IEEE 802.3ap

Proposal for 10Gbps Serial Backplane PHY using Unified Signaling

Supporters and Contributors

Stewart Goudie	Acuid
Charles Moore	Agilent
Ransom Stephens	Agilent
Zhi Wong	Altera
Ali Ghiasi	Broadcom
Riccardo Badalone	Diablo Tech
Dana Bergey	FCI
Joe Abler	IBM
David Stauffer	IBM
Jeffery Lynch	IBM
Pravin Patel	IBM
Harmeet Bhugra	IDT
Mike Oltmanns	Interconnect Technologies
Peter Pupalaikis	LeCroy
Joe Caroselli	LSI Logic
Cathy Liu	LSI Logic
Jeff Sinsky	Lucent
Mary Mandich	Lucent
Marcus Duelk	Lucent
Andrew Adamiecki	Lucent
Chuck Byers	Lucent
David McCallum	Molex
Dimitry Taich	Mysticom Inc
Graeme Boyd	PMC-Sierra
Brian VonHerzen	Rapid Prototypes
Mike Lerer	Rapid Prototypes
Marv Lavoie	Tektronix
Bill Hagerup	Tektronix
Andre Szczepanek	Texas Instruments
Apoorv Srivastava	Vitesse*
Majid Barazande-Pour	Vitesse*
John Khoury	Vitesse*
Nitish Amin	Vitesse*
Justin Gaither	Xilinx
Steve Anderson	Xilinx
Brian Seemann	Xilinx
Brian Brunn	Xilinx
Tom Palkert	Xilinx

* Vitesse supports the switchable Cd tap in the transmitter in order to support legacy NRZ receivers. All other issues related to signal and channel models still requires further study and Vitesse will await the outcome of the signal- and channel ad-hoc committees

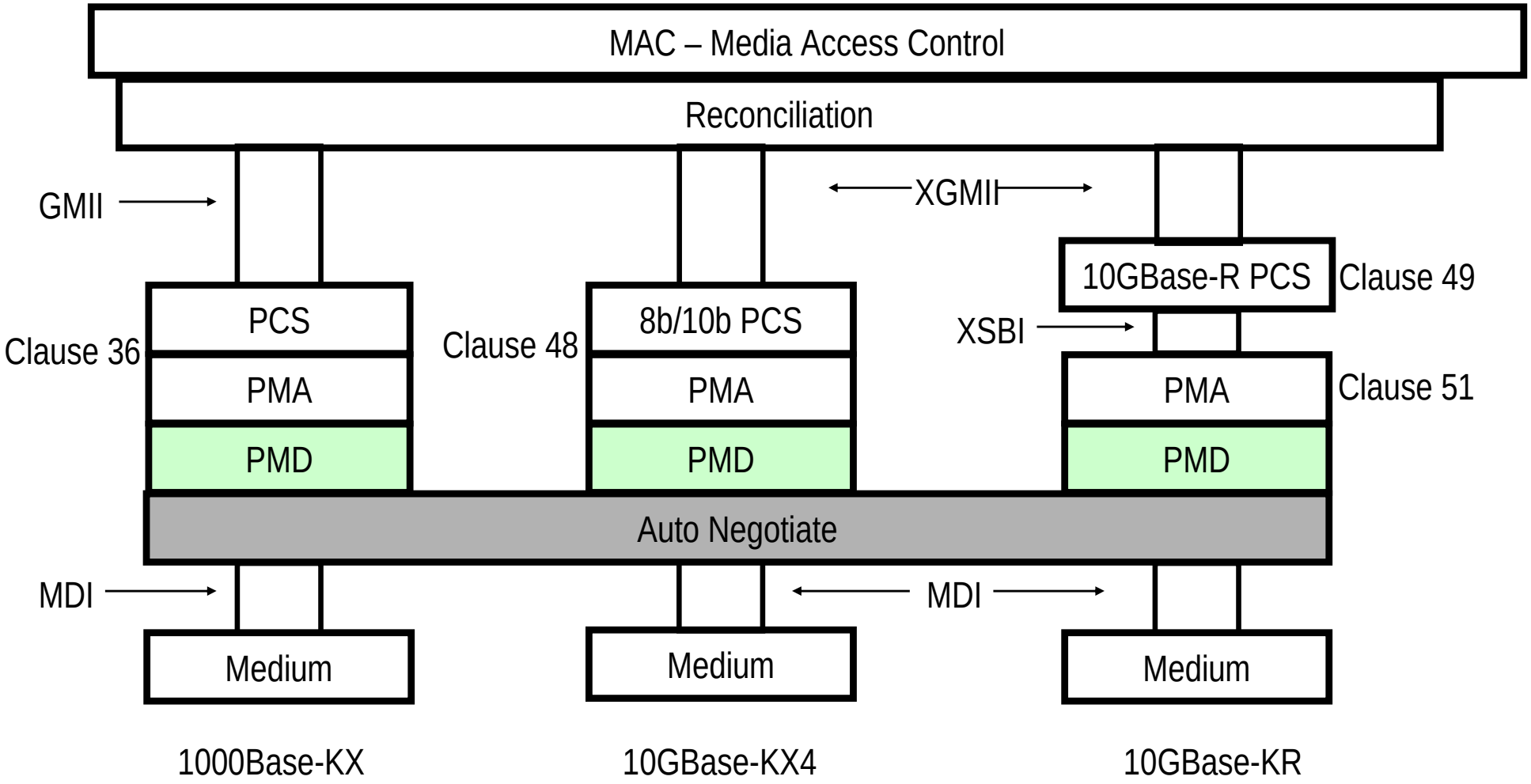
Objectives

- Propose a new PMD sublayer for 10Gbps Serial link across proposed channel using Unified signaling
- The proposal allows flexibility in the implementation.
- The proposal provides an optimal solution with balanced equalization between TX and RX

Agenda

- Overview
- Channel Training
- TX specifications
- RX specifications
- Channel Model
- Simulation Data
- Conclusion

