Power Matters

Securing GNSS with PTP & SyncE

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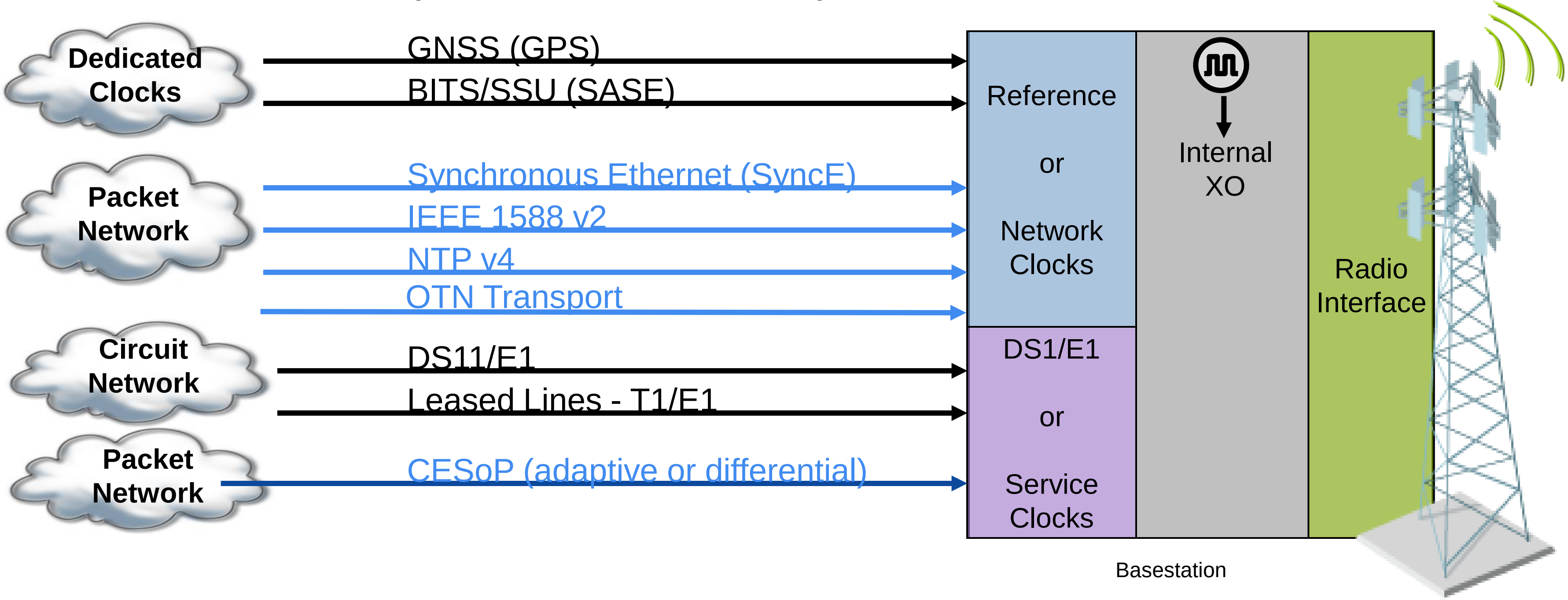
Introduction

- Base stations and other end nodes need reliable synchronization
- Typically GPS was used in the United States, but other technologies can be used to augment or replace GNSS during an interruption
- Time distribution in a node shown in APTSC model
  - Use of GNSS as primary source of time and frequency
  - Backup with SyncE for frequency
  - Backup with PTP for time and frequency
    - PTP Network Monitoring to prepare for GNSS outage
- Example performance
  - Switching between GNSS, PTP and SyncE
  - Frequency transfer over SyncE

Overview of Synchronization Sources

- Equipment will have a variety of input synchronization sources
  - Traditional Electrical: DS1/E1, SONET/SDH, GNSS (GPS)
  - Next Gen. Electrical: SyncE
  - Packet: IEEE1588 (PTP)
- Synchronization sources may be used a common clock for entire node, or may only be a clock to time an individual DS1/E1
- Need to be able to synchronize to a variety of clock sources



Synchronization Sources - Failure Modes

- GNSS
  - Damage to antenna cabling or antenna
  - Local jamming
  - Full GNSS outage – bad upload of data to satellites
- PTP
  - Network outage
  - Increase in network congestion
- SyncE
  - Fiber cut/Network outage

- Note: SyncE and PTP may not have the same outage patterns due to different paths through the network

Redundancy & Reliability

- During IEEE1588 failures, SyncE enables low phase movement for long term stability
- GNSS, SyncE & PTP failures are not likely to occur at the same time
  - Reduces need for expensive oscillator during holdover as holdover periods shortened
- Multiple PTP server monitoring on diverse logical & physical paths
- PTP Slave should provide critical hitless reference switching features
  - Example references - Packet to Packet, Packet to Electrical, Electrical to Packet, Electrical to Electrical
  - Application should accept both physical layer (GNSS, SyncE) and protocol layer (IEEE1588) references

