Telecom Access Solutions

White Paper

RF Return Solutions

Contents

1. **Overview**

MSOs are looking for innovative ways to gain a competitive edge to deliver triple play features to their customers in order to compete successfully with other carriers offering higher bandwidth services. At the same time, their business demands that they leverage as much of the existing infrastructure in their network.

Gigabit Passive Optical Network (GPON) is currently the world leading technology for new deployments of triple play services. With the technology described in this White Paper, MSOs can deploy GPON to offer the new services, provide new revenue generating features to the subscribers, all while protecting their infrastructure investments.

RF return path technology is a key enabler of the service provider's revenue stream for Pay-Per-View and Video-on-Demand services. With a complete analog HFC plant, these services are simply offered over the traditional MSO infrastructure. Although the introduction of GPON to the MSO network offers an excellent mechanism for delivery high quality video over the 1550 nm wavelength, there are challenges in dealing with the RF return path that seamlessly travelled towards the head-end from the customer set-top-boxes.

It is imperative to leverage existing infrastructure costs when deploying FTTH, but it is equally important to preserve the backend management system and service provisioning systems as well since these costs are also significant. This paper will describe the existing architecture of the MSO network pertaining to RF return and then discuss the various options for RF return solutions with a specific emphasis on "IP Path Integrated" RF return.

2. Cable HFC's Video Return Channel Architecture

Existing Multiple Systems Operator (MSO) Hybrid Fiber/Coax (HFC) networks transport downstream and upstream signals on separate fibers from the head-end. These fibers are terminated at a local fiber node where the signals are combined onto the same Coax cable to the neighborhood. There is no standard waveband plan on the fiber portion of the network. However, 1550 nm is typically used for the downstream signal and 1310 nm or 1590 nm is typically used for upstream (return) signal. On the Coax portion of the network, the frequency spectrum of 54 MHz to 870 MHz is used for the downstream signal and 5MHz to 42MHz is used for the upstream signal. At this point in the network, the return signal is frequently referred to as RF return. Figure 1 depicts a fiber-node bridging a 5-42 MHz RF signal onto an upstream wavelength.

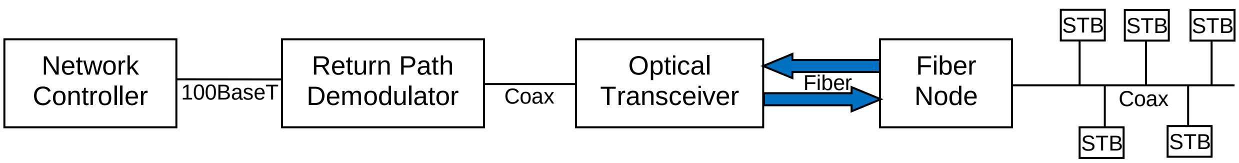

Figure 1 ***MSO HFC Return Channel Topology***

The fiber-node's RF interface supports up to 2000 Customer Premises Equipment (CPE) devices, depending on bandwidth requirements (e.g. cable modem). The RF return signal is bridged from the Coax plant onto an upstream wavelength and is bridged back onto Coax at the Optical Transceiver. The RF Return signal is then demodulated at the head-end by a Return Path Demodulator and IP packets are retrieved from the Asynchronous Transfer Mode (ATM) data stream that is carried on the RF signal. The packets are then forwarded to the Network Controller which controls service platform interaction with the Set Top Boxes (STBs).

3. FTTH Video and RF Return Channel Solution

Within the GPON Fiber to the Premises (FTTP) architecture of Figure 2, the downstream RF signal from the head-end (comprising spectrum from 54 MHz to 870 MHz) is amplified and converted to a 1550 nm wavelength optical signal by the Optical Line Terminal - Video (OLT-V) equipment. The optical signal is wave division multiplexed with PON's 1490 nm data wavelength from the OLT for downstream transmission to ONTs (Optical Network Terminals) on the same fiber. The same fiber also carries the 1310 nm upstream data burst signals from all ONTs to the OLT. The downstream 1550 nm Cable TV (CATV) signal is converted back to an RF signal by the ONT and forwarded to subscriber Set Top Boxes (STBs) over Coax. The PON standards do not provide for an upstream video optical signal in the fiber network. Therefore, an alternate path needs to be provided for the return channel RF signals from the STBs in order to reach the video head-end.

