Timing for VLBI

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CNS Systems

IVS TOW Meeting

Haystack – Sept 21-24, 2003

What Timing Performance Does VLBI Need?

- The VLBI community (Radio Astronomy and Geodesy) uses Hydrogen Masers at 40-50 remote sites all around the world. To achieve ~10° signal coherence for ~1000 seconds at 10 GHz we need the two oscillators at the ends of the interferometer to maintain relative stability of $\approx [10°/(360° \cdot 10^{10}\text{Hz} \cdot 10^{3}\text{sec})] \approx 2.8 \cdot 10^{-15}$ @ 1000 sec
- To correlate data acquired at 16Mb/s, station timing at relative levels ~50 nsec or better is needed. After a few days of inactivity, this requires $\approx [50 \cdot 10^{-9} / 10^{6}\text{ sec}] \approx 5 \cdot 10^{-14}$ @ 10^{6} sec
- In Geodetic applications, the station clocks are modeled at relative levels ~30 psec over a day $\approx [30 \cdot 10^{-12}/86400\text{ sec}] \approx 3.5 \cdot 10^{-16}$ @ 1 day
- Since VLBI defines UT1, we need to control $[UTC_{(USNO)} - UTC_{(VLBI)}]$ to an accuracy ~100 nsec or better.

The difference between Frequency and Time

Oscillators and Clocks

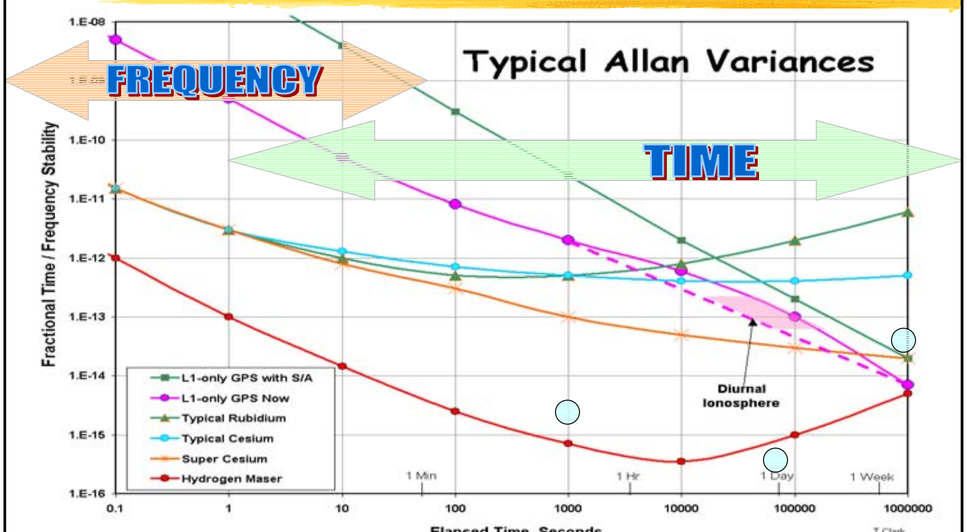
Oscillator
- •Pendulum
- •Escapement Wheel
- •Crystal Oscillator
- •Oscillator Locked to Atomic Transition
  - •Rubidium (6.8 GHz)
  - •Cesium (9.1 GHz)
  - •Hydrogen Maser (1.4 GHz)

Events that occur with a defined **FREQUENCY** nsec -- minutes

Integrator and Display = Clock
- •Gears
- •Electronic Counters
- •Real Clocks

Long-Term **TIMING** seconds - years

The Allan Variance – A graphical look at clock performance



Why do we need to worry about "Absolute Time" (i.e. Accuracy) in VLBI?

- To get the correlators to line up for efficient processing, the relative time between stations needs to be known to ~ 100 nsec.
- The correlators maintain their "magic tables" that relates the GPS timing data reported by different stations to each other.
- In the past, geodetic and astronomical VLBI data processing has been done by fitting the data with "station clock polynomials" over a day of observing, and then discarding these results as "nuisance parameters" that are not needed for determining baseline lengths, source structure, etc.
- The uncalibrated and unknown offsets now range from 1-10 usec at many VLBI stations.

1

Why do we need to worry about "Absolute Time" (i.e. Accuracy) in VLBI?

- The ***ONLY*** reason for worrying about "absolute time" is to relate the position of the earth to the position of the stars:
  - Generating Sidereal Time to point antennas.
  - Measuring UT1 (i.e. "Sundial Time") to see changes due to redistribution of mass in/on the earth over long periods of time.
  - Knowing the position of the earth with respect to the moon, planets and even the the GPS satellites.

2

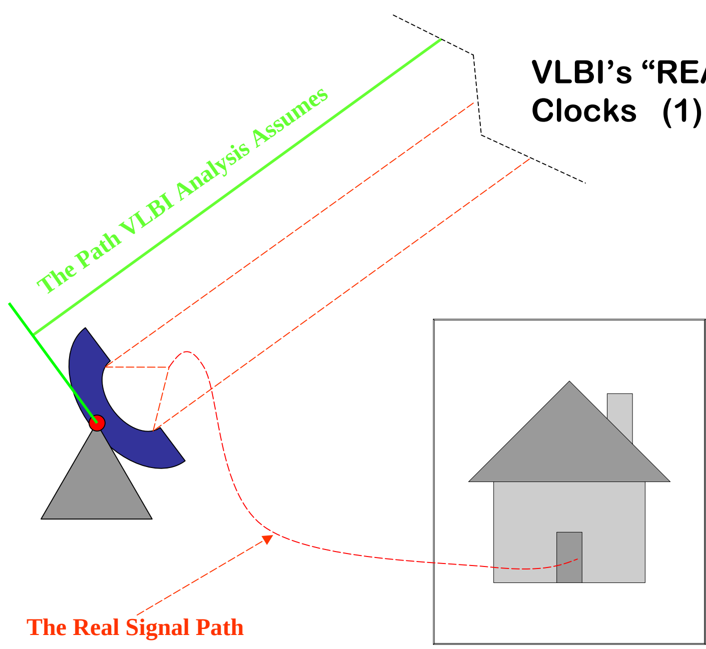
Why do we need to worry about "Absolute Time" (i.e. Accuracy) in VLBI?

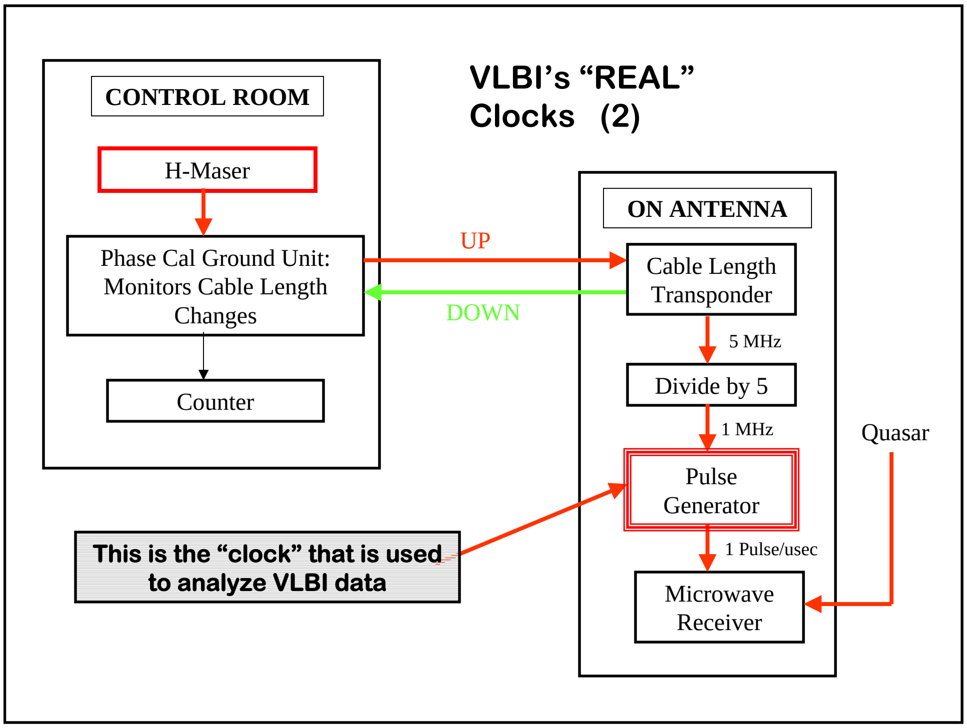
At the stations this means that we will need to pay more attention to timing elements like

