C2M Training on 128GFC Links

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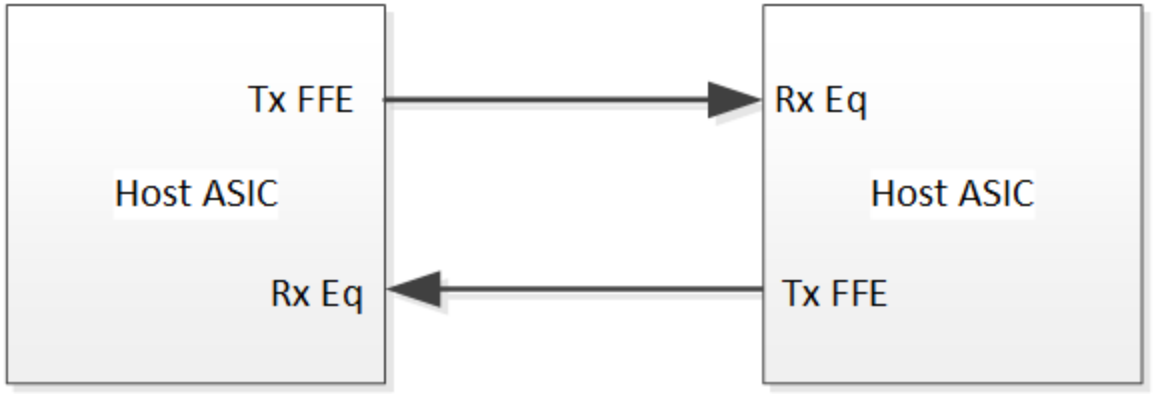
Rationale

- Tuning of FFE taps on host ASIC
  - Number of FFE taps will see an increase for 128GFC links
  - Healey_3ck_01b_0718.pdf showed that enhanced Tx FFE could possibly outperform RxFFE in the receiver
  - Enhancements to FFE in the host ASIC transmitter could help maintain power budgets for the module. 802.3ck still debating options for stronger FFE vs more equalization in module receiver.
- Output emphasis in the module
  - Module supports taps for output emphasis
- Tuning of TxFFE in Host ASIC and output emphasis in module
  - No automated mechanism exists today
  - Manual tuning used
    - Find the best operating point by sweeping all combinations and measure BER
    - Time consuming per platform/per link. Cannot adjust for PVT
    - Gets more time consuming/difficult as number of taps increases and link budgets get tighter at higher speeds
    - Non optimal operating point on most systems as no adjustments for operating conditions

What should we do

- Provide a mechanism to run transmitter training to tune FFE taps between the Host ASIC and its connected module on C2M interfaces
- Make it part of link bring up for the 128GFC protocol
- Do it in a way that has minimal impact on link bring up time on C2M links
- Host ASIC already supports tuning of taps for copper links
- Module does not support Transmitter training protocol yet
- Module would need to support Transmitter Training similar to the host ASIC

C2C Link Bring Up Procedure



- LSN is completed
- Training commences using TTS frames. Training is intended for a receiver to adjust FFE on its connected transmitter.
- TF(Training Fixed) bit in TTS is set to 0 by the Host ASIC on either side to indicate that TxFFE adjustments are possible.
- TxFFE and RxEq are adjusted by the Host ASIC as part of training
- When training is complete, TC(Training Complete) bit in TTS is set to 1
- When the transmitted and received TC=1 in the Host ASIC, Training finishes

