

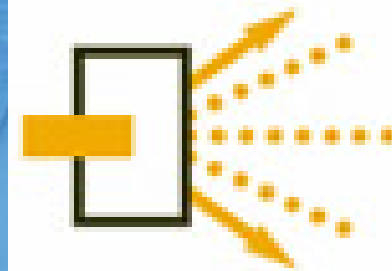
VITESSE

06-496r1 SAS-2 Electrical Specification Proposal

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SAS-2 Phy Working Group

11/7/06



Serial
Attached
SCSI

YOUR PARTNER FOR SUCCESS

Motivation

- Multiple SAS-2 Test Chips Have Been Built and Tested, SAS-2 Product Designs are Starting, To Date We Do Not Have a Electrical Specification or Outline of One.

Propose Initial Transmitter and Receiver Electrical Specifications

- Definitions & Compliance Points
- Reference Devices
- Transmitter Device Signaling
- Receiver Device Signaling
- Channel Compliance
- Open Issues



References:

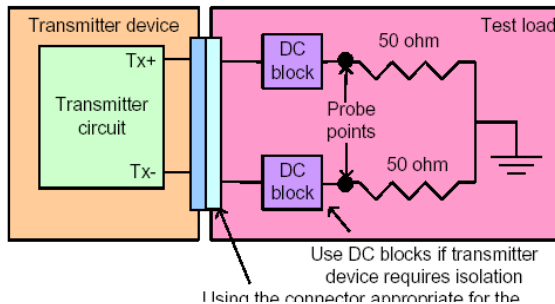
- 06-419R1 SAS-2 Reference Transmitter and Receiver Specification Proposal
- 06-206R2 SAS-2 Data Eyes vs. De-Emphasis
- 06-053R0 Roadmap to SAS-2 Physical Layer Specification
- 06-052R0 Enhanced SFF-8470, SFF-8086 and SATA Cable at 6Gbps
- 05-204R1 Towards a SAS-2 Physical Layer Specification
- 05-426R0 SAS-2 Cable Reach Objective and Crosstalk
- 05-425R1 SAS-2 Channel Model Simulations
- 05-342R0 SAS-2 Adaptive Equalizer Physical Layer Feasibility
- 05-341R1 Updated Test and Simulation Results in Support of SAS-2
- 05-203R0 SAS-2 6Gbps Test Results

Compliance Points and Devices Should be Consistent with SAS-1

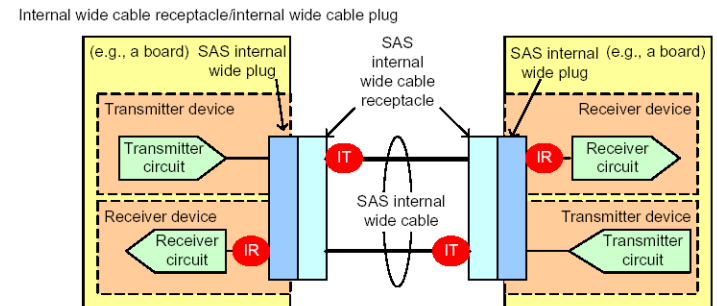
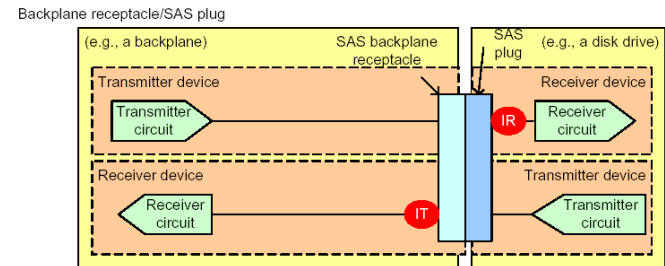
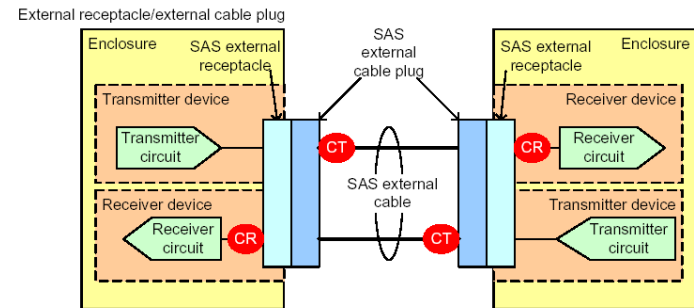
- Compliance Points (SAS1.0 see Section 5)
- Tx Device
- Rx Device
- Zero Length Tx Test Load

