60802 Time Sync Contribution Discussion

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Version 2

References

- 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

Agenda

- Discussion on what we need to decide.
- Normative Requirements
- Informative Text
- What Else?

What do we need to decide?

During this meeting...so that we can write the required contribution...

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

During this meeting…

- Decide (majority of) what the normative requirements will be and how they will be specified
- Decide (majority of) what will be in informative text

- Simulations to prove the details of some of the requirements are ongoing (some may be presented tomorrow) but should be possible to agree on normative / informative split and how normative requirements will be specified even if details (values) change

- Does the group agree?

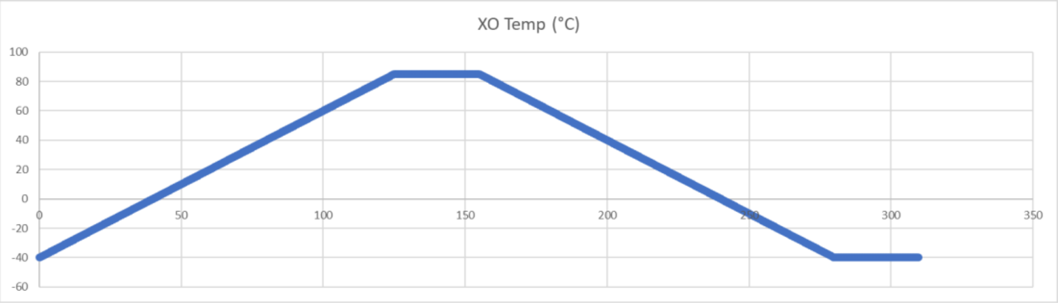
Normative Requirements

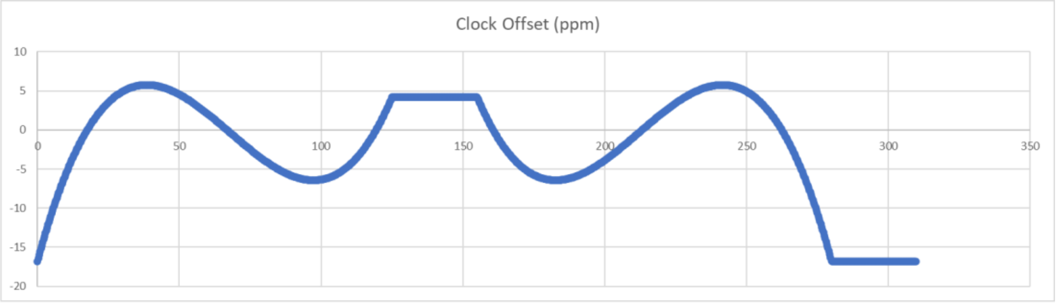
Clock Requirements – 1

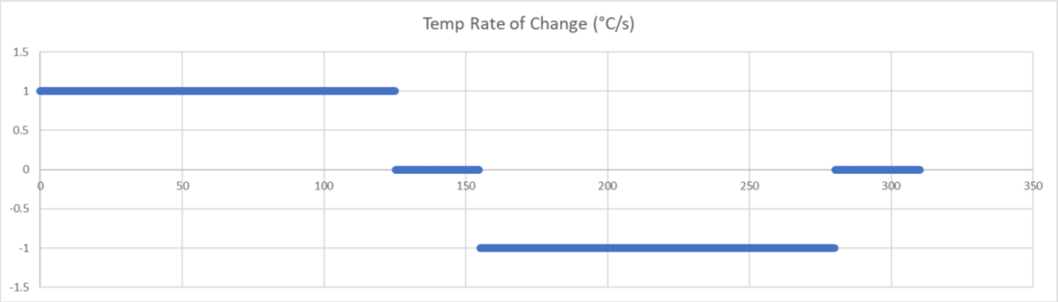
Topic	Value
Range of fractional frequency offset relative to the TAI frequency for LocalClock (used for timeReceiver, Grandmaster, or PTP Relay Instance) or Clock Target	±50 ppm
Range of rate of change of fractional frequency offset for LocalClock (used for timeReceiver, Grandmaster, or PTP Relay Instance)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

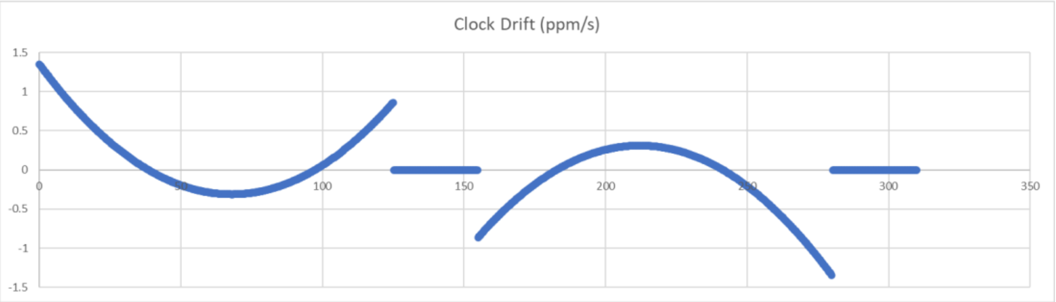
- May split timeReceiver and Grandmaster ppm/s requirement – tighter requirement for Grandmaster.
- Is the LocalClock ppm/s requirement OK? (See next 3 slides.)
- Must be maintained over manufacturer's stated operating conditions (including temperature and temperature ramp ranges)...which 60802 does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

