Studying Packet Equipment with a Probe and Packet Metrics
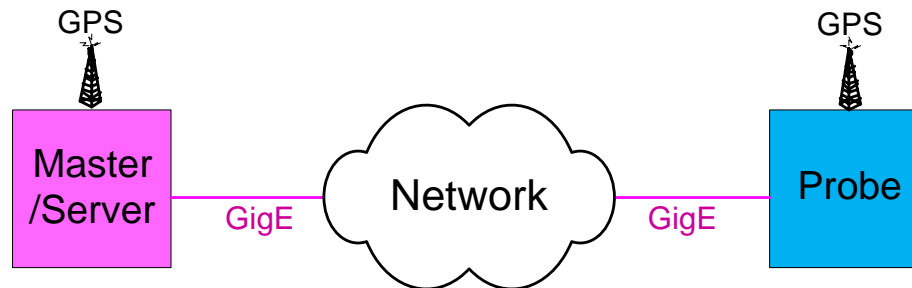
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Presentation Outline

- Introduction
  - Packet probe
  - Metrics

- Characterizing PTP Equipment
  - (1) Grandmaster clock (traditional metrics)
  - (2) Transparent clock (packet metrics)
  - (3) Boundary clock #1 "Good" (time and frequency packet metrics)
  - (4) Boundary clock #2 "Marginal"
  - (5) Boundary clock #3 "Unstable"

- Characterizing NTP Equipment
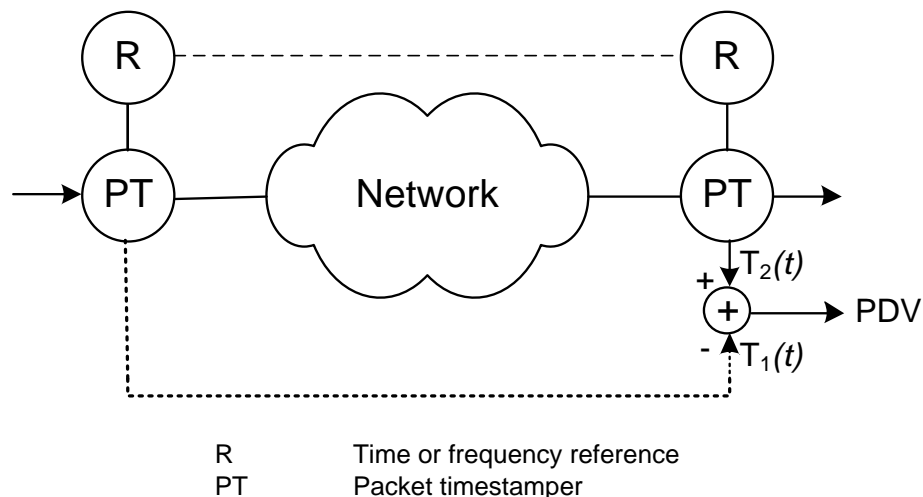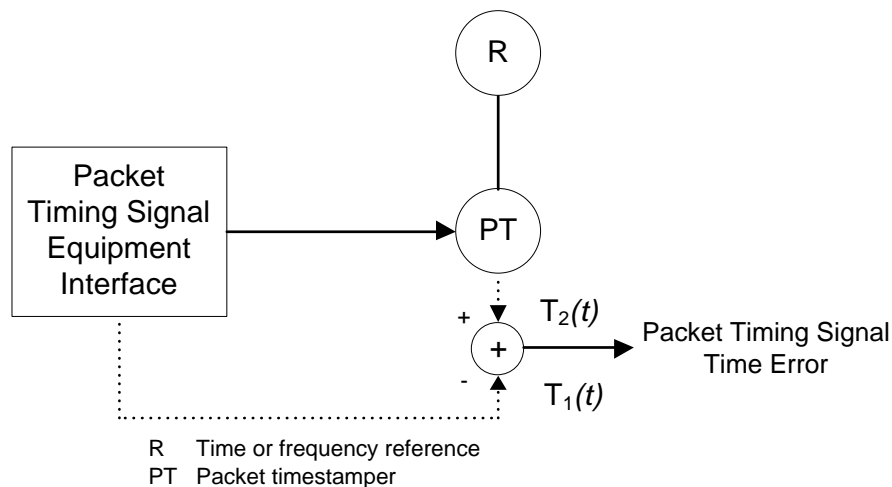 - (1) NTP server

- Conclusions

Packet Probe

Network PDV Measurement

PTP/NTP Equipment Characterization

Packet Probe (G.8260 View)

Network PDV Measurement

R   Time or frequency reference
PT   Packet timestamper
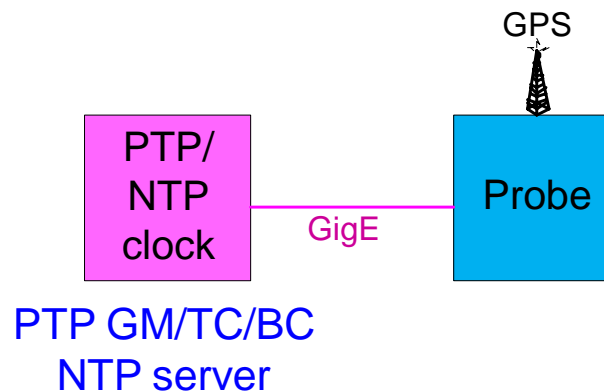
Packet Equipment Characterization
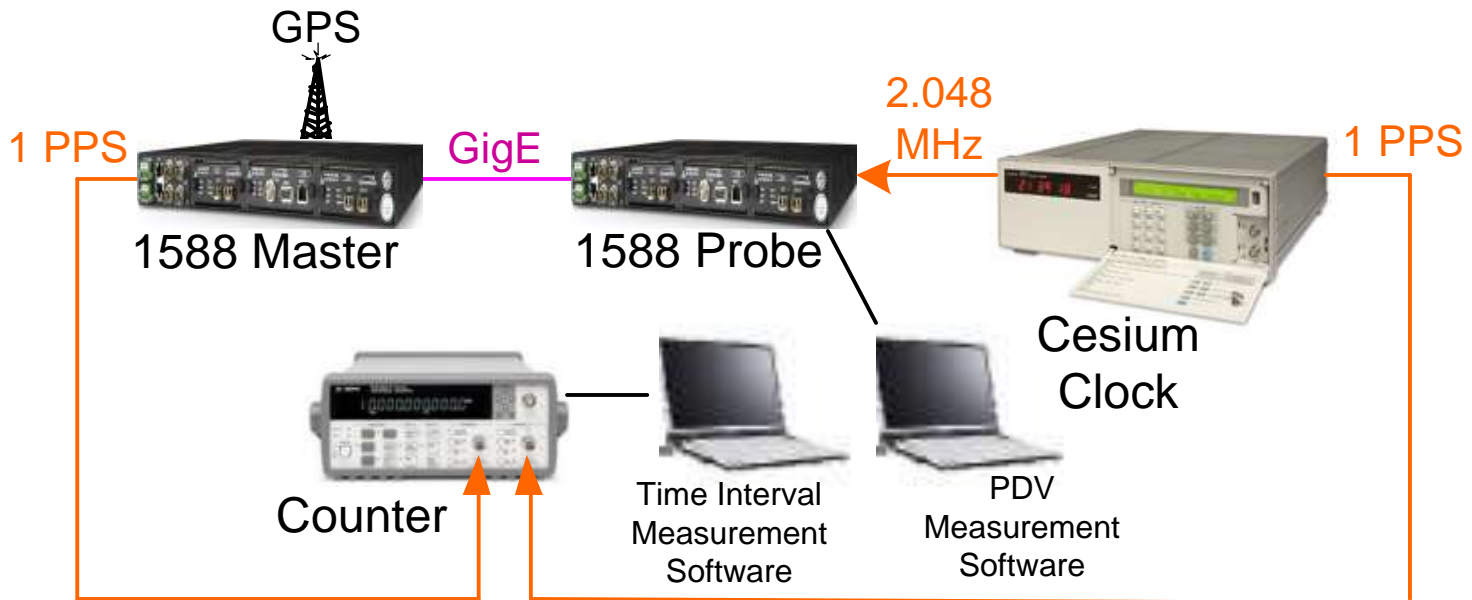

R   Time or frequency reference
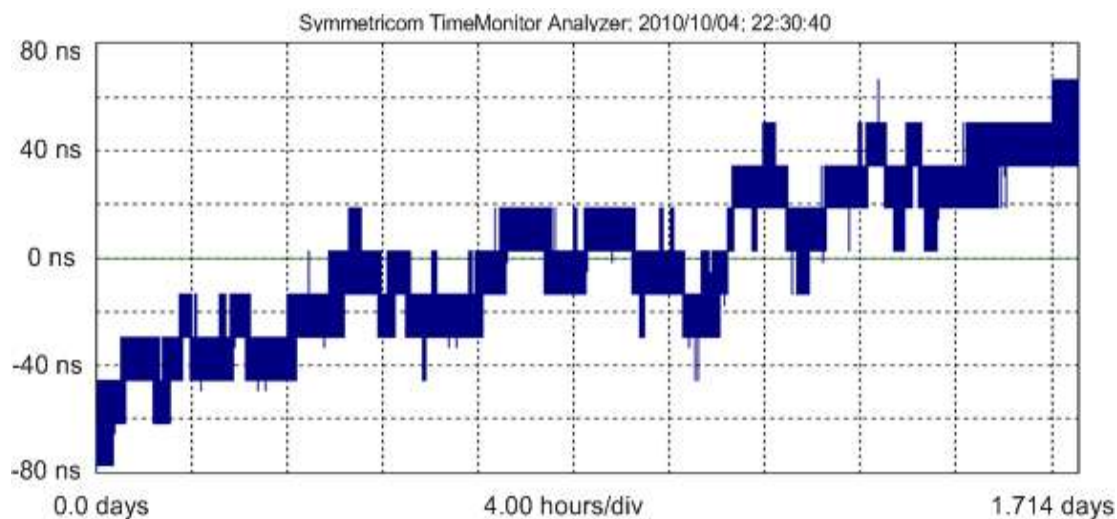PT   Packet timestamper

