CALNEX PARAGON-X

Testing 1588v2 PTP

Introducing Calnex Solutions Ltd

Calnex

- Company founded in January 2006.
- Executive team with over 100 years of experience in telecom test instrumentation.
- Rapporteur of the ITU-T study group 15 - Q13
- First customer shipments February 2008.
  - Tier1 Service Providers
  - Tier1 & Tier2 Equipment Manufacturers
  - Component & Clocking Vendors
- De-facto Test Equipment for 1588v2, Sync-E, CES, NTP testing & Eth-OAM.

Example Calnex Paragon Customers

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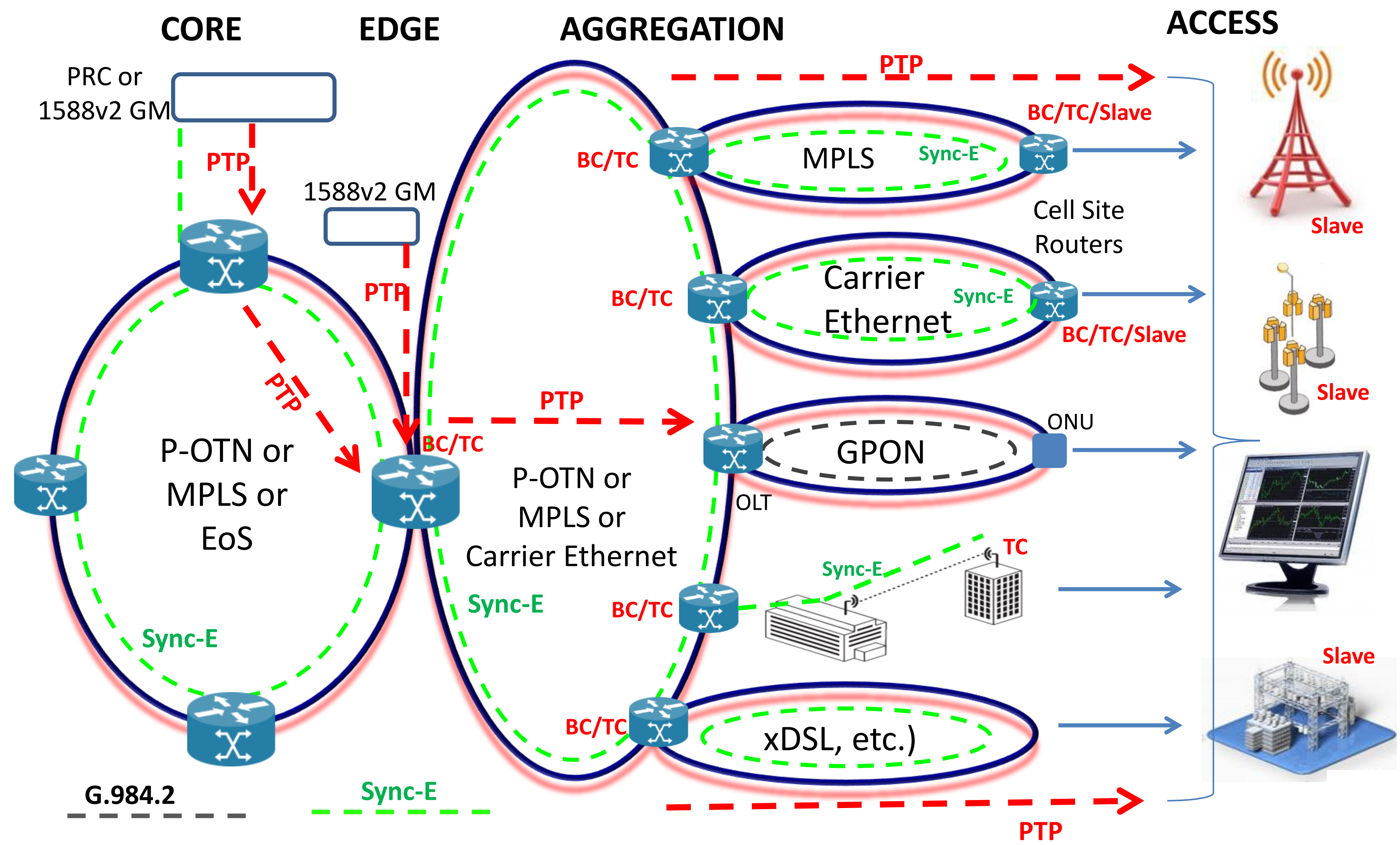
Service Providers

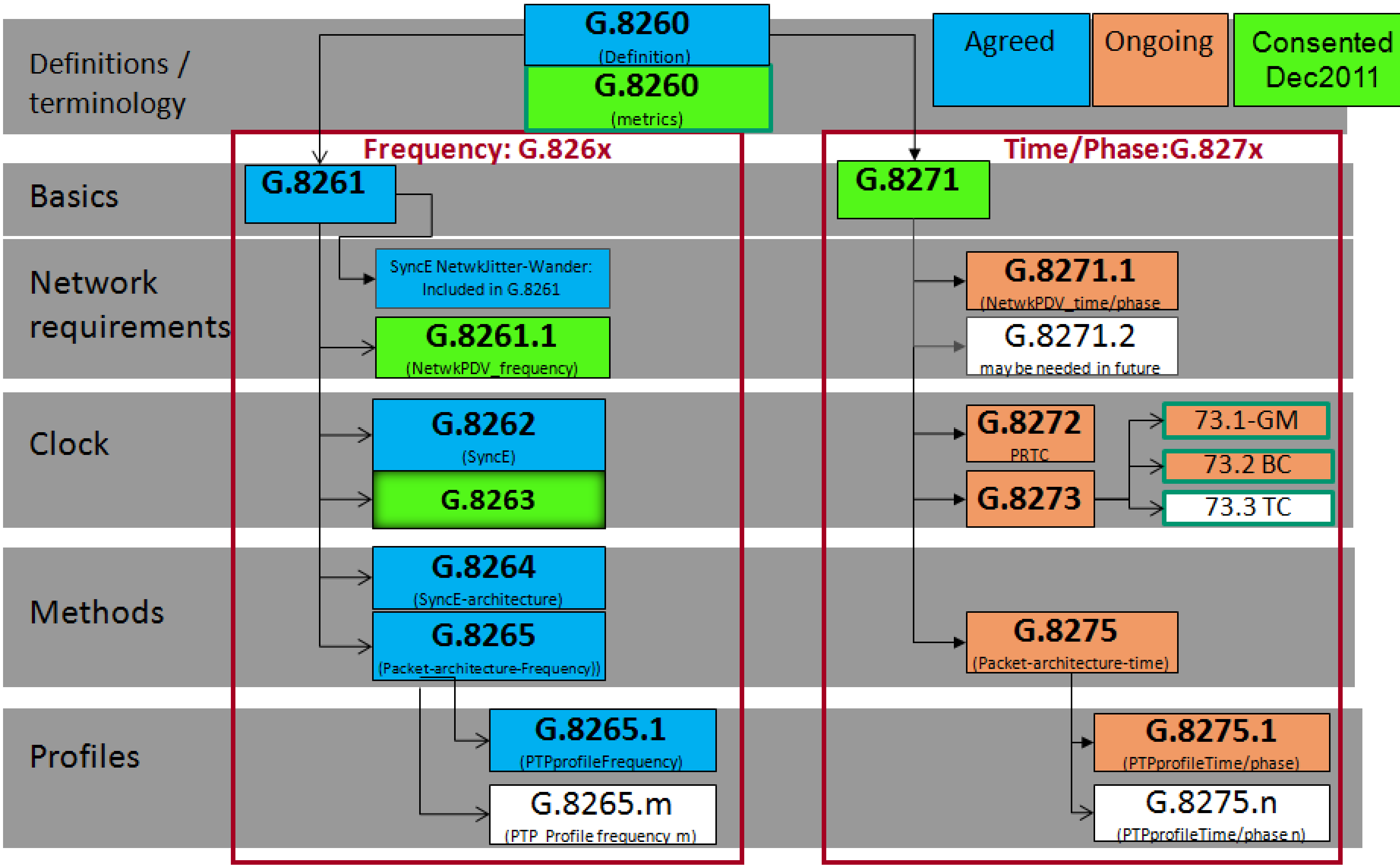
Systems Suppliers

Components, Clocks, Labs, etc.

1588v2 and SyncE in the Network



ITU-T standards

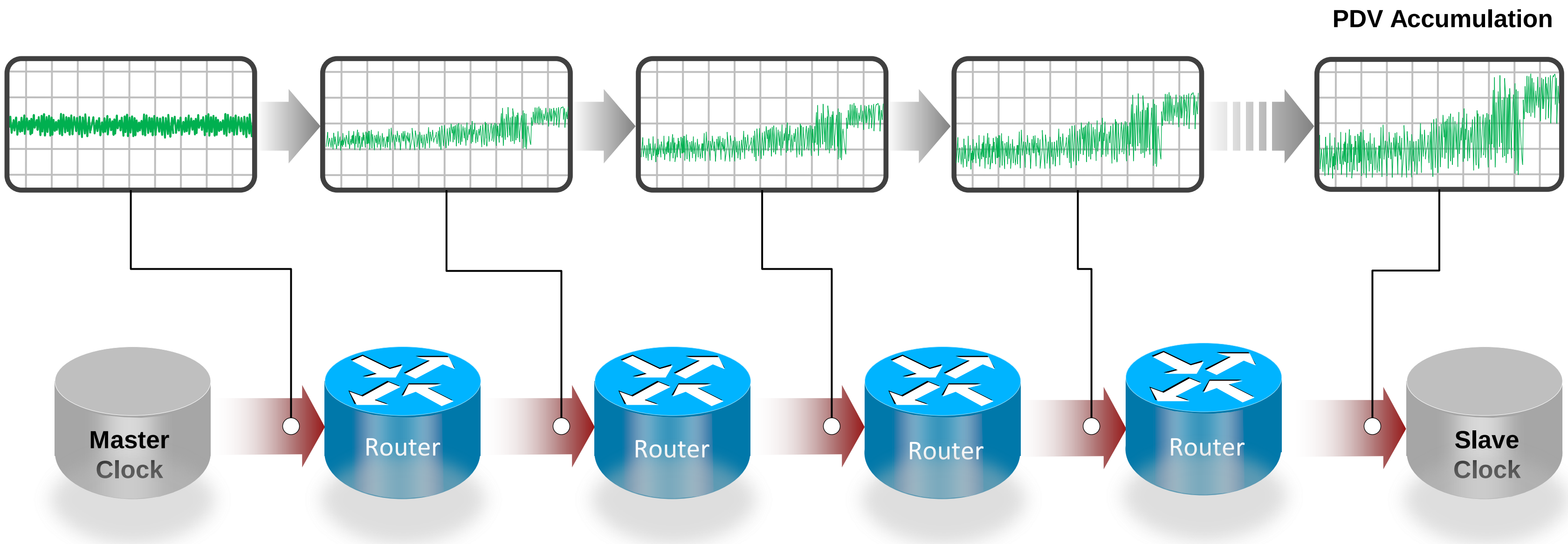


Part 1 – Testing Network Elements

Ordinary Clocks

(1588v2 Slave Clocks)

A network with no BCs/TCs



- In a network with non 1588-aware switches, PDV and Asymmetry can be significant.
- Slave clock recovery is a challenge.
  - Tests have shown Frequency recovery is easier but Phase/Time recovery is a challenge

