

RCM Reference User Manual

RCM Reference User Manual

Copyright © 2011, 2012, 2013, 2014 Jackson Labs Technologies, Inc.

1	Introduction	1
1.1	Overview	1
1.2	General Safety Precautions	2
1.2.1	Antenna Lightning Protector	2
1.2.2	Grounding	2
1.2.3	Power Connections	3
1.2.4	Environmental Conditions	3
2	Quick-Start Instructions	5
2.1	Powering Up the Unit	5
2.1.1	PCB Photos	6
2.1.2	Mechanical Drawings	6
2.1.3	Notes on Signal Interfacing	9
2.1.4	Coaxial Connectors	10
2.1.5	Main Power and Control Connector	10
2.1.6	Typical Phase Noise Performance	10
2.2	Remote serial control	11
2.2.1	Loop parameter adjustment	11
3	SCPI-Control Quick Start Instructions	13
3.1	Introduction	13
3.2	General SCPI Commands	13
3.2.1	Quick Start Commands	13
3.2.2	*IDN?	13
3.2.3	HELP?	14
3.3	GPS Subsystem	14
3.3.1	NMEA Support	14
3.3.2	GPS:GPGGA	14
3.3.3	GPS:GGASTat	15
3.3.4	GPS:GPRMC	15
3.3.5	GPS:GPZDA	15
3.3.6	GPS:INITial:DATE <yyyy,mm,dd>	15
3.3.7	GPS:INITial:TIME <hour,min,sec>	16
3.4	PTIME Subsystem	16
3.4.1	PTIME:DATE?	16
3.4.2	PTIME:TIME?	16
3.4.3	PTIME:TIME:STRing?	16
3.4.4	PTIME:TINterval?	16
3.4.5	PTIME?	16
3.5	SYNChronization Subsystem	17
3.5.1	SYNChronization:HOLDOver:DURation?	17
3.5.2	SYNChronization:HOLDOver:INITiate	17
3.5.3	SYNChronization:HOLDOver:RECOvery:INITiate	18
3.5.4	SYNChronization:SOURce:MODE	18
3.5.5	SYNChronization:PLL:10MHZ [NARrow:MEDIum:WIDE]	18
3.5.6	SYNChronization:PLL:100MHZ [NARrow:MEDIum:WIDE]	18
3.5.7	SYNChronization:PLL?	18
3.5.8	SYNChronization:SOURce:STATE?	19
3.5.9	SYNChronization:TINterval?	19
3.5.10	SYNChronization:FEEstimate?	19

- 3.5.11 SYNChronization:LOCKed? 19
- 3.5.12 SYNChronization:OUTput:1PPS:RESET [ON|OFF] 19
- 3.5.13 SYNChronization:health? 19
- 3.5.14 SYNChronization?. 20
- 3.6 DIAGnostic Subsystem 21
 - 3.6.1 DIAGnostic:ROSCillator:EFControl:RELative? 21
 - 3.6.2 DIAGnostic:ROSCillator:EFControl:ABSolute? 21
 - 3.6.3 DIAGnostic:LIFetime:COUNT? 21
- 3.7 MEASURE Subsystem 21
 - 3.7.1 MEASure:VOLTage?. 21
 - 3.7.2 MEASure:CURRent?. 21
 - 3.7.3 MEASure?. 22
- 3.8 SYSTEM Subsystem 22
 - 3.8.1 SYSTem:COMMunicate 22
 - 3.8.1.1 SYSTem:COMMunicate:SERial:ECHO 22
 - 3.8.1.2 SYSTem:COMMunicate:SERial:PROmpt 22
 - 3.8.1.3 SYSTem:COMMunicate:SERial:BAUD 22
 - 3.8.2 SYSTem:STATus? 22
 - 3.8.3 SYSTem:FACToryReset ONCE 23
- 3.9 SERVO Subsystem. 23
 - 3.9.1 SERVo:FASTlock 23
 - 3.9.2 SERVo:FALEngth 24
 - 3.9.3 SERVo:COARSeDac 24
 - 3.9.4 SERVo:DACGain 24
 - 3.9.5 SERVo: EFCScale 24
 - 3.9.6 SERVo:EFCDamping 25
 - 3.9.7 SERVo:SLOPe 25
 - 3.9.8 SERVo:TEMPCOMPensation 25
 - 3.9.9 SERVo:AGINGcompensation 25
 - 3.9.10 SERVo:PHASECORrection 25
 - 3.9.11 SERVo:1PPSoffset 25
 - 3.9.12 SERVo:TRACe 25
 - 3.9.13 SERVo? 26

4 Firmware Upgrade Instructions 29

- 4.1 Introduction 29
- 4.2 ISP Flash Loader Utility installation. 29
 - 4.2.1 Philips LPC2000 Flash Utility 29
 - 4.2.2 Flash Magic Flash Programming Utility. 30
- 4.3 Putting the PCB into In-Circuit Programming (ISP) mode 30
- 4.4 Downloading the firmware 30
 - 4.4.1 Philips LPC2000 Flash Utility 30
 - 4.4.2 Flash Magic Flash Programming Utility. 32
- 4.5 Verifying Firmware Update 35

5 GPSSCon Utility 37

- 5.1 Description 37
- 5.2 Installation 37
- 5.3 Using GPSSCon 37
 - 5.3.1 Setting the options. 37
 - 5.3.1.1 Communication Parameters. 38

5.3.1.2	Auxiliary parameters . . . . .	.38
5.3.1.3	Other options . . . . .	.40
5.3.2	Sending manual commands to the receiver . . . . .	.40
5.3.3	Use of the mouse in graph mode . . . . .	.41
5.3.4	Exporting the graphics . . . . .	.43
5.4	Interpreting the Data. . . . .	.44
6	Certification and Warranty . . . . .	.45
6.1	Certification . . . . .	.45
6.1.1	Warranty . . . . .	.45
6.1.2	Limitation of Warranty. . . . .	.45
6.1.3	Exclusive Remedies . . . . .	.46

1 Introduction

1.1 Overview

The Jackson Labs Technologies, Inc. RCM Reference board is a ruggedized, ultra-low-phase-noise 10MHz/100MHz crystal oscillator reference. The RCM Reference combines two low-g ovenized crystal oscillators, power supplies, power filters, two isolated +20.5dBm RF output amplifiers, and optional external 10MHz and 1PPS reference inputs on a 2.0 x 4.0 x 1.0 inch PCB board.

The RCM Reference board can be locked to either an external 10MHz signal or an external 1PPS signal and has auto-switching capability from 10MHz lock to 1PPS lock as a fall-back in case the external 10MHz reference is removed or fails. The unit will lock to within better than +/-500ps to the external 10MHz reference typically with a <1.5Hz loop bandwidth, or to within +/-10ns to the external 1PPS reference (rms/1-sigma) after 24 hours of locking when in 1PPS-locking mode. In the absence of either external reference, the RCM Reference board will have a drift stability of better than 0.5ppb per day long-term.

The use of a 10MHz double-oven OCXO and a single-oven 100MHz OCXO that is phase-locked to the 10MHz OCXO provides better close-in phase noise performance, lower g-sensitivity, much lower thermal sensitivity, and significantly improved holdover stability than the 100MHz OCXO can provide by itself. The RCM reference achieves a phase noise performance of -100dBc/Hz at 10Hz offset, and -130dBc/Hz at 100Hz offsets from the 100MHz carrier, and noise floors of -172dBc/Hz at 1MHz offset typically. The 10MHz CMOS output achieves -95dBc/Hz at 1 Hz offset, and -130dBc/Hz at 10Hz offset typically when 1PPS locked. An exceptional low-g sensitivity of only 0.3ppb per g per axis allows operation in moving platforms and provides good vibration-noise rejection. Allan Deviations of 2E-012 at 1s, and 2E-012 over 3 hours are possible when locked to noisy external 1PPS references such as GPS receivers.

The unit also provides 1PPS outputs and inputs, and can be phase synchronized with less than 1ns unit-to-unit uncertainty typically. The RCM Reference operates from a single +12V supply, consumes less than 0.39A steady-state current, and operates from -45C to +85C.

The RCM Reference allows four operating modes:

- 1) 10MHz Synchronized.** In this mode the unit phase-locks to an external 10MHz Sine Wave or CMOS reference with a sub 1.5Hz loop bandwidth. The unit thus can operate as a phase noise filter while still providing the Allan Deviation (ADEV) performance of the reference source
- 2) 1PPS Synchronized.** In this mode the unit uses a field-proven loop algorithm to lock to an external (noisy) 1PPS reference such as GPS receivers can provide. Loop Time Constants of 10's of seconds to 1000's of seconds can be selected to filter out 1PPS noise such as GPS sawtooth noise.

Please note that the unit can automatically switch to 1PPS sync-mode if the external 10MHz reference fails or is disconnected.

3) Free-Running operation. No external references are attached or required. This stand-alone mode allows operation with crystal-aging compensation via software loop, and drift of down to 0.1ppb over the first day, and a maximum drift of 0.5ppb long-term.

4) Holdover Mode. This mode is identical to mode 3) and is automatically entered in case the unit stops receiving any external 10MHz or 1PPS reference input signals.

The board includes an RS-232 serial control port for NMEA and SCPI communication, a 32bit processor that runs a Real Time OS, one CMOS-5V 10MHz output, two 100MHz +20.5dBm outputs, one 3.3V 1PPS CMOS output phase synchronized to an optional 1PPS input signal, a 10MHz external reference input, and precision voltage references and DACs.

Figure 1.1 RCM 10MHz and 100MHz Reference



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 Antenna Lightning Protector

For units that use external GPS receivers as the 1PPS reference, always use a UL approved and properly installed GPS Antenna Lightning protector on the coaxial GPS antenna feed to prevent damage, injury, and/or death in case of a lightning strike.

1.2.2 Grounding

To avoid damaging the sensitive electronic components in the RCM Reference 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.

1.2.3 Power Connections

Make sure to connect the DC power to the device following the polarity indicated in Section 2.1 . The power-pins are diode-protected and will not be damaged if the +12V power input wires are reversed.

1.2.4 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 50,000 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

To operate the unit, simply follow these two steps:

1) If an external 10MHz reference source is to be used, then connect a 10MHz Sine Wave reference signal to connector J3 (10MHz REF IN). The signal can range from +7dBm to +15dBm. Or alternatively connect a 3.3V or 5V 1PPS signal with 50ms max duty cycle to connector J2 (1PPS IN). Please note the 1PPS input is DC-terminated with a 50 Ohms resistor to ground

2) Connect +12V (+/-1V) DC Power to J1 pins 3 and 4 on the unit, and ground to pins 1 and 2 of J1

=> The unit will consume up to 12W (1A) of power during oscillator warmup

Please note that the unit can operate as a highly-stable and accurate reference source by itself in the absence of an external 1PPS or 10MHz reference input.

The unit will now lock to the external 10MHz or 1PPS signal (Red LED D1 is blinking when a 1PPS reference or 10MHz reference is being received) and will indicate proper lock and no events pending when the Green LED D1 goes on. Once the green LED D1 is on, the unit will output 10MHz with significantly better than 1ppb frequency accuracy to the external reference.

