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NRSC/ATTC and CRC D/U Ratios Comparison

The performance of the FM analog signal in presence of analog or hybrid FM-IBOC interference.

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Ottawa, November 2009

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CRC

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A presentation entitled "IBOC Coverage and Interference" was given at the National Association of Broadcasters (NAB) in the fall of 2006 by Doug Vernier of V-Soft Communications [1]. This slideshow included D/U ratios representing the performance of the FM analog signal in presence of analog or hybrid FM-IBOC interference, as measured in 2001 by the NRSC/ATTC in the laboratory and also in field tests [2]. Similarly, in 2007 the Communications Research Center (CRC) Canada also did some D/U laboratory measurements on the effect of adding FM-IBOC signal in the FM analog environment in Canada [3]. Thus this report is intended to provide a comparative overview between the USA and the Canadian results.

The main objective:

- The NRSC/ATTC focused their work in order to preserve a good signal quality within an existing FM analog station protected contour while adding interfering FM-IBOC digital signal. Consequently very little data was obtained outside the protected contour.
- The CRC objective was to determine the effect of adding FM-IBOC signals into the Canadian FM analog environment, which has a different regulatory context than the USA. For example, the field strength of the protected contour is lower in Canada, therefore more vulnerable to interference situations occurring at its fringe. Also the 2nd adjacent channels have higher protection levels resulting in a greater distance between two 2nd adjacent FM analog stations. Hence the CRC tested the effect of having FM-IBOC digital interference near the limits of the FM analog station protected contour.

D/U ratios:

- The D/U ratios result from a combination of laboratory tests and field measurements of eight USA FM stations by the NRSC. The Advanced Television Technology Center (ATTC), an independent testing facility, was selected to conduct laboratory tests. In addition data collection in the field was done using test vehicles provided by iBiquity Digital Corporation. These vehicles utilized four analog FM receivers and an iBiquity FM IBOC prototype receiver for capturing analog and IBOC radio transmissions, respectively.
- The D/U ratios result exclusively from laboratory measurements at the CRC.

Type of tests and threshold point:

- The NRSC/ATTC did subjective tests as well as objective tests.
  The *subjective* "tune out" threshold point was based on the Mean Opinion Score (MOS) results where half of the persons in the evaluation group stopped listening to the program material. The test audio samples were created using the MPEG-2 AAC codec. The results obtained with this codec might have to be revised since the actual FM-IBOC technology uses a proprietary iBiquity perceptual audio coding algorithm. It is also

believed that the NRSC/ATTC analog audio samples recorded in the laboratory were judged more critically by the listeners than were the samples recorded in the field because the automobile receivers were operating in stereo when the samples in the laboratory were recorded, and in mono when most of the samples in the field were recorded, and interference is usually more noticeable during stereophonic reception than it is during monophonic reception.
The *objective* threshold was based on a measured 30 dB WQP S/N ratios. A strong correlation was first confirmed between the subjective tune out points with the objective 30 dB WQP S/N ratio in the iBiquity test report.

- The CRC testing was *subjective* only and the threshold was pegged at the level 3 of the CCIR scale upon the assumption that most listeners would turn off the radio at that point, irrespective of the blending point from stereo to mono. Therefore, some receivers were still transmitting in stereo at this point while others had already blended to mono depending on the receiver's technical characteristics.

Desired signal power level:

- Since the NRSC/ATTC focused their work within their protected contour, the desired signal power level was strong (-47 dBm).
- The CRC D/U ratios were determined using a desired FM signal power level near the limits of the protected contour (-62 dBm).

In fact, the choice of the desired power level should not influence the conclusion of the study since the results are presented in D/U ratios. Moreover, the CRC verified with success that the D/U ratios were essentially independent from the selected desired power level.

Noise:

- The NRSC/ATTC added RF "background noise" to the co- and adjacent channel laboratory tests in order to compare the results with field measurements in which the RF white noise is the most important interference to the signal. The added noise (corresponding to 30,000K) results did not turn out to be very different from the field results. Another laboratory measurement sequence was made with no added noise as a "sanity check" and this confirmed the added noise to be representative of the reality.
- The CRC did not add any noise to the co- and adjacent channel laboratory tests.

