GPS-1000
GPS Disciplined Oscillator (GPSDO)

User Manual

Revision A

090-01584-000

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Sales and Technical Support

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1 Introduction

1.1 Overview

The GPS-1000 GPSDO includes an extremely high-performance GPS receiver that can acquire and track up to 50 GPS signals down to a state of the art –160dBm, a 32bit processor that runs a Real Time OS, a low-noise sine wave 10MHz output, 1PPS UTC synchronized output, RS-232 control interface, precision voltage references, and DACs.

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

1.2.1 Grounding

To avoid damaging the sensitive electronic components in the GPS-1000 GSPDO, 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 GPS antenna.

1.2.2 Power Connections

Make sure to connect the DC power to the device following the polarity indicated in "Quick-Start Instructions" on page 3. Do not reverse the power pins as this will cause serious damage to the circuit board.

1.2.3 Environmental Conditions

This instrument is designed to operate at a maximum relative non-condensing humidity of 95% and at altitudes of up to 4000 meters. Refer to the specifications tables for the ac mains voltage requirements and ambient operating temperature range.

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2 Quick-Start Instructions

2.1 Powering Up the Unit

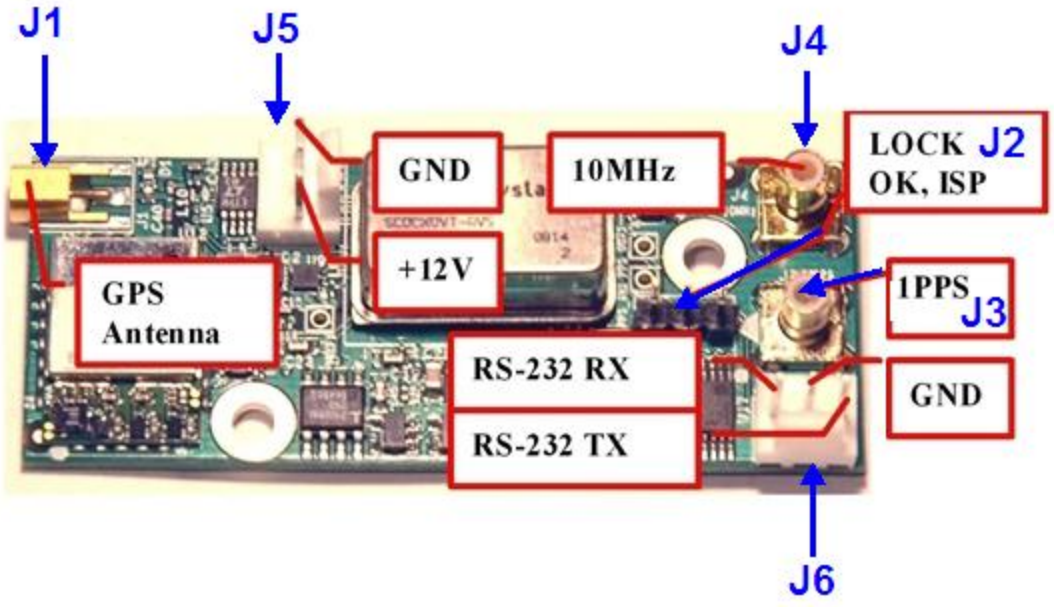
The unit is powered from a 8V - 14V DC source. The current is typically less than 0.15A at 12V. Connect a +12V power supply to J5. The connector style is a Molex Part Number 22-23-2031 connector.

Do not reverse the polarity of the power connector, this will damage the unit.

2.1.1 Major connections

The major connections and features of the GPS-1000 PCB are shown in Figure 2.1 and Table 2.1 to Table 2.6.

Figure: 2. 1 Major connections to GPS-1000



2.1.2 GPS-1000 hardware connectors

Table: 2. 1 Connector J5

Name	+12V
Function	+12V Supply
Specification	8.0V-14.0V DC, <0.5A, <10mVac
Pinning	3 +12V, 2-GND, 1-GND

Table: 2. 2 Connector J4

Name	Sine Out
Function	10MHz Output
Specification	+11dBm +/-3dB 10MHz Output
Pinning	Center-Sine Output, Shield-GND

Table: 2. 3 Connector J3

Name	1PPS Out
Function	1PPS Output
Specification	3.3V CMOS, Rising Edge Synchronized
Pinning	Center-1PPS Output, Shield-GND

Table: 2. 4 Connector J6

Name	RS-232
Function	RS-232 Communication
Specification	115Kbaud, 8N1, RS-232
Pinning	3-RX, 2-GND, 1-TX

Table: 2. 5 Connector J1

Name	Antenna
Function	GPS Antenna
Specification	3.0V Amplified Antenna MMCX connector
Pinning	Center-RF Input, Shield-GND

Table: 2. 6 Connector J2

Name	ISP/Status
Function	Alarm/Lock Status indicators, and Enable-ISP Flash Download Mode
Specification	Pin 3: 3.3V CMOS outputPin 2: 4.7Kohm pull-up on open collector to 3.3V
Pinning	3-LOCK-OK indicator, can drive an LED 2-ALARM (unlock) indicator, needs buffering 1-GND [Connect pin 2 to ground during power-on to enter ISP flash-firm ware-download mode]

2.2 Coaxial Connector types

There are three coaxial connectors on the GPS-1000 board. They are the following types:

- J1, antenna: MMCX
- J3, 1PPS output: SMB
- J4, 10MHz sine output: SMB

2.3 Connecting the GPS Antenna

Connect the GPS antenna to the BNC to MMCX cable adapter.

Caution: use a Lightning Arrestor on your Antenna setup.

Use an amplified GPS antenna that is 3V LNA compatible. The GPS-1000 GPS receiver is a 50 channel high-sensitivity GPS receiver with very fast lock time. It does not require any self-survey or position-hold mode (auto survey), and thus can be used in mobile platforms.

The GPS-1000 is capable of generating standard navigation messages (see GPS:GPGGA and GPS:GPRMC RS-232 commands) that are compatible with most GPS based navigation software. Please note that GPS-1000 indicates MSL height (rather than GPS height) in its GPGGA, GPS? and syst:stat? output strings.

The GPS receiver generates a 1PPS time signal that is phase synchronized to UTC. This 1PPS signal is used to frequency-lock the 10MHz Sine-Wave output of the GPS-1000 GPSDO to UTC, thus disciplining the unit's 10MHz frequency output to the US Naval master clock for very high frequency accuracy (typically better than 1ppb of frequency accuracy when locked to GPS).

2.4 Remote serial control

The unit is controlled via the Serial port at 115200 baud, 8N1. Other baud rates can be set via SCPI commands.

Connect the RX, TX, and GND pins of connector J6 to a standard RS-232 connector, attaching the GPS-1000 unit to your PC's Hyperterminal, or the optional GPSCon software package. An RS-232 level shifter is built into the GPS-1000 PCB. A free control/graphing program for Windows named **Z38XX** is available on the Jackson Labs Technologies, Inc. website.

2.4.1 "Help" and command overview

A listing of the available RS-232 commands can be shown by typing "help?".
"*IDN?" can be used to see if the connection works. Both commands need to be followed by pressing "Enter".

2.4.2 Loop parameter adjustment

All loop parameters can be controlled via the RS-232 serial port.
Loop parameters are optimized for the OCXO and saved on the board as factory settings.
Changing the factory settings may result in a deterioration of the unit's performance.
The commands to control the loop parameters are part of the servo? command. See also the **SERVO Subsystem** section below.

The individual commands are:

