ENGINEERING EXTRA

KNOCK KNOCK
What to do when the FCC arrives on your doorstep for a station inspection. Page 4

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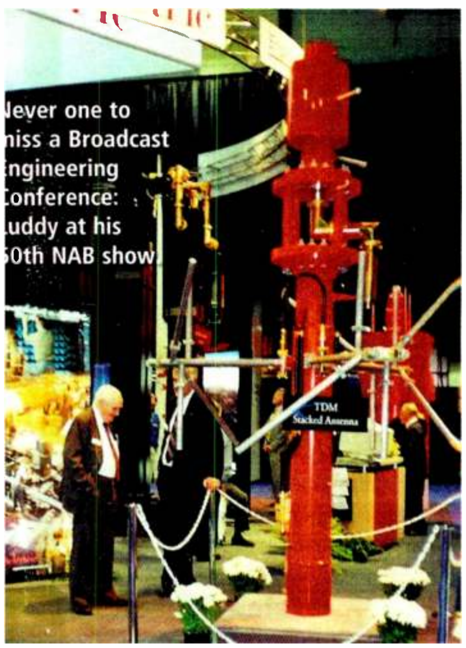
In Love with Radio Since President Hoover

We Talk With E. Noel Luddy, 93, About His Eight Remarkable Decades of Broadcast Engineering



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uddy at his
0th NAB show

Photo courtesy SPX Communication Technology

BY TOM MCGINLEY

E. Noel Luddy is without doubt one the longest-serving and most revered senior statesmen of our industry.

Beginning with ham radio in 1930 at age 13, Luddy fell in love with both the hobby and profession of radio, and has stayed in love. His career began at a small AM station in Kentucky. He worked in the military as a radio officer for the Army during World War II, and eventually took a position at the Radio Corporation of America during the years of explosive growth in the radio industry following the war. Luddy finally decided to retire in 2008. His distinguished career included a span of more than 50 years working for RCA and Dielectric.

ENGINEER INTERVIEW

Luddy celebrated his 93rd birthday in December. He resides in Columbia, Pa. Radio World chatted with him via e-mail.

You've been working in and associated with broadcast engineering for longer than probably everyone who reads this interview, Noel. Tell us how you got the "radio bug" as a young lad and decided to make it a career.

My grandfather, Diddy, was very mechanical and got me interested in cars and working on equipment. I shifted to radio in my early teens. It was exciting to talk on ham radio to people hundreds of miles away. People from the neighborhood came to our house to hear me talk to people far away. It was a very big deal in the early 1930s.

Tell us about your educational background.

We moved around some. I was in Kentucky and Ohio. I was always interested in radio. I attended the University of Toledo and the University of Kentucky. I did well and completed seven semesters, but I couldn't wait to actually work full-time in radio. I was given a chance to work for radio station WLAP in Lexington, Ky., and I bolted out of college to take the job.

You studied electrical engineering but did not finish a degree and instead went to work as a radio engineer. If you could roll back the clock, would you change that decision and how would you advise others now facing a similar choice?

(continued on page 20)

Concentric Colocation: A Unique Solution

How to Fit One Directional Array Inside Another

BY CRIS ALEXANDER

The idea of colocation is nothing new. We have been sharing sites among FM, TV and even AM stations for decades. The earliest FM and TV antennas were installed on AM towers, mostly because they were co-owned with the sister AM (which was the dominant medium in those days) and because the AM towers were already in place.

A DAY IN THE LIFE

During my career, I have had numerous occasions to colocate stations in just about every combination. But a few years ago, a different kind of opportunity presented itself as a rather elegant solution to a longstanding problem with one of our Denver AM stations. Perhaps that experience may provide inspiration

(continued on page 18)

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RADIOWORLD
ENGINEERING EXTRA
ol. 35, No. 5 February 16, 2011

Next Issue of RADIO WORLD March 1, 2011
Next Issue of ENGINEERING EXTRA April 13, 2011

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UBSCRIPTIONS
adio World, P.O. Box 282, Lowell, MA 01853
ELEPHONE: 888-266-5828 (USA only 8:30 a.m.–5 p.m. EST)
78-667-0352 (Outside the US) FAX: 978-671-0460
VEB SITE: www.myRWNews.com
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adio World Founded by Stevan B. Dana

adio World (ISSN: 0274-8541) is published bi-weekly with
dditional issues in February, April, June, August, October and
ecember by NewBay Media, LLC, 28 East 28th Street, New
ork, NY 10016. Phone: (703) 852-4600, Fax: (703) 852-4582.
eriodicals postage rates are paid at New York, NY 10079 and
dditional mailing offices. POSTMASTER: Send address changes to
adio World, P.O. Box 282, Lowell, MA 01853.

EPRINTS: Call or write Caroline Freeland, 5285 Shawnee Rd.,
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FROM THE TECH EDITOR

Interest in LPFM Validates Radio

New Law Also Offers FCC an Opportunity to Make Some Beneficial Changes

BY MICHAEL LECLAIR

Legislation to permit an increase in low-power FM services was signed by President Obama in January. The law instructs the FCC to eliminate third-adjacent-channel protections and allow waivers of second-adjacent protections under certain conditions.

To achieve a second-adjacent waiver, an LPFM proponent would be allowed for the first time to use propagation models that take terrain into account, for example in a situation where a mountain ridge would limit the field strength of an LPFM in a specific direction. These changes are predicted to make available a significant number of new channels for LPFM.

In return for its consent, the National Association of Broadcasters received some additional specific protections for full-service stations, including a confirmation that first- and second-adjacent protections would remain, with the exception noted above. In densely populated areas a full-service station could shut down an LPFM if the latter causes interference, even in some cases beyond its protected contour. Finally, the bill preserved third-adjacent protections for stations that use analog subcarriers to provide radio reading services.

These events have led to speculation that we could see a second LPFM window with a large wave of applications from community groups. Given the determination and grit with which proponents have pursued their goal, I suspect thousands might file.

LOW-POWER ROOTS

I have a lot of respect for the idea of community radio. My own career in broadcasting began at a noncommercial educational station, and I know a fair number of people in the industry who had a similar start. At their best, noncom educational stations speak to their communities with local programming and often are operated directly by community members. What's not to like?

A low-power station gives a community organization a mass media outlet that would otherwise be hard to acquire. The flexibility of radio allows groups with relatively few resources to operate in a widely available medium, unlike more expensive types such as television and newspapers.

Those of us who have been around long enough will recall the many Class D noncom stations at high schools and colleges. When the Class D license was eliminated, most improved their facilities and migrated to the NCE band; not all survived. LPFM revives the idea of limited coverage with reduced responsibilities.

Low-power stations potentially offer a way to rejuvenate broadcasting by bringing into the field a new array of potential owners and new ideas on how to make radio. They also provide a potential pool for full-service licensees to call on as current radio talent matures and retires.

The immense interest in this band also demonstrates the validity of radio as a broadcast medium. Even with their limited coverage, LPFMs likely will attract many more applicants than there are channels available. This is a good reason for the FCC to consider one of the more moderate FM band expansion proposals: Allow the use of 87.5 through 87.9 MHz for LPFM and noncom educational service. These frequencies, currently lying fallow in most areas of the country and of little use for digital television broadcasting, would be readily deployed and widely used if appended to the FM band.

WAIT FOR THE DETAILS

I must point out that for existing full-service stations, the new legislation offers little gain. The worst-case allocation scenario would place third-adjacent stations at the very edge of coverage for a full-service station. On older radios this could affect reception, particularly in the region close to the LPFM transmitter.

Add in operators with limited sophistication and high modulation ambitions (or faulty equipment), and interference could increase substantially. Broadcasters must remain vigilant to encroachment from new signals. They will need to document complaints and pursue them with the FCC. But it is hard to see the exact outlines of potential interference until we know more about the changes the commission will adopt.

While Congress can pass legislation to guide the FCC, any engineer knows that the political process rarely produces fully designed systems. It remains the task of the FCC to implement rules that will provide a good balance between protecting full-service stations while allowing a reasonable number of potential LPFM channels. In spite of optimism on the LPFM side, the simple elimination of third-adjacent protections will not suddenly open up hundreds of new channels in highly populated urban markets. If full-service stations are unhappy with the way LPFM is implemented, they have the right and resources to fight back against any interference.

The new law also requires the FCC to complete a study on the economic effects of LPFM on full-service broadcasters. This may be used to guide LPFM deployments.

Before a new LPFM window is opened, the FCC will need to issue a notice of proposed rule making that outlines how new allotments will be awarded.

A CHANCE TO FIX TRANSLATORS?

The new law also is likely to resolve the current freeze of a large number of translator applications filed in a 2003 window. There appears to be movement toward an accord amongst LPFM proponents and translator applicants to allow some of these applications to proceed after a review of the effects on potential LPFM allotments.

REC Networks, a supporter of LPFM stations, has proposed that at least two LP-100 allotments be preserved in a given market, following a specific contour overlap formula. If a translator applicant can demonstrate this availability, its application could be unfrozen.

REC also proposes to remediate some of the worst aspects of the much-criticized 2003 window. This includes the dismissal of technically faulty applications, limiting applicants to one translator per market and eliminating applications not filed by existing AM or FM station owners at the time of the window. REC also proposes a system to resolve mutually exclusive applications that rewards localism. Entities with translators at the greatest distance from their associated stations would receive the lowest preference. The text of its proposals can be read in PDF form at *http://tinyurl.com/rwrec1*.

REC's commonsense proposals go a long way to address the faults of the 2003 translator window and point the way to a more reasonable translator allocation system.

THIS ISSUE

FEBRUARY 16, 2011

Open the Door, Let 'Em In

What to Do When The FCC Knocks?

BY CHARLES S. FITCH

SBE certification is the emblem of professionalism in broadcast engineering. To help you get in the exam-taking frame of mind Radio World Engineering Extra poses a typical question in each Certification Corner. Although similar in style and content to exam questions, these are not from past exams nor will they be on future exams in this exact form.

... And I'm Here to Help

Question posed in the Oct. 13 issue
(Exam level: CBRE)

It's a little after 8 p.m. and your five-station cluster has settled into night automation operation. As usual, you are the last in the building.

But now there are two people at the front door, holding up federal FCC IDs to the security camera. They request to inspect your station(s).

Are they entitled to inspect at this late hour?

a. No, it's a constitutional right to have an attorney present when questioned. They can come back when your attorney is present.
b. No, it's after business hours, and meaningful management presence is absent
c. No, you're off the clock
d. No, tours are only given by appointment
e. Yes

The simple rule of thumb: *If you are radiating, you are subject to inspection.* The answer to today's question is the last one, "e."

The Enforcement Bureau, the part of the FCC that inspects or orders up an inspection, wants absolutely no confusion on this issue and has published on its website answers to just about any inspection scenario questions you might ask. See *www.fcc.gov/eb/other-info/inspect.html.*

You can quote those pages to management or ownership if someone tells you that FCC inspection access is optional. In truth, as with the Borg, resistance is futile.

