Jackson Labs

Fury User Manual

Document: 80200505
Version: 1.1
Date: 9 March, 2011

Fury User Manual

Copyright © 2010, 2011 Jackson Labs Technologies, Inc.

1 Introduction . . . 1
1.1 Overview . . . 1
1.2 General Safety Precautions . . . 1
1.2.1 Grounding . . . 1
1.2.2 Power Connections . . . 1
1.2.3 Environmental Conditions . . . 1

2 Quick-Start Instructions . . . 3
2.1 Powering Up the Unit . . . 3
2.1.1 Power Supply Requirements . . . 3
2.1.2 Major connections . . . 4
2.1.3 Connecting the GPS Antenna . . . 5
2.1.4 Initiating Auto Survey mode . . . 6
2.1.4.1 Backup Battery . . . 7
2.1.5 Connecting an LCD Display . . . 7
2.1.5.1 LCD Contrast . . . 8
2.1.6 Menu switch (Keypad) . . . 8
2.1.7 External 1PPS input option . . . 9
2.2 Remote serial control . . . 10
2.2.1 “Help” and command overview . . . 11
2.2.2 Loop parameter adjustment . . . 11

3 SCPI-Control Quick Start Instructions . . . 13
3.1 Introduction . . . 13
3.2 General SCPI Commands . . . 13
3.2.1 *IDN? . . . 13
3.2.2 HELP?. . . . 13
3.3 GPS Subsystem . . . 13
3.3.1 GPS:INITial . . . 14
3.3.1.1 GPS:INITial:DATE . . . 14
3.3.1.2 GPS:INITial:TIME . . . 14
3.3.1.3 GPS:INITial:POSition . . . 15
3.3.2 GPS:POSition . . . 15
3.3.2.1 GPS:POSition . . . 15
3.3.2.2 GPS:POSition SURVey . . . 15
3.3.2.3 GPS:POSition HOLDSURVey . . . 15
3.3.2.4 GPS:POSition LAST . . . 15
3.3.2.5 GPS:POSition:SURVey:STATe ONCE . . . 15
3.3.2.6 GPS:POSition:SURVey:MAXPoints . . . 15
3.3.2.7 GPS:POSition:HOLD:LAST? . . . 16
3.3.3 GPS:REFerence . . . 16
3.3.3.1 GPS:REFerence:ADELay . . . 16
3.3.3.2 GPS:REFerence:TRAIM . . . 16
3.3.3.3 GPS:REFerence:TRAIM:RSVIDs? . . . 16
3.3.3.4 GPS:REFerence:PULse:SAWtooth? . . . 16
3.3.3.5 GPS:REFerence:PUlse:ACCuracy? . . . 16
3.3.3.6 GPS:REFerence:PULse? . . . 17
3.3.4 GPS:SATellite . . . 17
3.3.4.1 GPS:SATellite:TRACking:EMANgle . . . 17
3.3.4.2 GPS:SATellite:TRAcking:COUNt? . . . 17

© 2010 Jackson Labs Technologies, Inc.

3.3.4.3 GPS:SATellite:VISible:COUNt? . . . 17
3.3.4.4 GPS:SATellite:VISible:COUNt? . . . 17
3.3.4.5 GPS:POSition 3DFix . . . 17
3.3.4.6 GPS:GPGGA . . . 17
3.3.5 GPS:STATus . . . 18
3.3.5.1 GPS:STATus . . . 18
3.3.5.2 GPS:STATus:STRing . . . 19
3.3.6 GPS? . . . 19
3.4 PTIME Subsystem . . . 19
3.4.1 PTIMe:TZONe? . . . 20
3.4.1.1 PTIMe:TZONe? . . . 20
3.4.1.2 PTIMe:DATE? . . . 20
3.4.1.3 PTIMe:TIME? . . . 20
3.4.2 PTIMe:TIME:STRing? . . . 20
3.4.2.1 PTIMe:TINTerval? . . . 20
3.4.2.2 PTIME? . . . 20
3.4.3 PTIMe:LEAPsecond . . . 21
3.4.3.1 PTIMe:LEAPsecond:PENDing? . . . 21
3.4.3.2 PTIMe:LEAPsecond:ACCumulated? . . . 21
3.4.3.3 PTIMe:LEAPsecond:DATE? . . . 21
3.4.3.4 PTIMe:LEAPsecond:DURation? . . . 21
3.4.3.5 PTIMe:LEAPsecond? . . . 21
3.5 SYNChronization Subsystem . . . 21
3.5.1 SYNChronization:HOLDover:DURation? . . . 22
3.5.2 SYNChronization:SOURce:MODE . . . 22
3.5.3 SYNChronization:SOURce:STATE? . . . 22
3.5.4 SYNChronization:TINTerval? . . . 22
3.5.5 SYNChronization:IMMEdiate . . . 22
3.5.6 SYNChronization:FEEstimate? . . . 22
3.5.7 SYNChronization:LOCKed? . . . 23
3.5.8 SYNChronization? . . . 23
3.5.9 SYNChronization:SOURce:MODE [GPS|EXTernal|AUTO] . . . 23
3.5.10 SYNChronization:HOLDover:DURation? . . . 23
3.5.11 SYNChronization:HOLDover:INITiate . . . 23
3.5.12 SYNChronization:HOLDover:RECovery:INITiate . . . 24
3.5.13 SYNChronization:TINTerval? . . . 24
3.5.14 SYNChronization:IMMEdiate . . . 24
3.5.15 SYNChronization:FEEstimate? . . . 24
3.5.16 SYNChronization:LOCKed? . . . 24
3.5.17 SYNChronization? . . . 24
3.6 DIAGnostic Subsystem . . . 24
3.6.1 DIAGnostic:ROSCillator:EFControl:RELative? . . . 25
3.6.2 DIAGnostic:ROSCillator:EFControl:ABSolute? . . . 25
3.7 MEASURE Subsystem . . . 25
3.7.1 MEASure:TEMPerature? . . . 25
3.7.2 MEASure:VOLTage? . . . 25
3.7.3 MEASure:CURRent? . . . 25
3.7.4 MEASure? . . . 25
3.8 SYSTEM Subsystem . . . 25
3.8.1 SYSTem:COMMunicate . . . 26
3.8.1.1 SYSTem:COMMunicate:SERial:ECHO . . . 26
3.8.1.2 SYSTem:COMMunicate:SERial:PROmpt . . . 26

© 2010 Jackson Labs Technologies, Inc.

3.8.1.3 SYSTem:COMMunicate:SERial:BAUD . . . 26
3.8.2 SYSTem:STATus? . . . 26
3.8.3 SYSTem:FACToryReset ONCE . . . 26
3.9 SERVO Subsystem . . . 26
3.9.1 SERVo:COARSeDac . . . 27
3.9.2 SERVo:DACGain . . . 27
3.9.3 . . . SERVo: EFCScale28
3.9.4 SERVo:EFCDamping . . . 28
3.9.5 SERVo:SLOPe . . . 28
3.9.6 SERVo:TEMPCOmpensation . . . 28
3.9.7 SERVo:AGINGcompensation . . . 28
3.9.8 SERVo:PHASECOrrection . . . 28
3.9.9 SERVo:1PPSoffset . . . 29
3.9.10SERVo:QUIet . . . 29
3.9.11SERVo:TRACe . . . 29
3.9.12SERVo? . . . 29

4 Firmware Upgrade Instructions . . . 31
4.1 Introduction . . . 31
4.2 Recording Factory Calibration data . . . 31
4.3 Preparing the Desktop Unit for software installation. . . . 32
4.4 Putting the PCB into In-Circuit Programming (ISP) mode . . . 33
4.5 ISP Flash Loader Utility installation . . . 34
4.5.1 Philips LPC2000 Flash Utility . . . 34
4.5.2 Flash Magic Flash Programming Utility . . . 34
4.6 Downloading the firmware . . . 34
4.6.1 Philips LPC2000 Flash Utility . . . 34
4.6.2 Flash Magic Flash Programming Utility . . . 36
4.7 Updating Parameters . . . 39
4.8 Entering the calibration parameters in case the Flash was corrupted for some reason. . 40

5 GPSCon Utility . . . 41
5.1 Description . . . 41
5.2 Installation . . . 41
5.3 Using GPSCon . . . 41
5.3.1 Setting the options . . . 41
5.3.1.1 Communication Parameters . . . 42
5.3.1.2 Auxiliary parameters . . . 42
5.3.1.3 Other options . . . 44
5.3.2 Sending manual commands to the receiver . . . 44
5.3.3 Use of the mouse in graph mode . . . 45
5.3.4 Exporting the graphics . . . 47
5.4 Interpreting the Data . . . 48

6 Performance . . . 49
6.1 Introduction . . . 49
6.2 Performance Parameters . . . 49
6.2.1 Allan Variance and Deviation . . . 49
6.2.2 . . . 51
6.3 Conclusions . . . 51

7 Certification and Warranty 53
7.1 Certification 53
7.1.1 Warranty 53
7.1.2 Limitation of Warranty 53
7.1.3 Exclusive Remedies 54

© 2010 Jackson Labs Technologies, Inc.

1 Introduction

1.1 Overview

The Fury GPSDO includes a Motorola M12+ or M12M GPS receiver, a 32bit processor that runs a Real Time OS, LCD and Keypad interfaces, CMOS and Sine-Wave 10MHz outputs, 1PPS output, RS-232 control interface, precision voltage references, and DACs.

Fury can be configured via the RS-232 control port to support both positive and negative EFC control.

1.2 General Safety Precautions

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

1.2.1 Grounding

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

1.2.2 Power Connections

Make sure to connect the DC power to the device following the polarity indicated in Section 2.1 . Do not reverse the power pins as this will cause serious damage to the circuit board.

1.2.3 Environmental Conditions

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

© 2010 Jackson Labs Technologies, Inc.

© 2010 Jackson Labs Technologies, Inc.

2 Quick-Start Instructions

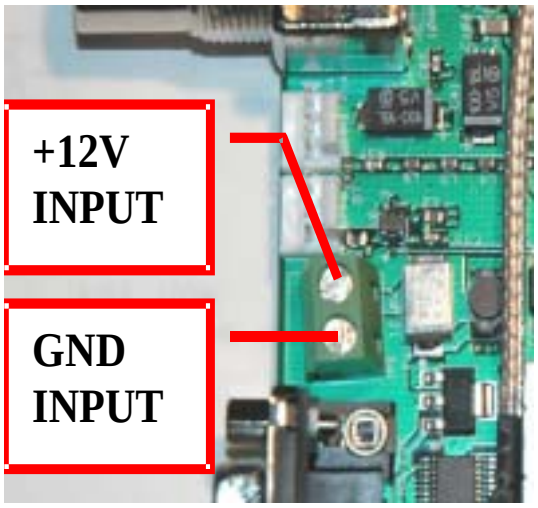
2.1 Powering Up the Unit

2.1.1 Power Supply Requirements

The Fury GPSDO requires 11.0 - 14.0V DC source capable of supplying 0.45A steady state. During the OCXO warm-up phase the current could rise to 0.8A. The rise time from 0 to 9V should be less than 10ms. Most switching power supplies are faster than that but a linear power supply may not satisfy this requirement. If the rise time is less than 10ms, the unit may not power up correctly. If this happens, it is possible to reboot the unit by pressing the Reset button after power up. See Figure 2.2 to locate the Reset button.

The small green power connector has its positive side toward the BNC connector. The current is typically 0.45A steady-state with internal DOCXO. Connect a clean +12V power source to the green connector block as shown in Figure 2.1.

Figure 2.1 Power supply connections.



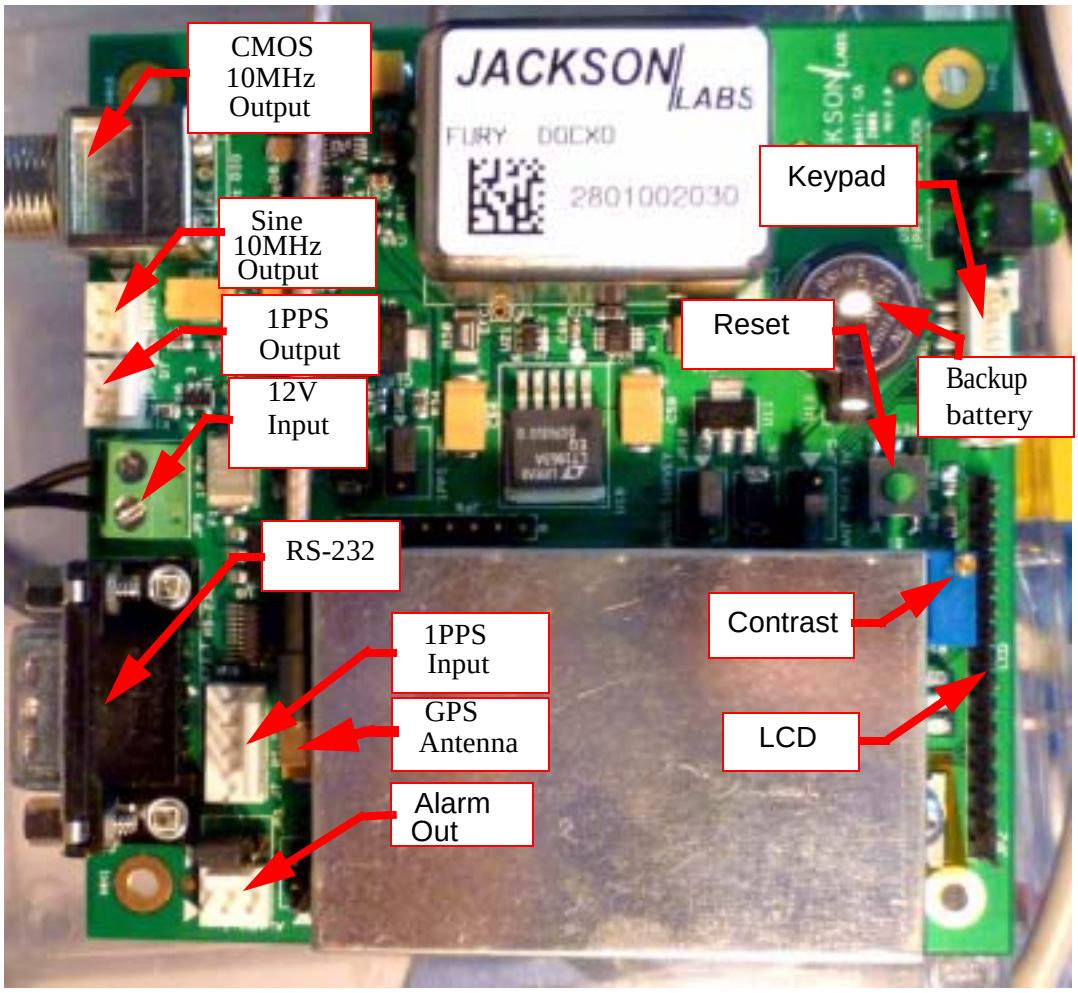
© 2010 Jackson Labs Technologies, Inc.

