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Passive WDM Fiber Optic Hardware Selection

AEN177, Revision 0

Wavelength Division Multiplexing (WDM), allows the increase of network bandwidth using simultaneous data streams (i.e. “channels”) that are transported as separate wavelengths over a single optical fiber. By combining (“multiplexing”) multiple wavelengths onto a single optical fiber, WDM optimizes fiber capacity otherwise unachievable with traditional single channel schemes. WDM equipment multiplexes, transmits, and then separates, or “demultiplexes” wavelengths, as well. Coarse WDM (CWDM) offers up to 18 channels over a fiber (Appendix A), whereas Dense WDM (DWDM) supports 40 to 80 channels per fiber, depending on spacing (Appendix B). There are two main transmission options for a WDM fiber optic link: The first utilizes a ‘fiber pair’ in duplex communications whereby one fiber is dedicated to downstream (or forward) transmission and the second fiber is dedicated to upstream (or return) transmission; the second option utilizes a single fiber where bidirectional downstream and upstream transmissions occur simultaneously.

WDM Market Overview

Continued growth in communication services and ever-increasing bandwidth demands are pushing technological and architectural boundaries and driving change in today’s optical networks. Below are the most common demands and drivers for WDM applications.

- Commercial and municipal services are being augmented through transition from dedicated fibers to shared fibers in a network with CWDM.
- PON evolution from GPON (2.5 Gbps) to higher speeds such as XGS-PON (10 Gbps), NG-PON2 (10-40 Gbps), and even 25G-PON and 50G-PON is utilizing wavelengths that allow coexistence (overlay) of advanced services. WDM devices (Coexistence Elements) enable this overlay on current GPON.
- Hybrid Fiber-Coaxial (HFC) network evolution is promoting Fiber Deep (driving to node+0) and Distributed Access Architectures. As node population increases and transmission shifts to digital ethernet, DWDM is used more in dense channel configurations.
- The densification of 4G/LTE and deployment of 5G in wireless networks is resulting in tremendous growth of radios (cell sites, or antennas), whereby X-haul (back, mid, front) becomes a good candidate for CWDM and/or DWDM.
- Network Convergence further brings the desire to share a common fiber infrastructure for commercial, residential, and wireless services overlay. In conjunction with CWDM and DWDM, the utilization of custom Band WDM (BWDM) allows combination of services of different optical wavelengths.

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Published: 08/18/2022

Passive WDM Hardware

Body When the decision is reached that WDM technology will be utilized, the next step is to select the hardware elements that contain the devices (wavelength filters) that perform the WDM (multiplexing and demultiplexing) functions. This AE Note will guide you through the process of selecting hardware for both inside and outside plant applications considering the functions needed from the WDM solution. Understanding the WDM functions as well as the optical network architecture is the basis for selecting the attributes that go into the integrated WDM hardware and overall platform selection and Bill-of-Material (BOM) generation.

Fiber Transport vs. Multiplexing & Demultiplexing

The fiber that carries the multiplexed wavelengths is called the Common leg (typically marked as COM on the hardware). There are two main configurations of WDM transport used: The first is a 2-fiber ("duplex") communication scheme in which the forward (downstream) traffic is multiplexed onto a single common fiber and then subsequently demultiplexed at the remote side (Figure 1) where the wavelengths are received individually by the respective transceivers. The remote transceivers also simultaneously return communication via the remote side multiplexer on a dedicated, but separate, return (upstream) fiber. At the (source-side) switching center, the return traffic is then demultiplexed and directed to the respective transceiver on that end.

