

TimeMonitor

**Synchronization Measurements and Analysis
on Clock, Data, and Packet Network Signals**



A Leading Provider of Smart, Connected and Secure Embedded Control Solutions



SMART | CONNECTED | SECURE

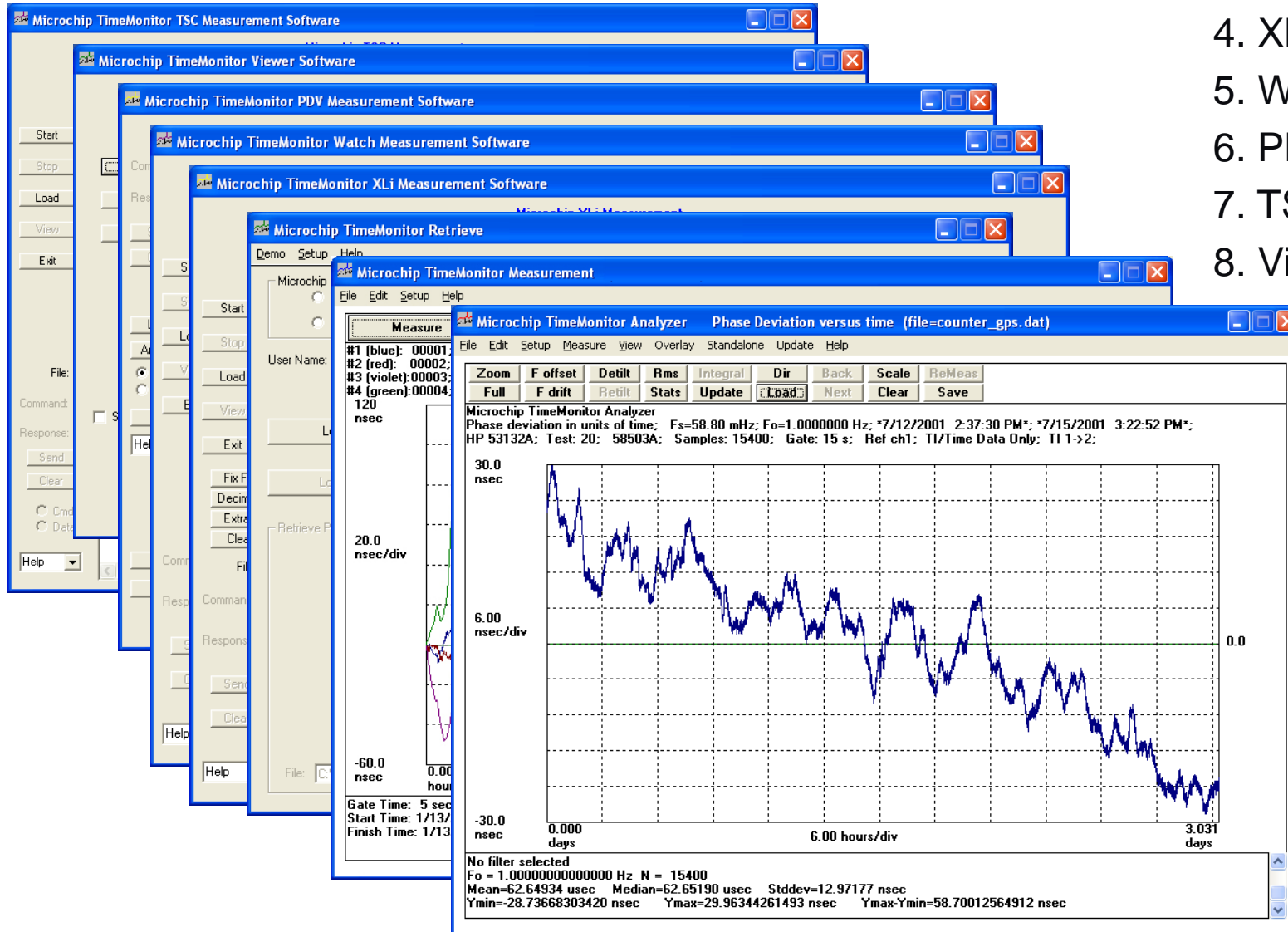
Part Number: 098-00926-000

Revision A – January 2021

TimeMonitor

TimeMonitor: Eight Applications

1. Analyzer
2. Measurement
3. Retrieve
4. Xli
5. Watch
6. PDV
7. TSC
8. Viewer



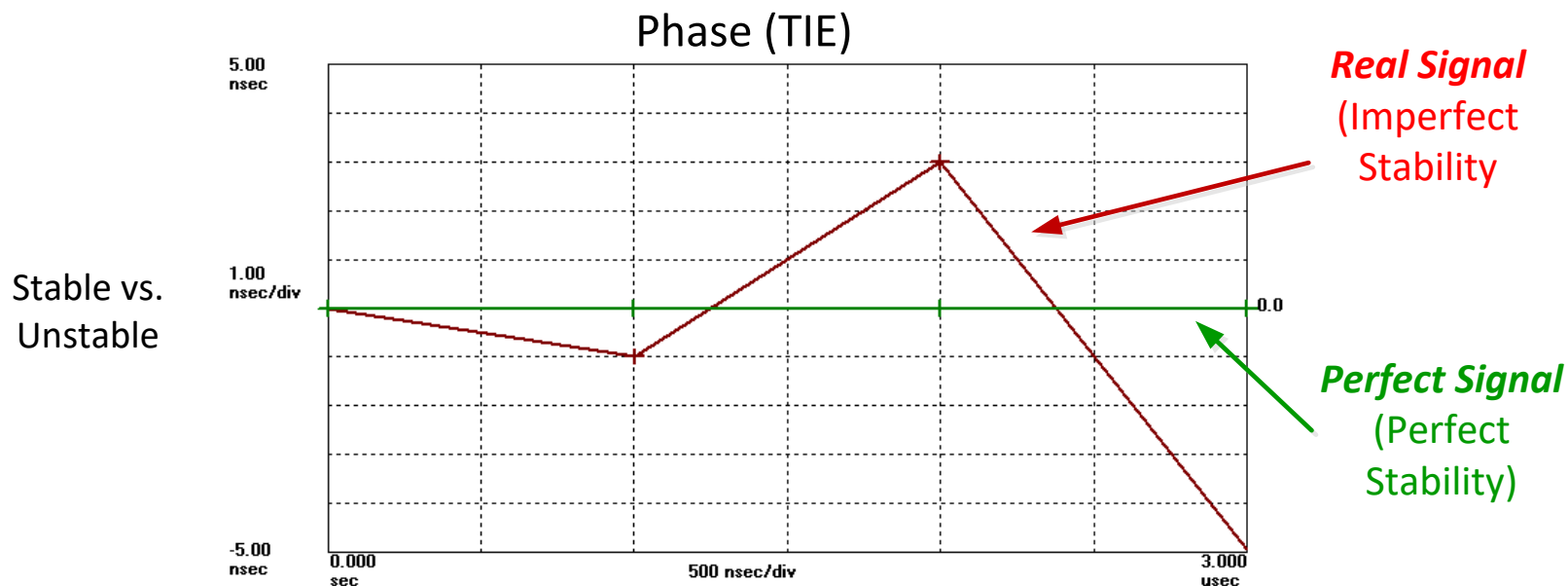
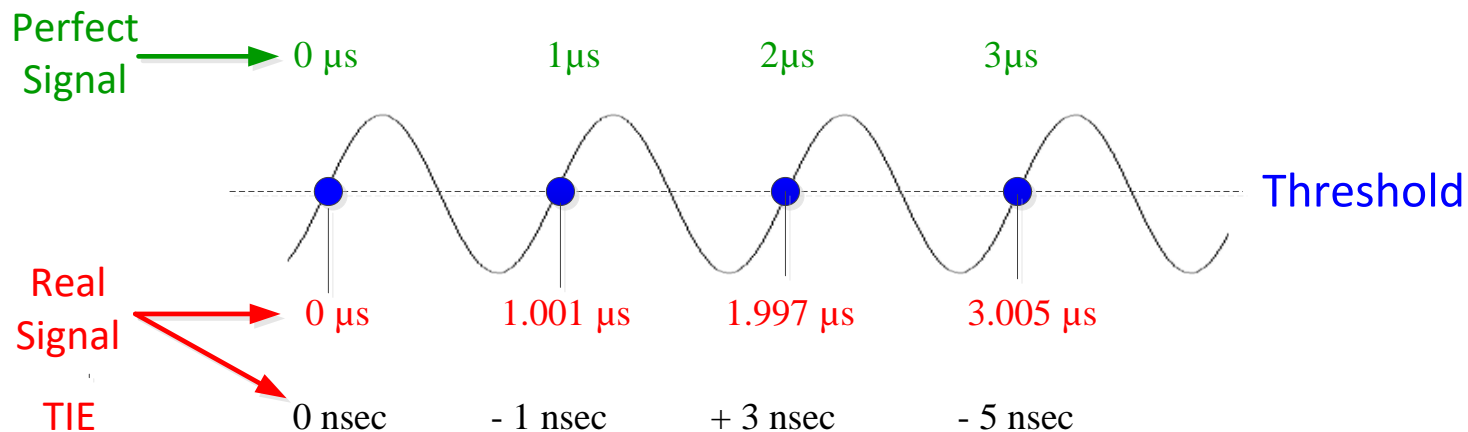
Presentation Outline

- **Sync Measurements**
 - Phase and Frequency
 - Analysis: MTIE, TDEV, ADEV, Phase Noise
 - Accuracy vs. Stability
- **Packet Measurements**
 - TIE vs. PDV
 - Equipment: Packet Probe
 - Analysis: Packet Selection, PDF, CDF
 - Two-way Analysis
- **TimeMonitor Software**
 - TimeMonitor Overview
 - TimeMonitor Analyzer
 - TimeMonitor Measurement
 - TimeMonitor PDV
 - Using TimeMonitor Analyzer for Packet Data
 - Integration/Test Automation: TimeMonitor Analyzer “Command Line”
 - Integration/Test Automation: TimeMonitor Analyzer “DLL”

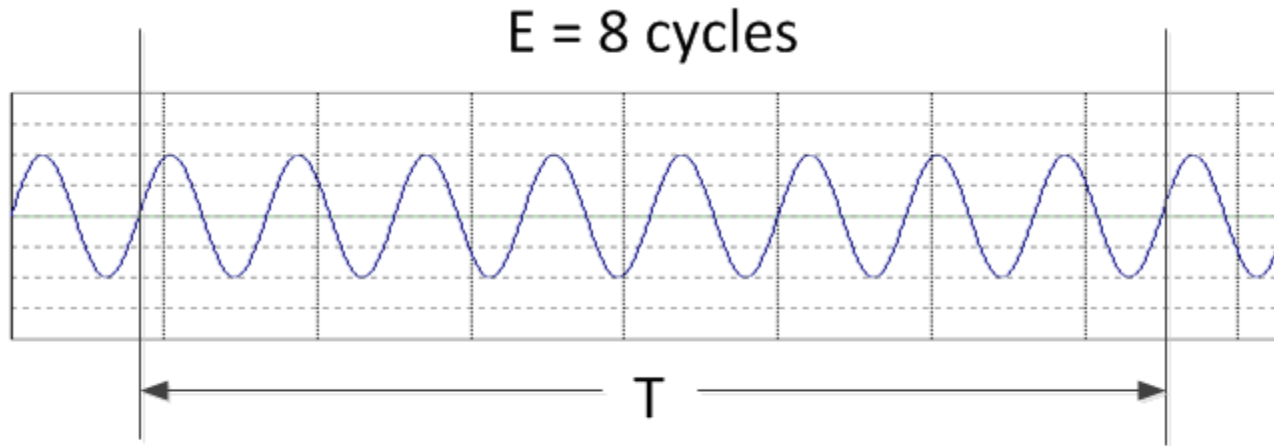
Sync Measurements



Phase



Frequency



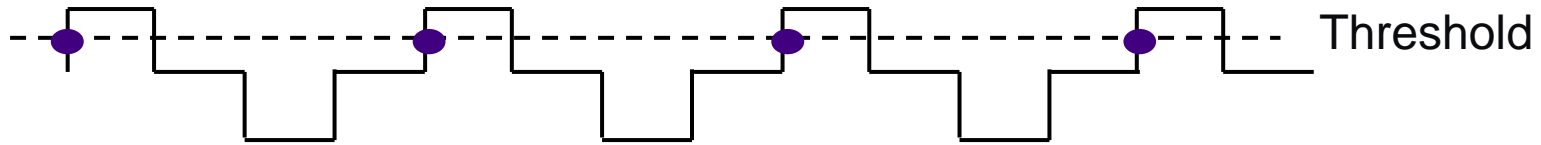
$$\text{Frequency} = E/T$$

$$\text{If } T = 8 \mu\text{sec}, F = 8\text{cycles}/8\text{E-6sec} = 1 \text{ MHz}$$

Frequency = the number of cycles per second
Ideal frequency source generates a pure sine wave

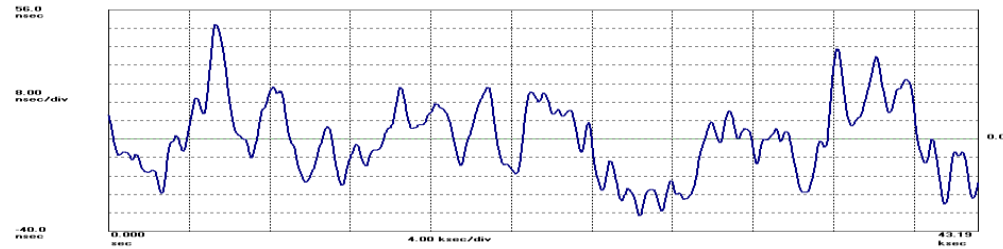
TIE Measurements

1. Timestamps



2. Phase

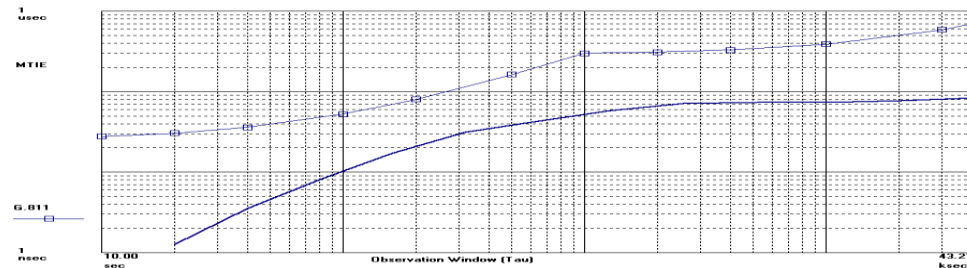
Phase deviation in units of time: $F_s=100.0$ MHz; $F_o=10.000000$ MHz; 02/26/96; 10:42:45
HP-81725 time interval analyzer
GPS timing receiver: 12 hours locked



Phase Deviation
or TIE

3. Analysis

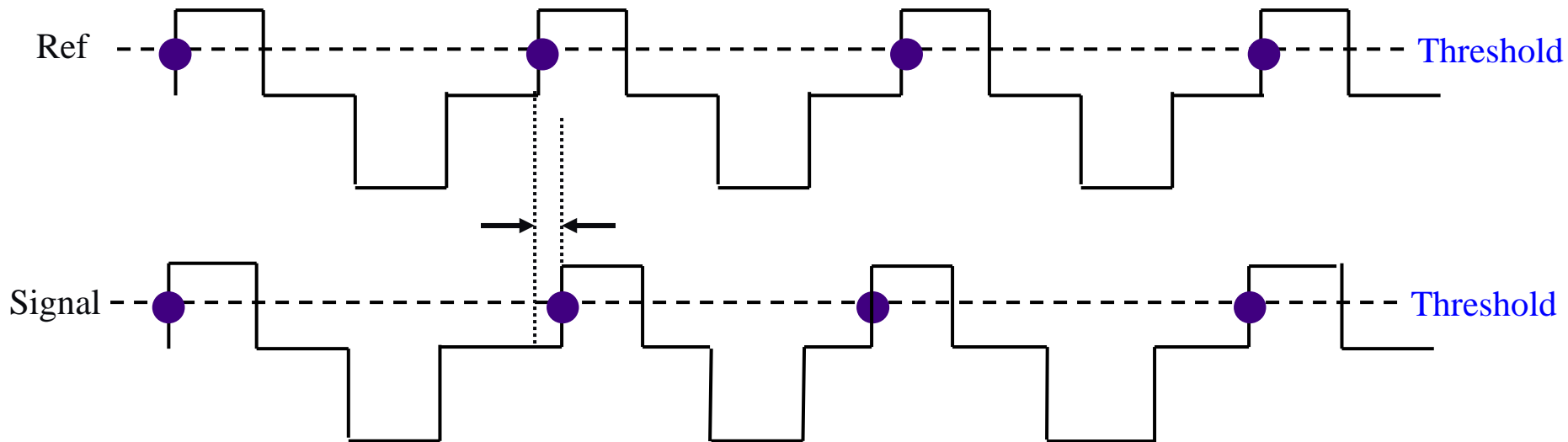
MTIE: $F_o=10.00$ MHz; $F_s=100.0$ MHz; 02/26/96; 10:42:45
HP-81725 time interval analyzer
GPS timing receiver: 12 hours locked



MTIE, TDEV,
Allan Variance,
Frequency, PPSD,
etc.

TIE Measurements Using a Reference Signal at the Same Frequency

A time interval counter is used to time threshold crossings of a signal very precisely. This process is unaffected by amplitude modulation.



Timestamps: 1 MHz signal

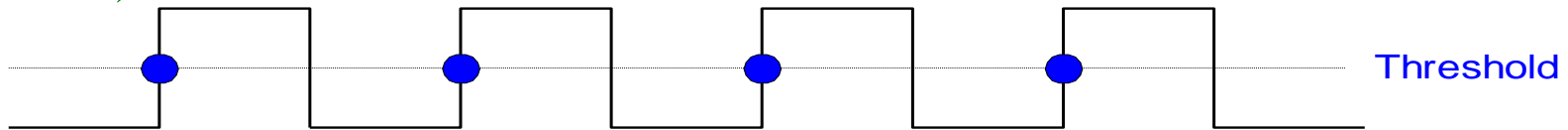
Perfect
mathematical
reference
(constant carrier)

0 μs

1 μs

2 μs

3 μs



Real
signal
measurement

0 μs

1.001 μs

1.997 μs

3.005 μs

$\phi_{\text{dev}} (\text{time})/\text{TIE}$

0 nsec

- 1 nsec

+ 3 nsec

- 5 nsec

$\phi_{\text{dev}} (\text{degrees})$

0°

- 0.36°

+ 1.08°

- 1.8°

$\phi_{\text{dev}} (\text{UI})$

0 UI

- 0.001 UI

+ 0.003 UI

- 0.005 UI

Phase Modulation Signal Model

$$v(t) = a(t) \cdot \sin(\phi(t))$$

$$\phi(t) = \omega_o \cdot t + \theta(t)$$

$$\phi(t_i) = \omega_o \cdot t_i + \theta(t_i) = n_i \cdot 2\pi$$

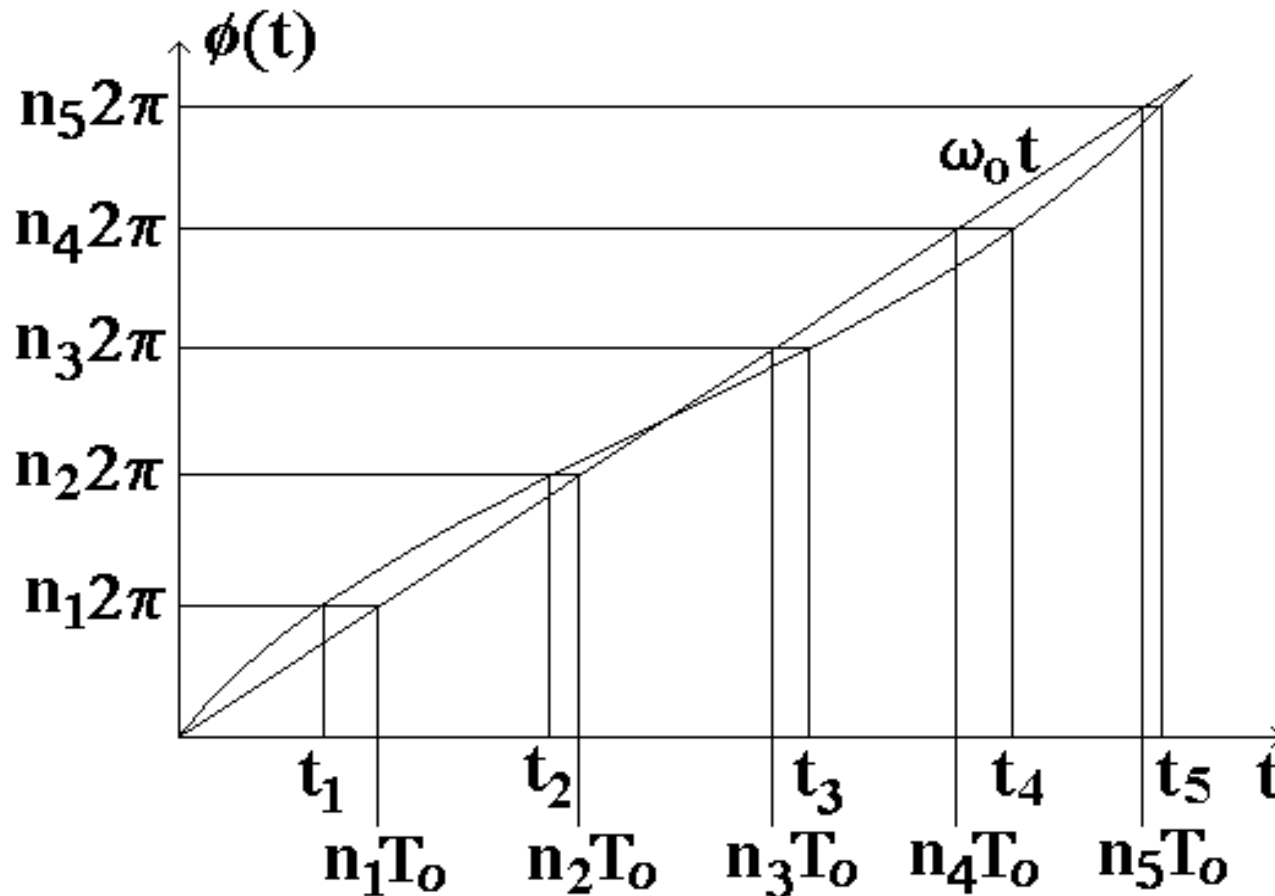
Phase deviation or TIE

→ $\theta(t_i) = n_i \cdot 2\pi - \omega_o \cdot t_i = \omega_o \cdot (n_i \cdot T_o - t_i)$

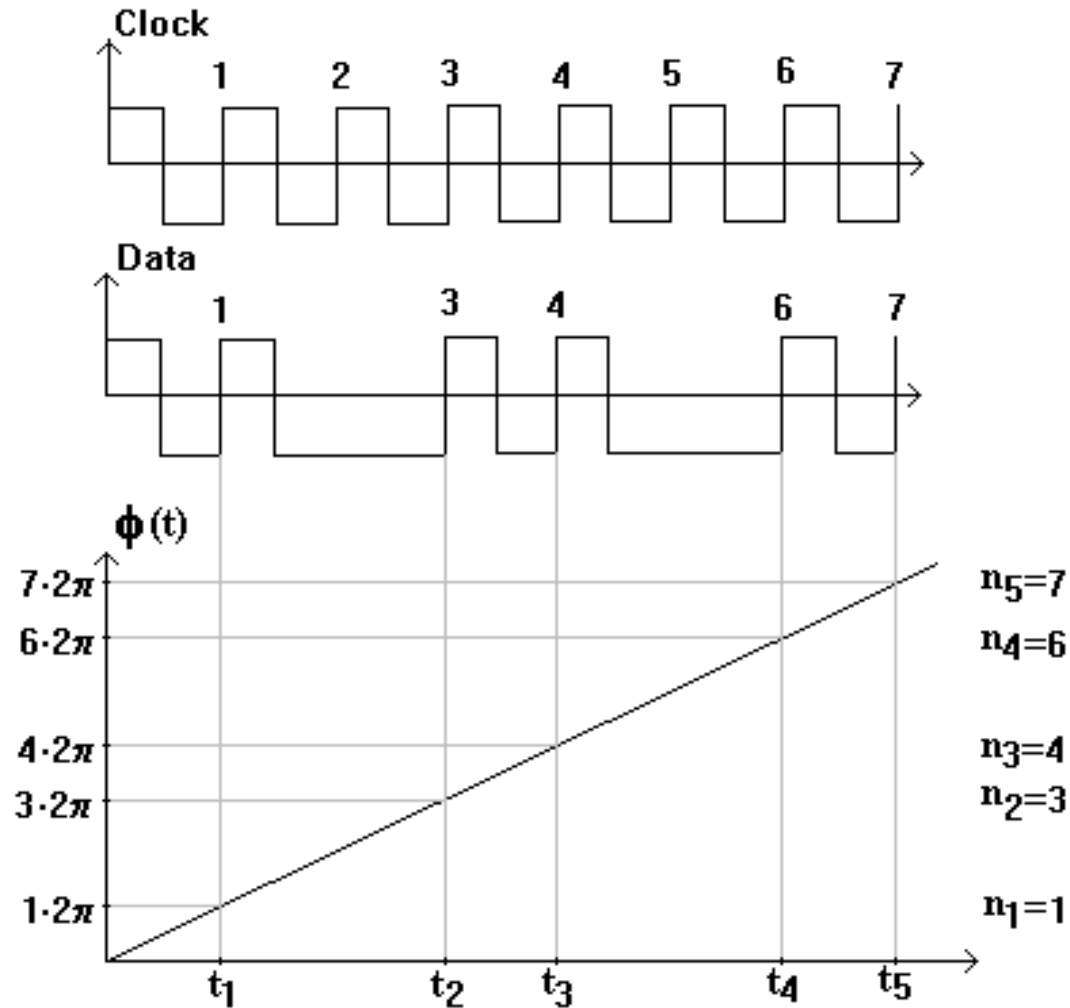
Reference
frequency

Phase vs. Time

Phase deviation (TIE) is the difference between these two curves



Data Signal Phase vs. Time



Sync Measurement Analysis

1. Sync equipment measurements (lab) and
 2. Sync interface measurements (network)
- For synchronization measurements, the measurement analysis used primarily is:

- Phase (TIE)
- Frequency (fractional frequency offset)
- Frequency accuracy
- MTIE
- TDEV

All are derived from phase

- MTIE and TDEV analysis shows comparison to ANSI, Telcordia, ETSI, & ITU-T requirements

3. Oscillator measurements

- For oscillators:
 - ADEV
 - Phase noise
 - Tempco (temperature coefficient of frequency)

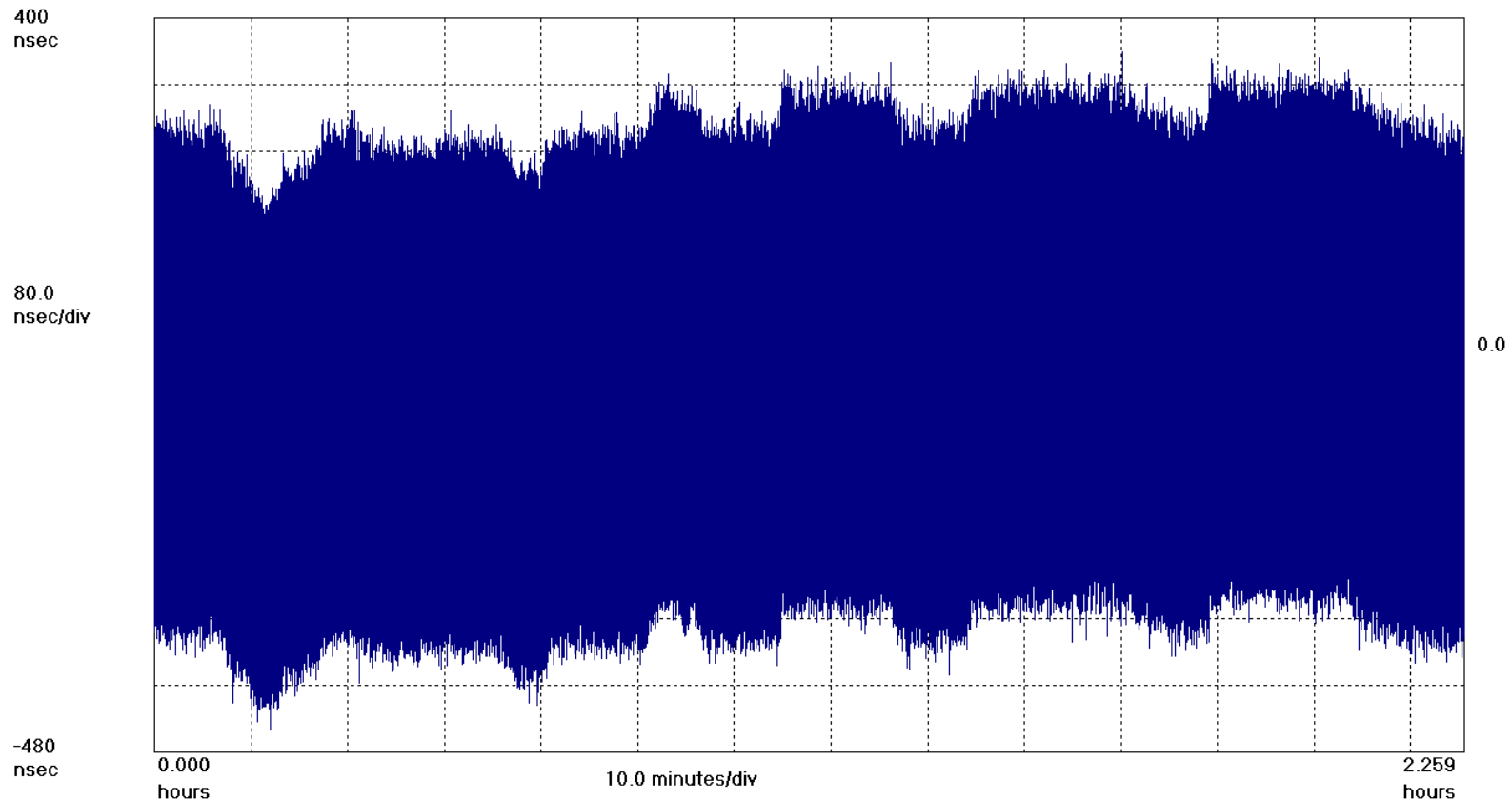
Analysis from Phase: Jitter & Wander

Signal with jitter and wander present

Symmetricom TimeMonitor Analyzer

Phase deviation in units of time; $F_s=31.48$ Hz; $F_o=2.0480000$ MHz; 01/16/98;10:58:04

No filter



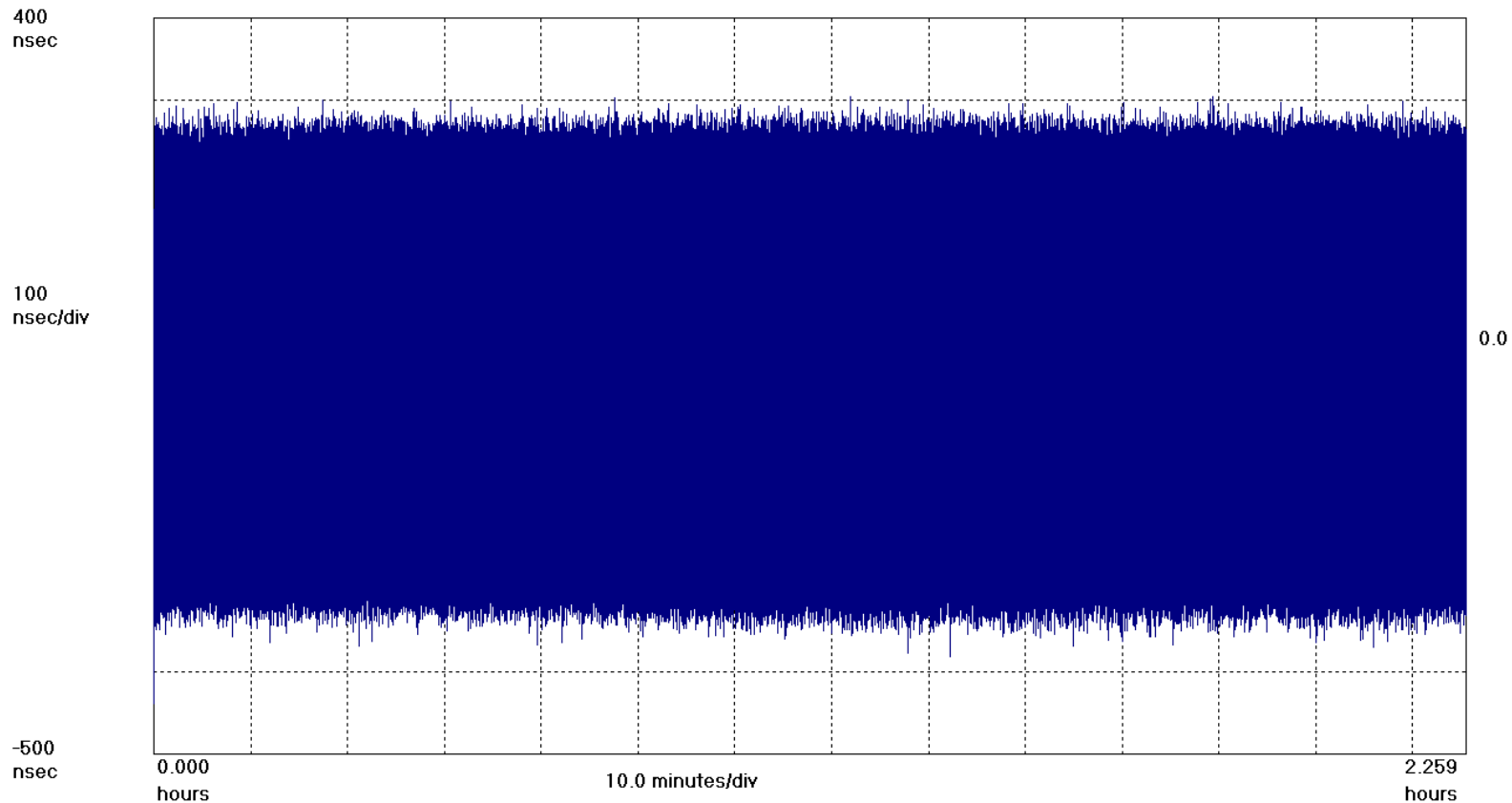
Analysis from Phase: Jitter

Jitter: Filter out low-frequency components with high-pass filter
Jitter = 740 nsec peak-to-peak = 1.52 UI peak-to-peak (E1)

Symmetricon TimeMonitor Analyzer

Phase deviation in units of time: $F_s=31.48$ Hz; $F_o=2.0480000$ MHz; 01/16/98;10:58:04

Jitter: high-pass filter applied



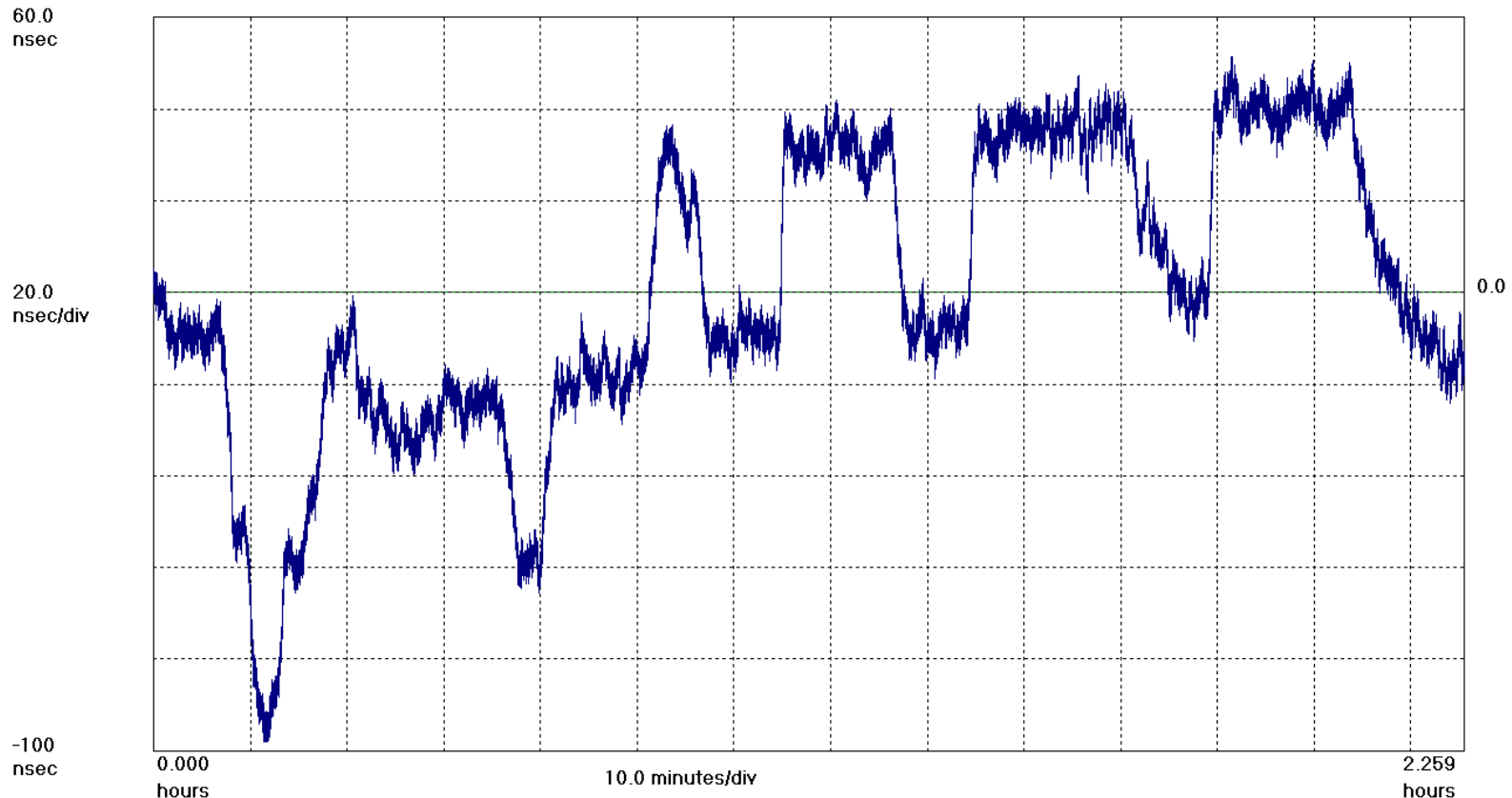
Analysis from Phase: Wander

Wander: Filter out high-frequency components with low-pass filter

Symmetricon TimeMonitor Analyzer

Phase deviation in units of time; $F_s=31.48$ Hz; $F_o=2.0480000$ MHz; 01/16/98;10:58:04

Wander: low-pass filter applied

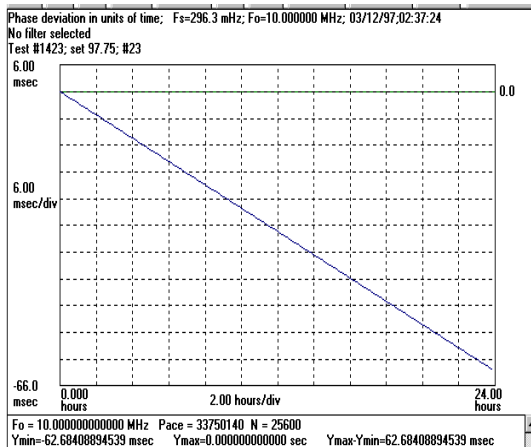


Analysis from Phase: Frequency

- Recall the relationship between frequency and phase:

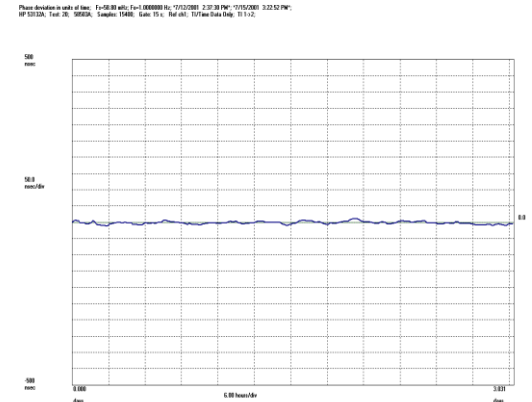
$$\omega = \frac{d\phi}{dt}$$

- Important point: Frequency is the slope in the phase plot



← Frequency offset present

No offset: ideal phase plot (flat) →



Analysis from Phase: Frequency

Timestamps(μ s):	0	1.001	1.997	3.005	4.002	4.999	6.003
ϕ dev (ns):	0	-1	+3	-5	-2	+1	+3

Phase deviation slope

$$\Delta\phi_{\text{dev}} = \Delta N \cdot T_o - \Delta t = (\Delta N - f_o \Delta t) / f_o$$



$$f_{\text{dev}} = f - f_o = \Delta N / \Delta t - f_o = (\Delta N - f_o \Delta t) / \Delta t = \Delta\phi_{\text{dev}} \cdot f_o / \Delta t$$

$$f_{\text{off}} = f_{\text{dev}} / f_o$$

For example, take the average f_{dev} over the first 3 cycles:

$$\text{Frequency Deviation} = -5\text{nsec} \cdot 10^6\text{Hz} / 3.005\mu\text{sec} = -1.7\text{ kHz}$$

$$\text{Fractional Frequency Offset} = -1.7\text{ kHz} / 1\text{MHz} = -1.7\text{ parts per thousand}$$

Frequency

F Frequency: $F = E/T$ (number of cycles/time)

F_0 Nominal frequency: F_0

FDEV Frequency deviation: $FDEV = F - F_0$

FFO Fractional frequency offset: $FFO = FDEV / F_0 = (F - F_0) / F_0$

Example: $E = 1\,000\,000$; $T = 0.999\,999\,997\,500$ sec

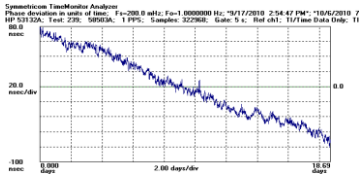
$$F = E/T = 1000000/0.9999999975 = 1.000\,000\,002\,500 \text{ MHz}$$

$$F_0 = 1 \text{ MHz}$$

$$FDEV = F - F_0 = 2.5 \text{ mHz}$$

$$FFO = FDEV / F_0 = 2.5 \cdot 10^{-9} = 2.5 \text{ PPB} \leftarrow$$

Analysis from Phase: Frequency



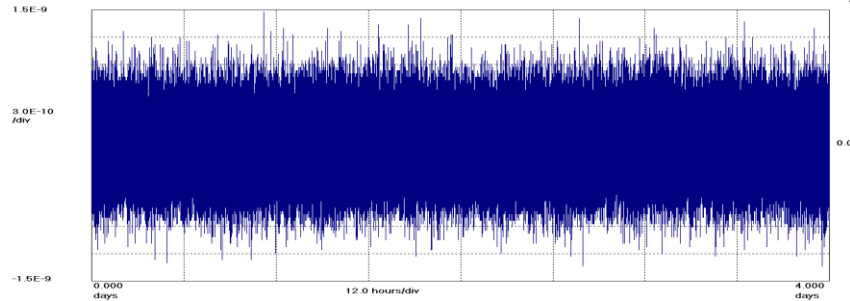
→ $-8.97 \cdot 10^{-14}$

Frequency Accuracy

$$\omega = \frac{d\phi}{dt}$$

slope/linear: frequency offset
curvature/quadratic: frequency drift

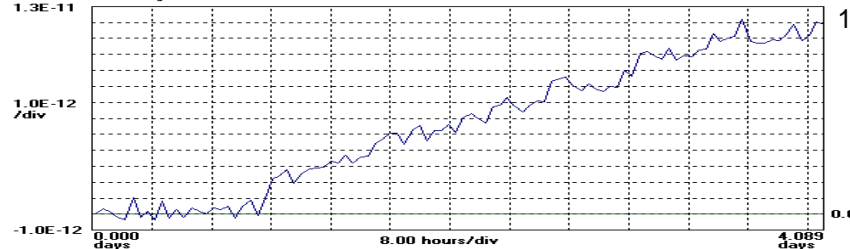
Symmetricom TimeMonitor Analyzer
Fractional frequency offset: F=740.7 mHz; Fo=2.048 MHz; 08/15/98 07:55:45
Holdover after 24 hours



1.5 E-9

Point-by-point

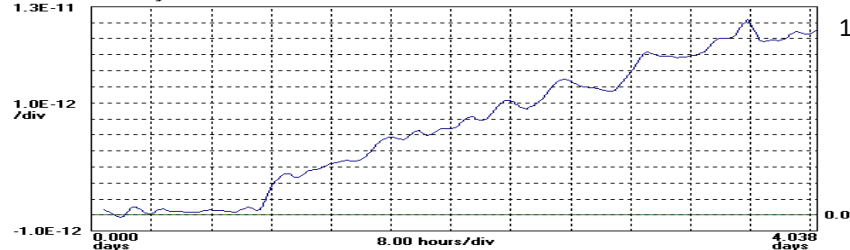
Symmetricom TimeMonitor Analyzer (file=demo_holdover.pan)
Least square fit fractional frequency offset vs. time: N=100; 1/18/07; 19:44:26
SSU holdover 4 days



1.2 E-11

Segmented LSF

Symmetricom TimeMonitor Analyzer (file=demo_holdover.pan)
Fractional frequency offset: Overlap phase averaging; A=200; N=11056; Fs=32.26 mHz; Fo=2.048 MHz; 1/18/07
SSU holdover 4 days

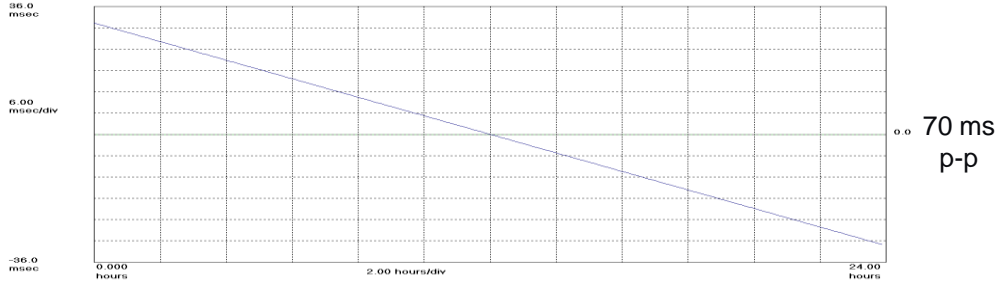


1.2 E-11

Sliding Window Averaging

Frequency Offset and Drift

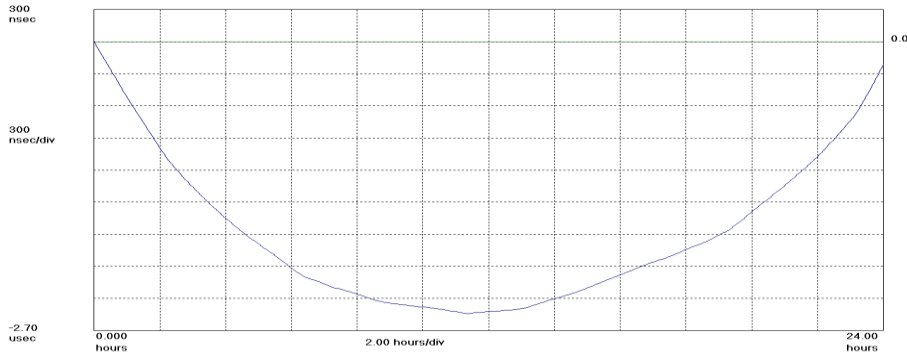
Symmetricon TimeMonitor Analyzer
Phase deviation in units of time: $F_s=296.3$ MHz; $F_o=10.000000$ MHz; 03/12/97.02:37.24
Test #1423; set 97.76; #23; Fo offset = $-7.255E-7$; Fo reference = 10.000000000000 MHz



