

TimeSpy

User Manual

P/N: 900000132

Revision B

**For Brandywine Communications products with the
following Part Numbers:**

770000010

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Revision History

REVISION	DATE	COMMENT
A	03/23/2010	Created Brandywine version of Manual
B	02/12/2014	Incorporated updated version of the manual.

Preface

Purpose

This manual has been written as a guide for the operation of Time & Frequency Solutions' TimeSpy Measurement Instrument

Audience

This manual is intended for use by engineers & operators responsible for the operation of this equipment.

Revision History

Revision History

Issue	Date	Revision History
1	30 Nov 2006	Amended from 0210EY000P (NP, SME)
2	27 Feb 2007	Updated, detail added (NCH, SME)
3	1 Sept 2008	Updated, detail added, PTP (NCH)
4	3 December 2009	TimeSpy Elite additions (NCH)
5	5 February 2010	NMEA + Pulse addition (NCH)
6	24 March 2010	HQ not available on basic model (NCH)
7	29 June 2010	External Reference (NCH)
8	28 July 2010	PTP Updated (SME)
9	18 October 2010	Pulse Output program, Elan deleted (NCH)
10	19 September 2011	Frequency Measurement & SFP (NCH)
11	13 October 2011	China Mobile Time Difference (NCH)
12	19 October 2011	Engineering log update (NCH)
13	21 October 2012	Revised Ext Ref (NCH)
14	25 November 2012	Position Averaging, OCXO Status (NCH)
15	8 March 2013	50bps BCD Timecode added (NCH)
16	18 March 2013	Input selection table updated (NCH)

Warnings & Cautions

Warnings

Dangerous voltages exist in this equipment. Do not attempt any repair without first switching off power to the system, at the rear panel switch, and removing the power input connector.

Nickel, cadmium, lead and lithium are toxic substances. A nickel cadmium battery, lithium battery or lead acid battery is dangerous if broken or dismantled. If any battery chemicals come into contact with skin, wash with copious amount of water, and seek medical attention as required. If the battery is swallowed seek immediate medical attention. Return any faulty batteries to the manufacturer, properly packaged, for disposal.

The liquid crystal display can be hazardous if broken or dismantled. If any liquid crystal chemicals come into contact with skin, wash with soap and water. Return the faulty display to the factory, for disposal.

Most board assemblies contain tantalum capacitors or electrolytic capacitors. Both types can explode under fault conditions. Take appropriate precautions when servicing the unit with the lid removed.

Cautions

This unit should only be serviced by qualified personnel, no user serviceable parts inside.

Several Board Assemblies contain static sensitive devices. Appropriate procedures must be used when handling these items.

Care must be taken in physically handling the system. When lifting the instrument, appropriate lifting procedures must be followed that appropriate to the weight of the unit.

Limited Warranty Information

Hardware and Embedded Software

For a period of one (1) year from date of shipment by Time and Frequency Solutions Ltd. (TFS), TFS warrants that all Products shall be free from defects in design, material, and workmanship; shall conform to and perform in accordance with TFS's published specification, if any; and shall have good and valid title. This warranty will survive inspection, acceptance, and payment by the Buyer. TFS does not warrant that the operation of such Products will be uninterrupted or error free. This warranty does not cover failures caused by acts of God, electrical or environmental conditions; abuse, negligence, accident, loss or damage in transit; or improper site preparation.

This warranty shall be null and void in the event (i) Buyer or any third party attempts repair of the goods without TFS's advance written authorization; (ii) defects are the result of improper or inadequate maintenance by Buyer or third party; (iii) of damage to said goods by Buyer or third party-supplied software, interfacing or supplies; (iv) of improper use (including termination of non-certified third party equipment on TFS's proprietary interfaces and operation outside of the product's specifications) by the Buyer or third party; or (v) the goods are shipped to any country other than that originally specified in the Buyer's purchase order.

Goods not meeting the foregoing warranty will be repaired or replaced, at TFS's option, upon return to TFS's factory freight prepaid; provided, however, that the Buyer has first obtained authorization from TFS.

TFS reserves the right to disallow a warranty claim following an inspection of returned product. When a warranty claim is questioned or disallowed, TFS will contact the Buyer by telephone or in writing to resolve the problem.

Software

TFS warrants that for a period of ninety (90) days from date of shipment by TFS the accompanying media will be free from defects in materials and workmanship under normal use. The physical media warranty does not apply to defects arising from misuse, theft, vandalism, fire, water, acts of God, or other similar perils. TFS will not be liable for any damages caused by the Buyer's failure to fulfil its responsibilities as stated above.

Limitation of Liability

The remedies provided herein are the Buyer's sole and exclusive remedies. In no event or circumstances will TFS be liable to the Buyer for indirect, special, incidental or consequential damages, including without limitation, loss of revenues or profits, business interruption costs, loss of data or software restoration, or damages relating to the Buyer's procurement of substitute products or services. Except for liability for personal injury or property damage arising from TFS's negligence or wilful misconduct, in no event will TFS's total cumulative liability in connection with any order of TFS's Goods, from all causes of action of any kind, including tort, contract, negligence, strict liability, and breach of warranty, exceed the total amount paid by the Buyer. Some Jurisdictions do not allow certain limitations or exclusions of liability, so the above limitations or exclusions may not apply to all buyers.

The foregoing warranty is in lieu of all other warranties, expressed or implied, including, but not limited to, any implied warranties of title, merchantability, or fitness for a particular purpose howsoever arising.

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Chapter 1:

Introduction to TimeSpy

Product Overview

TimeSpy is a portable instrument for applications where the accurate measurement, validation, analysis and datalogging of time data or time-stamping of events is required. Examples of applications include the validation of equipment outputs, those where time is distributed over large distances or to many sites, or where time is distributed across computer networks. A variety of time data sources can be measured, including pulses (1 pulse per second, 1 pulse per minute, 1 pulse per hour), analogue and digital timecodes, serial timecodes, network time protocol (NTP) and precise time protocol (PTP). Frequency sources can also be measured using the fibre, differential or TTL input capability.

TimeSpy includes an internal clock which utilises a Rubidium Frequency Standard, or optionally a Quartz Oscillator, as its timebase. Through the use of an internal satellite receiver, the internal clock is automatically synchronised to Beidou or GPS which is steered to follow UTC thus providing an absolute reference for the measurements. Using the received satellite signals, the frequency of the Reference Frequency Standard is constantly disciplined, ensuring that the timebase of the instrument is maintained at its most accurate. From this a TimeSpy Reference Clock 1 Pulse Per Second (PPS) is generated for comparison to the Input Time Sources. By these means, accurate and absolute measurements are consistently achieved for all Time Sources.

The disciplined oscillator 10MHz output and TimeSpy 1pps signals are available to the User.

TimeSpy is normally powered from an external AC supply. The instrument also includes an internal rechargeable battery supply. Through use of the battery supply, the instrument can be operated for a minimum of 2 hours without the need for the AC supply. Upon reconnection to the AC supply, the internal batteries are recharged.

An integral GPS antenna is included on the instrument. Through the use of this antenna, and the internal battery supply, the unit can be synchronised to GPS by placing the instrument in an external location and awaiting synchronisation. The instrument can then be placed in the location for the measurements and reconnected to the AC supply if available. The instrument also includes the capability for the use of an external GPS active antenna for synchronisation to GPS. To obtain the highest accuracy the unit should be continuously powered with GPS available and allowed to discipline the internal frequency source for at least 24hours.

TimeSpy is designed to be highly portable. It is housed in a portable instrument case allowing it to be utilised at any appropriate location. A special wheeled transport carrying case is available.

The user can select internal memory or supply an external USB memory stick for the location of datalogged files of measurement data for analysis purposes.

TIMESPY TFS PART NUMBERS

TIMESPY (non-SFP models)

TFS P/N	MODEL NAME	OPTIONS		CHASSIS P/N
0770AA000N	TIMESPY	Quartz	Spare Inputs (rear)	0770AB000A
0770AA000P	TIMESPY	Rubidium	Spare Inputs (rear)	0770AB000B
0770AA000R	TIMESPY	Quartz	Ref Inputs (rear)	0770AB000E
0770AA000S	TIMESPY	Rubidium	Ref Inputs (rear)	0770AB000F

TIMESPY ELITE (SFP models)

TFS P/N	MODEL NAME	OPTIONS		CHASSIS P/N
0770SF000PA	TIMESPY ELITE	Quartz	Spare Inputs (rear)	0770AB000AA
0770SF000PB	TIMESPY ELITE	Rubidium	Spare Inputs (rear)	0770AB000BA
0770SF000PC	TIMESPY ELITE	Quartz	Ref Inputs (rear)	0770AB000EA
0770SF000PD	TIMESPY ELITE	Rubidium	Ref Inputs (rear)	0770AB000FA

Technical Specifications

TimeSpy Frequency Reference Options

Model	Oscillator	Frequency Reference stability	Frequency ageing without GPS	Loss of Time accuracy without GPS
TimeSpy-Quartz	Quartz OCXO	1×10^{-12} over 100s	3×10^{-9} per month	± 700 ns per hour
TimeSpy	Rubidium	3×10^{-12} over 100s	3×10^{-11} per month	± 30 ns per hour

Measurement Reference Source Summary

- Internal C/A Code GPS Receiver with case-mounted antenna
- External GPS Antenna connector provided
- Optional Beidou Receiver
- Time Accuracy (1σ) 25ns over 24hrs with GPS reception
- Internal Time Interval Measurement: 0.2ns resolution with built-in self-calibration

TimeSpy Elite



TimeSpy Elite Measurement Sources

Measurement Interfaces		Connector	Input Measurement Accuracy Against GPS		Input Specifications
			Time (1 σ)	Resolution	
Pulse (1pps / 1ppm / 1pph) Frequency	Fibre	ST	25ns	0.2ns	820nm -7.6dBm max (or 1300nm -11dBm max - to special order)
	Differential	Twin BNC	25ns	0.2ns	Common mode -7V+12V Differential threshold -0.3V min +0.3V max Input Impedance 22k min
	TTL	50ohm BNC	25ns	0.2ns	Nominal Input 0V to 2.5V Low: 0- 0.9V; High: 1.4V-5V Input Impedance 1.2kohm
Relay / optoisolator		Twin BNC	25ns	0.2ns	Isolated inputs. TimeSpy connects 1.2kohm from +5V to contacts from isolated supply
1kHz AC Timecode		50ohm BNC	1 μ s	100ns	Nominal Input: 10Vpp Peak to Peak Min / Max: 2.5Vpp /12Vpp Input Impedance: 60kohm
DCLS HAVEQUICK 50bps BCD DCF77	Fibre	ST	25ns	0.2ns	820nm -7.6dBm max (or 1300nm -11dBm max - to special order)
	Differential	Twin BNC	25ns	0.2ns	Common mode -7V+12V Differential threshold -0.3V min +0.3V max

DC Timecodes					Input Impedance 22k min
	TTL	50ohm BNC	25ns	0.2ns	Nominal Input 0V to 2.5V Low: 0- 0.9V; High: 1.4V-5V Input Impedance 1.2kohm
Network Connection NTP / SNTP / PTP V1/V2	RJ-45		±70ns	20ns	100Base-T Ethernet
	SFP		25ns	8ns	1Gbps Ethernet
RS422/RS485 Serial Message Start and NMEA or China Mobile ToD plus Pulse	9-pin D-type		100ns	0.2ns	Common mode -7V+12V Differential threshold -0.3V min +0.3V max. Input Impedance 22k min
RS232 Serial Message Start and NMEA or China Mobile ToD plus Pulse	9-pin D-type		1 μs	0.2ns	Input Voltage Range ±30V max Low threshold 0.8V max; High threshold 2.4V Input impedance 3kohm min 7kohm max

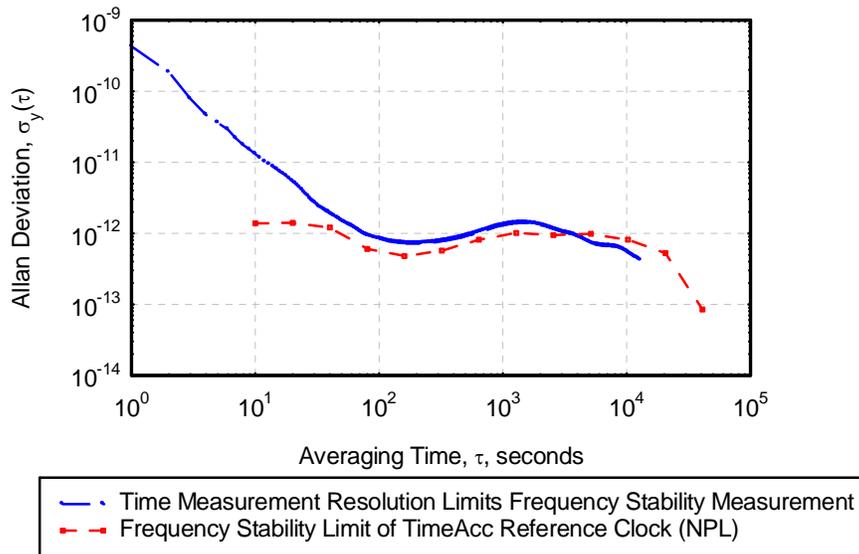
TimeSpy Frequency Measurement Specification

Parameter	TTL Input	Fibre Input	Differential Input	Rear 10MHz Input
Frequency Range	40Hz to 50MHz	40Hz to 50MHz	40Hz to 25MHz	40Hz to 50MHz
Input Level	Low: 0- 0.9V; High:1.4V-5V Input Impedance 1.2kohm User termination recommended	850nm standard, 1300nm special -12.6dBm Peak Input Power	Differential threshold -0.3V min +0.3V max. Common mode -7V+12V Input Impedance 22k min	100mVrms min

Frequency Measurement Stability Limits Over various averaging times (Rubidium)

Averaging Time	Mod $\sigma_y(\tau)$
1s	5E-10
10s	5E-11
100s	5E-12
1000s	1.5E-12
10,000s	8E-13

FREQUENCY STABILITY LIMITS OF TIMEACC MEASUREMENT
Measurement of 2.048MHz plus 0.1Hz (+4.883E-8)



TimeSpy Outputs

Output Interface	Connector	Output Specifications
Alarm relay output	9-pin D-type	NO/NC/COM Voltage Free Contacts 0.3A at 125VAC; 1A at 30VDC
RS232 User port	9-pin D-type	RS232 Port for diagnostics
RS232 Measurement Port	9-pin D-type	China Mobile Time of Day and Status
RS422 Measurement Port	9-pin D-type	China Mobile Time of Day and Status
1pps output	50ohm BNC	0V to 5V pulse from 50ohms
1pps output RS422	Twin BNC	0V to 5V RS422 pulse output
Programmable Pulse output	50ohm BNC	0V to 5V pulse from 50ohms
10MHz output	50ohm BNC	0V to 5V square wave from 50ohms
Timecode AC	50ohm BNC	1kHz modulated Timecode output; 6V peak to peak from 50ohms
Timecode DCLS; TTL	50ohm BNC	0V to 5V DCLS Timecode output from 50ohms

TimeSpy (1pps/10MHz) Laboratory Reference Inputs

Laboratory Reference Signal	Connector	Input Specifications
1pps	50ohm BNC	Nominal Input 0V to 2.5V Low: 0- 0.9V; High: Min 1.4V-5V Input Impedance 1.2kohm
10MHz	50ohm BNC	Min 1.4V. Input Impedance 1.2kohm.

Chapter 2:

Product Familiarisation

Initial Setup

The TimeSpy Measurement Instrument is supplied with an AC supply lead, a short antenna patch lead, a USB Memory and this Operations Manual.

Before **any** external power source is connected to TimeSpy, confirm that the supply voltage is suitable for its use. Labelling on the rear panel of TimeSpy indicates the specified input voltage range.

The unit should then be connected to an external AC supply and switched on for a minimum of 4 hours in order to charge the unit's internal batteries.

Warning

Use of an incorrect supply voltage with the TimeSpy Instrument may result in damage to the equipment and may cause a fire risk. Equipment that has been damaged through incorrect supply voltage(s) is expressly excluded from Time & Frequency Solutions' equipment warranty.

TimeSpy Front Panel

The following view shows the front panel of TimeSpy Elite

Touch Screen

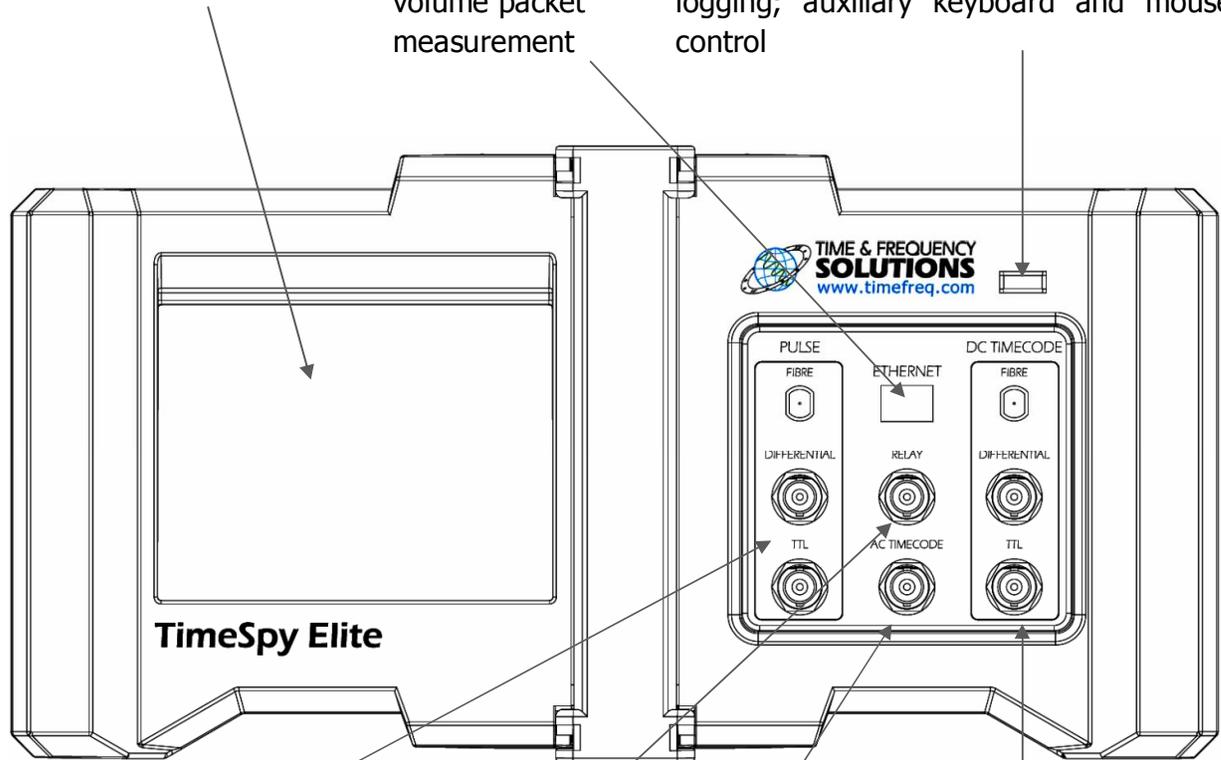
Configuration control and Instrument display.

SFP Socket

1Gbps SFP Socket for precision high volume packet measurement

USB Connection

USB 1.1 Memory connection for program upload and optional location for data logging; auxiliary keyboard and mouse control



Pulse Inputs

Pulse per Second, Minute or Hour input
Frequency Input
ST Fibre
Twin BNC
BNC

Relay Input

Isolated Contact Open
Contact Close
Twin BNC

AC Timecode Inputs

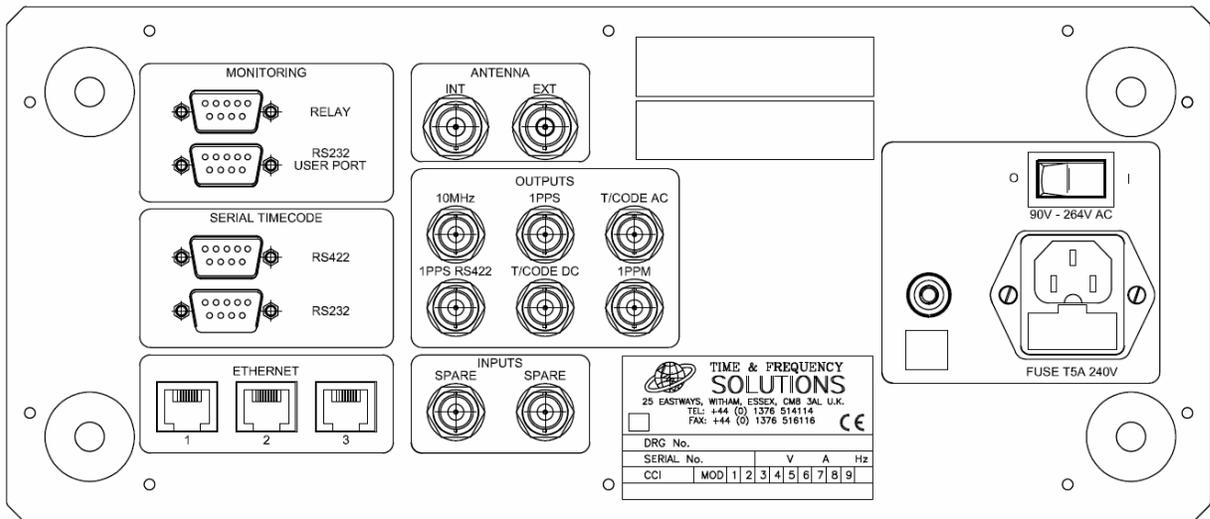
Modulated (AC) Timecode input
BNC

DC Timecode

DC Level Shift (DCLS) and single-ended logic level Timecode Input
ST Fibre
Twin BNC
BNC

TimeSpy Rear Panel

- Antenna INT** Internal Case mounted GPS antenna
- Antenna EXT** External active antenna connection with 5V supply (BNC)
- 10MHz Output** Instrument 10MHz Oscillator output (BNC)
- 1pps Output** Instrument 0-5V 1pps output (BNC)
- AC Timecode** Modulated Carrier Timecode Output (BNC)
- 1pps RS422** Instrument 1pps differential output (twin BNC)
- T/Code DC** DC Timecode output (BNC)
- Pulse Output** Programmable Pulse (default is 1 pulse per minute) output (BNC)
- 1pps Input** Optional 1pps External Reference Input (BNC)
- 10MHz Input** Optional 10MHz External Reference Input and Frequency Measurement AC Input (BNC)



- Relay alarm contacts** Voltage-free alarm (9 Way D-Type Plug) "normally open" and "normally closed" contacts
- User Port** RS232 Raw data and diagnostic port (9 Way D-Type Socket)
- Serial Measurement** RS232 (9 Way D-Type Socket) and RS422 (9 Way D-Type Plug) user message input for start-of-message and NMEA plus Pulse time stamp.
- 100BaseT** Network connection for Network Time Protocol, Precise Time Protocol and network operations (3 off RJ45)
- Power Switch** Turns the unit's AC or battery power on or off.
- AC Connection** 90-260V AC fused power connector (IEC)

TimeSpy Measurement Signal Characteristics and Connector Pin Assignments

Connector	Pin	Assignment	Input Signal
Pulse Input Fibre (ST)	Input	Fibre ST Connector	850nm standard, 1300nm special -12.6dBm Peak Input Power
Pulse Input Differential (Twin BNC)	Inner Male Inner Female Outer	Signal - Signal + Ground	Common mode -7V+12V Diff threshold -0.3V min +0.3V max Input Impedance 22k min User termination recommended
Pulse Input TTL (BNC)	Inner Outer	Signal Ground	Nominal Input 0V to 2.5V Low: 0- 0.9V; High:1.4V-5V Input Impedance 1.2kohm User termination recommended
Relay Measurement Input (9-way D plug)	Inner Male Inner Female Outer	Signal Isolated return Signal Isolated source Ground	See page 59 of this manual Contact sensing via 5V DC-DC converter supplied 1k source and high speed opto-coupler.
AC Timecode Input (BNC)	Inner Outer	Signal Ground	10V pp nominal into 47k (2.5Vpp to 12Vpp at code maximum pk-pk) Transformer i/p factory option
DC Timecode Fibre (ST)	Input	Fibre ST Connector	850nm standard, 1300nm special -12.6dBm Peak Input Power
DC Timecode Input Differential (Twin BNC)	Inner Male Inner Female Outer	Signal - Signal + Ground	Common mode -7V+12V Diff threshold -0.3V min +0.3V max Input Impedance 22k min User termination recommended
DC Timecode Input TTL (BNC)	Inner Outer	Signal Ground	Nominal Input 0V to 2.5V Low: 0- 0.9V; High:1.4V-5V Input Impedance 1.2kohm User termination recommended
RS422 Serial Timecode Measurement Input (9-way D plug)	1 3 4 6 8 5	Ground 422 Tx- 422 Rx+ 422 Rx- 422 Tx+ Ground	RS422 For Start of Message time any format For NMEA 4800 baud, 8 bits, No Parity, 1 Stop bit \$GPRMC or \$GPZDA message China Mobile ToD 9600 baud, 8 bits, No Parity, 1 Stop (Input and Output)
RS232 Serial Timecode Measurement Input (9-way D socket)	1 2 3 5	Ground 232 Tx 232 Rx Ground	RS232 For Start of Message time any format any rate For NMEA 4800 baud, 8 bits, No Parity, 1 Stop bit \$GPRMC or \$GPZDA message. China Mobile ToD 9600 baud, 8 bits, No Parity, 1 Stop (Input and Output)
Network connection (RJ45)	1, 2, 4, 6	Auto MDI X	10BASE-T / 100BASE-T IEEE 802.3 Control port
Network Connection SFB (Elite Model)	Plug-in Module	Multiple	1Gbit/s Fibre or Copper Fibre FINISAR FTLF8524P2BNW Copper 3COM 3CSFP93-C

TimeSpy Antenna and Output Signal Characteristics and Pin Assignments

Connector	Pin	Assignment	Signal
Antenna Int (BNC)	Inner Outer	Internal Antenna signal output Ground	Frequency 1575 MHz +/- 4MHz Length-60mm Width-50mm Height-18mm Gain 13dB
Antenna Ext (BNC)	Inner Outer	Signal to Satellite Receiver and 5V antenna supply Ground	GPS Receiving frequency 1575.42MHz GPS Acquisition sensitivity -130dBm GPS Tracking sensitivity -138dBm BD Sensitivity -110dBm (Option)
RS232 User Port (9-way D socket)	1 2 3 4 5 6 7 8	DCD TxD RxD DSR GND DTR CTS RTS	RS232 Factory default 9600 baud 8 bits no parity 1 stop bit
10MHz Output (BNC)	Inner Outer	Signal Ground	0-5V 50:50 mark-space nominal from 50R Typical Rise Time into 50R load (0V to 1.7V) <4ns
1PPS Output (TTL)	Inner Outer	Signal 0-5V Ground	200ms high from 50R, rising edge on-time Typical Rise Time (0V to 1.7V) <4ns
1PPS Output (RS422)	Inner Male Inner Female Outer	Signal + Signal - Ground	RS422 52Mbps Precision delay Diff output across 50R load 2Vpp min; Common output 2V min Typical Rise Time (0V to 1.7V) <4ns
Pulse (default 1pulse per minute) Output (TTL)	Inner Outer	Signal 0-5V 200ms high from 50R, rising edge on-time Ground	Programmable at HH:MM:SS with option to set HH, MM, or SS to ignore Pulse length 20µs to 1s (default 200ms) high from 50R, rising edge on-time Typical Rise Time (0V to 1.7V) <4ns
AC Timecode Output	Inner Outer	Signal IRIG B IEEE:1344 Ground	Amplitude modulated 3:1 6Vpp from 50R at max amplitudes
DCLS Timecode Output (TTL)	Inner Outer	Signal IEEE:1344 0-5V from 50R Ground	RS422 52Mbps Precision delay interface Diff output across 50R load 2Vpp min; Common output 2V min Typical Rise Time (0V to 1.7V) <4ns
Network connection (RJ45)	1, 2,4, 6	Auto MDI X	10BASE-T / 100BASE-T IEEE 802.3 User Interface port (optionally can be separated from measurement port)
Network Connection SFB (Elite Model)	Plug-in Module	Multiple	1Gbit/s Fibre or Copper Fibre FINISAR FTLF8524P2BNW

			Copper 3COM 3CSFP93-C
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TimeSpy (1pps/10MHz) External Reference Signal Characteristics and Pin Assignments

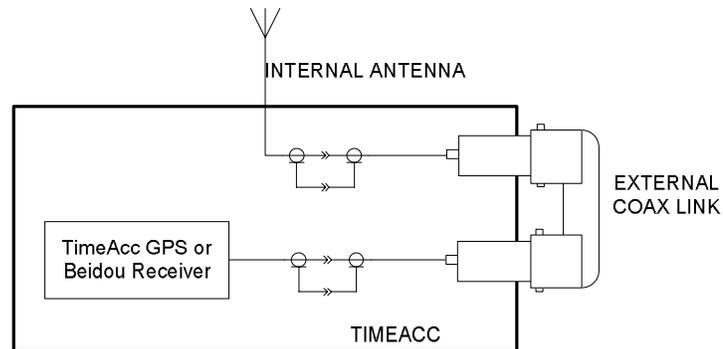
Connector	Pin	Assignment	Signal
Reference 1pps Input (BNC)	Inner Outer	Signal Ground	Recommended Input 0V to 2.5 when terminated by 50 ohms Low: 0- 0.9V; High:1.4V-5V Input Impedance 1.2kohm User termination recommended
Reference 10MHz Input (BNC)	Inner Outer	Signal Ground	Nominal Input 1Vrms sinewave (+13dBm) when terminated by 50 ohms Minimum Input 225mVrms (+0dBm) Input Impedance 1.2kohm User termination recommended

Chapter 3:

TimeSpy Instrument Operation

GPS Antenna Selection

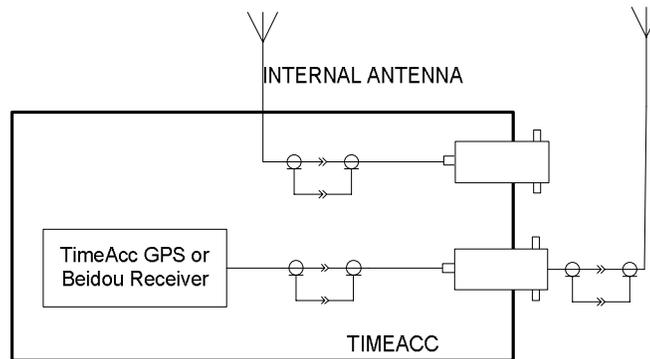
An antenna is required for the instrument to obtain time. For portable use, there is one on the top of the instrument which is suitable in conditions where TimeSpy can be placed with a clear view of the sky. For this built-in antenna to be operational the satellite receiver coaxial link lead supplied must be fitted between the connectors marked 'Internal' and 'External'.