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







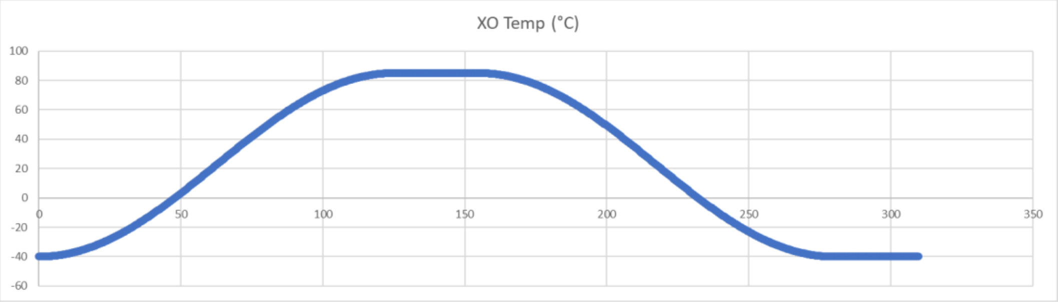


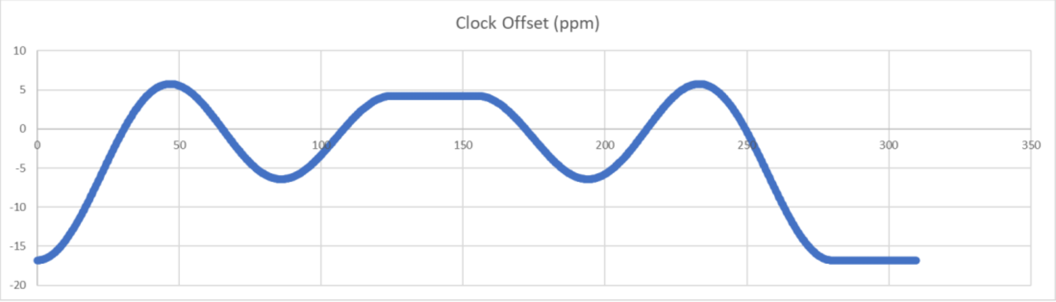
Inputs		
Temp Max	85	°C
Temp Min	-40	°C
Temp Ramp Rate	1	°C/s
Temp Hold	30	s

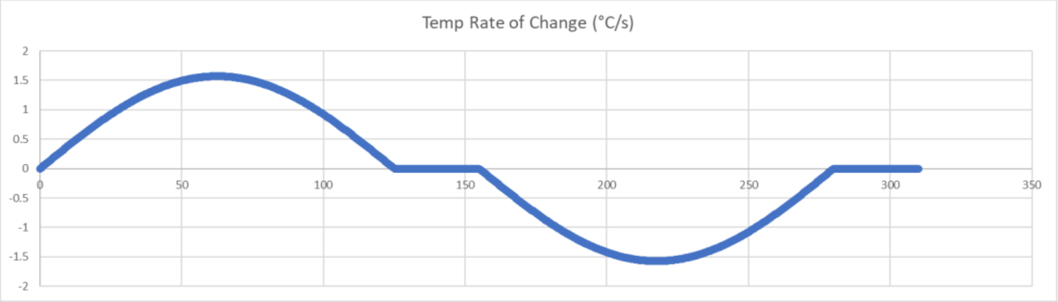
Temp Rate of Change		
MAX	1.00	°C/s
MIN	-1.00	°C/s

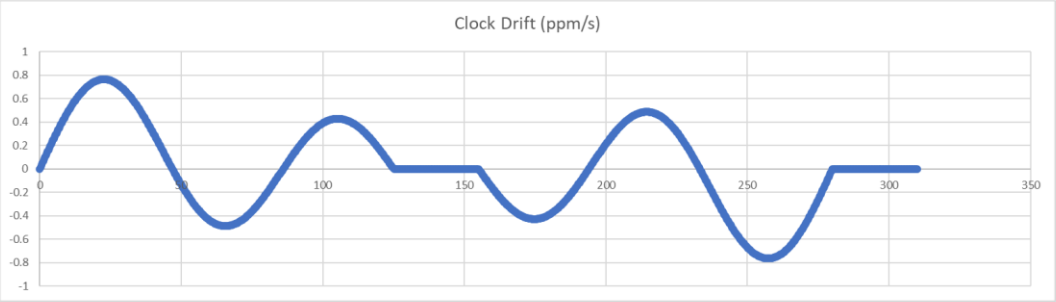
Clock Drift		
MAX	1.35	ppm/s
MIN	-1.35	ppm/s