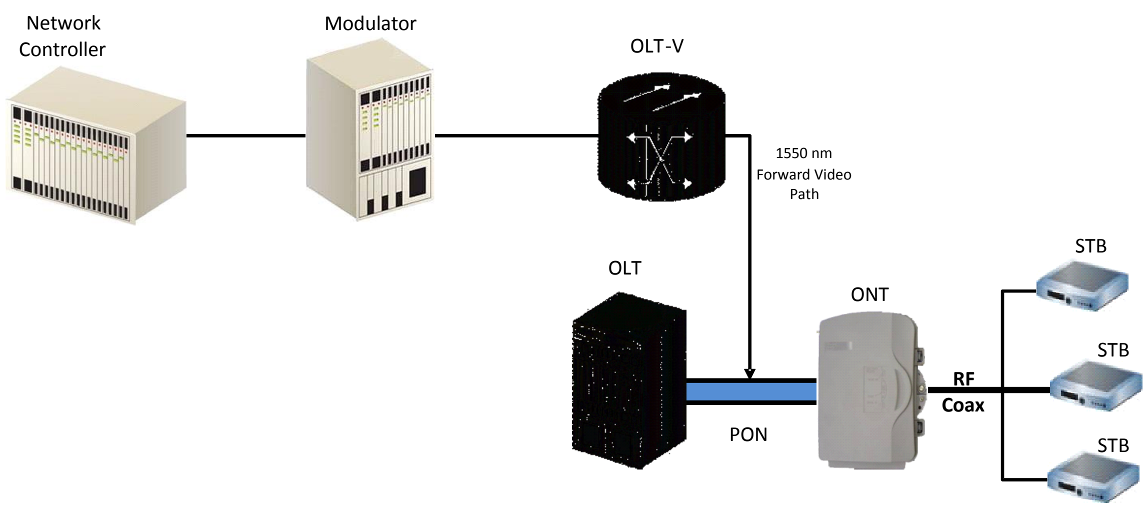

Figure 2 ***GPON Fiber to the Premises (FTTP)***

3.1 Considerations for Motorola Based Systems

The Motorola RF Return system is based on the ANSI/SCTE 55-1 standard. SCTE 55-1 defines a contention based method for determining when a STB may transmit upstream data. Specifically, it uses a combination of a query-response protocol and a contention protocol to determine when the STB can transmit data to the head-end. This system allows for a loose timing relationship between the STB and the head-end.

3.2 Considerations for Scientific Atlanta Based Systems

Scientific Atlanta systems are based on the ANSI/SCTE-55-2 standard. SCTE 55-2 defines a contentionless transmission scheme based on the Digital Audio Visual Council (DAVIC) standard. This scheme uses Time Division Multi-Access (TDMA) to guarantee bandwidth for each STB. This system results in a tight timing relationship between a STB and the head-end.

4. GPON System RF Return Approaches

In a GPON network, there are currently three approaches being used to provide a path for the RF return signal to reach the video head-end. These are RF over Glass, Packet Aware RF Return, and Transparent RF Return.

4.1 RF over Glass

RF Over Glass (RFoG) moves the fiber node depicted in Figure 1 from a centralized location to the customer premises. The HFC network then utilizes RF signals over Coax only within the subscriber's home. Since there is minimal change in the functionality of the HFC access for the home, there is limited impact to provisioning and billing systems, head-end, set-top boxes, cable modems and or other prior existing devices. RFoG will require an additional WDM filter/combiner, return path receiver per PON as well as relevant and costly network and fiber management adjustments.