Table 33 — Compliance points

Compliance point	Type	Description
IT	intra-enclosure (i.e., internal)	The signal from a transmitter device (see 3.1.245), as measured at probe points in a test load attached with an internal connector (e.g., with a SAS plug (see 5.2.3.2.1), SAS internal cable receptacle (see 5.2.3.2.2), SAS internal cable SATA-style signal cable receptacle (see ATA/ATAPI-7 V3), SAS backplane receptacle (see 5.2.3.2.3), SAS internal wide cable receptacle (see 5.2.3.4.2), SAS internal wide plug (see 5.2.3.4.3), SAS internal compact wide cable plug (see 5.2.3.4.5), or SAS internal compact wide receptacle (see 5.2.3.4.6))
IR	intra-enclosure (i.e., internal)	The signal going to a receiver device (see 3.1.152), as measured at probe points in a test load attached with an internal connector.
CT	inter-enclosure (i.e., cabinet)	The signal from a transmitter device, as measured at probe points in a test load attached with an external connector (e.g., with a SAS external cable plug (see 5.2.3.3.2), a SAS external receptacle (see 5.2.3.3.3), a SAS external compact cable plug (see 5.2.3.3.5), or a SAS external compact receptacle (see 5.2.3.3.6)).
CR	inter-enclosure (i.e., cabinet)	The signal going to a receiver device, as measured at probe points in a test load attached with an external connector.



Examples

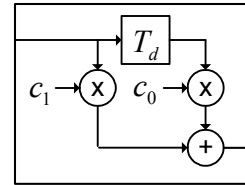


The Tx and Rx Reference Devices (see T10-419r1)

- Used for Link Simulation and Channel Compliance
- Not a Design Guideline, actual Designs must exceed the Performance of these Reference Devices

- Reference Transmitter

Reference Transmitter		Units
Ref Tx # Taps De-Emphasis	2	Taps
Ref Tx De-Emphasis	6	dB
Ref Tx De-Emphasis Tap Spacing	1	UI

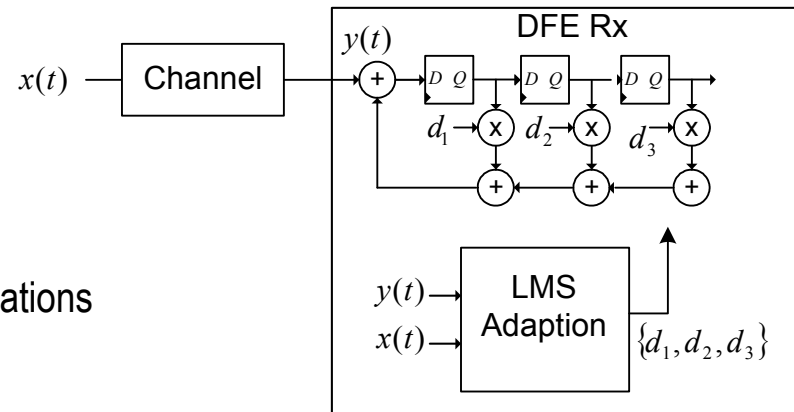


$$DE_{dB} = 20 \text{Log}_{10} \left(\frac{c_1 + c_0}{c_1 - c_0} \right)$$

$$c_1 = 0.7488 \quad c_0 = -0.2488$$

- Reference Receiver

Receiver		Units
Reference Rx # DFE Taps	3	taps
DFE Tap Spacing	1	UI
Coefficient Adaptation Algorithm	LMS*	



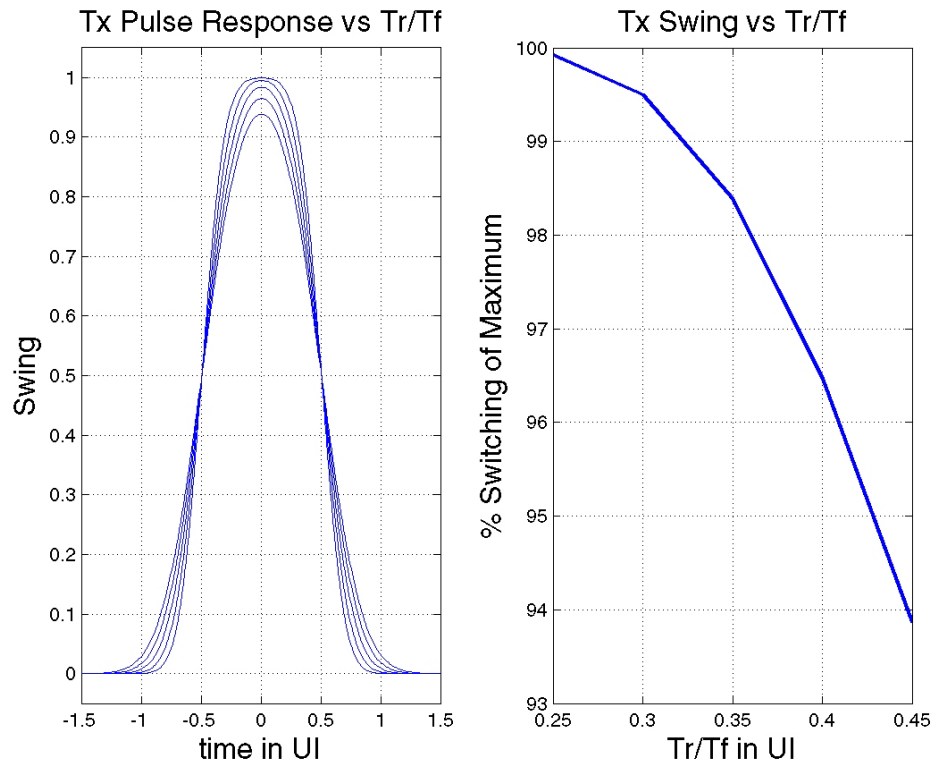
* See Lee and Messerschmitt, Digital Communications

