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SFF-8665 Rev 1.9.4

Template Rev 1.1



SFF-8665

Specification for

QSFP+ 4X ~~28 Gb/s~~ Pluggable Transceiver Solutions

Rev 1.9.4 April 1, 2022

SECRETARIAT: SFF TA TWG

This specification is made available for public review at <https://www.snia.org/sff/specifications>. Comments may be submitted at <https://www.snia.org/feedback>. Comments received will be considered for inclusion in future revisions of this specification.

The description of the connector in this specification does not assure that the specific component is available from connector suppliers. If such a connector is supplied, it should comply with this specification to achieve interoperability between suppliers.

ABSTRACT: This specification defines ~~the physical interface, low speed electrical, and management interface requirements of a~~ QSFP+ 4X pluggable transceiver solutions ~~including: QSFP10, QSFP14, QSFP28, QSFP56, and QSFP112, popularly known as QSFP. It gathers the appropriate/unique Base Electrical, Optical, Common Management, Module/Plug Form factor, Host connector and cage specifications into a clearly delineated solution for users.~~

POINTS OF CONTACT:

Tom Palkert
Samtec

Chairman SFF TA TWG
Email: SFF-Chair@snia.org

~~Address 1~~

~~Address 2~~

~~Address 3~~

~~Ph:~~

~~Email: tom.palkert@samtec.com~~

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FOREWORD

The development work on this specification was done by the SFF TA TWG, an industry group. Since its formation as the SFF Committee in August 1990, the membership has included a mix of companies which are leaders across the industry.

For those who wish to participate in the activities of the SFF TA TWG, the signup for membership can be found at <https://www.snia.org/sff/join>.

REVISION HISTORY

Rev 1.6

- Moved reference SFF specs to 2.1 Industry Documents and expanded the list
- Moved SFF-8672 and SFF-8683 to Figure 3-1 plus complementary sections
- Added using interfaces to Application Specific Criteria

Rev 1.7

- Clarified introductory paragraph of SFF-8662 and SFF-8672

Rev 1.8

- Add multiple generations to Abstract

Rev 1.9

- Modified Figure 3-1 to include explanatory details

Rev 1.9.1

February 2, 2022:

- Incorporated figures for all generations of QSFP pluggable transceiver solutions

Rev 1.9.2

February 8, 2022:

- Additional updates based on discussion

Rev 1.9.3

March 25, 2022:

- Additional editorial changes based on review ballot comments

Rev 1.9.4

April 1, 2022:

- Additional changes based on comment resolution discussion

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1. Scope

In an effort to broaden the applications for storage devices, an ad-hoc industry group of companies representing system integrators, peripheral suppliers, and component suppliers decided to address the issues involved.

The SFF Committee was formed in August, 1990 and the first working document was introduced in January, 1991. This specification defines the physical interface, low speed electrical, and management interface requirements of QSFP+ 4X pluggable transceiver solutions including: QSFP10, QSFP14, QFSP28, QSFP56, and QSFP112.

Other standards (e.g., IEEE, FC-PI-6, etc.) define the performance requirements for QSFP connectors used to transmit signals at various data rates using optical modules or cable assemblies.

2. References and Conventions

2.1 Industry Documents

The following documents are relevant to this specification:

- ~~ASME Y14.5~~ Dimensioning and Tolerancing
- ~~EIA-364-1000~~ Environmental Test Methodology for Assessing the Performance of Electrical Connectors and Sockets Used in Controlled Environment Applications
- ~~FC-PI-5~~
- ~~FC-PI-6~~
- ~~IEEE Std 802.3bj~~ 100 GbE
- ~~EN61000-4-2~~ ESD specification
- ~~GR-253-CORE~~
- ~~IEC 61754-7~~ MPO optical connectors
- ~~IEC 61754-20~~ Dual LC optical connectors
- ~~InfiniBand~~ Architecture Specifications for FDR and EDR
- ~~JESD22-A114-B~~ JEDEC ESD specification OIF Common Management Interface
- ~~NEBS-GR-63~~ Thermal specification
- ~~REF-TA-1011~~ Cross-Reference to Select SFF Connectors
- ~~SAS-3~~
- ~~SFF-8636~~ Shielded Cables Common Management Interface Management Interface for 4-lane Modules and Cables
- ~~SFF-8661~~ QSFP+ ~~28 Gb/s~~ 4X Pluggable Module
- ~~SFF-8662~~ QSFP+ 28 Gb/s 4X Connector (Style A)
- ~~SFF-8663~~ QSFP+ 28 Gb/s ~~4X~~ Cage (Style A)
- ~~SFF-8672~~ QSFP+ ~~4X~~ 28 Gb/s ~~4X~~ Connector (Style B)
- ~~SFF-8679~~ QSFP+ 4X ~~Base Specification~~ Hardware and Electrical Specification
- ~~SFF-8683~~ QSFP+ ~~14 Gb/s~~ Cage
- ~~SFF-TA-1027~~ QSFP2 Connector, Cage, and Module
- ~~SFF-TA-1029~~ QSFP Cabled Cage and Connector
- ~~TIA-568~~ Aligned key (Type B) MPO patch cords
- ~~TIA/EIA-604-10A~~ Dual LC optical

2.2 Sources

The complete list of SFF documents which have been published, are currently being worked on, or that have been expired by the SFF Committee can be found at <https://www.snia.org/sff/specifications>. Suggestions for improvement of this specification will be welcome, they should be submitted to <https://www.snia.org/feedback>.

