136.10 Channel characteristics

The channel is defined between TP0 and TP5 to include the transmitter and receiver differential controlled impedance printed circuit board and the cable assembly as illustrated in Figure 136–2. The channel insertion loss, return loss, COM, and the transmitter and receiver differential controlled impedance printed circuit board parameters are provided informatively in 136A.1 through 136A.4.

Channel definitions apply for links between two PHYs of the same type, 50GBASE-CR, 100GBASE-CR2, or 200GBASE-CR4.

136.11 Cable assembly characteristics

Cable assemblies defined in this subclause contain insulated conductors terminated in a connector at each end for use as link segments between MDIs. Cable assemblies are primarily intended as point-to-point links between 50GBASE-CR, 100GBASE-CR2, or 200GBASE-CR4 PHYs using controlled impedance cables.

The cable assembly types are specified in Table 136C-1. Each cable assembly has an achievable cable length of at least 3 m.

50GBASE-CR has five specified MDI connectors, including single lane, four lane and eight lane connections. 100GBASE-CR2 and 200GBASE-CR4 have 4 specified MDI connectors including four and eight lane connectors. All cable assembly measurements are to be made between TP1 and TP4 with cable assembly test fixtures as specified in Annex 136B. These cable assembly specifications are based upon twinaxial cable characteristics, but other cable types are acceptable if the specifications of this subclause are met.

Table 136–14 provides a summary of the cable assembly characteristics for 50GBASE-CR, 100GBASE-CR2, and 200GBASE-CR4, and references to the subclauses addressing each parameter.

The specifications for the cable assembly types are identical except the number of lanes.

136.11.7.2 Signal and crosstalk paths used in calculation of COM

Cable assemblies have several form factors, as described in Annex 136C. The choice of signal and crosstalk paths for calculation of COM is specific to each cable assembly form factor, as specified in Table 136-16.

Table 136-16: MDI Crosstalk channels

	SFP28		QSFP28 or microQSFP		QSFP-DD or OSFP	
	NEXT	FEXT	NEXT	FEXT	NEXT	FEXT
SFP28	1	1	1	3	1~~8~~	7
QSFP28 or microQSFP	4	3	4	3	4~~3~~	7
QSFP-DD or OSFP	8	7	8	7	8~~7~~	7

.

136.12 MDI specifications

This subclause defines the 50GBASE-CR, the 100GBASE-CR2, and the 200GBASE-CR4 Media Dependent Interface (MDIs). The MDI couples the PMD (specified in 136.8 and 136.9) to the cable assembly (specified in 136.11). The MDI types available for each PHY type are shown in Table 136-17.

For 50GBASE-CR, the mechanical interface between the PMD and the cable assembly may be a

mated pair of connectors meeting the requirements of 110.11.1 (single-lane MDI), a mated pair of connectors meeting the requirements of 92.12.1.1 or 136.12.1 (four-lane MDI) or a mated pair of connectors meeting the requirements of 136.12.2 or 136.12.3 (eight-lane MDI). The plug connector is used on the cable assembly and the receptacle is used on the PMD. For the multi-lane MDIs, each of the paired transmit and receive lanes (SL0, DL0), (SL1, DL1), (SL2, DL2), (SL3, DL3) etc may be used for the transmit and receive connections (SL and DL). If the multi-lane MDI does not utilize the maximum number of transmit and receive connections available it shall fill the pair transmit and receive lanes starting with the lowest numbered pair of transmit and receive lanes, i.e. SL0, DL0 first, SL1, SL1 second, etc.
For 100GBASE-CR2 or 200GBASE-CR4, the mechanical interface between the PMD and the cable assembly is a mated pair of connectors meeting the requirements of 92.12.1.1 or 136.12.1 (four-lane MDI) or 136.12.2 or 136.12.3 (eight-lane MDI). The plug connector is used on the cable assembly and the receptacle is used on the PMD. For 100GBASE-CR2 four-lane MDI, the paired transmit and receive lanes for one PHY shall be (SL0, DL0) and (SL1, DL1), and if a second PHY uses the same MDI connector it uses (SL2, DL2) and (SL3, DL3). For 100GBASE-CR2 eight-lane MDI, the paired transmit and receive lanes for one PHY shall be (SL0, DL0) and (SL1, DL1). For a second PHY using the same eight lane MDI connector it uses (SL2, DL2) and (SL3, DL3). A third PHY using the same eight lane MDI connector uses (SL4, DL4) and (SL5, DL5) with a fourth PHY using (SL6, DL6 and SL7, L7).

For 50GBASE-CR, 100GBASE-CR2 and 200GBASE-CR4 plug connectors, the receive lanes are AC-coupled; the AC-coupling shall be within the plug connectors. It should be noted that there may be various methods for AC-coupling in actual implementations. The low-frequency 3 dB cutoff of the AC-coupling shall be less than 50 kHz. It is recommended that the value of the coupling capacitors be 100 nF. The capacitor limits the inrush charge and baseline wander.

Table 136-17 Physical layer MDI connector types

MDI types	**Physical Layer**			
	50GBASE-CR	**100GBASE-CR2**	**200GBASE-CR4**	**Reference**
SFP28	x1			110.11.1
QSFP28	x1, x2, x4	x1, x2	x1	92.12.1.1
microQSFP	x1, x2, x4	x1, x2	x1	136.12.1
QSFP-DD	x1, x2, x4, x8	x1, x2, x4	x1, x2	136.12.2
OSFP	x1, x2, x4, x8	x1, x2, x4	x1, x2	136.12.3

136.12.1 Four-lane microQSFP MDI connector

The four-lane microQSFP MDI uses the plug and receptacle as defined in the microQSFP MSA (www.microqsfp.com). This MDI may also be used as a single lane MDI due to its inherent density and thermal aspects. When used as a single lane MDI, the transmit and receive lanes used must be (SL0, DL0). The cable assembly connector shall be the microQSFP plug as illustrated in Figure 136–11. The PMD connector shall be the microQSFP receptacle with the mechanical mating interface as illustrated in Figure 136-12. The connectors shall have data signal and signal ground contact assignments as specified in Table 136-18 and electrical performance consistent with the signal quality and electrical requirements of 136.9 and 136.10.

