Application Note

Extend Reach with Ethernet Redrivers and Retimers for 10GbE and Other 10–12.5 Gbps Applications

ABSTRACT

Since the introduction of 10GbE (10 Gigabit Ethernet) by IEEE 802.3 in 2002 and IEEE802.3ap for Ethernet backplanes in 2007, 10GbE has evolved into a universal interface across a variety of industrial applications. Ethernet redrivers and retimers have also become increasingly popular as data rates rise to improve high-speed signal integrity margins and increase system interoperability across a variety of high-speed applications. TI's wide portfolio of 10GbE redrivers and retimers span multiple channel configurations to suit a variety of Ethernet application use cases and requirements. Moreover, these redrivers and retimers may be considered for use in other popular adjacent 10–12.5 Gbps protocols. With proper selection and utilization, redrivers and retimers offer a convenient and cost-effective way to ensure that a great high-speed connection is always within reach.

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1 Introduction

Since the introduction of 10GbE (10 Gigabit Ethernet) by IEEE 802.3 in 2002 and IEEE802.3ap for Ethernet backplanes in 2007, 10GbE has evolved into a universal interface across a variety of industrial applications. Today, despite ever-increasing demands to support 25GbE and 50GbE interfaces, the 10GbE (10.3125 Gbps) interface remains ever-present in telecommunications, data center switch, wireless base station, servers, and storage networks as the default interface for transporting large bandwidths of network information. 10GbE and similar data rate interfaces have also seen adoption in video-over-IP infrastructures, medical imaging (for example, CT scan, ultrasound scanner, medical endoscope, and cameras), and industrial communication switches.

Ethernet redrivers and retimers have also become increasingly popular as data rates rise. These signal conditioning devices improve signal integrity and enable reliable, error-free high-speed link connectivity. In today’s highly integrated systems, it is all too easy to envision applications where long, lossy PCB trace lengths or passive cables cause link issues. Moreover, non-ideal noisy ASIC Tx signals can result in marginal eye mask compliance at front ports, while aggressor crosstalk in high-density PCB areas diminishes the SNR (signal-to-noise ratio) needed for error-free operation at the far-end Rx.

This application note addresses the advantage of signal conditioning, presents key applicable 10GbE and 40GbE standards and signal conditioning applications, and provides guidance about how to select the most appropriate redriver or retimer. Lastly, this document offers an overview for applying 10GbE redrivers and retimers to support adjacent 10–12.5 Gbps protocols.

2 Advantage of Signal Conditioning for High-Speed Integrity

As data rates rise to meet the bandwidth demands of an increasingly connected society, there are several persistent signal integrity challenges, highlighted in Figure 2-1.

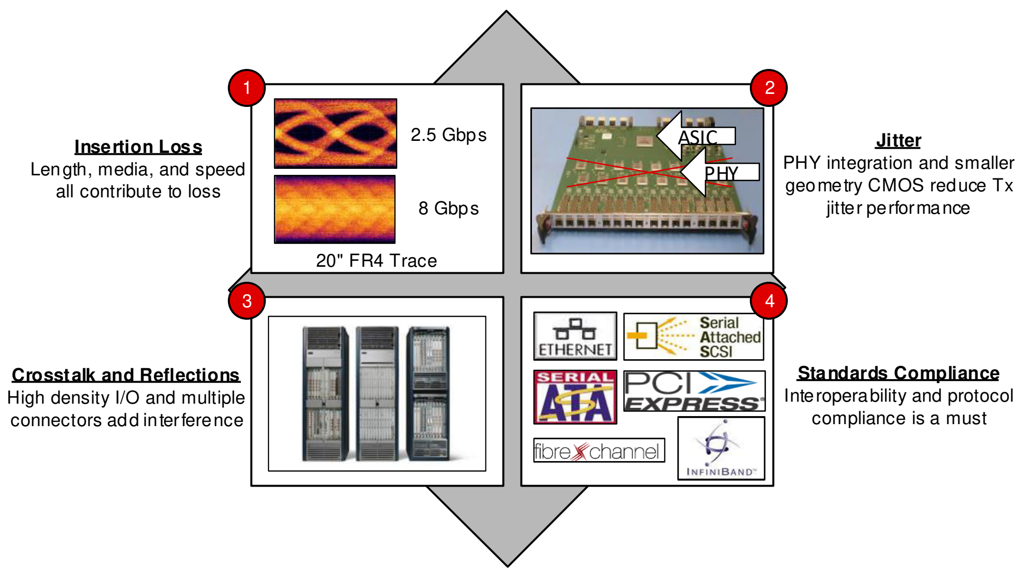

Figure 2-1. Key Signal Integrity Challenges for Increasing Data Rates

These challenges are summarized below:

1. **Increased IL (Insertion Loss):** SNR degrades as data rates increase. Typically the IL for a given length of PCB trace or cable increases logarithmically with frequency.
2. **Increased ASIC/FPGA Integration:** Greater integration and smaller process nodes improve the capability and throughput of a given FPGA or ASIC while reducing the number of external PHYs. However, there is often a tradeoff in analog performance, resulting in sub-optimal high-speed jitter performance from the FPGA or ASIC Tx.
3. **Increased Board Complexity and Signal Density:** In high-density I/O applications, there is a constant challenge to counteract crosstalk and reflections while avoiding overheating of closely spaced components.

4. **Diversity of Standards Interoperability:** Design expertise is required to generate a successful product in a limited amount of time. Systems must be able to meet the demands of ever-changing industry and standards revisions.

2.1 Reach Issues at Higher Data Rates

Among the previously mentioned challenges for increasing bandwidth needs, perhaps the most common issue for signal integrity is the drastic increase in IL as a function of frequency. For example, take a typical use case for an ASIC located on a server blade that must connect to a JBOD (Just a Bunch Of Disks) shown in Figure 2-2.

