VOICE & TIMING SOLUTIONS
For a New Global Network

Use of Combined Synchronous Ethernet & IEEE-1588 in Wireless TDD applications

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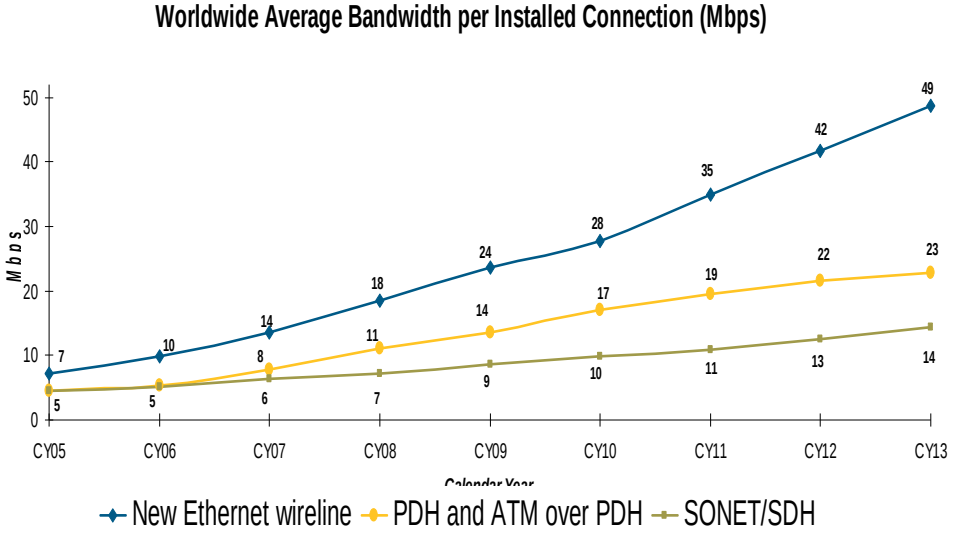
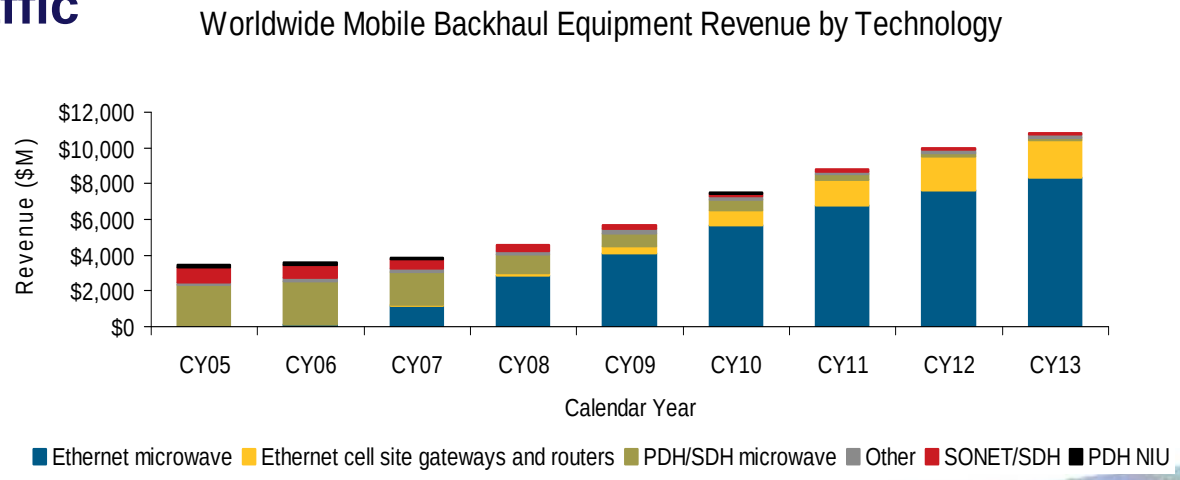
ZARLINK
SEMICONDUCTOR

Wireless remains Strong

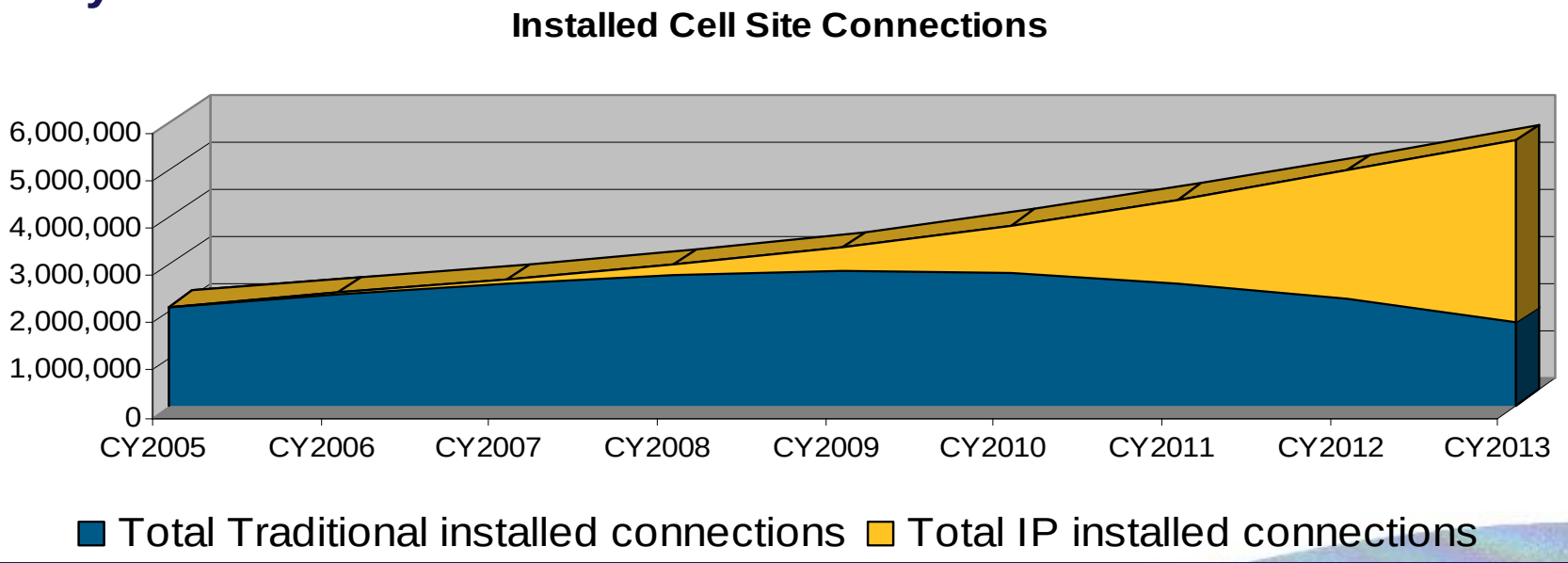
- **Backhaul investments jump by 19% in 2008, forecast to jump by 24% in 2009**
- **Increasing demand for innovative Data Services**
- **T1/E1 backhaul costs prove inhibitive to supporting the growth in traffic**





