High-Density Fiber Infrastructure Application Note: WDM-PON Multiplexing Schemes and SFP Transceiver Integration Standards

TECHNOLOGY OVERVIEW

WDM-PON (Wavelength Division Multiplexing Passive Optical Network) represents the definitive evolution in fiber access infrastructure, delivering protocol-transparent, point-to-point connectivity over a shared passive optical distribution network. By assigning a dedicated wavelength to each subscriber or service endpoint, WDM-PON eliminates the bandwidth contention inherent in legacy TDM-PON architectures while preserving the economic benefits of passive outside plant deployment. This application note establishes the multiplexing schemes, transceiver integration standards, and hardware design criteria required for carrier-grade WDM-PON deployment in high-density fiber infrastructure.



SFP+/QSFP INTERFACE MAPPING

The physical layer of a WDM-PON system relies on precise wavelength routing and standardized transceiver interfaces. The following multiplexing schemes are supported across the platform's line card portfolio:

- Coarse Wavelength Division Multiplexing (CWDM): Utilizes 20 nm channel spacing across the 1270–1610 nm spectrum, supporting up to 18 channels over a single feeder fiber. Ideal for cost-sensitive enterprise and campus applications.
- Dense Wavelength Division Multiplexing (DWDM): Provides 100 GHz or 50 GHz channel spacing in the C-band (1530 – 1565 nm), enabling 40 to 96 bidirectional channels. Required for carrier-grade metro and regional access networks.

- Arrayed Waveguide Grating (AWG) Routing: Passive AWG multiplexers in the outside plant perform wavelength demultiplexing with insertion losses below 3 dB, ensuring power budget compliance for distances up to 20 km without amplification.

SFP transceiver integration is governed by MSA (Multi-Source Agreement) standards to ensure interoperability across OLT (Optical Line Terminal) and ONU (Optical Network Unit) endpoints. Key integration parameters include:

- SFP+ (10G) and SFP28 (25G) form factors with DWDM/CWDM wavelength-coded optics.
- QSFP28 (100G) for high-capacity trunking between OLT line cards and upstream aggregation.
- Digital Diagnostic Monitoring (DDM) via I2C for real-time wavelength drift, optical power, and temperature telemetry.
- Hot-swappable cage design with EMI shielding and latching mechanisms rated for 500+ insertion cycles.

REDUNDANT POWER SYSTEM

The WDM-PON platform employs a dual-redundant, hot-swappable power architecture to ensure uninterrupted service in carrier environments. Each

power module delivers load-sharing DC output with independent AC/DC conversion stages. Failure of a single module triggers automatic failover within 10 ms, with no impact on active wavelength channels or transceiver operation.

- Input voltage: 100–240 VAC, 50/60 Hz or -48 VDC nominal.
- Power module redundancy: 1+1 or N+1 configurations.
- Inrush current limiting and surge protection per IEC 61000-4-5.
- Front-panel LED status per module: OK, FAIL, AC PRESENT.

CAPABILITY METRICS

The following metrics define the baseline performance envelope for the WDM-PON multiplexing and SFP integration platform:

- Maximum channel count: 96 bidirectional DWDM channels.
- Per-channel line rate: 1.25G, 10G, 25G, or 100G depending on transceiver type.
- Passive split ratio: 1:32 (AWG-based) or 1:64 (power splitter-based CWDM).
- Reach: 20 km (standard), 40 km (extended reach with amplification).
- Insertion loss budget: 18 dB (Class B+), 28 dB (Class C+).
- Transceiver management: SFF-8472 DDM, SFF-8636 for QSFP28.
- Wavelength stability: ±0.1 nm over temperature and lifetime.

Parameter	Specification
Form Factor	Modular OLT Chassis, 2RU to 14RU
Switching Capacity	Up to 3.2 Tbps per chassis (full duplex)
Power Supply	Dual Hot-Swappable Redundant AC/DC, 1+1 or N+1
Multiplexing Schemes	CWDM (18 ch), DWDM (96 ch), AWG passive routing
Transceiver Interfaces	SFP+ (10G), SFP28 (25G), QSFP28 (100G)
Max Reach	40 km (extended reach with amplification)
Wavelength Stability	± 0.1 nm over temperature and lifetime
Management	SFF-8472 DDM, SFF-8636, NETCONF/YANG, OpenFlow
Operating Temperature	-40°C to +65°C (NEBS Level 3)
Compliance	ITU-T G.694.1/2, IEEE 802.3ah/av/ca, RoHS, NEBS L3

COMPLIANCE AUDIT

The platform has been audited against the following international standards and regulatory directives:

- ITU-T G.694.1 (DWDM grid), G.694.2 (CWDM grid), G.698.3 (multichannel optical interfaces).
- IEEE 802.3ah (EPON), 802.3av (10G-EPON), 802.3ca (25G/50G-EPON).
- MSA: SFF-8431 (SFP+), SFF-8402 (SFP28), SFF-8665 (QSFP28).
- RoHS 2011/65/EU, WEEE 2012/19/EU.
- IEC 60825-1 (laser safety), IEC 60950-1 / 62368-1 (equipment safety).
- NEBS Level 3 (GR-1089-CORE, GR-63-CORE) for central office deployment.

SCALING STRATEGY

To accommodate growing subscriber density and emerging 5G xHaul requirements, the WDM-PON platform supports incremental scaling without forklift upgrades:

- Modular OLT chassis with 2, 4, 8, or 16 line card slots.
- Software-defined wavelength assignment via SDN controller integration (NETCONF/YANG, OpenFlow).
- Pay-as-you-grow transceiver deployment: start with CWDM, migrate to DWDM via firmware-enabled channel plans.

- In-service firmware upgrade for line cards and transceivers with hitless operation.

- Future-ready support for 50G-PON and coherent access optics.