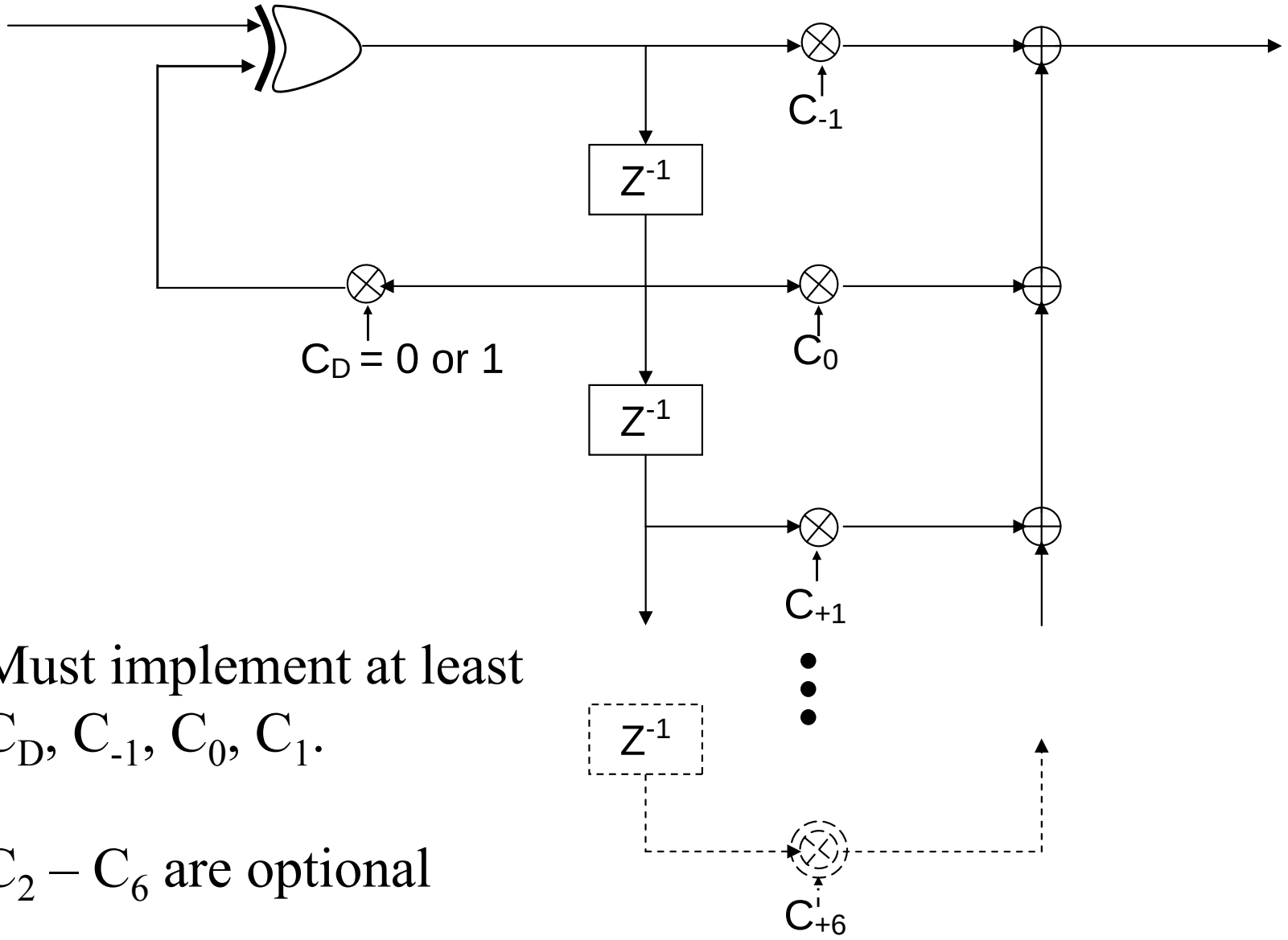
Layer Model


MAC – Media Access Control
Reconciliation
GMII
XGMII
10GBase-R PCS
Clause 49
Clause 36
PCS
Clause 48
8b/10b PCS
XSBI
PMA
PMA
Clause 51
PMD
PMD
PMD
Auto Negotiate
MDI
MDI
Medium
Medium
Medium
1000Base-KX
10GBase-KX4
10GBase-KR

Overview

- Use Existing Clause 51 and 49 for PMA and PCS layer
- Define Transmitter characteristics
  - Based on TX mask, output amplitude, jitter, etc
- Define basic TX equalizer Architecture
- Adopt a Normative Channel Model
- Defined receiver characteristics
  - Jitter tolerance, return loss, etc.
  - Require operation with compliant TX over normative channel.
  - Allows implementation flexibility in RX
    - NRZ with Equalization
    - DuoBinary
    - Hybrid Architectures
- TX Equalization can be controlled by RX.
  - Inc/Dec control over TX Equalizer taps.
    - Allow the RX to choose optimal TX equalization for RX technology.
    - Efficient TX and RX implementations

