VOICE & TIMING SOLUTIONS
For a New Global Network

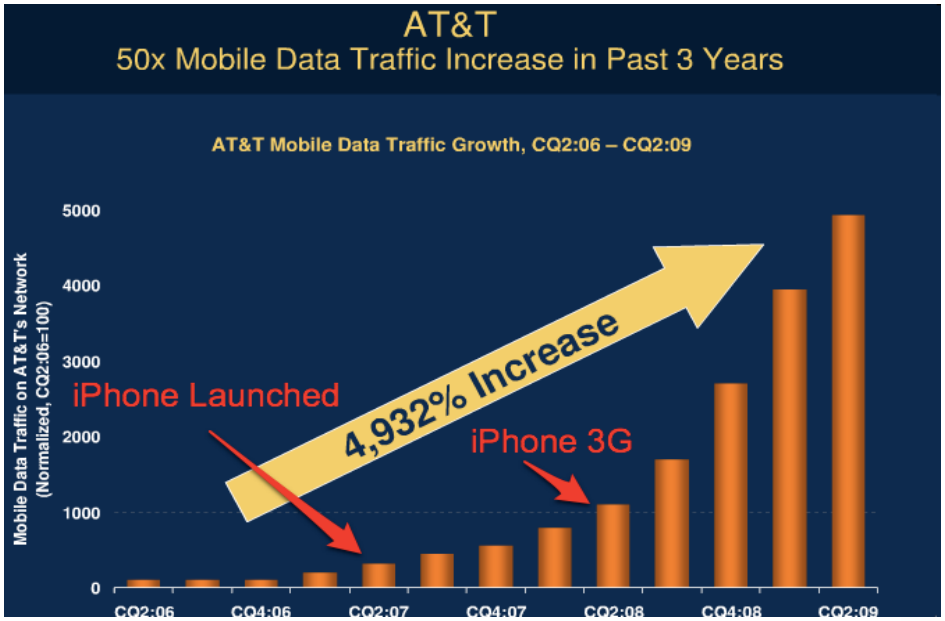
Hybrid Mode Synchronous Ethernet & IEEE-1588 in Wireless TDD applications

Jeremy Lewis – Zarlink Semiconductor

ZARLINK SEMICONDUCTOR

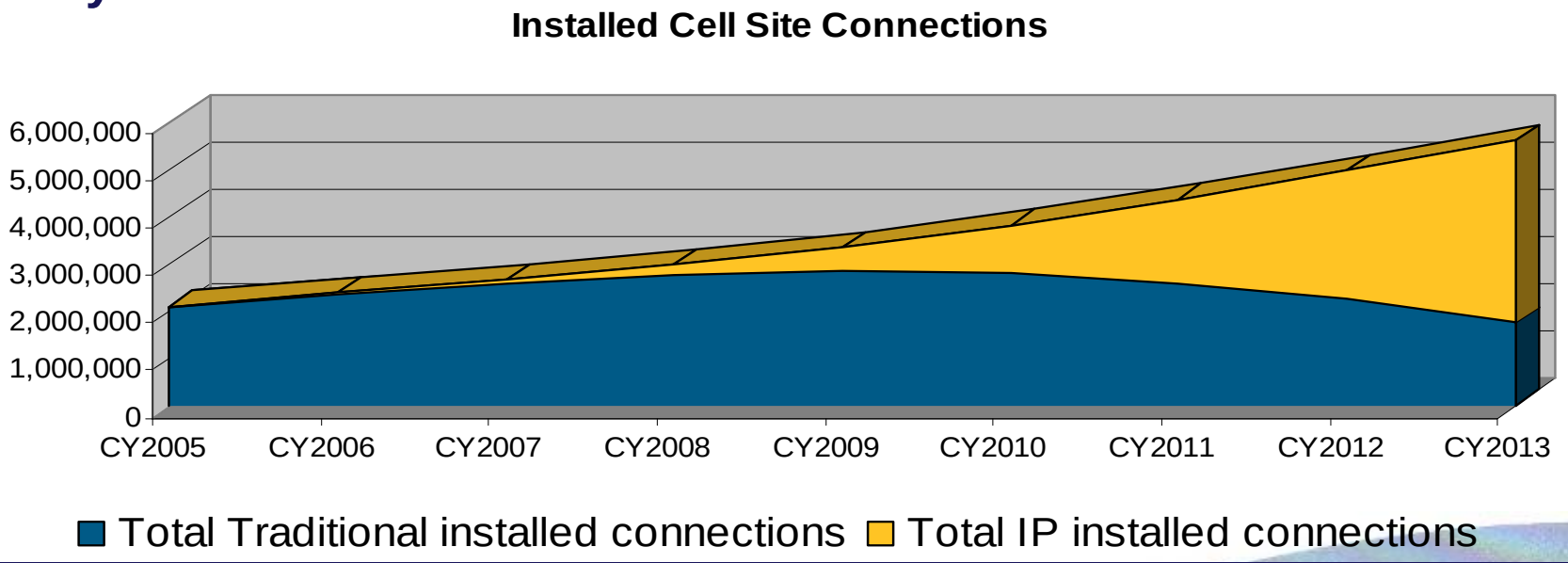
The Focus on Backhaul

- **AT&T to Spend $2B More on Wireless in 2010**
- **More than $18Bn in total spend for 2010**
  - **Dan Jones, Site Editor – Unstrung**
- **Networks streaming towards overload**
  - **Jenna Wortham, Global edition of the New York Times**



