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POSITION PAPER - A Voluntary North American Digital Radio Standard

Objective

The purpose of this document is to advocate for the development of a voluntary North American digital radio standard, harmonizing regulatory and technical elements in Canada, Mexico and the United States of America. This would encourage the rapid adoption of the technology and enhanced digital services, which will benefit the consumer and all industry stakeholders.

This document was developed by the NABA Radio Committee in the Digital Radio Working Group, and focuses on the In-Band, On-Channel (IBOC) HD Radio™ technology developed by DTS Inc. (formerly iBiquity Digital Corporation) in North America. The technology has been approved for use in the United States by the Federal Communications Commission (FCC) and in Mexico by the Federal Institute of Telecommunications (IFT). Experimental authority has been granted for HD Radio transmission in Canada by the Canadian Radio-television and Telecommunications Commission (CRTC). It is logical to consider the harmonization of regulation and voluntary standardization of HD Radio across all of North America to maximize the potential economic, regulatory and service quality benefits across all borders.

The analysis and recommendation for a voluntary HD Radio IBOC standard is based on present spectrum availability within North America. AM and FM HD Radio broadcasting allow for the voluntary migration and evolution to digital broadcasting without requiring additional spectrum. This document includes information to support discussion and co-operation between policy makers and regulatory entities across the North American continent.

Executive Summary

The development of a voluntary digital radio broadcast standard in North America will greatly benefit listeners by providing for new and enhanced broadcasting services that are accessible across the entire continent. Having a continental digital radio market will assist broadcasters in planning and creating a unified set of program and data services compatible across the majority of OEM automotive receivers, arguably the most impactful and relevant platform for radio listening. The standardization of digital radio services simplifies content creation toolsets for data and program service vendors, reducing cost and complexity of development and system testing. These actions all help realize the rapid adoption of digital radio.

1. The Consumer Benefit

As with other consumer electronics (CE) digital upgrades, the HD Radio system provides consumers substantial advantages over legacy analog technology. CE digital transitions have historically given consumers better quality, more choice and more services, and interactivity, benefits that are all realized by the HD Radio system.

HD Radio technology improves audio quality: consumers receive sound quality equal to or better than (depending upon bit rate) analog FM. The potential for CD-like sound quality for over the air services is possible. HD Radio signals are much less prone to interference than existing analog signals as well, leading to cleaner audio.

HD Radio technology increases choice: through the multicasting capability, digital FM broadcasters are able to offer multiple audio channels over a single FM frequency. The new audio channels, known as HD2, HD3, etc., offer consumers new, diverse, targeted content. Multicasting has led to an explosion of programming creativity, with formats such as dance, garage band, gospel, bluegrass, jazz, comedy and indie rock. A greater selection of audio choices has expanded listener appetites for new music. These new audio sources are often referred to as “infinite shelf space” and radio needs these additional channels to meet a more diverse consumer taste in music.

The opportunity for additional public service programming exists including emergency alerting and programming, minority language programming, and community services and information. The opportunity to better serve the listener is all enhanced by digital radio.

The HD Radio system provides new services and interactivity: by using Program Service Data (PSD), stations can display text information such as artist, song title, station call letters or other real-time information like stock quotes and sports scores on the radio’s screen. Market research suggests that program associated information is an important feature for customer satisfaction. Industry-leading companies are implementing systems to deliver real-time and on-demand traffic data to consumers using HD Radio technology. Working with CE manufacturers, music tagging for HD Radio technology is supported, enabling consumers to purchase music they hear on the radio through on-line music stores. Station logo and cover art image support are available through the HD Radio feature known as “Artist Experience.” Through Artist Experience, the listener is presented with an image-rich enhancement to their listening experience. Commercial announcements may also be enhanced with client logos and product images.

Emergency Alerts may be enhanced by HD Radio technology’s ability to provide images and text content in addition to the traditional audio information contained in the alerts. Digital receivers, even while in a standby mode, are able to receive HD Radio Emergency Alert messages and turn on during the announcement. This feature significantly increases the effectiveness of emergency alerts.

Other advanced services in the early stages of implementation include an electronic program guide and store-and-replay functionality. For consumers, digital radio standardization would make possible a uniform product offering, enhancing the user experience with familiar graphical user interface (GUI) displays tailored to the services offered by a common digital radio platform.

Finally, since all local radio station dial positions can remain the same, the HD Radio system requires little or no change in well-established consumer behavior. Consumers purchasing HD Radio receivers will simply tune to their favorite programs and stations and enjoy the digital upgrades in quality, choice and services automatically as stations transition from analog to digital.

2. The Broadcaster Benefit

The HD Radio system facilitates a smooth upgrade to digital broadcasting by using existing infrastructure and minimizing implementation costs, providing a means for broadcasters to compete against new digital media and grow the broadcast industry. Broadcasters’ existing studios, towers and antenna equipment are maintained under the HD Radio system. Each station will require a new digital exciter to provide basic HD Radio services and a digital service multiplexer, known as the Importer, to enable multicasting and other advanced services. The overall upgrade costs for a station range from USD $23,000 to $195,000, depending on its existing infrastructure, with an average around USD $100,000. Stations will be able to preserve their current consumer base and retain all brand equity associated with their dial positions, typically developed at great expense over long periods of time. HD Radio technology has the potential to provide broadcasters new revenue through multicasting, advanced data services and other new applications.

New business models enabled by HD Radio technology include expanding current offerings, such as additional programming streams through multicasting, as well as the transmission of news services, and wireless data and other advanced digital applications, which are becoming widespread in North America. A radio station's revenue potential is increased by allowing broadcasters to better target listening audiences and offer niche services. And, the HD Radio system provides radio broadcasters with the most economical means of transmitting wireless data services to mobile platforms such as GPS and portable entertainment devices and smart phones. Hundreds of millions of units of these products are sold each year. Having access to mobile platforms is key to growing the broadcasting industry marketplace. Using the HD Radio system, radio broadcasters have the potential to compete in this market with sufficient bandwidth and a low cost, high quality digital data pipe.

Widespread adoption of analog FM as an application feature on mobile phones and digital media players is paving the way for future adoption of HD Radio technology on these devices. Several media players have already incorporated analog FM tuners, and a significant percentage of smart phones sold into the US, Mexico and European markets include analog FM tuners.