The unit will lock to an external 10MHz reference within less than 2 seconds typically once the OCXO has warmed-up after power-on, which typically takes less than 4 minutes at room temperature. The unit will take up to 1 hour to light up the Green LED when locked to only the external 1PPS input. By default the unit prioritizes the 10MHz reference input over the external 1PPS input.

Lock to the external 10MHz reference is indicated by a bright, solid Green light on LED D13. Lock of the internal 100MHz OCXO to the internal 10MHz OCXO is indicated by a bright, solid light on LED D23. During OCXO warmup, these LED's

will blink quickly, and the blinking will slow down as the OCXO approaches lock, then light up continuously once lock is achieved. The 10MHz LOCK LED D13 and the 10MHz Input Sense LED D18 will not light up in the absence of an external 10MHz reference signal.

Connect a terminal program (TeraTerm is recommended) to the unit via the RS-232 serial connector pins 8 and 10 on connector J1 with 115.2KB 8N1 settings and no flow-control.

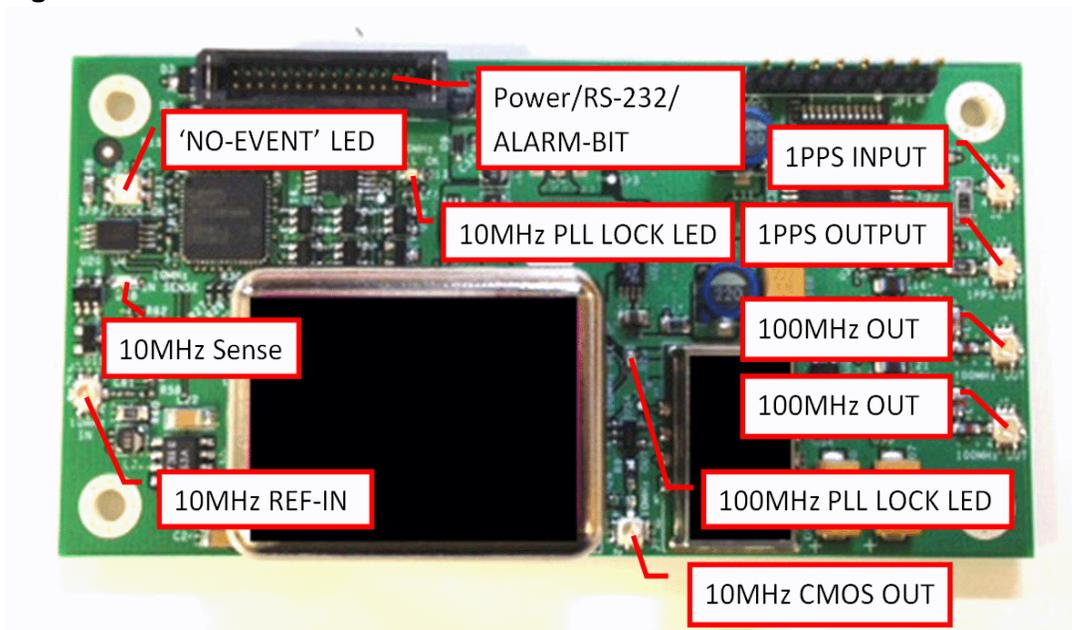
Try some of these SCPI commands:

```
help?
syst:stat?
diag?
sync?
meas?
```

2.1.1 PCB Photos

The RCM Reference PCB is shown in [Figure 2.1](#).

Figure 2.1 RCM Reference 10MHz/100MHz PCB



2.1.2 Mechanical Drawings

The following drawings show the mechanical dimensions and the pinout of the RCM Reference PCB:

Figure 2.2 RCM Reference Mechanical Dimensions

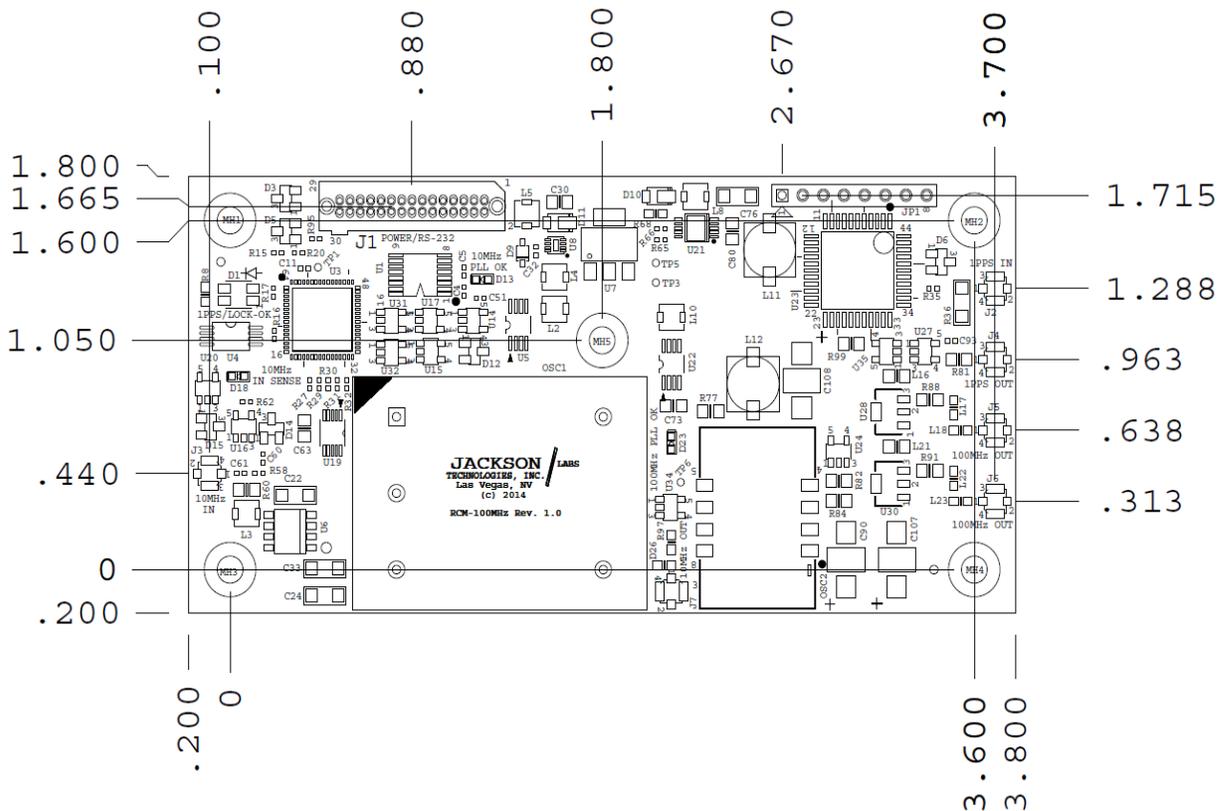


Table 2.1 shows the RCM Reference revision 1.0 hardware pin descriptions

Table 2.1 RCM Reference hardware connectors

Ref	Name	Function	Specification	Description
J1 Pins: 1,2,5,6,9, 11,12,13, 15,17,18, 19,21,23, 25,27,29, 30	GROUND	GROUND	GROUND	GROUND
J1 Pin 3 and Pin 4	+12V Prime Power	Prime Power	+12V DC, +/-1V, <+/-50mV AC, 1A during warmup, <0.4A steady state at 25C	DC +12V Power Input. Reverse-Polarity protected
J1 Pin 7	1PPS CMOS 3.3V OUTPUT #2	Secondary 1PPS output	3.3V LVCMOS, <1ns rise-time. 50 Ohms series-terminated output, do not end-terminate signal with less than 1K Ohms, aligned to J2 1PPS external reference to within +/-2.5ns typically. 20.48us pulse width.	1PPS output signal, rising-edge aligned to external 1PPS reference, or driven by internal 10MHz OCXO phase when in holdover

J1 Pin 8	RS-232 TX	RS-232 transmit pin	RS-232 level output	RS-232 transmit output from the RCM module. Generates SCPI and NMEA output strings
J1 Pin 10	RS-232 RX	RS-232 receive pin	RS-232 level input	RS-232 receive input to the RCM module. Accepts SCPI commands
J1 Pin 14	RESET#	Reset input signal	Pulled to +3.3V internally by 4.7K Ohms resistor, pull to ground (open collector pull) to assert system reset	Pulling this pin to ground through a switch or open-collector output will reset the RCM module internal microprocessor
J1 Pin 16	ISP#	In Circuit Programming Enable pin	Pulled to +3.3V internally by 4.7K Ohms resistor, pull to ground (open collector pull) during reset or during power-up to switch the microprocessor into In System Programming mode for Flash memory upgrade of the firmware	Pulling this pin to ground through a switch or open-collector output during power-on or during reset will place the internal microprocessor into In System Flash Firmware Update mode (see chapter 4 for details)
J1 Pin 20	1PPS OUTPUT and LOCK OK Built-In-Self-Test (BIT)	1PPS output sense, Lock and Event# indicator	3.3V LVCMOS	3.3V: Unit Locked to reference, 1PPS output is not damaged, and no events are pending 0V: Hardware or software Event is pending (events can be queried via the sync:health? command)
J1 Pin 22	PLL OK BIT	10MHz and 100MHz PLL OK indicator	3.3V LVCMOS	3.3V: 10MHz PLL (if in external 10MHz REF-IN mode) and 100MHz PLL are locked and healthy 0V: 10MHz or 100MHz PLL has failed to lock
J1 Pin 24	10MHz REF IN Sense BIT	Senses 10MHz external Reference	3.3V LVCMOS	3.3V: External 10MHz Ref Input is receiving a high-frequency AC signal (AC signals >1MHz will be detected) 0V: No AC signal detected on external 10MHz Ref Input
J1 Pin 26	1PPS REF IN Sense BIT	Senses 1PPS external Reference	3.3V LVCMOS	3.3V: External 1PPS Ref Input is receiving a 1Hz reference signal 0V: No external 1PPS Ref Input detected
J1 Pin 28	Power Supply Failure Sense BIT	Senses failure in internal power supplies	3.3V LVCMOS	3.3V: Internal Power Supplies are operating 0V: One or more internal Power Supplies has a failure
J3	10MHz REF INPUT	10MHz Sine Wave Reference Input	10MHz +/-4Hz, +5dBm to +17dBm (+22dBm damage level), 50 Ohms terminated	10MHz Reference Input, the internal OCXO's, 1PPS counter, and the microprocessor are synchronized to this reference.