Transmitter Device Signal Characteristics

- Measured into a Zero Length Test Load (CT and IT)
- Through a Mated Connector

Transmitter	SAS-2			Units
	Min	Nominal	Max	
Bit Rate		6000		MBps
Differential Voltage (pk-pk) Vpk	800		1200	mV
Transition Time (20%-80%)	0.25 / 41.667		0.45 / 75	UI /ps
Tx De-Emphasis	5		7	dB
DC Differential Impedance	60	100	115	ohm
DC Impedance Mismatch			5	ohm
DC Common Mode Impedance	15	25	40	ohm
Differential Return Loss			see Plot	dB
Common Mode Return Loss			see Plot	dB
Max. Intra-Pair Skew			15	ps
Max. Tx Output Imbalance rms(Vp,Vn)			10	%
Common Mode Generation V Pk-Pk			50	mV
Random Jitter			0.15	UI
Deterministic Jitter			0.15	UI
Total Jitter			0.3	UI
AC Coupling Cap			12	pF

- Propose $Tr/Tf = \{ 0.25 \rightarrow 0.45 UI \} \rightarrow \{ 41.6667 \rightarrow 75ps \}$
- Look at % Switching as a Function of Tr/Tf
- Proposed Range Provides 94% Max Swing and Reasonable Range for Process, Temperature and Voltage Yield



Transmitter Device De-Emphasis Measurement

Transmitter De-Emphasis

- Measured into a Zero Length Test Load (CT and IT)
- 6 dB Target 5→7 dB Tolerance
- 23% Tolerance Window

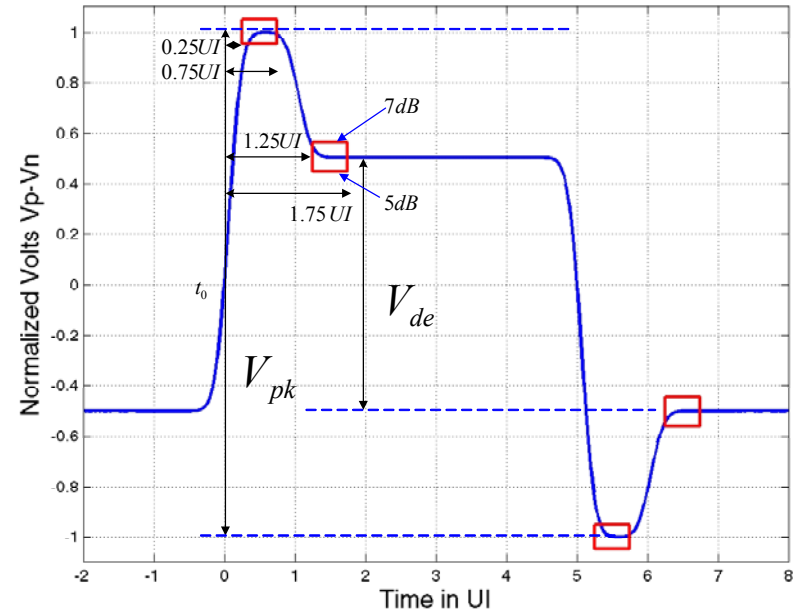
Vpk mV	Vde mV	DE (dB)	CutBack (%)	DE Vtol	DE Vtol %
1200	675	5	44		
1200	601	6	50	139	23%
1200	536	7	55		
800	450	5	44		
800	401	6	50	93	23%
800	357	7	55		

- Modified Proposed Measurement Technique
 - Similar to IEEE 10GBase-KR
 - Define Window for Voltage Measurements

V_{pk} = Maximum Voltage Measured $t_0 + 0.25 \cdot T$ to $t_0 + 0.75 \cdot T$

V_{de} = Minimum Voltage Measured $t_0 + 1.25 \cdot T$ to $t_0 + 1.75 \cdot T$

$$DE_{dB} = 20 \log_{10} \left(\frac{V_{pk}}{V_{de}} \right) \quad Cutback = \frac{V_{pk} - V_{de}}{V_{pk}}$$

