

# AT&T Open GPON

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## NFV OLT Line Card Specification

**Revision 1.2**



**OPEN**

Compute Project

## Foreword

I'd like to acknowledge the inputs, advice, and partnership of Randy Clark in development of this spec. His knowledge and experience made significant improvements and avoided fatal pitfalls in this work. Also to my colleagues at AT&T and at the other Service Providers who provided invaluable insights into how the Open GPON Line Card could be used. Lastly, the OCP, without whose support and existence this type of work would not be possible.

Tom Anschutz

## Revision History

Revision	Date	Author	Description
.01	6/9/2015	Tom Anschutz	Initial Release
.02	8/28/2015	Tom Anschutz	First set of Updates based on initial
.03	9/10/2015	Randy Clark	Updated architecture
.1	9/11/2015	Tom Anschutz	First OCP Draft
1.1	2/24/2016	Tom Anschutz	Second OCP Draft
1.2	2/24/2016	Randy Clark	Celestica Update based on first design

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## Scope

This document outlines the technical specifications for the AT&T Open GPON Line Card submitted to the Open Compute Foundation. This document represents the work and contributions of both AT&T and Celestica.

## Overview

This document describes the technical specifications of the Open GPON Line Card. The term line card is used in a virtual sense. The system is a physical 1RU box (pizzabox) that is self-contained, and not part of a multi-card chassis system. However, this physical box is considered a line card in a virtual, scale-out system where such line cards are attached to a fabric (e.g. leaf and spine) that interconnects them to create large scale-out virtual network elements<sup>1</sup>. The Open GPON Line Card is a cost optimized access design focused on NFV Infrastructure deployments which support 2.5Gbps GPON access connectivity and provide 40Gbps uplinks to the ToR or Spine layer of the network. The switch supports forty eight SFP ports that each operates at 2.5Gbps downstream (egress) and 1.25Gbps upstream (ingress) six QSFP+ ports that operate as four 10Gbps ports each. These six physical ports are arranged in a 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 GPON Line Card is a PHY-Less design with the SFP connections directly attaching to the XAUI and SERDES interfaces of the PMC-Sierra PAS5211 GPON SoC for OLT. This silicon provides low cost, latency, and power; and includes a high level of component integration to reduce system complexity. The Open GPON Line Card supports traditional features found in Top of Rack switches such as:

- Redundant field replaceable power supply and fan units
- A variety of supported power supply voltages
- Support for “Front to Back” or “Back to Front” air flow direction
- A 1RU design that supports standard 19” rack deployments as well as standard 21” Open Rack and also 23” telco rack deployments.

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 line card application for a virtualized scale-out OLT.

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<sup>1</sup> 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>

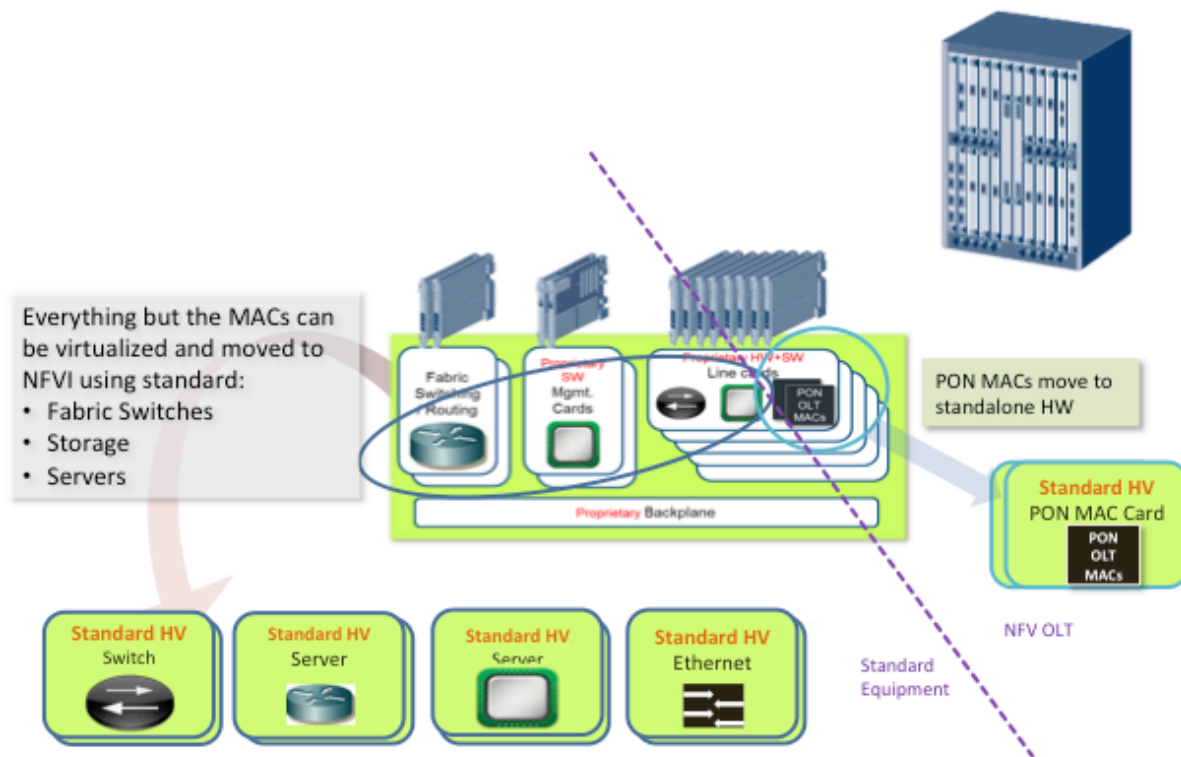
- A small, simplified, self-contained traditional OLT device that can be used in non-NFVI environments.
- The ability to manage and control the device using a separate out-of-band port.
- The ability to synchronize and distribute timing from upstream toward ONUs.

The 4 variations are not mutually exclusive, and are now described in more detail.

## Virtual OLT

The first application embodies the AT&T Open GPON Line Card. 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 GPON Line Card connects to ToR devices that aggregate traffic and also provide transport for management and control. In other words, the management and signaling use the same physical interfaces as does the user traffic. Because the Open GPON Line Card has a remote SDN controller, there were concerns with the typical single management port becoming a single point of failure or bottleneck. By performing the control in-band over the redundant ToR switch links, a higher level of SDN control availability is provided. In addition to SDN control, the low-level management processes that might be typically performed by a small processor on a GPON line card are performed outside the box, in a separate commodity server. This allows managing many line cards 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 GPON 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 GPON Line Card 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.

