FireFly-1A Quick Start Instructions – rev. 1.4

The following is a short description on how to use the FireFly-1A GPSDO.

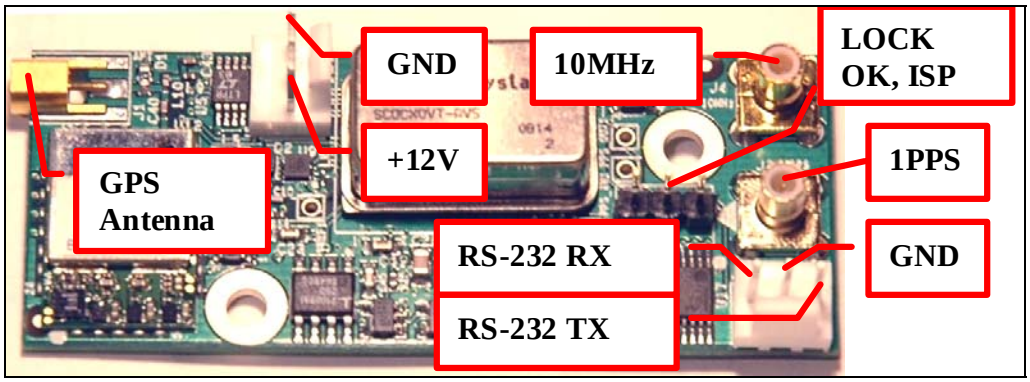
Table of Contents

Introduction

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

Major connections

The major connections and features of the FireFly-1A PCB are shown below:



The following table shows the FireFly-1A revision 2.0 hardware connectors:

Ref	Name	Function	Specification	Pinning
J5	+12V	Clean +12V Supply	8.0V-14.0V DC, <0.5A, <10mVac	3 +12V, 2-GND, 1-GND
J4	Sine Out	10MHz Output	+11dBm +/-3dB 10MHz Output	Center-Sine Output, Shield-GND
J3	1PPS Out	1PPS Output	3.3V CMOS, Rising Edge Synchronized	Center-1PPS Output, Shield-GND
J6	RS-232	RS-232 Communication	115Kbaud, 8N1, RS-232	3-RX, 2-GND, 1-TX
J1	Antenna	GPS Antenna	3.0V Amplified Antenna MMCX connector	Center-RF Input, Shield-GND
J2	ISP/Status	Alarm/Lock Status indicators, and Enable-ISP Flash Download Mode	Pin 3: 3.3V CMOS output Pin 2: 4.7Kohm pull-up on open collector to 3.3V	3-LOCK-OK indicator, can drive an LED 2-ALARM (unlock) indicator, needs buffering 1-GND [Connect pin 2 to ground during power-on to enter ISP flash-firmware-download mode]

Power

The unit is powered from a 8V - 14V DC source. The current is typically less than 0.15A at 12V. Connect a clean +12V power supply to J5. Do not reverse the polarity of the power connector, this will damage the unit. The connector style is a Molex Part Number **22-23-2031** connector.

Connecting the GPS Antenna

Connect the GPS antenna to the BNC to MMCX cable adapter. Caution: use a Lightning Arrestor on your Antenna setup. Use an amplified GPS antenna that is 3V LNA compatible. The FireFly-1A GPS receiver is a 50 channel high-sensitivity GPS receiver with very fast lock time. It does not require any self-survey or position-hold mode (auto survey), and thus can be used in mobile platforms.

FireFly-1A is capable of generating standard navigation messages (see GPS:GPGGA and GPS:GPRMC RS-232 commands) that are compatible with most GPS based navigation software. Please note that FireFly-1A indicates MSL height (rather than GPS height) in it's GPGGA, GPS? and syst:stat? output strings.

The GPS receiver generates a 1PPS time signal that is phase synchronized to UTC. This 1PPS signal is used to frequency-lock the 10MHz Sine-Wave output of the FireFly-1A GPSDO to UTC, thus disciplining the units' 10MHz frequency output to the US Naval master clock for very high frequency accuracy (typically better than 1ppb of frequency accuracy when locked to GPS). Over the long term, the FireFly-1A will out-perform free-running Cesium Atomic Frequency Standards.

