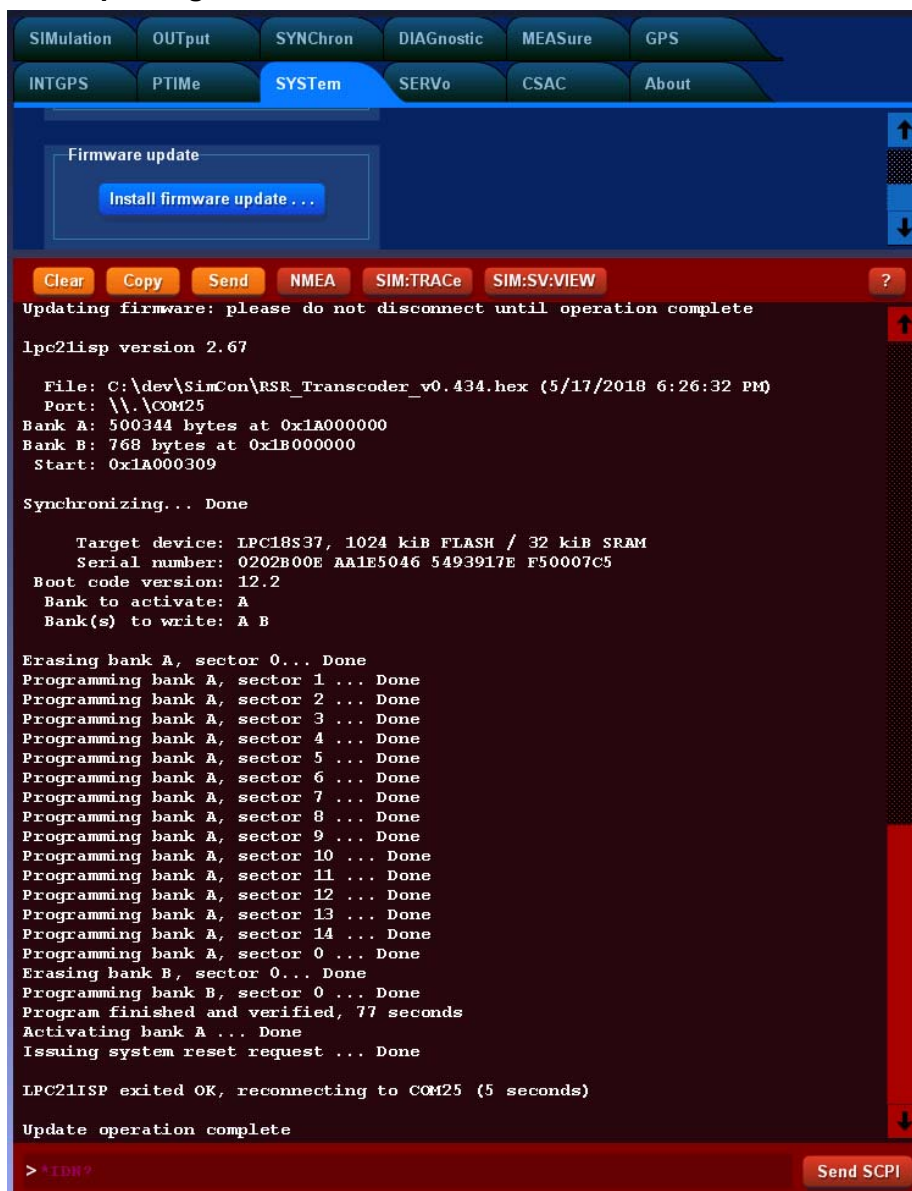
After prompting for the location of the downloaded .hex file, SimCon will install the firmware update, restart the device, and reestablish the connection automatically. The update process normally takes less than three minutes.

4.9 The Display Panel

Figure 4.10 Display Panel
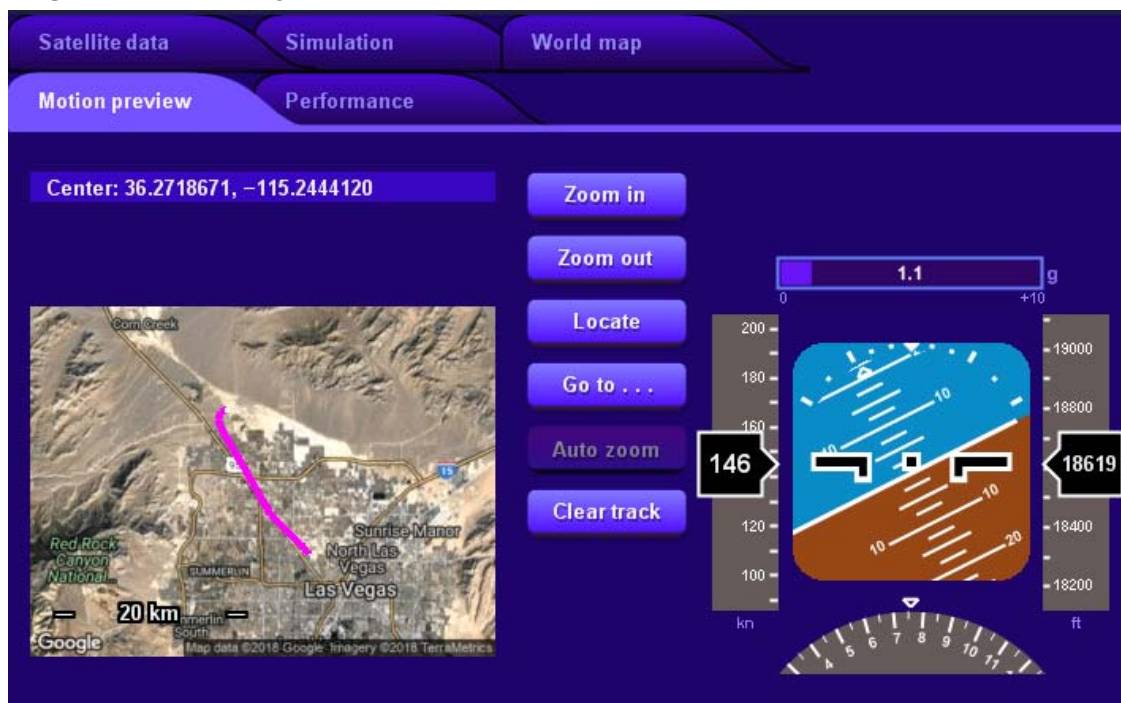
SimCon uses the **Display** panel to present real-time updates of simulation state information, ranging from map locations and motion instrumentation to hardware performance graphs (Figure 4.10). Five pages of data and graphs are available when a hardware connection exists. The desired page can be selected by clicking on the appropriate tab at the top of the panel. In the absence of a connection to a CLAW or RSR Transcoder device, only the **Motion Preview** tab is available.

4.9.1 Motion Preview and Simulation tabs

The **Motion Preview** and **Simulation** tabs are similar in function and appearance. They provide a visual representation of the simulated fix and vehicle orientation information in the status header. The main difference is that the **Simulation** tab always tracks the information from the connected hardware as reported by periodic SIMulation:POSition? queries, while the **Motion Preview** data is based on the state of the motion preview operation in progress, if any.

If an Internet connection is available, maps will be displayed in both tabs. Clicking on the map will recenter it at the coordinates displayed above the map area. Several buttons to the immediate right of the map display allow the center location, zoom level, and coordinate history to be manipulated as required.

4.9.1.1 *Zoom in / Zoom out* buttons

These buttons determine the resolution of the displayed map. The available zoom range will vary from one locale to the next.

You can also use the mouse scroll wheel to adjust the zoom level, as long as the mouse cursor is positioned above the map area.

4.9.1.2 *Locate* button

The map may be recentered manually by left-clicking on the desired location while the crosshair cursor is visible. Clicking on the map does not alter the reference fix coordinates used by either the motion preview or the simulator itself. To return to the reference fix location associated with the currently-selected tab, press the **Locate** button.

In the **Motion Preview** tab, the reference location follows the most recent REF command in the Motion Control Language program being previewed. The reference location for the **Motion Preview** tab can also be set manually with the **Go to…** button.

In the **Simulation** tab, the reference location is the most recent fix obtained from responses to the periodic SIMulation:POSition? queries issued by SimCon. This fix location, in turn, will vary depending on whether the connected simulator hardware is running in FIXED or MOTION mode.

4.9.1.3 *Go to...* button

This button is available only in the **Motion Preview** tab. It will bring up a dialog box that allows you to enter a new reference location. Upon clicking the **OK** button in the dialog box, the map will be recentered at the new location.

Note that executing a Motion Command Language program will reset the reference location, replacing any coordinates entered in the **Go to …** button dialog box. Changes made to the map reference location with **Go to …** will not affect the fix location or other properties of any current or subsequent motion preview operation. To use a selected map location in a REF command or other command that accepts latitude and longitude parameters, you can center the map at the desired location by clicking on it, then click the **Map** button on the appropriate program line in the **Motion** panel.

4.9.1.4 *Auto zoom* button

As seen in Figure 4.10, the map displays in both the **Motion Preview** and **Simulation** tabs will maintain a historical record of up to one million coordinate fixes emitted by either the simulator hardware or the motion preview process. As each successive fix is recorded, it becomes part of a visible track that is rendered in magenta as an overlay on the map display. When the **Auto zoom** button is depressed, SimCon will continuously adjust the map center location and zoom level to keep the entire track in view.

Auto zoom mode is enabled by default. It will be cancelled automatically if you press the **Locate** button, enter a new reference location with the **Go to …** button, or change the zoom level manually with the **Zoom in** or **Zoom out** buttons or mouse wheel.

4.9.1.5 *Clear track* button

The **Clear track** button will clear all recorded fix coordinates, erasing any visible track displayed on the map in the **Motion Preview** or **Simulation** tab.

The coordinate history maintained in the **Simulation** tab is cleared automatically when the **Run** button in either the status header or the **Motion** panel is pressed to execute a Motion Command

Language program on the simulator hardware. Similarly, the coordinate history maintained in the **Motion Preview** tab is cleared automatically when a new motion preview operation is initiated by pressing the **Preview…** and **Start** buttons in the **Motion** panel.

4.9.2 World Map tab

Figure 4.11 'World map' display with satellite ground tracks
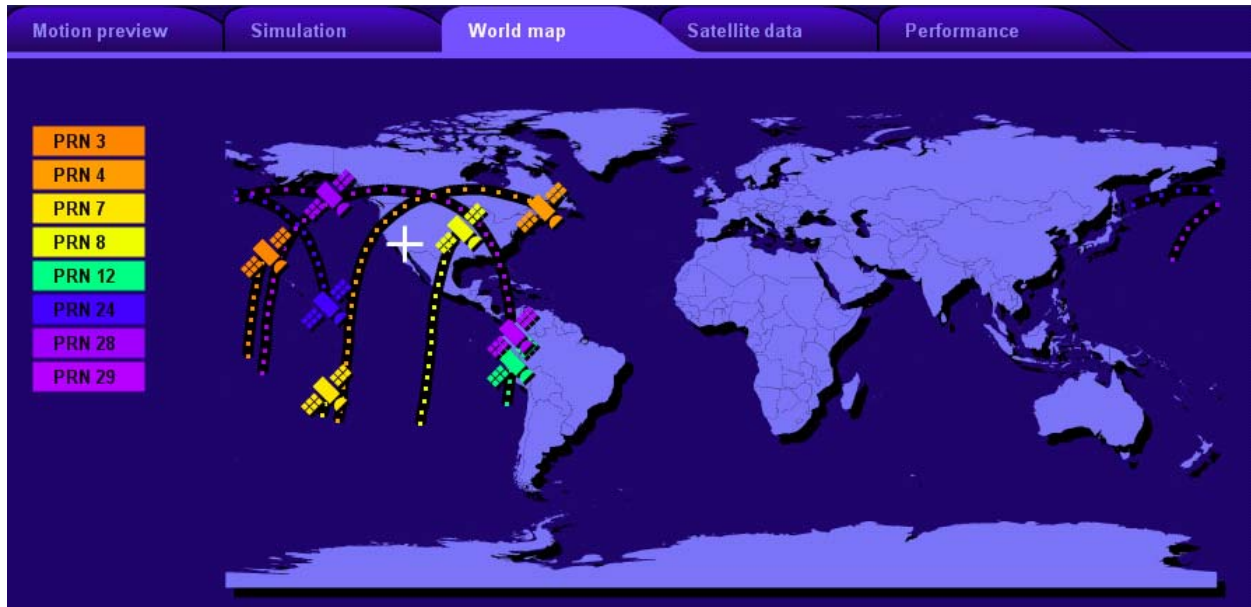
The **World Map** tab is available when a hardware connection is active. It displays the simulated GNSS satellite constellation as seen in Figure 4.11, along with up to 24 hours of ground-track coordinate history for each space vehicle. Ground track information is sampled and recorded at 10-minute intervals.

4.9.3 Satellite Data tab

Figure 4.12 SV data table and polar plot
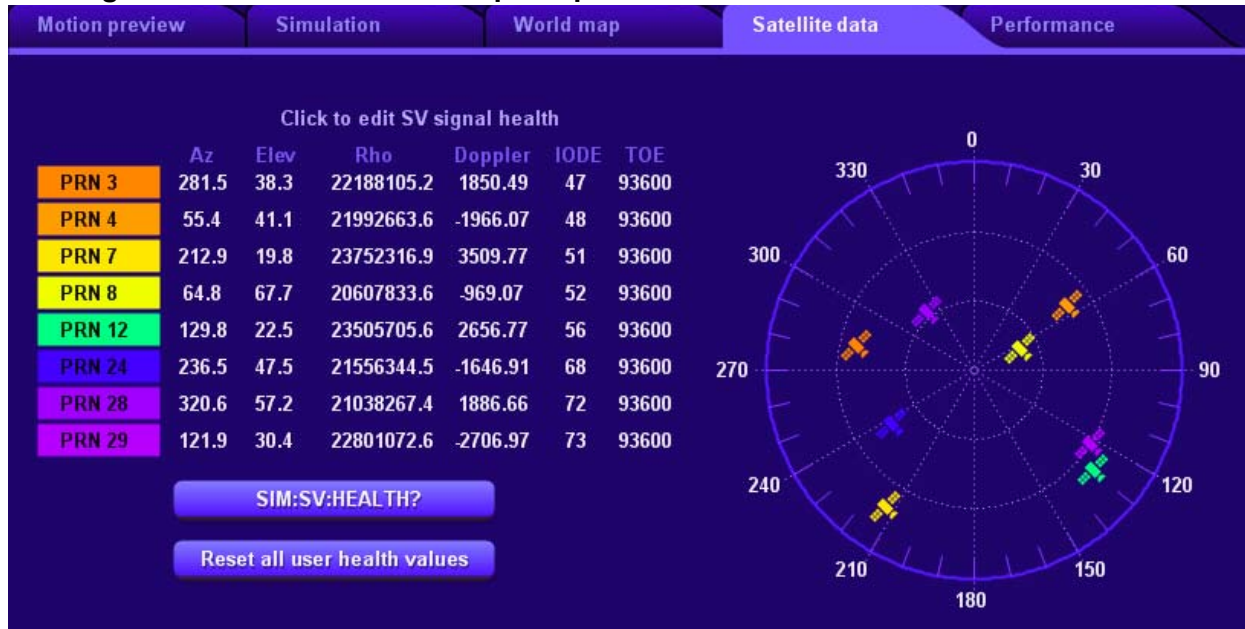
The **Satellite Data** tab shown in Figure 4.12 is available when a hardware connection is active. It displays space vehicle locations on an az-el polar plot, rendered from the perspective of the simulated receiver location. Each concentric circle represents 30 degrees of elevation.

The data table displayed to the left of the az-el plot is obtained from the responses to periodic SIMulation:SV:VIEW? queries issued by SimCon. In the table, the PRN number broadcast by each space vehicle is shown in the color-coded box at far left. The **Az** column displays the vehicle's azimuth in degrees, **El** is its elevation in degrees, **Rho** is its distance from the simulated receiver location in meters, and **Doppler** is the satellite's apparent frequency offset from L1 in Hz.   **IODE** is the reference number for the current ephemeris, and **TOE** is its reference time-of-week in seconds.

Satellite signal health words may be specified in the **Satellite Data** tab on a per-SV basis. By default, the GPS signal health words for each SV are broadcast exactly as they appear in the simulated navigation data. Normally all transmitted values are equal to 0x00 (healthy). By clicking on a given SV's row in the chart, you can specify a different health word to be broadcast in accordance with the IS-GPS-200 specification (Figure 4.13).

When a user-specified signal health word is provided, SimCon issues a SIM:SV:HEALTH command for the given satellite, treating the specified signal health value as the OR bitmask field and setting the AND bitmask to zero. As a result, the specified health word will be emitted instead of the value from the navigation data.   (Note, however, that if SIM:LNAV:HEALTH is set to 1, the health words from the navigation data are always transmitted verbatim, regardless instead of any user-specified bitmask values.)

In the dialog shown in Figure 4.13, you can specify any of the health words defined in IS-GPS-200. Click **Set specified health word** to issue the corresponding SIM:SV:HEALTH command, or Cancel to exit the dialog without changing the health word.

Figure 4.13 SV data table and polar plot, showing SV health dialog
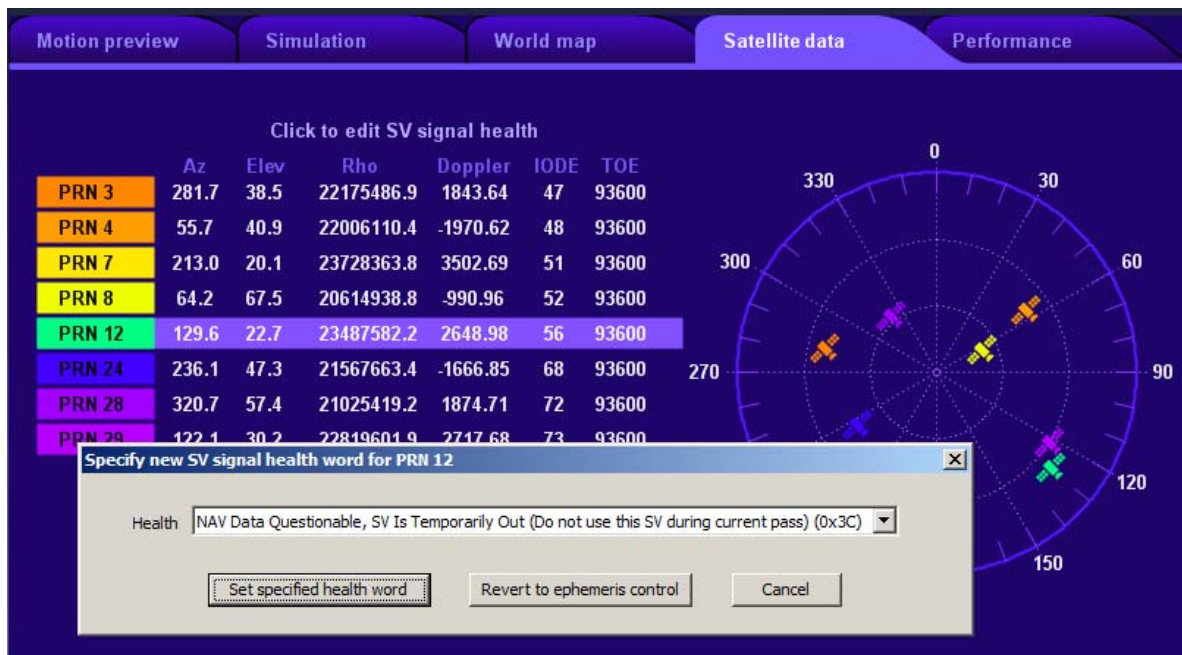
Clicking **Revert to ephemeris control** in the dialog will set the AND bitmask for the selected SV signal health word to its default value of 0xFF and the OR bitmask to its default value of 0x00. The latter operation can be executed for all SVs by clicking on the button labeled **Reset all user health values** in the **Satellite Data** tab itself.

4.9.3.1 SIM:SV:HEALTH? button

This button will issue a SCPI SIM:SV:HEALTH? query, causing the current user health bitmasks to be displayed in the **Terminal** panel. If the **Terminal** panel is not open when this query is issued, the response will not be visible.

4.9.3.2 *Reset all user health values* button

As noted above, this button will set the user health bitmasks for all 32 satellites to their factory default values (AND=0xFF, OR=0x00). All satellite signal health words will subsequently be derived from the navigation data.

4.9.4 Performance tab

Figure 4.14 Typical performance graph display

Several types of performance graphs are available in the **Performance** tab of the **Display** panel, suitable for general monitoring, troubleshooting, and performance verification purposes.

Graph data is recorded continuously, even when the **INTGPS** display, the **Performance** tab, or the entire **Display** panel is not visible. When any of several buttons to the right of the graph area in figure 7.14 are pressed, SimCon plots the corresponding SCPI query responses versus time as they arrive from the hardware. You can position the mouse cursor over any of these graphs to display the corresponding X and Y coordinate values, and zoom in by left-clicking and dragging a selection box around the desired target area.

Figure 4.14 shows an example of monitoring the target GPS receiver's 1PPS accuracy (GPS:PPSERRor? query) while Figure 4.15 shows an example of monitoring the target GPS receiver's horizontal position accuracy (GPS:POSERRor? query). More information on configuring the target receiver is available in Section 3.8.16.2 .

Figure 4.15 GPS:POSERRor? performance graph display

Internally, graph data is recorded at one-second intervals for the first hour (3600 seconds), ten-second intervals during the remainder of the first day (86400 seconds), and 60-second intervals for up to a week.

Below the graph shown in figure 7.14, three buttons can be seen:
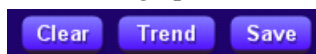
The **Clear** button simply erases all recorded data from the displayed graph, while the **Trend** button displays the overall slope of the recorded data points.

The **Save** button prompts for a filename to receive a saved copy of either the graph data or the contents of the graph window itself. If the provided filename ends in .txt, the sample data will be recorded to the ASCII text file at 16-digit precision. One sample per line will be recorded, representing data logged at one-second intervals. Conversely, if the filename ends in **.png**, **.gif**, **.jpg**, **.tga**, **.bmp**, or **.pcx**, the graph window contents will be saved to an image file of the specified type.

In the example shown in Figure 4.14, the MEAS:POWersupply? button was selected to display the power supply input voltage for a CLAW simulator. Approximately 17 seconds later the external +12V power supply was disconnected, forcing the CLAW to operate on approximately +4 volts from an overloaded USB connection. Significant ripple is visible on the graph in addition to the undervoltage condition itself. The resulting performance degradation was then observed by switching to the **INTGPS** graph, as shown in Figure 4.16.

Figure 4.16 INTGPS deviation map and S/N display
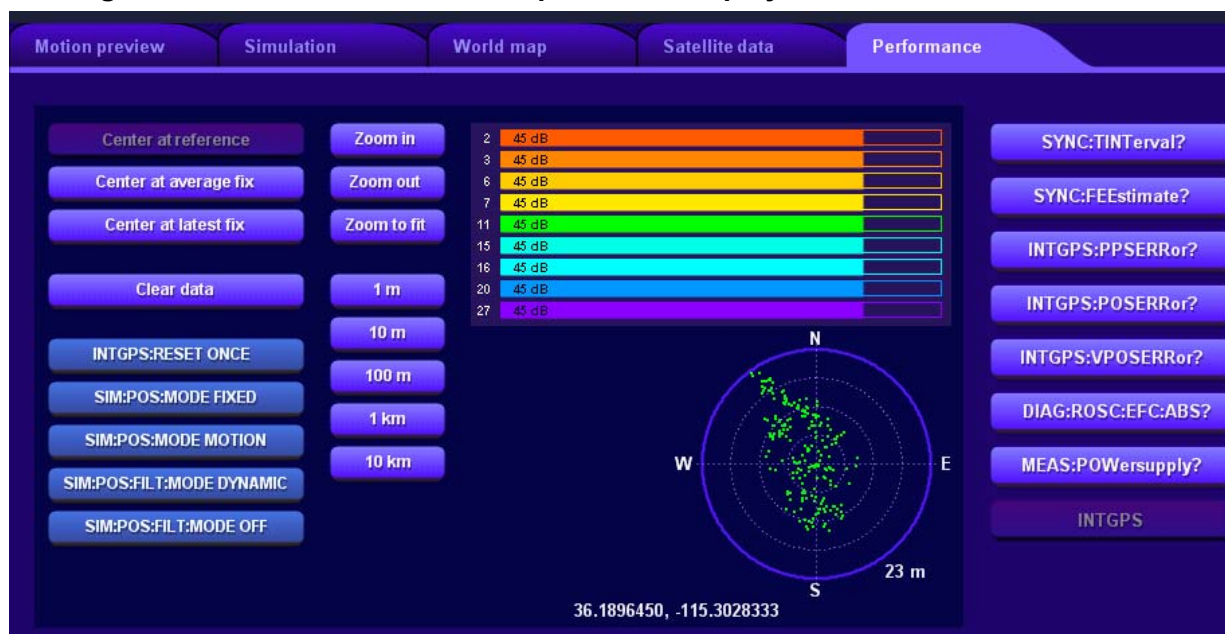
In the **INTGPS** display, the current signal-to-noise ratios reported by the internal GNSS monitor receiver are displayed in a bar-graph format. Additionally, fixes reported by the internal GNSS receiver are recorded and rendered as dots on a deviation map. The deviation map is a polar plot that displays one or more latitude/longitude fixes relative to a specific center location. When rendering the deviation map, SimCon displays the most recent 86400 fixes obtained from $GPGGA messages sent by the CLAW or RSR Transcoder's internal GNSS monitor receiver.

The **INTGPS** performance plot is unique in that its graph area contains several buttons in addition to the deviation map. The buttons labeled **Zoom in**, **Zoom out**, **Zoom to fit**, and **1 m** through **10 km** are self-explanatory, while the other buttons are described below.

4.9.4.1 *Center at Reference* button

The button labeled **Center at Reference** will position the origin of the polar plot at the reference location used by the simulator hardware. The reference location is the most recent fix location reported by periodic SIMulation:POSition? queries issued by SimCon.

4.9.4.2 *Center at Average Fix* button

This button will position the origin of the polar plot at a location corresponding to the arithmetic mean of all INTGPS:GPGGA fixes received from the internal GNSS receiver since the device was powered up or the Clear data button was pressed.

4.9.4.3 *Center at Latest Fix* button

This button will position the origin of the polar plot at the location of the most recent INTGPS:GPGGA response.

4.9.4.4 *Clear Data* button

This button will clear the recorded fixes, removing them from the deviation map.

4.9.4.5 SCPI shortcut buttons

The buttons shown in blue on the **INTGPS** display are provided for convenience when working with the deviation map. They can eliminate the need to open the **Controls** panel to issue frequently-used commands. A brief summary of each button appears below; refer to the SCPI command reference in Chapter 6 for detailed descriptions.

4.9.4.5.1 *INTGPS:RESET ONCE*

This button issues a cold-reset command to the internal GNSS monitoring receiver.

Depending on their selected dynamics mode and other factors, GNSS receivers may have difficulty maintaining their fix when the simulated receiver location undergoes rapid change. Loss-of-fix conditions may occur during high-speed maneuvers in MOTION mode or when significant changes to the FIXED position are commanded via SIMulation:POSition:LLH. Additionally, because the simulator maintains separate latitude, longitude, and altitude fix values for the FIXED and MOTION modes, loss-of-fix conditions may occur during transitions between the two modes even when no motion program has been executed and no recent changes to the fixed position have been commanded. The **INTGPS:RESET ONCE** button may be helpful in all of these cases if it is difficult to establish a valid fix after significant movement of the simulated receiver location. The new fix location will typically be recognized by the receiver in less than one minute after a reset.

The **INTGPS:RESET ONCE** button will not erase any recorded fixes that are currently visible on the map. Use the **Clear data** button for this purpose.

4.9.4.5.2 *SIM:POS:MODE FIXED/MOTION*

These buttons set the simulator position mode to FIXED or MOTION.