USING TIMEACC'S INTERNAL ANTENNA

**External
Antenna**

If an external antenna is to be used this may be connected at 'External Antenna'. In this case the patch lead is not required.



USING TIMEACC WITH EXTERNAL ANTENNA

The external antenna must be 'active', that is to say contain a pre-amplifier to compensate for the signal loss in the cable connection, or must be a connection from an antenna distribution amplifier system. TimeSpy provides 5Vdc out of its antenna socket to power an active antenna through the coax connection. If an external antenna is used then the user must be aware of the additional delay caused by the antenna cable (typically 5ns per metre) and must compensate for this delay by selecting the Reference Time & Oscillator screen (see Operation below), touching Set Up to call for the Reference Clock Setup screen and entering the cable delay into the Antenna Calibration box. Time & Frequency Solutions Ltd. can supply a calibrated antenna for external use.

**Cable Delay
Measurement**

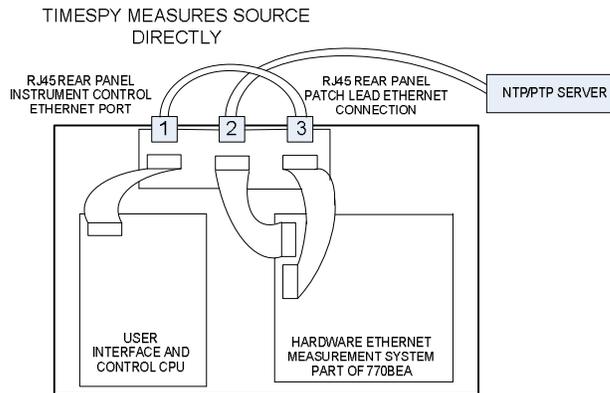
TimeSpy itself can make a 50ohm coaxial cable delay measurement quickly and simply. One end of the cable under test is connected to the 1pps Reference Output 50ohm BNC socket at the rear of TimeSpy. The other end is connected to the 50ohm Pulse Input of TimeSpy through a 50ohm in-line termination, or to a BNC 'T' with a 50ohm termination connected to the free input of the 'T'. "1pps" is selected as Input Time Source at the Source Selection page. The Time Difference Measurement will display the cable delay directly in nanoseconds.

Ethernet Port Selection (Rear Panel)

TimeSpy Ethernet Ports

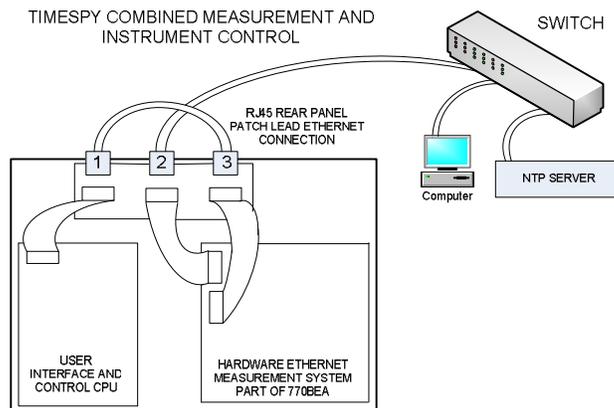
TimeSpy has 3 rear panel Ethernet ports to allow for optional separated instrument control and 10/100baseT measurement operation. Port 1 connects to the Instrument graphical user interface and main CPU. Port 2 connects to the high speed hardware packet capture and measurement system. Port 3 acts as a hub so that when port 1 & 3 are connected via a short link cable, a single Ethernet connection to the instrument may be used for both network time measurements and for remote management and file transfer, as described above for TimeSpy. If it is desired to make direct measurements of a network time source without other network traffic present the connection is made as shown below. You can measure a time source directly (without a crossover lead) because TimeSpy's auto MDI-X auto detects this requirement and switches accordingly

Network Time Server Measurement Only



Simultaneous Control and Measurement

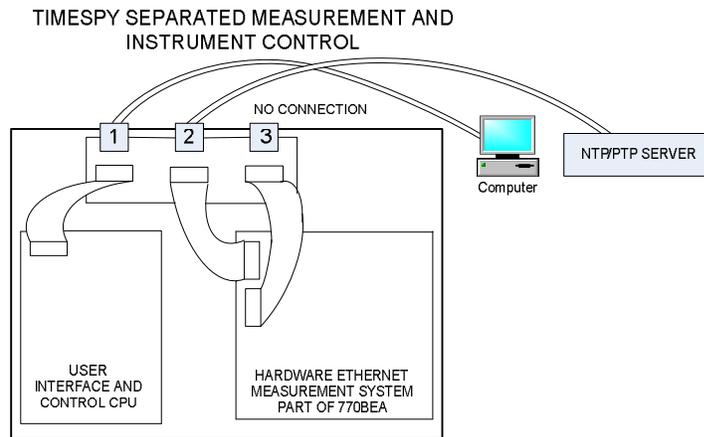
If simultaneous measurement and remote control is required then the arrangement becomes



This has the advantage of requiring only a single cable and switch port on the system's network, however it does constrain the TimeSpy to having only one IP address, and means that measurement and remote administration must take place on the same subnet. In some circumstances, traffic related to remote management could influence measurement results.

***TimeSpy
Separate
Control and
Measurement
Subnets***

Optionally (consult factory) it will be possible to use the connections shown below



***Separated
Remote Control
and Server
Measurement***

When the link between ports 1 & 3 is removed, as above, two independent Ethernet connections to the instrument can be used (consult factory for this feature). The connection to port 1 allows remote management and file transfer; the connection to the high speed packet capture and measurement port 2 is used for time measurements. Port 3 MUST NOT BE CONNECTED when this configuration is used. When the ports are connected separately, remote management traffic can use a different subnet to that on which measurement is taking place and there will be no interaction between administration traffic and the measurement results. The IP address and subnet mask of the measurement port will need to be configured manually because the use of DHCP is not possible when this arrangement is used.

Powering On

A power switch is provided on the TimeSpy Instrument and is located on the rear of the unit. The power switch connects both AC and battery power to TimeSpy.

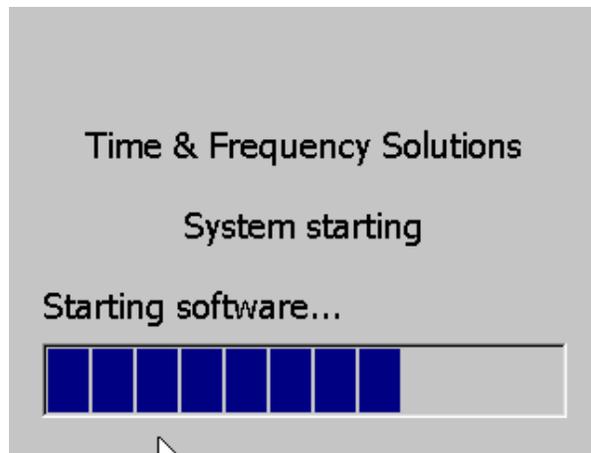
Position I turns TimeSpy on

Position 0 turns TimeSpy off

Should no AC power be present the Instrument will be powered from its internal battery for up to 2 hours. The recharge time is 4 hours and is done only when AC is powering the instrument. If AC power is available it should be used.

Initialisation

After TimeSpy has been powered on, the equipment will go through an initialisation period and display start-up screens as follows.



Operation

TimeSpy will make Time Difference measurements between its reference one pulse per second, derived from its disciplined Reference Oscillator, and a selected external Time Source. It can also make Frequency and Frequency Difference Measurements

A positive time measurement indicates the measured time source is late compared to the reference time generated by TimeSpy; a negative measurement indicates the time source is early.

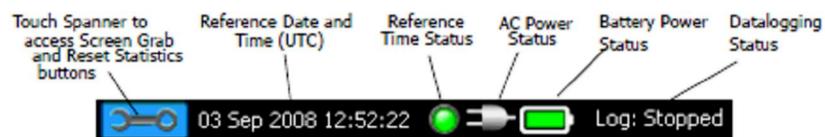
These Time and Frequency Difference measurements can be viewed on the front panel and also selectively logged to internal memory or an external USB memory stick.

Configuration of these features is through various User Menus which are described in the following sections.

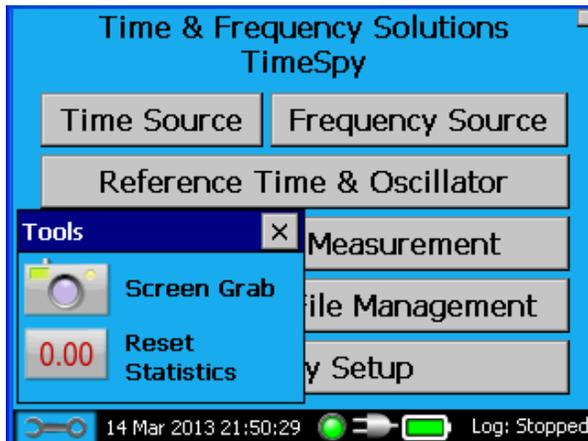
Status Bar

Every TimeSpy screen has a status bar at the bottom of the screen which gives instant access to Screen Grab and Statistics Reset functions for any current measurement screen. It also displays TimeSpy's reference time (UTC), Reference Time status, AC Power status, Battery Status and Logging status.

The Status bar is illustrated in the diagram below. Touching the spanner symbol opens the small TimeSpy Tools window as shown below:-



**'Print
Screen'
facility**



Before using the print screen facility, ensure that a USB memory stick is plugged into the front panel USB socket. It may take up to a minute for the presence of the stick to be recognised. Touching Screen Grab in the TimeSpy Tools window will copy the current screen (behind the Tools Menu) to a file on the memory stick. Note that when the Tools menu is active, the time in the status bar is frozen. During the save the remaining screen contents are 'frozen', an hourglass is displayed and a change of screen is not possible until a window announcing the end of the save pops up. Close this window before trying to access other buttons on the screen. A screen save operation can take 30s to an average USB memory stick but some memories are much slower.

**Reset
Statistics**

Touching Reset Statistics will reset the averaging and standard deviation calculations on the current measurement screen, if one is showing.

**Reference
Time and
Date**

More detail about the Reference Time and Date (UTC) is available on the Reference Time and Oscillator page accessed by touching that bar on the Main Menu. This page is described below in Chapter 4 of this manual.

**Reference
Time Status
Indicator**

The Reference Time status indicator is always illuminated in one of 3 colours as follows:-

Green indicates that TimeSpy reference time is locked to time

received from satellites and TimeSpy's reference oscillator is being steered so that TimeSpy's time follows the satellite receiver or external 1pps on-time reference point. More detail is available on the Reference Time and Oscillator page.

Yellow indicates that time has been acquired from GPS, or manually entered, but is currently being updated internally from the reference oscillator which is in 'holdover' due to loss of satellite reception or due to rejection of the current 1pps reference from the satellite receiver, or external 1pps reference, because of inconsistent timing of this reference. It also warns, when the condition exists, that the rubidium or quartz frequency controller is near the end of its control range, higher than +28672 or below -28672, that is to say has 12.5% of its control remaining. Check the value on the Reference Time and Oscillator page and if this condition persists contact the factory (see Customer Support at the end of this manual).

Red indicates that time has not yet been acquired from the satellite receiver, has not been manually entered or is not trusted because the internal reference oscillator cannot be properly controlled, or a 10MHz external reference has been selected but not connected.

AC Power Status Indicator

The AC Power status indicator shows AC Power available in the illustration of the status bar above. The AC connector icon is 'crossed out' if AC Power is not available



Battery Power Status Indicator

The Battery Power indicator shows a battery filled with green when the internal battery power source is fully charged. During charging the green content of the symbol is dotted.



When the battery is in use, the green filling shrinks according to the estimated remaining battery life.



Near the end of life the symbol changes to a thin red line warning of battery exhaustion. At this point ac power should be connected as soon as possible. TimeSpy will be shut down automatically to prevent damage to the battery.



Main Menu

The Main Menu gives access to all of the instrument functions. As do all TimeSpy screens, it contains a status bar at the bottom, as described in the Status Bar section above.



Before starting Measurements

Before starting to make measurements it is recommended that the user views the Reference Time & Oscillator pages to verify satellite reception, antenna cable delay compensation and reference clock performance as described in the next chapter.

Chapter 4

Reference Time and Oscillator

Touch the Reference Time & Oscillator bar at the Main Menu screen to view the status of Satellite reception and reference oscillator disciplining. Disciplining is the name given to the automatic adjustments applied by TimeSpy to its internal oscillator in order to remove any residual frequency error and align a 1pps derived from the oscillator with precise time from the satellite system or external reference. After about 10 minutes warm-up the reference screen looks like this:-



Reference Date and Time The current UTC time, day of year and date is given at the top. Day of the year counts from 1 to 365, or 366 in the case of a Leap Year.

Reference System This line reports the Reference System in use. For some receivers the user may choose the Satellite System as described under the Setup of Reference Receiver and Oscillator below. Optionally external 1pps and 10MHz may be selected as described under Operation from External 10MHz on page 31.

Satellites Tracked This line reports the number of satellites tracked. The satellite receiver is able to track up to 12 satellites simultaneously if there are a sufficient number in view more than a few degrees above the horizon. At least 4 satellites must be tracked to permit navigation to a precise position and allow TimeSpy to start to discipline the frequency of its internal frequency standard. Usually this is possible within about 7

minutes of start up in a completely unknown location. If an antenna is connected then a number of satellites may be shown as tracked even though 1pps External Reference is selected as the current reference source. No information is used from satellites in that case.

Reference Loop Status This line describes the status of the disciplining algorithm as Slow, Medium or Fast. When at Fast, recalculations and adjustments of the Frequency Controller are made once per second. As time goes on the corrections become less frequent as the Oscillator matches GPS time more closely; the control loop time constant is automatically increased after at least an hour of satellite reception and Medium is displayed. After a further 4 hours during which the update interval is 16 seconds the Loop Status reaches Slow, indicating the best oscillator control and adjustments are reduced to 32 second intervals. TimeSpy must run for at least 13 hours from switch-on before the calibration value for the rubidium controller is updated in non-volatile memory. This value is available at the next power-on to allow higher accuracy of operation in less time.

Reference Instant Phase This line shows the value of the most recent Instantaneous Phase (Time Difference) measurement made between the satellite receiver or external reference 1pps and 1pps derived from TimeSpy's reference oscillator. Occasionally it may show a large value which has been rejected as indicated by the yellow indicator in the status bar.

Reference Mean Phase This line shows the most recent and averaged Phase (Time Difference) measurements made between the GPS (or external 1pps) and the TimeSpy's Oscillator derived 1pps. The GPS PPS remains internal to the Instrument; when GPS is the reference in use TimeSpy's measurements are always made with reference to the Oscillator derived 1pps by the additional high resolution time interval measurement system. In this way the jitter of the GPS 1pps signal is removed.

Reference Frequency Control This line shows the Frequency Controller value supplied to the Oscillator. It is automatically updated as required by the disciplining algorithm to steer the reference frequency and time to follow GPS time. As the disciplining algorithm moves from Fast through to Slow the rate of update will diminish as the Instrument more closely tracks GPS time.

Last Oscillator Adjustment Last Osc Adjust shows the day of year and time at which the most recent adjustment was made to the reference oscillator in the process

described above.

**Rubidium
Status**

Shows the Rubidium Reference Oscillator as 'COLD', 'LOCKED' or 'FAILED' (out of adjustment). When the Rubidium is COLD after TimeSpy is first switched on its frequency accuracy is poor and measurements should not be attempted. 'LOCKED' indicates that Rubidium has locked its internal VCXO to the highly stable atomic transition of the ground state of the Rb87 isotope, confined in a vapour cell within the device. 'LOCKED' status should be reached within 10minutes of switching on. 'LOCKED' in this description does not relate to the GPS disciplining process described above. If after 10 minutes the 'LOCKED' status has not been reached 'FAIL' is displayed.

OCXO Status

In the case where the optional high stability ovened quartz oscillator is fitted in place of the Rubidium the start-up status is shown as 'OCXO COLD':



When the oscillator has warmed-up (after between 5 and 10 minutes) the status is shown as 'OCXO READY':



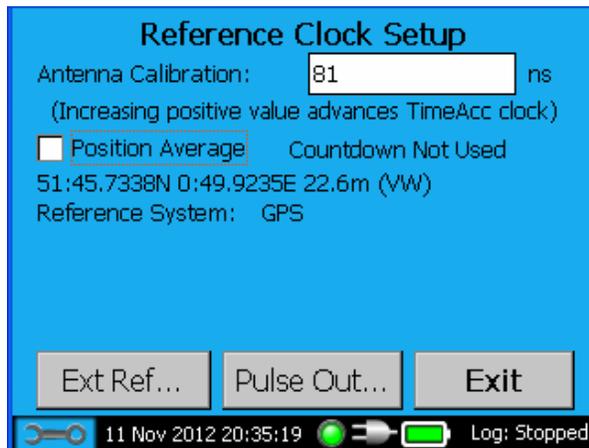
An OCXO status is declared FAILED if the frequency controller value has less than about 12% frequency control available in either direction, or if a repeated attempt to lock it to the reference source has failed.

**Reference
Clock Setup**

Touch the bar labelled Setup on the Reference Time and Oscillator page to access user entries relating to the Reference Clock within TimeSpy, including selection of optional external reference sources for TimeSpy (1PPS/10MHz).

**Antenna Delay
Compensation**

If an external antenna is used the cable delay must be measured or estimated from its length. 5ns per metre is a typical figure; cable delay measurement is described on page 15. The delay value is entered in nanoseconds. Make the entry soon after switch-on so that it can be included in the disciplining process. Touch Setup at the Reference Time and Oscillator page described above to reach the Reference Clock Setup screen. Touching the box for receiver calibration value allows a delay value for the cable to be entered (a positive value compensates for delay). TimeSpy's disciplining will gently slew the reference 1pps to remove the offset.



**Reference
System**

Indicates which reference system is in use to provide reference time (GPS, Beidou or External 1pps Reference). At present only the GPS receiver has the position averaging mode available. Even when the External Reference 1pps has been selected position averaging can continue to be performed.

**Position
Average**

A checkbox next to Position Average on this screen allows the user to turn on or off position averaging. Averaging may be turned off or on by touching the checkbox. If the instrument is turned off then the state

of averaging is saved and recalled at the next power on. A previously averaged position value is NOT reused – a further averaging period is started.

***Position
Average
Countdown***

The value of a seconds' countdown interval until averaging is completed is shown. The averaging period is 8 hours (28,800s) during which at least four satellites are available. When the countdown is complete, the GPS receiver goes into fixed position operation at the averaged position and the display shows Countdown Complete. The averaged position in Latitude, Longitude (degrees, minutes, decimal minutes) and Altitude (metres) is displayed in the line below. A following designation in brackets indicates VW for Valid Position not in China, VCN for Valid position inside China.

TRAIM

The receiver will recover time in fixed position mode provided that at least two satellites are available but TimeSpy will ignore the recovered time unless at least 3 satellites are available. TRAIM (Time Receiver Autonomous Integrity Monitoring) is operational in fixed position mode meaning that the receiver attempts to eliminate the contribution of a bad satellite to time information.

***Countdown Not
Used***

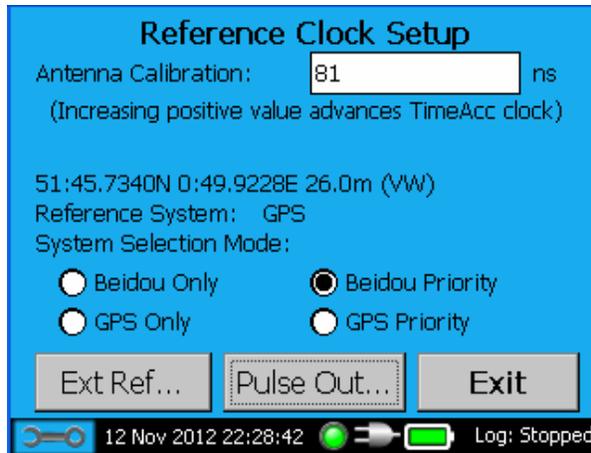
If position averaging is not used, Countdown Not Used is displayed. The estimated position is updated each second by the receiver when at least four satellites are received. TRAIM is not available. If a first position fix has been completed TimeSpy can track time from a single satellite but does not use measurement of the 1pps as a reference unless at least three satellites are available.

***Position
Average
Restart***

If the Position Averaging box is unchecked then rechecked by the user a new 8 hour averaging period will be commenced and any previous averaging will be discarded.

***Satellite
System
Selection***

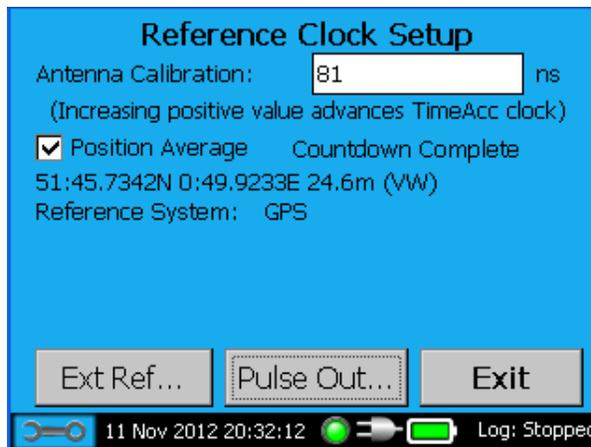
In the case where the reference receiver allows the selection of a satellite system the selected system and the Selection Mode are shown on this page. The page below gives the example of the settings available when a GPS/Beidou receiver is fitted. The Position Averaging option is not shown because it is always enabled by this type of receiver.



**External
Reference
Clock Selection**

TimeSpy has an option that allows the selection of an External Reference 1pps or 1pps and 10MHz. This facility allows laboratories to use TimeSpy to make measurements relative to their own reference clock. Under these conditions time and date are maintained independently of the satellite system, though they may be initialised by time from satellites if desired.

The Reference Clock Setup page has an additional button to give access to the External Reference Clock page

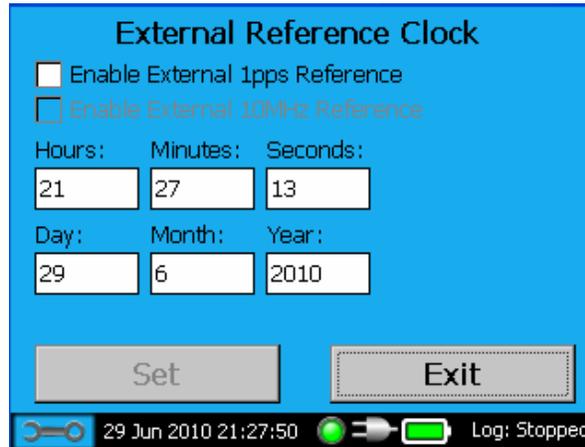


Touch Ext Ref Clock to view the External Reference Clock Page

**External
Reference
Clock Set Up**

The user has the option to use only an external 1pps as time reference, or to use 1pps as time reference and 10MHz as frequency reference to TimeSpy's internal reference clock for timekeeping. On entry to the External Reference Clock page the current time and date shown by TimeSpy are captured into time and date entry fields for editing by the user. If TimeSpy has been allowed to synchronise to the

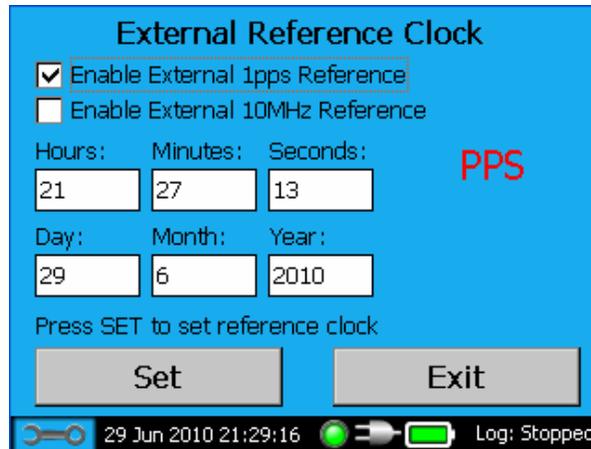
satellite receiver time then the time and date would have been correct when the page was accessed and provide a useful starting point for user time and date entry if the user wants to make a change of time.



***Operation from
External 1pps
Reference***

When operating in External Reference mode an external reference 1pps must be connected to provide reference time but the use of an external 10MHz is optional. TimeSpy does not allow the External 10MHz clock to be selected on its own. The internal rubidium clock is disciplined to the external reference 1pps when running from an external 1pps reference alone so that TimeSpy's own 1pps and 10MHz becomes aligned to the external 1pps. Time difference measurements of a selected source are made using two high precision measurements, giving two time difference measurements (TimeSpy-Source) and (TimeSpy-ExtRef). The subtraction (TimeSpy-Source) – (TimeSpy-ExtRef) is performed to find ExtRef-Source which is output as the measurement. In this way, although it may take some time for TimeSpy to steer its own 1pps into exact alignment with the external reference 1pps, the measurement of the user's source signal is always precise with reference to the external reference 1pps connected. The GPS Antenna Calibration is NOT applied when an external 1pps is used as reference.

