

# **LN CSAC GPSDO User Manual**

---

# **LN CSAC GPSDO User Manual**

**Copyright © 2014, Jackson Labs Technologies, Inc.**

<b>1</b>	<b>Introduction</b>	<b>1</b>
1.1	Overview	1
1.2	Operating Principles	2
1.3	Dual Independent Microprocessor Controls	3
1.4	General Safety Precautions	4
1.4.1	Use an approved Antenna Lightning Protector	4
1.4.2	Grounding	4
1.4.3	Power Connections	4
1.4.4	Environmental Conditions	4
<b>2</b>	<b>Quick-Start Instructions</b>	<b>5</b>
2.1	Powering Up the Unit	5
2.2	Controlling the unit from a PC's USB port	5
2.3	Phase Noise and ADEV Post Filter RS-232 serial port	6
2.4	Major connections	7
2.4.1	Harness Pinning	8
2.4.2	Harness Connectors J1 and J3	10
2.4.3	Connecting the GPS Antenna	10
2.4.4	Connecting an LCD Display	10
2.4.4.1	LCD Key	12
2.4.4.2	LCD Display Pages	13
2.5	Loop parameter adjustment	17
2.6	Performance graphs	19
<b>3</b>	<b>SCPI-Control Quick Start Instructions</b>	<b>23</b>
3.1	Introduction	23
3.2	General SCPI Commands	23
3.2.1	*IDN?	24
3.2.2	HELP?	24
3.3	GPS Subsystem	24
3.3.1	GPS:SATellite:TRacking:COUNT?	25
3.3.2	GPS:SATellite:VISible:COUNT?	25
3.3.3	NMEA Support	25
3.3.4	GPS:PORT <RS232   USB>	25
3.3.5	GPS:PORT?	26
3.3.6	GPS:GPGGA	26
3.3.7	GPS:GGASat	26
3.3.8	GPS:GPRMC	26
3.3.9	GPS:GPZDA	26
3.3.10	GPS:GPGSV	27
3.3.11	GPS:PASHR	27
3.3.12	GPS:XYZSpeed	28
3.3.13	GPS:DYNAMic:MODE	28
3.3.14	GPS:DYNAMic:MODE 8 (Automatic Dynamic Mode)	30
3.3.15	GPS:DYNAMic:STATe?	31
3.3.16	GPS:REFerence:ADELay <float> <s   ns> [-32767ns,32767ns]	31
3.3.17	GPS:REFerence:PULse:SAWtooth?	31
3.3.18	GPS:RESET ONCE	31
3.3.19	GPS:TMODe <ON   OFF   RSTSURV>	32
3.3.20	GPS:SURVey ONCE	32

3.3.21	GPS:SURVey:DURation <sec>	32
3.3.22	GPS:SURVey:VARiance <mm^2>	32
3.3.23	GPS:HOLD:POSition <cm, cm, cm>	32
3.3.24	GPS:SURVey:STATus?	32
3.3.25	GPS:INITial:DATE <yyyy,mm,dd>	33
3.3.26	GPS:INITial:TIME <hour,min,sec>	33
3.3.27	GPS:JAMlevel?	33
3.3.28	GPS:FWver?	33
3.3.29	GPS?	33
3.4	GYRO SUBSYSTEM	33
3.4.1	GYRO:MODE <ON   OFF>	34
3.4.2	GYRO:TRACE <int> [0,255].	34
3.4.3	GYRO:PORT <RS232   USB>	34
3.4.4	GYRO:PORT?	34
3.4.5	GYRO:CAL <float,float,float,float,float,float>	35
3.4.6	GYRO:CAL:COMPUTE.	35
3.4.7	GYRO:SENS and GPS:CAL:RESET	35
3.4.8	GYRO:GLOAD?	35
3.5	PTIME Subsystem	35
3.5.1	PTIME:DATE?	36
3.5.2	PTIME:TIME?	36
3.5.3	PTIME:TIME:STRing?	36
3.5.4	PTIME:TINTerval?	36
3.5.5	PTIME:OUTput <ON   OFF>.	36
3.5.6	PTIME:LEAPsecond?	36
3.5.7	PTIME?	36
3.6	SYNChronization Subsystem	37
3.6.1	SYNChronization:HOLDoVer:DURation?	37
3.6.2	SYNChronization:HOLDoVer:INITiate	37
3.6.3	SYNChronization:HOLDoVer:RECOvery:INITiate	38
3.6.4	SYNChronization:SOURce:MODE	38
3.6.5	SYNChronization:SOURce:STATE?	38
3.6.6	SYNChronization:TINTerval?	38
3.6.7	SYNChronization:IMMEdiate.	38
3.6.8	SYNChronization:FEEstimate?	38
3.6.9	SYNChronization:LOCKed?	38
3.6.10	SYNChronization:OUTput:1PPs:RESET <ON   OFF>	39
3.6.11	SYNChronization:OUTput:1PPs:RESET?	39
3.6.12	SYNChronization:OUTput:FILTer <ON   OFF>	39
3.6.13	SYNChronization:OUTput:FILTer?	39
3.6.14	SYNChronization:HEALth?	39
3.6.15	SYNChronization:TINTerval:THREshold [50,2000]	40
3.6.16	SYNChronization?	40
3.7	DIAGnostic Subsystem	41
3.7.1	DIAGnostic:ROSCillator:EFControl:RELative?	41
3.7.2	DIAGnostic:ROSCillator:EFControl:ABSolute?	41
3.7.3	DIAGnostic:LIFetime:COUNt?	41
3.7.4	DIAGnostic?	41
3.8	MEASURE Subsystem	41
3.8.1	MEASure:TEMPerature?	41
3.8.2	MEASure:VOLTage?	42
3.8.3	MEASure:CURRent?	42

3.8.4	MEASure:POWersupply?	.42
3.8.5	MEASure?	.42
3.9	SYSTEM Subsystem	.42
3.9.1	SYSTem:COMMunicate:SERial:ECHO	.43
3.9.2	SYSTem:COMMunicate:SERial:PRompt	.43
3.9.2.1	SYSTem:COMMunicate:SERial:BAUD	.43
3.9.3	SYSTem:FACToryreset ONCE	.43
3.9.4	SYSTem:ID:SN?	.43
3.9.5	SYSTem:ID:HWrev?	.43
3.9.6	SYSTem:LCD:CONTRast [0,1.0]	.43
3.9.7	SYSTem:LCD:CONTRast?	.43
3.9.8	SYSTem:LCD:PAGE [0,8]	.43
3.9.9	SYSTem:LCD:PAGE?	.44
3.9.10	SYSTem:COMMunicate:USB:BAUD <9600   19200   38400   57600   115200>	.44
3.9.11	SYSTem:COMMunicate:USB:BAUD?	.44
3.9.12	SYSTem:STATus?	.44
3.10	SERVO Subsystem	.44
3.10.1	SERVo:DACGain	.45
3.10.2	SERVo:EFCScale	.45
3.10.3	SERVo:EFCDamping	.45
3.10.4	SERVo:TEMPCompensation	.45
3.10.5	SERVo:AGINGcompensation	.45
3.10.6	SERVo:PHASECOrrrection	.46
3.10.7	SERVo:1PPSoffset	.46
3.10.8	SERVo:TRACe	.46
3.10.9	SERVo?	.46
3.11	CSAC Subsystem	.47
3.11.1	CSAC:RS232?	.47
3.11.2	CSAC:STeer?	.47
3.11.3	CSAC:STATus?	.47
3.11.4	CSAC:ALarm?	.48
3.11.5	CSAC:MODE?	.49
3.11.6	CSAC:CONTRast?	.49
3.11.7	CSAC:LASer?	.49
3.11.8	CSAC:TCXO?	.49
3.11.9	CSAC:SIGnal?	.49
3.11.10	CSAC:HEATpackage?	.49
3.11.11	CSAC:TEMP?	.49
3.11.12	CSAC:FWrev?	.49
3.11.13	CSAC:SN?	.50
3.11.14	CSAC:LIFETIME?	.50
3.11.15	CSAC:STeer:LATch ONCE	.50
3.11.16	CSAC?	.50
<b>4</b>	<b>Firmware Upgrade Instructions</b>	<b>.51</b>
4.1	Introduction	.51
4.2	ISP Flash Loader Utility Installation	.51
4.3	Putting the PCB into In-Circuit Programming (ISP) mode	.51
4.4	Downloading the Firmware	.52
4.4.1	Using the Flash Magic Flash Programming Utility	.52
4.5	Verifying Firmware Update	.55

<b>5</b>	<b>GPSSCon Utility</b>	<b>57</b>
5.1	Description	57
5.2	Z38xx Utility.	57
5.3	GPSSCon Installation	57
5.4	Using GPSSCon	57
5.4.1	Setting the options.	58
5.4.1.1	Communication Parameters.	58
5.4.1.2	Auxiliary parameters.	58
5.4.1.3	Other options	60
5.4.2	Sending manual commands to the receiver	61
5.4.3	Use of the mouse in graph mode	61
5.4.4	Exporting the graphics	63
<b>6</b>	<b>Certification and Warranty</b>	<b>65</b>
6.1	Certification.	65
6.1.1	Warranty	65
6.1.2	Limitation of Warranty	65
6.1.3	Exclusive Remedies	66

# 1 Introduction

## 1.1 Overview

The LN CSAC GPSDO is based on the popular CSAC GPSDO and the FireFly-IIA GPSDO boards, combining both of these boards onto one single PCB. The LN CSAC GPSDO includes OCXO crystal circuitry to filter phase noise and significantly improve Allan Deviation (ADEV) performance of the CSAC oscillator. The LN CSAC GPSDO combines the very fast warmup and ultra high frequency accuracy of the standard JLT CSAC GPSDO with the very low phase noise and ultra high Allan Deviation (ADEV) performance of the JLT FireFly-IIA board onto one single fully integrated PCB.

The LN CSAC GPSDO is a game-changing, disruptive technology culminating from decades of research sponsored by the U.S. Government. It is a breakthrough technology that allows a Cesium Vapor Cell Atomic Reference Oscillator to be packaged in a unit several orders of magnitudes smaller than legacy products, with more than an order of magnitude in power reduction, and less than 2 minutes warm-up on the CSAC oscillator to be operational, while out-performing many industry-standard Atomic Oscillators. The unit is available with a temperature range of  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$  and greater than 100,000 hours MTBF.

To improve phase noise and ADEV performance over the standard CSAC GPSDO, the LN CSAC uses an SC-cut single or double oven OCXO as a microprocessor-controlled 10MHz post-filter. The post filter is phase-locked to the raw CSAC oscillator output with a very long time constant (very small bandwidth, in the order of 0.01Hz or less). This assures that the phase noise, and ADEV performance below 100s of the CSAC oscillator is generated and defined by the SC-cut crystal, rather than the low-cost TCXO built into the CSAC oscillator itself. This allows for long-term Cesium stability, with excellent short term stability and phase noise, approaching up to 30dB in noise improvement at 1Hz to 10Hz offsets from the carrier. ADEV at 1s is improved by an order of magnitude or more with this setup.

The LN CSAC GPSDO provides an impressive frequency accuracy, long-term stability, and fast lock with low power consumption. By using a high-end SC-cut crystal oscillator filter, the Jackson Labs Technologies, Inc. LN CSAC GPSDO improves the phase noise and ADEV performance of the unit, and adds an isolated distribution amplifier with four output channels at 10MHz. The LN CSAC GPSDO provides LCD, RS-232 and USB serial links for command and control.

For long term Stratum-1 frequency accuracy and constant calibration the LN CSAC 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  $-160\text{dBm}$ , a 32-bit processor that runs a Real Time OS, a low-noise 10MHz

distribution amplifier with four highly Isolated 10MHz Sine Wave outputs, one 5MHz CMOS output, one 1PPS UTC synchronized CMOS output, RS-232 and USB control interfaces, and a generic LCD interface. The LN CSAC GPSDO also includes a high-performance time-interval-counter that can measure the internally generated 1PPS signal from the GPS receiver or an externally supplied 1PPS reference signal with a resolution of 20 picoseconds. The LN CSAC oscillator is phase-locked to either of these two 1PPS signals with better than 0.3ns average phase accuracy typically. Software compensation measures residual aging, thermal, and g-sensitivity errors of the LN CSAC oscillator, and applies electronic compensation to reduce these residual errors. This error compensation can improve performance especially in GPS-denied environments, and allows monitoring of the LN CSAC health and detection of performance abnormalities in the system.

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

## 1.2 Operating Principles

A Cesium Vapor Cell is excited from a VCEL Laser source. The VCSEL is modulated at 4.6 GHz to produce a complementary pair of sidebands separated by the cesium ground state hyperfine frequency of 9.2 GHz. As Cesium supply depletion is not a lifetime limiting factor in the LN CSAC, the LN CSAC GPSDO implementation allows operational lifetimes that potentially exceed those of Cesium beam standards by far.

The Hyperfine transition frequency of the Cesium Vapor cell is affected by adverse environmental influences, and long-term frequency and phase errors are thus present in the LN CSAC. To calibrate these errors out and achieve phase-lock to USNO UTC, the LN CSAC GPSDO uses a GPS receiver to generate a highly accurate, though unstable 1PPS signal, and this 1PPS signal is compared with a 1PPS signal generated by the CSAC 10MHz VCXO. The VCEL is digitally tuned to shift the frequency up or down slightly and very slowly to keep the CSAC 1PPS reference in phase-lock with the GPS generated 1PPS signal. This allows a very close tracking of the U.S. USNO 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. With this software PLL system the short-term instability of the GPS receiver is filtered by the CSAC, while the CSAC's long-term drift is removed by the GPS receiver, resulting in both a very good short-term as well as USNO phase-locked long-term performance.

