SFF-8665

Specification for

QSFP+ 4X Pluggable Transceiver Solutions

Rev 1.9.64   July 9April 1, 20224

SECRETARIAT: SFF TA TWG

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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 QSFP+ 4X pluggable transceiver solutions including: QSFP10, QSFP14, QSFP28, QSFP56, and QSFP112.

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1 **FOREWORD**
2 The development work on this specification was done by the SFF TA TWG, an industry group. Since its formation
3 as the SFF Committee in August 1990, the membership has included a mix of companies which are leaders across
4 the industry.
5
6 For those who wish to participate in the activities of the SFF TA TWG, the signup for membership can be found at
7 https://www.snia.org/sff/join.
8
9 **REVISION HISTORY**
10 **Rev 1.6**
11   -   Moved reference SFF specs to 2.1 Industry Documents and expanded the list
12   -   Moved SFF-8672 and SFF-8683 to Figure 3-1 plus complementary sections
13   -   Added using interfaces to Application Specific Criteria
14 **Rev 1.7**
15   -   Clarified introductory paragraph of SFF-8662 and SFF-8672
16 **Rev 1.8**
17   -   Add multiple generations to Abstract
18 **Rev 1.9**
19   -   Modified Figure 3-1 to include explanatory details
20 **Rev 1.9.1**   *February 2, 2022*:
21   -   Incorporated figures for all generations of QSFP pluggable transceiver solutions
22 **Rev 1.9.2**   *February 8, 2022*:
23   -   Additional updates based on discussion
24 **Rev 1.9.3**   *March 25, 2022*:
25   -   Additional editorial changes based on review ballot comments
26 **Rev 1.9.4**   *April 1, 2022*:
27   -   Additional changes based on comment resolution discussion
28 **Rev 1.9.5**   *July 9, 2024*:
29   -   Added chart for QSFP224
30   -   Additional changes based on comment resolution discussion
31
32
33

1   **CONTENTS**

23   **FIGURES**

42   ~~**TABLES**~~

45

1. Scope

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 and QSFP224.

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:
- OIF   Common Management Interface
- SFF-8636   Management Interface for 4-lane Modules and Cables
- SFF-8661   QSFP+ 4X Pluggable Module
- SFF-8662   QSFP+ 28 Gb/s 4X Connector (Style A)
- SFF-8663   QSFP+ 28 Gb/s Cage (Style A)
- SFF-8672   QSFP+ 4X 28 Gb/s Connector (Style B)
- SFF-8679   QSFP+ 4X Hardware and Electrical Specification
- SFF-8683   QSFP+ Cage
- SFF-TA-1027   QSFP2 Connector, Cage, and Module
- SFF-TA-1029   QSFP Cabled Cage and Connector

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
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
OIF	Optical Internetworking Forum (OIF)	http://www.oiforum.com

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.

American	French	ISO
0.6	0,6	0.6
1,000	1 000	1 000
1,323,462.9	1 323 462,9	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

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.

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.

4. General Description

This specification provides references to the required SFF specifications necessary to implement QSFP 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.

The specifications provide a common solution for combined four-channel ports that may support: Ethernet, Fibre Channel, ~~Infiniband~~InfiniBand, SAS, 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.
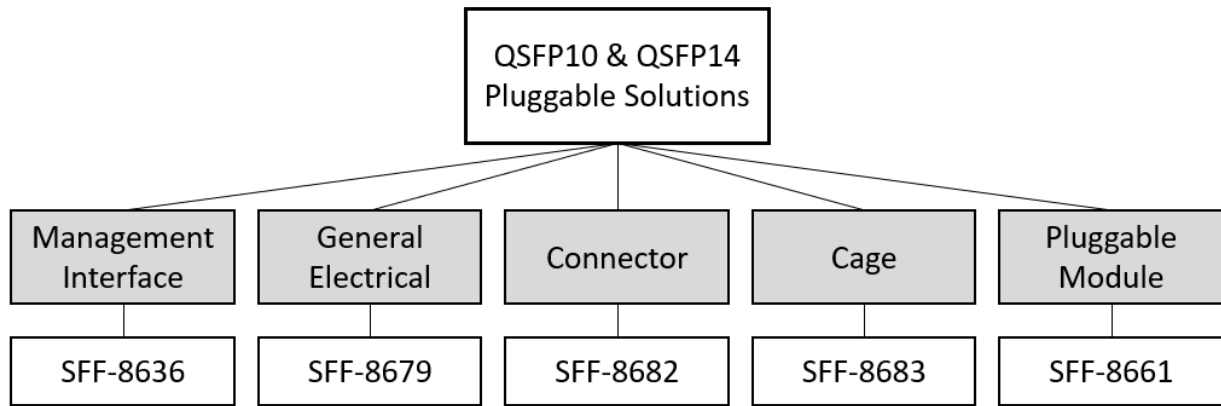

