Application Note

IBOC signal measurement by using Willtek's 9100 Series Handheld Spectrum Analyzer

boosting wireless efficiency

Introduction

IBOC (In-Band On-Channel) technology is the development of new digital communication technologies which sends high quality digital signals that analog AM and FM radio use today. These digital signals can be picked up by new digital radios, while they have no impact on traditional analog reception and provide for enhanced sound fidelity, improved reception, and news data services. IBOC is a method of transmitting near-CD quality audio signals to radio receivers along with new data services such as station, song, and artist identification, stock and news information, as well as local traffic and weather bulletins.

What is IBOC?

IBOC, In-Band On-Channel digital audio broadcasting, allows AM and FM radio stations to simultaneously broadcast new digital services – audio channels and wireless data and their traditional analog signal in their current spectrum. The IBOC technology is designed to bring the benefits of digital audio broadcasting to today's radio while preventing interference to the "host" analog signal and stations on adjacent channels.

IBOC refers to the method of transmitting a digital radio broadcast signal centered on the same frequency as the AM or FM station's present frequency. For FM stations, the transmission of the digital signal occupies the sidebands above and below the center FM frequency (e.g., 97.9 MHz). AM band transmissions also place the digital signal in sidebands above and below the existing AM carrier frequency. By this means, the AM or FM station's digital signal is transmitted in addition to the existing analog signal. In both instances, the digital emissions fall within the spectral emission mask of the AM or FM channel.

Hybrid IBOC spectrum

A brief description of the hybrid FM signal may be helpful. The digital signal surrounding the host FM analog signal consists of hundreds of Orthogonal Frequency Division Multiplex (OFDM) carriers, often referred to in IBOC literature as sub-carriers. These sub-carriers are grouped in two ways. First, there are two fundamental groups, located on the upper and lower sidebands (USB and LSB) of the analog FM carrier. Second, these sideband groups consist of Primary Main sub-carriers and some optional extended sub-carriers. Figure 1 shows a simplified image of the hybrid spectrum.

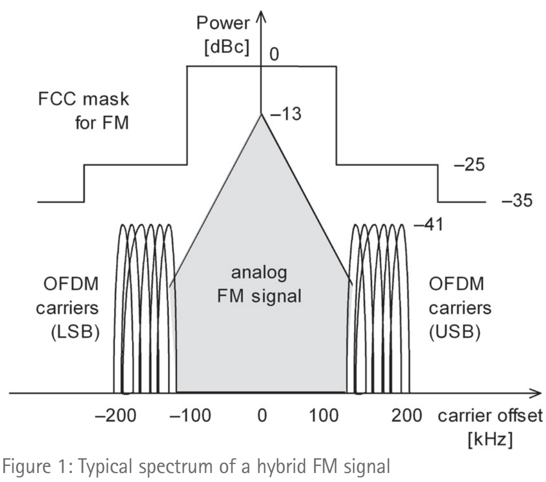

Figure 1: Typical spectrum of a hybrid FM signal

The power in a 1 kHz sample of each FM sideband is approximately 41 dB below the power of the analog FM carrier. Each individual subcarrier is about 46 dB below the analog FM carrier. With 191 sub-carriers in each FM sideband, the total power in an FM sideband is 23 dB below the analog FM carrier.

The IBOC FM hybrid mode places low-level digital carriers in the upper and lower sidebands of the analog spectrum as shown in Figure 2. These carriers are modulated with redundant information to convey the digital audio and data. The implementation on AM is similar in that the upper and lower sidebands contain low level digital signals. Since the analog AM signal is amplitude modulated (as opposed to frequency modulation), the AM IBOC hybrid signal can carry digital information in a quadrature phase component. Thus some of the digital information can be placed directly beneath, or in quadrature to the analog modulation as shown in Figure 2.

