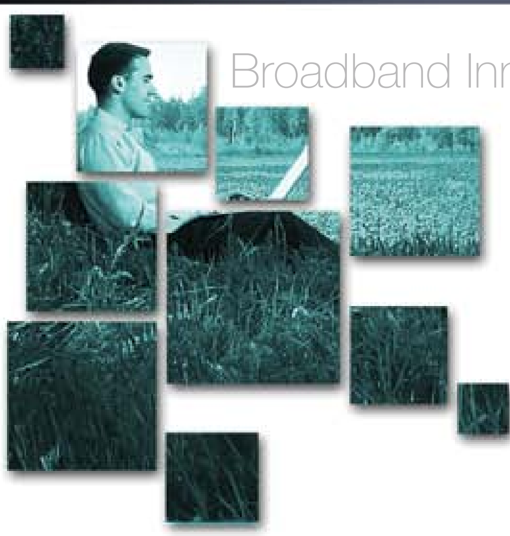
CTDI Products: End-to-End Solutions

RF over Glass (RFoG) Tech Brochure

Broadband Innovation



Network evolution has positioned MSOs as leading providers of video, voice, and data services. They have leveraged their broadcast video excellence to dominate the residential triple-play market. Competitors are responding quickly though, with low-cost fiber networks that deliver gigabits of bandwidth to both residential and business subscribers. To continue their market-leading residential position and further expand into the lucrative business services market, MSOs continue to evolve their network strategies to solve the challenges of today's HFC systems. Increasingly, MSOs are turning to RFoG technology from CTDI as the solution.

RFoG

RFoG is RF over Glass. It is a technique used in the access network to deliver services to the subscriber location using the same RF/DOCSIS technology as traditional HFC systems. With RFoG, the portion of the HFC network that was coax is now an optical fiber as shown below.

