Sync Tested Mesh Microwave System

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CCSL Microwave Solution

- CCSL have developed a self-organising mesh microwave solution for small-cell backhaul
- Chronos assisted with characterising elements of the system for synchronisation performance

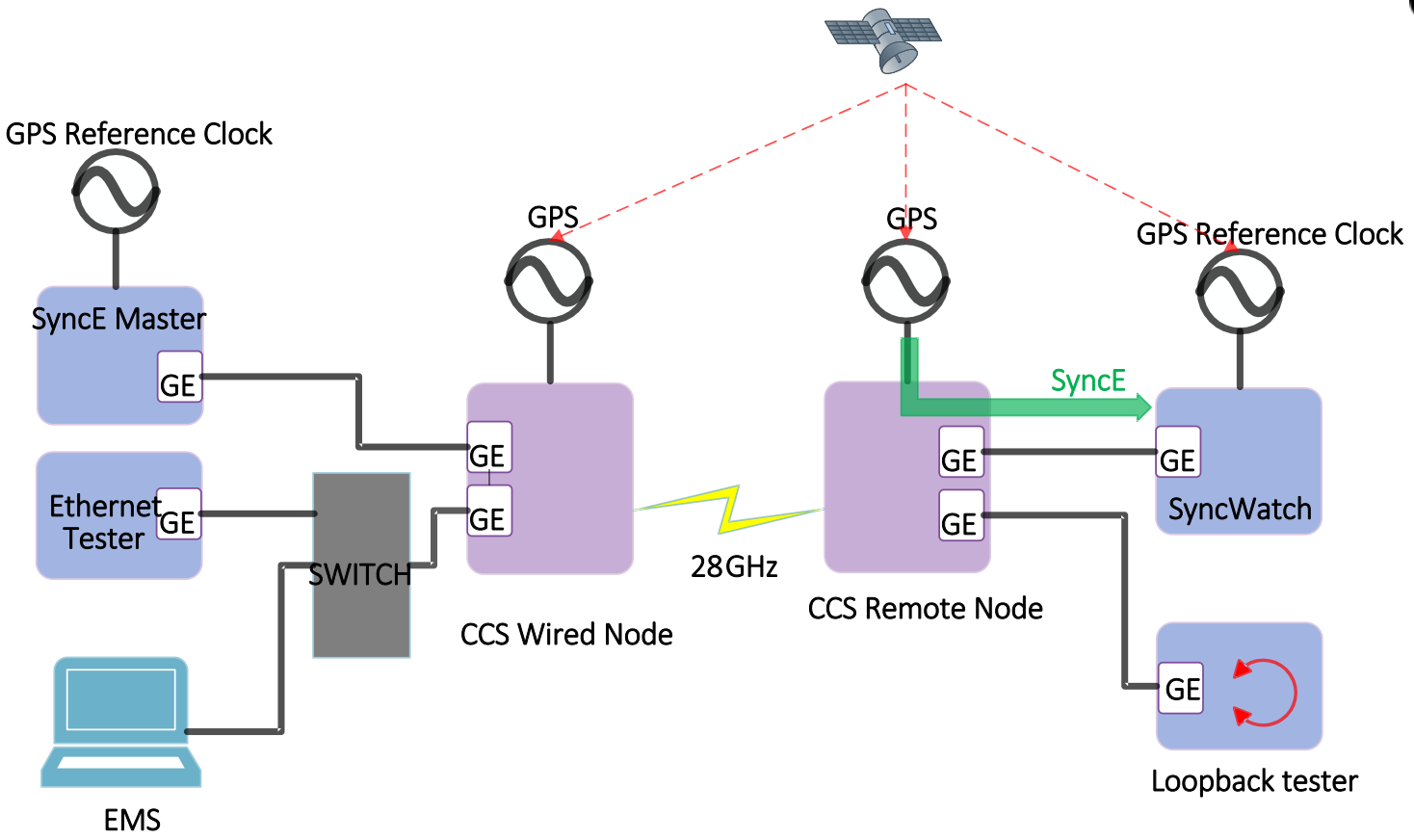
- **System Features**
  - Compact design for street furniture
  - No alignment. Very easy/quick to deploy
  - 480Mbps Ethernet with QoS
  - Simple planning, easy organic growth

- **Synchronisation Features**
  - Integrated GPS, SyncE
  - Low latency, low transient, fast switching
  - Auto switch to secondary sync source if GPS fails