The 10MHz VCXO used in the CSAC oscillator exhibits phase noise and numerous spurs on the output of the CSAC. A microprocessor-controlled cleanup loop filter based on the JLT FireFly-IIA technology uses the 10MHz output of the CSAC VCXO, and steers a high-end SC-cut crystal oscillator with extremely low phase noise and ultra-high ADEV performance. This digital PLL loop has a time constant of more than 100s, and thus any phase noise and ADEV noise generated by the CSAC oscillator itself below 100s is filtered-out by the SC-cut post-filter. This allows close-in phase noise performance of -100dBc/Hz or better at 1Hz offset, a noise floor of -160dBc/Hz or better, and ADEV performance of  $2E-012$  from 0.1s to 10s on the highest-performance OCXO options. Three filtered 10MHz output are available, as well as one raw CSAC-generated 10MHz output is made available. The raw CSAC 10MHz output can be used for applications requiring the fastest frequency performance after power-on (120s lock after power-on to much better than 1ppb frequency accuracy) while the three filtered outputs take longer to stabilize as they are produced by an ovenized crystal oscillator that takes longer to stabilize than the CSAC VCXO itself. A customer's application may



use the raw 10MHz output initially after power-on to achieve the best frequency accuracy possible, then switch to the filtered 10MHz output once the ovenized crystal oscillator stabilizes to within customer-defined requirements. The FireFly-IIA software of the OCXO crystal post filter constantly measures the aging and temperature coefficients of the SC-cut crystal oscillator, and compensates for crystal aging and crystal tempo to improve ADEV performance within the loop bandwidth, and initial lock time after power on.

## 1.3 Dual Independent Microprocessor Controls

The LN CSAC GPSDO is conceptually a combination of the CSAC GPSDO board, connected together with the FireFly-IIA Disciplined oscillator board onto one single PCB. The GPS receiver used on the FireFly-IIA board is removed, and replaced by the CSAC oscillator signal. Dual processors allow independent status query and control of loop parameters and setup functions of both the CSAC oscillator, and the on-board filter OCXO. Thus the LN CSAC board is really a combination of the LN CSAC GPSDO and the FireFly-IIA board both built into one single fully integrated PCB.

The FireFly-IIA part of the board is connected to the CSAC GPSDO side of the board with only three electrical connections:

- 1) Shared +12V Power supply
- 2) 10MHz from the CSAC drives the FireFly-IIA 1PPS reference input
- 3) LOCK\_OK Status of the FireFly-IIA OCXO informs the LN CSAC GPSDO of OCXO status

The CSAC oscillator thus provides 10MHz to the FireFly-IIA circuitry on the PCB as a reference to discipline the internal OCXO to. This 10MHz is divided in an FPLD by  $10E+06$  to generate a local 1PPS signal, which is then fed into the FireFly-IIA time capture circuitry in lieu of the GPS receiver 1PPS signal. Thus the FireFly-IIA circuitry phase-locks the OCXO to the CSAC-generated 10MHz signal just as it would normally lock the OCXO to the GPS receiver generated USNO 10MHz reference.

The CSAC oscillator in turn is locked to the on-board GPS generated 1PPS signal, and is thus long-term phase-disciplined to the 10MHz USNO master reference oscillator. The result of this cascaded phase lock system is extremely good short- as well as long-term stability, and at the same time extremely good frequency accuracy and stability even in GPS-denied applications by using an internal Cesium Atomic reference.

The frequency accuracy, phase noise, ADEV, and warmup performance of the LN CSAC is competitive to, and in many cases exceeds the performance of the highest performance commercial Cesium Frequency References available on the market today at price points, size, weight, and power consumption (SWAP) being typically an order of magnitude lower than these commercially available high-end Cesium Standards.

The FireFly-IIA side of the board provides a LOCK\_OK signal (and corresponding Green LOCK OK LED) to the CSAC processor side, and the user may query the lock status of the OCXO through the CSAC-side serial port. The OCXO lock status is indicated in the CSAC Health status query as health item 0x1000 (see the description of the SYNC:HEALTH? status command). The unit will only indicate a fully locked and healthy status (SYNC:HEALTH == 0x0) if both the CSAC and the SC-cut OCXO are deemed locked by their respective control microprocessors.

Three serial control ports are available on the LN CSAC board: two CSAC GPSDO ports (RS-232 and USB) and one FireFly-IIA RS-232 control port. The FireFly-IIA control port is usually used to configure the OCXO loop bandwidth and warmup parameters, to download firmware into the FireFly-IIA microcontroller, and/or query the status of the OCXO phase locked loop inside the FireFly-IIA system. Most user applications will only use the CSAC GPSDO side serial interfaces as the LOCK OK status of the FireFly-IIA side of the board is available on the LN CSAC GPSDO microprocessor interface as well by using the `sync:health?` command.

## 1.4 General Safety Precautions

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

### 1.4.1 Use an approved Antenna Lightning Protector

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

### 1.4.2 Grounding

To avoid damaging the sensitive electronic components in the LN CSAC GPSDO 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.

### 1.4.3 Power Connections

Make sure to connect the DC power to the device following the polarity indicated in Section [2.4](#).

### 1.4.4 Environmental Conditions

This instrument is intended for indoor use. The use of a properly installed GPS 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.

# 2 Quick-Start Instructions

## 2.1 Powering Up the Unit

The LN CSAC GPSDO may be powered from an external 11.0V to 14.0V (12V nominal) DC source. Initial power consumption during OCXO warmup can approach 10W, while steady-state power consumption at 25C ambient is typically <4.5W.

The internal USB port provides a convenient way to establish serial communications to the unit via a standard USB serial link, while the standard RS-232 interface allows legacy SCPI and NMEA applications.