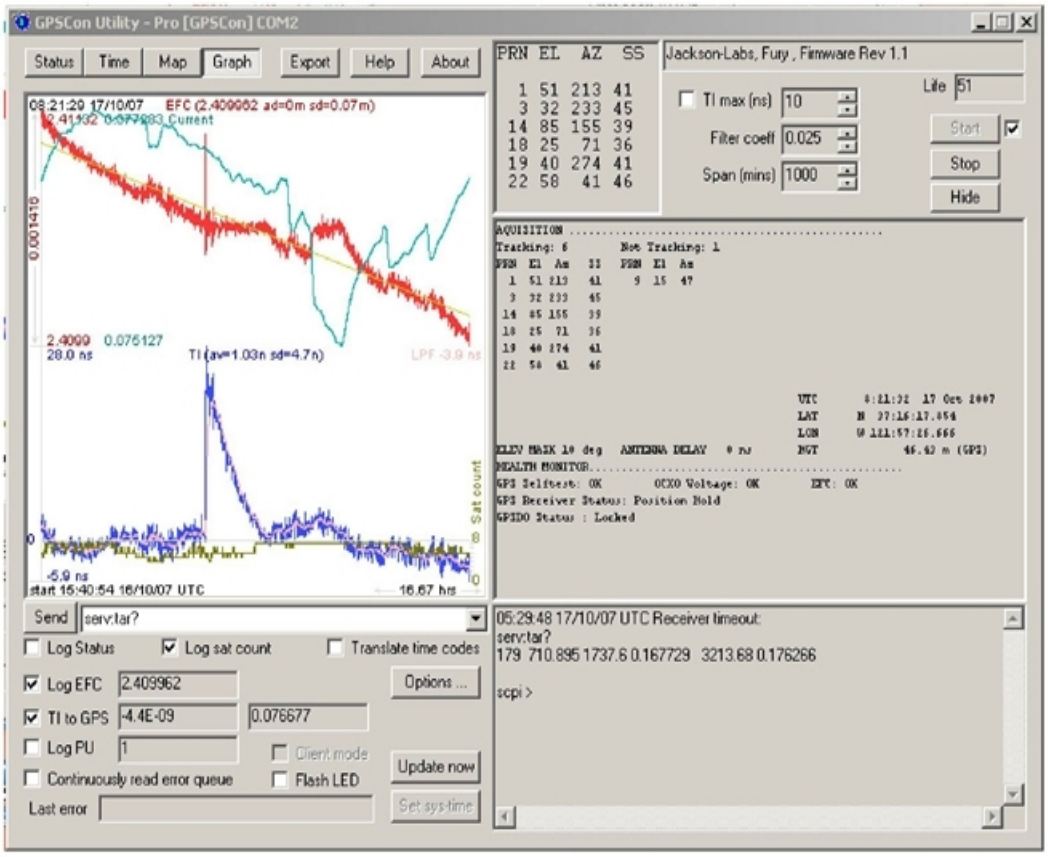
- **Electronic Frequency Control (EFC) Scale**, this is the proportional gain of the Proportional Integral Differential (PID) loop:
  - Higher values will give both quicker convergence and faster locking of the GPS time (lower loop time constant).
  - Lower values give less noise.
  - Values range from 0.7 and 6.0 are typical.

- **EFC Damping**, overall IIR filter time constant:
  - Higher values increase loop time constant.
  - Values range from 10 to 50 are typical. .
  - Setting this value too high may cause loop instability.

- **Phase compensation**, this is the Integral part of the PID loop. Phase compensation corrects phase offsets between the GPS-1000 1PPS signal and the UTC 1PPS signal as generated by the GPS receiver:
  - Set higher values for tighter phase-following at the expense of frequency stability.
  - Values range from 4 - 30, where 25 is the default.
  - Setting this value too high may cause loop instability.

A well-compensated unit will show performance similar to the following plot when experiencing small perturbations

Figure: 2. 2 GPS-1000 phase compensation plot



In this plot, the:

- **Blue** trace is UTC offset (phase error) of the local oscillator (in nanoseconds).
- **Red** trace is EFC voltage showing how the loop compensates for ambient temperature changes. Notice the compensating rise in the red trace over periods of dropping ambient temperature.
- **Magenta** trace shows the change in ambient temperature.

Wording in the figure above, TI(av=1.03n, sd=7n)
where:

- **av** is the phase offset to UTC and in this example it is 1.03 nanoseconds.
- **sd** is the standard deviation of this phase offset, and in this example it is 7 nano-seconds.

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3 SCPI-Control Quick Start Instructions

3.1 Introduction

The SCPI (**S**tandard **C**ommands for **P**rogrammable **I**nstrumentation) subsystem is accessed via the RS-232 interface and a terminal program. By default the terminal settings are 115200, 8N1.

There are a number of commands that can be used as listed below. Most of these are identical or similar to Symmetricom 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-1000 GPSDO.
Additional information regarding the SCPI protocol syntax can be found on the following web site:
http://www.scpiconsortium.org

Please refer to the document SCPI-99.pdf for details regarding individual SCPI command definitions. A basic familiarity with the SCPI protocol is recommended when reading this chapter.

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-1000 GPSDO.

3.3 GPS Subsystem

Note: Please note that GPS-1000 displays antenna height in MSL Meters rather than in GPS Meters on all commands that return antenna height.

The GPS subsystem regroups all the commands related to the control and status of the GPS receiver.

The list of the commands supported is the following :

- GPS:SATellite:TRAcking:COUNt?
- GPS:SATellite:VISible:COUNt?
- GPS:GPGGA <int> [0,255]
- GPS:GGASTat <int> [0,255]
- GPS:GPRMC <int> [0,255]
- GPS:XYZSPeed <int> [0,255]
- GPS:POSition?
- GPS:RESET ONCE
- GPS

3.3.1 GPS:SATellite

This group of commands describe the satellite constellation.

3.3.2 GPS:SATellite:TRAcking:COUNt?

This query returns the number of satellites being tracked.

3.3.3 GPS:SATellite:VISible:COUNt?

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

3.3.4 NMEA Support

The following two commands allow the GPS-1000 GPSDO to be used as an industry standard navigation GPS receiver. The GPGGA and GPRMC 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-1000 RS-232 interface.

Once enabled, the GPS-1000 will send out information on the RS-232 transmit pin automatically every N seconds, where N is an integer of value 0 to 255 seconds.

All incoming RS-232 commands are still recognized by GPS-1000 since the RS-232 interface transmit and receive lines are completely independent of one another.

Please note that the position, direction, and speed data is delayed by one second from when the GPS receiver internally reported these to the GPS-1000 Microprocessor. The position therefore is valid for the 1PPS pulse previous to the last 1PPS pulse at the time the data is sent (one second delay). The time and date are properly output with correct UTC synchronization to the 1PPS pulse immediately prior to the data being sent.

Once set, the following two commands will be stored in non volatile memory, and will generate output information even after power to the unit has been cycled.

3.3.5 GPS:GPGGA

This command instructs the GPS-1000 to send the NMEA standard string $GPGGA every N seconds, with N in the interval [0,255]. The command is disabled during the initial 4 minute OCXO warmup 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.

3.3.6 GPS:GGASTat

This command instructs the GPS-1000 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 4 minute OCXO warmup phase.

This command has the following format:

GPS:GGASTat <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 SERVo:TRACe 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 OCXO performance.

GGASTat 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:GPRMC

This command instructs the GPS-1000 to send the NMEA standard string $GPRMC every N seconds, with N in the interval [0,255]. The command is disabled during the initial 4 minute OCXO warmup phase.

This command has the following format:

GPS:GPRMC <int> [0,255]

3.3.8 GPS:XYZSPeed

Firmware version 0.909 and later add 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, as well as the Time Of Week in milliseconds.

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.

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

GPS:XYZSPeed <int> [0,255]

3.3.9 GPS:POSition?

This command will return the position and height of the GPS antenna, including velocity and track over ground.

3.3.10 GPS:RESET ONCE

This command will re-initialize the GPS receiver.

3.3.11 GPS?

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

3.4 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 :

- PTIMe:TZONe?
- PTIMe:DATE?
- PTIMe:TIME?
- PTIMe:TIME:STRing?
- PTIMe:TINTerval?
- PTIME?

3.4.1 PTIMe:TZONe?

Returns the local time zone offset.

3.4.2 PTIMe:DATE?

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

3.4.3 PTIMe:TIME?

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

3.4.4 PTIMe:TIME:STRing?

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

3.4.5 PTIMe:TINTerval?

This query is equivalent to the command SYNChronization:TINTerval

3.4.6 PTIME?

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

- PTIME:DATE?
- PTIME:TIME?
- PTIME:TZONE?
- PTIME:TINTerval?

3.5 SYNChronization Subsystem

This subsystem regroups the commands related to the synchronization of the GPS-1000 with the GPS receiver.

The list of the commands supported for this subsystem is the following:

- SYNChronization:SOURce:MODE [GPS|EXTernal|AUTO]
- SYNChronization:SOURce:STATE?
- SYNChronization:HOLDover:DURation?
- SYNChronization:HOLDover:INITiate
- SYNChronization:HOLDover:RECovery:INITiate
- SYNChronization:TINTerval?
- SYNChronization:IMMEdiate
- SYNChronization:FEEstimate?
- SYNChronization:LOCKed?
- SYNChronization?

3.5.1 SYNChronization:SOURce:MODE [GPS|EXTernal|AUTO]

The board may be configured to lock to an external 1PPS source, or the internal GPS receiver. A small through-hole pad next to the SMA connectors labeled “1PPS IN” may be used to feed an external CMOS rising-edge 1PPS signal with 0V < x <5V signal level, and 1us minimum pulse width into the unit. Use one of the various ground pins on the board as a 1PPS signal return.

By default the unit is set to GPS. It may be hard-coded to only use the external 1PPS source by setting EXT, or it may be auto-switched to the external 1PPS signal if the internal GPS receiver does not generate 1PPS pulses for longer than 15 seconds if the signal is too weak, or there is a GPS failure. When set to the AUTO setting, the unit will switch back to the internal GPS receiver once 1PPS pulses are generated internally again.

3.5.2 SYNChronization:HOLDover:DURation?

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 reference oscillator was not locked to GPS. 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 Receiver is not in holdover; a value of 1 indicates the Receiver is in holdover.