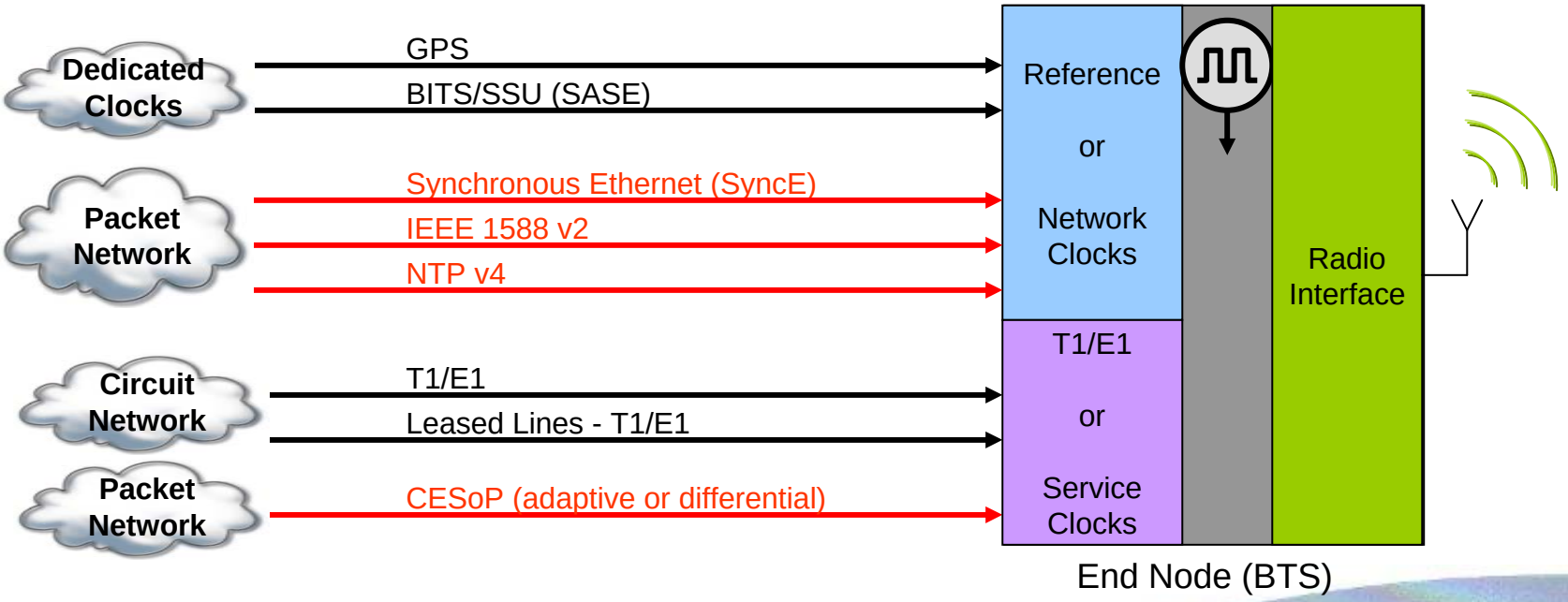
The Move to an IPRAN

- **Pressure on the backhaul**
  - **Increasing data Services driving bandwidth demand**
  - **Increasing number of BTS/NodeB per Cell site driving bandwidth demand**
  - **Increasing costs of traditional backhaul**
- **Synchronization?**



IPRAN Synchronization

- **BTS/Node B equipment have a variety of options for clock synchronization sources**
- **Synchronization sources may be used as a common clock for the entire node, or may only be a clock to time an individual T1/E1**



IPRAN Synchronization

- **Wireless FDD – Frequency & Wander**
- **Wireless TDD – Frequency, Wander & Time Alignment**

Technology	Frequency Accuracy (ppb/ppm)	Frequency (MTIE/TDEV)	Phase/Time (Time of Day)
GPS	Yes	Yes	Yes
Synchronous Ethernet (Physical Layer)	Yes	Yes	No
IEEE 1588 v2 (Protocol Layer)	Yes	Yes	Yes
T1/E1 (Leased Lines)	Yes	Yes	No
CESoP (e.g. PWE3 or RTP) (Protocol Layer) (Adaptive or Differential)	Yes	Yes	No

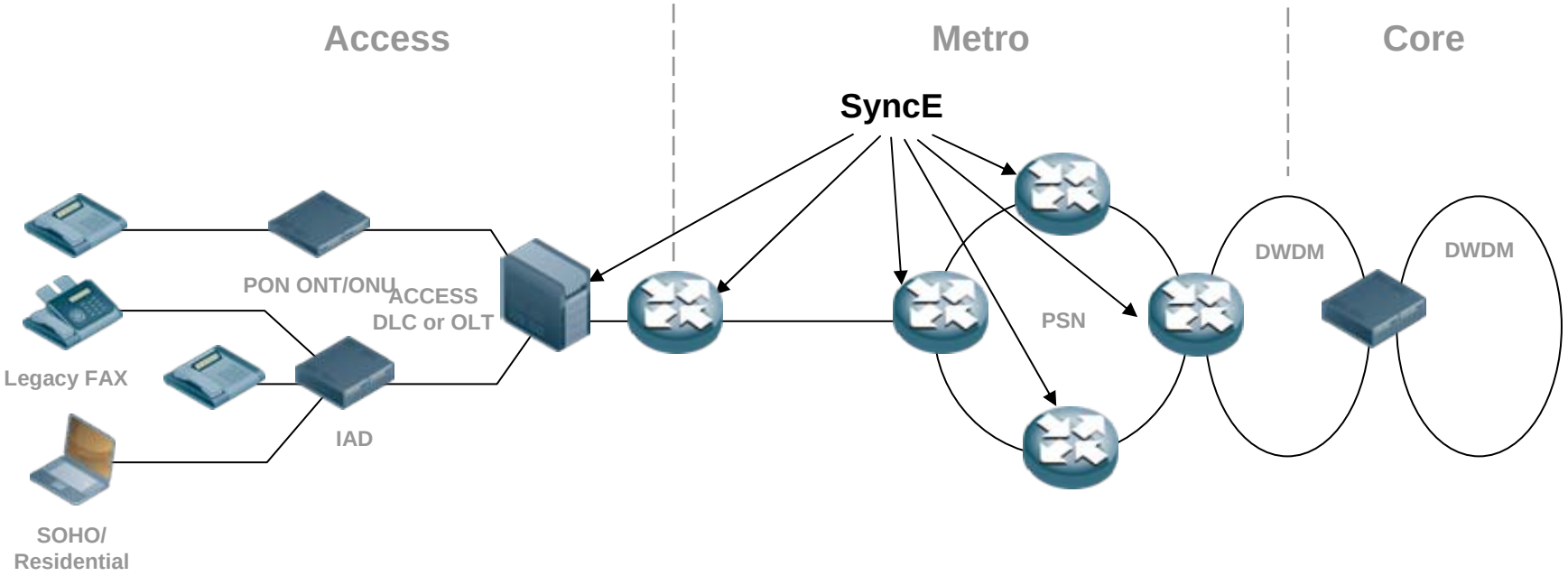
IPRAN Synchronization

- **UMTS-FDD is the dominant technology today**
  - **WCDMA**
- **Increasingly we will see TDD technologies be deployed**
  - **CDMA, WiMAX, LTE-TDD**
- **TDD technologies require very accurate Time of Day alignment between basestations**
  - **This allows for efficient use of the spectrum while providing seamless handover of the handset from one Base Station to the other**
- **All TDD technologies use GPS today, Wireless Operators have long since sort an alternative**