APTSC - Assisted Partial Timing Support Clock

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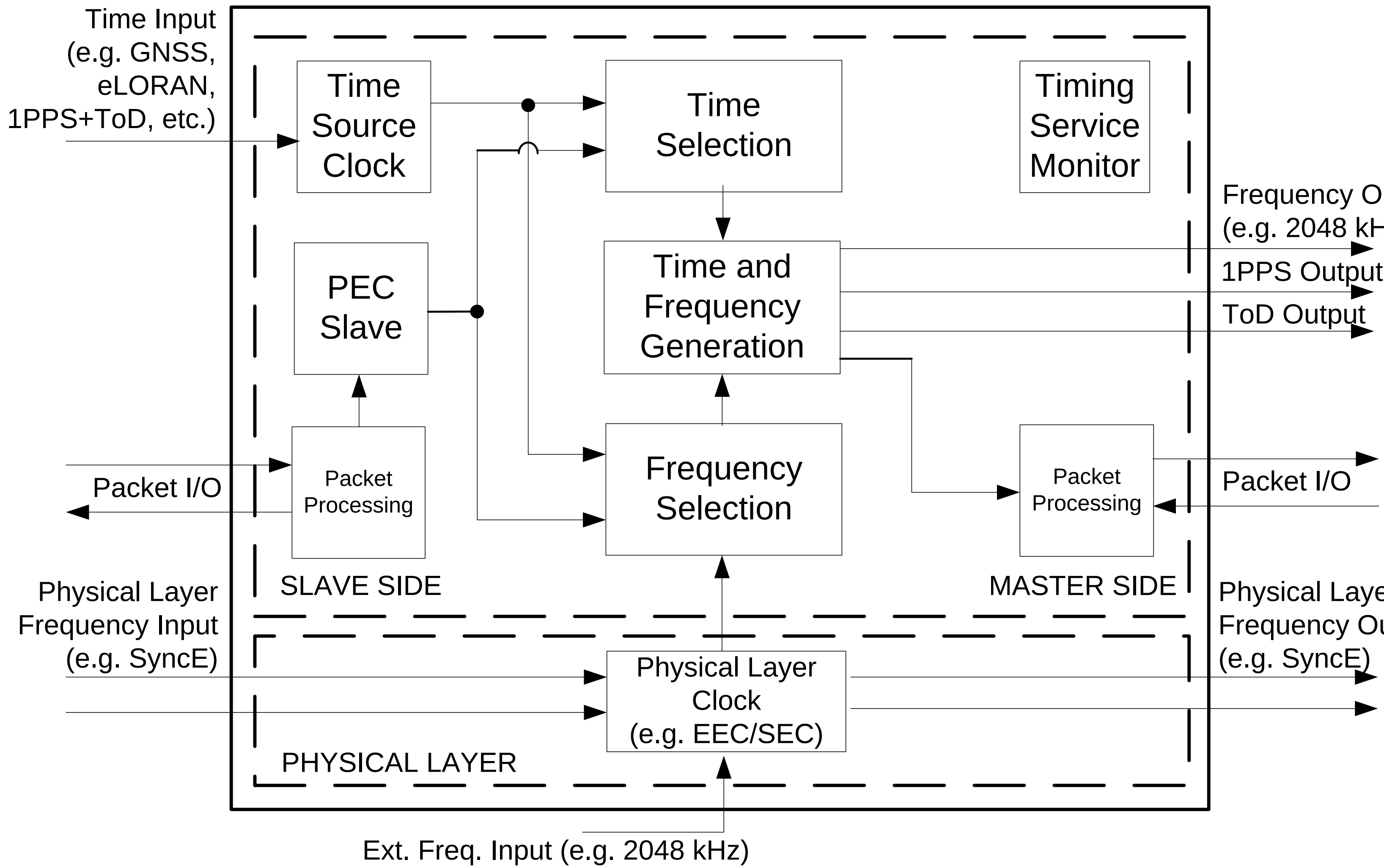
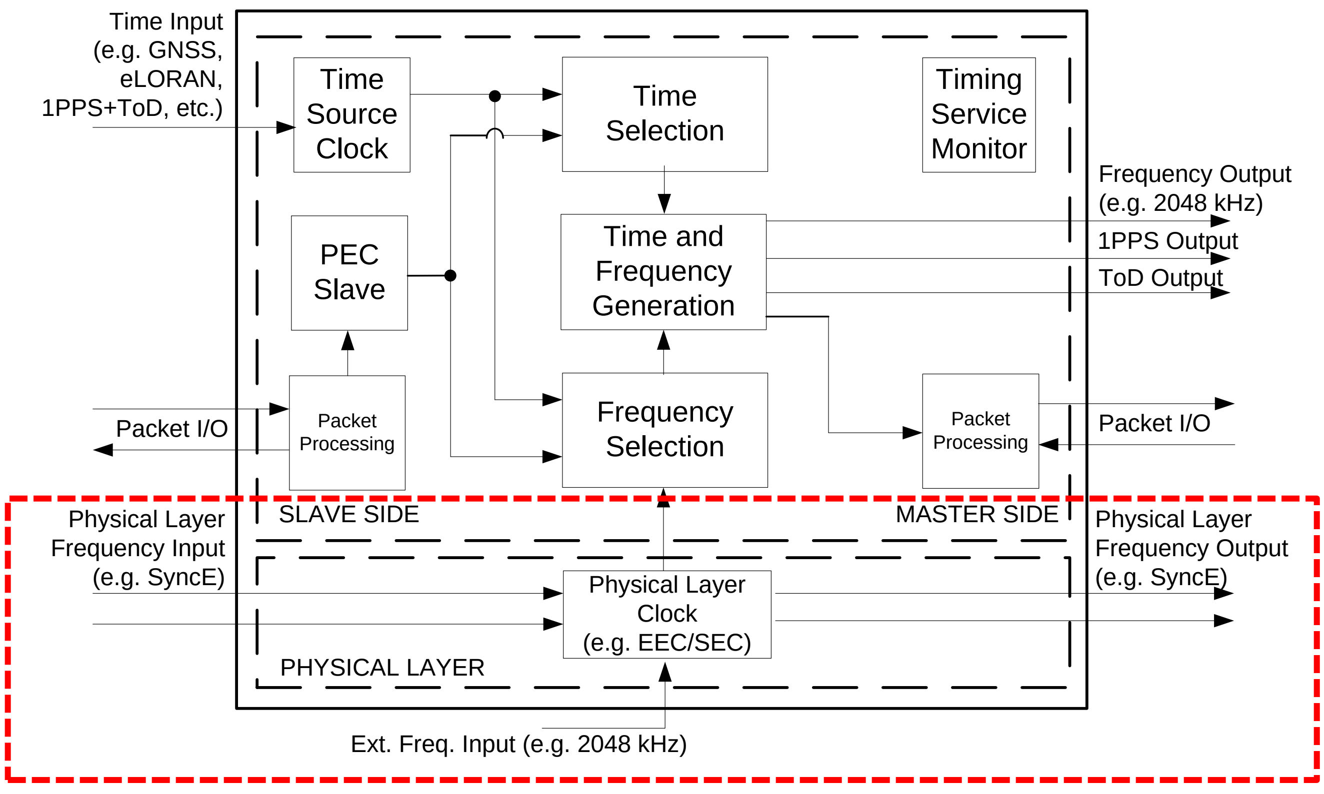
- Details of the redundant timing sources feeding a single node and their interactions
- Show clock input and outputs
- Different sources are represented
- Show path of time and frequency through the model
- Based on ITU-T COM15-C0549-E (May 2014) from Sprint
  - Contribution provided functional model for APTSC