Metrics

- Traditional Clock Metrics
  - ADEV, TDEV, MTIE
  - Traditionally applied to oscillators, synchronization interfaces

- Frequency Transport Packet Metrics
  - minTDEV, MAFE, MATIE
  - Applied to one-way packet delay data

- Time Transport Packet Metrics
  - minOffset, minTDISP
  - Applied to two-way packet delay data
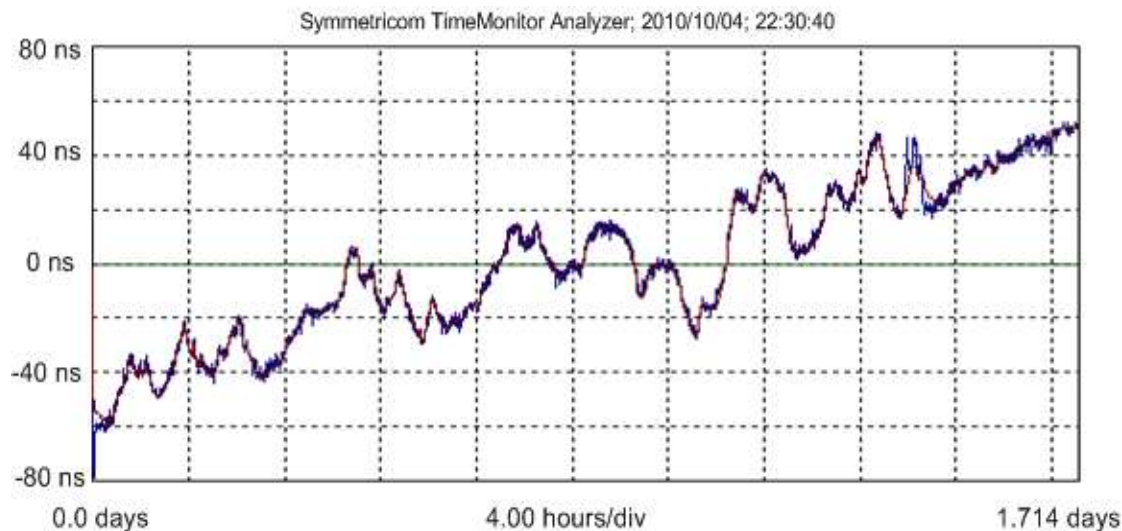 - Assesses link asymmetry

Grandmaster Measurement Setup

GPS

1 PPS

GigE

2.048 MHz

1 PPS

1588 Master

1588 Probe

Cesium Clock

Counter

Time Interval Measurement Software

PDV Measurement Software

Grandmaster Clock

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

Raw unfiltered probe measurement

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

Overlay of filtered probe and 1PPS measurement

Grandmaster Clock

Traditional Metrics Applied to Filtered Probe Measurement

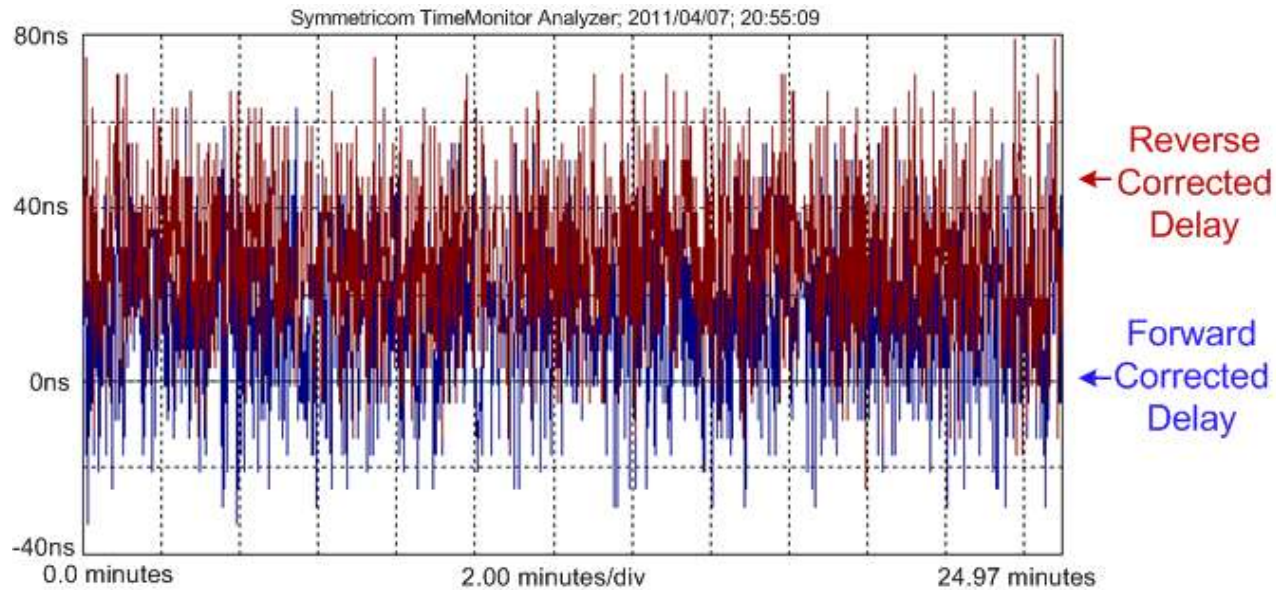Symmetricom TimeMonitor Analyzer; 2010/10/04; 22:30:40

MTIE below G.811 PRC mask

TDEV below G.811 PRC mask
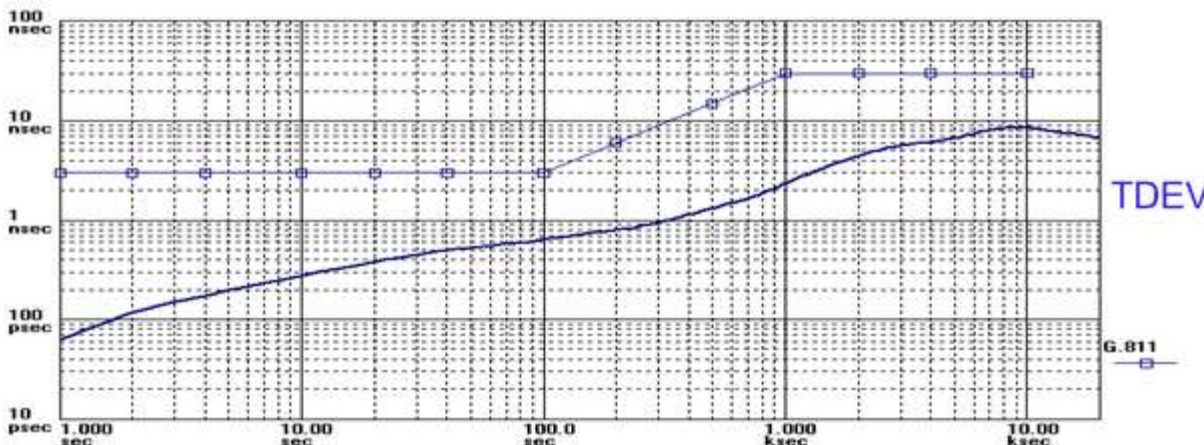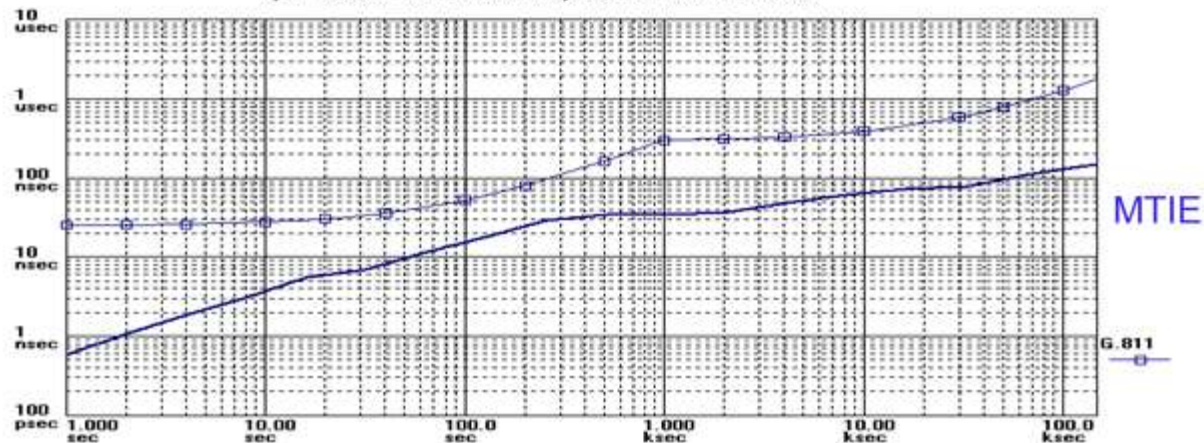
Transparent Clock Measurement Setup

