VIAVI Solutions

HD CSAC Low Power GPS Disciplined Oscillator

From Jackson Labs Technologies, acquired by VIAVI Solutions

About this User Guide

This prefix explains how to use this User Guide and includes the following topics:

Purpose and scope

This manual is intended to help you use the capabilities of the HD CSAC LP GPSDO.

This manual includes task-based instructions that describe how to configure, use, and troubleshoot the test capabilities available on your instrument assuming it is configured and optioned to support the capabilities.

Assumptions

This manual is intended for novice, intermediate, and experienced users who want to use their instrument effectively and efficiently. We are assuming that you have basic computer experience and are familiar with basic telecommunication concepts, terminology, and safety.

Related Information

This manual is application-oriented and contains information about using these instruments to test service carried on each of the listed networks. It includes an overview of testing features, instructions for using the instruments to generate and transmit traffic over a circuit, and detailed test result descriptions. This manual also provides contact information for VIAVI's Technical Assistance Center (TAC).

Conventions

This manual uses conventions and symbols, as described in the following tables.

Table 1 Text formatting and other typographical conventions

Item(s)	Example(s)
Buttons, keys, or switches that you press or flip on a physical device.	Press the **On** button. – Press the **Enter** key. – Flip the **Power** switch to the on position.
Buttons, links, menus, menu options, tabs, or fields on a PC-based or Web-based user interface that you click, select, or type information into.	Click **Start** – Click **File > Properties**. – Click the **Properties** tab. – Type the name of the probe in the **Probe Name** field.
Directory names, file names, and code and output messages that appear in a command line interface or in some graphical user interfaces (GUIs).	`$NANGT_DATA_DIR/results` (directory) – `test_products/users/defaultUser.xml` (file name) – `All results okay.` (output message)

Table 1 Text formatting and other typographical conventions (Continued)

Item(s)	Example(s)
Text you must type exactly as shown into a command line interface, text file, or a GUI text field.	– Restart the applications on the server using the following command: **`$BASEDIR/startup/npiu_init restart`** Type: **`a:\set.exe`** in the dialog box.
References to guides, books, and other publications appear in *this typeface*.	Refer to *Newton's Telecom Dictionary.*
Command line option separators.	`platform [a|b|e]`
Optional arguments (text variables in code).	`login [platform name]`
Required arguments (text variables in code).	`<password>`

Table 2 Symbol conventions

	This symbol indicates a note that includes important supplemental information or tips related to the main text.
	This symbol represents a general hazard. It may be associated with either a DANGER, WARNING, CAUTION, or ALERT message. See Table 3 for more information.
	This symbol represents an alert. It indicates that there is an action that must be performed in order to protect equipment and data or to avoid software damage and service interruption.
	This symbol represents hazardous voltages. It may be associated with either a DANGER, WARNING, CAUTION, or ALERT message. See Table 3 for more information.
	This symbol represents a risk of explosion. It may be associated with either a DANGER, WARNING, CAUTION or ALERT message. See Table 3 for more information.
	This symbol represents a risk of a hot surface. It may be associated with either a DANGER, WARNING, CAUTION, or ALERT message. See Table 3 for more information.
	This symbol represents a risk associated with fiber optic lasers. It may be associated with either a DANGER, WARNING, CAUTION or ALERT message. See Table 3 for more information.
	This symbol, located on the equipment, battery, or the packaging indicates that the equipment or battery must not be disposed of in a land-fill site or as municipal waste, and should be disposed of according to your national regulations.

Table 3 Safety definitions

Term	Definition
DANGER	Indicates a potentially hazardous situation that, if not avoided, *will* result in death or serious injury. It may be associated with either a general hazard, high voltage, or other symbol. See Table 2 for more information.
WARNING	Indicates a potentially hazardous situation that, if not avoided, *could* result in death or serious injury. It may be associated with either a general hazard, high voltage, or other symbol. See Table 2 for more information.
CAUTION	Indicates a potentially hazardous situation that, if not avoided, could result in minor or moderate injury and/or damage to equipment. It may be associated with either a general hazard, high voltage, or risk of explosion symbol. See Table 2 for more information. When applied to software actions, indicates a situation that, if not avoided, could result in loss of data or a disruption of software operation.
ALERT	Indicates that there is an action that must be performed in order to protect equipment and data or to avoid software damage and service interruption.

Safety and compliance information

The following sections describe the safety and compliance information for the HD CSAC Low Power GPSDO.

California Proposition 65

California Proposition 65, officially known as the Safe Drinking Water and Toxic Enforcement Act of 1986, was enacted in November 1986 with the aim of protecting individuals in the state of California and the state's drinking water and environment from excessive exposure to chemicals known to the state to cause cancer, birth defects or other reproductive harm.

For the VIAVI position statement on the use of Proposition 65 chemicals in VIAVI products, see the Hazardous Substance Control section of the VIAVI Policies & Standards web page at: https://www.viavisolutions.com/en-us/corporate/legal/policies-standards#sustain

Product Environmental Compliance

VIAVI is committed to compliance with all applicable laws and regulations controlling the use of hazardous substances in its products, as well as the disposal of equipment (including batteries) and waste packaging. For details, see the VIAVI Policies & Standards web page or contact the VIAVI WEEE Program Management team at Global.WEEE@ViaviSolutions.com.

Technical assistance

If you require technical assistance, call 1-844-GO-VIAVI. For the latest TAC information, go to https://support.viavisolutions.com.

Table of Contents

1

Introduction

This chapter discusses the following topics:

About the HD CSAC Low Power GPSDO

The HD CSAC Low Power GPSDO is a GPS Disciplined Oscillator (GPSDO).

Operating Principles

A Cesium Vapor Cell is excited from a VCEL Laser source. The VCSEL is modulated at 4.6 GHz to produce a complementary pair of sidebands separated by the cesium ground state hyperfine frequency of 9.2 GHz. As Cesium supply depletion is not a lifetime limiting factor in the HD CSAC, the HD CSAC Low Power GPSDO implementation allows operational lifetimes that potentially exceed those of Cesium beam standards by far.

The Hyperfine transition frequency of the Cesium Vapor cell is affected by adverse environmental influences, and long-term frequency and phase errors are thus present in the HD CSAC Low Power GPSDO. To calibrate these errors out and achieve phase-lock to USNO UTC, the HD CSAC Low Power GPSDO uses a GNSS receiver to generate a highly accurate, though unstable 1PPS signal, and this 1PPS signal is compared with a 1PPS signal generated by the CSAC 10MHz VCXO. The VCEL is digitally tuned to shift the frequency up or down slightly and very slowly to keep the CSAC 1PPS reference in phase-lock with the GNSS generated 1PPS signal. This allows a very close tracking of the U.S. USNO UTC 1PPS signal to within tens of nanoseconds anywhere in the world, out-performing even the best free-running Atomic References in the long run. With this software PLL system the short-term instability of the GNSS receiver is filtered by the HD CSAC Low Power GPSDO, while the CSAC's long-term drift is removed by the GNSS receiver, resulting in both a very good short-term as well as USNO phase-locked long-term performance. The HD CSAC Low Power GPSDO uses a Jackson Labs Technologies, Inc. designed loop algorithm and capture hardware that far outperforms the CSAC's internal factory loop algorithm and time-capture hardware, and at the same time provides better control of the loop parameters for fine-tuning to different application scenarios by the user.

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.

Use an approved antenna lightning protector

The use of an approved and properly grounded antenna lightning protector on the GNSS antenna is required to prevent damage, injury, or death in case of a lightning strike.

Grounding

To avoid damaging sensitive electronic components in the HD CSAC Low Power GPSDO, always make sure to discharge any built-up electrostatic charge to a good ground source, such as the power supply ground. This should be done before handling the circuit board or anything connected to it, such as the GNSS antenna.

Power connections

Ensure the DC power is connected to the device following the polarity indicated in "Major connections" on page 7.

Environmental conditions

This instrument is intended for indoor use. The use of a properly installed GNSS Antenna Lightning Protector is required. It is designed to operate at a maximum relative non-condensing humidity of 95% and at altitudes of up to 50,000 meters. See **LINK TO SPECS** for the DC and AC mains voltage requirements and ambient operating temperature.

2

Quick-Start Instructions

This chapter discusses the following topics:

Powering up the unit

The HD CSAC Low Power GPSDO is powered from an external 4.85V to 5.15V (5V nominal) 0.15A DC source. The typical steady-state power consumption of the unit is 112mA at 5V (0.56W) with GNSS reception, and 0.45W with the GNSS receiver in deep-sleep mode (CSAC holdover/flywheel mode).

The GNSS receiver power supply is under user control, allowing you to disable the GNSS receiver for additional power savings when running in CSAC holdover (flywheel) mode without GNSS. In order to disable the GNSS receiver and its power supply as well as the GNSS antenna 3.3V power output the unit will need to be set into external 1PPS locking mode with the following SCPI serial command:

```
SYNC:SOURC:MODE:EXT
```

Sending this command once will turn off the units' GNSS power supply, and put the unit into external 1PPS locking mode. The user does not need to supply an external 1PPS pulse and can leave the 1PPS input un-connected, but if supplied the unit will now lock to the external 1PPS reference on pin 11 of connector J1.

To turn the power supply for the GNSS receiver and the GNSS antenna back on please send the following command on one of the two serial interfaces:

```
SYNC:SOUR:MODE GPS
```

The GNSS receiver will now be powered up again. The GNSS receiver is powered-on by default when the unit is shipped from the factory.

These two commands are stored in NV memory on the board, and the user thus only needs to send them once to the unit. Power consumption is reduced by about 100mW or more when the GNSS receiver is turned-off, representing an almost 20% overall power savings when in CSAC holdover mode.

Operating the unit from the RS-232 port

Perform the following steps to operate the unit from the RS-232 port.

1. Connect a 3.3V-compatible GNSS antenna to connector J4.
2. Plug in a clean DC power source of +5V to the power pin 16 of connector J1.

> **NOTE**
>
> The power pinout of the low power HD CSAC unit has been changed from the Legacy 12V HD CSAC unit to prevent damage to the board when inadvertently plugging in a legact 12V power supply into the 5V HD CSAC Low Power GPSDO.

3 Plug in the Ground connection to pins 14 and 15 of connector J1. RS-232 serial TX and RX signals are available on pins 9 and 8 respectively of connector J1.

> **CAUTION**
> Do not supply the board with a voltage other than the rated 5V operating voltage. Using a 12V power supply will severely damage the board and void the warranty.

Once serial communications have been established, try sending and experimenting with the following SCPI commands:

- SYST:STAT?
- GPS?
- SYNC?
- DIAG?
- MEAS?
- SCAC?
- HELP?

The cost-free Jackson Labs **GPSCon Utility** software package available on the JLT website support page (see Chapter 5 of this manual) is recommended for monitoring and controlling the unit via the RS-232 serial port. The Jackson Labs GPSCon program can be downloaded from the following website:

www.jackson-labs.com/index.php/support

The unit will now lock to GPS (Red LED is blinking when satellites are being received) and will indicate proper lock when the Green LED goes on. Once the green LED is on, the unit will output 10MHz with significantly better than 1ppb frequency accuracy.

The GNSS receiver establishes the internal antenna-gain right after power-on, so for proper operation the GNSS antenna should always be connected prior to turning on the power supply.

Major connections

The major connections and features of the HD CSAC Low Power GPSDO PCB are shown in Figure 1.

Figure 1 Major connections and features

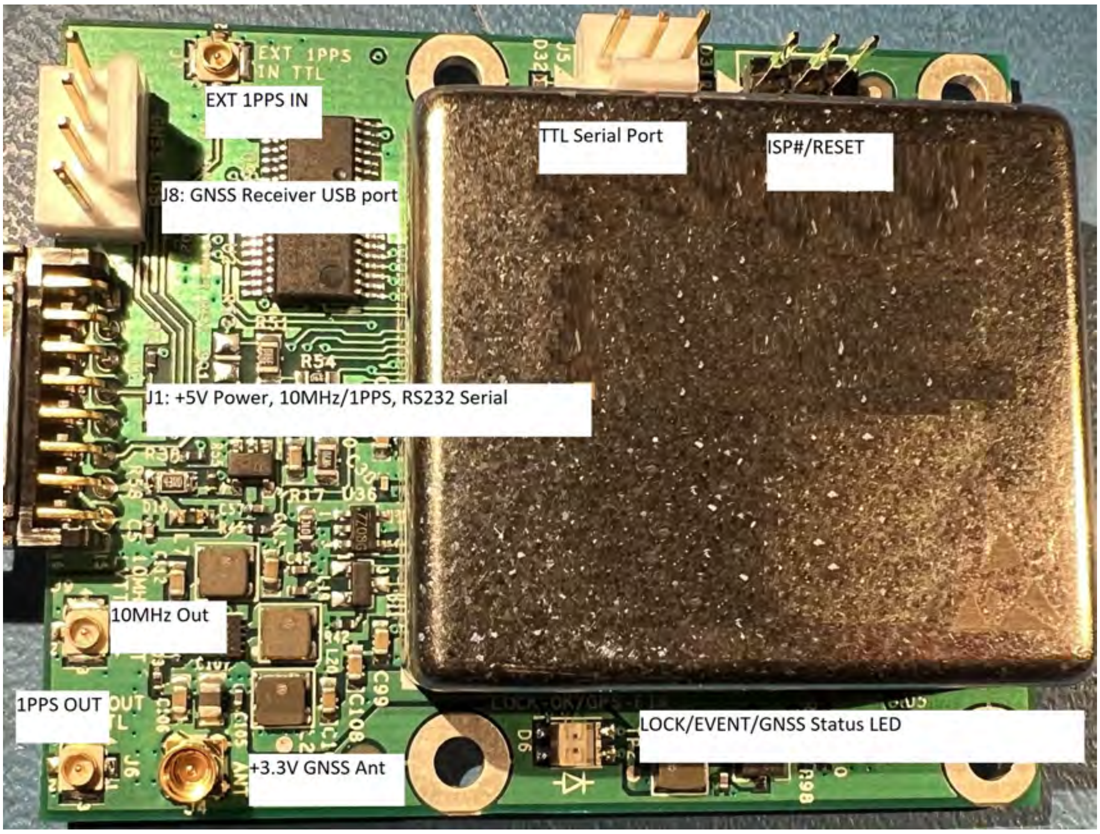


Table 1 describes the functions supported on connector J1.

Table 1 Connector J1 pinout

Ref	Name	Function	Specification
J1-1	+10MHz LVDS output	10MHz differential output	+10MHz LVDS, +/-300mV, terminate to -10MHz LVDS through 100 Ohms resistor
J1-2	-10MHz LVDS Output	10MHz differential output	-10MHz LVDS, +/-300mV, terminate to +10MHz LVDS through 100 Ohms resistor
J1-4	-1PPS LVDS Output	1PPS differential output	-1PPS LVDS, +/-300mV, terminate to +1PPS LVDS through 100 Ohms resistor
J1-5	+1PPS LVDS Output	1PPS differential output	+1PPS LVDS, +/-300mV, terminate to -1PPS LVDS through 100 Ohms resistor

Table 1 Connector J1 pinout

Ref	Name	Function	Specification
J1-7	LOCK_OK_OUT	Indicates that no internal events are pending, the hardware is ok, and the HD CSAC is locked to GPS.	3.3V CMOS output can drive up to 5mA, series-terminated by 33 Ohms
J1-8	RX_232	RS-232 receive data	RS-232 level
J1-9	TX_232	RS-232 transmit data	RS-232 level
J1-10	1PPS_CMOS	1PPS output in 3.3V CMOS level format. Do not terminate, use 1M or higher input impedance.	CMOS/TTL compatible 1PPS output, series-terminated by 50Ohms. <1ns rise and fall time. Do not end-terminate signal.
J1-11	PPS_IN	External alternate 1PPS input	TTL, 3.3V and 5V CMOS compatible
J1-13	10MHz Output	CMOS 10MHz output. Do not terminate, use 1M or higher input impedance.	3.3V CMOS level can drive up to 15mA, series-terminated by 50Ohms. <1ns rise and fall time. Keep wires shorter than 2 inches on this signal.