Figure 1: HFC and RFoG Topologies

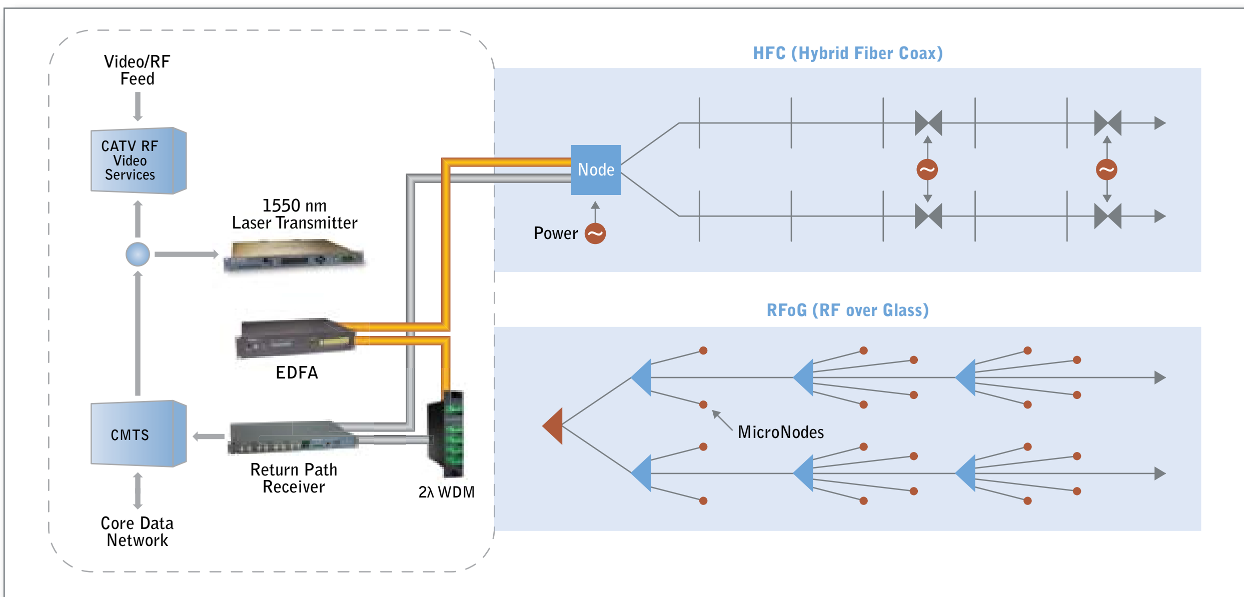


Figure 2: A Headend Centric HFC Design

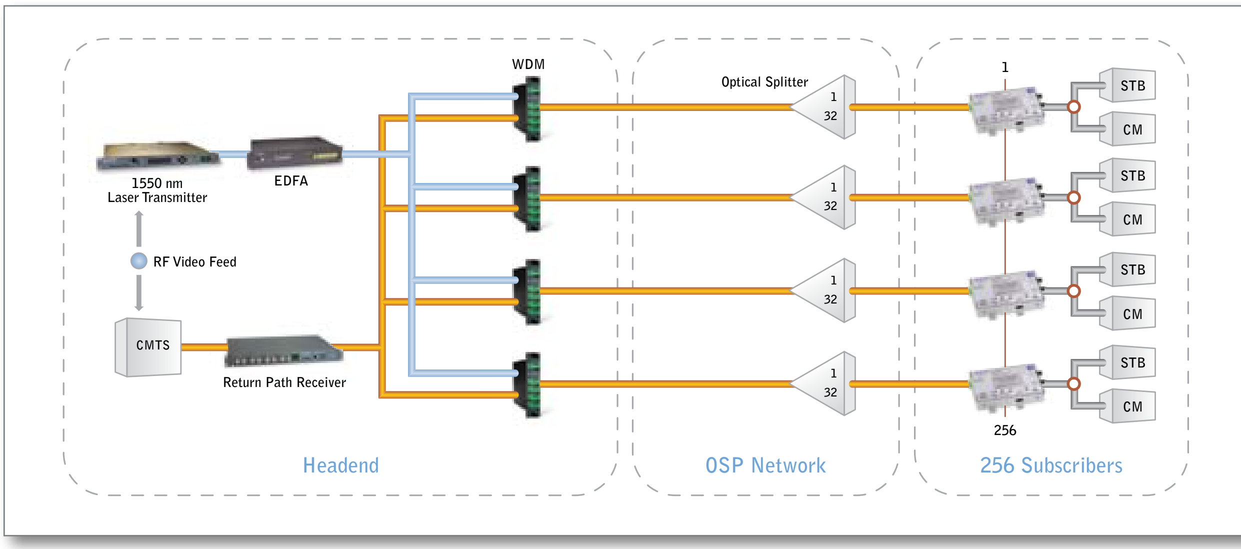


