SAASM GSPDO User Manual

Document:	80200520
Version:	1.1
Date:	15 January, 2015

SAASM GPSDO User Manual

1 Introduction

1.1 Overview

The SAASM GPSDO combines the anti-spoofing and anti-jamming capabilities of a SAASM GPS receiver with two different oscillator options optimized for different application profiles: a Microsemi Chips Scale Atomic Clock (CSAC) or a double ovenized crystal oscillator (DOCXO). The SAASM HD CSAC GPSDO, the CSAC variant of this product, exhibits extremely low power consumption and heat generation, very fast atomic frequency lock to better than 1ppb accuracy (within 2 minutes typically), very low physical height, extremely low sensitivity to acceleration such as tilt, and very good holdover performance for extended periods and is thus optimized for critical timing applications. The SAASM FireFly-IIA, the DOCXO variant, offers an additional +8dBm Sine Wave 10MHz output with exceptionally low Phase Noise (typically less than -100dBc/Hz at 1Hz offset), very good ADEV performance, and very low sensitivity to temperature changes (0.2ppb stability from -20°C to +75°C typically) and is thus optimized for applications that require a very high stability with very low noise 10MHz reference.

The SAASM HD CSAC GPSDO and SAASM FireFly-IIA provide an RS-232 serial port for command and control, and operate from a +12V power supply. They includes CMOS and LVDS 10MHz outputs, and CMOS and LVDS 1PPS outputs. Both are function compatible to the FireFly-II board, and shares the same IO connector, while adding SAASM capabilities. The SAASM HD CSAC GPGSDO drastically reduces power consumption while improving performance. Generic NMEA and SCPI (GPIB) commands on the serial interface allow for very fast integration into legacy applications, and by using the NMEA serial strings the unit can behave like a standard GPS receiver with the added security and capabilities of a SAASM GPS receiver.

The SAASM HD CSAC GPSDO and SAASM FireFly-IIA feature the Rockwell Collins MicroGRAM dual frequency L1/L2 SAASM GPS receiver and has been approved for use in DoD applications. While keyed, the SAASM capabilities provide anti-spoofing security and allow the receiver to operate in hostile GPS-denied or jammed environments. The L1/L2 tracking also increases accuracy by enabling the measurement and elimination of error due to atmospheric delays. The SAASM GPS receiver is keyed through the an RS-232-level DS101 port, and zeroized with prime power through the SCPI interface or with battery backup power by grounding or driving low with an open collector output an input pin.

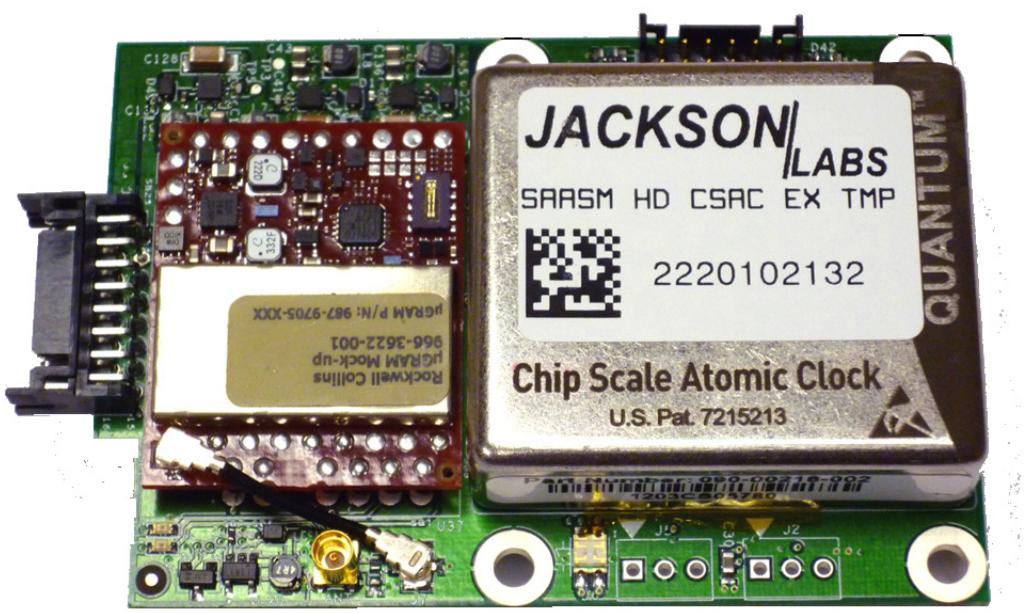
The SAASM HD CSAC GPSDO and SAASM FireFly-IIA also include Hot-Start and Pass-Through capabilities with an external DAGR. During a Hot-Start, the external ICD-153 device provides GPS navigation and PVT data, allowing the internal SAASM receiver to immediately obtain a GPS fix. With the Pass-Through feature, the SAASM HD CSAC GPSDO uses the PVT and precise time

(1PPS) information from the external ICD-153 device in place of the data from the internal SAASM receiver.

For long term Stratum-1 frequency accuracy and constant calibration, the CSAC is phase locked to within 0.3ns average phase accuracy typically with either the internal SAASM GPS 1PPS, external DAGR 1PPS, or other externally applied 1PPS input. The SAASM HD CSAC GPSDO includes a high-performance time-interval-counter that can measure the reference 1PPS with a resolution of 20 picoseconds. Software compensation on the 32-bit processor running a Real Time OS measures residual aging error of the CSAC oscillator, and applies electronic compensation to reduce the effect of this error. The error compensation can improve performance especially in environments with no access to GPS signals, and allows monitoring of the CSAC health and detection of performance abnormalities in the system.

The SAASM HD CSAC GPSDO is available in two functionally compatible board configurations: T-3 and BDR. Figure 1.1 shows the T-3 configuration of the SAASM HD CSAC GPSDO. The SAASM FireFly-IIA is available in the BDR configuration. The two configurations differ in size, mounting hole and connector locations. Details are available in Section 2.3 . This manual refers to both the SAASM HD CSAC GPSDO and the SAASM FireFly-IIA as the SAASM GPSDO with differences described where applicable.

Figure 1.1 T-3 Configuration of the SAASM HD CSAC GPSDO



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 CSAC, the

SAASM HD 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 CSAC. To calibrate these errors out and achieve phase-lock to USNO UTC, the SAASM HD 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.

1.3 General Safety Precautions

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

1.3.1 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.

1.3.2 Grounding

To avoid damaging the sensitive electronic components in the SAASM 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.

1.3.3 Power Connections

Make sure to connect the DC power to the device following the polarity indicated in Section 2.3 .

1.3.4 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%, at speeds up to 1200 m/s and at altitudes up to 16,000 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 SAASM HD CSAC GPSDO is powered from an external 11.0V to 14.0V (12V nominal) 0.15A DC source. The SAASM FireFlyFireFly-IIA is powered from an 11.0V to 13.0V (12V nominal) power supply with a current requirement of 0.65A during warmup, and <0.3A nominal at 12V.

2.2 Operating the unit from the RS-232 port

1) Connect a 3.3V-compatible GPS antenna to connector J4.

2) Plug in a clean DC power source of +12V to the power pins 15 and 16 of connector J1. Plug in the Ground connection to pins 12 and 14 of connector J1. RS-232 Serial TX and RX signals are available on pins 9 and 8 respectively of connector J1. Make sure not to accidentally short-out adjacent pins 13 and 15 of connector J1 as this would severely damage the board.

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?

The third-party application GPSCon is recommended for monitoring and controlling the unit via the RS-232 serial port. 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

Z38xx provides real-time monitoring of the operation of the GPSDO, 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.

The unit will now lock to GPS (Red LED is blinking when satellites are being received) and will indicate proper lock when the Green LED goes on. Once the green LED is on, the unit will output 10MHz with significantly better than 1ppb frequency accuracy.

2.3 Major connections

The major connections and features of the SAASM HD CSAC GPSDO's T-3 and BDR configurations are shown in Figure 2.1 and Figure 2.2 respectively. The connections and features of the SAASM FireFly-IIA are the same as the SAASM HD CSAC GPSDO's BDR configuration with the addition of the low phase noise Sine-Wave output on J9 as shown in Figure 2.3.

Figure 2.1 Major connections and features of the T-3 SAASM HD CSAC GPSDO

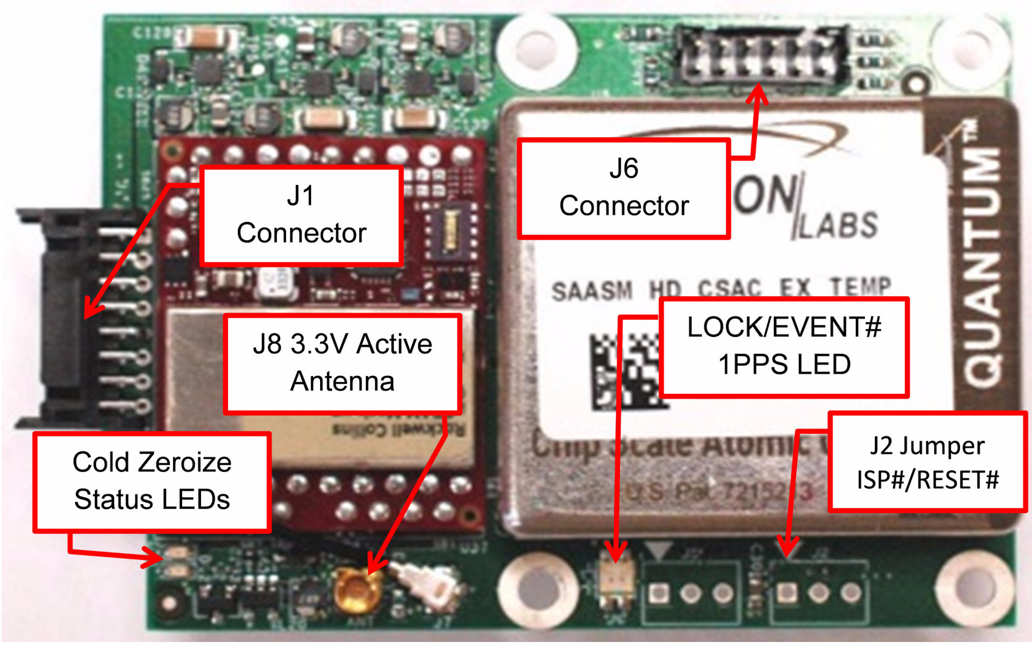


Figure 2.2 Major connections and features of the BDR SAASM HD CSAC GPSDO

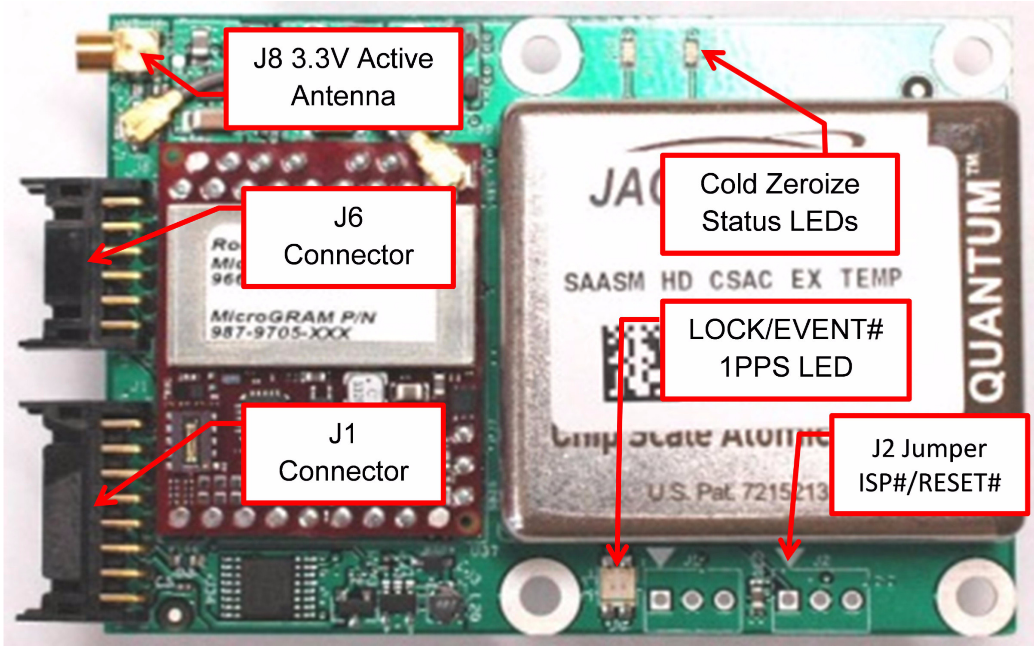
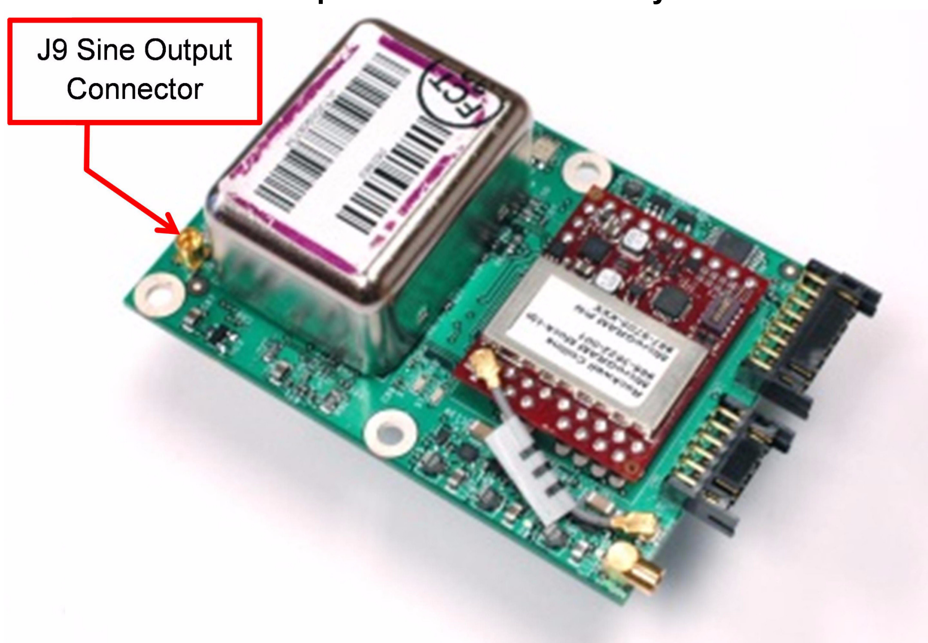


Figure 2.3 Sine Wave Output of the SAASM FireFly-IIA



The T-3 and BDR configurations have different connector locations, but the pin functions for the cooresponding connectors are the same. Table 2.1 and Table 2.2 show the functions supported on connectors J1 and J6 respectively.