Required Transmit Linear Equalizer Architecture



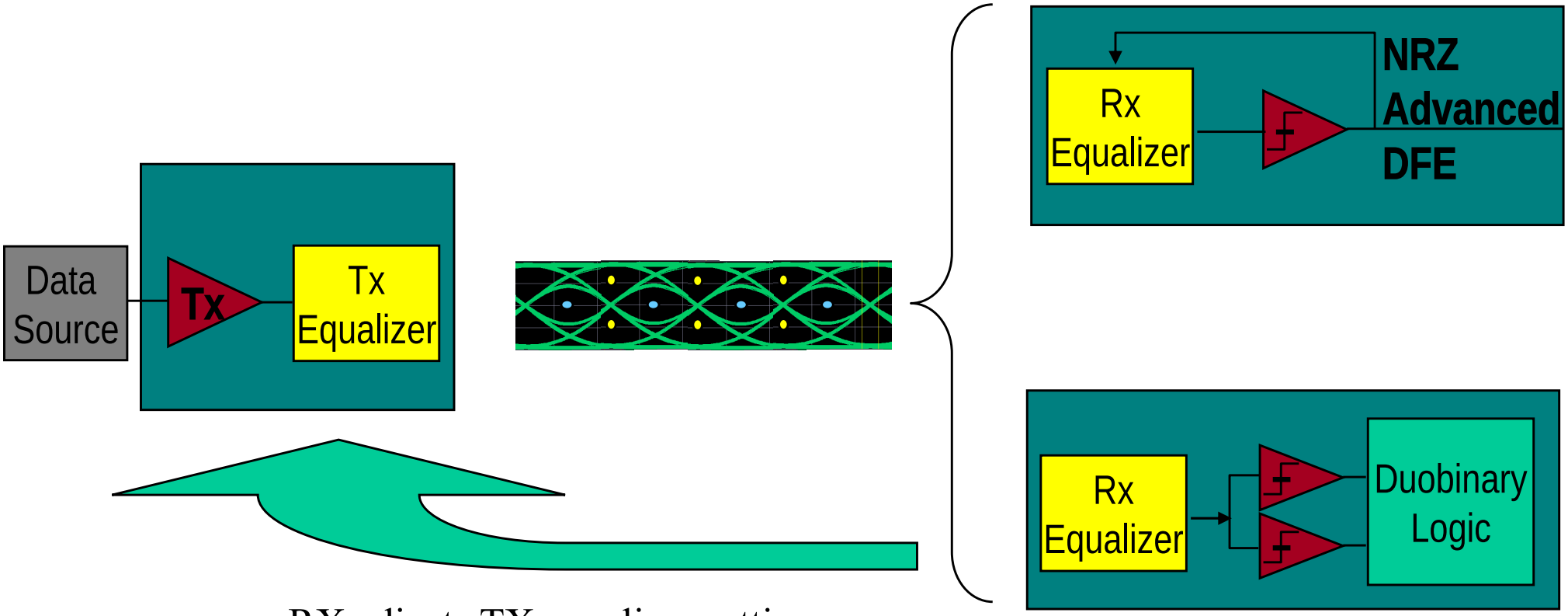
Must implement at least C_D, C_{-1}, C_0, C_1.

C_2 – C_6 are optional

Why Selectable C_D

- Allows Duobinary receivers to be simplified.
- Similar behavior/effect as selectable filter coefficients
- Leverages compatibility with existing and emerging 10G serial devices like XFP, OIF, etc.
- Allows earlier, broad market availability of competitive silicon offerings.
- Moves standards process forward.
- Enables the future & supports the present

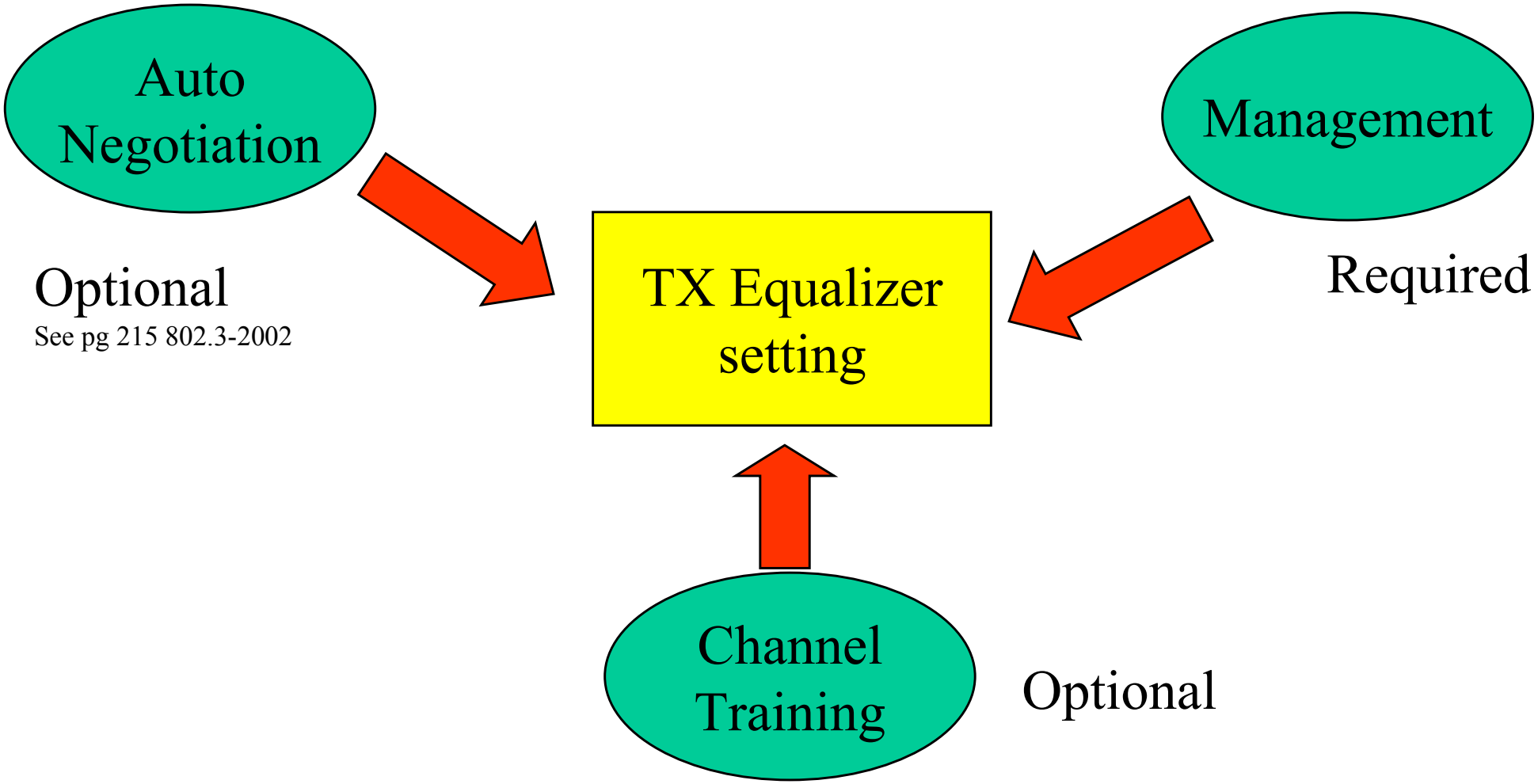
Same TX Signal Optimally Filtered for RX