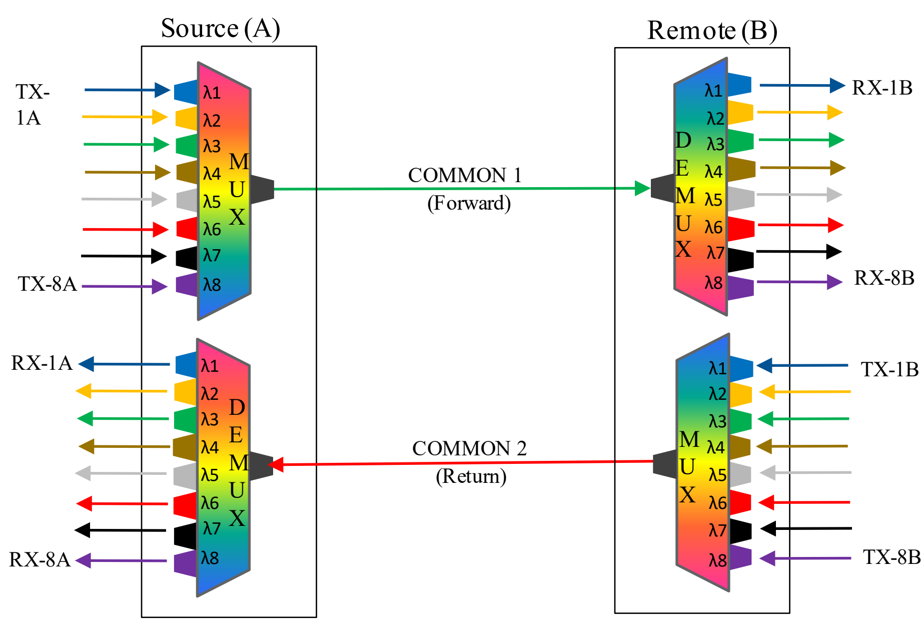

Figure 1: Two-fiber transport with unidirectional traffic on dedicated forward and return fibers using a MUX & DeMUX device. It is an 8-channel (8 λ's) example using a MUX & DeMUX operation. In the switching center (source-side), there is an 8-channel MUX and an 8-channel DeMUX in the solution. Both the MUX and DeMUX use the same wavelengths (aka., channels, or "colors†"). An identical MUX and DeMUX device is used on the remote side. The forward common fiber is connected to the DeMUX. The return common fiber is connected to the MUX.

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Published: 08/18/2022

† *The term "color" is used in the industry primarily for identification reasons and as an explanatory aid. Actual wavelengths are above the visible spectrum and not a useful attribute for identifying channels through visual inspection in the field, or otherwise.*

Because there are dedicated fibers for the forward and return path transmissions, the same wavelengths can be used for forward and return traffic between the respective transceivers. This WDM hardware solution would be referred to (and labeled) as a MUX & DeMUX device because it has one set of filters dedicated for multiplexing and a duplicate set of filters for demultiplexing functions (**Figure 2**). Furthermore, when a fiber is terminated into a hardware cassette, module or equivalent housing, it is typically denoted as a "port" and will usually correspond with a specific connector (adapter), but it depends on the type of connection as to whether a port can allow connection to multiple fibers. Usually, a single port corresponds with a single fiber, but this is not always the case. Otherwise, if the fiber is simply available for splicing in, say, a splice tray or cassette, it is still simply referred to as a leg.

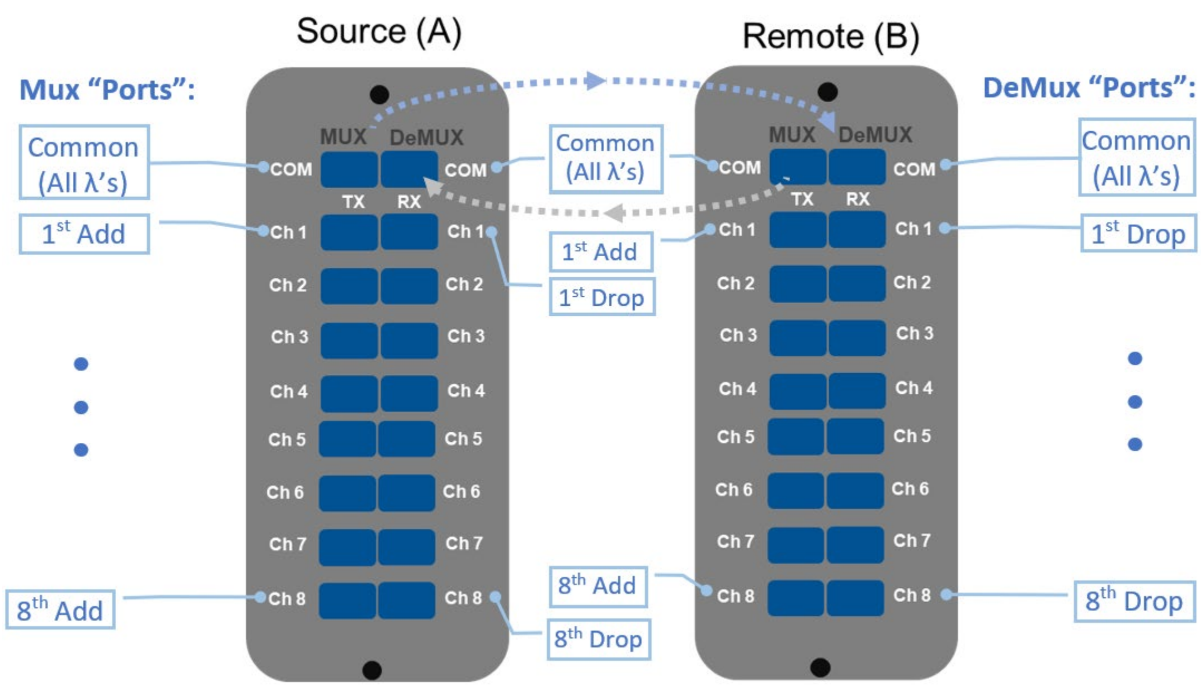

Figure 2: MUX & DeMUX 8-channel modules for a 2-fiber transport system. Note that only COM and ADD/DROP ports shown. If remaining traffic continued, an optional EXP port would also exist.

The second method for WDM transport is comprised of a 1-fiber system (**Figure 3**). In this scenario, both the forward and return traffic are propagating bidirectionally on the same fiber. Unlike the 2-fiber transport, the forward and return wavelengths cannot be the same* for interference reasons. To prevent interfering forward and return transmissions, each pair of transceivers has a different downstream and upstream wavelength (λ). The WDM hardware used in this case would be referred to as a MUX or a DeMUX (**Figure 4**). Alternatively, this is referred to as an A-side and a B-side. The transmit and receive wavelength ports are flipped (transposed) on either side to match respective transceiver functions for source and remote.

