Fury Quick Start Instructions – rev. 1.4

The following is a short description on how to use the Fury GPSDO, with additional detail on the external-OCXO SMA version.

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1.   Introduction

The Fury GPSDO SMA version (Fury SMA) 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, and precision voltage references and DACs. It requires an external voltage-controllable frequency source to operate. The standard Fury product includes an OCXO on the main PCB, and does not require an external frequency source.

On Fury with the SMA connector option, an external OCXO or similar 10MHz reference source with EFC control input needs to be connected to Fury via SMA connectors. The Fury unit can accept reference sources with 0dBm to +13dBm power output and 0V to 5V EFC control input. Fury can be configured via the RS-232 control port to support both positive and negative EFC control. Standard Fury units with internal OCXO do not have SMA connectors.

2.   Major connections

The major connections and features of the Fury PCB are shown below:
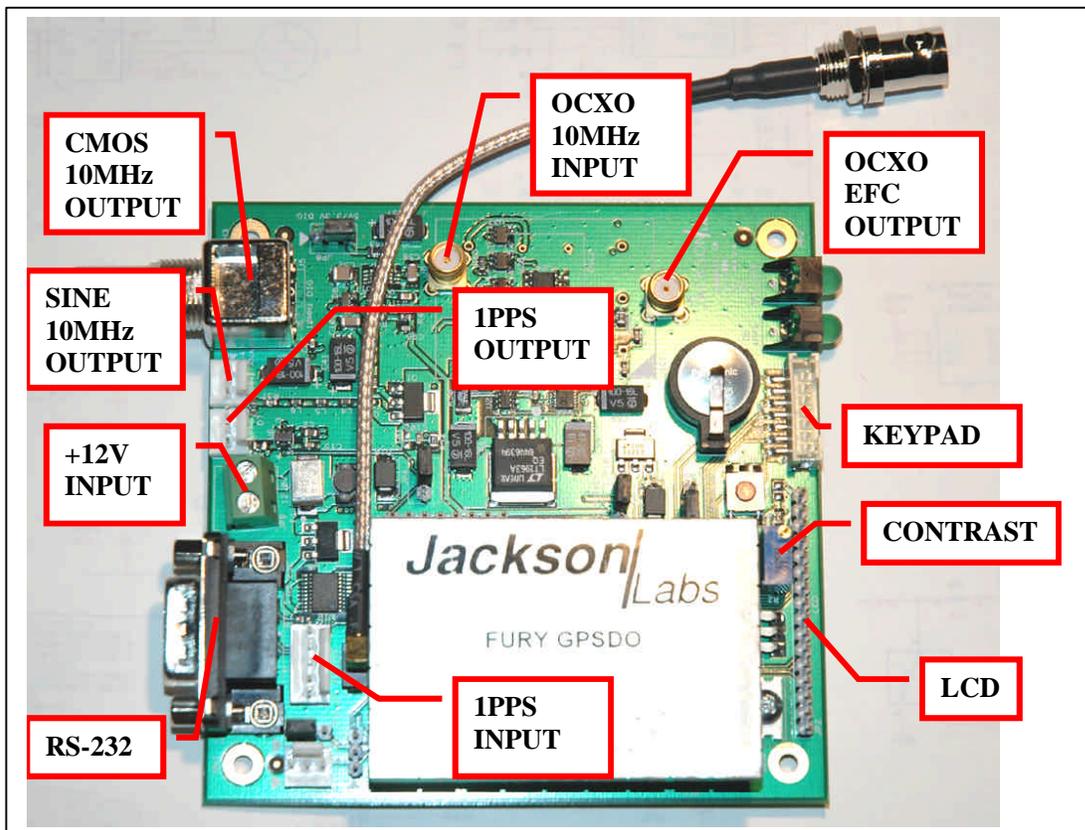
The following table shows the Fury revision 2.0 hardware connectors:

Ref	Name	Function	Specification	Pinning
J4	Sine Out	Sine Wave Out	10.0MHz, +7dBm (+-3dBm), 50Ohms, End-Terminate	3-Sine, 2-GND, 1-GND
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 out pin 5 with 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. Power

The unit is powered from a 11.0 - 14.0V DC source. The small green power connector has its positive side toward the BNC connector. The current is typically less than 0.3A without the OCXO. Connect a clean +12V power source to the green connector block as follows:
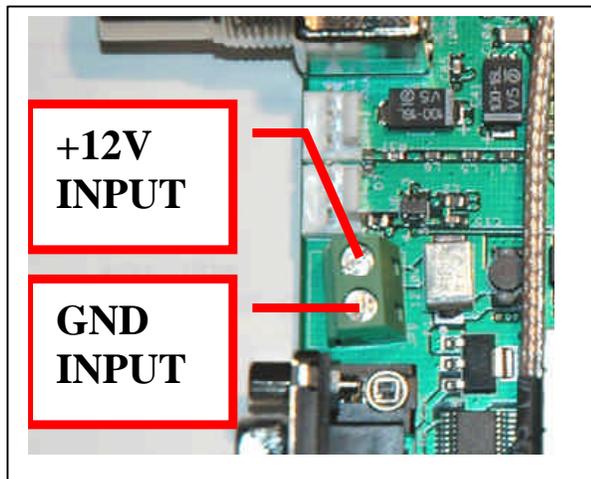
2.2. Connecting an OCXO or other voltage-controlled 10MHz frequency source (not needed for standard OCXO unit)

An OCXO must be connected, and powered-on prior to powering-on the Fury PCB. The Fury CPU uses the OCXO's 10MHz signal as it's CPU clock, so the unit will not start up properly if the Fury is turned-on prior to applying power to the OCXO. Connect the OCXO's 10MHz output (using an SMA cable) to the SMA connector next to the BNC connector. Connect the OCXO EFC input to the SMA connector next to the two status LEDs:
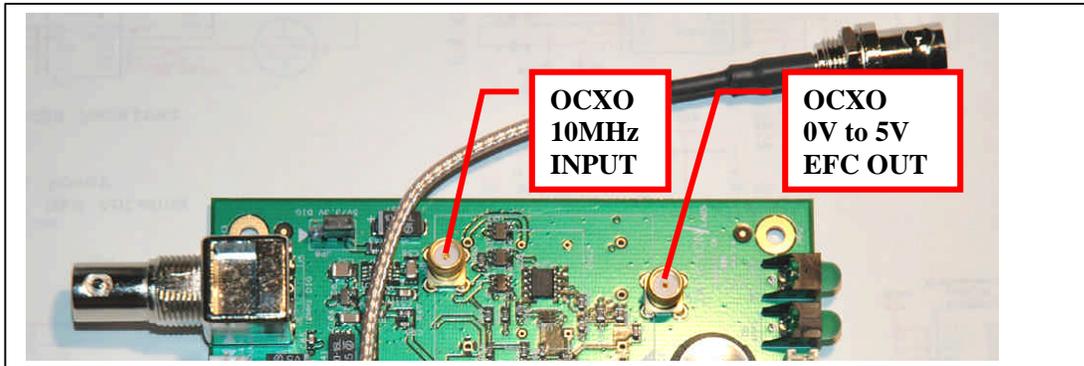
2.3. Connecting the GPS Antenna