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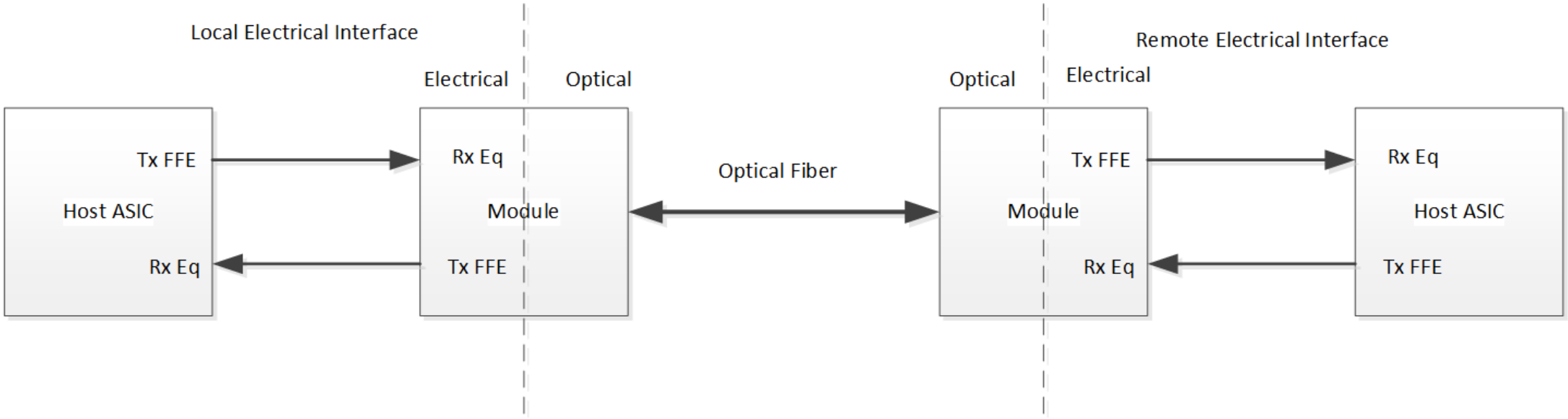
C2M Link Breakdown



- TxFFE and Rx Equalization in both Host ASIC and Module
- TxFFE and Rx EQ need to be at the right values for the link to operate optimally
- Local Side/Remote Side labelled to distinguish the two sides for discussion

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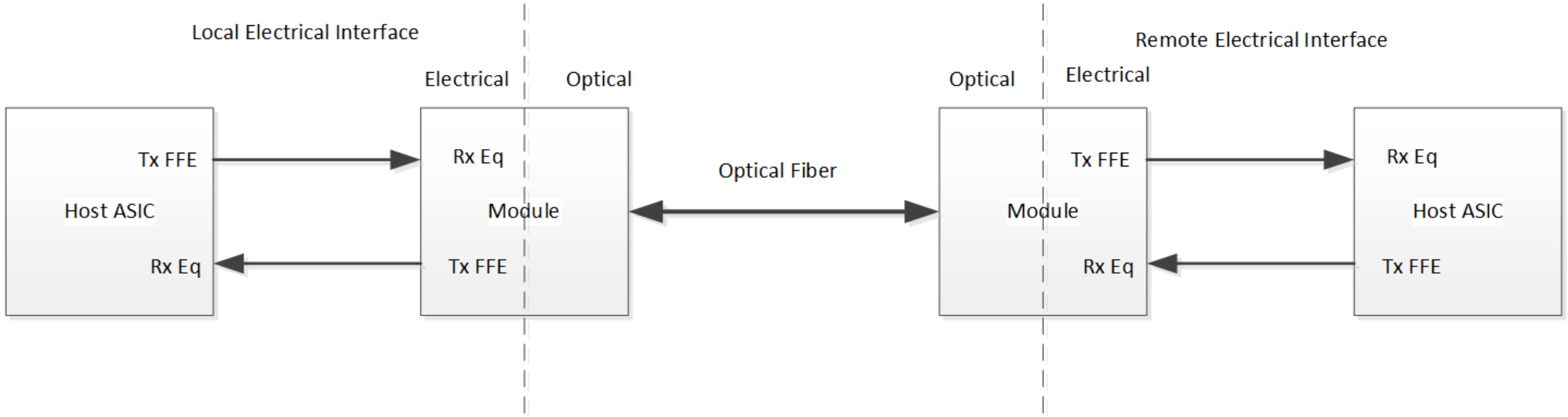
C2M Link Bring Up Procedure



- LSN is completed. LSN runs between the Local and Remote ASIC to select the highest common speed of operation. Module is in pass through mode responding only to rate select changes during LSN.
- Next, Training commences using TTS frames. Training is intended for a receiver to adjust Tx FFE on its connected transmitter. ASIC/Module are programmed to let them know the commencement of training.
- However, so far, the module does not support tuning of its Tx FFE
- Training of the Remote Tx FFE on the Host ASIC is not possible by the Local Host ASIC Rx due to optics connection in the middle