Other standards may be obtained from the organizations listed below:

Standard	Organization	Website
ASME	American Society of Mechanical Engineers (ASME)	https://www.asme.org

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Electronic Industries- Alliance (EIA)	Electronic Components Industry Association- (ECIA)	https://www.ecianow.org
IEEE	Institute of Electrical and Electronics Engineers (IEEE)	https://www.ieee.org
Fibre Channel standards	International committee for Information Technology Standards (INCITS)	https://www.incits.org
InfiniBand	InfiniBand Trade Association (IBTA)	http://www.infinibandta.org
JEDEC	Joint Electron Deice Engineering Council (JEDEC)	https://www.jedec.org
OIF	Optical Internetworking Forum (OIF)	http://www.oiforum.com
SAS and other ANSI- standards	International Committee for Information- Technology Standards (INCITS)	http://www.incits.org

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2.3 Conventions

The following conventions are used throughout this document:

DEFINITIONS

Certain words and terms used in this standard have a specific meaning beyond the normal English meaning. These words and terms are defined either in the definitions or in the text where they first appear.

ORDER OF PRECEDENCE

If a conflict arises between text, tables, or figures, the order of precedence to resolve the conflicts is text; then tables; and finally figures. Not all tables or figures are fully described in the text. Tables show data format and values.

LISTS

Lists sequenced by lowercase or uppercase letters show no ordering relationship between the listed items.

EXAMPLE 1 – The following list shows no relationship between the named items:

- a. red (i.e., one of the following colors):
A. crimson; or
B. pink;
b. blue; or
c. green.

Lists sequenced by numbers show an ordering relationship between the listed items.

EXAMPLE 2 -The following list shows an ordered relationship between the named items:

- 1. top;
2. middle; and
3. bottom.

Lists are associated with an introductory paragraph or phrase and are numbered relative to that paragraph or phrase (i.e., all lists begin with an a. or 1. Entry).

DIMENSIONING CONVENTIONS

The dimensioning conventions are described in ASME-Y14.5, Geometric Dimensioning and Tolerancing. All dimensions are in millimeters, which are the controlling dimensional units (if inches are supplied, they are for guidance only).

NUMBERING CONVENTIONS

The ISO convention of numbering is used (i.e., the thousands and higher multiples are separated by a space and a period is used as the decimal point). This is equivalent to the English/American convention of a comma and a period.

Table comparing American, French, and ISO numbering conventions for 0.6, 1,000, and 1,323,462.9.

3. Keywords, Acronyms, and Definitions

For the purposes of this document, the following keywords, acronyms, and definitions apply.

3.1 Keywords

May: Indicates flexibility of choice with no implied preference.

Optional: Describes features which are not required by the SFF specification. However, if any feature defined by the SFF specification is implemented, it shall be done in the same way as defined by the specification. Describing a feature as optional in the text is done to assist the reader.

Should: Indicates flexibility of choice with a strongly preferred alternative.

3.2 Acronyms and Abbreviations

PCB: Printed Circuit Board

PF: Press Fit

PTH: Plated Through Hole

RA: Right Angle

RAND: Reasonable and Non-Discriminatory

SMT: Surface Mount Technology There are no acronyms or abbreviations defined for this document.

3.3 Definitions

Connector: Each half of an interface that, when joined together, establish electrical contact and mechanical retention between two components. In this specification, the term connector does not apply to any specific gender; it is used to describe the receptacle, the plug or the card edge, or the union of receptacle to plug or card edge. Other common terms include: connector interface, mating interface, and separable interface.

~~**Contact mating sequence:** A term used to describe the order of electrical contact established/terminated during mating/un-mating. Other terms include: contact sequencing, contact positioning, mate first/break last, EMLB (early mate late break) staggered contacts, and long pin/short pin.~~

~~**Contacts:** A term used to describe connector terminals that make electrical connections across a separable interface.~~

Module: In this specification, module may refer to a plug assembly at the end of a copper (electrical) cable (passive or active), an active optical cable assembly, an optical transceiver, or a loopback.

~~**Plug:** A term used to describe the connector that contains the penetrating contacts of the connector interface as shown in Figure 3-1. Plugs typically contain stationary contacts. Other common terms include male, pin connector, and card edge.~~

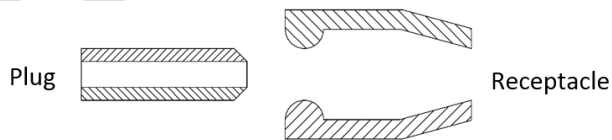


Figure 3-1 Plug and Receptacle Definition

~~**Plated through hole termination:** A term used to describe a termination style in which rigid pins extend into or through the PCB. Pins are soldered to keep the connector or cage in place. Other common terms are through hole~~

or PTH.

