GPS-3x00 User's Guide

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Trademarks

GPS-3X00 USER'S GUIDE

Preface

NOTICE TO CUSTOMERS

All documentation becomes dated, and this manual is no exception. Microchip tools and documentation are constantly evolving to meet customer needs, so some actual dialogs and/or tool descriptions may differ from those in this document. Please refer to our website (www.microchip.com) to obtain the latest documentation available.

Documents are identified with a "DS" number. This number is located on the bottom of each page, in front of the page number. The numbering convention for the DS number is "DSXXXXXXXXA", where "XXXXXXXX" is the document number and "A" is the revision level of the document.

For the most up-to-date information on development tools, see the MPLAB® IDE online help. Select the Help menu, and then Topics, to open a list of available online help files.

PURPOSE OF THIS GUIDE

The GPS-3x00 user guide provides basic recommendations for designing products to use Microchip's GPS-3x00. The guidelines in the document are generic because specific product requirements vary from one application to the other.

This material consists of a brief description of design supported by block diagrams, description of environmental issues, installation guidelines, and unit operation.

WHO SHOULD READ THIS GUIDE

This document is intended for engineers and telecommunications professionals who are designing, installing, operating, or maintaining time, frequency, and synchronization systems having a requirement for a low profile and highly precise frequency generator.

To use this document effectively, you should have a good understanding of digital telecommunications technologies and analog frequency generation and synthesis techniques.

DOCUMENT LAYOUT

This guide contains the following sections:

- **Chapter 1. "Introduction"**: Provides an overview of the product, describes the major hardware and software features, and lists the system specifications.
- **Chapter 2. "GNSSDO Quick-Start Instructions"**: Contains the Principle of Operation, Start-Up Sequence, and aspects related to first power-up.
- **Chapter 3. "SCPI-Control Quick Start Instructions"**: Provides an overview of the telemetry interface and command structure.
- **Chapter 4. "Firmware Upgrade Instructions"**: Describes how to update the GPS-3x00 firmware.
- **Chapter 5. "GPSCon Utility"**: Contains information about using the GPSCon utility for monitoring and control.

GPS-3x00 User's Guide

CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

DOCUMENTATION CONVENTIONS

Description	Represents	Examples
Arial font:		
Italic characters	Referenced books	*MPLAB® IDE User's Guide*
	Emphasized text	...is the *only* compiler...
Initial caps	A window	the Output window
	A dialog	the Settings dialog
	A menu selection	select Enable Programmer
Quotes	A field name in a window or dialog	"Save project before build"
Underlined, italic text with right angle bracket	A menu path	*File>Save*
Bold characters	A dialog button	Click **OK**
	A tab	Click the **Power** tab
N'Rnnnn	A number in verilog format, where N is the total number of digits, R is the radix and n is a digit.	4'b0010, 2'hF1
Text in angle brackets < >	A key on the keyboard	Press <Enter>, <F1>
Courier New font:		
Plain Courier New	Sample source code	`#define START`
	Filenames	`autoexec.bat`
	File paths	`c:\mcc18\h`
	Keywords	`_asm, _endasm, static`
	Command-line options	`-Opa+, -Opa-`
	Bit values	`0, 1`
	Constants	`0xFF, 'A'`
Italic Courier New	A variable argument	`file`.o, where `file` can be any valid filename
Square brackets [ ]	Optional arguments	`mcc18 [options] file [options]`
Curly brackets and pipe character: { | }	Choice of mutually exclusive arguments; an OR selection	`errorlevel {0|1}`
Ellipses...	Replaces repeated text	`var_name [, var_name...]`
	Represents code supplied by user	`void main (void) { ... }`

WARNINGS, CAUTIONS, RECOMMENDATIONS, AND NOTES

Warnings, Cautions, Recommendations, and Notes attract attention to essential or critical information in this guide. The types of information included in each are displayed in a style consistent with the examples below.

WARNING
To avoid serious personal injury or death, do not disregard warnings. All warnings use this style. Warnings are installation, operation, or maintenance procedures, practices, or statements, that if not strictly observed, may result in serious personal injury or even death.

CAUTION
To avoid personal injury, do not disregard cautions. All cautions use this style. Cautions are installation, operation, or maintenance procedures, practices, conditions, or statements, that if not strictly observed, may result in damage to, or destruction of, the equipment. Cautions are also used to indicate a long-term health hazard.

> **Note:** All notes use this style. Notes contain installation, operation, or maintenance procedures, practices, conditions, or statements that alert you to important information, which may make your task easier or increase your understanding.

WHERE TO FIND ANSWERS TO PRODUCT AND DOCUMENT QUESTIONS

For additional information about the products described in this guide, please contact your Microchip representative or your local sales office. You can also contact us on the web at www.microsemi.com/ftdsupport.

When this manual is updated the latest version will be available for downloading from Microchip's web site. Manuals are provided in PDF format for ease of use. After downloading, you can view the manual on a computer or print it using Adobe Acrobat Reader.

Manual updates are available at: www.microsemi.com/ftdsupport

RELATED DOCUMENTS AND INFORMATION

See your Microchip representative or sales office for a complete list of available documentation. To order any accessory, contact the Microchip Sales Department. See www.microsemi.com/sales-contacts/0 for sales support contact information. If you encounter any difficulties installing or using the product, contact Microchip Frequency and Time Systems (FTS) Services and Support:

U.S.A. Call Center: including Americas, Asia and Pacific Rim

Frequency and Time Systems

3870 N 1st St.

San Jose, CA 95134

Toll-free in North America: 1-888-367-7966

Telephone: 408-428-7907

Fax: 408-428-7998

email: ftd.support@microsemi.com

Internet: www.microsemi.com/ftdsupport

Europe, Middle East, and Africa (EMEA)

Microchip FTS Services and Support EMEA

Altlaufstrasse 42

85635 Hoehenkirchen-Siegertsbrunn

Germany

Telephone: +49 700 3288 6435

Fax: +49 8102 8961 533

email: ftd.emeasupport@microsemi.com

email: ftd.emea_sales@microsemi.com

THE MICROCHIP WEBSITE

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- **General Technical Support** – Frequently Asked Questions (FAQs), technical support requests, online discussion groups, Microchip consultant program member listing
- **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives

CUSTOMER SUPPORT

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- Distributor or Representative
- Local Sales Office
- Field Application Engineer (FAE)
- Technical Support

Customers should contact their distributor, representative or field application engineer (FAE) for support. Local sales offices are also available to help customers. A listing of sales offices and locations is included in the back of this document.

Technical support is available through the website at:
http://www.microchip.com/support.

DOCUMENT REVISION HISTORY

Revision A (July 2020)

- Initial release of this document as Microchip DS50003017A.

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Chapter 3. SCPI-Control Quick Start Instructions

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NOTES:

Chapter 1. Introduction

1.1 OVERVIEW

The GPS-3x00 Global Navigation Satellite System Disciplined Oscillator (GNSSDO) offers the traditional benefits of Rubidium Reference oscillators such as high stability and very low drift, but differentiates itself from legacy products by operating with extremely low phase noise, very low power consumption, and small size and weight. The GPS-3x00 also integrates a sophisticated software control and monitoring system, a GPS/Glonass/BeiDou/QZSS/SBAS receiver, a wide-range avionics power supply, USB/LCD/RS232/RS422/CMOS interfaces, and an ovenized Phase Noise and ADEV filter oscillator with world-class performance.

Please note that throughout this document as well as on the LCD display and serial interface we refer to the Chip Scale Atomic Clock (CSAC). This is to be interpreted as being synonymous with the Rubidium MAC for the purposes of backwards compatibility with the GPS-2700 and related software. Similarly this unit offers multi-satellite system reception, and the terms GPS, GNSSDO, GNSS, and GPSDO can also be used interchangeably for purposes of this discussion.

The heart of the GPS-3x00 is a Rubidium Vapor Cell oscillator manufactured by Microchip. The internal Microchip Miniature Atomic Clock (MAC) breakthrough VCSEL laser technology and small Rubidium vapor cavity allow the Atomic Reference Oscillator to be packaged in a unit significantly smaller and with significantly less power consumption than legacy products. The MAC is binned into two different performance versions, and paired with appropriate performance level ovenized Crystal oscillators (OCXOs). The highest performance version operates with a Phase Noise performance rivaling that of the lowest noise reference oscillators on the market (–115 dBc/Hz at 1 Hz offset and a noise floor of less than –168 dBc/Hz is a typical performance, for example) and combines this ultimate Phase Noise performance with extremely good ADEV performance (less than 6E-013 ADEV from 0.1s to 5s and better than 8E-014 ADEV at 100Ks is typical on the Ultimate Performance option), a level of performance that used to require combining various different reference sources to achieve. The unit is available with a temperature range of –40°C to +70°C and greater than 200,000 hours MTBF. The unit is packaged in a precision machined, gold-plated Aluminum enclosure.
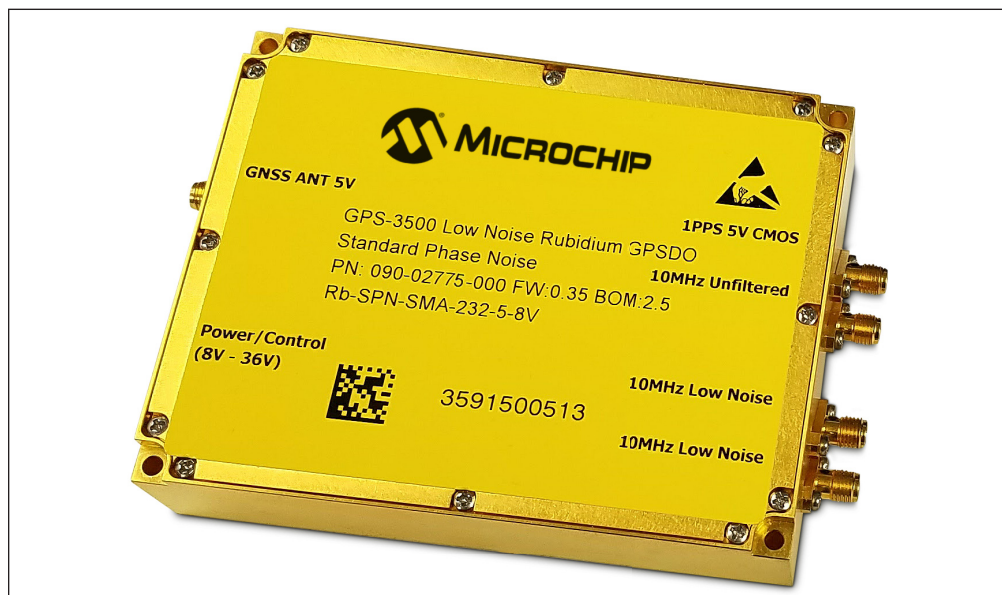
FIGURE 1-1: GPS-3x00 GNSSDO.

The GPS-3x00 enclosure has three separate 10 MHz Sine Wave SMA outputs, two CMOS 1PPS outputs, an optional external 1PPS input, an antenna connector with internal antenna bias power supply, and a sophisticated serial control interface with NMEA output capability. The GPS-3x00 board (internally to the enclosure) provides an additional 10 MHz Sine output, a 5 MHz CMOS output, LCD interface, RS-422 interface including 10 MHz and 1PPS in and out, and a USB serial link for command and control, and is powered from an aviation bus compatible power supply that operates from 8V up to 36V with reverse polarity protection, and can thus be directly connected to an aircraft's or vehicles' 12V or 24V power bus.

For long term Stratum-1 frequency accuracy and constant calibration the GPS-3x00 includes an extremely high-performance GNSS receiver that can acquire and track up to 72 GNSS signals down to a state of the art –167 dBm allowing indoor reception, and supports the simultaneous reception of various GNSS systems such as GPS, Glonass, BeiDou, QZSS, SBAS, and Galileo (Galileo with a firmware update when the constellation becomes available).

The GPS-3x00 also includes a high-performance triple time-interval-counter that can measure the internally generated 1PPS signal from the GPS receiver or an externally supplied 1PPS reference signal as well as the phase difference between the Rubidium oscillator and the Crystal Filter oscillator all simultaneously with a resolution of 20 picoseconds per second. The Rubidium oscillator is phase-locked to either of the two 1PPS signals with better than 0.2 ns average phase accuracy typically, and the Crystal Filter oscillator can be phase locked to better than 0.3 ns average steady-state phase accuracy to the Rubidium reference typically. Software compensation measures residual aging, thermal, and g-sensitivity errors of the oscillators, and applies electronic compensation to reduce these residual errors. This error compensation can improve performance especially in GNSS-denied environments, and allows monitoring of the Rubidium and Crystal oscillator health, and detection of performance abnormalities in the system. A complex Built-In Self Test (BIST) system constantly monitors the units' health and performance and issues a TTL alert as well as pushed or polled status sentences.

Generic NMEA and SCPI (GPIB) commands on three serial interfaces allow very fast integration into legacy applications, and by using the NMEA serial strings the unit can behave like a standard GNSS receiver albeit with better than 1 meter horizontal accuracy typically, and full WAAS/EGNOS/MSAS SBAS as well as Glonass/GPS/Bei-

Dou/QZSS support out-of-the-box. The SCPI command interface is fully backwards compatible to the GPS-2700command systems, and the unit can thus be used as a drop-in upgrade for applications designed for these products.

1.2   OPERATING PRINCIPLES

A Rubidium Vapor Cell is excited from a VCSEL Laser source. The VCSEL is modulated at 3.4 GHz to produce a complementary pair of sidebands separated by the Rubidium ground state hyperfine frequency of 6.834 GHz. The hyperfine transition frequency of the Rubidium Vapor cell is affected by adverse environmental influences, and long-term frequency and phase errors are thus present in the MAC as in every Atomic Clock. To calibrate these errors out and to achieve phase-lock to UTC(GNSS), the GPS-3x00 uses a GNSS receiver to generate a highly accurate, though unstable 1PPS signal, and this noisy 1PPS signal is compared with a 1PPS signal generated by the MAC-sourced 10 MHz using a 20 ps time interval counter. The VCSEL is digitally tuned to shift the frequency up or down slightly (in 0.001 parts per trillion or 1E-015 resolution) and very slowly to keep the MAC 1PPS reference in phase-lock with the GNSS-generated 1PPS signal. This allows a very close tracking of the UTC 1PPS signal to within tens of nanoseconds anywhere in the world, out-performing even the best free-running Atomic References in the long run. Selection of the GNSS system being activated allows tracking various different world-wide UTC time systems, with UTC(NIST) being a default UTC reference. With this software PLL system the short-term instability of the GPS receiver is filtered by the MAC, while the MAC's long-term drift is removed by the GNSS receiver, resulting in both a very good short-term as well as tightly UTC phase-locked long-term performance.

The 10 MHz VCXO used in the MAC oscillator exhibits fairly high phase noise and numerous spurs on the output of the MAC. A dedicated ovenized phase noise cleanup oscillator is phase-locked to the MAC 10MHz output with selectable time constants (loop bandwidth), which allows generation of world-class phase noise and ADEV performance while maintaining the superior drift performance and stability of the MAC Rubidium. Spurs are also removed to eliminate phantom targets in radar applications for example. Software commands allow either the cleanup phase noise filter, or the raw 10 MHz output of the MAC to be selected on the "unfiltered" SMA connector, as well as selection of the 1PPS time domain from the MAC or the Crystal OCXO. Two additional SMA connectors are permanently connected to the filter OCXO to maintain the extremely low phase noise floor. The two oscillators may have small phase offsets to each other, and will have different jitter/wander performance levels. Both the average phase offsets between the GNSS receiver 1PPS and the Rubidium oscillator, as well as the Rubidium oscillator to the OCXO phase offsets can be monitored on a second-to-second basis in 20 ps resolution, and this information can be used by a users' application to compensate phase offsets to sub nanosecond levels.