1588 Master

1588 Probe

FE

FE

Cesium Clock

PDV Measurement Software

Transparent Clock
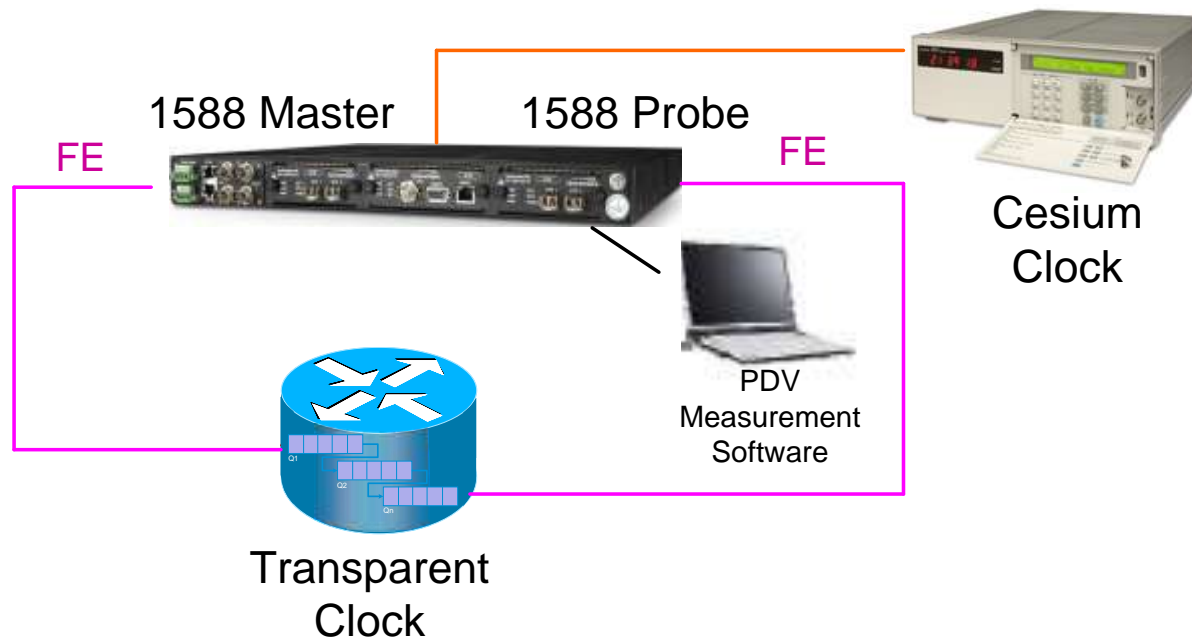
Transparent Clock

Forward Measured Delay and Correction Field Match
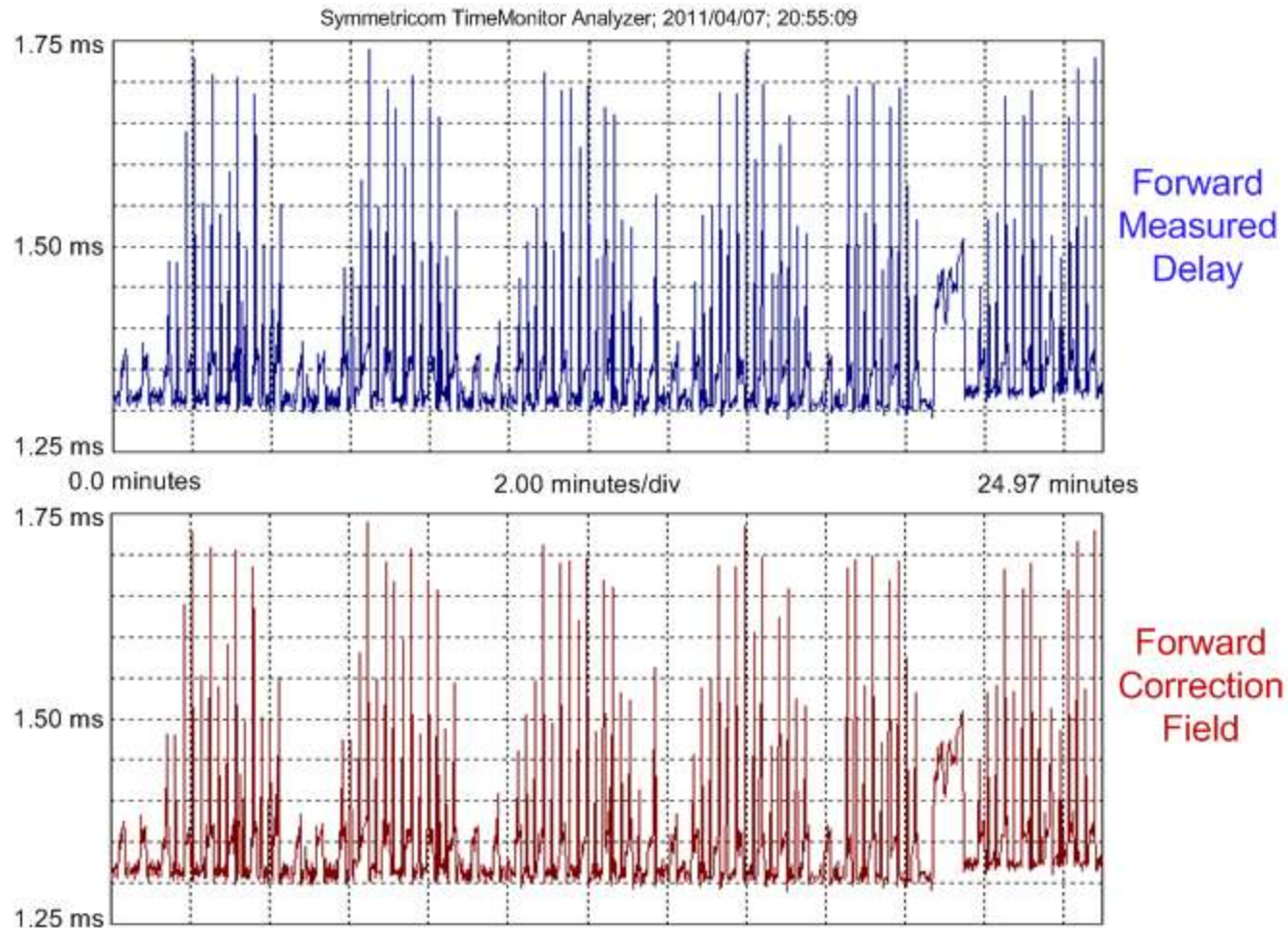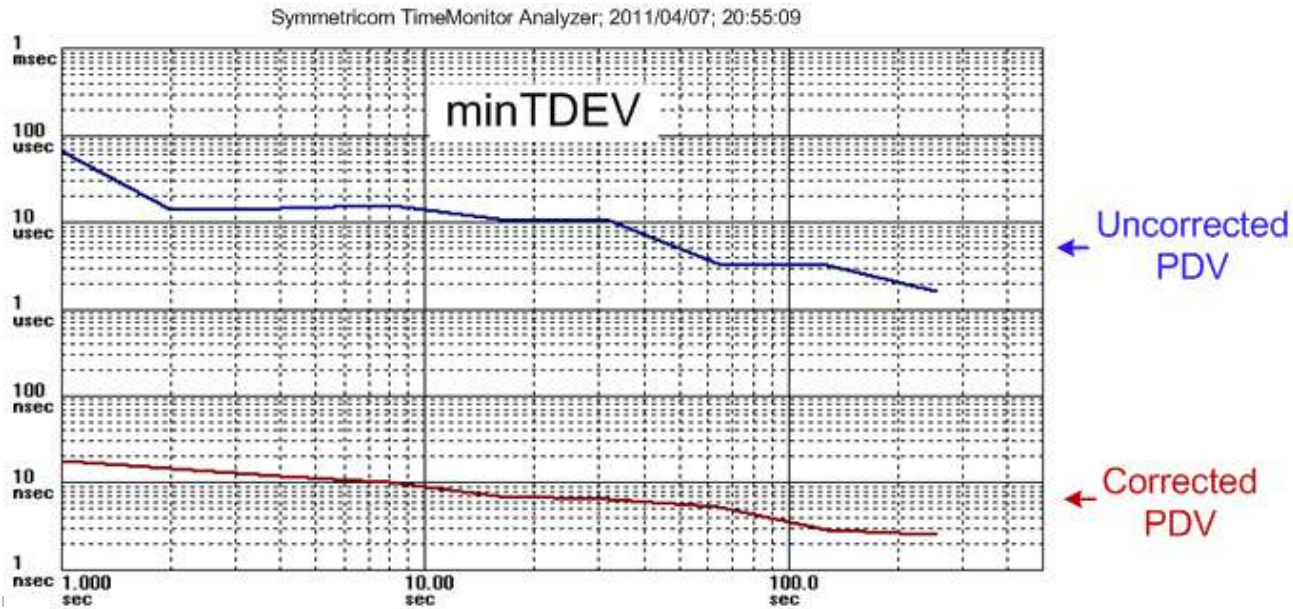
Transparent Clock