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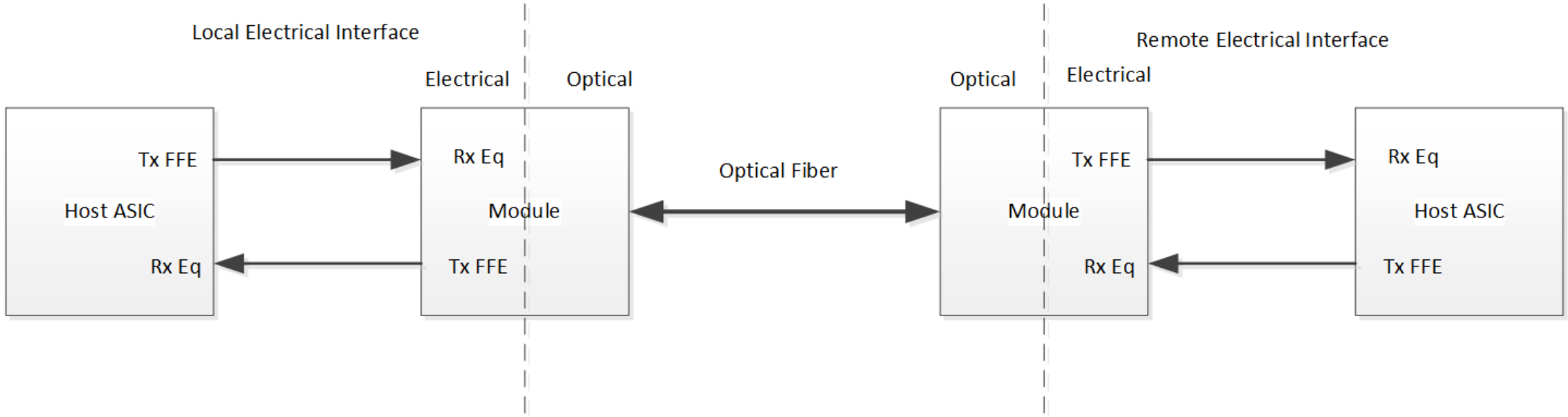
C2M Link Bring Up Procedure Continued



- TF(Training Fixed) bit in TTS is set to 1 by the Host ASIC on either side to indicate that TxFFE adjustments are not possible.
- The Host ASIC on either side uses the training period tune its RxEq. No requests to update TxFFE are sent.
- When tuning of its own RxEq is complete, TC(Training Complete) bit in TTS is set to 1 by the Host ASIC on its transmit TTS
- When the transmitted and received TC=1 in the Host ASIC, Training finishes
- TxFFE in Host ASIC and Module is required to be set by other mechanisms outside the scope of the standard. It is NOT part of training during link bring up.

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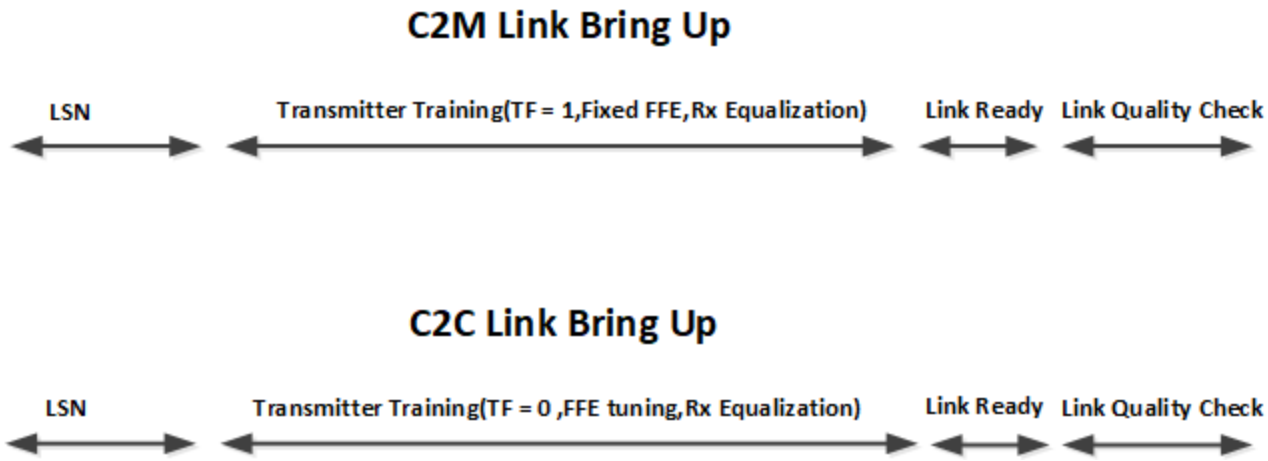
C2M vs C2C Link Bring Up Flow



