What's The Difference Between Satellite Radio And HD Radio?

Electronic Design
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If you like to listen to the radio, you have a few choices. There's AM and FM radio, as well as satellite and HD radio. Satellite and HD Radio both are digital forms of broadcast radio, but they're very different.

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Background

Broadcast radio continues to be primarily an analog venture, at least in the U.S. Thousands of analog AM and FM radio stations broadcast daily to millions of radios across the nation. On the other hand, TV started as an analog technology but is now only available in a digital format, at least in the U.S. In 2009, the original NTSC analog TV systems were shut down in favor of the ATSC 8VSB digital television standard now implemented in all U.S. TV sets.

Ironically, less than 20% of U.S. homes get their TV over the air using this standard. Most homes have cable or satellite TV, both of which today are primarily digital as well. Analog radio has persisted because it's "good enough" as is and still making money for its stations. Yet digital radio has finally emerged in several forms, namely satellite radio and HD Radio. Both are widely available but neither has fully replaced analog AM and FM.

The impetus for the development of digital broadcast radio is multi-faceted. The state of digital and modulation technology made it possible, providing a "just because we can" factor. More important is the incentive to improve broadcast quality and reliability. AM radio is heavily affected by noise. Lightning,

power lines, and other noise sources have always degraded AM performance on all but the most powerful stations. For FM radio, noise is less of a problem but multipath fading and shorter range have also caused quality problems.

All of these issues diminish considerably or go away completely when digital techniques are deployed. Furthermore, sound quality is improved thanks to the ability of digital methods to transmit higher audio frequencies in a limited bandwidth. The added benefit of multicasting, transmitting multiple broadcasts simultaneously in the same channel, has also made digital radio a popular favorite.

Two separate digital technologies emerged in the early 2000s to greatly improve broadcast radio: satellite radio and a terrestrial technology known as HD Radio.

HD Radio

HD Radio does not stand for high-definition radio. It is just a brand name of the iBiquity Digital Corporation, the inventor of the HD Radio technology. The Federal Communications Commission (FCC) blessed the company in 2002, authorizing it as the digital radio technology of the U.S. It has taken years for the technology to develop, but today it's widely available. It's present in both the AM and FM bands in the U.S.

HD Radio uses the same spectrum now occupied by the standard AM and FM bands. The same stations broadcast the digital component simultaneously with the analog signals. The AM spectrum extends from 535 to 1705 kHz, and FM ranges from 88 to 108 MHz. In addition, the digital signals do not replace the legacy analog AM and FM signals. Instead, the digital signals form an overlay to the existing station frequency assignments.

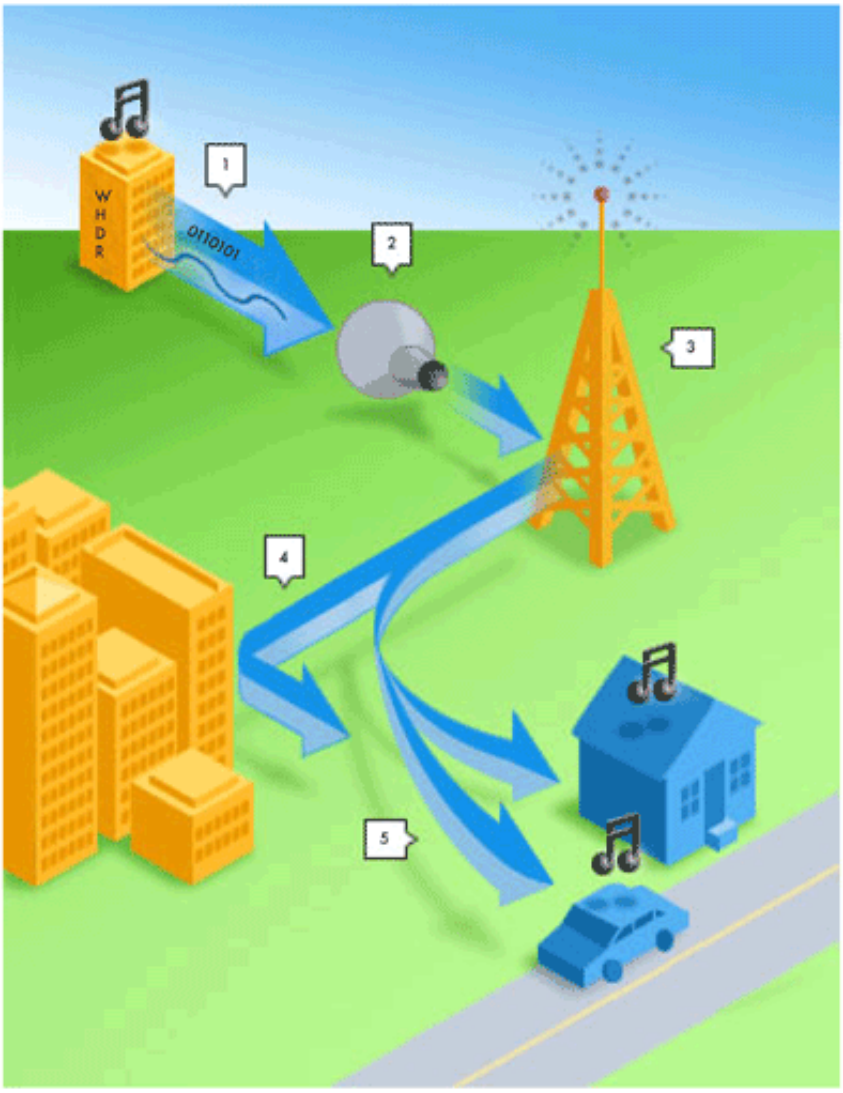
In the AM band, the normal 10-kHz bandwidth is extended to 20 kHz. In the FM band, the regular 200-kHz bandwidth is extended to 440 kHz, providing extra space for the digital signal. A standard analog AM or FM receiver just ignores the digital signal. An HD Radio receiver recognizes the digital signal and uses it to reproduce the originally transmitted audio.