Harness pinning

Table 2 describes the cable harness J1 pinout.

Table 2 J1 pinout

Pin	Name
1	+10MHz LVDS
2	-10MHz LVDS
3	GND
4	-1PPS LVDS

Table 2 J1 pinout

Pin	Name
5	+1PPS LVDS
6	GND
7	LOCK_OUT_OK
8	RX RS-232
9	TX RS-232
10	1PPS_CMOS
11	PPS_IN
12	GND
13	10MHz CMOS
14	GND
15	GND
16	+5V

Table 3 describes the miscellaneous connectors.

Table 3 Miscellaneous connectors.

Ref	Name	Function	Specification	Pinning
J2	ISP/RESET	ISP/RESET jumper	GND pin 1 or 3 to activate	J2-1:ISP; J2-2:GND; J2-3:RST#
J4	Antenna	GNSS Antenna	3.3V Amplified Antenna, MMCX connector	Center: RF Input; Shield: GND
J5-1	RXD-TTL	TTS Serial Input into the board	3.3V or 5V CMOS or TTL level	J5-1 Input into HD CSAC board
J5-2	GND	Serial port ground	GND	J5-2 GND
J5-3	TXD-TTL	TTL Serial Output from the board.	3.3V CMOS output	J5-3 Output from HD CSAC board
J6	1PPS_CMOS_U.FL	1PPS output. Also see J1-10 in Table 1.	3.3V CMOS level, see also J1-10 in Table 1.	Center: 1PPS Output; Shield: GND
J7	1PPS_IN_U.FL	1PPS input, see also J1-11 inTable 1.	3.3V or 5V CMOS or TTL level, see also J1-11 in Table 1.	Center: 1PPS Input; Shield: GND
J8-1	GND	USB port ground	Ground for USB port of GNSS Receiver	J8-1 GND
J8-2	USB-	USB port Data-	Data- for USB port of GNSS Receiver	J8-2 Data-

Table 3 Miscellaneous connectors.

Ref	Name	Function	Specification	Pinning
J8-3	USB+	USB port Data+	Data+ for USB port of GNSS Receiver	J8-3 Data+
J8-4	+5V	USB port 5V input	5V input for USB port of GNSS Receiver. Also supplies power to HD CSAC Low Power GPSDO. See J1-16 in Table 1.	J8-4 +5V
J9	10MHz_OUT_U.FL	CMOS 10MHz output, see also J1-13 in Table 1.	3.3V CMOS level, see also J1-13 in Table 1.	Center: 10MHz Output; Shield: GND

Harness connectors J1 and J5

The manufacturer for connectors J1 is Hirose. A mating housing part number for this connector is available from Digikey, and crimp pins are also available from Digikey for different wire sizes:

http://search.digikey.com/scripts/DkSearch/dksus.dll?Detail&name=H2025-ND

The part number of the connectors soldered onto the HD CSAC Low Power GPSDO PCB is *Hirose PN: DF11-16DP-2DS52.*

The manufacturer for the TTL serial port connector J5 is Molex, and the connector J5 has Molex PN: *22-11-2032*.

Concurrent-GNSS capabilities

HD CSAC Low Power GPSDO with firmware revision 0.74 and later and uBlox 8 GNSS receiver is capable of simultaneously receiving up to three concurrent GNSS systems at one time. Firmware revision 0.74 and later also supports the HD CSAC Low Power GPSDO with uBlox 6 GPS receiver. Concurrent GNSS operation aids performance by allowing reception of up to 72 GNSS satellites in challenged reception areas such as in urban canyons, under foliage, indoors, or close to the earth's poles, etc. Using multiple GNSS systems also increases robustness by not relying on a single GNSS system. Several of the systems operate at different carrier frequencies, so using multiple GNSS systems can increase immunity against jamming which often occurs at only one carrier frequency.

The multiple GNSS systems each have their own reference time and representation of UTC. For example, GPS uses the GPS time standard and provides a method to convert GPS time to UTC as defined by the US Naval Observatory (USNO). GLONASS, Galileo and BeiDou have similar reference times and UTC definitions. The HD CSAC Low Power GPSDO with multi-GNSS support automatically adjusts for offsets between the different GNSS time reference standards and synchronizes the 1PPS output to UTC

(USNO) when GPS is being received. If GPS is not being received, the 1PPS output is synchronized to the best representation of UTC (USNO) available.

The selection of GNSS systems is made with the GPS:SYST:SEL command as detailed in "GPS:SYSTem:SELect [GPS | SBAS | QZSS | GAL | BD ^GLO]" on page 33. As these systems operate at different carrier frequencies with different bandwidths, it is necessary to use a GNSS antenna that is designed to receive all the required GNSS systems. Please note that the new and emerging Galileo system is now functional, and uses the same carrier frequency as GPS L1, albeit with a wider bandwidth. In our experience Galileo sats can be received with good C/No carrier to noise figures (>40dB) with standard legacy GPS antennae and distribution amplifiers/splitters. JLT thus recommends enabling at a minimum GPS, Galileo, and SBAS concurrently with the command: `GPS:SYST:SEL GPS GAL SBAS`, see also "GPS:SYSTem:SELect [GPS | SBAS | QZSS | GAL | BD ^GLO]" on page 33. Using other GNSS systems such as Glonass will require an antenna system designed to support Glonass signals.

HD CSAC Low Power GPSDO with firmware revision 0.75 and later and uBlox 8 GNSS receiver adds better support for legacy GPS receiver by switching the main talker ID to $GP for GGA, JLT GGA, RMC, and ZDA commands. This command allows the HD CSAC Low Power GPSDO to output NMEA sentences with navigation and PVT data for GPS only, see "GPS:NMEA:TALKid <GP | GN>" on page 34 for detailed operations and restrictions on talker ID mode.

The internal GNSS receiver can track up to three different GNSS systems and track up to 24 satellites concurrently, such as GPS, Galileo, Glonass, and SBAS at the same time. However only two different carrier frequencies may be received at any given time. So BeiDou and Glonass cannot be enabled concurrently when either GPS, Galileo, SBAS, or QZSS are simultaneously enabled as that would require tracking three different carrier frequencies.

Attempting to configure an invalid combination of GNSS systems or configure GNSS systems on HD CSAC Low Power GPSDO without uBlox 8 receiver with the `GPS:SYST:SEL` command will result in a Command Error response with no change to the configuration.

Connecting the GNSS antenna

Connect the GNSS antenna to connector J4 using the BNC to MMCX cable adapter.

> **CAUTION**
>
> Use a Lightning Arrestor on your antenna setup.

Use an amplified GNSS antenna that is 3.3V LNA compatible. The HD CSAC Low Power GPSDO GNSS (GPS for uBlox 6) receiver is a 72 (50 for uBlox 6 receiver) channel high-sensitivity multi-GNSS receiver with very fast lock time.

The HD CSAC Low Power GPSDO with uBlox 8 receiver can either be used in stationary applications using the automatic self-survey (Auto Survey with Position Hold) feature, or it can be used in mobile platforms. Using Position Hold mode improves timing and frequency accuracy especially in GPS-challenged antenna locations such as under foliage or with strong multipath signals.

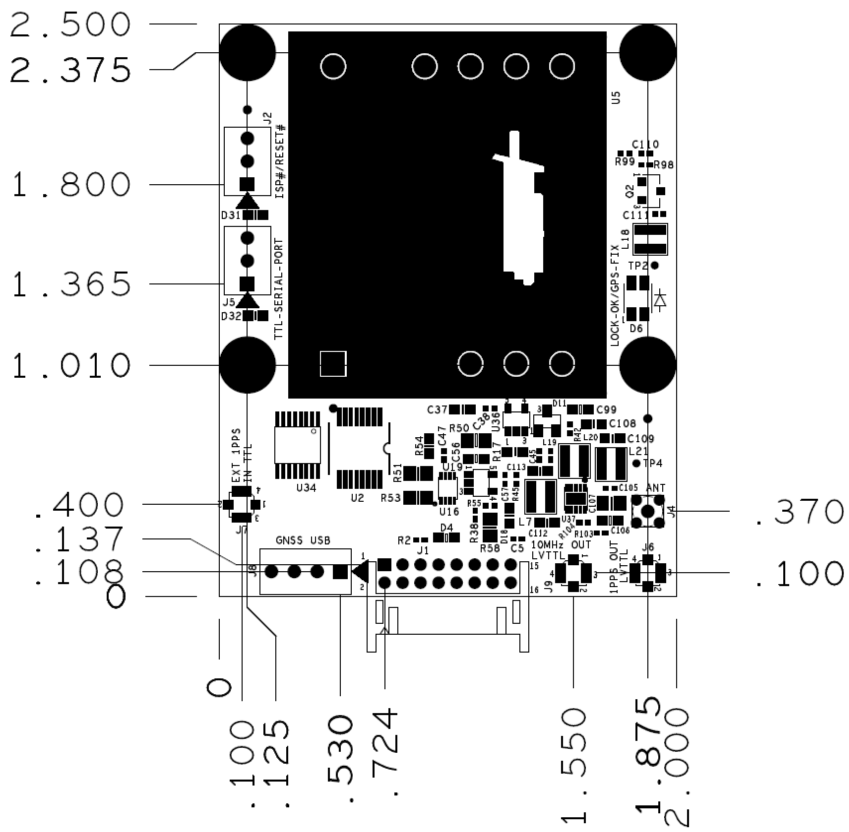
The HD CSAC Low Power GPSDO is capable of generating standard navigation messages (see "GPS:GPGGA <int> [0,255]" on page 23, "GPS:GPZDA <int> [0,255]" on page 24, "GPS:GPGSV <int> [0,255]" on page 24, "GPS:PASHR <int> [0,255]" on page 25, and "GPS:GPRMC <int> [0,255]" on page 24 serial commands) that are compatible with most GPS based navigation software.

The GNSS 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 HD CSAC Low Power GPSDO to UTC, thus disciplining the unit's Atomic Clock 10MHz frequency output to the US Naval master clock for very high frequency accuracy (typically better than 10 digits of frequency accuracy when locked to GPS). Using a high-performance Timing GNSS receiver allows operation with a phase stability error of typically less than +/-15 nanoseconds anywhere in the world.

Mechanical Drawing

Figure 2 shows the HD CSAC Low Power GPSDO mechanical drawing.

Figure 2 HD CSAC Low Power GPSDO mechanical drawing



Loop parameter adjustment

HD CSAC Low Power GPSDO with firmware revision 0.74 and later adds support for two different phase loop time constant settings for the CSAC to accommodate different mission scenarios (stationary versus mobile, steady state operation versus power cycling, etc.). These time constants determine the behavior of the unit during steady state operation, and when a frequency error is induced into the CSAC by adverse environmental effects such as tilt/shock of the unit, or due to thermal shocks. See "SERVo:MODE <OFF | NORMal | FAST | AUTO>" on page 50 for details in configuring different loop time constant settings.

All loop parameters can be controlled via the serial ports. Loop parameters are optimized for the Atomic Oscillator on the board, and changing the factory settings may cause the unit's performance to deteriorate. Table 4 shows the recommended loop time constraints for HD CSAC Low Power GPSDO.

Table 4 Recommended loop settings

Usage	Normal Time Constant	Fast Time Constant
Loop Behavior	Benign	Aggressive
SERV:EFCS	0.6	2.0
SERV:PHASECO	1.2	10.0
SERV:EFCD	10	5

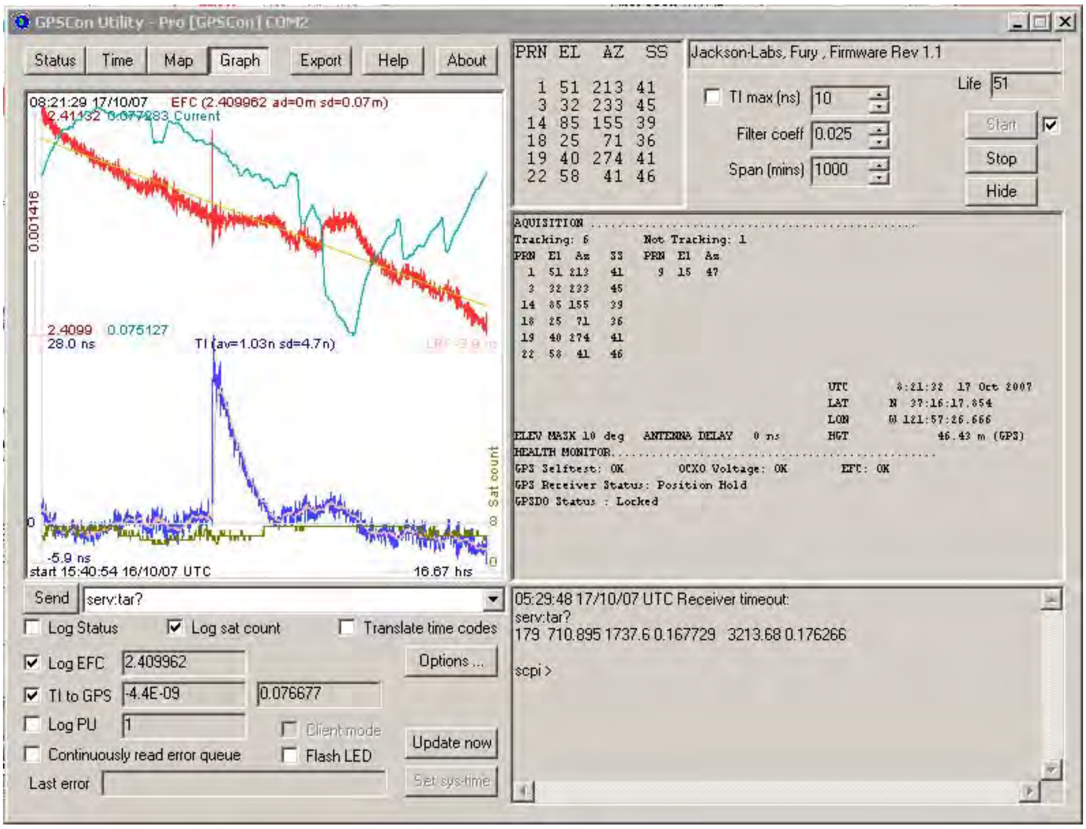
The commands to control the loop time constants are part of the SERVo? command. See also the "SERVO Subsystem" on page 49.

The individual commands are:

- **EFC Scale**: 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 0.6 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 5 to 50. Setting this value too high may cause loop instability.
- **Phase compensation**: The Integral part of the PID loop. This corrects phase offsets between the HD CSAC Low Power GPSDO 1PPS signal and the UTC 1PPS signal as generated by the GNSS receiver. Set higher values for tighter phase-following at the expense of frequency stability. Typical values range from 1 - 30. Setting this value too high may cause loop instability.

A well-compensated unit will show performance similar to the plot in Figure 3 when experiencing small externally stimulated frequency perturbations.