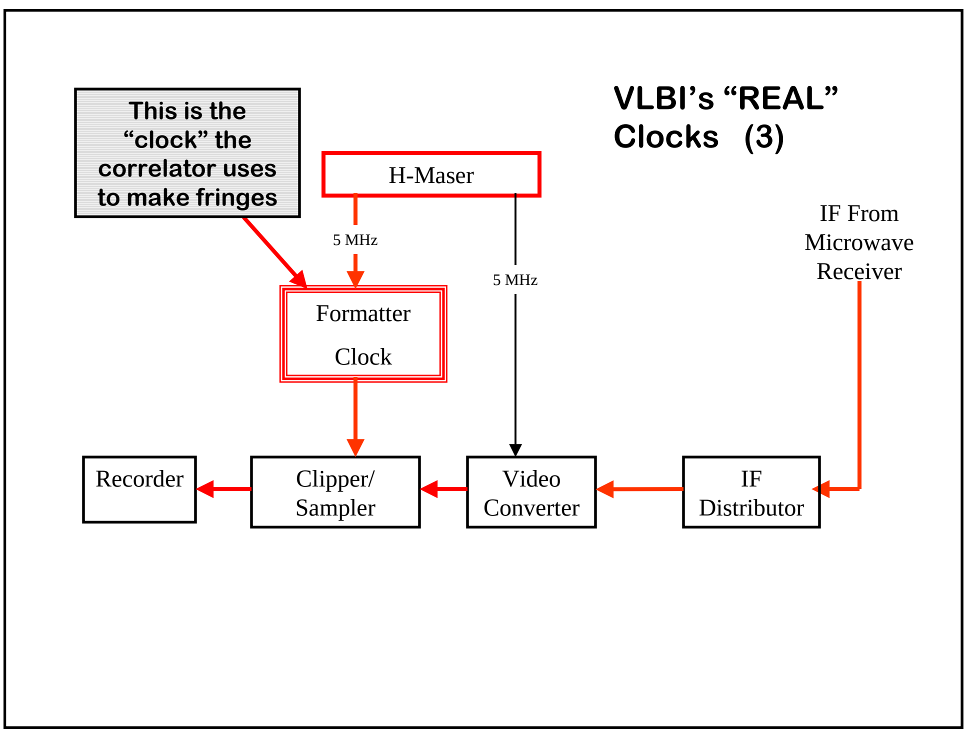
- Frequency Standard and Station Timing
- The lengths of cables
- The geometry of the feed/receiver to the antenna.
- Calibration of instrumental delays inside the receiver and backend. The development of new instrumentation is needed.
- The care with which system changes are reported to the correlators and the data analysts.

3

VLBI's "REAL" Clocks (1)



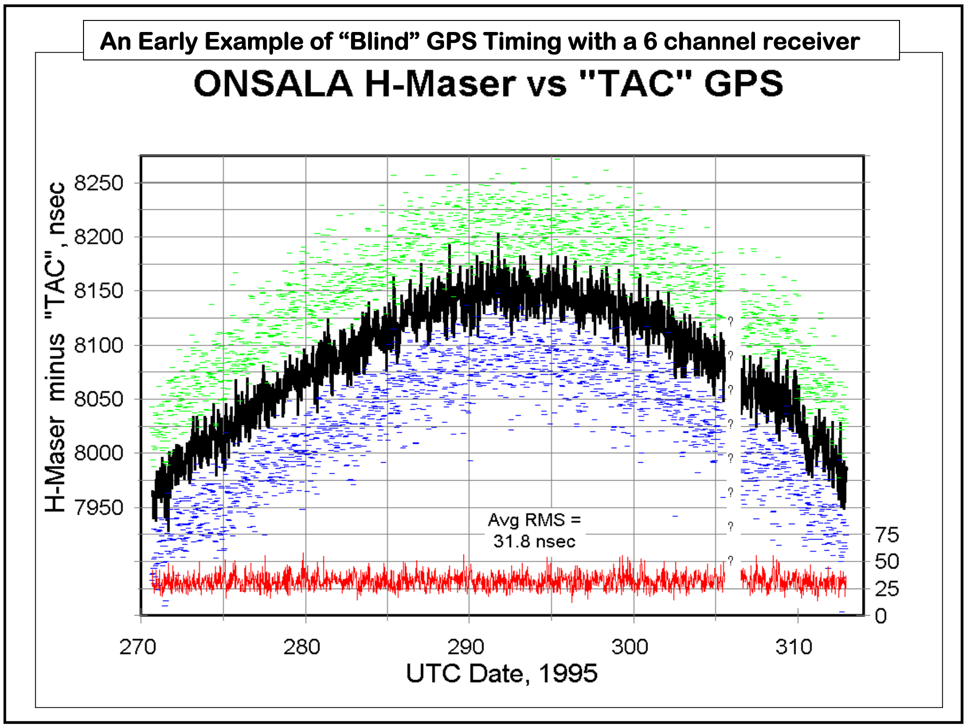

VLBI's "REAL" Clocks (2)
CONTROL ROOM
H-Maser
Phase Cal Ground Unit: Monitors Cable Length Changes
Counter
UP
DOWN
ON ANTENNA
Cable Length Transponder
5 MHz
Divide by 5
1 MHz
Pulse Generator
1 Pulse/usec
Microwave Receiver
Quasar
This is the "clock" that is used to analyze VLBI data

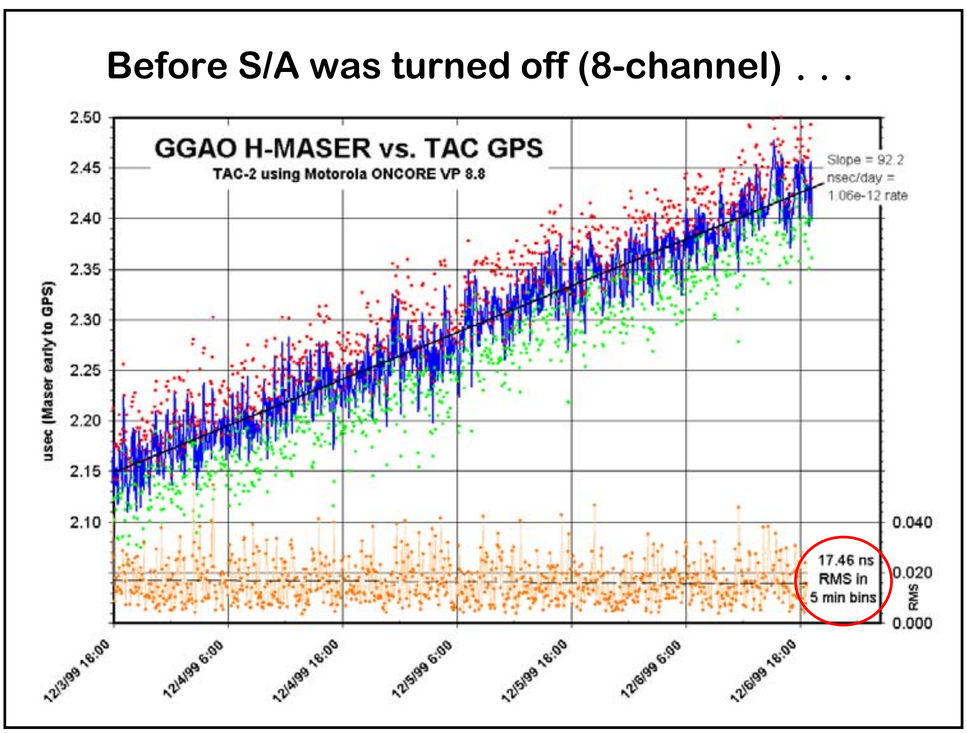

VLBI's "REAL" Clocks (3)
This is the "clock" the correlator uses to make fringes
H-Maser
5 MHz
5 MHz
Formatter Clock
IF From Microwave Receiver
Recorder
Clipper/ Sampler
Video Converter
IF Distributor

Setting VLBI Clocks Time & Rate with GPS
-- 3 possible ways--

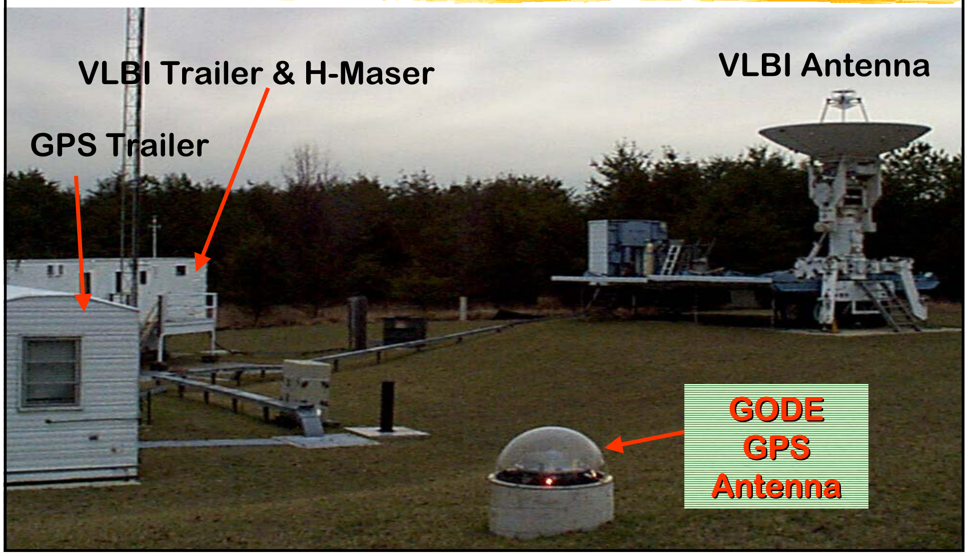
- Compare two distant clocks by observing the same GPS satellite(s) at the same time (called <u>Common View</u>)
  - Requires some intervisibility between sites
  - Requires some near-Real-Time communication
  - Links you directly to the "Master Clock" on the other end at ~1 nsec level
- Use <u>Geodetic GPS receivers</u> (i.e. as an extension of the IGS network)
  - Requires high quality (probably dual frequency) receiver (TurboRogue, Z12, etc), but it's hard to gain access to the internal clock.
  - Requires transferring ~1 Mbyte/day of data from site
  - Requires fairly extensive computations using dual-frequency data to get ~300 psec results with ionosphere corrections
  - Allows Geodetic community to use VLBI Site for geodesy & ionosphere network
- **<u>Blindly use the Broadcast GPS Timing Signals as a clock</u>**
  - **Single Frequency L1 only (until 2004)**
  - **Yields ~10 nsec results with < $1000 hardware**