A paragraph from the FCC site succinctly sums up the issue:

Q: What happens if I do not allow the FCC agent to inspect my equipment?
A: Failure to allow inspection forecloses the opportunity to resolve the problem. Thus, refusal to allow inspection is a serious challenge to the commission's authority to inspect radio stations and is a violation of the rules. Such a refusal may lead to revocation of a license, maximum monetary forfeiture or other commission sanctions.

FCC staffers, unlike those of the IRS in my experience, usually are courteous and justifiably proud of the team they're on and the mission they fulfill. They will show you all the FCC ID you want.

If something makes you suspect a prank (say, the inspector looks about 19 and is wearing a halter top), call the FCC "emergency desk" at (202) 418-1122. Within minutes you'll know whether she is bogus or a real (if youthful) inspector who simply may have failed to read the book "Fashion in the Workplace."

Many FCC officials have worked in their assigned regions for years. If you have not had the pleasure of meeting them you should know them by reputation. So if inspector Lamont Cranston, a legend in your FCC district, shows up at your door with picture ID and his sidekick, don't be a smarty and act stupid.

FCC employees are people too; they may have come far to visit you. So be a good host and let them know where the washroom is. If you have refreshments on hand, offer them. You want these official visitors to see you as professional and open. Be respectful, factual, accurate and, above all else, truthful.

Keep records close at hand. Public copies can be conformed but the originals of documents should be in the station offices. (A "conformed" copy is a duplicate of a document on which the signatures are printed or typed, rather than signed by hand.) Most of my clients store originals of critical documents, such as the main license, in a locked cabinet or safe in the GM's office.

When it comes to paperwork, leave no doubt.

On conformed copies that are kept in the public file, note on the front page the total pages, the initials of who copied it and the date copied. Multipage document copies should always be stapled together.

If documents are in binders, provide an index on the front and put the documents inside in clear sheet carriers with a label for what is inside the carrier.

There are a few brilliant, inspired and talented FCC attorneys out there. The best advice I ever got from them about documents was to organize and identify your paperwork such that if all of it ever fell in a mess of a heap on the floor, every page could be identified on its own and put back into its proper place in moments. Such precise organization should be your goal.

A Notice of Apparent Liability is not something you want to receive. The goal is to avoid it through effective and complete compliance. An NOAL that sticks could open you to a license challenge. It usually involves a monetary fine and may be a drain on your time and legal budgets. Finally, it can brand you or your employer as unprofessional and sloppy.

(A postscript: Lamont Cranston was the name of "The Shadow." *Who knows what evil lies in the hearts of men?* Like many of the inspectors I've encountered, he knew your violations even before he arrived. One of the great radio detectives, the Shadow confounded offenders in more than 900 episodes. Orson Welles amongst other great talents voiced the character.

What has this got to do with the FCC?

Do you know the title of the only movie in which an FCC inspector was the hero? He actually got the girl in the end. It was "Phantom from Space," produced in 1953. The FCC was disguised as the CAA, the Communication Authority. Handsome "B" actor Ted Cooper played the CAA inspector.

None of the above trivia will ever be on an SBE exam.)

The deadline for signing up for the next cycle of SBE certification exams is March 25 for exams given at the NAB Show in April.

Missed some Certification Corners or want to review them for your next exam? Find past Certification Corner articles under the Columns tab at radioworld.com.

It's Not the Flux Capacitor, Marti

Question for next time
(Exam level: CBRE)

Your remote crew tells you that there is something wrong with their 10 watt 160 MHz RPU transmitter. On site you realize that you need to substitute a dummy load to ascertain if the problem is the transmitter or antenna. Your dummy is back on the bench but in your kit you have the resistors listed below. How can you quickly arrange them to make a workable 50 ohm load?

Quan	Value (ohms)	Power handling (watts)
4	100k	1/2
2	620	1/2
2	150	1/2
4	100	1
1	100	5

a. There is no solution as the 1/2 watts will blow no matter what at 10 watts input.
b. Put all the above resistors in parallel.
c. Put the four 100 ohm 1 watts in parallel and then series these with the 100 ohm 5 watt.
d. Make a series parallel network out of the four 100 ohm 1 watts (two series 100 ohms with these series pairs in parallel) and this network paralleled with the 100 ohm 5 watt.
e. Parallel all the 100 ohm resistors.

Putting the IBOC Quality Metric to the Test

Can We Predict IBOC Coverage Based on Digital Signal Integrity?

BY PHILIPP A. SCHMID

The author is research engineer at Nautel Ltd. in Hackett's Cove, Nova Scotia, Canada.

Even HD Radio signals transmitted with a good spectrum are not guaranteed to be high-quality signals as seen by a receiver. Spectrum measurements are useful for quantifying out-of-band emissions, but they reveal little about the in-band signal quality.

The recently introduced IBOC signal quality metric provides a standardized method for validating the in-band HD Radio signal quality for FM IBOC signals. This paper takes a detailed look at the definition of the metric, provides a framework for determining acceptable signal quality and presents measurement results based on an open MATLAB-based implementation.

The impact of peak reduction algorithms on the IBOC signal quality is explained. Nautel's advanced peak reduction algorithm is demonstrated to meet the IBOC quality specifications. It is shown how the algorithm can be configured to produce superior peak reduction performance or superior IBOC quality compared to the standard IBOC signal. With the IBOC quality metric a broadcaster can now adjust the transmitter for optimal efficiency, reducing operating costs while ensuring the market is well served.

Other factors are shown to have equally significant impact on IBOC signal quality, such as transmitter clock stability and FM overmodulation. This paper presents an open method for computing the IBOC quality metric, but also calls for transmitter and modulation monitor-based implementations to equip the broadcast engineer with the tools to ensure high-quality HD Radio transmission.

1 INTRODUCTION AND MOTIVATION

Unlike traditional analog signaling, degradation of a digital broadcast signal is usually not detected as a gradual degradation of the delivered audio; rather it causes a gradual degradation of the built-in forward error correction (FEC) to the point of breakdown. This makes it difficult for the broadcaster to monitor digital signal broadcast quality. To the listener, this is only apparent as an increased audio dropout rate near the edge of the service contour causing a general reduction of effective coverage area.

What is needed is a standardized metric to reliably determine the quality of a digital in-band, on-channel signal in the FM band before the signal is lost at the edge of the service contour. The metric must be obtained on live broadcast signals from samples taken at the transmitter site or using receive antennas. Second, a frame of reference needs to be established, allowing broadcasters to determine if a particular installation is performing as expected.

The motivation of this paper is to detail the established IBOC quality metric for FM, introduce an implementation to measure the metric in the field and provide a frame of reference by presenting results gathered using the proposed implementation. Sources impacting IBOC quality are also discussed.

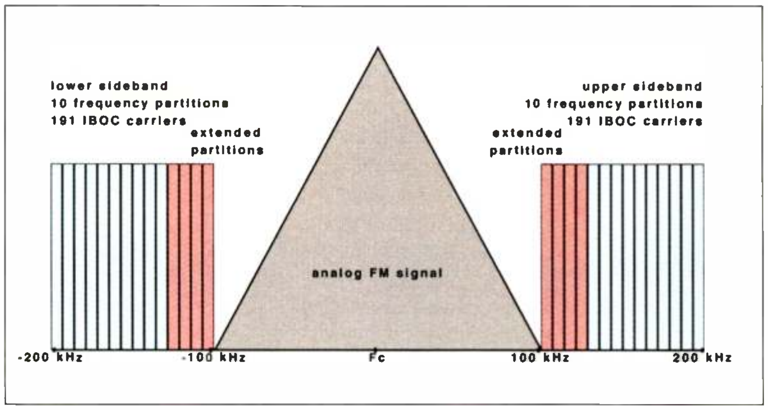

Fig. 1: FM IBOC spectrum

1.1 IBOC Signaling

IBOC transmission is defined by the National Radio Systems Committee and the physical signal transmission is specifically detailed in the air interface design description. Only a brief overview of IBOC signaling is given here.

Fig. 1 shows the spectrum allocation of FM IBOC. IBOC places a 100 kHz sideband on either side of the traditional FM signal. Each sideband is composed of 10 frequency partitions made up of 18 data-carrying carriers and one reference carrier that allows a receiver to lock on to the signal. An additional reference carrier is placed on the outside of the spectrum, such that each group of 18 data carriers is flanked by a reference carrier on either side. In total, 382 carriers are employed in the basic MP1 service mode, and enhanced modes may enable an additional four frequency partitions on each sideband, increasing the total number of carriers to 534.

1.2 Standard Quality Metrics

A commonly used quality metric applied to digital modulation schemes is the error vector magnitude or its reciprocal, the modulation error ratio.

The EVM is often expressed as a percentage as shown in Equation 1. The ratio represents the absolute magnitude of an error vector compared to a reference point corresponding to a constellation point without error. Similarly, the MER defined by Equation 2 in essence captures the amount of ideal or reference power over the error power. Both metrics work on the same principle of comparing the error vector to a reference vector as shown in Fig. 2.

$$\mathrm{EVM}(\%) = 100\% \sqrt{\frac{P_{\mathrm{error}}}{P_{\mathrm{reference}}}} \quad (1)$$

$$\mathrm{MER(dB)} = 10\log_{10}\left(\frac{P_{\mathrm{reference}}}{P_{\mathrm{error}}}\right) \quad (2)$$

Comparing error vector power levels to reference power levels seems a relatively straightforward concept. However, as Fig. 2 shows, the measured constellation point is composed of the sum of the intended reference vector and the error vector. In order to determine the ratio of reference to error power, we need to be able to determine the reference vector. The error vector is then simply the difference between the measured and the reference vector.

The challenge is to determine the reference vector from a signal containing errors. This involves the steps of symbol tracking, basic channel estimation and symbol demodulation

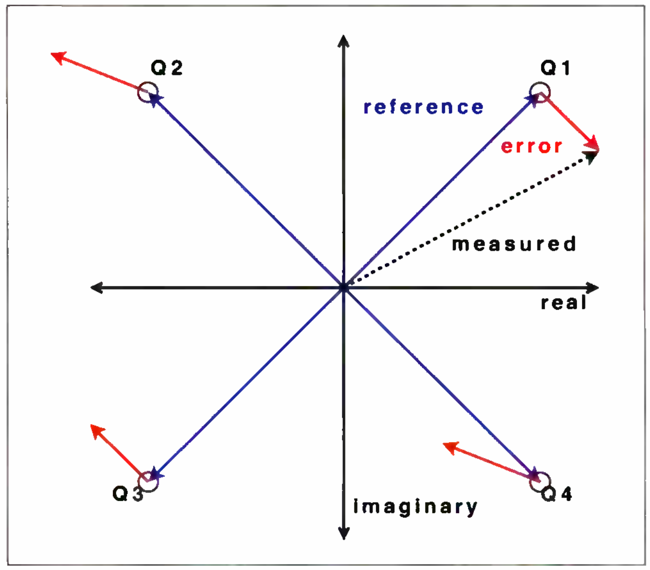

Fig. 2: QPSK constellation with error vectors

similar to what a typical receiver performs. Hence, we need to adapt the generic MER/EVM metrics specifically for FM IBOC as defined in the "Transmission Signal Quality Metrics for FM IBOC Signals," simply referred to as "the spec" in this paper.

