

Texas Instruments

# Signal Conditioning: Common Challenges & Solutions

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**Hyperlinks:**

[Signal Conditioning Portfolio](#)

[Extend Reach and Distribute Signals](#)

[Signal Conditioning Resources](#)

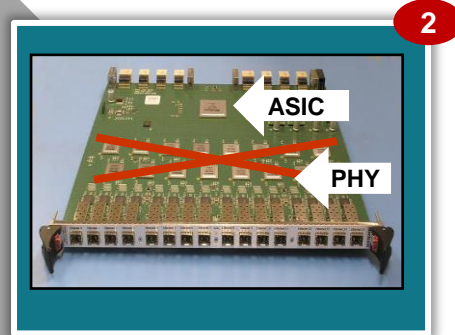
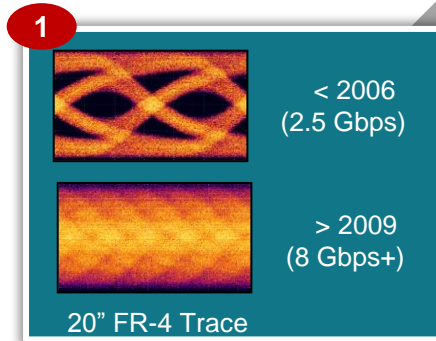
[Webench Interface Designer Visualizer](#)