Frequency and Phase

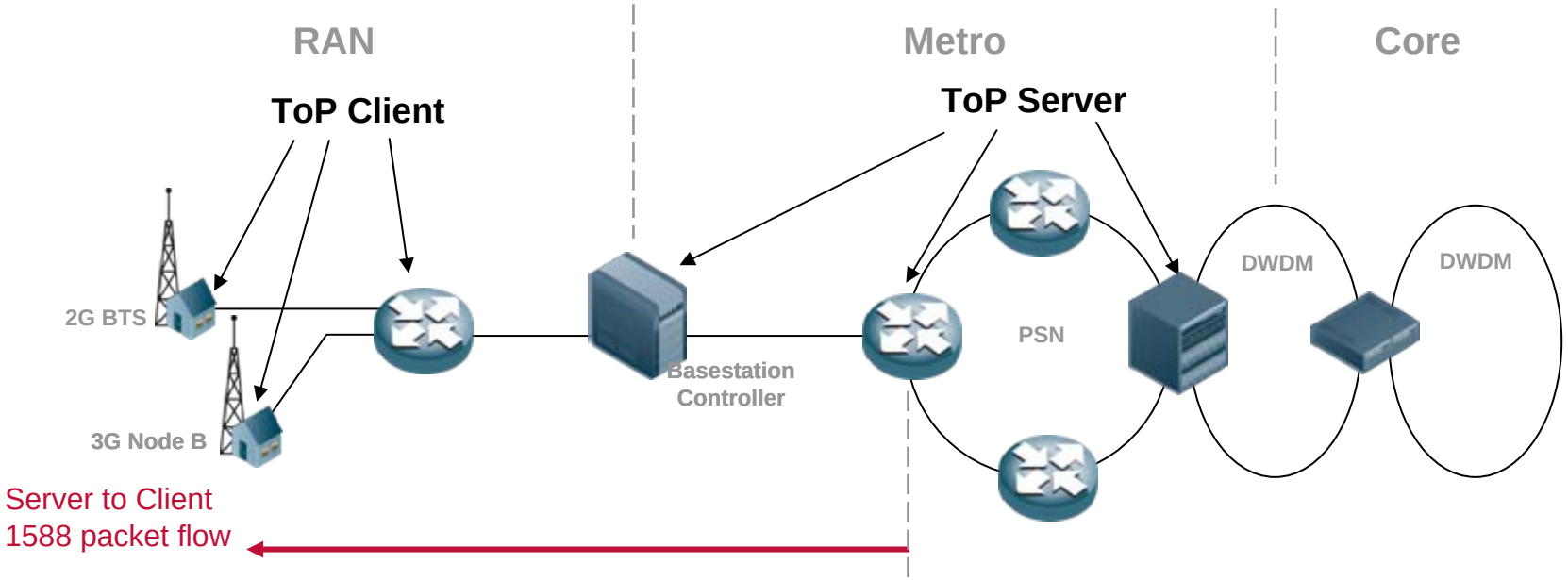
- **Freq transfer is well suited to the physical layer**
- **Phase transfer is well suited to packet networks**
- **SyncE is a freq transfer mechanism while 1588 is a phase transfer mechanism**
- **Both can be used independently and in combination to address the synchronization needs of the network**
- **Operators would like to see the widespread use of SyncE because of its accuracy and Management capabilities**
- **1588 is a technology used in existing networks and for Time Synchronization**

Frequency Synchronization Using SyncE



- **SyncE allows operators to offer synchronous services over upgraded or new packet network infrastructure**
- **SyncE applies a simple, reliable, and well understood method of distributing synchronization over the physical layer of a packet networks**
- **SyncE is based on a well established SONET/SDH synchronization distribution models, it's highly accurate over 10 nodes and more**

Phase Synchronization Using IEEE 1588



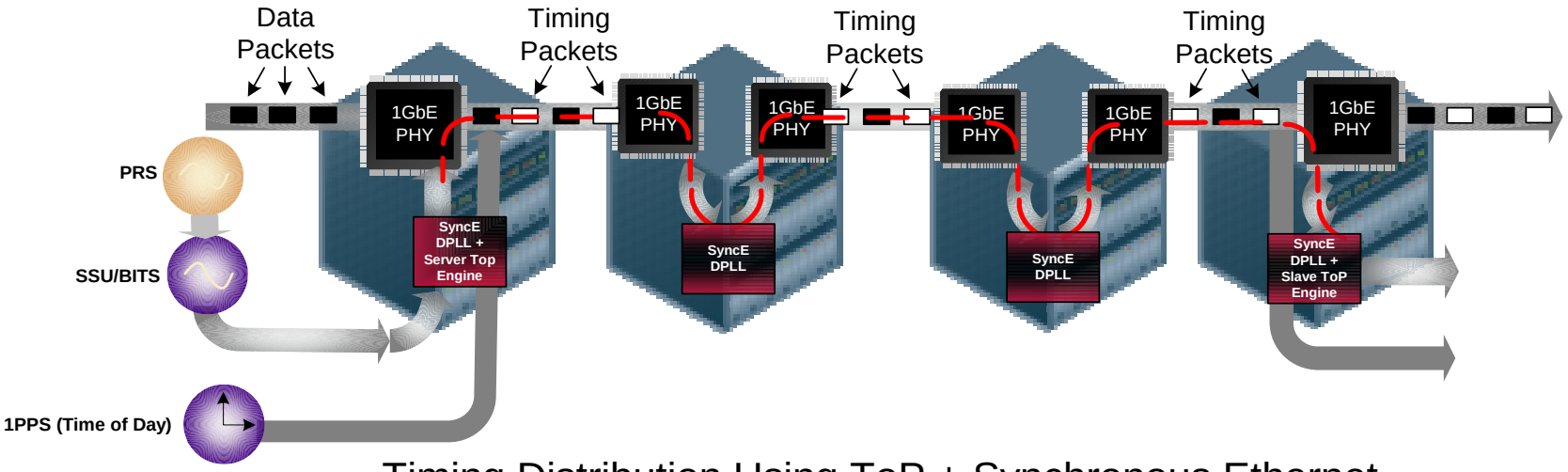
- **1588 allows operators to offer synchronous services over an existing packet network infrastructure**
- **1588 provides a method of distributing frequency synchronization and time of day alignment over packet switched network**
- **1588 functionality is only required at both ends of the connection**

Time of Day Alignment

- **Two main Parameters affect the quality of phase alignment**
  1. **Recovered clock wander**
     - **Network Packet Delay Variation:** size and loading of a given network
     - **Client oscillator stability:** cost performance trade off
  2. **Link delay asymmetry**
     - **Path Asymmetry:** forward and reverse path are different
     - **Load Asymmetry:** forward and reverse path asymmetry, this varies as network condition vary
- **Use of physical layer synchronization techniques. For example the clock can be extracted from the physical layer using SyncE**
  - **Less than 100nsec TIE over 100,000 sec test period**

Hybrid Mode

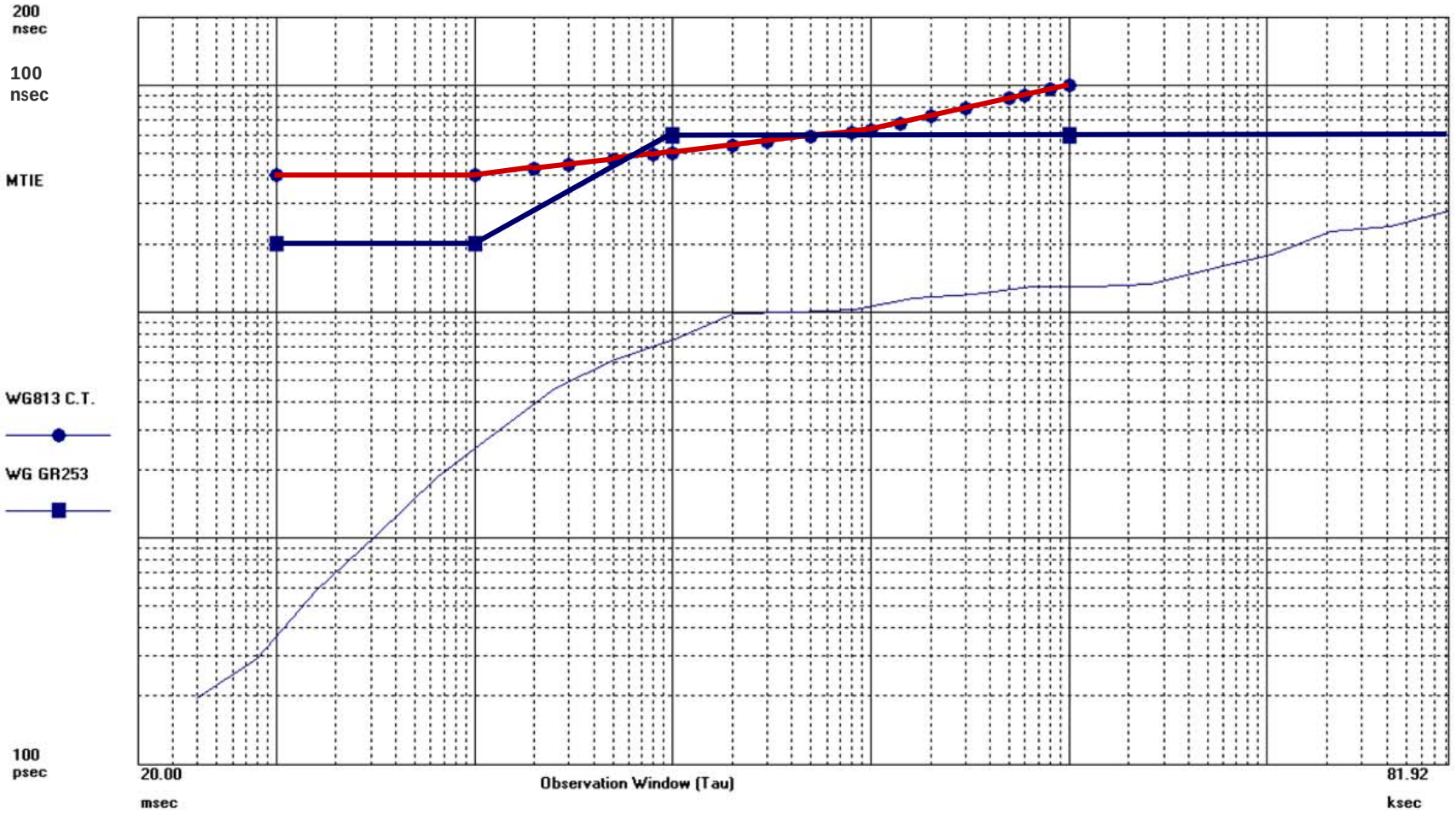
- **Hybrid mode combines SyncE and IEEE 1588**
  - **An accurate frequency is obtained through SyncE**
  - **An accurate Time of Day alignment is obtained through 1588**



