Testing **Synchronization**: the **5G** challenge



IEEE 1588v2 / PTP, NTP, SyncE, 1PPS, ToD, IRIG-B, E1, 10 MHz, 2048 kHz, 1544 kHz





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Agenda

- 1. From Distributed to Centralized RAN.
- 2. xGenius timing and synchronization testing tool.
- 3. G.8272 PRTC qualification.
- 4. G.8273.2 T-BC / T-TSC qualification.
- 5. G.8271.1 / G.8271.2 network qualification.
- 6. Future developments and concluding remarks





The Fronthaul connects the cell site antenna (RRH) with a central office (BBU)





The 5G Fronthaul

Distributed baseband and radio processing. Optical Ethernet network interfaces to the radio sites

Synchronization to the radio site is now PTP (ITU-T G.8275.1, G.8275.2) and SyncE





Cellular Network Requirements

Global Requirements

Application	ITU-T Classes	TE
GSM, WCDMA-FDD, LTE-FDD	-	None
CDMA2000	-	3 μs, 10 μs
TD-SCDMA	4	1.5 μs
WIMAX-TDD	4, 5	1 μs, 1.5 μs
LTE-TDD	3, 4	1.5 μs, 5 μs
NR-TDD	4	1.5 μs

Cluster Requirements

Application	ITU-T Classes	ΤΕ
LTE / NR carrier aggregation	4A, 6A, 6B	130 ns, 260 ns, 3 μs

- The 1.5 µs requirement still applies to 5G.
- A new kind of requirement for clusters apply to neighboring cells.



2 xGenius Handheld Test Platform

↓ ∑ •• Recently used ♥ ●	Running uctors/ uctors/ Results-> Event logger 2018-03-07-203327 1.200000e+01 nt A.Cik./Fib.Dev	
Message timing (PTP (EEE 1588)) Event logger Fort A Clock status (PTP)		The second secon
Results Port A Event logger Diversities		CONFIG
A Construction		
Started 07/03/2018 20:3 Banning 00:08:20	3:28 20:3346 2018 02-07 20:33*	16 203446
Event	2019-03-07 203327 Days Hours Minu	2018-03-07 20:35:31 tes Seconds
ALBEDO		XGenius Transmission & Synchronization

- Light, battery powered, "selfcontained".
- 8" touch screen, advanced plots.
- Built-in Rubidium or OCXO.
- Integrated GNSS receiver.
- PTP, SyncE and background traffic emulation.
- Real time wander analysis (MTIE, TDEV).
- Time-stamped capture (10 Gb/s) based on GNSS clock.
- SNMP automation





xGenius Test / Reference Port Panel





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xGenius OCXO vs. Rubidium











- ITU-T G.8272 is the standard for a telecom primary time clock with an accuracy level of 100 ns (class A) or 40 ns (class B).
- ITU-T G.8272.1 improves the PRTC standard by defining the ePRTC, a 30 ns accurate clock.
- Typically, PRTCs are disciplined by external time sources such as GNSS. ePRTCs are connected to PRCs.



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PRTC Test: Setup





PRTC Test: Results



Testing time (s)



T-BC / T-TSC Test: Requirements

T-BC / T-TSC Class	Dynamic TE low-pass filtered- TDEV
А	4 ns
В	4 ns
С	2 ns
D	For further study

Low freq (~0 Hz)

Unfiltered

T-BC / T-TSC Class	Dynamic TE low-pass filtered- MTIE
A	40 ns
В	40 ns
С	10 ns
D	For further study

T-BC / T-TSC ClassPermissible range of constant TE- cTEA±50 nsB±20 nsC±10 nsDFor further study

T-BC / T-TSC Class	Maximum absolute TE - max TE
A	100 ns
В	70 ns
С	30 ns
D	For further study





T-BC / T-TSC Test: Setup



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T-BC / T-TSC Test: Single Tester Setup

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T-BC / T-TSC Test: Results

T-BC 2-wayTE Test

T-BC Test: Background Traffic

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Router latency when

TE Budget

• TE accumulates in the path from the PRTC to the end application (G.8271.1 model).

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$$\max |TE_{N}| \leq \sum_{i=1}^{N} |cTE_{i}| + \sum_{j=1}^{N-1} |linkTE_{j}| + \sqrt{\left\{\sum_{i=1}^{N} \left[\max |d^{L}TE_{i}(t)|\right]^{2}\right\}} + \left[\max |d^{H}TE_{N}(t)|\right]^{2}$$

- Operation limits are assigned to each individual network element.
- Phase noise due to congestion and other causes has to be taken into account.
- A margin is assigned to accommodate holdover periods and rearrangement events.

Network Test: FTS

- G.8271.1 Reference point C limits.
 - Low frequency TE (constant and slowly changing TE): $1.1 \, \mu s$ (max).
 - High frequency TE (fast TE): 200 ns (peak-to-peak).
 - MTIE (slow and fast TE): Special mask to be met.

Network Test: PTS, APTS

forward and reverse path latency

- Key metric: *pktSelected2WayTE*.
 - APTS: 1.1 µs (peak-to-peak).
 - PTS: 1.1 μs (max).
- Selection window is 200 s, selection percentage is 0.25%.

Network Test: Setup and Results

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- Simplified T-TSC / T-BC test (single unit test).
- Traffic replay.
- Capture triggers.
- PTP impairment generation (tolerance / transfer tests) (?).

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