AT&T Open XGS-PON SoC Based

4-Port Remote vOLT Specification

Revision 1.0

OPEN
Compute Project

Revision History

Revision	Date	Author	Description
1.0	March 3, 2016	Robert Mapes	Initial Release

Contents

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Scope

This document defines the technical specifications for the AT&T Open XGS-PON 4-port Remote vOLT that will be used as a platform in an Open Compute Project.

Overview

This document describes the technical specifications of the Open XGS-PON PON 4-port Remote vOLT designed by AT&T. The system is a physically Hardened outdoor unit that is self-contained, and not part of a physical chassis system. However, this physical box is attached to a fabric (e.g. leaf and spine) that interconnects it to create large scale-out virtual network elements[1].

The Open XGS-PON 4-port Remote vOLT is a cost optimized access design focused on NFV Infrastructure deployments which support 10Gb/10Gb PON access connectivity and provide **40Gb** uplinks to the ToR (Top of Rack) or Spine layer of the network.

The switch supports 4 x XFP XGS-PON links that each operate at 10Gb downstream (egress) and 10Gb upstream (ingress), 1x QSFP28 ports that operate as up to four 10Gb ports each. These 4 physical ports are designed to support 1-1 active-standby arrangement, where each lane in a primary port has a corresponding backup in a failover port. Other applications are also envisioned and described below.

The Open XGS-PON 4-port Remote vOLT is a PHY-Less design with the XFP connections directly attaching to the XFI and SERDES interfaces of the Broadcom BCM68628 xPON SoC for OLT. This silicon provides low cost, latency, low power and includes a high level of component integration to reduce system complexity.

Applications of this design include some specific variations and considerations in order to address a broader market and set of collaborators for this project. Specifically, the set of variations considered include:

- The simplified and cost-optimized virtualized scale-out OLT.
- A small, simplified, self-contained traditional OLT device that can be used in non-NFVI environments.
- The ability to manage and control the device using a separate out-of-band port.
- The ability to synchronize and distribute timing from upstream toward ONUs.
- The 4 variations are not mutually exclusive, and are now described in more detail.

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[1] This type of system is described in ETSI NFV architecture, where it comprises the Infrastructure that supports Network Functions Virtualization – often called NFVI. Additionally, the open software beyond that described in this specification is collected and distributed as one of the use cases for the ONS2015 - CORD project at ON.Labs. See https://wiki.onosproject.org/display/ONOS/ONOS+Use+Cases

Virtual OLT

The first application embodies the Open XGS-PON 4-port Remote vOLT. In this application the device is envisioned to be part of a NFVI deployment, where compute, storage, and other cloud infrastructure are part of the environment. In this environment, the Open XGS-PON 4-port Remote vOLT connects to ToR devices that aggregate traffic and also provides transport for management and control.

Moreover, the low-level management processes that might be typically performed by a processor on a XGS-PON 4-port Remote vOLT are performed outside the box, in a separate commodity server. This allows managing many vOLTs from a small number of commodity servers, and conserves compute and storage in the same way that performing aggregation in the ToR switch conserves aggregation typically performed on line cards to interface several XGPON PHY chips to a backplane or fabric. The arrangement also allows for an overall system design where there is no single point of failure that affects the entire Open XGS-PON 4-port Remote vOLT and allows application of cloud application architecture to software that was previously hosted on embedded processors.

This system is described as a disaggregated or virtual OLT because the various software and hardware components that were once integrated into a single physical device have been separated and supported in a distributed way across NFV infrastructure. By doing this it becomes more likely to re-use components among disparate networking functions and to independently scale resources and investments according the specific application of the technology.

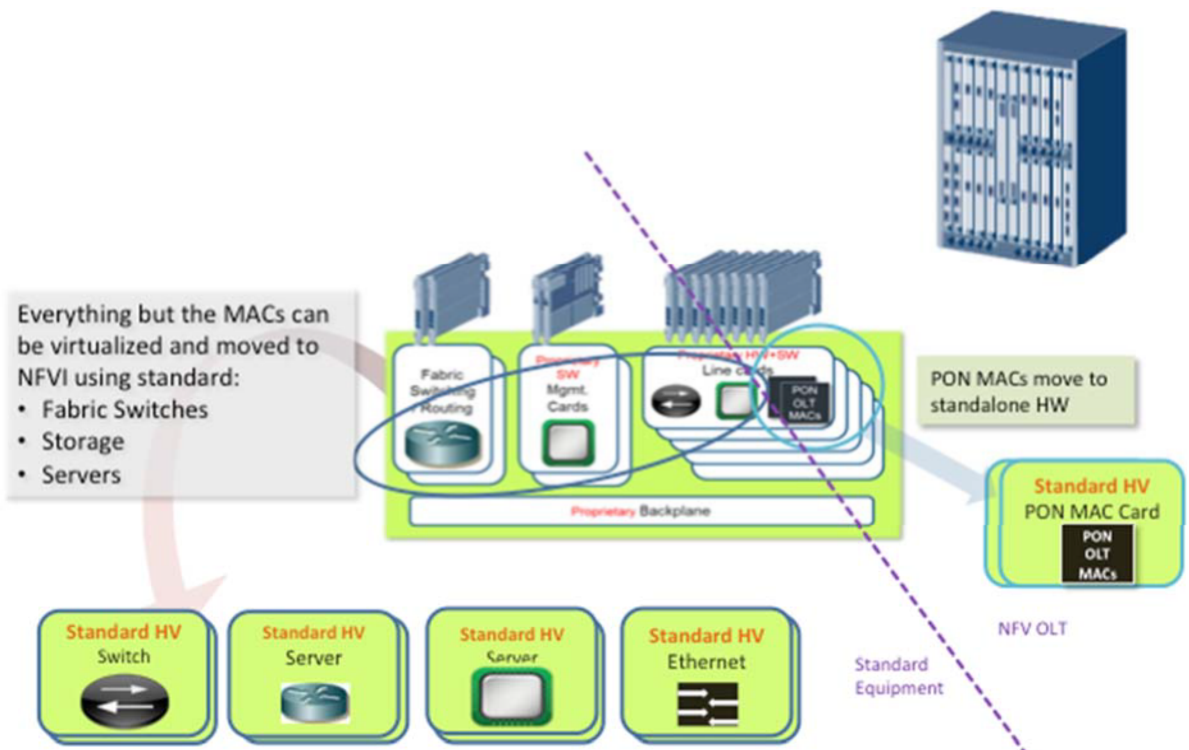


Figure 1 - Virtual OLT

Figure 1 shows the disaggregation of a typical OLT and the mapping of its functions to NFV infrastructure.

The backplane or fabric of the OLT is mapped to the fabric of NFVI (ToR and EoR / leaf & spine switches).The interfaces to the fabric (what were card edge connectors) become simple Ethernet interfaces.

The control and management functions are embodied in SDN control and Orchestration with a software stack that will be described shortly. Processing and configuration are mapped to compute and storage in NFVI. The figure shows that almost all the components in an OLT, those to the left of the dashed line, can be mapped to standard high-volume (HV) components found in NFVI. The exception is in the XGPON PHY chips. Those are not typically found in NFVI and those are what this specification describes.
In the Virtual OLT, the application of the AT&T Open XGS-PON 4-port Remote vOLT is to facilitate attaching XGPON PHY chips to the fabric of NFVI – as shown in Figure 2.

