Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of:	)	
	)	
Digital Audio Broadcasting Systems	)	MM Docket No. 99-325
And Their Impact on the Terrestrial	)	
Radio Broadcast Service	)	

Comments of Barry D. McLarnon

I am filing the following comments as an individual. I am a independent consultant and Professional Engineer, registered in the Province of Ontario. I have more than thirty years of experience in the analysis and design of communications systems, both analog and digital. My experience with digital broadcasting systems, primarily the Eureka 147 DAB system, dates back to the late 1980s. My motivation for filing comments on this docket stems from two principle concerns:

1. After studying all of the available reports on the iBiquity IBOC systems, I have come to the conclusion that these reports present a one-sided view of this technology and its attributes. I therefore want to bring to light certain facts that have been omitted or glossed over in these reports.

2. As a Canadian citizen, I am concerned that widespread deployment of IBOC technology in the United States will create interference that will have a serious negative impact on AM and FM broadcast services in Canada. Moreover, I believe that, at least in the case of AM, IBOC operations are not permissible under the terms of the bilateral agreement between our two countries.

My comments specifically address the hybrid AM and FM IBOC systems that were identified in the Commissions DAB R&O, and now form the basis for the proposed rulemaking. As an engineer with extensive experience in this area, I fully recognize the advantages that a digital transmission system can bring to the table, in terms of noise-free reception, multipath tolerance, carriage of new data services, and so on. However, a hybrid system that overlays such a system on an existing analog service represents a serious compromise, trading off the quality of the analog service in many instances in order to gain a limited digital service. Moreover, this tradeoff is not within the control of individual broadcasters, since the new service is gained largely at the expense of others, many of whom are unwilling or unable to take part in this transition. The details of this tradeoff remain poorly understood, because they have been downplayed by the proponents of the new technology. In particular, there has been no independent and unbiased engineering study that would provide a realistic assessment of the impact of hybrid IBOC deployment on the radio broadcast services currently enjoyed by members of the public who own an estimated 800,000,000 analog receivers. I do not purport to provide such a study; I am simply pointing out the need for it.

Hybrid IBOC causes a drastic increase in occupied bandwidth.

A key parameter of any radio emission, particularly one that is channelized, is its occupied bandwidth. The Commission's definition of occupied bandwidth is[1] "the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated by a given emission". If we are modifying the emission in some fashion, then we need to know whether this will result in a change in the occupied bandwidth, and if so, the change should be quantified in order to assess the impact on adjacent channels. This in turn will provide a good indication whether existing emission masks and allocation rules are adequate to support the modification. Given the importance of this parameter, and the fact that techniques to measure it are well known, it is remarkable that it does not seem to be addressed in any of the documents and reports dealing with the IBOC systems. IBOC proponents would have us believe that, because the hybrid emission remains "under the mask", that there is no significant impact on occupied bandwidth. This is far from being the truth.

The effect of hybrid IBOC on the occupied bandwidth of an FM station is quite easy to estimate. The power spectral density of the analog signal can be modeled as a symmetrical triangular shape when plotted on a logarithmic power scale, dropping from a peak at the carrier frequency with a constant slope. This model is due to Kroeger and Peyla[2], who determined that the average slope for several stations observed in the Washington DC area was 0.36 dB/kHz, and the model appears in a number of the reports on IBOC from iBiquity and the NRSC. My own observations indicate that the model is a reasonable approximation of broadcast FM signal spectra, though there is considerable variation in the slope from station to station. Using this model, one can calculate the occupied bandwidth (as defined above) of the "average" analog FM signal to be 111 kHz. When the digital sidebands are added between 129 kHz and 198 kHz from the carrier frequency, with a total power of -23 dBc per sideband, the overall power increases by 1%, which appears insignificant. However, recalculating the occupied bandwidth shows that it has increased to 222 kHz! In fact, for a range of slopes around 0.36 dB/kHz, it is easy to show that the occupied bandwidth doubles when the IBOC digital sidebands are added.