Figure 136-11- x4 microQSFP plug

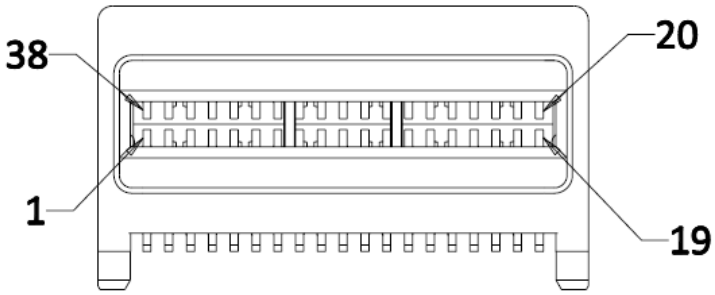

Figure 136-12 - microQSFP example MDI board receptacle

Table 136-18 - microQSFP lane to MDI connector contact mapping

Pad	Lane	Description
1	GND	Ground
2	SL2n	Transmitter Inverted Data Input
3	SL2p	Transmitter Non-Inverted Data Input
4	GND	Ground
5	SL4n	Transmitter Inverted Data Input
6	SL4p	Transmitter Non-Inverted Data Input
7	GND	Ground
13	GND	Ground
14	DL3p	Receiver Non-Inverted Data Output
15	DL3n	Receiver Inverted Data

		Output
16	GND	Ground
17	DL1p	Receiver Non-Inverted Data Output
18	DL1n	Receiver Inverted Data Output
19	GND	Ground
20	GND	Ground
21	DL2n	Receiver Inverted Data Output
22	DL2p	Receiver Non-Inverted Data Output
23	GND	Ground
24	DL4n	Receiver Inverted Data Output
25	DL4p	Receiver Non-Inverted Data Output
26	GND	Ground
32	GND	Ground
33	SL3p	Transmitter Non-Inverted Data Input
34	SL3n	Transmitter Inverted Data Input
35	GND	Ground
36	SL1p	Transmitter Non-Inverted Data Input
37	SL1n	Transmitter Inverted Data Input
38	GND	Ground

136.12.2 Eight-lane QSFP-DD MDI connector

The eight-lane QSFP-DD MDI uses the plug and receptacle as defined in the QSFP-DD MSA. (www.qsfp-dd.com) The cable assembly connector shall be the QSFP-DD plug as illustrated in Figure 136–13. The PMD connector shall be the QSFP-DD receptacle with the mechanical mating interface as illustrated in Figure 136-14. The connectors shall have data signal and signal ground contact assignments as specified in Table 136-19 and electrical performance consistent with the signal quality and electrical requirements of 136.9 and 136.10.