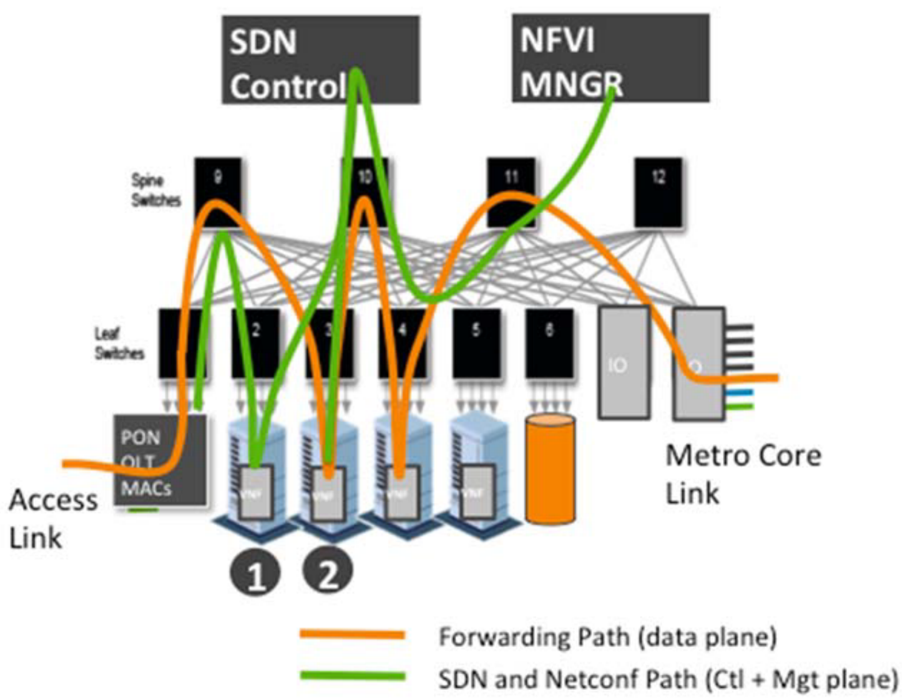


Figure 2 shows the Open XGS-PON 4-port Remote vOLT attached to typical ToR (Leaf) switches in the lower left corner. Shown prominently at the top are processes that are run inside the compute VNFs at point 1 and 2. These processes provide the management and control plane functions that manage and control the overall system including the xPON OLT chips within the Open XGS-PON 4-port Remote vOLT.

The software used to support this system is partly shown in Figure 3. At the lowest level of the figure we find firmware and hardware drivers that are part of the software loaded and run on the BCM68628 SoC chip. That software is pushed to the chip and then subsequently configured and managed through a matching low-level API. The OMCI massaging interacts with the BCM68628 OLT device SDK (sending and receiving OMCI packets). In this case, the OLT device acts as proxy to the ONUs. These elements are colored blue because they are proprietary and specific to the BCM68628, and would need to be replaced to support other chips and PHY technologies.

The next layer up is shown in purple and represents open source software. The lowest layer of this software consumes OLT API calls and OMCI signaling and creates a homogenized abstraction of an OpenFlow controlled OLT – largely patterned after an Ethernet switch. This abstraction is then plugged into the southbound side of an OpenFlow agent and configuration management block, and that software comprises all the code to generically manage and control the Open XGS-PON 4-port Remote vOLT.

The next layer in the software stack is an OpenFlow Controller and configuration. These might be combined or separate software. Finally, in green, we see the applications that embody the control plane and management applications for a number of access technologies and instances of each.

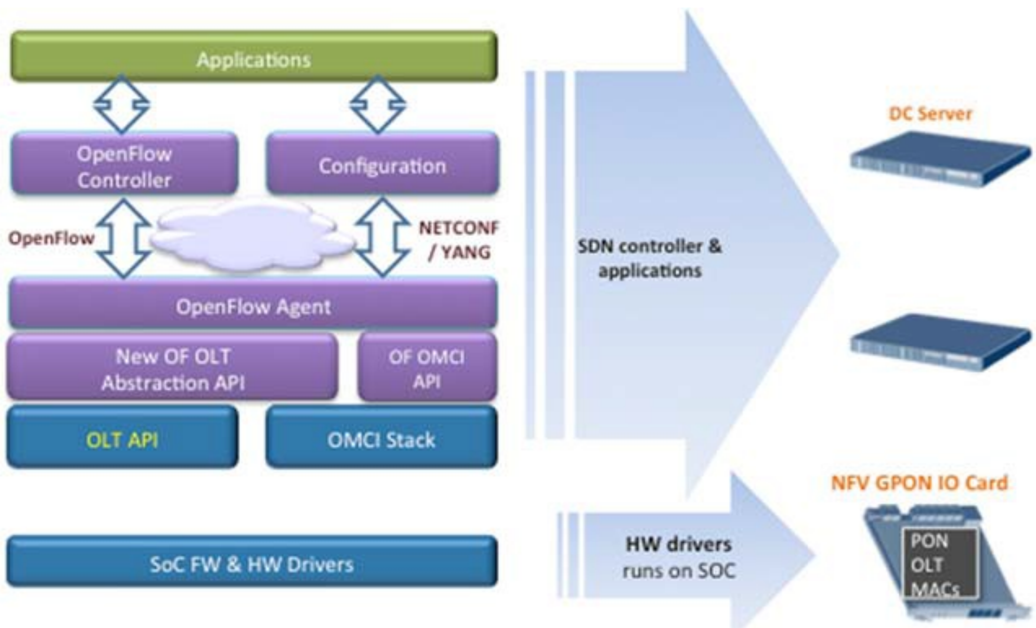


Figure 3 - Software stack for Open VOLT XGS-PON 4-port Remote vOLT

To support this application, the Open XGS-PON 4-port Remote vOLT minimizes the number of components populated on the system board and leverages external, scalable, available and re-usable components instead.

This is the most basic and economic instantiation of this design. Management is performed through external processes and is communicated through a virtual LAN that isolates that traffic from customer traffic. Specifically, there is a need to support OOB (out of band management) LAN. The design does still support a variety of power supply options, airflow options, and a baseboard management controller (BMC) to manage these resources.

XGS-PON Network

A 10 Gigabit Services PON (XGS-PON) network allows symmetrical 10G/10G PON network to support verity of applications. These are the main network features:

- Supports data rate of : ~10Gbps (9953Mbps) DS/~10Gbps (9953Mbps) US
- Support at least 128 ONTs per PON Link.
- GEM mode only
- Support up to 128 ONUs and default Alloc-IDs per XGS-PON MAC
- Supporting up to 4K GEMs per GEM port-IDs
- Support ToD synchronization per G.989.3 for XGS-PON
- Support ONU power saving operation per G.989.3
- Support enabling or disabling downstream AES encryption for each channel identified by Port_ID. The default shall be enabled (note: the default does not apply to multicast Port_ID).
- Support native IPv6.
- Support dual stacked IPv4/IPv6.
- System will be capable of providing symmetric bandwidth allocation.

Figure 4 shows a typical XGS-PON Network.

