ENABLING TUNER TECHNOLOGY FOR ALL-DIGITAL CABLE TV NETWORKS

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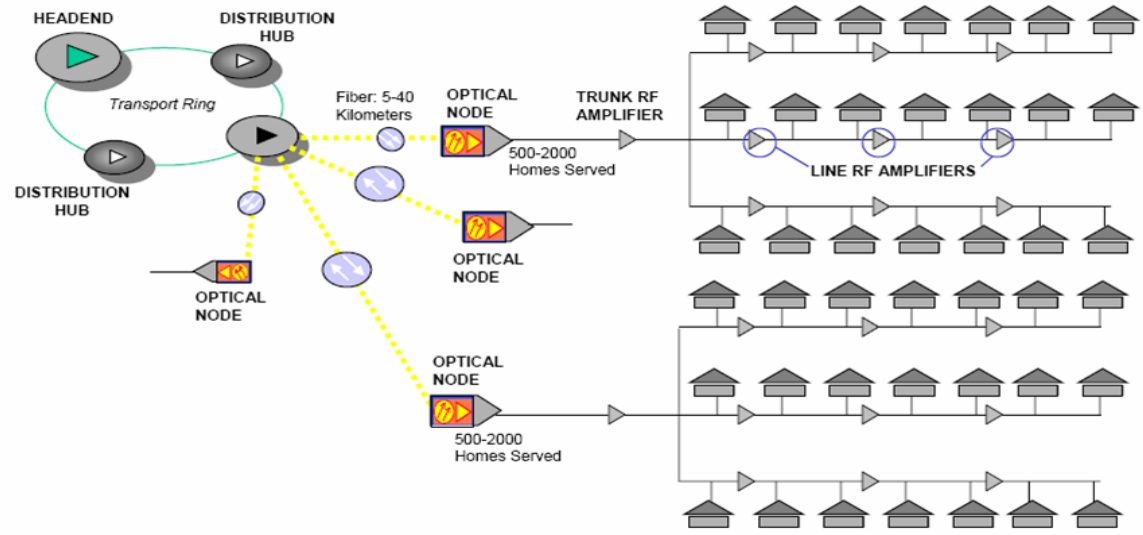
Global uptake of digital TV and increasing market pressures from alternative services are making cable television operators rethink their delivery of broadband. Particularly across North America, operators are rapidly deploying competitive services in order to retain customers and attract new ones. To achieve this, cable multiple service operators (MSOs) are looking for new or enhanced technologies. Those under consideration include: switched digital video, 1-GHz systems, node splitting, wider Internet Protocol (IP) pipeline, and multimedia home networking solutions. Over the long term, they are also looking to move to all digitally modulated or "digital" cable networks and reconfigure the old analog spectrum in their networks to deliver even more digital and high-definition channels. For the set-top box, the move to 1GHz and an all-digital infrastructure will require a space-saving, cost-effective tuner solution that delivers the performance required by next-generation systems.

A NEW MODEL

For years, North American cable operators have deployed services using a hybrid fiber-coax model (Figure 1). This model primarily uses a fiber-optic network from the headend (the source of programming and stored video-on-demand files) which connects to distribution hubs. From the hubs, the network optical fiber connects to optical nodes. The downstream signal is a radio frequency modulated signal that typically begins at 50 MHz and ranges as high as 1000 MHz. Coaxial cable runs from the node through a neighborhood and into homes (about 90% of North American homes are wired with coaxial cable). Each optical node supports about 25 to 2000 homes, with 500-1000 homes typically serviced per node today.