Sync Performance Testing

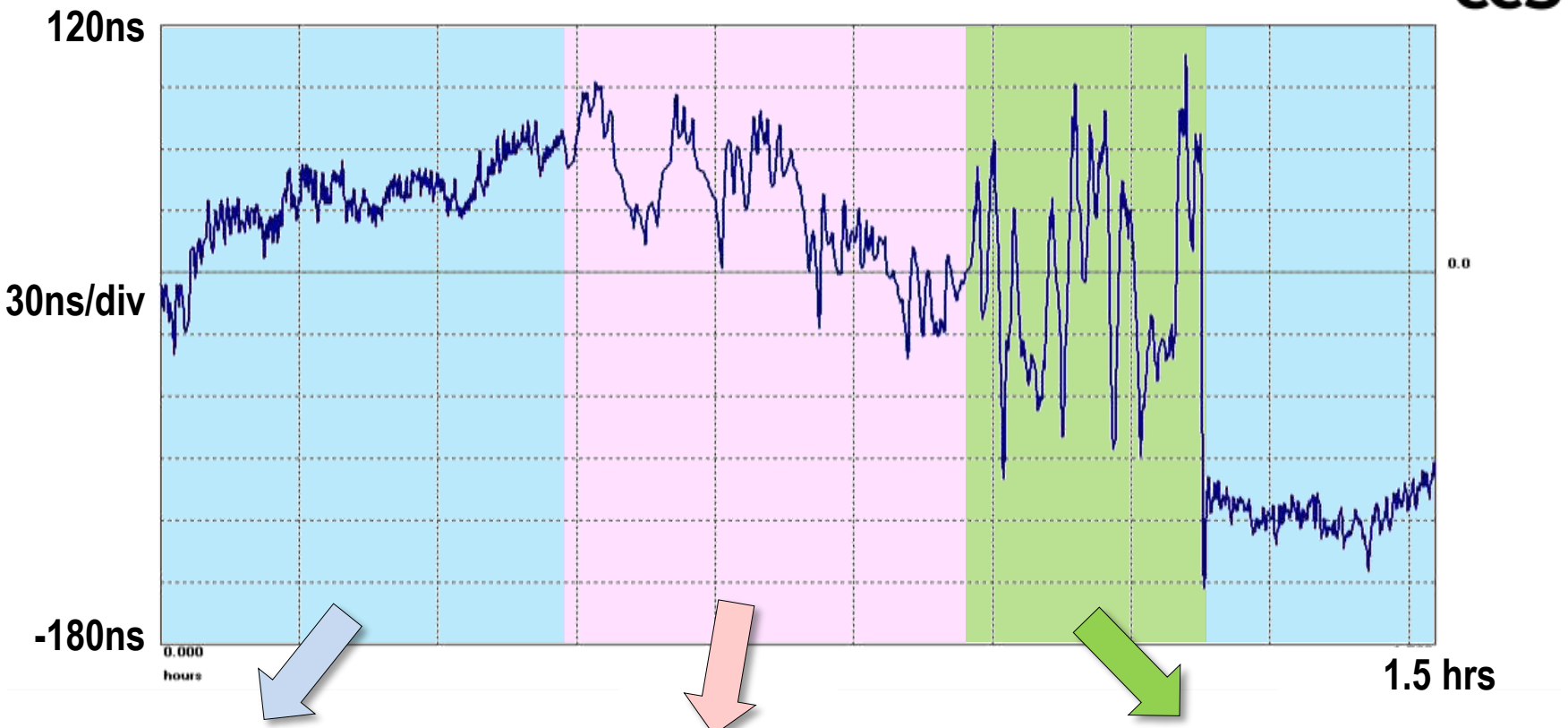
- Characterise equipment SyncE output performance under 3 operational modes
  - GPS Lock
  - GPS Fail, recover clock from neighbouring radio GPS – via one hop Radio Link
  - GPS Fail on two nodes, recover clock from remote SyncE line – via one hop Radio Link
- Characterise processing latency and Packet Delay Variation under various traffic and topology conditions
- Equipment used
  - CCSL Umbra v3
  - SyncWatch (SyncE, PTPv2), Paragon (SyncE Master)
  - Traffic Generator – (Sunrise 10G)

SyncE Test Setup

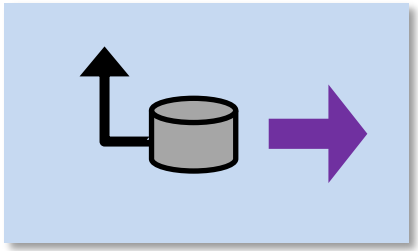


- **Traffic load 40% of maximum throughput, packet size 1518 bytes**
- **Remote Node SyncE at 1G Electrical to be measured for TIE and MTIE**
  - **Measurement reference GPS**

