



Optical Networking Edge Solutions Overview

Total Access 5000 Series

Version 1.3

Updated on September 20, 2019

Contents

Introduction	3
Leadership and Innovation	3
Financially Strong	3
ADTRAN Value	4
Optical Networking Edge (ONE) Portfolio	5
Equipment Descriptions	6
Total Access 5000 Series	6
Total Access 5000 Series Common Modules	7
Switch Module200 2-100/2-40 GigE (SM200)	7
Switch Module40 4-10 GigE (SM40)	7
Management and Switch Module20 2-10GE (MSM20)	8
Bridging System Controller Module (SCM)	8
Total Access 5000 Series Transport Optical Switch Modules	9
Ethernet Transport Optical Switch (ETOS-10)	9
Ethernet Transport Optical Switch (ETOS-1)	9
OTN Transport Optical Switch-1-8 (OTOS-1-8)	10
OTN Transport Optical Switch-2-16 (OTOS-2-16)	10
Quad 10G OTN Transponder (TPR-10-4)	11
TPR-10-4 Interface Types and Mapping	11
TPR-10-4 Protection and Loopbacks	11
Pluggable Optics	12
DWDM Transceivers	12
CWDM Transceivers	12
Pseudo Wire Emulation (PWE)	13
Transparent SONET/SDH over Packet (TSoP) Optics	13
Virtual Container over Packet (VCoP) Optics	13
Wavelength Division Multiplexing Modules	14
44-Channel DWDM Mux/Demux	14
88-Channel DWDM Mux/Demux	14
Four Channel DWDM OADM	15
Eight Channel DWDM Mux/Demux	15
Four Channel CWDM Mux/Demux	16
Seven Channel CWDM Mux/Demux	16
Wide Wavelength-Division Multiplexing Optical Coupler and Multiplexer	17
Dispersion Compensation Modules	18
Optical Amplification Modules	19
Reconfigurable Optical Add Drop Multiplexer (ROADM)	20
2 Degree Mini Amplified ROADM System	21
4 Degree Mini Amplified ROADM System	21
WDM Module Racking	22
1RU WDM Filters Housing	22
Carrier Module	22
Total Access 5004 Resource Module	22
Total Access 5000 Series Accessories	23
Fiber Manager	23
Clear Cover	23
WDM Accessories	24

Y-cable Applications	24
Optical Splitter and Coupler Variants	24
Training	25
Recommended Training Courses	25
Network Care Program Options	26
Design Criteria Guidelines	27
Initial Design Information	27
Optical Characterizations	27
Appendices	28
MARS (Mini Amplified ROADM System)	29
Dispersion Compensation Module - Bragg-Grating Based	29
Dispersion Compensation Module - Fiber Based	30
Optical Amplification Modules	30
WDM Modules	30
Switch Module ERPS Feature Matrix	32
Switch Module LAG Feature Matrix	32
Switch Module Interface Speeds	32

Introduction

At ADTRAN, Inc., we believe amazing things happen when people connect. From the cloud edge to the subscriber edge, we help communications service providers around the world manage and scale services that connect people, places and things to advance human progress. Whether rural or urban, domestic or international, telco or cable, investor or co-op owned utility, enterprise or residential — ADTRAN solutions optimize existing technology infrastructures and create new, multi-gigabit platforms that leverage cloud economics, data analytics, machine learning and open ecosystems — the future of global networking.

Leadership and Innovation

ADTRAN, Inc. is a leading global provider of networking and communications equipment. Headquartered in Huntsville, Alabama, with sales offices strategically located throughout the United States and around the world. Our mission is to be a trusted provider of global communications solutions, to develop innovative technologies used to create products and services that make communications simpler and more affordable for people everywhere. ADTRAN fosters an entrepreneurial environment supported by enthusiastic employees who exhibit an unwavering commitment to personal integrity and support our customers beyond their expectations.

Incorporated in 1985, ADTRAN began operations in 1986. From a humble beginning with only seven employees, ADTRAN has grown into a global leader in telecommunications with more than 2,000 employees. Likewise, the company serves a diverse customer base that spans more than 68 countries.

Financially Strong

ADTRAN has been a leading provider of access solutions for over 30 years. From the company's inception, ADTRAN has demonstrated an unprecedented record of financial strength and continuum of profitability setting the standard for this industry. The company is well positioned for strong growth moving forward.

Detailed financial information can be accessed at the link below:

<http://investors.adtran.com/overview/default.aspx>

ADTRAN Value

Our unique approach, unmatched domain expertise and innovative platforms, make anything possible. With products for both carrier and enterprise markets, the company is uniquely positioned to provide complete end to end solutions that produce the greatest network efficiency and at the lowest total cost of ownership. Service providers depend on ADTRAN equipment to connect central offices or remote terminals directly to subscriber equipment, thus enabling the delivery of voice, video and Internet services. ADTRAN also supports business customers with a full line of business-class networking solutions. With the demand for bandwidth increasing at phenomenal rates, ADTRAN is at the forefront of the development of new technologies that will enable service providers to glean more bandwidth from their existing infrastructure as well as new virtualized technologies that will pave the way for greater network scale and efficiency, enabling new services to reach more customers faster than ever before.

Best-in-Class Customer Service and Support

- Comprehensive training and certification programs
- Expert pre-sales network design assistance
- Recognized industry leader in support that offers flexible installation and support offerings to meet your needs
- Technical support staffed with degreed and certified engineers with the expertise to meet your needs quickly and efficiently

Technological Leadership

- Contributor to network access architecture (including SDN and NFV), management and interoperability standardization in the Broadband Forum
- Contributor to the development of ITU-T VDSL2, Gfast, GPON, XG-PON, XGS-PON, and NG-PON standards
- Participation in industry-critical organizations: ATIS, BITAG, Broadband Forum, CELTIC, ETSI, FSAN, FTTH Council, ITU-T, MEF, TIA, UK NICC, UNH IOL, and the Wi-Fi® Alliance
- Pioneering advancements in broadband and other standards underlying today's most widely deployed business access and transport technologies

Professional Services

- Delivers Network Care Programs for ongoing network maintenance and support
- Furnishes turn-key Network Integration services for multi-vendor projects
- Implements value added engineering, management and quality control services
- Partners with service providers to streamline operational processes and reduce costs
- Supports the complete life cycle solution for network operations specific to services delivery

Quality Commitment

- Committed to corporate sustainability and environmental compliance
- Maintain reasonable and appropriate security measures to protect corporate data and information assets
- Extensive in-house labs for reliability testing, component failure analysis, and compliance testing
- ISO 9001:2015, ISO 14001:2015, ISO 27001:2013 and TL 9000 R6.0/R5.0 NSAI certified supplier
- Long-standing, corporate-wide commitment to quality assurance
- Stringent post-production quality assurance testing

Supply Chain Robustness

- World class supply chain strategy demonstrating unprecedented business continuity
- Despite two co-incident 100 year events, the March 2011 Tohoku earthquake in Japan and April 2001 Super Outbreak, ADTRAN set shipping records in that same impacted quarter
- Best in class diversification supported by four global manufacturing and distribution sites on three continents

Optical Networking Edge (ONE) Portfolio

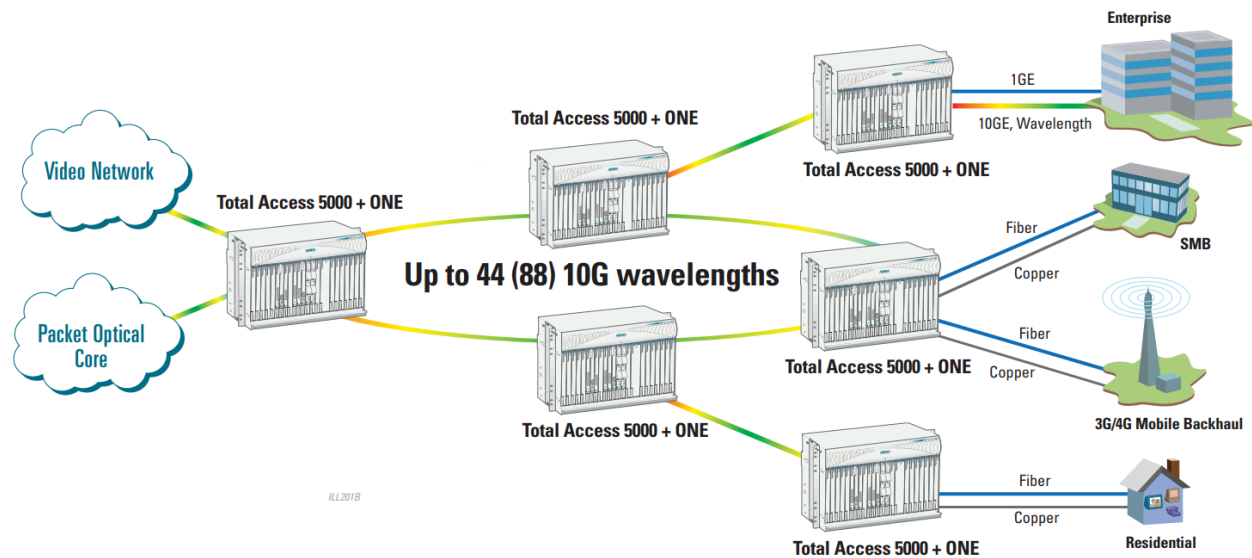
The ADTRAN Optical Networking Edge (ONE) System consists of a multi-layer, scalable portfolio of modules. The ONE System provides a Packet Optical Transport Solution that seamlessly integrates into existing residential Total Access 5000 Series systems.