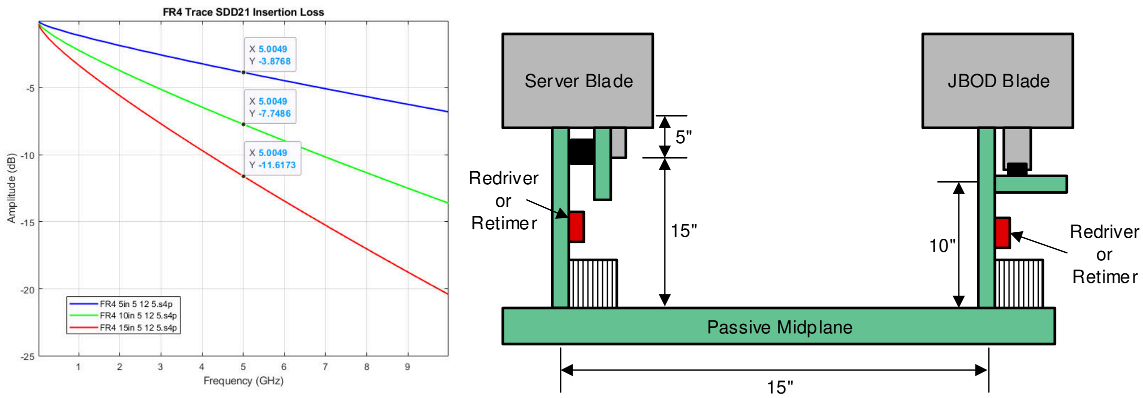

Figure 2-2. IL Increases with Frequency While PCB Distance Remains the Same

Taking the use case of a server blade ASIC to JBOD ASIC, the total distance is approximately 5 + 15 + 15 + 10 = 45”. Note that additional connectors and cables contribute further to IL, reflection (return loss), and other channel impairments. At 625 MHz (1GbE Nyquist), the insertion loss for 45” FR4 totals less than 10 dB. However, at 5 GHz (10GbE Nyquist), the total loss for the same PCB trace length ([2 x 11.62] + 7.75 + 3.88) becomes nearly 35 dB!

It is clear that the IL presents a challenge for ASICs to maintain high-speed link integrity requirements. Moreover, parasitic effects, such as random jitter, cross-talk, and reflections, play a larger role at high speeds in reducing the overall SNR (signal-to-noise ratio). Combined, these signal impairments can overwhelm a system, resulting in either compliance failure or poor system performance.

2.2 Signal Conditioning as an Economic and Practical High-Speed Solution

There are several ways to counteract high-speed reach extension issues and reduce IL.

1. Reduce the ASIC-to-ASIC distance and thereby reduce total IL.
2. Use higher-grade, low-loss PCB dielectrics to reduce dB/in. while maintaining the same ASIC-to-ASIC distance.
3. Use signal conditioning devices such as redrivers and retimers mid-channel while maintaining the same ASIC-to-ASIC distance.

Reducing the distance from ASIC to ASIC (Option 1) is often not feasible. Various architectural factors dictate the minimum high-speed trace length or cable distance for a given system. This leaves hardware designers with the choice of either low-loss PCB materials (Option 2) or signal conditioning devices (Option 3).

There is a fundamental trade-off between using low-loss PCB materials without signal conditioning and using standard PCB materials with signal conditioning. Low-loss PCB materials can significantly reduce the dB/in. IL of a channel, but it comes with a significant cost adder. An example of this trade-off at 5 GHz Nyquist for 10GbE applications can be seen in Table 2-1.

Table 2-1. PCB Dielectric Material Approximate IL and Approximate Cost Factor at 5 GHz(1)

Material	Board Loss	Tan (δ)	Dielectric Constant (ε_R)	IL (dB/in)	Approximate Cost Factor
Standard Typical FR4	High Loss	0.02	4	0.91	1.0x
Isola 370HR		0.016	4.17	0.82	1.1x
Isola FR406		0.014	4.29	0.78	1.1x
Nelco 4000-6		0.012	4.12	0.73	1.2x
Isola FR408		0.011	3.7	0.69	1.2x
Getek	Medium Loss	0.01	3.9	0.67	1.3x
Nelco 4000-13 EP		0.009	3.7	0.65	1.3x
Nelco 4000-13 EP SI		0.008	3.2	0.61	1.3x
Rogers 4350B	Low Loss	0.0037	3.48	0.53	1.7x
Megtron 6		0.002	3.4	0.49	1.7x

(1) Assumptions used for estimating IL:
- Conductor = Copper Microstrip
- Copper Thickness = 1.4 mils (1 oz.)
- Dielectric Height = 5 mils
- Trace Width = 5 mils

Low-loss materials may be advantageous for small prototypes and short-term savings in complexity. However, the added cost factor for low-loss materials becomes an issue for high-volume production builds. Excessively high PCB manufacturing costs reduce profit margins, especially when these materials are only needed to address a sub-section of the total PCB area. Lastly, designers must remember that high-grade PCB dielectrics only address the concern of IL. These premium materials cannot resolve excessive random jitter, cross-talk, or reflections.

In contrast to the shortcomings of Options 1 (not practical) and 2 (not cost-effective), signal conditioning devices (Option 3) provide an efficient and economical solution for addressing reach extension challenges. Redrivers and retimers offer a CTLE (continuous time linear equalizer) to resolve excessive IL. When applied, the CTLE provides an inverted EQ frequency response that acts to reverse the IL effect of the channel. Redrivers may be applied with standard PCB materials on a subset of traces that exceed the equalization capability of the far-end Rx. They may also be used in systems where additional signal integrity margin is needed to ensure compliance or error-free operation. In scenarios where channel impairments are more severe, retimers with CDR (clock and data recovery) may be used to reset the jitter budget, while advanced signal conditioning schemes such as DFE (decision feedback equalizer) remove the effects of crosstalk, and reflections. Retimers also provide the advantage of enabling real-time physical layer diagnostics that are beneficial both during development and after installment in the field.