J7	10MHz Output	Low-Phase-Noise 10MHz OCXO output	DC-coupled, 5V CMOS, 50 Ohms series-terminated, do not end-terminate signal with less than 1K Ohms	Ultra Low Phase Noise 10MHz reference output from internal Double-Oven 10MHz OCXO, phase-locked to external 10MHz reference or external 1PPS reference
J4	1PPS CMOS 3.3V OUTPUT #1	Primary 1PPS output	3.3V LVCMOS, <1ns rise-time. 50 Ohms series-terminated output, do not end-terminate signal with less than 1K Ohms, aligned to J2 1PPS external reference to within +/-2.5ns typically. 20.48us pulse width	1PPS output signal, rising-edge aligned to external 1PPS reference, or driven by internal 10MHz OCXO phase when in holdover
J2	1PPS INPUT	1PPS External Reference input	1PPS pulse, 0V to 5V (max), maximum on-duty-cycle 50ms, DC-terminated to ground via 50 Ohms resistor	1PPS Reference Input. The 1PPS outputs are rising-edge phase-aligned to this input signal within three seconds to better than +/-2.5ns typically
J5	100MHz Output #1	100MHz Sine Wave Output	AC-coupled, 100MHz Sine Wave, +20.5dBm +2dB, -0.5dB, terminate with 50 Ohms, Harmonics <50dBc, Spurious <80dBc, +/-15V DC max allowed	100MHz Sine Wave output, phase-locked to 10MHz internal OCXO
J6	100MHz Output #2	100MHz Sine Wave Output	AC-coupled, 100MHz Sine Wave, +20.5dBm +2dB, -0.5dB, terminate with 50 Ohms, Harmonics <50dBc, Spurious <80dBc, +/-15V DC max allowed	100MHz Sine Wave output, phase-locked to 10MHz internal OCXO

2.1.3 Notes on Signal Interfacing

The external 1PPS input reference is gated to reduce the possibility of spurious pulses causing a delinquent phase-shift of the 1PPS output signal when the 1PPS reference cable is disconnected for example. Once a 1PPS phase alignment has been achieved after an initial 3 pulses are received, the unit will gate-disable the 1PPS input connector for about 1280ns less than exactly one second. This prevents the problem of disconnecting of the 1PPS coax cable during the pulse high-time of the external 1PPS pulse to generate spurious 1PPS pulses in the unit due to cable connector bounce. Once the unit has gated the input for slightly less than 0.999,999 seconds, external pulses are once again allowed to re-synchronize the internal 1PPS counter. The internal 1PPS counter is clocked by the 100MHz output multiplied by 2x, so it internally runs at 200MHz with a 5ns cycle time. This allows synchronization to the external 1PPS signal to within +/-2.5ns uncertainty, and removes all errand pulses with more than -1280ns offset to the previous 1PPS input.

Do not terminate the 10MHz CMOS and 1PPS CMOS signals with impedances less than 1K Ohms, these signals are properly series-terminated with 50 Ohms and can thus drive long 50 Ohms coax cables with no over/under-shoot or ringing.

The unit will immediately try to lock to an external 10MHz reference input if such a signal is applied after power-on. It will be able to achieve lock to the external 10MHz signal within typically 4 minutes after power-on at 25C, and if the 10MHz signal is within +/-4 Hz or better of absolute 10MHz. In the absence of an external 10MHz reference signal, the unit will wait 7 minutes after power-on, then locking to the external 1PPS reference signal will begin if an external 1PPS input signal is present. The unit will require 12 to 15 minutes typically to achieve lock to within 0.2ppb frequency accuracy. The external 1PPS signal is also used to synchronize the 1PPS output, and if the 1PPS external reference is removed the unit will produce a 1PPS output signal generated by the 100MHz output signal divided by exactly 100,000,000 and for a length of 20.48us, and will remain phase aligned to the external 1PPS reference within the drift of the internal 10MHz DOCXO.

In the absence of both a 10MHz and 1PPS external reference inputs the unit will go into high-stability holdover mode during which the internal 10MHz DOCXO is compensated by a software aging-compensation algorithm. The unit will continue to produce very stable 10MHz, 100MHz and 1PPS output signals with typically less than 0.5ppb long-term drift per day. In the absence of any 1PPS external reference pulses the unit will randomly align its 1PPS output to exactly 100,000,000 cycles of the 100MHz output for a length of 20.48us.

2.1.4 Coaxial Connectors

The RF connectors of the RCM Reference are compatible to the Samtec MH1RP, and Amphenol A-1JB series of connectors, and sample mating cables can be purchased at www.digkey.com with part number: MH113-MH1RP-01BJ1-0152

2.1.5 Main Power and Control Connector

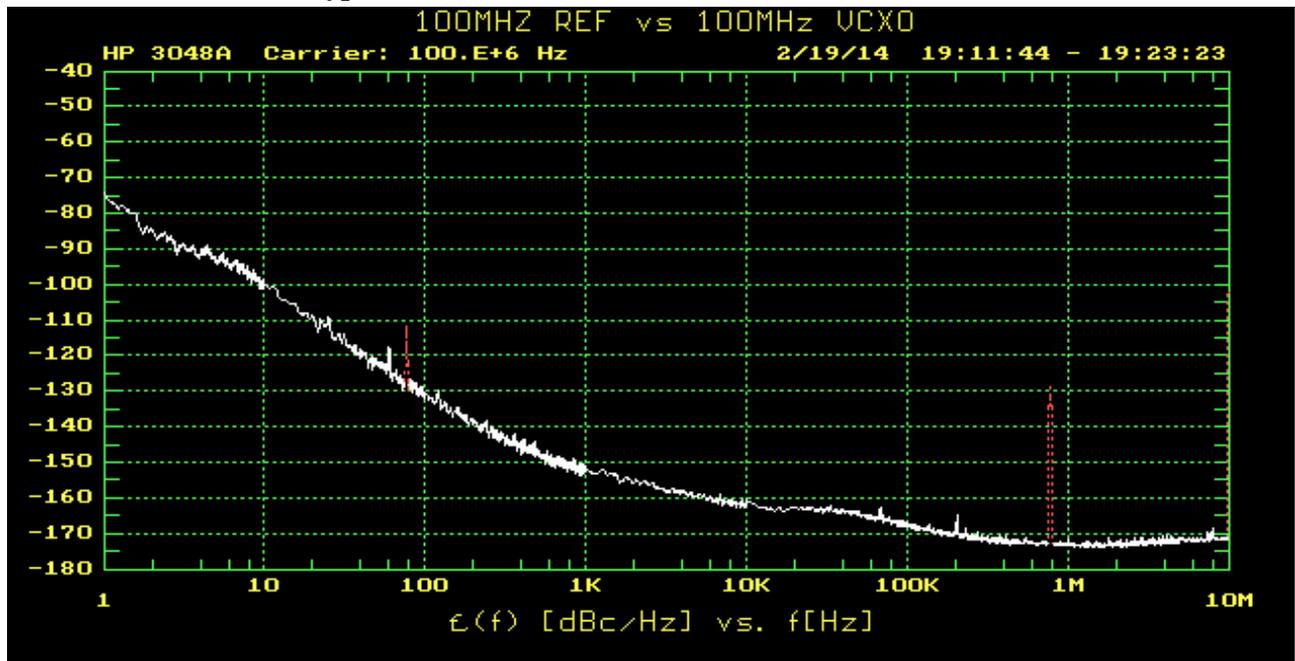
Power is applied to the RCM Reference board through the 30-pin Samtec connector J1. This connector has Samtec PN: TFM-115-01-S-D-WT, and is compatible to Samtec cable harnesses PN: SFSDT-15-30-G-10.00-DR-NDX and others. The connector uses mechanical retention latches.

The unit is powered from a +11.0V to +13.0V DC source, with +12.0V nominal voltage. The current is typically less than 0.39A at 12V at +25C ambient steady-state, and ~1A during OCXO warmup at 12.0V. Connect a clean +12V power supply to pins 3 and 4 of J1, and ground to pins 1 and 2 of J1.

2.1.6 Typical Phase Noise Performance

The following figure shows a typical Phase Noise performance plot when the unit is in holdover mode:

RCM Reference Typical 100MHz Phase Noise in holdover mode



2.2 Remote serial control

The unit is controlled via the RS-232 serial port at 115200 baud, 8N1. Other Baud Rates can be set via SCPI commands.

Attach the RCM Reference unit to your PC's Hyperterminal, the optional GPSCon software package (see Chapter 5 of this manual), or a third-party freeware Windows-based application program called Z38xx. This program is available on the Jackson Labs Technologies, Inc. website under the following URL as a free download:

<http://www.jackson-labs.com/assets/uploads/main/Z38XX.zip>

2.2.1 Loop parameter adjustment

All loop parameters can be controlled via the serial port.

Loop parameters are optimized for the OCXO on the board when locking to the external 1PPS reference, and changing the factory settings may result in the unit's performance to deteriorate. These loop parameters do not affect the loop behavior when the unit is locking to the external 10MHz reference input.

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

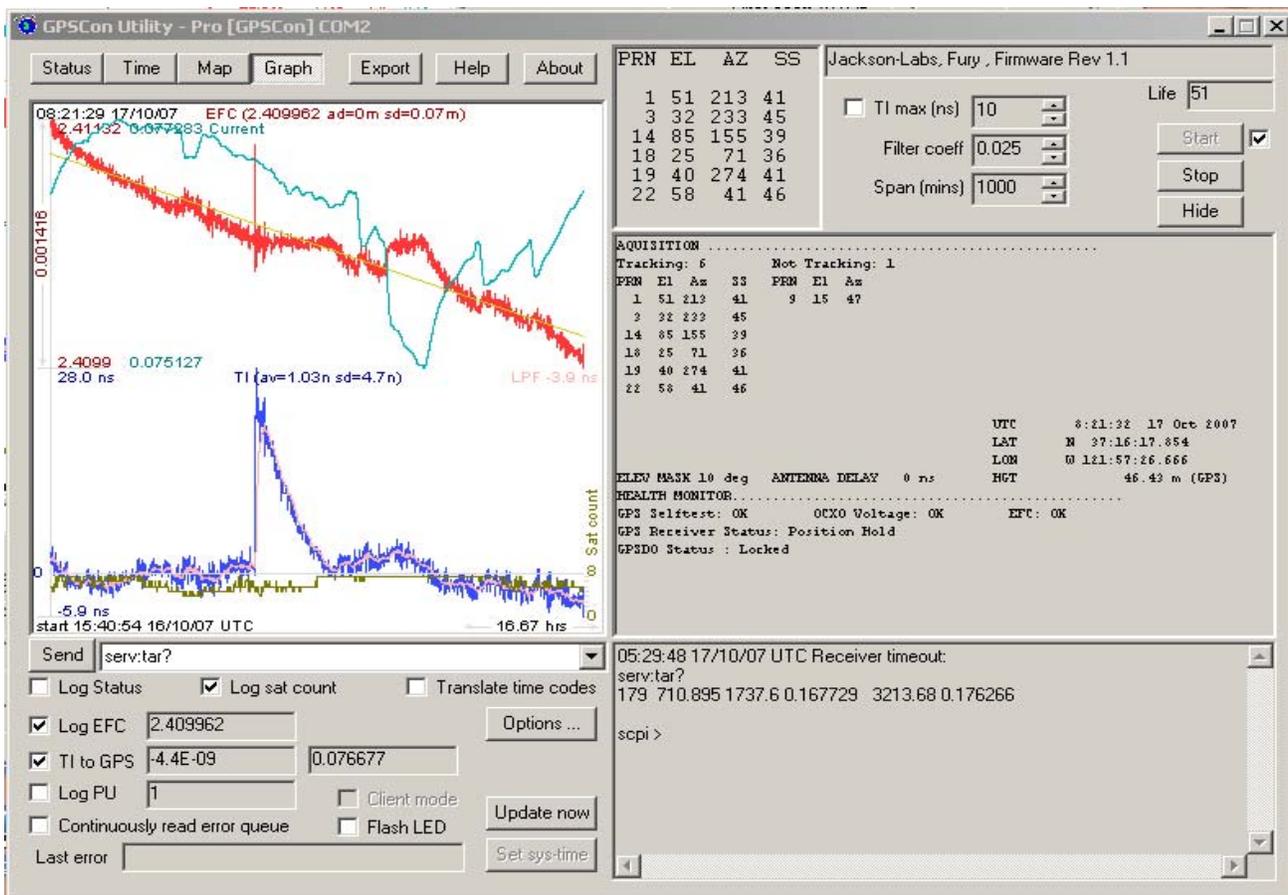
noise. Values between 0.7 (good double oven OCXO) and 6.0 (simple single-oven OCXO) are typical.

