Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554–0001

In the Matter of	)	
	)	
Revitalization of the AM Radio Service	)	MB Docket No. 13–249

To: The Commission and Media Bureau

COMMENTS

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I. INTRODUCTION AND ABSTRACT

1. My name is Jonathan E. Hardis, and I offer these comments in response to the *Notice of Proposed Rulemaking*, FCC 13–139, "Revitalization of the AM Radio Service," of October 31, 2013.[1] I offer these comments as an individual and as a frequent listener to the broadcast radio service.

2. I am of a generation where AM radio has been a big part of my life. Growing up in the Washington, DC area, the first contest I ever won was a promotion on WTOP, long before it adopted an "all news" format. (Technically, my mother won, because I was a minor.) The listener who could first call in and guess the winning item on a page in the redemption catalog of Top Value (trading) Stamps would win a large number of the stamps.[2] I deduced the pattern of which winning items were being chosen in successive call-in contests, and I still remember the trip down to Broadcast House at 40th and Brandywine to pick up our prize. I also have fond

[1] *See* http://fjallfoss.fcc.gov/edocs_public/attachmatch/FCC-13-139A1.pdf (hereinafter *"NPRM"*). *See also* 78 FR 69629–69639, http://www.gpo.gov/fdsys/pkg/FR-2013-11-20/pdf/2013-27838.pdf, November 20, 2013.
[2] In the 1960s, Top Value Stamps were ubiquitous in the Washington, DC area, as Giant Food Stores, among others, offered them as purchase rewards.

memories of (Ed) Walker and (Willard) Scott on WRC,[3] back in the days when the personalities on the radio were as important as the music that they played. I listened to Mac McGarry in the afternoons, well before first meeting him on the set of *It's Academic*. Later, I lived four years in the Boston area, where I spent many hours listening to WEEI and The Spirit of New England, WBZ. In Chicago, I grew to appreciate the local color and sense of community that WGN provided. And yes, I admit to many hours of listening to WLS in its years as "Musicradio." The first 18 seconds of the movie Ferris Bueller's Day Off (1986) captures a time and place for me, and I imagine for many other Chicagoland residents as well.[4]

3. Nonetheless, nostalgia is a poor basis for rulemaking. And this rulemaking proceeding needs better-defined goals. "Revitalization," it seams, is a term onto which one can project most any manifestation of angst and ambition. In the large, this proposed rulemaking has an immediate aspiration considerably less grand than whatever a "revitalization" might be. It proposes revision of six technical rules and regulatory policies that would have little if any effect on overcoming the purported problems of limited fidelity (*NPRM* at 4) and environmental RF noise (*NPRM* at 5). This does not mean that the six proposals are necessarily ill advised, and I expect that the Commission will receive many well-informed comments as to their merits.

4. In these comments, however, I respond to the Commission's invitation (*NPRM* at 45) to contribute to the record in broader terms about "revitalization," and other steps that might be taken to promote it. First, I discuss the meaning of "revitalization," appropriate metrics, what might be achievable through receiver improvements, and how the Commission might foster them. Second, I would be remiss if I did not go on record here to reiterate in the AM context an

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[3] http://www.thejoyboys.com

[4] *Hear* http://www.youtube.com/watch?v=UX_rPkWzlqs. The voices are WLS staff announcers Fred Winston and Don Nelson. The music is the WLS "shotgun" jingle, from JAM Creative Productions.

issue that I have previously brought to the Commission's attention in the FM context (MM Docket No. 99–325). IBOC digital transmission, in its "hybrid" (analog/digital simulcast) mode, far exceeds the out-of-band emission allowed under the Commission's rules (47 C.F.R. § 73.44, for the AM service). Any serious effort to reduce interference on the AM band must begin by correcting this error—which can also be done expeditiously. And third, in anticipation of many comments proposing the inauguration of all-digital broadcasting on the AM band, I comment on that issue as well. I *support* the opportunity of broadcasters to elect an all-digital transmission format, subject to two basic requirements: rigorous respect for analog broadcasters—including those operators who might pursue better-fidelity analog operation in bandwidths of up to 10 kHz—through strict adherence to both the letter and the intent of the Commission's technical rules; and open publication of a technical standard that documents the digital signal in such full, clear, concise, and exact terms as to enable any persons skilled in the art to which they pertain to make fully functional and compatible apparatus. This, too, is an issue that I've raised repeatedly on MM Docket No. 99–325, and which bears upon the instant docket as well.

II. THE PURPOSES AND GOALS OF THIS RULEMAKING SHOULD BE BETTER DEFINED

A. The "Vitality" of the AM Band Can Be Best Measured by the Demand for Broadcast Licenses

5. The *NPRM* (at 2) suggests a simple metric for the "vitality" of the AM band: the number of hours that the public listens to AM, as opposed to FM radio. This ratio is decreasing, and two causes are cited: insufficient fidelity, and increased interference. The Commission is correct that it is within your regulatory authority to adopt technical standards that address both fidelity and interference. However, there are several other causes, and the "fraction of listening hours" metric is not necessarily the best one.

6. For example, another cause for the shift in listening habits is the shift in the Commission's media ownership policies over the years. Many markets today have clusters of radio stations under common ownership. Such an owner has the freedom, like never before, to allocate his resources in a manner that attracts the most listeners. That is, he is free to put the most popular programming on the stations that have the greatest reach. In large part, this has caused the migration of historically popular AM programming to the FM band. It isn't that the public is shunning AM radio, it's that they no longer find on AM the programming that they want. (As a resident of the Washington, DC area, I can attest that this is why I listen to AM radio a lot less than I used to. Were it not for professional football play-by-play coverage remaining on AM, I would not be listening to it much, if at all.) Unless the Commission gets into the business of regulating programming formats (which neither I nor others are advocating), the "revitalization" discussion must come with the acceptance that the AM band will increasingly be used for niche and experimental programming. It will, indeed, attract fewer listeners than FM, and that this is to be expected. Optimal allocation of resources is not necessarily a bad outcome.

7. In addition to broadcasters' programming choice, there are other causes for declining listening hours over which the Commission has no control. Part and parcel with programming is the technical quality of receivers that consumers choose to buy, at the price points available.

8. What, then, might be a better metric for the "vitality" of the band? I propose that the Commission go back to basics and measure the AM band's vitality (or lack thereof) by the demand for broadcast licenses—whether or not that demand is from incumbent broadcasters. Ultimately it is in the interest of licensees to build strong audiences through attractive programming and quality sound. The radio industry was born from such entrepreneurship, and creative competition can maintain the vitality of the AM service going forward.

B. The Commission Has Already Addressed the "Fidelity" Issue

9. To many, the chief problem on AM is the purported inability to offer music programming at a quality that contemporary listeners would find acceptable. The *NPRM* introduces this point (at 4), and Commissioner Clyburn speaks of "newer, higher-fidelity media services" in her Statement.[5] Yet, the reduction of AM bandwidth from 15 kHz to 10 kHz in the 1987–1989 time frame was then billed as the creation of the "full-fidelity" AM radio service. As the New York Times reported:[6]

> In a demonstration of cooperation seldom witnessed in the highly competitive worlds of broadcasting and electronics, station owners and major electronics companies are banding together to save AM radio.

[5] Statement of Acting Chairwoman Mignon L. Clyburn, at http://fjallfoss.fcc.gov/edocs_public/attachmatch/FCC-13-139A2.pdf. *See also* NPRM at 6.
[6] Peter H. Lewis, "*AM Radio is Hoping Full Fidelity Lures Listeners*," New York Times (Business Day), April 1, 1987. Yes, April 1. Electronically at http://www.nytimes.com/1987/04/01/business/business-technology-am-radio-is-hoping-full-fidelity-lures-listeners.html. This process culminated in the Commission's adoption of the NRSC–2 consensus standard as a regulatory standard in 1989. 4 FCC Rcd. No. 9, 3835–3842, online at http://transition.fcc.gov/Bureaus/Mass_Media/Databases/documents_collection/89-118.pdf.

> The result, which should be apparent to listeners in two years or less, will be the clear reception of high-fidelity AM signals that approach FM in sound quality.
>
> "Listeners will hear full-fidelity AM radio for the first time in their lives," said Thomas R. McGinley, director of engineering for the First Media Group of Washington, D.C., which owns three AM and eight FM radio stations.
>
> Mr. McGinley and others in the broadcasting industry contend that if AM is given the same chances that FM has received to compete with such rival state-of-the-art technologies as tape and digital disks, the sharp decline in AM's popularity can be arrested and reversed.
>
> …
>
> Mr. Keller of the N.A.B. said most member stations have enthusiastically embraced the [NRSC–2] standard in the last two months. And, he said, Delco and other major radio makers have said they will implement the NRSC standard, "a rather simple process," in sets by January 1988. As a result, high-fidelity AM radios might appear in automobiles as soon as the 1989 model year.

In addition to providing better sound quality, this work was done in the cause of reducing susceptibility to RF noise and interference.

