Association for Passive Optical LAN
Passive Optical LAN Technical Specification
Division 27.0 – June 2022
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PART 1 – GENERAL

1.01 SECTION INCLUDES

A. This specification describes technical and performance criteria for deploying a passive optical LAN capable of providing connectivity for a number of different applications/services.

B. The components described in this section include passive and active hardware necessary to deliver a variety of services described herein as well as many other standards based applications not included in this document.

1.02 SYSTEM DESCRIPTION

Services: The Passive Optical LAN also referred to as Gigabit Passive Optical Network (GPON) shall provide, at a minimum, the following services over a converged optical infrastructure. Other than end device connections (i.e. category cable or coaxial jumper connections to end devices) all signal transport shall be over single-mode optical fiber.

A. Ethernet – Must be capable of supporting all industry-recognized protocols to provide Ethernet connectivity throughout the facility.
B. RFoG (Radio Frequency over Glass) – Must be capable of supporting coaxial-based RF television content delivery.
C. Voice – Must be capable of supporting analog and voice over internet protocol (VoIP).

1.03 ALTERNATIVES

The following information shall be required for each alternative component with submittal of the bid response:

A. Product samples
B. Detailed product specifications
C. Independent test results verifying the product specifications

1.04 CODES, STANDARDS, AND CERTIFICATIONS

All work, including but not limited to: cabling, pathways, support structures, wiring, equipment, installation, workmanship, maintenance, and testing shall comply with the latest editions of the National Electrical Code® (NEC®), National Electrical

Safety Code, all applicable local rules and regulations, equipment manufacturers' instructions, and the National Electrical Contractors Association (NECA) Standard of Installation. In case of discrepancy or disagreement between the documents noted above, the Systems Integrator shall satisfy the most stringent requirements.

1.05 ABBREVIATIONS AND ACRONYMS

A. AHJ: Authority Having Jurisdiction
B. ATP: Acceptance Test Plan
C. BOM: Bill of Materials
D. IDF: Intermediate Distribution Facility
E. MDF: Main Distribution Facility
F. MTBF: Mean Time Between Failures
G. NFPA: National Fire Protection Association
H. NMS: Network Management System
I. POL: Passive Optical LAN
J. GPON: Gigabit Passive Optical Network
K. RFoG: Radio-Frequency-over-Glass
L. RoHS: Restriction of Hazardous Substances
M. SNMP: Simple Network Management Protocol
N. SOW: Statement of Work
O. TR: Telecom Room
P. ER: Equipment Room
Q. MBPS: Megabits per second
R. GBPS: Gigabits per second
S. VoIP: Voice over Internet Protocol
T. IEEE: Institute of Electronics Engineers
U. OLT: Optical Line Terminal
V. ONT: Optical Network Terminal
W. LED: Light-emitting diode
X. VLAN: Virtual Local Area Network
Y. Information Outlet: ONT

1.06 DEFINITIONS

A. Acceptance: Expressed approval by the customer
B. Active: Component that requires AC/DC power for operation
C. Systems Integrator: The prime contractor/integrator bidding the project
D. Subcontractor: A qualified and experienced contractor performing a portion of the deployment for the Systems Integrator

E. Optical Line Terminal (OLT) or Headend Equipment: The equipment that connects to the network core, aggregates services, and distributes across the single-mode optical fiber to the Optical Network Terminal

F. Passive: Component that does not require AC/DC power for operation

G. Optical Network Terminal (ONT) or end user device: The equipment that receives communication signals from the OLT and then converts media to Ethernet, RF coax, copper voice, and often injects Power over Ethernet for such required devices

1.07 DESIGN REQUIREMENTS

A. The overall intent of a Passive Optical LAN is to provide a robust and universally available platform from which multiple technologies can share connectivity.

B. All connectivity between MDF/Signal source and end location shall consist of single-mode fiber.

1. Jumpers and short lengths of coaxial and/or unshielded twisted-pair (UTP) cable may be used to extend coverage of active components.