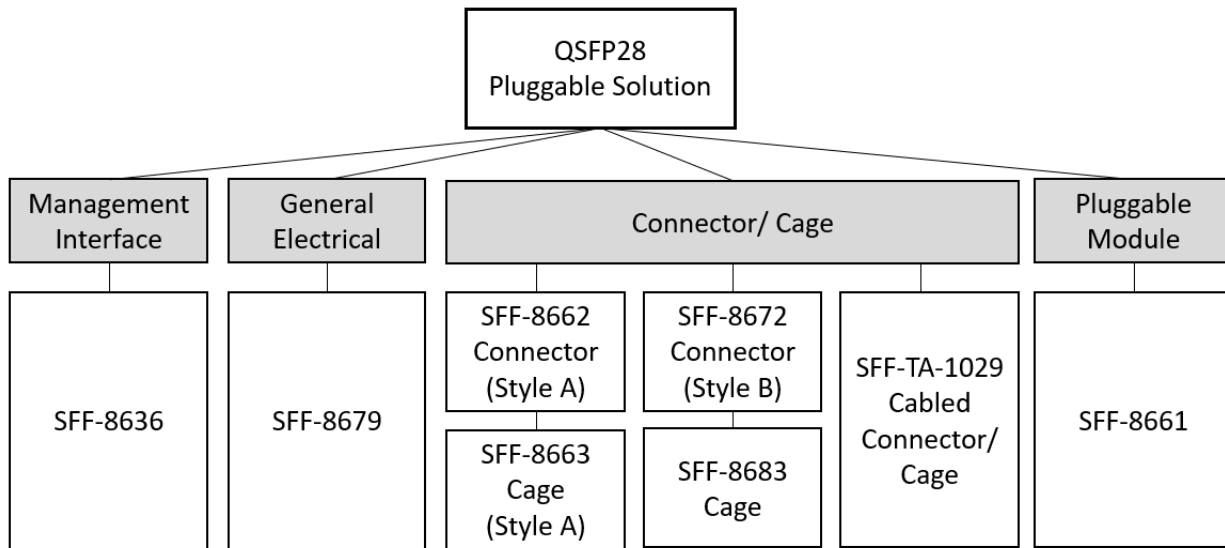**Figure 4-1 QSFP10 and QSFP14 Pluggable Transceiver Solutions**