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. Microchip assumes no liability for the customer's failure to comply with these requirements.

1.3.1   Use an Approved Antenna Lightning Protector

The use of an approved, and properly grounded antenna lightning protector on the GNSS antenna is required to prevent damage, injury or death in case of a lightning strike.

1.3.2 Grounding

To avoid damaging the sensitive electronic components in the GPS-3x00 always make sure to discharge any built-up electrostatic charge to a good ground source, such as power supply ground. This should be done before handling the circuit board or anything connected to it, i.e. the GNSS antenna.

1.3.3 Power Connections

Make sure to connect the DC power to the device following the polarity indicated in Section 2.6.

1.3.4 Environmental Conditions

This instrument is intended for indoor use. The use of a properly installed GNSS Antenna Lightning Protector is required. 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 tables for the DC and AC mains voltage requirements and ambient operating temperature range. This product consumes more than 5W of power in steady-state conditions, and will heat up accordingly. Sufficient cooling of the backplate is required to maintain operation at or below +70°C on the backplate.

Chapter 2. GNSSDO Quick-Start Instructions

2.1   ORDERING OPTIONS

The two versions of the Miniature Atomic Clock (MAC) based GNSSDOs are:

• GPS-3500: High Performance Phase Noise, ADEV, Thermal Stability, and Hold-over performance (MAC-based)

• GPS-3300: Base Phase Noise, ADEV, Thermal Stability, and Holdover performance (MAC-based)

Specifications and loop parameters change between these ordering options, but all units support the same basic SCPI and GNSS feature set. Differentiation is done by selecting the type and quality of atomic clock oscillator, as well as the type and quality of the Crystal Phase Noise Filter oscillator.

2.2   POWERING UP THE UNIT

The GPS-3x00 may be powered from an external 8V to 36V DC source, with +12V nominal. The unit consumes typically around 18W for several minutes during warm-up, and will then settle into a steady state power consumption of less than 5.6W. A power supply of 12V with at least 1.5A capability is suggested. The CSAC ordering option of the product consumes less than 1.4W steady state (less than 0.12A at 12V).

Serial communications can be established through the RS-232 or USB ports at 115,200 baud, 8N1, no flow-control set on the terminal. It is recommended to use the TeraTerm Pro application or a similar application. Once serial communications have been established, the user can try sending, and experimenting with the following useful SCPI commands:

• SYST:STAT?
• GPS?
• SYNC?
• DIAG?
• MEAS?
• CSAC? or MAC?
• HELP?

2.3   BLOCK DIAGRAM

Figure 2.1 depicts the block diagram of the GPS-3x00. The unit is built around the MAC Rubidium oscillator that controls a time interval counter with three channels and 20 ps resolution. The main processor measures the phase offsets between the MAC oscillator, the GNSS 1PPS pulse, and the Filter Oscillator 1PPS pulse, as well as the optional externally supplied 1PPS references. The processor then steers the MAC and Crystal Filter oscillators to be phase-coherent to each other and to the 1PPS reference signals. The two oscillator phase time domains then generate their 10 MHz and 1PPS output signals, allowing the user to select which 1PPS and 10 MHz outputs are routed to the buffered SMA connector outputs. After power on the two oscillator time domains are quickly frequency locked, however they may have phase offsets of up to several 100 nanoseconds during warm-up and when disturbed by aggressive temperature changes

or mechanical shock/vibration etc which will slowly be corrected to zero phase offsets by the control loops. The phase offsets of the 1PPS references to the MAC oscillator, and the MAC oscillator to the filter oscillator can be queried by the serial command SYNC:TINT? and any time.

FIGURE 2-1: Block Diagram of the GPS-3x00.

2.4 OPERATING THE UNIT

1. Connect a 5V-compatible GPS or Glonass antenna to the GNSS connector. Either GPS or Glonass, or combined GPS/Glonass L1 antennae are supported. It is recommended to use active antennae with at least +10 dB internal gain, and a maximum allowable gain of +50 dB.

2. Plug in a short USB to RS-232 cable adapter or a standard NULL modem male connector to the RS-232 female plug on the power supply cable harness (supplied with the unit). Plug in a clean DC power source of between 8V to 32V (36V max) to the power pins 15 and 16 of the 16-pin connector J1. Plug in the Ground connection to pins 12 and 14 of connector J1. RS-232 Serial TX and RX signals are available on pins 9 and 8 respectively of connector J1. Make sure not to accidentally short-out adjacent pins 13 and 15 of connector J1 as this would damage the board.

WARNING
When operating the unit outside of its enclosure or with an open lid, please make sure not to confuse power connector J1 and LCD connector J3 because these two connectors are mechanically identical and are therefore easy to mix up. Applying power to LCD connector J3 will severely damage the PC board.

The unit will now discipline its oscillators to the GNSS system. A Lock indication (+3.3V) on pin 7 of connector J1, on the internal Green LED, and on the SCPI status sentences will typically happen in less than 20 minutes after power-on with a GNSS

antenna connected. Without a GNSS feed, the unit will work as a traditional Atomic Clock in Rubidium holdover mode, and in this mode the unit will slowly blink the internal Green LED and the LOCK OK output on pin 7 at 0.25 Hz to indicate when the unit has internally locked the OCXO to the Rubidium reference, the unit is healthy, and no events are pending. No indication on the internal Green LED and on pin 7 (0V) signifies that an event happened or the unit is not warmed up and locked yet, and this event status can be queried in detail with the SYNC:HEALTH? and other SCPI commands.

Please note that the GNSS receiver establishes the internal antenna-gain right after power-on, so for proper operation the GNSS antenna should always be connected prior to turning on the power supply.

The operator may use Hyperterminal, TeraTerm, GPSCon, or any other serial control software to send commands and query status from the unit. The third-party application GPSCon is recommended for monitoring and controlling the unit.

The RS-232 serial port on the main 16-pin connector operates in parallel to the enclosure-internal USB serial port, and commands can be sent and queried independently to and from both connectors. English language SCPI commands are available to switch the default serial output of the unit from the RS-232 serial port to the USB port and vice-versa. Please note that using the standard enclosure shields the internal USB connector from being accessible by the user. The PCB will have to be operated outside of the enclosure, or the enclosure will have to be modified to allow access to this and a host of other internally accessible connectors.

2.5   ACCESSING INTERNAL CONNECTIONS

The unit contains various internal connectors such as the RS-422 interfaces, the LCD connector, 5 MHz output, and an additional 10 MHz buffered output. The unit may be operated with the lid opened (removed), or the lid may be modified to allow additional connections such as low-profile bulkhead DB-9 connectors to provide external accessibility to these connections.

2.6 MAJOR CONNECTIONS

The major connections and features of the GPS-3x00 PCB are shown in Figure 2-2.
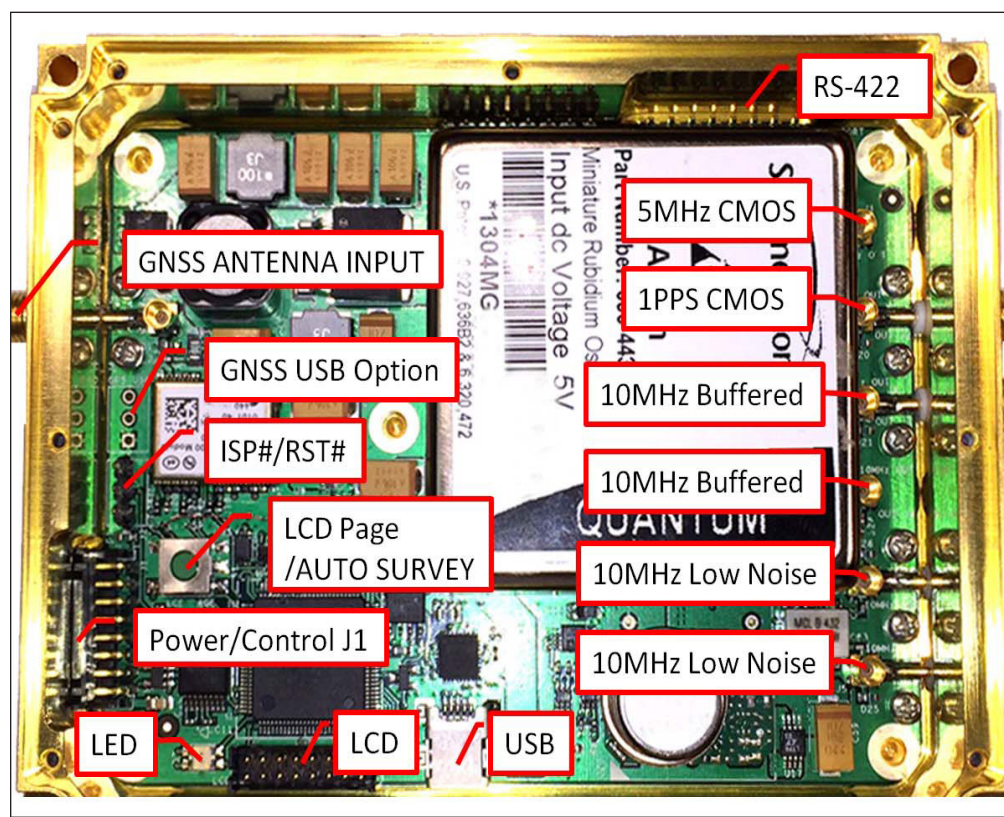
FIGURE 2-2: *Major Connections and Features of the GPS-3x00 PCB.*

Table 2-1 shows the functions supported on connector J1. This connector is compatible to the GPS-2700 connector J1, except pin 13 which is now a secondary CMOS 5V 1PPS output.

TABLE 2-1: CONNECTOR J1 PINOUT

Ref	Name	Function	Specification
J1-1	ISP#	Enter ISP mode	GND pin 1 to activate
J1-2	RST_IN#	Reset the instrument	GND pin 2 to activate
J1-5	LCD_KEY	Cycle through the LCD pages. Initiate Auto-Survey. Wired in parallel with switch S1.	GND momentarily to cycle LCD pages. GND for more than 8 seconds to initiate Auto-Survey.
J1-7	LOCK_OK_OUT	+3.3V constant indicates that no internal events are pending, the hardware is okay, and the MAC and OCXO are locked to GNSS. A 0.25 Hz blinking indicates GNSS holdover with OCXO lock to Rubidium. 0V indicates an EVENT or NO LOCK (warm-up).	3.3V CMOS output can drive up to 5 mA, series-terminated by 33Ω.
J1-8	RX_232	RS-232 receive data	RS-232 level, 115.2 KB, 8N1
J1-9	TX_232	RS-232 transmit data	RS-232 level, 115.2 KB, 8N1

TABLE 2-1: CONNECTOR J1 PINOUT (CONTINUED)

Ref	Name	Function	Specification
J1-10	GPS_RS232	Raw NMEA output from GNSS receiver in RS-232 level format.	RS-232 level, 38.4 KB, 8N1
J1-11	1PPS_IN	External alternate 1PPS input	TTL, 3.3V and 5V CMOS compatible
J1-13	1PPS_OUT	5V CMOS 1PPS output.	5V CMOS either from MAC oscillator or OCXO oscillator (software selectable), series-terminated with 50Ω.

2.6.1 Harness Pinning

Table 2-2 is a table of the cable harness J1 pinout.

TABLE 2-2: J1 PINOUT

Pin	Name
1	ENTER_ISP#
2	RST_IN#
3	GND
4	GND
5	LCD_KEY
6	GND
7	LOCK_OK_OUT
8	RX RS-232
9	TX RS-232
10	GPS_RS232
11	1PPS_IN
12	GND
13	1PPS_OUT
14	GND
15	+8V to +36V
16	+8V to +36V

TABLE 2-3: MISCELLANEOUS CONNECTORS

Ref	Name	Function	Specification	Pinning
J2	ISP#/RESET#	ISP/RESET jumper	GND pin 1 or pin 3 to activate	J2-1:ISP; J2-2:GND; J2-3:RST#
J4	GNSS USB	Optional USB connection to GNSS receiver.	USB 2.0. To enable: move R42 to position R43, stuff connector J4. Connect to uBlox uCenter application	J4-1: GND; J4-2: DM; J4-3: DP
J5	GNSS Antenna	GNSS Antenna	5V Amplified L1 GPS and/or Glonass Antenna, +10 dB to +50 dB antenna gain recommended	Center: RF Input; Shield: GND

TABLE 2-3:   MISCELLANEOUS CONNECTORS (CONTINUED)

Ref	Name	Function	Specification	Pinning
OUT_J1	5 MHz OUT	5 MHz output	5V CMOS series-terminated with 50Ω	Center: RF output; Shield: GND
OUT_J2	1PPS OUT	1 pps output	5V CMOS either from MAC oscillator or OCXO oscillator (software selectable), series-terminated with 50Ω	Center: RF output; Shield: GND
OUT_J3-J6	10 MHz Buffered	10 MHz output from isolated distribution amplifier	Sine wave, +13 dBm (±1 dBm) either from MAC oscillator or OCXO oscillator (software selectable). Leave unterminated when unused.	Center: RF output; Shield: GND
OUT_J5-J6	10 MHz Unbuffered	10 MHz unbuffered output directly from OCXO	Sine wave, +5 dBm (+5 dBm, -2 dBm). Terminate with 50Ω when unused.	Center: RF output; Shield: GND

2.6.2   RS-422 Connector JP2

The unit supports RS-422 level differential input and outputs on internal connector JP2. RS-422 levels are essentially high-speed 3.3V CMOS outputs with the capability to drive 120Ω differential terminations as defined in the RS-422 standard. 10 MHz, 1PPS, and SCPI serial stream outputs in RS-422 levels are available, as well as an optional RS-422 1PPS input which is ored' to the 1PPS CMOS input signal on connector J1. Please note that connector JP2 only contains the differential RS-422 signals, and does not contain a ground shield pin. It is recommended that the differential RS-422 signal wires are shielded to the enclosure (system) ground for added noise immunity. Leave unused outputs unterminated. Connector JP2 has the following pinout:

TABLE 2-4:   RS-422 CONNECTOR JP2 PINOUT

Ref	Name	Function	Specification
JP2-1	SERIAL OUTN	SCPI/NMEA Serial Port TX–	RS-422, 115.2 Kbaud 8N2, connected in parallel to the RS-232 TX signal
JP2-2	SERIAL OUTP	SCPI/NMEA Serial Port TX+	RS-422, 115.2 Kbaud 8N2, connected in parallel to the RS-232 TX signal
JP2-3	1PPS INN	1PPS external input–	RS-422 level, ORED with J1 1PPS input. Terminated by 120Ω to 1PPS INP
JP2-4	1PPS INP	1PPS external input+	RS-422 level, ORED with J1 1PPS input. Terminated by 120Ω to 1PPS INN
JP2-5	1PPS OUTN	1PPS OUT–	RS-422 level, either from MAC oscillator or OCXO oscillator (software selectable)
JP2-6	1PPS OUTP	1PPS OUT+	RS-422 level, either from MAC oscillator or OCXO oscillator (software selectable)
JP2-7	10 MHz OUTN	10 MHz OUT–	RS-422 level
JP2-8	10 MHz OUTP	10 MHz OUT+	RS-422 level

2.6.3 Harness Connectors J1 and J3

The manufacturer for connectors J1 and J3 is Hirose. A mating housing part number for this connector is available from Digikey, and crimp pins are also available from Digikey for different wire sizes:

http://search.digikey.com/scripts/DkSearch/dksus.dll?Detail&name=H2025-ND

The equivalent part number of the connectors soldered onto the GPS-3x00 PCB is: Hirose DF11-16DP-2DSA01

2.6.4 Connecting the GPS/Glonass Antenna

Connect the GPS/Glonass antenna to connector J6. The unit will work with a GPS, Glonass, or combined GPS/Glonass active antenna. Caution: use a Lightning Arrestor on your Antenna setup. Use an amplified antenna that is 5V compatible. The GPS-3x00 GPS receiver is a 72 channel high-sensitivity GNSS receiver with very fast lock time. The unit can either be used in stationary applications using the automatic self-survey (Auto Survey with Position Hold) feature, or it can be used in mobile platforms. Using Position Hold mode improves timing and frequency accuracy especially in GPS/Glonass-challenged antenna locations such as under foliage or with strong multipath signals.