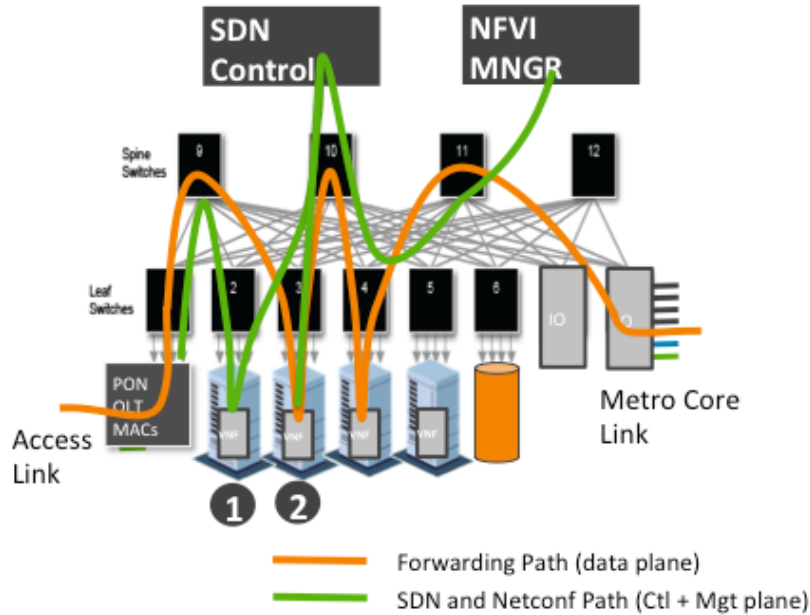
The backplane or fabric of the OLT is mapped to the fabric of NFVI (ToR and EoR / leaf & spine switches)

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 GPON 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 GPON Line Card is to facilitate attaching GPON Phy chips to the fabric of NFVI – as shown in Figure 2.





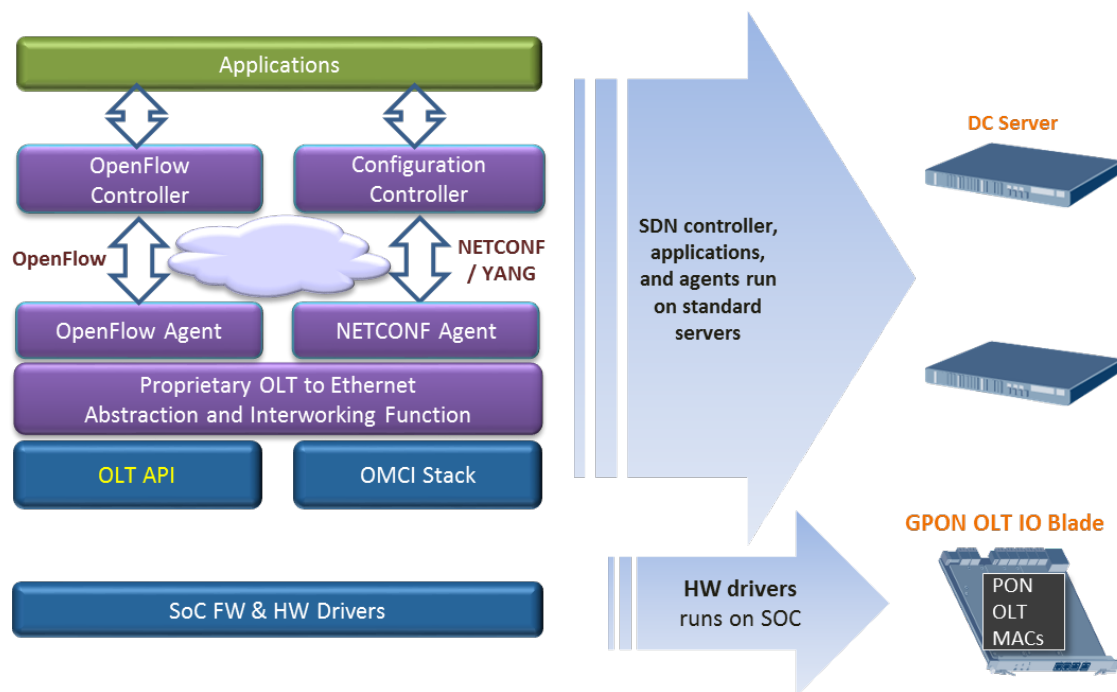
**Figure 2 - Typical application of Open GPON Line Card**

Figure 2 shows the Open GPON Line Card 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 GPON chips within the Open GPON Line Card.

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 PAS5211 SoC chip. That software is pushed to the chip and then subsequently configured and managed through a matching low-level API and OMCI Stack which is run on a commodity server. These two pieces are colored blue because they are proprietary and specific to the PAS5211, 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 Proprietary 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 also a NETCONF agent, and that software comprises all the code to generically manage and control the Open GPON Line Card.

Consuming OpenFlow and NETCONF from the Open GPON Line Card and from other elements, the next layer in the software stack is an OpenFlow Controller and configuration Controller. These might be combined or separate software and both often referred to as SDN controllers. 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 GPON Line Card**

To support this application, the Open GPON Line Card 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 no out of band management LAN, no onboard processor, no onboard storage, and no provision to synchronize timing across the platform. This and all designs support a variety of power supply options, airflow options, and a baseboard management controller (BMC) to manage these resources. Finally, there is a Management Port provided to communicate with the BMC for firmware updates and simple IPMI-like functions.

## Mini OLT

The next application of this technology moves to the opposite extreme. In this case the Open GPON Line Card is extended with Processing, Storage, and an internal management LAN to facilitate the device becoming a stand-alone OLT device. From a hardware perspective, the board is populated in addition to the components of the virtual OLT with an Intel CPU and RAM, Flash storage, and a 16 Port Ethernet switch. The latter interconnects the management and control paths among the CPU, 12 PAS5211 SoCs, BMC and an external management port. This application is useful in one-off applications, in lab and development environments, and in places where NFVI isn't available or desired. The software stack for this device can be identical to that used in the virtual OLT: where either part or even all the software shown in Figure 3 is hosted on the onboard CPU. However, it is also possible to optimize. For example, control and management applications could be written directly to PMC APIs. Obviously, hybrid

approaches are also possible by making other software placement choices, and other software not shown above could also be run on the CPU. Note however, that this design has several single points of failure, and is not as robust from the perspective of availability as the virtual OLT.