Press fit: A term used to describe a termination style in which collapsible pins penetrate the surface of a PCB. Upon insertion, the pins collapse to fit inside the PCB's plated through holes. The connector or cage is held in place by the interference fit between the collapsed pins and the PCB.

Receptacle: A term used to describe the connector that contains the contacts that accept the plug contacts as shown in Figure 3-1. Receptacles typically contain spring contacts. Other common terms include female and socket connector.

Right Angle: A term used to describe either a connector design where the mating direction is parallel to the plane of the printed circuit board upon which the connector is mounted or a cable assembly design where the mating direction is perpendicular to the bulk cable.

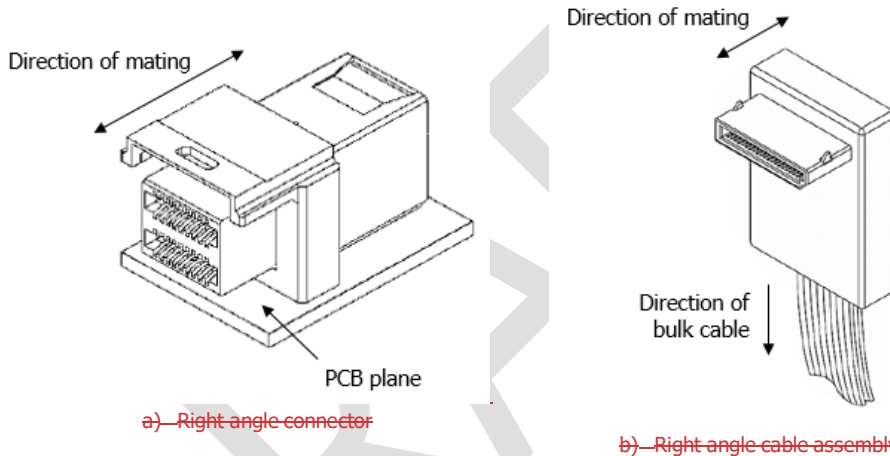


Figure 3-2 Right Angle Connector and Cable Assembly

Surface mount: A term used to describe a termination style in which solder tails sit on pads on the surface of a PCB and are then soldered to keep the connector or cage in place. Other common terms are surface mount technology or SMT.

Termination: A term used to describe a connector's non-separable attachment point such as [a connector contact to a bulk cable/ a cage to a PCB or flex circuit/ bulk cable to a PCB or flex circuit/ solder tail to PCB]. Common PCB terminations include: surface mount (SMT), plated through hole termination (PTH), and press fit (PF). Common cable terminations include: insulation displacement contact (IDC), insulation displacement termination (IDT), wire slots, solder, welds, crimps, and brazes.

4. General Description

This specification provides references to the required SFF specifications necessary to implement QSFP-28 Gb/s pluggable transceiver modules that operate at various speeds. It includes mechanical specifications required by the host i.e., the host connector, the host card cage, and mechanical specifications of the pluggable module. In addition, the SFF specifications necessary to implement the module management interface and the common electrical/optical base specifications are referenced.

The specifications provide a common solution for combined four-channel ports that may support: Ethernet, and/or Fibre Channel, and/or Infiniband, and/or SAS, and/or SONET/SDH specifications. The connectors used in such applications are subject to the requirements of the appropriate standard. This specification encompasses design(s) capable of supporting multimode and single mode modules, passive copper, active copper, and active optical cables.

The Ethernet, Fibre Channel, InfiniBand, SAS, SONET/SDH, and other standards define performance requirements on the characteristic impedance and ability to transmit multi-gigabit signals for cable assemblies and backplanes. The connectors used in such applications are subject to the requirements of the appropriate standard.

A flow chart of the required SFF specifications is shown in Figure 3-1.

