Extended link training protocol

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Extended Link Training for high-rate optical links

- Link training as defined in IEEE 802.3 and other standards is based on Link Training (LT) frames that carry a control/status overhead and a PRBS payload.
  - Using the training procedures as defined, the receiver can either request a special Tx equalizer preset or control a limited number of tap coefficients for electrical links.
  - No peer Tx equalizer training capabilities are defined for optical links.
- For optical links operating at high rates, it is beneficial to provide extended training beyond the capabilities provided by conventional Link Training (LT).
  - Conventional LT has low effective bandwidth since each new request must be acknowledged by the receiver.
  - Back Channel for Extended Training (BCET) intent is to improve efficiency of the link training protocol.
- Optional BCET provides a message-based mechanism for peer transmitter control and status exchange, and supports both write and read operations.
- This presentation describes a protocol example
  - Specific messages to be carried are for further discussion

What can BCET be used for ?

- Standard APSU (802.3dj Annex 178B) O1 ILT frame does not allow optical link training
  - Adding electrical link training capabilities is possible, but it is only able to control linear equalizers
    - Select a preset out of 6, fine tune equalizer coefficients
    - No read of peer transmitter configuration
- Optical interfaces based on advanced DSPs support several useful features that can be configured to improve performance
  - BCET supports large messages transactions
- Possible uses of BCET
  - Read transmitter configuration
  - Provide SNR information
  - Support non-linear equalization – Full look-up table configuration
  - Identify transmitter capabilities

Extended Link Training protocol - General

- Standard APSU + Back Channel for Enhanced Training (BCET)
  - Start with standard APSU to set initial transmitter parameters and training pattern
  - Switch to BCET messaging
  - Once BCET is done, standard APSU ILT frames and method are used to finish APSU and move to data mode
- BCET basics:
  - Uses 802.3dj Annex 178B ILT frame structure but with re-defined control and status fields
    - The frame payload is as defined in Annex 178B
    - ILT frame handling as defined in Annex 178B, with some exceptions
  - Messages can be any length and are carried in the ILT frame control field “pages”
    - Pages are grouped into blocks.
    - A block contains eight pages; the final block of a message may contain from one to eight pages.
    - Consecutive pages of a block are transmitted (each several times) without waiting for an acknowledgment
    - Acknowledgment is per block
    - A message is the complete information exchanged between BCET endpoints.
      - Message consistency is guaranteed by the protocol
    - Each message is divided into one or more pages to be carried in the overhead control field.
  - Read and write peer actual configuration

BCET pages – Control field example

First	Bit(s)	Name
Control	15:14	Reserved
	13:12	Page control = 10
	11:8	Type
	7	BCET
	6:5	Page ID = 00
	4:0	Type

Subsequent	Bit(s)	Name
Control	15:14	Reserved
	13:12	Page control = 00, 01
	11:8	Message data
	7	BCET
	6:5	Page ID
	4:0	Message data

Last	Bit(s)	Name
Control	15:14	Reserved
	13:12	Page control = 11
	11:8	Message data
	7	BCET
	6:5	Page ID = 00
	4:0	Message data

Type

Bit 11	Bit 10	Bit 9	Bit 8	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D11	*D10*	*D9*	*D8*	*D4*	*D3*	*D2*	*D1*	*D0*
Message type						D/C	R/W	CRC

D/C: Data/Control, RW: Read/Write, CRC: CRC appended to message

- D7 reserved in 802.3dj Annex 178B, is used as an indication of BCET training frame
- D6 and D5 are used to allow future versions of BCET frame headers
- Page control field toggles to identify a new page even if nothing else changed