3.5.3 SYNChronization:HOLDover:INITiate

This command will place the unit into a forced holdover state, while still indicating the difference between the internal 1PPS generated by the OCXO and the GPS generated 1PPS. This command is useful to measure the OCXO drift when in holdover. Please note that the Time Interval Counter is limited to +/-2000ns display range. The time interval difference may be displayed with the SYNC? command.

3.5.4 SYNChronization:HOLDover:RECovery:INITiate

This command terminates a manual holdover that was initiated with the SYNC:HOLD:INIT command, and returns the unit to normal GPS locking mode.

3.5.5 SYNChronization:TINTerval?

This query returns the difference or timing shift between the GPS-1000 1 PPS and the GPS 1 PPS signals. The resolution is 1E-10 seconds.

3.5.6 SYNChronization:IMMEdiate

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

3.5.7 SYNChronization:FEEstimate?

This query returns the Frequency Error Estimate. It is similar to the Allan Variance using a 1000s measurement interval and comparing the internal 1PPS to GPS 1PPS offset.

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

3.5.8 SYNChronization:LOCKed?

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

3.5.9 SYNChronization:health?

This query returns a hexadecimal number indicating the system's health-status.. Error flags are encoded in a binary fashion so that each flag occupies one single bit of the binary equivalent of the hexadecimal health-status flag.

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 OCXO coarse-DAC is maxed-out at 255	HEALTH STATUS |= 0x1;
If the OCXO coarse-DAC is mined-out at 0	HEALTH STATUS |= 0x2;
If the phase offset to UTC is >250ns	HEALTH STATUS |= 0x4;
If the run-time is < 300 seconds	HEALTH STATUS |= 0x8;
If the GPS is in holdover > 60s	HEALTH STATUS |= 0x10;
If the Frequency Estimate is out of bounds	HEALTH STATUS |= 0x20;
If the OCXO voltage is too high	HEALTH STATUS |= 0x40;
If the OCXO voltage is too low	HEALTH STATUS |= 0x80;
If the short-term-drift (ADEV @ 100s) > 100ns	HEALTH STATUS |= 0x100;
For the first 7 minutes after a phase-reset, or a coarsedac change:	HEALTH STATUS |= 0x200;

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

1) UTC phase > 250ns: 0x4
2) OCXO voltage too high: 0x40
3) GPS in holdover: 0x10

'Oring' these values together results in:

0x40 | 0x10 | 0x4 = 0x54

The unit would thus indicate: **HEALTH STATUS: 0x54**
A health status of 0x0 indicates a properly locked and warmed-up unit that is completely healthy.

3.5.10 SYNChronization?

This query returns the results of these six queries :

- SYNChronization:SOURce:MODE?
- SYNChronization:SOURce:STATE?
- SYNChronization:LOCKed?
- SYNChronization:HOLDover:DURation?
- SYNChronization:FEEstimate?
- SYNChronization:TINTerval?
- SYNChronization:health?

3.6 DIAGnostic Subsystem

This subsystem regroups the queries related to the diagnostic of the OCXO.

The list of the commands supported for this subsystem is as follows:

- DIAGnostic:ROSCillator:EFControl:RELative?
- DIAGnostic:ROSCillator:EFControl:ABSolute?

3.6.1 DIAGnostic:ROSCillator:EFControl:RELative?

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

3.6.2 DIAGnostic:ROSCillator:EFControl:ABSolute?

This query returns the Electronic Frequency Control (EFC) output value of the internal reference oscillator. It returns a value in volts between 0 and 5 V

3.7 MEASURE Subsystem

This subsystem regroups the queries related of some parameters that are measured on the GPS-1000 board.

The list of the commands supported for this subsystem is the following:

- MEASure:VOLTage?
- MEASure:CURRent?
- MEASure?

3.7.1 MEASure:VOLTage?

This command is not supported in GPS-1000, and will return undetermined values.

3.7.2 MEASure:CURRent?

This query returns the current drawn by the OCXO. This current varies in order to keep a stable temperature inside the OCXO.

3.7.3 MEASure?

This query returns the result of the two following queries:

- MEASure:VOLTage?
- MEASure:CURRent?

3.8 SYSTEM Subsystem

This subsystem regroups the commands related to the general configuration of the GPS-1000.

The list of the commands supported for this subsystem follows:

- SYSTem:COMMunicate:SERial:ECHO <ON | OFF>
- SYSTem:COMMunicate:SERial:PROmpt <ON | OFF>
- SYSTem:COMMunicate:SERial:BAUD <9600 | 19200 | 38400 | 57600 | 115200>
- SYSTem:STATus?
- SYSTem:FACToryReset ONCE

3.8.1 SYSTem:COMMunicate

SYSTem:COMMunicate:Serial:ECHO
This command enables/disables echo on RS-232.

This command has the following format:
SYSTem:COMMunicate:SERial:ECHO <ON | OFF>

SYSTem:COMMunicate:SERial:PROmpt
This command enables/disables the prompt “scpi>” on the SCPI command lines. The prompt must be enabled when used with the software GPSCon.

This command has the following format:
SYSTem:COMMunicate: SERial:PROmpt <ON | OFF>

SYSTem:COMMunicate:SERial:BAUD
This command sets the RS-232 serial speed. The serial configuration is always 8 bit, 1 stop bit, no parity, no HW flow control. Upon Factory reset, the speed is set at 115200 bauds.

This command has the following format:
SYSTem:COMMunicate:SERial:BAUD <9600 | 19200 | 38400 | 57600 | 115200>

3.8.2 SYSTem:STATus?

This query returns a full page of GPS status in ASCII format. The output is compatible with GPSCon.

3.8.3 SYSTem:FACToryReset ONCE

This command applies the Factory Reset setting to the EEPROM. All aging, tempco, and user parameters are overwritten with factory default values.

3.9 SERVO Subsystem

This subsystem regroups all the commands related to the adjustment of the servo loop:

- SERVo:COARSeDac <int> [0,225]
- SERVo:DACGain <int> [0.1,10000]
- SERVo: EFCScale <float>[0.0 , 500.0]
- SERVo:EFCDamping <float>[0.0 , 4000.0]
- SERVo:SLOPe <NEG | POS >
- SERVo:TEMPCOmpensation <float> [-4000.0, 4000.0]
- SERVo:AGINGcompensation <float> [-10.0, 10.0]
- SERVo:PHASECOrrection <float> [-100.0, 100.0]
- SERVo:1PPSoffset <int> ns
- SERVo:QUIet <ON | OFF>
- SERVo:TRACe <int > [0,255]
- SERVo?

3.9.1 SERVo:COARSeDac

This command sets the coarse Dac that controls the EFC. The GPS-1000 control loop automatically adjusts this setting. The user should not have to change this value.

This command has the following format:

SERVo:COARSeDac <int> [0,225]

3.9.2 SERVo:DACGain

This command is used for factory setup.

3.9.3 SERVo: EFCScale

Controls the Proportional part of the PID loop. Typical values are 0.7 (double oven OCXO) to 6.0 (simple single oven OCXO). Larger values increase the loop control at the expense of increased noise while locked. Setting this value too high can cause loop instabilities.

This command has the following format:

SERVo: EFCScale <float>[0.0 , 500.0]

3.9.4 SERVo:EFCDamping

Sets the Low Pass filter effectiveness of the DAC. Values from 2.0 to 50 are typically used. Larger values result in less noise at the expense of phase delay.

This command has the following format:

SERVo:EFCDamping <float>[0.0 , 4000.0]

3.9.5 SERVo:SLOPe

This parameter determines the sign of the slope between the EFC and the frequency variation of the OCXO. This parameter should be set to match your OCXO's EFC frequency slope.

This command has the following format:

SERVo:SLOPe <NEG | POS >

3.9.6 SERVo:TEMPCOmpensation

This parameter is a coefficient that reflects the correlation between the Current provided to the OCXO and the EFC. This coefficient is automatically computed and adjusted over time by the Symmetricom, Inc. firmware.

This command has the following format:

SERVo:TEMPCOmpensation <float> [-4000.0, 4000.0]

3.9.7 SERVo:AGINGcompensation

This parameter is a coefficient that represents the drift of the EFC needed to compensate the natural drift in frequency of the OCXO due to aging. This coefficient is automatically computed and adjusted over time by the Symmetricom, Inc. firmware.

This command has the following format:

SERVo:AGINGcompensation <float> [-10.0, 10.0]

3.9.8 SERVo:PHASECOrrection

This parameter sets the Integral part of the PID loop. Loop instability will result if the parameter is set too high. Typical values are 10.0 to 30.0.

This command has the following format:

SERVo:PHASECOrrection <float> [-100.0, 100.0]

3.9.9 SERVo:1PPSoffset

This command sets the GPS-1000 1PPS signal's offset to UTC in 16.7ns steps.
Using the SERV:1PPS command results in immediate phase change of the 1PPS output signal.