Test the Slave Clock’s robustness to PDV and Asymmetry

Test the Slave Clock

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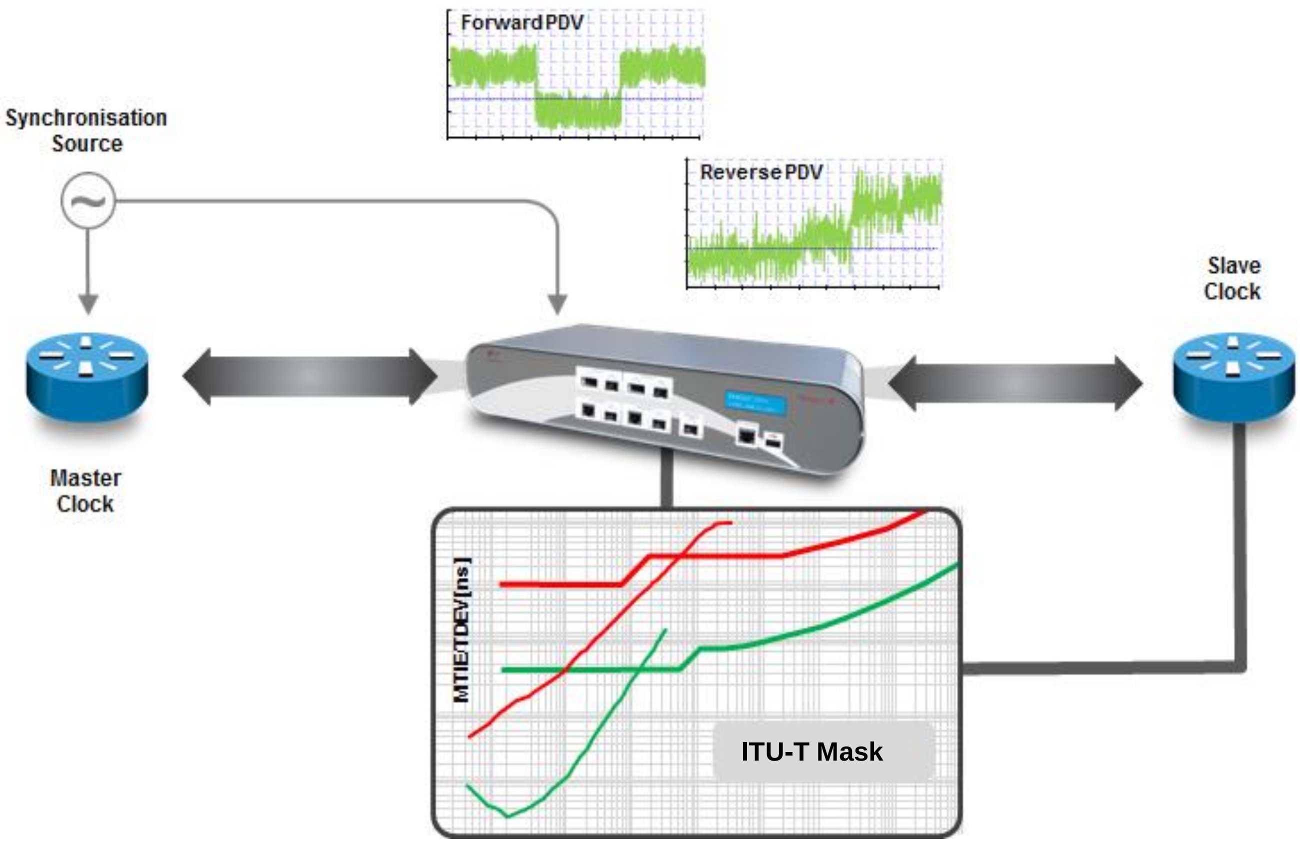
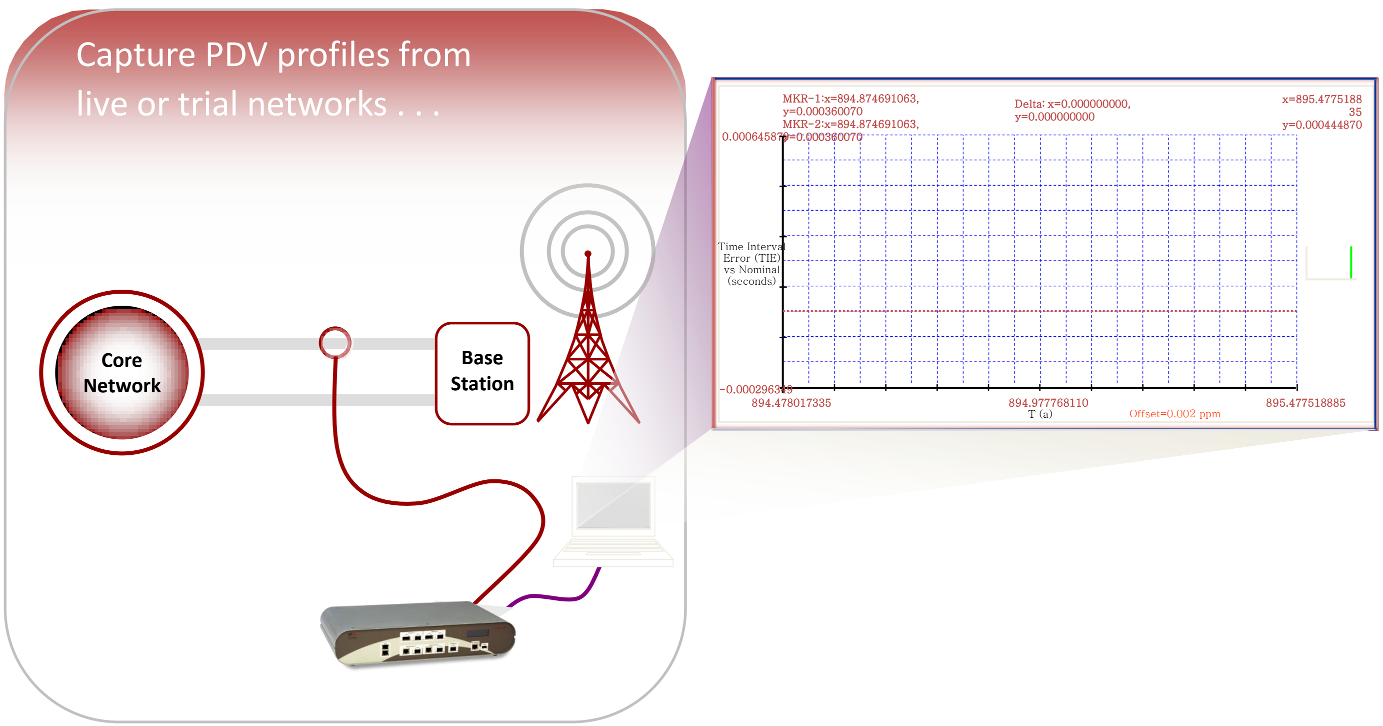


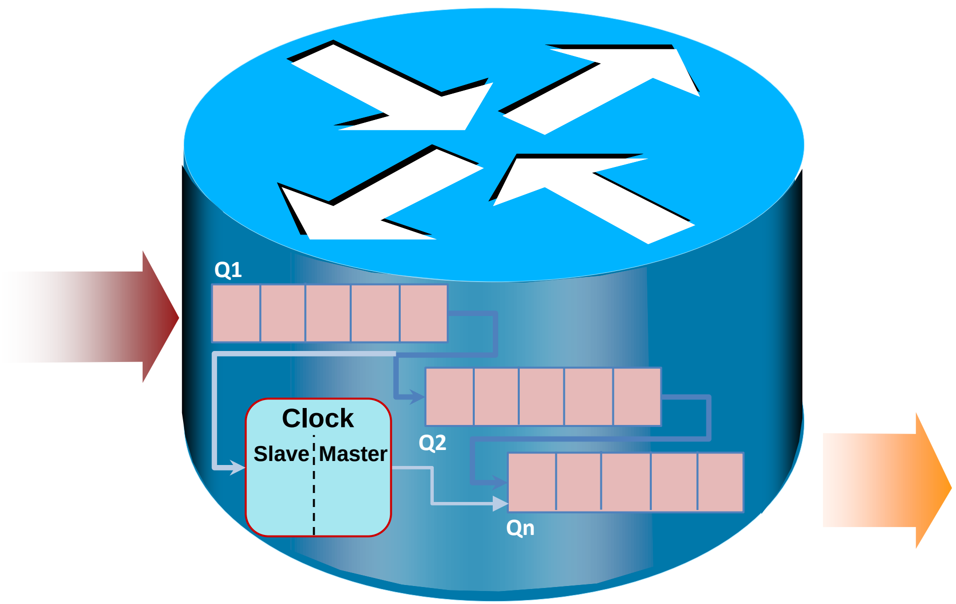
1. **Apply PDV**
   (G.8261 test cases)
2. **Measure E1/T1**
   (to G.8261.1, etc.)
3. **Measure 1pps, ToD**
   (vs. specified limits)

Real-world testing



Boundary Clocks (BCs)

Boundary Clocks



Boundary Clocks reduce PDV accumulation by:

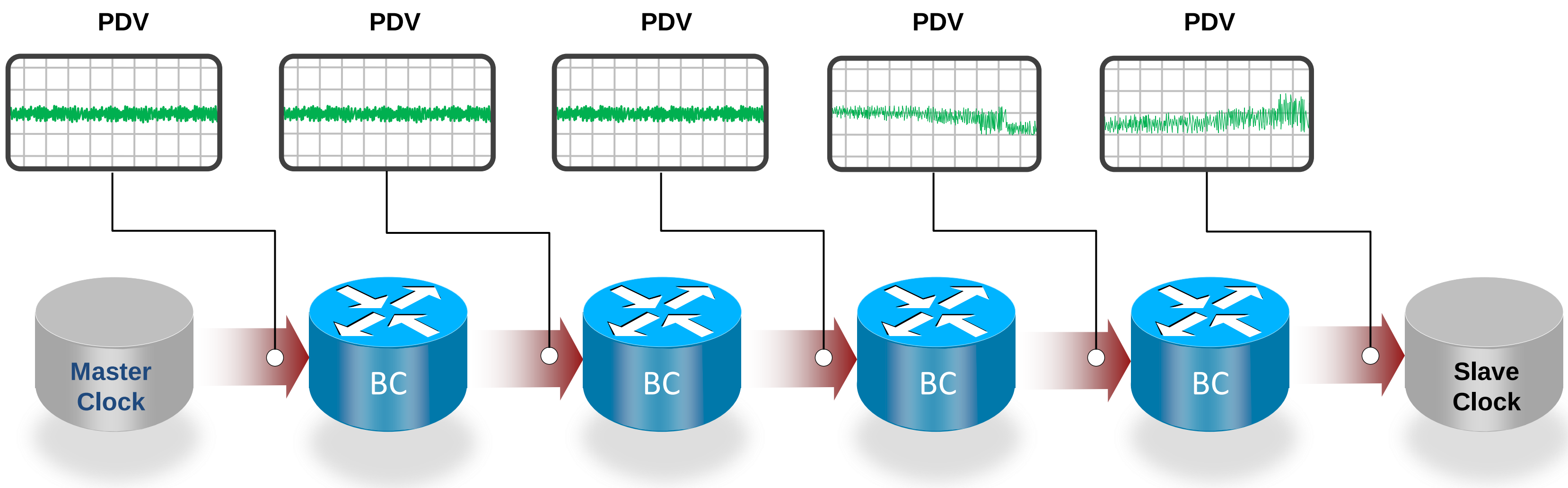
Terminating the PTP flow and recovering the reference timing.