Connect the GPS antenna to the BNC cable, and select the GPS Antenna voltage with the Jumper as shown below. Caution: use a Lightning Arrestor on your Antenna setup.
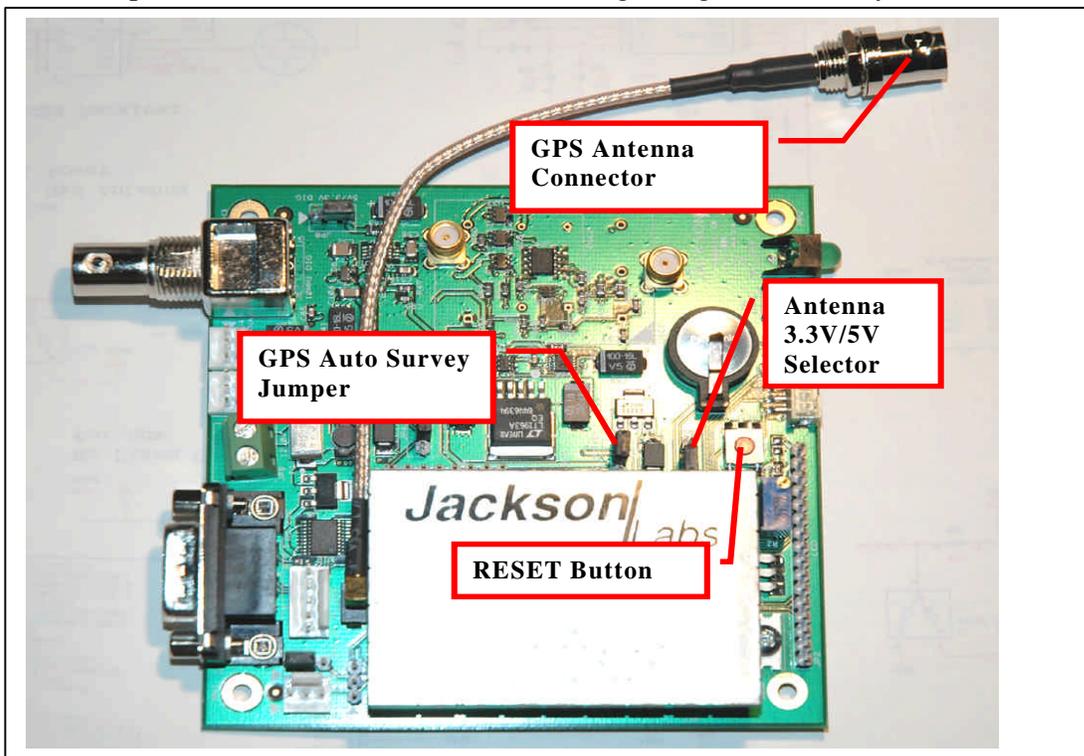
2.4. Initiating Auto Survey mode

Use the "Auto Survey" jumper (see image above) only <u>after</u> 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.

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.