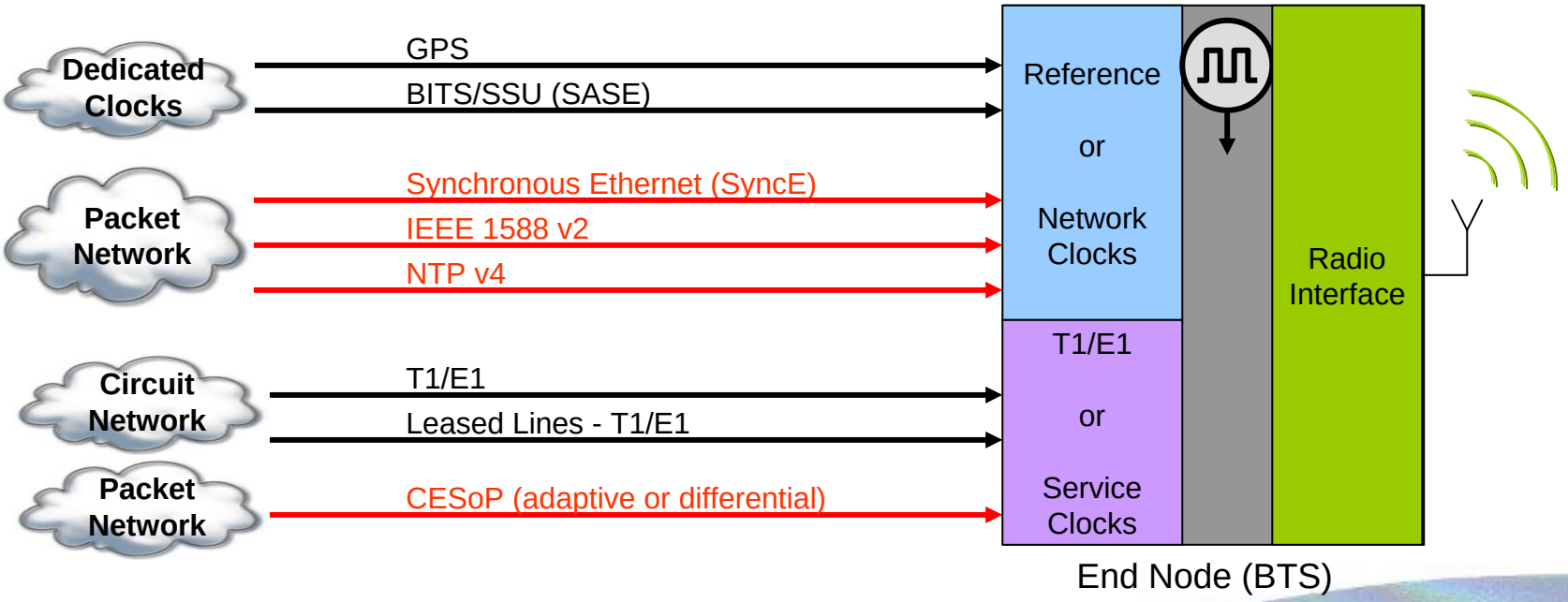
The Move to an IPRAN

- **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

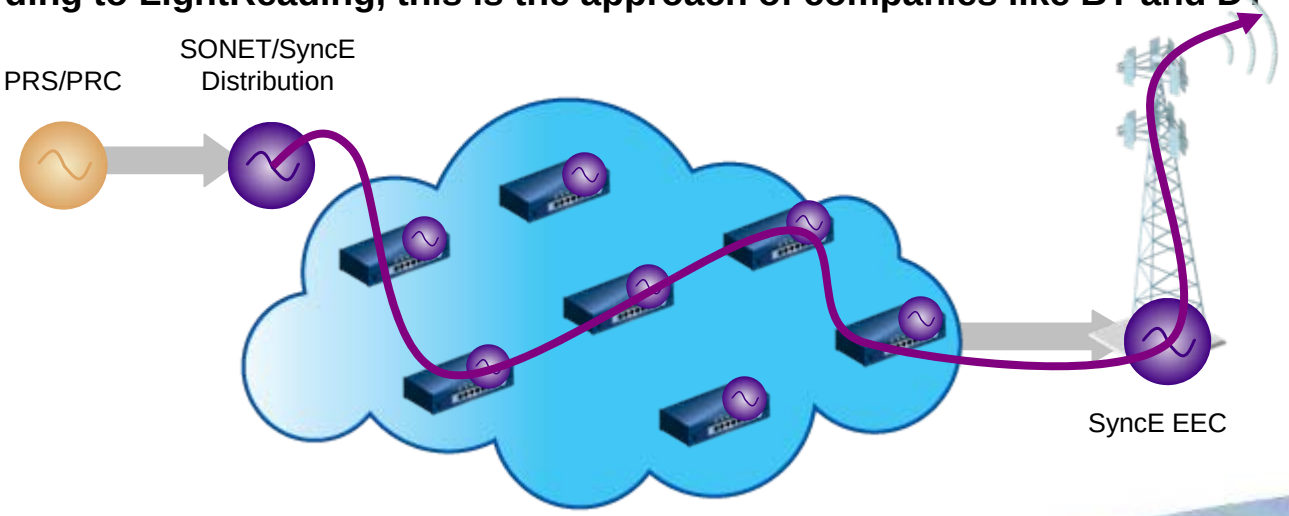
- **UMTS-FDD is the dominant technology today**
  - **WCDMA**
- **Increasingly we will see TDD technologies be deployed**
  - **CDMA, WiMAX, LTE-TDD**
- **TDD technologies require very accurate Time of Day alignment between basestations**
  - **This allows for efficient use of the spectrum while providing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

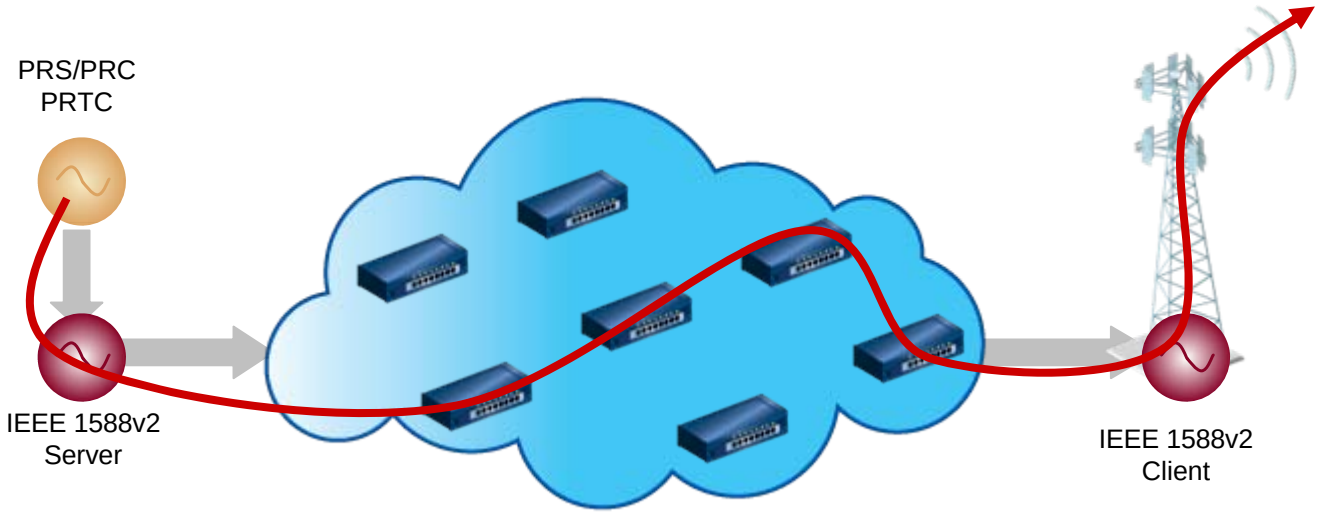
Deployment of SyncE

- **Adding or Inter-mix SyncE with existing SONET Synchronization Chain**
  - **Ethernet network elements are added, extending existing SONET synchronization chains**
  - **For greenfield Ethernet networks deploy SyncE throughout**
  - **Robust, reliable technology for applications where SONET/T1 is used today**
  - **Supports frequency accuracy for basestations (GSM, WCDMA-FDD, LTE-FDD)**
  - **Supports frequency for traffic and synchronization MTIE & TDEV (PBX, enterprise)**
  - **Does not support phase or time synchronization (CDMA2000, WCDMA-TDD, TD-SCDMA, Mobile WiMAX) – still need GPS**
  - **According to LightReading, this is the approach of companies like BT and DT**