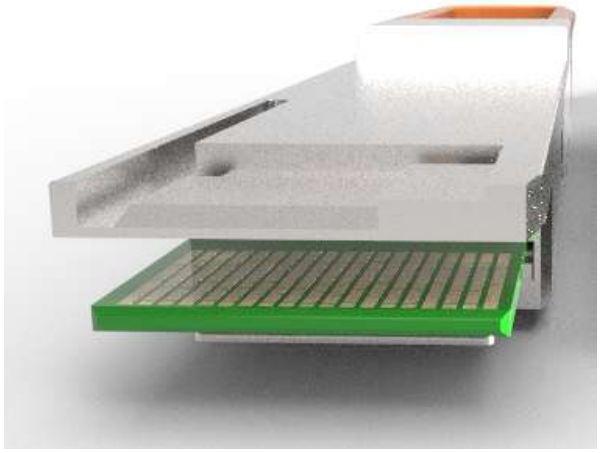

Figure 136-13 -QSFP-DD plug

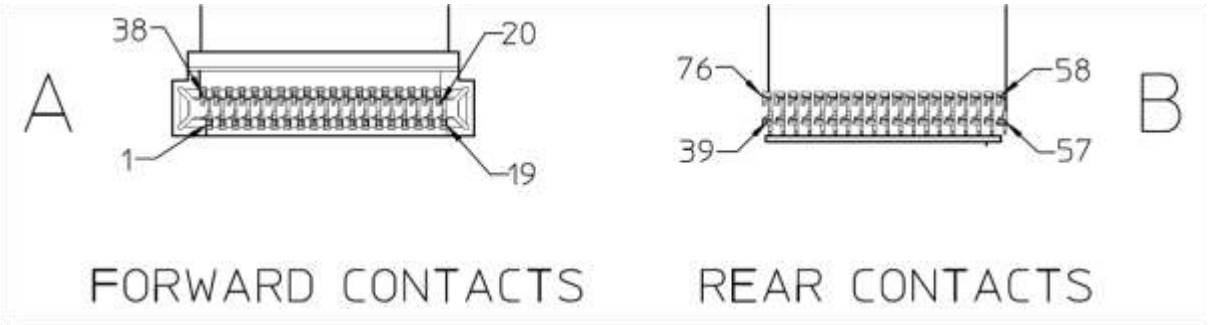

Figure 136-14-QSFP-DD example MDI board receptacle

Table 136-19 - QSFP-DD lane to MDI connector contact mapping

Pad	Lane	Description
1	GND	Ground
2	SL2n	Transmitter Inverted Data Input
3	SL2p	Transmitter Non-Inverted Data Input
4	GND	Ground
5	SL4n	Transmitter Inverted Data Input
6	SL4p	Transmitter Non-Inverted Data Input
7	GND	Ground
13	GND	Ground
14	DL3p	Receiver Non-Inverted Data Output
15	DL3n	Receiver Inverted Data Output
16	GND	Ground
17	DL1p	Receiver Non-Inverted Data Output
18	DL1n	Receiver Inverted Data Output
19	GND	Ground
20	GND	Ground
21	DL2n	Receiver Inverted Data Output
22	DL2p	Receiver Non-Inverted Data Output
23	GND	Ground
24	DL4n	Receiver Inverted Data Output
25	DL4p	Receiver Non-Inverted Data Output
26	GND	Ground
32	GND	Ground
33	SL3p	Transmitter Non-Inverted Data Input
34	SL3n	Transmitter Inverted Data Input
35	GND	Ground
36	SL1p	Transmitter Non-Inverted Data Input
37	SL1n	Transmitter Inverted Data Input
38	GND	Ground
39	GND	Ground
40	SL6n	Transmitter Inverted Data Input
41	SL6p	Transmitter Non-Inverted Data Input
42	GND	Ground
43	SL8n	Transmitter Inverted Data Input
44	SL8p	Transmitter Non-Inverted Data Input
45	GND	Ground
51	GND	Ground
52	DL7p	Receiver Non-Inverted Data Output
53	DL7n	Receiver Inverted Data Output
54	GND	Ground
55	DL5p	Receiver Non-Inverted Data Output
56	DL5n	Receiver Inverted Data Output
57	GND	Ground
58	GND	Ground
59	DL6n	Receiver Inverted Data Output
60	DL6p	Receiver Non-Inverted Data Output
61	GND	Ground
62	DL8n	Receiver Inverted Data Output
63	DL8p	Receiver Non-Inverted Data Output
64	GND	Ground
65	NC	No Connect
70	GND	Ground
71	SL7p	Transmitter Non-Inverted Data Input
72	SL7n	Transmitter Inverted Data Input

73	GND	Ground
74	SL5p	Transmitter Non-Inverted Data Input
75	SL5n	Transmitter Inverted Data Input
76	GND	Ground

136.12.3 Eight-lane OSFP MDI connector

The eight-lane OSFP MDI uses the plug and receptacle as defined in the OSFP MSA (www.osfpmsa.org).
The cable assembly connector shall be the OSFP plug as illustrated in Figure 136–15. The PMD connector shall be the QSFP-DD receptacle with the mechanical mating interface as illustrated in Figure 136-16. The connectors shall have data signal and signal ground contact assignments as specified in Table 136-20 and electrical performance consistent with the signal quality and electrical requirements of 136.9 and 136.10.