Figure 3: A Hub Centric HFC Design

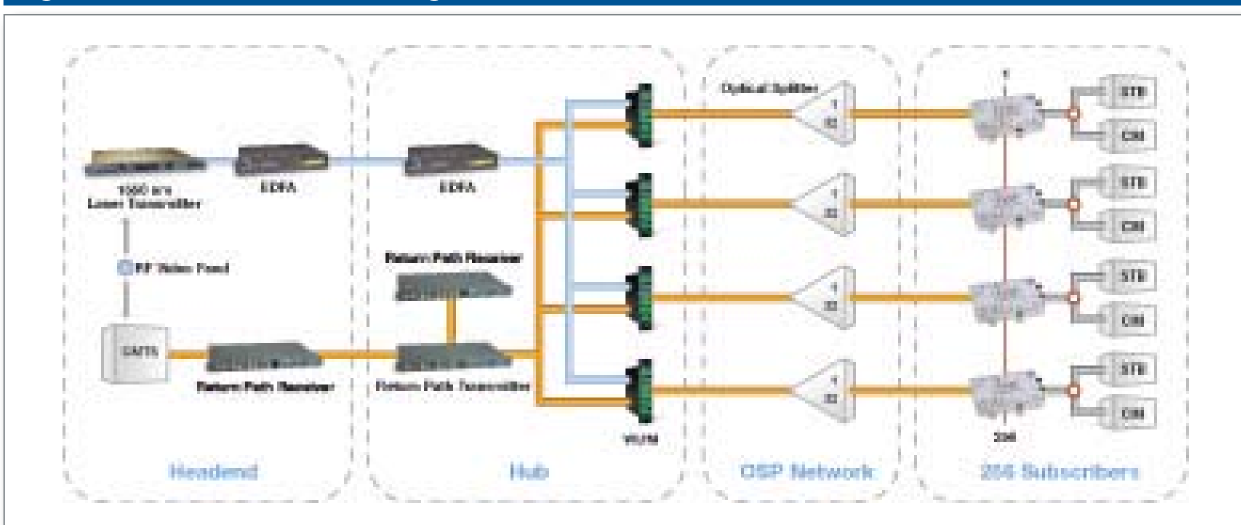
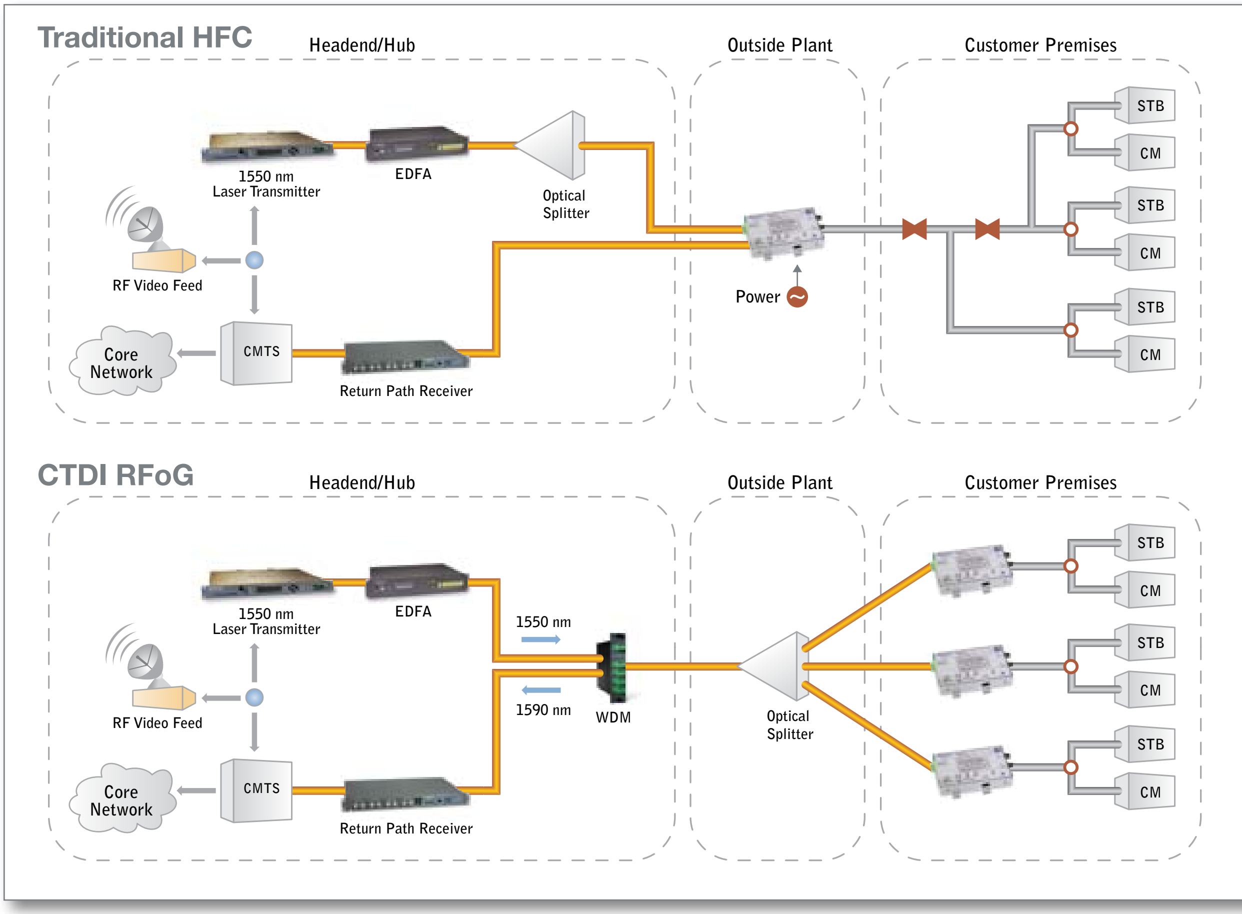