**Standard duplex direct-detect WDM transceivers assumed.*

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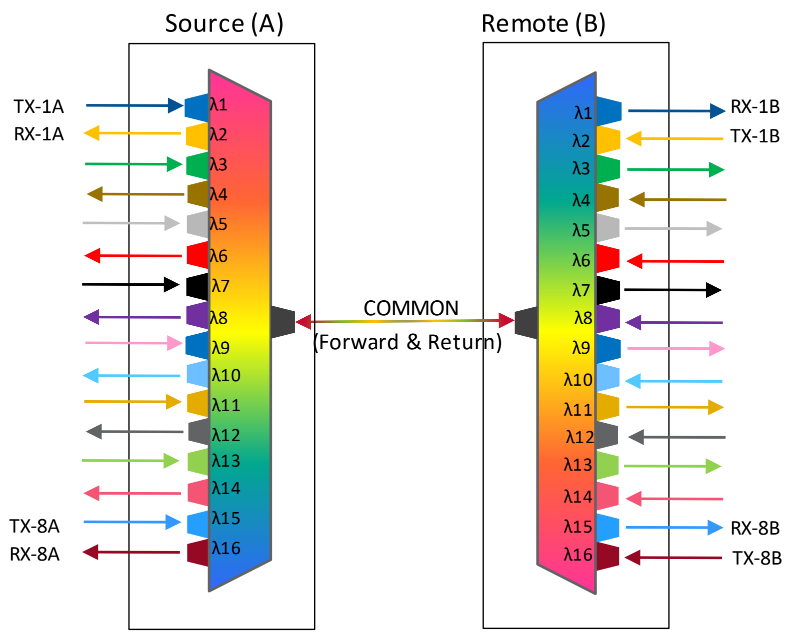

Figure 3: One-fiber transport example with bidirectional traffic on a shared common fiber. As in Figure 1, this is still 8-duplexed channels. However, the number of wavelengths on a device is 16 distinct channels (λ's) instead of 8 channels that are duplicated, or reused.

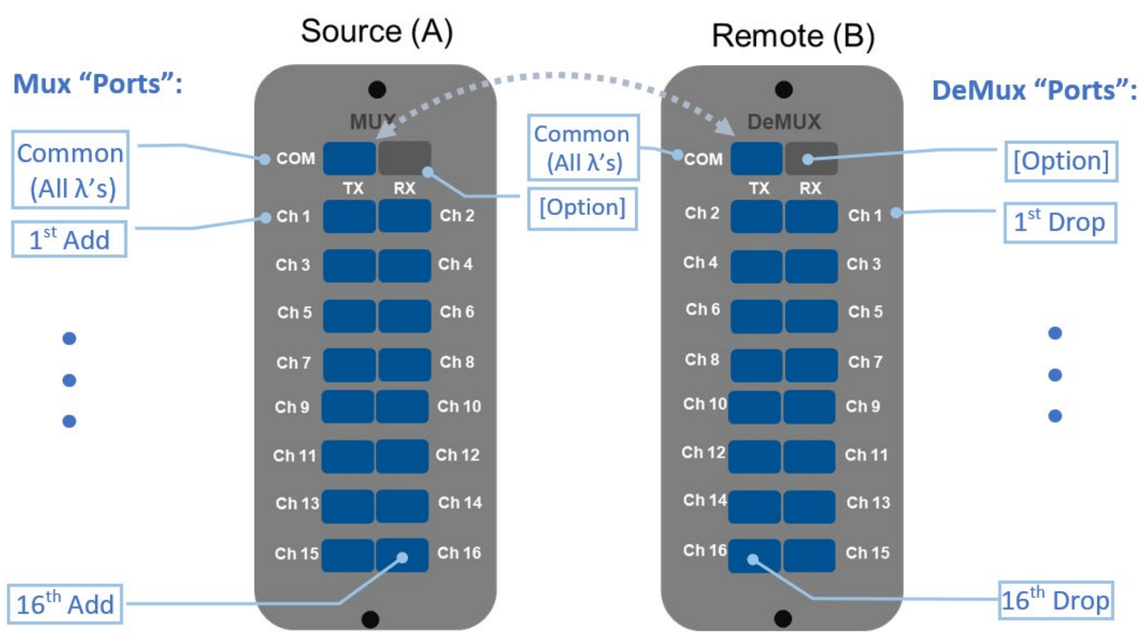

Figure 4: MUX & DeMUX 16-channel modules for a 1-fiber transport system. Note that only COM and ADD/DROP ports shown. If remaining traffic continued, an (optional) EXP port would also exist.

Understanding the transport architecture for upstream/downstream transmission will determine the number of COM fibers/ports needed.

Channels & Wavelength Plan

Channels reference the wavelengths, bands of spectrum, or services that will be combined onto the network (**Figures 5 & 6**). ITU standards provide details on the specific wavelength values, quantity, and spacing options between channels. The specific number of these channels and wavelengths used for MUX and/or DeMUX functions will be important in deciding the form factor of the hardware solution.