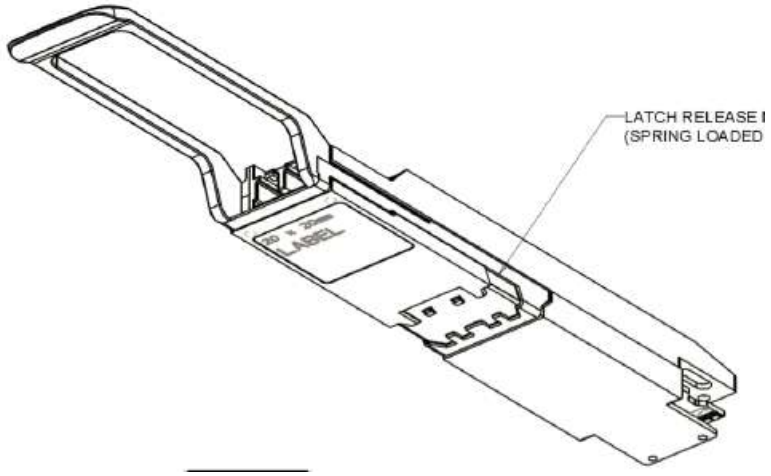

Figure 136-15 - OSFP cable assembly plug

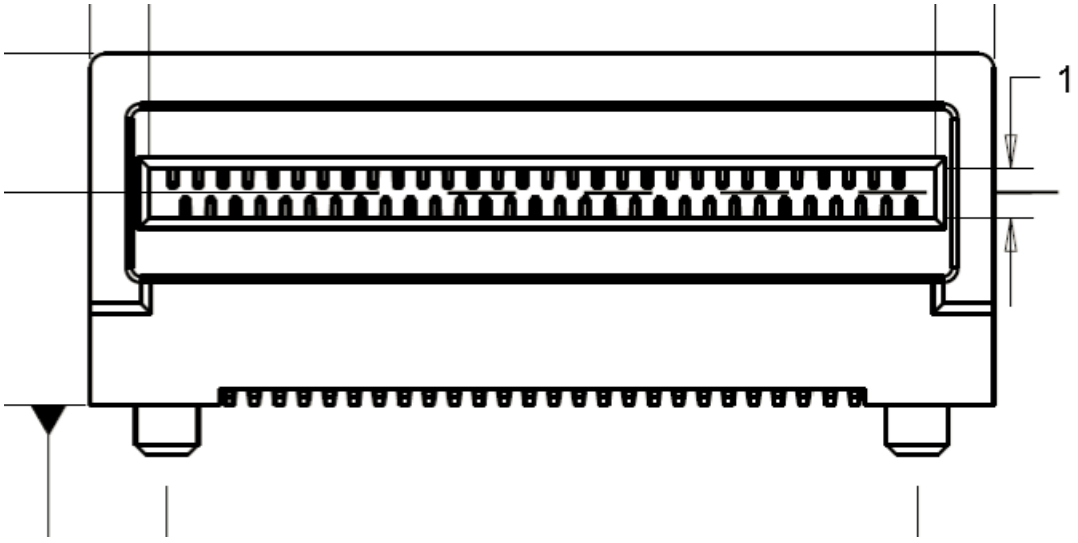

Figure 13-16 - OSFP example MDI board receptacle

Table 136-20 - OSFP lane to MDI connector contact mapping

Pad	Lane	Description
1	GND	Ground
2	SL2p	Transmitter Non-Inverted Data Input
3	SL2n	Transmitter Inverted Data Input
4	GND	Ground
5	SL4p	Transmitter Inverted Data Input
6	SL4n	Transmitter Non-Inverted Data Input
7	GND	Ground
8	SL6p	Ground
9	SL6n	Receiver Non-Inverted Data Output
10	GND	Receiver Inverted Data Output
11	SL8p	Ground
12	SL8n	Receiver Non-Inverted Data Output
18	GND	Receiver Inverted Data Output
19	DL7n	Receiver Inverted Data Output
20	DL7p	Receiver Non-Inverted Data Output
21	GND	Ground
22	DL5n	Receiver Inverted Data Output
23	DL5p	Receiver Non-Inverted Data Output
24	GND	Ground
25	DL3n	Transmitter Non-Inverted Data Input
26	DL3p	Transmitter Inverted Data Input
27	GND	Ground
28	DL1n	Transmitter Non-Inverted Data Input
29	DL1p	Transmitter Inverted Data Input
30	GND	Ground
31	GND	Ground
32	DL2p	Transmitter Inverted Data Input
33	DL2n	Transmitter Non-Inverted Data Input
34	GND	Ground
35	DL4p	Transmitter Inverted Data Input
36	DL4n	Transmitter Non-Inverted Data Input
37	GND	Ground
38	DL6p	Receiver Non-Inverted Data Output
39	DL6n	Receiver Inverted Data Output
40	GND	Ground
41	DL8p	Receiver Non-Inverted Data Output
42	DL8n	Receiver Inverted Data Output
43	GND	Ground
48	GND	Ground
49	SL7n	Receiver Inverted Data Output
50	SL7p	Receiver Non-Inverted Data Output
51	GND	Ground
52	SL5n	Receiver Inverted Data Output
53	SL5p	Receiver Non-Inverted Data Output
54	GND	Ground
55	SL3n	Receiver Non-Inverted Data Output
56	SL3p	Receiver Non-Inverted Data Output
57	GND	Ground
58	SL1p	Transmitter Non-Inverted Data Input
59	SL1n	Transmitter Inverted Data Input
60	GND	Ground

136C.1 Overview This annex describes form factors for the cable assemblies specified in 136.11 and for hosts with either 50GBASE-CR, 100GBASE-CR2, or 200GBASE-CR4 Physical Layers. Hosts have five specified MDI connectors, single-lane (SFP28, specified in 110.11.1) and four-lane (QSFP28, specified in 92.12.1.1 and microQSFP, specified in 136.12.1) and eight-lane (QSFP-DD, specified in 136.12.2 and OSFP, specified in 136.12.3). This creates five host interface types and multiple cable assembly types with different combinations of the connectors at each end. These host and cable assembly types are referred to as form factors, distinguishing both the host receptacle (MDI) and the cable assembly plug. Cable assemblies denoted as 50GBASE-CR, 100GBASE-CR2, and 200GBASE-CR4, have a common set of electrical parameters specified in 136.11. These specifications are based on the 100GBASE-CR4 cable assembly specifications (see 92.10) with referenced parameters specified at 13.28 GHz to account for the increase in signaling rate. The 50GBASE-CR is a single-lane cable assembly (and can also be implemented as a multiple version using a four- or eight-lane MDI for high density applications), enabling a 3 m length. The 100GBASE-CR2 is a two-lane cable assembly (and can also be implemented as a multiple version using a four-lane and eight-lane MDI for high density applications) , enabling a 3 m length. The 200GBASE-CR4 is a four-lane cable assembly, enabling a 3 m length. The possible combinations of host form factors, cable assembly form factors and lengths are summarized in Table 136C–1.

Table 136C-1 Host and cable assembly combinations

Cable assembly combination	**Physical Layer**		
	50GBASE-CR	**100GBASE-CR2**	**200GBASE-CR4**
SFP28 to SFP28	x		
QSFP28 to 4xSFP28	x		
QSFP28 to 4xmicroQSFP	x		
microQSFP to 4xSFP28	x		
microQSFP to 4xmicroQSFP	x		
QSFP-DD to 8xSFP28	x		
OSFP to 8xSFP28	x		
QSFP28 to QSFP28	x	X	
QSFP28 to 2xQSFP28	x	X	
microQSFP to microQSFP	x	X	
microQSFP to 2xmicroQSFP	x	X	
QSFP-DD to 4xQSFP28	x	X	
QSFP-DD to 4xmicroQSFP	x	X	
OSFP to 4xQSFP28	x	X	
OSFP to 4xmicroQSFP	x	X	
QSFP-DD to 2xQSFP28	x	X	X
QSFP-DD to 2xmicroQSFP	x	X	X
OSFP to 2xQSFP28	x	X	X
OSFP to 2xmicroQSFP	x	X	X
QSFP-DD to QSFP-DD	x	X	X

OSFP to OSFP	x	X	X

136C.2 Host form factors

136C.2.1 SFP28 host form factor

A host may use the SFP28 receptacle specified in 110.11.1 as the MDI for a 50GBASE-CR PHY as shown in Table 136C-1. This is referred to as an SFP28 host form factor.

136C.2.2 QSFP28 host form factor

A host may use the QSFP28 receptacle specified in 92.12.1.1 as the MDI for four 50GBASE-CR PHYs, one or two 100GBASE-CR2 PHYs or one 200GBASE-CR4 PHY. This is referred to as a QSFP28 host form factor.

A QSFP28 form factor host can also form up to four 50 Gb/s links as shown in Table 136C-1.