This command has the following format:

SERVo:1PPSoffset <int> ns

3.9.10 SERVo:TRACe

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

This command has the following format:

SERVo:TRACe <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][Fine DAC][UTC offset ns][Frequency Error Estimate][Sats Visible][Sats Tracked][Lock State][Health Status]

Please see the **SYNChronization?** command for detailed information on decoding the health status indicator values.

Note: health status information is available with firmware versions 0.913 and later.
The Lock State variable indicates one of the following states:

Value	State
0	OCXO warmup
1	Holdover
2	Locking (OCXO training)
4	[Value not defined]
5	Holdover, but still phase locked (stays in this state for about 100s after GPS lock is lost)
6	Locked, and GPS active

3.9.11 SERVo?

This command returns the result of the following queries:

- SERVo:COARSeDac?
- SERVo:DACGain?
- SERVo: EFCScale?
- SERVo:EFCDamping?
- SERVo:SLOPe?
- SERVo:TEMPCOmpensation?
- SERVo:AGINGcompensation?
- SERVo:PHASECOrrection?
- SERVo:1PPSoffset?
- SERVo:TRACe?

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4 Firmware Upgrade Instructions

4.1 Introduction

The following is a short tutorial on how to upgrade the GPS-1000 firmware. Please follow the instructions in-order to prevent corrupting the GPS-1000 Flash, which may require reflashing at the factory.

With some practice, the entire Flash upgrade can be done in less than one minute, even though the following instructions appear lengthy.

4.2 ISP Flash Loader Utility installation

There are two Flash loader utilities available to upgrade the GPS-1000 firmware.

- The Philips LPC2000 utility at the Jackson Labs Technologies, Inc. support website can be downloaded and stored.

- The Flash Magic utility is available for download on the Flash Magic website: http://www.flashmagictool.com/

If you have problems installing either of these utilities, contact customer support.

4.2.1 Philips LPC2000 Flash Utility

The first is the Philips LPC2000 utility version 2.2.3.

Please note that some computers are known to be incompatible with the LPC2000 flash utility. Preliminary investigations show Windows Media Center and/or Centrino vPro processor systems to create download difficulties. Please use a different computer if you experience problems such as the download breaking up in the middle of the transfer. Or, alternatively, you may use the Flash Magic programming tool.

Please ensure that you have at least version 2.2.3 of the LPC2100 flash utility installed. Earlier versions may not recognize the LPC2138 processor used on the GPS-1000 boards.

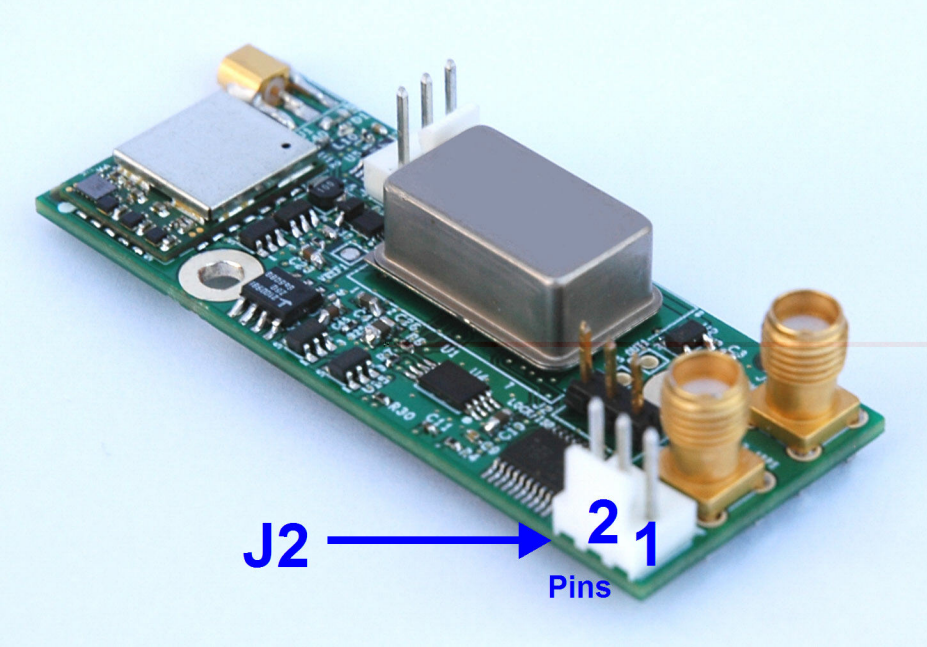
4.2.2 Flash Magic Flash Programming Utility

The second utility is the Flash Magic tool available on the Flash Magic website: http://www.flashmagictool.com/

4.3 Putting the PCB into In-Circuit Programming (ISP) mode

Momentarily short-out pins 1 and 2 of header J2 using a jumper or other conductive material during power-on. Both LED's 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 J2



4.4 Downloading the firmware

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-1000, as indicated in Section "Major connections" on page 3.

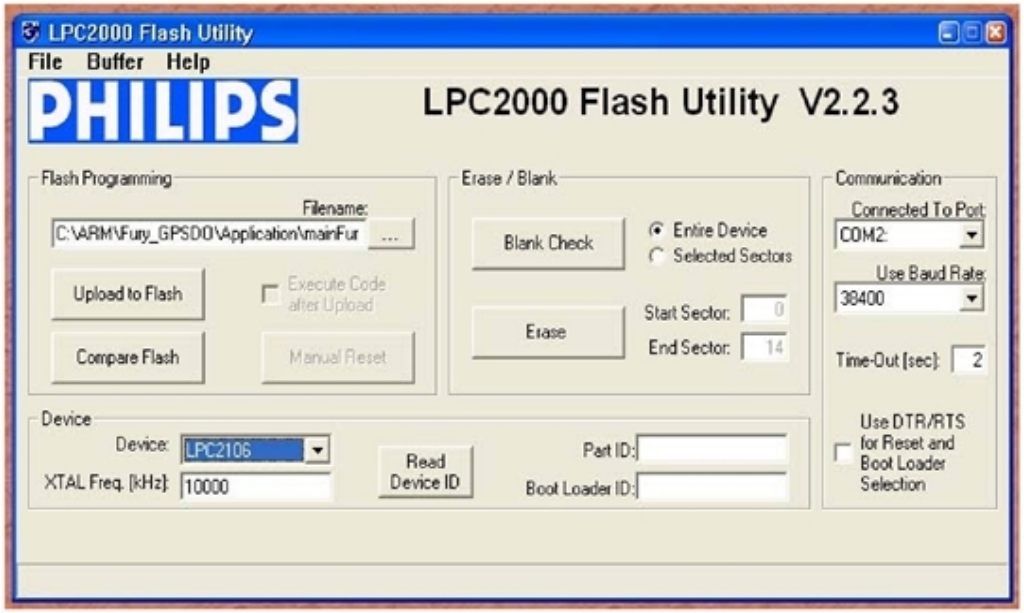
Download the latest version of GPS-1000 firmware from Jackson Labs Technologies, Inc. support website and store it. The file is in .hex format.

4.4.1 Philips LPC2000 Flash Utility

A) Open the LPC2000 utility. Set the COM port in the LPC2000 application as needed on your PC.
B) Select the Baud Rate of the LPC2000 utility to be 38400 or slower. Faster Baud rates will not work properly.
C) Press the "READ DEVICE ID" button; this should then show "LPC2138" in the DEVICE window if the unit is communicating correctly to the application.

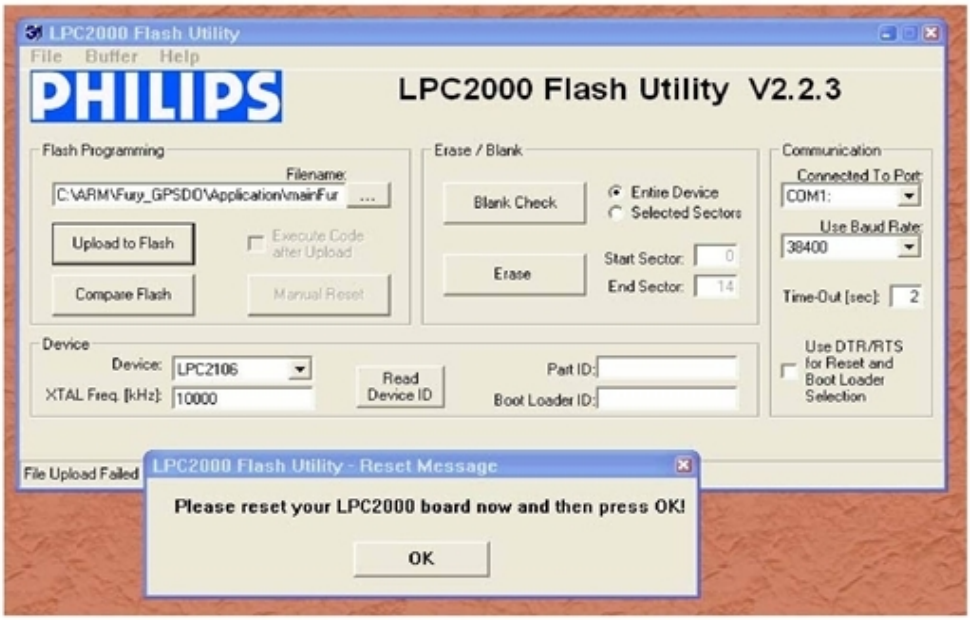
Do NOT(!) press the “erase” button under any circumstances, doing so may erase factory calibration data, the unit will not operate and will have to be returned to the factory. Pressing the “erase” button on the ISP utility will thus void the warranty.