70 ms
p-p

Original oscillator phase measurement (0.7ppm frequency offset)

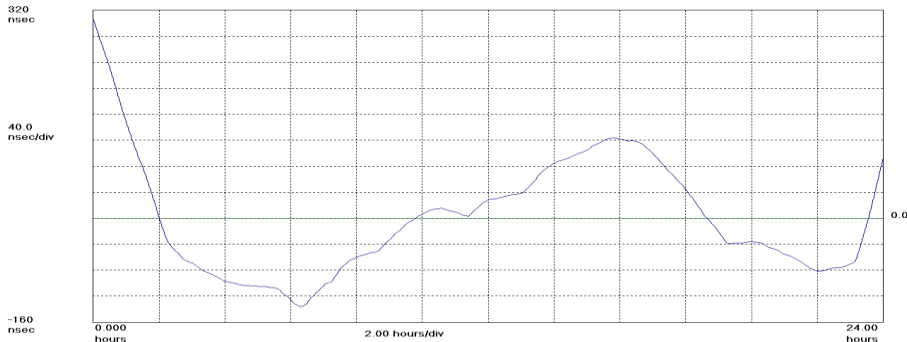
Symmetricon TimeMonitor Analyzer
Phase deviation in units of time: $F_s=296.3$ MHz; $F_o=9.9999927$ MHz; 03/12/97.02:37.24
Test #1423; set 97.76; #23; Frequency Drift Rate = 2.078 mHz/day; $2.078E-10$ /day



2.5 μ s
p-p

Frequency offset removed (quadratic shape shows linear frequency drift of 0.2 ppb/day)

Symmetricon TimeMonitor Analyzer
Phase deviation in units of time: $F_s=296.3$ MHz; $F_o=9.9999927$ MHz; 03/12/97.02:37.24
Test #1423; set 97.76; #23; Frequency Drift Rate = 2.078 mHz/day; $2.078E-10$ /day



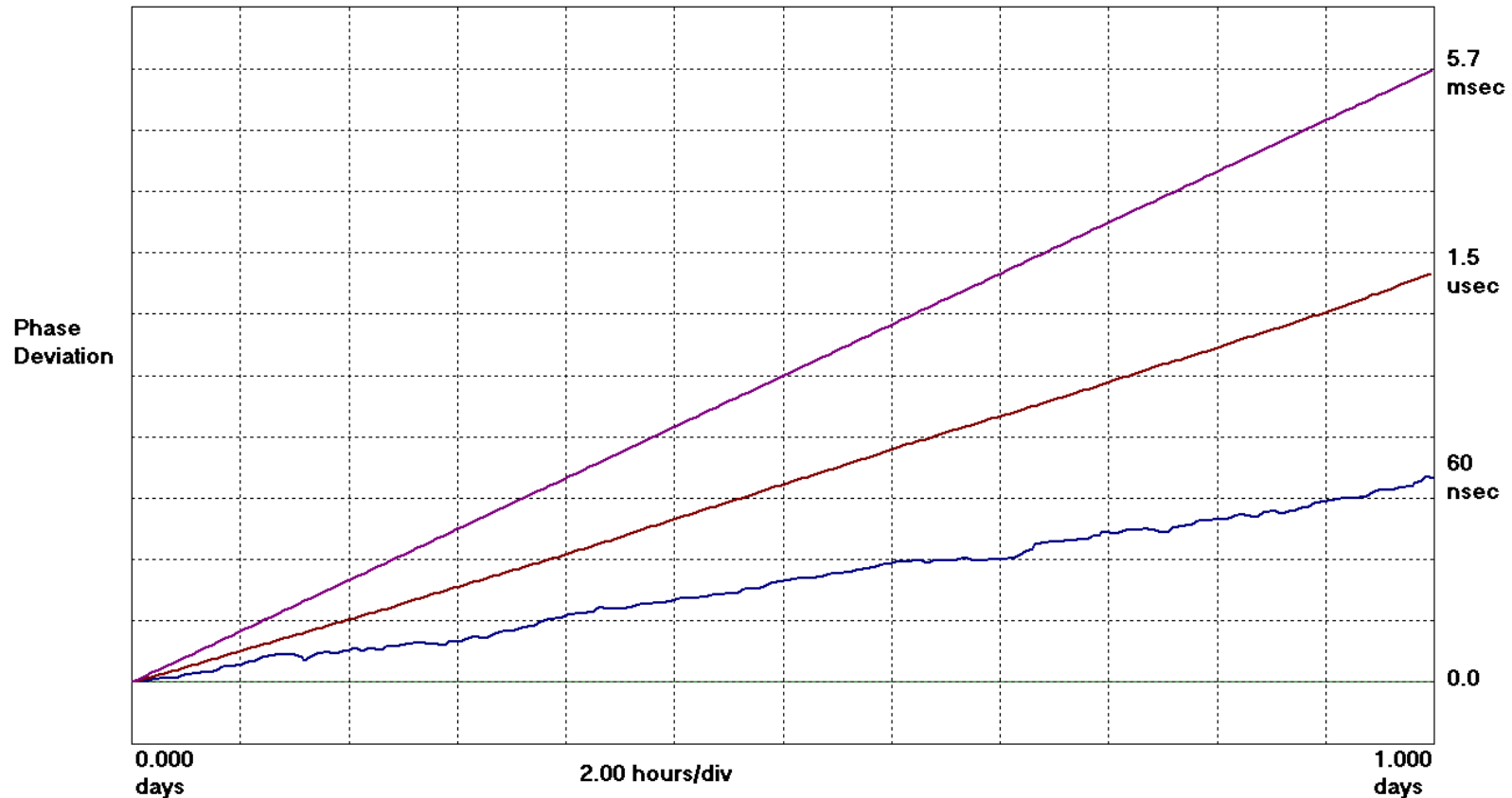
500 ns
p-p

Frequency drift removed (shows residual phase movement)

Frequency Accuracy and Stability

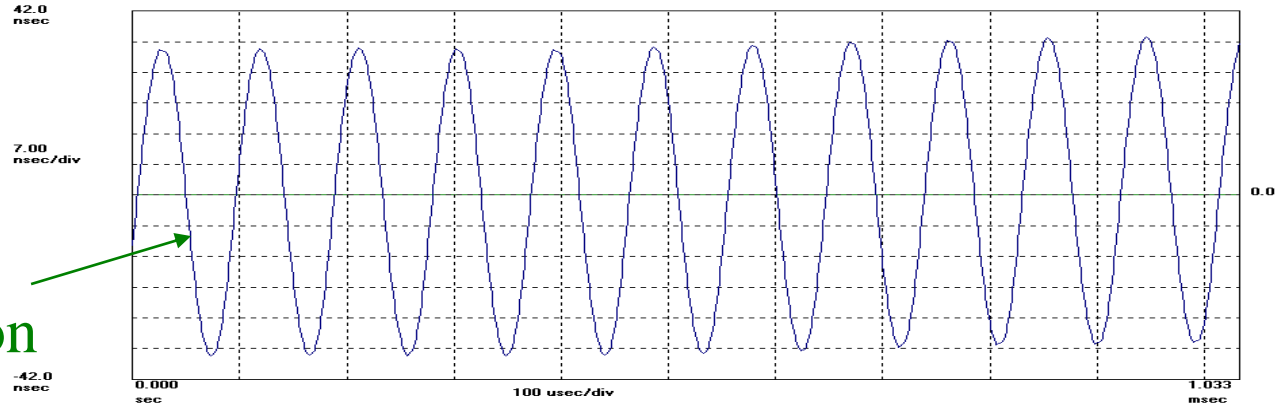
Quartz, Rubidium, and Cesium

Quartz: Frequency offset=6.4E-08; Frequency Drift=2.3E-11/day; 02/27/98; 16:54:58
Rubidium; Frequency offset=1.7E-11; Frequency Drift=2.0E-12/day; 05/05/02; 19:22:26
Cesium; Frequency offset=6.6E-13; Frequency Drift=3.3E-18/day; 11/12/99; 07:02:04



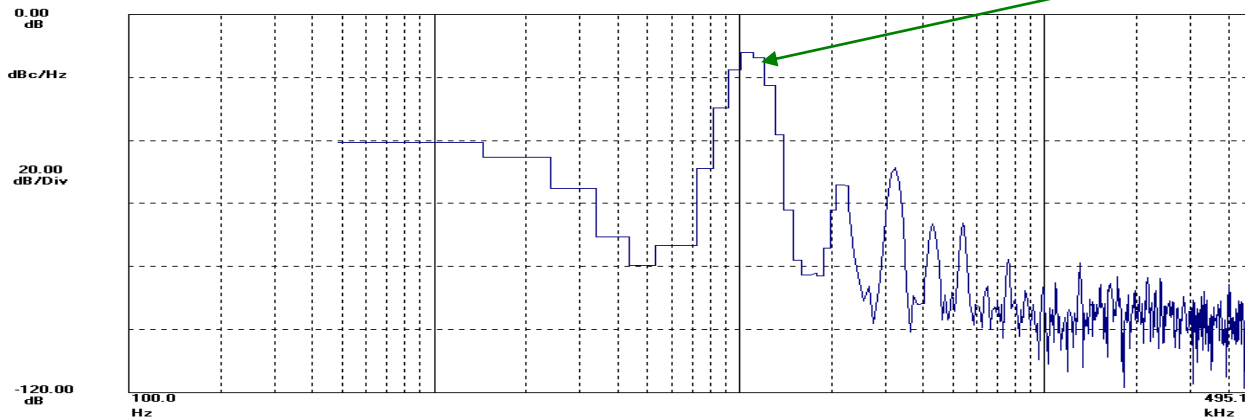
Analysis from Phase: Phase Power Spectral Density

Phase deviation in units of time: $F_s=990.1$ kHz; $F_o=99.999421$ MHz; 03-07-1994
HP E1725 time interval analyzer
Frequency Modulation



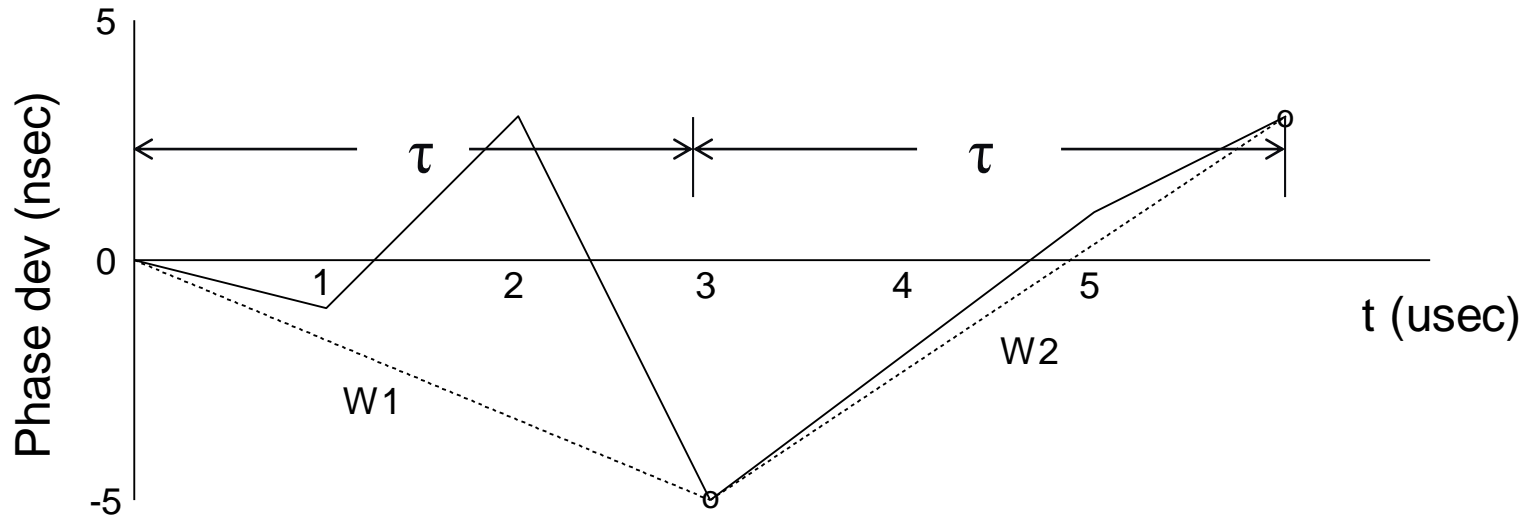
10 kHz
modulation

N=1024; Gaussian window; Avg=1; Noise BW=1.911 kHz; $F_s=990.1$ kHz; $F_o=100.0$ MHz; 03-07-1994
HP E1725 time interval analyzer
Frequency Modulation



10 kHz
component

Allan Variance



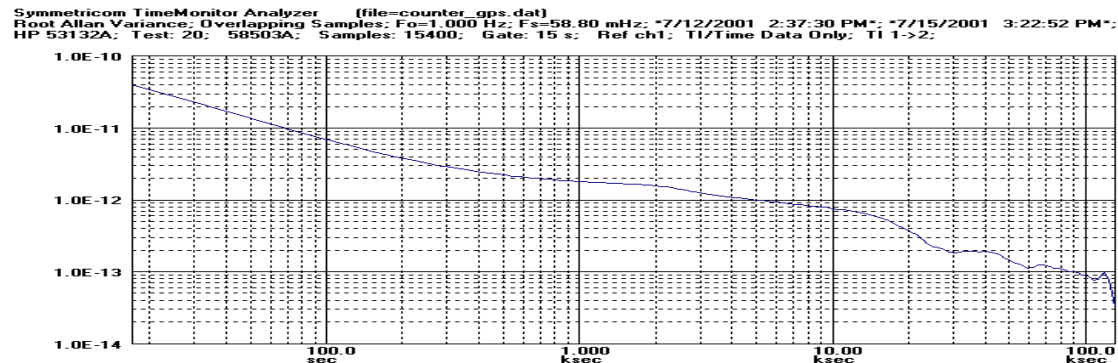
Allan Variance is a measurement of frequency **stability** used for characterizing oscillators.

$$\text{Difference in slope} = \Delta W = W2 - W1 \Rightarrow AVAR = \frac{1}{2} \langle (\Delta W_{\tau})^2 \rangle$$

Change in
frequency

ADEV Plot:

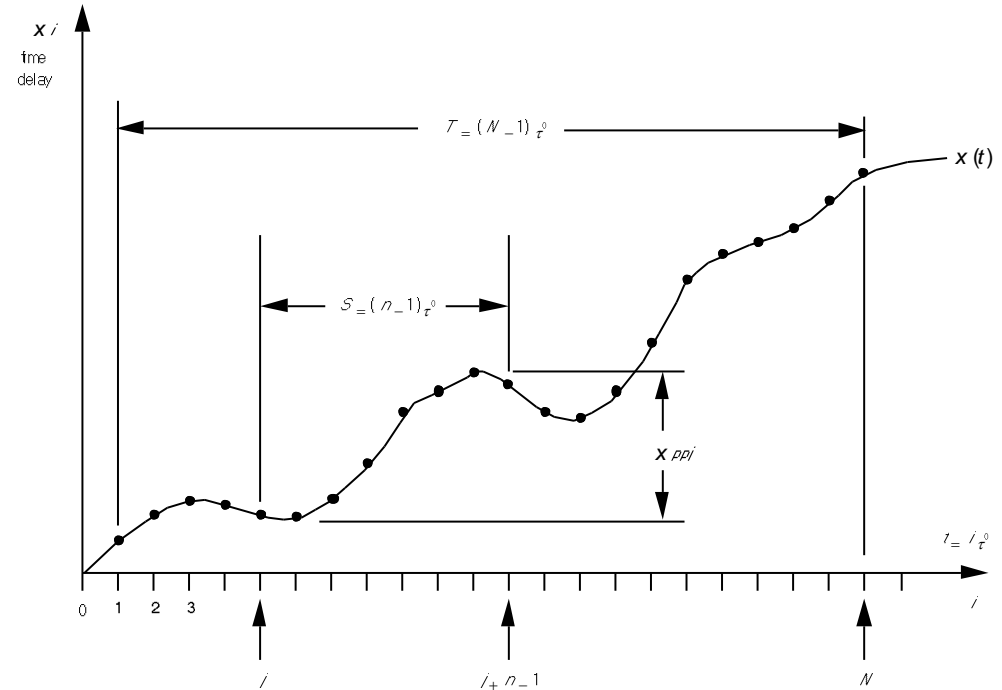
$$(ADEV = \sqrt{AVAR})$$



Analysis from Phase: MTIE/TDEV

$$MTIE(S) = \max_{j=1}^{N-n+1} \left[\max_{i=j}^{n+j-1} (x_i) - \min_{i=j}^{n+j-1} (x_i) \right]$$

MTIE is a peak detector
MTIE detects frequency offset

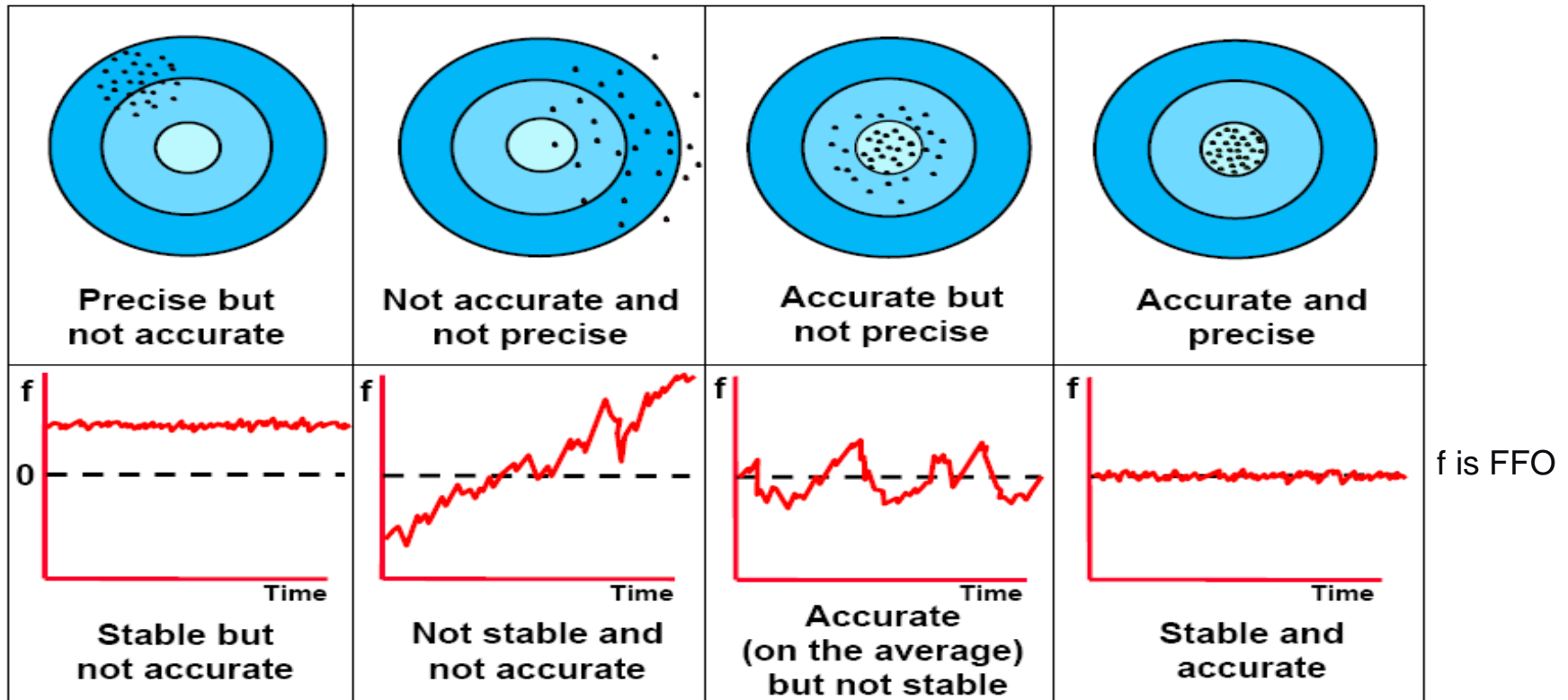


$$\sigma_x(\tau) = TDEV(\tau) = \sqrt{\frac{1}{6} \left\langle \left[\frac{1}{n} \sum_{i=1}^n x_{i+2n} - 2 \frac{1}{n} \sum_{i=1}^n x_{i+n} + \frac{1}{n} \sum_{i=1}^n x_i \right]^2 \right\rangle}$$

TDEV is a highly averaged “rms” type of calculation
TDEV shows white, flicker, random walk noise processes
TDEV does not show frequency offset

MTIE and TDEV analysis allows comparison to ATIS, Telcordia, ETSI, & ITU-T requirements

Stability and Accuracy

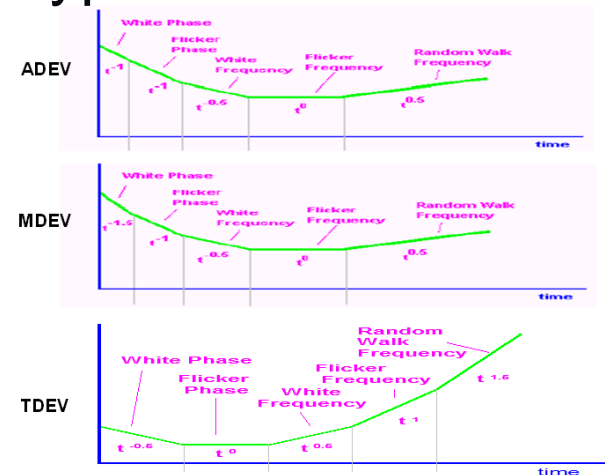


The Allan Variance family of analysis metrics is concerned with the characterization of stability

Diagram from "Time Domain Representation of Oscillator Performance", Marc A. Weiss, Ph.D. NIST

Systematics and Stochastics

- Systematics
 - Frequency offset
 - Frequency drift
 - Environmentals (temperature, humidity, pressure, etc.)
- When systematics are removed, what remains is noise (stochastic processes). Five major noise types:
 - WPM (white phase modulation)
 - FPM (flicker phase modulation)
 - RWPM = WFM (random walk PM = white FM)
 - FFM (flicker frequency modulation)
 - RWFM (random walk frequency modulation)

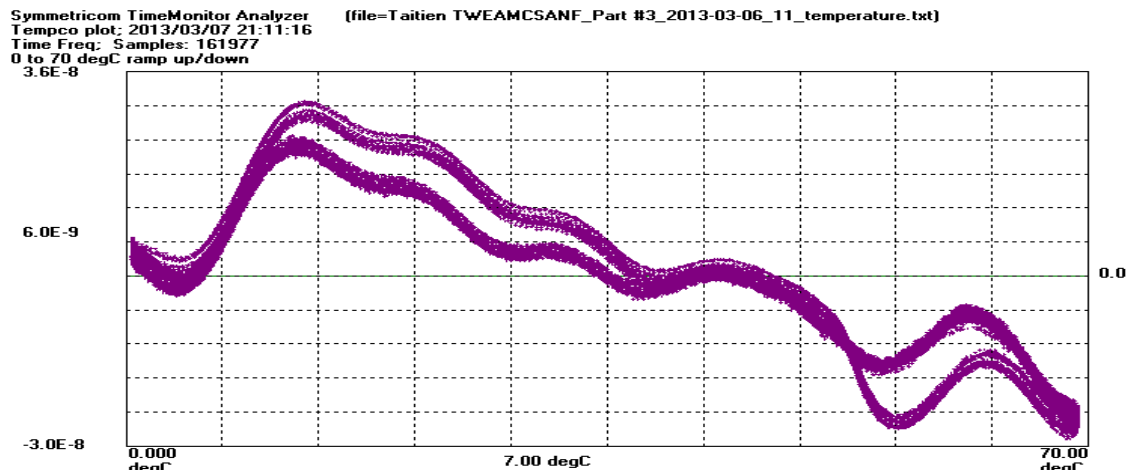


*ADEV slope: -1.0 (WPM); -1.0 (FPM); -0.5 (RWPM); 0 (FFM); 0.5 (RWFM)
*MDEV slope: -1.5 (WPM); -1.0 (FPM); -0.5 (RWPM); 0 (FFM); 0.5 (RWFM)
*TDEV slope: -0.5 (WPM); 0 (FPM); 0.5 (RWPM); 1.0 (FFM); 1.5 (RWFM)

Oscillator Testing

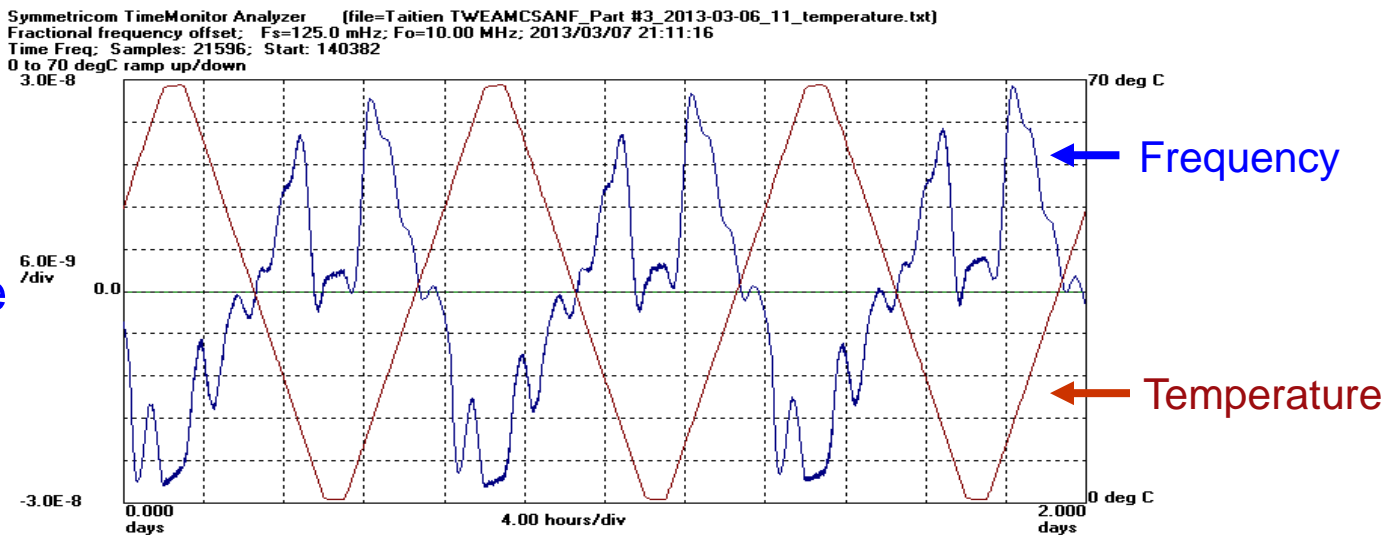
Tempco

Tempco



15 days
22 cycles
60 ppb p-p
over 70° C

F&T vs. time

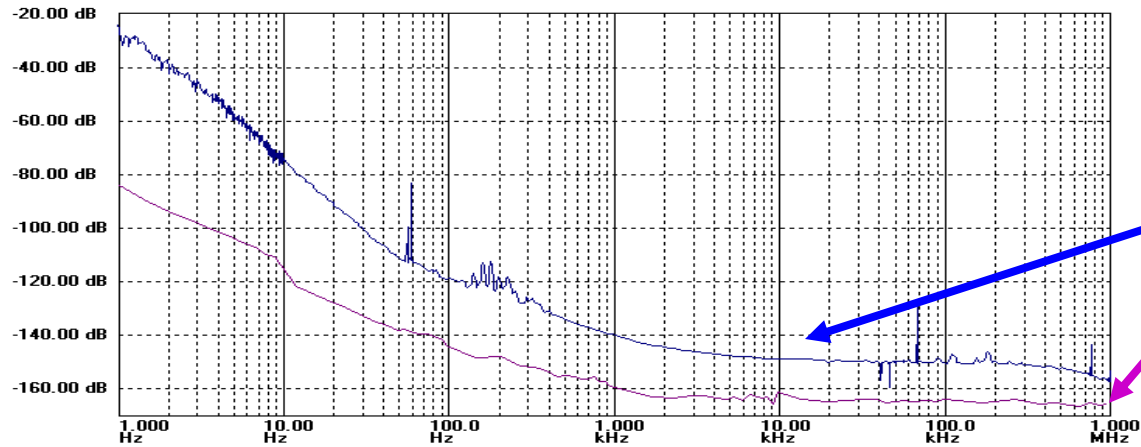


Oscillator Testing

Phase Noise & ADEV

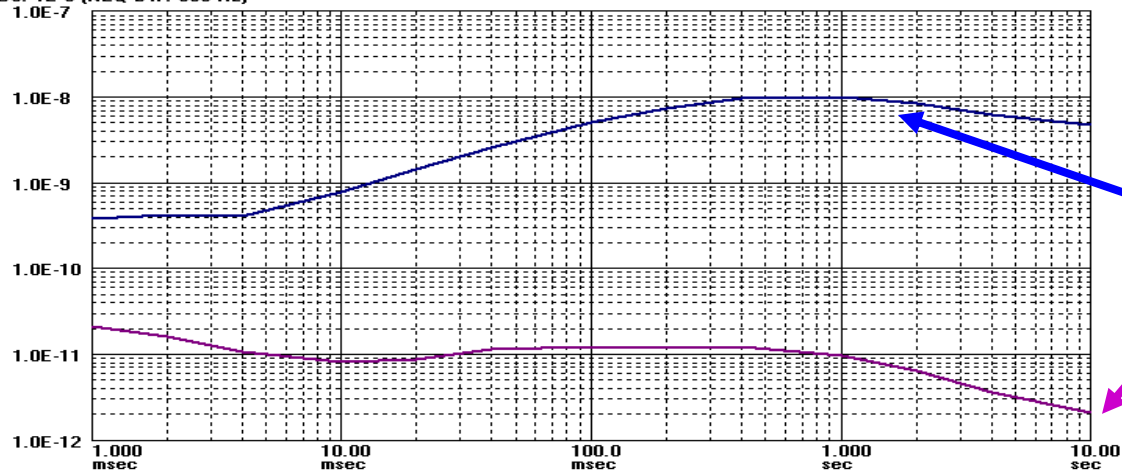
Phase
Noise

Symmetricon TimeMonitor Analyzer (file=meas-2013_01_29-14_40_31-0001.tss)
TSC 5120A phase noise plot: 1/29/2013 2:47:06 PM
PPSD (dBc/Hz); Samples: 8562



ADEV

Symmetricon TimeMonitor Analyzer (file=meas-2013_01_29-14_40_31-0001.tsa)
Allan deviation plot: 1/29/2013 2:47:02 PM
TSC 5120A ADEV; Samples: 16
TAU0: 1E-3 (NEQ BW: 500 Hz)

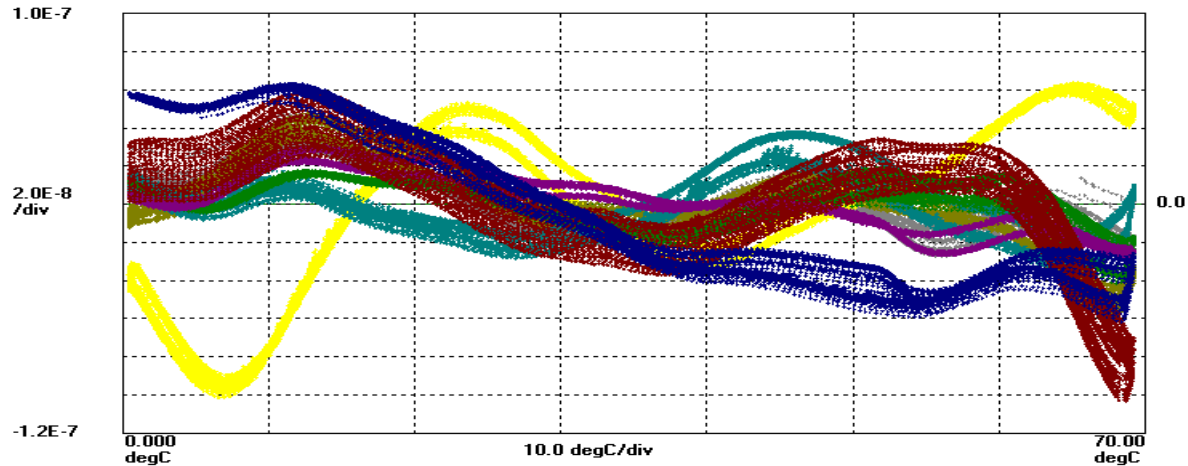


Oscillator Testing

Overlay Results

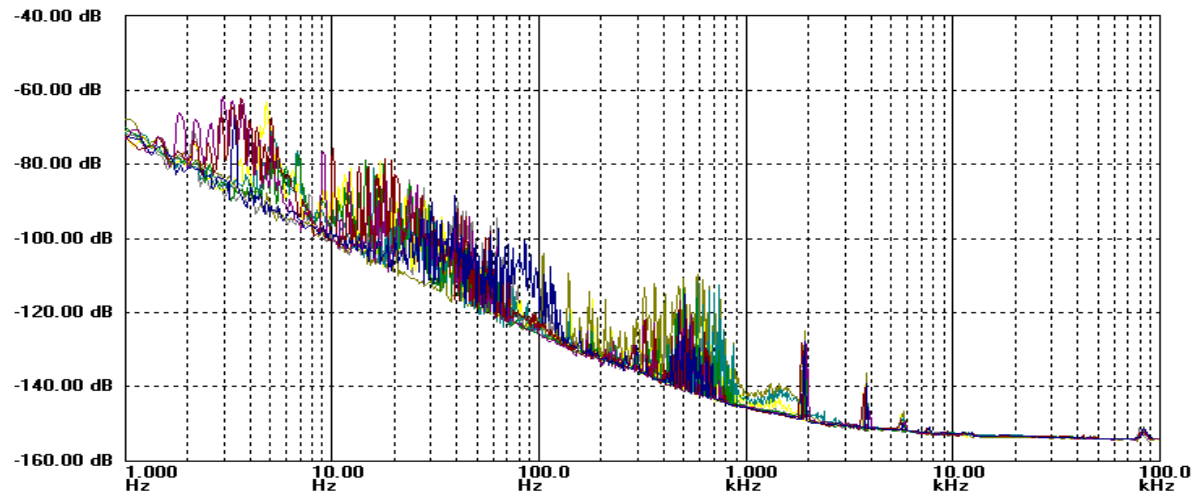
Tempco

Symmetricon TimeMonitor Analyzer (file=)
Tempco plot: 2013/03/07; 21:11:14



Phase Noise

Symmetricon TimeMonitor Analyzer (file=)
Phase noise plot



Packet Measurements

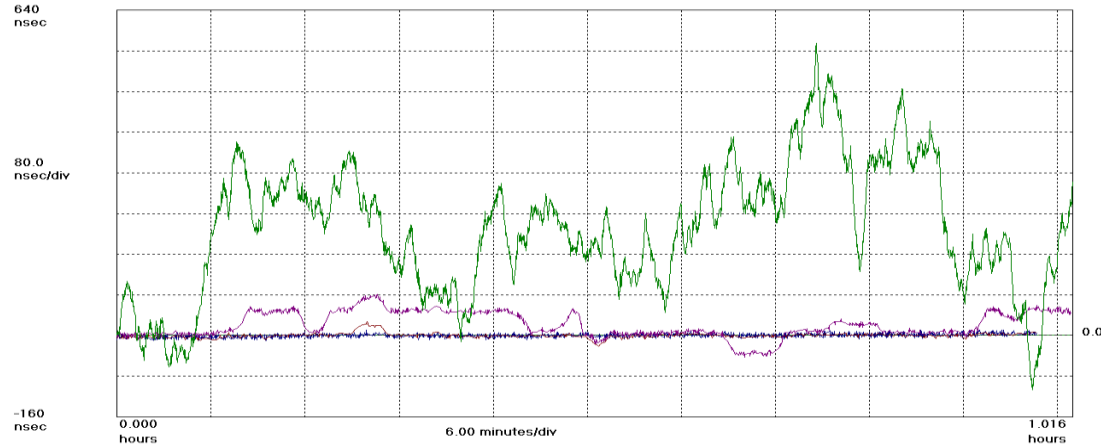


“TIE” vs. “PDV”

- **“TIE” vs “PDV”**
 - Traditional TDM synchronization measurements: signal edges are timestamped producing a sequence of samples (“circuit-switched network”)
 - Packet timing measurements: packet departure/arrival times are sampled and packet delay sequences are formed (“packet-switched network”)
 - Both require (1) PRC/GPS; (2) Precision HW timestamping; (3) PC + SW
- **Measurement equipment:**
 - TIE: Counters, TIA’s, Test-sets, BITS, SSU, GPS receivers
 - PDV: IEEE 1588 probes, NTP probes, network probes
- **TIE measurements are still important in a packet world:**
 - Needed for the characterization of packet servo slaves such as IEEE 1588 slave devices
 - There are still oscillators and synchronization interfaces to characterize
 - “TIE” measurement/analysis background important to the understanding of “PDV” measurement/analysis
 - Many of the tools can be applied to either “TIE” or “PDV” data such as TDEV or spectral analysis
 - But there are new tools and new approaches to be applied to “PDV” with some of the traditional “TIE” tools less effective for “PDV” analysis

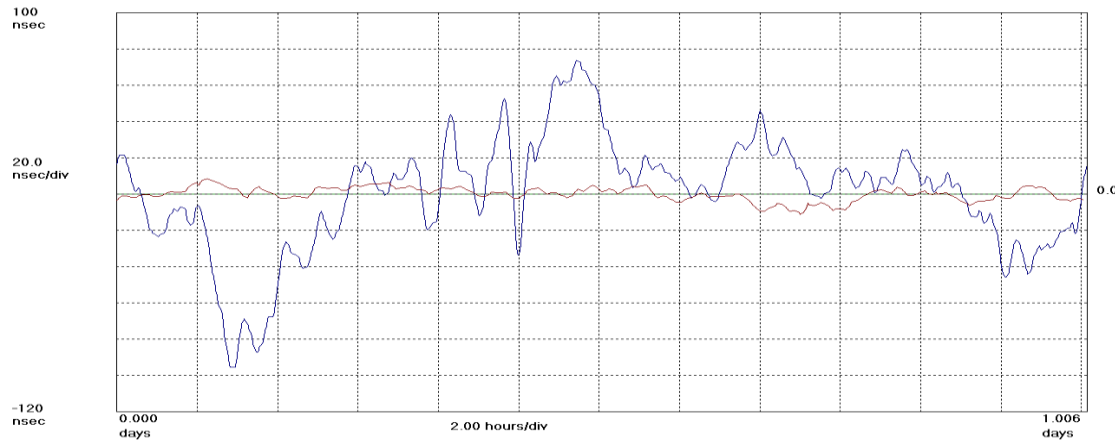
TIE Measurements: Network vs. Equipment

Symmetricon TimeMonitor Analyzer
Phase deviation in units of time: $F_s=1.021$ Hz; $F_o=2.0480000$ MHz; 04/16/96; 15:21:37
1: PSTN input to MSC; 2: Output from MSC; 3: Output from BSC; 4: Output from DXX



Network
TIE

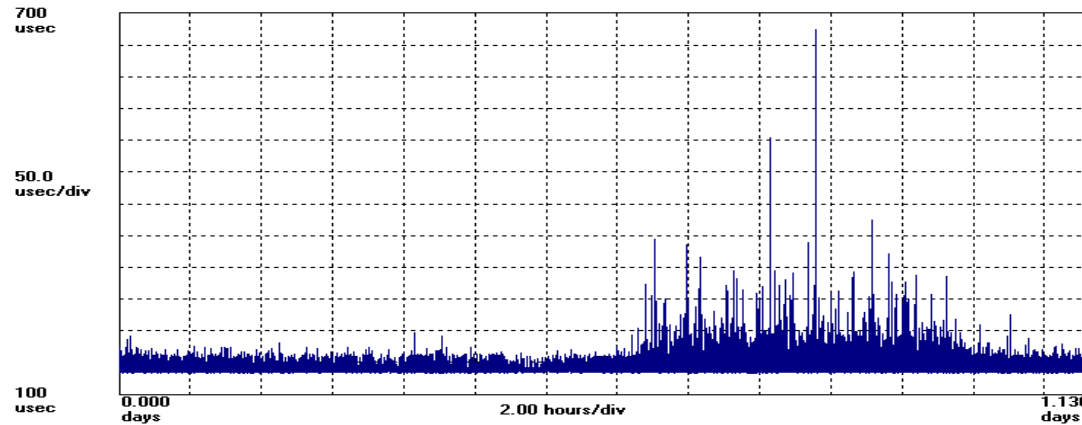
Symmetricon TimeMonitor Analyzer
Phase deviation in units of time: $F_s=200.0$ MHz; $F_o=1.0000000$ Hz; 09/05/98; 21:46:54
1: 58503 GPS; 09/05/1998; 21:46:54; *** SA present ***; 2: 58503 GPS; 05/06/2000; 05:34:28; *** SA turned off ***



Equipment
TIE

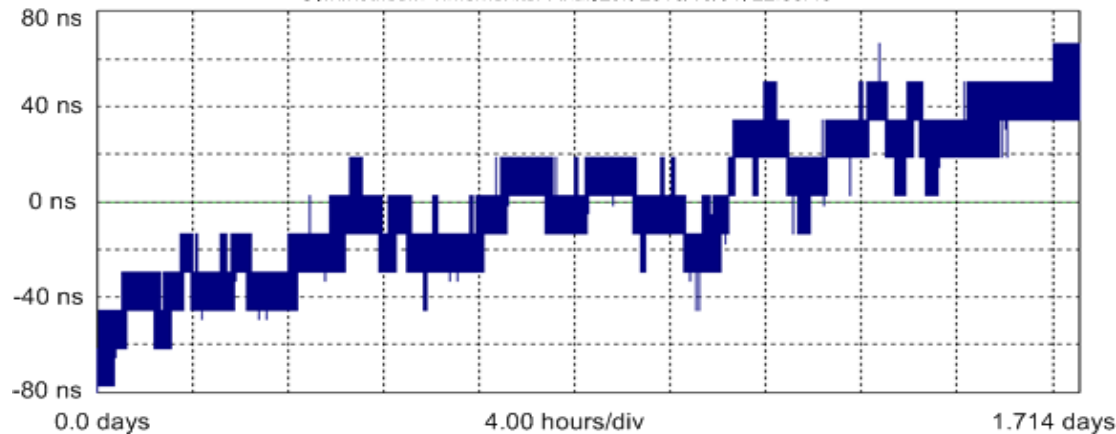
PDV Measurements: Network vs. Equipment

Symmetricon TimeMonitor Analyzer
Phase deviation in units of time: $F_s=499.4$ MHz; $F_o=10.000000$ MHz; 2006/08/30 17:07:10
Tahiti Phase: Samples: 49036; UUID: 00005501000A; Initial phase offset: 134.730 usec



Network
PDV

Symmetricon TimeMonitor Analyzer; 2010/10/04; 22:30:40

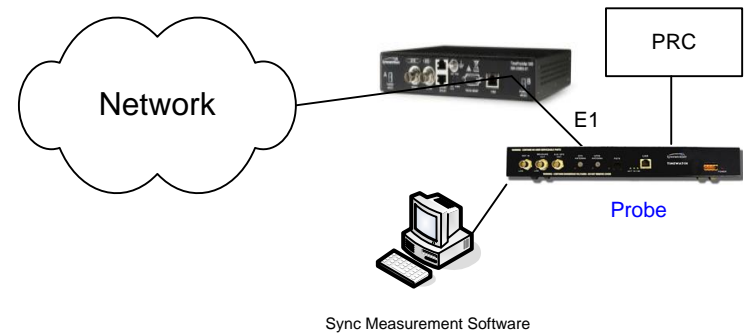
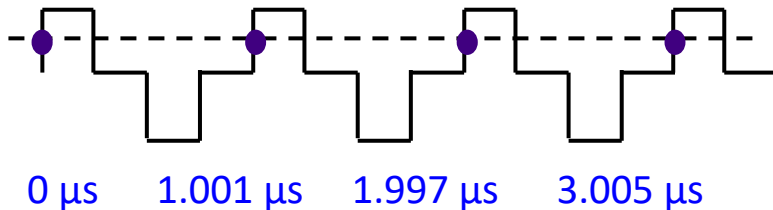


Equipment
PDV

Frequency Signal “TIE” vs. “PDV”

- **“TIE” (Single Point Measurement)**

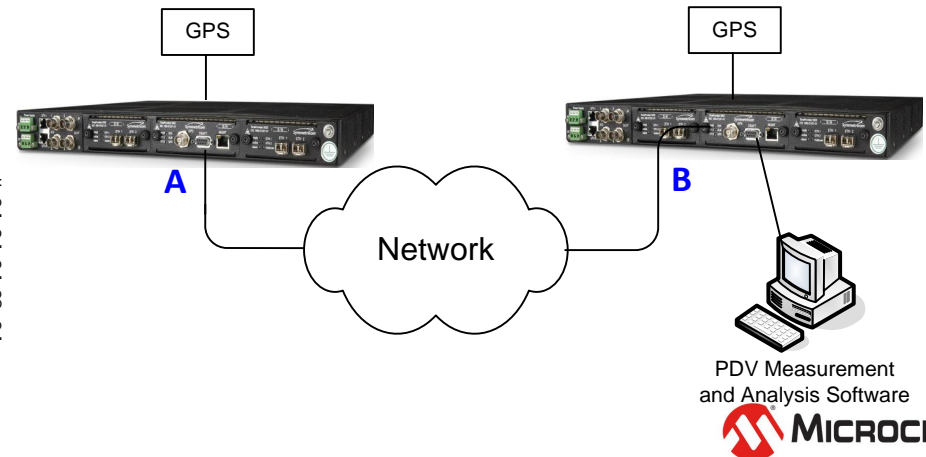
- Measurements are made at a single point – a single piece of equipment in a single location - a phase detector with reference - is needed