136C.2.3 microQSFP host form factor

A host may use the microQSFP receptacle specified in 136.12.1 as the MDI for a single, two, three or four 50GBASE-CR PHYs, one or two 100GBASE-CR2 PHYs or one 200GBASE-CR4 PHY as shown in Table 136C-1. This is referred to as a microQSFP host form factor. This MDI may also be used as a single lane MDI~~ due to it's inherent density and thermal aspects. When used as a single lane MDI, the transmit and receive lanes used must be (SL0, DL0).~~

136C.2.4 QSFP-DD host form factor

A host may use the QSFP-DD receptacle specified in 136.12.2 as an~~the~~ MDI for eight 50GBASE-CR PHYs, four 100GBASE-CR2 PHYs or two 200GBASE-CR4 PHYs as shown in Table 136C-1. This is referred to as a QSFP-DD host form factor.

136C.2.5 OSFP host form factor

A host may use the OSFP receptacle specified in 136.12.3 as the MDI for eight 50GBASE-CR PHYs, four 100GBASE-CR2 PHYs or two 200GBASE-CR4 PHYs as shown in Table 136C-1. This is referred to as an OSFP host form factor.

136C.3 Cable assembly form factors

136C.3.1 Single lane to single lane cable assembly form factor

The single lane to single lane cable assembly has SFP28 plugs, specified in 110.11.1, on both ends. It may be used to connect two SFP28 form factor hosts (see 136C.2.1) with a single 50 Gb/s link. The cable assembly is illustrated in Figure 136C–1.

The electrical characteristics of a cable assembly for this form factor are specified in 136.11, using the definitions in 136.11.7.2.1.

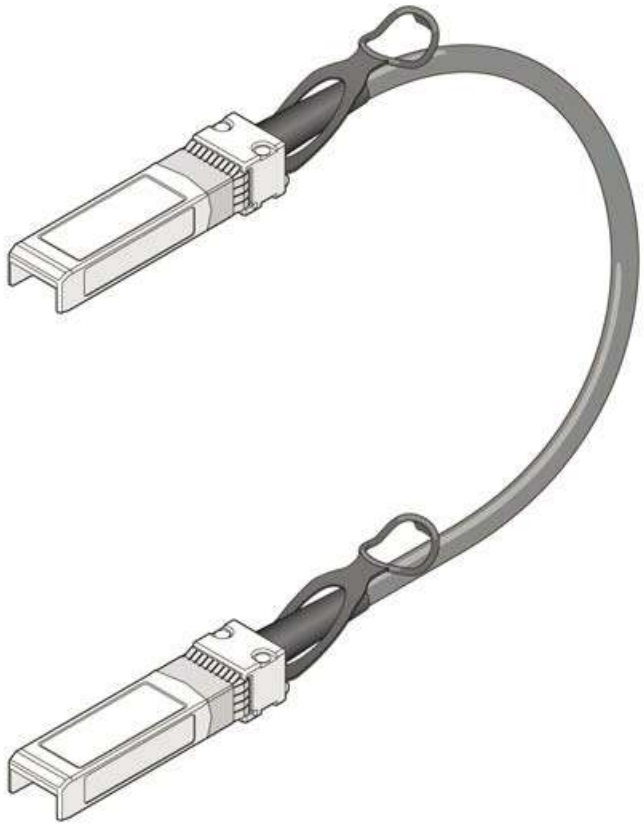

Figure 136C–1—Single lane to single lane cable assembly

Note: Image is a representative plug and not the sole solution

136C.3.2 Four lane to four lane and two lane to two lane cable assembly form factors

The four lane to four lane and the two lane to two lane cable assembly form factors use QSFP28 plugs, specified in 92.12, on both ends, microQSFP plugs on both ends as specified in 136.12.1 or a combination of QSFP28 on one end and microQSFP on the other end. They may be used to connect two QSFP28 or microQSFP form factor hosts (see 136C.2.2 or 136C.2.3) with up to four 50 Gb/s links. The cable assembly is illustrated in Figure 136C–2.

The electrical characteristics of these cable assemblies for these form factors are specified in 136.11, using the definitions in 136.11.7.2.4.

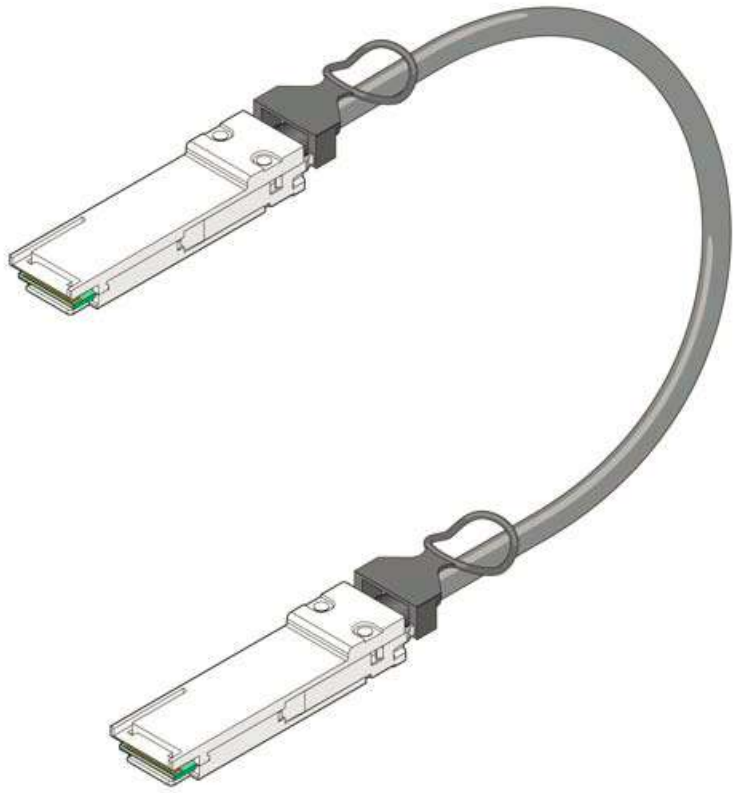

Figure 136C–2—Four lane to four lane and two lane to two lane cable assembly

Note: Image is a representative plug and not the sole solution

136C.3.3 Four Lane to single lane breakout cable assembly form factor

The four lane to single lane breakout cable assembly can use either a QSFP28 plug as specified in 92.12.1.1 or a microQSFP plug as specified in 136.12.1 on one end, and four SFP28 plugs as specified in 110.11.1 on the other end. It may be used to connect a QSFP28 or microQSFP form factor host (see 136C.2.2 or 136C.2.3) to up to four SFP28 form factor hosts (see 136C.2.1) with one 50 Gb/s link to each SFP28 host. The cable assembly is illustrated in Figure 136C–3.