APTSC - Modified APTSC Model



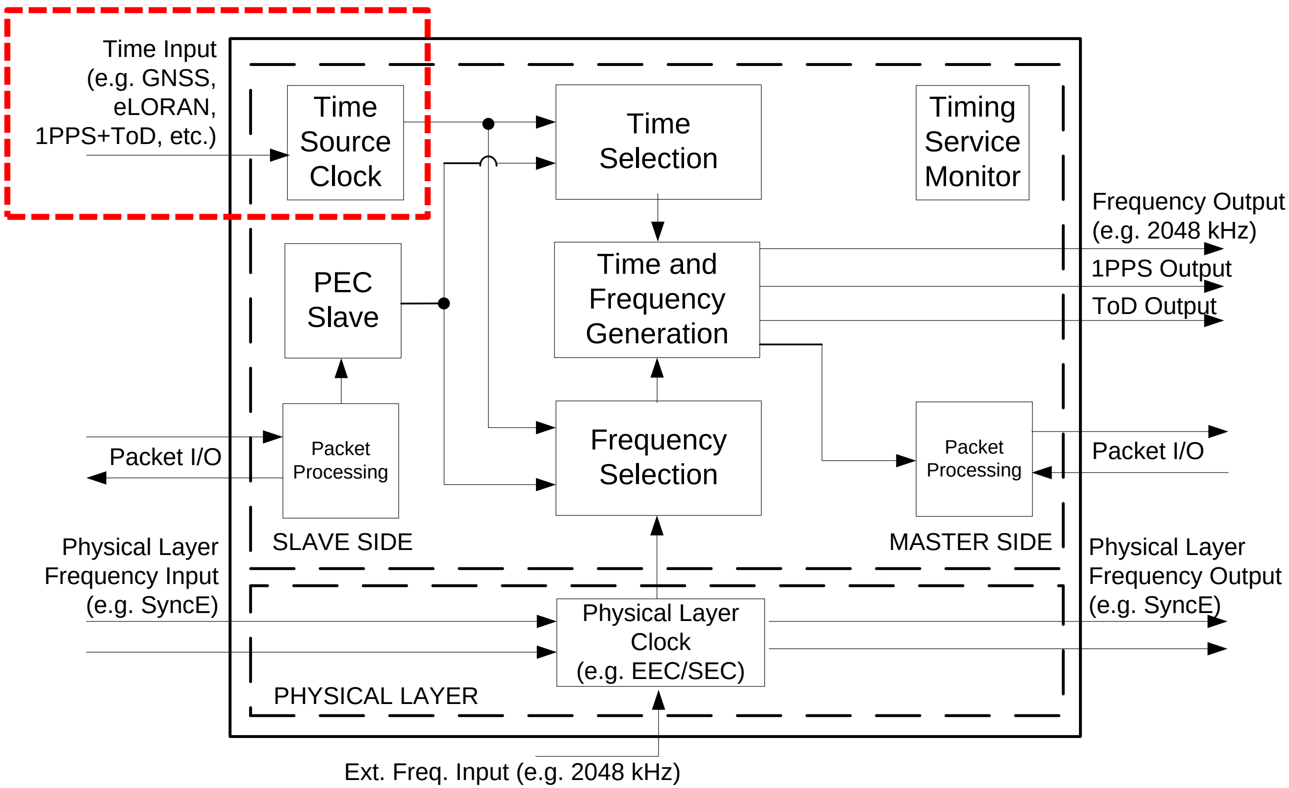
APTSC - SyncE

- SyncE frequency support for holdover
- Better than a OCXO local oscillator
- Multiple SyncE sources in most network elements



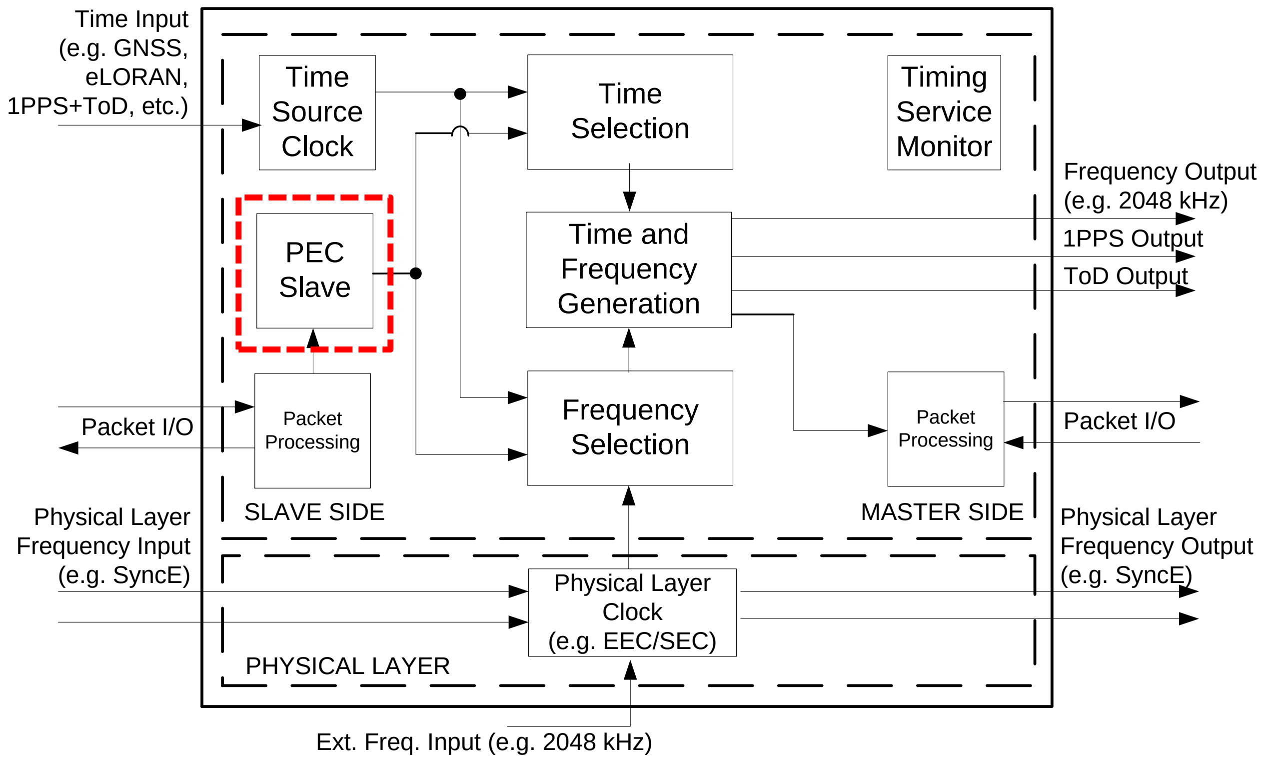
APTSC – Other time inputs

- Separate GNSS and local time inputs
  - GPS is most common, but other sources may be available in the future
  - GNSS output phase can be used to estimate the network performance to prepare for outages