For the AM signal, we do not have a mathematical model, but we do know that the occupied bandwidth is less than 20 kHz. In fact, it is probably less than 10 kHz in many cases, particularly with the talk programming that now predominates on the AM band. Even with music programming, broadcasters have recognized that most AM receiver manufacturers have reduced their audio bandwidths to less than 5 kHz, and are concentrating their transmitted energy in this region accordingly. A conservative estimate of typical AM occupied bandwidth would be 14 kHz. Now, when IBOC is added, there are primary digital sidebands in the region from 10.356 to 14.717 kHz from the carrier frequency, and they have a total power of -13 dBc. This is slightly less than 5% of the total (analog plus digital) power, so we are approximately reaching the 95% power point when

[1] 47CFR§2.202

[2] B.W. Kroeger and P.J. Peyla, "Compatibility of FM Hybrid In-Band On-Channel (IBOC) System for Digital Audio Broadcasting", *IEEE Trans. Broadcasting*, Vol. 3, No. 4, December 1997, pp. 421-430.

we include everything inside these sidebands, and we have to include most of the digital subcarriers in order to encompass 99% of the total power. Since the digital sidebands have an essentially flat power spectrum, we have to include about 80% of them, which results in an estimated occupied bandwidth of about 28 kHz. In other words, just as in the FM system, **adding the IBOC digital signal approximately doubles the occupied bandwidth of the AM emission**.

Section 4.2 of the US-Canada bilateral agreement on AM broadcasting[3] states: "Classes of emission other than A3E, for instance to accommodate stereophonic systems, could also be used on condition that the energy level outside the necessary bandwidth does not exceed that normally expected in A3E...". The "necessary bandwidth" is defined as 10 kHz. The hybrid AM IBOC system increases the occupied bandwidth of an AM station to approximately 28 kHz, and the increased power is nearly all well outside the necessary bandwidth of the AM signal. It is hard to see how any reasonable person could interpret this new energy as not exceeding "that normally expected in A3E". I therefore submit that use of the hybrid AM IBOC system is in contravention of this agreement.

<u>Hybrid IBOC results in a drastic increase in interference power in the adjacent channels.</u>

In assessing the potential for interference to adjacent channel stations, it is useful, and revealing, to look at the amount of power deposited by an emission into the adjacent channels. Like the expansion of the occupied bandwidth, this is a topic that is avoided in the iBiquity and NRSC reports. Simply stating that interference will not increase significantly because existing emission masks are respected is a subterfuge that hides the problem. Clearly, the masks were designed to limit the peaks of transient out-of-band emissions resulting from the analog modulation, not to contain a digital emission having a constant power spectral density that lies just under the mask. The important parameter, as far as interference is concerned, is the *average power* radiated into the adjacent channels, since this will determine the "interference temperature" from that source at a receiver (in addition, of course, to out-of-band energy that is accepted by the receiver due to limitations in filtering).

Again using the mathematical model for the FM signal, we can calculate the average power deposited into a first adjacent channel by integrating the PSD on one side using the limits of 100 kHz and 300 kHz from the carrier frequency. For the "average" FM signal with slope 0.36 dB/kHz, this power turns out to be -39 dBc. Now, when we add the digital sidebands to the emission, each sideband contributes an average power of -23 dBc in each first adjacent channel, bringing the total in each channel to -22.8 dBc. In other words, if the model is accurate, **on average, interference to first adjacent stations will increase by about 16 dB when hybrid IBOC is added to FM stations.** The actual increase will depend on the type of modulation (e.g., mono versus stereo) and the audio processing used, but it will almost certainly be substantial in all cases. In addition, the subjective effects of the interference are likely to be greater than this difference indicates, since interference from the IBOC digital sidebands of a first adjacent extends from 2 to 71 kHz from the

[3] *Agreement Between the Government of the United States of America and the Government of Canada Relating to the AM Broadcasting Service in the Medium Frequency Band,* 1984.

center frequency of the desired station, with a flat power spectrum, while analog interference from a first adjacent is more concentrated near the edge of the band.

For the AM signal, we do not have a mathematical model, but we do know that the majority of the power is within 5 kHz from the carrier frequency, and almost none is beyond 10 kHz. The shape of the power spectrum is very important as well, since from the point of view of a first adjacent channel, it rolls off quickly as it approaches the center of that channel. Lowpass filtering and de-emphasis in the receiver can therefore mitigate much of the adjacent channel interference. If interference is audible, it tends to be transient in nature. The fact that AM reception is often quite acceptable with first adjacent analog interference at 0 dB D/U or worse (see discussion of receiver characteristics below) provides an informal proof of this. Interference from a first adjacent hybrid IBOC signal is much different: there is now a noise-like signal with a constant power of -16 dBc (referred to the carrier power of the interfering signal), and it falls on top of a critical part of one of the desired signal's sidebands, from 356 Hz to 4717 Hz from its carrier frequency. Objectively, this likely represents an increase of the order of at least 10 dB in the average interference power deposited into each first adjacent channel by the station when it goes IBOC. Due to the spectral distribution of this energy, the subjective effects will be much worse than an increase of this order might indicate.