# Signal Conditioning Challenges

# Identify key challenges: Loss, jitter, x-talk

## Insertion Loss

Length, media, and speed all contribute to loss

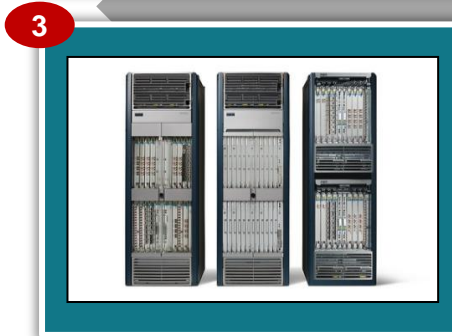


## Jitter

Phy integration and smaller geometry CMOS reduce Tx jitter performance

## Crosstalk & Reflections

High density I/O and multiple connectors add interference



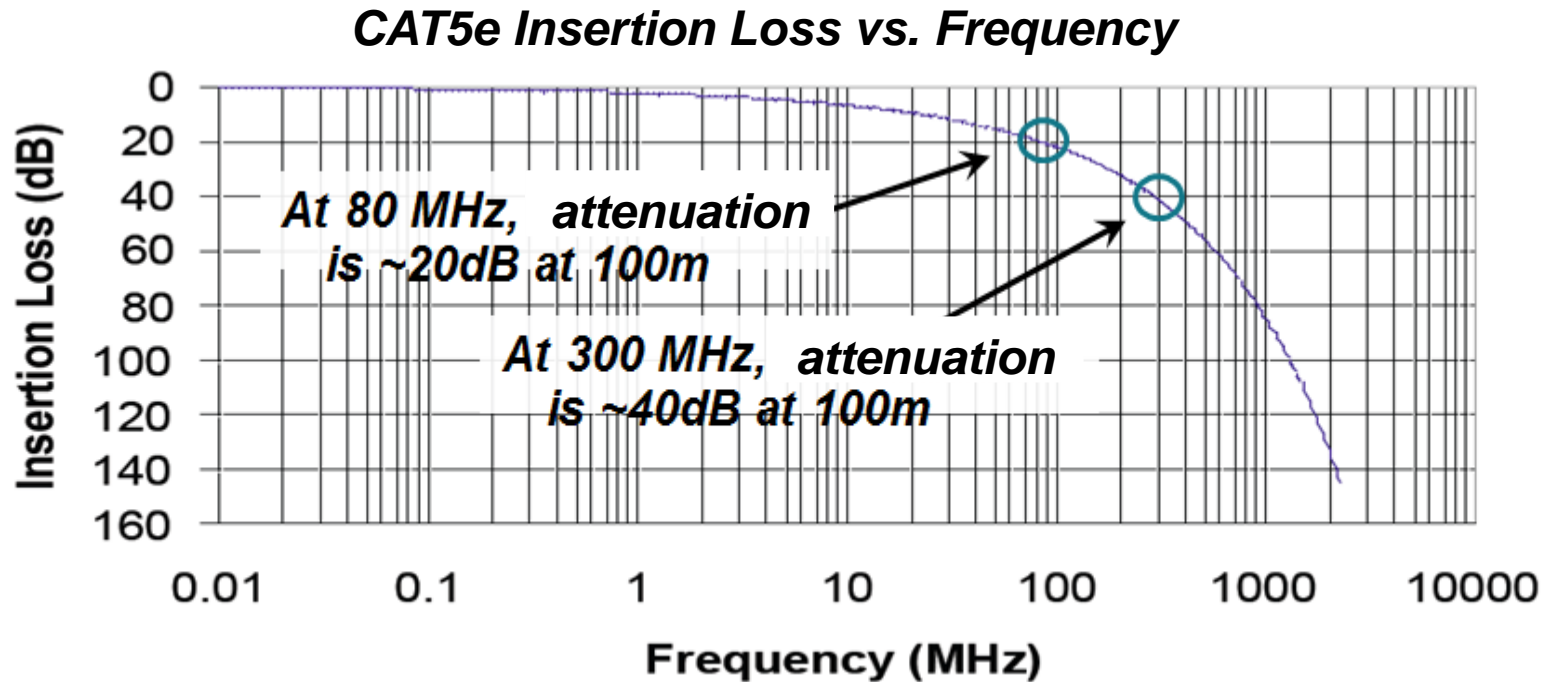
## Standards Compliance

Interoperability and protocol compliance is a must

# Loss

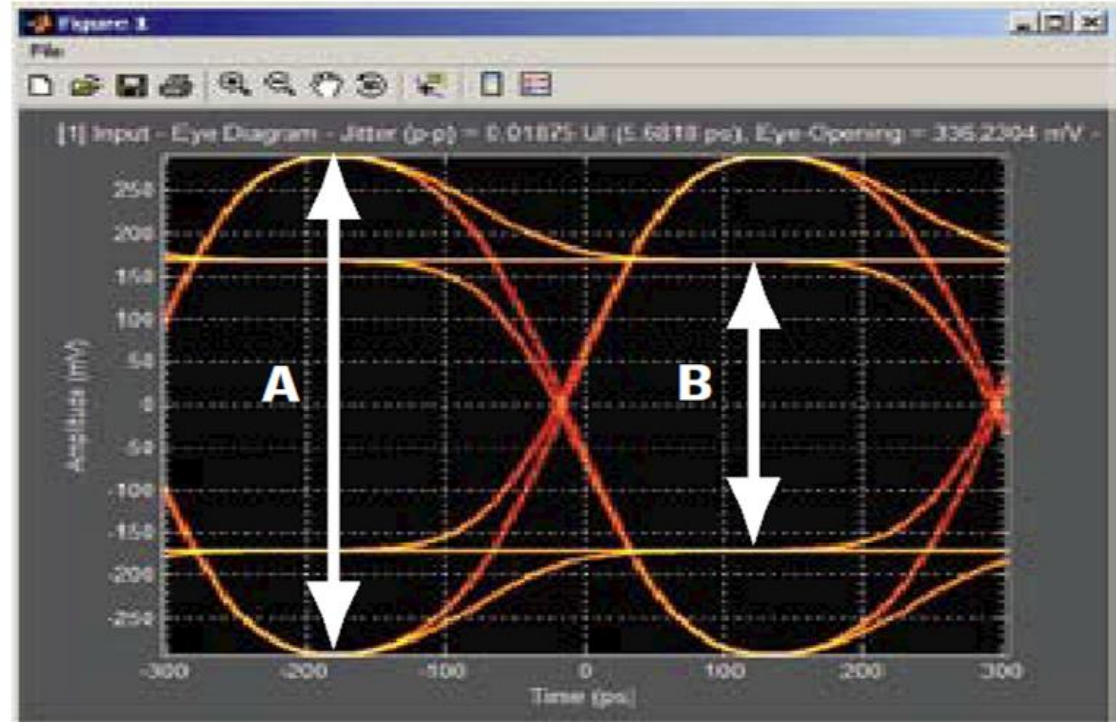
ANSI TIA/EIA-568-B.2 specifies insertion loss (dB) as a function of frequency (MHz), per 100m of cable:

$$\text{InsertionLoss} = 1.967\sqrt{f} + 0.023f + \frac{0.050}{\sqrt{f}}$$



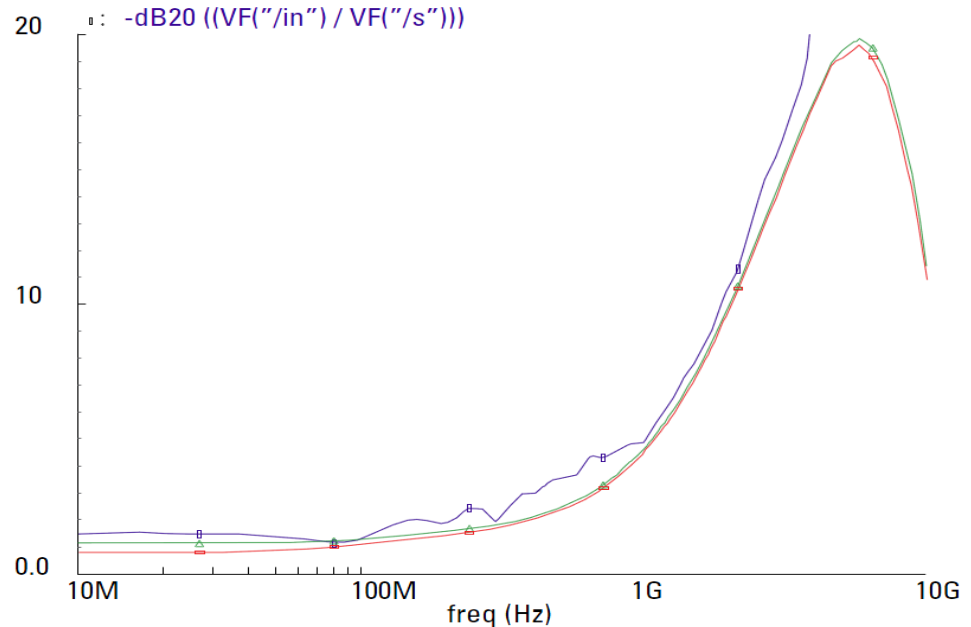
# Pre-emphasis & de-emphasis

- Pre-Emphasis & De-Emphasis techniques address high frequency media loss by applying a frequency-selective boost or attenuation to the data at the transmit end
- Pre-Emphasis
  - Edge energy is boosted by creating an overshoot on every edge
  - Typically used with LVDS
- De-Emphasis
  - Edges are kept the same, but the settled amplitude is attenuated
  - Typically used with CML