10. I fully expect that there will be a number of comments that overlook this work, and that cast AM radio as an even older technology of ancient vacuum tubes and galena crystals. However, if the audio fidelity of the AM service is indeed a regulatory goal, then the inquiry should first begin as a retrospective analysis of the outcome of the NRSC–2 rulemaking in 1989. Did it achieve its intended goals? If not, why not? What might be the obstacles to its success today?

11. At the time, then-Commissioner Patricia Diaz Dennis issued a separate statement saying in part, "Today's decision is a significant step forward in our efforts to reduce AM interference. I hope that AM licensees will move quickly to comply with the new standard, and

that receiver manufacturers will get the message and give consumers the option of buying higher quality AM receivers."[7] Put another way, is AM fidelity in fact an already-solved problem for those willing to get with the program?

12. In recent years, many AM broadcasters have voluntarily limited the audio bandwidth of their stations to 5 kHz (which corresponds to ±5 kHz from the carrier frequency), rather than using the available 10 kHz.[8] (This is a simple setting on their audio processing electronics that can be easily changed at will.) A reason given was that the typical AM radio receiver was unable to reproduce sound above 5 kHz anyway, and that the energy would be better utilized at lower frequencies. Another was the reduction of adjacent-channel interference under nighttime, "skywave" propagation conditions.[9] (Skeptics claimed that the larger motivation was to support AM hybrid-mode IBOC deployment. And the concern about reducing skywave interference does not extend to stations broadcasting digitally, as they also require ±10 kHz, or more.)

13. While the industry adopted the AMAX certification program in 1993 to promote high-quality AM, the standard has been largely unimplemented. This is a classic breakdown of the "network effect." When major broadcasters fail to offer 10 kHz programming, there is less incentive for receiver manufacturers to improve the quality of their products. And vice versa.

14. I am uncomfortable with those so willing to declare defeat, particularly when they have mixed motives—and the Commission should be uncomfortable, too. If there is genuine

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[7] 4 FCC Rcd. No. 9, 3835–3842, "In the matter of Amendment of the Commission's Rules to improve the quality of the AM Broadcast Service by reducing adjacent channel interference and by eliminating restrictions pertaining to the protected daytime contour," MM Docket No. 88–376, First Report and Order, April 12, 1989; FCC 89–118 online at http://transition.fcc.gov/Bureaus/Mass_Media/Databases/documents_collection/89-118.pdf.

[8] *See*, e.g., Letter from Jeff Littlejohn to radio engineers at Clear Channel stations, September 29, 2004, reproduced at http://www.radioworld.com/Default.aspx?tabid=64&ArticleId=16315. *See also* National Radio Systems Committee (NRSC) Guideline G100-A, "Bandwidth Options for Analog AM Broadcasters," September 2012, at http://www.nrscstandards.org/SG/NRSC-G100-A.pdf.

[9] NRSC-G100-A at Sec. 3.1, *ibid*.

interest in improving the audio quality on the AM band, then there would be no better place to start the discussion than how to break this impasse.

C. There Is Room for Improvement in Receiver Technology, and the Commission Should Foster Such Improvement

15. AM is referred to jokingly as "Ancient Modulation." And it is indeed true that receivers can be quite simple, even composed of coils of wire wound around oatmeal boxes.[10] However, the simplicity of AM belies its beauty. While the receivers may be simple, they need not necessarily be. One can apply the gamut of 21st century communication theory and digital signal processing techniques towards making AM receivers better than they have ever been before. That the consumer can trade off cost (and energy consumption) for performance is an attractive feature, rather than a problem. So too is the property that the same AM signal is compatible with many generations and grades of receivers. As a step towards the revitalization of the AM band, the Commission should encourage the development of advanced receiver technology, even as it refrains from regulating receiver performance.

16. The simplest AM receivers are based on a technique known as "envelope detection." That is, they track the amplitude of the carrier. However, the AM signal contains more information than just that. Of particular note, AM impresses two copies of the same information into the signal, one at frequencies above the carrier, one below. Such redundancy, as clearly demonstrated in the digital experience, is the basis for noise reduction and error correction. This particular redundancy can too be exploited to help differentiate signal from noise. Of course, this is nothing new, and manufacturers of high-end receivers have been

[10] The origin of the "oatmeal box" reference, also cited in the Comments of Henry B. Ruhwiedel (December 7, 2013, at http://apps.fcc.gov/ecfs/document/view?id=7520961083) is explained by Brian Belanger, "Construction and Operation of a Simple Homemade Radio Receiving Outfit," http://nvlpubs.nist.gov/nistpubs/sp958-lide/016-018.pdf, and the publication that it describes, NBS Circular No. 120, April 24, 1922, online at http://nvlpubs.nist.gov/nistpubs/circ/1922/circ120.pdf.

exploiting this property for years.[11] And as digital signal processing chips have become more widely available and less expensive, such techniques have become even easier to implement.[12]

17. There is additional information in the AM signal that, to my knowledge, remains to be exploited. For example, a typical AM receiver (other than those in vehicles) contains a single magnetic-dipole antenna—a coil of wire usually wound around a ferrite core. A receiver with two or three such antennae, perpendicular to each other, could use the signal's propagation direction and direction of polarization to help further differentiate signal from noise. An audio signal contains additional redundancies, both temporal and spectral—that is, it is far from being fully entropic. This is well known, and is a technical basis for digital audio compression, such as MP3. These same redundancies could be exploited by digital filters to further help discriminate signal from noise. (In a related matter, a modern receiver could automatically determine the bandwidth that a broadcaster is using and adjust accordingly—analogous to the manual bandwidth switch on an AMAX compliant receiver.) Likewise, interference affecting the AM band is itself not fully entropic, and digital filtering could be based on the signatures of the interference. Of particular note, since AM channels are only 10 kHz apart, AM suffers from characteristic adjacent-channel crosstalk, particularly at night. However, a receiver that digitally samples spectrum across ±20 kHz (or more) off-carrier can simultaneously decode three adjacent channels, and attempt to "diagonalize the matrix" to reduce the crosstalk. In short, there are significant opportunities for improving AM receivers, and it strikes me as an interesting engineering challenge. I imagine that others would feel the same way as well.

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[11] *See*, e.g., H. Matsunaga and K. Takayama, "Multifunction AM/FM Noise Reduction System," Fujitsu Ten Tech J. No. 5, pp. 37–48 (1992). Online at http://www.fujitsu-ten.com/business/technicaljournal/pdf/5-4E.pdf.

[12] *See*, e.g., A. Hatakeyama et al., "Reception performance improvement of AM/FM tuner by digital signal processing technology," Fujitsu Ten Tech J. No. 25, pp. 22–31 (2005). Online at http://www.fujitsu-ten.com/business/technicaljournal/pdf/25-3.pdf.

18. On January 4, 2011, President Obama signed Public Law 111–358, the America COMPETES Reauthorization Act. Section 105 of this Act added section 24 (Prize Competitions) to the Stevenson-Wydler Technology Innovation Act of 1980, to provide agencies with authority to conduct prize competitions in order to spur innovation, solve tough problems, and advance their core mission, as called for in the President's Strategy for American Innovation.[13] The development of a 21st century AM receiver would be an ideal subject for such a prize. It would be a significant challenge, yet a technically accessible one, to university engineering students across the Nation. I believe that they would be up to the task. Furthermore, the Commission (and any industry entities that might be so interested) could offer technical support to the students in establishing experimental transmitter facilities by which their designs might be tested. I'll leave it to the technical experts at the Commission (and to reply commenters) to propose precise goals that such a prize contest might entail, as well as what the prize award itself might be. The benefits of such a prize competition would be two fold. First, it would give the Commission a good indication of what is technically possible, through actual demonstration. Furthermore, to address the Commission's concern about waning interest in the AM band by younger Americans, nothing builds interest as much as does a sense of ownership.

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[13] *From* Boris Bershteyn and Steven VanRoekel (Office of Management and Budget), "Memorandum for General Counsels and Chief Information Officers for Executive Departments and Agencies, Prize Authority in the America COMPETES Reauthorization Act" August 9, 2011; Online at https://cio.gov/wp-content/uploads/downloads/2012/09/Prize_Authority_in_the_America_COMPETES_Reauthorization_Act.pdf. This authority extends to the FCC—see FAQ #1 therein. *See also* Tom Kalil and Robynn Sturm (Office of Science and Technology Policy), "Congress Grants Broad Prize Authority to All Federal Agencies," December 21, 2010, Online at http://www.whitehouse.gov/blog/2010/12/21/congress-grants-broad-prize-authority-all-federal-agencies, and "Implementation of Federal Prize Authority: Fiscal Year 2012 Progress Report," December 2013, online at http://www.whitehouse.gov/sites/default/files/microsites/ostp/competes_prizesreport_dec-2013.pdf.