- Training on C2M links is run with TF=1 in the training frame
- No support in module for Training protocol. Simple pass through.
- TF=1 is used as the FFE taps on host ASIC at the far end cannot be adjusted
- Protocol goes through the motions of transmitter training end to end similar to C2C links
- Used to optimize Rx equalization in the host ASIC

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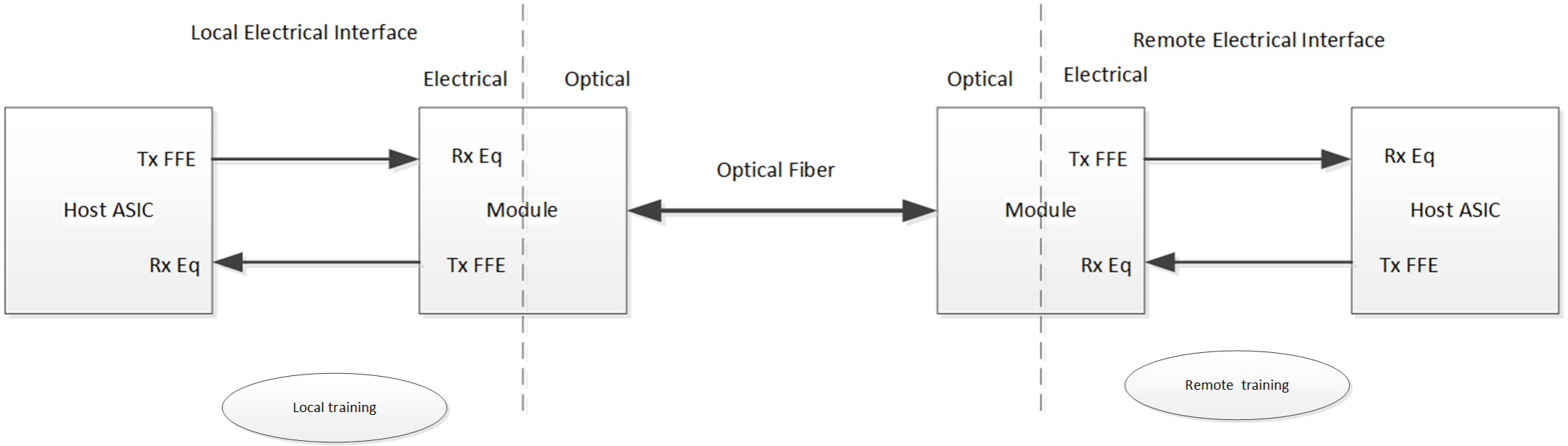
Changes for 128GFC for C2M link bring up



- Run Transmitter Training on C2M with TF=0 just like for the C2C links. Module supports Transmitter Training just like the Host ASIC.
- Transmitter Training tunes the C2M links in parallel on the Local Side and Remote Side. Makes TxFFE adjustments on both the Module and Host ASIC on each side.
- No need to run additional Transmitter Training after between the local and remote host ASIC as Rx equalization is already tuned during the C2M training stage
- Host ASIC on each side sets the TC bit when Training on its side between the module/Host ASIC is complete same as in current protocol
- When the transmitted and received TC=1 in the Host ASIC, Training finishes

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Changes for 128GFC for C2M link bring up(Continued)