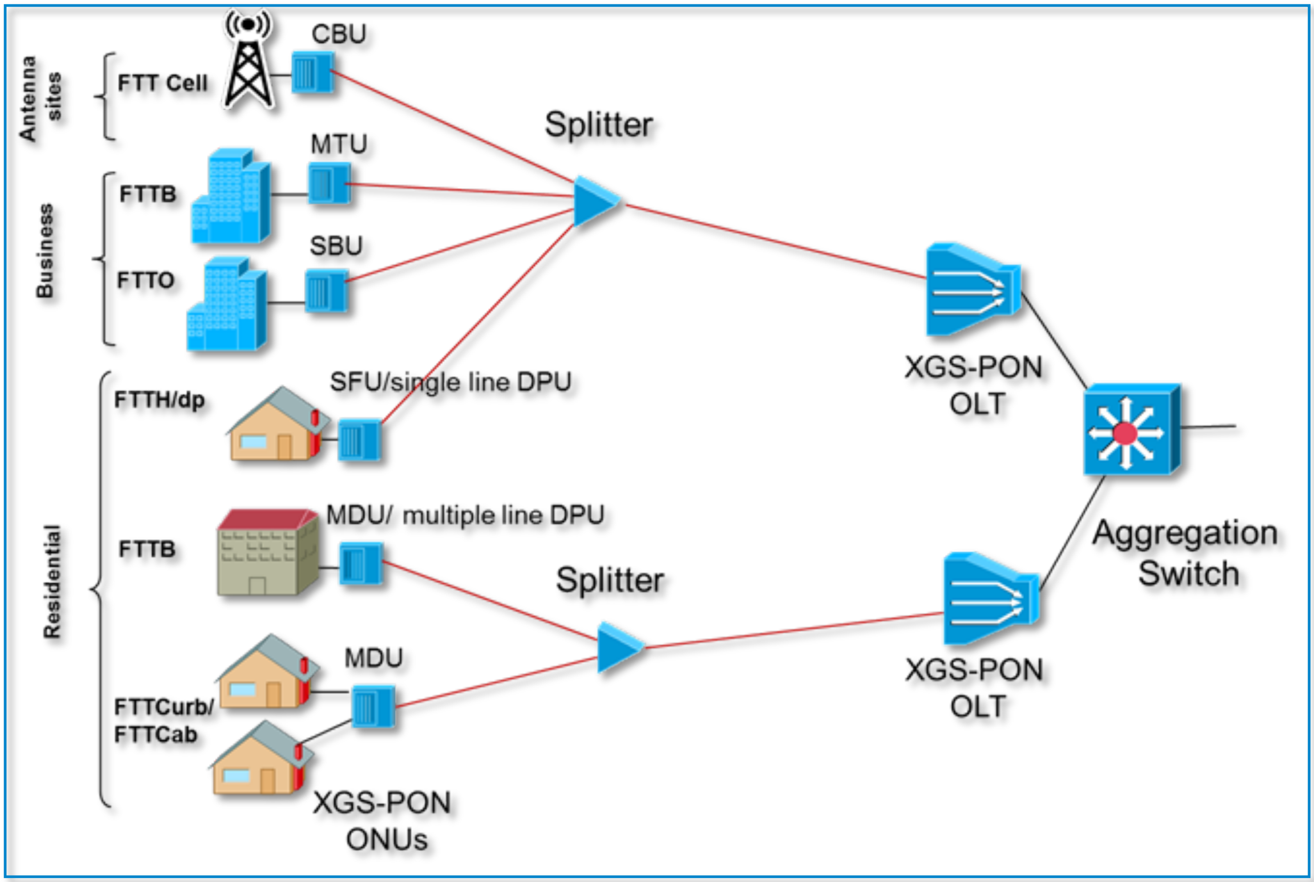


Figure 4 - XGS-PON Network

Virtual OLT Box – Main Hardware Blocks

The XGS-PON 4-port Remote vOLT system is a physical Hardened outdoor unit and consists of the following main HW modules:

xPON SoC – Broadcom BCM68628

- The BCM68628 is a high-performance, single-chip, cost-effective OLT PON MAC SoC with support XGPON1, XGS-PON, NGPON2 and 10G-EPON.
- The SoC provides two ports of XGS-PON (10G/10G) links.
- The BCM68628 integrates NNI SerDes and MAC interfaces, ICF (Interconnect Function), PON MACs, and Burst mode PON SerDes interfaces.
- Supports external packet buffer for XGS-PON reassembly.
- Supports 800 MHz, 32-bit DDR3
- Size: 33 mm X 33 mm

Host CPU

- Using Broadcom's XLP208
- Memory: DRAM - 2GByte DDR3 72bit, NAND Flash + SDIO
- Management ports: 1000 Base-T Ethernet + UART
- Additional Interfaces: PCIe gen 2.0, SPI, I2C, GPIOs, IRQs

Control FPGA

- Serves for general ‘glue logic’ applications
  - For example: I2C control, LEDs, Interrupts + I/O expender, PS control, Power sequencing
- FPGA device (Reference PN): XC3S700AN-4FGG484C
- Number of IOs: 372
- Size: 23x23 mm
- Total ball count: 484

Broadcom BCM88270 QUX - Switching & TM device

- The BCM88270 is a high-performance, single-chip, cost-effective switch and TM
- Performance - 120Gbps; 120Mpps
- OAM, 1588, SyncE Telecom DPLL
- 120Gbps- 28 x3.125G+ 8x10.3G SerDes
- TM - 32K queues, 32Mb on-chip buffering, Packet packing for improved burst absorption
- Max classification rules – can be the number of LLIDs/GEMs (Tunnel IDs) – 64K
- Size: 25x25 mm

PON Links

The XGS-PON 4-port Remote vOLT system is designed to support up to four PON links. The links will be using XFP modules.

Each BCM68628 device will be connecting to two XFP modules.

- Reference the ITUT standard G.9807.1

Uplink

The XGS-PON 4-port Remote vOLT system is designed to support up to 4 links on the uplink side. All links will be connected directly from the BCM88270 QUX device to the single QSFP28 module placed in the front panel.

The dedicated links from the BCM88270 QUX device towards the QSFP28 module is configured to work in 10.3Gbit SERDES mode (XFI).

In case that uplink redundancy is required, it will be based on the QSFP28 module located on the front panel. Redundancy should be managed and controlled by the Host CPU application which will determine when and in which conditions the uplink redundancy should be active.

Timing

The next application covers a case for timing distribution. This application is largely independent of the previous ones. That is, regardless of whether there is an onboard management LAN or processor and storage, there are situations when distributing timing is desired. The typical case for including timing distribution is where XGS-PON/XGPON is used to provide backhaul for cell sites, but this is not a universal requirement for using xPON for cell site backhaul. In this application a Synchronization Management Unit is added to the system to facilitate SyncE and IEEE 1588 timing paths.

This overall design supports all the aforementioned use cases, and allows the omission or depopulation of various components as manufacturing options to source the device for the various use cases.

Main supporting standards:

- ITU-T G.8261 / G.8262 / G.8264 SyncE on all interfaces
- SyncE status message support
- IEEE 1588v2 ordinary clock (slave only)
- Internal Stratum-3 Clock with holdover to meet ITU-T G.813
- ToD synchronization per G.XGS-PON/G.989. 3