2 IBOC QUALITY METRIC EXPLAINED

The IBOC quality metric performs like an HD Radio receiver without actually decoding the signal's payload data.

Before the IBOC quality metric can be computed, a series of steps to properly arrive at an IBOC constellation plot are required and are detailed below.

2.1. Basic IBOC Demodulation

IBOC demodulation is performed on a complex in-phase and quadrate (IQ) signal at a nominal sampling rate of 744187.5 Hz, where the IBOC signal is perfectly centered around 0 Hz. The sample rate is determined by the symbol rate of 344.5 symbols per second and each symbol is composed of 2160 discrete time samples.

Each symbol is composed of 2048 samples representing the actual IBOC carriers from indexes –1024 to 1023. Of course, only the carriers for a given service mode are enabled and are restricted to within the range of –546 to 546. Each symbol receives a 112 sample cyclic prefix extension that serves as a guard interval.

(continued on page 8)

IBOC

(continued from page 6)

The modulator applies a pulse shaping function on the extended symbol. The pulse shaping function is shown in Equation 3 as applied to a 2048+112-sized symbol. The pulse shaping function is simply a quarter rising sine wave for the first 112 samples and a quarter falling sine wave for the trailing 112 samples and unity in between. It serves the same goal of reducing inter symbol interference (ISI) by providing a 150 µs guard interval. This pulse shaping function is sample-by-sample multiplied to the 2160 sample vector representing our symbol.

$$h(\xi)=\begin{cases}\cos\left(\pi\dfrac{112-\xi}{2*112}\right) & \text{if } 0<\xi<112\\ 1 & \text{if } 112\le\xi\le 2048\\ \cos\left(\pi\dfrac{2048-\xi}{2*112}\right) & \text{if } 2048<\xi<2160\\ 0 & \text{elsewhere}\end{cases} \qquad (3)$$

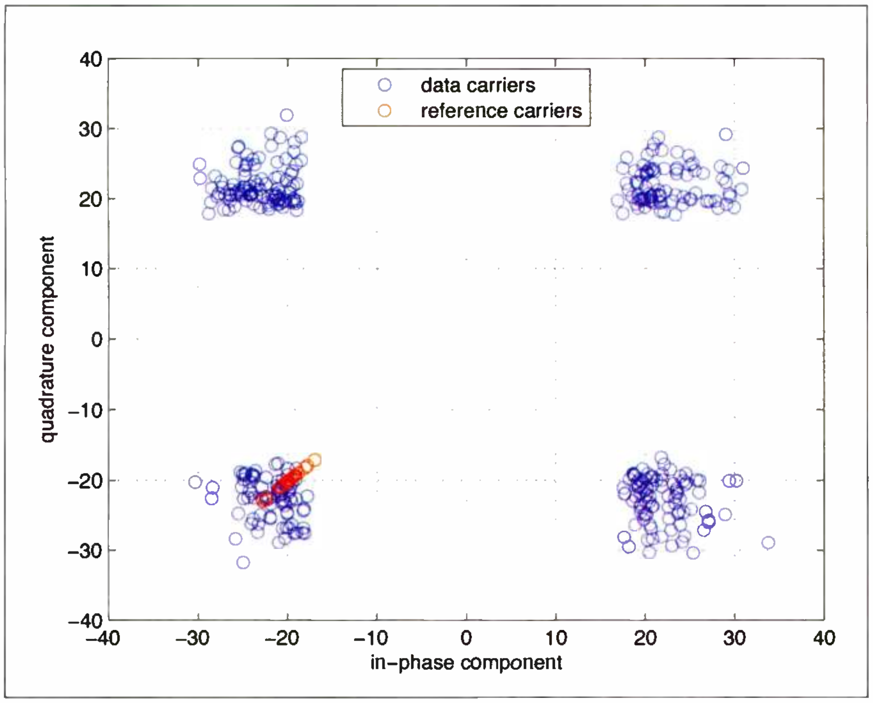

Fig. 3: IBOC modulator output constellation

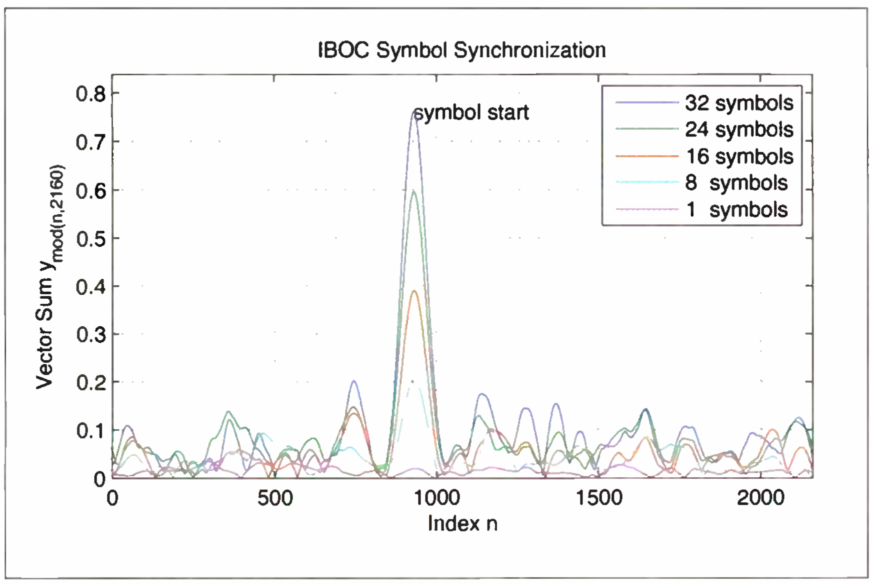

Fig. 4: IBOC symbol start detection using cyclic prefix autocorrelation

The demodulator can perfectly reconstruct the 2048 point vector that was initially used to create the time domain symbol. Since the first 112 samples are identical to the last 112 samples prior to pulse shaping, if we apply the pulse shaping function a second time to the same vector, then the first 112 samples are effectively multiplied with a $\sin^2\theta$ term while the trailing 112 samples are multiplied with a $\cos^2\theta$ term. Employing the Pythagorean trigonometric identity, $\sin^2\theta + \cos^2\theta = 1$, allows us to recover the first 112 samples exactly as they were prior to applying the pulse shaping function and transmission.

With the symbol's original 2048 point time domain vector restored, we can now determine each individual carrier in the frequency domain through a fast Fourier transform (FFT) operation and create a constellation plot across all carriers. An example of such a plot is shown in Fig. 3.

2.2 Signal Capture

The above demodulation steps work well on an ideal signal such as vectors captured straight from an IBOC modulator. For this paper, results were captured using a real-time spectrum analyzer (Tektronix RSA3303B) as an independent piece of test equipment. In order for the above demodulation steps to work, the captured signal must first be sample rate converted to the IBOC sample rate of 744187.5 Hz, since the spectrum analyzer captures samples at a higher sampling rate.

At the correct sample rate we must now determine the start of an IBOC symbol to within 1–2 samples. Note that most likely there also are sub-sample delays, which are later dealt with by adjusting the reference carriers. Autocorrelation of the cyclic prefix provides a method to determine the start of an IBOC symbol. This method takes an arbitrary time domain sample and multiplies it with the conjugated sample 2048 samples later (see Equation 4). If the particular sample is part of the cyclic prefix at the start of an IBOC symbol, then the 2048th sample later will be in phase with the current sample and may vary by the scalar of the pulse shaping function. This means the complex multiplication will always result in a real value (or close to a real value if noise is present).

On the other hand, if the current sample and the next sample 2048 later are in two different symbols, the multiplication will produce a complex value with a random phase component.

$$y_{\text{mod}}(n,2160)=y_{\text{mod}}(n,2160)+x_n \bullet x^{*}_{n+2048} \qquad (4)$$

where n spans the length of the vector less 2048

Over the span of a single symbol, the start of the IBOC symbol is not yet apparent. This is why Equation 4 runs across a longer vector. With each additional symbol, the cyclic prefix samples continue to add a real value to the running sum $y[n]$ in Equation 4 while the other samples' random phases will tend to cancel with one another. After 16 to 32 symbols, the resultant cyclic vector $y[n]$ holds a half cycle sine wave over the 112 samples of the cyclic prefix and all other samples only hold residual values. Running the vector y through a matched filter rejects random noise further for better results. The absolute peak of the vector y represents the start of the IBOC symbol. Fig. 4 shows how the symbol start becomes apparent across additional iterations.

2.3 Delay and Frequency Tracking

With the start of an IBOC symbol determined to within 1–2 samples, we can now demodulate the IBOC symbol as described previously. The spec denotes the resulting demodulated carriers as vector $r_{n,m}$, where n represents a symbol in the entire vector and m represents an index to a reference carrier within that symbol.

In order to be able to support randomly captured signals, we must be able to compensate for fractional sample delays. The effects of time delays are given by the discrete-time Fourier transform property of time shifting:

$$x[n-n_d] \longleftrightarrow e^{-j\omega n_d} X(e^{j\omega}) \qquad (5)$$

This means that a single sample delay ($n_d = 1$ or 1.34 µs) introduces a phase shift in all carriers depending on the carrier's relative frequency. So for carrier 546 (the right most carrier of the upper sideband), the phase shift is given by:

$$-\frac{546}{2048}\bullet 360^\circ = -96^\circ$$

Fig. 5 depicts the reference carriers under fractional sample delays. The upper and lower sidebands diverge in opposite directions as the delay increases.

It is apparent that compensation for fractional sample delays is required to avoid unwarranted impact on the quality metric. The spec analyzes the reference carriers across the entire vector by summing the square of each reference carrier across all symbols and taking the angle of the resultant sum, denoted as ϕ_m. This correction angle is later applied to the raw constellation $r_{n,m}$ to form the phase-adjusted reference carriers, denoted as $u_{n,m}$ in the spec.

Errors in sampling frequency will cause carrier energy to bleed into neighboring frequency bins, but this only becomes significant for a sampling frequency error in the order of 1/2048 or 488 ppm and can be ignored for our purposes. On the other hand, even small sampling frequency errors will introduce a creeping delay offset. A 1 ppm frequency error introduces a fractional sample delay of 0.002 samples every symbol. Over a 512 symbol window this error grows to an entire sample delay, significantly degrading the metric as the final symbols would have phase errors similar to the ones shown in Fig. 5.

The spec solves this problem by turning ϕ_m into a two-dimensional version $\phi_{n,m}$ that allows a different

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IBOC

(continued from page 8)

phase correction per carrier as time progresses. The rate of change in the reference carrier phase is estimated and applied to $\varphi_{n,m}$ as an averaged slope in the phase change on each reference carrier (the slope is frequency-dependent as seen in Equation 5). With this correction, we can capture the IBOC signal with a frequency error of up to ±2.5 ppm over 512 symbols or ±10 ppm over 128 symbols.