The GPS-3x00 is capable of generating industry standard navigation messages (see GPS:GPGGA, GPS:GPZDA, GPS:GPGSV, GPS:PASHR, GPS:GSV, and GPS:GPRMC serial commands) that are compatible with most GPS/Glonass based navigation software. These navigation messages may either be sent out of the RS-232 and RS-422 serial port, or the USB serial port.

2.6.5 Selecting GNSS Systems

The GNSS receiver of the GPS-3x00 is capable of receiving several different GNSS systems at the same time providing better performance especially in challenged or denied environments. The unit may be operated with GPS, SBAS, and Glonass simultaneous operation, or with GPS or Glonass only operation. It can also operate in BeiDou or QZSS only mode where these signals are available. The GNSS receiver allows up to two different GNSS systems to be operated at the same time. Up to 24 satellites can be received at any given time per GNSS system. It is recommended that Glonass operation is only enabled when a Glonass or Glonass/GPS compatible antenna system is being used. Glonass uses wider signal bandwidth, so requires Glonass-compatible splitters, and antennae. It is also recommended that SBAS is enabled whenever GPS or QZSS is selected.

Please note that Glonass reception is disabled by default when the unit is shipped from the factory.

GNSS systems are enabled via the GPS:SYST:SEL serial command, with GPS, SBAS, and QZSS enabled by default.

The GNSS receiver generates a 1PPS time signal that is phase synchronized to UTC (GPS) or UTC (Glonass/BeiDou/QZSS). This 1PPS signal is used to frequency-lock the 10 MHz Sine-Wave output of the GPS-3x00 to UTC, thus disciplining the unit's Atomic Clock 10 MHz frequency output to the relevant UTC reference clock for very high frequency accuracy (typically better than 11 digits of frequency accuracy when locked to GPS or Glonass). Using a high-performance Timing GNSS receiver allows operation with a phase stability error of typically less than ±10 nanoseconds steady-state anywhere in the world.

2.6.6   Connecting an LCD Display

An optional, industry standard alphanumeric LCD display may be connected to the unit for displaying status information. LCD's with 16x2 characters are optimal, but 20x2 or 20x4 displays may also work. An example low-cost display is available from www.mouser.com:

Newhaven Display PN: NHD-0216K1Z-NSW-BBW-L

The connector drives the LCD directly. The 5V power pin can be used to drive the LCD's backlighting, and additional external circuitry if the current draw is limited to 0.15A or less. Contrast of the LCD is adjusted via software command.

Figure 2-3 shows the mechanical connections. A schematic showing the connections from the GPS-2700 to the LCD panel is shown in Figure 2-4.

FIGURE 2-3:   *LCD Display Connection.*

TABLE 2-5:   LCD CONNECTOR J3 PINOUT

Pin	Name
1	CONTRAST
2	+5V
3	GND
4	LCD_RS
5	For factory use only
6	LCD_RDWR
7	For factory use only
8	LCD_ENABLE
9	For factory use only
10	LCD_DATA4
11	For factory use only
12	LCD_DATA5
13	For factory use only
14	LCD_DATA6
15	For factory use only
16	LCD_DATA7
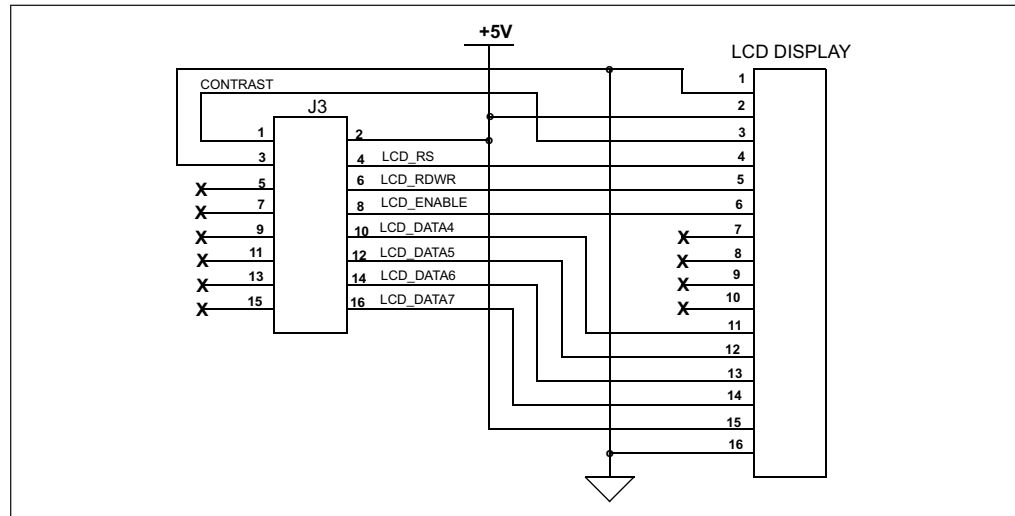
FIGURE 2-4: *LCD Display Connections.*

The Power and Ground symbols in Figure 2-4 are for reference only. 5V power on con-nector J3 is available to drive the LCD display and its backlight, and the user may draw a total of 150 mA of power from this connector for external circuitry.

2.6.6.1 LCD KEY

The LCD Key is activated by pressing S1 on the PCB (see Figure 2-2), or by grounding J1 pin 5. Momentarily activating the key cycles through the LCD display pages described in **Section 2.6.6.2 "LCD Display Pages"**. The LCD page can also be selected with the SYST:LCD:PAGE serial SCPI command. The last page displayed is remembered in NVRAM, and will be shown upon power up.

Activating the key for at least 8 seconds initiates the Auto-Survey sequence and switches the LCD to the Survey status display page. The Auto-Survey can also be ini-tiated with the GPS:SURV ONCE SCPI command. The unit will automatically enable Position Hold mode after the Auto-Survey sequence has ended, which typically takes around 1 hour to complete.

2.6.6.2 LCD DISPLAY PAGES

Following are the LCD display pages:

• Time/Date: (Figure 2-5) This page shows the time, date, number of tracked Satel-lites, and the lock status (PH = Position Hold mode, AS = Auto Survey mode, UL = Unlocked operation).

FIGURE 2-5: *Time/Date Display Page.*

• GNSS Position: (Figure 2-6) This page shows the GPS coordinates of the antenna position.

FIGURE 2-6: *GNSS Position Display Page.*

- GPS Height: (Figure 2-7) This page shows the height in MSL of the GNSS antenna, as well as the operating mode (HOLD = Position Hold mode).

FIGURE 2-7: *GPS Height Display Page.*

- MAC Steering: (Figure 2-8) This page shows the internal STATUS indication of the MAC oscillator itself. 0x0 indicates normal operation. It also shows the MAC Oscillator steering offset required to maintain UTC lock, which is normalized to 1E-012 offsets. The MAC steering offset is programmed into the MAC oscillator NVRAM once every 24 hours, at which point the offset is set to "0" again. This allows the MAC oscillator to power-on with the last internal offset stored in NVRAM, effectively storing the calibration parameter inside the MAC oscillator once per day.

FIGURE 2-8: *MAC Steering Display Page.*

- MAC Status: (Figure 2-9) This page displays the following Rubidium Vapor Cell status: Heater Power, Cell Temperature (in °C), and TCXO Steering Voltage (0V to 2.5V). The TCXO is locked to the Rubidium Vapor Cell via a Phase Locked Loop, and generates the 10 MHz output frequency.

FIGURE 2-9: *MAC Status Display Page.*

- TI and FE: (Figure 2-10) TI in the left upper row is the time interval offset in nanoseconds between the internal MAC oscillator phase and UTC phase as generated by the GNSS receiver. The right upper row displays the TI interval in nanoseconds between the MAC Rubidium phase and the OCXO phase. The PLL control loop will try to zero this offset over time as the unit follows UTC via the Satellite transmissions. FE indicates the Frequency Error Estimate of the relevant loop, which is a unit-less number, and is estimated by comparing the UTC/MAC and MAC/OCXO phase offset from 1000 seconds ago to the present phase offsets. This is similar to the Allan Deviation number for a measurement interval of 1000 seconds. Smaller numbers are better, but numbers below 1E-012 are below the noise floor of the instrument. A number of 4E-012 for example can be loosely interpreted to be a phase drift of the 10 MHz and 1PPS outputs of 4 picoseconds per second averaged over 1000 seconds as compared to the UTC master clock re-created by the GNSS receiver.

FIGURE 2-10: *TI and FE Display Page.*

- Navigation: (Figure 2-11) This page displays the following Navigation status: Course (in degrees), Speed (knots), operating mode, and altitude (feet).

FIGURE 2-11: *Navigation Display Page.*

- GNSS/UTC Time: (Figure 2-12) This page displays the following UTC/GNSS Time information: UTC time (hh:mm:ss), GNSS time (hh:mm:ss) and leapsecond offset (seconds).

FIGURE 2-12: *GPS/UTC Time Display Page.*

- Survey Status: (Figure 2-13) This page displays the status (NOT ACTIVE, ACTIVE or VALID), duration (seconds) and variance (mm^2) of the position survey.

FIGURE 2-13: *Survey Status Display Page.*

2.7   LOOP PARAMETER ADJUSTMENT

All loop parameters can be controlled via the serial ports. The firmware typically offers three different phase loop time constants for the filter oscillator loop to accommodate different mission scenarios (stationary versus mobile, steady state operation versus power cycling, etc). These time constants determine the behavior of the unit during steady state operation, and when a frequency error is induced into the filter oscillator by adverse environmental effects such as tilt/shock of the unit, or due to thermal shocks.

The loop adjustments typically include a SHORT/MEDIUM/LONG time constant option. The following table shows typical parameter settings for the Ultimate and Premium Noise ordering options:

TABLE 2-6:   RECOMMENDED FILTER LOOP SETTINGS (PREMIUM AND ULTIMATE PN OPTIONS)

Usage	Slow Time Constant	Medium Time Constant	Fast Time Constant
Loop Behavior	Benign	Moderate	Aggressive
SERV:DACGAIN	50	50	50
SERV:EFCS	2	4	6
SERV:PHASECO	240	600	2000
SERV:EFCD	6	4	2
SERV:FAST	2	2	1
SERV:FALE	1800	1800	1800

The commands to control the loop parameters are part of the SERV? command structure. See the SERVO Subsystem section in Chapter 3.

The individual commands are:

- EFC Scale: This is the proportional gain of the PID loop. Higher values will give quicker frequency convergence, and faster locking to the GNSS reference (lower loop time constant), lower values give less noise.
- EFC Damping: Overall IIR filter time constant. Higher values increase loop time constant. Setting this value too high may cause loop instability. Due to the low noise floor of the time interval counter and references, this unit can operate with low settings values of 2 to 4 typically.
- Phase Compensation: This is the Integral part of the PID loop. This corrects phase offsets between the GPS-3x00 1PPS signal and the crystal filter 1PPS sig-

nal. Set higher values for tighter phase-following at the expense of frequency stability

A well-compensated Standard Phase Noise option unit will have the shortest loop time constant of all the ordering options, and will show performance similar to the plot in Figure 2-14 when experiencing small externally stimulated frequency perturbations.

FIGURE 2-14: *Behavior of Standard Noise Option Unit with an Induced Phase Error.*

2.8 PERFORMANCE GRAPHS

Figure 2-15 shows the typical Allan Deviation of the GPS-3x00 with Ultimate Performance Option when locked to GPS in a stable environment, and after one week of warm-up and burn-in. The ADEV performance approaches 8E-014 per day when locked to GPS. The light blue, dashed line is the ADEV performance of the buffered 10 MHz output when selected to the MAC oscillator as a driving source, and the solid magenta line is the performance when selecting the Ultimate Phase Noise filter OCXO as a source for the buffered output. The significant ADEV improvement by the filter OCXO below several 100 seconds averaging time intervals is clearly visible.
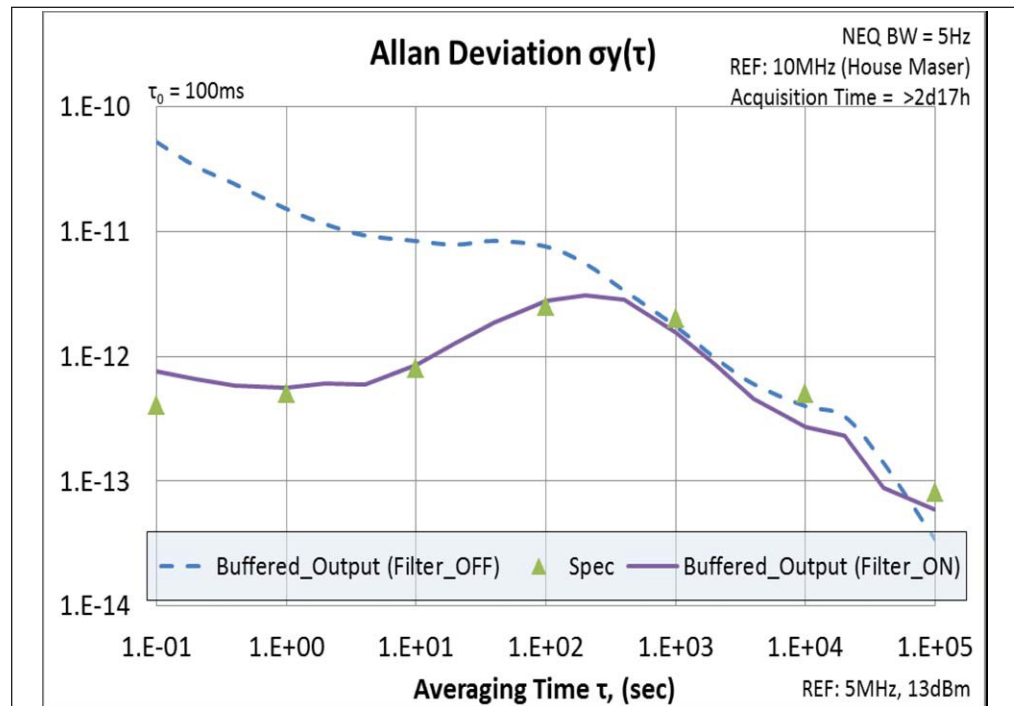
FIGURE 2-15: *Allan Deviation of GPS-3x00 When Locked to GPS.*