An Isolated, Remote VLBI Site --
Urumqi in Xinjiang Province, China


An Early Example of "Blind" GPS Timing with a 6 channel receiver
ONSALA H-Maser vs "TAC" GPS
H-Maser minus "TAC", nsec
8250
8200
8150
8100
8050
8000
7950
Avg RMS =
31.8 nsec
75
50
25
0
270
280
290
300
310
UTC Date, 1995


Before S/A was turned off (8-channel) . . .
GGAO H-MASER vs. TAC GPS
TAC-2 using Motorola ONCORE VP 8.8
usec (Maser early to GPS)
2.50
2.45
2.40
2.35
2.30
2.25
2.20
2.15
2.10
Slope = 92.2
nsec/day =
1.06e-12 rate
17.46 ns
RMS in
5 min bins
0.040
0.020
0.000
RMS
12/3/99 16:00
12/4/99 6:00
12/4/99 18:00
12/5/99 6:00
12/5/99 18:00
12/6/99 6:00
12/6/99 18:00

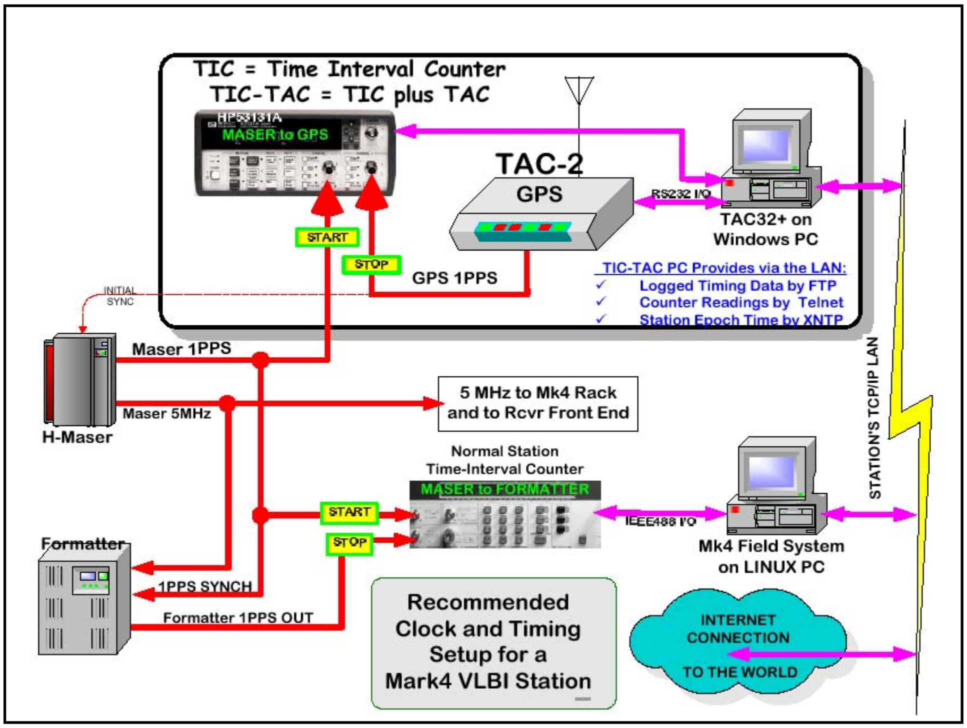
GGAO (Goddard Geophysical & Astronomical Observatory)



How we got ~30 nsec timing even with S/A

- Start with a good timing receiver, like the Motorola ONCORE
- Average the positioning data for ~1-2 days to determine the station's coordinates. With S/A on, a 1-2 day average should be good to <5 meters. Or if the site has been accurately surveyed, use the survey values.
- Lock the receiver's position in "Zero-D" mode to this average.
- Make sure that your Time-Interval Counter (TIC) is triggering cleanly. Start the counter with the 1 PPS signal from the "house" atomic clock and stop with the GPS receiver's 1PPS.
- Average the individual one/second TIC reading over ~5 minutes.

- These steps were automated in the SHOWTIME and TAC32Plus Software.

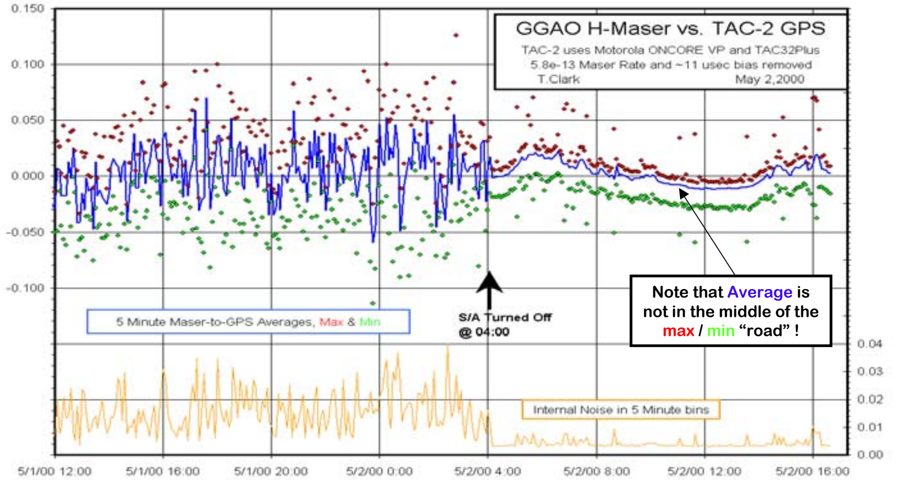


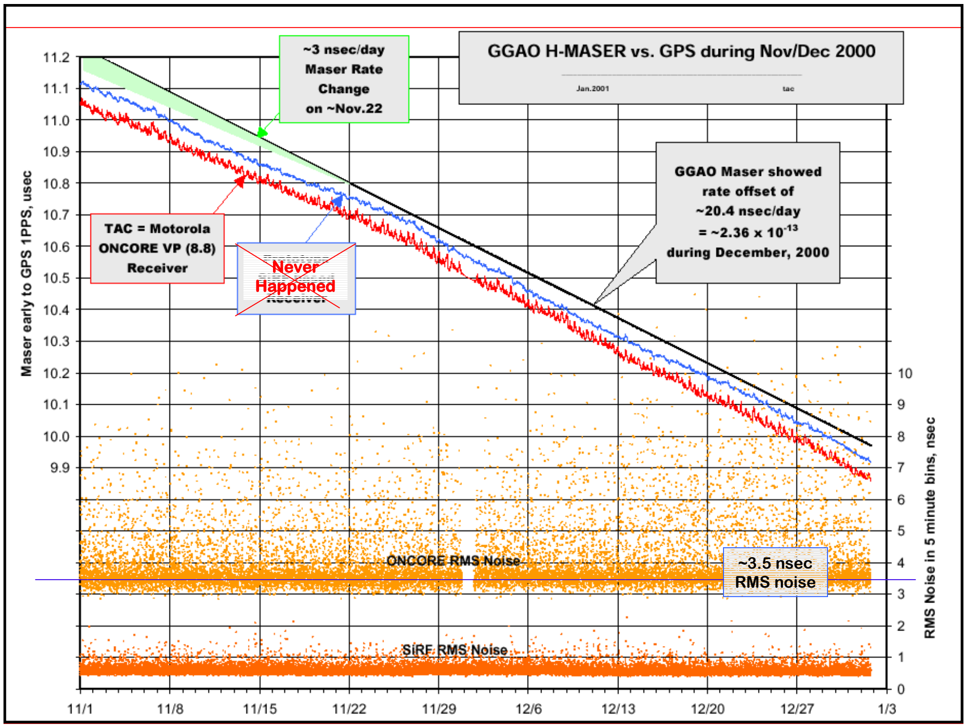
Let Us Now Discuss . . .

- What happened when S/A was turned off on May 2nd, 2000.
- Sawtooth and Glitches
- Some recent results obtained with Motorola's newest low cost timing receiver (the M12+)

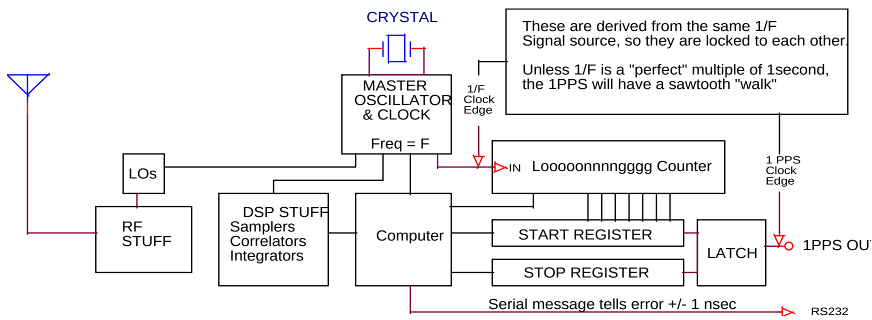
What happened when S/A went away?

Using 8-channel Motorola ONCORE VP Receiver . . .