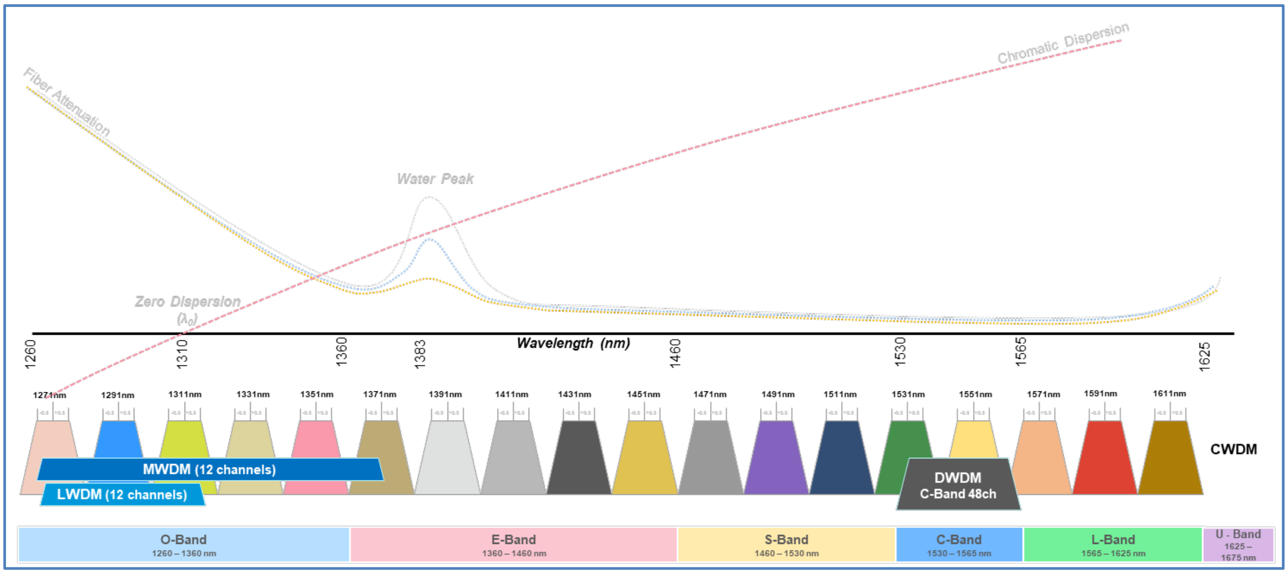

Figure 5: Optical Fiber WDM Spectrum (Channel assignments)

- CWDM (Coarse Wavelength Division Multiplexing): 18 channels @ 20 nm spacing (ITU-T G.984.2).
- DWDM (Dense Wavelength Division Multiplexing): up to 48 channels @ 100GHz spacing in C-band; L-band, as well as 12.5 GHz to 200 GHz spacing options, 'defined' (ITU-T G.694.1).
- LWDM (LAN Wavelength Division Multiplexing): 12 channels; IEEE 802.3ba\bs (and CCSA).
- MWDM (Mid- or Metro Wavelength Division Multiplexing): 12 channels; ITU-SG15 Q6 OTN (and CCSA).
- FWDM or BWDM (Filter-based or Band Wavelength Division Multiplexing): Various pre-set or custom wavelength ranges (or bands) that can be managed as an intermediate group of wavelengths or services.
- PON Services – Different PON technologies operate at specific upstream and downstream wavelengths. For coexistence scenarios, where one or more services will be overlayed via WDM, the specific services (inputs) need to be identified. This integrated WDM device is referred to as a Coexistence Element (CEX).

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Common Services:

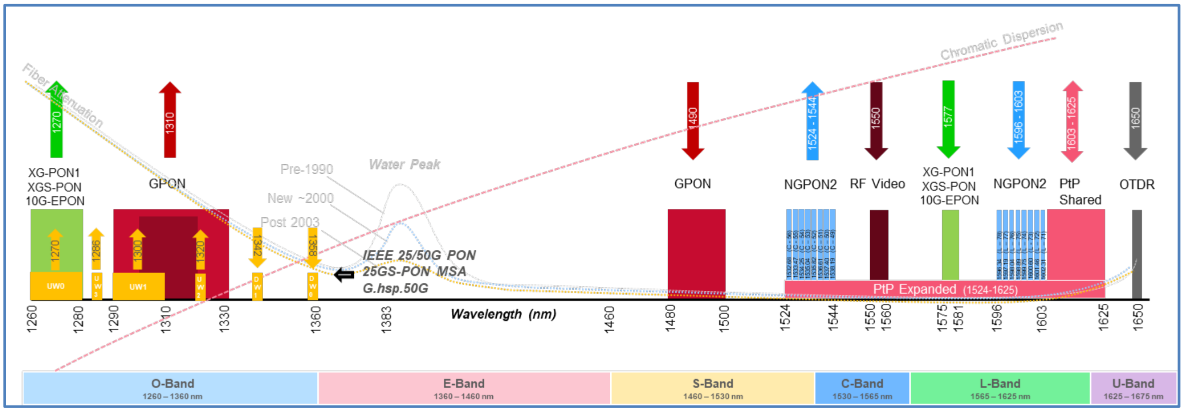


Figure 6: Optical Fiber WDM Spectrum (Protocols & Services)