The electrical characteristics of a cable assembly for this form factor are specified in 136.11, using the definitions in 136.11.7.2.2 and 136.11.7.2.3.

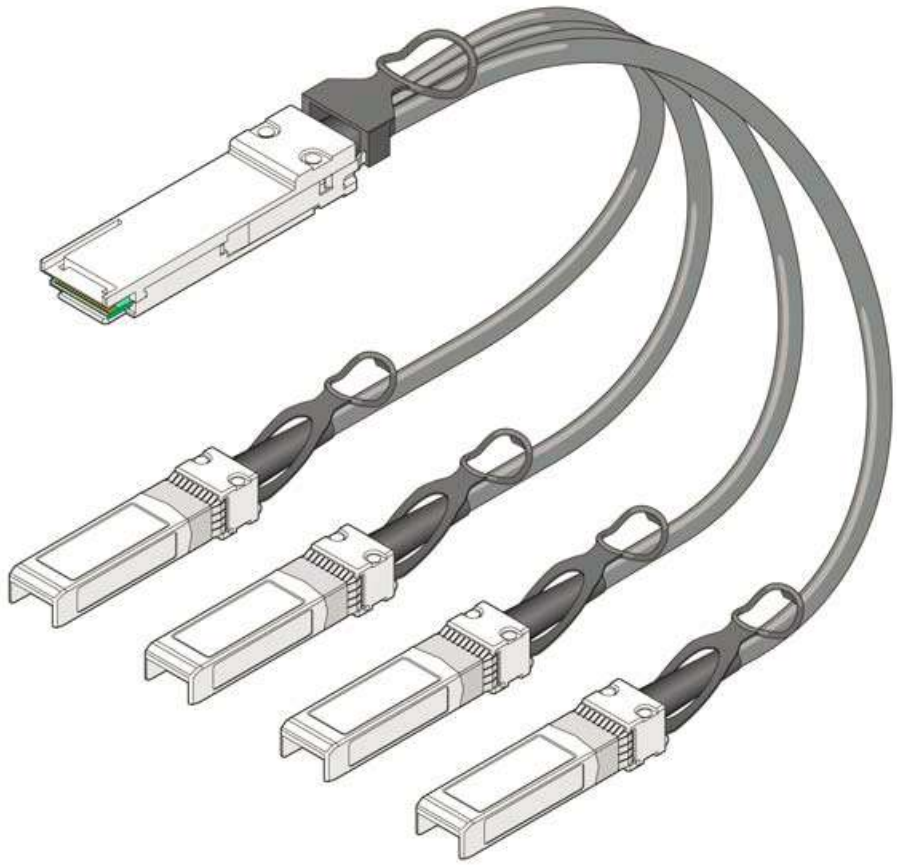

Figure 136C–3—Four lane to single lane breakout cable assembly

Note: Image is a representative plug and not the sole solution

136C.3.4 Four Lane to two lane breakout cable assembly form factor

The four lane to two lane breakout cable assembly can use either a QSFP28 plug as specified in 92.12.1.1 or a microQSFP as specified in 136.12.1 on the near end, and two QSFP28 or microQSFP plugs on the far end. It may be used to connect a QSFP28 or microQSFP form factor host (see 136C.2.2 or 136C.2.3) to two QSFP28 or microQSFP form factor hosts with two 50 Gb/s links to each far end host. The cable assemblies are illustrated in Figure 136C–4.

The electrical characteristics of a cable assembly for this form factor are specified in 136.11, using the definitions in 136.11.7.2.2 and 136.11.7.2.3.

