



ON TIME SYNCHRONIZATION OVER MICROWAVE LINKS

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TIME SYNCH APPLICATIONS



- › Telecom
- › Utility
- › Banking/Trading

Case study on HFT:

Early June this year (2013), a system at Thomson Reuters released ISM manufacturing information to their HFT hedge fund clients, 15 ms ahead of the market in general. Within a few milliseconds, 369 individual stocks moved down and \$28 million changed hands. The glitch was caused by a tiny clock synchronization issue but caused an outrage among traders and public.

ISM - Institute of Supply Management, <http://www.ism.ws/>

TIME/PHASE PERFORMANCE, TELECOM



> ITU-T G.8271.1

Budget Component	Failure scenario a)	Failure scenario b)	Long Holdover periods (e.g. 1 day)
PRTC (ce_{ref})	100 ns	100 ns	100 ns
Holdover and Rearrangements in the network (TE_{HO})	NA	400 ns	2400 ns
Random and error due to SyncE rearrangements (dTE')	200 ns	200 ns	200 ns
Node Constant including intrasite (ce_{ptp_clock}) (Note1)	550 ns (50ns/NE)	550 ns (50ns/NE)	550 ns
Link Asymmetries (ce_{link_asym}) (Note2)	250 ns	100 ns	100 ns
Rearrangements and short Holdover in the End Application (TE_{REA})	250 ns	NA	NA
End application (TE_{FA})	150 ns	150 ns	150 ns
Total (TE_D)	1500 ns	1500 ns	3500 ns (Note3)

CHALLENGES TO PACKET BASED SYNCHRONIZATION

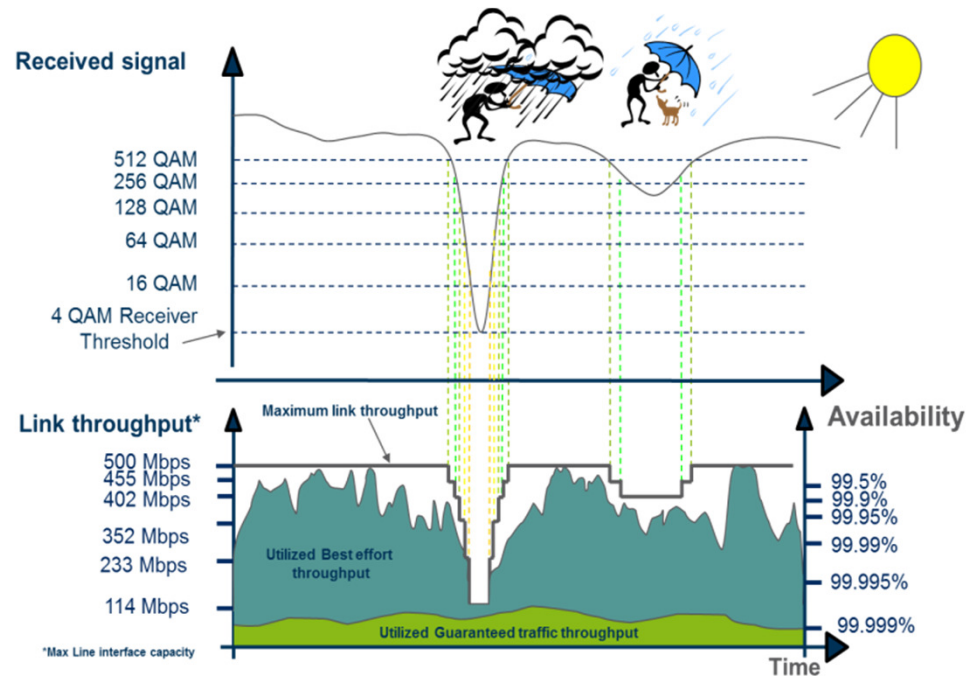


- › PDV
- › Packet loss
- › Time stamp accuracy
- › Link and path asymmetry
- › Holdover