III. THE COMMISSION'S INTERFERENCE PROTECTION RULES SHOULD BE RIGOROUSLY ENFORCED

A. Overview of the Issue

19. The *NPRM* notes repeatedly that increasing interference on the AM band is a significant problem. "As the Commission has previously stated, a 'combination of higher fidelity alternatives to AM radio and increased interference to AM radio have caused an erosion of the AM radio audience and the loss of young listeners to other programming outlets." (*NPRM* at 2) "The availability of higher fidelity alternatives and increased interference to AM radio has led to a steady decline in AM listenership." (*NPRM* at 6) Furthermore, the Commission has adopted technical rules to reduce interference. (*NPRM* at 7) One key to the revitalization of the AM band is to rigorously enforce those rules.

20. One of the interference protection rules of particular importance is § 73.44 (47 C.F.R. § 73.44), "AM transmission system emission limitations." Among other things, this rule defines the so-called AM emission mask. If the Commission's technical rules were "the rules of the road," the emission mask would be the lane stripes. The mask requires broadcasters to stay with the lane that corresponds to their assigned frequency. It puts strict limits on how much broadcast power may be emitted outside of the broadcaster's assigned lane, whether or not that power is intended for a useful purpose. The reason is simple: so-called spurious and out-of-band emissions interfere with adjacent channels on the band, and broadcasters have a duty to respect the frequencies that are assigned to others.

21. I raise this here because of a significant lapse in enforcement of § 73.44 in recent times. The AM IBOC system, as deployed today in hybrid mode, broadcasts 15.8 times the out-of-band power that is allowed by the emission mask. If the Commission is serious about reducing interference on the AM band, this must stop. Broadcasters that have deployed hybrid-digital

transmission systems should be ordered to either bring their digital signal into compliance with § 73.44, or discontinue it entirely.

22. It has been often repeated that IBOC hybrid-digital broadcasting fits within the AM emission mask. (See, e.g., § 73.402(c) of the Commission's rules, which states that a "Hybrid DAB System" is "a system which transmits both the digital and analog signals within the spectral emission mask of a single AM or FM channel.") However, many repetitions do not make this statement true—regrettably, it is not. The AM IBOC system, as deployed today in hybrid mode, broadcasts significantly more power out-of-band than is allowed by the emission mask. I fully realize that it is widely believed that hybrid-digital broadcasting fits the mask, and therefore claims to the contrary will be subject to heightened skepticism and scrutiny. Thus, my comments here must be precise, highly detailed, and thoroughly documented. I am up to that challenge. In the end, this should resolve the paradox that has been apparent to many: how the IBOC signal could both purportedly fit the mask and at the same time cause so much obvious interference.

23. The root cause of the discrepancy between popular belief and engineering fact arises from the conflation of two different engineering concepts: power, and power spectral density. Power, measured in watts (or kilowatts), is generally well understood. Power spectral density (PSD), measured in watts/hertz (or watts/kilohertz, etc.), is less so. PSD describes how total power (watts) is distributed over the spectrum, marginally how much incremental power is found in narrow, incremental portions of the band. Adding to the confusion is that decibels (dB) are often used instead of watts. When decibels are used, it implies a fraction (i.e., a percentage, or a ratio), though instead of giving the fraction (percentage) in usual terms, it gives it as a logarithm. This can be useful for engineering purposes, but it also serves to make the situation

less transparent for non-engineers. Here, we often use the unit "dBc," which means fractions (percentages) of the carrier power (e.g., as authorized, or when unmodulated). By way of example, a power level that is 1% of carrier power can also be expressed as –20 dBc. The common logarithm of 1% (0.01) is –2. This is the fraction expressed in "bels." To get "decibels" (1/10s of bels), you multiply by 10: –20 dBc. Fractions less than 100% are negative numbers when expressed in decibels. The smaller the fraction, the more negative the number will be.

B. Engineering Facts About the Hybrid-Mode IBOC System

24. The digital portion of hybrid-mode IBOC transmission consists of a single, time-modulated emission that is in some ways similar to an analog AM signal. The modulated signal is carefully crafted to synthesize 163 individual tones (some of which may have no amplitude) at audio frequencies of up to 15 kHz.[14] Over time, the tones change in phase and/or amplitude. These values, as received, are quantized and used to represent digital data.[15] The 163 tones are called "subcarriers" because they each convey a distinct portion of the digital information. While the digital signal is physically realized as a single, time-varying signal, it is mathematically convenient to represent the signal in the frequency domain rather than the time domain. In the frequency domain, the subcarriers are numerous enough, and packed densely enough, to be spectrally similar to white noise. However, unlike actual white noise, the phases of the subcarriers are constructed in such a way as to minimize the noise that would affect a typical on-channel analog receiver. No such noise cancellation occurs for analog receivers on adjacent-channels, where the IBOC signal appears as ordinary noise.

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[14] The careful crafting is described in detail in Section 13, "OFDM Signal Generation," of Doc. No. SY_IDD_1012s rev. F, HD Radio™ Air Interface Design Description - Layer 1 AM, iBiquity Digital Corporation, August 23, 2011; electronically at http://www.nrscstandards.org/download.asp?file=NRSC-5-C.asp.

[15] Doc. No. SY_IDD_1012s, *Id.*, *passim*.

25. Numerically, the 163 subcarriers (numbered –81 to +81, including 0) are spaced 181.7 Hz apart.[16] Their center frequencies span –14,716.6 Hz to +14,716.6 Hz (±81 × 181.7 Hz, showing additional significant digits).[17] Logically, the subcarriers are organized into three groups: primary, secondary, and tertiary. The secondary and tertiary subcarriers all have frequencies of less than 10 kHz. They are all in-band, and do not concern us here. The 50 primary subcarriers are organized into two groups, called "sidebands": lower (25 subcarriers, numbered –81 to –57) and upper (25 subcarriers, numbered 57 to 81). They span frequencies 10,356.1 Hz to 14,716.6 Hz removed from the carrier. Each subcarrier has a nominal power of –30 dBc (0.1% of carrier power).[18] Together, each sideband has a nominal power of –16.02 dBc (2.5% of carrier power).[19] Both the upper and lower sidebands together have a nominal power of –13.01 dBc (5% of carrier power).[20]

26. The primary sidebands may also be described by their power spectral density. On average, the power in each sideband (–16.02 dBc) is uniformly distributed over 4,542.16 Hz (25 × 181.7 Hz, showing additional significant digits). Therefore, in commonly used units, their power spectral density is –22.59 dBc/kHz, or alternatively, –52.59 dBc/Hz.[21] However, for an historical reason to be explained below, unusual units of dBc/(300 Hz) are sometimes used. Expressed in those units, the power spectral density of the primary sidebands is

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[16] Value as rounded to four significant digits. The exact value is the rational number 1488375/8192. Doc. No. SY_IDD_1012s, *Id*., at Section 3.5

[17] *See*, e.g., Doc. No. SY_IDD_1012s, *Id*., Figure 5-2.

[18] Doc. No. SY_IDD_1082s rev. F, HD Radio™ AM Transmission System Specifications, iBiquity Digital Corporation, August 24, 2011, e.g., at Table 4-5 and Figure 4-5; electronically at http://www.nrscstandards.org/download.asp?file=NRSC-5-C.asp.

[19] 10 × log(25) = 13.98. 13.98 – 30 = –16.02.
This value also appears in Table 4-6 of Doc. No. SY_IDD_1082s, *Id*.

[20] 10 × log(50) = 16.99. 16.99 – 30 = –13.01.

[21] 10 × log(4542.16 Hz/1000 Hz) = 6.57. –16.02 – 6.57 = –22.59. The computation for dBc/Hz is similar, with "1000" (for kHz) replaced by "1" (for Hz).

–27.82 dBc/(300 Hz).[22] It is important to note that –22.59 dBc/kHz, –27.82 dBc/(300 Hz), and –52.59 dBc/Hz are all equal to each other, just as are the specifications 1 yard, 3 feet, and 36 inches.

27. The foregoing specification, that the power spectral density of the primary sidebands is –27.82 dBc/(300 Hz), refers to their *nominal* power. There will be slight variations due to engineering tolerances. In addition, the IBOC standards specify a limit that should not be exceeded, even including normal variability. That limit is 1 dBc/(300 Hz) greater than nominal, or –26.8 dBc/(300 Hz).[23]

C. The AM Emission Mask

28. § 73.44 of the Commission's rules, "AM transmission system emission limitations,"[24] is a vital rule for minimizing harmful interference on the AM band. In order to maintain the vitality of the AM band, this rule must be rigorously enforced. Among other things, it sets strict limits on the amount of power that an AM broadcaster may emit outside of his assigned band. While some emission is inevitable, given the laws of physics, the rule guards against unnecessary, spurious emission and out-of-band emission that would interfere with other broadcasters on adjacent channels.