Remote serial control

- The unit is controlled via the Serial port at 115200 baud, 8N1. Other Baud Rates can be set via SCPI commands.
- Connect the RX, TX, and GND pins of connector J6 to a standard RS-232 connector, attaching the FireFly-1A unit to your PC's Hyperterminal, or the optional GPSCon software package. An RS-232 level shifter is built into the FireFly-1A PCB. A free control/graphing program for Windows called Z38XX is available on the Jackson Labs Technologies, Inc. website under the "support" tab.

"Help" and command overview

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

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

Loop parameter adjustment

- All loop parameters can be controlled via the RS-232 serial port.
- Loop parameters are optimized for the OCXO on the board, and changing the factory settings may result in the units' performance to deteriorate.

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

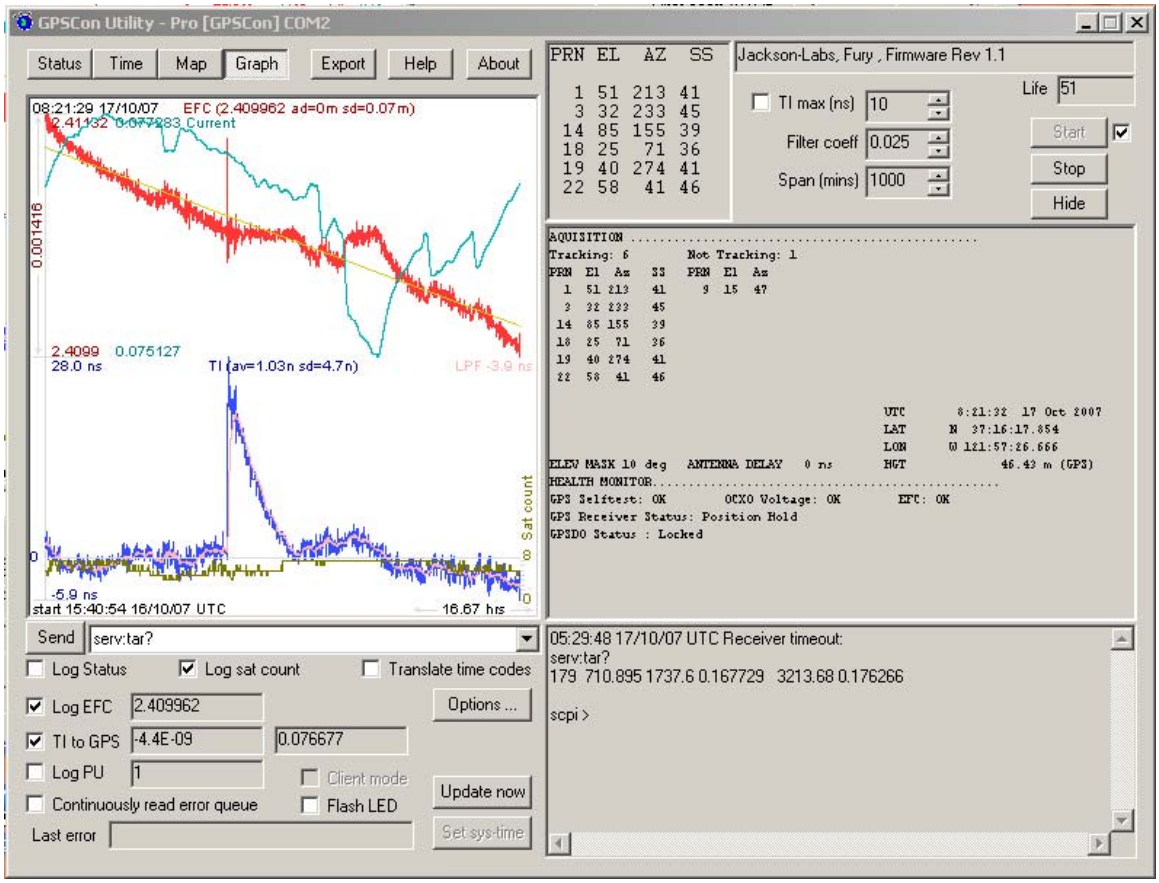
The individual commands are:

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

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

Phase compensation: this is the Integral part of the PID loop. This corrects phase offsets between the FireFly-1A 1PPS signal and the UTC 1PPS signal as generated by the GPS receiver. Set higher values for tighter phase-following at the expense of frequency stability. Typical values range from 4 - 30, 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 when experiencing small perturbations:



SCPI-Control Quick Start Instructions

The SCPI subsystem is accessed via the RS-232 interface and a terminal program. By default the terminal settings are 115200, 8N1.

There are a number of commands that can be used as listed below. Most of these are identical or similar to Symmetricom 58503A commands.

GPS Subsystem

Please note that FireFly-1A displays antenna height in MSL Meters rather than in GPS Meters on all commands that return antenna height [the legacy Fury GPSDO uses GPS height].

N.B.: firmware version 0.909 and later add a new 3D velocity command GPS:XYZSPeed.

The GPS subsystem regroups all the commands related to the control and status of the GPS receiver. The list of the commands supported is the following :

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

GPS:SATellite

This group of commands describe the satellite constellation.

GPS:SATellite:TRAcking:COUNt?

This query returns the number of satellites being tracked.

GPS:SATellite:VISible:COUNt?

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

NMEA Support

The following two commands allow the FireFly-1A GPSDO to be used as an industry standard navigation GPS receiver. The GPGGA and GPRMC NMEA commands comprise all necessary information about the antenna position, height, velocity, direction, satellite info, fix info, time, date and other information that can be used by standard navigation applications via the FireFly-1A RS-232 interface.

Once enabled, FireFly-1A will send out information on the RS-232 transmit pin automatically every N seconds. All incoming RS-232 commands are still recognized by FireFly-1A since the RS-232 interface transmit and receive lines are completely independent of one another.

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

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

GPS:GPGGA

This command instructs the FireFly-1A to send the NMEA standard string $GPGGA every N seconds, with N in the interval [0,255]. The command is disabled during the initial 4 minute OCXO warmup phase.
This command has the following format:

GPS:GPGGA <int> [0,255]

GPGGA shows height in MSL Meters, this is different from traditional GPS receivers that display height in GPS Meters. The difference between MSL and GPS height can be significant, 35m or more are common.

GPS:GGASTat

This command instructs the FireFly-II to send a modified version of the NMEA standard string $GPGGA every N seconds, with N in the interval [0,255]. The command is disabled during the initial 7 minute OCXO warmup phase.
This command has the following format:

GPS:GGASTat <int> [0,255]

This command replaces the regular NMEA GGA validity flag with a decimal number indicating the lock-state of the unit. Please see section **SERVo:TRACe** for a detailed description of the lock state variable. The command allows capture of the position and other information available in the GGA command, as well as tracking the lock state and health of the units' OCXO performance.

GGASTat shows height in MSL Meters, this is different from traditional GPS receivers that display height in GPS Meters. The difference between MSL and GPS height can be significant, 35m or more are common.

GPS:GPRMC

This command instructs the FireFly-1A to send the NMEA standard string $GPRMC every N seconds, with N in the interval [0,255]. The command is disabled during the initial 4 minute OCXO warmup phase.
This command has the following format:

GPS:GPRMC <int> [0,255]

GPS:XYZSPeed

Firmware version 0.909 and later add a 3D velocity vector output command. Enabling this command will output a 3 dimensional velocity vector indicating the units' speed in centimeters per second as well as the Time Of Week in milliseconds.

X, Y, and Z speed are individually given, and are independent of each other. An accuracy estimate in centimeters per second is also given. The velocity data is time-stamped using the time-of-week with a resolution of milliseconds. Use the following format to generate the velocity vector every N seconds, with N in the interval [0,255]:

GPS:XYZSPeed <int> [0,255]

GPS:POSition?

