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CNS Systems, Inc.
Communication, Navigation and Surveillance

Tac32Plus, Tac32Multi Time Interval Counter (TIC) Module

Taking Precision Timing To A New Level

. . .

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Revision History

Date	Significant Actions
19-Jun-1998	Initial draft
20-Jun-1998	Added Background section text
10-Sep-1998	Revised the Introduction section. Added details to the Requirements chapter.
21-Sep-1998	Editorial changes and new images based on the transfer of information to the Tac32Plus help files.
16-Dec-1998	Tac32Plus Version 2.0.0 release.
26-Mar-1999	Deleted cost justification section.
15-Jun-1999	Corrected errors reported by various users. Included new features of Tac32Plus Version 2.2.0.
24-Sep-2001	Change TIC setup instructions to set MATH = OFF.
02-Aug-2002	Minor corrections to "Recalling the Settings from Memory"

This document contains material derived, with permission, from works developed by Dr. Thomas A. Clark in connection with his Totally Accurate Clock (TAC and TAC-2) design on which the CNS Clock™ is based. Some of Mr. Clark's work was done for NASA and some for his own personal use. Mr. Clark's documentation can be found on the Internet at *ftp://aleph.gsfc.nasa.gov/GPS/totally.accurate.clock*.

Introduction

Adding Advanced Functionality to Tac32.

Tac32Plus is an advanced version of the Tac32 GPS control and display software for Windows 95, 98 and NT that adds features to support special purpose commercial and scientific applications.

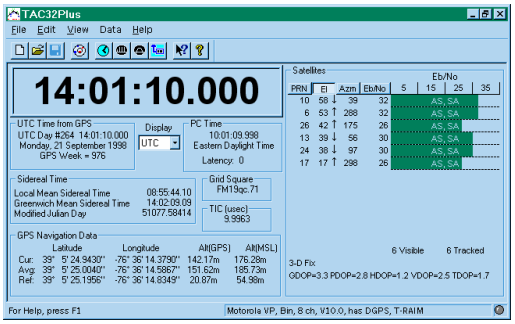
Scope

While Tac32Plus may include other advanced features, this document discusses only one – the Time Interval Counter (TIC) Module.

This module provides an interface with a HP53131A universal counter along with special purpose logging and display features that facilitate the statistical characterization and evaluation of the CNS Clock™ against another precision clock.

Baseline Software, Tac32

The baseline Tac32 software provides features to support the use of GPS for high accuracy timing and provides basic support for operation of a Motorola Oncore VP as a differential GPS (DGPS) reference station.



The main screen displays the time in BIG DIGITS. You can select from UTC, PC time, Greenwich Mean Sidereal time, Local Mean Sidereal time, or PC clock error displays.

Smaller windows show detains about GPS time, Local time, Sidereal time, GPS Navigation data, and GPS satellite status.

You can enable audible time ticks (to assist in setting your wrist-watch). Tac32 can automatically reset the PC's internal clock with about 25 msec accuracy. All the time display updates and audible ticks happen

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synchronously with the GPS 1 PPS signal because the PC reads the tick on its DCD line.

Tac32 allows you enter timing offsets and handles all the arithmetic. It allows you to make easy corrections for time delays in cables and the instrument. It reports (with 1 nsec resolution) the actual epoch of the 1PPS tick and it gives you an estimate of the accuracy of the tick.

Tac32 displays which satellites are being using and which satellites are above the horizon. This includes a bar-graph "S-meter" for each of the GPS satellites currently in lock, which are updated once per second.

Tac32 lets you change operating modes (timing vs. position, elevation masks, satellite selection criteria, etc) easily and when you are running in position determination mode, it will handle all the position averaging tasks for you.

All the configuration selections are saved when changes are made and restored when Tac32 is restarted.

Tac32 runs on Windows NT 4.0 and Windows 95. Recommended minimum configuration is Pentium 120 with 32 Mb RAM. Tac32 takes about 5Mb RAM to run and does not like being swapped out of memory because of the real-time nature of its operation.

Tac32Plus

Tac32Plus has all the features of Tac32. To those features it adds advanced capabilities that support specialized applications.

Time Interval Counter (TIC) module.

Provides an interface with a HP53131A or HP53132A Universal Counter along with special purpose logging and display features that facilitate the statistical characterization and evaluation of the CNS Clock™ against another precision clock.

Remote control of logging functions via TCP/IP

Tac32Plus has the capability to remotely control its logging functions using a Telnet session over TCP/IP. This capability may be exercised either manually, using any Telnet client, or automatically, by the use of a custom control program. In either case Tac32Plus is the Telnet Server and the user interface program is the Client.