- **“PDV” (Dual Point Measurement)**

- Measurements are constructed from packets time-stamped at two points – in general two pieces of equipment, each with a reference, at two different locations – are needed

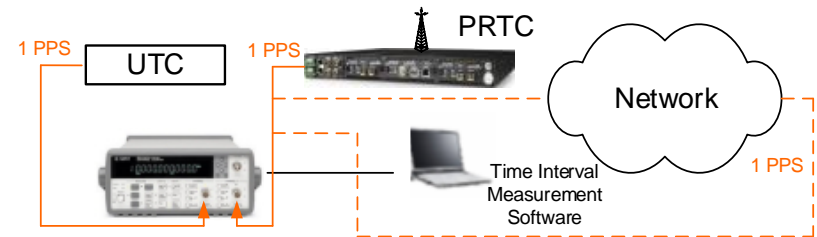
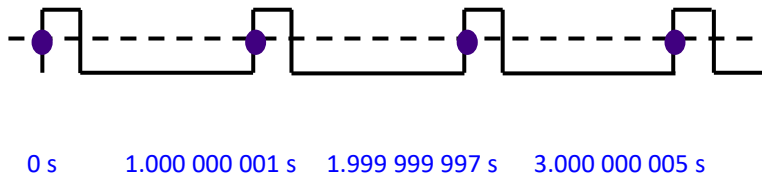
	Timestamp A	Timestamp B
F	1233166476.991204496	1233166476.991389744
R	1233166476.980521740	1233166476.980352932
F	1233166477.006829496	1233166477.007014512
R	1233166476.996147084	1233166476.995977932
F	1233166477.022454496	1233166477.022639568
R	1233166477.011771820	1233166477.011602932



Time Signal “Physical” vs. “Packet”

- **“1 PPS” (Single Point Measurement)**

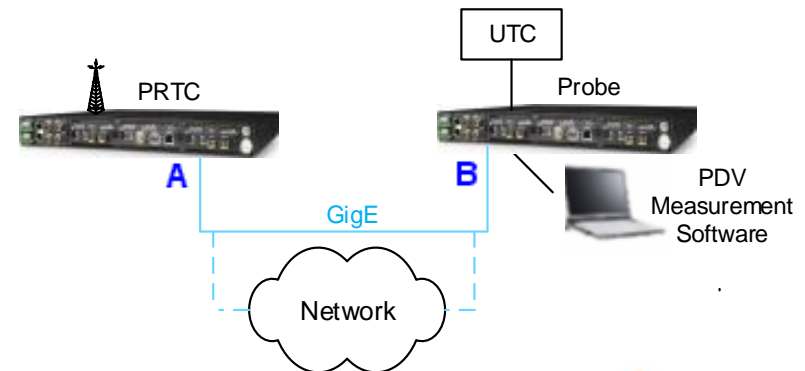
- Measurements are made at a single point – a single piece of equipment in a single location - a phase detector with reference - is needed



- **“Packet” (Dual Point Measurement)**

- Measurements are constructed from packets time-stamped at two points – in general two pieces of equipment, each with a reference, at two different locations – are needed

	Timestamp A	Timestamp B
F	1286231440.883338640	1286231440.883338796
R	1286231441.506929352	1286231441.506929500
F	1286231441.883338640	1286231441.883338796
R	1286231442.506929352	1286231442.506929500
F	1286231442.883338640	1286231442.883338796
R	1286231443.506929352	1286231443.506929516



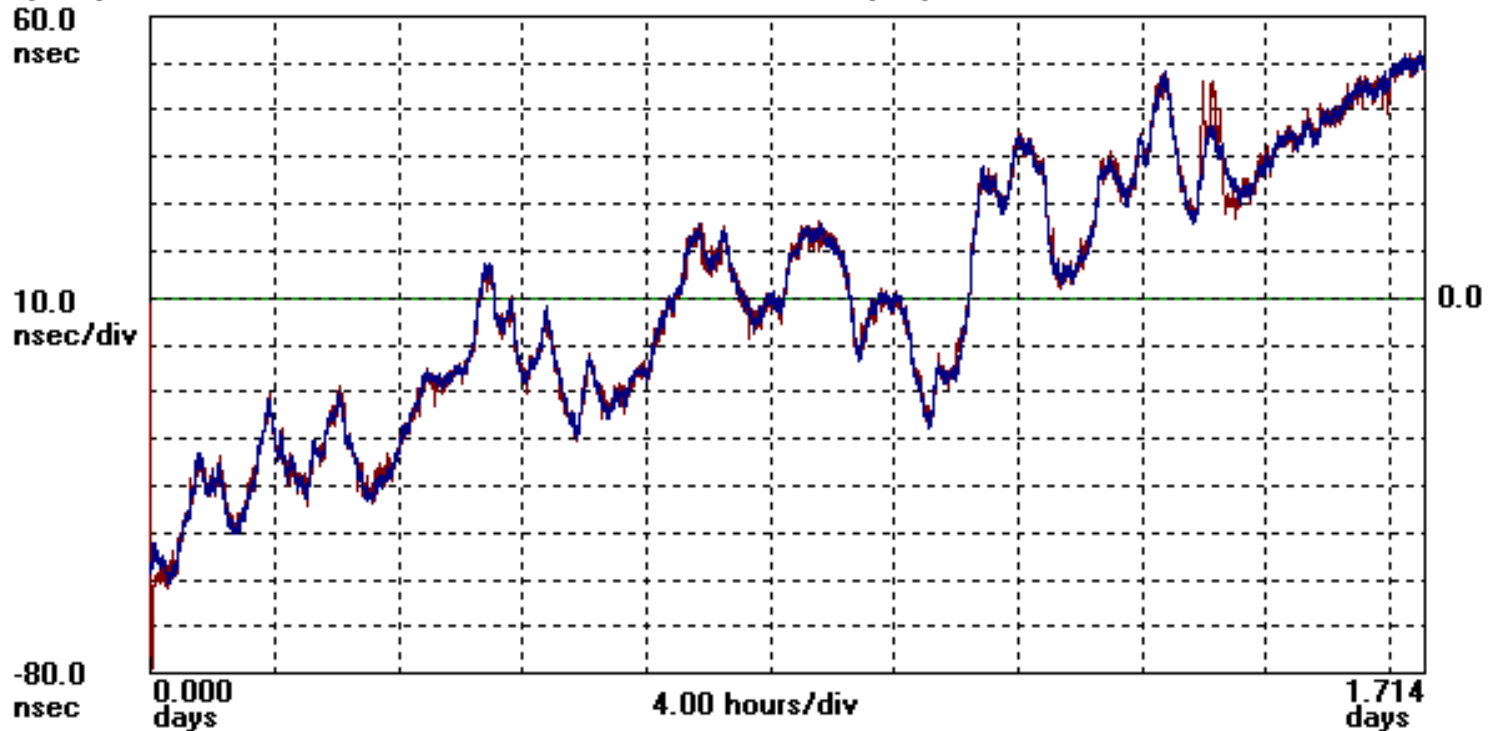
Grandmaster Test PPS and Packet Probe

Physical 1PPS signal measurement and packet signal
tested with probe match

Microsemi TimeMonitor Analyzer

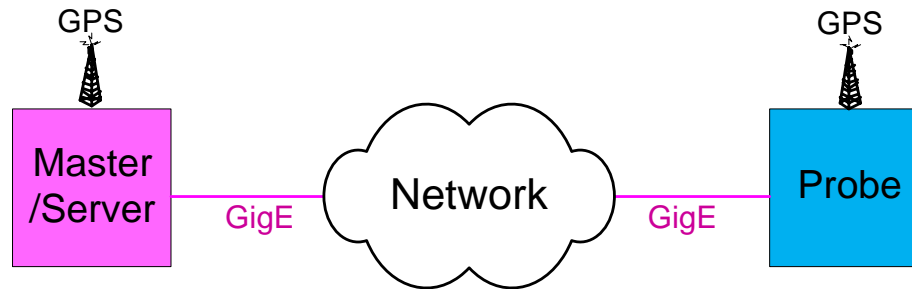
Phase deviation in units of time; $F_s=499.8$ mHz; $F_o=1.0000000$ Hz

1 (blue): HP 53132A; Test: 4474; 1588 Master; 1PPS; 2 (red): TP5000 Probe;

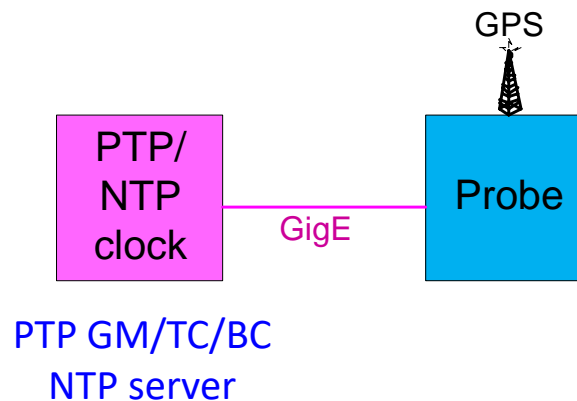


Packet Probe

Network PDV Measurement

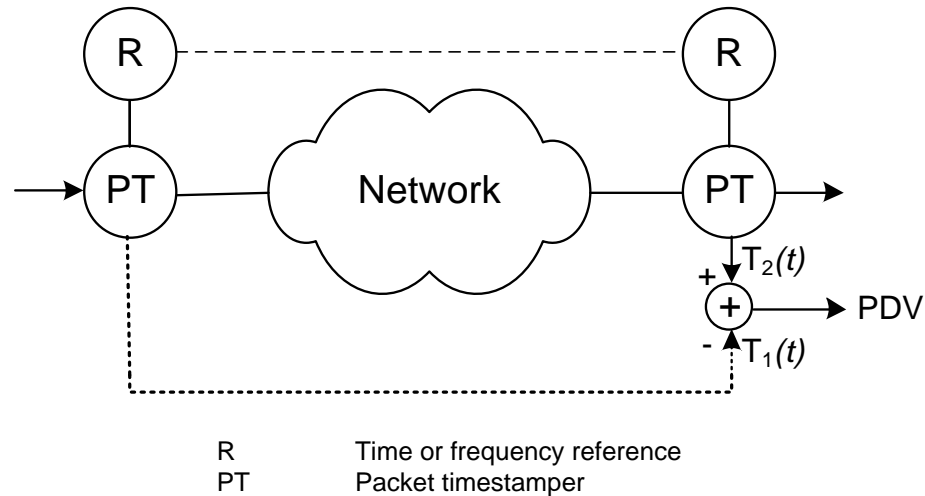


PTP/NTP Equipment Characterization

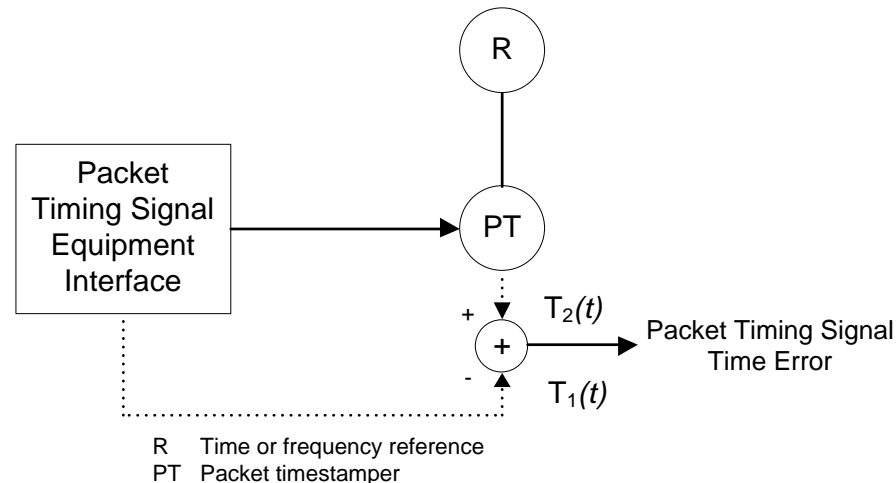


Packet Probe (G.8260 View)

Network PDV Measurement



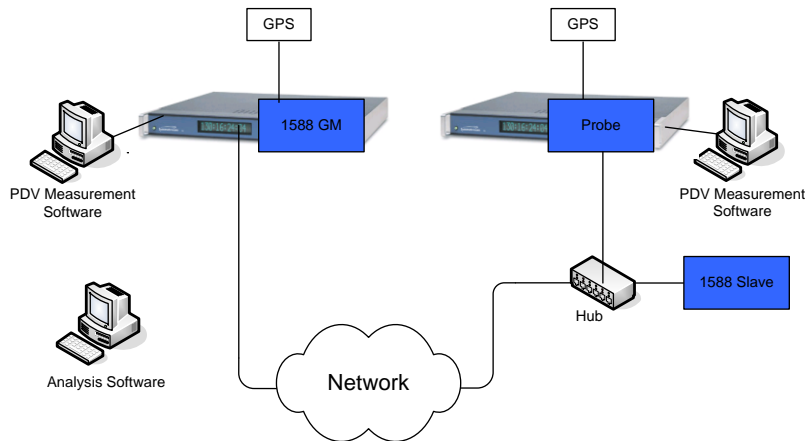
Packet Equipment Characterization



“PDV” Measurement Setup Options

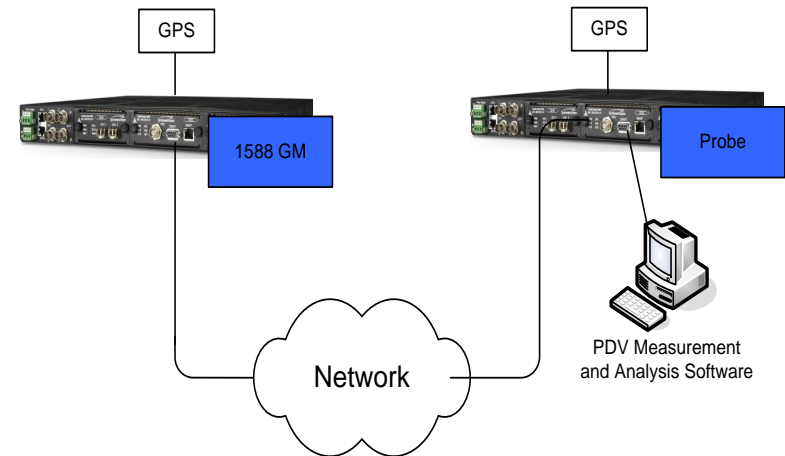
Passive Probe

- (1) Hub or Ethernet Tap
- (2) IEEE 1588 Slave
- (3) Collection at Both Nodes



Active Probe

- (1) No Hub or Ethernet Tap Needed
- (2) No IEEE 1588 Slave Needed
- (3) Collection at Probe Node Only

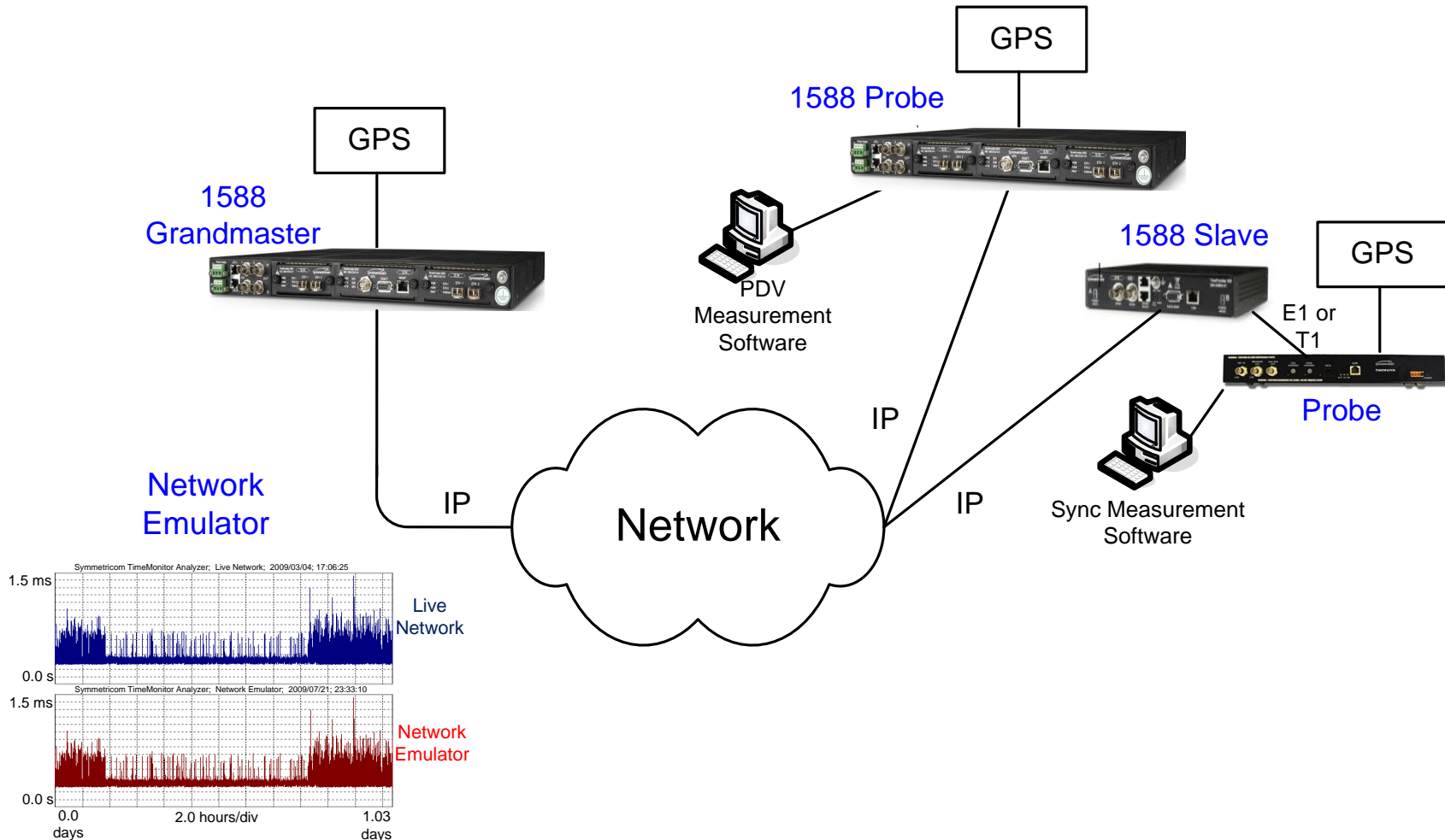


• “PDV”

- Ideal setup - two packet timestampers with GPS reference so absolute latency can be measured as well as PDV over small to large areas
- Alternative setup (lab) – frequency (or GPS) locked single shelf with two packet timestampers
- Alternative setup (field) – frequency locked packet timestampers – PDV but not latency can be measured

“TIE” and “PDV”

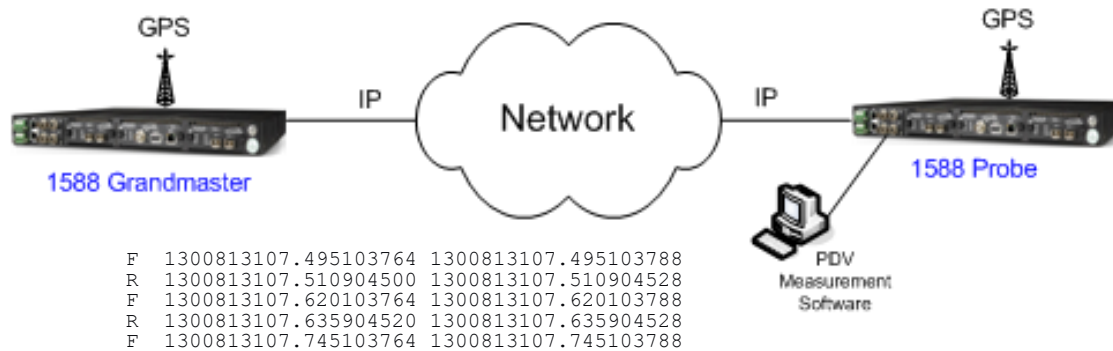
In most packet network measurement setups, both “TIE” and “PDV” are measured at the same time



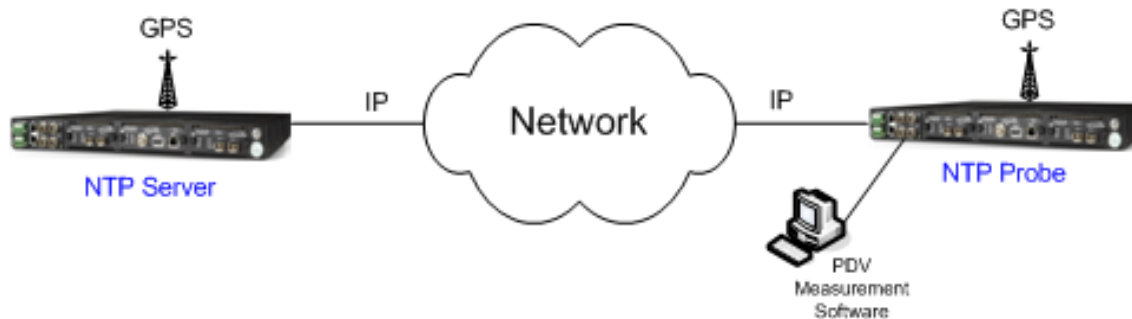
PTP and NTP Probes

Either PTP or NTP packets can be used for probing.

- In some circumstances, one or the other might be more suitable.
- For example, NTP is useful for probing over the public internet because of NAT (network address translation) challenges.



PTP



NTP

```
N,D1335140,190A968D,D1335140,190AA710,D1335140,190AD026,D1335140,190ADB2F
N,D1335140,1D0A9EB0,D1335140,1D0AA755,D1335140,1D0AD004,D1335140,1D0ADBCF
N,D1335140,210A9EB0,D1335140,210AA710,D1335140,210AD026,D1335140,210ADB2F
N,D1335140,250A9EB0,D1335140,250AA710,D1335140,250ACFBF,D1335140,250ADB46
N,D1335140,290A9EB0,D1335140,290AA710,D1335140,290AD026,D1335140,290ADB2F
```

“TIE” Analysis vs. “PDV” Analysis

“TIE” Analysis (G.810)

- Phase (TIE)
- Frequency accuracy
- Dynamic frequency
- MTIE
- TDEV

“PDV” Analysis (G.8260)

- Phase (PDV)
- Histogram/PDF*, CDF**, statistics
- Dynamic statistics
- MATIE/MAFE
- TDEV/minTDEV/bandTDEV
- Two-way metrics: minOffset etc.

► The importance of raw TIE/PDV:

- Basis for frequency/statistical/MTIE/TDEV analysis
- Timeline (degraded performance during times of high traffic?)
- Measurement verification (jumps? offsets?)

* *PDF = probability density function*

** *CDF = cumulative distribution function*

Stability Metrics

- **Traditional Clock Metrics**

- ADEV, TDEV, MTIE
- Traditionally applied to oscillators, synchronization interfaces
- Also applied to lab packet equipment measurements **GM, BC**

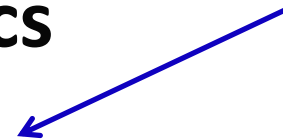
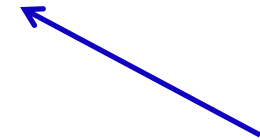
- **Frequency Transport Packet Metrics**

- minTDEV, MAFE, MATIE
- Applied to one-way packet delay data
- FPP/FPR/FPC (floor packet percent/rate/count)

- **Time Transport Packet Metrics**

- minOffset or combine one-way (FPP, MAFE, etc.)
- Applied to two-way packet delay data
- Assesses link asymmetry

Packet
Networks



Stability metrics for PDV

■ Packet Selection Processes

1) **Pre-processed**: packet selection step prior to calculation

- Example: **TDEV**(PDVmin) where PDVmin is a new sequence based on minimum searches on the original PDV sequence

2) **Integrated**: packet selection integrated into calculation

- Example: **minTDEV**(PDV)

■ Packet Selection Methods

• Minimum: $x_{\min}(i) = \min[x_j] \text{ for } (i \leq j \leq i + n - 1)$

• Percentile: $x'_{pct_mean}(i) = \frac{1}{m} \sum_{j=0}^b x'_{j+i}$

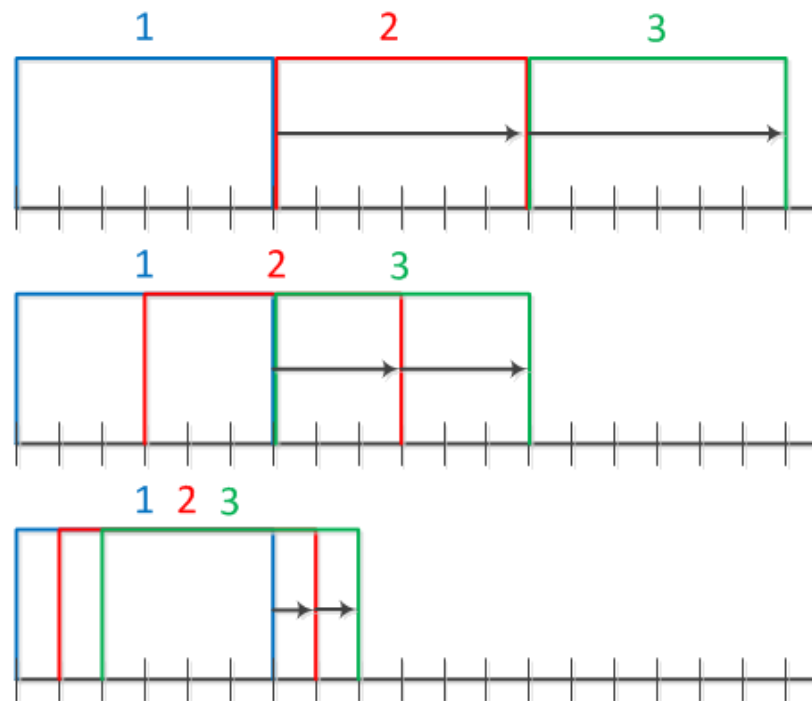
• Band: $x'_{band_mean}(i) = \frac{1}{m} \sum_{j=a}^b x'_{j+i}$

• Cluster:
$$x(n\tau_0) = \frac{\sum_{i=0}^{(K-1)} w((nK+i)\tau_p) \cdot \phi(n,i)}{\sum_{i=0}^{(K-1)} \phi(n,i)} \quad \phi(n,i) = \begin{cases} 1 & \text{for } |w(nK+i) - \alpha(n)| < \delta \\ 0 & \text{otherwise} \end{cases}$$

Packet Selection Windows

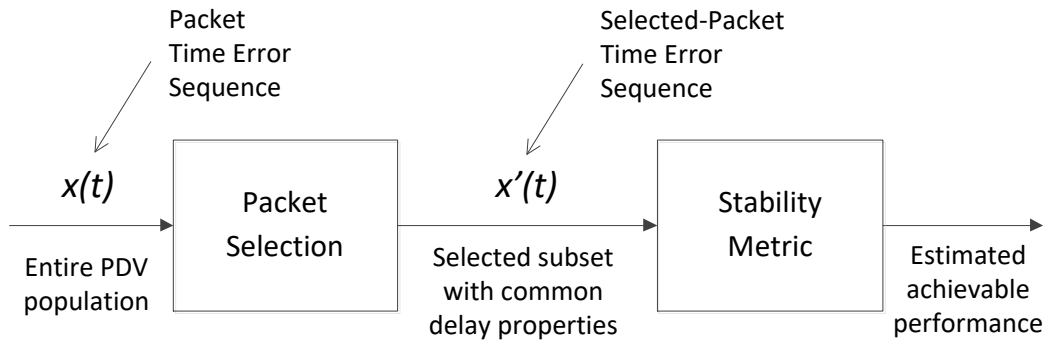
■ Windows

- **Non-overlapping windows**
(next window starts at prior window stop)
- **Skip-overlapping windows**
(windows overlap but starting points skip over N samples)
- **Overlapping windows**
(windows slide sample by sample)

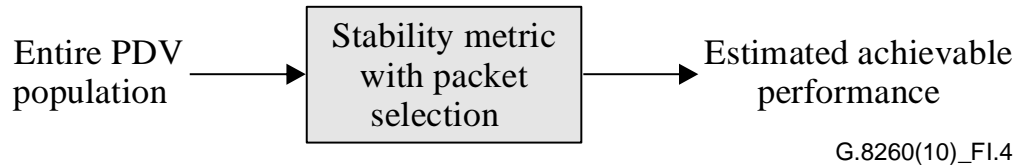


- Packet Selection Approaches (e.g. selecting fastest packets)
 - Select X% fastest packets (e.g. 2%)
 - Select N fastest packets (e.g. 10 fastest packets in a window)
 - Select all packets faster than Y (e.g. all packets faster than 150μs)

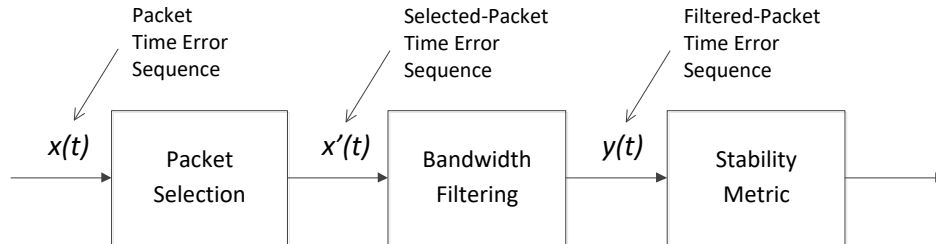
G.8260 Appendix I Metrics



Pre-processed packet selection



Integrated packet selection



Metrics including pre-filtering

FPC, FPR, FPP: Floor Packet Count/Rate/Percent

PDV metrics studying minimum floor delay packet population

Time Transport: Two-way metrics

Packet Time Transport Metrics

MeanPathDelay: $r(n) = \left(\frac{1}{2}\right) \cdot [R(n) + F(n)]$

TwowayTimeError: $\eta_2(n) = \left(\frac{1}{2}\right) \cdot [R(n) - F(n)]$

pktSelectedMeanPathDelay: $r'(n') = \left(\frac{1}{2}\right) \cdot [R'(n') + F'(n')]$

pktSelectedTwowayTimeError: $\eta_2'(n') = \left(\frac{1}{2}\right) \cdot [R'(n') - F'(n')]$

Ideal F/R: floor
(“lucky” packets: fastest)

min2wayTE: $\eta_2^m(n) = \left(\frac{1}{2}\right) \cdot [R^m(n) - F^m(n)]$

pct2wayTE $\eta_2^p(n) = \left(\frac{1}{2}\right) \cdot [R^p(n) - F^p(n)]$

cluster2wayTE $\eta_2^c(n) = \left(\frac{1}{2}\right) \cdot [R^c(n) - F^c(n)]$

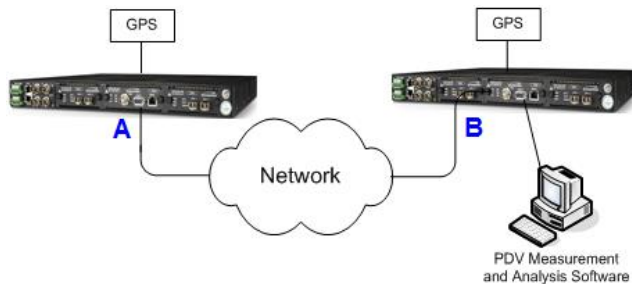
Ideal 2way TE: zero
(no asymmetry)

psTDISP (min/pct/clst time dispersion): ps2wayTE{y} plotted against psMeanPathDelay{x} as a scatter plot

ps2wayTE statistics: ps2wayTE statistic such as mean, standard deviation, median, 95 percentile plotted as a function of time window tau; min/maxATE

Weighted average: $w(n) = [a \cdot F(n) + (1 - a) \cdot R(n)]$ where $0 \leq a \leq 1$

Packet Delay Sequence



Packet Delay Sequence

```
R,00162; 1223305830.478035356; 1223305830.474701511
F,00167; 1223305830.488078908; 1223305830.490552012
R,00163; 1223305830.492882604; 1223305830.489969511
F,00168; 1223305830.503473436; 1223305830.505803244
R,00164; 1223305830.508647148; 1223305830.505821031
F,00169; 1223305830.519029300; 1223305830.521302172
R,00165; 1223305830.524413852; 1223305830.521446071
F,00170; 1223305830.534542972; 1223305830.536801164
R,00166; 1223305830.540181132; 1223305830.537115991
F,00171; 1223305830.550229692; 1223305830.552551628
```

Packet
Timestamps

Forward

#Start: 2009/10/06 15:10:30

```
0.0000, 2.473E-3
0.0155, 2.330E-3
0.0312, 2.273E-3
0.0467, 2.258E-3
0.0623, 2.322E-3
```

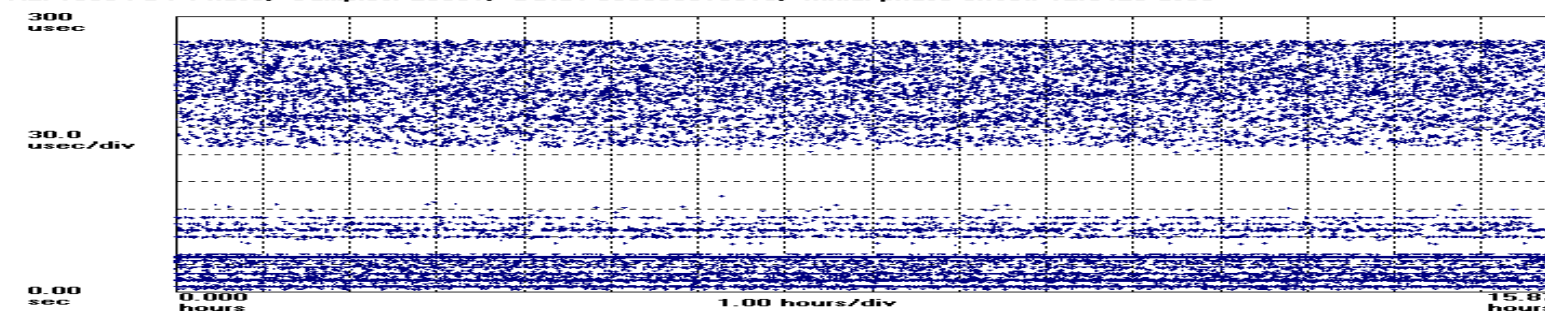
Reverse

#Start: 2009/10/06 15:10:30

```
0.0000, 3.334E-3
0.0153, 2.913E-3
0.0311, 2.826E-3
0.0467, 2.968E-3
0.0624, 3.065E-3
```

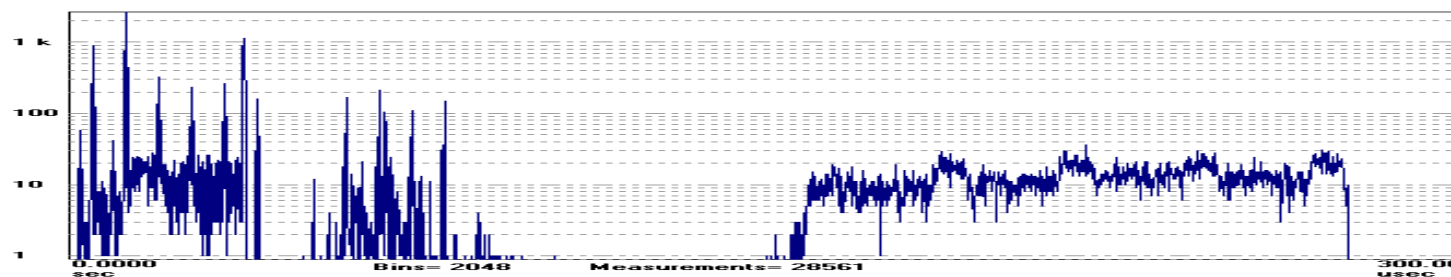
Packet Delay Distribution

Symmetricom TimeMonitor Analyzer (file=xl_1588_pdv.tah)
 Phase deviation in units of time: Fs=500.0 MHz; Fo=10.000000 MHz; 2006/06/09 01:11:06
 XLI 1588 PDV Phase; Samples: 28561; UUID: 000055010016; Initial phase offset: 12.5420 usec



Packet
Delay
Sequence

Symmetricom TimeMonitor Analyzer
 Phase Deviation Histogram: Fs=500.0 MHz; Fo=10.00 MHz; 2006/06/09 01:11:06
 Tahiti Phase; Samples: 28561; UUID: 000055010016; Initial phase offset: 12.5420 usec

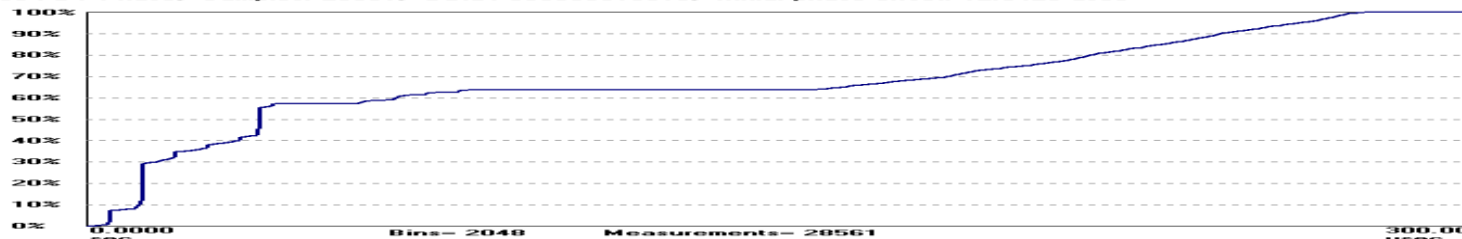


PDF

Minimum: 1.904297 usec	Mean: 96.71927 usec
Maximum: 275.2441 usec	Standard Deviation: 97.34 usec
Peak to Peak: 273.3 usec	Population: 28561 Percentage: 100.0%

Statistics

Symmetricom TimeMonitor Analyzer (file=xl_1588_pdv.tah)
 Phase Deviation CDF: Fs=500.0 MHz; Fo=10.00 MHz; 2006/06/09 01:11:06
 XLI 1588 PDV Phase; Samples: 28561; UUID: 000055010016; Initial phase offset: 12.5420 usec

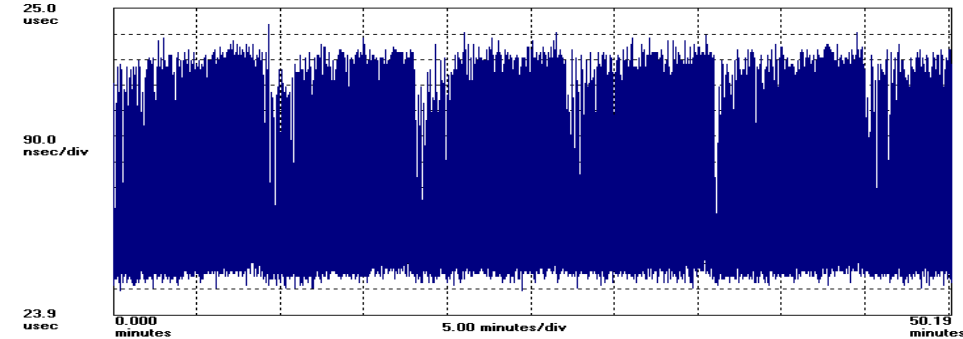


CDF

50pct: 37.65 us; 90pct: 245.5 us; 95pct: 261.9 us; 99pct: 272.3 us; 99.9pct: 274.5 us

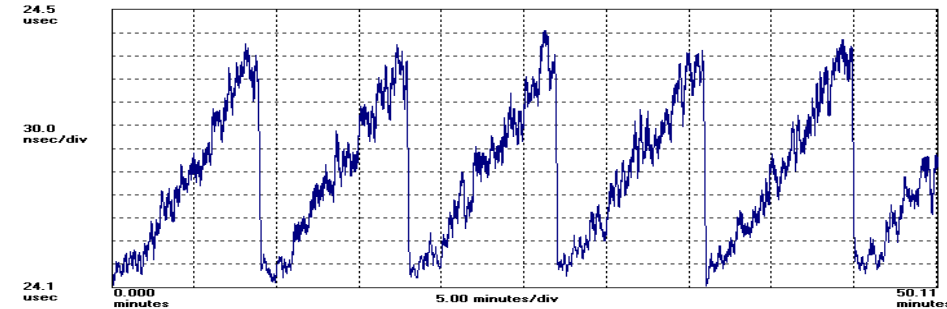
Tracked Packet Delay Statistics

Symmetricom TimeMonitor Analyzer (file=destination-2007_09_19-09_39.cap)
Phase deviation in units of time: Fs=16.66 Hz; Fo=10.000000 MHz; 2007/09/19 07:45:00
XL: 1588 PDV Phase; Samples: 50185; Start: 5114; Threshold: 27.0000 us; UUID: 00A069012F09; Initial phase offset: 24.1950 usec



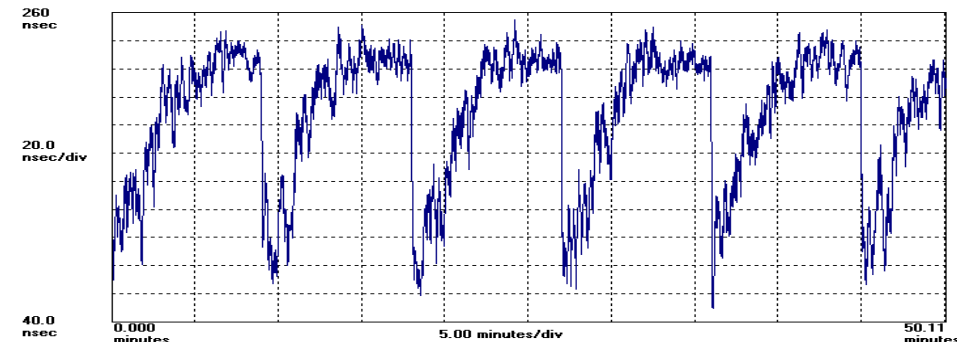
Raw packet delay appears relatively static over time

Symmetricom TimeMonitor Analyzer (file=pdv-2007_09_19-09_39_mean.pan)
Phase deviation in units of time: Fs=16.66 Hz; Fo=10.000000 MHz; 2007/09/19 07:45:00
Phase Mean; Overlap: Tau=10s; A=167; N=50019;



Mean vs. time shows cyclical ramping more clearly

Symmetricom TimeMonitor Analyzer (file=pdv-2007_09_19-09_39_stddev.pan)
Phase deviation in units of time: Fs=16.66 Hz; Fo=10.000000 MHz; 2007/09/19 07:45:00
Phase Standard Deviation; Overlap: Tau=10s; A=167; N=50019;



Standard deviation vs. time shows a quick ramp up to a flat peak

Packet Metrics

TDEV

$$\sigma_x(\tau) = TDEV(\tau) = \sqrt{\frac{1}{6} \left\langle \left[\frac{1}{n} \sum_{i=1}^n x_{i+2n} - 2 \frac{1}{n} \sum_{i=1}^n x_{i+n} + \frac{1}{n} \sum_{i=1}^n x_i \right]^2 \right\rangle}$$

minTDEV

$$\sigma_{x_min}(\tau) = \min TDEV(\tau) = \sqrt{\frac{1}{6} \left\langle [x_{\min}(i+2n) - 2x_{\min}(i+n) + x_{\min}(i)]^2 \right\rangle} \quad x_{\min}(i) = \min[x_j] \text{ for } (i \leq j \leq i+n-1)$$

bandTDEV

$$\sigma_{x_band}(\tau) = bandTDEV(\tau) = \sqrt{\frac{1}{6} \left\langle [x'_{band_mean}(i+2n) - 2x'_{band_mean}(i+n) + x'_{band_mean}(i)]^2 \right\rangle} \quad x'_{band_mean}(i) = \frac{1}{m} \sum_{j=a}^b x'_{j+i}$$

PDV noise type
characterization
w/ packet selection

1. TDEV is bandTDEV(0.0 to 1.0)
2. minTDEV is bandTDEV(0.0 to 0.0)
3. percentileTDEV is bandTDEV(0.0 to B) with B between 0.0 and 1.0

MATIE

$$MATIE(n\tau_0) \cong \max_{1 \leq k \leq N-2n+1} \frac{1}{n} \left| \sum_{i=k}^{n+k-1} (x_{i+n} - x_i) \right|, \quad n = 1, 2, \dots, \text{integer part } (N/2)$$

MAFE

$$MAFE(n\tau_0) = \frac{MATIE(n\tau_0)}{n\tau_0}$$

minMAFE

$$\min MAFE(n\tau_0) \cong \frac{\max_{1 \leq k \leq N-2n+1} \left| \sum_{i=k}^{n+k-1} (x_{\min}(i+n) - x_{\min}(i)) \right|}{n\tau_0} \quad \text{where } n = 1, 2, \dots, \text{integer part } (N/2) \text{ and where } x_{\min}(i) = \min[x_j] \text{ for } (i \leq j \leq i+n-1)$$

PDV frequency transport performance

FPP

$$FPP(n, W, \delta) = \left(\frac{\tau_P}{W} \right) \times FPC(n, W, \delta) \times 100 \% \quad \text{for } (K-1) \leq n < N$$

where

$$FPC(n, W, \delta) = \sum_{j=n-(K-1)}^n \phi_F(j, \delta) \quad \text{for } (K-1) \leq n < N$$

PDV phase/frequency delivery

References: (1) ITU-T G.8260 *Definitions and terminology for synchronization in packet networks*, Appendix I, Feb. 2012

(2) ATIS-0900003.2010 Technical Report: *Metrics Characterizing Packet-Based Network Synchronization*, Oct. 2010.

