60802 Time Sync Contribution Discussion – 2nd December 2022

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Version 1

References

1. David McCall “60802 Update on Time Sync” https://www.ieee802.org/1/files/public/docs2022/60802-McCall-Update-On-Time-Sync-Status-15-Nov-1122-v2.pdf
2. David McCall “60802 Time Sync Contribution Discussion” https://www.ieee802.org/1/files/public/docs2022/60802-McCall-Time-Sync-Contribution-Discussion-17-Nov-1122-v2.pdf

Agenda

- Schedule
- Normative Requirements – Further Review & Discussion
- Using Sync message and new TLV to calculate NRR
  - Normative requirement vs. informative text?
    - What is the new algorithm? Use both pDelayResp & Sync+TLV? Implications of variability (unsynchronised processes)?
  - Implications for standby & switching to a new GM?
    - pDelayInterval?
    - How to make the switch, i.e. transition process?
- Informative Text
- What Else?

Schedule

- Intent is to have Time Sync contribution to Jordon Woods by Christmas
- Jordon will integrate the contribution into a pre-draft during first two weeks of 2023
- Pre-draft will be reviewed during 802.1 Interim (Baltimore, MA; 15th-20th January) to ensure it addresses all comments

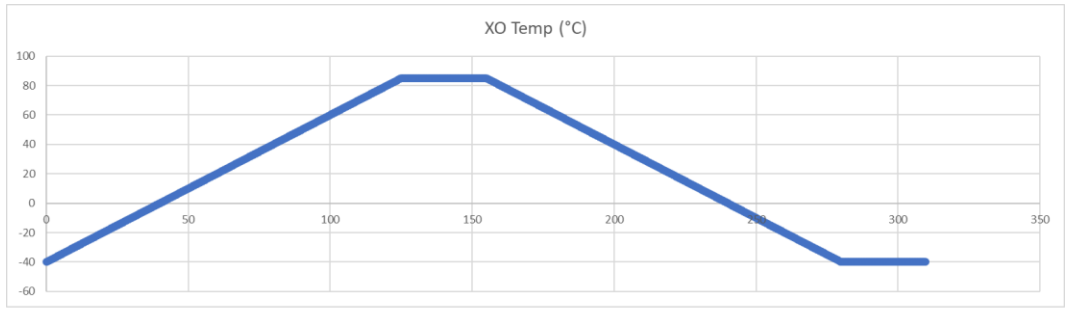
Normative Requirements

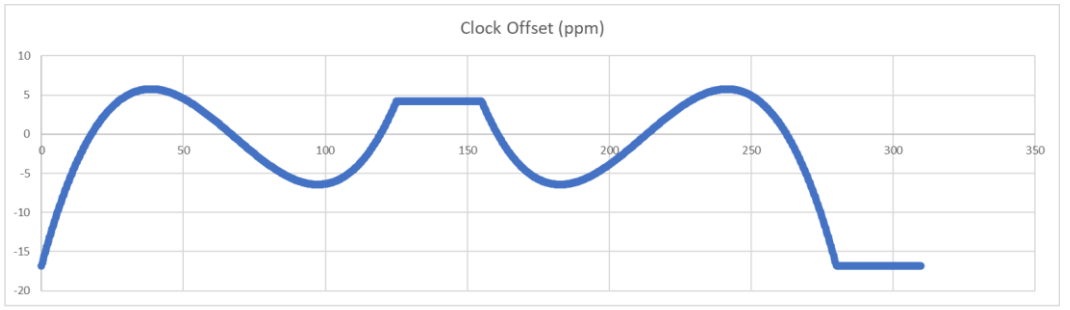
Clock Requirements – 1

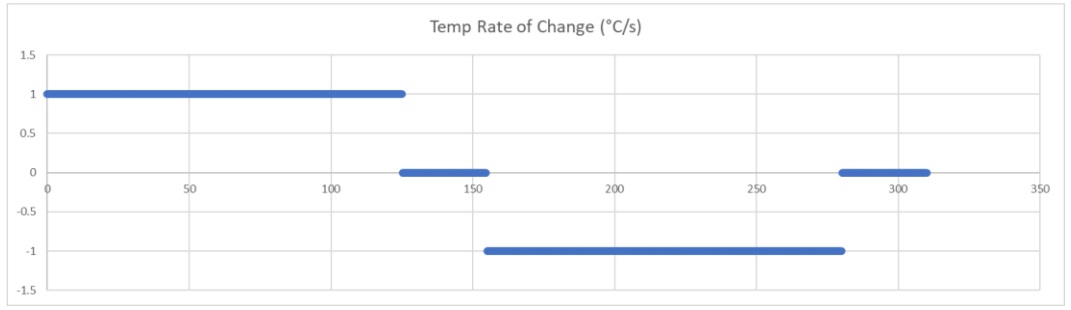
Topic	Value
Range of fractional frequency offset relative to the TAI frequency for LocalClock (used for timeReceiver, Grandmaster, or PTP Relay Instance) or Clock Target	±50 ppm
Range of rate of change of fractional frequency offset for LocalClock (used for timeReceiver, Grandmaster, or PTP Relay Instance)	-1.35 ppm/s to +2.12 ppm/s
Range of rate of change of fractional frequency offset for ClockTarget	±3 ppm/s

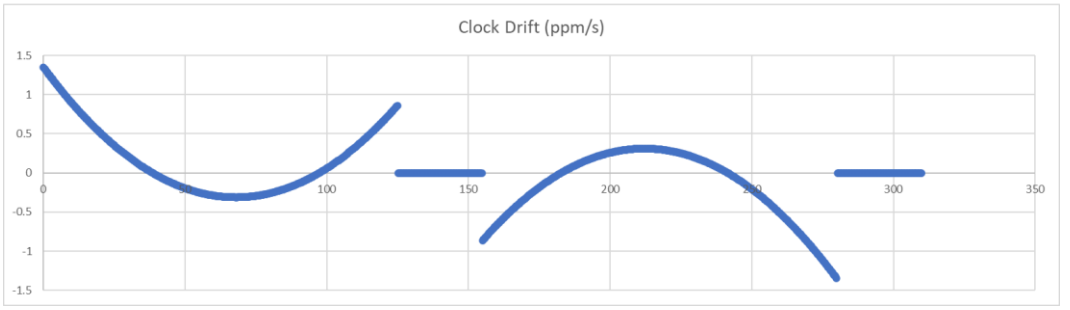
- May split timeReceiver and Grandmaster ppm/s requirement – tighter requirement for Grandmaster.
- Is the LocalClock ppm/s requirement OK? (See next 3 slides.)
- Must be maintained over manufacturer's stated operating conditions (including temperature and temperature ramp ranges)...which 60802 does not specify.

Clock Drift Example – Linear Temperature Ramp: 1°C/s ↕ (125s ↕)