ONE is a convergence of several networking protocols and capabilities that deliver unmatched network access, as well as edge, metro, and regional scalability. This enables service providers to efficiently address the bandwidth challenges and the increasing demand for video services, mobile data backhaul, cloud computing, and other emerging services.

The ONE portfolio provides seamless operations from access to transport networks and enables service providers to extend the bandwidth efficiencies of the core out to the optical edge.

Based on the modular architecture of the [Total Access 5000 Series](#), the ONE solution combines the following capabilities with advanced network management features for a complete multi-layer, multi-service delivery, aggregation, and transport solution:

- Agile photonic based on ROADM system on a blade
- Coarse or Dense Wavelength Division Multiplexing (CWDM or DWDM)
- Scalable Carrier Ethernet (CE) with subtended rings and networking
- Multi-Service Optical Transport Network (OTN)
- Port by port redundancy
- ERPSv2 Virtual Rings



ADTRAN ONE Solutions Overview

Equipment Descriptions

Total Access 5000 Series

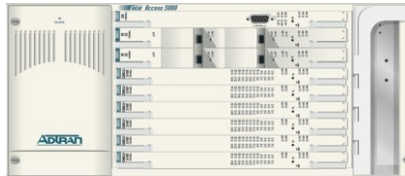
ADTRAN Total Access 5000 Series provides an ultra-flexible, high-capacity, deep fiber solution. The Total Access 5000 Series is a carrier class Multi-service Access and Aggregation Node (MSAN) that bridges the gap between existing and the next-generation networks — like 10G PON. With a pure Ethernet core, the system supports services over copper and fiber, easily scaling to support even the most bandwidth-intensive applications. The Total Access 5000 Series provides the bandwidth and Ethernet switching capabilities needed to deliver a highly profitable service offering and meet a variety of legacy and emerging service requirements.

Total Access 5000



- 9 RU, 23-inch brackets
- System Controller Module slot
- Two redundant Switch Module slots
- Twenty-one Access Module slots

Total Access 5006



- 5 RU, 19-inch brackets
- System Controller Module slot
- Two redundant Switch Module slots
- Six Access Module slots

Total Access 5004



- 2 RU, 19-inch brackets
- Two redundant Management and Switch Module slots
- Four Access Module slots

Total Access 5000 Series Common Modules

Switch Module200 2-100/2-40 GigE (SM200)



The SM200 is intended for deployment with the Total Access 5000 system. Quad Small Form-factor Pluggables ports — two QSFP28(100G), two QSFP+ (40G) — serve as the network interfaces to the system and other Total Access nodes. The SM200 also provides common system functions, controls communication between access modules and the System Controller Module (SCM), and interface to the high-speed backplane through the Total Access Switch Module Input/Output (SMIO). Redundant ports can be deployed in protected pair, cross-slot Link Aggregation (LAG), Ethernet Ring Protection Switching (ERPS), and ERPS over LAG configurations. The SM200 will support 100G ERPS and 40G of bandwidth per slot of the Total Access 5000. The SM200 offers a great enhancement if planning to support 10/10G Fixed XGS-PON services.

When used in a non-redundant fashion, a single SM200 has full non-blocking bandwidth between the backplane to the Access Modules — up to 21 individual dedicated 20 Gbps busses to the SM — and the faceplate uplink ports, 280 Gbps total from two QSFP28 (100G) and two QSFP+ (40G) Ports per SM200. When used in a redundant fashion, the combined SM200s bandwidth is 1.92 Tbps to additionally support their shared 520 Gbps Peer Port.

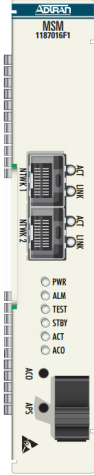
Switch Module40 4-10 GigE (SM40)



The SM40 is intended for deployment with the Total Access 5000/5006 system. The SM40 provides network data aggregation for the Total Access 5000/5006 system. Small Form-Factor Pluggable (SFP) Gigabit Ethernet ports (both SFP and SFP+) serve as the network interface to the system and other Total Access nodes. The SM40 also provides common system functions, controls communication between access modules and the System Controller Module (SCM), and interface to the high-speed backplane through the Total Access Switch Module Input/Output (SMIO). The SM40 offers several different redundancy types for its uplink configuration. Redundant ports can be deployed in protected pair, cross-slot Link Aggregation (LAG), Ethernet Ring Protection Switching (ERPS), and ERPS over LAG configurations. The SM40 is capable of 20G ERPS over LAG and 40G of bandwidth per slot when redundant Switch Modules are present in the Total Access 5000 chassis. When the SM40 is used with the [ETOS-10](#), the chassis is capable of supporting 40G ERPS rings.

The SM40 supports Link Aggregation Control Protocol (LACP). LACP facilitates increased link capacity by creating 802.3ad trunks that exchange packets between Ethernet interfaces more efficiently. 802.1Q and Q-in-Q (double tagging) enables the Total Access 5000 system to support both single and double tagged Ethernet frames. When used in a non-redundant fashion, a single SM40 has full non-blocking bandwidth between the backplane to Access Modules — up to 21 individual dedicated 20 Gbps busses to the SM — and the faceplate uplink ports, 40 Gbps total from four SFP+ (10G) Ports per SM40. When used in a redundant fashion, the combined SM40s bandwidth is 1.121 Tbps to additionally support their shared 80 Gbps Peer Port.

Management and Switch Module20 2-10GE (MSM20)



The MSM20 is intended for deployment with the Total Access 5004 system. The MSM20 provides network data aggregation for the Total Access 5004 system. Two Small Form-Factor Pluggable (SFP+) serve as the network interface to the system and other Total Access nodes. The MSM20 provides common system functions, controls communication between access modules and the interface to the high-speed backplane. The MSM20 supports Link Aggregation Control Protocol (LACP). LACP facilitates increased link capacity by creating 802.3ad trunks that exchange packets between Ethernet interfaces more efficiently. 802.1Q and Q-in-Q (double tagging) enables the Total Access 5004 system to support both single and double tagged Ethernet frames.

Bridging System Controller Module (SCM)



The SCM provides the logical user interface to the entire Total Access 5000/5006 system. SCMs enable the provisioning of modules, alarm status monitoring, the querying of performance data, and the initiation of tests for any module in the primary (Host) or expansion (Client) shelves. The Bridging SCM provides various interfaces for both local and remote management of the Total Access 5000/5006 system. The SCM support Simple Network Management Protocol (SNMP), Command Line Interface (CLI), Transaction Language 1 (TL1), Telnet, SSHv2, local craft access, and Ethernet Bridging.

Total Access 5000 Series Transport Optical Switch Modules

Ethernet Transport Optical Switch (ETOS-10)



The ETOS-10 allows service providers the ability to deliver as well as aggregate 1, 2.5, and 10 GigE carrier grade services. Services can then be transported on a per wavelength basis using only a single fiber uplink to aggregate and transport multiple services whether for residential triple play, mobile backhaul or business Ethernet services. The core Ethernet features of this product include a flexible Ethernet processor and a leading density of 10 Gigabit Ethernet SFP+ standard or DWDM fiber interfaces. The ETOS-10 supports flexible traffic management, Ethernet flow mapping, prioritization, tagging, and versatile management options which are required to respond to the demand for premium services. The backplane can support up to 20G on the [SM40](#) and [MSM20](#). When the ETOS-10 is used with the [SM40](#), the chassis is capable of supporting 40G ERPS rings.

In the case of the ETOS-10, the ports can be both user and network facing. The ETOS-10 supports high-speed (HS) network interfaces and mid-speed (MS) client interfaces in a single module. The ETOS-10 supports up to two 1 Gbps MS optical or copper Ethernet interfaces, and eight 10 Gbps HS optical Ethernet network interfaces. Each MS interface can be provisioned independently to support 1G or 2.5G. Each HS interface can be provisioned independently to support 1G, 2.5G, or 10G.

Ethernet Transport Optical Switch (ETOS-1)



The ETOS-1 muxponder supports high-speed (HS) network interfaces and mid-speed (MS) client interfaces in a single module. The ETOS-1 supports up to sixteen 100 Mbps or 1 Gbps MS optical or copper Ethernet interfaces, and two 10 Gbps HS optical Ethernet network interfaces. All Ethernet traffic is contained within the ETOS-1, flowing between the front-access ports.

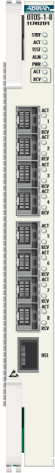
The ETOS-1 operates as an Ethernet infrastructure aggregation platform and an Ethernet service termination platform. It supports both direct customer interfaces (UNI: User-to-Network Interface) and direct connection to customer premises NTE (MEN: Metro Ethernet Network). Any client port can be configured as an MEN network port or UNI port. Backplane is for management traffic only (1G).

Each physical Interface is provided by a Small Form-Factor Pluggable (SFP) or 10G Small Form-factor Pluggable (XFP), accessed from the ETOS-1 front panel.

