



Characterizing PCI Express® Lanes with Channel Degradation

Jit Lim

Senior Technologist

Tektronix



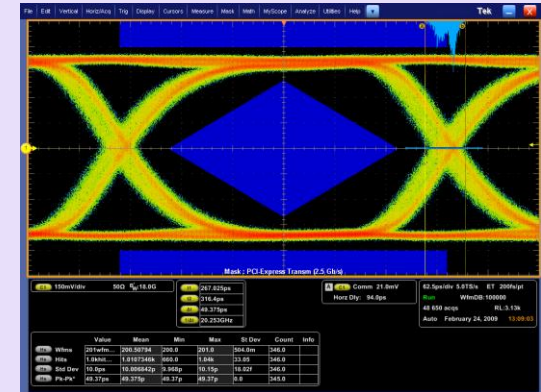
Agenda

- Trends in Phy layer testing
- Extracting s-parameters for an impaired channel
- Analyzing the results at the pins of a device after de-embedding the replica channel or test fixture
- Characterizing a Tx channel with an embedded Compliance Channel
- Validating a link after receiver equalization
- Generating a Rx signal with pre/de-emphasis, replica channel, and jitter impairment
- Analysis considerations
- Q & A

Trends in Physical Layer Testing

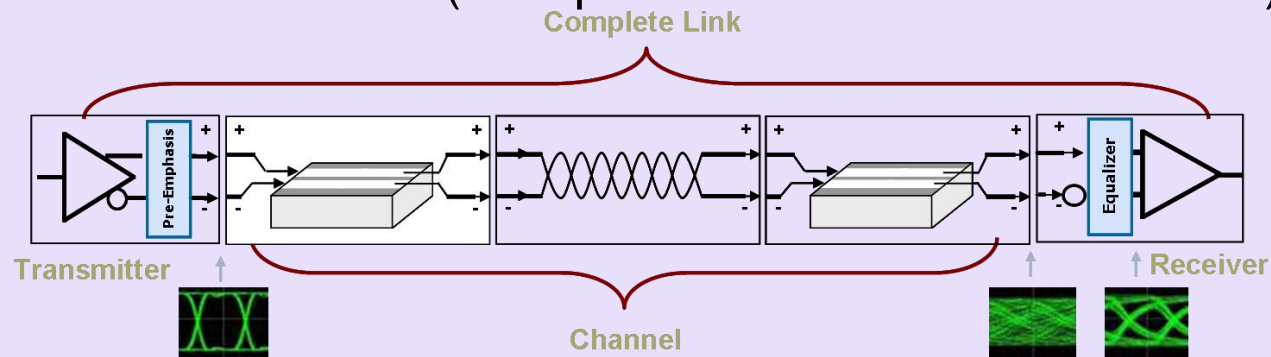
■ Traditional methods

- ✓ Basic amplitude and timing measurements
- ✓ Mask and template testing
- ✓ Histogram-based jitter measurements