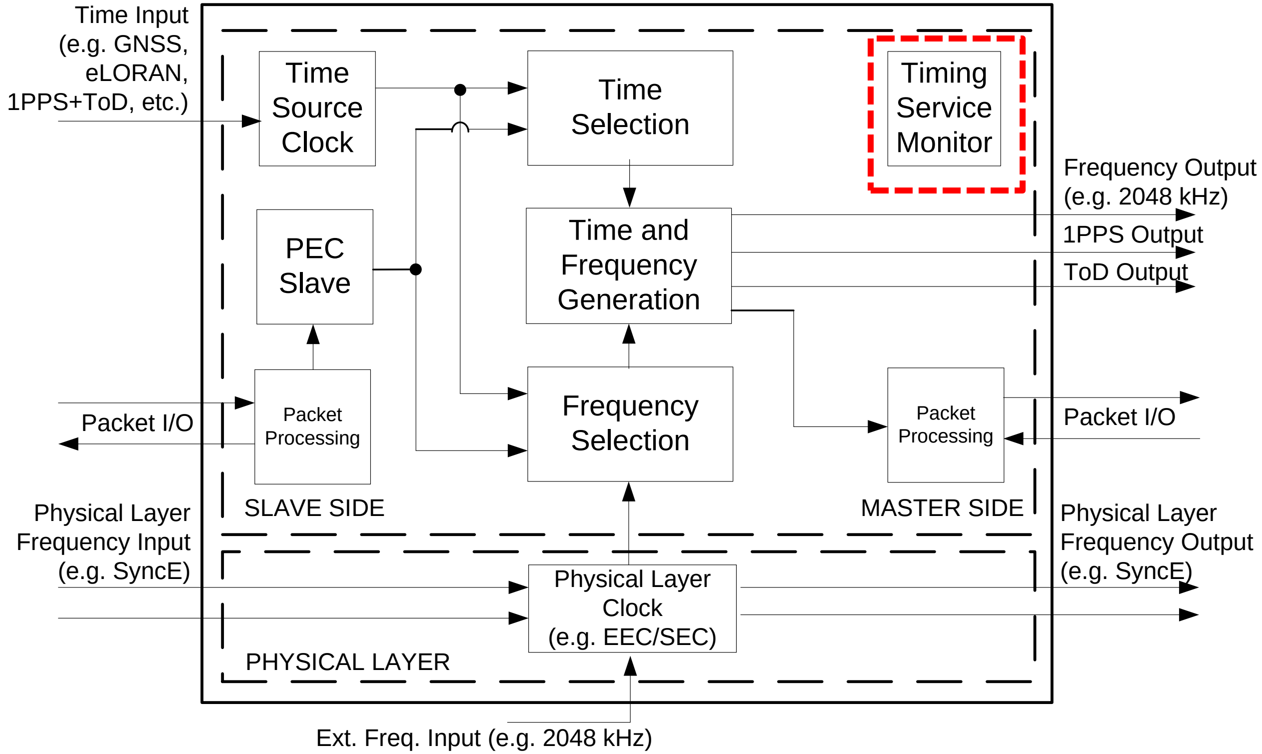
APTSC - PEC Slave

- In active PEC Slave
  - Main purpose is to output phase (and frequency)
    - Frequency transfer only when backing up GNSS
  - Needs to follow correct GM selection per profile



APTSC – PTP Monitoring

- Timing Service Monitor function for network when using GNSS – Similar to PEC Slave
  - Measure network delay and PTP performance for use during GNSS outage
  - Provide network metrics for central network monitoring



Performance monitoring

- Active PEC Slave
  - Main purpose is to output phase (and frequency)
    - Frequency only when backing up GNSS
  - Needs to follow correct GM selection per profile
- Timing Service Monitor (Monitor PEC)
  - Separate monitor allows a different GM to be used
  - Separate monitor allows the GNSS input to be used to calculate asymmetries in network
  - Separate monitor allows 3rd party network operators to monitor their network without impacting any services i.e. switching GMs to find the optimal network path
- Both solutions
  - Allow network monitoring and alarms to signal corrective actions before any network impact

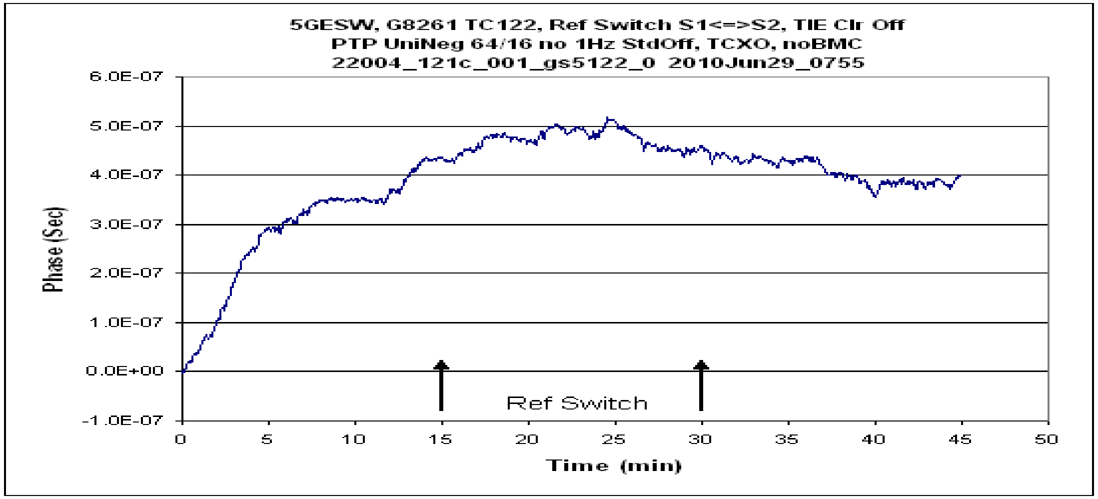
Timing over Packet:
Reference Switching Performance