2.4 Carrier Equalization

IBOC receivers perform linear equalization in order to be able to correct for transmission channel variations. The metric proposes a basic linear equalization method in order to capture the non-linear effects. The linear equalization performed on the reference carriers can also be used to quantify the linear effects. For example, by looking at the phase adjustment φ_m, group delay variation across the IBOC signal can be captured. Similarly, the absolute magnitude of the reference carriers $smag_m$ is needed to equalize frequency dependent amplitude variations. Therefore, $smag_m$ can also be used to enforce a maximum gain variation across the band.

$$C_{n,k} = \frac{19(1+j)}{(19-k)smag_m e^{j\varphi_{n,m}} + k\,smag_{m+19} e^{j\varphi_{n,m+19}}} \qquad (6)$$

A constant equalizer is computed across the span of the signal vector and is defined as Equation 6 on a frequency partition basis (19 carriers). The equalization on each carrier is interpolated between adjacent reference carriers.

Fig. 6 depicts a typical equalizer curve across the IBOC carriers as captured on a 20 kW transmitter. Note that the phase adjustment also includes the adjustment for delay and frequency tracking.

2.5 Measurement Definitions

The IBOC quality metric is not a single number, but rather it is a collection of values that have to be interpreted in conjunction.

2.5.1 Group Delay and Gain

Group delay and gain variation are linear effects that can be detected and quantified based on the phase equalization φ_m and magnitude equalization $smag_m$. Gain variation is rather straightforward; it simply expresses the highest power reference carrier over the lowest power reference carrier in decibels. Because the IBOC modulator introduces some amplitude variation on the reference carriers as part of the peak reduction algorithm, enough reference carriers must be averaged to smooth out this effect.

Group delay is related to the fractional sample delay mentioned above and is measured by looking at the phase of adjacent reference carriers, $\varphi_{m+19} - \varphi_m$. We are only interested in the variation of group delay across the band, because it represents the amount of phase equalization a receiver would have to perform on the transmitted signal.

2.5.2 Reference Carrier MER

The equalization vector $C_{n,k}$ is indirectly applied to the reference carriers as the phase correction is applied to the reference vector $u_{n,m}$ and a standard MER metric as described above is taken on the reference carriers and each carrier is referenced to its averaged magnitude $smag_m$. It is important that reference carriers maintain a high degree of quality, since any error in the reference carriers will manifest itself in misinterpreted data carriers at the receiver.

2.5.3 Reference Carrier to Data Carrier Ratio

It has been found that the standard IBOC modulator produces reference carriers with a 0.5 dB lower power level compared to the remaining data carriers. In order to account for this, the IBOC quality metric measures the power ratio of reference carriers to data carriers, denoted as R, and uses that ratio to adjust the reference point for the data carrier MER metric.

2.5.4 Data Carrier MER

The standard MER metric needs to be modified for IBOC data carriers, since standard IBOC modulators implement peak reduction algorithms that intelligently modify the signal constellation in order to minimize the peak-to-average power ratio (PAPR). In some cases, random data carriers receive a boost in power if they help to cancel an instantaneous peak in the time domain. This causes a potentially large deviation from the reference point and negatively impacts the MER measurement, even though this boost has not negatively impacted the receivability of the data carrier.

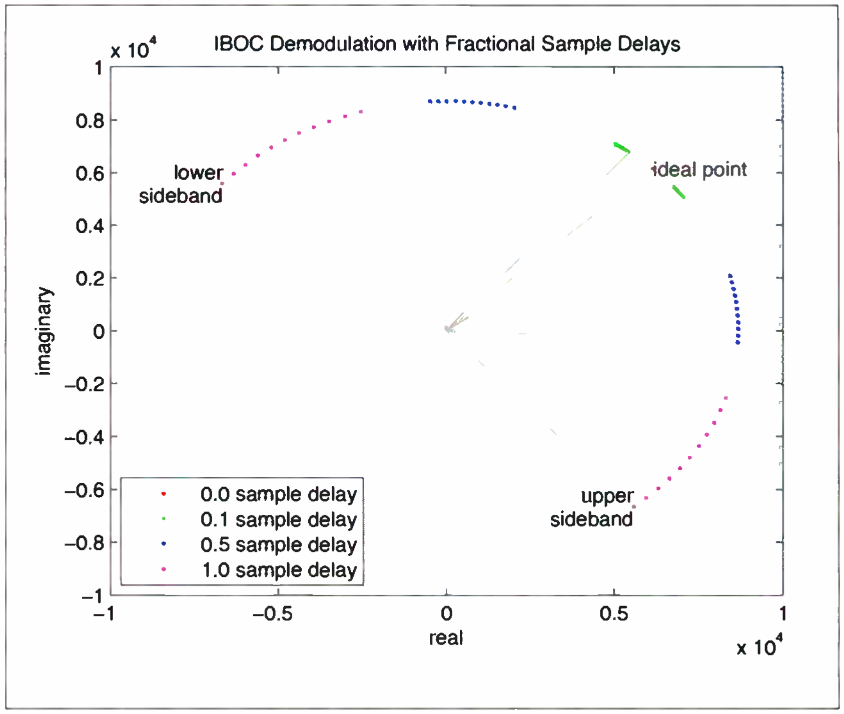

Fig. 5: Effects of fractional sample delay on reference carriers

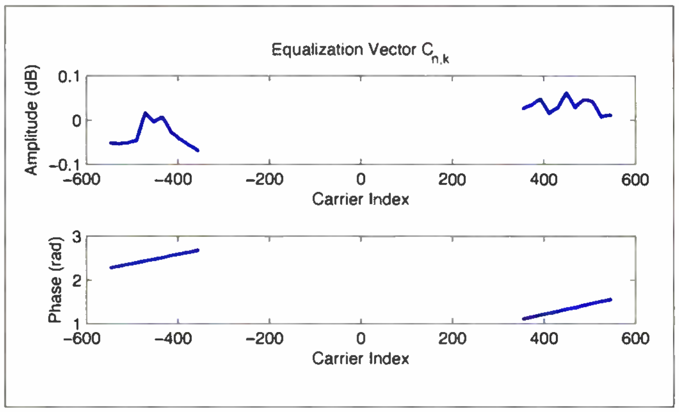

Fig. 6: Typical equalizer captured on 20 kW transmitter

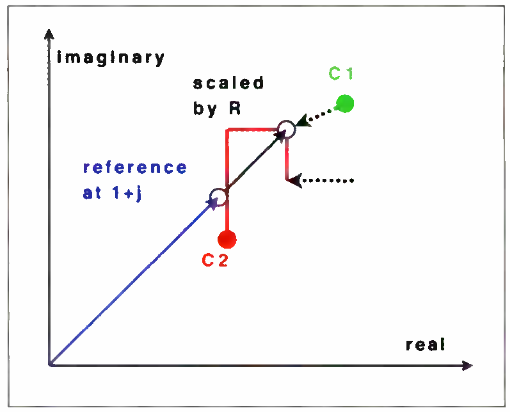

Fig. 7: Modified MER for data carriers

Fig. 7 provides a graphical representation of how the modified MER is computed. The metric is computed on the equalized signal vector $v_{n,m+k}$, which nominally places all reference carriers at $1 + j$. The metric then scales the reference point by the factor R. This adjusts the data carrier MER with respect to the average data carrier power.

There are three cases to consider. Point C1 in Fig. 7 is a boosted carrier, which does not contribute to the noise metric. Point C2, the second case, does contribute to the noise as indicated by the red lines to the scaled reference point. The last case is if only the real or imaginary component is below the reference point. In this case only the violating dimension is counted. Numerically, this is represented in Equation 7.

$$\max\left(0, R-\left|\Re/\Im\left(v_{n,m+k}\right)\right|\right) \qquad (7)$$

2.6 Defining Acceptable IBOC Quality

With a defined MER metric we can now compare IBOC signals with one another either on the same transmitter or on another transmitter provided the IBOC power level is the same. What we really want to do is correlate IBOC signal quality to the impact on reception and the effective coverage area.

Using an ideal IBOC signal with added noise, the noise power level was determined under which a bit error tester first exhibits intermittent bit errors. Fig. 8 depicts the constellation at that noise level without any PAPR reduction induced noise and can be compared to the standard IBOC constellation shown in Fig. 3. The figure also shows that this noise level places the noise at around 6 dB below the IBOC carriers. Note that the IBOC Forward Error Correction can provide some level of service to within 4 dB of the IBOC carriers. With the breakdown point defined, any transmitter contributed noise will degrade reception. So at an ambient noise level of 56 dB–Hz, the received noise level can be expressed as shown in Equation 8.

$$N_{C_d/N_0} = -10\log_{10}\left(10^{\frac{56\,\mathrm{dB-Hz}}{10}} + 10^{\frac{\mathrm{TX\,Noise}}{10}}\right) \qquad (8)$$

Equation 8 requires the transmitter noise to be

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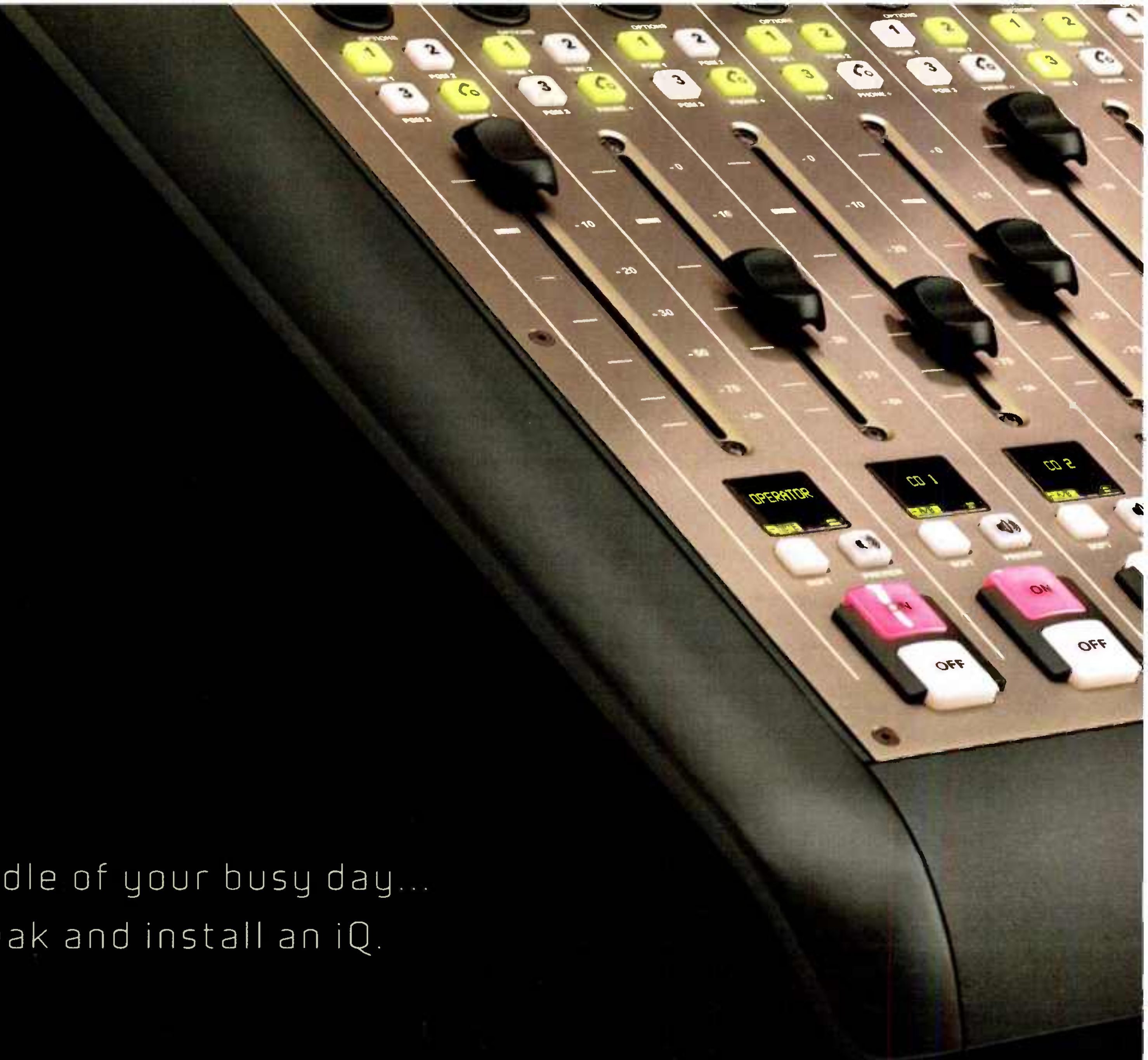