EFC Damping: overall IIR filter time constant. higher values increase loop time constant. 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 RCM Reference 1PPS signal and the UTC 1PPS signal as generated by the external 1PPS reference. 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 shown in [Figure 2.3](#) when experiencing small perturbations:

Figure 2.3 RCM Reference phase compensation plot



3 SCPI-Control Quick Start Instructions

3.1 Introduction

The SCPI (Standard Commands for Programmable Instrumentation) subsystem is accessed via the TTL or USB serial interfaces and a terminal program. By default the terminal settings are 115200, 8N1, no flow-control.

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 RCM Reference.

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 Quick Start Commands

For a quick start, try the following SCPI serial port commands:

```
help?  
sync?  
meas?  
diag?  
*IDN?
```

3.2.2 *IDN?

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

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

3.2.3 HELP?

This query returns a list of the commands available for the RCM Reference.

3.3 GPS Subsystem

The GPS subsystem is only partially supported on the RCM Reference since it does not have a GPS receiver. It does however support NMEA time and date related commands with the aid of the user manually setting time and date once after power-on. The internal RTC will maintain time and date with the stability of the internal 10MHz OCXO, and NMEA commands can be enabled to output time and date on the serial ports.

3.3.1 NMEA Support

No navigation information is available on the NMEA output, but time and date can be maintained and transmitted on the relevant NMEA sentences once set by the user using the GPS:INIT:TIME and GPS:INIT:DATE commands.

The NMEA time and date outputs are synchronized to the rising edge of the incoming 1PPS reference. Please note that without an initial 1PPS reference input pulse the NMEA output strings will not be generated unless the option SYNC:OUT:RESET:1PPS ON command has been sent to enable the unit to generate asynchronous internal 1PPS pulses for the NMEA engine.

Once enabled, RCM Reference will send out information on the TTL and USB serial transmit pin automatically every N seconds. All incoming serial commands are still recognized by RCM Reference since the serial interface transmit and receive lines are completely independent of one another.

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.

3.3.2 GPS:GPGGA

This command instructs the RCM Reference to send the NMEA standard string \$GPGGA every N seconds, with N in the interval [0,255]. The command is disabled until an external 1PPS reference is applied, or the command SYNC:OUT:1PPS:RESET ON is selected.

This command has the following format:

GPS:GPGGA <int> [0,255]

No position or velocity information is available as the RCM Reference board does not contain a GPS receiver.

3.3.3 GPS:GGASat

This command instructs the RCM Reference 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 until an external 1PPS reference is applied, or the command SYNC:OUT:1PPS:RESET ON is selected.

This command has the following format:

```
GPS:GGASat <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.

No position or velocity information is available as the RCM Reference board does not contain a GPS receiver.

3.3.4 GPS:GPRMC

This command instructs the RCM Reference to send the NMEA standard string \$GPRMC every N seconds, with N in the interval [0,255]. The command is disabled until an external 1PPS reference is applied, or the command SYNC:OUT:1PPS:RESET ON is selected.

No position or velocity information is available as the RCM Reference board does not contain a GPS receiver.

This command has the following format:

```
GPS:GPRMC <int> [0,255]
```

3.3.5 GPS:GPZDA

This command instructs the RCM Reference to send the NMEA standard string \$GPZDA every N seconds, with N in the interval [0,255]. The command is disabled until an external 1PPS reference is applied, or the command SYNC:OUT:1PPS:RESET ON is selected.

No position or velocity information is available as the RCM Reference board does not contain a GPS receiver.

This command has the following format:

```
GPS:GPZDA <int> [0,255]
```

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

In order to have the RCM Reference generate valid time and date outputs, the user must manually set the date in the RTC using this command. This command is compatible to the PTIME:OUT ON command available on the JLT CSAC GPSDO boards, and the unit can thus be auto-synced to the CSAC GPSDO acting as the master reference to allow automatic time and date synchronization of

these units to each other. The internal RTC is driven by the highly stable OCXO 10MHz signal, and thus has very high accuracy.

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

In order to have the RCM Reference generate valid time and date outputs, the user must manually set the time in the RTC using this command. This command is compatible to the PTIME:OUT ON command available on the JLT CSAC GPSDO boards, and the unit can thus be auto-synced to the CSAC GPSDO acting as the master reference to allow automatic time and date synchronization of these units to each other. The internal RTC is driven by the highly stable OCXO 10MHz signal, and thus has very high accuracy.

3.4 PTIME Subsystem

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

PTIME:DATE?

PTIME:TIME?

PTIME:TIME:STRing?

PTIME:TINterval?

PTIME?

3.4.1 PTIME:DATE?

This query returns the current calendar date. The year, month, and day are returned.

3.4.2 PTIME:TIME?

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

3.4.3 PTIME:TIME:STRing?

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

3.4.4 PTIME:TINterval?

This query is equivalent to the command SYNChronization:TINterval

3.4.5 PTIME?

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

PTIME:DATE?

PTIME:TIME?

PTIME:TINterval?

3.5 SYNChronization Subsystem

This subsystem regroups the commands related to the synchronization of the RCM Reference with the external 1PPS or 10MHz reference. The list of the commands supported for this subsystem is the following:

SYNChronization:SOURce:MODE [10MHZ|1PPS|AUTO]

SYNChronization:SOURce:STATE?

SYNChronization:HOLDOver:DURation?

SYNChronization:HOLDOver:STATe?

SYNChronization:HOLDOver:INITiate

SYNChronization:HOLDOver:RECOvery:INITiate

SYNChronization:OUTput:1PPS:RESET [ON|OFF]

SYNChronization:TINterval?

SYNChronization:IMMEdiate

SYNChronization:FEEstimate?

SYNChronization:LOCKed?

SYNChronization?

3.5.1 SYNChronization:HOLDOver:DURation?

This query returns the duration of the present or most recent period of operation in the holdover and holdover processes. This is the length of time the reference oscillator was not locked to the external 1PPS or 10MHz reference, and thus “coasting”. The time units are seconds. The first number in the response is the holdover duration. The duration units are seconds, and the resolution is 1 second. If the Receiver is in holdover, the response quantifies the current holdover duration. If the Receiver is not in holdover, the response quantifies the previous holdover. The second number in the response identifies the holdover state. A value of 0 indicates the Receiver is not in holdover; a value of 1 indicates the Receiver is in holdover.

3.5.2 SYNChronization:HOLDOver:INITiate

The SYNC:HOLD:INIT and SYNC:HOLD:REC:INIT commands allow the user to manually enter and exit the holdover state, even while external reference signals are still being properly received. This command only affects the external 1PPS tracking mode, and is inactive when in external 10MHz tracking mode. This forced-holdover allows the unit to effectively disable reference locking, while still keeping track of the state of the 1PPS output in relation to the 1PPS signal as generated by the external reference. When the unit is placed into forced-holdover with this command, the unit will indicate the time interval difference between the 1PPS output and the external 1PPS or 10MHz reference signal by using the SYNC:TINT? command. This allows the user to see the OCXO drift when not locked to the external reference for testing purposes. All other frequency-disciplining

functions of the unit will behave as if the external reference was disconnected from the unit while in this forced-holdover state.

3.5.3 SYNChronization:HOLDOver:RECOvery:INITiate

This command will disable the forced holdover state (see the SYNC:HOLD:INIT command). The unit will resume normal external reference locking operation after this command has been sent.

3.5.4 SYNChronization:SOURce:MODE

SYNChronization:SOURce:MODE [10MHZ | 1PPS | AUTO]

The SOURce:MODE command selects the synchronization source for the internal 10MHz ovenized oscillator. The source is selected between an external 10MHz reference input on connector J3 or an external 1PPS input on connector J2. Switching the source is either done manually with the 10MHZ or 1PPS command options, or automatically with the AUTO command option. When AUTO mode is enabled, the unit only switches to the 1PPS input when the external 10MHz input is not present. The unit will go into holdover (10MHz DOCXO flywheel mode) when no external reference is applied.

3.5.5 SYNChronization:PLL:10MHZ [NARrow:MEDIum:WIDe]

The PLL:10MHZ command configures the PLL bandwidth. The three bandwidth options are Narrow (default), Medium and Wide. Changing the PLL bandwidth can have a significant impact on the close-in phase noise of the 100MHz output. The default option is Narrow which will result in a 10MHz PLL loop bandwidth of approx 1.5Hz locking to the external 10MHz reference input.

3.5.6 SYNChronization:PLL:100MHZ [NARrow:MEDIum:WIDe]

The PLL:100MHZ command configures the PLL bandwidth of the loop that locks the 100MHz OCXO to the 10MHz internal OCXO. The three bandwidth options are Narrow (default), Medium and Wide. Changing the PLL bandwidth can have a significant impact on the close-in phase noise of the 100MHz output. The default option is Narrow which will result in a 100MHz PLL loop bandwidth of less than 50Hz to the internal 10MHz OCXO. The 10MHz OCXO has slightly less g-sensitivity (0.3ppb versus 0.5ppb per g per axis) than the 100MHz OCXO, so a wider PLL bandwidth may result in slightly lower phase noise under vibration. Changing the loop bandwidth from narrow to wide also lowers the phase noise above the bandwidth limit at the expense of the phase noise below the loop bandwidth limit.

3.5.7 SYNChronization:PLL?

This query returns the results of these two queries:

SYNChronization:PLL:10MHZ?

SYNChronization:PLL:100MHZ?

3.5.8 SYNChronization:SOURce:STATE?

This query shows the state of the external 10MHz/1PPS synchronization option.

3.5.9 SYNChronization:TINTerval?

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

3.5.10 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 the external 1PPS offset.

Values less than 1E-012 are below the noise floor, and are not significant.

3.5.11 SYNChronization:LOCKed?

This query returns the lock state (0=OFF, 1=ON) of the PLL controlling the internal 10MHz oscillator.

3.5.12 SYNChronization:OUTput:1PPS:RESET [ON|OFF]

This command allows the generation of the NMEA output sentences upon power-on without an external 1PPS reference being connected to the unit. By default the unit does not generate an internal 1PPS pulse that triggers the NMEA output until the unit has received an external 1PPS pulse. With the command SYNC:OUT:1PPS:RESET ON the unit can now be configured to generate an asynchronous NMEA output after power-on even if an external 1PPS input is not connected to the unit. Once the external 1PPS signal is applied, the NMEA output sentences will align themselves to the external 1PPS. The default setting is OFF which means the NMEA output sentences are not generated until an external 1PPS signal has been applied to the unit. The CMOS 1PPS output pulse of the RCM Reference is generated by a PLD and not under software control. This 1PPS output pulse will be asynchronous after power-on until at least three external 1PPS pulses have been received. At that time the 1PPS CMOS output will be phase-synchronized to the external 1PPS reference input to within +/-2.5ns typically. Both the NMEA and the CMOS 1PPS outputs will continue to be generated even if the external 1PPS reference is being removed. The accuracy will then follow the internal 10MHz OCXO accuracy.

3.5.13 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 the external 1PPS reference is >250ns	HEALTH STATUS |= 0x4;
If the run-time is < 300 seconds	HEALTH STATUS |= 0x8;
If the OCXO 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 when 1PPS-locked	HEALTH STATUS |= 0x100;
For the first 7 minutes after a phase-reset, or a coarsedac change	HEALTH STATUS |= 0x200;
If the 100MHz PLL is not locked to the internal 10MHz OCXO	HEALTH STATUS |= 0x400;
If the 10MHz PLL is not locked to the external 10MHz reference (this error status bit is disabled in 1PPS locking mode)	HEALTH STATUS |= 0x2000;
If the external 10MHz reference is not present (this error status bit is disabled in 1PPS locking mode)	HEALTH STATUS |= 0x4000;
If a power supply failure is detected	HEALTH STATUS |= 0x8000;
If 1PPS external reference is not present when in 1PPS locking mode	HEALTH STATUS |= 0x10000;
If a failure is detected in the CMOS 1PPS output signal driver	HEALTH STATUS |= 0x20000;

As an example, if the unit is in holdover, and the OCXO voltage is too high, and the 1PPS phase offset while in 1PPS locking mode is > 250ns then the following errors would be indicated:

- 1) 1PPS phase > 250ns: 0x4
 - 2) OCXO voltage too high: 0x40
 - 3) Unit is 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.

3.5.14 SYNChronization?

This query returns the results of these four queries:

SYNChronization:SOURce:MODE?
 SYNChronization:SOURce:STATE?
 SYNChronization:LOCKed?
 SYNChronization:HOLDover:DURation?
 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?
 DIAGnostic:LIFetime:COUNT?

3.6.1 DIAGnostic:ROSCillator:EFControl:RELative?

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

3.6.2 DIAGnostic:ROSCillator:EFControl:ABSolute?

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

3.6.3 DIAGnostic:LIFetime:COUNT?

This command returns the number of hours the unit has been powered-on.

3.7 MEASURE Subsystem

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

MEASure:VOLTage?
 MEASure:CURRent?
 MEASure?

3.7.1 MEASure:VOLTage?

This query returns the power supply voltage applied to the OCXO (~10.45V)

3.7.2 MEASure:CURRent?

This command is not supported on the RCM Reference board.

3.7.3 MEASure?

This query returns the result of the following query:

```
MEASure:VOLTage?
```

3.8 SYSTEM Subsystem

This subsystem regroups the commands related to the general configuration of the RCM Reference. 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 TTL serial. 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 TTL 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:PHASECOrrrection <float> [-100.0, 100.0]
SERVo:1PPSoffset <int> ns
SERVo:QUIet <ON | OFF>
SERVo:TRACe <int > [0,255]
SERVo:FASTlock <int> [1,20]
SERVo:FALEngth <int> [100,20000]
SERVo?
  
```

3.9.1 SERVo:FASTlock

The FASTlock feature is only available when operating in the 1PPS LOCK mode. It is not active when locking to an external 10MHz reference input.

The FASTlock command enables the FASTLOCK mode, and sets its gain parameter. Fastlock works by momentarily multiplying the EFCScale gain to a value determined by this SERVo:FASTlock parameter. Gain values of 1x to 20x can be set, with a gain of 1x effectively disabling the FASTLOCK feature.

By selecting gain values of >1, the PLL loop parameter Proportional gain (SERV:EFCScale) will be increased after power on, thus increasing loop aggressiveness and improving lock PLL time. It is not desirable to maintain a high loop gain for longer than necessary to lock the PLL since high loop gains come at the expense of increased phase noise (reduced short term stability). The FASTLOCK mechanism will automatically reduce the FASTLOCK gain over a period of time specified by the SERVo:FALEngth command, during which time the FASTLOCK gain is slowly decreased from its initial value to 1.0x.

Setting the FASTLOCK gain to 2 for example will result in the Proportional gain value stored in the SERVo:EFCScale parameter to be multiplied by 2x initially after power on.

This dynamic gain is slowly reduced until the gain is back to 1.0x, the value stored in the SERVo:EFCScale parameter.

For example:

if we set `SERVo:FASTlock` to 2, and `SERVo:FALEngth` to 3600, and `SERVo:EFCScale` is set to 0.7. Then initially the unit will multiply the EFCscale by 2x, and an effective EFCscale value of 1.4 is applied to the PLL loop.

This increased gain value difference will be reduced every second by $1/3600$, so that the gain after two seconds would be: 1.3998, until after 3600 seconds the gain has been reduced back to its long term value of 0.70 as stored in the `SERVo:EFCscale` parameter.

Disabling the FASTLOCK mode is accomplished by setting the `SERVo:FASTlock` to 1. This will set the dynamic gain to 1.0, effectively disabling the fastlock feature.

This command has the following format:

```
SERVo:FASTlock <int> [1,20]
```

3.9.2 `SERVo:FALEngth`

This command adjusts the length of time during which the FASTLOCK feature is active, please see the command `SERVo:FASTlock` above.

It can be set from 100 seconds to 20.000 seconds. The Dynamic FASTLOCK gain is slowly reduced until it reaches a gain of 1.0 after the `FALEngth` period of seconds. During this time the PLL loop gain is increased by the amount specified in the `SERVo:FASTlock` parameter, which will result in a faster initial phase lock to UTC after power-on, while giving the lowest possible noise floor (best short term stability) during normal operation.

This command has the following format:

```
SERVo:FALEngth <int> [100,20000]
```

3.9.3 `SERVo:COARSeDac`

This command sets the coarse DAC that controls the EFC. The RCM Reference 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]
```

3.9.4 `SERVo:DACGain`

This command is used for factory setup.

3.9.5 `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]
```

3.9.6 SERV0: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:

```
SERV0:EFCDamping <float>[0.0 , 4000.0]
```

3.9.7 SERV0: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:

```
SERV0:SLOPe <NEG | POS >
```

3.9.8 SERV0:TEMPCOmpensation

This command is not supported on the RCM Reference board.

3.9.9 SERV0: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:

```
SERV0:AGINGcompensation <float> [-10.0, 10.0]
```

3.9.10 SERV0:PHASECOrrrection

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:

```
SERV0:PHASECOrrrection <float> [-100.0, 100.0]
```

3.9.11 SERV0:1PPSoffset

This command is not supported on the RCM Reference board.