## Separate Management LAN

The next application of this technology moves toward the center. In this case the Open GPON Line Card is extended only with an internal management LAN, and depopulates processing and storage. From a hardware perspective, the board is populated with an additional 16 Port Ethernet switch. The latter interconnects the management and control paths among the 12 PAS5211 SoCs, BMC, and an external management port. This might be a desirable option for infrastructure practices where management is done on separate physical infrastructure for economic or security reasons. However, like before, the management LAN is a single point of failure, and this approach is not as robust as the virtual OLT. Note also that the control plane (OpenFlow) uses the management plane, and that a failure of this LAN is likely to affect customer service. Said another way, the out of band management plane might be desirable from, say, a security perspective, but it changes the largest single failure scope from 4 PONs to the entire box. That is, using in-band management and control reduces the largest single failure domain on the box to a single GPON SoC and uplink which supports 4 PON ports.

## 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 GPON is used to provide backhaul for cell sites, but this is not a universal requirement for using GPON for cell site backhaul.

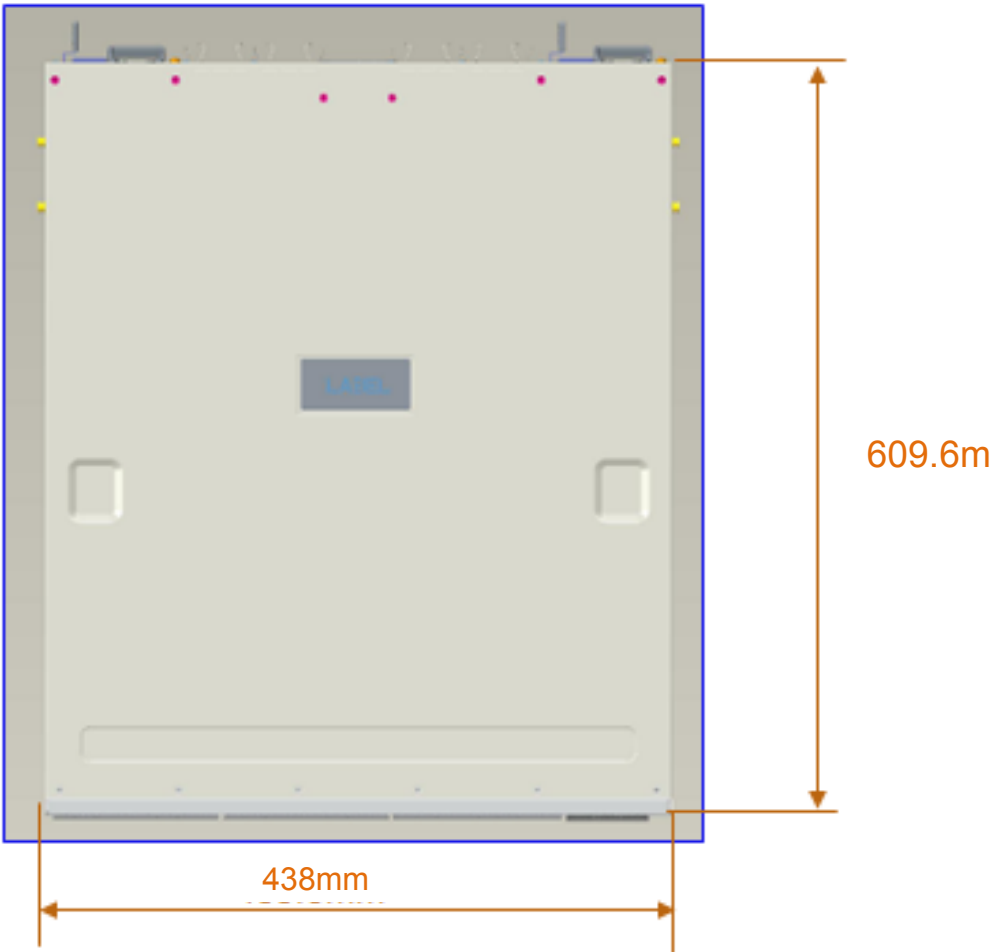
In this application a Synchronization Management Unit is added to the system to facilitate SyncE and IEEE 1588 timing paths.

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.