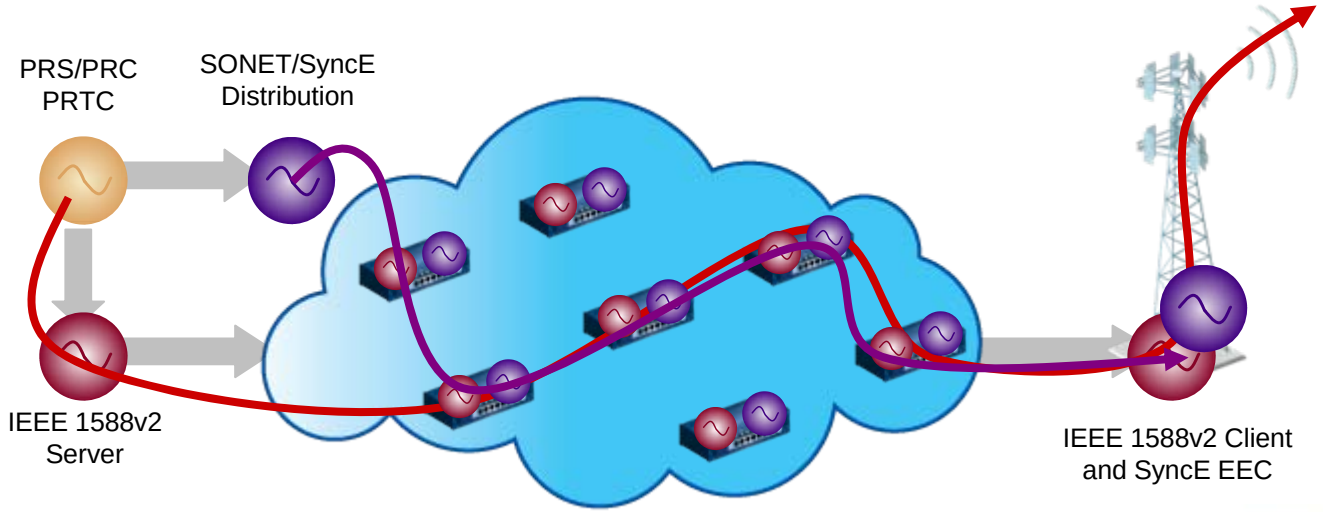
Deployment of IEEE 1588-2008

- **Upgrade RAN end points with IEEE 1588-2008**
  - **IEEE 1588-2008 client is embedded in the basestation**
  - **Will support GSM, WCDMA-FDD and LTE-FDD applications requiring frequency accuracy (50 ppb)**
  - **Will support frequency requirements (traffic MTIE) for enterprise (PBX) or CES**
  - **Challenging to support phase and time (CDMA2000, WCDMA-TDD, TD-SCDMA, Mobile WiMAX) unless the Ethernet network is smaller and the performance of the client oscillator is high**
  - **Does not require a change to existing switches & routers in the Ethernet network**
  - **Operates over any Packet network**



Deployment of both SyncE & IEEE 1588-2008

- **Ethernet Networks with SyncE-enabled and 1588-aware switches/routers**
  - **The technologies work together, as SyncE provides syntonization for IEEE 1588v2**
  - **Add phase and time synchronization by enabling IEEE 1588-2008**
    - **May also add Boundary Clock protocol in all nodes to further improve performance**
  - **Supports high performance frequency accuracy, phase and time synchronization**
  - **Published performance reports from China Mobile, up to 20-30 nodes in the Ethernet Network, and performance < 250 ns time alignment**
  - **ITU-T working on specifications where every node is 1588-aware for time synchronization**

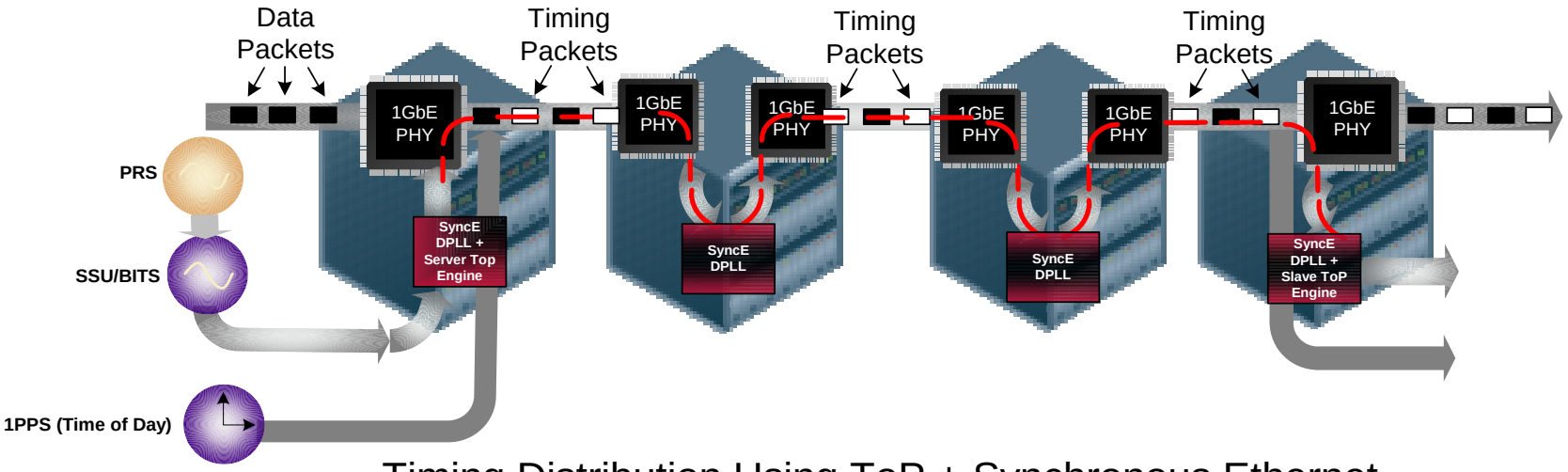


Time of Day Alignment

- **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

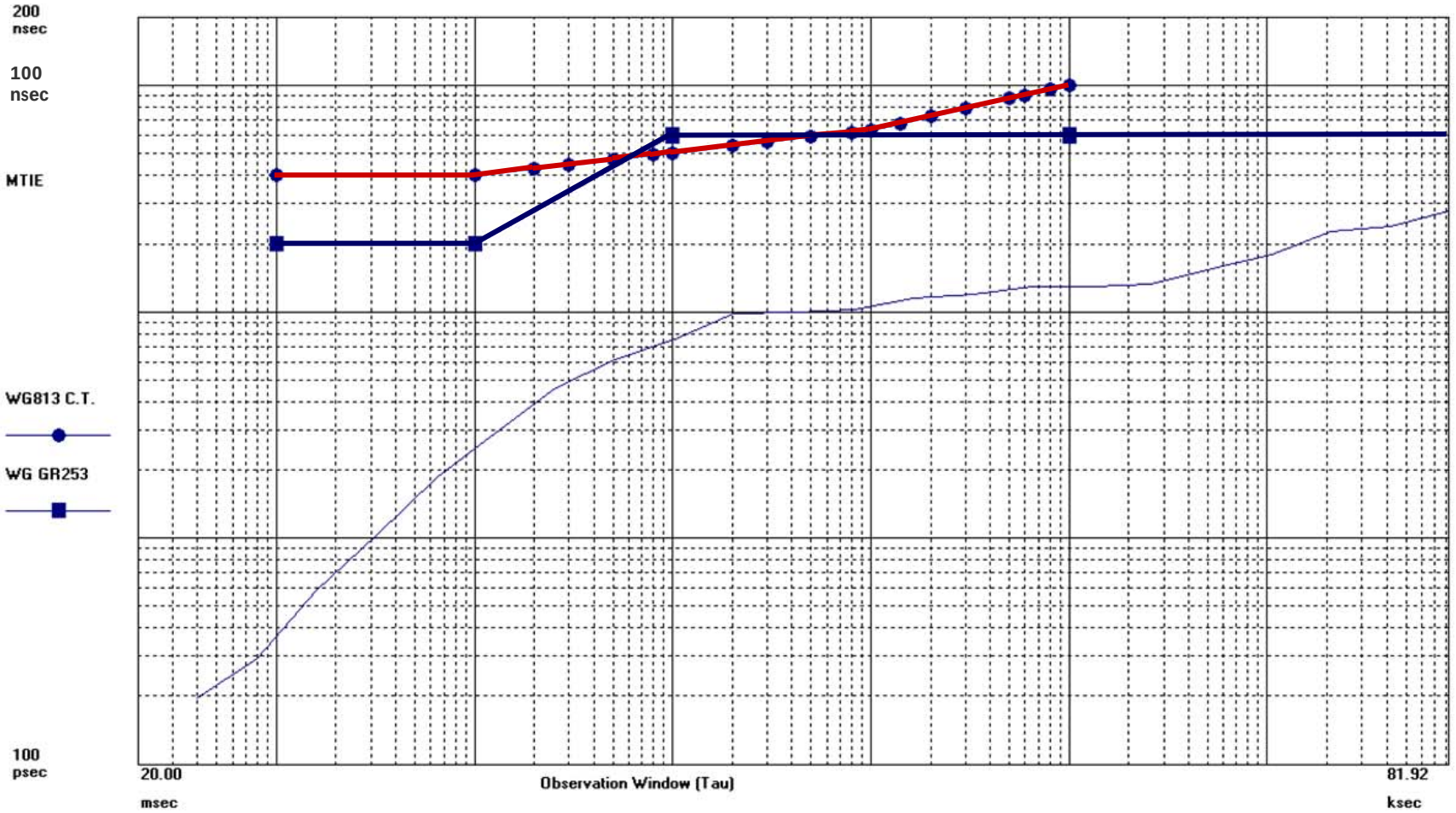
- **Hybrid mode combines SyncE and IEEE 1588**
  - **An accurate frequency is obtained through SyncE**
  - **An accurate Time of Day alignment is obtained through 1588**