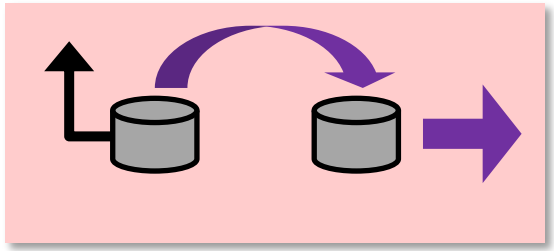
SyncE Modes – Performance Overview



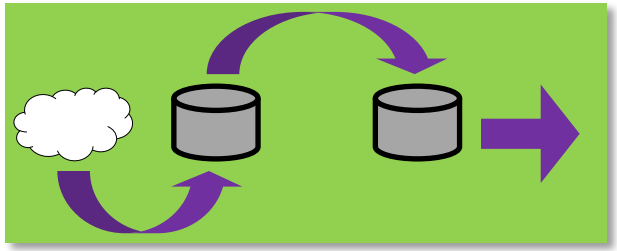
GPS Locked



GPS Locked Neighbour

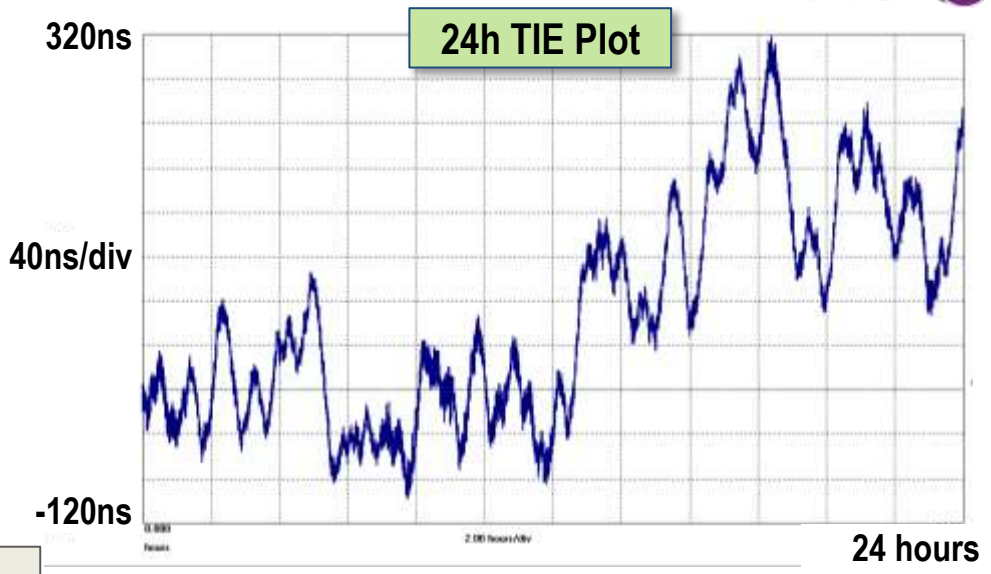


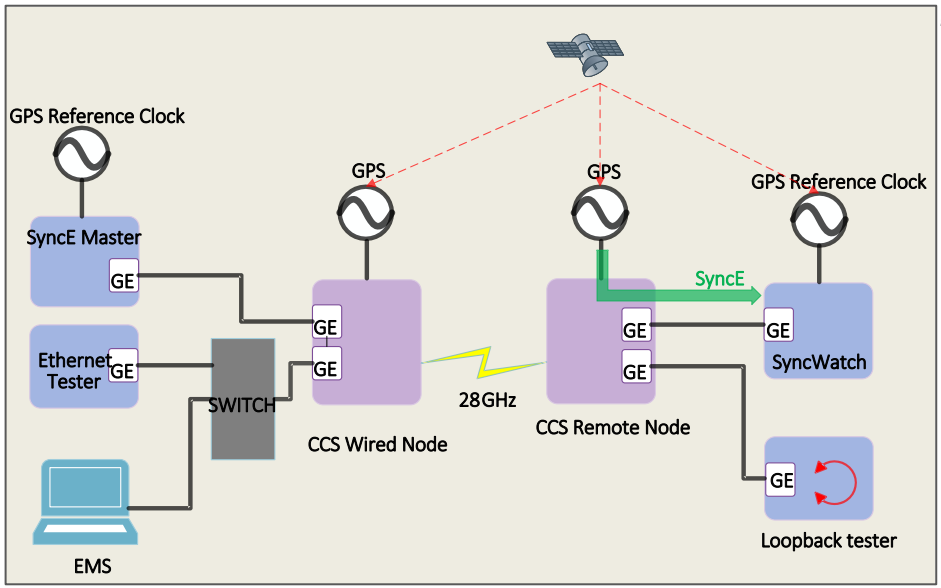
Network Locked Neighbour

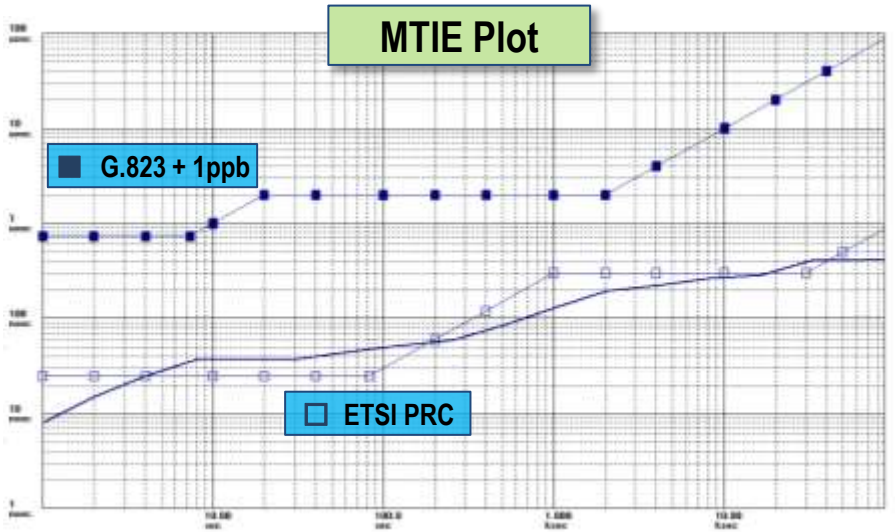


SyncE output when GPS Lock (Baseline)

- Testing normal operation (GPS Lock) performance of a single node
- Oscillator is low-noise VCXO
- Performance just outside PRC mask
- Well under G.823+1ppb mask