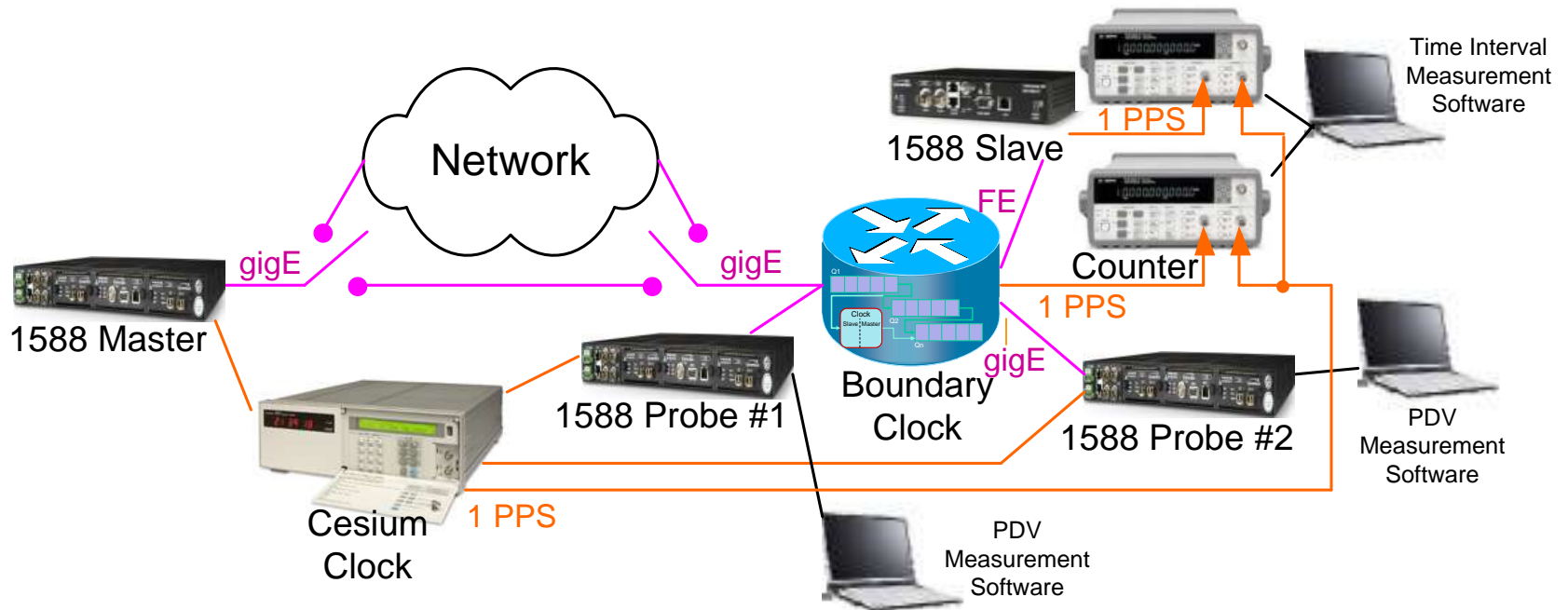## Reverse Measured Delay and Correction Field Match
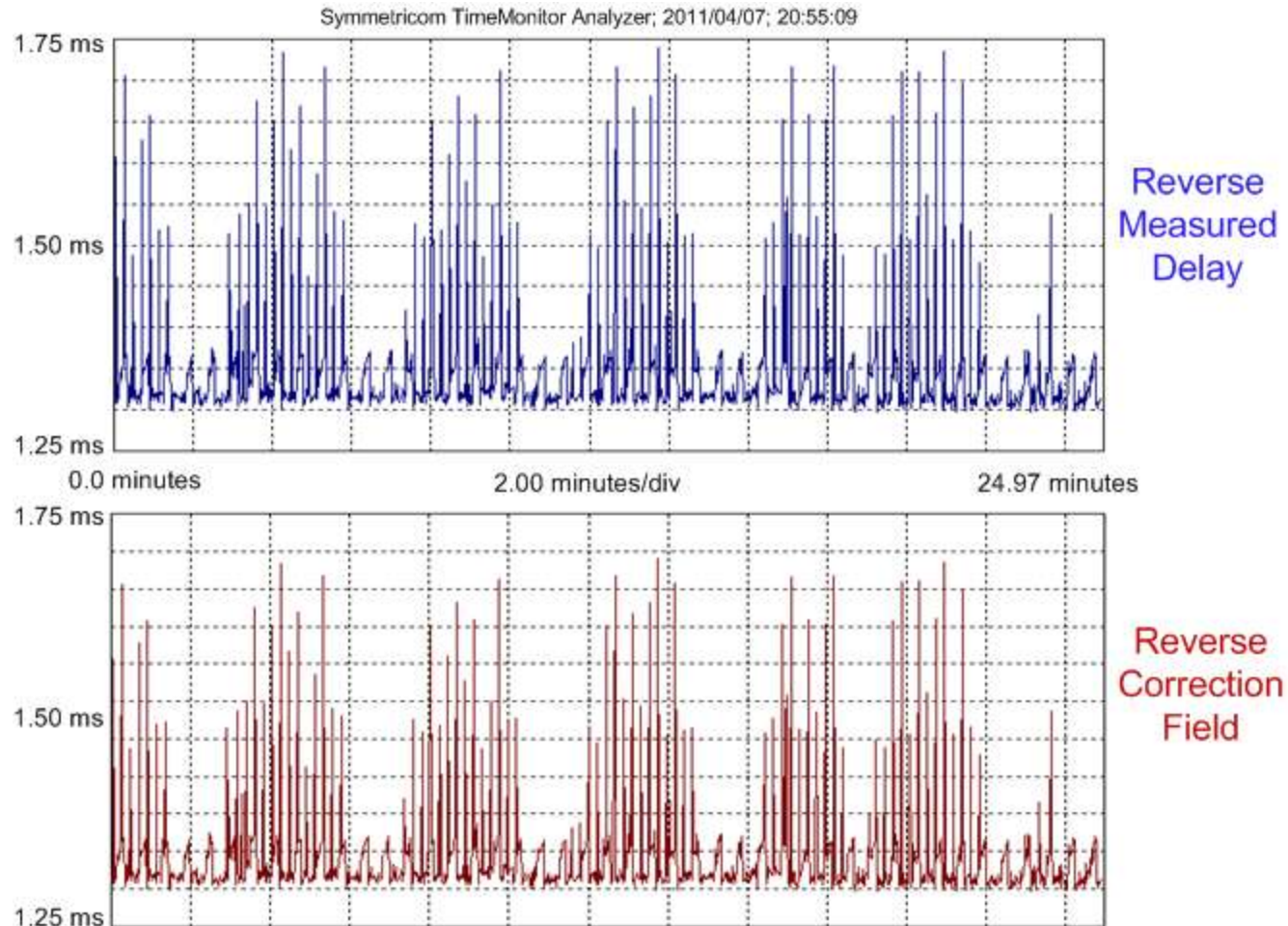
Transparent Clock

TC correction reduces "ms" to "ns"
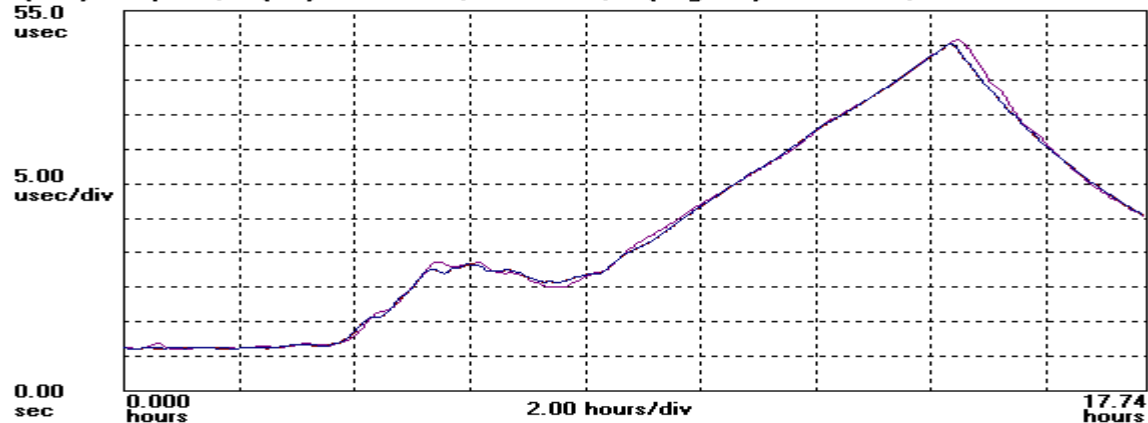
TC correction reduces minTDEV 3 orders of magnitude
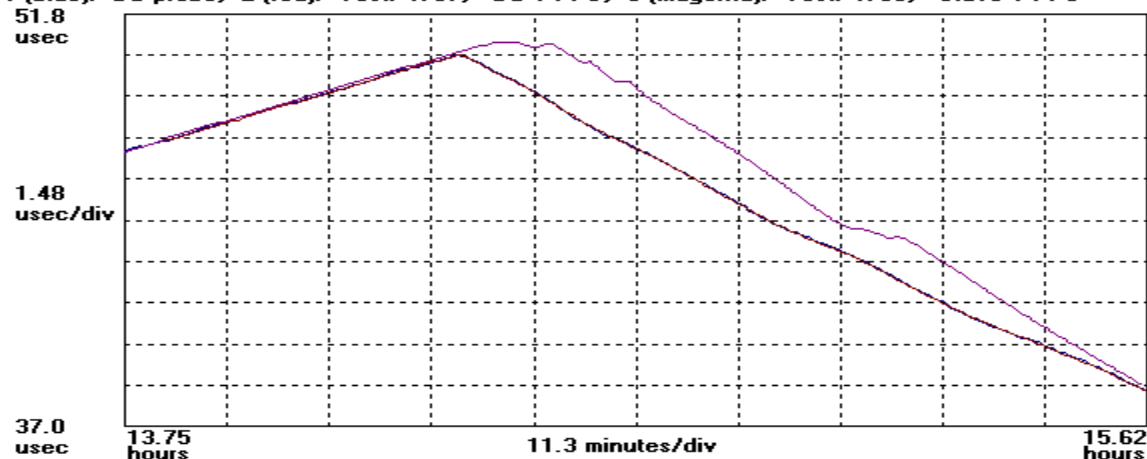
Boundary Clock Measurement Setup

Boundary Clock

Boundary Clock Measurement: 3 Approaches
(1) Packet probe; (2) BC 1PPS; (3) Connected slave 1PPS

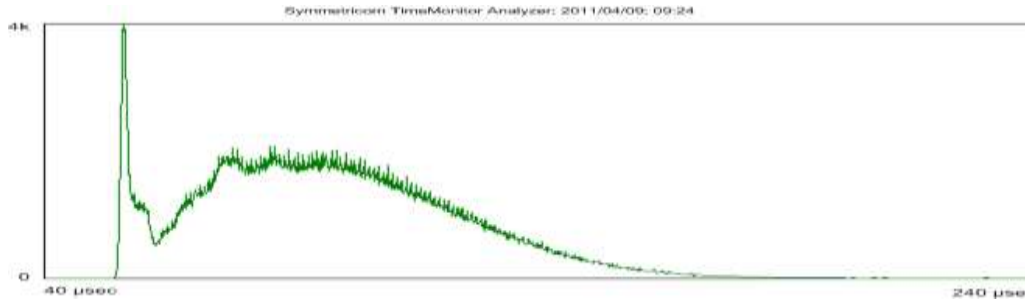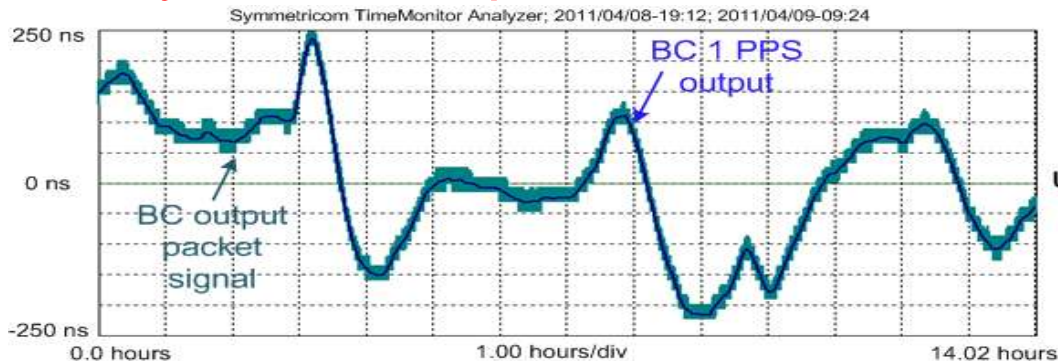# Boundary Clock #1

