Comparison of ACT and TDD Propagation Delay

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October 9, 2025

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Introduction

- This presentation does an apples-to-apples comparison of ACT and TDD propagation delay through the PHY
- This evaluation does not account for the full end-to-end propagation delay, but only the fundamental differences in the ACT vs TDD propagation delay

- The analysis is based on the following texts:
  - ACT - https://ieee802.org/3/dm/public/0925/8023-200_ACT_D0p7a.pdf
  - TDD - https://ieee802.org/3/dm/public/0725/Baseline_Text_for_TDD_PHY_V1.1_07_14_25.pdf

- Much of this analysis was previously shared on the 802.3dm reflector
  - See https://ieee802.org/3/ISAAC/email/msg00542.html

Calculating the Delay

- The propagation delay can be separate into five main components

FEC_Delay	← Inherent FEC encoding and decoding delay
+ Quiet_Period_Delay	← No data is transmitted during Quiet Period
+ Refresh_Header_Delay	← No data is transmitted during Refresh Header
+ ~~Implementation_Sepcific_Delay~~	← Every implementation can have different delay
~~+ Cable_Propagation_Delay~~	← Propagation delay over the link segment
= Total_Delay	← The total delay over the link

- The implementation specific delay is impossible to quantify, by its very nature, but it is mostly independent of ACT vs TDD implementation
- The cable propagation delay is independent of the modulation
- For this apples-to-apples comparison, the cable and implementation specific delays are ignored

FEC Delay

- The FEC propagation delay is calculated according to

$$FEC\_Delay = (2*N-K+1)*m/R$$

  - N is the total number of symbols in the RS-FEC
  - K is the number of data symbols in the RS-FEC
  - m is the number of bits per RS-FEC symbols
  - R is the line rate
  - The calculation assumes that no interleaving is used

TDD Quiet Period and Refresh Header

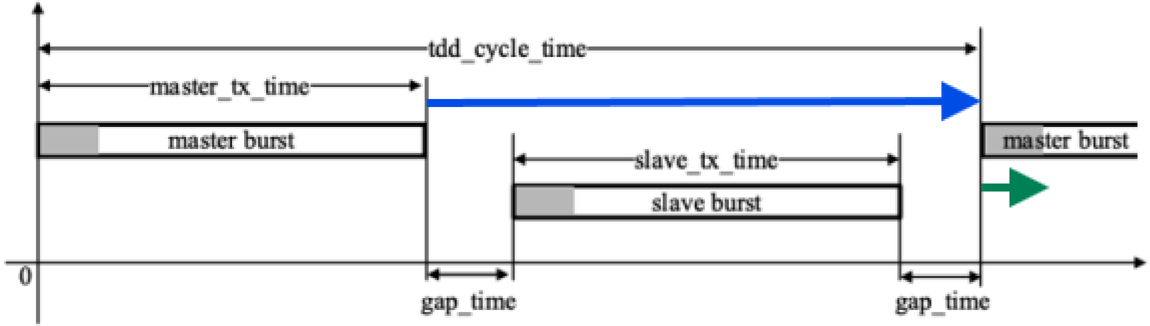

Figure 200-13 from: https://ieee802.org/3/dm/public/0725/Baseline_Text_for_TDD_PHY_V1.1_07_14_25.pdf

- Above is Figure 200-13 from the TDD text proposal in Madrid:

  Baseline_Text_for_TDD_PHY_V1.1_07_14_25.pdf
- The blue arrow has been added to represent the **quiet period** for the Master
- The green arrow has been added to represent the duration of the **refresh header** for the Master
- No data is transmitted during the **quiet period** and the **refresh header**, so this time adds directly to the TDD propagation delay

Quiet Period Delay

- TDD quiet periods are
  - **9040ns** for Master
  - **773ns** for Slave
- ACT has **no** propagation delay due to quiet period

> TDD_qt_d_timer
>
> A timer used to control the duration for the QUIET period DATA state of PHY control state. A value of 9040 ns for the MASTER PHY and a value of 773.33 ns for the SLAVE PHY.

Text from page 41 of Baseline_Text_for_TDD_PHY_V1.1_07_14_25.pdf

Refresh Header Delay

- According to tables 200-5 and 200-6 on the right the refresh headers in data mode are
  - 480 symbols for 2.5G
  - 960 symbols for 5G and 10G
- The TDD refresh header durations are
  - 160ns = 480/3GHz for 2.5G
  - 160ns = 960/6GHz for 5G and 10G
- TDD has **160ns** propagation delay due to the refresh header duration
- ACT has **no** propagation delay due to refresh header

tx_mode	refresh_header N_r(symb)	training_payload N_p(symb)
SEND_TS	560	13200
SEND_TA	480	26000
SEND_TA_EXT	N/A	N/A
SEND_N	480	26000

Table 200-5 N_r and N_p value for 2.5G+100MBASE-T1/V1 (SLAVE)TX

tx_mode	refresh_header N_r (symb)	training_payload N_p(symb)
SEND_TS	560	13200
SEND_TA	960	52000
SEND_TA_EXT (10G only)	960(10G Only)	52000(10G Only)
SEND_N	960	52000

Table 200-6 N_r and N_p value for 5G/10G + 100MBASE-T1/V1 (SLAVE) TX

Tables from page 31 of
Baseline_Text_for_TDD_PHY_V1.1_07_14_25.pdf

Calculated Theoretical Propagation Delay

	Data Rate [Gbps]	R [Gbps]	N	K	m	FEC Delay [ns]	Quiet Period [ns]	Refresh Period [ns]	Total Delay [ns]
ACT	0.1 US	0.117	50	46	6	2821	0	0	**2821**
	2.5	2.813	360	326	10	1404	0	0	**1404**
	5	5.625	360	326	10	702	0	0	**702**
	10	11.25	360	326	10	351	0	0	**351**
TDD	0.1 US	3	130	124	8	365	9040	160	**9565**
	2.5	3	130	122	8	371	773	160	**1304**
	5	6	130	122	8	185	773	160	**1118**
	10	12	130	122	8	93	773	160	**1026**

- The table above shows the calculated propagation delay for ACT and TDD
- The FEC delay calculation input is in the yellow section of the table
- The delay values are in the blue section of the table

Comparing the Propagation Delay

Data Rate [Gbps]	ACT Delay [ns]	TDD Delay [ns]	Delay Difference [ns]	Delay Difference [diff/ACT]
0.1 US	**2821**	9565	-6745	-239%
2.5 DS	1404	**1304**	101	7%
5 DS	**702**	1118	-416	-59%
10 DS	**351**	1026	-675	-192%

- The table above shows comparison of the propagation delay for ACT and TDD
- The comparison shows that TDD has 7% lower delay for 2.5G downstream, but for all other cases TDD has 60% to 240% higher delay than ACT

- It is worth noting that these results are in stark contrast with conclusion drawn on pages 13 and 17 of [Gauthier_Wang_3dm_01c_091525.pdf]

Summary

- This presentation provides a technical apples-to-apples comparison of propagation delay for ACT and TDD
- Earlier version of this calculation was previously shared on the 802.3dm email reflector, with a request for comments or corrections
- The comparison shows that for 2.5Gbps Downstream the TDD propagation delay is 7% less than corresponding propagation delay for ACT
- The comparison shows that for 100Mbps Upstream, 5Gbps Downstream, and 10Gbps Downstream, the TDD propagation delay is 60% to 240% higher than the propagation delay for ACT

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