Physical Overview

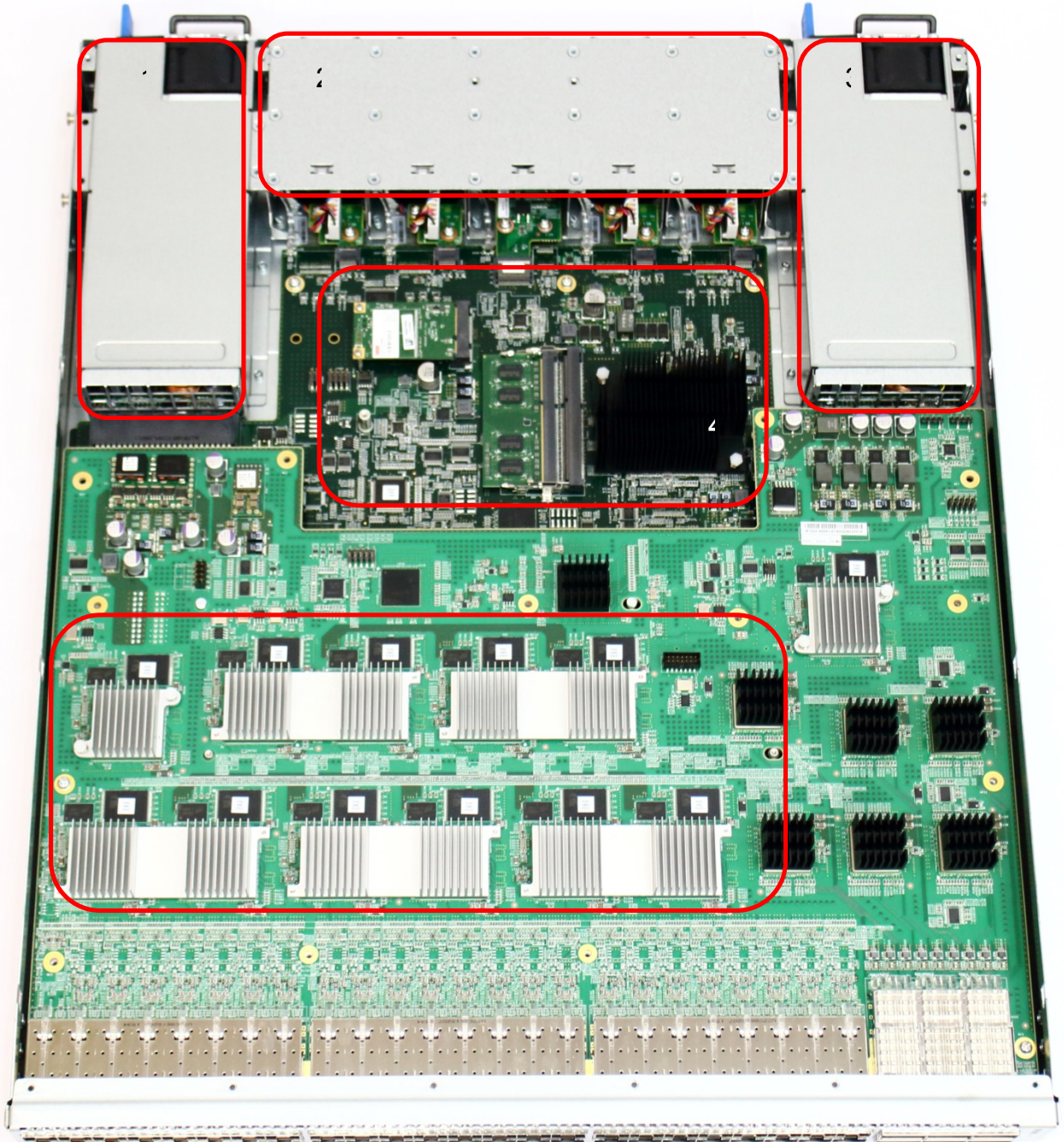
Maximum Dimensions

	Inches	Millimeters
Length -	24	609.6
Width – 19" rack	17.25 with ears for 19"	433.8
Height – 1 RU	1.75	44.45
Note: Width does not include mounting ears – which must have holes or closed slots. Depth does not include PSU handles.		



## Top View

The top view of the Open GPON Line Card shows the PCB and associated components in the system.

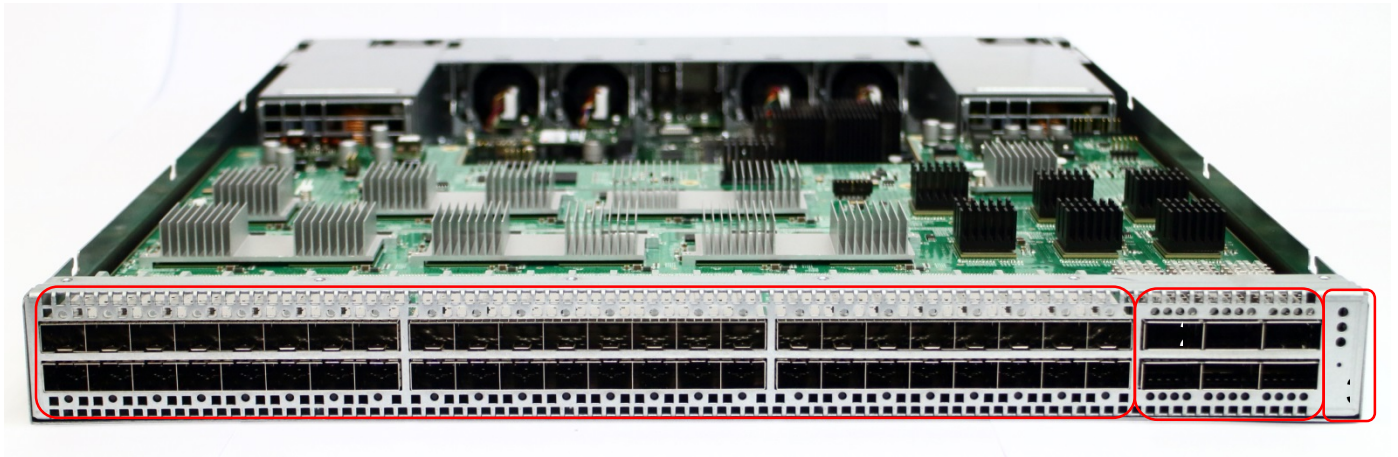


1. Hot swappable power supply #1
2. Hot swappable fan modules
3. Hot swappable power supply #2
4. Optional CPU system

5. 12 GPON devices – PAS5211



## Front View



1. GPON SFP Ports with LEDs Above and Below
2. Ethernet QSFP Ports with LEDs Above and Below
3. System and PSU LED indicators, and Reset Button

The front panel view of the Open GPON Line Card includes the following key components:

- Forty Eight SFP Ports
  - Capable of operating at 2.5Gb GPON speeds with standard GPON OLT SFP modules
- Six QSFP+ ports
  - Operating as 4x10Gb Ethernet channels with standard QSFP+ modules or 10Gb Ethernet via QSFP to SFP+ break out cables (4x10Gb)
- System LEDs
- Reset switch

### Front Panel LED Definitions

LED Name	Description	State
PSU1	Led to indicate status of	Green - Normal Amber - Fault
PSU2	Led to indicate status of	Green - Normal Amber - Fault
Diag	LED to indicate system diagnostic test	Green – Normal Amber – Fault detected
FAN	LED to indicate the status of the	Green – All fans operational Amber – One or more fan fault
LOC	LED to indicate Location of	Amber Flashing – Set by management to locate switch Off – Function not active
SFP LEDS	LED built into SFP cage ( one per SFP port) 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 LEDs	Each QSFP+ has four LEDs to indicate status of the individual 10G	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



