Jackson Labs

FireFly-1A User Manual

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FireFly-1A User Manual

1 Introduction

1.1 Overview

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.

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 FireFly-1A 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.

2 Quick-Start Instructions

2.1 Powering Up the Unit

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. The connector style is a MolexPart Number 22-23-2031 connector.

Warning: Do not reverse the polarity of the power connector, this will damage the unit.

2.1.1 Major connections

The major connections and features of the FireFly-1A PCB are shown in :Figure 2.1.

Figure 2.1 Major connections to FireFly-1A

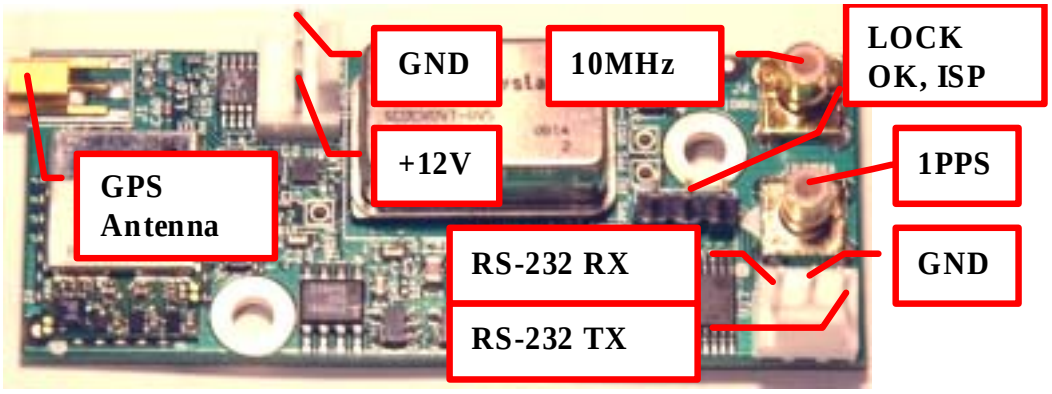


Table 2.1 shows the FireFly-1A revision 2.0 hardware connectors

Table 2.1 FireFly-1A 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]

2.2 Coaxial Connector types

There are three coaxial connectors on the FireFly-1A board. They are the following types:

J1, antenna: MMCX

J3, 1PPS output: SMB

J4, 10MHz sine output: SMB

2.3 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 its 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 unit’s 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.

2.4 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.

2.4.1 "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".

2.4.2 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 unit's performance to deteriorate.

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

The individual commands are:

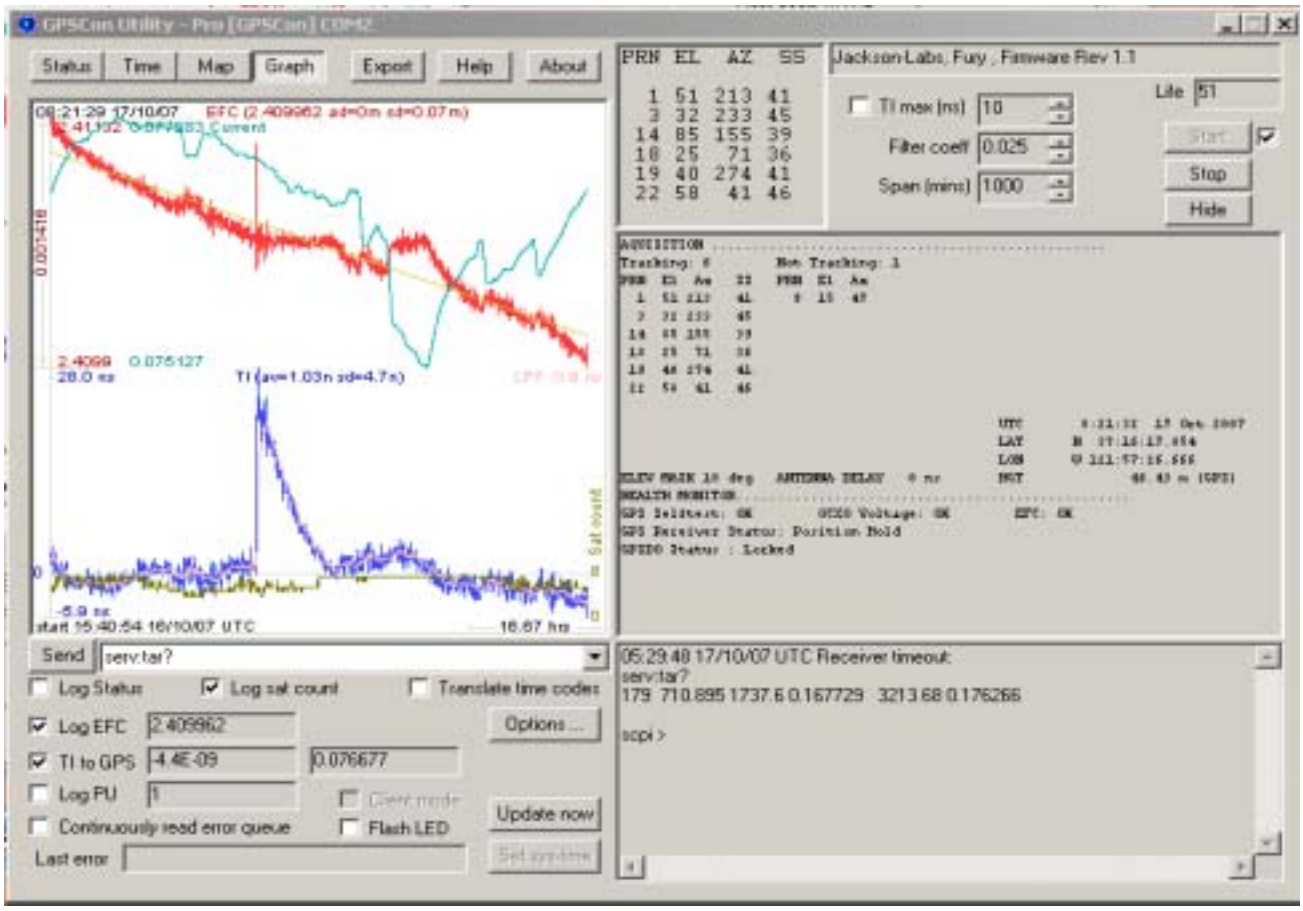
EFC Scale: this is the proportional gain of the PID loop. Higher values will give quicker convergence, and faster locking of the GPS time (lower loop time constant), lower values give less noise. Values between 0.7 and 6.0 are typical.

