FTTP CPE Components The Current and Future View

Abstract

This article reviews the architecture and components of the triple-play CPE required by the recent FTTP (Fiber To The Premises) RFP in the US market. The current architecture and components available meet the functionality and performance requirements but are not low enough in cost for Contract Manufacturers. The current high cost is the major barrier for mass deployment. The evolution of new optics technologies and the ability to integrate more functionality into a single IC, both for digital and analog needs, will enable a decrease in BOM (Bill of Materials) costs as well as reduce the assembly efforts. Most importantly, it will shorten the food chain by eliminating the need for a transceiver manufacturer.

Background

Why Fiber Access

Fiber optics has been recognized as the best media to support the single connection because of its high bandwidth capacity over longer distances, enhanced overall network reliability and service quality leading to a faster rollout of powerful broadband services. FTTP (Fiber To The Premises) will enable service providers to deliver nearly unlimited bandwidth and a full range of applications directly to business and residential customers. FTTP can accommodate the 'triple-play' bundle of services, i.e. - next-generation applications such as ultra high-speed Internet access and networking, multiple voice lines and high-definition video applications and other innovative applications.

Why PON

Passive Optical Networks (PON) offer a number of benefits over competing copper-based and fiber-based technologies.

Since a PON is passive, there are no active electronics in the loop. This translates into significantly lower maintenance costs (OPEX). With fewer network elements, there are fewer points of failure so operational costs (OPEX) and requirements are minimized as well.

A PON architecture is future-proof; capable of handling today's voice, video and data applications; and equally capable of handling applications that will emerge in the future. As a result, a PON eliminates the need for costly future plant upgrades and enhancements.

A PON enables a service provider to offer additional services and increase revenue. With PON architecture, a service provider can offer a wide range of high-margin offerings. See Figure 1 – 'Triple-play' BPON Network Diagram.

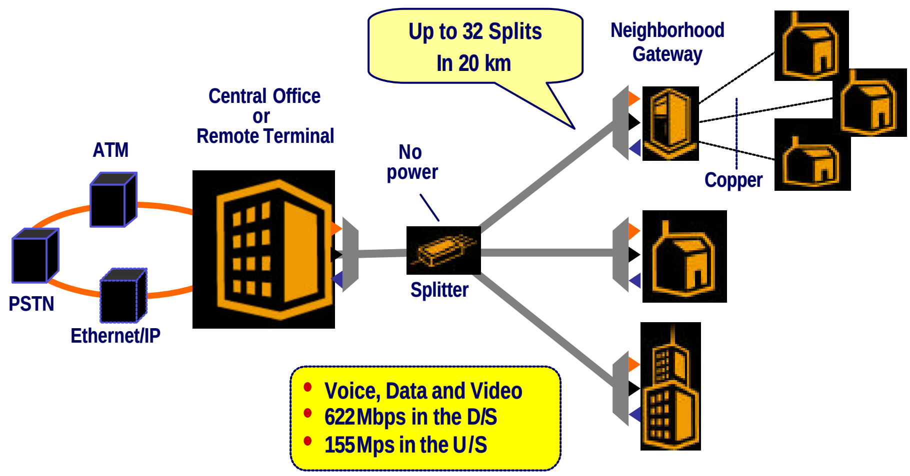

Figure 1 – 'Triple-play' BPON Network Diagram

'Triple Play' FTTH ONT

Optical Network Termination (ONT) for Fiber to the Premises (FTTP) networks should be an International Telecommunications Union (ITU) G.983 compliant device for use in residential telephony networks. This device should support three optical wavelengths; two downstream at 1490 nm and 1550 nm, and one upstream at 1310 nm. Up to 32 ONTs can be installed on a single PON depending on the support of the OLT and optical budget of the network.

The ONT should support one to four individually addressable POTS ports. The ONT should also supports a single 10/100BaseT Ethernet port for 'always-on' High Speed Internet services.

To provide complete Full Service Access Network (FSAN) functionality, the ONT should support the delivery of Cable Television services over the same single fiber. Cable services are then converted to the 75 Ohm coaxial network already installed in most homes. In order to support Video on Demand and other advanced Cable television services, the ONT must convert the cable set-top return channel to the PON packet stream for delivery over the upstream optical wavelength.

Current CPE Architecture

The general block diagram of a current ONT is shown in Figure 2 – Typical BPON ONT Block Diagram.