RX adjusts TX equalizer settings
For optimum signal performance

Receiver may be implemented using
Variety of methods

TX Equalizer Settings can be set Many ways



Negotiation Sequence

- Speed is Selected
- Training is requested (via Next pages)
- Master and Slave are selected
  - (via Next pages consistent with 1000B-T)
- Initial values of TX filter are selected by RX (via next pages)

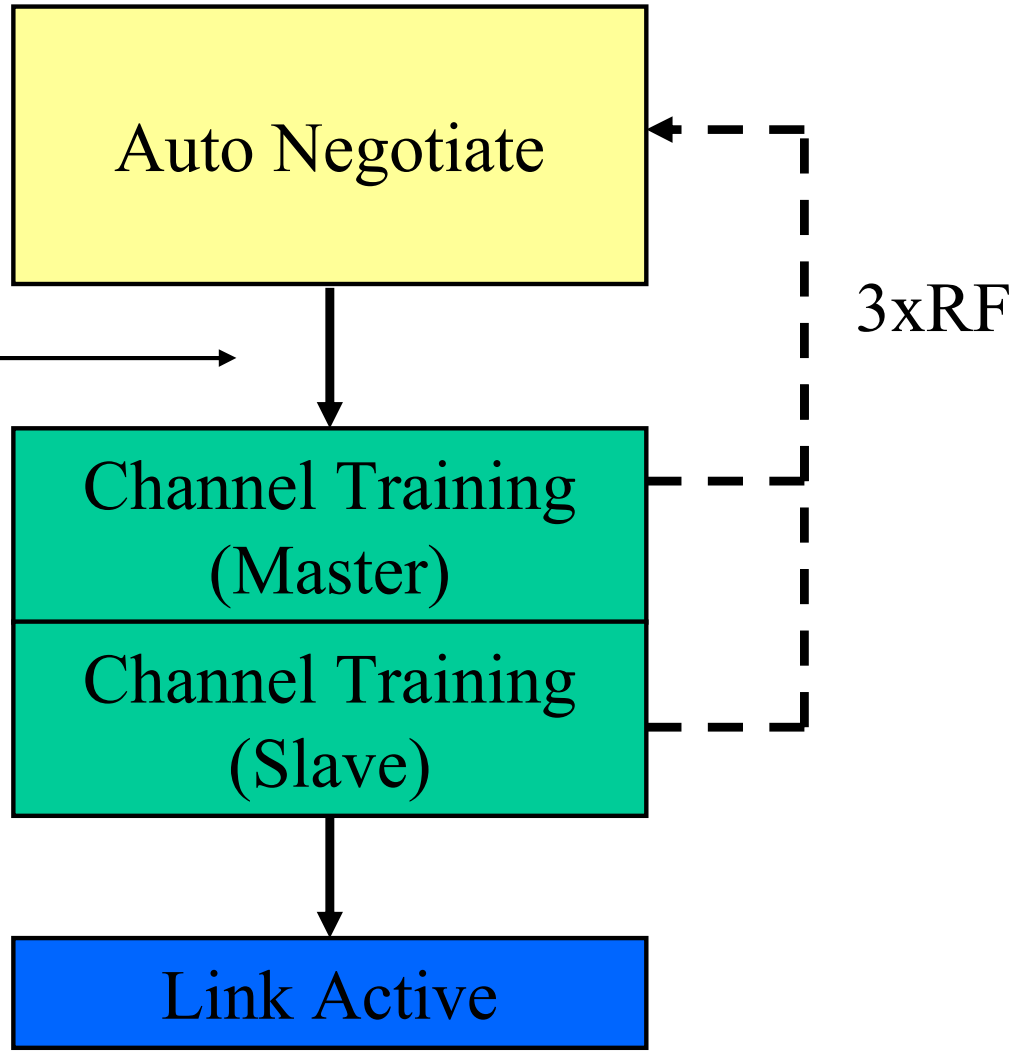
SSP_LINK_GOOD and Training requested

Master TX and Slave RX are Trained

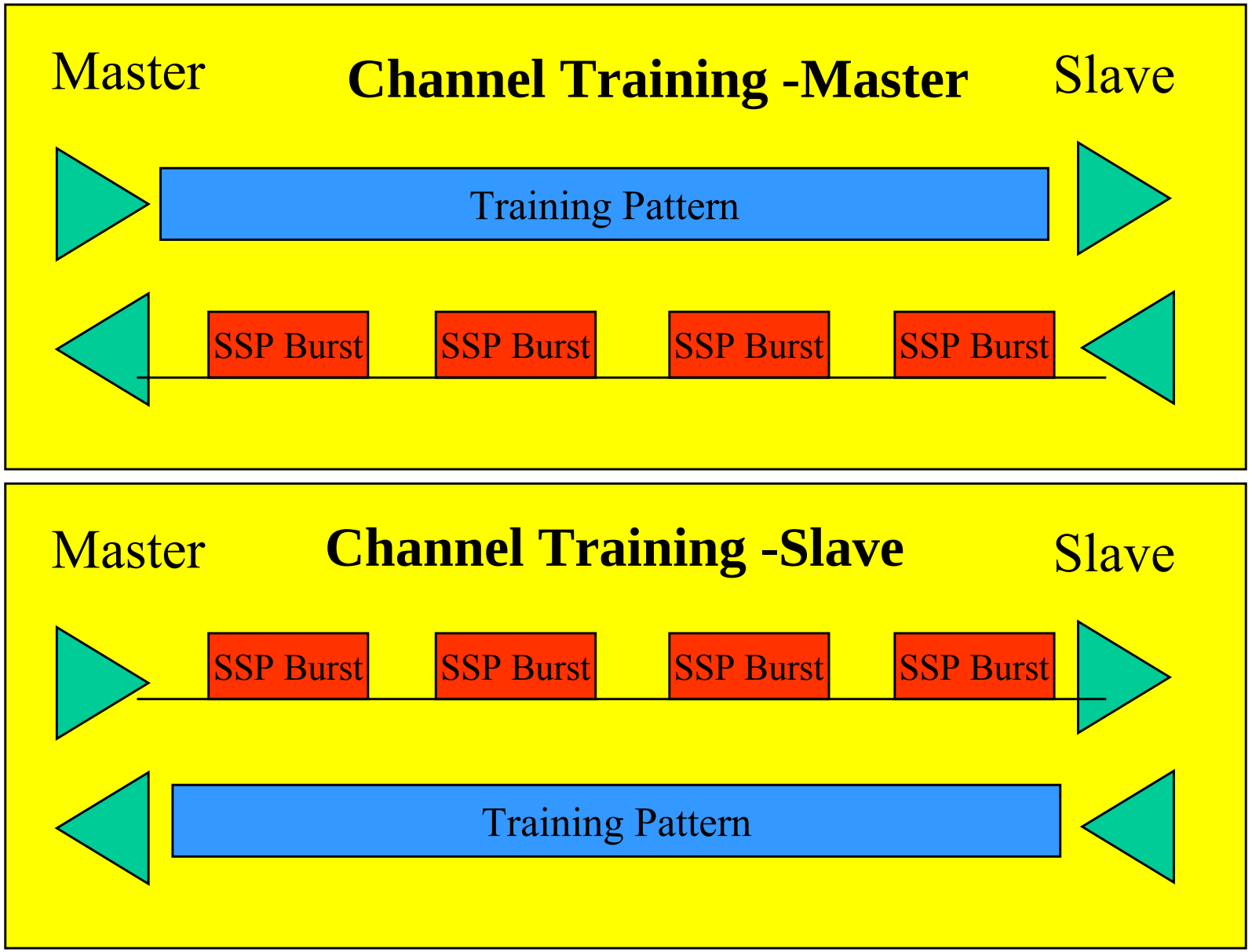
Slave TX and Master RX are Trained

3xTraining_Complete

All Coefficient update fields remain in Hold, and Cd flag remain constant in order to be a valid Training Complete Word.



Channel Training



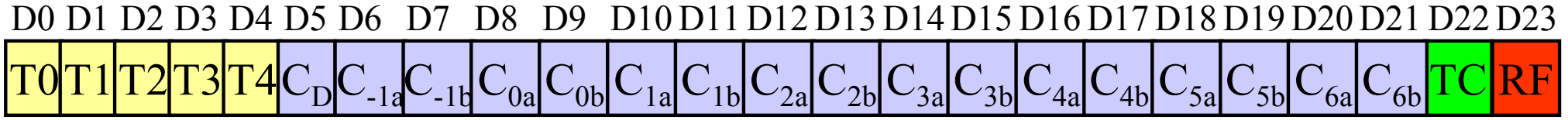
Channel Training

- During Auto Negotiation following is identified:
  - Speed is Selected
  - Training is requested
  - Master and Slave are selected (consistent with 1000B-T)
  - Initial values of TX filter are selected by RX (via next pages)
- During Channel Training - Master
  - Master will send Training pattern continuously
  - Slave sends SSP encoded words to update Masters TX EQ settings until Slave RX has adapted Master TX and Slave RX equalizers acceptable level determined by Slave RX