ETOS ERPS Feature Matrix

	ETOS-1	ETOS-10
ERPSv1	•	•
ERPSv2 — multi instances/laddering	•	•
Max Number of Nodes on Ring	32	32
Max Number of Rings Supported	9/18	5/10
Max Ring Nodes Across All Rings	512	320
1G Ring Speed	•	•
2.5G Ring Speed		•
10G Ring Speed	•	•
Single Slot ERPS	•	•
Max Number of Cross Slot ERPS Rings	18	10
Max Number of Cross Slot Y-cables	18	10
Max Number of Link Protection Groups	18	10
Max Number of Link Aggregation Groups	18	10

OTN Transport Optical Switch-1-8 (OTOS-1-8)

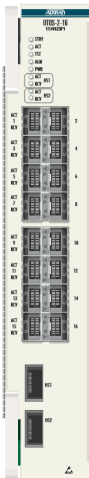


The OTN Transport Optical Switch-1-8 (OTOS-1-8) is a single slot module. The OTOS-1-8 includes a high-speed (HS) network interface and mid-speed (MS) client interfaces. The OTOS-1-8 provides one OTU2 XFP interface for the Network Port (HS), and up to eight SFP interfaces for the Client Ports (MS). All traffic is contained within the OTOS-1-8, flowing between the front panel ports.

MS interfaces use SFPs to operate at SONET rates of OC-3, OC-12, or OC-48; 1 GigE and OTU1 or the SDH equivalents of STM-1, STM-4, and STM-16, respectively. The rate for each MS port can be configured independently. The HS port uses an XFP to operate at OTU2 rates. Mappings supported within the OTU2 include ODU1 and ODU0.

OTOS-1-8 supports equipment redundancy when using an LMIO2 Personality Module. The HS ports can be used in a protection group in this equipment redundant pair. The MS ports can also be used in pairs for protection switching.

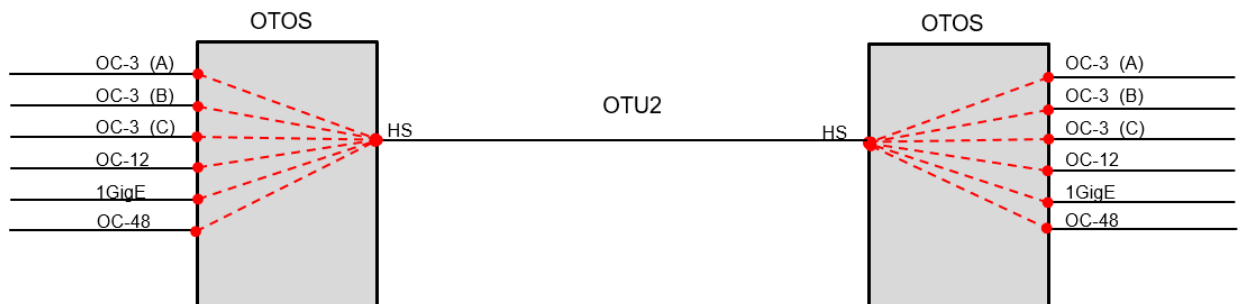
OTN Transport Optical Switch-2-16 (OTOS-2-16)



The OTN Transport Optical Switch-2-16 (OTOS-2-16) is a double slot module. The OTOS-2-16 includes a high-speed (HS) network interface and mid-speed (MS) client interfaces. The OTOS-2-16 provides two OTU2 XFP interfaces for the Network Ports (HS), and up to 16 SFP interfaces for the client interfaces (MS). All traffic is contained within the OTOS-2-16, flowing between the front panel ports.

MS interfaces use SFPs to operate at SONET rates of OC-3, OC-12, or OC-48; or the SDH equivalents of STm-1, STM-4, and STM-16; Fibre Channel rates of 1GFC or 2GFC and OTU1. The rate for each MS port can be configured independently. The HS ports use an XFP to operate at OTU2 rate. Mappings supported within the OTU2 include ODU1, ODU1 sub-rate timeslots, and ODU0.

OTOS-2-16 supports equipment redundancy when using an LMIO2 Personality Module. The HS and MS ports of an OTOS-2-16 can be used in protection groups with like ports of an OTOS-2-16 as part of an equipment redundant pair.



OTOS Example Configuration: High-speed port used as an aggregate (10G muxponder mode)

Quad 10G OTN Transponder (TPR-10-4)



The **Quad 10G OTN Transponder (TPR-10-4)** is installed in a [Total Access 5000 Series](#) chassis. The TPR-10-4 is a dual channel single slot module that functions as an optical transponder/regenerator with four 10 Gbps XFP ports.

In a transponder application, the Client Interface (OC-192, 10GE, 10GFC, or 8GFC) is mapped into an OTN signal (OTU2, OTU2e, OTU2f, etc) on the Line Interface. In this application, OTN adds Forward Error Correction (FEC). In a regenerator application, the same signal type is mapped from the Client Interface to the Line Interface (example: OC-192 to OC-192, 10GE to 10GE, etc.).

The TPR-10-4 monitors performance on all four optical inputs. The signal timing is passed through transparently in both directions. 10G Ethernet timing can be passed through when using Bit Synchronous Map (BMP) mapping and the Line Interface as an OTU2e signal. Optical fiber access is provided by LC connectors on the XFPs that plug into the cages on the front panel.

TPR-10-4 Interface Types and Mapping

		Line Interface										
		STM-64	OC-192	10GE WAN	10GE LAN	10GFC	OTU2 async	OTU2 sync	OTU2 GFP-T	OTU2 GFP-F	OTU2e	OTU2f
Client Interface	STM-64	•						•				
	OC-192		•					•				
	10GE WAN			•				•				
	10GE LAN				•					•	•	
	8GFC								•			
	10GFC					•						•
	OTU2 async						•					
	OTU2 sync							•				
	OTU2 GFP-F									•		
	OTU2e										•	

TPR-10-4 Protection and Loopbacks

		Equipment Protection			
		Standalone		Redundant	
		Client	Line	Client	Line
Y-cable				•	
1+1 Automatic Protection Switching			•		
Facility LoopBack		•	•	•	•
Terminal LoopBack		•	•	•	•

Pluggable Optics

The ADTRAN Total Access 5000 Series Modules are designed for optimum system performance and reliability when used with ADTRAN Pluggable Optics (SFP, cSFP, SFP+, and XFP). ADTRAN continuously evaluates Pluggable Optics from various component suppliers in an effort to ensure availability of appropriate options for our customers. This continuing process protects customers and their system/network from potentially detrimental effects caused by non-ADTRAN optics.

ADTRAN adheres to this design strategy to ensure:

- Performance over operating temperature
- Compliance with industry standards such as NEBS
- Optical network performance including Optical Signal to Noise Ratio (OSNR)
- Compatibility with connected equipment
- Integration with system diagnostic reporting

DWDM Transceivers

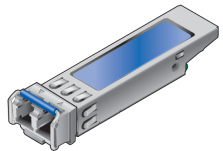


The DWDM Transceivers are fully duplex serial electric, serial optics with both transmit and receive functions that provides a high speed link at a nominal rate of 10 Gbps and at distances of 80 km. The optics come in SFP+ and XFP form-factors and also include fixed wavelength optics and tunable optics. The fixed wavelength optics operate on the C-band at 100 GHz spacing. The tunable SFP+ optics are controlled by software on the host module and can operate on the C-band at 50 GHz spacing.

Transmit wavelength: 1529.55 to 1563.86 nm

Receive wavelength: 1260 to 1600 nm

CWDM Transceivers



The CWDM Transceivers are fully duplex serial electric, serial optics with both transmit and receive functions that provides a high speed link at a nominal rate of 10 Gbps and at distances of 10 km and 70 km. The optics come in SFP+ and XFP form-factors.

Transmit wavelength: 1471, 1491, 1511, 1531, 1551, 1571, 1591, and 1611 nm

Receive wavelength: 1260 to 1620 nm

Pseudo Wire Emulation (PWE)

Network transport service providers and their users are seeking to rationalize their networks by migrating their existing services and platforms onto IP-enabled packet switched networks (PSN). This migration requires communications services that can emulate the essential properties of traditional communications links over a PSN. Relying upon pseudo wire technology is an integral component of these network convergence architectures. Pseudo Wire Emulation will specify the encapsulation, transport, control, management, interworking, and security of services emulated over IETF-specified PSNs.

Transparent SONET/SDH over Packet (TSoP) Optics

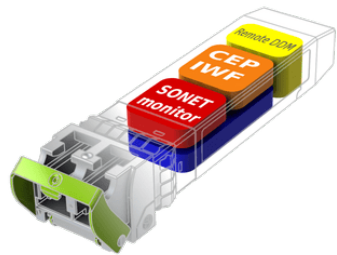


The SFP provides Transparent SONET/SDH over Packet (TSoP). Applications include migration and integration of SONET/SDH transport in packet switched networks, transparent SONET/SDH over Ethernet networks, and upgrading a SONET/SDH microwave link to GbE packet radio links.

Virtual Container over Packet (VCoP) Optics



The SFP provides DS3 Virtual Container over Packet (VCoP). Applications for the DS3 Circuit Emulation SFP include migration and integration of transport in packet switched networks. Compatible cables can be purchased separately from ADTRAN.