Table 2.1 Connector J1 pin functions

Ref	Name	Function	Specification
J1-1	+10MHz LVDS Output	10MHz differential output	+10MHz LVDS, +/-300mV, terminate to -10MHz LVDS through 100 Ohms resistor
J1-2	-10MHz LVDS Output	10MHz differential output	-10MHz LVDS, +/-300mV, terminate to +10MHz LVDS through 100 Ohms resistor
J1-4	-1PPS LVDS Output	1PPS differential output	-1PPS LVDS, +/-300mV, terminate to +1PPS LVDS through 100 Ohms resistor
J1-5	+1PPS LVDS Output	1PPS differential output	+1PPS LVDS, +/-300mV, terminate to -1PPS LVDS through 100 Ohms resistor
J1-7	LOCK_OK_OUT	Indicates that no internal events are pending, the hardware is ok, and the HD CSAC is locked to GPS.	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	VBATT*	Battery backup voltage input for cold-zeroize	2V to 5V battery, 3.6V nominal
J1-11	PPS_IN**	External alternate 1PPS input	3.3V TTL, 3.3V LVCMOS compatible
J1-13	10MHz Output	CMOS 10MHz output. Do not terminate, use 1M or higher input impedance.	5V CMOS level can drive up to 15mA, series-terminated by 50Ohms. <1ns rise and fall time. Keep wires shorter than 2 inches on this signal.

* Supports 3V or 3.7V lithium battery, 2 or 3 alkaline batteries in series, or 2 or 3 NiCd/NiMh batteries in series.

** Do not drive J1-11 higher than 3.3V. J1-11 is internally connected to J6-4. Only one of these pins should be externally driven.

Table 2.2 Connector J6 pin functions

Ref	Name	Function	Specification
J6-1	ZERO_ACK#	Cold Zeroize acknowledge output	Active low 3.3V CMOS output
J6-2	FORCE_ZERO#	Force Zeroize input	Short to ground or pull low through open collector output. Internally pulled high to VBATT with 5K resistor.

J6-4	5V PPS In*	1PPS Input	TTL, 3.3V and 5V CMOS compatible
J6-5	DS101 TX	DS101 TX output	RS-232 level
J6-6	DS101 FCI	DS101 FCI input	RS-232 level
J6-7	DS101 FCO	DS101 FCO output	RS-232 level
J6-9	DS101 RX	DS101 RX input	RS-232 level
J6-10	COM2 TX	MicroGRAM COM2 TX	RS-232 level
J6-11	COM2 RX	MicroGRAM COM2 RX	RS-232 level
J6-12	5V 1PPS Out	5V 1PPS output	5V CMOS level

* J6-4 is internally connected to J1-11. Only one of these pins should be externally driven. Only J6-4 can accept a 5V 1PPS input.

2.3.1 Harness Pinning

Table 2.3 and Table 2.4 show the cable harness J1 and J6 pinouts respectively.

Table 2.3 J1 pinout

Pin	Name
1	+10MHz LVDS
2	-10MHz LVDS
3	GND
4	-1PPS LVDS
5	+1PPS LVDS
6	GND
7	LOCK_OUT_OK
8	RX RS-232
9	TX RS-232
10	VBATT
11	PPS_IN
12	GND
13	10MHz CMOS
14	GND
15	+12V
16	+12V

Table 2.4 J6 pinout

Pin	Name
1	ZERO_ACK#
2	FORCE_ZERO#
3	GND
4	5V_PPS_IN
5	DS101 TX
6	DS101 FCI
7	DS101 FCO
8	GND
9	DS101 RX
10	COM2 TX
11	COM2 RX
12	5V 1PPS Out

Table 2.5 Miscellaneous connectors

Ref	Name	Function	Specification	Pinning
J2	ISP/RESET	ISP/RESET jumper	Ground pin 1 during reset or during power-on to activate ISP mode. Ground pin 3 momentarily to initiate hardware reset.	J2-1:ISP; J2-2:GND; J2-3:RST#
J8	Antenna	GPS Antenna	3V Amplified L1 / L2 Antenna, MMCX connector	Center:RF Input; Shield: GND
J9	Sine Out	10 MHz Sine-Wave Output	+8dBm +/-2dBm into 50 Ohms	Center: 10MHz; Shield: GND

2.3.2 Harness Connectors J1 and J6

The manufacturer for connectors J1 and J6 is Hirose. Mating housing part numbers for this connector is available from Digikey, and crimp pins are also available from Digikey for different wire sizes. The J1 mating connector is available at:

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

and the J6 mating connector is available at:

http://search.digikey.com/scripts/DkSearch/dksus.dll?Detail&name=H2024-ND

The part number of the J1 connectors soldered onto the T-3 and BDR configurations of the SAASM GPSDO PCB is:

Hirose DF11-16DP-2DS52

The part numbers of the J6 connector soldered onto the T-3 configuration PCB is:

Hirose DF11-12DP-2DSA01

The part number of the J6 connector soldered onto the BDR configuration PCB is:

Hirose DF11-12DP-2DS52

2.3.3 Connecting the GPS Antenna

Connect the GPS antenna to connector J8 using a BNC to MMCX cable adapter. Caution: use a Lightning Arrestor on your Antenna setup. For full operation with keys, use an amplified L1/L2 GPS antenna. The active antenna should be 3.3V LNA compatible and draw between 9.0 and 60.0 mA.

The SAASM 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.

The GPS receiver generates a 1PPS time signal that is phase synchronized to UTC. This 1PPS signal is used to frequency-lock the 10MHz output of the SAASM 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.

2.3.4 Low Phase Noise Sine-Wave Output

Only on the SAASM FireFly-IIA, the J9 MMCX connector outputs a low phase noise Sine-Wave output with an output amplitude of +8dBm nominal +/-2dBm.

2.4 Loop parameter adjustment

All loop parameters can be controlled via the serial ports.

Loop parameters are optimized for the Atomic or Ovenized 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 SAASM 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 2.7 when experiencing small perturbations.

2.5 Cold Zeroize

The Cold Zeroize function uses an internal microcontroller to command the MicroGRAM SAASM GPS receiver to perform a CV Zeroize operation using only battery power provided to the VBATT pin (J1-10). The Cold Zeroize function is only available when power provided to the VBATT pin and prime power removed from J1-15 and J1-16. The VBATT pin can be left unconnected if the Cold Zeroize function is not required

The Cold Zeroize function is activated by grounding or pulling low with an open collector output the FORCE_ZERO# pin (J6-2). During the zeroize operation, the ZERO_ACK# pin (J6-1) is driven high, and after the MicroGRAM acknowledges a successful zeroize operation, the ZERO_ACK# is driven low. If an attempt to zeroize is unsuccessful, the microcontroller will repeat the command to zeroize indefinitely until a successful zeroize is confirmed, or until the FORCE_ZERO# pin is no longer grounded. During the Cold Zeroize operation, the average power consumption with a 3V battery is 110 mW. When transitioning back to normal power operation, release the FORCE_ZERO# pin before applying prime power.

The Cold Zeroize Status LEDs D51 and D52 provide a visual indication of the Cold Zeroize state. For the locations of the Cold Zeroize Status LEDs, see Figure 2.1 for the T-3 and Figure 2.2 for the BDR boards. During prime power operation, LED D51 is on continuously and LED D52 is off. During Cold Zeroize operation, the LED D52 is on continuously and LED D51 is off. After confirmation of successful zeroize, LED D52 blinks once per second until the FORCE_ZERO# pin is no longer grounded.

2.6 DAGR Pass-Through Mode

In DAGR Pass-Through mode the PVT data including the 1PPS reference from an external DAGR device is used in place of the PVT data generated by the internal MicroGRAM receiver. Using a DAGR that already has a GPS fix, the SAASM GPSDO can immeadiately provide valid PVT data through the SCPI interface and discipline the CSAC oscillator. DAGR Pass-Through mode is especially useful when the internal MicroGRAM does not have valid almanac data and would take longer (up to 12.5 minutes) to download from the GPS satellites before a GPS fix and valid UTC time is available. The GPS:DAGR:MODE command described in Section 3.3.20 enables and disables the DAGR Pass-Through mode. The GPS:DAGR:PVTstate? query command described in Section 3.3.23 returns the status of the DAGR Pass-Through mode.

When in DAGR Pass-Through mode, the external DAGR can also provide Hot Start data to the internal MicroGRAM, so the MicroGRAM can immediately obtain a GPS fix. Hot start data includes, precise time, GPS alamanc and ephemeris data and current position. Once the SAASM GPSDO is in DAGR Pass-Through mode, a Hot-Start transfer is initiated on the DAGRs menu.

The external DAGR is connected through J6 pins 4 (5V_1PPS_IN), 10 (COM2 TX) and 11 (COM2 RX). The 5V_1PPS_IN pin should be connected to the 1PPS output of the DAGR. COM2 TX and

COM2 RX should be connected to the DAGR COM1 RX and TX respectively. Note that the TX and RX connections should be in a cross-over configuration.

2.7 Physical Dimensions

Figure 2.4 and Figure 2.5 show mechanical drawing of the SAASM HD CSAC GPSDO T-3 and BDR boards respectively. The board thickness is 63 mils with <0.1 inch height for all components on the bottom of the board. The tallest component on the top of the board is the CSAC oscillator with a height above the board of 0.45 inches. The mounting hole diameter are 125 mils.

Figure 2.6 shows the mechanical drawing of the SAASM FireFly-IIA. The physical dimensions of the SAASM FireFly-IIA are identical to the SAASM HD CSAC GPSDO BDR configuration with the exception of height. The tallest component on the SAASM FireFly-IIA is the DOCXO with a height above the board of 0.75 inches.