In summary, signal conditioning devices such as redrivers and retimers are economic and practically diverse solutions that accomplish the goals of both link extension and robust product performance.

3 Redriver and Retimer Functionality and Tradeoffs

Redrivers and retimers are designed to resolve high-speed signal integrity issues. These devices are placed mid-channel between a source Tx and far-end Rx. When optimized, these devices work to negate losses over PCB trace or cable by equalizing and outputting an improved, regenerated signal to ensure both adequate reach extension and improved link margins. These devices also enable flexible channel design where the length may exceed the maximum IL normally allowed by a given specification.

Figure 3-1 illustrates key capabilities available for various redriver and retimer options in TI's portfolio of 10–12.5 Gbps signal conditioning portfolio.

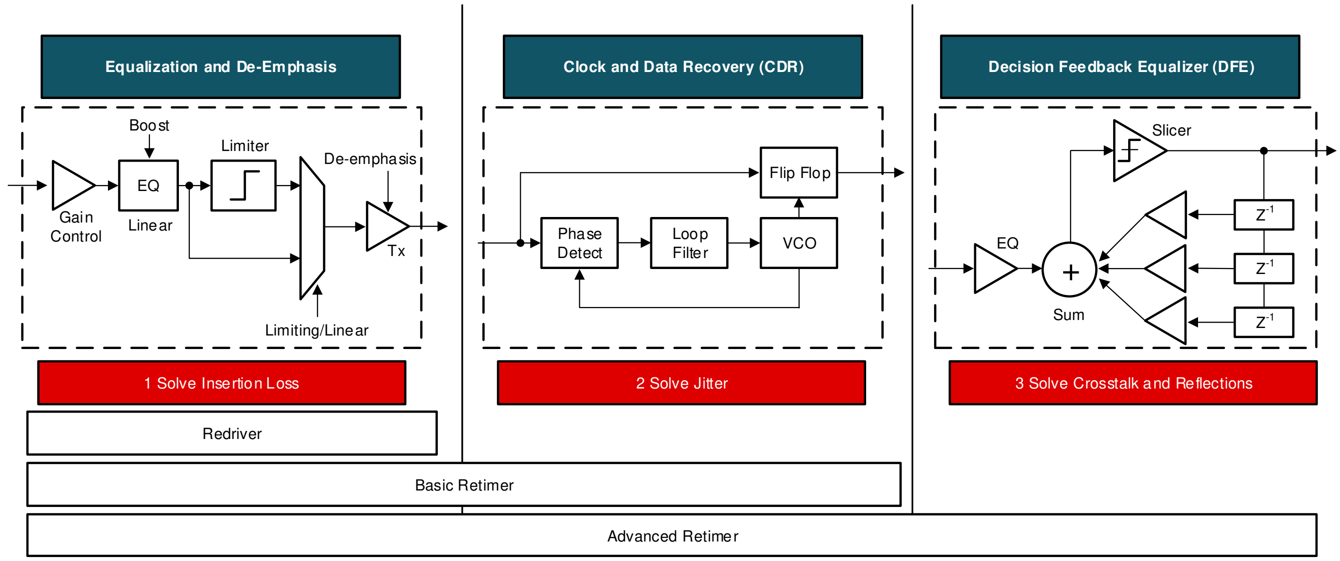

Figure 3-1. TI 10–12.5 Gbps Redriver and Retimer Functional Capabilities

3.1 Key Advantages and Disadvantages of Redrivers and Retimers

Table 3-1 highlights key advantages and disadvantages to consider when deciding between using redrivers or retimers in system applications. These statements are based on TI's signal conditioning portfolio, though they are largely applicable to redrivers and retimers in the industry.

Table 3-1. System Advantages and Disadvantages of Redrivers and Retimers

	Advantages	Disadvantages
Redriver (CTLE Only)	• Minimal to no programming required • No minimum operating data rate • Ultra-low latency • Linear channel enables LT (link training) support • Protocol-agnostic • Cheapest option	• Manual CTLE tuning is often needed • CTLE only compensates for jitter associated with channel IL • Cannot compensate for reflections or crosstalk
Basic Retimer (CTLE + CDR)	• Adaptive CTLE • CDR resets jitter budget and removes excessive random jitter • Enables longer total system reach than redriver due to regeneration of signal on clean internal clock • On-chip Eye Opening Monitor (EOM) for diagnostic purposes	• Some programming may be required • Operating data rate is dependent on VCO lock range • CDR and limiting driver cannot be used for LT support
Advanced Retimer (CTLE + DFE + CDR)	• Same benefits as listed above for Basic Retimer advantages • Adaptive DFE to compensate crosstalk and reflection	• Some programming may be required. Operating data rate is dependent on VCO lock range • CDR and limiting driver cannot be used for LT support • Most expensive option

3.2 Using Link Budget to Determine Between Redriver and Retimer

Aside from the inherent system advantages of redrivers and retimers described in Table 3-1, the choice of redriver or retimer may be determined by assessing the end-to-end link budget between connected ASICs. In a high-speed system, the ASIC Rx normally features equalization capability required by a given specification. As the PCB or cable length between ASICs approaches and begins to exceed the ASIC Rx EQ's limits, redrivers are ideal candidates. As the insertion loss between ASICs significantly exceeds the ASIC's Rx EQ capability, retimers are essential choices as a mid-channel device to enable up to double the overall channel reach.

The following example illustrates a practical way to discern between redrivers and retimers based on the expected ASIC-to-ASIC link budget for a typical 10GbE or 40GbE backplane application. Based on the fitted attenuation limits and IL equations found in IEEE802.3 Annex 69, the IL plot in Figure 3-2 is generated.