3. The Benefit to Manufacturers and Retailers

Manufacturers and retailers have a strong interest in upgrading radio technology from analog to digital. A uniform digital radio standard across North America would incentivize manufacturers that have benefited tremendously from previous digital product upgrades, and the broad base of manufactures building various HD Radio products will capture that same opportunity in radio's digital transition.

The basic existing analog radio technology, which has been stable for many years, offers limited opportunity to add new features, and thus limits sales growth. The HD Radio system provides manufacturers with an opportunity to upgrade a very large product category. The large installed base of analog radio equipment is being replaced over time, and new audio products, even whole new product categories, are being developed with increased functionality and potentially higher profit margins. For high growth wireless devices like mobile phones, media players, personal navigation systems, telematics systems and converged versions of these consumer electronics products, HD Radio technology offers the potential to increase device functionality by adding digital radio to these devices with the potential benefit of delivering wireless data and audio services. For automotive OEM and tier 1 suppliers, a uniform North American product offering means reduced receiver head unit model inventory, and the ability to conduct more thorough testing of a reduced subset of receivers, resulting in better performance and lower costs.

4. Benefit to Regulatory Agencies

Allocation of new spectrum for digital radio is not required as the HD Radio IBOC signal is carried within the same frequencies that broadcasters currently utilize. As a result of these and other factors, in a first Report and Order in October 2002, the FCC selected the HD Radio IBOC system as the sole technology AM and FM radio broadcasters will use to upgrade to digital in the United States. In March 2007, in a Second Report and Order, the FCC adopted service rules and other requirements for terrestrial digital radio. Subsequent regulatory actions by the FCC since then have implemented incremental improvements and modifications to operational parameters such as allowing increased transmit power in the digital sidebands of HD Radio signals.

In Mexico, HD Radio technology was adopted officially by the CoFeTel (now known as El Instituto Federal de Telecomunicaciones or IFT) on June 16, 2011. Since the formal adoption more than 70 radio stations have upgraded to HD Radio technology and offer over 115 Digital Programs. HD Radio technology has a presence in 4 of the top 10 Mexican markets with 33% population coverage. The technology may be found in 15 OEM automotive brands in Mexico across 50 models.

In Canada, the CRTC released a targeted policy review of the commercial radio sector (Broadcasting Regulatory Policy CRTC 2014-554) on October 28th 2014. Included in this review was a flexible approach for introducing HD Radio technology in Canada, designed to allow for innovation and experimentation. Licensees are required to apply to Innovation, Science and Economic Development Canada (ISED) for experimental authorization and inform the CRTC in writing of any experimentation with HD Radio (or other digital radio technologies) that they undertake, including the type of service they intend to provide.

Presently, twelve radio stations are on-air with HD Radio in Canada across seven markets: Toronto, Hamilton, Vancouver, Markham, Montreal, Ottawa and Calgary. While limited, this represents a significant increase within a twelve month period.

Adoption of HD Radio in Canada has a number of issues that need to be addressed in this experimental period. ISED deals with spectrum and technical issues in Canada, and has yet to provide broadcasters with a consistent technical framework or provisional technical rules to understand the full impacts of more widespread deployment. Operating parameters are authorized on a case by case basis and only the stations directly involved have knowledge. A database is currently not available to permit stations to gain knowledge from prior experience.
An opportunity to develop consistent technical rules and share the experience gained may encourage innovation and experimentation on a broader scale.

ISED has acknowledged the need for an engineering study, which could then be shared with the CRTC and the Radio Advisory Board of Canada (RABC), to gain an understanding of the adjacent channel impacts of HD Radio technology on existing radio stations. Understanding the impact of HD Radio technology on the existing broadcast infrastructure in Canada and a simple and supportive licensing regime would give Canadian broadcasters the confidence that a transition is both possible and desirable.

Implementation of HD Radio requires radio stations to pay licensing fees to the patent holder to use the technology. While main station (HD1) license fees have been waived during experimentation for broadcasters who implement the technology ahead of formal adoption, a uniform licensing policy is available following formal adoption. The certainty and stability of future licence fees are a factor in employing the technology. The affordability and flexibility of fees will contribute to further deployment.

Market information

Broadcast radio continues to play a critical role in everyday life throughout North America. Radio's role is so pervasive that it is often taken for granted. Radio remains a primary source of information and entertainment for the majority of the residents of North America, providing music, news, weather, traffic and information. Consumers are able to receive these program services virtually everywhere free of charge. Radio is ubiquitous. Audiences wake up and go to sleep listening to radio. People listen to radio in the home, while driving, at work, exercising, while walking down the street, on the beach, in the park, and while shopping.

The radio receiver remains one of the most ubiquitous devices in our lives. It is estimated that there are over 575 million radio receivers in use today in the United States. Over 92% of all people over the age of 12 listen to the radio every week. As of June 2016, there were more than 15,330 licensed radio stations. The average American listens to AM or FM radio more than 22 hours per week.

Canada has a little more than 1,250 radio stations. In 2016, Numeris reports that nearly 90% of Canadian consumers, 12 years or older, tune in weekly spending almost 18 hours of their media time with radio.

In Mexico there are more than 1,300 radio stations. PwC Mexico reports that more than 7 out of 10 Mexicans listen to radio and on average spend 18% of their day doing so.

There are fundamental aspects of radio broadcasting which define the service. Radio broadcasts are traditionally free; the consumer does not need a subscription and is not charged a fee. As a result, radio's penetration is unrivalled by other services. Radio is inherently local because of the nature of radio coverage. In turn, radio provides one of the best sources of local information and, to a large extent, reflects the tastes, values and interests of the local community each station serves. Although individual radio broadcasts are inherently local, radio broadcast availability is presumed to be universal. Anyone driving from coast to coast expects to be able to receive radio broadcasts, using the same receiver, throughout the country and indeed throughout North America.

Another important aspect of radio is the relatively low cost of receivers. Although audiophiles can spend considerable sums on a high-end receiver, radio can also serve the listener who can only afford a basic portable or clock radio. In addition, radio's role in society goes beyond entertainment. HD Radio receivers available today are capable of functioning in an all-digital mode, an advanced service mode (not currently authorized) in which the analog carrier is eliminated, allowing for higher-power digital signals that can provide even greater coverage. As such these receivers are already "seeding" the future for radio, insuring its place in the digital world.