- To accomplish this , simply setting the TF=0 is not sufficient
- Module/Host ASIC need to know that the commands they respond to are from the near side, not ‘bleed through’ from the far side.
- To do this, propose adding specific new command/status bits in the training frame that will be used only on C2M links. Host ASIC is programmed in ‘C2M mode’ prior to train start.
- The new command bit from the module is used by the Host ASIC when it is on a C2M link
- The new command bit from the Host ASIC is used by the module
- A separate status bit is added that is used when the Module/Host ASIC are training each other on a C2M link to signal training complete on the C2M link by each one of them
- In C2M mode, TC is set by the Host ASIC when the training has been completed on the C2M link by both the module and the Host ASIC.
- TC bit received from Remote side indicates to the Local Side that Remote Side is ready to move to next stage of link bring up.
- TC bits from Local side indicates to the Remote Side that Local Side is ready to move to next stage of link bring up.
- When C2M training is complete on the Local and Remote Side, link bring up moves to the next stage

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Additional Command/Status bits in Training Frame Definition

- ASICC2MTrain bit
  - Command bit set by the host ASIC to indicate local training should proceed
  - Module responds to training frame commands on its Electrical RX when this bit is set
  - Host ASIC ignores this bit on its RX
- ModuleC2MTrain bit
  - Command bit set by the Module to indicate local training should proceed
  - Host ASIC responds to training frame commands on its RX when this bit is set
  - Module optical TX is a simple pass through of TTS frames received on its electrical RX

LocalC2MTrainComplete Bit

- Status bit set by the module and host ASIC to indicate local Training is complete
- Once the received and transmitted bits in the Training frame are set for the LocalC2MTrainComplete bit, the host ASIC will set the TC bit to indicate that training between the Host ASIC and module is complete
- Once the received and transmitted TC bits are 1, training completes

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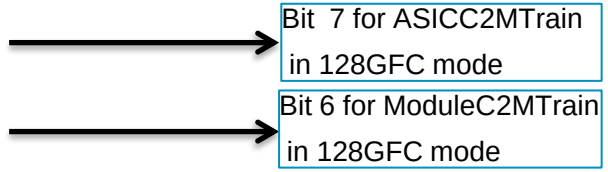
TTS Frame Control Field

Table 18 - 64GFC Training Frame Control field

Bits	Field name	Content
15-14	Extended Marker	Set to 11b: Extended marker for 32GFC. Set to 10b: Extended marker for 64GFC. Set to 01b: reserved. Set to 00b: for 16GFC.
13-12	Initial Condi-tion request	Set to 11b: Preset 3. Set to 10b: Preset 2. Set to 01b: Preset 1. Set to 00b: Individual Coefficient Control.
11	Reserved	Transmit as zero, ignore on receipt.
10	Parallel Lane Support	Set to one: parallel lanes are supported. Set to zero: parallel lanes are not supported.
9-8	Modulation and Precoding request	Set to 11b: PAM4 with precoding. Set to 10b: PAM4 Set to 01b: reserved Set to 00b: PAM2.
7-5	Reserved	Transmit as zero, ignore on receipt.
4-2	Coefficient Select	Set to 110b: c(-2) Set to 111b: c(-1) Set to 000b: c(0) Set to 001b: c(1)
1-0	Coefficient Request	Set to 11b: No equalization Set to 10b: Decrement Set to 01b: Increment Set to 00b: Hold



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TTS Frame Status Field

Table 19 - 64GFC Training Frame Status field

Bits	Field name	Content
15	Receiver Ready	Set to one: training is complete and receiver is ready for data. Set to zero: request for Training to continue.
14	SN	Set to one: transmitter has not completed LSN. Set to zero: transmitter has completed LSN.
13	Reserved	Transmit as zero, ignore on receipt.
12	TF	Set to one: transmitter is operating with Fixed Coefficients. Set to zero: transmitter coefficients may be trained by the receiver.
11-10	Modulation and Precoding Status	Set to 11b: PAM4 with precoding. Set to 10b: PAM4. Set to 01b: reserved Set to 00b: PAM2
9	Receiver frame lock	Set to one: frame boundaries identified. Set to zero: frame boundaries not identified.
8	Initial Condi-tion Status	Set to one: updated. Set to zero: not updated.
7	Parity	Parity bit to provide DC balance.
6	Reserved	Transmit as zero, ignore on receipt.
5-3	Coefficient Select Echo	Set to 110b: c(-2) Set to 111b: c(-1) Set to 000b: c(0) Set to 001b: c(1)
2-0	Coefficient Status	Set to 111b: reserved Set to 110b: coefficient at limit and maximum voltage Set to 101b: reserved Set to 100b: maximum voltage Set to 011b: coefficient not supported Set to 010b: coefficient at limit Set to 001b: updated Set to 000b: not updated