Each position mode supported by the CLAW and RSR Transcoder is associated with its own internal latitude, longitude, and altitude state. MOTION mode is set automatically when a Motion Command Language program is run on the simulator hardware, but FIXED mode must be restored manually after the motion program finishes executing if you wish to return the simulated receiver location to the fixed location specified with SIMulation:POSition:LLH. You can accomplish this by pressing the **SIM:POS:MODE FIXED** button in the **INTGPS** graph view on the **Performance** tab, the **Fixed simulation** button in the status header, or the **FIXED** button in the SIMulation:POSition:MODE box in the **Controls** panel.

4.9.4.5.3 *SIM:POS:FILT:MODE DYNAMIC / OFF*

These buttons determine whether or not a low-pass integrating filter is applied to fixes transmitted by the CLAW or RSR Transcoder in FIXED position mode. The filter can help the receiver remain locked when significant changes to the fix position are commanded with SIMulation:POSition:LLH.

The position filter is not used in MOTION position mode. However, when returning to FIXED position mode, the filter action can result in a very long, gradual transition back to the fixed location

previously established by SIMulation:POSition:LLH. Press the SIM:POS:FILT:MODE OFF button if this effect is undesired.

4.10 The Motion Panel

Figure 4.17 Motion Panel

The **Motion** panel shown in Figure 4.17 provides quick, convenient access to the Motion Command Language features supported by the SIMulation subsystem described in Section 6.3 . Various controls available in the **Motion** panel can be used to create, edit, and preview Motion Command Language programs, upload programs to nonvolatile memory on the CLAW or RSR Transcoder hardware, and retrieve programs previously stored there.

Conceptually, the **Motion** panel can be divided into three vertically-separated regions: the *selection buttons*, the *program list*, and the *operation buttons*. Each will be discussed in turn below.

4.10.1 Selection buttons

At the top of the **Motion** panel, three sets of mutually-exclusive "radio buttons" can be seen, along with a single checkbox control. These buttons work in conjunction with the commands in the program list area.

The radio buttons can be used to select alternative units of distance, acceleration, and time for display and entry of the command parameters in the program list.   Clicking on a unit selection button will deselect the currently-selected unit in the same group. At the same time, the relevant parameter labels in the program list area will change to conform to the newly-selected unit, and existing parameter values will be rescaled accordingly.

While the unit selection buttons are largely self-explanatory, please note that the rescaling process is not completely reversible. Some minor precision loss can be expected when switching between units of widely-differing magnitude such as feet and miles. This effect can also result in range-checking errors in some circumstances, such as when operating at the Wassenaar-mandated dynamics limits. It may be necessary to use slightly lower parameter values if unexpected error messages are received when using nonstandard units.

As noted below, individual commands in the program list may be included or excluded from motion preview operations by clicking the checkboxes next to the appropriate lines. The checkbox near the upper-left corner of the overall **Motion** panel provides "Select all" / "Select none" functionality. It will automatically be checked if all of the individual lines are checked, or unchecked if any lines are unchecked. When unchecked, left-clicking the control will select all currently-unselected lines. Conversely, if the box is clicked when already checked, all currently-selected lines will be deselected.

4.10.2 Program list

The largest part of the display area occupied by the **Motion** panel is the "program list," which is devoted to the Motion Command Language commands that define the simulated vehicle trajectory in MOTION position mode.

The motion program may consist of up to 100 lines, processed sequentially as described in Section 6.3 . It may be executed as a "motion preview" within SimCon itself, or it may be uploaded to the CLAW or RSR Transcoder hardware to drive the actual RF simulation. Both motion preview and simulation operations are supported by controls on the **Motion** panel. Each operation has a dedicated map display tab on the **Display** panel, as previously discussed.

In SimCon, the first two lines in the program list always consist of DYN and REF commands, respectively. This requirement is enforced by SimCon rather than the simulator hardware, but it is strongly recommended in all cases. Lines 3 through 100 may contain any combination of Motion Command Language commands in any order.

Each line in the program list consists of three columns. These columns are referred to as *line controls*, *commands*, and *parameters* respectively, and are described below.

Figure 4.18 Motion command list elements
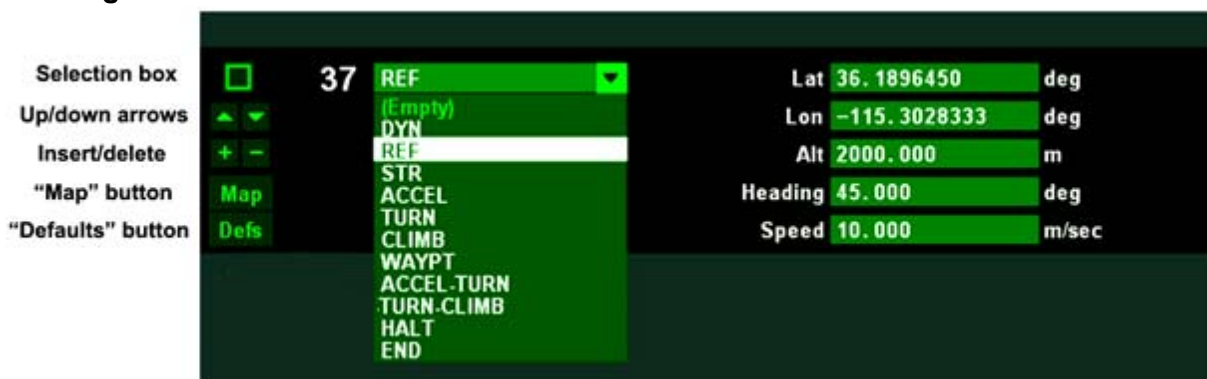
4.10.2.1 Line controls

As seen in Figure 4.18, the leftmost column in each line consists of a few small buttons that apply only to the command associated with that particular line. Only the buttons that apply to the currently-selected command will appear.

Selection box

The checkbox can be used to selectively determine which commands will be executed in a motion preview operation. It has no effect unless the **Selected** button is pressed in the **Preview . . .** submenu described below.

The first two lines in a Motion Command Language program consist of DYN and REF commands that cannot be deselected. No selection box will appear in these lines.

Up/down arrows

When either of these buttons is pressed, the line will exchange places with the one immediately above or below it. As noted previously, the first two lines cannot be deselected or moved, so they do not have up/down arrows. Line 3 does not have an up-arrow button, while line 100 does not have a down-arrow button.

Insert/delete
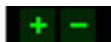
The + button inserts a blank line after the current one, moving all following lines down one slot to make room. The - button moves all subsequent lines up one slot, overwriting the current one.

Lines 1 and 100 do not include either of these buttons. Line 2 includes only the + button.

"Map" button
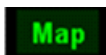
The **Map** button appears on lines where the currently-selected command accepts latitude and longitude parameters. These include **REF**, **WAYPT**, and **HALT**.

If the **Display** panel is open and either the **Motion Preview** or **Simulation** tab is visible, pressing the **Map** button will copy the center coordinates from the displayed map to the relevant parameters in the Motion Command Program line. Otherwise, pressing the **Map** button will result in an error message.

"Defaults" button

Pressing this button will reset all parameters for the selected command to their factory default values.

4.10.2.2 Command Selection

Command entry in the **Motion** panel is intuitive - simply click on the dropdown menu and select the desired command. (Tip: if the list extends below the bottom of the program list area, use the mouse wheel to scroll the list up.)

4.10.2.3 Parameters

As each command is highlighted in the dropdown menu, the appropriate parameter set for that command automatically appears at right. For convenience, any parameters that have been entered for

a previously-selected command are retained when a new command is chosen. They can be recovered simply by reselecting the prior command.

4.10.3 Operation buttons

At the bottom of the display area occupied by the **Motion** panel, a number of buttons are provided to carry out various operations on Motion Command Language programs. These are described below.
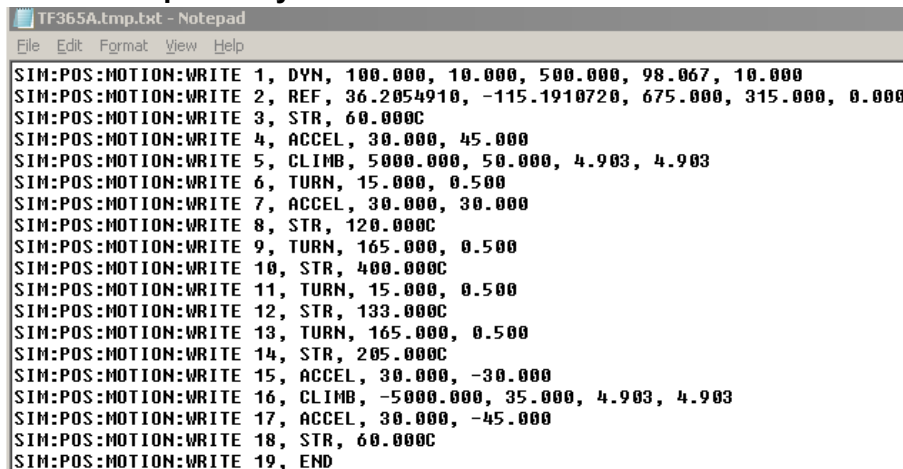
4.10.3.1 *Clear* button

The **Clear** button provides a convenient way to reset all lines in the program to their default (empty) state. As with other controls in the **Motion** panel, the **Clear** button has no effect on any program stored in simulator hardware unless it is followed by a **Simulator…Write** command, described in Section 4.10.3.5 below.

4.10.3.2 *Edit* button

The **Edit** button allows you to edit the Motion Command Language program manually in a text editor. When **Edit** is pressed, SimCon will write the program to a temporary text file and pass it to the system's default editor application, typically Windows Notepad (Figure 4.19).

Figure 4.19 File opened by Edit button

```
TF365A.tmp.txt - Notepad
File  Edit  Format  View  Help
SIM:POS:MOTION:WRITE 1, DYN, 100.000, 10.000, 500.000, 98.067, 10.000
SIM:POS:MOTION:WRITE 2, REF, 36.2054910, -115.1910720, 675.000, 315.000, 0.000
SIM:POS:MOTION:WRITE 3, STR, 60.000C
SIM:POS:MOTION:WRITE 4, ACCEL, 30.000, 45.000
SIM:POS:MOTION:WRITE 5, CLIMB, 5000.000, 50.000, 4.903, 4.903
SIM:POS:MOTION:WRITE 6, TURN, 15.000, 0.500
SIM:POS:MOTION:WRITE 7, ACCEL, 30.000, 30.000
SIM:POS:MOTION:WRITE 8, STR, 120.000C
SIM:POS:MOTION:WRITE 9, TURN, 165.000, 0.500
SIM:POS:MOTION:WRITE 10, STR, 400.000C
SIM:POS:MOTION:WRITE 11, TURN, 15.000, 0.500
SIM:POS:MOTION:WRITE 12, STR, 133.000C
SIM:POS:MOTION:WRITE 13, TURN, 165.000, 0.500
SIM:POS:MOTION:WRITE 14, STR, 205.000C
SIM:POS:MOTION:WRITE 15, ACCEL, 30.000, -30.000
SIM:POS:MOTION:WRITE 16, CLIMB, -5000.000, 35.000, 4.903, 4.903
SIM:POS:MOTION:WRITE 17, ACCEL, 30.000, -45.000
SIM:POS:MOTION:WRITE 18, STR, 60.000C
SIM:POS:MOTION:WRITE 19, END
```

After making any desired changes to the program, save the file and exit from Notepad. If SimCon detects that the temporary text file has been modified by the user, it will automatically reload the program from the file.

If you exit from Notepad without saving the file, no changes will be made to the program in SimCon.

4.10.3.3 *Load / Save* buttons

The **Load** button prompts you to specify a text file containing the Motion Command Language program to be loaded by SimCon. The loaded file will overwrite any unsaved commands in the program list. Conversely, **Save** will write the current Motion Command Language program to a text file. The file may be reloaded later by pressing the **Load** button.

4.10.3.4 *Preview* menu

Pressing the green button labeled Preview …will open a horizontal submenu resembling Figure 4.20 below.

Figure 4.20 Motion Preview menu

The buttons on this menu are used to initiate and control the Motion Preview process.

This button closes the submenu, restoring the **Preview…** button.

The **Start** button begins execution of the current Motion Command Language program in preview mode. This operation takes place entirely within SimCon, and does not require (or interact with) any simulator hardware.

If the **Motion Preview** tab in the **Display** panel is not already visible when the **Start** button is pressed, it will automatically be opened. Assuming the **Auto zoom** function is enabled, the map view in the **Motion Preview** tab should center itself at the location of the **REF** command on line 2 of the program, and the motion path should become visible (Figure 4.21).

Figure 4.21 Motion Preview in progress
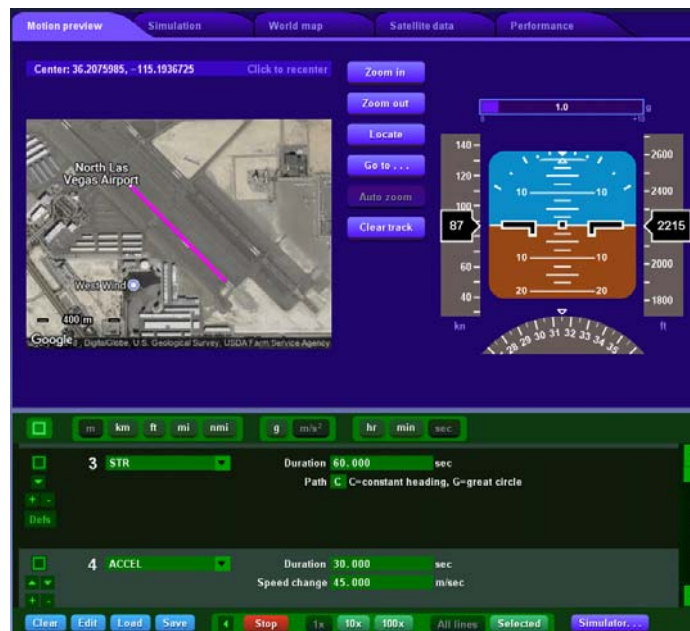
Assuming the program does not terminate immediately, the green Start button will change to a red Stop button while the preview runs.

By default, the motion preview runs in real time (1x). At any time during the motion preview, these buttons may be used to accelerate the timebase by 10x or 100x.

By default, all lines in the program list are executed when the **Start** button is pressed to initiate a motion preview. If you press the **Selected** button, only those lines with a checked selection box will be executed.

The mandatory **DYN** and **REF** commands in lines 1 and 2 cannot be deselected and are always executed.

4.10.3.5 Simulator control buttons

The buttons in this group are available when a CLAW or RSR Transcoder simulator is connected.

This button closes the submenu, restoring the **Preview…** button.

The **Read** button will retrieve the Motion Command Language program that was most recently uploaded to the device with the **Write** button. It issues a SCPI SIMulation:POSition:MOTION:READ 1 command to the connected device and copies the returned program lines to the program list, overwriting any existing commands.

The **Write** button clears the nonvolatile storage with SIMulation:POSition:MOTION:ZEROize, then issues a series of SIMulation:POSition:MOTION:WRITE commands for each non-empty line in the program list. Upon successful completion of a **Write** operation, the **Run** button may be used to execute the program on the simulator.
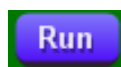
The **Run** button issues a SIM:POS:MOTION:START 1 command to the connected device. The device will switch to SIM:POS:MODE MOTION if it is not already in MOTION position mode. It will then begin execution of the Motion Command Language program that was most recently uploaded to nonvolatile storage with the **Write** button.

If the **Simulation** tab in the **Display** panel is not already visible when the **Run** button is pressed, it will automatically be opened. The progress of the motion simulation can be followed in this tab, as well as by observing the status header at the top of the SimCon application window. During execution of a motion simulation, the **Run** button in both the status header and the **Motion** panel will turn red and act as a **Stop** button. The **Pause** button in the **Motion** panel will also be enabled:

When pressed, the **Pause** button will temporarily stop the simulation by issuing SIM:POS:MOTION:PAUSE. It will be replaced by the **Resume** button as shown below, which will issue SIM:POS:MOTION:RESUME when pressed.

4.10.4 Example program

The SimCon installation includes an ASCII text file, **north_las_vegas.txt**, which contains a typical Motion Command Language Program to help acquaint new users with the motion preview and simulation operations described above.

After loading the file into SimCon with the **Load** button, the program can be examined and modified by scrolling through program list, previewed in a standalone SimCon installation with **Preview… Start**, or uploaded and executed on CLAW or RSR Transcoder hardware with the **Write** and **Run** commands.   The resulting motion track should appear as shown in Figure 4.22.

Figure 4.22 Example program north_las_vegas.txt

4.11 The Health Panel

When enabled, the **Health** panel appears at the far right edge of the SimCon application window. This panel provides a visual indication of the status bits reported by the connected device in response to periodic SYNChronization:HEALth? queries.

Normal / ready condition

Abnormal condition

Caution

Data unavailable, not applicable, or not ready

The specific indicators on the **Health** panel may vary from one device to the next. Refer to Section 6.7.3 for detailed information about the SYNChronization:HEALth? bitfield.

Figure 4.23 Health display
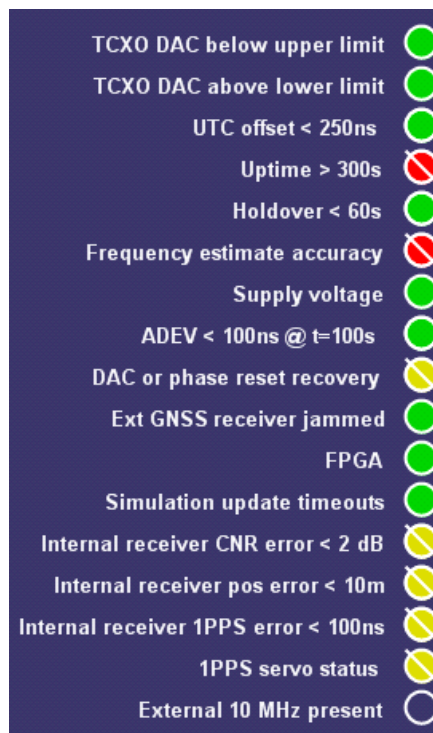
4.12 Attributions

SimCon includes the open-source components listed below.

4.12.1 NanoSVG / TinyXML (Zlib)

NanoSVG: Copyright (c) 2013-2014 Mikko Mononen

TinyXML: Copyright (c) 2000-2006 Lee Thomason

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4.12.2 Yoga / stb_image / stb_image_write (MIT)

Yoga: Copyright (c) 2014-present, Facebook, Inc.

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4.12.3 lpc21isp (LGPL3)

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SimCon is distributed with a copy of the full lpc21isp distribution with source code and licensing information, including a copy of the GNU Lesser General Public License and GNU General Public License. Refer to lpc21isp.zip in the SimCon installation directory.

5 GPSCon Utility

5.1 Description

GPSCon - Jackson Labs Edition is a program for the monitoring and control of a Jackson Labs Technologies, Inc. GPSDO, Simulator and receiver products. It communicates with the receiver using the SCPI command set.

GPSCon has been replaced by the freeware program SimCon available for download from the JLT website support page as described in Chapter 4, however GPScon is useful in monitoring and controlling the built-in TCXO or CSAC GPSDO features when locking and disciplining the internal oscillators to external 1PPS reference signals.

A free version of the GPSCon utility is compatible with Jackson Labs products and is available for download from the support section of the Jackson Labs website:

> http://www.jackson-labs.com/index.php/support

5.2 Installation

Extract the contents of the ZIP file downloaded from the Jackson Labs website and execute the MSI installer. Follow the on-screen instructions to complete the installation of GPSCon.

5.3 Using GPSCon

The GPSCon utility has a help file that should be consulted in order to get the full functionality of this utility. Only a few of the features and commands are mentioned in this appendix for convenience.

5.3.1 Setting the options

To set up the options for your GPSCon session, press the 🔧 wrench icon under the menu bar, or select Settings / Options on the menu. The window shown in Figure 5.1 will appear. You can then select various options on the tabs.

Figure 5.1   Options window
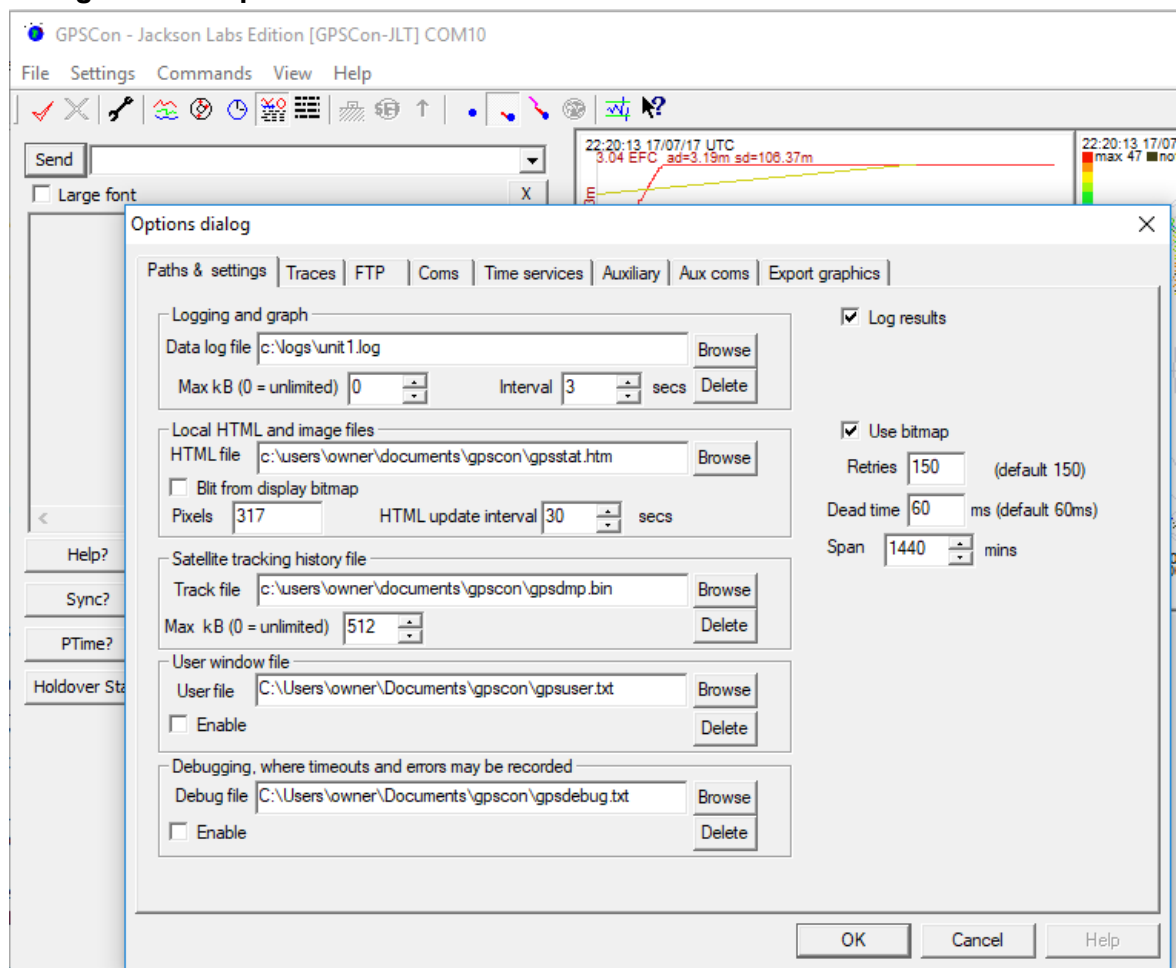
5.3.1.1 Communication Parameters

Before you can use GPSCon you must set the communication parameters for your system. Open the dialog box by pressing the ⚒ wrench icon. Then select the "Coms" tab. You will see the window shown in Figure 5.2. Available COM ports on your system will be highlighted by an asterisk. Select the correct COM port for your computer and set the baud rate to 115200, parity to None, Data Bits to 8 and Stop Bits to 1. Set Flow Control to "None". Once you have configured the communication parameters, press the "OK" button to close the window.

5.3.1.2 Auxiliary Parameters

After pressing the ⚒ wrench icon, you can select the "Auxiliary" tab to configure auxiliary measurements. See Figure 5.3 for an example of an auxiliary measurement. You will notice that the "Aux1" request string has been set to `meas:current?<CR>` and the "Trace to go to" is set to trace position 6. See "Trace position" diagram for the arrangement of the trace positions in the trace window. In this example the data obtained from the meas:current? query will be plotted in trace position 6.

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5.3.1.3 Traces Parameters

After pressing the ⚷ wrench icon, you can select the "Traces" tab to configure the trace labels and vertical plot ranges. See Figure 5.4 for an example of an auxiliary measurement. The labels and parameters are completed by default for traces 1 through 5. The auxiliary trace defined on the auxiliary tab for trace 6 has the label "Temp" to indicate that the OCXO current from the meas:current? query is a measure of temperature. Any of the eight traces can be replaced by auxiliary traces as described in Section 5.3.1.2 . Press the "Help" button for a full description of each option in the Traces tab.

Figure 5.2   Setting the communications parameters
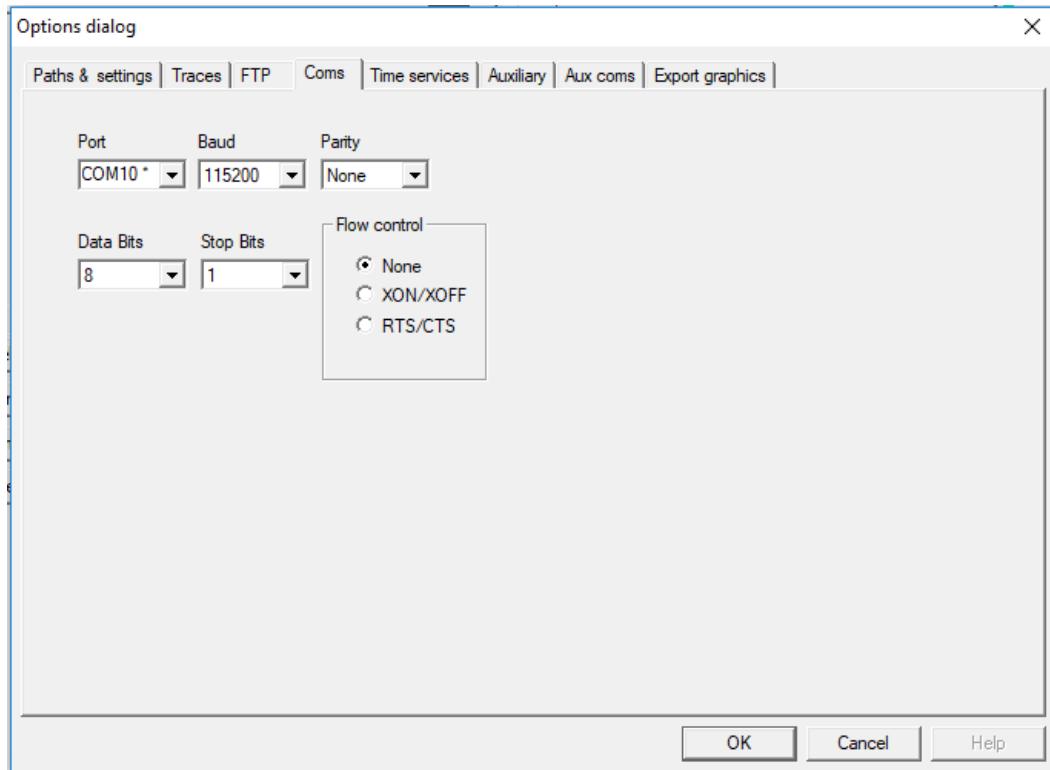
Figure 5.3   Auxiliary Parameters window

Figure 5.4   Traces Parameters window

5.3.2 Sending manual commands to the receiver

You can send SCPI commands manually by using the drop-down box in the upper left of the main window as shown in Figure 5.5. Care must be taken when sending these commands, so be sure that the command that you select is supported by the RSR GNSS Transcoder™. Once you've selected the command you can press "Send" to send it to the RSR GNSS Transcoder™. You can also send common commands by clicking on the buttons below the message window. You can hover over the buttons to see the exact command that will be sent.