- GPON – ITU G.984.2
- XG-PON1 – ITU-T G.987.1
- XGS-PON – ITU-T G.9807.1
- 10G EPON – IEEE 802.3av
- NGPON2 – ITU-T G.989.2*
- Point-to-Point (PtP) overlay option. Additional C and L-band channels that can be overlayed on PON services. Reference ITU-T G.989.
- 25G/50G EPON – IEEE 802.3ca
- 25G PON – 25GS-PON MSA
- 50G PON – ITU-T G.hsp.50G/G.9804 (.1, .2, .3)
- OTDR and Point to Point (PtP DWDM) options are also considered as inputs to the CEX.

Note(s): Some combinations of services are not possible.
*The 4 channel NGPON2 Mux, WM1, is a separate WDM device to overlay the multiwavelength of NGPON2 prior to the CEX.

Published: 08/18/2022

Ancillary Functions: Additional capabilities to WDM hardware that allow for non-service interrupting features.

- ❑ **Upgrade (UPG):**
- ✓ CWDM→ UPG or EXP port (but not both) is used to cascade additional CWDM channels not originally available on the first device. This is done by connecting this port to the COM of the new device.
- ✓ DWDM→ UPG port is used to cascade additional C-band channels not originally used on the first device.

- ❑ **Express (EXP):**
- ✓ CWDM→ EXP port has the same function as an UPG. One or the other is selected, but not both.
- ✓ DWDM→ EXP port is used to cascade channels outside of the C-band (i.e., CWDM overlay channels).

- ❑ **Monitor or Test (MON):**
- ✓ The Monitor or Test port is used to tap a small percentage of power (usually < 5%) of the Common signal. This can be done as independent directional receive (RX) or transmit (TX) MON ports. It can also be a combined TX + Rx port for bidirectional transmission on a single fiber.
- ✓ The MON port can be connected to a power meter or Optical Spectrum Analyzer to see wavelength specific information.

- ❑ **OTDR:**
- ✓ The OTDR port is a specific monitor port for OTDR Monitoring in the U-band (1625nm-1675nm).

- ❑ **1310nm Wideband:**
- ✓ The 1310nm wideband port is not the same as the 1311nm CWDM channel. It is used on some 1310nm gray optic legacy systems or as a CATV return path.
- ✓ When the 1310nm port is used, it will limit the available CWDM channels that can be combined to 1371nm, 1391nm, 1411nm, 1431nm, 1451nm, 1471nm, 1491nm, 1511nm, 1531nm, 1551nm, 1571nm, and 1611nm.

- ❑ **1550nm Wideband:**
- ✓ The 1550nm wideband port is not the same as the 1511nm CWDM channel. It is used on some 1550nm gray optic legacy systems.
- ✓ When the 1550nm port is used, it will limit the available CWDM channels that can be combined to 1271nm, 1291nm, 1311nm, 1331nm, 1351nm, 1371nm, 1391nm, 1411nm, 1431nm, 1451nm, 1471nm, and 1491nm.

Published: 08/18/2022

Overall Fiber Requirements

To determine the hardware options for a WDM solution, determine the TOTAL number of channels and ancillary functions desired by utilizing Table A below. Compare the number of required services to the port capacity of the hardware solution with the desired connectivity option. The respective hardware matrices show the capacities and limitations of the platform and its individual component and sub-component, or device (cassette, module, tray, housing, etc.). In some situations, it may be desirable or necessary to concatenate hardware sub-components within a given solution platform to reach the overall functional service requirements (e.g., through either a patchcord, or "jumper", between modules/cassettes, or fiber splicing between trays). Consult with a Corning Systems Engineer for more information and guidance on the use of these hardware matrix tables, and general system design recommendations.

Item #	Function/Service (Assume 1F per Channel/Service)	Quantity
I.	Common Traffic, MUX-or-DeMUX or MUX-&-DeMUX	(1 or 2)
II.	MUX (add) Channels (or PON CEX Services)	(1 to N)
III.	DeMUX (drop) Channels	(1 to N)
IV.	Upgrade (UPG) Option (CWDM or DWDM)	(0 or 1)
V.	Express (EXP) Option (DWDM)	(0 or 1)
VI.	Monitor Option	(0 to 2)
VII.	Wideband (1310 and/or 1550 nm) Option	(0 to 2)
VIII.	OTDR Option	(0 or 1)
IX.	**Sum Total of Channels, Options & Services**	

Table A: Total "Port" Tally for FOH Selection

Fiber Optic Hardware (FOH) Solutions:

- Environment: Inside vs. Outside Plant (ISP vs. OSP) Fiber Management
- System Architecture: Central Switching (CSP), Local Convergence (LCP) or Network Access (NAP) Point administration and/or distribution (fiber quantities).
- Termination Method: Connectorized vs. Splice (900 or 250 µm)
- Port (Adapter) Type: SC, LC, mDC (VSFF); UPC or APC Polish level
- Ruggedized Ports: OptiTap®, OptiTip®, Single fiber Pushlok™, or Multi-fiber Pushlok™.