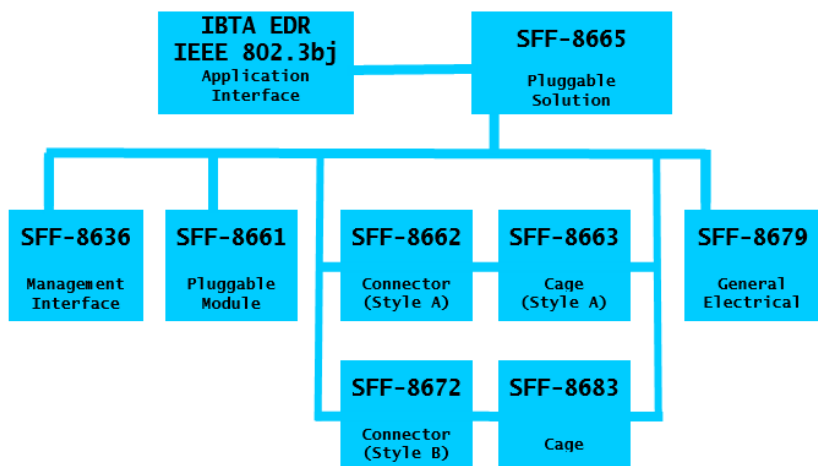


Figure 4-1 Specifications Needed to Implement a 28 Gb/s Pluggable Transceiver

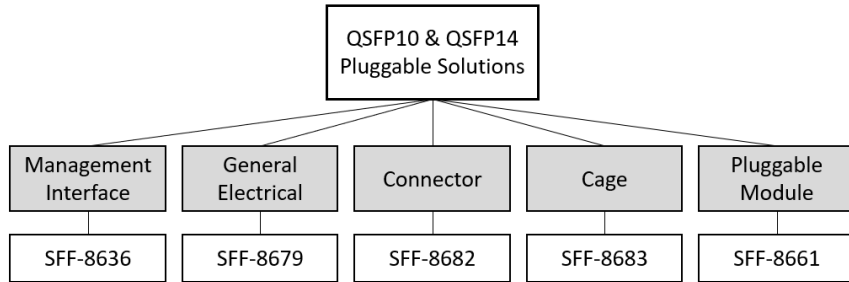


Figure 4-1 QSFP10 and QSFP14 Pluggable Transceiver Solutions

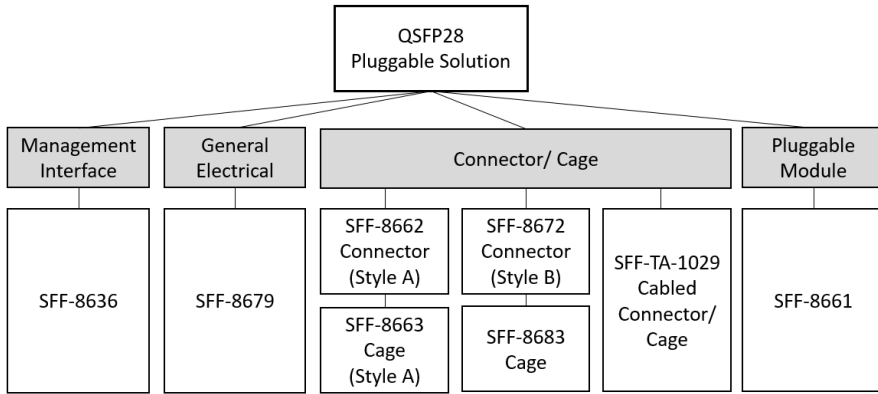


Figure 4-2 QSFP28 Pluggable Transceiver Solution

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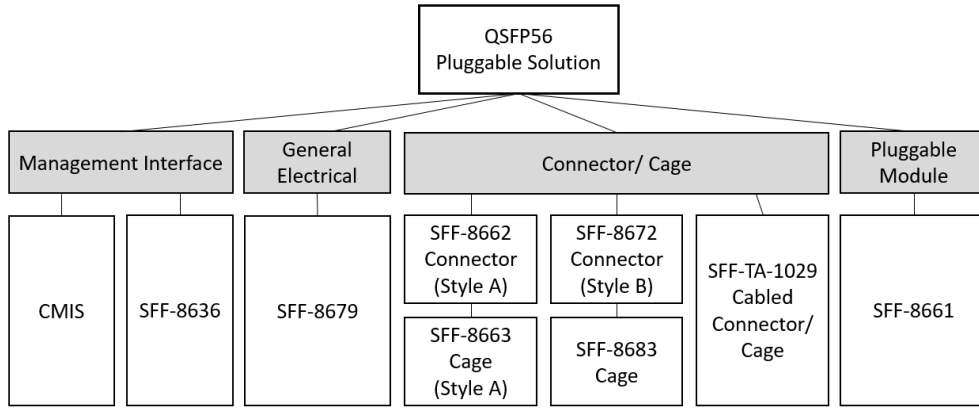


Figure 4-3 QSFP56 Pluggable Transceiver Solution

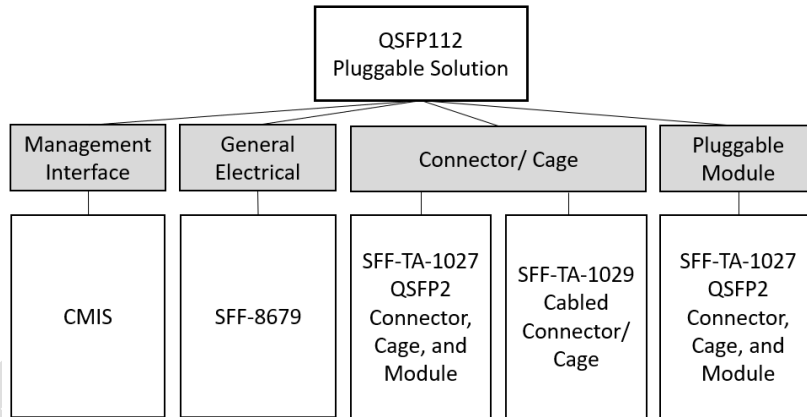


Figure 4-4 QSFP112 Pluggable Transceiver Solution

5. Overview of Referenced Specifications

5.1 SFF-8636 Management Interfaces

The [Shielded Cables Common Management Interface](#) specifications defines a common management interface for 4-lane cable assemblies. [It](#) defines a common on-volatile memory map and protocol utilized for managed external cable interface implementations [based on a Two-Wire-Interface \(TWI\) as described on https://www.i2c-bus.org/twi-bus](https://www.i2c-bus.org/twi-bus).

Memory map details and communication protocol used to transfer the information are described within this specification. This approach facilitates a common memory map and management interface for applications with different mechanical, physical layer and otherwise different implementations.