C. All active components located in the horizontal shall be either powered locally with AC or via remote DC power. Any DC power shall comply with NEC Class 2 or Class 3 requirements transmitted over copper conductors either as a stand-alone cable or composite/hybrid Copper/Optical Fiber cables. These conductors should be sized appropriately for voltage drop and considerations shall be made for future applications.

D. LAN Design

1. LAN connectivity provided by Passive Optical LAN infrastructure shall be designed to the following:

a. POL – Optical fiber-based technology that relies on single-mode fiber backhaul to a passive optical splitter typically placed in an IDF. The split ratios are determined by the design and the optical splitter is fed by a single or dual input optical fiber from the Optical Line Terminal in the MDF. Dual inputs are required when physical redundancy of either active headend components or feeder fiber diversity is desired; redundancy is not required and most deployments do not have this redundancy aside from the 'northbound' or switching cards in the OLT.

1) Architecture requires a minimum of a simplex single-

mode fiber run from the ONT back to the splitter located in a zone or ER.

2) When splitters are located outside of the TR adequate sparing of the fiber cable feeding the zone should be implemented as per BICSI sparing standards for Optical LAN.

3) Power can be provided locally or via DC power from a remote NEC Class 2 / Limited Power compliant supply.

1.08 PERFORMANCE REQUIREMENTS

A. Optical Fiber Infrastructure

1. General: Optical fiber cabling shall be tested and certified after installation as described below and as required for cable manufacturer's warranty.
2. Fiber testing shall be performed on all optical fibers in completed end-to-end system. Fiber optic testing shall be done in accordance with international standards recommendations for ITU-T G.984 and ANSI/TIA-568-C.x
    a. Fiber testing should meet all manufacturer requirements for warranty consideration
    b. Fiber shall be Channel tested and/or Link tested
        1) Channel Testing – Fiber shall be tested through the splitter for end to end testing inclusive of all link losses to ensure connectivity of active components is within Manufacturer's acceptable dB range
        2) Link Testing – Fiber shall be tested outside of the splitter for each infrastructure component to ensure link loss is within Manufacturer's acceptable dB range
            a) If performing Link testing only, Optical Splitter loss must be factored into the total link loss to ensure combined link loss is within an acceptable range as per Manufacturer's documented acceptable dB range.
3. Fiber connector: In order to improve system's performances and to reduce turn up failures, best practices recommend that every fiber connector of the installed optical system is cleaned with proper cleaning tools and inspected with a fiber inspection probe. This implies cleanliness of both connectors in a mated pair between a jumper/cable and the bulkhead.

4. The system loss measurements shall be provided at 1310 and 1550 nm for single-mode optical fibers.
5. Each tested span must test to a value less than or equal to value determined by calculating a link loss budget of the entire passive infrastructure from the OLT to any given ONT to include loss derived from the optical splitter.
6. Loss is 0.75dB, return loss shall be greater than -45dB for 1310 and 1550nm Insertion loss for optical splitter should be 3.2dB for every 1:2 ratio
7. Optical splice loss shall be 0.3dB or better with TIA-568 and average providers
8. Attenuation testing: Attenuation testing shall be performed with a stable launch condition using 2-m jumpers to attach test equipment to cable plant. The light source shall be left in place after a valid power reference is performed according to the industry standards and power meter moved to far end to take measurements. Attenuation testing can also be performed faster with built-in industry standards thresholds using an automated light source and power meter called OLTS (Optical Loss Test Set).
9. Loss budget: Shall be determined by the manufacturer's specifications for the components within the optical link and is typically between -18dB and -28dB respectively, depending on installed system GPON class.
10. Link loss: A mated connector-to-connector interface shall be considered a single connector. Loss numbers for installed link shall be calculated by taking sum of bidirectional measurements and dividing that sum by two. All links not meeting requirements of standard shall be brought into compliance by Systems Integrator, at no additional cost to owner.
11. Troubleshooting : Tier-2 troubleshooting to locate fiber breaks or other impairments on optical fiber links must be performed using an out-of-band PON-optimized OTDR (Optical Time Domain Reflectomer) with 1625 or 1650nm filtered port that can test through optical PON splitters from the ONT towards the OLT.
12. Documentation: Final documentation shall be submitted to owner's representative prior to commissioning data system and final contract payment according to submittals in this section:
    a. Must have a complete "as built" picture for each fiber link for network documentation and future reference
        1) Pre-connectorized cables, although factory tested, should still be required.
    b. Individual splice loss data (where applicable)

c. As-installed diagrams

B. LAN Performance

Speed/Link

1. All client-based LAN ports shall support a maximum link speed of no less than 1Gbps performed using a non-limited 1Gbps speed test device.