Figure 2-16 shows a comparative typical ADEV plot of the Standard Performance option unit with Phase Noise Filter enabled (blue trace), Phase Noise filter disabled and unit locked to GPS (magenta trace) and the unit in holdover with the phase noise filter disabled (green trace). While enabling the TCXO filter on the standard performance option actually increases ADEV noise below several 100 second averaging intervals, it significantly improves the units Phase Noise and Spur performance.
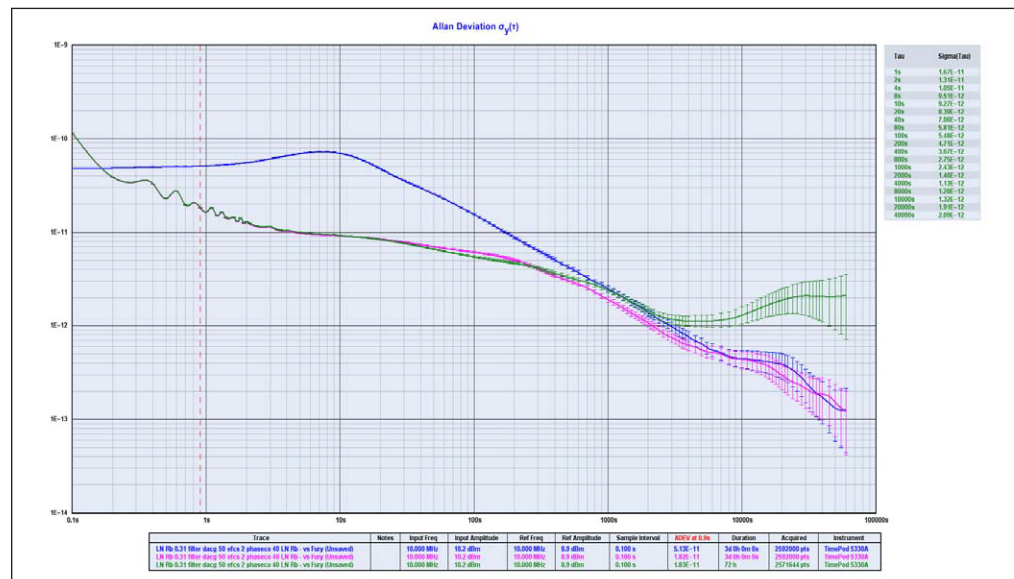
FIGURE 2-16: *Allan Deviation of Three Different Operating Modes.*

Figure 2-17 compares the performance of the Premium Noise option unit when locked to different GNSS systems, and in Position Hold mode versus 3D mobile mode. All tests were done with the unit properly warmed up, and in a stationary location. The light blue trace is Glonass only, mobile mode. The green trace is GPS only, mobile mode. The red trace is GPS only in Position Hold mode. The magenta trace is Glonass only in Position Hold mode. The performance differences between Glonass and GPS systems in Position Hold mode are insignificant in this measurement, however there are significant performance advantages in using GPS versus Glonass in 3D mobile mode.
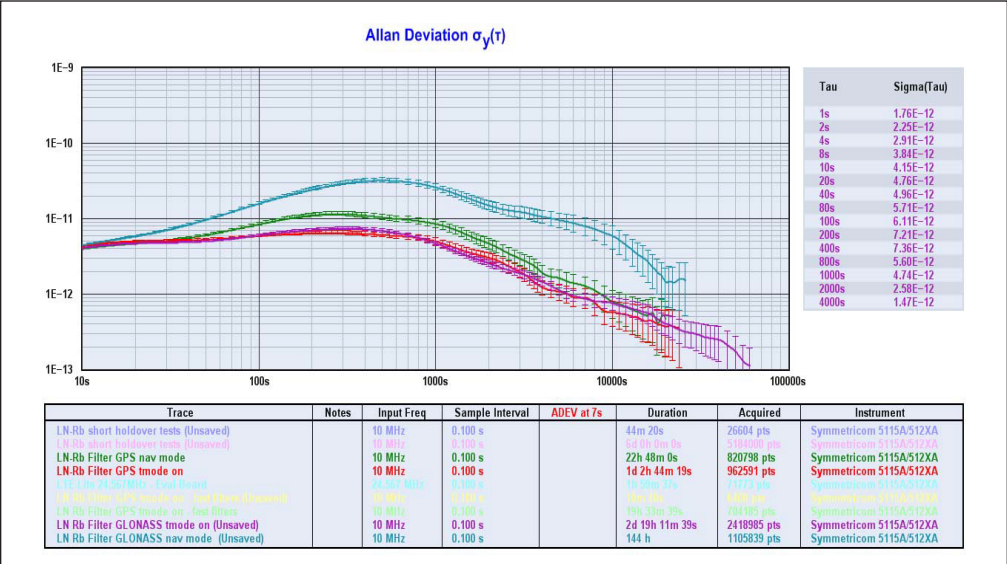
FIGURE 2-17: *ADEV Performance for Various GNSS Operating Modes.*

Figure 2-18 shows the a typical warm-up phase offset behavior of the Premium OCXO option unit after power-on. The frequency will quickly stabilize, and the phase will slowly adjust over the next number of hours. During this time the phase offset error between the MAC oscillator and the GPS 1PPS, and the MAC oscillator and the filter OCXO may be queried with the SYNC:TINT? serial command. Full stabilization of the phases to each other to nanosecond levels may take up to 24 hours or longer, depending on how long the unit had been powered-off, and how stable the environment is.
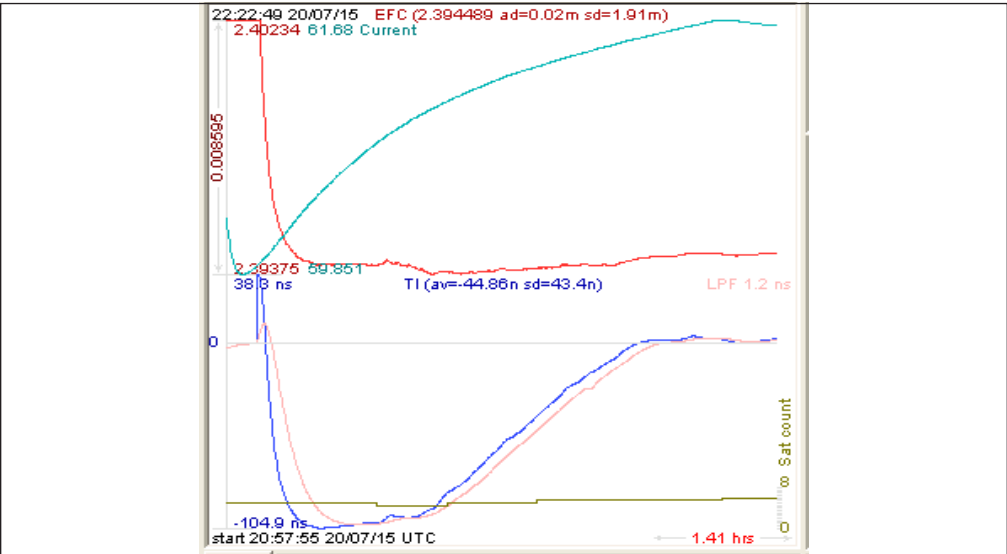
FIGURE 2-18: *Typical OCXO Filter Phase Offset Behavior after Power-On.*
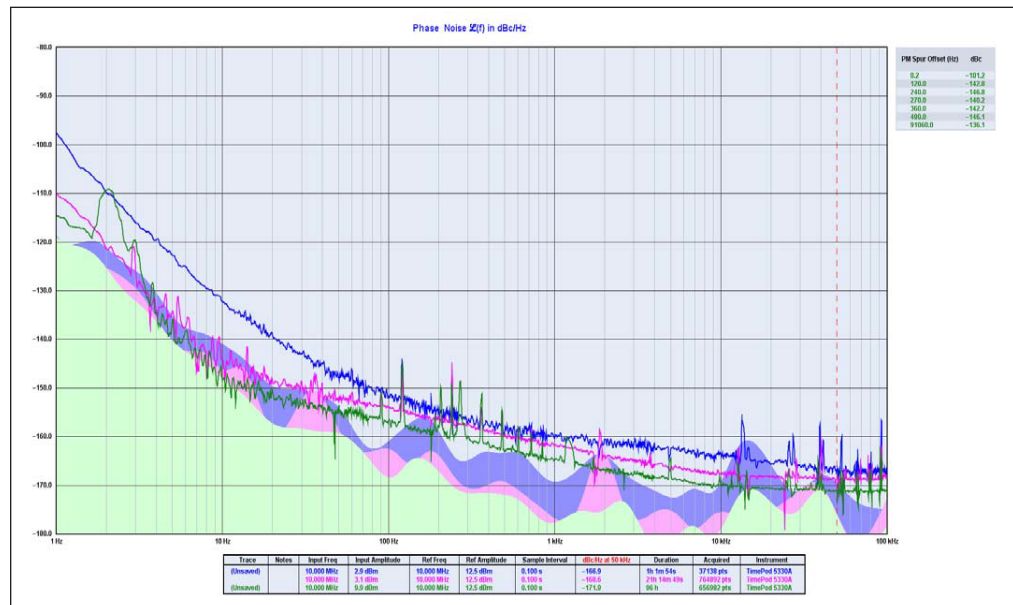
FIGURE 2-19: *Typical Phase Noise Performance of Different Ordering Options.*

Figure 2-20 compares the performance of the TCXO filtered Phase Noise output to the raw MAC oscillator output Phase Noise spectrum. The TCXO clearly removes all spurs present in the MAC output, and significantly improves the overall Phase Noise performance of the unit. Selecting the TCXO output versus the raw MAC output does come at a slight ADEV performance penalty at averaging intervals of less than several 100 seconds, so enabling or disabling the TCXO filter on the standard performance option depends on the application requirements (Phase Noise or ADEV priority).
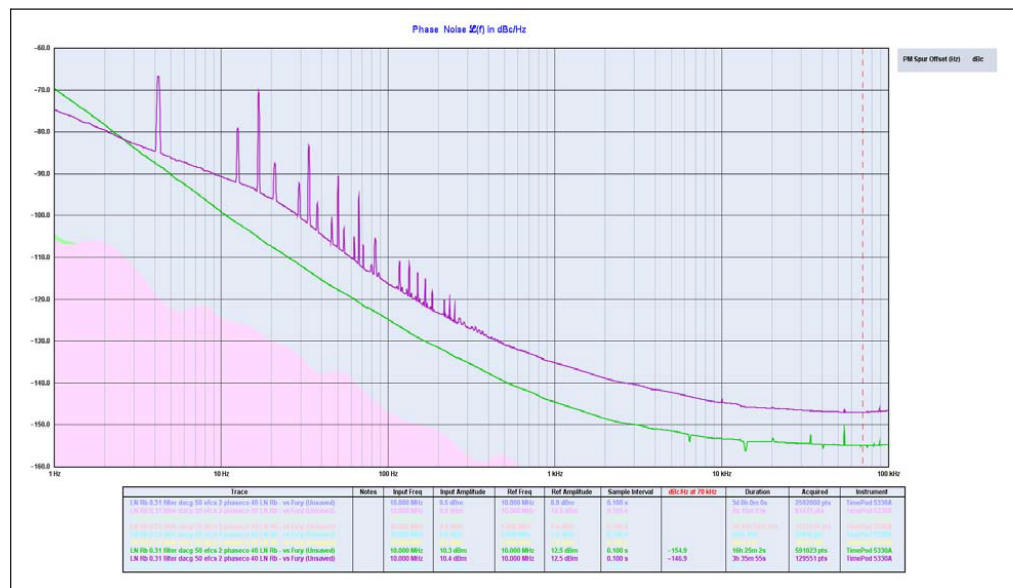
FIGURE 2-20: *TCXO Phase Noise Filter versus MAC-Only Output.*

Figure 2-21 shows the a typical phase noise performance of the unit when ordered with the low-power, low-noise Cesium Atomic Clock (CSAC) oscillator option.
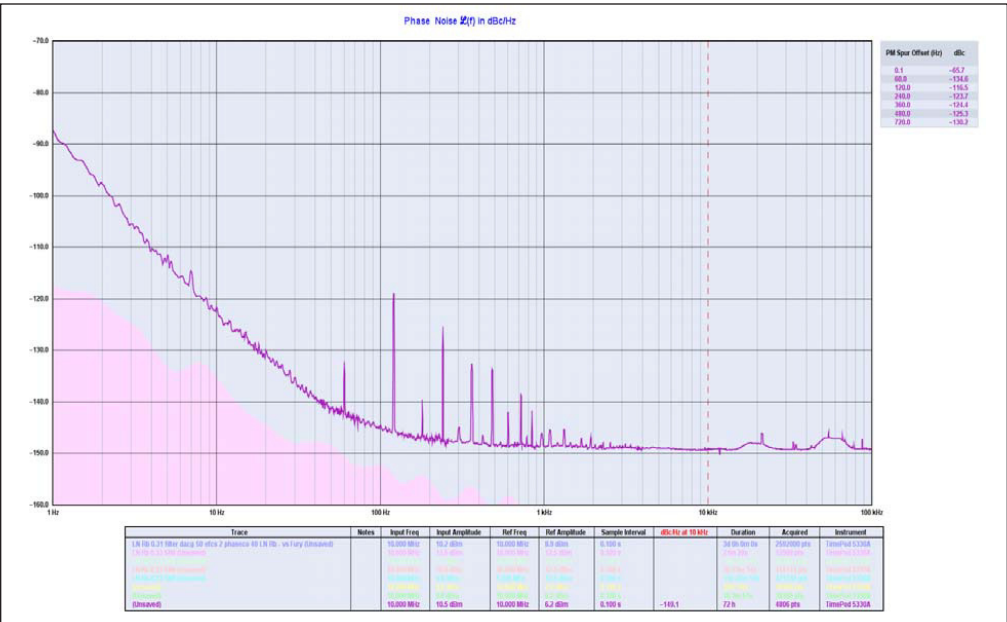
FIGURE 2-21: *Typical Phase Noise Performance of Low-Power, Low-Noise CSAC.*

Chapter 3. SCPI-Control Quick Start Instructions

3.1   INTRODUCTION

The GPS-3x00 GNSSDO has two serial ports that can be used simultaneously for accessing the Standard Commands for Programmable Instrumentation (SCPI) subsystem by using a host system terminal program such as TeraTerm Pro or HyperTerminal. By default the terminal settings are 115200, 8N1, no flow-control.

There are a number of commands that can be used as listed below. Most of these are identical or similar to Symmetricom/Agilent 58503A commands. To get a listing of the available commands, send the HELP? query. This will return a list of all the available commands for the GPS-3x00 GNSSDO.

Commands can be entered in either caps or lower-case, and only the characters listed in caps in the below command reference 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 a Quick-Start, the user may want to try sending the following commands to the unit:

SYST:STAT?
HELP?
GPS?
SYNC?
DIAG?
CSAC?

3.2   GENERAL SCPI COMMANDS

3.2.1   *IDN

This query outputs an identifying string. The response will show the following information: <company name>, <model number>, <serial number>, <firmware revision>

3.2.2   HELP?

This query returns a list of the commands available for the GPS-3x00 GNSSDO.

3.3   GPS SUBSYSTEM

> **Note:**   Please note that GPS-3x00 GNSSDO displays antenna height in MSL Meters rather than in GPS Meters on all commands that return antenna height [the legacy Fury GNSSDO uses GPS height]. The NMEA position fixes are in the WGS84 coordinate system, while the X,Y, and Z velocity vectors are given in the ECEF coordinate system.

The GPS subsystem regroups all the commands related to the control and status of the GNSS receiver. The list of the commands supported is the following:

GPS:SAT:TRA:COUN?

GPS:SAT:VIS:COUN?

GPS:PORT <RS232 | USB>

GPS:PORT?

GPS:GPGGA <int> [0,255]

GPS:GGAST <int> [0,255]

GPS:GPRMC <int> [0,255]

GPS:GPZDA <int> [0,255]

GPS:GPGSV <int> [0,255]

GPS:PASHR <int> [0,255]

GPS:XYZSP

GPS:DYNAM:MODE <int> [0,7]

GPS:DYNAM:MODE 8 (Automatic Dynamic Mode)

GPS:DYNAM:MODE?

GPS:DYNAM:STAT?

GPS:REF:ADEL <float> <s | ns > [–32767ns,32767ns]

GPS:REF:PUL:SAW?

GPS:RESET ONCE

GPS:TMOD <ON | OFF | RSTSURV>

GPS:SURV ONCE

GPS:SURV:DUR <sec>

GPS:SURV:VAR <mm^2>

GPS:HOLD:POS <cm, cm, cm>

GPS:SURV:STAT?