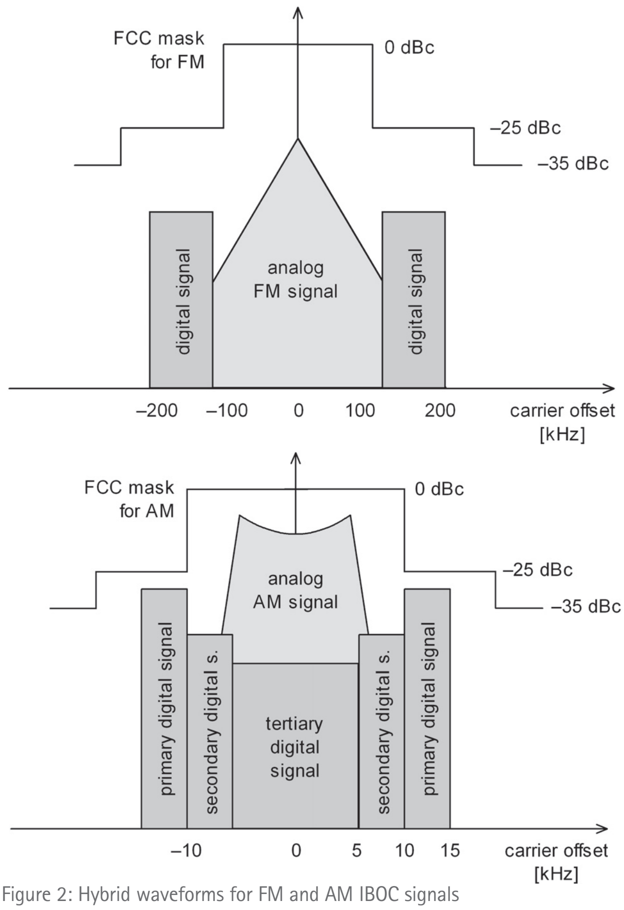

Figure 2: Hybrid waveforms for FM and AM IBOC signals

IBOC measurements with Willtek's 9100 Series Spectrum Analyzer

The measurement process by using Willtek's 9100 Handheld Spectrum Analyzer is very convenient and familiar. There are many setting options to be followed, so the results may vary and one must be able to interpret the measurements. Here are two examples or templates for the FM and AM IBOC measurements by using 9100 Handheld Spectrum Analyzer; the signal was generated by using the Noise Com Digital Signal Generator DSG9000 HD Radio.

FM spectral emissions limits

Analog transmissions will remain within the Federal Communications Commission (FCC) emissions mask in accordance with CFR Title 47 and as summarized in Table 1. Measurements of the analog signal are made at the antenna input by averaging the power spectral density in a 1-kHz bandwidth over a 10-second segment of time.

Table 1: Spectral emission mask for FM

Offset from carrier frequency (kHz)	Power spectral density relative to unmodulated analog FM carrier (dBc/Hz)
120 to 240	–25
240 to 600	–35
greater than 600	–80, or –43 – (10 log (power in watts)), whichever is less, where power in watts refers to the total unmodulated transmitter output carrier power

According to FM transmission system requirements, any emission appearing on a frequency removed from the carrier by between 120 kHz and 240 kHz inclusive must be attenuated at least 25 dB below the level of the unmodulated carrier. Compliance with this requirement will be deemed to show the occupied bandwidth to be 240 kHz or less. The FM sidebands are usually ±129 to 198 kHz (69 kHz on each side) and 191 OFDM carriers on each sideband.

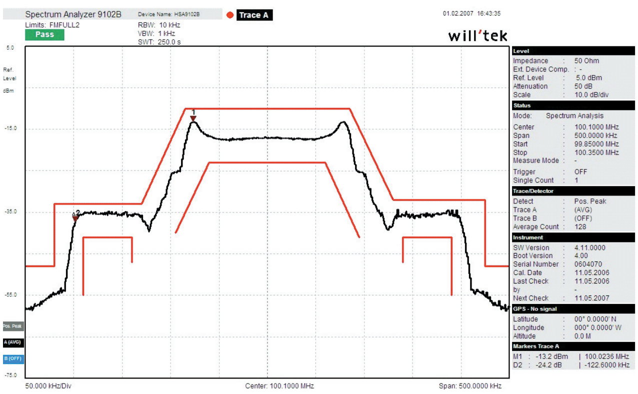

Figure 3: FM IBOC signal measurement using the 9100

AM spectral emissions limits

Hybrid and all digital transmissions shall remain within the FCC emissions mask as summarized in Table 2. All measurements assume a measurement resolution bandwidth of 300 Hz. More stringent spectral emissions limits will most likely be required to minimize interference to an IBOC carrier from adjacent IBOC carriers.