**Manual Time
Entry**

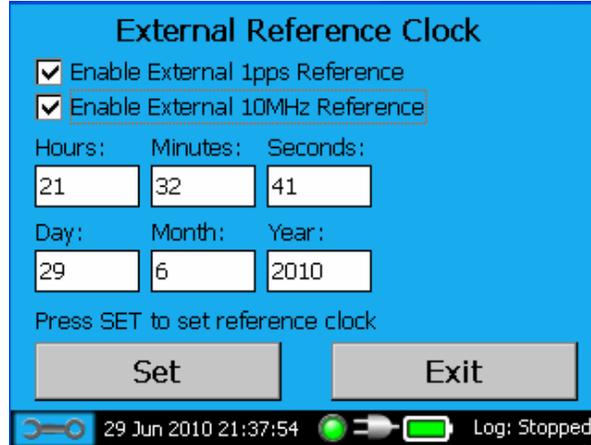


The moment Enable External 1pps Reference box is ticked by the user TimeSpy selects that source and begins synchronisation to it. Following 'jam' synchronisation, by resetting counters, any remaining time difference is measured and removed by 10ns steps such that the final time difference between the pulse at the rear 1pps socket and TimeSpy's internal reference clock is less than 10ns. The status indicator at the bottom of the screen becomes yellow for a few seconds during this alignment with External 1pps. TimeSpy continues with the value of GPS Time assigned to the nearest Ext_1pps updates, if it was previously locked to GPS, but no longer takes time and date from GPS. The SET button becomes available. A red 'PPS' message pulses on and off to indicate the instant of TimeSpy's seconds' count update. If a different time and date is required (or there was no GPS synchronised starting point and the status indicator is red) then the user can enter a time and date value in advance of the required time and press Set when the red PPS appears to apply the time and date to the second just commencing. The status indicator is set to green when the final SET is confirmed.

In the case where External 10MHz Reference is not being used the disciplining of the internal rubidium timebase from the external 1pps source allows the portable aspect of TimeSpy to be retained. If required, TimeSpy can be disconnected from the AC supply and external reference signals then moved elsewhere to perform measurements for as long as the rubidium stability is better than the desired accuracy of measurement.

The External Reference state is recalled if the instrument is switched-off then restarted. The date and time must be re-entered and the status indicator will remain red until that is done.

**Operation from
External 10MHz**



As soon as the Enable External 10MHz Reference box is checked TimeSpy routes that signal to replace the internal rubidium oscillator as the reference to the 100MHz VCXO clocking the divider chain that generates internal clock signals for TimeSpy. Frequency control of the internal rubidium is 'frozen'. Derived signals include 10MHz Output, 5MHz for dual time interval measurement interpolator calibration (200ns), 1kHz for processor interrupt and timekeeping, and 1pps for synchronisation and measurement. The derived 1pps is initially jam synchronised then stepped into alignment within +/-10ns of the external 1pps reference. Any residual offset between the External Reference 1pps and the derived 1pps does not affect measurements because TimeSpy makes the two measurements described above (TimeSpy-Source) and (TimeSpy-Ext1pps). It calculates [(TimeSpy-Source) - (TimeSpy-Ext1pps)] to find Ext1pps-Source. In this description 'TimeSpy' is 1pps output from a counter chain clocked by 100MHz which is locked to the External 10MHz Reference. Any time offset that TimeSpy contains disappears in the subtraction.

**1pps Output
with External
10MHz
reference**

The 1pps output of TimeSpy in this configuration is trimmed to within +/-10ns of the Ext_1pps reference, when the external 10MHz frequency reference is selected, by phase stepping of the 100MHz VCXO output.

**10MHz Output
with External
10MHz
reference**

The External 10MHz is converted to a square wave to provide the reference for the 100MHz VCXO. The VCXO is divided to 10MHz and this signal is buffered and fed out as 10MHz when the External 10MHz is selected.

Warning

If the enable External 10MHz is ticked, but no reference is connected,

then the output 10MHz and 1pps have the stability of a free-running VCXO. Pulse and timecode measurements will be inhibited and a warning "No_10MHz_Ref" will be sent to any engineering datalog. The status indicator will be red and remain red until the references are correctly connected and time is entered at the Reference Clock screen.

The External Reference 10MHz input is AC coupled and can be used as an AC input for frequency measurement if is not in use as reference.

***Reference
Clock Display
when Using
External 1pps***



When External Reference 1pps only has been enabled on the External Reference Clock page the Reference System is displayed as External PPS. The satellite receiver continues to operate and the number of Satellites Tracked continue to be displayed; however, as long as External PPS is displayed as reference, no use is made of data or timing from the receiver. When a stable 1pps external reference is connected the Instantaneous Phase reading, updated each second, is not expected to vary by more than 1ns from the previous reading at each update and will eventually be steered close to zero.

***Change of
Reference
Source***

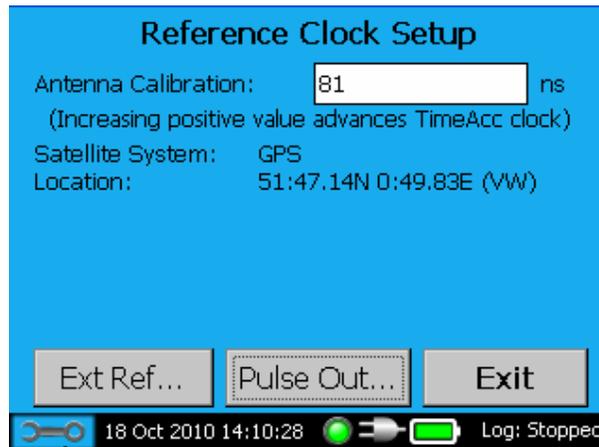
Once External 1pps Reference has been selected and synchronisation completed, using coarse and fine time synchronisation, time differences "TimeSpy-Ext1pps" of less than 1500ns are corrected by adjustment of the rubidium oscillator frequency alone. Larger time differences that persist will be corrected by time stepping. If a different External 1pps is connected with less than 1500ns time difference is subsequently connected, replacing the one to which synchronisation has been acquired, then the user can speed up the process by deselecting and reselecting the External 1pps Reference, by touching the box to disable then re-enable selection, forcing a new rapid synchronisation.

***Restarting
after previous
External 1pps
selection***

It will be necessary to re-enter the reference clock time after start up if external reference is selected and in this case the user may prefer to have the instrument reacquire time from satellites, waiting for the status indicator to become green, then select external reference operation to continue with the acquired time independently of the satellite system.

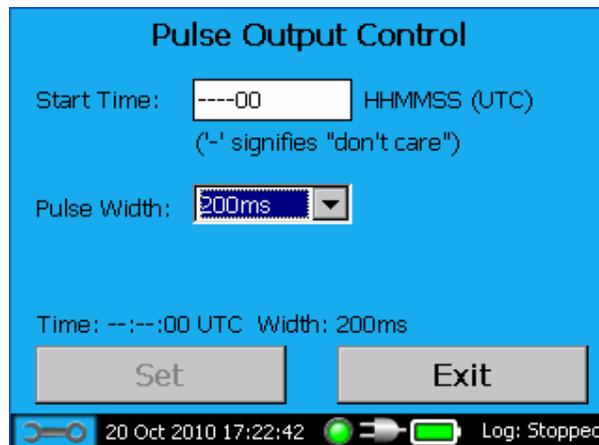
***TimeSpy
Reference
Pulse Output***

The rear panel carries a PULSE Output socket in the outputs group. This pulse output is programmable. From the Main Menu, touch the Reference Time and Oscillator bar followed by Setup



At the Reference Clock Setup page, touch "Pulse Out..." to access the Pulse Output Control page.

***TimeSpy Pulse
Output Control***

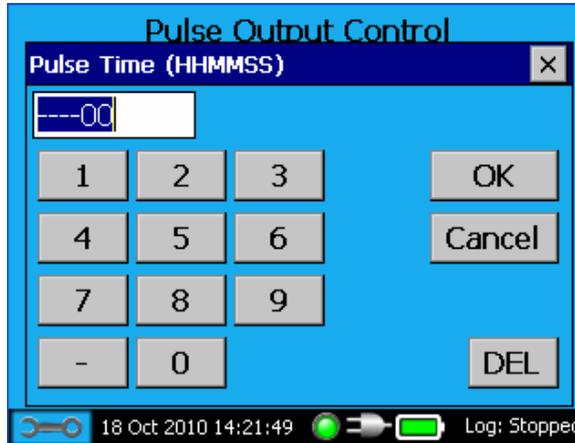


At this page the start time and pulse width can be programmed. The above picture shows the default setting displayed if no user entry has been made. The pulse is output when Reference Clock time equals Start Time; fields which are not compared are entered as dashes. The default entry has dashes for Hours and Minutes so only the seconds are

compared and the pulse is output once per minute at 00 seconds.

***Pulse Output
Start Time
Entry***

To specify a different start time, touch the box containing the Start Time. A keypad appears to allow the new entry.

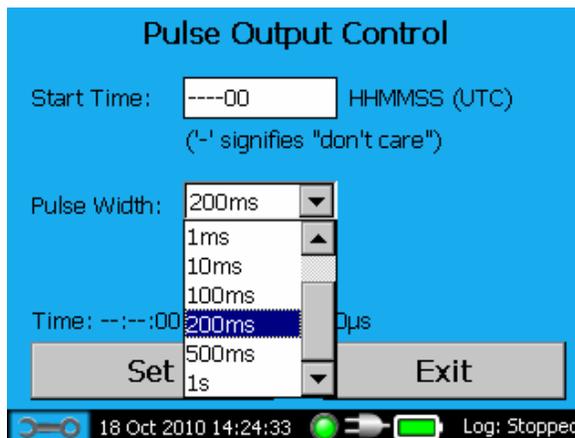


The box contains six digits for Hours, Minutes and Seconds UTC within a day. If a legal time is entered then the pulse will be output once a day at that time. Press OK to accept the new time and exit, or press Cancel to exit without making changes.

For more frequent pulse outputs a hyphen can be entered at any digit which is to be omitted from the comparison with Reference Clock Time. If a string of six hyphens are entered then the pulse is output once per second. In this way pulse output can be arranged once per second, once per 10 seconds, once per minute and so forth.

***Pulse Output
Pulse Width
Selection***

The pulse width of the output is selected from a drop-down list



The list contains the values 20µs, 100µs, 1ms, 10ms, 100ms, 200ms, 500ms, 1s. Note that setting a pulse width of 1s to be output once per second will result in a permanently high level output.

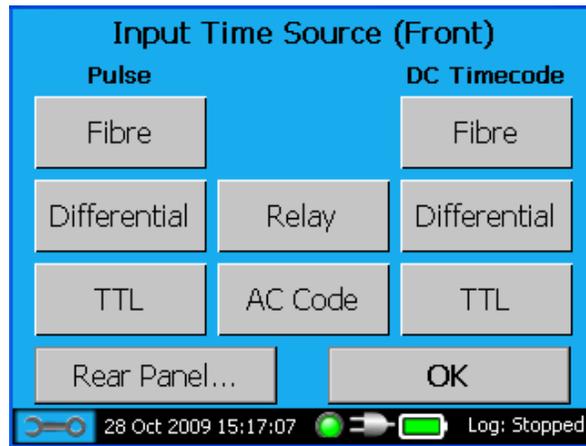
Following Start Time and Pulse Width selection the user can press Set to use the new settings and save them in non-volatile memory, or press Exit to quit Pulse Output Control with no changes made. In that case, if entries have been made, a Pulse Output warning message is displayed asking "Do you want to save the new settings".

Chapter 5

Input Time Source Selection Menu

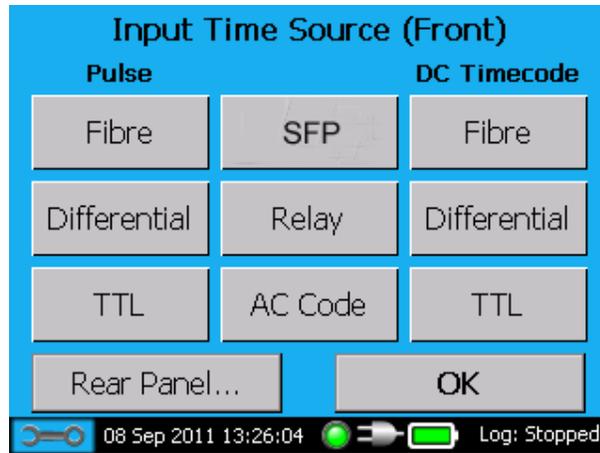
***TimeSpy
Input Time
Source
Selection
(Front)***

TimeSpy has two Input Time Source pages, one each for front and rear connections to the instruments. The buttons on the screen are located in the same rows and columns as the physical connectors. The screen for the front connectors is shown below for the case where TimeSpy does not have an SFP module socket on the front panel:-



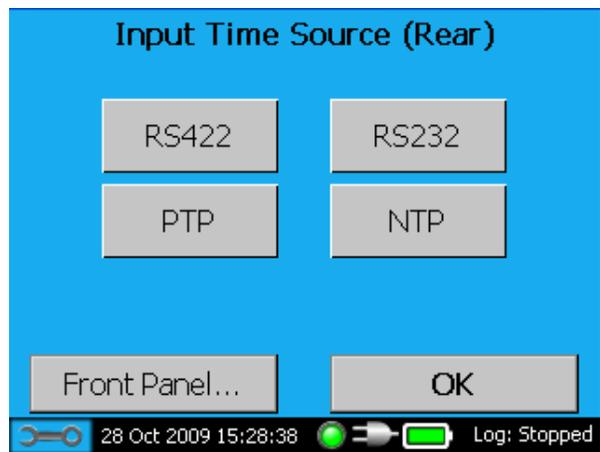
***TimeSpy Elite
Input Time
Source
Selection
(Front)***

If an SFP module is detected (TimeSpy Elite) an extra button is available for access to its setup



Time Source Selection (Rear)

Touch the **Rear Panel** button to access the buttons corresponding to connectors on the rear of the instrument

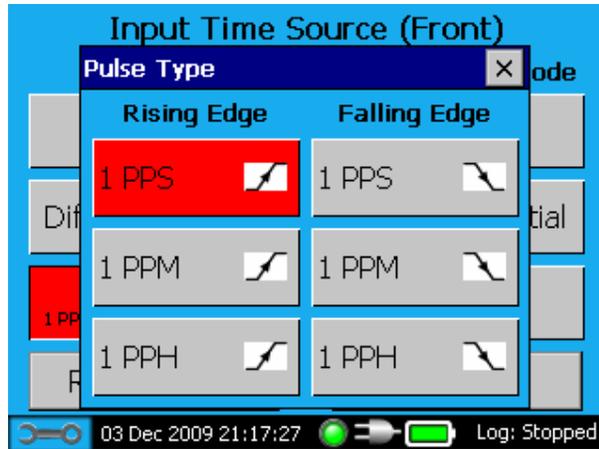


Instruments with SFP have PTP and NTP selection options accessible from the front panel SFP button

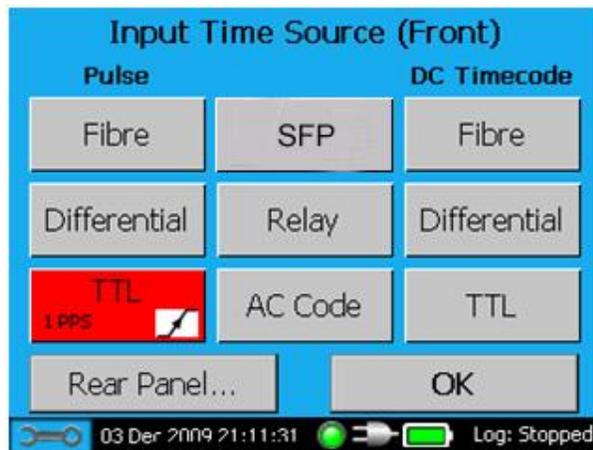
Pulse Type Selection

TimeSpy allows selection of the rising edge or falling edge of the input signal, or the polarity of DC timecodes, by means of additional screens. Control of polarity is available for all but AC Code which is expected to be of the correct polarity.

In the case of Pulse selection, when a choice of differential, TTL or fibre input type is made, for example TTL, a further window appears inviting selection of pulse type and polarity as shown below

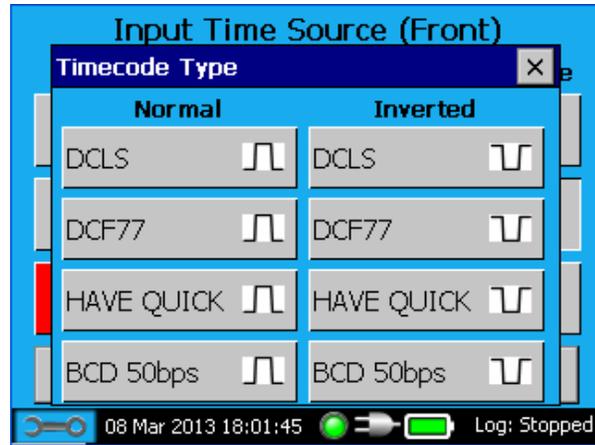


When the Pulse Type and Polarity is selected on return the Input Time Source screen carries an indication of the selection. The chosen input source is highlighted in red, the pulse type is annotated and the edge type is illustrated:

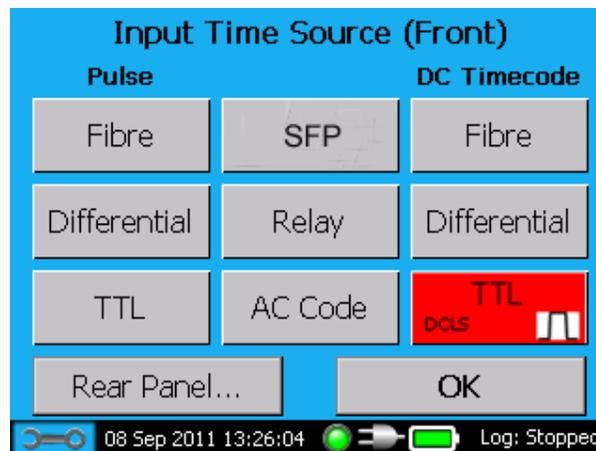


***Timecode
Type Selection***

When a Timecode Fibre, Differential or input selection is made the Timecode Type window appears allowing selection of Timecode Type and Polarity. The polarity is illustrated by a waveform on the associated button as shown below:-



After the Type and polarity selection the Input Time Source window indicates the source in red with a picture of the pulse polarity



**Modulated
Carrier
Measurement
Selection**

By selecting the AC Code bar, followed by OK, the Time Difference measurement will be of the modulated carrier signal present at the AC Timecode Input. After up to ten seconds the timecode type is automatically detected by the reader, the active edge of the timecode start-of-frame is identified and a PPS is derived from it. Modulated carrier timecodes were designed for telemetry and recording purposes in range timing applications. They are also widely used for general purpose master-to-slave synchronisation and time displays. The Modulated carrier codes read by TimeSpy employ 1kHz or 250Hz carrier, amplitude modulated by the variable pulse-width of the code. This is described in more detail below. The Timecode to be measured can be one of:

IRIG-B (IEEE 1344), IRIG-B (200-04), IRIG B, AFNOR (NFS87-500), NASA 36, 2137, XR3

***DC Level Shift
Measurement
Selection***

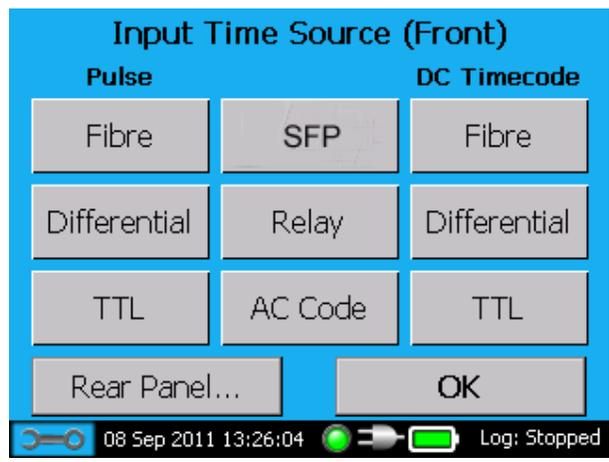
The Input Time Source (Front) screen offers the choice of the 3 inputs, corresponding to the connector positions on the front of the instrument, underneath the heading DC Timecode. The section above has described the configuration of these inputs for polarity and Timecode. When the input selection has been made, the Timecode type is automatically detected by the timecode reader and the active edge of the timecode start-of-frame identified. This edge is measured against the Instrument reference 1PPS. These codes are capable of higher precision time transfer than the modulated codes, ultimately of equal precision to the 1pps signal.

Have Quick and DCF77 codes are selected as described above under the polarity selection.

DCF77 polarity may be manually selected but TimeSpy automatically detects DCF77 polarity and will automatically reverse the user's selection within about 5 seconds if polarity reversal is determined necessary by analysis of the code.

***RS232 or
RS422
Measurement
Selection***

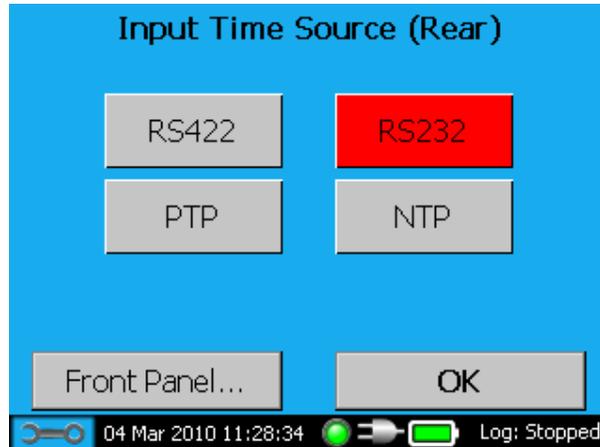
Selection is made at the Input Time Source (Rear) screen. At the Input Selection (Front) screen touch the button labelled Rear Panel...



***Input Time
Source***

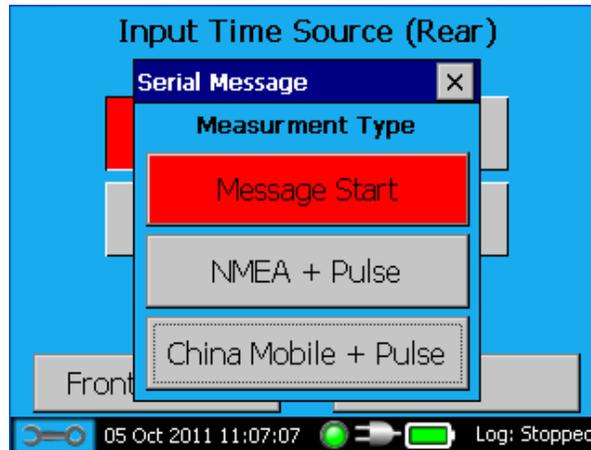
At the rear screen individual RS232 or RS422 input connection is specified by the named button.

**Selection
(Rear)**



**Serial Message
Measurement
Type Selection**

When the choice of RS422 or RS232 has been made TimeSpy routes the input signal from the designated rear panel socket to the measurement system and the user must choose on a further sub-screen which type of measurement is required.



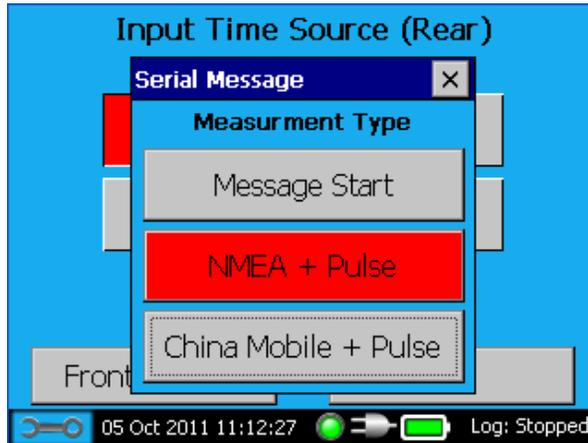
**Serial Message
Start Time
Measurement**

Touch this bar on the pop-up Measurement Type selection screen, followed by OK, to select measurement of the signal present at either the previously selected port. The measurement is made of the rising edge of the first start bit of the first character seen in the message occurring up to 100ms prior to the Instrument reference time PPS. The message start may be also be after this PPS; whenever the start, it must be complete by 900ms after the reference clock 1pps so that the next message start can be identified. TimeSpy then displays the Time Difference Measurement screen showing the Time Source as 'ASCII serial message'. In fact, Message Start measurement mode, the message may have any format and can equally well

be a binary message because the message content is not read.

***Selection of
Serial Message
with Pulse***

To access the NMEA + Pulse or China Mobile + Pulse measurement facility on TimeSpy, after selecting Rear Panel and RS232 (or RS422) the user makes the selection at the Serial Message window:-



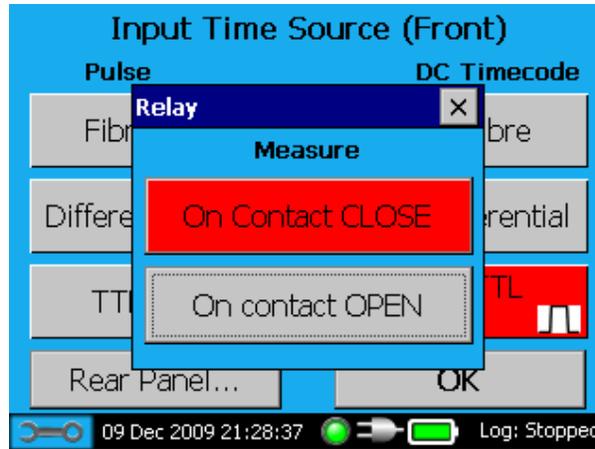
Touch NMEA + Pulse or China Mobile + Pulse and press OK to confirm the choice. If RS422 was chosen, connect the serial input to the rear panel RS422 Serial Timecode input and the pulse to the front panel twin BNC differential pulse input. For RS232 connect the serial input to the rear panel RS232 Serial Timecode input and the pulse to the front panel TTL pulse input.

***Connection of
Serial Message
and Pulse***

When measurements of a NMEA or China Mobile format message with an accompanying pulse are made and RS232 is chosen, as above, the single-ended 'TTL' pulse input is automatically selected by TimeSpy for input of the accompanying pulse. If RS422 is chosen the differential input at the front of the instrument is automatically selected for the pulse input. Refer to RS232 NMEA Serial Message with Pulse Measurement on page 56 and China Mobile ToD and 1pps Measurement on page 57

***Relay Contact
Selection***

At the Input Time Source (Front) screen touch the RELAY bar to bring up the screen



Connection to the relay measurement input circuit is through the central twin BNC on the front panel of TimeSpy. See Relay Contact Measurement on page 59 for details of the relay interface circuit and connections.

Network Time Protocol (NTP) Measurement Selection

The NTP selection button for the rear connector is located on the Input Source Selection (Rear) screen. NTP is operated over Ethernet computer networks using a method described in a document known as RFC1305. In many large distributed computer networks the time can be distributed using the protocol to little better than millisecond precision, which may be adequate for its purpose. However the method is capable of much higher precision which TimeSpy can measure where it is available.

TimeSpy's Elite connection to the network is through its front panel SFP connector.

For the measurement to take place the IP address of the server to be measured must be entered into TimeSpy. Additionally, TimeSpy itself needs to have its own IP address in the same domain on the Network on which access to the NTP server under investigation is possible, or for access to a router which connects to the server on another network via a Gateway address. TimeSpy can be configured to obtain its Internet, Gateway and Subnet Mask Addresses automatically from a DHCP server, if there is one present on same the network, otherwise TimeSpy's IP address and Subnet Mask address must be manually entered. This process is described in more detail below.