System Overview

Main Block Diagram

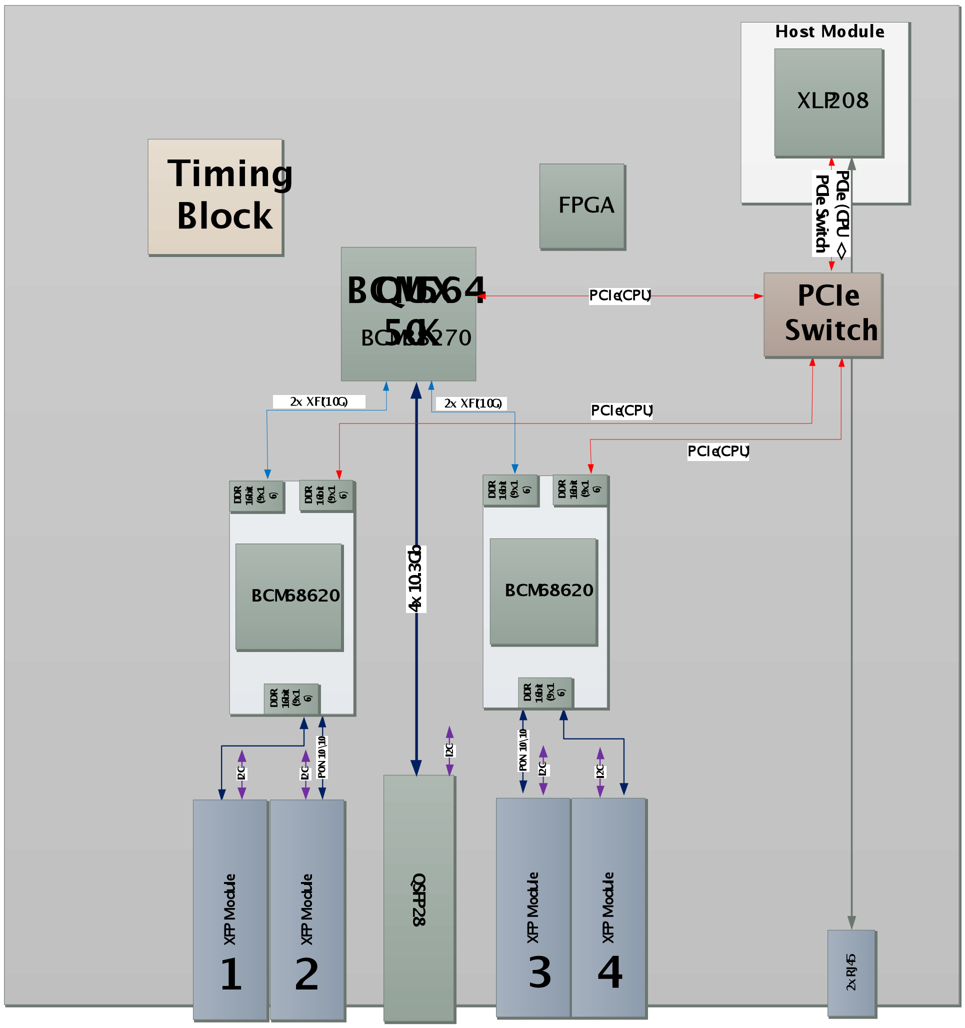


Figure 5 - Main system Block diagram

The block diagram in Figure 5 shows 2x BCM68628 devices connected to the QUX BCM88270 switch design which can support the various use cases described previously.

- The FPGA provides chassis management
- All main devices are managed by the main CPU block using PCIe interface and PCIe switch devices to allow all devices connectivity.
- The CPU block also provides optional for remote LAN management.
- All the chassis devices are connected through an I2C network such as PSUs, Thermals, System LEDs
- The I2C switch FPGA provides multi master support, and Chassis Management arbitration.

- Each BCM68628 SoC is connecting directly to the PON XFP cage using the PON link physical connection and two 10G XFI links to the QUX device for the network uplink.
- Redundancy is managed by the CPU and the host management application.

Channels Connectivity

In this section we will review the channels connectivity types between the different main devices

BCM68620 to QUX (BCM688270)

The QUX device (BCM88270) will be connected to the BCM68628 (AKA Maple B0) using XFI (10.3Gb) SerDes link. 4 links are connected directly and to two Maple devices. Please see image below

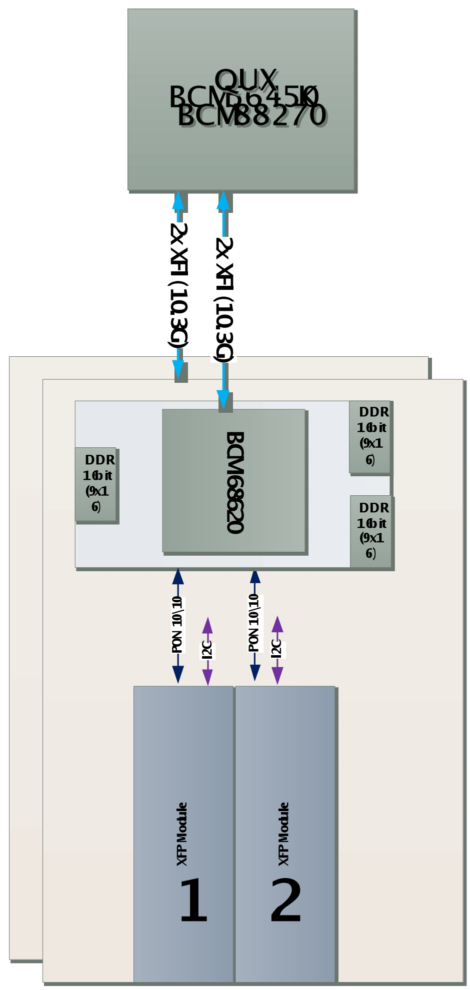


Figure 6 - BCM88270 to BCM68628 Connectivity Scheme

BCM68620 to PON Optical Modules

The BCM68628 device will be connected to the XGS-PON optical modules using two symmetrical 9.95328Gb/s links. Each BCM68628 device will be connecting to two XGS-PON optics. Please see image below

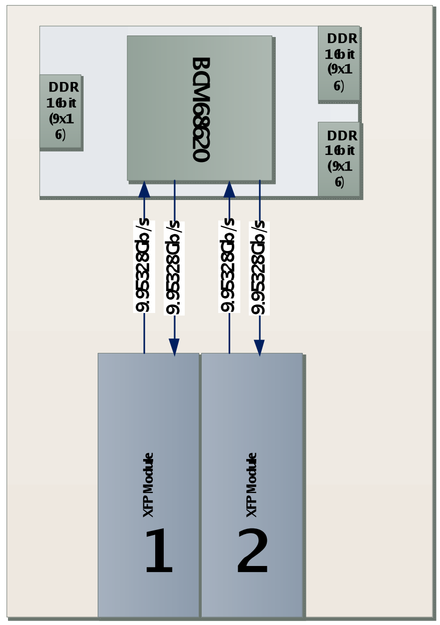


Figure 7 - BCM68628 to XGS-PON Modules Connectivity Scheme

QUX (BCM 88270) to QSFP28 Modules

The QUX device (BCM88270) will be connected to the QSFP28 Modules using XFI (10.3Gb) SerDes link or 20.6Gb link. 4 links are connected directly to one QSFP28QSFP28 modules/cages. Please see image below

Figure 8 - QUX to QSFP28 Connectivity

Supporting different Uplink connectivity modes

The XGS-PON 4-port Remote vOLT link connectivity and configuration architecture can support various uplink link modes which can be configured differently based on the required BW For example -

- For **40G** – the can be configured 4x 10.3G (XFI) mode

Board placement

The below figure illustrates the board placement for the vOLT box. The placement consists of the following main elements:

Front Panel

- PON Links: 4x XFP ports
- Uplink Ports:
  - Main active - 1x QSFP28

LEDs

- QSFP28 LEDs
  - Two per XFP Module (Link, Activity)
  - Two per QSFP28 port (Link, Activity)
  - System and PSU LED indicators
- Console management port (RJ-45) – two stacked ports
- Reset button