Built-in SNTP time server.

The user can activate or deactivate the internal NTP server and select the server mode. The server operates in a unicast (inquiry/response) mode and supports both the SNTP Server (RFC 1769) and UDP/IP Server (RFC 868) protocols.

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Ability to run as a service under Windows NT®.
Microsoft® Windows NT® supports an application type known as a service. A Win32-based service conforms to the interface rules of the Service Control Manager (SCM). It can be started automatically at system boot, by a user through the Services control panel applet, or by a Win32-based application that uses the service functions included in the Microsoft® Win32® application programming interface (API). Services can execute even when no user is logged on to the system.

Tac32Multi

Tac32Multi has all the features of Tac32Plus and adds the ability to interface with up to eight Time Interval Counters simultaneously. Tac32Multi logs data for all active TICs in a set of related log files.

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Background and Need

NASA's Atomic Clocks.

The long-term performance of a precision *frequency* standard must be calibrated by a source of accurate epoch *time* directly traceable to the international time services (i.e. the USNO Master Clock) to provide accurate (sub-microsecond) epoch time tagging.

Monitoring of the accuracy of a precision *frequency* standard requires comparison with an independent, outside *time* standard.

Remote monitoring of the performance of a precision *frequency* standard requires direct network access to the data files.

The Trimble FTS8400 is Obsolete

Users of the Trimble FTS-8400 GPS timing receivers will soon need to replace them because they will stop working on August 21, 1999.

NASA and their partners around the world operate the Satellite Laser Ranging (SLR) and Very Long Baseline Interferometry (VLBI) networks. These networks use the FTS8400 GPS timing receivers. The current status indicates that:

- The Trimble/FTS8400's originally cost about $30,000 some 15 years ago and are due for a replacement with more modern hardware.
- The FTS8400s will die on August 21, 1999 because of the GPS equivalent of a Y2K problem – the GPS week 1024 roll-over.
- The CNS Clock™ (or Dr. Clark's TAC) performs a factor ~10 better than the FTS8400s, and cost under $1000.
- The CNS Clock™ (or Dr. Clark's TAC) needs to be used with a counter, and an excellent commercial time interval counter, the HP53131A, costs only $1725.
- The present logging software that supports the FTS8400 needs to be replaced. A cost-effective solution is to plan to acquire new ~$2000

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Pentium PCs (running Windows NT Server) for each station and using an adaptation of the Tac32 support software.

Why Do We Need A GPS Clock?

It is common for people to be confused over timing requirements. In fact, there are separate (but related) needs for *time* and *frequency.*

Each SLR and VLBI station is equipped with a precision *frequency* standard – a Hydrogen Maser at the VLBI stations, or a Cesium standard at the current SLR stations, or a GPS-disciplined Rubidium or Crystal standard in the new SLR2000 stations. This working "flywheel" can be called the "house clock" and serves as the reference for picosecond-level precision time intervals (including microwave carrier phase reference). This long-term performance of this *frequency* standard must be calibrated by a source of accurate epoch *time* directly traceable to the international time services (i.e. the USNO Master Clock). There is a need for preserving/improving the ability to compare the "house clock" with the USNO Master Clock because:

- The scientific applications of VLBI and SLR data requires accurate (sub-microsecond) epoch time tagging in order to be of any use.

- Efficient analysis/processing of the VLBI/SLR data requires the guarantee of long-term consistency of these time tags.

- Monitoring of the accuracy of the *frequency* generated by the "house clock" (the Maser/Cesium/Rubidium standard mentioned above), requires comparison with an independent, outside *time* standard.

In past years, NASA solved these problems by carrying (not too portable) travelling clocks to all their sites. This was later replaced/augmented by the use of LORAN timing. Then in the early 80's they made the transition to GPS, using the (now outmoded, antique) Trimble FTS8400 units (costing ~$30,000); the FTS8400 's have done yeoman's service, but it is now time for their retirement.

It is asserted that the SLR and VLBI networks will continue to have a mandatory requirement for GPS-based timing forever! Since the VLBI and SLR networks have similar timing requirements, and since their activities can be made much more cost-effective if they have a common solution, and because the present FTS8400-based capabilities will die in about a year a solution to this problem is needed now.

Some side benefits to the early adoption of this scheme are:

- FTS8400 users will save money (by improving operational efficiency and by not attempting to maintain the old FTS8400s);

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- users will achieve an order-of-magnitude improvement in the accuracy of the epoch *time* available at their stations; and

- this solution will solve some station communication and coordination problems (by better integration of the information flow using the Internet).

All this can be accomplished for a one-time cost around $5000 per station!