Hardware Port Capacity Matrix:

Note: There will be instances where the capacity of a particular hardware solution can allow multiple WDM MUX/DeMUX/CEX channels inside a single device, or multiple devices inside of a single FOH component. Check the complete product configuration specification(s) for details.

Published: 08/18/2022

Inside Plant Solutions

Central Switching Point (CSP)

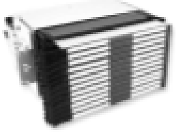
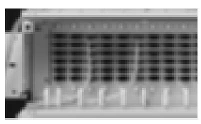
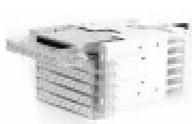
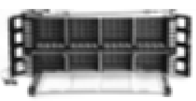
Frame-Mount Housings			Maximum WDM Configuration Parameters								
Solution	Component	Device	SC Capacity			LC Capacity			mDC Capacity		
ISP CSP	Housing	Varies	Max	Qty	Tot	Max	Qty	Tot	Max	Qty	Tot
Centrix™		Splice Cassette	24F	12	288F	36F	12	432F	108F	12	1296F
LGX® Compatible		Module, Single	12F	12	144F	24F	12	288F	N/A	N/A	N/A
		Module, Double	24F	6	144F	48F	6	288F	N/A	N/A	N/A
		Housing	72F	1	72F	144F	1	144F	N/A	N/A	N/A
EMF (FMS)		Module, Single	12F	6	72F	24F	6	144F	N/A	N/A	N/A
		Module, Double	24F	3	72F	48F	3	144F	N/A	N/A	N/A
EDGE™		MTP Cassette	N/A	N/A	N/A	12F	48	576F	36F	48	1728F

Table 1: ISP Frame-Mounted Housing Capacities

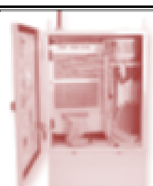
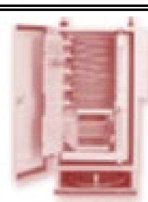
Pad-/Pole-/Wall-Mounted Cabinets			Maximum WDM Configuration Parameters								
Solution	Component	Device	SC Capacity			LC Capacity			mDC Capacity		
ISP LCP	Cabinet	Module	Max	Qty	Tot	Max	Qty	Tot	Max	Qty	Tot
OptiTect® Indoor LCC, CE Series		Module	64F	14	864F	64F	14	864F	N/A	N/A	N/A
OptiTect® Indoor LCC, LS Series		Module	64F	14	864F	64F	14	864F	N/A	N/A	N/A
OptiTect® Indoor LCC, Gen III Series		Module	64F	7	432F	64F	7	432F	N/A	N/A	N/A

Table 2: ISP Wall-Mounted Cabinet Capacities

Published: 08/18/2022

Outside Plant Solutions

Network Access Point (NAP)

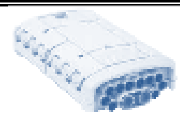
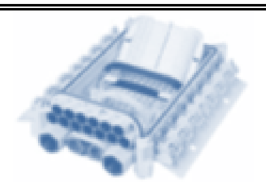
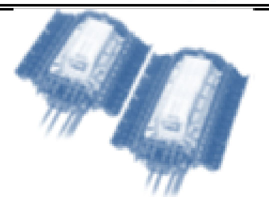
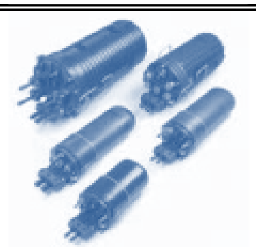
	Splice Closures & Terminals			Maximum WDM Configuration Capacities									
	Solution	Component	Dev.	Port Capacity			Splice Capacity			Cable Capacity			
	OSP NAP	Closure/Terminal	Tray	Max	Qty	Total	Max	Qty	Total	Feed	Dist	Drop	Total
BPEO Size 0	FDP Drop		Splice	24F	1	24F	12F	2	24F	2	2	12	16
	FDP Branch		Splice	24F	1	24F	12F	2	24F	2	8	1	11
	Pushlok™		Pigtail	24F	1	24F	12F	2	24F	2	8	1	11
BPEO Size 1	FDP Drop		Splice	18F	2	36F	12F	3	36F	2	0	16	18
	FDP Branch		Splice	18F	2	36F	12F	3	36F	2	10	0	12
	Pushlok™		Pigtail	18F	2	36F	12F	3	36F	2	10	0	12
	Connect		Pigtail	18F	2	36F	12F	3	36F	2	10	0	12
BPEO Size 1.5	FDP Drop		Splice	24F	3	72F	12F	6	72F	2	2	25	29
	FDP Branch		Splice	24F	3	72F	12F	6	72F	2	2	13	17
	Pushlok™		Pigtail	24F	3	72F	12F	6	72F	2	2	12	16
	OptiTap®		Pigtail	24F	3	72F	12F	6	72F	2	2	4	8
	Connect Drop		Pigtail	24F	1	24F	12F	2	24F	2	2	16	20
	Connect Bran.		Pigtail	24F	2	48F	12F	4	48F	2	2	13	17
BPEO Size 2	BDP Connect		Pigtail	24F	1	24F	12F	4	48F	2	16	(32)	18
BPEO Size 3	BPD Connect		Pigtail	24F	6	144F	12F	14	168F	2	16	(32)	18
Fiber Dome Closure (FDC)	FDC 08M-A		Tray	12F	3	36F	12F	3	36F	2	8	16	26
	FDC-08M NG		Tray	48F	1	48F	48F	1	48F	2	8	16	26
	FDC-08M OptiTap®		Tray	48F	1	48F	48F	1	48F	2	0	8	10
OptiSheath®	UCA Series OptiTap® OptiTip®		Pigtail	16F	1	16F	12F	3	36F	2	0	16	18