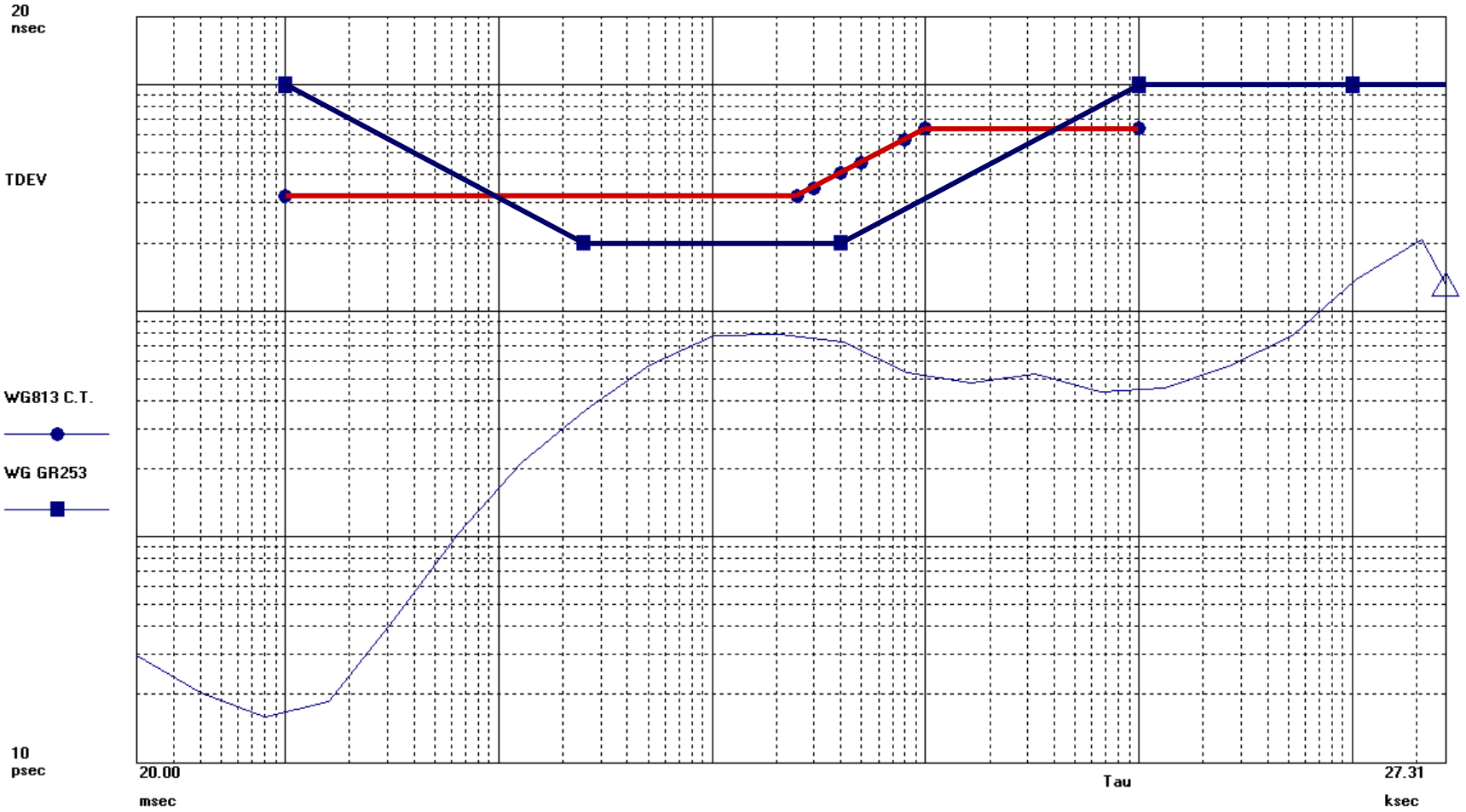
Timing Distribution Using ToP + Synchronous Ethernet

Test results for SyncE Only

SyncE, 10 Node MTIE Results



SyncE, 10 Node TDEV Results

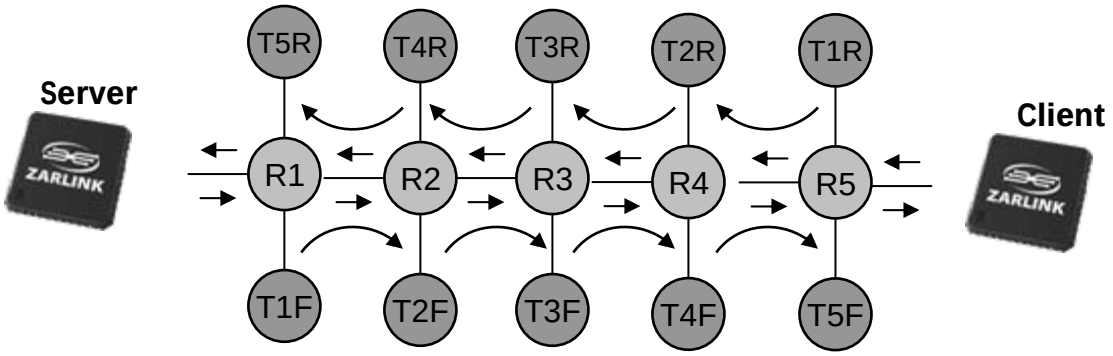


Test results for IEEE 1588 only

Test Results

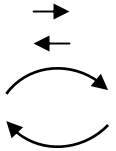
- **The following are Time of Day plots for various traffic Test Cases for a 5 node network**
  - **All nodes are GbE Routers**
  - **Link Delay asymmetry will be small**
- **Numerous G.8261 Test Cases have been used**
- **Many will cause traffic asymmetry**
- **TDD technologies require less than +/-1us**

Network Setup



Notes:

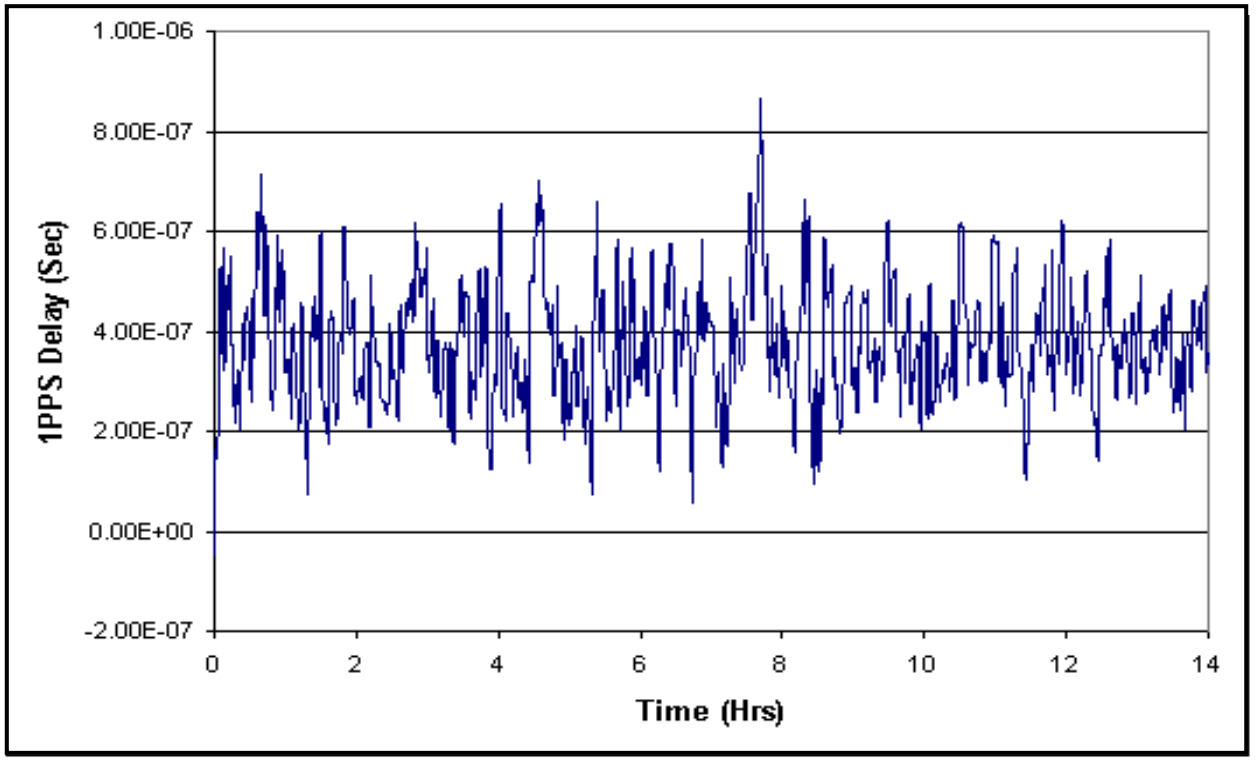
1. R - GE (1 Gbps) Gigabit Routers (L3 Cisco 7600)
2. T - Traffic Generator (R is reverse path, F is forward path)
3. ToP protocol is IPV4 UDP Port 319
4. Traffic Generators are GE (1 Gbps); IXIA 1600 or similar



Forward Timing Over Packet
Reverse Timing Over Packet
Forward Traffic
Reverse Traffic