2.5. 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. The below image shows how the LCD is connected to connector JP2.
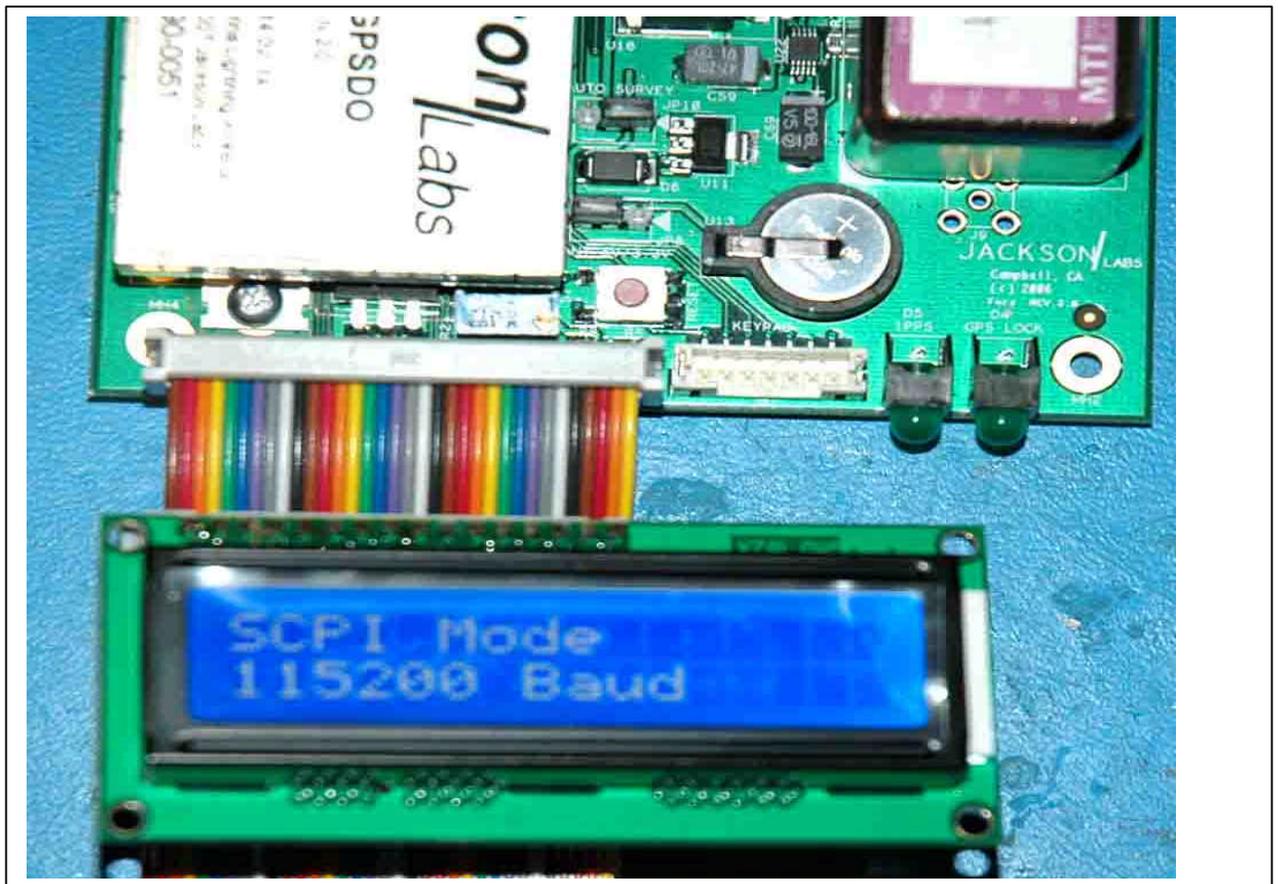
2.6.LCD Contrast

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.

2.7.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!