Radio provides critical public service as a central part of the Emergency Alert System (EAS) in the U.S., and with similar alerting systems in Canada and Mexico. Radio is a primary means of dissemination of news and information, and as a source for public service announcements. In other words, radio informs, enlightens and entertains all key elements for a civil society.

The basic motivations for transitioning from analog to digital technology are enhanced performance, added capabilities, reliability, flexibility and cost efficient manufacturing. Despite the obvious benefits of digital radio, terrestrial radio has remained one of the last bastions for analog service, due in part to the large installed base of analog receivers requiring replacement as well as the low cost of including analog radio in other products (for example, the inclusion of analog FM radio in smart phones). While recent broadcast standards activities indicate increasing interest in the digitalization of VHF band II (87.5 to 108 MHz), many countries lack the additional spectrum required to accommodate a parallel transition of radio from analog to digital service on a new frequency assignment. This is certainly the case in North America.

IBOC technology allows broadcasters to add digital signals to their existing analog broadcasts without new spectrum ("hybrid" broadcasts), while providing the capability for an eventual move to all-digital transmission. In short, the technology acts as a bridge from analog to digital services.

To be clear, the hybrid mode includes both the existing analog and the new digital services. Broadcasters are using this mode during rollout of the technology to permit the continued operation of analog-only radios while new HD Radio receivers deliver the new enhanced services as well as existing analog reception. In the future, when the market penetration of HD radio receivers is sufficiently high, broadcasters may switch to the all-digital mode resulting in additional benefits including greater digital coverage (than available in hybrid mode) and the potential for greater throughput.

HD Radio technology supports low-cost receivers; a significant factor for digital audio broadcasting deployment and acceptance. IBOC transmission methodology utilizes adjacent digital signals that permit existing tuner components and antenna circuitry commonly used in the manufacture of analog signal receivers to be employed.

A Comparison of Digital Radio Technologies

1. HD Radio Technology

While numerous digital radio systems have been deployed worldwide, few realize the level of commercial acceptance as the In-Band, On-Channel (IBOC) HD Radio Technology in North America. Both the United States and Mexico have selected the IBOC approach as it does not compel the broadcaster to forfeit an existing listener base to develop a new audience for the digital service. IBOC preserves the analog broadcast located on the main frequency assignment by adding a low-level digital signal immediately adjacent to the analog signal and within the existing frequency allocation. This combined analog and digital signal is known as a hybrid IBOC signal.

IBOC, as implemented by the HD Radio system, retains the full power of the analog signal, while adding digital carriers within a controlled bandwidth and at lower power levels (than the analog "host"). This design allows for adjustment of the bandwidth and power of the digital signal, making possible controllable tradeoffs between coverage of the digital signal and adjacent channel availability. The FM hybrid IBOC digital signal is capable of delivering up to four digital audio programs (one replicating the analog service) along with the analog transmission. The AM hybrid HD Radio digital signal is limited to delivering a single digital audio program replicating the analog service. Eventually, as the transition matures, analog radio would be shut down in favor of all-digital services. A more detailed description of the HD Radio system is provided in Appendix A.

The HD Radio brand of IBOC technology is successfully being used to deliver enhanced traffic and data services to OEM and aftermarket automotive receivers. These traffic services are presently in operation in the United States and Mexico as commercial services and experimentally in Canada. A voluntary North American digital radio standard would reinforce the economic benefits of a common broadcast infrastructure as well as streamlining product inventory requirements for tier one and OEM suppliers to the automotive industry delivering these services.

2. Digital Audio Broadcasting (DAB and DAB+)

DAB and its successor technology, DAB+, are “cellular” based radio technologies that have found favor within ITU Region 1 and more recently, within ITU Region 3 (in particular, Australia). DAB is deployed as a network of wideband transmitter sites, known as a “multiplex”. Each multiplex broadcasts multiple audio channels in a single wideband data stream.

Each multiplex by design covers a small geographic footprint. In order to expand coverage (particularly in larger metropolitan areas), a “single frequency network” or SFN approach of linking adjacent transmitting multiplexes is utilized to provide uniform contiguous coverage. This network of multiplexes is referred to as an “ensemble”. A broadcast ensemble can transmit up to 25 program channels (with DAB+) dependent on program channel bandwidth. A DAB receiver first tunes the entire multiplexed signal, and then the user selects the program to which they want to listen.

The deployment of the DAB and DAB+ ensemble assumes a cooperative sharing of the cost in construction and operation among the broadcasters participating in the ensemble. The cost of constructing a DAB ensemble (consisting of many multiplexes) can be significant. Without the help of the large government subsidies typical in European countries, it would be prohibitive for most radio stations to finance their share of the cost from local advertising revenue. This is especially true in smaller markets, where the infrastructure costs would be nearly the same as in major markets but without enough programming content to use all the all the multiplex capacity. Therefore, fewer stations would share the infrastructure cost, and the resulting cost per service would be considerably higher.

DAB+ receivers are plentiful especially in countries that have established or are planning to establish “FM sunset” dates. Fueled by these sunset dates, automobile manufacturers have broadly adopted the technology in their product offerings. Table top radios in a variety of stylish forms abound at competitive price points.

3. Digital Radio Mondiale

Digital Radio Mondiale (DRM) was developed in 1997 as a digital broadcasting technology for shortwave and medium wave broadcast (now called “DRM30”). A variant of DRM, DRM+, was introduced in 2009 to support FM and VHF broadcasting. DRM30 and DRM+ utilize digital-only signals on a separate frequency (*i.e.*, one not being used for analog transmissions) inside the existing broadcast bands. In 2006, DRM introduced Single Multi Channel Simulcast (SMCS) as a way for AM analog broadcasters to transition to digital radio. SMCS utilizes the transmission of both amplitude modulated (AM) and Digital Radio Mondiale (DRM) signals (with the same programming) in the same or adjacent channel space.

The DRM system is highly flexible and is designed to allow for trading off audio quality for system coverage. Generally speaking, with DRM signals better (digital) coverage is made available at reduced audio quality and vice-versa.

Although developed as a European technology, no countries within Europe have designated DRM as their broadcast standard. Only India has selected DRM30 as an AM and shortwave standard, but its implementation in that country is progressing slowly. Russia elected DRM as a standard in 2009 but then canceled the program in April of 2012. The lack of receiver availability has often been cited as one of the major concerns for the viability of the technology.