Boundary Clock Input/Output Probe Measurements
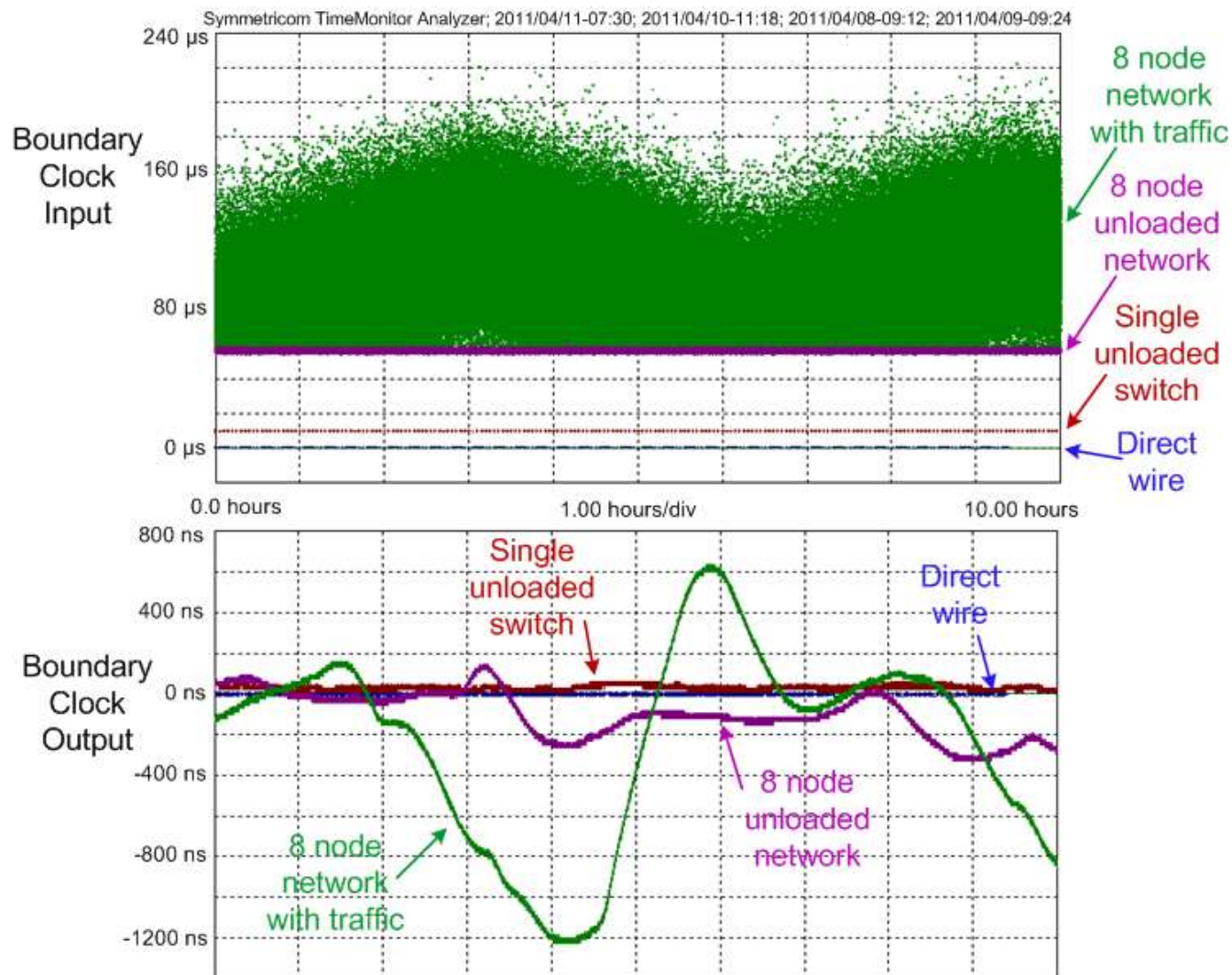
8 Node Network w/ Traffic Input PDV Histogram

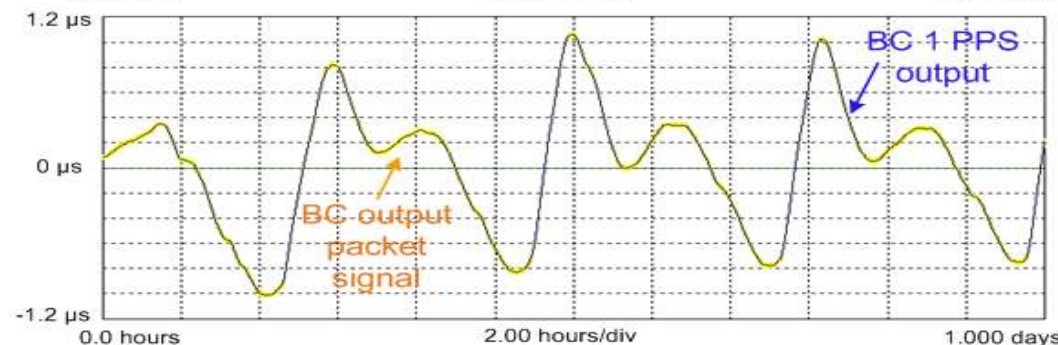Most of the PDV data is at the floor

Boundary Clock Output Probe/1PPS Measurements

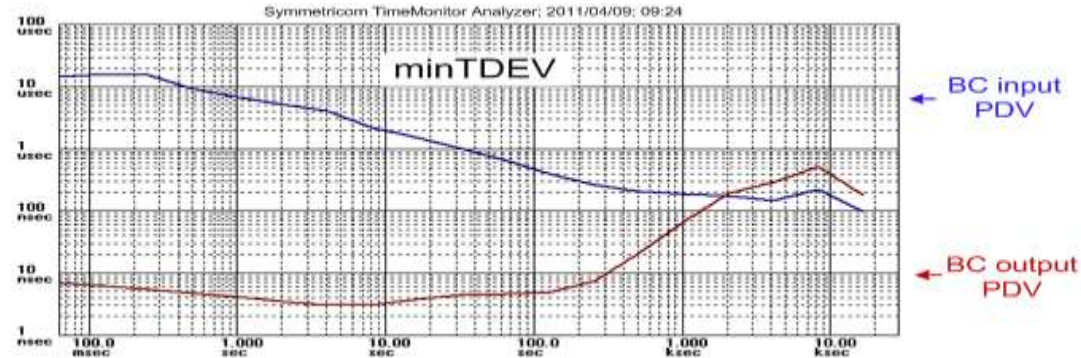**Symmetricom**
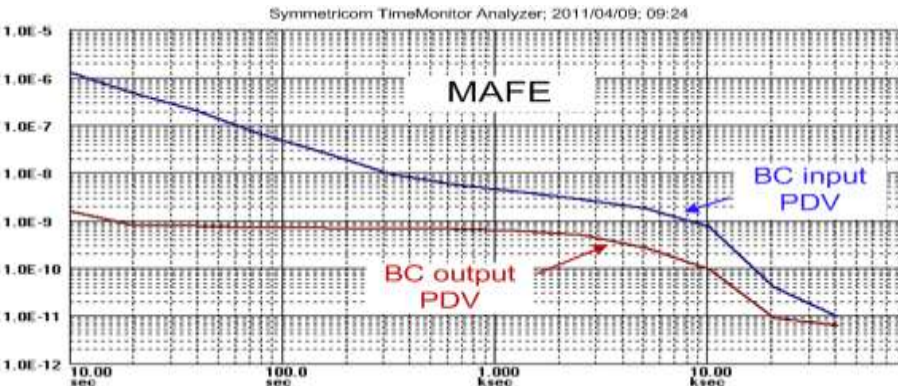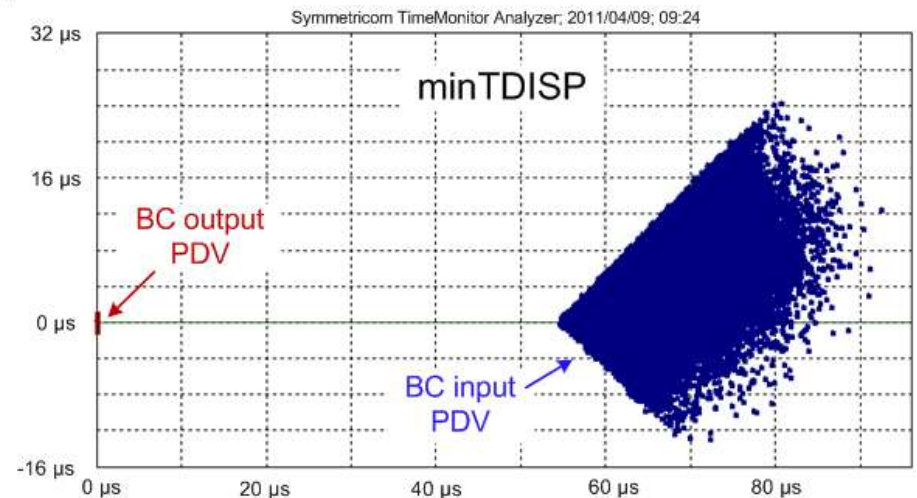
BC minTDEV & MAFE
Transfer Characteristics