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?  
help?
```

## 2.2 Controlling the unit from a PC's USB port

- 1) Connect a 5V-compatible GPS antenna to connector J4.
- 2) Connect a suitable 12V, 1A low-noise DC power supply to power connector J1.
- 3) Plug in a standard USB cable to USB connector U14. Plug the other end into a standard USB computer connector.

**WARNING: PLEASE MAKE SURE NOT TO CONFUSE POWER CONNECTOR J1 AND LCD CONNECTOR J3 AS THESE TWO CONNECTORS ARE**

**MECHANICALLY IDENTICAL AND ARE THUS EASY TO CONFUSE.  
APPLYING POWER TO LCD CONNECTOR J3 WILL SEVERELY DAMAGE THE  
BOARD**

No software driver is typically required when operating under Windows XP/7/8 or later as Windows has the required USB driver already built-in. The board uses an industry-standard FTDI USB to serial controller, and drivers may be downloaded from the FTDI website if necessary. Once installed, the unit should simply show up as a new Serial Comm Port, and the operator may use Hyperterminal, TeraTerm Pro, 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. This software is available at:

<http://www.realhamradio.com/gpscon-info.htm>

JLT also provides a freeware control program called Z38xx and this application program can be downloaded from the following website:

[www.jackson-labs.com/index.php/support](http://www.jackson-labs.com/index.php/support)

The RS-232 serial port on connector J1 operates in parallel to the USB serial port, and commands can be sent and queried independently to and from both connectors. English language SCPI (GPIB) 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, so user applications can use one of the two serial ports for NMEA pushed output sentences, and the other port for SCPI control commands for example.

The unit will now lock to GPS (Red LED D6 is blinking when satellites are being received) and will indicate proper lock of both the CSAC oscillator AND the on-board OCXO when the Green LED D6 goes on. Once the green LED D6 is on, the unit will output 10MHz and 5MHz on the outputs with significantly better than 1ppb frequency accuracy.

The FireFly-IIA side of the board uses LED D26 to indicate status. The Red LED D26 will start blinking with a 1/2Hz heartbeat as soon as power is turned-on to indicate that the CSAC-generated 10MHz signal is properly being utilized to discipline the on-board OCXO to the CSAC. Once the OCXO is fully warmed-up and disciplined to the CSAC oscillator, LED D26 will start to light up Green while continuing to blink Red.

Please note that LED D6 will not light up green as long as the OCXO lock indicator LED D26 is not lit up. LED D6 indicates system status of both the CSAC oscillator and the OCXO, and both need to be locked and healthy to indicate properly on Green LED D6.

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

## **2.3 Phase Noise and ADEV Post Filter RS-232 serial port**

The FireFly-IIA side of the LN CSAC GPSDO has its own independent RS-232 connector J6 which is typically only used for debugging and experimentation. The FireFly-IIA RS-232 serial port J6 may be used to query the health and status of the on-board OCXO and disciplining phase locked loop. It may also be used to set the loop control parameters of the FireFly-IIA OCXO section of the LN CSAC GPSDO. Please refer to the FireFly-IIA user manual for a description of the command and control sentences available on connector J6, taking into account that the FireFly-IIA side of the board does not contain a GPS receiver, and thus all FireFly-IIA GPS receiver related commands are inactive on connector J6.

In a typical user application, the LN CSAC GPSDO control ports on connectors J1 and U14 are the only serial ports used, and the status of the FireFly-IIA side of the LN CSAC GPSDO board can be queried by using the sync:health? command on connectors J1 and U14.

## 2.4 Major connections

The major connections and features of the LN CSAC GPSDO PCB are shown in Figure 2.1.

**Figure 2.1 Major connections and features of the LN CSAC GPSDO**

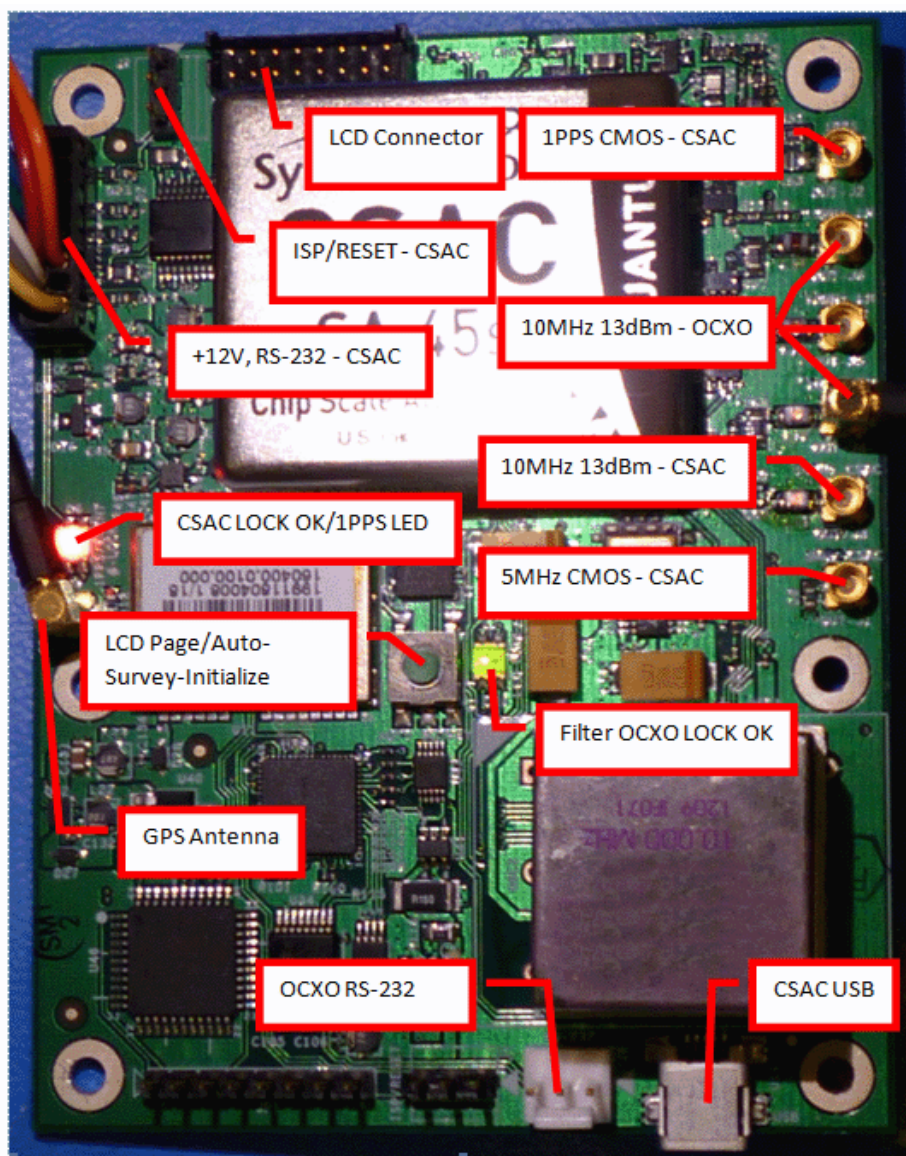


Table 2.1 shows the functions supported on connector J1

**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	Indicates that no internal events are pending, the hardware is ok, the CSAC is locked to GPS, and the OCXO is locked to the CSAC oscillator.	3.3V CMOS output can drive up to 5mA, series-terminated by 33 Ohms
J1-8	RX_232	RS-232 receive data	RS-232 level
J1-9	TX_232	RS-232 transmit data	RS-232 level
J1-10	GPS_RS232	Raw NMEA output from GPS receiver in RS-232 level format.	RS-232 level
J1-11	PPS_IN	External alternate 1PPS input	TTL, 3.3V and 5V CMOS compatible
J1-13	ALARM	Wired in parallel to the Red LED, blinks at 0.5Hz whenever a 1PPS pulse is received.	3.3V CMOS level can drive up to 5mA, series-terminated by 33 Ohms

## 2.4.1 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_OUT_OK
8	RX RS-232
9	TX RS-232
10	GPS_RS232
11	PPS_IN
12	GND
13	ALARM
14	GND
15	+12V
16	+12V

**Table 2.3 Miscellaneous connectors**

Ref	Name	Function	Specification	Pinning
J2	ISP/RESET	ISP/RESET jumper	GND pin 1 or 3 to activate	J2-1:ISP; J2-2:GND; J2-3:RST#
J4	Antenna	GPS Antenna	5V Amplified Antenna, MMCX connector	Center:RF Input; Shield: GND
OUT_J1	5MHz OUT	5MHz output	5V CMOS	Center:RF output; Shield: GND
OUT_J2	1PPS OUT	1pps output	5V CMOS	Center:RF output; Shield: GND
OUT_J3-J6	10MHz OUT	10MHz output	Sine wave, +13dBm (+/3dBm) <b>N.B.: OUT-J3 is generated by the CSAC oscillator itself, while OUT-J4/J5/J6 are generated by the Noise-Filter SC-cut Crystal OCXO</b>	Center:RF output; Shield: GND
J6	OCXO RS-232	Serial Port of FireFly-IIA OCXO section of board	RS-232 levels	J6-1: TX, J6-2: GND, J6-3: RX
J7	OCXO ISP	ISP/LOCK OK of FireFly-IIA section of board	OCXO LOCK OK: 3.3V 5mA ISP: GND pin 2 to pin 1 to during power-on to put FireFly-IIA section of board into ISP mode	J7-1: GND, J7-2: ISP, J7-3: OCXO LOCK OK

## 2.4.2 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 part number of the connectors soldered onto the LN CSAC GPSDO PCB is:

Hirose DF11-16DP-2DSA01

## 2.4.3 Connecting the GPS Antenna

Connect the GPS antenna to connector J4 using the BNC to MMCX cable adapter. Caution: use a Lightning Arrestor on your Antenna setup. Use an amplified GPS antenna that is 5V compatible. The LN CSAC GPSDO GPS receiver is a 50 channel high-sensitivity GPS 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-challenged antenna locations such as under foliage or with strong multipath signals.

The LN CSAC GPSDO is capable of generating standard navigation messages (see GPS:GPGGA, GPS:GPZDA, GPS:GPGSV, GPS:PASHR, and GPS:GPRMC serial commands) that are compatible with most GPS based navigation software. These navigation messages may either be sent to the RS-232 serial port or to the USB serial port.

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 LN CSAC GPSDO to UTC, thus disciplining the unit's Atomic Clock 10MHz frequency output to the US Naval master clock for very high frequency accuracy (typically better than 10 digits of frequency accuracy when locked to GPS). Using a high-performance Timing GPS receiver allows operation with a phase stability error of typically less than +/-15 nanoseconds anywhere in the world.

## 2.4.4 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](http://www.mouser.com):

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

The connector drives the LCD directly, and the 5V pin can also be used to drive the LCD's backlighting. Contrast of the LCD is adjusted via software command.

**Figure 2.2** shows the mechanical connections. A schematic showing the connections from the LN CSAC GPSDO to the LCD panel is shown in **Figure 2.3**



Figure 2.2 LCD display connection

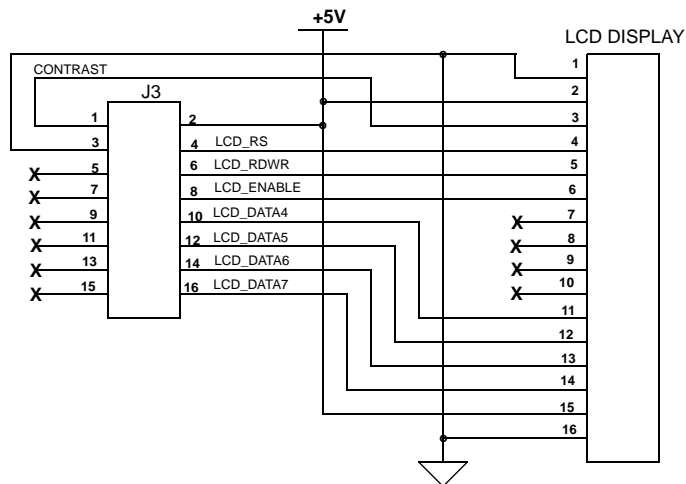


Table 2.4 LCD connector J3 pinout

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 2.3 LCD display connections**



The Power and Ground symbols in **Figure 2.3** are for reference only. 5V Power on connector J3 is available to drive the LCD display and its backlight only.

### 2.4.4.1 LCD Key

The LCD Key is activated by pressing S1 on the PCB (see **Figure 2.1**), or by grounding J1 pin 5. Momentarily activating the key cycles through the LCD display pages described in Section **2.4.4.2**.

The LCD page can also be selected with the SYSTem:LCD:PAGE SCPI command. The last page displayed is remembered in NVRAM, and will be shown upon power up.

Activating the key for 8 seconds initiates the Auto-Survey and starting with firmware version 0.71, switches the LCD to the Survey status display page. The Auto-Survey can also be initiated with the GPS:SURVey ONCE SCPI command.

## 2.4.4.2 LCD Display Pages

Following are the LCD display pages:

- **Time/Date:** (Figure 2.4) This page shows the time, date, number of tracked Satellites, and the lock status (PH = Position Hold mode)

Figure 2.4 Time/Date display page



- **GPS Position:** (Figure 2.5) This page shows the GPS coordinates of the antenna position

Figure 2.5 GPS position display page



- **GPS Height:** (Figure 2.6) This page shows the height in MSL of the GPS antenna, as well as the operating mode (HOLD Position Hold mode)