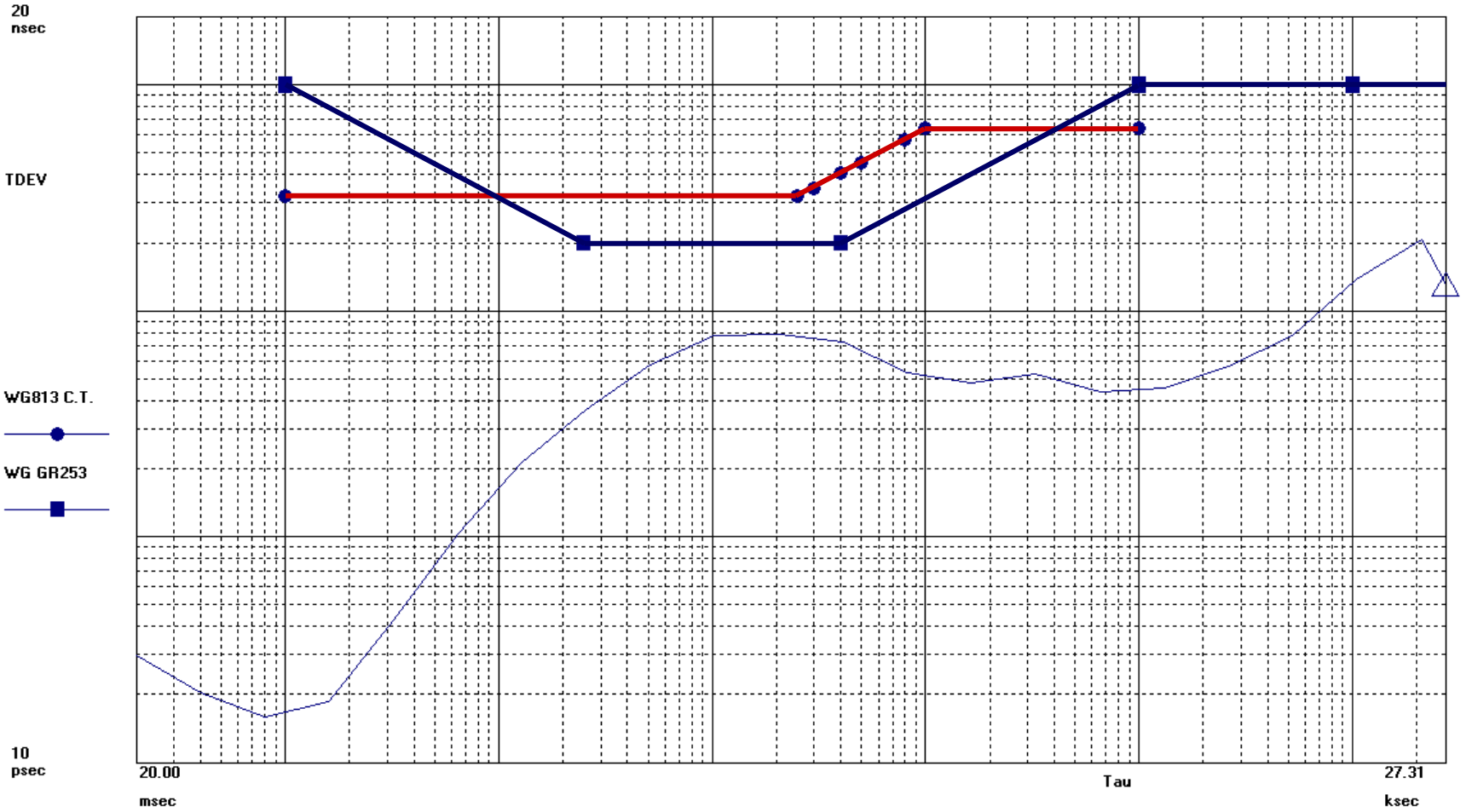
Timing Distribution Using ToP + Synchronous Ethernet

Test results for SyncE Only

SyncE, 10 Node MTIE Results



SyncE, 10 Node TDEV Results

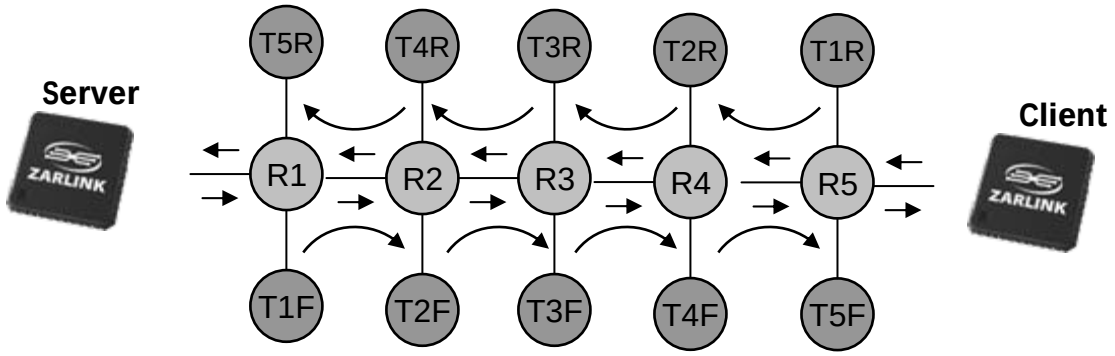


Test results for IEEE 1588 only

Test Results

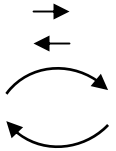
- **The following are Time of Day plots for various traffic Test Cases for a 5 node network**
  - **All nodes are GbE Routers**
  - **Link Delay asymmetry will be small**
- **Numerous G.8261 Test Cases have been used**
- **Many will cause traffic asymmetry**
- **TDD technologies require less than +/-1us**

Network Setup



Notes:

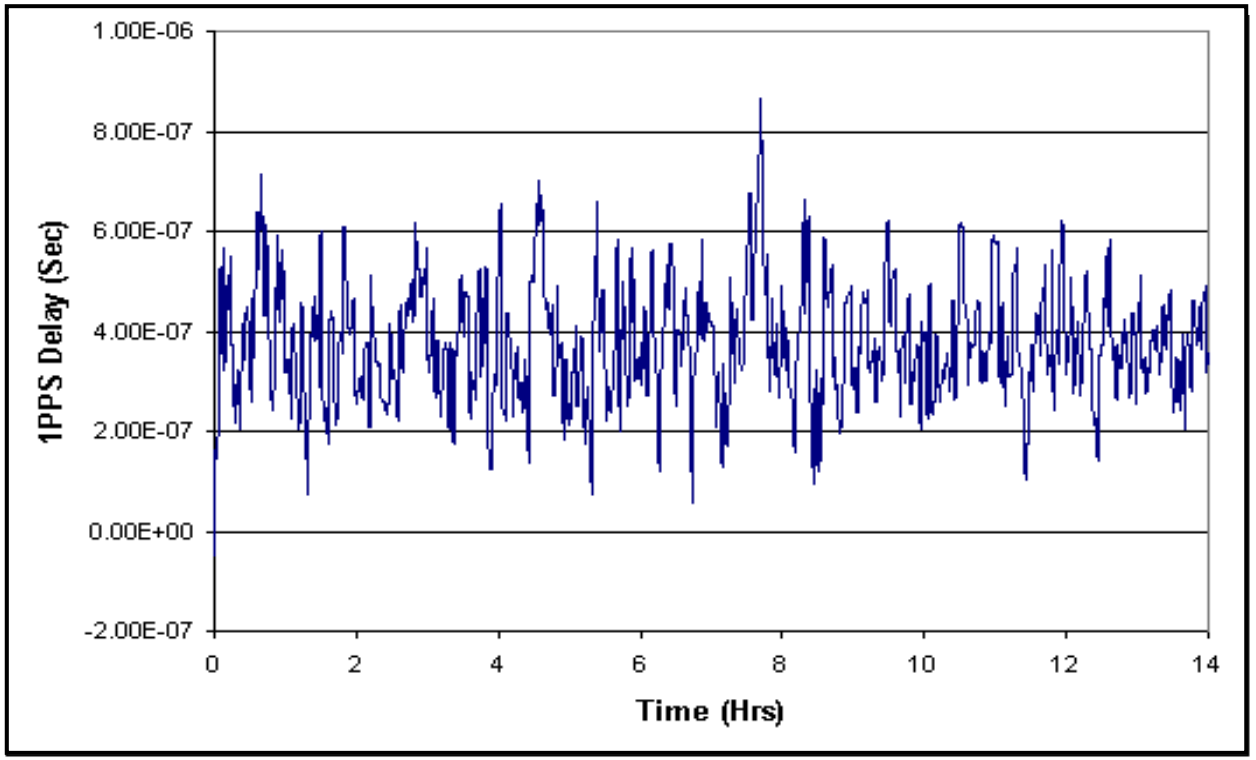
1. R - GE (1 Gbps) Gigabit Routers (L3 Cisco 7600)
2. T - Traffic Generator (R is reverse path, F is forward path)
3. ToP protocol is IPV4 UDP Port 319
4. Traffic Generators are GE (1 Gbps); IXIA 1600 or similar