Figure 2.4 T-3 SAASM HD CSAC GPSDO Board Mechanical Drawing

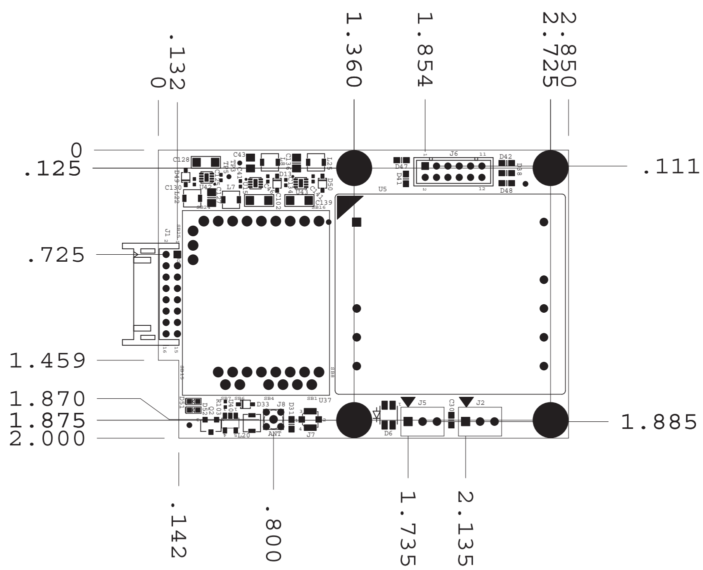


Figure 2.5 BDR SAASM HD CSAC GPSDO Board Mechanical Drawing

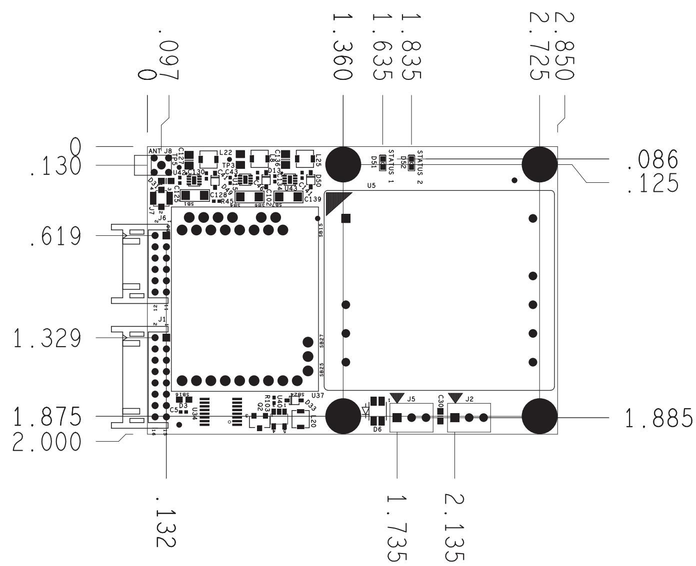


Figure 2.6 SAASM FireFly-IIA Board Mechanical Drawing

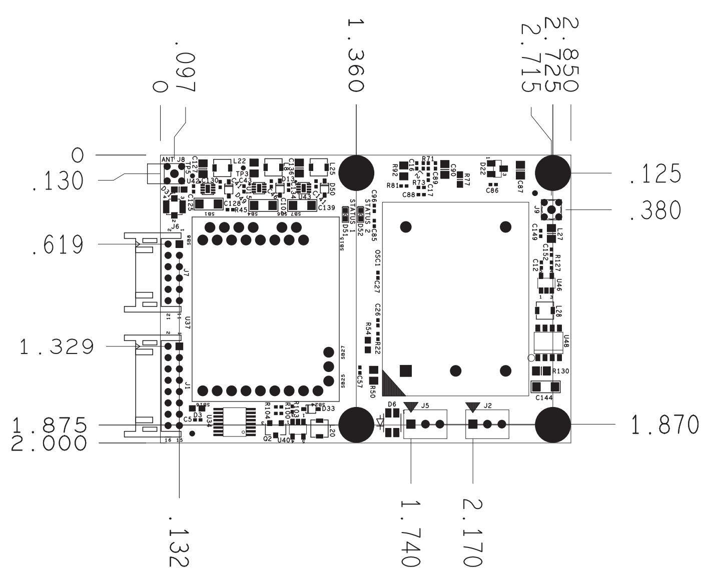
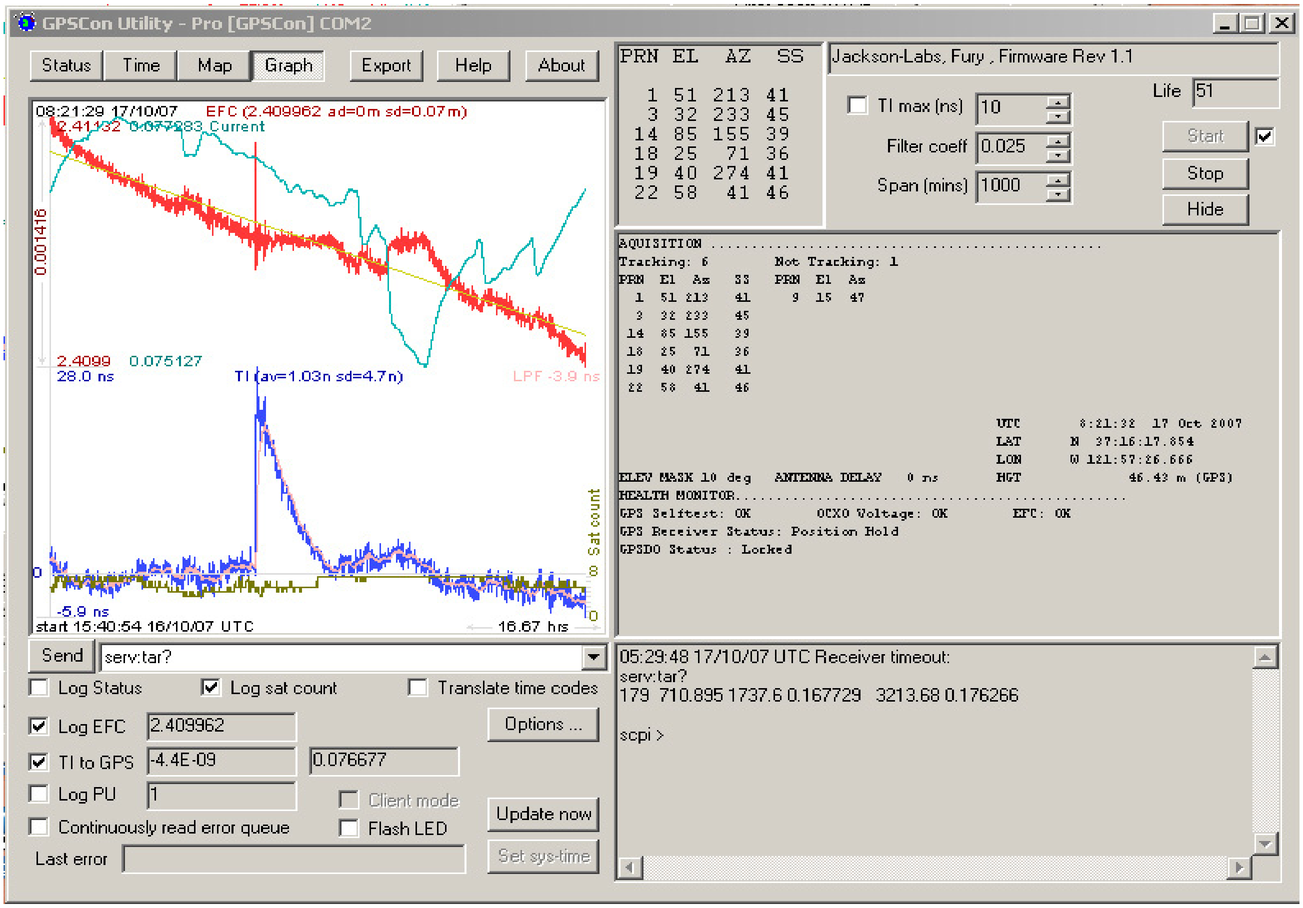


Figure 2.7 SAASM HD CSAC GPSDO phase compensation plot



2.8 Performance graphs

Figure 2.8 shows the typical Allan Deviation of the SAASM HD CSAC GPSDO unit when locked to GPS. ADEV performance approaches 1E-013 per day when locked to GPS. The plot shows that at averaging intervals of 1000 seconds and more the GPS disciplining algorithm starts to improve the performance of the CSAC oscillator.

Figure 2.8 Typical Allan Deviation of SAASM HD CSAC GPSDO when locked to GPS

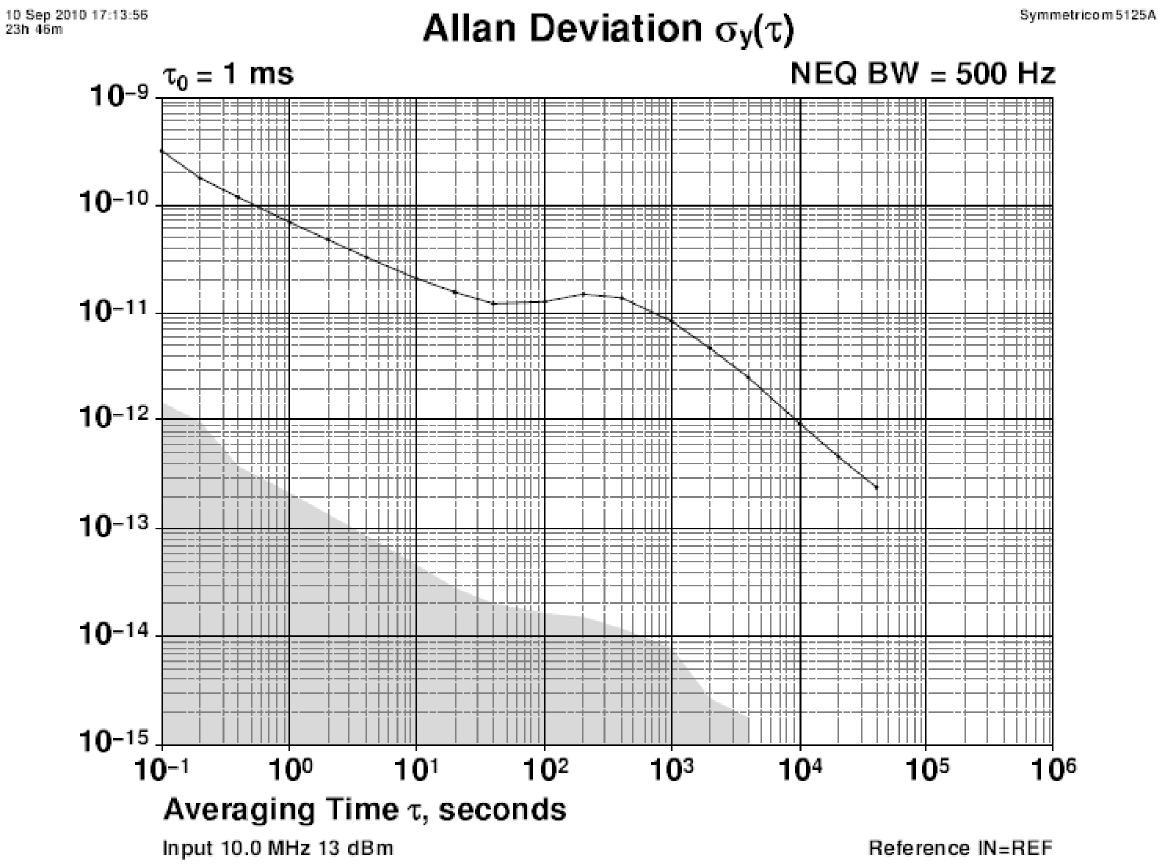
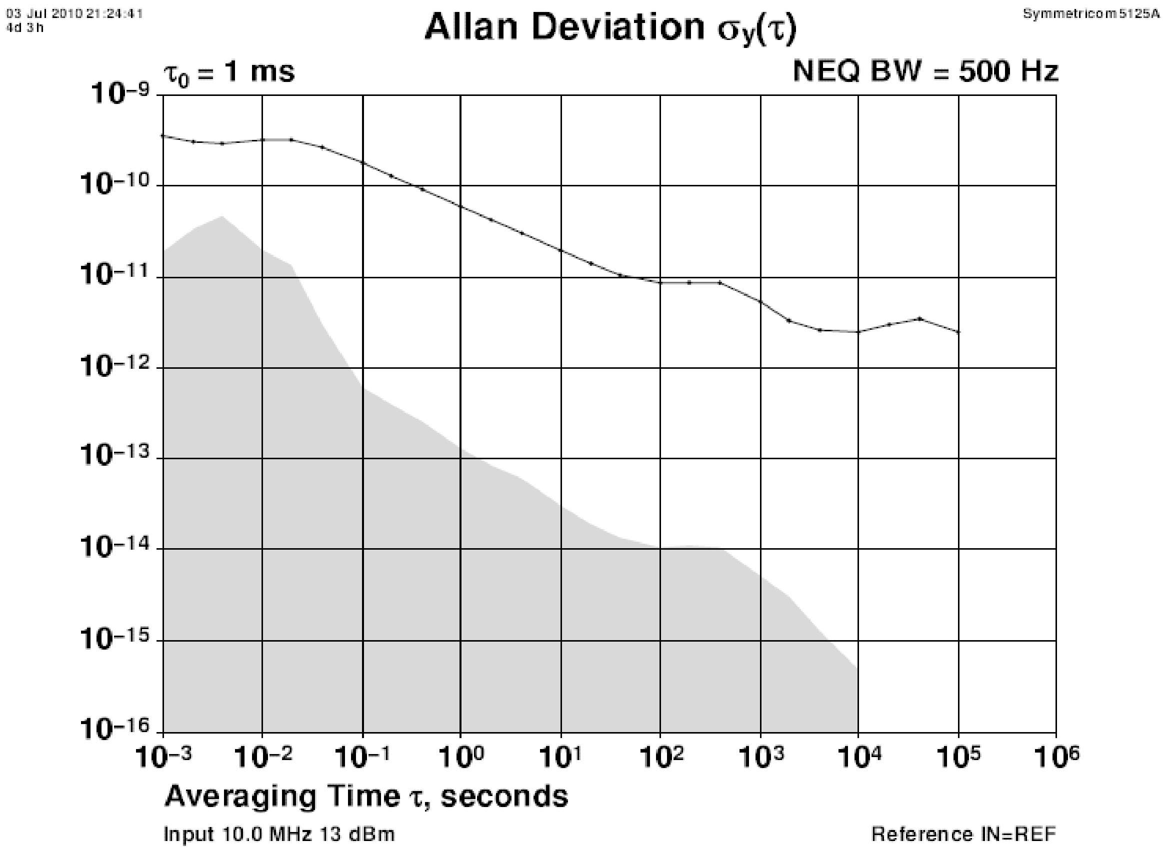


Figure 2.9 shows the Allan Deviation of the free running unit (GPS holdover, no GPS antenna is attached) is quite good, approaching 5E-012 over 100,000 seconds in this typical plot.

Figure 2.9 Typical Allan Deviation of free running CSAC



As shown in Figure 2.10, the Phase Noise of the SAASM HD CSAC GPSDO unit.