Hybrid IBOC is incompatible with current allocation rules.

The Commission has stated[4] that "Test results have indicated that hybrid IBOC operation is consistent with the Commission's allocation rules. It is anticipated that hybrid operation would also conform to the allocation standards contained in our international agreements governing AM and FM stations". I must respectfully beg to differ. Although the concept of IBAC (In-Band Adjacent Channel) DAB was rejected some years ago, it has now sneaked in through the back door. The iBiquity hybrid FM IBOC system is 100% IBAC, and the hybrid AM IBOC system is predominantly IBAC.

As shown in the foregoing analysis, hybrid IBOC operation results in a huge increase in the occupied bandwidth of an AM or FM emission, and a substantial increase in the average power deposited into the first adjacent channels. Moreover, the subjective effects of the interference are likely to be even more significant than the numerical increases indicate, due to the redistribution of the emission's power spectrum towards its outer edges. It should be obvious that this redistribution puts existing allocation rules in jeopardy, and that existing emission masks are inadequate to protect the integrity of these rules.

The acid test of this is to consider the digital sidebands (only the primary digital sidebands in the case of AM) as *new stations*, and see what impact they have *vis-à-vis* the allocation rules. Of course, we must assume for the moment that the interference to analog reception from an emission on a given channel depends only on the average power of that emission within the channel, and not whether it is analog or digital. This is clearly a matter that needs further study.

The hybrid FM system creates two new "stations" in the first adjacent channels, each with a

[4] *DAB NOI*, at 71

total power of -23 dBc. For a 50 kW station, each would therefore be 250 Watts. Current allocation rules provide protection of +6 dB D/U for first adjacents. If a station currently at +6 dB D/U adds IBOC, it creates a new source of co-channel interference to first adjacents at +29 dB D/U. Since the allocation rules specify a minimum of +20 dB D/U for co-channel assignments, this does not appear to be a problem. However, second adjacency is a different story. The Commission's rules permit second adjacents to be as high as -40 dB D/U on a desired station's protected contours. Therefore, a second adjacent station adding IBOC creates a new first adjacent interference source at -17 dB D/U, which is 23 dB higher than would be permitted by the first adjacent protection rules. Obviously, given the spectral concentration of the energy on the far side of the first adjacent channel, the effect is not equivalent to an analog FM signal of the same average power on that channel; on the other hand, this difference is unlikely to make up for a 23 dB shortfall. At least one of the receivers tested by iBiquity showed serious problems in such a scenario.

The hybrid AM system creates two new "stations" in the first adjacent channels, each with a total power of -16 dBc (actually slightly higher, but we will ignore the secondary digital sidebands). For a 50 kW station, each would therefore be 1250 Watts. Current allocation rules provide protection of +6 dB D/U for first adjacents. If a station currently at +6 dB D/U adds IBOC, it creates a new source of co-channel interference to first adjacents at +22 dB D/U. This is significant, since it is 4 dB more interference power than is permitted by the Commission's allocation rules for co-channel stations. Moreover, the majority of existing allocations were created when first adjacent protection was only 0 dB D/U, and this figure still applies to the Canada-US bilateral agreement on AM broadcasting. In this case, the new digital "station" is fully **10 dB higher in average power than would be permissible for a co-channel analog station**. For second adjacents, current domestic rules specify 0 dB D/U, so a new first adjacent signal created by IBOC at +16 dB D/U is compliant with first adjacent rules. In the Canada-US agreement, however, second adjacent protection is only -29.5 dB D/U. At this level, the first adjacent interference is at -13.5 dB, or 13.5 dB higher than the first adjacent protection specified in the agreement. In addition, there are many existing second adjacent allocations in the US with negative D/U ratios approaching this level. Many of the AM receiver tests conducted to date (discussed further below) confirm that these scenarios do create serious interference problems. One such interference situation (KNRC-1150 and KJJD-1170 in the Denver area) has already resulted in the offending station discontinuing IBOC operation.