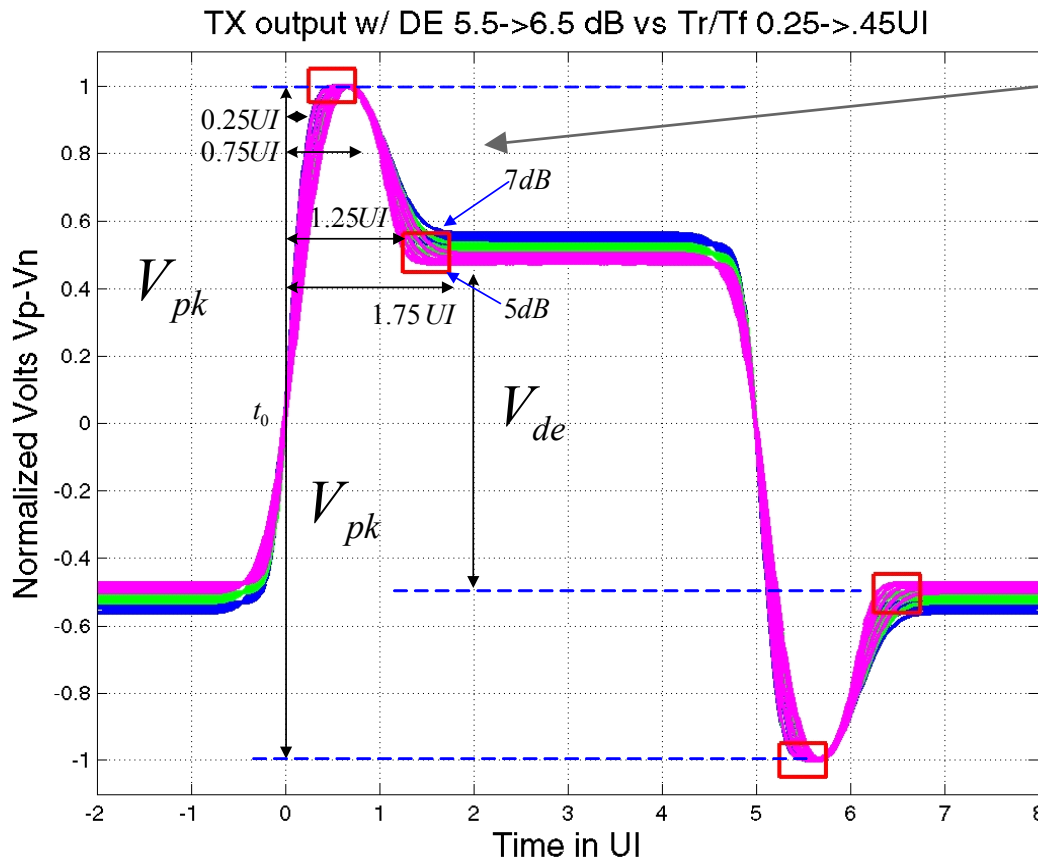


All Voltage Measurements Referenced to Zero Crossing

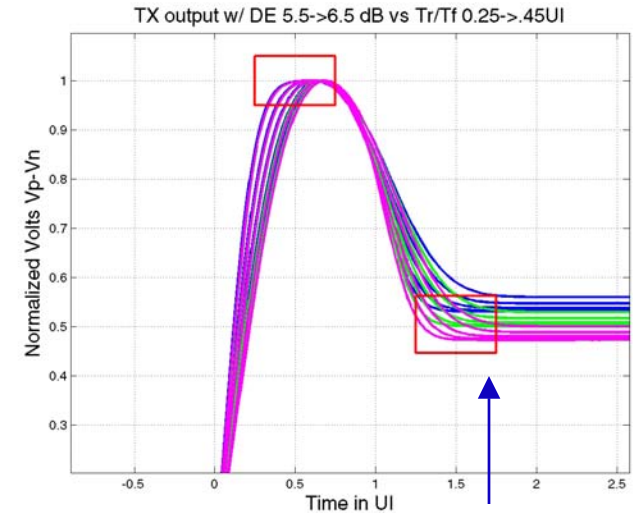
Transmitter Device De-Emphasis Measurement

Transmitter De-Emphasis & Tr/Tf Specifications Are Consistent

- Sweep Tr/Tf 0.25→0.45 UI
- Sweep Ideal DE 5.5→6.5 dB
- All Pass the 5→7 dB Specification