CHALLENGES OF MICROWAVE LINKS



- > Adaptive Modulation
- > Radio Link Bonding
- > Asymmetry

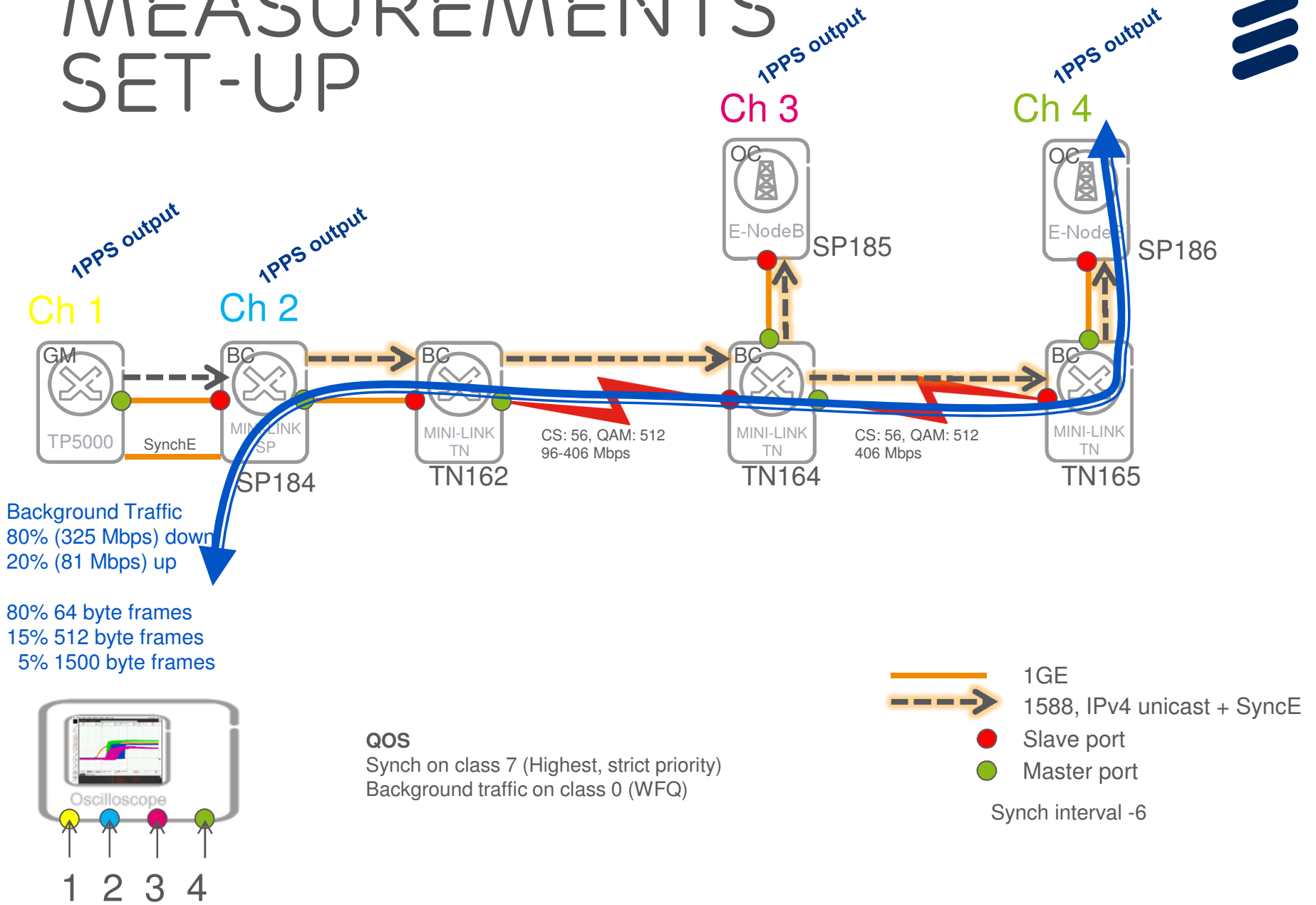


MEASUREMENTS TEST CASES

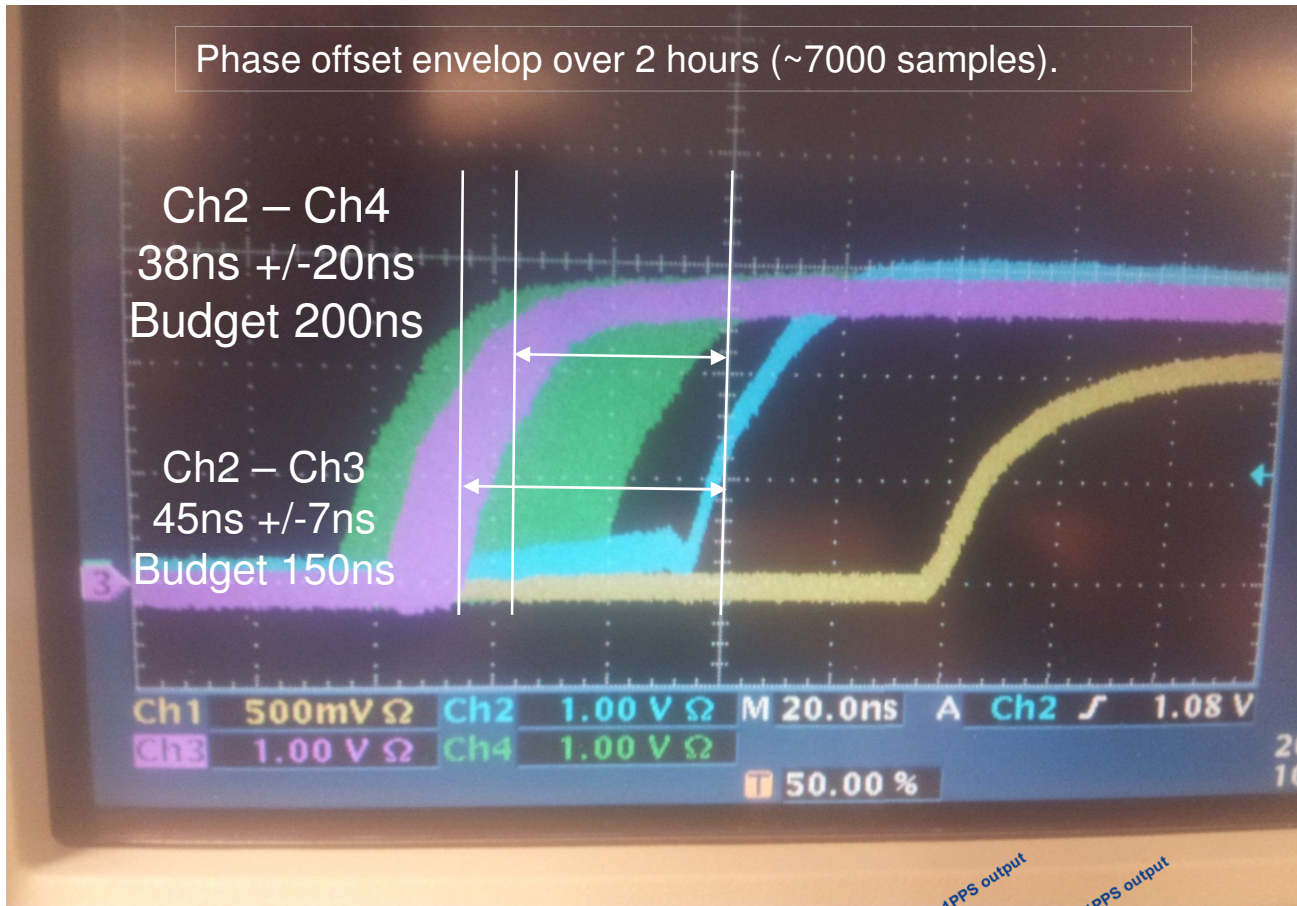


- › Performance, with background traffic
- › Performance, without background traffic
- › Performance, deep fading (AdMod)
- › Performance, link interruption
- › Performance, node restart