It should be recognized that, with hybrid IBOC, new digital signals are being launched from analog platforms that were allocated when different rules were in place. Stating that current allocation rules provide adequate protection from these "digital missiles" is clearly incorrect. The right thing to do would be to treat these new adjacent channel signals as distinct entities, and apply the allocation rules to them accordingly.

<u>Receiver characterization for analog compatibility has been inadequate.</u>

Receiver performance is central to the issue of interference. Only by characterizing a sufficiently large sampling of different receivers in appropriate interference environments can one be confident about predicting the impact on the population at large. In its comments on the MITRE Corporation study of third adjacent FM interference[5], the NAB points to an OET study of 21 receivers that was characterized as a "fairly small" sample, and admonishes the Commission as follows: "the Commission should not rely on the results yielded from six receivers as the basis for determining whether or not third adjacent channel protection for LPFM stations can be eliminated". Why then should it be acceptable to rely on results yielded from only four receivers to determine the extent of adjacent channel IBOC interference? It is claimed that these four receivers were carefully selected to be representative of their classes, but the details behind the selection process are unclear, and the fact remains that these are only four samples from a vast array of receivers that can have wildly different characteristics. How, for example, can a single Sony boom-box receiver possibly be considered to be representative of all portable receivers? Moreover, subsequent studies, such as those purporting to show few problems with AM IBOC nighttime operation, have focused on an even smaller subset of these four receivers.

Even within the limited scope of receivers tested for analog compatibility with IBOC, potential problems have been evident from the outset. For example, in the case of FM, the laboratory test results[6] for the Delphi car radio when subjected to first adjacent interference with D/U = +6 dB showed significant degradation in signal-to-noise ratio (SNR) when IBOC was turned on. The drop in SNR was in the 10-23 dB range (depending on whether noise was added to the signal), and the resulting SNR was just slightly over 30 dB, which roughly corresponded to the "tune-out" threshold at which half of listeners would stop listening. In tests where the D/U ratio was set to -4 dB, and to -14 dB, drops in SNR of 20 to 32 dB occurred, and the resulting SNR was well below the tune-out threshold. These tests indicate a strong potential for serious degradation to analog reception inside the protected contours of first adjacent stations, and complete destruction of reception outside those contours.

The laboratory tests of second adjacent interference to FM receivers also showed problems, most notably with the Technics home hi-fi unit. This receiver provided usable performance when subjected to analog interference at D/U ratios as low as -40 dB. When IBOC was added to the interfering signal, however, reception quality deteriorated noticeably at D/U = -30 dB, and became unusable at D/U = -35 dB (i.e., below the "tune-out" threshold).

These results were largely dismissed when evaluated by the NRSC, but they are indicative that existing reception outside of protected contours will largely be lost when the hybrid FM IBOC system is in widespread use. There is also considerable potential for analog reception to be seriously degraded inside protected contours.

With the hybrid AM IBOC system, the situation with regard to analog compatibility is less clear, at least initially. The laboratory test results[7] for the four receivers showed that all of them suffered some significant degradation when IBOC was added to a first adjacent interfering signal at +15 dB D/U, though in most cases the quality did not drop below the "tune-out" threshold.. At 0 dB D/U, reception was unusable with IBOC in all cases, but it was also unusable with analog interference alone. We shall return to this point in a moment, because it is of critical importance. These results indicate that the impact of first

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[5] Comments of NAB in MM Docket No. 99-25, filed October 14, 2003.
[6] *FM IBOC DAB Laboratory and Field Testing*, iBiquity Digital Corp., August 2001.
[7] *AM IBOC DAB Laboratory and Field Testing*, iBiquity Digital Corp., January 4, 2002.

adjacent IBOC would be most significant somewhere between these D/U ratios. This begs the question of why there were no tests done for an intermediate level between 0 and +15 dB D/U, particularly in light of the fact that the domestic protection level for AM first adjacents falls in this range, at +6 dB D/U.

For second adjacent AM interference, laboratory test results were made available only for the same three widely-spaced D/U ratios (0, +15, +30 dB) as for the first adjacent tests. The effects of interference, with or without IBOC, were predictably negligible at +30 dB, and only the Sony receiver showed some significant degradation due to IBOC at +15 dB. Clearly, more effort should have gone into characterizing the receivers at D/U ratios less than +15 dB, particularly at negative D/U ratios. Ratios less than 0 will occur whenever the protected groundwave contours of second adjacent stations overlap, and this is not at all uncommon in practice. In fact, negative D/U ratios occur frequently. It is rather difficult to infer the potential effects of second adjacent IBOC interference in these situations when we have only data from a single relevant D/U ratio to work with. Nevertheless, two of the tested receivers (Sony and Technics) showed severe degradation to analog reception when IBOC was added to a second adjacent interference source. When the D/U ratios become negative, it seems clear that these and similar receivers will be in serious trouble.