2.8.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 the following image:
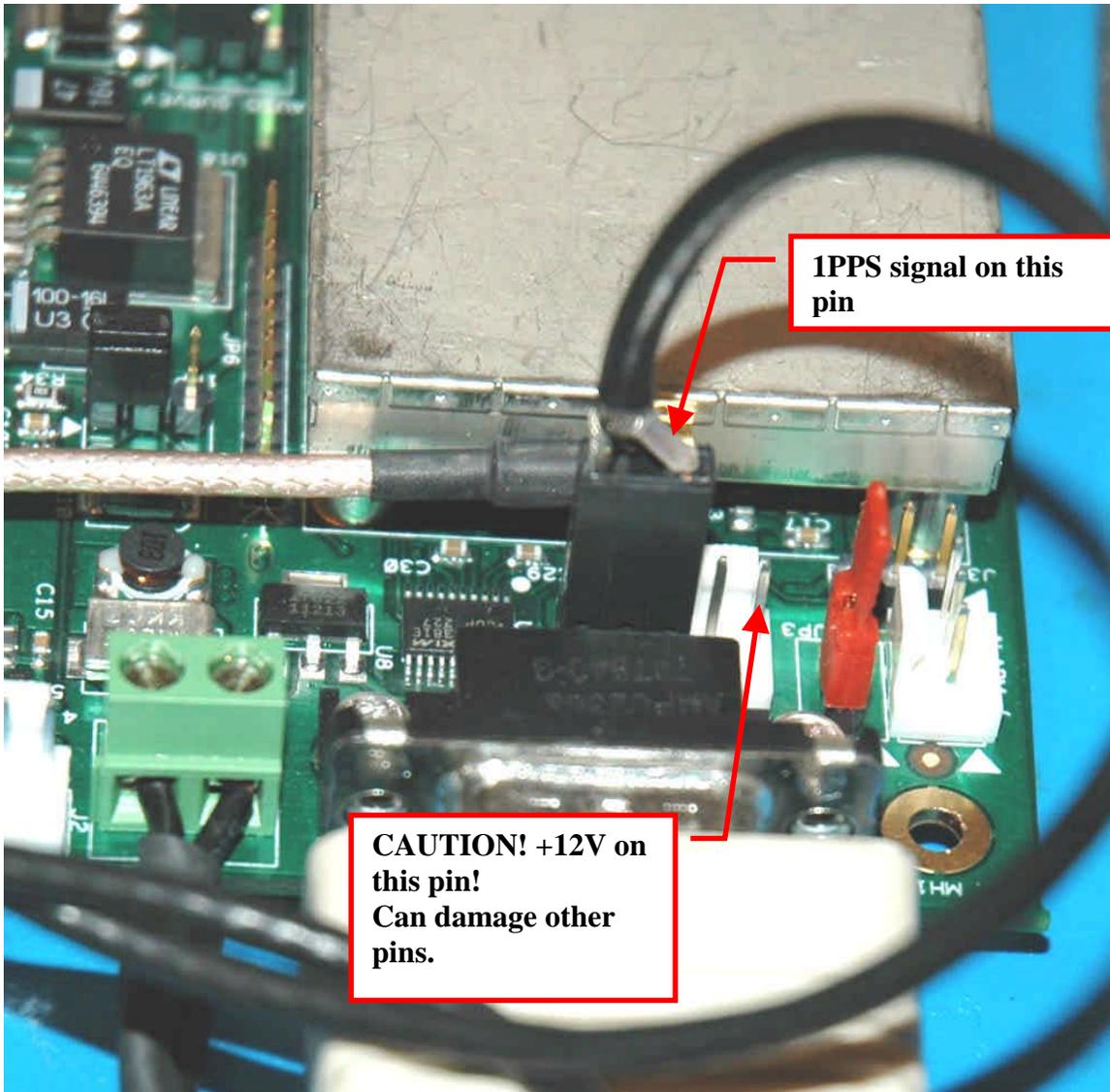
1PPS signal on this pin

CAUTION! +12V on this pin! Can damage other pins.

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?

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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
    - o 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:
    - o 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:
    - o 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.

3.   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". 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.

3.1. "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".

3.2. Loop parameter adjustment

- 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 OCXO's, 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.