Since digital signals take up so much more bandwidth than analog signals, how does HD Radio achieve its higher-quality audio? It uses digital audio compression and the popular wireless modulation scheme known as orthogonal frequency division multiplexing (OFDM). Virtually all digital audio products like cell phones, Voice over Internet Protocol (VoIP) phones, MP3 players, and digital TVs use some form of audio compression to reduce the data rate to conserve bandwidth.

HD Radio uses its own special version of digital compression to squeeze the higher-frequency audio down to a reasonable bandwidth. The result is that on the AM band, the system can transmit audio frequencies up to 8 to 15 kHz in contrast to the normal 5-kHz maximum of standard AM broadcasts. As a result, HD AM radio sounds more like FM.

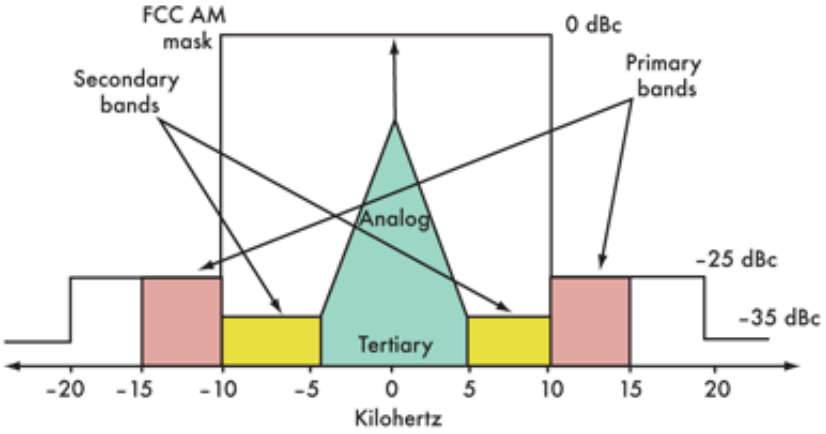
In the FM band, which normally transmits up to 15-kHz audio, an HD station now can go up to about 20 kHz, giving an FM digital signal CD quality. In both cases, the difference is noticeably better. Noise and fading problems virtually disappear.

Figure 1 shows the HD Radio process. After the audio is compressed, it undergoes additional processing including scrambling, forward error correction (FEC), and interleaving to improve signal robustness under noisy and fading conditions. Then the signal is treated to OFDM modulation.