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expressed in terms of a C_d/N_0 noise figure. For a given MER measurement, use Appendix B in the spec to translate it into this noise figure. The difference in N_{C_d/N_0} to the 56 dB−Hz breakdown point represents the approximate loss in coverage area due to the transmitter induced noise.

Table 1 correlates a measured data carrier MER to an expected reduction in IBOC coverage area. An MER level of 14 dB causes a 0.5 dB reduction in the service contour and may present a good point for judging acceptable IBOC performance.

A second use of Table 1 is to be able to compare IBOC signals at different power levels. Take two transmitters A and B running at identical FM analog power levels.

Transmitter A operates with an IBOC injection ratio of −11 dBc, while Transmitter B operates at a lower IBOC power with an injection ratio of −12 dBc. Assume Transmitter A is measuring a MER of 9 dB, causing a reduction in service contour of 1.38 dB, while Transmitter B has an MER of 16 dB, only causing a reduction of 0.31 dB. Transmitter B is expected to perform just as well, if not better, than Transmitter A, which runs at a higher IBOC injection level.

Data Carrier MER	Reduction in Service Contour
18 dB	0.22 dB
17 dB	0.25 dB
16 dB	0.31 dB
15 dB	0.37 dB
14 dB	0.48 dB
13 dB	0.59 dB
12 dB	0.74 dB
11 dB	0.91 dB
10 dB	1.13 dB
9 dB	1.38 dB
8 dB	1.73 dB

Table 1: Approximate reduction in coverage area due to transmitter MER

3 MEASURING IBOC QUALITY

For this work, the IBOC quality was measured by capturing the IBOC signal with a real-time spectrum analyzer and computing the IBOC quality with the mathematics software program MATLAB.

3.1 Comparing Modulator and Transmitter Outputs

Because PAPR reduction noise is dominating the constellation noise, rather than taking the MER metric at face value, one should compare the MER out of the modulator with the MER out of the transmitter. Table 2 presents a comparison of IBOC quality from a standard IBOC modulator and the transmitter output of a 20 kW Nautel transmitter. As shown in Table 2, this particular transmitter only imposes a slight degradation to the modulator signal and meets or exceeds all specifications. Because of the amplitude modulation on the reference carriers, a significant amount of error remains in the gain variation measurement as seen by the 0.6 dB of gain variation in the ideal modulator signal. About 1 dB degradation in the MER metric is acceptable considering that even test instrumentation is bound to degrade this metric.

metric	modulator	transmitter	Δ
Δ Gain	0.6 dB	1.2 dB	0.6 dB
Δ Group Delay	0 ns	106 ns	−106 ns
Data/Ref	0.56 dB	0.56 dB	0 dB
MER_{ref} avg	21.7 dB	20.8 dB	−0.9 dB
MER_{ref} min	20.8 dB	19.7 dB	−1.1 dB
MER_{data} avg	18.1 dB	17.7 dB	−0.4 dB
MER_{data} min	17.4 dB	16.2 dB	−1.2 dB

Table 2: IBOC quality comparison between IBOC modulator test vector results and Nautel 20 kW transmitter output (128 symbols)

3.2 Using the IBOC Quality Metric

The IBOC quality metric is a useful tool in validating and troubleshooting IBOC transmitter installations. This document looks at how to use the IBOC quality metric to measure the impact of peak reduction, transmitter clock stability and FM modulation on the IBOC signal.

3.2.1 IBOC Peak Reduction

Nautel has put significant research in advanced IBOC peak reduction algorithms and presented on the topic at the broadcast engineering conference in previous years. Using the algorithms, significant gains in transmitter output power (TPO) can be obtained particularly for low-level combined FM+IBOC transmitters. The impact on IBOC reception has been validated for this improved IBOC signal through bit error tests and on-air tests. The IBOC quality metric now provides a method to quantitatively express the impact of peak reduction noise on the IBOC signal. With the introduced measurement technique it is possible to validate and compare the operation of peak reduction algorithms.

The fundamental principle of peak reduction is to trade constellation noise for a reduction in the signal's PAPR (peak-to-average power ratio). An ideal IBOC constellation could exhibit a theoretical signal peak of 26 dB above the average power, but 12 dB is typically used as a practical input back-off (IBO). Clipping instantaneous power peaks introduces noise into the signal. Similar to the standard IBOC modulator, Nautel's peak reduction algorithm maintains some of the clipping noise in the constellation while suppressing out-of-band noise. The more aggressively the signal is clipped, the more constellation noise is generated.

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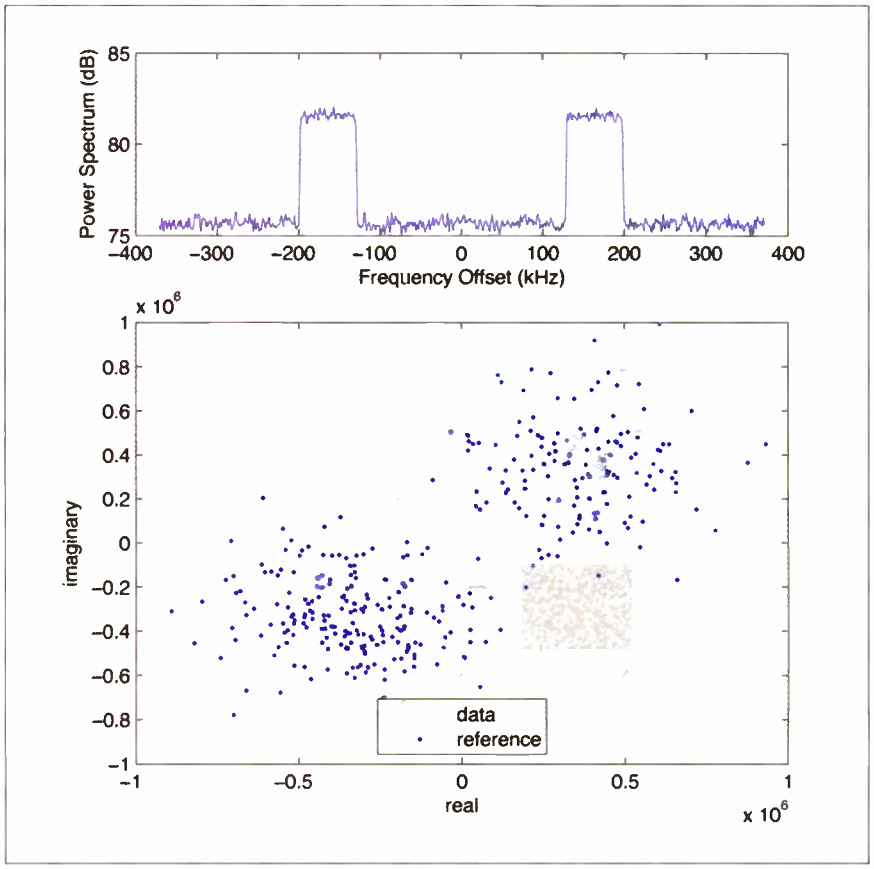

Fig. 8: IBOC constellation with 56 dB−Hz added AWGN at the edge of IBOC reception and corresponding power spectrum at 1 kHz RBW

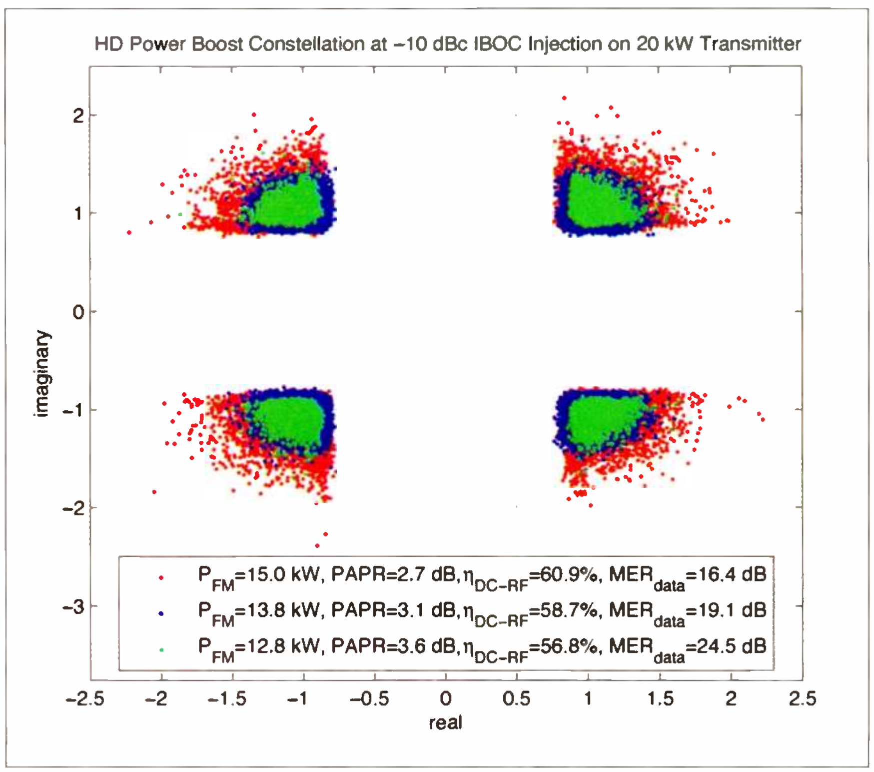

Fig. 9: IBOC constellation of Nautel's advanced peak reduction algorithm with varied PAPR settings demonstrating the tradeoff between improved peak reduction and MER. Results are captured at the output of a Nautel 20 kW transmitter operating in hybrid FM+IBOC mode at a −10 dBc IBOC injection ratio.