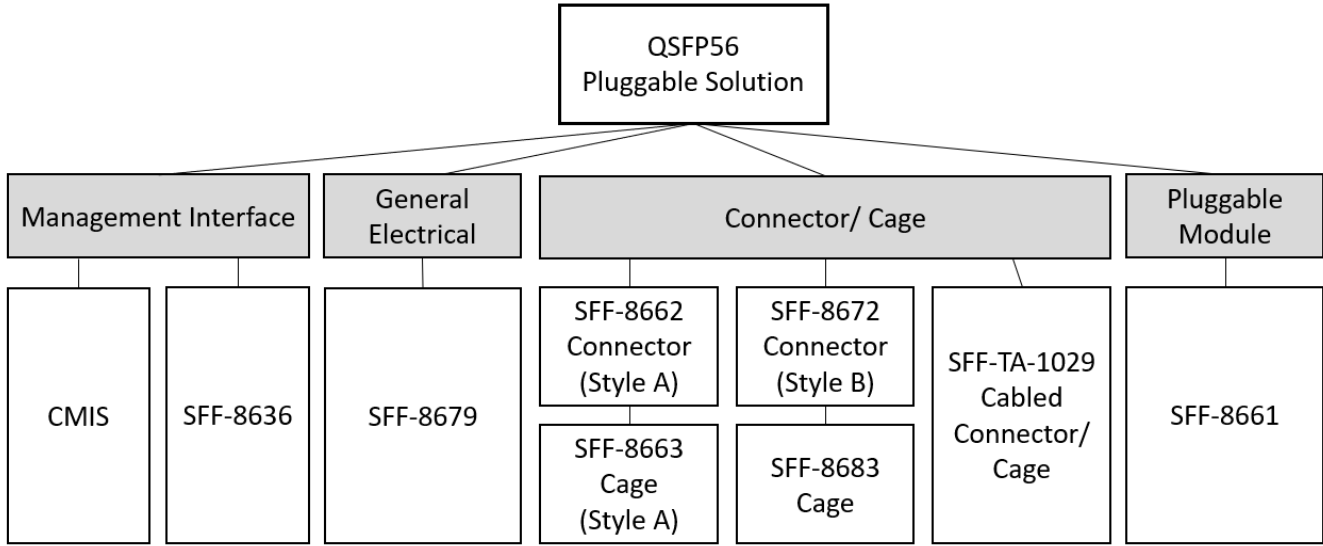**Figure 4-2 QSFP28 Pluggable Transceiver Solution**

```
                              QSFP56
                          Pluggable Solution

  Management Interface    General Electrical       Connector/ Cage              Pluggable Module

  CMIS    SFF-8636        SFF-8679    SFF-8662      SFF-8672     SFF-TA-1029    SFF-8661
                                     Connector    Connector     Cabled
                                     (Style A)    (Style B)     Connector/
                                                                Cage
                                     SFF-8663     SFF-8683
                                     Cage         Cage
                                     (Style A)
```

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2   **Figure 4-3 QSFP56 Pluggable Transceiver Solution**
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                              QSFP112
                          Pluggable Solution

  Management        General          Connector/ Cage            Pluggable
  Interface         Electrical                                  Module