  - Slave will send Training_Complete flag 6 times and transition to Channel Training - Slave
  - Master will transition to Channel Training – Slave after 3 consecutive Training_complete words received. All coefficients must remain in hold state and Cd must remain constant for all Training_complete words to be valid.
  - If Slave is unable to Train it will send Remote Fault flag 6 times and go back to renegotiate
  - If Master receives Remote Fault for 3 consecutive words it will go back to renegotiate
- During Channel Training – Slave
  - Same as Channel Training – Master except Slave transmits training pattern and master transmits SSP encoded words.

Channel Training timing example

- 80uS between SSP bursts
- >12 TX coefficient updates per msec
- Assume 3 tap FIR + 1 C_D tap
  - 8 bit resolution on each tap
  - 256+256+256 = 61.44msec

SSP encoded training word



- T0-T4 : set to all 1's
- C_D : tap value 0 or 1
- C_{-1a},C_{-1b} Coefficient Update field
  - 00 : hold
  - 01 : increment
  - 10 : decrement
  - 11 : invalid
- TC : Training Complete
- RF : Remote Fault

Training Pattern

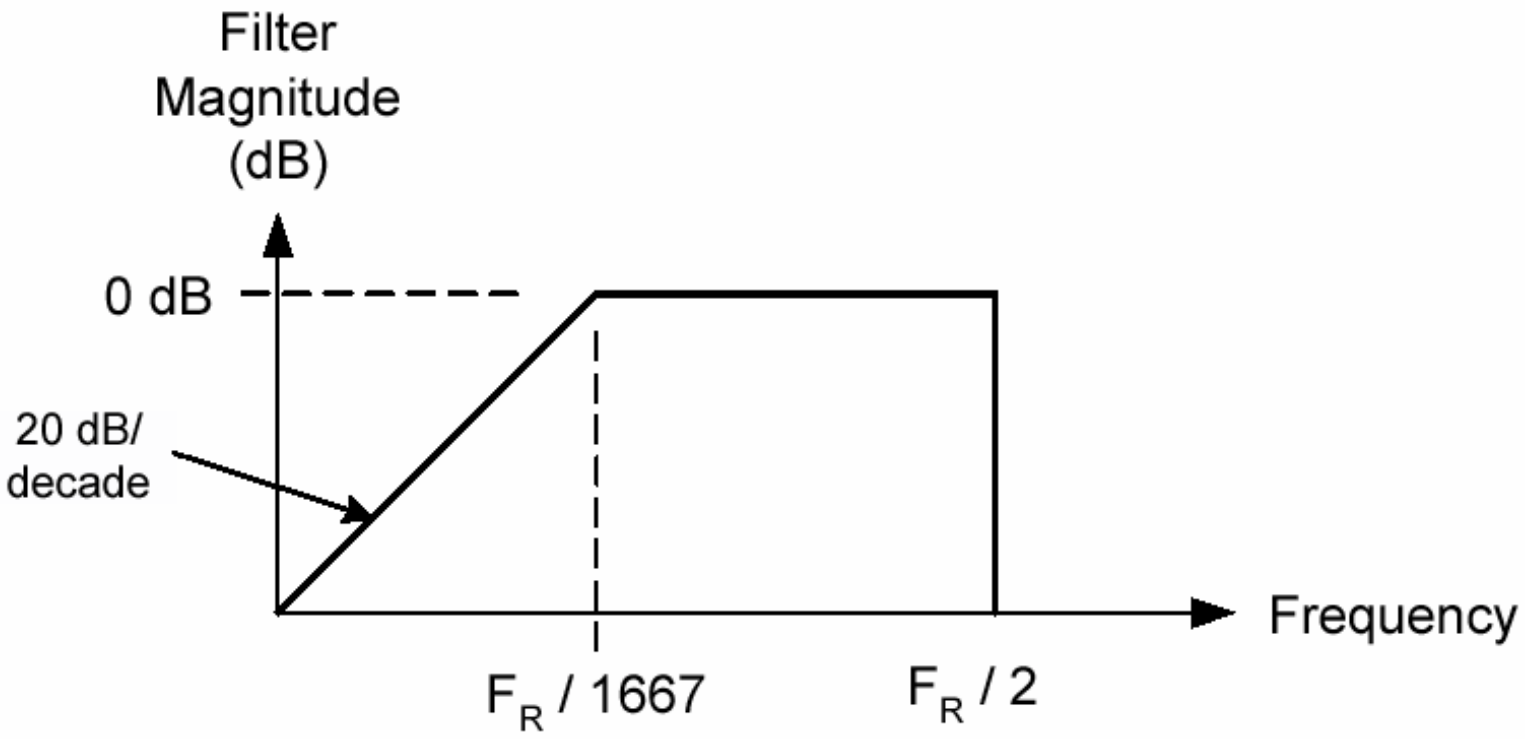
- Could be as simple as encoded idle pattern from PCS
  - Already scrambled
- PRBS31
- Clause 49 Square Wave
- Customized pattern