Floor Packet Count/Rate/Percent

$$FPC(n, W, \delta) = \sum_{j=n-(K-1)}^n \phi_F(j, \delta) \quad \text{for } (K-1) \leq n < N$$

$$FPR(n, W, \delta) = \frac{FPC(n, W, \delta)}{W} \quad \text{for } (K-1) \leq n < N$$

$$FPP(n, W, \delta) = \left(\frac{\tau_P}{W} \right) \times FPC(n, W, \delta) \times 100 \% \quad \text{for } (K-1) \leq n < N$$

Floor Packet Calculation:

- (1) Find floor
- (2) Fix cluster (e.g. 150 μ s) above floor
- (3) Count packets within cluster in successive windows (e.g. 200s)
- (4) For FPR, divide by window length
- (5) For FPP, divide by window packet total and multiply by 100

Example case:

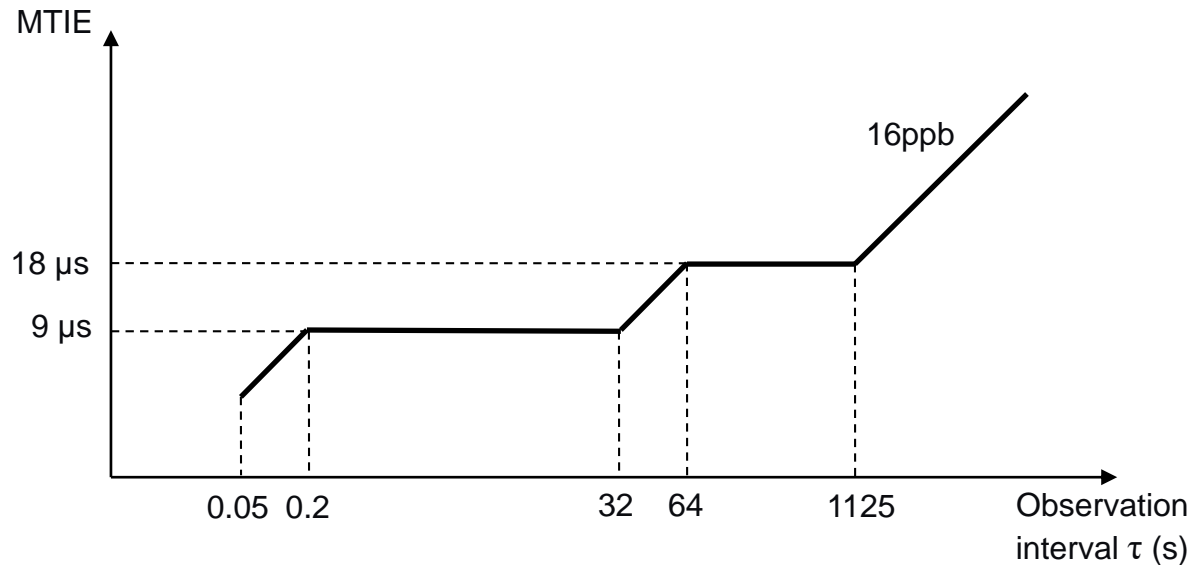
- (1) 200 second window
- (2) 64 pkt/s

	Min	Max
FPC	0 pkt	12800 pkt
FPR	0 pkt/s	64 pkt/s
FPP	0%	100%

Packet Frequency Transport

G.8261.1

Output Wander



$$FPP(n, W, \delta) = \left(\frac{\tau_p}{W} \right) \times FPC(n, W, \delta) \times 100 \% \quad \text{for } (K-1) \leq n < N$$

where

$$FPC(n, W, \delta) = \sum_{j=n-(K-1)}^n \phi_F(j, \delta) \quad \text{for } (K-1) \leq n < N$$

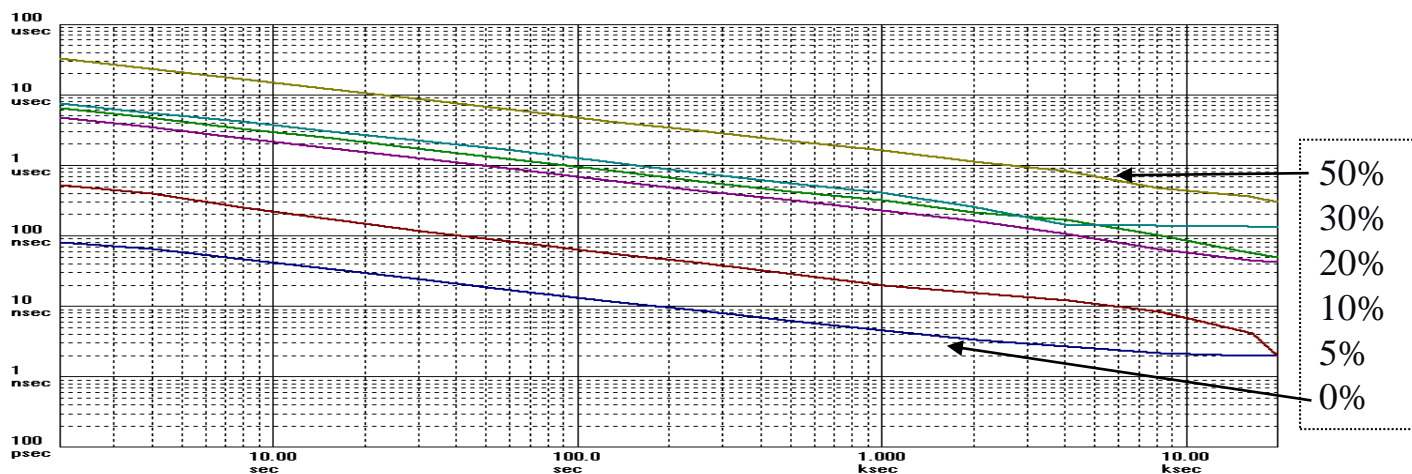
PDV

With window interval $W = 200$ s and fixed cluster range $\delta = 150 \mu\text{s}$ starting at the floor delay, the network transfer characteristic quantifying the proportion of delivered packets that meet the delay criterion should satisfy $FPP(n, W, \delta) \geq 1\%$

That is, the floor packet percentage must exceed 1%.

TDEV & minTDEV with Traffic

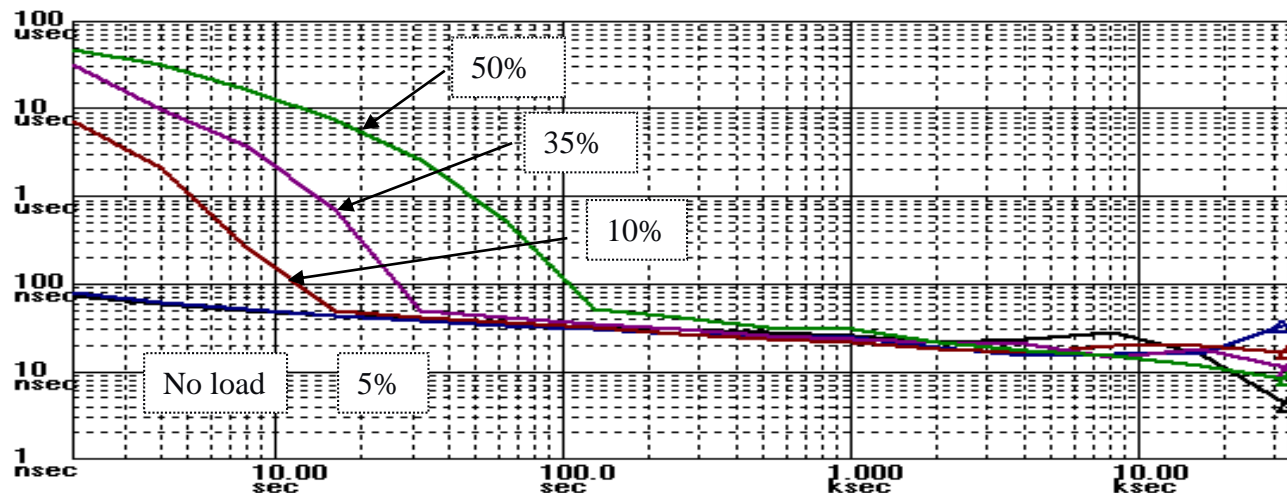
TDEV



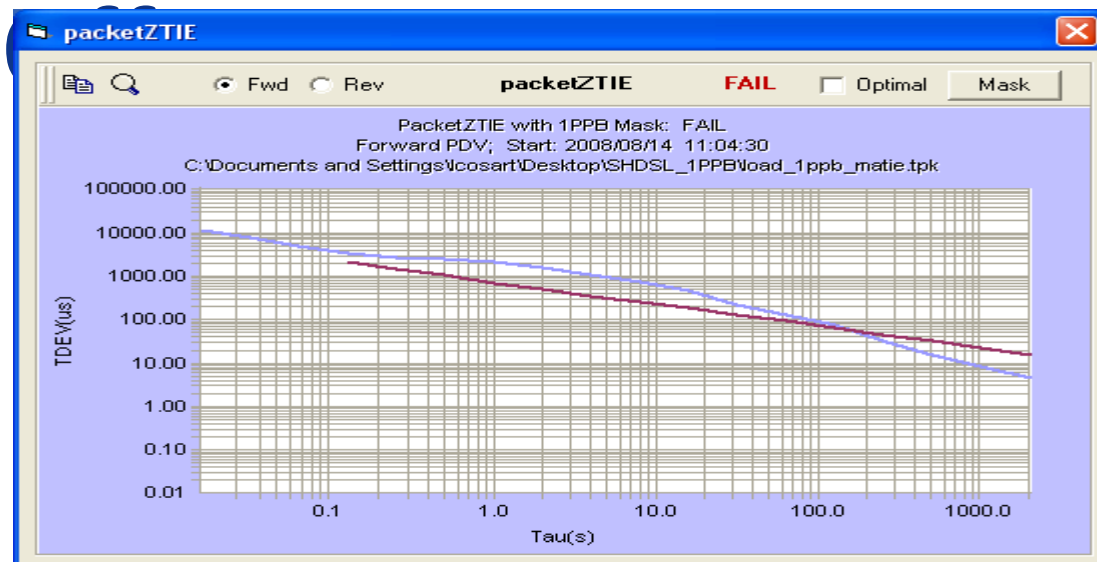
Lower levels of noise with the application of a MINIMUM selection algorithm
minTDEV at various traffic levels on a switch (0% to 50%) converge

Symmetricom TimeMonitor Analyzer (file=multilayer_switch_40percentSB60.txt)
minTDEV; No. Avg=1; Fo=10.00 MHz; 2006/09/19; 15:28:30

minTDEV



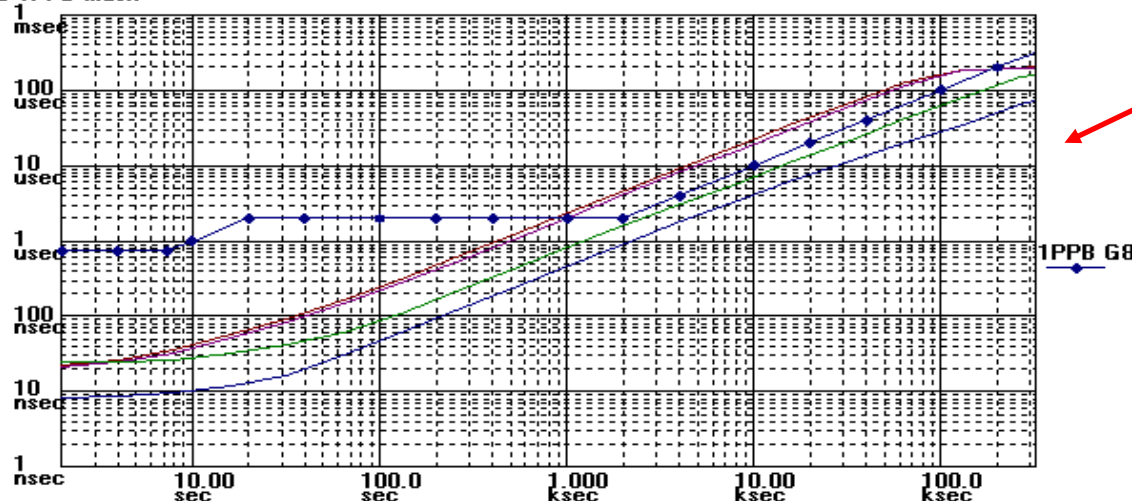
MATIE and 1588 Slave Frequency



Packet measurement

Packet data analysis:
1PPB offset predicted

Symmetricon TimeMonitor Analyzer
MTIE; Fo=2.048 MHz; Fs=499.8 mHz; 2009/09/04; 17:08:49
G.823 1PPB mask



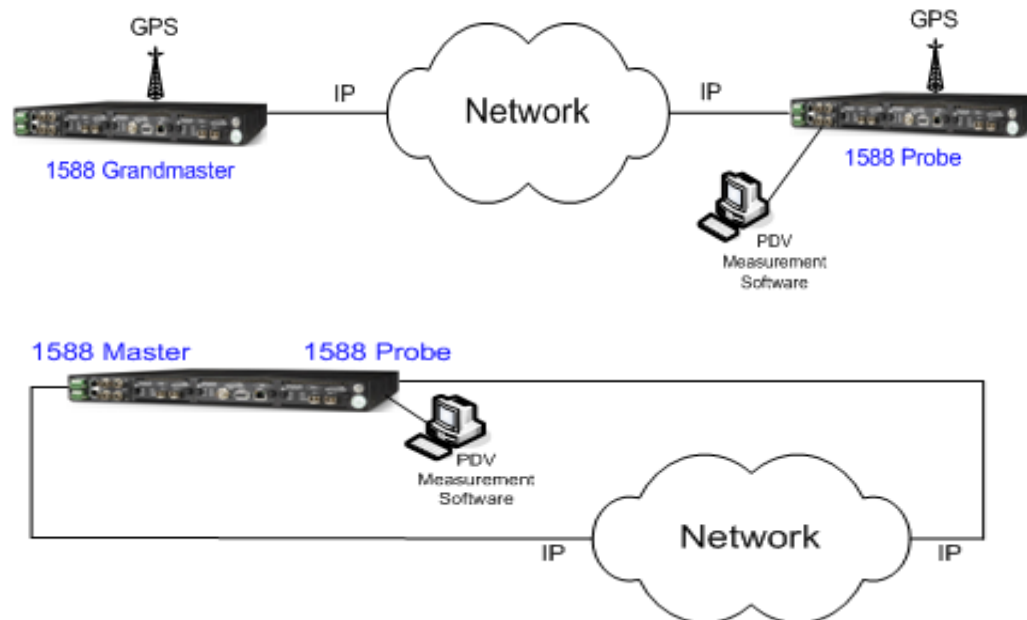
Sync measurement

1588 slave performance:
1 PPB offset measured

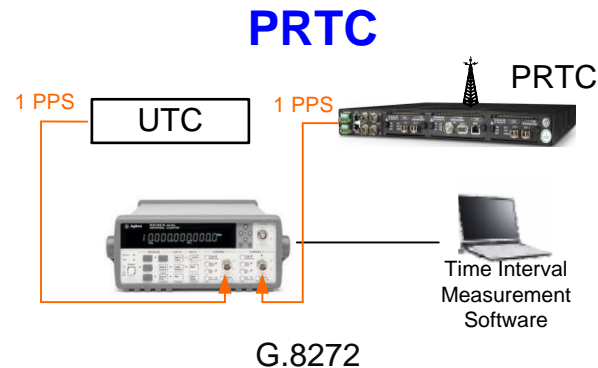
Packet Time Transport

“PDV” measurement setup for time transport

- ✓ – Ideal setup - two packet timestampers with GPS reference so absolute latency can be measured as well as PDV over small to large areas
- ✓ – Alternative setup (lab) – frequency (or GPS) locked single shelf with two packet timestampers
- ✗ – Alternative setup (field) – frequency locked packet timestampers – PDV but neither latency nor asymmetry can be measured



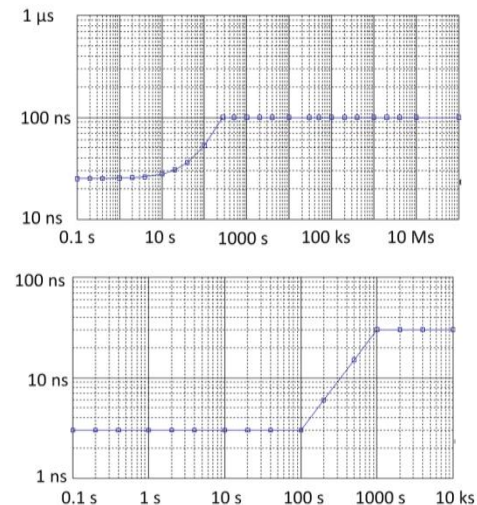
Time Accuracy and Stability Requirements



Time Accuracy
Time Error: $\leq 100\text{ns}$

MTIE

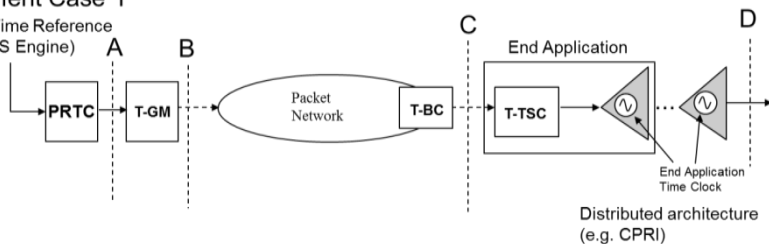
Time Stability
TDEV



MTIE is G.811 with 100 ns maximum
TDEV is G.811 exactly

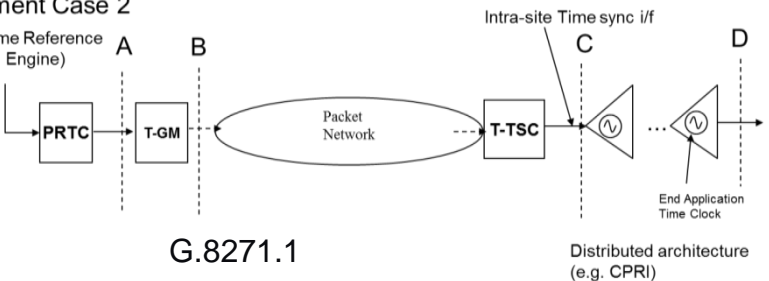
Packet Network Limits

Deployment Case 1
Network Time Reference
(e.g. GNSS Engine)



A: Time Error: $\leq 100\text{ns}$

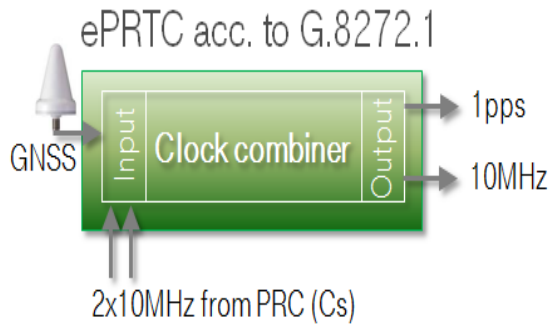
Deployment Case 2
Network Time Reference
(e.g. GNSS Engine)



C: Time Error: $\leq 1.1\mu\text{s}$

ePRTC: Enhanced PRTC G.8272.1

ePRTC

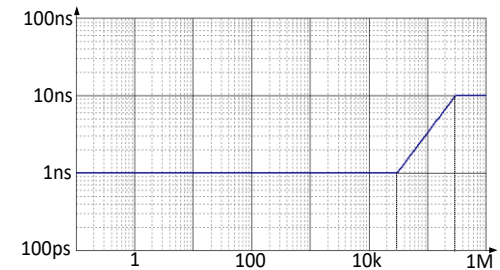
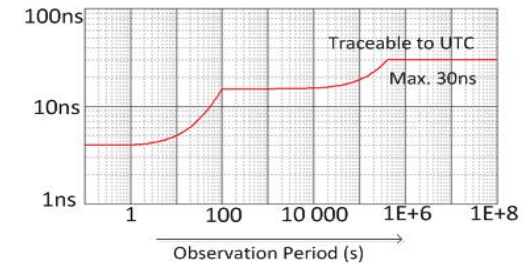


Time Accuracy
Time Error: $\leq 30\text{ns}$

Time Stability

MTIE

TDEV



ePRTC Attributes

- Reliability: Immune from local jamming or outages
- Autonomy: Atomic clock sustained timescale with & without GNSS connection
- Coherency: 30ns coordination assures overall PRTC budget

Time Transport: Two-way packet delay

Forward Packet Delay Sequence

#Start: 2010/03/06 17:15:30

0.0000, 1.47E-6
0.1000, 1.54E-6
0.2000, 1.23E-6
0.3000, 1.40E-6
0.4000, 1.47E-6
0.5000, 1.51E-6

#Start: 2010/03/06 17:15:30

0.0000, 1.47E-6, 1.11E-6
0.1000, 1.54E-6, 1.09E-6
0.2000, 1.23E-6, 1.12E-6
0.3000, 1.40E-6, 1.13E-6
0.4000, 1.47E-6, 1.22E-6
0.5000, 1.51E-6, 1.05E-6

Reverse Packet Delay Sequence

#Start: 2010/03/06 17:15:30

0.0000, 1.11E-6
0.1000, 1.09E-6
0.2000, 1.12E-6
0.3000, 1.13E-6
0.4000, 1.22E-6
0.5000, 1.05E-6



Two-way Data Set

Time(s)	f(μs)	r(μs)	f'(μs)	r'(μs)
0.0	1.47	1.11		
0.1	1.54	1.09	1.23	1.09
0.2	1.23	1.12		
0.3	1.40	1.13		
0.4	1.47	1.22	1.40	1.05
0.5	1.51	1.05		

Minimum Search Sequence

Constructing f' and r'
from f and r with a 3-
sample time window

0.1	-0.07
0.4	-0.18

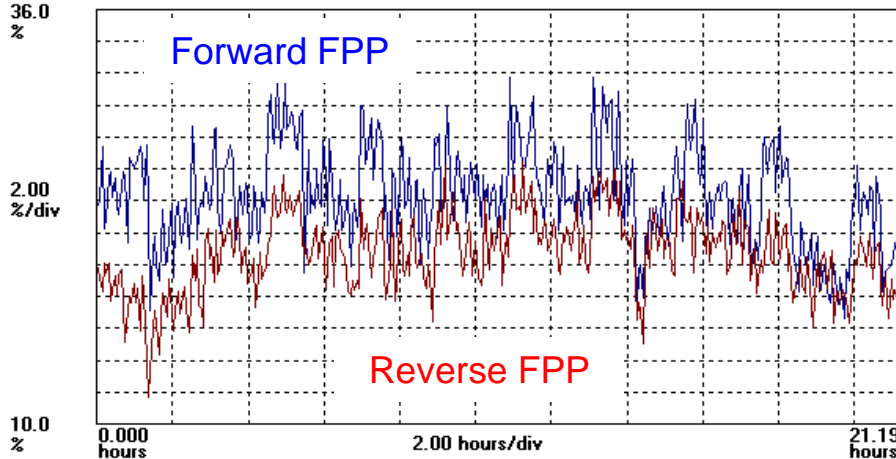
min2wayTE

$$\eta_2'(n') = \left(\frac{1}{2}\right) \cdot [R'(n') - F'(n')]$$

Time Transport: Two-way metrics

Forward/Reverse FPP

Symmetricon TimeMonitor Analyzer
Floor Packet Percent: Window=200 s; Range=50.0 us; Floor=-54.3 us; Fmin; T=200 s; A=3200; N=382
1 (blue): Fwd FPP; 2 (red): Rev FPP



Comments:

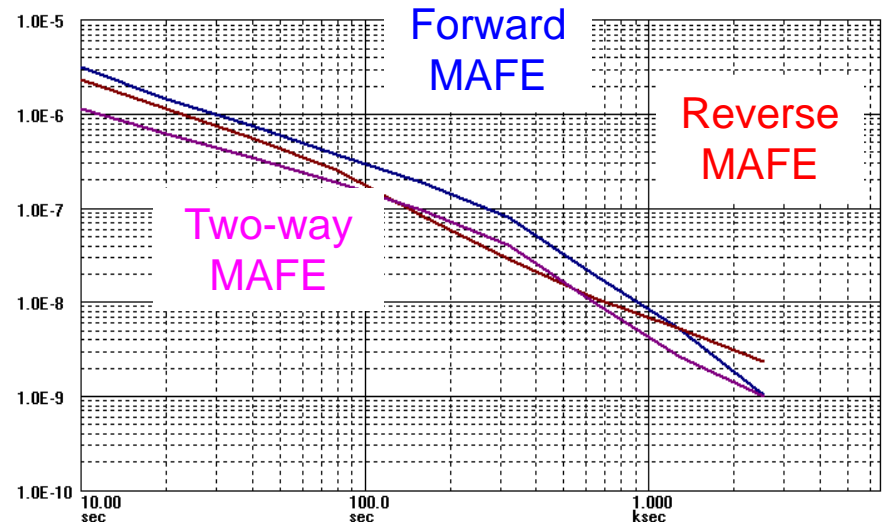
- (1) Knowledge of asymmetry and latency in both directions is critical
- (2) Offset is a fundamental two-way calculation
- (3) Ideal fwd/rev packet: floor
Ideal offset: zero

Approaches:

- (1) Based on both one-way sequences
- (2) Based on a single sequence constructed from both one-way sequences (e.g. offset)

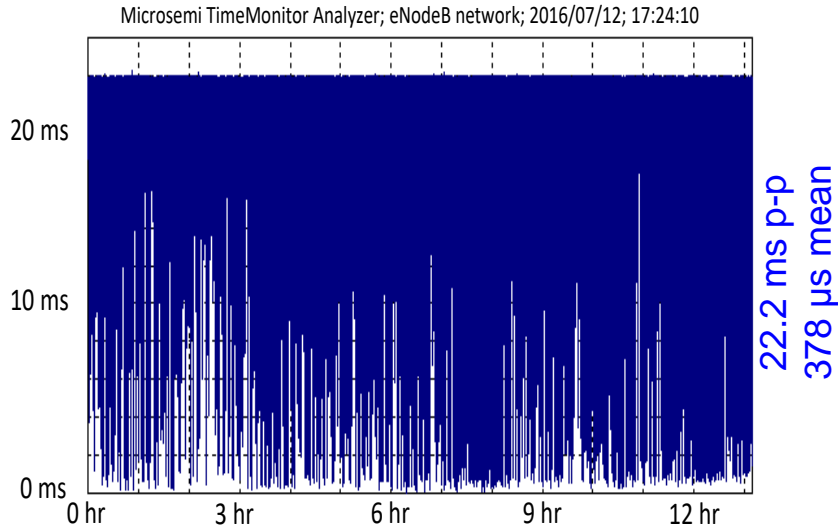
Two-way MAFE (MAFE of minOffset)

Symmetricon TimeMonitor Analyzer (file=probe-2008_09_04-12_54d.tpk)
MAFE; Fo=10.00 MHz; Fs=100.6 mHz; 2008/09/04; 16:55:05

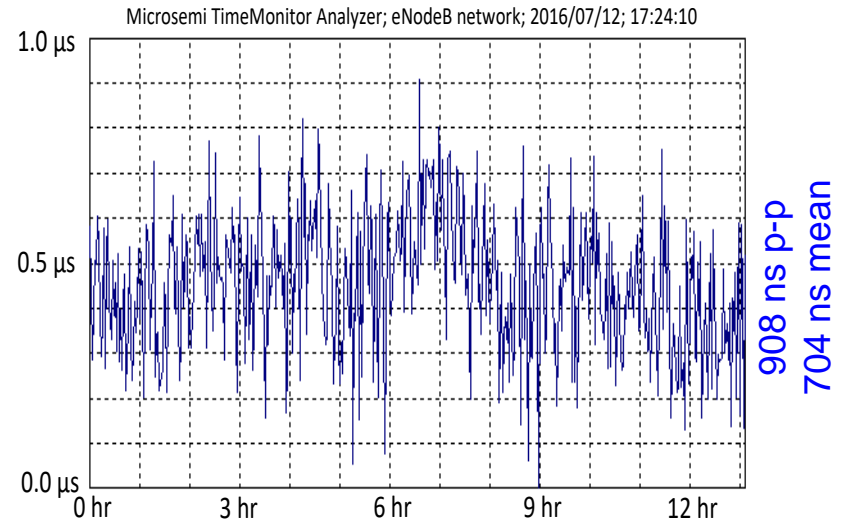


Time Transport: Two-way metrics

2wayTE



pktSelected2wayTE



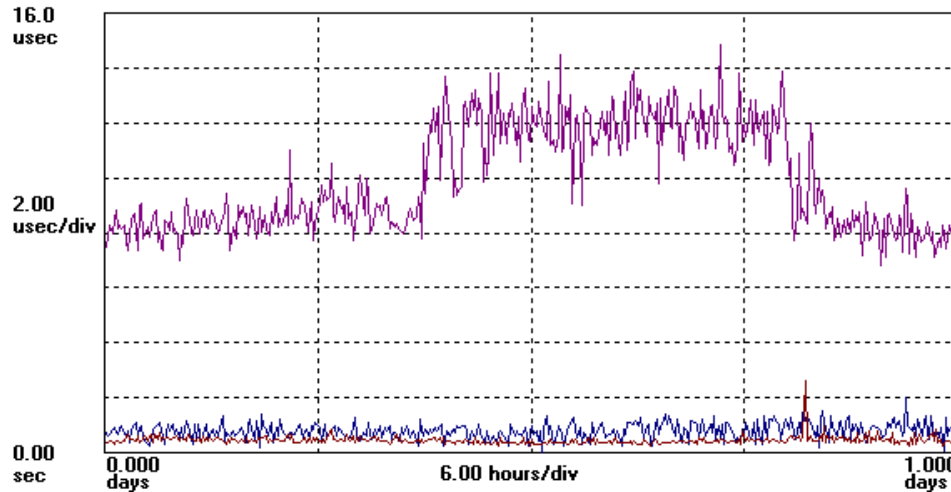
Both 2wayTE and pktSelected2wayTE plots with minimum set to 0. Mean value from unadjusted data.

Selection window = 100s
Selection percentage = 0.5%
Peak-to-peak pktSelected2wayTE = 908 ns
(G.8271.2 draft APTS limit: <1150 ns)

Case Studies: Five Networks

#1,#2,#3 PDV Percentile: 1%

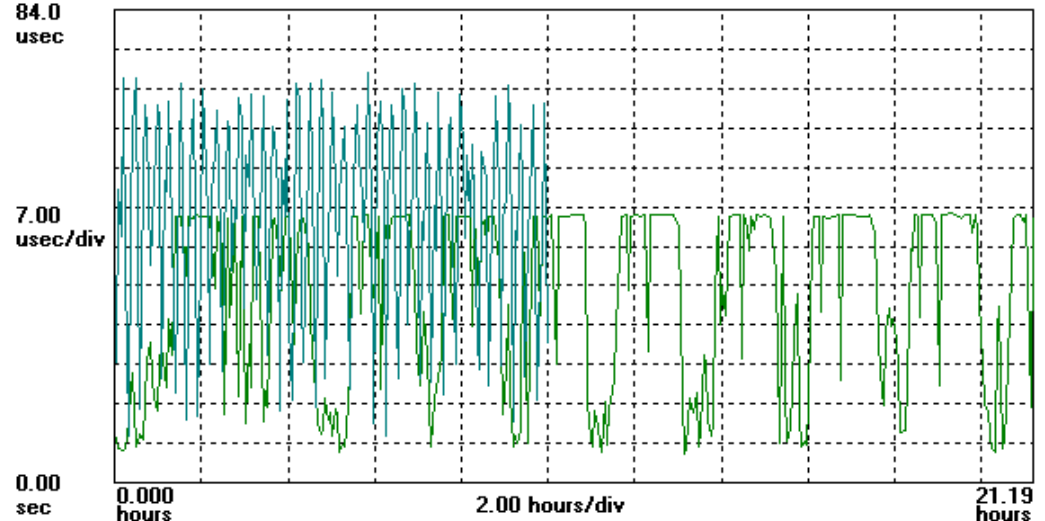
Symmetricon TimeMonitor Analyzer
Phase deviation in units of time; Fs=499.4 mHz; Fo=10.000000 MHz; 2006/08/30; 21:07:10



What FPP level could be set to get at least 1% of the packets?

#4,#5 PDV Percentile: 1%

Symmetricon TimeMonitor Analyzer
Phase deviation in units of time; Fs=16.00 Hz; Fo=10.000000 MHz; 2013/03/27; 20:03:11
4 [green]: Phase Floor Percentile; Tau=200s; P=1%; A=3200; F=32; N=382; 2013/03/27; 20:03:11; 5 [cyan]
84.0 usec

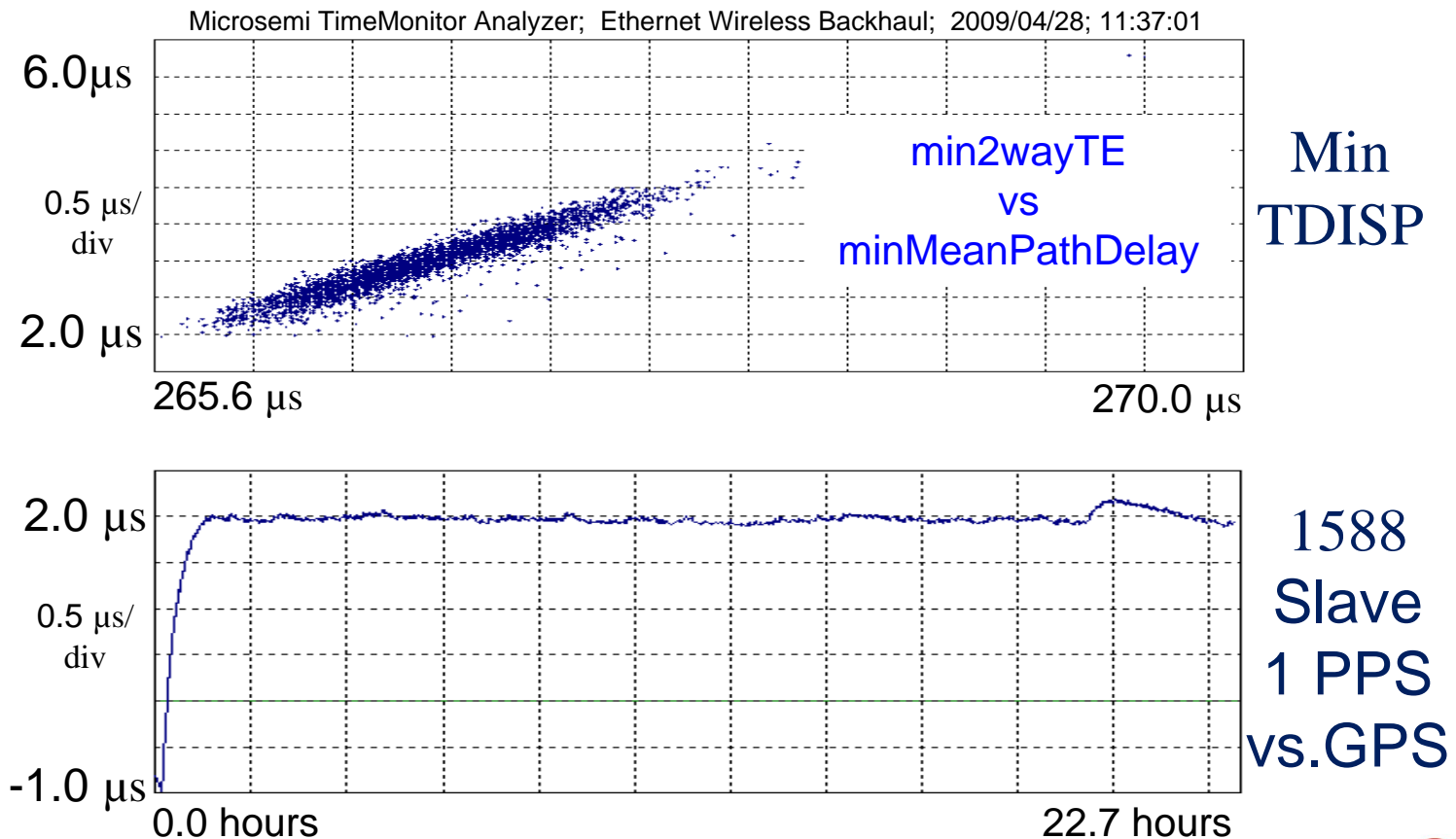


	Max 1 Percentile
U.S. Ethernet south	2.04 μ sec
U.S. Ethernet north	2.60 μ sec
Backhaul N America	13.8 μ sec
Eth/SONET	47.8 μ sec
Backhaul Europe	72.6 μ sec

Two-way Time Error \Leftrightarrow Network Asymmetry

Asymmetry in Wireless Backhaul

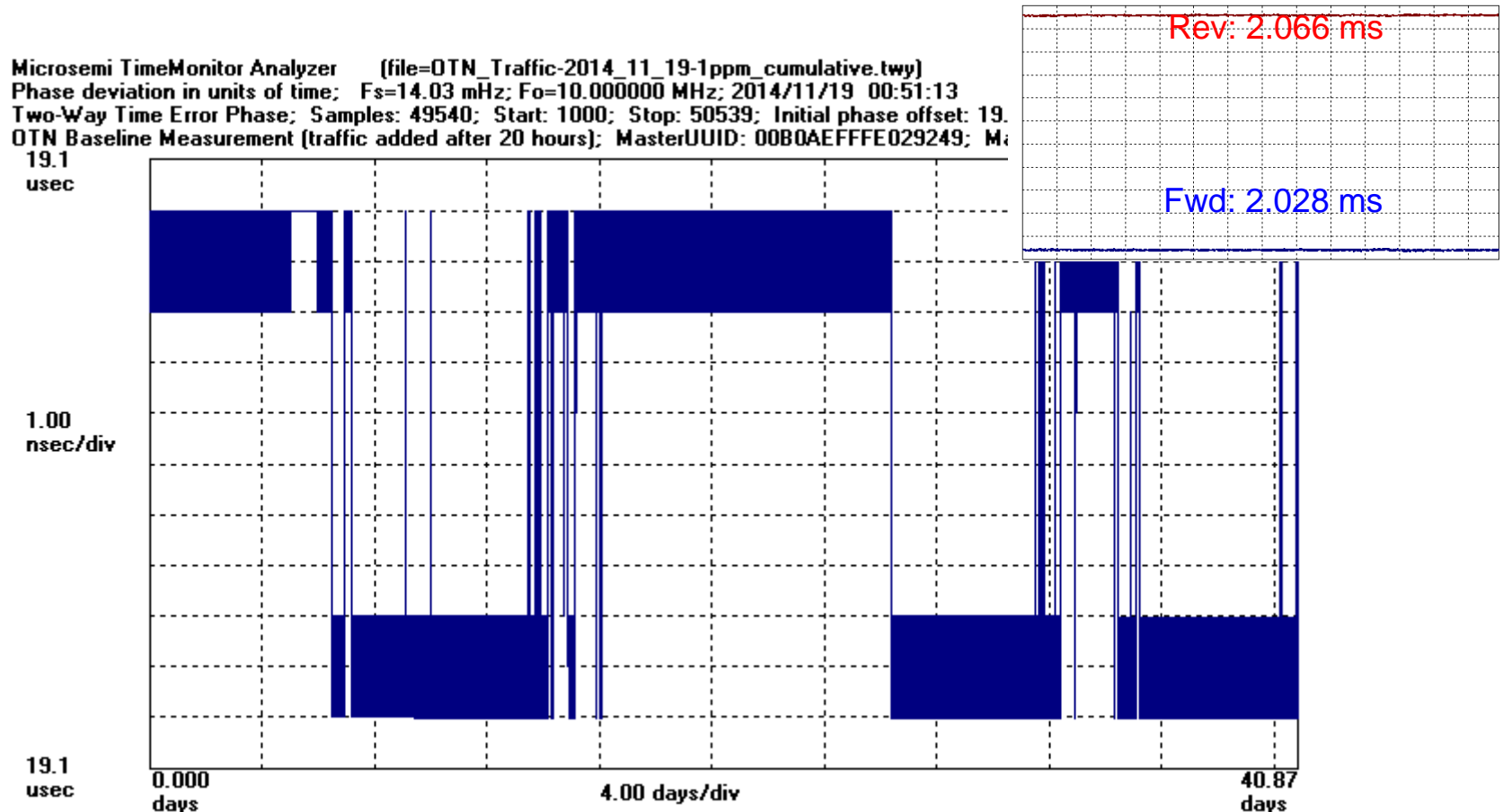
(Ethernet wireless backhaul asymmetry and IEEE 1588 slave 1PPS under these asymmetrical network conditions)



Case Studies: Network Asymmetry over Fiber

150 km fiber PTP over OTN transport

(2wayTE is 19.1 μsec which represents the 38.2 μsec difference between forward and reverse one-way latencies)



Time Transport Measurements

- Packet time transport measurements require common time scale reference at both ends of the network being studied (GNSS at both ends is a way to do this)
- Asymmetry is everywhere, asymmetry is invisible to the IEEE 1588 protocol, thus asymmetry has a direct bearing on the ability to transport time precisely
- The “offset” calculation is a direct measure of asymmetry
- There are two ways to assess time transport: (1) measuring a 1PPS reference at the node being studied and (2) measuring a packet signal at the node being studied
- Packet metrics for time transport must use both forward and reverse streams together rather than separately as is the case for frequency transport
- Packet metrics for time transport can make use of much of the methodology used for packet frequency transport metrics

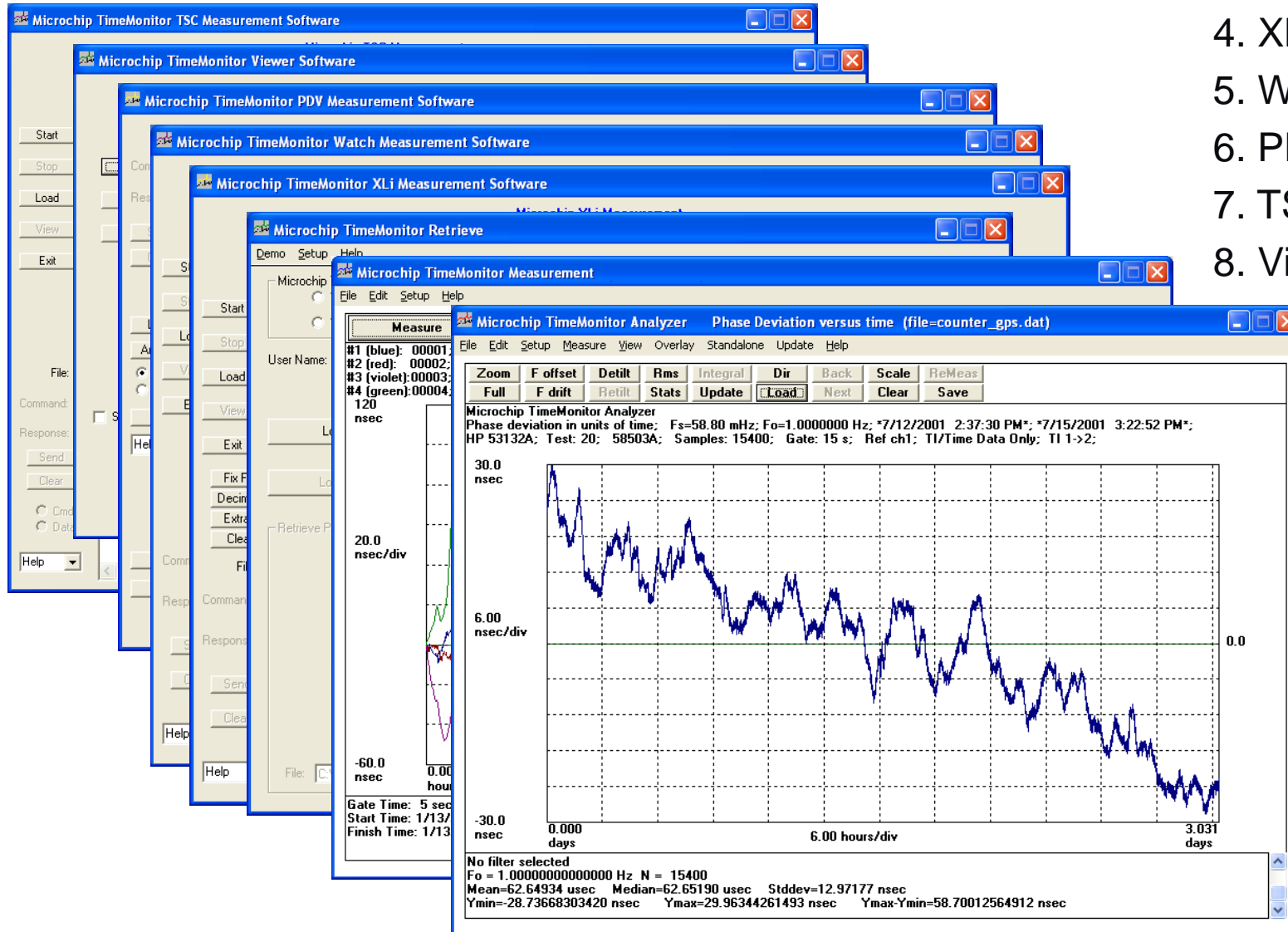
TimeMonitor



TimeMonitor

TimeMonitor: Eight Applications

1. Analyzer
2. Measurement
3. Retrieve
4. Xli
5. Watch
6. PDV
7. TSC
8. Viewer

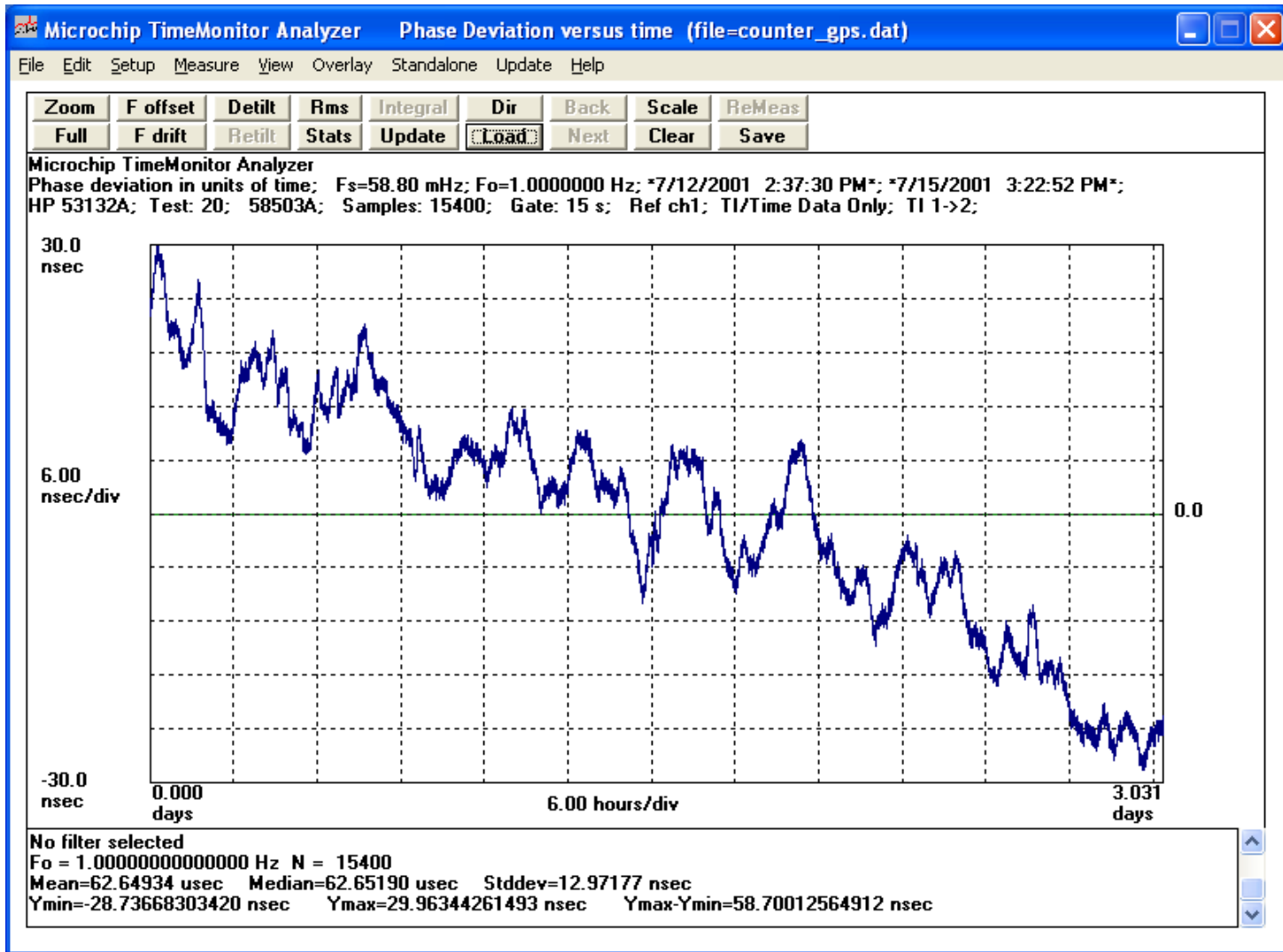


TimeMonitor 5.0

There are eight TimeMonitor software applications:

- ➔ 1. **TimeMonitor Analyzer Software** imports and analyzes data from more than 40 sources
 - a. Test equipment from Agilent, Tektronix, Acterna, Pendulum, etc
 - b. Microsemi NE (GPS, SSU, BITS) measurement data
 - c. Counter data via TimeMonitor Measurement
 - d. Analysis tool for TimePictra and TimeScan NMS Software
 - e. Packet data: TP5k, Peerstats, Rawstats, XLi IEEE 1588 PDV, Blade PTP PDV, QoSmetrics
- ➔ 2. **TimeMonitor Measurement Software** collects data and displays phase (or frequency) using inexpensive off-the-shelf counters (can collect temperature data simultaneously also) GPIB/USB/LAN
- 3. **TimeMonitor Retrieve Software** collects performance data from Microsemi NE's: TS3000, TS2700, TimeHub, 55400, DCD, RTHC, OT21, SSU-2000, TimeProvider
- 4. **TimeMonitor XLi Software** collects phase or frequency data from the XLi shelf
- 5. **TimeMonitor Watch Software** collects phase data from the SyncWatch Probe
- 6. **TimeMonitor PDV Software** collects packet timing data from the TP5000 Probe (PTP Ethernet, Multicast, Unicast; NTP)
- 7. **TimeMonitor TSC Software** collects phase noise data from the TSC 5120A (Boulder)
- ➔ 8. **TimeMonitor Viewer Software** view TP 4100 monitor measurement files (for more extensive analysis use TimeMonitor Analyzer for importing these files)

TimeMonitor Analyzer



Using TimeMonitor Analyzer

- **FILE menu:** used to load data (> 40 different data types including counter data, testset data, GPS, SSU/BITS, NTP and IEEE 1588 packet data) and for saving data, printing, and modifying data sets
- **EDIT menu:** copy graph for importing into applications such as Word, save graph to BMP file
- **SETUP menu:** VIEW and DISPLAY setups
- **VIEW menu:** perform various forms of analysis on a data set such as phase, Allan Deviation, phase power spectral density, histograms, statistics, MTIE, and TDEV
- **HELP menu:** access help file and readme file, also calculator and notepad

Using TimeMonitor Analyzer

- **ZOOM button:**
 - Used with mouse to zoom in on plots
 - FULL button returns to the full plot
 - MTIE Zoom and TDEV Zoom used w/phase zooms
- **F offset button:**
 - Used with two mouse clicks (on phase plot)
 - When SHIFT is held down uses the full data set
- **F drift button:**
 - Used with two mouse clicks (on phase plot)
 - When SHIFT is held down uses the full data set
- **DeTilt button:**
 - Used to remove frequency offset (on phase plot)

TimeMonitor Analyzer

View Setup

Setup for viewing data sets; removing offset, removing drift, filtering, time units, phase units, etc.