Figure 4: HFC and RFoG Comparison



Note that there are many similarities between the networks. The headend/hub equipment is the same for both architectures. The same laser transmitter, EDFA, return path receiver, and CMTS are used to deliver services to the outside plant network. CPE — set top boxes, cable modems, E-MTAs — along with the subscriber's wiring are also the same for both architectures. And that means that operational systems and practices are the same for both networks, greatly simplifying the migration from HFC to an optical network. Indeed, one of the most attractive technical aspects of RFoG is its compatibility with HFC. Both technologies operate side-by-side without interference in the access network.

One difference is in the transmission media between headend or hub and subscriber. A single fiber is used from the headend to the MicroNode device. This is accomplished by using 2 wavelengths for transmission; one for downstream and the other for the return path. 1550nm is used for the forward (downstream) path, and 1590nm is used for the return. The result is that less fiber is used in the outside plant, saving both materials and installation costs. It also means better utilization of existing optical cables, avoiding expensive additions to an installed network.

A second difference seen in Figures 1 and 2 is that power is no longer needed in the outside plant with RFoG. HFC nodes require commercial power, and they require battery backup to ensure uninterrupted operation. Nodes also need standby emergency generators — either dedicated or portable — for power outages lasting beyond the few hours of battery life.

By simply transmitting RF optically over fiber instead of electrically over coaxial cable, the MicroNode RFoG system delivers all the capabilities of current HFC/DOCSIS networks with several added performance advantages that include:

- Downstream capacity improvements
- Return path capacity improvements
- Low noise operation
- Simple addition of Ethernet PON-based services

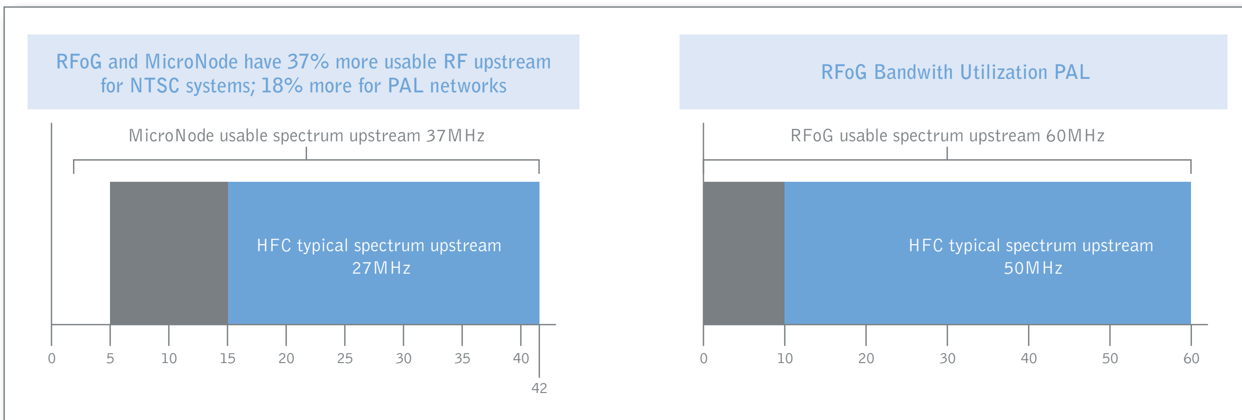
Downstream Capacity Improvements

One performance advantage is expanded downstream capacity. By operating to 1GHz, MicroNode RFoG adds 130MHz of forward path spectrum to 870MHz systems, which is a 15% gain in bandwidth. Of course to make use of that added capacity, laser transmitters and EDFAs must support the 1GHz bandwidth as well.

Return Path Capacity Improvements

Downstream capacity is typically less of a concern for MSOs than the return path. CTDI's RFoG solution helps relieve the upstream congestion, where most bottlenecks occur.

Figure 5: MicroNode RFoG Upstream Bandwidth



The return path capacity is expanded because of the inherently low-noise performance of the MicroNode RFoG system.Low noise comes from three factors

1. Inherently low noise of a passive optical network
2. Noise-squelching properties of the MicroNode return path burst-mode operation
3. Low noise circuitry in CTDI products

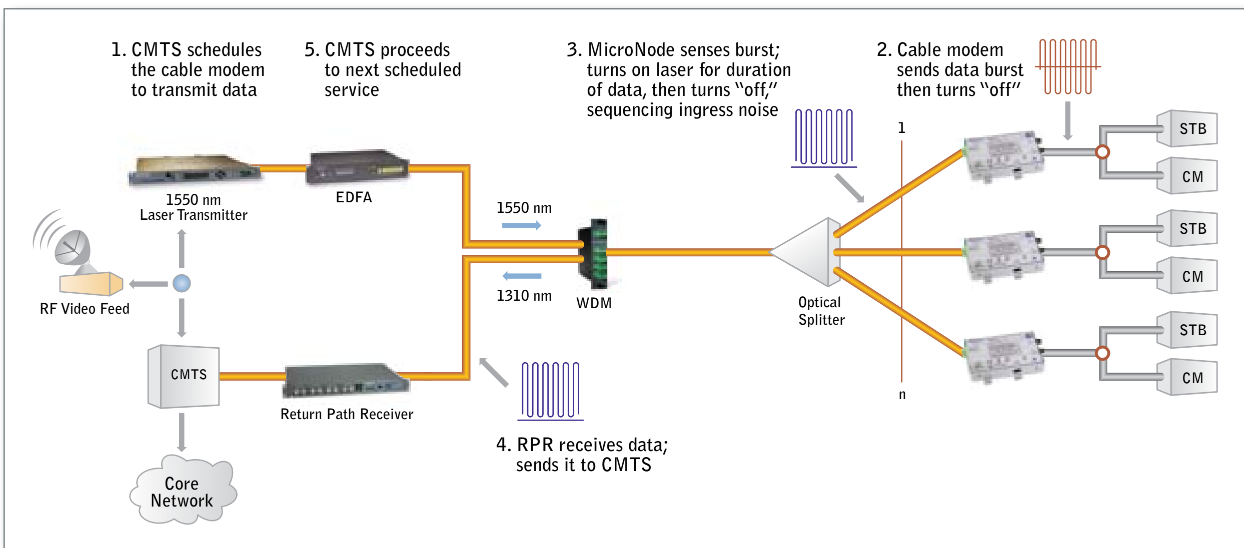
In an HFC network, all of the coax in a subscriber's location is always connected to the network. That invariably includes a number of unterminated points — the coax connectors in a home without a device attached — which act as entry points for noise into the network. Each of these points becomes an antenna, picking up electrical noise from vacuum cleaners, hairdryers, cell phones, fan motors, and the other electrical noise sources in every home and business. Since all of these "antennas" are always connected, noise from every one is added onto the coax plant as ingress noise.