Driver Characteristics Table

Parameter	Value	units
Baud rate tolerance	10.3125GBd +/- 100ppm	GBd
Diff. Amplitude (1) maximum minimum	1200 800	mVp-p mVp-p
Common-Mode Voltage	TBD	V
Diff. Output Return Loss minimum	Figure	dB
Output Template	Figure	V
Transition Time min Measured between 20% and 80%	24	ps
Output Jitter (2) Random Deterministic Total	 .15 0.15 0.3	 UIp-p UIp-p UIp-p

(1) Measured at Peak of the Output Waveform
(2) With TX Jitter Filter Applied

TX Jitter Filter



Note: F_R is bit rate

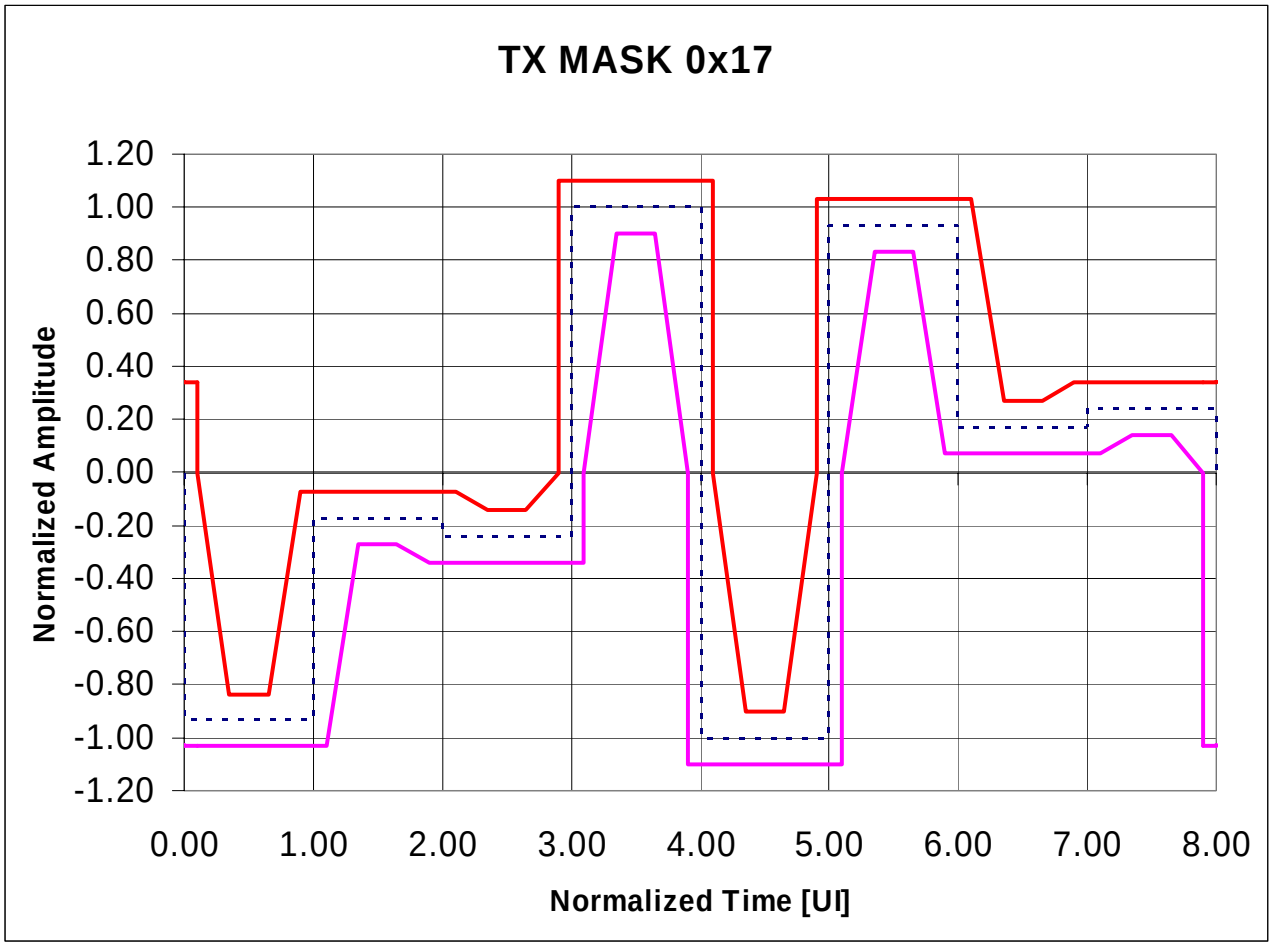
TX Mask

- Equalized TX mask
  - Must meet mask with at least one set of tap values of its EQ.
- Ensures the TX equalizer(s) has sufficient granularity, and range.
- Provides the RX a basis for what to expect and must receive through a compliant channel