Figure 5.5   Sending manual commands
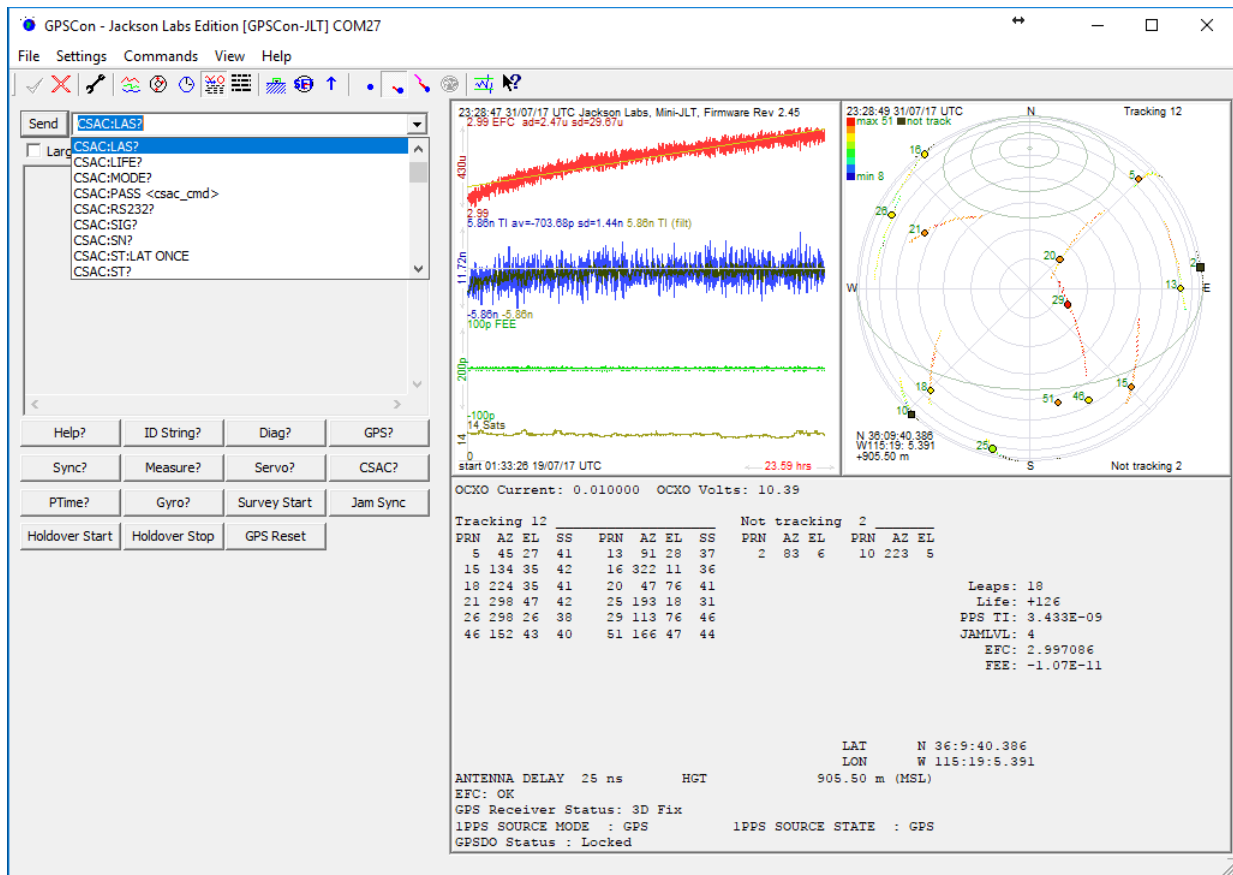
5.3.3 Using the Mouse in the Graph Window

Refer to Figure 5.6 for the following description. The default view in GPSCon is "All" which you can select with the View/All menu option. To see a larger view of the graph, select the View/Graph menu option.

In the graph window the horizontal range of the graph can be set using he mouse. Set the start time by left clicking on the desired start point. If you wish, the stop time may also be set by right clicking the desired stop point. The set start and stop times can be removed by left double-clicking anywhere on the graph.

Since this is harder to describe than to actually do, here is a paraphrase of the above:

"To zoom in: The mouse is used to set the left extent and the right extent of the portion of the curve that the user wants to fill the screen. Click once with the left mouse button on the point that marks the left side of what you want to be the magnified curve. Immediately that point becomes the left end of the curve. Then similarly click the right mouse button on the curve at the time you wish to be the right most portion of the magnified curve and it immediately becomes the end point on the right side. And, finally to return to the zoomed out ("fit to window") view, left double-click on the curve."

When you have locked the start and stop time using the mouse, you can scroll left or right through the data. To scroll to a later time, use Shift + Left click. To scroll to an earlier time, use Shift + Right click.

Figure 5.6   Graph display

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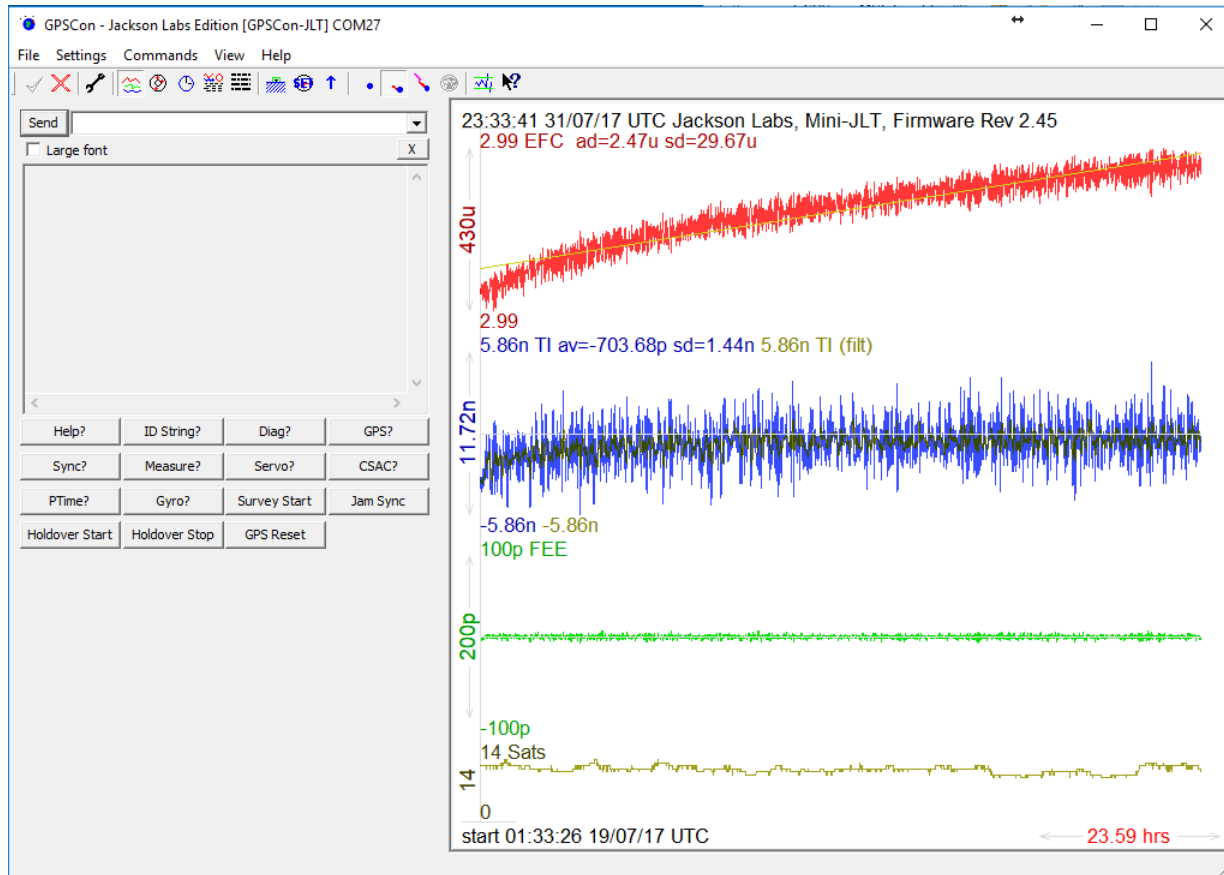
Figure 5.7   Expanded Graph Display
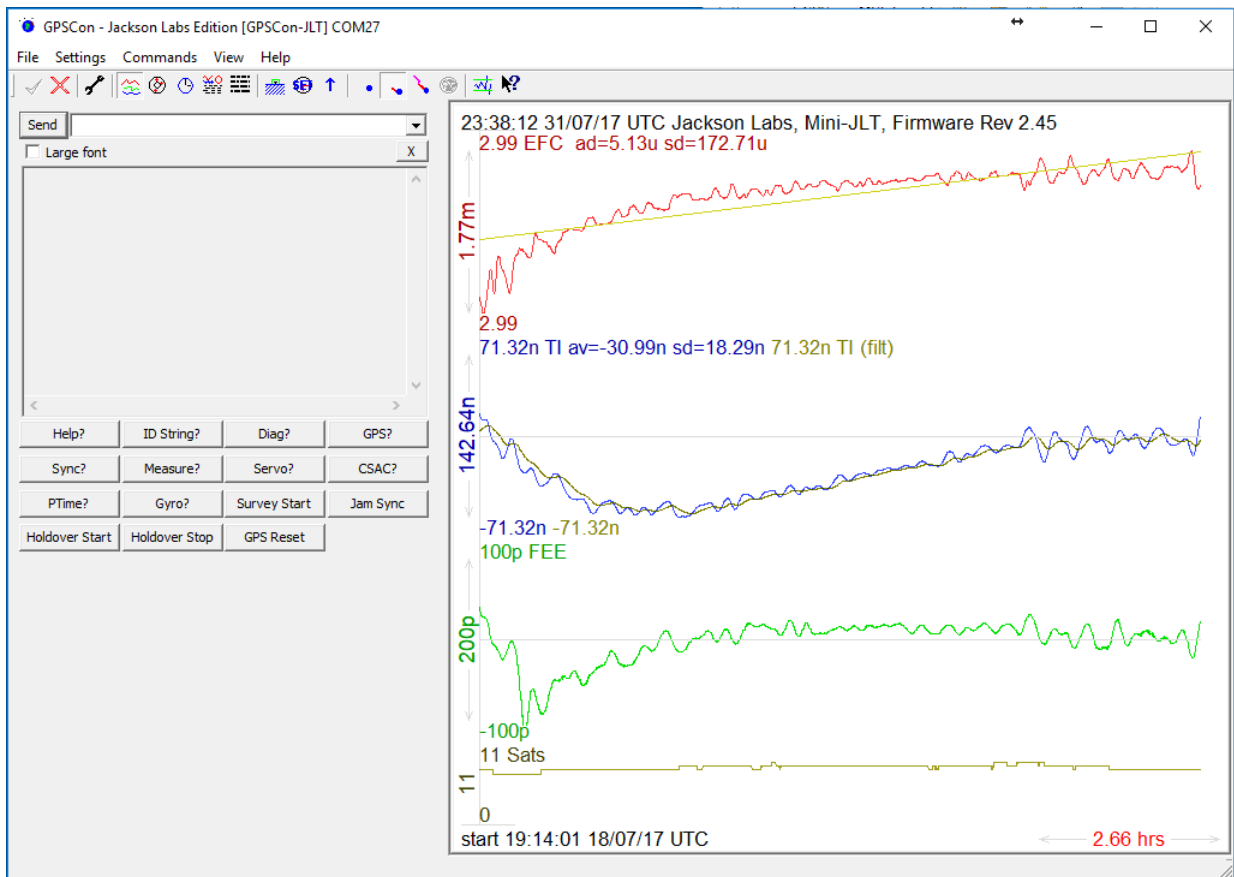
5.3.4 Exporting the graphics

The settings which control the export function are contained in the "Export graphics" tab in the Options dialog.

Export allows you to create an image file of the graph and/or the satellite trails map. You can select which you want by specifying a file for the Graph path and/or Map path. If you export the graph, you have the option to export only that which is currently visible, or to export the graph which is a plot of the entire logfile contents. Use the checkbox "Export all graph data" to make this choice.

You may select a size of the exported images in X and Y. The file format may be .BMP, .JPG, .GIF, or .PNG. Your settings will be stored and will become the default values the next time you open this dialog.

If you choose to export the graph, you might want to override the TI max setting in force on the screen display. You may do this by entering a non-zero value into the 'Override TI' control. A value of zero causes the export to take the same setting if any as the screen display.

The export may be done automatically on a timed basis. Simply enter a non-zero value in seconds to choose an export time interval. To manually export in accordance with the settings, press the 'Export' button.

Figure 5.8   Captured Data Example
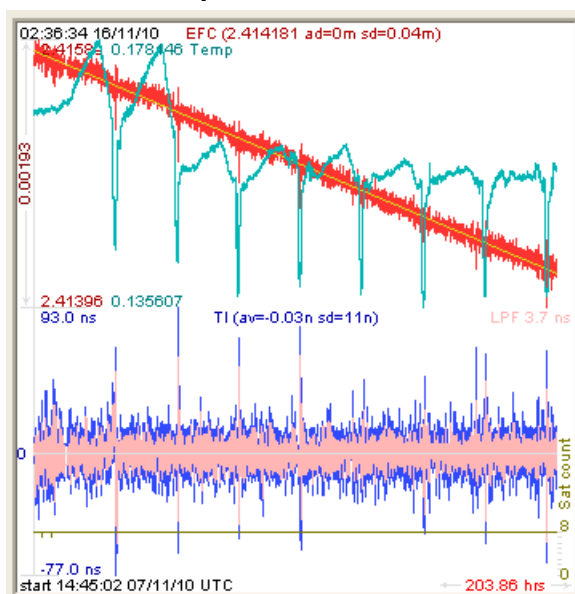
Figure 5.9   Zoomed Captured Data Example
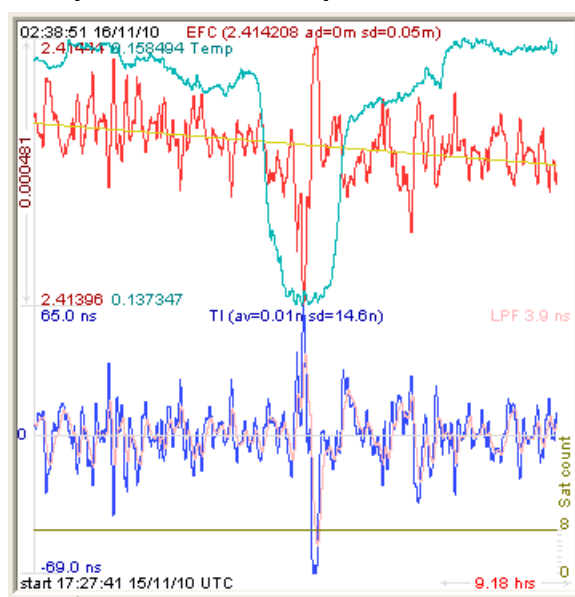
5.4 Interpreting the Data

Figure 5.8 shows the data acquired by the RSR GNSS Transcoder™ unit over a period of more than 200 hours The red trace is EFC (crystal frequency control voltage). The crystal is aging (becoming faster in frequency over time). This requires the control voltage to be lowered to maintain precisely 10.0MHz. A drift of ~2mV is visible over 200 hours. On the left side of the screen the EFC range over this 200 hour plot is displayed vertically as 0.00193V. This means the drift of the EFC voltage

due to aging is ~88mV per year. The EFC sensitivity of the crystal is about 8Hz per volt, so the crystal ages at:

$$8Hz/V * 0.088V/Year = 0.704Hz/Year \text{ drift.}$$

At 10MHz:

$$0.704Hz / 10MHz = 7.04E\text{-}08 \text{ aging rate per year.}$$

This is the same as 0.2ppb drift due to aging per day.This crystal aging is fully compensated by the firmware with and without GPS reception of course.

The board temperature is shown in turquoise. We can see it ranges from 0.135607A to 0.178146A. The OCXO current jumps lower every 24 hours because the unit is sitting next to a window, and the sun shines onto the OCXO in the evenings, heating it up, and thus making the unit use lower power during that event.

In Figure 5.9, which is a zoom of Figure 5.8, we can see the phase offset error of the internal OCXO to the UTC GPS reference. We can see the maximum drift is -77ns to +93ns. The average is (TI av=-0.03ns). The standard deviation over the 200 hour plot is sd=11ns. This means the average error of the 10MHz phase of this unit over 200 hours is only +/-11ns rms. Or, in other words the average jitter (wander) over 200 hours of operation is:

$$11ns / 200Hrs = 1.528E\text{-}014$$

or in other words the unit performs as well as a high-quality cesium atomic reference clock over long periods of time. The unit disciplines its internal 10MHz reference to within less than +/-80ns peak to peak of UTC at all times, which is less than one complete clock cycle at 10MHz.

6 SCPI Command Reference

6.1 Introduction

The RSR GNSS Transcoder™ is typically used in one of three operating modes. This chapter describes the SCPI commands that are used to control and monitor these operating modes. The available modes are:

1) Static position simulation with only time/date advancing

2) Dynamic position simulation with position, velocity, heading, and time/date advancing based on motion commands stored in internal NV memory

3) Real-time PVT transcoding where the RF output simulation follows externally-provided 1Hz PVT NMEA reference strings as well as externally provided 1PPS reference UTC timing pulses

The RSR GNSS Transcoder™ includes a USB connector (J2) that provides access to the SCPI (**S**tandard **C**ommands for **P**rogrammable **I**nstrumentation) subsystem through the use of a host system terminal program such as Tera Term or HyperTerminal or a high-level control application such as SimCon or GPSCon. By default the terminal settings are 115200, 8N1, no flow control. The SCPI interface can be used to query the status of the unit, generate NMEA compatible output sentences, or set up and control simulations and transcoding.

More than 150 SCPI commands are supported by the RSR GNSS Transcoder™, many of them identical or similar to Symmetricom/Agilent 58503A commands. Additionally, virtually all of the SCPI commands supported by the RSR GNSS Transcoder™ are 100% compatible with the CLAW GPS Simulator™ from Jackson Labs Technologies. To get a listing of the available commands, send the HELP? query. This will return a list of all the available commands and their syntax.

Commands can be entered in either caps or lower-case, and **only the characters shown in capital letters in the command reference below need to be typed in.**

Additional information regarding the SCPI protocol syntax can be found on the following web site:

http://www.ivifoundation.org/scpi/

A basic familiarity with the SCPI protocol is recommended when reading this chapter.

As many setup commands use standard GPS nomenclature, JLT recommends review and consideration of the GPS standard specification IS-GPS-200 available here:

> http://www.gps.gov/technical/icwg/

As a Quick-Start, the user may want to try sending the following commands to the unit:

sim?

syst:stat?

help?

gps?

ptim?

sync?

6.2 General SCPI Commands

6.2.1 *IDN?

This query outputs an identifying string. The response will typically show the following information:
<company name> <model name>, <firmware revision> (<FPGA revision>)

6.2.2 HELP?

This query returns a list of the commands available for the RSR GNSS Transcoder™.

6.3 Simulation Subsystem

The Simulation subsystem groups all of the commands associated with controlling the simulation and transcoding features. The list of commands supported is the following:

SIMulation:MODE <AUTO|MANUAL|SIM|TRANSCODE>

SIMulation:STATe?

SIMulation:COMmand <START|STOP>

SIMulation:HOLDover:MODE <OFF|ON|LIMIT>

SIMulation:HOLDover:STATe?

SIMulation:HOLDover:LIMIT <int> [5,86400]

SIMulation:HOLDover:INDicate <ON|OFF>

SIMulation:POSition?

SIMulation:POSition:MODE <FIXed | MOTION>

SIMulation:POSition:LLH <lat>,<lon>,<alt>

SIMulation:POSition:ECEF <x,y,z>

SIMulation:POSition:FILTer?

SIMulation:POSition:FILTer:MODE <OFF | DYNAMIC>

SIMulation:POSition:FILTer:LLH?

SIMulation:POSition:FILTer:ECEF?

SIMulation:POSition:FILTer:VMAX <float> [1.0,600.0]

SIMulation:POSition:FILTer:AMAX <float> [0.1,40.0]

SIMulation:POSition:FILTer:JMAX <float> [0.1,1000]

SIMulation:POSition:MOTION?

SIMulation:POSition:MOTION:WRITE <line>,<command>

SIMulation:POSition:MOTION:READ <line>

SIMulation:POSition:MOTION:START <line>

SIMulation:POSition:MOTION:STOP

SIMulation:POSition:MOTION:PAUSE

SIMulation:POSition:MOTION:RESUME

SIMulation:POSition:MOTION:ZEROize

SIMulation:TRACe <interval>

SIMulation:SV?

SIMulation:SV:VIEW?

SIMulation:SV:EXCLude <+/-prn>

SIMulation:SV:PATHloss <ON|OFF>

SIMulation:SV:ANTenna <UNITY|NORTH|SOUTH|EAST|WEST|PATCH>

SIMulation:SV:MASK <mask angle>

SIMulation:SV:HEALTH <sv 1-32> <mask 00-ff> <bits 00-ff>

SIMulation:SV:ASflag <0 | 1>

SIMulation:SV:HDOP?

SIMulation:SV:VDOP?

SIMulation:SV:TDOP?

SIMulation:SV:TRACe <prn>

SIMulation:TIME:MODE <ASSIGNed|CONTinuous|REFerence|TIMer>

SIMulation:TIME:START:TIME hh,mm,ss.sss

SIMulation:TIME:START:DATE yyyy,mm,dd

SIMulation:TIME:LEAPsecond:ACCumulated <seconds>

SIMulation:TIME:LEAPsecond:DATE yyyy,mm,dd

SIMulation:TIME:LEAPsecond:DURation <seconds>

SIMulation:TIME:LEAPsecond?

SIMulation:TIME:UTCoffset:A0 <a0>

SIMulation:TIME:UTCoffset:A1 <a1>

SIMulation:TIME:UTCoffset:DELTATLS <deltatls>

SIMulation:TIME:UTCoffset:TOT <tot>

SIMulation:TIME:UTCoffset:WNT <wnt>

SIMulation:TIME:UTCoffset:WNLSF <wnlsf>

SIMulation:TIME:UTCoffset:DN <dn>

SIMulation:TIME:UTCoffset:DELTATLSF <deltatlsf>

SIMulation:TIME:UTCoffset?

SIMulation:TIME:CALibrate <float> [-2000000000.0,2000000000.0]

SIMulation:TIME:FREQuency <float> [-1000.0,1000.0]

SIMulation:TIME?

SIMulation:IONosphere:A <a0>,<a1>,<a2>,<a3>

SIMulation:IONosphere:B <b0>,<b1>,<b2>,<b3>

SIMulation:IODCmsb <int> [0,3]

SIMulation:LNAV:IONosphere <subframe> <word> <data>

SIMulation:LNAV:EPHemeris <prn> <subframe> <word> <data>

SIMulation:LNAV:WRITE

SIMulation:LNAV:EEPROM?

SIMulation:LNAV:ACTIVE?

SIMulation:LNAV:SELect <SYNTH | USER | LIVE>

SIMulation:LNAV:HEALTH <0|1>

SIMulation:GPGGA <int> [0,255]

SIMulation:GPRMC <int> [0,255]

SIMulation:NMEA <nmea string>

SIMulation?

6.3.1 SIMulation:MODE

The SIM:MODE command selects the simulation mode. Available options are Auto, Manual, Simulation, and Transcoding.

This command has the following format:

SIMulation:MODE <AUTO|MANUAL|SIM|TRANSCODE>

Please note that all modes except MANUAL will typically result in an RF output shortly after power up without user intervention. The following table summarizes each mode:

Simulation Mode	Description
AUTO	If NMEA data and 1PPS are present from an external receiver at power-up time, then start transcoding; otherwise start the configured simulation. This is the default mode.
MANUAL	No simulation from power up. SIM:COMmand must be used to start the simulation.
SIM	From power up or if simulation not running, start the configured simulation.
TRANSCODE	Wait for NMEA data and 1PPS from an external receiver via the RS-232 port, then start transcoding as NMEA data is being received.

6.3.2 SIMulation:COMmand

To control the RF output state, the SIMulation:COMmand allows both starting and stopping the output. The SIM:COM START command is required to start a simulation and enable RF output in the Manual simulation mode. The SIM:COM STOP command will stop the current simulation and change the simulation mode to Manual.

The command has the following format:

SIMulation:COMmand <START|STOP>

6.3.3 SIMulation:STATe?

This query responds with the current simulation state. Possible responses include:

STOPPED

DETECTING GPS

WAITING GPS FIX

WAITING PPS

STARTING

RUNNING

TRANSCODING

STOPPING

WAITING TIMER

The STOPPING and STARTING states each occur for only 0.1 seconds when transitioning to and from RUNNING, so they are unlikely but possible query responses. The RF output is disabled for all states except for RUNNING and TRANSCODING. The RUNNING or TRANSCODING states are indicated by the RF Active LED blinking at 5Hz. The WAITING GPS FIX and WAITING PPS are two states that occur before the TRANSCODING state. The WAITING TIMER state occurs before the RUNNING state when the SIM:TIME:MODE TIMER setting is enabled.

The DETECTING GPS, WAITING GPS FIX and WAITING PPS are states that occur before the TRANSCODING state. DETECTING GPS indicates that the required NMEA sentences (RMC or

ZDA and GGA) are not being received, or the external GPS receiver detection or configuration is not complete. WAITING GPS FIX means that the fix status in the NMEA data does not indicate a valid fix. Finally, WAITING PPS indicates that no external 1PPS is applied in the case of the GPS, EXTERNAL, or HOLDOVER sync source modes as described in Section 6.7.5 . When the NMEA data, valid fix and 1PPS conditions have been met, the unit will indicate the TRANSCODING state.

6.3.4 SIMulation:HOLDover:MODE

The simulation holdover mode controls the behavior when the external PVT reference indicates that position information is invalid while operating in Transcoding simulation mode.

The format of this command is:

SIMulation:HOLDover:MODE <OFF|ON|LIMIT>

When the LIMIT mode is selected, the limit time is specified with the SIM:HOLD:LIMIT command, and the RF output is disabled when the unit reaches the specified holdover time limit described in Section 6.3.6 . The SIM:HOLD:STATe? query responds with the current ON/OFF state of the holdover.

6.3.5 SIMulation:HOLDover:STATe?

This command responds with the current ON/OFF state of holdover when operating in transcoding simulation mode. The ON state indicates that the transcoding PVT is based on the local oscillator's holdover performance and/or the INS dead reckoning if operating in the INS simulation position filter mode.

6.3.6 SIMulation:HOLDover:LIMIT

This command specifies the limit in seconds that the holdover state should remain active in the Limit simulation holdover mode. The maximum limit is 1 day or 86400 seconds. Once this holdover limit is reached the RF output will be disabled. For longer holdover periods, use the ON simulation holdover mode.

The format of this command is:

SIMulation:HOLDover:LIMIT <int> [5,86400]

6.3.7 SIMulation:HOLDover:INDicate

This command selects the holdover indicate mode. With holdover indicate mode ON, the unit decreases the signal strength of the highest elevation satellite by 6dB to indicate that the holdover state is active. An amplitude reduction of 6dB should easily be distinguished as a significant reduction in SNR as reported by the target receiver, while still allowing that signal to be tracked and used in the PVT solution. If the highest elevation satellite changes during holdover then the reduced signal strength satellite will also change.

The format of this command is:

SIMulation:HOLDover:INDicate <ON|OFF>

6.3.8 SIMulation:POSition:MODE

This command sets the position mode to either the Fixed or Motion mode. The fixed position input is detailed in Section 6.3.9 and Section 6.3.10 , while the motion commands are detailed starting in Section 6.3.22 .