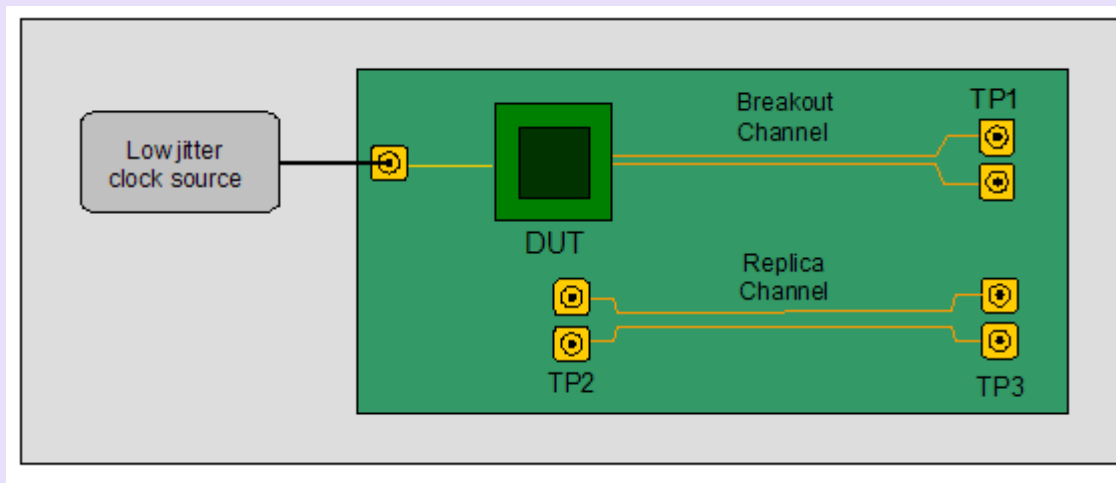
■ Emerging requirements

- ✓ Receiver Equalization (CTLE/DFE) to handle closed eye specifications
- ✓ S-Parameter-based de-embedding
- ✓ Channel emulation (Compliance Interconnect Channel)



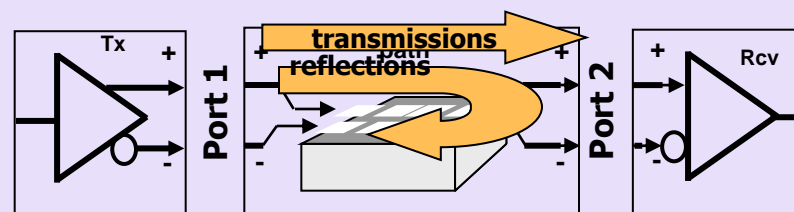
De-embed/deconvolve the Channel

- Measurements are defined at the pins of the transmitter
- S-Parameters are taken of the replica channel, which needs to reproduce the electrical characteristics of the breakout channel
- Ideally, breakout channel is less than 6 inches
- Measurements are taken at TP1 and the channel is de-embedded back to the pins of the receiver



S-parameter Extraction

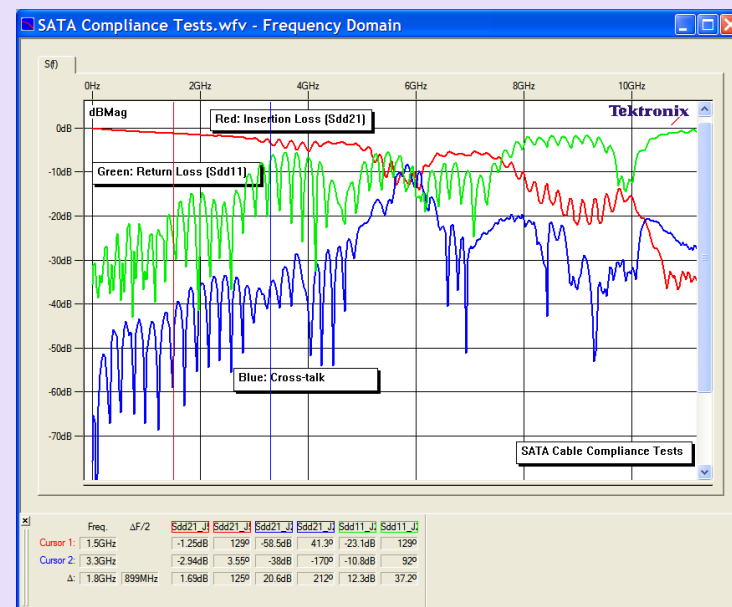
Frequency-domain characterization of reflections and loss in a network