Conclusion

In this brief Position Paper, NABA has provided information on the HD Radio IBOC digital radio technology which has been adopted for use in the U.S. and Mexico and is currently authorized for experimental use in Canada.

NABA is supportive of and encourages broadcasters and regulators in all three countries to work together to advance the rollout of HD Radio digital radio services across North America and to harmonize the use and regulation of digital radio in the AM and FM broadcast bands to create a *de facto* voluntary North American digital radio standard.

NABA further encourages all North American broadcasters to participate in the activities of the NABA Radio Committee to help achieve these goals. NABA is a resource and an advocate for IBOC digital radio and the NABA Radio Committee exists to further the interests of terrestrial radio broadcasting across the continent.

Appendix A
HD Radio System Description

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Introduction

This Appendix is a high-level description of the HD Radio system. It is intended for broadcasters considering transmission of digital radio signals; equipment manufacturers designing digital radio receivers; and anyone else interested in how HD Radio technology works. Minimal technical knowledge is required.

The system supports new audio and data services that coexist with existing frequency modulation (FM) analog service on VHF Band II assignments from 87.5 MHz to 108 MHz and existing amplitude modulation (AM) analog services in the medium wave (MW) portion of the medium frequency band (MF) from 535 kHz to 1705 kHz. Operation in these frequency ranges is subject to certain regulatory conditions. Therefore, the North American digital radio system standard adoption and deployment is proposed in accordance with these regulatory conditions, while ensuring operation of the existing analog broadcasting services.

Interference protection requirements for FM sound broadcasting in Band II are defined by the International Telecommunication Union – Radiocommunication Sector (ITU-R). HD Radio technology was designed to satisfy the frequency spacing and spectral mask for FM sound broadcasting for Band II in ITU-R Region 2.

This Appendix focuses on the simultaneous "hybrid" transmission of existing analog FM with digital HD Radio signals. Some sections may also apply to the hybrid of existing analog AM with digital HD Radio signals. While all-digital transmission is a functional mode in deployed HD Radio receivers, transmission in this mode has only been used experimentally and is not covered in this Appendix.

Detailed information on HD Radio technology is available from the National Radio Systems Committee (NRSC, a technical standards-setting body co-sponsored by the Consumer Technology Association and the National Association of Broadcasters; see in particular the NRSC-5 Standard) at http://www.nrscstandards.org, and DTS, Inc. (developers and implementers of HD Radio technology) at http://www.dts.com.

Overview

HD Radio technology is a method to transmit digital radio signals. It allows digital radio signals to exist in the same band as analog AM and FM radio signals, and on the same channel as these existing signals. This is generically known as "in-band, on-channel" or "IBOC" (pronounced EYE-bahk) digital radio. As noted in the Position Paper, in the hybrid mode of operation, existing analog radio signals are preserved; low-level HD Radio digital signals are added immediately adjacent to (or in the case of AM HD Radio, underneath of) an analog signal. HD Radio technology provides a comprehensive and flexible transition to an "all-digital" world, whenever it may occur, since it also supports an all-digital mode of operation in which an all-digital radio signal would occupy that same spectrum. No new spectrum allocations are required for the digital radio signal, either now or in the future.

The HD Radio signal can contain the same content as an existing analog radio signal, including audio and related metadata such as song title and artist. It can contain additional audio channels and metadata. Moreover, other digital content can also be transmitted, such as images or data that are unrelated to any of the audio programs — all on the same HD Radio signal.

All existing analog radio receivers are compatible with hybrid transmissions of analog FM and HD Radio signals. HD Radio receivers for audio will blend from an analog to a digital radio signal, if it is available. If a digital radio signal is not available, the receiver will stay tuned to the analog FM signal.

HD Radio technology was evaluated extensively in the United States by the National Radio Systems Committee (NRSC), resulting in a recommendation to the FCC for the adoption of the HD Radio IBOC technology. Subsequent to the NRSC evaluation of IBOC, the NRSC developed the NRSC-5 IBOC Digital Radio Broadcasting Standard. The latest version of this standard may be found at the following URL: http://www.nrscstandards.org.

Supported Services and Bandwidth Management

Audio is one of many types of services supported by the HD Radio system. A few services are mandatory; the remaining services are optional.

Main Program Service

The **Main Program Service** (MPS) is the primary digital audio channel from the broadcaster. If the radio station is transmitting a hybrid of the analog radio signal and the digital HD Radio signal, then the MPS is a digital simulcast of the analog signal. In this way, the analog audio acts as a “backup” to the digital audio, and HD Radio receivers will “blend” from the analog to the digital audio and vice versa depending upon reception conditions.

As a digital audio signal, the MPS can offer better audio quality than the analog signal. Static, noise, and other impairments found in analog signals do not exist in the MPS. The audio quality is consistent throughout the digital signal coverage area.

The MPS is commonly known as “HD-1”, and is a mandatory part of the HD Radio signal.

Supplemental Program Service

The Supplemental Program Service (SPS) provides for additional digital audio channels on the same HD Radio signal as the MPS.

These channels may contain different programming than the MPS, such as foreign-language programs, other music formats, or simulcasts from a different radio station. SPS audio quality can be similar to that of the MPS. Unlike the MPS, the SPS audio channels do not have an analog backup, and when the digital signal is lost by the receiver, the SPS audio channels will mute.

Multiple SPSs are supported. Each SPS is commonly known as “HD-2,” “HD-3,” etc., and SPS is an optional part of the HD Radio signal.

Program Service Data

The MPS and each SPS can contain textual **Program Service Data** (PSD) that is synchronized to the current audio program. Examples include the artist and title of a song, the phone number for a talk show, the score of game, or the name and slogan of a commercial advertiser.

HD Radio PSD is equivalent to the Program Service (PS) and RadioText (RT) features of the RDS digital data subcarrier used with analog FM.

Use of PSD is optional, but is recommended to match the HD Radio listening experience with analog FM containing RDS.

Advanced Application Services

Advanced Application Services (AAS) are data channels on the same HD Radio signal as MPS and SPS (if SPS services are present). Examples include images of logos for the radio station or advertiser, or album artwork linked to specific songs. These services can greatly enhance the radio listening experience, matching that provided by internet-based audio streaming services, but with no additional data usage fees for the listener.