Warning: Do not reverse the polarity of the power connector. The Fury board is protected against reverse polarity by a diode. Although the Fury won't be damaged, it could damage the power supply by short-circuiting it.

2.1.2 Major connections

The major connections and features of the Fury PCB are shown in Figure 2.2.

Figure 2.2 Major connections and features of the Fury board.



The following table shows the Fury revision 2.0 hardware connectors:

Ref	Name	Function	Specification	Pinning
J4	Sine Out	Sine Wave Out	10.0MHz, +7dBm (+-3dBm), 50Ohms, End-Terminate	3-Sine, 2-GND, 1-GND

© 2010 Jackson Labs Technologies, Inc.

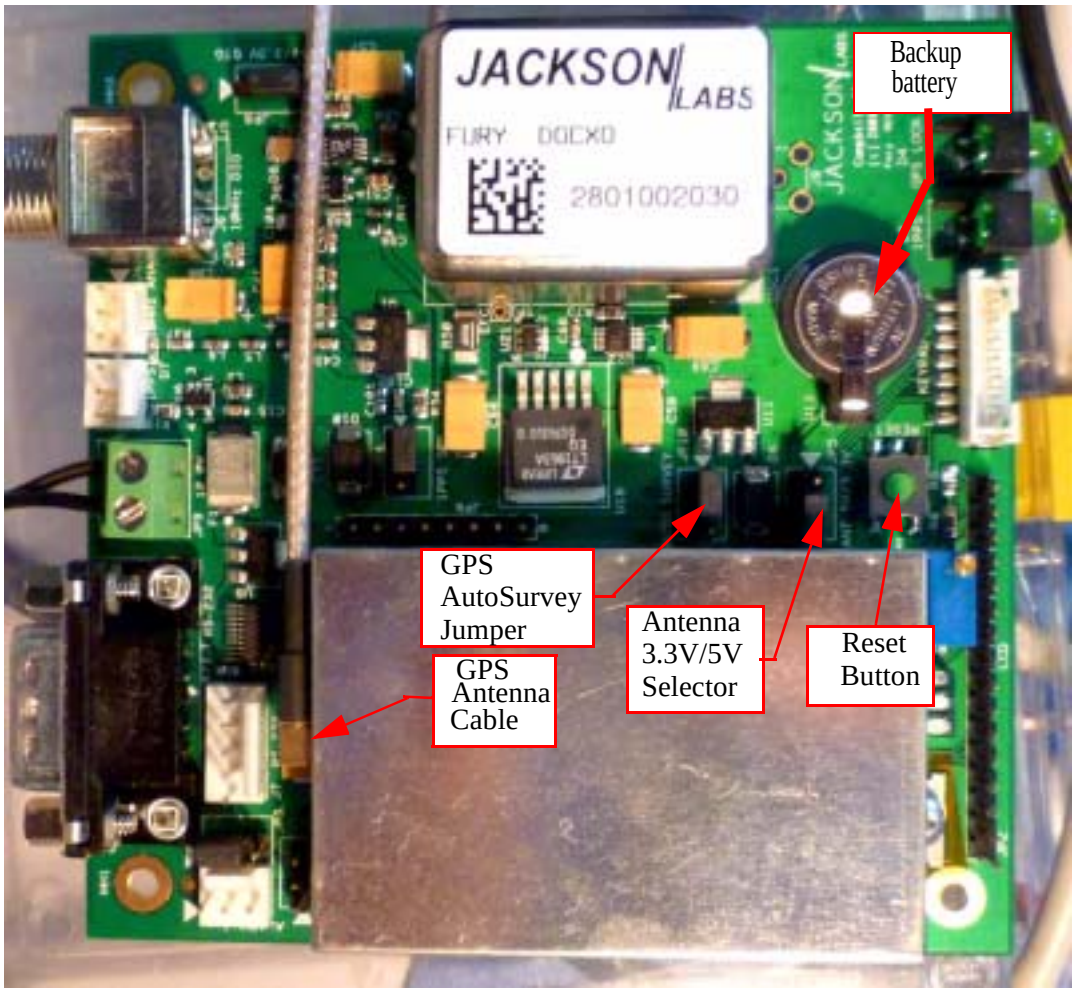
J6	CMOS Out	TTL/CMOS Out	3.3V/5Vpp 50Ohms, Do Not Terminate	1-Digital Output, 2-GND
JP8	J6 Output Select	J6 3.3V or 5Vpp	Jumper	3-2 J6 is 5Vpp, 2-1 J6 is 3.3Vpp
J5/Option	CMOS Out	Option for J6	(see J6)	3-TTL, 2-GND, 1-GND
JP9	Power	Clean +12V Supply	11.0V-14.0V DC, <1.0A, <10mVac	1-12V, 2-GND
JP5	Ant Power	3.3V/5V Ant Select	Jumper Option	1-2: 3.3V Ant, 2-3: 5V Ant
P1	RS-232 SYS	SCPI Control	RS-232	2-RXD, 3-TXD, 5-GND
J3	1PPS In	1PPS Input Option	3.3V max, Only use w/o GPS!	1-GND, 2-GND, 3-1PPS
JP6	ISP	Factory Diag	None	None
JP4	1PPS Select	GPS/OCXO 1PPS	Jumper Option	1-2 OCXO 1PPS, 2-3 GPS RAW 1PPS
J2	1PPS Out	1PPS Output	5V CMOS, 50Ohms, Do Not Terminate	3-1PPS Output, 2-GND, 1-GND
J1	Alarm	Alarm Indicator	3.3V TTL, 1=Alarm, 0=OK	3-Alarm, 2-GND, 1-GND
JP3	ISP Select	Enable Flash ISP	Jumper Option	3-2 ISP enabled, 2-1 Normal
JP10	Auto Survey	GPS Auto Survey	Jumper Option	3-2 Enable Auto Survey, 2-1 Normal
J7	External 1PPS In	Backup 1PPS Input	CMOS/TTL Input (5V max).	1-GND, 3- 1PPS-in, 5- +12V Caution: Do not short pin5 to pin 4.
JP1	Keypad Option	Keypad Connect	Short To GND to press key	5-Select Menu, 6-GND, 7-3.3V (<20mA), 4/3/2/1 NC
JP2	LCD	16x2 LCD Connect	HD44780 Type, TTL	1-GND, 2-+5V, 3-Contrast, 4-RS, 5-RW, 6-EN, 7/8/9/10-GND, 11-DA4, 12-DA5, 13-DA6, 14-DA7, 15-LED+, 16-LED-

2.1.3 Connecting the GPS Antenna

Connect the GPS antenna to the BNC cable, and select the GPS Antenna voltage with the Jumper as shown in Figure 2.3.

Warning: Use a Lightning Arrestor on your Antenna setup.

Figure 2.3 Antenna connector and configuration jumpers.



2.1.4 Initiating Auto Survey mode

Use the “Auto Survey” jumper (see Figure 2.3) only after applying power to the unit. Momentarily set the jumper to the position closest to the GPS receiver-can until the right-most LED (“LOCK” LED) starts blinking at ½Hz to indicate the unit is in Auto Survey mode. Do not forget to remove this jumper once the LOCK LED starts blinking. If the Jumper is accidentally left in the Auto Survey position during power-on, the unit will not boot up.

The unit will need about 3 hours to one night to do auto-survey to establish its new GPS position. Auto Survey can be started by using the Auto Survey jumper JP10, by sending an SCPI command, or by connecting a keypad and pressing the button for 10+ seconds. Auto survey is active as long as the "lock" LED blinks at 1/2Hz. Auto Survey mode can be queried with the “GPS?” command. “Survey State 1” will indicate Auto Survey to be active.

Enter “GPS:POS:SURV:STAT ONCE” to start Auto Survey mode manually.

© 2010 Jackson Labs Technologies, Inc.

You may also enter the length of the Auto Survey (in seconds) before initiating an Auto Survey with the following command (1000 seconds shown as an example, 10,000 seconds are set as the default):

GPS:POS:SURV:MAXP 1000

2.1.4.1 Backup Battery

There is a known issue wth the backup battery. Sometimes the GPS receiver may not properly lock to GPS sattelites. This has been traced to the small lithium coin-cell backup battery and potential corruption in the Almanac and RTC that is driven by the backup battery labeled U13. The backup battery is used to aid the GPS receiver to achieve lock faster. It is not required for normal operation, and may be removed. (see Figure 2.3 for location of backup battery)

Removing the backup battery will sometimes actually aid in faster GPS aquisition, as well as make the unit perform a "cold start" auto-survey automatically after power-on due to the lost almanac and GPS receiver settings including the position-hold position.

While the backup battery can last up to 10 years if the GPS receiver is powered externally, it can also discharge within 6 to 8 months if the board is placed in storage, and create problems when not fully charged.

Jackson Labs Technologies, Inc. recommends removing the backup battery unless the unit has to perform without initiating an auto-survey after power-on.

2.1.5 Connecting an LCD Display

An optional, standard 16x2 LCD with 16 pin connector may be connected to the unit for displaying status information. Larger displays such as 20x4 LCD displays may also work. Figure 2.4 shows how the LCD is connected to connector JP2.

© 2010 Jackson Labs Technologies, Inc.

Figure 2.4 LCD display connection.

2.1.5.1 LCD Contrast

The LCD contrast will likely need to be adjusted with the small blue Potentiometer next to the LCD connector. Use a small screwdriver to carefully turn the pot (10-turn pot) until you see characters clearly on the LCD display.

2.1.6 Menu switch (Keypad)

A single-button, momentary-short switch can be connected to pins 5 and 6 of connector JP1 (white connector next to LCD connector). Pressing this button will cycle the LCD through its various status pages.

The only data input that is done with the single switch is setting the unit into Auto Survey mode by holding down the switch for 10+ seconds. All other settings are done via the SCPI interface, which is more or less HP/Symmetricom 58503A compliant.

PLEASE NOTE THAT THE UNIT HAS TO BE SET TO "SCPI MODE" ON THE LCD FOR THE SERIAL PORT TO WORK AND ACCEPT COMMANDS! SCPI MODE IS ENABLED BY DEFAULT WHEN THE UNIT IS SHIPPED FROM THE FACTORY. WHEN NOT IN "SCPI MODE" THE RS-232 BUFFER IS DISABLED. THE REASON FOR THIS IS THAT THE RS-232 BUFFER COULD

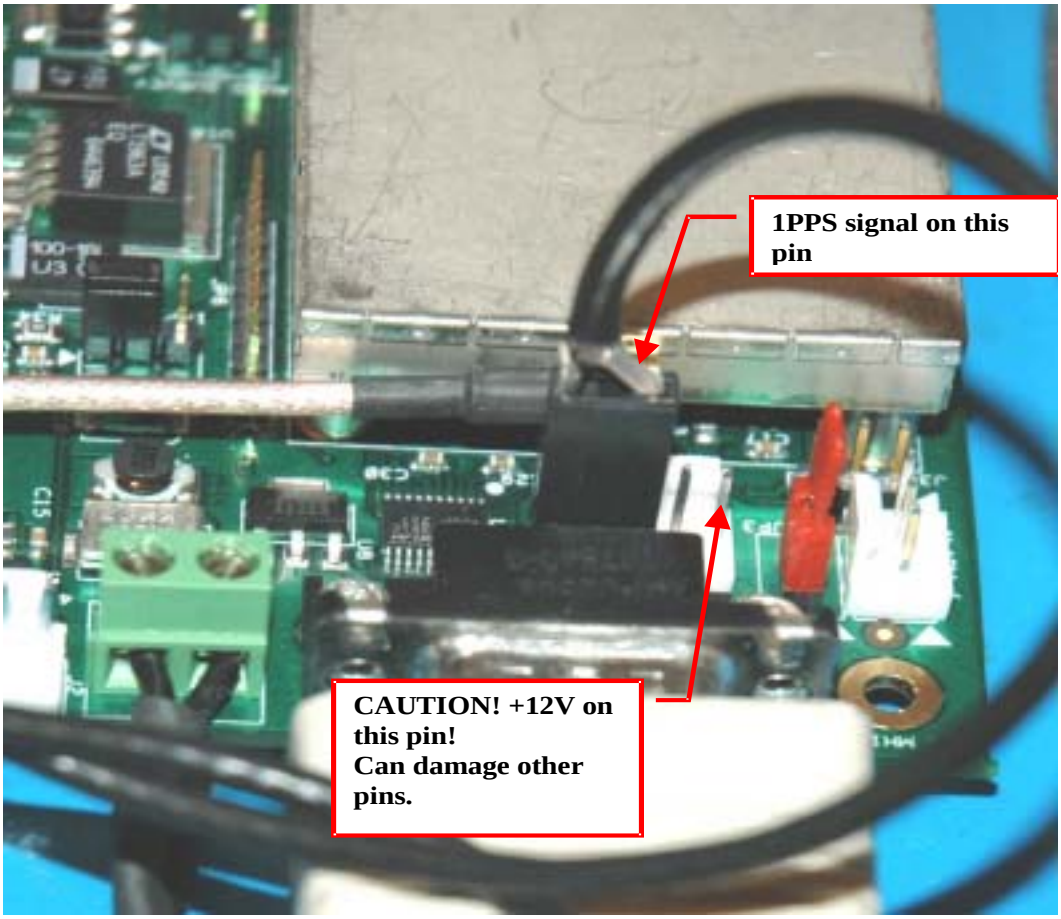
© 2010 Jackson Labs Technologies, Inc.

