

Selecting TI SigCon Devices for SFF-8431 SFP+ Applications

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ABSTRACT

The SFF-8431 MSA specification enables 10G Ethernet port side support of various physical media types through the SFP+ module form factor. SFF-8431 defines high-speed electrical specifications for multiple SFP+ host-to-module interface types suitable for specific physical media, from short reach and long reach optical fiber links to Twinax direct attach copper cable links. Consequently, the SFP+ host IC requirements will depend on the interface types supported by the network application. This document outlines the SFP+ physical medium dependent (PMD) options, and assists in mapping them to product part numbers from TI's Signal Conditioning (SigCon) family.

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1 List of Acronyms

AOC— Active optical cable

CTLE— Continuous time linear equalizer

DFE— Decision feedback equalizer

DWDM— Dense wavelength division multiplexing

EDC— Electronic dispersion compensation

FIR— Finite Impulse response

LRM— IEEE defined term for 10G optical modules launching single-mode laser optical output onto multi-mode fiber

OM1, OM2 and OM3—Types of multi-mode fiber

PMD— Physical medium dependent

SMF— Single mode fiber

2 Summary of SFF-8431 PMD Types

[Table 1](#) lists the three SFF-8431 SFP+ interface types, along with PMDs generally supported by each one. In addition, [Table 1](#) lists the corresponding SFF-8431 sections defining the host Tx and Rx specifications for each interface type.

Table 1. SFF-8431 Interfaces and PMD Types

SFF-8431 SFP+ Interface Type	SFP+ PMDs Supported	SFP+ Host Tx Requirements	SFP+ Host Rx Requirements
Limiting	10GBASE SR – up to 300 m OM3 fiber 10GBASE LR/ER – 10 km/40 km SMF direct-attach active optical cable (AOC) – up to 10 m Typical Application: Enterprise and data center switching	Section 3.5 “Host Transmitter”	Section 3.5 “Host receiver supporting limiting module”
Linear	10GBASE-LRM – OM1 fiber Linear 10GBASE ZR – 80 km SMF Linear 10GBASE DWDM – 80 km SMF Typical Application: Switching applications supporting legacy multi-mode fiber, optical routing and transport router links requiring extended SMF reach	Section 3.5 “Host Transmitter”	Section 3.5 “Host receiver supporting linear module”
Twinax direct-attach copper cable (10GSFP+CU)	Passive cables – per SFF-8431, typical lengths up to 5 m Active cables – per SFF-8431, typical lengths up to 10 m Typical Application: Data center top of rack switch to server connectivity	Section 3.5 “Host Transmitter” plus additional specifications per Appendix E	Appendix E “SFP+ Host receiver supporting 10GSFP+CU”

3 Choosing Limiting Versus Linear SFP+ Interfaces

As highlighted in [Table 1](#), while the host Tx requirements across SFP+ interface types are the same, the host Rx requirements vary on account of the SFP+ module Rx topology used for each interface type. [Figure 1](#) shows the basic module topologies used across the three SFP+ interface types.

- Limiting modules are the most commonly used type, supporting both multi-mode and single-mode fiber.
- Direct-attach cables (optical and copper) are suitable for links of 10 m length and less.
- Linear interface modules can be used to enable optical equalization by the host:
 - LRM is a linear PMD variant targeted at enterprise and data center switching applications using legacy multi-mode fiber with lower effective modal bandwidth (for example, OM1)
 - Linear modules (for example, ZR and DWDM) may be used in single-mode fiber (SMF) applications to enable very-long reaches for telecom routing and transport

