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# Some Implications of 10BASE-T1L for TSN, particularly IEC/IEEE 60802

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# Intro

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- 10BASE-T1L is included in the list of Common PHY and MAC Options (5.6.1) of IEC/IEEE 60802d1.2
  - For Process Automation, 10BASE-T1L is an essential technology to replace various legacy technologies for relatively long distances and in harmful environments

- There are some gaps that need to be discussed and addressed
  1. 10BASE-T1L and Frame Preemption / MAC Merge sublayer
  2. 10BASE-T1L and IEEE 802.1AS-2020 Link Delay Threshold
  3. 10BASE-T1L and IEC/IEEE 60802 / IEEE 802.1AS-2020 Performance Requirements

# (1) 10BASE-T1L and Frame Preemption / MAC Merge

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The topic was already discussed in earlier meetings, see 60802-woods-Preemption-Gap-0920-v01.pdf .

CFI (Call for interest) was raised and is currently discussed in the 802.3 March plenary

> *With the conclusion of IEEE Std 802.3cg-2019, the Ethernet Standard has renewed interest in Ethernet at lower speeds. Renewed interest has broadened the application areas. This has already spawned a project for enhancements to the 10 Mbps shared-media (aka multidrop) operation on mixing segments in IEEE P802.3da; however, the point-to-point PHYs are outside the written scope of the IEEE P802.3da PAR. This call for interest is to consider enhancements related to the use of the point-to-point operation in single pair ethernet, including* ***for example, use of 10BASE-T1L with MACMERGE****. The proposed study group would explore* ***any needed enhancements to use the new PHYs in Time-Sensitive Networking (TSN) and industrial networking environments****.*

# (2) 10BASE-T1L and 802.1AS Link Delay Threshold (1)

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Measured link delay is used as one of severeal criteria to determine whether connected equipment implements gPTP or whether a non-AS capable system may be in-between.

Only 2 initial values for the threshold are defined (Table 11-1) and referred to as mandatory initial values by the PICS (MDFDPP-30).

IEEE Std 802.1AS-2020
IEEE Standard for Local and Metropolitan Area Networks—Timing and Synchronization for Time-Sensitive Applications

**Table 11-1—Value of meanLinkDelayThresh for various links**

| Link | Value of meanLinkDelayThresh (ns) (see NOTE) |
|---|---|
| 100BASE-TX, 1000BASE-T | $800_{10}$ |
| 100BASE-FX, 1000BASE-X | FFFF FFFF FFFF FFFF FFFF FFFF$_{16}$ |

NOTE—The actual propagation delay for 100BASE-TX and 1000BASE-T links is expected to be smaller than the above respective threshold. If the measured mean propagation delay (i.e., meanLinkDelay; see 10.2.5.8) exceeds this threshold, it is assumed that this is due to the presence of equipment that does not implement gPTP. For 100BASE-FX and 1000BASE-X links, the actual propagation delay can be on the order of, or larger than, the delay produced by equipment that does not implement gPTP; therefore, such equipment cannot be detected by comparing measured propagation delay with a threshold. In this case, meanLinkDelayThresh is set to the largest possible value (i.e., all 1s).

**TP, <100m**

$800\ ns \approxeq 144\ m \quad (@\ 0.6\ c_0)$
$\approxeq 100\ m + 245\ ns$

**FO, longer distances**

$\approx infinity$

# (2) 10BASE-T1L and 802.1AS Link Delay Threshold (2)

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10BASE-T1L specifies a maximum propagation delay of **8 834 ns** (146.7.1.3 Maximum link delay).
There are also other PHYs in the list of options in 60802 that do not support 100 m link distance.

Proposals (2 alternative options)

a) replace "Link" with "PHY distance" or "expected link delay" and add a note that there may be a need to customize the threshold (and how), and remove this item from the PICS, and/or

b) base detection of asCapable on link delay variation instead of link delay upper bound.

Questions:

- Is or was this topic already addressed?
- Are there experiences regarding a reasonable safety margin to detect devices that do not implement gPTP?
    - ► 60802 specifies a PTPInstance contribution of *-50 ns* to + *50 ns* to dTE (see next slide).