Table 3: Splice Closure & Terminal Capacities

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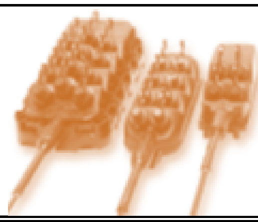
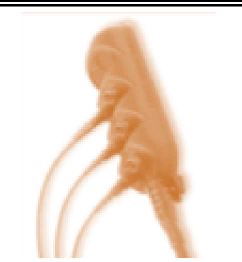
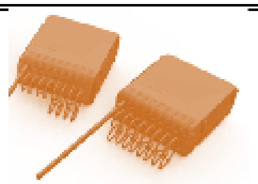
	Distribution (Stubbed) Terminals			Maximum Fiber (“Port”) Capacities								
	Solution	Component	Dev.	Terminal Port Options				Cable (Stub) Port Options				
	OSP NAP	Terminal	Term.	Opti Tap®	Opti Tip®	Push lok™	Max Fib	Bare Fiber	Opti Tip®	LC	SC	Max Fib
OptiSheath®	4-Port Multiport		MOB	4	0	0	4	4	0	0	0	4
			MTB	4	0	0	4	0	1	0	0	4
	6-Port Multiport		MOB	6	0	0	6	6	0	0	0	6
			MTB	6	0	0	6	0	1	0	0	6
	8-Port Multiport		MOB	8	0	0	8	8	0	0	0	8
			MTB	8	0	0	8	0	1	0	0	8
	12-Port Multiport		MOB	12	0	0	12	12	0	0	0	12
			MTB	12	0	0	12	0	1	0	0	12
OptiSheath®	2-Port Multiport		MF2	0	2	0	4	4	1	4	4	4
			MF4	0	2	0	8	8	1	8	8	8
	4-Port Multiport		MF2	0	4	0	8	8	1	8	8	8
			MF4	0	4	0	16	16	0	16	16	16
	6-Port Multiport		MF2	0	6	0	12	12	1	12	12	12
			MF4	0	6	0	24	24	0	24	24	24
	8/9-Port Multiport		MF2	0	8	0	16	16	0	16	16	16
			MF4	0	9	0	36	36	0	36	36	36
	12-Port Multiport		MF2	0	12	0	24	24	0	24	24	24
			MF4	0	12	0	48	48	0	48	48	48
Evolv™	2-Port Evolv		DM/F	0	0	2	2	2	1	-	-	2
	4-Port Evolv		DM/F	0	0	4	4	4	1	-	-	4
	6-Port Evolv		DM/F	0	0	6	6	6	1	-	-	6
	8-Port Evolv		DM/F	0	0	8	8	8	1	-	-	8
	12-Port Evolv		DM/F	0	0	12	12	12	1	-	-	12
	16-Port Evolv		DM/F	0	0	16	16	16	-	-	-	16

Table 4: Distribution Terminal Capacities

Local Convergence Point (LCP)

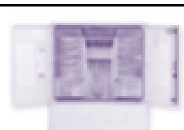
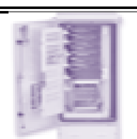
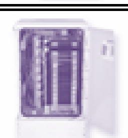
Pad-/Pole-/Wall-Mounted Cabinets			Maximum WDM Configuration Parameters								
Solution	Component	Device	SC Capacity			LC Capacity			mDC Capacity		
OSP LCP	Cabinet	Module	Unit	Qty	Total	Unit	Qty	Total	Unit	Qty	Total
OptiTect® Outdoor LCC, LS Series		Module	64F	14	864F	64F	14	864F	N/A	N/A	N/A
OptiTect® Outdoor LCC, Gen III Series		Module	64F	7	432F	64F	7	432F	N/A	N/A	N/A
OptiTect® LCC, HD Series, Centrix™		Module, LS	64F	14	896F	64F	14	896F	N/A	N/A	N/A
		Cassette	24F	36	896F	36F	36	1296F	72F	36	2592F
Evolv™ Panel Access Cabinet (PAC)		Module, LS or RMS	64F	14	864F	64F	14	864F	N/A	N/A	N/A

Table 5: Local Convergence Cabinets (LCC)