INTRODUCE SOME SWITCHING NOISE ONTO THE OUTPUTS OR ONTO THE 12V POWER SUPPLY. THE DC-DC SWITCHING REGULATOR IS DISABLED IN ORDER TO ALLOW THE MOST QUIET OPERATION POSSIBLE.

2.1.7 External 1PPS input option

Beginning with firmware version 1.15 and above, an (optional) external TTL level 1PPS input can be connected to the Fury board on connector J7 pin 3, see Figure 2.5.

Figure 2.5 External 1PPS input.



The unit can use this external 1PPS input instead of the internal, GPS generated, 1PPS.

Switching to the external 1PPS has two modes of operation:

- The manual mode where the user chooses specifically the 1 PPS source input using the following SCPI command:

  SYNC:SOUR:MODE < GPS | EXT >

While in this mode, the unit will remain using this 1 PPS input even during holdover.

- In automatic mode the unit switches automatically to the external 1PPS source when the unit goes into holdover for more than 15 seconds. The unit will switch back automatically after the GPS

1PPS source reappears for at least 3 seconds. The automatic mode can be selected with the following SCPI command:

SYNC:SOUR:MODE AUTO

The state of the 1PPS input selection can be checked with the SCPI query SYNC:SOUR:STATe?

The 1PPS selection is stored in memory and will remain active after power cycling or reset of the unit.

Using the external 1PPS input allows the Fury GPSDO very flexible operation in a number of different application scenarios:

- Fury as a Rubidium Clean-Up Loop

  The Fury can act as a PLL clean-up loop for noisy Rubidium sources. Connecting the Rubidium's 1PPS output to the external 1PPS input, and setting the mode to EXT will allow the Fury to generate a very clean, low phase-noise 10MHz and 1PPS output

- Fury with FailSafe operation:

  Any external 1PPS source with long-term stability equal to, or better than the Fury's internal OCXO can be used to discipline the Fury in case the internal GPS receiver goes into holdover mode for any reason such as Sat signal too weak, GPS receiver failure, antenna failure, etc. External sources do not have to be synchronized to UTC, the 1PPS pulse may have any phase relationship to UTC, as long as it's stability is equal to or better than the Fury's LTS.

- Using two cascaded Fury units as a double-redundant frequency source:

  Connect the 1PPS output of one Fury to the external 1PPS input of the second unit, and set the second unit to SYNC:SOUR:MODE AUTO. This will automatically switch the second Fury to the first Fury's output signal in case the second units' internal GPS goes into holdover for whatever reason. To provide even better reliability, both Fury's should connect to separate GPS antennas, and the first Fury may ultimately be connected to an external atomic clock as a triple-redundant system in case GPS reception is totally denied for whatever reason.

The 1PPS optional input is compatible to 3.3V CMOS signals, as well as 5V TTL signals. Signals must be 0V < x < 5.0V to prevent damage to the unit. The unit will lock onto signals with rising edge synchronization. The signal rising edge maximum time is 10ns 10% to 90%. Pulse width should be 1us or longer. A Phase relationship to UTC is not needed on this 1PPS input. The stability of the external 1PPS signal should be as good, or preferably significantly better than the Fury's OCXO long-term-stability, otherwise the performance of the Fury may actually be degraded when operating from the external 1PPS signal.

2.2 Remote serial control

- The unit is controlled via the Serial port at 115200 baud, 8N1, but this only works if the LCD display shows "SCPI MODE" (default setting). The RS-232 receiver is disabled outside of the "SCPI" display page. Swap through the pages with a momentary-on type button connected to JP1 pins 5 and 6.
- Use a standard 9-pin NULL-MODEM cable to connect the Fury unit to your PC's Hyperterminal, or the optional GPSCon software package.

When using Hyperterminal or similar terminal program on your PC, you must disable hardware handshaking (flow control).

© 2010 Jackson Labs Technologies, Inc.

2.2.1 “Help” and command overview

- A listing of the available RS-232 commands can be shown by typing in "help?".

- "*IDN?" can be used to see if the connection works. Both commands need to be followed by pressing “Enter”.

2.2.2 Loop parameter adjustment

LOOP PARAMETERS ARE PRE-SET TO OPTIMAL VALUES BY THE FACTORY. CHANGING THESE VALUES IS NOT NECESSARY UNDER NORMAL CIRCUMSTANCES.

- All loop parameters can be controlled via the RS-232 serial port.

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

The individual commands are:

DAC Gain: this parameter adjusts the Fury control loop to the EFC-versus-Frequency gain of your OCXO. Some experimentation may be required to find the optimum DAC Gain for your particular OCXO.

For typical OCXOs, the EFC gain of the OCXO can vary from +/-1Hz, to +/-20Hz for a 0V to 5V EFC swing. HP 10811 units for example may have +/-2Hz for a full 0V to 5V swing.

Use the following approximate guidelines to adjust DAC GAIN:

MAX. OCXO Frequency Deviation	**Recommended DAC GAIN setting**	**Examples**
0.2Hz	2000.0	Rubidium
2Hz	250.0	10811
20Hz	30.0	Typical OCXO
40Hz	15.0	MTI OCXO

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 (good double oven OCXO) and 6.0 (simple single-oven OCXO) are typical.

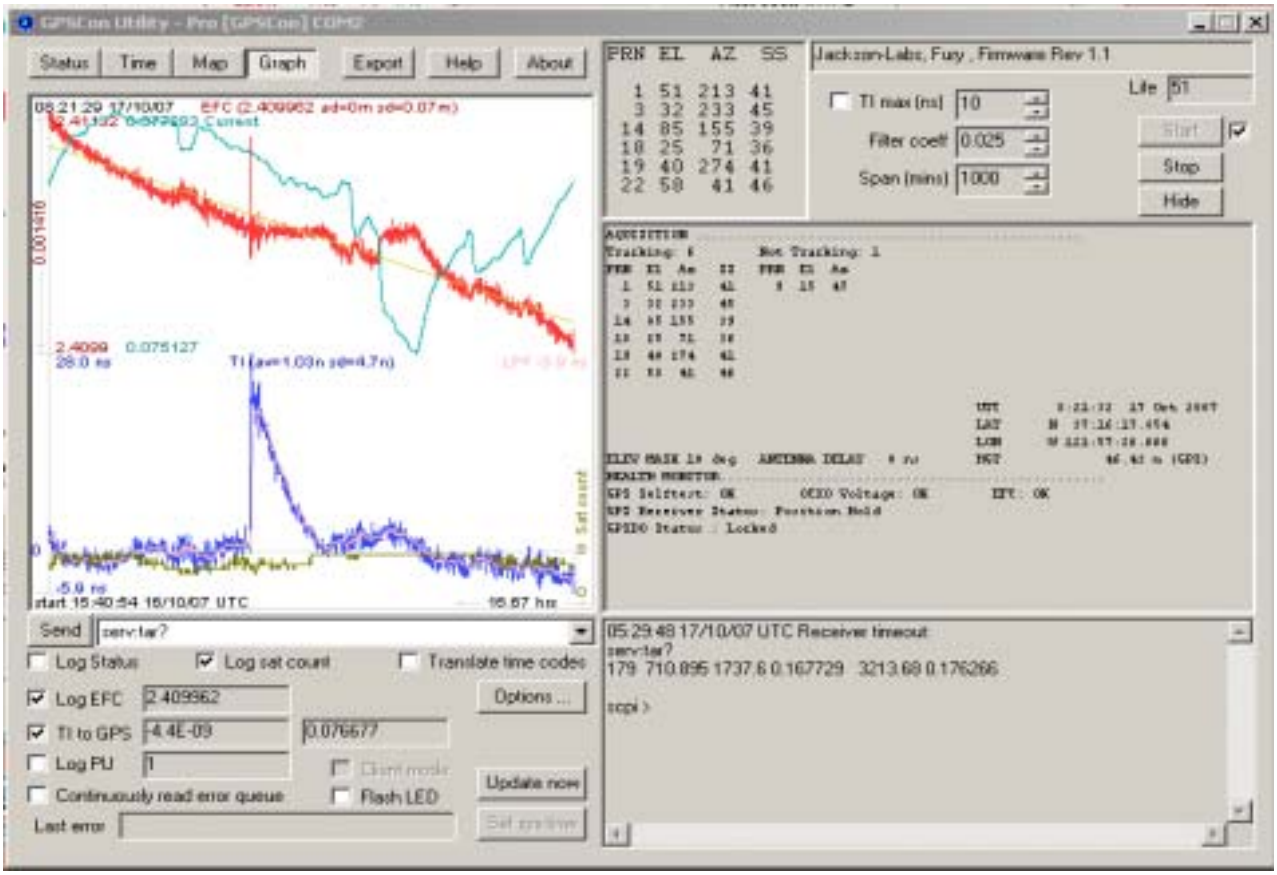
© 2010 Jackson Labs Technologies, Inc.

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. Set higher values for tighter phase-following at the expense of frequency stability. Typical values range from 4 - 30, 25 being the default. Setting this value too high may cause loop instability.

A well-compensated unit will show performance similar to the plot in Figure 2.6 when experiencing small perturbations.

Figure 2.6 .Fury phase compensation plot.



© 2010 Jackson Labs Technologies, Inc.

3 SCPI-Control Quick Start Instructions

3.1 Introduction

The SCPI (**S**tandard **C**ommands for **P**rogrammable **I**nstrumentation) subsystem is accessed via the RS-232 connector using a DB-9 Null Modem cable and a terminal program. By default the terminal settings are 115200, 8N1.

There are a number of commands that can be used as listed below. Most of these are identical 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 Fury GPSDO.

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

http://www.scpiconsortium.org

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

3.2 General SCPI Commands

3.2.1 *IDN?

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

<company name>, <model number>, <serial number>, <firmware revision>

3.2.2 HELP?

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

3.3 GPS Subsystem

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 :

© 2010 Jackson Labs Technologies, Inc.

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

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

GPS:INITial:POSition <N|S, <deg,min,sec>, E|W <deg,min,sec>, <height in meters> >

GPS:POSition <N|S>,<deg,min,sec>, <E|W>, <deg,min,sec>, <height in meters>

GPS:POSition SURVey

GPS:POSition HOLDSURVey

GPS:POSition LAST

GPS:POSition:SURVey:STATe ONCE

GPS:POSition:HOLD:LAST?

GPS:POSition 3DFix

GPS:REFerence:ADELay <float> <s | ns >

GPS:REFerence:TRAIM ON | OFF

GPS:REFerence:TRAIM:RSVIDs?

GPS:REFerence:PULse:SAWtooth?

GPS:REFerence:PUlse:ACCuracy?

GPS:REFerence:PULse?

GPS:SATellite:TRACking:EMANgle <int> [0,89]

GPS:SATellite:TRACKing:COUNt?

GPS:SATellite:VISible:COUNT?

GPS:GPGGA <int> [0,255]

GPS:STATus?

GPS:STATus:STRing?

GPS?

3.3.1 GPS:INITial

This group of commands facilitates the initial tracking. It allows the user to give the receiver an initial estimate of the current time and date and position

If the receiver is tracking already at least one satellite, the receiver will ignore any attempt to change the date or time. If the receiver is computing a 3D Fix, it will ignore any attempt to change its currently calculated position.

3.3.1.1 GPS:INITial:DATE

This command is used to enter the date. This command has the following format:

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

3.3.1.2 GPS:INITial:TIME

This command is used to enter an initial time. This command has the following format:

© 2010 Jackson Labs Technologies, Inc.

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

3.3.1.3 GPS:INITial:POSition

This command is used to enter an estimate of the position. This command has the following format:

GPS:INITial:POSition <N|S>,<deg,min,sec>, <E|W>, <deg,min,sec>, <height>

3.3.2 GPS:POSition

This group of commands deals with the position of the GPS antenna.

3.3.2.1 GPS:POSition

This command specifies the position of the GPS antenna. The format of this command is the following:

GPS:POSition <N|S>,<deg,min,sec>, <E|W>, <deg,min,sec>, <height in meters>

This command specifies the position of the GPS antenna. That position will become the LAST HOLD position. To actually activate that position into the GPS receiver, use the command GPS:POSition LAST

3.3.2.2 GPS:POSition SURVey

This command stops the current running auto-survey. The receiver will take its current average position as its hold position.

3.3.2.3 GPS:POSition HOLDSURVey

This command does like the GPS:POSition SURVEY and also stores that position in the LAST HOLD position.

3.3.2.4 GPS:POSition LAST

The parameter LAST denotes the LAST HOLD position . This command cancels the current auto-survey (if any) and restores the last position setting. This command together with the command GPS:POSition allows to skip the autosurvey process. This command is very useful when the user knows the precise location of the GPS Antenna already.