Some Specific Implementation Issues

In this system, the "house" to GPS time-interval measurement relies a dedicated counter. The reason is that to achieve RMS timing with ~20-30 nsec long-term stability, it is necessary to perform time-interval average (TIA) measurements. In VLBI, it has been seen that trying to share TIA clock comparison functions with a utility station counter is a programming nightmare. Further, no two breeds of counters have similar instrument control functions and data output formats. One advantage of the old FTS8400's was that they all looked the same, so that simple, routine network-wide data logging procedures could be devised.

The $1725 HP53131A Time Interval Counter (TIC) is an impressive device. The HP53131A has 10-digit resolution, and makes time interval measurements with 500 psec one-shot resolution. [An alternative is the HP53132A , with 12-digit and 150 psec, costing $2595. There is no compelling need for spending the extra $870. In the following comments, all HP53131A features apply to the more expensive HP53132A]. The HP53131A is a half-width, 3.5" high module. Rack mounting adapters cost an additional $52. It might be desirable to purchase the $100 option that puts the input connectors on the rear panel. Under any circumstances, a properly equipped HP53131A counter is under $2000.

Additional options: Some higher stability time-base options ($600, $900 or $1500) options are available, but are unnecessary since the "house clock" is already available. 3 GHz ($800) or 5 GHz ($2350) frequency counter options are available but would be unnecessary since the '131 is to be devoted to TIA measurements between the "house clock" and GPS.

The HP53131A has two independent data outputs. It comes equipped with full HPIB (IEEE-488) control. In addition, it also has a simple-to-use RS232 output (normally intended for a serial printer) on a standard 9-pin connector (a 9-pin female-to-female null modem cable is all that is required to plug it into a PC). When running in TIA mode, this port delivers data that looks like:

```
10.311,8  u               < Raw time-interval samples,
10.155,8  u               < output once/second with
10.285,8  u               < 500 psec resolution
10.251,8  u
10.094,8  u
10.226,3  u
10.194,8  u
```