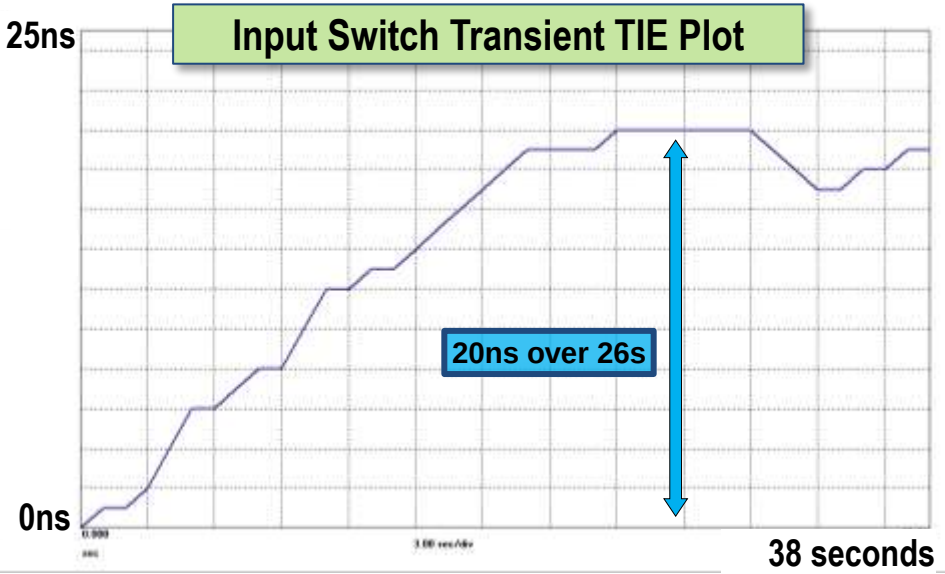


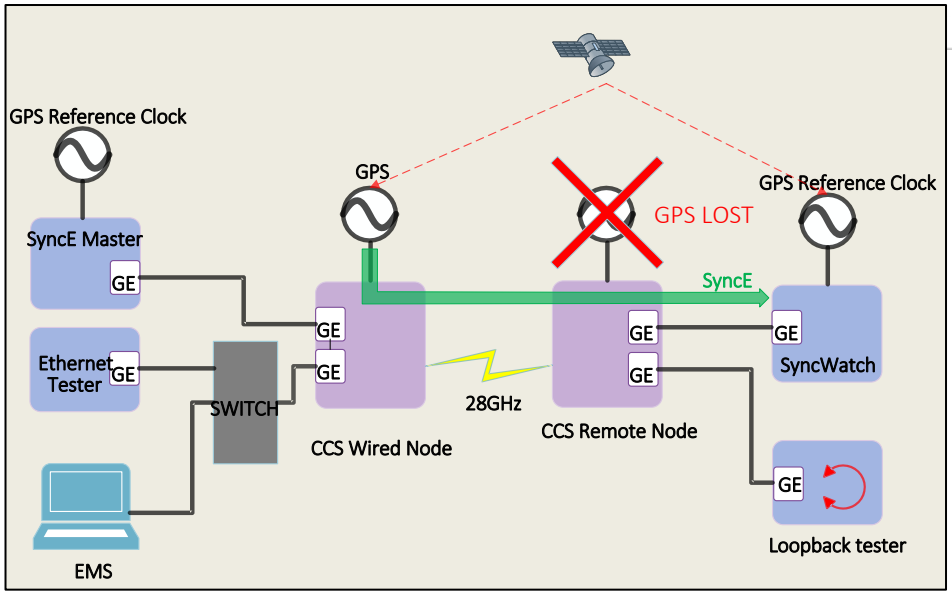


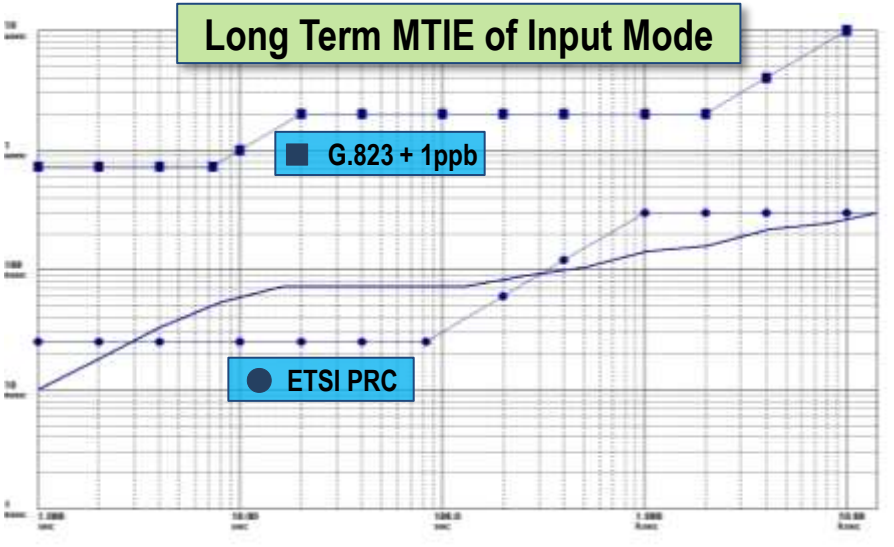


Reference from GPS Locked Neighbour

- Switch off GPS on measured node
- Node recovers sync from GPS locked neighbour
- Switching transient low
- Medium-term wander increases, long term performance remains the same