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

Phase compensation: this is the Integral part of the PID loop. This corrects phase offsets between the 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 plot in Figure 2.2 when experiencing small perturbations

Figure 2.2 FireFly-1A phase compensation plot



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 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.To get a listing of the available commands, send the HELP? query. This will return a list of all the available commands for the FireFly-1A 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 FireFly GPSDO.

3.3 GPS Subsystem

Note: 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].

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

3.3.1 GPS:SATellite

This group of commands describe the satellite constellation.

3.3.2 GPS:SATellite:TRAcking:COUNt?

This query returns the number of satellites being tracked.

3.3.3 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 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.

3.3.5 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.

3.3.6 GPS:GGASTat

This command instructs the FireFly-1A 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 unit's 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.

3.3.7 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]

3.3.8 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 unit's 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]

3.3.9 GPS:POSition?

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

3.3.10 GPS:RESET ONCE

This command will re-initialize the GPS receiver.

3.3.11 GPS?

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

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?

PTIMe:DATE?

PTIMe:TIME?

PTIMe:TIME:STRing?

PTIMe:TINTerval?

PTIME?

3.4.1 PTIMe:TZONe?

Returns the local time zone offset.

3.4.2 PTIMe:DATE?

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

3.4.3 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.

3.4.4 PTIMe:TIME:STRing?

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

3.4.5 PTIMe:TINTerval?

This query is equivalent to the command SYNChronization:TINTerval

3.4.6 PTIME?

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

PTIME:DATE?

PTIME:TIME?

PTIME:TZONE?

PTIME:TINTerval?

3.5 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?

3.5.1 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.

3.5.2 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.

3.5.3 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.

3.5.4 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.

3.5.5 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.

3.5.6 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.

3.5.7 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.

3.5.8 SYNChronization:LOCKed?

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

3.5.9 SYNChronization:health?

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

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

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

3.5.10 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?

SYNChronization:health?

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?

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 FireFly-1A. The list of the commands supported for this subsystem is the following:

MEASure:VOLTage?

MEASure:CURRent?

MEASure?

3.7.1 MEASure:VOLTage?

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

3.7.2 MEASure:CURRent?

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

3.7.3 MEASure?

This query returns the result of the two following queries:

MEASure:VOLTage?

MEASure:CURRent?

3.8 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

3.8.1 SYSTem:COMMunicate

3.8.1.1 SYSTem:COMMunicate:SERial:ECHO

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

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

3.8.1.2 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]

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 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]

3.9.2 SERVo:DACGain

This command is used for factory setup.

3.9.3 SERVo: EFCScale

Controls the Proportional part of the PID loop. Typical values are 0.7 (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 OCXO's 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 Technologies, Inc. firmware. 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 Technologies, Inc. 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]

3.9.9 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

3.9.10 SERVo:TRACe

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

This command has the following format:

SERVo:TRACe <int > [0,255]

An example output is described here:

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

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

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

Note: 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

3.9.11 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?

4 Firmware Upgrade Instructions

4.1 Introduction

The following is a short tutorial on how to upgrade the FireFly-1A GPSDO firmware. Please follow the instructions in-order to prevent corrupting the FireFly-1A Flash, which may require reflashing at the factory.

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

4.2 ISP Flash Loader Utility installation

There are two Flash loader utilities available to upgrade the FireFly-1A 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/

4.2.1 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 LPC2138 processor used on the FireFly-1A boards.