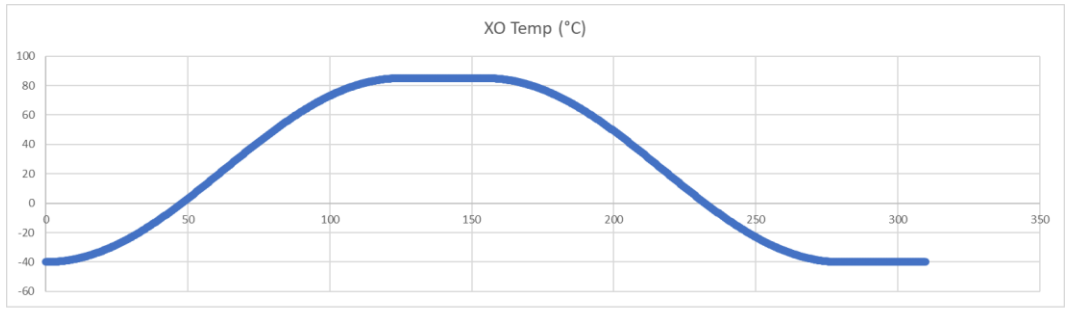


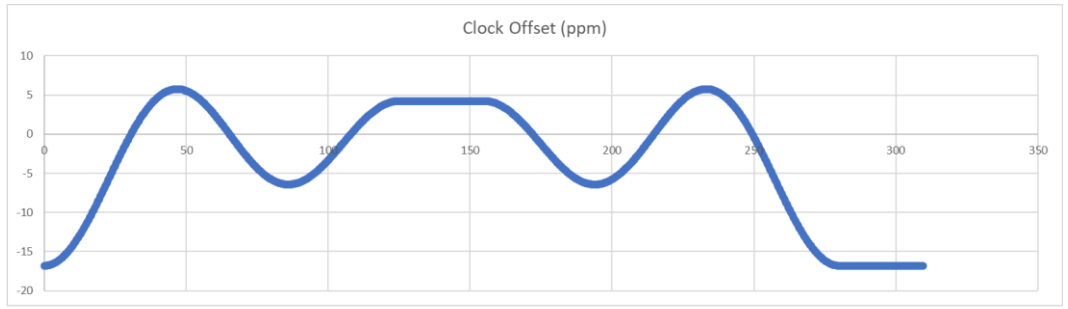
Inputs		
Temp Max	85	°C
Temp Min	-40	°C
Temp Ramp Rate	1	°C/s
Temp Hold	30	s

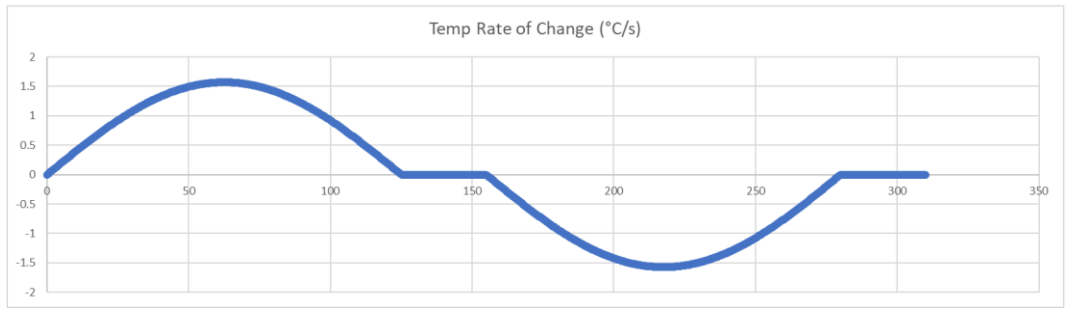
Temp Rate of Change		
MAX	1.00	°C/s
MIN	-1.00	°C/s

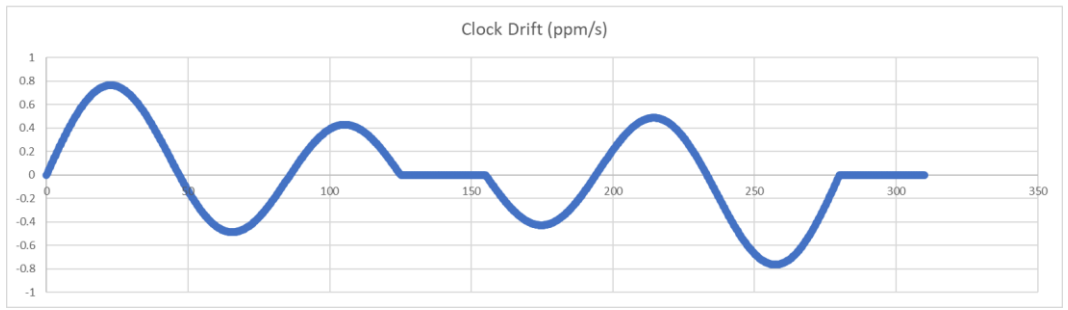
Clock Drift		
MAX	1.35	ppm/s
MIN	-1.35	ppm/s