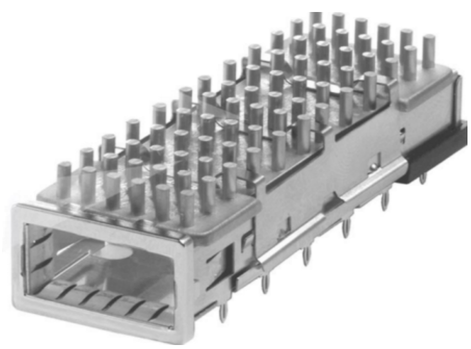


Figure 9 - Single XFP Module

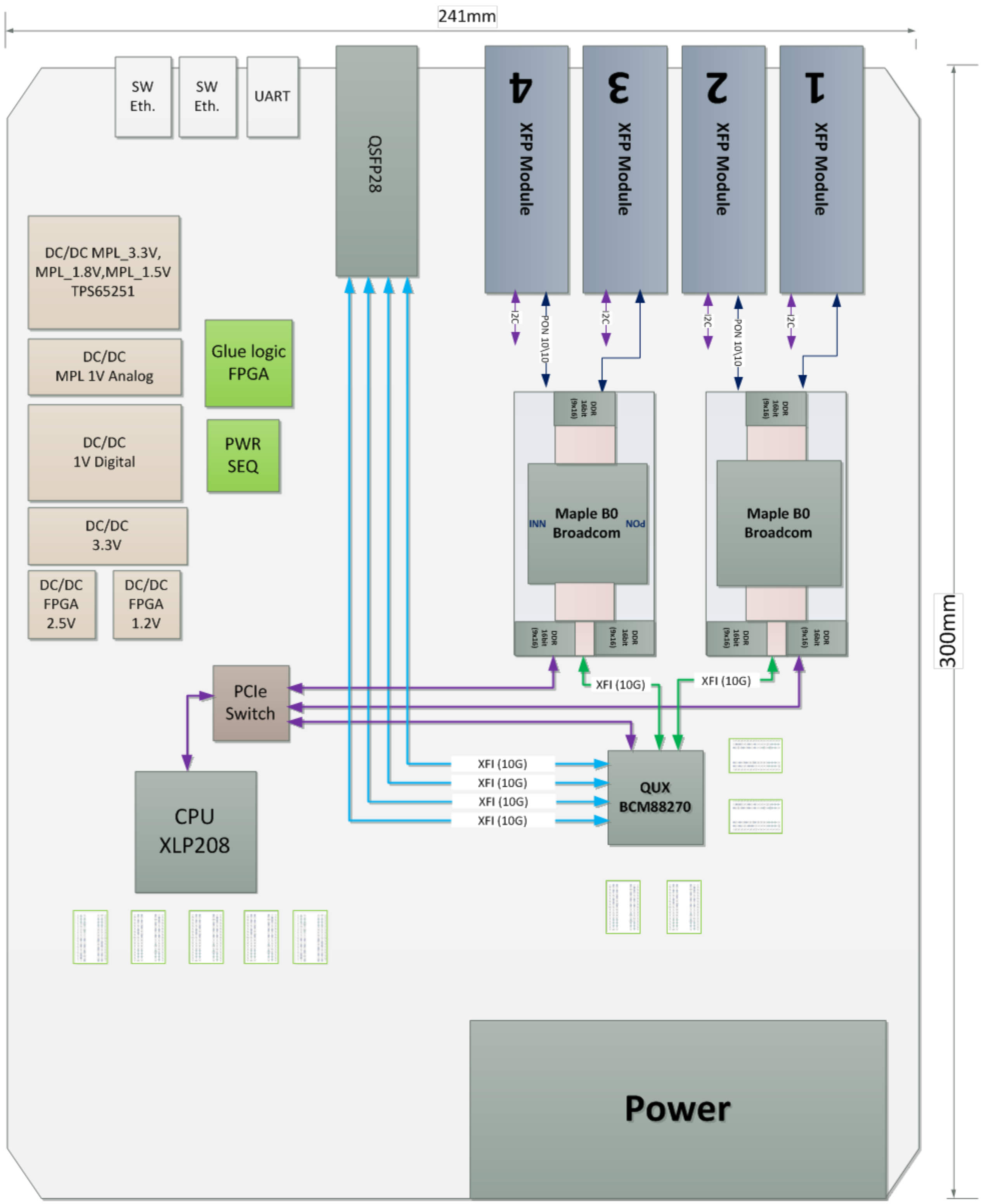


Figure 10 - vOLT Box Board suggested placement

PCB Board Set

The XGS-PON 4-port Remote vOLT is composed of a single main PCB that contains all the main blocks and connectivity to front and rear panel connections.

Physical Overview

Dimensions

	Inches	Millimeters
Length	9.645	245
Width	11.81	300
Height	1.73	44
Note: Width does not include mounting ears.		

Panel LED Definitions

LED Name	Description	State
Diag	LED to indicate system diagnostic test	Green – Normal Amber – Fault detected
LOC	LED to indicate Location of switch in Data	Amber Flashing – Set by management to locate switch Off – Function not active
XFP LEDS	LED built into XFP cage to indicate port status	On Green/Flashing – Port up with active ONTs . Flashing indicates activity On Amber – Port up with no active ONTs Off – No Link/Port down
QSFP Break out LED s	Each QSFP28 has four LEDs to indicate status of the individual	On Green/Flashing – Individual 10G port has link at 10G. Flashing indicates activity Off – No Link
OOB LED	LED to indicate link status of 10/100/1000	On Green/Flashing - port has link Off – No link

Power Supply Options

The XGS-PON 4-port Remote vOLT requires the support of two modes:

1) -48V DC line input
2) Pedestal power outlet

General Specifications

Software Support

The XGS-PON 4-port Remote vOLT supports a base software package composed of the following components:

BMC support

AMI BMC or OpenBMC

Open Network Linux (Optional CPU Module)

See http://opennetlinux.org/ for latest supported version

Power Consumption

The total estimated system power consumption of the XGS-PON 4-port Remote vOLT is 58.0 Watts. This is based upon worst case power assumptions for traffic, optics used, and environmental conditions. Typical power consumption is ~60 Watts (Max.)

Main Blocks	Qnt.	Typ. (W)	Max. (W)	Total Typ. (W)	Total Max. (W)
16x BCM68628+ 16x XGS-PON Optics + BCM88470+DDRs	1			<135	<150
QSFP28 Module	1	3.0	3.5	3.0	3.5
FPGA	1	1.1	1.3	1.1	1.3
PCIe Switch	1	1.0	1.2	1.0	1.2
Timing (DPLL, clocks)	1	0.4	0.5	0.4	0.5
CPU + Memory	1	3.0	3.5	3.0	3.5
				42.0	48.3
Power Supply efficiency	1	6.3	9.7	6.3	9.7
Total estimated Power				48.2	58.0

Environmental

- 0 to 70 Degrees C operating range
- -40 to 70 Degrees C storage temperate range
- Humidity 5% to 95% non-condensing (operational and storage)
- Vibration – IEC 68-2-36, IEC 68-2-6

- Shock – IEC 68-2-29
- Acoustic Noise Level – Under 60dB in 40 degree C
- Altitude - 15,000 (4572 meters) tested operational altitude

Safety

- NRTL/ Canada
- CB (Issued by TUV/RH)
- China CCC

Electromagnetic Compatibility

- CE
- EN55022 Class A
- EN55024
- EN61000-3-2
- EN61000-3-3
- FCC Title 47, Part 15, Subpart B Class A
- VCCI Class A
- CCC

ROHS

Restriction of Hazardous Substances (6/6)
Compliance with Environmental procedure 020499-00 primarily focused on Restriction of Hazardous substances (ROHS Directive 2002/95/EC) and Waste and Electrical and Electronic Equipment (WEEE Directive 2002/96/EC)

Vibration and Shock

The motherboard meets shock and vibration requirements according to the following IEC specifications: IEC78-2-(*) and IEC721-3-(*) Standard & Levels.

