State of the Art – December 2002
By Chip Morgan, President – CMBE, Inc.
2072 words
==========

# HD Radio Primer

Here's a quick overview of the state of digital radio and how it affects you today. iBiquity Digital's HD Radio™ technology (formerly known as IBOC) allows AM and FM broadcasters to transmit digital quality audio alongside today's analog-based broadcasts. Consumers will receive these enhanced broadcasts with "radically improved fidelity" and future on-demand interactive audio and wireless data services, including traffic reports, weather alerts, breaking news, sports highlights, market updates, radio program information and much more.

If you haven't been paying attention to the details of HD Radio, now's the time you'll have to start. You'll be asked for your opinion and to make recommendations about what to do about it, now that the FCC has approved it on an interim basis for digital radio in the USA. The technology includes the transmission of digital signals simultaneously with existing analog audio signals in both the AM and the FM systems. The digital signals are broadcast at low levels on the upper and lower edges of the analog signal. The digital signal is designed to be very robust where interference is received from other digital stations or adjacent analog stations. Unfortunately, there is no mechanism for increasing the robustness of the analog signal in the new plan, except by converting to digital. In fact, as more and more stations change to digital, analog stations will receive increased interference from adjacent channel stations.

Digital radio will be phased in over a period of time, starting with the hybrid mode, which maintains the existing analog signal, and combines it with a low level digital signal in the analog sidebands. Over time, the channels will become more digital in the "Extended Hybrid Mode," and then fully digital in the "All-Digital Mode," when analog audio will be discontinued. Unlike digital TV, digital radio has no mandatory schedule for the conversion at this time.

As in all compressed audio delivery systems, there is considerable digital signal processing latency, so listening to the full digital signal will include a long delay in transmission. In order to achieve the instant tuning that radio listeners expect, the first audio heard from a new digital audio station will be analog, and then it will blend to the digital signal after the digital signal is acquired. The reverse process occurs at the edge of the digital signal coverage so that the audio blends to analog as the digital signal fades. This reduces the "cliff effect" when digital signal is lost. When the system is fully digital, a low bandwidth digital signal will change to a higher bandwidth signal under the same conditions.

The AM and the FM digital signals are modulated using Orthogonal Frequency Division Multiplexing (OFDM), a parallel modulation scheme in which the data stream simultaneously modulates a large number of orthogonal subcarriers. The composition of the digital subcarriers can support several configurations, so that the system can provide data services, various audio formats and low bit rate audio. The AM digital signal uses Quadrature Amplitude Modulation (QAM) on each OFDM subcarrier.

## The FCC Rules

Recent action by the FCC authorizes immediate interim HD Radio operation for AM and FM stations. All stations wanting to go digital during the interim period while the FCC develops the official rules for digital radio must apply for a Special Temporary Authorization (STA). The FCC expects that by January 2003 a simple letter with specific information will be all that is required, much the same as the change from mono to stereo (on FM) was handled many years ago. In order to transmit HD Radio, stations not already testing with IBOC must notify the FCC of the following information: The date planned for commencement of HD operation; a certification that the IBOC facilities conform to the iBiquity hybrid specifications; the name and telephone number of a technical representative; transmitter output power; a certification that analog ERP remains as authorized; a certification that the interim operation would not cause humans to receive excessive RF radiation; and, if applicable, any power reduction in an AM station's primary digital carrier.

## How It Affects You Today

If your facility has modern equipment, conversion to digital may be as simple as adding a digital exciter and notifying the FCC that you're on the air in digital. Some stations may need a minor modification of existing equipment, and others may need new transmitters and combining systems. Approximate costs for conversion to digital are estimated to be between $30,000 and $200,000. Power costs will increase slightly for a low level combined system. They may increase substantially for a high level combining system. If your station currently uses bit reduced audio compression for storage of audio or in the STL system, quality problems may arise in the conversion to digital transmission. As a general rule, bit reduction should be avoided when possible or used with great caution.

## The Transmitter

There are two methods of transmitting the hybrid analog/digital system -- the low-level combining system and the high level combining system. AM systems generally use low-level combining. High level can be used in theory, but due to the nature of the modulation scheme, the phase relationship between the digital and analog signals must be maintained. FM systems can use either low or high-level combining. Low-level means that the combining occurs at the exciter level, with an analog and a digital exciter combined into the power amplifier, and then to the antenna. If a recent transmitter is in place with flat response across the baseband and adequate

power to handle both analog and digital, it may be able to be converted to digital under the low-level combining plan.

High-level combining means that the output of a full power analog transmitter and the output of a full power digital transmitter are combined and fed to the antenna. Low-level combining on FM may require the replacement of the transmitter and the addition of the digital exciter, or in a high-level system, a new analog and a new digital transmitter may be required. In a high-level FM system the analog transmitter needs to run about 10 percent higher power to compensate for the typical 0.5dB loss in the high level combiner. The digital combiner loss is about 10dB or 90 percent of digital power. The digital transmitter runs at –20dBc below the analog power. AN FM station with an analog TPO of 10kW would have a digital carrier power of 100 watts. Assuming typical combiner loss, the analog transmitter would need to run at 11.1kW and the digital transmitter would need an average power of 1kW. The digital transmitter will also need to be sized to accommodate an additional 5.5dB for Peak to Average Ratio (PAR).