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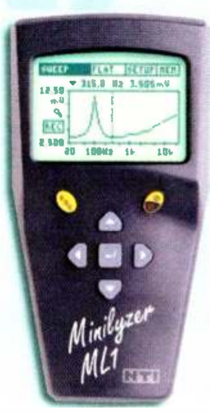

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IBOC

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A balance between peak reduction and constellation noise must be struck. Fig. 9 demonstrates this tradeoff on a 20 kW Nautel transmitter with an IBOC signal injected at −10 dBc. Nautel's peak reduction can produce a hybrid FM+IBOC signal with a PAPR as low as 2.7 dB. This signal fully complies with the IBOC quality metric and produces an MER roughly 1 dB below what the standard IBOC modulator would produce (see Table 2). According to Table 1, this only causes a negligible impact on the signal's service contour. However, it means that a 20 kW transmitter can produce up to 15 kW of FM carrier power or a TPO of 16.5 kW including the IBOC component. The standard IBOC signal typically requires a 4 dB IBO under similar conditions producing about 11 kW of FM power.

If the transmitter's FM power is reduced to 13.8 kW, it is then operating with an IBO of 3.1 dB. Rather than wasting this power overhead, as the standard IBOC modulator would do, Nautel's peak reduction can adaptively utilize the headroom in order to improve the signal quality. With peaks of 3.1 dB, the improved signal exhibits a better MER compared to the standard signal while still providing significant improvements in peak reduction. Additionally, if we allow peaks of 3.5 dB it remains somewhat better than the standard IBOC signal, but Nautel's peak reduction also improves the constellation noise floor by over 6 dB compared to the standard IBOC signal. The output power level is now reduced to 12.8 kW.

Using Table 1 a broadcaster can now determine the IBOC quality required for a selected IBOC injection ratio to appropriately service his or her market.

3.2.2 Transmitter Clock Stability

While the IBOC quality metric itself does not quantify transmitter clock stability, during the implementation of the IBOC quality metric it has been observed that the metric depends on the transmitter clock producing a constant output frequency. The metric can deal well with frequency offsets between the transmitting and receiving clocks. It does not, however, deal well with a changing transmitter clock and expects it to be stable within the capture interval. Depending on whether the transmitter clock speeds up or slows down, the IBOC quality metric would first determine the average frequency offset.

At the beginning of the capture vector, the constellation would experience a rotation in one direction and at the end it would experience a rotation in the other direction as shown in Fig. 10.

Note, these effects can only be measured using an independent piece of test equipment with an independent reference clock. Transmitter or exciter-based computation of the metric based on the same reference clock would not show this effect, as both clocks would experience a frequency shift in the same way. For true IBOC quality measurements, an external piece of test equipment should be employed with a high-quality reference crystal. The internal reference crystal of the Tektronix RSA3303B real-time spectrum analyzer has been found to be sufficient, as the results in Table 2 have shown.

3.2.3 FM Modulation

Some cases of FM modulation have been reported to cause FM to IBOC interference. For example, some instances of 96 kHz subcarrier modulation have shown impact on the extended IBOC carriers closest to the FM signal. While this particular issue requires some further investigation, this document explores whether the IBOC quality metric can detect cases of FM overmodulation.

Fig. 11 shows a severe case of FM overmodulation. A 1 kHz modulating tone has been chosen because of its characteristic spectrum making it easy to spot in a power spectrum. The tone has been overmodulated to a 178 percent modulation level. Unaffected reference carriers maintain a high MER value of around 19 dB, while reference carriers affected by the FM modulation drop by 20 dB or more. For this investigation, the MER numbers should not be collapsed into a single number, but should be maintained on a frequency partition basis, as shown in Fig. 11. This provides a frequency reference pinpointing the source of signal degradation, which could also be useful in determining other noise sources such as adjacent-channel interference.

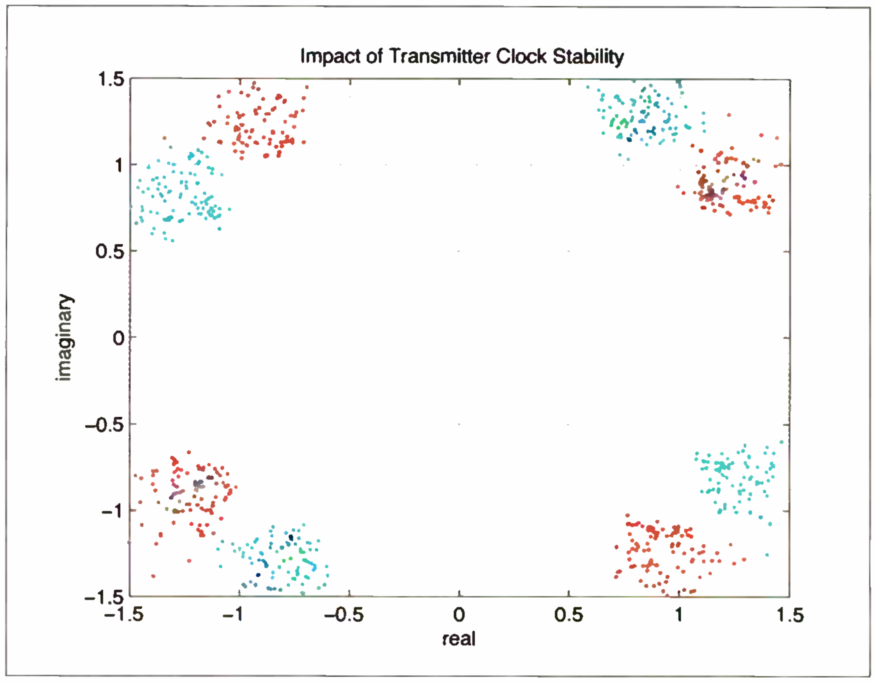

Fig. 10: Impact of transmitter clock stability with initial IBOC Ethernet-based synchronization (two symbols are shown, 470 ms apart)

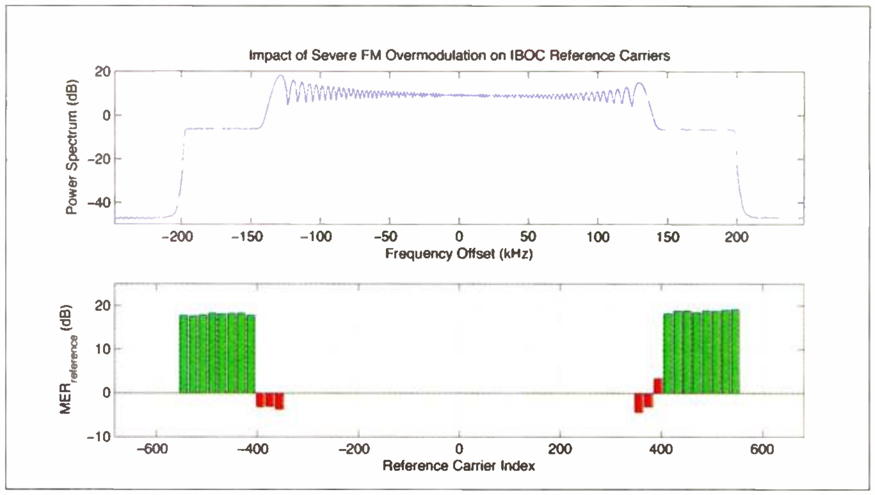

Fig. 11: Impact on IBOC reference carrier MER at 178% FM modulation of a 1 kHz tone

4 CONCLUSION

The IBOC quality metric makes it clear that not every watt of IBOC power is equal, and various factors can affect the receivability of the IBOC signal: FM modulation can impact the innermost IBOC carriers, transmitter clock stability issues can cause instantaneous rotations in the constellation, and peak reduction algorithms can introduce nonlinear noise into the signal constellation.

This paper has detailed the definition of the IBOC quality metric, established a framework for determining acceptable IBOC quality and demonstrated results gathered from a MATLAB-based implementation of the quality metric. The IBOC quality metric is a broadcaster's essential tool to protect the investment in IBOC broadcast infrastructure by ensuring that a high-quality IBOC signal is broadcast. Along with Nautel's peak reduction algorithm, the IBOC quality metric allows a broadcaster to tune their broadcast transmitter for improved IBOC signal quality and efficiency, in turn reducing operating costs while serving their market. For this reason, Nautel is planning to make the IBOC quality metric available on transmitter user interfaces, and also encourages modulation monitor manufacturers to include such a feature in their products.

The author thank the members of the working group defining the IBOC quality metric for their individual contributions to standardize this important IBOC signal metric.

This paper is based on a presentation given at the Broadcast Engineering Conference of the 2010 NAB Show.

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COLOCATION

(continued from page 1)

for others facing siting issues.

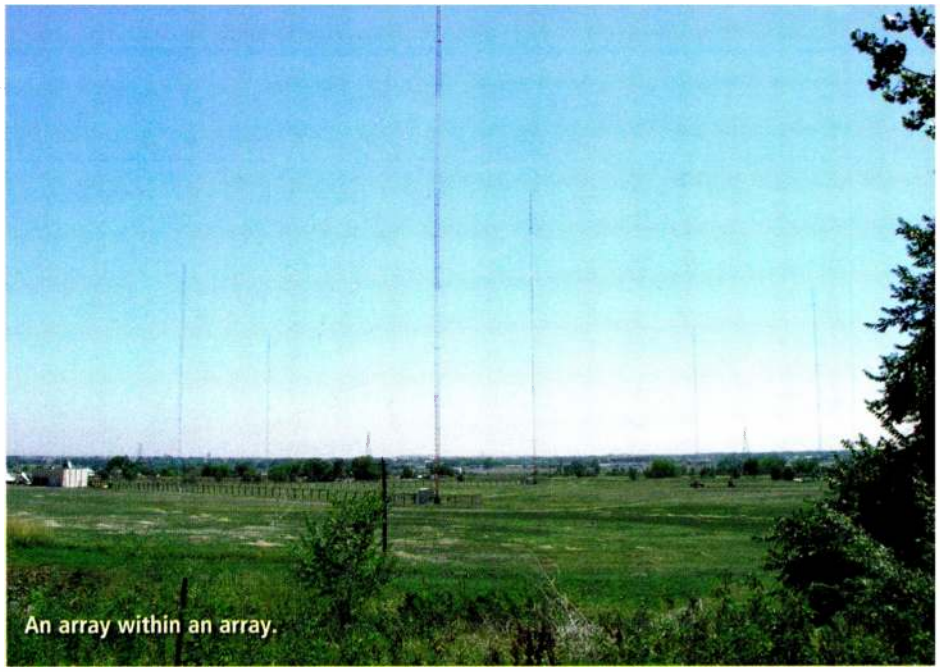
The issue was that one of our stations was a daytimer on 800 kHz, a Mexican clear channel and home of 150 kW XEROK in Ciudad Juarez, just across the border from El Paso.