Some additional test data for the Delphi and Sony receivers, covering a wider range of D/U ratios and with finer steps, can be found in the Clark report[8]. For the Delphi receiver, it shows the SNR with second adjacent analog interference remaining above 30 dB until the D/U ratio drops below -45 dB, while with IBOC the same transition occurs at only -15 dB D/U, a difference of 30 dB. For the Sony unit, the SNR remains above 30 dB with analog interference until the D/U drops below -15/-24 dB D/U (for lower/upper second adjacent, respectively), while with IBOC the transition occurs at about +10/+1 dB D/U, a difference of about 25 dB.

Now, returning to the question of first adjacent interference, and those poor test results at 0 dB D/U for analog-only interference. To anyone who is experienced in listening to AM skywave signals at night, this result should seem at odds with reality. With an average quality receiver, such as a typical car radio, it is possible to receive many listenable signals at night, particularly on the "clear" channels. This reception is taking place in an environment where the average first adjacent D/U ratio is generally 0 dB or less, and usually both first adjacents are significant interference sources. Another example is from the field tests conducted by Clear Channel[9] on reception of WARK (1490) in the presence of first adjacent interference from WTOP (1500). Not only was WARK "very listenable" on a variety of receivers at 0 dB D/U, but this remained true when the D/U ratio was as low as -12 dB. When WTOP turned on IBOC, reception was destroyed at the latter D/U ratio, and noticeably or significantly impaired at all other D/U ratios, except one case where the D/U exceeded +20 dB. Yet another example is the WOR/WLW field tests (see further discussion below), in which many instances of acceptable analog reception were noted in the presence of first adjacent analog interference at 0 dB or worse.

[8]Glen Clark and Scott Metker, *Study of present Analog Signal to Noise Ratios in the AM band and the Changes that Could Result with the Introduction of IBOC Digital Radio Signals*, prepared for iBiquity Digital Corp., January 2002.
[9]Jeff Littlejohn, *Statement of Clear Channel Communications Regarding AM IBOC Field Observations*, presented to the NRSC, March 6, 2002.

The members of the NRSC DAB Subcommittee were very much aware of this discrepancy too. In Appendix D of their report[10], they show test results for four car radios that still delivered listenable audio with analog interference at -30 dB D/U! This, however, was for an interfering signal modulated by a 400 Hz tone, which is a far cry from the NRSC processed noise or music used in iBiquity's laboratory tests. Typical conditions in real world AM broadcasting evidently lie between these two extremes. This topic is explored further in another part of the NRSC report, Appendix H, where it states:

"The objective of the compatibility test program is to measure differences found with the introduction of the digital signal. The undesired modulation models used for the objective and subjective tests were based on fully processed wideband music, a program format that does not fit the majority of contemporary nighttime AM broadcast stations. Assuming that the 10 kHz LP filtered audio is representative of contemporary music interference, the objective and subjective test data in the iBiquity report is representative of the A to A interference from analog stations with a music format. To make the laboratory tests represent real world interference, the test should have been conducted with talk and music interferers."

In order to underline this point, the Appendix includes results from an informal listening tests involving skywave reception of several clear channel stations. WSB (750 kHz), for example, was received clearly in spite of the presence of first adjacent WJR (760 kHz) at -10 dB D/U. It is also mentioned that if WJR turned on IBOC, reception of WSB would be obliterated as its signal-to-noise ratio would drop to about 5 dB. The author of this Appendix concludes that "off air monitoring shows that good AM audio is being received in the presence of 0 dB D/U first adjacent signals". This information, however, was not factored into the conclusions drawn in the main body of the NRSC report, where a blanket statement is made that "today's AM radios" are unable to provide acceptable audio quality with analog first adjacent interference even at +10 dB D/U, despite all evidence to the contrary.

A look at the spectrum plot for the analog interference (in the iBiquity test report, Appendix H) explains this difference between the laboratory test results and real world observations. The plot shows an extremely "heavy" analog signal with a near-flat spectrum out to 10 kHz from the carrier. This is an absolute worst case situation for first adjacent interference from analog, but few, if any, real world AM signals actually look anything like this.