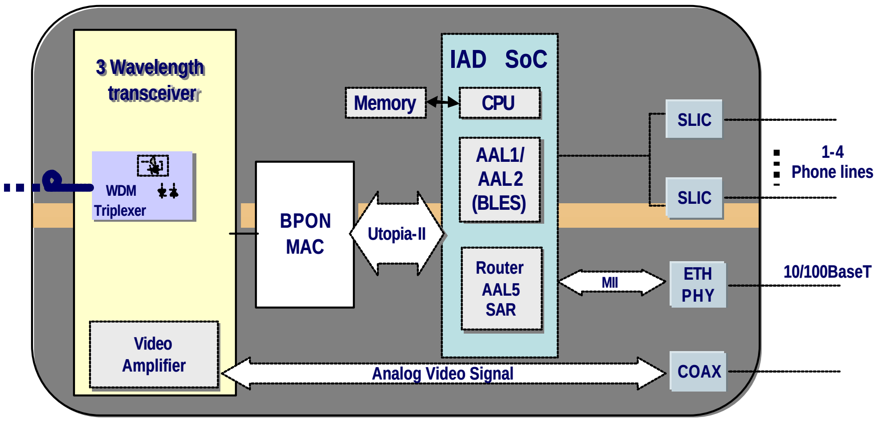

Figure 2 – Typical BPON ONT Block Diagram

Three Wavelength Optical Transceivers

The Transceiver is responsible for the physical connection between the user premises and the Central Office (CO). It receives data at 1490 nm and sends burst traffic on 1310 nm. A third wavelength, 1550 nm, is used for analog video broadcast.

BPON Media Access Controller

The media access controller is responsible for the unique transmission control protocol of the PON system. The BPON MAC controls the PON burst mode data transfer. Burst data is transmitted from many homes located at varying distances from the Central Office. Upstream data has to be received at the OLT (Optical Line Terminator) card in the CO, in a coordinated manner, to ensure that data bursts from each home do not collide with others. Downstream data is broadcast from the CO to the homes, where the MAC has to filter the data destined for each home. The communication line between the CPE and the CO requires a CPE MAC in each home and one CO MAC (one for 32 homes) in the Central Office.

IAD SOC

The IAD (Integrated Access Device) SOC (System On Chip) is the unit which controls the CPE. This unit integrates the control processor with its peripherals like Interrupt controllers, Timers, Memory controller with data manipulations logic like AAL5 SAR, Ethernet MAC and Phy, AAL2/AAL1 voice SAR. Some of the devices integrate additional data functions such as IPsec in silicon for enhanced security, USB port and WiFi interfaces.

SLIC

This unit is the interface to the POTS (Plain Old Telephony System) phone through an RJ11 jack. It includes the logic needed to terminate the Tip and Ring signaling along with a codec to convert analog to digital voice streams. Some of the units include DSP to allow voice compression and echo cancellations. It also supports the needed voltage to apply ringing to the phones.

BPON MAC Architecture

As mentioned above, this unit controls the PON logic. A typical architecture of such an IC is built from the following:

- Utopia interface – This is the standard ATM bus interface which connects many of the existing IAD SOCs.
- CPU interface – This is the interface for external CPU which controls the MAC.
- Internal Multi-unit BUS – An internal bus that connects the various units of the IC and allows modular design and better data transfer performance.
- Cell/packet memory – Buffers for the ATM traffic to allow flow control in both directions.
- BPON receive block – This is the block which is responsible for cell delineation, traffic discard, PLOAM (Physical Layer OAM) handling and Grant handling.
- BPON transmit block – This is the block which controls the burst transmission of upstream data according to the Grant map received by the OLT.
- Transceiver interface – High speed serial data and control interface

Some of the existing devices in the market have already achieved a certain level of integration. This device includes an integrated CDR (Clock Data Recovery) and a SERDES (SErializer/DESerializer). See Figure 3 – BPON MAC Block Diagram.