Generating a new PTP flow using the local time reference, (locked to the recovered time).

There is no direct transfer of PDV from input to output.

A Boundary Clock is in effect a back-to-back Slave+Master.

A network with 1588v2 BCs



- Boundary Clocks (BCs) are back-to-back Slave-Masters
- BCs recover and re-generate the 1588v2 clocking
- With a network of BCs, PDV contribution (per hop) is only from BC and link
- PDV experienced by Slave is minimised

Test the BC's Output Noise, Noise Transfer and Noise Tolerance

Why Test Boundary Clocks?

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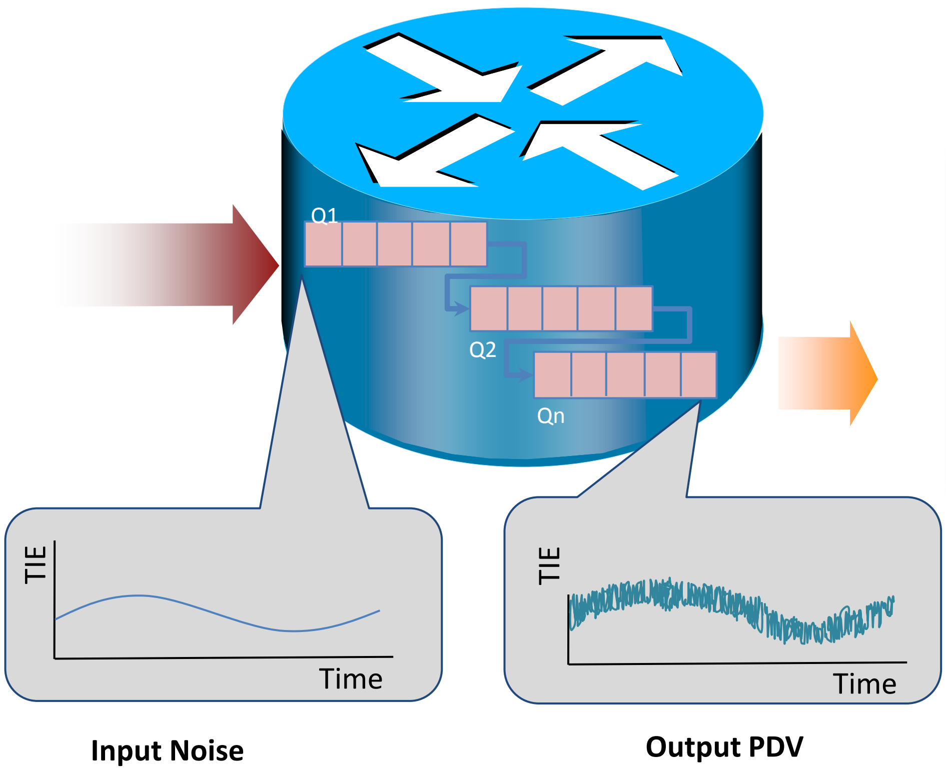


Potential Sources of PDV:

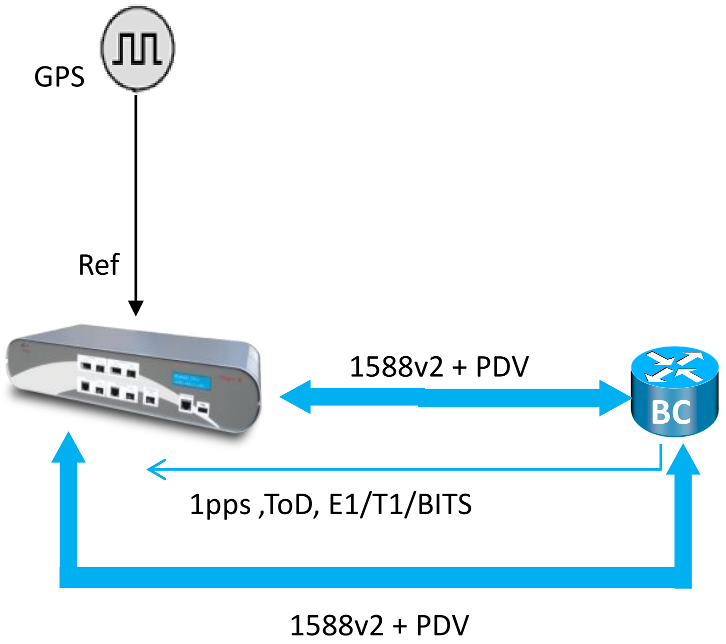
a) *Clock Wander*

- Each BC recovers the clock and re-generates a new timing signal. This can lead to the introduction of low frequency clock wander,
- Chains of BCs can lead to the accumulation of low-frequency clock wander.

b) *High-freq. PDV from BC*

- PDV from BC **Output Buffer Queue**;
  - 12 µs for 1514 byte packet
  - 525 µs for 64kB Jumbo packet
- PDV from other internal queues.
- Affected by other High Priority Traffic?

Test the Boundary Clock



ITU-T **G.8273.2** will specify the performance of a BC.

Noise generation

Noise tolerance

Noise transfer

Phase Transient Response

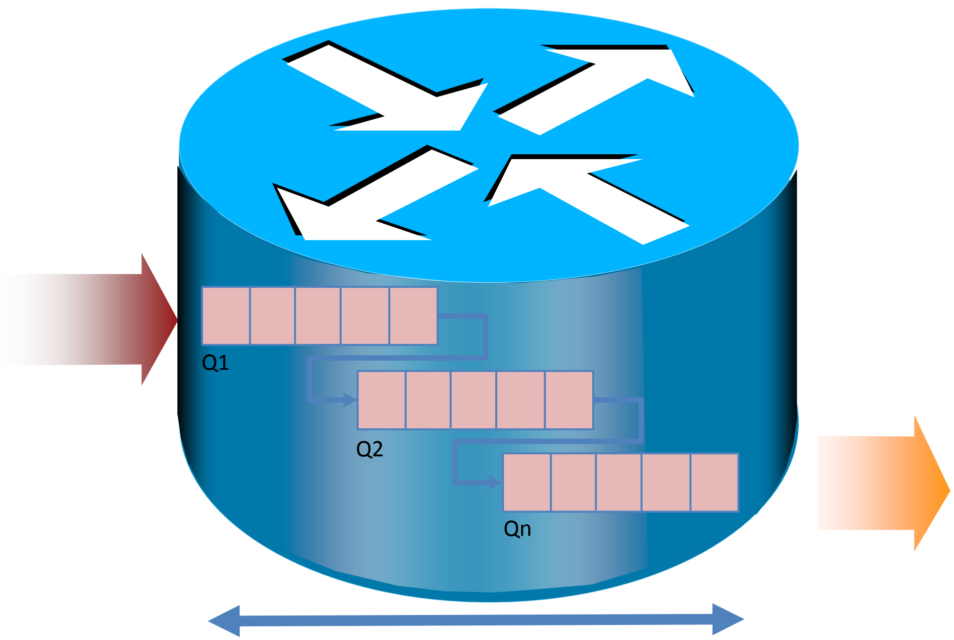
Transparent Clocks (TCs)

Transparent Clocks

Transparent Clocks reduce PDV by;

Calculating the time a PTP packet resides in the TC device (in nsec) and insert the value into the CorrectionField.

Using the CorrectionField, the Slave or terminating BC can effectively remove the PDV introduced by the TC.



Packet Delay in TC Device
inserted into correctionField
at output of Transparent Clock device

PTP Message Header Format

Bits							
7	6	5	4	3	2	1	0
transportSpecific				messageType			
Reserved				versionPTP			
messageLength							
domainNumber							
Reserved							
Flags							
correctionField							
Reserved							

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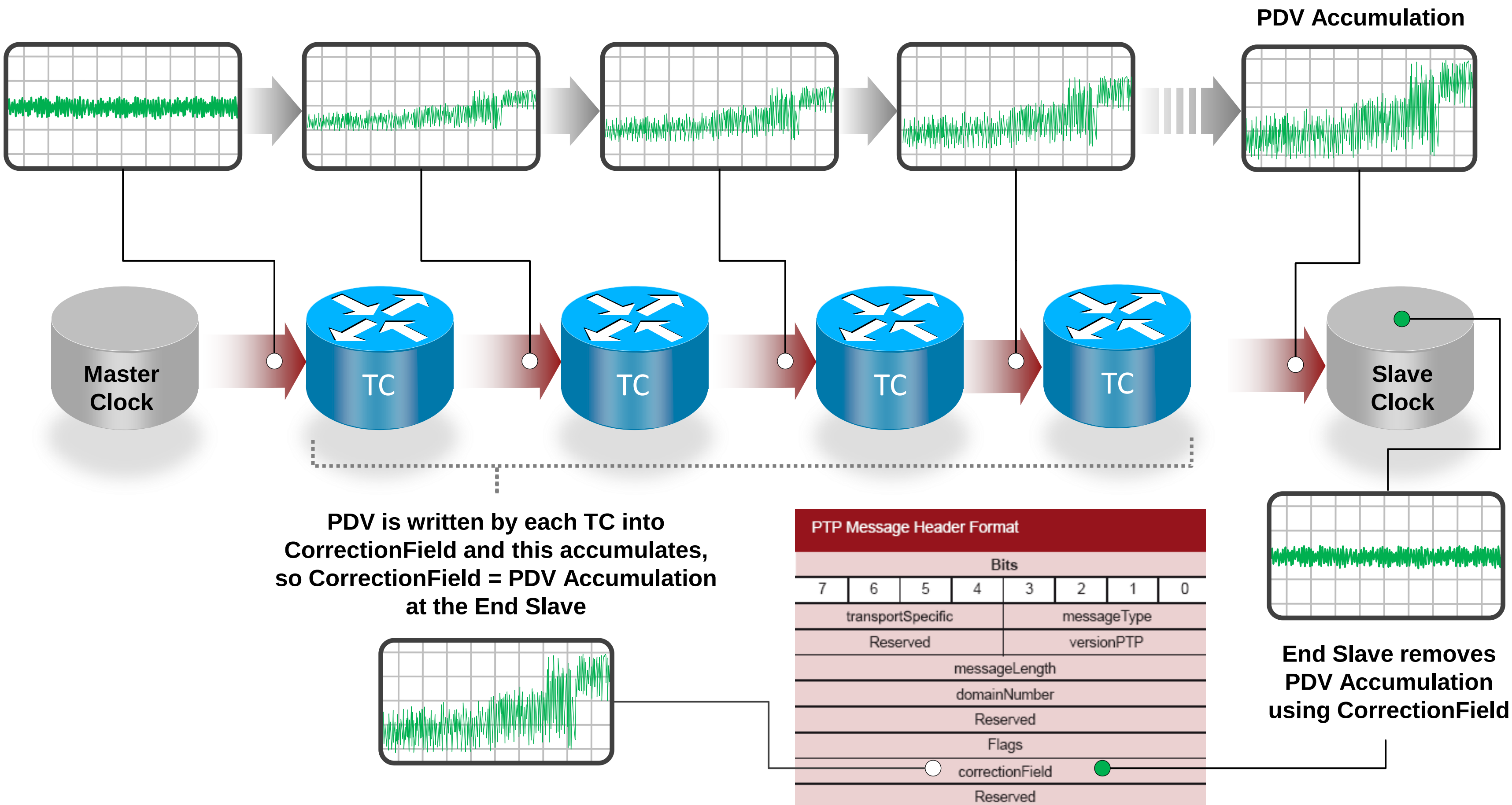
A network with 1588v2 TCs