The Clark report has more detailed information on the performance of the Delphi and Sony receivers with first adjacent interference, but it is based upon the same analog interference source as the laboratory test results referred to previously, and thus it shares the same flaws. It shows analog reception becoming poor even at relatively high D/U ratios (i.e., +15 dB), which flies in the face of reality.

To summarize the situation regarding analog receiver characterization:

1. Considering the far-reaching consequences of hybrid IBOC deployment, an insufficient

[10] *Evaluation of the iBiquity Digital Corporation IBOC System, Part 2 – AM IBOC*, NRSC DAB Subcommittee, April 6, 2002.

sample of receivers has been tested for analog compatibility.

2. For the limited number of receivers that have been tested, there are generally insufficient data points available from which to draw firm conclusions about their performance with and without IBOC interference. Rather than use a few fixed D/U ratios, standard ITU-R test methodology should have been used to determine the D/U ratios at which interference becomes significant.

3. The laboratory tests, at least for the AM receivers, do not provide an accurate assessment of receiver behavior when subjected to analog interference from adjacent channels. The quality of AM reception is generally much higher than is indicated by these tests.

4. Despite the limited scope of receiver testing to date, there is still considerable evidence that there will be very serious interference problems with analog receivers in both bands. Deployment of hybrid IBOC will result in massive losses in the coverage currently enjoyed by many stations beyond their protected contours. Given the D/U ratios at which interference is evident, coverage loss and deteriorated quality of service will also occur inside protected contours, particularly with the AM system.

<u>The case for nighttime operation of hybrid AM IBOC remains weak.</u>

In its *DAB R&O*, the Commission wisely refrained from permitting operation of hybrid AM IBOC at night, pending more studies of the interference problems. The NAB is now recommending that the Commission issue blanket authorization for such operation to all stations with current nighttime authorization, and in support of this recommendation, they are citing two reports issued by iBiquity. Like their previous reports dealing with IBOC, these reports contain much useful data, but the conclusions reached are biased and self-serving.

In the report[11] dealing with nighttime field tests, results are given for reception tests with and without IBOC between Class A stations WLW (700 kHz) and WOR (710 kHz). Although both stations have nighttime protection to their 0.5 mV/m contours, it is claimed that they have theoretical NIF contours of 2.7 mV/m and 1.7 mV/m, respectively. Subjective audio tests were conducted using recordings made during transitions between IBOC and non-IBOC mode on the interfering station. Although attempts were made to select segments in which the D/U ratio remained the same on both sides of the transition, this was clearly not wholly successful. Appendixes C through E of the report show several instances in which the average D/U ratio differed by 3 to 6 dB between the IBOC and non-IBOC halves of the segment, thus invalidating the comparison to some degree. There are also a number of results that seem clearly anomalous, showing improvements in subjective quality when IBOC was turned on. And with the selection of the recordings to be tested entirely in the hands of the proponent, what guarantees are there that we are seeing an unbiased sampling of the results? The report also fails to provide details on the reception conditions that existed during the tests (e.g., propagation indices, local and atmospheric noise levels), or how observed field strengths compared with predicted levels.

[11] *Field Report, AM IBOC Nighttime Compatibility*, iBiquity Digital Corp., October 31, 2003.

These reservations aside, I concur with the report's conclusion that "Interference from IBOC is D/U dependent and is expected to have its greatest impact below 0 dB D/U ratio". When you consider that at 0 dB D/U, the signal-to-noise ratio of the desired signal has already plummeted to no more than 16 dB due to co-channel noise from the primary digital sideband, you can see that, if anything, this is an understatement. However, it is stated that this is of little consequences, since D/U ratios this low occur largely outside the theoretical NIF contour. While this may well be true, the critical question is this: how much useful reception currently lies outside this artificial line? If the answer is "very little", then we should pose a follow-up question: has the notion of "protected contour" become meaningless? If it is the case that co-channel interference sources are dominant in the NIF calculations (and that these co-channel stations are real, and not artifacts from a notoriously unreliable database), then we may have to concede that these NIFs reflect reality. This report, however, conveniently provides evidence to the contrary. In the majority of instances where the D/U was 0 dB or less, analog reception was quite satisfactory when IBOC was not present on the first adjacent station. This fact alone undermines the report's conclusion that "the primary service area of the station should not be affected by IBOC". This is simply not true, unless you accept a rather drastic redefinition of the term "primary service area". This report provides further proof that, in today's AM broadcast environment, successful reception with analog first adjacent interference at 0 dB D/U or lower is very common. Therefore there is a huge potential for loss of coverage due to IBOC on first adjacents.