3.3.2.5 GPS:POSition:SURVey:STATe ONCE

This command starts an auto-survey. The auto-survey lasts about 3 hours. In some occasions, it can even last longer if the GPS antenna is not properly placed. An auto-survey can be stopped at anytime with the command GPS:POSition SURVey.

3.3.2.6 GPS:POSition:SURVey:MAXPoints

This command specifies the number of acquisition points needed to achieve an Autosurvey. By default, the Motorola M12+ does an average of 10000 acquisition points (e.g about three hours)

© 2010 Jackson Labs Technologies, Inc.

before to exit the Autosurvey. At the expense of a slightly less accurate hold position, the Autosurvey duration can be shortened significantly using this command. This command has the following format:

GPS:POSition:SURVey:MAXPoints <int> [0,10000]

When the unit has received the number of 1PPS signals specified by this command, it will issue a specific command to the GPS to stop the autosurvey : this is equivalent than issuing the SCPI command GPS:POSition HOLDSURVey.

3.3.2.7 GPS:POSition:HOLD:LAST?

This query displays the LAST HOLD position.

3.3.3 GPS:REFerence

This subgroup of commands are about the 1 PPS Reference pulse.

3.3.3.1 GPS:REFerence:ADELay

This command sets the GPS antenna delay value in seconds (or nanoseconds if the unit is specified). The format of the command is the following:

GPS:REFerence:ADELay <float> <s | ns >

3.3.3.2 GPS:REFerence:TRAIM

This command turns on or off the M12+ T-RAIM (Time Receiver Autonomous Integrity Monitoring). This is an algorithm implemented in the GPS receiver that uses redundant satellite measurements to confirm the integrity of the timing solution. This algorithm requires at least 4 tracked satellites in order to be able to generate the 1 PPS signal. T-RAIM is enabled by default on Factory reset.

This command is the following format:

GPS:REFerence:TRAIM ON | OFF

3.3.3.3 GPS:REFerence:TRAIM:RSVIDs?

This query displays a 32-bit field number which indicates which SIDS were removed by T-TRAIM.

3.3.3.4 GPS:REFerence:PULse:SAWtooth?

This query displays the current value in nanoseconds of the negative sawtooth time error of the next 1 PPS pulse estimated by the GPS receiver. This value is in the range [-128 ns,+127ns]

3.3.3.5 GPS:REFerence:PUlse:ACCuracy?

This query displays the 1-sigma accuracy estimate in nanoseconds of the 1 PPS pulse estimated by the GPS receiver. This value is in the range [0, 65635]

© 2010 Jackson Labs Technologies, Inc.

3.3.3.6 GPS:REFerence:PULse?

This query displays the status of the 1 PPS pulse. (0=off, 1=on)

3.3.4 GPS:SATellite

This group of commands describe the satellite constellation.

3.3.4.1 GPS:SATellite:TRACking:EMANgle

This command sets the Elevation Mask Angle. The receiver will attempt to track satellites for which the elevation angle is greater then the satellite mask angle. The format of the command is the following:

GPS:SATellite:TRACking:EMANgle <int> [0,89]

This parameter is set at 10 on Factory Reset.

3.3.4.2 GPS:SATellite:TRAcking:COUNt?

This query returns the number of satellites being tracked.

3.3.4.3 GPS:SATellite:VISible:COUNt?

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

3.3.4.4 GPS:SATellite:VISible:COUNt?

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

3.3.4.5 GPS:POSition 3DFix

This command places the GPS receiver in 3DFix mode instead of position-hold mode.

3.3.4.6 GPS:GPGGA

FIRMWARE REVISION 1.22 AND LATER UPDATE:

Beginning with FW rev. 1.22, the GPGGA command will actually generate both the NMEA GGA as well as the RMC output command. The NMEA RMC string generates additional information such as the Date, and is thus quite useful. The GPS:GPGGA command will enable or disable the GGA and RMC strings at the same time, there is no method to generate either one or the other string separately. Please contact the factory, or download legacy firmware revision 1.21 available on the Jackson Labs Technologies, Inc. website under the support tab if you require the system not to generate the RMC string.

© 2010 Jackson Labs Technologies, Inc.

This command instructs the Fury to send the NMEA standard strings $GPGGA and $GPRMC every N seconds, with N in the interval [0,255]. The output is not valid during the initial 12 minute OCXO warmup phase, and during the initial GPS Auto Survey phase.

This command has the following format:

GPS:GPGGA <int> [0,255]

3.3.5 GPS:STATus

This subgroup of queries will display the status of the GPS receiver as described in the Motorola M12+ GPS Receiver User Guide.

3.3.5.1 GPS:STATus

The query returns a 16-bit decimal number with the following description:

Bit15-13:	111= 3D Fix	
	110 =2D Fix	
	101=Propagate Mode	
	100= Position Hold	
	011=Acquiring Satellites	
	010=Bad Geometry	
	001=Reserved	
	000=Reserved	
Bit 12-11	Reserved	
Bit 10	Narrow band tracking mode	
Bit 9	Fast Acquisition Position	
Bit 8	Filter Reset to Raw GPS Resolution	
Bit 7	Cold Start (no almanac or out of data almanac)	
Bit 6	Differential Fix	
Bit 5	Position Lock	
Bit 4	Autosurvey Mode	
Bit 3	Insufficient Visible Satellites	
Bit 2-1	Antenna Sense :	00 = OK
		01 = OverCurrent
		10 = UnderCurrent
		11= NotValid
Bit 0	Code Location	0=External,1=Internal

This query is suitable for parsing from Host software.

© 2010 Jackson Labs Technologies, Inc.

3.3.5.2 GPS:STATus:STRing

This query will display the GPS status as described in the query GPS:STATus in an ASCII form suitable for display.

3.3.6 GPS?

The query displays at once all the configuration of the GPS receiver.

Here is an example of the output of such a query:

ANTENNA DELAY:2e-09
MASK ANGLE:10
TRACKED SATS :6
VISIBLE SATS :7
SURVEY STATE :0
TIME ZONE :-7,00
ACTUAL POSITION:
N,37,17,58.9510
W,121,57,33.7390
45.40 m
LAST HOLD POSITION:
N,0,0,0.0000
E,0,0,0.0000
0.00 m
PULSE STATUS:1
PULSE ACCURACY:44
PULSE SAWTOOTH:-4
TRAIM FILTER:1
TRAIM REMOVED SVIDS:00000000

3.4 PTIME Subsystem

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

PTIMe:TZONe <hour,min> [-12,12],[0,59]
PTIMe:TZONe?
PTIMe:DATE?
PTIMe:TIME?
PTIMe:TIME:STRing?

© 2010 Jackson Labs Technologies, Inc.

PTIMe:TINTerval?

PTIME?

PTIMe:LEAPsecond:PENDing?

PTIMe:LEAPsecond:ACCumulated?

PTIMe:LEAPsecond:DATE?

PTIMe:LEAPsecond:DURation?

PTIMe:LEAPsecond?

3.4.1 PTIMe:TZONe?

Sets the time zone local time offset to provide an offset from UTC to serve as the basis for all reported time. This command has the following format:

PTIMe:TZONe <hour,min> [-12,12],[0,59]

3.4.1.1 PTIMe:TZONe?

Returns the local time zone offset.

3.4.1.2 PTIMe:DATE?

This query returns the current calendar date. The local calendar date is always referenced to UTC time, offset by any local time zone value that has been provided by the user. The year, month, and day are returned.

3.4.1.3 PTIMe:TIME?

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

3.4.2 PTIMe:TIME:STRing?

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

3.4.2.1 PTIMe:TINTerval?

This query is equivalent to the command SYNChronization:TINTerval

3.4.2.2 PTIME?

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

PTIME:DATE?

PTIME:TIME?

PTIME:TZONE?

PTIME:TINTerval?

© 2010 Jackson Labs Technologies, Inc.

3.4.3 PTIMe:LEAPsecond

3.4.3.1 PTIMe:LEAPsecond:PENDing?

This query identifies if a leap second is pending. This query looks ahead to indicate a pending leap second. A value of 0 indicates no leap second is pending. A value of 1 indicates a leap second is pending. The leap second adjustment can be either the addition of a second or the subtraction of a second.

3.4.3.2 PTIMe:LEAPsecond:ACCumulated?

Returns the leap second difference accumulated between GPS time and UTC time since the beginning of GPS time. The time units are seconds.

3.4.3.3 PTIMe:LEAPsecond:DATE?

Returns the date of the future the leap second (usually UTC June 30 or UTC December 31) or the last one if a future one is not scheduled yet.

3.4.3.4 PTIMe:LEAPsecond:DURation?

This query identifies whether a leap second is pending, distinguishes between leap seconds which extend the minute, and leap seconds which shorten the minute. This query returns the duration of the minute corrected by the next leap second. The duration units are seconds. The return value is 59, 60 or 61:

-A value of 59 indicates subtraction of 1 second is pending.

-A value of 60 indicates no leap second pending.

-A value of 61 indicates addition of 1 second is pending. Returns the duration of the minute corrected by the next leap second.

3.4.3.5 PTIMe:LEAPsecond?

This query display at one the result of the 4 following queries:

PTIMe:LEAPsecond:PENDing?

PTIMe:LEAPsecond:ACCumulated?

PTIMe:LEAPsecond:DATE?

PTIMe:LEAPsecond:DURation?

3.5 SYNChronization Subsystem

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

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

SYNChronization:SOURce:STATE?

© 2010 Jackson Labs Technologies, Inc.

SYNChronization:HOLDover:DURation?

SYNChronization:TINTerval?

SYNChronization:IMMEdiate

SYNChronization:FEEstimate?

SYNChronization:LOCKed?

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. 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:SOURce:MODE

The Source:Mode command allows an optional external TTL level 1PPS input to be connected to the Fury board, on connector J7 pin 3.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]

3.5.3 SYNChronization:SOURce:STATE?

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

3.5.4 SYNChronization:TINTerval?

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

3.5.5 SYNChronization:IMMEdiate

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

3.5.6 SYNChronization:FEEstimate?

This query returns the Frequency Error Estimate.

© 2010 Jackson Labs Technologies, Inc.

3.5.7 SYNChronization:LOCKed?

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

3.5.8 SYNChronization?

This query returns the results of the four following queries :

SYNChronization:SOURce:MODE?

SYNChronization:SOURce:STATE?

SYNChronization:HOLDover:DURation?

SYNChronization:TINTerval?

SYNChronization:FEEstimate?

SYNChronization:LOCKed?

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

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

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

3.5.10 SYNChronization:HOLDover:DURation?

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

3.5.11 SYNChronization:HOLDover:INITiate

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

© 2010 Jackson Labs Technologies, Inc.

3.5.12 SYNChronization:HOLDover:RECovery:INITiate

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

3.5.13 SYNChronization:TINTerval?

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

3.5.14 SYNChronization:IMMEdiate

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

3.5.15 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.

3.5.16 SYNChronization:LOCKed?

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

3.5.17 SYNChronization?

This query returns the results of these six queries :

SYNChronization:SOURce:MODE?

SYNChronization:SOURce:STATE?

SYNChronization:LOCKed?

SYNChronization:HOLDover:DURation?

SYNChronization:FEEstimate?

SYNChronization:TINTerval?

3.6 DIAGnostic Subsystem

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

DIAGnostic:ROSCillator:EFControl:RELative?

DIAGnostic:ROSCillator:EFControl:ABSolute?

© 2010 Jackson Labs Technologies, Inc.

3.6.1 DIAGnostic:ROSCillator:EFControl:RELative?

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

3.6.2 DIAGnostic:ROSCillator:EFControl:ABSolute?

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

3.7 MEASURE Subsystem

This subsystem regroups the queries related of some parameters that are measured on-board on the Fury. The list of the commands supported for this subsystem is the following:

MEASure:TEMPerature?

MEASure:VOLTage?

MEASure:CURRent?

MEASure?

3.7.1 MEASure:TEMPerature?

This query returns the temperature of the sensor located next to the OCXO.

3.7.2 MEASure:VOLTage?

This query returns the power supply voltage applied to the OCXO (ca. 10.5 V)

3.7.3 MEASure:CURRent?

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

3.7.4 MEASure?

This query returns the result of the three following queries:

MEASure:TEMPerature?

MEASure:VOLTage?

MEASure:CURRent?

3.8 SYSTEM Subsystem

This subsystem regroups the commands related to the general configuration of the Fury. The list of the commands supported for this subsystem follows:

© 2010 Jackson Labs Technologies, Inc.

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

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

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

SYSTem:STATus?

SYSTem:FACToryReset ONCE

3.8.1 SYSTem:COMMunicate

3.8.1.1 SYSTem:COMMunicate:SERial:ECHO

This command enables/disables echo on RS-232. It is preferable to disable the echo when used with the software GPSCon. This command has the following format:

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

3.8.1.2 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>

3.8.1.3 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>

3.8.2 SYSTem:STATus?

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

3.8.3 SYSTem:FACToryReset ONCE

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

3.9 SERVO Subsystem

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

SERVo:COARSeDac <int> [0,225]

SERVo:DACGain <int> [0.1,10000]

© 2010 Jackson Labs Technologies, Inc.

SERVo: EFCScale <float>[0.0 , 500.0]

SERVo:EFCDamping <float>[0.0 , 4000.0]

SERVo:SLOPe <NEG | POS >

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

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

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

SERVo:1PPSoffset <int> ns

SERVo:QUIet <ON | OFF>

SERVo:TRACe <int > [0,255]

SERVo?

