Signal Conditioning Challenges
Identify key challenges: Loss, jitter, x-talk

**Insertion Loss**
Length, media, and speed all contribute to loss

**Crosstalk & Reflections**
High density I/O and multiple connectors add interference

**Jitter**
Phy integration and smaller geometry CMOS reduce Tx jitter performance

**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”
Random jitter

SERDES Bathtub Curve Performance

- Minimize Deterministic Jitter (DJ)
  - Use Equalization
- Minimize Random Jitter (RJ)
  - Use Low-Noise Clocks

Random jitter reduces the eye opening

Scope Results

- Eye Open
- Eye closing due to jitter

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
Solve Key Challenges: Loss, Jitter, X-talk

Equalization & De-Emphasis Driver
- EQ
- Limiter
- DEemphasis
- Gain control
- Boost
- Linear
- Limiting/Linear
- Tx

Solve Insertion Loss

Clock Data Recovery (CDR)
- Phase Detect
- Loop Filter
- Flip Flop
- VCO

Solve Jitter

Decision Feedback EQ (DFE)
- Slicer
- SUM
- Delay Tap-1
- Delay Tap-2
- Delay Tap-3

Solve X-Talk, Reflections

Repeater

Retimer

Advanced Retimer
TI repeater portfolio

TI Repeaters Support:

- CPRI & OBSAI
- SAS Gen 1/2/3
- SATA Gen 1/2/3
- PCIe Gen 1/2/3
- Fibre Channel
- 100GbE & 4x 25GbE
TI retimer portfolio

**EXISTING**

- **DS100RT410**
  8.5 to 11.3G CDR
  Quad Channels

- **DS100DF410**
  8.5 to 11.3G CDR+DFE
  Quad Channels

- **DS110RT410**
  8.5 to 11.3G CDR
  Quad Channels

- **DS110DF410**
  8.5 to 11.3G CDR+DFE
  Quad Channels

- **DS110DF1610**
  8.5 to 11.3G, DFE
  16-channel, 4x4 xpoint

- **DS125RT410**
  9.8 to 12.5G CDR
  Quad Channels

- **DS125DF410**
  9.8 to 12.5G CDR+DFE
  Quad Channels

- **DS125DF1610**
  9.8 to 12.5G, DFE
  16-channel, 4x4 xpoint

- **DS250DF410**
  20.6 – 25.8G, DFE
  4-channel, 2x2 crosspoint

- **DS250DF210**
  20.6 – 25.8G, DFE
  2-channel, 2x2 crosspoint

**NEW**

- **DS110DF111**
  8.5 to 11.3G, DFE
  One Lane

- **DS125DF111**
  9.8 to 12.5G, DFE
  One Lane

- **DS250DF810**
  20.6 – 25.8G, DFE
  8-channel, 2x2 crosspoint

- **DS280DF810**
  20.2 – 28.4G, DFE
  8-channel, 2x2 crosspoint

**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.

<table>
<thead>
<tr>
<th>TI SigCon Product</th>
<th>Level of Signal Conditioning</th>
<th>Functional Blocks Implemented</th>
<th>10G Part Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repeater</td>
<td>Insertion Loss Compensation</td>
<td>Rx EQ, Tx De-emphasis</td>
<td>DS100BR111, DS100BR410</td>
</tr>
<tr>
<td>Retimer</td>
<td>Loss + Jitter</td>
<td>Adaptive Rx EQ, Tx De-emphasis, CDR</td>
<td>DS100RT410, DS110RT410</td>
</tr>
<tr>
<td>Advanced Retimer</td>
<td>Loss + Jitter + Crosstalk + Reflections</td>
<td>Adaptive Rx EQ + DFE, CDR, Tx De-emphasis</td>
<td>DS100DF410, DS110DF410, DS110DF111, DS125DF410, DS125DF111, DS125DF1610</td>
</tr>
</tbody>
</table>
Advanced signal conditioning made easy

Industry-leading interface solutions – backplane, front port, optical, active cables