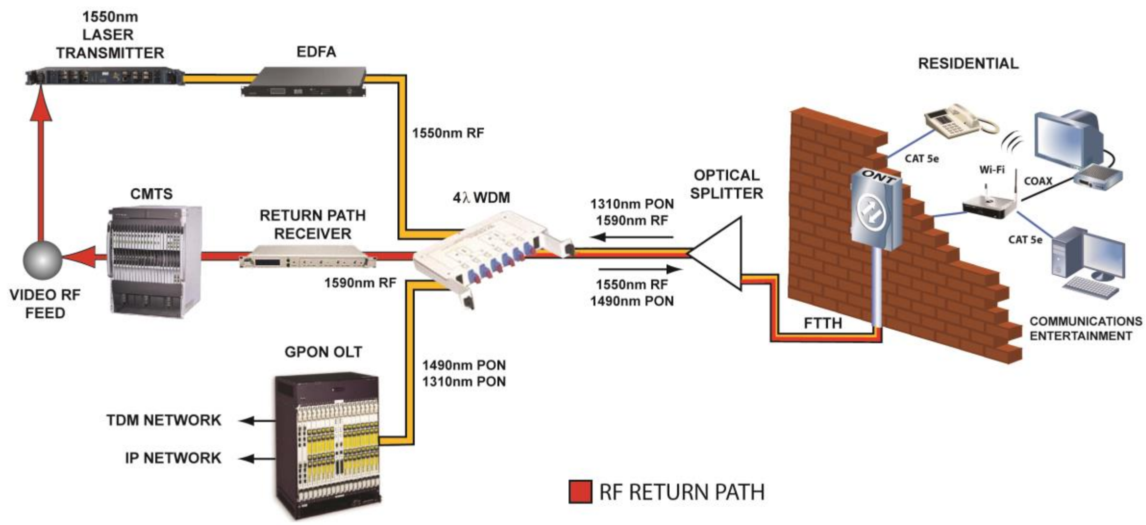

Figure 2 ***RF Over Glass***

4.2 Integrated RF Return (Packet Aware RF Return Mode)

Integrated RF Return in Packet Aware RF Return (PARR) mode involves moving the functionality normally found in the head-end modulator referenced in Figure 1 into the ONT. The video return channel RF signal is first terminated by the RF receiver at the ONT. That is, the RF data is sampled from the RF carrier signal and sent to a higher layer packet decode function within the ONT. This function then reassembles the upstream packets from the ATM cells that are retrieved from the data stream carried on the RF signal.