3.9.12 SERV0: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:

```
SERV0: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. 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 external-1PPS lock is lost)
6	Locked, and GPS active

3.9.13 SERV0?

This command returns the result of the following queries:

SERV0:COARSeDac?

SERV0:DACGain?

SERV0:EFCScale?

SERV0:EFCDamping?

SERV0:SLOPe?

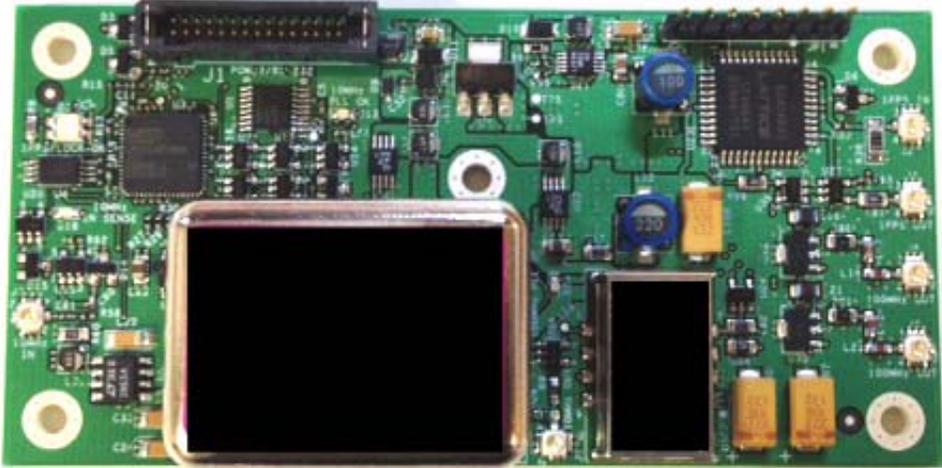
SERV0:TEMPCompensation?

SERV0:AGINGcompensation?

SERV0:PHASECOrrrection?

SERV0:1PPSoffset?

SERV0:TRACe?



4 Firmware Upgrade Instructions

4.1 Introduction

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

With some practice, the entire Flash upgrade can be done in less than five minutes, 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 RCM Reference firmware. You can download the Philips LPC2000 utility from the Jackson Labs Technologies, Inc. website under the Support tab:

<http://www.jackson-labs.com/index.php/support>

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 RCM Reference 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 the ISP# pin 16 of connector J1 to pin 18 (GROUND) of connector J1 of the RCM Reference board to ground the ISP# pin during power-on. It may be useful to connect a push-button to pin 16 and pin 18 of J1 to allow in-field firmware upgrades on the RCM Reference PCB. 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.

4.4 Downloading the firmware

Download the latest version of RCM Reference 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. The RCM Reference is RS-232 level compatible.

4.4.1 Philips LPC2000 Flash Utility

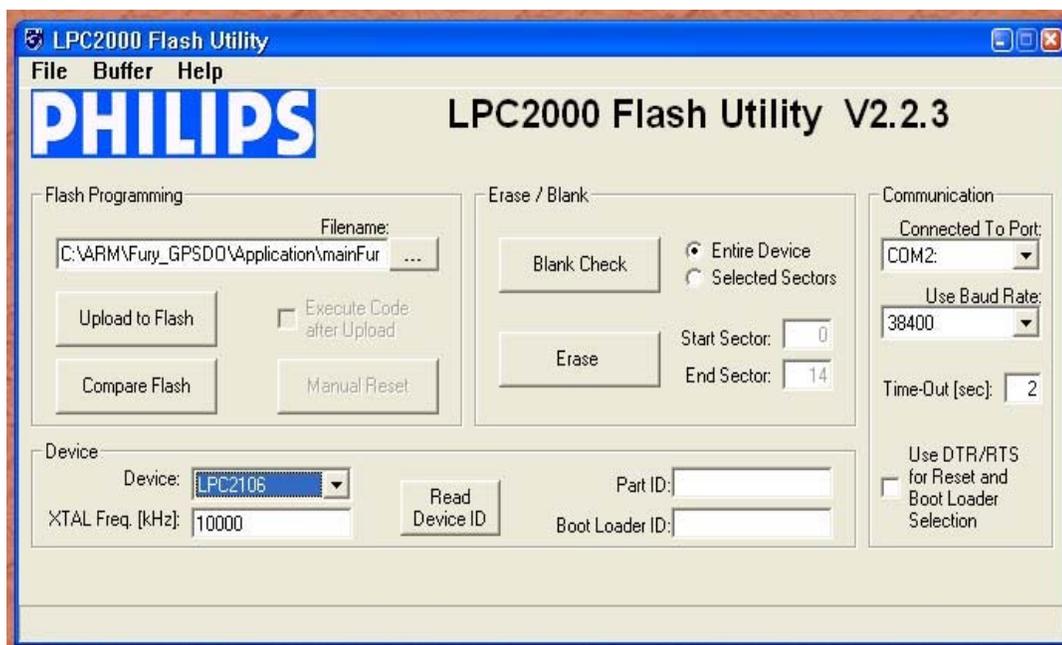