Figure: 4. 2 LPC2000 flash utility



The “DEVICE” should show up as “LPC2138” after pressing “READ DEVICE ID”
Point the “Filename” to the directory where the hex file is stored.
D) Start the download by pressing “Upload to Flash” button. The window below should appear if the correct COM port has been chosen:

Figure: 4. 3 LPC2000 flash download



Press the “OK” button, and the download should start.

Note: Sometimes this process has to be repeated several times (from step B above).

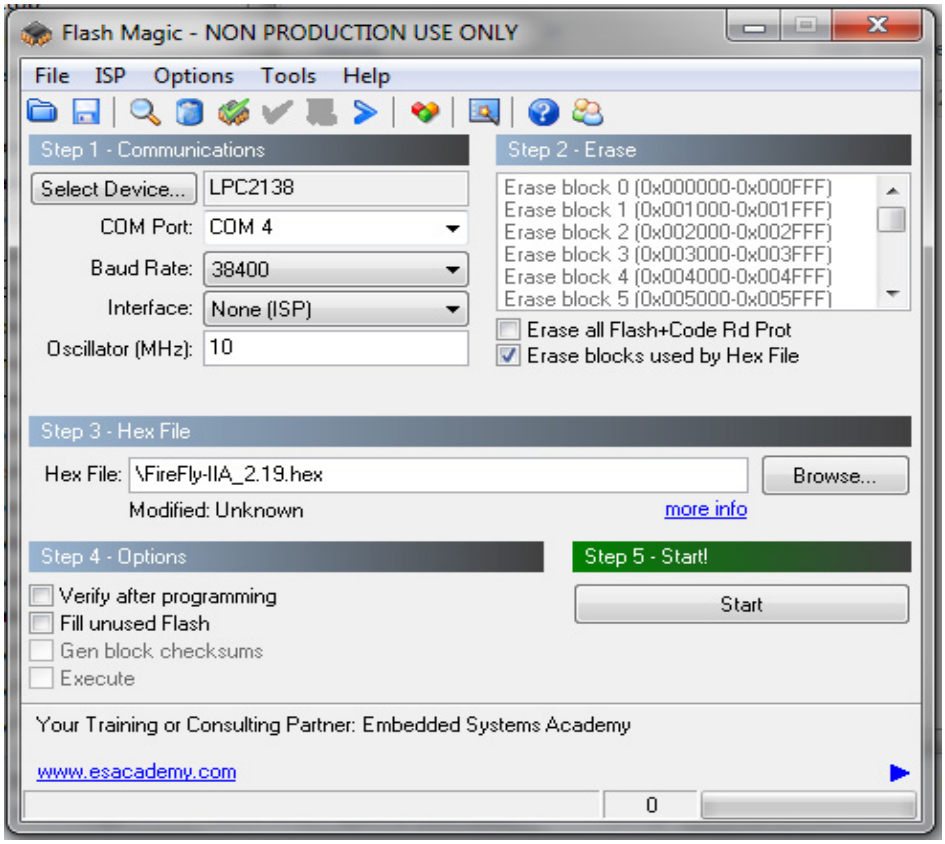
Note: It is not necessary to press “reset” as the utility requested in the utility dialog window. Just press “OK”.

DO NOT PRESS THE “ERASE” BUTTON AT ANY TIME! THIS WILL RENDER THE PCB USELESS AND IT CAN ONLY BE RECOVERED AT THE FACTORY!

4.4.2 Flash Magic Flash Programming Utility

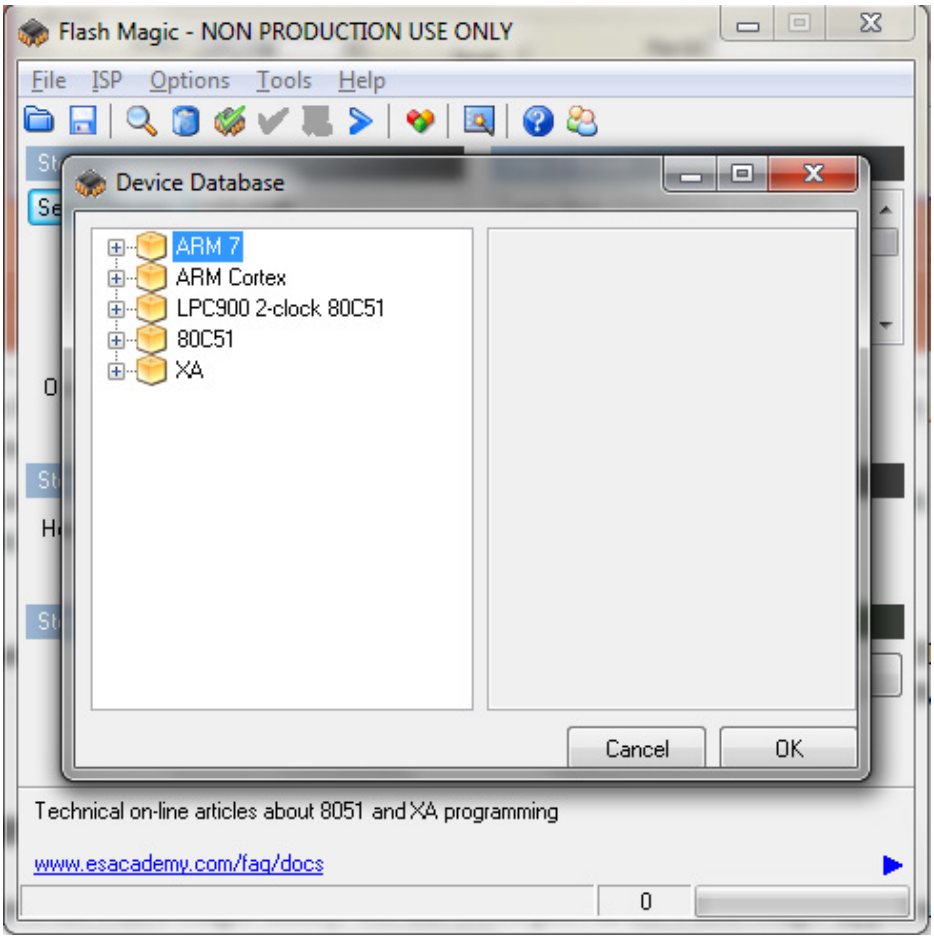
A) Open the Flash Magic utility. Set the COM port in the Flash Magic application as needed on your PC. Set “Interface” to “None (ISP)”.

Figure: 4. 4 Flash Magic utility



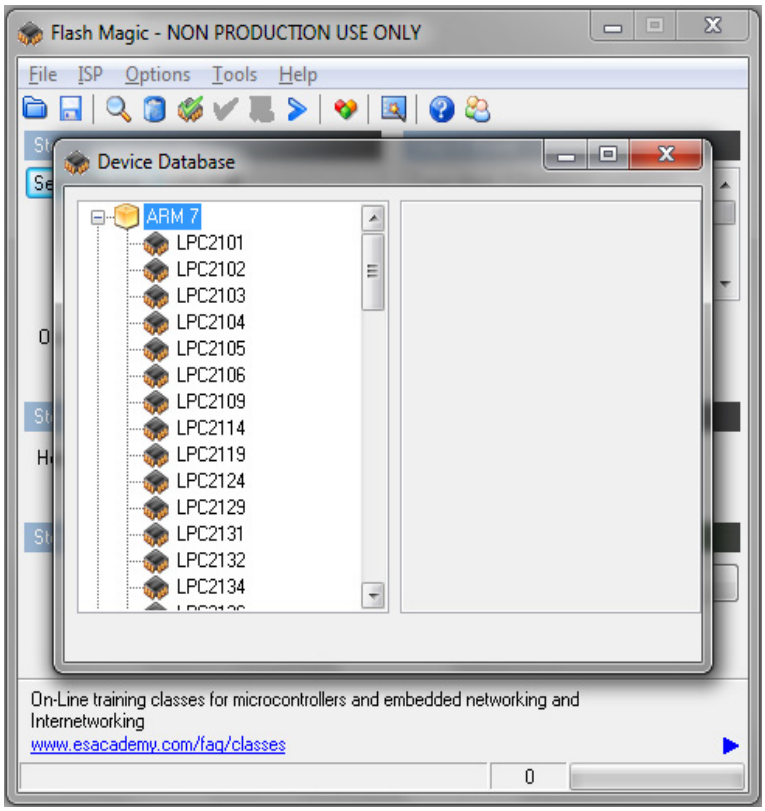
B) Press the “Select Device” button and the window shown below will appear:

Figure: 4. 5 Device selection window



C) Expand the ARM7 folder and select the LPC2138 processor.

