What Is Broadband Digital Access?

White Paper

Overview

For more than three decades cable operators have been dealing with the challenges of optical fiber links that use analog intensity modulation (AIM). AIM can take an electrical signal containing a broadband RF spectrum and send it over an optical fiber with a very simple optical receiver that recovers that electrical signal for transmission over a coaxial feeder network. However, AIM has the disadvantages that it requires relatively high optical power, works over only relatively short fiber distances, and the output RF signal power and performance degrade as the optical distance increases.

Digital optical fiber transmits digital data over an optical fiber by varying the intensity of the light to represent 1s and 0s. Compared to AIM, digital fiber can work over much greater distances, requires much less optical power, and the signal quality doesn't degrade as the fiber length is increased over the normal operating distance. What's more, numerous optical fiber applications outside of the cable industry use digital fiber, allowing for economies of scale with respect to hardware cost and performance.

The Rise of Broadband Digital Access Technology

Broadband digital access (BDA) is a new technology developed by AOI as part of the Quantum Bandwidth product group. BDA allows cable operators to take advantage of digital optical fiber performance while providing the same RF services for coaxial feeder plant as conventional analog optics. It utilizes the existing hub infrastructure (routers, modulators, CMTSs, RF combiners/splitters, and other hardware). It also utilizes the existing back-office infrastructure while not requiring massive retraining of the personnel that support these facilities. Furthermore, BDA can provide significantly higher system performance than that obtainable from conventional AIM optical links. BDA technology is a simpler, lower cost alternative to distributed access architecture (DAA).

An Overview of BDA Technology

Broadband digital access uses the same basic technology as digital return. However, this technology has been extended to cover the downstream frequency ranges as well.

A simplified block diagram of the basic BDA technology is shown in Figure 1. Broadband RF is applied to the input of the BDA link. A high-speed analog to digital converter (A/D) converts the RF to a sequence of binary digital words. These binary digital words are then serialized and framed for transmission over a digital optical link.

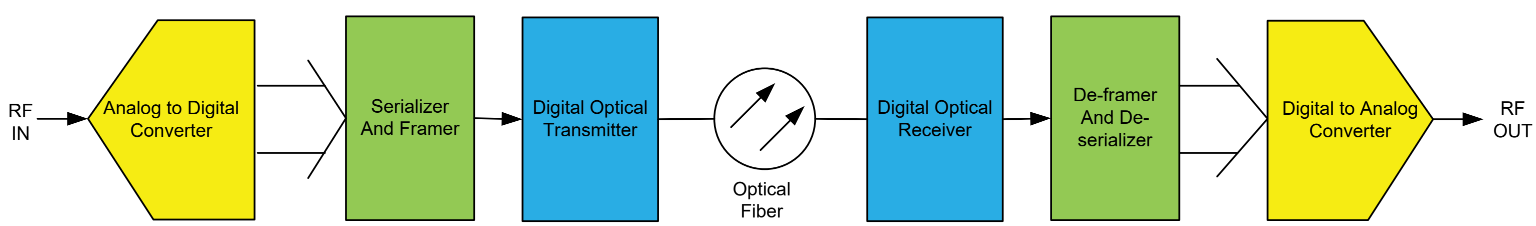

Figure 1. BDA basic technology (simplified)

A digital optical transmitter then sends the digital data over an optical fiber to a digital optical receiver. The received digital data is de-framed, de-serialized and applied to a high-speed digital to analog converter (D/A). The output of the D/A is the broadband RF that was applied to the input.

From an end-to-end standpoint the link appears to be a lossless piece of coaxial cable with broadband RF in and broadband RF out. The link has the advantage over an AIM link that it can operate over much greater fiber distances and at much lower optical power. It also has the advantage that the RF level out is independent of the optical loss. In a conventional analog intensity modulated optical link the RF level out changes as the fiber loss changes. The RF level out of a BDA link is constant and does not depend on fiber length or optical loss.