4.2.2 Flash Magic Flash Programming Utility

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

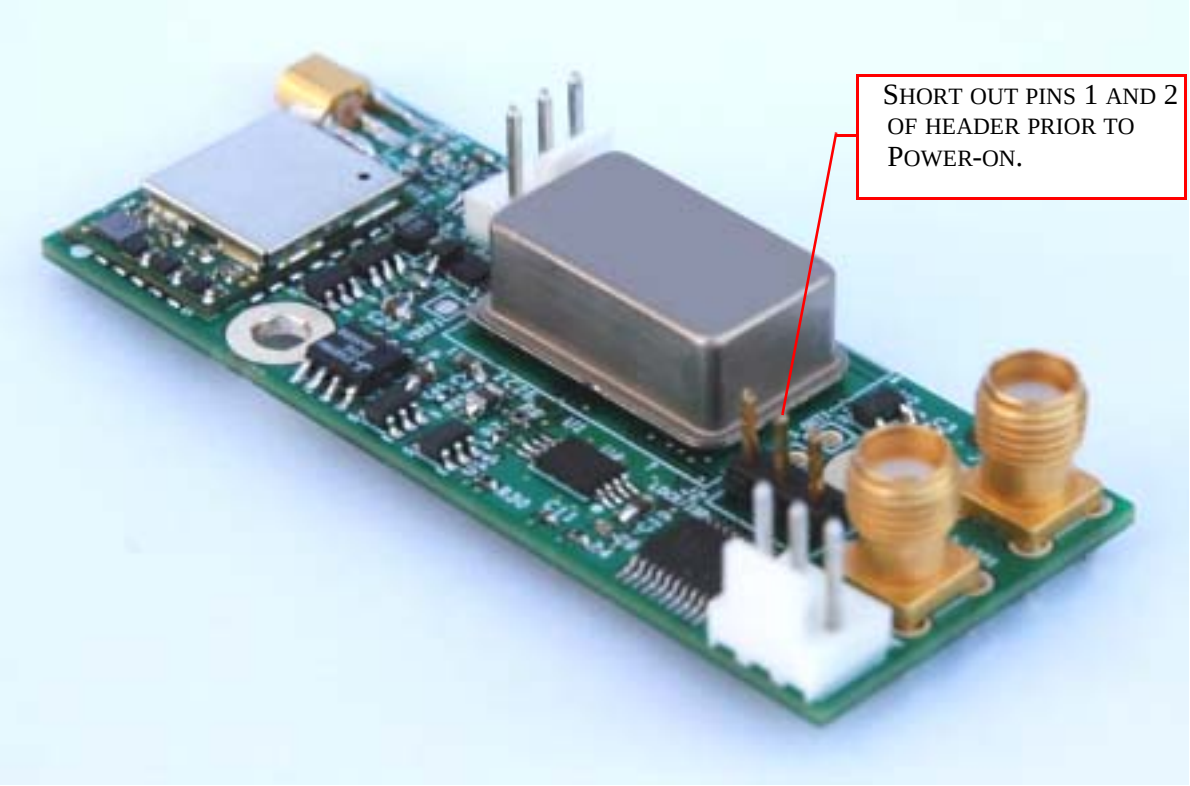
http://www.flashmagictool.com/

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

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

Momentarily short-out pins 1 and 2 of header J2 using a jumper or other conductive material during power-on. Both LED's should remain off, indicating the unit is properly placed into ISP mode. If the LED's light up after power-on, the unit is not in ISP mode.

Figure 4.1 Location of J2



4.4 Downloading the firmware

Download the latest version of FireFly-1A 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 FireFly-1A as indicated in Section 2.1.1 .

4.4.1 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.

C) Press the “READ DEVICE ID” button, this should then show “LPC2138” 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.

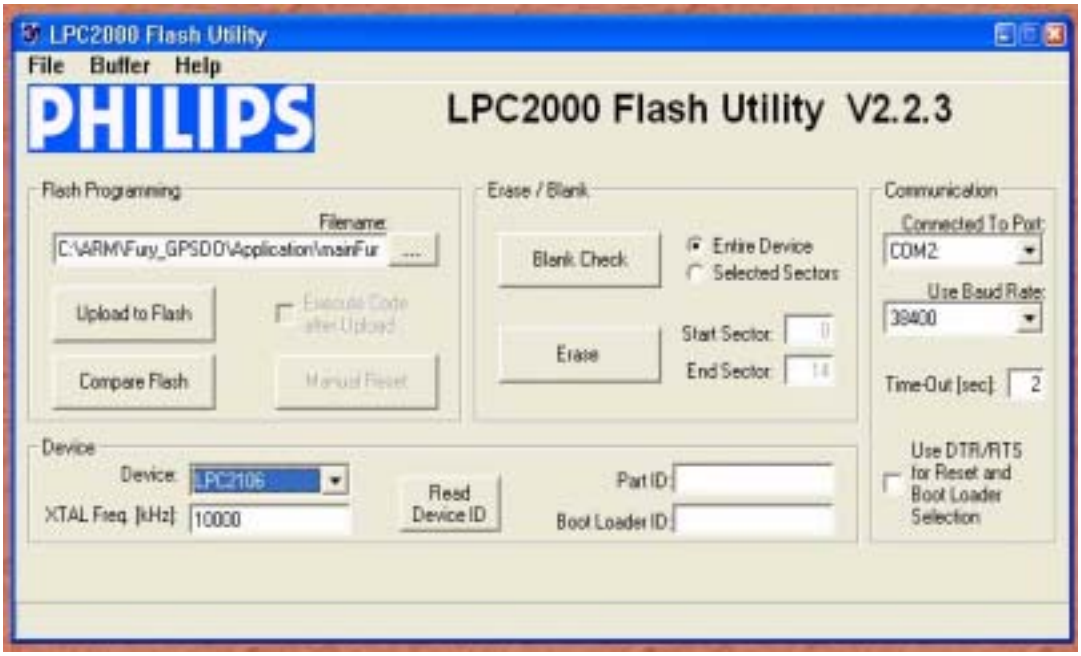
A) Open the LPC2000 utility. Set the COM port in the LPC2000 application as needed on your PC.

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 4.2 LPC2000 flash utility



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 “LPC2138” 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 window in Figure 4.3 should appear if the correct COM port has been chosen etc:

Figure 4.3 LPC2000 flash download

Press the “OK” button, and the download should start. Sometimes the utility gets confused and this process (from item 4.4 B)) has to be tried several times.

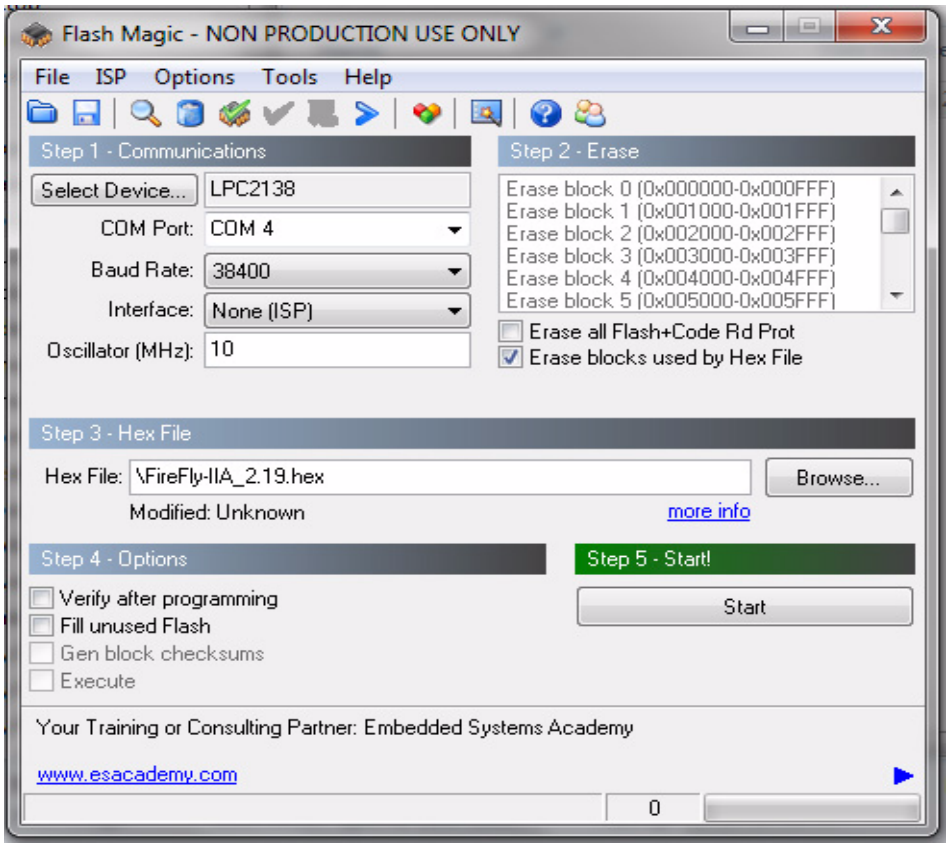
It is not necessary to press “reset” as the utility is asking. Just press “OK” on the utility window’s button.