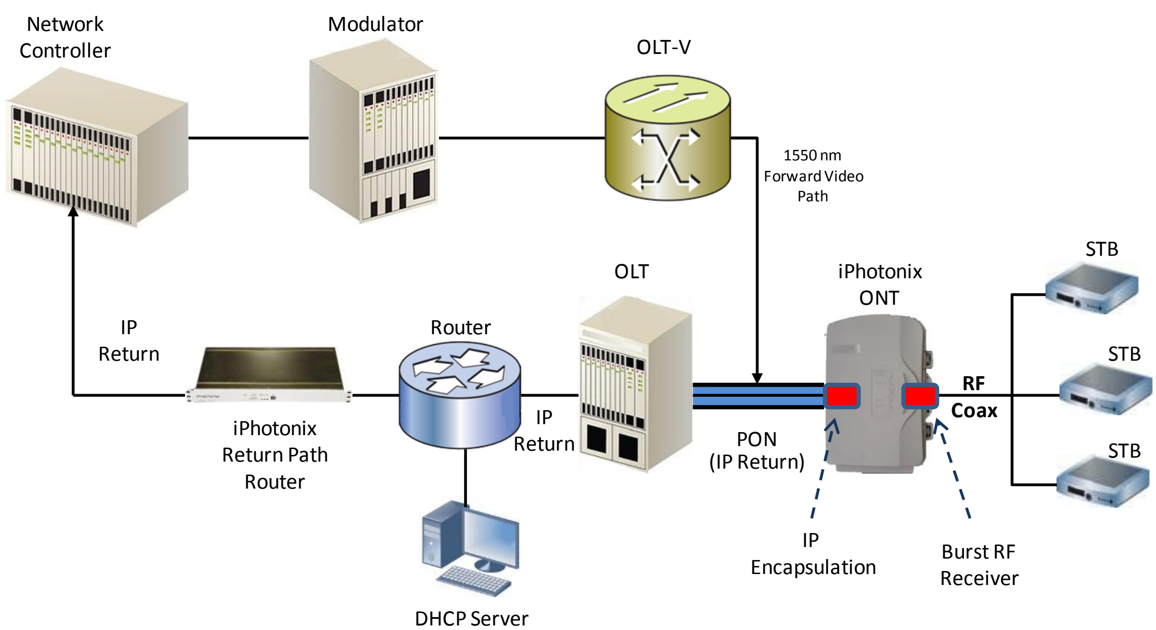

FIGURE 3. *Packet Aware RF Return*

4.3 Integrated RF Return (Transparent RF Return Mode)

Integrated RF Return in the Transparent RF Return (TRR) mode involves terminating the RF return signal at the ONT and tunneling the signal as a packetized bit stream toward the head-end. At the head-end, a modulator receives the packetized bit stream and modulates it back into the expected RF return signal. This signal is them demodulated by the video network's standard demodulator at the head-end.

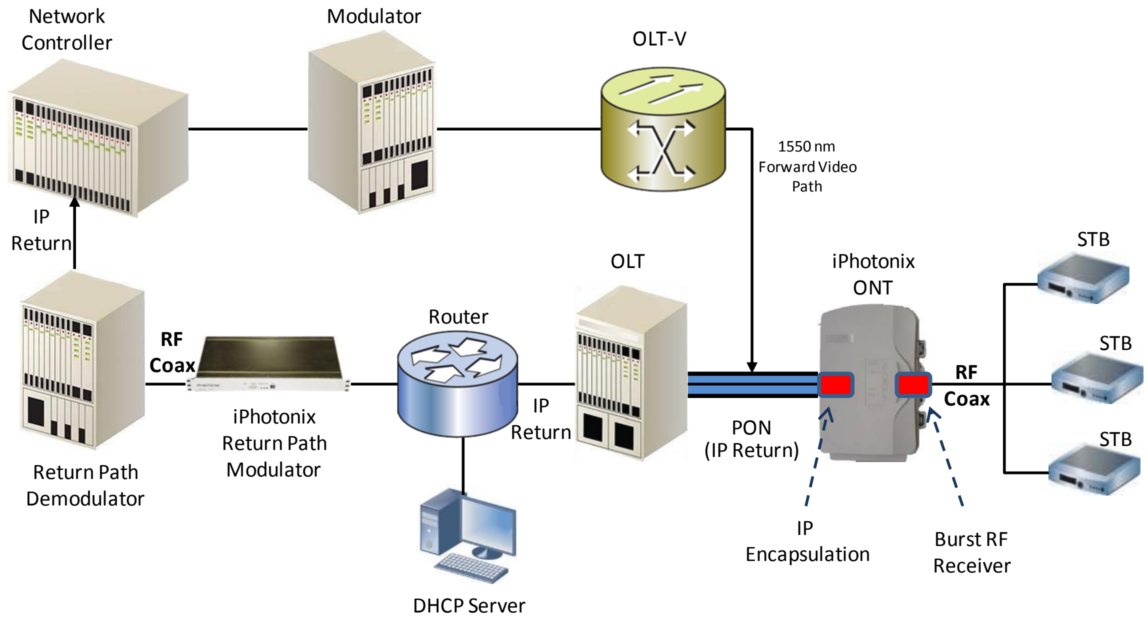

FIGURE 4. Transparent RF Return (TRR)

5. RF Return Solution Comparison

Each of the RF Return solutions has its own set of advantages and disadvantages.

RFoG in most cases will provide full DOCSIS compliant RF Return capability. However, to permit the coexistence of GPON and RFoG, an additional second laser and DWDM splitter/combiner functionality must be added to the ONT. In addition, RFoG will require an additional 1590nm filter and O/E converter at the head end. This makes RFoG an expensive solution when compared against the alternatives.