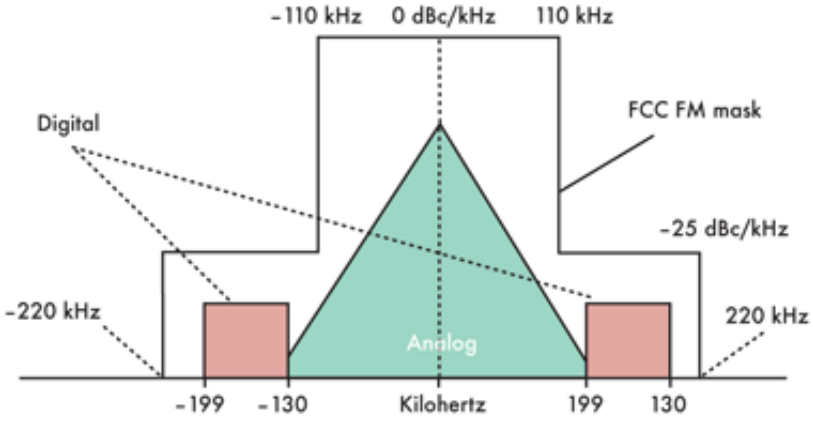


1. The HD Radio process begins with the station combining the analog and digital audio signals with text (1). It then compresses the digital signals using iBiquity's compression technology (2) and sends the package of signals to the transmitter, where the broadcast occurs (3). The signals undergo some interference and multipath fading, minimized by the HD process (4). Finally, the signals are received at vehicle and home radios (5). (courtesy of iBiquity Digital Corp.)

Figure 2 and Figure 3 show the spectrum plots for both AM and FM signals. The OFDM signals appear in the spectrum above and below the regular analog sidebands. In the AM signal in Figure 2, the analog transmission occupies the standard spectrum 5 kHz above and below the carrier. Then there are two sets of digital channels. The primary channels extend from about 10 to 15 kHz above and below the carrier. The secondary channels extend from about 5 to 10 kHz above and below the carrier. Note the FCC spectrum masks that mark the regulatory boundaries for all related emissions.



2. The standard analog signal in the AM band is within the normal 10-kHz bandwidth, while the digital spectrum is above and below the ±5-kHz limits. Modulation is OFDM with QAM. The FCC mask shows the spectral limits allowed.



3. The standard analog signal in the FM band is within a 260-kHz bandwidth with digital sidebands outside the ±130-kHz limits. Modulation is OFDM with QAM. The FCC mask shows the spectral limits allowed.

In addition, tertiary sidebands exist in the ±5-kHz range overlaid in quadrature to the standard analog carrier. There are 81 OFDM carriers with a spacing of 181.7 Hz. The primary carriers use 64-state quadrature amplitude modulation (64QAM) while the secondary sidebands use 16-phase quadrature amplitude modulation (16QAM). The tertiary sideband carriers use quadrature phase-shift keying (QPSK). The 36-kbit/s digital audio bit stream allows an upper-frequency response in the 8- to 15-kHz range.

In Figure 3, the FM spectrum shows the standard analog FM signal occupying the area 130 kHz above and below the carrier. The OFDM digital data occupies the spectrum from ±130 to 200 kHz. There are 10 partitions of 18 subcarriers each in the digital spectrum. How those are used depends on the applications for each station.

HD Radio also has several cool features. Because of the additional bandwidth gained in the digital format, HD Radio stations can offer additional channels of information. Known as multicasting, it allows radio stations to broadcast additional content such as foreign language programs, alternative music venues, or even additional talk radio shows concurrently with the regular broadcast. With no extra bandwidth or channel assignments necessary, a station can bring in extra listeners as well as new advertising. Such multicast stations designated HD2 and HD3 are widely available on FM channels.

Another feature, Program Service Data, lets your radio display text like song titles and artists. Some stations

also provide real-time traffic data and other public service announcements this way. And, some HD radios have an iTunes tagging feature that lets you tag a song you heard and add it to your iTunes account for later purchase.

Currently there are just over 2100 U.S. stations transmitting HD Radio. Most are FM. There are also many manufacturers of HD Radio receivers. You can get HD Radio as a standard offering in many car radios today. Aftermarket HD Radio devices are also available. Many high-fidelity stereo receivers include HD Radio. Tabletop HD radios are widely available. HD Radio is free, but you do have to have an HD-capable radio to receive it. You can find out more about HD Radio at www.hdradio.com or www.ibiquity.com. Check these sites to identify local HD stations and your radio options.

Satellite Radio

The FCC approved satellite broadcast radio in 1992, but it took years for companies to raise the money, build a system, and launch the satellites. XM Satellite Radio and Sirius Satellite Radio started commercial service in 2001 and 2002, respectively. Both use channels in the 2.3-GHz microwave S-band, but their systems are considerably different.

In 2008, the two companies merged to form Sirius XM Radio. SiriusXMhas 22.9 million subscribers across the U.S. Sirius XM Canada, a separate company in which the U.S.-based Sirius XM Radio has a minority interest, has more that 2.1 million subscribers in Canada.SiriusXM programming offerscommercial-free music, premier sports talk and live events, news and comedy, exclusive entertainment, and the most comprehensive Latin music, sports, and talk programming in radio. Customers subscribing to the satellite radio service get access to more than 130 channels of Sirius XM programming for $14.49 per month.