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

4.4.2 Flash Magic Flash Programming Utility

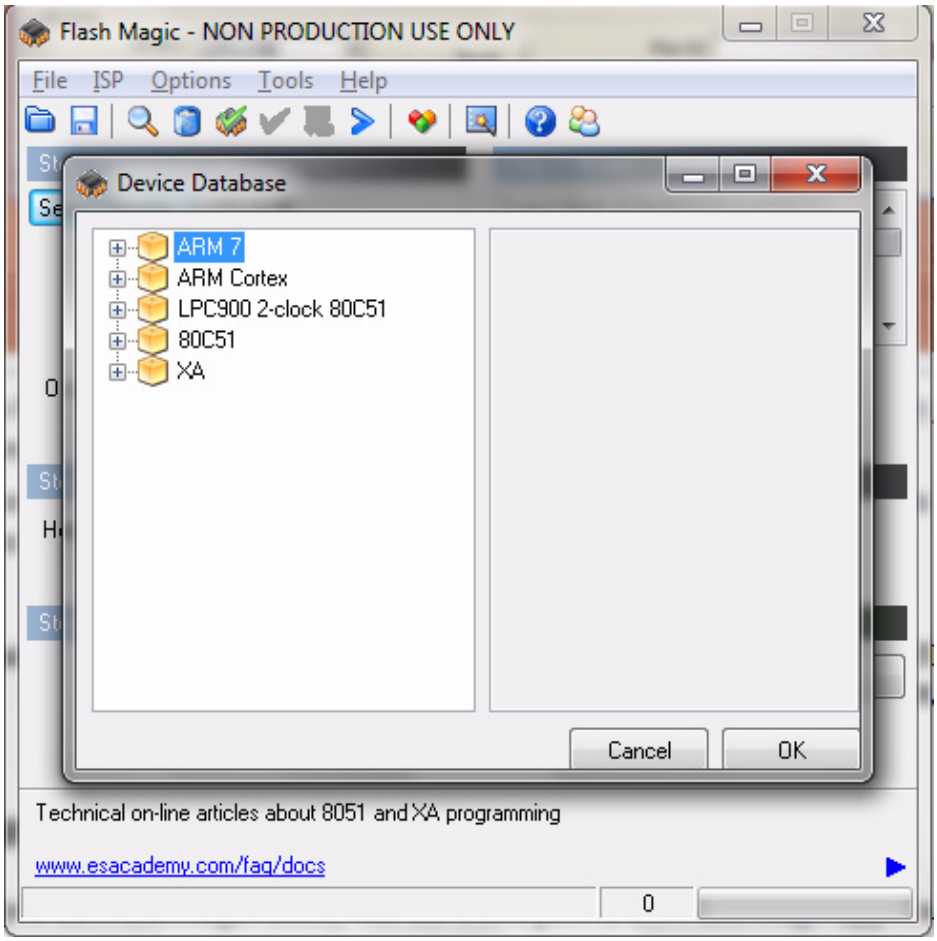
A) Open the Flash Magic utility. Set the COM port in the Flash Magic application as needed on your PC. Set “Interface” to “None (ISP)”.

Figure 4.4 Flash Magic utility



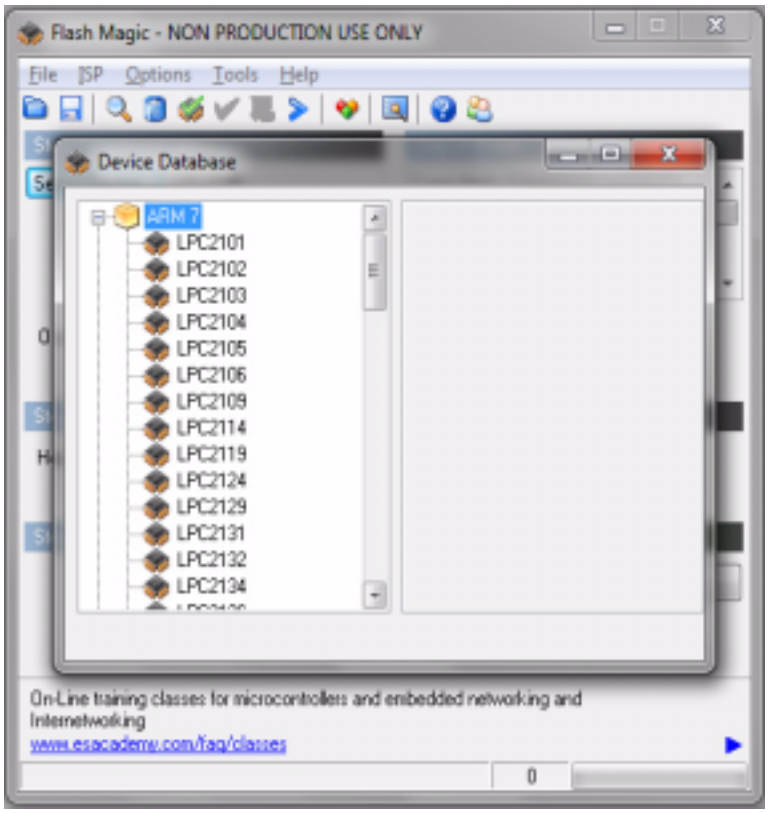
B) Press the “Select Device” button and the window shown in Figure 4.5 will appear:

Figure 4.5 Device selection window



C) Expand the ARM7 folder and select the appropriate processor, in this case the LPC2138.