Table 2: Spectral emission mask for AM

Offset from carrier frequency (kHz)	Level relative to unmodulated carrier (dB)
10.2 to 20	–25
20 to 30	–35
30 to 60	–5 – 1 dB/kHz * f
60 to 75	–65
> 75	–80, or –43 – (10 log (power in watts)), whichever is less

The digital signal is transmitted in primary and secondary sidebands on either side of the analog host signal, as well as in tertiary sidebands beneath the analog host signal as shown in Figure 4. In addition, status and control information is transmitted on reference sub-carriers located on either side of the main carrier. Each sideband has both an upper and a lower component. The PIDS (Primary IBOC Data Service) logical channel is transmitted in individual sub-carriers just above and below the frequency edges of the upper and lower secondary sidebands.

The power level of each OFDM subcarrier is fixed relative to the unmodulated main analog carrier. However, the power level of the secondary, PIDS, and tertiary sub-carrier is adjustable. The IBOC signals shown in Figure 3 and Figure 4 were gener-

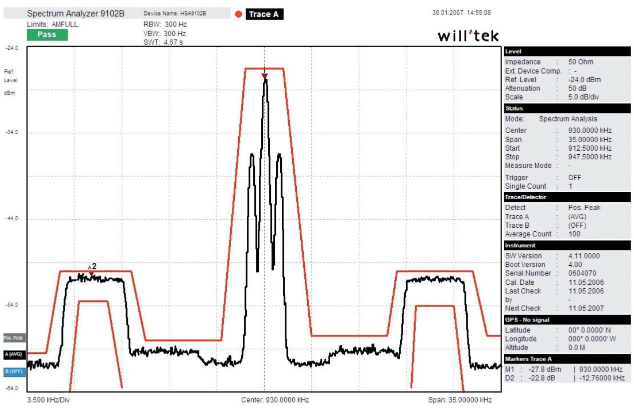

Figure 4: AM IBOC signal measurement by using 9100 Spectrum Analyzer

ated with a Noise Com DSG9000 HD Radio signal source. The DSG9000 series instruments are certified by iBiquity Digital Corporation, the sole developer and licenser of Digital HD Radio technology. These instruments are designed for production testing with a simplified user interface and also include one vector for AM, and one vector for FM HD Radio.

The above two templates for both IBOC measurements can also be downloaded from Willtek's website at www.willtek.com

References

[1] Broadcast Signal Lab (http://www.broadcastsignallab.com)

[2] Technical papers from iBiquity Digital Corporation (http://www.ibiquity.com)

[3] IBOC FM Transmission Specification http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-02-286A2.pdf

[4] IBOC AM Transmission Specification http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-02-286A3.pdf

[5] Noise Com DSG9000 HD Radio Signal Generator http://www.noisecom.com/content/Products/Components/DSG9000/DSG9000.pdf

Willtek Communications GmbH
85737 Ismaning
Germany
Tel: +49 (0) 89 996 41-0
Fax: +49 (0) 89 996 41-440
info@willtek.com

Willtek Communications UK
Cheadle Hulme
United Kingdom
Tel: +44 (0) 161 486 3353
Fax: +44 (0) 161 486 3354
willtek.uk@willtek.com

Willtek Communications SARL
Roissy
France
Tel: +33 (0) 1 72 02 30 30
Fax: +33 (0) 1 49 38 01 06
willtek.fr@willtek.com

Willtek Communications Inc.
Parsippany
USA
Tel: +1 973 386 9696
Fax: +1 973 386 9191
willtek.cala@willtek.com
sales.us@willtek.com

Willtek Communications
Singapore
Asia Pacific
Tel: +65 6827 9670
Fax: +65 6827 9601
willtek.ap@willtek.com

Willtek Communications Ltd.
Shanghai
China
Tel: +86 21 5835 8039
Fax: +86 21 5835 5238
willtek.cn@willtek.com

will'tek

9100/AN719/0807/EN