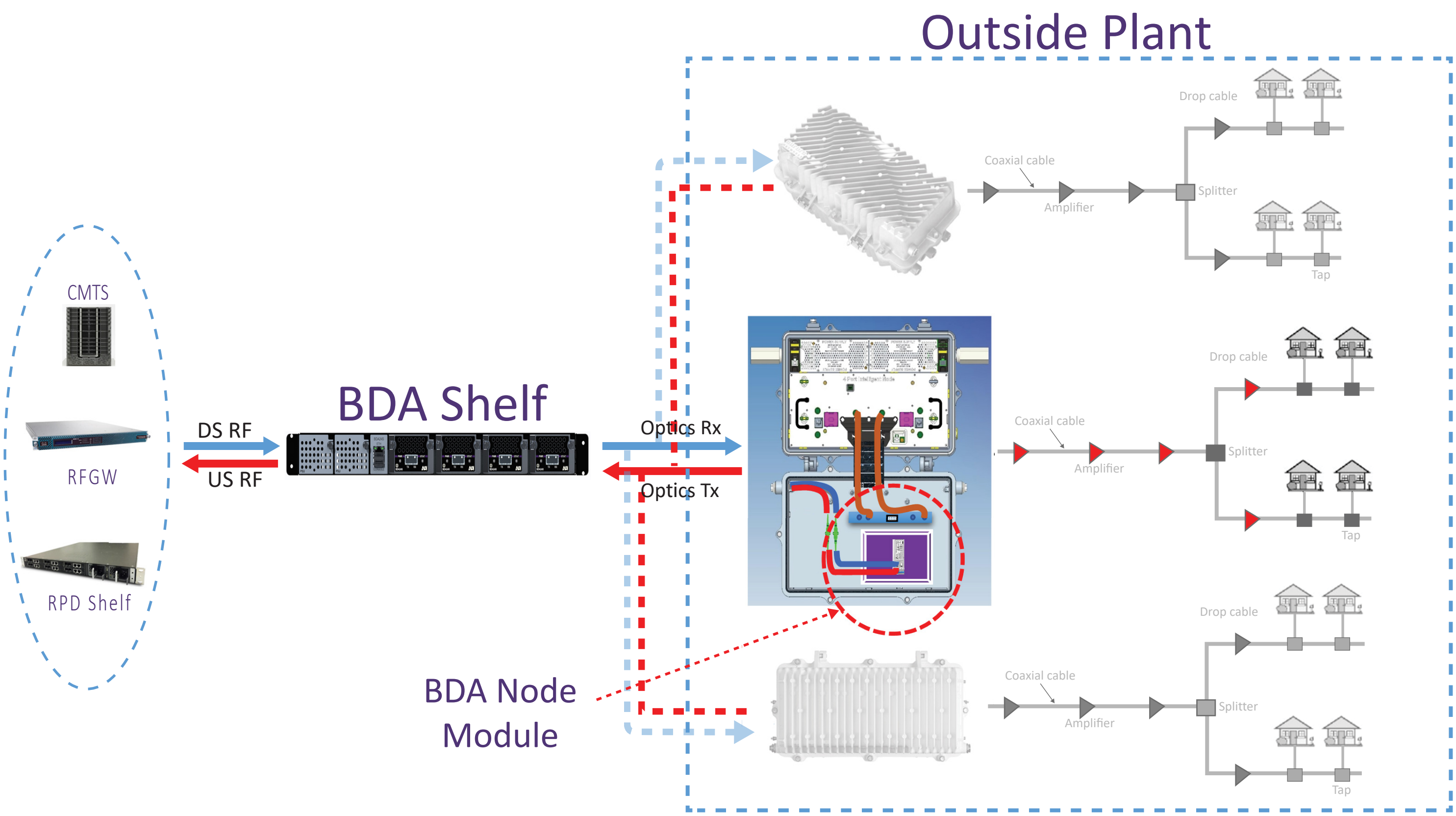

Figure 2. A typical BDA system block diagram

Figure 2 is a block diagram depicting how BDA is used in an entire system. Separate links of the type shown in Figure 1 are used for downstream and upstream. The BDA system consists of a digital access shelf that is located in the hub and a BDA node module. The BDA node module takes the place of conventional downstream optical receivers and upstream optical transmitters and can be configured to fit most nodes. A block diagram of the BDA node module is shown in Figure 3.