Figure 4.6 Expanded device selection window



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 4.4 .

H) Go to Step 5 and press “Start”. You wil observe the firmware being downloaded to the FireFly-1A.

4.5 Verifying Firmware Update

Remove the jumper from header J2, and power cycle the unit. Both LED’s should blink.

During power on, the unit sends an ID string out of the serial port at 115200 Baud by default. The firmware version can also be queried by sending the *IDN? command. Verify that the firmware version is the version that was downloaded.

5 GPSCon Utility

5.1 Description

GPSCon is a program for the monitoring and control of a variety of GPS time and frequency standard receivers. It communicates with the receiver using the SCPI command set. This utility can be obtained directly from Real Ham Radio.com at the following URL:

http://www.realhamradio.com/gpscon-buy-now.htm

Important note: On newer, faster computers running Windows 7, GPSCon may not acquire data correctly. 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.

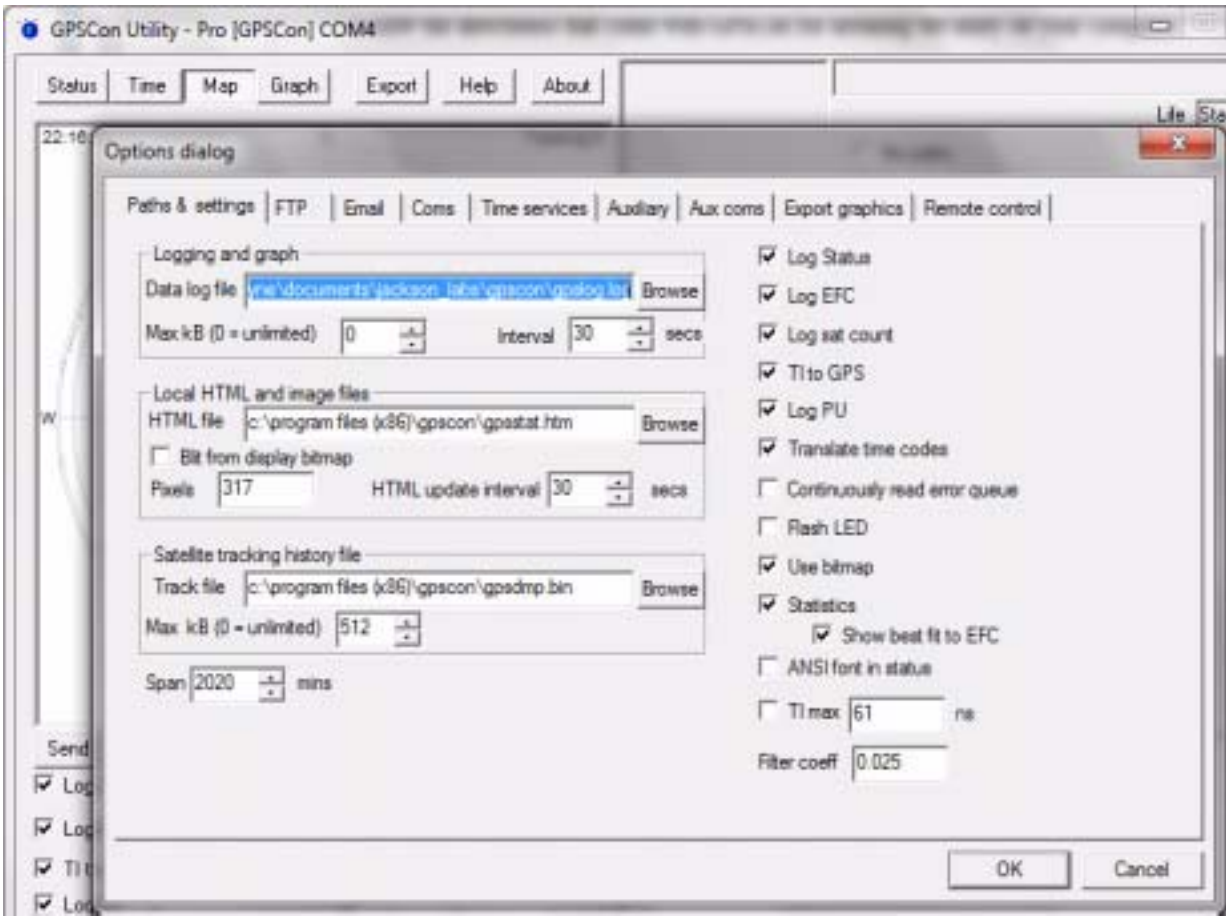
5.3 Using GPSCon

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.

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.