Boundary Clock
Two-way Metric
Transfer
Characteristic

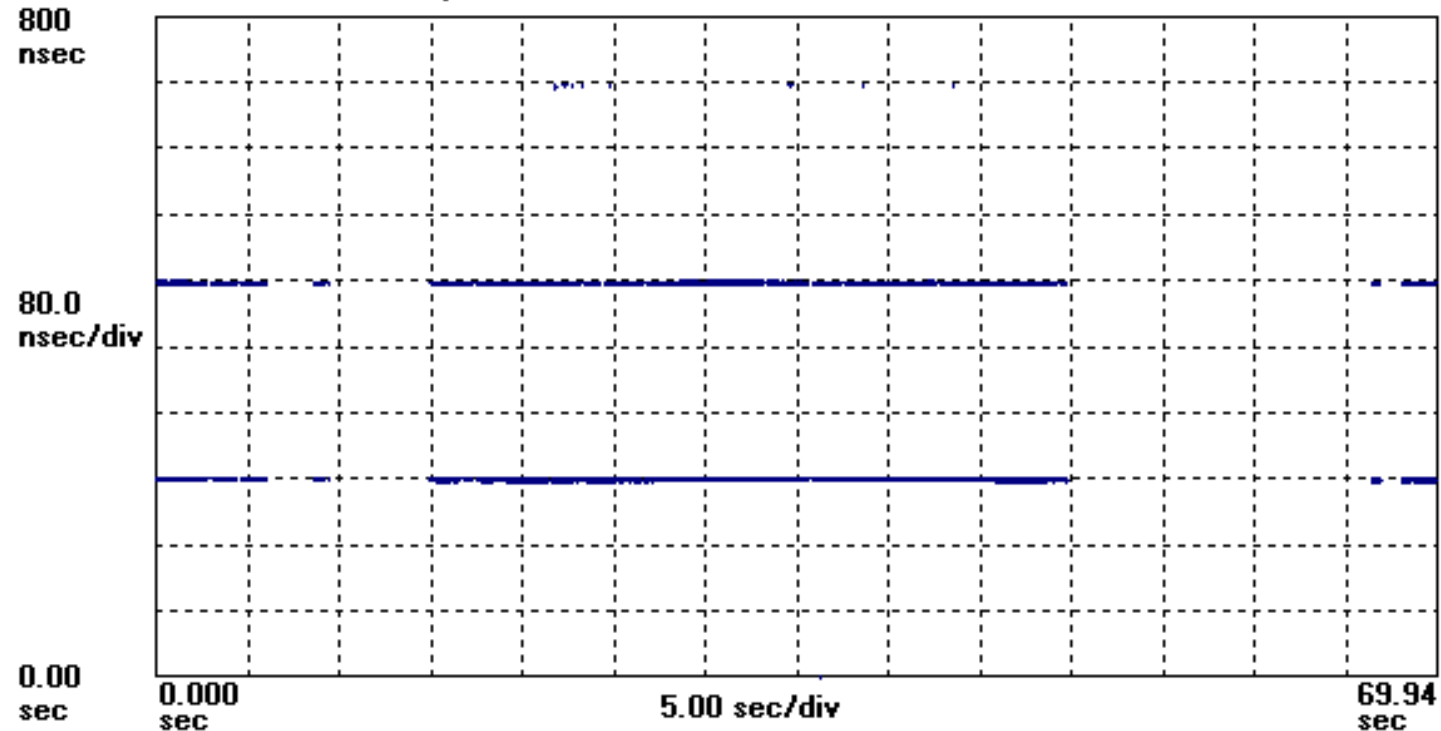BC output is
at the origin:
Indicates network
path symmetry

Boundary Clock #2

Probe shows 240ns BC timestamp quantization

Symmetricom TimeMonitor Analyzer
Phase deviation in units of time; Fs=40.34 Hz; Fo=10.000000 MHz; 1970/01/05 19:52:04
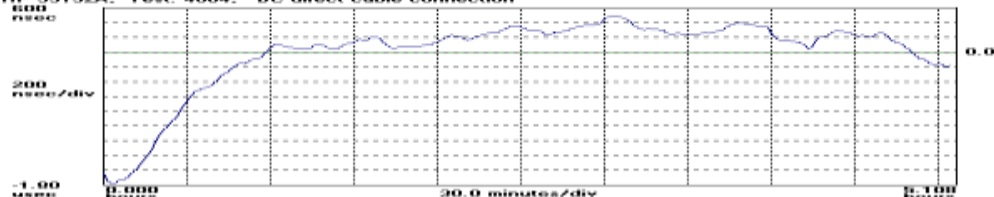TP5000 Fwd PDV Phase; Samples: 2822; BC direct cable connected

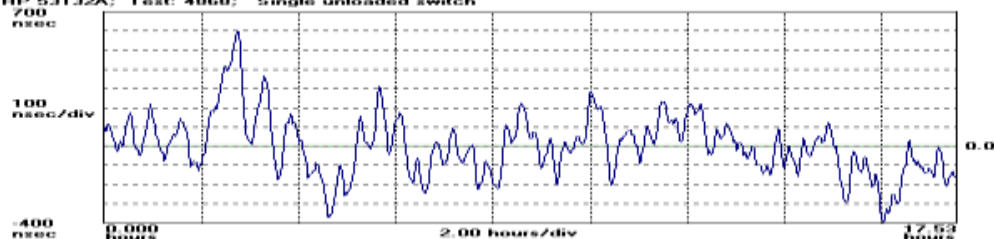The approach of measuring a BC 1PPS or frequency signal is preferred in this case

Boundary Clock #2

Direct cable: 1.8 µs p-p
(167 ns p-p after 1 hour)

Single unloaded switch:
1.0 µs p-p
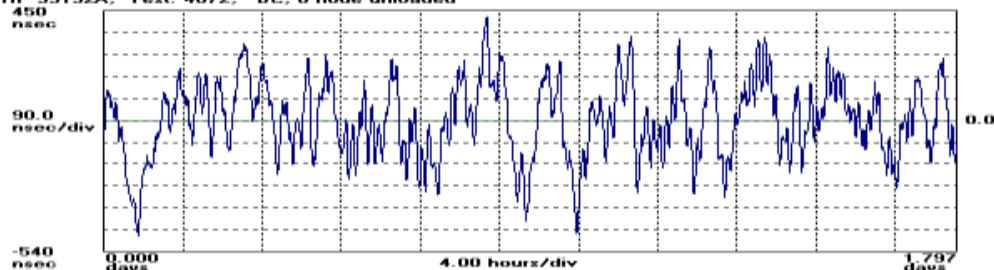
8-node unloaded network:
900 ns p-p
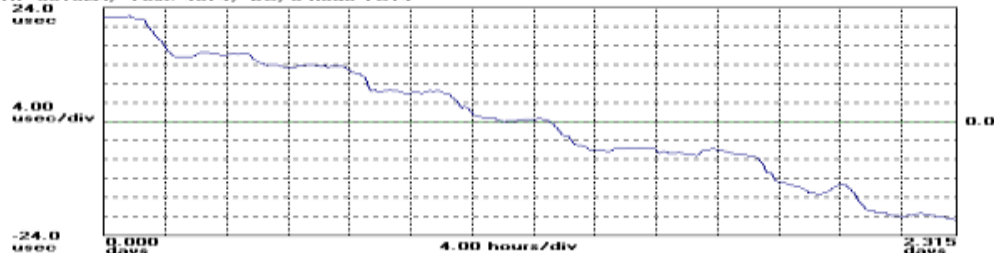
8-node loaded network:
80 µs p-p; -1.7 E-10 freq offset

Large Movement in the Output with Direct Cable Input

Symmetricom TimeMonitor Analyzer
Phase deviation in units of time; Fs=249.9 mHz; Fo=1.0000000 Hz; *4/28/2011 7:59:48 AM*; *6/3/2011 1:24:46 PM*;
HP 53132A; Test: 4809; BC; 1PPS; Samples: 782198
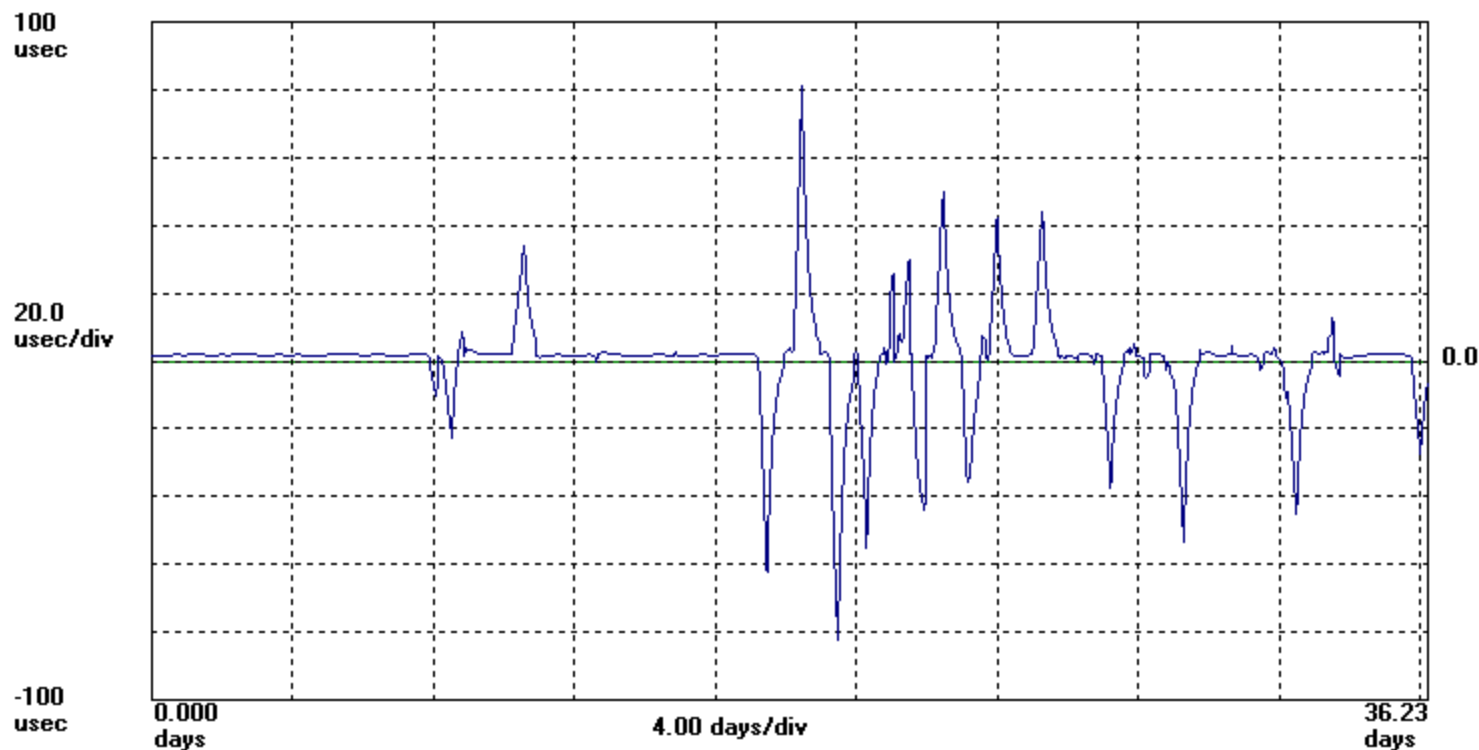
<10 ns p-p at the input

