

# IBOC TECHNOLOGY: A Review

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**Abstract:** *The Band on-channel (IBOC) solution using the same FM channel has been further developed in the United States, to replace the CD -quality stereo quality FM transmission. National Radio Systems Committee (NRSC) has commented iBiquity Digital Corporation 's FM IBOC system to determine simulate IBOC operation with existing FM radio receiver compatibility. This article outlines IBOC, the status quo of the technology and IBOC basic techniques affect the Australian broadcasting potential environmental right.*

**Keywords:** *IBOC, ibiquity Digital Corporation, broadcasting, stereo*

## What is IBOC:

IBOC (in the same frequency band) 1 digital broadcasting technology, also known as the International Digital System C, by conventional FM radio broadcasts in the same analog and digital programming without the need to facilitate the introduction of digital sound broadcasting (DSB ) of the new spectrum assignment to a digital signal.

IBOC is capable of transmitting a variety of audio services and wireless data services. On a basic level, it will broadcast transmission and digital audio programs, including song title, artist, and station information data. Expected initial receiver application, including the ability to display simple text and audio program information. Expects more data services, including services like paging, including passing traffic, weather, sports scores, stock quotes and targeted messages.

Developed by the iBiquity Digital Corporation IBOC technology focus is to work within the existing broadcast infrastructure digital transition of. The IBOC digital signal is placed in the existing analogue FM spectrum emission mask, and as a result of IBOC as possible without having to make a

new frequency assignment will not be interrupted or existing broadcast infrastructure to implement digital solutions.

The proposed use their existing broadcast transmission equipment and studio equipment only with added IBOC exciter and, in limited circumstances, to upgrade transmitters.

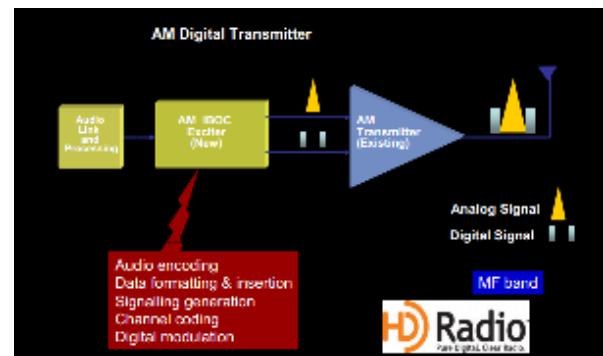


Fig: 1 AM IBOC system

## Status of IBOC:

The National Radio Systems Committee (NRSC) has released its FM IBOC (In Band On Channel) Digital Radio Evaluation Report, as adopted on November 29, 2001 and recommends that the iBiquity FM IBOC system as evaluated by the NRSC should be authorized by the FCC (Federal Communications Commission) as an enhancement to FM broadcasting in the United States.

The International Telecommunications Union (ITU) is in the process of including IBOC as Digital System C in Recommendation ITU-R BS.

The IBOC system tested and presented in the NRSC evaluation reports used MPEG- 2 AAC<sup>2</sup> as an audio compression technology. It is proposed by iBiquity Digital Corporation to use its own audio compression technology in commercial IBOC equipment but this substitution is not expected to impact on the IBOC test results.

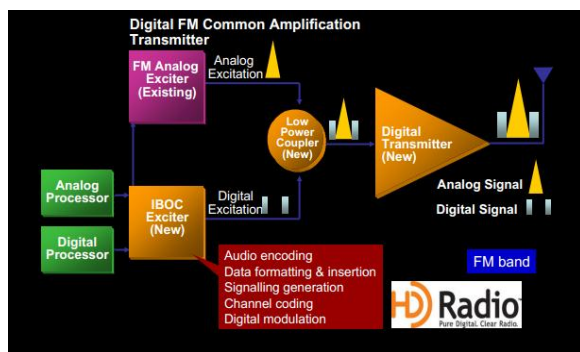


Fig: 2 FM IBOC systems

### IBOC Modes of Operation:

There are three IBOC modes of operation. IBOC allows transition from analog to digital through a *Hybrid* and *Extended Hybrid* mode of operation, before adopting an *All Digital* mode of operation. The digital signal is modulated onto a large number of subcarriers, using orthogonal frequency division multiplexing (OFDM), which are transmitted simultaneously.

**Hybrid Mode:** In this mode the digital signal is inserted within a 69.041 kHz bandwidth, 129.361kHz on either side of the analog FM signal.

The IBOC Hybrid mode digital signal is transmitted in sidebands either side of the analog FM signal and each sideband is approximately 23 dB below the total power in the FM signal. The hybrid sidebands are referred to as primary Main (PM) sidebands.