Ingress noise has the most impact in the lower spectrum of the return path band, typically so much that the lower 10MHz (5MHz – 15MHz) is not used for return transmission. CTDI's MicroNode transceivers operate differently, reducing ingress noise so that lower 10MHz can be reclaimed. This 10MHz spectrum increase can be used to offer faster cable modem services or to avoid expensive CMTS expansion.

RFoG accomplishes lower ingress noise by operating in burst mode for return transmission. The unterminated points still exist (just as with HFC), but each subscriber location is isolated from the network by the MicroNode transceiver. "Burst mode" means that the MicroNode is only transmitting when its respective cable modem(s) or set top box(s) are transmitting to the CMTS or STB controller. MicroNode transceivers operate in turn as each cable modem is polled, so only one is transmitting at any given time. When it is not transmitting, the MicroNode transceiver is "off", effectively disconnecting or squelching the noise from every point connected to it. Thus, noise is connected to the network only during the "on" transmission period, and that noise is only from the subscriber's location for that specific MicroNode device.

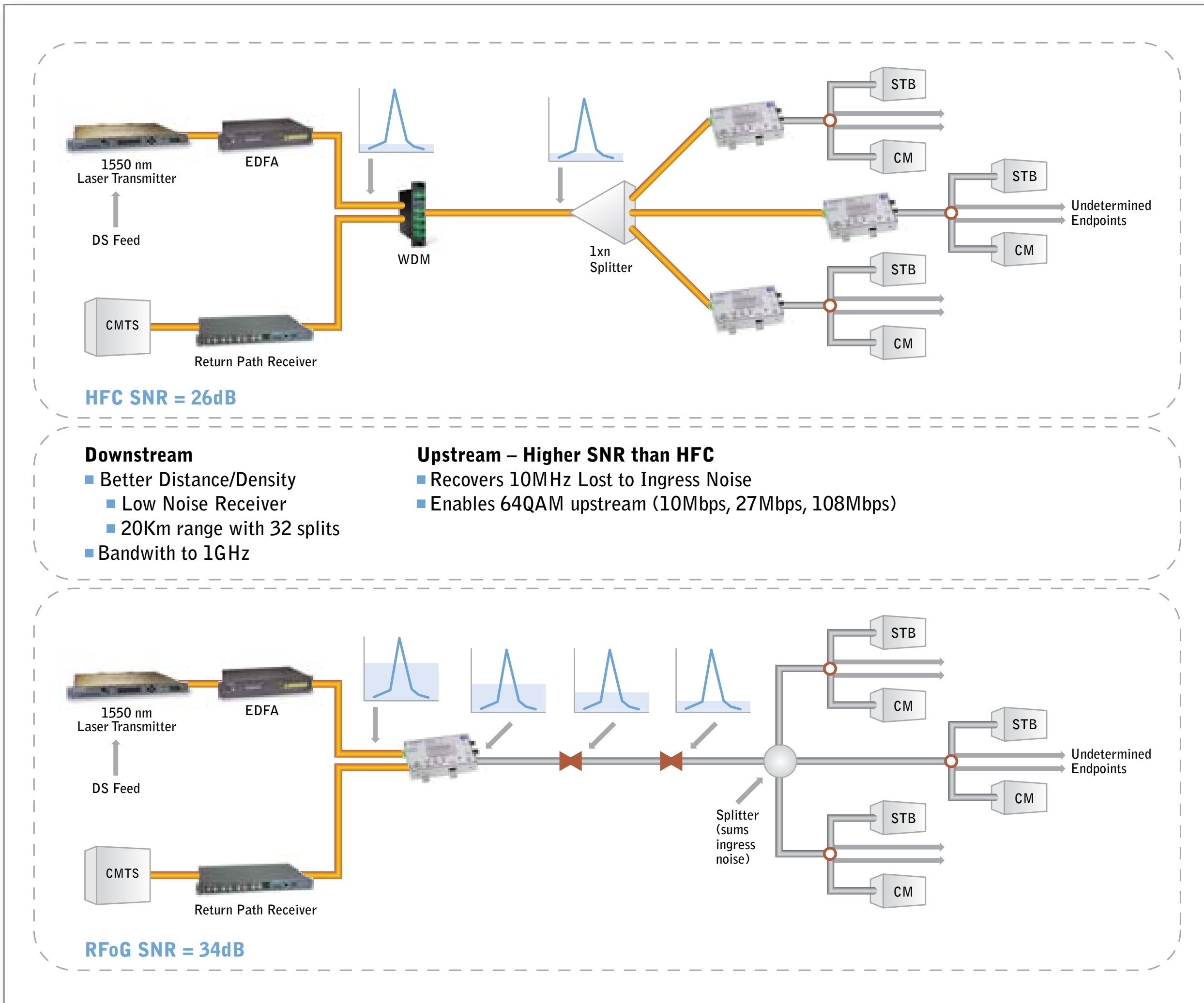
Figure 6 illustrates the burst mode sequence.