>160µs p-p at the output

Boundary Clock Comparison

Loaded 8-node network

Symmetricom TimeMonitor Analyzer
MTIE; Fo=1.000 Hz; Fs=498.9 mHz; 2011/04/09; 09:24:40

BC #3

102µs @24h

BC #2

32µs @24h

1.6µs @24h

BC #1

NTP Server Measurement Setup

GigE

2.048 MHz

NTP Server

NTP Probe

PDV Measurement Software

Cesium Clock
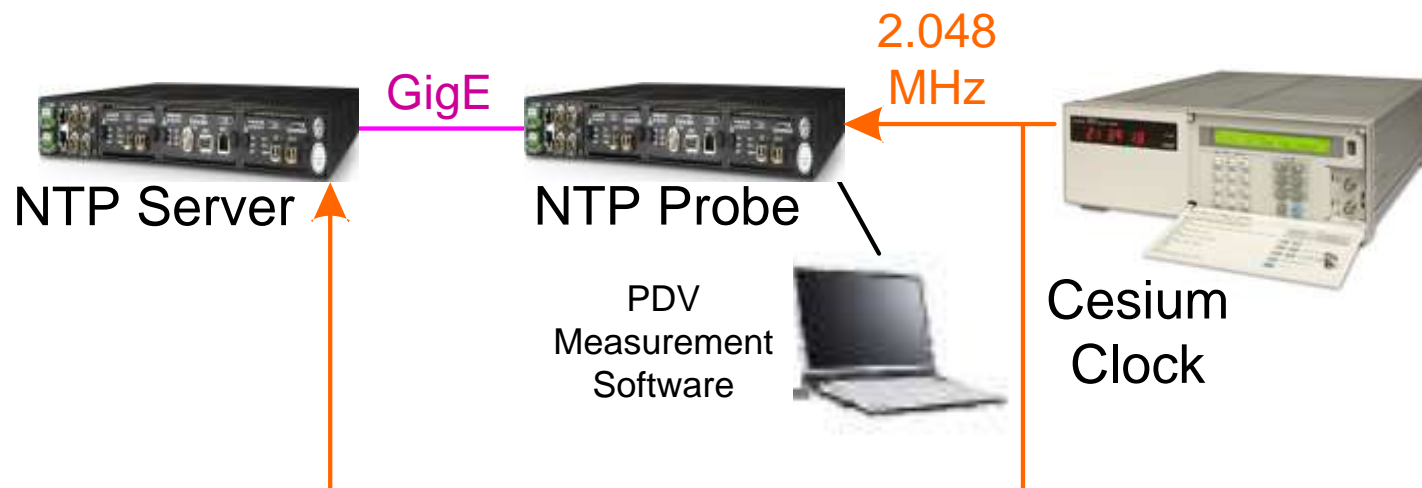
NTP Server

Checking NTP Server Timestamp Quantization

Symmetricom TimeMonitor Analyzer
Phase deviation in units of time;   Fs=64.00 Hz; Fo=10.000000 MHz; 2011/10/25 18:02:52
TP5000 NTP Fwd PDV Phase; Samples: 20865; Start: 2; Initial phase offset: -7.91624 nsec; Eth1 to Eth2 lo
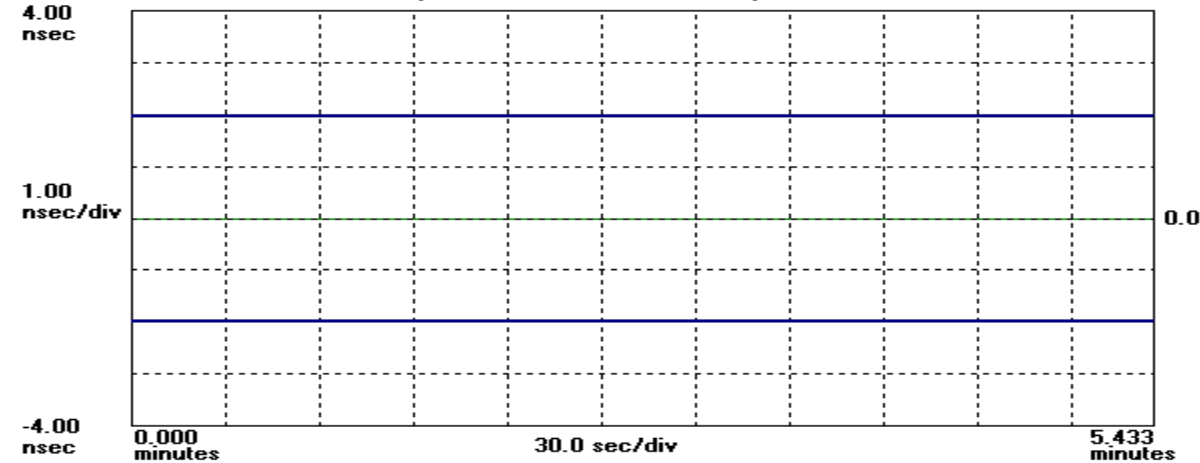
5 minute measurement shows 4ns quantization (GigE fiber)

Symmetricom TimeMonitor Analyzer
Phase deviation in units of time;   Fs=64.00 Hz; Fo=10.000000 MHz; 2011/10/25 18:02:52
TP5000 NTP Fwd PDV Phase; Samples: 20865; Start: 2; Initial phase offset: -7.91624 nsec; Eth1 to Eth2 lo
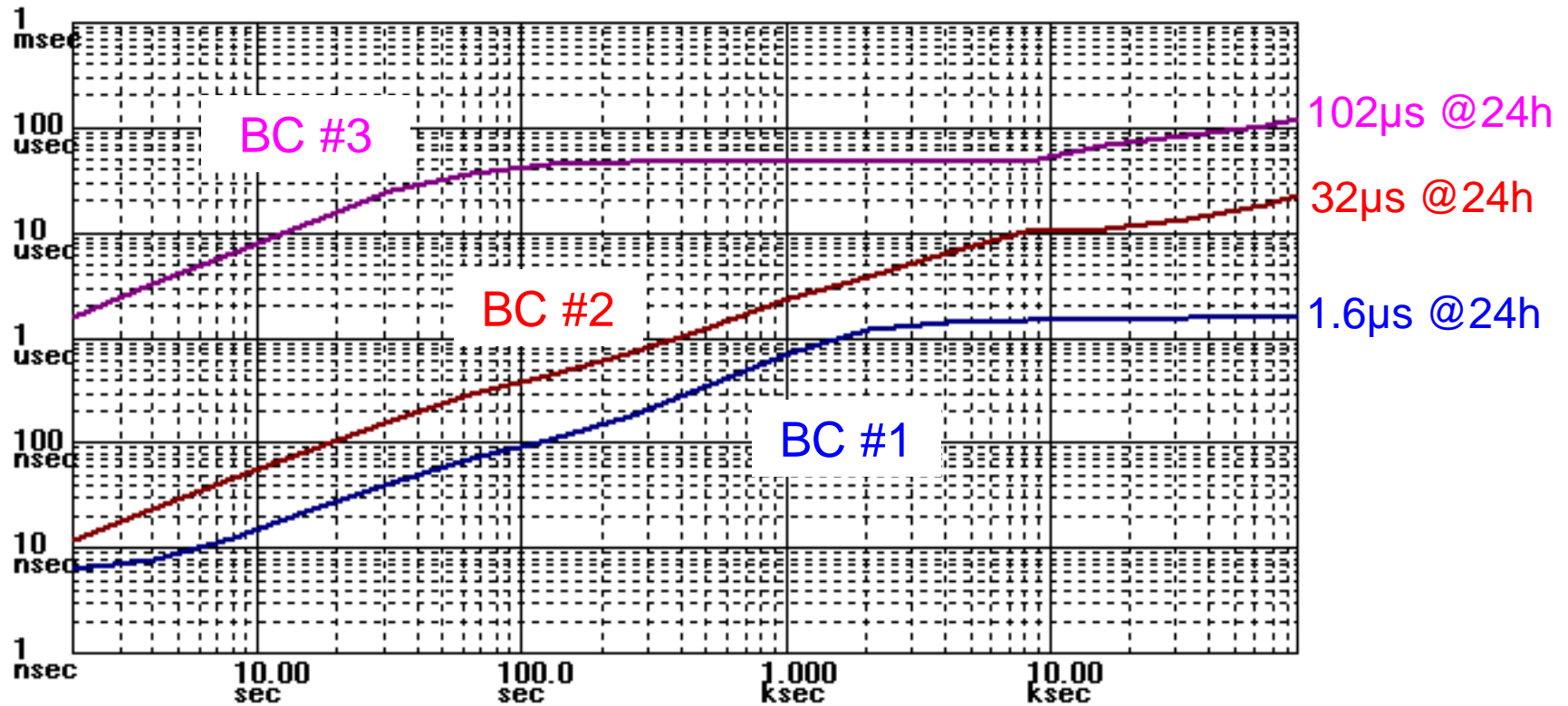
Zoom shows individual measurement samples