Power over Ethernet

2. As specified, some ports shall comply with iEEE standards of:
   a. 802.3af
   b. 802.3at
   c. Roadmap for 802.3bt

1.09 SUBMITTALS

A. Submittal Requirements with Bid Response:

1. Product Data: Submit manufacturer datasheets for the following components:
   a. Optical fiber cable and hardware
   b. Splitters and WDM combiners
   c. All active components included in the proposal
   d. Any required submittals that are non PON related; firestop, cable tray, racks…
2. Shop Drawings: Submit the following items:
   a. Proposed riser and horizontal cabling diagram
   b. Overlay of system components on floor plans
   c. Typical room schematic depicting all services fed from the ONT and the location of ONT/s, set-top boxes, phones, wireless access points, etc.
   d. Bill of materials (BOM)
3. Statement of Work (SOW) / Proposal Narrative
4. Provisioning documentation example that will be used to collect network engineering architecture.
5. Integration Test Plan:
   a. Perform fully integrated convergence testing for all services that will be implemented (voice, video, data)
   b. Provide past performance of such integration testing
6. Acceptance Test Plan (ATP): Submit sample ATP
7. Warranty Documents:
   a. Submit for all manufactured components specified in this section
   b. Submit Systems Integrator’s system warranty

c. Submit manufacturer's extended warranty

B. Submittal Requirements Prior to Start of Construction

1. Overlay of system components on floor plans
2. Bill of materials (BOM)
3. Maintenance service contract
4. Day-Two support plan for monitoring of equipment and issue resolution flow
5. Statement of Work (SOW): The Systems Integrator shall submit an SOW that has been accepted by the customer or customer's designated representative.
6. Acceptance Test Plan (ATP): The Systems Integrator shall submit an ATP that has been accepted by the customer or customer's designated representative.

C. Submittal Requirements at Close Out

1. Drawings: Submit as-built drawings indicating:
   a. Cable routing, splitters, couplers, and labeling schema
   b. Active component locations, layout, and configuration
2. Test Reports: Submit all passive component test results.
3. Field Reports: Submit optical test results for all fiber runs including field terminations in electronic format
4. Configuration documentation mapping out all network provisioning; network engineering architecture.
5. Operation and Maintenance Data: Submit hardware and software manuals for all active components
6. Warranty Documents
   a. Submit for all manufactured components specified in this section
   b. Submit Systems Integrator's system warranty
   c. Submit manufacturer's extended warranty

1.11 WARRANTY

A. Manufacturer Warranty

1. Splitters & Couplers: Five-year limited warranty from date of system acceptance
2. Fiber Optic Cable: 25-year limited warranty from date of system acceptance
3. Active Components: One-year limited warranty from date of system installation

PART 2 PRODUCTS

2.01 HARDWARE COMPONENTS

A. Passive Optical LAN Hardware

1. Standards
   a. Describe your compliance to applicable standards (i.e. ITU); provide a list of standards compliance and membership/participation on standards bodies and forums.
   b. All equipment shall be Underwriters Laboratory (UL)-compliant (plus cUL or Canadian Standards Association [CSA] for Canadian deployments)