The format of this command is:

SIMulation:POSition:MODE <FIXed | MOTION>

6.3.9 SIMulation:POSition:LLH

This command specifies the current fixed position in Latitude, Longitude and Height (LLH) coordinates. Height is the GPS height or height above the reference ellipsoid and not height above Mean Sea Level (MSL).

The format of this command is:

SIMulation:POSition:LLH <lat>,<lon>,<alt>

where latitude and longitude are in degrees and altitude is in meters.

The fields are separated by commas. Up to two of the three parameters are optional. Parameters that are not present are not changed. For example, the command:

SIM:POS:LLH ,,1000.0

sets only the simulated altitude to 1000.0 meters, leaving the latitude and longitude unchanged from their previous settings.

The parameters are immediately applied to the position filter input, but the simulated position may change gradually over time depending upon the SIM:POS:FILTER... settings. Only if the simulation position filter mode is set to OFF will the fixed position be applied immediately as the simulated position. If the simulated position filter mode is set to ON, the position will traverse from the previous simulated position to the new position with the specified dynamics parameters for maximum jerk, maximum acceleration and maximum velocity. See Sections 6.3.14 to 6.3.16 for more details on the dynamics parameters that affect how the unit simulates a transition from one position to the next.

6.3.10 SIMulation:POSition:ECEF

This command specifies the current fixed position in Earth-Centered-Earth Fixed (ECEF) coordinates. The x,y,z parameters are in meters.

The format of this command is:

SIMulation:POSition:ECEF <x,y,z>

Unlike the SIM:POS:LLH command, all three x,y,z parameters are required.

6.3.11 SIMulation:POSition:FILTer:MODE

This command selects the position filtering mode that affects how the current input position (fixed position or external PVT source) is applied to the current simulation/transcoding position. See Section 3.8.8 for a more detailed description of the filter modes.

The format of this command is:

> SIMulation:POSition:FILTer:MODE <OFF | DYNAMIC>

The OFF mode causes the input position to be immediately applied to the simulated position. The DYNAMIC mode moves the simulation position to the input position gradually, limiting velocity, acceleration and jerk to maximum values specified in the VMAX, AMAX and JMAX parameters described below.

The DYNAMIC mode is configured for maximum dynamics using the VMAX, AMAX and JMAX parameters in the commands described in Sections 6.3.14 , 6.3.15 , and 6.3.16 .

6.3.12 SIMulation:POSition:FILTer:LLH?

This query command responds with the current filtered simulation position in LLH format.

6.3.13 SIMulation:POSition:FILTer:ECEF?

This query command responds with the current filtered simulation position in ECEF format.

6.3.14 SIMulation:POSition:FILTer:VMAX

This command specifies the maximum velocity used to configure the position filtering in DYNAMIC and INS position filtering modes. VMAX is then applied to move from the old simulated position to the new simulated position. VMAX is specified in m/s.

The format of this command is:

> SIMulation:POSition:FILTer:VMAX <float> [1.0,600.0]

6.3.15 SIMulation:POSition:FILTer:AMAX

This command specifies the maximum acceleration used to configure the position filtering in DYNAMIC and INS position filtering modes. AMAX is then applied to move from the old simulated position to the new simulated position. AMAX is specified in m/s^2.

The format of this command is:

> SIMulation:POSition:FILTer:AMAX <float> [0.1,40.0]

6.3.16 SIMulation:POSition:FILTer:JMAX

This command specifies the maximum jerk (change in acceleration) used to configure the position filtering in DYNAMIC and INS position filtering modes. JMAX is then applied to move from the old simulated position to the new simulated position. JMAX is specified in m/s^3

The format of this command is:

> SIMulation:POSition:FILTer:JMAX <float> [0.1,1000]

6.3.17 SIMulation:POSition:FILTer:VIN

This command specifies the input velocity filter constant used by the position filter in DYNAMIC position filtering mode. Adjusting this setting can affect the stability of the position filtering and should generally be left at the factory default setting.

The format of this command is:

SIMulation:POSition:FILTer:VIN <float> [0.0,1.0]

6.3.18 SIMulation:POSition:FILTer:VOUT

This command specifies the output velocity filter constant used by the position filter in DYNAMIC position filtering mode. Adjusting this setting can affect the stability of the position filtering and should generally be left at the factory default setting.

The format of this command is:

SIMulation:POSition:FILTer:VOUT <float> [0.0,1.0]

6.3.19 SIMulation:POSition:FILTer:POUT

This command specifies the output position filter constant used by the position filter in DYNAMIC position filtering mode. Adjusting this setting can affect the stability of the position filtering and should generally be left at the factory default setting.

The format of this command is:

SIMulation:POSition:FILTer:POUT <float> [0.0,1.0]

6.3.20 SIMulation:POSition:FILTer:DELay

This command specifies the position filter delay in seconds. Adjusting the delay can calibrate out position error at high velocities due to synchronization errors between the simulation time and position. A positive delay setting will advance the position along the current trajectory. A negative delay setting will set back the position along the current trajectory.

The format of this command is:

SIMulation:POSition:FILTer:DELay <float> [-1.0,1.0]

6.3.21 SIMulation:POSition:FILTer?

This query responds with the output from the following SIM:POS:FILT... queries:

SIM:POS:FILT:LLH?
SIM:POS:FILT:ECEF?
SIM:POS:FILT:MODE?
SIM:POS:FILT:VMAX?
SIM:POS:FILT:AMAX?
SIM:POS:FILT:JMAX?

SIM:POS:FILT:VIN?

SIM:POS:FILT:VOUT?

SIM:POS:FILT:POUT?

SIM:POS:FILT:DELAY?

6.3.22 SIMulation:POSition:MOTION:WRITE

This command writes one motion command into non-volatile memory starting at the storage location line number specified. The format of this command is:

SIMulation:POSition:MOTION:WRITE <line>,<command>

where <line> is the line number and <command> is the command string. Valid starting line numbers are 1 through 100. The final command must always be END which stops the RF output.

When a syntax error occurs with a motion command, a Command Error message is output and that motion command line is ignored. So it is useful to read back the stored commands using the SIM:POS:MOTION:READ command to verify that the correct motion commands have been stored.

6.3.23 SIMulation:POSition:MOTION:READ

This command reads back the motion commands stored starting at the specified storage location line until an END command is reached. The output motion commands follow the motion command syntax in Section 6.3.29 , but the format and precision levels of the values originally entered may have changed as the parameters are stored as floating-point numbers and not as the original command text.

The format of this command is:

SIMulation:POSition:MOTION:READ <line>

where <line> is the motion command storage line to start reading back (1 - 100).

6.3.24 SIMulation:POSition:MOTION:START

This command sets the start position in the motion command storage for playback during a simulation. The simulation will start at the motion command storage line specified by this command and continue until an END command is received or the end of the motion command storage area is reached. Note that in order to play back stored motion commands, the simulation position mode must be set to MOTION with the SIM:POS:MODE command detailed in Section 6.3.8 .

The format of this command is:

SIMulation:POSition:MOTION:START <line>

where <line> is the motion command storage line to start the simulation (1 - 100).

6.3.25 SIMulation:POSition:MOTION:STOP

This command stops the current motion command processing and stops the current simulation if in Manual simulation mode.

6.3.26 SIMulation:POSition:MOTION:PAUSE

This command pauses motion command processing and makes the current simulated position the previous simulated position.

6.3.27 SIMulation:POSition:MOTION:RESUME

This command resumes motion command processing after previously being paused with the SIM:POS:MOTION:PAUSE command.

6.3.28 SIMulation:POSition:MOTION:ZEROize

This command erases entire the motion command storage.

6.3.29 Simulation Motion Command Language

The Motion Command Language is designed to define the motion trajectory during the simulation using limits and specified dynamics. The dynamics specified in all commands are also subject to the maximum dynamics of the vehicle specified in the Dynamics (DYN) command. Because the Dynamics command can significantly affect the resulting motion defined by a series of commands, it is highly recommended that the Dynamics command be the first command in a series of Motion Commands. See Section 6.3.29.1 for a description of the Dynamics command. If no Dynamics command is received, the default dynamics parameters are taken from the filter dynamics parameters defined in the SIM:POS:FILTER... commands.

The Reference command specifies the starting location, heading and speed of the simulated motion. Again because this affects the remainder of the simulation, it is highly recommended to include the Reference command as the second command in a series of Motion Commands. See Section 6.3.29.2 for a description of the Reference command. If no Reference command is received, the default start position, velocity and heading is the fixed position defined in the SIM:POS:LLH command at zero velocity and heading north (0 degrees).

The commands that define the motion are processed sequentially for the required amount of time to complete the commanded motion. These commands include Straight, Accelerate, Turn, Climb, Waypoint, Combined Accelerate/Turn, Combined Turn/Climb, Goto, Halt, and End. The motion commands are processed until an END command is reached. At this point the simulation stops and the RF output is disabled.

6.3.29.1 Dynamics

The Dynamics command specifies the linear (in the direction of motion) and lateral (orthogonal to the direction of motion) dynamics limits for all motion. It is recommended that the Dynamics command be the first command in a series of motion commands. The Dynamics command can also be used in the middle of a sequence of Motion Commands to change the vehicle dynamics.

The format of this command is:

> DYN,<max linear speed>,<max linear accel>,<max linear jerk>,<max lateral accel>,<max lateral jerk>

where

<max linear speed> is in m/s,

<max linear accel> is in m/s^2,

<max linear jerk> is in m/s^3,

<max lateral accel> is in m/s^2, and

<max lateral jerk> is in m/s^3.

6.3.29.2 Reference

The Reference command specifies the starting position, velocity and heading. It should be used as the second Motion Command after the Dynamics command in a series of commands.

The format of this command is:

REF,<latitude>,<longitude>,<altitude>,<heading>,<speed>

where

<latitude> is in +/- degrees,

<longitude> is in +/- degrees,

<altitude> is in m above the ellipsoid,

<heading> is in degrees from north, and

<speed> is in m/s.

6.3.29.3 Straight

The Straight command specifies level (constant altitude) motion at the current heading and speed for the specified duration. The constant heading / great circle option controls if the path over a long distance will maintain a constant heading and spiral towards the poles, or if the path of the largest circle around the earth is followed. With a constant heading, the heading is only reversed 180 degrees when the north or south pole is reached.

The format of this command is:

STR,<duration><C|G>

where <duration> is in seconds, and C is constant heading and G is great circle.

6.3.29.4 Accelerate

The Accelerate command specifies a period of level motion at the current heading for the specified duration and positive or negative change in speed.

The format of this command is:

ACCEL,<duration>,<change in speed>

where <duration> is in seconds and <change in speed> is in m/s.

6.3.29.5 Turn

The Turn command specifies a period of level motion at the current speed with the specified heading change and lateral acceleration. The combination of the current speed and lateral acceleration will determine the radius of the curve and the time required to complete the turn.

The format of this command is:

TURN,<heading change>,<lateral acceleration>

where <heading change> is in degrees and <lateral acceleration> is in g (1 g = 9.81 m/s^2).

6.3.29.6 Climb

The Climb command specifies a period of increase or decrease in altitude at the current constant heading and speed. The parameters specified include the change in height, height rate, lateral acceleration at the start and lateral acceleration at the end.

The format of this command is:

CLIMB,<change in height>,<height rate>,<lateral accel start>,<lateral accel end>

where

<change in height> is in m,

<height rate> is in m/s,

<lateral accel start> is in m/s^2, and

<lateral accel end> is in m/s^2.

6.3.29.7 Waypoint

The Waypoint command specifies a final position and heading with changes in heading at a specified lateral acceleration at the current speed.

The format of this command is:

WAYPT,<latitude>,<longitude>,<altitude>,<final heading>,<lateral acceleration>

where

<latitude> is in degrees,

<longitude> is in degrees,

<altitude> is in m above the ellipsoid,

<final heading> is degrees from north (currently unused),

<lateral acceleration> is in m/s^2 (currently unused).

6.3.29.8 Combined Accelerate/Turn

The Combined Accelerate/Turn command specifies motion at a constant altitude at the current speeds that is a combination of accelerating linearly and turning. The parameters specified are heading change, lateral acceleration and change in speed. Since with a constant lateral acceleration, the turning radius is affected by the current speed and the current speed is changing with acceleration, the turning radius will also vary. The time required to complete the motion command is determined by the time required to complete the turn.

The format of this command is:

        ACCEL-TURN,<heading change>,<lateral acceleration>,<change in speed>

where

        <heading change> is in degrees,

        <lateral acceleration> is in g (1 g = 9.81 m/s^2), and

        <change in speed> is in m/s.

6.3.29.9 Combined Turn/Climb

The Combined Turn/Climb command specifies motion that is a combination of turning and climbing. The parameters specified are heading change, height change, height rate and lateral acceleration.

The format of this command is:

        TURN-CLIMB,<heading change>,<height change>,<height rate>,<lateral acceleration>

where

        <heading change> is in degrees,

        <height change> is in m,

        <height rate> is in m/s, and

        <lateral acceleration> is in m/s^2.

6.3.29.10 Halt

The Halt command specifies motion that ends at a specified location. Starting at the current speed and heading, the position changes as quickly as possible to the end location while limited to the maximum dynamics in the Dynamics command.

The format of this command is:

        HALT,<latitude>,<longitude>,<altitude>

where

        <latitude> is in degrees,

        <longitude> is in degrees, and

        <altitude) is in m above the ellipsoid.

6.3.29.11 Goto

The Goto command alters the motion command sequence by executing the command specified by the line number parameter.

The format of this command is:

        GOTO,<line>

        This command is useful for creating infinite motion simulations by specifying a previous line number.

6.3.29.12 End

The End command specifies the end of a sequence of Motion Commands and stops the simulation and RF output.

The format of this command is:

> END

6.3.30 SIMulation:POSition?

The SIM:POS? query combines the query responses from the following queries:

> SIM:POS:MODE?
>
> SIM:POS:LLH?
>
> SIM:POS:ECEF?
>
> SIM:POS:FILT:LLH?

6.3.31 SIMulation:TRACe

This command sets the output rate for the periodically generated statistics output for the simulation. The format of this command is:

> SIMulation:TRACe <interval>

where <interval> is the delay in seconds between simulation trace output in seconds. Zero indicates the simulation trace output is disabled.

The simulation trace output has the form:

> [yy-mm-dd] [hh:mm:ss.sss] [wn] [tow] [update count] [state] [sat count]

Where

> [yy-mm-dd] and [hh:mm:ss.sss] are the UTC date and time used in the simulation,
>
> [wn] and [tow] are the GPS week number and time of week,
>
> [update count] is the 10 Hz simulation update count starting at 0,
>
> [state] is the simulation state (see table below), and
>
> [sat count] is the number of satellites in the simulation.

Below is example output:

```
17-04-27 09:17:35.243 1946 379055.243 6166544 7 10
17-04-27 09:17:36.243 1946 379056.243 6166554 7 10
17-04-27 09:17:37.243 1946 379057.243 6166564 7 10
17-04-27 09:17:38.243 1946 379058.243 6166574 7 10
```

The state number is a numeric representation of the state response from the SIM:STATE? query as defined in the following table:

State	SIM:STATE? output
1	STOPPED
2	DETECTING GPS
4	WAITING GPS FIX
5	WAITING PPS
6	STARTING
7	RUNNING
8	STOPPING
9	TRANSCODING
10	WAITING TIMER

6.3.32 SIMulation:SV:VIEW?

This query responds with a list of the current satellites in view at the GPS RF output with one satellite per line and includes additional statistics. The format of the output is:

```
SV     AZ     EL         RHO    Doppler IODE     TOE
01  258.6   40.7   22011451.0  -1070.07    85  381600
06  127.6   61.0   20849785.2  -1582.25    90  381600
15  343.2   65.0   20704186.0    195.51    99  381600
19  217.7   47.4   21559605.7   2459.13   103  381600
24  117.4   32.3   22646533.1   2050.72   108  381600
20   46.0   40.6   22029195.3  -2617.34   104  381600
10  314.3   28.0   23029289.3   3055.80    94  381600
```

where SV is the PRN number, AZ is the azimuth in degrees, EL is the elevation in degrees, RHO is the distance in meters, Doppler is the frequency offset from L1 in Hz, IODE is the reference number for the current ephemeris, and TOE is the reference time-of-week in seconds for the current ephemeris.

6.3.33 SIMulation:SV:EXCLude

This command configures specific PRN numbers to be excluded from the simulation. PRNs must be excluded individually with separate SIM:SV:EXCL commands. PRNs can also be individually removed from the exclude list by specifying a negative PRN number. This parameter is stored in NV memory and automatically applied after power-on.

The format of this command is:

SIMulation:SV:EXCLude <+/-prn>

6.3.34 SIMulation:SV:PATHloss

This command sets enables or disables the attenuation of the satellite signal strength based on pathloss. Satellites farther from the user (i.e. satellites closer to the horizon) will be attenuated more. When pathloss is ON, signal power is reduced as a function of $1/d^2$.

The format of this command is:

SIMulation:SV:PATHloss <ON|OFF>

6.3.35 SIMulation:SV:ANTenna

This command sets the current selected antenna model. The default antenna model is UNITY. The following table summarizes each option:

Antenna Model	Description
UNITY	Gain of one in all directions
NORTH	North window view: satellites to south attenuated 20 dB
SOUTH	South window view: satellites to north attenuated 20 dB
EAST	East window view: satellites to west attenuated 20 dB
WEST	West window view: satellites to east attenuated 20 dB
PATCH	Typical patch antenna

The format of this command is:

SIMulation:SV:ANTenna <UNITY|NORTH|SOUTH|EAST|WEST|PATCH>

6.3.36 SIMulation:SV:MASK

This command sets the minimum elevation angle above the horizon for a satellite to be enabled. The mask angle can be configured with a negative angle, but most receivers will only use satellites above the horizon.

The format of the command is:

SIMulation:SV:MASK <mask angle>

where <mask angle> is the elevation mask angle in degrees from -90 to 90 degrees. This parameter is stored in NV memory and automatically applied after power-on. The default mask is 10 degrees.

6.3.37 SIMulation:SV:HEALTH

This command causes the health word for the specified satellite to be ANDed with the specified bitmask and OR'ed with the specified word prior to being emitted in the subframe data.

The format of this command is:

SIMulation:SV:HEALTH <sv 1-32> <mask 00-ff> <bits 00-ff>

The mask and bits parameters should be specified as two-digit hex values. The query SIM:SV:HEALTH? returns the current list of user-specified health values and masks for each satellite.

6.3.38 SIMulation:SV:ASflag

This command sets the Anti-Spoofing flag as broadcast in the satellite navigation data. Some target receivers including most SAASM receivers require the AS flag to be set in order to operate correctly.

The format of this command is:

SIMulation:SV:ASflag <0 | 1>

6.3.39 SIMulation:SV:HDOP?

This command queries and returns the Horizontal Dillution of Precision (HDOP) provided by the current simulation assuming that all transmitted satellites are received. The reported simulation HDOP may be lower (better) than reported by the target GPS receiver if some satellites are not being used, for example, because of a higher elevation mask angle configured on the target receiver.

6.3.40 SIMulation:SV:VDOP?

This command queries and returns the Vertical Dillution of Precision (VDOP) provided by the current simulation assuming that all transmitted satellites are received. The reported simulation VDOP may be lower (better) than reported by the target GPS receiver if some satellites are not being used, for example, because of a higher elevation mask angle configured on the target receiver.

6.3.41 SIMulation:SV:TDOP?

This command queries and returns the Time Dillution of Precision (TDOP) provided by the current simulation assuming that all transmitted satellites are received. The reported simulation TDOP may be lower (better) than reported by the target GPS receiver if some satellites are not being used, for example, because of a higher elevation mask angle configured on the target receiver.

6.3.42 SIMulation:SV:TRACe

This command enables the trace output for an individual satellite at a 10 Hz serial output rate. Only one satellite can be enabled at one time and setting the selected PRN to 0 will disable the output. Also, the satellite must be in view for the output to be enabled. Use the SIM:SV:VIEW? query to determine which satellites are in view.

The format of this command is:

SIMulation:SV:TRACe <prn>

where <prn> is the satellite PRN number 1 to 32 or 0 for none. This parameter is stored in NV memory and automatically applied after power-on.

6.3.43 SIMulation:SV?

This query command will output the query results from the following queries:

SIM:SV:EXCL?
SIM:SV:MASK?

SIM:SV:TRAC?

6.3.44 SIMulation:TIME:MODE

This command sets the simulation Time mode of the when running in Simulation mode. When using the ASSIGNED time mode, the simulation will always start with the time and date assigned with the SIM:TIME:START... commands.

When using the CONTINUOUS time mode, the simulation will use the current time provided by an external GNSS receiver or UTC time manually set with the GPS:INIT:TIME and GPS:INIT:DATE commands. If the current time has not been set, then the time will be set to the value set by the SIM:TIME:START... commands at the beginning of first simulation run. If the simulation is stopped and started again the selected set time will be propagated by the local clock.

When using the REFERENCE time mode, the simulation will use the time provided by the external GPS reference.

When using the TIMER mode, the simulation will delay start until the current system date and time as reported by the PTIME? response matches the start date and time defined by the SIM:TIME:START:TIME and SIM:TIME:START:DATE commands described below. The simulation state as reported by the SIM:STATE? response will be WAITING TIMER before the system date/time and simulation state date/time match. The precision of the simulation start is within +/- 100 ms.

The format of this command is:

SIMulation:TIME:MODE <ASSIGNed|CONTinuous|REFerence|TIMer>

This parameter is stored in NV memory and automatically applied after power-on. Changing the configured time mode is only allowed when the simulation is stopped.

6.3.45 SIMulation:TIME:START:TIME

This command sets the fixed UTC start time used in the simulation when the simulation Time mode is set to Fixed. The GPS receiver time will reflect this value when the simulation begins. This parameter is stored in NV memory and automatically applied after power-on.

The format of this command is:

SIMulation:TIME:START:TIME hh,mm,ss.sss

6.3.46 SIMulation:TIME:START:DATE

This command sets the fixed start date of the simulation when in the simulation Time mode is set to Fixed. The GPS receiver will indicate the this time when the simulation begins. This parameter is stored in NV memory and automatically applied after power-on.

The format of this command is:

SIMulation:TIME:START:DATE yyyy,mm,dd

6.3.47 SIMulation:TIME:LEAPsecond:ACCumulated

This command sets the current UTC to GPS time offset in seconds and provides a simplified method of setting the UTC correction parameters in the SIM:TIME:UTC... commands. This parameter is stored in NV memory and automatically applied after power-on.

When using Transcoding simulation mode or Reference simulation time mode and the time reference is provided by an external ublox GNSS receiver, the SIMulation:TIME:LEAPsecond parameters are automatically updated when the current and pending leap second data is available. This allows the target GPS receiver to maintain the correct UTC time during a leap second event without manually entering the leapsecond data with the SCPI interface.

The format of this command is:

> SIMulation:TIME:LEAPsecond:ACCumulated <seconds>

6.3.48 SIMulation:TIME:LEAPsecond:DATE

This command sets the date of the next or previous pending leap second. If the date is after the simulation time, then a leap second is pending and will be simulated. This command provides a simplified method of setting the UTC correction parameters in the SIM:TIME:UTC... commands. This parameter is stored in NV memory and automatically applied after power-on.

The format of this command is:

> SIMulation:TIME:LEAPsecond:DATE yyyy,mm,dd

6.3.49 SIMulation:TIME:LEAPsecond:DURation

This command sets the duration of a pending leap second event. Valid values are 59, 60 and 61. If no leap second is pending, the value should be set to 60. This command provides a simplified method of setting the UTC correction parameters in the SIM:TIME:UTC... commands. This parameter is stored in NV memory and automatically applied after power-on.

The format of this command is:

> SIMulation:TIME:LEAPsecond:DURation <seconds>

6.3.50 SIMulation:TIME:LEAPsecond?

This query command will output the query results from the following queries:

> SIM:TIME:LEAP:ACC?
>
> SIM:TIME:LEAP:DATE?
>
> SIM:TIME:LEAP:DUR?

6.3.51 SIMulation:TIME:UTCoffset:A0

This command specifies the UTC offset parameter A0. This parameter is stored in NV memory and automatically applied after power-on. The parameter is defined in the IS-GPS-200 specification.

The format of this command is:

SIMulation:TIME:UTCoffset:A0 <a0>

6.3.52 SIMulation:TIME:UTCoffset:A1

This command specifies the UTC offset parameter A1. This parameter is stored in NV memory and automatically applied after power-on. The parameter is defined in the IS-GPS-200 specification.

The format of this command is:

SIMulation:TIME:UTCoffset:A1 <a1>

6.3.53 SIMulation:TIME:UTCoffset:DELTATLS

This command specifies the UTC offset parameter DELTATLS. This parameter is stored in NV memory and automatically applied after power-on. The parameter is defined in the IS-GPS-200 specification.

The format of this command is:

SIMulation:TIME:UTCoffset:DELTATLS <deltatls>

6.3.54 SIMulation:TIME:UTCoffset:TOT

This command specifies the UTC offset parameter TOT. This parameter is stored in NV memory and automatically applied after power-on. The parameter is defined in the IS-GPS-200 specification.

The format of this command is:

SIMulation:TIME:UTCoffset:TOT <tot>

6.3.55 SIMulation:TIME:UTCoffset:WNT

This command specifies the UTC offset parameter WNT. This parameter is stored in NV memory and automatically applied after power-on. The parameter is defined in the IS-GPS-200 specification.

The format of this command is:

SIMulation:TIME:UTCoffset:WNT <wnt>

where wnt is a GPS week number (not mod 256 or 1024).

6.3.56 SIMulation:TIME:UTCoffset:WNLSF

This command specifies the UTC offset parameter WNLSF. This parameter is stored in NV memory and automatically applied after power-on. The parameter is defined in the IS-GPS-200 specification.

The format of this command is:

SIMulation:TIME:UTCoffset:WNLSF <wnlsf>

where wnt is a GPS week number (not mod 256 or 1024).

6.3.57 SIMulation:TIME:UTCoffset:DN

This command specifies the UTC offset parameter DN. This parameter is stored in NV memory and automatically applied after power-on. The parameter is defined in the IS-GPS-200 specification.

The format of this command is:

SIMulation:TIME:UTCoffset:DN <dn>

6.3.58 SIMulation:TIME:UTCoffset:DELTATLSF

This command specifies the UTC offset parameter DELTATLSF. This parameter is stored in NV memory and automatically applied after power-on. The parameter is defined in the IS-GPS-200 specification.

The format of this command is:

SIMulation:TIME:UTCoffset:DELTATLSF <deltatlsf>

6.3.59 SIMulation:TIME:UTCoffset?

This query command returns the response of the following individual queries:

SIM:TIME:UTC:A0?

SIM:TIME:UTC:A0?

SIM:TIME:UTC:DELTATLS?

SIM:TIME:UTC:TOT?

SIM:TIME:UTC:WNT?

SIM:TIME:UTC:DN?

SIM:TIME:UTC:DELTATLSF?

6.3.60 SIMulation:TIME:CALibrate

This command sets a time offset in nanoseconds for the timing simulation. Normally this offset can be set to zero, but nonzero values can be used to compensate for constant timing offsets in the external GPS reference or to precisely calibrate internal hardware delays. A positive time offset results in moving the simulation time forward, while a negative time offset delays simulation time.

The format of this command is:

SIMulation:TIME:CALibrate <float> [-2000000000.0,2000000000.0]

6.3.61 SIMulation:TIME:FREQuency

This command sets a frequency offset in parts per billion for the timing simulation. Normally this offset should be set to zero, but nonzero values can be used for some simulation tests to simulate a jump in frequency in the target receiver's oscillator, for example.

The format of this command is:

SIMulation:TIME:FREQuency <float> [-1000.0,1000.0]

6.3.62 SIMulation:TIME?

This query command returns the response of the following individual queries:

SIM:TIME:MODE?

