

# 10GBASE-T Programmable THP Proposal

A stylized illustration in the background shows a person in a suit shaking hands with two laptops. The person is in the center, with one laptop to the left and one to the right. The person's hands are extended towards the laptops, suggesting a deal or agreement. The illustration is rendered in a simple, sketchy style with flat colors.

IEEE P803.2an Task Force  
Austin, May '05

A stylized illustration in the background shows a person in a suit shaking hands with a laptop. The person is in the center, with their hands extended towards the laptop. The illustration is rendered in a simple, sketchy style with flat colors.

Brett McClellan - Solarflare

A stylized illustration in the background shows a person sitting at a desk with a laptop and papers. The person is on the left, looking at the laptop. There are several papers or books on the desk. The illustration is rendered in a simple, sketchy style with flat colors.

# Supporters

- **Pedro Reviriego – Agere**
- **Albert Molina – Agere**
- **Jose Tellado – Teranetics**
- **Amir Mezer – Intel**
- **Albert Vareljian – KeyEye**
- **Bill Woodruff – Aquantia**
- **Ariel Yagil – Texas Instruments**
- **Katsutoshi Seki – NEC Electronics**



# Introduction

- Previous contributions have shown that programmable THP coefficients provide SNR improvements over the fixed THP sets
- We are proposing mandatory support for a programmable 16-tap THP.
  - This will require an exchange of 16 coefficients per cable pair with up to 8-bits per coefficient.
- This proposal provides for an coefficient exchange protocol with minimal changes to the PHY Control State diagram and to the Info Field.

# Startup State Machine

- Both devices will start transmitting the training pattern with THP in either bypass mode (an option selected at Autoneg by the receiver) or using fixed FIR THP as per D2.0.
  - Per comment: slave begins transmitting with  $\text{THP}_M$  (or bypass) &  $\text{PBO}_M$
- During PMA Training Init the Master and Slave get to acquire descrambler state (same as D2.0).
- In the PMA Training Init state, the master and slave will exchange THP coefficients in groups of four using the Info Field defined in the following slides. This requires at least 16 different exchange frames. PBO will also be requested in the exchange frame.
- Following coeff exchange, each PHY will announce a transition to the PMA Training Update state and start the Transition Counter. After the counter times out, the PHY's will simultaneously enter the PMA Training Update state and enable the THP precoders with the requested coeff's and use the requested PBO.

# Startup State Machine cont.

- While in the PMA Training Update state each receiver may choose to send additional coefficient exchanges to the link partner until the max\_wait timer has reached 1.5 seconds.
  - This leaves 500ms for final training.
- The PBO setting may not be changed during PMA Training Update
- A PHY is required to support these coefficient updates in the THP but is not required to request new coefficients from the link partner.
  - Therefore a PHY may use all of the remaining time purely for final training.

link\_control = DISABLE + pma\_reset = ON

DISABLE 10GBASE-T TRANSMITTER

link\_control = ENABLE

SLAVE SILENT  
start maxwait\_timer  
tx\_mode <= SEND\_Z

config = SLAVE \*  
scr\_status = OK

NOTE- maxwait\_timer is reset only upon transition from DISABLE 10GBASE-T TRANSMITTER state or Send PCS Link OK State.

config = MASTER

PMA Training Init M  
PBO<sub>M</sub> <= PBO\_incr  
THP<sub>M</sub> <= THP\_incr  
tx\_mode <= SEND\_T  
Send IF<sub>M</sub>

PMA Training Init S  
PBO<sub>S</sub> <= PBO<sub>M</sub>  
THP<sub>S</sub> <= THP<sub>M</sub> or bypass  
tx\_mode <= SEND\_T  
Send IF<sub>S</sub>

Decode IF<sub>S</sub> = Transition\_Training\_Update \*  
transition\_count = 0

Decode IF<sub>M</sub> = Transition\_Training\_Update \*  
transition\_count = 0

simultaneous transition

PMA Training Update M  
PBO<sub>M</sub> <= PBO IF<sub>S</sub>  
THP<sub>M</sub> <= THP IF<sub>S</sub>  
tx\_mode <= SEND\_T  
Send IF<sub>M</sub>