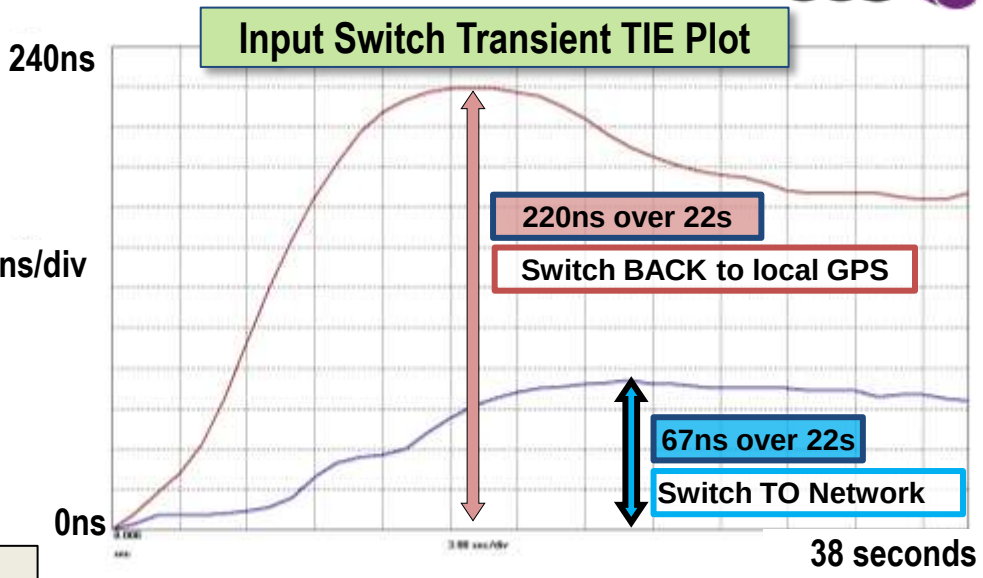


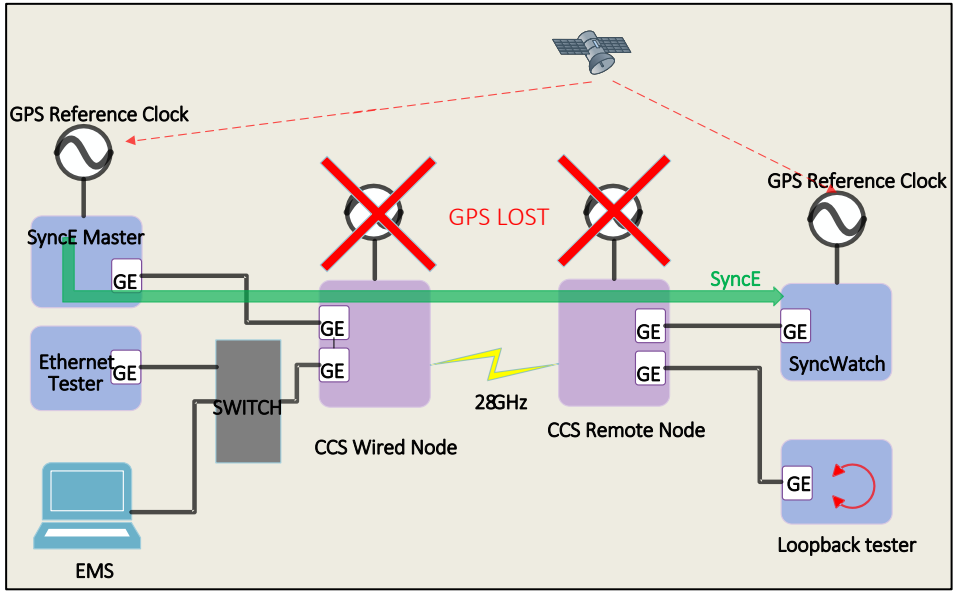


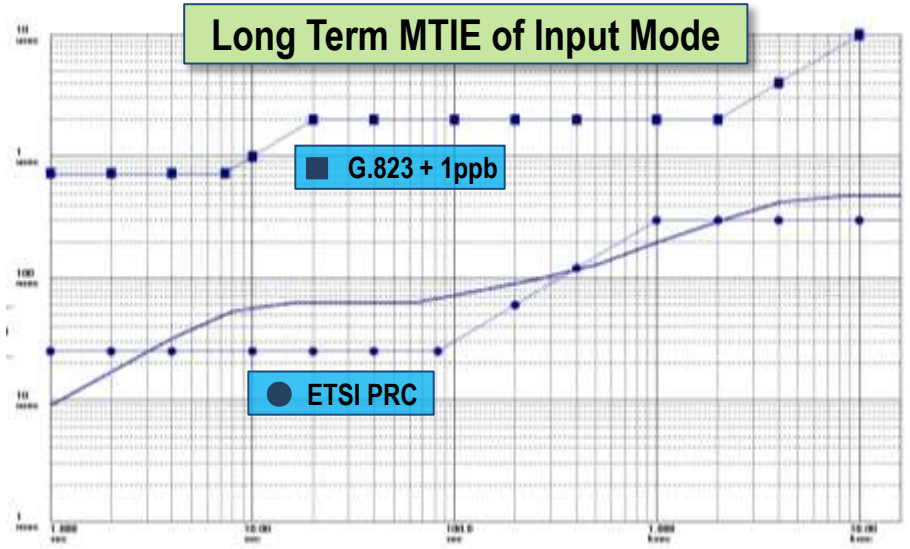


External SyncE Line Locked Neighbour

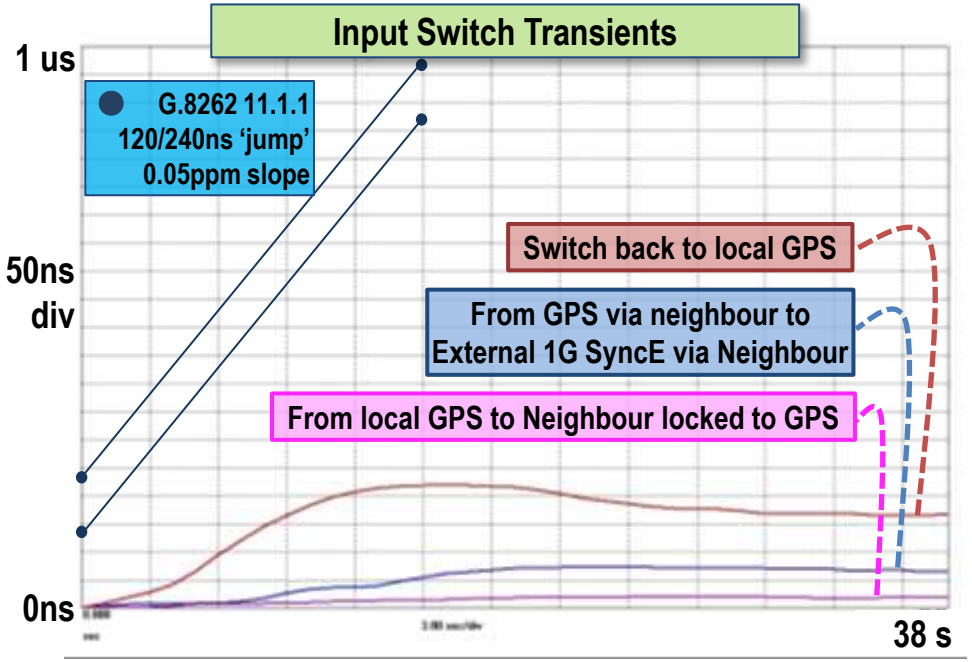
- Switch off GPS on neighbour node also
- Node recovers sync from neighbour that is locked to external 1G SyncE line
- Switching transient low
- Long-term wander increases slightly
- Switch BACK to GPS (normal operation) caused largest transient in testing (220ns)