SIM:TIME:START:TIME?

SIM:TIME:START:DATE?

6.3.63 SIMulation:IONosphere:A

This command configures the a0 through a3 ionospheric parameters that are part of the GPS navigation message. This parameter is stored in NV memory and automatically applied after power-on. The parameter is defined in the IS-GPS-200 specification.

The format of this command is:

SIMulation:IONosphere:A <a0>,<a1>,<a2>,<a3>

6.3.64 SIMulation:IONosphere:B

This command configures the b0 through b3 ionospheric parameters that are part of the GPS navigation message. This parameter is stored in NV memory and automatically applied after power-on. The parameter is defined in the IS-GPS-200 specification.

The format of this command is:

SIMulation:IONosphere:B <b0>,<b1>,<b2>,<b3>

6.3.65 SIMulation:IODCmsb

This command sets the 2 Most Significant Bits (MSBs) of the 10-bit IODC field of the GPS navigation data. The remaining 8 Least Significant Bits (LSBs) are set equal to the IODE field for each satellite ephemeris.

The format of this command is:

SIMulation:IODCmsb <int> [0,3]

6.3.66 SIMulation:LNAV:IONosphere

The SIM:LNAV:IONosphere command supports the transmission of user-specified ionospheric/UTC correction parameters to the simulator for storage in nonvolatile memory.

The format of this command is:

SIMulation:LNAV:IONosphere <subframe> <word> <data>

The following describes the parameters accepted by SIM:LNAV:IONosphere:

<subframe> The GPS LNAV subframe number to be addressed by the command. Subframe numbers range from 1 to 5, inclusive, corresponding to the subframes described in IS-GPS-200H Appendix II ("GPS NAVIGATION DATA STRUCTURE FOR LNAV DATA"). Currently the supported only subframe number is 4.

<word> The starting word position within the subframe at which the <data> will be written. Supported word positions range from 2 through 9 inclusive, based on an initial index of zero.

<data> A series of consecutive 24-bit hexadecimal values to be written to the subframe beginning at the specified <word>. Each 24-bit value consists of six ASCII hex characters (nibbles). No spaces or other characters should appear anywhere within the <data> string. Up to eight 24-bit values may be specified as long as the final <word> position does not exceed the maximum index (9).

An example of this command is:

SIM:LNAV:ION 4 2 780502FFFF2603FFFB000003000000034EA8120000000000

6.3.67 SIMulation:LNAV:EPHemeris

The SIM:LNAV:EPHemeris command supports the transmission of user-specified ephemeris parameters to the simulator for storage in nonvolatile memory.

The format of this command is

SIMulation:LNAV:EPHemeris <prn> <subframe> <word> <data>

The following describes the parameters accepted by SIM:LNAV:ION:

<prn> The destination satellite identified by its PRN number (1-32 inclusive).

<subframe> The GPS LNAV subframe number to be addressed by the command. Subframe numbers range from 1 to 5, inclusive, corresponding to the subframes described in IS-GPS-200H Appendix II ("GPS NAVIGATION DATA STRUCTURE FOR LNAV DATA"). Supported subframes range from 1 to 3 inclusive.

<word> The starting word position within the subframe at which the <data> will be written. Supported word positions for subframes 2 and 3 range from 2 through 9 inclusive, based on an initial index of zero. Supported word positions for subframe 1 are 2, 6, 7, 8, and 9.

<data> A series of consecutive 24-bit hexadecimal values to be written to the subframe beginning at the specified <word>. Each 24-bit value consists of six ASCII hex characters (nibbles). No spaces or other characters should appear anywhere within the <data> string. Up to eight 24-bit values may be specified as long as the final <word> position does not exceed the maximum index (9).

Data written by SIM:LNAV:EPHemeris is stored in a temporary RAM buffer on the simulator platform. Once a complete set of ephemerides have been transmitted to the simulator, they must be committed to EEPROM storage by issuing a SIM:LNAV:WRITE command.

An example of this command is:

SIM:LNAV:EPH 1 1 2 EA1000
SIM:LNAV:EPH 1 1 6 00000C0F2A3000FFFD076908
SIM:LNAV:EPH 1 2 2 0FFE193088C04D8C00FE13038C40781046A10D74D62A3000
SIM:LNAV:EPH 1 3 2 002B6B8EB403FFD7277453311CDD18355339FFA9590F1238

6.3.68 SIMulation:LNAV:WRITE

The SIM:LNAV:WRITE command must be issued to store the ionospheric/UTC parameters and ephemerides most recently uploaded by SIM:LNAV:ION and SIM:LNAV:EPH to nonvolatile (EEPROM) memory. After issuing SIM:LNAV:WRITE, the command SIM:LNAV:SELECT USER may be transmitted to select the uploaded navigation data for simulation.

6.3.69 SIMulation:LNAV:EEPROM?

The SIM:LNAV? query returns a list of all ionospheric/UTC and ephemeris parameters stored in EEPROM. The 24-bit words are returned one at a time in the form of individual SIM:LNAV:EPH and SIM:LNAV:ION commands.

6.3.70 SIMulation:LNAV:ACTIVE?

The SIM:LNAV? query returns a list of all ionospheric/UTC and ephemeris parameters actively used in the current simulation. The 24-bit words are returned one at a time in the form of individual SIM:LNAV:EPH and SIM:LNAV:ION commands.

6.3.71 SIMulation:LNAV:SELect

The SIM:LNAV:SELect command determines whether internally-generated navigation data or user-uploaded navigation data is used for simulation. The format of this command is:

> SIMulation:LNAV:SELect <SYNTH | USER | LIVE>

SYNTH mode selects the internally generated synthesized constellation with circular orbits and precisely 12 hour orbit periods. This is the default mode.

USER mode selects the user-uploaded ephemeris and ionospheric/UTC parameters.

LIVE mode selects ephemeris, almanac and ionospheric/UTC parameters received from the external GPS receiver in Novatel binary command format.

6.3.72 SIMulation:LNAV:HEALTH

This query returns the current health override flag value.   0 is the default, indicating that the health words are modified with the bitmasks and values provided to the SIMulation:SV:HEALTH command, while a value of 1 causes the ephemeris and almanac health values to be used without modification.

The format of this command is:

> SIMulation:LNAV:HEALTH <0|1>

6.3.73 SIMulation:GPGGA

This command instructs the RSR GNSS Transcoder™ to send the NMEA standard string $GPGGA every N seconds, with N in the interval [0,255]. The output GPGGA sentence uses the simulated time and position data and is useful for comparison with PVT data output from the target GPS receiver. The GPGGA output is only enabled when the simulation state is RUNNING or TRANSCODING.

This command has the following format:

SIMulation:GPGGA <int> [0,255]

GPGGA shows height in MSL Meters; this is different from traditional GPS receivers that display height in GPS Meters. The difference between MSL and GPS height can be significant, with 35m or larger discrepancies being common.

6.3.74 SIMulation:GPRMC

This command instructs the RSR GNSS Transcoder to send the NMEA standard string $GPRMC every N seconds, with N in the interval [0,255]. The output GPRMC sentence uses the simulated time and position data and is useful for comparison with PVT data output from the target GPS receiver. The GPRMC output is only enabled when the simulation state is RUNNING or TRANSCODING.

This command has the following format:

SIMulation:GPRMC   <int> [0,255]

6.3.75 SIMulation:NMEA <nmea string>

This command is used to accept NMEA data over the SCPI port. For this command to work, the GPS:PORT setting must be SCPI as described in Section 6.10.29 .

6.4 SIMulation?

This query responds with the output from the following SIM... queries:

SIM:MODE?

SIM:STATE?

SIM:HOLD:MODE?

SIM:HOLD:STATE?

SIM:HOLD:LIMIT?

SIM:HOLD:IND?

SIM:TRACe?

This query also returns the firmware version, FPGA version, and FPGA diagnostics code.

6.5 Output Subsystem

The commands in the OUTPUT subsystem control various features of the GPS RF and 10MHz output, as well as the built-in RF synthesizer functionality. The list of commands supported is the following:

OUTput:TEST <OFF | SWEEP | TONE | TWOTONE | RAND>

OUTput:DCBlock

OUTput:POWer <power> dBm

OUTput:OFFset <offset> dBm

OUTput:10Mhz <ON | OFF>

OUTput?

6.5.1 OUTput:TEST

This command enables the test signal mode on the SMA RF output that can be used for calibration, spectrum analyzer tests, RF front-end testing or as a jamming test signal. The signal amplitude of the test signal can typically be set as high as -85 dBm. The RF power level is set with the OUT:POWer command.

The format of this command is:

OUTput:TEST <OFF | SWEEP | TONE | TWOTONE | RAND>

The following table describes each of the test modes:

Antenna Model	Description
OFF	Default setting for normal GPS signal output
SWEEP	Single CW tone, swept +/- 1.023 MHz either side of 1,575.42 MHz over approximately 30 seconds
TONE	Single CW tone at 1,575.42 MHz
TWOTONE	Two CW tones spaced approximately +/- 50 kHz either side of 1,575.42 MHz. Each tone has 6 dB lower amplitude than the OUT:POWER setting.
RAND	Baseband (complex) white noise generated by two independent maximal-length shift registers with cycle times of approximately 30 minutes

6.5.2 OUTput:DCBlock

This command is not supported on the RSR GNSS Transcoder™. The RF output is always DC-coupled and has a 186-ohm load resistor to ground to simulate an industry-standard GPS antenna load for the target receiver. To avoid damage to the RSR GNSS Transcoder™'s internal load resistor, an external DC block rated for operation at 1.5 GHz *must* be used in line with the antenna connection when the receiver supplies more than 6V at its antenna port.

6.5.3 OUTput:POWer?

This command sets the power level at the RF output jack on an individual satellite basis. The valid range is -105 dBm to -125 dBm plus the current OUT:OFFset setting. For example if an external 10 dB attenuator is attached to the RF output and OUT:OFFset is set to -10 dB, then the valid range for the OUTput:POWer? command is -115 to -135 dBm. Similarly, if a 10 dB amplifier is connected to the RF output, and the OUT:OFFset is set to +10 dB then the valid range for OUTput:POWer command is -95 to -115 dBm.

The OUT:POWer command sets the simulator's RF output power from the perspective of a single satellite, not the entire constellation. When N satellites are transmitting, the total RF output power will be approximately $10*\log_{10}N$ dB greater than specified.

The nominal output power of a live GPS satellite signal at the surface of the earth is typically about -125 dBm, but is often a few dB higher to allow for a reduction in power as the satellite ages. Additionally, target GPS receivers often expect to be used with an amplified antenna, so the output power is typically set higher than -125 dBm for optimum performance of the target GPS receiver.

The format of this command is:

OUTput:POWer <power> dBm

This parameter is stored in NV memory and automatically applied after power-on. The dBm nomenclature is optional.

6.5.4 OUTput:OFFset

This command sets the output power offset to compensate for an external attenuator (negative offset) or amplifier (positive offset). The offset value adjusts the value provided to the OUT:POWer command so that the true output power from the RF signal chain including the attenuator or amplifier matches that of the OUT:POWer setting. The format of this command is:

OUTput:OFFset <offset> dBm

The dBm nomenclature is optional.

The offset also affects the valid range of the OUTput:POWer command setting.

6.5.5 OUTput:10Mhz

This command enables/disables the buffered 10 MHz internal oscillator CMOS output on J4 pin 12. By default the output is disabled to reduce noise and power consumption and must be enabled with the ON setting. The format of this command is:

OUTput:10Mhz <ON | OFF>

This parameter is stored in NV memory and automatically applied after power-on.

6.5.6 OUTput?

This query command outputs the query responses from the following separate queries:

OUT:POWer?

OUT:OFFset?

OUT:10MHz?

6.6 Calibration Subsystem

The Calibration Subsystem is used for factory calibration of the output power and should not be user-modified. Please contact JLT for information on recalibrating the output power.

6.7 SYNChronization Subsystem

This subsystem groups the commands related to the phase and frequency synchronization of the RSR GNSS Transcoder™ with the GPS receiver. The list of the commands supported for this subsystem is the following:

SYNChronization:SOURce:MODE <GPS | EXTernal | NMEA | HOLDover>

SYNChronization:SOURce:STATE?

SYNChronization:HOLDover:DURation?

SYNChronization:HOLDover:STATe?

SYNChronization:HOLDover:INITiate

SYNChronization:HOLDover:RECovery:INITiate

SYNChronization:OUTput:1PPS:RESET [ON|OFF]

SYNChronization:TINTerval?

SYNChronization:TINTerval:THReshold [50,2000]

SYNChronization:IMMEdiate

SYNChronization:FEEstimate?

SYNChronization:LOCKed?

SYNChronization:HEAlth?

SYNChronization?

6.7.1 SYNChronization:HOLDover:STATe?

This query returns the current holdover state with possible responses being NONE, MANUAL, or ON. NONE indicates the holdover state is off. MANUAL indicates the holdover is manually enabled with the SYNC:HOLD:INIT command. ON indicates that holdover is enabled due to lack of external GNSS receiver 1PPS or valid GNSS fix.

6.7.2 SYNChronization:HOLDover:DURation?

This query returns the duration of the present or most recent period of operation in the holdover. This is the length of time the reference oscillator was not locked to the external GNSS receiver 1PPS, and is thus "coasting". The first number in the response is the holdover duration. The duration units are seconds, and the resolution is 1 second. If the receiver is in holdover, the response quantifies the current holdover duration. If the receiver is not in holdover, the response quantifies the length of the previous holdover. The second number in the response identifies the holdover state. A value of 0 indicates that the receiver is not in holdover; a value of 1 indicates that the Receiver is in holdover.

6.7.3 SYNChronization:HOLDover:INITiate

The SYNC:HOLD:INIT and SYNC:HOLD:REC:INIT commands allow the user to manually enter and exit the holdover state, even while GNSS signals are still being properly received. This forced-holdover allows the unit to effectively disable GNSS disciplining of the internal oscillator, while still keeping track of the state of the 1PPS output in relation to the UTC 1PPS signal as

generated by the GNSS receiver. When the unit is placed into forced-holdover with this command, the unit will indicate the time interval difference between the 1PPS output and the GNSS receiver 1PPS by using the SYNC:TINT? command up to a limit of +/-2000ns. This allows the user to see the oscillator drift when not locked to GNSS signals for testing purposes, or to prevent the GNSS receiver from being spoofed and affecting the oscillator frequency accuracy. All other frequency-disciplining functions of the unit will behave as if the GNSS antenna was disconnected from the unit while in this forced-holdover state.

6.7.4 SYNChronization:HOLDover:RECovery:INITiate

This command will disable the forced holdover state (see the SYNC:HOLD:INIT command). The unit will resume normal GNSS disciplining operation after this command has been sent.

6.7.5 SYNChronization:SOURce:MODE

This command selects between the EXTernal, GPS, NMEA and HOLDover sync modes. Both the EXTernal and GPS modes use the same 1PPS input for disciplining the oscillator and synchronizing precise timing, but the GPS mode also gates the 1PPS based on the GNSS status of the external receiver as indicated in the NMEA serial sentences from the GNSS receiver. The External mode uses the 1PPS reference input to synchronize precise timing and discipline the oscillator regardless of the GNSS status.

The NMEA sync mode uses the NMEA input to synchronize the system time to millisecond-level precision. The NMEA sync mode is required to transcode in the absence of an externally-supplied 1PPS reference signal.

The Holdover sync mode uses the 1PPS reference input only to synchronize the system time to nanosecond-level precision, but does not discipline the oscillator. The Holdover sync mode is useful when the 1PPS available is not stable enough discipline the oscillator or be used as a continuous timing reference for simulation.

The format of this command is:

SYNChronization:SOURce:MODE <GPS | EXTernal | NMEA | HOLDover>

6.7.6 SYNChronization:SOURce:STATE?

This command is implemented, but always reports the same state as the SYNC:SOUR:MODE command setting in the RSR GNSS Transcoder™.

6.7.7 SYNChronization:TINTerval?

This query returns the difference or timing shift between the RSR GNSS Transcoder™ internal oscillator 1PPS phase and the externally-supplied 1PPS reference phase. The resolution is 1E-010 seconds.

6.7.8 SYNChronization:TINTerval:THReshold [50,2000]

This command selects the oscillator 1PPS phase-offset threshold as compared to the reference 1PPS at which point the unit will initiate a counter-reset (jam-sync) aligning the oscillator generated 1PPS with the reference 1PPS phase. The oscillator phase is slowly and continuously adjusted toward 0ns offset to the externally-supplied reference 1PPS phase as long as the phase difference is less than the THReshold phase limit. The oscillator generated 1PPS phase is allowed to drift up to this threshold before a jam-sync is initiated. The default setting is 220ns, allowing a drift of up to +/-220ns. Reaching this selected threshold will cause a jam-sync phase-normalization to be initiated, which will reset the counter phase that generates the internal 1PPS output. It will also cause the SYNC:HEAlth? Status to indicate 0x200, and the lock status to become "unlocked". By selecting a larger phase window the user can prevent these phase resets (jam-syncs) of the output 1PPS from happening too frequently in environments where airflow or thermal changes are expected, especially on units without the CSAC option.

6.7.9 SYNChronization:IMMEdiate

This command initiates a near-instantaneous alignment of the GNSS 1PPS and Receiver output 1PPS phases. To be effective, this command has to be issued while the unit is not in holdover.

6.7.10 SYNChronization:FEEstimate?

This query returns the Frequency Error Estimate, similar to the Allan Variance using a 1000s measurement interval, by comparing the internal 1PPS to GNSS 1PPS phase offset.

Values less than 1E-012 are below the noise floor, and are not significant.

6.7.11 SYNChronization:LOCKed?

This query returns the lock state (0=OFF, 1=ON) of the PLL controlling the TCXO.

6.7.12 SYNChronization:OUTput:1PPS:RESET [ON|OFF]

This command allows the generation of the 1PPS output pulse upon power-on without an external GNSS receiver being connected to the unit. By default the unit does not generate a 1PPS pulse until the GNSS receiver has locked onto the satellites. With the command SYNC:OUT:1PPS:RESET ON the unit can be configured to generate an asynchronous 1PPS output after power-on even if a GNSS antenna is not connected to the unit. The ON setting will also allow the NMEA output strings to be generated in the absence of an externally-provided 1PPS reference input. Once the GNSS receiver locks, the 1PPS pulse will align itself to UTC by stepping in 10 equally spaced steps toward UTC alignment. The default setting is OFF which means the 1PPS pulse is disabled until proper external reference GNSS lock is achieved. Changing this setting requires a reset or power-cycle for the new setting to become effective.

6.7.13 SYNChronization:HEAlth?

The SYNChronization:HEAlth? query returns a hexadecimal number indicating the system's health status. Error flags are encoded in a binary fashion so that each flag occupies one single bit of the binary equivalent of the hexadecimal health status flag. This allows for easy query and fully-orthogonal status indications using only one single hex parameter.

The following system parameters are monitored and indicated through the health-status indicator. Individual parameters are 'ored' together which results in a single hexadecimal value encoding the following system status information:

If the TCXO coarse-DAC is maxed-out at 255	HEALTH STATUS |= 0x1;
If the TCXO coarse-DAC is mined-out at 0	HEALTH STATUS |= 0x2;
If the phase offset to UTC is >250ns	HEALTH STATUS |= 0x4;
If the run-time is < 300 seconds	HEALTH STATUS |= 0x8;
If the GNSS receiver is in holdover > 60s	HEALTH STATUS |= 0x10;
If the Frequency Estimate is out of bounds	HEALTH STATUS |= 0x20;
If the supply voltage is too high	HEALTH STATUS |= 0x40;
If the supply voltage is too low	HEALTH STATUS |= 0x80;
If the short-term-drift (ADEV @ 100s) > 100ns	HEALTH STATUS |= 0x100;
For the first 3 minutes after a phase reset, or a coarse DAC change:	HEALTH STATUS |= 0x200;
If the GNSS receiver indicates a strong jamming signal of >=50 (range is 0 to 255) (supported only on uBlox external receivers)	HEALTH STATUS |= 0x800;
If FPGA error occurs	HEALTH STATUS |= 0x2000;
If simulation update timeouts occur	HEALTH STATUS |= 0x4000;
If internal GPS receiver C/No values out of range (>2dB error)	HEALTH STATUS |= 0x8000;
If internal GPS receiver position out of range (>10 meters)	HEALTH STATUS |= 0x10000;
If internal GPS receiver 1PPS timing out of range (>100 ns)	HEALTH STATUS |= 0x20000;
If internal GPS receiver has not achieved lock after 100 seconds	HEALTH STATUS |= 0x40000;

As an example, if the unit is in GNSS receiver holdover, and the voltage is too high, and the UTC phase offset is > 250ns then the following errors would be indicated:

1) UTC phase > 250ns: 0x4

2) Voltage too high: 0x40

3) GNSS receiver in holdover: 0x10

'Oring' these values together results in:

  0x40 | 0x10 | 0x4 = 0x54

The unit would thus indicate: HEALTH STATUS: 0x54

A health status of 0x0 indicates a properly locked, and warmed-up unit that is completely healthy and has no flagged events.

6.7.14 SYNChronization?

This query returns the results of these four queries:

> SYNChronization:SOURce:MODE?
>
> SYNChronization:SOURce:STATE?
>
> SYNChronization:LOCKed?
>
> SYNChronization:HOLDover:DURation?
>
> SYNChronization:health?

6.8 DIAGnostic Subsystem

This subsystem groups the queries related to the diagnostic of the internal oscillator. The list of the commands supported for this subsystem is as follows:

> DIAGnostic:ROSCillator:EFControl:RELative?
>
> DIAGnostic:ROSCillator:EFControl:ABSolute?
>
> DIAGnostic:LIFetime:COUNt?

6.8.1 DIAGnostic:ROSCillator:EFControl:RELative?

This query returns the Electronic Frequency Control (EFC) output value of the internal reference oscillator. It returns a percentage value between -100% to +100%.

6.8.2 DIAGnostic:ROSCillator:EFControl:ABSolute?

This query returns the Electronic Frequency Control (EFC) output value of the internal reference oscillator. It returns a value in volts.

6.8.3 DIAGnostic:LIFetime:COUNt?

This command returns the number of hours the unit has been powered-on.

6.9 MEASURE Subsystem

This subsystem groups the queries related to some parameters that are measured on-board on the RSR GNSS Transcoder™. The list of the commands supported for this subsystem is the following:

> MEASure:TEMPerature?
>
> MEASure:VOLTage?
>
> MEASure:POWersupply?

MEASure:POWersupply:V12?

MEASure:POWersupply:V25?

MEASure:CURRent?

MEASure?

6.9.1 MEASure:TEMPerature?

This query returns the internal CSAC temperature if the optional CSAC is enabled.

6.9.2 MEASure:VOLTage?

This query returns the TCXO EFC voltage for units without optional CSAC, and the CSAC telemetry internal TCXO EFC voltage for units with optional CSAC.

6.9.3 MEASure:POWersupply?

This query returns the power supply voltage applied to the prime-power input (~7V to 36V).

6.9.4 MEASure:POWersupply:V12?

This query returns the internally regulated 1.2V supply voltage.

6.9.5 MEASure:POWersupply:V25?

This query returns the internally regulated 2.5V supply voltage.

6.9.6 MEASure:CURRent?

This command is included for backwards compatibility and responds with the CSAC temperature if the optional CSAC is enabled.

6.9.7 MEASure?

This query returns the result of the two following queries:

MEASure:TEMPerature?

MEASure:VOLTage?

MEASure:POWersupply?

MEASure:POWersupply:V12?

MEASure:POWersupply:V25?

6.10 GPS Subsystem

Note: Please note that the RSR GNSS Transcoder displays antenna height in GPS height in meters on the SCPI port rather than in MSL height on all commands that return antenna height except for standard NMEA output sentences with fields defined as MSL height. This corresponds with the GPS height input for all altitude input in the Simulation options.

The GPS subsystem includes all of the commands related to the control and status of an external GNSS receiver. Some of these commands are supported with a Generic GPS type, while other commands are supported only with the uBlox or Rockwell GPS types. Please see Section 6.10.1 for details on setting and querying the GPS type.

The list of the commands supported by Generic receivers is the following:

> GPS:TYPE?
>
> GPS:TYPE:MODE <AUTO | UBLOX | ROCKWELL | NMEA>
>
> GPS:SATellite:TRAcking:COUNt?
>
> GPS:SATellite:VISible:COUNt?
>
> GPS:GPGGA <int> [0,255]
>
> GPS:GPRMC <int> [0,255]
>
> GPS:GPZDA <int> [0,255]
>
> GPS:GPGSV <int> [0,255]
>
> GPS:PASHR <int> [0,255]
>
> GPS:HEIGHT?
>
> GPS:HEIGHT:MSL?
>
> GPS:HEIGHT:GPS?
>
> GPS:INITial:DATE <yyyy,mm,dd>
>
> GPS:INITial:TIME <hour,min,sec>
>
> GPS:PORT <SCPI | RS232>
>
> GPS:PPSERRor?
>
> GPS:POSERRor?
>
> GPS:VPOSERRor?
>
> GPS?

The list of commands supported by externally-connected uBlox and Rockwell GNSS receivers is the following:

> GPS:REFerence:PULse:SAWtooth?
>
> GPS:RESET ONCE
>
> GPS:FWver?

The list of commands supported only by externally-connected uBlox receivers is the following:

> GPS:XYZSPeed <int> [0,255]
>
> GPS:DYNAMic:MODE <int> [0,8]
>
> GPS:DYNAMic:STATe?

GPS:REFerence:ADELay <float> <s | ns > [-32767ns,32767ns]

GPS:TMODe <ON | OFF | RSTSURV>

GPS:SURVey ONCE

GPS:SURVey:DURation <sec>

GPS:SURVey:VARiance <mm2>

GPS:HOLD:POSition <cm, cm, cm>

GPS:SURVey:STATus?

GPS:SYST:SELect [GPS | SBAS | QZSS | GAL | BD | GLO]

GPS:JAMlevel?

The list of commands supported only by externally-connected Rockwell receivers is the following:

GPS:DAGR:MODE <ON | OFF>

GPS:DAGR:MODE?

GPS:DAGR:XFERstate?

GPS:DAGR:PVTstate?

GPS:SASTAT:YTRACK?

GPS:SASTAT:CVZStatus?

GPS:SASTAT:CVKFStatus?

GPS:SASTAT:CVStatus?

GPS:SASTAT:VERification?

GPS:SASTAT:CVExp?

GPS:SASTAT:KDP?

GPS:SASTAT:ANTISpoof?

GPS:SASTAT <int> [0,255]

GPS:ZEROize START

GPS:ZEROize?

6.10.1 GPS:TYPE?

This command queries the current externally-connected GNSS type. The response is one of the following: UBLOX, ROCKWELL or NMEA. The GPS type is set automatically when in GPS:TYPE:MODE AUTO. Otherwise, the GPS type matches the selected type mode as described below.

6.10.2 GPS:TYPE:MODE

This command selects the GNSS type mode. The default mode is AUTO so that the GNSS type is automatically selected shortly after power up based on serial port queries to the GNSS receiver. To override the automatic selection, use the UBLOX, ROCKWELL or NMEA option. The NMEA option will require industry-standard NMEA sentences including GPGGA and GPRMC to be sent to the unit's RS-232 serial port at either 9600 or 38400 baud.

The format of this command is:

GPS:TYPE:MODE <AUTO | UBLOX | ROCKWELL | NMEA>

6.10.3 GPS:SATellite:TRAcking:COUNt?

This query returns the number of satellites being tracked.

6.10.4 GPS:SATellite:VISible:COUNt?

This query returns the number of satellites (PRN) that the almanac predicts should be visible at the current simulated date, time, and position.

6.10.5 NMEA Support

The following commands allow the RSR GNSS Transcoder™ to be used as an industry standard navigation multi-GNSS receiver. The GPGGA, GPGSV, GPRMC, PASHR and GPZDA NMEA commands comprise all necessary information about the antenna position, height, velocity, direction, satellite info, fix quality info, time, date and other information that can be used by standard navigation applications via the USB serial interface.