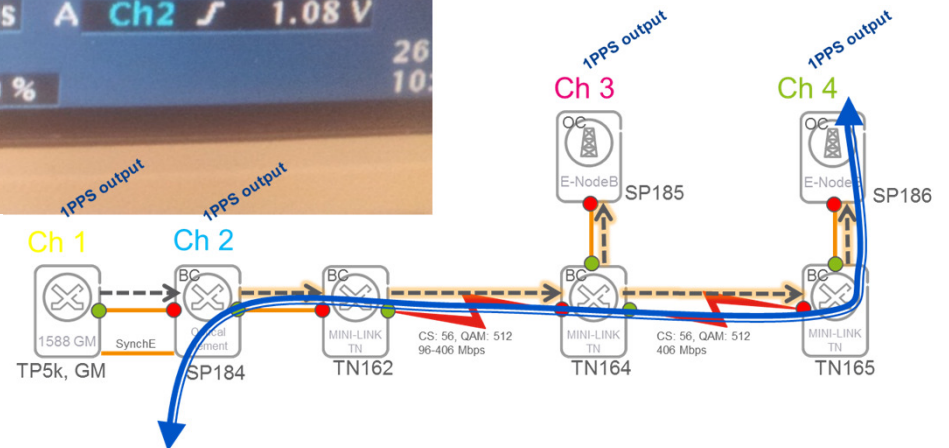
MEASUREMENTS SET-UP



PERFORMANCE, WITH BACKGROUND TRAFFIC



Same behavior without background traffic



PERFORMANCE, ADAPTIVE MODULATION



- › Fading 512-4 QAM: No change in phase offset behavior

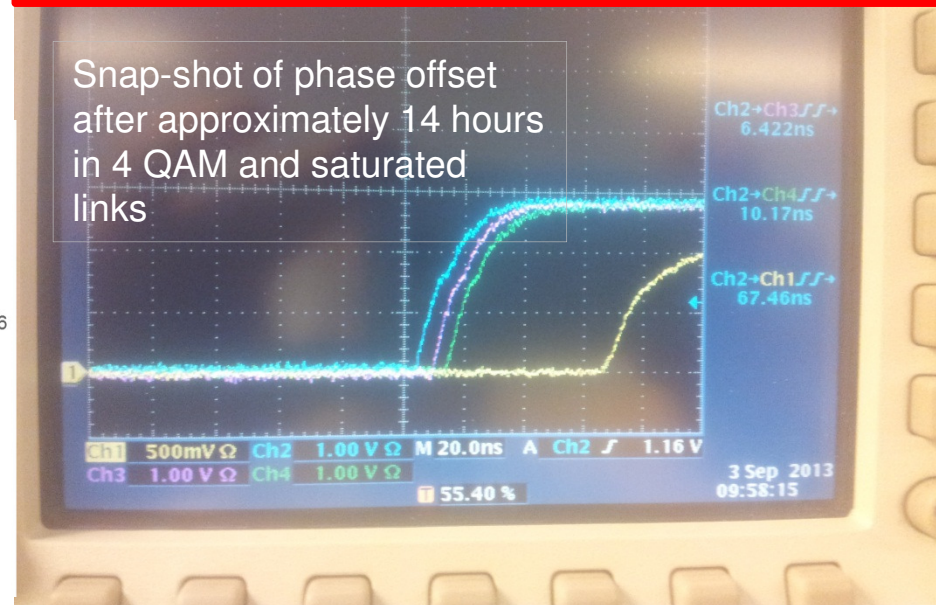
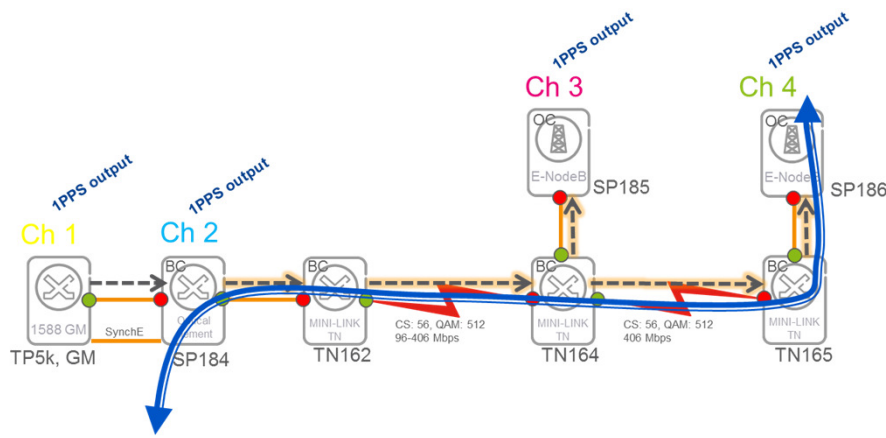
Modulation (QAM)	Capacity (Mbps)	BGT saturation DL/UL (% of link capacity)
512	406	80/20
256	369	88/22
128	326	100/25
64	285	100/28
32	237	100/34
16	189	100/43
4	94	100/86

PERFORMANCE, CONSTANT DEEP FADING



- Constant 4 QAM with saturated links over night showed no negative impact.

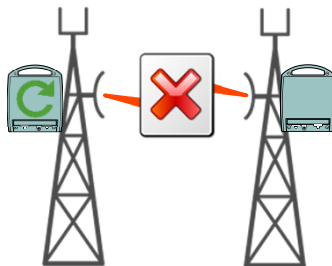
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PERFORMANCE, LINK INTERRUPTION AND NODE RESTART



- › At link-down (first link) or node (TN162) restart the 1PPS output from Ch3 (SP185) and Ch4 (SP186) was muted.
- › After link-up or node restored, Ch3 output was restored after ~3 minutes. Ch4 output was restored ~2 minutes after Ch3.



CONCLUSION



- › Distributing phase synch over microwave links can be made compliant with ITU-T G.8271.1, where:
 - › The performance is traffic independent
 - › The performance is AdMod independent
 - › The restoration after interrupts is fairly fast
 - › The static error is within limits after restoration of synch and is asymptotically reduced over time



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