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```
N      : 100              < Shows 100 second TIA interval,
STD DEV: 0.057,107  u     < followed by Std Dev (57.1 ns),
MEAN   : 10.183,871 u     < Mean offset (10183.871 nsec),
MAX    : 10.311,8   u     < and extrema seen during this
MIN    : 10.038,3   u     < (100 sec) TIA sample interval.
10.223,3  u               < Then the '131 resumes the
10.236,8  u               < once/second output until the
10.206,8  u               < next TIA (100 sec) interval.
```

This data can be captured and then passed it through a simple filtering program which reformats the data into two files – the TIA (typically 100 sec) samples, and (optionally) the "raw" 1 second data samples. This allows for easy import into EXCEL or MATLAB.

The Glue Required

With the CNS Clock™ (or Dr. Clark's TAC) and the inexpensive, off-the-shelf HP53131A time interval counter we have the genesis of a complete replacement for the FTS8400s ready to go. The only thing needed to "glue" it together is some software.

The CNS Clock™ hardware and Tac32 software were developed to provide high accuracy timing capabilities to support R&D activities of the air transport industry. It solved the particular problem of needing to synchronize several Windows NT computers being used for data acquisition with aircraft. The CNS Clock™ hardware was developed incorporating Dr. Clark's TAC-2 design.

Discussions with Dr. Clark (NASA) led to the design of this software module to integrate HP53131A counter support into Tac32 to meet the needs of the timing community that formerly used the FTS8400.

Thus, the Tac32Plus TIC module is designed to log either time-tagged "raw" (1/sec) TIC measurement and/or the TIA statistical measurements from a HP53131A in a format suitable for use by other programs (like EXCEL, MATLAB, etc).

Tac32Plus runs on any 32-bit Windows platform (W95/98/NT) and the only computer requirement is two serial ports (one for the TAC-2, one for the HP53131A counter).

Networking of Data files

Assuming this computer is connected to the station LAN, the data files can be made available to other machines for permanent logging and/or analysis and/or transmission back to "home". This can be accomplished by a variety of methods:

1. The Windows computer can "put" the files via its standard internet connection; or

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2. If the computer is running Windows NT, it can be available as a file server on the Internet; or

3. If the station is running Microsoft Networking (MSN), then the data files are directly accessible by other computers at the station; or

4. In the case of the VLBI stations, where the Field System is running LINUX, the SAMBA software supplied with LINUX also supports MSN.

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Requirements

Compare a GPS Clock to another Precision Clock.

The Tac32Plus Time Interval Counter (TIC) module provides an interface with a HP53131A Universal Counter along with special purpose logging and display features that facilitate the statistical characterization and evaluation of the CNS Clock™ against another precision clock.

Key design goals are:

- Provide log files in a format suitable for post processing by commonly available tools, such as Excel™.
- Provide log files in a format suitable for distribution over a Local Area Network (LAN) and/or the Internet. All logs are to be maintained "closed" to support remote network access.
- Provide the ability for site personnel to plot the behavior of their frequency standard locally using Tac32Plus.
- Specialized formats for files and graphics may be included if there is a need.

Log File Formats

Use the New Tic Data Log command to create a new Time Interval Counter data log file set. Use the Open Tic Data Log command to append data to an existing Time Interval Counter data log file set. Log files are always opened as a set of three files; an averaging log file, a time interval log file and a configuration log file.

The Averaging Log

The averaging log collects the statistical data from the HP53131A or 53132A Time Interval Counter (TIC) or by calculating the statistics internally based on the sawtooth corrected TIC data.

When using external TIC data, Tac32Plus combines the TIC data sets into single lines with time stamp (derived from GPS) and formats the data elements into a form suitable for direct import into a spread sheet program.

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For example, with time stamp format set to "Excel" and log file format set to comma delimited (".csv"):

Data from TIC	N : 100 STD DEV: 0.056,840 u MEAN : 10.223,769 u MAX : 10.353,8 u MIN : 10.096,8 u
Averaging Log	36044.652940,100,0.056840,10.223796,10.3538,10.0968

When using internal data to generate the averaging data the log file is generated in the same format.

The data elements in each line of the Averaging Log are, in order:

- Time Stamp: selectable format (see Time stamp section).
- Number of samples: established during the manual TIC setup procedure.
- Standard Deviation of the sample set, in microseconds.
- Mean of the sample set, in microseconds.
- Maximum value in the sample set, in microseconds.
- Minimum value in the sample set, in microseconds.

Notice that the log has a single time stamp while the data from the Time Interval Counter (TIC) arrives in a set of discrete lines over a short period of time. Fortunately the TIC always bundles the averaging lines together and delivers them at 9600 bps. The time stamp represents the most recent time received from the GPS receiver, synchronized by the 1PPS signal, when the log entry is written. The time stamp therefor has a precision of about 100 msec and accuracy of +0.0, –1.0 seconds relative to UTC (mean = -0.5 seconds).

Note: Data values that are very small or very large may be represented in exponential format.

The Time Interval Log

The time log collects the time interval data from the HP53131A or 53132A Time Interval Counter (TIC) and combines it with the most recent time, sawtooth and estimated accuracy data from the GPS receiver. This data is written to the log in single lines in a form suitable for direct import into a spread sheet program.

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For example, with time stamp format set to "Excel" and log file format set to comma delimited (".csv"):

Data from TIC	10.223,8 u 10.299,3 u 10.259,3 u 10.220,3 u
Tac32Plus Time Interval Log	36044.652327,10.2338,15,28 36044.652338,10.2993,-48,29 36044.652350,10.2593,-48,29 36044.652362,10.2203,-5,29

The data elements in each line of the Time Interval Log are, in order:

- Time Stamp: selectable format (see Time stamp section).
- Time interval reading from the HP53131A or 53132A Time Interval Counter (TIC).
- GPS receiver "sawtooth" clock error data.
- GPS receiver accuracy estimate (for future use).

The time stamp represents the most recent time received from the GPS receiver, synchronized by the 1PPS signal, when the log entry is written. The time stamp therefor has a precision of about 100 msec and accuracy of +0.0, –1.0 seconds relative to UTC (mean = -0.5 seconds).

The Configuration Log

The configuration file contains administrative information about the opening and closing times for the log files, GPS receiver and program settings when the files are opened and changes to GPS or program settings as they occur.

At a minimum, this log will contain:

- Reference Latitude, longitude and altitude.
- Switch settings, offsets,
- file name, open time.

For example, with time stamp format set to "Excel:

```
1999164.797489 ; Created TAC32Plus TIC Data Logs Sun Jun 13 19:08:23 1999 UTC
1999164.797489 @@En - RAIM (8-ch) ENABLED, limit = 500 nsec, 1PPS is ON always.
1999164.797489 ; Recording time data every 20 seconds
1999164.797489 ; Average data file based on external TIC data.
1999164.797558 ; Closed TAC32Plus TIC Data Logs Sun Jun 13 19:08:29 1999 UTC
1999164.797732 ; Opened TAC32Plus TIC Data Logs Sun Jun 13 19:08:44 1999 UTC
1999164.797732 ; Recording time data every 20 seconds
1999164.797732 ; Average data file based on internal sawtooth corrected data.
1999164.797848 ; Closed TAC32Plus TIC Data Logs Sun Jun 13 19:08:54 1999 UTC
```


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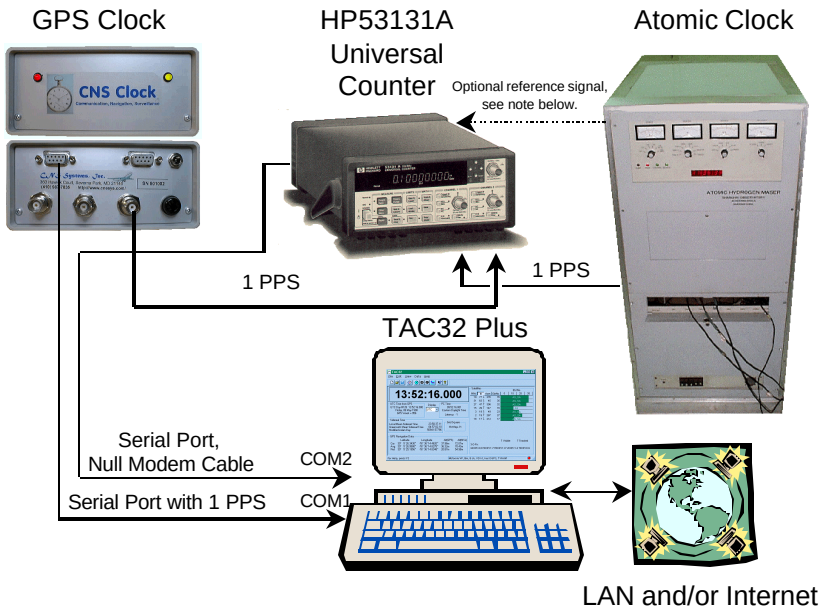
Architecture

How the System Elements Fit Together.

Hardware

The architecture is shown in the figure below. The Hydrogen Maser atomic clock is shown for reference only. Any clock with a one-pulse-per-second output may be used, even another GPS clock or a suitably equipped pendulum clock.



***Note1**:The optional reference signal for the counter requires that the reference frequency match the counter's reference input specification. For example, the HP53131A will accept 1, 5 or 10MHz while the HP53132A requires 10MHz only. Many atomic clocks and other reference oscillators do not provide 10MHz.*

***Note 2**:The CNS Clock™ shown in the figure above is a commercial version of the Totally Accurate Clock (TAC) designed by Dr. Thomas A. Clark (NASA). For more information on the CNS Clock™ see http://www.cnssys.com/.*

Note 3: Computer port numbers COM1 and COM2 are shown for reference only. Tac32Plus supports any configuration of serial communication ports.

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Counter Setup

Setting Up the HP53131A Universal Counter.

HP53131A Universal Counter

Unfortunately the HP53131A Universal Counter cannot be remotely controlled using its serial port. It does have a GPIB port that could be used for this purpose but that would have significantly increased the system cost. Support for the GPIB port may be added in the future.

Because of this it is necessary to set up the counter manually using the front panel controls. The setup need only be done once if the settings are stored in memory. After that, the settings can be recalled easily from memory whenever the counter is powered up.

The following sections describe the process of setting up the counter, storing the settings in memory and recalling the settings from memory.

Signal Connections

The start channel (channel 1) should always be the Unit Under Test (UUT), the atomic clock. The stop channel (channel 2) should always be the reference signal, in this case, the CNS Clock™ or TAC supplied GPS reference signal.

Note: USNO, JPL, NIST, and NASA use this as THE standard in time interval measurements. The FTS 8400 was hard wired internally to only have a start channel as an input.

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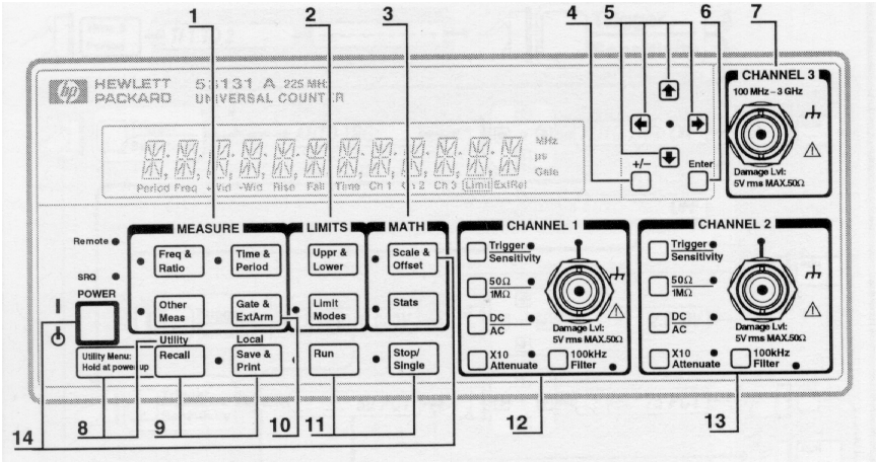
Front Panel Controls

The following setup instructions will refer to the front panel controls of the HP53131A as shown in the following figure. The HP52132A can be used if desired.



Note: Unit shown has Option 080 which is not needed for this setup.