The host analog signal may be mono or stereo, and may include subsidiary communication channels. The total power of the digital sidebands is 20 dB below the nominal power of the FM analog carrier with power relative to the total analog FM power of  $-41.39$  dB/kHz.

**Extended Hybrid Mode:** This mode includes the hybrid mode and additional digital signals are inserted closer to the analog signal, utilising a 27.617 kHz bandwidth, 101.744 kHz on either side of the analog FM signal.

The IBOC Extended Hybrid mode digital sidebands are extended towards the analog FM signal to increase digital capacity. The extended hybrid sidebands are referred to as Primary Extended (PX) sidebands. The total power of the digital sidebands is 20 dB below the nominal power of the FM analog carrier with power relative to total analog FM power of

$-41.39$  dB/kHz.

**All Digital Mode:** This mode replaces the analog signal with additional digital signals and also includes the digital signals of the Hybrid and Extended Hybrid modes.

With IBOC all Digital, The primary digital sidebands are extended as in IBOC Extended Hybrid and the analog signal is removed and replaced by lower power digital secondary sidebands, thus expanding the digital capacity. The total power of the digital sidebands is 10 dB below the nominal power of the replaced FM analog carrier with power relative to the total analog FM power of  $-31.39$  dB/kHz. Of the above three IBOC modes, it should be noted that the only the IBOC Hybrid Mode has been evaluated by the NRSC.

### IBOC Capabilities:

IBOC enables the broadcaster to select the desired audio quality and data transmission rate however, as expected; there is a tradeoff between audio quality and the data transmission rate. The audio quality at 96 kb/s is near CD quality but in Hybrid mode this only allows 1 kb/s for data. IBOC allows the bit rate to be adjusted in 8 kb/s steps. By transmitting audio at the satellite DARS<sup>3</sup> bit rate of 64 kb/s, additional data capacity, exceeding that of the current generation of mobile phones (9 – 19kb/s), is available. At times when audio quality is not as important, the audio bit rate may be reduced to as low as 48 kb/s but audio quality will be reduced to near telephone audio quality.

IBOC incorporates a 4.5 second delay between the analog and digital audio signals. The receiver initially acquires the analog signal and takes a few seconds to begin to decode the audio on the digital sidebands. If 10% of the digital data blocks sent are corrupted during transmission, the IBOC receiver reverts to the analog signal. This is referred to as the “blend-to-analog” feature of IBOC. The blend process is perceived to have the same quality as the analog audio and the process itself does not degrade the audio quality below that of analog.

Field tests indicate that Hybrid FM IBOC digital coverage is comparable to analog coverage but IBOC reception can be obtained in areas where the analog service is currently of an unacceptable quality due to interference such as co-channel interference, impulse noise and multi-path fading. The

enhancements claimed over traditional analog FM broadcasting include:

- almost full immunity from typical FM multipath reception problems;
- significantly improved full stereo coverage;
- flexible data casting opportunities: and
- efficient means for FM broadcasters to begin the transition to digital broadcasting
- Use of OFDM in IBOC allows on-channel digital repeaters.

It is expected that there will be a trade off in audio signal-to-noise ratios in some areas where 1<sup>st</sup> adjacent (IBOC) stations overlap, but this is only expected where 1<sup>st</sup> adjacent interference currently exists with adjacent channel analog services.

The iBiquity field tests conducted with eight FM broadcasting stations in the US, concluded that digital coverage with one hundredth the power (-20dB) of analog, extended to the 45 - 50 dBu signal level. **Impact on Broadcast Planning**

In addressing the impact of the introduction of IBOC on broadcasting planning in Australia, there are two key issues that are worthy of noting. The first issue is IBOC's compliance with the spectral emissions mask of the Australian FM broadcasting service and the second is the effect on the required protection ratio between FM services, which determines the separation distance between FM broadcasting services.