Quantitative insight into the causes of signal integrity problems

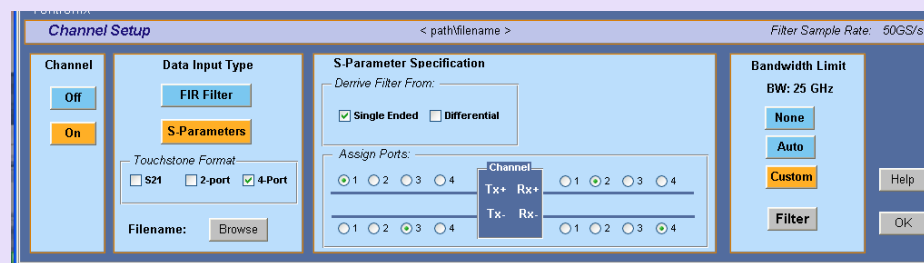
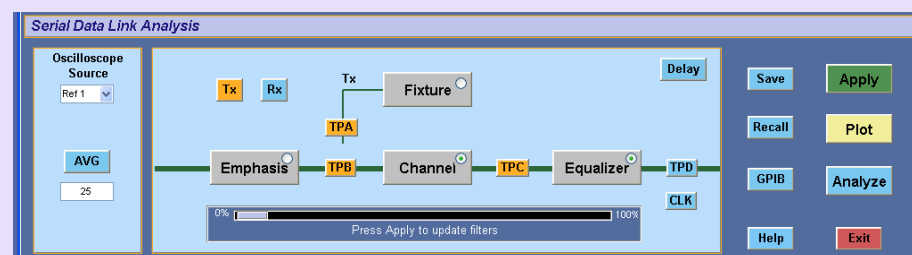
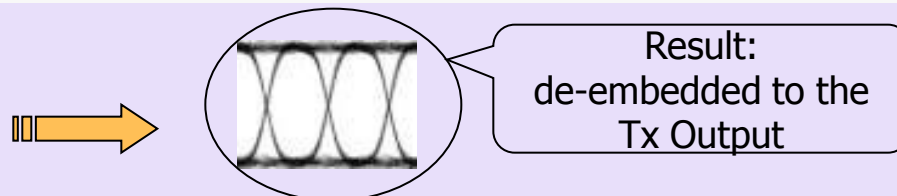
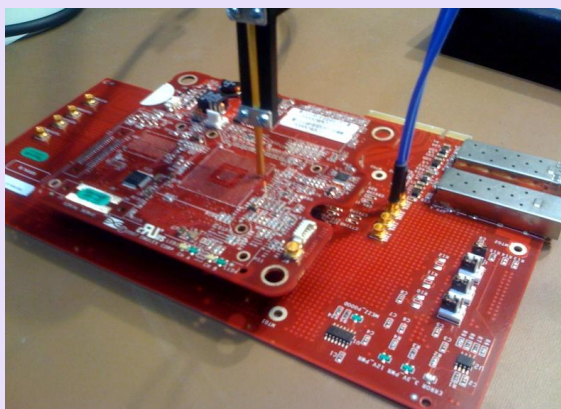
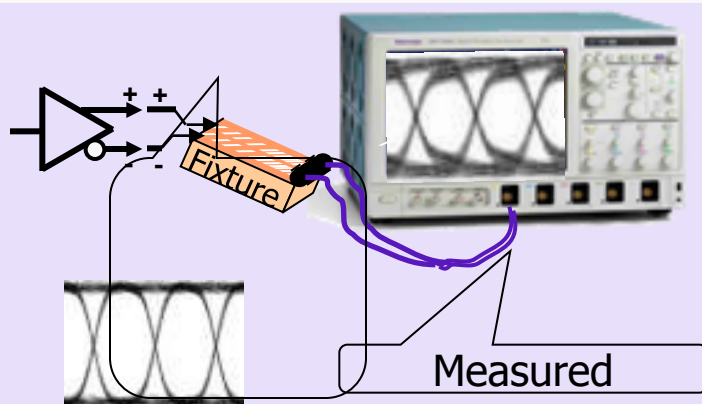
Common S-parameter Measurements:

- Differential return loss
- Differential insertion loss
- Frequency domain crosstalk



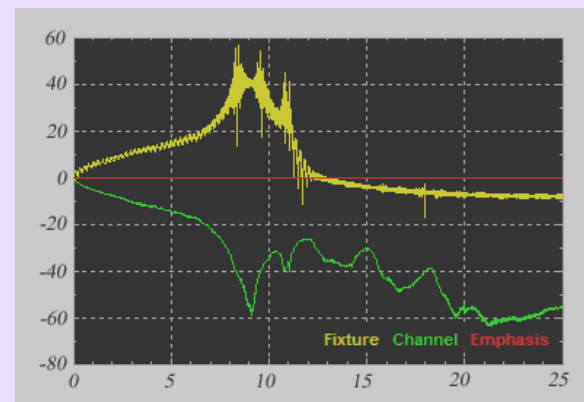
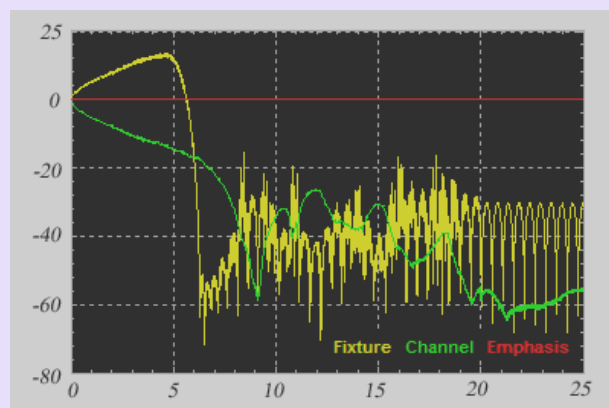
De-embedding a fixture, breakout channel, or replica channel