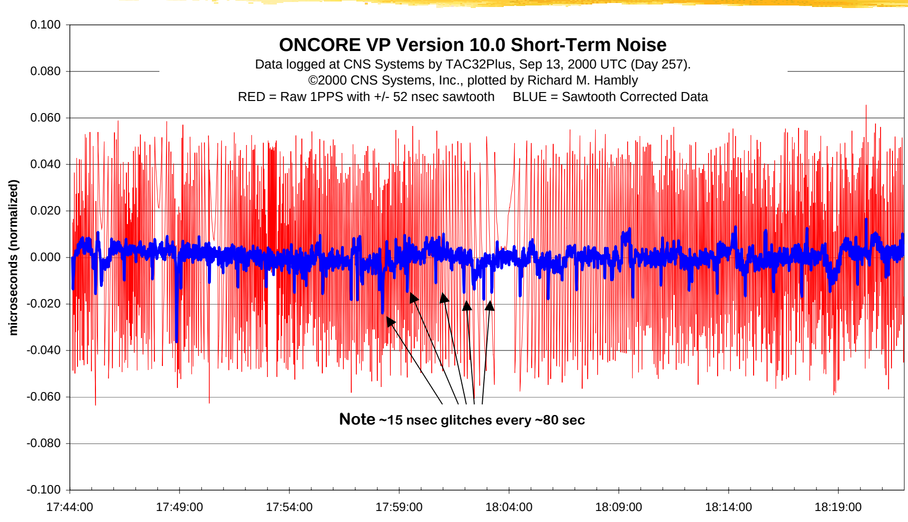
What is the sawtooth effect ????



- For the older Oncore, F=9.54 MHz, so the 1/F sawtooth has a range of +/- 52 nsec (104 nsec peak-to-peak)
- The new Oncore M12+ has F ≈ 40 MHz, so the sawtooth has been reduced to +/- 13 nsec (26 nsec).

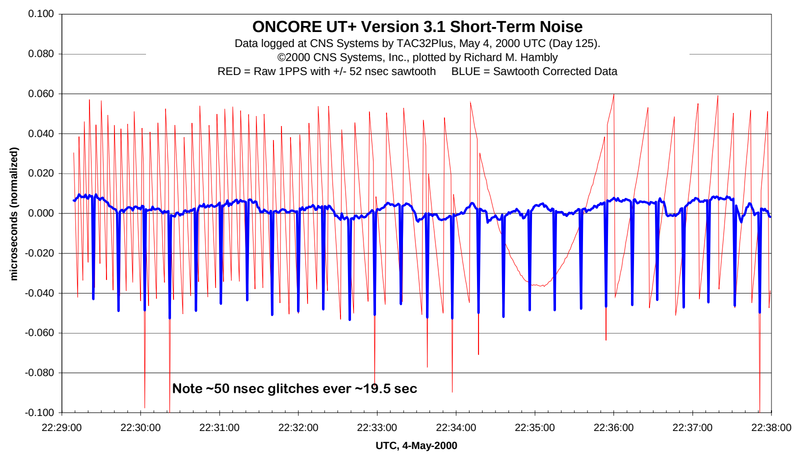
An example of 1PPS sawtooth

Motorola VP (10.0)



An example of 1PPS sawtooth

Motorola UT+ (3.1)



CNS Systems' Test Bed at USNO

Calibrating the "DC" Offset of the new M12+ receiver.

We have observed that the ONCORE firmware evolution from 5.x ⇒ 6.x ⇒ 8.x ⇒ 10.x has been accompanied by about 40 nsec of "DC" timing offsets.

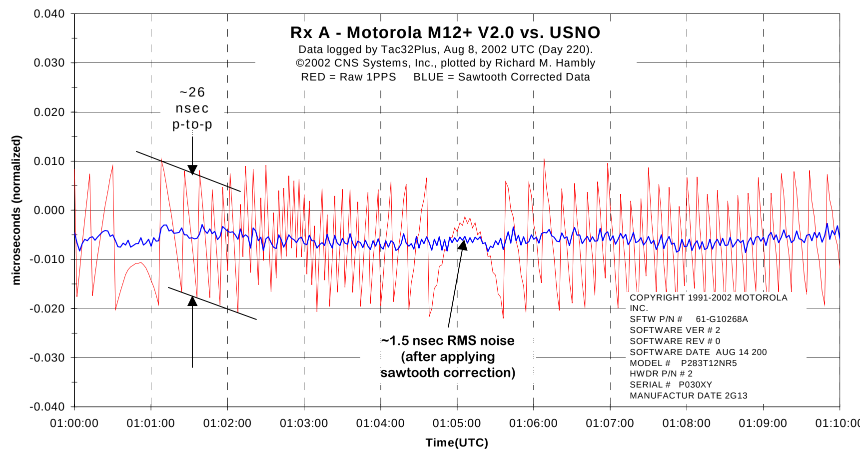
Motorola tasked Rick to make the new M12+ receiver be correct.

Tac32Plus software simultaneously processes data from four Time Interval Counters and four CNS Clocks, writing 12 logs continuously.

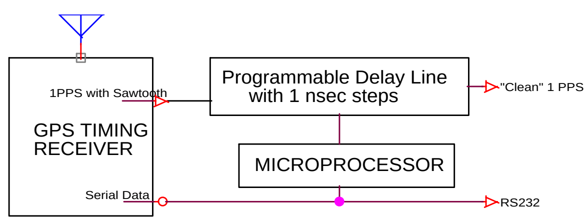
Time Interval Counters compare the 1PPS from each CNS Clock (M12+) against the USNO's UTC time tick.

An example of 1PPS sawtooth

with the new Motorola M12+ receiver



How could the sawtooth be eliminated ???

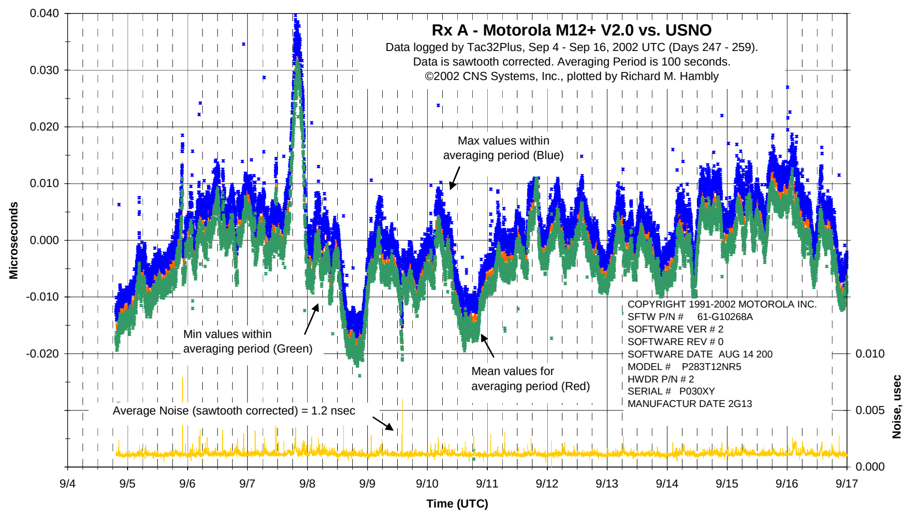


A POSSIBLE WAY TO ELIMINATE THE ANNOYING SAWTOOTH

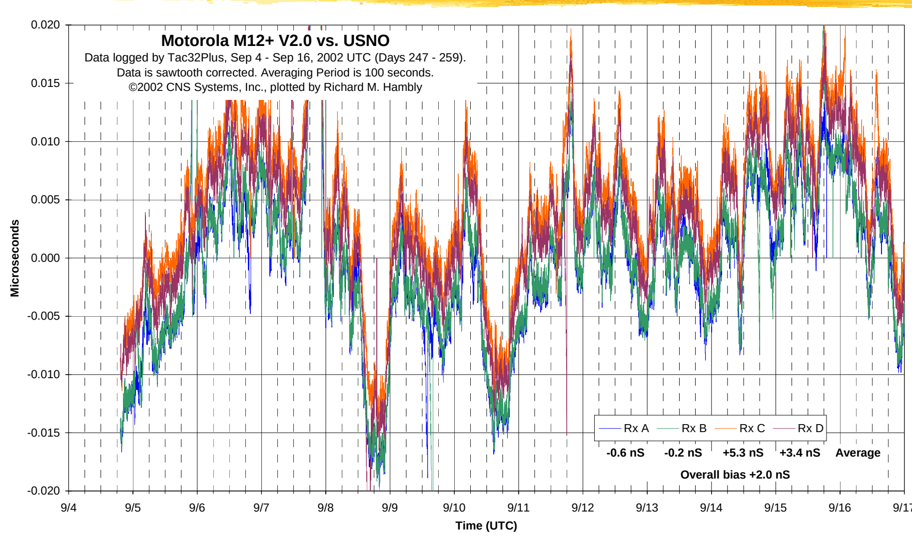
Stay tuned for this! Talk to Rick,

Individual M12 Clock Performance

Receiver (A) average "DC" offset = -0.6 ns



Comparing four M12+ Timing Receivers



What Happened on 9/7/02 ?

September 7, 2002.

This picture is a two hour composite of 85 different photos spanning 21:07 thru 23:10 EDT on Sept. 7th (01:07 thru 03:10 UTC Sep. 8).

September 8, 2002.