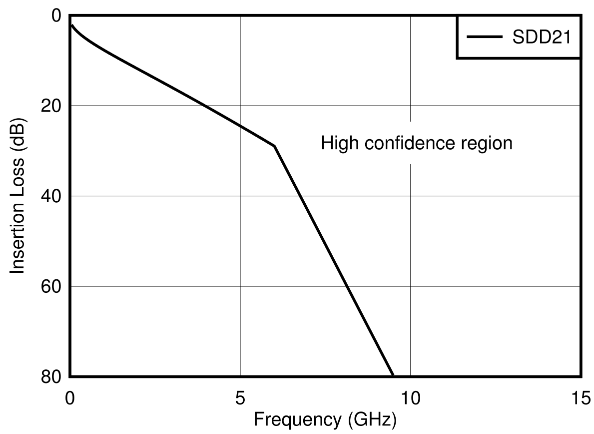

Figure 3-2. Insertion Loss Limit for 10GBASE-KR and 40GBASE-KR4 (IEEE802.3 Annex 69, Figure 69B-5)

The maximum IL at 5 GHz is 25.19 dB. With this in mind, signal conditioning may be considered as the overall link approaches and exceeds the maximum IL limit (25.19 dB), as shown in Figure 3-3.

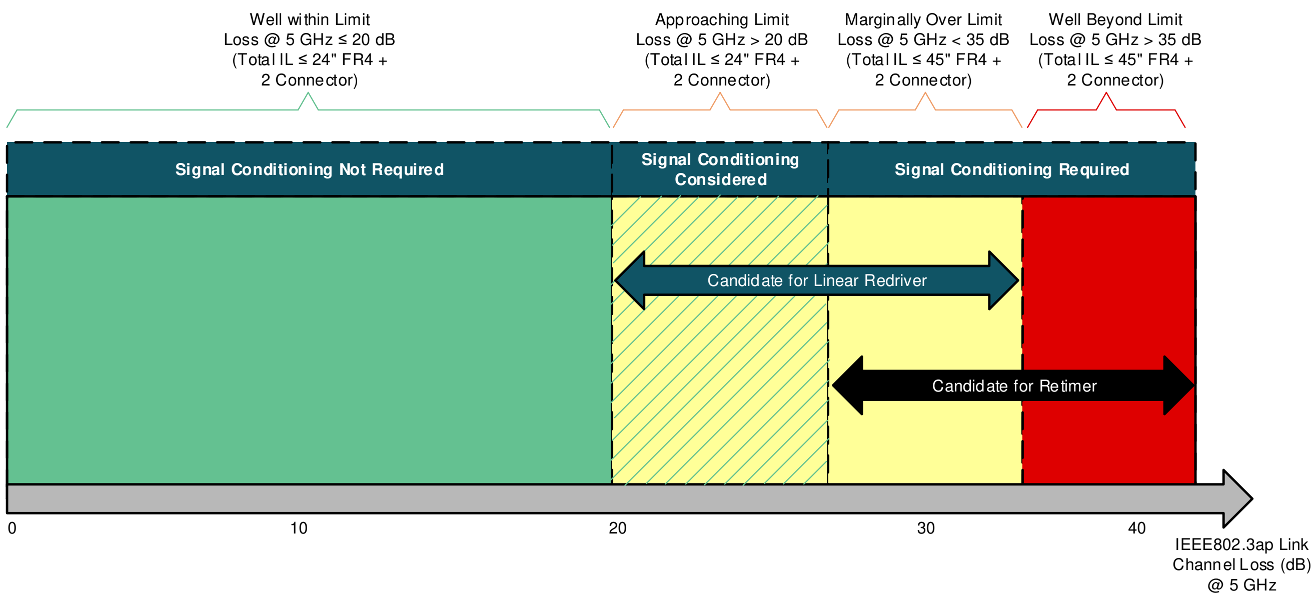

Figure 3-3. Link Budget Example to Determine Redriver Verses Retimer for 10GbE Backplane Applications

4 Key 10GbE and 40GbE Applications and Standards

The IEEE802.3 standard includes many subsections to address applications using 10.3125 Gbps NRZ signaling per lane. To determine the appropriate subsection, it is important to note the application use case (backplane PCB, optical, or copper interface), number of lanes used, and aggregate link data rate. The most popular 10GbE aggregation is 40GbE, which is constructed by combining 4 x 10GbE lanes. In 40GbE applications, the same 10GbE per lane electrical interface requirements are applicable.

Note

The IEEE802.3 standard accommodates a 100GbE interface by aggregating 10 x 10GbE lanes. However, this interface has not been widely used due to large industry adoption of 4 x 25GbE lanes.

4.1 Application Use Cases

Regardless of the end equipment, the majority of 10GbE and 40GbE application use cases can be categorized as either a backplane or front-port application. Figure 4-1 shows typical locations where redrivers and retimers can be found in Ethernet backplane or front-port applications to improve overall link margin and robustness.