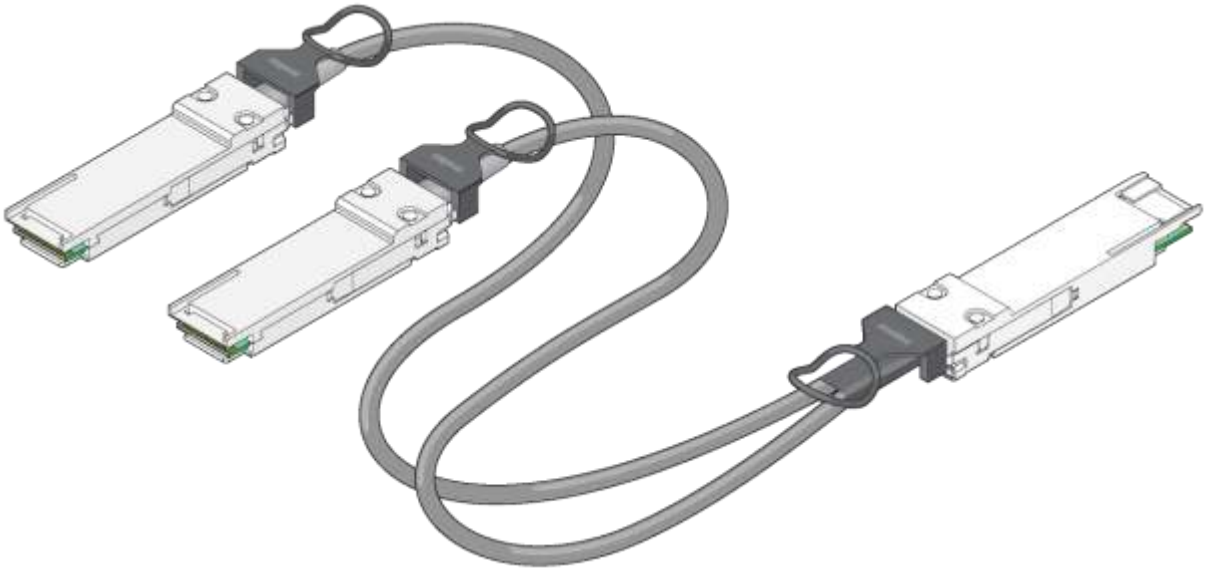

Figure 136C–4—Four lane to two lane cable assembly

Note: Image is a representative plug and not the sole solution

136C.3.5 Eight Lane to single lane breakout cable assembly form factor

The eight lane to single lane breakout cable assembly can use either a QSFP-DD plug as specified in 136.12.2 or an OSFP plug as specified in 136.12.3 on the near end, and eight SFP28 plugs as specified in 110.11.1 on the far end. It may be used to connect a QSFP-DD or OSFP form factor host (see 136C.2.4 or 136C.2.5) to up to eight SFP28 form factor hosts (see 136C.2.1) with one 50 Gb/s link to each SFP28 host. The cable assemblies are illustrated in Figure 136C–5.

The electrical characteristics of a cable assembly for this form factor are specified in 136.11, using the definitions in 136.11.7.2.2 and 136.11.7.2.3.

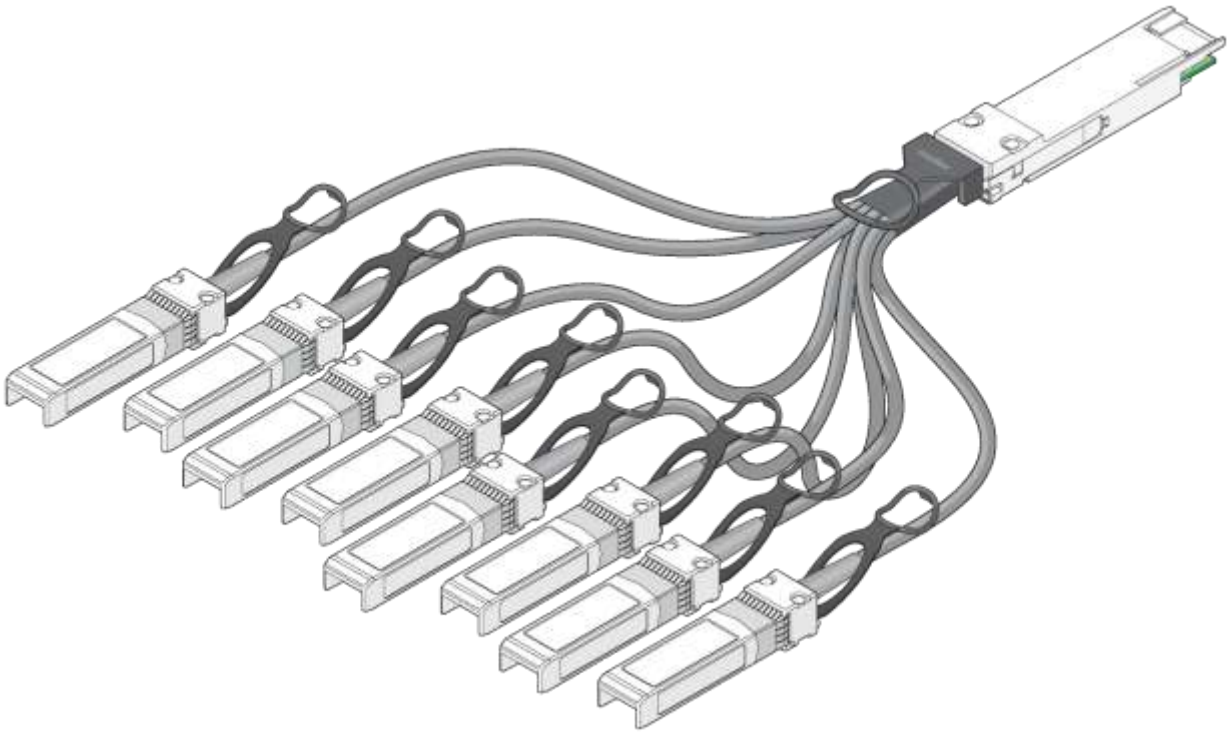

Figure 136C-5-Eight lane to single lane breakout cable assembly

Note: Image is a representative plug and not the sole solution

136C.3.6 Eight Lane to two lane breakout cable assembly form factor

The eight lane to two lane breakout cable assembly can use either a QSFP-DD plug as specified in 136.12.2 or a OSFP as specified in 136.12.3 on the near end, and four QSFP28 or microQSFP plugs as specified in 92.12.1.1 or 136.12.1 on the far end. It may be used to connect a QSFP-DD or OSFP form factor host (see 136C.2.4 or 136C.2.5) to four QSFP28 or microQSFP form factor hosts (see 136C.2.2 or 136C.2.3) with two 50 Gb/s links to each far end host. The cable assemblies are illustrated in Figure 136C–6.

The electrical characteristics of a cable assembly for this form factor are specified in 136.11, using the definitions in 136.11.7.2.2 and 136.11.7.2.3.