AAS data does not necessarily have to relate to any audio program, or even the radio station itself. Examples include emergency alerts for severe weather, earthquakes, or terrorism; real-time road traffic data for navigation devices; or remote switching of electrical devices to optimize the load on the electric power grid. Broadcasters can potentially generate additional recurring revenue by transmitting these services for a third party.

Station Information Service

The **Station Information Service** (SIS) contains basic, non-audio information about the radio station, such as the call sign, frequency, slogan, or electronic program guide (EPG), among other things. This is similar to the basic information found in the RDS digital data subcarrier used with analog FM.

The SIS also contains control information about the HD Radio signal, such as technical details for other services available on the signal. Receivers use the SIS data as part of the HD Radio signal acquisition process.

The SIS is a mandatory part of the HD Radio signal.

Bandwidth Management

HD Radio signals have a limited amount of bandwidth, constrained primarily by the AM and FM radio channel allocation rules.

For maximum audio fidelity, the entire HD Radio signal bandwidth could be used for the MPS and the SIS (which uses very little bandwidth). If one SPS is required, then half of the bandwidth could be allocated for the MPS, and the other half could be allocated to the SPS. But if the SPS is primarily for monaural talk radio, then substantially less than half of the bandwidth can be used for the supplemental service, and the bandwidth of the MPS can be increased to more than half.

These examples highlight some of the many possible combinations; the broadcaster is free to re-allocate the given bandwidth as needed.

Implementing HD Radio Transmissions

System Configurations

The HD Radio system, utilizing an IBOC approach, allows for a smooth evolution from analog sound broadcasting to comprehensive digital sound and data broadcasting. In support of this evolution, the system introduces two conceptual configurations of operation. HD Radio receivers are designed to support both configurations so consumers only need to upgrade from existing analog equipment to HD Radio equipment once:

Hybrid configuration: both analog and digital signals are transmitted in a single radio channel. This may be considered a transitional configuration. Broadcasters and consumers alike see little benefit in the immediate termination of analog broadcasting as would be required if a digital radio system was implemented that required broadcasters and consumers to immediately “switch” to a new system, not compatible with existing analog service. The benefit of the hybrid configuration is that analog sound broadcasting service is maintained, while simultaneously offering new digital sound and data services, receivable on HD Radio receivers. This configuration supports simulcasting of audio programs on analog and digital signals and supports smooth audio “blending” between the two (for the MPS);

All-digital configuration: a digital signal only is transmitted in the radio channel. This may be considered a future implementation. In this configuration the broadcast stations cease transmitting analog sound service and broadcast only the digital sound and data services; consumers who have upgraded to HD Radio receivers during the transmission of hybrid services will continue to receive the all-digital signals as well.

Basic Infrastructure

The HD Radio signal is a different signal than the existing analog radio signal, and requires different types of equipment to transmit. However, this equipment is typically used in conjunction with existing analog equipment. In some cases existing equipment can be used to transmit both analog and HD Radio signals. In other cases, existing equipment may need to be updated or augmented to accommodate HD Radio transmission.

For analog FM, existing systems transmit a signal approximated by the red line shown in **Figure 1**, labeled "FM." The entire transmission system is tuned specifically for the center frequency of the radio station (represented as 0 kHz frequency offset in **Figure 1**), for the bandwidth of the red line (approximately 100 kHz away from the center on both sides), and for the authorized power of the radio station.

To transmit the HD Radio digital signal with an existing analog FM signal, additional equipment is needed to transmit the signals represented by the gray bars, *PL* and *PU*, shown in **Figure 1** and which represent the HD Radio "digital sidebands." Note that the HD Radio signals are placed below (left) and above (right) the analog FM signal; the FM signal itself remains essentially unchanged. The total occupied bandwidth of the analog plus HD Radio digital signal is approximately ±200 kHz.

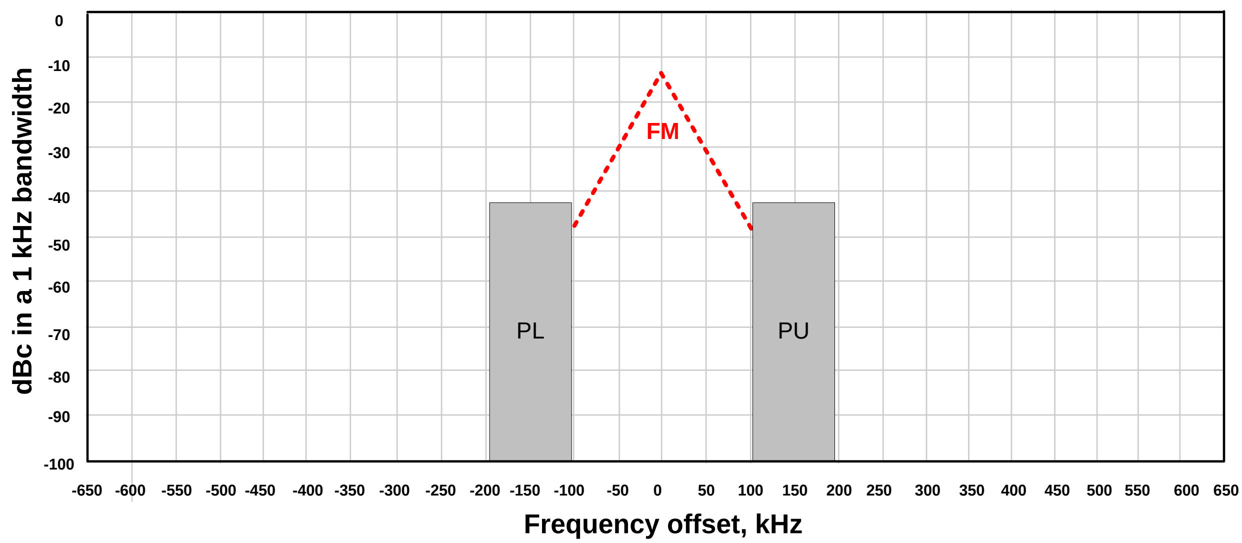

Figure 1: Hybrid analog FM and HD Radio signals

In some cases, an existing analog system can already transmit the wider bandwidth and handle the additional power required for the HD Radio signal digital sidebands. If so, less equipment and fewer modifications are required to implement HD Radio transmissions.