  CMIS              SFF-8679    SFF-TA-1027    SFF-TA-1029    SFF-TA-1027
                                QSFP2          Cabled         QSFP2
                                Connector,     Connector/     Connector,
                                Cage, and      Cage           Cage, and
                                Module                        Module
```
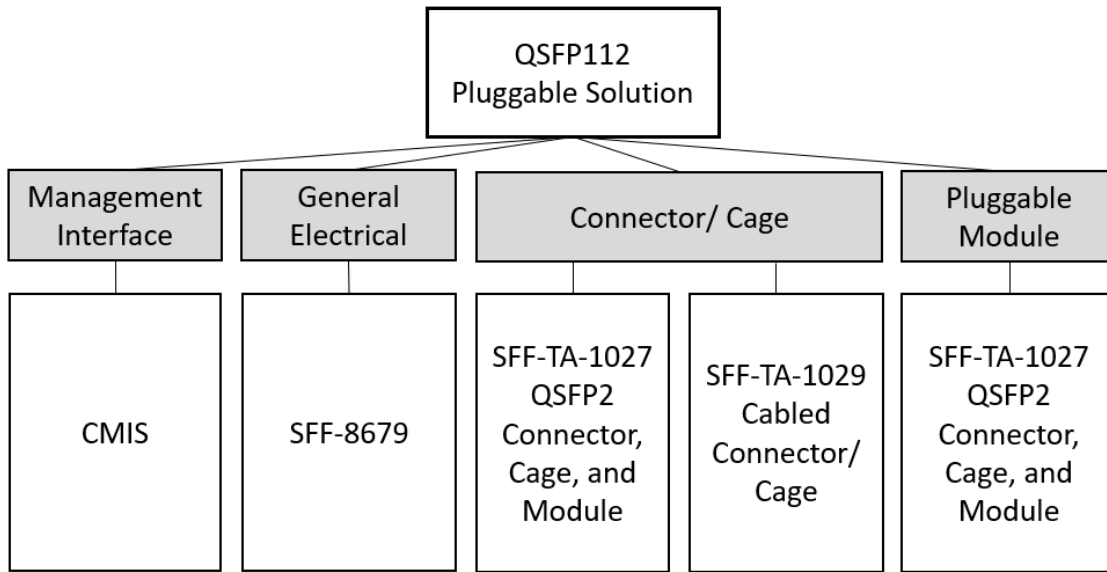
5
6   **Figure 4-4 QSFP112 Pluggable Transceiver Solution**
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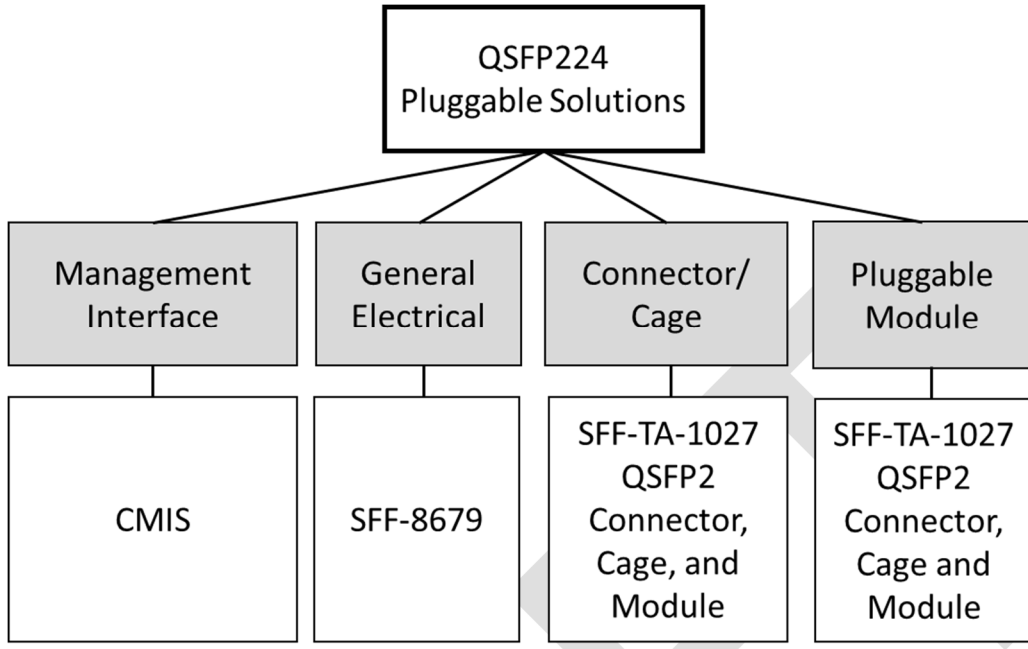2 **Figure 4-5 QSFP224 Pluggable Transceiver Solution**
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5. Overview of Referenced Specifications

5.1   Management Interfaces

These specifications define a common management interface for 4-lane cable assemblies. They define 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.

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.
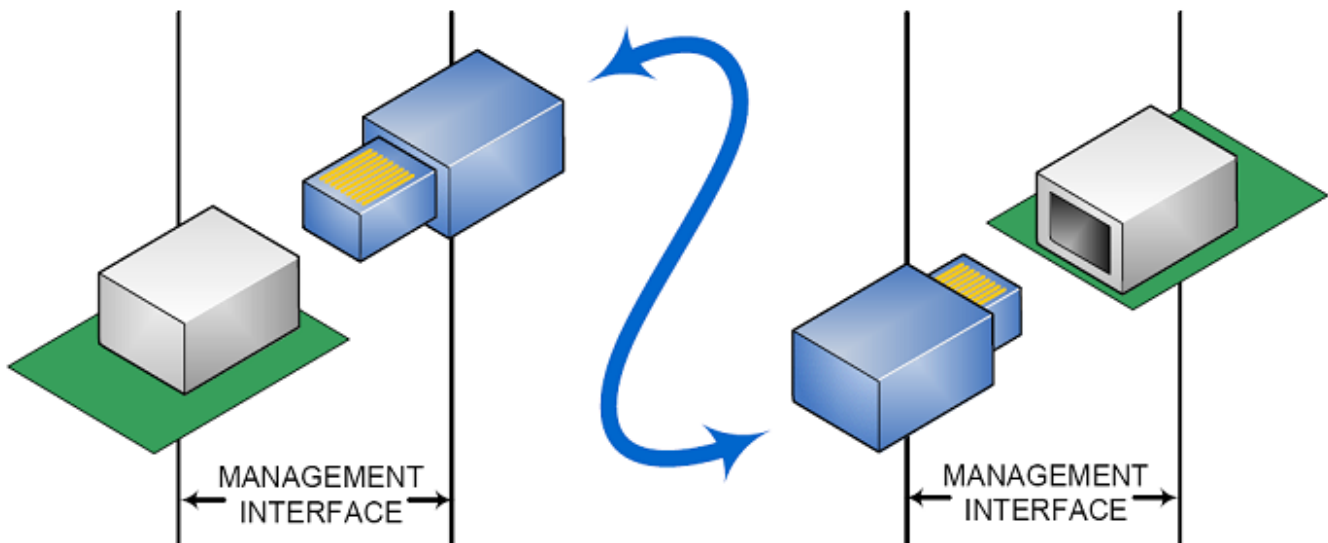
Figure 5-1 Management Interface

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

      d.   Link training may be used to optimize parameters of a signal shaping filter in the upstream transmit SerDes, based on requests from the downstream receive SerDes (of any type: adaptive or not).

5.2   General Electrical

SFF-8679 defines the pin outs, the electrical, the optical, the power supply, the ESD and the thermal characteristics of the cable plugs and pluggable modules.
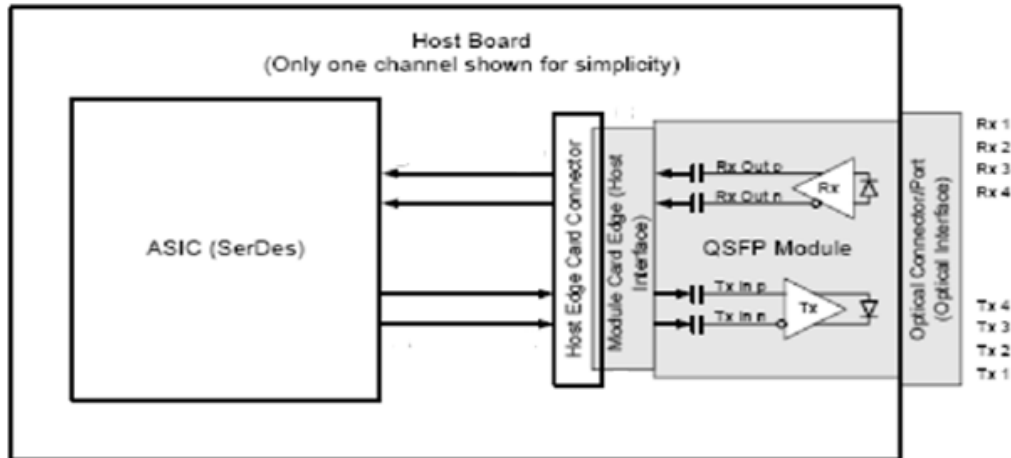
Figure 5-2 Application Reference Model

5.3   Connector, Cage, and Module Specifications