***Precision Time
Protocol IEEE
1588 (PTP)
Selection***

By touching the PTP bar, followed by OK, the Time Difference measurement will be of the time obtained from a PTP time server. Like NTP, PTP operates over a network connection, but is designed primarily for use in localised areas and can deliver sub-microsecond accuracy. TimeSpy can measure sources using PTP V1 or PTP V2 in multicast or unicast modes, using either IPV4 or Ethernet (Layer 2) packets. There is also the choice between using the Delay Request or Peer (Path) Delay Mechanisms in measuring the network delays. This process is described in more detail under Precision Time Protocol Measurement (page 66 of this manual).

***DCF-77
Timecode
Measurement
Selection***

DCF77 is selected by touching the button corresponding to the desired input socket Fibre, TTL or Differential at the Input Time Source (front) screen, then by selecting DCF77 (in the column marked Normal for positive polarity).

The Time Difference measurement will be of the DC DCF-77 1pps code presented at the DC Timecode Input (Fibre, Differential or TTL). DCF77 is a 'slow-code' which transmits one bit per second as pulse-width modulated data, in a pattern first used to modulate the carrier of the DCF77 Mainflingen 77.5kHz transmitter but subsequently employed by master clock equipment to synchronise slave clocks on a wired distribution system.

***Have Quick
Measurement
Selection***

Have Quick is selected by touching the button corresponding to the desired input socket Fibre, TTL or Differential at the Input Time Source (front) screen, then by selecting Have Quick (in the column marked Normal for positive polarity). The usual choice will be TTL and Positive Polarity.

TimeSpy can read and identify Have Quick as described in ICD-GPS-060 (also known as HQII) and the variant known as Saturn (HQIIA). It also reads and identifies Extended Have Quick (XHQ) described in the NATO standard STANAG 4430. The measurement procedure is described under Have Quick Measurement starting on page 51.

***50bps BCD
Measurement***

50bps BCD is selected by touching the button corresponding to the desired input socket and can be Fibre, TTL or Differential at

Selection

the Input Time Source (front) screen, then by selecting 50bps BCD (in the column marked Normal for positive polarity). The usual choice will be Differential and Positive Polarity.

TimeSpy can read and identify 24 and 40 bit frames of 50bps BCD time code. The 40bit code is described in ICD-GPS-060 and is also known as Time Data 2 (TD-2). The 24 bit code contains time of day only. The measurement procedure is described under 50bps BCD Measurement starting on page 53. Contact the sales office for information on the availability of Time Data 1 (TD-1)

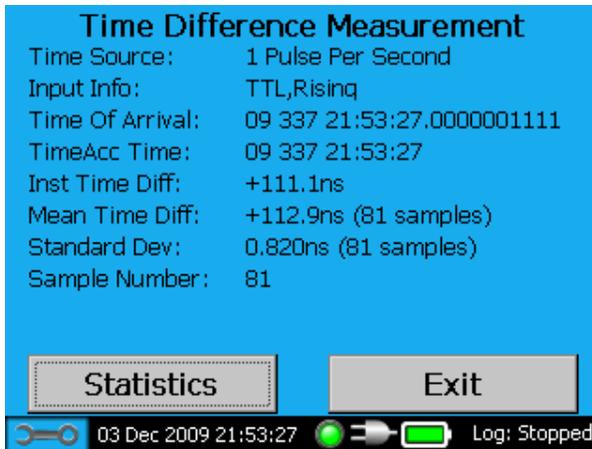
Chapter 6

Input Time Source Measurement

When a pulse input selection has been completed at the Input Time Source page the user touches OK and the Time Difference Measurement display is automatically presented for the previously selected source. If no source is previously selected by the user then the TTL 1 Pulse per Second input (rising edge) is automatically chosen if Input Time Source Measurement is touched at the main menu screen.

***1PPS, 1PPM
1PPH
Measurement***

The input signal must be connected to the Pulse input socket at the front of TimeSpy. The input threshold for TimeSpy's measurement at the TTL input is pre-set to 1.25Vdc; the first rising edge above this threshold from the start of a measurement period that runs from 'on-time' -0.5s to +0.5s will trigger the measurement. The choice of threshold allows a 5V pulse from a 50ohm source impedance to be terminated in 50ohm at TimeSpy to be measured at 50% of its full terminated height of 2.5V. It is good practice to terminate the connected pulse source to eliminate false readings due to 'ringing' on a negative transition being interpreted as the rising edge.



Time Source The Time Source is indicated, for example 1 Pulse Per Second in the example above, with input information such as TTL, Rising.

Time of Arrival The time of arrival is shown as Year tens and units, followed by Day of the Year number (January 1st = 1) then hours minutes and seconds as far as tenths of a nanosecond. The time value is updated with each new pulse arrival.

Reference Clock Time Reference Clock time shows the time at which the measurement was recorded in the same format but without fractional seconds.

Instantaneous Time Difference The Instantaneous Time Difference, within the second, is displayed as a simple number which can range from -0.5 to +0.5 seconds where zero is exactly on time; a positive sign indicates that the signal under test arrived late compared with the instrument reference clock update.

Time Difference Sign A negative Instantaneous Time Difference measurement indicates that the Input Time comes before the Instrument PPS within the second. A positive measurement indicates that the Input Time comes after the Instrument PPS. The measurement range within any one second is -499999999.9ns to +500000000ns.

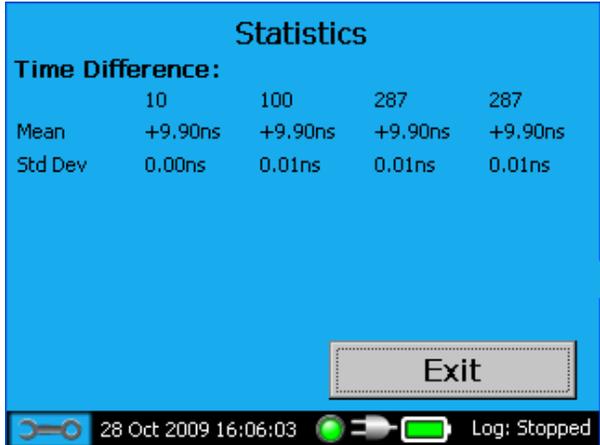
Mean Time Difference The Mean Time Difference, eventually over 100s, is illustrated on this page together with the Standard Deviation of the measurements made.

Standard Deviation Standard deviation is the statistical calculation used to indicate the variability of individual 1pps measurements from the mean within the number of samples collected (eventually 100 on this page).

It is the root-mean-square (RMS) deviation of the individual measurement values from their mean value.

Statistics

This information is available when the Statistics button is touched:-



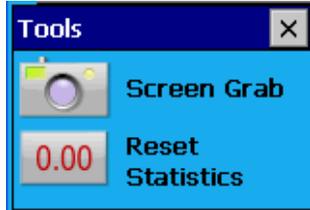
Four columns carry the mean and standard deviation of the time difference measurements for eventual sample counts of 10, 100, 1,000 and 10,000 (normally the number of seconds is the same because samples are taken once per second). The mean is the total of the values of all the samples divided by the number of samples in the total sample count. Standard Deviation is the root-mean-square (RMS) of the deviation of the values of the samples from the mean value of the samples. The target number of samples for each column of the display from left to right are 10, 100, 1000, and 10,000.

When the target count is reached for a column the calculation continues by addition of the latest sample to the calculation and removal of the earliest so that there are always 10, 10, 1000 or 10,000 samples in the calculation for that column.

During the period when the target count has not been reached the total number of samples collected at the time of display is shown. In the case of the display above 287 samples had been collected. This means that only the 10 and 100 columns have been completed, the other 2 columns make their calculation on the 287 samples available so far so they must show the same result until the target numbers of samples have been reached.

**Reset
Statistics**

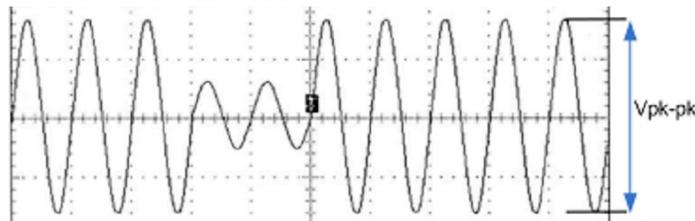
Recall that by touching the spanner in the status bar at the bottom of the screen the TimeSpy Tools menu is called up:



Touch Reset Statistics to clear the displayed statistics and restart all the counts.

**AC Code
Measurement**

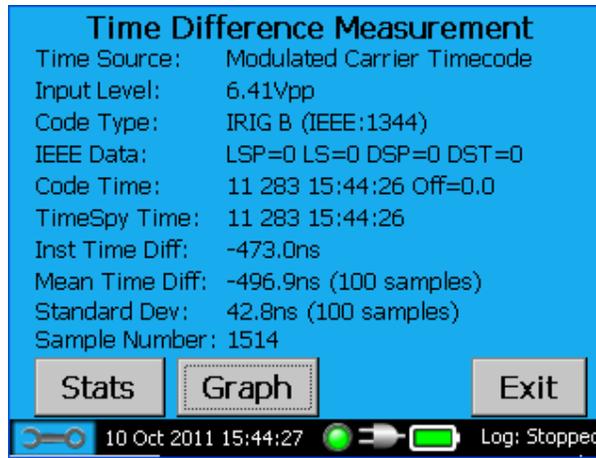
Touch Input Time Source Selection, AC Code, and then OK to reach the measurement screen for modulated carrier timecodes. Modulated Carrier timecode waveforms measured by TimeSpy have the type of waveform shown below



AGC Action

TimeSpy uses precision automatic gain control (AGC) to measure the time difference of signals which are in the range 2.5Vpkpk to 12Vpk-pk. Outside the high and low limits TimeSpy displays **TOO LOW** or **TOO HIGH** after the Input Level Measurement. Measurements and time decoding may still be possible at reduced accuracy at carrier amplitudes outside these limits.

When no AC signal is connected to the AC Code input socket then the automatic gain of TimeSpy's reader (AGC) will advance to maximum; when a signal is subsequently connected no update of the measurement screen will appear for several seconds until the gain has been sufficiently reduced for the timecode frame start points to be recognised. At least 10 further seconds of good reception are then required for the code type to be fully identified.



Input Level

TimeSpy displays its measurement of Vpk-pk shown in the diagram above.

Code Type

The Code Type description defaults to IRIG B whilst analysis takes place over 10 seconds. If IEEE or AFNOR data is found then additional parameters and code values are displayed

IEEE:1344 Parameters

LSP is Leap Second Pending which is '1' up to 59 seconds before leap second insertion

LS are '0' for a Positive Leap Second '1' for a negative leap second.

DSP is Daylight Savings Pending which becomes '1' for up to 59 seconds before Daylight Savings Time (DST) change.

DST is set to 1 if Daylight Savings Time is applied.

Off is the Offset reported in the code meaning that the IRIG Code Time + Offset equals UTC time (the Offset value includes Daylight Savings Time). In the screen example Daylight Savings Time is applied (DST=1) and the Offset Off is -2 hours. Thus the IEEE 1344 IRIG code tells us that UTC equals coded time 18:45:35 – 2 hours, namely 16:45:35.

Code Time Update

Because Code Time is acquired at the end of a second to which it applies TimeSpy time on this screen is adjusted by minus 1s for direct comparison with code time; the exact instants of update on the screen may appear unsynchronised due to sampling by the screen update process; the precise time difference within the second should be judged by the Inst Time Diff value reported. The time in the status bar is TimeSpy's actual reference time and can be seen 1 second advanced as expected in the above screen shot.

Note that although the Code Time is decoded, it does not form part of

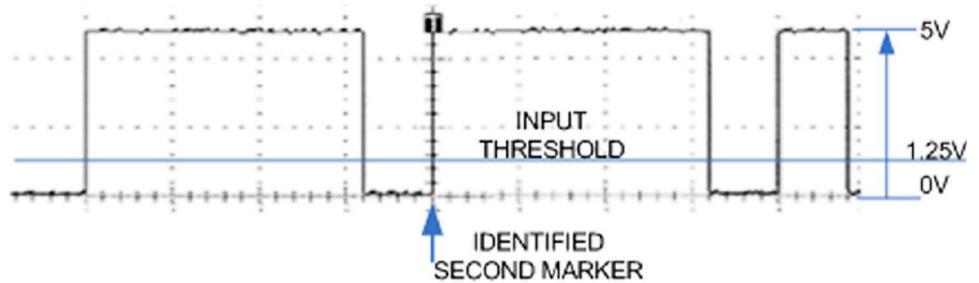
the time difference reported on this screen.

DC Level Shift

At the Input Time Source (Front) screen select touch Fibre, Differential or TTL corresponding to the connector in use and choose DCLS in Normal or Inverted column to suit the code being measured.

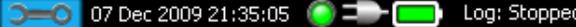
The code waveform below is typical of a Normal polarity IRIG B waveform suitable for connection to the TTL input.

The input threshold at 1.25V allows a 5V signal from a 50ohm source to be terminated in 50ohm at TimeSpy's input by placement of a 50ohm through-termination. However, IRIG timecode sources sometimes have 600ohm or higher impedance and should not be terminated.



DC Level Shift Measurement Screen

Time Difference Measurement	
Time Source:	DC Level Shift Timecode
Input Level:	Not Available
Code Type:	IRIG B 200-04
IEEE Data:	N/A
Code Time:	09 341 21:35:04
TimeAcc Time:	09 341 21:35:04
Inst Time Diff:	+41.8ns
Mean Time Diff:	+41.7ns (28 samples)
Standard Dev:	0.115ns (28 samples)
Sample Number:	28

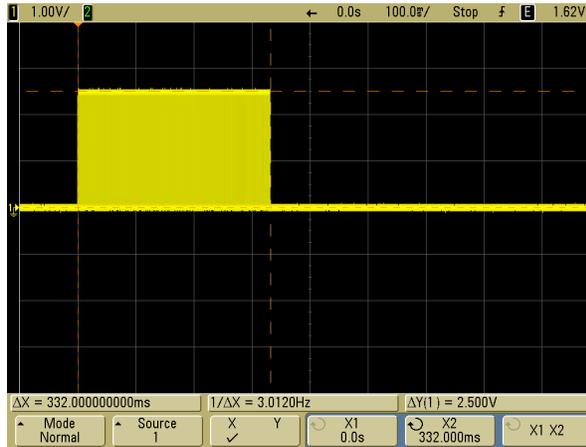

07 Dec 2009 21:35:05 Log: Stopped

Have Quick Measurement

Follow the procedure Have Quick Measurement Selection on page 44 of this manual to select the measurement facility. The specification of Have Quick is found in the Navstar GPS Phase III Interface Control Document GPS-060. Extended Have Quick is specified in the NATO Standardisation Agreement STANAG 4430. The electrical signal is 0 to 5V so is connected to the TTL input of TimeSpy. The complete message frame takes up to 331.2ms to be completed, at which point TimeSpy will update the measurement screen when the full contents of the message are known. For this reason there is a visible delay in the

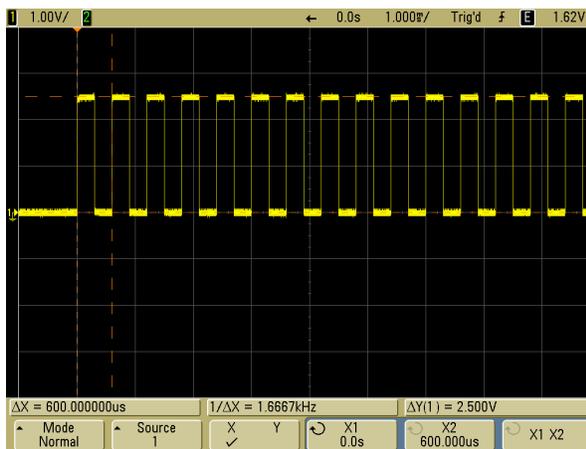
update time of the Code Time in the TimeSpy display. The complete frame over 1 second is shown below

Have Quick Frame



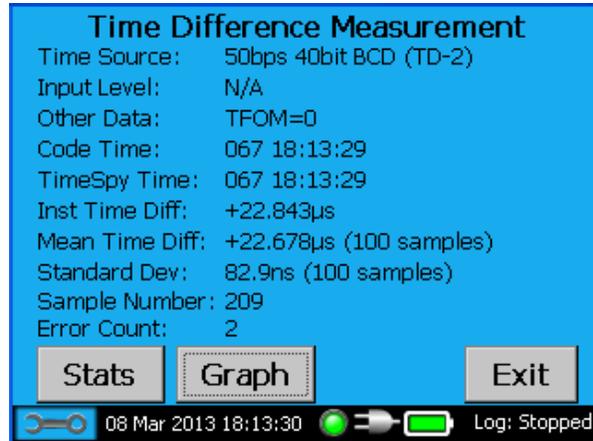
Have Quick Start of Frame on-time point

The signal employs bi-phase Manchester II transmission with a logical '1' being 300μs of a high state followed by 300μs of a low state. A logical '0' is 300μs low followed by 300μs high. At the start a phasing pattern of 240ms contains just zeros so appears as a square wave at 1.667kHz. TimeSpy identifies the first rising edge of the code frame for the precise time measurement reported as Instantaneous Time Difference. The start of a frame is shown in more detail below



Have Quick Measurement Screen

The measurement screen shows the Time Source Type as Have Quick or Have Quick (Extended). Have Quick code carries Year, Day of Year and Time of Day together with a Time Figure of Merit (TFOM). Extended Have Quick adds Leap Second Indicators shown as LP (1=leap second pending), LSD (Leap Second Day being the day of year number on which it takes place).

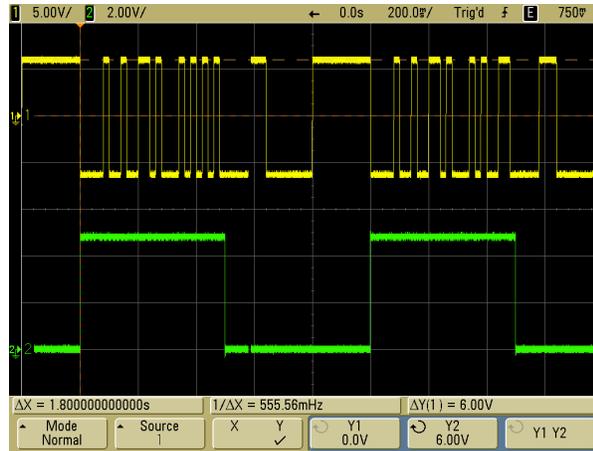


***50bps BCD
Measurement***

Follow the procedure 50bps BCD Measurement Selection on page 44 of this manual to select the measurement facility. The specification of 40bit 50bps BCD is found in the Navstar GPS Phase III Interface Control Document GPS-060. The 24 bit version omits day of year and TFOM and carries time of day only; TimeSpy shows TFOM value as N/A in this case. The electrical signal as standard is differential (D.D-SD 1399 (Navy) or V11) so is connected to the differential time code input of TimeSpy. The complete message frame carries the time data for the epoch at the start of the frame and takes 1s to be transmitted, at which point TimeSpy will update the measurement screen when the full contents of the message are known. For this reason TimeSpy time, underneath the Code time on the display, is captured at the start of the code frame one second earlier so that it displays the same time when the code is correct.

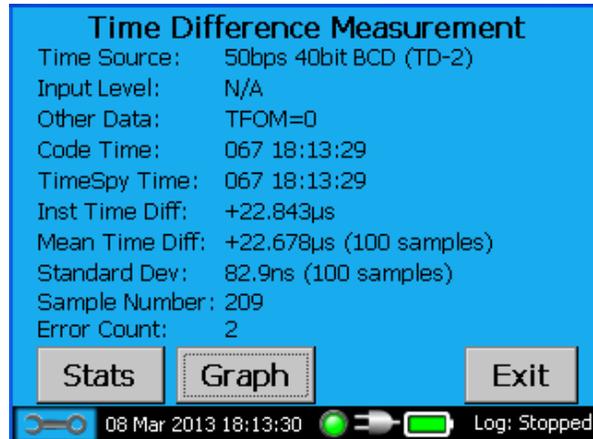
***50bps BCD
Start of Frame
on-time point***

The data viewed by placing an oscilloscope probe on the positive line of the differential pair is shown below with a reference 1Hz signal below it; the rising edge of the 1Hz is on-time. TimeSpy identifies the corresponding falling edge at the start of a new second of 50bps BCD data and directs it to the precision time difference measurement hardware



**50bps BCD
Measurement
Screen**

The measurement screen shows the Time Source Type as 50bps 40bit (TD-2) or 50bps 24bit. The 40bit version carries Day of Year and Time of Day together with a Time Figure of Merit (TFOM). The error count is incremented when a new time frame is found to contain time data which is not 1s advanced on the previous frame.

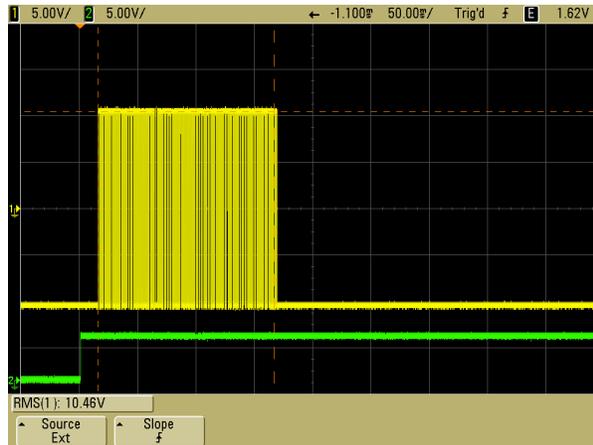


**ASCII Serial
Message**

“Serial Message Start Time Measurement ” selection is described starting on page 41.

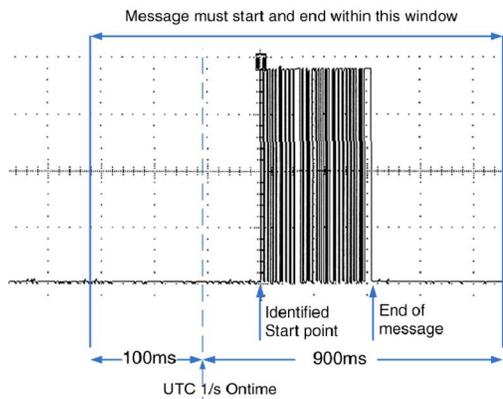
The user can connect an RS232 serial data source to the RS232 input or an RS422 source to the RS422 input; the connectors are at the rear of the instrument. On TimeSpy only one of these sources may be connected during measurements because the data from each connector is OR’ed for measurement after the serial input buffer for the data type in use.

An oscilloscope picture of a typical NMEA message, in this case at the RS232 input, with an accompanying pulse, is shown below.



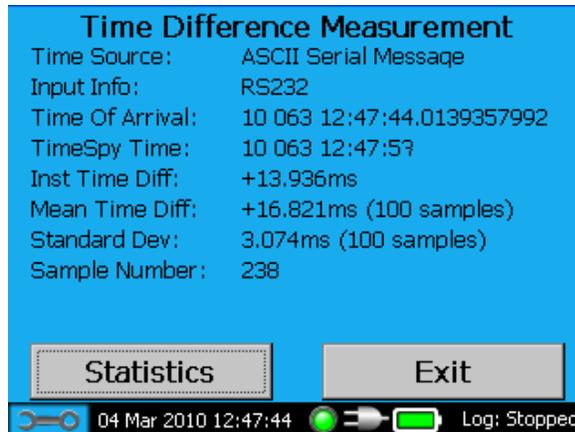
**ASCII Serial
Message Start
Measurement**

In this mode TimeSpy opens a signal gate at 900ms after the current second's on-time point (100ms prior to the next second's on-time). The first start bit transition detected in a serial message triggers the measurement (see 'identified start point') and closes the gate, locking out any further transitions in the serial message until the next gate time. An on-time message can have a maximum length of 900ms. This timing is illustrated below showing the arrival of an RS232 serial message.



**ASCII Serial
Message Start
Measurement
Screen**

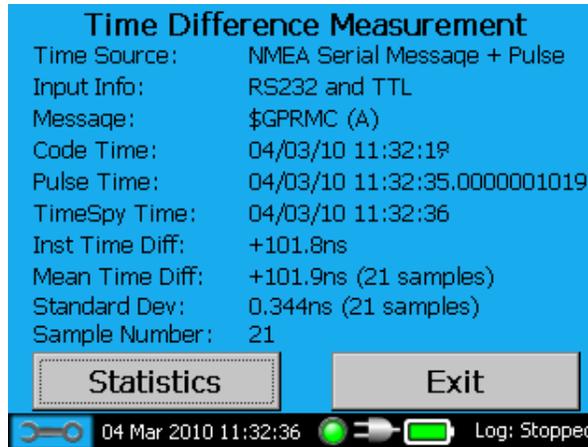
In the Measurement Start mode TimeSpy identifies the first start bit as shown above. In this example the start is about 14ms after the reference 1pps



***RS232 NMEA
Serial Message
with Pulse
Measurement***

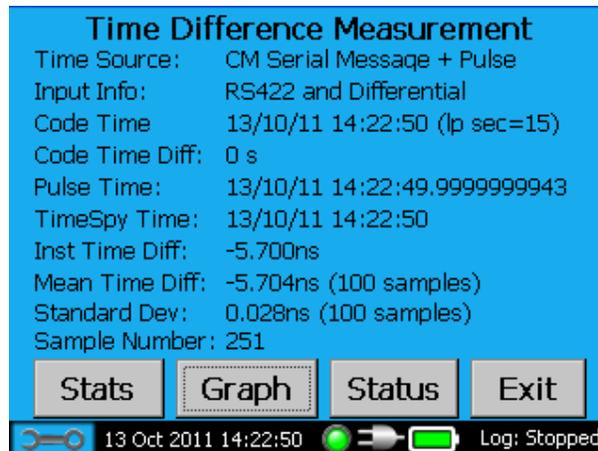
TimeSpy will read and automatically identify specific NMEA 0183 messages. NMEA is the National Marine Electronics Association (of the USA); standard 0183 describes serial character and message formats for Interfacing Marine Electronic Navigational Devices. For many years the same message structure has been widely adopted in GPS receivers. Many are capable of recovering precise time and provide a pulse output of which the epoch may be described by data in the accompanying messages.

Refer to "Connection of Serial Message and Pulse " on page 42. TimeSpy displays the Difference Measurement screen for NMEA Serial Message + Pulse. It extracts the time and date information for display as 'code time', measures the Pulse Time and displays TimeSpy reference clock time for comparison. Statistics of the pulse time are displayed in the usual way. TimeSpy automatically identifies \$GPRMC and \$GPZDA messages and displays the time and date decoded from those messages as Code Time. \$GPRMC messages include a field which carries a single character A or V where A is 'normal' and V is 'warning' usually meaning that the time cannot be trusted. This character is displayed after the Message type description.