1. Measurement function menu keys
2. Limits menu keys
3. Math menu keys
4. Sign (+ or -) selection toggle key
5. Data Entry/Select (or arrow) keys
6. Enter numeric data (terminate) key
7. 3.0/5.0GHz RF input channel (optional)
8. Utility menu key (Hold during power-up to access Utility functions.)
9. Recall, Save and Print menu keys
10. Gate and External Arm menu key
11. Measurement control keys
12. Channel 1 Trigger/Sensitivity menu key and input conditioning keys
13. Channel 2 Trigger/Sensitivity menu key and input conditioning keys
14. Calibration menu key (Hold Scale & Offset key during power-up to access Calibration functions.)

NOTE: It is normal operation for the fan in the HP 53131A/132A to continue to run after the POWER key is cycled off. As long as ac power is applied to the Counter, the fan will run.

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First Time Setup

Power On: Press and release the POWER button.

Channel Settings: Set up Channel 1 [12] to match the characteristics of the unit under test (atomic clock) and Channel 2 [13] to match the CNS Clock™ and TAC signal characteristics. For each channel perform each of the following operations.

- Press the trigger sensitivity button [12, 13]. The light next to these buttons will be on during menu selection. Using the Data Entry/Select (arrow) keys [5] to set values and the trigger sensitivity button [12, 13] to scroll through the selection menu, make the following selections.
  - AUTO TRG OFF
  - LEVEL: 1.000
  - SLOPE: POS
  - SENSITIVITY: LOW
  - COMMON 1: OFF

  Be sure to repeat this for the other channel.

Note: The channel settings are based on one-pulse-per-second signals from each clock that are "positive-going edge on-time" with an amplitude of 3 to 5 volts into 50 ohms. Some older Cesium and Rubidium atomic clocks(e.g., HP5061, HP5065, HP5071) output signals that are much different, such as 0 to 20 volt pulses. These may require changes to the trigger level, slope and/or other settings. If the user has a clock with a "negative-going edge on-time", the start channel must be set accordingly.

- Press the 50Ω/1MΩ button to select CH 1: 50 OHM and CH 2: 50 OHM. The light next to these buttons should be on.
- Press the DC/AC button to select CH 1: DC and CH 2: DC. The light next to these buttons should be on.
- Be sure the light next to the X10 Attenuate is off. If not press the button to turn it off.
- Be sure the light next to the 100KHz Filter is off. If not press the button to turn it off.

Set the measurement mode: Press the Time and Period button one or more times, as necessary, to select TI 1 TO 2. The light next to this button will stay on.

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Set up math and statistics: Press the Scale and Offset button [3]. Using the Data Entry/Select (arrow) keys [5] to set values and the Scale and Offset button [3] to scroll through the selection menu, make the following selections.

- SCAL: 1.000000
- OFFS: 0.000000
- SEE OFFSET ? (ignore)
- MATH: OFF
- MATH HELP ? (ignore)

Now press the Stats button [3]. Using the Data Entry/Select (arrow) keys [5] to set values and the Stats button [3] to scroll through the selection menu, make the following selections.