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

GPS:RESET ONCE

This command will re-initialize the GPS receiver.

GPS?

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

PTIME Subsystem

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

PTIMe:TZONe?

PTIMe:DATE?

PTIMe:TIME?

PTIMe:TIME:STRing?

PTIMe:TINTerval?

PTIME?

PTIMe:TZONe?

Returns the local time zone offset.

PTIMe:DATE?

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

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.

PTIMe:TIME:STRing?

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

PTIMe:TINTerval?

This query is equivalent to the command SYNChronisation:TINTerval

PTIME?

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

PTIME:DATE?

PTIME:TIME?

PTIME:TZONE?

PTIME:TINTerval?

SYNChronization Subsystem

This subsystem regroups the commands related to the synchronization of the FireFly-1A with the GPS receiver. The list of the commands supported for this subsystem is the following:

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

SYNChronization:SOURce:STATE?

SYNChronization:HOLDover:DURation?

SYNChronization:HOLDover:INITiate

SYNChronization:HOLDover:RECovery:INITiate

SYNChronization:TINTerval?

SYNChronization:IMMEdiate

SYNChronization:FEEstimate?

SYNChronization:LOCKed?

SYNChronization?

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.

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.

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.

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.

SYNChronization:TINTerval?

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

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.

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.

SYNChronization:LOCKed?

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

SYNChronization?

This query returns the results of these four queries :

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

SYNChronization? Health Status Indicator (firmware 0.913 and later)

The last line in the sync? query is a hexadecimal number indicating the systems health-status. Error flags are encoded in a binary fashion so that each flag occupies one single bit of the binary equivalent of the hexadecimal health-status flag.

The following system parameters are monitored and indicated through the health-status indicator. Individual parameters are 'ored' together which results in a single hexadecimal value encoding the following system status information:

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

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

1) UTC phase > 250ns: 0x4
2) OCXO voltage too high: 0x40

3) GPS in holdover: 0x10

'Oring' these values together results in:

0x40 | 0x10 | 0x4 = 0x54

The unit would thus indicate: **HEALTH STATUS: 0x54**

A health status of 0x0 indicates a properly locked, and warmed-up unit that is completely healthy.

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?

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%. :

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

MEASURE Subsystem

This subsystem regroups the queries related of some parameters that are measured on-board on the FireFly-1A. The list of the commands supported for this subsystem is the following:

MEASure:VOLTage?

MEASure:CURRent?

MEASure?

MEASure:VOLTage?

This command is not supported in FireFly-1A, and will return undetermined values.

MEASure:CURRent?

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

MEASure?

This query returns the result of the three following queries:

MEASure:VOLTage?

MEASure:CURRent?

SYSTEM Subsystem

This subsystem regroups the commands related to the general configuration of the FireFly-1A. 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

SYSTem:COMMunicate

SYSTem:COMMunicate:SERial:ECHO

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

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

SYSTem:COMMunicate:SERial:PROmpt

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

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

SYSTem:COMMunicate:SERial:BAUD

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

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

SYSTem:STATus?

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

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.

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?

SERVo:COARSeDac

This command sets the coarse Dac that controls the EFC. The FireFly-1A 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]

SERVo:DACGain

This command is used for factory setup.

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]

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]

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 >

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. This command has the following format:

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

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]

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]

SERVo:1PPSoffset

This command sets the FireFly-1A 1PPS signal's offset to UTC in 16.7ns steps.

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

This command has the following format:

SERVo:1PPSoffset <int> ns

SERVo:TRACe

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

This command has the following format:

SERVo:TRACe <int > [0,255]

An example output is described here:

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

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

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

N.B.: health status information is available with firmware versions 0.913 and later.

The Lock State variable indicates one of the following states:

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

SERVo?

This command returns the result of the following queries:

SERVo:COARSeDac?

SERVo:DACGain?

SERVo: EFCScale?

SERVo:EFCDamping?

SERVo:SLOPe?