- When measuring the signal, the channel impacts the result
- What does the signal look like at the Tx, without the channel?



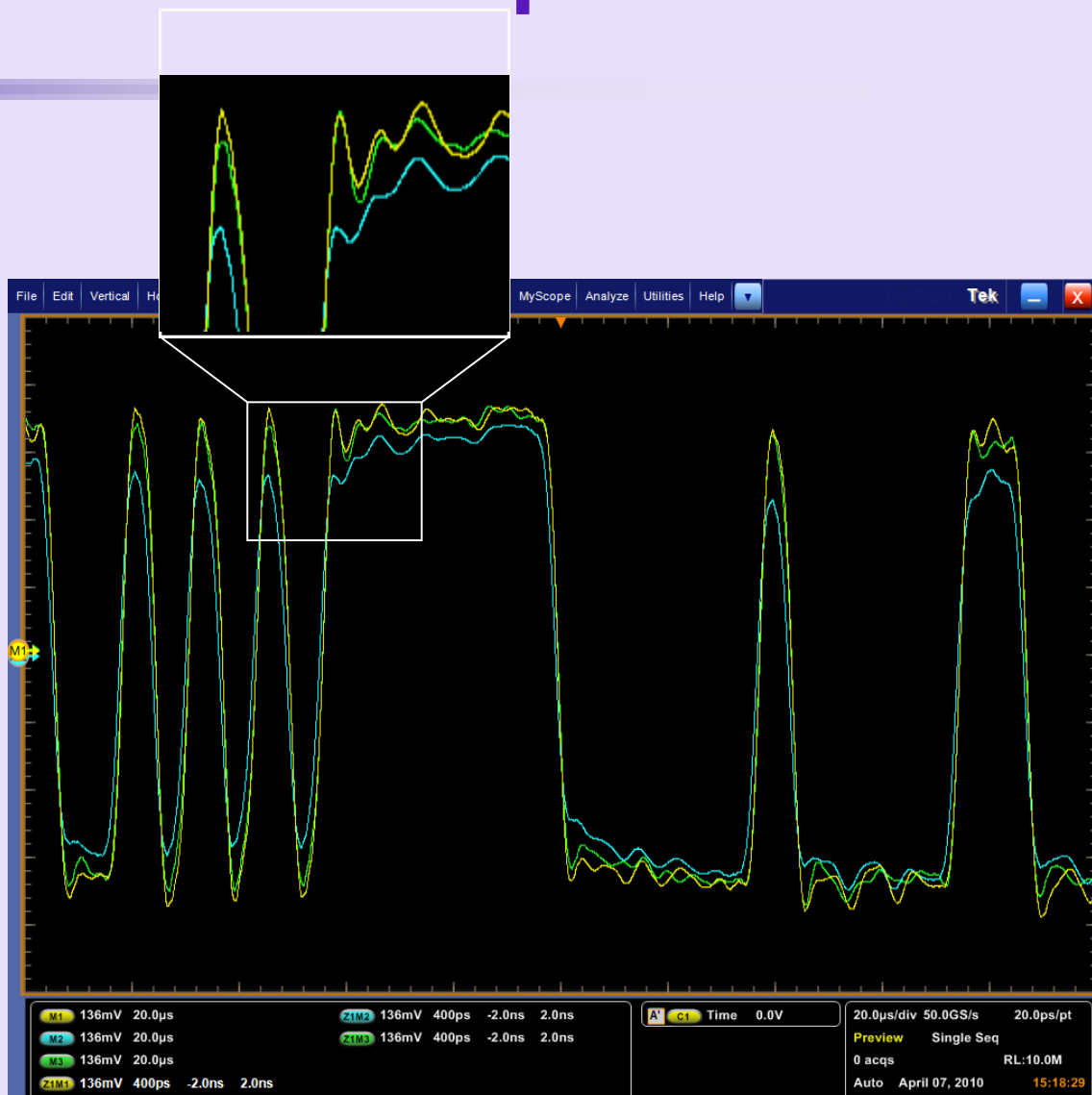
De-embedding Considerations

- Successful de-embedding starts with good quality board design and S-Parameter data
 - ✓ Matched impedance, low loss structures
 - ✓ No significant resonances, or large dips
- Quality of de-embedding
 - ✓ Eye height and jitter
 - ✓ SNR