- USE: ALL MEAS
- ON SINGLE: 1
- SHOW: MEAN
- N: 100
- STATS: ON

The lights next to these buttons will stay on indicating that the functions are active.

Activate the serial port: Press the Save & Print button [9] multiple times, if necessary, and set PRINT: ON.

Begin Continuous Operation: Press the Run button [11]. The light next to the Run button should stay on and the light next to the Stop/Single button should be off.

Other Functions: Be sure the light next to the Limit Modes button [2] is off. If not, press the Limit Modes button [2] multiple times, if necessary, and set LIM TEST: OFF.

Storing the Settings in Memory

The settings can be saved in the counter's memory for later recall. The counter has 20 user selectable memories numbered 1 through 20. Memory 0 is reserved for power-on default settings.

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Press the Save & Print button [9] multiple times, if necessary, and set ***SAVE: 1*** (or choose any other memory number using the Data Entry/Select (arrow) keys [5]). Press the Enter button [6] to complete the operation.

Press the ***Run*** button [11] to return to normal operation.

Recalling the Settings from Memory

The counter has 20 user selectable memories numbered 1 through 20. Memory 0 is reserved for power-on default settings. If the settings have previously been saved, they can easily be recalled after a power-up or at any time to restore the counter to the correct settings.

Press the ***Recall*** button [9]. The display will show ***RECALL: 0*** (or the last used memory channel). Select the correct memory channel number *(normally channel 1)* using the Data Entry/Select (arrow) keys [5]). Press the Enter button [6] to complete the operation.

Then return the counter to its normal mode by pressing the ***Run*** button [11].

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Tac32Plus Setup

Setting Up Tac32Plus and the GPS Receiver.

Tac32 and the GPS Clock

Tac32 is fully described *in CNS Clock™ and Tac32 Installation and Operation*. The operations described in the chapter *Getting Started* should be performed to permit the GPS receiver to operate in high accuracy timing mode. These operations are:

- Set up the hardware.
- Install the Tac32Plus software.
- Set the initial reference position
- Compensate for antenna and measurement cable delays.
- Perform a self-survey and reset the reference position.
- Set the GPS receiver to 0-D navigation mode.
- Set timing offsets, if needed.

Once these operations have been performed Tac32Plus is ready to begin operation. The following sections describe the additional operational features associated with the Hydrogen Maser atomic clock interface.

Activating the Logs

The file menu provides access to the logging and program exit commands.

New TIC Log File command

Use this command to create a new TIC log set. Select the type of new log file set you want to create, select the time stamp format and select a file name using the New TIC Log File dialog box.

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You can open an existing TIC log file set with the Open TIC Log command.

Open TIC Log File command