GPS:INIT:DATE <yyyy,mm,dd>

GPS:INIT:TIME <hour,min,sec>

GPS:SYST:SEL [GPS | SBAS | QZSS | GAL | GLO]

GPS:JAM?

GPS:FW?

GPS?

3.3.1   GPS:SAT:TRA:COUN?

This query returns the number of satellites being tracked.

3.3.2   GPS:SAT:VIS:COUN?

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

3.3.3   NMEA Support

The following commands allow the GPS-3x00 GNSSDO 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 info, time, date and other information that can be used by standard navigation applications via the GPS-3x00 GNSSDO serial interface.

Once enabled, the GPS-3x00 GNSSDO will send out NMEA sentences on the serial transmit pin automatically every N seconds. All incoming serial commands are still recognized by GPS-3x00 GNSSDO because the serial interface transmit and receive lines operate completely independent of one another.

For compatibility with existing GPS-only products, the GPS-3x00 GNSSDO's NMEA output only uses the GPS NMEA sentence headers (GPGGA, GPGSV, etc) regardless of the GNSS systems enabled. Also, the GPGSV output uses a modified satellite numbering scheme as detailed in Section 3.3.10 to allow all different GNSS system satellites to be differentiated. Any combination of any two GNSS systems can be tracked simultaneously such as GPS with Glonass, or QZSS with BeiDou.

Please note that due to internal double-buffering the position, direction, and speed data is delayed by one second from when the GPS receiver internally reported these to the GPS-3x00 GNSSDO 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 commands will be stored in NV memory, and generate output information even after power to the unit has been cycled.

3.3.4   GPS:PORT <RS232 | USB>

This command specifies the communication port where the NMEA messages will be sent.

3.3.5   GPS:PORT?

This query returns the port where the NMEA messages are sent.

3.3.6   GPS:GPGGA

This command instructs the GPS-3x00 GNSSDO 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, this is different from traditional GPS receivers that display height in GPS Meters. The difference between MSL and GPS height can be significant, 35m or more are common.

3.3.7   GPS:GGAST

This command instructs the GPS-3x00 GNSSDO to send a modified version of 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:GGAST <int> [0,255]

This command replaces the regular NMEA GGA validity flag with a decimal number indicating the lock-state of the unit. Please see section 3.10.12 for a detailed description of the lock state variable. The command allows capture of the position and other information available in the GGA command, as well as tracking the lock state and health of the unit's oscillator performance.

GGAST 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, 35m or more are common.

3.3.8 GPS:GPRMC

This command instructs the GPS-3x00 GNSSDO 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]

3.3.9 GPS:GPZDA

This command instructs the GPS-3x00 GNSSDO 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]

3.3.10 GPS:GPGSV

This command instructs the GPS-3x00 GNSSDO 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]

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

TABLE 3-1: PRN NUMBERING SCHEME FOR GNSS SYSTEMS

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

3.3.11 GPS:PASHR

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

eeeee.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 GPS-3x00 GNSSDO to send the NMEA standard string $PASHR every N seconds, with N in the interval [0,255]. The command is disabled during the initial 2 minute CSAC warm-up phase.

This command has the following format:

    GPS:PASHR <int> [0,255]

3.3.12   GPS:XYZSP

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]:

    GPS:XYZSP <int> [0,255]

3.3.13   GPS:DYNAM: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 can now 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:DYNAM:MODE <int> [0,8]

Sending the following command to the GPS-3x00 will select a stationary GNSS dynamic model for example:

GPS:DYNAM:MODE 1

The following table lists all available modes:

TABLE 3-2:   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.

The GPS-3x00 GNSSDO uses a GNSS receiver that 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, and solving the GNSS signal only for time as the position is not expected to change. Two modes can be selected for Auto Survey operation (see Section 3.3.19 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:DYNAM: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:DYNAM:MODE.

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

    GPS:DYNAM:STATE?

3.3.14   GPS:DYNAM:MODE 8 (Automatic Dynamic Mode)

Automatic Dynamic Mode allows the GPS-3x00 GNSSDO firmware to automatically configure the GNSS receiver Kalman filter parameters based on actual mission velocities and motion profiles, drastically improving overall performance. The unit will try to set the GNSS receiver to the optimal setting for any given velocity. The unit is able to set 7 different modes, as shown in section 3.3.13.

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

TABLE 3-3:   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 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, both 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 a velocity of 100 knots is achieved.

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

    GPS:DYNAM:MODE?

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

    GPS:DYNAM:STAT?

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 GNSS receiver, and are stored in Non Volatile memory.

3.3.15   GPS:DYNAM:STAT?

This query returns the actual state of the dynamic model, chosen by the firmware to be applied to the GNSS receiver depending on vehicle velocity. It returns a value between 0 and 7, which correspond to one of the dynamic models defined in Table 3-3.

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 GNSS Timing Mode is set to ON or to RSTSURV, the dynamic state will always be set to 1 (Stationary).

3.3.16   GPS:REF:ADEL <float> <s | ns > [-32767ns,32767ns]

The ADEL command allows bi-directional 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. Typical antenna delays for a 30 foot antenna cable with 1.5 ns 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 co-incident 1PPS pulse outputs. Please note that during normal operation the 1PPS pulse may wander around the UTC 1PPS pulse while the unit is tracking the GNSS signals. The present offset between the 1PPS output and the UTC 1PPS signal can be queried with the command SYNC:TINT? and this offset should be taken into account when calibrating two unit's 1PPS outputs to each other, because the lock algorithms will try to steer the CSAC for a 0.0 ns offset to the UTC 1PPS time-pulse, and the crystal oscillator to a 0.0 ns offset to the Rubidium oscillator phase.

3.3.17 GPS:REF:PUL:SAW?

This command returns the momentary sawtooth correction factor that the GNSS receiver indicated.

3.3.18 GPS:RESET ONCE

Issues a reset to the internal GNSS receiver. This can be helpful when changing the antenna for example, since the GNSS receiver measures the antenna system's C/No right after reset, and adjusts its internal antenna amplifier gains accordingly. It takes approximately 1 minute for locking to commence after a GPS reset, as indicated by the red blinking LED inside the enclosure.

3.3.19 GPS:TMOD <ON | OFF | RSTSURV>

This command selects the Timing Mode of the 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 exactly 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 GNSS receiver.

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

3.3.20 GPS:SURV ONCE

This command starts a 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:SURV:DUR and GPS:SURV:VAR.

3.3.21 GPS:SURV:DUR <sec>

This command sets the Survey minimal duration.

3.3.22 GPS:SURV:VAR <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 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.

3.3.23   GPS:HOLD:POS <cm, cm, cm>

This command allows the user to specify manually the exact position of the antenna. This command will overwrite the Hold position in NVRAM. Subsequent Survey will overwrite also the Hold position. The Hold position is stored in ECEF coordinates.

3.3.24   GPS:SURV:STAT?

This query displays the current status of the survey. The status of the survey is in one of the 3 states:

ACTIVE: A survey is in progress.
VALID: A survey has been achieved successfully and the GNSS receiver is now using this Hold position as reference.
INVALID: No survey are in progress or have 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.

3.3.25   GPS:INIT: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 to the PTIME:OUT ON command described in Section 3.5 to allow automatic time and date synchronization of two units to each other. The internal RTC is driven by the highly stable Rubidium oscillator's 10 MHz signal, and thus has very high accuracy.

3.3.26   GPS:INIT: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 to the PTIME:OUT ON command described in Section 3.5 to allow automatic time and date synchronization of two units to each other. The internal RTC is driven by the highly stable Rubidium oscillator's 10 MHz signal, and thus has very high accuracy.

3.3.27   GPS:SYST:SEL [GPS | SBAS | QZSS | GLO]

This command selects the GNSS systems that are enabled in the GNSS receiver and are used to generated the timing and positioning information for the NMEA data, and to generate the 1PPS reference for the GNSSDO. The command is followed by any combination of the currently supported GNSS system abbreviations GPS, SBAS, QZSS, BeiDou, and GLO (GLONASS).

3.3.28   GPS:JAM?

The GNSS receiver will detect, and flag jamming interference with levels ranging from 0 (no jamming) to 255 (strong jamming). Any level exceeding 50 in combination to loss of GNSS lock will cause a SYNC:HEALTH 0x800 event to be flagged, and the unit to disable the LOCK_OUT_OK signal on connector J1.

3.3.29   GPS:FW?

This command returns the firmware version used inside the GNSS receiver itself.

3.3.30   GPS?

This query displays the configuration, position, speed, height and other relevant data of the GNSS receiver in one convenient location.

3.4   GYRO SUBSYSTEM

The following Gyro commands are supported:

GYRO:MODE <ON | OFF>
GYRO:TRACE <int> [0,255]
GYRO:PORT <RS232 | USB>
GYRO:PORT?
GYRO:CAL <float,float,float,float,float,float>
GYRO:CAL:COMPUTE
GYRO:CAL:RESET
GYRO:SENS <float,float,float>
GYRO:GLOAD?

3.4.1   GYRO:MODE <ON | OFF>

Enables or disables electronic compensation. This feature must be calibrated at the factory before it can be used.

3.4.2   GYRO:TRACE <int> [0,255]

This command sets up the output period of the Accelerometer data (in g's per axis, and in tilt in Degrees per axis). The fastest period is 50 ms (20 outputs per second) achieved when setting the command to GYRO:TRACE 1. The resolution of this command is 1/20th of a second. Setting the command to 0 disables the Accelerometer output.

This command has the following format:

GYRO:TRACE <int> [0,255]
GYRO:TRACE? returns the setting of the period of this command.

The output of the system is in six floating point numbers: the acceleration on the X, Y, and Z axis in g's, and the tilt of the X, Y, and Z axis in degrees (–90 to +90).

Please note that the Accelerometer has its best resolution and accuracy when the earth's gravitational acceleration is perpendicular to the axis to be measured. Thus the sensors accuracy and resolution will be best when the tilt of any axis is around 0 degrees. The worst performance (with an accuracy of only ~ ±5 degrees) is when any of the axis are at their ±90 degree angles, this is due to the fact that a SIN(g-load) calculation is done to generate the output normalized to degrees, and the vector is thus least sensitive at ±90 degree angles.

Acceleration can be measured with up to ±3g range on all three axis. Please note that since the tilt angle is calculated from the acceleration vectors (using gravity as a reference) that the tilt angles will actually exceed ±90 degrees when acceleration greater than 1g is applied.

3.4.3   GYRO:PORT <RS232 | USB>

This commands specifies the communication port where the GYRO traces will be sent.

3.4.4   GYRO:PORT?

This query returns the port where the GYRO traces are sent.

3.4.5   GYRO:CAL <float,float,float,float,float,float>

Similar to the GPS:GYRO:CAL command. Used to manually calibrate the gain and off-set of the Accelerometer output. Please see the GPS:GYRO:CAL command for details. See also the GYRO:CAL:COMPUTE command for a semi-automated calibration method.

3.4.6   GYRO:CAL:COMPUTE

This command can be used to automatically compute the offset and gain compensation of the accelerometer output for units that are not factory-calibrated. The goal is to have the unit indicate a range of ±1.0g on all three axis when slowly rotated through the axis, as well as 0.0g for any axis that is perpendicular to the earth's gravity.

The user must establish the minimum and maximum g-loads that are displayed on all three axis by slowly tilting the unit over 180 degrees on all three axis. These values are written down on a piece of paper, and the system calculates the required gain and off-set parameters to scale the accelerometer output to ±1g peak-to-peak scale, and 0g indication based on entering these values. The GYRO:CAL:COMPUTE command will query the user for the maximum and minimum indicated g-loads. The GYRO:TRACE 10 command can be used to help establish the g-indications on the three different axis to aid in this calibration.

3.4.7   GYRO:CAL:RESET

Used for factory calibration of Gyro subsystem.

3.4.8   GYRO:SENS <float,float,float>

Used for factory calibration of Gyro subsystem.

3.4.9   GYRO:GLOAD?

This command will return the present acceleration on the X, Y, and Z axis.

3.5   PTIME SUBSYSTEM

The PTIME subsystem regroups all the commands related to the management of the time.The list of the commands supported is the following:

```
PTIM:DATE?
PTIM:TIME?
PTIM:TIME:STR?
PTIM:TINT?
PTIM:OUT <ON | OFF>
PTIM:LEAP?
PTIM:LEAP:PEND?
PTIM:LEAP:ACC?
PTIM:LEAP:DATE?
PTIM:LEAP:DUR?
PTIM?
```

3.5.1   PTIM:DATE?

This query returns the current calendar date. The local calendar date is referenced to UTC time. The year, month, and day are returned.

3.5.2   PTIM:TIME?

This query returns the current 24-hour time. The local time is referenced to UTC time. The hour, minute, and second is returned.

3.5.3   PTIM:TIME:STR?

This query returns the current 24-hour time suitable for display (for example, 13:24:56).

3.5.4   PTIM:TINT?

This query is equivalent to the command SYNC:TINT.

3.5.5   PTIM:OUT <ON | OFF>

This command allows connecting two units together through the serial port with a null-modem cable, and having the master unit send time and date information to the slave unit. The slave unit's 1PPS reference input can also be driven by the master unit's 1PPS output signal, by setting the slave unit to external 1PPS sync mode using the SYNC:SOUR:MODE ext command. This allows time-synchronization at the nanosecond level 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 serial port once per second.

3.5.6   PTIM:LEAP?

This command returns the results of the four following queries:

   PTIM:LEAP:PEND?
   PTIM:LEAP:ACC?
   PTIM:LEAP:DATE?
   PTIM:LEAP:DUR?

3.5.7   PTIM:LEAP:PEND?

This command returns 1 if the GPS Almanac data contains a future pending leap second data 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.

3.5.8   PTIM:LEAP:ACC?

This command will return 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).

3.5.9   PTIM:LEAP:DATE?

This command returns the date of the pending leap second, if any.

3.5.10   PTIM:LEAP:DUR?

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.

3.5.11   PTIM?

This query returns at once the result of the five following queries:

   PTIM:DATE?

PTIM:TIME?
PTIM:TINT?
PTIM:OUT?
PTIM:LEAP:ACC?

3.6   SYNCHRONIZATION SUBSYSTEM

This subsystem regroups the commands related to the synchronization of the GPS-3x00 GNSSDO and filter oscillator with the GNSS receiver or external 1PPS reference. Some commands in the SYNC subsystem depend on the currently selected servo loop from the SERV:SEL command (see Section 3.10.1). Two phase locked loops are running in parallel, and the user must select one of the two phase locked loops prior to interrogation of that particular loop, otherwise it may be unclear which loop is providing the data. The list of the commands supported for this subsystem is the following:

SYNC:HOLD:DUR?
SYNC:HOLD:INIT
SYNC:HOLD:REC:INIT
SYNC:SOUR:MODE <GPS | EXT | AUTO>
SYNC:SOUR:STAT?
SYNC:TINT?
SYNC:TINT:CSAC?
SYNC:TINT:FILT?
SYNC:TINT:THR [50, 2000]
SYNC:IMME
SYNC:FEE?
SYNC:LOCK?
SYNC:OUT:1PPS:RESET <ON | OFF>
SYNC:OUT:1PPS:RESET?
SYNC:OUT:1PPS:DOMAIN <CSAC | FILT>
SYNC:OUT:1PPS:DOMAIN?
SYNC:OUT:FILT <ON | OFF>
SYNC:OUT:FILT?
SYNC:HOLD:STAT?
SYNC?

3.6.1   SYNC:HOLD:DUR?

This query returns the duration of the present or most recent period of operation in the holdover and holdover processes. This is the length of time the Rubidium oscillator was not locked to the GNSS receiver or external 1PPS reference, and thus "coasting". The time units are seconds. 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 previous holdover. The second number in the response identifies the holdover state. A value of 0 indicates the GNSSDO is not in holdover; a value of 1 indicates the GNSSDO is in holdover. This command only operates on the Rubidium oscillator servo loop.