# Receive equalization

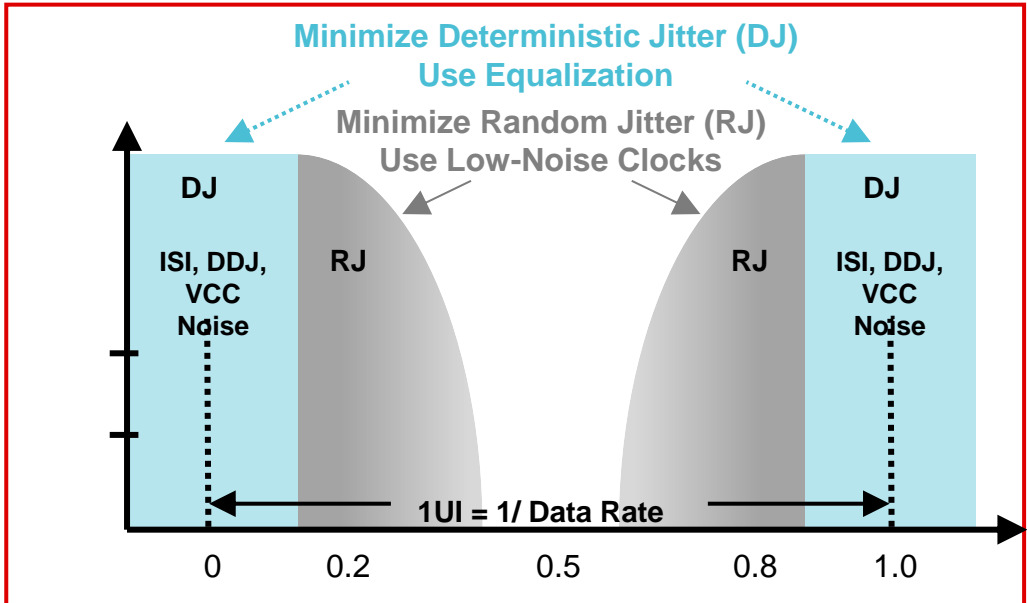
- Equalization is applied at the receive end
  - Selectively boosts high-frequency data
  - Compensates for the media's high frequency roll-off
  - Includes a high-pass filter that ideally has a frequency response exactly opposite to the media loss that the equalizer is attempting to compensate
  - Equalizers may be active or passive; fixed, variable or adaptive
- Active Equalizers
  - Can add gain to high frequencies while attenuating low frequencies
  - Works best with low-level signals
  - Can often be “programmable”



\*Inverse Channel Response (blue) and Matching Equalizer Response (green)

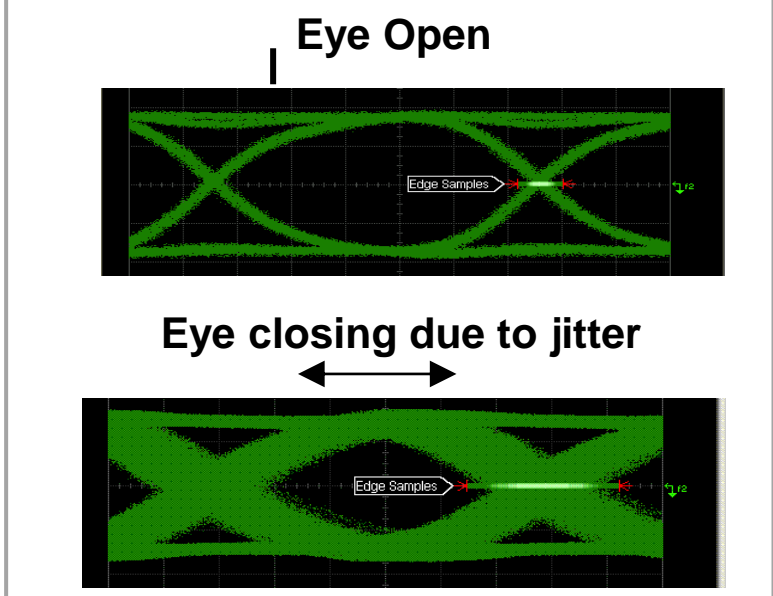
# Random jitter

## SERDES Bathtub Curve Performance



Random jitter reduces the eye opening

## Scope Results



Clock jitter is a critical requirement in high speed SERDES

# Crosstalk

Crosstalk is interference caused by adjacent data channels and/or clocks and contributes to periodic jitter that can degrade system performance:

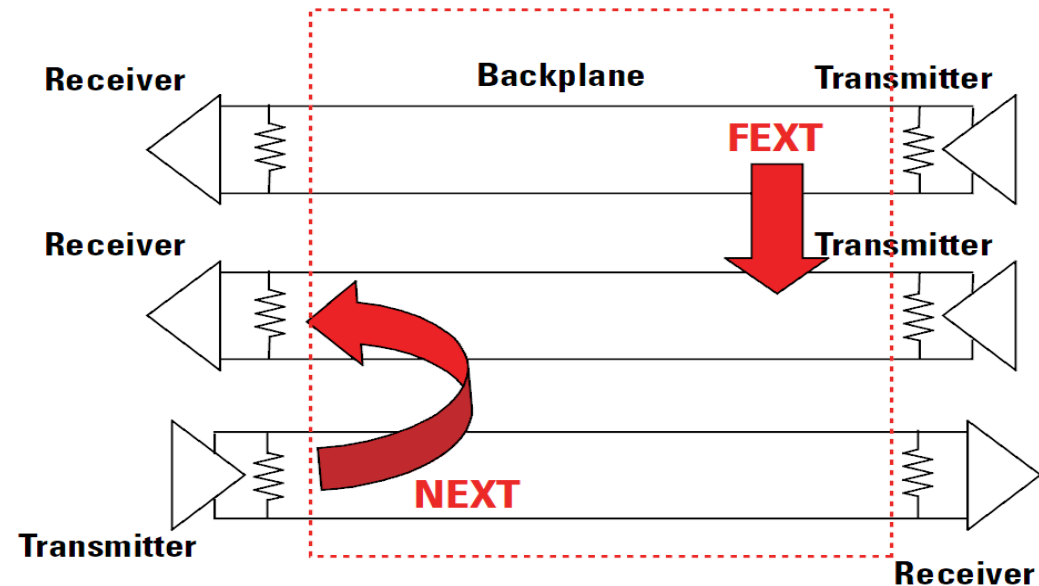
## Far-End Crosstalk (FEXT)

- Crosstalk noise is injected into the victim channel at the far end of a channel and is measured at the receiver

## Near-End Crosstalk (NEXT)

- Crosstalk noise usually from an adjacent transmitter is injected at the receive end and is measured at the receiver

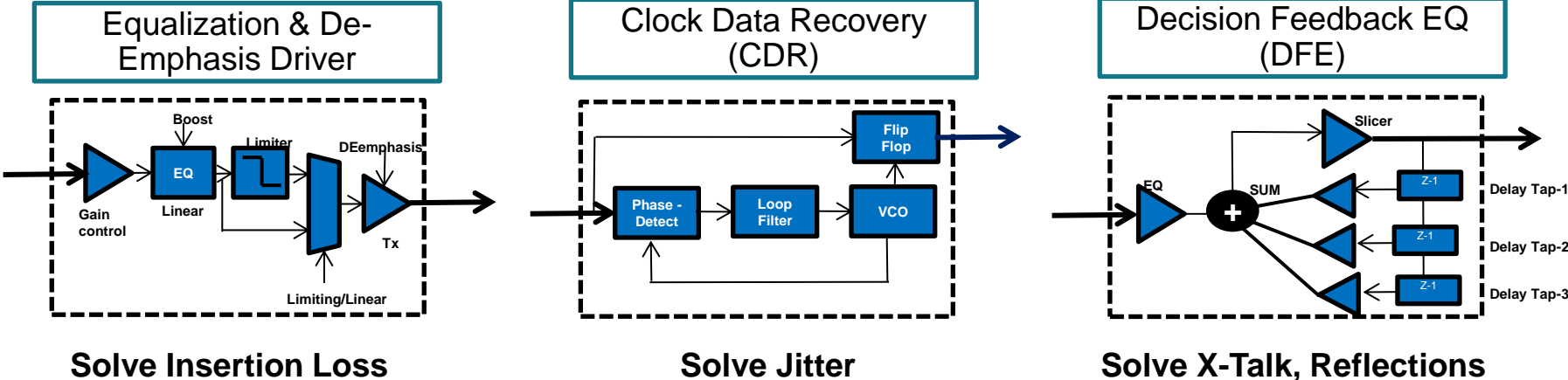
## Far-End & Near-End Crosstalk Examples





# Signal Conditioning Solutions

# Solve Key Challenges: Loss, Jitter, X-talk



Repeater

Retimer

Advanced Retimer

# TI repeater portfolio

EXISTING

NEW

Repeater/ Redriver	TI Repeater Portfolio			
	PCIe	SAS/SATA	10G-KR	100GbE
	<b>DS125BR820</b> PCIe 1/2/3, SAS 1/2/3, SATA 6G, 10G/40G Ethernet (KR4, SR4, LR4, CR4) Octal Channel			
	<b>DS125BR111</b> PCIe 1/2/3, SAS 1/2/3, SATA 6G One Lane (Single Port)			
	<b>DS125BR800A</b> PCIe 1/2/3, SAS 1/2/3, SATA 6G Octal Channel			
	<b>DS125BR401A</b> PCIe 1/2/3, SAS 1/2/3, SATA 6G Quad Lane			
	<b>DS80PCI810</b> PCIe Gen-1/2/3 Octal Channel	<b>DS100BR410</b> SAS II, SATA 6G Quad Channel	<b>DS100KR800</b> 10G-KR Octal Channel	
	<b>DS80PCI402</b> PCIe Gen-1/2/3 Four Lane	<b>DS100BR210</b> SAS II, SATA 6G Dual Channel	<b>DS100KR401</b> 10G-KR Quad Lane	
	<b>DS80PCI102</b> PCIe Gen-1/2/3 One Lane	<b>DS64BR401</b> SAS II, SATA 6G Four Lane	<b>DS100BR210</b> 10G-KR Dual Channel	<b>DS280BR820</b> 100GbE SR4/LR4/CR4/KR4 Octal Channel
	<b>DS50PCI402</b> PCIe Gen-1/2 Four Lane	<b>DS64BR111</b> SAS II, SATA 6G One Lane	<b>DS100BR111</b> 10G-KR One Lane	<b>DS280BR810</b> 100GbE SR4/LR4/CR4/KR4 Octal Channel