BCET Status field example

15	Receiver ready	1 = Training is complete and the receiver is ready for data 0 = Request for training to continue
14:10	Reserved	Transmitted as zero, ignored by receiver
9	Receiver frame lock	1 = Frame boundaries identified 0 = Frame boundaries not identified
8	Reserved	Transmitted as zero, ignored by receiver
7	Parity	Even parity bit
7:3	Reserved	Transmitted as zero, ignored by receiver
2:0	Acknowledge	2 1 0 1 1 x = Message NACK 1 0 x = Block NACK 0 1 x = Block ACK 0 0 x = Message ACK

- Bits 2:0 reserved in 802.3dj Annex 178B O1 format frames and carrying Coefficient status in E1 format frames, are used to acknowledge blocks and messages
  - Bit 0 is a toggle bit. It toggles (0 to 1, 1 to 0) to indicate a new ACK/NACK
- Receiver ready, Receiver frame lock and Parity operation is the same as in ILT

BCET blocks example

256 bytes message paylaod

First	Bit(s)	Name	Value
Control	15:14	Reserved	00
	13:12	Page control	10
	11:8	Type	
	7	BCET	1
	6:5	Page ID	00
	4:0	Type	

Subsequent	Bit(s)	Name	Value
Control	15:14	Reserved	00
	13:12	Page control	01
	11:0	D[8:0], BCET, Page ID	

Subsequent	Bit(s)	Name	Value
Control	15:14	Reserved	00
	13:12	Page control	00
	11:0	D[8:0], BCET, Page ID	

Subsequent	Bit(s)	Name	Value
Control	15:14	Reserved	00
	13:12	Page control	01
	11:0	D[8:0], BCET, Page ID	

Subsequent	Bit(s)	Name	Value
Control	15:14	Reserved	00
	13:12	Page control	00
	11:0	D[8:0], BCET, Page ID	

Subsequent	Bit(s)	Name	Value
Control	15:14	Reserved	00
	13:12	Page control	01
	11:0	D[8:0], BCET, Page ID	

Subsequent	Bit(s)	Name	Value
Control	15:14	Reserved	00
	13:12	Page control	00
	11:0	D[8:0], BCET, Page ID	

Subsequent	Bit(s)	Name	Value
Control	15:14	Reserved	00
	13:12	Page control	01
	11:0	D[8:0], BCET, Page ID	

Block 1

Subsequent	Bit(s)	Name	Value
Control	15:14	Reserved	00
	13:12	Page control	00
	11:0	D[8:0], BCET, Page ID	

Subsequent	Bit(s)	Name	Value
Control	15:14	Reserved	00
	13:12	Page control	01
	11:0	D[8:0], BCET, Page ID	

Subsequent	Bit(s)	Name	Value
Control	15:14	Reserved	00
	13:12	Page control	00
	11:0	D[8:0], BCET, Page ID	

Subsequent	Bit(s)	Name	Value
Control	15:14	Reserved	00
	13:12	Page control	01
	11:0	D[8:0], BCET, Page ID	

Subsequent	Bit(s)	Name	Value
Control	15:14	Reserved	00
	13:12	Page control	00
	11:0	D[8:0], BCET, Page ID	

Subsequent	Bit(s)	Name	Value
Control	15:14	Reserved	00
	13:12	Page control	01
	11:0	D[8:0], BCET, Page ID	

Subsequent	Bit(s)	Name	Value
Control	15:14	Reserved	00
	13:12	Page control	00
	11:0	D[8:0], BCET, Page ID	

Subsequent	Bit(s)	Name	Value
Control	15:14	Reserved	00
	13:12	Page control	01
	11:0	D[8:0], BCET, Page ID	

Block 2

Lat	Bit(s)	Name	Value
Control	15:14	Reserved	00
	13:12	Page control	11
	11:0	D[8:0], BCET, Page ID	

Block 32

Summary

- What was presented:
  - An extension of link training to support extended training features
- Usage includes:
  - Read transmitter configuration
  - Provide SNR information
  - Support non-linear equalization – Full look-up table configuration
  - Identify transmitter capabilities
- A future detailed proposal may be provided in P802.3dv