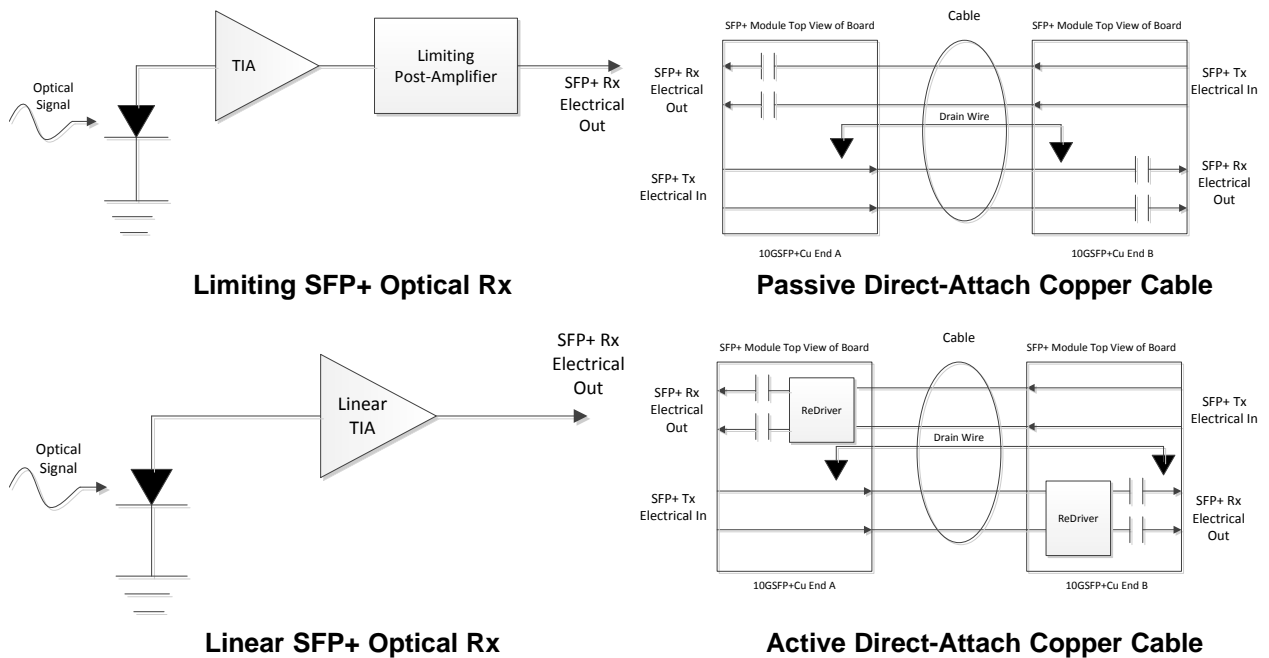


Figure 1. SFP+ PMD Topologies

4 Host Support of SFP+ PMDs

Given the SFP+ module Rx topologies used across interfaces, the performance required for the SFP+ host Rx IC is described as follows:

1. Limiting modules (and direct-attach AOCs):

- The host Rx must compensate only for the host PCB channel between the SFP+ module and the host ASIC (trace plus SFP+ connector).
- As compensation of optical fiber dispersion effects is not required, EDC is not required for SFP+ limiting links.

2. Linear modules:

- A linear electrical signal of specified voltage modulation amplitude (VMA) is output by the SFP+ module Rx.
- The host is then expected to equalize the full electrical-optical-electrical link (that is, both electrical and optical domain amplitude distortion and dispersion).
- Given the need to compensate for optical channel effects, EDC is required to meet the BER requirements of 10GBASE-LRM links (as specified by IEEE 802.3aq).
- For linear DWDM and ZR links, due to the use of single-mode fiber, the optical dispersion effects are less severe than OM1 fiber optical stressors specified for 10GBASE-LRM links.
 - A CTLE-DFE-based EQ architecture with sufficient boost can meet the link BER requirements.

3. 10GSFP+ Cu cables:

- The SFP+ host retimer Rx must be able to compensate for both the SFP+ host PCB channel as well as the signal impairments from the SFP+ Twinax cable assembly.
- EDC is not required for 10GSFP+ Cu cable links.
 - A CTLE-DFE-based EQ architecture with sufficient boost can meet the link BER requirements.

5 TI SigCon Product Overview

Figure 2 captures the three different product types from TI's SigCon family, showing a simple block diagram for each. Table 2 provides a brief description of the functionality for each product type.