Bit 13 or LocalC2MTrainComplete in 128GFC mode

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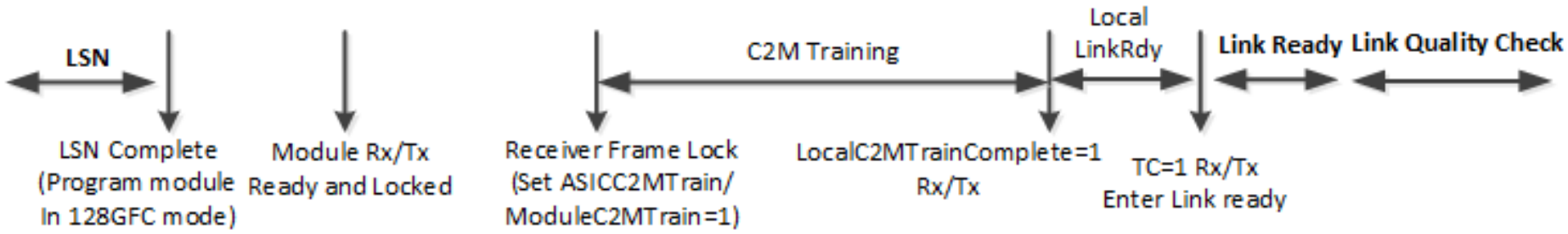
Proposed Link Bring Up on C2M links flow



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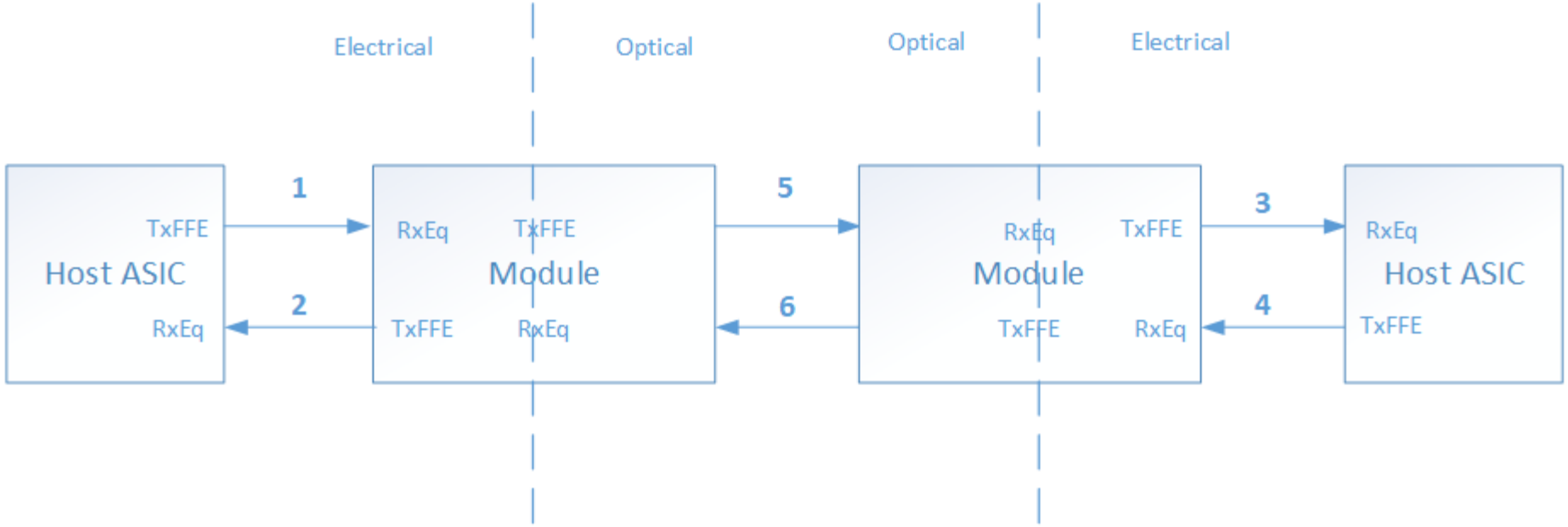
What about the Optical Segment of the Link?