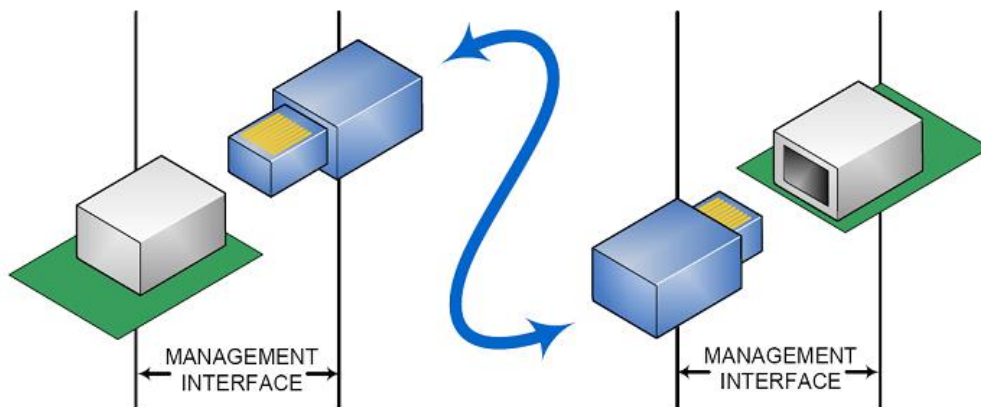


Figure 5-15-1 Management Interface

5.1.1 SFF-8636

The 'Management Interface for 4-lane Modules and Cables Specification' is intended for use by modules at 56 Gbps and below. It is backwards compatible to 1 Gbps modules.

SFF-8636 defines a common memory map and protocol that can be used to manage both 4-channel pluggable transceiver modules and 4-channel managed external cable interface implementations. Physical layer and mechanical details of the interface are outside the scope of the document. Memory map details and communication protocol used to transfer the information are described in the document. This approach facilitates a common memory map and management interface for modules or cable assemblies with different mechanical, physical layer, and other characteristics. Examples include the QSFP+ family and mini multilane connectors for SAS (see REF-TA-1011).

This specification does not apply to the CFP MSA family of modules, which use the MDIO interface and a different memory map.

5.1.2 CMIS

The Common Management Interface Specification (CMIS) defines a generic management communication interface together with a generic management interaction protocol between hosts and managed modules.

The CMIS specification was developed to allow host and module software implementers to utilize a common code base across a variety of form factors and across a variety of module capabilities, and to foster the possibility of vendor agnostic management for standardized module functions.

To this end CMIS specifies a small core of basic functionality that all modules must implement and a larger evolving set of optional features whose implementation is advertised in the so-called management memory map of a module. This advertisement approach allows host software to adapt to optional module capabilities at runtime while ensuring interoperability with all modules at a basic level.

CMIS-compliant modules transfer a well-defined set of management operations for an associated data over a CMIS-defined Management Communication Interface (MCI); e.g., an I2C-based interface. The basic management operations are simple and allow the host to access a 256 byte addressable memory window, with mechanisms to dynamically switch 128 byte sized data pages of a much larger management memory space into the upper half of that host addressable memory window.

Note: This limited set of basic operations and the very small byte-oriented memory window are traced back to SFF-8636 and allow simple transducers or transceivers to be CMIS managed. For complex modules, extension mechanisms are implemented on top of these basic elements.

The physical form factor scope of CMIS includes pluggable or onboard form factors such as QSFP-DD, OSFP, or 21 COBO. However, CMIS is developed as a generic management interface specification and can be implemented in a variety of existing form factors, such as QSFP, or also in future form factors. Generic advertisement fields in the management memory map inform the host about the particular form factor and whether a module can be managed in a CMIS compliant fashion.

The functional scope of CMIS includes module types which may range from electrical cable assemblies (also referred to as modules, unless cable assemblies are specifically mentioned) and active transceiver modules to versatile coherent DWDM modules with integrated framers.

The following classifications can be used to distinguish functional module types or module applications:

- a. **Data agnostic** ("basic") **system interfaces** map bit streams from host lanes to media lanes and vice versa, without knowledge of data formats and without participation in any communication protocol for that bit stream. Examples include cable assemblies and transceivers at lower lane data rates, e.g., 100GBASE-SR4 modules
- b. **Data format aware** ("complex") **system interfaces** perform interface related single or multi-lane data processing (such as lane de-skewing and FEC coding); e.g., 400ZR modules
- c. **Client encapsulation** ("multiplex") **applications** encapsulate one or more (single or multi-lane) host signals into a newly framed (single or multi-lane) network signal that may be transmitted and monitored independent of the host signals. Such modules employ framers with additional overhead for independent media side data link termination, encapsulating host signals as payload, and comprising functionality like framing, mapping, aggregation (multiplexing), switching, or distribution (inverse multiplex) functionality

The specification scope of this CMIS revision covers both system interface modules and client encapsulation modules with at most (multiples of) eight host lanes and with management communication based on I2C.