2. Core platform (OLT) requirements
   a. Hardware requirements
      1) Explain the proposed end-to-end network architecture: i.e., L2 aggregation, connections to core switch, structured cabling, and all the components of the solution.
      2) Optical line terminal (OLT) must support all L2 data management and localized-switching/hairpinning at a L2 level.
      3) Offered solution shall consist of complete equipment list of components with description and part numbers.
      4) Multiple OLT form factor should be available in order to cost-effectively be able to deploy this solution in small, medium, and large locations.
      5) The bidder shall provide details of physical dimensioning of the offered system as height, width and length and power requirements.
      6) Clearly state the maximum port density of each form factor as well as the optimal power consumption per port of your solution.
      7) Offered system (if chassis-based) shall be scalable by inserting or replacing any OLT circuit cards. Northbound or switching cards shall be hot-pluggable.
      8) The chassis shall have local status monitoring and indication by means of light-emitting diodes (LEDs) per OLT port:
         a) Indicates power on/off status

b) Indicates internal device failure status
c) Indicates alarm status

9) The chassis shall support Ethernet port for linking with element management system (EMS) for out-of-band management.
10) Describe how the solution will support or migrate seamlessly to support higher uplink bandwidth in the future.
11) Offered system shall operate without degradation of performance in a temperature-controlled environment within the following environmental condition ranges:
    a) Temperature -40ºC to +55ºC (up to +75ºC for splitters)
    b) Relative Humidity: 0% to 95% (non-condensing)
12) Switching capacity of offered chassis shall be described by the bidder.
13) The vendor shall describe the platform's support of localized switching/hairpinning within the platform.
14) The chassis shall have forced cooling by fans with redundant operation.
15) The solution shall have redundant power supply connections.
16) System Redundancy
    a) The chassis shall be configurable with redundant controller modules.
    b) Switchover to the standby controller module in cases of primary controller failure shall be automatic and should have minimal impact for management of the network.
17) The solution shall have a reach of 20km from the OLT location. Clarify if your solution can be further extended for campus-type deployments.
18) All Northbound/Uplink ~~Cards~~ must support both SR & LR (modular optics operating over s/m fiber – call out 40 gb)
19) The solution shall be powered by Manufacturer recommended powering option (AC or DC).

b. Software requirements

1) The uplink/controller card shall have non-volatile memory in which the system configuration shall be stored, enabling the system to boot-up automatically to the stored configuration after a power failure has occurred.
2) The uplink control unit shall be responsible for the Operations, Administration and Maintenance (OAM) functions and shall be configurable from craft terminal and management systems.
3) A record of the system's alarms and performance (past and current status) shall be stored in the non-volatile memory. The controller unit shall be responsible for gathering and displaying alarm information from all the modules/cards/units in the element.
4) The chassis shall support at least following alarm output and control:
    a) Critical alarm output
    b) Major alarm output
    c) Minor alarm output
5) Offered system shall support End-to-End quality of service (QoS) solution for the entire network. Explain how this can be accomplished with your solution.
6) The system shall support traffic prioritization by scheduling and queuing traffic based on:
    a) Ethernet priority 802.1P
    b) Differentiated services code point (DSCP)
7) The system shall support:
    a) IEEE 802.1Q VLAN
    b) IEEE 802.1P
    c) IEEE 802.3ad Link aggregation for 1GbE and 10GbE across uplink cards
    d) IEEE 802.1s MSTP for 1GbE and 10GbE.
    e) TYPE-B PON Protection as defined by G984 GPON Standard.
    f) The system shall support 4096 VLANs including manufacturer reserved VLANs
8) The OLT shall be multicast-capable supporting Internet Group Multicast Protocol (IGMP) version 2 or higher with the following functionality:
    a) IGMP Snooping with Proxy reporting

b) Multicast subscriber management
c) Multicast capability on line modules/cards
d) Multiple multicast VLAN capability to support more than one video content source

9) Connection admission control (CAC) shall be supported for multicast users to ensure that authenticated users enjoy high quality services
10) The network shall support data encryption in the downstream direction (minimum 128 bits advanced encryption standard [AES]).