While night operation was allowed on the channel, the question was, "Why bother?" With such high interference levels from that "border blaster" at night, it was hardly worthwhile to go to all the trouble of building out and operating a multi-tower array to protect the entire Mexican border from Brownsville to Tijuana.

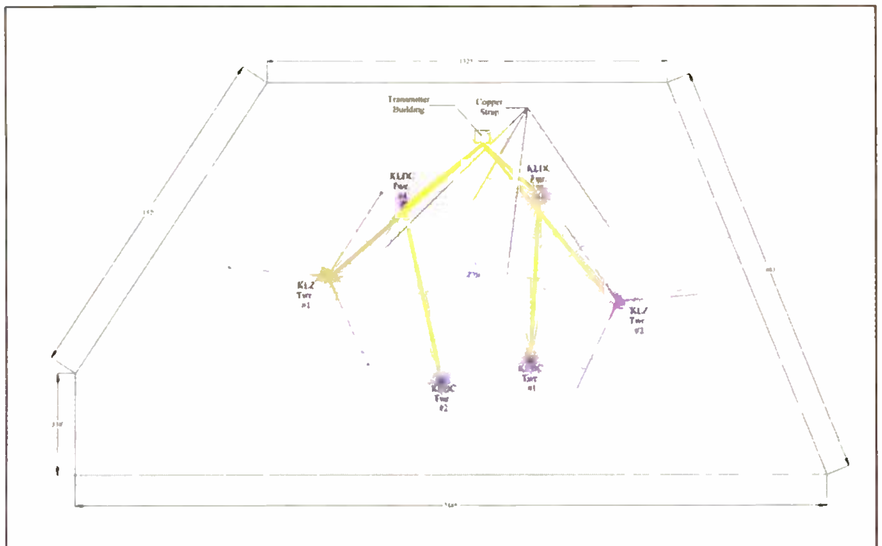
are generally all located on "DA Row" along the South Platte River. There are many reasons for this: good conductivity, flood plain land not otherwise useful for development and good distance from airports and flyways. So naturally I began my search in this same area … and ended it at my own doorstep, so to speak, at a 50-acre site we already owned: 560 kHz, KLZ.

WIDELY SPACED ARRAY

It occurred to me that the two-tower 560 kHz KLZ array was a bit of an odd duck. It was a wide-spaced (197 degrees) broadside array with nearly 1,000 feet of available dirt between the two towers.



An array within an array.



CAD was used to position the new array within the old 'on paper.'

ATU and filter cabinets at KLZ Tower No. 2.

And so it was that as an AM major change window approached, I began looking for alternatives for the station. My search didn't have far to go.

I found that the next channel up, 810 kHz, was a good bet for our little daytimer. The daytime allocation would support 2.2 kW from the existing site and three-tower directional array, and there was room to do something meaningful at night too — if I could find the right site.

I had four basic criteria on the new frequency: Protect KGO in San Francisco; protect WGY in Schenectady; provide interference-free community of license coverage to Brighton, Colo.; and provide interference-free night coverage to as much of the Denver metro area as possible. Piece of cake, right?

In reality, as AM nighttime allocations go on U.S. clear channels, that really wasn't too tall an order. We'd need a broad null to the west for KGO, a broad null to the east for WGY and lobes both north and south for the two interference-free coverage areas. I could do that with a four-tower parallelogram or trapezoid. So the challenge became where to put this four-tower array.

In the Denver market, AM stations

How often does that happen?

I started with the original 1962 as-built survey of the KLZ site showing the property boundaries, the improvements, transmitter building, towers and guy paths, bringing that into a CAD environment. Then I did a rough directional array design to get the tower layout I would need. The tower layout was brought into the CAD drawing and moved around as a unit until I found an optimum location. All of the four new towers and their guy wires needed to be a reasonable distance from the existing KLZ towers and their guy wires while retaining the proper spacing and orientation.

The results were a pleasant surprise. There would be more than enough room for the two directional arrays to share the same site without sharing any towers (important because the height of the KLZ towers would make management of the vertical radiation difficult). The new four-tower array would fit completely *within* the existing KLZ array — an array within an array. Concentric colocation!

At that point, I was off to the races. I completed the directional antenna designs for both day and night, completed and filed the FCC application and then started on zoning and use permit at the county.

The new night towers would only be 200 feet high, so no FAA approval, marking or lighting would be required. That helped us at the county because galvanized, unpainted, unlit towers really do present a small visual impact, always important where neighbors are involved. This did result in electrically short towers (58 electrical degrees), but the array still more than met minimum efficiency and was no problem with the FCC.

One other thing came into play at this point. In a totally unrelated action, the county approached me about the northwest corner of our property where it wanted to construct a viaduct for a bike/jogging trail. They were seeking a one-acre easement from us for this purpose because they didn't otherwise have the land to accommodate the approaches to the viaduct. It occurred to me that a quid pro quo might be in the offing if I played my cards right.

As we filed the use permit application for the new towers, I noted the easement request in the narrative and stated that we would be willing to simply deed over that one-acre corner of our parcel. The staff jumped on that and in no time we had a deal!

The remainder of the project went like clockwork. The FCC granted the application very quickly. Excavations were made for the tower base piers and guy anchors, steel was stacked, trenches were opened for the transmission and sample lines, and a complete new ground system was installed for both stations. KLZ stayed on the air during all this work, but sometimes at reduced power.

Next came a new Kintronic phasing and coupling system for both the new array and the old. This included pass/reject filters for all six towers and detuning components for the two KLZ towers. The new 810 towers were sufficiently short that they would be no factor at 560 kHz if we would simply float them on that frequency.

However, the 450-foot KLZ towers are 131 degrees tall on 810 kHz and required careful detuning. We did this by exciting one of the 810 towers with 100 watts. We placed a field intensity meter on a tripod situated roughly halfway between the driven tower and each of the 560 towers in turn, with the meter oriented toward the 560 tower and perpendicular to the driven tower. We were able to walk the re-radiation down to a point where I could hear on the FIM a co-channel station in South Dakota beating with the remnants of the 100 watts from the driven tower a few hundred feet away.

Tune-up went very quickly and we had the new pattern nailed and proofed within days of first RF excitation. We had some work to do on KLZ because the new 560-pass/810-reject filters created some bandwidth issues on 560. We had employed slope correction in some of the networks, but that ended up working against us, producing a "knot" in the impedance plot instead of the smooth horseshoe we were seeking.

Still, this was relatively easy to deal with and in short order we had program test authority and were operating both stations from the concentric arrays. No second- or third-order IM products were observed from this operation, a testament to the effectiveness of the filters and the broadband design of the Nautel transmitter power amplifiers.

Night coverage was everything we hoped for. The community of license receives a nice, fat lobe as does most all of the Denver metro area (with the exception of the far western suburbs — that KGO protection again).

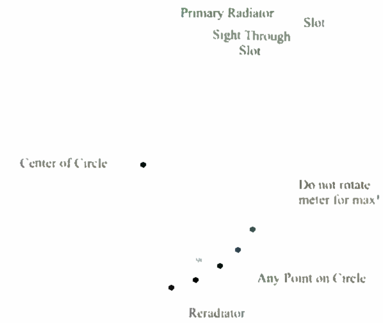
Interestingly, the three-tower inline day array turned out to be a lot harder to tune up on the new frequency than the four-tower trapezoid night array; we had some very localized re-radiation that gave us a lot of grief at the tune points. But we got it done and soon had a much improved day signal for the station as well.

In the end, we spent very little money to turn a sleepy 1 kW daytimer into a full-market 24-hour facility without buying any dirt or developing a site de novo. We now have a very efficient operation that makes better use of facilities that we already owned, keeping the neighbors and politicians happy in the process.

Without a doubt, this was a unique situation. I can't imagine there are that many two-tower, wide-spaced arrays out there on very low frequencies that might lend themselves to concentric colocation. But if the time comes when you have to find a new home for that AM, don't discount existing sites because the tower line is all wrong. Perhaps partial tower sharing is an option. As sites get scarcer we're all going to have to get more creative.

Cris Alexander is director of engineering at Crawford Broadcasting and a past recipient of SBE's Broadcast Engineer of the Year award.

ARC MEASUREMENTS TO DETERMINE RE-RADIATION



Finding out the inverse distance field (IDF) of a potential re-radiator may seem like a daunting task but it is accomplished easily using a technique called arc measurements.

Using a topo map, start by drawing a line between the station's tower and the re-radiating object. Draw an arc centered on the midpoint of that line with a radius equal to half the distance between tower and re-radiator. Mark likely accessible points around that arc starting as close as possible to the re-radiator and extending around to about three-fourths of the distance to the station's tower. Enter these as waypoints in your DGPS/WAAS-equipped GPS.

Now take the FIM out into the field and locate the closest point to the re-radiator with the GPS as possible. With the FIM on a tripod, orient it so that the electrostatic break slot in the bottom (the top when opened) of the lid/antenna is oriented toward the station's tower (use it like a gunsight). Do not rotate the FIM for maximum signal! Read the field strength and log it along with the distance. Repeat at as many of the other points around the arc as you can access.

Back at the shop, plot distance vs. field strength on a piece of log-log paper and graphically analyze the plot to determine the inverse distance field. It's as easy as that!

LUDDY

(continued from page 1)

I always regretted not getting my BSEE degree. I could have gone back after the war, but with a family and a full work schedule, I didn't do it.

I didn't finish my semester at the University of Kentucky, but I did meet my wife at the radio station. So I was glad to meet the girl of my dreams and have a job that I loved. If I could roll back the clock, I would have gone back after the war to complete my degree.

You served our country with distinction in World War II. Tell us how you used your radio background in the service as well as some of the highlights of your military experience.

I went in as a private in the Army and went to Camp Crowder in Missouri to begin with, but it didn't take long for them to recognize that I had special skills and education that was needed in the war effort. I joined the Signal Corps and was transferred to Fort Monmouth, N.J. I taught a course in electrical engineering at Camp Crowder and assisted the radio instructor at Fort Monmouth.

I received orders to go overseas and left for San Francisco on my birthday, Dec. 1, 1942. We took a Norwegian freighter on Christmas Eve, not knowing our destination. I was sent to the headquarters of the South Pacific command, headed by General Halsey. I was appointed radio officer for all of the Army communications in the South Pacific.

