Planned Time Sync Comments on SA Ballot

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Background

- Following presentation of [1]…
  - Geoff Garner, "Revised Multiple Replication 60802 Time Domain Simulation Results for Cases with Drift Tracking Algorithms and PLL Noise Generation, Version 2", Contribution to IEC/IEEE 60802, May 2024
- …the group consensus is that the goal of 1 µs time sync accuracy over 100 network hops can be met.

Level Complete!
You Win!!!

- However, the latest simulations indicate that some minor changes are required to the specification. These will be proposed via comments on the SA Ballot.
- This contribution documents the expected changes.

Table 9 - Clock Control System requirements

Table 11 – Clock Control System requirements

Topic	Value
Maximum Bandwidth ~~(Hz)~~	1,0 Hz
Minimum Bandwidth ~~(Hz)~~	~~0,7~~ 0,9 Hz
Maximum Gain Peaking ~~(dB)~~	2,2 dB
Minimum absolute value of Roll-off	20 dB/decade
NOTE 1 For more information regarding the clock control system see Annex C. NOTE 2 The values contained in this table apply to both the Working Clock and Global Time.	

Table 11 – Minimum Endpoint Filter Bandwidth

- The current endpoint filter bandwidth requirement in Table 11 of IEC/IEEE 60802/D2.4 [3] is that it be in the range 0.7 Hz – 1.0 Hz
- The revised simulation results in [1] indicate that the max|dTE_R| objective of 500 ns can be met for endpoint filter bandwidths in the range 0.9 Hz to 1.5 Hz.
- It was decided in discussion of [1] to retain 1.0 Hz as the maximum bandwidth, but change the minimum bandwidth requirement to 0.9 Hz
- Then the minimum bandwidth requirement in Table 11 of [3] (2nd row after the table header) needs to be changed to:
  - Minimum Bandwidth: 0,9 Hz

Table 14 - Error generation limits for PTP End Instance

Table 14 – Error generation limits for PTP End Instance

Topic	Value
Working Clock (acting as ClockTarget) at PTP End Instance minus Working Clock (acting as Clock Source) at Grandmaster, while… • WorkingClock (acting as ClockSource) at Grandmaster is stable. • Local Clock at upstream PTP Instance is stable. • meanLinkDelay between upstream PTP Instance and PTP Relay Instance is negligible	Allowable range of cTE: -10 ns to +10 ns Allowable range of dTE: -15 ns to +15 ns
Working Clock (acting as ClockTarget) at PTP End Instance minus Working Clock (acting as Clock Source) at Grandmaster, while… • WorkingClock (acting as ClockSource) at Grandmaster PTP Instance, fractional frequency offset with respect to the nominal frequency is increasing at 1 ppm/s • Local Clock at upstream PTP Instance is stable. • meanLinkDelay between upstream PTP Instance and PTP Relay Instance is negligible	Allowable range of cTE: -10 ns to +10 ns Allowable range of dTE: ~~-230~~ -145 ns to +20 ns
Working Clock (acting as ClockTarget) at PTP End Instance minus Working Clock (acting as Clock Source) at Grandmaster, while… • WorkingClock (acting as ClockSource) at Grandmaster PTP Instance, fractional frequency offset with respect to the nominal frequency is increasing at 1 ppm/s • Local Clock at upstream PTP Instance, fractional frequency offset with respect to the nominal frequency is increasing at 1 ppm/s • meanLinkDelay between upstream PTP Instance and PTP Relay Instance is negligible	Allowable range of cTE: -10 ns to +10 ns Allowable range of dTE: ~~-230~~ -145 ns to +20 ns
meanLinkDelay measured by the PTP End Instance minus the actual path delay	±3 ns