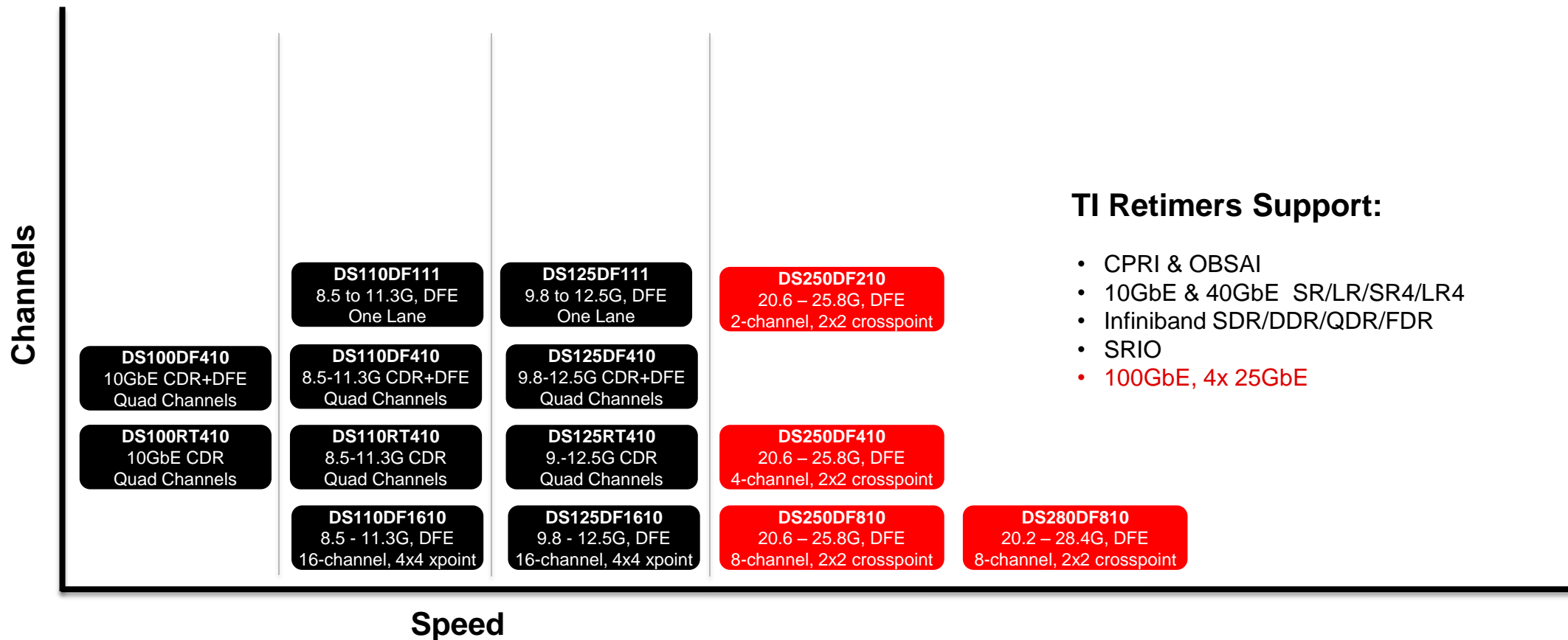
## TI Repeaters Support:

- CPRI & OBSAI
- SAS Gen 1/2/3
- SATA Gen 1/2/3
- PCIe Gen 1/2/3
- 10GbE & 40GbE KR4/CR4/SR4/LR4
- Fibre Channel
- 100GbE & 4x 25GbE

# TI retimer portfolio

EXISTING

NEW



## TI Retimers Support:

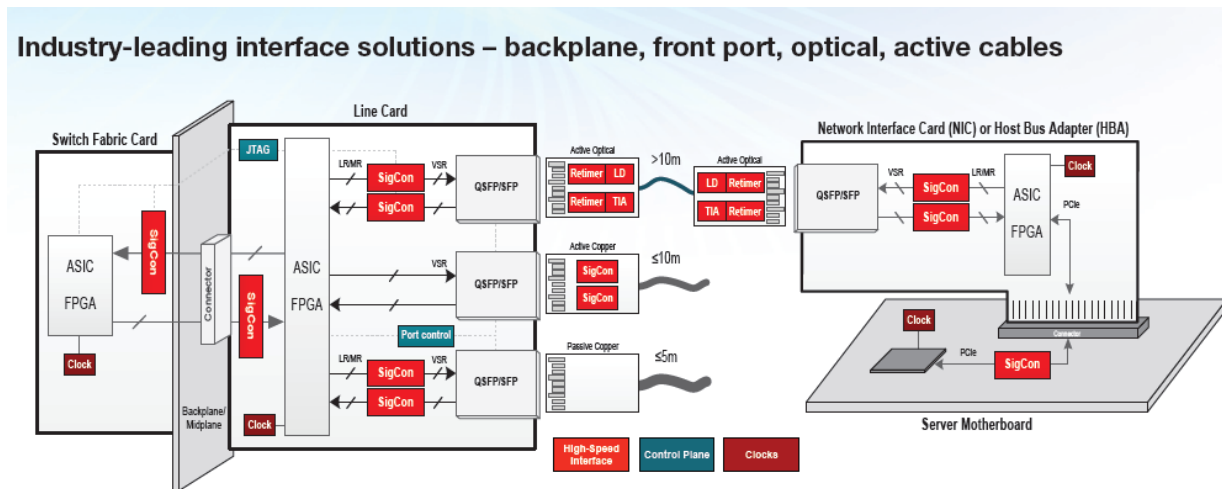
- CPRI & OBSAI
- 10GbE & 40GbE SR/LR/SR4/LR4
- Infiniband SDR/DDR/QDR/FDR
- SRIO
- 100GbE, 4x 25GbE

# Signal conditioner devices for SFF-8431 SFP+

- The SFF-8431 MSA specification enables 10G Ethernet port side support of various physical media types through the SFP+ module form factor.

