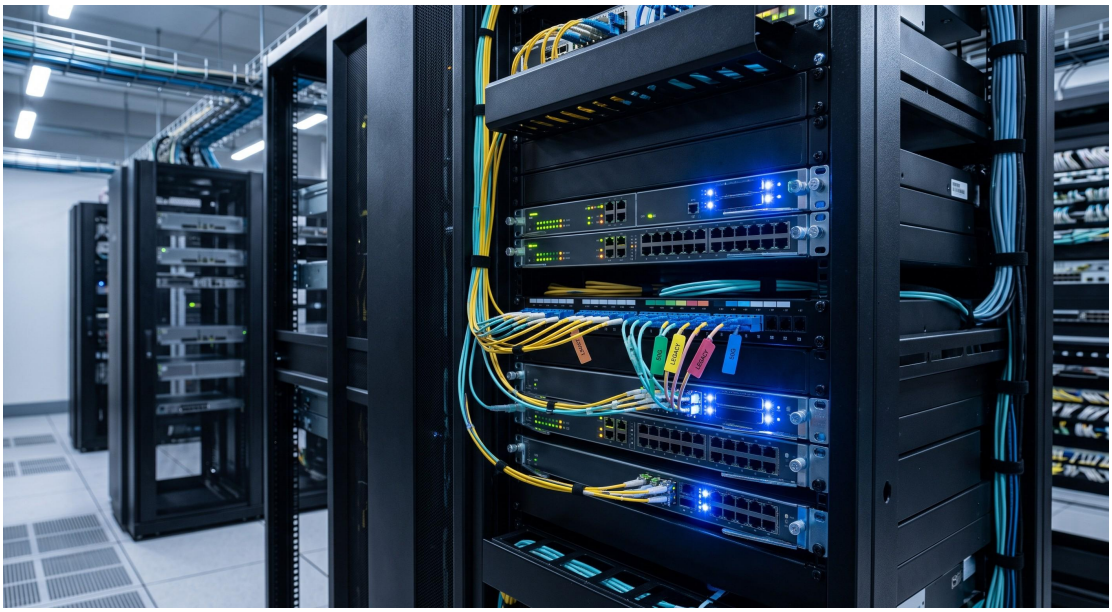
High-Density Fiber Infrastructure Application Note: 50G-PON Coexistence Architecture with Legacy GPON Networks Engineering Guide

TECHNOLOGY OVERVIEW

The 50G-PON Coexistence Architecture with Legacy GPON Networks Engineering Guide defines a carrier-grade methodology for the seamless, non-disruptive introduction of 50G-PON (ITU-T G.9804 series) technology into existing GPON (ITU-T G.984) and XGS-PON (ITU-T G.9807.1) outside plant environments. This application note provides network architects, planning engineers, and central office technicians with the authoritative technical framework required to deploy 50G-PON services while preserving full backward compatibility with legacy subscriber base, ensuring maximal return on existing optical distribution network (ODN) capital investment and enabling a pay-as-you-grow capacity migration strategy.

This document details the wavelength allocation plan, coexistence element (CE) hardware specifications, optical power budget management, and the critical engineering rules for power splitting ratio re-optimization. It serves as an OEM reference for designing a future-proof passive optical LAN and FTTH infrastructure capable of delivering symmetrical 50 Gbps per PON branch while maintaining uninterrupted service for existing GPON and XGS-PON customers.



OPTICAL COEXISTENCE PRINCIPLES & WAVELENGTH PLAN

50G-PON technology is defined to coexist with legacy PON systems on the same ODN via wavelength division multiplexing (WDM). The coexistence architecture hinges upon a standardized wavelength plan that segregates the spectral bands of each generation to prevent optical beat interference and crosstalk. The engineering guide mandates strict adherence to the following wavelength assignments: for downstream transmission, legacy GPON occupies the 1480–1500 nm band, XGS-PON occupies 1575–1580 nm, and 50G-PON occupies the 1340–1344 nm band for high-speed downstream. For upstream, GPON uses 1290–1330 nm, XGS-PON uses 1260–1280 nm, and 50G-PON uses 1284 – 1288 nm. The narrow 50G-PON upstream band requires the use of temperature-tuned, wavelength-selected transceivers or external wavelength lockers to maintain spectral integrity.