3.6.2   SYNC:HOLD:INIT

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 or external 1PPS are still being properly received. This forced holdover allows the unit to effectively disable locking to the GNSS receiver or external 1PPS reference, while still keeping track of the state of the 1PPS output in relation to the UTC 1PPS reference. 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/external 1PPS signal with the SYNC:TINT:CSAC? command. This allows the user to see the Rubidium oscillator drift when not locked to GPS for testing purposes, or to prevent the GNSS receiver from being spoofed and affecting the Rubidium frequency accuracy. All other frequency-disciplining functions of the unit will behave as if the GNSS antenna or external 1PPS were disconnected from the unit while in this forced holdover state. This command only operates on the Rubidium oscillator servo loop.

3.6.3   SYNC:HOLD:REC:INIT

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

3.6.4   SYNC:SOUR:MODE <GPS | EXT | AUTO>

The SYNC:SOUR:MODE command allows an optional external 3.3V CMOS, 5V CMOS or TTL level 1PPS input to be connected to the GPS-3x00 GNSSDO board on pin 11 of connector harness J1, or via the RS-422 1PPS input (both inputs are ored' together internally). The unit can use this external 1PPS input instead of the internal, GNSS receiver generated 1PPS. Switching to the external 1PPS is either done manually with the EXT command option, or automatically with the AUTO command option in case the GNSS receiver loses a GNSS fix for any reason. The command has the following format:

SYNC:SOUR:MODE <GPS | EXT | AUTO>

This command only operates on the Rubidium oscillator servo loop.

3.6.5   SYNC:SOUR:STAT?

This query shows the state of the external 1PPS synchronization option. This command only operates on the Rubidium oscillator servo loop.

3.6.6   SYNC:TINT?

This query returns the difference or Time Interval between the Rubidium or filter oscillator 1PPS output and the loop reference. The resolution is 1E-10 seconds. This command operates on the currently selected servo loop.

3.6.7   SYNC:TINT:CSAC?

This query returns the Time Interval between the Rubidium oscillator 1PPS output and the GNSS receiver or external 1PPS reference. This command only operates only on the Rubidium oscillator servo loop.

3.6.8   SYNC:TINT:FILT?

This query returns the Time Interval between the filter oscillator 1PPS output and the Rubidium oscillator 1PPS output. This command operates only on the filter servo loop.

3.6.9   SYNC:IMME

This command initiates a near-instantaneous alignment of the Rubidium or filter oscillator 1PPS output with the reference 1PPS. To be effective, this command has to be issued while not in holdover. This command operates on the selected servo loop.

3.6.10   SYNC:FEE?

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

Values less than 1E-012 are below the noise floor and are not significant. This query reports the value for the selected servo loop.

3.6.11   SYNC:LOCK?

This query returns the lock state (0=OFF, 1=ON) of the PLL controlling the Rubidium or filter oscillator. This query reports the value for the selected servo loop.

3.6.12   SYNC:OUT:1PPS:RESET <ON | OFF>

This command allows the generation of the 1PPS pulse upon power-on without an external GNSS antenna 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 now be configured to generate an asynchronous 1PPS output after power-on even if a GNSS antenna is not connected to the unit. 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 GPS lock is achieved. This command requires a power cycle or system reset to be activated.

3.6.13   SYNC:OUT:1PPS:RESET?

This query returns the 1PPS output on reset setting.

3.6.14   SYNC:OUT:1PPS:DOMAIN <CSAC | FILT>

This command selects between the Rubidium and filter oscillator 1PPS outputs on the 1PPS SMA connector. The CSAC option selects the Rubidium oscillator 1PPS, while the FILT option selects the filter oscillator 1PPS. The phase of these two selections may vary by more than 100 ns during warm-up, and this phase difference can be queried by commands described in section 3.6.6.

3.6.15   SYNC:OUT:1PPS:DOMAIN?

This query returns the 1PPS output domain setting.

3.6.16   SYNC:OUT:FILT <ON | OFF>

This command enables/disables the Phase Noise filter on the buffered 10 MHz frequency output connectors. If selected (ON) the output of the filter oscillator is routed to the buffered outputs. If de-selected (OFF) the raw 10 MHz output of the MAC Rubidium is routed to the buffered outputs.

3.6.17   SYNC:OUT:FILT?

This query returns the Phase Noise filter setting.

3.6.18   SYNC:HEA?

The SYNC:HEA? query returns a hexadecimal number indicating the servo loop'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 query reports the status of the selected servo loop, see Section 3.10.1.

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 phase offset to reference is >210 ns	HEALTH STATUS |= 0x4;
If the run-time is <200 seconds	HEALTH STATUS |= 0x8;
If the reference is in holdover >60s	HEALTH STATUS |= 0x10;
If the Frequency Estimate is out of bounds	HEALTH STATUS |= 0x20;
If the short-term-drift (ADEV @ 100s) >100 ns	HEALTH STATUS |= 0x100;
For the first 3 minutes after a phase-reset	HEALTH STATUS |= 0x200;
If the Rubidium Oscillator indicates an alarm	HEALTH STATUS |= 0x400;
If the GNSS receiver indicates a strong jamming signal of ≥50 (range is 0 to 255) and has no GNSS fix	HEALTH STATUS |= 0x800;
If the filter oscillator loop is not locked (with Rubidium oscillator loop selected only)	HEALTH STATUS |= 0x1000;

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

1.   UTC phase >250 ns: 0x4
2.   GNSS receiver in holdover: 0x10

'Oring' these values together results in:

   0x10 | 0x4 = 0x14

The unit would thus indicate: HEALTH STATUS: 0x14 and the Green LED as well as the LOCK_OK output on connector J1 would go off, indicating an event is pending.

A health status of 0x0 indicates a properly locked, and warmed-up unit that is completely healthy.

3.6.19   SYNC:TINT:THR <int> [50,2000]

This command selects the Rubidium or filter 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 Rubidium or filter oscillator generated 1PPS with the reference 1PPS phase. The Rubidium or filter oscillator 1PPS phase is allowed to drift up to this threshold before a jam-sync is initiated. The Rubidium or filter oscillator phase is slowly and continuously adjusted toward 0 ns offset to the reference 1PPS while the phase difference is less than the THR phase limit. The default setting is 220 ns, allowing a drift of up to ±220 ns. Reaching this selected threshold will cause a jam-sync phase-normalization to be initiated, which will also cause the SYNC:HEA? Status to indicate 0x200, and the Green LED to be turned-off for several minutes. This command operates on the selected servo loop, see section 3.10.1.

3.6.20   SYNC?

This query returns the results of the following queries:

   SYNC:SOUR:MODE?
   SYNC:SOUR:STAT?
   SYNC:OUT:1PPS:RESET?

SYNC:OUT:1PPS:DOMAIN?
SYNC:LOCK?
SYNC:HOLD:STAT?
SYNC:HOLD:DUR?
SYNC:FEE?
SYNC:TINT?
SYNC:TINT:THR?
SYNC:OUT:FILT?
SYNC:HEA?

3.7   DIAG SUBSYSTEM

This subsystem regroups the queries related to the diagnostic of the CSAC.The list of the commands supported for this subsystem is the following:

DIAG:ROSC:EFC:REL?
DIAG:ROSC:EFC:ABS?
DIAG:ROSC:EFC:ABS:CSAC?
DIAG:ROSC:EFC:ABS:FILT?
DIAG:LIF:COUN?

3.7.1   DIAG:ROSC:EFC:REL?

This query returns the Electronic Frequency Control (EFC) output value of the rubidium or filter oscillator. It returns a percentage value between –100% to +100%. This query returns the value for the selected servo loop, see Section 3.10.1.

3.7.2   DIAG:ROSC:EFC:ABS?

This query returns the Electronic Frequency Control (EFC) steering value of the Rubidium or filter oscillator in parts-per-trillion (1E-012) or Volts respectively. This query returns the value for the selected servo loop, see Section 3.10.1.

3.7.3   DIAG:ROSC:EFC:ABS:CSAC?

This query returns the Electronic Frequency Control (EFC) steering value of the MAC Rubidium oscillator in parts-per-trillion (1E-012).

3.7.4   DIAG:ROSC:EFC:ABS:FILT?

This query returns the Electronic Frequency Control (EFC) steering value of the filter oscillator in Volts.

3.7.5   DIAG:LIF:COUN?

This query returns the time since power on of the MAC Rubidum oscillator in hours.

3.7.6   DIAG?

Sending the command DIAG? returns the following:

Relative oscillator setting
Absolute oscillator setting
Time since power-on in hours (lifetime)

An example of the syntax:

SCPI > DIAG?
EFC Relative: 0.025000%
EFC Absolute: 5
Lifetime: +871

3.8   MEASURE SUBSYSTEM

The MEASURE subsystem regroups the queries related to parameters that are measured on-board the GPS-3x00 GNSSDO.

3.8.1   MEAS:TEMP?

Displays the PCB temperature inside the MAC Rubidium and around the filter oscillator.

3.8.2   MEAS:VOLT?

Displays the MAC Rubidium oscillator internal TCXO steering voltage.

3.8.3   MEAS:CURR?

Legacy SCPI command, instead of OCXO current this command displays either the internal Rubidium temperature or PCB temperature around the filter oscillator. This query reports the value for the selected servo loop, see Section 3.10.1.

3.8.4   MEAS:POW?

Displays the power supply input voltage.

3.8.5   MEAS?

The MEAS? query returns the results of the following four queries:

MEAS:TEMP?
MEAS:VOLT?
MEAS:CURR?
MEAS:POW?

3.9   SYSTEM SUBSYSTEM

This subsystem regroups the commands related to the general configuration of the GPS-3x00 GNSSDO. The list of the commands supported for this subsystem follows:

The list of the commands supported for this subsystem follows:

SYST:COMM:SER:ECHO <ON | OFF>
SYST:COMM:SER:PRO <ON | OFF>
SYST:COMM:SER:BAUD <9600 | 19200 | 38400 | 57600 | 115200>
SYST:FACT ONCE
SYST:ID:SN?
SYST:ID:HW?
SYST:LCD:CONT [0,1.0]
SYST:LCD:CONT?
SYST:LCD:PAGE [0,8]
SYST:LCD:PAGE?
SYST:COMM:USB:BAUD <9600 | 19200 | 38400 | 57600 | 115200>
SYST:COMM:USB:BAUD?
SYST:STAT?

3.9.1   SYST:COMM:SER:ECHO <ON | OFF>

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:

SYST:COMM:SER:ECHO <ON | OFF>

3.9.2   SYST:COMM:SER:PRO <ON | OFF>

This command enables/disables the prompt "scpi>" on the SCPI command lines. The prompt must be enabled when used with the software GPSCon Utility. This command has the following format:

SYST:COMM:SER:PRO <ON | OFF>

3.9.3   SYST:COMM:SER:BAUD <9600 | 19200 | 38400 | 57600 | 115200>

This command sets the RS-232 port serial speed. The serial configuration is always 8 bit, 1 stop bit, no parity, no flow control. Upon Factory reset, the speed is set at 115200 baud. This command has the following format:

SYST:COMM:SER:BAUD <9600 | 19200 | 38400 | 57600 | 115200>

3.9.4   SYST:FACT ONCE

This command applies the Factory Reset setting to the NVRAM. All aging, tempco, and user parameters are overwritten with factory default values, and the unit should be self-calibrated by operating with GNSS reception for 72+ continuous hours.

3.9.5   SYST:ID:SN?

This query returns the serial number of the board.

3.9.6   SYST:ID:HW?

This query return the Hardware version of the board.

3.9.7   SYST:LCD:CONT [0,1.0]

This command sets the contrast of the LCD. Typical settings are 0.2.

3.9.8   SYST:LCD:CONT?

This query returns the current contrast of the LCD.

3.9.9   SYST:LCD:PAGE [0,8]

This command displays the requested page on the LCD. Ten different pages are supported as described in Section 2.6.6.2. Table 3-4 lists the LCD page numbers and corresponding names.

TABLE 3-4:   SUPPORTED DISPLAYS ON LCD PAGES

Value	LCD Page
0	Time/Date
1	GNSS Position
2	GNSS Height
3	GNSS Systems
4	Rubidium Oscillator Steering
5	Rubidium Oscillator Status
6	Loop TINT and FEE
7	GPS/UTC Time
8	Survey Status

3.9.10 SYST:LCD:PAGE?

This query returns the current page of the LCD.

3.9.11 SYST:COMM:USB:BAUD <9600 | 19200 | 38400 | 57600 | 115200>

This command sets the speed of the serial USB port.

3.9.12 SYST:COMM:USB:BAUD?

This query returns the speed of the serial USB port.

3.9.13 SYST:STAT?

This query returns a full page of GNSS status in ASCII format. The output is compatible with GPSCon. This command returns one of the most comprehensive GNSS and oscillator status pages.

3.10 SERVO SUBSYSTEM

This subsystem regroups all the commands related to the adjustment of the Rubidium and filter oscillator servo loops:

SERV:SEL <CSAC FILT>

SERV:LOOP <ON | OFF>

SERV:COARS <int> [0 | 255]

SERV:DACG <float> [0.1, 10000]

SERV:EFCS <float> [0.0, 500.0]

SERV:EFCD <int> [2, 4000]

SERV:TEMPCO <float> [-4000.0, 4000.0]

SERV:AGING <float> [-10.0, 10.0]

SERV:PHASECO <float> [-2000.0, 2000.0]

SERV:1PPS <int> ns

SERV:TRAC:PORT <RS232 | USB>

SERV:TRAC <int> [0,255]

SERV:FAST <1, 20>

SERV:FALE <100, 20000>

SERV?

3.10.1 SERV:SEL <CSAC | FILT>

The GPS-3x00 GNSSDO has two separate servo loops, one loop for the MAC Rubidium being disciplined by the GNSS receiver, and the second loop for the filter oscillator being disciplined by the MAC Rubidium. This command selects the enabled servo loop for the currently used SCPI interface commands. The selected servo loop for the RS-232 and USB interfaces can be configured independently. Several of the SYNC subsystem commands and all of the SERV subsystem commands will act on the currently selected servo loop. The CSAC option selects the Rubidium oscillator loop that locks to the GNSS receiver or external 1PPS reference to the atomic oscillator, and the FILT option selects the filter oscillator loop that locks the filter oscillator to the MAC Rubidium oscillator. The third-party applications GPSCon or Z38xx can be used to graph and monitor either loops' performance.

3.10.2   SERV:LOOP <ON | OFF>

This command enables or disables the servo loop for the selected servo loop. With the loop disabled, no changes are made to the oscillator frequency control. Normally the servo loop is left enabled.

3.10.3   SERV:COARS <int> [0 | 255]

This command sets the coarse DAC that controls the EFC voltage on the filter servo loop. This command is only available when the filter servo loop is selected. The filter servo control loop automatically adjusts this setting. The user should not have to change this value, but it is useful to establish filter loop lock time constants by artificially applying an incorrect steering voltage to the filter oscillator and monitoring the subsequent loop behavior.

This command has the following format:

SERV:COARS <int> [0,225]

3.10.4   SERV:DACG <float> [0.1, 10000]

This command is used for factory setup.

3.10.5   SERV:EFCS <float> [0.0, 500.0]

Controls the Proportional part of the PID loop for the selected servo loop. Typical values are 0.7 to 6.0. Larger values increase the loop control gain (reducing the loop time constant) at the expense of increased noise while locked. Setting this value too high can cause loop instabilities.