In other cases, if the existing system cannot transmit the wider bandwidth and/or handle the additional power, then existing equipment may need to be upgraded, or additional equipment may be needed. Some broadcasters even choose a separate transmitter site exclusively for the HD Radio digital signal, and leave the existing analog transmitter system on-the-air as-is (choosing to combine the analog and digital signals in the antenna system).

Power, Signal Strength, and Coverage

In the original design of the HD Radio system, two key factors were considered in determining the power used to transmit the digital portion of the HD Radio signal:

The coverage of the digital HD Radio signal should be similar to the coverage of the analog FM signal;

Because of the greater efficiency of the digital transmission system, a lower signal strength (than used for analog FM) should be sufficient to successfully receive an HD Radio signal.

Transmitted radio frequency (RF) power is usually expressed in units of watts, such as 100 kilowatts (100 kW). Although the power of HD Radio signals can also be expressed in watts, it is generally more useful to use decibels below the analog carrier (dBc). For example, the total power of the HD Radio signals shown in **Figure 1** is approximately 20 decibels below the analog carrier (−23 dBc per digital sideband).

The scale of a decibel is logarithmic rather than linear. So if the power of the analog signal is 100,000 W, the power of the digital signal at:

−20 dBc, the power is 1.0% of 100,000 W, or 1,000 W;

−14 dBc, the power is 4.0% of 100,000 W, or 4,000 W;

−10 dBc, the power is 10.0% of 100,000 W, or 10,000 W.

In the United States, FM stations are authorized by the Federal Communications Commission (FCC) to operate at −14 dBc (4.0% of the analog signal power) down to a minimum of −20 dBc (1.0% of analog). The maximum allowed power is −10 dBc below the analog FM signal (10% of analog) but requires the broadcaster to submit to the FCC an engineering submission demonstrating adequate protection of nearby radio signals. At this highest power level, the outdoor and indoor digital reception coverage typically outperforms analog reception coverage under similar conditions.

High-Level Combining (Separate Amplification)

Three principal methods are used for producing the HD Radio hybrid FM signal. The method that was most popular at the introduction of HD Radio technology is known as “high-level combining” or “separate amplification” and is shown in **Figure 2**. With this method, the existing station transmitter has its output combined with the output of a separate digital transmitter compatible with HD Radio technology. The resulting hybrid signal is then fed to the existing station antenna.

HD Radio FM high-level combining uses two transmitters to produce the transmitted signal. This approach requires the addition of an HD Radio digital transmitter and the associated combiner, filter and digital exciter. Since both an analog and digital transmitter will be operated at the site, power demands may require the upgrade of electrical service to the facility. Heat load will also increase and may require additional cooling to remain within acceptable limits.

The high-level combining method is inefficient due to power differences between the analog and digital portions of the signal. In order to achieve the requisite isolation and linearity, RF combiners used for hybrid HD Radio signal generation sacrifice approximately 10% (~0.5 dB) of the analog power and 90% (~10 dB) of the digital power to a reject load. However, because the digital power requirements in HD Radio technology are low (−20 dBc to −10 dBc), this loss is tolerable.

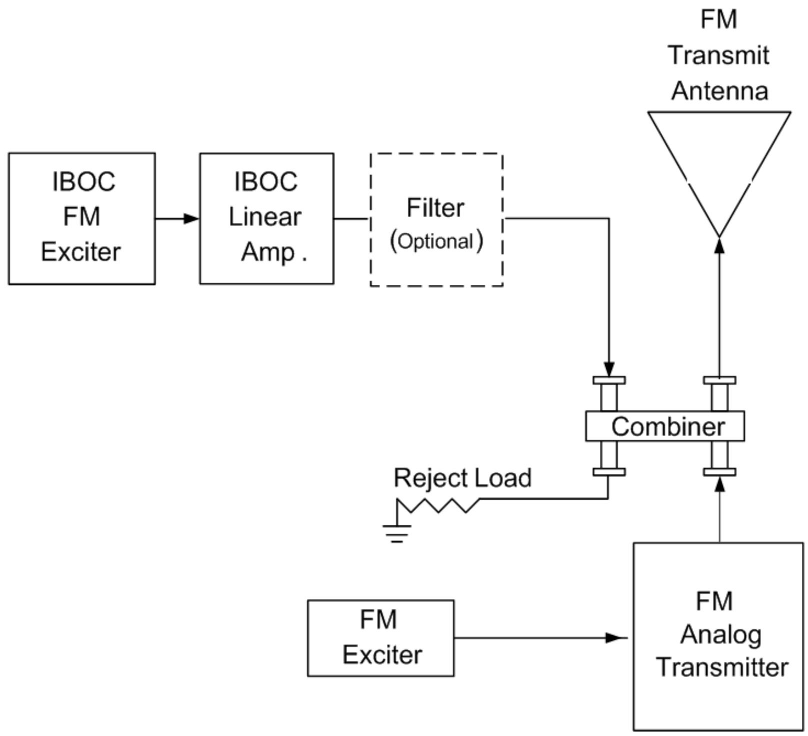

Figure 2: FM HD Radio high-level, separate amplification

Another issue is that of peak-to-average ratio (PAR). Because the digital signal varies in amplitude as well as frequency, the PAR of an FM hybrid HD Radio signal is about 5.5 dB. For example, in the case of an FM station with an analog total power output (TPO) of 10 kW, the digital carrier power of the HD Radio signal would be 1000 watts at −10 dBc or 100 watts at −20 dBc. Assuming combiner loss as discussed above, the analog transmitter would need to be increased to 11.1 kW to overcome combiner insertion loss. The digital transmitter would have to provide for an average output power of 1 kW to overcome the 10 dB combiner loss for −20 dBc injection. The IBOC transmitter would also need to be sized to accommodate 5.5 dB of additional overhead for PAR. This sizing for peak power would amount to approximately three and a half times the average power requirement.

Low-level Combining (Common Amplification)

A second method for producing a hybrid IBOC signal is “low-level combining” or “common amplification” as depicted in **Figure 3**. In this implementation, the output of an analog FM exciter is combined with the output of an HD Radio exciter. The combined signal is fed to a broadband linear amplifier to raise the power to the desired TPO. This method is both power and space efficient and reduces the number of independent elements in the broadcast chain.