View Setup

Clock/Carrier Frequency

☒ User Specified ☐ Remove Offset ☐ Remove Drift ☐ Data Clock Recovery

Frequency:

NOTE: The specified frequency will be used for ALL calculations.

Most recent calculation: 1.00000000000000 Hz

☐ DS1 ☐ DS3 ☐ E1 ☒ Other

Phase Units

☒ Time ☐ UI ☐ Degrees ☐ Radians

Time Units

☒ Auto ☐ Days ☐ Hours ☐ Minutes ☐ Seconds

Frequency

☐ Averaging

Phase

☒ Remove avg ☐ Retain initial value
☐ Remove median ☐ Retain shift auto
☐ Initial to zero ☐ Midway min/max
☐ Final to zero ☐ Minimum to zero

☐ Resample ☐ Shift
☐ Grid ☐ Linear ☐ Spline

Parameters for:

Frequency

To change parameter value, double click on parameter or select Modify.

☐ Phase ☐ MTIE ☐ MATIE
☒ Frequency ☐ TDEV ☐ MAFE
☐ TI ☐ FP ☐ ADEV ☐ Holdover
☐ Spectrum ☐ MDEV ☐ Histogram

Averaging: Off
Averaging Type: Tau
Overlap: Disabled
Tau: 10 s
LSF Samples: 100
Drift Samples: 50
Drift Units: Per Day
Time Axis: Linear
Calculation: Fractional Frequency Offset

Filter

OK
Cancel

TimeMonitor Analyzer

Display Setup

Set up x/y axes, add masks, edit title, etc.

Display Setup

Title: **Label** | Title1 | Title2 | Title3 | Title4 | DateTime

Font Size: 8

Plot Size: SVGA

☐ Plot Color: Blue

Max Time in sec: 30.0000 ns

Min Time in sec: -30.0000 ns

Min Time: 0.00000 d

Max Time: 3.03131 d

Unit/Div: x: 250 md, y: 6.0 ns

Save X | Recall X | Save Y | Recall Y

☒ Bold | ☒ Top Label
☐ Dots Only | ☒ Plot Label
☐ Thick Plots | ☒ Grid Label
☐ Show Points | ☐ No Labels
☐ Whole Mask | ☒ Plot Only
☐ File Name | ☒ Show X-axis
☐ Y Lock | ☐ Show Floor

Time Units
☒ Auto | ☐ Days | ☐ Hours | ☐ Minutes | ☐ Seconds

Maximum Points: 1 000 000

Autoscale
Get Autoscale Values | ☒ Autoscale Always
Get Zoomed Values | Help

Show Masks
☐ ETSI PDH
☐ ETSI SEC
☐ ETSI SSU
☐ ETSI PRC
Change Masks

Environmental Data
☐ Temperature
☐ Humidity
☐ Dew Point
☐ Oven Current
☐ Fahrenheit Units
T Max: 100
T Min: -100
H Max: 100
H Min: 0

Phase Digits:
Phase Unit:
X/Y Unit:

OK | Cancel

TimeMonitor Analyzer

Change Masks

(Hit “Change Masks” button in Display Setup Form)

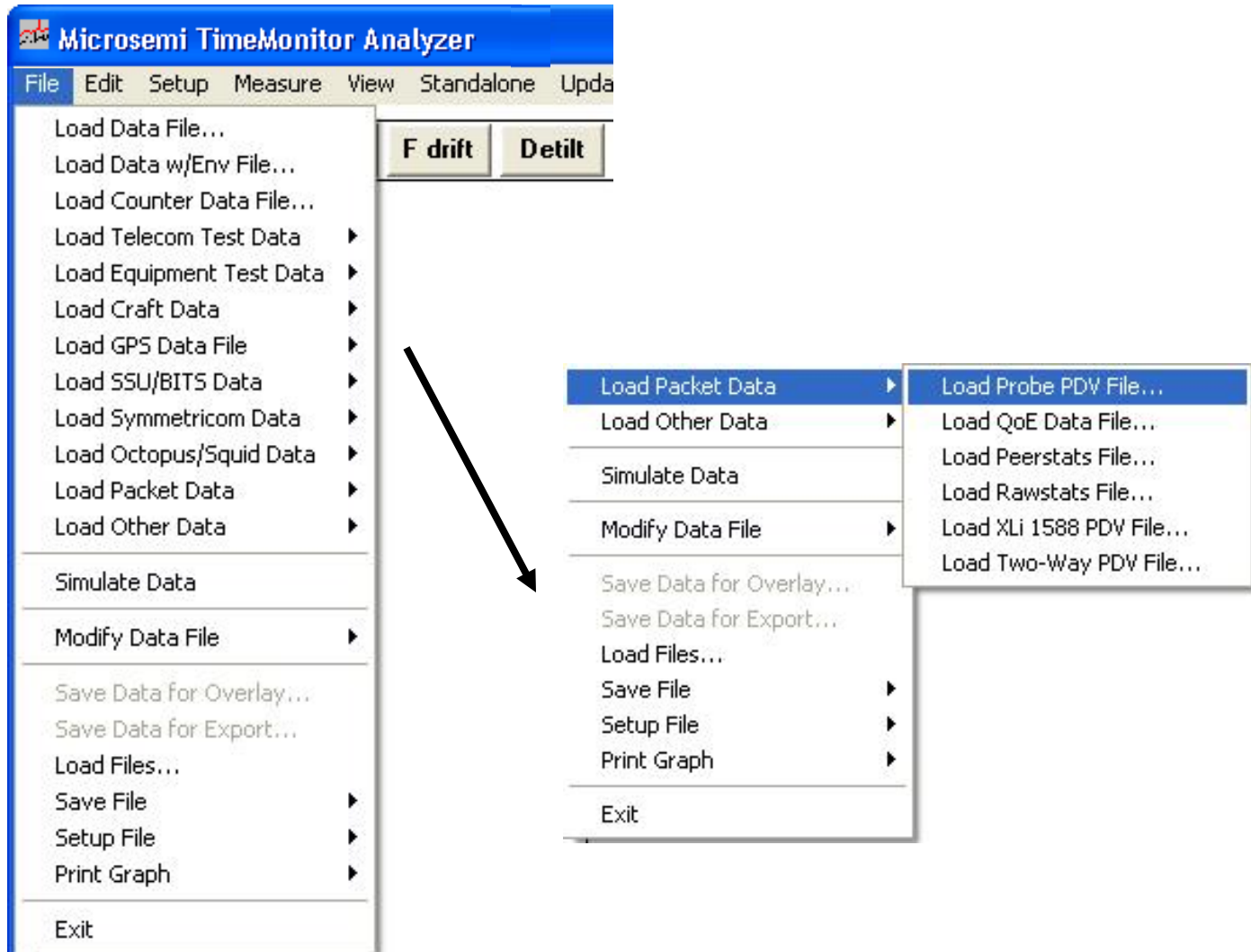
Change File Names for Masks

To change, click a "Change" button, select a file, then click the OK button.

Mask1 File Name: G811.lmt	<input type="button" value="Change"/>	<input type="button" value="View"/>
Mask2 File Name: G811-1.lmt	<input type="button" value="Change"/>	<input type="button" value="View"/>
Mask3 File Name: G8272.lmt	<input type="button" value="Change"/>	<input type="button" value="View"/>
Mask4 File Name: G8272-1.lmt	<input type="button" value="Change"/>	<input type="button" value="View"/>

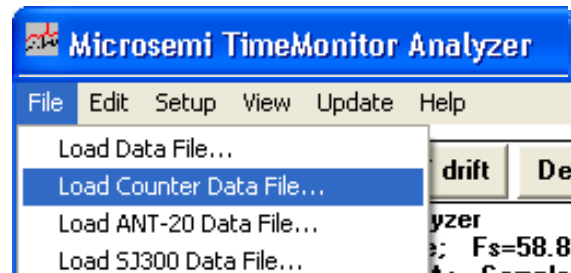
TimeMonitor Analyzer

File Menu



TimeMonitor Analyzer

Load Counter Data



Load Counter TI File

☐ Set manual reference
☐ Set no reference
☐ Force one measurement/second
☐ Force one measurement/two seconds

☐ Select Start ☐ Select Stop ☐ Decimate

Total points: 15400

Start point:

Stop point:

[Ctrl-Alt left click on plot to obtain point number]

Decimate:

Reference Calculation

- ☒ None
- ☐ Remove Offset
- ☐ Remove Drift

Phase

- ☒ Remove average phase
- ☐ Remove median phase
- ☐ Set final phase to zero
- ☐ Set initial phase to zero
- ☐ Retain initial phase value
- ☐ Retain initial shift auto
- ☐ Set minimum phase to zero
- ☐ Midway minimum/maximum

Reference

- ☒ Channel 1 Reference
- ☐ Channel 2 Reference
- ☐ Data clock recovery

Channel 1 Freq (Hz):

Channel 2 Freq (Hz):

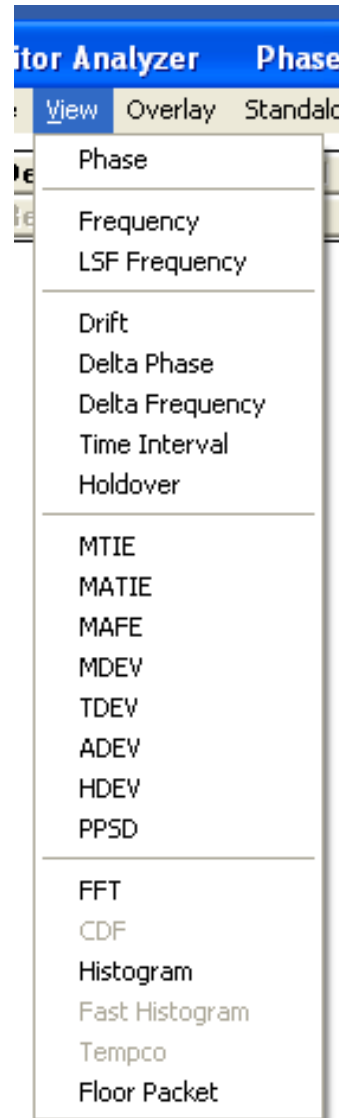
Glitch threshold:

Channel 1 cable delay:

Channel 2 cable delay:

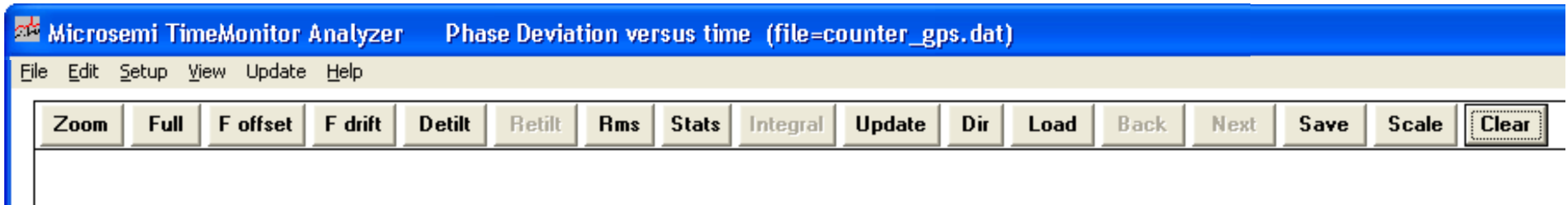
TimeMonitor Analyzer

View Menu



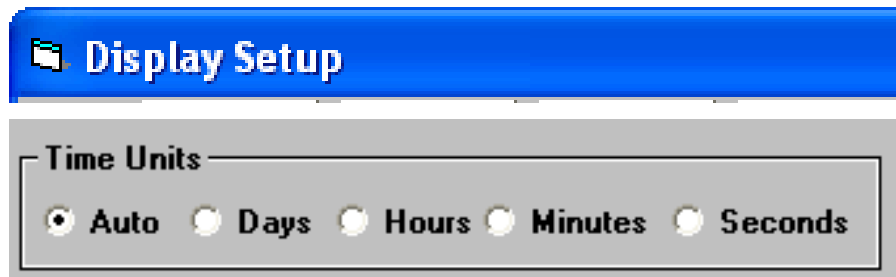
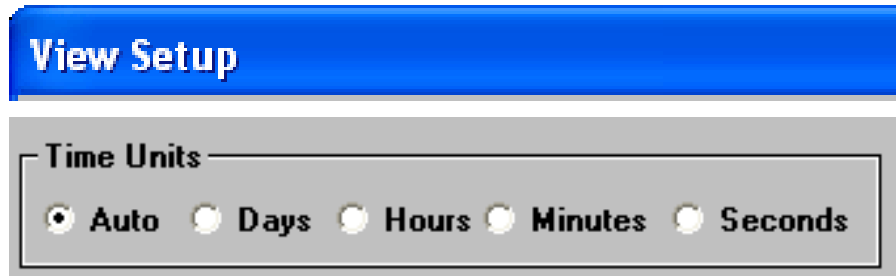
TimeMonitor Analyzer

Buttons



TimeMonitor Analyzer

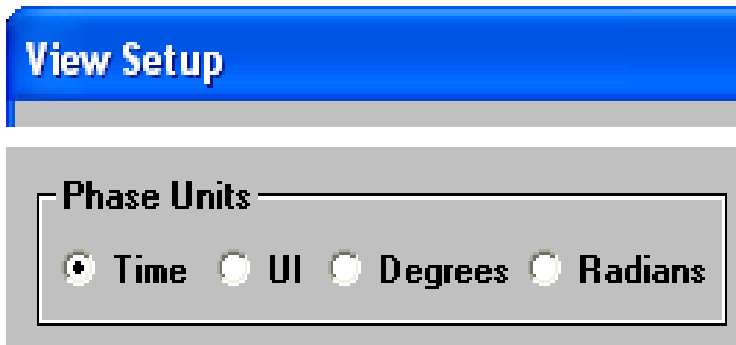
Time Units



- Seconds, Minutes, Hours, and Days available
- Accessible from either View Setup or Display Setup

TimeMonitor Analyzer

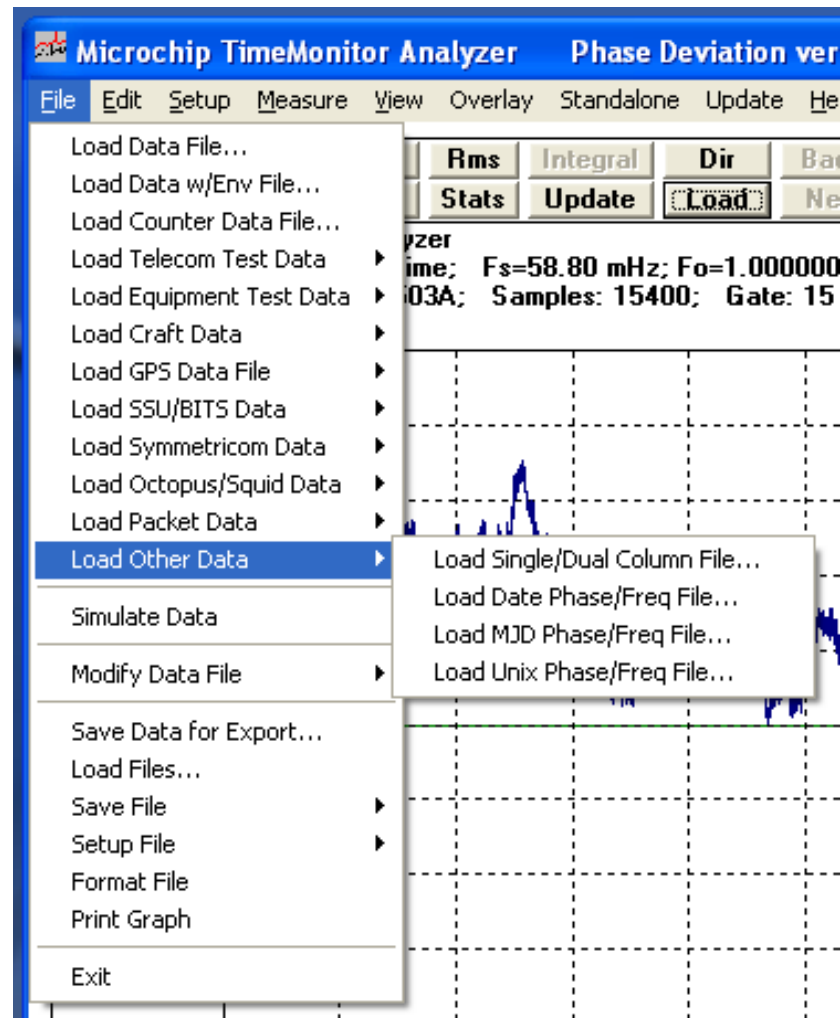
Phase Units



- Most sync phase measurements use “Unit Time” (particularly wander)
- UI (unit interval) is used for peak-to-peak jitter measurements

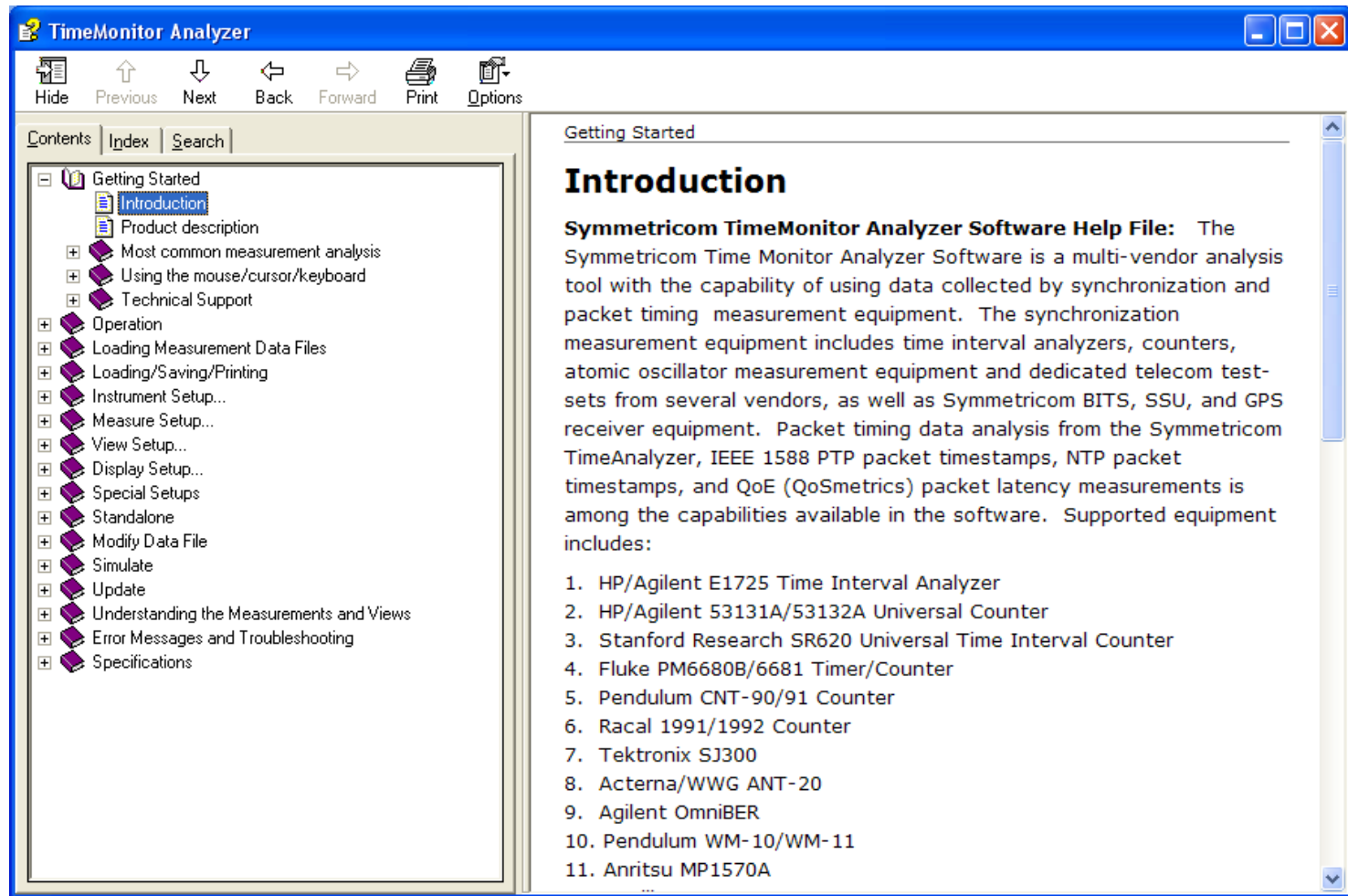
TimeMonitor Analyzer

“Load Other Data” Grouping



Using TimeMonitor Analyzer

Help File/User Guide (>500 pages!)



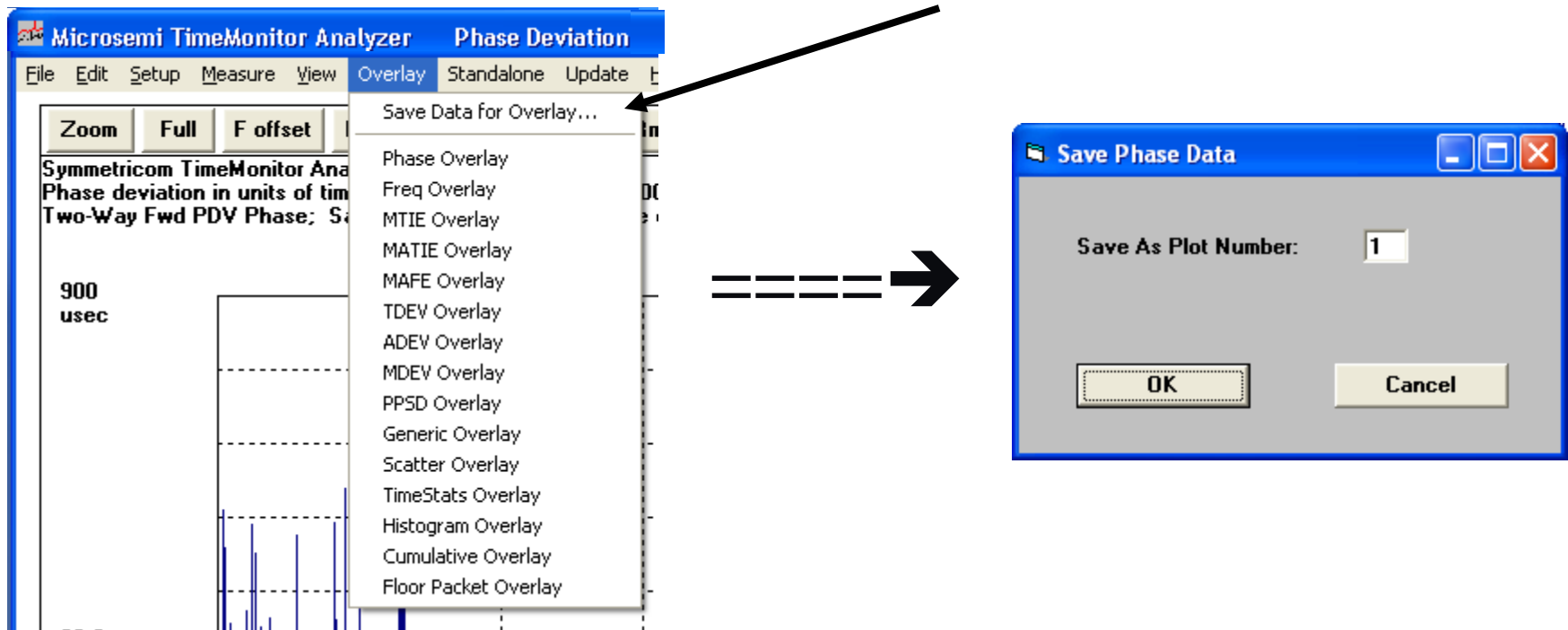
TimeMonitor Analyzer

Measurement Overlay

- **Measurements which can be overlaid:**
 - Phase Deviation
 - Fractional Frequency Offset
 - ADEV/MDEV
 - MTIE
 - TDEV
 - Scatter (eg. Tempco)
 - TimeStats
 - Histogram
 - FPP
- **Useful for comparing measurements such as:**
 - Simultaneously made measurements
 - Successive measurements made on the same signal

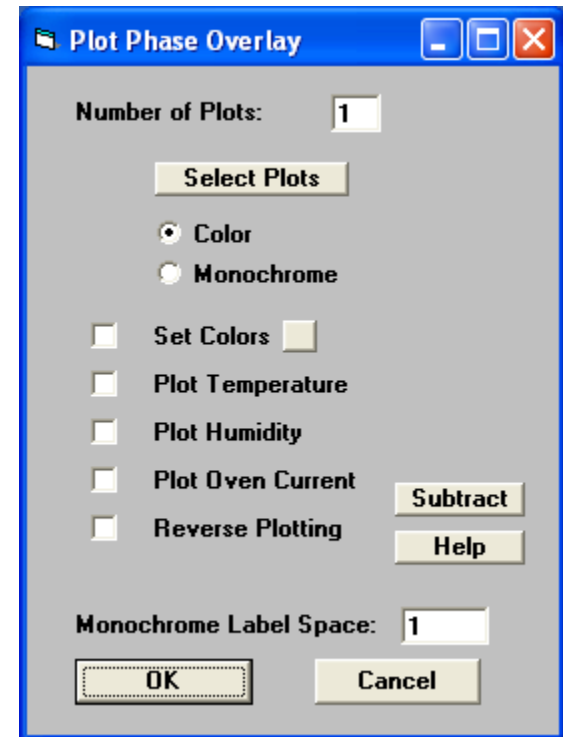
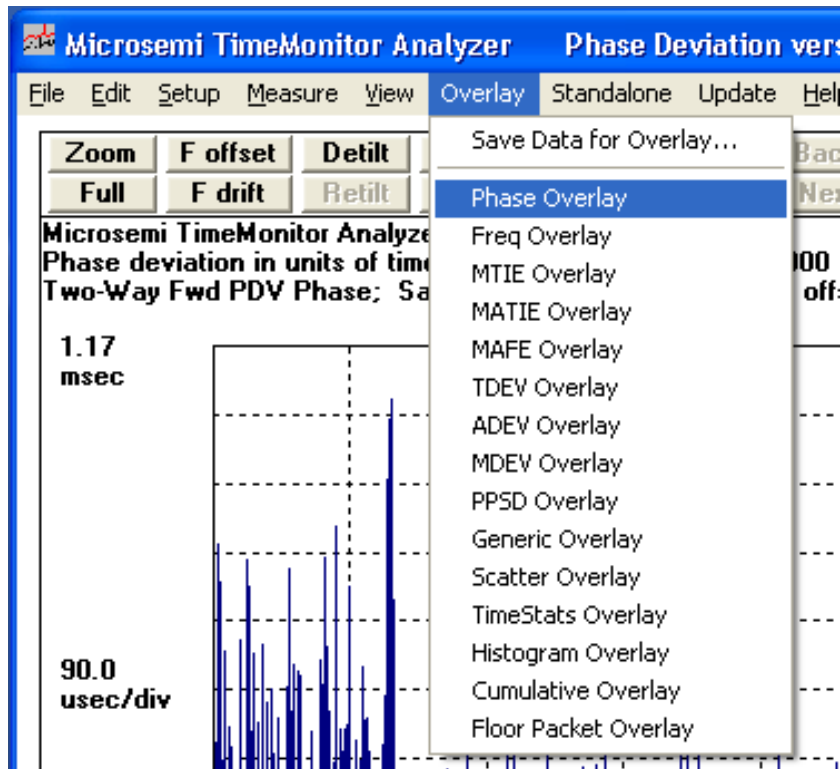
TimeMonitor Analyzer

Preparing Overlay Measurements



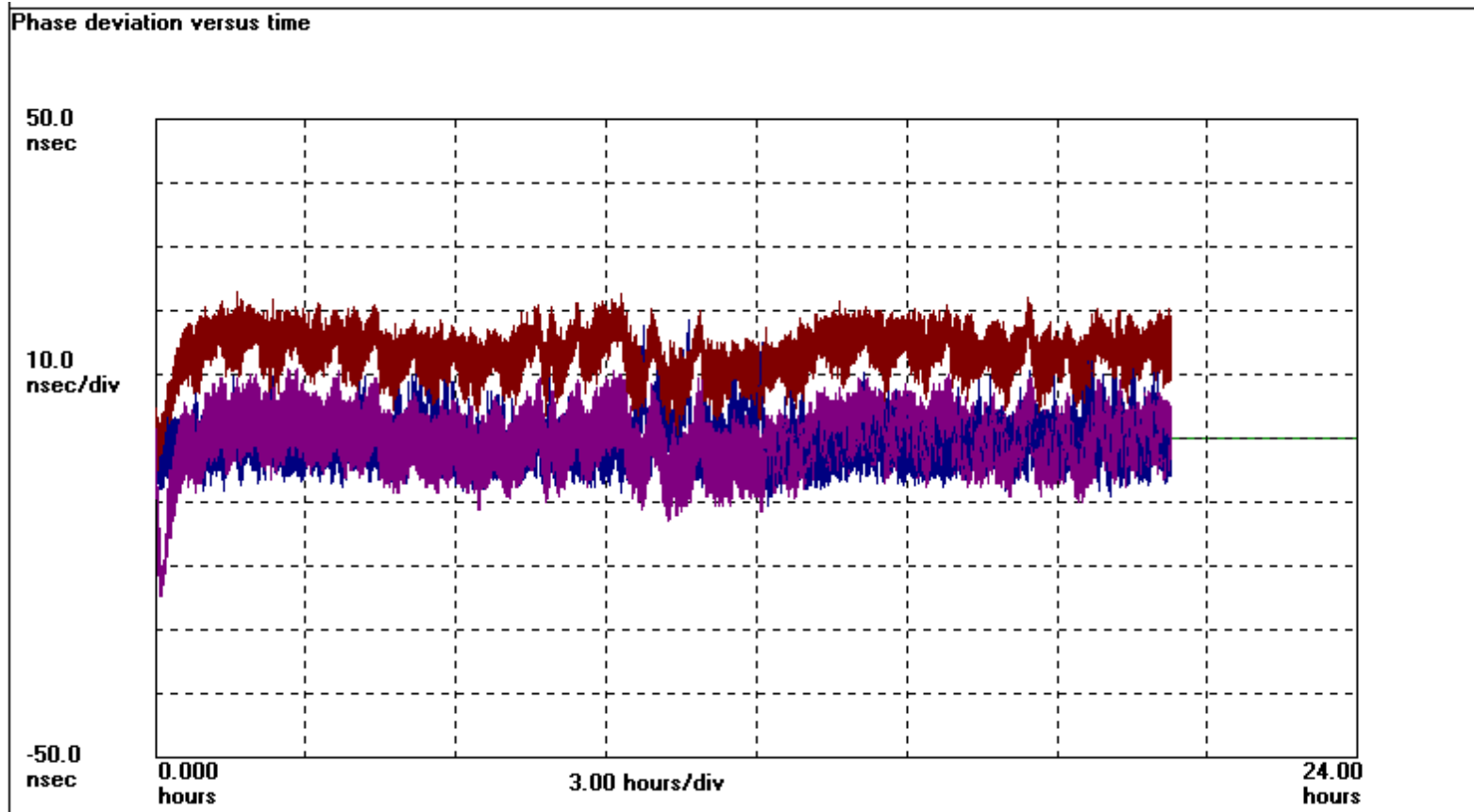
TimeMonitor Analyzer

Viewing Overlay Measurements



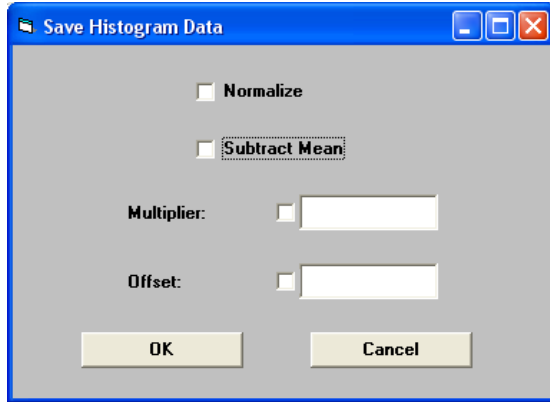
TimeMonitor Analyzer

Example Overlay Measurements

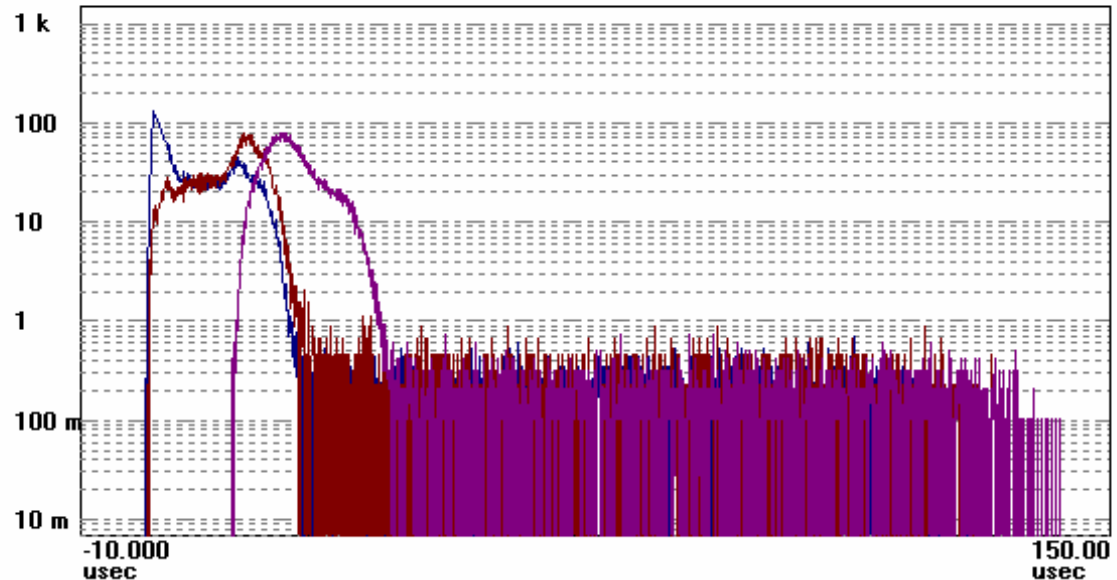


TimeMonitor Analyzer

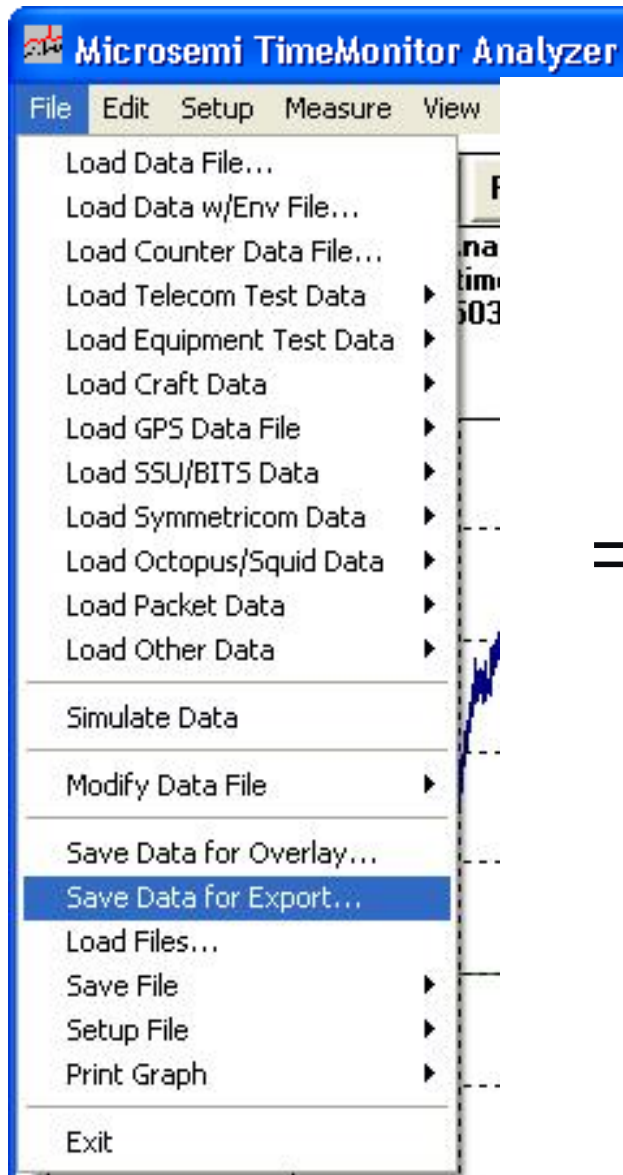
Example Histogram Overlay



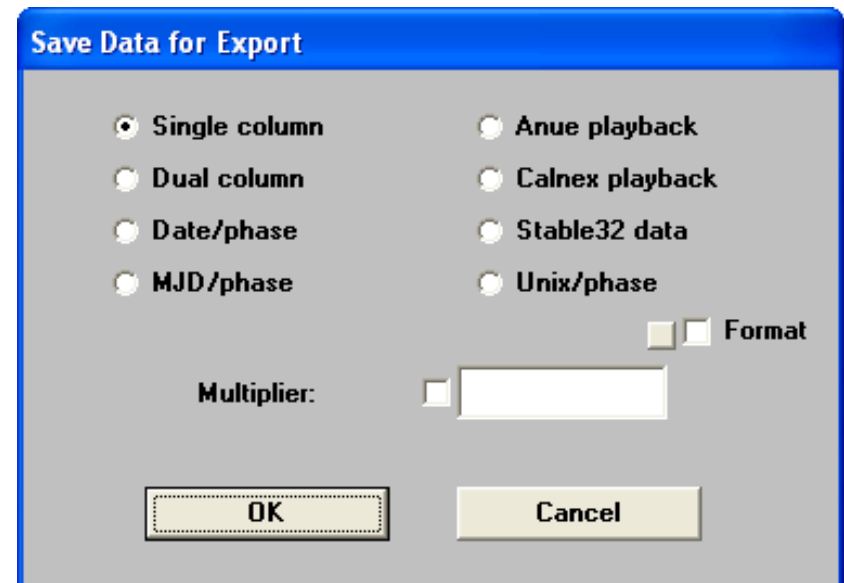
Symmetricon TimeMonitor Analyzer (file=network_with_latency_changes03.txt)
Phase Deviation Histogram; Fs=63.99 Hz; Fo=10.00 MHz; 2009/11/06; 10:55:06



TimeMonitor Analyzer



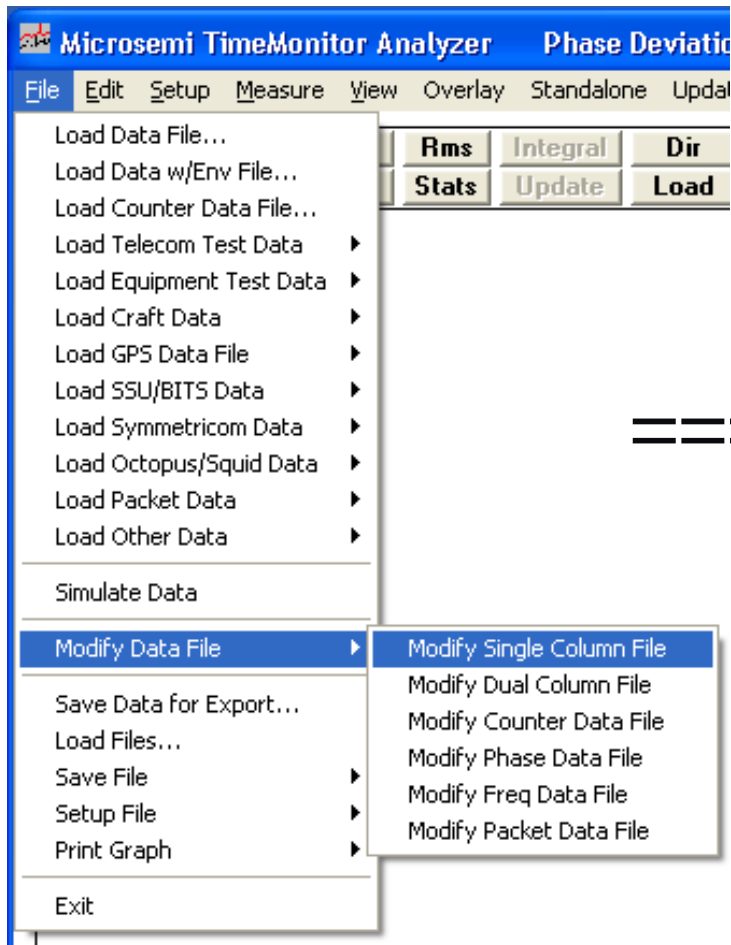
Save Data for Export



TimeMonitor Analyzer

Modify Single Column File

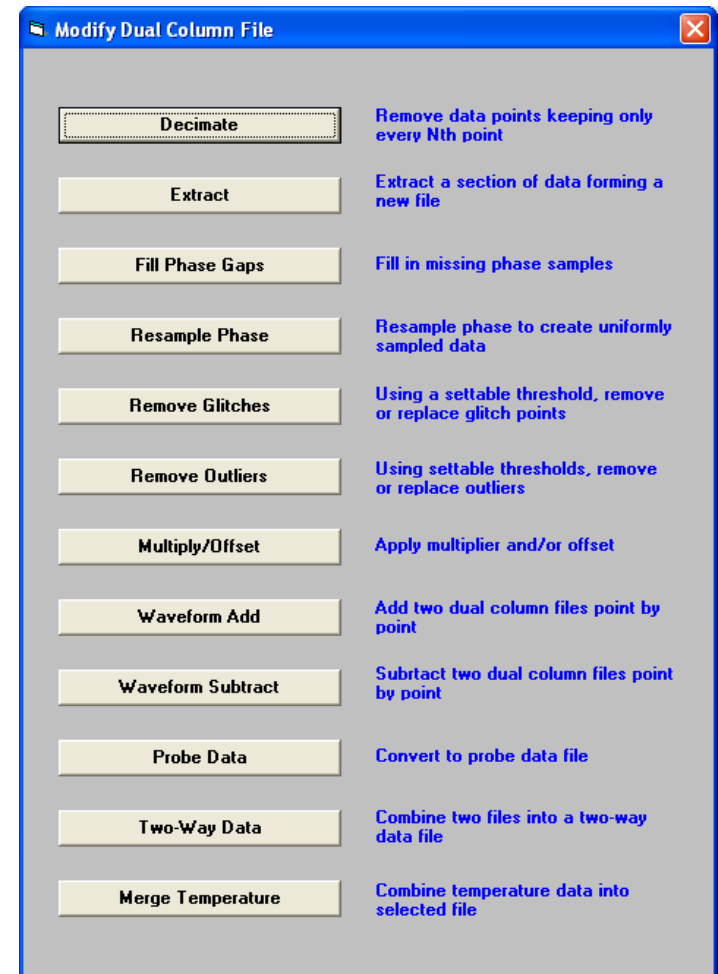
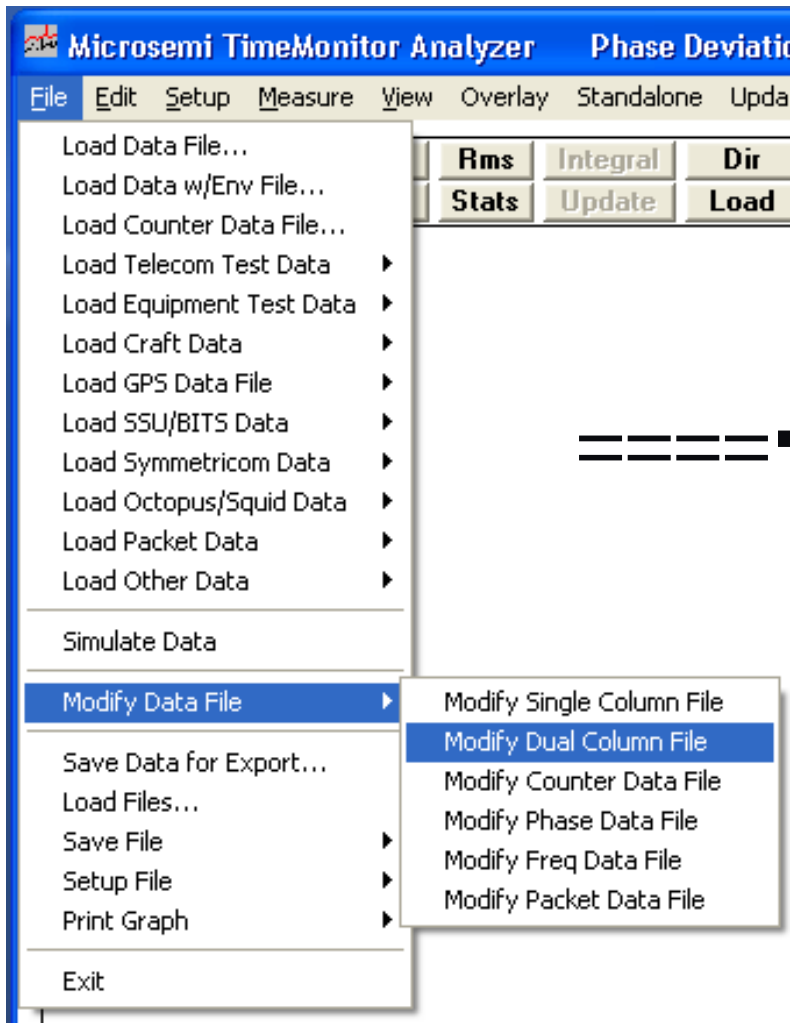
(Ctrl-Alt mouse click useful for finding points for “extract”)