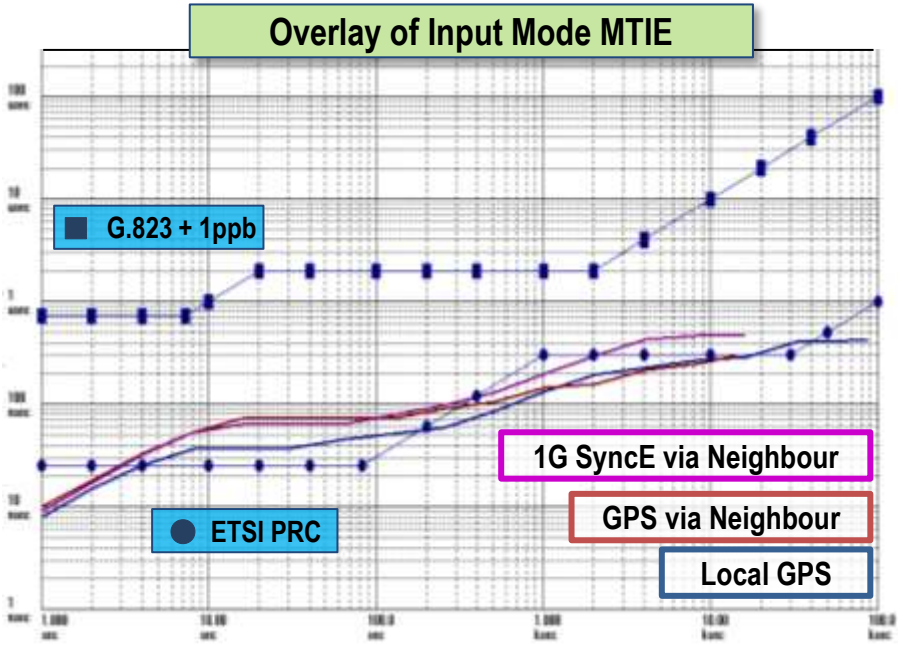






SyncE Output Performance Overlays

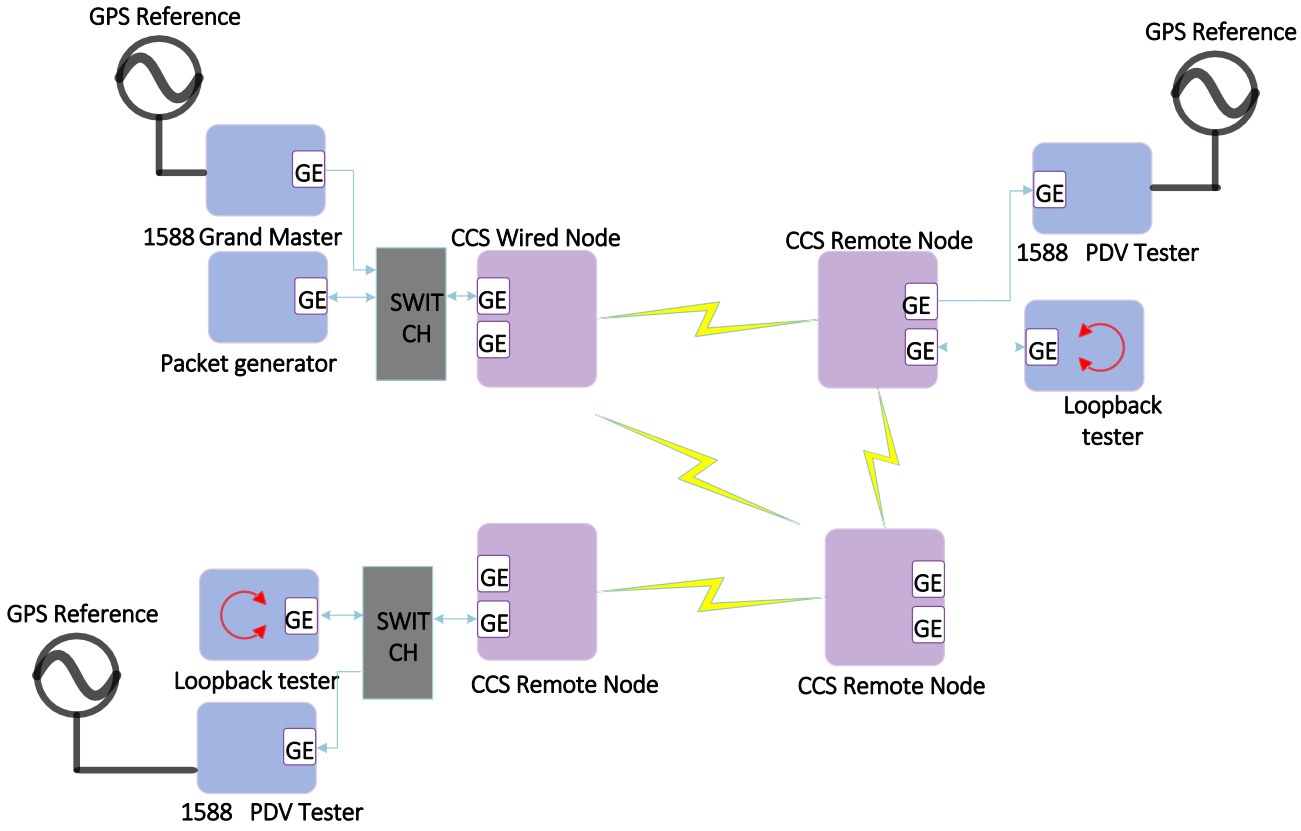




- Masks plotted are from G.8262 switching transients – these seem 'loose' and actual performance likely to be driven by specific operator downstream requirements
- Largest transient believed caused by wander between SyncE external line source and the wander from local GPS
  - No 'standards' masks for switching between PRC sources

- Performance consistent across all 3 modes
- Medium-term wander most adversely affected by input mode however effect is small
- Again, tough to know which masks are 'applicable' here, will be driven by operator downstream requirements