Test the TC's Accuracy by measuring CorrectionField error

Testing TC Accuracy

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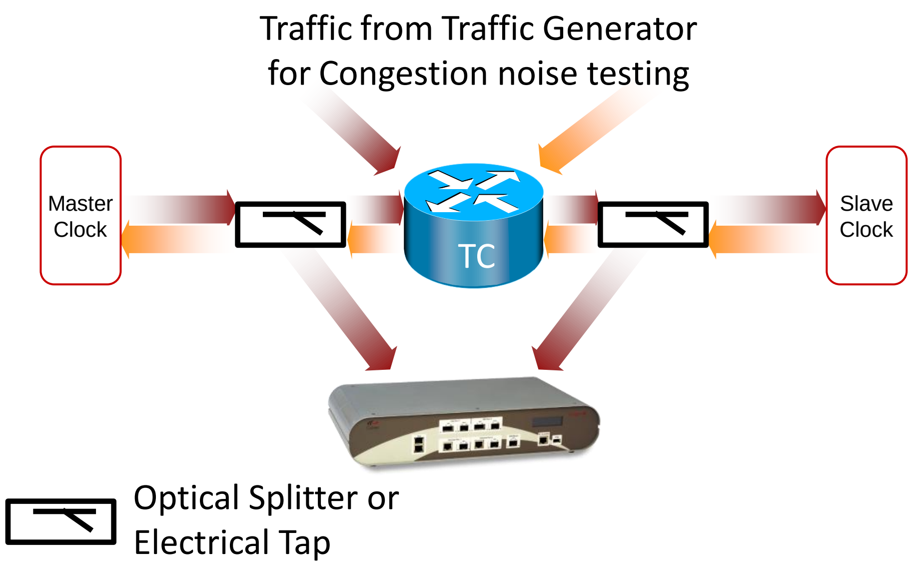
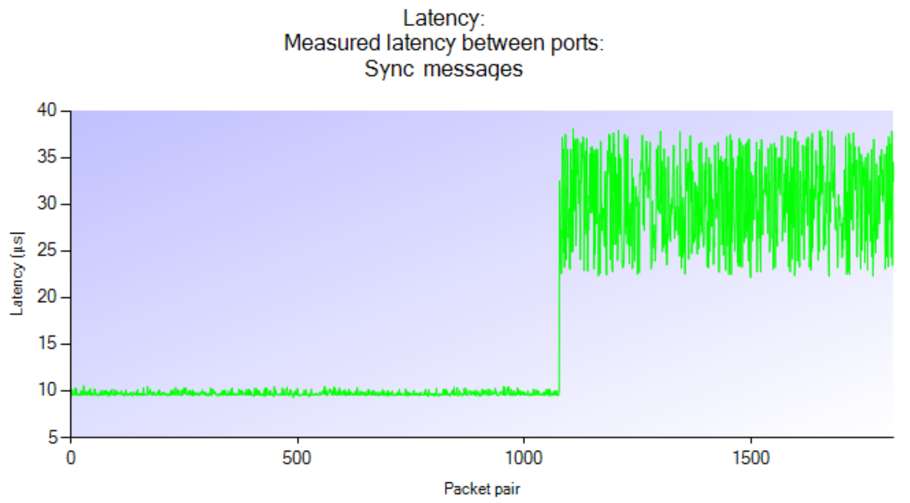
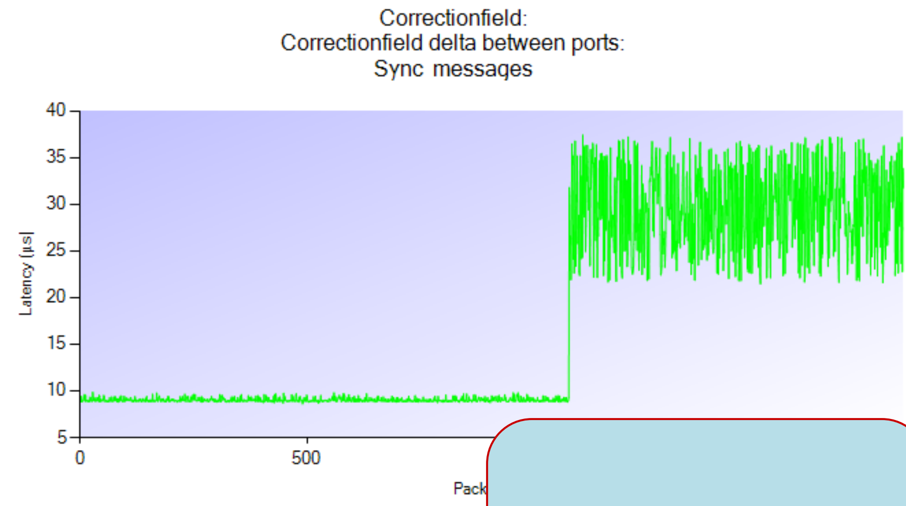


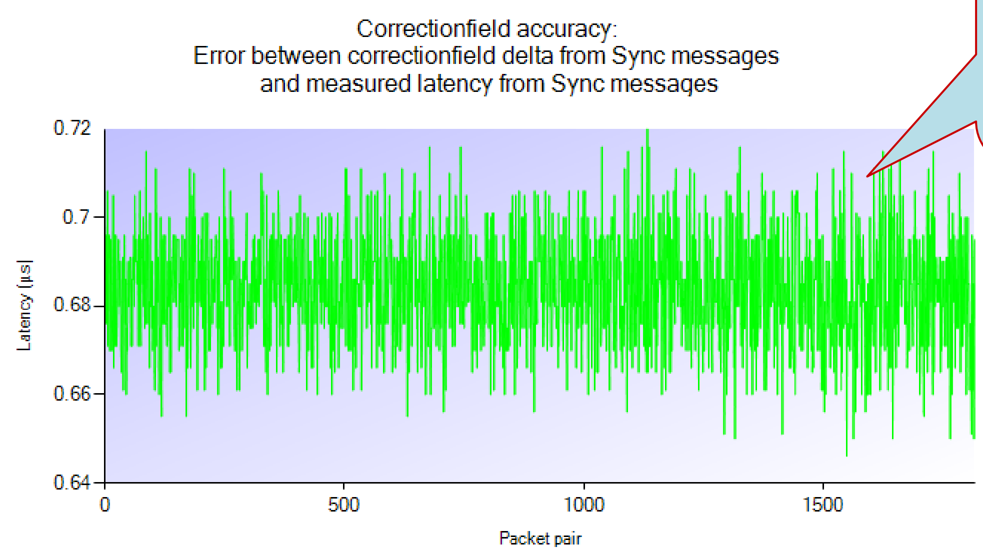
1. Measure the packet-by-packet latency across the TC.
2. Determine the change to the correctionField value for each message.
3. Accuracy is the difference in the actual latency compared to the change in Correctionfield value.

- Measure impact of correctionField on Sync PDV.
    1. Vary traffic packet size.
    2. Vary traffic priority.
    3. Vary traffic utilisation.
- Repeat for Sync & Del_req PDV.
  Test in 1-Step and 2-Step modes.
- **Accuracy Spec is ≤ 50ns (IEEE C.37.238)**
- Calnex Paragon-X measurement accuracy is 5ns

TC Accuracy example results







35nsec pk-to-pk per TC

(Network of 2 TCs)