Figure: 4. 6 Expanded device selection window



D) Select the Baud Rate of the Flash Magic utility to be 38400 or slower. Faster Baud rates will not work properly.
E) Set the Oscillator (MHz) to “10”.
F) Check the box marked “Erase blocks used by Hex File”.

> Do 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 thus void the warranty.

G) Under “Step 3 - Hex File” browse for the hex file that you downloaded in step "Downloading the firmware" on page 22.
H) Go to Step 5 and press “Start”. You will observe the firmware being downloaded to the GPS-1000.

4.5 Verifying Firmware Update

Close the programming utility and open a terminal window.

After the flash update is done, remove the jumper from header J2, and 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 new downloaded version.

5 GPSCon Utility

5.1 Description

GPSCon is a program for the monitoring and control of a variety of GPS time and frequency standard receivers. It communicates with the receiver using the SCPI command set.

This utility can be obtained directly from Real Ham Radio.com at the following URL: http://www.realhamradio.com/gpscon-buy-now.htm

GPSCon Utility works well on Windows 7, if started as an "administrator" and in XP-compatibility mode. For assistance with installing the GPSCon Utility, contact support at the Jackson Labs Technologies, Inc. website.

5.2 Installation

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

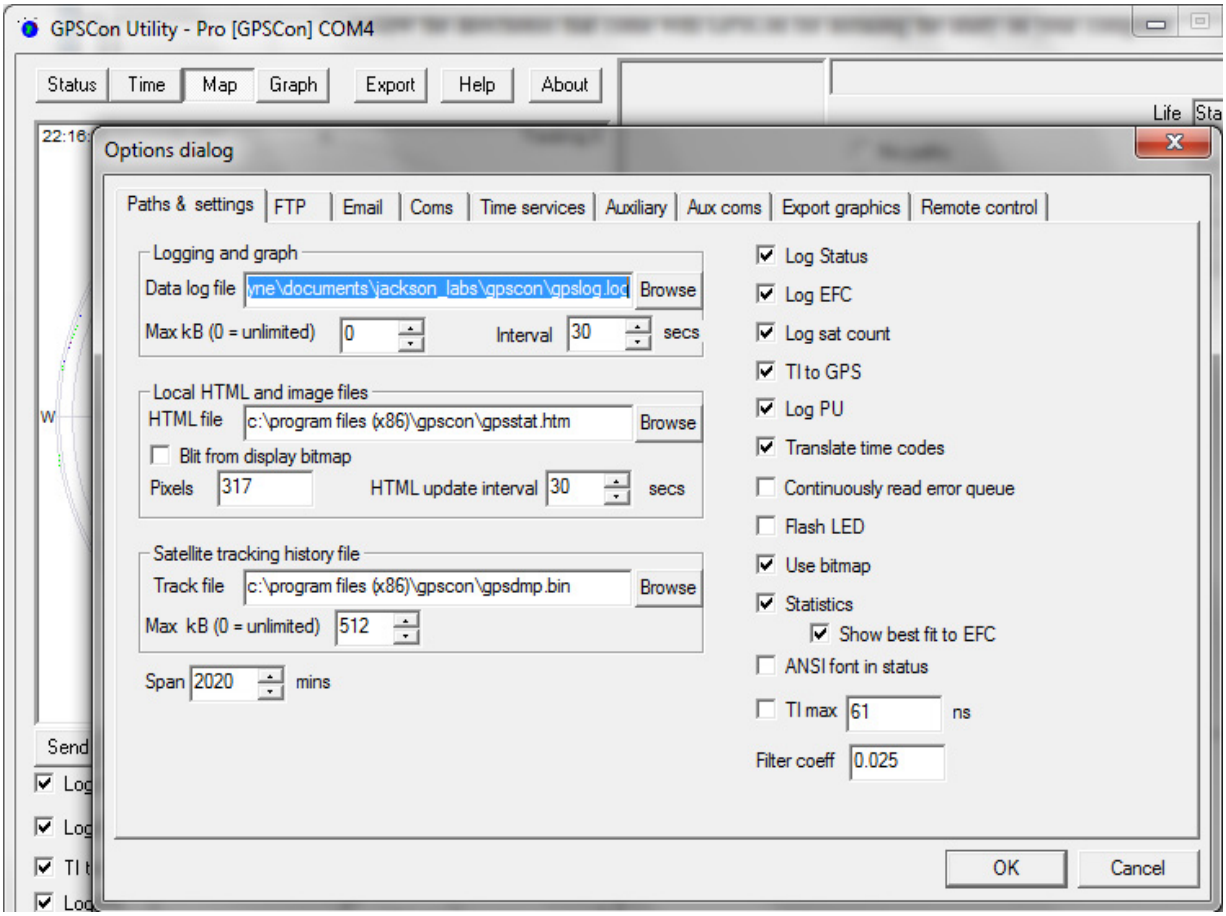
5.3 Using GPSCon

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

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 below will appear. Set options by selecting from the tabs.

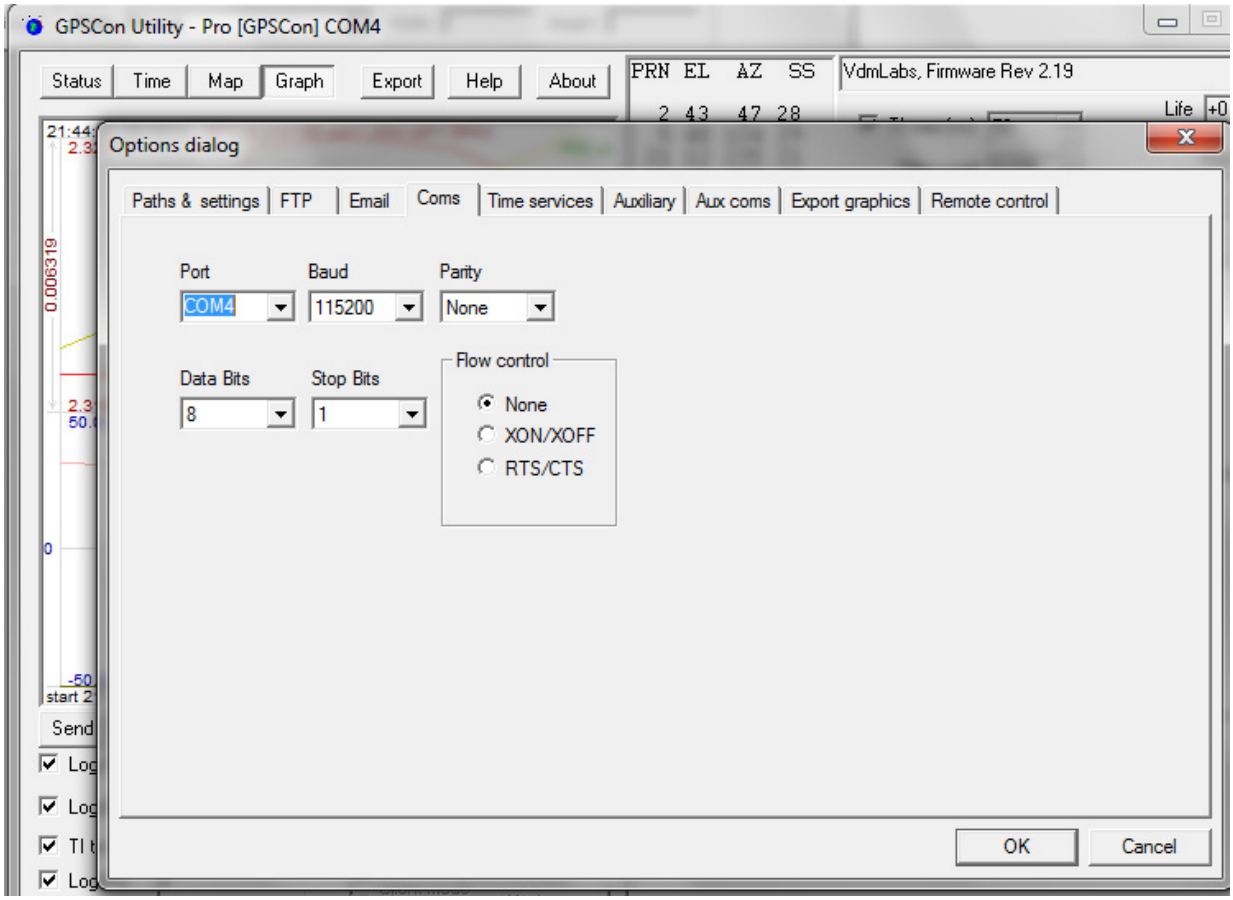
Figure: 5. 1 Options window



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 the following image. 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.