***China Mobile
ToD and 1pps
Measurement***

Refer to RS232 or RS422 Measurement Selection and following information on page 40. The baud rate and character format of TimeSpy’s serial data receiver is automatically set to 9600 baud, 8 data bits, No Parity, 1 Stop bit when China Mobile Time of Day is selected. Normally RS422 should be chosen as the interface type and the pulse must therefore be connected to the differential pulse input. At the Measurement Type screen described on page touch the “China Mobile + Pulse” bar followed by OK to see the Measurement Screen

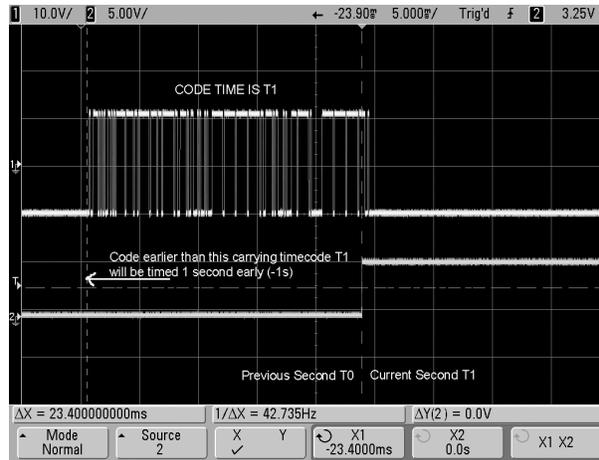


If the pulse is not connected (or is not connected to the correct input port then only the Code Time will update. GPS time in the received message is converted to UTC for display, using the GPS-UTC leap second count in the message. The time difference TimeSpy – Code Time is displayed as Code Time Diff. The China Mobile Time of Day Datalog shows the time at which the pulse was received together with the whole number of seconds of TimeSpy-Timecode differenc in the Ref-Timecode column:

Sample	Source	Date	HH:MM	Seconds	Ref-Source ns	Ref-Timecode s	Ref Clk Status
1	2D	13/10/2011	14:29	9.999999994	-5.7	0	OK
2	2D	13/10/2011	14:29	10.999999999	-5.7	0	OK
3	2D	13/10/2011	14:29	11.999999999	-5.7	0	OK
4	2D	13/10/2011	14:29	12.999999999	-5.7	0	OK

**China Mobile
ToD Code Time
Evaluation**

TimeSpy measures the time at which the ToD message arrives in order to determine the value of Ref – Timecode in whole seconds. The boundary at which the ToD message first start bit is placed in the previous or current second is about 23ms earlier than the current second update, corresponding to the end of the ToD message at the current second. If the code carrying the time for the current second T1 arrives earlier than that then its arrival time is assigned to the previous second T0 so that when the calculation Ref-Timecode T0-T1 is carried out it will be -1s. The time of arrival of the first start bit of the ToD code can be measured using the ASCII Serial Message Start Measurement described on 55 of this manual



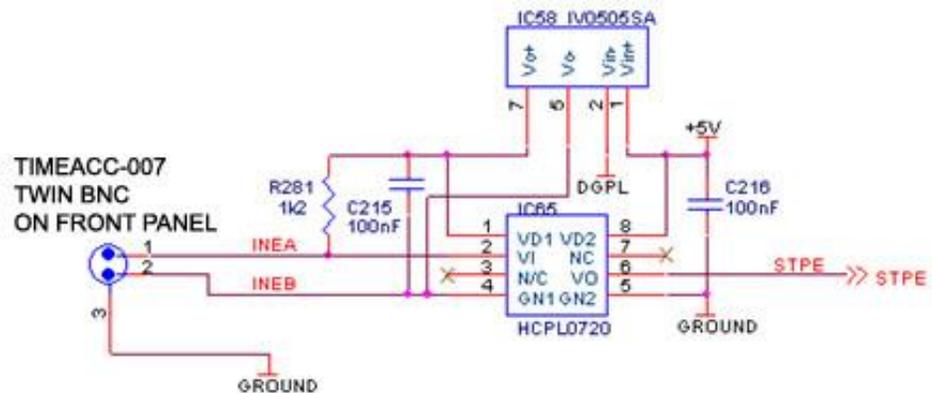
**China Mobile
ToD Status**

Touch Status on the Time Difference Measurement screen to view additional information decoded from the China Mobile message including the GPS Time, Leap Seconds, Jitter and Status.



Relay Contact Measurement

Relay contact opening or closing can be sensed for precise time measurement. The twin BNC in the centre of the front panel carries two isolated connections fed by a contact sensing circuit. The contacts to be measure must normally be 'free', that is to say they have no voltage present on them when open or shut. The sensing is provided by TimeSpy which sources an isolated 5V through 1k2 to the female contact in the twin BNC. The return is via the male contact in the isolated BNC. Neither of these internal pins has any connection to ground. The input circuit is shown below:-



IC58 supplies the isolated 5V into pin 1 of the twin BNC (female pin). When the pins are unconnected by any external circuit current through the 1k2 passes into the input of the high-speed opto-isolator IC65. This device has only 40ns propagation delay allowing the input to be used for general purpose high-speed event timing, if a fully isolated input is required, as well as for simple mechanical contact opening or closing. Select contact On Contact Close or On contact Open to suit the application and measurement required (see Relay Contact Selection on page 42).

**TimeSpy
Network Time
Protocol set up**

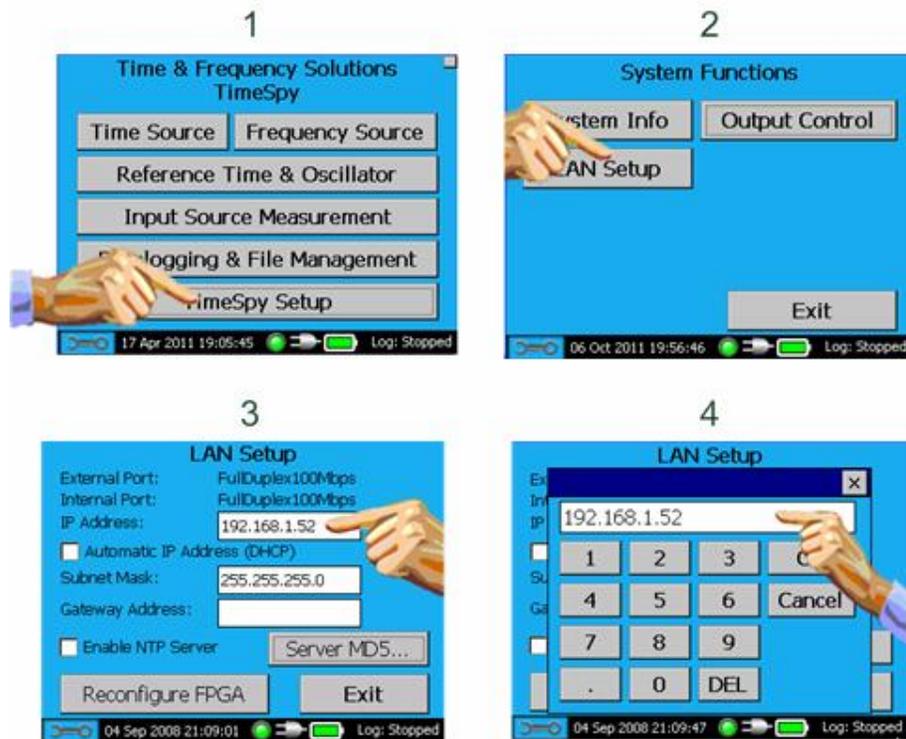
Connect TimeSpy to a network, or directly to an NTP server network port, though its rear-panel RJ45 connector. See Ethernet Port Selection (Rear Panel) on page 16 for a description of the 3 rear panel RJ45 connectors.

TimeSpy Elite setup is described in the paragraphs following "TimeSpy Elite NTP via SFP Module" on page 62.

**Manual Entry of
TimeSpy's IP
Address**

TimeSpy must have its own IP Address for operation on a network or with an NTP server. If a specific address is desired or has been allocated by an administrator then it can be entered manually

Starting at the Main Menu, follow the steps shown in the figure below:-



**Automatic
entry of
TimeSpy's IP
Address**

Note at step 3, if TimeSpy is connected to a network on which a DHCP server is present, and automatic address allocation is required, then simply check the Automatic IP Address (DHCP) box. The entry boxes will become 'greyed'. The DHCP server will automatically supply TimeSpy with IP address, subnet mask and gateway addresses. If the user wants to allocate an address manually then at stage 3 above he must uncheck the Automatic IP Address (DHCP) box and enter an IP address, subnet mask and, if the server to be measured lies outside of

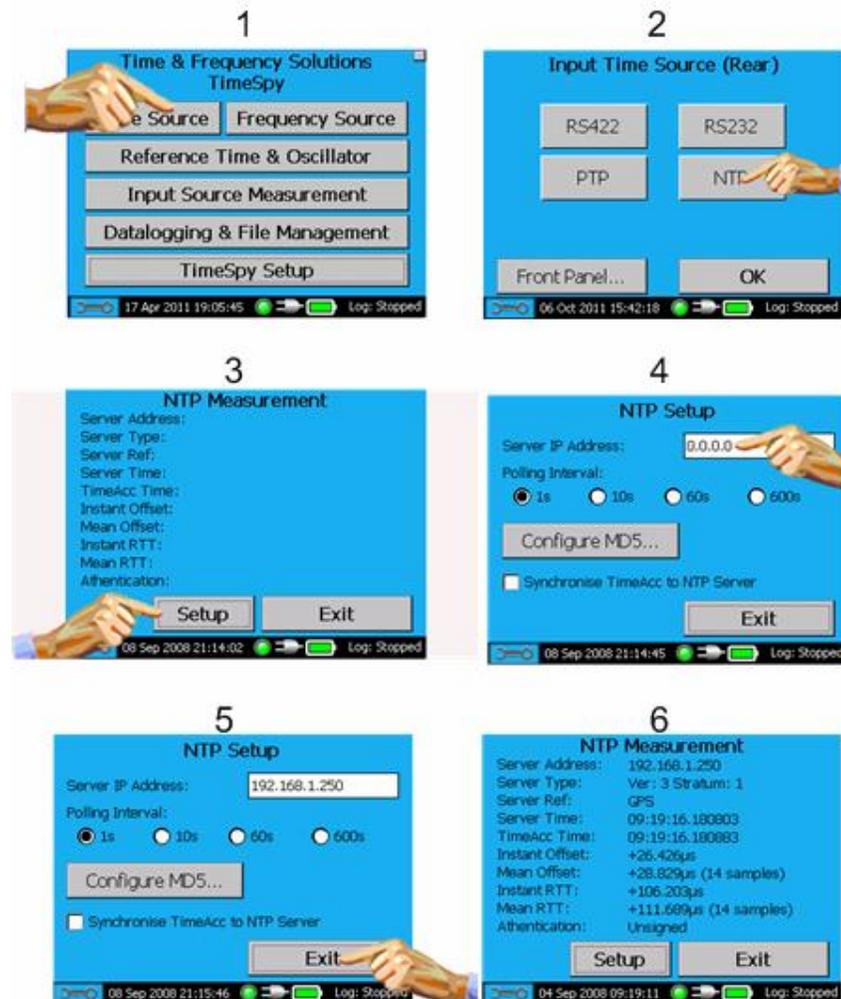
the local area network, a Gateway Address through which the NTP server can be reached. In each case the relevant box is touched in figure 3 and the keyboard pops up to allow address entry as in 4. The user must then touch Exit to leave this data entry screen. If changes have been made, TimeSpy will ask "Do you want to save the new network settings?" at which OK should be touched to update the settings

NTP Server Address Entry

Touch Exit to leave the LAN setup screen and touch Exit again to leave the System Functions screen to return to Input Time Source Selection.

NTP Setup Screen

Follow the steps below from the main menu to reach the NTP measurement and setup screens.



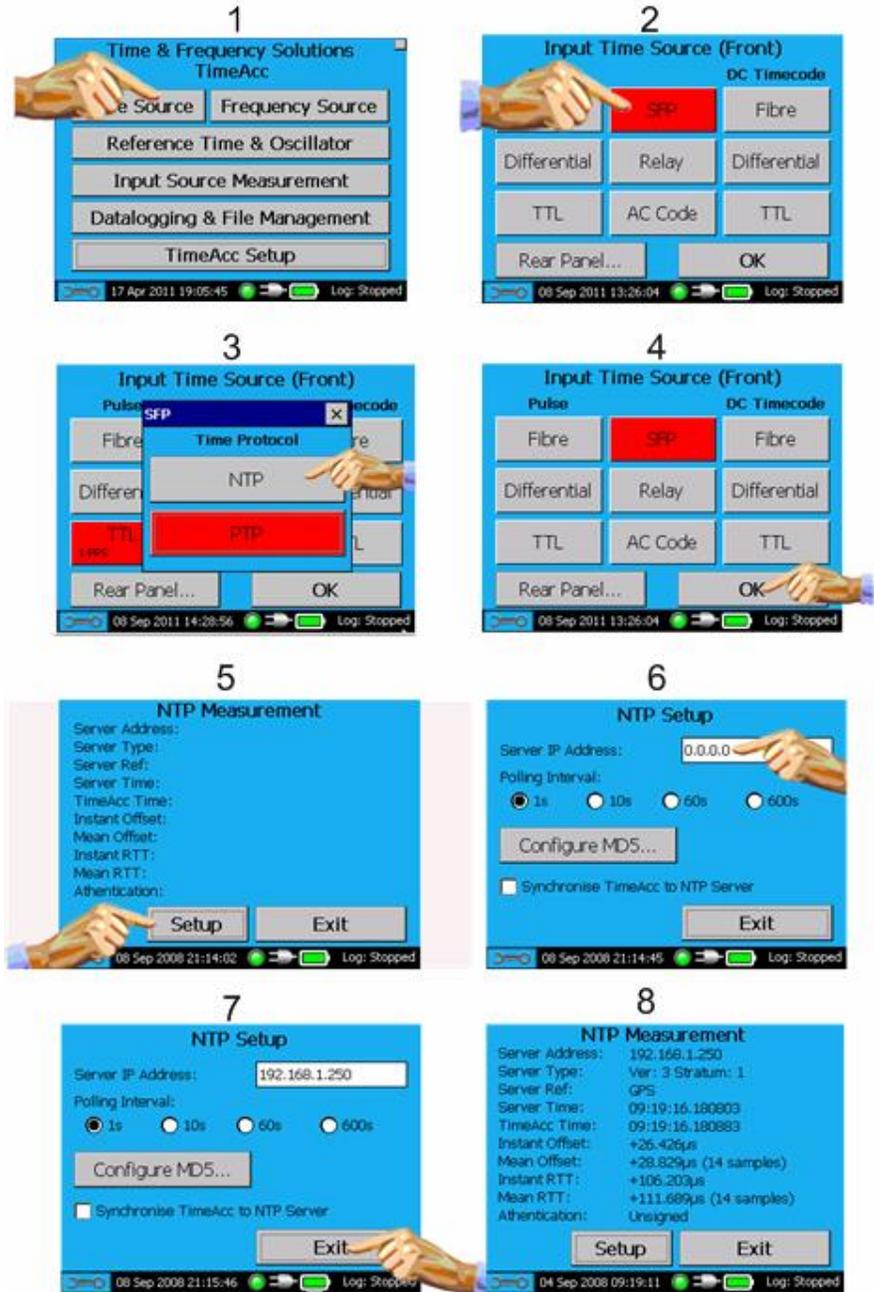
Selecting the IP Address box in step 5 brings up the numeric data entry

form in which an NTP Server Address must be defined. Note that, after power-down, the defined NTP server address is lost and must be re-entered at this page.

**TimeSpy Elite
NTP via SFP
Module**

**SFP Protocol
Selection**

TimeSpy Elite is equipped with the SFP option at the front panel; make sure that the desired SFP type is correctly installed prior to switch-on. Follow the sequence shown below to set up and view the NTP measurement screen



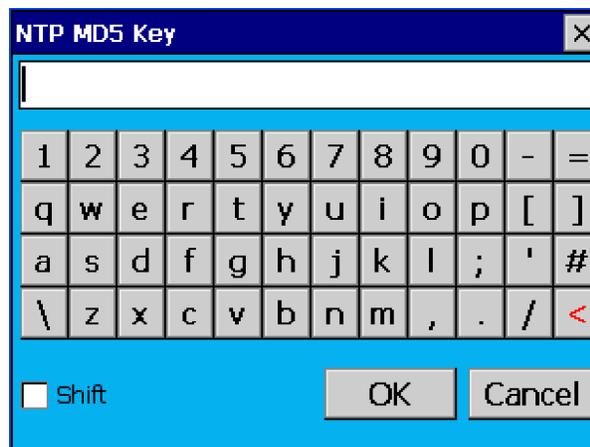
Polling Interval TimeSpy acts as a client to the designated NTP server and determines how often the dialogue with the server will take place. As a default, the interval is set to once per second. Polling Interval can be selected by touching the chosen radio button after step 4 above to select the value from 1, 10, 60 or 600 seconds. Note that, while it is interesting and useful to obtain repeated time estimations from the server to compare with TimeSpy's reference time, normally a client will poll the server at a minimum interval of 64 seconds as recommended by RFC1305.

MD5 Authentication If the NTP server uses MD5 Authentication and the key ID and key are known then the user can authenticate the server packets by checking the "Use MD5 Authentication" box at step 4 above. Note that the client can obtain time from the server without the key, the purpose of the key is to assure the client that the origin of the message is genuine – the content of the message, namely UTC, is already 'public'.

Entry of the MD5 Key ID is made by touching on the "MD5 Key Id" box in the NTP Setup screen and the use of TimeSpy's numeric data entry form. The Key Id is a number between 1 and 65535. Similarly touching on the MD5 Key box brings up the TimeSpy's alphabetic entry keyboard allowing entry of the required 1 to 8 ASCII characters.

An NTP server using MD5 adds the Key ID as 32 bits (of which only 16 are required) and the 'message digest', the result of 'hashing' the NTP packet with the key, as 128 bits to the end of the NTP packet. Note that the server has first to strobe its current time then calculate the message digest before it can transmit server time. TimeSpy is able to detect this additional delay.

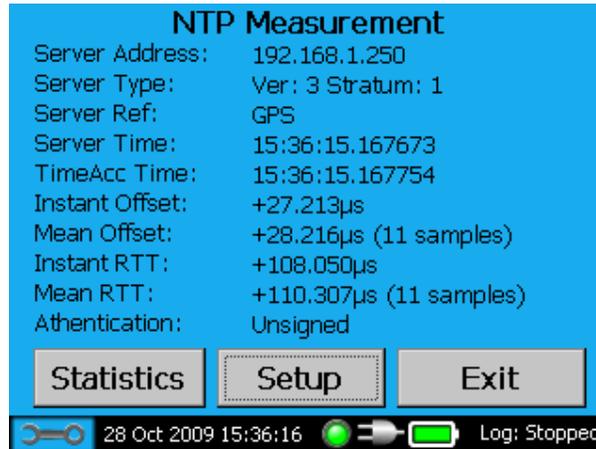
Entry of the MD5 Key



Network Time Touch Input Time Source Selection, NTP, and then OK to reach the

Protocol Measurements

measurement screen for NTP Measurements. Touch Setup at this page to enter the NTP Server IP Address, Polling Interval and, if required, MD5 Key Id and MD5 Key as described under Input Time Source Selection above. Touch Exit to Exit Setup when complete and return to the NTP Measurement Page.



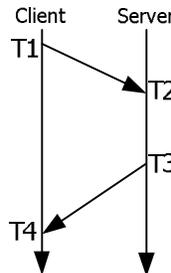
After each poll of the designated NTP server TimeSpy updates the NTP Measurement screen.

Instant Offset

Network Time Protocol requires four time measurements of specially designed packets as follows

- T1 = time of transmission from client (TimeSpy)
- T2 = time of receipt at server
- T3 = time of transmission from server
- T4 = time of receipt at client (TimeSpy)

These times can be shown diagrammatically for server and client each having a timescale, in this case, that goes down the page



TimeSpy calculates the time difference of the server using the same method as a standard NTP client, with the benefit of precision time-stamping of T1 and T4 using its specially developed hardware to place the client time stamps at the Physical Line Driver (PHY). In this way errors in timing introduced by the NTP packet reception and processing

latency are removed. It is reliant on the server for the precision of T2 and T3. Unlike a normal NTP client, TimeSpy also has a precision reference clock. The instant offset between this reference clock time 'TimeSpy' and 'Server' is calculated as TimeSpy-Server by averaging the results of two time difference measurements to find

$$1/2[(T1-T2) +(T4-T3)]$$

The sign convention used is such that a server which is slow or delayed results in a positive Instant Offset result. The resulting offset is the sum of the difference between the transmission delays (assumed equal by NTP but asymmetric in practice) and the difference between the server's clock time and TimeSpys reference clock time.

Round Trip Time

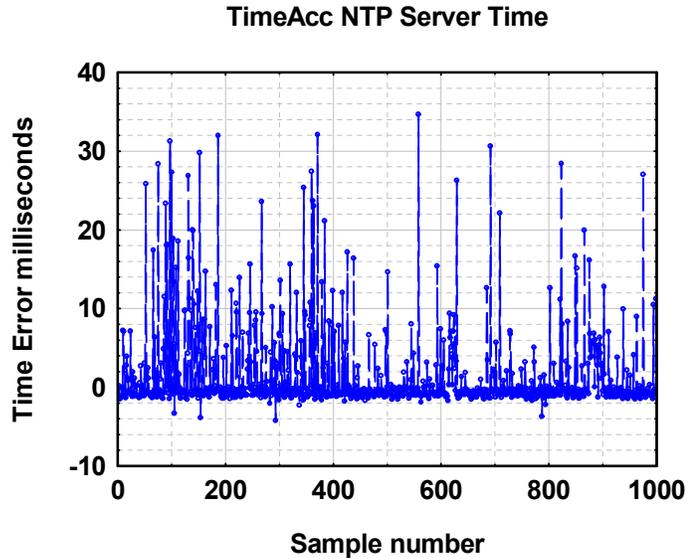
RTT is the Round Trip Time is the sum of the time it takes for the first client packet to reach the server and the time for the resulting server packet to reach the client. The 'dead time' of the server is therefore not included in Round Trip Time. It can be expressed as

$$[(T2-T1)+(T4-T3)]$$

or equally well as $[(T4-T1)-(T3-T2)]$

TimeSpy as NTP Server

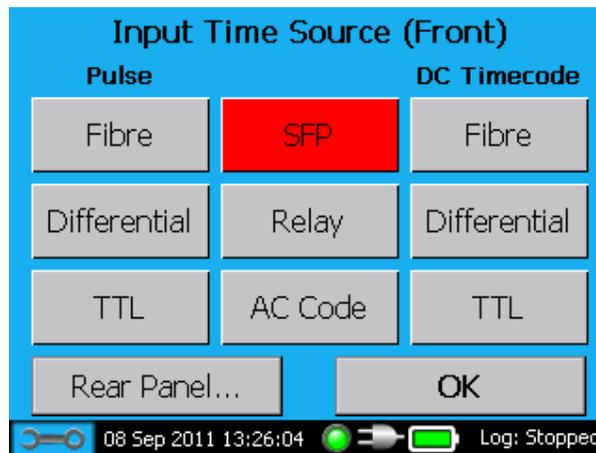
An NTP server capability is built-in to TimeSpy. Although the server is synchronised by TimeSpy's very precise reference clock it does NOT use the hardware measurement techniques employed by TimeSpy in its primary role when it acts as a client to measure and quantify the performance of other NTP servers. To enable TimeSpy's own server make sure that TimeSpy has been given an IP address and (see TimeSpy Network Time Protocol set up) at step 3 of the entry procedure check the box "Enable NTP Server" on the LAN Setup page. Enter TimeSpy's IP address as the server address for any client it is desired to test. The precision of the server is limited by the Graphical User Interface which provides this feature of TimeSpy. The mean time error of TimeSpy's server is about 1ms and its standard deviation measures 5ms. The poor accuracy and high standard deviation result from the simple design of the server within the user interface operating system causing large outliers. The server is intended to be only a basic 'go/no go' test facility.



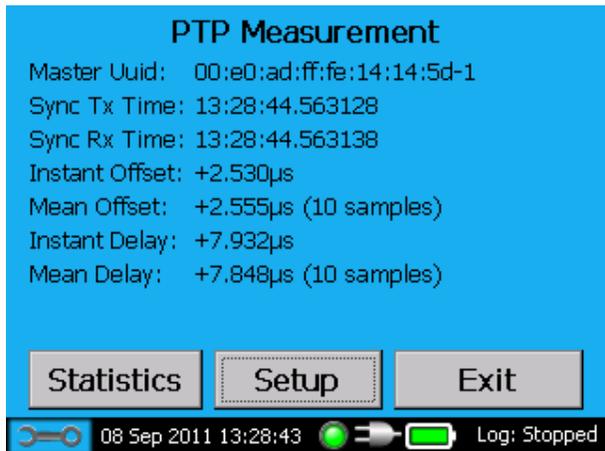
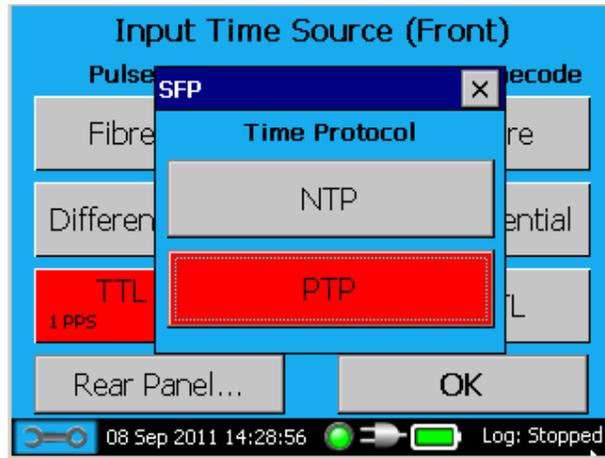
Precision Time Protocol Measurement

See Precision Time Protocol IEEE 1588 (PTP) Selection as described on page 44 of this manual; measurement of IEEE1588-V2 PTP Grandmaster Clocks is provided. Touch Input Time Source Selection, PTP, and then OK to reach the measurement screen for PTP Measurements.

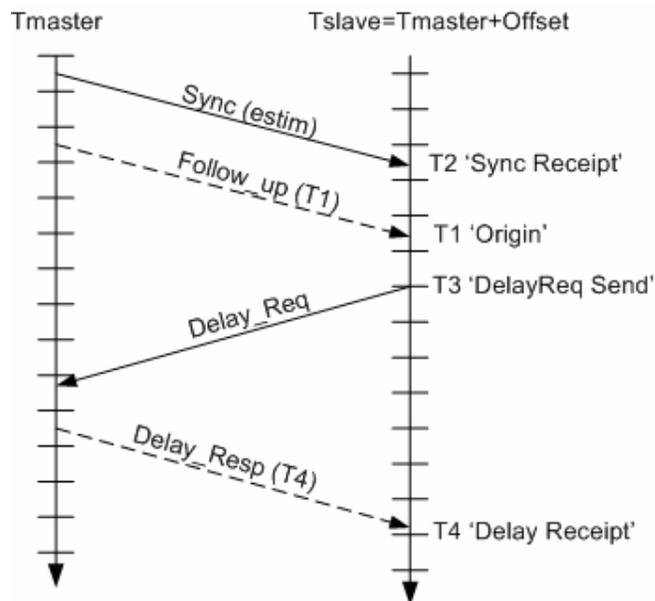
If the instrument is fitted with SFP then touch Time Source at the main menu, front panel where the SFP button is visible



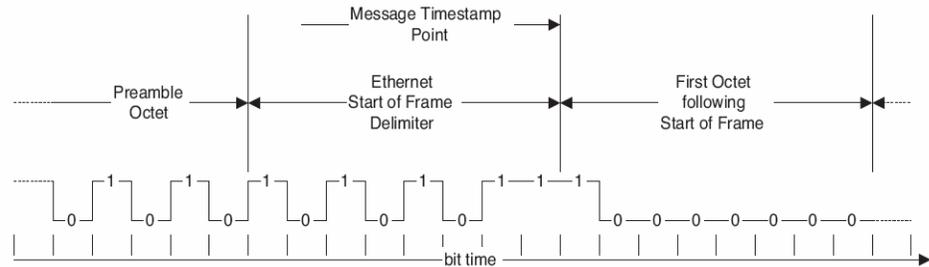
Select the protocol by touching PTP on the SFP Time Protocol screen that appears



***PTP
Measurement
Detail***



T1 and T4 are values that the Grandmaster clock transmits to TimeSpy. T2 and T3 are time measurements that TimeSpy makes using its special physical layer measurement hardware. This hardware listens to an incoming Ethernet packet, then identifies and times the first edge of the first octet immediately following the Start Frame section of the packet.



An offset measurement is made which estimates the difference between the Grandmaster and TimeSpy. A delay measurement is also made, which is the time taken for the time to be transferred from the Grandmaster.