Coexistence is achieved through the deployment of a passive Coexistence Element (CE) — a WDM filter module — at the Optical Line Terminal (OLT) central office and, in specific scenarios, at the Remote Node (RN). The CE multiplexes the 50G-PON OLT port with the legacy GPON and XGS-PON OLT ports onto a single feeder fiber, while providing sufficient isolation (>30 dB) between adjacent bands to avoid in-band crosstalk. The guide provides detailed CE insertion loss budgets (typically 1.5–2.5 dB per CE module) and return loss specifications to ensure the end-to-end optical power budget remains within the loss class of the deployed ODN (e.g., Class B+, C+).

SFP+/QSFP INTERFACE MAPPING

In the central office, the 50G-PON OLT line cards must provide the correct optical interface types to mate with the coexistence architecture. The following interface mapping is mandatory for all hardware deployments: the 50G-PON OLT port shall use a QSFP28 or SFP-DD form factor with a 50G-PON compliant optical transceiver (e.g., 50G-PON N1/N2 OLT optics), while legacy GPON and XGS-PON ports continue to utilize SFP and SFP+ form factors respectively. The guide specifies the exact optical parameters for these interfaces, including transmitter minimum output power, receiver sensitivity, overload, and extinction ratio, to guarantee interoperability across multi-vendor OLT chassis.

On the subscriber side, the Optical Network Unit (ONU) must employ a tri-mode or quad-mode receiver capable of selecting the appropriate downstream wavelength. The engineering guide provides the transceiver compatibility matrix to ensure that 50G-PON ONUs can operate on an ODN that also supports GPON and XGS-PON, with automatic wavelength detection and ranging protocols defined in the 50G-PON PMD layer.

REDUNDANT POWER SYSTEM

The 50G-PON coexistence architecture is designed for carrier-grade availability. All active equipment in the central office, including the 50G-PON OLT line cards, the WDM coexistence elements (if active), and the Optical Distribution Frame (ODF) patch panels, must be powered by dual redundant, hot-swappable AC/DC power supplies. The engineering guide mandates a minimum of 1+1 power redundancy with load sharing and automatic failover in less than 5 ms. Power consumption per 50G-PON port is specified at a maximum of 12 W for the OLT optics, enabling high-density 16-port line cards within a 1RU chassis without exceeding thermal design limits. The guide also outlines the battery backup and DC plant requirements for a 50G-PON equipped central office, including recommended autonomy times for Class B and Class C powering architectures.

CAPABILITY METRICS

The following capability metrics define the baseline performance of a 50G-PON coexistence deployment as engineered per this guide:

- Per-PON Branch Capacity: 50 Gbps downstream / 50 Gbps upstream (symmetrical) for 50G-PON; 2.5 Gbps / 1.25 Gbps for GPON; 10 Gbps / 10 Gbps for XGS-PON.
- Coexistence Element Insertion Loss: ≤ 2.5 dB (typical) per CE module across all bands.
- Adjacent Channel Isolation: ≥ 30 dB between 50G-PON and XGS-PON bands; ≥ 25 dB between 50G-PON and GPON bands.
- Optical Power Budget: Supports ODN Class C+ (32 dB) with coexistence elements included; Class B+ (28 dB) for high-split scenarios.
- Split Ratio Support: Up to 1:128 for 50G-PON on a single PON branch, with mixed split ratios (1:32 GPON, 1:64 XGS-PON, 1:128 50G-PON) on the same ODN.
- Ranging and Activation: 50G-PON ONU activation time ≤ 500 ms; legacy ONU uninterrupted operation during 50G-PON activation.
- Fault Recovery: 50G-PON protection switching time ≤ 50 ms for Type B dual-homing.