NTP Server

Symmetricom

GigE Copper vs. Fiber

Symmetricom TimeMonitor Analyzer
Phase deviation in units of time; Fs=2.000 Hz; Fo=10.000000 MHz; 2011/10/25 18:57:28
Two-Way Fwd/Rev PDV Phase; Samples: 168; TP5k#1 NTP server TP5k#3 NTP probe copper; ServerIP: 1(
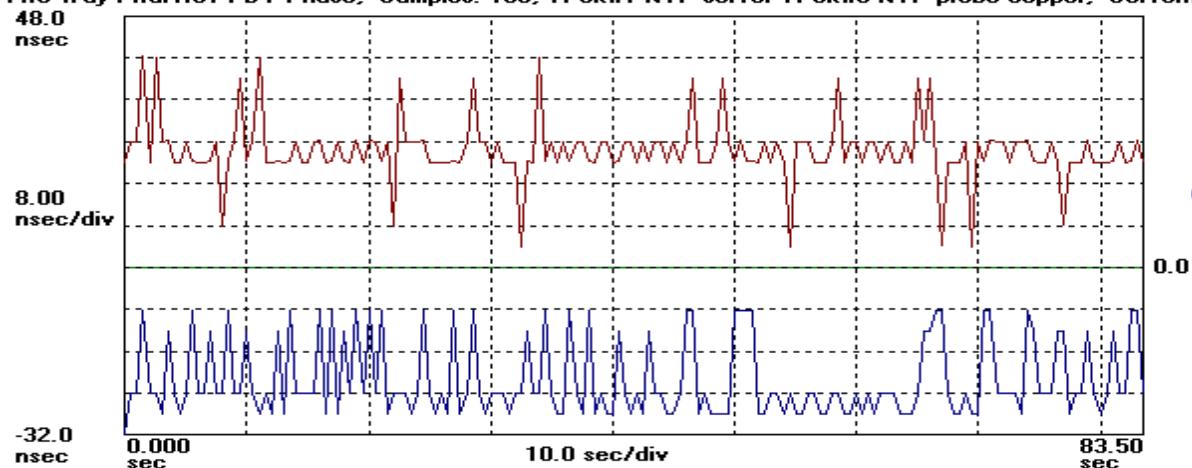
GigE copper 20 to 30 ns p-p
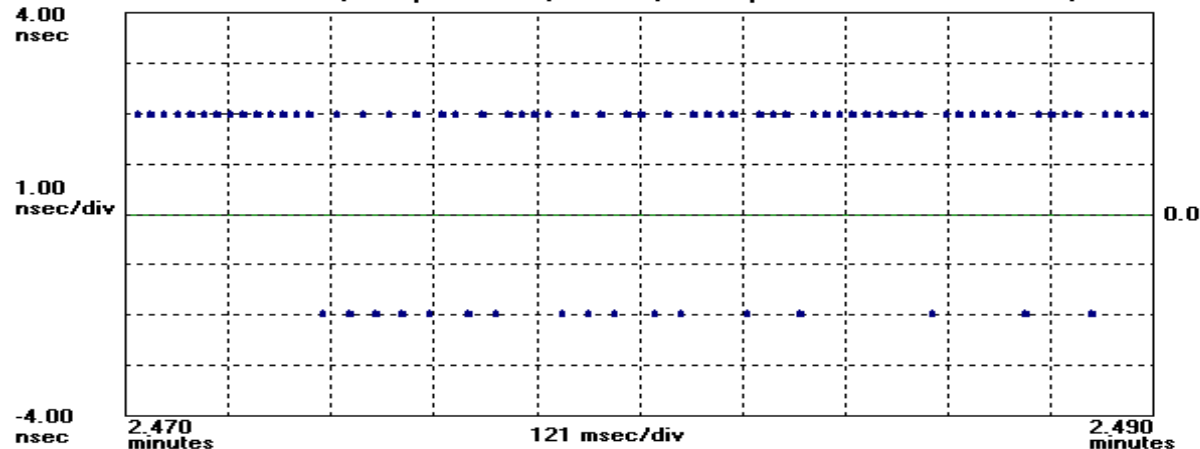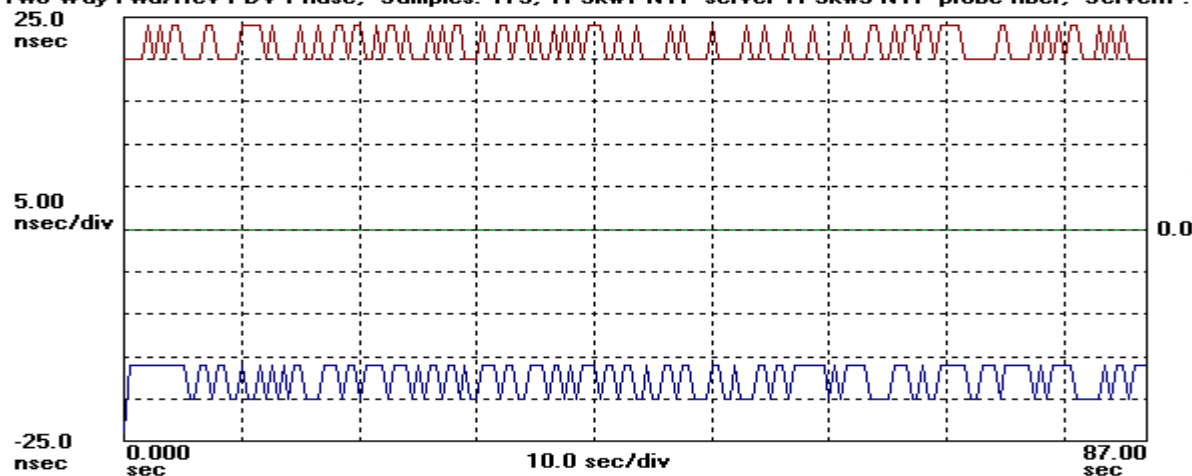
Symmetricom TimeMonitor Analyzer
Phase deviation in units of time; Fs=2.000 Hz; Fo=10.000000 MHz; 2011/10/25 19:03:25
Two-Way Fwd/Rev PDV Phase; Samples: 175; TP5k#1 NTP server TP5k#3 NTP probe fiber; ServerIP: 10.1

GigE fiber 4 ns p-p

NTP Server

NTP server: Holdover 2.5 days

Symmetricom TimeMonitor Analyzer   (file=probe3-2011_10_26--10_30.txt)
Phase deviation in units of time;   Fs=1.000 Hz; Fo=10.000000 MHz; 2011/10/26; 17:30:26
1 (blue): Time Phase; Samples: 225298; Stop: 225298; NTP server 4 days; 2011/10/26; 17:30:26; 5 (cyan)
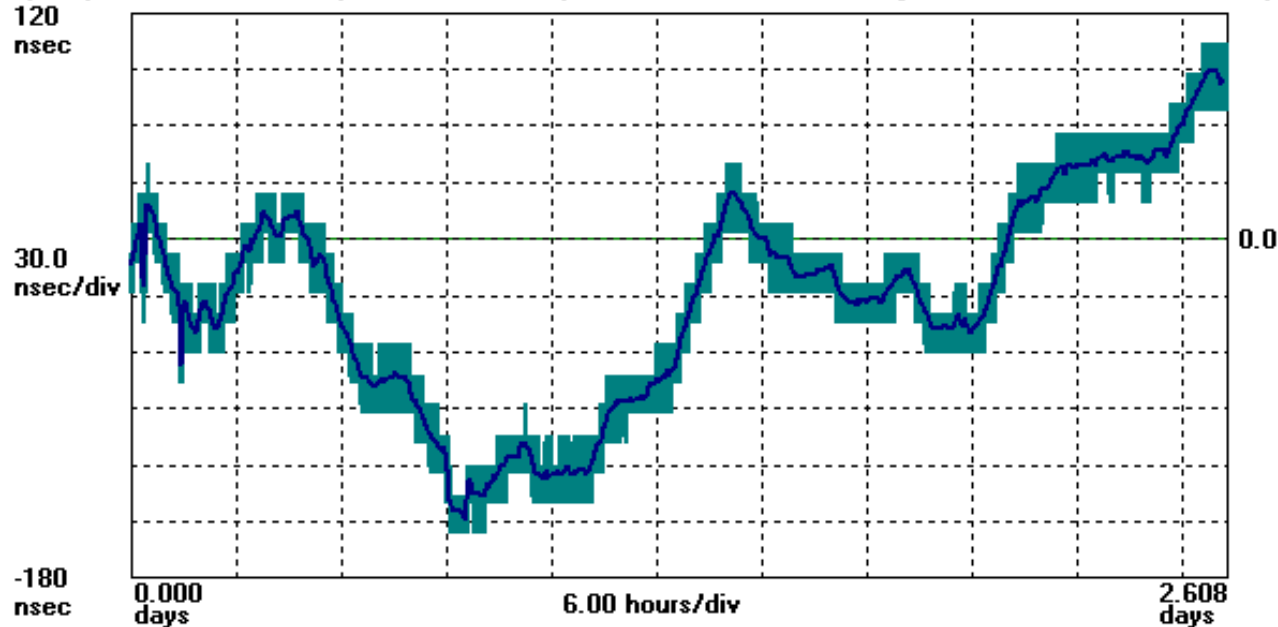
Cyan: Unfiltered packet signal
Blue: Filtered packet signal (running average)

Summary

- PTP and NTP probes are useful both for (1) studying network PDV and for (2) studying packet equipment

- Packet equipment performance varies considerably (BC#1, BC#2, BC#3)

- Traditional metrics can be applied to packet data
  - Grandmaster clock and NTP server characterization

- Packet metrics are important for:
  - (1) Network PDV
  - (2) Characterizing GM,TC,BC,NTP equipment

- Analogous to traditional metrics:
  - (1) Network synchronization interface analysis
  - (2) Oscillator and synchronization equipment characterization

Thank You

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