TimeMonitor Analyzer

Modify Dual Column File

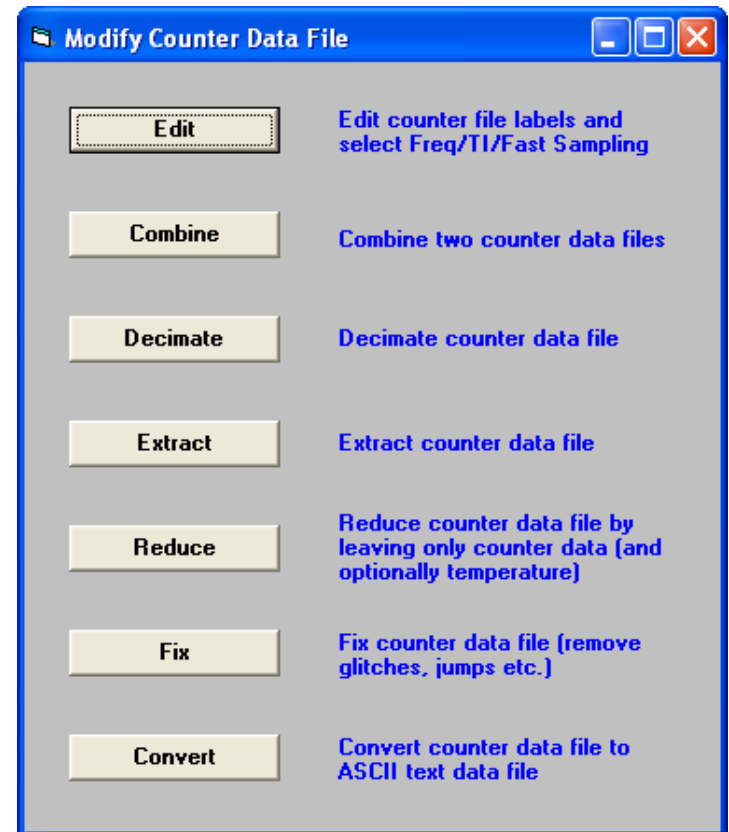
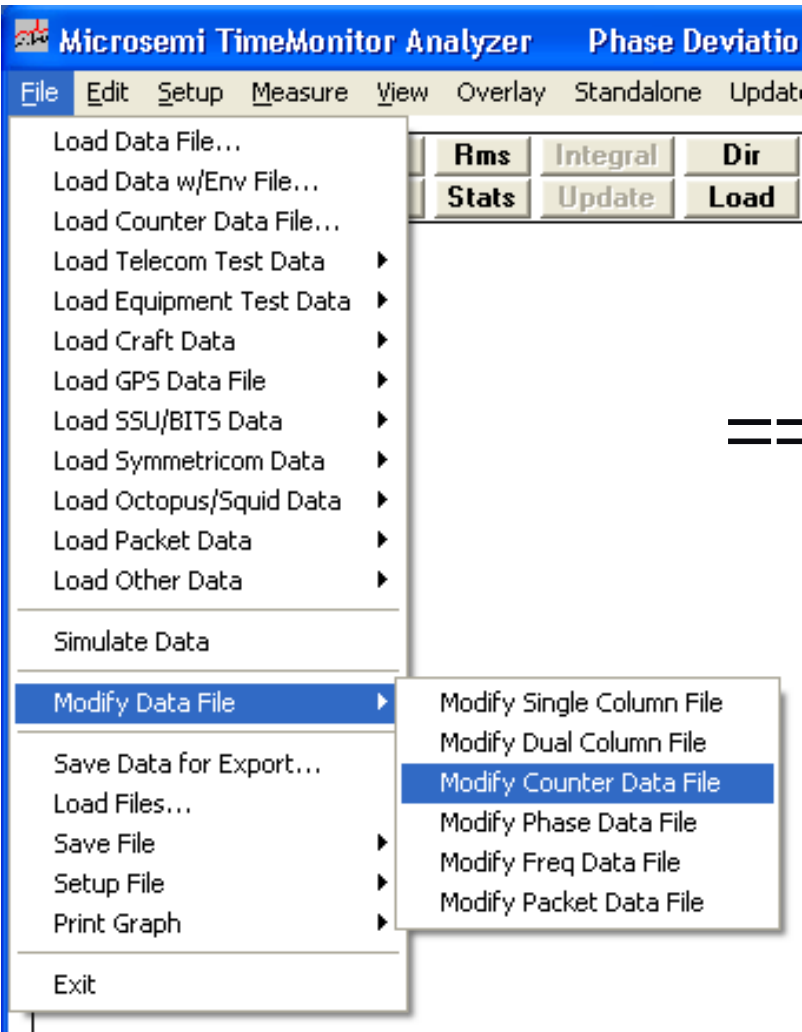
(Ctrl-Alt mouse click useful for finding points for “extract”)



TimeMonitor Analyzer

Modify Counter Data File

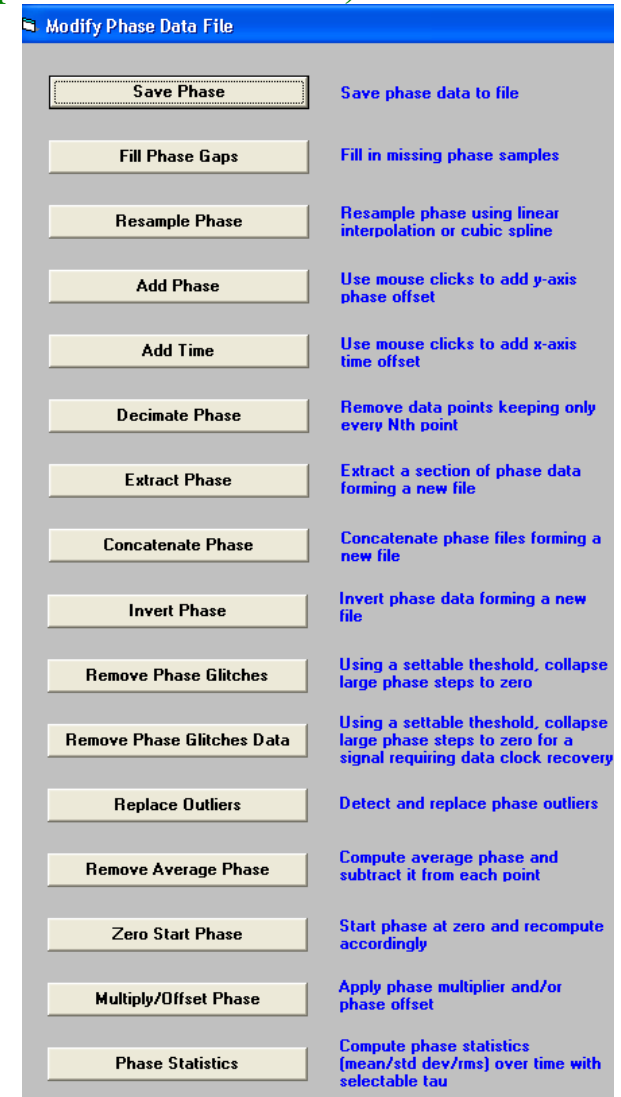
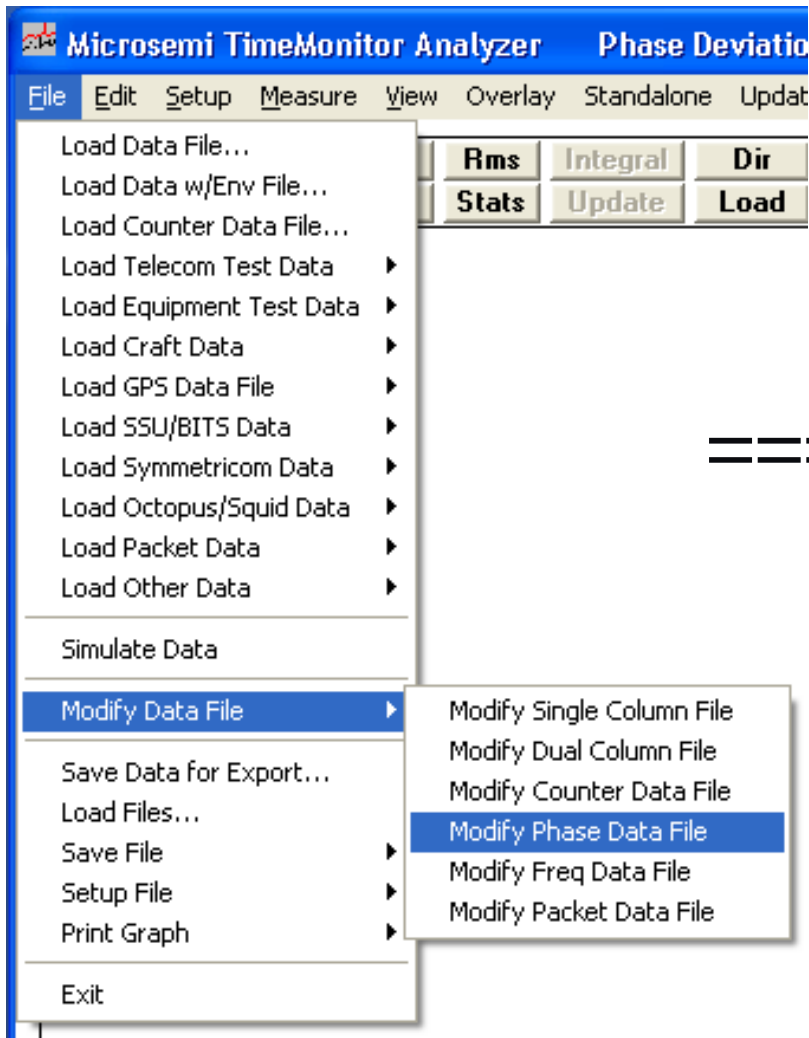
(Ctrl-Alt mouse click useful for finding points for “extract”)



TimeMonitor Analyzer

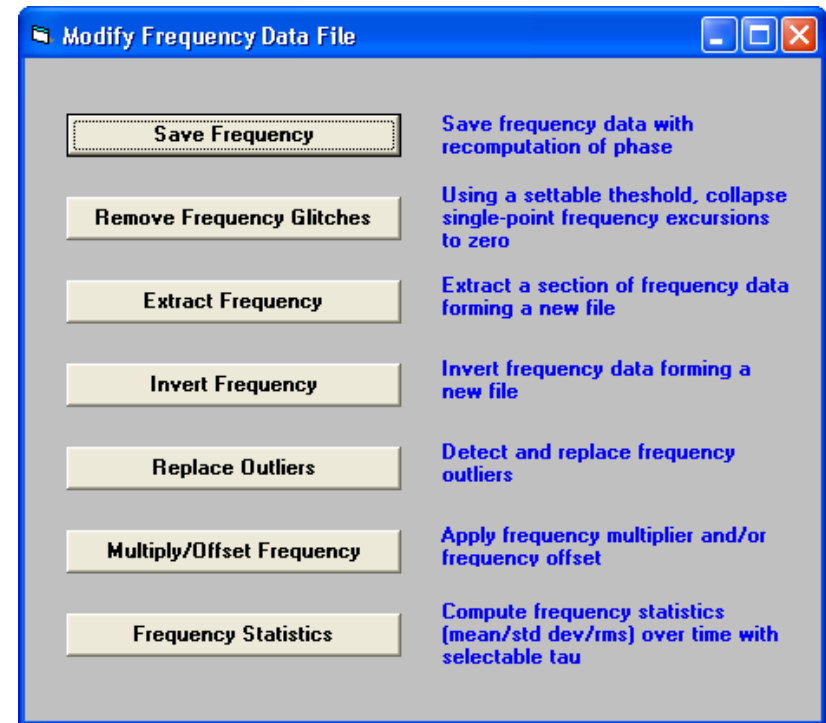
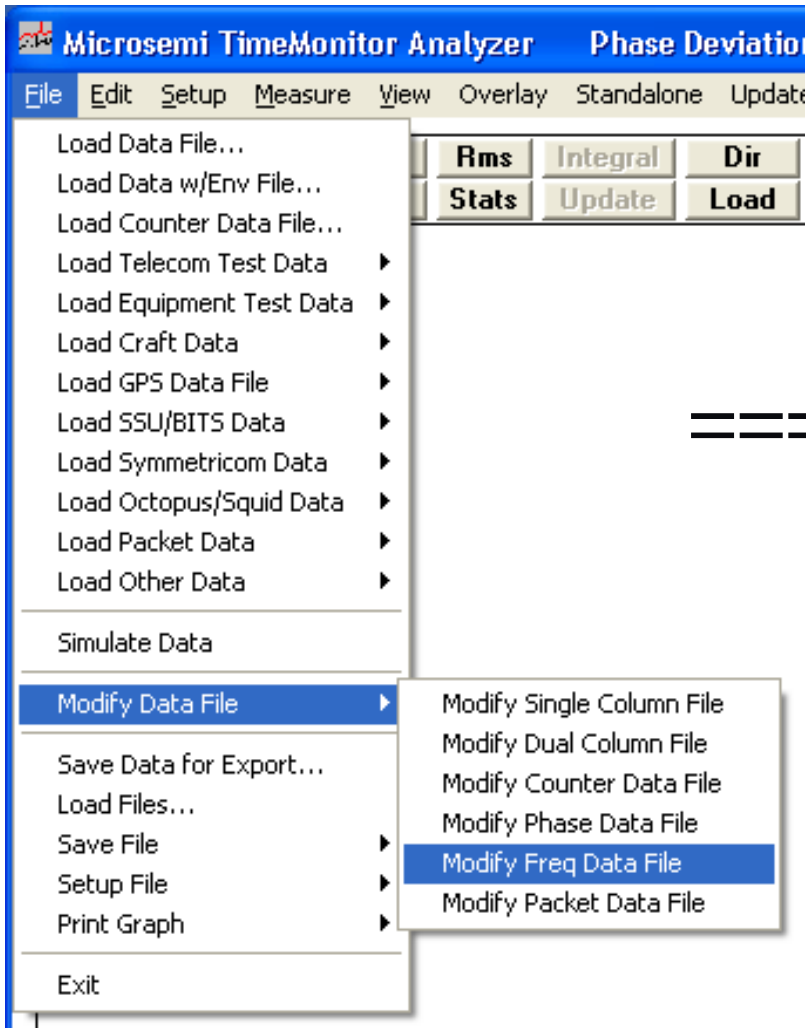
Modify Phase Data File

(Ctrl-Alt mouse click useful for finding points for “extract”)



TimeMonitor Analyzer

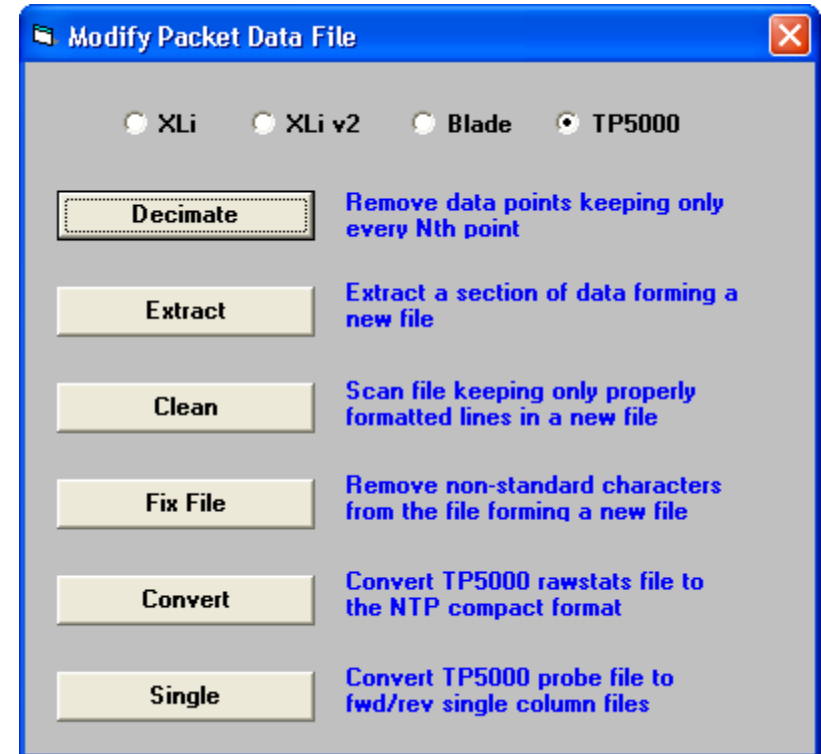
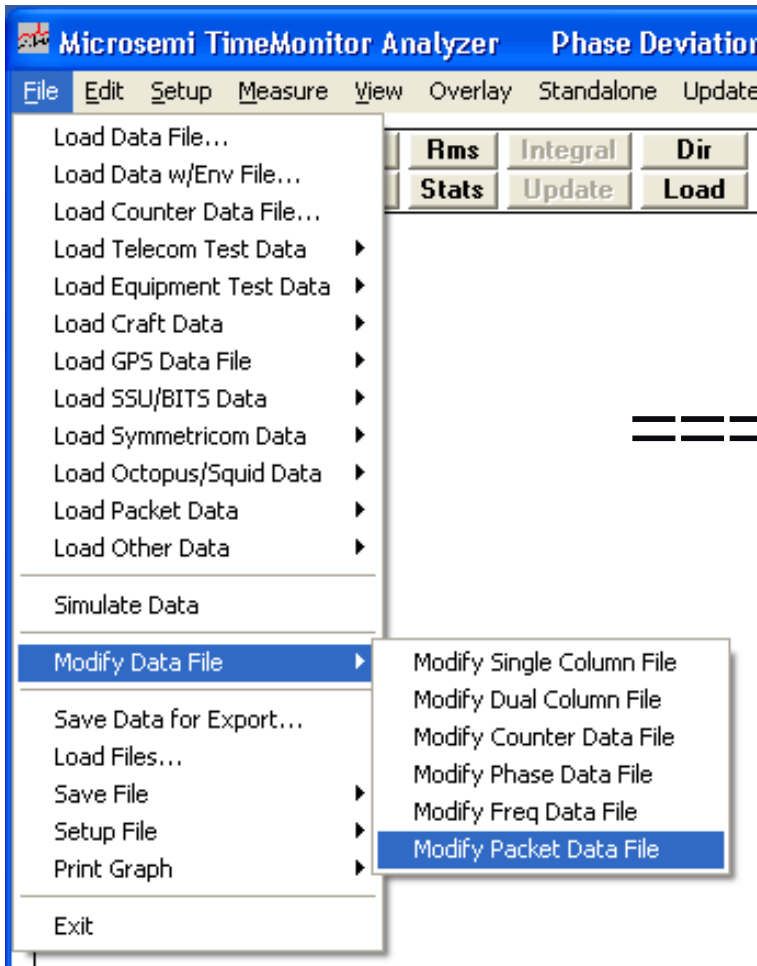
Modify Frequency Data File
(Ctrl-Alt mouse click useful for finding points for “extract”)



TimeMonitor Analyzer

Modify Packet Data File

(Ctrl-Alt mouse click useful for finding points for “extract”)



TimeMonitor Analyzer

Phase Statistics

Parameters for: Phase

To change parameter value, double click on parameter or select Modify.

Modify>>

☒ Phase ☐ MTIE ☐ MATIE
☐ Frequency ☐ TDEV ☐ MAFE
☐ TI ☐ FP ☐ ADEV ☐ Holdover
☐ Spectrum ☐ MDEV ☐ Histogram

Phase Stats: On
Statistic: Mean
Windowing: Tau
Overlap: Disabled
Analysis: Use Phase
Tau: 10.000 s
Time Axis: Linear

Phase Statistic

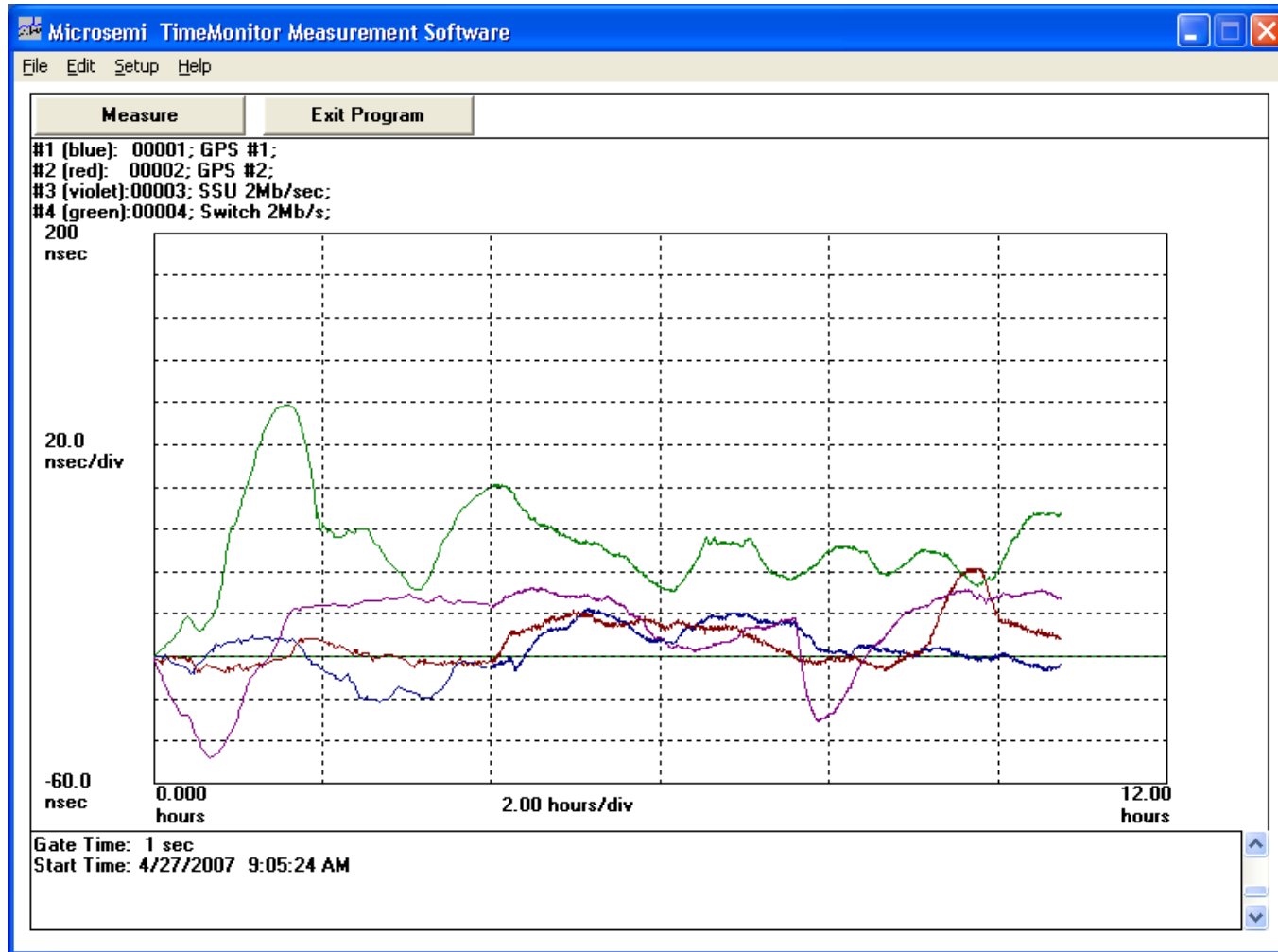
Select Phase Statistic:

- Mean
- Stddev
- Min
- Max
- Median
- Floor Max
- Floor Avg
- Cluster Avg
- Percentile
- Percentile Avg

OK

Cancel

TimeMonitor Measurement



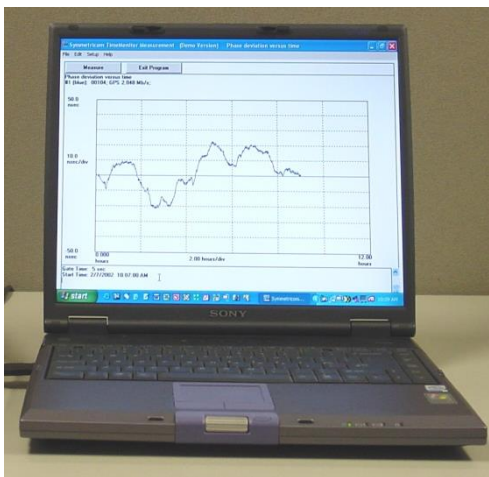
TimeMonitor Measurement

Sync Measurement Equipment List

1. Cesium clock or GPS receiver
2. Counter
3. Laptop computer with GPIB card/cable (or USB or LAN)
4. Microsemi TimeMonitor Analyzer Software
5. Microsemi TimeMonitor Measurement Software
6. Oscilloscope
7. DVM and Temperature Probe

TimeMonitor Measurement

Sync Measurement Equipment



PC



Counter



GPIB



PRC



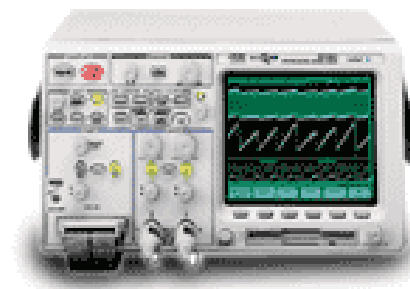
DVM



Temperature
Probe



Synthesizer



Oscilloscope

TimeMonitor Measurement

Supported Counters



Agilent 53220/30A



HP 53131/32A



Pendulum CNT 90/91



SR 620



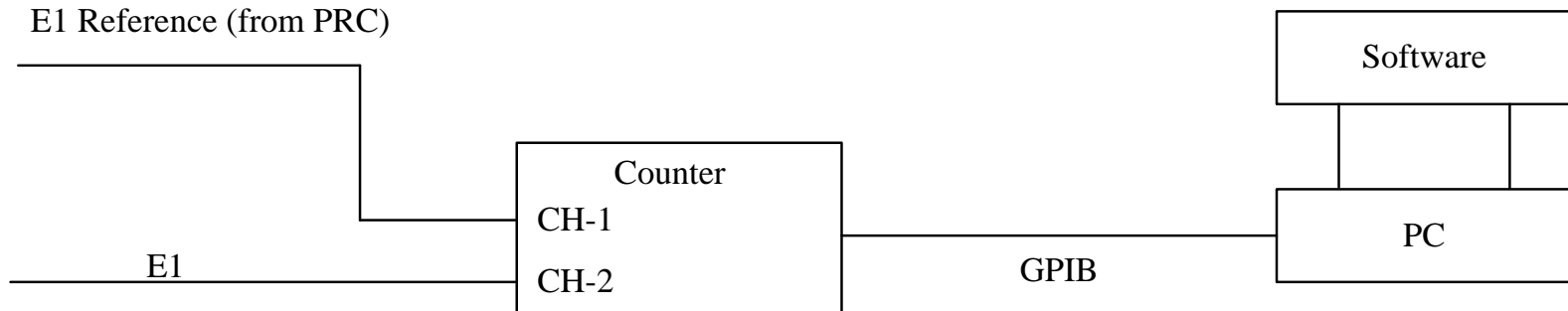
Fluke PM6681



Racal 1991/2

TimeMonitor Measurement

Counter Measurement Block Diagram

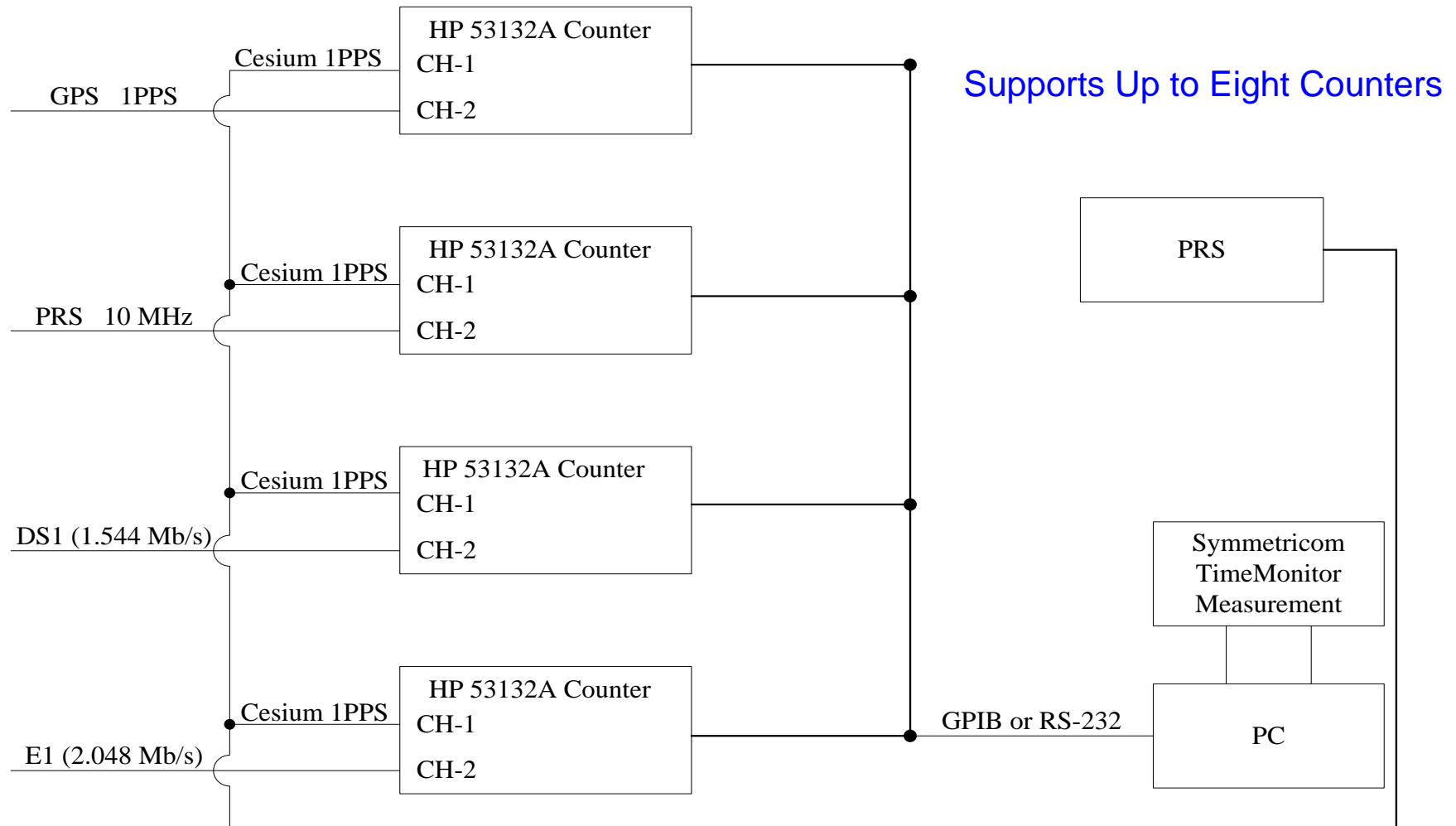


- ▶ Signals could be at other rates, for example
 - T1/DS1 (1.544 M) • 1 PPS
 - E1 (2.048 M) • 10 MHz
 - DS2 (6.312 M) • STS-1/OC-1 electrical (51.84 M)
 - DS3 (44.76 M) • 140 Mb/s Tributary (139.264 M)
 - 64 kbit • STS-3/STM-1/OC-3 electrical (155.52 M)
- ▶ Clock or data signal (software does data clock recovery)
- ▶ When working with a balanced signal, a balun and termination pad are likely required



TimeMonitor Measurement

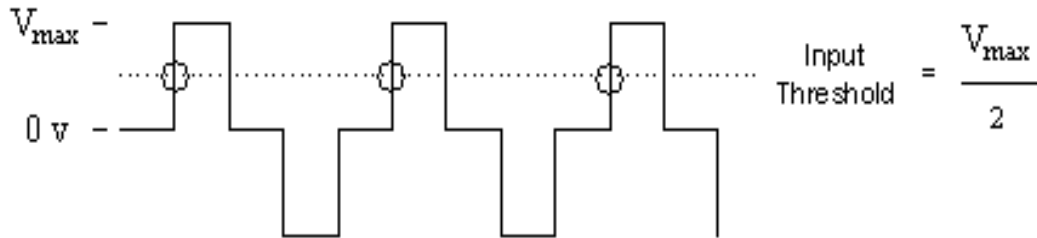
Multiple Counter Setup



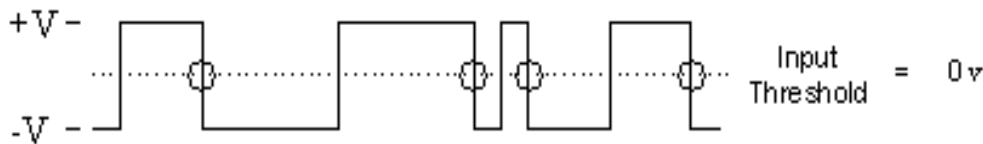
TimeMonitor Measurement

Counter Measurement Setup

- Setting thresholds – consider the signal
- Is it a bipolar signal?



← 0 volts is not OK

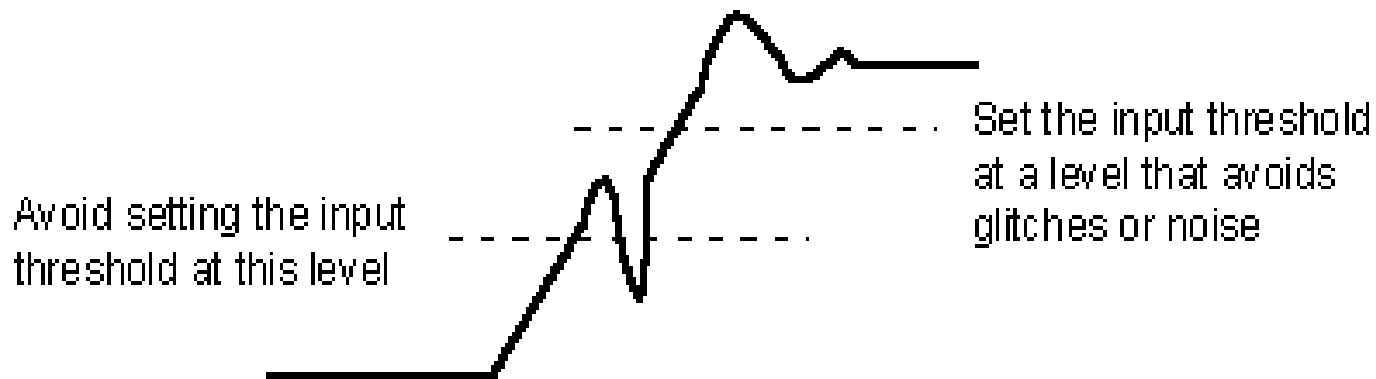


← 0 volts is OK

TimeMonitor Measurement

Counter Measurement Setup

- An oscilloscope is a useful tool for working with noisy signals



Using TimeMonitor Measurement

- **SETUP menu**

- Instrument Setup: select HP/SR/Fluke/Racal/Pendulum instrument, select and setup GPIB/RS232/TCPIP interface, and other system parameters
- Measurement Setup: setup for individual measurements (up to 8 counters can be used) including labels, counter setup, and signal parameter setting

- **HELP menu**

- Access to help file and readme file

Using TimeMonitor Measurement

- **MEASURE button:**
 - Start measurement
- **STOP button:**
 - Stop (pause) measurement
- **COPY button:**
 - Create snapshot copy (copies) of measurement files
- **RESET PLOT button:**
 - Restart plotting with next measurement point
 - Has no effect on data stored in files (no loss of previous data)
- **PLOT button:**
 - Start plotting during live measurement
- **NO PLOT button:**
 - Stop plotting during live measurement
- **EXIT PROGRAM button:**
 - Exit program

TimeMonitor Measurement

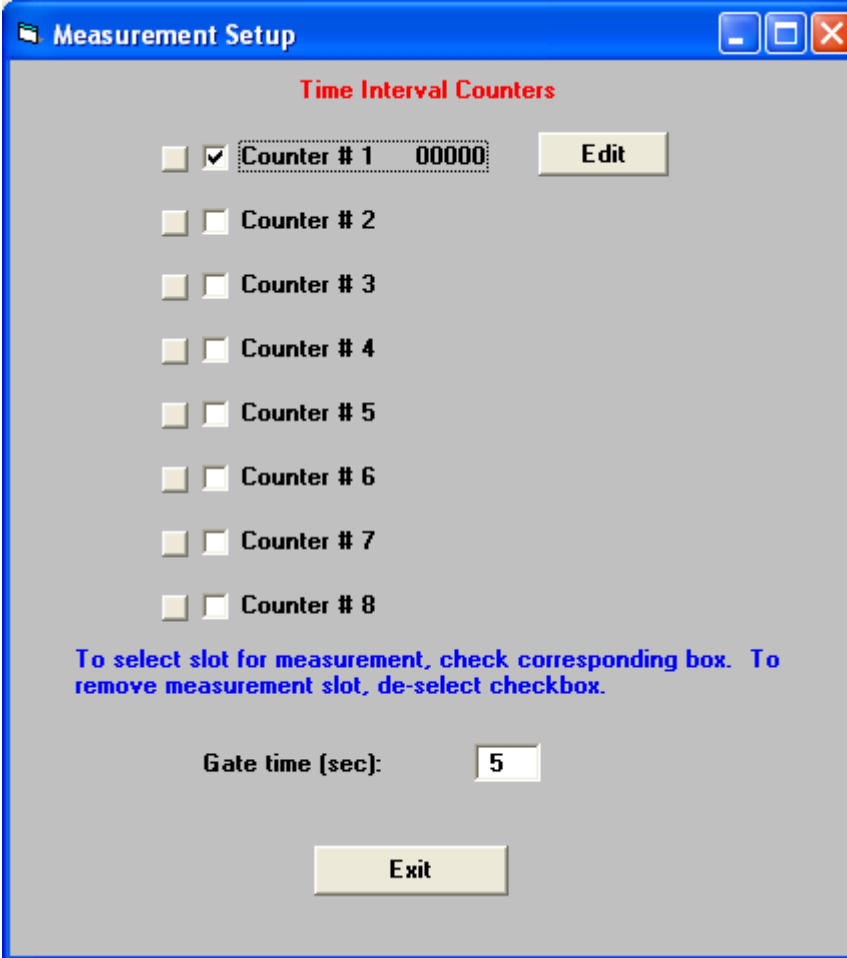
Instrument Setup

The screenshot shows the 'Instrument Setup' dialog box with the following settings:

- Instrument:** HP 53132A (selected), Fluke PM6681, SR620, Agilent 53220A, Pendulum CNT-90, Racal 1991.
- Measure:** Counter (selected), Counter/Temperature, Counter/Temperature HP DVM.
- Interface:** NI GPIB (selected), Agilent GPIB, USB, LAN, TCP/IP, RS232, RS232 multiple. A 'Setup' button is present.
- Fast Sampling:** Single Shot (selected).
 - Fast Sampling Setup:** Fast Sample Divider: 1, Single Shot Points: 100.
- Plot Live Data:** (unchecked)
- Do Not Disable:** (unchecked)
- Do Not Store Time:** (unchecked)
- Retain Original Start Time:** (unchecked)
- Auto Save Data:** (unchecked)
- Manual Counter Setup:** (unchecked)
- Plot Size:** SVGA (selected from dropdown)
- Maximum Points:** 1 000 000
- Auto Save Interval:** 1 minute (selected), 1 hour, 1 day, 10 minutes, 4 hours, 2 days, 30 minutes, 12 hours, 7 days.
- Gate time (sec):** 5
- File Format:** Standard
- Reset Test Number:** (button)
- OK** and **Cancel** buttons.

TimeMonitor Measurement

Measurement Setup



The screenshot shows a Windows-style dialog box titled "Measurement Setup". It features a blue title bar with standard minimize, maximize, and close buttons. The main content area has a light gray background. At the top, the text "Time Interval Counters" is displayed in red. Below this, there are eight rows, each representing a counter. Each row starts with a small square icon, followed by a checkbox. The first row, "Counter # 1", has its checkbox checked and shows a value of "00000" in a dotted text box. To the right of the first row is an "Edit" button. The other seven rows, "Counter # 2" through "Counter # 8", have their checkboxes unchecked. Below the list of counters, there is a blue instruction text: "To select slot for measurement, check corresponding box. To remove measurement slot, de-select checkbox." At the bottom of the dialog, there is a label "Gate time (sec):" followed by a text box containing the number "5". An "Exit" button is located at the very bottom center of the dialog.

Time Interval Counters

Counter #	Value	Action
Counter # 1	00000	<input checked="" type="checkbox"/> Edit
Counter # 2		<input type="checkbox"/>
Counter # 3		<input type="checkbox"/>
Counter # 4		<input type="checkbox"/>
Counter # 5		<input type="checkbox"/>
Counter # 6		<input type="checkbox"/>
Counter # 7		<input type="checkbox"/>
Counter # 8		<input type="checkbox"/>

To select slot for measurement, check corresponding box. To remove measurement slot, de-select checkbox.

Gate time (sec):

Exit

TimeMonitor Measurement

Individual Measurement Setup

(Select Counter Checkbox or if checkbox already selected, press “Edit” button)

The screenshot shows a Windows-style dialog box titled "Individual Measurement Setup". The dialog has a blue title bar with standard minimize, maximize, and close buttons. The main area is light gray and contains the following elements:

- Counter # 1**: A label for the first counter.
- Test #:** A text field containing "00000".
- Label 1:**, **Label 2:**, and **Label 3:**: Three empty text input fields.
- Log:** A larger empty text input field.
- Reference** section (enclosed in a box):
 - ☒ Channel 1 Reference
 - ☐ Channel 2 Reference
 - ☐ Data clock recovery
 - Ch 1 Freq:** A text field with "10.0000 MHz".
 - Ch 2 Freq:** A text field with "10.0000 MHz".
 - Three buttons: **DS1**, **E1**, and **10 MHz**.
 - A **Help** button is located to the right of the radio buttons.
- ☐ Retain TI Shift Auto
- At the bottom, three buttons: **Load Prior Labels**, **Setup Counter**, and **Exit** (which has a dashed border).

TimeMonitor Measurement

Counter Setup

(Press “Setup Counter” button in Individual Measurement Setup screen)

The screenshot shows a software window titled "HP 53132A Counter #1". It contains two main sections for "Channel 1" and "Channel 2". Each channel has a "Trigger Level" set to "0.00 V". Below this, there are three sub-sections: "Slope", "Impedance", and "Coupling". For Channel 1, the "Slope" is set to "Pos", "Impedance" is "50 Ohm", and "Coupling" is "DC". For Channel 2, the "Slope" is "Pos", "Impedance" is "50 Ohm", and "Coupling" is "DC". At the bottom left, there is a "Reference" section with "Internal" and "External" options, where "Internal" is selected. A yellow "Exit" button is located at the bottom right.