PMA Training Update S  
PBO<sub>S</sub> <= PBO IF<sub>M</sub>  
THP<sub>S</sub> <= THP IF<sub>M</sub>  
tx\_mode <= SEND\_T  
Send IF<sub>S</sub>

loc\_rcvr\_status = OK \*  
rem\_rcvr\_status = OK \*  
transition\_count = 0

loc\_rcvr\_status = OK \*  
rem\_rcvr\_status = OK \*  
transition\_count = 0

simultaneous transition

IF<sub>S</sub> = Coeff\_Exchange \*  
transition\_count = 0

IF<sub>M</sub> = Coeff\_Exchange \*  
transition\_count = 0

PCS Training  
start minwait\_timer  
tx\_mode <= SEND\_N

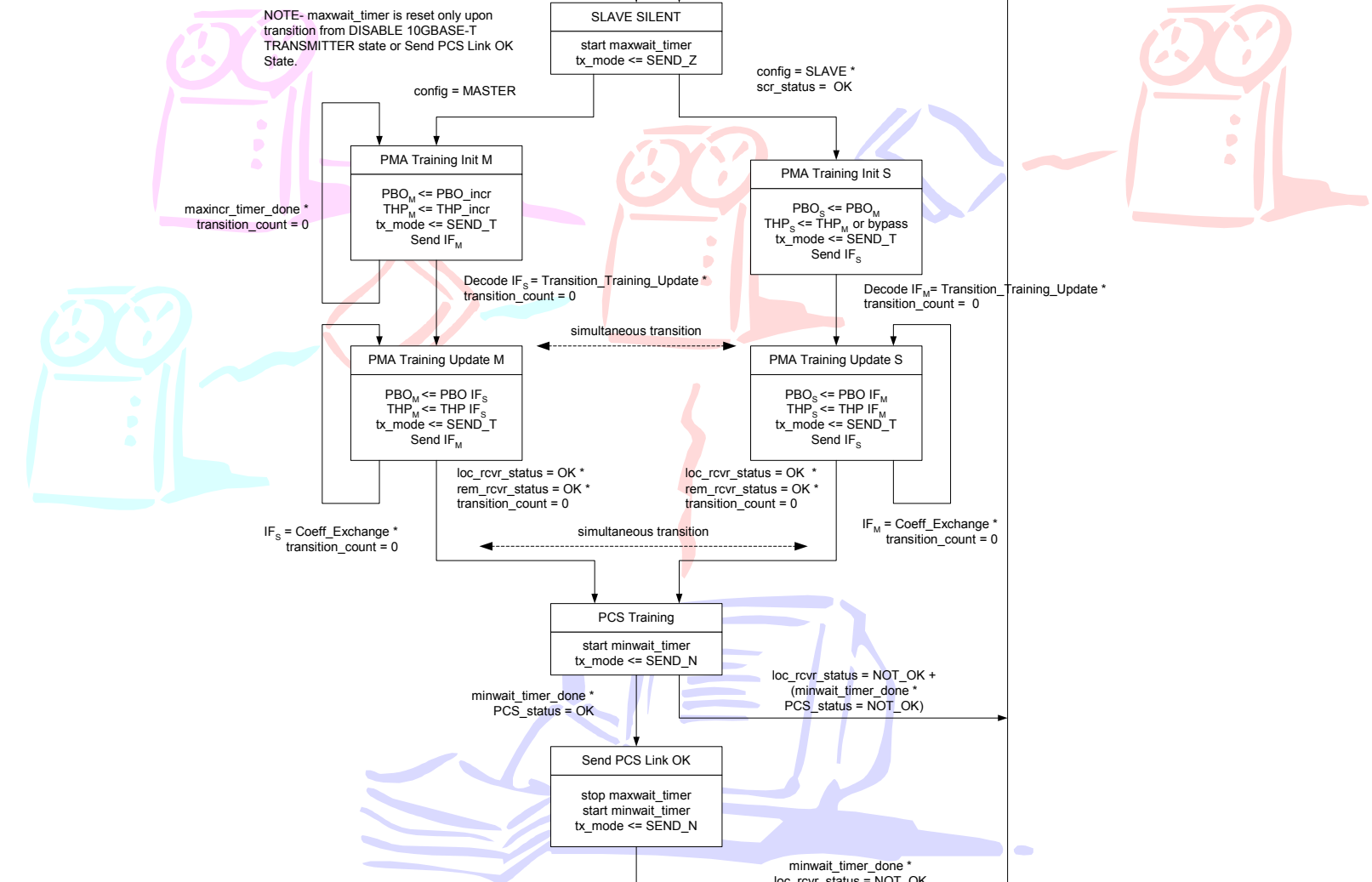
minwait\_timer\_done \*  
PCS\_status = OK

loc\_rcvr\_status = NOT\_OK +  
(minwait\_timer\_done \*  
PCS\_status = NOT\_OK)