Use this command to open an existing TIC log file set. Select the type of file set you want to open in the Open Log File dialog box and enter a name or select from the displayed list.

You can create new logs with the New Log File command.

Closing the Logs

Use this Close command under the File/TIC Log files menu to close an active TIC log file set.

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Optional Capabilities

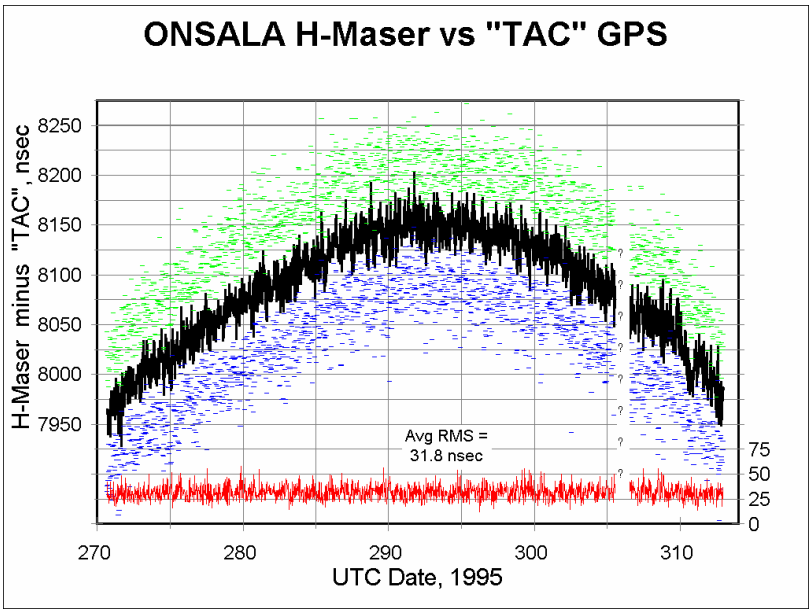
Plotting the results.

Note: The capabilities described in this section have not been implemented. They are presented here only for discussion purposes to consider features that might be implemented in the future.

Tac32Plus can generate real time plots of the accumulated data, similar to the plots generated by NASA's post processing software. This allows the system operators to get immediate feedback on the performance of their system.

Onsala Plot

The Onsala plot measures the drift rate of the Hydrogen Maser over a long period of at least one month. The Onsala plot was developed by Dr. Tom Clark (NASA) at the Onsala Space Observatory in Sweden during September 1995 using a TAC



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(prototype of the CNS Clock™) to monitor the performance of their Hydrogen Maser.

The 1 PPS signals from their Hydrogen Maser oscillator and the TAC were compared in a good quality HP 53131A time-interval counter with an HPIB for data acquisition. The counter made 30 second time-interval averages of the Maser-to-TAC time interval and logged the data on a computer every 30 seconds.

Dr. Clark processed the raw logs for the Day#270 to Day#312 interval. The 30 second raw numbers were averaged in 30 minute bins. The RMS deviation of the 30 second numbers in each 30 minute bin were computed, and the max/min values in the bin were noted. The only "sanity" tests were to screen out occasional bad readings (logged time-of-day didn't increment properly, or the reading differed from a running mean by more than 1 usec) [except for day #306 where a number of really strange reading were in the logs and were discarded en masse].

The Onsala plot above shows the graphical results. The heavy line (an inverted parabola going between ~7950 and ~8150 nsec) is the 30 minute averages of the 30 second counter readings. The small tick marks extending ~+/- 100 to 150 nsec around this line are the individual max/min differences from the mean.

At the bottom of the plot (use the scale on the right-hand side) are the RMS values for each 30 second measurement in each 30 minute bin. The overall average RMS value of these points is about 32 nsec.

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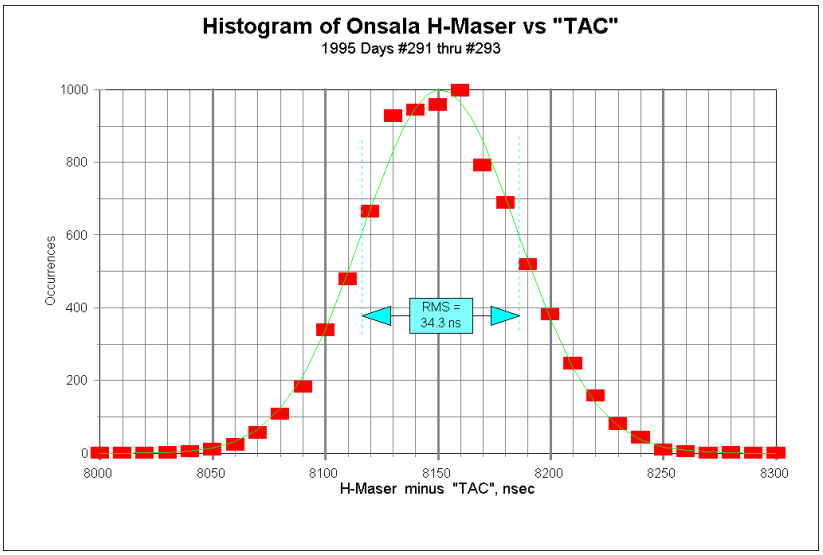
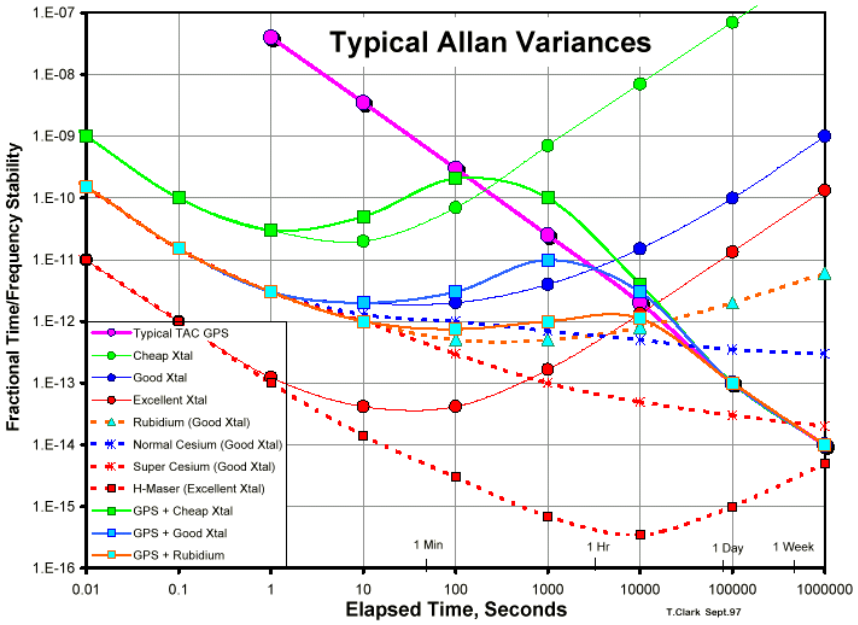


The figure above shows the histogram of 30-second Onsala data for the Day#291 through Day#293 period (when the OSO clock had essentially zero drift with respect to GPS). Superimposed on the plot is a Gaussian curve for the measured ~34 nsec RMS (mathematically 1000*exp((t-8151)/49)^2).

Allan Variance Chart

see HP1289 application note.



Bias, rate offset, linear change in rate. Subtract off the "non surprises". Then at, say, 1, 10, 100, 1000 second offsets do

$$\text{å}\,(t_{10} - t_0).$$

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