Channel	Trigger Level	Slope	Impedance	Coupling
Channel 1	0.00 V	Pos	50 Ohm	DC
Channel 2	0.00 V	Pos	50 Ohm	DC

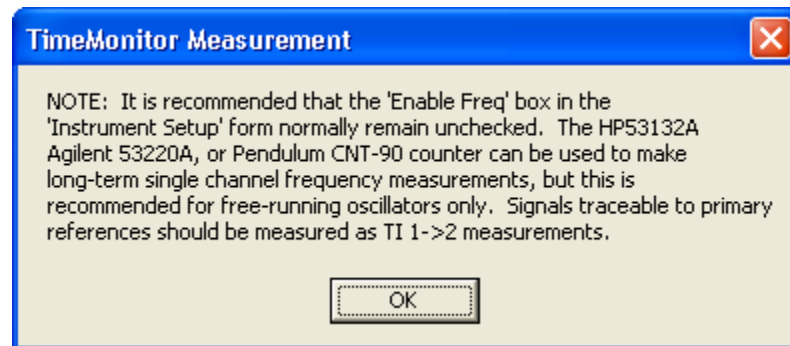
Reference: ☒ Internal ☐ External

Exit

TimeMonitor Measurement

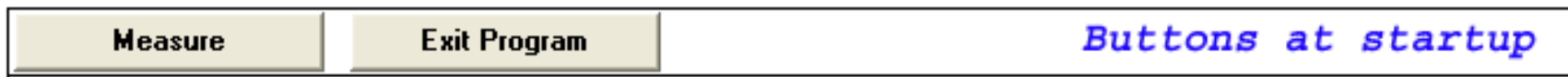
TI 1>2 vs. Frequency Measurements

- In most cases TI 1>2 measurements are used
- TI 1>2 is related to phase (TIE) but is not exactly the same
 - To compute TIE from TI 1>2, “rollovers” must be accounted for
 - Rollovers occur when the TI 1>2 passes through 0 (negative direction)
 - Rollovers occur when the TI 1>2 passes through one period (positive direction)
- **Frequency measurements**
 - Used for free-running oscillators only
 - HP 53132A, Agilent 53220/230A, or Pendulum CNT 90/91 required
 - Long gate times are required (5 seconds or more recommended)



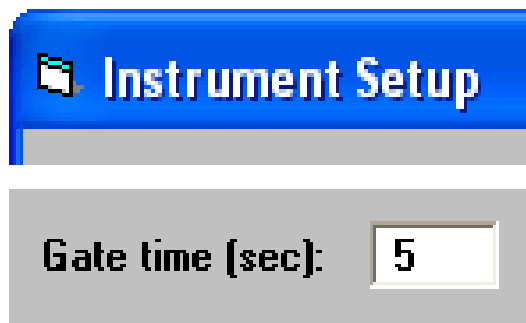
TimeMonitor Measurement

Buttons



TimeMonitor Measurement

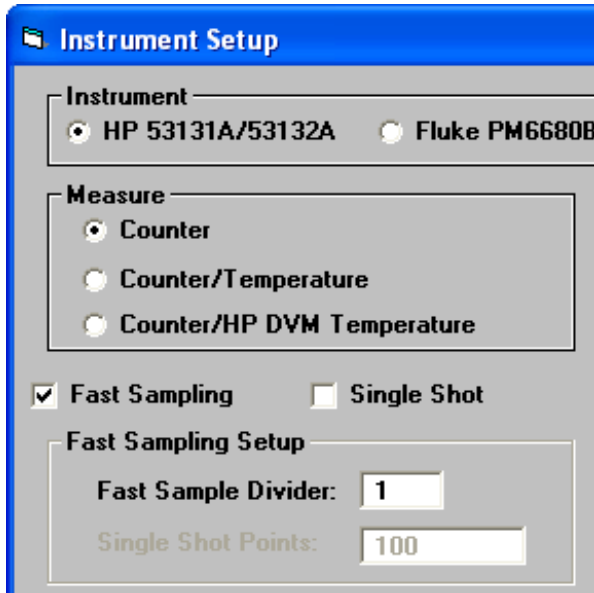
Regular Sampling



- Sampling governed by “Gate Time” which can range from 1 second to 255 seconds
- Sampling faster than 1 Hz requires selecting “Fast Sampling”

TimeMonitor Measurement

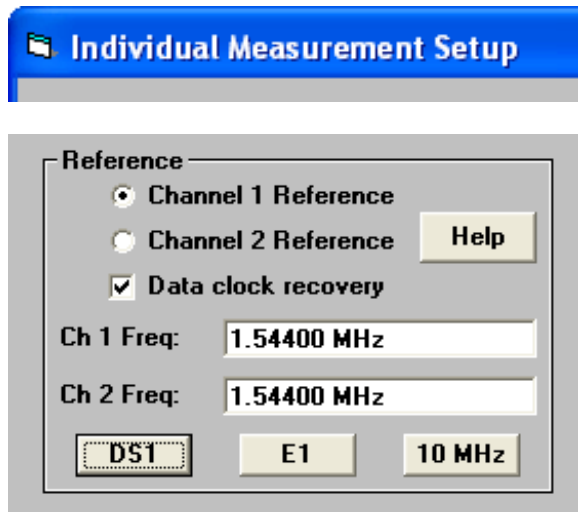
Fast Sampling



- Two types:
 - Fast Sampling
 - Fast Sampling Single Shot
- Fast Sample Divider
 - Controls sample rate
 - “1” is fastest, larger numbers slow down the sample rate increasingly
- Single Shot
 - Disables plotting, computations, and disk access during the measurement for fastest possible measurement rate
- Requires GPIB/HPIB interface
 - Regular sampling must be used for RS232 and TCP/IP

TimeMonitor Measurement

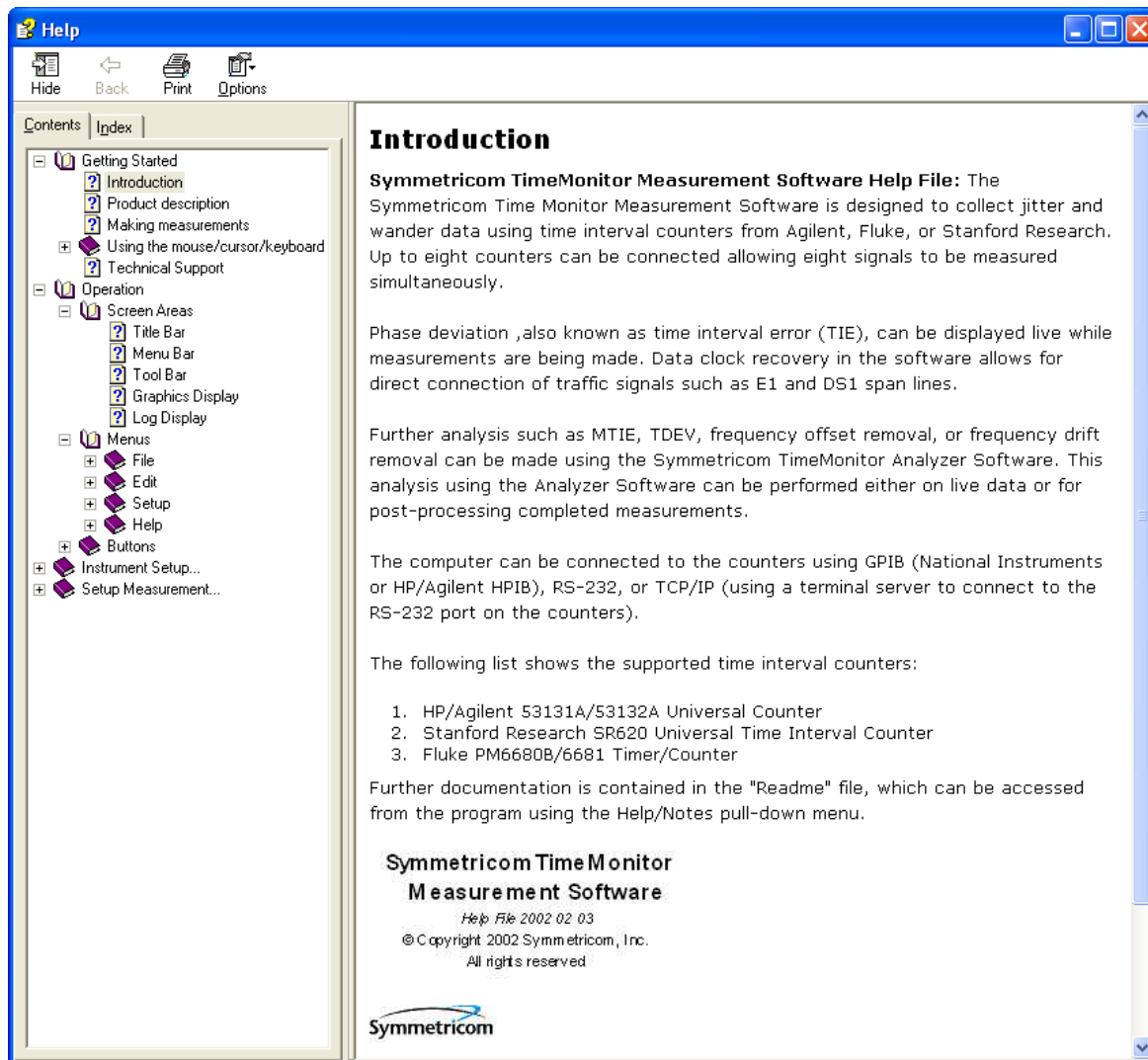
Signal Rate Setup



- Signal rates of reference and measured signals need to be specified
 - Reference signal can be Chan1 or Chan2
 - Chan1 rate is the same or submultiple of Chan2
 - Example: Chan1 = Chan2 = 1.544 MHz
 - Example: Chan1 = 1PPS, Chan2 = 1.544 MHz
 - Example: Chan1 = 5 MHz, Chan2 = 10 MHz
 - Use “data clock recovery” if either or both signals are traffic bearing (eg. DS1 or E1)

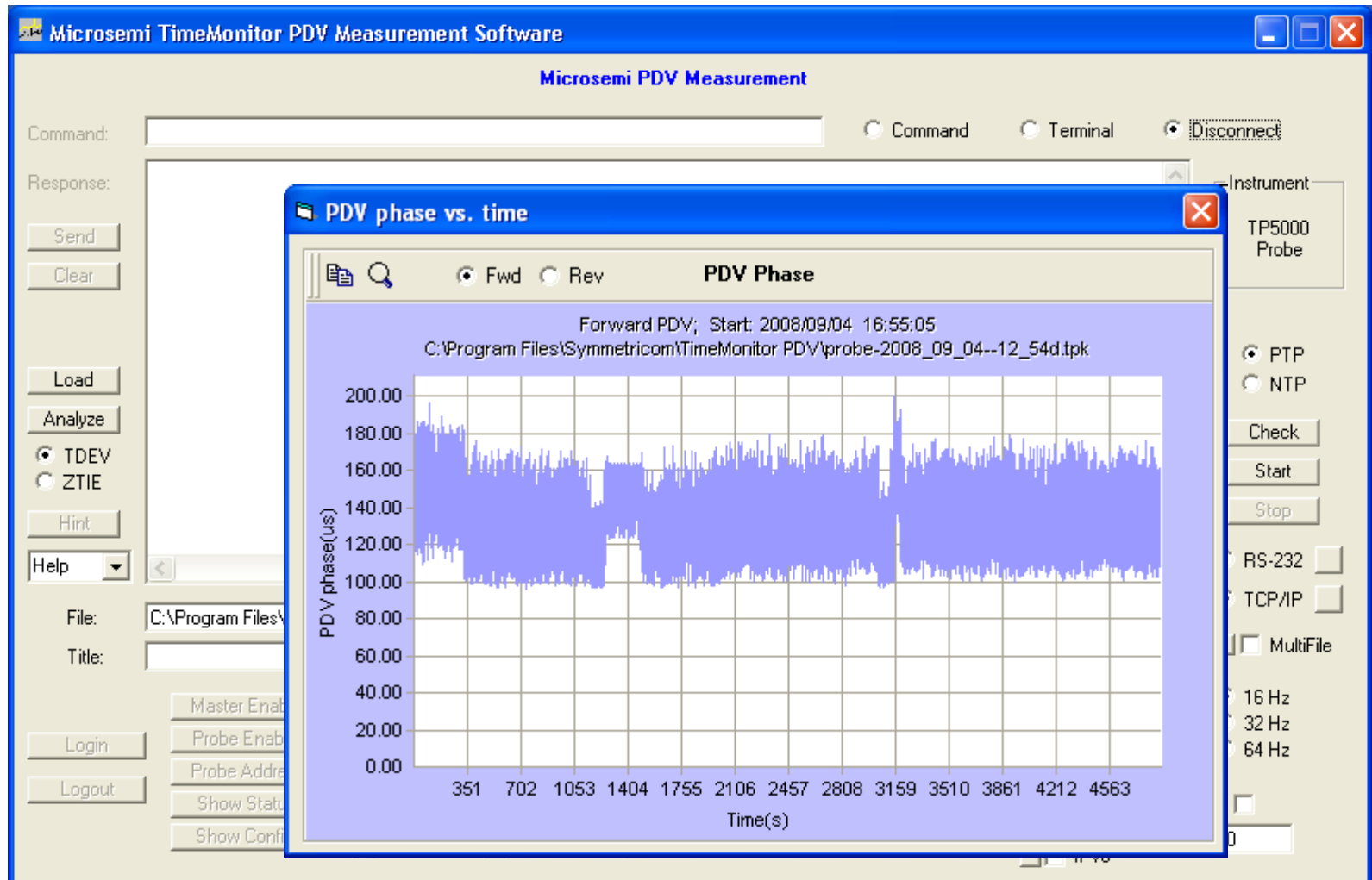
TimeMonitor Measurement

- Help file



TimeMonitor PDV

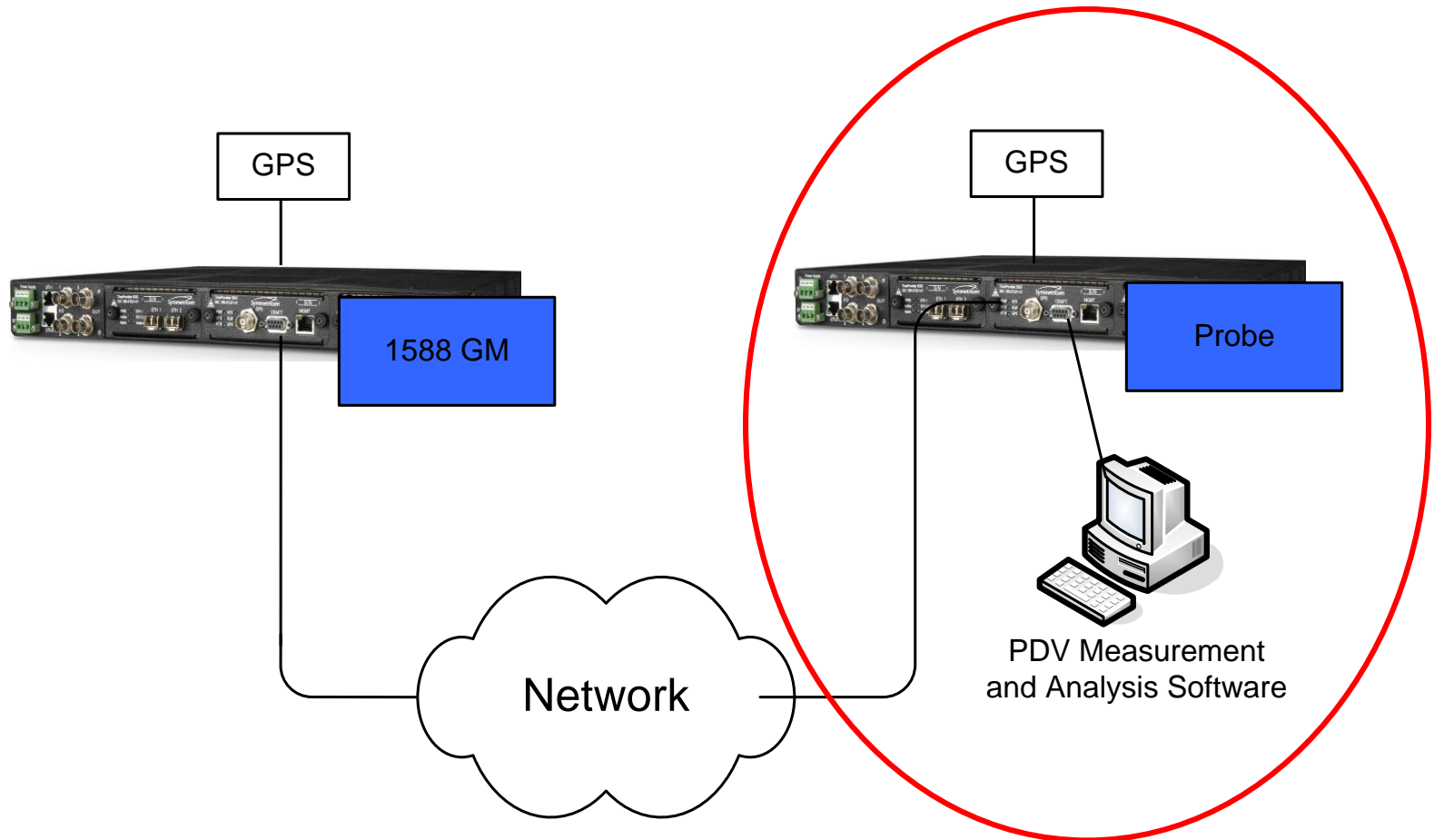
TimeMonitor PDV



TimeMonitor PDV

TP5000 Probe

Released with TP5000 V1.1 (Mid-2009)



TimeMonitor PDV

TP5000 Probe

Data Collection with TimeMonitor PDV Software

The screenshot shows the Microsemi TimeMonitor PDV Measurement Software interface. The window title is "Microsemi TimeMonitor PDV Measurement Software". The main area is titled "Microsemi PDV Measurement".

On the left side, there are buttons for "Send", "Clear", "Load", "Analyze", "TDEV", "ZTIE", "Hint", and a "Help" dropdown menu. Below these are "Login" and "Logout" buttons.

The top right has radio buttons for "Command", "Terminal", and "Disconnect" (selected). Below these are buttons for "Check", "Start", and "Stop".

The right side has a section for "Instrument" with "TP5000 Probe" selected. Below this are radio buttons for "PTP" (selected) and "NTP". There are checkboxes for "RS-232", "TCP/IP" (selected), and "MultiFile".

The bottom section contains a table for "CLK ID Master/Probe" with columns for "Master" and "Probe". The table includes fields for "Address", "Netmask", and "Gateway".

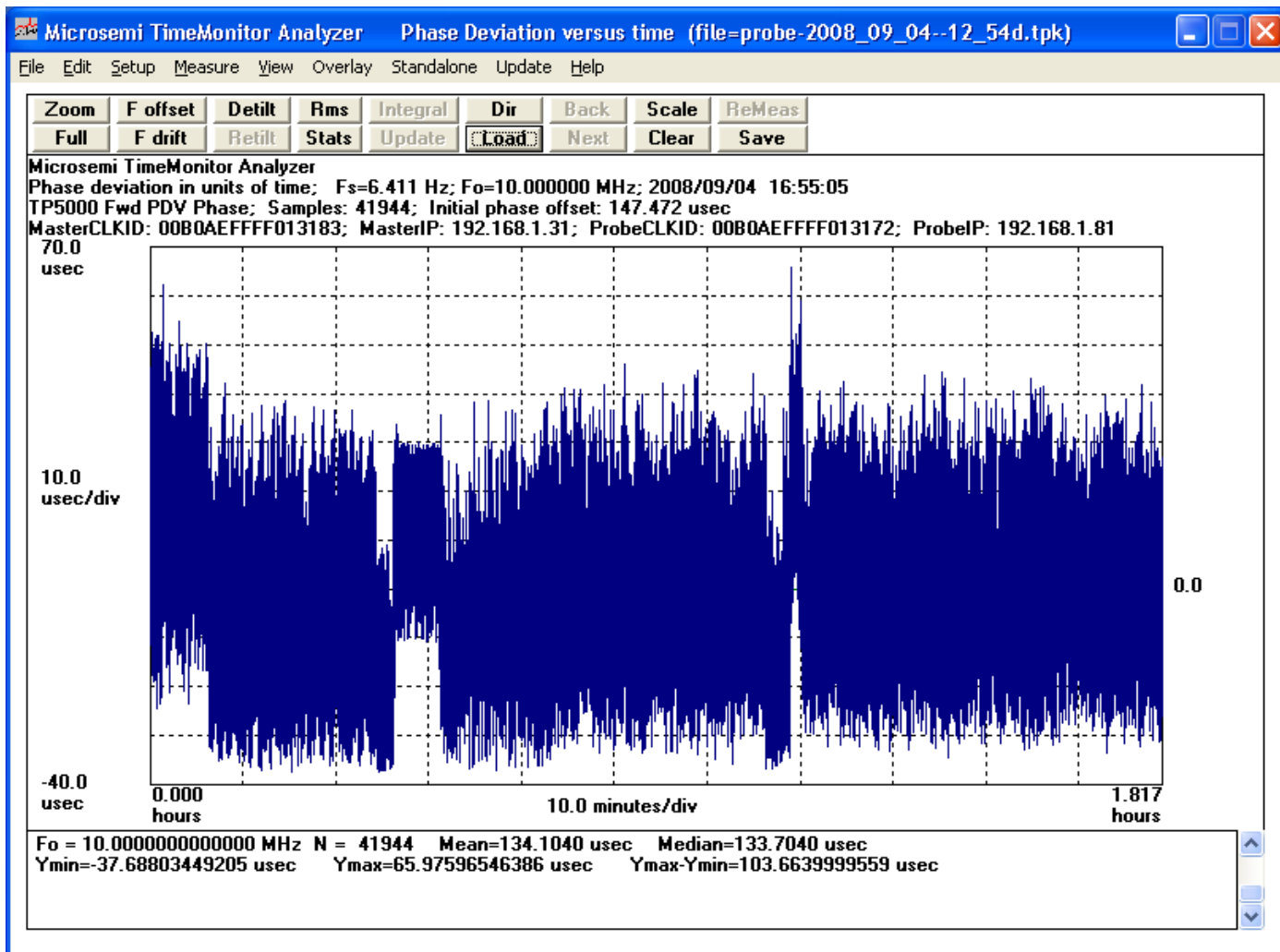
Below the table are checkboxes for "Unicast", "Multicast", and "Ethernet". There are also checkboxes for "VLAN", "IPv4", and "IPv6".

On the far right, there are radio buttons for "1 Hz", "2 Hz", "4 Hz", "8 Hz", "16 Hz", "32 Hz", and "64 Hz". There is a "Reduce rate:" checkbox and a "Duration:" field set to "300".

TimeMonitor PDV

TP5000 Probe

Data Viewing and Analysis with TimeMonitor Analyzer Software



Built-in Analysis

The screenshot shows the Microsemi TimeMonitor PDV Measurement Software interface. A large black arrow points to the 'Log' button in the left sidebar. The main window displays a 'Microsemi PDV Measurement' dialog. The 'File' field contains 'C:\Program Files\Symmetricom\TimeMonitor PDV\data\probe.tpk'. The 'Monitor' section is active, showing Ethernet settings for 'Eth1' and 'Eth2'. The 'Probe' section shows IP addresses and netmasks. The 'Reduce rate' section is also visible.

Microsemi PDV Measurement

Command: ☐ Command ☐ Terminal ☒ Disconnect

Response:

Buttons: ☒ TDEV ☐ ZTIE

File:

Title:

Master Enable

Monitor ☒ Only ☐ Diff ☐ On ☐ Firewall Off ☐ Ext On

CLK ID Master/Probe

	Master	Probe
Address:	10.1.0.31	10.2.0.41
Netmask:	255.255.255.0	255.255.255.0
Gateway:	10.1.0.1	0.0.0.0

☐ Unicast ☐ Multicast ☐ Ethernet ☐ VLAN

Probe ☐ 1 Hz ☐ 2 Hz ☐ 4 Hz ☐ 8 Hz ☐ 16 Hz ☐ 32 Hz ☐ 64 Hz

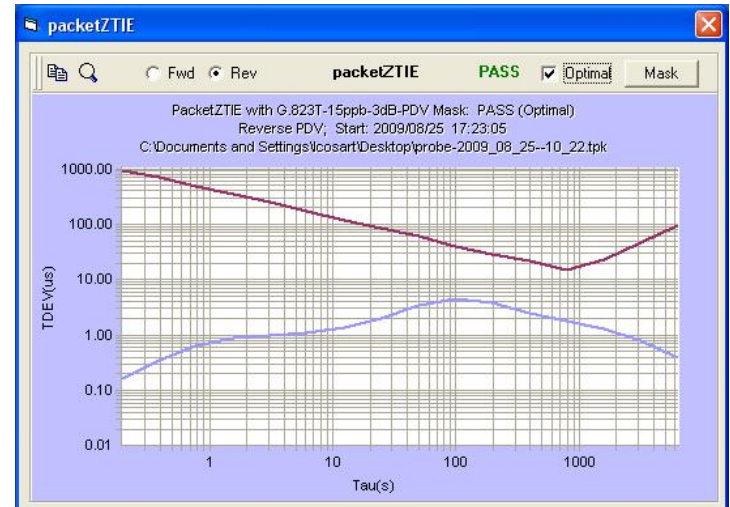
Reduce rate: ☐ Duration:

☐ IPV4 ☐ IPV6

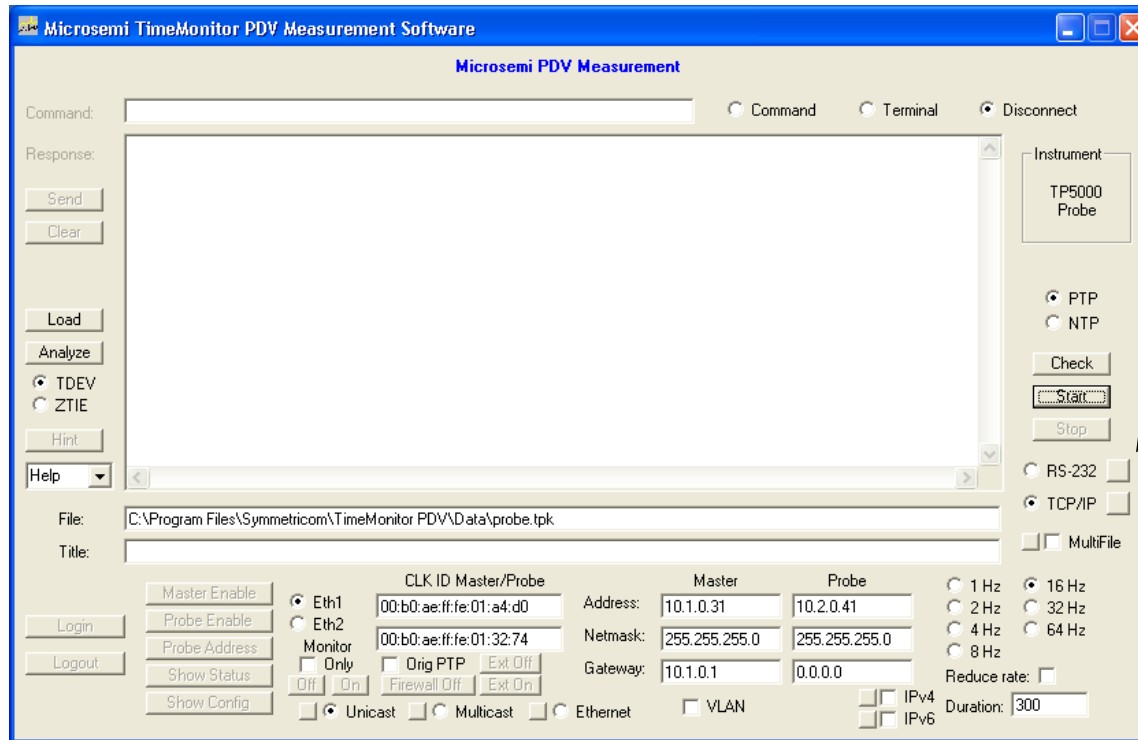
Instrument TP5000 Probe

☒ PTP ☐ NTP

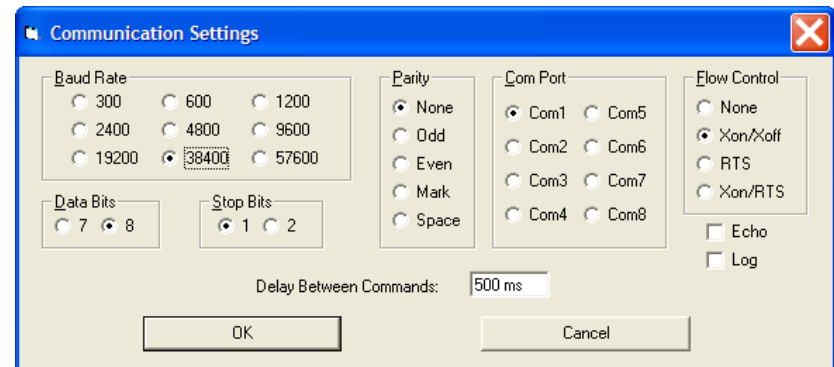
☐ RS-232 ☐ TCP/IP ☐ MultiFile



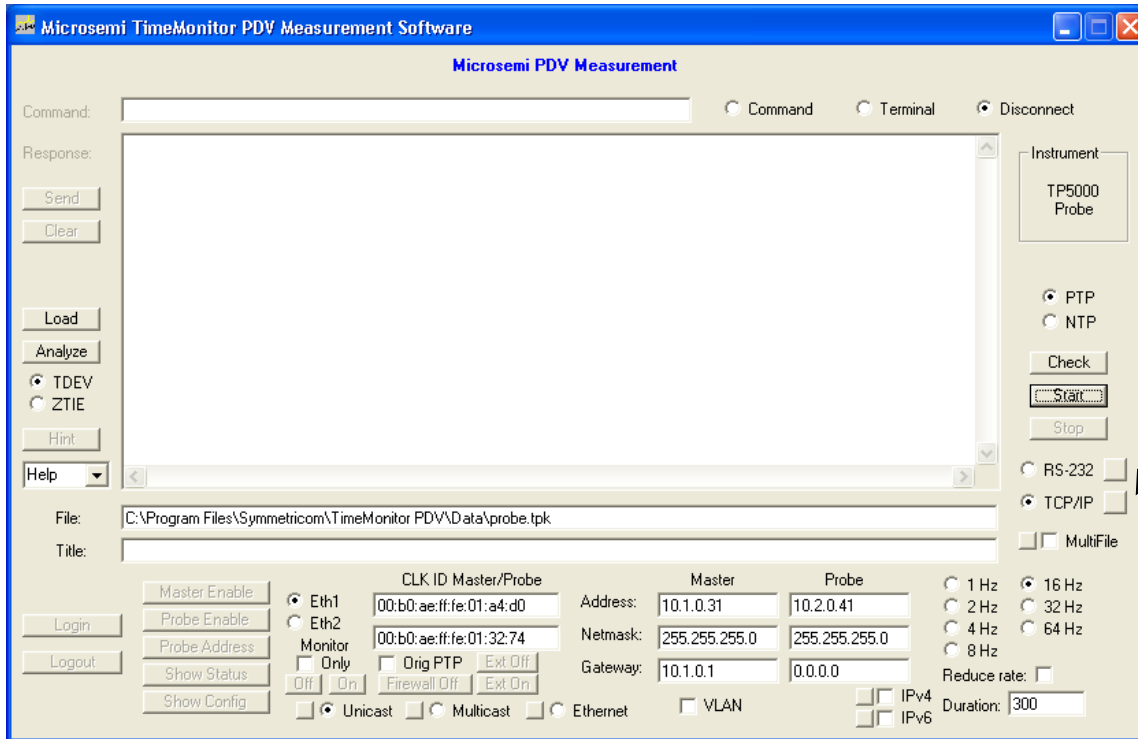
TimeMonitor PDV



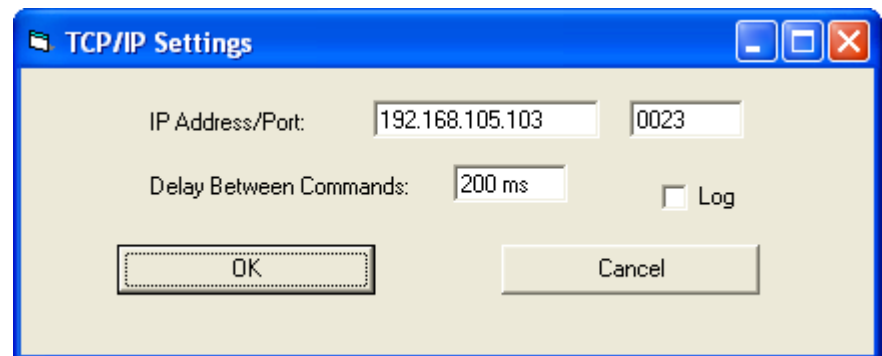
RS-232 setup
TP5000 craft port
57600 baud



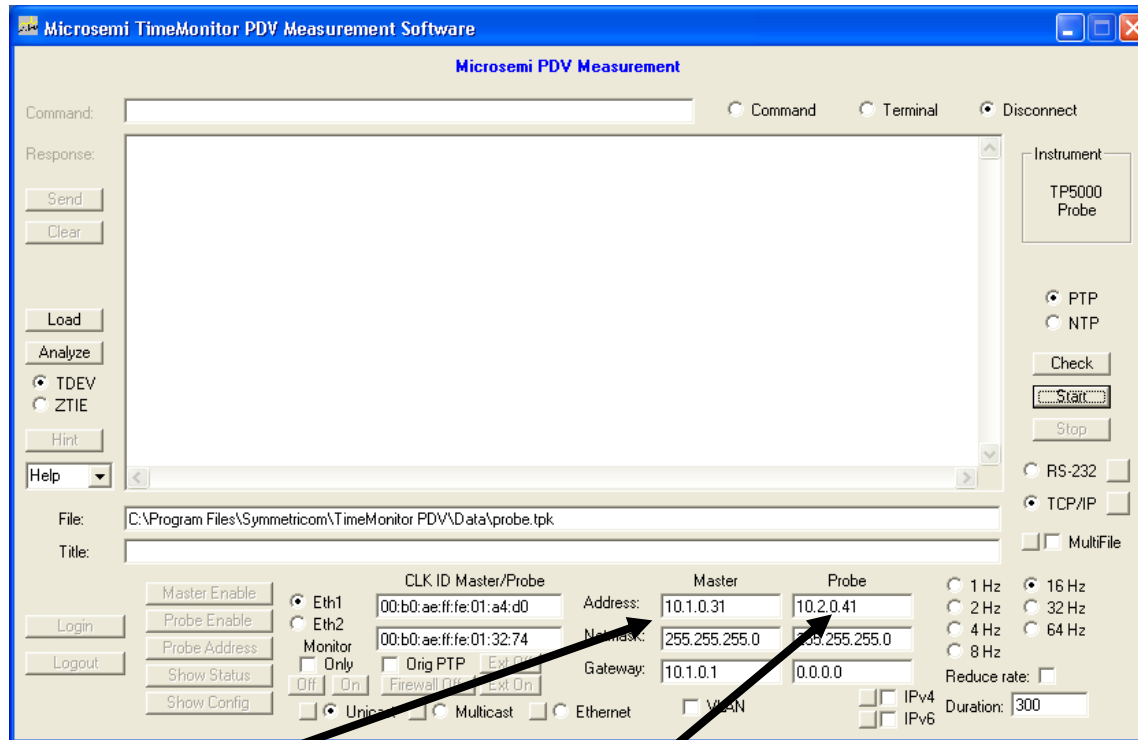
TimeMonitor PDV



TCP/IP setup
TP5000 IMC management port



TimeMonitor PDV

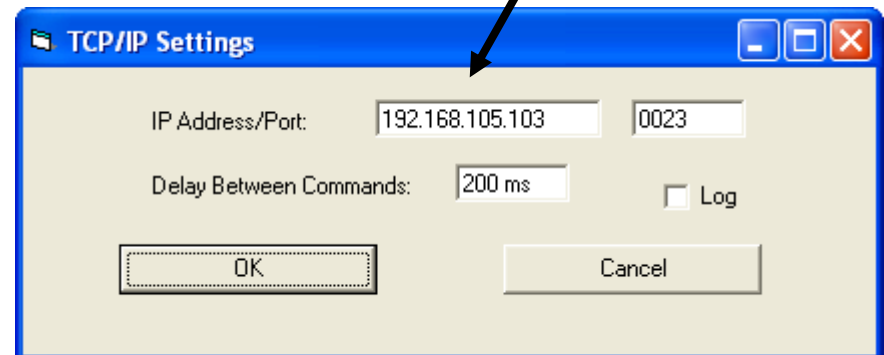


3 IP Addresses

TP5000 IMC management port IP

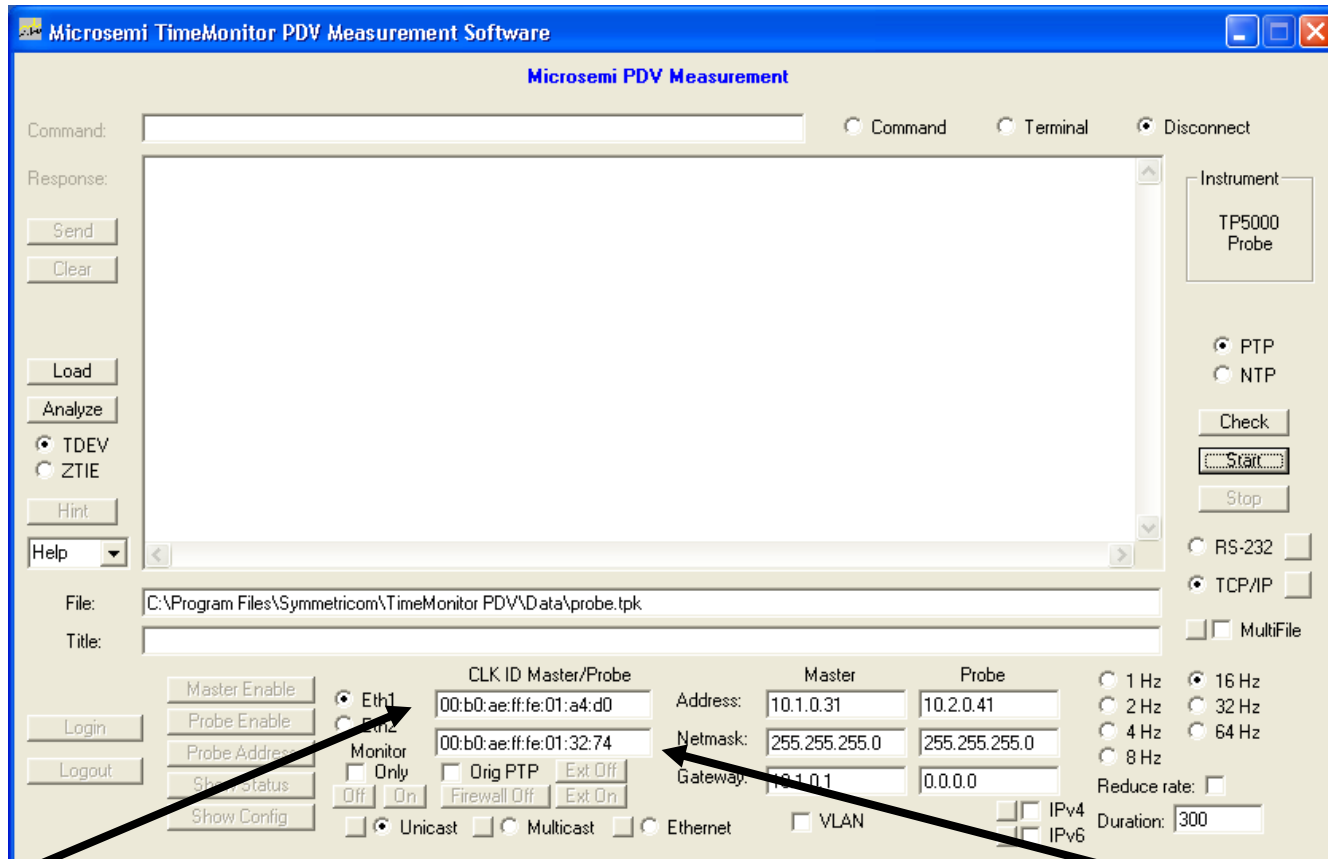
Grandmaster IP

TP5000 Probe IOC IP



TimeMonitor PDV

2 Clock ID's



Grandmaster CLK ID

TP5000 Probe CLK ID

TimeMonitor PDV

The screenshot shows the Microsemi TimeMonitor PDV Measurement Software interface. The window title is "Microsemi TimeMonitor PDV Measurement Software". The main title bar is "Microsemi PDV Measurement".

Annotations with arrows pointing to specific controls:

- Enable Probe:** Points to the "Probe Enable" button in the bottom left section.
- Set Probe Address:** Points to the "Probe Address" button in the bottom left section.
- Show Probe Configuration:** Points to the "Show Config" button in the bottom left section.
- Turn Off Firewall:** Points to the "Firewall Off" button in the bottom right section.
- Set Probe Sync Rate:** Points to the "16 Hz" radio button in the bottom right section.

Key interface elements include:

- Command/Response Area:** "Command:" text box, "Response:" text box, "Send", "Clear", "Load", "Analyze" buttons.
- Instrument Selection:** "Instrument" dropdown showing "TP5000 Probe".
- Protocol Selection:** "PTP" (selected) and "NTP" radio buttons, "Check", "Start", "Stop" buttons.
- Connection Type:** "RS-232" and "TCP/IP" radio buttons, "MultiFile" checkbox.
- Network Configuration:** "CLK ID Master/Probe" section with "Eth1" and "Eth2" radio buttons, "Monitor" checkbox, "Only" checkbox, "Orig PTP" checkbox, "Ext Off" and "Ext On" buttons, "Firewall Off" and "Firewall On" buttons, "Unicast" and "Multicast" radio buttons, "Ethernet" checkbox, "VLAN" checkbox.
- Master/Probe Settings:** "Master" and "Probe" columns with "Address", "Netmask", and "Gateway" fields.
- Sync Rate:** "1 Hz", "2 Hz", "4 Hz", "8 Hz", "16 Hz" (selected), "32 Hz", "64 Hz" radio buttons.
- Other Settings:** "Reduce rate:" checkbox, "Duration:" field set to "300".