Clock Drift Example – Sinusoidal Temperature Ramp: 125s ↕







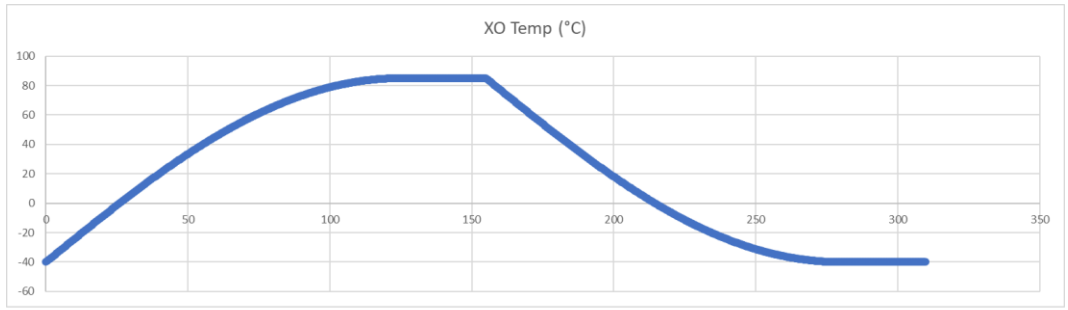


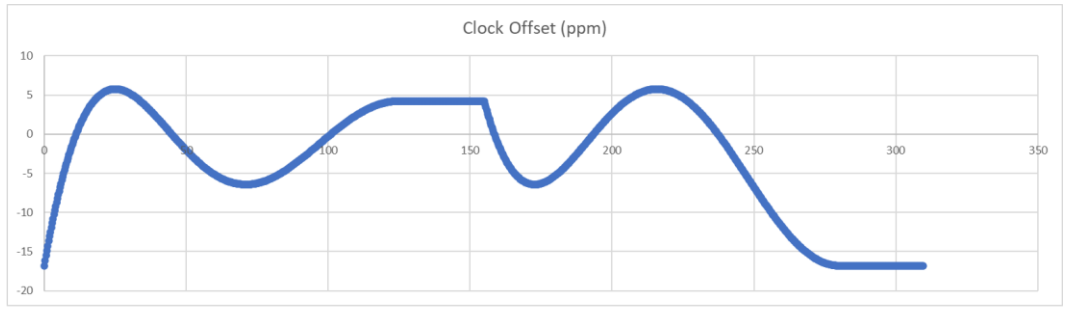
Inputs		
Temp Max	85	°C
Temp Min	-40	°C
Temp Ramp Period	125	s
Temp Hold	30	s

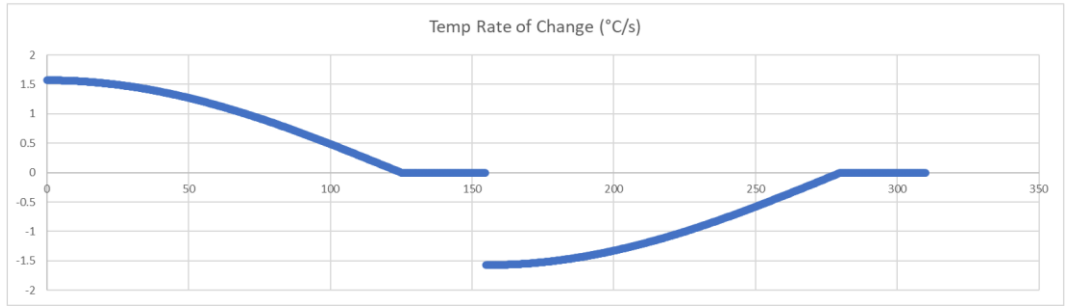
Temp Rate of Change		
MAX	1.57	°C/s
MIN	-1.57	°C/s

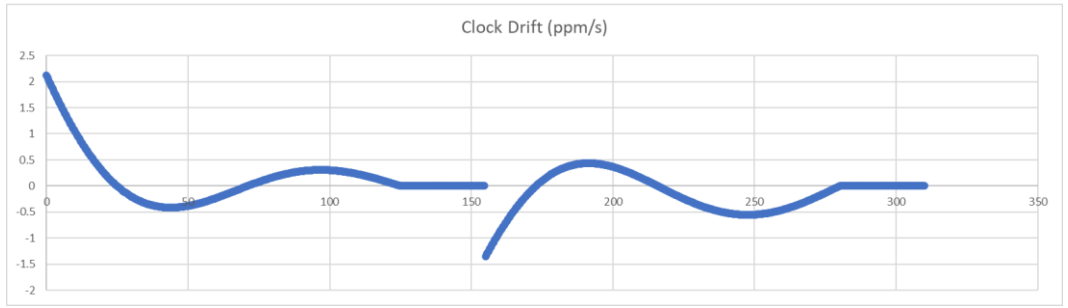
Clock Drift		
MAX	0.76	ppm/s
MIN	-0.76	ppm/s

Clock Drift Example – Half-Sinusoidal Temperature Ramp: 125s ↕









Inputs		
Temp Max	85	°C
Temp Min	-40	°C
Temp Ramp Period	125	s
Temp Hold	30	s

Temp Rate of Change		
MAX	1.57	°C/s
MIN	-1.57	°C/s

Clock Drift		
MAX	2.12	ppm/s
MIN	-1.35	ppm/s

Clock Requirements – 2

Topic	Value
Total range of frequency adjustment for ClockTarget used for Global Time	±1000 ppm over any observation interval of 1 ms
Total range of frequency adjustment for ClockTarget used for Local Clock	±250 ppm over any observation interval of 1 ms

- Need to align “Required Values” with comment resolution.