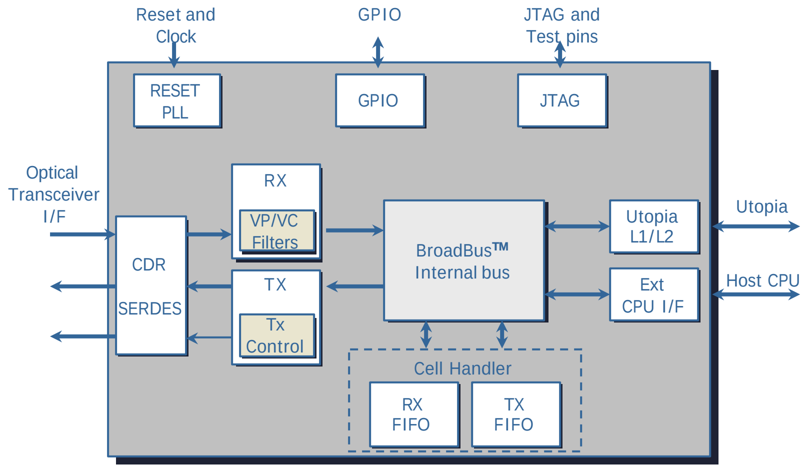

Figure 3 – BPON MAC Block Diagram

Transceiver Architecture

The transceiver is a unit that is responsible for photon to electron transformation. At the heart of the transceiver there is a bulk optic WDM module that separates the three wavelengths. Each of the wavelengths is than manipulated accordingly. The continuous downstream data (1490 nm) is filtered and amplified by a limiter amplifier IC. The burst upstream (1310 nm) is controlled by a burst mode laser driver IC. This IC controls the minimal laser turn-on delay to meet the requirements of the protocol. The downstream Video broadcast streams (1550 nm) are manipulated by the video receiver circuitry that transfers it to a 75 ohm coax connector. This circuitry includes an AGC (Automatic Gain Control) on all the video channels. See Figure 4 – Three Wavelength Transceiver with Embedded Video Receiver Block Diagram.

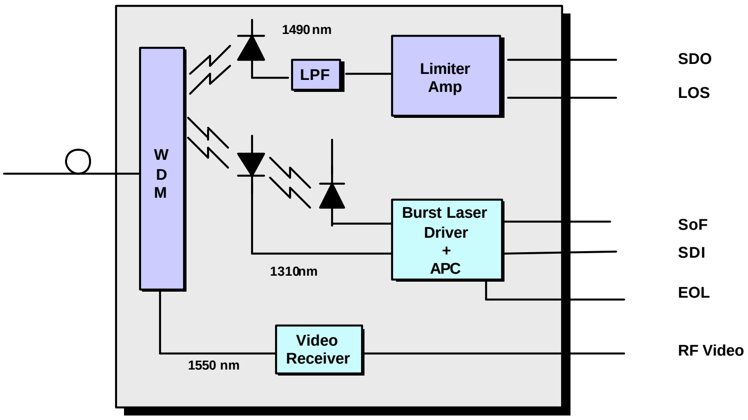

Figure 4 – Three Wavelength Transceiver with Embedded Video Receiver Block Diagram

Future CPE Architecture

The architecture of the CPE mentioned above meet the market needs and are fully compliant with the current technologies standards.. It supports all the features and provides outstanding performance. When looking at how similar broadband technologies (DSL and Cable modem) evolved, it is clear that this technology needs a higher level of ICs integration, simpler assembly and production processes at a very low cost. This will enable Contract Manufacturers (CMs) to enter the market with affordable products that will enable high speed broadband services.

In order to achieve this target, the PON components industry needs to evolve in three directions:

1. Significant cost reduction of the optics
2. Integration of the analog at the front-end
3. High level of integration for the digital part

See Figure 5 – Future Architecture for Triple-play CPE.