5.3.1   Connectors

There are multiple SFF specifications (SFF-8662, SFF-8672, SFF-8682, SFF-TA-1027, and SFF-TA-1029) that define the physical interface and general performance requirements of QSFP connector variants. summarizes the connectors and cages that make up QSFP+ pluggable transceiver solutions and shows which cages are used with specific connectors. All QSFP connector variants are backwards compatible mechanically, though later versions enable use at higher data rates. SFF-TA-1029 defines a cabled QSFP connector variant.

5.3.1.1   QSFP10 and QSFP14 connector

The QSFP10 and QSFP14 connector is defined in SFF-8682. It defines the terminology and physical requirements for the mating interface and physical embodiment of the 0.8 mm connector. The connector intermates with previous generations of lower speed QSFP connectors. The requirements on the characteristic impedance and ability to transmit multi-gigabit signals for cable assemblies and backplanes is defined in the appropriate standard.

5.3.1.2   QSFP28 and QSFP56 connector

The QSFP28 and QSFP56 connector are defined in SFF-8672, SFF-8662 and SFF-TA-1029. The connector specifications define the complete mechanical dimensions of the 28 Gbs 0.8mm connector. The connector system was designed to satisfy the needs for gigabit serial data transmission applications where signals have rise times typically in the range of 20ps over a nominal 100 ohm differential balanced copper link with a common mode balance of 32.5 ohm. Design goals where Minimization of crosstalk and Minimum common mode and differential impedance discontinuity across the connector interface and speeds of up to 28 Gigabits/second on both rows of contacts. SFF-8672 defines the Type B connector, SFF-8662 define the Type A connector and SFF-TA-1029 defines