Figure 2.10 Typical Phase Noise of the SAASM HD CSAC GPSDO

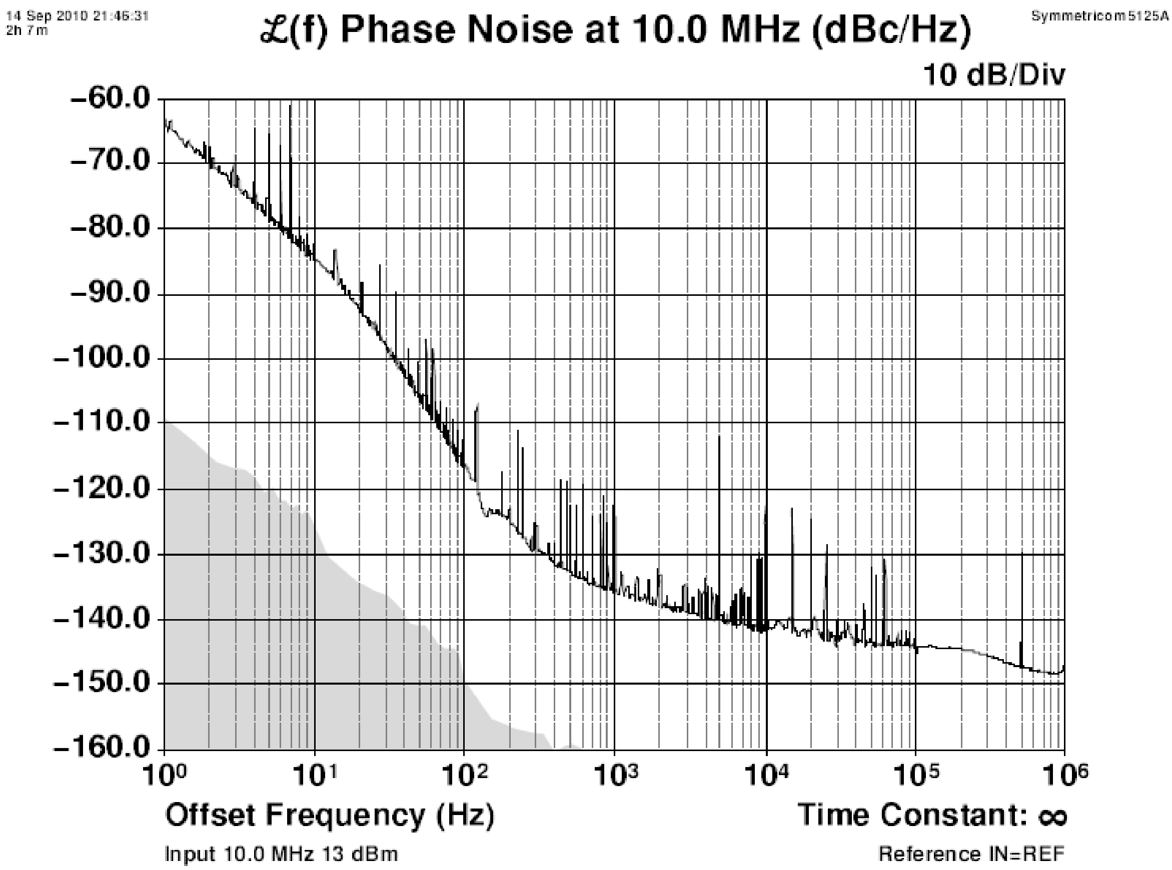


Figure 2.11 shows the typical Allan Deviation of the SAASM FireFly-IIA unit when locked to GPS. ADEV performance approaches XXX per day when locked to GPS. The plot shows that at averaging intervals of XXX seconds and more the GPS disciplining algorithm starts to improve the performance of the DOCXO oscillator.

Figure 2.11 Typical Allan Deviation of the SAASM FireFly-IIA when locked to GPS

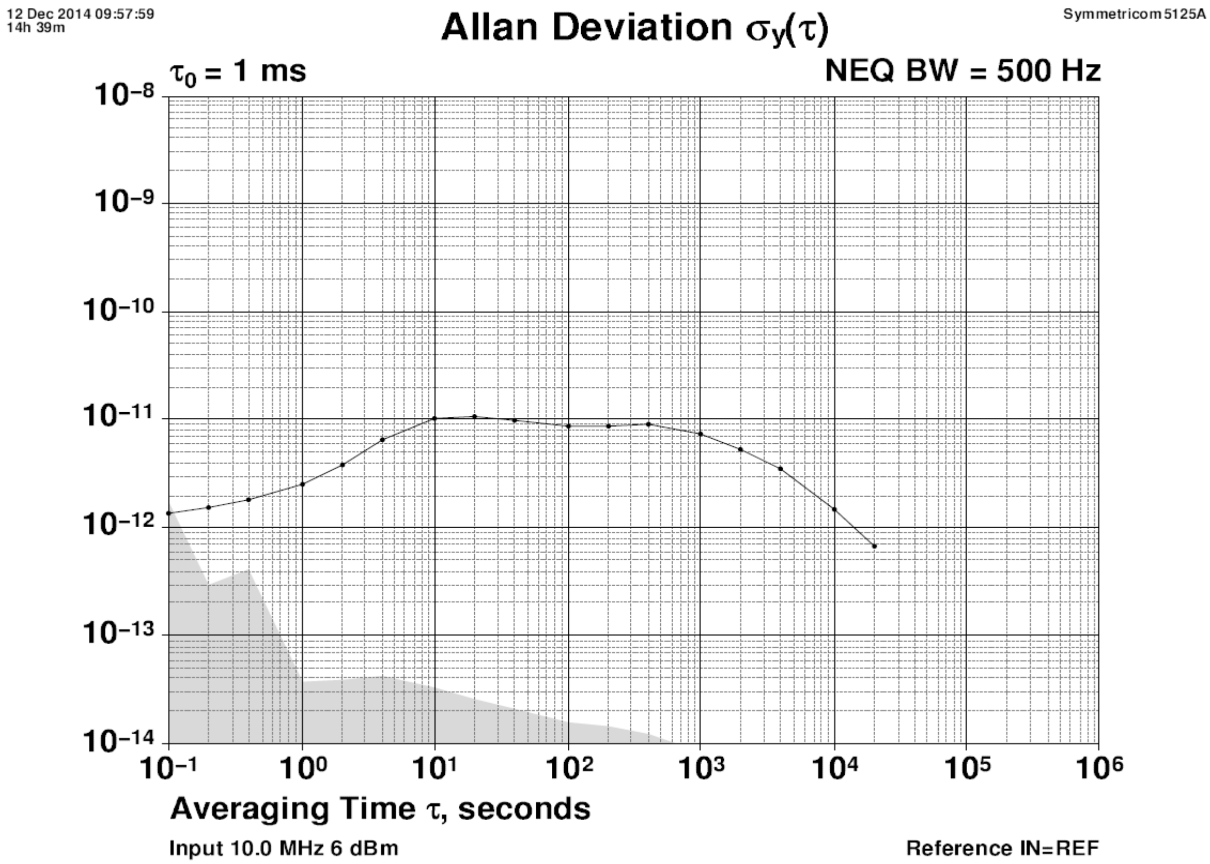
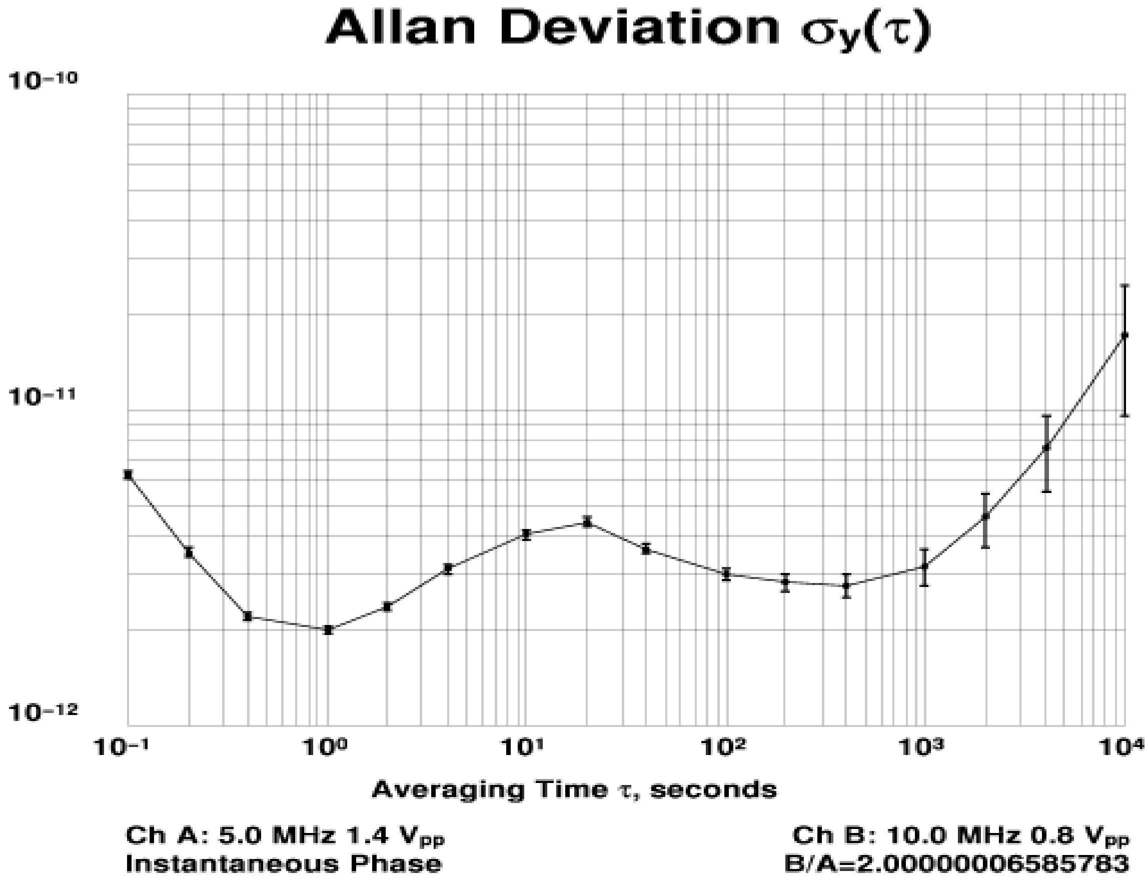


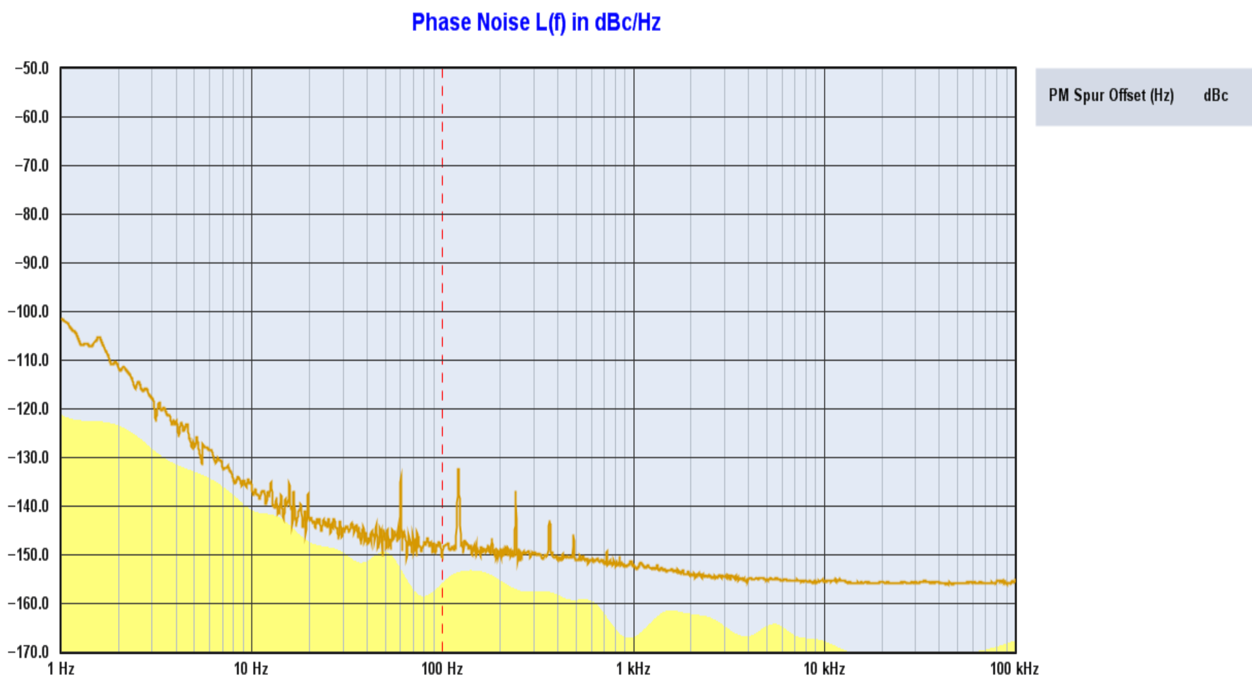
Figure 2.12 shows that the Allan Deviation of the free running SAASM FireFly-IIA (GPS holdover, no GPS antenna is attached) after 5+ days of calibration with GPS.

Figure 2.12 Typical Allan Deviation of free running DOCXO



As shown in Figure 2.13, the Phase Noise of the SAASM FireFly-IIA is quite good and shows very few spurs.

Figure 2.13 Typical Phase Noise of the SAASM FireFly-IIA



Trace	Notes	Input Freq	Sample Interval	dBc/Hz at 100 Hz	Duration	Acquired	Instrument
(Unsaved)		10.000 MHz	0.100 s		2h 27m 50s	88700 pts	TimePod 5330A
(Unsaved)		10.000 MHz	0.100 s		13m 2s	7822 pts	TimePod 5330A
(Unsaved)		10.000 MHz	0.100 s		1d 6h 0m 0s	1080001 pts	TimePod 5330A
(Unsaved)		10.000 MHz	0.100 s		3m 44s	2236 pts	TimePod 5330A
(Unsaved)		10.000 MHz	0.100 s		4m 25s	2650 pts	TimePod 5330A
(Unsaved)		10.000 MHz	0.100 s	−148.7	48 h	3600 pts	TimePod 5330A

3 SCPI-Control Quick Start Instructions

3.1 Introduction

The SAASM GPSDO has an RS-232 serial port that can be used for accessing the SCPI (**S**tandard **C**ommands for **P**rogrammable **I**nstrumentation) subsystem by using a host system terminal program such as TeraTerm or Hyperterminal. By default the terminal settings are 115200, 8N1. The serial interface can send out standard NMEA messages, while simultanteously accepting SCPI commands from the user.

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 SAASM GPSDO.

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

http://ivifoundation.org/scpi/

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:help?

syst:stat?

help?

gps?

sync?

diag?

3.2 General SCPI Commands

3.2.1 *IDN?

This query outputs an identifying string. The response will show the following information:

<model name>, Firmware Rev <firmware rev>

3.2.2 HELP?

This query returns a list of the commands available for the SAASM GPSDO.

3.3 GPS Subsystem

Note: Please note that SAASM 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.