These measurements are given on the measurement and statistics pages. The Measurement page reports the Master Uuid, which is the PTP port address and number, the Instant and Mean Offsets and Delays. The Statistic page gives results over longer time periods.

PTP Statistics



The key times described above can be found in TimeSpy’s datalog of the PTP measurement for each PTP ‘transaction’, together with the ‘offset’ of the Grandmaster measured against TimeSpy’s reference clock. See Example PTP Datalog File on Page 88.

PTP Delay

There are two delay mechanisms, either Delay Request or Peer (Path)

Mechanisms

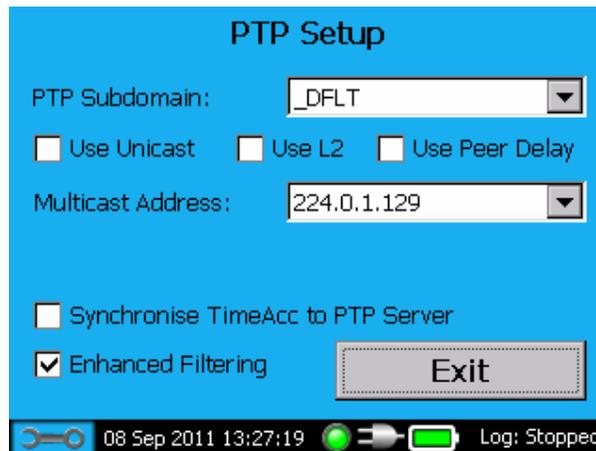
Delay methods. With Delay Request mechanism the delay right back to the Clock is measured, possibly through many Transparent PTP clocks.

Peer Delay

With Peer Delay mechanism the delay only to the neighbouring PTP port is measured. The PTP device with this port also maintains a link delay measurement to its neighbouring PTP port, this being so for all links in the path back the Clock being measured. As a Sync Packet passes through all the PTP Ports its timestamp is adjusted at each step by the link delay to the PTP port from which it was obtained. The Clock Time is calculated as the received Sync Packet time, corrected for the Peer Delay measurement made to the neighbouring PTP port. Peer Delay measurements are made by the unit transmitting a time-stamped Peer Delay Request multicast packet on address 224.0.0.107 (IPV4) or 01-80-C2-00-00-0E (L2). Neighbouring ports give the Peer Response packet.

PTP Measurement Operation

Touch Setup at this page to view the PTP Subdomain and address box pages.



PTP Subdomain

The PTP Subdomain is the synchronisation network on which the Grandmaster or Boundary Clock to be measured is situated. The subdomain *_DFLT* refers to domain 0 of IEEE1588-V2, *_ALT1* to *_ALT3* refers to domains 1 to 3. Further domains 4 to 255 can also be selected in the drop down list.

A Grandmaster or Boundary clock can operate in two ways to distribute time. It can send Announce and Sync messages either on a multicast address, or to a unicast address. When operating in unicast mode the address of the Clock to be measured has to be specified. Measurements can be made in two addressing modes, using either

IPV4 or Ethernet (Layer 2, or L2) Addressing, as set out in IEEE1588-V2, Annex D or Annex F.

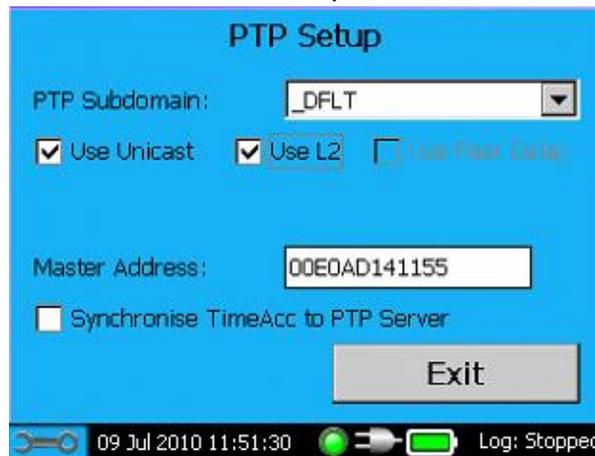
**MULTICAST
OPERATION**

When in IPV4 multicast mode the unit must be configured with the multicast address which can be one of 224.0.1.129/130/131. The default IEEE1588-V2 IPV4 multicast address is 224.0.1.129. In L2 mode the multicast MAC address is defined as 01-1B-19-00-00-00.

The unit will then listen for Sync Packets on the multicast address. When one is received, it will send a delay packet to measure the network delays.

**UNICAST
OPERATION**

When in unicast mode a Grandmaster or Boundary clock will send, by prior negotiation, Sync and Announce packets once per second to the unit. The unit has to be set up with either the IP or MAC address of the Clock. An IPV4 address has to be reachable, so, if the Grandmaster clock is on another IP Subdomain, the unit's Gateway and Netmask addresses also need to be specified. Likewise for L2 measurements the underlying network has to be configured to allow the Clock to be reached from the measurement point.





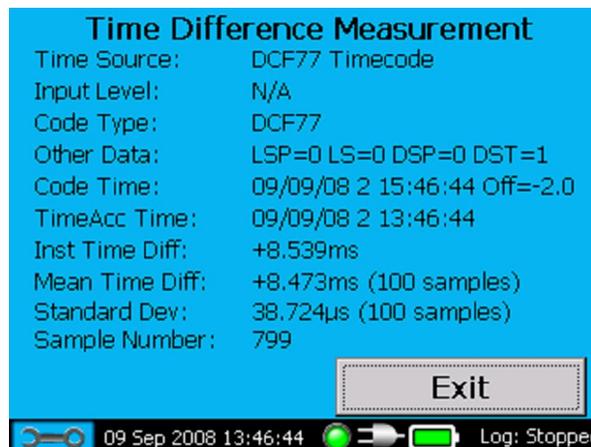
When the unit receives a Sync Packet it will send a delay packet to complete the measurement.

Network Considerations

Two UDP port numbers are used in the PTP protocol when using IPV4. PTP_Sync or Delay_Req PTP messages are defined as EventPorts, called ptp-event by IANA (Internet Assigned Ports Authority), and this port number is 319. PTP Follow_Up and Delay_Resp port called ptp-general is port 320. It is necessary that IP packets with these UDP port numbers are allowed through any network devices between the unit and the PTP Clock being measured.

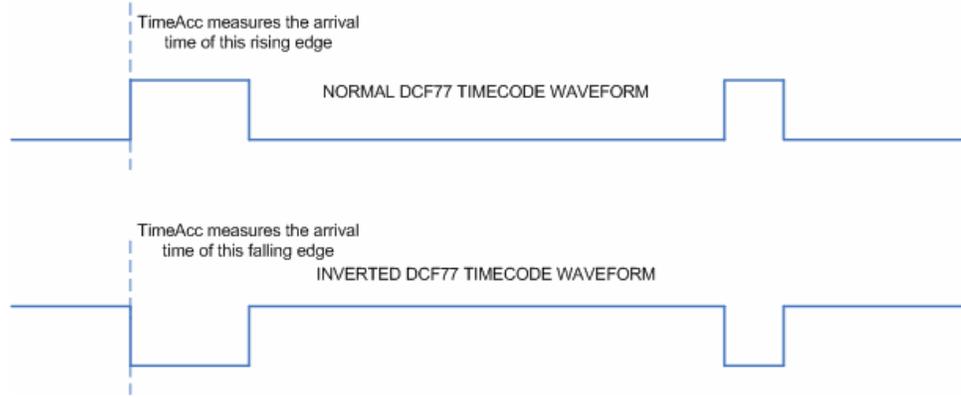
DCF-77 Timecode

Touch Input Time Source Selection, DCF-77 Timecode, and then OK to reach this measurement screen. See DCF-77 Timecode Measurement Selection on Page 44 of this manual. The DCF-77 source should be connected to the appropriate DC Timecode input connector at the front of TimeSpy. The TTL input accepts logic level signals in the range 0 to 5V with a threshold that is preset to 1.25V, allowing a 50ohm source 0 to 5V logic signal to be terminated at TimeSpy by 50ohms.



**Polarity of
DCF77**

The polarity of the DCF-77 code is automatically assessed continuously over 5 seconds and the polarity of the measurement is reversed at the end of the 5 second period if the signal is found to be inverted. A non-inverted DCF-77 timecode has a positive rising edge at the second update with DC input at high logic level for 100 or 200ms.



An inverted timecode will be recognised after 5 seconds and the measurement of the falling edge of the pulse will be automatically selected.

**DCF-77
Decoding**

On first access to the DCF-77 measurement screen, if no signal is connected to the DC Timecode input, then no data is shown. On reception of the first seconds' marker update commences (and will continue even if the signal is disconnected). If no signal was previously connected then time and date will be shown as zero with an incrementing seconds count that is not yet synchronised. At the first detection of second 59 (at which the second's marker is absent) the DCF77 decoder will synchronise the seconds count to the received timecode and proceed to decode the time and date information contained in the code during the following minute. When the seconds roll-over from 59 to 00 at the end of this minute the time decoded during the minute will be displayed. The decoded time is displayed in a line above TimeSpy time in the same format for direct comparison; the decoded time does not form part of the time difference calculation which shows the time difference of the active edge of the seconds marker, polarity selected as described above.

**DCF-77 Other
Data**

Off Offset is normally shown as 0.0, -1.0 or -2.0
Offset is the number of hours to add to the code time to calculate UTC
Other Data is shown as

LSP Leap Second Pending (DCF-77 second19)
LS Leap second sign (not available, always 0 for positive)
DSP Daylight Savings Pending (DCF-77 marker 16)
DST Daylight Savings Time (1 or 2 markers 17 and 18)

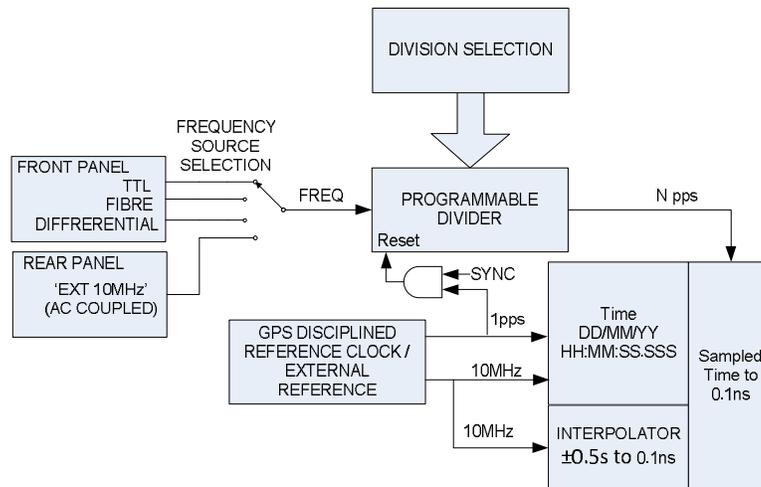
Chapter 7

Frequency Measurement

Introduction

A frequency divider facility in TimeSpy allows frequency measurements to be made continuously. A programmable divider counts cycles of the input frequency and the divider output pulse time of arrival is measured against TimeSpy reference clock time and recorded. From the subsequent pulse arrival time and the division value the frequency is calculated over the pulse interval. Usually, though not necessarily, the frequency measured has a nominal value which is already well known and the divider can be set so that the pulse output, shown in the diagram as Npps, is either 1 or 10Hz. TimeSpy's continuous measurement method allows short term and long term stability measurements to be made.

Block Diagram of Operation



Input Selection

The frequency source can be selected from one of TimeSpy's DC coupled front panel inputs, namely TTL, Fibre or Differential, or, if the external 10MHz reference is not in use, from the Rear Panel 'EXT 10MHz' input which is AC coupled.

Division Selection

TimeSpy can divide the input frequency by any integer value from 2 to 134,217,727. Usually this value is set by the user to the value in Hz of the frequency which it is desired to measure. The signal Npps shown in the diagram above is then 1pps (or 10pps). After the division value is selected TimeSpy automatically synchronises the divider so that the phase of the Npps signal is approximately aligned with the reference

clock 1pps. This synchronisation sets the initial phase difference 1pps-Npps to a relatively low value for convenience. If faster measurements of frequency are required the user can check a box to set the division value to a tenth of the frequency so that the signal Npps becomes 10pps and measurements are then made at ten times per second to a resolution of between 100ps and 200ps

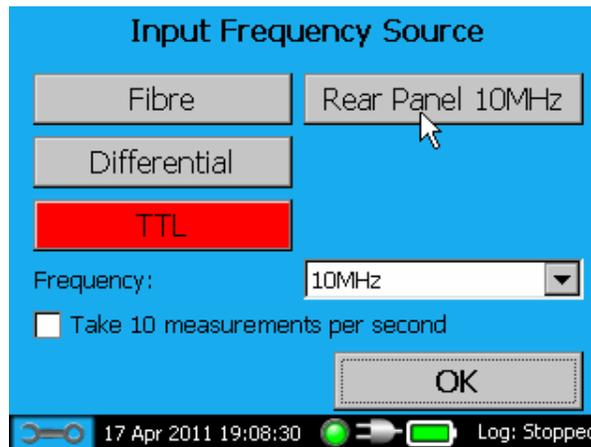
Frequency Measurement Selection

Frequency measurement is accessed from the main menu page by touching Frequency Source bar

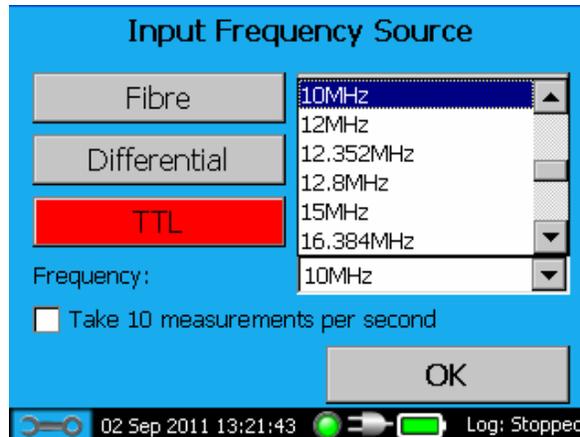


Input Frequency Source Selection and Configuration

Touching the Frequency Source bar calls up the Input Frequency Source selection and configuration screen



**Frequency
Divider
Selection**



At this screen the user specifies the frequency to be measured by selection from a drop down list of frequencies.

On confirmation by 'OK' the divider is set to the chosen frequency value so that the nominal measurement rate is once per second. If the 'Take 10 measurements per second' box is checked then the division value is set to one tenth of the frequency so that the measurement rate is nominally ten times per second. The list of nominal frequencies is shown below; others may be added. The default setting at start-up is 10MHz until the user has made a selection. If the nominal frequency to be measured is not in the list it can be measured with any divider setting provided that the rate is not faster than about 10 readings per second.

**Frequency
Calculation**

TimeSpy calculates the exact frequency using the difference between sample times and the divider value used. If T1 is a sample time followed by the next sample time T2 with division N then

$$\text{Frequency } f = \frac{N}{T1-T2}$$

Frequency is displayed in units of Hz with comma separation. In the datalog the commas are removed to prevent the number being interpreted as separate items in the log. The number of digits after the decimal point is limited to those which are relevant to the measurement resolution.

**Fractional
Frequency
Difference**

The fractional frequency difference is calculated as $\frac{f-f_0}{f_0}$

where f is the measured frequency and f₀ is the nominal frequency as selected by the user. The advantage of choosing N to be the value of the nominal frequency is that the fractional frequency value is then reported as a relatively small and simple positive or negative number

indicating the frequency departure from the nominal value. The frequency difference results are displayed and logged in scientific notation with the number of digits that are relevant to the measurement resolution.

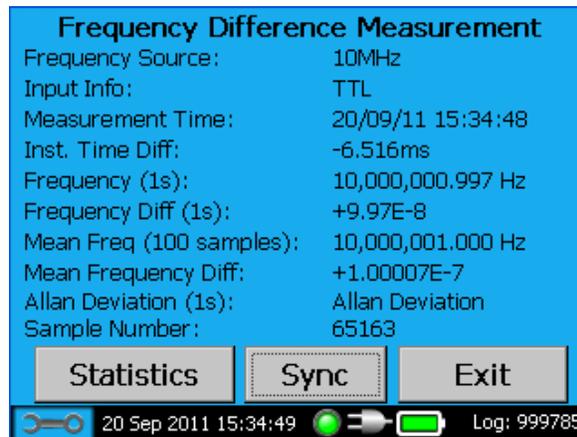
**Nominal
Frequency List**

The nominal frequency selections in the drop-down list are

50Hz	10kHz	1.544MHz	12.352MHz	24MHz	(64MHz)
60Hz	32.768kHz	2.048MHz	15MHz	32MHz	(64.8MHz)
100Hz	64kHz	5MHz	16.38MHz	40MHz	(70MHz)
1kHz	100kHz	10MHz	19.9608MHz	50MHz	(80MHz)
8kHz	1MHz	12MHz	20MHz	(60MHz)	

The front panel TTL input is limited to 50MHz

**Frequency
Display**



- Frequency Source:** The nominal frequency selected by the user. It determines the count of input cycles at which an output pulse is generated and measured by the time interval measurement system
- Input Info:** The input socket selected. Possible inputs are TTL, Differential, Fibre or Rear Panel 10MHz input socket
- Measurement Time:** The date and time of the end of the previous measurement and the start of the current measurement
- Inst. Time Diff:** The time difference of the pulse out of the frequency divider from reference clock time. When measurements are made at the nominal once per second rate the difference will be static for an input frequency which is exactly the nominal frequency. For readings at 10x per second the difference will be in 100ms intervals.
- Frequency (1s):** Frequency calculated from the difference between the most recent real-time of arrival of the pulse out

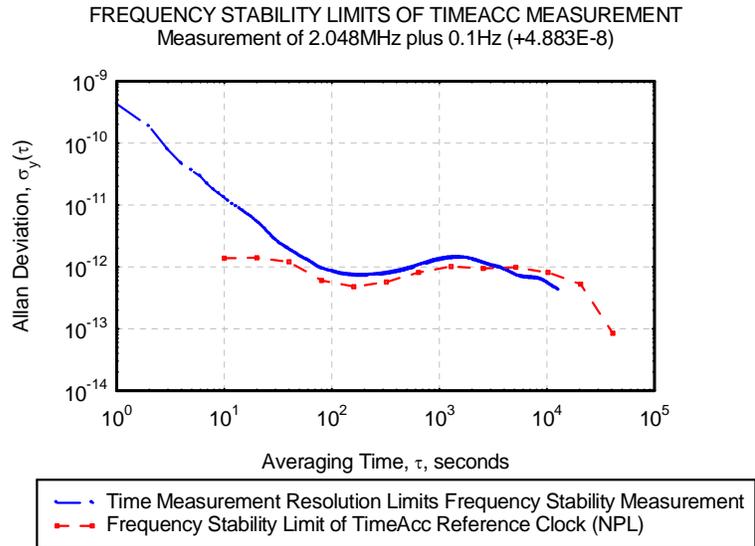
- of the frequency divider and the preceding pulse's arrival time. Time of day of the pulses from the frequency divider are saved in 100ps units.
- Frequency Diff (1s):** Fractional frequency difference of the calculated frequency above from the nominal frequency that sets the frequency divider value.
- Mean Frequency:** Frequency calculated from the difference between the most recent real-time of arrival of the pulse and the arrival time of the pulse 100 samples previously. If less than 100 samples have been received then the arrival time of the earliest available pulse is used in conjunction with the most recent pulse arrival time and actual number of samples (which is shown counting upwards to 100 in the brackets). The number is shown in Hz with sufficient decimal places for the precision of the result.
- Mean Freq Diff:** Fractional frequency difference of the calculated mean frequency above from the nominal frequency that the user has chosen to set the frequency divider value.
- Allan Deviation:** The square root of the Allan variance, a statistical calculation, known as $\sigma_y(\tau)$, intended to estimate frequency stability due to noise processes. Allan variance is defined as one half of the time average of the squares of the differences between successive pairs of the frequency differences over the sampling period
- Sample Number:** The number of frequency measurements since the selection of this measurement function or since SYNC was touched.
- SYNC** This button can be touched to reset the frequency divider that generates the pulses for time stamping and frequency calculation. In this way the time difference value can be set to a relatively low number corresponding to a cycle or two of the frequency being measured. Any existing statistics are also reset. The first subsequent frequency calculation requires two pulse time measurements so cannot occur until about 3 seconds later.

Limits of

Over averaging periods of less than 50s the frequency stability

**Frequency
Stability
Measurement**

measurement limits of the instrument are dominated by the resolution of the time measurement. At averaging times >50s the frequency stability of the reference clock is comparable and measurement resolutions of about 1E-12 are achieved from 100s onwards. These results were measured with an input frequency which was 10MHz plus 1Hz. The time measurement resolution and reference clock stability limits are illustrated below.



**Frequency
Datalog**

Frequency Datalog files have the format shown below.

Sample	Source	Date	HH:MM	Seconds	Time Diff ns	Frequency	Freq Diff	Ref Clk Status
1	OE09	07/09/2011	20:18	25	-1011.8	2048000.001	4.00E-10	OK
2	OE09	07/09/2011	20:18	26	-1012.3	2048000.001	5.00E-10	OK
3	OE09	07/09/2011	20:18	27	-1012.9	2048000.001	6.00E-10	OK
4	OE09	07/09/2011	20:18	28	-1013.4	2048000.001	5.00E-10	OK
5	OE09	07/09/2011	20:18	29	-1013.8	2048000.001	4.00E-10	OK

The columns are defined by commas and the rows by new lines within a simple text file

Column	Description of Information logged in the Column
Sample	Datalog sample since the start of logging
Source	A code describing the input source including the division selected from the division table/ nominal frequency index. The zeroes in this source and index are changed to the letter 'O' so that the string is accepted as text by the spreadsheet program.
Date	The date at the end of the frequency measurement
HH:MM	Hours and minutes of time at the end of the frequency measurement

Seconds	Seconds at the end of the frequency measurement
Time Diff	Time difference of the frequency divider output pulse
Frequency	Frequency measurement (0.001Hz high in example)
Freq Diff	Frequency difference from nominal value
OK	Reference Clock Status

Chapter 8

Datalogging and File Management

The measurements made by TimeSpy can be recorded for archiving and further analysis. The files can be saved internally in Compact Flash memory (for transfer over a network connection) or onto a USB memory stick, if one is installed in the front panel. If this function is required, ensure that a USB memory is installed in the Instrument's USB1.1 port. It will take a few moments for the presence of the stick to be recognised.

Datalogging Setup

The Datalogging control screen is reached by touching the Main Menu Datalogging and File Management bar.



Select the data logging frequency in the drop down box 'Save one sample out of' from 1 in 1, 10, 60, 100, 1000 or 3600.

To start select the START button, and to stop select the STOP button. A file is created at the 'root directory' of the USB memory. Its name is derived from the current date, "yymmdd_x.csv".

The 'full engineering data' selection box is to allow detailed data to be collected. The file name is "yymmdd_Ex.csv". This option will be described in more detail below.

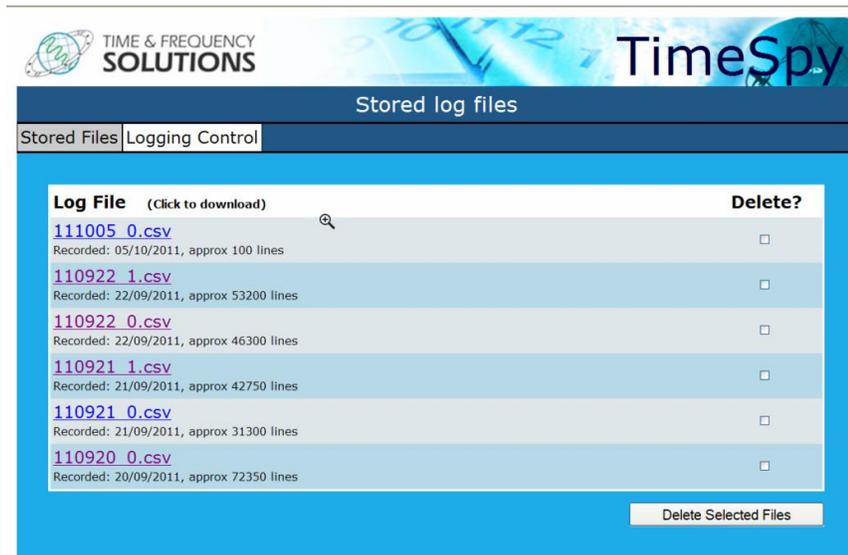
Log Julian Date (MJD)

The 'Log Julian date' selection box changes the first field of data in the logged file from Sample Number to Modified Julian Date (MJD). MJD is

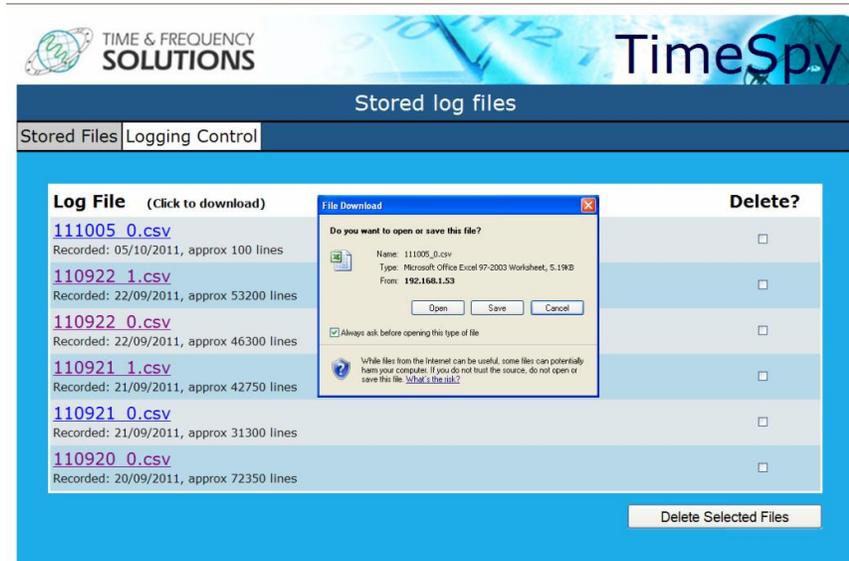
often used by National Standards laboratories for the time-tagging of data and so provides an easy way to compare data. It is a day count from a starting point of midnight on November 17, 1858. The integer part (whole days) is currently 5 digits in length and reached 51544 on 1st January 2000. TimeSpy logs all the leading digits plus a decimal point followed by 5 further digits to give about 1 second resolution in time-tagging data. It readily allows the continuity of the time base for the recorded samples to be maintained when logging of data is suspended then restarted to a new file.

**Web Page
Access to
Stored Files**

Files logged to Compact Flash memory inside TimeSpy are transferred out of TimeSpy by network access controlled through the web page. To access TimeSpy's web page, enter the IP address of TimeSpy into a web browser address bar. For example, if TimeSpy has been allocated the IP address 192.168.1.52 in the IP address entry procedure described above, enter its value in the bar as <http://192.168.1.52>. When access has been gained the Stored Files page is presented as below:-



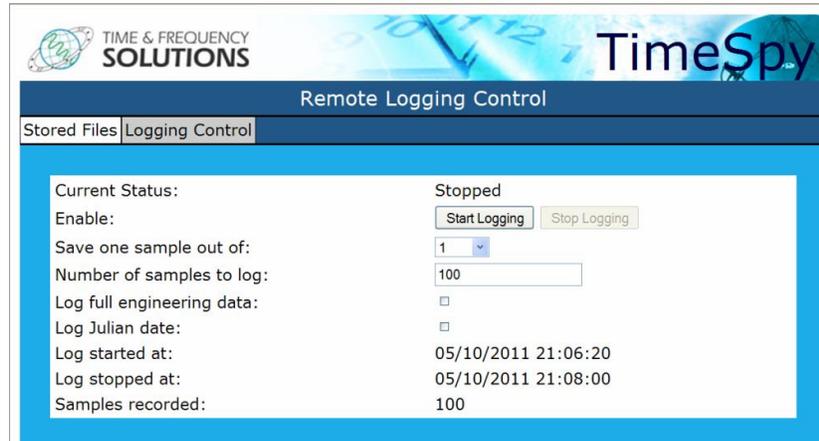
Files are sorted so that the latest file to be completed is at the top of the list on the page. The approximate number of datalogged lines is displayed. If logging is currently enabled, the filename in use is not displayed because it cannot be transferred or deleted until it is stopped. Clicking on the name of a file in the visible list opens a file download window which allows it to be transferred to the host computer:-



The transferred file remains in the Compact Flash memory of TimeSpy but can be deleted if the user ticks the delete box and confirms the deletion.