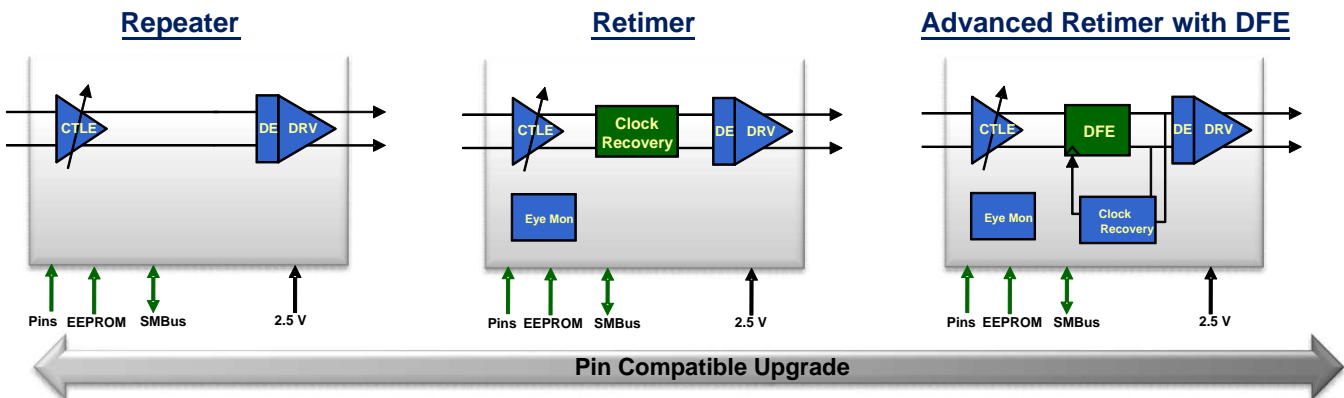


Figure 2. TI SigCon Products Block Diagrams

Table 2. SigCon Product Summary

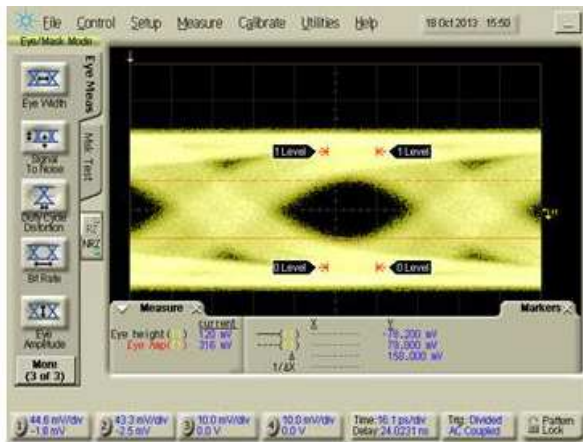
TI SigCon Product	Level of signal conditioning	Functional blocks implemented	10G Part Numbers
Repeater	Insertion loss compensation	Rx EQ, Tx de-emphasis	DS100BR111 DS100BR410
Retimer	Loss + jitter	Adaptive Rx EQ, Tx de-emphasis, CDR	DS100RT410 DS110RT410

Table 2. SigCon Product Summary (continued)

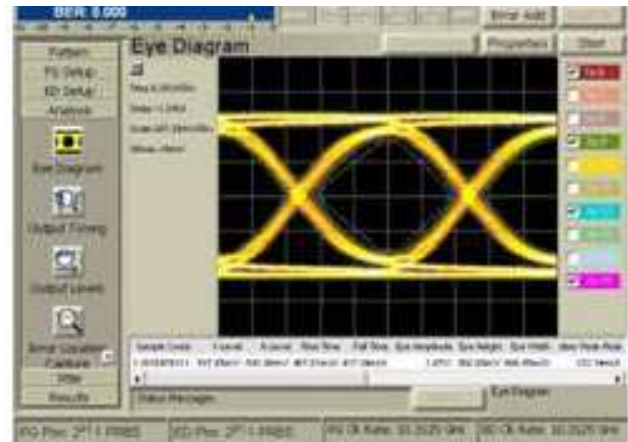
TI SigCon Product	Level of signal conditioning	Functional blocks implemented	10G Part Numbers
Advanced retimer	Loss + jitter + crosstalk + reflections	Adaptive Rx EQ + DFE, CDR, Tx de-emphasis	DS100DF410 DS110DF410 DS110DF111 DS125DF410 DS125DF111 DS125DF1610

TI's 10G products cover three levels of signal conditioning performance and multiple channel count options. Thus, switch or router developers can readily find a TI solution that optimally meets the performance trade-off needs of their application. Figure 3 and Figure 4 provide examples of typical performance for TI products in 10GE SFP+ applications.