**Figure 2.6 GPS height display page**

- **CSAC Steering:** (Figure 2.7) This page shows the internal ALARM indication of the CSAC oscillator itself. 0x0 indicates normal operation. Also shows the CSAC Oscillator steering offset required to maintain UTC lock, which is normalized to 1E-012 offsets. The CSAC steering offset is programmed into the CSAC oscillator NVRAM once every 24 hours, at which point the offset is set to "0" again. This allows the CSAC oscillator to power-on with the last internal offset stored in NVRAM, effectively storing the calibration parameter inside the CSAC oscillator once per day.

**Figure 2.7 CSAC steering display page**

- **CSAC Status:** (Figure 2.8) This page displays the following Cesium Vapor Cell status: Laser Current (LI), Cell Temperature (in ° C), and TCXO Steering Voltage (0V to 3.3V). The TCXO is locked to the Cesium Vapor Cell via a Phase Locked Loop, and generates the 10MHz output frequency.

Figure 2.8 CSAC status display page



- **TINT:** (Figure 2.9) TINT is the time interval offset between the internal CSAC oscillator phase, and UTC as generated by the GPS receiver. It is displayed in nanoseconds. The PLL control loop will try to zero this offset over time as the unit follows UTC at NIST in Colorado via the Satellite transmissions. FEE indicates the Frequency Error Estimate, which is a unit-less number, and is estimated by comparing the UTC phase offset from 1000 seconds ago to the present phase offset. This is similar to the Allan Deviation number for a measurement interval of 1000 seconds. Smaller numbers are better, but numbers below  $1E-12$  are below the noise floor of the instrument. A number of  $4E-12$  for example can be loosely interpreted to be a phase drift of the 10MHz and 1PPS outputs of 4 picoseconds per second averaged over 1000 seconds as compared to the UTC master clock at NIST in Colorado.

Figure 2.9 TINT display page



**Navigation:** (Figure 2.10) This page displays the following Navigation status: Course (in degrees), Speed (knots), operating mode, and altitude (feet).

**Figure 2.10 Navigation display page**



**GPS/UTC Time:** (Figure 2.11) This page displays the following UTC/GPS Time information: UTC time (hh:mm:ss), GPS time (hh:mm:ss) and leapsecond offset (seconds).

**Figure 2.11 GPS/UTC Time display page**



**Survey status:** ( ) This page displays the status (NOT ACTIVE, ACTIVE or VALID), duration (seconds) and variance (mm<sup>2</sup>) of the position survey.

**Survey status display page**



## 2.5 Loop parameter adjustment

All loop parameters can be controlled via the serial ports.

Loop parameters are optimized for the Atomic Oscillator on the board, and changing the factory settings may cause the unit's performance to deteriorate.

The commands to control the loop parameters are part of the servo? command. See also the **SERVO Subsystem** section below.

The individual commands are:

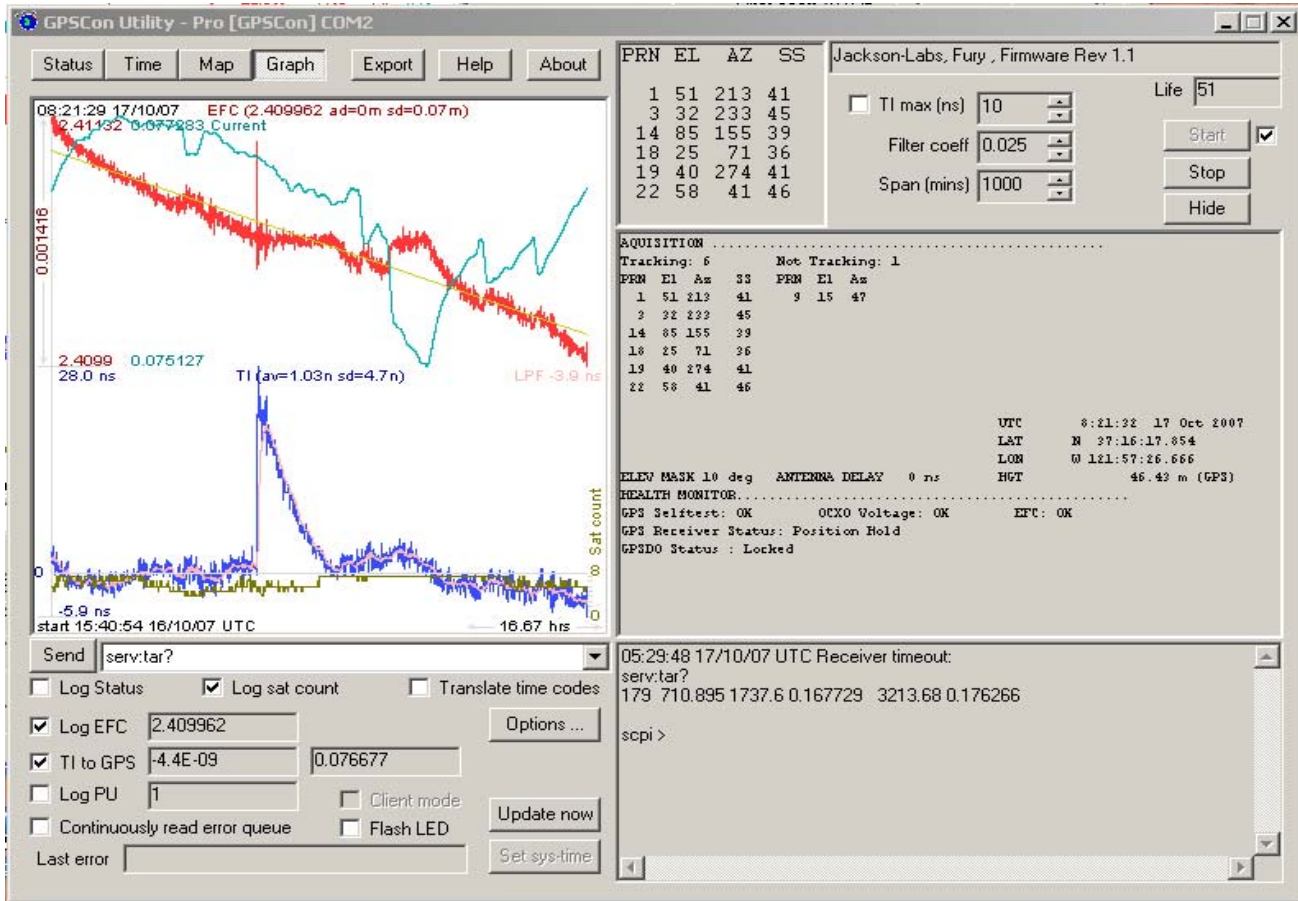
**EFC Scale:** this is the proportional gain of the PID loop. Higher values will give quicker convergence, and faster locking of the GPS time (lower loop time constant), lower values give less noise. Values between 0.7 and 6.0 are typical.

**EFC Damping:** overall IIR filter time constant. higher values increase loop time constant. Jackson Labs Technologies, Inc. typically uses values between 10 to 50. Setting this value too high may cause loop instability.

**Phase compensation:** this is the Integral part of the PID loop. This corrects phase offsets between the LN CSAC GPSDO 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. Typical values range from 4 - 30. Setting this value too high may cause loop instability.

A well-compensated unit will show performance similar to the plot in [Figure 2.12](#) when experiencing small perturbations.

Figure 2.12 LN CSAC GPSDO phase compensation plot





## 2.6 Performance graphs

Figure 2.13 shows the typical Allan Deviation of the LN CSAC GPSDO with single oven OCXO in a thermally stable environment. Long-term GPS-locked ADEV performance approaches 1E-013 per day.

Figure 2.13 Typical Allan Deviation of LN CSAC with single oven OCXO option

15 Nov 2012 11:18:07  
17h 4m

Symmetric5125A

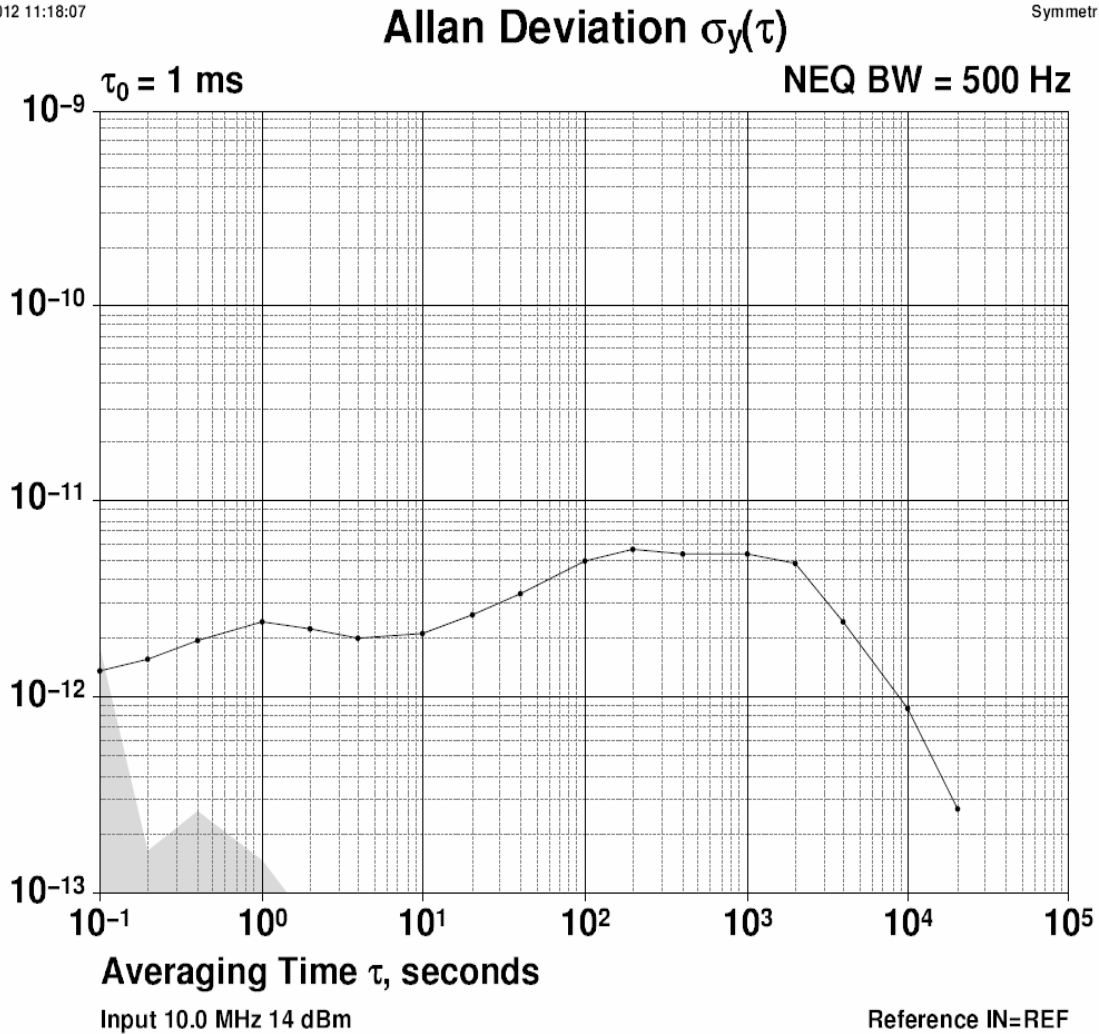
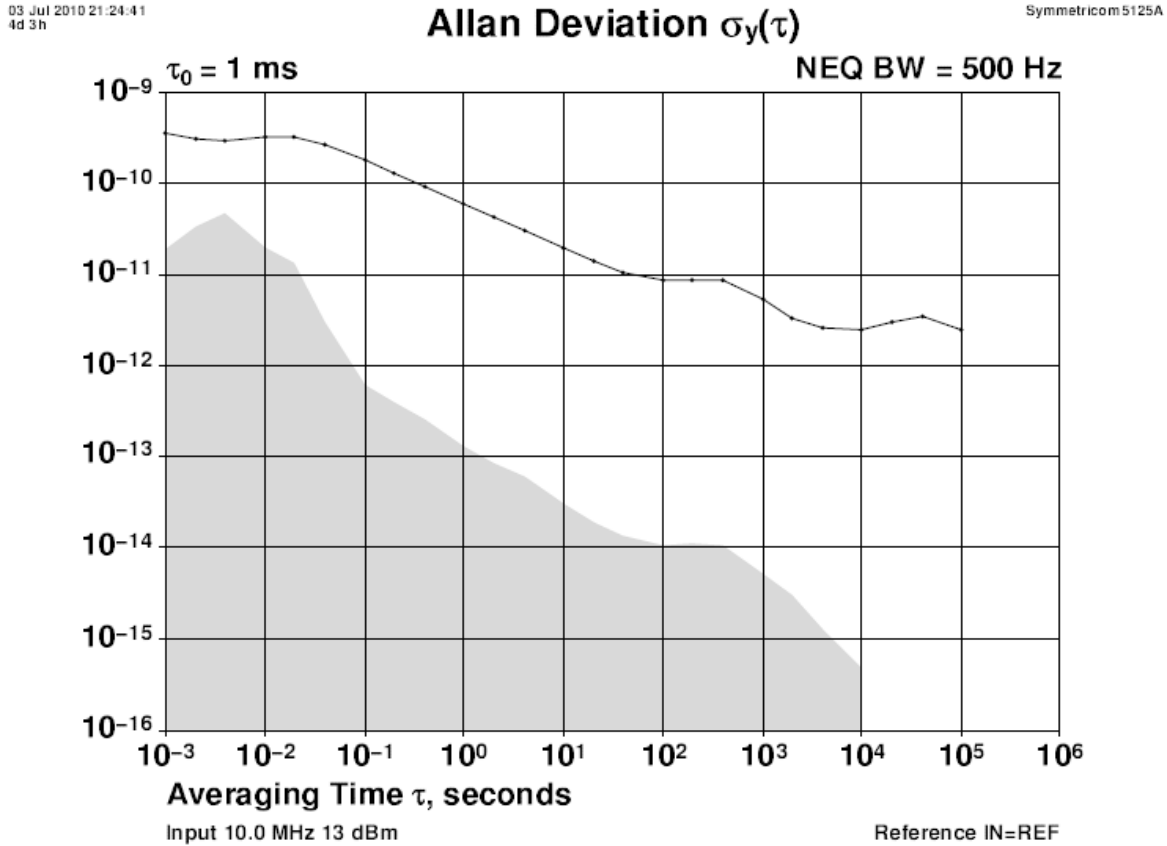


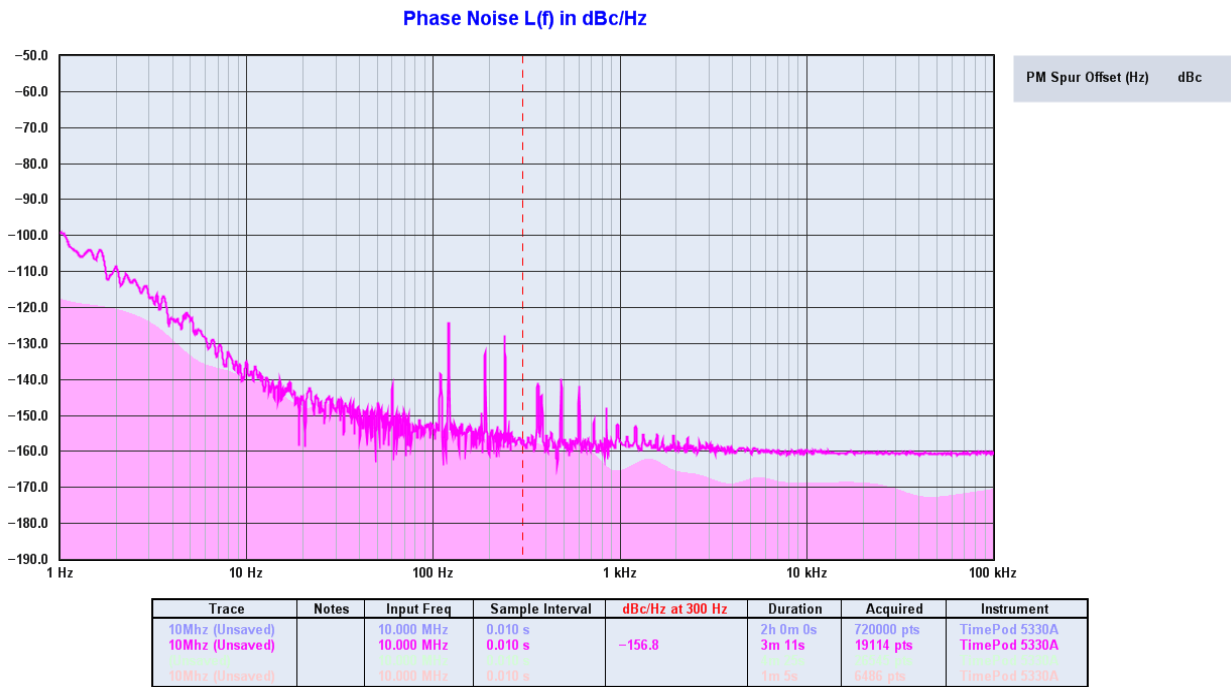
Figure 2.14 shows that the Allan Deviation of the free running CSAC unit bypassing the OCXO ADEV filter (GPS holdover, no GPS antenna is attached) is quite good, approaching  $5E-012$  over 100,000 seconds in this typical plot. Notice the increased short term stability noise below 1000s averaging intervals as this 10MHz output bypasses the OCXO ADEV filter.

Figure 2.14 Allan Deviation of free running CSAC, measured at CSAC 10MHz output



As shown in **Figure 2.15**, the Phase Noise of a typical LN CSAC GPSDO unit shows a noise floor of about  $-160\text{dBc/Hz}$ , with few spurs, most of which are 60Hz power supply related.

**Figure 2.15 Typical Phase Noise of the LN CSAC GPSDO with DOCXO option**





# 3 SCPI-Control Quick Start Instructions

## 3.1 Introduction

The LN CSAC GPSDO has three serial ports that can be used simultaneously for accessing the SCPI (Standard Commands for Programmable Instrumentation) subsystem by using a host system terminal program such as TeraTerm or Hyperterminal. By default the terminal settings are 115200, 8N1.

Two of these serial ports (J1, U14) are connected to the CSAC GPSDO microprocessor, and the third RS-232 serial port (J6) is connected to the internal FireFly-IIA microprocessor.

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 LN CSAC 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.

As a Quick-Start, the user may want to try sending the following commands to one of the serial interfaces:

**syst:stat?**

**help?**

**gps?**

**sync?**

**diag?**

## 3.2 General SCPI Commands

The following command summary is valid for the CSAC GPSDO serial interfaces J1 and U15. The LN CSAC GPSDO board also contains a built-in FireFly-IIA microprocessor interface (J6) for

control of the OCXO disciplining process, please see the JLT FireFly-IIA user manual for a review of the command syntax on the FireFly-IIA serial interface J6 as this is typically only used during the debugging and evaluation phase of the LN CSAC GPSDO.

### 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 LN CSAC GPSDO.

## 3.3 GPS Subsystem

*Note: Please note that LN CSAC GPSDO displays antenna height in MSL Meters rather than in GPS Meters on all commands that return antenna height [the legacy Fury GPSDO 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 GPS receiver. The list of the commands supported is the following:

GPS:SATellite:TRacking:COUNT?

GPS:SATellite:VISible:COUNT?

GPS:PORT <RS232 | USB>

GPS:PORT?

GPS:GPGGA <int> [0,255]

GPS:GGATat <int> [0,255]

GPS:GPRMC <int> [0,255]

GPS:GPZDA<int> [0,255]

GPS:GPGSV<int> [0,255]

GPS:PASHR<int> [0,255]

GPS:XYZSPeed

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

GPS:DYNAMic:MODE 8 (Automatic Dynamic Mode)

GPS:DYNAMic:MODE?

GPS:DYNAMic:STATe?

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

GPS:REFerence:PULse:SAWtooth?

GPS:RESET ONCE

GPS:TMODE <ON | OFF | RSTSURV>

GPS:SURVey ONCE  
 GPS:SURVey:DURation <sec>  
 GPS:SURVey:VARiance <mm^2>  
 GPS:HOLD:POSition <cm, cm, cm>  
 GPS:SURVey:STATus?  
 GPS:INITial:DATE <yyyy,mm,dd>  
 GPS:INITial:TIME <hour,min,sec>  
 GPS:JAMlevel?  
 GPS:FWver?  
 GPS?

### 3.3.1 GPS:SATellite:TRAcking:COUNt?

This query returns the number of satellites being tracked.

### 3.3.2 GPS:SATellite:VISible:COUNt?

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

### 3.3.3 NMEA Support

The following five commands allow the LN CSAC GPSDO to be used as an industry standard navigation GPS 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 LN CSAC GPSDO RS-232 interface.

Once enabled, LN CSAC GPSDO will send out information on the RS-232 transmit pin automatically every N seconds. All incoming RS-232 commands are still recognized by LN CSAC GPSDO 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 LN CSAC GPSDO Microprocessor, so the position is valid for the 1PPS pulse previous to the last 1PPS pulse at the time the data is sent (one second delay). The time and date are properly output with correct UTC synchronization to the 1PPS pulse immediately prior to the data being sent.

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

### 3.3.4 GPS:PORT <RS232 | USB>

This commands 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 LN CSAC GPSDO to send the NMEA standard string \$GPGGA 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: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:GGASTat

This command instructs the LN CSAC GPSDO 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 2 minute CSAC warm-up 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 CSAC 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.

### 3.3.8 GPS:GPRMC

This command instructs the LN CSAC GPSDO to send the NMEA standard string \$GPRMC 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:GPRMC <int> [0,255]
```