A) Open the LPC2000 utility. Set the COM port in the LPC2000 application as needed on your PC.

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.

Figure 4.1 LPC2000 flash utility



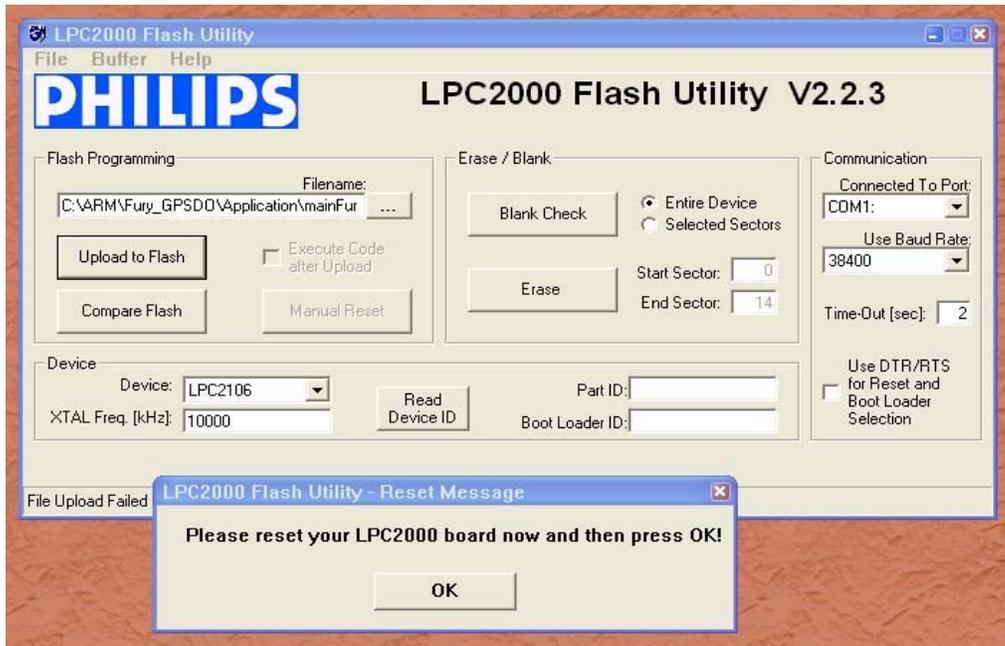
Please note that the “Use Baud Rate” setting needs to be set to 38400 Baud or less, it will not work faster than 38400 Baud.

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 following window should appear if the correct COM port has been chosen etc.:

Figure 4.2 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.

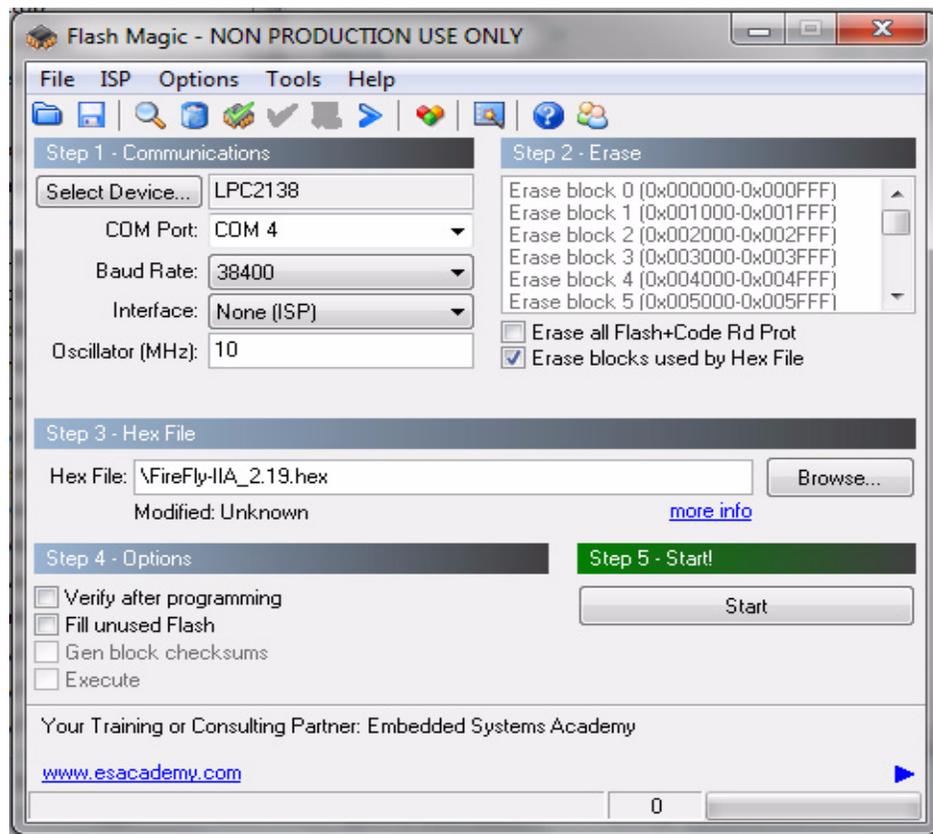
It is not necessary to press “reset” as the utility is asking. Just press “OK” on the utility window’s button.

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

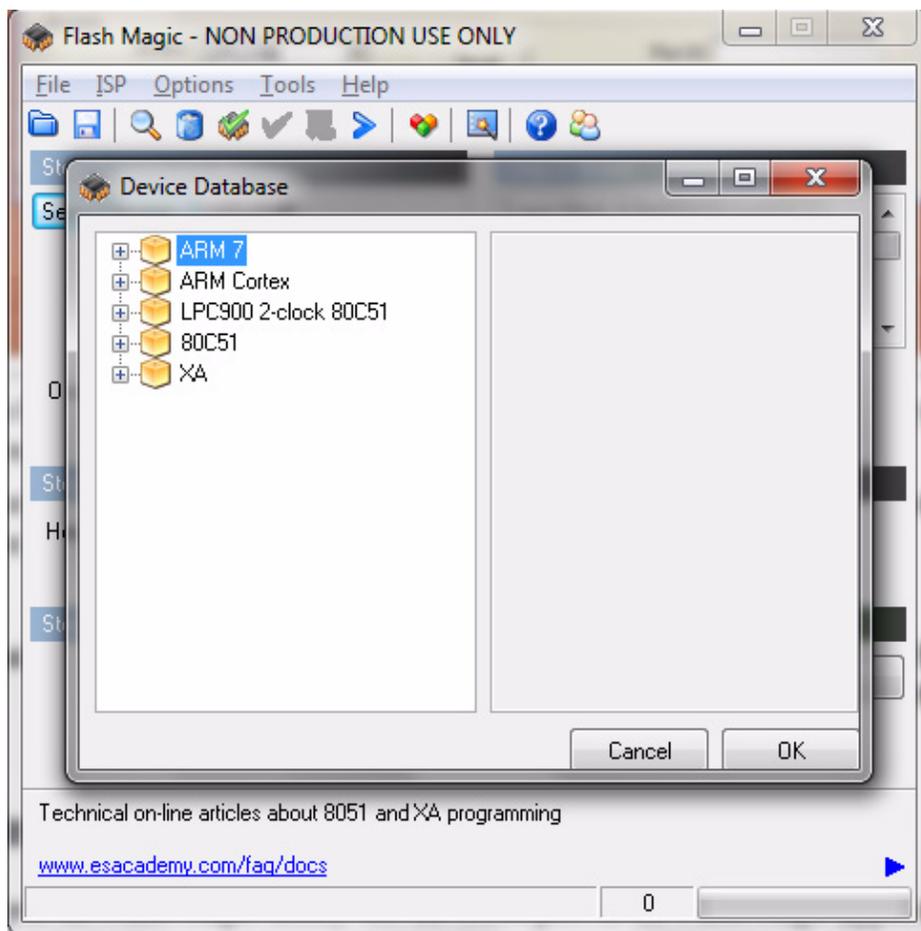
A) Open the Flash Magic utility. Set the COM port in the Flash Magic application as needed on your PC. Set “Interface” to “None (ISP)”.

Figure 4.3 Flash Magic utility

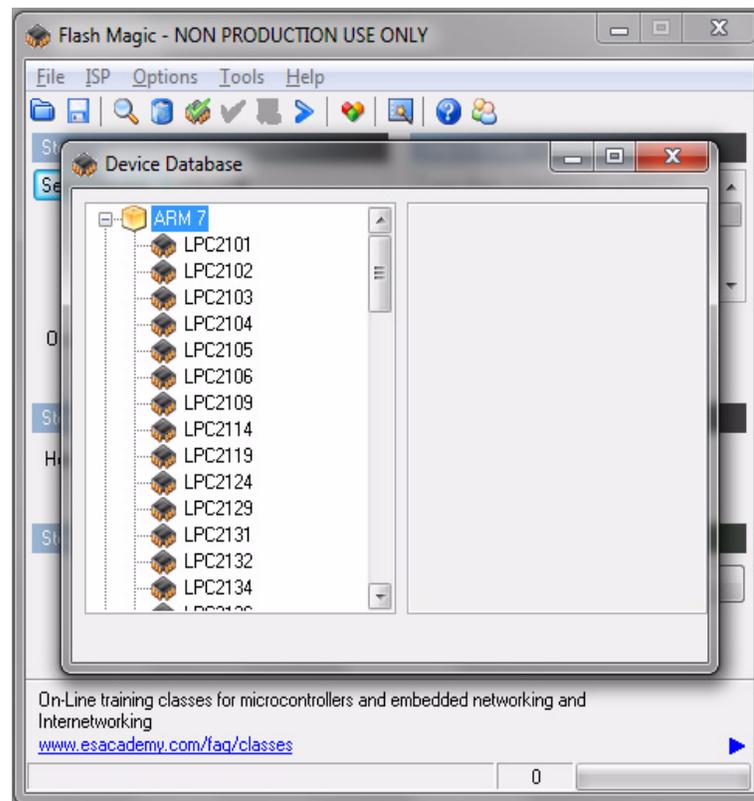


B) Press the “Select Device” button and the window shown in **Figure 4.4** will appear:

Figure 4.4 Device selection window



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

Figure 4.5 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 will observe the firmware being downloaded to the RCM Reference.

4.5 Verifying Firmware Update

Power cycle the unit with the pin 16 of J1 (ISP#) left floating. The Red LED should light up momentarily.

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>

GPSCon can be used to monitor the RCM Reference, even though the board does not contain an internal GPS receiver.

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.