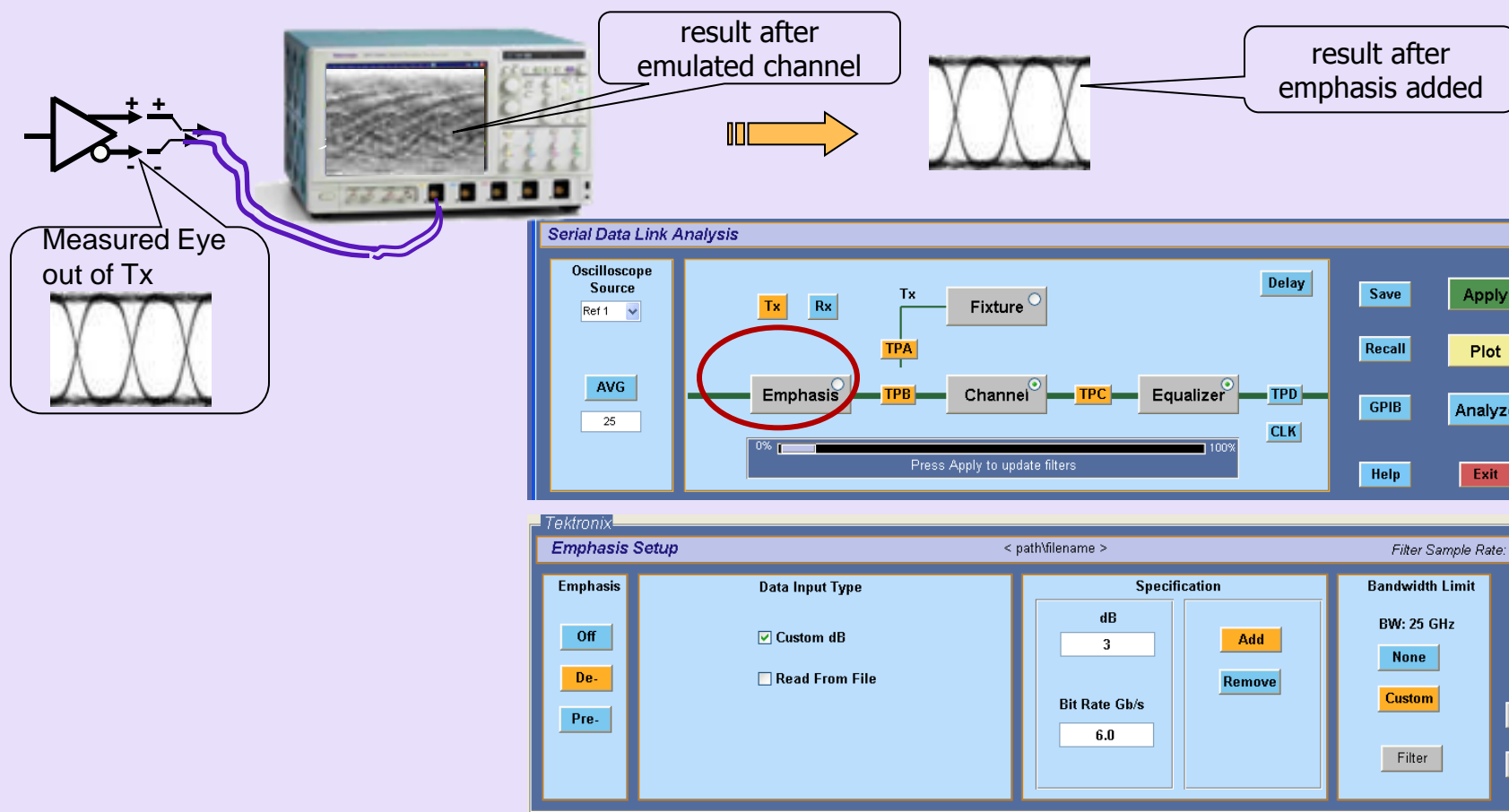
Short Channel Example

- 3" trace
- 8 Gb/s PRBS
- Test results
 - ✓ No channel (yellow)
 - ✓ Far end (blue)
 - ✓ After de-embed (green)