**Datalog
Remote Control
by Web Page
Access**

Clicking on the Logging Control tab gives access to the Logging Control page as below:-



This page can be used to set the same parameters for logging as the Datalogging and File Management page of TimeSpy itself and to start and stop the logging remotely.

**Format of
Datalog Files**

The datalogged files have a Comma Separated Variable (CSV) format, allowing easy importing into other PC applications, in particular spreadsheet programs such as Microsoft Excel. The first few lines of every datalog file form a header that gives details of TimeSpy hardware and software for traceability purposes. Each line of the header is

preceded by a semi-colon to give it the status of 'comment' and be treated as such by any subsequent programming. A typical header is:-

Datalog File Header

```
; 13 Dec 2012 17:26:35,Datalog started
; 13 Dec 2012 17:26:35,GUI Version: 1.3.0.193
; 13 Dec 2012 17:26:35,Net interface version: 1.3.0.193
; 13 Dec 2012 17:26:35,Net interface firmware: 3
; 13 Dec 2012 17:26:35,Ethernet address: 00:80:66:03:f3:24
; 13 Dec 2012 17:26:35,Serial number: 293.430.9560
; 13 Dec 2012 17:26:35,Measurement System: 0770CA-B V026
; 13 Dec 2012 17:26:35,Hardware: 0770EB-A V006
; 13 Dec 2012 17:26:35,Receiver: FEC-4850266-005
; 13 Dec 2012 17:26:35,Timecode Reader: 0770CB-A V017HQ
; 13 Dec 2012 17:26:35,Reference System: Ext 10MHz + Ext PPS
```

Following the header the logged data format is typically:-

n,rr,dd/mm/yyyy,hh:mm:ss.ssssssssss,ii,i,j

where:

n – sample number starting from 1

Source Selection Codes

rr – Time Source selected. When datalogged the zero is replaced with the letter O to prevent Excel from automatically formatting the information.

<i>Time Source</i>	<i>TTL</i>	<i>Fibre</i>	<i>Differential</i>	<i>Inverted TTL</i>	<i>Inverted Fibre</i>	<i>Inverted Differential</i>	SIGSEL ->Reader VTAB2-> IPSEL EPLD
1PPS	01	11	21	81	91	A1	3
1PPM	02	12	22	82	92	A2	3
1PPH	03	13	23	83	93	A3	3
Mod Carrier	04						2
DC Level Shift	05	15	25	85	95	A5	4
Serial Message	06		26				0
Relay On Close On Open	00			80			6
NTP	07						As previous
PTP	07						As previous
DCF-77	08	18	28				5
Own GPS 1pps	09						1
Have Quick	0A	1A	2A	8A	9A	AA	7
Spare Fibre		1B			9B		3
NMEA + Pulse	0C		2C				3
RS232/422 China Mobile	0D	1D (Not used)	2D		8D (Not used)	9D (Not used)	AD (Not used)
Frequency	0E	1E	2E	4E	8E (Not used)	9E (Not used)	AE (Not used)
50bps BCD	0F	1F	2F		8F	9F	AF

dd/mm/yyyy , hh:mm , ss . ssssssssssss – Time of Arrival of the Source signal that triggered the measurement

iii Time Difference between Time Source and TimeSpy's Reference

Clock time, in nanoseconds. The Time Difference is expressed as the value of (TimeSpy-Source), giving a positive result for a source event time which lags behind TimeSpy time and a negative result for a source which is ahead of TimeSpy time.

j Ref Clk Status is reported as "OK", "WARN", "ERR" , "UNK", "EXT_1pps"

The first 'uncommented' line prior to the data in the log contains a description of the fields in the datalog. After reading the file into a spreadsheet these descriptions become the headings of the columns. It is then only necessary to adjust the width of the columns to achieve a record as shown below as an example of a 10 sample log of a 1pps source.

***Example of a
1pps Datalog
File***

The datalog file can be loaded into any text reading application (such as Microsoft Notepad). After the header described above in the paragraph "Datalog File Header" on page 84 will be found typically:-

```
Sample,Source,Date,HH:MM,Seconds,Time Diff ns,Ref Clk Status
1,01,2009/12/10,10:34,48.0000001251,125.1,OK
2,01,2009/12/10,10:34,49.0000001259,125.9,OK
3,01,2009/12/10,10:34,50.0000001259,125.9,OK
4,01,2009/12/10,10:34,51.0000001253,125.3,OK
5,01,2009/12/10,10:34,52.0000001259,125.9,OK
6,01,2009/12/10,10:34,53.0000001262,126.2,OK
7,01,2009/12/10,10:34,54.0000001253,125.3,OK
8,01,2009/12/10,10:34,55.0000001251,125.1,OK
9,01,2009/12/10,10:34,56.0000001253,125.3,OK
10,01,2009/12/10,10:34,57.0000001252,125.2,OK
; 10 Dec 2009 10:34:57,TimeSpy Datalog stopped
```

***Reference
Clock Status
Descriptions***

Each field of data is separated by a comma. The last field carries TimeSpy's reference clock status shown as OK in the example. The possible status indications are

"OK", "WARN", "ERR" , "UNK", "EXT_1pps"

During normal operation the user will see OK with occasional WARN indications because of temporary receiver conditions which include

- Time message from GPS receiver does not compare with time received in the previous message from the receiver
- Time is marked as not valid by the GPS receiver
- The 1pps from the receiver is beyond the acceptable time interval from the reference clock 1pps.
- The 1pps from the receiver is more than 50ns displaced from exactly one

second since the last 1pps from the receiver.

If the reference time is invalid or has not been received within the last 20 seconds, the status is ERR, otherwise the following logic is used:

First, determine 'Oscillator Status'

For Rubidium oscillator, oscillator status is 0 = NONE, 1 = COLD, 2 = LOCKED, 3 = FAILED

If an OCXO is fitted rather than rubidium then oscillator status is 'FAILED' if frequency is control out of range, is 'COLD' if the loop status is 'FAST' or is otherwise 'LOCKED'.

Once the oscillator status is known, the clock status is set as followed:

Oscillator COLD or FAILED, clock status = ERR (Error)

Else

for any of the conditions described above = WARN

else

clock status = OK

If the condition is WARN but external 1pps is selected then EXT_1pps is reported as status

Example of a Datalog file in a spreadsheet

In a spreadsheet the commas identify the columns and the data become neatly tabulated:-

Sample	Source	Date	HH:MM	Seconds	Time Diff ns	Clk Status
1	1	10/12/2009	10:34	48	125.1	OK
2	1	10/12/2009	10:34	49	125.9	OK
3	1	10/12/2009	10:34	50	125.9	OK
4	1	10/12/2009	10:34	51	125.3	OK
5	1	10/12/2009	10:34	52	125.9	OK
6	1	10/12/2009	10:34	53	126.2	OK
7	1	10/12/2009	10:34	54	125.3	OK
8	1	10/12/2009	10:34	55	125.1	OK
9	1	10/12/2009	10:34	56	125.3	OK
10	1	10/12/2009	10:34	57	125.2	OK

In the case where the MJD box has been checked the sample number is replaced by the MJD value, the day count in including fractions of the day to 5 decimal places, allowing 1 second resolution. MJD and the advantages of using it are described in the paragraph "Log Julian Date (MJD)" on page 81 of this manual.

**MJD Datalog
Example**

MJD	Source	Date	HH:MM	Seconds	Time Diff ns	Clk Status
55175.44118	1	10/12/2009	10:35	18	125.1	OK
55175.44119	1	10/12/2009	10:35	19	125.5	OK
55175.4412	1	10/12/2009	10:35	20	125.1	OK
55175.44122	1	10/12/2009	10:35	21	125	OK
55175.44123	1	10/12/2009	10:35	22	125.9	OK
55175.44124	1	10/12/2009	10:35	23	124.8	OK
55175.44125	1	10/12/2009	10:35	24	125.1	OK
55175.44126	1	10/12/2009	10:35	25	125.3	OK
55175.44127	1	10/12/2009	10:35	26	124.8	OK
55175.44128	1	10/12/2009	10:35	27	124.6	OK

**Example
TimeCode
Datalog File**

Time code datalogs show the code time and time difference within the second measured by TimeSpy. An example of IRIG-B time code datalog is shown below, omitting the file header described above in the paragraph "Datalog File Header" on page 84:-

Sample	Source	CodeYear	CodeDayOfYear	CodeTime	Time Diff ns	Clk Status
1	4	9	344	18:00:40	-22681.2	OK
2	4	9	344	18:00:41	-22581.1	OK
3	4	9	344	18:00:42	-22581.1	OK
4	4	9	344	18:00:43	-22581.3	OK
5	4	9	344	18:00:44	-22481.1	OK
6	4	9	344	18:00:45	-22481.3	OK
7	4	9	344	18:00:46	-22481.2	OK
8	4	9	344	18:00:47	-22481.2	OK
9	4	9	344	18:00:48	-22381.1	OK
10	4	9	344	18:00:49	-22381.1	OK

**Example NTP
Datalog File**

When an NTP source is selected the datalog contains the four time stamp times T1, T2, T3 and T4. See Network Time Protocol Measurements on page 63 of this manual for a description of these time stamps. NTP time error is calculated by TimeSpy as TimeSpy-NTP time and so has the same time convention as other measurements (the sign is positive if NTP time is retarded compared with TimeSpy). The next-to-last column shows this figure. The last column shows Round Trip time (refer to the paragraph "Network Time Protocol Measurements" on page 63 for a description of the time stamp times). The file header is omitted for clarity as it is the same as described in the paragraph "Datalog File Header" on page 84; the datalog section of the file loaded into a spreadsheet is shown below.

Sample	Server IP	T1 dd/mm/yyyy hh:mm	T1 ss.sssssss	T2 dd/mm/yyyy hh:mm	T2 ss.sssssss	T3 dd/mm/yyyy hh:mm	T3 ss.sssssss	T4 dd/mm/yyyy hh:mm	T4 ss.sssssss	TimeSpy -NTP time ns	RTT ns
1	192.168.1.250	10/12/2009 13:31	49.303821	10/12/2009 13:31	49.303848	10/12/2009 13:31	49.304328	10/12/2009 13:31	49.3044071	26111	106505
2	192.168.1.250	10/12/2009 13:31	50.300296	10/12/2009 13:31	50.300322	10/12/2009 13:31	50.300731	10/12/2009 13:31	50.3008184	30575	114292
3	192.168.1.250	10/12/2009 13:31	51.173737	10/12/2009 13:31	51.173764	10/12/2009 13:31	51.174134	10/12/2009 13:31	51.1742148	27335	108075
4	192.168.1.250	10/12/2009 13:31	52.119339	10/12/2009 13:31	52.119366	10/12/2009 13:31	52.119799	10/12/2009 13:31	52.1198864	30270	113557
5	192.168.1.250	10/12/2009 13:31	53.080654	10/12/2009 13:31	53.080681	10/12/2009 13:31	53.081095	10/12/2009 13:31	53.0811844	31277	115769
6	192.168.1.250	10/12/2009 13:31	54.09273	10/12/2009 13:31	54.092756	10/12/2009 13:31	54.093107	10/12/2009 13:31	54.0931916	29190	111749
7	192.168.1.250	10/12/2009 13:31	55.068426	10/12/2009 13:31	55.068454	10/12/2009 13:31	55.068867	10/12/2009 13:31	55.0689492	27240	109253
8	192.168.1.250	10/12/2009 13:31	56.097324	10/12/2009 13:31	56.097352	10/12/2009 13:31	56.09784	10/12/2009 13:31	56.0979242	28085	111417
9	192.168.1.250	10/12/2009 13:31	57.082414	10/12/2009 13:31	57.082441	10/12/2009 13:31	57.08291	10/12/2009 13:31	57.0829997	31583	116552
10	192.168.1.250	10/12/2009 13:31	58.092739	10/12/2009 13:31	58.092766	10/12/2009 13:31	58.093309	10/12/2009 13:31	58.0933895	26628	107098
; 10 Dec 2009 13:31:58 TimeAcc Datalog stopped											

**Example PTP
Datalog File**

When a PTP source is selected the datalog contains the source identification and individual time-stamps. As for other datalogs, to help with the importation into spreadsheet programs, the time values are shown as date and time with a separate column for seconds. PTP time offset is calculated by TimeSpy as TimeSpy-PTP time and so has the same time convention as other measurements (the sign is positive if NTP time is ahead of TimeSpy). The calculation of PTP time follows the method described in IEEE 1588(E): 2002 and 2008, now known as Version 1 and Version 2 PTP respectively. The master clock which TimeSpy measures is known as the Parent Clock. The resulting measurement of the parent clock time is output in the next to last column of the log as (TimeSpy-PTP time) as shown below in the example loaded into a spreadsheet. The file header is omitted for clarity as it is the same as described in the paragraph Datalog File Header on page 84. Parent Id is the unique identifier of this clock. The paragraph "PTP Measurement Detail" on page 67 of this manual illustrates the time stamps shown in the datalog below.

Sample	Parent Id	Origin hh:mm	Org ss.sssssss	Sync Receipt hh:mm	SR ss.sssssss	Delay/Req Send hh:mm	D/S ss.sssssss	Delay Receipt hh:mm	DR ss.sssssss	M->S delay ns	S->M delay ns	1Way delay ns	TimeAcc- PTP time ns	PtpVersion
1	00:60:6e:ff:fe:7c:12:a9-1	20/03/2009 13:08	48.7100033	20/03/2009 13:08	48.7100015	20/03/2009 13:08	48.90784499	20/03/2009 13:08	48.90784423	1174	-767	204	971	2
2	00:60:6e:ff:fe:7c:12:a9-1	20/03/2009 13:08	49.73011717	20/03/2009 13:08	49.73011834	20/03/2009 13:08	49.92532627	20/03/2009 13:08	49.92532551	1166	-767	200	967	2
3	00:60:6e:ff:fe:7c:12:a9-1	20/03/2009 13:08	50.72987549	20/03/2009 13:08	50.72987667	20/03/2009 13:08	50.93124134	20/03/2009 13:08	50.93124059	1182	-759	212	971	2
4	00:60:6e:ff:fe:7c:12:a9-1	20/03/2009 13:08	51.87053297	20/03/2009 13:08	51.87053414	20/03/2009 13:08	52.04322067	20/03/2009 13:08	52.04321991	1174	-767	204	971	2
5	00:60:6e:ff:fe:7c:12:a9-1	20/03/2009 13:08	52.87994925	20/03/2009 13:08	52.87995043	20/03/2009 13:08	53.14541082	20/03/2009 13:08	53.14541007	1182	-751	216	967	2
6	00:60:6e:ff:fe:7c:12:a9-1	20/03/2009 13:08	53.87999721	20/03/2009 13:08	53.8799984	20/03/2009 13:08	54.12486918	20/03/2009 13:08	54.12486839	1190	-799	196	995	2
7	00:60:6e:ff:fe:7c:12:a9-1	20/03/2009 13:08	55.03025573	20/03/2009 13:08	55.03025693	20/03/2009 13:08	55.23431507	20/03/2009 13:08	55.23431427	1198	-807	196	1003	2
8	00:60:6e:ff:fe:7c:12:a9-1	20/03/2009 13:08	56.05012997	20/03/2009 13:08	56.05013117	20/03/2009 13:08	56.22713862	20/03/2009 13:08	56.22713783	1198	-799	200	999	2
9	00:60:6e:ff:fe:7c:12:a9-1	20/03/2009 13:08	57.05013845	20/03/2009 13:08	57.05013965	20/03/2009 13:08	57.2524631	20/03/2009 13:08	57.25246229	1198	-819	190	1009	2
10	00:60:6e:ff:fe:7c:12:a9-1	20/03/2009 13:08	58.19062377	20/03/2009 13:08	58.19062496	20/03/2009 13:08	58.45504186	20/03/2009 13:08	58.45504109	1190	-771	210	981	2

**Engineering
Datalog
Description**

Touch the box to place a tick against Log Engineering Data on the Datalogging set up screen (see page 81)

The full Engineering Log is a powerful feature of TimeSpy that allows all key data to be logged to a file. In particular, three internal messages

are saved from the time code reader and measurement systems. Unrequested messages from the subsystems are also recorded so that all of the instrument activity is traceable. The contents are described below

The CSV (comma-separated variable) format log files include a description of each column which will appear at the head of that column when imported into a spreadsheet (Excel or similar application)

TimeSpy Engineering Log with AC Timecode selected as source.

First 15 columns, See continuation below

Samp	'T'	GPS Time hhmmss dow ddmmyy LpYr	'P'	(TimeSpy- Ref) Inst ns	(TimeSpy- Ref) Mean ns	Rb Control	Control Status	Sats Tracked	last Rb update DOY	last Rb update hh:mm:ss	Rb Stat	Rx_Cal ns	Battery Volts	Charge State	Rx Mode	Sat system
1	T	12293711201090	P	-20	-30	-11482	0	8	12	12:29:36	21	78	27.511	9		

Column Header	Explanation																		
Sample	Consecutive count of individual measurements																		
'T'	Fixed letter at start of TimeSpy reference clock time (set to 't' if time is invalid)																		
GPS Time	Reference clock time obtained from GPS																		
'P'	Fixed letter at start of TimeSpy reference clock control detail																		
(TimeSpy-Ref) Inst ns	If GPS is the selected Ref, Instantaneous TimeSpy 1pps time minus GPS 1pps Time (positive value means TimeSpy is ahead of GPS). If External 1pps is selected, TimeSpy 1pps time –Ext Ref 1pps time																		
(TimeSpy-Ref) Mean ns	Average value of the above time difference computed in a running average of 8 to 32 samples																		
Rb Control	Rubidium frequency control (range is -32768 to +32767)																		
Control Status	ASCII hex byte value containing 8 status bits describing frequency controller <table border="1" style="margin-left: 20px;"> <thead> <tr> <th>Bit 7</th> <th>Bit 6</th> <th>Bit 5</th> <th>Bit 4</th> <th>Bit 3</th> <th>Bit 2</th> <th>Bit 1</th> <th>Bit 0</th> <th>Control</th> </tr> </thead> <tbody> <tr> <td>EFC out-of-range</td> <td>Bad GPS time comparison</td> <td>No valid time from</td> <td>Phase out of limits</td> <td>Phase noise (not used)</td> <td>Rb cold or faulty</td> <td>0 1 0</td> <td>0 0 1</td> <td>Fast Med Slow</td> </tr> </tbody> </table>	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Control	EFC out-of-range	Bad GPS time comparison	No valid time from	Phase out of limits	Phase noise (not used)	Rb cold or faulty	0 1 0	0 0 1	Fast Med Slow
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Control											
EFC out-of-range	Bad GPS time comparison	No valid time from	Phase out of limits	Phase noise (not used)	Rb cold or faulty	0 1 0	0 0 1	Fast Med Slow											
Sats Tracked	Number of satellites currently tracked																		
last Rb update DOY	The day of year on which the rubidium frequency was last trimmed																		
last Rb update DOY	The time at which the rubidium frequency was last trimmed																		
Rb_Stat	Status of the rubidium '0' = none (information not available) '1' =Cold '2'=rubidium resonance lock '3'=rubidium fail																		
Rx_Cal ns	User entry of compensation for antenna cable length (usually calculated as 5ns per metre)																		
Battery Volts	Voltage of TimeSpy's internal battery																		
Charge State	'9'=ac connected, fully charged '8'=charging '5'=in-use, fully charged '4'=2/3 charged '3'=1/3 charged '2'=Low battery warning																		
Rx Mode	Mode of the satellite receiver. '1' Beidou Only '2' GPS Only '3' Beidou Priority '4' GPS Priority																		
Satellite System	'1' GPS In Use '2' Beidou In Use																		

TimeSpy Engineering Log (remaining columns continued from above) with internal reference

'M'	Source	ddmmyy	hhmmss	TimeSpy-source ns	't'	Timecode Reader Data	Timecode Carrier Level	High/Norm/Low	Logged At
M	04	120109	122935.999	-1322.7	T	122935101212010908IA000F110118087	6.47	N	36.507

With external reference selected

In the case where an external 1pps reference is in use, two precision time measurements are taken, in order that Ref-Source can be calculated for display and logging, so the table contains new headings and an additional column:-

'M'	Source	ddmmyy	hhmmss	Ref-source ns	TimeSpy-Ref ns	't'	Timecode Reader Data	Timecode Carrier Level	High /Norm /Low	Logged At
M	04	120109	122935.999	-1322.7	250.6	T	122935101212010908IA000F110118087	6.47	N	36.507

Column Header	Explanation																																																																				
'M'	Fixed letter at start of TimeSpy's high-precision pulse measurement of the start-of-frame time																																																																				
Source	A number describing the source being measured 01=1pps 02=1ppm 03=1pph 04=AC Timecode 05=DCLS Timecode 06=Serial 07=NTP(retain previous) 08=DCF77 09=Own GPS_1pps 0A=Have Quick 0C=NMEA+1pps 0D=China Mobile 0EXX=Frequency (XX=divider index in hex). The leading 0 changes according to interface type (1=fibre 2=differential 9=inverted fibre A=inverted differential)																																																																				
ddmmyy	Day month year at which the pulse representing start of timecode frame was received																																																																				
hhmmss	Day month year at which the pulse representing start of timecode frame was received (to 1ms)																																																																				
Ref-source ns <i>(if external 1pps is used)</i>	External 1pps ref time minus source 1pps or reader start-of-frame time (calculated from (TimeSpy-Source) and (TimeSpy-Ref) where Ref is the External 1pps reference).																																																																				
TimeSpy-Ref ns <i>(if external 1pps is used)</i>	TimeSpy internal 1 pps ref time minus external 1pps ref time																																																																				
TimeSpy-Source ns If internal 1pps is used	TimeSpy 1 internal 1pps ref time minus the exact start-of-frame time (positive value means source is late compared with TimeSpy) or exact pulse source time																																																																				
't'	Fixed header introducing timecode reader message. Each of 33 characters is described below <table border="1" style="margin-left: 20px;"> <tr> <td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td><td>15</td><td>16</td><td>17</td><td>18</td><td>19</td><td>20</td> </tr> <tr> <td>T</td><td>H</td><td>H</td><td>M</td><td>M</td><td>S</td><td>S</td><td>DOW</td><td>d</td><td>d</td><td>d</td><td>D</td><td>D</td><td>M</td><td>M</td><td>Y</td><td>Y</td><td>Lp</td><td>DSTAT</td><td>EOF</td><td>TCT</td> </tr> </table> <table border="1" style="margin-left: 20px;"> <tr> <td>21</td><td>22</td><td>23</td><td>24</td><td>25</td><td>26</td><td>27</td><td>28</td><td>29</td><td>30</td><td>31</td><td>32</td><td>33</td> </tr> <tr> <td>DFB/LSD</td><td>DTOFF / LSD</td><td>DTOFF / LSD</td><td>DQUAL/TFOM</td><td>PM</td><td>PC</td><td>BPC</td><td>BPC</td><td>BPC</td><td>BPC</td><td>LEV</td><td>LEV</td><td>LEV</td> </tr> </table>	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	T	H	H	M	M	S	S	DOW	d	d	d	D	D	M	M	Y	Y	Lp	DSTAT	EOF	TCT	21	22	23	24	25	26	27	28	29	30	31	32	33	DFB/LSD	DTOFF / LSD	DTOFF / LSD	DQUAL/TFOM	PM	PC	BPC	BPC	BPC	BPC	LEV	LEV	LEV
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20																																																	
T	H	H	M	M	S	S	DOW	d	d	d	D	D	M	M	Y	Y	Lp	DSTAT	EOF	TCT																																																	
21	22	23	24	25	26	27	28	29	30	31	32	33																																																									
DFB/LSD	DTOFF / LSD	DTOFF / LSD	DQUAL/TFOM	PM	PC	BPC	BPC	BPC	BPC	LEV	LEV	LEV																																																									

Timecode reader message contents

Index	NAME	Range	Description of Data Received from Time-code Reader. Note that most timecodes do not contain all the data in this table.																								
0	t	T or t	T means Valid Time (time compares satisfactorily with previous time code time) t means that the message does not appear to contain Valid Time																								
1	H	0 to 3	Tens of hours																								
2	H	0 to 9	Hours																								
3	M	0 to 5	Tens of minutes																								
4	M	0 to 9	Minutes BCD																								
5	S	0 to 6*	Tens of seconds (*For IEEE:1344 compatible input code positive leap second only, else 5)																								
6	S	0 to 9	Seconds																								
7	DOW	1 to 7	Day of Week (Monday=1)																								
8	d	0 to 3	Hundreds of days-in-year																								
9	d	0 to 6	Tens of days-in-year																								
10	d	0 to 6	Days-in-year																								
11	D	0 to 3	Tens of days																								
12	D	0 to 9	Days																								
13	D	0 to 1	Tens of months																								
14	D	0 to 9	Months																								
15	Y	0 to 9	Tens of Years																								
16	Y	0 to 9	Years																								
17	Lp	0 or 1	No leap second pending indication in the timecode (IEEE:1344) Leap second is pending (set for seconds = 00 to 58 or 59 of the last minute prior to the leap second)																								
18	DSTAT	0 to F	<table border="1" style="display: inline-table; vertical-align: middle;"> <tr> <td>3</td> <td>2</td> <td>1</td> <td>0</td> </tr> <tr> <td>Valid Time</td> <td>Error Bypass</td> <td>0</td> <td>0</td> </tr> </table> Result of reader's error checks on the time (The data in the output message is always raw data decoded from the incoming code)	3	2	1	0	Valid Time	Error Bypass	0	0																
3	2	1	0																								
Valid Time	Error Bypass	0	0																								
19	EOF	I,X,x,N,R,Z,H	Sync Pattern detected: I=IRIG X=2137 x=XR3 (250Hz carrier) N=NASA36 R=error (overrun) Z=None H=Have Quick																								
20	TCT	A, B, E, Y, U,Q,X	A=AFNOR B=IRIG B E=IRIG B IEEE:1344 Y=IRIG B 200-04 (has Year) U=Unique (not IRIG code) Q = Standard Have Quick X= Extended Have Quick																								
21	DFB Or 100 LSD	0 to F	<table border="1" style="display: inline-table; vertical-align: middle;"> <tr> <td>3</td> <td>2</td> <td>1</td> <td>0</td> </tr> <tr> <td>DST</td> <td>DSP</td> <td>LS</td> <td>LSP</td> </tr> </table> DFB Decoded value of IEEE Four Bits in ASCII Hex Daylight Saving Time , DST Pending, Leap sec direction (0=Add, 1=Delete Leap Sec), LS Pending OR Leap Second Day (100's) for Have Quick Reader	3	2	1	0	DST	DSP	LS	LSP																
3	2	1	0																								
DST	DSP	LS	LSP																								
22	DTOFF Or 10LSD	0 to 9	<table border="1" style="display: inline-table; vertical-align: middle;"> <tr> <th colspan="4">MSB</th> <th colspan="4">LSB</th> </tr> <tr> <td>7</td> <td>6</td> <td>5</td> <td>4</td> <td>3</td> <td>2</td> <td>1</td> <td>0</td> </tr> <tr> <td>Sign</td> <td>0</td> <td>0</td> <td>16</td> <td>8</td> <td>4</td> <td>2</td> <td>1</td> </tr> </table> IEEE:1344 MSB of Local time Offset Value (including DST if active) received in timecode input and added by 210KG to timecode time to convert it to UTC for 210 CPU. Offset is a 5 bit binary number 0 to 31 with sign in msb (1=minus) representing total number of half-hours of offset Local time is UTC minus this number (including sign, so add if negative) OR Leaps Second Day (10's) for Have Quick Reader	MSB				LSB				7	6	5	4	3	2	1	0	Sign	0	0	16	8	4	2	1
MSB				LSB																							
7	6	5	4	3	2	1	0																				
Sign	0	0	16	8	4	2	1																				
23	DTOFF Or LSD	0 to F	IEEE:1344 Local time Offset LSB (see above) OR Leap Second Day (units) for Have Quick reader																								
24	DQUAL TFOM	0 to B, or F	IEEE:1344 Quality indicator as received in timecode 0=Locked, Maximum Accuracy F= Failed, data unreliable 1=1ns 2=10ns 3=100ns ...B=10s OR Have Quick TFOM																								
25	PM	0 or 1	IEEE:1344 Parity in message																								
26	PC	0 or 1	Calculated Parity of message content																								
27	BPC	0 to 9	Thousands of error by-passed input timecode messages BCD																								
28	BPC	0 to 9	Hundreds of error by-passed input timecode messages BCD																								
29	BPC	0 to 9	Tens of error by-passed input timecode messages BCD																								
30	BPC	0 to 9	Units of error by-passed input timecode messages BCD																								
31	LEV	0 to 2	100's I/P level (000 to 255)																								
32	LEV	0 to 9	10's I/P level																								
33	LEV	0 to 9	1's I/P level																								

Last 3 columns of the Engineering Log

Column Header	Explanation
Timecode Carrier Level	Peak-to-peak value (Volts) of the high level part of the time-code carrier
High/Norm/Low	H=Carrier level too high for accurate measurement N=Normal level L=Too low
LoggedAt	The approximate real-time seconds count estimated by the GUI software of when the datalog was saved

Importing a full The *.csv log file is automatically sorted into columns by most

**Engineering
Log into Excel**

spreadsheet programs. For improved layout, right-click the header descriptions line only and click 'format cells' then choose the 'Alignment' tab. Under 'Text Control' check the box 'wrap text'. To change the format of the GPS Time column, highlight column C only, click 'Format Cells' and choose the 'Number' tab. Set 'decimal places' to 0 and click OK. Double click the boundaries at the lettered columns at the top of the spread-sheet, or drag the columns to fit the data width.