29. In relevant part, the rule reads as follows:

> **§ 73.44 AM transmission system emission limitations.**
>
> (a) The emissions of stations in the AM service shall be attenuated in accordance with the requirements specified in paragraph (b) of this section. Emissions shall be measured using a properly operated and suitable swept

[22] 10 × log(4542.16 Hz/300 Hz) = 11.80. –16.02 – 11.80 = –27.82. This calculation agrees with the documented power spectral density of the upper and lower primary sidebands, as given in the first two rows of Table 4-5, "OFDM Subcarrier Amplitude Scaling," in Doc. No. SY_IDD_1082s, *Id*.
[23] *See*, e.g., Doc. No. SY_IDD_1012s, *Id*., at Section 4.5 and the tables therein.
[24] *See* 47 C.F.R. § 73.44.

> frequency RF spectrum analyzer using a peak hold duration of 10 minutes, no video filtering, and a 300 Hz resolution bandwidth, except that a wider resolution bandwidth may be employed above 11.5 kHz to detect transient emissions. Alternatively, other specialized receivers or monitors with appropriate characteristics may be used to determine compliance with the provisions of this section, provided that any disputes over measurement accuracy are resolved in favor of measurements obtained by using a calibrated spectrum analyzer adjusted as set forth above.
>
> (b) Emissions 10.2 kHz to 20 kHz removed from the carrier must be attenuated at least 25 dB below the unmodulated carrier level, …

There is no doubt that the exact meaning of these words will be disputed in reply comment. Therefore, I present them with specificity and in their historical context.

30. Prior to 1955, the Commission published the *Standards of Good Engineering Practice Concerning Standard Broadcast Stations*. However, in 1955 the Commission was requested by Federal Register Division, National Archives and Records Service, General Services Administration, to codify these standards, and it did so. As first published in the Federal Register (20 FR 9041, 9050, December 9, 1955), the Commission adopted the following formal rule:

> **§ 3.46** *Transmitter*.
>
> …
>
> (c) The station equipment shall be so operated, tuned, and adjusted that emissions are not radiated outside the authorized band which cause or are capable of causing interference to the communications of other stations. Spurious emissions, including radio frequency harmonics, and audio frequency harmonics, shall be maintained at as low a level as practicable at all times in accordance with good engineering practice. In the event interference is caused to other stations by modulating frequencies in excess of 7500 cycles or spurious emissions, including radio frequency harmonics and audio frequency harmonics outside the band plus

> or minus 7500 cycles of the authorized carrier frequency, the licensee or permittee small [*sic*, presumably "shall"] install equipment or make adjustments which limit the emissions to within this band or to such an extent above 7500 cycles as to reduce the interference to where it is no longer objectionable.

31. A distinguishing feature of the 1955 rule was that it was not a quantitative one. Qualitatively, spurious emissions were to be at "as low a level as practicable," but in practice that could be subjective. This changed in 1959, when the Commission first adopted quantitative specifications for spurious and out-of-band emissions. Under the Commission's rules, "spurious" and "out-of-band" emissions are distinct types of emissions (§ 2.1 in the current codification). The 1959 rule applied to "any" emissions, no longer being limited to "spurious" ones. The Commission's interests, at the time, included setting a *de minimis* threshold for all emissions for type certification of transmitters (a standard to be effective January 1, 1960). What were then rules § 3.40 and § 3.46 were amended as follows (24 FR 7274–7275, September 10, 1959):

> **§ 3.40 Transmitter; design, construction, and safety of life requirements**
>
> (a) …
>
> (12) Any emission appearing on a frequency removed from the carrier by between 15 kc and 30 kc, inclusive, shall be attenuated at least 25 db below the level of the unmodulated carrier. Compliance with the specification will be deemed to show the occupied bandwidth to be 30 kc or less.
>
> **§ 3.46 Transmitter.**
>
> …
>
> (c) The station equipment shall be so operated, tuned, and adjusted that emissions outside of the authorized channel do not cause harmful interference to the reception of other radio stations. Standard broadcast stations employing radio transmitters type accepted after January 1, 1960, shall maintain the bandwidth occupied by their emissions in accordance with the specifications set forth in § 3.40(a). Stations employing transmitters installed or type accepted prior to

> January 1, 1960, shall achieve the highest degree of compliance practicable with their existing equipment. In either case, should harmful interference to the reception of other radio stations occur, the licensee may be required to take such further steps as may be necessary to eliminate the interference.

32. Over the years, the Commission's rules were recodified. In 1982, during the Reagan Administration, there was a major push to eliminate unnecessary rules and to simplify those that remained. As a result of this "reregulation" effort, a new rule was created (§ 73.44) out of related aspects of what were then rules § 73.40 (formerly §3.40) and § 73.46 (formerly §3.46). The Final Rule notice contained no indication of intent to otherwise change the substantive provisions of what remained in § 73.44. The new rule required, in relevant part (47 FR 8583, 8588, March 1, 1982):

> **§ 73.44 AM transmission system emission limitations.**
>
> (a) Stations using main transmitters type accepted after January 1, 1960 must meet the following emission limitations.
>
> (1) Any emission appearing on a frequency removed from the carrier by between 15 kHz and 30 kHz inclusive, must be attenuated at least 25 dB below the level of the unmodulated carrier. Compliance with this specification will be deemed to show the occupied bandwidth to be no greater than 30 kHz.
>
> (2) ….
>
> (b) Stations using main transmitters installed or type accepted before January 1, 1960, must achieve the highest degree of compliance with the limitations specified in paragraph (a) of this section practicable with the equipment in use as of that date.
>
> (c) Should harmful interference be caused to the reception of other broadcast or non-broadcast stations by out of band emissions, the licensee may be directed to achieve a greater degree of attenuation than specified in paragraphs (a) and (b) of this section.
>
> (d) ….

33. It is important to note that none of the foregoing expressions of the rule had any specifications for power spectral density. They spoke of "attenuation," a term that implies a simple ratio of power. The unit of measurement used, "dB below the level of the unmodulated carrier" (what we now call "dBc") is consistent with this intent. The rule pertained to two power measurements and their ratio, the power within the range of frequencies near the unmodulated carrier, and the power within the range of frequencies 15 kHz to 30 kHz off-carrier. The power distributions within those frequency ranges were not relevant.

34. Rule § 73.44 as we now know it (and stated above in 29) was adopted in 1989.[25] The main purpose of the amendment was to, "reduce the current occupied RF bandwidth of AM broadcast transmitters from 30 kHz to a nominal 20 kHz to achieve a reduction in interference levels and to improve the reception quality of the AM service."[26] To do this, the rule change tightened the AM emission mask, among other things moving the –25 dBc plateau from 15 kHz to 30 kHz, to now be 10.2 kHz to 20 kHz. "Occupied bandwidth" is a well-defined term in the Commission's technical rules.[27] It is, "[t]he 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." Here, –25 dBc (0.3% of carrier power) is consistent with this definition. (The rule allows additional power, within tight limits, beyond 20 kHz as well, more closely approaching in total the 0.5% limit.)

35. Another difference between this version of the rule and the ones that preceded it is that it gives instructions (in (a)) as to how the emissions are to be measured. It specifies the use

[25] 4 FCC Rcd. No. 9, 3835–3842, "In the matter of Amendment of the Commission's Rules to improve the quality of the AM Broadcast Service by reducing adjacent channel interference and by eliminating restrictions pertaining to the protected daytime contour," MM Docket No. 88–376, First Report and Order, April 12, 1989; FCC 89–118 online at http://transition.fcc.gov/Bureaus/Mass_Media/Databases/documents_collection/89-118.pdf

[26] *Id*. at 2

[27] *See* 47 C.F.R. § 2.202(a)

of an "RF spectrum analyzer," with a "300 Hz resolution bandwidth." This provision is explained at 41 of the Commission's First Report and Order[28]

> We note Bonneville'[s] concern that use of 300 Hz spectrum analyzer resolution may not detect transient bursts of splatter above 10 kHz. The 300 Hz resolution bandwidth is primarily necessary to accurately resolve the steep attenuation characteristic slope between 10 kHz and 10.5 kHz. For higher frequencies, where emission rolloff is more gradual, a narrow bandwidth is less critical in ascertaining spectrum content. Consequently, a wider bandwidth could be employed in this region. To alleviate this concern, a wider resolution bandwidth may be employed to measure emitted frequencies offset beyond 11.5 kHz in cases where splatter interference from fast risetime emission bursts is suspected.

36. There is no indication in the record that the Commission intended the new emission mask to be in any way more permissive than it had been before. Specifically, there is no indication that the Commission intended to change the rule from being a specification of power (i.e., –25 dBc) to being a specification of power spectral density (i.e., –25 dBc/(300 Hz)). 300 Hz is merely a measurement resolution that is sufficiently fine to resolve the spectrum in the 10 kHz to 10.5 kHz region. 100 Hz resolution would have served that purpose too. And furthermore, the rule allows wider resolution bandwidths (e.g., 1 kHz) at frequencies removed from the carrier by more than 11.5 kHz. The rule is completely unambiguous on this point. Were the amendment to be redefining the emission mask to be –25 dBc/(300 Hz), then it would be permitting a total power of up to 9.8 kHz $\times$ –25 dBc/(300 Hz) = –9.86 dBc (10.3% of carrier power)[29] on each sideband plateau, which far exceeds the limit of 0.5% of carrier power to achieve an occupied bandwidth of (nominally) 20 kHz.