Once enabled, the unit will send out NMEA sentences on the USB port automatically every N seconds. All incoming serial commands are still recognized by the unit, since the serial interface transmit and receive lines operate completely independently of one another.

For compatibility with existing GPS-only products, the units's NMEA output uses only the GPS NMEA sentence headers (GPGGA, GPGSV, etc.) regardless of the GNSS systems enabled on an external uBlox receiver. Also, the GPGSV output uses a modified satellite numbering scheme as detailed in Section 6.10.9 to allow multiple, possibly concurrent GNSS system satellites to be differentiated in the GPGSV message.

Please note that due to internal double-buffering that the position, direction, and speed data is delayed by one second from when the external GNSS receiver reported these to the internal microprocessor. Consequently the position is valid for the 1PPS pulse previous to the last 1PPS pulse at the time the data is sent (one second delay). The time and date are properly output with correct UTC synchronization to the 1PPS pulse immediately prior to the NMEA data being sent.

Once set, the following command settings will be stored in NV memory, and generate NMEA output information even after power to the unit has been power cycled.

By default NMEA strings are not generated until at least one external 1PPS reference pulse has been received. The unit can be set to output NMEA data asynchronously and regardless of the external 1PPS pulse status by using the ON setting of the SYNC:OUT:1PPS:RESET command as described in Section 6.7.12

6.10.6 GPS:GPGGA

This command instructs the RSR GNSS Transcoder™ to send the NMEA standard string $GPGGA every N seconds, with N in the interval [0,255]. The command is disabled during the initial warm-up phase.

This command has the following format:

GPS:GPGGA <int> [0,255]

GPGGA shows height in MSL Meters.

6.10.7 GPS:GPRMC

This command instructs the RSR GNSS Transcoder to send the NMEA standard string $GPRMC every N seconds, with N in the interval [0,255]. The command is disabled during the initial warm-up phase.

This command has the following format:

GPS:GPRMC   <int> [0,255]

6.10.8 GPS:GPZDA

This command instructs the RSR GNSS Transcoder to send the NMEA standard string $GPZDA every N seconds, with N in the interval [0,255]. The command is disabled during the initial warm-up phase.

This command has the following format:

GPS:GPZDA   <int> [0,255]

6.10.9 GPS:GPGSV

This command instructs the RSR GNSS Transcoder to send the NMEA standard string $GPGSV every N seconds, with N in the interval [0,255]. The command is disabled until the GNSS receiver achieves a first fix.

GPS:GPGSV <int> [0,255]

Please note that due to the large number of GNSS satellites that can be tracked in this unit, more than the customary four GSV messages can be sent once per second. With multiple GNSS systems enabled, a typical sky view may generate up to six GSV messages per second.

To simultaneously support all available GNSS systems, the following PRN numbering scheme modified from the traditional NMEA standard is being used:

GNSS Type	SV Range	GPGSV PRN vehicle numbering
GPS	G1-G32	1-32
SBAS	S120-S158	33-64,152-158
Galileo	E1-E36	301-336
BeiDou	B1-B37	401-437
IMES	I1-I10	173-182
QZSS	Q1-Q5	193-197
GLONASS	R1-R32, R?	65-96,0

6.10.10 GPS:PASHR

The PASHR command alongside the GPZDA command will return a complete list of relevant parameters including time, date, position, velocity, direction, altitude, quality of fix, and more. As an example, the PASHR string has the following data format:

$PASHR,POS,0,7,202939.00,3716.28369,N,12157.43457,W,00087.40,????,070.01,000.31,-000.10, 05.6,03.5,04.3,00.0,DD00*32

Please note that the length of the string is fixed at 115 characters plus the two binary 0x0d, 0x0a termination characters.

$PASHR,POS,0,aa,bbbbbb.00,cccc.ccccc,d,eeeee.eeeee,f,ggggg.gg,hhhh,iii.ii,jjj.jj,kkkk.kk,ll.l, mm.m,nn.n,00.0,p.pp,*[checksum]

Where:

aa: Number of Sats

bbbbbb.00: Time of Day UTC

cccc.ccccc,d: Latitude,S/N

eeee.eeeee,f: Longitude,W/E

ggggg.gg: Antenna Height in meters

hhhh: Four fixed '?' symbols

iii.ii: Course Over Ground

jjj.jj: Speed in Knots

kkkk.k: Vertical Velocity in meters/s

ll.l: PDOP

mm.m HDOP

nn.n VDOP

00.0 Static number

p.pp: Firmware version

This command instructs the RSR GNSS Transcoder to send the NMEA standard string $PASHR every N seconds, with N in the interval [0,255]. The command is disabled during the initial warm-up phase.

This command has the following format:

GPS:PASHR <int> [0,255]

6.10.11 GPS:XYZSPeed

This command is a 3D velocity vector output command. Enabling this command will output a 3-dimensional velocity vector indicating the unit's speed in centimeters per second in the ECEF coordinate system.

X, Y, and Z speed are individually given, and are independent of each other. An accuracy estimate in centimeters per second is also given. The velocity data is time-stamped using the time-of-week with a resolution of milliseconds.

Additionally, the number of accrued leap seconds is indicated in this message, which allows proper calculation of GPS time from UTC time as indicated by other messages, as well as proper handling of leap second events.

Use the following format to generate the velocity vector every N seconds, with N in the interval [0,255]:

> GPS:XYZSPeed <int> [0,255]

This command is supported only with an external uBlox GNSS receiver.

6.10.12 GPS:HEIGHT:MSL?

This query returns the Mean Sea Level height in meters which differs from the GPS ellipsoid height by up to +/-100 meters. This difference varies depending upon the simulated location. The MSL to GPS height differences are calculated by the internal uBlox GNSS monitoring receiver, and reported based on the height delta at the simulated GPS position.

6.10.13 GPS:HEIGHT:GPS?

This query returns the height above the GPS ellipsoid in meters at the currently simulated GPS position.

6.10.14 GPS:HEIGHT?

This command returns the output from the following queries:

GPS:HEIGHT:MSL?

GPS:HEIGHT:GPS?

6.10.15 GPS:DYNAMic:MODE

This command allows the user to select the dynamic motion model being applied to the Kalman filters in the GNSS receiver. This allows for larger amounts of filtering for lower velocity applications, effectively reducing noise and multipath interference. Applications with high acceleration or velocity can then be used with fast filter settings to allow for the most accurate GNSS coordinates to be provided in high-dynamic applications such as Jet aircraft. Doppler tracking is enabled in all airborne modes, as Carrier Phase tracking is very difficult to achieve in high velocity applications. The GNSS receiver will perform Carrier Phase tracking for non-airborne modes.

The command has the following syntax:

> GPS:DYNAMic:MODE <int> [0,8]

Sending the following command to the RSR GNSS Transcoder will select a stationary GNSS dynamic model for example:

> gps:dynam:mode 1

The following table lists all available Dynamic modes:

Table 6.1 Supported Dynamic GNSS Operating Modes

Value	Model	Application
0	Portable	Recommended as a default setting
1	Stationary	Used in stationary applications
2	Pedestrian	Used in man-pack, pedestrian settings
3	Automotive	Vehicular velocity applications
4	Sea	Used on ships, where altitude is expected to be constant
5	Airborne <1g	Airborne applications with less than 1g acceleration
6	Airborne <2g	Airborne applications with less than 2g acceleration
7	Airborne <4g	Airborne applications with less than 4g acceleration
8	Automatic Mode	Select one of the above states (0 – 7) based on the actual velocity of the vehicle

If the external GNSS receiver is a timing-grade uBlox receiver it is capable of running in a stationary mode with Position Auto Survey called Position Hold Mode. This mode increases timing stability by storing the position into memory, solving the GNSS signal only for time as the position is not expected to change. This allows operation with only one visible satellite, as well as over-determination of the timing pulse when multiple satellites are tracked. Two modes can be selected for Auto Survey operation (see section 6.10.21 for a description of the GPS:TMODE command):

1) Manually setting Timing Mode to ON with a hard-coded position in NVRAM

2) Enabling Auto Survey to start automatically after power-on by setting Timing Mode to RSTSURV

If either one of the above two GPS:TMODE Auto Survey/Position Hold modes is selected, the GPS:DYNAMIC:MODE command is disabled internally and its setting is ignored as the unit does not expect any motion on the antenna. In this case, the dynamic state as programmed into the GNSS receiver is set to STATIONARY independent of the user selection for GPS:DYNAMIC:MODE.

The current dynamic state being applied to the GNSS receiver can be queried with the command

GPS:DYNAMIC:STATE?

This command is supported only with an external uBlox GNSS receiver.

6.10.16 GPS:DYNAMic:MODE 8 (Automatic Dynamic Mode)

Automatic Dynamic Mode allows the RSR GNSS Transcoder firmware to automatically configure an external uBlox GNSS receiver's Kalman filter parameters based on actual mission velocities and motion profiles, drastically improving overall performance. The unit will try to set the uBlox GNSS receiver to the optimal setting for any given velocity. The unit is able to set 7 different modes, as shown in section 6.10.15 .

The following table shows the Dynamic mode the unit will program into the uBlox GNSS receiver when Automatic Mode is selected (Dynamic Mode 8).

Table 6.2   Auto Dynamic Mode Switching Rules

Velocity Threshold	Selected Dynamic Model	Fallback to lower setting
0 – 2 knots	Stationary	none
>2 knots	Pedestrian	<1 knots
>10 knots	Automotive	<8 knots
>60 knots and >400 Feet/min climb/descent	Airborne 1g	<50 knots
>150 knots	Airborne 2g	<130 knots
>240 knots	Airborne 4g	<210 knots

In this Automatic mode, the unit will configure the uBlox GNSS receiver based on the actual vehicle velocity. Please note that in order to switch from the Automotive mode into the first Airborne (1g) mode, a vehicle velocity greater than 60 knots as well as a climb/descent rate greater than 400 feet per minute are required. Alternatively, a vehicle velocity of greater than 100 knots will also initiate a switch into airborne-1g mode. Without an appropriate climb/descent, the unit will remain in Automotive mode unless the 100-knot velocity threshold is exceeded.

The following command returns the setting of the GNSS dynamics model:

GPS:DYNAMic:MODE?

The actual state chosen by the firmware for the GNSS receiver based on vehicle velocity can be queried with the command:

GPS:DYNAMic:STATe?

A value between 0 and 7 is then returned depending on vehicle dynamics.

The dynamic state is always set to STATIONARY if one of the Position Hold Auto Survey stationary modes is selected using the command GPS:TMODE, as the Position Hold mode setting overrides any dynamic state user setting.

Settings will be applied immediately to the uBlox GNSS receiver, and are stored in nonvolatile memory. This command is supported only with an external uBlox GNSS receiver.

6.10.17 GPS:DYNAMic:STATe?

This query returns the dynamic model chosen by the firmware to be applied to the external uBlox GNSS receiver depending on vehicle velocity. It returns a value between 0 and 7 which corresponds to one of the dynamic models defined in the Table in section 6.10.16 .

This state can be different from the user-selected Dynamic model mode for two reasons:

• if the dynamic mode is set to 8 (Automatic mode), the state will reflect the dynamic model being applied to the GNSS receiver depending on actual vehicle dynamics
• if the GPS Timing Mode is set to ON or to RSTSURV, the dynamic state will always be set to 1 (Stationary)

This command is supported only with an external uBlox GNSS receiver.

6.10.18 GPS:REFerence:ADELay <float> <s | ns > [-32767ns,32767ns]

The ADELay command allows bidirectional shifting of the 1PPS output in relation to the UTC 1PPS reference in one nanosecond steps. This allows antenna cable delay compensation, as well as retarding or advancing the 1PPS pulse arbitrarily to calibrate different units to each other for example. Typical antenna delays for a 30 foot antenna cable with 1.5ns per foot propagation delay would be compensated with the following command:

GPS:REF:ADEL 45ns

This command can be used to fine-tune different units to have coincident 1PPS pulse outputs. This command is supported only with an external uBlox GNSS receiver.

6.10.19 GPS:REFerence:PULse:SAWtooth?

This command returns the momentary sawtooth correction factor indicated by the GNSS receiver. This command is supported with both an external uBlox GNSS receiver and a Rockwell Microgram or RSR Puck loaded with custom JLT NMEA firmware.

6.10.20 GPS:RESET ONCE

Issues a reset to the external GNSS receiver. This can be helpful when changing the antenna, for example; many GNSS receivers measure the antenna system's C/No right after reset and adjust their internal antenna amplifier gains accordingly. It takes approximately 1 minute for GPS lock to occur

after a GNSS receiver reset. The externally-connected GNSS receiver is reconfigured to power-on default specifications when issuing this command.

6.10.21 GPS:TMODe <ON | OFF | RSTSURV>

This command selects the Timing Mode of an external timing-enabled uBlox GNSS receiver.

If the Timing Mode is OFF, the receiver will act as a regular GNSS receiver in 3D mobile mode. This mode has to be chosen if the unit is used with a moving antenna.

If the Timing Mode in ON, the timing features of the GNSS receiver are enabled. At power-up, the Hold position stored in NVRAM will be sent to the GNSS receiver and will be used as the reference. In order to use this mode, the receiver position must be known as accurately and precisely as possible. Errors in the Hold position will translate into time errors depending on the satellite constellation.

The Hold position can be set manually by the user or can be the result of a position Auto Survey executed by the uBlox GNSS receiver.

If the Timing Mode is set to RSTSURV, the uBlox GNSS receiver will start an Auto Survey every time the unit is powered-on and following the Survey sequence, the uBlox GNSS receiver will run with the timing features enabled. Once in Position Hold mode, the antenna location should be held completely stationary. This command is supported only with an external Timing uBlox GNSS receiver.

6.10.22 GPS:SURVey ONCE

This command starts an Auto Survey. At the end of the Survey, the calculated Hold position will be stored in NVRAM. The Survey parameters can be set with the command **GPS:SURVey:DURation** and **GPS:SURVey:VARiance.** This command is supported only with an external Timing uBlox GNSS receiver.

6.10.23 GPS:SURVey:DURation <sec>

This command sets the survey minimal duration. It is supported only with an external Timing uBlox GNSS receiver.

6.10.24 GPS:SURVey:VARiance <mm^2>

This command specifies the minimum variance of the average position computed during the survey. This minimum value is used as a threshold under which the uBlox GNSS receiver can stop the survey. The GNSS receiver will stop the Survey when the minimal duration has been reached and the variance of the average position is under the specified minimum variance. This command is supported only with an external Timing uBlox GNSS receiver.

6.10.25 GPS:HOLD:POSition <cm, cm, cm>

This command allows the user to manually specify the exact position of the antenna. This command will overwrite the Hold position in NVRAM. A subsequent Auto Survey will overwrite this Hold

position. The Hold position is stored in ECEF coordinates. This command is supported only with an external Timing uBlox GNSS receiver.

6.10.26 GPS:SURVey:STATus?

This query displays the current status of the Auto Survey. The survey status will be reported as one of the following 3 states:

ACTIVE : a survey is in progress

VALID: a survey has been achieved successfully and the uBlox GNSS receiver is now using this Hold position as reference.

INVALID: no survey is in progress or has been achieved since the last power cycle.

When in ACTIVE or VALID state, this query will also display the duration, the Hold position in ECEF coordinates and the position variance. This command is supported only with an external Timing uBlox GNSS receiver.

6.10.27 GPS:INITial:DATE <yyyy,mm,dd>

This command allows the manual setting of the internal RTC DATE when operating the unit in GNSS-denied environments. This command is compatible with the PTIME:OUT ON command described in section 6.12.5 to allow automatic time and date synchronization of two units to each other. This command can also be used to set the date for simulations when using the Continuous Simulation Time mode.

6.10.28 GPS:INITial:TIME <hour,min,sec>

This command allows manual setting of the internal RTC TIME when operating the unit in GNSS-denied environments. This command is compatible with the PTIME:OUT ON command described in section 6.12.5 to allow automatic time and date synchronization of two units to each other. This command can also be used to set the time for simulations when using the Continuous Simulation Time mode.

6.10.29 GPS:PORT <SCPI | RS232>

This command selects the source for NMEA data between the SCPI and RS232 ports. When using the SIMulation:NMEA command described in Section 6.3.75 to provide NMEA data over the SCPI port, the GPS:PORT setting must be SCPI. Normally the setting should be RS232 to support an externally connected GPS receiver.

6.10.30 GPS:PPSERRor?

This command queries and returns the difference in seconds between the external GPS receiver's 1PPS rising edge and the current simulator time.

This query is useful for monitoring the timing accuracy of the target GPS receiver by connecting the 1PPS output of that receiver to the RSR GNSS Transcoder's external 1PPS input. The

synchronization source mode should be in NMEA mode (SYNC:SOUR:MODE NMEA) when connecting the target GPS receiver this way.

This query is also useful for monitoring how closely the simulation time matches the reference 1PPS input when the synchronization source mode is EXTernal or GPS.

6.10.31 GPS:POSERRor?

This command queries and returns the horizontal difference in meters between the position reported by the external GPS receiver and the simulated position.

This query is useful for monitoring the horizontal position accuracy of the target GPS receiver with the target GPS receiver connected to the RSR GNSS Transcoder's external GPS receiver RS232 port. Please note that the target GPS receiver should not be connected this way in the TRANSCODE simulation mode.

This query is also useful for monitoring the performance of the simulation position filtering when using the TRANSCODE mode with an external GPS receiver providing the input position data.

6.10.32 GPS:VPOSERRor?

This command queries and returns the vertical difference in meters between the position reported by the external GPS receiver and the simulated position.

This query is useful for monitoring the vertical position accuracy of the target GPS receiver with the target GPS receiver connected to the RSR GNSS Transcoder's external GPS receiver RS232 port. Please note that the target GPS receiver should not be connected this way in the TRANSCODE simulation mode.

This query is also useful for monitoring the performance of the simulation position filtering when using the TRANSCODE mode with an external GPS receiver providing the input position data.

6.10.33 GPS:SYST:SELect [GPS | SBAS | QZSS | GAL | BD | GLO]

This command selects the GNSS systems that are enabled in an externally connected uBlox-8 GNSS receiver. The command is followed by any combination of the currently supported GNSS system abbreviations GPS, SBAS, QZSS, BD (BeiDou), GAL (Galileo) and GLO (GLONASS). Up to three concurrent GNSS systems plus SBAS may be enabled at any time. This command is supported only with an external uBlox generation 8 or later GNSS receiver.

Only two different L1 carrier frequencies are allowed to be received at any given time. GPS, Galileo, QZSS, and SBAS count as one frequency, while BeiDou and Glonass each count as a separate frequency. For example, while GPS, Galileo, and Glonass can be received concurrently, reception of BeiDou or Glonass will limit the user to only one other GNSS system. Any illegal GNSS system combinations will result in a "command error" response from the system. A typical example of this command is:

GPS:SYST:SEL GPS SBAS GAL GLO

As of the date of this manual, the GPS:SYST:SEL command is not currently supported on the RSR Transcoder™.

6.10.34 GPS:RATE [1|10]

This command selects the solution rate and GPGGA/GPRMC NMEA output rate in Hz enabled on an externally connected uBlox receiver. Only 1Hz and 10Hz rates are supported.

6.10.35 GPS:JAMlevel?

Externally-connected uBlox GNSS receivers will detect and flag jamming interference at levels ranging from 0 (no jamming) to 255 (strong jamming), and will report the observed jamming level with this command. This command is supported only with an external uBlox GNSS receiver.

6.10.36 GPS:FWver?

This command returns the firmware version used inside the externally-connected GNSS receiver itself. This command is supported with both an external uBlox GNSS receiver and a Rockwell Microgram or RSR Puck.

6.10.37 GPS:DAGR:MODE

This command sets the DAGR pass-through mode. An external DAGR DB-15 serial and 1PPS interface may be connected to the externally connected MicroGRAM or RSR Puck SAASM receiver COM-2 port as long as these have the custom JLT NMEA timing firmware loaded by the Rockwell Collins factory. When DAGR pass-through mode is ON, external DAGR PVT data including the 1PPS reference is passed through the internal MicroGRAM receiver COM-2 port and provided in place of locally computed PVT data from the internal MicroGRAM. The GPS:DAGR:PVTstate? query response described in Section 6.10.40 indicates if the MicroGRAM has successfully transitioned to DAGR pass-through PVT mode.

When DAGR pass-through mode is ON, the internal MicroGRAM can also accept Hot-Start data from the external DAGR allowing downloading Almanac and Ephemeris as well as PVT data to the MicroGRAM. Once the MicroGRAM has successfully transitioned to DAGR PVT mode, the hot start is typically initiated from the external DAGR. The GPS:DAGR:XFERstate query response described in Section 6.10.39 indicates the success or failure of an attempted hot start.

The format of this command is:

GPS:DAGR:MODE <ON | OFF>

This command works only with an external MicroGRAM or RSR Puck.

6.10.38 GPS:DAGR:MODE?

This query displays the current DAGR pass-through mode. This command does not indicate the success or failure of entering the DAGR pass-through mode, but only the currently selected mode from the GPS:DAGR:MODE command. Use the GPS:DAGR:PVTstate? query to determine the success or failure of entering DAGR pass-through mode.

This command works only with an external Rockwell Collins MicroGRAM or RSR Puck with custom JLT Timing firmware loaded at the factory.

6.10.39 GPS:DAGR:XFERstate?

This query displays the DAGR / Hot-Start Transfer Status using the values in the following table:

Value	Status
0	None, no transfer initiated
1	In Progress
2	Done
3	Error

This command works only with an external Rockwell Collins MicroGRAM or RSR Puck.

6.10.40 GPS:DAGR:PVTstate?

This query displays the DAGR pass-through status using the values in the following table:

Value	Status
0	None, DAGR pass-through mode off
1	Initializing
2	Done
3	Error

This command works only with an external Rockwell Collins MicroGRAM or RSR Puck.

6.10.41 GPS:SASTAT:YTRACK?

This query displays the number of satellites being tracked in Y-Code. If the MicroGRAM or RSR Puck is not keyed, this value should always be 0. The maximum value is 12. This command works only with an external Rockwell Collins MicroGRAM or RSR Puck.

6.10.42 GPS:SASTAT:CVZStatus?

This query displays the CV Zeroize Status using the values in the following table:

Value	Status
0	Verified
1	Failed
2	None, not attempted

This command works only with an external Rockwell Collins MicroGRAM or RSR Puck.

6.10.43 GPS:SASTAT:CVKFStatus?

This query displays the Key Fill Status using the values in the following table:

Value	Status
0	Not Valid
1	Valid

The Key Fill Status will indicate Valid for at least 1 second to indicate a valid key fill operation. To avoid missing the Valid response, the Key Fill Status can also be monitored continuously by monitoring field d of the periodic $SASTAT output described in Section 6.10.49 . This command works only with an external Rockwell Collins MicroGRAM or RSR Puck.

6.10.44 GPS:SASTAT:CVStatus?

This query displays the CV Status using the values in the following table:

Value	Status
0	Not Keyed
1	Keyed

This command works only with an external Rockwell Collins MicroGRAM or RSR Puck.

6.10.45 GPS:SASTAT:VERification?

This query displays the Verification Status using the values in the following table:

Value	Status
0	CV Verified
3	Nav Pending
5	Not Current
7	No CVs

This command works only with an external Rockwell Collins MicroGRAM or RSR Puck.

6.10.46 GPS:SASTAT:CVExp?

This query displays the CV Expiration Status using the values in the following table:

Value	Status
0	No
1	Yes, yes if expiration iminent

This command works only with an external Rockwell Collins MicroGRAM or RSR Puck.

6.10.47 GPS:SASTAT:KDP?

This query displays the KDP Health Status using the values in the following table:

Value	Status
0	Alive
1	Dead

This command works only with an external Rockwell Collins MicroGRAM or RSR Puck.

6.10.48 GPS:SASTAT:ANTISpoof?

This query displays the Anti-Spoof Status using the values in the following table:

Value	Status
0	OK
1	Error

This command works only with an external Rockwell Collins MicroGRAM or RSR Puck.

6.10.49 GPS:SASTAT <int> [0,255]

This command instructs the RSR GNSS Transcoder™ to send the $SASTAT proprietary NMEA output sentence every N seconds, with N in the interval [0,255]. The command is disabled during the initial oscillator warm-up phase. This command has the following format:

GPS:SASTAT <int> [0,255]

The $SASTAT output gives all status information from all of the DAGR and SAASM-related queries described in Sections 6.10.37 through 6.10.48 . The $SASTAT command has the following format:

$SASTAT,hhmmss.sss,aa,b,c,d,e,f,g,h,i,j,k*[checksum]

Where:

hhmmss.sss: Current UTC Time at the start of the previous second

aa: Number of Satellites in Y-Code Track

b: CV Zeroize Status

c: CV Status

d: CV Fill Status

e: Verification Status

f: CV Expiration Status

g: KDP Health Status

h: Anti-Spoof Status

i: DAGR Transfer Status

j: DAGR PVT State

k: DAGR PVT Mode

The [checksum] follows the NMEA standard checksum. This command works only with an external Rockwell Collins MicroGRAM or RSR Puck.

6.10.50 GPS:ZEROize START

This command starts the CV Zeroize operation on the MicroGRAM or RSR Puck receiver. The START parameter must be included, otherwise the command is not accepted. The format of this command is:

GPS:ZEROize START

The response from the GPS:SASTAT:CVZStatus? query provides the result of the CV Zeroize operation. This command works only with an external Rockwell Collins MicroGRAM or RSR Puck.

6.10.51 GPS:ZEROize?

This query displays the CV Zeroize Status and is equivalent to the GPS:SASTAT:CVZStatus? query described in Section 6.10.42 . This command works only with an external Rockwell Collins MicroGRAM or RSR Puck.

6.10.52 GPS?

This query displays the configuration, position, speed, height and other relevant data of the external GNSS receiver in one convenient location.

6.11 INTGPS Subsystem

The INTGPS subsystem groups all the commands related to the control and status of the internal monitoring GNSS receiver. The internal GNSS receiver is used to monitor the RF output signal on the SMA connector, providing a sanity check for the simulated position and calibrating the timing for the simulated signal. The list of the commands supported is the following:

INTGPS:SATellite:TRAcking:COUNt?

IINTGPS:SATellite:VISible:COUNt?

INTGPS:GPGGA <int> [0,255]

INTGPS:GPRMC <int> [0,255]

INTGPS:GPGSV <int> [0,255]

INTGPS:GPZDA <int> [0,255]

INTGPS:PASHR <int> [0,255]

INTGPS:XYZSPeed <int> [0,255]

INTGPS:HEIGHT?

INTGPS:HEIGHT:MSL?

INTGPS:HEIGHT:GPS?

INTGPS:DYNAMic:MODE <int> [0,8]

INTGPS:DYNAMic:STATe?

INTGPS:REFerence:PULse:SAWtooth?

INTGPS:RESET ONCE

INTGPS:JAMlevel?

INTGPS:FWver?

INTGPS:PPSERRor?

INTGPS:POSERRor?

INTGPS:VPOSERRor?

INTGPS:SYSTem:STATus?

INTGPS?

6.11.1 INTGPS:SATellite

This group of commands describe the satellite constellation as seen by the internal GNSS receiver.

6.11.2 INTGPS:SATellite:TRAcking:COUNt?

This query returns the number of satellites being tracked by the internal GNSS receiver.

6.11.3 INTGPS:SATellite:VISible:COUNt?

This query returns the number of satellites that the almanac predicts should be visible at the current simulated date, time, and position.

6.11.4 Internal GNSS Receiver NMEA Support

The following commands allow the RSR GNSS Transcoder™ to provide standard NMEA data from the internal GNSS receiver. The GPGGA,GPRMC, GPGSV, PASHR and GPZDA NMEA commands comprise all necessary information about the antenna position, height, velocity, direction, satellite info, fix info, time, date and other information that can be used by standard navigation applications or as a comparison with the simulation results from the target GPS receiver.

