10GBase-T EEE Specifications

Refresh, Quiet, Alert

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Aquantia, August 13, 2008

Definition and Usage

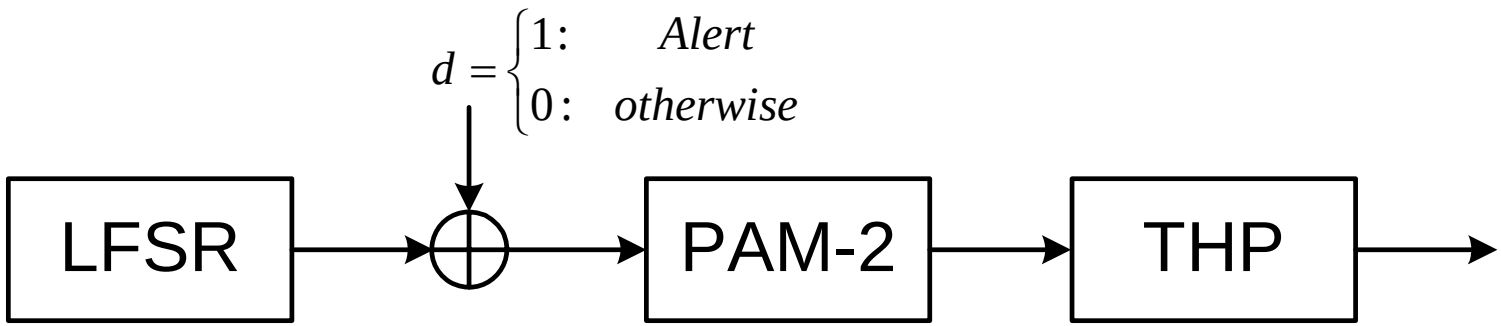
- Refresh: is used to update receiver parameters
  - Timing information
  - Filter coefficients
- Alert: indicates a transition to full speed mode
- Quiet: allows PHY to shut down major blocks for power saving

Desirable Features

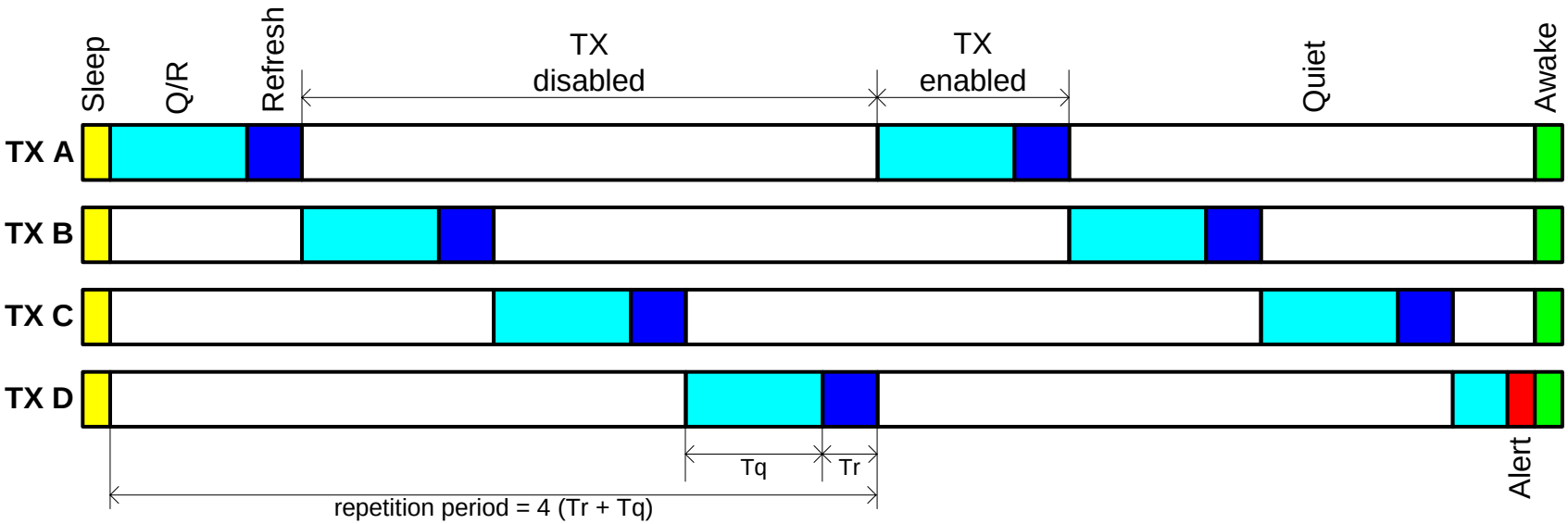
- Define the new signals in the existing framework of 10GBase-T to avoid:
  - new signal specification
  - new test definition
- Refresh signal specifications should allow:
  - simple coefficient update for filters
  - simple timing recovery
- Alert signal specifications should accommodate:
  - simple detection with low-power detector implementation
  - robust detection to avoid false positives and negatives
  - fast detection for rapid return to normal mode