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[28] 4 FCC Rcd. No. 9, 3835–3842, *Id*. at 41

[29] $10 \times \log(9{,}800 \text{ Hz}/300 \text{ Hz}) = 15.14$. $15.14 - 25 = -9.86$.

D. Emissions in the IBOC Hybrid-Mode System Far Exceed the AM Emission Mask

37. § 73.44 of the Commission's rules require that "Emissions 10.2 kHz to 20 kHz removed from the carrier must be attenuated at least 25 dB below the unmodulated carrier level." Hybrid-mode IBOC broadcasting has emissions 13.01 dB below the unmodulated carrier level in this spectral range. Since –13.01 dBc exceeds –25 dBc by 11.99 dBc (equal to a multiplicative factor of 15.8 times the allowed power), it does not conform to the rule, nor is it even close.

38. There is some indication in the record that Enforcement Bureau has, on occasion, treated distinct spectral features separately in enforcement of the rule. There are two spectral features present: upper and lower primary sidebands. Each sideband might be considered an emission of –16.02 dBc. Even under a rules interpretation where each sideband might be considered separately, –16.02 dBc exceeds the –25 dBc standard by 8.98 dBc (equal to a multiplicative factor of 7.9 times the allowed power).

39. I have made substantively the same showing on MM Docket No. 99–325 with respect to the FM IBOC system as well.[30] In that proceeding, there have been two different theories advanced as to why my reading of the rules (§ 73.317 for FM, § 73.44 here) is incorrect. I anticipate that either or both will be again presented to the Commission in reply to these comments. While the Commission should defer to other parties in the articulation of their own positions, in the interest of a more complete record, I address each of these theories as I best understand them now.

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[30] *See*, e.g., Application for Review of Jonathan E. Hardis, April 8, 2010, MM Docket No. 99–325, at 10–21 (http://fjallfoss.fcc.gov/ecfs/document/view?id=7020408278), and Comments of Jonathan E. Hardis, December 19, 2011, MM Docket No. 99–325, at 5–16 (http://fjallfoss.fcc.gov/ecfs/document/view?id=7021751134). To date, the Commission has not taken action with respect to either of these matters.

1. The iBiquity Opposition

40. The first of the theories was from iBiquity Digital Corporation.[31] In essence, what iBiquity argues is that the Commission's spectral emission masks refer to power spectral density (rather than power), even though they do not say so explicitly. "Mr. Hardis appears to take issue with iBiquity's methodology, which measures the [FM] digital signal level in a 1 kHz bandwidth."[32] For AM, the analogous methodology would be to measure the digital signal level in a 300 Hz bandwidth. Under this theory, since –27.82 dBc/(300 Hz) is less than –25 dBc, the digital signal fits the spectrum mask. (Never mind that the units of measurement are different, that it's an "apples and oranges" comparison.)

41. There are many reasons why this theory may be shown to be incorrect. First, when the Commission means to specify a power spectral density in its rules, it does so clearly. See, e.g., § 15.407, "In addition, the peak power spectral density shall not exceed 4 dBm in any 1–MHz band." § 95.639, "the peak power spectral density shall not exceed 800 microwatts per megahertz in any 1 megahertz band." Second, in order to specify a power spectral density, you must give an appropriate unit of measurement. "dBc" is not an appropriate unit of measurement for power spectral density. I have already pointed out that the IBOC primary sidebands have power spectral densities of –22.59 dBc/kHz, –27.82 dBc/(300 Hz), and –52.59 dBc/Hz — all of which are equal. There is no reason to believe that, prior to 1989, § 73.44 would have implied units of dBc/(300 Hz). dBc/kHz would have been much more natural (in which case one could point out that –22.59 exceeds –25 by 2.41, for whatever that's worth). And even after 1989, there is nothing in the record to indicate that the Commission's intent was that incremental power in each 300 Hz of spectrum should be separately *and independently* compared to –25 dBc.

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[31] Reply Comments of iBiquity Digital Corporation, January 24, 2012, MM Docket No. 99–325; electronically at http://fjallfoss.fcc.gov/ecfs/document/view?id=7021755151.
[32] *Id*., at p. 3.

42. What iBiquity attempts to do in its construction of the rule is to divide spectrum into numerous 300 Hz segments and to say that the rule is satisfied if the power in each segment, *independently of the others*, is less than –25 dBc (0.3% of carrier power). Between 10.2 kHz and 15 kHz off-carrier there are 32 such segments (taking into account the spectrum both above and below the carrier). Under iBiquity's construction, the AM emission mask would allow powers in this band of up to 32 × –25 dBc, which equals –9.95 dBc (10.1% of carrier power). And why stop at 15 kHz? The –25 dBc plateau extends to 20 kHz. If there were –25 dBc (0.3% of carrier power) in each 300 Hz segment along the full range, then in total there would be –6.85 dBc (20.7% of carrier power) out of band.

43. Recalling that the purpose of the § 73.44 is to set a *de minimis* threshold that's indicative of an achievable minimum for out-of-band emissions, 20.7% of carrier power is not a reasonable engineering value for an achievable minimum. Nor is 10.1%, or 5%, or even 2.5%. 2.5% of carrier power—which is what is transmitted in each of the IBOC primary sidebands—is 1,250 watts for a 50,000 watt station. That's enough power for a separate radio station in and of itself. And with two sidebands, that makes two of them! Even with 1960-vintage technology, 0.3% of carrier power was a reasonable engineering value for sufficiently small out-of-band emissions to constitute *de minimis* emissions.

44. Furthermore, as documented *supra*, the stated purpose of the 1989 amendment to § 73.44 was to, "reduce the current occupied RF bandwidth of AM broadcast transmitters from 30 kHz to a nominal 20 kHz." According to the definition in § 2.202(a) of the Commission's rules, a hybrid-digital IBOC signal has an "occupied bandwidth" of approximately 30 kHz, not 20 kHz. An IBOC sideband of 2.5% of carrier power exceeds the § 2.202(a) standard (0.5%) by a factor of 5. The only consistent interpretation of § 73.44 is that emissions in the entire band

10.2 kHz to 20 kHz removed from the carrier must be limited to –25 dBc (0.3% of carrier power). This has been the standard of the rule since its beginning, and this is what the rule still means today.

45. I suspect that one of the reasons that the concepts of power and power spectral density have been conflated as they have been has to do with the operation of an RF spectrum analyzer, as § 73.44 now prescribes. An RF spectrum analyzer is an instrument that creates a data plot in the frequency domain, where each data point in the plot represents the power in a slice of spectrum. The width of the slices is adjustable, the so-called resolution bandwidth. Well, what is actually plotted by a spectrum analyzer? There are two different circumstances that commonly arise. If there is a spectral feature that's narrower in bandwidth than the resolution bandwidth, the amplitude of the spectral feature on the spectrum analyzer is the total, integrated power in that feature. That is, if you make the resolution bandwidth wider, the power measurement of the feature's peak (hence its total power) will remain the same. Prior to the introduction of IBOC broadcasting, most of the spectral features that broadcast engineers encountered fit this description. Conversely, if there is a spectral feature that's wider in bandwidth than the resolution bandwidth (as are 5 kHz IBOC sidebands, with a 300 Hz resolution bandwidth), then the data from the spectrum analyzer are of power spectral density. Furthermore, the resolution bandwidth used is much more significant. The values measured are not constant, but rather rise and fall proportionate to the resolution bandwidth. When the resolution bandwidth is reduced, the measured power goes down—not because there is less power, but because you've chosen to use a smaller window through which to view a smaller portion of it.

46. This point is key, so please allow me to reiterate it. The spectral power density of the primary sidebands is –22.59 dBc/kHz, –27.82 dBc/(300 Hz), and –52.59 dBc/Hz — all of which are equal (just as 1 yard, 3 feet, and 36 inches are all equal). This means that an RF spectrum analyzer will read –22.59 dBc if the resolution bandwidth is 1 kHz, –27.82 dBc if the resolution bandwidth is 300 Hz, and –52.59 dBc if the resolution bandwidth is 1 Hz. These numbers, –22.59, –27.82, and –52.59, are not useful metrics for the interference potential for an IBOC sideband in and of themselves, as they are primarily determined by the arbitrary setting of a knob on the measurement instrument. The relevant metric is the total out-of-band power, just as the total in-band power is the relevant metric for the strength of a broadcast station's signal.