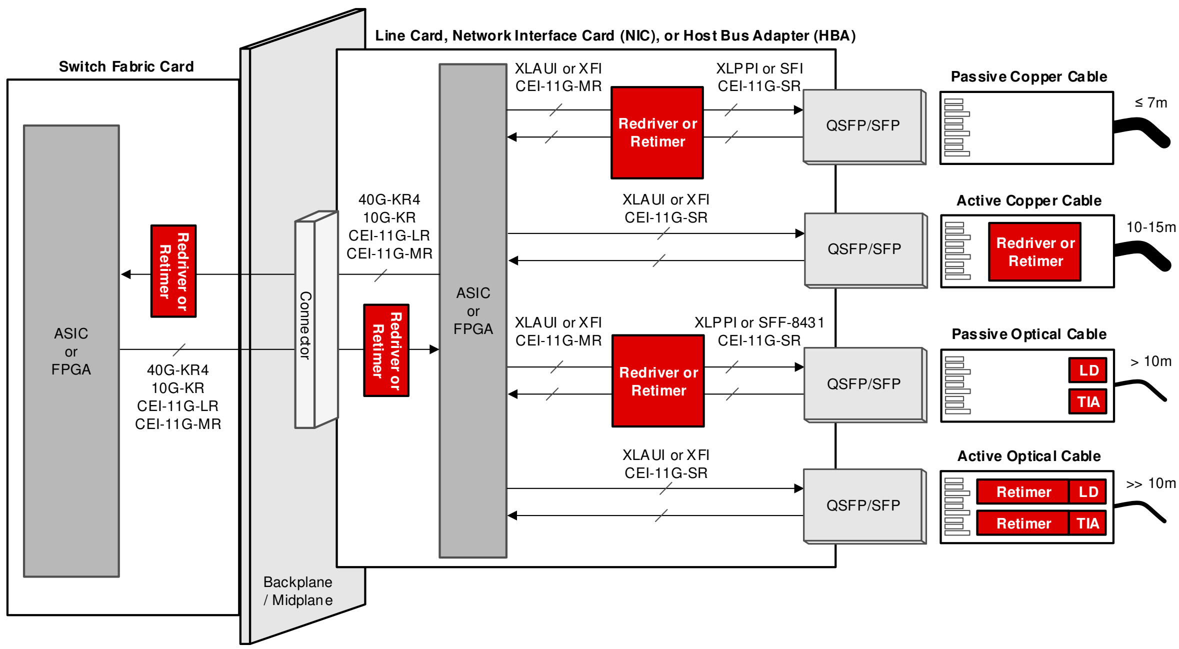

Figure 4-1. Typical Application Use Cases for Signal Conditioning in a 10GbE or 40GbE System

Table 4-1 may be used as a high-level guide regarding typical environmental characteristics for the various Ethernet application use cases shown in Figure 4-1.

Table 4-1. Environmental Characteristics for 10GbE and 40GbE Applications

Use Case	Location of Signal Conditioner	Description
Backplane/ Midplane	PCB Backplane between ASICs	• Rigid PCB connecting multiple cards together through 2+ connectors • Interconnect between switch blade and server blade in a chassis • Interconnect between line card and switch fabric in a router / aggregation switch • Long PCB trace (1m) and multiple sources of crosstalk due to dense routing
Front-port passive copper	Host-side PCB	• Passive copper twin-axial cable carrying 2+ differential pairs up to 7m • Interconnect between rack-mounted server and top-of-rack switch • Cabling within a rack • High-loss cable with different loss profile compared to PCB

Table 4-1. Environmental Characteristics for 10GbE and 40GbE Applications (continued)

Use Case	Location of Signal Conditioner	Description
Front-port active copper	Host-side PCB OR Inside attach module	• Active copper twin-axial cable powered by host PCB using signal conditioning inside cable for extended reach (10m to 15m) • Interconnect between ToR and aggregation switch / router • Cabling between multiple racks • Can be treated like optical since cable is active
Front-port optical	Host-side PCB OR Inside attach module	• Retimed/un-retimed fiber optic cable from 10m to multiple kilometers • Interconnect between rows and rooms within a data center and between buildings • Highly-specified electrical-to-optical and optical-to-electrical interfaces

Within each application use case, the key performance metrics and IC form factor requirements vary. Table 4-2 provides a summary of general considerations for Ethernet redrivers and retimers in these application scenarios.

Table 4-2. Key Considerations for 10GbE and 40GbE Applications

Application Use Case	Benefit of Signal Conditioning	Key Performance Metrics	IC Form Factor Requirements
Backplane/ Midplane	• Reach Extension • Signal Distribution	• Reach • Crosstalk • Reflections	• High Channel Density • Function Integration
Front Port Host-side PCB (Copper or Optical)	• Reach Extension • Increased Eye Mask Margin	• Reach • Power • Jitter	• Fits on PCB behind port • Function Integration
Front Port Module PCB (Copper or Optical)	• Reach Extension • Increased Eye Mask Margin	• Reach • Power • Jitter	• Very small package • No heat sink • Function Integration

4.2 IEEE802.3, OIF-CEI, and Module Interface 10GbE and 40GbE Standards

IEEE802.3, OIF-CEI (Optical Interconnect Forum – Common Electrical I/O), and various module interface electrical specifications are all interrelated within the Ethernet ecosystem. Table 4-3 provides a simplified reference for applicable electrical specifications related to 10GbE and 40GbE data transmission. In addition, relevant signal conditioning is recommended based on the given application.

Table 4-3. Applicable 10GbE and 40GbE Standards for Signal Conditioners

		Host/Port-Side			Backplane/ Midplane
Interface Type		**C2C (Chip-to-Chip)**	**C2M (Chip-to-Module)**	**C2C (Chip-to-Chip)**	**C2C (Chip-to-Chip)**
		PCB Trace (to Signal Conditioner)	**Optical**	**Copper**	**PCB Trace**
Electrical Standard	10GbE	XFI	SFI (Limiting & Linear) SFF-8431	SFI Linear	10GBASE-KR
	40GbE	XLAUI	XLPPI (Linear)	XLPPI	40GBASE-KR4
Module Form Factor Type	10GbE	XFP	SFP+	SFP+ (DAC)	N/A
	40GbE	CFP	QSFP	QSFP (DAC)	N/A
OIF-CEI Standard		CEI-11G-SR	CEI-11G-SR	CEI-11G-SR	CEI-11G-LR CEI-11G-MR
Recommended Signal Conditioning Device		Retimer	Redriver (Linear) Retimer (Limiting)	Redriver	Redriver (if LT required)(1) Retimer (if LT not required)

(1) LT: Link Training

Note

XFI (10GbE) and XLAUI (40GbE) C2C interfaces are for port-side interaction between host ASIC and signal conditioner (e.g. retimer), whereas the signal conditioner is inside the XFP (10GbE) or CFP (40GbE) optical module, respectively. SFI and XLPPI assume no signal conditioning within the module.