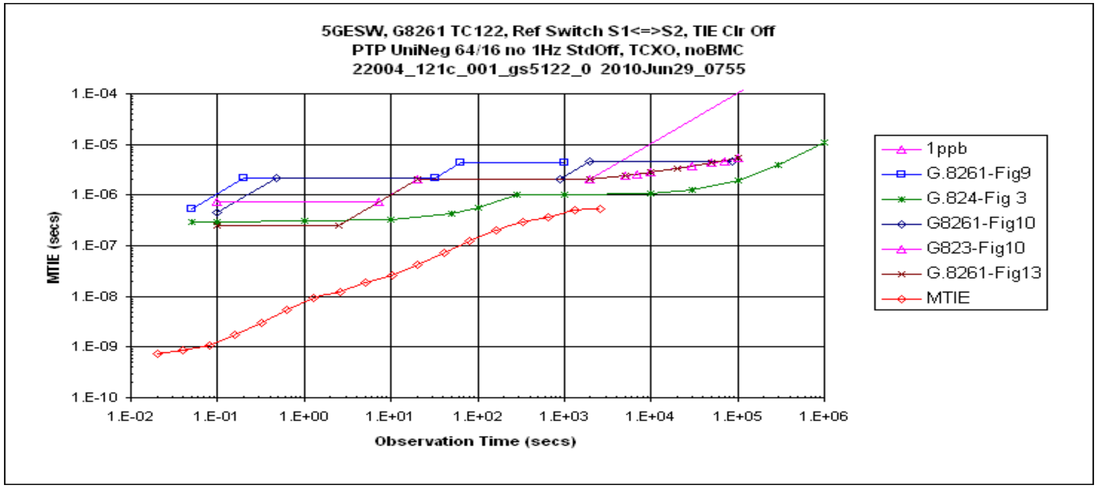
Reference Switching - Overview

- Both GMs were locked to GNSS
- Loaded network for GM#A to client, no traffic from GM#B to client
- Reference switching done after 15 minute test time
  - Second switch 15 minutes later (30 minutes into test)
- Frequency Client
  - Test 1 - GM#A to GM#B to GM#A
  - Test 2 - GM#A to SyncE to GM#A
- Phase Client
  - Test 3 - GM#A to GM#B to GM#A
  - Test 4 - GM#A to GPS to GM#A

Reference Switching (Frequency) #1

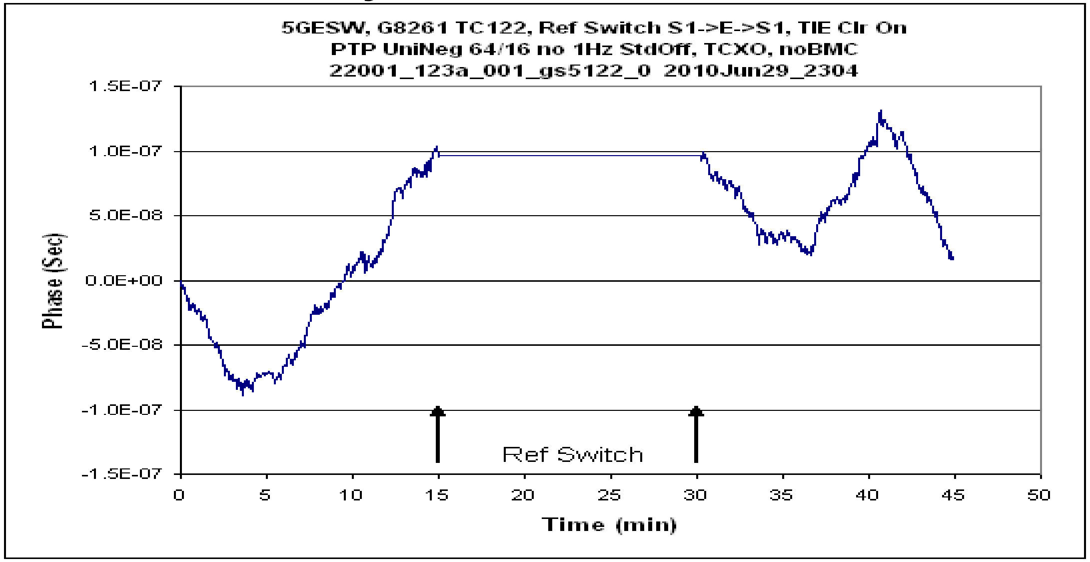
- IEEE1588 GM #A to IEEE 1588 GM #B to IEEE1588 GM #A