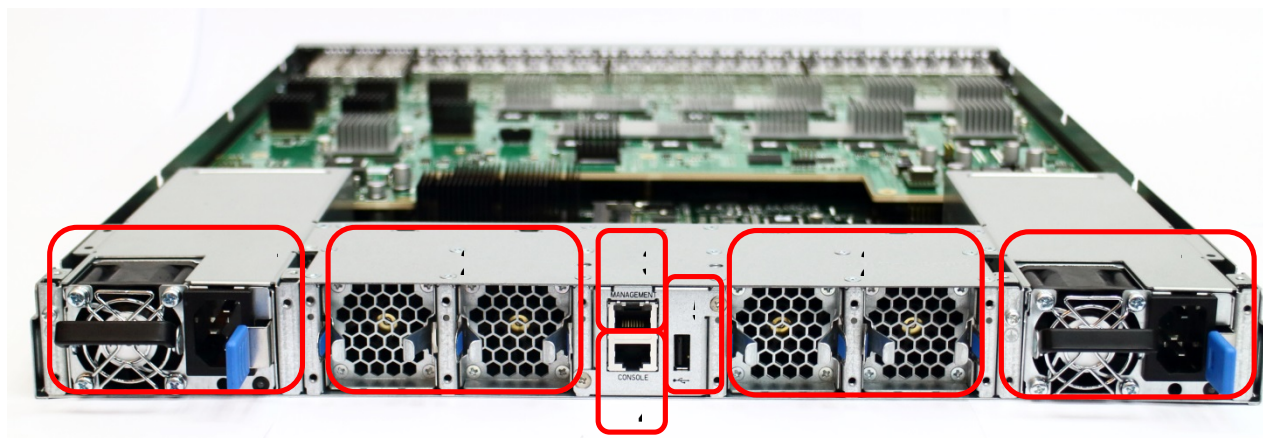
### SFP Interface Module support

2.5Gb GPON SFP Modules	Standard 2.5Gb SFP modules including but not limited to:
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### QSFP+ Interface Module Support

40Gb SFP+ Optical Modules	Standard 40Gb QSFP+ modules including but not limited to: 40GBASE-SR4, 40GBASE-LR4, 40GBASE-ER AOC.
Direct Attach Copper (DAC)	Standard DAC cables including but not limited to: Passive cable up to 5m. Active

### Rear View



1. Two Hot swappable Power Supplies
2. Four Individual Hot swappable Fan modules
3. Out of band management port (Optional)
4. Console Port (Optional)
5. USB Type A port (Optional)

The rear view of the Open GPON Line Card includes the following key components:

- Four (3+1) redundant hot swappable fan modules
  - Color coding to indicate airflow direction
- Two redundant hot swappable power supply modules
  - LED per power supply to indicate status

- Color coding to indicate airflow direction
- Mini USB 2.0 type “A” port
  - Used for optional external storage
- RJ45 10/100/1000 Ethernet management port (Optional)
  - Connected directly to the BMC and optional system CPU
  - Provides optional Serial over LAN for virtual console
  - Optional Sync-E Source
- Console Port (Optional / Debug)

## Field Replaceable Units

### Power Supply Modules

The Open GPON Line Card supports two hot swappable PSUs and needs only one to operate. The PSU form factor is 40mmx74mmx185mm. The system can support different matching PSU types (e.g. AC or DC) which have the same form factor. It's highly desirable that OCP re-use common supplies in vOLT, ToR and EoR switches, and even servers where the form factor and power capacity allow.

460W AC PSU (support forward and reversed airflow)

Delta DPS460KBD (F2B)

Delta DPS460KBE (B2F)

- Input: 100~240VAC, 50/60 Hz
- Output: 12V/460W
- AC/DC efficiency: >88%(20%~100% load@230VAC/50Hz)
- Hot-swap FRU
- Load-sharing, 1+1 Redundancy

550W HVDC PSU (support forward airflow)

Delta DPS550AB6A (F2B)

- Input: 100~240VAC, 50/60 Hz
- Input: 180~300VDC
- Output: 12V/550W
- AC/DC efficiency: >90%(20%~100% load@230VAC/50Hz)
- Hot-swap FRU
- Load-sharing, 1+1 Redundancy

550W -48V DC PSU (support forward and reversed airflow)

Acbel R1CD2551A-G (F2B)

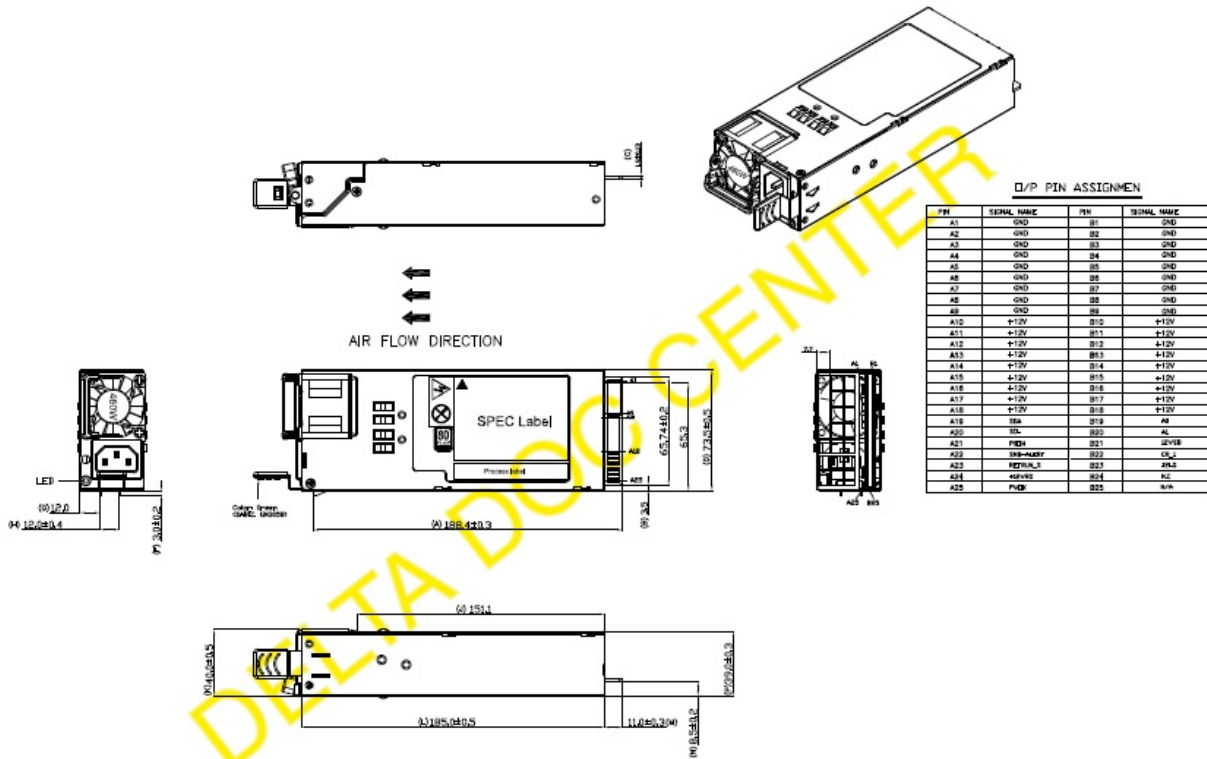
Acbel R1CD2551A-\* (B2F)