Separate and Dual-Input Antenna

The third implementation is known as the separate antenna method. This methodology takes one of two forms; physically separate antennas for the analog and digital signals, as depicted in **Figure 4**, or a dual-input antenna shown in **Figure 5**.

In the separate antenna implementation, signals are routed from independent digital and analog amplifiers to dedicated radiating elements for each signal. Two methods of separate antenna implementation are in use today. The basic form is an independent antenna for the digital signal, often previously installed as an analog backup antenna. A physically separate antenna is often problematic as it can be difficult to achieve parity between analog and digital coverage.

The second method, known as an interleaved antenna, places a digital antenna "bay" at the mid-point of the analog radiating element array. In this design, the phase of the digital antenna elements is typically inverted (i.e., installed upside down) to provide additional isolation between the analog and digital signals.

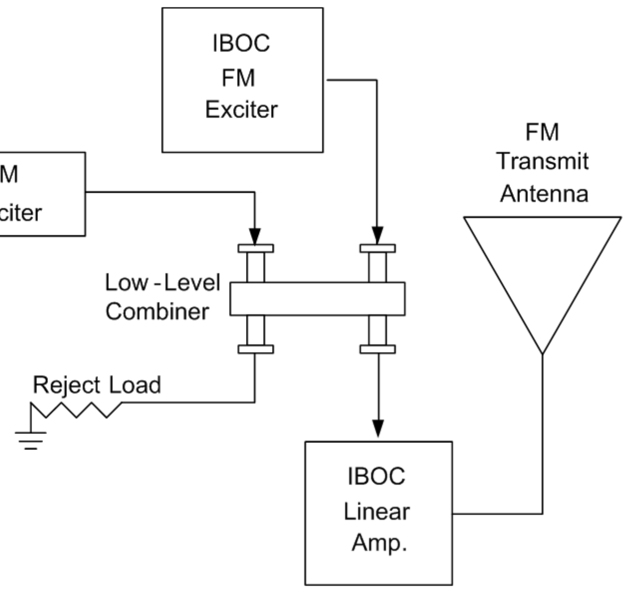

Figure 3: FM HD Radio low-level, common amplification

Regardless of which separate antenna method is employed, the FCC authorizes use of this method in the United States as follows:

The digital transmission must use a licensed auxiliary antenna;

The auxiliary antenna must be within three seconds of latitude and longitude of the main antenna (used for the analog transmission);

The height above average terrain (HAAT) of the auxiliary antenna must be between 70 and 100 percent of the HAAT of the main antenna.

When using the separate antenna method, it is important for the digital antenna to have a minimum of 40 dB of isolation from the analog antenna in order to keep intermodulation products within acceptable limits. Attention to the proper placement of the antenna elements along with the use of an RF isolator on one or both transmitters may be required to minimize mutual coupling.

Replicating radiating element placement with regard to the leg and crossbar portions of the tower, for both the analog and digital transmitting elements, will help to ensure that the patterns of the digital and analog antennas are congruent. Since physically separate radiators are employed in this design, analog signal radiation may be superior to the digital signal radiation due to the height difference between the centers of radiation (analog will be higher). Despite this drawback, the advantage of using separate antennas is the elimination of the combiner loss. Dual-input antennas have the advantage that the center of radiation is identical for both the analog and digital aperture resulting in near-identical analog and digital RF coverage.

Since system designs vary in dimension as well as configuration, the physical space and implementation constraints should be reviewed with equipment manufacturers to determine the appropriate solutions.

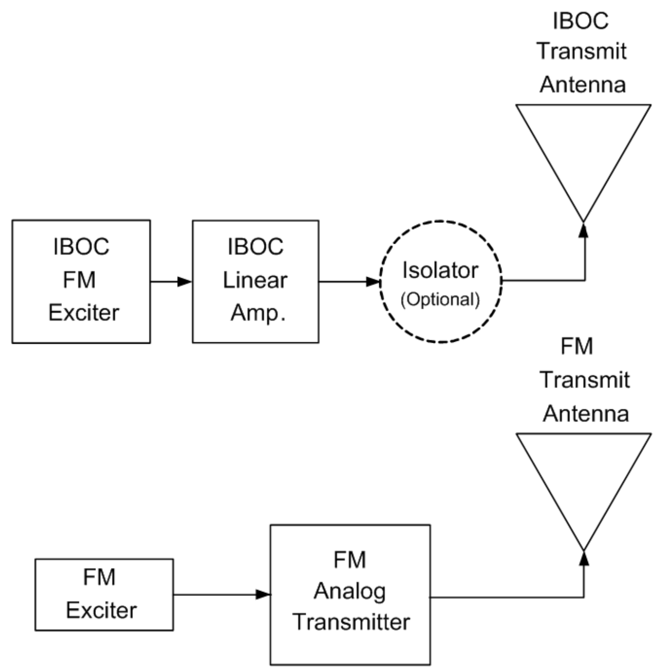

Figure 4: FM HD Radio Separate Antenna Implementation

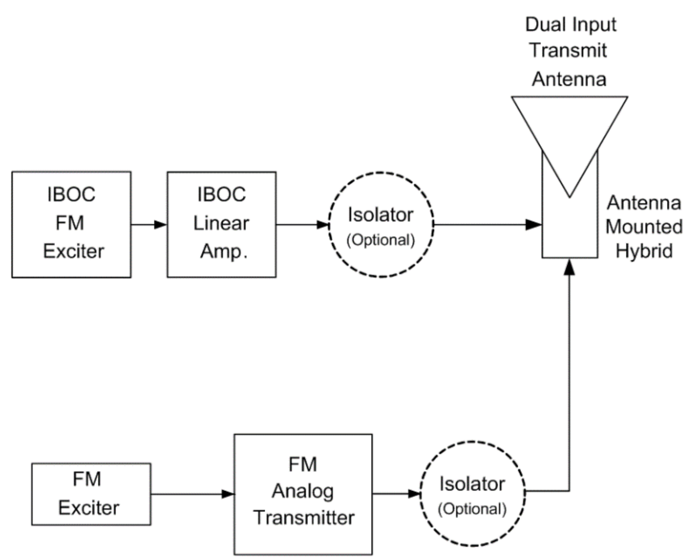

Figure 5: FM HD Radio Dual-Input Antenna Implementation

Simulcast and Analog/Digital Audio Blending

An effective method for dealing with RF channel fading in a mobile reception environment (for example, radio reception in a moving automobile) is to provide a second channel conveying the same information. Transmitting the same information on a second channel shifted in time can enhance the total system performance when the two channels are recombined at the receiver. This technique is called “time diversity.”