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:GGASTat <int> [0,255]

GPS:GPRMC <int> [0,255]

GPS:GPZDA<int> [0,255]

GPS:GPGSV<int> [0,255]

GPS:PASHR<int> [0,255]

GPS:XYZSP<int> [0,255]

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

GPS:REFerence:PULse:SAWtooth?

GPS:RESET ONCE

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

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

GPS:FWver?

GPS?

GPS:DAGR:MODE <ON | OFF>

GPS:DAGR:MODE?

GPS:DAGR:XFERstate?

GPS:DAGR:PVTstate?

GPS:SASTAT:YTRACK?

GPS:SASTAT:CVZStatus?

GPS:SASTAT:CVKFStatus?

GPS:SASTAT:CVStatus?

GPS:SASTAT:VERification?

GPS:SASTAT:CVExp?

GPS:SASTAT:KDP?

GPS:SASTAT:ANTISpoof?

GPS:SASTAT <int> [0,255]

GPS:ZEROize START

GPS:ZEROize?

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 four commands allow the SAASM 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 SAASM GPSDO J1 RS-232 interface.

Once enabled, the SAASM GPSDO will send out information on the RS-232 transmit pin automatically every N seconds. All incoming RS-232 commands are still recognized by SAASM 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 SAASM 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 command is not supported in the SAASM GPSDO.

3.3.5 GPS:PORT?

This command is not supported in the SAASM GPSDO.

3.3.6 GPS:GPGGA

This command instructs the SAASM 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 SAASM 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 the section on 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 SAASM 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 SAASM 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 SAASM 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,eeeee.eeeee,f,ggggg.gg,hhhh,iii.ii,jjj.jj,kkkk.kk,ll.l,mm.m,nn.n,00.0,p.pp,*[checksum]

Where:

aa: Number of Sats

bbbbbb.00: Time of Day UTC

cccc.ccccc,d: Latitude,S/N

eeee.eeeee,f: Longitude,W/E

ggggg.gg: Antenna Height in meters

hhhh: Four fixed '?' symbols

iii.ii: Course Over Ground

jjj.jj: Speed in Knots

kkkk.k: Vertical Velocity in meters/s

ll.l: PDOP

mm.m HDOP

nn.n VDOP

00.0 Static number

p.pp: Firmware version

This command instructs the SAASM 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 not supported in the SAASM GPSDO.

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

This command is not supported in the SAASM GPSDO.

3.3.14 GPS:REFerence:PULse:SAWtooth?

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

3.3.15 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.

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

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 3.4.5 to allow automatic time and date synchronization of two units to each other. The internal RTC is driven by the highly stable 10MHz reference oscillator (CSAC or DOCXO), and thus has very high accuracy.

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

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 3.4.5 to allow automatic time and date synchronization of two units to each other. The internal RTC is driven by the highly stable 10MHz reference oscillator (CSAC or DOCXO), and thus has very high accuracy.

3.3.18 GPS:FWver?

This command returns the firmware version used inside the GPS receiver itself. The expected format of the firmware version from the MicroGRAM receiver is xxx-xxxx-xxx were x are decimal digits.

3.3.19 GPS?

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

3.3.20 GPS:DAGR:MODE <ON | OFF>

This command sets the DAGR pass-through mode. When DAGR pass-through mode is ON,external DAGR PVT data including the 1PPS reference is passed through the internal MicroGRAM receiver and provided in place of PVT data from the internal MicroGRAM. The GPS:DAGR:PVTstate? query response described in Section 3.3.23 indicates if the MicroGRAM has successfully transitioned to DAGR PVT mode.

When DAGR pass-through mode is ON, the internal MicroGRAM can also accept Hot-Start data from the external DAGR. Once the MicroGRAM has successfully transitioned to DAGR PVT mode, the hot start is typically initiated from the external DAGR. The GPS:DAGR:XFERstate query response described in Section 3.3.22 indicates the success or failure of an attempted hot start.

3.3.21 GPS:DAGR:MODE?

This query displays the current DAGR pass-through mode. This command does not indicate the success or failure of entering the DAGR pass-through mode, but only the currently selected mode from the GPS:DAGR:MODE command. Use the GPS:DAGR:PVTstate? query to determine the success or failure of entering DAGR pass-through mode.

3.3.22 GPS:DAGR:XFERstate?

This query displays the DAGR / Hot-Start Transfer Status using the values in the following table:

Value	Status
0	None, no transfer initiated
1	In Progress
2	Done
3	Error

3.3.23 GPS:DAGR:PVTstate?

This query displays the DAGR pass-through status using the values in the following table:

Value	Status
0	None, DAGR pass-through mode off
1	Initializing
2	Done
3	Error

3.3.24 GPS:SASTAT:YTRACK?

This query displays the number of satellites being tracked in Y-Code. If the MicroGRAM is not keyed, this value should always be 0. The maximum value is 12.

3.3.25 GPS:SASTAT:CVZStatus?

This query displays the CV Zeroize Status using the values in the following table:

Value	Status
0	Verified
1	Failed
2	None, not attempted

3.3.26 GPS:SASTAT:CVKFStatus?

This query displays the Key Fill Status using the values in the following table:

Value	Status
0	Not Valid
1	Valid

The Key Fill Status will indicate Valid for atleast 1 second to indicate a valid key fill operation. To avoid missing the Valid response, the Key Fill Status can also be monitored continuously by monitoring field d of the periodic $SASTAT output described in Section 3.3.32 .

3.3.27 GPS:SASTAT:CVStatus?

This query displays the CV Status using the values in the following table:

Value	Status
0	Not Keyed
1	Keyed

3.3.28 GPS:SASTAT:VERification?

This query displays the Verification Status using the values in the following table:

Value	Status
0	CV Verified
3	Nav Pending
5	Not Current
7	No CVs

3.3.29 GPS:SASTAT:CVExp?

This query displays the CV Expiration Status using the values in the following table:

Value	Status
0	No
1	Yes, yes if expiration iminent

3.3.30 GPS:SASTAT:KDP?

This query displays the KDP Health Status using the values in the following table:

Value	Status
0	Alive
1	Dead

3.3.31 GPS:SASTAT:ANTISpoof?

This query displays the Anti-Spoof Status using the values in the following table:

Value	Status
0	OK
1	Error

3.3.32 GPS:SASTAT <int> [0,255]

This command instructs the SAASM GPSDO to send the $SASTAT proprietary NMEA output sentence every N seconds, with N in the interval [0,255]. The command is disabled during the initial 2 minute CSAC warm-up phase. This command has the following format:

GPS:SASTAT <int> [0,255]

The $SASTAT output gives all status information from all of the DAGR and SAASM-related queries described in Sections 3.3.20 through 3.3.31 . The $SASTAT command has the following format:

$SASTAT,hhmmss.sss,aa,b,c,d,e,f,g,h,i,j,k*[checksum]

Where:

hhmmss.sss: Current UTC Time at the start of the previous second

aa: Number of Satellites in Y-Code Track

b: CV Zeroize Status

c: CV Status

d: CV Fill Status

e: Verification Status

f: CV Expiration Status

g: KDP Health Status

h: Anti-Spoof Status

i: DAGR Transfer Status

j: DAGR PVT State

k: DAGR PVT Mode

The [checksum] follows the NMEA standard checksum.

3.3.33 GPS:ZEROize START

This command starts the CV Zeroize operation on the MicroGRAM receiver. The START parameter must be included, otherwise the command is not accepted. The format of this command is:

GPS:ZEROize START

The response from the GPS:SASTAT:CVZStatus? query provides the result of the CV Zeroize operation.

3.3.34 GPS:ZEROize?

This query displays the CV Zeroize Status and is equivalent to the GPS:SASTAT:CVZStatus? query described in Section 3.3.25 .

3.4 PTIME Subsystem

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

PTIMe:DATE?

PTIMe:TIME?

PTIMe:TIME:STRing?

PTIMe:TINTerval?

PTIME:OUTput <on|off>

PTIMe:LEAPsecond?

PTIME?

3.4.1 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.

3.4.2 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.

3.4.3 PTIMe:TIME:STRing?

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

3.4.4 PTIMe:TINTerval?

This query is equivalent to the command SYNChronization:TINTerval

3.4.5 PTIME:OUTput <ON | OFF>

This command allows for auto-initialization of time and date between to Jackson Labs Technologies, Inc. GPSDO units. Initialization of time and date is accomplished by 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 master unit to automatically generate GPS:INIT:DATE and GPS:INIT:TIME sentences on the serial port once per second.

3.4.6 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).

3.4.7 PTIME?

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

PTIME:DATE?

PTIME:TIME?

PTIME:TINTerval?

PTIME:OUTput?

PTIME:LEAPsecond?

3.5 SYNChronization Subsystem

This subsystem regroups the commands related to the synchronization of the SAASM 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?

3.5.1 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.

3.5.2 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.

3.5.3 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.

3.5.4 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 SAASM 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>

3.5.5 SYNChronization:SOURce:STATE?

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

3.5.6 SYNChronization:TINTerval?

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

3.5.7 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.

3.5.8 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.

3.5.9 SYNChronization:LOCKed?

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

3.5.10 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.

3.5.11 SYNChronization:OUTput:1PPs:RESET?

This query returns the 1PPS output on reset setting.

3.5.12 SYNChronization:OUTput:FILTer <ON | OFF>

This command is not supported in the SAASM GPSDO.

3.5.13 SYNChronization:OUTput:FILTer?

This command is not supported in the SAASM GPSDO.

3.5.14 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 OCXO coarse-DAC is maxed-out at 255*	HEALTH STATUS |= 0x1;
If the OCXO coarse-DAC is mined-out at 0*	HEALTH STATUS |= 0x2;
If the phase offset to UTC is >250ns	HEALTH STATUS |= 0x4;
If the run-time is < 300 seconds	HEALTH STATUS |= 0x8;
If the GPS is in holdover > 60s	HEALTH STATUS |= 0x10;
If the Frequency Estimate is out of bounds	HEALTH STATUS |= 0x20;
If the 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;

* SAASM FireFlyFireFly-IIA only.

** SAASM HD CSAC GPSDO only.

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.

3.5.15 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- or DOCXO-generated 1PPS with the GPS generated UTC 1PPS phase. The CSAC/DOCXO 1PPS phase is allowed to drift up to this threshold before a jam-sync is initiated. The CSAC/DOCXO 1PPS 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.

3.5.16 SYNChronization?

This query returns the results of these 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?

3.6 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?

3.6.1 DIAGnostic:ROSCillator:EFControl:RELative?

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

3.6.2 DIAGnostic:ROSCillator:EFControl:ABSolute?

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

3.6.3 DIAGnostic:LIFetime:COUNt?

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

3.6.4 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

3.7 MEASURE Subsystem

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

3.7.1 MEASure:TEMPerature?

Displays the PCB temperature around the CSAC/DOCXO oscillator.

3.7.2 MEASure:VOLTage?

This command displays the CSAC steering voltage and is only supported on the SAASM HD CSAC GPSDO.

3.7.3 MEASure:CURRent?

Legacy SCPI command, command displays the internal CSAC temperature and is only supported on the SAASM HD CSAC GPSDO.

3.7.4 MEASure:POWersupply?

Displays the power supply input voltage.

3.7.5 MEASure?

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

MEASure:TEMPerature?

MEASure:VOLTage?

MEASure:CURRent?

MEASure:POWersupply?

3.8 SYSTEM Subsystem

This subsystem regroups the commands related to the general configuration of the SAASM 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:COMMunicate:USB:BAUD <9600 | 19200 | 38400 | 57600 | 115200>

SYSTem:COMMunicate:USB:BAUD?

SYSTem:STATus?

3.8.1 SYSTem:COMMunicate:SERial:ECHO

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

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

3.8.2 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>

3.8.3 SYSTem:COMMunicate:SERial:BAUD

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

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

3.8.4 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.

3.8.5 SYSTem:ID:SN?

This query returns the serial number of the board

3.8.6 SYSTem:ID:HWrev?

This query return the Hardware version of the board

3.8.7 SYSTem:STATus?

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

3.9 SERVO Subsystem

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

SERVo:COARSeDac <int> [0,255]

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:PHASECOrrection <float> [-500.0, 500.0]

SERVo:1PPSoffset <int> ns

SERVo:TRACe <int > [0,255]

SERVo?

3.9.1 SERVo:COARSeDac

This command is supported only on the SAASM FireFly-IIA and sets the coarse DAC that controls the EFC. The SAASM FireFly-IIA control loop automatically adjusts this setting. The user should not have to change this value.

This command has the following format:

SERVo:COARSeDac <int> [0,255]

3.9.2 SERVo:DACGain

This command is used for factory setup.

3.9.3 SERVo:EFCScale

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

3.9.4 SERVo:EFCDamping

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

SERVo:EFCDamping <int>[2 , 4000]

3.9.5 SERVo:TEMPCOmpensation

This command is only supported on the SAASM FireFly-IIA. This parameter is a coefficient that reflects the correlation between the temperature of the DOCXO versus the required frequency steering. Monitoring the tempco and aging parameters provides a mechanism to track the health of the DOCXO 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]

3.9.6 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/DOCXO 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]

3.9.7 SERVo:PHASECOrrection

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

SERVo:PHASECOrrection <float> [-500.0, 500.0]

3.9.8 SERVo:1PPSoffset

This command sets the SAASM 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:

SERVo:1PPSoffset <int> ns

3.9.9 SERVo:TRACe

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

This command has the following format:

SERVo:TRACe <int > [0,255]

An example output is described here:

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

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

Please see the **SYNChronization: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

3.9.10 SERVo?

This command returns the result of the following queries:

SERVo:COARSeDac?

SERVo:DACGain?

SERVo:EFCScale?

SERVo:EFCDamping?

SERVo:TEMPCOmpensation?

SERVo:AGINGcompensation?

SERVo:PHASECOrrection?

SERVo:1PPSoffset?