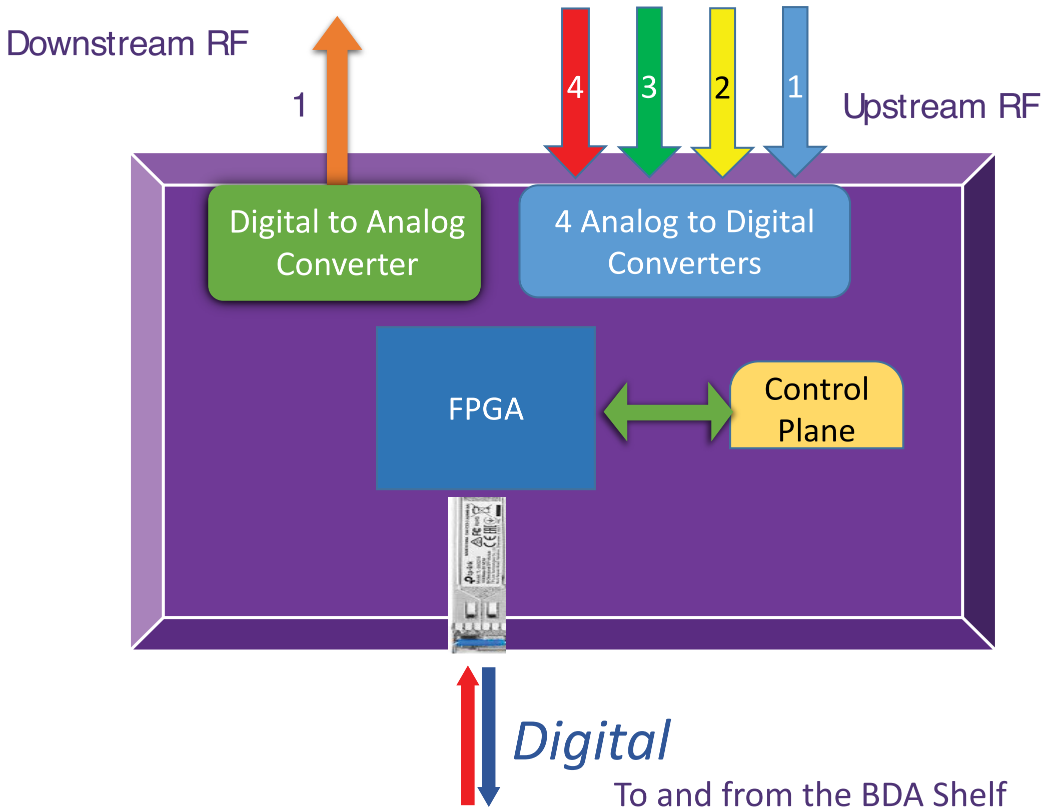

Figure 3. BDA node module block diagram

The BDA upstream can handle up to four separate links of up to 204 MHz in width. These links could support up to four-way node segmentation in the upstream for up to four separate upstream service groups, as illustrated in Figure 4. Configuration of the node upstream segmentation can be done remotely at the hub, if desired.