Transmitter Specifications: Signal Path

- Training path: LFSR + PAM2 + THP
- Training LFSR, free running, non-stop
- Direct sequence spread spectrum (DSSS) encoding of Alert indicator bit (d)
- THP coefficients same as in normal mode
- Transmit power (PBO) and PSD (both magnitude and phase responses) identical to normal mode



Transmit Specifications: Staggered Signaling



- Time unit: T = 1 LDPC frame = 256 PAM2 symbols = 320 ns
- Refresh duration: Tr = M*T
- Q/R duration: Tq = N*T
- Alert duration: Ta = P*T

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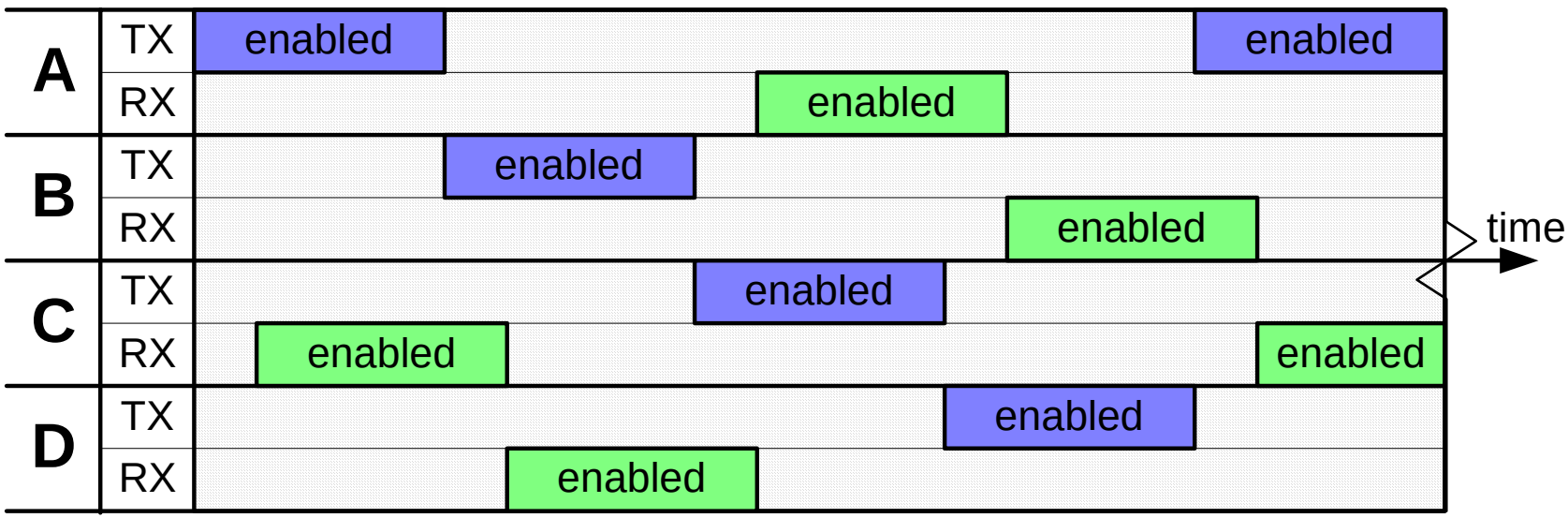
Transmit Specifications: Staggered Signaling