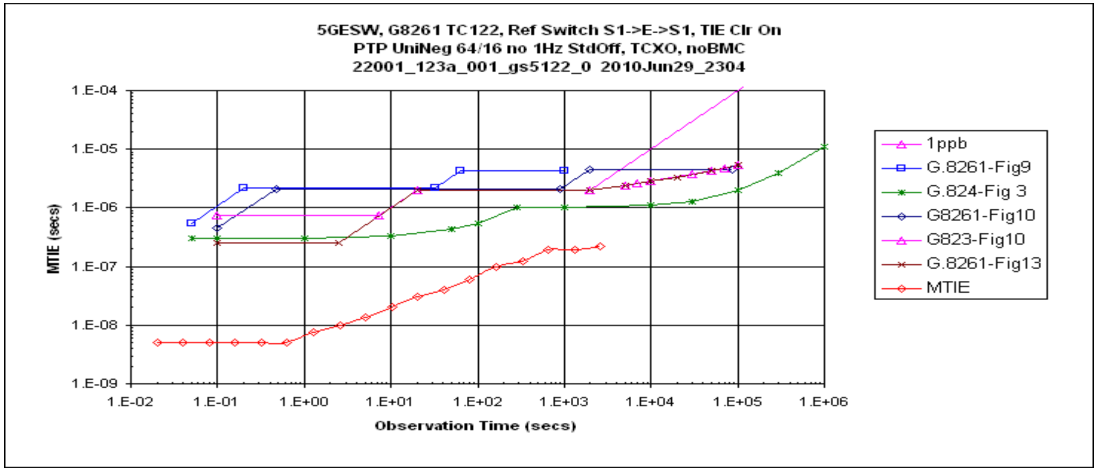




Reference Switching (Frequency) #2

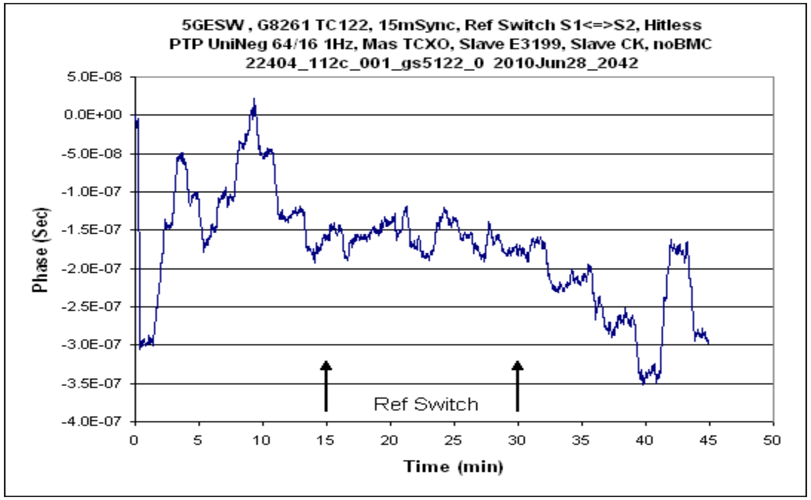
- IEEE1588 GM #A to SyncE to IEEE1588 GM #A