47. Finally, in iBiquity's theory they attempt to make hay on purported differences between the words "any" and "all." "The plain wording of Section 73.317 says 'any' emission. It does not say 'all', 'the aggregate' emissions or 'total integrated power'. Thus, the actual wording of the rule does not support Mr. Hardis' contention that the total integrated power of the digital sideband must fall under the Section 73.317 limit."[33] While the current version of § 73.44 does not use the term "any emission," prior versions did. Therefore, analysis of this point might be instructive as to the intent of the rule. Ultimately, the Commission has the authority to interpret its own rules. However, as a matter of usual interpretation, iBiquity is incorrect. The words "any" and "all" are nearly synonymous.[34]

> We have noted that "the adjective 'any' is not ambiguous; it has a well established meaning." *Lyes v. City of Riviera Beach*, 166 F.3d 1332, 1337 (11th Cir. 1999) (en banc) (internal quotation marks omitted). "Read naturally, the word 'any' has an expansive meaning . . . . [When] Congress [does] not add any language limiting the breadth of that

[33] Reply Comments of iBiquity Digital Corporation, *Id*., at p. 3.
[34] Southern Company v. Federal Communications Comm., 99-15160 (11th Cir. 2002); online at http://www.fcc.gov/ogc/documents/opinions/2002/99-15160.doc

> word, . . . 'any' means 'all.'" *Merritt v. Dillard Paper Co.*, 120 F.3d 1181, 1186 (11th Cir. 1997) (citation omitted) (internal quotation marks omitted).

And should a party attract the Commission's attention for possible violation of the rules, they might well receive an inquiry that includes the following boilerplate:[35]

> For purposes of this letter, the following definitions apply:
> "Any" shall be construed to include the word "all," and the word "all" shall be construed to include the word "any."

In actuality, as documented in 31, *supra*, the word "any" is used to be inclusive of any and all types of emissions, purposely incorporating both "spurious" and "out of band" emissions into the rule.

2. The Joint Parties Opposition

48. The second of the theories was from a group of broadcast engineers who signed an "Engineering Statement."[36] In essence, what the broadcast engineers argue is that it is standard practice to treat each spectral feature separately, and that each subcarrier qualifies as a separate spectral feature. Applying their theory to the AM context, the engineers argue that since each subcarrier in the primary sidebands is –30 dBc, and since –30 dBc is less than –25 dBc, the emissions fit the mask. However, there were no authorities cited as to either of these two points: that the rules (§ 73.317 for FM, § 73.44 here) apply on a per-spectral-feature basis, or that subcarriers (or even sidebands) would qualify as distinct spectral features. Since the subcarriers are 181.7 Hz apart, a resolution bandwidth of 300 Hz is not sufficiently small to resolve them within the sidebands, in typical operation of an RF spectrum analyzer.

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[35] See, e.g., Letter from Peter H. Doyle to Radio Power, Inc., DA 12–185, February 10, 2012; online at http://hraunfoss.fcc.gov/edocs_public/attachmatch/DA-12-185A1.pdf.
[36] Reply Comments of the Joint Parties, January 24, 2012, MM Docket No. 99–325; electronically at http://fjallfoss.fcc.gov/ecfs/document/view?id=7021755325.

49. This theory fails for essentially the same reasons as the previous one. If it were true that the emission mask allowed out-of-band emissions of –25 dBc (0.3% of carrier power) in each of 50 concurrent instances (the number of subcarriers in the primary sidebands), then the total out-of-band power being radiated would be –8.01 dBc (15.8% of carrier power). As with the previous theory, this interpretation and construction do not yield either a reasonable engineering value for *de minimis* out-of-band emission, or an occupied bandwidth of 20 kHz, as defined by § 2.202(a) of the Commission's rules.

50. Furthermore, this interpretation and construction would not require that you stop at 50 instances. One could place 106 subcarriers 181.7 Hz apart in the spectral range –20 kHz to –10.2 kHz and 10.2 kHz to 20 kHz. Then, the total out-of-band power being radiated would be –4.75 dBc (33.5% of carrier power). And by spacing the subcarriers even closer together … well, you get the point. This interpretation and construction would permit out-of-band emissions to be arbitrarily high. Indeed, on the FM side (where there are 382 subcarriers) I pointed out that this interpretation and construction allow out-of-band emissions that are 20% more powerful than the carrier from which they arise.[37] The essential fact is that the hybrid-digital signal does not consist of 50 (or more) separate emissions. It is one emission—from one broadcast transmitter and one radiating antenna system. Describing the signal as 50 subcarriers is nothing but an analytic convenience.

E. The Commission Should Not Make an Exception for AM IBOC Hybrid-Digital Mode

51. I have presented the Commission with a solid and detailed factual analysis that shows that emissions in the IBOC system hybrid-digital mode significantly exceed the AM emission mask, and are thus in conflict with § 73.44 of the Commission's interference protection

[37] Reply Comments (Late Filed / Ex Parte) of Jonathan E. Hardis, January 29, 2012, MM Docket No. 99–325; electronically at http://apps.fcc.gov/ecfs/document/view?id=7021857139.

rules. Nonetheless, the Commission has authority to waive the rule or to change it, if it finds that doing so would serve the public interest. Given that the Commission is now receiving comments on ways to "revitalize" the AM service, it would seem an opportune time to address the point that it should not grant any such exemption.

52. There is no dispute that interference on the AM band is a serious problem, but on the other hand there is no dispute that hybrid-digital broadcasting provides benefits, including higher fidelity sound. Wherein lies the balance?

53. In 2002, IBOC broadcasting on the AM band was inaugurated with great optimism and promise.[38] In their Petition for Rulemaking, iBiquity Digital (then, USADR) expected that, after 12 years, the Nation could sunset hybrid-digital broadcasting and inaugurate all-digital broadcasting.[39] However, things have turned out differently. 12 years later, according to independent observers, the number of AM stations actually broadcasting digitally is approximately 173, down from 245 in 2010[40]—this, out of approximately 4,727 AM stations nationwide.[41] And if you wanted to buy an AM digital receiver, you would be hard pressed to find one without a car attached. The only digital radios sold today for use outside of the

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[38] "*Digital Audio Broadcasting Systems and Their Impact on the Terrestrial Radio Broadcast Service*," First Report and Order, 17 FCC Rcd 19990–20016 (2002); electronically at http://fjallfoss.fcc.gov/edocs_public/attachmatch/FCC-02-286A1.pdf.

[39] 15 FCC Rcd 1722–1749, Notice of Proposed Rule Making in the Matter of *Digital Audio Broadcasting Systems And Their Impact On the Terrestrial Radio Broadcast Service*, MM Docket No. 99–325 (FCC 99–327), Nov. 1, 1999, at 8; electronically at http://transition.fcc.gov/ftp/Bureaus/Mass_Media/Databases/documents_collection/99-327.pdf.

[40] "AM IBOC Stations on the Air," http://topazdesigns.com/iboc/station-list.html, visited January 18, 2014. The actual number is disputed, and there is no authoritative source. *See also*, Leslie Stimson, "AM HD Radio Has Stalled. Now What?" August 31, 2010, Radio World Online, at http://www.radioworld.com/article/am-hd-radio-has-stalled-now-what/3774. The sidebar, "How Many AMs are HD?" compares estimates then available—including 245 using the same basis as the 173 count now reported. As of January 18, 2014, FCC reports 293 "licensed" stations. http://licensing.fcc.gov/cgi-bin/ws.exe/prod/cdbs/pubacc/prod/sta_list.pl?Service=AM&digital_status=H

[41] "Broadcast Station Totals as of December 31, 2013," January 8, 2014; http://fjallfoss.fcc.gov/edocs_public/attachmatch/DOC-325039A1.pdf

dashboard either do not receive the AM band or else cost more than $1000.[42] As the Commission noted under similar circumstances 12 years ago, "CEA argues that if significant consumer demand existed for technologies such as C-QUAM AM stereo and AMaX, these products would be widely available in the marketplace."[43]

54. Notwithstanding the waning interest in AM IBOC radio and the lack of significant consumer demand, does it offer any redeeming public benefit? Essentially, an AM IBOC radio receives the same programming as does an analog AM radio—the main difference being improvement in sound quality. However, sound quality and its importance are both subjective.

55. On the flip side, it is generally accepted that IBOC broadcasting in the hybrid-digital mode creates significant adjacent-channel interference on the AM band. As of this writing (January 18), approximately one quarter of the comments appearing on the ECFS in this docket raise the issue of IBOC interference—even though the *NPRM* did not explicitly include it among its inquiries. The Commission has a long-standing prohibition against negotiated or otherwise consensual interference in the AM broadcast band.[44] Furthermore, the Commission has long held that listeners, rather than broadcasters, are the primary beneficiaries of the Commission's interference protection rules.[45] Therefore, it is not dispositive if broadcasters are willing to

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[42] http://hdradio.com/get-a-radio/home-radio and http://hdradio.com/get-a-radio/portable, visited January 7, 2014. The Insignia NS-BHDIP01 is a discontinued product. http://www.insigniaproducts.com/products/portable-audio-players/NS-BHDIP01.html, visited January 7, 2014.