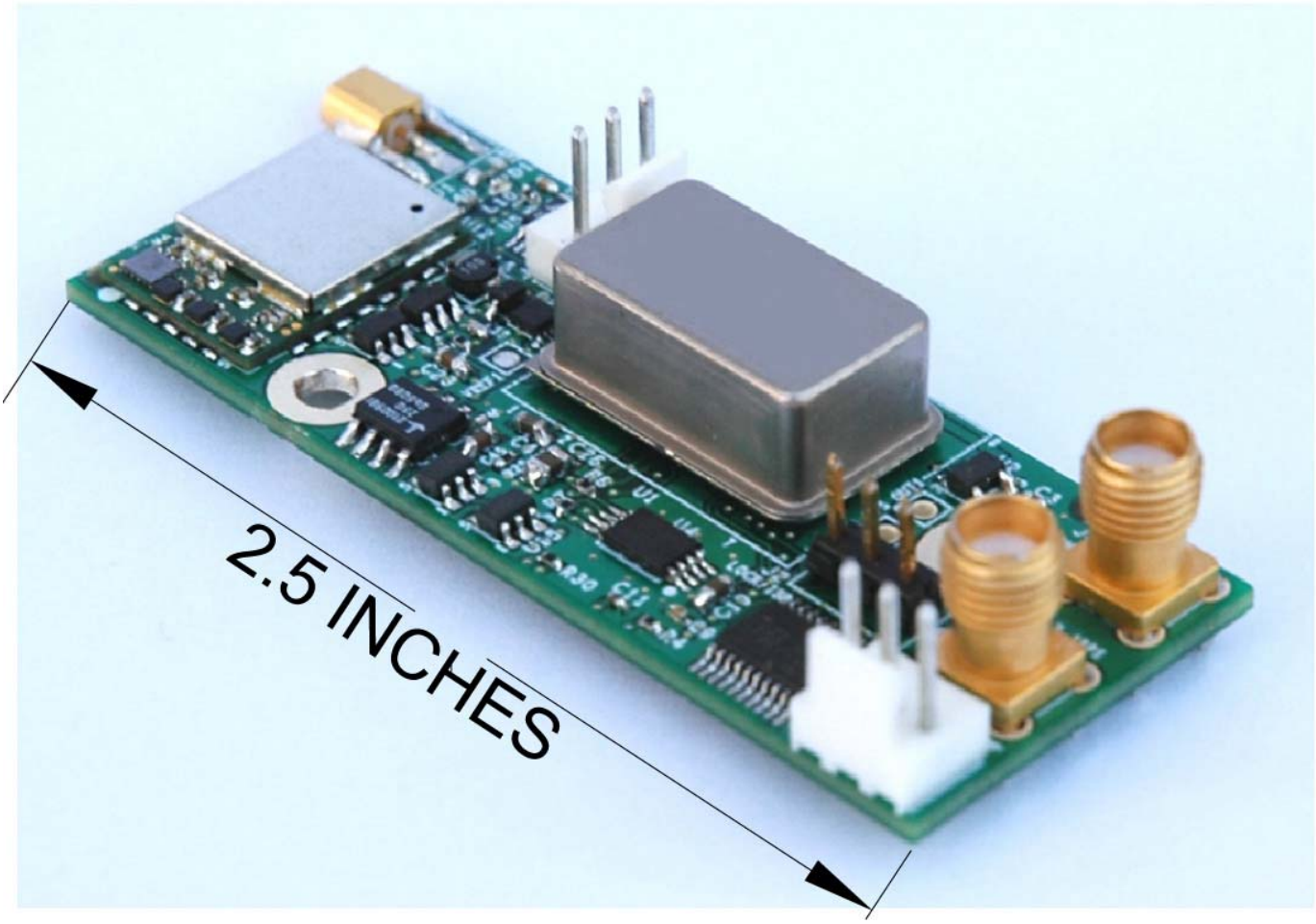
SERVo:TEMPCOmpensation?

SERVo:AGINGcompensation?

SERVo:PHASECOrrection?

SERVo:1PPSoffset?

SERVo:TRACe?


2.5 INCHES