This command has the following format:

SERV:EFCS <float> [0.0, 500.0]

3.10.6   SERV:EFCD <int> [2, 4000]

Sets the Low Pass filter effectiveness of the time interval counter data for the selected servo loop. Values from 2.0 to 50 are typically used. Larger values result in less noise at the expense of phase delay and may cause loop instability.

This command has the following format:

SERV:EFCD <int> [2, 4000]

3.10.7   SERV:TEMPCO <float> [-4000.0, 4000.0]

This parameter is a coefficient that reflects the correlation between the temperature of the Rubidium or filter oscillator versus the required frequency steering. Monitoring the tempco and aging parameters provides a mechanism to track the health of the Rubidium or filter oscillator. Excessively high values that appear from one day to the next could be an indicator of failure on the board. This coefficient is automatically computed and adjusted over time by the firmware.

This command has the following format:

SERV:TEMPCO <float> [-4000.0, 4000.0]

3.10.8   SERV:AGING <float> [-10.0, 10.0]

This parameter is a coefficient that represents the drift of the EFC needed to compensate the natural drift in frequency of the Rubidium or filter oscillator due to aging. This coefficient is automatically computed and adjusted over time by the firmware. This command has the following format:

SERV:AGING <float> [-10.0, 10.0]

3.10.9 SERV:PHASECO <float> [-2000.0, 2000.0]

This parameter sets the Integral part of the PID loop for the selected servo loop, and therefore the time constant of the phase error correction mechanism. Larger values result in shorter time constants. Loop instability may result if the parameter is set too high. Typical values are 1.0 to 2000 depending on the loop being selected. This command has the following format:

SERV:PHASECO <float> [-2000.0, 2000.0]

3.10.10 SERV:1PPS <int> ns

This command is not supported on the GPS-3x00.

3.10.11 SERV:TRAC:PORT <RS232 | USB>

This command selects the serial port for trace debug output. This command has the following format:

SERV:TRAC:PORT <RS232 | USB>

3.10.12 SERV:TRAC <int> [0,255]

This command sets the period in seconds for the debug trace for the selected servo loop. Debug trace data can be used with Ulrich Bangert's "Plotter" utility or Excel to show UTC tracking versus time etc.

This command has the following format:

SERV:TRAC <int > [0,255]

An example output is described here:

08-07-31 373815 60685 -32.08 -2.22E-11 14 10 6 0x54

[date][1PPS Count][OCXO Fine DAC or MAC Steering][UTC offset ns][Frequency Error Estimate][Sats Visible][Sats Tracked][Lock State][Health Status]

Please see the SYNC:HEA? command for detailed information on how to decode the health status indicator values. The Lock State variable indicates one of the following states:

TABLE 3-5: LOCK STATE INDICATIONS

Value	State
0	Rubidium/filter oscillator warm-up
1	Holdover
2	Locking (Rubidium/filter training)
4	[Value not defined]
5	Holdover, but still phase locked (stays in this state for about 100 seconds after GNSS lock is lost)
6	Locked and GNSS active

3.10.13 SERV:FAST <int> [1, 20]

The FAST command enables the FASTLOCK mode, and sets its gain parameter for the selected servo loop. Fastlock works by momentarily multiplying the EFCS gain to a value determined by this SERV:FAST parameter. Gain values of 1x to 20x can be set, with a gain of 1x (100%) effectively disabling the FASTLOCK feature. By selecting gain values of >1, the PLL loop parameter Proportional gain (SERV:EFCS) will be increased after power on, thus increasing loop aggressiveness and reducing the PLL lock time and the loop time constant. It is not desirable to maintain a high loop gain for longer than necessary to lock the PLL since high loop gains come at the expense of increased

phase noise (reduced short term stability). The FASTLOCK mechanism will automatically reduce the FASTLOCK gain over a period of time specified by the SERV:FALE command, during which time the FASTLOCK gain is slowly decreased from its initial value to 1.0x.

Setting the FASTLOCK gain to 2, for example, will result in the Proportional gain value stored in the SERV:EFCS parameter to be multiplied by 2x initially after power on. This dynamic gain is slowly reduced until the gain is back to 1.0x, the value stored in the SERV:EFCS parameter.

For example, if we set SERV:FAST to 2, and SERV:FALE to 3600, and SERV:EFCS is set to 0.7, then initially the unit will multiply the EFCS by 2x, and an effective EFCS value of 1.4 is applied to the PLL loop. This increased gain value difference will be reduced every second by 1/3600, so that the gain after two seconds would be: 1.3998, until after 3600 seconds the gain has been reduced back to its long term value of 0.70 as stored in the SERV:EFCS parameter.

Disabling the FASTLOCK mode is accomplished by setting the SERV:FAST to 1. This will set the dynamic gain to 1.0, effectively disabling the fastlock feature.

This command has the following format:

SERV:FAST <int> [1,20]

3.10.14   SERV:FALE

This command adjusts the length of time during which the FASTLOCK feature is active, please see the command SERV:FAST 3.10.13.

The length parameter can be set from 100 seconds to 20,000 seconds. The Dynamic FASTLOCK gain is slowly reduced until it reaches a gain of 1.0 after the FALE period of seconds. During this time the PLL loop gain is increased by the amount specified in the SERV:FAST parameter, which will result in a faster initial phase lock to UTC after power-on, while giving the lowest possible noise floor (best short term stability) during normal operation.

This command has the following format:

SERV:FALE <int> [100,20000]

3.10.15   SERV?

This command returns the result of the following queries:

SERV:SEL?
SERV:LOOP?
SERV:COARSE? (only with filter servo loop selected)
SERV:DACG?
SERV:EFCS?
SERV:EFCD?
SERV:PHASECO?
SERV:TEMPCO?
SERV:AGING?
SERV:1PPS?
SERV:TRAC:PORT?
SERV:TRAC?
SERV:FAST?
SERV:FALE?

3.11 CSAC SUBSYSTEM

The following commands are used to query the microcontroller built into the Rubidium oscillator itself. Please note that the CSAC nomenclature is used instead of MAC for backwards compatibility to all legacy GPS-2700 products.

3.11.1 CSAC:RS232?

This query returns the state (OK or FAIL) of the serial communication between the main CPU and the Rubidium oscillator internal microcontroller. When the state is FAIL, there is a communication breakdown, and the unit should be power cycled to clear the communication error.

3.11.2 CSAC:ST?

This query returns the current Frequency Adjustment in units of parts-per-trillion (1E-012).

3.11.3 CSAC:STAT?

This query returns the status value in [0,1] as shown below:

0x0   MAC not locked
0x1   MAC locked

3.11.4 CSAC:MODE?

This query returns the Rubidium oscillator mode as shown below:

0x0000   Analog tuning disabled
0x0001   Analog tuning enabled

3.11.5 CSAC:TEC?

This query returns the Rubidium oscillator TEC Control value (in mDegC).

3.11.6 CSAC:TCXO?

This query returns the TCXO Tuning Voltage, 0VDC - 2.5VDC tuning range ~ ±10 ppm.

3.11.7 CSAC:SIG?

This query returns the indication of the Rubidium Vapor Cell DC interrogation signal level in mV.

3.11.8 CSAC:HEAT?

This query returns the Physics package heater power in mW.

3.11.9 CSAC:TEMP?

This query returns the Temperature measured by the Rubidium oscillator in °C.

3.11.10 CSAC:FW?

This query returns the Firmware version of the Rubidium oscillator unit.

3.11.11 CSAC:SN?

This query returns the Serial Number of the Rubidium oscillator in the form YYMMCSN-NNNN where YYMM is the year and month of production and NNNNN is the serialized unit of that month.

3.11.12   CSAC:LIFE?

This query returns the accumulated number of hours that the Rubidium oscillator has been powered on since the last factory reset of the GPS-3x00 GNSSDO board. The value is stored in the external NVRAM and updated every hour when the unit is powered on.

3.11.13   CSAC:ST:LAT ONCE

This command stores the momentary steering offset into the Rubidium oscillator's internal NVRAM. This is done automatically by the firmware once every 24 hours, so as not to damage the Rubidium oscillator's NVRAM which has a limited number of write cycles. The user may force this value to be stored into the Rubidium oscillator by issuing the CSAC:ST:LAT ONCE command.

3.11.14   CSAC?

This query displays all the CSAC queries defined above.

NOTES:

Chapter 4. Firmware Upgrade Instructions

4.1   INTRODUCTION

The following is a short tutorial on how to upgrade the GPS-3x00 GNSSDO firmware. Please follow the instructions in order to prevent corrupting the GPS-3x00 GNSSDO Flash, which may require reflashing at the factory.

With some practice, the entire Flash upgrade can be done in less than two minutes, even though the following seems like a fairly long list of instructions.

4.2   ISP FLASH LOADER UTILITY INSTALLATION

Flash Magic utility is recommended to upgrade the contents of Flash memory on the GPS-3x00 GNSSDO. It 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.

4.3   PUTTING THE PCB INTO IN-CIRCUIT PROGRAMMING (ISP) MODE

Momentarily short-out pins 1 and 3 on the 16-pin main power connector J1, or alternatively pins 1 and 2 of ISP#/RESET# header J2 (on the PCB inside the enclosure) using a jumper wire or other conductive material during power-on (See Figure 4-1). Both LED's on the PCB should remain off, indicating the unit is properly placed into ISP mode. If the LED's light up after power-on, the unit is not in ISP mode.

FIGURE 4-1:   *Location of Header J2 Internally to the Enclosure.*

4.4 DOWNLOADING THE FIRMWARE

Download the latest version of GPS-3x00 GNSSDO firmware from the support website and store it in a place that will be remembered. The file is in .hex format. The unit needs to be connected to the computer's RS-232 serial port prior to firmware download. Connect a DB-9 serial connector to the GPS-3x00 GNSSDO as indicated in Section 2.5. Please note that the unit can only be upgraded through the RS-232 port, not through the USB serial port.

4.4.1 Using the Flash Magic Flash Programming Utility

1. Open the Flash Magic utility. Set the COM port in the Flash Magic application as needed on your PC. Set "Interface" to "None (ISP)".
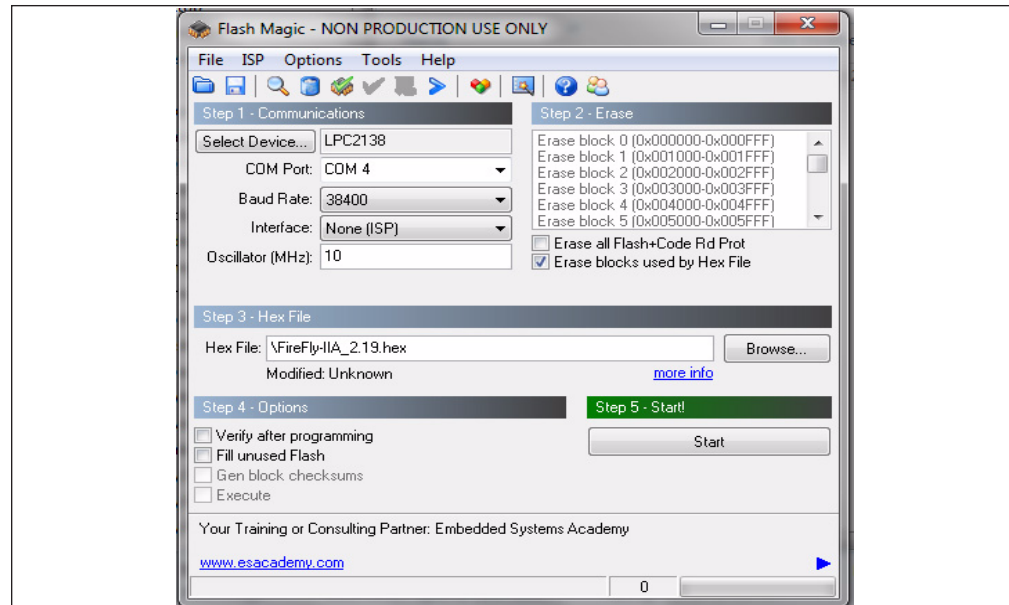

FIGURE 4-2: *Flash Magic Programming Utility.*

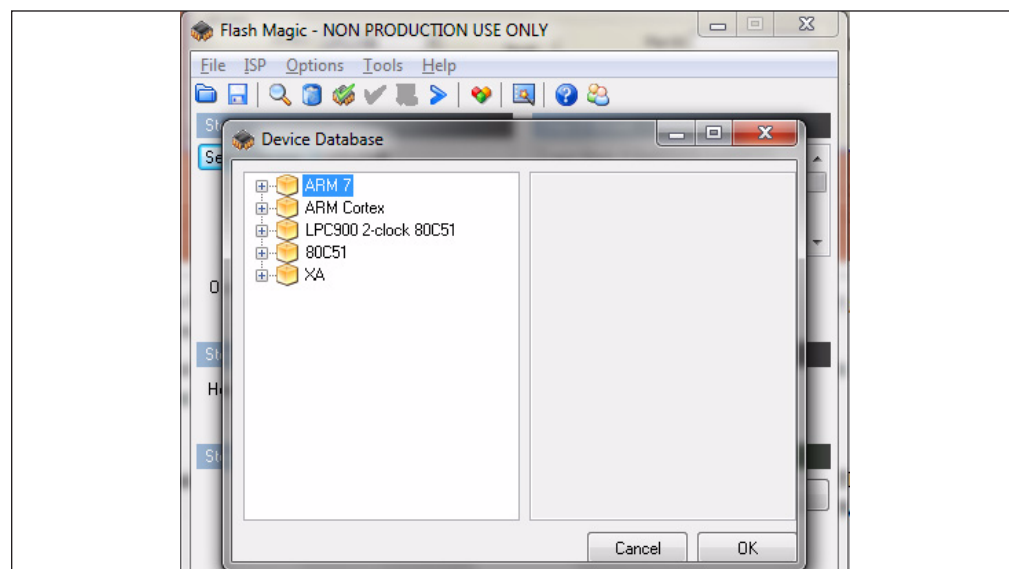2. Press the "Select Device" button and the window shown in Figure 4-3 will appear:

FIGURE 4-3: *Device Selection Window.*

3. Expand the ARM CORTEX folder and select the appropriate processor, in this case the LPC1768.
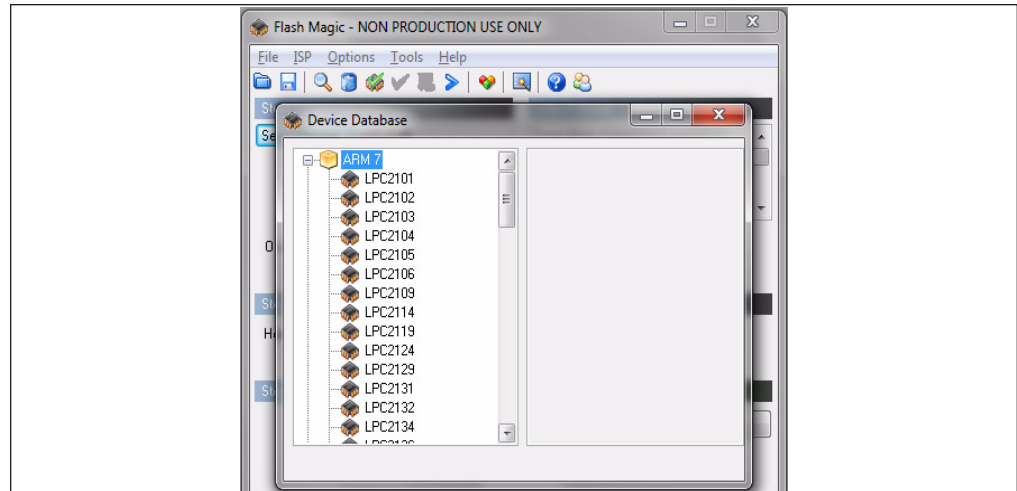

FIGURE 4-4:   Expanded Device Selection Window.