EFC Damping: overall IIR filter time constant. higher values increase loop time constant. We typically use 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 following plot for small perturbations:
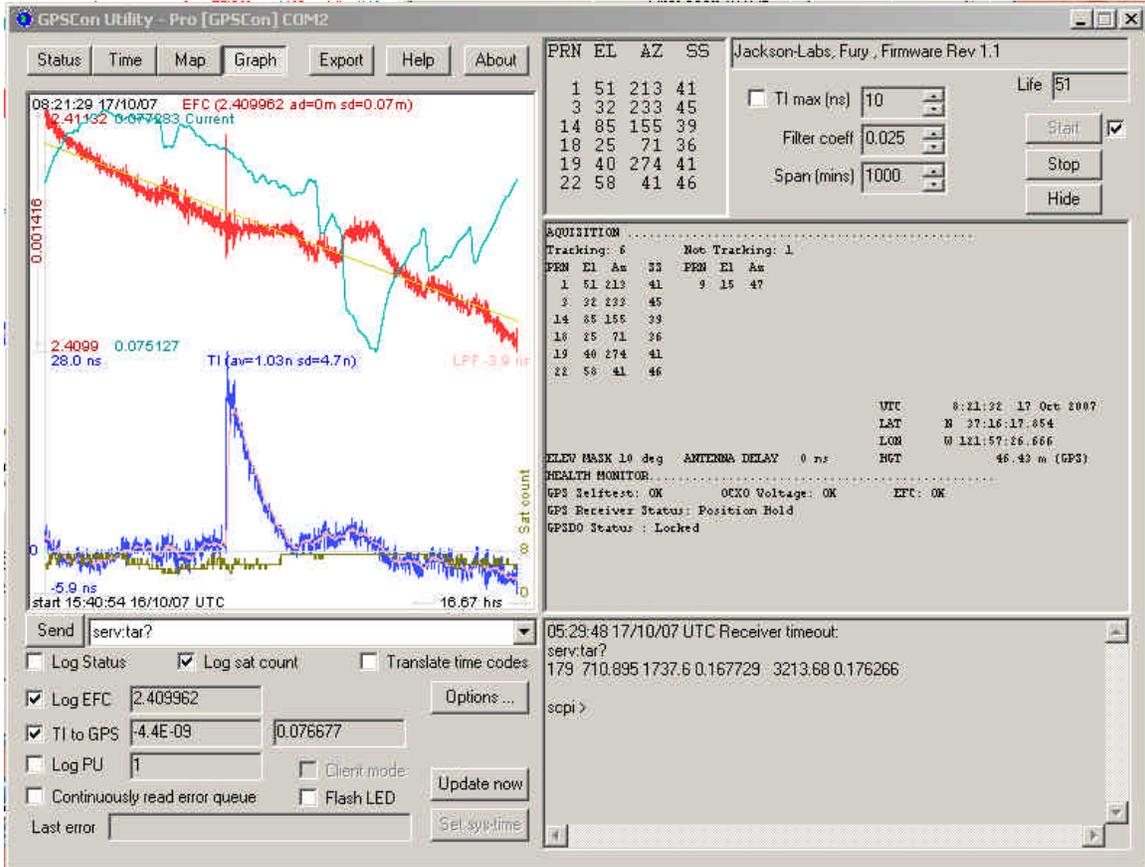
4.   SCPI-Control Quick Start Instructions

The SCPI 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.

4.1.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 :

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?

4.1.1.   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.

4.1.1.1.   GPS:INITial:DATE

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

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

4.1.1.2.   GPS:INITial:TIME

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

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

4.1.1.3.   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>

4.1.2.   GPS:POSition

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

4.1.2.1.   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

4.1.2.2.   GPS:POSition   SURVey

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

4.1.2.3.   GPS:POSition   HOLDSURVey

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

4.1.2.4.   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.

4.1.2.5.   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.

4.1.2.6.   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) 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

4.1.2.7.   GPS:POSition:HOLD:LAST?

This query displays the LAST HOLD position.

4.1.3. GPS:REFerence

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

4.1.3.1. 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 >

4.1.3.2. 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

4.1.3.3. GPS:REFerence:TRAIM:RSVIDs?

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

4.1.3.4. 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]

4.1.3.5. 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]

4.1.3.6. GPS:REFerence:PULse?

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

4.1.4. GPS:SATellite

This group of commands are about the satellites constellation.

4.1.4.1. 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.

4.1.4.2.   GPS:SATellite:TRACKing:COUNt?
This query returns the number of satellites being tracked.

4.1.4.3.   GPS:SATellite:VISible:COUNt?
This query returns the number of satellites (PRN) that the almanac predicts should be visible, given date, time, and position.

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

4.1.4.5.   GPS:GPGGA
This command instructs the Fury to send the NMEA standard string $GPGGA every N seconds, with N in the interval [0,255]. The command is disabled 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]

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

4.1.5.1.   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

Bit 0   Code Location 0=External,1=Internal

This query is suitable for parsing from Host software.

4.1.5.2.   **GPS:STATus:STRing**

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

4.1.6.   **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

4.2.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?

PTIMe:TINTerval?