APPENDIX A: Channel Wavelengths for Coarse Wavelength Division Multiplexing

	CWDM (nm)	MWDM (nm)	LWDM (nm)
	(20nm centerline spacing)	(CWDM center +/- 3.5nm)	(800GHz spacing +/- 1.03nm)
1	1271	1267.5	1269.23
2	1291	1274.5	1273.54
3	1311	1287.5	1277.89
4	1331	1294.5	1282.26
5	1351	1307.5	1286.66
6	1371	1314.5	1291.1
7	1391	1327.5	1295.56
8	1411	1334.5	1300.05
9	1431	1347.5	1304.58
10	1451	1354.5	1309.14
11	1471	1367.5	1313.73
12	1491	1374.5	1318.35
13	1511		
14	1531		
15	1551		
16	1571		
17	1591		
18	1611		

Published: 08/18/2022

APPENDIX B: Channel Wavelengths for Dense Wavelength Division Multiplexing

DWDM Channels

100 GHz Channels	Wavelength (in nm)	Frequency (in THz)	100 GHz Channels	Wavelength (in nm)	Frequency (in THz)
(DWDM Channel C**36**)	1548,51	193,60	(DWDM Channel C**72**)	1520,25	197,20
(DWDM Channel C**35**)	1549,32	193,50	(DWDM Channel C**71**)	1521,02	197,10
(DWDM Channel C**34**)	1550,12	193,40	(DWDM Channel C**70**)	1521,79	197,00
(DWDM Channel C**33**)	1550,92	193,30	(DWDM Channel C**69**)	1522,56	196,90
(DWDM Channel C**32**)	1551,72	193,20	(DWDM Channel C**68**)	1523,34	196,80
(DWDM Channel C**31**)	1552,52	193,10	(DWDM Channel C**67**)	1524,11	196,70
(DWDM Channel C**30**)	1553,33	193,00	(DWDM Channel C**66**)	1524,89	196,60
(DWDM Channel C**29**)	1554,13	192,90	(DWDM Channel C**65**)	1525,66	196,50
(DWDM Channel C**28**)	1554,94	192,80	(DWDM Channel C**64**)	1526,44	196,40
(DWDM Channel C**27**)	1555,75	192,70	(DWDM Channel C**63**)	1527,22	196,30
(DWDM Channel C**26**)	1556,55	192,60	(DWDM Channel C**62**)	1527.99	196,20
(DWDM Channel C**25**)	1557,36	192,50	(DWDM Channel C**61**)	1528,77	196,10
(DWDM Channel C**24**)	1558,17	192,40	(DWDM Channel C**60**)	1529,55	196,00
(DWDM Channel C**23**)	1558,98	192,30	(DWDM Channel C**59**)	1530,33	195,90
(DWDM Channel C**22**)	1559,79	192,20	(DWDM Channel C**58**)	1531,12	195,80
(DWDM Channel C**21**)	1560,61	192,10	(DWDM Channel C**57**)	1531,90	195,70
(DWDM Channel C**20**)	1561,42	192,00	(DWDM Channel C**56**)	1532,68	195,60
(DWDM Channel C**19**)	1562,23	191,90	(DWDM Channel C**55**)	1533,47	195,50
(DWDM Channel C**18**)	1563,05	191,80	(DWDM Channel C**54**)	1534,25	195,40
(DWDM Channel C**17**)	1563,86	191,70	(DWDM Channel C**53**)	1535,04	195,30
(DWDM Channel C**16**)	1564,68	191,60	(DWDM Channel C**52**)	1535,82	195,20
(DWDM Channel C**15**)	1565,50	191,50	(DWDM Channel C**51**)	1536,61	195,10
(DWDM Channel C**14**)	1566,31	191,40	(DWDM Channel C**50**)	1537,40	195,00
(DWDM Channel C**13**)	1567,13	191,30	(DWDM Channel C**49**)	1538,19	194,90
(DWDM Channel C**12**)	1567,95	191,20	(DWDM Channel C**48**)	1538,98	194,80
(DWDM Channel C**11**)	1568,67	191,10	(DWDM Channel C**47**)	1539,77	194,70
(DWDM Channel C**10**)	1569,59	191,00	(DWDM Channel C**46**)	1540,56	194,60
(DWDM Channel C**09**)	1570,42	190,90	(DWDM Channel C**45**)	1541,35	194,50
(DWDM Channel C**08**)	1571,24	190,80	(DWDM Channel C**44**)	1542,14	194,40
(DWDM Channel C**07**)	1572,06	190,70	(DWDM Channel C**43**)	1542,94	194,30
(DWDM Channel C**06**)	1572,89	190,60	(DWDM Channel C**42**)	1543,73	194,20
(DWDM Channel C**05**)	1573,71	190,50	(DWDM Channel C**41**)	1544,53	194,10
(DWDM Channel C**04**)	1574,54	190,40	(DWDM Channel C**40**)	1545,32	194,00
(DWDM Channel C**03**)	1575,37	190,30	(DWDM Channel C**39**)	1546,12	193,90
(DWDM Channel C**02**)	1576,20	190,20	(DWDM Channel C**38**)	1546,92	193,80
(DWDM Channel C**01**)	1577,03	190,10	(DWDM Channel C**37**)	1547,72	193,70