The SFP provides OC-3/OC-12 Virtual Container over Packet (VCoP). Applications for the OC-3/OC-12 circuit emulation SFP include migration and integration of SONET transport in packet switched networks, aggregation of low fill SONET links, and network frequency synchronization between Ethernet and SONET.

Available Pseudo Wire Emulation Optics

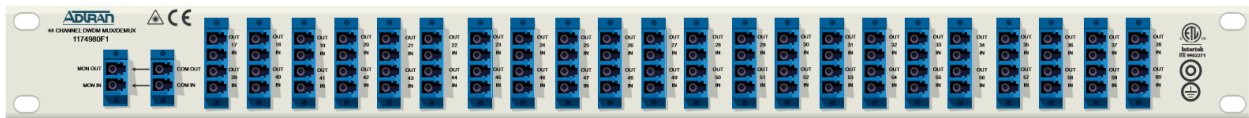
	OC-3/STM-1	OC-12/STM-4	OC-48/STM-16	DS3	OC-3/OC-12
Protocol	TSoP	TSoP	TSoP	VCoP	VCoP
Module Type	SFP	SFP	SFP+	SFP	SFP
Media Type	Fiber	Fiber	Fiber	Copper	Fiber
Electrical Interface	1.25 Gbps	1.25 Gbps	10.3 Gbps	1.25 Gbps	1.25 Gbps
Optical Interface	155 Mbps	622 Mbps	2.488 Gbps		155/622 Mbps
Connector	Dual LC	Dual LC	Dual LC	Mini Coax DIN	Dual LC
Distance	40 km	40 km	2 km	450 ft	15 km

Wavelength Division Multiplexing Modules

44-Channel DWDM Mux/Demux

The 44-Channel Dense Wavelength Division Multiplexing (DWDM) Mux/Demux is based on athermal Arrayed Waveguide Gratings (AWG) technology with 100 GHz channel spacing. The 44-Channel DWDM Mux/Demux operates in the full C-band supporting Channels 17 (1563.86 nm) through 60 (1529.55 nm). In addition to the 44 Mux and Demux ports there are two monitor ports (MON IN and MON OUT) for monitoring the traffic ports.

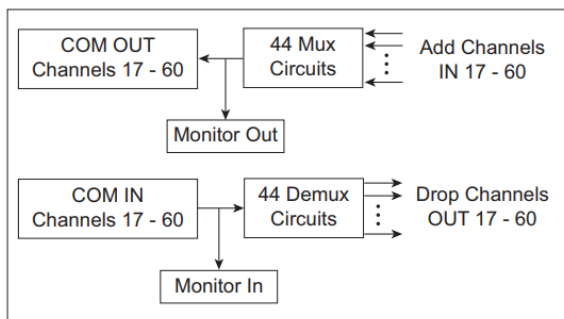
The Composite Input (COM IN) port can carry up to 44 DWDM wavelengths at 100 GHz spacing that are demultiplexed into individual wavelengths at the OUT ports for each channel. Individual wavelengths applied to the IN ports for each channel are multiplexed onto the Composite Output (COM OUT) port, which may carry up to 44 DWDM wavelengths at 100 GHz spacing.



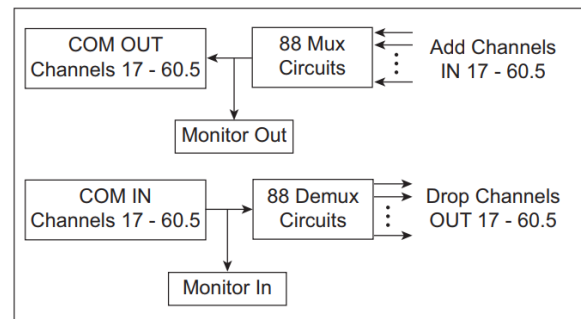
88-Channel DWDM Mux/Demux

The 88-Channel Dense Wavelength Division Multiplexing (DWDM) Mux/Demux is based on athermal Arrayed Waveguide Gratings (AWG) technology with 50 GHz channel spacing. The 88-Channel DWDM Mux/Demux operates in the full C-band supporting Channels 17 (1563.86 nm) through 60.5 (1529.16 nm). In addition to the 88 Mux and Demux ports there are two monitor ports (MON IN and MON OUT) for monitoring the traffic ports.

The Composite Input (COM IN) port can carry up to 88 DWDM wavelengths at 50 GHz spacing that are demultiplexed into individual wavelengths at the OUT ports for each channel. Individual wavelengths applied to the IN ports for each channel are multiplexed onto the Composite Output (COM OUT) port, which may carry up to 88 DWDM wavelengths at 50 GHz spacing.

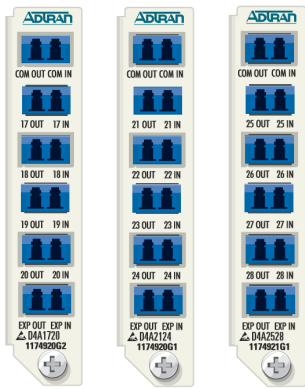


44-Channel DWDM Mux/Demux Diagram



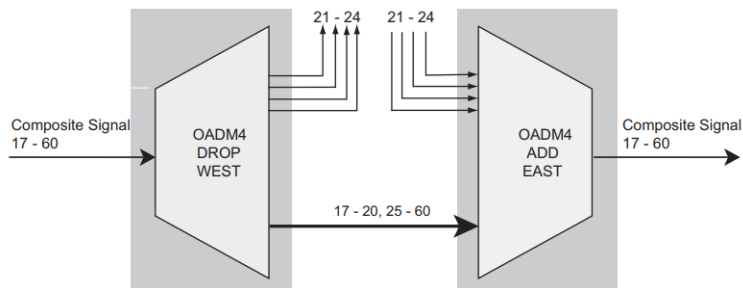
88-Channel DWDM Mux/Demux Diagram

Four Channel DWDM OADM



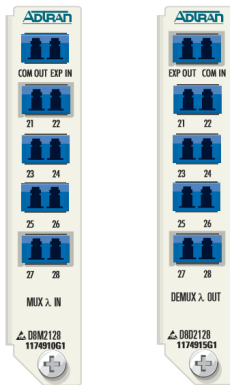
The Four Channel Dense Wavelength Division Multiplexing (DWDM) OADM combines an optical multiplexing function with an optical demultiplexing function. The OADM multiplexes and adds up to four DWDM wavelengths onto a composite DWDM signal. It also demultiplexes and drops up to four wavelengths from an incoming composite DWDM signal. In addition, each OADM supports express ports EXP IN and EXP OUT for passing wavelengths through that are not being multiplexed or demultiplexed.

The Four Channel DWDM OADM operates in the full C-band supporting Channels 17 (1563.86 nm) through 60 (1529.55 nm) at 100 GHz spacing. It can be inserted in a [1RU WDM Filters Housing panel](#), [Carrier Module](#), or Total Access 5004 chassis [Resource Module](#) slot.



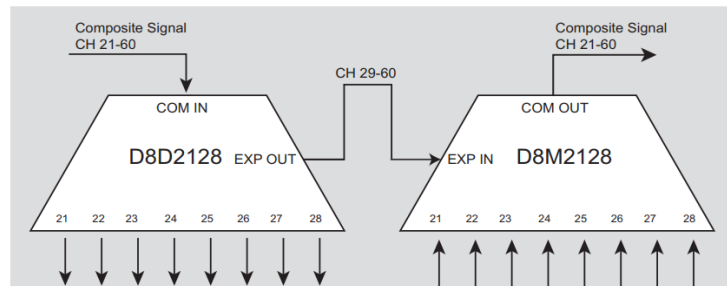
Four Channel DWDM OADM Wavelength Flow Diagram

Eight Channel DWDM Mux/Demux



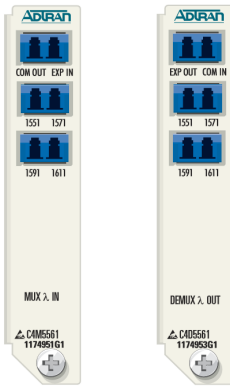
In the figure below, channels 21-28 are being demultiplexed from the incoming fiber (COM IN) to demux ports 21-28 and re-routed to an ONE module, switch module port, or other device that includes DWDM optics. The other devices also transmit on channels 21-28 which are multiplexed from mux ports 21-28 on to the outgoing fiber (COM OUT). In addition, each Mux/Demux supports express ports, labeled EXP, for passing wavelengths through that are not being multiplexed or demultiplexed.

The Eight Channel DWDM Mux/Demux operates in the C-band supporting Channels 21 (1560.61 nm) through 36 (1548.51 nm) at 100 GHz spacing. It can be inserted in a [1RU WDM Filters Housing panel](#), [Carrier Module](#), or Total Access 5004 chassis [Resource Module](#) slot.