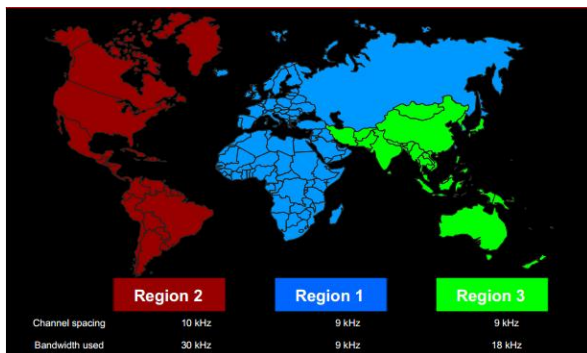


Fig: 3 ITU standard regions

### The FM Spectral Emissions mask:

The emission standard for the Australian Frequency Modulation Sound Broadcasting Service specifies the maximum values for out-of-band and spurious outputs. This is referred to as the spectral emissions mask. This limits the out-of-band and spurious outputs and restricts any emission appearing on a frequency removed from the carrier. Between 120 kHz and 240 kHz, emissions are to be attenuated by at least 25 dB below the level of the unpopulated carrier. Any output appearing on a frequency removed from the carrier by more than 240kHz, up to and including 600 kHz, is to be attenuated by the at least 35dB below the level of the unpopulated carrier. Any output appearing at a frequency removed from the carrier by more than 600kHz is to be attenuated by the least  $43+10\log P$  dB (Where P is transmitter power in watts) below the level of the unpopulated carrier, or 80dB whichever is the lesser attenuation. All three IBOC digital transmission modes are proposed to operate well below the FM radio spectral emissions mask. The diagram above indicates the Hybrid Mode within the FCC's emissions mask.

### IBOC Evaluation and Protection between FM Services:

Compatibility testing of the Hybrid IBOC System was undertaken using the FCC's required protection ratios for the level of desired signal to the interferer(D/U) for a desired signal of -62 dBm (54 dBuV/m). The FCC's protection ratios considered during IBOC testing include a co-channel desired-to-undesired (D/U) signal strength ratio of 20 dB; a first adjacent channel D/U of 6 dB; and a second and third adjacent channel D/U of -40 dB. The FCC desired or service signal strength is based on median  $f(50,50)$  field strength and the undesired or interfering signal strength is based on median  $f(50,10)$  field strength. The ITU recommends protection ratios<sup>5</sup> of 45(37) dB<sup>6</sup> for co-channel protection; 7(7) dB for 200 kHz carrier frequency separations; and -20(-20) dB for 400 kHz carrier frequency separations.

| Hybrid mode             | DAB | IBOC-AM                        | IBOC-FM                                    | DRM  |
|-------------------------|-----|--------------------------------|--|--|
| Channel width           | -   | 30 kHz                         | 400 kHz                                    | 9, 10, 18, 20, 27, 30 kHz                  |
| Modulation              | -   | COFDM                          | COFDM<br>1068 carriers                     | COFDM<br>100 - 400 carriers                |
| Useful digital rate     | -   | audio: 36 kbps<br>data: 4 kbps | audio: 96 kbps<br>data: 4 kbps             | 4.8 - 72 kbps                              |
| Efficiency              | -   | up to 0,75 bps / Hz            | up to 0,25 bps / Hz                        | 0,5 - 1,6 bps / Hz                         |
| Multi service           | -   | up to 2<br>one audio, one data | up to 4<br>audio, data<br>adjustable rates | up to 4<br>audio, data<br>adjustable rates |
| Audio quality (analog)  | -   | 4,5 kHz<br>mono                | FM stereo                                  | 4,5 kHz<br>mono                            |
| Audio quality (digital) | -   | FM quality<br>mono             | CD quality<br>mono - stereo                | FM quality<br>mono - stereo                |
| Data services (analog)  | -   | No                             | RDS  | No   |
| Data services (digital) | -   | PAD                            | PAD, N PAD                                 | PAD, N PAD                                 |

Fig: 4 Technical details table

**IBOC Testing and Results:**

The Advanced Television Technology Centre (ATTC) conducted compatibility testing of the IBOC System and submitted its report<sup>8</sup> to the NRSC. Again it should be noted that this testing only included the IBOC Hybrid mode. The NRSC evaluated the data provided by ATTC and concluded that:

Listeners should not perceive an impact on the analog host signal, nor on the analog signals of carriers that are either co-channel or 2<sup>nd</sup> adjacent channel (+/- 400 kHz) with respect to the IBOC signal

A limited number of listeners may perceive an impact outside the protected area on the analog signals of carriers that are 1<sup>st</sup> adjacent channel (+/- 200 kHz) with respect to the IBOC signal.

*Host Compatibility:* The objective test results (attachment A) on IBOC interference to the host analog, shows that there is negligible effect on very selective receivers (automotive) but a reduction in audio signal-to- noise of up to 10 –15 dB can result with less selective receivers (home stereos and portable receivers).