### 3.3.9 GPS:GPZDA

This command instructs the LN CSAC GPSDO to send the NMEA standard string \$GPZDA 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:GPZDA <int> [0,255]

### 3.3.10 GPS:GPGSV

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

GPS:GPGSV <int> [0,255]

### 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,eeee.eeeee,f,ggggg.gg,hhhh,iii.ii,jjj.jj,kkkk.kk,ll.l,mm.m,nn.n,00.0,p.pp,*[checksum]
```

Where:

- aa: Number of Sats
- bbbbbb.00: Time of Day UTC
- cccc.ccccc,d: Latitude,S/N
- eeee.eeeee,f: Longitude,W/E
- ggggg.gg: Antenna Height in meters
- hhhh: Four fixed '?' symbols
- iii.ii: Course Over Ground
- jjj.jj: Speed in Knots
- kkkk.k: Vertical Velocity in meters/s
- ll.l: PDOP
- mm.m HDOP
- nn.n VDOP
- 00.0 Static number
- p.pp: Firmware version

This command instructs the LN CSAC GPSDO 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:XYZSPeed

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

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

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

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

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

### 3.3.13 GPS:DYNAMic:MODE

This command allows the user to select the dynamic motion model being applied to the Kalman filters in the GPS 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 GPS coordinates to be provided in high-dynamic applications such as Jet aircraft. Doppler tracking is enabled in all airborne modes, as Carrier Phase tracking is very difficult to achieve in high velocity applications. The GPS will perform Carrier Phase tracking for non-airborne modes.

The command has the following syntax:

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

Sending the following command to the LN CSAC GPSDO will select a stationary GPS dynamic model for example:

```
gps:dynam:mode 1
```

The following table lists all available modes:

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

The LN CSAC GPSDO uses a GPS 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 GPS 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:DYNAMIC:MODE command is disabled internally and its setting is ignored as the unit does not expect any motion on the antenna. In this case, the dynamic state as programmed into the GPS receiver is set to STATIONARY independent of the user selection for GPS:DYNAMIC:MODE.

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

GPS:DYNAMIC:STATE?

Please note that this command syntax has changed from previous products such as the FireFly-IIA GPSDO units which did not support Position Hold Auto Survey modes.

### 3.3.14 GPS:DYNAMIC:MODE 8 (Automatic Dynamic Mode)

Automatic Dynamic Mode allows the LN CSAC GPSDO firmware to automatically configure the GPS receiver Kalman filter parameters based on actual mission velocities and motion profiles. The unit will try to set the GPS 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 GPS receiver when Automatic Mode is selected (Dynamic Mode 8).

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

In this Automatic mode, the unit will configure the GPS 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.

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

```
GPS:DYNAMIC:MODE?
```

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

```
GPS:DYNAMIC:STATE?
```

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

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

Settings will be applied immediately to the GPS receiver, and are stored in Non Volatile memory.

### 3.3.15 GPS:DYNAMIC:STATE?

This query returns the actual state of the dynamic model, chosen by the firmware to be applied to the GPS receiver depending on vehicle velocity. It returns a value between 0 and 7, which correspond to one of the dynamic models defined in the Table in section 3.3.14 .

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 GPS receiver depending on actual vehicle dynamics
- if the GPS Timing Mode is set to ON or to RSTSURV, the dynamic state will always be set to 1 (Stationary)

### 3.3.16 GPS:REFERENCE:ADELay <float> <s | ns > [-32767ns,32767ns]

The ADELay 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 1.5ns per foot propagation delay would be compensated with the following command:

```
GPS:REF:ADEL 45ns
```

This command can be used to fine-tune different units to have 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 GPS 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, since the lock algorithms will try to steer the CSAC for a 0.0ns offset to the UTC 1PPS time-pulse.

### 3.3.17 GPS:REFERENCE:PULSE:SAWtooth?

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

### 3.3.18 GPS:RESET ONCE

Issues a reset to the internal GPS receiver. This can be helpful when changing the antenna for example, since the GPS 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.

### 3.3.19 **GPS:TMODE** <ON | OFF | RSTSURV>

This command selects the Timing Mode of the GPS.

If the Timing Mode is OFF, the GPS will act as a regular GPS. This mode has to be chosen if the unit is mobile.

If the Timing Mode is ON, the timing features of the GPS are enabled. At power-up, the Hold position stored in NVRAM will be sent to the GPS 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 Survey executed by the GPS.

If the Timing Mode is RSTSURV, the GPS will start a Survey every time the unit is powered-on and following the Survey, the GPS will run with the timing features enabled.

### 3.3.20 **GPS:SURVey 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:SURVey:DURation** and **GPS:SURVey:VARiance**

### 3.3.21 **GPS:SURVey:DURation** <sec>

This command sets the Survey minimal duration.

### 3.3.22 **GPS:SURVey:VARiance** <mm<sup>2</sup>>

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 GPS can stop the Survey. The GPS 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:POSition** <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:SURVey:STATus?**

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

Firmware revision 0.57 and later adds support for manually setting the time and date in the RTC in the event that no GPS signals are available. This command allows setting the internal RTC DATE manually when operating the unit in GPS denied environments. This command is compatible to the **PTIME:OUT ON** command described in section 3.5.5. to allow automatic time and date synchronization of two units to each other. The internal RTC is driven by the highly stable CSAC 10MHz signal, and thus has very high accuracy.

### 3.3.26 **GPS:INITial:TIME <hour,min,sec>**

Firmware revision 0.57 and later adds support for manually setting the time and date in the RTC in the event that no GPS signals are available. This command allows setting the internal RTC TIME manually when operating the unit in GPS denied environments. This command is compatible to the **PTIME:OUT ON** command described in section 3.5.5. to allow automatic time and date synchronization of two units to each other. The internal RTC is driven by the highly stable CSAC 10MHz signal, and thus has very high accuracy.

### 3.3.27 **GPS:JAMlevel?**

Firmware revision 0.57 and later adds support for a GPS signal jamming-indicator. The GPS receiver will detect, and flag jamming interference with levels ranging from 0 (no jamming) to 255 (strong jamming). Any level exceeding 50 will cause a **SYNC:HEALTH 0x800** event to be flagged, and the unit to disable the **LOCK\_OUT\_OK** signal on connector J1.

### 3.3.28 **GPS:FWver?**

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

### 3.3.29 **GPS?**

This query displays the configuration, position, speed, height and other relevant data of the GPS 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:CALibrate <float,float,float,float,float,float>  
 GYRO:CALibrate:COMPute  
 GYRO:CALibrate:RESET  
 GYRO:SENSitivity <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 50ms (20 outputs per second) achieved when setting the command to GYRO:TRACE 1. The resolution of this command is 1/20 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) 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 offset 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 offset 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:SENS and GPS:CAL:RESET

Used for factory calibration of Gyro subsystem.

### 3.4.8 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:

```
PTIME:DATE?
PTIME:TIME?
PTIME:TIME:STRing?
PTIME:TINTerval?
PTIME:OUTput <on|off>
PTIME:LEAPsecond?
PTIME?
```

### 3.5.1 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.

### 3.5.2 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.

### 3.5.3 PTIME:TIME:STRing?

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

### 3.5.4 PTIME:TINTerval?

This query is equivalent to the command synchronization:TINTerval

### 3.5.5 PTIME:OUTput <ON | OFF>

Firmware revision 0.57 and later adds support for auto-initialization of time and date between to Jackson Labs Technologies, Inc. GPSDO units. This 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 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 PTIME:LEAPsecond?

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 GPS receiver (GPS Almanac is available).

### 3.5.7 PTIME?

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

PTIME:DATE?

PTIME:TIME?

PTIME:TINTerval?

PTIME:OUTput?

PTIME:LEAPsecond?

## 3.6 SYNChronization Subsystem

This subsystem regroups the commands related to the synchronization of the LN CSAC GPSDO with the GPS receiver. The list of the commands supported for this subsystem is the following:

```
SYNChronization:HOLDOVER:DURATION?  
SYNChronization:HOLDOVER:INITIATE  
SYNChronization:HOLDOVER:RECOVERY:INITIATE  
SYNChronization:SOURCE:MODE <GPS | EXTERNAL | AUTO>  
SYNChronization:SOURCE:STATE?  
SYNChronization:TINTERVAL?  
SYNChronization:IMMEDIATE  
SYNChronization:FEESTIMATE?  
SYNChronization:LOCKED?  
SYNChronization:OUTPUT:1PPS:RESET <ON | OFF>  
SYNChronization:OUTPUT:1PPS:RESET?  
SYNChronization:OUTPUT:FILTER <ON | OFF>  
SYNChronization:OUTPUT:FILTER?  
SYNChronization:HOLDOVER:STATE?  
SYNChronization:TINTERVAL:THRESHOLD [50,2000]  
SYNChronization?
```

### 3.6.1 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, 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 Receiver is not in holdover; a value of 1 indicates the Receiver is in holdover.

### 3.6.2 SYNChronization:HOLDOVER:INITIATE

The SYNC:HOLD:INIT and SYNC:HOLD:REC:INIT commands allow the user to manually enter and exit the holdover state, even while GPS signals are still being properly received. This forced-holdover allows the unit to effectively disable GPS locking, while still keeping track of the state of the 1PPS output in relation to the UTC 1PPS signal as generated by the GPS receiver. When the unit is placed into forced-holdover with this command, the unit will indicate the time interval difference between the 1PPS output and the GPS UTC 1PPS signal by using the SYNC:TINT? command. This allows the user to see the CSAC drift when not locked to GPS for testing purposes, or to prevent the GPS receiver from being spoofed and affecting the CSAC frequency accuracy. All

other frequency-disciplining functions of the unit will behave as if the GPS antenna was disconnected from the unit while in this forced-holdover state.

### 3.6.3 SYNChronization:HOLDOver:RECOvery:INITiate

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

### 3.6.4 SYNChronization:SOURce:MODE

The Source:Mode command allows an optional external 3.3V CMOS, 5V CMOS or TTL level 1PPS input to be connected to the LN CSAC GPSDO board on connector harness J1. The unit can use this external 1PPS input instead of the internal, GPS 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 GPS receiver goes into holdover mode for any reason. The command has the following format:

```
SYNChronization:SOURce:MODE <GPS | EXTernal | AUTO>
```

### 3.6.5 SYNChronization:SOURce:STATE?

This query shows the state of the external 1PPS synchronization option.

### 3.6.6 SYNChronization:TINTerval?

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

### 3.6.7 SYNChronization:IMMEdiate

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

### 3.6.8 SYNChronization:FEEstimate?

This query returns the Frequency Error Estimate, 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.

### 3.6.9 SYNChronization:LOCKed?

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

### 3.6.10 SYNChronization:OUTput:1PPs:RESET <ON | OFF>

This command allows the generation of the 1PPS pulse upon power-on without an external GPS antenna being connected to the unit. By default the unit does not generate a 1PPS pulse until the GPS 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 GPS antenna is not connected to the unit. Once the GPS 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.

### 3.6.11 SYNChronization:OUTput:1PPs:RESET?

This query returns the 1PPS output on reset setting.

### 3.6.12 SYNChronization:OUTput:FILTer <ON | OFF>

This command enables/disables the Phase Noise filter

### 3.6.13 SYNChronization:OUTput:FILTer?

This query returns the Phase Noise filter setting.

### 3.6.14 SYNChronization:HEAlth?

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

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 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 short-term-drift (ADEV @ 100s) > 100ns	HEALTH STATUS  = 0x100;
For the first 3 minutes after a phase-reset:	HEALTH STATUS  = 0x200;
If the CSAC Oscillator indicates an alarm	HEALTH STATUS  = 0x400;
If the GPS receiver indicates a strong jamming signal of >=50 (range is 0 to 255)	HEALTH STATUS  = 0x800;
If the internal Noise Filter OCXO is not locked, or the internal FireFly-IIA OCXO microcontroller indicates a pending Event that can be queried on RS-232 interface connector J6:	HEALTH STATUS  = 0x1000

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

- 1) UTC phase > 250ns:           0x4
- 2) GPS 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 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.

### 3.6.15 SYNChronization:TINterval:THReshold [50,2000]

This command selects the internal oscillator 1PPS phase-offset threshold as compared to UTC at which point the unit will initiate a counter-reset (jam-sync) aligning the CSAC generated 1PPS with the GPS generated UTC 1PPS phase. The CSAC 1PPS phase is allowed to drift up to this threshold before a jam-sync is initiated. The CSAC phase is slowly and continuously adjusted toward 0ns offset to UTC while the phase difference is less than the THReshold phase limit. The default setting is 220ns, allowing a drift of up to +/-220ns. Reaching this selected threshold will cause a jam-sync phase-normalization to be initiated, which will also cause an indication of the SYNC:HEALTH? Status of 0x200 to be indicated, and the Green LED to be turned-off for several minutes.

### 3.6.16 SYNChronization?

This query returns the results of the following queries:

SYNChronization:SOURce:MODE?  
 SYNChronization:SOURce:STATE?  
 SYNChronization:OUTput:1PPS:RESET?  
 SYNChronization:LOCKed?  
 SYNChronization:HOLDover:STATe?  
 SYNChronization:HOLDover:DURation?  
 SYNChronization:FEEstimate?  
 SYNChronization:TINterval?  
 SYNChronization:TINterval:THReshold  
 SYNChronization:OUTput:FILTer?  
 SYNChronization:HEAlth?

## 3.7 DIAGnostic Subsystem

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

DIAGnostic:ROSCillator:EFControl:RELative?

DIAGnostic:ROSCillator:EFControl:ABSolute?

DIAGnostic:LIFetime:COUNT?

### 3.7.1 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%.

### 3.7.2 DIAGnostic:ROSCillator:EFControl:ABSolute?

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

### 3.7.3 DIAGnostic:LIFetime:COUNT?

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

### 3.7.4 DIAGnostic?

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?
```

```
EFControl Relative: 0.025000%
```

```
EFControl Absolute: 5
```

```
Lifetime : +871
```

## 3.8 MEASURE Subsystem

The MEASURE subsystem regroups the queries related to parameters that are measured on-board the LN CSAC GPSDO.