Prescribed Materials

Disallowed Components

The following components are not used in the design of the motherboard:

- Components disallowed by the European Union's Restriction of Hazardous Substances
- Directive (RoHS 6)
- Trimmers and/or potentiometers
- Dip switches

Capacitors and Inductors

The following limitations apply to the use of capacitors:

- Only aluminum organic polymer capacitors made by high quality manufacturers are used; they must be rated 105°C
- All capacitors have a predicted life of at least 50,000 hours at 45°C inlet air temperature, under worst conditions

- Tantalum capacitors are forbidden
- SMT ceramic capacitors with case size > 1206 are forbidden (size 1206 are still allowed)
- Ceramic material for SMT capacitors must be X7R or better material (COG or NP0 type should be used in critical portions of the motherboard)
- Only SMT inductors may be used. The use of through whole inductors is disallowed.

A. Appendix: Equipment Physical Design Standards

A.1 Safety Requirements

The electromagnetic compatibility and electrical safety requirements for Carrier Grade equipment are primarily stated in Telcordia publication GR-1089-CORE Electromagnetic Compatibility and Electrical Safety Generic Criteria for Network Telecommunications Equipment.

R1-1: Equipment Type

The equipment supplier shall determine the Equipment Type and record the appropriate numerical equipment. To determine the Equipment Type, refer to GR-1089-CORE, Appendix B for all equipment. GR-1089-CORE provides guidelines for applying the aforementioned electromagnetic compatibility requirements. Application of the various criteria is a function of the type of equipment under consideration, its connection to the telecommunications network and the intended location of the equipment.

R1-2: Electromagnetic Interference

Equipment shall meet the radiated emission requirements stated in section 3.2 of GR-1089-CORE.

R1-3: Conducted Emissions

Equipment shall meet the conducted emission requirements stated in section 3.2 of GR-1089-CORE.

R1-4: Immunity

Equipment shall meet the immunity requirements stated in section 3.3 of GR-1089-CORE.

R1-5: Lightning and AC Power Faults

Equipment shall meet the applicable lightning and ac power fault requirements stated in sections 4 of GR-1089-CORE.

R1-6: Steady State Power Induction

Equipment shall meet the steady state power induction requirements stated in section 5 of GR-1089-CORE.

R1-7: Electrical Safety Criteria

Equipment shall meet the electrical safety requirements stated in section 7 of GR-1089-CORE.

R1-8: DC Potential Difference

Equipment shall meet the dc potential difference requirements stated in section 6 of GR-1089-CORE.

R1-9: Electrostatic Discharge (ESD) Immunity Criteria

Equipment shall meet the ESD immunity criteria requirements for normal operation and be tested for installation and repair objectives according to section 2.1.2 (ESD Immunity Criteria) of Telcordia's GR-1089-CORE, document. All tests shall be conducted as described in section 2.1.4 of GR-1089 and IEC Publication 61000-4-2.

R1-10: Special Requirements and Maintenance Information

Any additional equipment-specific requirements in paragraph 2.1.2.4 of GR-1089-CORE shall be described in the report.

R1-11: Electrical Fast Transient (EFT)

Equipment shall be tested in accordance with section 2.2 of Telcordia's GR-1089-CORE, document with tests conducted as described in section 2.2.1.

R1-12: Bonding and Grounding Requirements

Structures, equipment and power systems submitted for evaluation shall meet applicable Bonding and Grounding requirements of section 9 of GR-1089-CORE. For Ancillary reviews, only the short circuit test data of section 9.10 is required.

R1-13: Fire Spread

Field conditions for AIC deployment may require deployment in existing Carrier Communications Spaces that utilize Fire Code Exemptions and do not have automatic fire suppression. Store and compute equipment deployed in these locations shall meet the enhanced fire spread requirement below.

Equipment shall meet ATIS-0600319.2014 *Equipment Assemblies – Fire Propagation Risk Assessment Criteria* (see note below).

Note: Equipment may conform to this requirement by way of inherent design features that include all items below:

- Height of 2 RU or less
- Horizontally mounted main printed circuit board
- Metallic 5 sided enclosure with a metallic or non-metallic front cover or faceplate
- Non-metallic materials shall comply with ATIS-0600307 4.1

For equipment that does not meet the fire spread requirements of ATIS-0600319.2014 by way of inherent design features noted above, the manufacturer shall attest that the equipment has successfully passed the burn test as referenced in the ATIS document.

A.2 Minimum Infrastructure Operating Requirements

Minimum infrastructure operating requirements state that the equipment works as intended and can be installed efficiently. New equipment is required to integrate into the network seamlessly (fit, form and finish), without the impact or cost pressure to compensate for the product introduction. This supports the goal of having a "homogeneous" network that does not require special practices/procedures to accommodate each new equipment installation.

A.2.1 Environmental

R2-1: Outside Temperature and Humidity Operating Requirements

Equipment shall be designed and verified to meet the following requirements:

Table 2-1 Temperature and Humidity Limits Conditions

Conditions	Limits
Operating Temperature	-40°C to 70°C
Rate of Temperature Change	30°C / hr
Operating Relative Humidity	0% to 100%

R2-2: Altitude

Altitude conformance shall be stated by the manufacture via documentation containing specific product information and company identification information (logo). Typical forms of documentation are Product Data Sheets, Product Manuals or Letters of Attestation. Formal testing documentation from third party testing labs is an acceptable alternative.

- The equipment shall function within the limits established in R2-1 for altitudes between 60 meters (200 ft) below sea level through 1830 meters (6000 ft) above sea level.
- The maximum temperature limit stated in R2-1 may be de-rated 1°C for every 300 meters (1000 ft) segment above 1830 meters (6000 ft) but below 3960 meters (13,000 ft) above sea level. Operation above 3960 meters do not require confirmation.

R2-3: Energy Efficiency

When equipment is eligible for the United States Environmental Protection Agency (EPA) Energy Star® certification for Computer Servers, the supplier shall report if the equipment is EPA Energy Star® certified (Yes / No). If Yes, a copy of the written certification by a Certification Body recognized by the EPA for Computer Servers shall be provided. Eligibility criteria can be found at www.energystar.gov/specifications.

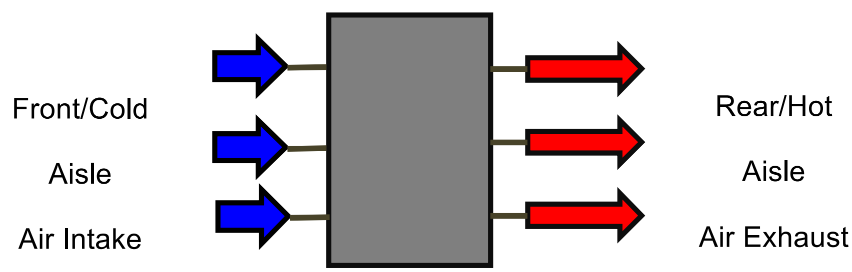
When applicable, the Alliance for Telecommunications Industry Solutions (ATIS) Telecommunications Energy Efficiency Requirements rating (TEER) shall be measured and reported. Reference ATIS-0600015.2009 and supplemental standard ATIS-0600015.01.2014, *Energy Efficiency for Telecommunication Equipment, Methodology for Measurement and Reporting – Server Requirements*, www.atis.org/docstore/default.aspx.

If the ATIS TEER rating is unknown, the latest SPECpower_ssj2008 server rating and output test document may be substituted. This benchmark is available from the Standard Performance Evaluation Corporation, 6685 Merchant Place, Suite 100, Warrenton, VA 20187. www.spec.org

R2-4: Equipment Air Flow

Establishing consistent air flow patterns for all network elements supports the efficient design and use of infrastructure cooling technologies.