Additional Information:

- a. The management memory map defines registers and memory locations that are accessible to the host.
- b. Versatile modules may be programmed to behave like modules of different classes
- c. System interfaces employing network side forward error correction (FEC) merely for media channel

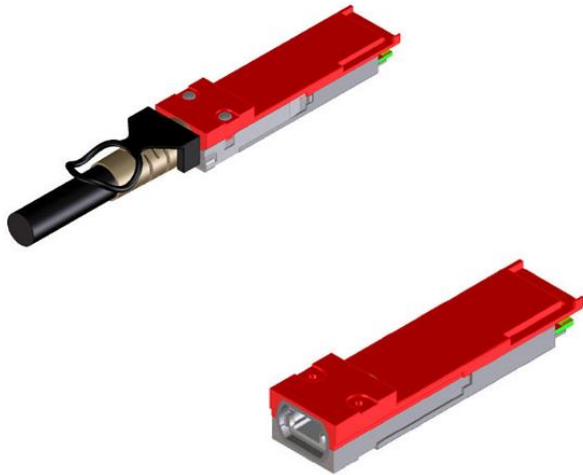
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enhancement, not for independent network link operation, are not considered to be client encapsulating.

5.2 — SFF-8661

This specification defines the terminology and mechanical requirements for a pluggable transceiver module/ plug-

It is also intended to facilitate the implementation of 1 x "n" ganged and the 2 x "n" stacked cage configurations based on the mechanical form factor defined in this specification.

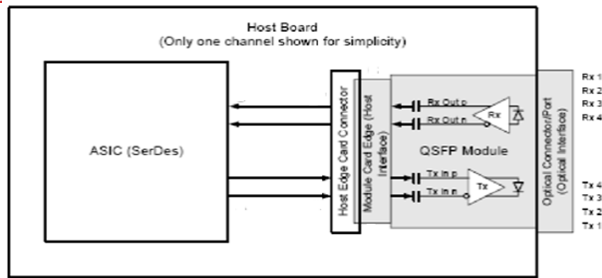


5.3

5.4 — Figure 5-2 Typical Cable Plug and Pluggable Module

1 **5.2 General Electrical**

2 SFF-8679 defines the pin outs, the electrical, the optical, the power supply, the ESD and the thermal characteristics
 3 of the cable plugs and pluggable modules.



4 **Figure 5-2 Application Reference Model**

5 **5.3 Connector, Cage, and Module Specifications**

6 **5.3.1 Connectors**

7 There are multiple SFF specifications (SFF-8662, SFF-8672, SFF-8682, SFF-TA-1027, and SFF-TA-1029) that define
 8 the physical interface and general performance requirements of QSFP connector variants. Table 5-1 summarizes
 9 the connectors and cages that make up QSFP+ pluggable transceiver solutions and shows which cages are used
 10 with specific connectors. All QSFP connector variants are backwards compatible mechanically, though later versions
 11 enable use at higher data rates. SFF-TA-1029 defines a cabled QSFP connector variant.
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16 **Table 5-1 Connectors and Cages for QSFP+ Pluggable Transceiver Solutions**

Pluggable Transceiver Solution	Connector	Cage
QSFP10 & QSFP14	SFF-8682	SFF-8683
	SFF-8672 (Style B)	
QSFP28 & QSFP56	SFF-8662 (Style A)	SFF-8663 (Style A)
	SFF-TA-1029 (Cabled solution)	SFF-TA-1029 (Cabled solution)
	SFF-TA-1027	SFF-TA-1027
QSFP112	SFF-TA-1029 (Cabled solution)	SFF-TA-1029 (Cabled solution)

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17 Examples of QSFP connectors are shown in Figure 5-3 through Figure 5-7.

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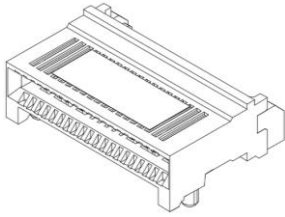


Figure 5-3 SFF-8662 Connector

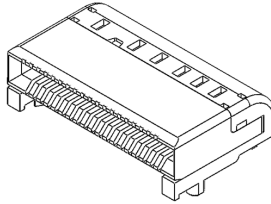


Figure 5-4 SFF-8672 Connector

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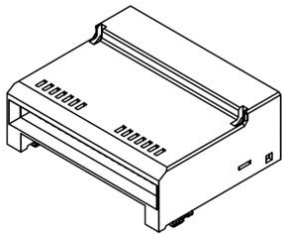


Figure 5-5 SFF-TA-1027 Connector

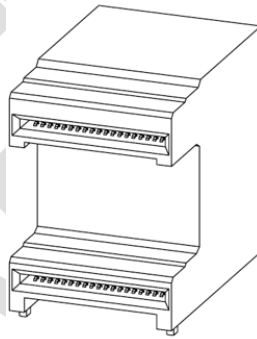


Figure 5-6 SFF-TA-1027 Stacked Connector

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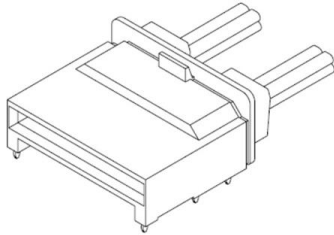


Figure 5-7 SFF-TA-1029 Cabled Connector

4

5

6

5.3.2 Cages

There are multiple SFF specifications (SFF-8663, SFF-8683, SFF-TA-1026, and SFF-TA-1029) that define the physical interface and general performance requirements of QSFP cage variants. Table 5-1 summarizes the connectors and cages that make up QSFP+ pluggable transceiver solutions and shows which cages are used with specific connectors. SFF-TA-1029 defines a cabled QSFP cage variant.