### 3.8.1 MEASure:TEMPerature?

Displays the PCB temperature around the CSAC oscillator.

### 3.8.2 MEASure:VOLTage?

Displays the CSAC TCXO steering voltage.

### 3.8.3 MEASure:CURRent?

Legacy SCPI command, instead of OCXO current this command displays the internal CSAC temperature.

### 3.8.4 MEASure:POWersupply?

Displays the power supply input voltage.

### 3.8.5 MEASure?

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

MEASure:TEMPerature?

MEASure:VOLTage?

MEASure:CURRent?

MEASure:POWersupply?

## 3.9 SYSTEM Subsystem

This subsystem regroups the commands related to the general configuration of the LN CSAC GPSDO. 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:FACToryreset ONCE

SYSTem:ID:SN?

SYSTem:ID:HWrev?

SYSTem:LCD:CONTRast [0,1.0]

SYSTem:LCD:CONTRast

SYSTem:LCD:PAGE [0,8]

SYSTem:LCD:PAGE?

SYSTem:COMMunicate:USB:BAUD <9600 | 19200 | 38400 | 57600 | 115200>

SYSTem:COMMunicate:USB:BAUD?

SYSTem:STATus?



### 3.9.1 SYSTem:COMMunicate:SERial:ECHO

This command enables/disables echo on RS-232. This command has the following format:

SYSTem:COMMunicate:SERial:ECHO <ON | OFF>

### 3.9.2 SYSTem:COMMunicate:SERial:PROmpt

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

SYSTem:COMMunicate: SERial:PROmpt <ON | OFF>

#### 3.9.2.1 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>

### 3.9.3 SYSTem:FACToryreset ONCE

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

### 3.9.4 SYSTem:ID:SN?

This query returns the serial number of the board

### 3.9.5 SYSTem:ID:HWrev?

This query return the Hardware version of the board

### 3.9.6 SYSTem:LCD:CONTRast [0,1.0]

This command sets the contrast of the LCD

### 3.9.7 SYSTem:LCD:CONTRast?

This query returns the current contrast of the LCD

### 3.9.8 SYSTem:LCD:PAGE [0,8]

This command displays the requested page on the LCD. Starting with firmware version 0.71, nine different pages are supported as described in Section 2.4.4.2 . The following table lists the LCD page numbers and corresponding names:

Value	LCD Page
0	Time/Date
1	GPS Position
2	GPS Height
3	CSAC Steering
4	CSAC Status
5	TINT
6	Navigation
7	GPS/UTC Time
8	Survey Status

### 3.9.9 SYSTem:LCD:PAGE?

This query returns the current page of the LCD.

### 3.9.10 SYSTem:COMMunicate:USB:BAUD <9600 | 19200 | 38400 | 57600 | 115200>

This command sets the speed of the serial USB port.

### 3.9.11 SYSTem:COMMunicate:USB:BAUD?

This query returns the speed of the serial USB port.

### 3.9.12 SYSTem:STATus?

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

## 3.10 SERVO Subsystem

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

SERVo:DACGain <float> [0.1,10000]

SERVo:EFCScale <float>[0.0 , 500.0]

SERVo:EFCDamping <int>[2 , 4000]

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

SERVo:AGINGcompensation <float> [-10.0, 10.0]  
SERVo:PHASECOrrrection <float> [-500.0, 500.0]  
SERVo:1PPSoffset <int> ns  
SERVo:TRACe <int > [0,255]  
SERVo?

### 3.10.1 SERVo:DACGain

This command is used for factory setup.

### 3.10.2 SERVo:EFCScale

Controls the Proportional part of the PID loop. Typical values are 0.7 to 6.0. 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]

### 3.10.3 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 <int>[2, 4000]

### 3.10.4 SERVo:TEMPCOMPensation

This parameter is a coefficient that reflects the correlation between the temperature of the CSAC versus the required frequency steering. Monitoring the tempco and aging parameters provides a mechanism to track the health of the CSAC 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 Jackson Labs Technologies, Inc. firmware. This command has the following format:

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

### 3.10.5 SERVo:AGINGcompensation

This parameter is a coefficient that represents the drift of the EFC needed to compensate the natural drift in frequency of the CSAC due to aging. This coefficient is automatically computed and adjusted over time by the Jackson Labs Technologies, Inc. firmware. This command has the following format:

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

### 3.10.6 SERVo:PHASECOrrrection

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:

```
SERV0:PHASECOrrrection <float> [-500.0, 500.0]
```

### 3.10.7 SERVo:1PPSoffset

This command sets the LN CSAC GPSDO 1PPS signal's offset to UTC in 100ns steps.

Using the SERV:1PPS command results in immediate phase change of the 1PPS output signal.