By my estimate, the area enclosed by the claimed 2.7 mV/m NIF contour for WLW is only about 20% of the area enclosed by their 0.5 mV/m groundwave contour which, in principle at least, is their primary service area. Are the owners of WLW willing to cede 80% of this area to interference, to say nothing of their secondary coverage? Do they recognize that a NIF of 2.7 mV/m or worse, while a theoretical artifice today, will become a harsh reality with nighttime IBOC? Of course, WLW is not the worst case one can imagine. With 690 kHz being a Canadian clear channel, WLW only has to be concerned with first adjacent IBOC interference from one side. Consider the fate of 690 kHz Class A station CINF in Montreal, which is in a position to get not only severe nighttime interference from WLW, but even greater interference levels from WRKO (680 kHz), should that station decide to convert to IBOC.

This report represents the only new field test data to become available since the *DAB R&O*. It examines interference only between a single pair of Class A stations. It fails to build a convincing case that there will be no harmful interference or significant loss of coverage between these two stations if they use IBOC at night. And even if you did accept the report's conclusions, it would be foolish to try and extrapolate them to infer the effects of nighttime IBOC in general. What will happen when IBOC is on both first adjacent channels? What about the effects of IBOC on second adjacents? How does the situation change when the neighboring channels are regional or local, rather than clear? This report clearly raises many more questions than it answers.

The second report[12] attempts to answer some of these questions, but through a simulation study rather than field tests. The approach taken is a useful and laudable one, since it takes into account actual receiver characteristics, and includes the effects of both first and second

[12] *AM Nighttime Compatibility Report, iBiquity Digital Corp., May 23, 2003.*

adjacent interference in addition to co-channel. This study is a good indication of where radio broadcast interference studies should be going in the future. That said, I have some serious reservations about this particular study, and the conclusions that are drawn in the report. The underpinnings of the study are subjective tests using recorded material gathered during laboratory tests of the receivers, with analog and digital interference at various D/U ratios. The subjective testing did not use standard ITU techniques, nor has the methodology used been validated by independent experts in the field (these comments also apply to all such studies conducted by iBiquity). As in previous studies, the effects of analog-only interference are greatly exaggerated by the use of an atypical, heavily-modulated wideband source. This can clearly be seen in Figure C-4, showing subjective test scores for the Delphi receiver with first adjacent interference. The test score for analog interference is already becoming poor when the D/U ratio falls to +6 dB, whereas we know that, in reality, good analog reception is often possible with negative D/U ratios.

Despite this bias towards exaggerating the extent of current interference problems, there are some interesting results in this report. Nearly all of the examples in the report were done with a single receiver model, based on the Delphi car radio. This is described as being a "worst case", but is actually far from it, being the best performer of the four receivers previously tested. In particular, it has very good immunity to second adjacent interference, either analog or digital. More illuminating are the results for the simulations involving the Sony portable receiver, which estimates that **20% of listeners using a receiver with similar characteristics, inside the 5 mV/m contours of desired stations, will be negatively impacted by IBOC interference.** Keeping in mind the fact that this is almost certainly an underestimate, due to the baseline assumption of severe analog interference as mentioned above, this is an extremely alarming statistic.

Here is where the report really goes off the deep end. The authors suggest that the Sony model is actually a less severe case than the Delphi, since the Sony receiver contains a directional antenna that can be used to null the source of IBOC interference, unless it happens to be roughly in the same or opposite direction as the desired station. As a general solution to the problem of IBOC interference, this suggestion is ludicrous. What about car radios whose characteristics are closer to the Sony than to the Delphi? What if the receiver's physical location is such that it cannot easily be rotated to get the desired nulling effect? What if the nulling capability is already being used to eliminate a co-channel interfering station or a local source of noise? What if there are multiple sources of IBOC interference? There are four adjacent channels with possible IBOC interference, and some of them may have more than one significant source (especially if they are not clear channels), so having only source of IBOC interference to deal with will be the exception, not the rule. The study could have predicted just how often there would be one dominant source of interference that could potentially be nulled, but if this was done, it was not reported.