Keep in mind that, unless low-level combining is used, it is likely that the transmission system will have higher electrical power requirements, higher heat output (requiring more building cooling capacity), and will require more floor space in the transmitter building.

## The Antenna

Stations must use their authorized antenna systems for transmitting the digital portion of the IBOC signal. FM stations can use their existing FM antenna if it can handle the power and has reasonable bandwidth. Most existing modern FM antennas will meet the requirements. AM antennas that are broadband enough for AM stereo will probably work for HD radio. Note that AM stereo and AM digital are not compatible. For FM stations, there are several possibilities for alternative antenna systems, such as using spatial separation between analog and digital antennas to provide the minimum 40dB of isolation required; or any other means of isolating the analog and digital transmissions, but none is currently authorized by the FCC pending further testing and consideration. AM stations must use low level combining during the hybrid phase while analog and digital are being transmitted. FM digital stations will be able to use on channel digital repeaters to fill in areas where coverage is poor due to terrain.

## Audio Issues

Stations are currently required to broadcast the same material in both analog and digital. There is a long delay in the audio for HD radio – approximately 8.4 seconds. The analog audio is delayed so that there is buffering time in the receivers for the digital signal. iBiquity has a new digital audio file format based on its Perceptual Audio Coder. Called .PAC or "dot PAC," it's for emerging trends in digital music distribution including copyright protection technology. The company says that the

format will provide the music industry with a tool for the management and protection of digital music content. Most of the well-known audio degradation which occurs in propagation of analog AM and FM transmission will be replaced with new forms of audio degradation that are expected to be less noticeable to the general public.

The audio bandwidth control in the AM system allows analog audio to be broadcast using either a 5kHz bandwidth or an 8kHz bandwidth. The 8kHz bandwidth reduces the robustness of the digital signal in the presence of second adjacent interference. The AM digital audio is 20.2kbps plus 16.2kbps on a second, less robust channel that is intended for providing stereo information for a total of 36.4kbps under optimal conditions. The FM system digital audio is 98.4kbps.

## Interference Issues

Because the system places digital in the sidebands of both AM and FM systems, it is the nearest adjacent channel stations that are broadcasting in analog which will be affected most by new stations adding HD Radio transmission. AM stations that are concerned about causing interference to adjacent stations may reduce the digital carriers to 6dB below nominal power. Pending additional testing of nighttime AM IBOC, AM stations are only allowed to transmit digitally during daytime hours.

## The Future

IBiquity's Perceptual Audio Coder for PAC technology uses psycho acoustic modeling to interpret human hearing and eliminate redundancies and irrelevancies in the audio signal. It is a form of digital compression that will be promoted for IBOC implementation in other devices, such as satellite radio, Internet broadcasting cellular telephony and other applications. Presumably if it is well accepted for terrestrial broadcasting in the US, it will be used more widely in the rest of the world and in other complimentary and competing technologies. If PAC technology becomes dominant in satellite and Internet broadcasting, one can envision a universal radio broadcasting standard with common receivers and large geographical coverage with local capabilities.

## How To Protect Your Coverage

If your station is not going to change to digital soon, you'll want to keep an eye on your neighbouring channels. AM stations especially need to watch the first adjacent stations above and below their frequency. If those stations go digital, you'll be receiving new interference and you'll want to request that they run at the reduced digital level allowed by the FCC to minimize first adjacent interference. If you don't ask, you may not receive the benefit of this. FM stations don't have that possibility, and will have to live with interference from adjacent channel digital stations. To protect your coverage, now is the time to make those long-delayed improvements in

your transmission system, and even if you never plan to go digital, you're now living in a digital radio world.

## Summary

Stations are allowed to transmit in HD digital effective immediately (with FCC notification), but many decisions have to be made about how and when to implement the system. For AM stations, the changeover can be fairly straightforward. Assuming the existing transmitter is solid state or PDM technology, and the antenna system is relatively broadband, an exciter replacement is sometimes all that's needed to go digital. FM stations can use high level or low level combining systems. Each method has advantages and disadvantages. Both AM and FM digital stations should use linear audio storage systems and STLs so that the best audio quality is transmitted. The transition to digital for radio has been designed to require minimal regulatory burden for the FCC, to allow broadcasters to utilize much of their existing plant, and to allow a backward and forward compatible system for consumers. Stations that have current technology will find the transition fairly inexpensive and straightforward. Stations that need upgrades should plan carefully to maximize their return on investment in existing and new equipment.

==========

Chip Morgan's company, CMBE, Inc., provides high performance support and services to broadcasters worldwide. For more information, please visit www.cmbe.com.