Figure 1: Typical hybrid fiber/coax network

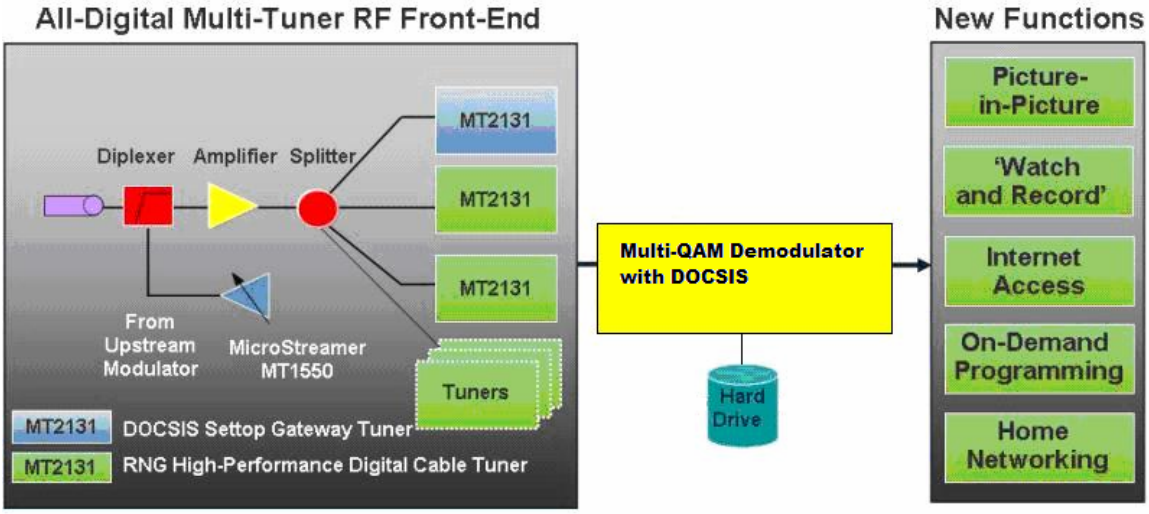


When these hybrid fiber/coax networks were first deployed, they used analog transmissions from 50 to 550MHz to broadcast all of the channels to the home. These systems were capable being upgraded to support transmissions up to 750MHz or, in some cases, even 860MHz. As cable network offerings expanded, MSOs have used this spectrum to deliver digital TV signals. Digital modulation is much more efficient than analog (meaning you can provide more channels in the same amount of bandwidth). Now, many MSOs are looking to expand their networks up to 1GHz, which will mean new changes to the infrastructure.

Once these additional digital channels are available, many MSOs are planning to go back and reconfigure the 50- to 550-MHz analog spectrum into signals using digital modulation. There will be considerable expense to perform the conversion and deliver an "all-digital" cable network, but the benefits can be significant. For instance, in a 6-MHz channel (US), an analog system can deliver one channel. With digital modulation, signals are broadcast in a highly-condensed format, making it possible to deliver up to10 standard definition channels or 2 high-definition channels in the same 6-MHz channel.

In addition, if several MSO's systems convert to an all-digital network architecture, then they could conceivably standardize and link their networks together to improve efficiency and generate new revenue from shared content provided to subscribers. This could be particularly valuable for video on demand (VOD) applications, eliminating the need for duplication between systems (networks) for rarely-accessed offerings. Moving to an all-digital network would require a digital set-top box or digital TV for each customer. Figure 2 shows the block diagram for a digital set top which can support regular channel programming as well as picture-in-picture, watch and record PVR functionality, Internet access, and on-demand programming. In-home networking can also be configured to interface with this architecture.

Figure 2: Block diagram example for a digital set-top box



INDUSTRY-RECOGNIZED REQUIREMENTS

In order to allow these digital networks to share content, industry standards are required. Comcast, North America's largest MSO, has released new standards, known as Comcast RNG (residential network gateway) that addresses all-digital set-top box requirements.

> ***RNG 100:*** Bare-bones set-top box targeted for low-end, standard-definition (MPEG-2) TV. These set tops basically just receive and display a digital channel on the TV.
>
> ***RNG 200:*** For multi-tuner HD/DVR set-top boxes. The multi-tuner, high-definition (MPEG-4) TV set-tops offer two-way communication, allows watch and record, DVR, and picture-in-picture, among other features.
>
> ***RNG 1000:*** High-end specification for "converged CPE" media centers with on-board MPEG-4 and HD technologies. Complementary to these set-top box specifications, the Society of Cable Telecommunications Engineers (SCTE) has released an all-digital cable network interface standard, known as SCTE-40 that defines the characteristics between the cable network plant and the set-top box. This is the recognized industry standard for digital network quality. Accordingly, suppliers of components for a digital set-top box must comply with this network interface standard. For the tuner, linearity is an important specification for compliance. Linearity has to do with the ability of a device to reject unwanted signals in order to minimize distortion of the signal.

All of the above standards have been recognized and adopted by CableLabs®, which will test the digital set-top boxes and network hardware to these standards.

REQUIRED TUNER TECHNOLOGY

Tuners for all-digital cable networks need to have a wide intermediate frequency (IF) bandwidth, superior linearity to comply with SCTE-40, and the ability to handle frequencies up to 1GHz. For some applications such as embedded multimedia terminal adapters (EMTAs) with battery backup, which are used in Voice over IP (VoIP) systems, the tuner must have low power consumption to conserve battery and thereby lengthen talk time in the event of a subscriber's power outage.