Figure 3 HD CSAC Low Power GPSDO phase compensation plot



Performance graphs

Figure 4 shows the typical Allan Deviation of the HD CSAC Low Power GPSDO unit when locked to GPS. ADEV performance approaches 1E-013 per day when locked to GPS. The plot shows the averaging intervals of 1000 seconds and more the GPS disciplining algorithm starts to improve the performance of the CSAC oscillator.

Figure 4 Allan Deviation of CSAC when locked to GPS

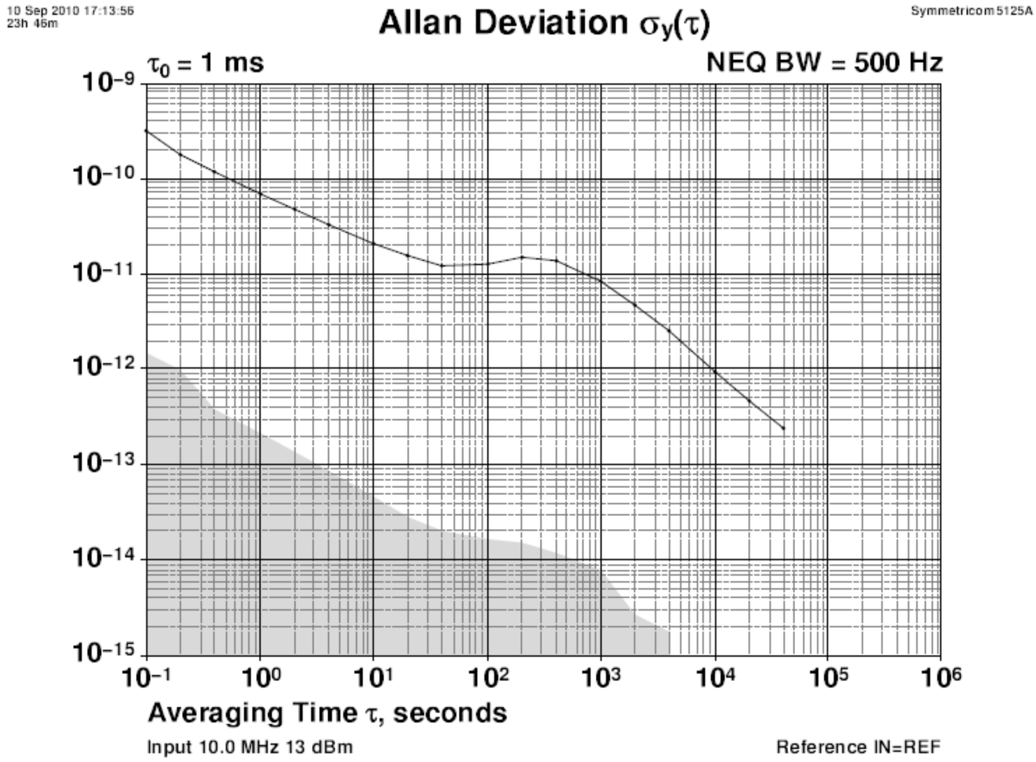
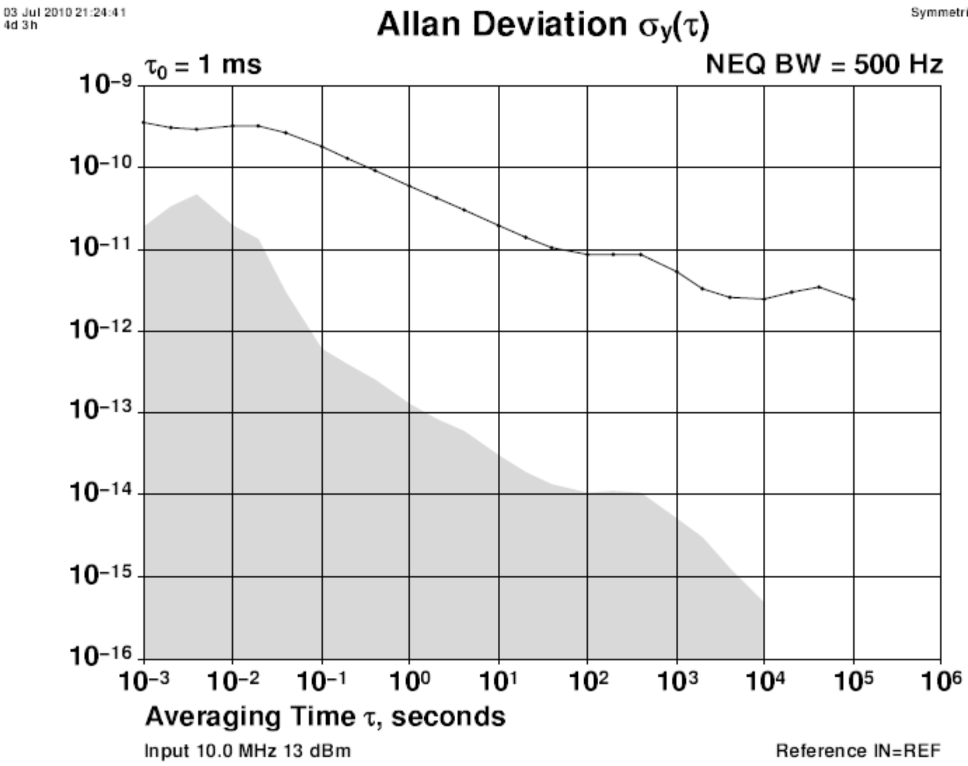


Figure 5 shows that the Allan Deviation of the free running unit (GPS holdover, no GNSS antenna is attached) is quite good, approaching 5E-012 over 100,000 seconds in this typical plot.

Figure 5 Allan Deviation of free running CSAC



3

SCPI-Control Quick Start Instructions

The following topics are discussed in this chapter:

Introduction

The HD CSAC Low Power GPSDO has two serial ports that can be used for accessing the Standard Commands for Programmable Instrumentation (SCPI) subsystem by using a host system terminal program such as TeraTerm or Hyperterminal. These ports operate simultaneously to each other, and can be set up to have pushed NMEA and other output sentences sent to either power, while the other port can be used for independent query and control commands. One port on connector J1 uses RS-232 levels, and the second port on connector J5 uses TTL levels only. By default the terminal settings are 115200, 8N1, no flow-control. The serial interface can send out standard NMEA messages, while simultaneously accepting SCPI commands from the user.

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 HD CSAC Low Power GPSDO.

Additional information regarding the SCPI protocol syntax can be found on the following web site: http://www.ivifoundation.org/scpi/

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.

As a Quick-Start, the user may want to try sending the following commands to one of the serial interfaces:

- **SYST:STAT?**
- **HELP?**
- **GPS?**
- **SYNC?**
- **DIAG?**

General SCPI commands

The following sections describe general SCPI commands.

*IDN?

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

<model number<, <firmware revision>

Help?

This query returns a list of the commands available for the HD CSAC Low Power GPSDO.

GPS subsystem

> **NOTE**
>
> HD CSAC Low Power GPSDO 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 NMEA position fixes are in the WGS84 coordinate system, while the X,Y, and Z velocity vectors are given in the ECEF coordinate system.

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

- GPS:SATellite:TRAcking:COUNt?
- GPS:SATellite:VISible:COUNt?
- GPS:PORT <RS232 | USB>
- GPS:PORT?
- GPS:GPGGA <int> [0,255]
- GPS:GGASTat <int> [0,255]
- GPS:GPRMC <int> [0,255]
- GPS:GPZDA <int> [0,255]
- GPS:GPGSV <int> [0,255]
- GPS:PASHR <int> [0,255]
- GPS:XYZSPeed <int> [0,255]
- GPS:GNGGA <int> [0,255]
- GPS:GGAGNSTat <int> [0,255]
- GPS:GNRMC <int> [0,255]
- GPS:GNZDA <int> [0,255]
- GPS:DYNAMic:MODE <int> [0,7]
- GPS:DYNAMic:MODE 8 (Automatic Dynamic Mode)
- GPS:DYNAMic:MODE?
- GPS:DYNAMic:STATe?
- GPS:REFerence:ADELay <float> <s | ns > [-32767ns,32767ns]
- GPS:REFerence:PULse:SAWtooth?
- GPS:RESET ONCE
- GPS:TMODe <ON | OFF | RSTSURV>
- GPS:SURVey ONCE
- GPS:SURVey:DURation <sec>

- GPS:SURVey:VARiance <mm^2>
- GPS:HOLD:POSition <cm, cm, cm>
- GPS:SURVey:STATus?
- GPS:INITial:DATE <yyyy,mm,dd>
- GPS:INITial:TIME <hour,min,sec>
- GPS:SYSTem:SELect [GPS | SBAS | QZSS | GAL | BD ^ GLO]
- GPS:NMEA:TALKid <GP | GN>
- GPS:NMEA:SVNum <GP | GN>
- GPS:JAMlevel?
- GPS:FWver?
- GPS?

GPS:SATellite:TRAcking:COUNt?

This query returns the number of satellites being tracked.

GPS:SATellite:VISible:COUNt?

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

NMEA Support

The following commands allow the HD CSAC Low Power GPSDO to be used as an industry standard navigation GNSS receiver. The GGA, GSV, RMC, ZDA and PASHR 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 HD CSAC Low Power GPSDO RS-232 interface.

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

To indicate the GNSS systems enabled and available to generate the NMEA data, the HD CSAC Low Power GPSDO's NMEA output includes a two character talker ID before the GGA, GLL, RMC, GSA, GSV, and ZDA sentence headers. Table 5 on page 25 shows the talker IDs for the supported GNSS systems. If more than one GNSS system is enabled and NMEA talker ID is set to GN, the talker ID of NMEA output is GN except for the GSV sentence which outputs multiple sets of sentences for each talker ID. See "GPS:NMEA:TALKid <GP | GN>" on page 34 for details in NMEA talker ID mode configuration. Also, the GSV output uses a modified satellite numbering scheme as detailed in Table 5 on page 25 to allow all different GNSS system satellites to be differentiated.

Please note that the position, direction, and speed data is delayed by one second from when the GNSS receiver internally reported these to the HD CSAC Low Power GPSDO 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 NMEA command settings will be stored in NV memory, and generate output information even after power to the unit has been cycled.

GPS:PORT <RS232 | USB>

This command is not supported in the HD CSAC Low Power GPSDO.

GPS:PORT?

This command is not supported in the HD CSAC Low Power GPSDO.

GPS:GPGGA <int> [0,255]

HD CSAC Low Power GPSDO with firmware revision 0.75 and later and uBlox 8 GNSS receiver adds support for switching the talker ID mode between GP and GN for GGA, JLT GGA, RMC, and ZDA commands. See Table on page 34 for detailed operations and restrictions on talker ID mode.

This command instructs the HD CSAC Low Power GPSDO to send the NMEA standard string $GPGGA every N seconds, with N in the interval [0,255]. The command is disabled during the initial 2 minute CSAC warm-up phase.

This command has the following format:

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

The GPGGA string has the following data format:

```
$GPGGA,hhmmss.00,llll.llll,S/N,yyyyy.yyyy,W/
E,f,ss,hh.h,aa.a,M,gg.g,M,,*[checksum]
```

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 <int > [0,255]” on page 53 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 CSAC performance.

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

GPS:GPRMC <int> [0,255]

HD CSAC Low Power GPSDO with firmware revision 0.75 and later and uBlox 8 GNSS receiver adds support for switching the talker ID mode between GP and GN for GGA, JLT GGA, RMC, and ZDA commands. See "GPS:NMEA:TALKid <GP | GN>" on page 34 for detailed operations and restrictions on talker ID mode.

This command instructs the HD CSAC Low Power GPSDO to send the NMEA standard string $GPRMC every N seconds, with N in the interval [0,255]. The command is disabled during the initial 2 minute CSAC warm-up phase.

This command has the following format:

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

The GPRMC string has the following data format:

```
$GPRMC,hhmmss.00,s,llll.llll,S/N,yyyyy.yyyy,W/
E,k.k,d.d,ddmmyy,,*[checksum]
```

GPS:GPZDA <int> [0,255]

HD CSAC Low Power GPSDO with firmware revision 0.75 and later and uBlox 8 GNSS receiver adds support for switching the talker ID mode between GP and GN for GGA, JLT GGA, RMC, and ZDA commands. See "GPS:NMEA:TALKid <GP | GN>" on page 34 for detailed operations and restrictions on talker ID mode.

This command instructs the HD CSAC Low Power GPSDO to send the NMEA standard string $GPZDA every N seconds, with N in the interval [0,255]. The command is disabled during the initial 2 minute CSAC warm-up phase.

This command has the following format:

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

The GPZDA string has the following data format:

```
$GPZDA,hhmmss.00,dd,mm,yyyy,+00,00*[checksum]
```

GPS:GPGSV <int> [0,255]

This command instructs the HD CSAC Low Power GPSDO to send the NMEA standard string $GPGSV every N seconds, with N in the interval [0,255]. The command is disabled until the GNSS receiver achieves a first fix.

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

HD CSAC Low Power GPSDO with firmware revision 0.74 and later and uBlox 8 GNSS receiver is capable of simultaneously receiving up to three concurrent GNSS systems and tracking up to 24 satellites at one time. When multiple GNSS systems are enabled in "GPS:SYSTem:SELect [GPS | SBAS | QZSS | GAL | BD ^GLO]" and talker ID mode is configured to GN in “GPS:NMEA:TALKid <GP | GN>”, multiple GSV sentences with different talker ID listed in Table 5 will be outputted.

For example, if GPS:SYST:SEL GPS SBAS GAL GLO command is sent and talker ID mode is GN, this command will have the following output format:

```
$GPGSV,x,x,ss,nn,ee,aaa,ss,...*[checksum]
$GLGSV,x,x,ss,nn,ee,aaa,ss,...*[checksum]
$GAGSV,x,x,ss,nnn,ee,aaa,ss,...*[checksum]
```

HD CSAC Low Power GPSDO with firmware revision 0.75 and later and uBlox 8 GNSS receiver adds support for switching the talker ID mode to GP for GSV command where only $GPGSV (i.e., no $GLGSV, $GAGSV, or $GBGSV) string will be outputted for GPS, SBAS, and QZSS. See “GPS:NMEA:SVNum <GP | GN>” on page 35 for more details on merging satellite information for other GNSS systems in $GPGSV sentence.

Table 5 PRN numbering scheme for GNSS systems

GNSS Type	SV Range	GPGSV PRN vehicle numbering	Talker ID
GPS	G1-G32	1-32	GP
SBAS	S120-S158	33-64,152-158	GP
Galileo	E1-E36	301-336	GA
BeiDou	B1-B37	401-437	GB
IMES	I1-I10	173-182	GP
QZSS	Q1-Q5	193-197	GP
GLOSNASS	R1-R32, R?	65-96,0	GL

GPS:PASHR <int> [0,255]

The PASHR command alongside the GPZDA command will give all relevant parameters such as time, date, position, velocity, direction, altitude, quality of fix, and more. As an example, the String has the following data format:

```
$PASHR,POS,0,7,202939.00,3716.28369,N,12157.43457,W,00087.4
0,????,070.01,000.31,-000.10,05.6,03.5,04.3,00.0,DD00*32
```

Please note that the length of the string is fixed at 115 characters plus the two binary 0x0d, 0x0a termination characters.

```
$PASHR,POS,0,aa,bbbbbb.00,cccc.ccccc,d,eeeee.eeeee,f,ggggg.
gg,hhhh,iii.ii,jjj.jj,kkkk.kk,ll.l,
mm.m,nn.n,00.0,p.pp,*[checksum]
```

where:

- aa: Number of Sats
- bbbbbb.00: Time of Day UTC
- cccc.ccccc,d: Latitude,S/N
- eeee.eeeee,f: Longitude,W/E
- ggggg.gg: Antenna Height in meters
- hhhh: Four fixed '?' symbols
- iii.ii: Course Over Ground
- jjj.jj: Speed in Knots
- kkkk.k: Vertical Velocity in meters/s
- ll.l: PDOP
- mm.m HDOP
- nn.n VDOP
- 00.0 Static number
- p.pp: Firmware version

This command instructs the HD CSAC Low Power GPSDO to send the NMEA standard string $PASHR every N seconds, with N in the interval [0,255]. The command is disabled during the initial 2 minute CSAC warm-up phase.