1 the cabled connector.
2
3 **5.3.1.3   QSFP112 connector**
4 The QSFP112 connector is defined in SFF-TA-1027 and SFF-TA-1029. SFF-TA-1027 defines a 1x1 connector with
5 footprint Styles A, B, & C and a 2x1 connector with footprint Styles A, B, C, & D. SFF-TA-1029 defines a cabled
6 connector.

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Table 5-1 Connectors and Cages for QSFP+ Pluggable Transceiver Solutions

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

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8 Examples of QSFP connectors are shown in Figure 5-3 through **Error! Reference source not found.**.
9
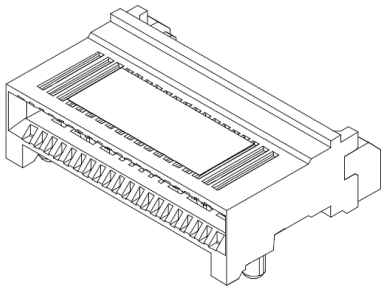
Figure 5-3 SFF-8662 Connector
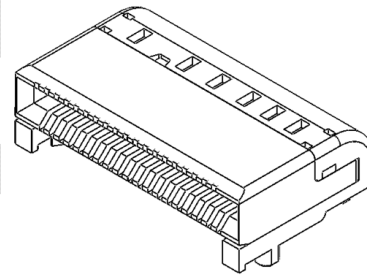
Figure 5-4 SFF-8672 Connector
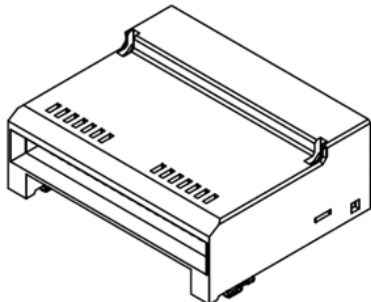
Figure 5-5 SFF-TA-1027 Connector
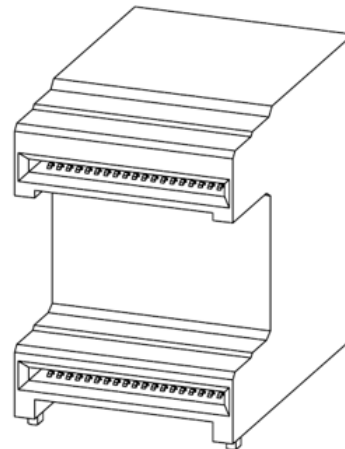
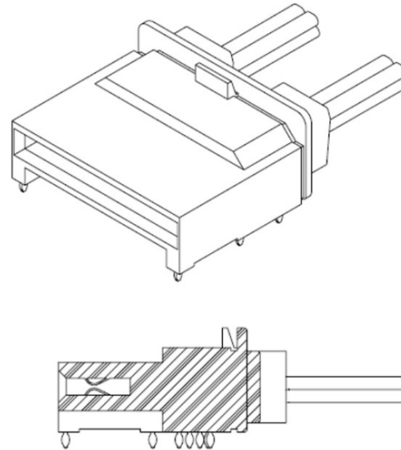**Figure 5-6 SFF-TA-1027 Stacked Connector**

Figure 5-7 SFF-TA-1029 Cabled Connector

5.3.2   Cages

There are multiple SFF specifications (SFF-8663, SFF-8683, SFF-TA-10276, 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.~~

5.3.2.1   QSFP10 and QSFP14 cages