TI SigCon Product	Level of Signal Conditioning	Functional Blocks Implemented	10G Part Numbers
Repeater	Insertion Loss Compensation	Rx EQ, Tx De-emphasis	DS100BR111 DS100BR410
Retimer	Loss + Jitter	Adaptive Rx EQ, Tx De-emphasis, CDR	DS100RT410 DS110RT410
Advanced Retimer	Loss + Jitter + Crosstalk + Reflections	Adaptive Rx EQ + DFE, CDR, Tx De-emphasis	DS100DF410 DS110DF410 DS110DF111 DS125DF410 DS125DF111 DS125DF1610

# Advanced signal conditioning made easy



## Industry's Best Analog Performance & Power Consumption

- Powered by BiCMOS SiGe process: 4x gain compared to CMOS
- 36 dB equalization at 5 GHz: up to 2x higher than competition
- 5 mW/Gbps power consumption: up to 2x lower than competition
- Less than 0.3UI residual jitter at 10Gbps
- Select from 8/4/2/1 channel configuration, 28 Gbps data rate

## Significantly Reduced System Design Complexity & BOM Cost

- Fully adaptive equalization
- No CDR reference clock needed
- Built-in eye monitor and PRBS generator
- Single power supply with integrated noise rejection filter
- Pin-compatible retimers and repeaters

# High-speed signal conditioning portfolio

## Comms Interface (Wired, Wireless)

### Products

- Retimer, Repeater/Redriver
- Crosspoint, Mux/Fanout
- 10/40/100/400 GbE
- CPRI, IB, FC

### Applications

- BTS RRU/ BBU
- Switches/Routers
- Telecom Backhaul



## Compute Interface (Enterprise, Client)

### Products

- Retimer, Repeater
- Crosspoint, Mux/Fanout
- PCIe, SAS, SATA

### Applications

- Servers
- Storage
- Notebooks, Docking
- Active cables



## Optical Interface (Datacenter, Wireless)

### Products

- CDR, Transceiver
- Post-Amp, Laser Driver
- TIA
- Optical Port controllers

### Applications

- Optical Modules
- Embedded Optics
- Active Optical Cables
- Front Port Controllers



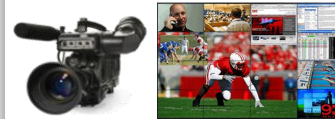
## Video Interface (Broadcast, Prosumer)

### Products

- Cable EQ, Driver
- Reclocker (CDR), Bi-dir I/O
- Aggregators
- SDI, UHD-Link

### Applications

- Broadcast Switch, Router
- Pro-Video Accessories
- Display wall, Signage
- A/V Distribution networks



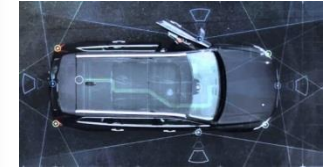
## Auto Interface (Data Backbones)