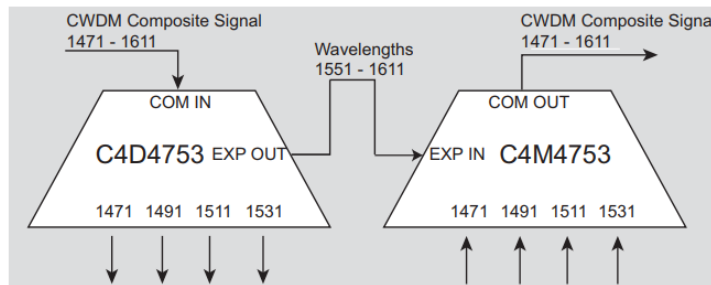
Eight Channel DWDM Mux/Demux Wavelength Flow Diagram

Four Channel CWDM Mux/Demux



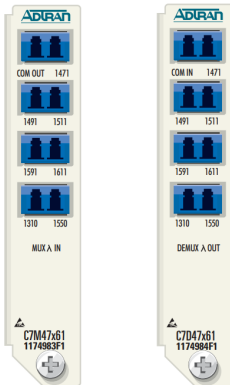
The Four Channel Coarse Wavelength Division Multiplexing (CWDM) Mux/Demux are optical multiplexer or demultiplexer products. The CWDM Mux products are used to multiplex four wavelengths onto the Transmit Composite CWDM signal. The CWDM Demux products are used to demultiplex four wavelengths from the Received Composite CWDM signal.

The Four Channel CWDM Mux/Demux supports wavelengths 1471, 1491, 1511, 1531, 1551, 1571, 1591, and 1611 nm. It can be inserted in a [1RU WDM Filters Housing](#) panel, [Carrier Module](#), or Total Access 5004 chassis [Resource Module](#) slot.

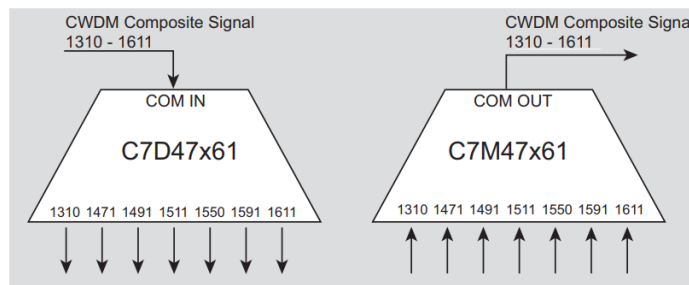


Four Channel CWDM Mux/Demux Wavelength Flow Diagram

Seven Channel CWDM Mux/Demux



The Seven Channel - 1310, 1550 and 5 Coarse Wavelength Division Multiplexing (CWDM) Mux and Demux Modules are optical multiplexer and demultiplexer products. These modules enable transport of existing legacy signals over 1310 and 1550 nm with new services (over five CWDM channels on the same fiber pair) without changing the optics in the existing products. The 1550 port can be used for an additional CWDM channel for a total of six CWDM channels plus 1310 nm. In addition, the 1550 port provides a complete C-band where [DWDM](#) filters may be connected to the 1550 port delivering a combined CWDM DWDM solution with up to 88 DWDM channels. It can be inserted in a [1RU WDM Filters Housing](#) panel, [Carrier Module](#), or Total Access 5004 chassis [Resource Module](#) slot.



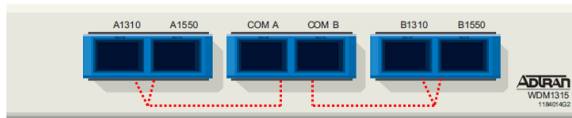
Seven Channel CWDM Mux/Demux Wavelength Flow Diagram

Wide Wavelength-Division Multiplexing Optical Coupler and Multiplexer

The WDM optical coupler and multiplexer are passive optical devices that multiplex and demultiplex two individual wavelengths over two single-mode fibers (1310 nm and 1550 nm). Each multiplexer is an independent bidirectional device used for multiplexing and demultiplexing the two individual wavelengths. It allows for the deployment of wavelength based services. For point-to-point applications, a single multiplexer is required at each node. For ring applications, two multiplexers are required at each node.

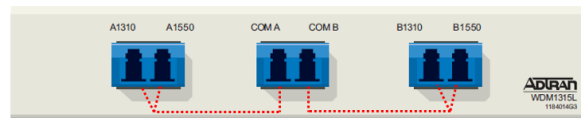


- SC/UPC connectors
- Fiber lead are 1 meter in length each
- Insertion Loss of 0.5 dB



WDM 1315 Optical Multiplexer

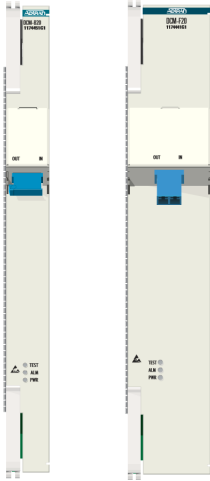
- SC/UPC connectors
- Insertion Loss of 0.8 dB
- Dimensions: 2.75" x 5" x 1" (H x W x D)



WDM 1315L Optical Multiplexer

- LC/UPC connectors
- Insertion Loss of 0.8 dB
- Dimensions: 2.75" x 5" x 1" (H x W x D)

Dispersion Compensation Modules

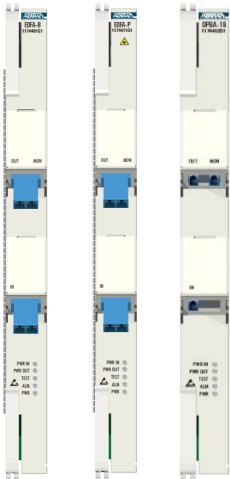


The **Dispersion Compensation Module Bragg-Grating Based (DCM-B)** is a single slot module that compensates for non-dispersion shifted Single Mode Fiber (SMF) over the ITU-T C-band. The module is placed at the end of a fiber span to remove the dispersion from the optical signal over a fixed length of fiber. The fiber carrying the signal with the dispersion is plugged into the IN port and the dispersion compensated signal exits through the OUT port. Optical fiber access is provided by LC connectors on the front panel. This module occupies a single module slot in the [Total Access 5000 Series](#) chassis.

The **Dispersion Compensation Module Fiber Based (DCM-F)** is a double-wide module. The module is placed at the end of a fiber span to remove the dispersion from the optical signal over a fixed length of fiber. The fiber carrying the signal with the dispersion is plugged into the IN port and the dispersion compensated signal exits through the OUT port. Optical fiber access is provided by LC connectors on the front panel. The module occupies two slots in the [Total Access 5000 Series](#) chassis.

Optical Amplification Modules

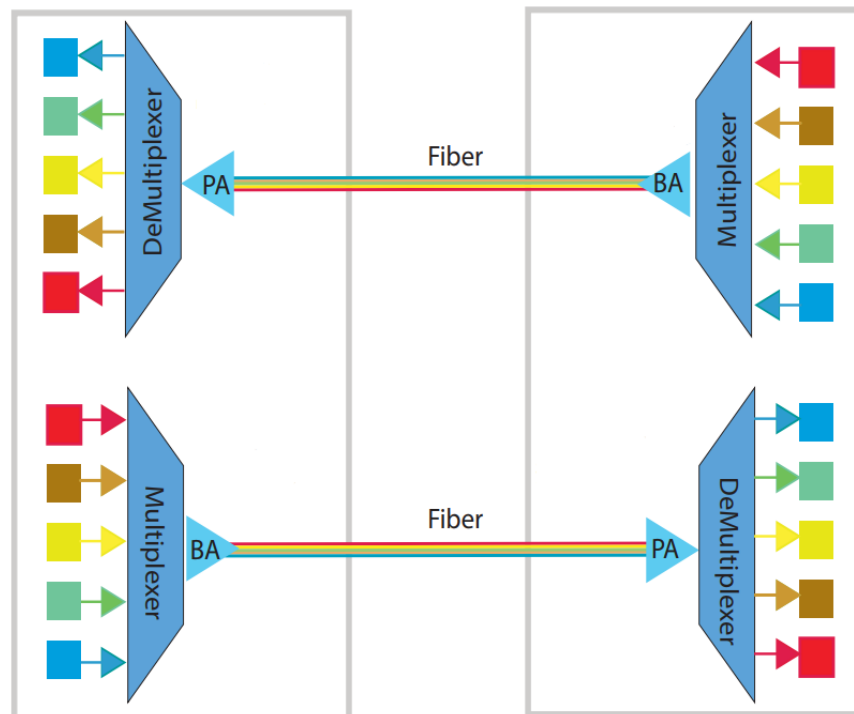
The optical amplification modules include the Optical Boost Amplifier Module (OBAM), Optical Pre-Amplifier Module and Optical Pre-amplifier/Booster Amplifier-18 (OPBA-18). The amplification modules are based on Erbium-Doped Fiber Amplifier (EDFA) technology, and designed to extend the reach of a multi-wavelength optical signal. The modules are important building blocks for edge, metro and regional optical networks. The EDFA modules help overcome the optical attenuation caused by the fiber the signals pass through, and the insertion loss of Dense Wavelength Division Multiplexing (DWDM) modules such as Optical Add Drop Multiplexers (OADMs) and [Reconfigurable Add Drop Multiplexers \(ROADMs\)](#). The EDFA amplifiers enable the implementation of longer transport networks without costly regeneration.



The **Optical Boost Amplifier Module (OBAM)** is used to boost the composite DWDM signal at the beginning of the fiber span. It is usually connected to the DWDM outgoing signal from a Mux, and designed to overcome the attenuation of the fiber span.

The **Optical Pre-Amplifier Module (OPAM)** is used to amplify the composite DWDM incoming signal to a power level greater than the minimum receiver sensitivity of the receiver. It is usually placed at the end of the span before the DWDM DeMux module.