The outcome of the field tests resulted in iBiquity concluding that, with IBOC turned on and off, listeners did not perceive any meaningful difference from the introduction

*First Adjacent Channel Compatibility (200 kHz).* The ATTC objective test results on IBOC interference on a 1<sup>st</sup> adjacent channel concluded that the addition of –22 dB digital sidebands on an adjacent analog channel, with a D/U

protection ratio of +6 dB, degrades the audio signal-to- noise of the wanted analog service by an average of 4.2 dB. In all receiver types tested, it was identified from objective testing that analog audio quality was reduced when IBOC digital sidebands were present on a 1<sup>st</sup> adjacent channel. The NRSC specifically identified that the audio quality of the analog aftermarket automotive radio, under moderate interference conditions was reduced from good to poor. Field test results indicate that there is some potential impact on analog first adjacent channels, but analysis of listening patterns conclude the number of affected listeners to be exceedingly small with, on average, only 0.6% of an FM stations existing analog listeners experiencing any impact from the introduction of IBOC. The NRSC identified that one of the greatest compatibility challenges facing FM IBOC was addressing the 1<sup>st</sup> adjacent channel interference potential to an existing analog service. This was after evaluating data in respect to moderate interference (+16 to +6 dB D/U) from subjective evaluation of audio in the field (speech programming).

As outlined above, the interference levels on which FM services are planned in Australia for 1<sup>st</sup> adjacent channels are 25 dB D/U for continuous interference and 17 dB D/U for tropospheric interference. The moderate interference signal of +16 dB D/U used in IBOC tests, that causes a degrading of audio quality is very similar to the protection requirement that required in Australian where +17 dB D/U is required for protection against tropospheric interference. Given a similar protection ratio (D/U), it is assumed that subjective assessment of audio quality with a moderate interference signal of +16 dB (D/U) would result in similar results in Australian under tropospheric interference conditions.

The objective test laboratory results for receivers using +16 dB D/U and +6 dB D/U protections are included at Attachment A. The analysis of the +16 dB D/U data gives a better indication as to the impact that IBOC would have in Australia under tropospheric interference conditions.

The test results show that with analog 1<sup>st</sup> adjacent channel interference, at a D/U of +6 and +16 dB, there is no difference in audio signal-to-noise with very selective receivers but the less selective receivers benefit from the

greater protection ratio (D/U).

With IBOC digital 1<sup>st</sup> adjacent channel interference at 6 dB (D/U), there is approximately a 20 dB reduction in audio signal-to-noise with very selective receivers whilst at 16 dB (D/U) there is an approximate 10 dB reduction. This reduction becomes approximately 10 dB and 3 dB respectively when the channel is subject to Additive White Gaussian Noise (AWGN) at a level of 30,000K<sup>9</sup>. The addition of a background noise component to RF signals under test has been done to make the subjective evaluation more realistic and comparable to 'real world' conditions.

The NRSC concluded that the tradeoffs, necessary for adoption of FM IBOC in the USA, are relatively minor. One tradeoff identified is that that a small decrease in signal-to-noise will be evident to some listeners in localized areas, where 1<sup>st</sup> adjacent stations operating with the FM IBOC system, overlap the coverage of the desired analog station.

*Second Adjacent Channel Compatibility (400 kHz).* Results of these field tests mirror the host compatibility results, indicating no meaningful difference in the analog signal with the digital signal turned on and off.

#### **Conclusions:**

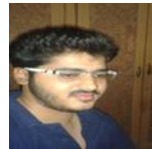
In IBOC emission spectrum, the three modes of operation, fell in love with Australian FM sound broadcasting services within the emission standards. Objective test results concluded that the introduction of hybrid IBOC digital transmission for the presence of signal and noise by reducing the potential for a significant reduction in home stereo receiver and a portable radio receiver host analog audio quality. This should not be a car radio receiver (very selective receiver) is obvious. ABC environment subjective evaluation unaware quality analog audio from the host to introduce any meaningful difference in the IBOC. Objective test results concluded that the introduction of hybrid IBOC digital transmission has a reduction potential of a first adjacent analog audio quality, the car radio receiver, the audio signal by - reducing noise. Reduce the audio quality is recorded in the objective and subjective evaluation of test results experienced in the United States. This effect is not expected to be large in Australia to a higher rate of protection is

planning for protection against a first adjacent channel interference. The effect, an extension of hybrid IBOC digital transmission and digital analog hosts and adjacent channel audio quality is like in the United States conducted the test has not been evaluated yet.

#### **REFERENCES:**

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#### **BIOGRAPHY:**



I am Rahul Chauahan, pursuing BTech.in Electronics and Communication stream from Global College of Technology, Jaipur. My areas of interest include signal processing, communication system. I am having keen interest in data base management. Always eager to gain knowledge from scratch to full analysis of topics of interest. I have attained various certificates for good programming skills in C,C++,DSA.I see myself as a part of Research and Development Cell in renowned multinational company after 3 years.