3. Optical Network Terminal (ONT) requirements
   a. All ONT data ports must support at minimum
      1) Link speeds of no less than 1Gbps.
      2) Power over Ethernet iEEE 802.3at and 802.3af compliancy
         a) Manufacturer should have ONT options in their roadmap that support IEEE 802.3bt interfaces
   b. The 802.3at-compliant interfaces shall support Link Layer Discovery Protocol-Media Endpoint Discovery (LLDP-MED) to configure the voice VLAN of the Internet Protocol (IP) Phones and Tagged wireless local area network (WLAN) Traffic for Access Points.
   c. The Ethernet interfaces shall support by default auto-negotiation of speed and duplex mode.
   d. Auto negotiation or manual configuration of 10Mbps, 100Mbps 1000Mbps and half-duplex or full duplex on ONT's access port shall be supported.
   e. IP traffic classifications shall be possible based on a set of rules such as the appropriate type of service (TOS) bit, based on Differentiated Services Code Point (DSCP) (TOS bit).
   f. The following shall be described by the bidder;
      1) Broadcast rate limiting
      2) UTP port auto detection.
      3) Maximum VLAN supported per user port shall be no less than eight per port.
      4) Physical Loop detection procedure on the interfaces
   g. Maximum multicast stream clients supported by system shall be no less than 2048.

4. Power Supplies
    a. Powered equipment included in this specification may be powered
        1) Locally (AC Power) – Locally from AC outlets via original equipment manufacturer (OEM) provided cords and/or power supplies
        2) Remote (DC Power) – Powered devices may receive their DC power from intermediate or centralized shelves that contain both the passive interconnect hardware for connecting the horizontal cabling to the riser cabling as well as provide DC power or from separate passive hardware and commercially available fuse panels. The intermediate centralized shelf shall have the following characteristics:
            a) Power Input: 110-240 VAC, 50-60 Hz power
            b) Output: 48 – 57 VDC, maximum 60 V (UL limit)
            c) Physical Characteristics
            d) Mounting: Rack mount – 19 in 1U

2.03 OPERATIONAL ELEMENT MANAGEMENT SYSTEM (EMS) REQUIREMENTS

A. The chassis shall support dedicated Ethernet and/or in-band management capability for linking with EMS
B. It shall be possible to turn on and off individual user ports by the EMS
C. It shall be possible to manage the LAN elements from a centralized location, using an EMS
D. It shall be possible to set and change configurations through a command-line interface (CLI), Local Web Interface, and/or EMS.
E. EMS shall provide a graphical user interface (GUI) that enables all the functionality of the EMS.
F. The EMS shall include tools, utilities, or aids for the automated mass upgrading of network elements.
G. The EMS shall support data backup record storage in a reliable, robust manner using a proven, scalable database engine.
H. The EMS shall provide highly granular role-based access to tasks and network elements.
I. The EMS must be scalable and be able to support multiple OLTs.

2.04 FIBER AND COMPOSITE CABLE AND COMPONENTS

A. General

1. The cable must meet the requirements of the National Electrical Code® (NEC®) Section 725 and Article 770.
2. Plenum Applications – Applicable Flame Test: NFPA 262. Cables shall be listed CL2P.
3. Finished cables shall conform to the applicable performance of the Insulated Cable Engineers Association, Inc. (ICEA) *Standard for Fiber Optic Premises Distribution Cable* (ICEA S-83-596).
4. The cable must be RoHS compliant.
5. The cable manufacturer shall be ISO 9001 registered.

B. Fiber Specification

1. Horizontal fiber at a minimum must be compliant with ITU-T G.657.A1, and ITU-T G.652.D as applicable
2. Maximum attenuation: 1310nm/ 1383 nm, 1550 nm by construction:
    a. Loose tube, ribbon: 0.4 db/km, 0.4 db/km, 0.3 dB/km
    b. Tight Buffer: 0.65 db/km, 0.65 db/km, 0.5 dB/km

2.05 Fiber Optic Apparatus

A. General Specifications- Panel shelves and wall-mount housing shall be used for combination of splicing pigtails, direct connectorization, or plug-and-play cabling. Shelf shall be designed for use as termination shelf only (direct connector termination) or as splice and termination shelf.

B. Building riser cabling shall not terminate directly to equipment, and patch panels shall be installed at both the headend and remote locations. Panels shall be sized to match fiber and/or copper termination count of cable being installed as well as allow for future expansion.