Once enabled, the RSR GNSS Transcoder™ will send out information on the USB serial interface automatically every N seconds. All incoming serial commands are still recognized by the RSR GNSS Transcoder™, since the serial interface transmit and receive lines are completely independent of one another. Please note that the NMEA output configured for the internal GNSS receiver appears identical to the NMEA output for the optional external GNSS receiver. To prevent confusing the output, only one (internal or external) NMEA sentence of each type should be enabled.

Please also note that the position, direction, and speed data is delayed by one second from when the GPS receiver internally reported these to the RSR GNSS Transcoder™'s microprocessor, so the position is valid for the 1PPS pulse previous to the last 1PPS pulse at the time the data is sent (one second delay). The time and date are properly output with correct UTC synchronization to the 1PPS pulse immediately prior to the data being sent.

Once set, the following two commands will be stored in NV memory, and will generate output information even after power to the unit has been cycled.

6.11.5 INTGPS:GPGGA

This command instructs the RSR GNSS Transcoder™ to send the NMEA standard string $GPGGA every N seconds, with N in the interval [0,255]. The command is disabled until the internal GNSS receiver achieves a first fix.

This command has the following format:

INTGPS:GPGGA   <int> [0,255]

Note that GPGGA shows height in MSL Meters; this is different from traditional GPS receivers that display height in GPS Meters. The difference between MSL and GPS height can be significant, with discrepancies of 35m or more being common. Also note that the simulation height is specified in GPS height above the reference ellipsoid, so the height returned by this NMEA message will vary from the simulated height by the GPS to MSL height difference at the particular location that is being simulated.

6.11.6 INTGPS:GPRMC

This command instructs the RSR GNSS Transcoder™ to send the NMEA standard string $GPRMC every N seconds, with N in the interval [0,255]. The command is disabled until the internal GNSS receiver achieves a first fix.

This command has the following format:

INTGPS:GPRMC   <int> [0,255]

6.11.7 INTGPS:GPGSV

This command instructs the RSR GNSS Transcoder™ to send the NMEA standard string $GPGSV every N seconds,

with N in the interval [0,255]. The command is disabled until the internal GPS receiver achieves a first fix.

INTGPS:GPGSV <int> [0,255]

6.11.8 INTGPS:XYZSPeed

This command is a 3D velocity vector output command. Enabling this command will output a 3 dimensional velocity vector indicating the unit's speed in centimeters per second in the ECEF coordinate system.

X, Y, and Z speed are individually given, and are independent of each other. An accuracy estimate in centimeters per second is also given. The velocity data is time-stamped using the time-of-week with a resolution of milliseconds.

Additionally, the number of accrued Leapseconds is indicated in this message, which allows proper calculation of GPS time from UTC time as indicated by other messages, as well as proper handling of Leapsecond events.

Use the following format to generate the velocity vector every N seconds, with N in the interval [0,255]:

> INTGPS:XYZSPeed <int> [0,255]

6.11.9 INTGPS:GPZDA

This command instructs the RSR GNSS Transcoder™ to send the NMEA standard string $GPZDA every N seconds, with N in the interval [0,255]. The command is disabled until the internal GNSS receiver achieves a first fix.

This command has the following format:

> INTGPS:GPZDA   <int> [0,255]

6.11.10 INTGPS:PASHR

The NMEA string $PASHR,POS has been added for compatibility to legacy GPS hardware. The PASHR command alongside the GPZDA command will give all relevant parameters such as time, date, position, velocity, direction, altitude, quality of fix, and more. As an example, the String has the following data format:

$PASHR,POS,0,7,202939.00,3716.28369,N,12157.43457,W,00087.40,????,070.01,000.31,-000.10, 05.6,03.5,04.3,00.0,DD00*32

Please note that the length of the string is fixed at 115 characters plus the two binary 0x0d, 0x0a termination characters.

$PASHR,POS,0,aa,bbbbbb.00,cccc.ccccc,d,eeeee.eeeee,f,ggggg.gg,hhhh,iii.ii,jjj.jj,kkkk.kk,ll.l, mm.m,nn.n,00.0,p.pp,*[checksum]

Where:

aa:Number of Sats

bbbbbb.00:Time of Day UTC

cccc.ccccc,d:Latitude,S/N

eeee.eeeee,f:Longitude,W/E

ggggg.gg:Antenna Height in meters

hhhh:Four fixed '?' symbols

iii.ii:Course Over Ground

jjj.jj:Speed in Knots

kkkk.k:Vertical Velocity in meters/s

ll.l:PDOP

mm.mHDOP

nn.nVDOP

00.0Static number

p.pp:Firmware Version (1.05 and above)

This command instructs the RSR GNSS Transcoder™ to send the NMEA standard string $PASHR every N seconds, with N in the interval [0,255]. The command is disabled until the internal GNSS receiver achieves a first fix.

This command has the following format:

INTGPS:PASHR <int> [0,255]

6.11.11 INTGPS:HEIGHT:MSL?

This query returns the Mean Sea Level height in meters which differs from the GPS ellipsoid height by up to +/-100 meters. This difference varies depending upon the location as reported by the internal GPS receiver. Please note that the simulation uses GPS height in commands such as the SIM:POS:LLH command described in Section 6.3.9

6.11.12 INTGPS:HEIGHT:GPS?

This query returns the GPS ellipsoid height in meters as reported by the internal GPS reference receiver. It is calculated from the internal uBlox GNSS receiver's MSL height parameter by subtracting the MSL to GPS ellipsoid height difference for the simulated position. This GPS height should reflect the simulated height as set in the simulation commands such as the SIM:POS:LLH command described in Section 6.3.9 .

6.11.13 INTGPS:HEIGHT?

This command returns the output from the following queries:

INTGPS:HEIGHT:MSL?

INTGPS:HEIGHT:GPS?

6.11.14 INTGPS:DYNAMic:MODE

This command allows the user to select the dynamic motion model applied to the Kalman filters in the internal monitoring GNSS receiver. This allows for larger amounts of filtering for lower velocity applications, effectively reducing noise and multipath interference. Applications with high acceleration can be used with fast filter settings to allow for the most accurate GPS coordinates to be provided in high-dynamic applications such as jet aircraft. Doppler tracking is enabled in all airborne modes, as Carrier Phase tracking is very difficult to achieve in high velocity applications. The GNSS receiver will perform Carrier Phase tracking for non-airborne modes.

The command has the following syntax:

INTGPS:DYNAMic:MODE <int> [0,8]

Sending the following command to the RSR GNSS Transcoder™ will select a stationary GNSS dynamic model, for example:

INTGPS:DYNAM:MODE 1

The following table lists all available modes:

Value	Model	Application
0	Portable	Recommended as a default setting
1	Stationary	Used in stationary applications
2	Pedestrian	Used in man-pack, pedestrian settings
3	Automotive	Vehicular velocity applications
4	Sea	Used on Ships, where altitude is expected to be constant
5	Airborne <1g	Airborne applications with less than 1g acceleration
6	Airborne <2g	Airborne applications with less than 2g acceleration
7	Airborne <4g	Airborne applications with less than 4g acceleration
8	Automatic Mode	Select one of the above states (0 – 7) based on the actual velocity of the vehicle

6.11.15 INTGPS:DYNAMic:MODE 8 (Automatic Dynamic Mode)

Automatic Dynamic Mode allows the RSR GNSS Transcoder™ firmware to automatically configure the internal monitoring GNSS receiver Kalman filter parameters based on simulated/transcoded velocities and motion profiles. The unit will try to set the internal GNSS receiver to the optimal setting for any given velocity. The unit is able to set 7 different modes, as shown in Section 6.11.14 .

The following table shows the Dynamic mode that the unit will program into the internal GNSS receiver when Automatic Mode is selected (Dynamic Mode 8).

Velocity Threshold	Selected Dynamic Model	Fallback to lower setting
0 – 2 knots	Stationary	none
>2 knots	Pedestrian	<1 knots
>10 knots	Automotive	<8 knots
>60 knots and >400 Feet/min climb/descent	Airborne 1g	<50 knots
>150 knots	Airborne 2g	<130 knots
>240 knots	Airborne 4g	<210 knots

In this Automatic mode, the unit will configure the internal GNSS receiver based on the simulated/transcoded vehicle velocity. Please note that in order to switch from the Automotive mode into the first Airborne (1g) mode, a vehicle velocity greater than 60 knots as well as a climb/descent rate greater than 400 feet per minute are required. Alternatively, a vehicle velocity of greater than 100 knots will also initiate a switch into airborne-1g mode.

Without an appropriate climb/descent, the unit will remain in Automotive mode.

The following command returns the setting of the GNSS dynamic model:

INTGPS:DYNAMic:MODE?

The actual state chosen by the firmware for the internal GNSS receiver based on vehicle velocity can be obtained with the command:

INTGPS:DYNAMic:STATe?

A value between 0 and 7 is then returned depending on simulated/transcoded vehicle dynamics.

Settings will be applied immediately to the internal GNSS receiver, and are stored in Non Volatile memory.

6.11.16 INTGPS:DYNAMic:STATe?

This query returns the actual state of the dynamic model chosen by the firmware to be applied to the internal GNSS receiver depending on simulated/transcoded vehicle velocity. It returns a value between 0 and 7, corresponding to one of the dynamic models defined in the Table in section 6.10.16 .

This state can be different from the user-selected Dynamic model mode if the dynamic mode is set to 8 (Automatic mode). In this case, the state will reflect the dynamic model being applied to the internal GNSS receiver depending on simulated/transcoded vehicle dynamics

6.11.17 INTGPS:REFerence:PULse:SAWtooth?

This command returns the momentary sawtooth correction factor from the internal monitoring GNSS receiver.

6.11.18 INTGPS:RESET ONCE

Issues a reset to the internal GNSS receiver. This can be helpful when changing amplitude settings on the simulation, since the internal GNSS receiver measures the RF output's C/No immediately after reset and adjusts its internal antenna amplifier gains accordingly. It takes approximately 1 minute for locking to commence after a GNSS receiver reset, as indicated by the internal GNSS 1PPS LED.

6.11.19 INTGPS:JAMlevel?

This command provides a signal-jamming indicator from the internal monitoring GNSS receiver. The internal GNSS receiver will detect and flag jamming interference at levels ranging from 0 (no jamming) to 255 (strong jamming). Normally the jamming level is low on a correctly-operating RSR GNSS Transcoder™.

6.11.20 INTGPS:FWver?

This command queries and returns the Firmware version used inside the internal monitoring uBlox GNSS receiver.

6.11.21 INTGPS:PPSERRor?

This command queries and returns the difference in seconds between the internal GPS receiver's 1PPS rising edge and the current simulator time

6.11.22 INTGPS:POSERRor?

This command queries and returns the difference in meters between the position reported by the internal GPS receiver and the transmitted 3D position.

6.11.23 INTGPS:VPOSERRor?

This command queries and returns the difference in meters between the altitude reported by the internal GPS receiver and the transmitted altitude.

6.11.24 INTGPS:SYSTem:STATus?

This query returns a full page of internal GPS receiver status in ASCII format. This command returns a comprehensive internal GPS receiver status pages.

6.11.25 INTGPS?

This query displays the configuration, position, speed, height and other relevant data of the internal monitoring GNSS receiver in one convenient location.

6.12 PTIME Subsystem

The PTIME subsystem groups all the commands related to the management of the internal RTC time including simulation time when running in the Continuous simulation time mode. Please note that the RSR GNSS Transcoder™ does not contain a battery-backup to maintain RTC time/date. Consequently the time/date is lost when power is removed, or when the unit is reset.

The list of the commands supported is the following:

> PTIMe:DATE?
>
> PTIMe:TIME?
>
> PTIMe:TIME:STRing?
>
> PTIMe:TINTerval?
>
> PTIME:OUTput <ON | OFF>
>
> PTIMe:LEAPsecond?
>
> PTIMe:LEAPsecond:PENDing?
>
> PTIMe:LEAPsecond:ACCumulated?
>
> PTIMe:LEAPsecond:DATE?
>
> PTIMe:LEAPsecond:DURation?
>
> PTIME?

6.12.1 PTIMe:DATE?

This query returns the current calendar date referenced to UTC time. The year, month, and day are returned.

6.12.2 PTIMe:TIME?

This query returns the current 24-hour time referenced to UTC. The hour, minute, and second is returned.

6.12.3 PTIMe:TIME:STRing?

This query returns the current 24-hour time suitable for display (for example, 13:24:56).

6.12.4 PTIMe:TINTerval?

This query is identical to the SYNChronization:TINTerval? query.

6.12.5 PTIME:OUTput <ON | OFF>

This command allows connecting two units together through the USB serial port, with the master unit sending time and date information to the slave unit. This allows time synchronization between two units which can be useful when operating in GPS/GNSS denied environments.

Sending the command PTIM:OUT ON will cause the unit to automatically generate GPS:INIT:DATE and GPS:INIT:TIME sentences on the USB serial port once per second.

6.12.6 PTIMe:LEAPsecond?

This command returns the results of the four following queries:

PTIMe:LEAPsecond:PENDing?

PTIMe:LEAPsecond:ACCumulated?

PTIMe:LEAPsecond:DATE?

PTIMe:LEAPsecond:DURation?

6.12.7 PTIMe:LEAPsecond:PENDing?

This command returns 1 if the GPS almanac data contains a future pending leap second date and 0 if no future leap second is pending or almanac data is not available. The GNSS receiver must have the GPS system enabled for the GPS almanac to be available. This command is compatible only with an external ublox GNSS receiver.

6.12.8 PTIMe:LEAPsecond:ACCumulated?

This command returns the internally applied leapsecond offset between GPS time and UTC time as stored in the EEPROM (GPS almanac not received yet) or as indicated by the GNSS receiver (GPS almanac is available).

6.12.9 PTIMe:LEAPsecond:DATE?

This command returns the date of the pending leap second, if any. This command is compatible onlywith an external ublox GNSS receiver.

6.12.10 PTIMe:LEAPsecond:DURation?

This command returns the duration of the last minute of the day during a leap second event. The returned value is 59, 60 or 61 if GPS almanac data is available, and 0 otherwise. A response of 60 indicates that no leap second is pending. This command is compatible only with an external uBlox GNSS receiver.

6.12.11 PTIME?

This query returns the result of the following queries:

PTIME:DATE?

PTIME:TIME?

PTIME:TINTerval?

PTIME:OUTput?

PTIME:LEAPsecond:ACCumulated?

6.13 SYSTEM Subsystem

This subsystem groups the commands related to the general configuration of the RSR GNSS Transcoder™. The list of the commands supported for this subsystem follows:

SYSTem:COMMunicate:SERial:ECHO <ON | OFF>

SYSTem:COMMunicate: SERial:PROmpt <ON | OFF>

SYSTem:COMMunicate:SERial:BAUD <AUTO | 9600 | 19200 | 38400 | 57600 | 115200>

SYSTem:COMMunicate:USB:BAUD <9600 | 19200 | 38400 | 57600 | 115200>

SYSTem:CPURESET

SYSTem:FACToryreset ONCE

SYSTem:USERreset ONCE

SYSTem:ISP

SYSTem:ID:SN?

SYSTem:ID:HWrev?

SYSTem:ID:UID?

SYSTem:STATus?

SYSTem:FLAGS?

6.13.1 SYSTem:COMMunicate:SERial:ECHO

This command enables/disables echo on the serial port. Echo should be turned off when using the Z38xx application program. This command has the following format:

SYSTem:COMMunicate:SERial:ECHO   <ON | OFF>

6.13.2 SYSTem:COMMunicate:SERial:PROmpt

This command enables/disables the prompt "scpi>" on the SCPI command lines. The prompt must be enabled when used with the GPSCon software. This command has the following format:

SYSTem:COMMunicate: SERial:PROmpt   <ON | OFF>

6.13.3 SYSTem:COMMunicate:SERial:BAUD

This command sets the external GPS serial speed. The serial configuration is always 8 bit, 1 stop bit, no parity, no flow control. The factory default setting is AUTO which will detect between 9600 and 38400 baud. This command has the following format:

SYSTem:COMMunicate:SERial:BAUD   <AUTO | 9600 | 19200 | 38400 | 57600 | 115200>

6.13.4 SYSTem:COMMunicate:USB:BAUD

This command sets the USB serial speed. The serial configuration is always 8 bit, 1 stop bit, no parity, no flow control. The factory default rate is 115200 baud, and it should not be changed in most circumstances. This command has the following format:

SYSTem:COMMunicate:USB:BAUD <9600 | 19200 | 38400 | 57600 | 115200>

6.13.5 SYSTem:CPURESET

This command resets the unit.

6.13.6 SYSTem:FACToryreset ONCE

This command applies the Factory Reset setting to the NVRAM. **WARNING: This operation resets all user parameters, erases stored motion commands and navigation data, and clears factory calibration parameters. Use of this command will require the device to be returned to Jackson Labs Technologies for recalibration.**

Sending this command once results in a warning being output. Sending the command a second time performs the factory reset.

6.13.7 SYSTem:USERreset ONCE

This operation resets all user parameters to their factory default values, and erases any motion commands and navigation data uploaded to the device by the user. Factory calibration is unaffected.

6.13.8 SYSTem:ISP

This command sets causes the unit to enter ISP mode for reprogramming.

6.13.9 SYSTem:ID:SN?

This query returns the serial number of the unit.

6.13.10 SYSTem:ID:HWrev?

This query returns the Hardware version of the module.

6.13.11 SYSTem:ID:UID?

This query returns four 32-bit hexadecimal words that are unique to the CPU in each individual unit.

6.13.12 SYSTem:STATus?

This query returns a full page of external GNSS receiver status data in ASCII format. The output is compatible with GPSCon. This command returns one of the most comprehensive external GNSS and oscillator status pages.

6.13.13 SYSTem:FLAGS?

The SYSTem:FLAGS? query returns two 32-bit hexadecimal values indicating the system's operational status. Each flag occupies a single bit position in one of the two words.

The first word contains the following status bits:

External 10 MHz reference present	FLAGS |= 0x1;
1PPS source present	FLAGS |= 0x2;
1PPS servo lock in progress	FLAGS |= 0x4;
1PPS servo lock complete	FLAGS |= 0x8;
CSAC present (RSR Transcoder™ only)	FLAGS |= 0x10;
CSAC locked (RSR Transcoder™ only)	FLAGS |= 0x20;
Valid GPS signal has been transmitted for >100 seconds	FLAGS |= 0x40;
Valid 3D fix reported by internal GNSS receiver	FLAGS |= 0x80;

The second word returned by SYSTem:FLAGS? is identical to the value returned by the SYNChronization:HEAlth? query. Refer to Section 4.7.13 for descriptions of these flag values.

6.14 SERVO Subsystem

This subsystem groups all the commands related to the adjustment of the servo loop:

> SERVo:LOOP?
> SERVo:COARSedac <int> [0,255]
> SERVo:DACGain <int> [0.1,10000]
> SERVo: EFCScale <float>[0.0 , 500.0]
> SERVo:EFCDamping <float>[0.0 , 4000.0]
> SERVo:SLOPe <NEG | POS >
> SERVo:TEMPCOmpensation
> SERVo:AGINGcompensation <float> [-10.0, 10.0]
> SERVo:PHASECOrrection <float> [-100.0, 100.0]
> SERVo:1PPSoffset <int> ns
> SERVo:TRACe <int > [0,255]
> SERVo?

6.14.1 SERVo:LOOP?

This command returns the currently enabled servo loop, either TCXO or CSAC. This command is supported only on the RSR GNSS Transcoder™ with the internal CSAC option.

6.14.2 SERVo:COARSedac

This command sets the coarse DAC that controls the TCXO EFC on units without the internal CSAC option. The RSR GNSS Transcoder™ control loop automatically adjusts this setting during disciplining. The user should not have to change this value.

This command has the following format:

SERVo:COARSedac <int> [0,255]

6.14.3 SERVo:DACGain

This command is used for factory setup. The format of this command is:

SERVo:DACGain <int> [0.1,10000]

6.14.4 SERVo:EFCScale

This command controls the Proportional part of the PID loop. Typical values are 0.5 to 3.0. Larger values increase the loop control at the expense of increased noise while locked. Setting this value too high can cause loop instability.

This command has the following format:

SERVo: EFCScale   <float>[0.0 , 500.0]

6.14.5 SERVo:EFCDamping

This command adjusts the damping factor of the lowpass filter in the DAC control loop. Values from 2.0 to 50 are typically used. Larger values result in less noise at the expense of phase delay.This command has the following format:

SERVo:EFCDamping <float>[0.0 , 4000.0]

6.14.6 SERVo:SLOPe

The parameter determines the sign of the slope between the EFC and the frequency variation of the TCXO. This parameter should be set to match the TCXO's EFC frequency slope and should not be changed from factory settings. This command has the following format:

SERVo:SLOPe <NEG | POS >

6.14.7 SERVo:TEMPCOmpensation

This command is not supported on the RSR GNSS Transcoder™ board.

6.14.8 SERVo:AGINGcompensation

This parameter is a coefficient that represents the drift of the EFC needed to compensate the natural drift in frequency of the TCXO or CSAC due to aging. This coefficient is automatically computed and adjusted over time by the Jackson Labs Technologies, Inc. firmware. This command has the following format:

SERVo:AGINGcompensation <float> [-10.0, 10.0]

6.14.9 SERVo:PHASECOrrection

This parameter sets the Integral part of the PID loop. Loop instability will result if the parameter is set too high. Typical values are 10.0 to 30.0. This command has the following format:

SERVo:PHASECOrrection <float> [-100.0, 100.0]

6.14.10 SERVo:1PPSoffset

This command sets the RSR GNSS Transcoder™ 1PPS signal's offset to UTC in 5.6ns steps.

Using the SERV:1PPS command results in immediate phase change of the 1PPS output signal.

This command has the following format:

SERVo:1PPSoffset <int> ns

6.14.11 SERVo:TRACe

This command sets the period in seconds for the debug trace output on the USB port. Debug trace data can be used with Ulrich Bangert's "Plotter" freeware utility to display UTC tracking and other parameters versus time.

This command has the following format:

SERVo:TRACe <int > [0,255]

An example of the generated output is:

08-07-31 373815 60685 -32.08 -2.22E-11 14 10 6 0x54

[date][1PPS Count][Fine DAC][UTC offset ns][Frequency Error Estimate][Sats Visible][Sats Tracked][Lock State][Health Status]

Please see the **SYNChronization:health?** command for detailed information on how to decode the health status indicator values. The Lock State variable indicates one of the following states:

Value	State
0	TCXO/CSAC warmup
1	Holdover
2	Locking (TCXO/CSAC training)

4	[Value not defined]
5	Holdover, but still phase locked (stays in this state for about 100s after GNSS lock is lost)
6	Locked, and external GNSS active

6.14.12 SERVo?

This command returns the result of the following queries:

SERVo:COARSedac?

SERVo:DACGain?

SERVo: EFCScale?

SERVo:EFCDamping?

SERVo:SLOPe?

SERVo:TEMPCOmpensation?

SERVo:AGINGcompensation?

SERVo:PHASECOrrection?

SERVo:1PPSoffset?

SERVo:TRACe?

6.15 CSAC Subsystem

The following commands are used to query the microcontroller built into the optional Chip-Scale Atomic Clock (CSAC) oscillator. These commands are available only on RSR GNSS Transcoder™ units equipped with the optional CSAC oscillator. The supported commands include:

CSAC:POWer <ON | OFF>

CSAC:RS232?

CSAC:STeer?

CSAC:STATus?

CSAC:ALarm?

CSAC:MODE?

CSAC:CONTrast?

CSAC:LASer?

CSAC:TCXO?

CSAC:SIGnal?

CSAC:HEATpackage?

CSAC:TEMP?

CSAC:FWrev?

CSAC:SN?

CSAC:LIFEtime?

CSAC:STeer:LATch ONCE

CSAC?

6.15.1 CSAC:POWer

This command enables/disables the low power mode on the CSAC oscillator. The low power mode is enabled when the power is set to OFF, at which point the CSAC will disable all its internal circuitry and the module will operate as a TCXO based unit. The default setting is ON.

When the CSAC power is OFF, the internal TCXO is used instead of the CSAC as the timing reference for the system. The SERVo:LOOP? query response outputs the current timing reference for the system (TCXO or CSAC).

The format of this command is:

CSAC:POWer <ON | OFF>

6.15.2 CSAC:RS232?

This query returns the state (OK or FAIL) of the serial communication between the main CPU and the CSAC internal microcontroller. When the state is FAIL, a communication interruption has occurred. The unit should be power cycled to clear the communication error.

6.15.3 CSAC:STeer?

This query returns the current Frequency Adjustment in units of parts-per-trillion (1E-012).

6.15.4 CSAC:STATus?

This query returns the status value in [0,9] of the CSAC oscillator as shown below:

Alarm	Definition
0	Locked
1	Microwave Frequency Steering
2	Microwave Frequency Stabilization
3	Microwave Frequency Acquisition
4	Laser Power Acquisition
5	Laser Current Acquisition
6	Microwave Power Acquisition
7	Heater equilibration
8	Initial warm-up
9	Asleep (ULP mode only)

6.15.5 CSAC:ALarm?

This query returns the CSAC oscillator Alarm value as shown below:

Alarm	Definition
0x0001	Signal Contrast Low
0x0002	Synthesizer tuning at limit
0x0010	DC Light level Low
0x0020	DC Light level High
0x0040	Heater Power Low
0x0080	Heater Power High
0x0100	uW Power control Low
0x0200	uW Power control High
0x0400	TCXO control voltage Low
0x0800	TCXO control voltage High
0x1000	Laser current Low
0x2000	Laser current High
0x4000	Stack overflow (firmware error)

6.15.6 CSAC:MODE?

This query returns the CSAC oscillator mode as shown below:

0x0001	Analog tuning enable
0x0002	Reserved
0x0004	Reserved
0x0008	1 PPS auto-sync enable
0x0010	Discipline enable
0x0020	Ultra-low power mode enable
0x0040	Reserved
0x0080	Reserved

6.15.7 CSAC:CONTrast?

This query returns an indication of signal level, typically ~4000 when locked and ~0 when unlocked.

6.15.8 CSAC:LASer?

This query returns the current (in mA) driving the laser.

6.15.9 CSAC:TCXO?

This query returns the TCXO tuning voltage. The tuning voltage range is 0-2.5 VDC, reported at +/- 10 ppm absolute accuracy.

6.15.10 CSAC:SIGnal?

This query returns an indication of signal level.

6.15.11 CSAC:HEATpackage?

This query returns the physics-package heater power, typically 15mW under normal operating conditions.

6.15.12 CSAC:TEMP?

This query returns the temperature measured by the CSAC unit in °C. Absolute accuracy is +/- 2°C.

6.15.13 CSAC:FWrev?

This query returns the firmware version of the CSAC's internal microcontroller.

6.15.14 CSAC:SN?

This query returns the serial number of the CSAC in the format YYMMCSNNNNN, where YYMM is the year and month of production and NNNNN is the serialized unit of that month.

6.15.15 CSAC:LIFEtime?

This query returns the accumulated number of hours that the CSAC has been powered on since the last factory reset of the RSR GNSS Transcoder™ board. The value is stored in the external NVRAM and updated every hour when the CSAC is powered on.

6.15.16 CSAC:STeer:LATch ONCE

This command stores the momentary steering offset into the CSAC internal NVRAM. This is done automatically by the firmware once every 24 hours to avoid exhausting the limited number of write cycles available to the CSAC NVRAM. The user may force this value to be stored into the CSAC by issuing the CSAC:STeer:LATch ONCE command.

6.15.17 CSAC?

This query displays all the CSAC queries defined above.

7

Alternative Firmware Upgrade Instructions

7.1 Introduction

The preferred method to update the RSR GNSS Transcoder™ firmware is to use the SimCon application as described in Chapter 4. Using SimCon allows in-situ fully-automated firmware updates without having to short out jumper pins on connector J3 as described below. Please follow the instructions in Section 4.3 for installing SimCon and Section 4.8.1 for updating the firmware.