1588v2 Application Notes

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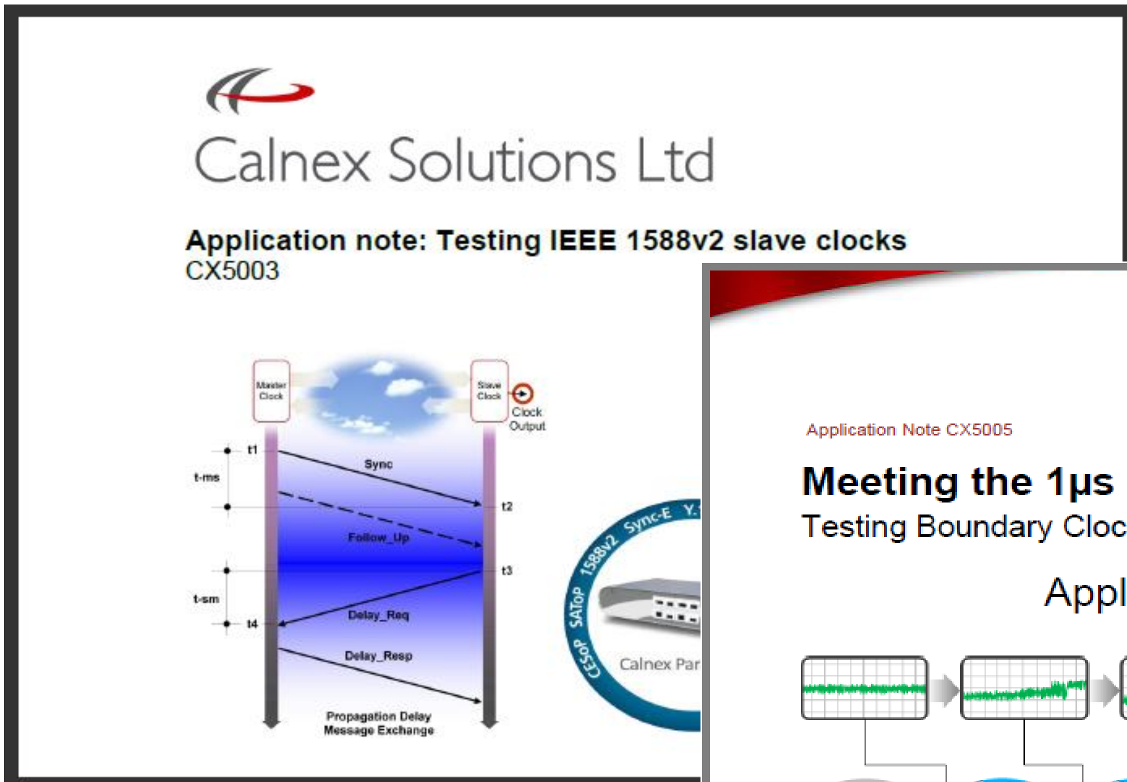
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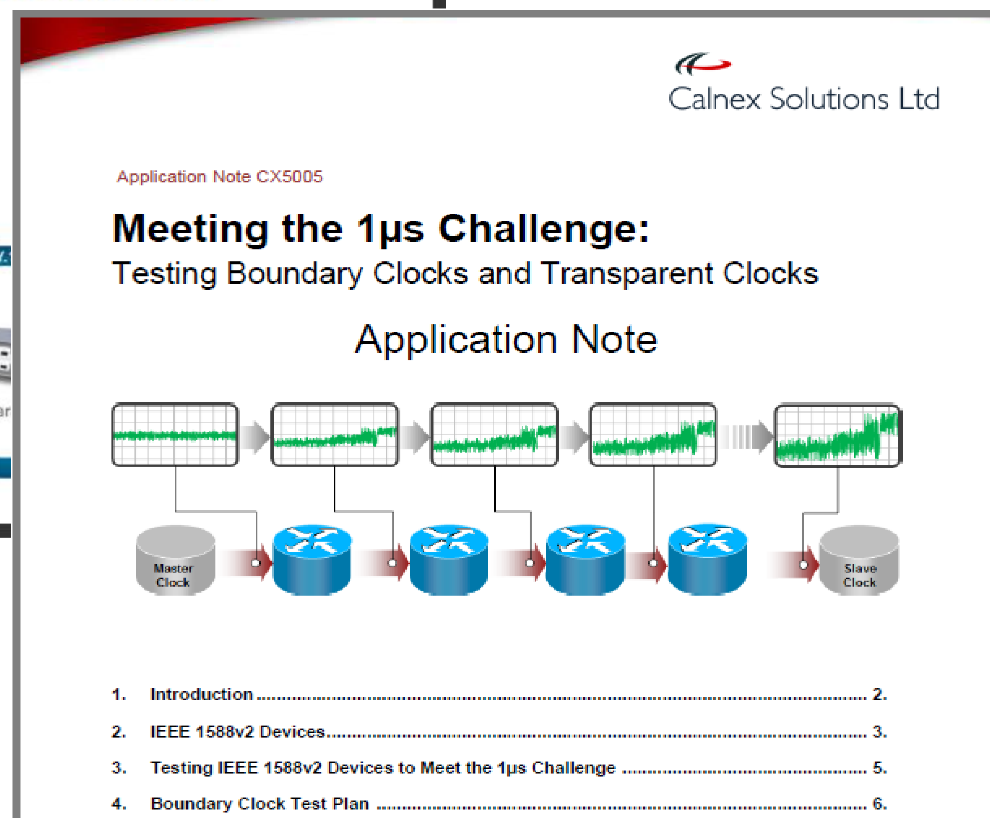
Application note: Testing IEEE 1588v2 slave clocks
CX5003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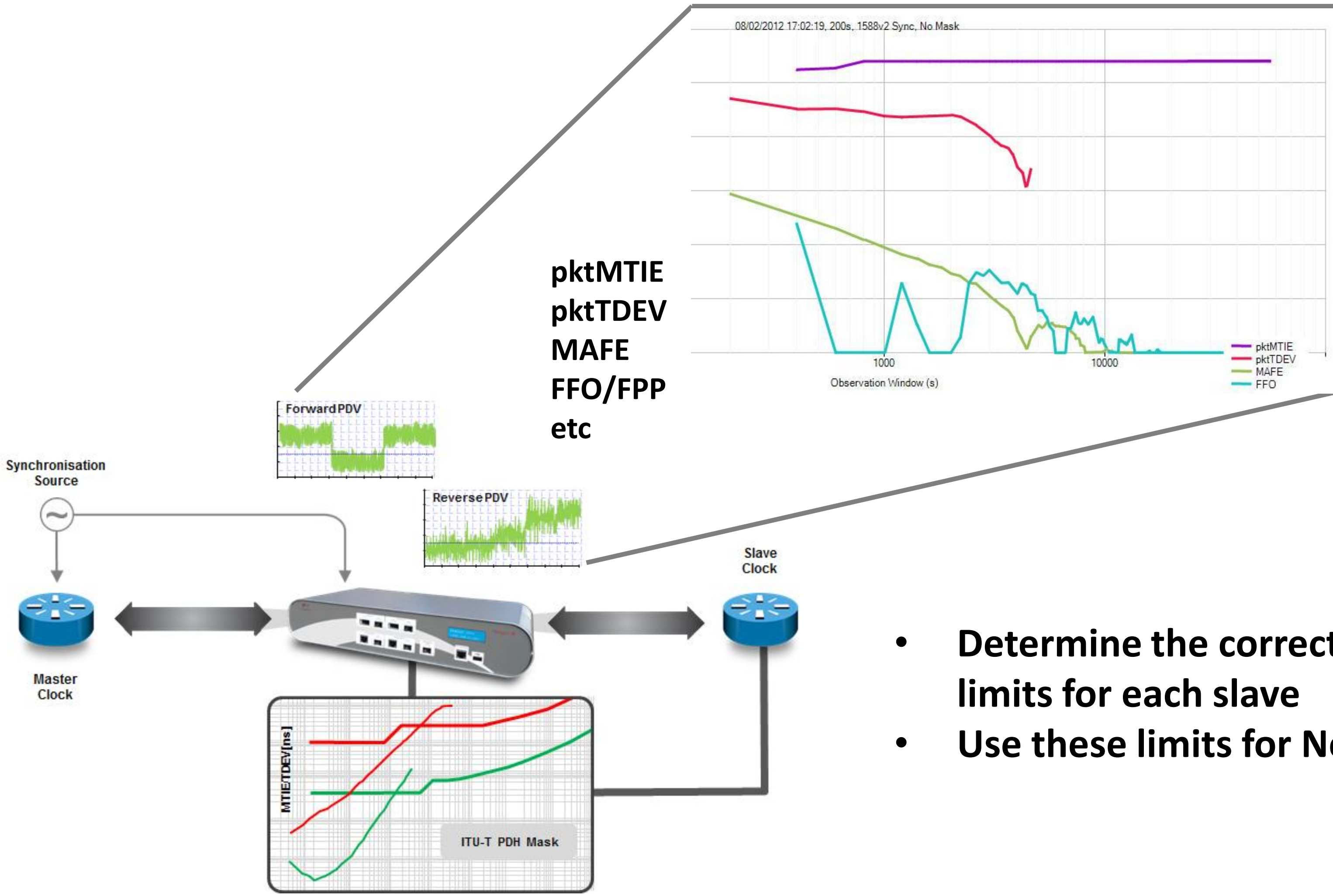
Application Note CX5005

Meeting the 1μs Challenge:
Testing Boundary Clocks and Transparent Clocks

Application Note

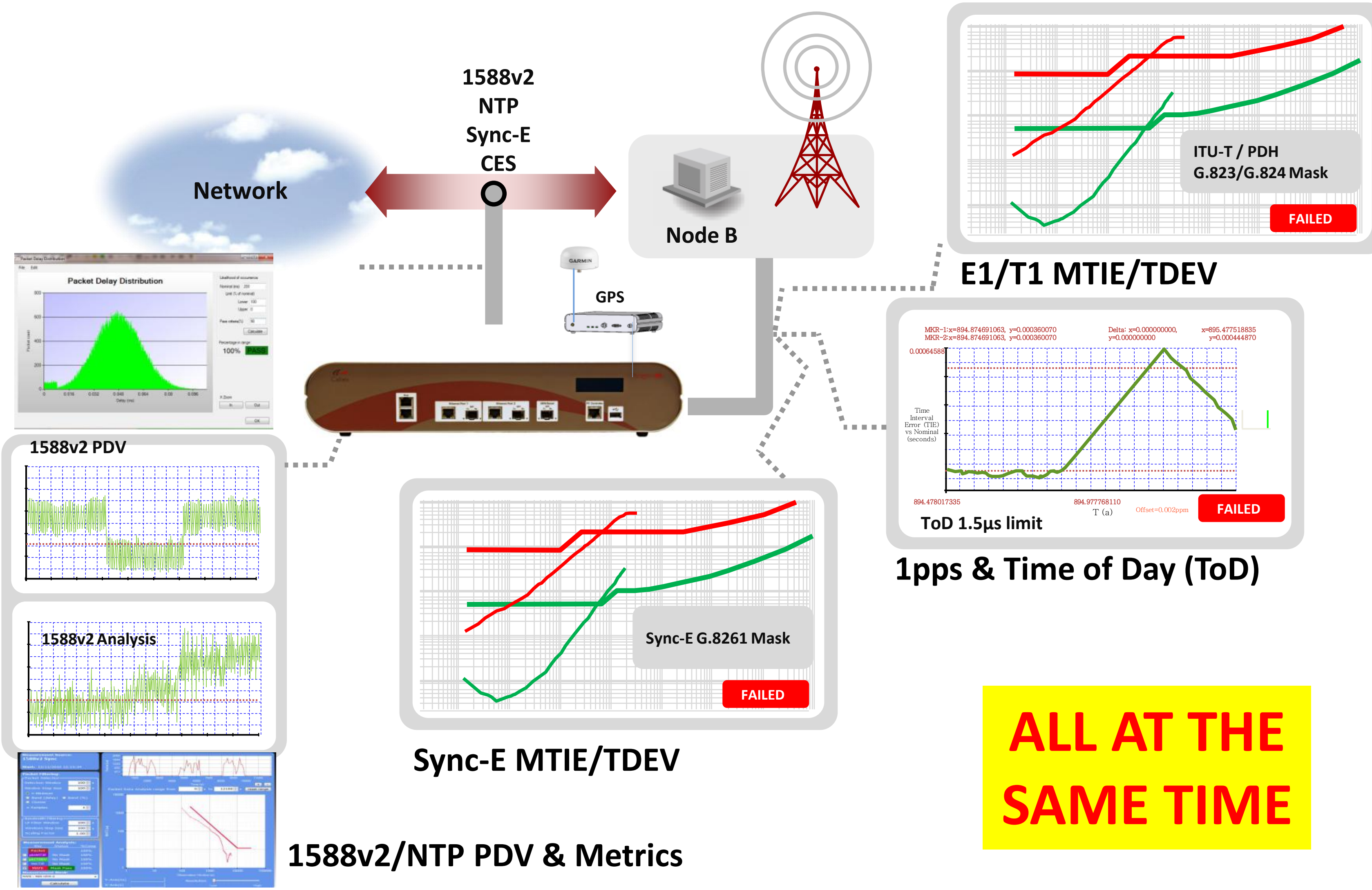
Part 2 – Testing Networks

Step 1 - Determine Network SLA



- Determine the correct Metric and limits for each slave
- Use these limits for Network SLA