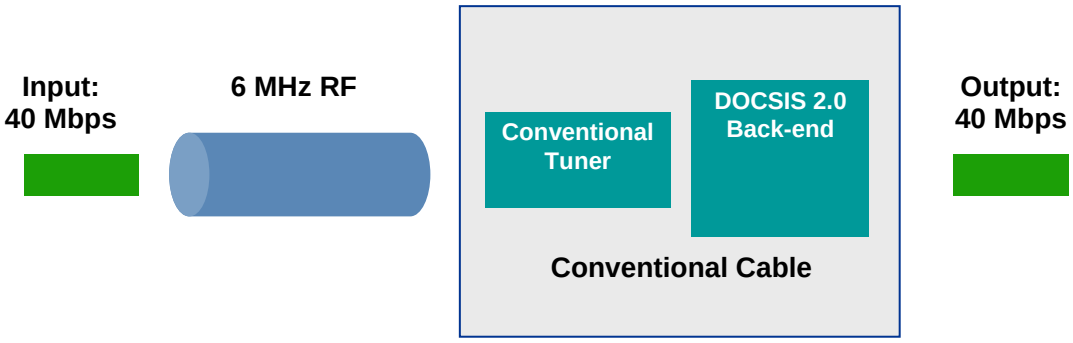
IF Bandwidth

In a digital cable network, MSOs expect that consumer use of bandwidth and downloadable services will increase. As the popularity of video-on-demand (VOD) grows, and as video inventory expands due to shared digital networking with other MSOs, the need for high-speed downloading will be crucial to the success of cable services versus alternative technologies.

The cable industry has responded to this need for increased data rates by developing the DOCSIS® 3.0 specifications. One new feature in DOCSIS 3.0 is channel bonding, which was

necessary in order to enable the use of multiple channels simultaneously. Conventional cable systems in the U.S., for instance, use 6-MHz channel bandwidths (Figure 3). In contrast, new digital systems use channel bonding to deliver bandwidths ranging from 64MHz up to 96MHz. For the tuner, this means that the wider its IF bandwidth, the fewer number of tuners will be required to accomplish channel bonding.

Figure 3: Conventional North American DOCSIS 2.0 and earlier cable modem



Early implementations used multiple tuners and demodulators to enable the multiple bonded channels in DOCSIS 3.0 (Figure 4). However, this was not a cost, power, or space efficient approach. Microtune responded to this new need with its MicroTuner™ MT2170 tuner, which is equipped with an industry-leading 96-MHz IF bandwidth (Figure 5). With an MT2170 tuner, a cable modem can download at 160Mb/s as compared to roughly 40 Mb/s downstream in a DOCSIS 2.0 modem. In a real-world application, this broader pipeline translates to a movie downloading in a matter of seconds as compared to minutes/hours. In commercial applications, the MT2170 enables the efficient transfer of video presentations and extremely large data files.