3.9.1 SERVo:COARSeDac

This command sets the coarse DAC that controls the EFC. The Fury control loop automatically adjusts this setting. The user should not have to change this value.

This command has the following format:

SERVo:COARSeDac <int> [0,225]

3.9.2 SERVo:DACGain

Adjusts the gain of the DAC circuitry to match the OCXO sensitivity to voltage changes. Typical values are 15.0 for OCXOs with +-20Hz deviation, and 150.0 for OCXOs with +-2Hz deviation.This command has the following format:

SERVo:DACGain <int> [0.1,10000]

THIS VALUE NEEDS TO BE ADJUSTED TO MATCH THE PARTICULAR OCXO YOU ARE USING WITH THE FURY GPSDO.

Use the following approximate guidelines to adjust DAC GAIN:

MAX. OCXO Frequency Deviation	**Recommended DAC GAIN setting**	**Examples**
0.2Hz	2000 to 5000	Rubidium
2Hz	250.0	10811
20Hz	30.0	Typical OCXO
40Hz	15.0	MTI OCXO

© 2010 Jackson Labs Technologies, Inc.

3.9.3 SERVo: EFCScale

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

This command has the following format:

SERVo: EFCScale <float>[0.0 , 500.0]

3.9.4 SERVo:EFCDamping

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

SERVo:EFCDamping <float>[0.0 , 4000.0]

3.9.5 SERVo:SLOPe

The parameter determines the sign of the slope between the EFC and the frequency variation of the OCXO. This parameter should be set to match your OCXOs EFC frequency slope. This command has the following format:

SERVo:SLOPe <NEG | POS >

3.9.6 SERVo:TEMPCOmpensation

This parameter is a coefficient that reflects the correlation between the Current provided to the OCXO and the EFC. This coefficient is automatically computed and adjusted over time by the Jackson-Labs firmware if the OCXO is powered by the Fury PCB itself. A linear relationship between OCXO current and ambient temperature must exist for Fury to properly compensate for ambient temperature changes. This command has the following format:

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

3.9.7 SERVo:AGINGcompensation

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

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

3.9.8 SERVo:PHASECOrrection

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

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

© 2010 Jackson Labs Technologies, Inc.

3.9.9 SERVo:1PPSoffset

This command sets the Fury 1PPS signal's offset to UTC in 16.7ns steps. For 1ns granularity see the command GPS:REFerence:ADELay.

Changing the GPS:REF:ADEL parameter results in the unit slowly locking to the new UTC phase offset. Using the SERV:1PPS command results in immediate phase change of the 1PPS signal at the expense of a lower resolution of only 16.7ns versus 1ns.

This command has the following format:

SERVo:1PPSoffset <int> ns

3.9.10 SERVo:QUIet

This command minimizes the output spurs by shutting down the LEDs and RS-232 transceiver. The LCD display must be set to any other mode than "SCPI MODE" for quiet mode to be fully activated. If SCPI mode is set, quiet mode will be disabled.

This command has the following format:

SERVo:QUIet <ON | OFF>

3.9.11 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]

3.9.12 SERVo?

This command returns the result of the following queries:

SERVo:COARSeDac?

SERVo:DACGain?

SERVo: EFCScale?

SERVo:EFCDamping?

SERVo:SLOPe?

SERVo:TEMPCOmpensation?

SERVo:AGINGcompensation?

SERVo:PHASECOrrection?

SERVo:1PPSoffset?

SERVo:TRACe?

© 2010 Jackson Labs Technologies, Inc.

© 2010 Jackson Labs Technologies, Inc.

4 Firmware Upgrade Instructions

4.1 Introduction

The following is a short tutorial on how to upgrade the Fury GPSDO firmware. Please follow the instructions in order to prevent corrupting the Fury 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 Recording Factory Calibration data

It is not necessary to do the following, but it is recommended that the factory calibration data is written down on paper in case the flash update fails for some reason. Follow the steps in this section to print out important calibration data:

A) The unit can be controlled via the Serial port at 115200 baud, 8N1 (defaults), but this only works if the LCD display shows "SCPI MODE". In Fury Desktop units the system is set to SCPI mode by default.

For Fury units with LCD connected, the RS-232 receiver is disabled outside of the "SCPI" display page. Swap through the LCD menu pages with a momentary-on type button connected to JP1 pins 5 and 6 until the LCD display shows “SCPI MODE". Make sure Hyperterm is set to the same Baud rate as shown in the LCD display (typically 115200 Baud)

B) At the prompt, type in: serv? and press [enter]. The data displayed in Figure 4.1 will appear (or something similar, every units data etc. will be different).

© 2010 Jackson Labs Technologies, Inc.

Figure 4.1 Fury factory calibration data output.

```
scpi > serv?
COARSE DAC : 121
EFC SCALE : 3.00
EFC DAMPING: 500
OCXO SLOPE : NEGATIVE
TEMPERATURE COMPENSATION : 262.00
AGING COMPENSATION : -0.00554
PHASE CORRECTION : 25.000000
1PPS OFFSET : 0 ns
TRACE : 0
```

[PLEASE NOTE THAT THE ABOVE VALUES ARE REPRESENTATIVE, AND SHOULD NOT BE ENTERED INTO YOUR FURY UNIT!]

Note down the **Coarse DAC, EFC Scale, EFC damping, OCXO slope, Temperature compensation** (this value is quite important and varies from unit to unit!), **aging compensation,** and **Phase correction** parameters so these can be typed in later in case these original values are lost for some reason.

4.3 Preparing the Desktop Unit for software installation

In order to upgrade the Fury firmware, the desktop enclosure has to be opened.

First and most importantly, disconnect the Fury unit from AC mains power, or from any other power source you may have connected.

Carefully remove the four screws on the faceplate (side with BNC connectors only) of the Fury units as shown in the following picture. Please note not to tighten the screws too much when re-assembling the unit, the screws may very easily strip the aluminum enclosure's threads.

Remove the four screws indicated by the red arrows in Figure 4.2.

© 2010 Jackson Labs Technologies, Inc.

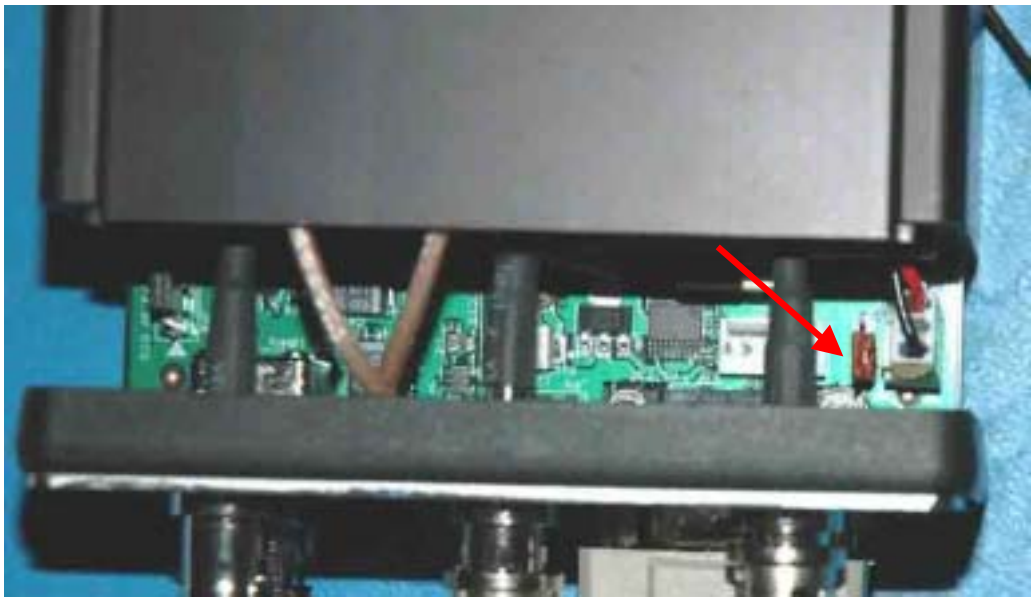
Figure 4.2 Fury faceplate removal.

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

After removing the four screws as described in the previous section., carefully pull-out the faceplate to about 1 inch in length until the Red Jumper JP3 (marked by the red arrow in Figure 4.3) is visible.

Using tweezers or very small pliers, move the jumper JP3 (next to RS232 connector) from position 1-2 to position 2-3. Be careful not to touch the adjacent cables and connector pins with the tweezers or pliers.

Figure 4.3 Jumper JP3 location.



Push the PCB back into the enclosure making sure that the unit is fully closed. Re-apply power to the unit.

Now press the RESET button or power cycle the unit. If the LED's blink, the jumper JP3 has not been set correctly, and the unit is not in ISP mode.

The unit has now been set to ISP mode, and is awaiting the firmware download.

4.5 ISP Flash Loader Utility installation

There are two Flash loader utilities available to upgrade the Fury firmware. You can download the Philips LPC2000 utility from the Jackson Labs Technologies, Inc. website under the Support tab:

http://www.jackson-labs.com/support.html

The Flash Magic utility is available for download on the Flash Magic website:

http://www.flashmagictool.com/

4.5.1 Philips LPC2000 Flash Utility

The first is the Philips LPC2000 utility version 2.2.3. Please note that some computers are known to be incompatible with the LPC2000 flash utility. Preliminary investigations show Windows Media Center and/or Centrino vPro processor systems to create download difficulties. Please use a different computer if you experience problems such as the download breaking up in the middle of the transfer. Or, alternatively, you may use the Flash Magic programming tool.

Please ensure that you have at least version 2.2.3 of the LPC2100 flash utility installed. Earlier versions may not recognize the LPC2136 processor used on the Fury boards.

4.5.2 Flash Magic Flash Programming Utility

The second utility is the Flash Magic tool available on the Flash Magic website:

http://www.flashmagictool.com/

If the Philips LPC2000 tool doesn't work, please use this one.

4.6 Downloading the firmware

Download the latest version of Fury 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 Fury serial port, P1.

4.6.1 Philips LPC2000 Flash Utility

A) Open the LPC2000 utility. Set the COM port in the LPC2000 application as needed on your PC.

B) Select the Baud Rate of the LPC2000 utility to be 38400 or slower. Faster Baud rates will not work properly.

© 2010 Jackson Labs Technologies, Inc.

C) Press the “READ DEVICE ID” button, this should then show “LPC2136” in the DEVICE window if the unit is communicating correctly to the application.

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

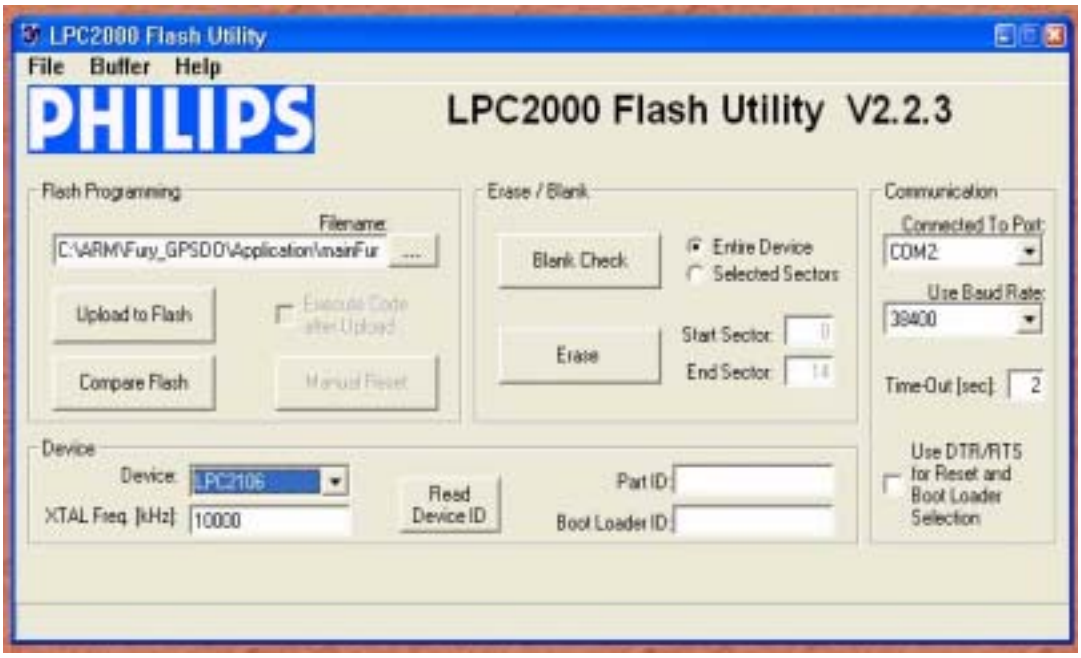
A) Open the LPC2000 utility. Set the COM port in the LPC2000 application as needed on your PC.

B) Select the Baud Rate of the LPC2000 utility to be 38400 or slower. Faster Baud rates will not work properly.

C) Press the “READ DEVICE ID” button, this should then show “LPC2136” in the DEVICE window if the unit is communicating correctly to the application.

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

Figure 4.4 LPC2000 Flash Utility settings.



Please note that the “Use Baud Rate” setting needs to be set to 38400 Baud or less, it will not work faster than 38400 Baud.

The “DEVICE” should show up as “LPC2136” after pressing “READ DEVICE ID”

Also, please point the “Filename” to the directory where you have stored the latest firmware hex file that is to be downloaded.

D) Start the download by pressing “Upload to Flash” button. The following window should appear if the correct COM port has been chosen etc.:

Figure 4.5 Starting the download with the LPC2000 Flash Utility.

Press the “OK” button, and the download should start. Sometimes the utility gets confused and this process (from item 4.6 B)) has to be tried several times.

It is not necessary to press “reset” as the utility is asking. Just press “OK” on the utility window’s button.