5 Selecting the Right Ethernet Redriver or Ethernet Retimer

TI offers a wide range of high performance Ethernet redrivers and retimers to support a variety of 10GbE and 40GbE application use cases. Some redrivers and retimers offer integrated mux/demux functionality or crosspoints to help easily distribute signals while compensating the signal integrity impairments.

There are several aspects of signal conditioners to consider when selecting a device that achieves optimal performance and cost efficiency. For answers to common questions about selecting the right signal conditioning device, refer to Table 5-1.

Table 5-1. Common Questions to Determine the Right Signal Conditioning Device

Question	Answer
How many redriver or retimer channels are needed?	• Depending on the number of data channels requiring signal conditioning, select an appropriate 2, 4, 8, or 16 channel device. • Signal conditioning applies to channels independently, so channels need not be correlated when routing to a signal conditioner (for example, Two 40GbE egress signals can be sent to a single eight-channel device).
Is signal conditioning needed in both ASIC transmitting and receiving directions?	• For applications where signal conditioning is needed in both ASIC transmit and receive directions, select a bidirectional device. • For applications where signal conditioning is needed in only one direction (for example, receive-side only), select a unidirectional device.
What are the data rates and sub-data rates that must be supported?	• Redrivers can operate with any data rate up to the maximum data rate supported. • Retimers can only operate with data rates and specified divide-by sub-rates within the VCO lock range.
How much total overall channel loss (IL) in dB at Nyquist must be supported?	• For significant IL (>30 dB at 5GHz), consider 10GbE retimers. • For intermediate IL (<30 dB at 5 GHz), consider 10GbE redrivers. • To assess the impact on signal integrity for a given redriver or retimer, designers are encouraged to use IBIS-AMI model simulations to verify device choice and IC placement in the anticipated system use case.
Is crosstalk and reflection significant?	• If yes, retimer with DFE is preferred. • If no, a redriver or basic retimer is recommended.
Is LT (link training) required in the system?	• If yes, a redriver must be used. Backplane and copper interfaces such as KR and CR that implement LT require a linear redriver to pass along the source Tx EQ coefficients transparently. • If no, either retimer or redriver may be used. TI's 10GbE retimers only support limiting interfaces. Alternatively, they can be used in backplane/copper interfaces where LT is optionally not used.

5.1 Two-Channel Signal Conditioning Devices

For either single or dual channel applications where signal conditioning is needed, such as XFI, SFP, or SFP+ optical and copper modules, two-channel Ethernet redrivers and retimers may be used. Bidirectional two-channel devices can be used to address a single differential Tx and Rx port, whereas unidirectional two-channel devices can be used to address two separate differential channels in either only Tx or Rx directions.

Table 5-2. Two Channel Ethernet Redriver and Ethernet Retimer Selection Guide

Part number	DS110DF111	DS125DF111	DS100BR111	DS125BR111	DS100BR210	DS100MB203	DS125MB203
Device type	Retimer	Retimer	Redriver	Redriver	Redriver	Redriver mux	Redriver mux
Channel	2	2	2	2	2	Dual 1:2 and 2:1	Dual 1:2 and 2:1
Direction	Bidirectional	Bidirectional	Bidirectional	Bidirectional	Unidirectional	Bidirectional	Bidirectional
Data rate	8.5G–11.3G 4.25G–5.65G 2.125G–2.825G 1.06G–1.41G	9.8G–12.5G 4.9G–6.25G 2.45G–3.125G 1.225G–1.56G	Up to 10.3G	Up to 12.5G	Up to 10.3G	Up to 10.3G	Up to 12.5G
CTLE	34dB, adaptive	34dB, adaptive	36dB	10dB	36dB	36dB	30dB
DFE	5 tap	5 tap	N/A	N/A	N/A	N/A	N/A
TX De-emphasis	up to –12dB	up to –12dB	up tp –12dB	Linear only	up to –12dB	up to –12dB	up to –12dB
Power (typ)	200mW/ch	200mW/ch	65mW/ch	65mW/ch	65mW/ch	65mW/ch	65mW/ch
CDR	Yes	Yes	N/A	N/A	N/A	N/A	N/A
Eye Monitor	Yes	Yes	N/A	N/A	N/A	N/A	N/A
Power supply	2.5V	2.5V	2.5V or 3.3V	2.5V or 3.3V	2.5V or 3.3V	2.5V or 3.3V	2.5V or 3.3V
Package	4mm x 4mm WQFN	4mm x 4mm WQFN	4mm x 4mm WQFN	4mm x 4mm WQFN	4mm x 4mm WQFN	10mm x 5.5mm WQFN	10mm x 5.5mm WQFN

5.2 Four-Channel Signal Conditioning Devices

For higher density port applications such as QSFP modules, CFP modules, or 40GbE backplanes, four-channel Ethernet redrivers and retimers may be used to reduce the number of signal conditioning components in the system and to increase efficiency. If bidirectional signal conditioning is needed, a four-lane (eight channel total), bidirectional device may be considered (see Section 5.3).