The **Optical Pre-amplifier/Booster Amplifier-18 (OPBA-18)** can be used as either a Pre-amplifier or a Booster amplifier via software provisioning. In the pre-amp mode the OPBA-18 can also function as an In-line amplifier.



ONE EDFA Amplification Module Example

Reconfigurable Optical Add Drop Multiplexer (ROADM)

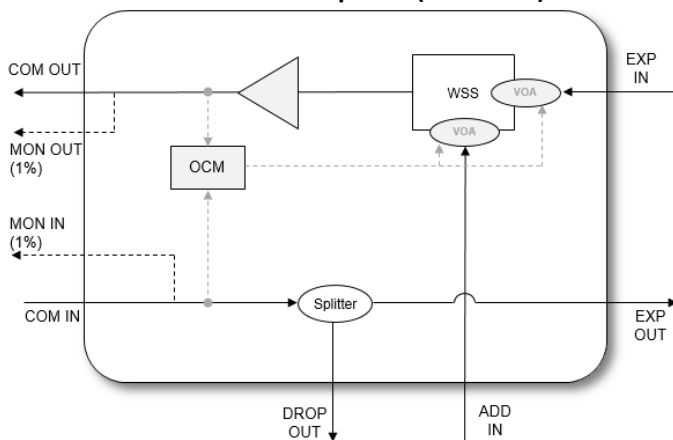
ADTRAN's mini amplified Reconfigurable Optical Add Drop Multiplexer (ROADM) delivers a system on a blade in the [Total Access 5000 Series](#) chassis.

The ROADM modules include wavelength provisioning based on Wavelength Selection Switch (WSS). The module allows flexible add/drop of any C-band wavelength combinations. It also supports amplification based on a dual stage Erbium-Doped Fiber Amplifier (EDFA) booster and pre-amplifier with access to the mid-stage. The amplifiers supports insertion of a [Dispersion Compensation Module \(DCM\)](#) in the mid-stage. The module has an Optical Channel Monitoring (OCM) capability with two internal monitoring points. OCM simplifies remote channel monitoring and the optical equalization process.

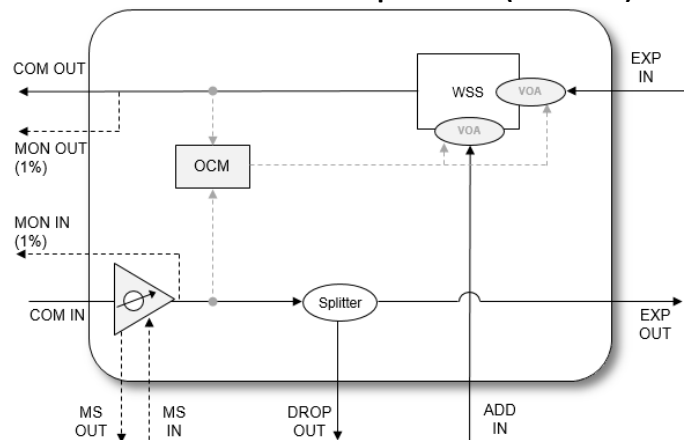
The following ROADMs are part of the Optical Networking Edge (ONE) portfolio:

- [2 Degree Mini Amplified ROADM System \(MARS-2\)](#)
- [2 Degree Mini Amplified ROADM System with Booster Amplifier \(MARS-2B\)](#)
- [2 Degree Mini Amplified ROADM System with Variable Gain Pre-amplification \(MARS-2P\)](#)
- [4 Degree Mini Amplified ROADM System with Variable Gain Pre-Amp and Booster Amp \(MARS-4PB\)](#)

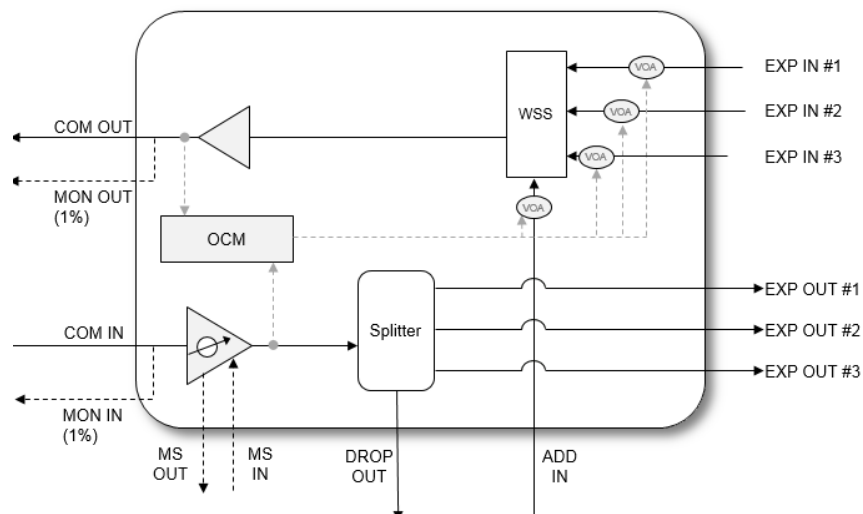
2 Degree Mini Amplified ROADM System with Booster Amplifier (MARS-2B)



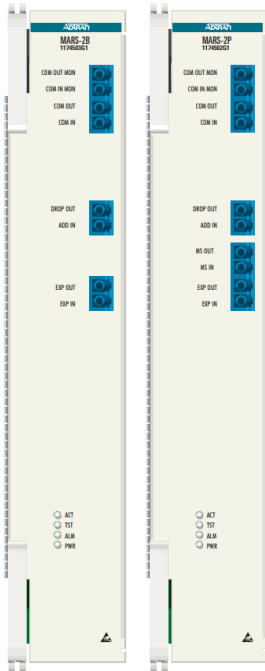
2 Degree Mini Amplified ROADM System with Variable Gain Pre-amplification (MARS-2P)



4 Degree Mini Amplified ROADM System with Variable Gain Pre-amplification and Booster Amplifier (MARS-4PB)



2 Degree Mini Amplified ROADM System



The MARS-2, MARS-2B, and MARS-2P supports 100 GHz channel spacing throughout the full C-band (1563.86 to 1529.55 nm). In 100 GHz channel spacing, the unit supports 44 wavelengths (ITU channels 17-60). The MARS-2, MARS-2B, and MARS-2P are compatible with modulation schemes for up to 100 Gbps transmission.

The use of Wavelength Selection Switch (WSS) allows individual or multiple wavelengths carrying data channels to be added and/or dropped from a transport fiber without converting the signals of the WDM channels to electronic signals then back to optical signals.

The MARS-2, MARS-2B, and MARS-2P occupy two slots in a [Total Access 5000 Series](#) chassis. A full 2-degree ROADM site contains two MARS-2/MARS-2B/MARS-2P modules connected together via the 'Express' interface.

The MARS-2, MARS-2B, and MARS-2P modules include the following features:

- Wavelength provisioning based on Wavelength Selection Switch
- Optical Channel Monitoring capability with two internal monitoring points
- Supports 100 GHz spacing, C-band wavelength combinations
- Supports 44 wavelengths, ITU channels 17-60 (1563.86 nm to 1529.55 nm)
- Threshold alarming on power levels at the aggregate and channel levels*
- Auto power balancing

***Note:** Only supported on MARS-2B and MARS-2P

4 Degree Mini Amplified ROADM System



The MARS-4PB supports 50 GHz and 100 GHz channel spacing throughout the full C-band (1563.86 to 1529.16 nm). In 50 GHz channel spacing, the unit supports 88 wavelengths (ITU channels 17-60.5). In 100 GHz channel spacing, the unit supports 44 wavelengths (ITU channels 17-60). The MARS-4PB also supports mixed 50 GHz and 100 GHz channel spacing. The MARS-4PB is compatible with modulation schemes for up to 100 Gbps transmission.

The use of Wavelength Selection Switch (WSS) allows individual or multiple wavelengths carrying data channels to be added and/or dropped from a transport fiber without converting the signals of the WDM channels to electronic signals then back to optical signals.

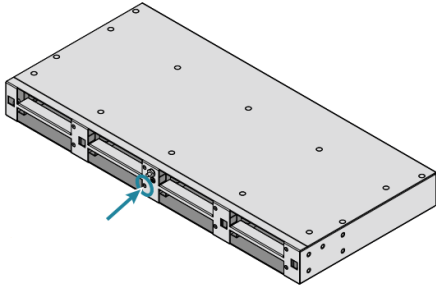
The MARS-4PB occupies two slots in a [Total Access 5000 Series](#) chassis. A full 4-degree ROADM site contains four MARS-4PB modules connected together via the 'Express' interface. This configuration requires eight slots.