SERVo:TRACE : 0

3.10 CSAC Subsystem

The following commands are used to query the microcontroller built into the CSAC oscillator itself. Commands in the CSAC Subsystem are not supported on the SAASM Firely-IIA.

3.10.1 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.

3.10.2 CSAC:STeer?

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

3.10.3 CSAC:STATus?

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

Alarm	**Definition**
0	Locked
1	Microwave Frequency Steering
2	Microwave Frequency Stabilization
3	Microwave Frequency Acquisition
4	Laser Power Acquisition
5	Laser Current Acquisition
6	Microwave Power Acquisition

Alarm	Definition
0	Locked
7	Heater equilibration
8	Initial warm-up
9	Asleep (ULP mode only)

3.10.4 CSAC:ALarm?

This query returns the Alarm value as shown below:

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

3.10.5 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

3.10.6 CSAC:CONTrast?

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

3.10.7 CSAC:LASer?

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

3.10.8 CSAC:TCXO?

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

3.10.9 CSAC:SIGnal?

This query returns the indication of signal level.

3.10.10 CSAC:HEATpackage?

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

3.10.11 CSAC:TEMP?

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

3.10.12 CSAC:FWrev?

This query returns the Firmware version of the CSAC unit.

3.10.13 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.

3.10.14 CSAC:LIFEtime?

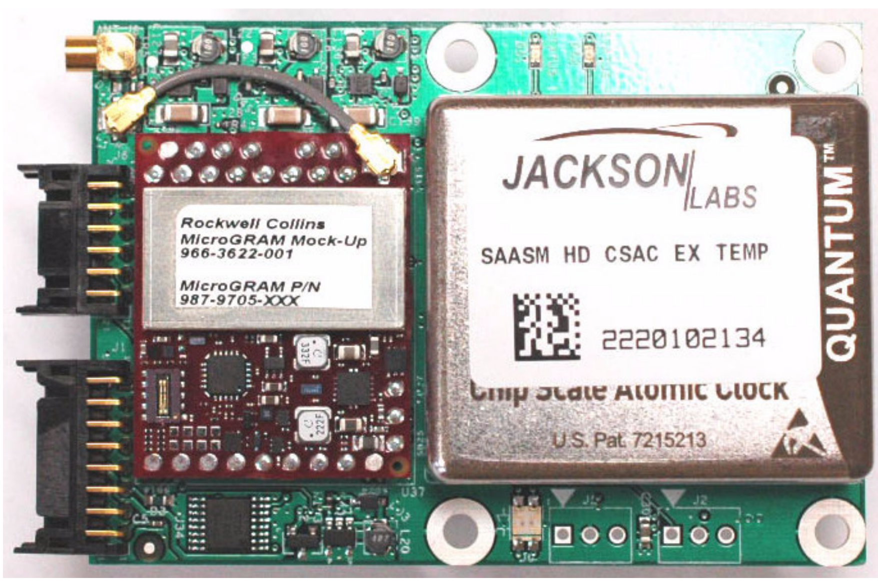
This query returns the accumulated number of hours that the CSAC has been powered on since the last factory reset of the SAASM HD CSAC GPSDO board. The value is stored in the external NVRAM and updated every hour when the CSAC is powered on.

3.10.15 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

3.10.16 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 SAASM GPSDO firmware. Please follow the instructions in order to prevent corrupting the SAASM GPSDO Flash, which may require reflashing at the factory.

With some practice, the entire Flash upgrade can be done in less than one minute, even though the following 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 SAASM 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 LPC1768 processor used on the SAASM 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 for the T-3 and Figure... for the BDR boards). 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 on T-3 Board

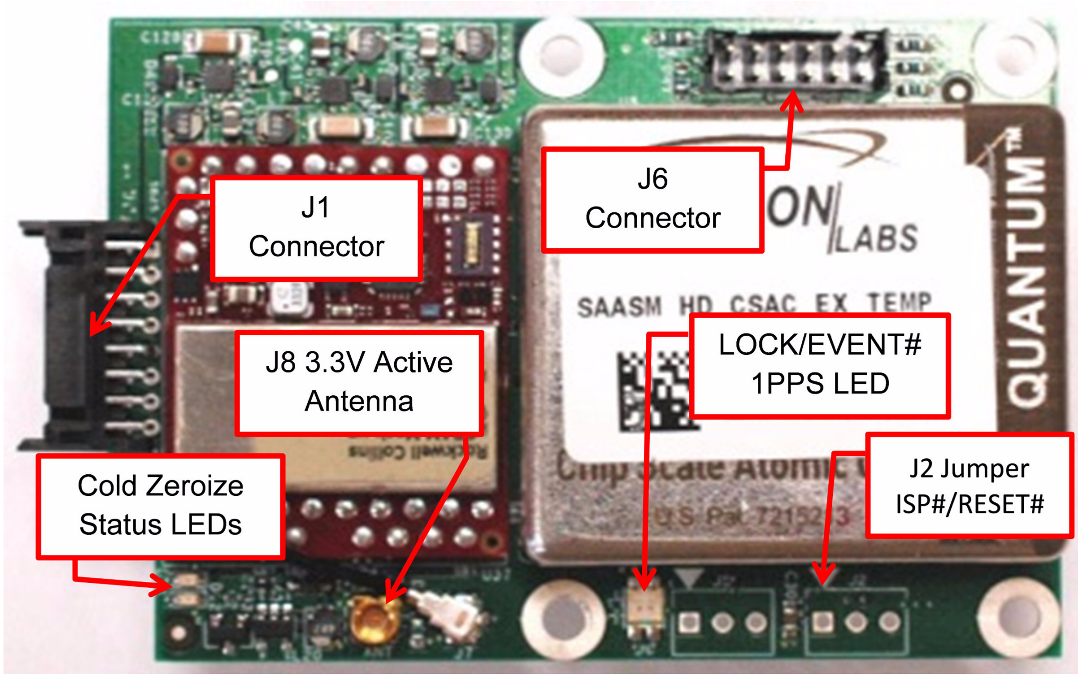
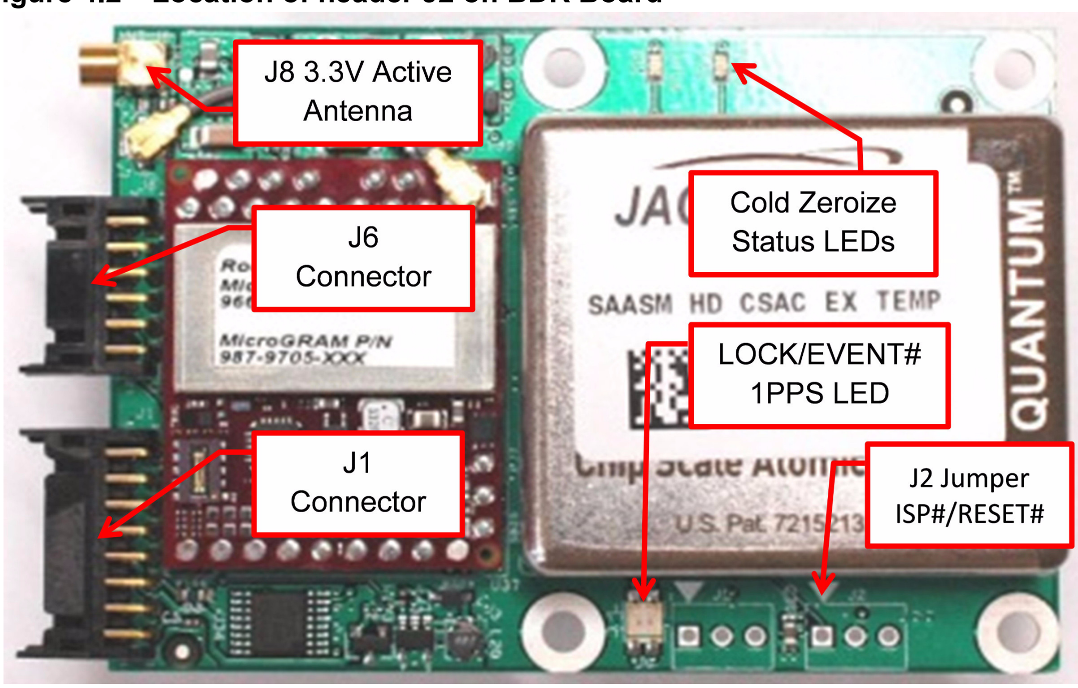


Figure 4.2 Location of header J2 on BDR Board



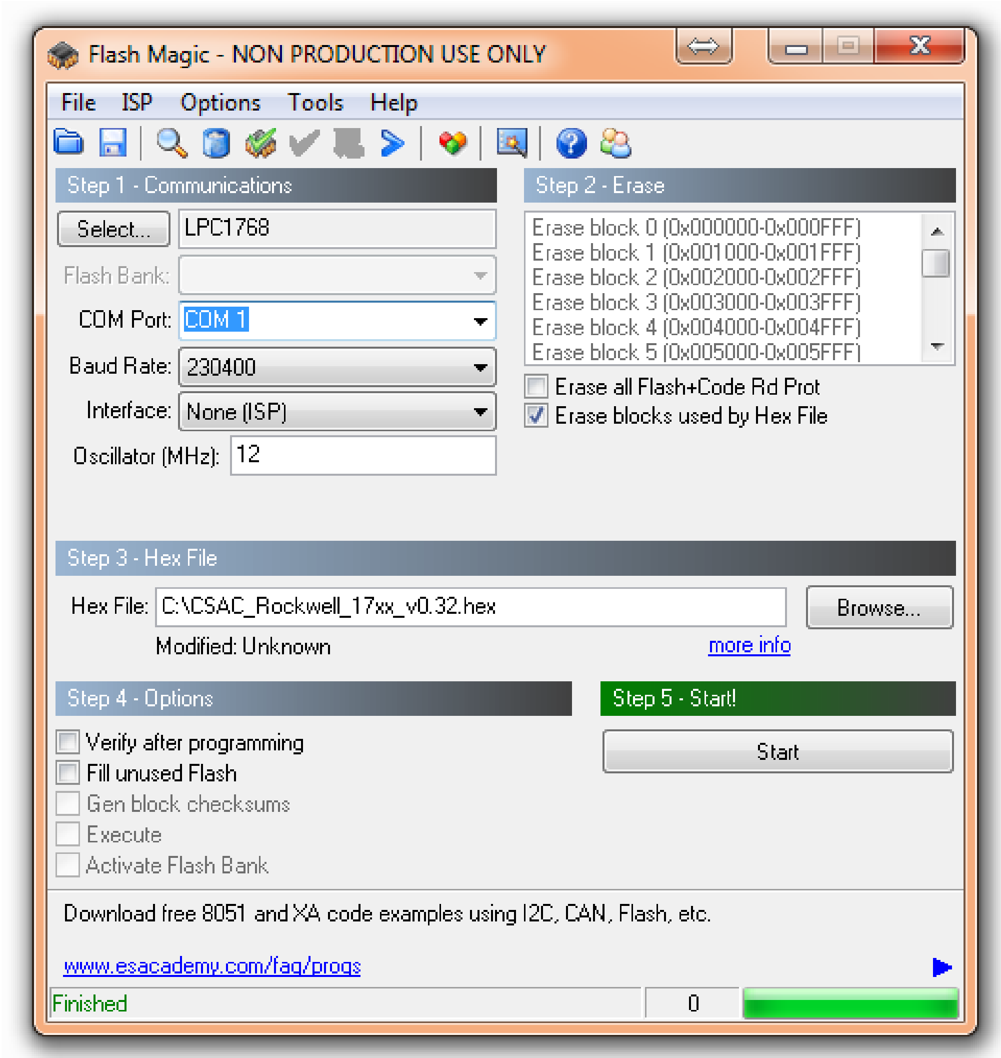
4.4 Downloading the Firmware

Download the latest version of SAASM GPSDO firmware from the Jackson Labs Technologies, Inc. support website and store it in a place that will be remembered. The firmware executable file for the T-3 and BDR boards are identical. 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 SAASM GPSDO as indicated in Section 2.3 .

4.4.1 Using the Flash Magic Flash Programming Utility

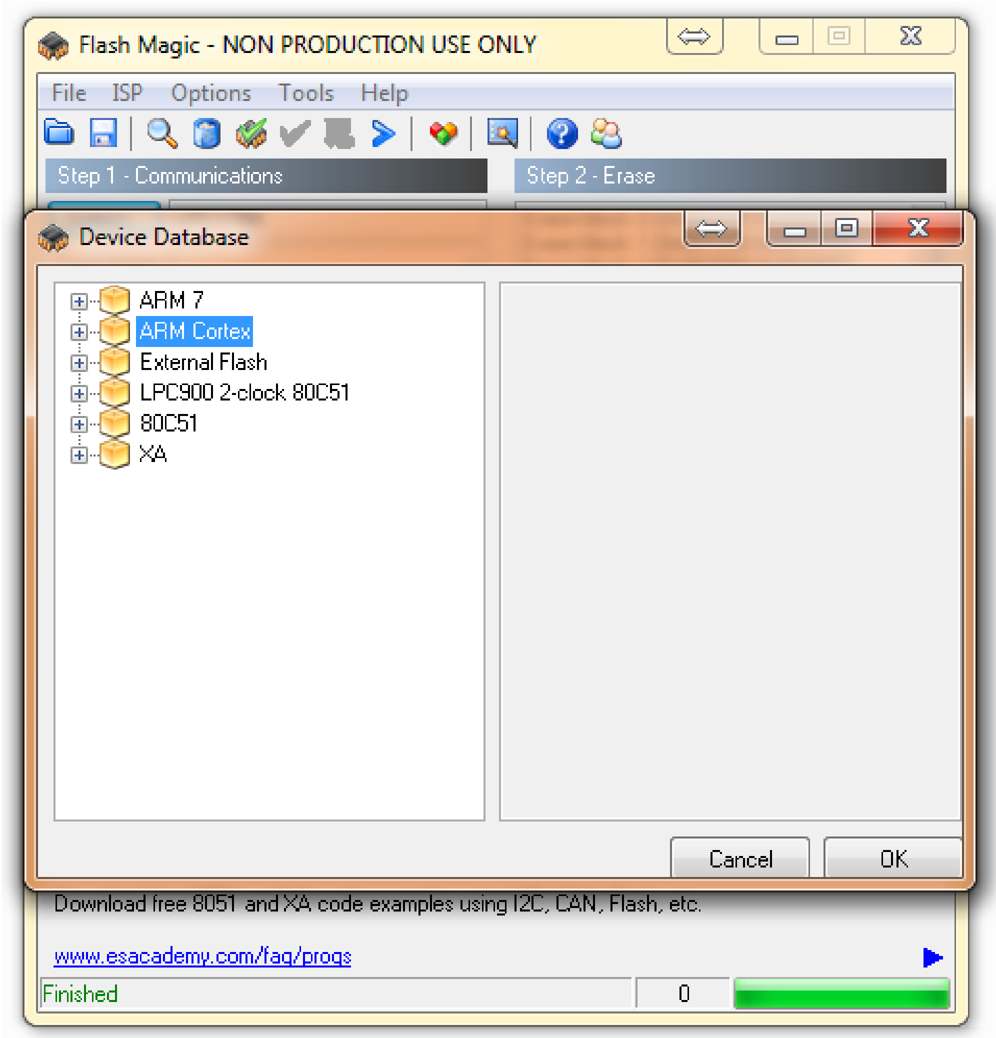
A) Open the Flash Magic utility. Set the COM port in the Flash Magic application as needed on your PC. Set "Interface" to "None (ISP)".