This command has the following format:

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

GPS:XYZSPeed <int> [0,255]

This command is 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 in the ECEF coordinate system.

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.

Additionally, the number of accrued Leapseconds is indicated in this message, which allows proper calculation of GPS time from UTC time as indicated by other messages, as well as proper handling of Leapsecond events.

Use the following format to generate the velocity vector every N seconds, with N in the interval [0,255]:

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

GPS:GNGGA <int> [0,255]

HD CSAC Low Power GPSDO with firmware revision 0.75 and later and uBlox 8 GNSS receiver adds support for switching the talker ID mode between GP and GN for GGA, JLT GGA, RMC, and ZDA commands. See "GPS:NMEA:TALKid <GP | GN>" on page 34 for detailed operations and restrictions on talker ID mode.

Similar to the GPS:GPGGA command. This command instructs the HD CSAC Low Power GPSDO to send the NMEA standard string $GNGGA every N seconds, with N in the interval [0,255]. The command is disabled during the initial 2 minute CSAC warm-up phase.

This command has the following format:

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

The GNGGA string has the following data format:

```
$GNGGA,hhmmss.00,llll.llll,S/N,yyyyy.yyyy,W/
E,f,ss,hh.h,aa.a,M,gg.g,M,,*[checksum]
```

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

GPS:GNRMC <int> [0,255]

HD CSAC Low Power GPSDO with firmware revision 0.75 and later and uBlox 8 GNSS receiver adds support for switching the talker ID mode between GP and GN for GGA, JLT GGA, RMC, and ZDA commands. See "GPS:NMEA:TALKid <GP | GN>" on page 34 for detailed operations and restrictions on talker ID mode.

This command instructs the HD CSAC Low Power GPSDO to send the NMEA standard string $GNRMC every N seconds, with N in the interval [0,255]. The command is disabled during the initial 2 minute CSAC warm-up phase.

This command has the following format:

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

The GNRMC string has the following data format:

```
$GNRMC,hhmmss.00,s,llll.llll,S/N,yyyyy.yyyy,W/
E,k.k,d.d,ddmmyy,,*[checksum]
```

GPS:DYNAMic:MODE <int> [0,7]

This command allows the user to select the dynamic motion model being applied to the Kalman filters in the GNSS receiver. This allows for larger amounts of filtering for lower velocity applications, effectively reducing noise and multipath interference. Applications with high acceleration can now be used with fast filter settings to allow for the most accurate GPS coordinates to be provided in high-dynamic applications such as Jet aircraft. Doppler tracking is enabled in all airborne modes, as Carrier Phase tracking is very difficult to achieve in high velocity applications.

The GNSS receiver will perform Carrier Phase tracking for non-airborne modes.

The command has the following syntax:

```
GPS:DYNAMic:MODE <int> [0,8]
```

Sending the following command to the HD CSAC Low Power GPSDO will select a stationary GNSS dynamic model for example:

```
GPS:DYNAM:MODE 1
```

Table 6 lists all available modes.

Table 6 Supported Dynamic GNSS operating modes

Value	Model	Application
0	Portable	Recommended as a default setting
1	Stationary	Used in stationary applications
2	Pedestrian	Used in man-pack, pedestrian settings
3	Automotive	Vehicular velocity applications
4	Sea	Used on ships, where altitude is expected to be constant
5	Airborne <1g	Airborne applications with less than 1g accelleration
6	Airborne <2g	Airborne applications with less than 2g accelleration
7	Airborne <4g	Airborne applications with less than 4g accelleration
8	Automatic Mode	Select one of the above states (0-7) based on the actual velocity of the vehicle.

The HD CSAC Low Power GPSDO with uBlox 8 GNSS receiver is capable of running in a stationary mode with Position Auto Survey called Position Hold Mode. This mode increases timing stability by storing the position into memory, and solving the GNSS signal only for time as the position is not expected to change. Two modes can be selected for Auto Survey operation (see “GPS:TMODe <ON | OFF | RSTSURV>” on page 31 for a description of the GPS:TMODE command):

1 Manually setting Timing Mode to ON with a hard-coded position in NV memory

2 Enabling Auto Survey to start automatically after power-on by setting Timing Mode to RSTSURV

If either one of the above two GPS:TMODE Auto Survey/Position Hold modes is selected, the GPS:DYNAMic:MODE command is disabled internally and its setting is ignored as the unit does not expect any motion on the antenna. In this case, the dynamic state as programmed into the GNSS receiver is set to STATIONARY independent of the user selection for GPS:DYNAMic:MODE.

The current dynamic state being applied to the GNSS receiver can be queried with the following command:

```
GPS:DYNAMic:STATE?
```

> **NOTE**
> This command syntax has changed from previous products such as the FireFly-IIA GPSDO units which did not support Position Hold Auto Survey modes.

GPS:DYNAMic:MODE 8 (Automatic Dynamic Mode)

Automatic Dynamic Mode allows the HD CSAC Low Power GPSDO firmware to automatically configure the GNSS receiver Kalman filter parameters based on actual mission velocities and motion profiles. The unit will try to set the GNSS receiver to the optimal setting for any given velocity. The unit is able to set 7 different modes, as shown in "GPS:DYNAMic:MODE <int> [0,7]" on page 27.

Table 7 shows the Dynamic mode the unit will program into the GNSS receiver when Automatic Mode is selected (Dynamic Mode 8).

Table 7 Auto Dynamic Mode switching rules

Velocity Threshold	Selected Dynamic Model	Fallback to lower setting
0 – 2 knots	Stationary	None
>2 knots	Pedestrian	<1 knots
>10 knots	Automotive	<8 knots
>60 knots and >400 Feet/ min climb/descent	Airborne 1g	<50 knots
>150 knots	Airborne 2g	<130 knots
>240 knots	Airborne 4g	<210 knots

In this Automatic mode, the unit will configure the GNSS receiver based on the actual vehicle-velocity.

> **NOTE**
> In order to switch from the Automotive mode into the first Airborne (1g) mode, both a vehicle velocity greater than 60 knots as well as a climb/descent rate greater than 400 feet per minute are required. Alternatively, a vehicle velocity of greater than 100 Knots will also initiate a switch into airborne-1g mode.
>
> Without an appropriate climb/descent, the unit will remain in Automotive mode.

The following command returns the setting of the GNSS dynamic model:

```
GPS:DYNAMic:MODE?
```

The actual state chosen by the firmware for the GNSS receiver based on vehicle velocity can be obtained with the command:

```
GPS:DYNAMic:STATe?
```

A value between 0 and 7 is then returned depending on vehicle dynamics.

The dynamic state is always set to STATIONARY if one of the Position Hold Auto Survey stationary modes is selected using the command GPS:TMODE for HD CSAC Low Power GPSDO with uBlox 8 receiver, as the Position Hold mode setting overrides any dynamic state user setting.

Settings are applied immediately to the GNSS receiver, and are stored in Non Volatile memory.

GPS:DYNAMic:STATe?

This query returns the actual state of the dynamic model, chosen by the firmware to be applied to the GNSS receiver, depending on vehicle velocity. It returns a value between 0 and 7, which correspond to one of the dynamic models defined in Table 7 on page 29.

This state can be different from the user-selected Dynamic model mode for two reasons:

- If the dynamic mode is set to 8 (Automatic mode), the state will reflect the dynamic model being aplied to the GNSS receiver depending on actual vehicle dynamics.
- If the GNSS Timing Mode is set to ON or to RSTSURV and the unit is a HD CSAC Low Power GPSDO with uBlox 8 receiver, the dynamic state will always be set to 1 (Stationary).

GPS:REFerence:ADELay <float> <s | ns> [-32767ns,32787ns]

The ADELay command allows bi-directional shifting of the 1PPS output in relation to the UTC 1PPS reference in one nanosecond steps. This allows antenna cable delay compensation, as well as retarding or advancing the 1PPS pulse arbitrarily. Typical antenna delays for a 30 foot antenna cable with 1.5ns per foot propagation delay would be compensated with the following command:

```
GPS:REF:ADEL 45ns
```

This command can be used to fine-tune different units to have co-incident 1PPS pulse outputs.

> **NOTE**
>
> During normal operation, the 1PPS pulse may wander around the UTC 1PPS pulse while the unit is tracking GNSS signals. The present offset between the 1PPS output and the UTC 1PPS signal can be queried with the command SYNC:TINT? and this offset should be taken into account when calibrating two unit's 1PPS outputs to each other, since the lock algorithms will try to steer the CSAC for a 0.0ns offset to the UTC 1PPS time-pulse.

GPS:REFerence:PULse:SAWtooth?

This command returns the momentary sawtooth correction factor that the GNSS receiver indicated.

GPS:RESET ONCE

Issues a reset to the internal GNSS receiver. This can be helpful when changing the antenna for example, since the GNSS receiver measures the antenna system's C/No right after reset, and adjusts its internal antenna amplifier gains accordingly. It takes approximately 1 minute for locking to commence after a GPS reset, as indicated by the red blinking LED.

GPS:TMODe <ON | OFF | RSTSURV>

HD CSAC Low Power GPSDO with firmware revision 0.74 and later and uBlox 8 GNSS receiver adds support for selecting the Timing Mode of the GNSS receiver.

If the Timing Mode is OFF, the receiver will act as a regular GNSS receiver. This mode has to be chosen if the unit is mobile.

If the Timing Mode in ON, the timing features of the GNSS receiver are enabled. At power-up, the Hold position stored in NV memory will be sent to the GNSS receiver and will be used as the reference. In order to use this mode, the receiver position must be known as exactly as possible.

Errors in the Hold position will translate into time errors depending on the satellite constellation.

The Hold position can be set manually by the user or can be the result of a Survey executed by the GNSS receiver.

If the Timing Mode is RSTSURV, the GNSS receiver will start a Survey every time the unit is powered-on and following the Survey, the GNSS receiver will run with the timing features enabled.

GPS:SURVey ONCE

HD CSAC Low Power GPSDO with firmware revision 0.74 and later and uBlox 8 GNSS receiver adds support for selecting the Timing Mode of the GNSS receiver.

This command starts a Survey. At the end of the Survey, the calculated Hold position will be stored in NV memory. The Survey parameters can be set with the command `GPS:SURVey:DURation` and `GPS:SURVey:VARiance`.

GPS:SURVey:DURation <sec>

HD CSAC Low Power GPSDO with firmware revision 0.74 and later and uBlox 8 GNSS receiver adds support for selecting the Timing Mode of the GNSS receiver.

This command sets the Survey minimal duration.

GPS:SURVey:VARiance <mm^2>

HD CSAC Low Power GPSDO with firmware revision 0.74 and later and uBlox 8 GNSS receiver adds support for selecting the Timing Mode of the GNSS receiver.

This command specifies the minimum variance of the average position computed during the Survey. This minimum value is used as a threshold under which the GNSS receiver can stop the Survey. The GNSS receiver will stop the Survey when the minimal duration has been reached and the variance of the average position is under the specified minimum variance.

GPS:SURVey:STATus?

HD CSAC Low Power GPSDO with firmware revision 0.74 and later and uBlox 8 GNSS receiver adds support for selecting the Timing Mode of the GNSS receiver.

This query displays the current status of the survey. The status of the survey is in one of the 3 states:

- ACTIVE — a survey is in progress
- VALID — a survey has been achieved successfully and the GNSS receiver is now using this Hold position as reference
- INVALID — no survey are in progress or have been achieved since the last power cycle

When in ACTIVE or VALID state, this query will also display the duration, the Hold position in ECEF coordinates and the position variance.

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

Firmware revision 0.57 and later adds support for manually setting the time and date in the RTC in the event that no GNSS signals are available. This command allows setting the internal RTC DATE manually when operating the unit in GPS denied environments. This command is compatible to the `PTIME:OUT ON` command described in Section “PTIMe:OUTput <ON | OFF>” on page 38 to allow automatic time and date synchronization of two units to each other. The internal RTC is driven by the highly stable CSAC 10MHz signal, and thus has very high accuracy.

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

Firmware revision 0.57 and later adds support for manually setting the time and date in the RTC in the event that no GNSS signals are available. This command allows setting the internal RTC TIME manually when operating the unit in GPS denied environments. This command is compatible to the PTIME:OUT ON command described in “PTIMe:OUTput <ON | OFF>” on page 38 to allow automatic time and date synchronization of two units to each other. The internal RTC is driven by the highly stable CSAC 10MHz signal, and thus has very high accuracy.

GPS:SYSTem:SELect [GPS | SBAS | QZSS | GAL | BD ^GLO]

HD CSAC Low Power GPSDO with firmware revision 0.74 and later and uBlox 8 GNSS receiver is capable of simultaneously receiving up to three concurrent GNSS systems at one time. Firmware revision 0.74 and later also supports the HD CSAC Low Power GPSDO with uBlox 6 GPS receiver.

This command selects the GNSS systems that are enabled in the GNSS receiver and are used to generate the timing and positioning information for the NMEA data, and to generate the 1PPS reference for the GPSDO. The command is followed by a list of the shortened names of the GNSS systems to enable. The shortened names of supported GNSS system include GPS, SBAS, QZSS, BD (BeiDou), GAL (Galileo) and GLO (GLONASS). Please see Section 2.3.3 for restrictions on the concurrent GNSS systems that can be enabled. Configuration with invalid combinations of GNSS systems or HD CSAC Low Power GPSDO without uBlox 8 receiver will result in a Command Error response and no change to the configuration.

The following example command will enable GPS, SBAS, Galileo and GLONASS all concurrently:

GPS:SYST:SEL GPS SBAS GAL GLO

The following command will query the currently enabled GNSS systems:

GPS:SYST:SEL?

The HD CSAC Low Power GPSDO with uBlox 8 receiver will respond to the query with the list of enabled GNSS systems such as:

GPS SBAS GAL GLO

HD CSAC Low Power GPSDO with firmware revision 0.75 and later and uBlox 8 GNSS receiver adds support for switching the talker ID mode between GP and GN for GGA, JLT GGA, RMC, and ZDA commands. See "GPS:NMEA:TALKid <GP | GN>" on page 34 for detailed operations and restrictions on talker ID mode.

GPS:NMEA:TALKid <GP | GN>

HD CSAC Low Power GPSDO with firmware revision 0.75 and later and uBlox 8 GNSS receiver adds support for switching the talker ID mode between GP and GN for GGA, JLT GGA, RMC, and ZDA commands.

This command has the following format and changed setting will be applied immediately to the CSAC GPSDO, and is stored in NV memory:

```
GPS:NMEA:TALKid <GP | GN>
```

The following command returns the NMEA talker ID mode stored in NV memory:

```
GPS:NMEA:TALKid?
```

Sending command with invalid parameter or HD CSAC Low Power GPSDO without uBlox 8 receiver will result in a Command Error response and no change to the configuration.