The MARS-4PB module includes the following features:

- Wavelength provisioning based on Wavelength Selection Switch
- Optical Channel Monitoring capability with two internal monitoring points
- Supports 50 GHz spacing, C-band wavelength combinations
- Supports 88 wavelengths, ITU channels 17-60.5 (1563.86 to 1529.16 nm)
- COM IN amplification based on a variable gain EDFA mid-stage amplifier
- COM OUT amplification based on an EDFA Boost amplifier
- Threshold alarming on power levels at the aggregate and channel levels
- Auto power balancing

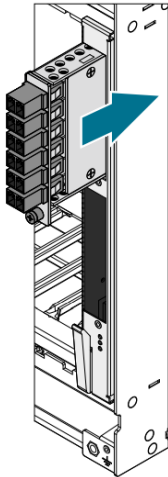
WDM Module Racking

1RU WDM Filters Housing



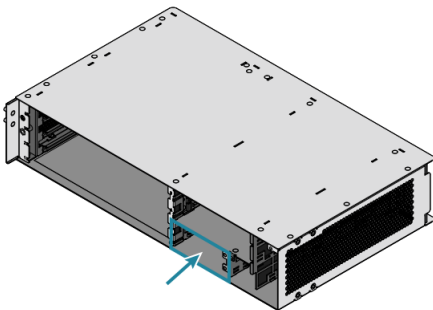
The 1RU WDM Filters Housing is designed for deployment in 19-inch, 23-inch, or ETSI equipment racks. It delivers high density WDM solutions for Central Office or Remote Terminal deployments in a compact 1RU form factor. Up to eight half slot WDM modules can be installed into the 1RU housing.

Carrier Module



The Carrier Module is a module used in a Total Access 5000 Series application. It has two slots that can house two half slot WDM modules. The Carrier Module communicates with the Total Access 5000 Switch Modules (SMs) and provides inventory information of the optical modules that are installed. The Carrier Module has no traffic monitoring capabilities. Communication with the SM is through the Total Access 5000 Series Chassis backplane. The Carrier Module can report the inventory status of any Mux, Demux, or OADM module installed.

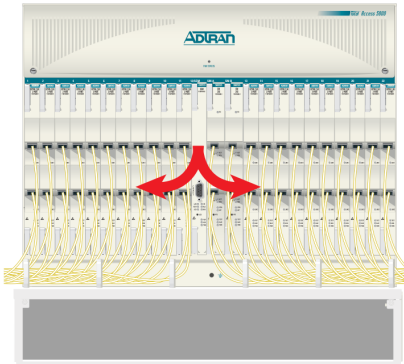
Total Access 5004 Resource Module



The Total Access 5004 chassis provides Resource Module slots to accommodate up to two half slot WDM modules. Slots not occupied will need blank panels installed in order to provide proper airflow and protection to the chassis.

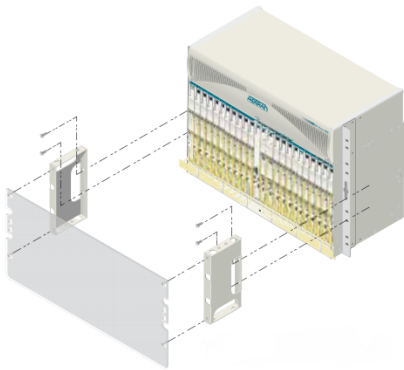
Total Access 5000 Series Accessories

Fiber Manager



The 2nd Generation Fiber Manager increases the number of fibers that can be routed on a Total Access 5000 chassis, and provides a 3RU closed baffle with a filter holder. The 3RU baffle provides front air-intake for the system. The Fiber Manager allows for the management of up to 330, 1.6 millimeter fibers, or 200, 2.0 millimeter fibers per side. The Fiber Manager mounts to the front of the Total Access 5000 chassis.

Clear Cover



The Clear Cover is a transparent plastic shield that attaches to the front of the Total Access 5000 chassis. It provides a protective shield for dense, fiber-managed deployments. The installed Clear Cover covers the entire width of the chassis and the entire height of the chassis module space, from just below the fan module to the bottom of the chassis, including the optional [Fiber Manager](#).

WDM Accessories

Y-cable Applications

Optical splitters and couplers are used in applications where a Y-cable concept is needed. For example, carriers may have a single fiber pair running to non-redundant equipment at a cell site, but would like equipment redundancy at the ONE node since the ONE node maybe transporting multiple cell sites.

The Y-cable Splitter is a 50/50 optical splitter that connects two optical devices to a single fiber span, or routes a single optical signal onto two different fibers. The Y-cable can only transmit one signal at a time (does not provide multiplexing function), so use with two optical devices is best accomplished in a redundant configuration where only one device is active at any one time. The Y-cable is bi-directional and can be used in either the transmit (Tx) or receive (Rx) direction, at either end of a fiber span depending on the function it is to provide.

When an existing optical path is upgraded from a stand-alone configuration to a redundant configuration, using Y-cables can eliminate the need to run new fiber spans for the Protect modules. Installing Y-cables at each end of the existing spans allows Working and Protect modules to share the same fibers.

Y-cable applications are supported on the following Total Access 5000 modules:

- Redundant [ETOS-1](#) modules
- Redundant [ETOS-10](#) modules
- Redundant [OTOS-1-8](#) modules
- Redundant [OTOS-2-16](#) modules
- Redundant [TPR-10-4](#) modules
- Redundant [Switch Modules*](#)

***Note:** Node 1 Ethernet Default Interface (EDI)

Optical Splitter and Coupler Variants

Optical splitters and couplers come in pigtail and canister variants. The pigtail variants have various connector types and lengths. The canister variants have two y-cable optical splitters (one for each signal direction) installed in a small canister. The canister is available in LC or SC connector types.



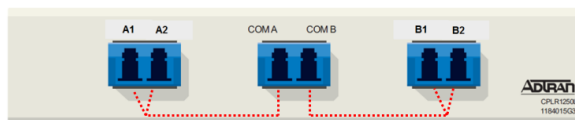
- LC/UPC connectors on split fibers
- LC/UPC connector on composite fiber
- Insertion Loss < 3.5 dB



- SC/UPC connectors on split fibers
- SC/UPC connector on composite fiber
- Insertion Loss < 3.4 dB

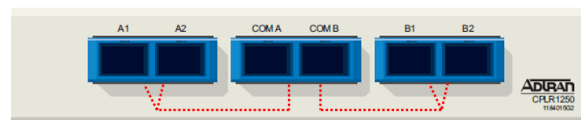


- LC/UPC connectors on split fibers
- SC/UPC connector on composite fiber
- Insertion Loss < 3.7 dB



Coupler 1250

- SC/UPC connectors
- Insertion Loss 3.4 dB max
- Dimensions: 2.75" x 5" x 1" (H x W x D)



Coupler 1250L

- LC/UPC connectors
- Insertion Loss 3.6 dB max
- Dimensions: 2.75" x 5" x 1" (H x W x D)

Training

ADTRAN offers a variety of training options, including instructor-led Installation and Maintenance training at our facilities in Huntsville, Alabama. Cost based on-site training is available at the customer location.

ADTRAN also offers web-based training that serves as a primer to the instructor led courses.

Many training options may be viewed at the ADTRAN Website Training Page:

https://www.adtran.com/web/page/portal/Adtran/wp_training_landing

- **Virtual** – Take advantage of live, expert instruction over the Web with our live Virtual training offering. This option transitions traditional classroom learning to the internet.
- **Classroom** – Students attending training at our training facilities will experience our special classroom and laboratory facilities designed to get the most out of every learning experience. In addition, these classes give students the opportunity to interact with peers from across the industry all while benefiting from others experiences.
- **Custom Classes** – Custom training classes are available for your organization either at your location, at an ADTRAN facility, or using ADTRAN Virtual Classroom.

Recommended Training Courses

Total Access 5000 Fundamentals – This online self-paced course provides an overview of the Total Access 5000. Topics covered include a hardware overview, topology and node expansion, VLAN tagging, CLI basics, procedures for system turn up, upgrading firmware, save/restore provisioning, and an introduction to the Web GUI.

Total Access 5000 ONE Training – Total Access 5000 ONE Training is designed for those students that will be responsible for either designing, installing, provisioning or maintaining the Total Access 5000 for ONE deployment. This course will include interactive lectures as well as lab exercises. Integrated hands-on lab exercises are designed to reinforce the classroom instruction. After completion of the course, the student should be able to turn-up, provision, and maintain the ADTRAN Total Access 5000 ONE system.

Training Matrix

	Duration	Prerequisites	Price	Location	Part Number
Total Access 5000 Fundamentals	3 hours	None	Free	Online	
Total Access 5000 ONE Training	5 days	TA5K Fundamentals	See BOM	ADTRAN	1600CSYS5020E
				Customer Site	1600CSYS5020C

Network Care Program Options

ADTRAN has evolved over time to a supplier of complex services delivery, for network-based solutions. Complete networks continue to be created and maintained using a wide variety of components, including hardware and software building blocks, sophisticated testing, management and planning tools and decades of experience. ADTRAN Services is uniquely qualified to successfully operationalize a project concept into tangible services revenue in multi-vendor service provider networks, including: feasibility, planning, engineering, installation, test, acceptance and ongoing asset management.