SiriusXM programming is broadcast in the U.S. and Canada to vehicles from every major automaker with factory-equipped satellite radios and to aftermarket radios for the home, office, car, truck, boat, and RV, as well as to mobile devices. Optional outdoor antenna kits are available to receive the best signal for listening to satellite radio inside the home or office.

The XM radio platform uses two geostationary satellites that cover the continental U.S. and Canada. Geostationary satellites orbit directly over the equator at a distance of about 22,300 miles from earth. They rotate in perfect synchronization with the earth's rotation, making them appear fixed in place in the sky. As a result, they're a nearly perfect radio relay platform. XM service is assigned 12.5 MHz of bandwidth in the frequency range of 2332.5 to 2345 MHz.

The Sirius radio platform uses a different approach, employing a single geostationary satellite and three geosynchronous satellites in highly inclined elliptical orbits over the U.S. The apogee is 29,300 miles and the perigee is 15,300 miles. The rotational period is 24 hours, and the satellite spacing is set so each satellite spends 16 hours a day over the coverage area but not at the same time, ensuring full coverage at all times. The high elliptical orbit helps reduce blind spots created by tall buildings and other obstacles that may affect signals from geostationary satellites.

Like GPS, satellite radio systems require a clear line of sight (LOS) path from the satellite to the receiver antenna. Obstacles such as trees and tall buildings can interrupt broadcasts, leading to listener complaints. To address this problem, content is simultaneously broadcast with a time offset from two satellites, each at a different location in the sky.

Additionally, Sirius XM uses a network of earthbound repeaters to receive the signals and rebroadcast them. Most repeaters are in large cities with tall buildings. The Sirius radio spectrum is also 12.5 MHz from

2320 to 2332.5 MHz. For each system, the 12.5 MHz of spectrum is divided into thirds with one segment assigned to the repeater network and the other two segments assigned to the transmitting satellites.

In both systems, the digital bit stream with all programmed channels is digitally compressed and uplinked to the satellites. Both systems use forward error correction (FEC) and encryption for full protection against non-subscribers. In the Sirius system, the bit rate in each 4-MHz channel is about 7.5 Mbits/s. Without the coding and encryption overhead, there's about 4.4 Mbits/s for the audio that's divided up among more than 100 channels. Voice-only broadcasts use low-bit-rate streams (about 24 kbits/s), and music broadcasts get streams of 40 to 64 kbits/s. This time division arrangement can be changed as needed. The modulation is QPSK.

The XM system is similar with compression, FEC, encryption, and time division multiplexing of channels to create a bit stream that is uplinked to the satellites that transmit the same signal to the earth receivers. The system uses six carriers in the 12.5-MHz bandwidth, each with 2 MHz to support the stream of time-multiplexed audio channels.

Sirius XM also makes content available online and via the Sirius XM Internet Radio App for the Apple iPad, iPhone, and iPod touch, as well as Android-powered smart phones and other connected devices.

Other Digital Radio Services

HD Radio and satellite radio make up the digital radio services in the U.S. But there are other digital radio services in use throughout the world, such as Digital Radio Mondiale (DRM), Digital Audio Broadcast (DAB), Digital Multimedia Broadcast (DMB), and WorldSpace.

DRM is a terrestrial service designed to replace standard AM and FM analog systems anywhere in the world. It is an open standard that can be used in any broadcast frequency range from a few hundred kilohertz to the VHF region. DRM can provide FM quality sound in narrow bandwidths of 4.5 to 5 kHz, but other modes can use 18 to 20 kHz. The audio is compressed with MPEG4 AAC v2, and the modulation is coded orthogonal digital frequency modulation (CODFM) with 64QAM. DRM is most widely used in Europe, and it transmits mainly in the popular shortwave (SW) bands from about 5 MHz to 19 MHz. A special receiver is required, of course.

DAB is a popular digital radio standard in the U.K. and Europe. It is the oldest digital broadcast radio and has been in operation since 1999. DAB uses the 174- to 240-MHz and 1452- to 1492-MHz frequency ranges. It's based upon the Eureka 147 standard. The audio is compressed with a version of MPEG, and FEC is added. The modulation is OFDM with differential quadrature phase shift keying (DQPSK). The format comprises 1536 subcarriers that are 1 kHz wide.

DMB is similar to DAB but used primarily in France and South Korea. WorldSpace offers satellite radio services in South America, Africa, and most of Asia with several geostationary satellites positioned appropriately. It uses the 1467- to 1492-MHz L-band.

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2. HD Radio
3. iBiquity Digital Corp
4. Digital Radio Mondiale
5. Digital Audio Broadcast and Digital Multimedia Broadcast

6. Sirius XM Satellite Radio

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