Clock Drift Example – Sinusoidal Temperature Ramp: 125s ↕







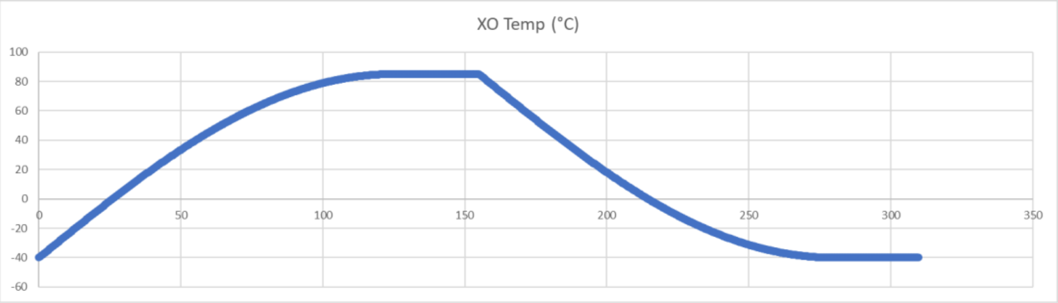


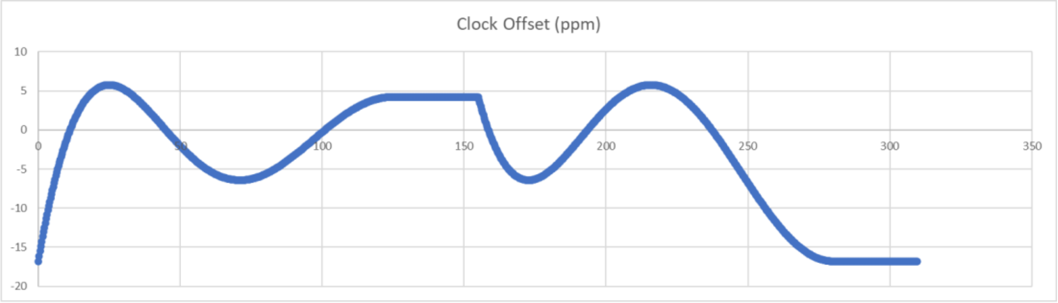
Inputs		
Temp Max	85	°C
Temp Min	-40	°C
Temp Ramp Period	125	s
Temp Hold	30	s

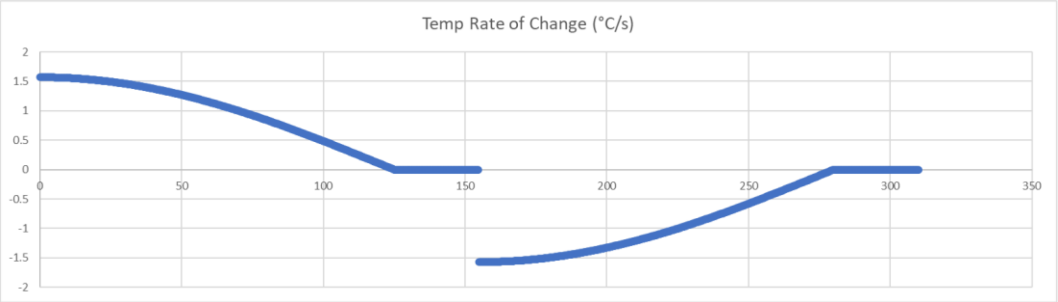
Temp Rate of Change		
MAX	1.57	°C/s
MIN	-1.57	°C/s

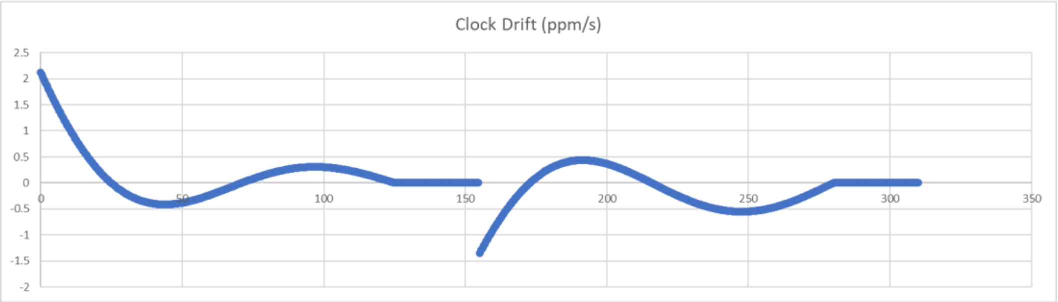
Clock Drift		
MAX	0.76	ppm/s
MIN	-0.76	ppm/s

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
Nominal pDelay Interval (pDelayInterval)	125 ms
Tpdelay2pdelay	120ms to 130ms

- 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.

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 ±0.1 ns 90% of errors ± Y ns
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?

Notes on previous slide...

- 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.

New TLV

- Sent after Sync message
- Contains t_{1out} timestamp (transmit time of Sync message)
- Contains Grandmaster ID
- Same timing requirement as Follow-up message?

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!