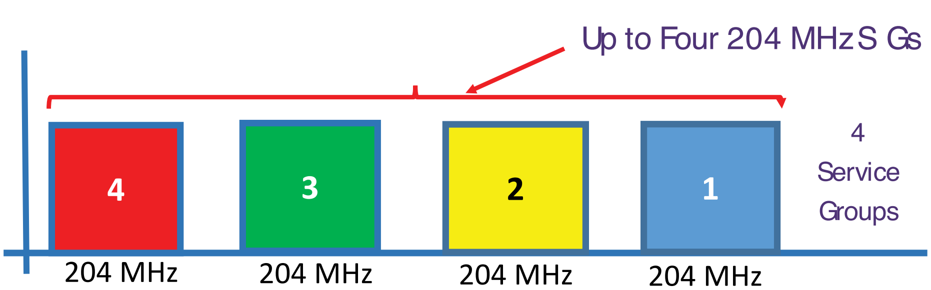

Figure 4. Upstream spectrum

The BDA downstream can support an RF spectrum up to 960 MHz wide located anywhere in the 54 MHz to 1218 MHz range. This is illustrated in Figure 5.

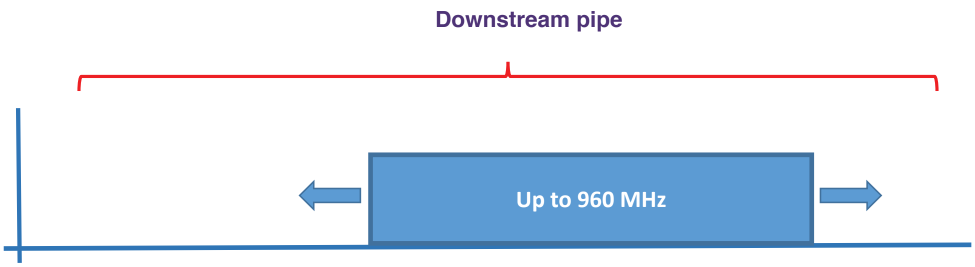

Figure 5 A typical BDA downstream spectrum

An Easy Migration Path

BDA can easily be deployed in an existing legacy plant having a maximum downstream frequency range of 750 MHz and using a subsplit band plan (5 MHz to 42 MHz upstream and 54 MHz to 750 MHz downstream). BDA can easily handle these frequency ranges. In such a case the improved fidelity of BDA with respect to a conventional analog intensity modulated optical link would give significantly improved system performance. MER in the mid-40s can be practically achieved at the node in such a case.

At some point, the downstream spectrum may be increased to 1002 MHz and a midsplit band plan may be adopted (5 MHz to 85 MHz upstream and 108 MHz to 1002 MHz downstream). In such a case the BDA can easily be reconfigured to handle the new downstream frequency range while automatically handling the upstream frequency range.

As a final step, the downstream spectrum may be increased to 1218 MHz and a highsplit band plan may be adopted (5 MHz to 204 MHz upstream and 258 MHz to 1218 MHz downstream). The BDA system is designed for a 204 MHz upstream. The downstream 960 MHz of bandwidth can easily be configured to cover the 258 MHz to 1218 MHz range.

Comparisons of BDA Versus DAA

Broadband digital access has several advantages over distributed access architecture while providing similar performance (MER at the node in the mid-40s). The BDA node module requires significantly less power than a DAA remote PHY device (RPD). Plus, the BDA node module boot-up time is on the order of a few seconds compared to several minutes for an RPD.

BDA does not require any changes to the RF hardware in the hub or hardware in the back office. More importantly, BDA does not require new personnel or retraining of existing personnel in the hub or back-office.

Other advantages of BDA with respect to DAA include:

1. It is operationally simple.
2. There is no need for time sync between devices in the network using protocols like IEEE 1588.
3. There is no need for additional security such as 802.1x.
4. No complex software upgrades are required.
5. There is no need for additional onboarding, provisioning and monitoring of devices.
6. It is a more cost-effective for many systems compared to DAA.

Migrate From Analog Optics to All Digital Optics

Broadband digital access allows a cable operator to migrate from analog intensity modulated optics to all digital optics while using the existing RF hardware in the hub and with existing nodes. Hub and back-office personnel are unchanged by the migration process. Performance is obtained that is comparable to DAA without its operational complexities and challenges.