# (3) T1L and 60802 / AS-2020 Performance Requirements (1)

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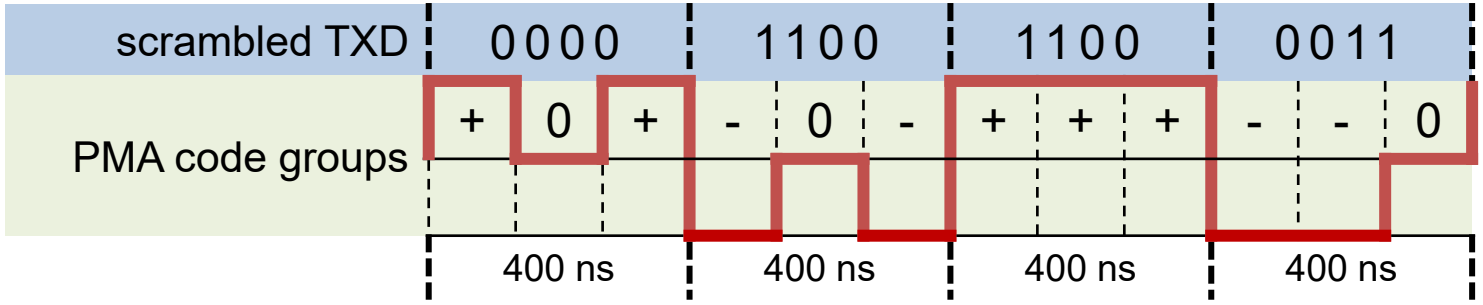
1. IEC 60802 d1.2 clause 6.2.8.2 specifies time error components due to relaying of time
   - Noise and timestamp granularity influences dTE, which shall be in the range of **+/- 50 ns**:

> 1182 The requirements for dTE are:
>
> 1183 – For a PTP Link, dTE is assumed to be zero.
>
> 1184 – For a PTP Instance, dTE shall be in the range of -50 ns to +50 ns.

2. Appendix B of IEEE 802.1AS-2020 specifies performance requirements
   - B.1.2 requires a clock granularity of 40 ns.
   - B.2.4 requires an accuracy of neighborRateRatio calculation of 0.1 ppm and states in a note that this will be achievable based on the 40 ns clock granularity and a maximum frequency offset of the clocks of 100 ppm.
   - Referenced in PICS

# (3) T1L and 60802 / AS-2020 Performance Requirements (2)

The 10BASE-T1L PHY codes 4 scrambled bits into a code group of 3 ternary symbols. A code group boundary occurs every 400 ns.




With MII, as discussed earlier this week (60802-Alsup-Timestamp-Precision-0321-v01.pdf ), RX_CLK and TX_CLK are sourced by the PHY. Constant delay in TX and RX direction can be achieved more or less straight-forward.

However, with **RMII and RGMII**, the transmit clock is not generated by the PHY and thus may generate variable delays to code group boundaries up to +/- 200 ns.

# (3) T1L and 60802 / AS-2020 Performance Requirements (3)

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- Possible mitigations and thoughts
  1. More extensive low pass filtering
     - CON: longer stabilization times at startup
     - CON: in case of only small frequency differences, beating will still cause problems
     - CON: will hardly work for a larger number of hops
     - BUT: are there any use cases for many hops with 10BASE-T1L?
  2. Implement a mechanism to get dynamic timestamping information from the PHY
     - Frequently read PHY delay over MDIO (may help for RGMII but difficult for RMII)
     - Define additional signaling, as discussed in 60802-Alsup-Timestamp-Precision-0321-v01.pdf
     - Correlate transmit clock in some way to the received data clock (inside the MAC)
  3. Requirements for TAS (802.1Qbv) are not confirmed for 10BASE-T1L links
     - Are limitations for the time synch accuracy acceptable for devices connected using 10BASE-T1L?