Air cooled equipment shall be designed and verified to utilize a cold aisle air inlet and a hot aisle exhaust. This is commonly known as front aisle air intake and rear aisle air exhaust. The nomenclature for the individual products may differed based on the equipment faces the manufacture calls “front” and ”rear”. The intake equipment face shall be orientated toward the cold aisle and the exhaust equipment face shall be orientated to the hot aisle.



R2-5: Acoustic Noise

Manufacturer shall report the measured acoustic noise of equipment. It is a strong preference and an objective that equipment not exceed an operating acoustic noise level of 78 dB sound power at 26°C, as measured according to ANSI ASA S12.10-2010, or a comparable industry standard.

R2-6: Equipment Units Design

Equipment physical design shall:

A. Incorporate the use of holes or closed slots in mounting hardware for attachment to equipment framework mounting surfaces

B. Be designed for 19” framework mounting

C. Accommodate mounting in equipment frameworks using a 1-3/4 x 19 inch mounting hole pattern.

A.2.2 Alarms and Indicators

R2-7: Alarms

An amber or red LED, located on the faceplate of the network element, shall be used to indicate the current status of any alarm. The LED shall be lit indicating that an alarm condition exists. The alarm LED is extinguished when all active alarms clear.

R2-8: Unit Indicator

It is preferred, but not required, that equipment provide a remotely activated blue LED on the faceplate and/or backplane of the Network Element to function as a unit indicator.

R2-9: Alarm Interconnections

Each NE in a bay shall produce its own unique set of alarm outputs. The interface for TL1/SNMP interconnection may be Ethernet RJ45, DB25 or RS422/449 (37 Pin). The interface for E2A Serial or Discrete interconnections may be wire-wrap pins or other non-proprietary connector.

A.2.3 Power

R2-10: AC and DC Power

Field conditions may be either AC or DC powered. It is strongly preferred that all equipment be available for purchase in AC and DC versions.

R2-11: AC Powered

AC powered equipment shall accommodate a voltage range from 110V to 240V.

R2-12: DC Power – Nominal -48Vdc

Nominal -48Vdc is the preferred and standard platform for power delivery to network equipment. If the equipment uses a DC voltage other than -48Vdc, it shall be provided with internal DC-DC converters to meet the intent of this requirement. The design criterion of the nominal -48Vdc power is based on a normal operating voltage between -50V to -56.7Vdc, with nominal rating of -48Vdc and low voltage of -40Vdc measured at the input terminals of the network equipment.

R2-13: DC Battery Return Configuration

Equipment battery return configuration shall be DC-I. Equipment configured with the battery return and chassis ground bonded together (DC-C) shall not be deployed in the network. The DC-C configuration cannot be utilized with dual plant equipment operation.

R2-14: DC Power - Terminations General

A. Power terminations shall be located on the rear of the chassis.
B. All power connections shall be clearly labeled and fully protected with a non-metallic, non-flammable cover.

R2-15: DC Power - Redundant Power Feeds

Redundant power feeders are required for all network equipment. Each element/shelf/circuit pack, whichever is the smallest independent load device of the equipment, shall obtain power from at least two power feeds.

R2-16: DC Power - Battery Return Conductor

Each power feeder shall have its own battery return conductor. This design concept shall also carry through directly to each piece of equipment.

R2-17: DC Connectors

Connectors used to attach the product to external power cabling shall conform to the following requirements (Refer to Table 2-2 for acceptable connectors):

A. 8 AWG and Larger Stranded Power Cable: Power input cable that will accept # 8 AWG or larger connector terminations shall use dual threaded post (stud) termination able to accept the appropriate two-hole crimp connection. The two post termination may be either 1',3/4", 5/8" or 1/2" on centers
B. 16 AWG to 10 AWG Stranded Power Cable: For applications where the size of wire supplying or distributing power to/from the equipment is 16 AWG to 10 AWG stranded power cable, pressure crimped ring type connectors shall be used on the power cable
    a. Equipment surface terminations shall accept crimp connections that meet the following specifications for 16 AWG and larger stranded power cable:
        i. UL486A Wire Connectors and Soldering Lugs for Use with Copper
        ii. UL467 Grounding and Bonding Equipment Conductors
        iii. UL 486C Splicing Wire Connectors
        iv. SAE-AS25036 (Insulated Copper Ring Crimped Terminal - Dimensions)
        v. SAE-AS7928 (Copper Ring Crimped Terminal – Specifications)
    b. Equipment submitted for approval should provide a UL listed (power) termination strip designed and designated as "field wireable" to insure product compliance with the UL listing of the product. This termination or barrier strip should be able to accommodate a ring lug connectors that comply with the UL, CSA and Mil Spec listings
C. 18 AWG Power Cable and Smaller: For applications where the size of wire supplying power to the equipment is 18 AWG power cable or smaller, mechanical connectors may be used.
D. The connectors shall be listed by a Nationally Recognized Test Laboratory for its intended use.
E. The connector shall be tested to assure long-term tightness and reliability. The following tests are acceptable for this requirement; IEC 60068-2-6, Basic Environmental Test Procedures, Part 2: Test Fc and Guidance: Vibration (sinusoidal); EIA Specifications 364-27B (Mechanical Shock Test Procedure for Electrical Connectors), 364-28D (Vibration Test Procedure for Electrical Connectors and Sockets), Telcordia GR-63-CORE and Telcordia GR-1089-CORE. Other vibration test procedures demonstrating long-term reliability will be considered for evaluation.
F. The product supplier shall provide documentation of routine maintenance (if any) associated with the supplied connector.
G. Wago type pressure spring connectors, connectors that crush the wire with a screw and snap-on type power connections are not approved for use and will be denied compliance.
H. Connecting hardware (bolts, nuts and washers) shall be Durium or silicon-bronze per ASTM B99. The Ny-Loc type nuts are not approved for use and will result in non-compliance.

Table 2-2 Temperature and Humidity Limits Conditions

	Acceptable termination	Associated Listings
22 AWG – 18 AWG	Mechanical; American Standard UNC threads (Class 2 fit)	Listed by NRTL, IEC 60068-2-6, EIA SPEC 364-27B, 364-28D
16 AWG – 10 AWG	One or Two hole crimp connection. American Standard UNC threads (Class 2 fit)	UL467, UL486A, UL486C, SAE-AS25036, SAE-AS7928
8 AWG – 1AWG 1/0-4/0 250MCM – 750MCM	Two hole crimp connection. American Standard UNC threads (Class 2 fit)	UL467, UL486A, UL486C, SAE-AS25036, SAE-AS7928

R2-18: Equipment DC Power Protection

All fuses and circuit breakers shall meet Quality Level III as defined by Telcordia SR-332.

R2-19: Filtered Battery

All equipment requiring "Filtered Battery" shall provide the filtering within the equipment.

R2-20: Special PDU

Even though not recommended, some equipment designed by various manufacturers require specific PDUs that are considered part of the system or equipment being evaluated which may include unique characteristics needed to serve their specific network device. These "special PDUs" must meet all the same design criteria identified in this document. If accepted, this "special PDU" would be listed as part of the equipment approval, purely as an integral part of the package and its approval is exclusive to the associated equipment. Furthermore, this "special PDU" should be reviewed to insure its integrity

R2-21: Visual Power Alarms and Status Indicator

The equipment shall provide visual power alarm and status indications by indicator devices mounted directly on the equipment and preferably at the top of the equipment bay. The equipment shall also be capable of transmitting alarm signals to an office alarm circuit and to sending circuits for remote surveillance using dry loop relay contacts or other means. Power alarm and status reporting information must be provided in the supplier's response documentation to be in compliance with this item

R2-22: Steady-State Input DC Voltage Requirements

The telecommunications load equipment shall meet its operational requirements at any input voltage of the correct polarity between and including the minimum and maximum values specified in Tables 1 in ATIS-0600315.