- So far we have talked about optimizing 1,2,3,4
- Benefits in terms of Reach/BER can be had by optimizing 5,6
- The Link training protocol in use on 1,2,3,4 can be used on 5,6 as well
- Module is already protocol aware on the Electrical segment
- Use the same logic to optimize the Optical segment



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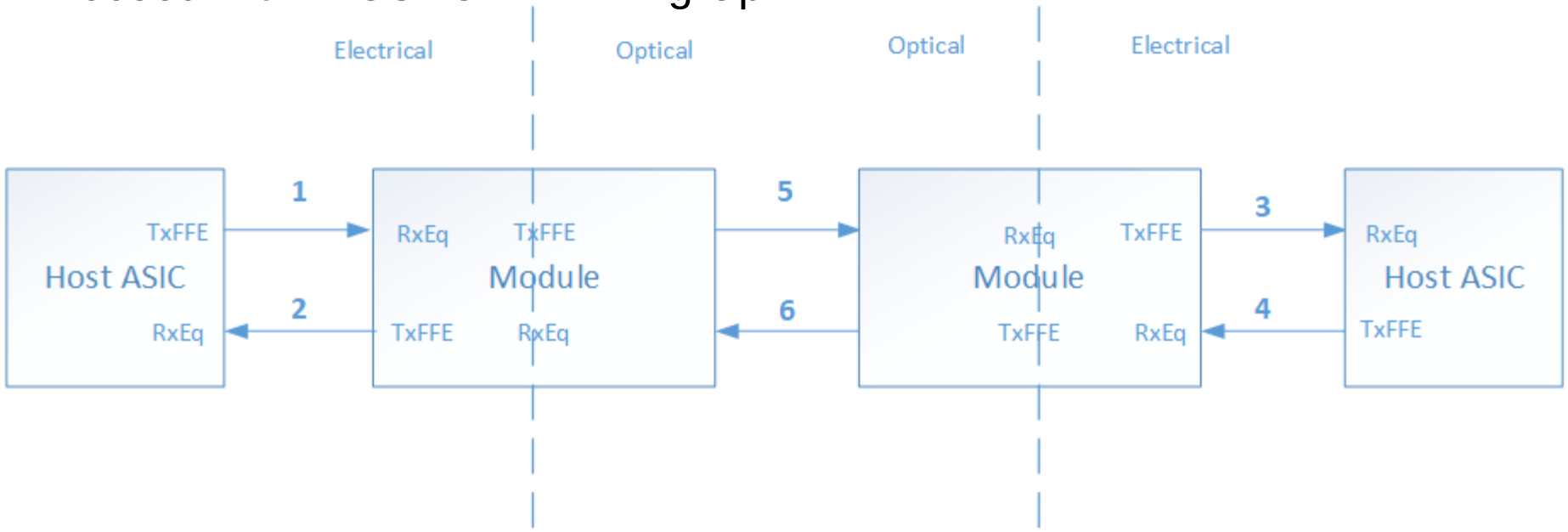
Link bring Up Sequence With Optical Side Training Inclusion

- Finish LSN
- Program module for 128GFC mode
- Kick Off Optical Segment Training(5,6) → New Step
- Wait for Optical Training to Finish → New Step
- Wait for Electrical CDR lock
- Kick off and Finish Electrical Segment Training(1,2,3,4)
- Proceed with 128GFC Link Bring Up



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Summary

- Support C2M Training on 128GFC links
- Allows for optimal tuning of these links on bring up
- Proposed mechanism and changes to TTS format for 128GFC to support this objective
- Host ASIC already supports training
- New feature for module. What will it take to support this for 128GFC?

Questions?

Thank You

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