Chapter 7 describes an alternative firmware update method using the Flash Magic. The entire flash upgrade can be done in less than five minutes, even though the following seems like a fairly long list of instructions.

7.2 ISP Flash Loader Utility Installation

Flash Magic is available for download on the Flash Magic website:

   http://www.flashmagictool.com/

Follow the directions given on the website for installing the utility on your computer.

Note: The Philips LPC2000 utility that is used on other Jackson Labs Technologies, Inc. products will not support the newer LPC18S37 processor used on this product.

7.3 Putting the PCB into In-Circuit Programming (ISP) mode

Momentarily short-out pins 1 and 2 of ISP#/RESET# header J3 using a jumper wire or other conductive material (tweezers etc.) during power-on (See Figure 7.1). All LEDs on the PCB should remain off, indicating the unit is properly placed into ISP mode. If the LEDs light up after power-on, the unit is not in ISP mode. If the unit is in the optional IP67 enclosure, then the ISP# pin is accessible at pin 6 of the DB-15 connector.

Figure 7.1   Location of ISP and Reset header J3


7.4 Downloading the Firmware

Download the latest version of RSR GNSS Transcoder™ firmware from the Jackson Labs Technologies, Inc. support website and store it. The file is in .hex format. The unit needs to be connected to the computer's USB serial port prior to firmware download. Connect a USB cable to USB connector J2 on the RSR GNSS Transcoder™. This will provide power to the board, as well as communications with the PC for downloading the firmware into the board. The ISP pin needs to be shorted for several seconds while plugging in the unit into a USB port to enable ISP mode.

7.4.1 Using the Flash Magic Programming Utility

If Flash Magic version is 11.20 or older, skip to Section 7.4.2 for instructions on Classic Version of Flash Magic

A) Open the Flash Magic utility. Select the correct Device LPC18S37 by clicking "Change..." and select LPC1800->LPC18S37.

Figure 7.2   Flash Magic Programming Utility v12 and later
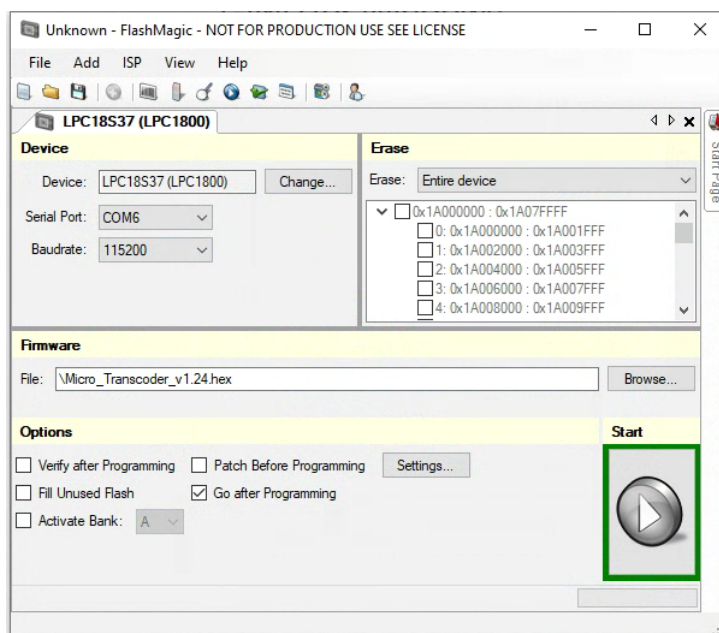
B) Select Erase "Sectors used by file" option as shown in Figure 7.3. This step is very important as the default Erase option is "Entire device". It may be helpful to select "Save Project" to save the Flash Magic settings for the FireFox for future firmware update.

Warning: Make sure the Erase option is selected as "Sectors used by file" at all time, leaving the Erase option as "Entire device" will erase factory calibration data, and the unit will not operate and will have to be returned to the factory. Programming the FireFox with the Erase "Entire device" option on the ISP utility will thus void the warranty.

Figure 7.3   Erase Sectors used by file
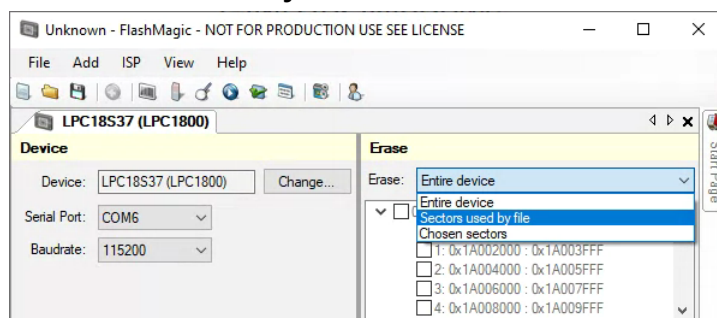
C) Change the COM port in the Flash Magic application as needed and select baud rate 115200 as shown in Figure 7.2. Slower baud rates will also work, but will take longer to finish the programming cycle.

D) Under "Firmware" section, click "Browse..." to browse for the hex file that you downloaded in Section 7.4 .

E) Check again for the Erase option "Sectors used by file" in Figure 7.3.

F) Go to "Start" section and press the gray start button ⊙ . You will observe the firmware being downloaded to the processor.

G) Verify the firmware update in Section 7.5 .

7.4.2 Using the Flash Magic Classic Version

A) Open the Flash Magic utility. Set the COM port in the Flash Magic application as needed on your PC. Set "Interface" to "None (ISP)".

**Figure 7.4   Flash Magic Programming Utility**
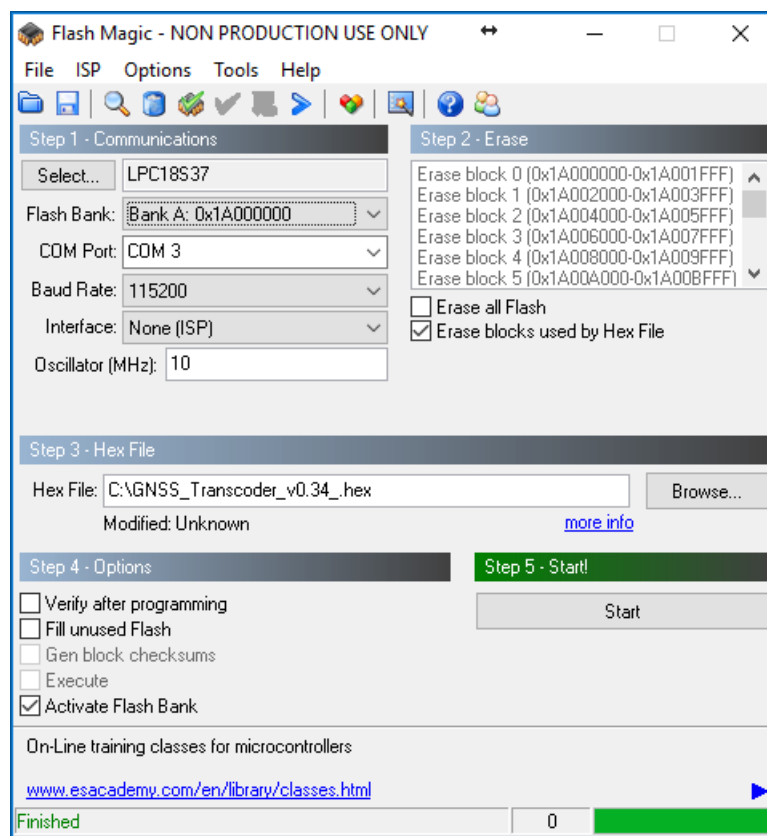
Please Note that the latest versions of Flash Magic contain a new communications option that is likely set incorrectly by default. If this setting is incorrectly selected, Flash Magic may not be able to communicate properly with the processor.

Open the "Options" and "Advanced Options" tabs on the application. Please ensure that the "Use My Line Feed Settings", "Send Line Feeds", and "Expect Line Feeds" options are all highlighted and selected as show in Figure 7.5 below

Press "OK" to get back to the main menu.

Figure 7.5   Required Flash Magic Communications Options
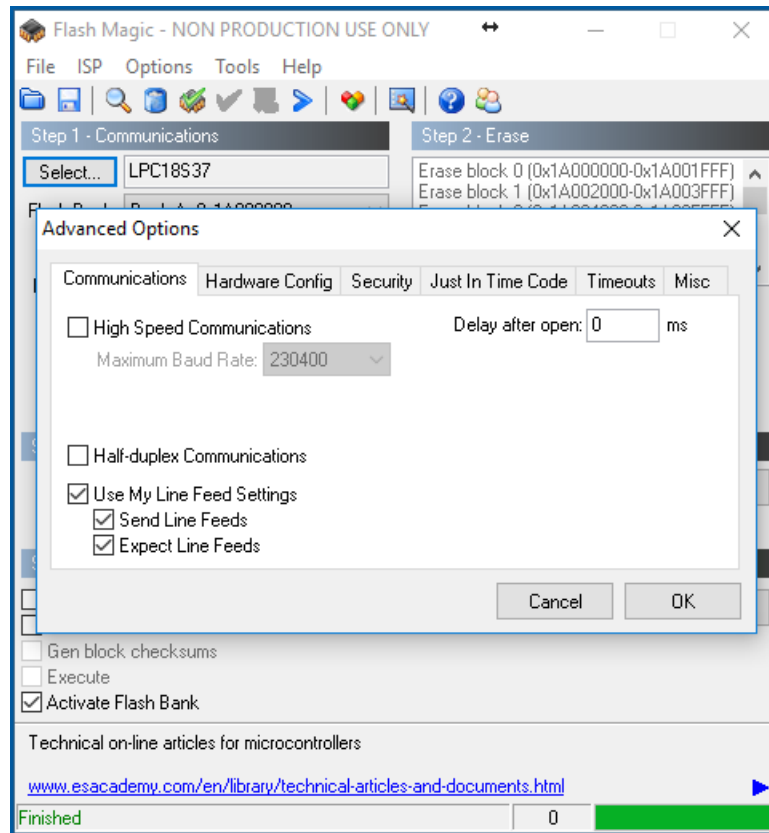
B) Press the "Select Device" button and the window shown in Figure 7.6 will appear:

Figure 7.6   Device selection window
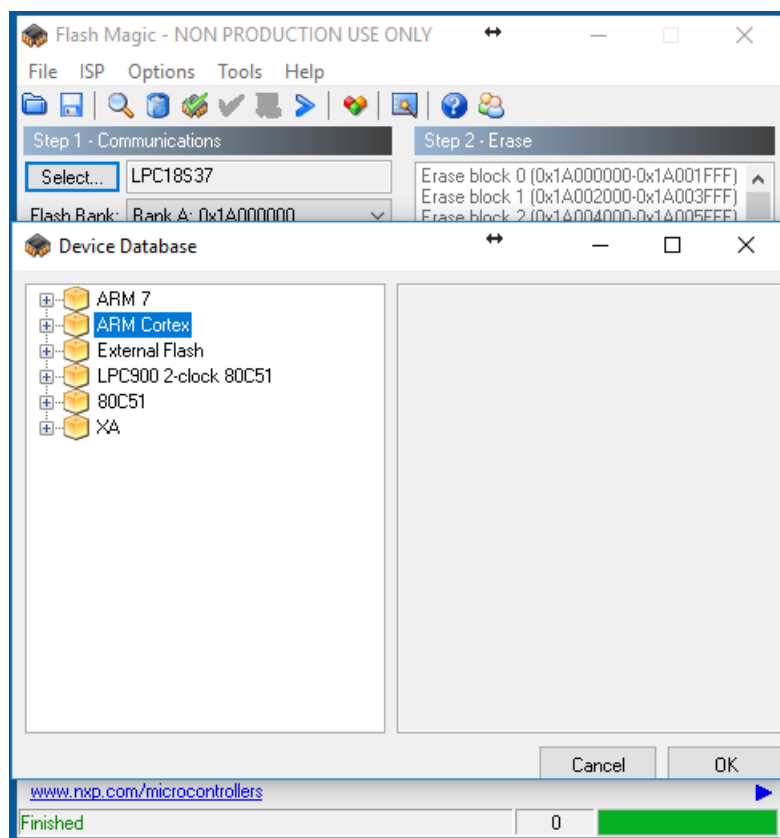
C) Expand the **ARM CORTEX** folder and select the appropriate processor, in this case the **LPC18S37**.

Figure 7.7   Expanded device selection window

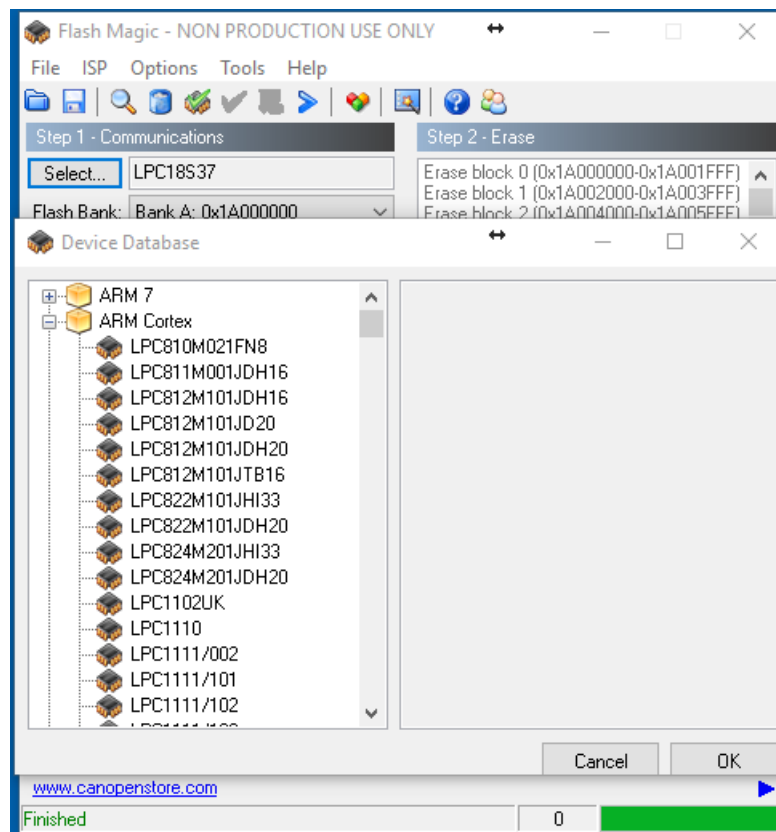D) Select the Baud Rate of the Flash Magic utility to be **115200.** Slower baud rates will also work, but will take longer to finish the programming cycle.

E) Set the Oscillator (MHz) to "10.0".

F) Check the box marked "Erase blocks used by Hex File".

Warning: Make sure NOT(!) to check the box marked "Erase all Flash" under any circumstances. This will erase factory calibration data, and the unit will have to be returned to the factory. Checking this box on the ISP utility will thus void the warranty.

G) Under "Step 3 - Hex File" browse for the hex file that you downloaded in step 7.4 .

H) Under "Step 4 - Options" check "Activate Flash Bank"

I) Go to Step 5 and press "Start". You will observe the firmware being downloaded to the processor.

7.5 Verifying Firmware Update

Power cycle the unit. The LEDs should light up.

During power on, the unit sends an ID string with the software version out of the USB serial port J2 at 115200 Baud by default. The firmware version can also be queried by sending the *IDN? command. Verify that the firmware version is the version that was downloaded.

8 Certification and Warranty

8.1 Certification

Jackson Labs Technologies, Inc. certifies that this product met its published specifications at time of shipment.

8.1.1 Warranty

This Jackson Labs Technologies, Inc. hardware product is warranted against defects in material and workmanship for a period of 1 (one) year from date of delivery. During the warranty period Jackson Labs Technologies, Inc. will, at its discretion, either repair or replace products that prove to be defective. Jackson Labs Technologies, Inc. does not warrant that the operation for the software, firmware, or hardware shall be uninterrupted or error free even if the product is operated within its specifications.

For warranty service, this product must be returned to Jackson Labs Technologies, Inc. or a service facility designated by Jackson Labs Technologies, Inc. Customer shall prepay shipping charges (and shall pay all duties and taxes) for products returned to Jackson Labs Technologies, Inc. for warranty service. Except for products returned to Customer from another country, Jackson Labs Technologies, Inc. shall pay for return of products to Customer. If Jackson Labs Technologies, Inc. is unable, within a reasonable time, to repair or replace any product to condition as warranted, the Customer shall be entitled to a refund of the purchase price upon return of the product to Jackson Labs Technologies, Inc.

8.1.2 Limitation of Warranty

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by the Customer, Customer-supplied software or interfacing, unauthorized modification or misuse, opening of the instruments enclosure or removal of the instruments panels, operation outside of the environmental or electrical specifications for the product, or improper site preparation and maintenance. **JACKSON LABS TECHNOLOGIES, INC. SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR**

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8.1.3 Exclusive Remedies

THE REMEDIES PROVIDED HEREIN ARE THE CUSTOMER'S SOLE AND EXCLUSIVE REMEDIES. JACKSON LABS TECHNOLOGIES, INC. SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

9 Revision History

9.1 Revision Table

Revision history of the RSR Transcoder™ User Manual is listed in Table 9.1.

Table 9.1   Revision History

Document ID	Release Date	ECN	Firmware Version
RSR Transcoder™ User Manual v1.7	28 February, 2020	N/A	1.24
Modifications	Updated 3.8.1 Transcoding with External PNT Source Updated 6.3.3 SIMulation:STATe? Updated Chapter 7 Alternative Firmware Upgrade Instructions Updated Chapter 9 Revision History		
RSR Transcoder™ User Manual v1.6	5 January, 2020	80200580	1.24
Modifications	Updated Chapter 9 Revision History		
RSR Transcoder™ User Manual v1.5	3 October, 2019	N/A	1.22
Modifications	Updated Section 3.8.1 Transcoding with External PNT Source Updated Section 3.8.16.2 External Receiver Performance Monitoring Updated Section 4.9.4 Performance tab Updated Section 6.3 Simulation Subsystem Updated Section 6.3.8 SIMulation:POSition:MODE Added Section 6.3.17 SIMulation:POSition:FILTer:VIN Added Section 6.3.18 SIMulation:POSition:FILTer:VOUT Added Section 6.3.19 SIMulation:POSition:FILTer:POUT Added Section 6.3.20 SIMulation:POSition:FILTer:DELay Updated Section 6.3.21 SIMulation:POSition:FILTer? Updated Section 6.7 SYNChronization Subsystem Updated Section 6.7.5 SYNChronization:SOURce:MODE Added Chapter 9 Revision History		
RSR Transcoder™ User Manual v1.4	13 May, 2019	N/A	1.15a

Document ID	Release Date	ECN	Firmware Version
Modifications	Updated Section 3.8.16.2 External Receiver Performance Monitoring Updated Figure 4.14 Typical performance graph display		

Document ID	Release Date	ECN	Firmware Version
RSR Transcoder™ User Manual v1.3	16 November, 2018	80200572	1.15
Modifications	Updated Section 3.8.2 Detecting and Configuring External GNSS Receiver Updated Section 3.8.2.2 Connecting a uBlox GNSS Receiver Updated Section 3.8.5 Configuring the GPS Constellation Updated Section 3.8.5.1 Uploading Almanac and Ephemerides Data Updated Section 3.8.12 Simulating Leap Second Event Added Section 3.8.16.2 External Receiver Performance Monitoring Updated Section 6.3 Simulation Subsystem Updated Section 6.3.3 SIMulation:STATe? Updated Section 6.3.31 SIMulation:TRACe Added Section 6.3.39 SIMulation:SV:HDOP? Added Section 6.3.40 SIMulation:SV:VDOP? Added Section 6.3.41 SIMulation:SV:TDOP? Updated Section 6.3.44 SIMulation:TIME:MODE Updated Section 6.3.71 SIMulation:LNAV:SELect Added Section 6.3.73 SIMulation:GPGGA Added Section 6.3.74 SIMulation:GPRMC Added Section 6.3.75 SIMulation:NMEA <nmea string> Updated Section 6.10 GPS Subsystem Added Section 6.10.29 GPS:PORT <SCPI | RS232> Added Section 6.10.34 GPS:RATE [1|10] Added Section 6.10.30 GPS:PPSERRor? Added Section 6.10.31 GPS:POSERRor? Added Section 6.10.32 GPS:VPOSERRor? Updaetd Section 6.13 SYSTEM Subsystem Added Section 6.13.4 SYSTem:COMMunicate:USB:BAUD		
RSR Transcoder™ User Manual v1.2	18 July, 2018	N/A	v1.01
Modifications	Updated Section 1.1 Overview Updated Section 1.2 Operating Principles Updated Section 1.3.1 Legacy GPS Receiver Compatibility Updated Section 1.3.2 Use an approved Antenna Lightning Protector Updated Section 1.3.4 Grounding Updated Section 1.3.5 Power Connections Updated Section 2.1 Introduction Updated Section 2.2 Power and Control Setup Updated Section 2.3 Connecting to a Target GPS Receiver's Antenna Input Updated Section 2.4 Simulation Control Updated Section 2.5 Simulating to Rockwell Collins DAGR with Battery Power Updated Section 3.1 Introduction Updated Section 3.2 Operating the Unit Updated Section 3.2.1 USB Control and Power Updated Section 3.2.2 DC Power supply: 7V to 36V Updated Section 3.3 Alternate Powering Supply Options Updated Section 3.3.1 Powering External GNSS Receivers Updated Section 3.3.2 Powering the RSR GNSS Transcoder™ From an External LiPo or LiIon Single-Cell Battery		

Document ID	Release Date	ECN	Firmware Version
Modifications (cont.)	Updated Section 3.4 Connecting to a Target GPS Receiver Updated Section 3.6 Major Features Updated Section 3.6.1 Power/Communication Connector J4 Updated Section 3.6.2 ISP#/SAASM Zeroize and RESET# Connector J3 Updated Section 3.6.3 RF SMA Connector J5 Updated Section 3.6.4 Optional CSAC Holdover Oscillator Updated Section 3.7 Optional Cable and Enclosure Solutions Updated Section 3.8 Operating Modes of the RSR GNSS Transcoder™ Updated Section 3.8.1 Transcoding with External PNT Source Updated Section 3.8.3 Manually entering Lat/Long/Height Simulation Coordinates Updated Section 3.8.4 Simulating from Internally Stored Motion Commands Updated Section 3.8.5.1 Uploading Almanac and Ephemerides Data Updated Section 3.8.7 Satellite Elevation Mask Angle Updated Section 3.8.8 Using the Position Filtering Capabilities Updated Section 3.8.9 Adjusting the RF Output Power Level Updated Section 3.8.10 Enabling RF Test-Tone Output Updated Section 3.8.11 Configuring the simulated Time and Date Updated Section 3.8.12 Simulating Leap Second Event Updated Section 3.8.13 Simulating 1023 Week Number Rollover Updated Section 3.8.16.1 External Rockwell Microgram and RSR Features Added Chapter 4 SimCon Utility Moved Chapter 5 GPSCon Utility Moved Chapter 6 SCPI Command Reference Updated Section 6.1 Introduction Updated Section 6.2.1 *IDN? Updated Section 6.3 Simulation Subsystem Updated Section 6.3.1 SIMulation:MODE Updated Section 6.3.2 SIMulation:COMmand Updated Section 6.3.3 SIMulation:STATe? Updated Section 6.3.7 SIMulation:HOLDover:INDicate Updated Section 6.3.11 SIMulation:POSition:FILTer:MODE Updated Section 6.3.14 SIMulation:POSition:FILTer:VMAX Updated Section 6.3.15 SIMulation:POSition:FILTer:AMAX Updated Section 6.3.16 SIMulation:POSition:FILTer:JMAX Updated Section 6.3.23 SIMulation:POSition:MOTION:READ Added Section 6.3.25 SIMulation:POSition:MOTION:STOP Added Section 6.3.26 SIMulation:POSition:MOTION:PAUSE Added Section 6.3.27 SIMulation:POSition:MOTION:RESUME Added Section 6.3.28 SIMulation:POSition:MOTION:ZEROize Updated Section 6.3.29.7 Waypoint Updated Section 6.3.29.9 Combined Turn/Climb Added Section 6.3.29.11 Goto Updated Section 6.3.31 SIMulation:TRACe Added Section 6.3.34 SIMulation:SV:PATHloss Added Section 6.3.35 SIMulation:SV:ANTenna Added Section 6.3.37 SIMulation:SV:HEALTH Added Section 6.3.38 SIMulation:SV:ASflag Updated Section 6.3.44 SIMulation:TIME:MODE Updated Section 6.3.47 SIMulation:TIME:LEAPsecond:ACCumulated Added Section 6.3.50 SIMulation:TIME:LEAPsecond?		

Document ID	Release Date	ECN	Firmware Version
Modifications (cont.)	Updated Section 6.3.55 SIMulation:TIME:UTCoffset:WNT Updated Section 6.3.56 SIMulation:TIME:UTCoffset:WNLSF Added Section 6.3.60 SIMulation:TIME:CALibrate Added Section 6.3.61 SIMulation:TIME:FREQuency Added Section 6.3.65 SIMulation:IODCmsb Added Section 6.3.72 SIMulation:LNAV:HEALTH Updated Section 6.4 SIMulation? Updated Section 6.5.2 OUTput:DCBlock Updated Section 6.7 SYNChronization Subsystem Added Section 6.7.1 SYNChronization:HOLDover:STATe? Updated Section 6.7.6 SYNChronization:SOURce:STATE? Updated Section 6.7.13 SYNChronization:HEAlth? Updated Section 6.9 MEASURE Subsystem Updated Section 6.9.3 MEASure:POWersupply? Updated Section 6.9.4 MEASure:POWersupply:V12? Updated Section 6.9.5 MEASure:POWersupply:V25? Updated Section 6.9.7 MEASure? Updated Section 6.10.10 GPS:PASHR Updated Section 6.10.15 GPS:DYNAMic:MODE Updated Section 6.10.33 GPS:SYST:SELect [GPS | SBAS | QZSS | GAL | BD | GLO] Updated Section 6.11 INTGPS Subsystem Added Section 6.11.21 INTGPS:PPSERRor? Added Section 6.11.22 INTGPS:POSERRor? Added SSection 6.11.23 INTGPS:VPOSERRor? Added Section 6.11.24 INTGPS:SYSTem:STATus? Updated Section 6.12.7 PTIMe:LEAPsecond:PENDing? Updated Section 6.12.9 PTIMe:LEAPsecond:DATE? Updated Section 6.12.10 PTIMe:LEAPsecond:DURation? Updated Section 6.13 SYSTEM Subsystem Updated Section 6.13.3 SYSTem:COMMunicate:SERial:BAUD Added Section 6.13.5 SYSTem:CPURESET Updated Section 6.13.6 SYSTem:FACToryreset ONCE Added Section 6.13.7 SYSTem:USERreset ONCE Added Section 6.13.8 SYSTem:ISP Added Section 6.13.11 SYSTem:ID:UID? Added Section 6.13.13 SYSTem:FLAGS? Updated Section 6.14.5 SERVo:EFCDamping Updated Section 6.14.11 SERVo:TRACe Updated Section 6.15 CSAC Subsystem Updated Section 6.15.2 CSAC:RS232? Updated Section 6.15.9 CSAC:TCXO? Updated Section 6.15.16 CSAC:STeer:LATch ONCE Updated Chapter 7 Alternative Firmware Upgrade Instructions	

Document ID	Release Date	ECN		Firmware Version
RSR Transcoder™ User Manual v1.1	13 September, 2017	N/A		v0.37
Modifications	Updated Section 3.8.1 Transcoding with External PNT Source Updated Section 3.8.8 Using the Position Filtering Capabilities Updated Section 6.3 Simulation Subsystem Updated Section 6.3.7 SIMulation:HOLDover:INDicate Updated Section 6.7.13 SYNChronization:HEAlth?			
RSR Transcoder™ User Manual v1.0	7 September 2017	N/A		v0.37
Modifications	Initial release			