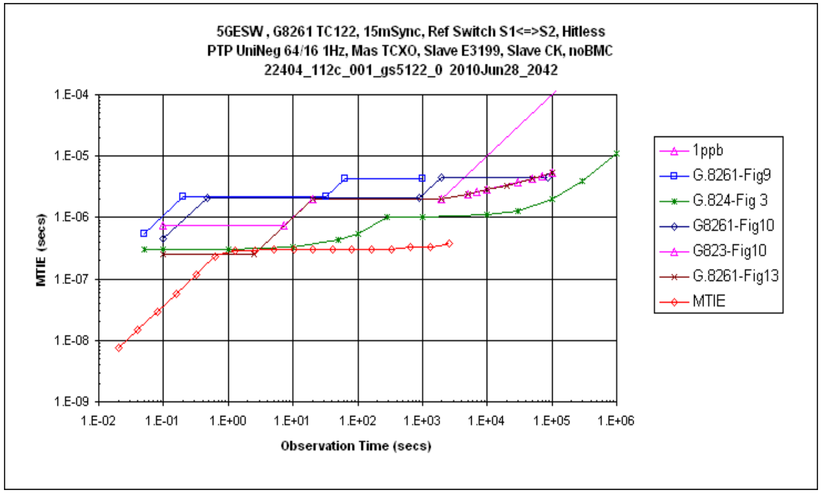


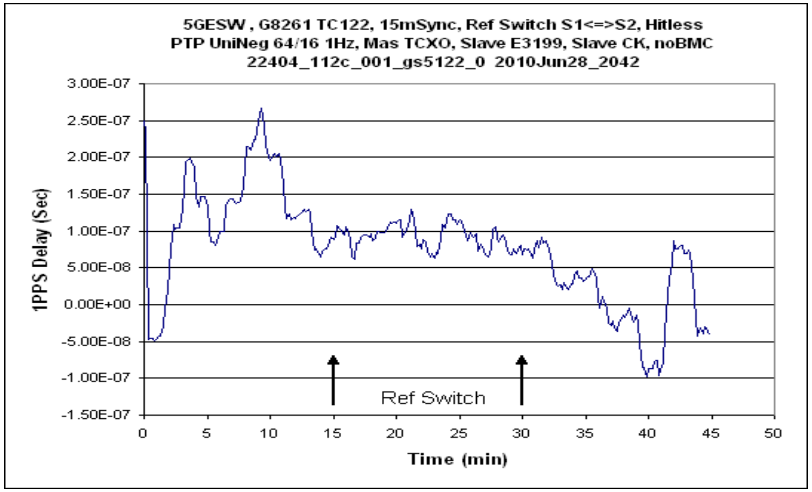


Reference Switching (Phase) #3

- IEEE1588 GM #A to IEEE 1588 GM #B to IEEE1588 GM #A

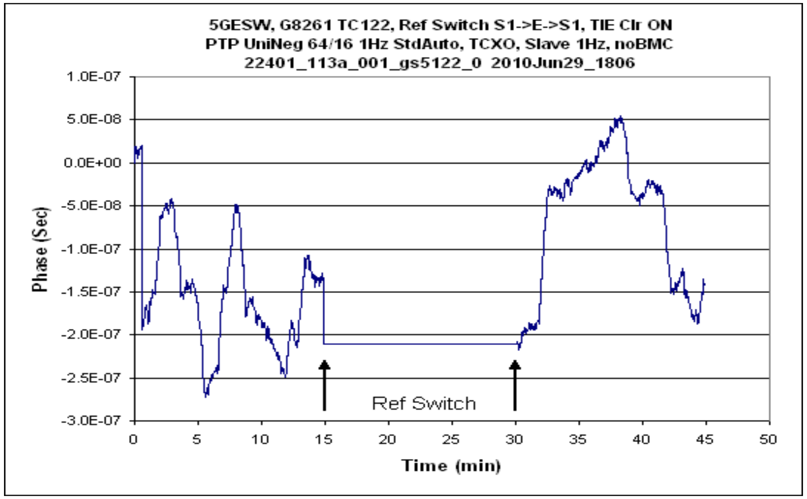


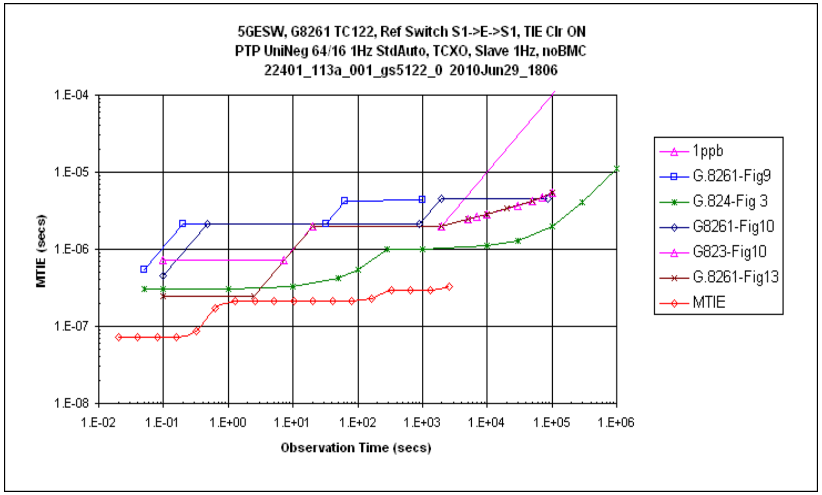


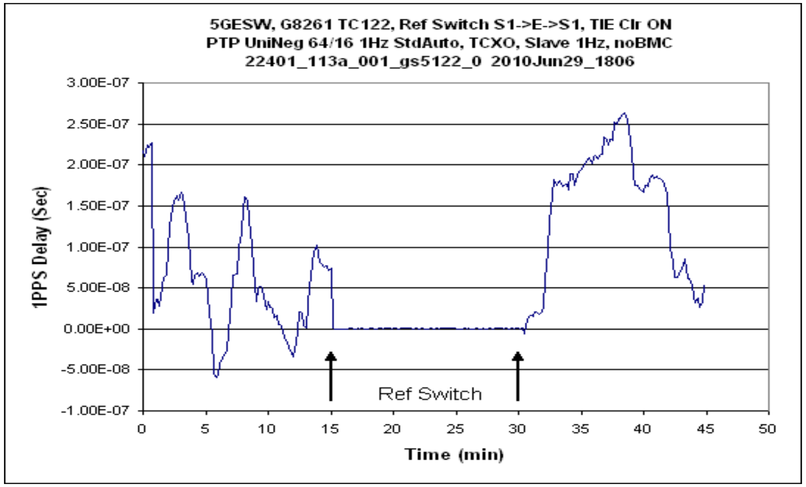


Reference Switching (Phase) #4

- IEEE1588 GM #A to GPS to IEEE1588 GM #A







Reference Switching - Summary

- 1 – Frequency Transfer
  - Good performance when switching between two Grand Masters
- 2 – Frequency Transfer
  - Good performance when switching to and from SyncE during a PTP outage
- 3 – Phase Transfer
  - Good performance when switching between two Grand Masters
- 4 – Phase Transfer
  - Good performance when switching to and from GPS during an outage

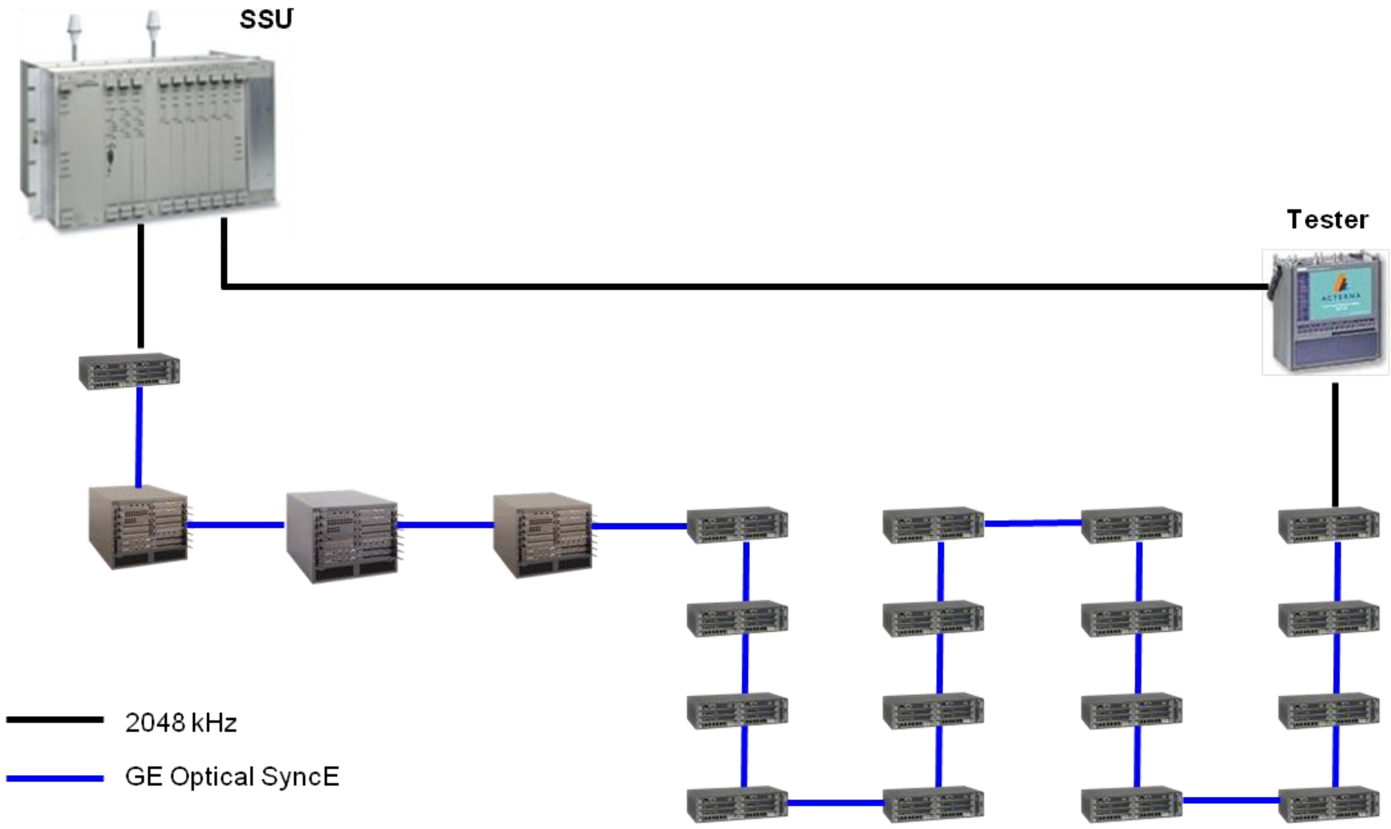
- All the frequency and phase inputs can be used as needed to provide good timing and synchronization to the base station during a failure in any one method