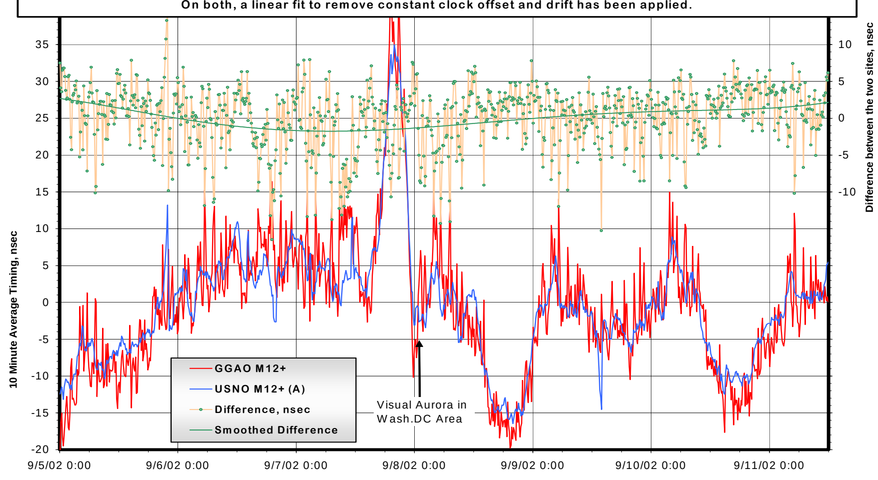
This picture is a four hour composite of 140 different photos spanning 20:00 thru 24:00 EDT on Sept. 8th (00:00 thru 04:00 UTC Sep. 9).

Each picture was an 87 second exposure with 3 seconds between frames. The trails on the picture are all due to airplanes. The bright loop is from a plane on final approach into BWI airport. Camera = Canon D60 shooting Hi Resolution JPEG at ISO 100 with TC-80 timer. Lens = Sigma f/2.8 20-40 mm set to 20 mm @ f/4.5

Short Baseline Test (USNO to NASA GGAO)

Comparing two new Motorola M12+ GPS Timing Receivers over the 21.5 km baseline between the US Naval Observatory (USNO) and the NASA Goddard Geophysical & Astronomical Observatory (GGAO).

Both data sets compare the GPS timing receiver to a local Hydrogen Maser clock. On both, a linear fit to remove constant clock offset and drift has been applied.



Where to get information?

These Slides and related material and our Salt Lake City ION 2000 paper:

http://gpstime.com

Information on Rick Hambly's CNS Clock, a commercial clone of my TAC-2:

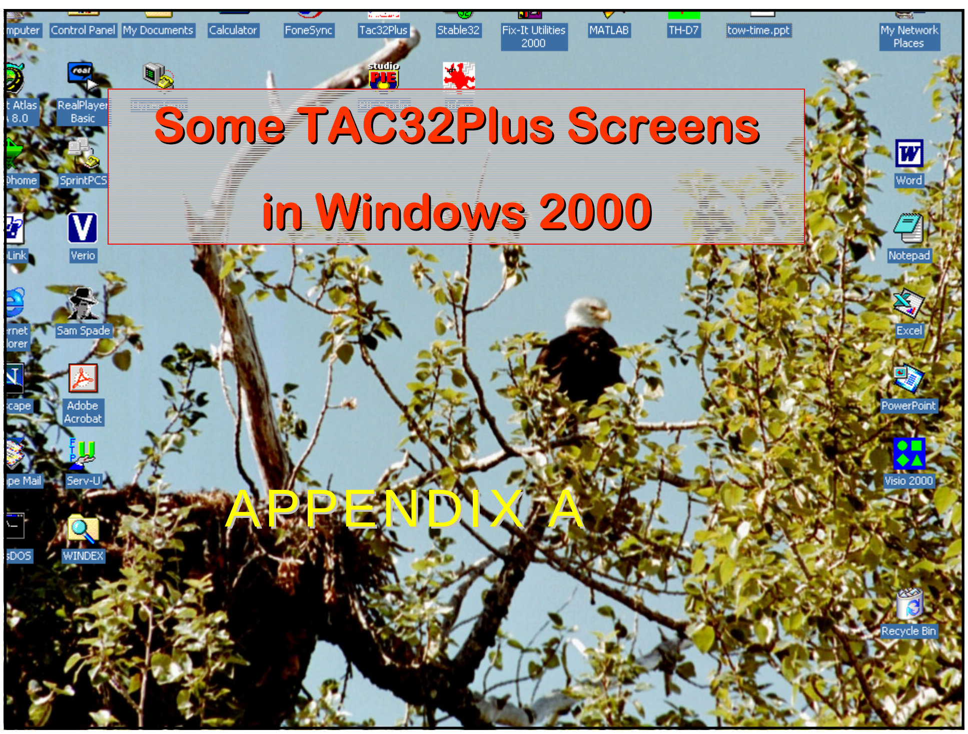
http://www.cnssys.com

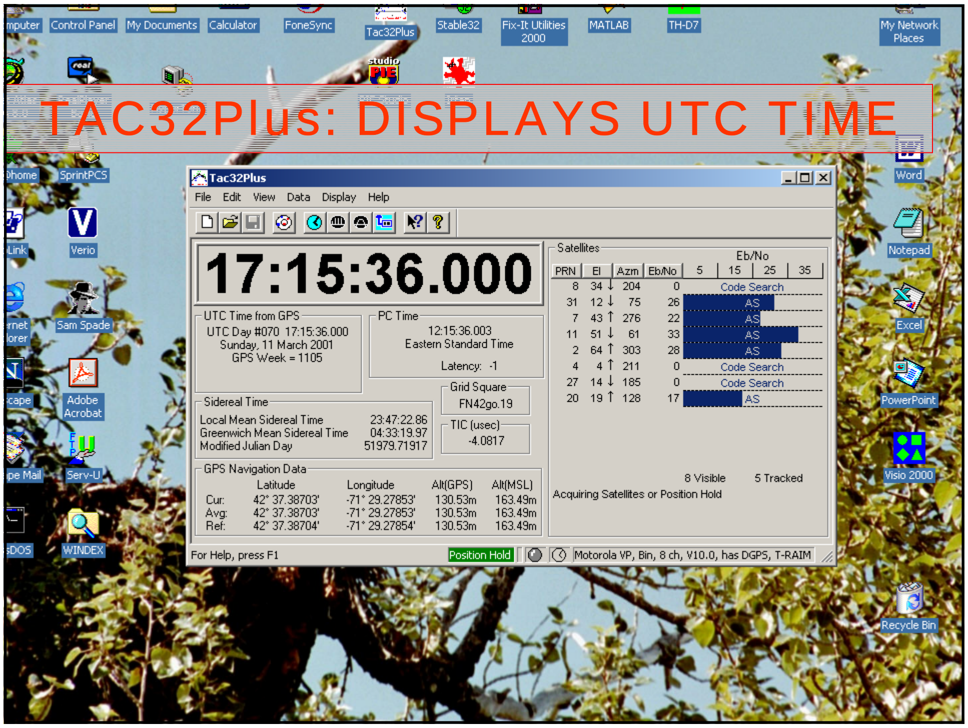
For ONCORE/TAC-2 receiver used as a LINUX xntp server:

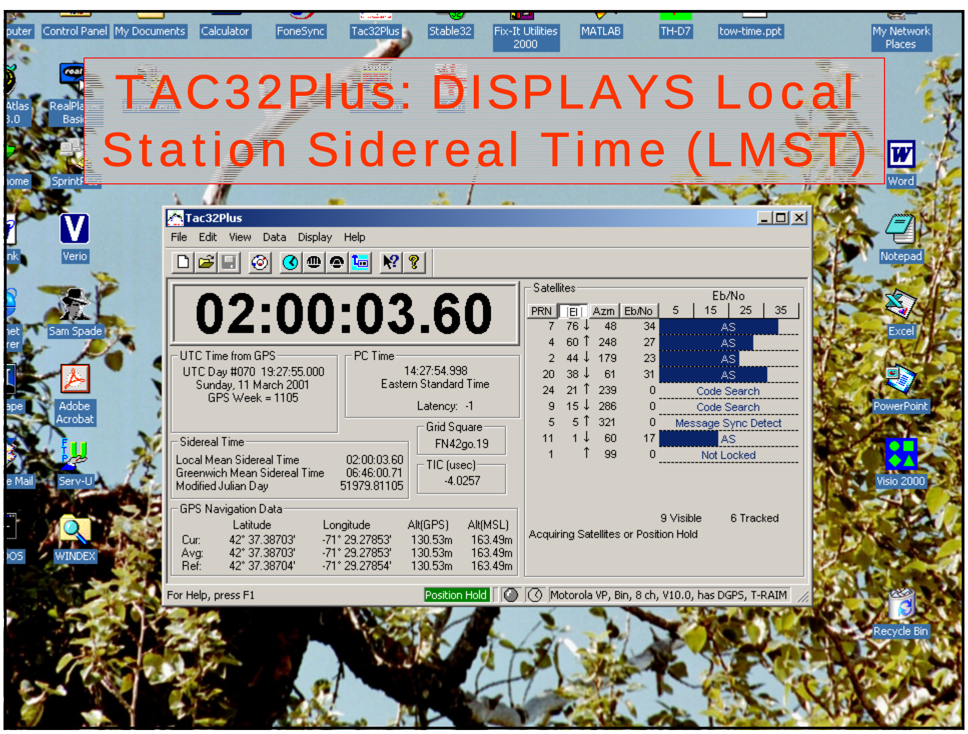
http://gpstime.com

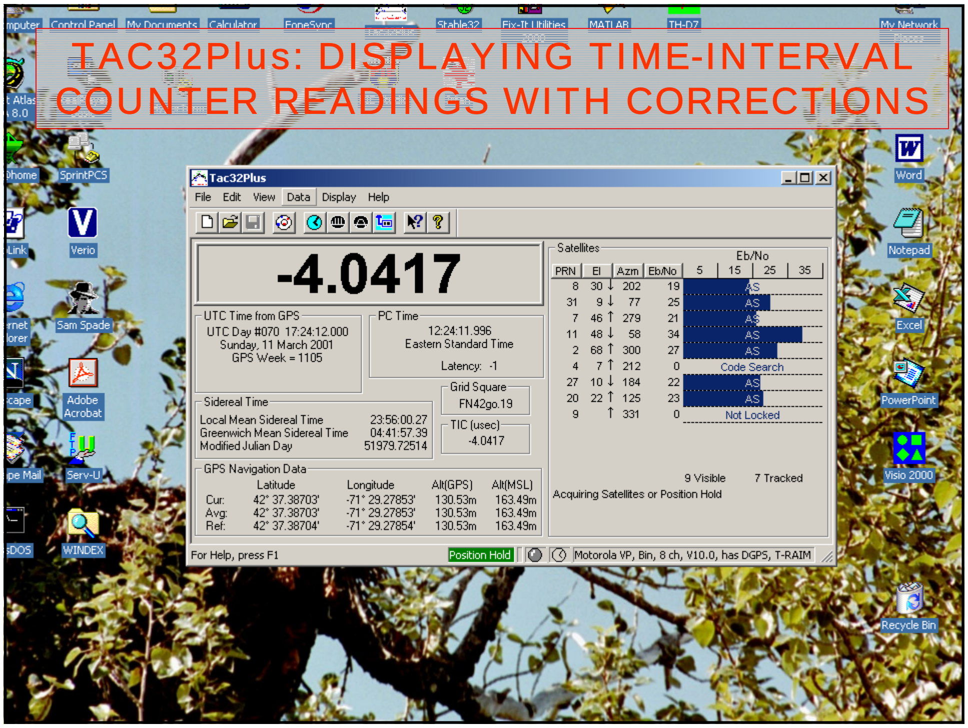
To contact me: mailto:w3iwi@toad.net

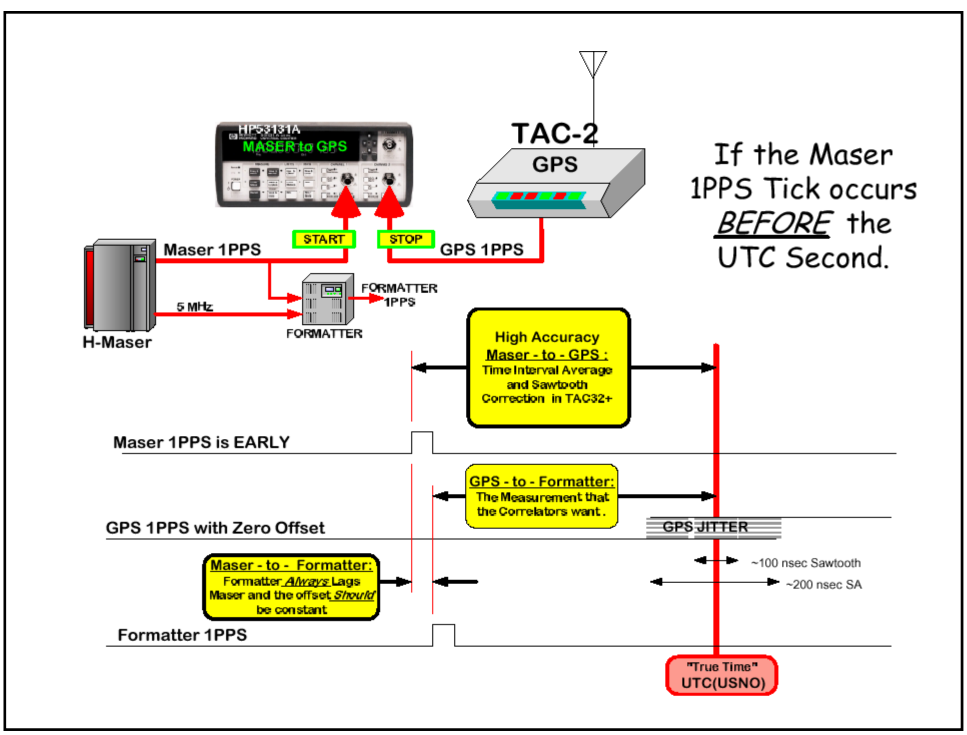
To contact Rick: mailto:rick@cnssys.com

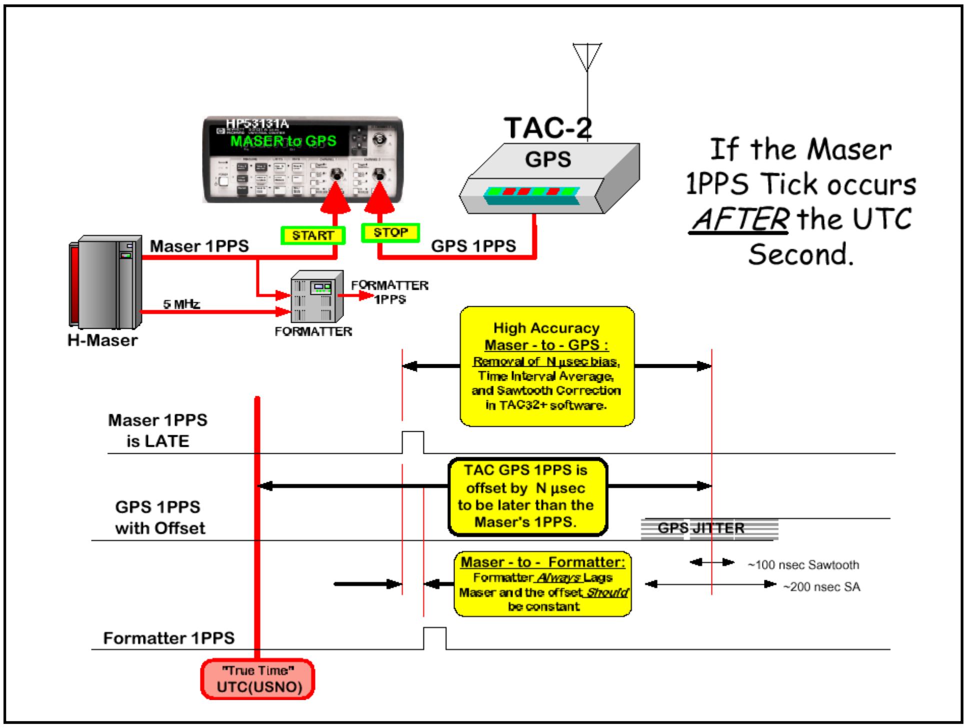



TAC32Plus: DISPLAYS UTC TIME
Tac32Plus
File Edit View Data Display Help
17:15:36.000
UTC Time from GPS
UTC Day #070 17:15:36.000
Sunday, 11 March 2001
GPS Week = 1105
PC Time
12:15:36.003
Eastern Standard Time
Latency: -1
Grid Square
FN42go.19
Sidereal Time
Local Mean Sidereal Time 23:47:22.86
Greenwich Mean Sidereal Time 04:33:19.97
Modified Julian Day 51979.71917
TIC (usec)
-4.0817
GPS Navigation Data
Satellites
8 Visible 5 Tracked
Acquiring Satellites or Position Hold
For Help, press F1
Position Hold
Motorola VP, Bin, 8 ch, V10.0, has DGPS, T-RAIM


TAC32Plus: DISPLAYS Local Station Sidereal Time (LMST)
Tac32Plus
File Edit View Data Display Help
02:00:03.60
UTC Time from GPS
UTC Day #070 19:27:55.000
Sunday, 11 March 2001
GPS Week = 1105
PC Time
14:27:54.998
Eastern Standard Time
Latency: -1
Grid Square
FN42go.19
Sidereal Time
Local Mean Sidereal Time 02:00:03.60
Greenwich Mean Sidereal Time 06:46:00.71
Modified Julian Day 51979.81105
TIC (usec)
-4.0257
GPS Navigation Data
Satellites
9 Visible 6 Tracked
Acquiring Satellites or Position Hold
For Help, press F1
Position Hold
Motorola VP, Bin, 8 ch, V10.0, has DGPS, T-RAIM


TAC32Plus: DISPLAYING TIME-INTERVAL COUNTER READINGS WITH CORRECTIONS
Tac32Plus
-4.0417
UTC Time from GPS
UTC Day #070 17:24:12.000
Sunday, 11 March 2001
GPS Week = 1105
PC Time
12:24:11.996
Eastern Standard Time
Latency: -1
Sidereal Time
Local Mean Sidereal Time 23:56:00.27
Greenwich Mean Sidereal Time 04:41:57.39
Modified Julian Day 51979.72514
Grid Square
FN42go.19
TIC (usec)
-4.0417
Satellites
9 Visible 7 Tracked
Acquiring Satellites or Position Hold
For Help, press F1
Position Hold
Motorola VP, Bin, 8 ch, V10.0, has DGPS, T-RAIM