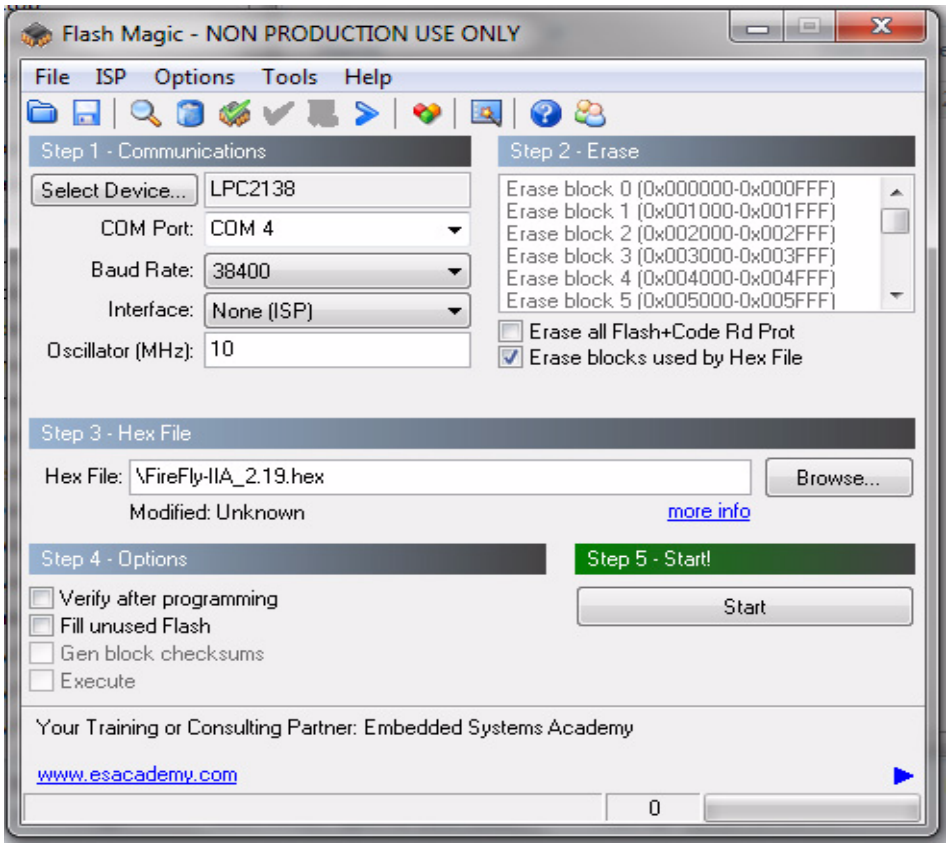
Warning: DO NOT PRESS THE “ERASE” BUTTON AT ANY TIME! THIS WILL RENDER THE PCB USELESS AND CAN ONLY BE RECOVERED AT THE FACTORY!

4.6.2 Flash Magic Flash Programming Utility

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

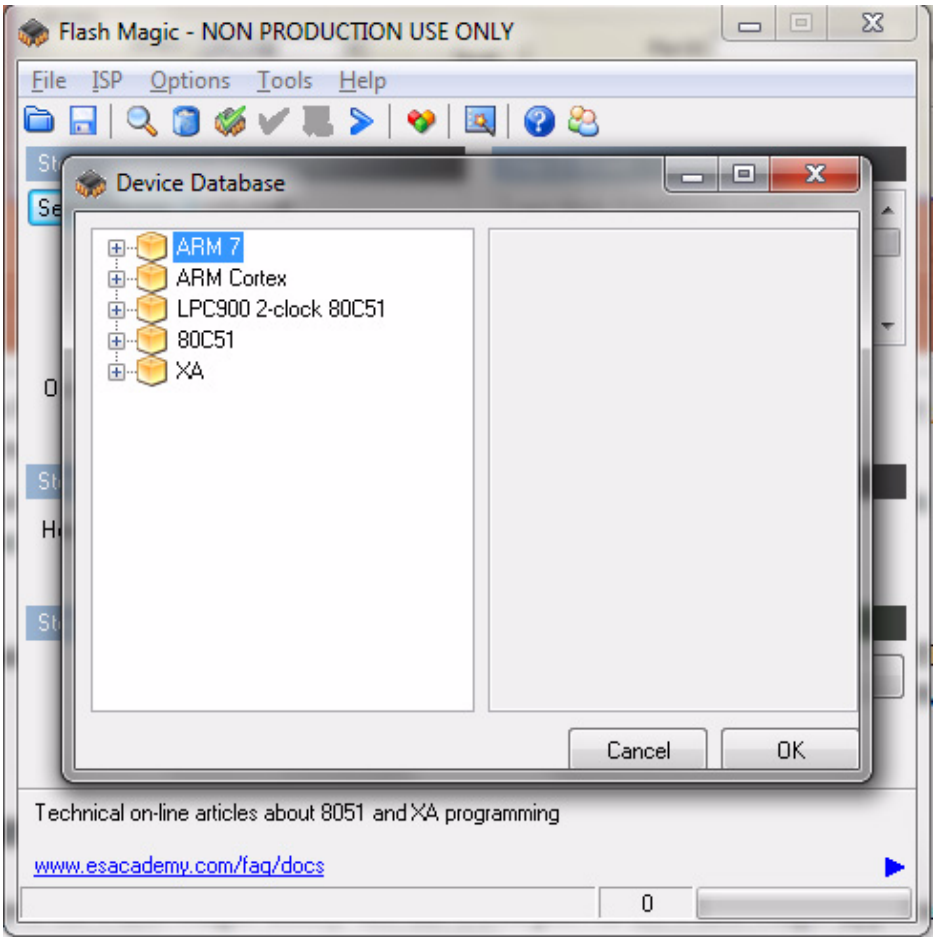
© 2010 Jackson Labs Technologies, Inc.

Figure 4.6 Flash Magic Flash Utility settings.



B) Press the “Select Device” button and the window shown in Figure 4.7 will appear:

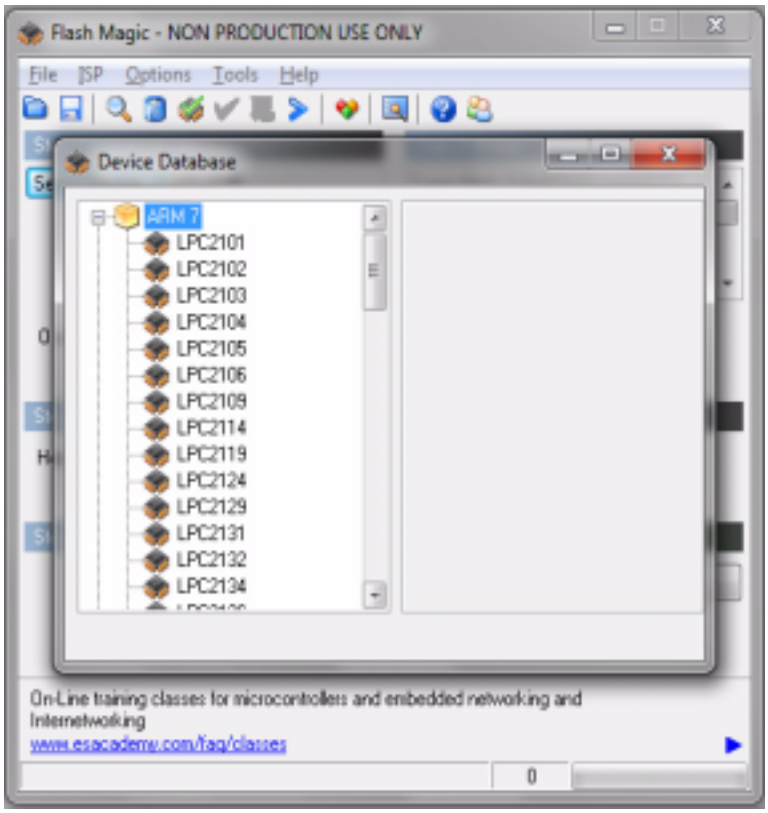
Figure 4.7 Device selection window in Flash Magic utility.



C) Expand the ARM7 folder and select the appropriate processor, in this case the LPC2136. See Figure 4.8.

© 2010 Jackson Labs Technologies, Inc.

Figure 4.8 Processor selection in Flash Magic utility.



D) Select the Baud Rate of the Flash Magic utility to be 38400 or slower. Faster Baud rates will not work properly.

E) Set the Oscillator (MHz) to “10”.

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

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 4.6 .

H) Go to Step 5 and press “Start”. You will observe the firmware being downloaded to the Fury.

4.7 Updating Parameters

A) After the download has finished, remove power from the unit.

B) Carefully pull out the PCB as described in Section 4.4 .

C) Re-adjust jumper JP3 to pins 1-2. This will allow normal operation after a power-cycle/reset.

Please note that jumper JP3 has to be in the 1-2 position (moved in the direction of the adjacent faceplate) in order for the unit to operate normally!

© 2010 Jackson Labs Technologies, Inc.

D) Close the flash programming utility, and restart hyperterm

E) Carefully push the PCB back into the enclosure, and add the screws to the enclosure, being careful not to strip the enclosures threads.

F) Press the RESET button, or power-cycle the unit.

The LED's should blink, and/or the ALARM LED should light up.

For units with LCD display, verify that the LCD is in the "SCPI MODE" page, and that the Baud rate shown in the LCD display matches the Hyperterm setting.

During power on, the unit sends an ID string to Hyperterm. The firmware version can also be queried by sending the *IDN? command. Verify that the firmware version is the version that was downloaded.

4.8 Entering the calibration parameters in case the Flash was corrupted for some reason.

Type the command serv? and compare the new settings to the old firmware's settings noted down on paper previously.

Re-enter any settings that do not match the previous settings of the older firmware.

Type "help?" to get instructions of how to enter the data into the "SERV" structure.

Verify that all settings have been correctly entered by typing "serv?" at the end of the data entry session.

© 2010 Jackson Labs Technologies, Inc.

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. If you encounter this problem, it is recommended that you install GPSCon on a slower computer using Windows XP.

5.2 Installation

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

5.3 Using GPSCon

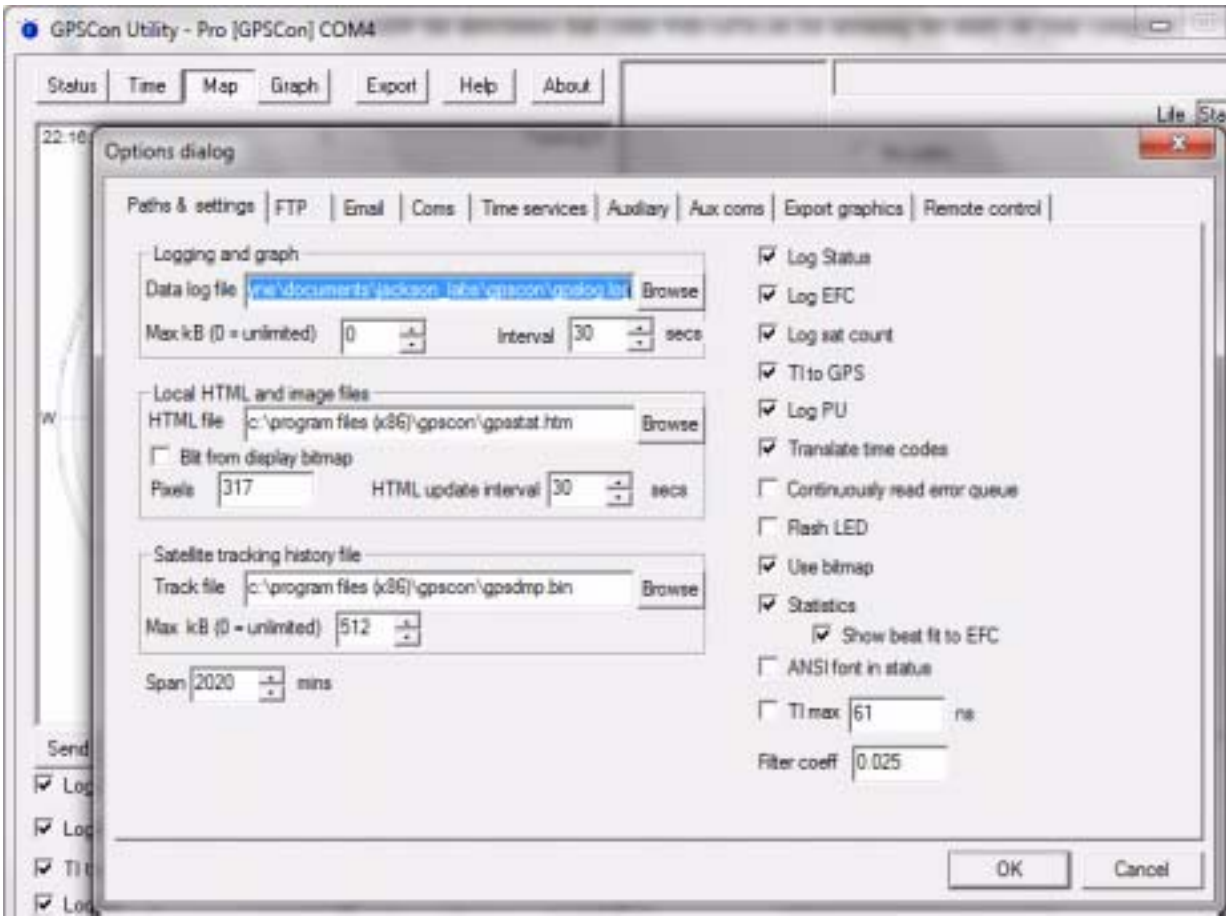
The GPSCon utility has a help file that should be consulted in order to get the full functionality of this utility. Only a few of the features and commands are mentioned in this appendix for convenience.