Close Up

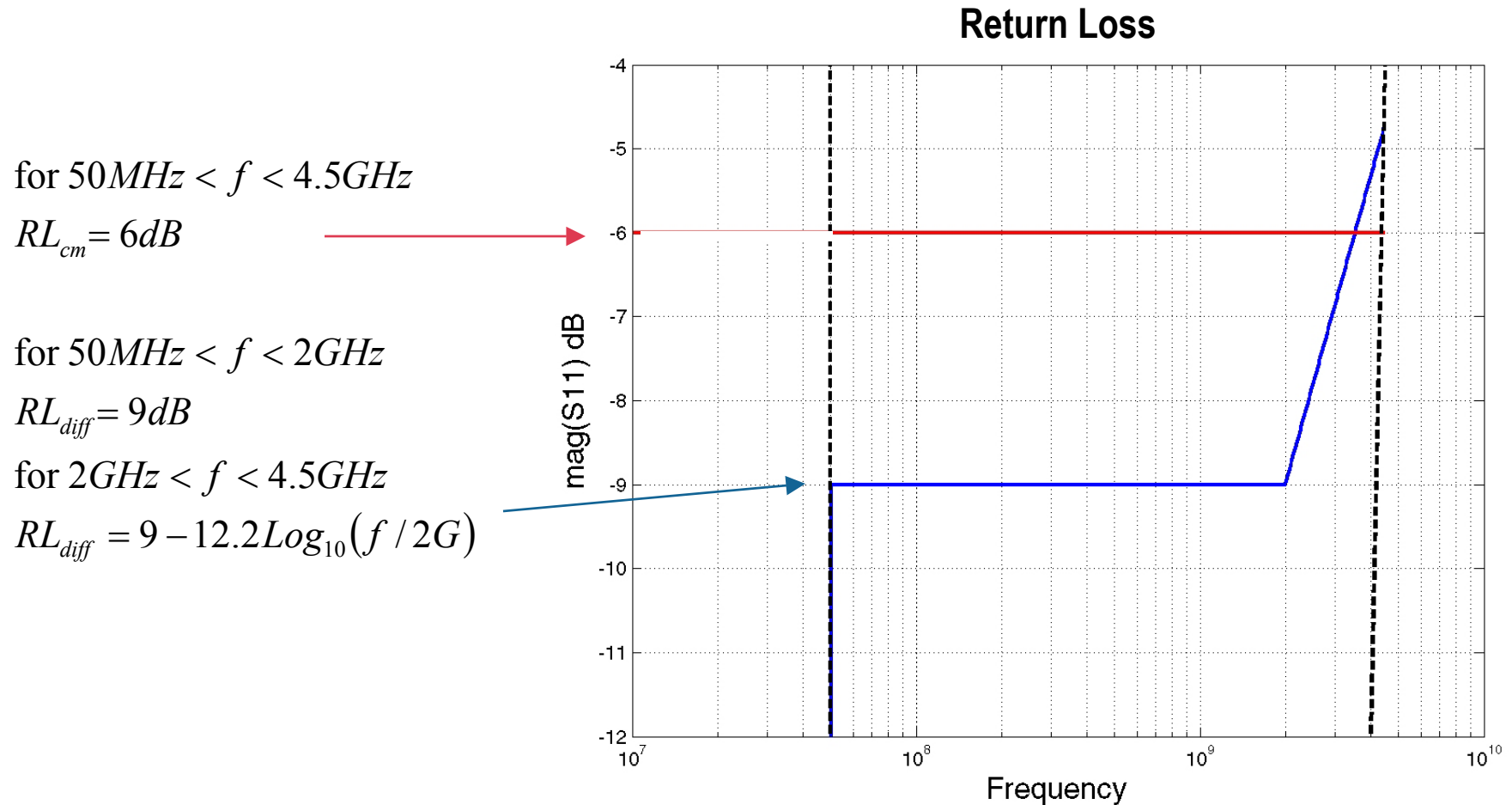


5→7dB
Specification

Transmitter Device Return Loss Specification

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Similar to 10GBase-KR and PCIE 2.0



SAS-2 Transmitter Device Proposed Numbers VITESSE

Receiver Device Signal Characteristics

- Measured at (CR and IR)

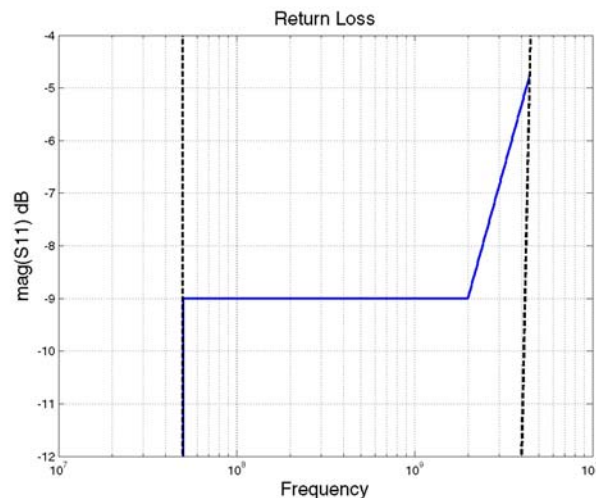
Receiver	SAS-2			Units
	Min		Max	
DC Differential Impedance		100		ohm
DC Common Mode Impedance	20		40	ohm
Differential Return Loss			See Plot	
Common Mode Return Loss			See Plot	
Common-Mode Tolerance (2-200MHz)	150			mV
Max Operational Input Voltage @ 6Gbps	1200			mV
Max Non-Operational Input Voltage	2000			mV