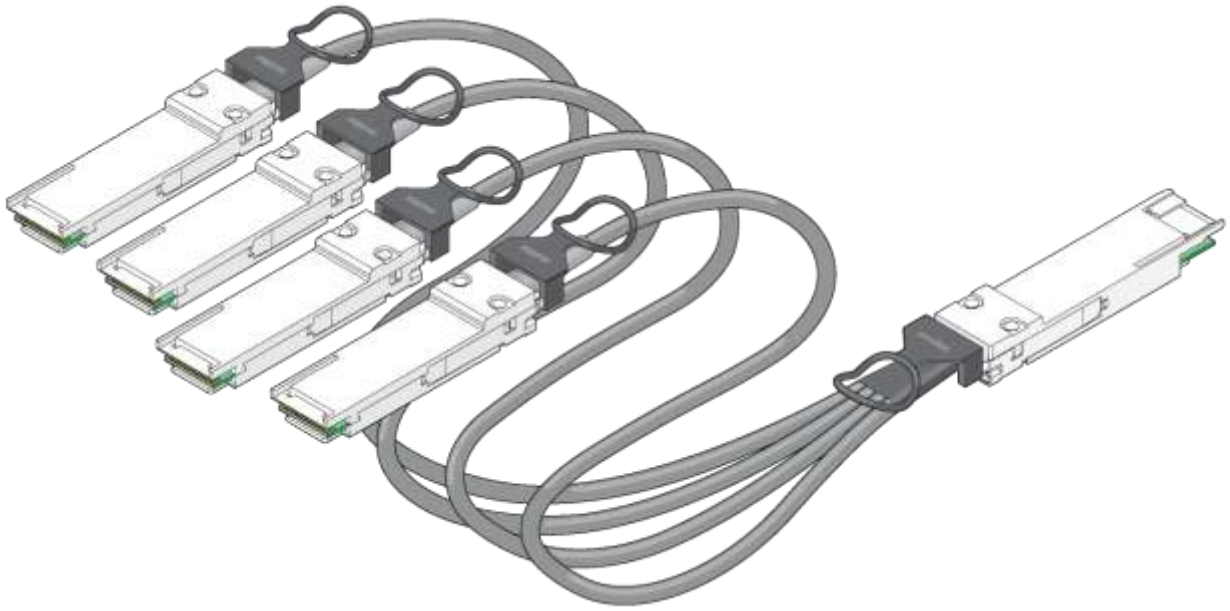

Figure 136C-6-Eight lane to two lane breakout cable assembly

Note: Image is a representative plug and not the sole solution

136C.3.7 Eight Lane to four lane breakout cable assembly form factor

The eight lane to four lane breakout cable assembly can use either a QSFP-DD plug as specified in 136.12.2 or a OSFP as specified in 136.12.3 on the near end, and two QSFP28 or microQSFP plugs as specified in 92.12.1.1 or 136.12.1 on the far end. It may be used to connect a QSFP-DD or OSFP form factor host (see 136C.2.4 or 136C.2.5) to two QSFP28 or microQSFP form factor hosts (see 136C.2.2 or 136C.2.3) with four 50 Gb/s links to each far end host. The cable assemblies are illustrated in Figure 136C–7.

The electrical characteristics of a cable assembly for this form factor are specified in 136.11, using the definitions in 136.11.7.2.2 and 136.11.7.2.3.

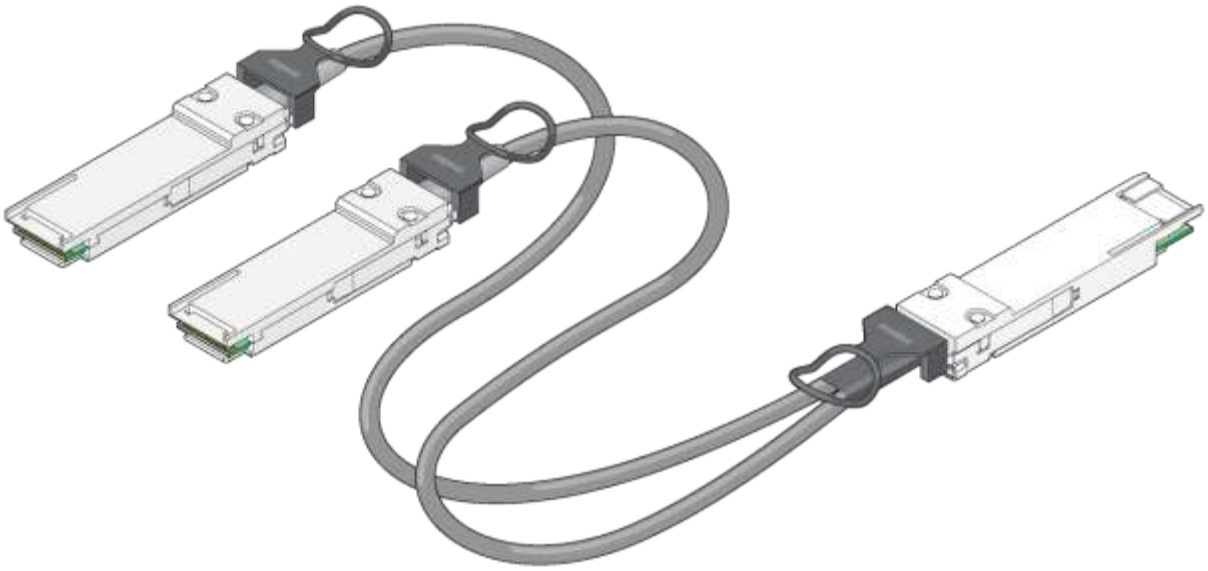

Figure 136C-7-Eight lane to four lane cable assembly

Note: Image is a representative plug and not the sole solution

136C.3.7 Eight Lane to eight lane cable assembly form factor

The eight lane to eight lane breakout cable assembly can use either a QSFP-DD plug as specified in 136.12.2 or an OSFP as specified in 136.12.3 on both ends or a combination of QSFP-DD and OSFP on either end. It may be used to connect a QSFP-DD or OSFP form factor host (see 136C.2.4 or 136C.2.5) to a QSFP-DD or OSFP form factor hosts with eight 50 Gb/s links to each far end host. The cable assemblies are illustrated in Figure 136C–8.

The electrical characteristics of a cable assembly for this form factor are specified in 136.11, using the definitions in 136.11.7.2.2 and 136.11.7.2.3.

Figure 136C-8-Eight lane to eight lane cable assembly

Note: Image is a representative plug and not the sole solution