Table 5-3. Four-Channel Ethernet Redriver and Ethernet Retimer Selection Guide

Part Number	DS100DF410	DS110DF410	DS125DF410	DS100BR410	DS100KR401	SN65LVCP114
Device type	Retimer	Retimer	Retimer	Redriver	Redriver	Redriver mux
Channel	4	4	4	4	8	Quad 1:2 and 2:1
Direction	Unidirectional	Unidirectional	Unidirectional	Unidirectional	Bidirectional	Bidirectional
Data rate	10.3G	8.5G–11.3G 4.25G–5.65G 2.125G–2.825G 1.06G–1.41G	9.8G–12.5G 4.9G–6.25G 2.45G–3.125G 1.225G–1.56G	Up to 10.3G	Up to 10.3G	Up to 14.2G
CTLE	34dB, adaptive	34dB, adaptive	34dB, adaptive	28dB	36dB	15dB
DFE	5 Taps	5 Taps	5 Taps	N/A	N/A	Yes
TX De-emphasis	Up to –12dB	Up to –12dB	Up to –12dB	Up to –9dB	Up to –12dB	Linear Only
Power (typ)	180mW/ch	180mW/ch	180mW/ch	55 mW/ch	65mW/ch	150mW/ch
CDR	Yes	Yes	Yes	N/A	N/A	N/A
Eye Monitor	Yes	Yes	Yes	N/A	N/A	N/A
Power supply	2.5V	2.5V	2.5V	2.5V	2.5V or 3.3V	2.5V or 3.3V
Package	7mm x 7mm WQFN	7mm x 7mm WQFN	7mm x 7mm WQFN	7mm x 7mm WQFN	10mm x 5.5 mm WQFN	12mm x 12mm NFBGA

5.3 Eight and 16-Channel Signal Conditioning Devices

For the highest-density port or backplane applications where signal distribution may also be required, TI offers both eight and 16-channel devices. The DS110DF1610 and DS125DF1610 Ethernet retimers are TI's most integrated 10–12.5 Gbps device with both advanced signal conditioning and integrated 4x4 crosspoints for signal routing.

Table 5-4. Eight and 16-Channel Ethernet Redriver and Ethernet Retimer Selection Guide

Part Number	DS110DF1610	DS125DF1610	DS100KR800	DS125BR820	DS125BR800A
Device type	Retimer Crosspoint (4x4)	Retimer Crosspoint (4x4)	Redriver	Redriver	Redriver
Channel	16	16	8	8	8
Direction	Unidirectional	Unidirectional	Unidirectional	Unidirectional	Unidirectional
Data rate	8.5G–11.3G 4.25G–5.65G 2.125G–2.825G 1.06G–1.41G	9.8G–12.5G 4.9G–6.25G 2.45G–3.125G 1.225G–1.56G	Up to 10.3G	Up to 12.5G	Up to 12.5G
CTLE	38dB	38dB	36dB	10dB	36dB
DFE	5 taps	5 taps	N/A	N/A	N/A
TX De-emphasis	3 Tap FIR	3 Tap FIR	Up to –12dB	Linear only	Up to –12dB
Power	235mW/ch	235mW/ch	65mW/ch	65mW/ch	65mW/ch
CDR	Yes	Yes	N/A	N/A	N/A
Eye Monitor	Yes	Yes	N/A	N/A	N/A
Power supply	2.5 V	2.5 V	2.5 V or 3.3 V	2.5 V or 3.3 V	2.5 V or 3.3 V
Package	15 mm × 15 mm FCBGA	15 mm × 15 mm FCBGA	10 mm × 5.5 mm WQFN	10 mm × 5.5 mm WQFN	10 mm × 5.5 mm WQFN

6 Adjacent 10–12.5 Gbps Interfaces for Signal Conditioners

The Ethernet redrivers and retimers mentioned in this application note primarily address 10GbE (10.3125 Gbps) interface applications. However, many of these redrivers and retimers may be used in other interfaces up to 12.5 Gbps due to similarities in electrical interface requirements. This subsection addresses popular adjacent 10–12.5 Gbps protocols where redrivers and retimers may be considered.

Note

When selecting either a redriver or retimer for an adjacent standard or proprietary interface, it is important to verify that the high-speed electrical input and output specifications in the system are suitable for the signal conditioning device and vice versa.

An overview of popular adjacent 10–12.5 Gbps protocols are provided in Table 6-1, with standards requiring LT (link training) or OOB (out-of-band) burst data support explicitly mentioned.

Table 6-1. 10GbE verses Adjacent Data Rate Standards

	Data Rate Support Required	Link Training or Burst Data Support Required?	Redriver or Retimer Recommended?
10GbE	10.3125 Gbps	LT for KR or CR only	Redriver / Retimer (LT Not Supported)
PCIe	2.5, 5, 8 Gbps	LT for Gen-3 (8 Gbps) only	Redriver Only
SAS	3, 6, 12 Gbps	LT for SAS-3 (12 Gbps) only OOB Burst for SAS 1-3	Redriver Only
SATA	1.5, 3, 6 Gbps	OOB Burst for SATA 1-3	Redriver Only
OIF–CEI	9.95–11.2 Gbps (CEI–11G–SR/MR/LR)	No	Redriver / Retimer
JESD204B	3.2–12.5 Gbps	No	Redriver / Retimer
CPRI	0.6144, 1.2288, 2.4576, 3.0720, 4.9152, 6.144, 8.1100, 9.8304, 10.1376, 12.1651 Gbps	No	Redriver / Retimer
Fibre Channel (GFC)	1.0625, 2.125, 4.25, 8.5 Gbps	No	Redriver / Retimer
Infiniband	10 Gbps (SDR)	No	Redriver / Retimer

6.1 Adjacent Protocols Requiring Link Training or Burst Data Support

Several adjacent 10–12.5 Gbps protocols require LT support or OOB burst data support to optimize signal integrity at the Tx driver side. The most popular adjacent interfaces requiring LT or OOB burst data support is PCIe (Peripheral Component Interconnect Express), SAS (Serial Attached Storage), and SATA (Serial ATA).

Although TI redrivers are often optimized to target specific interfaces, the redriver's linear channel design is inherently protocol agnostic, thus enabling a wide range of support for other popular or proprietary interfaces. Linear redrivers are ideal for preserving the various precursor and postcursor FIR tap settings used by the source Tx EQ during the LT tuning phase. In addition, the fast signal-detect response of the redriver enables OOB burst data support required by SAS and SATA.