PTP Protocol Requirements –
Sync & pDelay Interval

Topic	Value
Nominal Sync Interval (syncInterval) at the Grandmaster	125 ms
Tsync2sync at the Grandmaster	120ms to 130ms (140ms?)
Nominal pDelay Interval (pDelayInterval)	125 ms
Tpdelay2pdelay	120ms to 130ms (140ms?)

- Until now, simulations use...
  - Tpdelay2pdelay:
    - Time Series & most Monte Carlo: uniform distribution 90% - 130% of nominal value (112.5 ms to 162.5 ms)
    - Recent Monte Carlo: uniform distribution 95% - 105% of nominal value (118.75 ms to 131.25 ms)
  - Tsync2sync: Gamma distribution with 90% of messages within 10% of nominal (112.5 ms to 137.5 ms)
- IEEE 1588 requirements...
  - Tsync2sync: 90% of messages within 30% of nominal (87.5 ms to 162.5 ms)
  - Tpdelay2pdelay: minimum 90% of nominal (112.5 ms)
- Note: if we decide not to use pDelayResp messages as part of calculating NRR we may significantly increase the Nominal pDelay Interval.

Notes on PTP Protocol Requirements –
Sync & pDelay Interval

- Assumptions:
  - Implementation will be via a 10 ms timer, so 10 ms limits should be used.
  - Nominal values for pDelayInterval and SyncInterval will be the same.
- Nominal values are limited to ..., 31.25 ms, 62.5 ms, 125 ms, 250 ms, etc...
  - Simulations will determine whether 125 ms is the final choice.
- If 125ms is the choice...
  - IEEE 1588 requirement means 110ms is the minimum $T_{pdelay2pdelay}$ value to remain compliant.

PTP Protocol Requirements –
residenceTime & pDelayTurnaround

Topic	Value
Maximum Residence Time (residenceTime)	10 ms
Residence Time Distribution	95% < 8 ms
Sync Follow-up Message	<2.5 ms after Sync Message
Maximum pDelay Turnaround (pDelayTurnaround)	10 ms

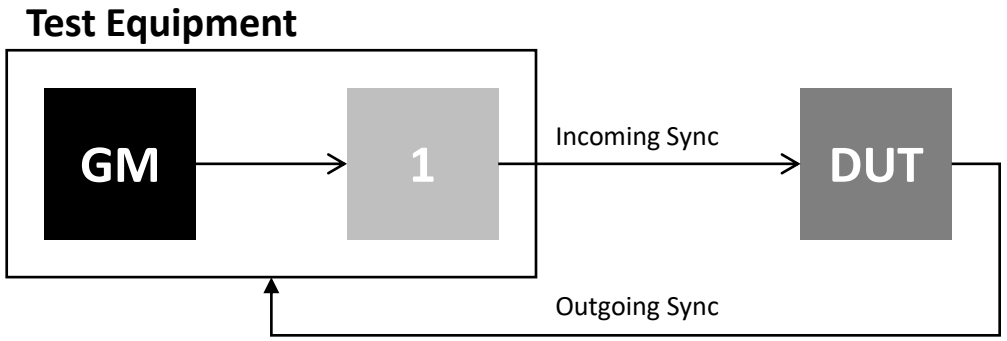
- Residence Time with 95% < 6.5 ms is from mean 5 ms, standard deviation 0.8333 ms (6σ = 5 ms)
  - For recent Monte Carlo simulations we assumed Gaussian distribution, mean 5 ms, standard deviation 0.8333 ms, truncated to 1 ms at the lower end and 10 ms at the upper end.
- Recommendation to move to Residence Time with 95% < 8 ms.
  - For 95% below 8 ms the simulation would use Gaussian distribution, mean 5 ms, standard deviation 1.8 ms, truncated to 1 ms at the lower end and 10 ms at the upper end.
- Sync Follow-up Message timing may be too aggressive. Need more feedback.
- No need for tighter pDelay Turnaround requirement
  - Minimal impact on Mean Link Delay measurement
  - No need for improved timing consistency of pDelayResp messaging if t_{1out} TLV is implemented
- Note: if we decide not to use pDelayResp messages as part of calculating NRR we may significantly increase the Nominal pDelayTurnaround interval.