The SFF-8683 specification defines the complete mechanical dimensions of the QSFP10 and QSFP14 cage. The cage system provides several implementation alternatives in terms of interoperability and EMI control that provide the increased data rate capability required for high speed applications. The cage system supports optional heat sink attachment and spring finger, elastomeric gasket and behind the bezel cages for EMI control.

5.3.2.2   QSFP28 and QSFP56 cages

The QSFP28 and QSFP56 cage is defined in SFF-8663 and SFF-TA-1029. SFF-8663 specification defines the terminology and mechanical requirements for a 28 Gb/s cage. The specification is also intended to facilitate the implementation of 1 x "n" ganged cages and the 2 x "n" stacked cage configurations. The specification has enhanced EMI characteristics when mated with a cage designed for the 28 Gb/s module. There are new cage dimensional requirements specified in this document to enable assembly with the 28 Gb/s Mini Multilane connector specified in SFF-8662. These new requirements do not affect the mating compatibility of QSFP+ modules with the new 28 Gb/s cage.

5.3.2.3   QSFP112 cages

The QSFP112 cage is defined in SFF-TA-1027 and SFF-TA-1029. SFF-TA-1027 defines 1x1 and 2x1 stacked cages with or without a riding heatsink. Both a legacy latch design and angled latch design are supported.
SFF-TA-1029 defines a cabled cage design.

These specifications may 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.
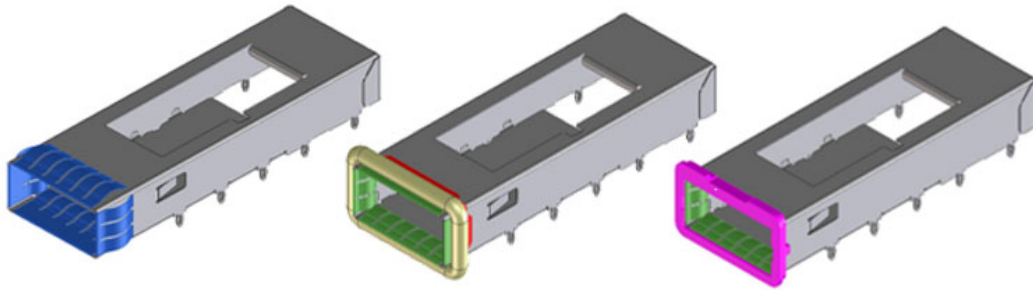
1
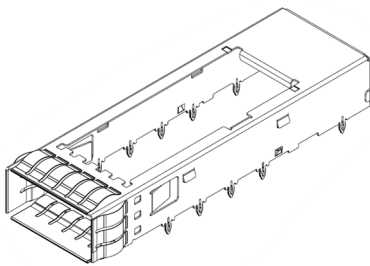2　　　　　　　　　　**Figure 5-8 SFF-8663 and SFF-8683 Cages**
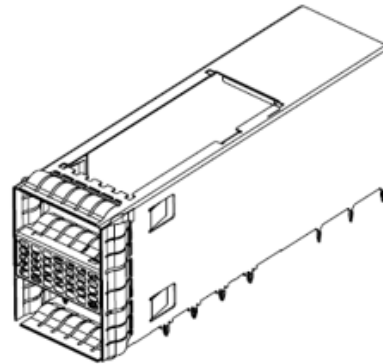

Figure 5-9 SFF-TA-1027 Cage　　　　　　**Figure 5-10 SFF-A-1027 Stacked Cage**