[43] "*Digital Audio Broadcasting Systems and Their Impact on the Terrestrial Radio Broadcast Service*," First Report and Order, 17 FCC Rcd 19990–20016 (2002), at 25; electronically at http://fjallfoss.fcc.gov/edocs_public/attachmatch/FCC-02-286A1.pdf.

[44] *See*, e.g., "*1998 Biennial Regulatory Review—Streamlining of Radio Technical Rules in Parts 73 and 74 of the Commission's Rules*," Notice of Proposed Rulemaking, MM Docket No. 98–93, 13 FCC Rcd 14849, FCC 98–117, June 15, 1998, at 4 and 5; online at http://www.fcc.gov/Bureaus/Mass_Media/Notices/1998/fcc98117.pdf.

[45] *See Eatonton and Sandy Springs, Georgia, and Anniston and Lineville, Alabama*, Report and Order, 6 FCC Rcd 6580, 6583 n.20 (MMB 1991), quoting *Millington, Maryland*, Memorandum Opinion and Order, 45 R.R.2d 1689, 1691 (BB 1979).

accept interference from hybrid-digital IBOC facilities, especially if in return for their acquiescence they receive additional royalties and license fees from the use of such facilities.[46] "The emission mask [specified in Section 73.44 of the Commission's rules] is integrally related to the Commission's AM allocations rules (principally Sections 73.37 and 73.182) which, in turn, rest on certain assumptions concerning tradeoffs between coverage and interference."[47] Therefore, one cannot consider § 73.44 in isolation. There would be cascading consequences that any blanket exemption or modification to § 73.44 would trigger.

56. As the Commission notes regularly, in order for an interested party to obtain a waiver or an exception to a rule, a petitioner must demonstrate that either: (i) the underlying purpose of the rule would not be served or would be frustrated by application to the present case, and that a grant of the waiver would be in the public interest; or (ii) in view of unique or unusual factual circumstances of the case, application of the rule would be inequitable, unduly burdensome, or contrary to the public interest, or the applicant has no reasonable alternative.[48] An applicant seeking a waiver faces a high hurdle and must plead with particularity the facts and circumstances that warrant a waiver.[49] This "high hurdle" is not met by those supporting excess power for AM IBOC in the hybrid-digital mode. On balance, it is difficult to justify a blanket waiver or modification of § 73.44 that benefits a small and dwindling number of listeners and licensees by at best a subjective metric. Waiver or modification of § 73.44 would not create any

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[46] According to the website of iBiquity Digital Corporation, their owners include, "15 of the nation's top radio broadcasters, including Clear Channel and CBS Radio." http://www.ibiquity.com/about_us/investor_information, visited January 11, 2014.

[47] "*Digital Audio Broadcasting Systems and Their Impact on the Terrestrial Radio Broadcast Service*," First Report and Order, 17 FCC Rcd 19990–20016 (2002), at 28; electronically at http://fjallfoss.fcc.gov/edocs_public/attachmatch/FCC-02-286A1.pdf.

[48] *See* 47 C.F.R. § 1.925(b)(3).

[49] *WAIT Radio v. FCC*, 413 F.2d 1153, 1157 (D.C. Cir. 1969), *aff'd*, 459 F.2d 1203 (1973), *cert. denied*, 409 U.S. 1027 (1972) (citing *Rio Grande Family Radio Fellowship, Inc. v. FCC*, 406 F.2d 664 (D.C. Cir. 968); Birach Broad. Corp., *Memorandum Opinion and Order*, 18 FCC Rcd 1414, 1415 (2003).

additional opportunities to receive information or entertainment programming; to the contrary, recent experience has demonstrated conclusively that out-of-band IBOC hybrid-digital-mode interference is causing significant harm to the vast majority of listeners and broadcast stations.[50] The preponderance of the public's interest lies in preventing this harm. It could be argued that the 173 radio stations out of 4,727 have proportionately greater significance because they include many of the principal Class A and Class B stations in major markets. However (repurposing a comic book slogan), with great power comes great responsibility.[51] The Commission must act impartially in the application and enforcement of its rules to protect all of its licensees and their listeners. It is the revitalization of the AM Band as a whole that is the subject of this proceeding, and which is ultimately the public interest objective.

[50] I anticipate reply comments that purport a lack of complaints, or if complaints their lack of validity. I do not believe that the formal complaint record is public, and even if it were, I would not comment on specific-party disputes. Nonetheless, this matter is neither obscure nor complicated. I invite the Commission and its staff to tune a standard AM radio up and down the dial, especially at twilight or at night, and to hear for yourselves the interference "hiss" caused by IBOC digital sidebands. And as for complaints, albeit informal ones, you need look no further than the comments and reply comments on this docket.

[51] This saying actually long predates Spider-Man. *See* http://en.wikiquote.org/wiki/Stan_Lee and the references therein.

IV. THE COMMISSION SHOULD SOLICIT COMMENTS ON INTRODUCING ALL-DIGITAL AM BROADCASTING

57. The *NPRM* (at 45) invites comments on potential all-digital AM operation. As I discussed *supra* (at 6), the future vitality of the AM band should arise, in part, by an acceptance of this spectrum for experimentation, that is, as a testing ground for new ideas—both in terms of program content and for technical innovation. All-digital broadcasting fits well within this paradigm. I encourage the Commission to continue to build a record that might lead to the introduction of all-digital AM operation.

A. The Commission's Technical Rules Should Provide Parity between Analog and All-Digital Operators

58. My support for all-digital AM operation is not unqualified. The Commission must also set policies and standards that create appropriate boundaries for all-digital operation. Chief among them is the principle that all-digital operation must respect analog operators—including those operators who might pursue better-fidelity analog operation in bandwidths of up to 10 kHz—by strict adherence to both the letter and the intent of the Commission's technical rules. That is, when a specification in the rules creates inequity between analog and digital stations because of the differences in spectral occupancy between the two, the specification should be adjusted for digital operation in order to maintain historical levels of interference protection.

59. I note, in this regard, that iBiquity's all-digital system, unlike the hybrid-digital system, does in fact have an occupied bandwidth of 20 kHz or less.[52] In the all-digital system, the primary subcarriers are located within 5 kHz of the carrier. The secondary and tertiary subcarriers are located between 5 kHz and 10 kHz removed from the carrier.[53] The primary subcarriers cause me little concern. They carry to so-called "core" data stream, which is what is

[52] Doc. No. SY_IDD_1012s, *Id*., and Doc. No. SY_IDD_1082s, *Id*.
[53] *See* Doc. No. SY_IDD_1012s, *Id*., at Figure 5–4.

essential for reception of programming.[54] The secondary and tertiary subcarriers carry the so-called "enhanced" data stream. This provides extra data capacity for additional audio quality and auxiliary services. "Optionally, the secondary and tertiary subcarriers may be disabled so that only the primary and PIDS sidebands are transmitted, reducing the total transmission bandwidth to less than 9.4 kHz."[55] While the secondary and tertiary subcarriers fit with the AM emission mask, depending on their power level they could occupy spectrum to a proportionately greater degree than analog broadcasting has, historically. This could affect the underlying assumptions behind the Commission's interference protection rules for adjacent channels. Therefore, the Commission should ensure that the power levels for the secondary and tertiary subcarriers—which are completely adjustable in software—do not exceed a level that creates harmful interference in excess of historical norms. Furthermore, the Commission is free to establish separate daytime and nighttime power specifications, which might be implemented automatically in the software.

B. All Operators on the AM Band Should Adhere to Open Specifications

60. The iBiquity system fares less well on another policy matter. Despite there being volumes of available documentation on the iBiquity system,[56] these public specifications are far from complete. While the public specifications describe how RF modulations should be interpreted as digital bits, there is scant information on what the data bits mean. Of greatest concern, there are no specifications for the audio encoding. That is, the iBiquity system broadcasts radio

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[54] *See*, e.g., Doc. No. SY_IDD_1014s, Rev. I, HD Radio™ Air Interface Design Description Layer 2 Channel Multiplex, iBiquity Digital Corporation, August 24, 2011, e.g., at Table 5-2; electronically at http://www.nrscstandards.org/download.asp?file=NRSC-5-C.asp.

[55] Doc. No. SY_IDD_1012s, *Id*., at p. 16.

[56] The NRSC–5 standard is available on-line at http://www.nrscstandards.org/download.asp?file=NRSC-5-C.asp. A synopsis of the standard, which incorporates the main technical documents by reference, is available on the ECFS at http://apps.fcc.gov/ecfs/document/view?id=7021898832.

on the public airwaves in a secret code. In and of itself, this is counter to all Commission precedent.[57] And as best as I can tell, there is no precedent in the entire history of Federal regulation for a Government agency to regulate on the basis of an essential specification that a private entity guards as a trade secret. There is no justification for the Commission to do so now.