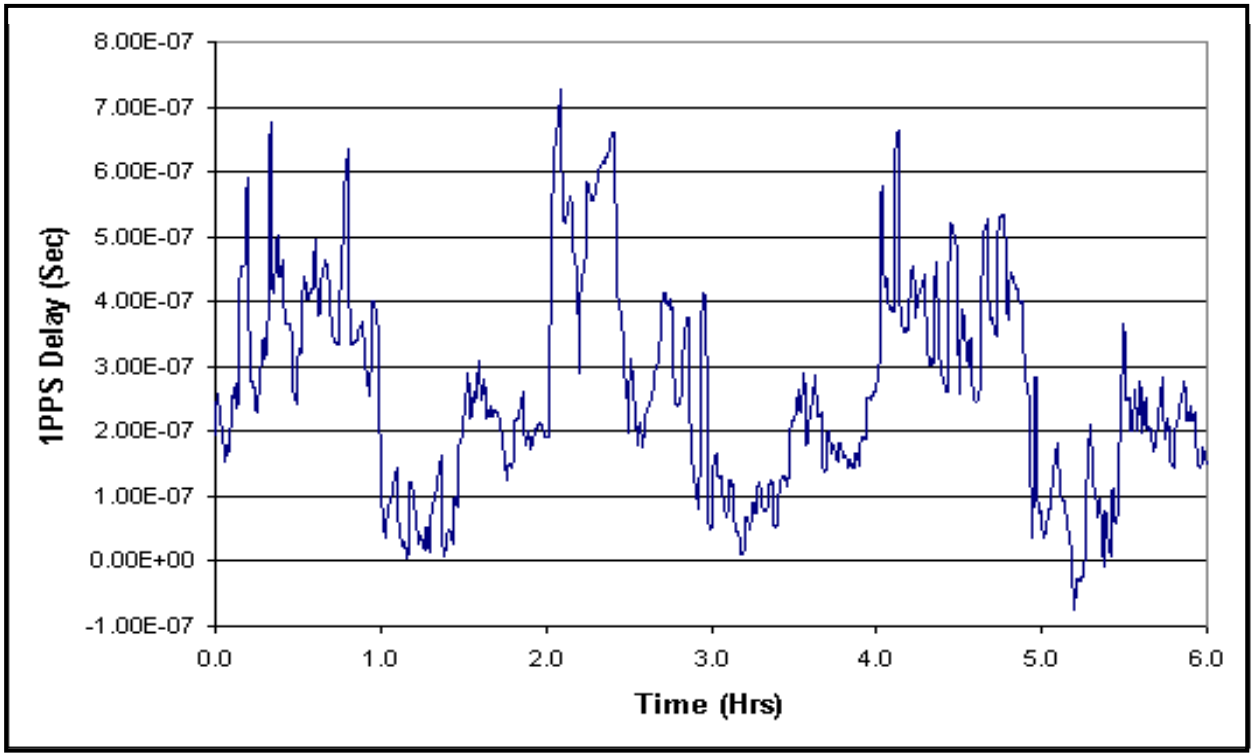
G.8261 TC12 Constant Traffic

- **1PPS Start -50ns**
- **1pps Delay 870ns/-50ns from Start**



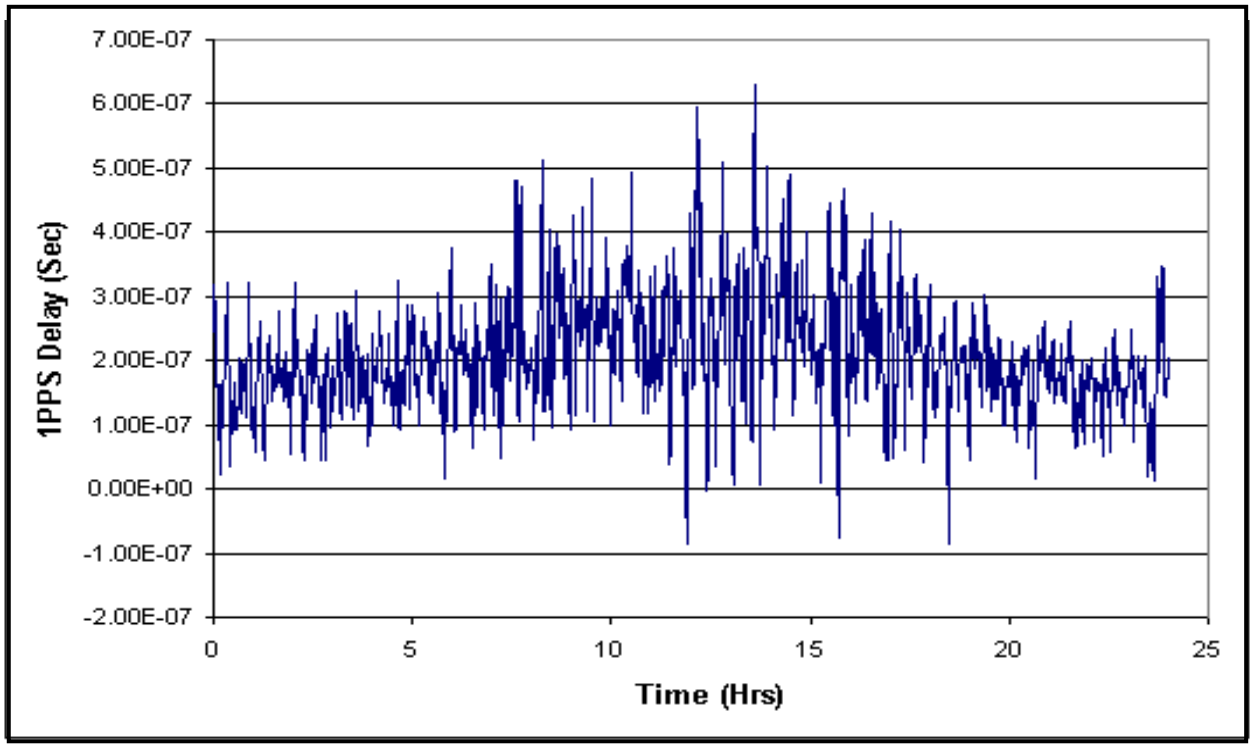
G.8261 TC13 Square

- **1PPS Start 195ns**
- **1pps Delay 730 ns/-75ns from Start**



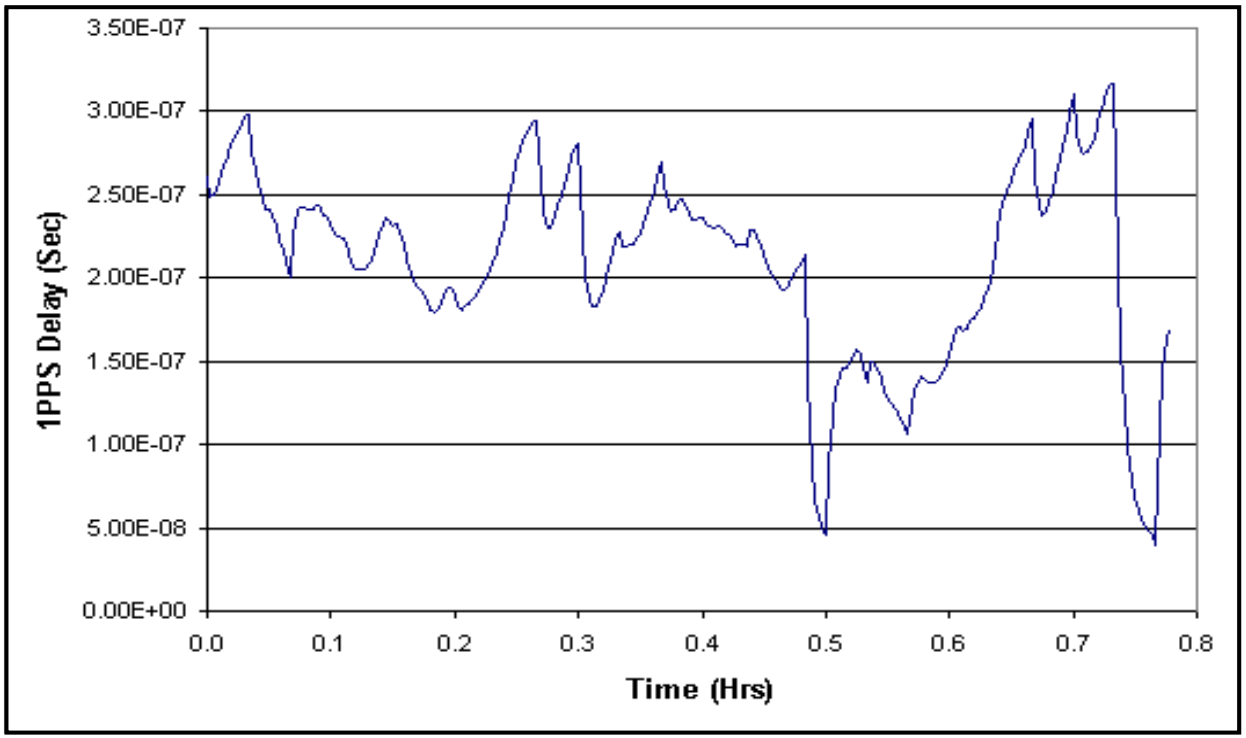
G.8261 TC14 Ramp

- **1PPS Start 318ns**