HD Radio technology takes advantage of time diversity in the MPS by introducing a time delay between the analog and digital transmitted versions of the simulcast MPS audio channel of four to eight seconds, and then by realigning these digital and analog signals in the receiver. Synchronizing the MPS digital audio service and the analog FM audio service is essential to allow HD Radio receivers to smoothly transition between the analog and the digital versions of the signal. This analog to digital audio transition is called “blending.”

HD Radio Service Modes

The HD Radio broadcasting system functionality affords many degrees of freedom in the choices that can be made to optimize system end-to-end performance.

These include:

Audio robustness versus audio quality and latency;

Data throughput versus data robustness;

Audio quality versus data throughput tradeoffs (upper Layers);

Scrambling;

Channel coding;

Interleaver design;

Allocation of the various digital subcarriers (which comprise the digital sidebands).

By choosing and combining these factors in appropriate ways, a wide variety of information data rates, audio/data combinations and bit error rate performance for anticipated channel conditions can be achieved.

For the HD Radio system, several such combinations have been defined, enumerated and designated for the hybrid FM system and the all-digital FM system. These designated combinations are the defined service modes of the HD Radio system.

Audio Service Definitions

In hybrid HD Radio systems, the analog portion of the over-the-air signal is identical to the signal of existing analog-only broadcasting systems. As previously noted, broadcasting using the HD Radio system is compatible with much of the existing analog-only broadcasting equipment and the transmitted signal is compatible with existing analog-only receivers. The FM analog program audio is the means by which the broadcast system maintains compatibility with analog-only receivers. It is used synergistically with the MPS digital audio in hybrid mode as backup audio, to provide improved robustness at the receiver under circumstances of signal fading and blockage.

As detailed above, multicast or SPS channels are additional audio channels that may be added in addition to the MPS. The amount of bandwidth allocated to the MPS and SPS channels is determined by HD Radio service mode selected and by the total number of audio streams transmitted. Digital audio is the primary or main audio delivery mode in both hybrid and all-digital modes. In all-digital mode, the main audio signal is augmented with another lower-latency and lower-bandwidth digital channel which acts as backup audio in lieu of the analog channel (used in hybrid mode, which no longer exists in all-digital mode). While the MPS channel is backed up by the analog signal, the SPS channels are stand-alone and receivers tuned to an SPS channel will mute when the digital signal becomes unreceivable.

Audio Classes

In the hybrid modes of operation, the maximum digital audio quality achievable for an MPS channel is described by audio service class 1 in **Table A-1**. The actual audio quality of a given digital audio channel is defined by the bitrate used for that audio channel which determines the audio frequency response, stereo separation and dynamic range (parameters shown for class 1 in **Table A-1** are realized for an MPS bit rate of 96 kbps which is the maximum available for a normal hybrid transmission). Class 2 audio service is, at a minimum, accomplished by the simulcast analog channel. Typically, the simulcast analog audio channel is stereophonic. In all-digital modes, a digital backup channel (separate from the main channel audio) is supported which can provide class 2 audio service.

Table A-1: Audio Service Classes

Class	Service	Audio Type	Maximum Audio Frequency Response	Maximum Stereo Separation (dB)	Maximum Dynamic Range	Quality Level
1	FM main	stereo	20 – 20,000 Hz	70 dB	96 dB	Virtual CD
2	FM backup	monophonic	20 – 15,000 Hz	N/A	65 dB	FM mono

Digital Data Service Definitions

The HD Radio system supports extensive datacasting services. Six data transport services have been defined for hybrid FM HD Radio as follows:

CODEC digital audio transport;

Text transport;

Control channel transport;

Packet/message transport;

File transport;

Generic streaming data transport.

To support these transport services, the HD Radio system has defined the following classes of data:

Table A-2: Classes of Data Service

Class	Service	System	Minimum Rate (bit/s)	Maximum Rate
1	Dedicated fixed rate	Hybrid, All-digital	860; FM	N/A
2	Adjustable rate	Hybrid, All-digital	0	Equal to at least the maximum rate of audio CODEC
3	Opportunistic variable rate	Hybrid, All-digital	0	Equal to maximum rate of audio CODEC

Dedicated fixed-rate services employ a fixed data rate that cannot be changed by the broadcaster. Adjustable rate services operate at a constant rate that, unlike fixed-rate services, is selectable and changeable by the broadcaster by trading off audio quality or robustness for data throughput. To increase the data rate, the broadcaster reduces the audio bit-rate (and therefore audio quality or robustness) and reallocates it to data. To increase audio quality, the data is reduced. The adjustable rate services operate by dynamically allocating digital subcarriers among error correction, audio and data services.

Opportunistic variable-rate services offer data rates that are dynamically related to the complexity of the encoded digital audio. Simpler audio passages (e.g., simple tones, narrow bandwidth audio, and silence) require lesser bit rates, permitting the unused throughput to be used for data. The audio encoder dynamically measures audio complexity and adjusts data throughput accordingly, without compromising the quality of the encoded digital audio.

Datacasting

Datacasting is defined as delivering data content from a content provider to a receiver end user via the HD Radio system. This data can include, but are not limited to, the following:

Streaming perceptual audio CODEC (HDC) applications;

Still and streaming video applications;

Message/packet based applications;

File-based applications;

Audio storage and retrieval applications;

Billing and management;

Text/XML (extended mark-up language) applications;

Specialized applications with specialized receivers;

Datacasting services with various defined levels of quality of service for each.

HD Radio system datacasting users are of three types:

Content providers who create and package content for broadcast over the HD Radio system;

Operations, administrative and maintenance (OAM) users who manage the broadcast system for content delivery, billing and other administrative tasks support;

Receiver end-users who make use of the content broadcast by the HD Radio system.

For purposes of datacasting definition and specification, the HD Radio system consists of two parts:

Broadcast network system that receives content from content providers and delivers it to individual broadcast station systems;

Broadcast station systems that receive content from the broadcast network system, or from local content providers for broadcast.

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