TimeMonitor PDV

Measurement
Check

Microsemi TimeMonitor PDV Measurement Software

Microsemi PDV Measurement

Command:

Response:

```
F,00044,1246399623,214620756,1246399623,214771804,+0000000000  
B,00043,1246399623,235278412,1246399623,235125980,+0000000000  
F,00045,1246399623,277120756,1246399623,277271884,+0000000000  
B,00044,1246399623,297778476,1246399623,297625980,+0000000000  
F,00046,1246399623,339620756,1246399623,339771388,+0000000000  
B,00045,1246399623,360278524,1246399623,360125980,+0000000000  
F,00047,1246399623,402120756,1246399623,402271468,+0000000000  
B,00046,1246399623,422778588,1246399623,422625980,+0000000000  
F,00048,1246399623,464620756,1246399623,464771532,+0000000000  
B,00047,1246399623,485278364,1246399623,485125980,+0000000000  
F,00049,1246399623,527120756,1246399623,527271612,+0000000000  
B,00048,1246399623,547778716,1246399623,547625980,+0000000000  
F,00050,1246399623,589620756,1246399623,589771692,+0000000000  
B,00049,1246399623,610278476,1246399623,610125980,+0000000000  
F,00051,1246399623,652120756,1246399623,652271484,+0000000000  
B,00050,1246399623,672778540,1246399623,672625980,+0000000000  
F,00052,1246399623,714620756,1246399623,714771548,+0000000000
```

Send
Clear
Analyze
TDEV
ZTIE
Hint
Help

Instrument
PacketTime Analyzer
Check
Start
Stop
RS-232
TCP/IP

File: C:\Program Files\Symmetricom\TimeMonitor PDV\Data\probe2-2009_06_09-15_22e.tpk
Title:

Probe Enable
Probe Disable
Probe Address
Probe Restart
Show Config
Login
Logout
Firewall Off

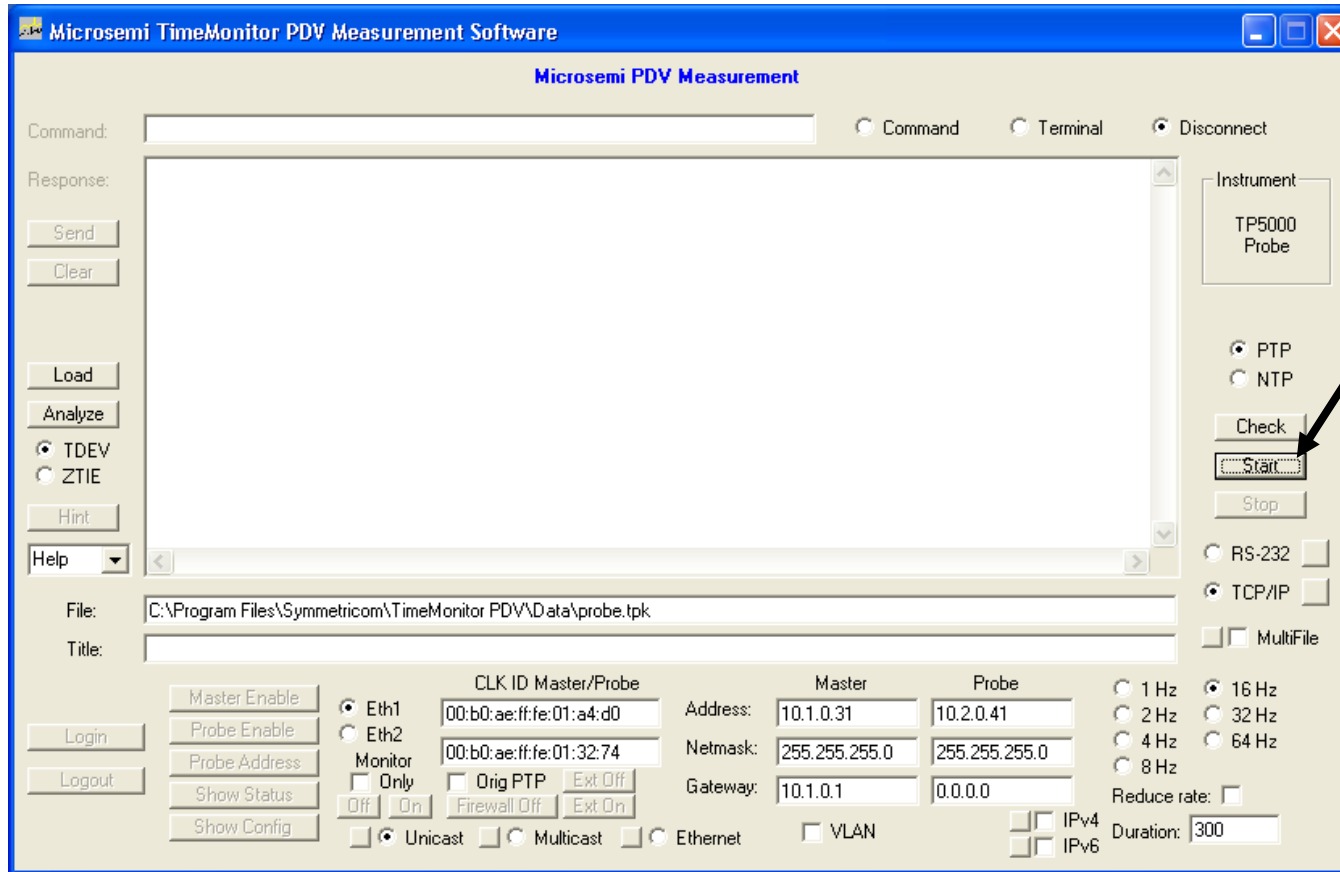
CLK ID Master/Probe
Eth1
Eth2
00:b0:ae:ff:fe:01:a4:d0
00:b0:ae:ff:fe:01:32:74

Master
Address: 10.1.0.31
Netmask: 255.255.255.0
Gateway: 10.1.0.1
VLAN

Probe
Address: 10.1.0.41
Netmask: 255.255.255.0
Gateway: 10.1.0.1

1 Hz
2 Hz
4 Hz
8 Hz
16 Hz
32 Hz
64 Hz
Reduce rate:
Duration: 300

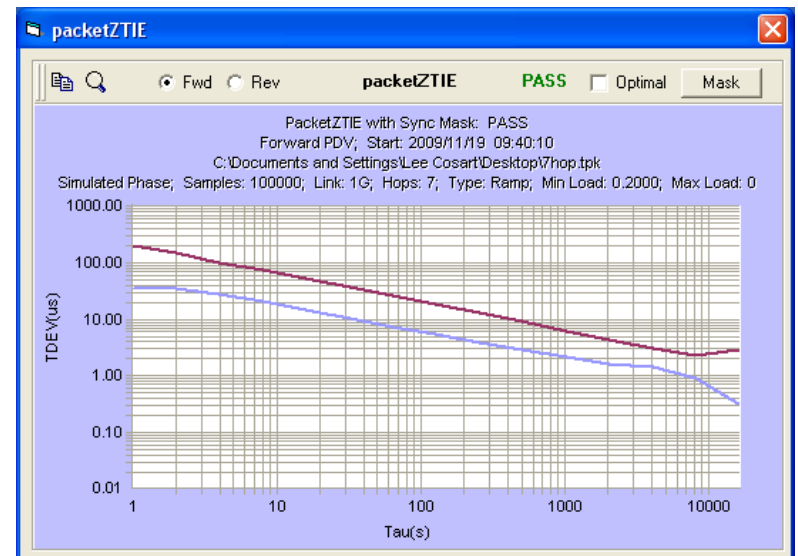
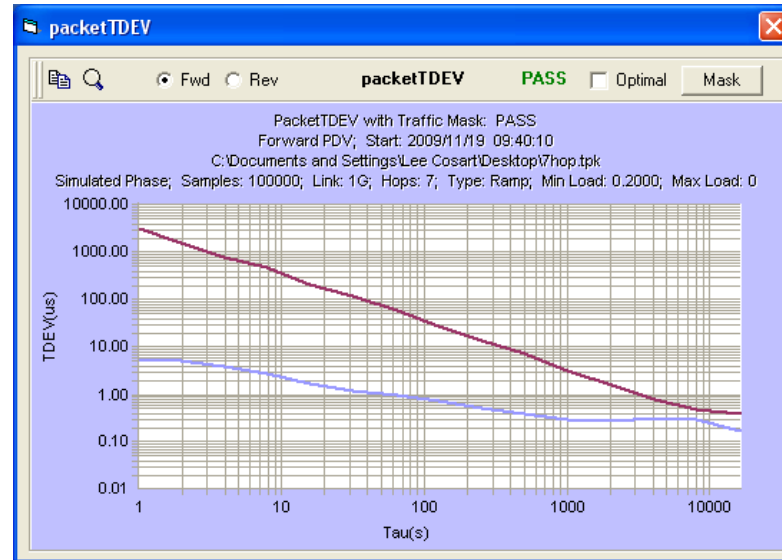
TimeMonitor PDV



**Measurement
Collection**

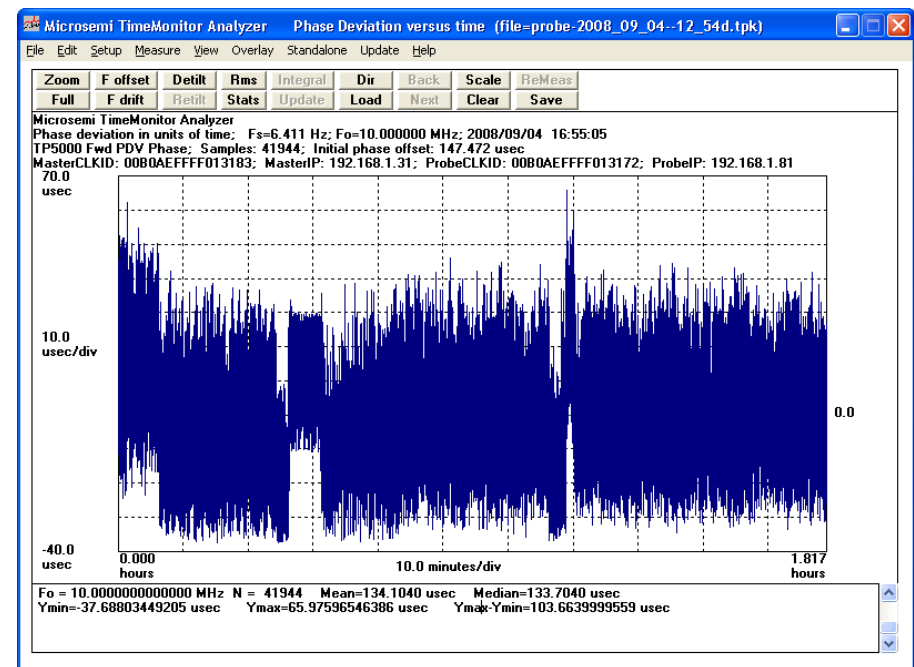
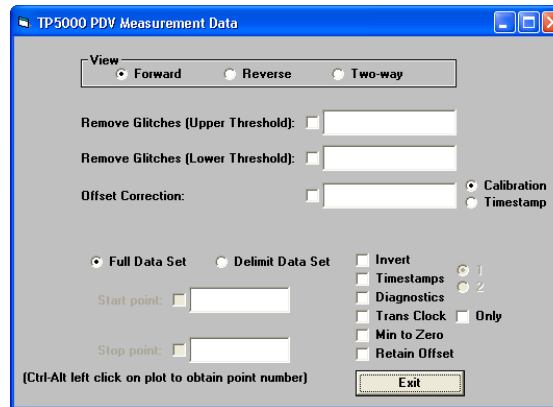
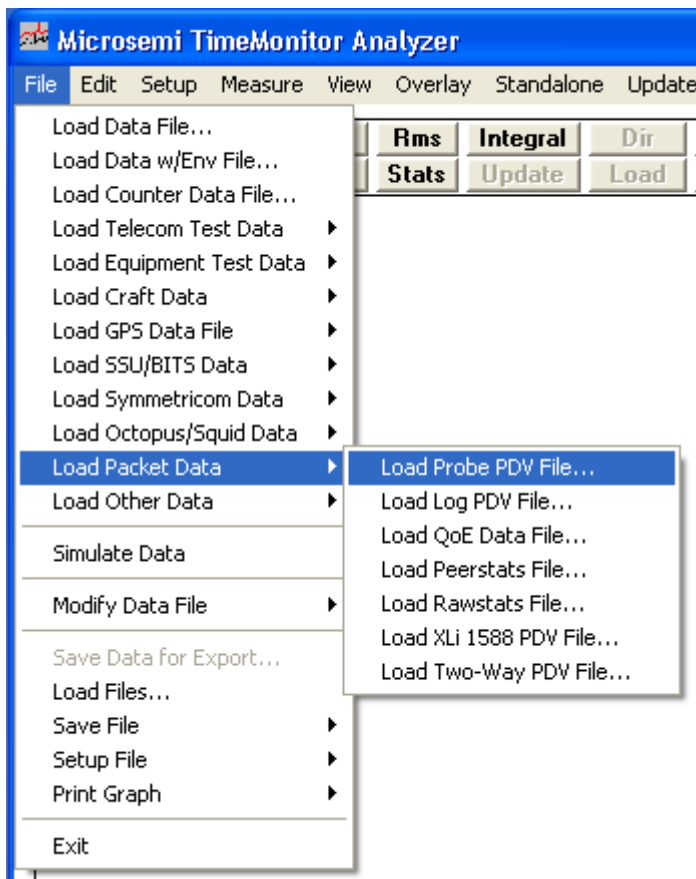
TimeMonitor PDV

Built-in Analysis

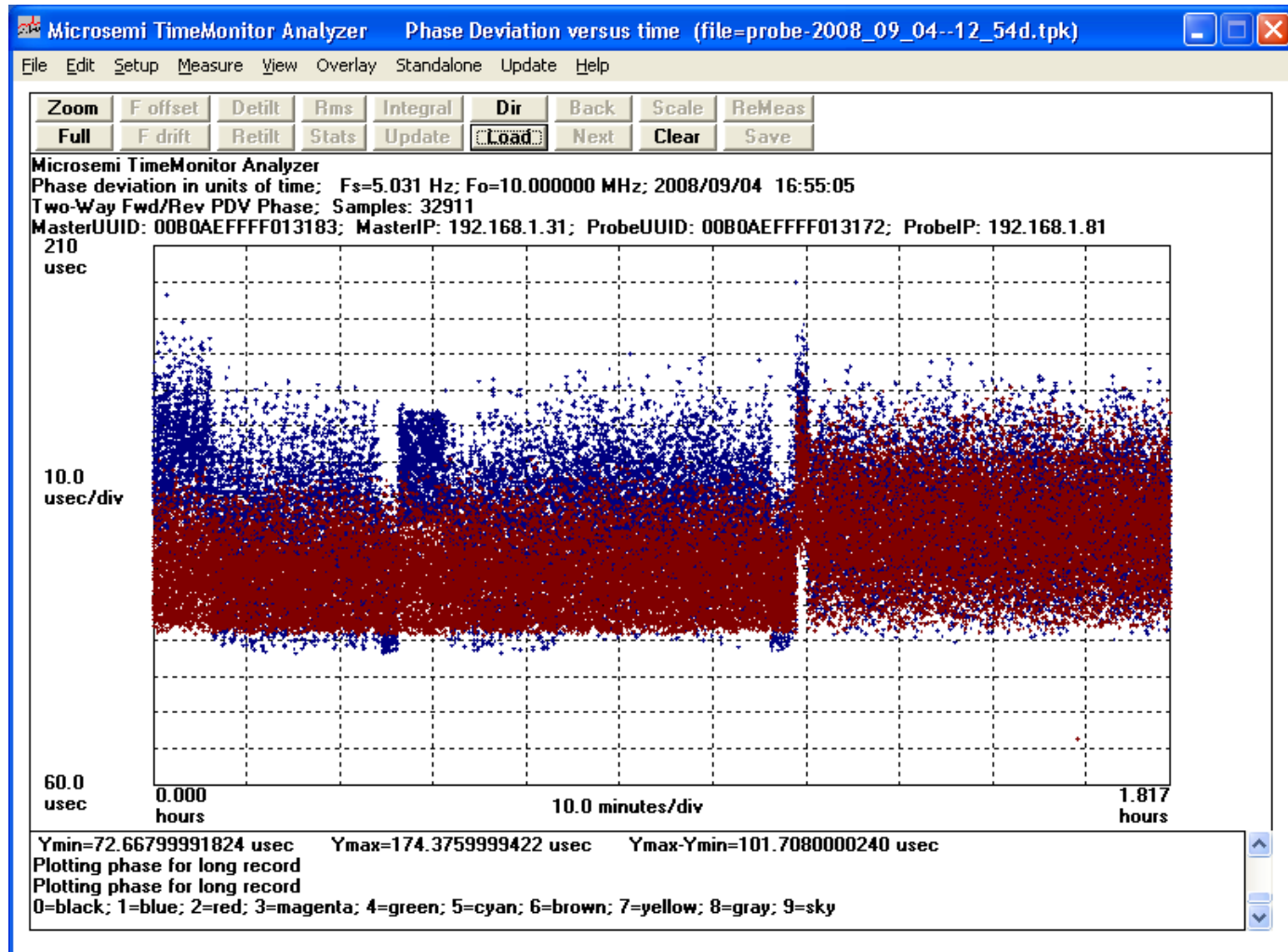


TimeMonitor PDV

Measurement View and Analysis with TimeMonitor Analyzer

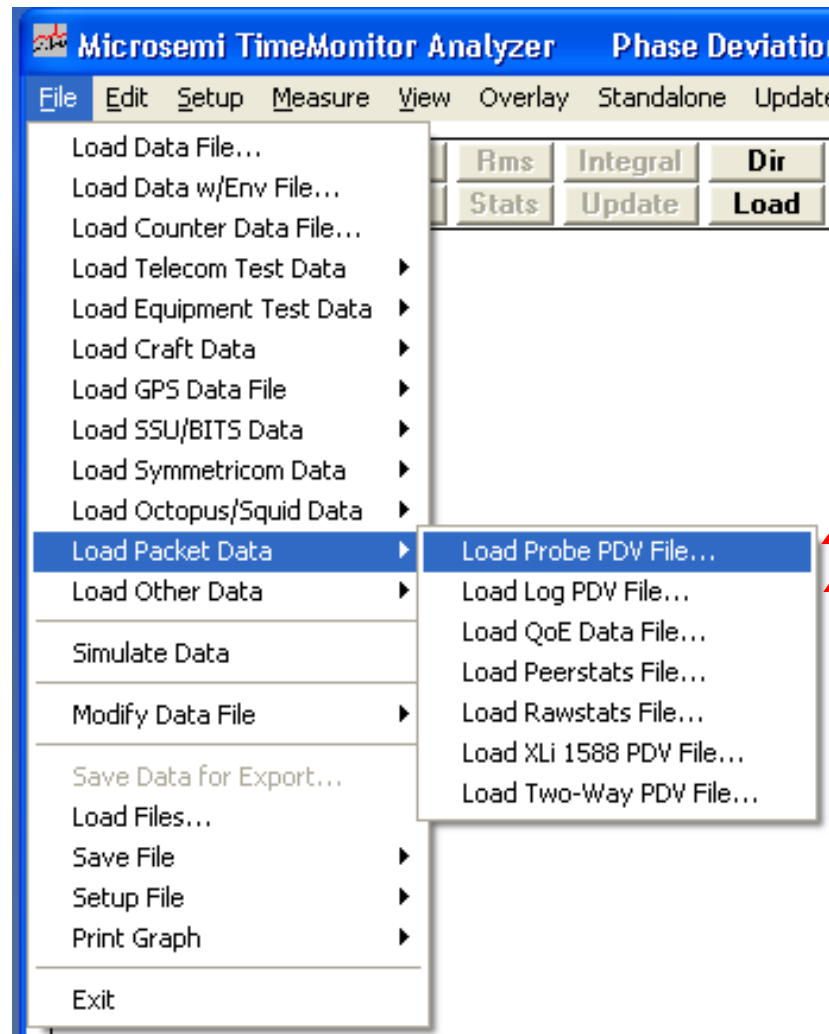


TimeMonitor Analyzer (Packet)



TimeMonitor Analyzer (Packet)

“Load Packet Data” Grouping

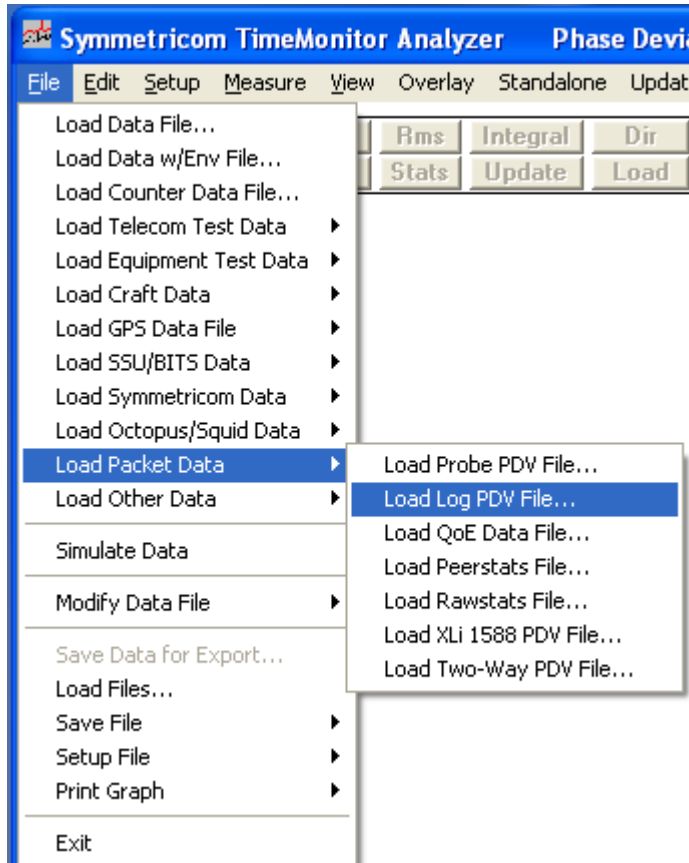


TP 5000 probe data

Ottawa PDV logs

TimeMonitor Analyzer (Packet)

Ottawa PDV logs



1. Capture Mode. (4 columns)
44 0 1262972561.737006469 1262972557.397397065
 2. Simulator Mode.
0.000000e+000
4.333500e-005
 3. Raw timestamp Logging Mode. (text/numbers)
Raw Input: Tx 00004EBCF794.06008FB4, Rx 0000000000000.207827F4
 4. Raw timestamp Logging Mode. (11 columns)
0,1,0,0,1321006330,330976962,0,0,775020765,0,0
0,0,0,0,880,768088716,0,1321006330,324050016,0,0
- .TXT extension except .DEC for simulator files

TimeMonitor Analyzer (Packet)

Packet Data Import: TP5000 Probe PTP

TP5000 PDV Measurement Data

View
☐ Forward ☐ Reverse ☒ Two-way ☐ Monitor

Remove Glitches (Upper Threshold): ☐

Remove Glitches (Lower Threshold): ☐

Offset Correction: ☐ ☒ Calibration ☐ Timestamp

☒ Full Data Set ☐ Delimit Data Set

Start point: ☐

Stop point: ☐

[Ctrl-Alt left click on plot to obtain point number]

☐ Invert ☐ Timestamps ☒ 1 ☐ 2
☐ Diagnostics ☐ Trans Clock ☐ Only
☐ Phase Hold ☐ Min to Zero ☒ Retain Offset

Exit

TimeMonitor Analyzer (Packet)

Packet Data Import: TP5000 Probe NTP

The screenshot shows a software window titled "TP5000 NTP PDV Measurement Data". The window has a blue title bar with standard Windows window controls (minimize, maximize, close). The main area is divided into several sections:

- View:** A group box containing seven radio buttons:
 - ☒ Transmit Delay
 - ☐ Return Delay
 - ☐ Both
 - ☐ Offset
 - ☐ Roundtrip
 - ☐ Roundtrip Full
 - ☐ Two-way Analysis
- Remove Glitches (Upper Threshold):** A checkbox followed by a text input field.
- Remove Glitches (Lower Threshold):** A checkbox followed by a text input field.
- Full Data Set / Delimit Data Set:** Two radio buttons, with "Full Data Set" selected.
- Start point:** A checkbox followed by a text input field.
- Stop point:** A checkbox followed by a text input field.
- Min to Zero:** A checkbox.
- Retain Offset:** A checkbox.
- Exit:** A button with a dashed border.

At the bottom of the window, there is a text instruction: "(Ctrl-Alt left click on plot to obtain point number)".

TimeMonitor Analyzer (Packet)

Packet Data Import: NTP Peerstats/Rawstats

Peerstats Measurement Data

IP Address: 127.127.45.0

Remove Repeated Points (Threshold): ☐

Remove Glitches (Threshold): ☐

☒ Full Data Set ☐ Delimit Data Set

Start point: ☐ ☒ Retain Offset

Stop point: ☐

(Ctrl-Alt left click on plot to obtain point number)

Rawstats Measurement Data

View

- ☒ Roundtrip Delay
- ☐ Transmit Delay
- ☐ Return Delay
- ☐ Transmit/Return Offset
- ☐ Two-way Analysis

IP Address: 69.25.96.14

Remove Repeated Points (Threshold): ☐

Remove Glitches (Threshold): ☐

☒ Full Data Set ☐ Delimit Data Set

Start point: ☐ ☒ Retain Offset

Stop point: ☐

(Ctrl-Alt left click on plot to obtain point number)

TimeMonitor Analyzer (Packet)

Percentile Average

Parameters for: Phase

To change parameter value, double click on parameter or select **Modify>>**

☒ Phase ☐ MTIE ☐ MATIE
☐ Frequency ☐ TDEV ☐ MAFE
☐ TI ☐ FP ☐ ADEV ☐ Holdover
☐ Spectrum ☐ MDEV ☐ Histogram

Phase Stats: On
Statistic: Percentile Avg
Windowing: Tau
Overlap: Disabled
Filter: Use Phase
Analysis: Use Phase Stats
Tau: 10.000 s
Pct: 0.05
Time Axis: Linear

Phase Statistic

Select Phase Statistic:

Mean
Stddev
Min
Max
Median
Floor Max
Floor Avg
Cluster Avg
Percentile
Percentile Avg

OK
Cancel

TimeMonitor Analyzer (Packet)

Cluster Average

Parameters for: **Phase**

To change parameter value, double click on parameter or select Modify.

Modify>>

☒ Phase ☐ MTIE ☐ MATIE
☐ Frequency ☐ TDEV ☐ MAFE
☐ TI ☐ FP ☐ ADEV ☐ Holdover
☐ Spectrum ☐ MDEV ☐ Histogram

Phase Stats: On
Statistic: Cluster Avg
Windowing: Tau
Overlap: Disabled
Analysis: Use Phase
Tau: 10.000 s
Cluster Width: 1.0000 us
Time Axis: Linear

Phase Statistic

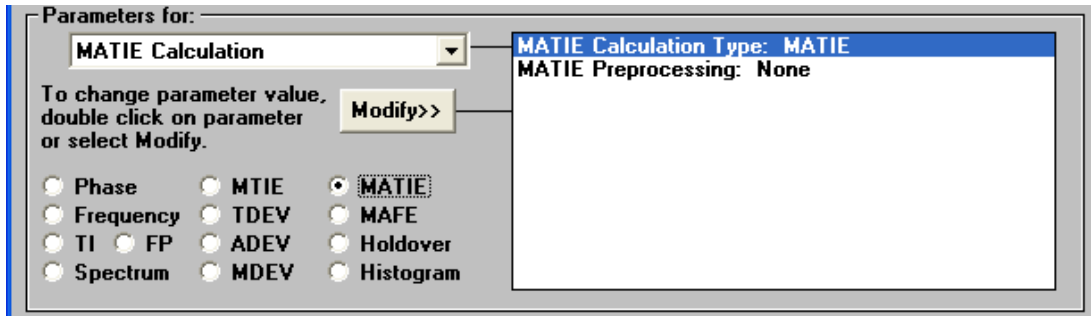
Select Phase Statistic:

Mean
Stddev
Min
Max
Median
Floor Max
Floor Avg
Cluster Avg
Percentile
Percentile Avg

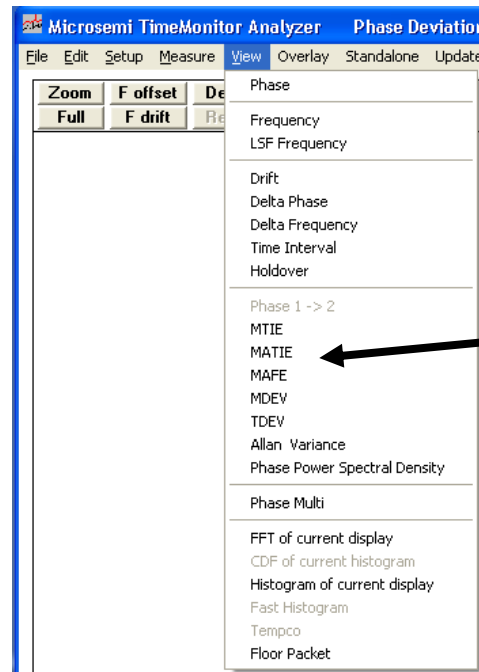
OK
Cancel

TimeMonitor Analyzer (Packet)

MATIE/MAFE Calculations

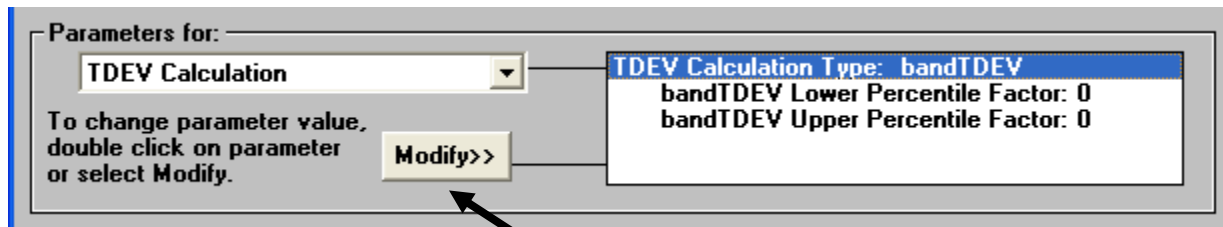


(in View Setup)

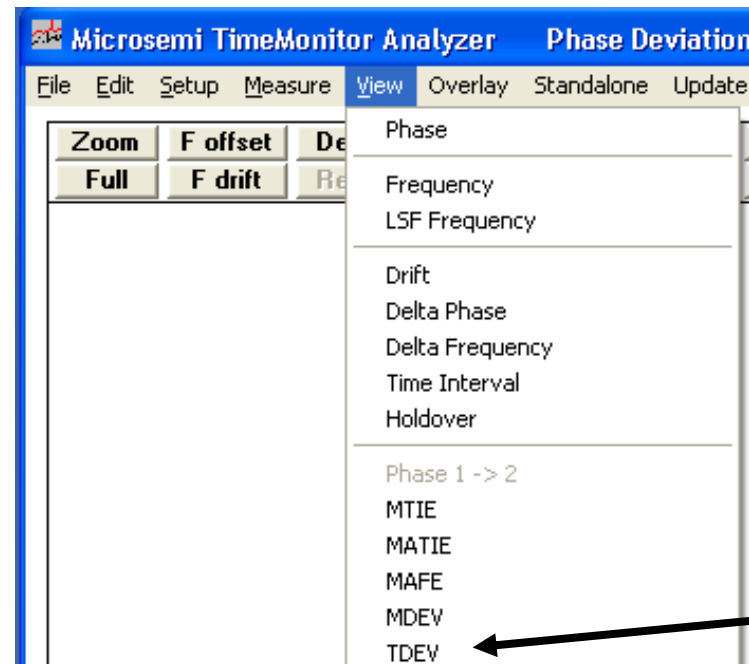
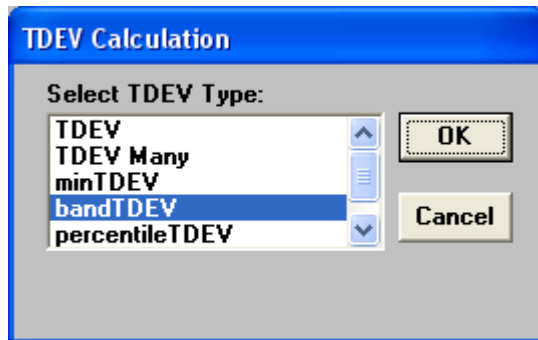


TimeMonitor Analyzer (Packet)

minTDEV/percentileTDEV/bandTDEV Calculations



(in View Setup)



TimeMonitor Analyzer (Packet)

FPP Calculations

Parameters for: **Floor Packet**

To change parameter value, double click on parameter or select Modify.

Modify>>

☐ Phase ☐ MTIE ☐ MATIE
☐ Frequency ☐ TDEV ☐ MAFE
☐ TI ☒ **FP** ☐ ADEV ☐ Holdover
☐ Spectrum ☐ MDEV ☐ Histogram

Calculation Type: FP Percent
Window: 10.000 s
Range: 50.000 us
Floor: Minimum
Floor Float: Disabled
Overlap: Disabled
Non-uniform: Disabled
Axis: Linear

(in View Setup)

Microsemi TimeMonitor Analyzer Phase Deviation

File Edit Setup Measure View Overlay Standalone Update

Zoom F offset De
Full F drift Re

Phase
Frequency
LSF Frequency
Drift
Delta Phase
Delta Frequency
Time Interval
Holdover
Phase 1 -> 2
MTIE
MATIE
MAFE
MDEV
TDEV
Allan Variance
Phase Power Spectral Density
Phase Multi
FFT of current display
CDF of current histogram
Histogram of current display
Fast Histogram
Tempco
Floor Packet

TimeMonitor Analyzer (Packet)

Two-Way Packet Measurement Data

View

- ☒ Forward
- ☐ Reverse
- ☐ Both
- ☐ Time Error
- ☐ Mean Path Delay
- ☐ cTE
- ☐ dTE-L
- ☐ dTE-H
- ☐ Offset
- ☐ Roundtrip
- ☐ Weighted Avg
- ☐ Difference
- ☐ TDISP
- ☐ minATE
- ☐ maxATE
- ☐ ppATE
- ☐ TE Max
- ☐ TE Mean
- ☐ TE Median
- ☐ TE Stddev
- ☐ TE Pct

ATE Many ☐

Tau (sec):

☐ Invert

☐ Overlap

☐ Skip

Remove Glitches (Upper Threshold):

Remove Glitches (Lower Threshold):

Time Offset Calibration:

Weighting Factor:

Cluster Width:

cTE Interval:

dTE Filter Cutoff:

TE Max Target: ☒ MinFwdRev ☐ MinRoundtrip ☐ Median

Pre-calc

- ☒ None
- ☐ Minimum
- ☐ Floor Avg
- ☐ Cluster Avg
- ☐ Percentile
- ☐ Percentile Avg

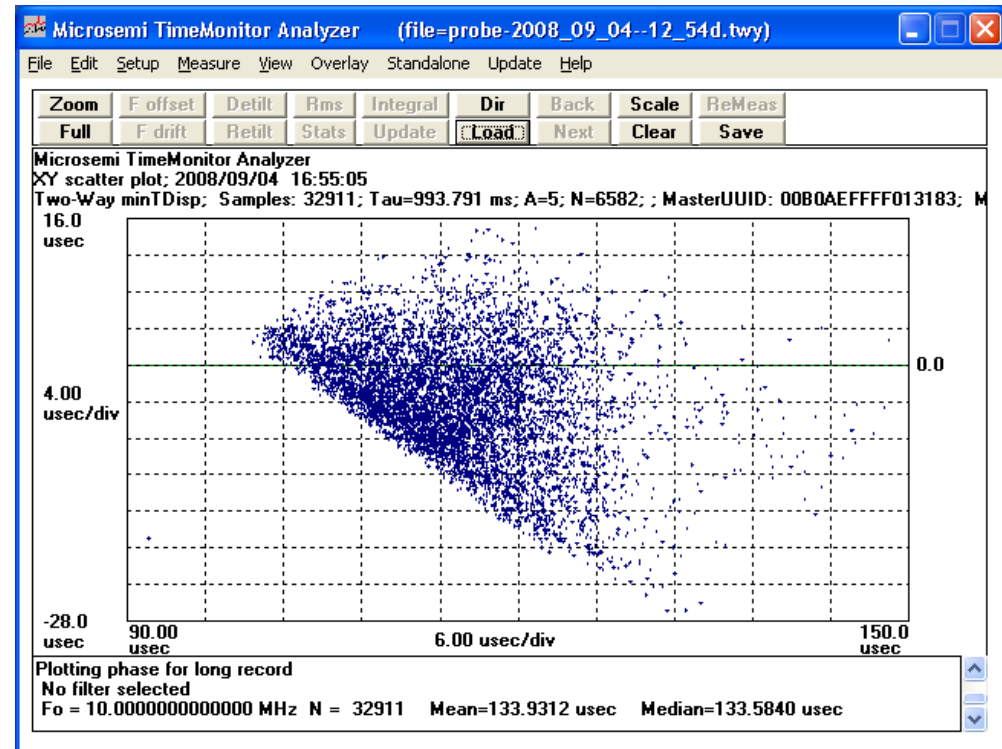
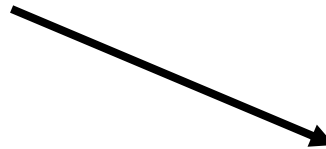
(Ctrl-Alt left click on plot to obtain point number)

☐ Phase Hold

☐ Min to Zero

☐ Retain Offset

Two-way Data Import



TimeMonitor Analyzer (Packet)

TP5k Probe Diagnostics

TP5000 PDV Measurement Data

View: ☒ Forward ☐ Reverse ☐ Two-way

Remove Glitches (Upper Threshold): ☐

Remove Glitches (Lower Threshold): ☐

Offset Correction: ☐ ☒ Calibration ☐ Timestamp

☒ Full Data Set ☐ Delimit Data Set

Start point: ☐

Stop point: ☐

(Ctrl-Alt left click on plot to obtain point number)

☐ Invert ☐ 1 ☐ 2

☐ Timestamps

☐ Diagnostics

☐ Trans Clock ☐ Only

☐ Min to Zero

☐ Retain Offset

Exit

TimeMonitor Analyzer (Packet)

TP5k Probe Diagnostics

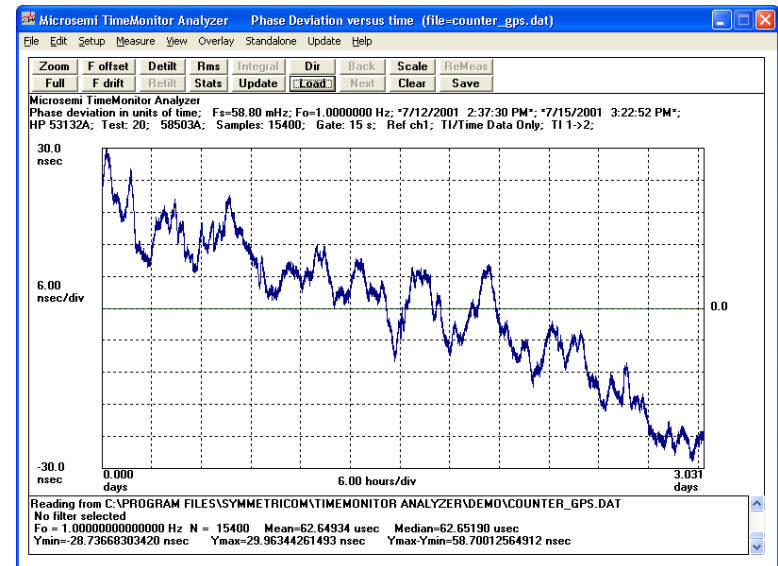
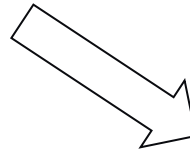
- Forward PDV: ***f.tpk***
- Reverse PDV: ***b.tpk***
- Cleaned file: ***clean.tpk***
- Header: ***header.txt***
- Other lines: ***debug.txt***
- Timestamps: ***t1.cap, t2.cap, t3.cap, t4.cap***
- Missing SeqID: ***seqf.txt, seqb.txt***
- Backwards timestamps: ***backf.txt, backb.txt***
- Repeated timestamps: ***repf.txt, repb.txt***
- Delay below lower threshold: ***lowf.txt, lowb.txt***
- Delay above upper threshold: ***highf.txt, highb.txt***

TMA “Command Line”

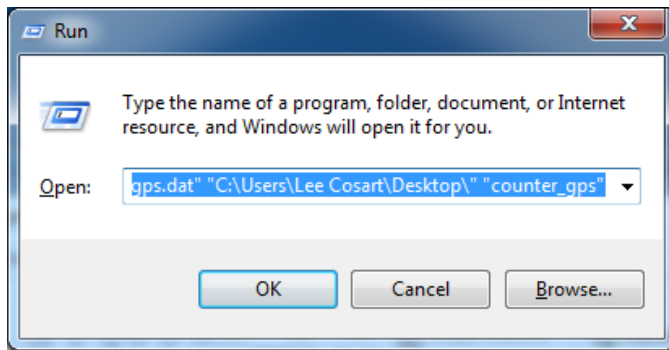
Integration: Launch TimeMonitor Analyzer with another application

Automation: Test automation

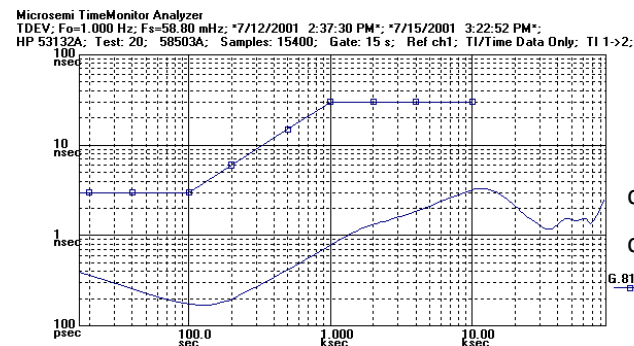
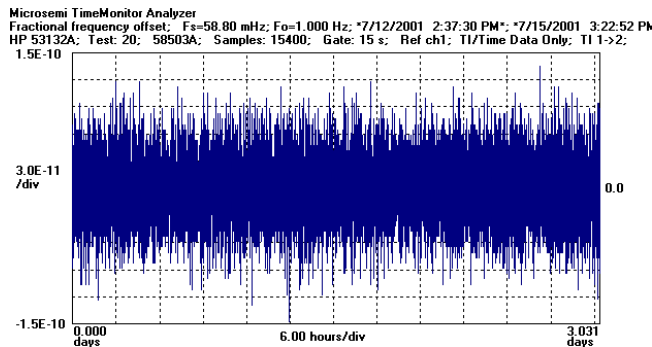
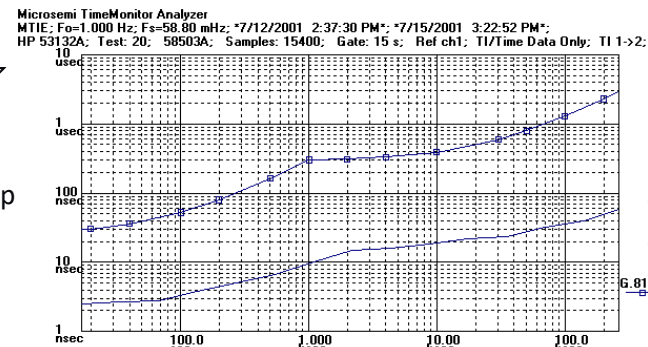
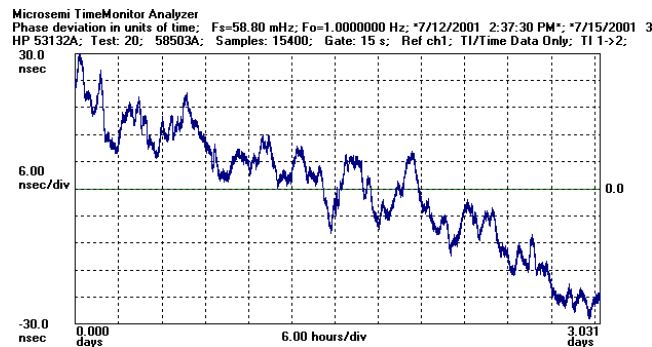
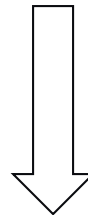
"C:\Program Files (x86)\Microchip\TimeMonitor Analyzer\phasana.exe" -launch -phase "C:\Program Files (x86)\Microsemi\TimeMonitor Analyzer\Demo\counter_gps.dat" "C:\Users\John Doe\Desktop\" "counter_gps"



TMA "Command Line"



"C:\Program Files (x86)\Microchip\TimeMonitor Analyzer\phasana.exe" -plot -file -setup -phase -freq -mtie -tdev "C:\Program Files (x86)\Microchip\TimeMonitor Analyzer\Demo\counter_gps.dat" "C:\Users\John Doe\Desktop\' "counter_gps" "c:\Temp\g811.stp"



TMA “Command Line”

- **Script (e.g. Python, Perl, Tcl, LabVIEW) or other calling program (e.g. C) can be used to process measurement files:**
 - Counter (DAT, ASC)
 - Single/Dual Column (TXT)
 - Packet Probe (TPK, AIT, TWY)
 - Other extensions than these six processed as single/dual column
- **Uses “inisetup.stp” (or optional “.stp” file in command)**
 - Setup masks, calculation parameters etc.
- **Supports all calculations**
 - -phase, -freq, -lsffreq, -mtie, -tdev, -adev, -mdev, -matie, -mafe
 - -hist, -cdf, -drift, -dphase, -dfreq, -ti, -ppsd, -fp, -tempco
- **Writes BMP files for script selected calculations**
 - Script can then be used to automatically place plots in a document
- **Writes dual column TXT files for script selected calculations**
 - These results can then be post-processed (mask pass/fail for example)

TMA “Command Line”

- **Example “Command Line”**

- "C:\Program Files (x86)\Microsemi\TimeMonitor Analyzer\phasana.exe" -plot -file -setup –slast -phase -freq -mtie -tdev "C:\Program Files (x86)\Microsemi\TimeMonitor Analyzer\Demo\counter_gps.dat" "C:\Users\John Doe\Desktop\" "counter_gps" "C:\Temp\g811.stp"

- **Parsing the “Command Line”**

- TimeMonitor EXE: "C:\Program Files (x86)\Microsemi\TimeMonitor Analyzer\phasana.exe"
- Indicate plot function: -plot
- Indicate file function: -file
- Indicate setup file (optional): -setup
- Indicate setup file loaded last (optional): -slast
- Choose calculation(s): -phase -freq -mtie -tdev
- Source file: "C:\Program Files (x86)\Microsemi\TimeMonitor Analyzer\Demo\counter_gps.dat"
- Destination directory: "C:\Users\John Doe\Desktop\"
- BMP/TXT file names: counter_gps
- Setup file name: "C:\Temp\g811.stp"

- **This “Command Line” produces four BMP and four dual column TXT files**

- counter_gpsPhase.bmp, counter_gpsFreq.bmp, counter_gpsMTIE.bmp, counter_gpsTDEV.bmp, counter_gpsPhase.txt, counter_gpsFreq.txt, counter_gpsMTIE.txt, counter_gpsTDEV.txt

TMA “Command Line”

Setup file options

1. **Use “inisetup.stp” if -setup and “<setup file name>” not in command**
 - “inisetup.stp” is in the TimeMonitor installation directory
2. **With -setup and file name without directory**
 - e.g. ... -setup ... “g811.stp”
 - Looks for setup file in TimeMonitor Analyzer installation directory
3. **With -setup and file name with directory**
 - e.g. ... -setup ... “C:\Temp\g811.stp”
 - Looks for setup file in the “C:\Temp\” directory in this case
4. **With -setup and -slast**
 - TimeMonitor Analyzer will load the setup file ***after*** loading the data file

TMA “Command Line”

- **Delimiting**

- Optional input file delimiting is available
- Delimits the input file according to point numbers in the file, for example, a 1000 point file could be delimited to start with the 150th point and stop with the 300th point with all analysis performed on that delimited sequence rather than the full 1000 points
- The syntax is to add -start and/or -stop parameters with each followed by a space and then an integer
- Example: "phasana.exe" -plot -file -start 800 -phase -freq -mtie -tdev "C:\Data\counter_gps.dat" "C:\Results\" "counter_gps"
- Example: "phasana.exe" -plot -file -stop 1600 -phase -freq -mtie -tdev "C:\Data\counter_gps.dat" "C:\Results\" "counter_gps"
- Example: "phasana.exe" -plot -file -start 800 -stop 1600 -phase -freq -mtie -tdev "C:\Data\counter_gps.dat" "C:\Results\" "counter_gps"

TMA “Command Line”

- **Overlays**

- Command line supports saving results as overlays
- Command line supports plotting overlay results as a BMP file

- **Save as Overlay**

- Numbered overlays range from 0 to 9
- Parameter is `–saveoverlay[N]`
- Example: `"phasana.exe" -saveoverlay1 -phase -freq -mtie -tdev "C:\Data\counter_gps.dat" "C:\Results\" "counter_gps"`
- Example: `"phasana.exe" -plot -file -saveoverlay1 -phase -freq -mtie -tdev "C:\Data\counter_gps.dat" "C:\Results\" "counter_gps"`

- **Plot Overlay**

- Overlays are individually selected
- Example: `"phasana.exe" -phase -mtie -tdev -overlay1 -overlay5 -overlay7 "C:\Results\" "counter_gps"`

- **Overlay Options**

- `-phase, -freq, -mtie, -tdev, -adev, -mdev, -matie, -mafe`
- `-hist, -cdf, -ppsd, -fp, -generic, -scatter, -timestats`

TMA “Command Line”

- **Debug mode (optional)**

- -debug parameter is used to invoke
- Dialog box content is directed to file “cmd_debug.txt”
- File “cmd_debug.txt” is located in the TimeMonitor Analyzer installation directory and in the “output” directory specified in the command as long as it exists
- In debug mode, message dialog box content is directed to that file and message dialog boxes are suppressed
- File “cmd_debug.txt” shows the parsing of the command (and the content of any message dialog box)
- Example: "phasana.exe" -debug -plot -file -phase -freq -mtie -tdev "C:\Data\counter_gps.dat" "C:\Results\" "counter_gps"

- **Debug file example:**

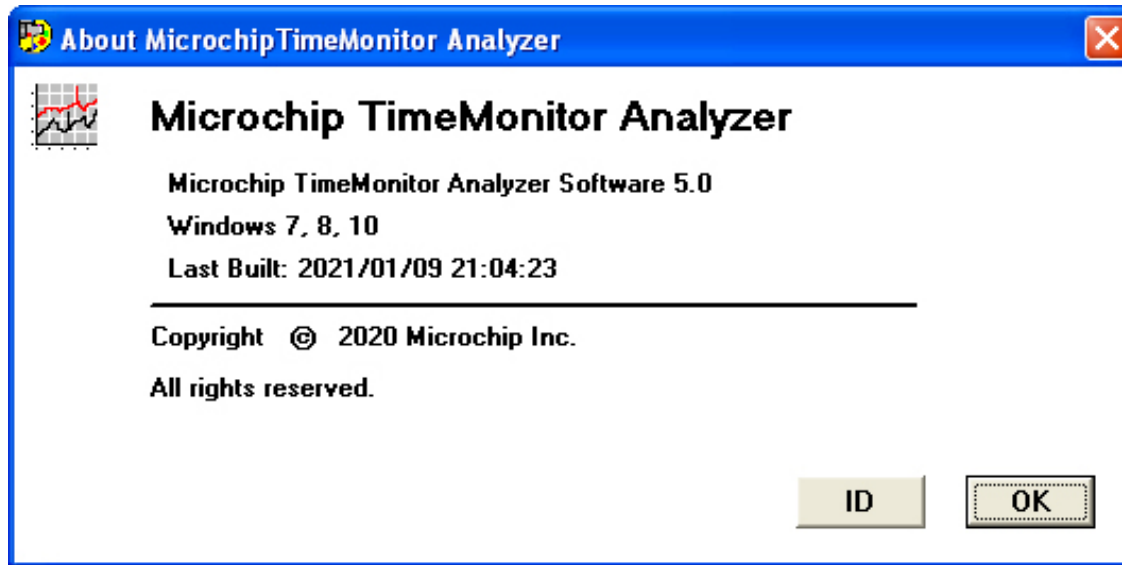
```
Input file: counter_gps.dat
Input directory:
C:\Vb\Office\Vb6\Projects\Phasana\Builds\b20140110\
Output file: counter_gps
Output directory: C:\Users\John Doe\Desktop\
Output bitmap selected
Output file selected
Delimiting selected
Start: 900
Stop: 1800
Phase calculation
Frequency calculation
MTIE calculation
TDEV calculation
```


TMA “Command Line”

Summary

- **Three options for directing calculations**
 - -plot: BMP files
 - -file: TXT dual column files
 - -saveoverlay<N>: save as overlay (e.g. -saveoverlay1)
- **Any combination of the three options can be selected in a single command**
- **Plot Overlays**
 - BMP files produced
- **Debug mode**
 - Writes parse of command to a file
 - The file also includes any message dialog box content with message dialog boxes suppressed

TMA “Command Line”



TimeMonitor Analyzer 4.0 or later
required for “Command Line”
functionality

TimeMonitor Analyzer 5.0
is required for full “Command Line”
functionality