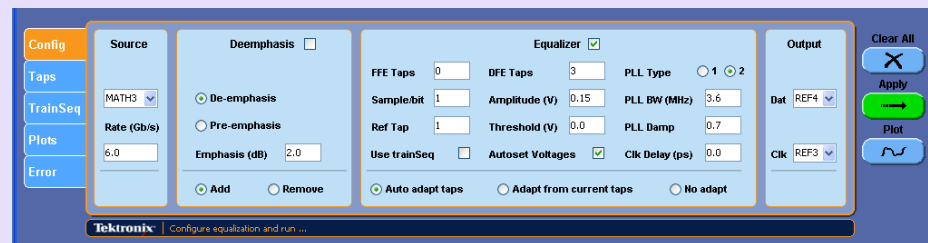
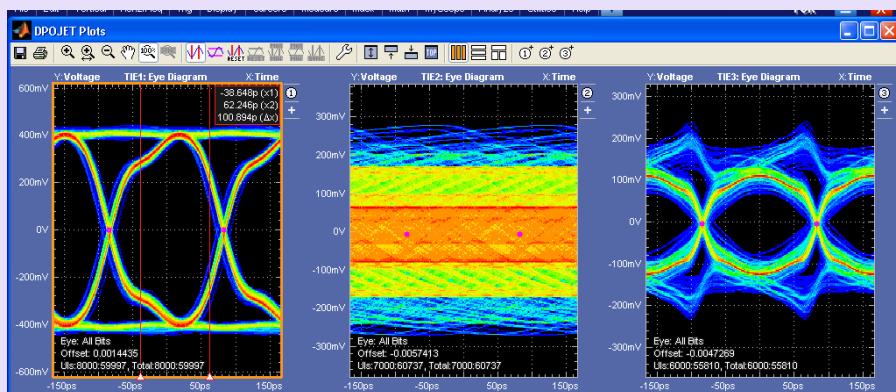
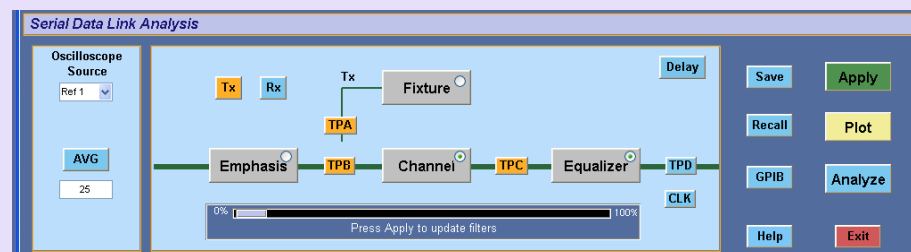
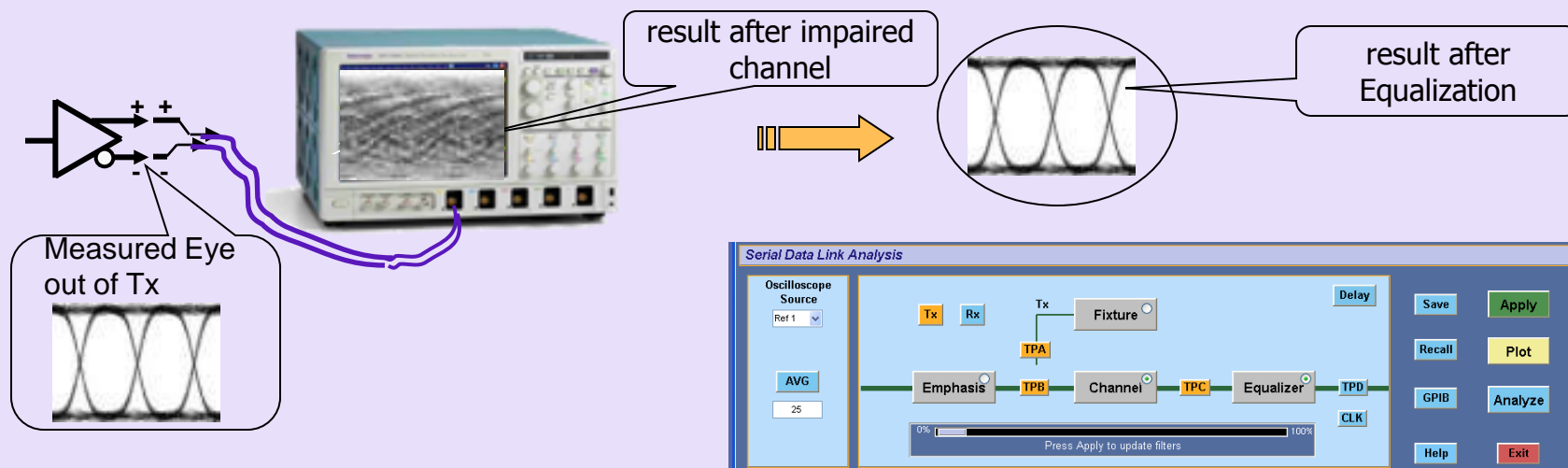
Embedding a Compliance Channel