SyncE: Example performance of SyncE over 20 nodes

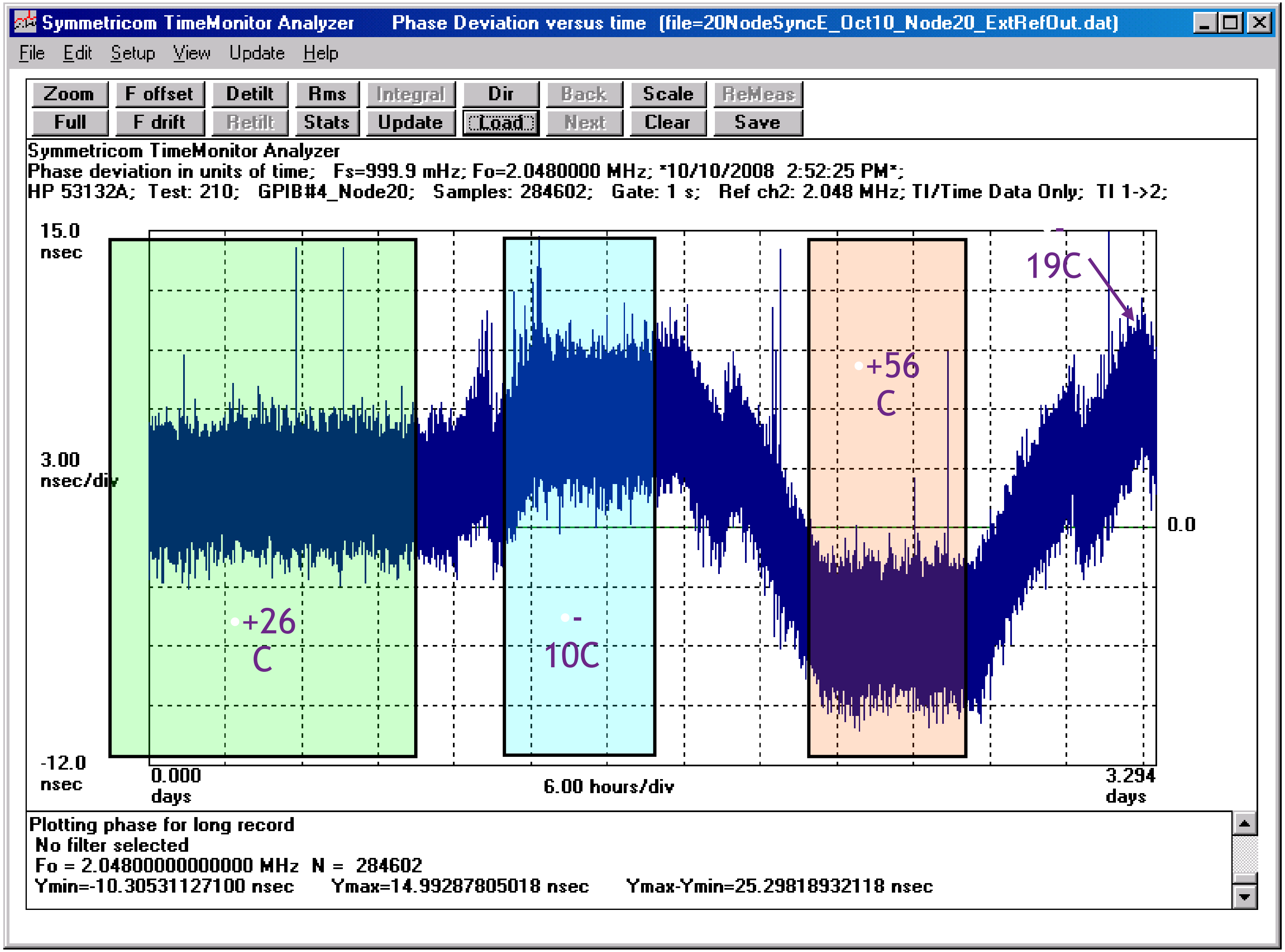
Example performance of SyncE over 20 nodes - overview

- Currently we are considering to use IEEE1588 to backup GNSS for up to 3 day period, with performance requirement of 800 ns. This contribution shows some bench results of SyncE (without IEEE1588 or GNSS) measured over a 3 day period, with performance much better than 800 ns.
- 20 SyncE nodes
- In the test, 6 of the nodes were placed in a thermal chamber and the temperature was varied over the test period between -10C and 56C
- The performance results show less than 27 ns MTIE over a 3 day period.
- Based on data presented in ITU Contribution presented at the March 2014 ITU meeting (COM15–C0491–E)

Example performance of SyncE over 20 nodes - Test network



Example performance of SyncE over 20 nodes - Results



Example performance of SyncE over 20 nodes - Summary

- This shows SyncE may be a useful technology to backup GNSS and PTP (in the APTSC scenario).
  - SyncE may be a useful backup for IEEE1588 (for partial timing support architecture in general).
  - SyncE may be useful to assist IEEE1588 to replace the functionality of a local oscillator (since the performance far exceeds off-the-shelf Stratum 3E oscillators).

Improvements with use of SyncE

- SyncE provides better synchronization than any local free-run oscillator
- SyncE may be a useful technology to backup GNSS and PTP (in the APTSC scenario).
- SyncE may be a useful backup for IEEE1588 (for partial timing support architecture in general).
- SyncE may be useful to assist IEEE1588 to replace the functionality of a local oscillator (since the performance far exceeds off-the-shelf Stratum 3E oscillators).

Summary

- APTSC using GPS, PTP (with monitoring), SyncE together provides the best solution for end node phase/time performance during GNSS outages
  - GPS to provide frequency and phase for the end unit
  - SyncE to provide additional frequency support
  - PTP to provide additional phase support
  - Monitor PEC to measure network performance and asymmetry to allow for better phase performance of PTP during GNSS interruption

APTSC Inputs	Phase Quality
GPS	Good
GPS/PTP	Better
GPS/PTP/SyncE	Best