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

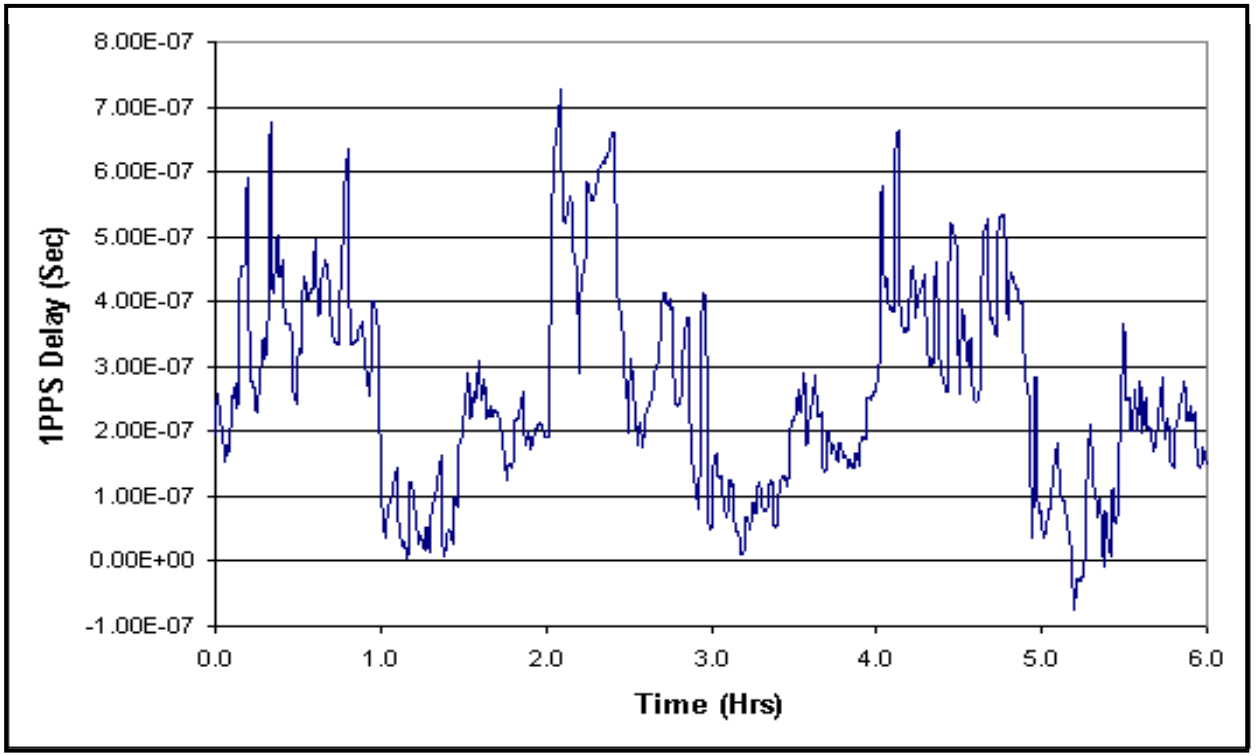
G.8261 TC12 Constant Traffic

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



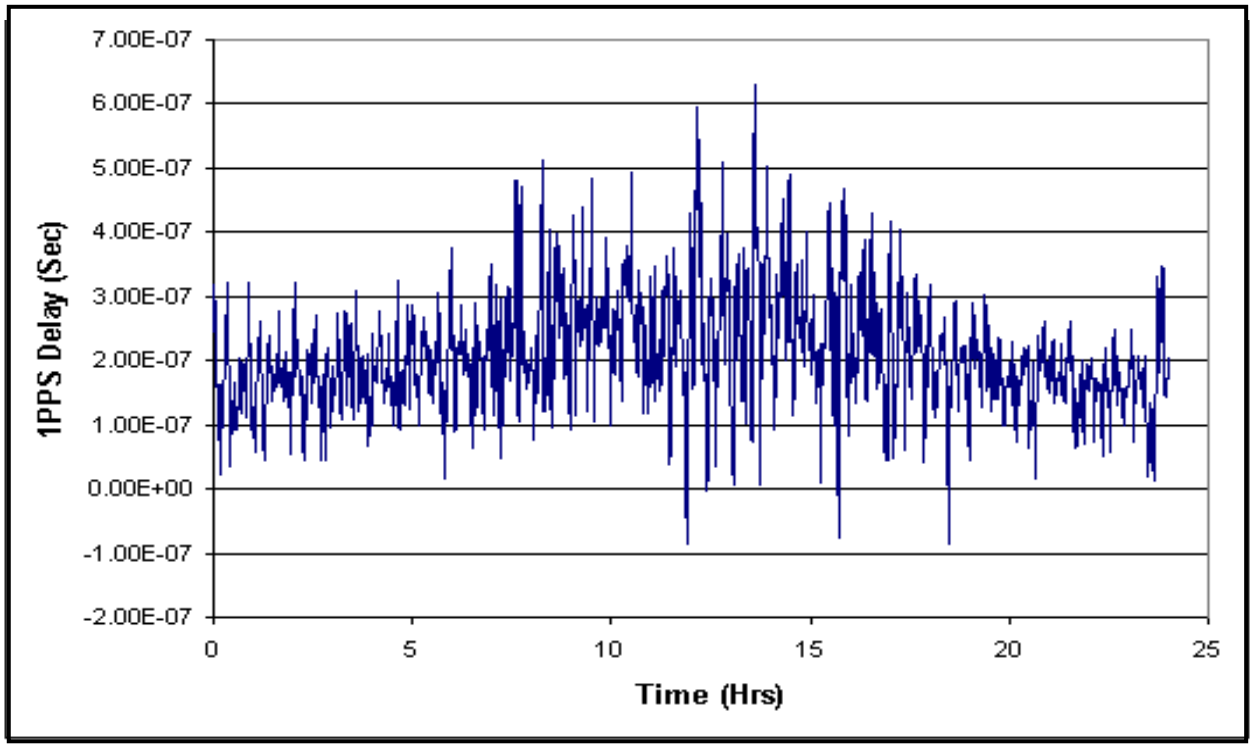
G.8261 TC13 Square

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



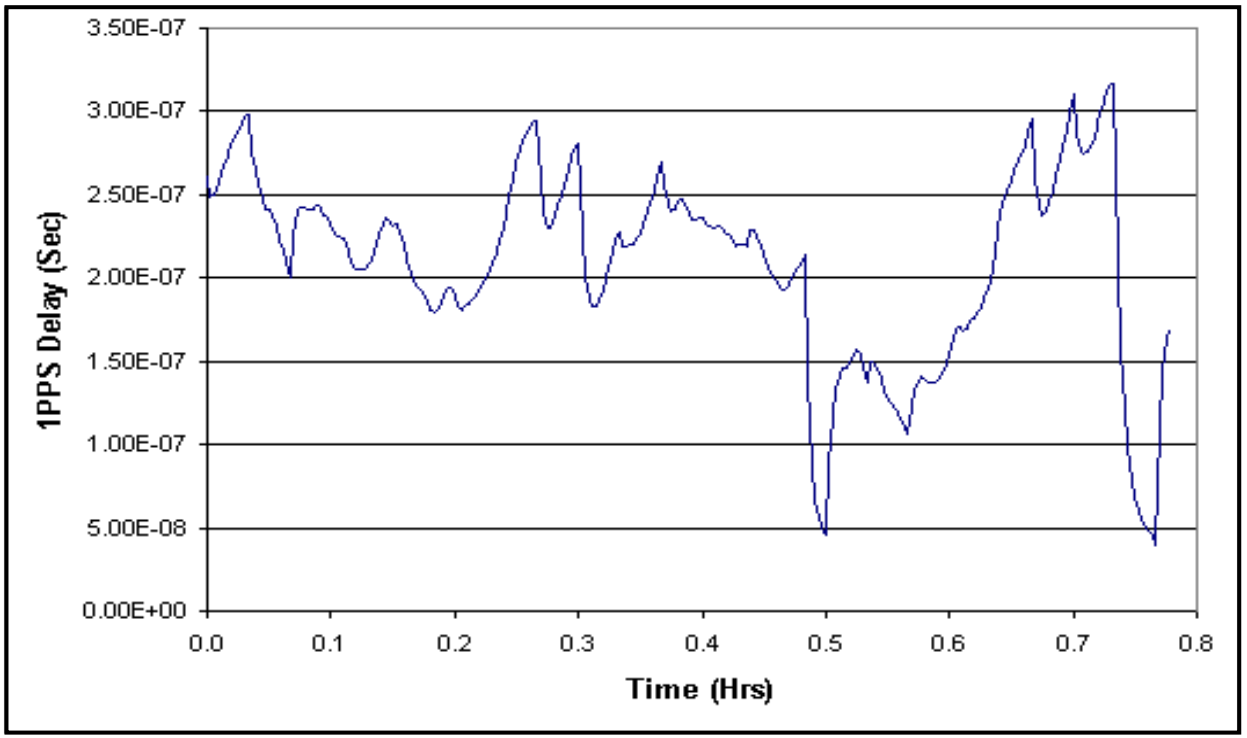