Figure 6: Burst Mode Operation Sequence



With HFC, ingress noise from all unterminated points is constantly summed onto the network. With RFoG, noise from only one location is connected to the network at any given time; there is no summing. The result is lower noise operation with RFoG, and that is what enables use of the lower 10MHz of return path bandwidth.

Figure 7: HFC and RFoG Noise Comparison

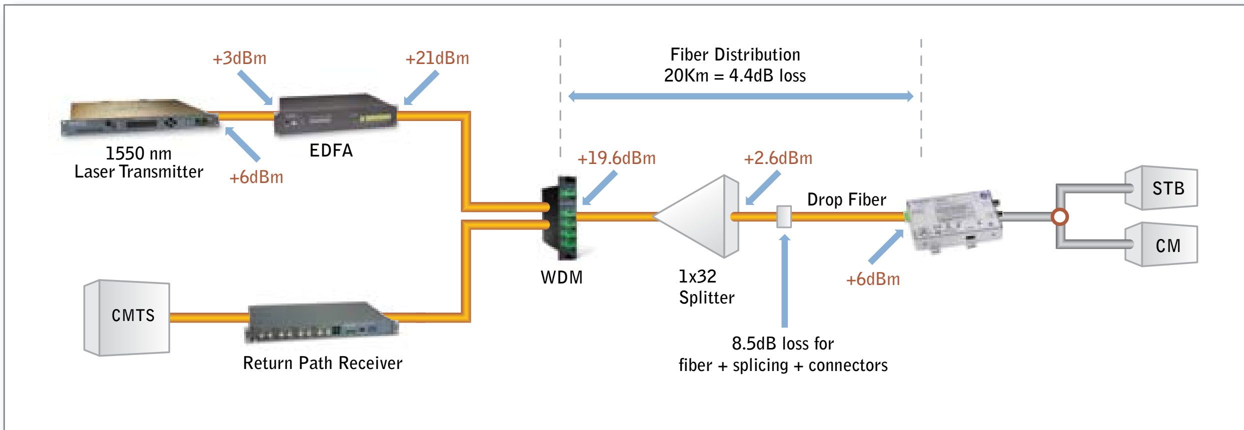


In addition to noise reduction from burst mode, CTDI has designed MicroNode transceivers and return path receivers with low-noise optical circuits. The improvements in an CTDI RFoG network, as noted in Figure 5, are as much as 8dB better SNR (Signal-to-Noise Ratio) than comparable HFC networks.

RFoG is configured as a passive optical network (PON), with standard 20Km reach and 32 splits, and having 28dB optical budget. Figure 6 illustrates typical downstream optical levels in the network.

This RF/DOCSIS architecture delivers all the benefits of PON — minimal fiber requirements, low installation costs, no powering or active elements in the OSP, high bandwidth, and high reliability.

Figure 8: Typical MicroNode RFoG Optical Levels



This network configuration also serves another, and perhaps even more important purpose. It is the basis for adding services with other systems. The HFC/DOCSIS network was built for residential services. It also performs well for SMB (small and medium business) subscribers and low-volume T1/E1 transport. However, there are a number of high-revenue customer applications in which the limits of HFC/DOCSIS become problematic. High speed Ethernet services (200Mbps up to 1Gbps and beyond) such as a data center or ISP might require, high-density wireless backhaul, such as multiple cell towers with 16 and more T1 circuits, and MDU facilities with residential and business subscribers in a single location are three of the many applications that stretch the capabilities of HFC.

With an CTDI RFoG network in place, serving these subscribers with the services they demand becomes much easier. Here is how it is done.

Once the RFoG system is in place, it will look much like the network architecture shown in Figure 7 using 1550nm and 1590nm wavelengths for two-way communication. This system can then be overlaid with a PON system such as CTDI's GEPON products (Figure 8). The PON system uses two different wavelengths — 1310nm and 1490nm — so there is no conflict between the two systems. Both use the same optical network configuration and design rules. The product of blending these networks together is shown in Figure 9.