for $50\text{MHz} < f < 2\text{GHz}$

$$RL_{diff} = RL_{cm} = 9\text{dB}$$

for $2\text{GHz} < f < 4.5\text{GHz}$

$$RL_{diff} = RL_{cm} = 9 - 12.2 \text{Log}_1$$



Jitter Tolerance?

A Compliant Channel

- Any Channel Which Will Operated at $1e-15$ With the Given Reference Transmitter and Receiver Device.
- Operation is Defined as Passing Link Analysis at the TBD Worst Case Corner.
- Simulation Methodology is up to the User, but is Expected to be Based on Estimated/Measured S-Parameters and Digital Communication Analysis Techniques.

SAS-2 S-Parameter Models Set Posted to the T10 Serve as Guidance

SSC Causes Measurement Issues:

- Tx Jitter Generation
- Rx Jitter Tolerance

Tx De-Emphasis Causes DJ Which Needs to be Removed Before Jitter Generation Can Be Estimated?

Question: Do we Want to Support a Low-Swing Mode for Short / Clean Channels?



- 400→600mV
- No De-Emphasis

Are We Going to Define a Rx Compliance Channel / Test?



Electrical Transmitter and Receiver Device Specifications Provided

- **Starting / Discussion Tables Provided for Development**

-  Rx Compliance Test ISI Generator (From 06-053r0)
-  LMS Analysis of HP24 w/ and w/ De-Emphasis

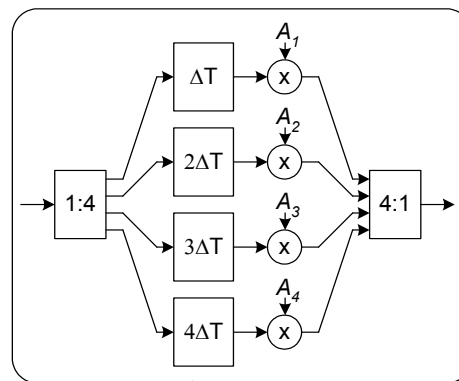
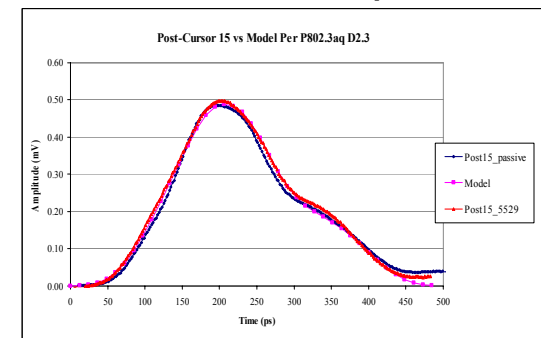
SAS-2 Receiver Compliance Test Hardware

See 06-053r0

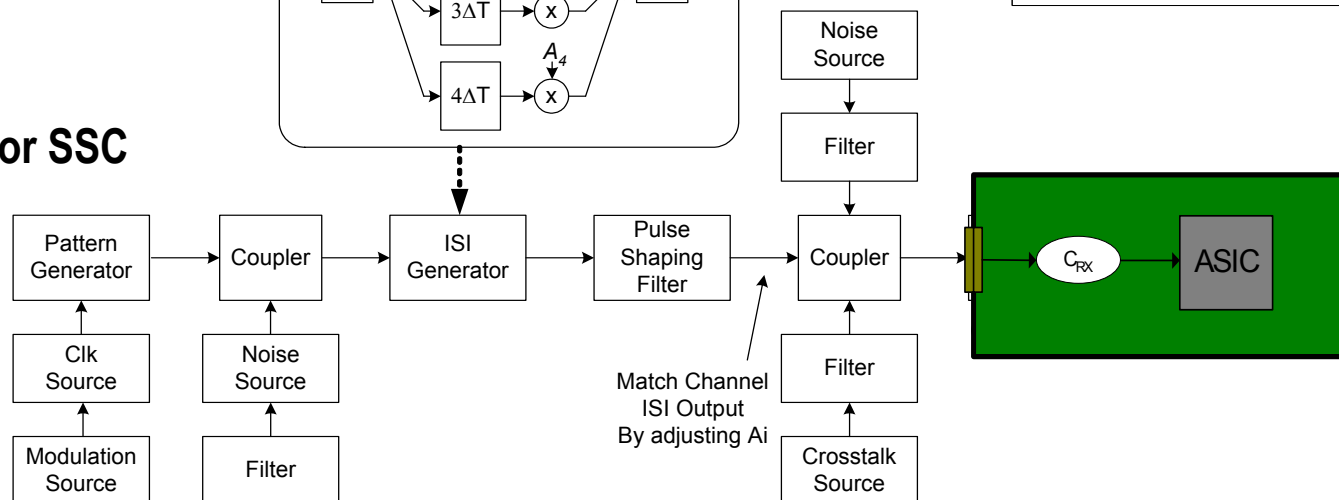
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- 📖 Receiver Compliance w/ Jitter, Crosstalk and Interference (same as OIF-CEI, & 10GBase-KR)
- 📖 Standardize Test Setup based on 10GBase-LRM ISI Generator
 - Generate ISI coefficients for channels of Interest
 - Calibrate and Test Through Mated Connector
 - Emulate Tx DE, C_{TX} & C