TX Mask

Test pattern is 0x17 repeating pattern

Masked based on 3 - tap EQ baseline values shown in simulation section of presentation

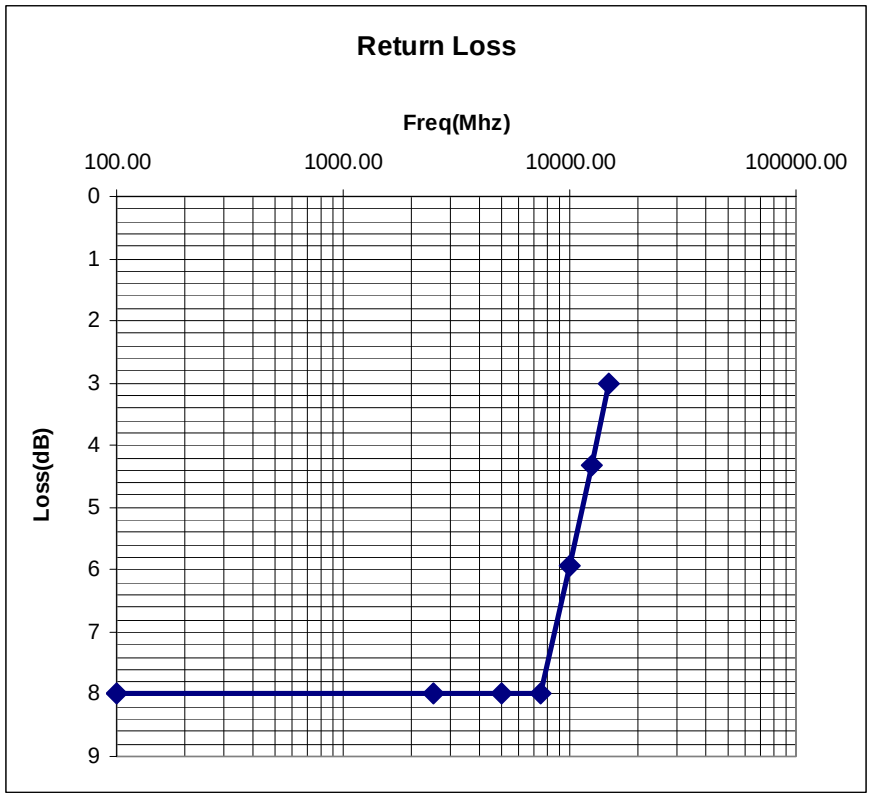


Differential Return Loss

$$\text{Return Loss}(f) \geq 8$$
$$\text{For } 100\text{Mhz} \leq f < 7.5\ \text{Ghz}$$

$$\text{Return Loss}(f) \geq 8 - 16.6 * \log\left(\frac{f}{7.5\text{Ghz}}\right)$$

$$\text{For } 7.5\text{Ghz} \leq f < 15\text{Ghz}$$



RX specification

Bit error ratio

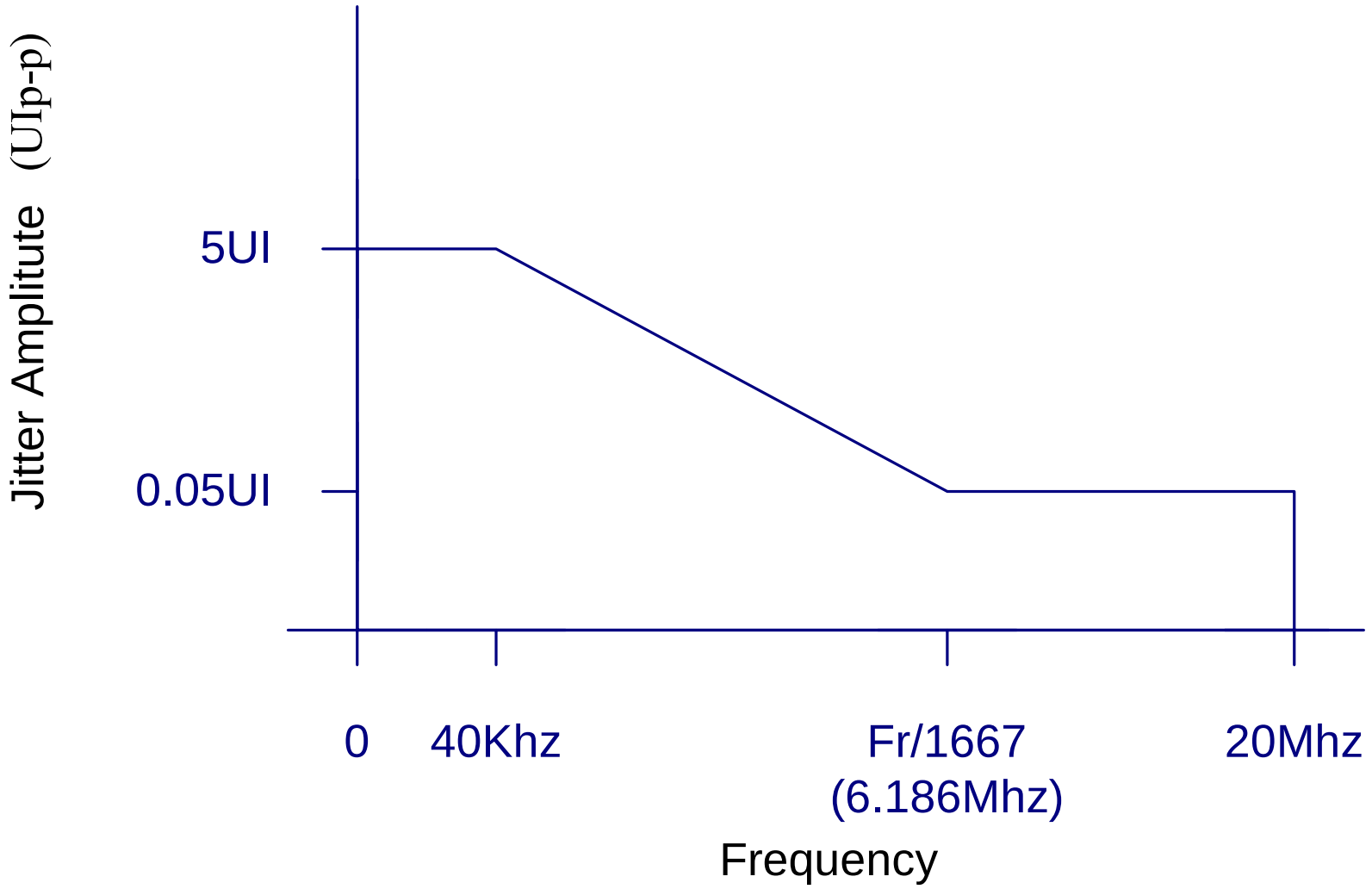
The receiver shall operate with a BER of better than 1E-12 when receiving a compliant transmit signal, as defined in X,through a compliant channel as defined in Y.