Integrated RF Return in TRR Mode provides a good RF Return solution because it is not sensitive to the message protocol being used between the STB and head-end. This means that it requires significantly less interoperation testing with the head-end vendor's equipment. It also means that an operator is free to perform software updates on its head-end equipment without fear of impacting RF Return functionality in the ONT.

A consideration of using Integrated RF Return in the TRR mode is that packet networks can sometimes cause variation in the arrival time of upstream RF Return packets. Since the use of TRR is totally transparent to the head-end equipment, variation in packet arrival time is managed by the iPhotonix RF Return Director 6550 & RF Return Modulator 6500 illustrated in figure 3 & 4.

Scientific Atlanta offers a head-end configuration that supports the receipt of RF Return packets directly from an IP network. This system requires a PARR based solution at the customer premises but it eliminates the need for an added device at the head-end.

Area	IP RF-Return	RFoG
Head-End infrastructure	No additional equipment required	Requires Micro-node
	Removes requirement for RPDs	RPDs must be added as customer base using new features increases
Fiber Distribution	Better bandwidth Utilization	Occupies Additional Wavelength
Customer Premises	No change to set-top-box	No change to set-top-box

6. **ONT Implementation for RF Return**

From an implementation perspective, it is possible to implement TRR and PARR on a single hardware base. This allows the deployment of an ONT that can be remotely provisioned to operate in either TRR or PARR mode.

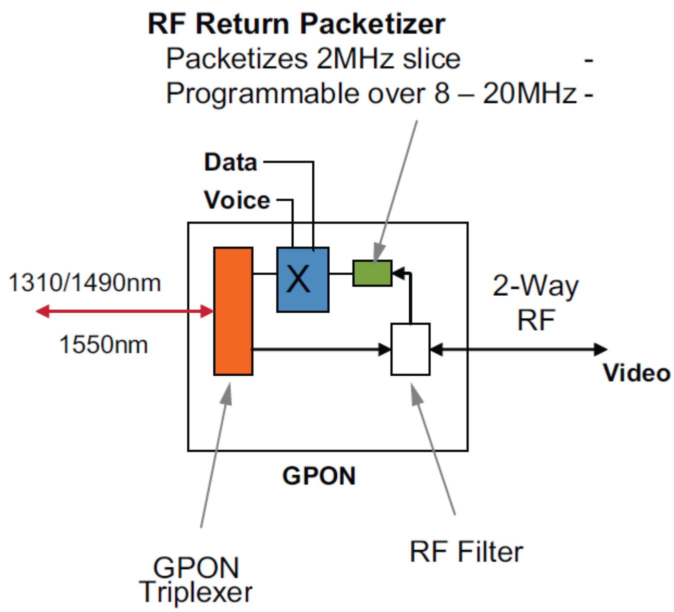

FIGURE 5. ONT with PARR/TRR support

7. **Conclusion**

GPON solutions are increasingly becoming viable options that allow MSOs to offer higher-bandwidth services while preserving the value of their infrastructure. Selecting the right RF return technology is the critical step towards these goals.

Integrated RF Return TRR and PARR modes provide backward compatibility with existing Motorola and S.A two-way video systems with flexible ONT provisioning for each system. This avoids the limitations of the 3-wavelength RFoG solution or cost of a 4-wavelength RFoG solution. Therefore, an ONT that can be provisioned for TRR or PARR is the optimum solution for RF Return.

RF Return Solution Comparison

RF Return Solution	Additional Head-end Equipment	Head-end Compatibility	Cost
PARR		SA	$
PARR	Simple Router	Moto	$$
TRR	Head-end Modulator	Moto	$$
RFOG	Micro-nodes RPDs	Moto/SA	$$$$

To Note:

There are also newer technologies such as MOCA, G.hn, Ethernet and DOCSIS that are reliant upon set top boxes to manage the integrated RF return path mechanism. These solutions fail to manage set top boxes already deployed and require a costly exchange of set top box to complete the solution. This paper does not address those options.