Figure 4: Channel bonding using conventional architecture

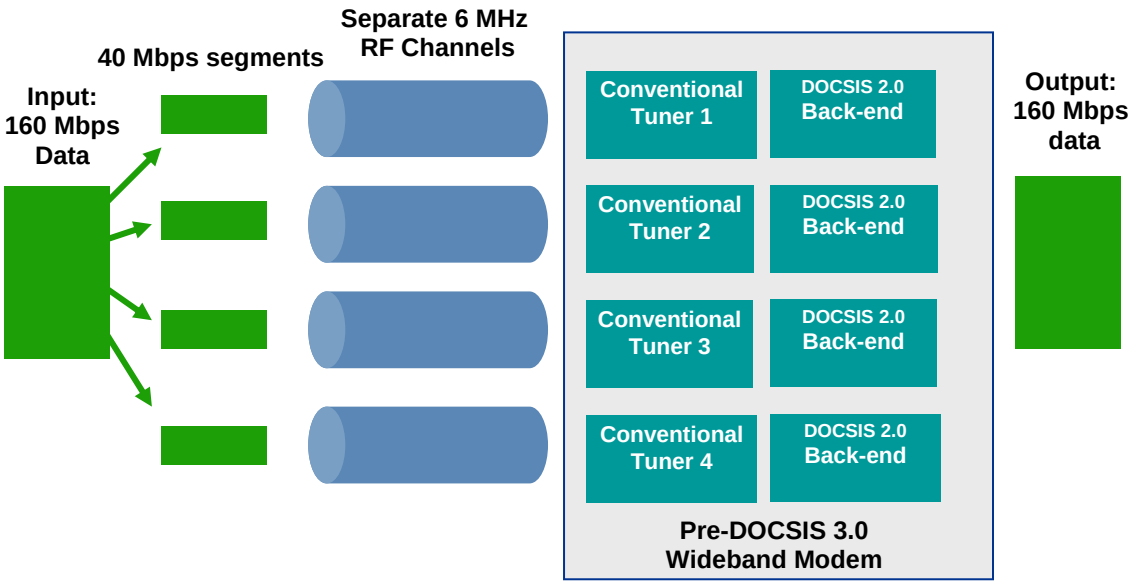
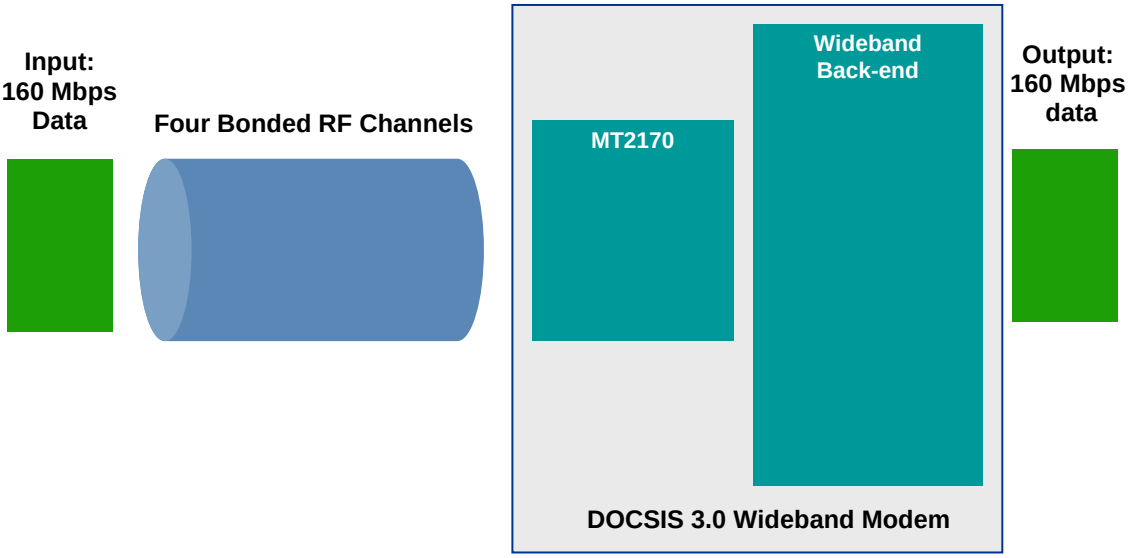


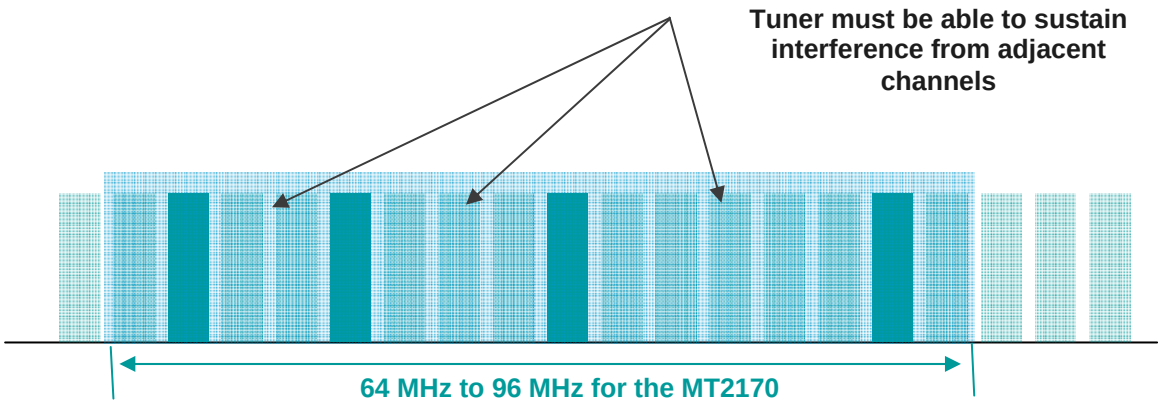
Figure 5: Channel bonding using MT2170 tuner



Wideband Tuners

Most MSOs will likely move to 1-GHz systems as a first step before taking their networks completely digital. This means that the tuners in digital set-tops must be able to detect and clearly tune channels in frequencies above the traditional 750- or 860-MHz spectrum. To support the 1-Ghz bandwidth, the set-top box either requires multiple narrowband tuners or a wideband single tuner implementation. To be successful, the wideband tuner must withstand the adjacent channel interference that occurs in non-contiguous channel bonding (Figure 6). Microtune's MT2170, for instance, was particularly designed for DOCSIS 3.0 wideband applications and it features excellent in-band flatness; the MT2170 tuner handles highly compressed digital data in the presence of noise and strong adjacent channel interferers. In addition, it maintains low output distortion even with high output levels.