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

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Data Rate</th>
<th>Function</th>
<th>Supporting TI Devices</th>
<th>Channels / Lanes</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCI Express 1.0 / 2.0</td>
<td>2.5 / 5.0 Gbps</td>
<td>Repeater with EQ and De-Emphasis</td>
<td>DS50PCI402</td>
<td>8 channel / 4 lane</td>
</tr>
<tr>
<td>PCI Express 1.0 / 2.0 / 3.0 (backwards compatible)</td>
<td>2.5 / 5.0 / 8.0 Gbps</td>
<td>Repeater with EQ and De-Emphasis</td>
<td>DS60PCI102, DS60PCI402, DS60PCI800, DS60PCI810, DS125BR401A, DS125BR800A</td>
<td>2 channel / 1 lane, 8 channel / 4 lane, 8 channel / 4 lane, 8 channel</td>
</tr>
<tr>
<td>PCI Express 1.0 / 2.0 / 3.0 (backwards compatible)</td>
<td>2.5 / 5.0 / 8.0 Gbps</td>
<td>Mux / Fan-out with EQ and De-Emphasis</td>
<td>DS100MB203, DS125MB203</td>
<td>Dual 2:1/1:2 mux + fanout, Dual 2:1/1:2 mux + fanout</td>
</tr>
<tr>
<td>SAS 2.0 / SATA 3.0 (backwards compatible)</td>
<td>3.0 / 6.0 Gbps</td>
<td>Repeater with EQ and De-Emphasis</td>
<td>DS64BR111, DS64BR401, DS100BR210, DS100BR410</td>
<td>2 channel / 1 lane, 8 channel / 4 lane, 2 channel / 4 channel</td>
</tr>
<tr>
<td>SAS 2.0 / SATA 3.0 (backwards compatible)</td>
<td>3.0 / 6.0 Gbps</td>
<td>Mux / Fan-out with EQ and De-Emphasis</td>
<td>DS64MB201, SN65LVCP114, DS125MB203</td>
<td>Dual 2:1/1:2 mux + fanout, Quad mux, Dual 2:1/1:2 mux + fanout</td>
</tr>
<tr>
<td>SAS 3.0 / SATA 3.0 (backwards compatible)</td>
<td>3.0 / 6.0 / 12.0 Gbps</td>
<td>Repeater with EQ and De-Emphasis</td>
<td>DS125BR401A, DS125BR800A, DS125BR820</td>
<td>8 channel / 4 lane, 8 channel</td>
</tr>
<tr>
<td>Ethernet 10GBASE-KR</td>
<td>10.3125 Gbps</td>
<td>Repeater with EQ and De-Emphasis</td>
<td>DS125BR820, DS100BR111, DS100BR210, DS100KR401, DS100KR800</td>
<td>2 channel / 1 lane, 2 channel / 8 channel, 8 channel / 4 lane, 8 channel</td>
</tr>
</tbody>
</table>
Signal Conditioning Applications
### Featured products: Network switch, router

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

25/28G Signal Conditioners are now in production!


View Products on [www.ti.com](http://www.ti.com).
- Full Datasheet Download
- Request Samples
- Order Evaluation kits
- Compare products

[View Products on www.ti.com](http://www.ti.com)
### Featured products: Server, storage

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<tr>
<td>DS125BR111</td>
<td>Repeater</td>
<td>PCIe/SAS/SATA 1/2/3</td>
<td>2</td>
<td>Up to 12.5</td>
<td>4x4 WQFN</td>
</tr>
<tr>
<td>DS125BR820</td>
<td>Repeater</td>
<td>PCIe/SAS/SATA 1/2/3, 40G-SR4/LR4/KR4/CR4</td>
<td>8</td>
<td>Up to 12.5</td>
<td>10x5.5 WQFN</td>
</tr>
<tr>
<td>DS80PCI810</td>
<td>Repeater</td>
<td>PCIe 1/2/3</td>
<td>8</td>
<td>Up to 8</td>
<td>10x5.5 WQFN</td>
</tr>
<tr>
<td>DS125MB203</td>
<td>Mux Buffer</td>
<td>PCIe/SATA 1/2/3, SAS 1/2</td>
<td>Dual 2:1 Dual 1:2</td>
<td>Up to 12.5</td>
<td>10x5.5 WQFN</td>
</tr>
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**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

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

Flexible signal routing + reach extension with the DS125DF1610 integrated cross-point!
Tools & Resources
WEBENCH® Interface Designer

- Simple and free to use on [http://www.ti.com/sigcon](http://www.ti.com/sigcon)
- Evaluate performance in minutes!

Free IBIS AMI channel simulation with TI products
Signal Conditioning Resources

• 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
• WEBENCH SigCon Architect:  http://www.ti.com/tool/sigconarchitect