

Duration of Half-Duplex Training

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Supporters

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Overview

- There is a proposal to reduce the duration of the half-duplex phase of training
 - [majomard_060722](#)
 - [majomard_061922](#)
- This is to present counter-arguments and suggest that we should be cautious in reducing this training time

Background: Training Time

- The overall training time is no more than ~100 ms
- There are 2 major training phases: half-duplex and full-duplex
- **Half-duplex:**
 - Master transmits while Slave is quiet
 - Master trains its echo canceller while Slave recovers timing and train equalizers
 - Duration is no more than ~40 ms
- **Full-duplex:**
 - Both Master and Slave transmit simultaneously
 - All filters are trained and optimized for link

Benefits of Reducing Half-Duplex Time (Quoted from [majomard_060722](#))

The following are mentioned as the motivations the proposal:

- To reduce the overall training time
 - Removed in a later presentation
- To allocate more time to full-duplex training

Proposal I: Reduce the duration slave

- Reduce the slave SILENT state to 20ms from 40ms
 - Master : From entry to SILENT state until en_slave_tx = 1 transmitted
 - Slave : Entry to exit of SILENT state
- Either reduce the total training time, or give more time for TRAINING state

Table 165-1

Timing
From entry to SILENT state until en_slave_tx = 1 transmitted
From entry of SILENT state until entry to COUNTDOWN
Entry to COUNTDOWN until entry of SILENT state
Entry to exit of PCS TEST
Total (Entry to SILENT to exit of PCS TEST)

Table 165-2

Timing

slide 4 of [majomard_060722](#)

Feasibility Arguments

(Quoted from [majomard_061922](#))

- Slave can quickly open the eye to detect Infocfield
- Master can do decent echo cancellation quickly
- Since half-duplex period of 10GBASE-T is ~20% of overall training time, it should also have the same proportion in 25GBASE-T1

Slave SII ENT state in Current 802.3cy text

- Slave has to detect the infocfield
- “During startup, prior to entering the TRAINING state, the SLAVE shall align its transmit 65B RS-FEC frame to within +0/-4 partial PHY frames of the MASTER as seen at the SLAVE MDI. The SLAVE Infocfield partial PHY frame count shall match the MASTER Infocfield partial PHY frame count for the aligned frame”
- Slave shall detect `en_slave_tx = 1` in master infocfield (PHY Control state diagram)
- The main task is making sure slave transmission does not cause problem for Master

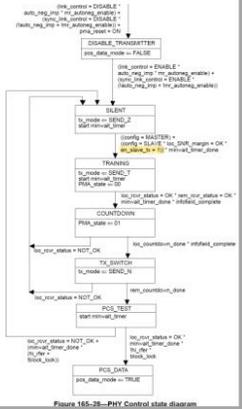


Figure 165-28—PHY Control state diagram

Startup timing: cy vs BASE-T

- There is imbalance between duration of states and tasks in cy standard
- Comparing to Base T (2.5/5/10G),
 - The timing of silent half duplex, and training state in cy is similar to timing of 2.5/5/10G base T before PBO exchange
- 2.5/5/10G base T links up after more than one second of the full training after PBO exchange

More than	Base T timing(ms)	Base T1 timing (ms)
Slave half duplex	350 (42% timing before PBO exchange)	40 (41% timing before link up)
Full duplex	480 (58% timing before PBO exchange)	56 (58% timing before link up)
Full duplex training	More than 1000ms of training before link up	

slides 6 and 7 of [majomard_061922](#)

Training Functions During Half-Duplex

- Slave training functions include some or all of the following:
 - Initial estimation of the channel
 - Analog configuration
 - Equalizer initialization
 - Timing recovery
 - Equalization training
- At the end of half-duplex training, the Slave is expected to
 - Have opened the eye to detect Infocfield
 - Achieve timing lock
- Master operation is primarily limited to echo canceller training

Complexity of Slave Training in Half-Duplex

- During half-duplex training, Slave has to
 1. Equalize the channel
 2. Capture the frequency offset
 3. Lock to the optimal phase
 4. Identify the training signal
- These operations have to be done
 - All simultaneously
 - From starting points which may be far off from optimal
- These challenges may not be present in full-duplex training and data mode as some of these tasks are already completed or the operating point is already close to the optimal

Complexity of Slave Training – cont'd

The operating regime of the receiver is very different from full-duplex and data mode

- With receiver starting far away from nominal operating point
 - With nonlinear and complex behavior of interdependent and interacting timing loop and equalizer adaptation loop
 - With the possibility of being stuck in trivial solutions or local minima
- ➔ Hard to analyze for a tight upper bound on training time

Complexity of Slave Training – cont'd

While the SNR requirement to open the eye is low, there are corner conditions with the possibility of

- Much longer training time to open the eye
- Complete failure to open the eye
- Opened eye but with slowly-drifting phase

Importance of Slave Training in Half-Duplex

- If Slave is not able to open the eye and lock the phase, training fails which requires another fresh training attempt
 - ➔ violates the requirement to bring up the link in less than 100 ms
- It is expected that the rate of training failure to be very low
- The allocated budget to half-duplex training is a limit on the maximum dwell time
 - If the eye is opened quickly the transition to full-duplex may happen earlier
 - The maximum dwell time should accommodate the longer training time for corner cases

Baud-Rate and Training Time

- With higher baud-rate, there are more training symbols available in unit time
 - Full-duplex training can take advantage of this fact for shorter training time
- The initial training time in half-duplex may be more limited by the dynamic response of the PLL and not as much by the number of available symbols
- The dynamic response of the PLL and timing control loop does not necessarily scale with baud-rate
 - The higher signaling bandwidth and the tighter clock jitter requirement may contribute to a slower response

Comparison to 10GBASE-T

The half-duplex portion of 10GBASE-T training is only ~20% of the total training time. Can this be extended to 25GBASE-T1?

- 10GBASE-T training is much more complex than 25GBASE-T1
 - There are significant interruptions in system in the middle of training:
 - Transmit power changes
 - THP is engaged
 - There is no counterpart to these events in 25GBASE-T1 training
- ➔ Comparison to 10GBASE-T may not be fair

Summary

- Slave training in half-duplex is not trivial
 - While the half-duplex training goals may not be typically hard to achieve, there are corner cases that may demand long training time
 - A failure in half-duplex training results in violation of the maximum 100 ms of startup time
 - The duration of half-duplex training may not shrink linearly by the higher baud-rate
 - The allocated time is a *maximum*, not preventing an earlier transition to full-duplex while accommodating the corner cases
- ➔ A reduction in duration of half-duplex has to be studied carefully