Correction Field, RR & NRR "Noise" Requirements

Topic	Value
Correction Field Stable Grandmaster (RR in Sync Message) Stable Upstream Node Local Clock (NRR) Stable Temperature (stable Local Clock)	Over X Sync messages, Correction Field... Mean error Y ns (Constant Time Error) 90% of errors ± Z ns (Dynamic Time Error)
Neighbour Rate Ratio – measured via Rate Ratio Stable Grandmaster (RR in Sync Message) Upstream Node Local Clock drifting at <Clock Drift Limit> (NRR) Stable Temperature (stable Local Clock)	Over X Sync messages, RR Field... Eliminate 90% of expected error?

- Dynamic clock drift ramp? Simulate temp ramp for Upstream Node Local Clock?
- Similar requirement for Rate Ratio drift if we need Rate Ratio drift compensation to achieve goal?

Correction Field, RR & NRR "Noise" Requirements



- When upstream node's clock drifts, error in RR field matches error in NRR.
- When GM clock drifts, error appears in RR field only
  - Applies to all error in RR due to nodes prior to upstream node, but for test purposes can be simplified to GM and one upstream node

Correction Field, RR & NRR "Noise" Requirements

- First requirement is focused on Timestamp Error (both Timestamp Granularity & Dynamic Time Stamp Error).
  - Test equipment keeps simulated upstream node (NRR) clock stable & GM (RR) clock stable. Also stable temp for DUT.
  - RR field should be nominally 1. Normative requirement for errors in Correction Field.
- Second requirement is focused on NRR tracking & compensation algorithm.
  - Test equipment simulates clock drift of upstream node.
  - Error in RR field should be limited to normative requirement (some percentage less than what would be expected without tracking & compensation).
  - NRR error will also result in additional error in Correction Field...but RR field is a more direct route to measuring the behaviour of interest.
- Possible (likely) third requirement focused on RR tracking & compensation algorithm.
  - Similar, to NRR, but test equipment simulates clock drift of GM.

Correction Field, RR & NRR “Noise” Requirements

- May want to split accuracy of cable delay measurement vs accuracy of residence time measurement.
  - Or not...might be better to have the expected split in informative text.
- More informative text required to clarify normative requirements.
  - Should look at other examples of how to measure static and dynamic time error from other (ITU, etc...) specs. Don’t reinvent the wheel.

Using Sync message and new TLV to calculate NRR

- Normative requirement vs. informative text?
  - What is the new algorithm? Use both pDelayResp & Sync+TLV? Implications of variability (unsynchronised processes)?
- Implications for standby & switching to a new GM?
  - pDelayInterval?
  - How to make the switch, i.e. transition process?

New TLV - Schedule

- Plan to include in a comment on next draft of 802.1ASdm
  - In parallel with 802.1ASdm PAR modification
- Best if we have a detailed proposed resolution (i.e. message content fully defined) to be included in the comment.
- Schedule? Experts to provide content? Review in this group?

Informative Text

Informative Text

(not a comprehensive list; mainly to identify what isn't normative)

- Timestamp Granularity & Dynamic Time Stamp Error
- meanLinkDelay Error Correction
- mNRRsmoothing
  - Using N^{th} previous pDelayResp / TLV information; taking an average of previous A calculations
- NRR drift measurement & compensation
  - Using N^{th} previous pDelayResp / TLV information; taking an average of previous A calculations; going back P messages and doing it again; assuming linearity between two measurements and compensating
- RR drift measurement & compensation

What Else?

Additional Contribution Areas?

- ClockMaster / ClockSlave & ClockSource / ClockTarget?
- Error model? Dynamic time error vs. Constant time error?
- Clock filtering / control loop (independent of implementation)
  - Must ensure comments are addressed

Thank you!