Network Care Programs include SLA services, extended warranty and maintenance programs to provide consistent equipment performance, network optimization services and co-located customer design and engineering services. ADTRAN Network Care Programs include the following valued components:

Network Care Program Matrix

	Basic Network Care	Enhanced Network Care	Total Network Care
Hardware Maintenance			
Extended warranty	•	•	•
Free repair	•	•	•
Dead on Arrival (DOA)	•	•	•
Next business day advanced replacement			•
Product Support			
Product Support assistance via email	•	•	•
<i>Outages</i> – All requests for outages must be initiated by phone and clearly communicated that the issue is outage related. Response targets are measured 24x7 for phone responses.	1 hour or less response time	1 hour or less response time	20 min or less response time
<i>Non-Outages</i> – Add 2 hours to response targets for emailed or web-initiated service requests. Non-outage requests for service made after normal business hours will be placed in the priority queue for the following business day.	6 hour or less response time	6 hour or less response time	4 hour or less response time
Training			
Access to ADTRAN’s Support Community – technical documentation, software notifications, feature requests	•	•	•
Vouchers for training classes*	1 voucher	2 vouchers	4 vouchers

***Note:** One voucher has a value of \$1000

Design Criteria Guidelines

ADTRAN would be happy to assist with Transport Network Design services. To expedite the design process before the request is submitted, a network drawing with as much detail as possible is highly recommended. Contact your regional Sales Engineer or Applications Engineering (application.engineer@adtran.com).

The customer can provide the following information or have it readily available:

Initial Design Information

- Expected/desired deployment date
- Number of sites
- Fiber type for each span
- Number of fibers available to use for each span
- Optical distance for each span
- Number of channels currently needed
- Number of channels needed for future growth
- Fixed channels and/or any-to-any (ROADM) channels
- Number of services needed to drop at site locations
- Bandwidth needed
- Any path redundancy required
- Any hardware redundancy required
- Rack space available
- Any temperature hardened components needed
- Existing SONET, DWDM, or other networks

Optical Characterizations

- Bi-directional connector-to-connector readings for each span
- Bi-directional Optical Return Loss (ORL) measurements for all fiber connectors
- Bi-directional Optical time-domain reflector (OTDR) plots for each span
- End-to-end Chromatic Dispersion (CD) testing
- End-to-end Polarization Mode Dispersion (PMD)

Designs generated without optical characteristics may not be feasible outside of certain conditions. The customer is responsible for acquiring additional equipment if the optical network is not within the bounds of the sample design.

Appendices

MARS (Mini Amplified ROADM System)

	MARS-2	MARS-2B	MARS-2P	MARS-4PB
Input Power Level	-34 to -2 dBm	-34 to -1 dBm	-29 to +8 dBm	-29 to +8 dBm (pre-amp)
				-25 to +8 dBm (boost)
Output Power Level	+17 dBm	+18 dBm	+18 dBm	+18 dBm (pre-amp)
				+21 dBm (boost)
Damage Threshold	+25 dBm	+25 dBm	+25 dBm	+25 dBm
Max Gain	+29 dB	+15 dB	+10 to +25 dB (variable)	+10 to +25 dB (variable)
				+20 dB
Typical Gain with Amp	+25.6 dB	+9.4 dB	+6.6 to +21.6 dB (variable)	+2.6 to +17.6 dB (variable)
				+10.4 dB
Max Noise Figure	6 dB	5.5 dB	18.5 to 5.8 dB (based on gain)	18.5 to 5.8 dB (based on gain)
				5.5
Typical Insertion Loss (no amp) COM IN to EXP OUT	-3.4 dB (amp provides +29)	-3.4 dB (no pre-amp)	-3.4 dB (amp provides +10 to +25)	-7.4 dB (amp provides +10 to +25)
Typical Insertion Loss (no amp) EXP IN to COM OUT	-5.2 dB	-5.6 dB (no booster)	-9.4 dB (no booster)	-9.6 dB (amp provides +20)
Typical Insertion Loss (no amp) COM IN to DROP OUT	-3.2 dB (amp provides +29)	-3.4 dB (no pre-amp)	-3.2 dB (amp provides +10 to +25)	-7.4 dB (amp provides +10 to +25)
Typical Insertion Loss (no amp) ADD IN to COM OUT	-5.4 dB	-5.6 dB (no booster)	-9.4 dB (no booster)	-9.6 dB (amp provides +20)
Variable Optical Attenuator (VOA)	0 to 15 dB	0-15 dB	0-15 dB	0-15 dB

Dispersion Compensation Module - Bragg-Grating Based

	DCM-B20	DCM-B40	DCM-B60	DCM-B80	DCM-B100
Distance	20 km	40 km	60 km	80 km	100 km
Dispersion at First Channel	-310 ps/nm	-619 ps/nm	-929 ps/nm	-1238 ps/nm	-1548 ps/nm
Dispersion at Last Channel	-356 ps/nm	-712 ps/nm	-1068 ps/nm	1423 ps/nm	-1779 ps/nm
Insertion Loss at 1525-1565 nm	≤3 dB	≤3 dB	≤3 dB	≤3 dB	≤3 dB
Polarization Mode Dispersion (PMD)	≤0.5 ps	≤0.5 ps	≤0.5 ps	≤0.7 ps	≤0.7 ps
Polarization Dependent Loss (PDL)	≤0.3 dB	≤0.3 dB	≤0.3 dB	≤0.3 dB	≤0.3 dB

Dispersion Compensation Module - Fiber Based

	DCM-F20	DCM-F40	DCM-F60	DCM-F80
Distance	20 km	40 km	60 km	80 km
Dispersion at First Channel	-340 ±10 ps/nm	-670 ±20 ps/nm	-1000 ±30 ps/nm	-1340 ±40 ps/nm
Insertion Loss at 1525-1565 nm	≤3.3 dB	≤4.7 dB	≤6.4 dB	≤8 dB
Polarization Mode Dispersion (PMD)	≤0.6 ps	≤0.8 ps	≤0.9 ps	≤1.0 ps
Polarization Dependent Loss (PDL)	≤0.1 dB	≤0.1 dB	≤0.1 dB	≤0.1 dB

Optical Amplification Modules

	OBAM	OPAM	OPBA-18
Input Power Level	-15 to +8 dBm	-35 to -1 dBm	-34 to -1 dBm (pre-amp) -25 to +8 dBm (boost)
Output Power Level	-5 to +18 dBm	-8 to +10 dBm	-19 to +18 dBm
Saturated Output Power	+18 dBm	+10 dBm	+18 dBm
Max Gain	+10 dB	+27 dB	+15 dB
Max Noise Figure	8.5 dB	5.5 dB	5.5 dB

WDM Modules

	44-Channel Mux/Demux	88-Channel Mux/Demux
Channels	17-60	17-60.5
Max Insertion Loss	6.3 dB	6.5 dB
Channel Spacing	100 GHz	50 GHz

	Four Channel DWDM OADM	Eight Channel DWDM Mux/Demux	Four Channel CWDM Mux/Demux	Seven Channel CWDM Mux/Demux
Channels	17-60	21-36	47-61	N/A
Total Insertion Loss per Channel	3.0 dB	4.4 dB	3.1 dB	3.6 dB
Total Insertion Loss per Express Port	2.0 dB	4.4 dB	1.6 dB	N/A
Express Wavelength Range	1500 to 1620 nm	1500 to 1620 nm	1260 to 1620 nm	1528 to 1565 nm
Connector Loss	≤0.13 dB	≤0.13 dB	≤0.13 dB	≤0.13 dB

Switch Module ERPS Feature Matrix

	ERPSv1 Supported	Max Number of Nodes on Ring	Max Number of Rings Supported	Max Number of Ring Nodes across all Rings	Ring Speed						Cross Slot ERPS
					ERPS					ERPS over LAG 20G	
					1G	2.5G	10G	40G	100G		
MSM20 (2x10G)	•	32	1	32	•	•	•				•
SM20 (2x1G)	•	32	1	32	•						•
SM25 (2x10G/2x1G)	•	32	1	32	•	•	•				•
SM30 (2x10G/2x1G)	•	32	1	32	•	•	•				•
SM40 (4x10G)	•	32	1	32	•	•	•			•	•
SM200 (2x40G/2x100G)	•	32	1	32	•	•	•	•	•	•	•

Note: Single Slot ERPS is not supported.

Switch Module LAG Feature Matrix

	Single Slot LAG	Cross Slot LAG	Active/Standby LAG Group	Active/Active LAG group	Max Number of LAG Groups	Max Number of Ports in Group	Max LAG Group Bandwidth	LAG (MEN)	LAG with LACP
MSM20 (2x10G)	•	•		•	1	2	20G (2x10G)	•	
SM20 (2x1G)	•	•	•	•	1	2	2G (2x1G)	•	•
SM25 (2x10G/2x1G)	•	•	•	•	2	4	20G (2x10G)	•	•
SM30 (2x10G/2x1G)	•	•	•	•	2	4	20G (2x10G)	•	•
SM40 (4x10G)	•	•	•	•	2	8	80G (8x10G)	•	•
SM200 (2x40G/2x100G) Note: Max Number of Ports in Group vary	•	•	•	•	4	4	400G (4x100G)	•	•
						4	160G (4x40G)		
						16	160G (16x10G)		
						16	40G (16x2.5G)		
						16	16G (16x1G)		

Note: SM/MSM ports are MEN ports only. UNI is not supported.

Switch Module Interface Speeds

	Faceplate Ports				
	1G	2.5G	10G	40G	100G
MSM20 (2x10G) (SFP+)	•	•	•		
SM20 (2x1G) (SFP)	•				
SM25 (2x10G/2x1G) (SFP+/SFP)	•	•	•		
SM30 (2x10G/2x1G) (SFP+/SFP)	•	•	•		
SM40 (4x10G) (SFP+)	•	•	•		
SM200 (2x40G/2x100G) (QSFP+/QSFP28)	• (breakout cable)	• (breakout cable)	• (breakout cable)	•	•