Several rules are applied when switching between GN and GP talker ID mode:

- The $GNxxx NMEA string is equivalent to corresponding $GPxxx NMEA string except for the main talker ID $GN at the header.
- Sending GPS:NMEA:TALK GP command or any of the GPxxx commands will change the talker ID mode to GP for all GGA, JLT GGA, RMC, and ZDA commands with any combination of GNSS systems enabled in "GPS:SYSTem:SELect [GPS | SBAS | QZSS | GAL | BD ^GLO]" on page 33.
- If talker ID mode is GN and only one GNSS system is enabled (i.e., GPS|SBAS|QZSS only, or Galileo only, or GLONASS only, or BeiDou only), the corresponding GNSS-specific talker ID listed in Table 5 on page 25 will be used.
- Sending GPS:NMEA:TALK GN command or any of the GNxxx commands will change the talker ID mode to GN for all GGA, JLT GGA, RMC, and ZDA commands when more than one GNSS system is enabled.
- If talker ID mode is GP, the GSV command will only contain the satellite information for GPS, SBAS, and QZSS only, if available. To include satellite info from other GNSS systems in $GPGSV string, GPS:NMEA:SVNum GN command discussed in Section "GPS:NMEA:SVNum <GP | GN>" on page 35 can be used.

The GPS:NMEA:TALK GP and GPxxx commands are useful for environment with poor GPS reception with multiple concurrent GNSS systems enabled to output valid navigation and PVT data for GPS system. See "Concurrent-GNSS capabilities" on page 11 for details of merits in concurrent GNSS systems.

The following commands can be used for enabling GPS, SBAS and Galileo at the same time but outputting GGA and RMC sentences every one second with talker ID $GP at the header:

- `GPS:SYST:SEL GPS SBAS GAL`
- `GPS:GPGGA 1`
- `GPS:GPRMC 1`

GPS:NMEA:SVNum <GP | GN>

HD CSAC Low Power GPSDO with firmware revision 0.75 and later and uBlox 8 GNSS receiver adds support for switching the talker ID mode to GP for GSV command where only $GPGSV (i.e., no $GLGSV, $GAGSV, or $GBGSV) string will be outputted for GPS, SBAS, and QZSS.

This command allows the HD CSAC Low Power GPSDO to include all available satellite information for GPS, SBAS, QZSS, Galileo, GLONASS, and BeiDou in $GPGSV string when the talker ID mode is set to GP in "GPS:NMEA:TALKid <GP | GN>" on page 34. The default mode for this command is GP which excludes satellite information for GNSS systems other than GPS, SBAS, and QZSS.

This command is effective only when the talker ID mode is GP meaning that GSV command will have GNSS-specific talker ID listed in Table 5 on page 25 for each GNSS system enabled if talker ID mode is GN.

This command has the following format:

```
GPS:NMEA:SVNum <GP | GN>
```

If talker ID mode is GP, sending GPS:NMEA:SVN GN command will include all satellites in view in multiple $GPGSV sentences for up to 24 satellites.

GPS:JAMlevel?

Firmware revision 0.57 and later adds support for a GNSS signal jamming indicator. The GNSS receiver will detect and flag jamming interference with levels ranging from 0 (no jamming) to 255 (strong jamming). Any level exceeding 50 will cause a SYNC:HEALTH 0x800 event to be flagged and the unit to disable the LOCK_OUT_OK signal on connector J1.

GPS:FWver?

This command returns the firmware versionused inside the GNSS receiver itself.

GPS?

This qurey displays the selected GNSS systems and NMEA talker ID for HD CSAC Low Power GPSDO with firmware revision 0.75 and later, and uBlox 8 receiver, configuration, position, speed, height, and other relevant data of the GNSS receiver in one convenient location.

GYRO Subsystem

The following Gyro commands are not supported in the HD CSAC Low Power GPSDO:

- `GYRO:MODE <ON | OFF>`
- `GYRO:TRAce <int> [0,255]`
- `GYRO:PORT <RS232 | USB>`
- `GYRO:PORT?`
- `GYRO:CALibrate <float,float,float,float,float,float>`
- `GYRO:CALibrate:COMPute`
- `GYRO:CALibrate:RESET`
- `GYRO:SENSitivity <float,float,float>`
- `GYRO:GLOAD?`
- `GYRO?`

GYRO:MODE <ON | OFF>

This command is not supported in the HD CSAC Low Power GPSDO.

GYRO:TRAce <int> [0,255]

This command is not supported in the HD CSAC Low Power GPSDO.

GYRO:PORT <RS232 | USB>

This command is not supported in the HD CSAC Low Power GPSDO.

GYRO:PORT?

This command is not supported in the HD CSAC Low Power GPSDO.

GYRO:CALibrate <float,float,float,float,float,float>

This command is not supported in the HD CSAC Low Power GPSDO.

GYRO:CALibrate:COMPute

This command is not supported in the HD CSAC Low Power GPSDO.

GYRO:CALibrate:RESET

This command is not supported in the HD CSAC Low Power GPSDO.

GYRO:SENSitivity <float,float,float>

This command is not supported in the HD CSAC Low Power GPSDO.

GYRO:GLOAD?

This command is not supported in the HD CSAC Low Power GPSDO.

GYRO?

This command is not supported in the HD CSAC Low Power GPSDO.

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:OUTput <ON | OFF>`
- `PTIMe:LEAPsecond?`
- `PTIMe:LEAPsecond:PENDing?`
- `PTIMe:LEAPsecond:ACCumulated?`
- `PTIMe:LEAPsecond:DATE?`
- `PTIMe:LEAPsecond:DURation?`
- `PTIMe?`

PTIMe:DATE?

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

PTIMe:TIME?

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

PTIMe:TIME:STRing?

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

PTIMe:TINTerval?

This query is equivalent to the command synchronization:TINTerval

PTIMe:OUTput <ON | OFF>

Firmware revision 0.57 and later adds support for auto-initialization of time and date between to Jackson Labs Technologies, Inc. GPSDO units. This allows connecting two units together through the serial port with a null-modem cable, and having the master unit send time and date information to the slave unit. The slave unit's 1PPS reference input can also be driven by the master unit's 1PPS output signal, by setting the slave unit to external 1PPS sync mode using the `SYNC:SOUR:MODE EXT` command. This allows time-synchronization at the nanosecond level between two units which can be useful when operating in GPS denied environments.

The following command returns the PTIME output setting stored in NV memory:

```
PTIMe:OUTput?
```

Sending the command `PTIM:OUT ON` will cause the unit to automatically generate `GPS:INIT:DATE` and `GPS:INIT:TIME` sentences described in "GPS:INITial:DATE <yyyy,mm,dd>" on page 33 and "GPS:INITial:TIME <hour,min,sec>" on page 33 on the serial port once per second.

PTIMe:LEAPsecond?

This command returns the results of the four following queries:

```
PTIMe:LEAPsecond:PENDing?
PTIMe:LEAPsecond:ACCumulated?
PTIMe:LEAPsecond:DATE?
PTIMe:LEAPsecond:DURation?
```

An example of a pending leapsecond event follows:

```
LEAPSECOND PENDING: 1
LEAPSECOND ACCUMULATED: 16
```

```
LEAPSECOND DATE: 2015,6,30
LEAPSECOND DURATION: 61
```

NOTE

The unit stores pending leapsecond events in non-volitile memory and applies them correctly, even if the antenna is removed prior to the leapsecond, as long as the pending information has been received and stored in non-volatile memory and the unit has a properly set RTC time and date. This feature sets JLT units apart from competitive products that only apply a leapsecond correctly if the GNSS antenna is connected to the unit during the actual leapsecond event, and may thus miss the leapsecond event entirely.

PTIMe:LEAPsecond:PENDing?

This command returns 1 if the GPS Almanac data contains a future pending leap second data and 0 if no future leap second is pending or Almanac data is not available. The GNSS receiver must have the GPS system enabled for the GPS Almanac to be available.

PTIMe:LEAPsecond:ACCumulated?

This command will return the internally applied leapsecond offset between GPS time and UTC time as stored in the EEPROM (GPS Almanac not received yet) or as indicated by the GNSS receiver (GPS Almanac is available).

PTIMe:LEAPsecond:DATE?

This command returns the date of the pending leap second, if any.

PTIMe:LEAPsecond:DURation?

This command returns the duration of the last minute of the day during a leap second event. The returned value is 59, 60 or 61 if GPS Almanac data is available, and 0 otherwise. A response of 60 indicates that no leap second is pending.

PTIMe?

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

```
PTIMe:DATE?
PTIMe:TIME?
```

```
PTIMe:TINTerval?
PTIMe:OUTput?
PTIMe:LEAPsecond:ACCumulated?
```

SYNChronization Subsystem

This subsystem regroups the commands related to the synchronization of the HD CSAC Low Power GPSDO with the GNSS receiver. The list of the commands supported for this subsystem is the following:

```
SYNChronization:HOLDover:DURation?
SYNChronization:HOLDover:STATe?
SYNChronization:HOLDover:INITiate
SYNChronization:HOLDover:RECovery:INITiate
SYNChronization:SOURce:MODE <GPS | EXTernal | AUTO>
SYNChronization:SOURce:STATe?
SYNChronization:TINTerval?
SYNChronization:IMMEdiate
SYNChronization:FEEstimate?
SYNChronization:LOCKed?
SYNChronization:OUTput:1PPS:RESET <ON | OFF>
SYNChronization:OUTput:1PPS:RESET?
SYNChronization:OUTput:1PPS:WIDTH <int> <ms | us >
[200us,600ms]
SYNChronization:OUTput:FILTer <ON | OFF>
SYNChronization:OUTput:FILTer?
SYNChronization:HEAlth?
SYNChronization:TINTerval:THReshold <int> [50,2000]
SYNChronization?
```

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 GNSS receiver 1PPS, 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.

SYNChronization:HOLDover:STATe?

This query returns the current holdover state with possible responses being NONE, MANUAL, or ON. NONE indicates the holdover state is off. MANUAL indicates the holdover is manually enabled with the SYNChronization:HOLDover:INITiate command. ON indicates that holdover is enabled due to lack of external GNSS receiver 1PPS or valid GNSS fix.

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 GPS signals are still being properly received. This forced-holdover allows the unit to effectively disable GPS locking, while still keeping track of the state of the 1PPS output in relation to the UTC 1PPS signal as generated by the GNSS receiver. 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 GPS UTC 1PPS signal by using the `SYNC:TINT?` command. This allows the user to see the HD CSAC drift when not locked to GPS for testing purposes, or to prevent the GNSS receiver from being spoofed and affecting the HD CSAC frequency accuracy. All other frequency-disciplining functions of the unit will behave as if the GNSS antenna was disconnected from the unit while in this forced-holdover state.

SYNChronization:HOLDover:RECovery:INITiate

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

SYNChronization:SOURce:MODE <GPS | EXTernal | AUTO>

The Source:Mode command allows an optional external 3.3V CMOS, 5V CMOS or TTL level 1PPS input to be connected to the HD CSAC Low Power GPSDO board on connector harness J1. This command also controls the power supply of the GNSS receiver for additional power savings in holdover/flywheel mode.

The internal GNSS receiver and the 3.3V GNSS antenna power supply voltage are automatically disabled when setting the unit to EXTERNAL 1PPS Mode using the `SYNC:SOUR:MODE EXT` command. The GNSS receiver and GNSS antenna power supply are turned on again when the unit is set to GPS disciplining mode using the `SYNC:SOUR:MODE GPS` command. This allows for optimal power savings when the GNSS receiver is not needed.

The unit can use this external 1PPS input instead of the internal, GPS-generated 1PPS. Switching to the external 1PPS is either done manually with the EXT command option, or automatically with the AUTO command option in case the GNSS receiver goes into holdover mode for any reason. The command has the following format:

```
SYNChronization:SOURce:MODE <GPS | EXTernal | AUTO>
```

The following command returns the current mode setting stored in NV memory:

```
SYNChronization:SOURce:MODE?
```

SYNChronization:SOURce:STATe?

This command returns the state of the `SYNC:SOUR:MODE` command, and may return GPS or EXT. The GNSS receiver power supply is shut-off when in EXTERNAL disciplining mode.

SYNChronization:TINTerval?

This query returns the difference or timing shift between the HD CSAC Low Power GPSDO 1PPS

and the GNSS 1PPS signals. The resolution is 1E-10 seconds.

SYNChronization:IMMEdiate

This command initiates a near-instantaneous alignment of the GPS 1PPS and Receiver output 1PPS.

To be effective, this command has to be issued while not in holdover.

SYNChronization:FEEstimate?

This query returns the Frequency Error Estimate, similar to the Allan Variance using a 1000s

measurement interval and comparing the internal 1PPS to GNSS 1PPS offset.

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

SYNChronization:LOCKed?

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

SYNChronization:OUTput:1PPS:RESET <ON | OFF>

This command allows the generation of the 1PPS pulse upon power-on without an external GNSS antenna being connected to the unit. By default the unit does not generate a 1PPS pulse until the GNSS receiver has locked onto the Satellites. With the command SYNC:OUT:1PPS:RESET ON the unit can now be configured to generate an asynchronous 1PPS output after power-on even if a GNSS antenna is not connected to the unit. Once the GNSS receiver locks, the 1PPS pulse will align itself to UTC by stepping in 10 equally spaced steps toward UTC alignment. The default setting is OFF which means the 1PPS pulse is disabled until proper GNSS lock is achieved.

SYNChronization:OUTput:1PPS:RESET?

This query returns the 1PPS output on reset setting.

SYNChronization:OUTput:1PPS:WIDTH <int> <ms | us > [200us,600ms]

HD CSAC Low Power GPSDO with Firmware revision 0.75 and later adds support for changing the pulse width of CSAC 1PPS output signal. By default the unit generate an asynchronous or UTC-aligned 1PPS pulse with pulse width of 600 ms. With the command SYNC:OUT:1PPS:WIDTH 200ms the unit can now configure the 1PPS pulse width to 200ms or any integer value between 200 us and 600 ms.

This command has the following format:

```
SYNChronization:OUTput:1PPS:WIDTH <int> <ms | us >
[200us,600ms]
```

The following command returns the current pulse width setting stored in NV memory:

```
SYNChronization:OUTput:1PPS:WIDTH?
```

The unit of parameter for this command can be either us or ms. For example, command

`SYNC:OUT:1PPS:WIDTH 200000us` and command `SYNC:OUT:1PPS:WIDTH 200ms` will both configure the pulse width to 200ms.

If the 1PPS output signal is already available before sending this command, a 1PPS pulse with the specified pulse width will be generated on the next second and every second thereafter.

SYNChronization:OUTput:FILTer <ON | OFF>

This command is not supported in the HD CSAC Low Power GPSDO.

SYNChronization:OUTput:FILTer?

This command is not supported in the HD CSAC Low Power GPSDO.

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 phase offset to UTC is >250ns	HEALTH STATUS|= 0x4;
If the run time is < 200 seconds	HEALTH STATUS|=0x8;
If the GNSS receiver is in holdover > 60s	HEALTH STATUS|=0x10;
If the Frequency Estimate is out of bounds	HEALTH STATUS|=0x20;
If the short-term-drift (ADEV @ 100s) > 100ns	HEALTH STATUS|=0x100;
For the first 3 minutes after a phase reset	HEALTH STATUS|=0x200;
If the HD CSAC Oscillator indicates an alarm	HEALTH STATUS|=0x400;
If the GNSS receiver indicates a strong jamming signal of >=50 (range is 0 to 255) and is in holdover	HEALTH STATUS|=0x800;

As an example, if the unit is in GNSS receiver holdover (see Section 3.6.2 for possible cause of holdover state) and the UTC phase offset is > 250ns then the following errors would be indicated:

1) UTC phase > 250ns: 0x4

2) GNSS receiver in holdover: 0x10

'Oring' these values together results in:

0x10 | 0x4 = 0x14

The unit would thus indicate: HEALTH STATUS: 0x14 and the Green LED as well as the LOCK_OK output would go off, indicating an event is pending.