HP53131A
MASER to GPS
TAC-2
GPS
If the Maser 1PPS Tick occurs BEFORE the UTC Second.
START
STOP
Maser 1PPS
GPS 1PPS
5 MHz
FORMATTER 1PPS
FORMATTER
H-Maser
High Accuracy Maser - to - GPS : Time Interval Average and Sawtooth Correction in TAC32+
Maser 1PPS is EARLY
GPS - to - Formatter: The Measurement that the Correlators want.
GPS 1PPS with Zero Offset
GPS JITTER
Maser - to - Formatter: Formatter Always Lags Maser and the offset Should be constant
~100 nsec Sawtooth
~200 nsec SA
Formatter 1PPS
"True Time" UTC(USNO)



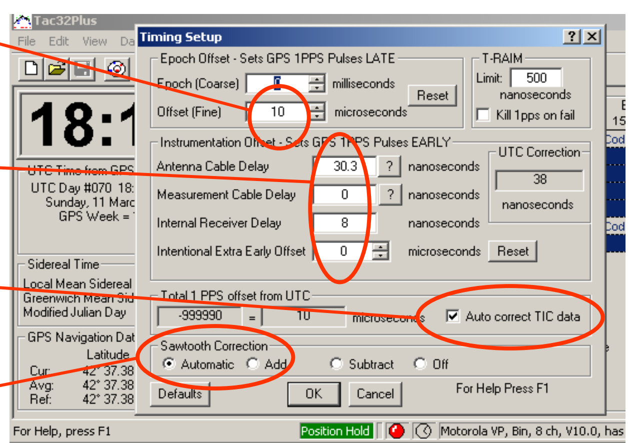
To Make Sure TAC32 is Logging the "true" Maser-to-GPS Time Interval:

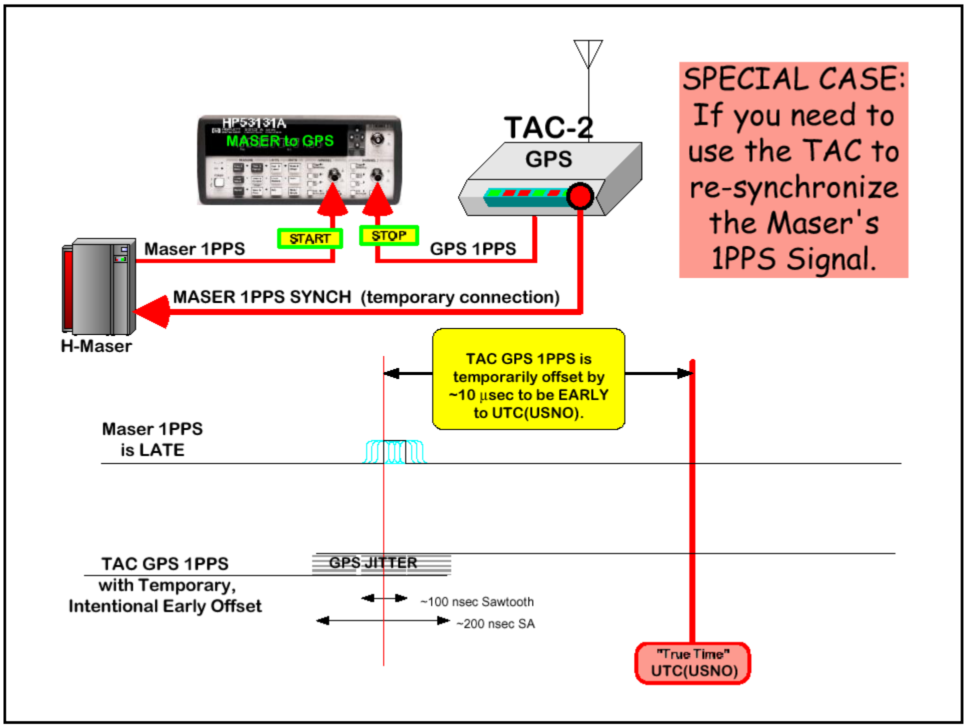
Offset GPS LATE if needed to be certain that GPS 1PPS is later than Maser 1PPS.

Be certain to account for the lengths of all coax cables.

Allow the software to correct for all timing offsets.

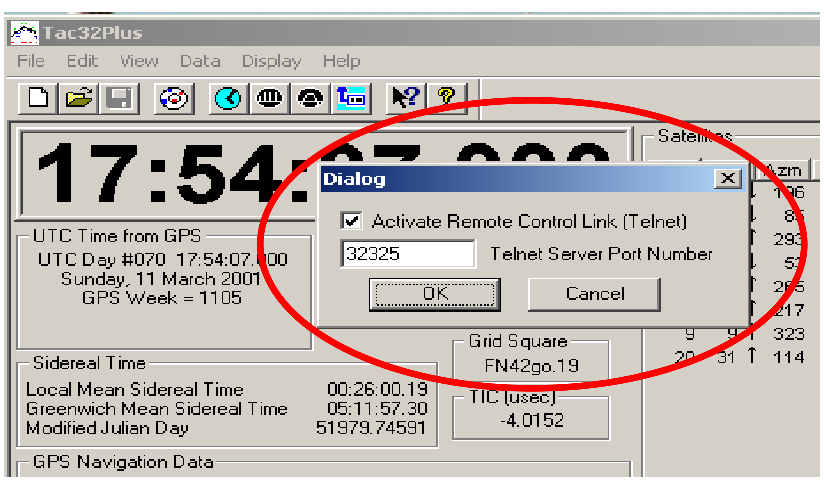
Allow software to correct the 1PPS pulse-to-pulse jitter



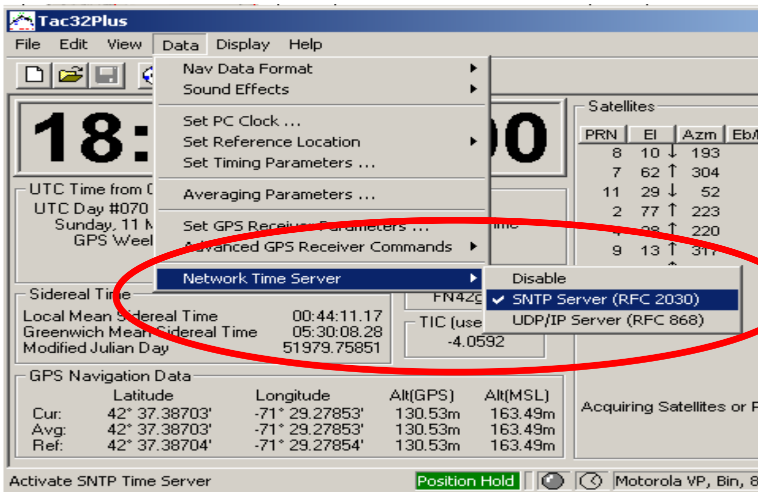


To Activate the LAN Telnet Link between TAC32Plus and the LINUX PC Field System, Hit Control-T:

Then Click on the check-box and the OK button



To Use TAC32Plus as your Station’s SNTP Network Timer Server:



APPENDIX B
TEXT MATERIAL

-- Field System Documentation for tacd

-- Ed Himwich’s documentation for gpsoff

-- David Holland’s HP53131 setup notes

tacd - Totally Accurate Clock (TAC) data

Syntax: tacd=action
tacd

Response: tacd/status,host,port,file,state
tacd/time,age,ddddd.ffffff,ss,aa,g.ggg.c.cccc,t.tttt
tacd/average,age,ddddd.ffffff,sec,rms,max,min,average

Settable Parameters:

action A key word specifying what you want from the TAC:
- status Return TAC status, also ?.
- time Return time.
- average Return average counters.
- cont Retrieve information from TAC every 100 centiseconds.
- stop Stop tacd from connecting to the TA and stop giving errors.
- start Undo the stop command, and does a restart.

Default (null) is to undo the effect of cont command.

Monitor-only Parameter:

status:
- host Computer that is hosting the TAC.
- port IP port being used to connect to TAC.
- file Name of the file being used to on host to record measurements.
- state Status of file (open or closed).

time:
- age OLD or NEW result. OLD indicates a previously logged result.
- ddddd.fffff The ddddd field may be yyddd or MJD or Excel date (days since1900.0). The ffffff field is always the time in fractions of a day.
- ss ONCORE receiver's +/- 52 nanosecond sawtooth correction to the GPS 1PPS (nanoseconds).
- aa An estimate of the accuracy of the GPS tick (nanoseconds).
- g.ggg Amount by which the GPS receiver's 1PPS output has been intentionally biased (microseconds).
- c.cccc Corrected (cooked) counter reading after applying the ss and g.ggg corrections (microseconds).
- t.tttt Raw counter reading (microseconds).

average:
- age OLD or NEW result. OLD indicates a previously logged result.
- ddddd.fffff The ddddd field may be yyddd or MJD or Excel date (days since 1900.0). The ffffff field is always the time in fractions of a day.
- sec Number of seconds of data going into average.
- rms RMS scatter of the sec data points about the average (microseconds).
- max The extreme maximum of the sec points (microseconds).
- min The extreme minimum of the sec points (microseconds).
- average Average counter reading (microseconds).

Comments:

A simple tacd command (with no =) causes either the current raw or current averaged measurement, depending on the last set-up of the tacd command, to be logged. If the command has not been set-up previously, a raw measurement is logged.

Since the time and average output records can contain values previously logged, values of OLD or NEW for age are used to distinguish previously logged and new results. This is intended to assist in identifying independent measurements for plotting (use NEW as the string in logpl).

It will startup with the Field System the tacd program gets the host and port assignment from the tacd.ctl control file. If no control file is available it will give a one time error and not attempt to open any host connections. If a control file is available and is empty tacd will sleep until a control file is provided and a start command is issued. If the file is not empty it will attempt to establish connection and then retrieve data every 30 seconds. If connection fails, it will keep on trying every 30 seconds until a connection is made.