- **1pps Delay 630ns/-90ns from Start**



G.8261 TC16 Congestion

- **1PPS Start 260 ns**
- **1pps Delay 320 ns/40 ns from Start**



Test results for Hybrid Mode

Test Results

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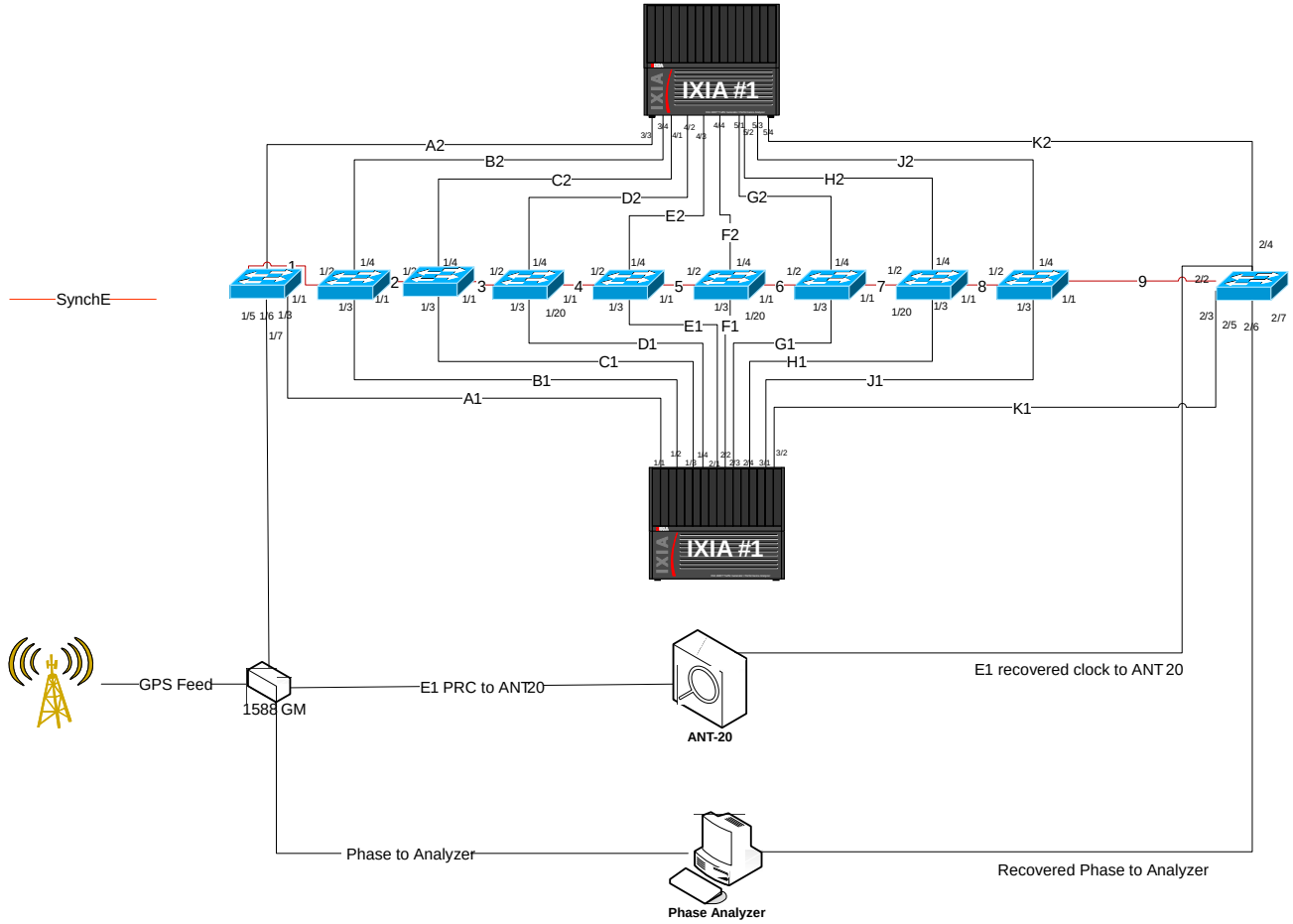
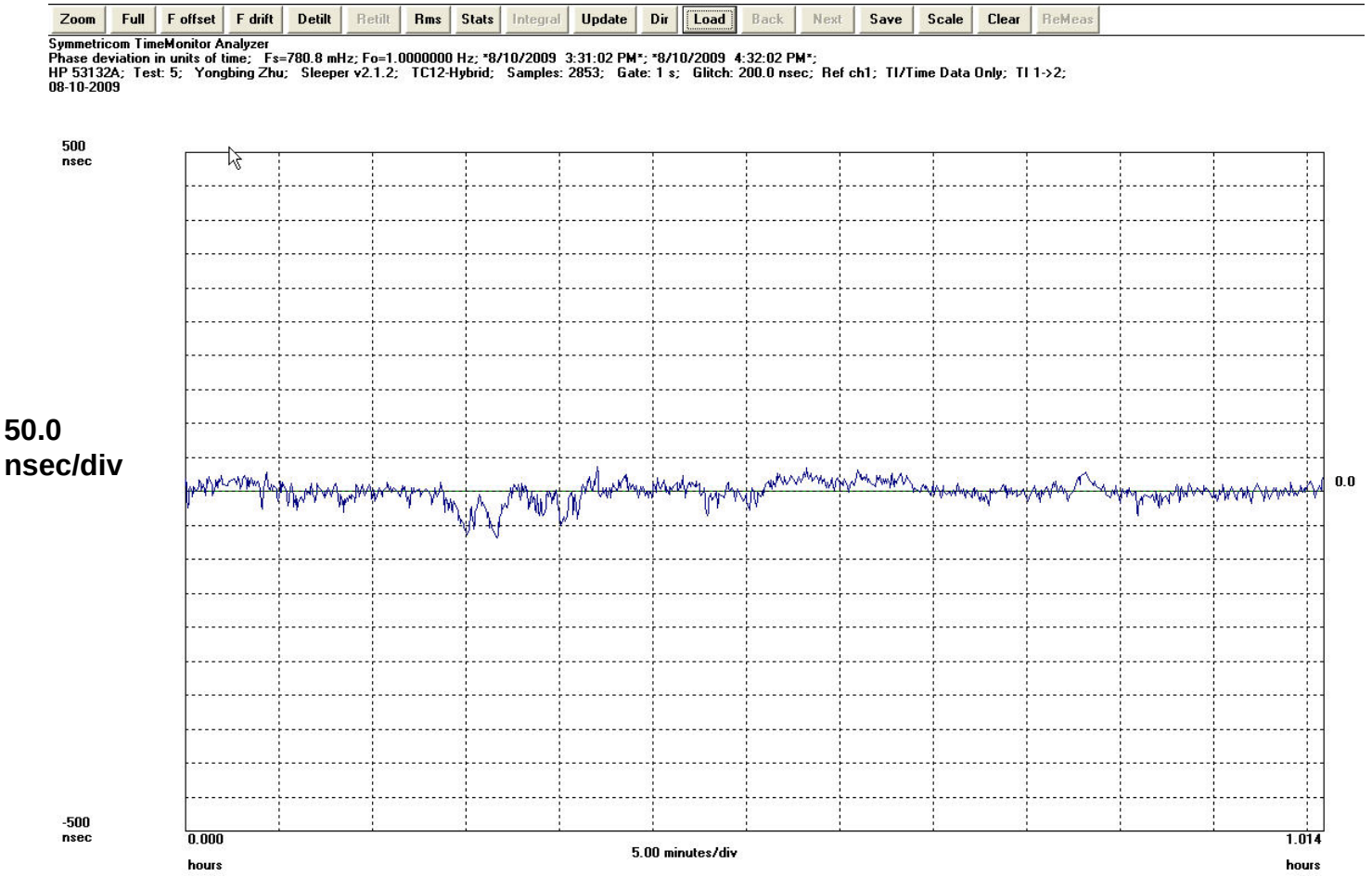
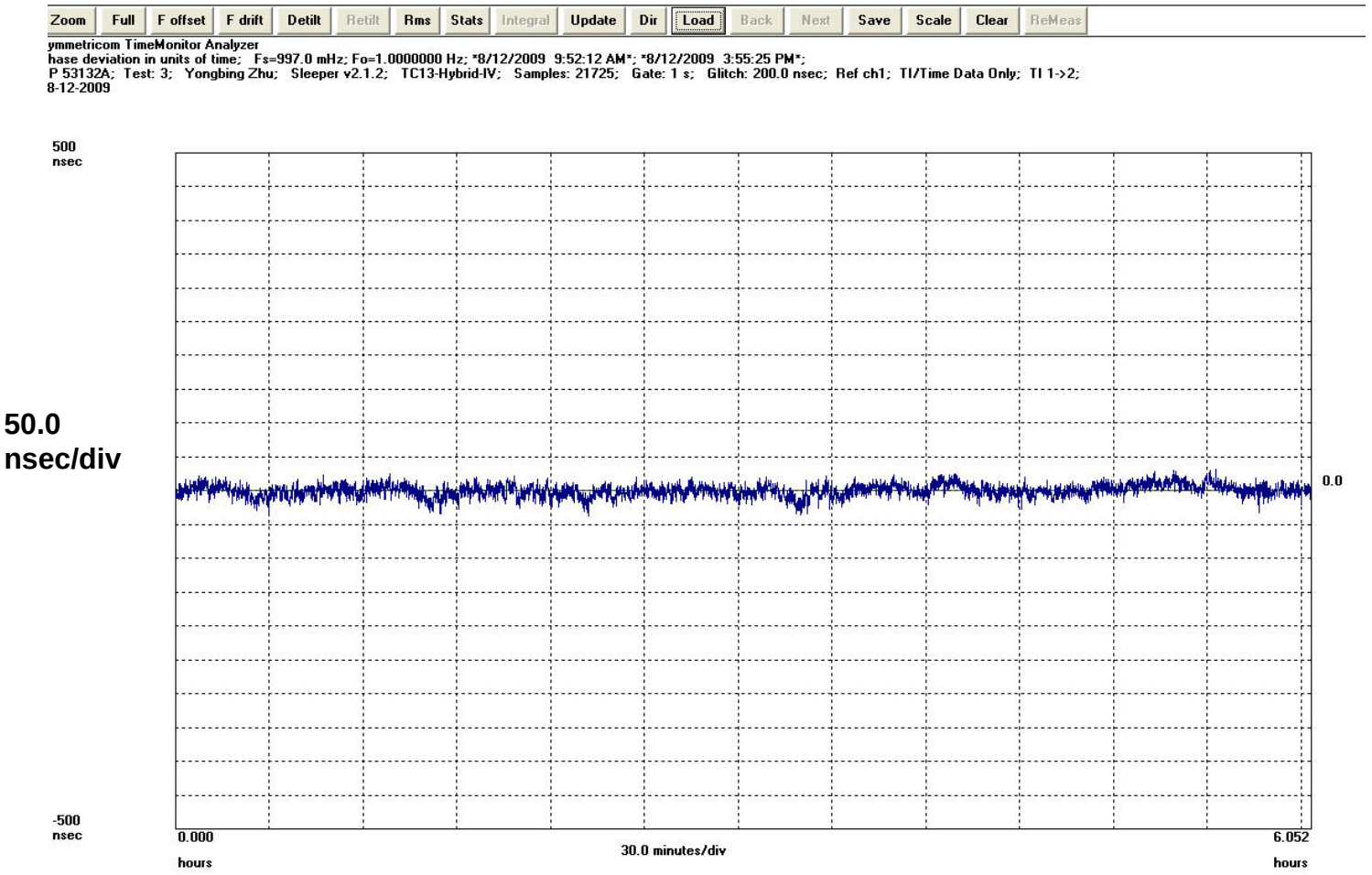