Figure 9: MicroNode RFoG Configuration

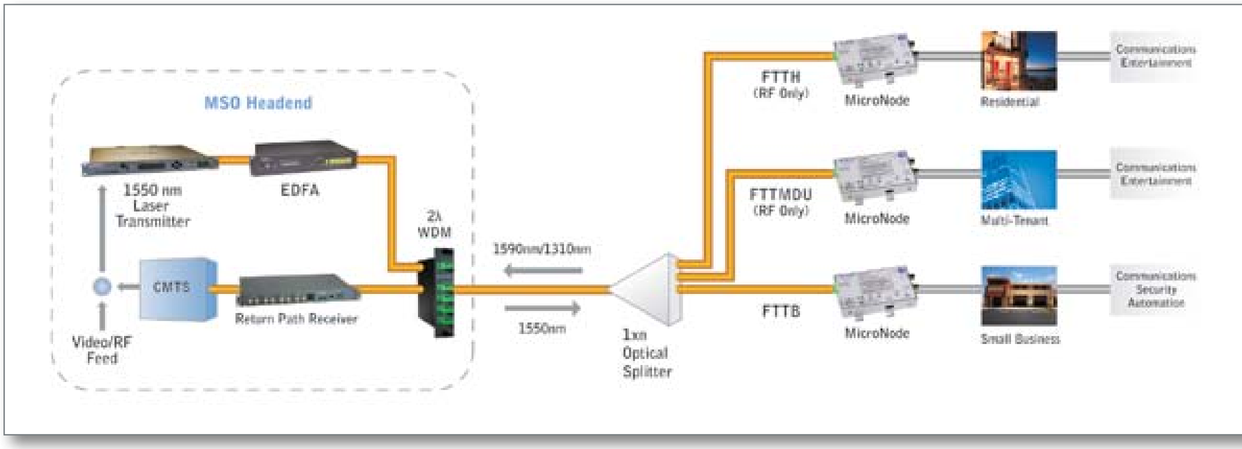
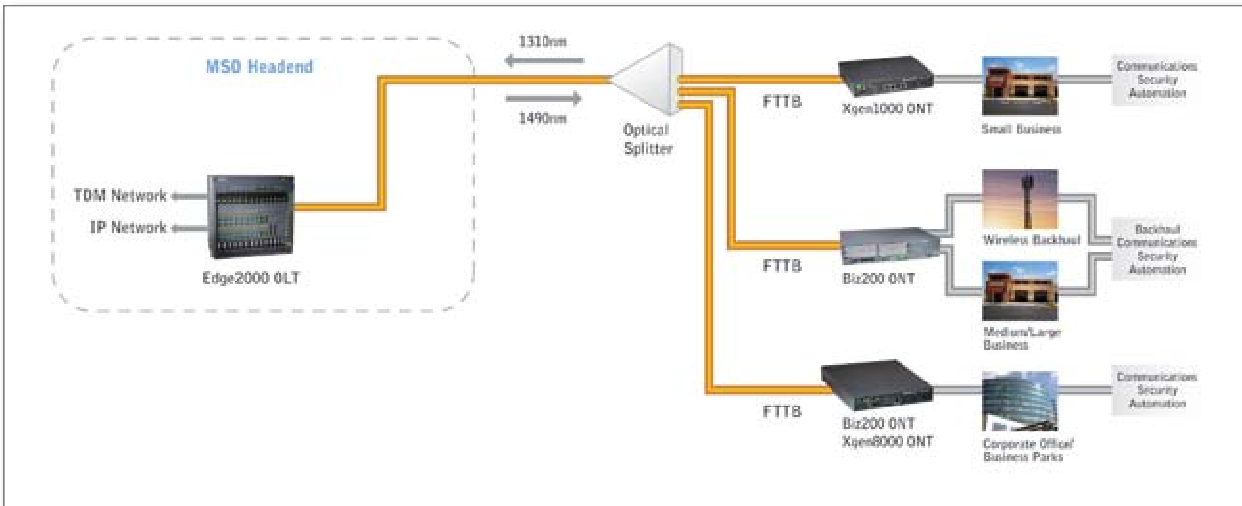