Figure 5.2 Setting the communications parameters

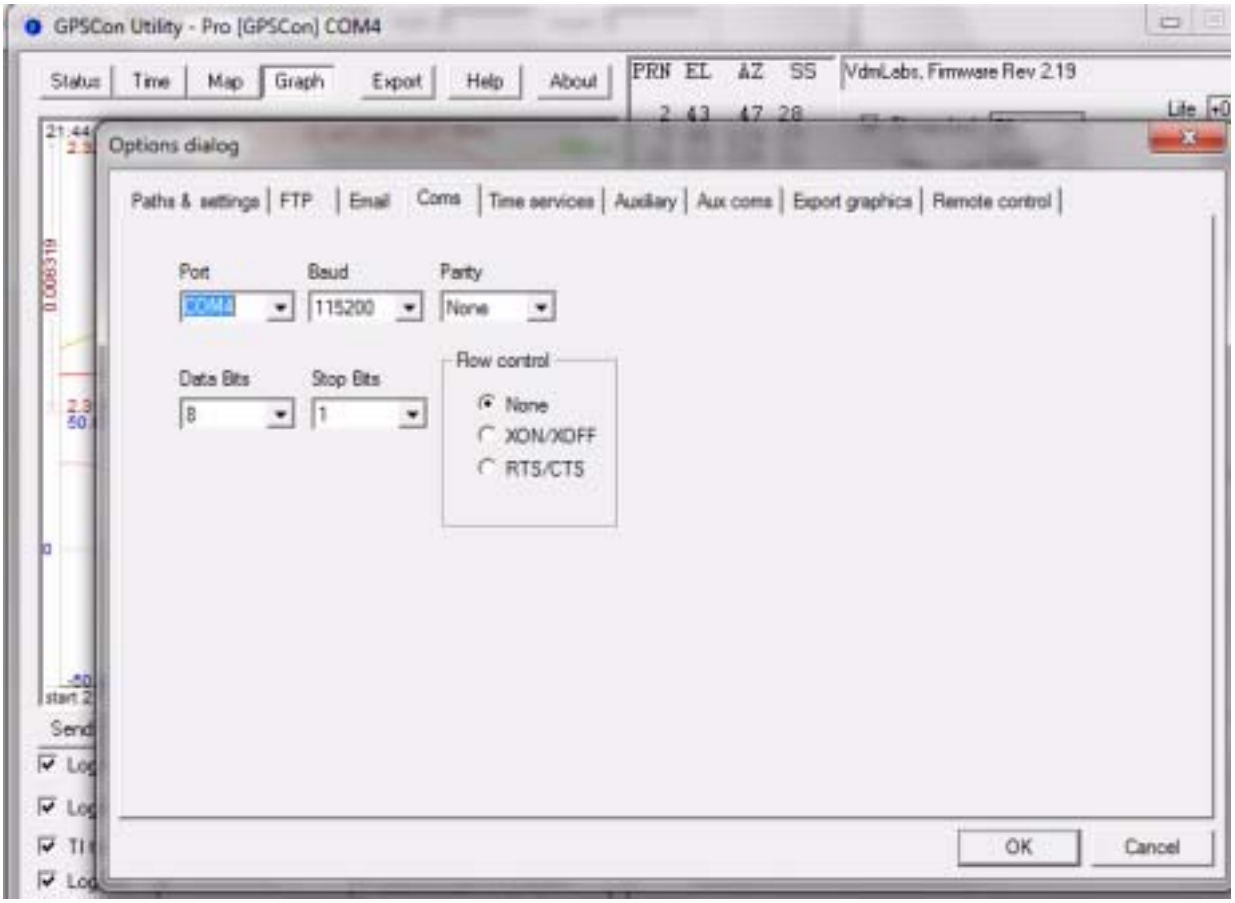
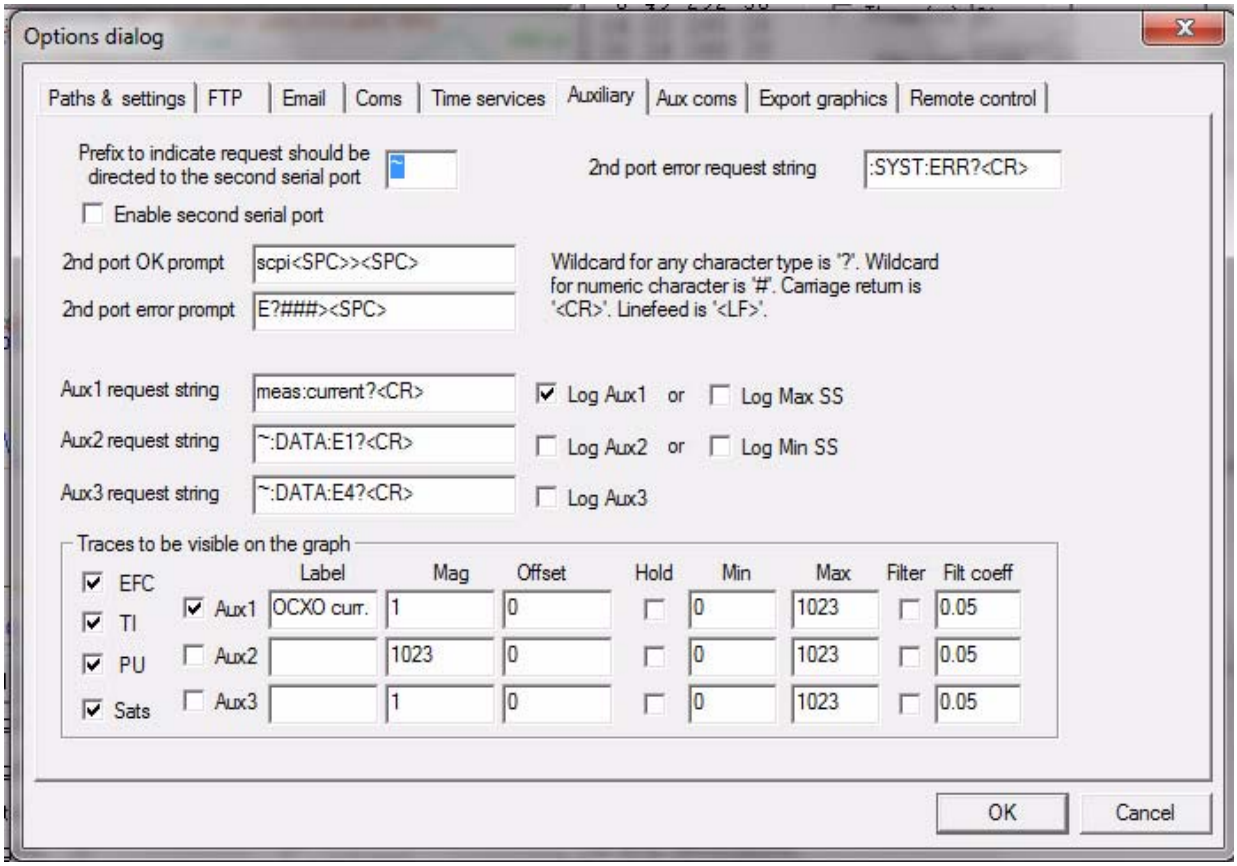