- Input: -40.5~-60VDC
- Output: 12V/550W
- AC/DC efficiency: >85% (20%~100% load@-48V)
- Hot-swap FRU
- Load-sharing, 1+1 Redundancy

800W 12V Power Adapter (forward airflow)

Celestica R0978-F0001-01

- Input: 11.5VDC 13VDC
- Output: 12V upto 800W
- Hot-swap FRU
- I2C/SMBUS/PMBUS support
- Load-sharing, 1+1 Redundancy



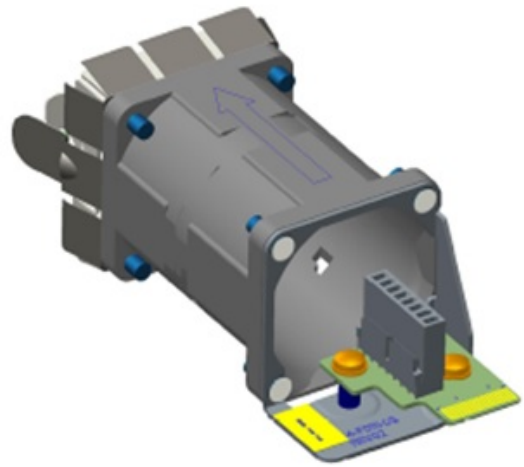
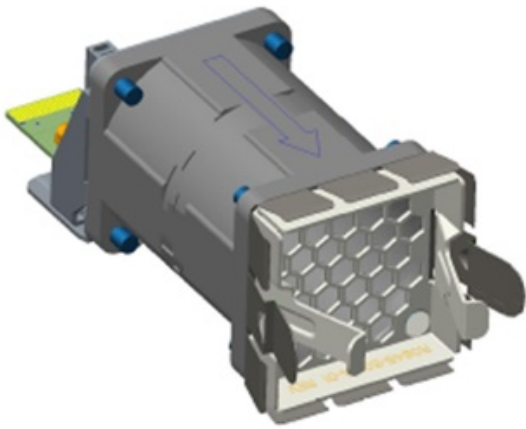
## Fan Modules

The Open GPON Line Card supports four individual fan modules. Each fan module supports two 40mmx40mmx54mm fans shown below. There are two fan module types, F2B and B2F. Both F2B and B2F fan module use the same fan, Delta, GFC0412DS-DC3Y. The only difference is in assembly. Again, it's desirable that the OCP re-use standard fan modules across a broad set of elements.

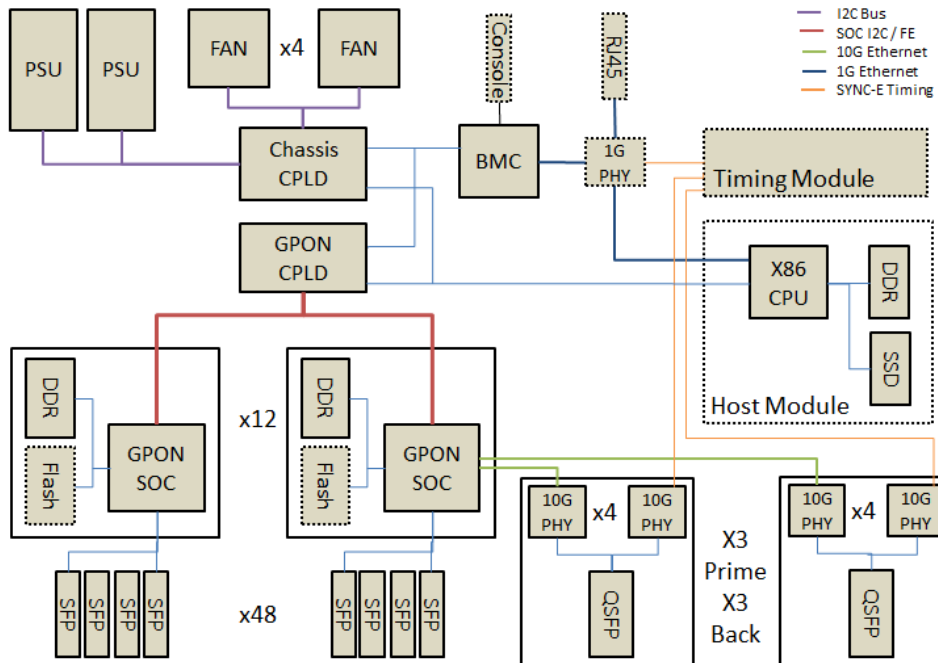
Pin assignments of the fan module are shown in the following table.

Signal Name	Pin Number	Description
12V	1,2,3,4,17,18,19	12V Power
GND	6,8,9,13,14,15,16	Ground
FAN_n_PRESENT	5	Fan module present signal 0: Fan module present 1: Fan module absent
FAN_n_F2B	20	Indicate Fan air flow 0: B2F 1: F2B
FAN_n_TACH	10	The TACH signal of the first fan on the fan module
FAN_n_PWM	7	The PWM signal of the first fan on the fan module
FAN_n+5_TACH	11	The TACH signal of the second fan on the fan module
FAN_n+5_PWM	12	The PWM signal of the second fan on the fan module

**Table 1 Fan Module Signals Definition**



## vOLT Block Diagram



The block diagram shows a single design which can support the various use cases described previously.