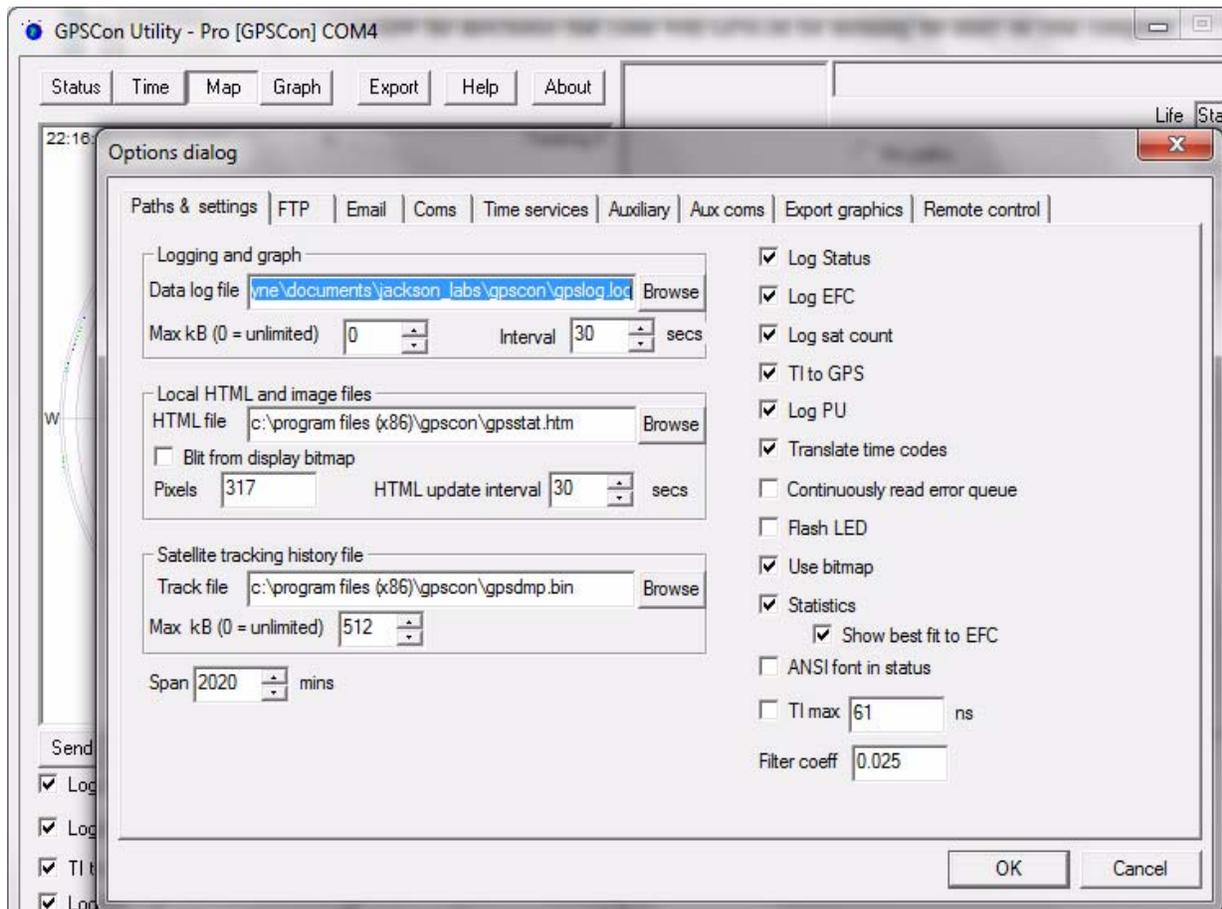
5.3 Using GPSCon

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

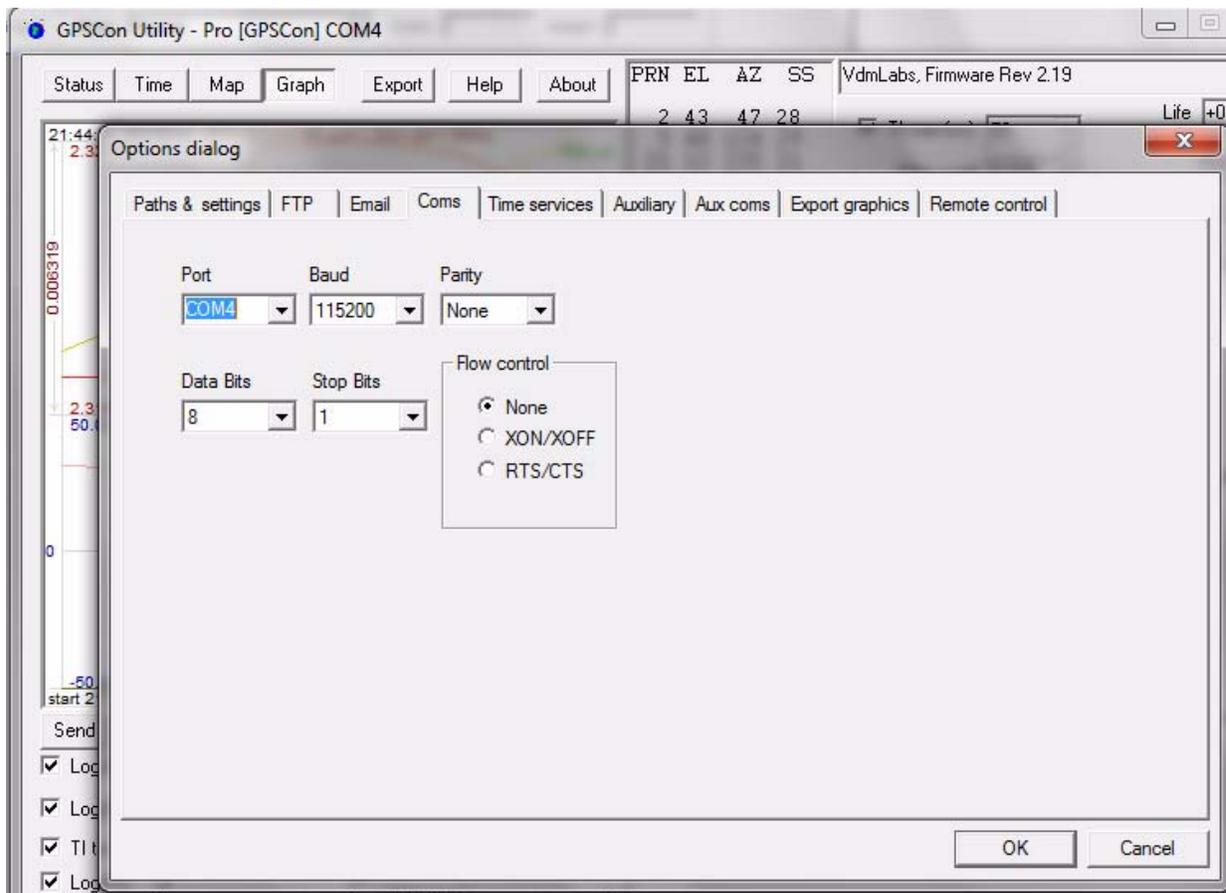
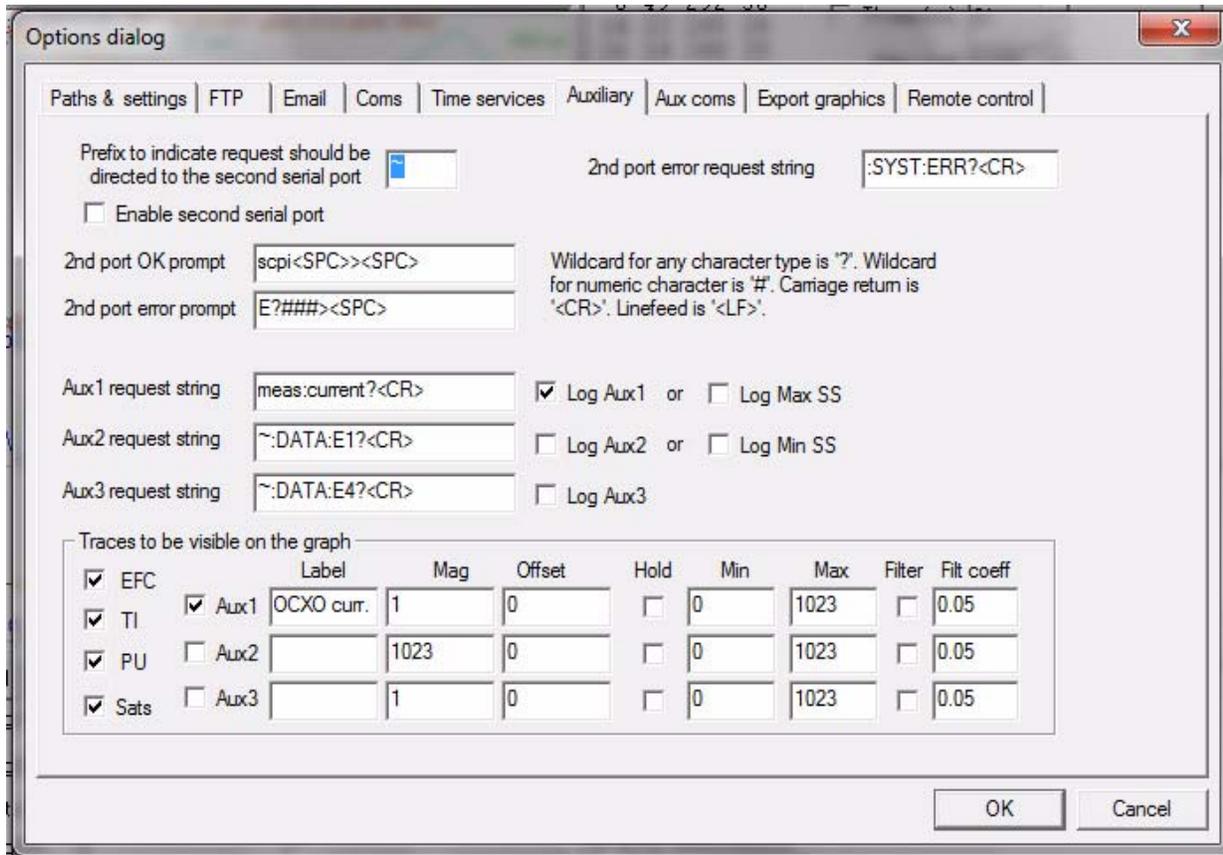


Figure 5.3 Auxiliary Parameters window



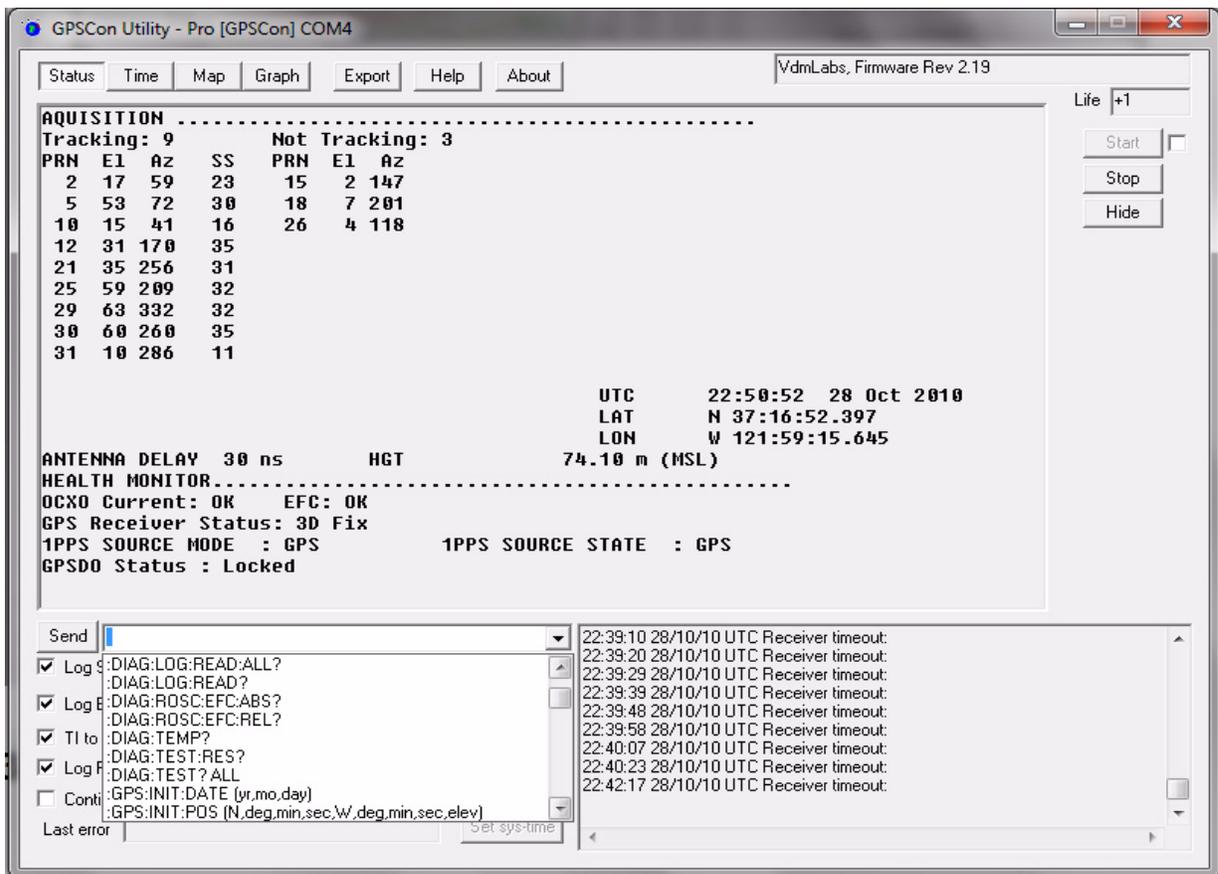
5.3.1.3 Other options

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 RCM Reference. Once you’ve selected the command, you can press “Send” to send it to the RCM Reference.

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

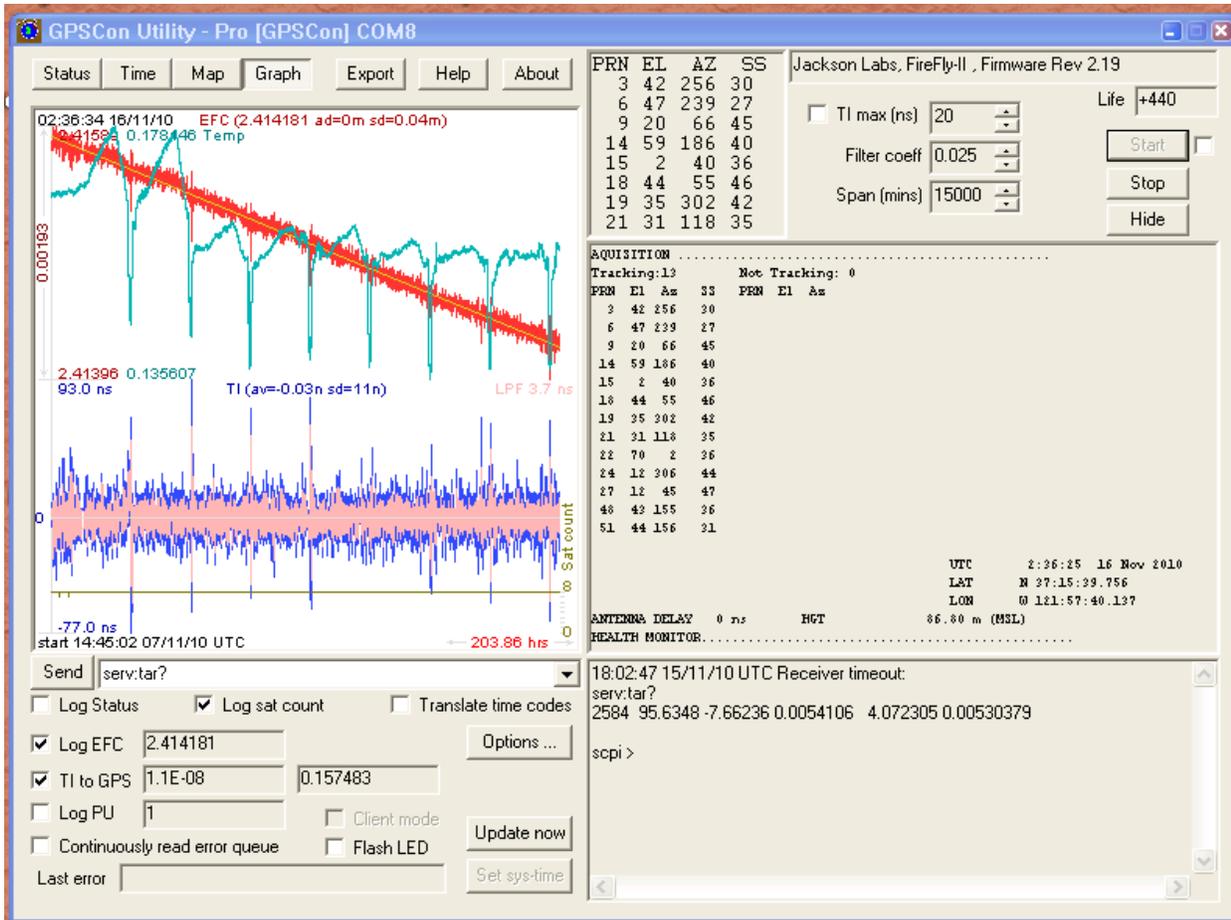
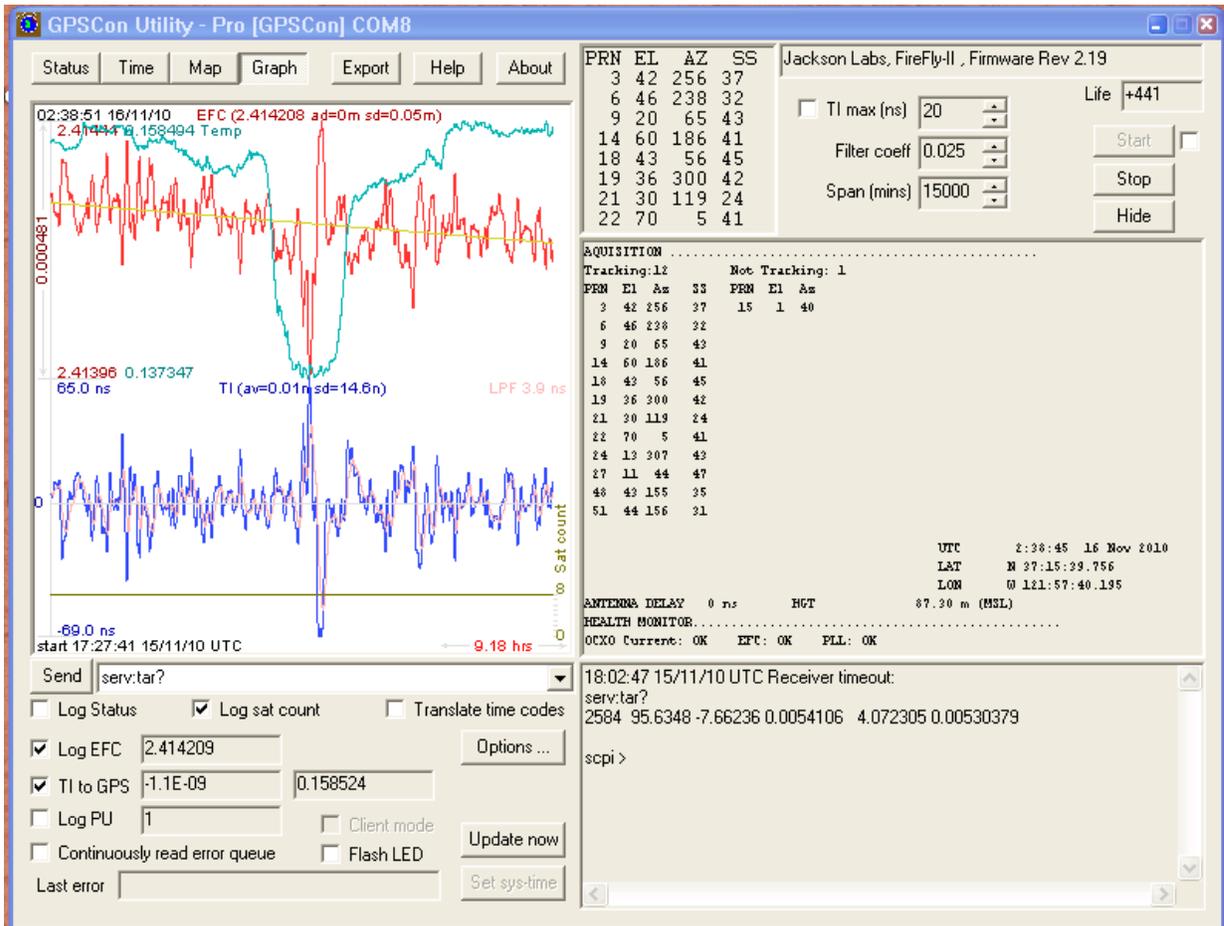


Figure 5.6 Expanded Graph Display



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 RCM Reference 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:

$$8\text{Hz/V} * 0.088\text{V/Year} = 0.704\text{Hz/Year drift.}$$

At 10MHz:

$$0.704\text{Hz} / 10\text{MHz} = 7.04\text{E-}08 \text{ aging rate per year.}$$

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.

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 external 1PPS 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:

$$11\text{ns} / 200\text{Hrs} = 1.528\text{E-}014$$

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 the external 1PPS reference 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**

PURPOSE. No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted by this document. Jackson Labs Technologies, Inc. products are not intended for use in medical, life saving, or life sustaining applications.

6.1.3 Exclusive Remedies

THE REMEDIES PROVIDED HEREIN ARE THE CUSTOMER'S SOLE AND EXCLUSIVE REMEDIES. JACKSON LABS TECHNOLOGIES, INC. SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.