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

SYNChronization:TINTerval:THReshold <int> [50,2000]

This command selects the internal oscillator 1PPS phase-offset threshold as compared to UTC at which point the unit will initiate a counter-reset (jam-sync) aligning the HD CSAC generated 1PPS with the GPS generated UTC 1PPS phase. The CSAC 1PPS phase is allowed to drift up to this threshold before a jam-sync is initiated. The HD CSAC phase is slowly and continuously adjusted toward 0ns offset to UTC while the phase difference is less than the THReshold phase limit. The default setting is 220ns, allowing a drift of up to +/-220ns. Reaching this selected threshold will cause a jam-sync phase-normalization to be initiated, which will also cause an indication of the SYNC:HEALTH? Status of 0x200 to be indicated, and the Green LED to be turned-off for several minutes.

SYNChronization?

This query returns the results of the following queries:

```
SYNChronization:SOURce:MODE?
SYNChronization:SOURce:STATe?
SYNChronization:OUTput:1PPS:RESET?
SYNChronization:OUTput:1PPS:WIDTH?
SYNChronization:LOCKed?
SYNChronization:HOLDover:STATe?
SYNChronization:HOLDover:DURation?
SYNChronization:FEEstimate?
SYNChronization:TINTerval?
SYNChronization:TINTerval:THReshold?
SYNChronization:OUTput:FILTer?
SYNChronization:HEAlth?
```

DIAGnostic Subsystem

This subsystem regroups the queries related to the diagnostic of the HD CSAC Low Power GPSDO.The list of the commands supported for this subsystem is the following:

```
DIAGnostic:ROSCillator:EFControl:RELative?
DIAGnostic:ROSCillator:EFControl:ABSolute?
DIAGnostic:LIFetime:COUNt?
```

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 -100.00% to +100.00%.

DIAGnostic:ROSCillator:EFControl:ABSolute?

This query returns the Electronic Frequency Control (EFC) steering value of the HD CSAC oscillator in parts-per-trillion (1E-012).

DIAGnostic:LIFetime:COUNt?

This query returns the time since power on of the CSAC oscillator in hours.

DIAGnostic?

Sending the command DIAG? returns the result of the three following queries:

`DIAGnostic:ROSCillator:EFControl:RELative?` : Relative oscillator setting

`DIAGnostic:ROSCillator:EFControl:ABSolute?` : Absolute oscillator setting

`DIAGnostic:LIFetime:COUNt?` : Time since power-on in hours (lifetime)

An example of the syntax:

```
scpi > diag?
EFControl Relative: 0.025000%
EFControl Absolute: 5
Lifetime : +871
```

MEASURE Subsystem

The MEASURE subsystem regroups the queries related to parameters that are measured on-board on the HD CSAC Low Power GPSDO. The list of the commands supported for this subsystem is the following:

```
MEASure:TEMPerature?
MEASure:VOLTage?
MEASure:CURRent?
MEASure:POWersupply?
```

MEASure:TEMPerature?

Displays the PCB temperature around the CSAC oscillator.

MEASure:VOLTage?

Displays the CSAC TCXO steering voltage.

MEASure:CURRent?

Legacy SCPI command, instead of OCXO current this command displays the internal CSAC temperature.

MEASure:POWersupply?

Displays the power supply input voltage.

MEASure?

The MEASure? query returns the results of the following four queries:

```
MEASure:TEMPerature?
MEASure:VOLTage?
MEASure:CURRent?
MEASure:POWersupply?
```

SYSTEM Subsystem

This subsystem regroups the commands related to the general configuration of the HD CSAC Low Power GPSDO. 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:FACToryreset ONCE
SYSTem:ID:SN?
SYSTem:ID:HWrev?
SYSTem:LCD:CONTrast [0,1.0]
SYSTem:LCD:CONTrast?
SYSTem:LCD:PAGE [0,8]
SYSTem:LCD:PAGE?
SYSTem:COMMunicate:USB:BAUD <9600 | 19200 | 38400 | 57600 |
115200>
SYSTem:COMMunicate:USB:BAUD?
SYSTem:STATus?
```

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

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

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

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

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

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

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

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

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

SYSTem:FACToryreset ONCE

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

SYSTem:ID:SN?

This query returns the serial number of the board.

SYSTem:ID:HWrev?

This query return the Hardware version of the board.

SYSTem:LCD:CONTrast [0,1.0]

This command is not supported in the HD CSAC Low Power GPSDO.

SYSTem:LCD:CONTrast?

This command is not supported in the HD CSAC Low Power GPSDO.

SYSTem:LCD:PAGE [0,8]

This command is not supported in the HD CSAC Low Power GPSDO.

SYSTem:LCD:PAGE?

This command is not supported in the HD CSAC Low Power GPSDO.

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

This command is not supported in the HD CSAC Low Power GPSDO.

SYSTem:COMMunicate:USB:BAUD?

This command is not supported in the HD CSAC Low Power GPSDO.

SYSTem:STATus?

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

SERVO Subsystem

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

```
SERVo:LOOP <ON | OFF>
SERVo:MODE <OFF | NORMal | FAST | AUTO>
SERVo:STATe?
SERVo:DACGain <float> [0.001, 10000]
SERVo:EFCScale <float> [0.0, 500.0]
SERVo:EFCDamping <int> [2, 4000]
SERVo:TEMPCOmpensation <float> [-4000.0, 4000.0]
SERVo:AGINGcompensation <float> [-10.0, 10.0]
SERVo:PHASECOrrection <float> [-500.0, 500.0]
```

```
SERVo:1PPSoffset <int> ns [-5000000, 5000000]
SERVo:TRACe:PORT <RS232 | USB>
SERVo:TRACe <int > [0,255]
SERVo:EFCScale:FAST <float> [0.0, 500.0]
SERVo:EFCDamping:FAST <int> [2, 4000]
SERVo:PHASECOrrection:FAST <float> [-500.0, 500.0]
SERVo?
```

SERVo:LOOP <ON | OFF>

This command enables or disables the servo loop for the selected servo loop. With the loop disabled,

no changes are made to the oscillator frequency control. Normally the servo loop is left enabled.

The following command returns the current loop setting where 1 means enabled:

```
SERVo:LOOP?
```

SERVo:MODE <OFF | NORMal | FAST | AUTO>

HD CSAC Low Power GPSDO with firmware revision 0.74 and later adds support for two different phase loop time constant settings. This command allows auto-setting of all of the servo loop time constants to factory-default values as described in Section 2.5 with one single command entry.

This command is useful in setting the filter loop time constants for different mission profiles to accommodate different usage scenarios of the HD CSAC Low Power GPSDO. The loop time constant of the CSAC can be chosen with these settings.

The AUTO mode lets the firmware determine by itself which loop time constant is used, thus optimizing the units' performance dynamically depending on the environmental effects on the CSAC. The AUTO setting will quickly react to phase perturbations and will try to set NORMal settings (long time constant) whenever the unit is in stable conditions to minimize residual noise, and to improve the ADEV performance of the filtered output as much as possible for a particular environment. NORMal settings are useful in stationary applications, whereas FAST settings are preferred for mobile applications such as in vehicles, man-packs, or aircraft.

The following command returns the current mode setting:

```
SERVo:MODE?
```

If SERVo:MODE OFF is sent or in factory-default settings, the SERVo:MODE? query will result in a Command Error response. By default, the servo mode is disabled and NORMal settings are used.

SERVo:STATe?

HD CSAC Low Power GPSDO with firmware revision 0.74 and later adds support for two different phase loop time constant settings. See Section 2.5 for details of recommended loop time constant settings.

This query responds with the current loop parameter settings, NORMAL or FAST. When the SERVo:MODE command is configured to AUTO, the SERVo:STATe? query responds with the automatically selected loop parameter setting, NORMAL or FAST. If the servo mode is currently in OFF setting, the SERVo:STATe? query will result in a Command Error response.

SERVo:DACGain <float> [0.001, 10000]

This command is used for factory setup.

SERVo:EFCScale <float> [0.0, 500.0]

HD CSAC Low Power GPSDO with firmware revision 0.74 and later adds support for two different phase loop time constant settings. See "Loop parameter adjustment" on page 14 for details of recommended loop time constant settings. Changing this parameter while response of `SERVo:STATe?` command is FAST will NOT change current operation of the servo loop. This command will be effective only when `SERVo:STATe` is NORMAL or `SERVo:MODE` is OFF.

Controls the Proportional part of the PID loop. Typical values are 0.6 to 6.0. 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]
```

The following command returns the current value for NORMAL EFC scale setting:

```
SERVo:EFCScale?
```

SERVo:EFCDamping <int> [2, 4000]

HD CSAC Low Power GPSDO with firmware revision 0.74 and later adds support for two different phase loop time constant settings. See Section 2.5 for details of recommended loop time constant settings. Changing this parameter while response of `SERVo:STATe?` command is FAST will NOT change current operation of the servo loop. This command will be effective only when `SERVo:STATe` is NORMAL or `SERVo:MODE` is OFF.

Sets the Low Pass filter effectiveness of the DAC. Values from 5 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 <int> [2, 4000]
```

The following command returns the current value for NORMAL EFC damping setting:

```
SERVo:EFCDamping?
```

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

This parameter is a coefficient that reflects the correlation between the temperature of the HD CSAC versus the required frequency steering. Monitoring the tempco and aging parameters provides a mechanism to track the health of the HD CSAC oscillator. Excessively high values that appear from one day to the next could be an indicator of failure on the board.

The HD CSAC has its own temperature compensation algorithm that is not compatible with internal temperature compensation algorithm in HD CSAC Low Power GPSDO firmware. By default automatic temperature compensation is disabled for HD CSAC Low Power GPSDO and default value is set to 0 which is equivalent to no additional temperature compensation is applied.

Assigning a non-zero value to this parameter may result in frequency instability, and assigned value will be stored in NV memory and remain unchanged. This command has the following format:

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

The following command returns the current value of the temperature compensation:

```
SERVo:TEMPCOmpensation?
```

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

This parameter is a coefficient that represents the drift of the EFC needed to compensate the natural drift in frequency of the HD CSAC 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]
```

The following command returns the current computed or manually configured value of the aging compensation:

```
SERVo:AGINGcompensation?
```

SERVo:PHASECOrrection <float> [-500.0, 500.0]

HD CSAC Low Power GPSDO with firmware revision 0.74 and later adds support for two different phase loop time constant settings. See Section 2.5 for details of recommended loop time constant settings. Changing this parameter while response of `SERVo:STATe?` command is FAST will NOT change current operation of the servo loop. This command will be effective only when `SERVo:STATe` is NORMAL or SERVo:MODE is OFF.

This parameter sets the Integral part of the PID loop. Loop instability will result if the parameter is set too high. Typical values are 1.0 to 30.0. This command has the following format:

```
SERVo:PHASECOrrection <float> [-500.0, 500.0]
```

The following command returns the current value for NORMAL Phase correction setting:

```
SERVo:PHASECOrrection?
```

SERVo:1PPSoffset <int> ns [-5000000, 5000000]

This command sets the HD CSAC Low Power GPSDO 1PPS signal's offset to UTC in 100ns 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 [-5000000, 5000000]
```

The following command returns the current value of the 1PPS offset setting:

```
SERVo:1PPSoffset?
```

SERVo:TRACe:PORT <RS232 | USB>

This command is not supported in the HD CSAC Low Power GPSDO.

SERVo:TRACe <int > [0,255]

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]

The following command returns the current value of the trace period:

```
SERVo:TRACe?
```

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:HEAlth?" on page 44 command for detailed information on how to decode the health status indicator values. The Lock State variable indicates one of the states in Table 8.

Table 8 Lock State indications

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

SERVo:EFCScale:FAST <float> [0.0, 500.0]

HD CSAC Low Power GPSDO with firmware revision 0.74 and later adds support for two different phase loop time constant settings. See "Loop parameter adjustment" on page 14 for details of recommended loop time constant settings. Changing this parameter while response of `SERVo:STATe?` command is NORMAL will NOT change current operation of the servo loop. This command will be effective only when `SERVo:STATe` is FAST and `SERVo:MODE` is not OFF.

Controls the Proportional part of the PID loop. Typical values are 0.7 to 6.0. 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:FAST <float> [0.0, 500.0]
```

The following command returns the current value for FAST EFC scale setting:

```
SERVo:EFCScale:FAST?
```

SERVo:EFCDamping:FAST <int> [2, 4000]

HD CSAC Low Power GPSDO with firmware revision 0.74 and later adds support for two different phase loop time constant settings. See "Loop parameter adjustment" on page 14 for details of recommended loop time constant settings. Changing this parameter while response of `SERVo:STATe?` command is NORMAL will NOT change current operation of the servo loop. This command will be effective only when `SERVo:STATe` is FAST and `SERVo:MODE` is not OFF.

Sets the Low Pass filter effectiveness of the DAC. Values from 5 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:FAST <int> [2, 4000]
```

The following command returns the current value for FAST EFC damping setting:

```
SERVo:EFCDamping:FAST?
```

SERVo:PHASECOrrection:FAST <float> [-500.0, 500.0]

HD CSAC Low Power GPSDO with firmware revision 0.74 and later adds support for two different phase loop time constant settings. See "Loop parameter adjustment" on page 14 for details of recommended loop time constant settings. Changing this parameter while response of `SERVo:STATe?` command is NORMAL will NOT change current operation of the servo loop. This command will be effective only when `SERVo:STATe` is FAST and `SERVo:MODE` is not OFF.

This parameter sets the Integral part of the PID loop. Loop instability will result if the parameter is set too high. Typical values are 1.0 to 30.0. This command has the following format:

```
SERVo:PHASECOrrection:FAST <float> [-500.0, 500.0]
```

The following command returns the current value for FAST Phase correction setting:

```
SERVo:PHASECOrrection:FAST?
```

SERVo?

This command returns the result of the following queries:

```
SERVo:LOOP?
SERVo:MODE? (if SERVo:MODE is not OFF)
SERVo:STATe? (if SERVo:MODE is not OFF)
SERVo:DACGain?
SERVo:EFCScale?
SERVo:EFCScale:FAST? (if SERVo:MODE is not OFF)
SERVo:PHASECOrrection?
SERVo:PHASECOrrection:FAST? (if SERVo:MODE is not OFF)
SERVo:EFCDamping?
SERVo:EFCDamping:FAST? (if SERVo:MODE is not OFF)
SERVo:TEMPCOmpensation?
SERVo:AGINGcompensation?
SERVo:1PPSoffset?
SERVo:TRACe:PORT?
SERVo:TRACe?
```

CSAC Subsystem

The following commands are used to query the microcontroller built into the HD CSAC oscillator itself:

```
CSAC:TYPE?
CSAC:LOCKed?
CSAC:RS232?
CSAC:STeer?
CSAC:STATus?
CSAC:ALarm?
CSAC:MODE?
CSAC:CONTrast?
CSAC:LASer?
CSAC:TCXO?
CSAC:SIGnal?
CSAC:HEATpackage?
CSAC:TEMPerature?
CSAC:FWrev?
CSAC:SN?
CSAC:LIFEtime?
CSAC:STeer:LATch ONCE
CSAC:POWer <ON | OFF>
CSAC?
```

CSAC:RS232?

This query returns the state (OK or FAIL) of the serial communication between the main CPU and the HD CSAC internal microcontroller. When the state is FAIL, there is a communication breakdown, and the unit should be power cycled to clear the communication error.

CSAC:STeer?

This query returns the current Frequency Adjustment in units of parts-per-trillion (1E-012).

CSAC:STATus?

This query returns the status value in [0,9] as shown in Table 9.

Table 9 CSAC Status definitions

Status	Definition
0	Locked
1	Microwave Frequency Setting
2	Microwave Frequency Stabilization
3	Microwave Frequency Acquizition
4	Laser Power Acquisition
5	Laser Current Acquistion
6	Microwave Power Acquisition
7	Heater equilibration
8	Initial warm-up
9	Asleep (ULP mode only)

CSAC:ALarm?

This query returns the Alarm value as shown in Table 10.

Table 10 CSAC Alarm Definitions

Alarm	Definition
0x0001	Signal Contrast Low
0x0002	Synthesizer tuning at limit
0x0010	DC Light level Low
0x0020	DC Light level High
0x0040	Heater Power Low
0x0080	Heater Power High
0x0100	uW Power control Low
0x0200	uW Power control High
0x0400	TCXO control voltage Low
0x0800	TCXO control voltage High
0x1000	Laser current Low
0x2000	Laser current High
0x4000	Stack overflow (firmware error)

CSAC:MODE?

This query returns the HD CSAC mode as shown in Table 11.

Table 11 CSAC Mode definitions

Mode	Definition
0x0001	Analog tuning enable
0x0002	Reserved
0x0004	Reserved
0x0008	1 PPS auto-sync enable
0x0010	Discipline enable
0x0020	Ultra-low power mode enable
0x0040	Reserved
0x0080	Reserved

CSAC:CONTrast?

This query returns the indication of signal level typically ~4000 when locked, and ~0 when unlocked.

CSAC:LASer?

This query returns the current (in mA) driving the laser.

CSAC:TCXO?

This query returns the TCXO Tuning Voltage, 0-2.5 VDC tuning range ~ +/- 10 ppm

CSAC:SIGnal?

This query returns the indication of signal level.

CSAC:HEATpackage?

This query returns the Physics package heater power typically 15mW under NOC.

CSAC:TEMPerature?

This query returns the Temperature measured by the HD CSAC unit in °C, absolute accuracy is +/- 2°C.

CSAC:FWrev?

This query returns the Firmware version of the HD CSAC unit.

CSAC:SN?

This query returns the Serial Number of the HD CSAC in the form YYMMCSNNNNN where YYMM is the year and month of production and NNNNN is the serialized unit of that month.

CSAC:LIFEtime?

This query returns the accumulated number of hours that the HD CSAC has been powered on since the last factory reset of the HD CSAC Low Power GPSDO board. The value is stored in the external NV memory and updated every hour when the HD CSAC is powered on.

CSAC:STeer:LATch ONCE

This command stores the momentary steering offset into the HD CSAC internal NV memory. This is done automatically by the firmware once every 24 hours, so as not to damage the HD CSAC NV memory which has a limited number of write cycles. The user may force this value to be stored into the HD CSAC by issuing the CSAC:STeer:LATch ONCE command.

CSAC:TYPE?

HD CSAC Low Power GPSDO with firmware revision 0.75 and later adds support for querying the model of HD CSAC on the HD CSAC Low Power GPSDO board.

CSAC:LOCKed?

HD CSAC Low Power GPSDO with firmware revision 0.75 and later adds support for querying the lock status of the HD CSAC. A value of 1 is returned if the HD CSAC is in atomic lock.

CSAC:POWer <ON | OFF>

HD CSAC Low Power GPSDO with firmware revision 0.74 and later adds support for sending the CSAC into Ultra-Low Power (ULP) mode. By default the normal power mode is ON and sending `CSAC:POWer OFF` command will put the CSAC in ULP mode.

The CSAC may loses atomic lock while in ULP mode. JLT thus recommends keeping the CSAC:POWer ON setting for normal operation and optimal performance on HD CSAC Low Power GPSDO.

This command has the following format:

```
CSAC:POWer <ON | OFF>
```

The following command returns the current power setting where ON means normal power mode:

```
CSAC:POWer?
```

CSAC?

This command returns the result of the following queries:

```
CSAC:TYPE?
CSAC:LOCKed?
CSAC:RS232?
CSAC:STeer?
CSAC:STATus?
CSAC:ALarm?
CSAC:MODE?
CSAC:CONTrast?
CSAC:LASer?
CSAC:TCXO?
CSAC:SIGnal?
CSAC:HEATpackage?
CSAC:TEMPerature?
CSAC:SN?
CSAC:FWrev?
CSAC:LIFEtime?
CSAC:POWer?
```

4

Firmware Upgrade Instructions

This chapter discusses the following topics:

Introduction

The following is a short tutorial on how to upgrade the HD CSAC Low Power GPSDO firmware. Please follow the instructions in order to prevent corrupting the HD CSAC Low Power GPSDO Flash, which may require reflashing at the factory.

With some practice, the entire Flash upgrade can be done in under one minute.

ISP Flash Loader Utility Installation

Jackson Labs Technologies, Inc. recommends using the Flash Magic utility to upgrade the contents of Flash memory on the HD CSAC Low Power GPSDO. It is available for download on the Flash Magic website: http://www.flashmagictool.com/

Follow the directions given on the website for installing the utility on your computer.

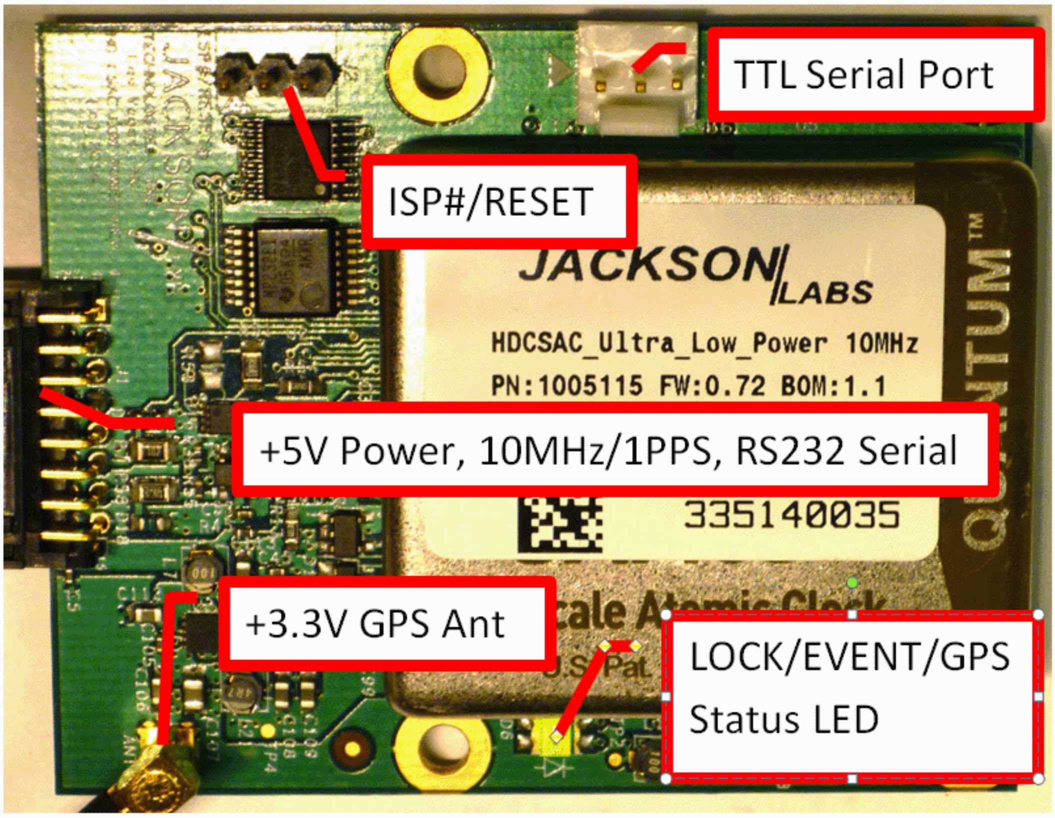
NOTE

The Philips LPC2000 utility that is used on other Jackson Labs Technologies, Inc. products will not support the newer LPC1768 low-power Cortex processor used on the HD CSAC Low Power GPSDO.

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, as shown in Figure 6. 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 6 Location of header J2



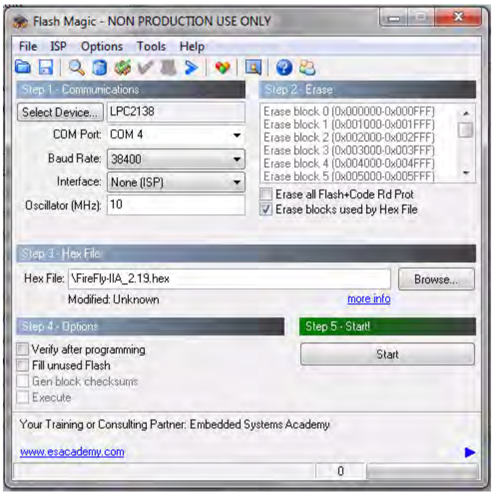
Downloading the firmware

Download the latest version of HD CSAC Low Power GPSDO firmware from the Jackson Labs Technologies, Inc. support website and store it in a place that will be remembered. The firmware executable file for the HD CSAC Low Power GPSDO and the HD CSAC boards are NOT identical because the two boards use different processors. 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 HD CSAC Low Power GPSDO as indicated in "Major connections" on page 7.

Using the Flash Magic flash programming utility

Figure 7 shows the Flash Magic programming utility.

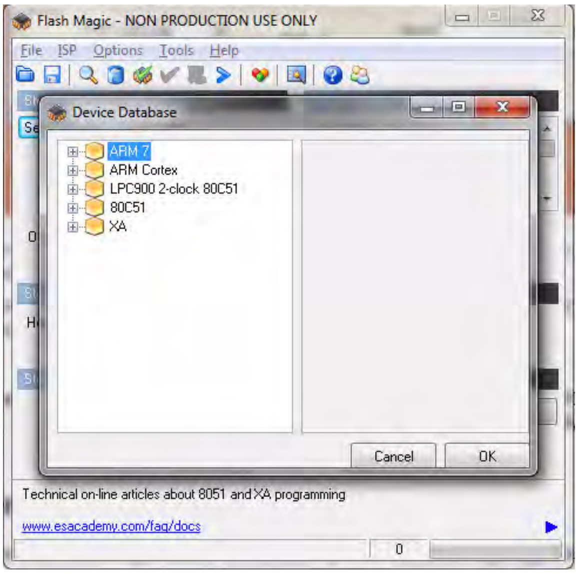
Figure 7 Flash Magic programming utility



Perform the following steps to use the Flash Magic flash programming utility.

1. Open the Flash Magic utility.
2. Set the COM port in the Flash Magic application as needed on your PC.
3. Set **Interface** to None (ISP).
4. Press the **Select Device** button. The Device Selection window appears, as shown in Figure 8.

Figure 8 Device Selection window



5. Expand the **ARM CORTEX** folder and select the appropriate processor, in this case **LPC1768**.
6. Select the **Baud Rate** of the Flash Magic utility to be 230.fKB or slower.
7. Set the **Oscillator (MHz)** to 10.
8. Check the box marked **Erase blocks used by Hex File**.
9. Under **Step 3 - Hex File**, browse for the hex file that you downloaded from the Jackson Labs Technologies support website.
10. Proceed to **Step 5** and press **Start**. The firmware is downloaded to the HD CSAC Low Power GPSDO.

5

GPSCon Utility

This chapter discusses the following topics:

Description

GPSCon - Jackson Labs Edition is a program for the monitoring and control of a Jackson Labs Technologies, Inc. GPSDO, Simulator and receiver products. It communicates with the receiver using the SCPI command set. This free version of the GPSCon utility is compatible only with Jackson Labs products is available for download from the support section of the Jackson Labs website:

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

Installation

Extract the contents of the ZIP file downloaded from the Jackson Lab's website and execute the MSI installer. Follow the on-screen instructions to complete the installation of GPSCon.

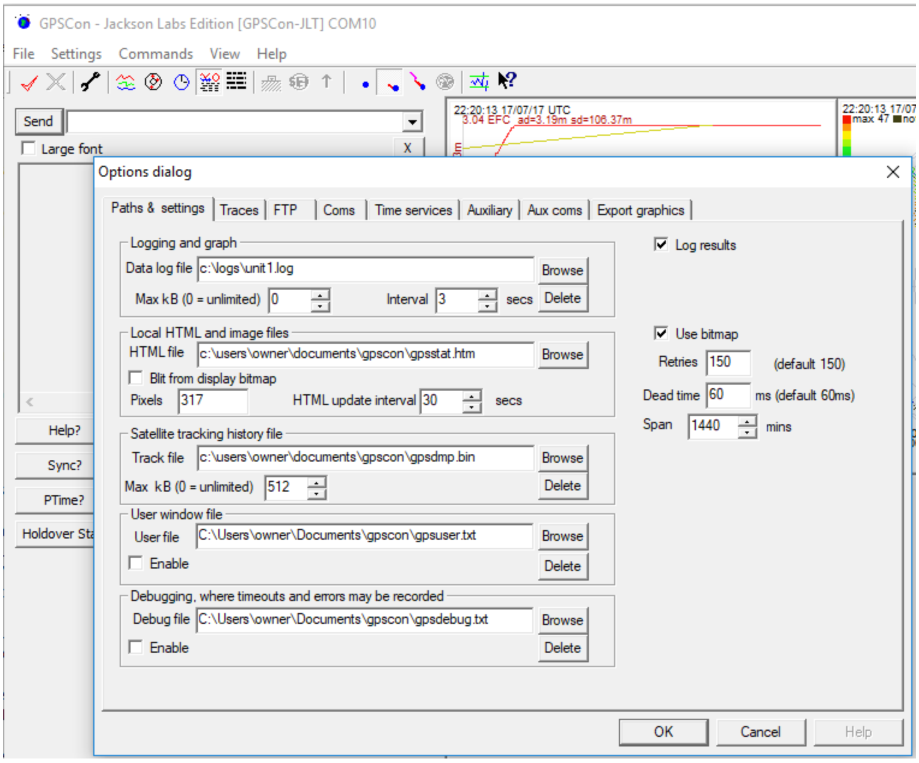
Using GPSCon

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 chapter for convenience.

Setting the options

To set up the options for your GPSCon session, press the wrench icon  under the menu bar, or select **Settings / Options** on the menu. The window shown in Figure 9 will appear. You can select from the tabs which options you wish to set.

Figure 9 Options window



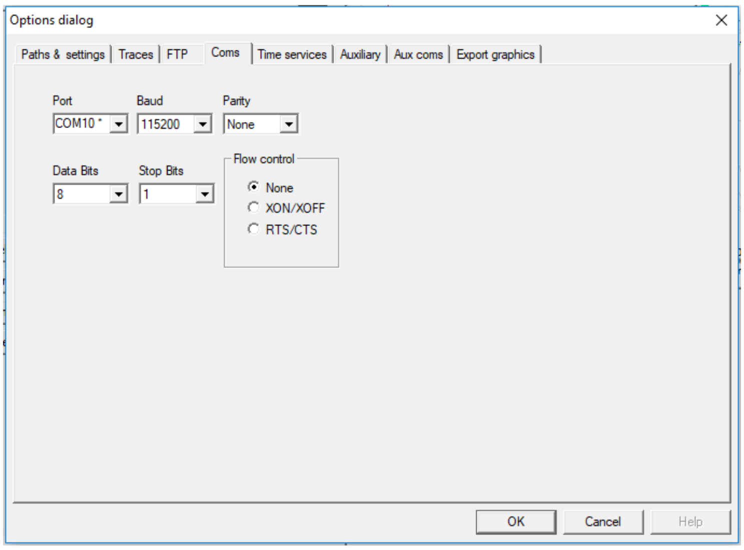
Communication parameters

Before you can use GPSCon you must set the communication parameters for your system.

1 Open the dialog box by pressing the wrench icon .

2 Select the **Coms** tab. The Coms tab appears, as shown in Figure 10.

Figure 10 Coms tab



3 Select the correct COM port for your computer's serial port connection.

> **NOTE**
> Available COM ports for your particular computer are indicated with a "*" symbol next to the COM port number in the drop-down menu. You can only select COM ports with this adjacent symbol.

4 Configure the parameters:

- Baud rate: 115200,
- Parity: None
- Data Bits: 8
- Stop Bits: 1
- Flow Control: None

5 Press the "OK" button to close the window.

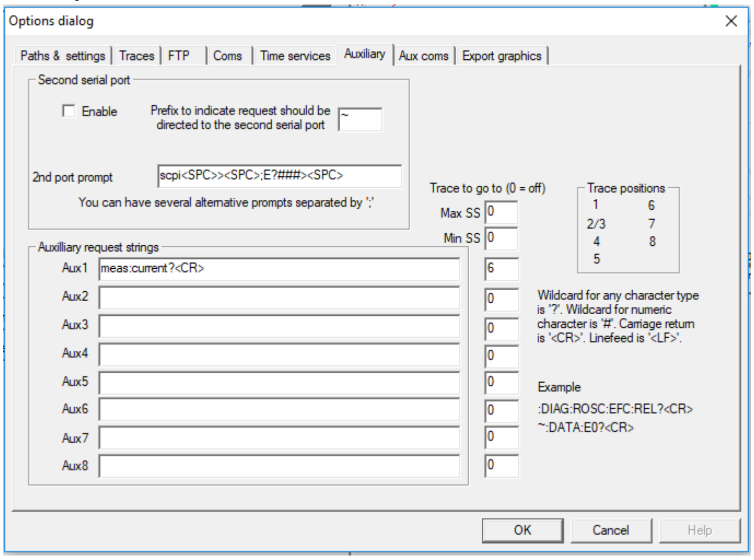
Auxiliary parameters

Perform the following steps to configure the auxiliary parameters.

1 Open the dialog box by pressing the wrench icon .

2 Select the **Auxiliary** tab. The Auxiliary tab appears, as shown in Figure 11.

Figure 11 Auxiliary tab



3 Configure the parameters.

> **NOTE**
> You will notice that the **Aux1** request string has been set to `meas:current?<CR>` and the **Trace to go to** is set to trace position 6. See Figure 12 for the arrangement of the trace positions in the trace window. In this example, the data obtained from the `meas:current?` query will be plotted in trace position 6.

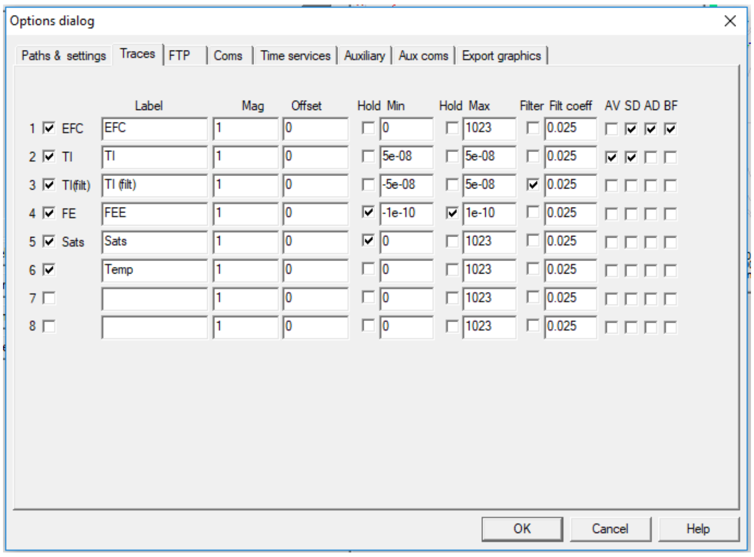
Trace parameters

Perform the following steps to configure the Trace labels and vertical plot ranges.

1 Open the dialog box by pressing the wrench icon .

2 Select the **Auxiliary** tab. The Auxiliary tab appears, as shown in Figure 12.

Figure 12 Trace parameters



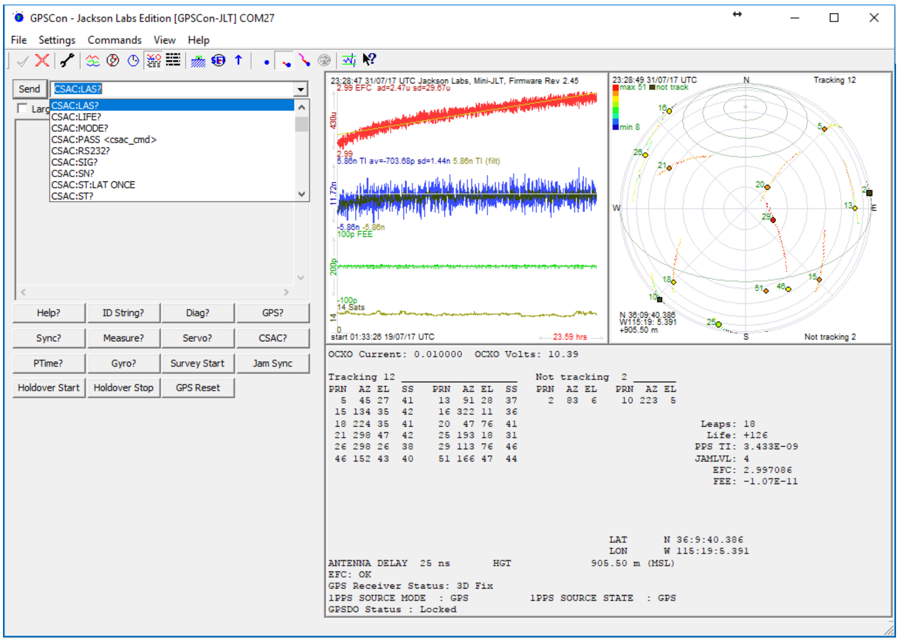
3 Configure the parameters.

The labels and parameters are completed by default for traces 1 through 5. Any of the eight traces can be replaced by auxiliary traces as described in "Auxiliary parameters" on page 68. Press the "Help" button for a full description of each option in the Traces tab.

Sending manual commands to the receiver.

You can send SCPI commands manually by using the drop-down box in the upper left of the main window as shown in Figure 13. Care must be taken when sending these commands so be sure that the command that you select is supported by the HD CSAC Low Power GPSDO. Once you've selected the command you can press "Send" to send it to the HD CSAC Low Power GPSDO. You can also send common commands by clicking on the buttons below the message window. You can hover over the buttons to see the exact command that is sent.

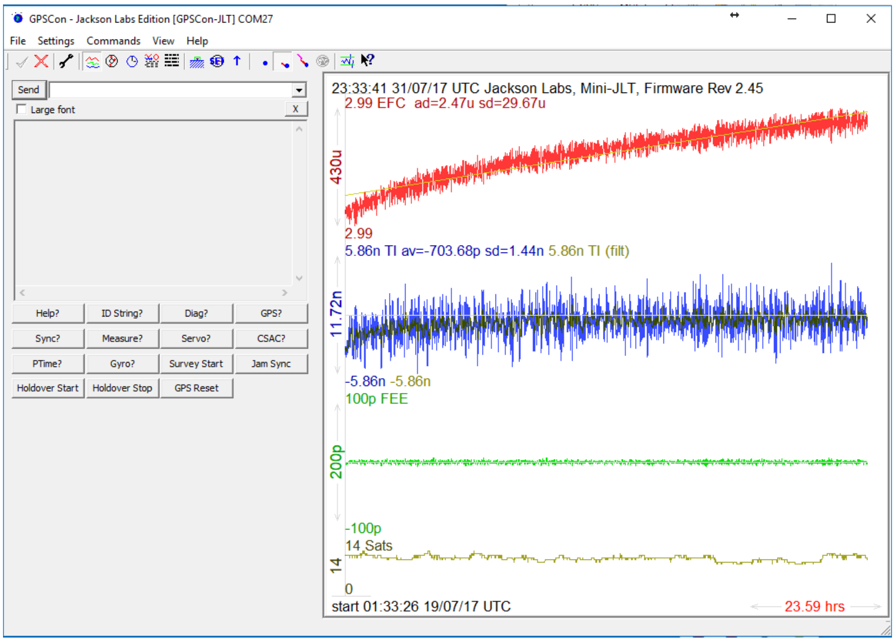
Figure 13 Sending manual commands



Using the mouse in the Graph window

Figure 14 shows the Graph display. The default view in GPSCon is **All**, which you can select with the **View/All** menu option. To see a larger view of the graph, select the View/ Graph menu option.

Figure 14 Graph display



You can set the horizontal range of the graph using the mouse. Perform the following steps to set the horizontal range.

1 Set the start time by clicking on the point that marks the left side of the curve to be magnified.

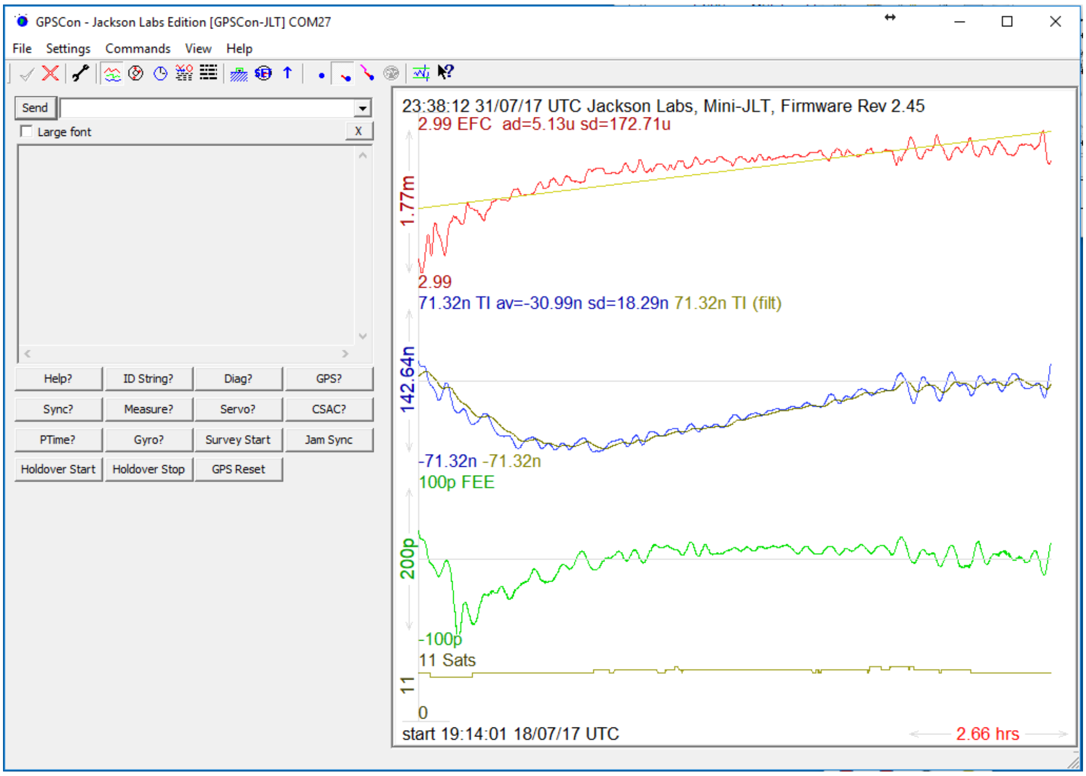
2 Set the stop time by right-clicking on the point that marks the right most portion of the magnified curve.

> **NOTE**
> The Set and Stop times can be removed by double-clicking anywhere on the graph.

3 Return to the “Fit to window” view by double left-clicking on the curve.

Figure 15 shows the expanded Graph display.

Figure 15 Expanded Graph display



When you have locked the start and stop time using the mouse, you can scroll left or right through the data:

- To scroll to a later time, use Shift + Left click
- To scroll to an earlier time, use Shift + Right click

6

Specifications

This chapter lists the specifications of the HD CSAC Low Power GPSDO.

Specifications

Table 12 lists the specifications.

Table 12 HD CSAC Low Power GPSDO specifications

Module Specification	Description
Long-Term Oscillator (without GPS – Zero aging with GPS)	Less than 0.3ppb per month in Holdover without GPS
Frequency Stability Over Temperature	Better than ±0.5E-09 (CSAC only, no GPS Disciplining, 0°C to +75°C)
1 PPS Accuracy	±15ns to UTC RMS (1-Sigma) GPS Locked in Position Hold mode
Frequency Accuracy	Better than ±2E-010 after 3 minutes operation with GPS lock
Holdover Drift (after 5 minute warmup with GPS lock)	<±2.5us drift per hour over worst case temperature range
Typical Holdover Drift (after 5 minute warmup with GPS lock)	<±1us drift per hour at 25°C ±5°C
ADEV (with GPS lock)	1s: <1E-10, 10s: <2.5E-11, 100s <2E-11, 1Ks: <1E-11, 10Ks: <2E-12
1 PPS Output (CSAC Flywheel Generated)	LVDS output, 3.3V CMOS output
10MHz Outputs	10MHz LVDS, 10MHz CMOS 3.3V
RS-232 and TTL serial ports	Independent RS-232 and TTL ports, 9.6K, 19.2K, 38.4K, 57.6K, 115.2K
RS-232 and TTL NMEA Output Sentences	NMEA 0183 rev. 2.3, Sentences: GGA, RMC, ZDA, PASHR, and others
External GPS option	1PPS input for optional external SAASM GPS receiver
GPS Frequency, Antenna	L1 C/A 1574MHz, Passive or Active Antenna 3.3V, MMCX Connector
GPS Receiver	50 Channels, Mobile, SBAS: WAAS, EGNOS, MSAS supported
Sensitivity	Acquisition -147 dBm, Tracking -160 dBm
GPS Time To First Fix	Cold Start - <30 sec, Warm Start - 1 sec, Hot Start - 1 sec
GPS Receiver Motion Adaptive Filter Settings (dynamic mode enabled)	Optimized depending on vehicle velocity (Auto-sensing, Auto-switching)
TTL Alarm Output	Hardware Event Indicator

Table 12 HD CSAC Low Power GPSDO specifications

Module Specification	Description
Warm Up Time / Stabilization Time Without GPS	<130s at +25°C to <5E-010 Accuracy Typ.
Supply Voltage (Vdd)	+5V ±5%
Power Consumption	<0.45W holdover or external 1PPS mode, <0.55W with GPS enabled
Operating Temperature	-10C to +70C
g-sensitivity	<0.2ppb per-g per-axis
Magnetic Sensitivity	Less than 0.4ppb per Gauss
Storage Temperature	-45°C to +85°C
MTBF	> 100,000 Hours
Connectors	CSAC oscillator socketed for easy upgrade
Phase Noise	– 10Hz: -75dBc/Hz – 100Hz: -115dBc/Hz – 1KHz: -128dBc/Hz – 10kHz: -134dBc/Hz – 100kHz: -140dBc/Hz

A

Document revision history

Table 1 HD CSAC Low Power GPSDO User Manual, 22171433

Revision	Date	Details
R000	March 2023	Initial version of user manual.

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