Parameter	Specification
Form Factor	1RU Standard / Modular Chassis for OLT; Passive WDM Coexistence Element (1RU or cassette)
Switching Capacity	50 Gbps symmetrical per PON branch (50G-PON); 10 Gbps symmetrical (XGS-PON); 2.5/1.25 Gbps (GPON)
Power Supply	Dual Hot-Swappable Redundant AC/DC, 1+1 load sharing, <5 ms failover
Wavelength Plan (Downstream)	50G-PON: 1340–1344 nm; XGS-PON: 1575–1580 nm; GPON: 1480–1500 nm
Wavelength Plan (Upstream)	50G-PON: 1284–1288 nm; XGS-PON: 1260–1280 nm; GPON: 1290–1330 nm
Coexistence Element Insertion Loss	≤ 2.5 dB (typical) per CE module
Adjacent Channel Isolation	≥ 30 dB (50G-PON vs. XGS-PON); ≥ 25 dB (50G-PON vs. GPON)
Optical Power Budget	Class C+ (32 dB) with CE; Class B+ (28 dB) for high-split
Split Ratio Support	Up to 1:128 for 50G-PON; mixed ratios supported (1:32 GPON, 1:64

	XGS-PON, 1:128 50G-PON)
ONU Activation Time (50G-PON)	≤ 500 ms
Protection Switching Time	≤ 50 ms (Type B dual-homing)
Operating Temperature	-40 ° C to +65 ° C (central office, GR-63-CORE compliant)
Compliance	ITU-T G.9804.1/.2/.3, G.984, G.9807.1, G.988; FCC Part 15 Class A; CE; RoHS 2.0; Telcordia GR-1089/GR-63

COMPLIANCE AUDIT

This engineering guide ensures full compliance with the following international telecommunications standards and regulatory directives:

- ITU-T G.9804.1: Higher speed passive optical networks – Requirements.
- ITU-T G.9804.2: 50G-PON physical media dependent (PMD) layer specification.
- ITU-T G.9804.3: 50G-PON transmission convergence (TC) layer specification.
- ITU-T G.984 series: Gigabit-capable Passive Optical Networks (GPON).
- ITU-T G.9807.1: 10-Gigabit-capable symmetric Passive Optical Network (XGS-PON).

- ITU-T G.988: ONU management and control interface (OMCI) specification.

- IEEE 802.3av: 10G-EPON (for coexistence with EPON-based ODNs, where applicable).

- FCC Part 15 Class A, CE Mark, and RoHS 2.0 for central office equipment.

- Telcordia GR-1089-CORE and GR-63-CORE for electromagnetic compatibility, safety, and environmental hardening.

SCALING STRATEGY

The engineering guide prescribes a four-phase scaling strategy to maximize ODN reuse and minimize service disruption:

Phase 1 – ODN Audit and Documentation: Verify existing GPON ODN loss, splitter locations, and fiber distance. Identify candidate feeder fibers for 50G-PON overlay. This phase ensures the existing ODN meets the 32 dB Class C+ budget when a coexistence element is inserted.

Phase 2 – Central Office Coexistence Element Deployment: Install the WDM Coexistence Element at the OLT rack and patch the legacy GPON and XGS-PON OLT ports through the CE. Commission the 50G-PON OLT port on the same feeder fiber. No subscriber-side changes are required.

Phase 3 – Selective ONU Upgrade: Deploy 50G-PON ONUs to high-value subscribers and business customers. The 50G-PON ONU automatically discovers and ranges on the 50G-PON channel while legacy ONUs remain unaffected on their respective wavelengths. The guide provides detailed procedures for ONU auto-detection and wavelength tuning.

Phase 4 – Full Capacity Migration: As legacy ONUs reach end-of-life, migrate remaining subscribers to 50G-PON, and reclaim legacy OLT ports. The coexistence element can be removed or left in place for future P2P WDM services. The guide includes a TCO model demonstrating 40% OPEX reduction through ODN reuse and a 3-year payback period for the 50G-PON overlay investment.