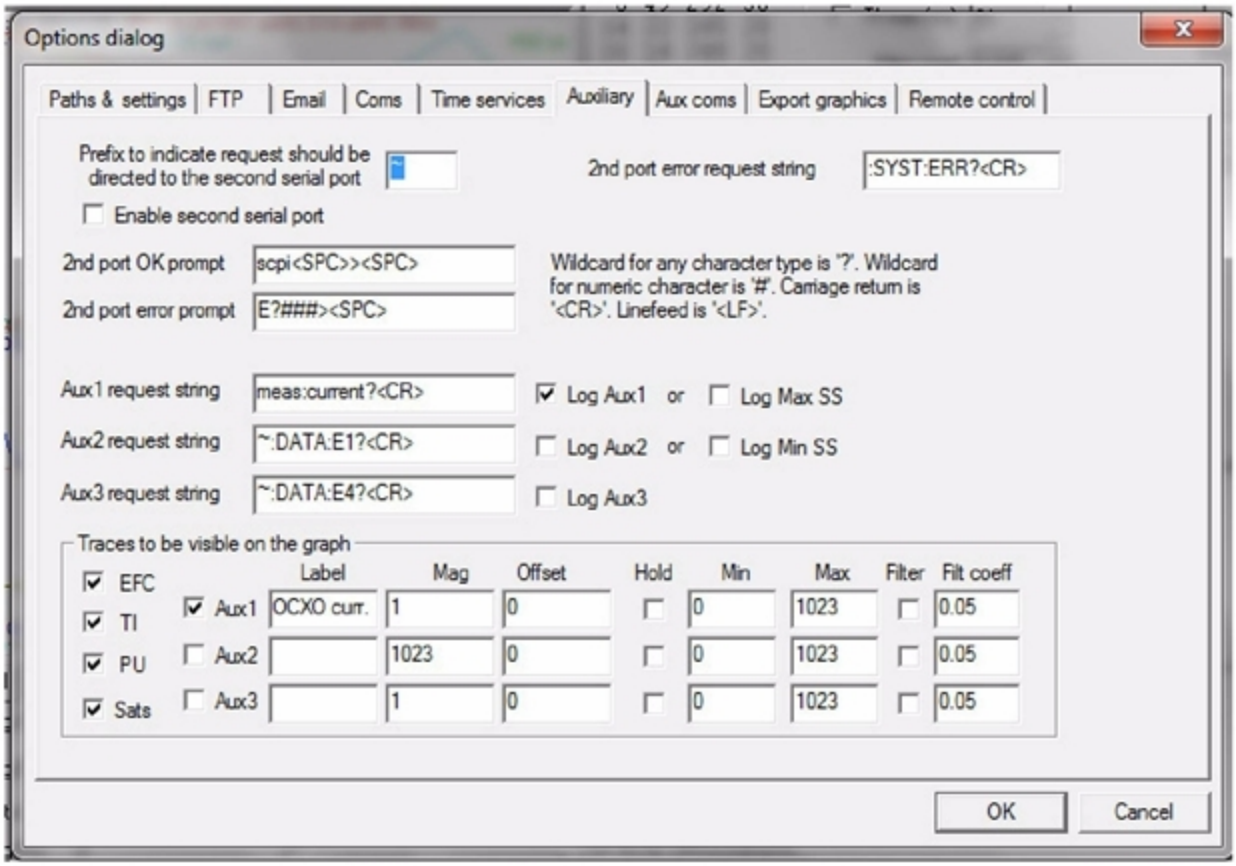
Figure: 5. 2 Setting the communications parameters



Auxiliary parameters

After pressing the “Options” button, you can select “Auxiliary” and set other options or measurements. See Auxiliary Parameters window below for an example of an auxiliary measurement. You will notice that the “Aux 1 request string” has been set to meas:current?<CD> 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 “OCXO curr” has been added.

Figure: 5. 3 Auxiliary Parameters window



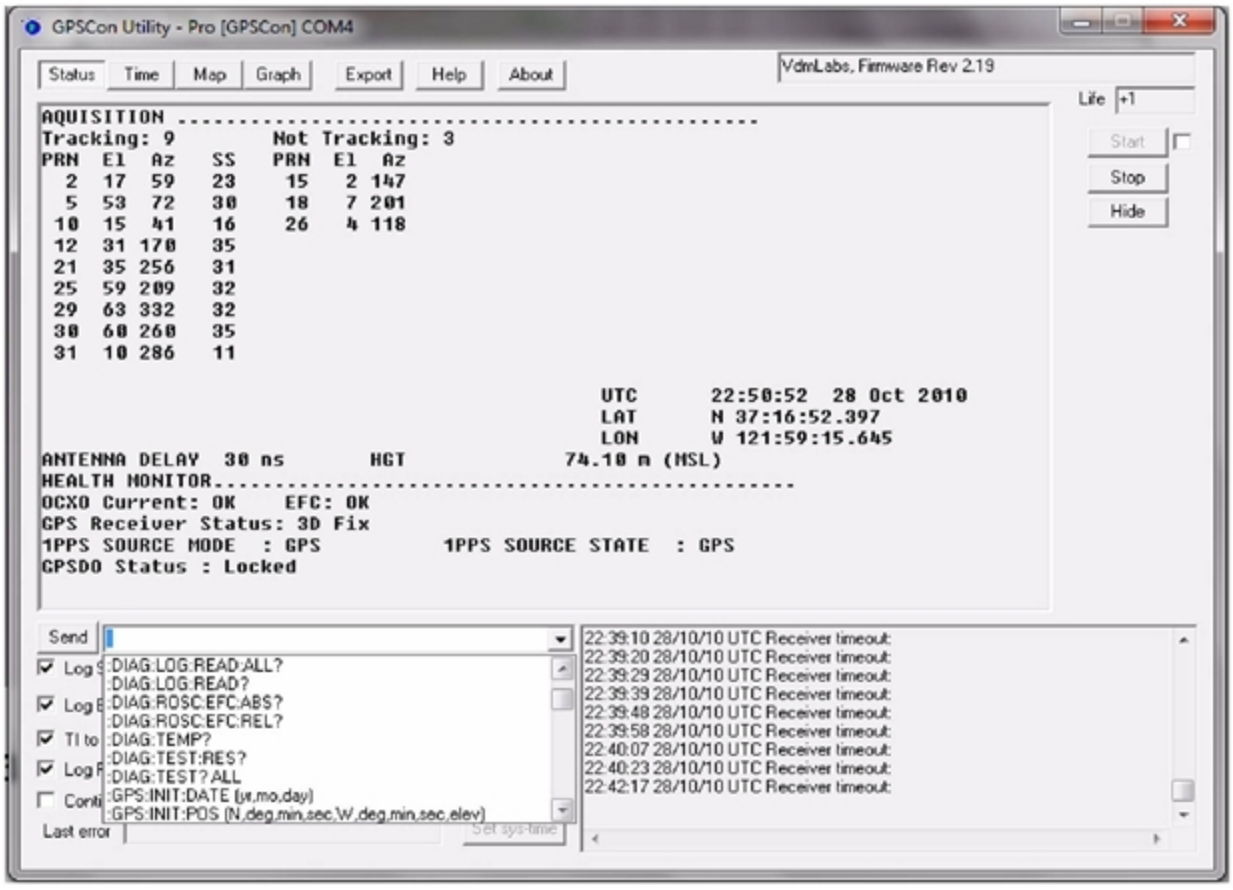
Other options

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.

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 the figure below. Care must be taken when sending these commands; so be sure that the command you select is supported by the GPS-1000 GPSDO. Once you've selected the command, press "Send" to send it to the GPS-1000.

Figure: 5. 4 Sending manual commands



5.3.3 Use of the mouse in graph mode

Refer to the following Graph display figure.
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 selected using the mouse.
Select the start time on the graph by left-clicking on the desired start point. The stop time may then be selected by right-clicking the desired stop point. This will zoom-in to the selected region of the graph, as shown in the following Expanded Graph display figure. The time span indication at the lower right of the graph will turn red to signify that mouse override is in effect.

When you have selected 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.

Note: these settings can later be deselected by left double-clicking anywhere on the graph. This then zooms-out, causing all captured data to be displayed.

In addition, 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.