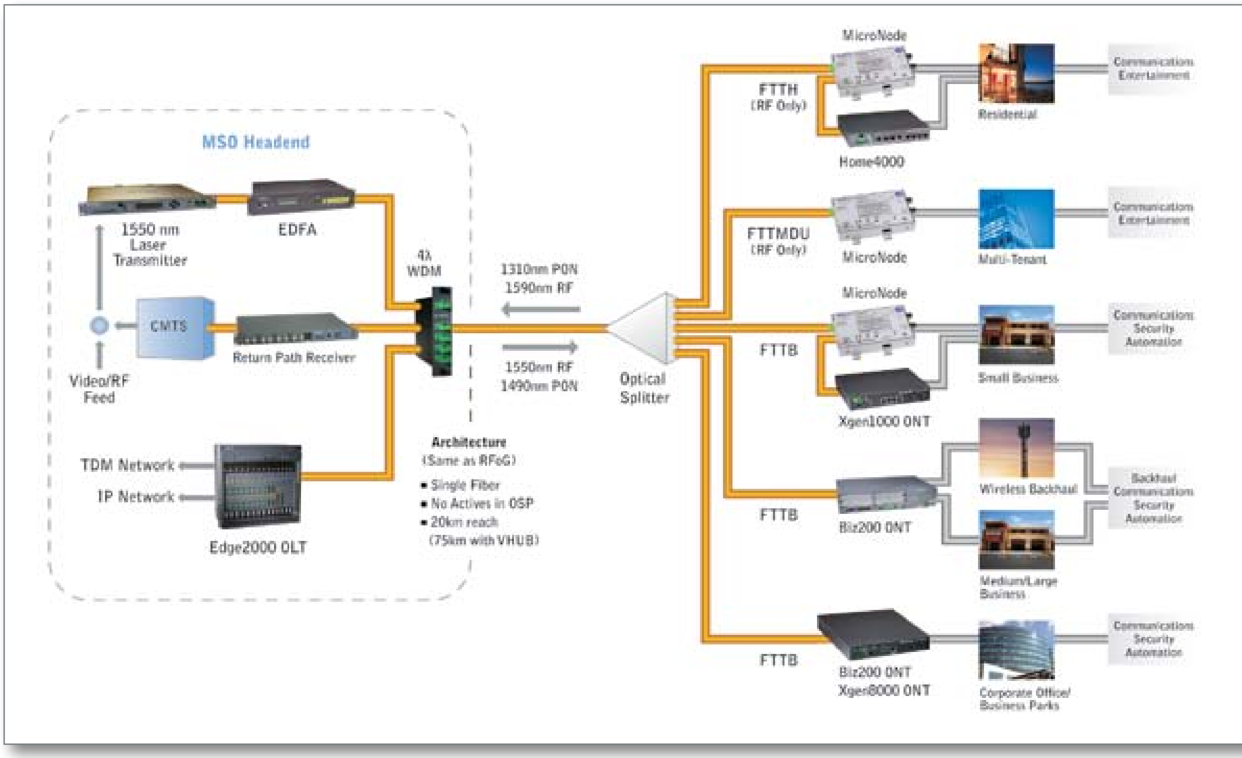
Figure 10: Ethernet PON Architecture



This combined network, which CTDI calls a Hybrid RF PON configuration, supports both RF/DOCSIS-based services plus the full service suit available from PON systems. Along with RF/DOCSIS, CTDI's GE-PON system supports:

- POTS (TDM) voice DS0 services
- TDM – T1/E1 transport with integrated 3-1-0 cross-connect functions
- VoIP – integrated into the ONT, with no separate gateway requirements
- IPTV – with IGMP proxy and snooping implemented at 3 points in the system
- Data – with rates to 1Gbps and 10Gbps per subscriber
- Rich Ethernet services – such as VLANs, QinQ, Hybrid Ports, Designated Services, ESAF, E-line, E-LAN

Figure 11: Hybrid RF PON Architecture



With the Hybrid RF PON in place, RF/DOCSIS-based services can continue when they are the best solution, and the PON system can be used for services that are better suited to Ethernet transport technology. This single access network supports residential, MDU/MTU, SMB, and large or corporate businesses with any service mix. As residential bandwidth needs increase, the RFoG payload can be offloaded to the PON system, avoiding expensive node-splitting, network builds, or other capacity balancing measures.

Beyond RFoG and Hybrid RF PON

An examination of RFoG technology would not be complete without noting one other advantage — the universal nature of the optical network. As shown above, migrating from an exclusively RFoG deployment to a Hybrid RF PON relies on a common optical network architecture. Technologies beyond RFoG and Hybrid RF PON are as yet undefined, but will surely depend on an optical network. For example, DPON, sometimes called DOCSIS 4, is a proposal for next-generation networks that is being considered among the communications industry. It operates with the same fiber optic network configuration that RFoG and Hybrid RF PON require. Once RFoG is deployed, the fiber is in place and need not change. Regardless of the transmission technology, the investment in an RFoG optical network today can be leveraged for tomorrow's systems. RFoG is a powerful solution for today's challenges, and it lays the foundation for transition to future technologies.

Summary

Service providers are increasingly turning to RFoG technology from CTDI to solve the challenges of today's HFC networks. There are many reasons to use RFoG that include both economic and technical advantages. The technical advantages include:

- Increase in downstream bandwidth to 1GHz
- Increase in return path bandwidth to use all return path spectrum; typically 10MHz
- Low noise operation, improving SNR

CTDI's MicroNode RFoG system leverages MSOs current access network investment.
The MicroNode RFoG solution uses existing:

- Headend and Hub Equipment: QAM modulators, laser sources, EDFAs, return receivers, CMTS
- Optical Distribution Network Equipment: WDM couplers, splitters, splicing, connector technology, fiber management Customer Premise Equipment: Set top boxes, cable modems, E-MTAs, wiring
- Operating and Billing Systems – OSS and BSS

Moreover, the CTDI RFoG solution provides a migration path to business services with a Hybrid RF PON configuration, and even to future technologies.

For more information regarding how CTDI solutions can help your business, please contact your local CTDI salesperson or visit www.ctdi.com.

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