The contents of file on the TAC host may contain averaged or un-averaged data depending on the set-up of the TAC.

File: gpsoff.txt, version: 1.3, Date: 2003 Sep 10

To: FS 9 stations

From: Ed Himwich, NVI/GSFC

Re: Clock Offsets

In order to facilitate the correlation and analysis of geodetic experiments, we would like stations involved in geodetic observing to start recording the GPS-to-Formatter clock offset in the log in a standard format. In the long run we plan to establish procedures for measuring the clock offsets at all station very precisely for scientific purposes as well. The current plan is an interim solution to give us more experience with the process and to help the correlators operate in a more automated fashion by reading the log contents.

For stations that currently report clock offset information to the VLBA correlator on a daily basis, it is expected that the VLBA correlator will continue to use the daily offset information to determine the clocks for correlation. The clock offset described by this memo is needed in addition to the daily data in order to track clock jumps that may happen during experiments.

For the interim approach, we would like each station to arrange to have the GPS-to-Formatter clock offset (or for experiments using S2 recorders, the GPS-to-S2 Recorder offset) displayed as the output of a station specific SNAP command called "gps-fmout". This command should measure the time interval started by the GPS 1 PPS and ended by the next occurring Formatter 1 PPS tick. The 1 PPS tick generated by the Formatter should be used (for S2 recorders you should use the 1 Hz REC output, please contact Georg Feil if you have questions about this), not the one that drives the Formatter. The reported value would normally be small, but might be almost as large as 1 second if the Formatter tick leads the GPS tick slightly.

In addition the integer portion of the clock offset should be measured by placing the command "sy=run setcl &" in "midob" procedures as well.

We don't require extremely precise measurements of the GPS offset; a precision of a few tenths of a microsecond should be fine for now. In most cases this should be achievable without doing any averaging. For example, using a TAC as the GPS 1 PPS source and a counter that reads to 0.1 microseconds should work well enough. In fact, if achieving this much precision would require averaging for your station, please let me know since for now we would like to avoid causing any delays that averaging might entail.

The output of the command should report the offset in units of seconds. A negative offset value or a offset value greater than 0.5 seconds implies that the the Formatter 1 PPS precedes the GPS 1 PPS (if this is routinely the case, the "fmout-gps" command should be used instead, see below). There may an arbitrary number of spaces before and/or after the value reported. The value may be preceded by an optional alphabetic string such as "S", "ST", or "T" (again with optional spaces preceding and/or trailing it) which some counters return to indicate that seconds of time are being measured. The actual value should be reported in ASCII as either a simple decimal value or in exponential form. In other ways this should have the appearance of a normal SNAP command response. As an example, please consider the following line (which actually shows more digits than are needed currently, note FS8 has a different time-tag field):

```
2001.102.23:45:12.02/gps-fmout/S       +4.4494E-06
```

During experiments, the GPS-to-formatter offset should be measured routinely by a "gps-fmout" command executed by the "midob" procedure. Over the course of an experiment, this will provide redundant measurements and should provide enough data to grossly estimate the drift rate.

Two possible ways to implement the "gps-fmout" command are:

(1) If you have a counter you can dedicate to this purpose and that can be read by the HPIB SNAP command, you can create a "gps-fmout" command by entering the following line at the end of the "stcmd.ctl" file in the "/usr2/control" directory and restarting the Field System (the spaces are significant):

```
gps-fmout    qkr 0402 01 FFFFFFFFF
```

This format is appropriate for FS versions 9.6.x. If you have a different version please contact Ed (weh@ivscc.gsfc.nasa.gov) for more information.

When you use the "gps-fmout" command implemented in this way to read the counter, you must it issue it in form: "gps-fmout=XX", where "XX" is the mnemonic for the counter from the "ibad.ctl" file in "/usr2/control".

If the Formatter (or S2 recorder) 1 PPS tick leads the GPS tick, you should use "fmout-gps" instead of "gps-fmout". This command would be implemented the same way except you would substitute "fmout-gps" for "gps-fmout" in "stcmd.ctl". For "fmout-gps", the counter must be set-up so that the time interval measured starts with the Formatter (or S2 Recorder) 1 PPS and ends with the GPS 1 PPS. Either or both of "fmout-gps" and "gps-fmout" may appear in a log as long as they measured in a complementary and consistent way. You should use whichever one normally gives the value with the smallest magnitude.

(2) You can write your own station command that will return the required value. This approach will be particularly useful if you do not have a counter the HPIB command can read or if this clock offset is measured by some other measurement system. Please contact me for details on how to do this if you are unsure. You can also use the "fmout-gps" command described above for this case if you prefer.

Once you have implemented the "gps-fmout" (or "fmout-gps") command using either approach, please be sure to place the command to read the offset in any and all versions of the "midob" procedure that you may use. Measuring this value during "midob" should become a standard part of your station's operation. If you need to set the state of switches and trigger levels so that the counter is measuring the correct offset when it is queried by the "gps-fmout" (or "fmout-gps") command, then you might want to place all the necessary commands (including the "gps-fmout" or "fmout-gps") in a special SNAP procedure so that it is "atomic", and call that procedure from "midob".

If you don't have a counter you can dedicate to this function, or you find your counter is broken for a particular experiment, or you cannot easily implement this command, you can enter the offset manually as a SNAP comment. Preferable this would be done at least twice during an experiment, at the beginning and the end. For example, you might type:

```
"gps-fmout/+4.4494E-06
```

However, we consider it very undesirable (and tedious) to have to do this manually and it should only be done that way as a last resort. If need to do this manually normally, please let me know.

If you don't have a counter and would choose to buy one to implement this we can recommend a good model that will be useful for both this interim solution and the longer term solution we are developing.

Please contact me if you have any questions or comments.

Regards, Ed (mailto:weh@ivscc.gsfc.nasa.gov)

Notes on HP 53131A counter set-up for monitoring 'gps - fmout' with the field system

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Purpose

This describes the setting up of an HP53131A counter in conjunction with the field system to record GPS-Formatter timing and also the additional definition required in the station procedure file. This method automatically reads either negative or positive values so you don't get a large figure if the stop pulse is before the start; it is also unnecessary to swap leads. An alternative method would be to exchange the inputs and also make the corresponding change in the command used, i.e. 'fmout - gps', however this is more time consuming if you need to swap cables around and could also lead to mistakes, although at most stations the leading pulse usually remains the same.

The HP53131A counter allows you to save the present settings for easy recall should they be lost due to a power interruption or other cause. This is also explained below

Counter set-up

The counter can be set up to read the time differences between various signals, Maser - GPS, Maser - Formatter, GPS - Formatter etc., by default it would normally be connected to read GPS-Formatter. As mentioned above, it can also be made to show negative values so you don't need to swap the inputs if, for example, the maser is after the GPS. It is also necessary to use a high stability external 10MHz reference, e.g. one which is locked to the maser, as the counter's internal clock is not good enough for 100ns over 1 second. The counter should automatically select the external reference when it is connected but be sure that 'extref' is showing on the counter display.

The front panel settings are:

Time & period, 'TI 1 TO 2' selected

Inputs CH1	CH2	
SENSTVTY MED	SENSTVTY HI	(see note 1)
SLOPE POS	SLOPE POS	
COMMON 1 OFF	COMMON 1 OFF	
AUTO TRIG OFF	AUTO TRIG OFF	
LEVEL 0.45v	LEVEL 1.0v	(see note 1)
50 OHM	50 OHM	
X10 ATT OFF	X10 ATT OFF	

Gate & ext arm   ARM AUTO   (see note 2)
DELAY TIME
TIME 0.50000 s

Scale & offset   MATH ON   (see note 3)
SCAL 1.00000
OFFS -1.0000

The counter should now display the correct timing values, if not see note 1.

To save the settings for recall later:
a) Press Save & Print button   SAVE: NO is displayed
b) Press the appropriate arrow key until SAVE: 1 is displayed
c) Press the Enter key.

The measurement settings are now saved in register 1.

To recall this press the Recall key until RECALL 1 is displayed

Then press either Enter or wait until the counter times out.

RECALL 1 is used in this example, but you could use RECALL 2, 3,..., 20, however 'Recall 0' is a backup register, which keeps the present settings when another recall is requested, you can't save to this recall position.

For more information, see the HP53131A operating guide, especially pages 2-50 and 2-51. At Ny-Alesund we save this in two recall positions, just in case ...

Field system commands

This information assumes that you have the counter connected to the HPIB bus and have named it 'gp' in the ibad.ctl file, see note 4. In the station procedure file you have the following definition :-

```
define clocko
hpib=gp, calc:data?
!+2s
gps-fmout=gp
enddef
```

Once you have added this, type 'clocko' to check it out, you should get the timing reported back from the counter and displayed on the field system screen.

Notes

1) Input settings might have to be adjusted on a specific site due to different signal levels, those shown here are used at the Ny-Alesund Observatory.

2) This sets a delay of 0.5 seconds to the first signal, so that it now shows a value of ~1 second

3) This sets the scale to give values between -0.5 to +0.5 seconds

4) Example 'ibad.ctl' file from Ny-Alesund:

```
        ibad.ctl
CA=dev03.0 (cable counter)
GP=dev15.0 (HP53131A timing)
```

'GP' is the mnemonic we use for the HP counter at Ny-Alesund but other stations might want to use a different mnemonic.

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