- What does the signal look like after the channel?
- What would the signal look like with preshoot and pre/de-emphasis



Receiver Equalization

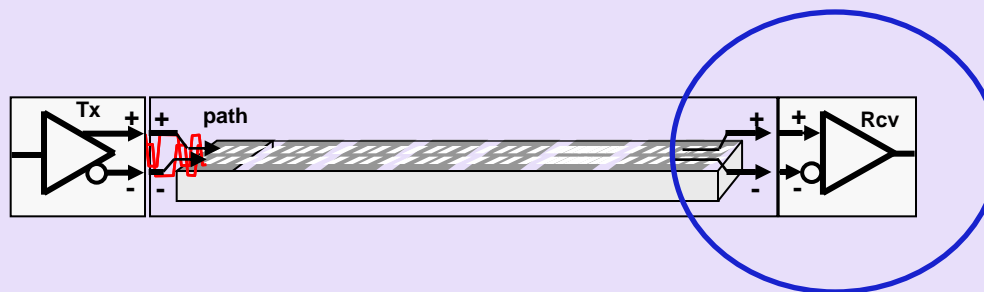
- What would the signal look like at the Rx, after Equalization?
- When measuring the signal after the impaired channel



Receiver Testing

- Limit, stress and compliance test your receiver design
- Stress your Receiver in absence of the transmitter and transmission lines
- Stress your receiver with a variety of limit stress and compliance test signals

High Speed Serial Data



Generating a Rx signal with pre/de-emphasis, replica channel, and jitter impairment

Base Pattern Transmitter Channel/Cable

Periodic Jitter (Pk-Pk)

		Magnitude:		Frequency (Hz):	Phase (°):
<input checked="" type="checkbox"/>	Sine	0.090	UI	2.000000 M	0.00
<input type="checkbox"/>	Sine	0.000	UI	10.000000 M	0.00
<input type="checkbox"/>	Sine	0.000	UI	10.000000 M	0.00
<input type="checkbox"/>	Sine	0.000	UI	10.000000 M	0.00

Random Jitter (RMS)

	Magnitude:		Frequency-Low (Hz):	Frequency-High (Hz):
<input checked="" type="checkbox"/> RJ1	0.013	UI	100.000 K	1.350000000 G
<input type="checkbox"/> RJ2	0.000	UI	100.000 K	1.350000000 G



Q and A

Thank You!



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