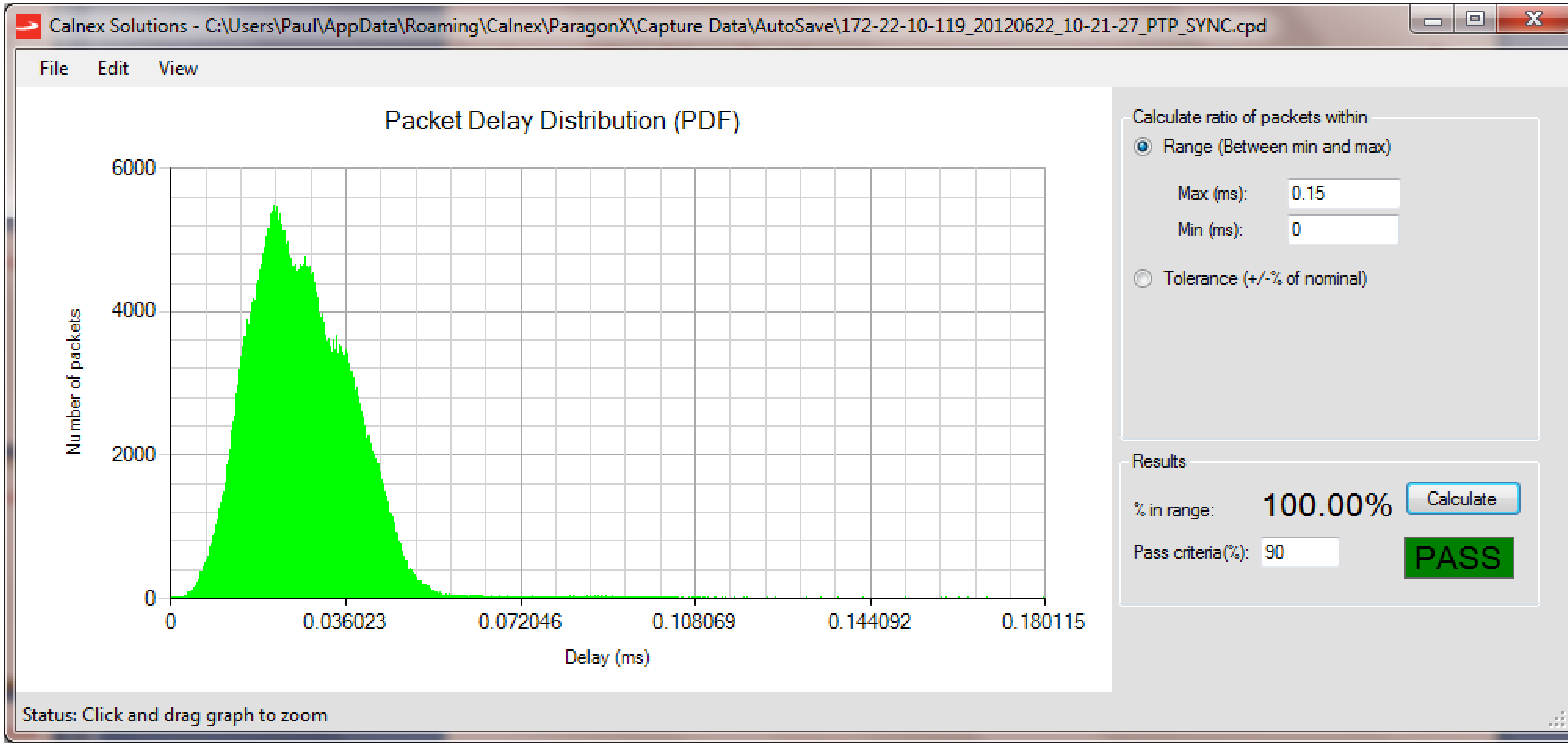
Step 2 – Measure SLA in the Network and Troubleshoot Issues



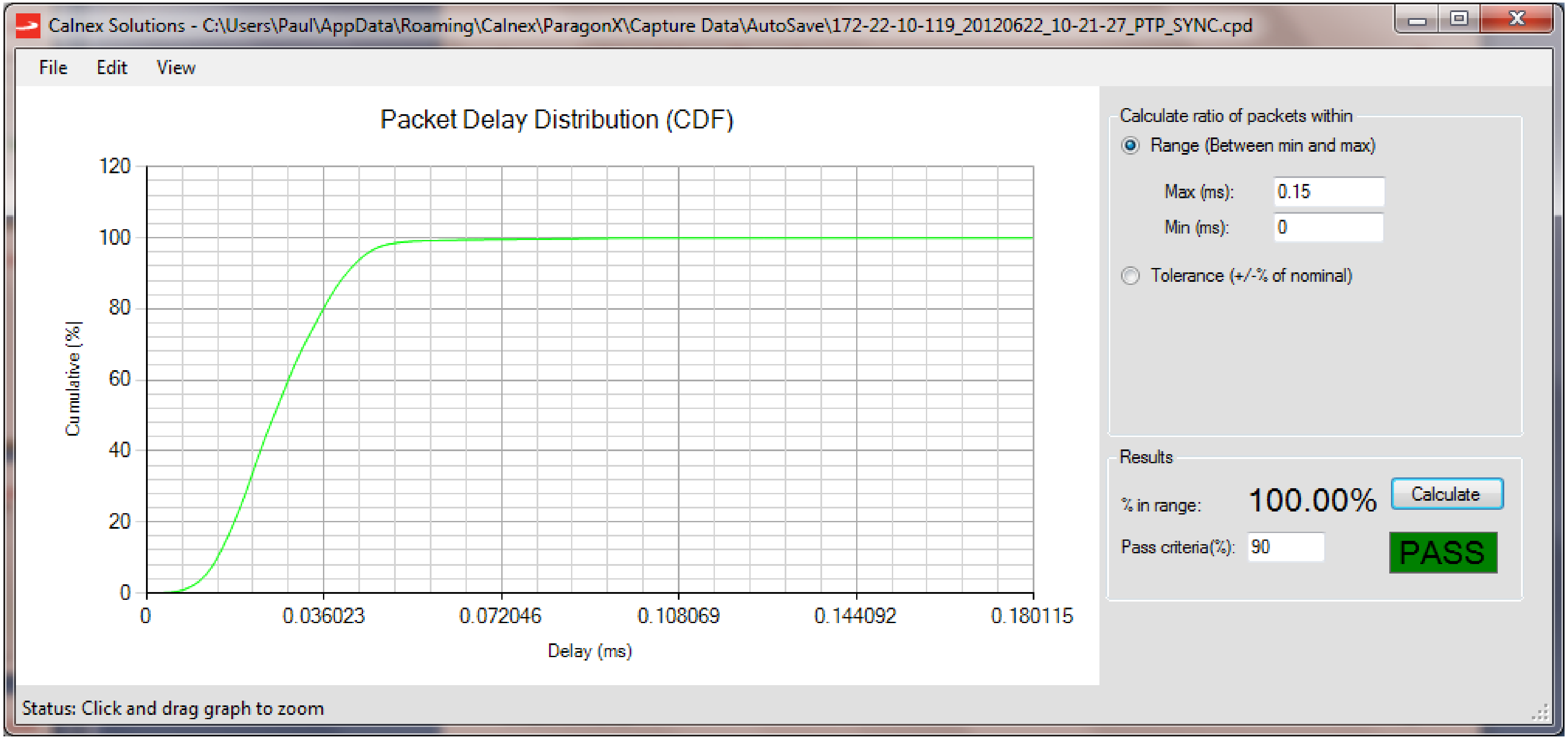
ALL AT THE SAME TIME

PTP Analysis
Graphical measurements

PDV Distribution
Probability Distribution Function

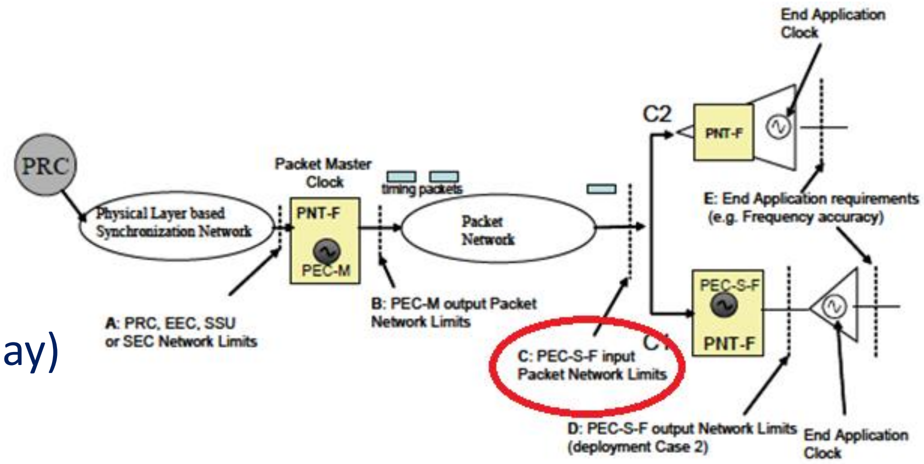


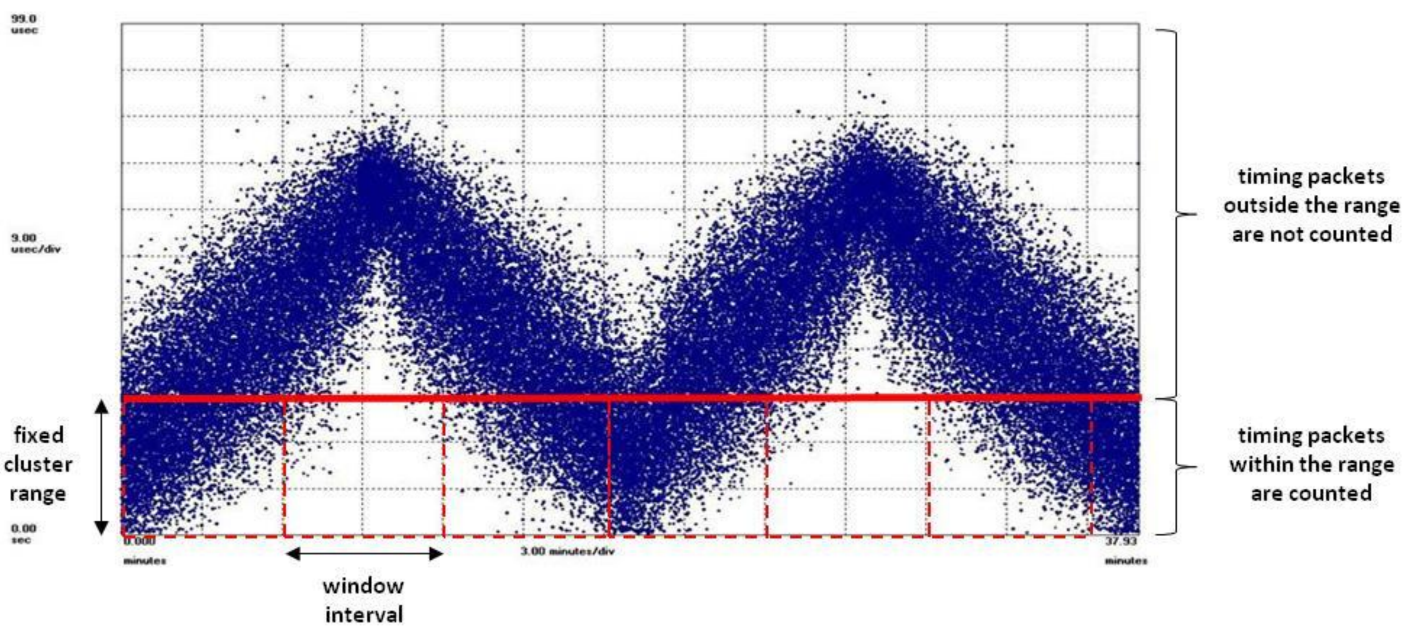
PDV Distribution
Cumulative Delay Function