Figure 4.3 Flash Magic programming utility



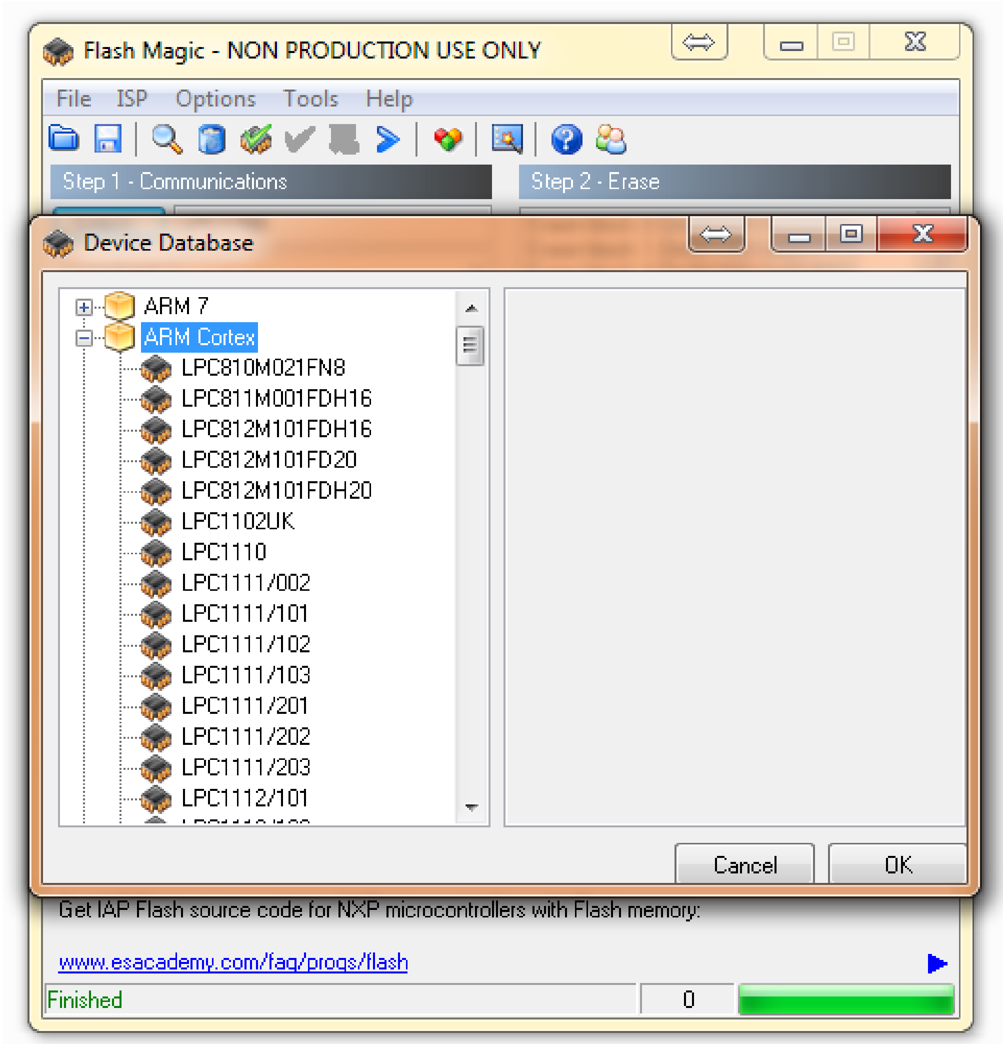
B) Press the "Select Device" button and the window shown in Figure 4.4 will appear:

Figure 4.4 Device selection window



C) Expand the ARM Cortex folder and select the appropriate processor, in this case the LPC1768.

Figure 4.5 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 SAASM 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 Z83XX utility is a PC monitor program for GPS Disciplined References (GPSR) which communicate using theSCPI (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

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.

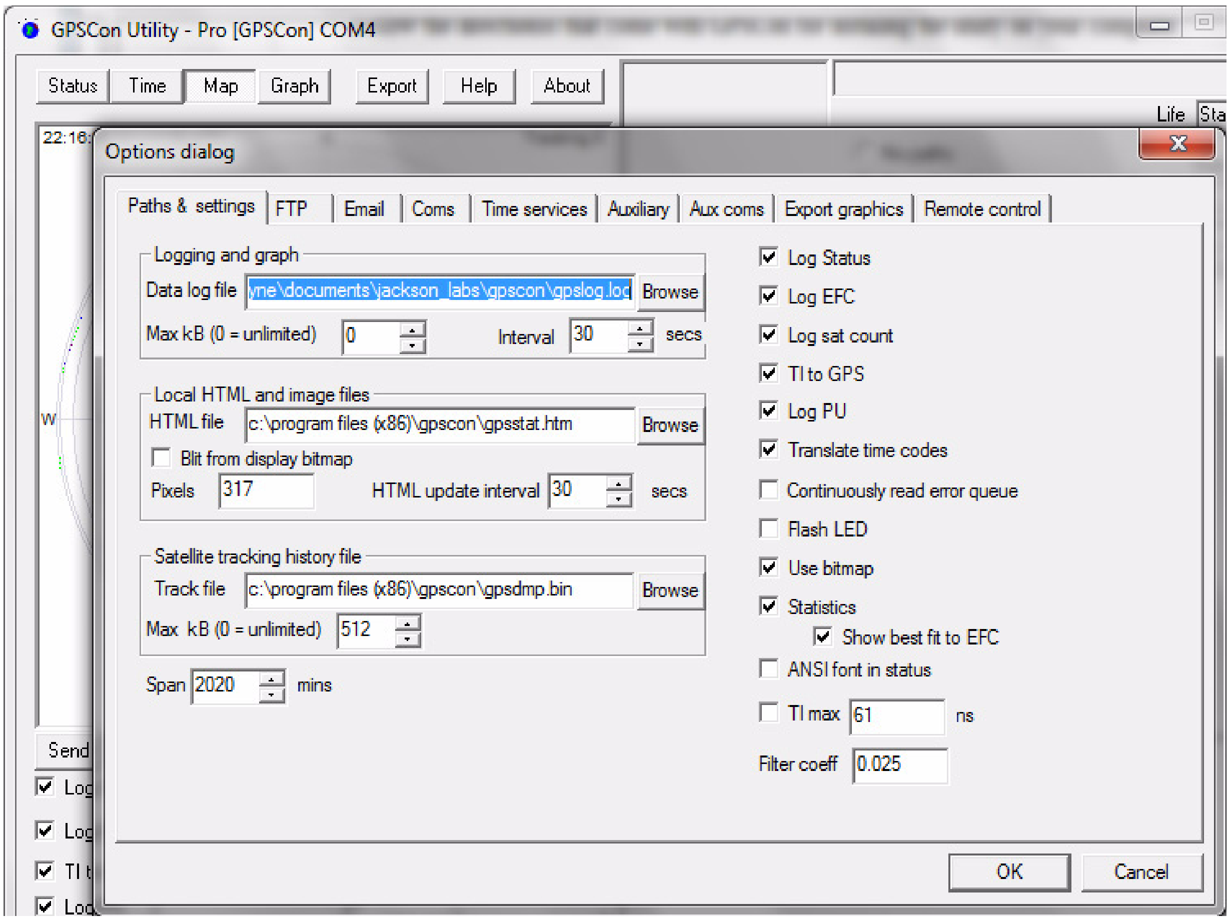
5.4 Using GPSCon

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

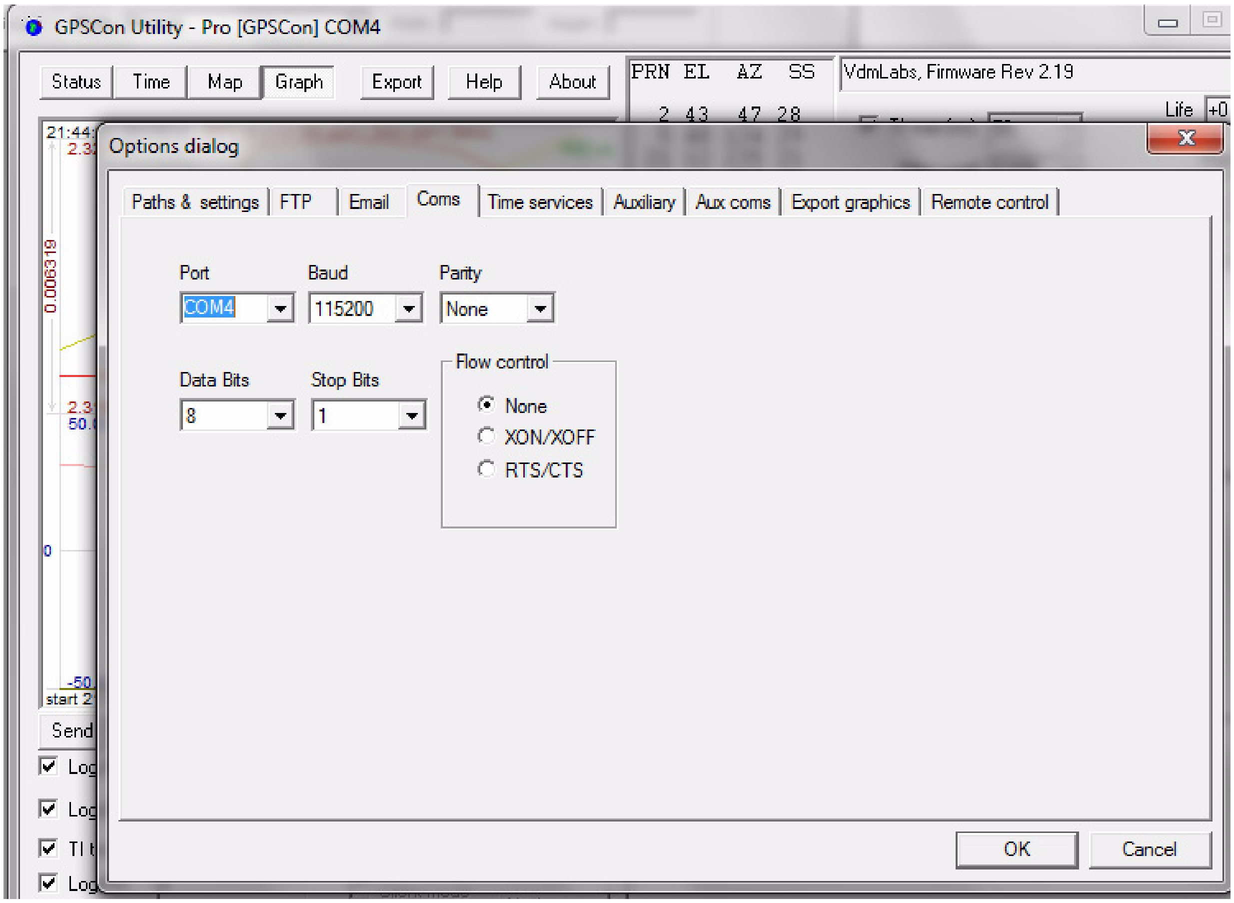
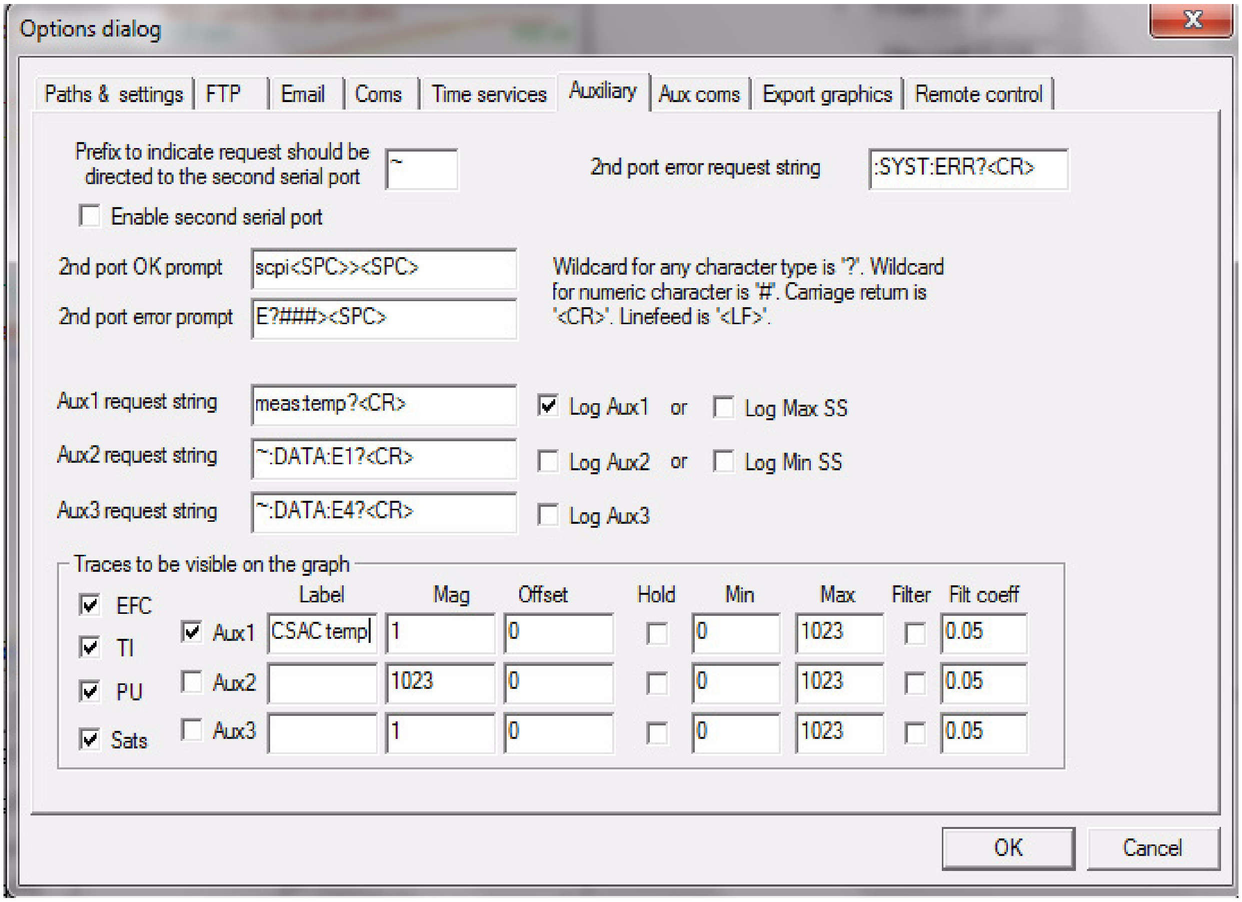