Figure 6: MT2170 adjacent channel interference for non-contiguous channel bonding



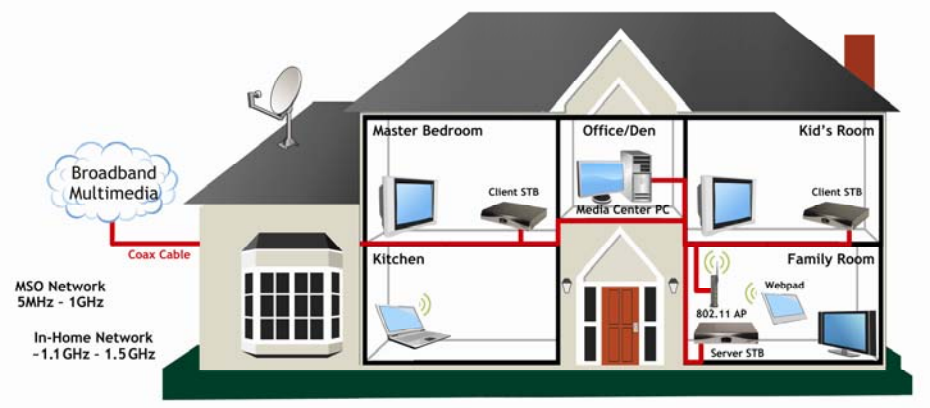
Power Consumption

One of the challenges of VoIP systems is the need to deliver phone service during a power outage. The industry has moved toward the use of EMTAs, which allow consumers to simply plug a phone into the back of a cable modem to enable VOIP service. The EMTAs have built-in batteries so the phone continues to operate during a power failure. By using tuners that are optimized for low-power consumption MSOs can extend the time customers will have phone access in these circumstances.

Future of Digital CATV

In addition to wider bandwidths, more digital channels, and faster download speeds, the future of digital cable is also includes in-home networking. The Multimedia-over-Coax-Alliance (MoCA) specification is an open, industry-driven initiative that seeks to advance the distribution of digital video and entertainment using existing coax in the home. This technology aims to provide the backbone for "whole-home entertainment networks" consisting of multiple wired and wireless products. MoCA allows end users to transfer their personal video, data, pictures, etc. from one consumer electronics device (such as a PVR set-top box, PC, or DVD recorder) to another within the home using existing coaxial cabling, as reflected in Figure 7.

Figure 7: Whole Home Entertainment and Communications Networks



Even when cable systems extend to 1-Ghz, MoCA networks will still need to interface seamlessly. The challenge in an in-home network application is that if data moves around the house at the same frequency as incoming cable signals, it can collide and interfere with video streaming, downloads, etc. The MoCA in-home network solution can be limited to a frequency range of approximately 1.1 to 1.5GHz. Microtune has developed tuners (MT2122 and MT2022) with a shifted local oscillator (LO) frequency up to 1.69 GHz which is outside the MoCA frequency range.

We can expect that the digital set-top box of the future will continue to have multiple tuners. While the set-top box will have a single wideband tuner for the 1-GHz bandwidth of digital channels, additional tuners will be required for PVR recording, programming guides, network messaging, and other functions. With multiple tuners in a set top, it is imperative that they have good isolation in order to avoid unintentional crosstalk between the tuners, which could cause pixilation on the TV screen or loss of signal.

Microtune Responds to Advanced Cable Needs:
Long an active player in the cable market, Microtune participated in CableLabs' DOCSIS 3.0 specification development and served on the DOCSIS 3.0 committee to define the specification. Its CATV portfolio is already broad, and the company continues to develop the necessary tuner technologies serve future needs of this market. Current offerings for digital CATV applications include:

- **DOCSIS® 3.0 Wideband Tuners for Cable Modems:** The MicroTuner MT2170 enables a wider (96 MHz) and faster (160 Mbps) pipeline into the home, enabling cable operators to compete with Telcos for wideband services: faster Internet, video downloads, and commercial services;
- **1-GHz Low-Power Tuner for VoIP Cable Modems:** The MT206X series of silicon tuners expands network capacity and reduces power consumption for battery-backed cable equipment;
- **1-GHz SCTE-40 Compliant Tuners Meet RNG Spec Requirements:** Set-top box tuners like MT2121/MT2122, MT2011/MT2022, and MT2131 provide high linearity to meet MSOs' network requirements;
- **1-GHz Cable Tuners Compatible with MoCA™ Home Networking Standard:** The MT2122 and MT2022 tuners enable cable set-top boxes and residential home gateways to support bandwidth-intensive video and home networking services.