G.8261 TC14 Ramp

- **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**

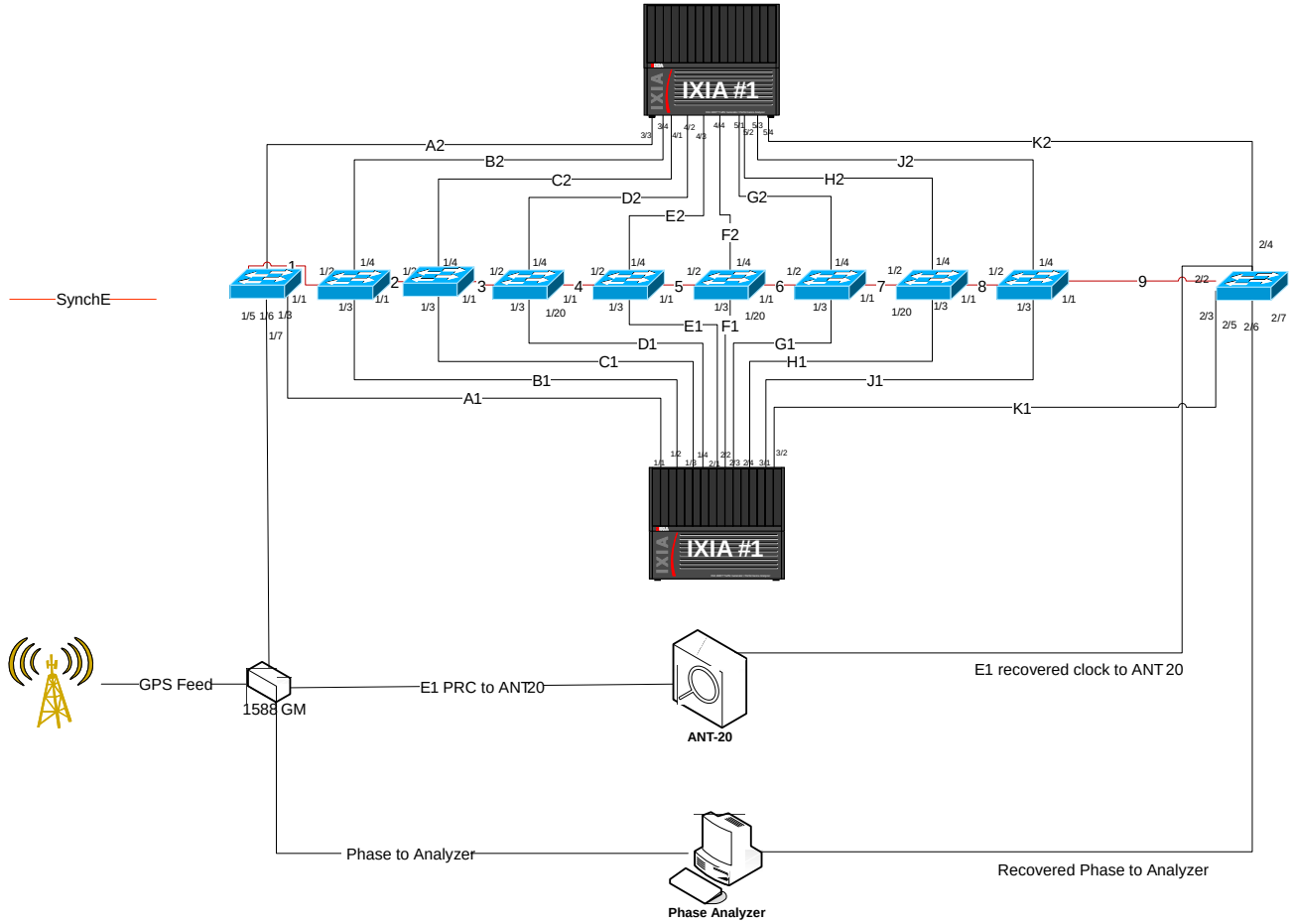


Test results for Hybrid Mode

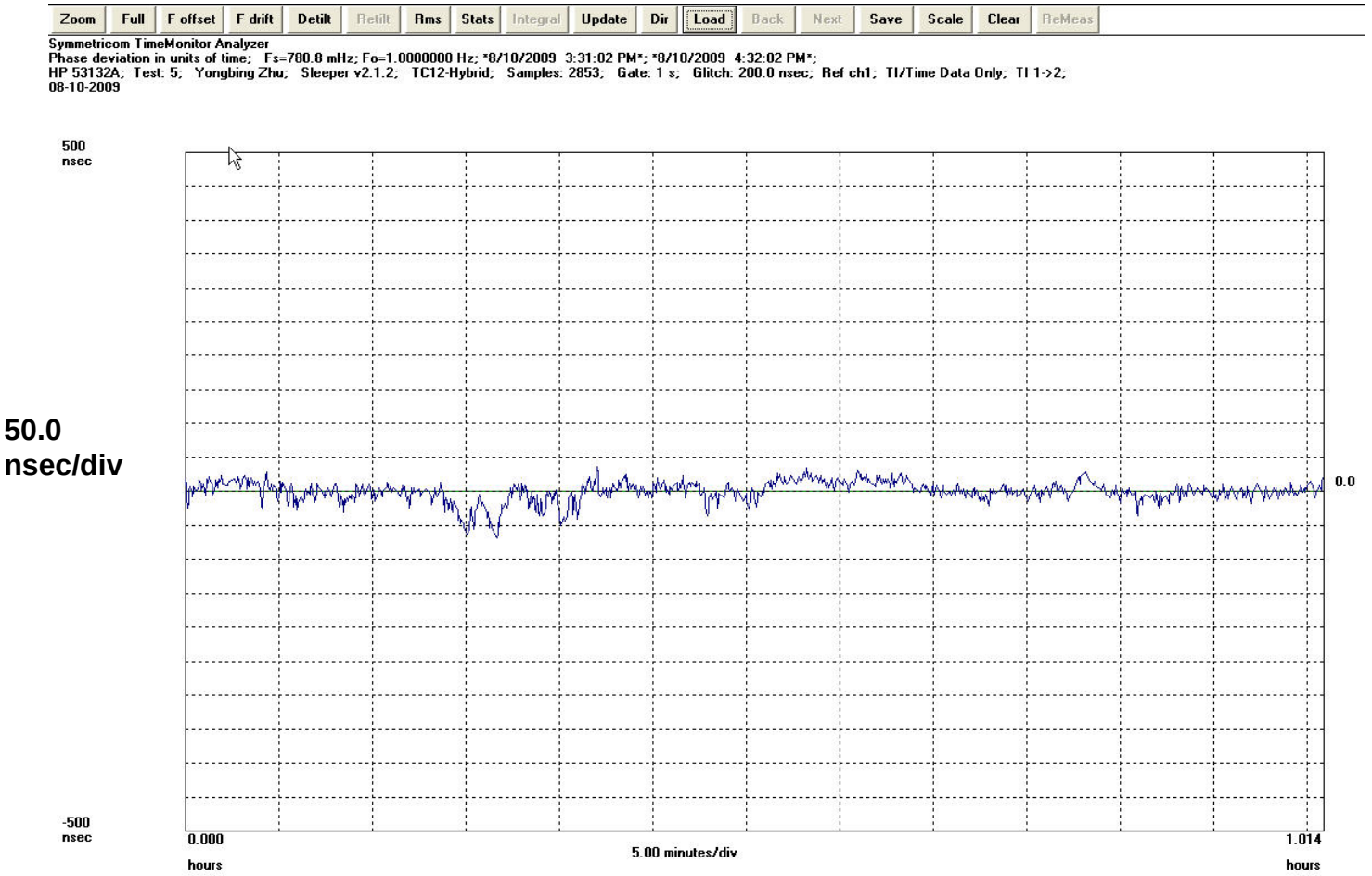
Test Results

- **The following are Time of Day plots for various traffic Test Cases for a 10 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**