R2-23: Undervoltage Requirements

Equipment shall operate properly when exposed to steady state undervoltage conditions and shall comply with the conformance criteria as described in ATIS-0600315. The equipment supplier shall provide a report containing the test methods and results for the above requirement.

R2-24: Minimum Operating Voltage

Specify the minimum voltage at which the equipment remains fully operational and verify the equipment will recover to a fully operational state after losing power.

R2-25: DC Power Current Drains

Battery return and current path information must be provided in the supplier's response documentation to be in compliance with this item. List 1, 1X, 2 and 2X drains shall be provided in the ESP Forms documentation.

List 1 Current Drain – The List 1 current drain, for a maximum configuration of cards and shelves, shall be provided in amperes on the appropriate ESP form. List 1 drain is the average busy-hour current at normal voltage and operating conditions. List 1 current drains are used to size batteries and rectifiers. The cumulative List 1 current drain is the current consumed on both the A and B supplies.

List 1X Current Drain - The current that will flow in one side of a dual powered circuit when the other supply circuit has failed and the power plant feeding the remaining circuit is at the normal operating voltage (float voltage).

List 2 Current Drain – The List 2 current drain, for a maximum configuration of cards and shelves, shall be provided in amperes on the appropriate ESP form. List 2 drain is the peak current during emergency operating limits of the EUT and with normal operating conditions (no short circuits or other malfunctions). This value is based on manufacturer-supplied data, and calculated to the AT&T minimum -42.64 Vdc engineering design level and equipment configuration.

List 2X Current Drain - The current that will flow in one side of a dual powered circuit if the other supply circuit is failed and the power plant feeding the remaining circuit is at 42.64Vdc, engineering design level, or the total power consumption of the network equipment in watts divided by 42.64Vdc.

R2-26: Overvoltage Requirements

Telecommunications load equipment shall not be permanently damaged or permanently have its performance degraded when an input voltage of correct polarity, with a value between 0 V and the maximum voltage level for each nominal voltage plant specified in Tables 1 of ATIS-0600315 is applied for any period of time.

Equipment shall operate properly when exposed to steady state overvoltage conditions, shall comply with the conformance and test results shall be recorded in a test report as described in ATIS-0600315.

R2-27: Overvoltage Transient Requirement

Equipment shall operate properly when exposed to an overvoltage transient condition, shall comply with the conformance criteria and test results shall be recorded in a test report as described in ATIS-0600315.

R2-28: Protective Device Operation Transient

Equipment shall operate properly when exposed to transient conditions, shall comply with the conformance criteria and test results shall be recorded in a test report as described in ATIS-0600315. Testing methods shall be utilized to ensure prevention of malfunction or damage.

R2-29: Electrical Noise Requirements

Noise immunity – Equipment shall operate properly when exposed to electrical noise, shall comply with the conformance criteria and test results shall be recorded in a test report as described in ATIS-0600315. Voiceband noise shall only apply to equipment with analog voiceband ports effective with GR-1089-CORE.

Noise returned by the telecommunications load equipment – Equipment shall not return excessive noise onto the DC power system, the equipment shall comply with the conformance criteria and test results shall be recorded in a test report as described in ATIS-0600315. Requirement 5.6.2.1, Voice Frequency Noise Requirements are no longer required effective with GR-1089-CORE Issue 6.

A.2.4 Airborne Contaminants

Equipment shall meet the Airborne Contaminants requirements for indoor equipment as stated in section 4.5 of GR-63-CORE and shall conform to the MFG test performed for 14 days as detailed in Telcordia GR-63, Issue 3.

R2-30: Fan Filter Requirements

A. Equipment larger than 1U shall conform to the fan filter requirements contained in GR-63-CORE

B. Equipment 1U or smaller will be accepted without fan filters.

C. GR-63-CORE, Objective 04-25 for fan filter alarms shall be a requirement.

A.2.5 Shock and Vibration

R2-31: Seismic - Vibration

Equipment shall be designed for service in high seismic risk locations. Equipment shall demonstrate conformance to Telcordia GR-63-CORE, or ATIS-0600329 earthquake requirements by having equipment assembly tested on shake table and submitting documentation of successful test results.

R2-32: Positive Latching

All network equipment shall have circuit pack latches or retainers to prevent pack and module walkout. Ejectors are not retainers and should not be used for that purpose.

R2-33: Office Vibrations

Equipment shall be designed for operation under office vibration conditions specified in Telcordia document GR-63-CORE.

A.2.6 Fiber

R2-34: Fiber Optic Cabling and Connectors

All references to SingleMode fiber shall be considered Bend Insensitive Fiber (BIF). All references to MultiMode fiber shall be considered Laser Optimized OM4.

R2-35: Fiber Optic Cable

Equipment shall be designed such that all fiber optic cables/jumpers/patch cords utilized shall adhere to Telcordia Standards as defined in GR-409, Generic Requirements for Premises Fiber Optic Cable and GR-326, Generic Requirements for Singlemode Optical Connectors and Jumper assemblies or equivalent TIA or ITU standards.

R2-36: Fiber Connector Boots

Equipment shall be designed to operate with fiber connector boots that are straight and **NOT** angled.

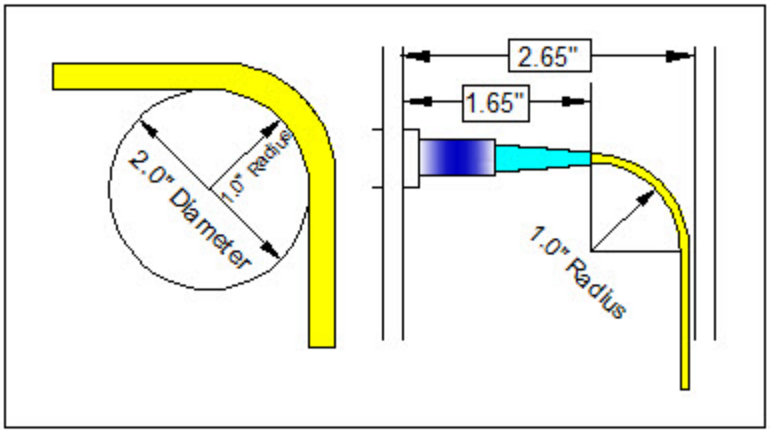
R2-37: Overall Fiber Connector and Boot Length

Equipment utilizing SC or LC fiber connectors shall be designed to operate with connector/boot assemblies that have a maximum overall dimension not exceeding 42mm (1.65 Inches) from tip of ferrule to rear of flexible boot.

R2-38: Fiber Bend Radius

Equipment shall provide fiber management facilities that maintain a minimum fiber bend radius of 1inch. See Figure 5-1

Figure 5-1: Bend Radius



R2-38: Minimum Distance Between Connector Housing and 90 Degree Bend

Equipment shall be designed such that it allows a minimum distance between connector housing and 90 degree fiber bend of 2.65 inches while maintaining a minimum fiber bend radius of 1inch. See Figure 5-1

R2-38: Space Between Door/Panel and Fiber Connector

To avoid pinching or reduction of minimum fiber bend radius, equipment shall be designed to accommodate a minimum distance between the fiber connector end face and any door/panel cover of 2.65 inches. See Figure 5-1

R2-38: Standard Fiber Connector

Equipment shall be designed operate with industry standard Singlemode or Multimode, SC-UPC, LC-UPC or MPO connectors. Application of connector type shall be determined by equip design or manufacturer.