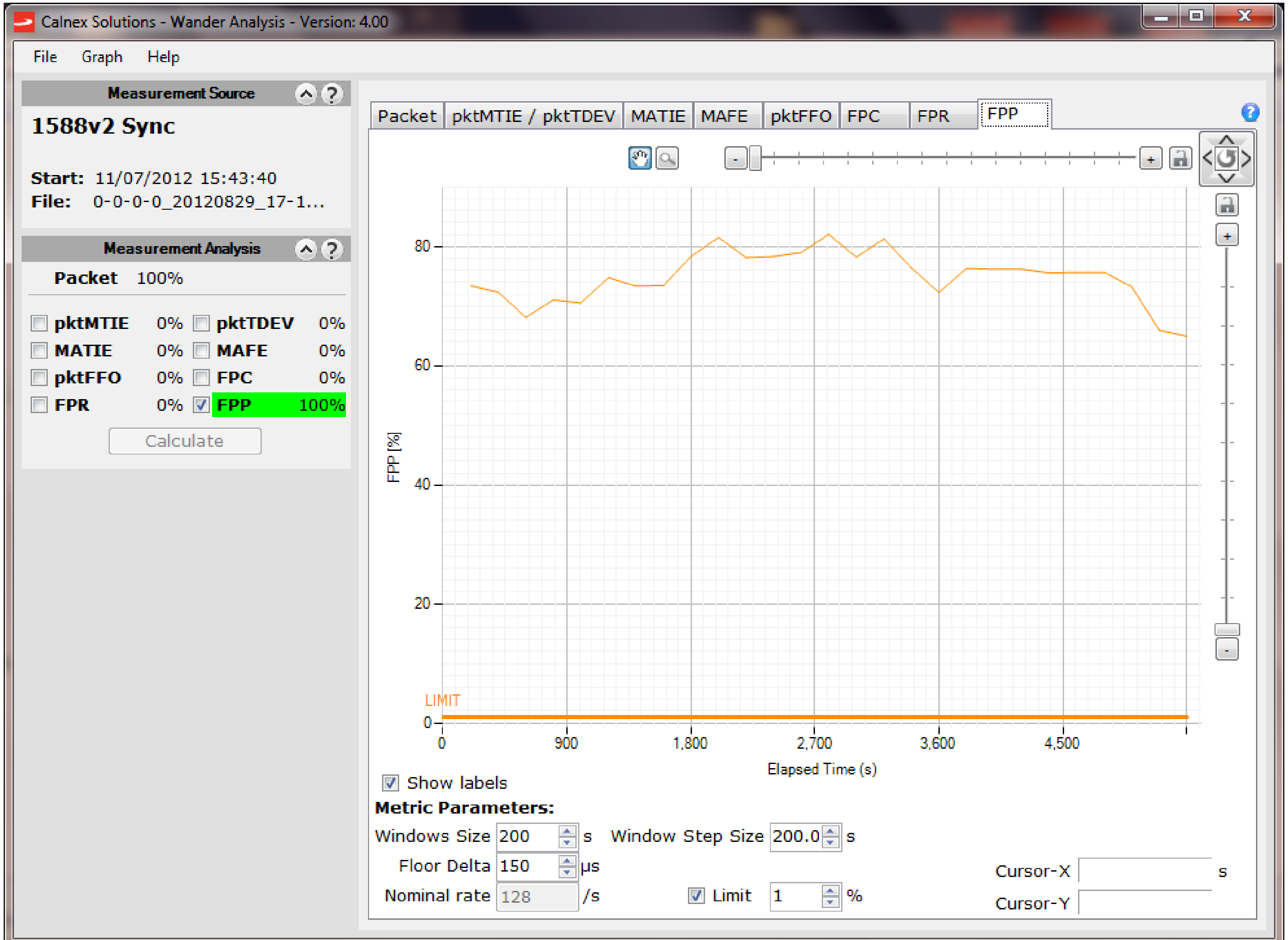
PDV Metrics
Floor Packet Population (G.8261.1)

- Packet Delay Variation network limit at point C of figure 3/G.8261.1 (for HRM-1)
- **Floor Packet Percent (FPP)**
- Window interval W = 200s
- Fixed cluster range δ = 150µs (from floor delay)
- **At least 1% of packets must fall in this cluster.**

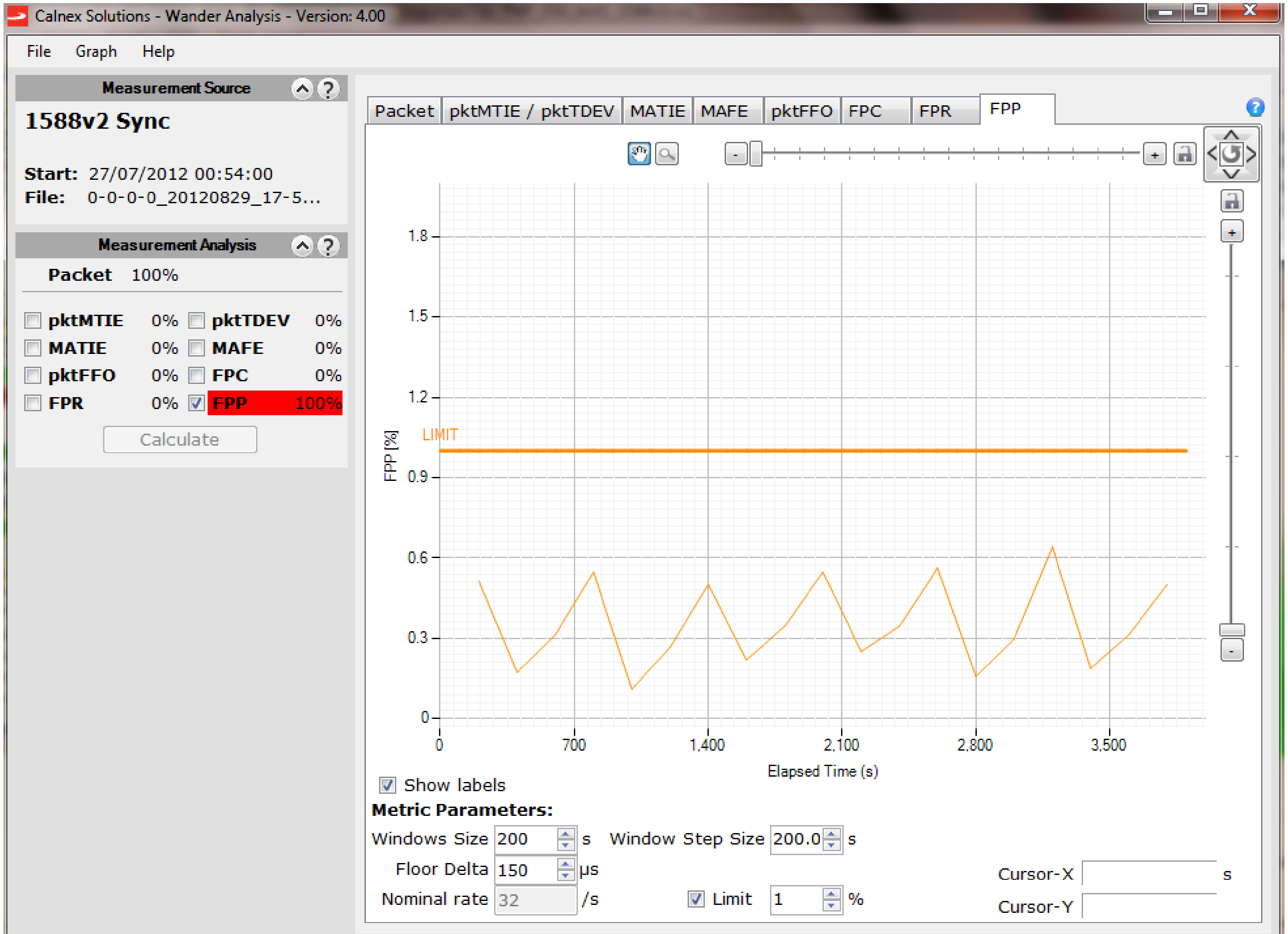




PDV Packet metrics – Pass FPP (Single microwave hop + multiple other hops)



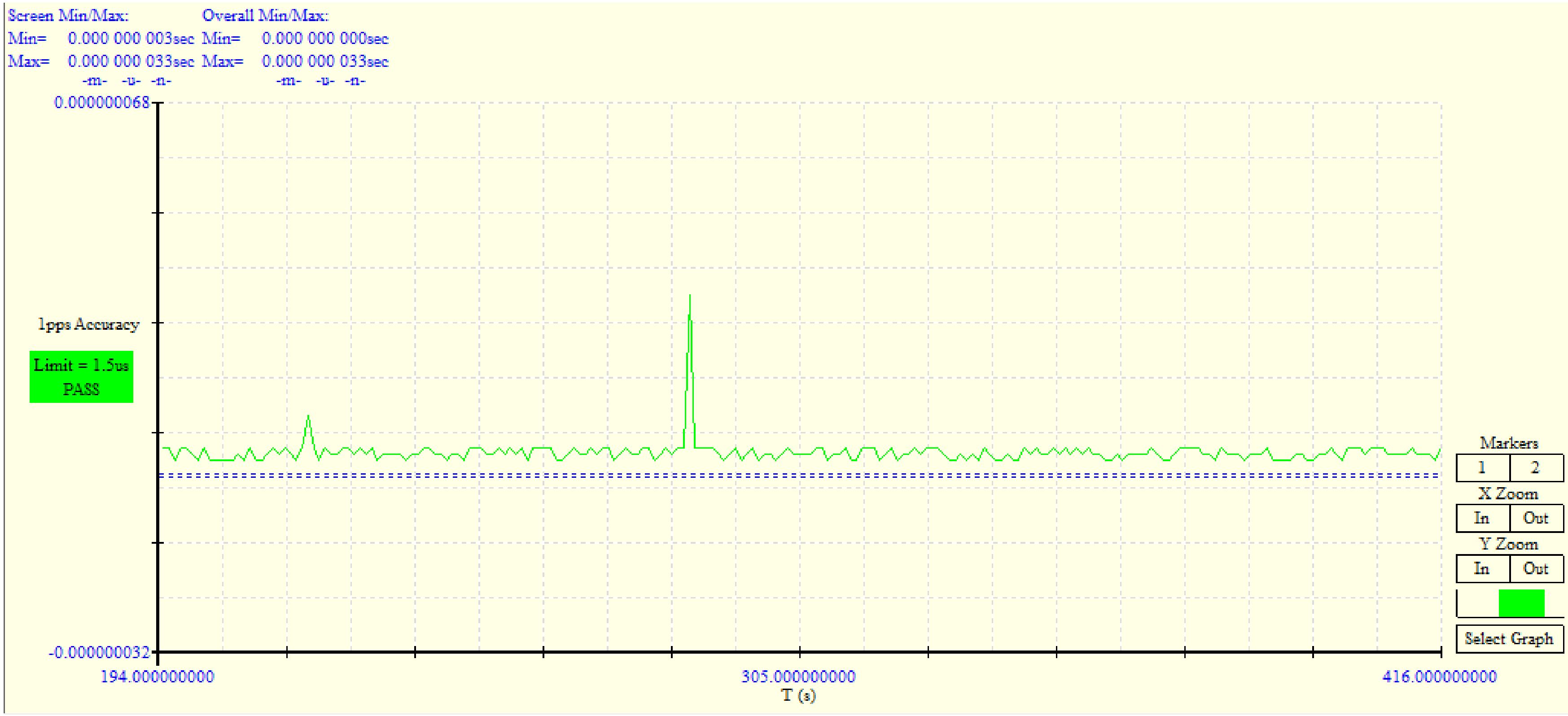
PDV Packet metrics – Fail FPP (Network included 10+ Microwave hops)



E1 analysis

Calnex Solutions - Wander Analysis - Version: 4.00
File
Graph
Help
Measurement Source
E1
Sample Period: 0.033s
Start: 22/06/2012 10:21:27
File: 0-0-0-0_20120627_16-2...
Measurement Analysis
TIE 100%
MTIE 100%
TDEV 100%
clkMAFE 0%
clkFFO 0%
Calculate
TIE [ns]
Time (s)
TIE data analysis range from 0 s to 3292 s
Reset range
MTIE / TDEV
clkMAFE
clkFFO
MTIE Mask
TDEV Mask
MTIE
TDEV
MTIE / TDEV [ns]
Observation Window (s)
Show labels
Metric Mask:
G.823 E1 PDH Interface
MTIE Pass
TDEV Fail
Resolution
Low
High
Cursor-X
s
Cursor-Y
ns