### Products

- Retimer, Repeater
- Crosspoint, Mux/Fanout
- 10/25GbE, PCIe

### Applications

- CPU-to-CPU interconnect
- ML (Machine Learning) interconnects



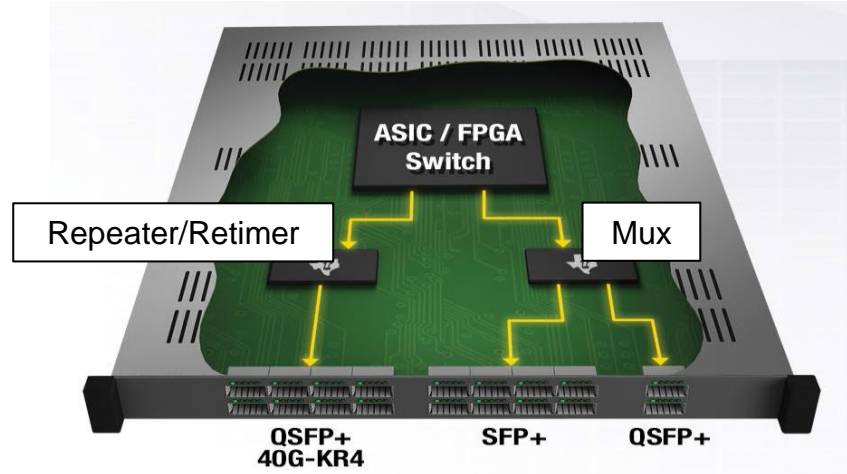
# Solutions for storage & I/O protocols

Protocol	Data Rate	Function	Supporting TI Devices	Channels / Lanes
PCI Express 1.0 / 2.0	2.5 / 5.0 Gbps	Repeater with EQ and De-Emphasis	DS50PCI402	8 channel / 4 lane
PCI Express 1.0 / 2.0 / 3.0 (backwards compatible)	2.5 / 5.0 / 8.0 Gbps	Repeater with EQ and De-Emphasis	DS80PCI102 DS80PCI402 DS80PCI800 DS80PCI810 DS125BR401A DS125BR800A	2 channel / 1 lane 8 channel / 4 lane 8 channel 8 channel 8 channel / 4 lane 8 channel
PCI Express 1.0 / 2.0 / 3.0 (backwards compatible)	2.5 / 5.0 / 8.0 Gbps	Mux / Fan-out with EQ and De-Emphasis	DS100MB203 DS125MB203	Dual 2:1/1:2 mux + fanout Dual 2:1/1:2 mux + fanout
SAS 2.0 / SATA 3.0 (backwards compatible)	3.0 / 6.0 Gbps	Repeater with EQ and De-Emphasis	DS64BR111 DS64BR401 DS100BR210 DS100BR410	2 channel / 1 lane 8 channel / 4 lane 2 channel 4 channel
SAS 2.0 / SATA 3.0 (backwards compatible)	3.0 / 6.0 Gbps	Mux / Fan-out with EQ and De-Emphasis	DS64MB201 SN65LVCP114 DS125MB203	Dual 2:1/1:2 mux + fanout Quad mux Dual 2:1/1:2 mux + fanout
SAS 3.0 / SATA 3.0 (backwards compatible)	3.0 / 6.0 / 12.0 Gbps	Repeater with EQ and De-Emphasis	DS125BR401A DS125BR800A DS125BR820	8 channel / 4 lane 8 channel
Ethernet 10GBASE-KR	10.3125 Gbps	Repeater with EQ and De-Emphasis	DS125BR820 DS100BR111 DS100BR210 DS100KR401 DS100KR800	2 channel / 1 lane 2 channel 8 channel / 4 lane 8 channel



# Signal Conditioning Applications

# Featured products: Network switch, router



Visit [www.ti.com/sigcon](http://www.ti.com/sigcon) for full sigcon solutions guide

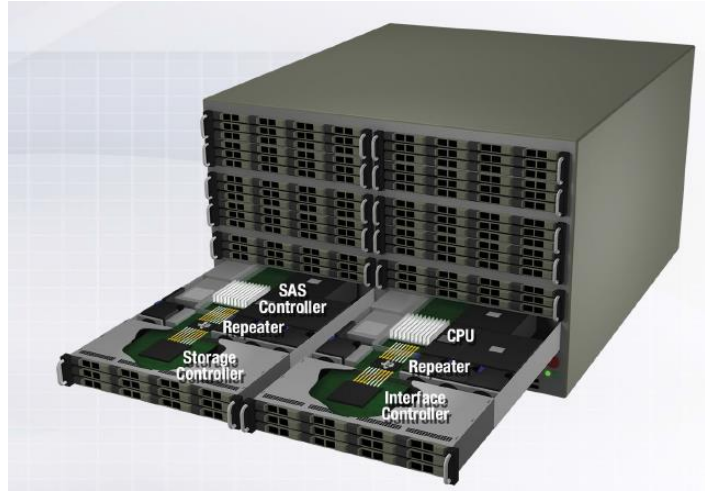
View Products on [www.ti.com](http://www.ti.com)

- Full Datasheet Download
- Request Samples
- Order Evaluation kits
- Compare products

Device	Device Type	Protocols*	Channels	Data Rate (Gbps)	Package (mm)
<b>DS100DF410</b>	Retimer	10GbE, SFF-8431, 40G-SR4/LR4	4	10.3125	7x7 WQFN
<b>DS250DF810</b>	Retimer	IEEE802.3bj, 100GbE, Infiniband EDR OIF-CEi-25G-LR/MR/SR/VSR	8	20.6 to 25.8	13x8 BGA
<b>DS100MB203</b>	Mux Buffer	10GbE, SFF-8431, 40G-SR4/LR4/CR4	Dual 2:1, Dual 1:2	Up to 10.3125	10x5.5 WQFN
<b>DS280BR810</b>	Repeater	IEEE802.3bj, 100GbE, Infiniband EDR OIF-CEi-25G-LR/MR/SR/VSR	8	Up to 28	13x8 BGA

25/28G Signal Conditioners are now in production!

# Featured products: Server, storage



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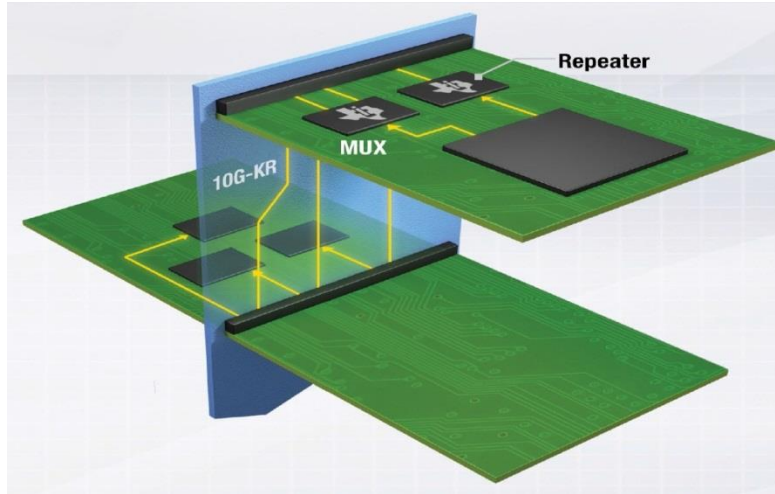
Device	Device Type	Protocols*	Channels	Data Rate (Gbps)	Package (mm)
DS125BR111	Repeater	PCIe/SAS/SATA 1/2/3	2	Up to 12.5	4x4 WQFN
DS125BR820	Repeater	PCIe/SAS/SATA 1/2/3, 40G-SR4/LR4/KR4/CR4	8	Up to 12.5	10x5.5 WQFN
DS80PCI810	Repeater	PCIe 1/2/3	8	Up to 8	10x5.5 WQFN
DS125MB203	Mux Buffer	PCIe/SATA 1/2/3, SAS ½	Dual 2:1 Dual 1:2	Up to 12.5	10x5.5 WQFN