5.3.1 Setting the options

To set up the options for your GPSCon session, press the “Options” button below the display area. The window shown in Figure 5.1 will appear. You can select from the tabs which options you wish to set.

© 2010 Jackson Labs Technologies, Inc.

Figure 5.1 Options window



5.3.1.1 Communication Parameters

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

5.3.1.2 Auxiliary parameters

After pressing the “Options” button, you can select “Auxiliary” and set other options or measurements. See Figure 5.3 for an example of an auxiliary measurement. You will notice that the “Aux 1 request string” has been set to `meas:current?<CD>` and the “Log Aux1” box is checked. In the area below labeled “Traces to be visible on the graph”, the box “Aux 1” is checked and the label “OCXO curr” has been added.

© 2010 Jackson Labs Technologies, Inc.

Figure 5.2 Setting the communications parameters

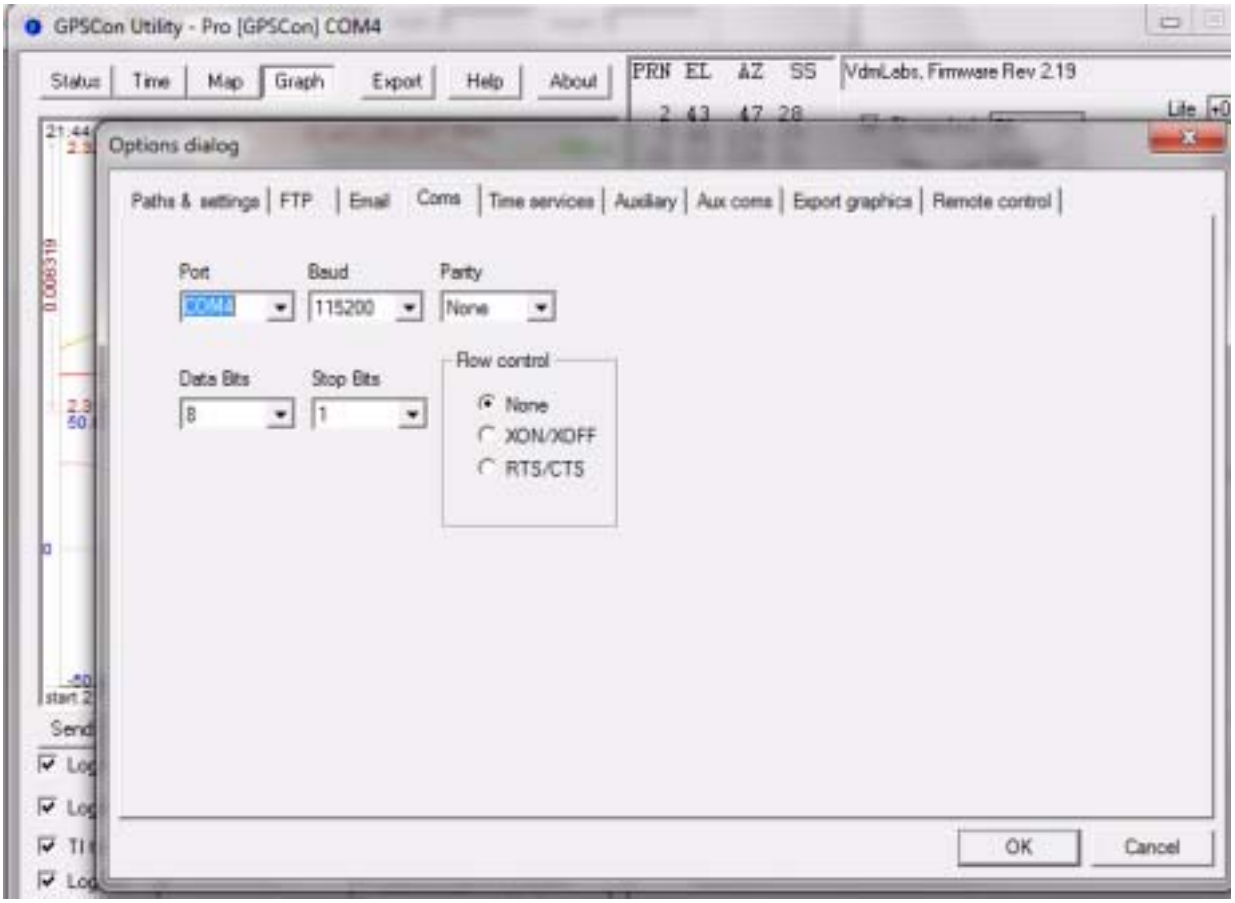
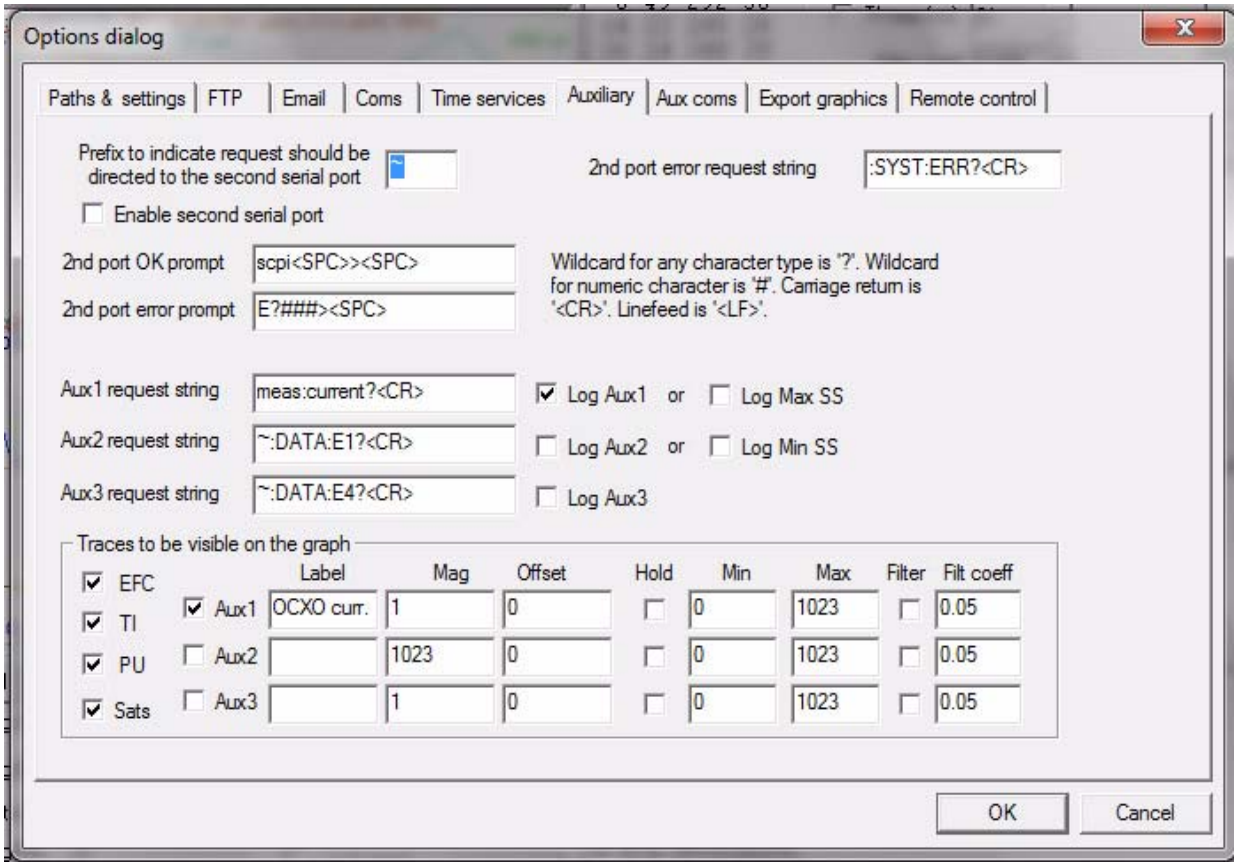


Figure 5.3 Auxiliary Parameters window



5.3.1.3 Other options

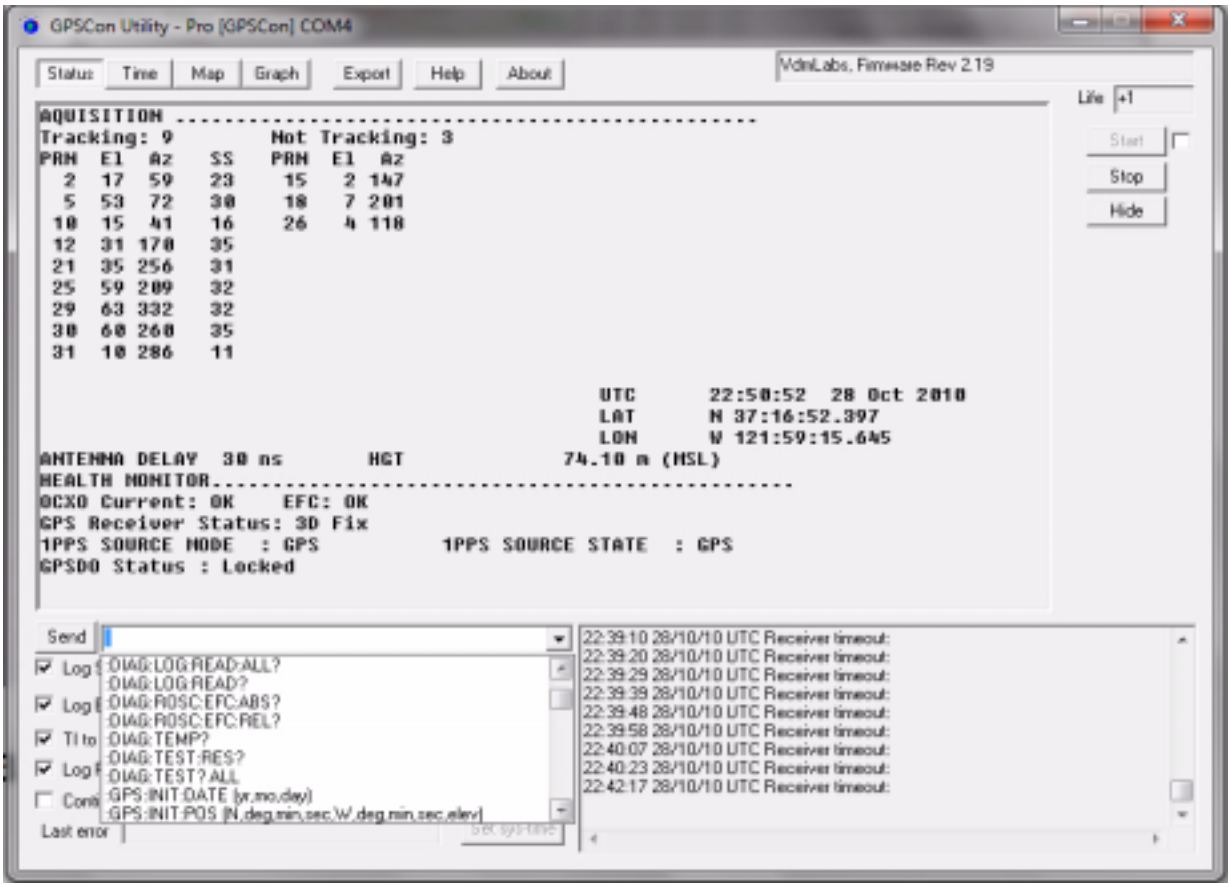
The other tabs in the options window can be selected and you can set whatever options you need, such as paths for logging or exporting graphics.

5.3.2 Sending manual commands to the receiver

You can send SCPI commands manually by using the drop-down box under the display window as shown in Figure 5.4. Care must be taken when sending these commands so be sure that the command that you select is supported by the Fury GPSDO. Once you've selected the command, you can press "Send" to send it to the Fury.

© 2010 Jackson Labs Technologies, Inc.

Figure 5.4 Sending manual commands



5.3.3 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."