The NRSC/ATTC added noise was part of the "U" component. This component is in fact the combination of noise and interfering signals. Thus the NRSC/ATTC laboratory measurements would reach the same D/U ratios as the CRC but with a weaker interfering signal because of the presence of the added noise. Though, this difference in the laboratory measurements should not have any effect since the results are presented in D/U ratios.

Receivers:

- The NRSC/ATTC acquired 4 commercially-available analog FM receivers for the field measurements. These selected receivers were representative of the vast majority of the top-selling model receivers in the USA in December 2000, according to the CEA's Market Research Department and USA receivers' performance experts.
  The laboratory and field data collected at weaker signal levels (outside the protected contour) were obtained using the automobile receivers. The data collected for the home hi-fi and portable receivers essentially served to confirm that these receivers are usually not capable of producing acceptable levels of audio quality when located beyond the desired station's protected contour in the presence of analog first adjacent channel interference.
- The CRC had 3 car radios out of the 5, the 2 others were home hi-fi. They consisted of loaned FM receivers dating a few years back. Newer models of the same brands ought to be available on the market at this point in time.

Program Material:

- The NRSC/ATTC used 3 types of processed program material: classical, rock, and speech. Mobile field test results were only conducted for rock/country programming.
- The CRC used more critical audio material (classic - EBU clarinet - and speech).

The FM-IBOC digital sidebands were about the same power level from the FM analog host since the NRSC/ATTC was -22 dBc and the CRC about -21 dBc.

D/U Results:

Adjacency	USA D/U Protection (Canadian D/U Protection)	NRSC/ATTC D/U	CRC D/U
Co-channel	+20 dB (+20 dB)	38 dB	34 dB
1st	+6 dB (+6 dB)	-7.5 dB	-2 dB
2nd	-40 dB (-26 dB)	-42 dB	-47 dB

Table 1 : Analog to Analog D/U Ratios

Adjacency	NRSC/ATTC D/U	CRC D/U
Co-channel	38 dB	32 dB
1st	3 dB	5 dB
2nd	-42 dB	-40 dB

Table 2 : Hybrid to Analog D/U Ratios

The receiver D/U ratios can be compared despite the fact that the NRSC/ATTC and the CRC had many differences in the measurement procedures and the test conditions.

In the case of the co-channel adjacent scenario, the conversion from an FM analog to a hybrid FM-IBOC interfering signal have no effect according to the NRSC/ATTC results and a loss of 2 dB for the CRC which is not significant (and can be attributed to the uncertainty margin error of the laboratory tests).

As expected, having the FM-IBOC interferer on the 1st adjacent channel is the worst case scenario. This is due to the presence of one of the FM-IBOC digital sidebands overlapping the desired signal. The NRSC/ATTC noted a degradation of 10 dB from having an FM analog to the hybrid FM-IBOC interferer while the CRC measured a loss of 7 dB.

The CRC 2nd adjacent tests outperformed by 5 dB the NRSC/ATTC in presence of an FM analog interferer. Notwithstanding this difference, both the NRSC/ATTC and the CRC have similar D/U ratios in presence of hybrid FM-IBOC interference.

According to both organizations D/U ratio results, the receivers' behaviour exhibits the same trends in presence of the hybrid FM-IBOC interfering signal.

References

[1] "IBOC Coverage and Interference" presented at NAB Radio & Broadcasters Clinic, Fall 2006, by Doug Vernier from V-Soft Communications.

[2] "NRSC/ATTC-R203 Evaluation of the iBiquity Digital Corporation IBOC System – Part 1 – FM IBOC" November 29, 2001 Part I – Report.

[3] "Laboratory Test Procedures for the FM IBOC Digital Transmission System", Barry McLarnon, P. Eng., Ver. 4.1, March 2007.