Given the flaws in this study, one cannot take seriously its conclusion that "complete conversion to IBOC at night will not noticeably degrade primary groundwave service in a vast majority of listening areas". On the contrary, rational analysis of the evidence points to chaos and floods of complaints long before "complete conversion" is reached, if nighttime operation is authorized.

Although not dealing with the compatibility issue, a third report[13], on performance of the IBOC system during the WLW/WOR field tests, is worth noting. The edge of "digital coverage" (where the final blend to analog occurs, though there are intermittent blends closer in) on four radials ranged from 2.5 to 3.7 mV/m for WLW, and 2.2 to 6 mV/m for WOR. The report says "although digital coverage will not extend to all areas currently able to receive analog signals, the digital signal will cover the primary service areas of these stations". Those "primary service areas" just keep shrinking! What the report neglects to mention is that the quoted "digital coverage" is for "core mode", which provides 20 kb/s monophonic audio. Earlier reports showed that the "enhanced mode", providing 36 kb's stereo audio (plus some dedicated data subcarriers) will often have significantly less coverage than core mode, especially at night. This information would be of considerable importance to an AM broadcaster who is counting on conversion to hybrid IBOC to provide "FM-like" quality to support a new format. It is unacceptable that this information has been suppressed in this report.

Conclusions

Because the iBiquity hybrid FM "IBOC" system is actually an IBAC system, and the hybrid AM "IBOC" system is predominantly IBAC, they cause a drastic increase in the occupied bandwidth compared to their host analog emission. They also cause a dramatic increase in interference power deposited into the first adjacent channels. These new digital emissions cannot be absorbed into these bands under current allocation rules without creating widespread interference to existing analog services. Emission masks intended to limit transient peaks in analog modulation cannot be packed with constant power digital emissions without wreaking havoc on adjacent channel stations.

If the hybrid IBOC experiment must continue (and there is no doubt that it will, given the investment that has already been made), then it should continue on FM only. It should be recognized, however, that due to the IBAC nature of the hybrid FM emission, the Commission's allocation rules are inadequate to protect stations from interference from second adjacent channels. There will be widespread loss of existing coverage outside of protected contours, and in some cases, significant interference inside these contours.

AM has inherently greater susceptibility than FM to interference and a more complex interference environment due to nighttime skywave. Add to this the fact that the AM hybrid IBOC system has significantly higher digital power relative to the analog power than does the FM system (7 dB higher in each first adjacent channel), and you have an untenable situation. As demonstrated above, the Commission's allocation rules are inadequate to protect stations from interference from hybrid IBOC on first and second adjacent channels. Even in daytime only operation, there will be many instances of serious interference to analog service inside protected contours, mainly from short-spaced second adjacents. At night, a band populated by many hybrid IBOC signals will become a quagmire of noise. Class A stations will be particularly hit hard, with most suffering partial or complete loss of secondary coverage, and significant shrinkage of their primary coverage areas. Only those stations having a NIF contour that is currently completely dominated by co-channel interference are likely to emerge relatively unscathed.

[13]*Field Report, AM IBOC Nighttime Performance*, iBiquity Digital Corp., October 20, 2003.

The hybrid AM IBOC system also creates an unacceptable situation for neighboring countries. In particular, the allocation rules in the Canada-US bilateral agreement on AM broadcasting preclude the use of the hybrid system when the primary digital sidebands are properly viewed as new, adjacent channel emissions. Moreover, adoption of the hybrid system would clearly contravene the provisions of the agreement that deal with occupied bandwidth.

The transition to digital broadcasting in the AM band by means of a hybrid overlay is unworkable, as it requires unacceptable tradeoffs in the quality and coverage of existing analog service. It should be set aside until such time as it becomes viable for broadcasters to begin an all-digital service that is truly IBOC in nature and can coexist with adjacent channel stations, whether they be analog or digital. Experimentation with the hybrid AM system should only be permitted on a non-interference basis. This means that the primary digital sidebands should be treated as distinct entities, and be subject to the allocation rules that would apply to the channels in which these sidebands lie. Although we do not know how interference from analog and digital sources compare subjectively, it must be assumed (i.e., for the purposes of RSS calculations), that emissions of equal average power within a given channel bandwidth are equivalent in terms of their potential to cause interference.

Respectfully submitted,

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