- The BMC provides chassis management, but this function can be delegated to any one of the GPON SOC or the Host CPU.
- All devices share the FE link which can extend externally for optional remote LAN management.
- All the chassis devices are connected through an I2C network such as FANs, PSUs, Thermals, System LEDs
- The GPON CPLD provides connection between GPON SOC and BMC/CPU to support firmware initialization and chassis management communication.
- Each GPON SOC connects to two 10G PHY for Main and Backup uplink connections.
- Optional CPU can run 3<sup>rd</sup> party full OLT stack and manage GPON SOC via FE network.





## X86 CPU Module Block Diagram

The Host Module will use standard COM-Express form factor and interface. This will allow a variety of different CPU options to be considered in different performance and price points including Intel Rangeley, Broadwell-DE, or ARM.

The COM-Express provides for difference form factors in a compatible mounting strategy which this platform will support.

Typical Host CPU for stand- alone OLT might include Broadwell-DE 2 to 6 Core with 16G RAM and 64G M.2 SSD.

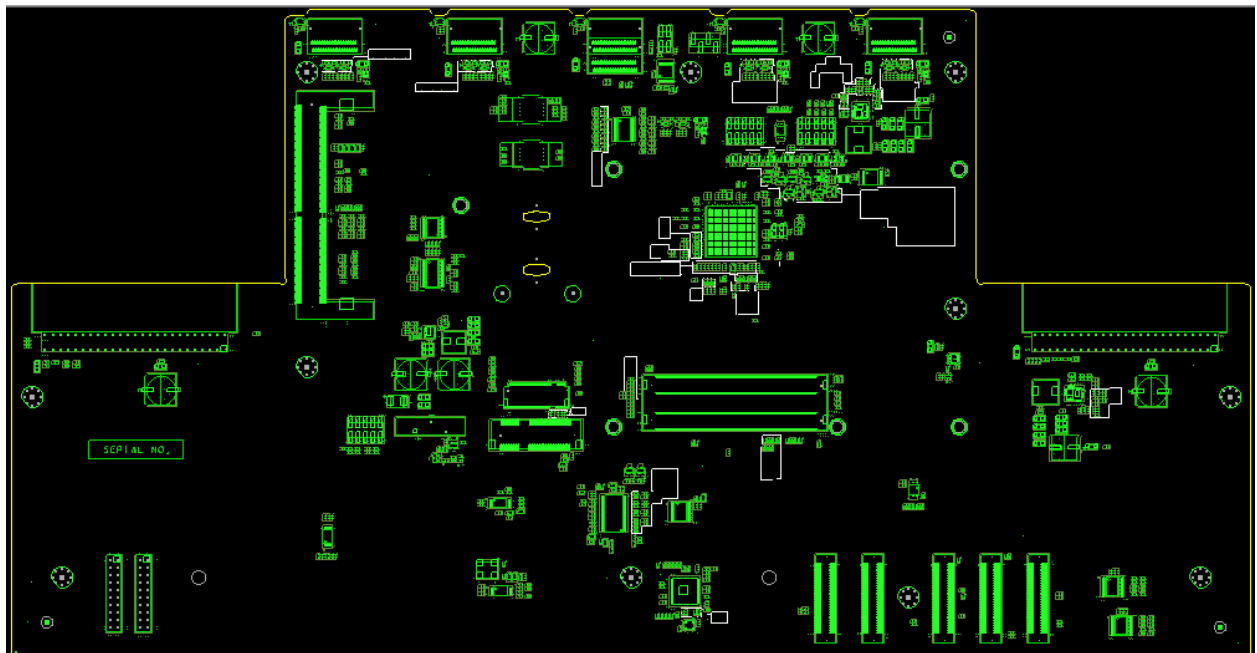
## PCB Board Set

The Open GPON Line Card is composed of the following PCBs:

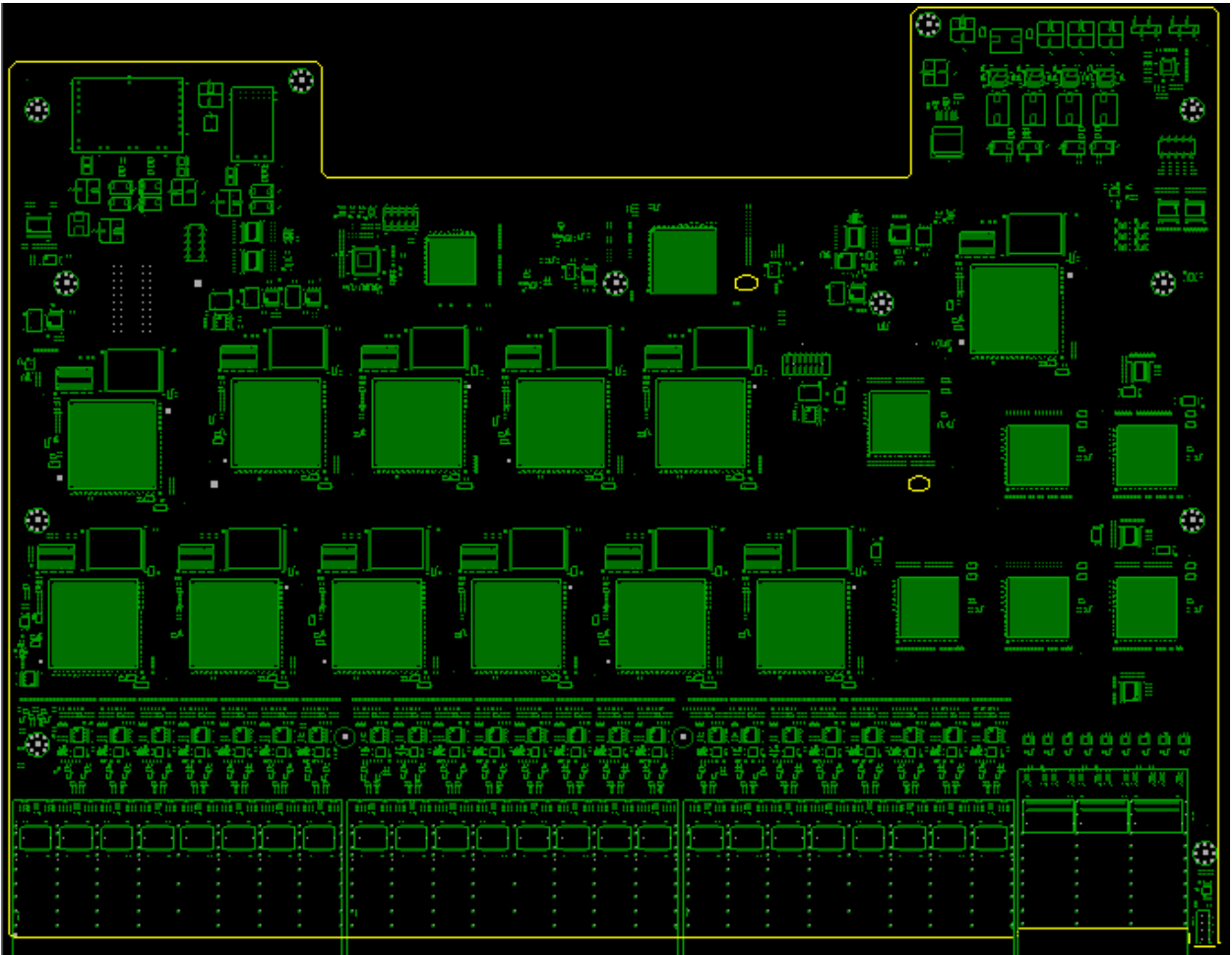
- Control Management Module board which connects PSU, FANs, and other PCBs into the system
- GPON Line Card board which contains all the unique GPON electronics and transceiver IO
- COM-E CPU Module PCB which provides option Host Control processing
- BMC Module PCB which provides the base chassis management logic control
- An optional Timing Module which can extract Sync-E and provide timing to the GPON SOCs