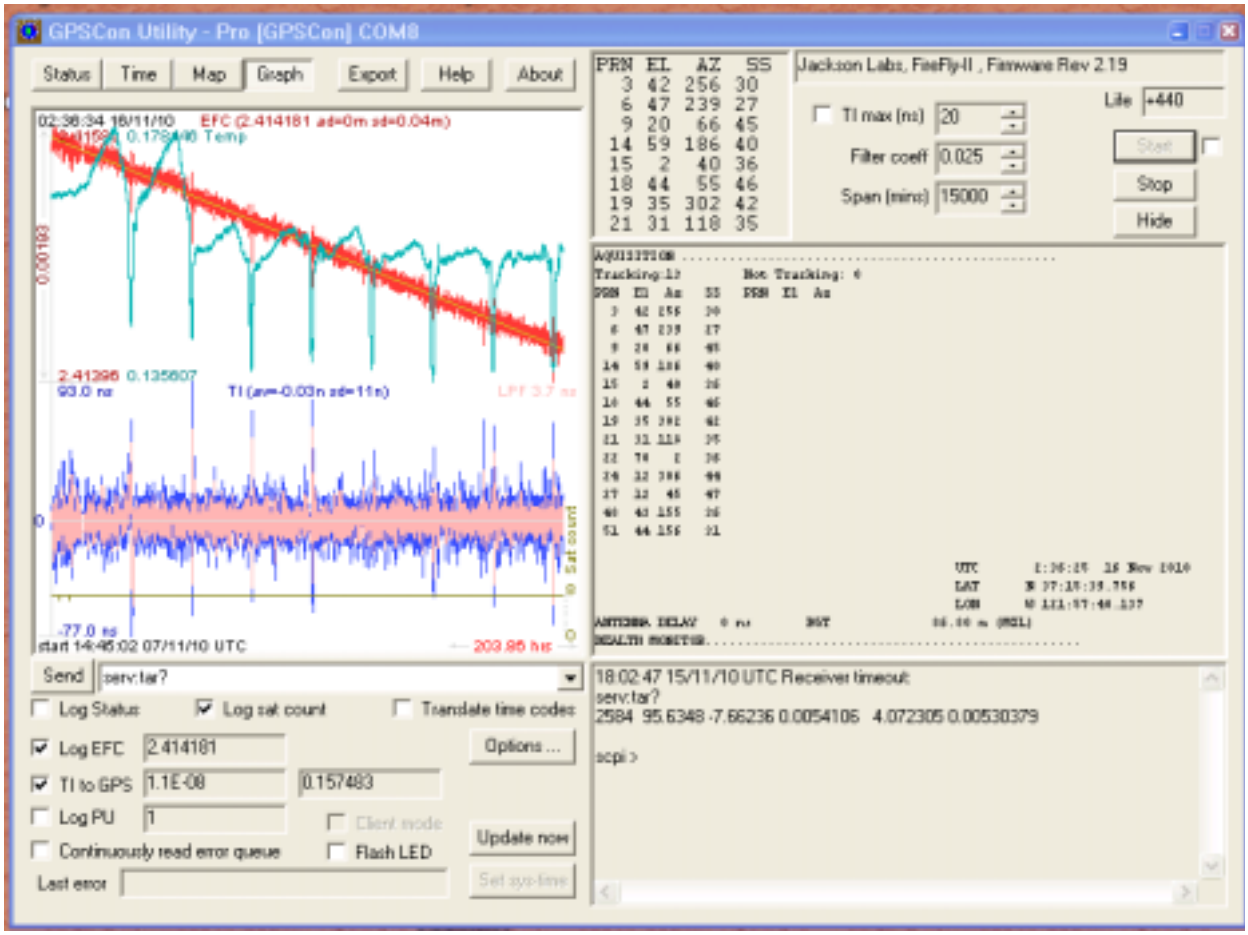
© 2010 Jackson Labs Technologies, Inc.

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.

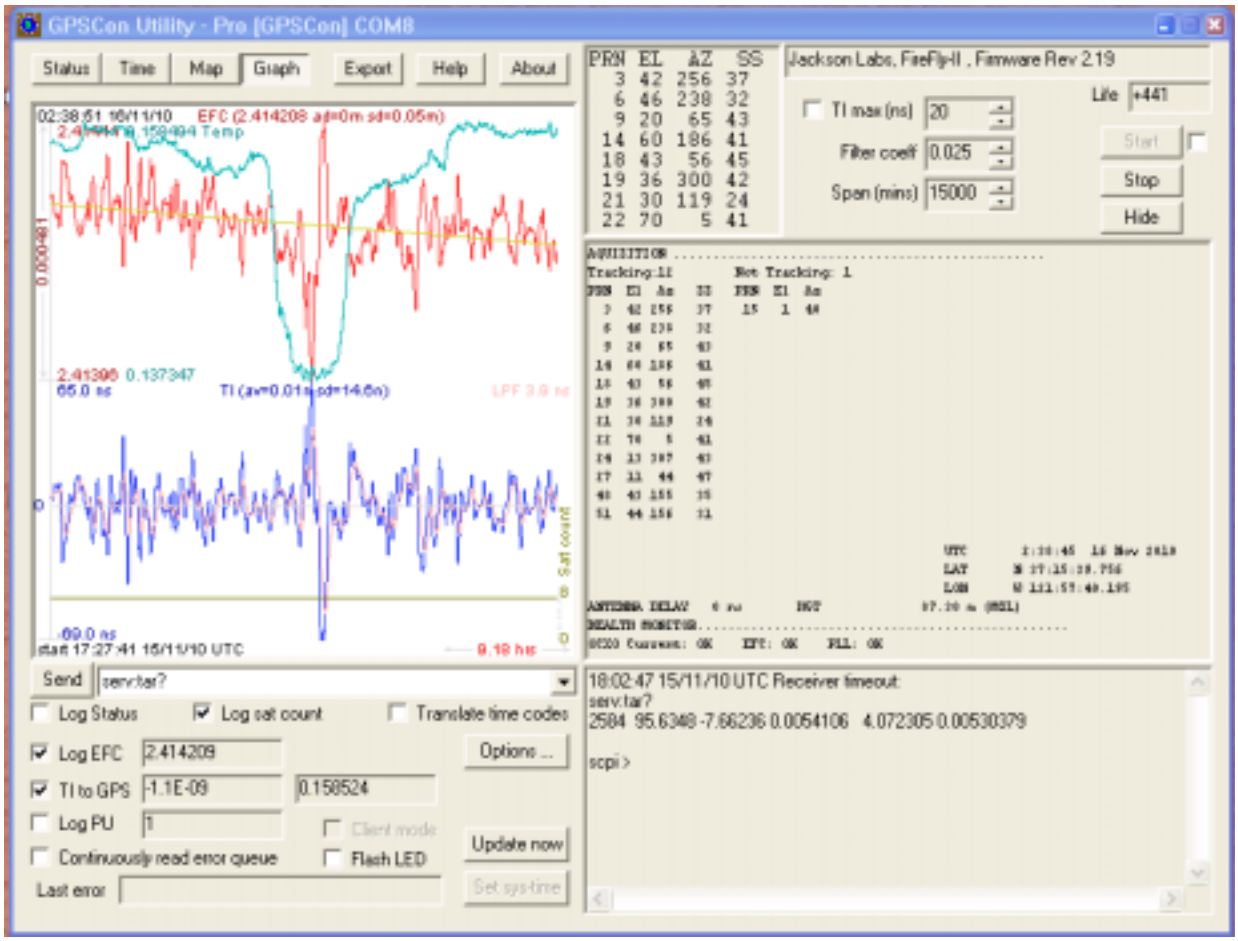
The time span indication at the lower right of the graph will turn red to signify that mouse override is in effect.

Figure 5.5 Graph display



© 2010 Jackson Labs Technologies, Inc.

Figure 5.6 Expanded Graph Display



5.3.4 Exporting the graphics

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

Export allows you to create an image file of either the graph or the satellite map. 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.

© 2010 Jackson Labs Technologies, Inc.

5.4 Interpreting the Data

Figure 5.5 shows the data acquired by the Fury unit over a period of more than 200 hours The red trace is EFC (crystal frequency control voltage). The crystal is aging (becoming faster in frequency over time). This requires the control voltage to be lowered to maintain 10.0MHz exactly. A drift of ~2mV is visible over 200 hours. On the left side of the screen the EFC range over this 200 hour plot is displayed vertically as 0.00193V. This means the drift of the EFC voltage due to aging is ~88mV per year. The EFC sensitivity of the crystal is about 8Hz per volt, so the crystal ages at:

8Hz/V * 0.088V/Year = 0.704Hz/Year drift.

At 10MHz:

0.704Hz / 10MHz = 7.04E-08 aging rate per year.

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

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

In Figure 5.6, which is a zoom of Figure 5.5, we can see the phase offset error of the internal OCXO to the UTC GPS reference. We can see the maximum drift is -77ns to +93ns. The average is (TI av=-0.03ns). The standard deviation over the 200 hour plot is sd=11ns. This means the average error of the 10MHz phase of this unit over 200 hours is only +/-11ns rms. Or, in other words the average jitter (wander) over 200 hours of operation is:

11ns / 200Hrs = 1.528E-014

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

© 2010 Jackson Labs Technologies, Inc.

6 Performance

6.1 Introduction

The Fury GPSDO represents the state-of-the-art in GPSDOs technology and provides the best performance/price ratio available today. This chapter presents some of the performance data of the Fury and compares it to more expensive competition.

6.2 Performance Parameters

The two (three?) most important parameters that determine the performance of a GPSDO are frequency accuracy and stability. The stability of the clock is determined by the Allan Variance or Allan Deviation.

6.2.1 Allan Variance and Deviation

The Allan variance (AVAR), also known as two-sample variance is a measure of frequency stability in clocks, oscillators and amplifiers. It is named after David W. Allan. It is expressed mathematically as:

$$\sigma y^2(\tau)$$

The Allan deviation (ADEV), is the square root of Allan variance. It is also known as sigma-tau, and is expressed mathematically as:

$$\sigma y(\tau)$$

The M-sample variance, is a measure of frequency stability using M samples, time T between measures and observation time ?. M-sample is expressed as:

$$\sigma y^2(M, T, \tau)$$

© 2010 Jackson Labs Technologies, Inc.

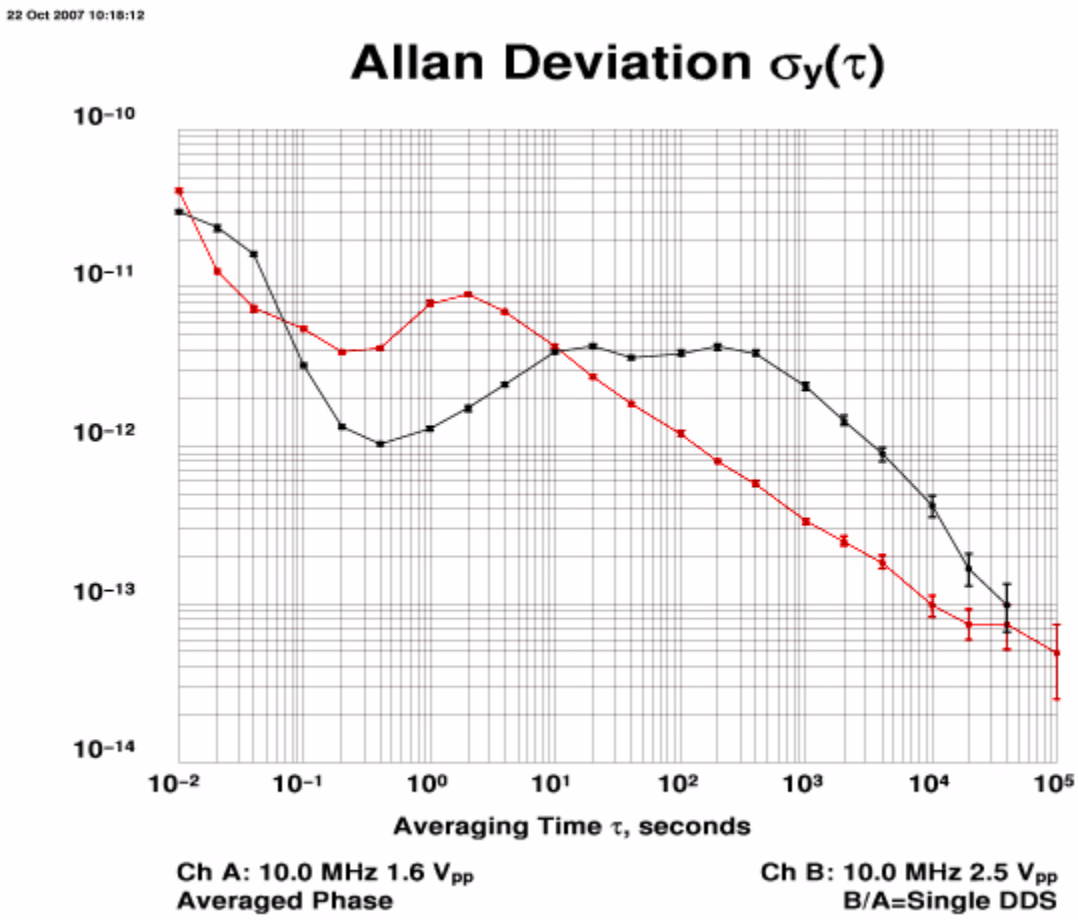
The Allan variance is intended to estimate stability due to noise processes and not that of systematic errors or imperfections such as frequency drift or temperature effects. The Allan variance and Allan deviation describe frequency stability.

Figure 6.1 is a graph of Allan deviation (ADEV) for the DOCXO Fury in comparison to the Symmetricon/Agilent 5071A Cesium Atomic Clock Standard costing many times more. The red trace is the Cesium long term ADEV of a typical 5071A unit. The black trace is the ADEV of a typical Fury DOCXO unit locked to GPS. It can be observed that the stability of the devices improves as the averaging period gets longer, since some noise types can be removed by averaging. At some point, however, more averaging no longer improves the results. This point is called the noise floor, or the point where the remaining noise consists of non-stationary processes such as aging or random walk. From the graph the following observations can be made:

- We can see that the Fury out-performs the more expensive Cesium by almost 10 to 1 at around 1 second measurement intervals.
- It performs better than the Cesium up to about 10 second measurement intervals.
- We can see that the Fury approaches the 5071A stability at about 40,000 second (11 hours) measurement intervals.
- In the worst case the Fury compares to the 5071A at 400 second intervals with 4E-012 to 6E-013. In other words, in the worst case, the Fury is only 6.7x worse at 400 second intervals. The Cesium unit is almost 36x times more expensive than the Fury yet the Fury will out-perform the Cesium over very long measurement periods.

© 2010 Jackson Labs Technologies, Inc.

Figure 6.1 Fury Allan Deviation



6.2.2

6.3 Conclusions

The conclusion that can be drawn from the above information is that the Fury GPSDO represents the best performance/price ratio on the market today ....

© 2010 Jackson Labs Technologies, Inc.

7 Certification and Warranty

7.1 Certification

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

7.1.1 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.

7.1.2 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.

7.1.3 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.

© 2010 Jackson Labs Technologies, Inc.