**Time Data in a
Full
Engineering
Log**

The last column of the engineering log notes the second and approximate fraction of a second at which the log was made. Normally the log is captured at half-way through the second so a typical log time is 33.504 seconds as shown below. The 'T' message at the start of the log carries reference clock time one second advanced and is expected to note 34 seconds in this example. The rubidium frequency control may be updated at 8s intervals in the SLOW control algorithm so will show a time that is from 7s to 0s behind the log time. The date and time at which the most recent timecode frame commenced is logged in the ddmmyy and hhmmss columns after Source description and is followed by the precise offset measurement to 0.1ns. The integer seconds count in this time will be for the current second, if the precise nanosecond quantity is positive, or for the previous second if the precise measurement is negative, with a millisecond count clarifying that offset. Timecode reader data will refer to the data captured by the reader during the previous second, because the code for the current second would have been partially complete at the log time, so will be 1.5s behind log time.

**Example Values
of Engineering
Log Times**

The following extract from a spreadsheet shows two lines from an example log of a DCLS IRIG signal. An summary of the times in the log follows in the table below.

Samp	'T'	GPS Time hhmmss dow ddmmyy LpYr	'P'	(TimeSpy -Ref) Inst ns	(TimeSpy- Ref) Mean ns	Rb Ctrl	Ctrl Stat	Sats Trkd	last Rb update DOY	last Rb update hh:mm:ss	Rb_Stat	Rx_ Cal ns	Bat Volts
1	T	14133442907100	P	-1	-14	-736	1	8	210	14:13:26	21	80	26.104
2	T	14133542907100	P	-23	-14	-722	1	8	210	14:13:34	21	80	26.107

Chrg State	Sat Sys	Ref	'M'	Src	ddmm yy	hhmmss	Ref- source ns	't'	Timecode Reader Data	Car Lev	H/ N/ L	Log'd At
9	21	0	M	5	290710	141332.999	-289.4	T	141332421029071008IA000F004695000	0	L	33.5
9	21	0	M	5	290710	141333.999	-291.4	T	141333421029071008IA000F014695000	0	L	34.5

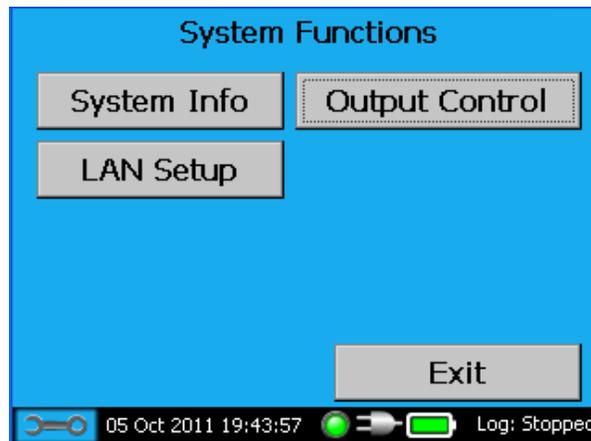
Column	Value in first example line	Seconds' Value	Explanation
GPS Time	14133442907100	34	Ref time advanced 1s
Last Rb Update	14:13:26	26	Some time earlier
Source measurement	14 13 33.999 (-289.4ns)	33.999....	The exact on-time measurement of the latest complete source timecode frame end prior to the log
Timecode value	14 13 32.....	32	Value of time coded in the latest complete source time frame (completed at start of second 33)
Logged at	33.5	33.5	Real time of log

Frequency Measurement Datalog

See page 79 for a description of Frequency Measurement Datalogging

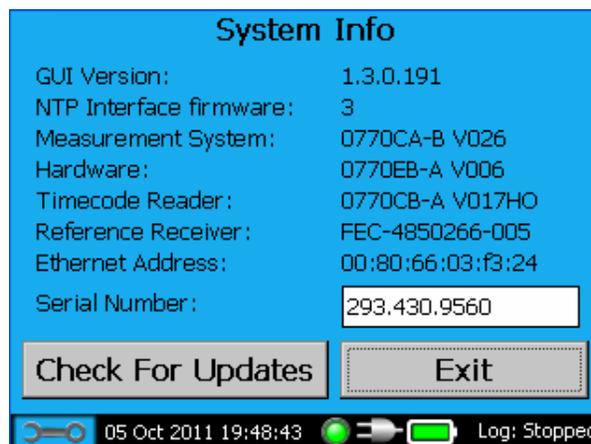
System Info

At the main menu touch the TimeSpy Setup bar to reach the System Functions screen



Software and hardware Version Display

Touch System Info to display the software versions of the various parts of TimeSpy



TimeSpy Serial Number

This page gives the version number of the graphical control program, the NTP Time Measurement Interface, the Measurement System and its hardware, and the Timecode Reader.

The Ethernet Address (MAC Address) is the unique identifier of TimeSpy's Network adapter. This address may be required to allow a factory upgrade of TimeSpy software that adds additional instrument functions; the serial number should not normally be changed unless the upgrade requires a different number in order for its additional functions to be enabled.

Software Update

Should an update be made available from Time & Frequency Solutions Ltd then follow this procedure to program TimeSpy's graphical user interface (GUI). Put the two files TimeSpyInst.CAB and TimeSpyProdSetup.CAB into the root directory of a USB memory and insert the memory into TimeSpy's USB socket. Wait for up to 40s for the memory stick to be recognised (the memory stick lamp will blink). On the main selection screen touch the "TimeSpy Setup" bar; on the System Functions screen touch "System Info". Finally, touch "Check for Updates". A window will pop up saying "There is new software on the USB disk. Would you like to install it?". Touch Yes. Wait for about 10s and see the message "The new software will be available when the instrument restarts". Turn off the power and turn on again to restart TimeSpy. The new software will automatically load and start.

Remote Control of TimeSpy

The LAN Setup screen has already been described as part of the setup of the instrument for NTP measurements

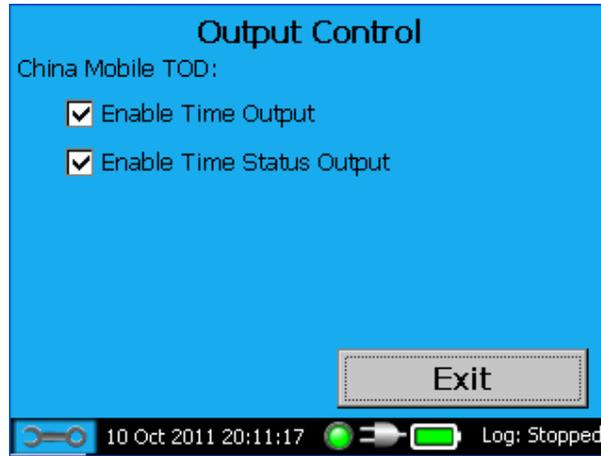


By noting the IP address (or operating with a manually entered IP address that is compatible with the network requirements) it is possible to gain remote access and control of the TimeSpy Measurement Instrument through a PC 'Virtual Network Connection' (VNC) application, such as that found at www.tightvnc.com. If changes to the publicly issued version of the application cause any problems with regard to remote access to TimeSpy please contact the factory to obtain a tested version.

Output Control

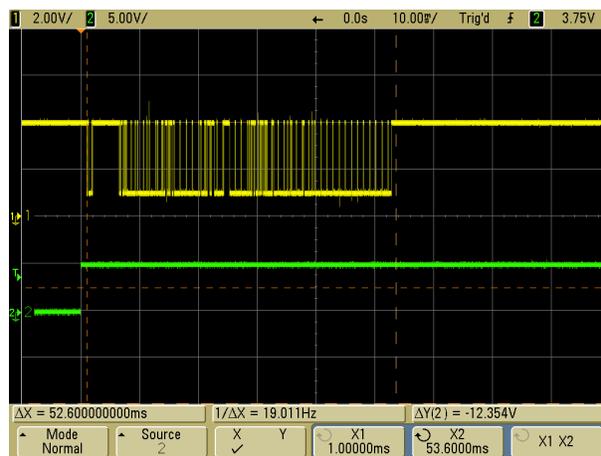
Touch TimeSpy Setup on the main menu to reach the System Functions page. Touch the Output Control bar on the System Functions page to

configure TimeSpy output.



China Mobile Output

China Mobile Time of Day output and China Mobile Time Status output can be enabled and disabled on this page. When enabled the measurement serial port parameters are set to 9600,8,N,1 and the messages are output simultaneously from the RS422 and RS232 measurement ports on the rear of the instrument. TimeSpy computes GPS time and gets the UTC to GPS offset from its internal GPS receiver to assemble the message. If for any reason the UTC to GPS offset is not available then a value of 15 seconds is used. The China Mobile Time of Day output first character is timed to start 1ms after the 1pps output of TimeSpy transitions to 'high' in accordance with the specification. When followed by the Time Status message the last character is completed at about 53ms after the start of the second. In the picture below the 1pps output is the lower green trace.



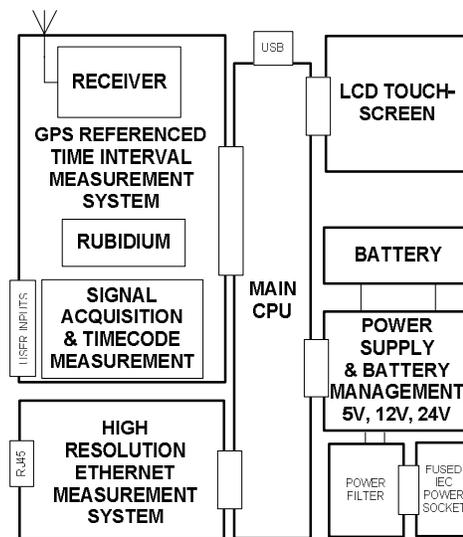
Chapter 9:

Technical Description

System Architecture

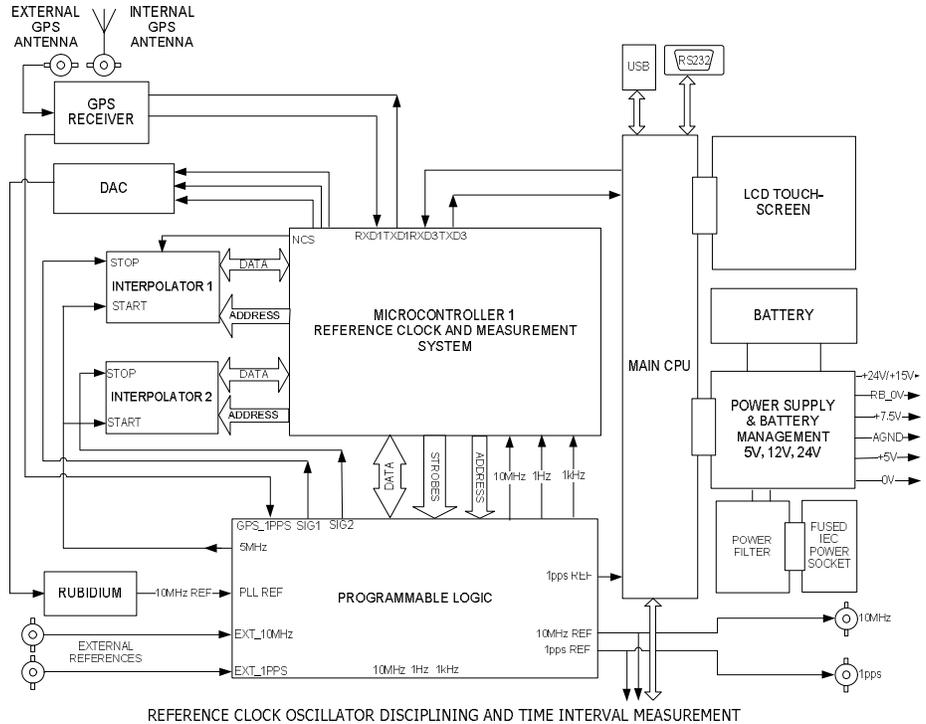
The reference and measurement part of the instrument is designed in three main blocks, with most of the circuitry installed on a single printed circuit board that carries connectors for subsidiary interfaces and the network measurement system

Overview



Large items such as the main power-supply, the battery and the Rubidium oscillator are bolted to the base of the instrument with the main PCB mounted above, interfacing directly to the front panel of the instrument.

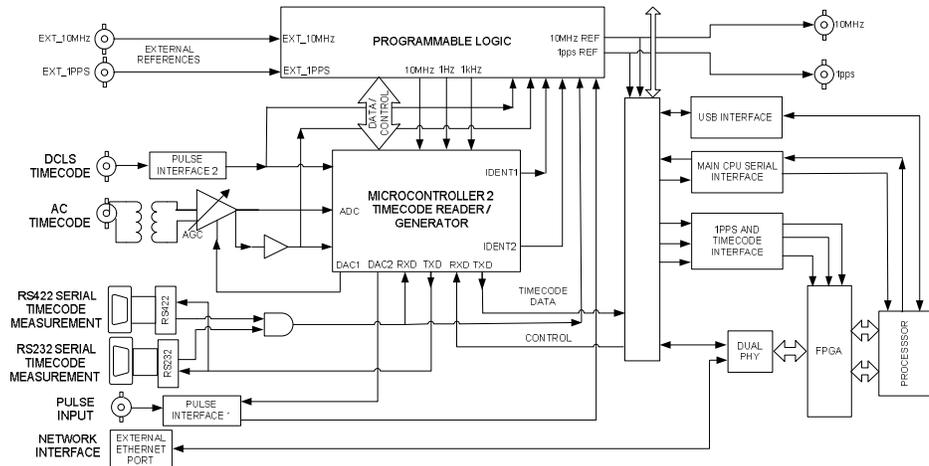
**Oscillator
Disciplining
and Time
Interval
Measurement**



A GPS or Beidou satellite receiver supplies a reference time string and 1pps. For continuous frequency correction of the reference the time interval between the satellite receiver 1pps and 1pps derived from the Rubidium 10MHz output is measured, averaged and integrated. The continuous measurement and adjustment strategy results in final corrections being applied at the smallest frequency step that can be made ($3E-14$). As an option an external 1pps and 10MHz can be selected as reference.

The derived 1pps reference is arranged to open a measurement gate once per second. 5MHz from the same synchronous counter system starts and restarts two potential measurement interpolations each 200ns. Signals to be measured are processed such that a single rising edge pulse represents the 'on-time' point. The chosen pulse closes the measurement gate and triggers the interpolator enabling time measurement to within a thousandth of the 200ns (200ps). After each measurement the same 5MHz is used to carry out a calibration of the interpolator, updating offset and scaling constants for each new sample. If a satellite receiver is chosen as reference source then its 1pps output is used to trigger the second interpolator. Alternatively the external 1pps is chosen as reference.

Signal Acquisition and Time-code Measurement



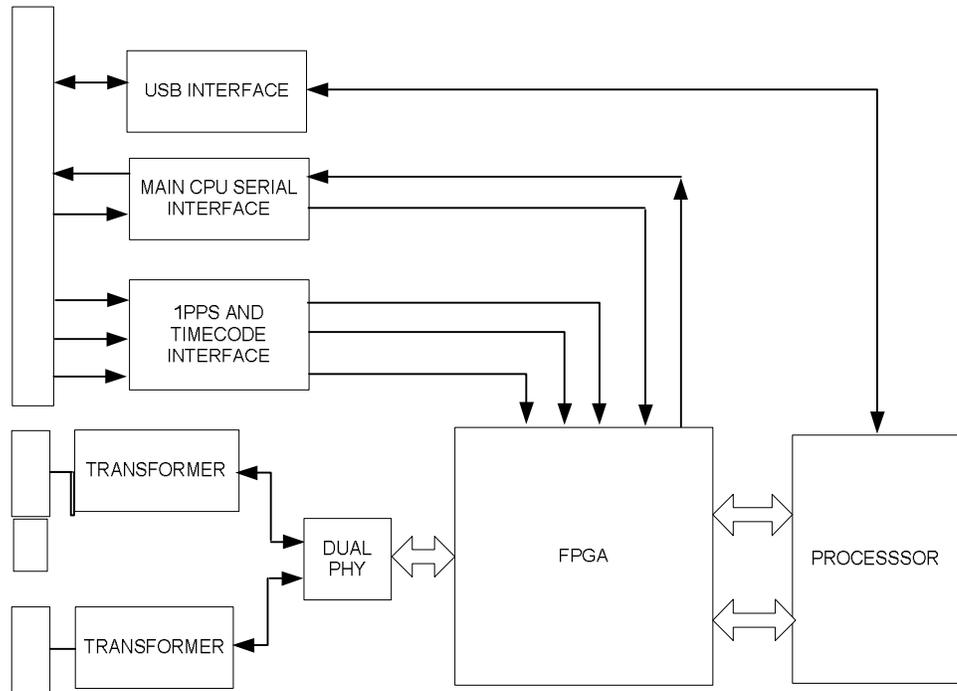
Signal Acquisition and Time Code Measurement

Each broad category of input has an interface designed to capture the input signal and locate the timing information with best precision. Provision is made for five broad types of input

- Pulsed Input such as 1 pulse per second.
- DC Timecode pulse-width modulated codes
- AC Timecode Inputs that use amplitude modulated carrier
- Network connection for precision packet timing
- RS232/RS422 Inputs for serial time-code and other pulses

Each physical input is buffered by appropriate hardware and connected to multiplexer circuitry for selection by Microcomputer 1 that receives commands from the main CPU and sends back measurement data for the chosen source as well as status of the GPS disciplining process for display. Measurements of Ethernet packet timing are carried out by separate dedicated circuitry.

**High
Resolution
Ethernet
Measurement
System (Rear
Panel)**



The Ethernet measurement system is a combination of custom measurement hardware along with application code executing on the main CPU. The custom hardware is capable of generic packet classification and high-precision time-stamping - it is ignorant of the specific network protocol in use. The measurement hardware uses an FPGA and dual Ethernet transceiver (PHY) to provide two 100Mbps Ethernet ports. One of these ports is connected within the instrument to the main CPU; the other port is externally available for connection to the equipment under test. An important, though secondary, function of the FPGA is to provide packet forwarding between these two ports, so that the main CPU can communicate on the external network - such forwarding is transparent to the CPU. The Ethernet ports are of the 'auto-crossover' type, allowing direct connection to the equipment under test without special cables or an intervening hub/switch.

A PLL in the FPGA is used to generate a local 50MHz clock from the reference 10MHz clock, and a synthesised UART + ASCII timecode reader is used to qualify the 1PPS signal. Using this combination of 10MHz, 1PPS and ASCII timecode, the FPGA continuously maintains current time as a 64-bit value, with a resolution of 20ns.

A microprocessor is included on the measurement hardware to provide FPGA configuration and communications to the user-interface

processor. It does not participate in network traffic or time-keeping.

Packet capture is performed on the 'external' Ethernet port. Independent transmit and receive filters are configured for this port - these filters consist of 'match' and 'mask' tables, which allow the unit to be set to only capture packets for a specific protocol. Captured packets are stored, along with the time of their capture, in a buffer within the FPGA. Captured packets and their time-stamps can subsequently be read by the main CPU, using its RS232 connection to the Ethernet hardware.

The direct capture and time-stamping of packets at the Ethernet transceiver eliminates a number of possible sources of measurement error, including interrupt service latency, Ethernet collision back-off, and MAC processing delays. Remaining sources of error include PHY delays and Ethernet switching or routing delays. The former are typically short enough to be neglected in current applications, and the latter can be avoided by direct connection of the instrument to the equipment under test. The FPGA is capable of filtering packets at 'wire speed'; its performance is unaffected by the density of packets on the network.

To measure performance of a server, the main CPU primes the capture hardware and then generates a client request. The Ethernet hardware captures and time-stamps both the outgoing request and the server response packets.

***TimeSpy Elite
SFP Network
Interface High
Speed
Measurement
System Option***

TimeSpy Elite has an SFP socket on the instrument front panel. SFP stands for Small Form-factor Pluggable, meaning that the transceiver allowing communication is plugged into TimeSpy. By choice of module this allows direct connection to single-mode fibre, multi-mode fibre or copper based networks at up to 1Gbit/s. TimeSpy's SFP measurement subsystem supporting this socket uses a further microcontroller and FPGA to transmit and receive Ethernet packets via an SFP transceiver module. Transmission and reception of packets is time-stamped by the FPGA. PTP protocol processing is provided by the microcontroller, with summary status and timing data made available to the user-interface system for display and logging, enabling higher packet rate processing.

The FPGA connects directly to the SFP module via a 1.25Gbps bidirectional link. A custom MAC and packet time-stamping and storage

mechanism can transmit packets at the request of the microcontroller, and can buffer received, time-stamped packets for processing by the microcontroller. FPGA timestamping clocks are phase-locked to the TimeSpy system frequency and time reference signals.

The microcontroller examines all received packets. Standard low-level network protocols such as ARP and ICMP are handled to facilitate normal network node behaviour (to support PING for example). PTP packets can also be handled within the microcontroller - each received PTP 'Sync' packet triggers the transmission of a 'Delay Request', and upon receipt of the 'Delay Response', a set of four timestamps and protocol status information is queued for collection by the user-interface computer. Performing all protocol processing within the SFP subsystem allows response latencies to be extremely low, allowing systems with high PTP Sync rates to be tested.

Packets using protocols not handled directly by the SFP subsystem can be accessed directly by the user-interface to allow broader protocol support for low-speed protocols (e.g. NTP)

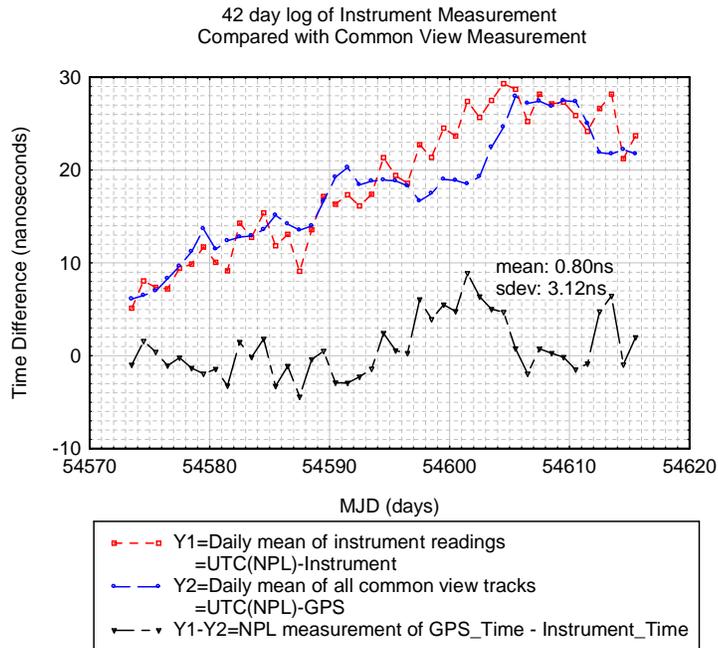
The connection between the user-interface and the SFP subsystem is high-speed USB.

Chapter 10

TimeSpy Reference Clock Performance

TimeSpy Measurement of Hydrogen Maser 1pps

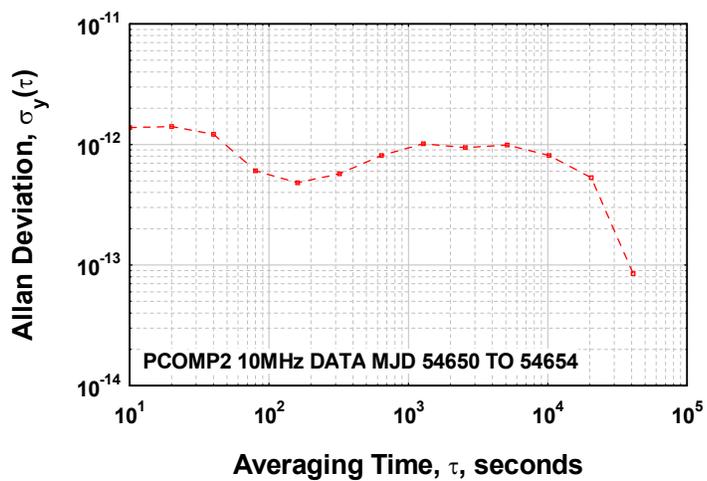
TimeSpy was used to measure 1pps derived from a Hydrogen Maser at NPL, Teddington for 42 days. It is shown plotted in red below. The same Hydrogen Maser 1pps was compared with GPS by Common View, as shown in the blue curve. Data from these two graphs are added to find TimeSpy's deviation from GPS as reckoned by common view measurement at NPL, shown in the black curve. It can be seen that this result (which includes uncertainties in the GPS Common View measurements) had a mean time error of less than 1ns with standard deviation of 3ns.



TimeSpy Frequency Stability

TimeSpy's measurements of the Hydrogen Maser 1pps was analysed by Stable32 (see www.wiley.com) to estimate TimeSpy's frequency stability as seen by direct measurement of a 1pps and therefore including the time interval measurement resolution of 0.2ns, which is the limit to its apparent stability for time intervals less than 100s. It can be seen that for 100s onwards the stability is about 1E-12, improving from 10,000s onwards to close to 1E-14 over 100,000 seconds

TIMEACC FREQUENCY STABILITY



Customer Support

All Brandywine Communications products come with a one-year warranty.

If your unit is still exhibiting problems not covered by the above troubleshooting guide, please contact us for technical support at support@brandywinecomm.com or call us at 714-755-1050.

If it becomes necessary to return your unit to the factory for repairs, please call us at 714-755-1050 extension 113 to arrange an RMA.