C. Optical splitter modules, if required, shall be utilized with integrated POL solutions.

1. Shall be able to mount in Panel Shelves or Panel Housings.
2. Shall utilize the OS2 single-mode (OS2) fiber category.
3. Shall utilize connected pigtail jumpers or support ports for fiber jumpers.
4. May utilize different split ratios based on project requirements such as 1x2, 1x8, 2x8, 1x32, 2x32, etc.

5. May utilize a dual input for redundancy options.
6. Shall support a wavelength range of 1260-1360 and 1480-1626 nm.

D. Fiber terminations for converged solutions at a zone or end locations shall be terminated into appropriately sized fiber panels or small wall terminals.

E. Fiber Termination Hardware:
1. Fiber Connector Housings:
    a. Shall fit in standard 19 in racks or wall mountable housings.
    b. Shall support fusion splicing for individual or ribbon fibers
    c.
2. Fiber Patch Panels:
    a. Shall support single-mode LC APC or SC APC adapters.
    b. Shall support fusion splicing for individual or ribbon fibers

3. Fiber Splice Cassettes:
    a. Shall support single-mode LC APC or SC APC adapters.
    b. Shall support fusion splicing for individual or ribbon fibers.

4. Fiber Optic Information Outlet:
    a. Faceplate shall support simplex keystone SC APC adapters.

F. Fiber Connectors: If pre-terminated fiber connectors are not used in cable assemblies and bulk ended fiber is utilized, specific field terminators should be utilized. Connectors must support single-mode OS2 fiber. Additional considerations should be made for:

1. Mechanical Field Fiber Terminations:
    a. Shall have a typical factory-tested insertion loss of 0.3 dB for APC connectors (LC or SC).
    b. Shall be Fiber-Optic Cable Intermateability Standard (FOCIS)-compliant with TIA/EIA 604-3 (SC), FOCIS 10 (LC) intermateability.
    c. Shall pass EIA/TIA 568-B.3 approvals.
    d. Shall pass Telcordia GR-1209 and GR-1221 design and test criteria.
    e. Shall not require polishing of the end face in the field and shall have factory-polished fiber stub in the connector

ferrule.

f. Shall not require the use of epoxies.

2. Splice-on Field Fiber Terminations:
   a. Single-Fiber Splice-On Connectors:
      1) Shall be FOCIS compliant with TIA/EIA 604-3 (SC) and TIA/EIA 604-10A (LC) intermateability.
      2) Shall meet Telcordia GR-326-CORE and GR-1081-CORE qualifications..
      3) Shall meet a typical/maximum insertion loss of 0.15/0.30 dB.
      4) Shall not require polishing of the end face in the field and shall have factory-polished fiber stub in the connector ferrule.
      5) Shall not require the use of epoxies.

   b. MPO-style (multifiber) Single-Mode Splice-On Connectors:
      1) Shall be designed to comply with the appropriate TIA/EIA FOCIS document.
      2) Shall have a ferrule constructed of polyphenylene sulfide (PPS) base.
      3) Shall not require polishing of the end face in the field and shall have factory-polished fiber stub in the connector ferrule.
      4) Shall not require the use of epoxies.
      5) Shall meet a typical/maximum insertion loss of 0.15/0.30 dB.

G. If remotely powered, solution shall be able to handle the internal termination of composite copper DC power and optical fiber cable without the use of third-party components. Headend components shall be capable of inclusion of power-limiting or conversion components that meet NEC Class 2 or 3 requirements.

2.06 Fiber Optic Patch Cords

A. General Specifications- To maintain channel integrity, optical fiber patch cords and pigtails shall be fabricated to meet the performance parameters corresponding to the optical fiber cable approved product type specified below. Patch cord and pigtail plug connectors shall be equipped with boots and shall have the same colors as related optical fiber backbone cables, unless specified or indicated otherwise. Optical fiber patch cords shall be available with the following options as specified or indicated:

a. Termination Types: SC APC, LC APC, MPO connector
b. Connector/cable configuration: Simplex, duplex or multifiber
c. Flame Rating: Riser, plenum, and/or LSZH™
d. Outside Diameters: 2.0, 2.9, or 3.0 mm
e. Lengths: As specified or indicated