PTIME?

PTIMe:LEAPsecond:PENDing?

PTIMe:LEAPsecond:ACCumulated?

PTIMe:LEAPsecond:DATE?

PTIMe:LEAPsecond:DURation?

PTIMe:LEAPsecond?

4.2.1.1.   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]

4.2.1.2.   PTIMe:TZONe?

Returns the local time zone offset.

4.2.1.3.   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.

4.2.1.4.   PTIMe:TIME?

This query returns the current 24-hour time. The local time is always referenced to UTC time, offset by any local time zone value that has been provided by the user. The hour, minute, and second is returned.

4.2.1.5.   PTIMe:TIME:STRing?

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

4.2.1.6.   PTIMe:TINTerval?

This query is equivalent to the command SYNChronisation:TINTerval

4.2.1.7.   PTIME?

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

PTIME:DATE?

PTIME:TIME?

PTIME:TZONE?

PTIME:TINTerval?

4.2.2.   PTIMe:LEAPsecond

4.2.2.1.   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.

4.2.2.2.   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.

4.2.2.3.   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.

4.2.2.4.   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.

4.2.2.5.   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?

4.3.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?

SYNChronization:HOLDover:DURation?

SYNChronization:TINTerval?

SYNChronization:IMMEdiate

SYNChronization:FEEstimate?

SYNChronization:LOCKed?

SYNChronization?

4.3.1.1.   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.

4.3.1.2.   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]

4.3.1.3.   SYNChronization:SOURce:STATE?

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

4.3.1.4.   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.

4.3.1.5.   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.

4.3.1.6.   SYNChronization:FEEstimate?

This query returns the Frequency Error Estimate

4.3.1.7.   SYNChronization:LOCKed?

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

4.3.1.8.   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?

4.4. 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?

4.4.1.1.   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%. :

4.4.1.2.   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

4.5. 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?

4.5.1.1.   MEASure:TEMPerature?

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

4.5.1.2.   MEASure:VOLTage?

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

4.5.1.3.   MEASure:CURRent?

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

4.5.1.4.   MEASure?

This query returns the result of the three following queries:

MEASure:TEMPerature?

MEASure:VOLTage?

MEASure:CURRent?

4.6. 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:

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

4.6.1.   SYSTem:COMMunicate

4.6.1.1.   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>

4.6.1.2.   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>

4.6.1.3. 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>

4.6.2. SYSTem:STATus?

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

4.6.3. 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.

4.7. SERVO Subsystem

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

SERVo:COARSeDac <int> [0,225]

SERVo:DACGain <int> [0.1,10000]

SERVo: EFCScale   <float>[0.0 , 500.0]

SERVo:EFCDamping <float>[0.0 , 4000.0]

SERVo:SLOPe   <NEG | POS >

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

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

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

SERVo:1PPSoffset   <int> ns

SERVo:QUIet   <ON | OFF>

SERVo:TRACe   <int > [0,255]

SERVo?

4.7.1.1. 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]

4.7.1.2. SERVo:DACGain

Adjusts the gain of the DAC circuitry to match the OCXO sensitivity to voltage changes. Typical values are 15.0 for OCXO's with +-20Hz deviation, and 150.0 for OCXO's 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	2000.0	Rubidium
2Hz	250.0	10811
20Hz	30.0	Typical OCXO
40Hz	15.0	MTI OCXO

4.7.1.3.   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]

4.7.1.4.   SERVo:EFCDamping

Set's 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]

4.7.1.5.   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 OCXO's EFC frequency slope. This command has the following format:

SERVo:SLOPe   <NEG | POS >

4.7.1.6.   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]

4.7.1.7.   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]

4.7.1.8.   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]

4.7.1.9.   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

4.7.1.10.   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>

4.7.1.11.   SERVo:TRACe

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

This command has the following format:

SERVo:TRACe   <int > [0,255]

4.7.1.12.   SERVo?

This query 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?