These specifications facilitate the implementation of 1 x "n" ganged cages and the 2 x "n" stacked cage configurations. Examples of QSFP cages are shown in Figure 5-8 through Figure 5-11.

Commented [HA1]: Is this true? What about SFF-8683 and SFF-TA-1029?

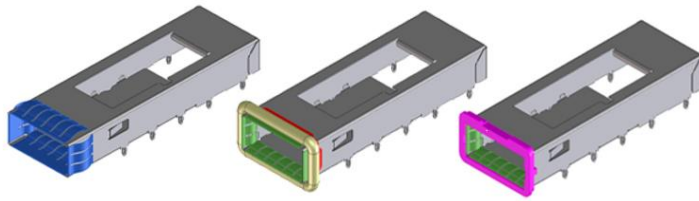


Figure 5-8 SFF-8663 and SFF-8683 Cages

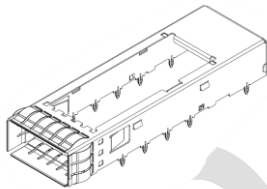


Figure 5-9 SFF-TA-1027 Cage

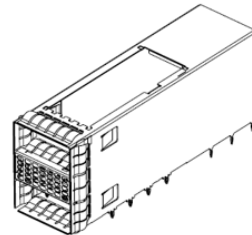


Figure 5-10 SFF-TA-1027 Stacked Cage

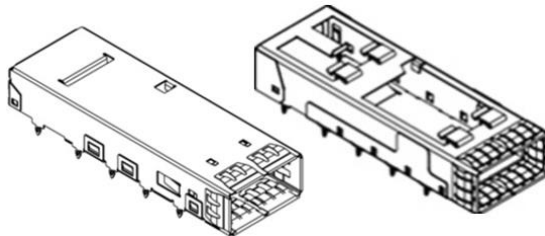
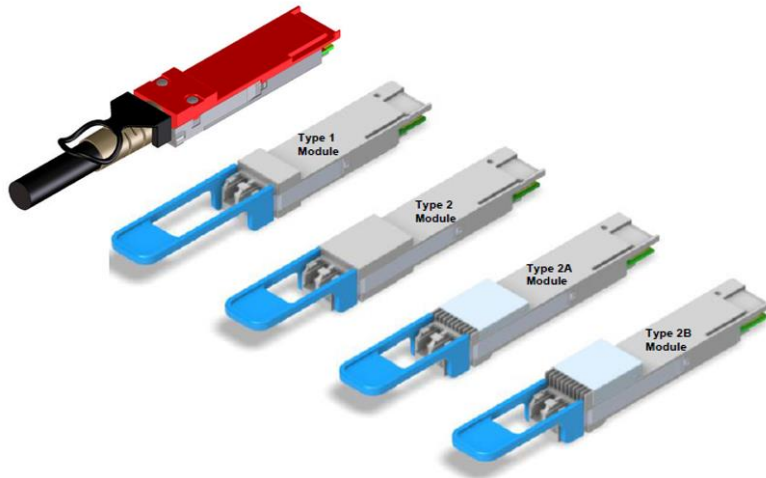


Figure 5-11 SFF-TA-1029 Cages

1 **5.3.3 Modules**

2 SFF-8661 and SFF-TA-1026 define the terminology and mechanical requirements for a pluggable transceiver
3 module/ plug. These two specifications define modules/ plugs that are backwards compatible mechanically, though
4 SFF-TA-1026 enables use at higher data rates.

5
6 These specifications also facilitate the implementation of 1 x "n" ganged and the 2 x "n" stacked cage configurations
7 based on the mechanical form factor defined in cage specifications listed in Section 5.3.2. Examples of QSFP
8 modules are shown in Figure 5-12.



10
11 **Figure 5-12 Typical Cable Plug and Pluggable Modules**

12
13 **5.6 SFF-8662**

14 This specification defines the physical interface and general performance requirements of the receptacle designed

DRAFT

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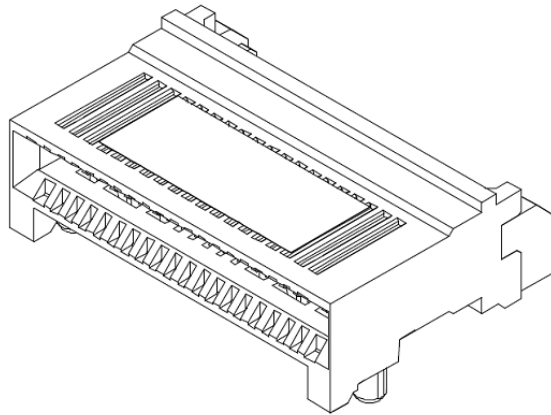
SFF-8665 Rev 1.9.4

Template Rev 1.1

1 for use in high speed serial interconnect applications when paired with SFF-8663.