Figure 5.3 Auxiliary Parameters window



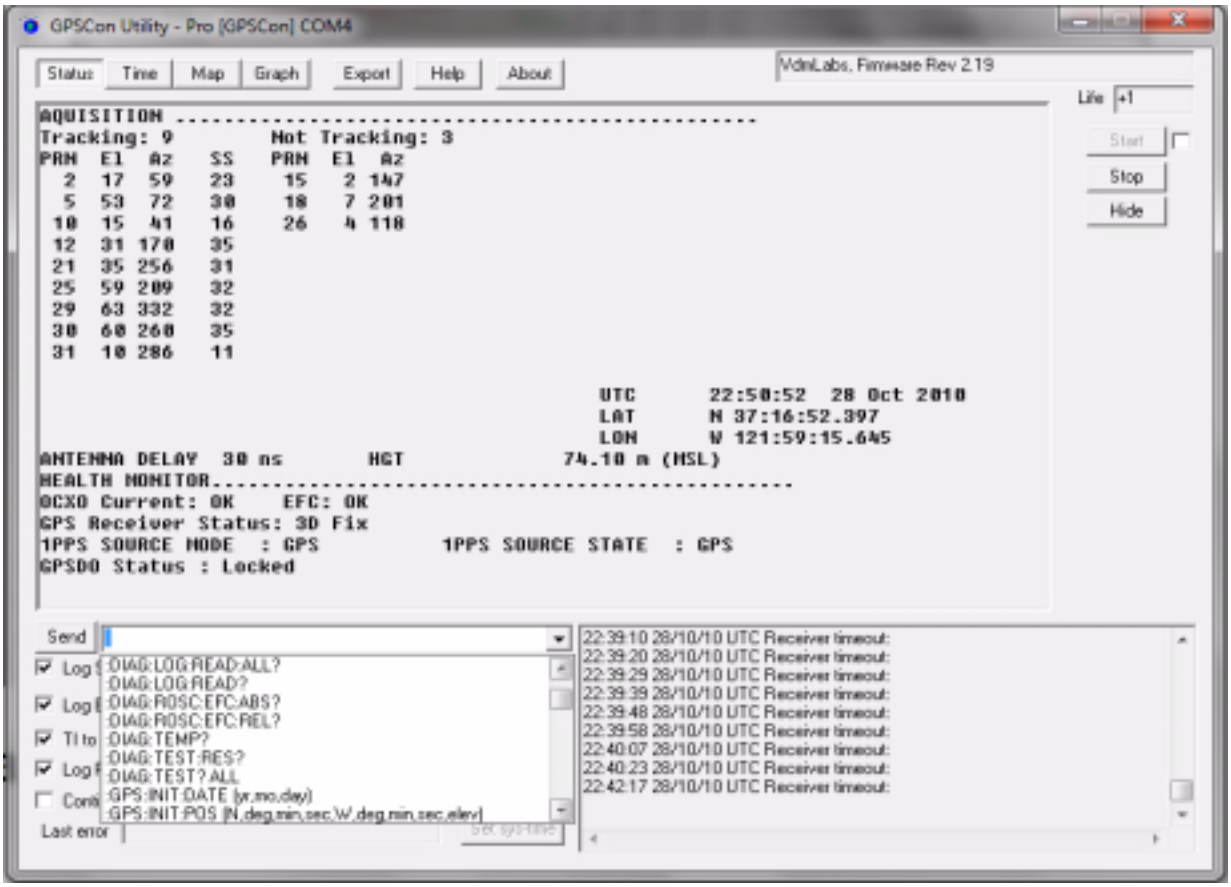
5.3.1.3 Other options

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 FireFly-1A GPSDO. Once you've selected the command, you can press "Send" to send it to the FireFly-1A.

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."

Remember, in order to see all the data in the log file, you must either set the span control to zero, or right double-click in the graph.

When you have locked the start and stop time using the mouse, you can scroll left or right through the data without changing the span. To scroll to a later time, use Shift + Left click. To scroll to an earlier time, use Shift + Right click. Double left click to release everything.