This command has the following format:

```
SERV0:1PPSoffset <int> ns
```

### 3.10.8 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:

```
SERV0: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:HEALTH?** command for detailed information on how to decode the health status indicator values. The Lock State variable indicates one of the following states:

Value	State
0	CSAC warmup
1	Holdover
2	Locking (CSAC 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

### 3.10.9 SERVo?

This command returns the result of the following queries:

SERVo:DACGain?  
SERVo:EFCScale?  
SERVo:EFCDamping?  
SERVo:TEMPCompensation?  
SERVo:AGINGcompensation?  
SERVo:PHASECOrrrection?  
SERVo:1PPSoffset?  
SERVo:TRACE : 0

## 3.11 CSAC Subsystem

The following commands are used to query the microcontroller built into the CSAC oscillator itself.

### 3.11.1 CSAC:RS232?

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

### 3.11.2 CSAC:STeer?

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

### 3.11.3 CSAC:STATus?

This query returns the status value in [0,9] as shown below:

<b>Alarm</b>	<b>Definition</b>
0	Locked
1	Microwave Frequency Steering
2	Microwave Frequency Stabilization
3	Microwave Frequency Acquisition
4	Laser Power Acquisition
5	Laser Current Acquisition
6	Microwave Power Acquisition
7	Heater equilibration
8	Initial warm-up
9	Asleep (ULP mode only)

### 3.11.4 CSAC:ALarm?

This query returns the Alarm value as shown below:

<b>Alarm</b>	<b>Definition</b>
0x0001	Signal Contrast Low
0x0002	Synthesizer tuning at limit
0x0010	DC Light level Low
0x0020	DC Light level High
0x0040	Heater Power Low
0x0080	Heater Power High
0x0100	uW Power control Low
0x0200	uW Power control High
0x0400	TCXO control voltage Low
0x0800	TCXO control voltage High
0x1000	Laser current Low
0x2000	Laser current High
0x4000	Stack overflow (firmware error)

### 3.11.5 CSAC:MODE?

This query returns the CSAC mode as shown below:

0x0001	Analog tuning enable
0x0002	Reserved
0x0004	Reserved
0x0008	1 PPS auto-sync enable
0x0010	Discipline enable
0x0020	Ultra-low power mode enable
0x0040	Reserved
0x0080	Reserved

### 3.11.6 CSAC:CONTRast?

This query returns the indication of signal level typically ~4000 when locked, and ~0 when unlocked.

### 3.11.7 CSAC:LASer?

This query returns the current (in mA) driving the laser.

### 3.11.8 CSAC:TCXO?

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

### 3.11.9 CSAC:SIGnal?

This query returns the indication of signal level.

### 3.11.10 CSAC:HEATpackage?

This query returns the Physics package heater power typically 15mW under NOC.

### 3.11.11 CSAC:TEMP?

This query returns the Temperature measured by the CSAC unit in °C, absolute accuracy is +/- 2°C.

### 3.11.12 CSAC:FWrev?

This query returns the Firmware version of the CSAC unit.

### **3.11.13 CSAC:SN?**

This query returns the Serial Number of the CSAC in the form YYMMCSNNNNN where YYMM is the year and month of production and NNNNN is the serialized unit of that month.

### **3.11.14 CSAC:LIFETIME?**

This query returns the accumulated number of hours that the CSAC has been powered on since the last factory reset of the LN CSAC GPSDO board. The value is stored in the external NVRAM and updated every hour when the CSAC is powered on.

### **3.11.15 CSAC:STeer:LATch ONCE**

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

### **3.11.16 CSAC?**

This query displays all the CSAC queries defined above.



# 4 Firmware Upgrade Instructions

## 4.1 Introduction

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

It is not expected that the built-in FireFly-IIA microcontroller of the LN CSAC GPSDO requires any future firmware updates, so the procedure to do firmware upgrades to that microcontroller will be published separately if the need arises.

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

## 4.2 ISP Flash Loader Utility Installation

Jackson Labs Technologies, Inc. recommends using the Flash Magic utility to upgrade the contents of Flash memory on the CSAC GPSDO. 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.

*Note: The Philips LPC2000 utility that is used on other Jackson Labs Technologies, Inc. products will not support the newer LPC2368 processor used on the CSAC GPSDO.*

## 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 (See [Figure 4.1](#)). 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 header J2**



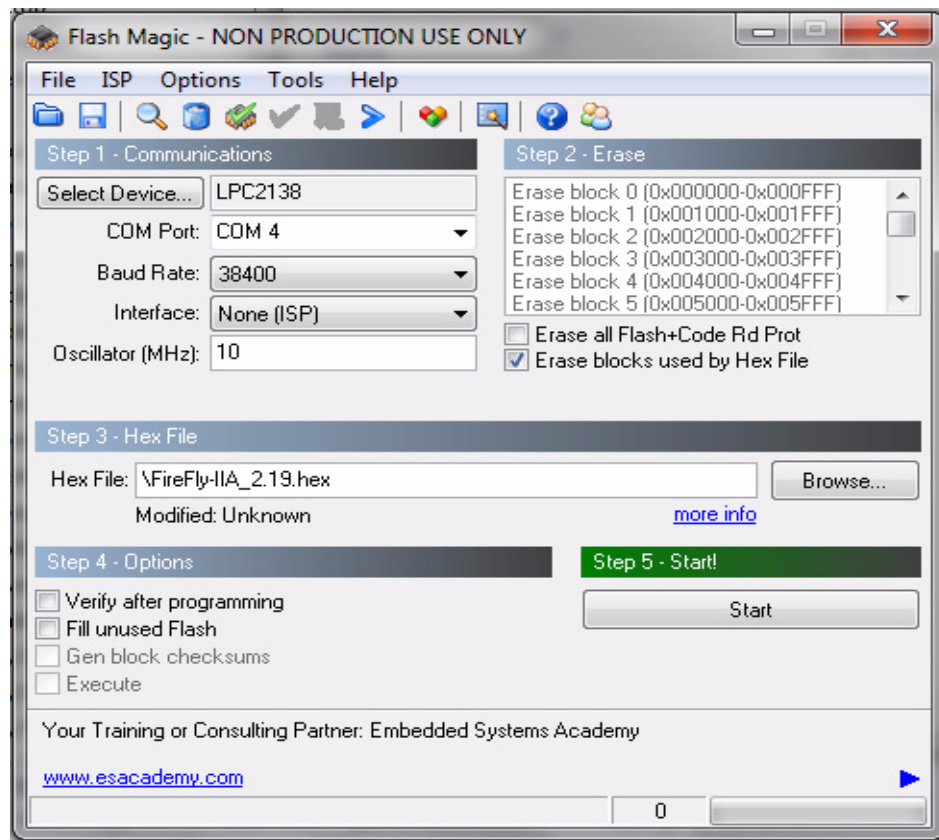
## 4.4 Downloading the Firmware

Download the latest version of CSAC GPSDO firmware from the Jackson Labs Technologies, Inc. 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 CSAC GPSDO as indicated in Section 2.4 . 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

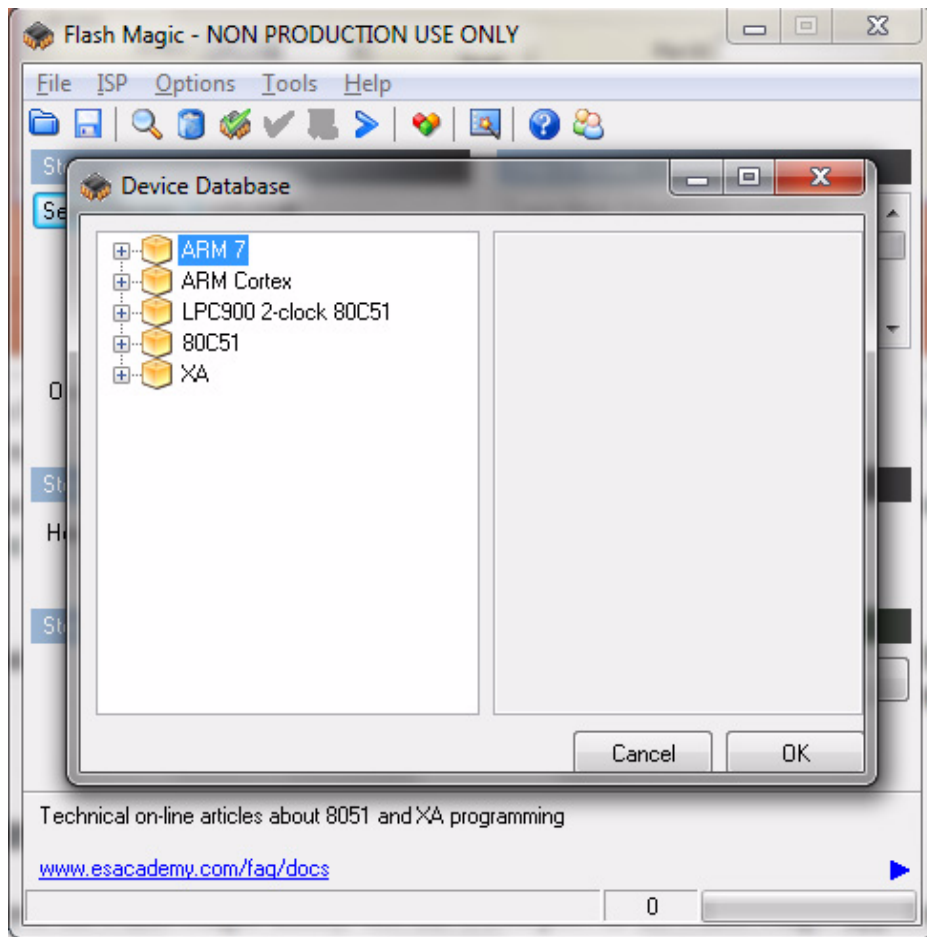
A) Open the Flash Magic utility. Set the COM port in the Flash Magic application as needed on your PC. Set “Interface” to “None (ISP)”.

Figure 4.2 Flash Magic programming utility

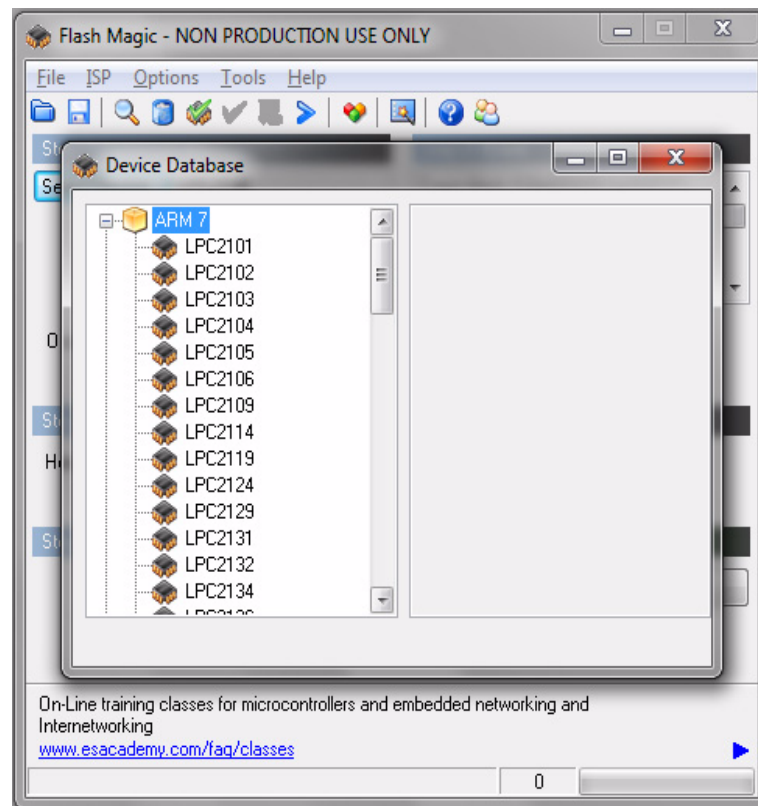


B) Press the “Select Device” button and the window shown in **Figure 4.3** will appear:

**Figure 4.3 Device selection window**



C) Expand the ARM7 folder and select the appropriate processor, in this case the LPC2368.

**Figure 4.4 Expanded device selection window**

D) Select the Baud Rate of the Flash Magic utility to be 230.4KB or slower.

E) Set the Oscillator (MHz) to "10".

F) Check the box marked "Erase blocks used by Hex File".