61. Indeed, one might view digital television broadcasting as case precedent for digital radio broadcasting. The Advanced Television Systems Committee (ATSC) established a bright-line test for documenting the advanced television system standard: "Complete functional system details (permitting those skilled in the art to construct a working system) were to be made publicly available."[58] The Commission has already considered and incorporated this principle into its rules for broadcast television.[59] No lesser standard should apply to broadcast radio.

62. It is often said that iBiquity's system is "proprietary," but the use of that term belies the problem. There are distinct types of intellectual property, patents and trade secrets among them. The Commission is well versed in how to deal with technology that is covered by patents, which is the usual form of intellectual property encountered in rulemaking.[60] In a

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[57] SCA services on the FM band were deemed to be not "broadcasting." In the matter of subscription television service, the Commission thought long and hard before allowing it. 23 F.C.C. 531–562 (October 17, 1957). The facts present here are significantly different.

[58] A/53: ATSC Digital Television Standard, Parts 1–6, 2007 (3 January 2007) at Annex A (Historical Background) 2.4; available electronically at http://www.atsc.org/cms/standards/a53/a_53-Part-1-6-2007.pdf.

[59] *See* 11 FCC Rcd. No. 13, 17771–17812, "In the Matter of Advanced Television Systems and Their Impact Upon the Existing Television Broadcast Service," MM Docket No. 87–268, *Fourth Report and Order*, December 27, 1996; FCC 96–493, online at http://transition.fcc.gov/Bureaus/Mass_Media/Orders/1996/fcc96493.pdf. The present codification is at 47 C.F.R. § 73.682(d) and 47 C.F.R. § 73.8000(b). At the time of the rulemaking that resulted in the *Fourth Report and Order*, the version of Standard A/53 then being considered and upon which comments were received did not relegate the policy statement at issue to an informational annex. It was squarely in the normative part of the standard, at Sec. 4.4.

[60] *See*, e.g., *Revised Patent Procedures of the Federal Communications Commission*, 3 FCC 2d 26–27 (1966), committing to record a Public Notice adopted December 1961, and as further explained at 3 FCC 2d 25 (1966). Online in part at http://www.gtwassociates.com/answers/fccpatpol.pdf.

nutshell, patents usually pose little issue provided that the patent holders agree to license them on "Reasonable and Non-Discriminatory" (RAND) terms—which for IBOC digital radio, iBiquity has done.[61] Patents are not my concern, even though there are a few bumps on this well-travelled road now and again.[62] I am concerned with trade secrets. And unlike patents, trade secrets do not expire.

63. Mandatory licensing in perpetuity is inherently unreasonable. The basic Jeffersonian bargain in the U.S. patent system is that an inventor gets a *limited* period of special rights in return for *fully* teaching how to manufacture and use an invention. At the conclusion of this limited period, the public gains full rights to manufacture and use the invention as they please. By retaining much of the IBOC system specification as a trade secret, iBiquity is trying to get a better deal at the back door of the FCC than they can get at the counter of the Patent Office. Since the specification is secret, they can exclude competition in the manufacture of compatible transmitters and receivers.[63] They can collect rents from the public for the use of their system. And furthermore, they can do these things in perpetuity—long after their patents expire. In many circumstances trade secrets do not pose a problem—innovators in a free market can compete on

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[61] "iBiquity has agreed to abide by the FCC's patent policy, which requires iBiquity to license all patents that are necessary for implementing IBOC broadcasting to all interested parties on reasonable and nondiscriminatory terms." Quanta Computer Inc., et al. v. LG Electronics, Inc., In the Supreme Court of the United States, No. 06–937, Brief for iBiquity Digital Corporation as Amicus Curiae Supporting Respondents, December 2007, at p. 9. Online at https://www.eff.org/files/filenode/quanta_v_lg/06-937bsaciBiquityDigitalCorporation.pdf. This statement is broader than similar statements regarding those patents necessary to practice standard NRSC–5.

[62] *See*, e.g., MB Docket No. 09–23, "*Petition for Rulemaking and Request for Declaratory Ruling Filed by The Coalition United to Terminate Financial Abuses of the Television Transition, LLC*," and comments therein. Online at http://apps.fcc.gov/ecfs/proceeding/view?name=09-23.

[63] All IBOC transmitters and receivers include software on which iBiquity holds copyright, a third type of intellectual property. *See* Quanta Computer Inc., et al. v. LG Electronics, Inc., Brief, *Id*. Their secret specifications necessitate using iBiquity as the vendor of the software, rather than competitors that might write their own, original software that would independently implement the specifications. This stifles competition on the basis of price, performance, and innovative features.

the merits of their products. But it is a problem if the Government adopts a secret system as a requisite National standard. The Commission should not frustrate the intent of the Constitution and the Congress in allowing patented inventions to enter the public domain after the limited period of exclusivity has expired.

64. Lest there be any doubt, I am not suggesting a bargain whereby iBiquity makes full disclosure of their specifications in return for inauguration of all-digital broadcasting. I am suggesting that the Commission insist that iBiquity make good on the bargain that they, themselves already offered in 1998, unconditionally. In their original Petition for Rulemaking, iBiquity's predecessor company offered that, "[t]he IBOC DAB standard should [] include all technical elements to ensure system compatibility."[64] And they called out three areas that a complete standard must address: audio coding, digital error correction and interleaving codes, and modulation.[65] The Commission agreed, determining that adoption of such a standard would facilitate the rollout of digital audio broadcasting, provide "regulatory clarity," and "compress the timeframe for finalizing the rules." [66] Yet here we are, more than 15 years later, with iBiquity not having made good on their offer.

65. Ironically, it was iBiquity themselves that first laid out the public interest argument for a complete standard. As they wrote in 1998,[67] in part:

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[64] USA Digital Radio, *Petition for Rulemaking*, October 7, 1998 (RM-9395), at IX.D (pp. 94–96); available electronically at http://gullfoss2.fcc.gov/cgi-bin/websql/prod/ecfs/comsrch_v2.hts?ws_mode=retrieve_list&id_proceeding=RM-9395&id_submission_type=PU, more specifically, http://gullfoss2.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=2170270005.
[65] *Id*.
[66] *Digital Audio Broadcasting Systems And Their Impact On The Terrestrial Radio Broadcast Service*, Further Notice of Proposed Rulemaking and Notice of Inquiry, 19 FCC Rcd 7505 (2004) at 56; electronically at http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-04-99A4.pdf.
[67] USA Digital Radio, *Petition for Rulemaking*, October 7, 1998 (RM-9395), *Id*., at IX.D.3 (pp. 96–98). (Internal footnote omitted.)

> The Commission noted in the DTV proceeding that a single standard would increase competition in price, service, and product features. This rationale for a standard is also present in this instance. The lower costs associated with a single standard will give numerous entities the ability and the incentive to introduce new products and to respond to consumer demand. In return, consumers will have greater access to technology with new features and functions.

By concealing rather than teaching the essential knowledge required to build compatible devices, the documentation publicly available today does not meet the public interest objective of giving "numerous entities" the ability to compete, and thus create substantial consumer benefits.

66. These comments should not come as a surprise. I have made substantially the same arguments in a Petition for Reconsideration[68] and an Application for Review,[69] both of which are pending Commission action. I hope that the Commission concludes action in these matters expeditiously.

67. Finally, as the Commission moves forward to consider all-digital broadcasting, there will be many commenters who will suggest that iBiquity has the only game in town. They don't. I expect that other commenters will suggest consideration of Digital Radio Mondiale[70] as an alternative technology. And should a champion for that technology come forward, having broad, international agreement on a path for all-digital AM would be an attractive option. An open standard (even one that requires patent licensing) and a world market would create the innovation and demand that IBOC lacks. Should the Commission be presented with such a proposal, I hope that you would give it due consideration.

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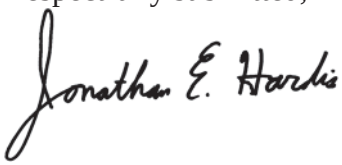
[68] Petition for Reconsideration of Jonathan E. Hardis, MM Docket No. 99-325, July 9, 2007; electronically at http://fjallfoss.fcc.gov/ecfs/document/view?id=6519550109.
[69] Application for Review of Jonathan E. Hardis, MM Docket No. 99–325, April 8, 2010; electronically at http://fjallfoss.fcc.gov/ecfs/document/view?id=7020408278.
[70] *See* http://www.drm.org.

V. CONCLUSION

68. For the foregoing reasons, the commission should: continue to pursue opportunities for "full fidelity" AM along the lines contemplated in 1989; foster improvement in receiver technology by, among other methods, establishing a prize competition to challenge young, creative engineers to innovate the AM radio of the 21st century and to gain a sense of ownership in the success of the band; rigorously enforce interference protection rules, in particular requiring IBOC hybrid-digital operators to limit out-of-band emissions to those allowed under § 73.44 of the Commission's rules; and to continue to build a record that might lead to an option for all-digital broadcasting on the AM band, subject to requirements of equity between broadcast modes and open specifications.

Respectfully submitted,



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