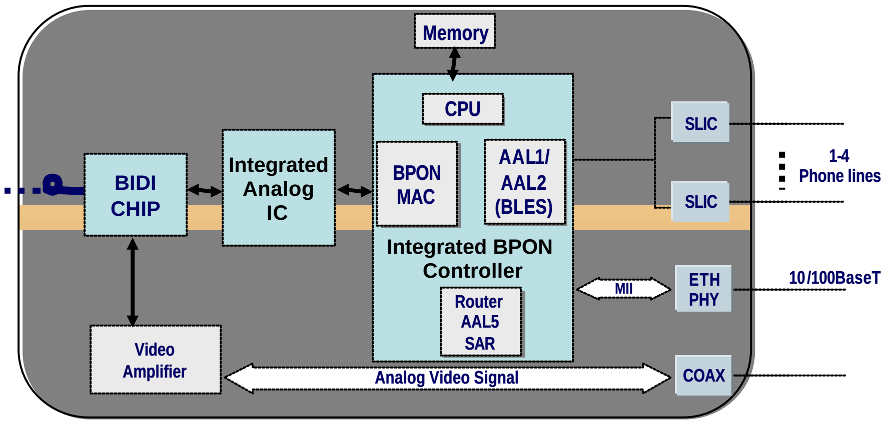

Figure 5 – Future Architecture for Triple-play CPE

From Bulk Optic to BiDi Chip

The current WDM part in the triple-play transceiver is a bulk optic component. This component is manually assembled and calibrated. It includes a laser diode for 1310 nm transmission and two pin diodes for the digital 1490 and analog 1550. All the three components are packaged into the standard to-can package. At the heart of the bulk optic module there are two Dichroic Mirrors which separate the three wavelengths. These mirrors are manually assembled and aligned and have a very low yield. See Figure 6 – Bulk Bidirectional Module for Three Wavelenghts

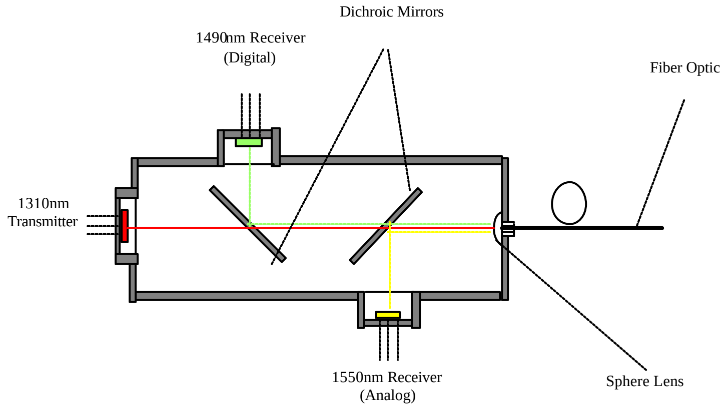

Figure 6 – Bulk Bidirectional Module for Three Wavelenghts

In the near future this bulk optic will be replaced by a better solution – the BiDi chip. This is an optical IC that has the same performance as the bulk optics but is manufactured automatically, even with low yields. This will reduce the cost of the optics dramatically and will make the overall CPE costs much more affordable.

The BiDi chip is based on waveguide technology that has matured and been widely accepted by the market. With the V-groove technology, it allows the separation of the three wavelengths efficiently. The laser diode, PIN diode and TIA (in their die form) are assembled automatically on the substrate and result in a chip instead of an old bulk module. See Figure 7 – BiDi chip for Three Wavelengths Architecture

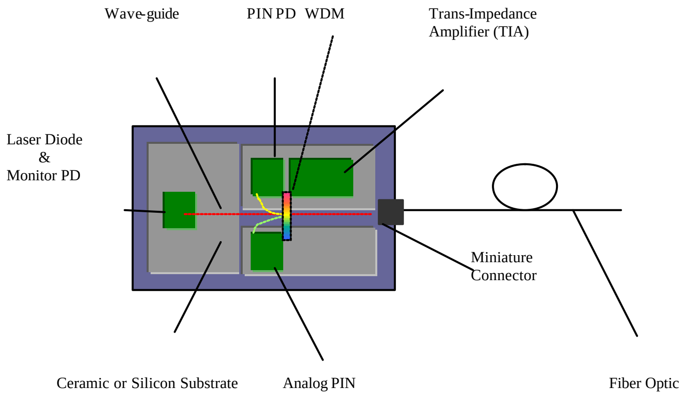

Figure 7 – BiDi chip for Three Wavelengths Architecture

Integrated Analog IC

As we can find integrated analog front-end in point-to-point networks, it is extremely likely that the triple-play PON technology will happen. We will find an analog IC that will integrate the continuous limiter-amplifier with the burst mode laser driver on a single IC.

Integrated PON Controller

An obvious integration effort will merge the BPON MAC with the IAD SOC. This is exactly how the DSL and cable modem technologies becomes affordable. With this integration, the ATM bus will be eliminated and PON controller will integrate all the data transfer from the Ethernet to the Optics.

Summary

The FTTP market is starting to flourish. More system vendors are involved in integrating BPON technology into their existing broadband platform. Operators are going to field trials and deployments.

While the functionality of FTTP CPE is clear, the internal components are going to evolve rapidly. The BiDi chip will allow CM to eliminate the need for transceivers and directly work with the fiber. In addition, the integration of the analog front-end and the PON controller will reduce the amount of active components and the size of the ONT. This will increase competition between the manufacturers and will increase the attractiveness of FTTP solutions. It will enable real broadband at an affordable price.