Send PCS Link OK

stop maxwait\_timer  
start minwait\_timer  
tx\_mode <= SEND\_N

minwait\_timer\_done \*  
loc\_rcvr\_status = NOT\_OK



# Current Info Field

- Info Field: 16 bytes
  - Start of Frame Delimiter: 4 bytes
    - BBA70000- minimum hamming distance of 7
  - Current TX setting: 1 byte
    - X, PBO(2:0), THP(3:0)
  - Next TX setting: 1 byte
    - X, PBO(2:0), THP(3:0)
  - Requested TX setting: 1 byte
    - X, PBO(2:0), THP(3:0)
  - Message Field : 1 byte
    - X(7:5),PBO\_increase (master only), loc\_rcvr\_status, trans\_to\_Training\_Update, trans\_to\_PCS\_Training, trans\_to\_slave\_silent
  - SNR Margin : 4 bits
    - SNR Margin in  $\frac{1}{2}$  dB steps from  $-2.5$ dB to  $+5$ dB
  - Transition Counter : 12 bits
    - Trans\_counter(11:0): # of frames until next transition
  - Reserved Field: 4 bytes
    - For future use or vendor field.
  - CRC16: 2bytes  $(x+1)(x^{15}+x+1)$

# Proposed Info Field

- Info Field: 16 bytes
  - Start of Frame Delimiter: 4 bytes
    - BBA70000- minimum hamming distance of 7
  - Current TX setting: 1 byte
    - X, PBO(2:0), THP(3:0)
  - Next TX setting: 1 byte
    - X, PBO(2:0), THP(3:0)
  - Requested TX setting: 1 byte
    - X, PBO(2:0), THP(3:0)
  - Message Field : 1 byte
    - **Coeff\_Exchange**, X(6:5), PBO\_increase (master only), loc\_rcvr\_status, trans\_to\_Training\_Update, trans\_to\_PCS\_Training, trans\_to\_slave\_silent
  - SNR Margin : 4 bits
    - SNR Margin in ½ dB steps from –2.5dB to +5dB
  - Transition Counter / **Coefficient Exchange Handshake**: 12 bits
    - Trans\_counter(11:0): # of frames until next transition
    - **Handshake bits used during coefficient exchange**
  - Reserved Field: 4 bytes / **Coefficient Field**: 4 bytes
    - **Transmits 1 of 4 groups of 8-bit coefficients for 4 channels.**
  - CRC16: 2bytes  $(x+1)(x^{15}+x+1)$



# Coefficient Exchange

- Programmable THP will be advertised during Auto-Negotiation.
- During PMA Training Init each PHY will begin a coefficient exchange by setting the **Coeff\_Exchange** flag in the message field.
- During coeff exchange, the Transition Counter bits are used as the **Coeff Exchange Handshake**
  - X(3:0): unused
  - Coeff Pair Received (1:0): 01 for A, 10 for B, 11 for C and 00 for D (default). This is the handshake to tell the remote unit the last coeffs received.
  - Coeff Group Received (1:0): 01 for 0:3, 10 for 4:7, 11 for 8:11 and 00 for 12:15 (default). This is the handshake to tell the remote unit the last coeffs received.
  - Coeff Pair Sent (1:0): 01 for A, 10 for B, 11 for C and 00 for D (default). This is the handshake to tell the remote unit the current coeffs being sent.
  - Coeff Group Sent (1:0): 01 for 0:3, 10 for 4:7, 11 for 8:11 and 00 for 12:15 (default). This is the handshake to tell the remote unit the the current coeffs being sent.
- The Reserved Field will be used to send 4 8-bit coeff's in each frame designated by the Coeff Pair Sent and Coeff Group Sent bits.

# Coefficient Exchange (cont.) & Format

- Each PHY begins the exchange by sending pair A coeff's 0:4 with Coeff Pair Sent=01 & Coeff Group Sent=01.
- The remote unit will acknowledge by setting Coeff Pair Received =01 & Coeff Group Received =01.
- Following each acknowledgement, the PHY will increment through the Coeff Group and Coeff Pair settings until Coeff Pair Sent=00 & Coeff Group Sent=00 & Coeff Pair Received =00 & Coeff Group Received =00. At this time, coeff exchange is done and the PHY's will set Trans\_to\_Update =1 and start the Transition Counter.
  - Note that the handshake is inherent in the sequence of Coeff Group & Pair bit values and must sent in the order described.
- Coefficient Format
  - 8 bits per coefficient. Use one byte per coefficient
  - Coefficient Range -2.0 to 1.984375 in steps of 0.015625

# Conclusion

- The proposed change allows for an exchange of 64 8-bit coefficients without changing the size or timing of the Info Field.
- Overall, the PHY Control State diagram has minimal changes.
- The coefficient exchange provides for handshaking between the the two PHY's.
- Each coefficient exchange can be performed in less than 1ms.