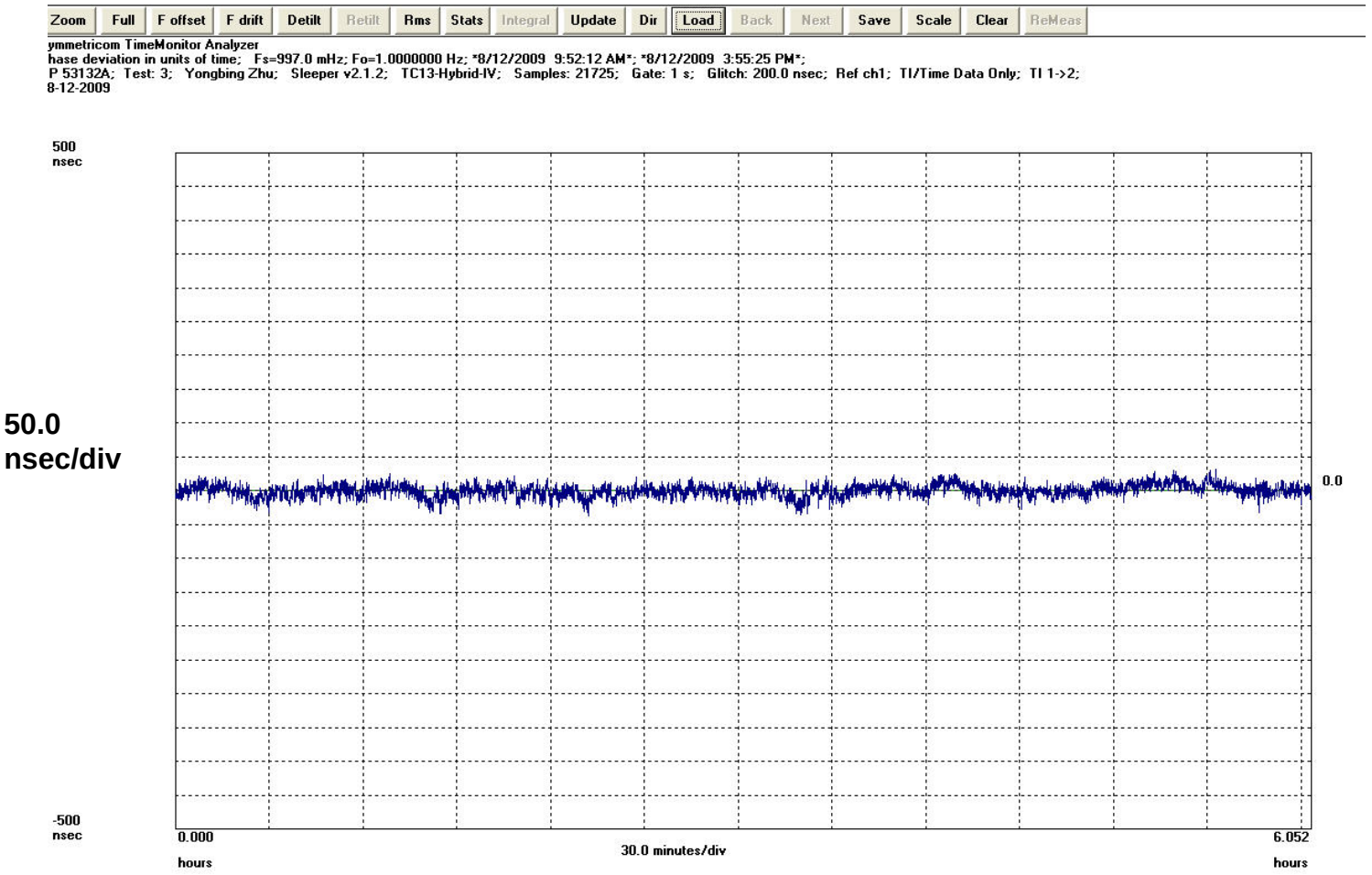
Network Setup



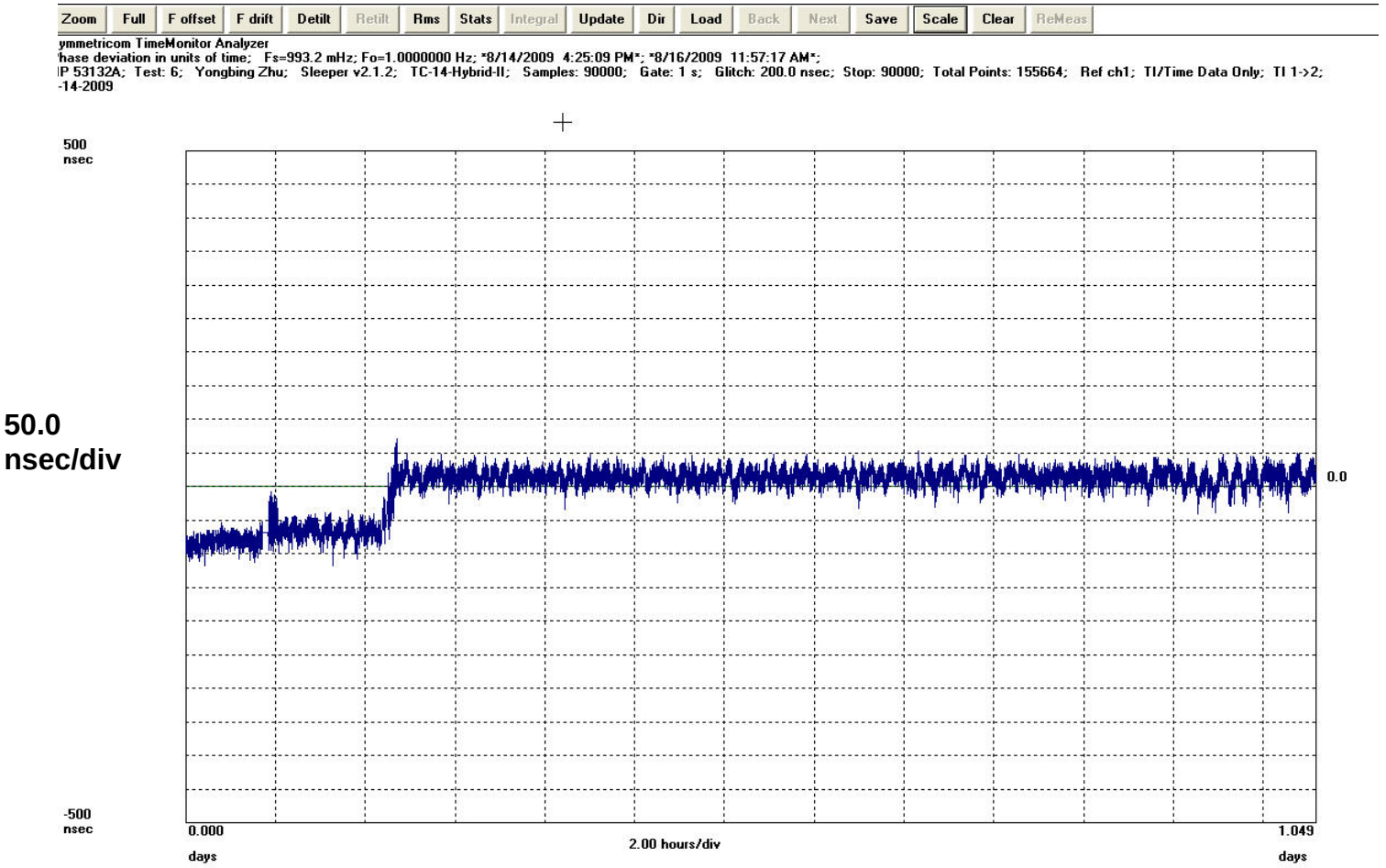
G.8261 TC12 Constant Traffic



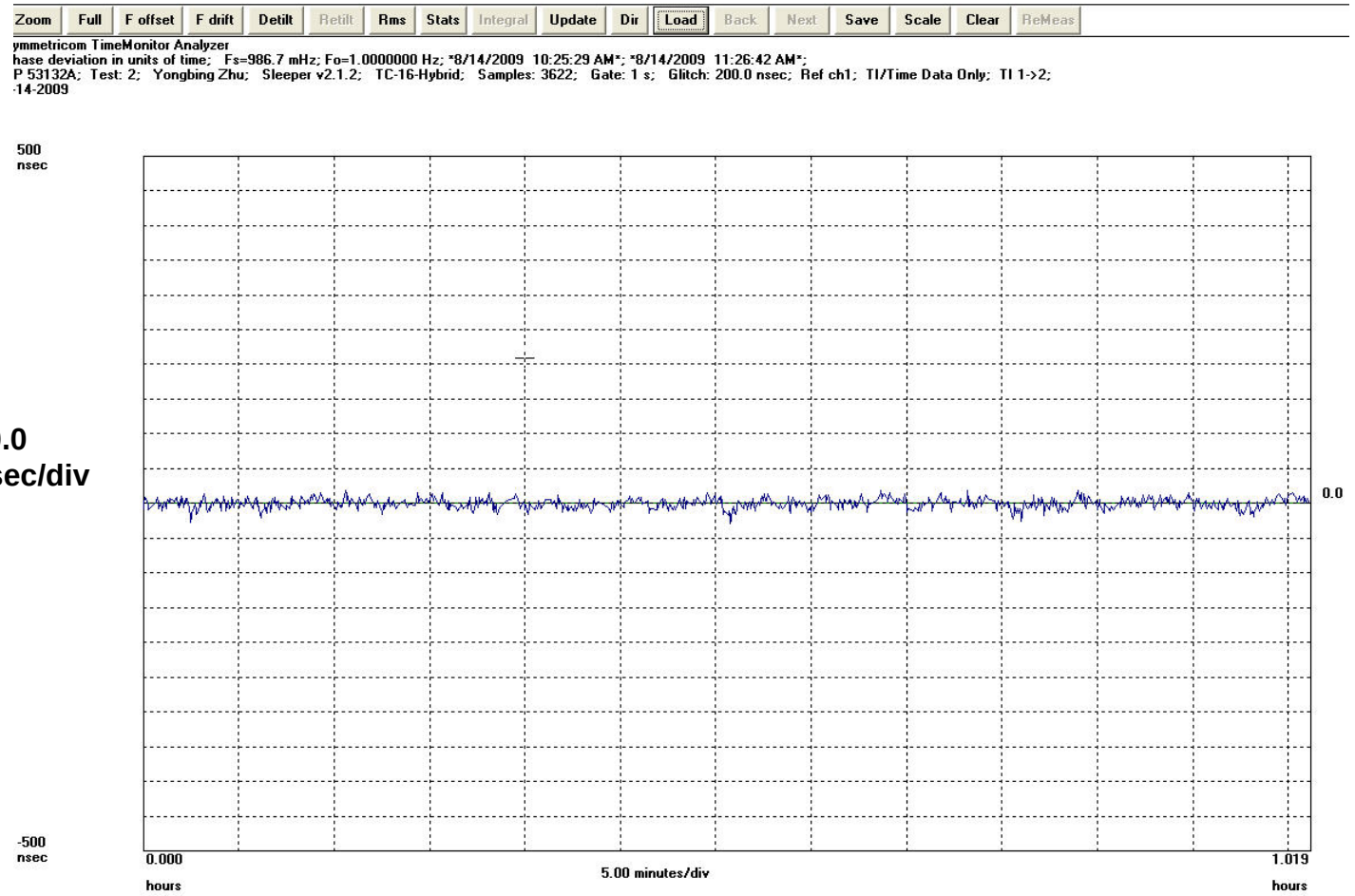
G.8261 TC13 Square



G.8261 TC14 Ramp



G.8261 TC16 Congestion



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**