Paraphrased from 54.6.4.1 of IEEE802.3ak-2004

RX Characteristics Table

Parameter	Value	units
Baud rate tolerance	10.3125GBd +/- 100ppm	GBd
Diff. Peak Amplitude maximum	1600	mVp-p
Error Rate	10^-12	
Diff. Return Loss minimum	See TX Ret. Loss	dB
Jitter Tolerance	See Figure	UI

RX Sinusoidal Jitter Tolerance

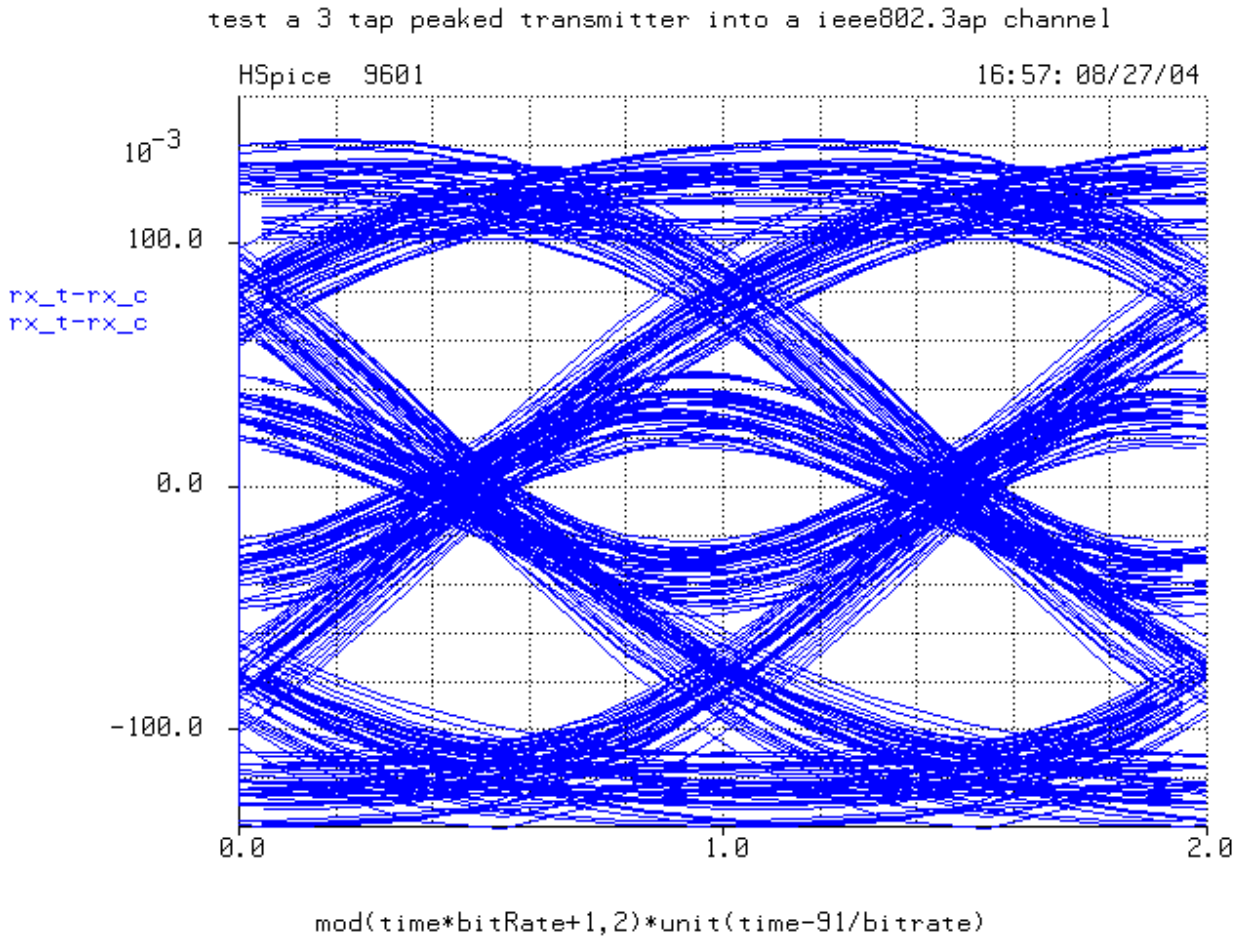


Channel Model

- Adopt a Normative Channel Model
- Current Informative channel model developed by Channel Ad Hoc determines the bounds of the normative model.
- Normative Channel Model is subject to change based on ongoing work by the Channel Ad Hoc.

Simulation Data

- 1Vp-p Output Amp
- 3 tap TX FFE
  - C(-1) = -0.035
  - C(0) = 0.585
  - C(1) = -0.380



RX eye after passing through Steve Anderson Synthesized Model
http://www.ieee802.org/3/ap/public/jul04/anderson_01_0704.pdf

TX Mask in slide 20 based on these Tap values

Data provided by Charles Moore – Agilent

Conclusion

- The proposal meets objective for 10Gbps Serial PMD
- Specified in a manner that is consistent with existing IEEE 802.3 PMD clauses
- Maintains compatibility with other 10Gbps serial electrical standards
- Provides a mechanism for the channel to be optimally equalized.
- Provides Consensus