**Warning:** Make sure NOT(!) to check the box marked "Erase all Flash+Code Rd Prot" under any circumstances, this may erase factory calibration data, and 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 4.4 .

H) Go to Step 5 and press "Start". You will observe the firmware being downloaded to the CSAC GPSDO.

## 4.5 Verifying Firmware Update

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 version that was downloaded.



# 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>

*Important note: On newer, faster computers running Windows 7, GPSCon may not acquire data correctly. Try running GPSCon in Windows XP compatibility mode, and as an administrator. If you encounter problems, it is recommended that you install GPSCon on a slower computer using Windows XP.*

## 5.2 Z38xx Utility

If the GPSCon utility is not available, you may use the Z38xx utility. The Z38XX utility is a PC monitor program for GPS Disciplined References (GPSR) which communicate using the SCPI (Standard Commands for Programmable Instrumentation) Protocol. It is available on the Jackson Labs Technologies, Inc. website under the “Support” tab:

[http://www.jackson-labs.com/assets/uploads/main/Z38XX\\_download.zip](http://www.jackson-labs.com/assets/uploads/main/Z38XX_download.zip)

The program provides real-time monitoring of the operation of the GPSR, including status information, GPS satellite information, timing and control information, holdover prediction, reference Allan Variance and even a UTC clock with second accuracy. It also displays various logs, and stores all measurements on file for later analysis.

## 5.3 GPSCon Installation

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

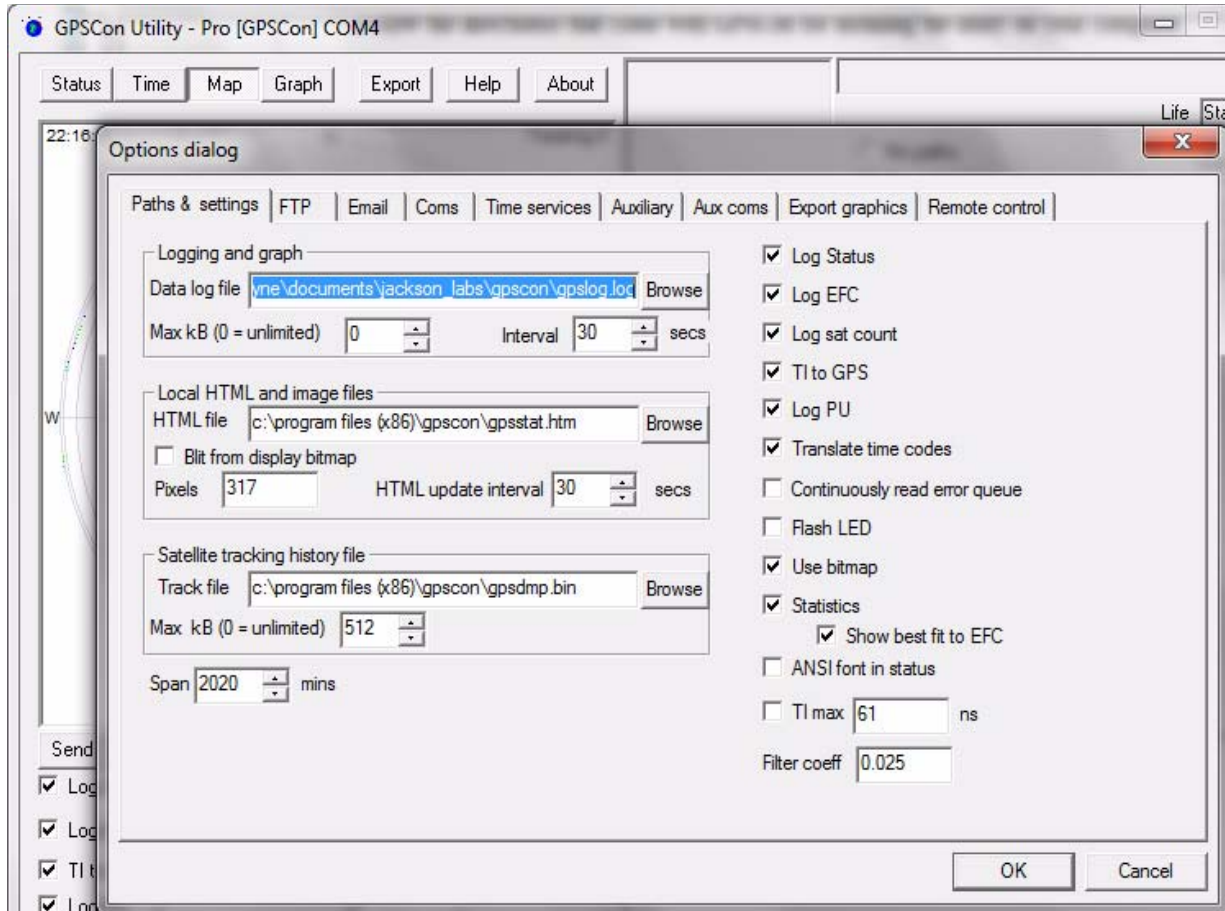
## 5.4 Using GPSCon

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.

## 5.4.1 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**



### 5.4.1.1 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.

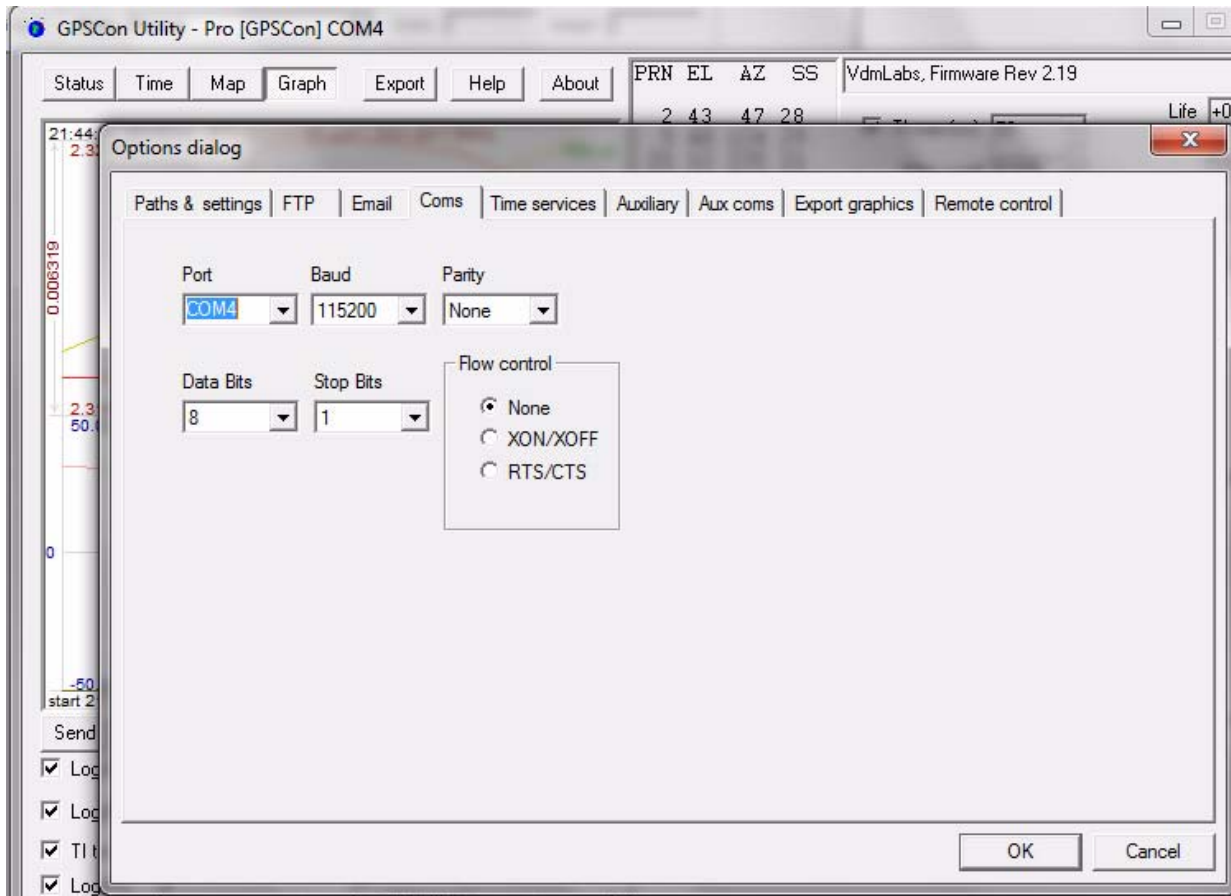
### 5.4.1.2 Auxiliary parameters

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

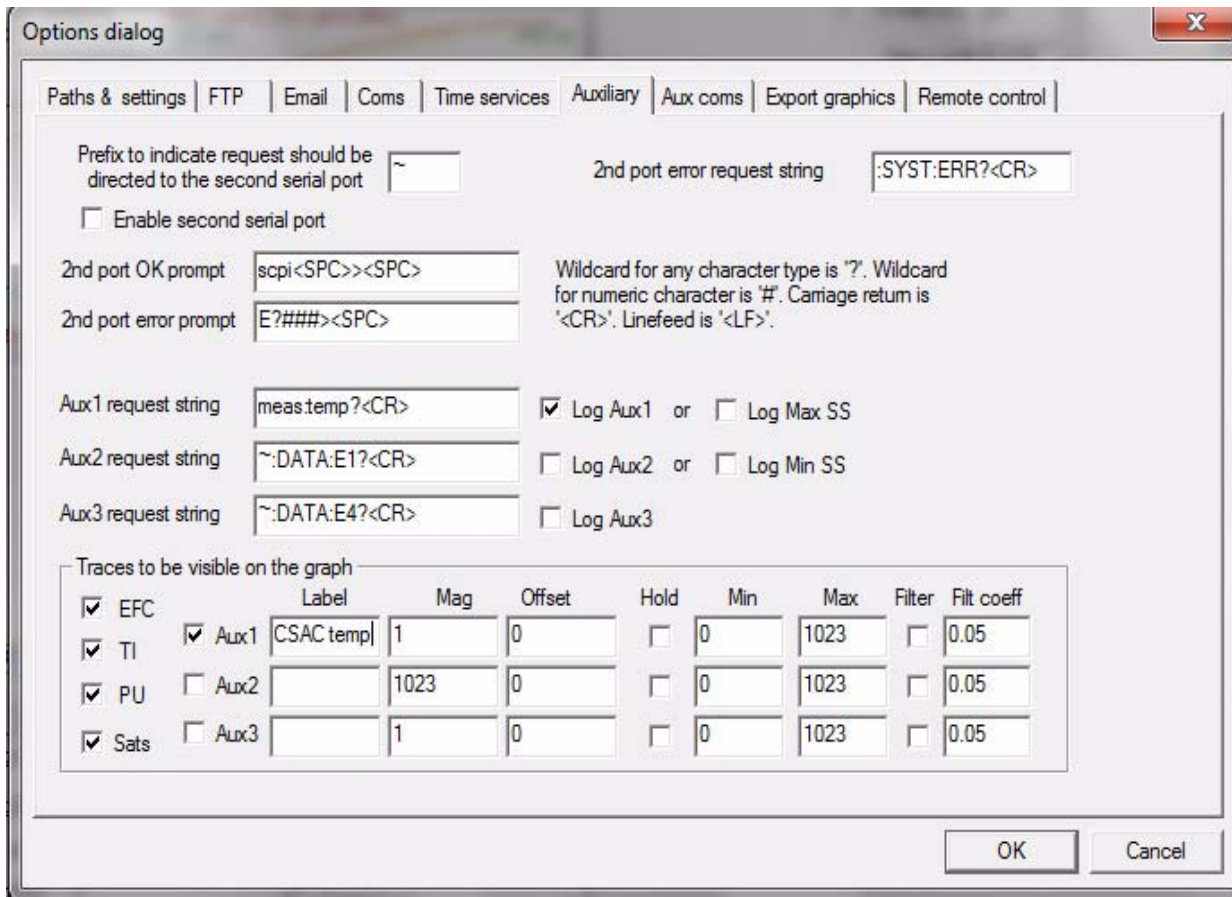


the area below labeled “Traces to be visible on the graph”, the box “Aux 1” is checked and the label “CSAC temp” has been added.

**Figure 5.2 Setting the communications parameters**



**Figure 5.3 Auxiliary parameters window**



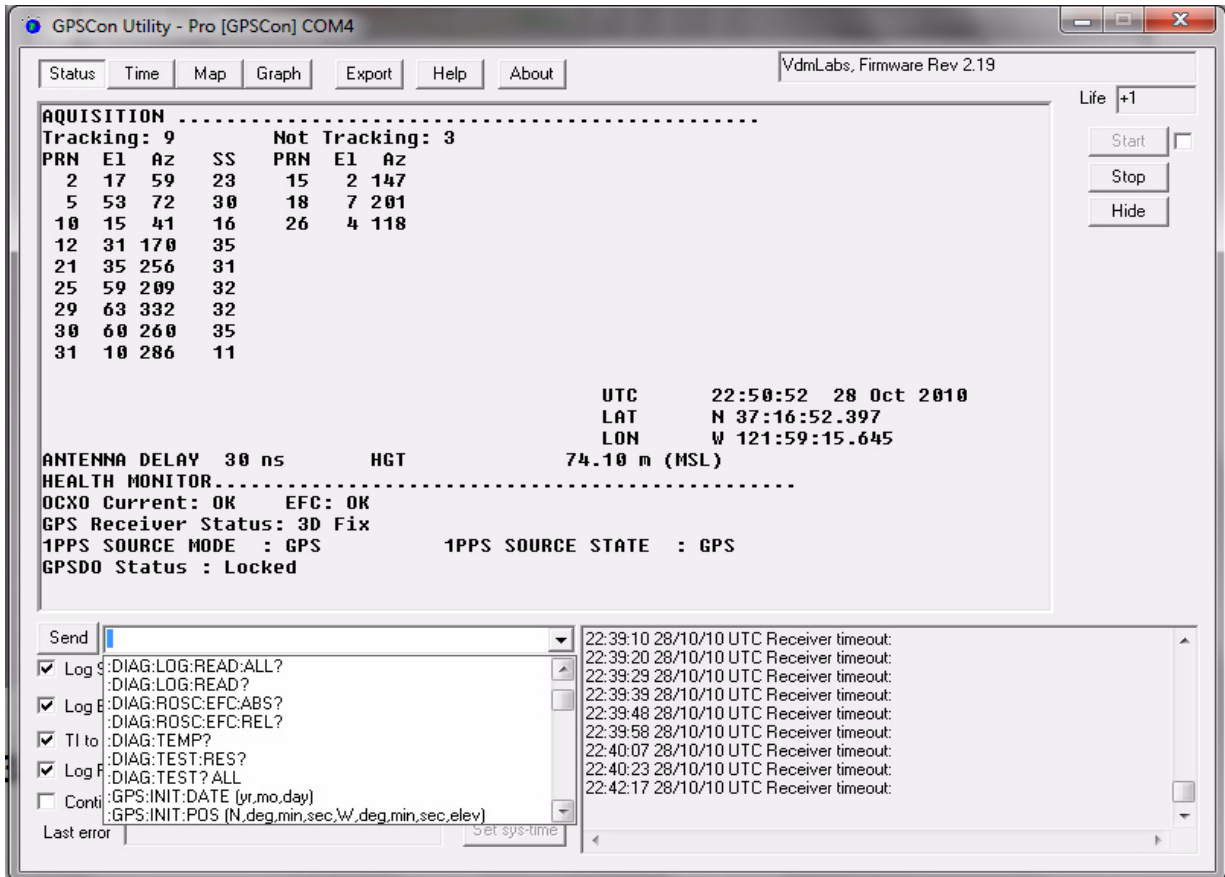
### 5.4.1.3 Other options

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.

## 5.4.2 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 CSAC GPSDO. Once you've selected the command, you can press "Send" to send it to the CSAC GPSDO.

**Figure 5.4 Sending manual commands**



## 5.4.3 Use of 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.

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

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

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**

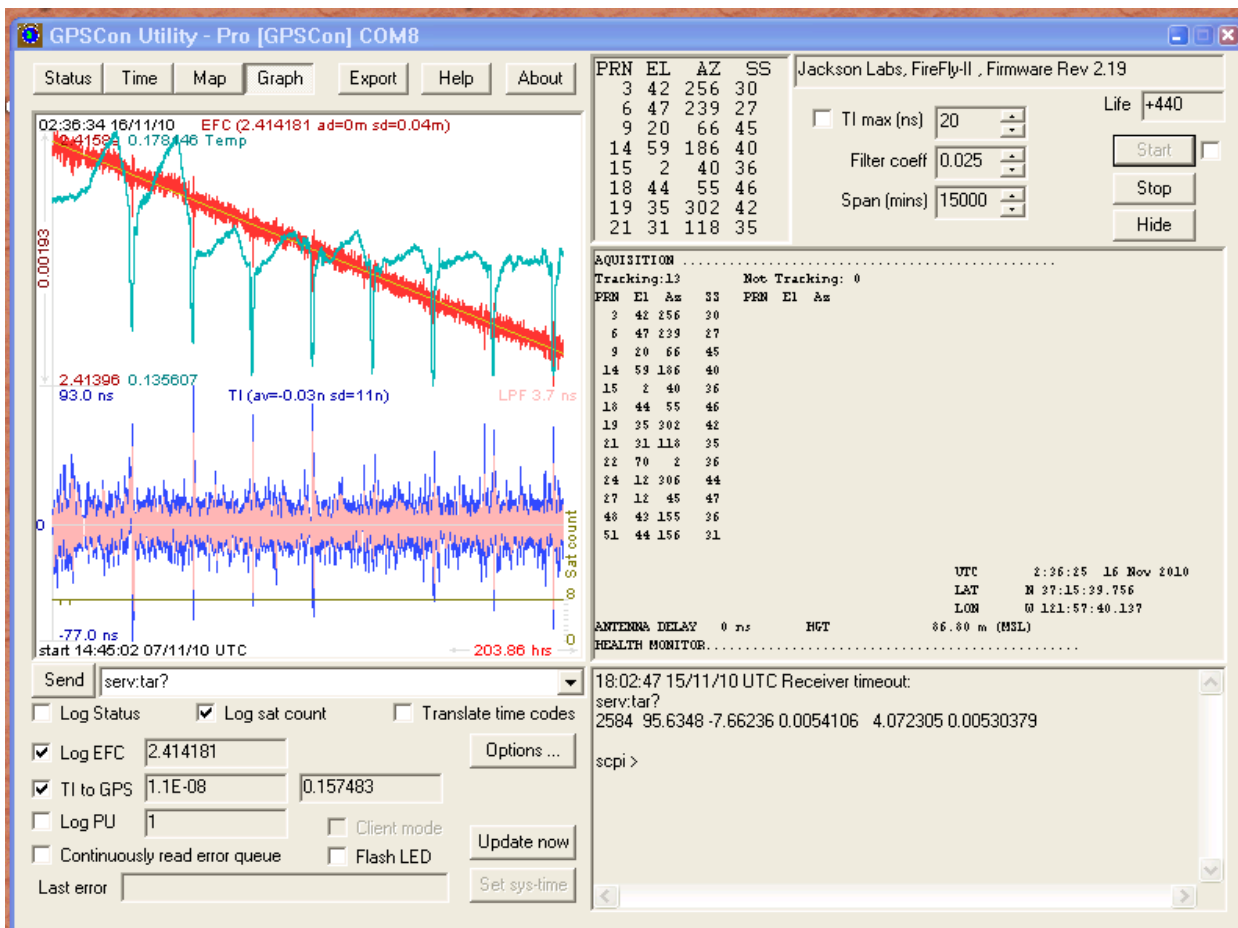


Figure 5.6 Expanded Graph Display



### 5.4.4 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. 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.



# 6 Certification and Warranty

## 6.1 Certification

Jackson Labs Technologies, Inc. certifies that this product met its published specifications at time of shipment.

### 6.1.1 Warranty

This Jackson Labs Technologies, Inc. hardware product is warranted against defects in material and workmanship for a period of 1 (one) year from date of delivery. During the warranty period Jackson Labs Technologies, Inc. will, at its discretion, either repair or replace products that prove to be defective. Jackson Labs Technologies, Inc. does not warrant that the operation for the software, firmware, or hardware shall be uninterrupted or error free even if the product is operated within its specifications.

For warranty service, this product must be returned to Jackson Labs Technologies, Inc. or a service facility designated by Jackson Labs Technologies, Inc. Customer shall prepay shipping charges (and shall pay all duties and taxes) for products returned to Jackson Labs Technologies, Inc. for warranty service. Except for products returned to Customer from another country, Jackson Labs Technologies, Inc. shall pay for return of products to Customer. If Jackson Labs Technologies, Inc. is unable, within a reasonable time, to repair or replace any product to condition as warranted, the Customer shall be entitled to a refund of the purchase price upon return of the product to Jackson Labs Technologies, Inc.

### 6.1.2 Limitation of Warranty

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by the Customer, Customer-supplied software or interfacing, unauthorized modification or misuse, opening of the instruments enclosure or removal of the instruments panels, operation outside of the environmental or electrical specifications for the product, or improper site preparation and maintenance. **JACKSON LABS TECHNOLOGIES, INC. SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR**

**PURPOSE.** No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted by this document. Jackson Labs Technologies, Inc. products are not intended for use in medical, life saving, or life sustaining applications.

### **6.1.3 Exclusive Remedies**

**THE REMEDIES PROVIDED HEREIN ARE THE CUSTOMER'S SOLE AND EXCLUSIVE REMEDIES. JACKSON LABS TECHNOLOGIES, INC. SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.**