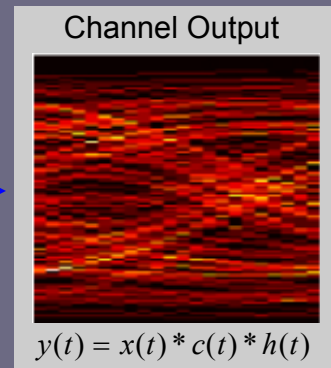
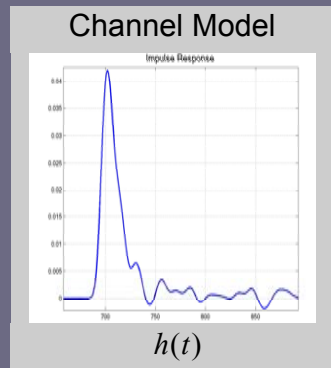
10GbE MMF Example



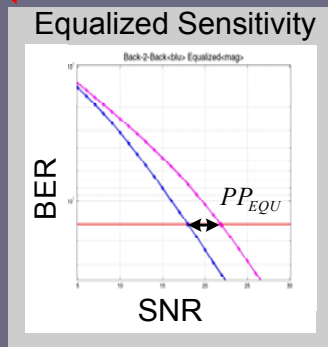
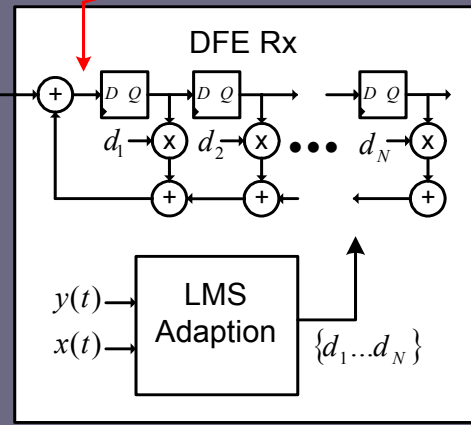
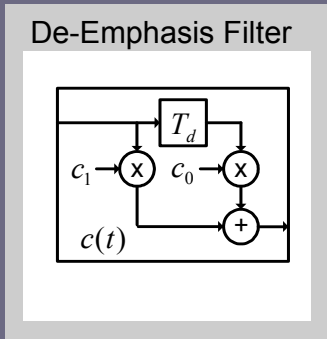
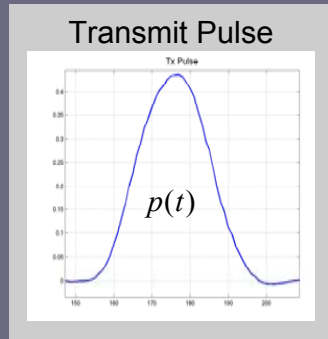
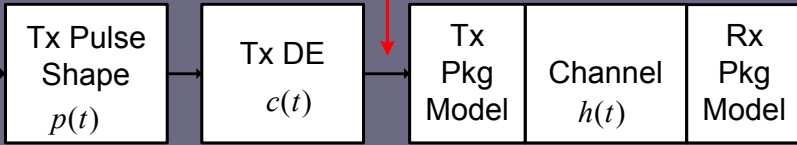
Needs Mod for SSC



S-Parameter Based Channel Mode



$$\sum_k a_k \delta_{t-kT}$$



Semi-Analytic BER Used to Estimate Sensitivity Plot

Mellitz Capacitive Package Mode
RL~ 7dB @3GHz

Pulse Shape Based on Test Chip

Simulation vs. Measured

- 6 Gbps Output Driver Test Chip
- 6dB 2 Tap De-Emphasis

Good Agreement With Measured

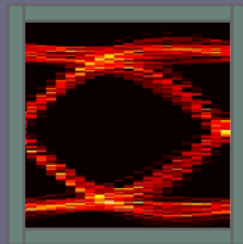
- Eye Opening and Eye Shape
- Jitter at Zero Crossing