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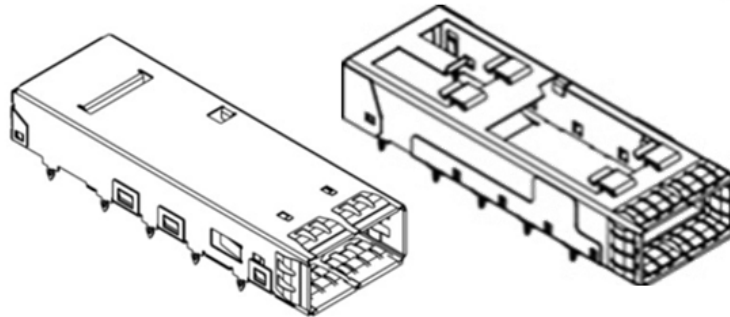6　　　　　　　　　　　　**Figure 5-11 SFF-TA-1029 Cages**
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5.3.3　　Modules

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

5.3.3.1　　QSFP10, QSFP14, QSFP28 and QSFP56 module

SFF-8661 defines the complete mechanical dimensions of the QSFP+ 4x module. This module provides interoperability and EMI control for the QSFP system. The QSFP+ module contains a printed circuit board that mates with an appropriately designed connector.

5.3.3.2　　QSFP112 module

The QSFP112 module is defined in SFF-TA-1027 and SFF-TA-1029. SFF-TA-1027 defines module mechanical dimensions that are identical to QSFP+ and QSFP28 modules unless specified otherwise (refer to SFF-8661). For QSFP2 modules, the bottom surface of the module within the cage shall be flat without a pocket.

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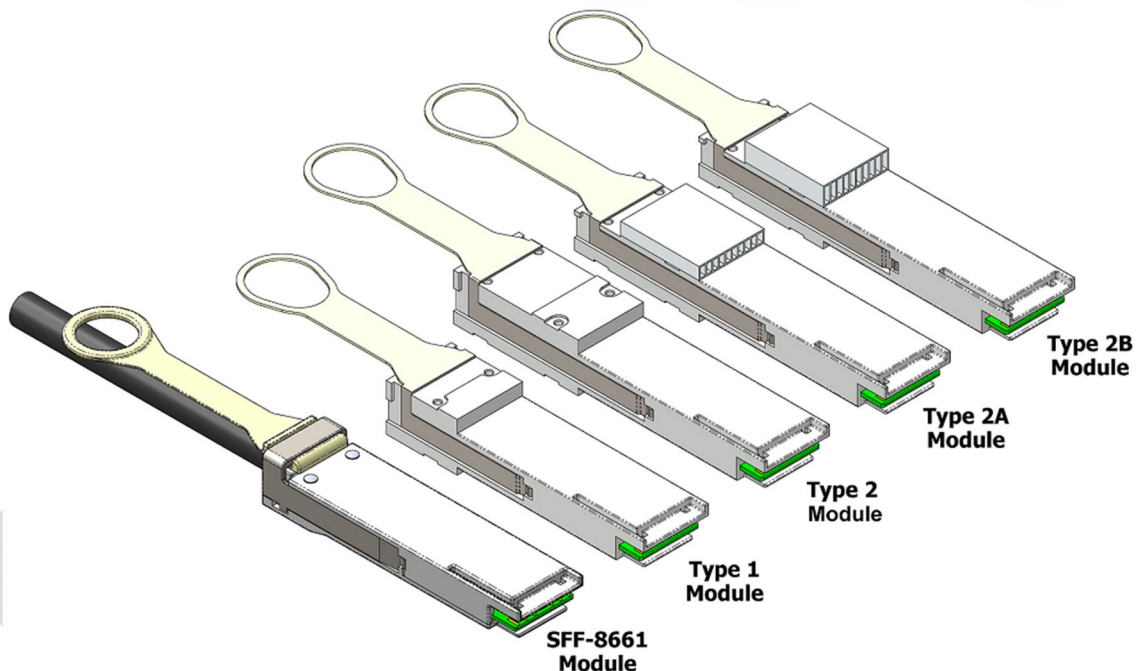

Figure 5-12 Typical Cable Plug and Pluggable Modules

6. QSFP Thermal Recommendations

High performance network environments need to cool pluggable optical modules efficiently. Higher power modules for QSFP systems must dissipate this heat effectively to ensure operational performance of the modules. Prudent module, cage, heat sink and overall system design for QSFP modules is shown to be effective. A future whitepaper will explain techniques that can be used to achieve this goal in QSFP module design and QSFP system design and provide both experimental and simulation studies to demonstrate their efficacy. (See www.qsfp-dd.com for thermal white paper)