2
3 The receptacle is used as the mating interface of the cable plug and pluggable module.

4 **5.7**

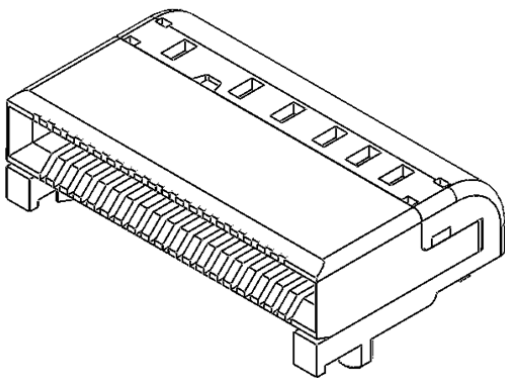


5
6 **Figure 5-3 SFF-8662 Host Connector Fixed Receptacle**

7
8 **SFF-8672**

9 This specification defines the physical interface and general performance requirements of the receptacle designed
10 for use in high speed serial interconnect applications when paired with SFF-8682.

11 The receptacle is used as the mating interface of the cable plug and pluggable modules.

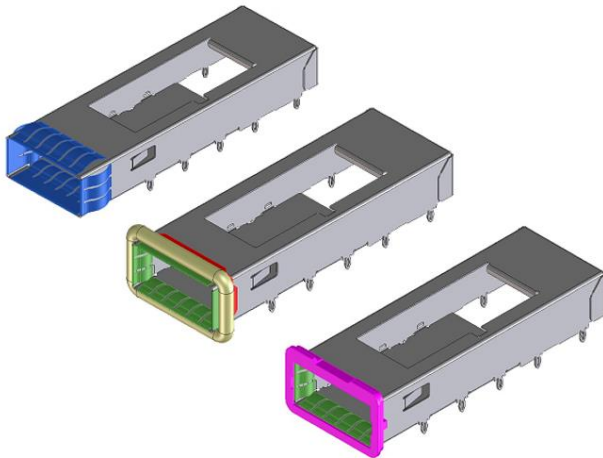


12
13
14 **Figure 5-5 SFF-8672 Host Connector Fixed Receptacle**

1 **5.8 — SFF-8663 and SFF-8683**

2 The mechanical dimensioning of the cages provides backwards mechanical compatibility between generations of
3 cable plugs and pluggable modules.

4 SFF-8663 facilitates the implementation of 1 x "n" ganged cages and the 2 x "n" stacked cage configurations.
5
6



7 **5.9 —**

8 **Figure 5-4 SFF-8663 and SFF-8683 Pluggable Module Cages**

9
10 ~~5.10 SFF-8672~~

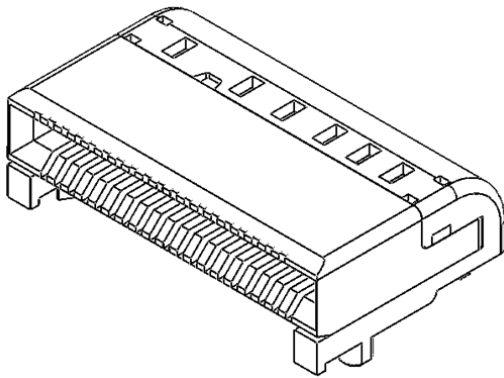
11 ~~5.11 This specification defines the physical interface and general performance~~
12 ~~requirements of the receptacle designed for use in high speed serial~~
13 ~~interconnector applications when paired with SFF-8683.~~

14 ~~5.12~~

15 ~~5.13 The receptacle is used as the mating interface of the cable plug and pluggable~~

1 ~~modules.~~

2 ~~5.14~~



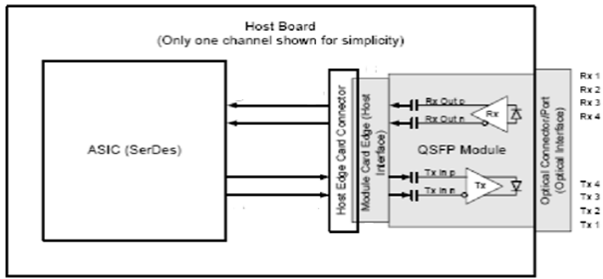
3 ~~5.15~~

4 ~~5.16 Figure 5-5 SFF-8672 Host Connector Fixed Receptacle~~

5 ~~5.17~~

6 ~~5.18 SFF-8679~~

7 This specification defines the pin-outs, the electrical, the optical, the power supply, the ESD and the thermal
8 characteristics of the cable plugs and pluggable modules.



9
10 Figure 5-105-6 Application Reference Model

11 **6. QSFP Thermal Recommendations**

12 High performance network environments need to cool pluggable optical modules efficiently. Higher power modules
13 for QSFP systems must dissipate this heat effectively to ensure operational performance of the modules. Prudent
14 module, cage, heat sink and overall system design for QSFP modules is shown to be effective. A future whitepaper
15 will explain techniques that can be used to achieve this goal in QSFP module design and QSFP system design and
16 provide both experimental and simulation studies to demonstrate their efficacy.
17