6dB De-Emphasis Simulated Eyes

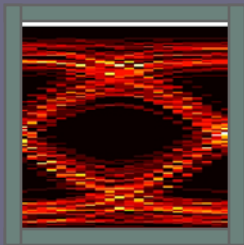
1m



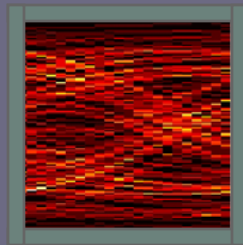
6m



10m

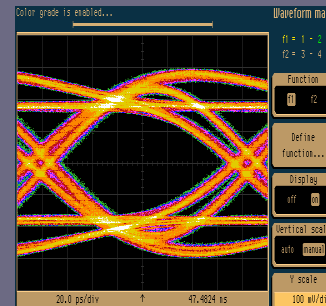


15m

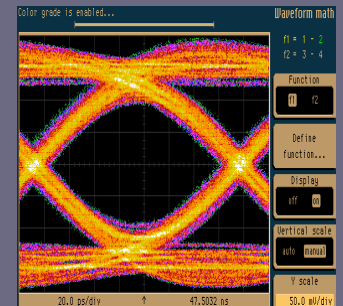


6dB De-Emphasis Measured Eyes

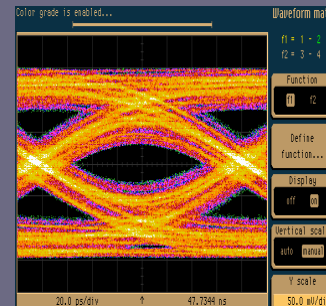
1m



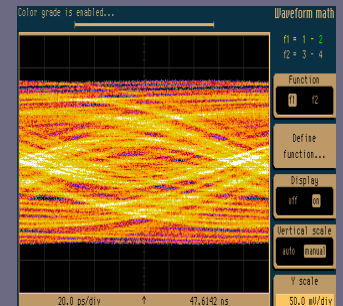
6m



10m

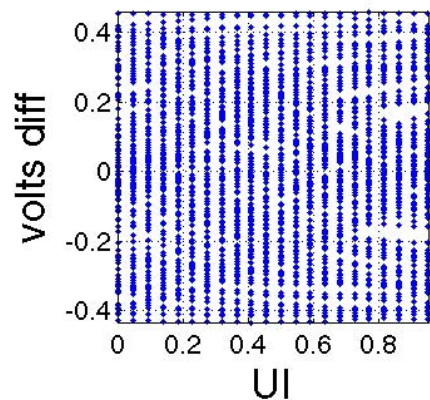


15m

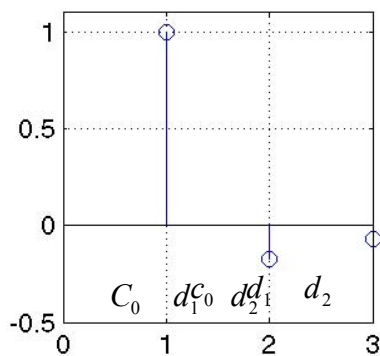


 LMS Solution to HP24

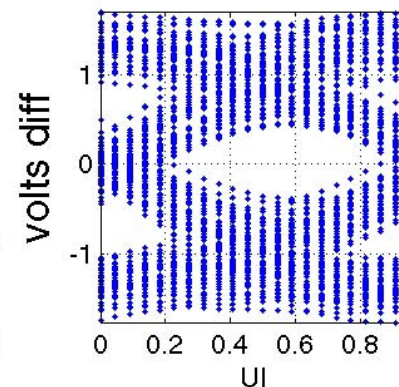
y(t) HP24 0dB



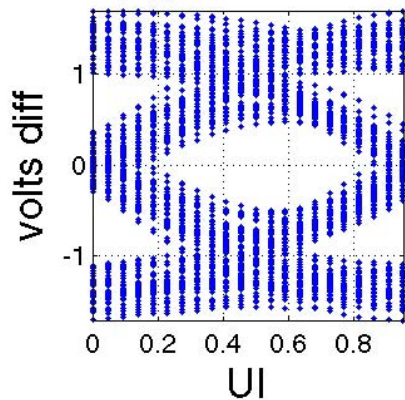
DFE Taps



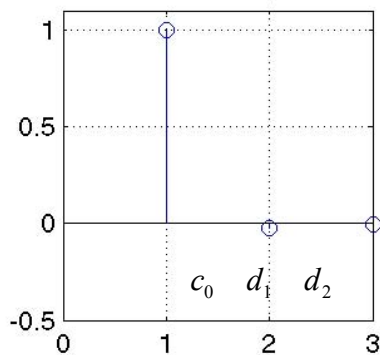
Q(t) HP24 0dB



y(t) HP24 6dB



DFE Taps



Q(t) HP24 6dB