[DS80PCI800 / 810 – Intel Blue Sheet #554841](#)

[DS80PCI810 – Only PCIe Gen-3 repeater \(redriver\) approved on \[PCI-SIG Integrator List!\]\(#\)](#)

[DS125BR111– On Intel Grantley reference designs \(#543623 on Intel portal\)](#)

# Featured products: Network backplane



Visit [www.ti.com/sigcon](http://www.ti.com/sigcon) for full sigcon solutions guide

View Products on [www.ti.com](http://www.ti.com)

- Full Datasheet Download
- Request Samples
- Order Evaluation kits
- Compare products

Device	Device Type	Protocols*	Channels	Data Rate (Gbps)	Package (mm)
<b>DS100KR800</b>	Repeater	10G-KR, 40G-KR4	8	Up to 10.3125	10x5.5 WQFN
<b>DS125BR820</b>	Repeater	10G-KR, 40G-KR4, PCIe/SAS/SATA 1/2/3, CPRI, OBSAI	8	Up to 12.5	10x5.5 WQFN
<b>DS125DF1610</b>	Retimer	10GbE, CPRI, OBSAI	16	9.8 to 12.5**	15x15 FCBGA
<b>DS125MB203</b>	Mux Buffer	10G-KR, PCIe/SATA 1/2/3, SAS 1/2, CPRI, OBSAI	Dual 2:1 Dual 1:2	Up to 12.5	10x5.5 WQFN

Flexible signal routing + reach extension with the [DS125DF1610](#) integrated cross-point!

# Tools & Resources

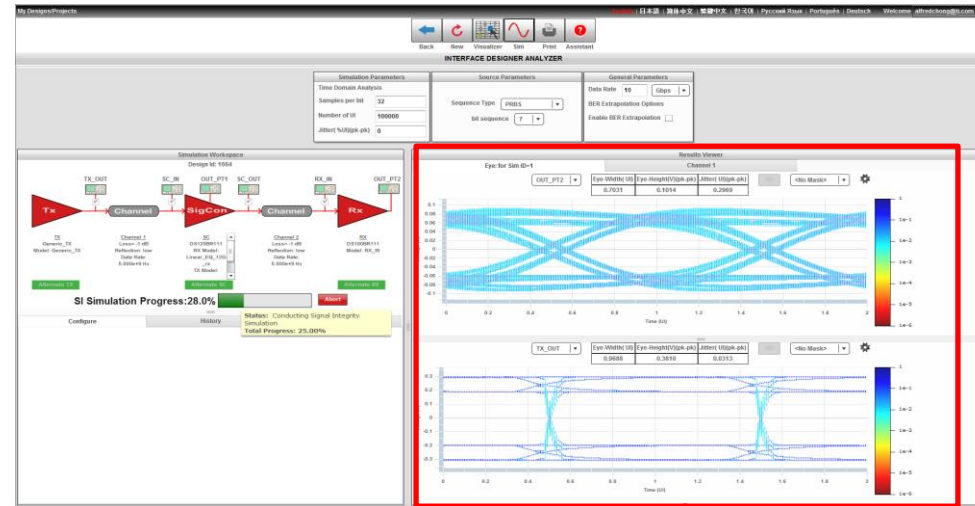
# WEBENCH® Interface Designer

WEBENCH® Designer *My Designs*

The interface shows a block diagram with a TX block, two Channel blocks, a central SigCon block, and an RX block. Below the diagram are configuration options:

- Tx: Generic Tx
- Mid Channel: TI Mid Channel SigCon
- Rx: Generic Rx
- Max Data Rate: 0 Gbps
- Device Mode: Differential
- Start Design**

- Simple and free to use on <http://www.ti.com/sigcon>
- Evaluate performance in minutes!



Free IBIS AMI channel simulation with TI products

# Signal Conditioning Resources

- Interface Communications Solutions: <http://www.ti.com/lit/sg/slyt577/slyt577.pdf>
- Extend Reach – Distribute Signals: <http://www.ti.com/lit/ml/slyb231/slyb231.pdf>
- The Intricacies of Signal Integrity in High Speed Communications: <http://www.ti.com/lit/an/slyt672/slyt672.pdf>
- Selecting TI SigCon Devices for SFF-8431 SFP+ Applications: <http://www.ti.com/lit/an/snla225/snla225.pdf>
- Signaling Rate Versus Distance for Differential Buffers: <http://www.ti.com/lit/an/slla302/slla302.pdf>
- LVDS Owner's Manual: <http://www.ti.com/lit/ml/snla187/snla187.pdf>
- WEBENCH SigCon Architect: <http://www.ti.com/tool/sigconarchitect>



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