PCB Outlines for the main elements are shown here:

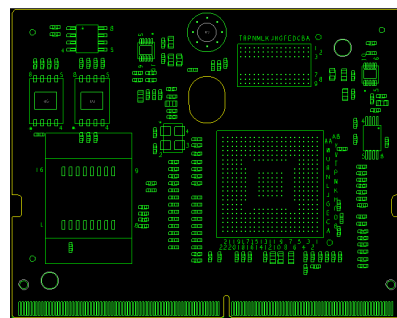
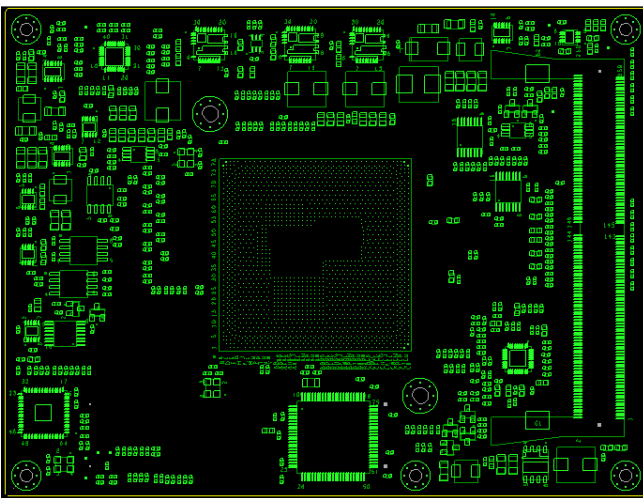
### Control Management Module



## GPON Line Card



## Com-E CPU and BMC Modules





## **Software Support**

The AT&T Open GPON Line Card supports a base software package composed of the following components:

### **BMC support**

AMI BMC or OpenBMC

### **U-Boot (Optional CPU Module)**

TBD

### **ONIE (Optional CPU Module)**

ONIE version 2014.08 or greater will be supported

### **Open Network Linux (Optional CPU Module)**

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

## Specification Requirements

AT&T has established specifications for servers and NFVI communications equipment that are intended to be used in Central Offices. These specs revisit classical NEBs requirements – particularly in the face of new resiliency and availability architectures. Servers that are not a single point of failure for their services (e.g. follow a typical cloud resiliency model) follow ATT-TP-76207. Telco devices that do have or comprise single points of failure for their services (e.g. the AT&T Open GPON OLT) follow ATT-TP-76208. These latter requirements are partially repeated here.

Specifications that require testing must be confirmed by an accredited agency recognized by the National Cooperation for Laboratory Accreditation or ISO/IEC Guide 25 or ISO/IEC 17025.

### Power Consumption

The total estimated system power consumption must be specified in watts. This is based upon worst case power assumptions for traffic, optics used, and environmental conditions. Typical power consumption should also be provided, as well as heat dissipation.

- ATIS TEER (ATIS-0600015.2009) should be measured and provided (Preferred)
- SPECpower\_ssj2008 can be substituted for ATIS TEER (Acceptable)
- US EPA Energy Star Certification is favored.
- Power terminations must be clearly labeled and fully protected with a non-metallic, non-flammable cover.
- ATT-TP-76208 lists additional power requirements for under and over voltage, grounding, and current characteristics.

### Environmental

- Light weight is favored
- 15 to 40°C operating range – de-rated 1°C for every 1000 ft (300 m) above 6000ft (1830m).
- Humidity 5% to 85% non-condensing (operational and storage)
- Vibration – IEC 68-2-36, IEC 68-2-6
- Shock – IEC 68-2-29
- Acoustic Noise Level – Under 78dB in 26 degree C
- Altitude: -200ft (-60 meters) to 6000ft (1830 meters).

### Safety

Fire Spread. Field conditions for telco deployment may require deployment in existing Carrier Communications Spaces that utilize Fire Code Exemptions and do not have automatic fire suppression. NFVI equipment, like the AT&T Open GPON OLT deployed in these locations must meet enhanced fire spread requirements:

Generally, the equipment must 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 four items below:

1. Height of 2 RU or less
2. Horizontally mounted main printed circuit board
3. Metallic 5 sided enclosure with a metallic or non-metallic front cover or faceplate
4. 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 must attest that the equipment has successfully passed the burn test as referenced in the ATIS document.

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

### **Electromagnetic Compatibility**

- GR-1089-CORE
- FCC Title 47, Part 15, Subpart B Class A

### **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)