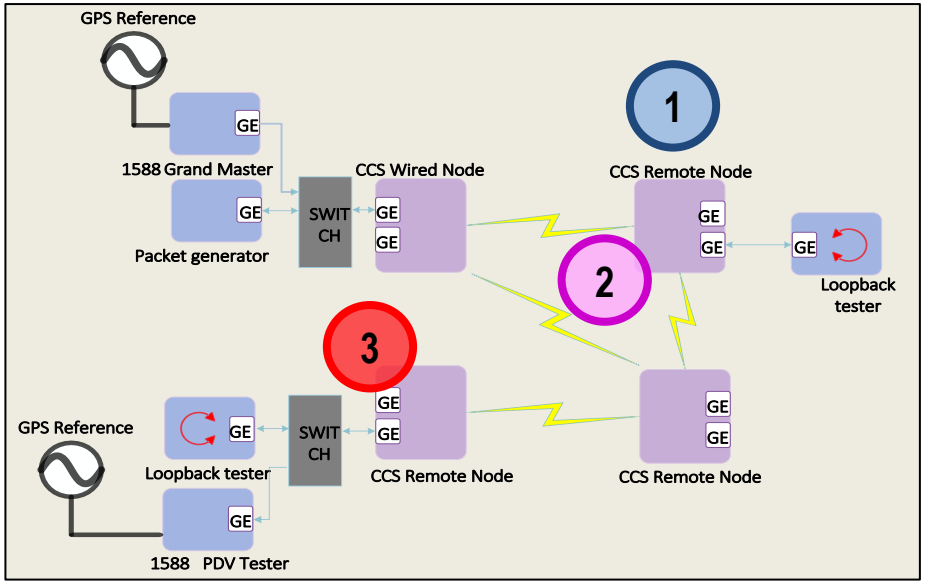
PDV Test Setup

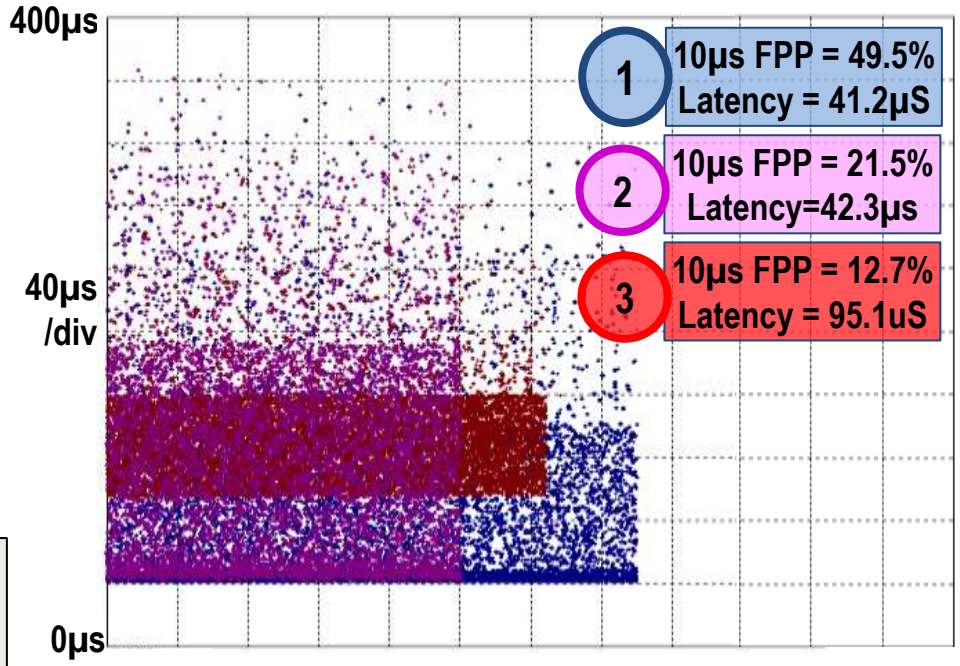


- Moved the PDV tester around to measure at different points in the mesh, changed configuration to force packet path
- GPS at both ends allows PDV and absolute one-way link(s) latency to be calculated
- Traffic loading was done with small (64 byte) and maximum (1518 byte) packets at 40%-60%

PDV Performance

- **Measured Floor Packet Percentage (10µs) to characterise the PDV 'added' by this system**
  - In a deployed network this is important as PTPv2 Slave requirements detailed in G.8261.1
  - In deployment this equipment will be at the edge and PTPv2 packets may already have large PDV
- **'Blocks' of packets nearer floor are an effect of software set 150µs packet scheduling period**
  - Most packets make this schedule, a smattering of packets miss and are put into next schedule





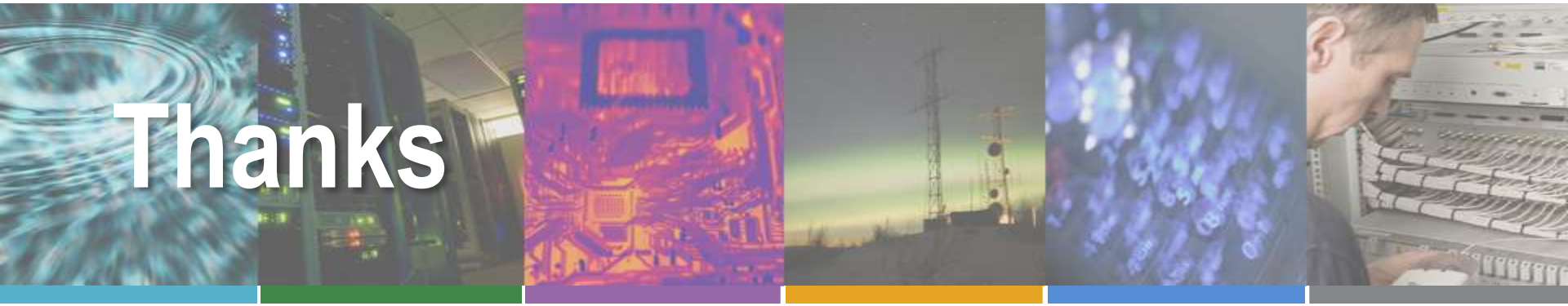
68 byte 40% traffic - 2 node chain - single hop

64 byte 60% traffic - single node feeding 2 nodes - 1 hop

1518 byte 50% traffic - 4 node chain, 3 hops

Conclusions / Thoughts

- **Synchronous Ethernet**
  - SyncE performance under normal and automatic switching scenarios was just over PRC quality
  - G.8262 input switch transient masks are easily achievable
  - Standards masks for wander transfer where ‘DUT’ is two devices over a proprietary ‘link’ rather than ‘through’ a single piece of equipment?
- **PTPv2 PDV Performance**
  - Latency was low (~42µs per link)
  - FPP good, future inclusion of transparent clocking should reduce PDV across links.
  - Are there likely to be specific operator requirements for PDV ‘transfer’ or ‘limits’ for a network ‘segment’ – i.e. ‘hand off’ from one transport medium to another?



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