Table 14 - PTP End Instance Error Generation Requirement - 1

- The steady-state phase offset due to the response of the second-order endpoint filter to a 1 ppm/s frequency drift is computed in [2] (slide 129) as

$$\text{steady-state-response} = \frac{A}{\omega_n^2}$$

where

ω_n = undamped natural frequency

ς = damping ratio = 2.1985 dB

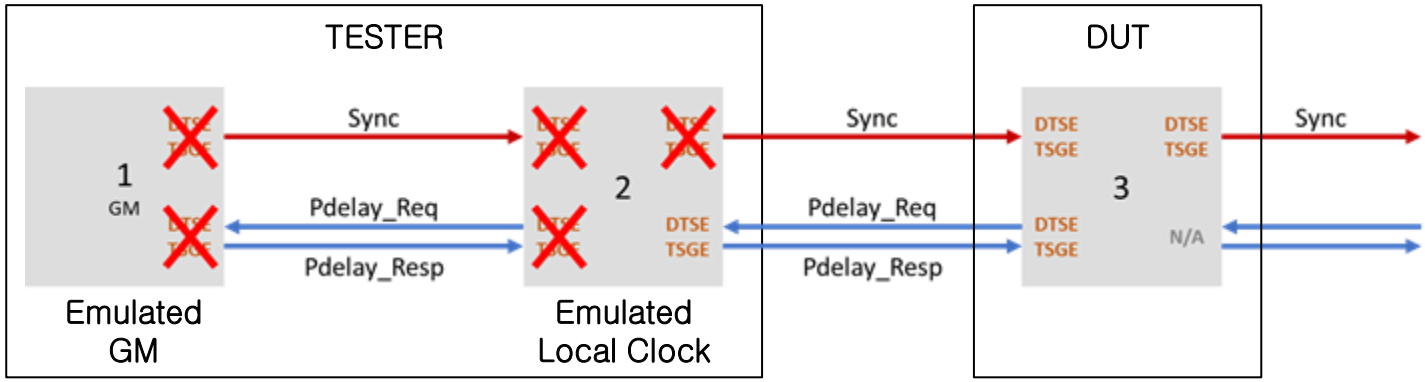
- In [2], the result is 104 ns for the case of endpoint filter undamped natural frequency of 3.1011 rad/s, or 3 dB bandwidth of 1 Hz

Table 14 - PTP End Instance Error Generation Requirement - 2

- For the case of the minimum allowed bandwidth of 0.9 Hz (see Table 14 of [3]), the dTE results are each multiplied by a factor of $(1.0/0.9)^2 = 1.235$
  - This is due to the factor of ω_n^2 in the denominator of the final equation on the previous slide (note that undamped natural frequency is proportional to 3 dB bandwidth)
  - This means that for a bandwidth of 0.9 Hz, the maximum absolute value of 104 ns computed on the previous slide becomes (104 ns)(1.2346) = 128.4 ns
  - Then, since the steady-state error due to the filter is negative, and assuming max|dTE| without the filter is the 15 ns of row 1 of Table 14 of [1], the lower end of the range of dTE for Table 14 with filtering is -128.4 ns – 15 ns = -143.4 ns =(approximately) -145 ns
- Then the allowable range of dTE in Table 14, rows 2 and 3 (following the table header) should be
  - -145 ns to +20 ns

Annex D - (Informative) Time Sync

- Add explanation for the asymmetric dTE normative requirements in Table 14
- Add explanation of the meanLinkDelay normative requirements in D.3.4, D.3.5 and D.3.6
- Add description of potential test for meanLinkDelay to D.4
  - In particular, where the test equipment should simulate TSGE and DTSE…



  - …i.e. only at the TX and RX ports to the DUT and only for Pdelay_Req and Pdelay_Resp messages.

References

[1] Geoffrey M. Garner, *Revised Multiple Replication 60802 Time Domain Simulation Results for Caes with Drift Tracking Algorithms and PLL Noise Generation, Version 2*, IEC/IEEE 60802 presentation, May 2024 (available at https://www.ieee802.org/1/files/public/docs2024/60802-garner-revised-time-domain-simul-results-with-drift-tracking-algorithms-and-PLL-noise-generation-multiple-replic-0524-v02.pdf)

[2] Geoffrey M. Garner, Revised 60802 Error Generation Time Series Simulation Results Version 1, IEC/IEEE 60802 presentation, April 26, 2024, (available at https://www.ieee802.org/1/files/public/docs2024/60802-garner-revised-error-generation-time-series-simulation-results-0424-v01.pdf)

[3] IEC/IEEE 60802, Draft D2.4