Table 6-2 provides an overview of adjacent standards where 10GbE linear redrivers are recommended.

Table 6-2. Redrivers Supporting Adjacent Protocols Requiring Link Training *

Part Number	DS100BR111	DS125BR111	DS100KR401	DS125BR820	DS125BR800A
Device type	Redriver	Redriver	Redriver	Redriver	Redriver
No. of Channels	2	2	8	8	8
Direction	Bidirectional	Bidirectional	Bidirectional	Unidirectional	Unidirectional
Data rate	Up to 10.3G	Up to 12.5G	Up to 10.3G	Up to 12.5G	Up to 12.5G
PCIe Support	Up to Gen-3	Up to Gen-3	Up to Gen-3	Up to Gen-3	Up to Gen-3
SAS Support	Up to SAS-2	Up to SAS-3	Up to SAS-2	Up to SAS-3	Up to SAS-3
SATA Support	Up to SATA-3	Up to SATA-3	Up to SATA-3	Up to SATA-3	Up to SATA-3

Note

*TI's 10–12.5 Gbps retimers are not suitable for designs requiring LT support due to the limiting nature of the channel design.

6.2 Adjacent Protocols Not Requiring Link Training or Burst Data Support

For adjacent protocols that do not require LT or OOB burst data support, both redrivers and retimers may be used. Redrivers can be used to support interfaces up to their maximum supported data rate. Retimers can be used to support interfaces whose operating data rate falls within the VCO lock range (or divide-by sub-rate).

Within these adjacent standards, it is important to note the retimer's VCO lock range to determine the specific data rates where CDR lock is supported. For example, the JESD204B standard spans a large range of data rates (3.2 to 12.5 Gbps). However, based on a specific application use case, such as with an AFE58JD48 eight-lane JESD output where only 5 Gbps per channel is needed to support 125 MSPS operation, any of TI's 10–12.5 Gbps may be used to lock to 5 Gbps incoming data.

Table 6-3 provides an overview of adjacent standards and specific operating data rates where TI's 10–12.5 Gbps retimers may be considered.

Table 6-3. Retimers Supporting Adjacent Protocols Not Requiring Link Training

Part Number	DS110DF111	DS125DF111	DS110DF410	DS125DF410	DS110DF1610	DS125DF1610
Device type	Retimer	Retimer	Retimer	Retimer	Retimer Crosspoint (4x4)	Retimer Crosspoint (4x4)
Channel	2	2	4	4	16	16
Direction	Bidirectional	Bidirectional	Unidirectional	Unidirectional	Unidirectional	Unidirectional
CDR Lock Data Rates	8.5G–11.3G 4.25G–5.65G 2.125G–2.825G 1.06G–1.41G	9.8G–12.5G 4.9G–6.25G 2.45G–3.125G 1.225G–1.56G	8.5G–11.3G 4.25G–5.65G 2.125G–2.825G 1.06G–1.41G	9.8G–12.5G 4.9G–6.25G 2.45G–3.125G 1.225G–1.56G	8.5G–11.3G 4.25G–5.65G 2.125G–2.825G 1.06G–1.41G	9.8G–12.5G 4.9G–6.25G 2.45G–3.125G 1.225G–1.56G
OIF-CEI (CEI-11G) CDR Lock Support	Full Range 9.95–11.2 Gbps	Full Range 9.95–11.2 Gbps	Full Range 9.95–11.2 Gbps	Full Range 9.95–11.2 Gbps	Full Range 9.95–11.2 Gbps	Full Range 9.95–11.2 Gbps
JESD204B CDR Lock Support	Limited Range 8.5G–11.3G 4.25G–5.65G	Limited Range 9.8G– 2.5G 4.9G–6.25G	Limited Range 8.5G–11.3G 4.25G–5.65G	Limited Range 9.8G– 2.5G 4.9G–6.25G	Limited Range 8.5G–11.3G 4.25G–5.65G	Limited Range 9.8G– 2.5G 4.9G–6.25G
CPRI* CDR Lock Support	Some Rates 10.1376G 9.8304G 4.9152G 2.4576G 1.2288G	Most Rates 12.1651G 10.1376G 9.8304G 6.144G 4.9152G 3.0720G 2.4576G 1.2288G	Some Rates 10.1376G 9.8304G 4.9152G 2.4576G 1.2288G	Most Rates 12.1651G 10.1376G 9.8304G 6.144G 4.9152G 3.0720G 2.4576G 1.2288G	Some Rates 10.1376G 9.8304G 4.9152G 2.4576G 1.2288G	Most Rates 12.1651G 10.1376G 9.8304G 6.144G 4.9152G 3.0720G 2.4576G 1.2288G
Fibre Channel (GFC) CDR Lock Support	Full Range 8.5G 4.25G 2.125G 1.0625G	Not Supported	Full Range 8.5G 4.25G 2.125G 1.0625G	Not Supported	Full Range 8.5G 4.25G 2.125G 1.0625G	Not Supported

Note

*TI's 25G portfolio may be considered for full CPRI data rate support (refer to the DS250DF230).

7 Summary

Signal conditioning devices such as redrivers and retimers improve high-speed signal integrity margins and increase system interoperability across a wide variety of high-speed applications. TI's wide portfolio of 10GbE redrivers and retimers span multiple channel configurations to suit a variety of Ethernet application use cases and requirements. Moreover, these Ethernet redrivers and retimers may be considered for use in other popular adjacent 10–12.5 Gbps protocols. With proper selection and utilization, redrivers and retimers offer a convenient and cost-effective way to ensure that a great high-speed connection is always within reach.

8 Revision History

Changes from Revision * (May 2020) to Revision A (January 2023)	Page
• Updated the numbering format for tables, figures, and cross-references throughout the document	1