- As shown in Figure 3, the TI retimer can recover data and provide a clean output for stressed input signals such as the SFF-8431 compliance test eye, which has about 0.5 UI of horizontal closure.
- Figure 4 shows typical output eye diagrams for TI's retimer and repeater solutions implemented as part of an SFP+ active direct attach copper cable:
 - Both the repeater and retimer devices are able to provide an open output eye.
 - For applications with tighter jitter requirements, the retimer solution provides the cleanest signal.



SFF-8431 Stressed Eye for Host Rx Compliance Tests



TI Retimer Output for SFF-8431 Stressed Input

Figure 3. TI Retimer Typical Performance for SFF-8431 Stressed Eye Rx Compliance Test

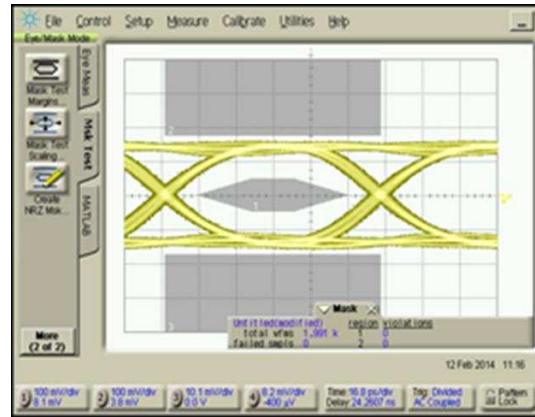


Figure 4. TI retimer Tx output performance for SFF-8431 Test Point B Output Eye Mask

6 TI SFP+ SigCon Selection Guide

Table 3 provides a detailed mapping of SFP+ PMD types to TI retimer part numbers:

Table 3. Selection Guide

Ethernet Protocol	Line Rate	SFP+ Interface	Line Encoding	Total Bandwidth per Port	Media Type	Typical Distance	TI Devices Supporting (DF410 – 4 ch) (DF1610 – 16 ch) (DF111 – 1 ch, bidirectional)
10GBASE-SR	10.3125 Gbps	Limiting	64b/66b	10G	Optical – OM3	100 m	DS100RT410 DS100DF410 DS110RT410 DS110DF410 DS110DF111 DS125DF410 DS125DF1610 DS125DF111 DS100BR111 ⁽¹⁾ DS100BR410 ⁽¹⁾
10GBASE-LR	10.3125 Gbps	Limiting	64b/66b	10G	Optical – SMF	10 km	
10GBASE-ER	10.3125 Gbps	Limiting	64b/66b	10G	Optical – SMF	40 km	
10GBASE-ZR	10.3125 Gbps	Limiting	64b/66b	10G	Optical – SMF	80 km	
10GBASE-DWDM	10.3125 Gbps	Limiting	64b/66b	10G	Optical – SMF	80 km	
SFP+ active optical cable (AOC)	10.3125 Gbps	Limiting	64b/66b	10G	Optical cable	10 m	
SFP+ passive direct-attach copper	10.3125 Gbps	10GSFP+ CU	64b/66b	10G	Copper cable	5 m (24 AWG)	
SFP+ active direct-attach copper	10.3125 Gbps	10GSFP+ CU	64b/66b	10G	Copper cable	10 m (24 to 30 AWG)	
10GBASE-ZR	10.3125 Gbps	Linear	64b/66b	10G	Optical – SMF	>80 km	
10GBASE-DWDM	10.3125 Gbps	Linear	64b/66b	10G	Optical – SMF	>80 km	
10GBASE-LRM	10.3125 Gbps	Linear	64b/66b	10G	Optical – OM1	220 m	

⁽¹⁾ Repeater part numbers are suitable for active direct-attach copper applications.

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