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

Figure 5.5 Graph display

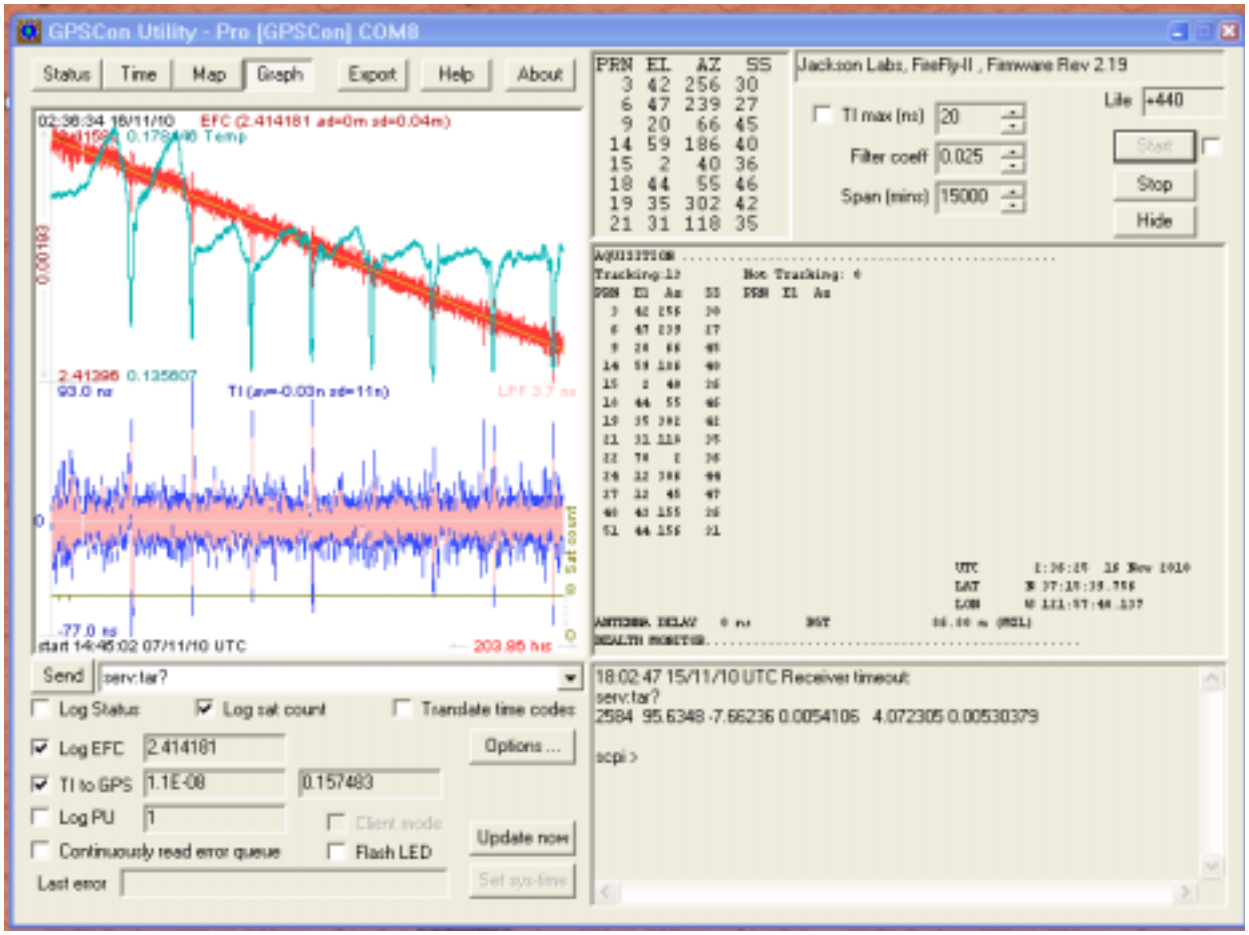
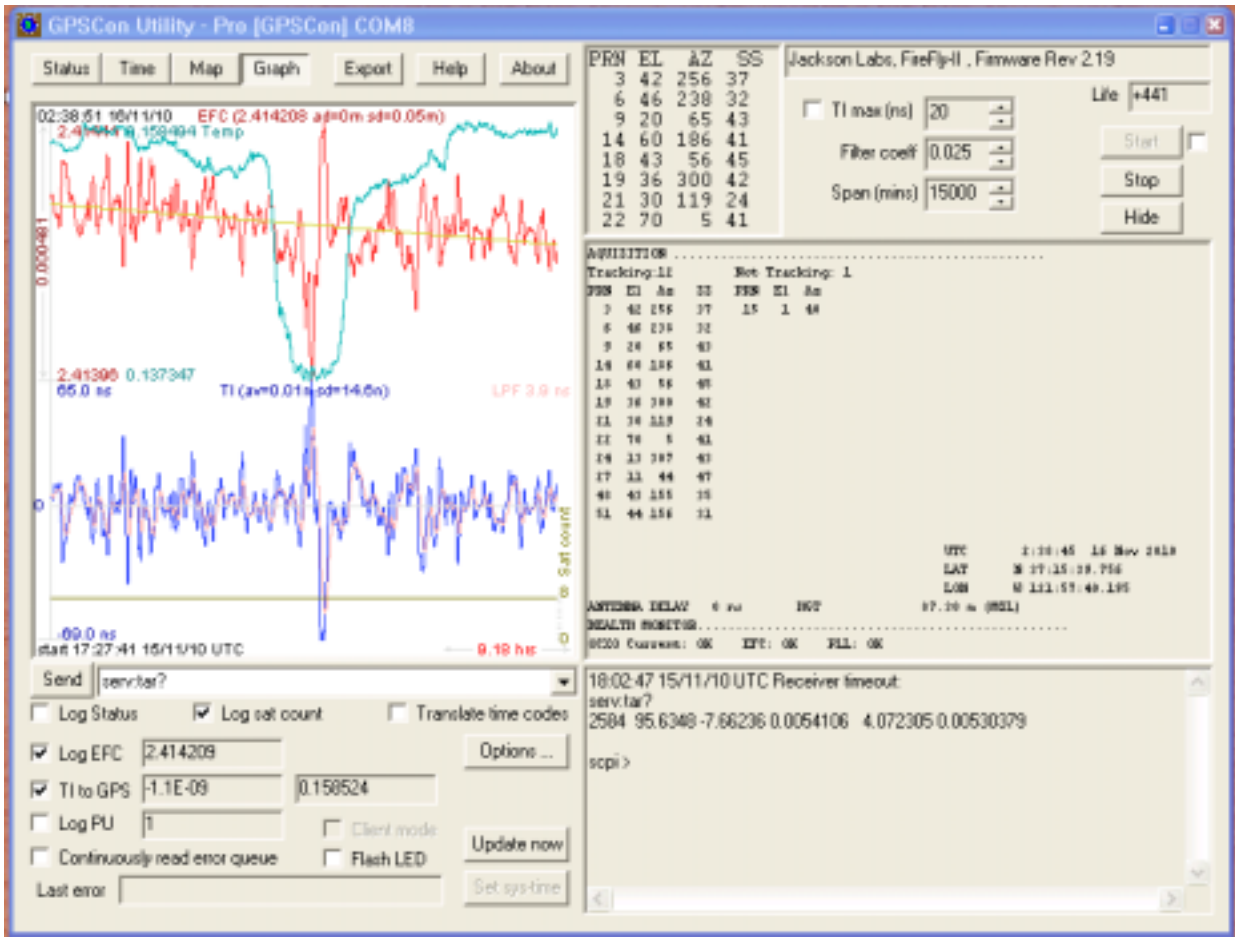


Figure 5.6 Expanded Graph Display



5.3.4 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.

5.4 Interpreting the Data

Figure 5.5 shows the data acquired by the FireFly-1A 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.

6 Certification and Warranty

6.1 Certification

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

6.1.1 Warranty

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

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

6.1.2 Limitation of Warranty

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

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