4. Select the Baud Rate of the Flash Magic utility to be 230.4 KB or slower.
5. Set the Oscillator (MHz) to "10".
6. Check the box marked "Erase blocks used by Hex File".

WARNING
Make sure to *not* check the box marked "Erase all Flash+Code Rd Prot" under any circumstances! This may erase factory calibration data, the unit will not operate, and will have to be returned to the factory. Checking this box on the ISP utility will void the warranty.

7. Under "Step 3 - Hex File" browse for the hex file that you downloaded in Step 4.4.
8. Go to Step 5 and press "Start". You will observe the firmware being downloaded to the GPS-3x00 GNSSDO.

4.5   VERIFYING FIRMWARE UPDATE

Power cycle the unit. Both LED's should blink.

During power on, the unit sends an ID string out of the serial port 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.

NOTES:

Chapter 5. GPSCon Utility

5.1   DESCRIPTION

GPSCon is a program useful in the monitoring and controlling a variety of GPS time and frequency standard receivers. It communicates with the receiver using the SCPI command set. GPSCon can be used to monitor either the Rubidium oscillator or filter oscillator servo loops by selecting the desired servo loop with the SERV:SEL command, see also Section 3.10.1. This utility can be obtained directly from the product web page.

5.2   INSTALLATION

Follow the directions that come with GPSCon for installing the utility on your computer.

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 chapter for convenience.

5.3.1   Setting the Options

To set up the options for your GPSCon session, press the "Options" button below the display area. The window shown in Figure 5-1 will appear. You can select from the tabs which options you wish to set.
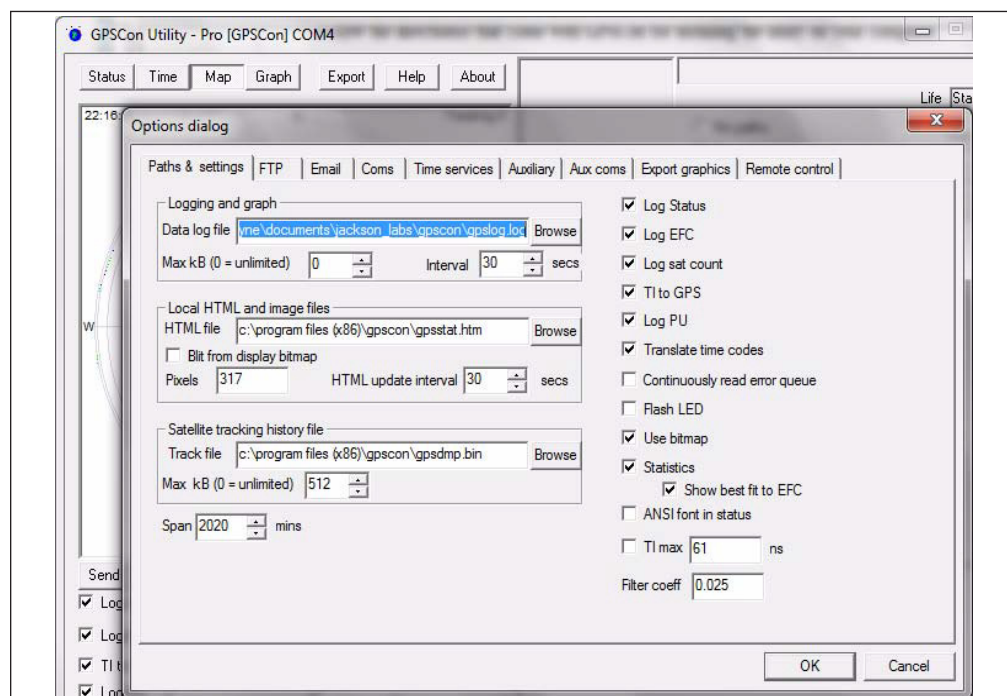

FIGURE 5-1:   Options Window.

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 "Options" button. Then select the "Coms" tab. You will see the window shown in Figure 5-2. 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 "Options" button, you can select "Auxiliary" and set other options or measurements. See Figure 5-3 for an example of an auxiliary measurement. You will notice that the "Aux 1 request string" has been set to `meas:temp?<CR>` and the "Log Aux1" box is checked. In the area below labeled "Traces to be visible on the graph", the box "Aux 1" is checked and the label "CSAC temp" has been added.

5.3.1.3 OTHER OPTIONS

The other tabs in the options window can be selected and you can set whatever options you need, such as paths for logging or exporting graphics.
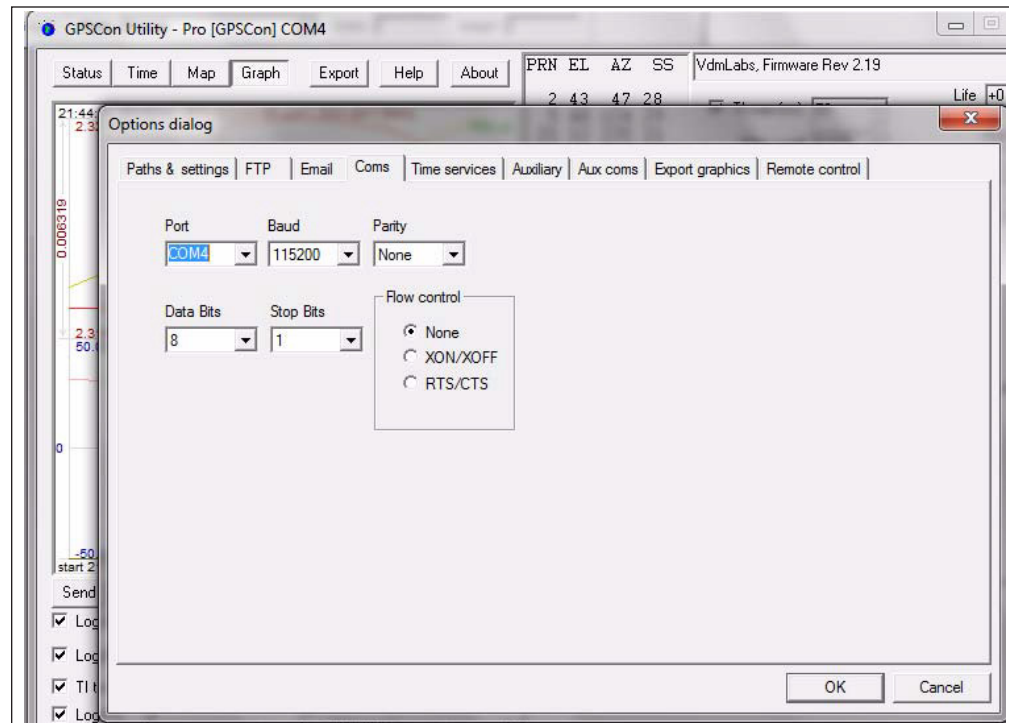

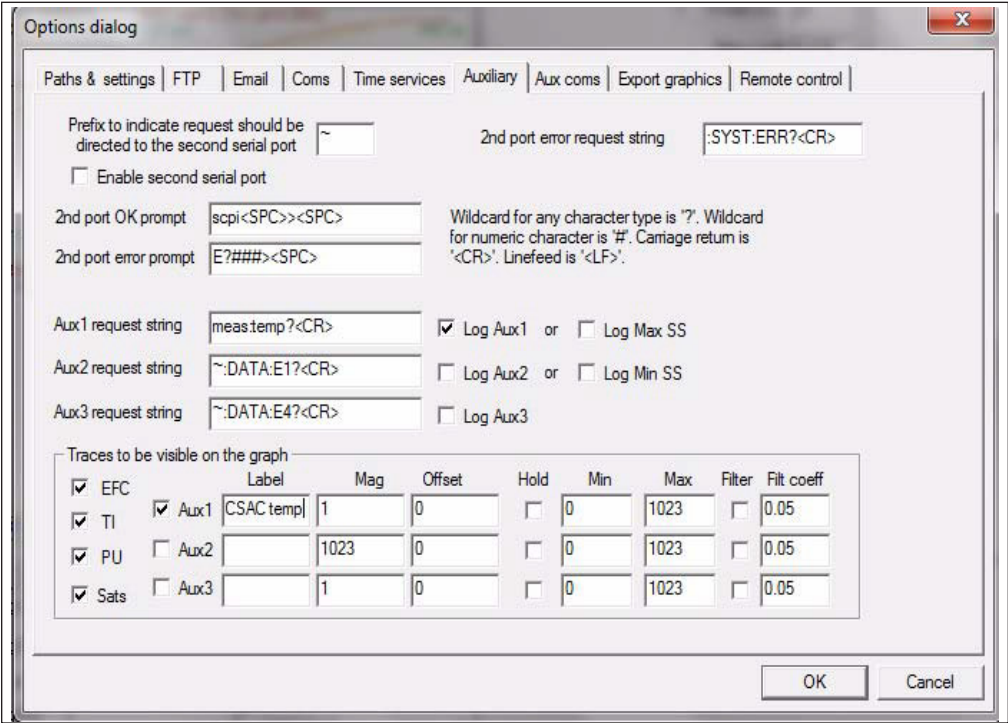***FIGURE 5-2:*** *Setting the Communications Parameters.*

FIGURE 5-3:   *Auxiliary Parameters Window.*

5.3.2   Sending Manual Commands to the Receiver

You can send SCPI commands manually by using the drop-down box under the display window as shown in Figure 5-4. Care must be taken when sending these commands so be sure that the command that you select is supported by the GPS-3x00. Once you've selected the command, you can press "Send" to send it to the GPS-3x00.
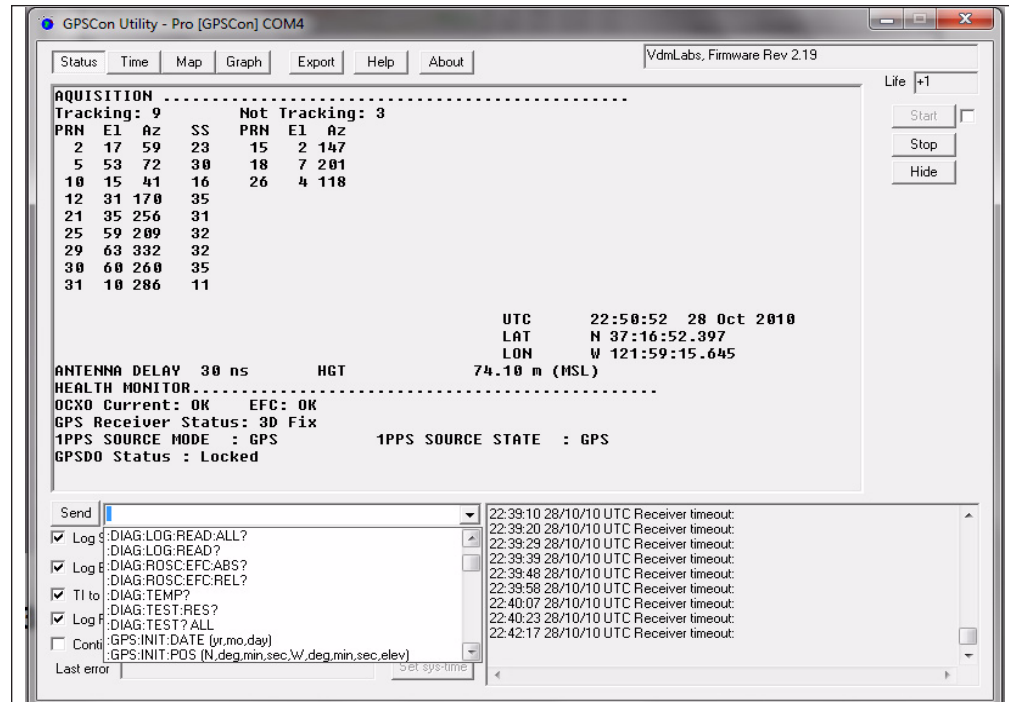

FIGURE 5-4:   *Sending Manual Commands.*

5.3.3   Using the Mouse in Graph Mode

Refer to Figure 5-5 for the following description. In graph mode the span of the graph may be set using the span setting. Alternatively, the start and or stop time of the graph may be locked using the mouse. Set the start time by left clicking on the desired start point. If you wish, the stop time may also be locked by right clicking the desired stop point. This can all be unlocked by left double-clicking anywhere on the graph. Double-click always causes all of the selected span data to be displayed. At the next update cycle, the selected span, if not set to zero, will be enforced. However, the left click, and if chosen the right click, always overrides the span setting.

To display all of the data in the file without manually setting the span to zero, you should right double-click in the graph. This has the effect of setting the start time to zero, the stop time to infinity, and asserting the mouse override condition. To release, left double-click.

Because 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."

Remember, in order to see all the data in the log file, you must either set the span control to zero, or right double-click in the graph.

When you have locked the start and stop time using the mouse, you can scroll left or right through the data without changing the span. To scroll to a later time, use Shift + Left click. To scroll to an earlier time, use Shift + Right click. Double left click to release everything.

The time span indication at the lower right of the graph will turn red to signify that mouse override is in effect.
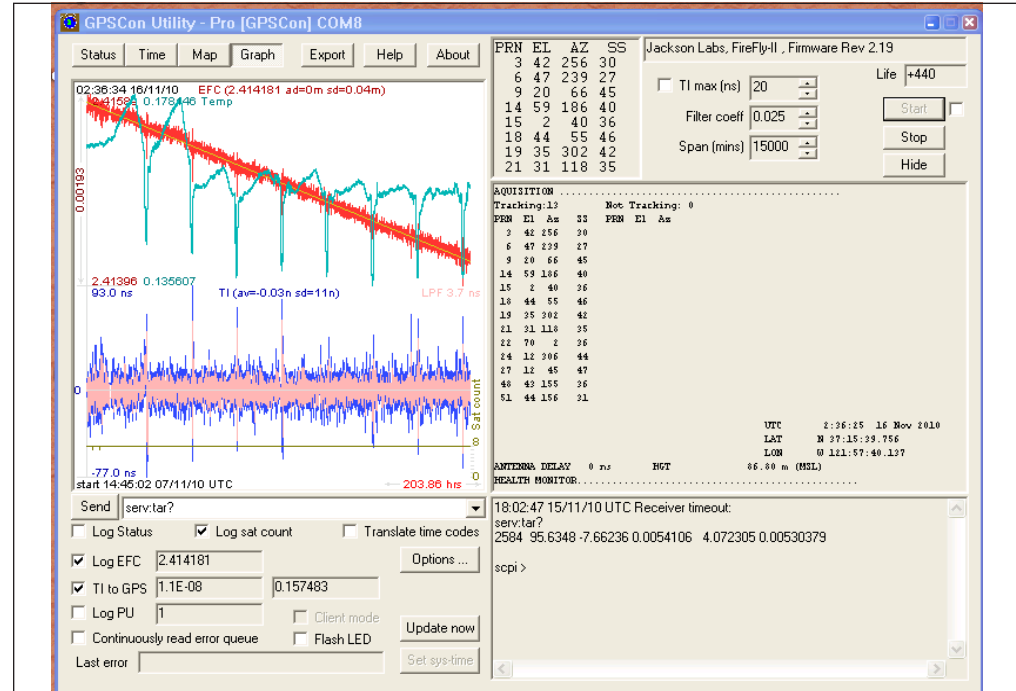

FIGURE 5-5: Graph Display.

FIGURE 5-6: Expanded Graph Display.

5.3.4 Exporting the Graphics

The settings that control the mode of the Export function are contained in the Options dialog.

Export allows you to create an image file of either the graph or the satellite map. You select which you want using the radio buttons. If you select '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 "All" to make this choice.

You may nominate a size in X and Y. The file format may be `.bmp`, `.jpg`, `.gif`, or `.png`. Your settings will be stored and will be the default 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.

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