- Only one transmitter channel is enabled at a time
  - Transmitter channels alternate in a round-robin fashion
  - 75% instant power saving
  - Only one NEXT and no FEXT canceller needed
  - Allows simplex operation, no need for echo canceller (proper coordination with link partner needed)
- An enabled transmitter starts with N frames that shall be either Quiet or Refresh (at the transmitter's discretion)
- The last M frames in an Enabled period shall be Refresh frames
- Alert is allowed any time while the transmitter is enabled and lasts for P frames and may split over Enabled intervals of 2 consecutive transmit channels
- A disabled transmitter is always quiet and may not transmit Alert

Link-Partner Coordination

- Goal: simplex operation with no need for echo canceller
- Prevent transmitter and receiver of the same channel to get enabled at the same time



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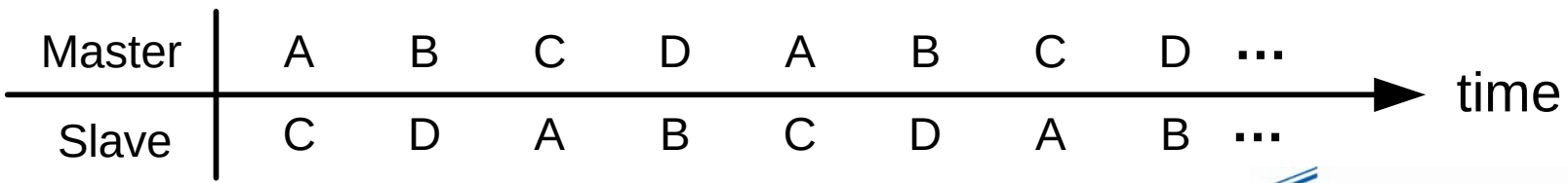
Link-Partner Coordination

- Each link-partner can enter LPI independently
- As first link-partner entering LPI, Master always start transmission on channel A and Slave on channel C
- Second link-partner entering LPI starts transmission on a channel staggered by 2 with respect to its receiving channel
- Enabled duration to be identical on both link-partners

Enabled transmit channel assignments when both link partners are in LPI mode



Link-Partner Coordination

- Second link-partner going to LPI should synchronize the start of the transmit-enabled period with an offset with respect to the start of the receive-enabled period
- A non-zero offset, chosen properly, can eliminate the need for NEXT cancellers on both sides during Refresh
- Assuming M<<N, a reasonable fixed offset to choose is (M+N)/2

Parameter Constraints

- (M+N) < 128 (~40 us) to provide frequent update opportunity for timing recovery and FIRs
  - track low frequency phase jitter and frequency offset
  - track channel variations due to thermal and mechanical effects
- (M+N) > 32 (~10 us) to ensure simplex operation with longest round trip delay
- P <= 4 (~1 us) to limit the return time to normal mode
- Enabled duration (M+N) to be identical on both sides

Parameter Negotiation

- Each link partner may request a different set of parameters: M, N and P
- Each transmitter should use link-partner's favorite parameters
- Parameters advertised and finalized during Auto-Negotiation:
  - Advertise favorite Enabled duration time (M+N)
  - Choose the maximum as the common value
  - Advertise the favorite M and N that adds up to the common Enabled duration
  - Advertise the favorite P

Receiver Considerations

- To detect Alert signal
  - No echo canceller, No FEXT canceller, 1 NEXT canceller, 1 FFE
- For filter update and timing recovery during Refresh
  - Implementation dependant, Echo cancellation and other circuits may be active only when update is needed
- Huge SNR margin (>30 dB): low probability of false-positive and false-negative for Alert detection
  - PAM-2 vs. DSQ128: +19 dB
  - 1 bit/frame (P=1): +24 dB
  - No LDPC: -9 dB

Summary

- DSSS (LFSR) + PAM2 + THP
  - No new signal specification (and test definition) needed
  - Minimal additional signal processing blocks in the transmit path
  - Larger SNR margin: robust, simple and rapid Alert detection
  - Simple FIR/timing update
- Channel staggering + link-partner coordination + parameter negotiation
  - One channel active at a time: 75% power savings
  - Simplex operation, no echo canceller
  - Only one NEXT canceller and no FEXT canceller