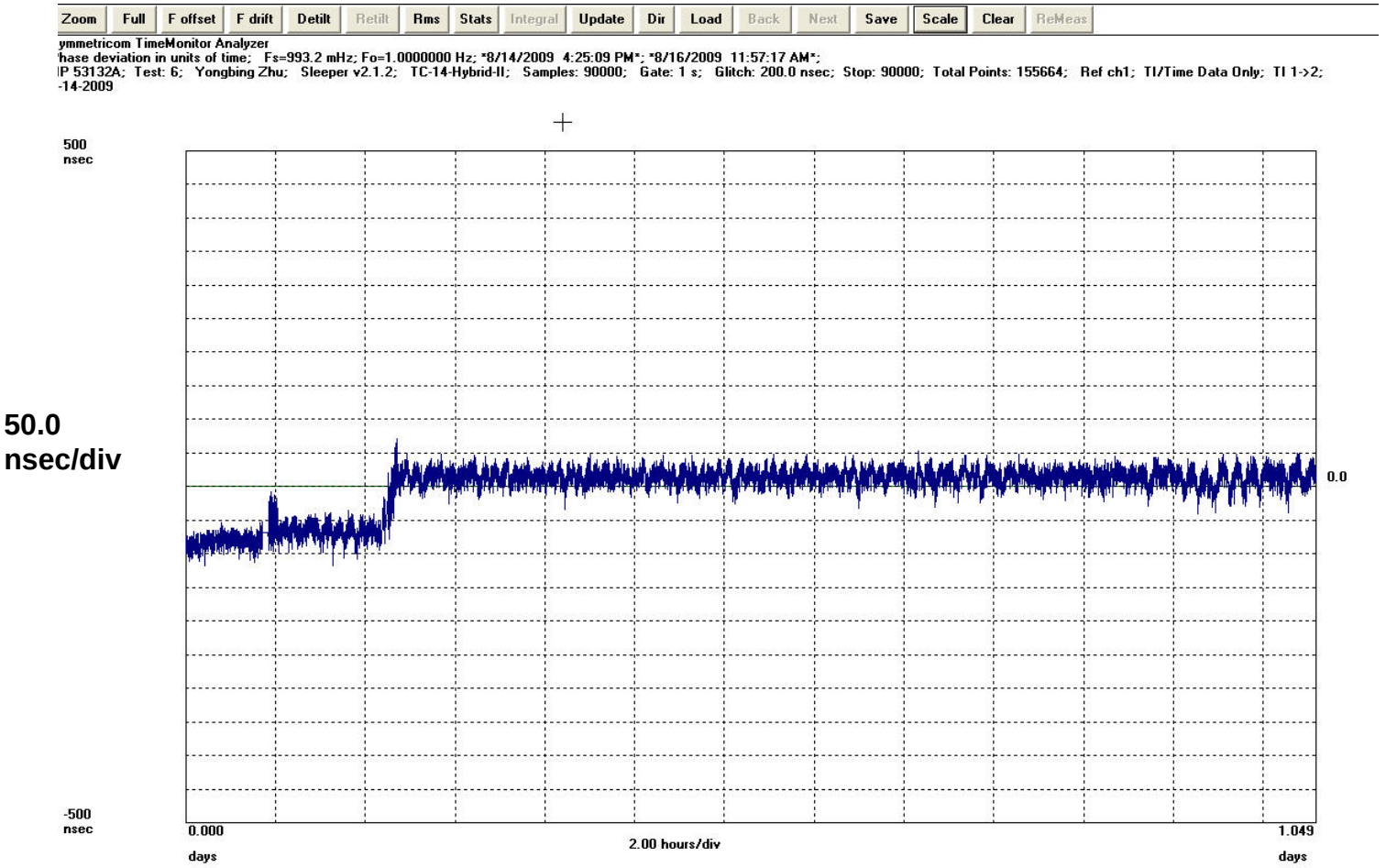
G.8261 TC12 Constant Traffic



G.8261 TC13 Square



G.8261 TC14 Ramp



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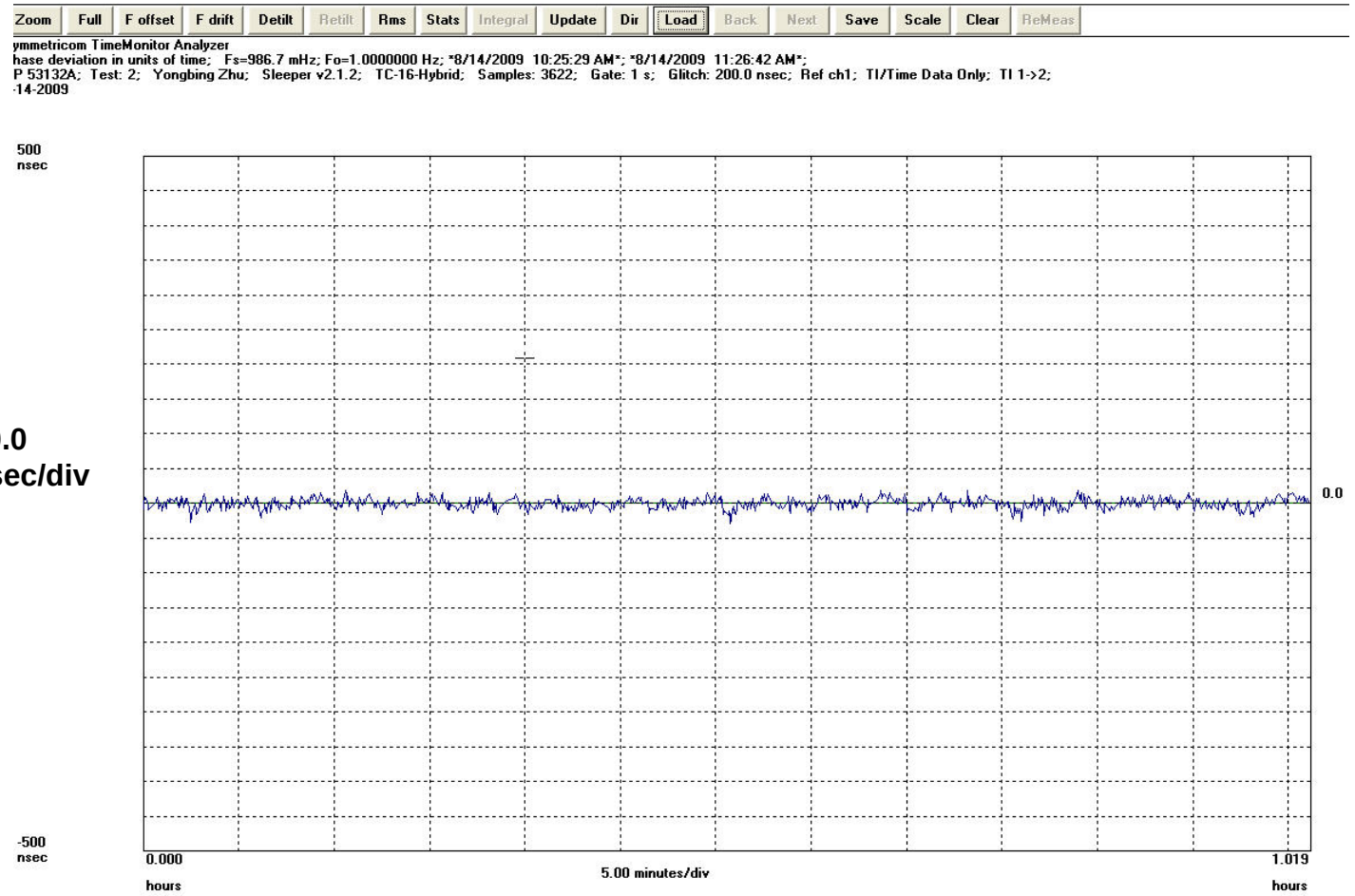

Conclusion

- **Traffic Density is increasing**
- **Move to an IPRAN is happening now**
- **Synchronization is key to allowing this migration**
- **3G & 4G technologies are increasingly requiring Time of Day Synchronization**
  - **CDMA, LTE-TDD, WiMax . .**
- **IEEE 1588 offers both Phase and Frequency synchronization**
  - **But SyncE offers better performance Frequency synchronization**
- **Combined 1588 and SyncE can offer better performance than 1588 alone**