Figure 5.3 Auxiliary parameters window



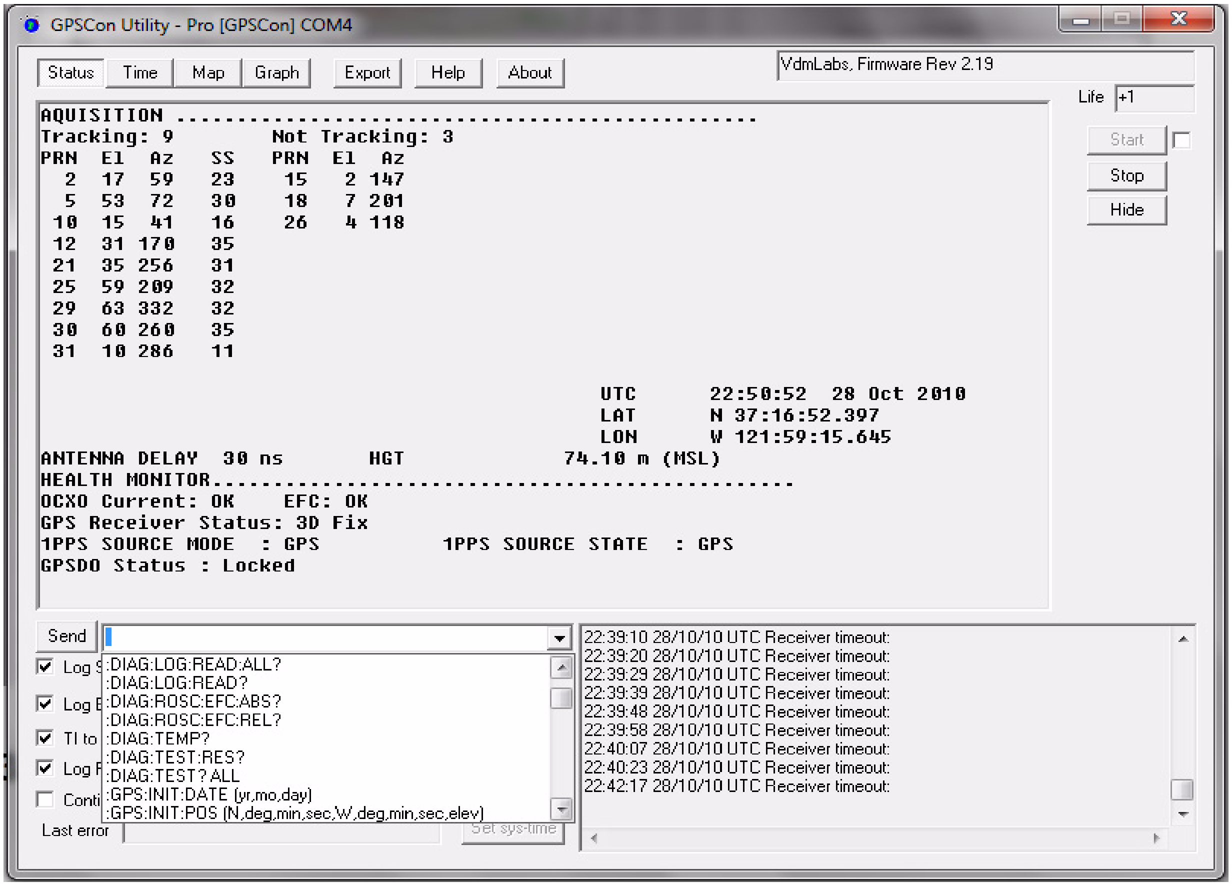
5.4.1.3 Other options

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

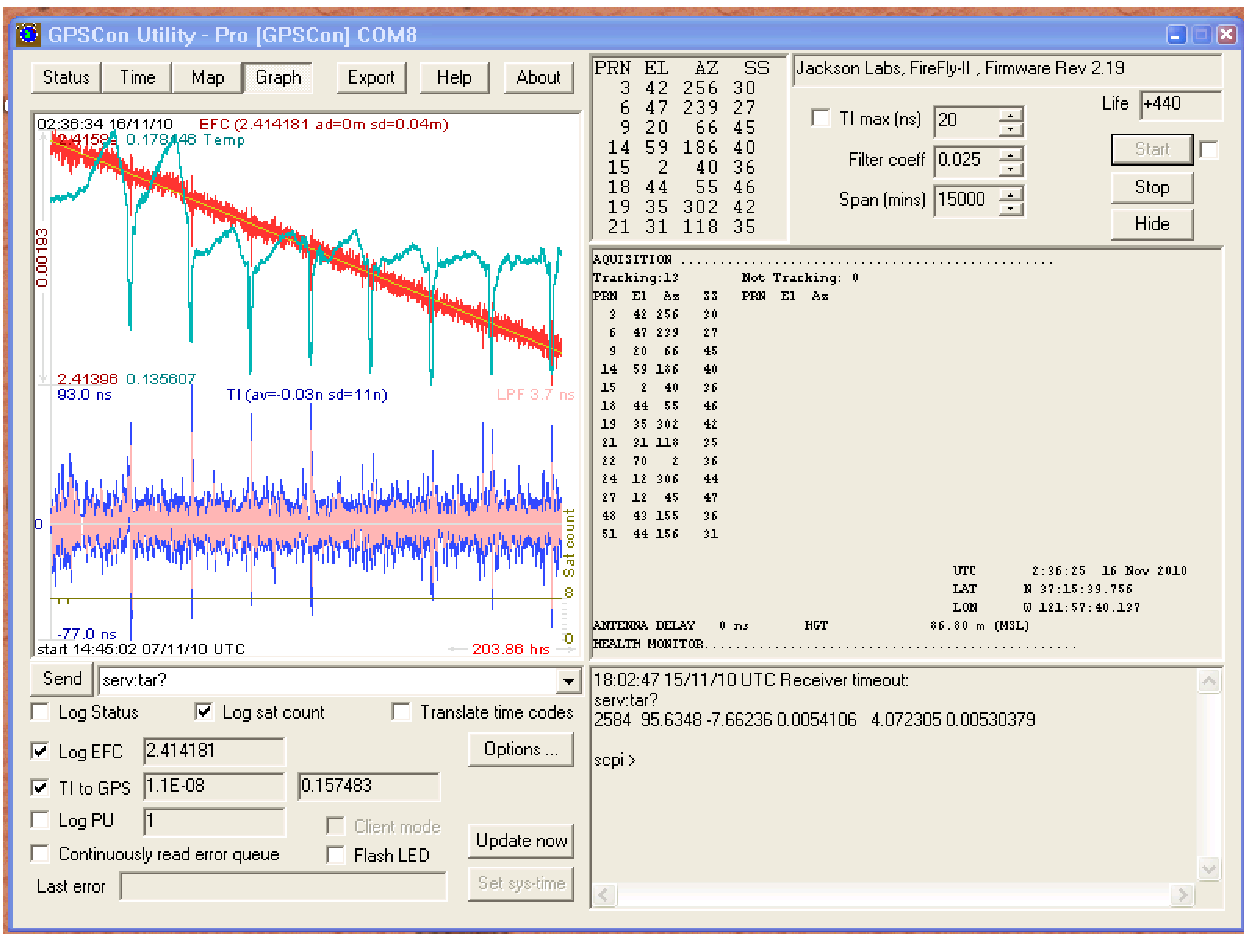
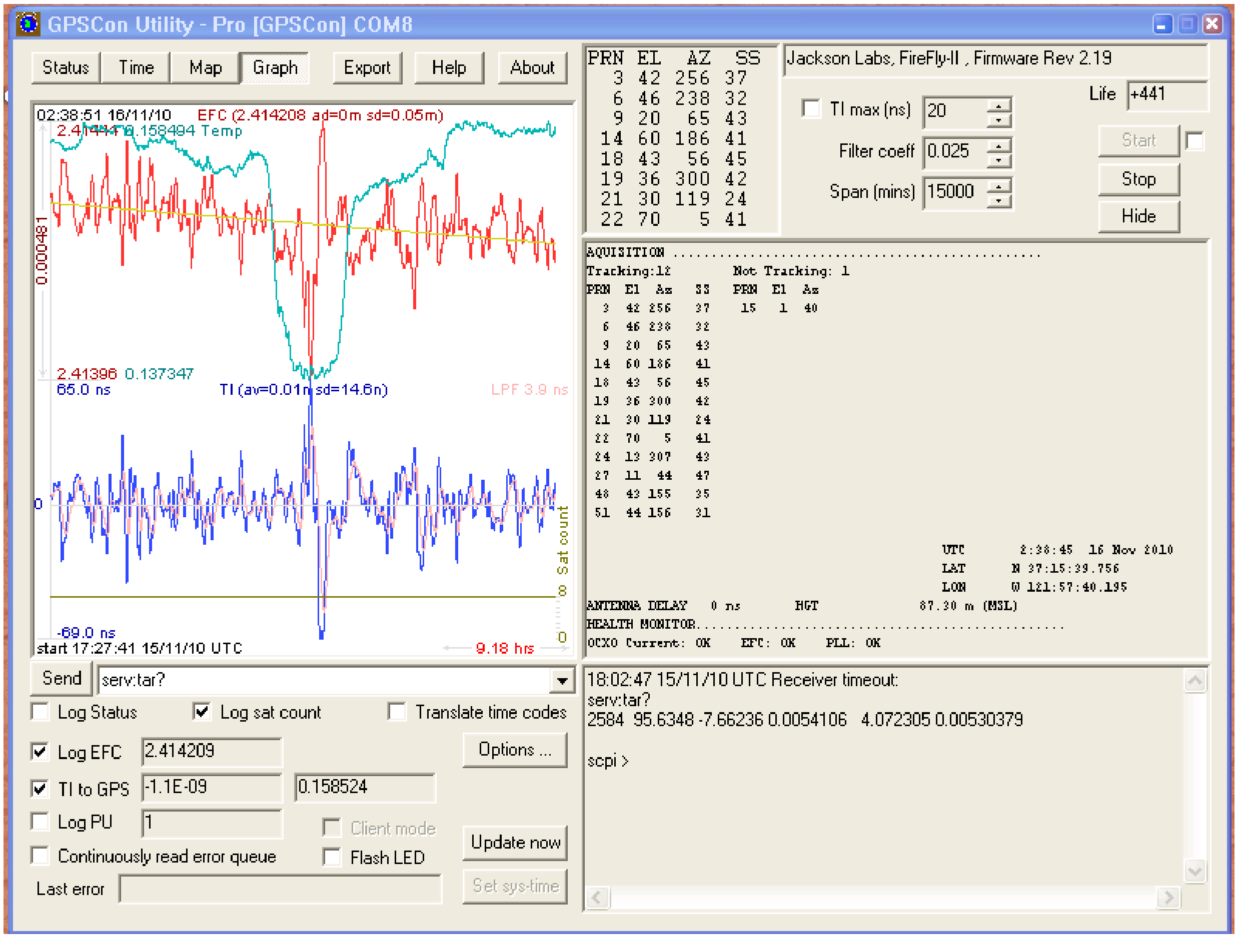


Figure 5.6 Expanded Graph Display



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**

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