1pps Analysis with Pass/Fail limits



Real-World Results

BC/TC– Trial Network Test

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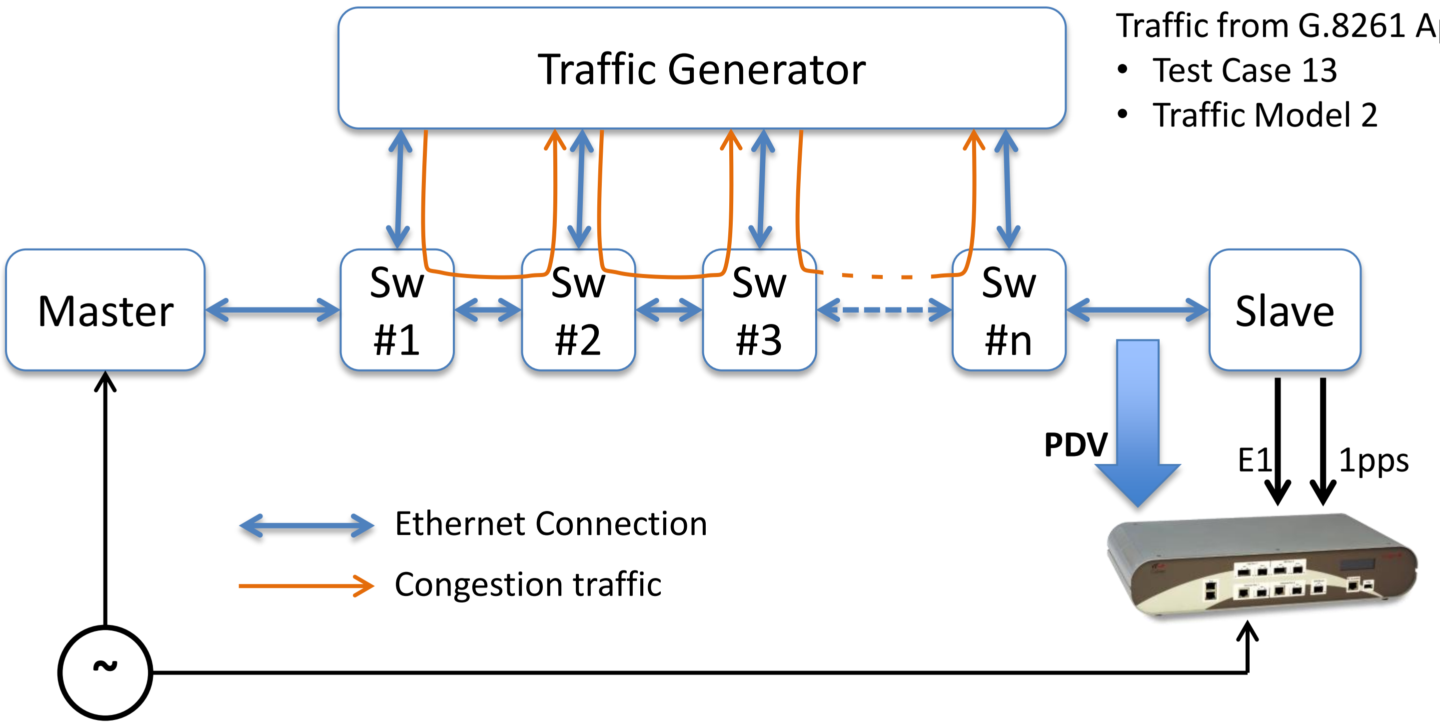


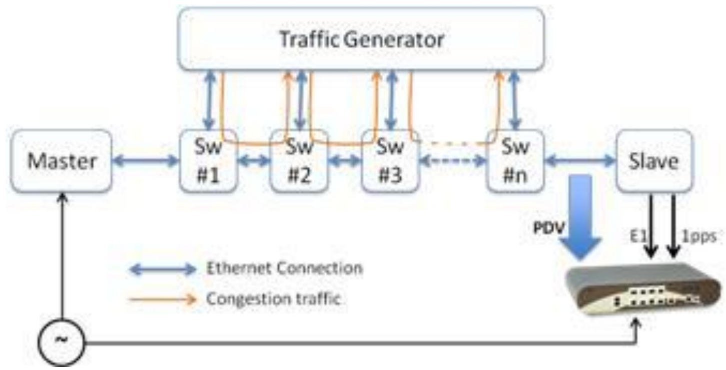
Traffic from G.8261 Appendix VI:

- Test Case 13
- Traffic Model 2

Example Network Configurations;

1.	**9** switches,	No On-path Support,	**No SyncE**	⇒	PTP for Frequency	& PTP for Phase
2.	**9** switches,	all **BC** mode,	**SyncE**	⇒	SyncE for Frequency	& PTP for Phase
3.	**5** switches,	all **BC** mode,	**No SyncE**	⇒	PTP for Frequency	& PTP for Phase
4.	**9** switches,	all **BC** mode,	**No SyncE**	⇒	PTP for Frequency	& PTP for Phase
5.	**9** switches,	all **TC** mode,	**SyncE**	⇒	SyncE for Frequency	& PTP for Phase
6.	**9** switches,	all **TC** mode,	**No SyncE**	⇒	PTP for Frequency	& PTP for Phase

Results:
BC networks



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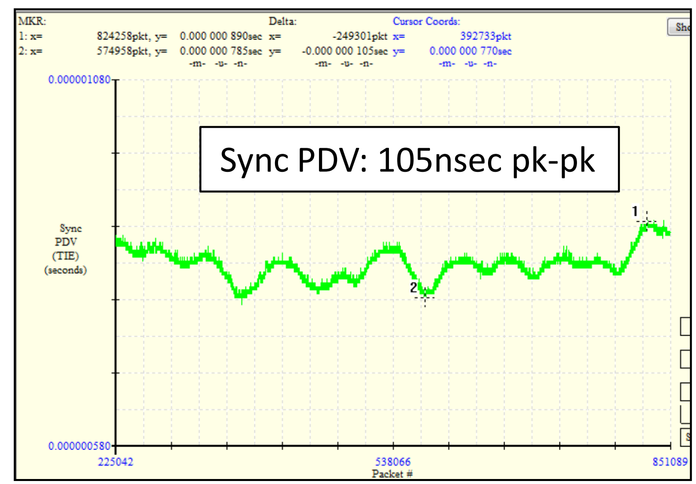
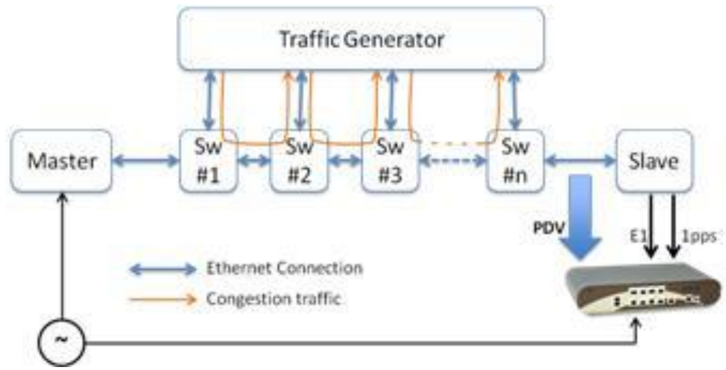
Test Set-up	PDV at input to slave	E1 wander (MTIE @ 5000sec)	1pps (pk-to-pk)
PEC + 9*Sw	86µsec	2.44µsec	2.70µsec
EEC + 9*BC	0.055µsec	0.019µsec	0.028µsec
PEC + 5*BC	0.070µsec	0.188usec	0.176µsec
PEC + 9*TC	0.105µsec	0.210µsec	0.220µsec



Observations when BCs utilised;

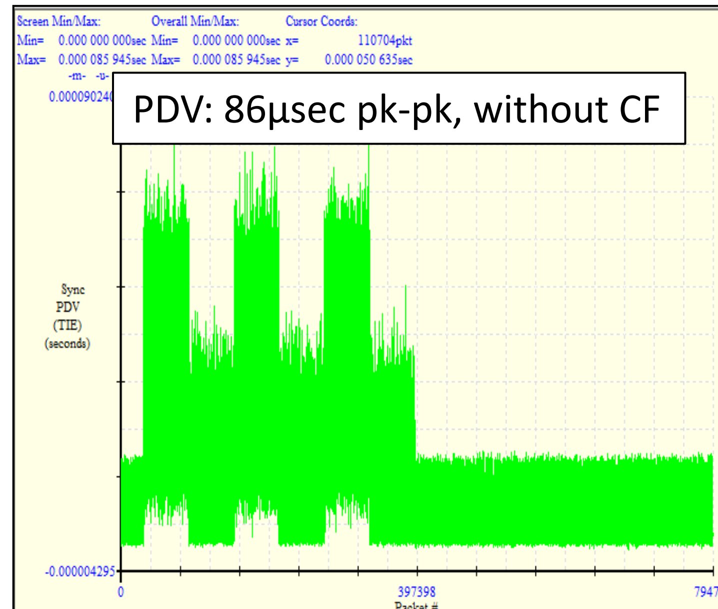
- SyncE (EEC) + PTP gave the best results.
- BCs reduce the impact of congestion traffic,
  but congestion can still impact the transfer of frequency &/or Phase.

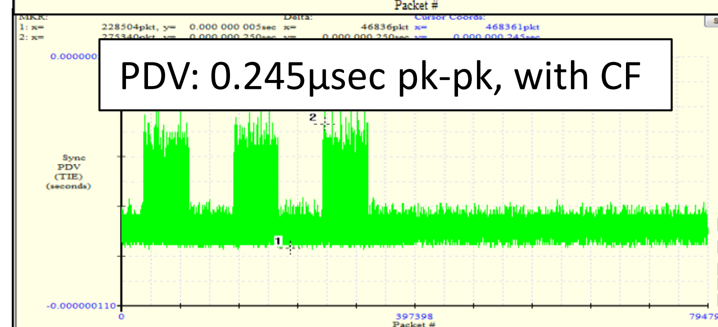
Results:
TC networks



Calnex

Test Set-up	PDV at input to slave	E1 wander (MTIE @ 5000sec)	1pps (pk-to-pk)
PEC + 9*Sw	86µsec	2.44µsec	2.70µsec
EEC + 9*TC	245nsec (86µsec)*	0.137µsec	0.112µsec
PEC + 9*TC		1.10µsec	1.75µsec





Observations when TCs utilised;

- SyncE (EEC) + PTP gave the best results.
- TCs reduce the impact of congestion traffic, **but** congestion can still impact the transfer of frequency &/or Phase.

Why Calnex?

- **Trust us, Calnex knows Sync**
  - Organisation-wide understanding of Sync and Testing
  - Leadership at Standards bodies
  - De-facto 1588v2 and SyncE test equipment – it's what your customer uses
- **The ONLY Full 1588v2 and SyncE Conformance tester**
  - G.8261 etc 1588v2 tests
  - G.8262 SyncE Jitter AND Wander
  - G.8264 SyncE ESMC tests
- **Clear Pass/Fail Analysis and Troubleshooting features**
  - Packet Metrics – pktMTIE, pktTDEV, MAFE, PDF, CDF, FPP, FFO, etc, etc.
  - PDV graphs is mutliple formats for clear and thorough analysis
  - 1pps and Time of Day
  - E1/T1/BITS – MTIE/TDEV
- **Dedicated 1588v2 BC and TC one-box solution**
  - Complete G.8273.2 and other BC tests
  - The only way to test TC accuracy to nanoseconds

THANK YOU

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