Figure: 5. 5 Graph display

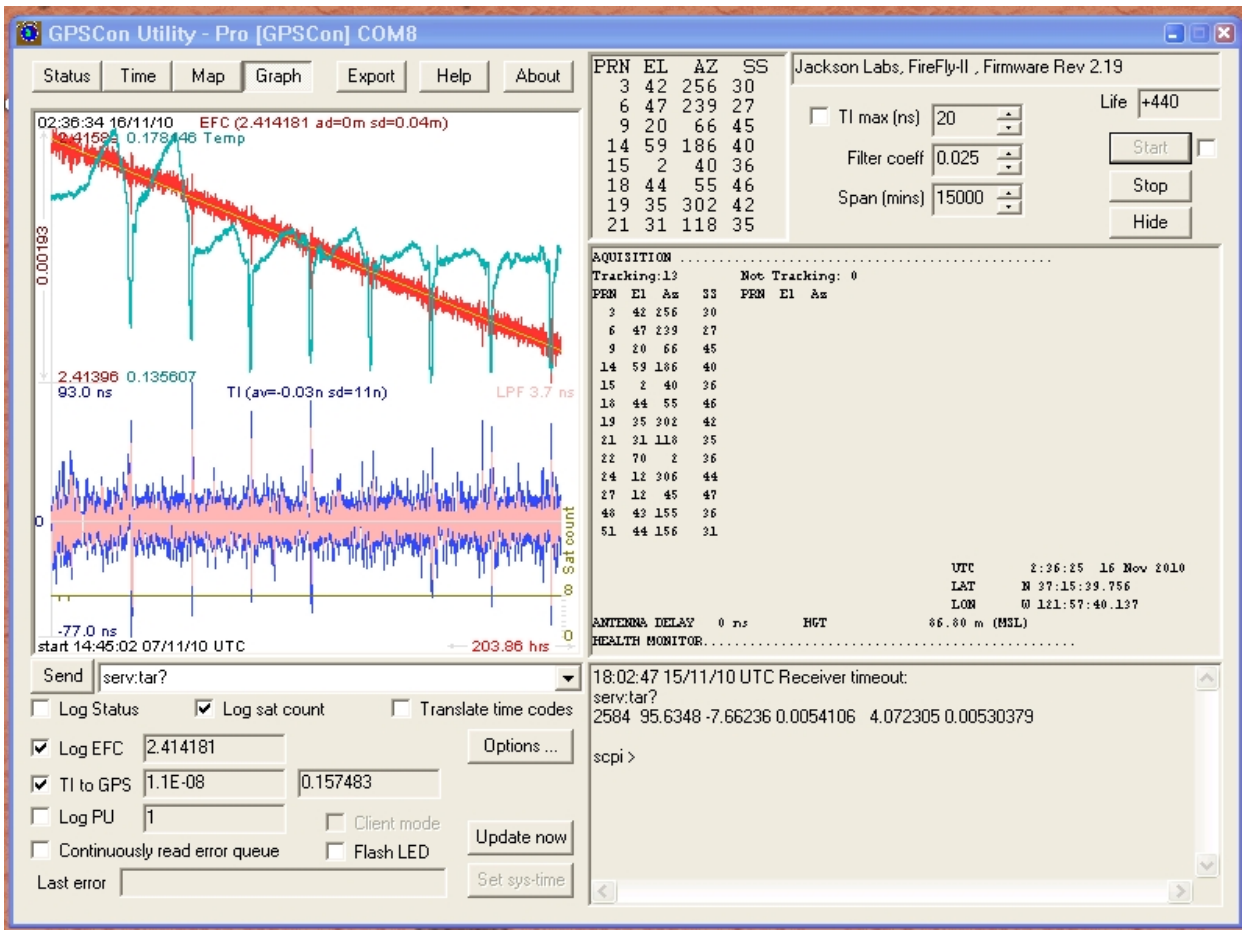
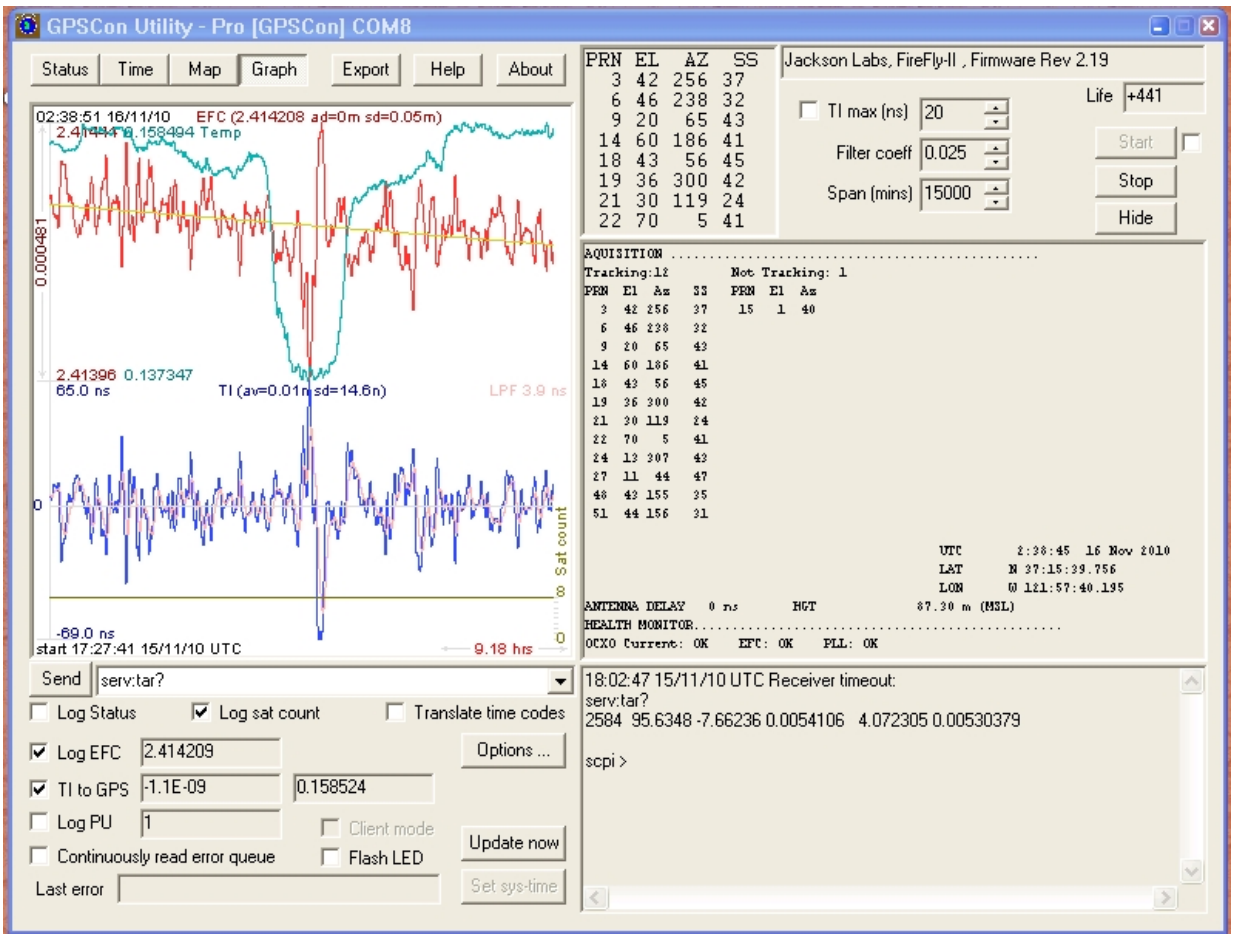


Figure: 5. 6 Expanded Graph Display



5.3.4 Exporting the graphics

The settings which 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. Select which one you want by 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.

5.4 Interpreting the Data

"Graph display" on page 35 shows the data acquired by the GPS-1000 unit over a period of more than 200 hours. The red trace is EFC (crystal frequency control voltage). The crystal is aging (becoming faster in frequency over time). This requires the control voltage to be lowered to maintain 10.0MHz exactly. A drift of ~2mV is visible over 200 hours. On the left side of the screen the EFC range over this 200 hour plot is displayed vertically as 0.00193V. This means the drift of the EFC voltage due to aging is ~88mV per year. The EFC sensitivity of the crystal is about 8Hz per volt, so the crystal ages at:
8Hz/V * 0.088V/Year = 0.704Hz/Year drift.

At 10MHz:
0.704Hz / 10MHz = 7.04E-08 aging rate per year.
This is the same as 0.2ppb drift due to aging per day.This crystal aging is fully compensated by the firmware, with and without GPS reception.

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

"Expanded Graph Display" on page 1 is a zoom of "Graph display" on page 35. In it we can see the phase offset error of the internal OCXO to the UTC GPS reference. We can also see the maximum drift is -77ns to +93ns. The average is (TI av=-0.03ns). The standard deviation over the 200 hour plot is sd=11ns. This means the average error of the 10MHz phase of this unit over 200 hours is only +/-11ns rms. Also, the average jitter (wander) over 200 hours of operation is 11ns / 200Hrs = 1.528E-014

The unit disciplines its internal 10MHz reference to within less than +/-80ns peak to peak of UTC at all times, which is less than one complete clock cycle at 10MHz.

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