# Backup: ongoing 802.1AS projects

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- Active / planned 802.1AS projects the author is aware of at the time of writing

| | |
|---|---|
| 802.1ASdm | Hot Standby |
| 802.1ASdn | YANG Data Model |
| 802.1ASdr | Alternative Terminology |
| 802.1AS-2020/Cor1 | Corrigendum 1 |

# Backup: MII, RMII and RGMII

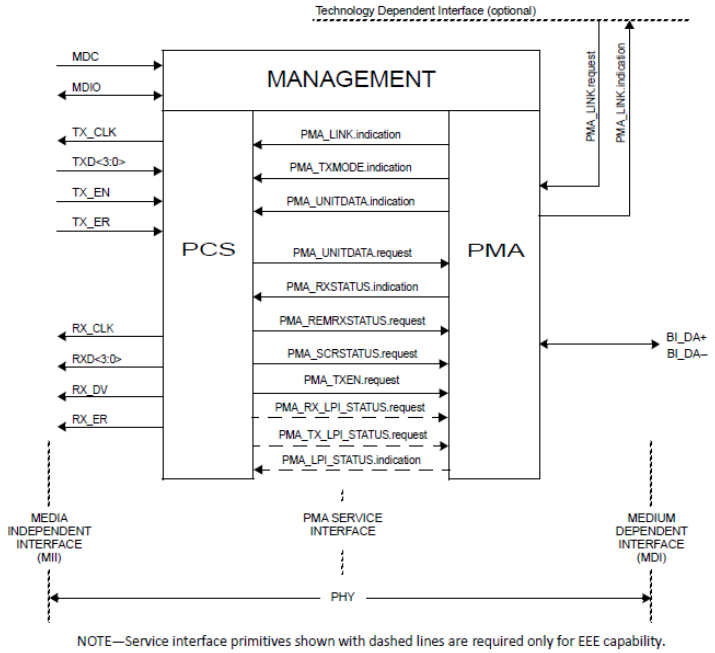
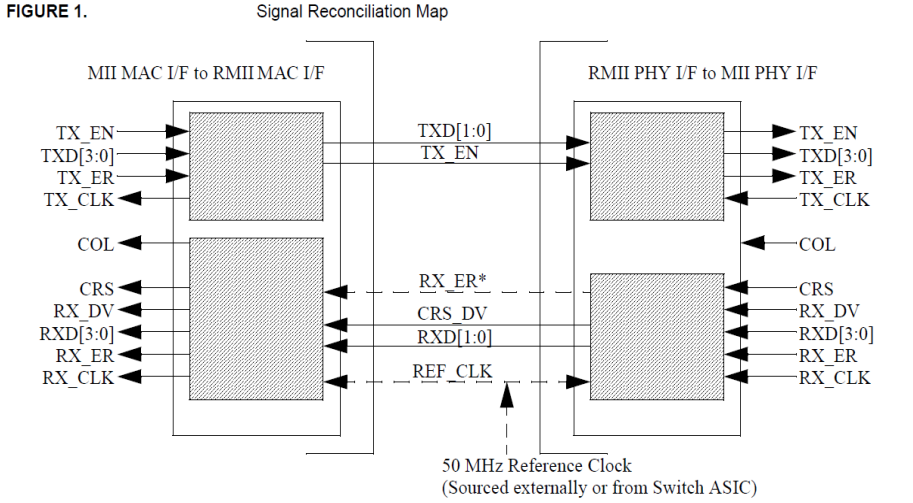



**Figure 146–2—10BASE-T1L PHY interfaces**

MII




RMII

| Signal Name | Source | Description |
|---|---|---|
| TXC | MAC | The transmit reference clock will be 125Mhz, 25Mhz, or 2.5Mhz +- 50ppm depending on speed. |
| TD[3:0] | MAC | Contains bits 3:0 on ↑ of TXC, bits7:4 on ↓ of TXC |
| TX_CTL | MAC | TXEN on Ç of TXC, and a logical derivative of TXEN and TXERR on È of TXC |
| RXC | PHY | The continuous receive reference clock will be 125Mhz, 25Mhz, or 2.5Mhz +- 50ppm. and shall be derived from the received data stream |
| RD[3:0] | PHY | bits 3:0 on Ç of RXC, bits7:4 on È of RXC |
| RX_CTL | PHY | RXDV on Ç of RXC, and a derivative of RXDV and RXERR on È of RXC |

RGMII