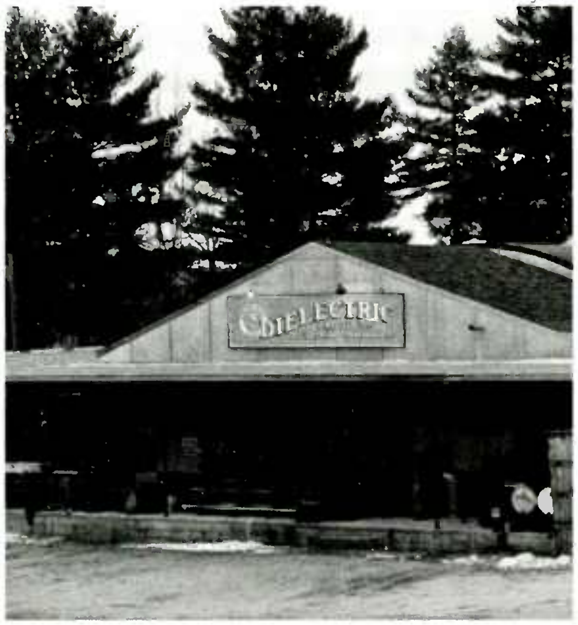
I quickly rose in responsibility and in rank. I was honored to be promoted from private to major while setting up many communications stations for the U.S. forces in islands such as Guam and New Caledonia, Fiji, Tahiti, New Hebrides and Guadalcanal. I was part of the communications team that coordinated the attack that helped end the war.

When the Japanese surrendered, I organized about 11 planes of equipment to be flown to Japan to set up communications there. By that time, with the victory in hand, I was given the opportunity to go home. And I took it.

After getting back home, I was in the Army Reserves for 5 years.

An early Dielectric antenna is packed for delivery via truck.

Images courtesy SPX Communication Technology



Dielectric antenna manufacturing facility of the 1950s.

After the war, you jumped right back into commercial radio as a station engineer. Tell us about radio during that period and what a typical day was like as the station's chief engineer.

It was difficult to get a good job after the war. A lot of soldiers were returning at the same time. I was fortunate that the Lexington station had an opening in their Amarillo, Texas, station, KFDA, and I packed up my family and took the job as chief engineer. It was an exciting time.

After the war, things were changing pretty quickly. There was always something to do. We did a lot of remotes, where we broadcasted from the advertiser's facility. As station chief engineer, I needed to be part repairman, part installation crew and arrange equipment and facilities for broadcasting in Amarillo.

After your KFDA stint, you took a job with RCA in Camden, N.J., in 1950 and became manager of broadcast transmitters. You spent many years there and are perhaps best remembered in that role. What was it like working at RCA?

Education Gets a Fourth 'R':

Radio School Will

Noel Luddy, left, and Chester Stratton, chief engineer at University of Kentucky radio station, work on one of the receiving sets which will be placed in Lee County mountain schools to receive broadcasts over WBKY, the new station operated by the U. of K. at Beattyville.

Making news: In the Louisville (Ky.) Courier Journal

At that time, RCA was certainly a recognized leader in the broadcast business. There were significant equipment improvements and new technology to keep things busy. Now, my area responsibility didn't just cover Amarillo, it covered the U.S. and parts of the world. I loved working and talking with the engineers, both with RCA and our customers.

Later, I was named as RCA's liaison engineer for the consulting engineers near Washington, D.C. I really enjoyed talking and interacting with the consulting engineers and helping them by providing equipment that met their needs.

After "retiring" from RCA, you started a second career of sorts with Dielectric, which had been building antennas for RCA. I remember buying a Dielectric FM antenna from you and Wally Warren back in the mid-1980s.

Dielectric is a wonderful company to work with. The people were very friendly and helpful. They have a great product line which helped my job also. I had the honor of representing Dielectric to the consulting engineers and the FCC. They had a first-class product line and the organization to back it up.

The other long-time association many of us remember about E. Noel Luddy was your long service with the Institute of Electrical and Electronics Engineers and Association of Federal Communications Consulting Engineers.

The time I spent with IEEE and AFCCE was a labor of love. I enjoyed the people so much. I really enjoyed helping to organize the program and line up the speakers. It kept me on the cutting edge with technology and I felt that I was helping people in the industry stay current and connected.

I'm not sure, but I think I got to almost 50 NAB conventions. We had a special reunion time with the ex-RCA folks. The people were great but I don't miss standing on my feet during those long NAB days.

Reflecting on your 76 years working in our industry, what is your assessment of where we are headed next and what advice would you give to a young aspiring engineer who wants to make broadcast engineering his lifelong career?

Things are moving so fast now, but the basic principals of technology and of business are the same. People need to be open to change, even into their '60s or '70s. I would recommend that engineers pursue getting their P.E. licenses. Continuing education is important.

It is also important that engineers conduct business in an ethical and honest fashion. Honesty is important in your dealings with everyone. We live in the greatest nation on earth and have incredible opportunities for personal growth and prosperity.

Tell us more about the E. Noel Luddy scholarship award and fund for students studying radio. Where can interested students find out about this program and apply for it?

Dielectric has established a scholarship for undergraduate students who are majoring in engineering or other fields associated with the broadcast and telecommunications industries. Details about the scholarship and an application form can be found at the AFCCE website at *www.afcce.org/enlsclrshp.htm.*

This interview would not have been possible without the assistance of Noel's son, Bill Luddy, who transcribed the answers. Thanks also to Sally Dixon, director, marketing and communications, SPX Communication Technology, for her assistance in arranging the interview.

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CHANGE

(continued from page 22)

With the recession and staff downsizing in all markets, there are quite a few capable and competent engineers who have found themselves out of work and sitting on the sidelines. In many cases, the lack of self-discipline or good judgment, unreliable work habits, poor communications, a poor attitude or inability to work effectively with others have been factors. Managers will always favor keeping another employee or hiring someone else who is not hampered by such shortcomings if the necessary skill sets are similar.

Learning how to change our attitude and the way we interact with others is perhaps a challenge best suited for Dr. Phil or perhaps a self-help motivational seminar by Wayne Dyer, Zig Ziglar or Dale Carnegie. There are certainly a ton of books on the subject to pick from. But for most, a trusted mentor or family member helps to get that personal "inner light of understanding" to turn on more quickly.

Old habits and mindsets die hard but for those who embrace an appropriate plan or program to change their behavior patterns for the better, life-changing results can occur.

After reflecting on where you want to go and what you want to become, make a resolution to commit to an action plan that can make it possible. Unless you really want something to change in your life and work every possible angle to achieve it, it's not likely to happen. Let's all endeavor to harness the power of change to help us reap big dividends in 2011.

Guy Wire is the pseudonym of a veteran broadcast engineer. Read his archive under the Columns tab at radioworld.com.

PRODUCTS & SERVICES SHOWCASE

Where's My Change?

What It Takes to Get Ahead in the New Year

BY GUY WIRE

The onset of a new year and the approach of a new spring compel us to think about where we've been the past year, where we are and where we want to go in the future.

For most of us still employed full-time in the midst of a fragile economy, the answer is simple and straightforward: Don't do anything stupid, and do whatever it takes to remain employed. For others who want to improve their fortunes and move up, creative thinking, good networking and a little risk-taking will be necessary.

Use the new year, the new season as an opportunity to take stock of what you're doing today, and also what you want to do with your career going forward. Life is short; tomorrow is guaranteed to no one.

THE PARADOX OF CHANGE

Everyone realizes that radio and the technology that propels it have undergone enormous changes over the past decade. But when you think about change, a pair of conflicting old adages emerges: "The only thing certain in life is change." However, "the more things change, the more they stay the same."

Let's consider the second one first. Radio really hasn't changed very much at all in the minds of consumers and advertisers. We provide entertainment, information and companionship. The winning stations do this better than the also-rans. This raison d'être for radio is not going to change.

We still play the new hits and the familiar songs folks want to hear. And we provide the news, traffic, weather and the conversation they care about. Morning shows still do zany off-the-wall stunts, and the best show hosts of every daypart still have many adoring fans.

The single most important change in recent years is that the delivery mechanism is no longer just an AM/FM radio, but also the Internet. We've added websites and streaming to extend our brands. But listeners have a lot more choices for both the sources and the devices they can use. Our first adage of change is driving that reality.

UP-TO-DATE TECHNOLOGY

Radio has always been dependent on those who build and maintain the technical infrastructure that launches the product. That's not going to change either.

Some may argue that the technology is now more complicated than what our predecessors of yesteryear had to deal with. I would contend that complexity has always been a challenge; now there simply is more technology to learn and control.

Ideal qualifications for a technical manager now include a background working with not only transmission and studio equipment, but also computer, LAN, wireless and IP-based systems including Internet, website and social networking platforms.

For those of you content to stay in your present role taking care of the existing systems you are responsible for, the imperative of ever-changing and improving technology will catch you. At some point most of you will have to deal with the challenge of installing and maintaining the updated replacement systems your managers and owners decide to acquire.

There are too many examples of old-school engineers who were skilled transmitter and analog equipment mechanics. But for whatever reason, they did not keep up adequately with the onslaught of digital and computer-based systems that found their way into their station operations. Many of them have changed careers, become RF contractors or retired; sometimes they've simply been replaced.

Most station and market cluster engineers have adapted to the reality that the digital and IP worlds have taken over our business at every level. How they choose to adapt and keep up depends on their personal circumstances and ability to learn and acquire new skill sets.

THE LUCK OF THE DRAW

Every individual is blessed with unique and innate abilities and talents. No one person gets all the goodies at birth. Some get more than others, but most everyone gets at least a few that can be leveraged into success in life and in the workplace. Good parenting and good teaching can compensate in those who draw short on raw talent and ability.

The key for every human being is to discover his or her own talents and strengths and concentrate on developing those that can become marketable skills. If you're lucky, using those skills to do what you most enjoy doing in a job and ultimately a successful career is one of the most satisfying accomplishments and rewards anyone can achieve in life.

It generally requires good analytical thinking and problem-solving to become a successful broadcast engineer. Being good with gadgets or good at math are plusses but don't necessarily guarantee a person will be a good real-world problem solver. It is probably more important to be a good communicator and be able to work with others effectively.

MAKING TECHNOLOGY DELIVER

Like almost everyone else in radio, managers and owners are enamored with but also fearful of the Internet and how the wireless revolution will affect our business. The smart ones increasingly are concerned about the torrent of technology change descending on virtually everyone in the industry. They expect their technical support departments to embrace new technology, learn it and enable it to keep their stations competitive and successful.

Ask any winning general manager to list their ideal qualifications for a chief engineer or technical manager and they will tell you: A solid background and successful track record working with not only transmission and studio equipment, but also computer, LAN, wireless and IP-based systems including Internet, website and social networking platforms.

That's a lot of technology for anybody to get their arms around, but it's not unreasonable for management to look for and hope to find someone that can handle it all. The younger generation of aspiring engineers generally will have most of the IP and studio gear end covered and typically only will need the transmission side to complete the lineup.

The job of managing technology in our business today goes beyond installation and maintenance. The larger scope of enabling technology for others includes sufficiently understanding the inner workings of a given system or application to be able to guide and assist the end users effectively.

When the users are creative content producers and important air talent, it is incumbent on us to find and give them the tools they ask for that allow them to be the most comfortable and most productive. When various options are available, it's really not up to us to decide unilaterally what is good enough or adequate. Management may have to adjudicate when reasonable differences of opinion occur.

THE PEOPLE PART

Managers always want employees with good people skills. The importance of that in today's environment cannot be overstated. Any multi-station cluster CE or technical manager spends much of his time communicating with management and other department heads. He then enables himself and others to make things happen.

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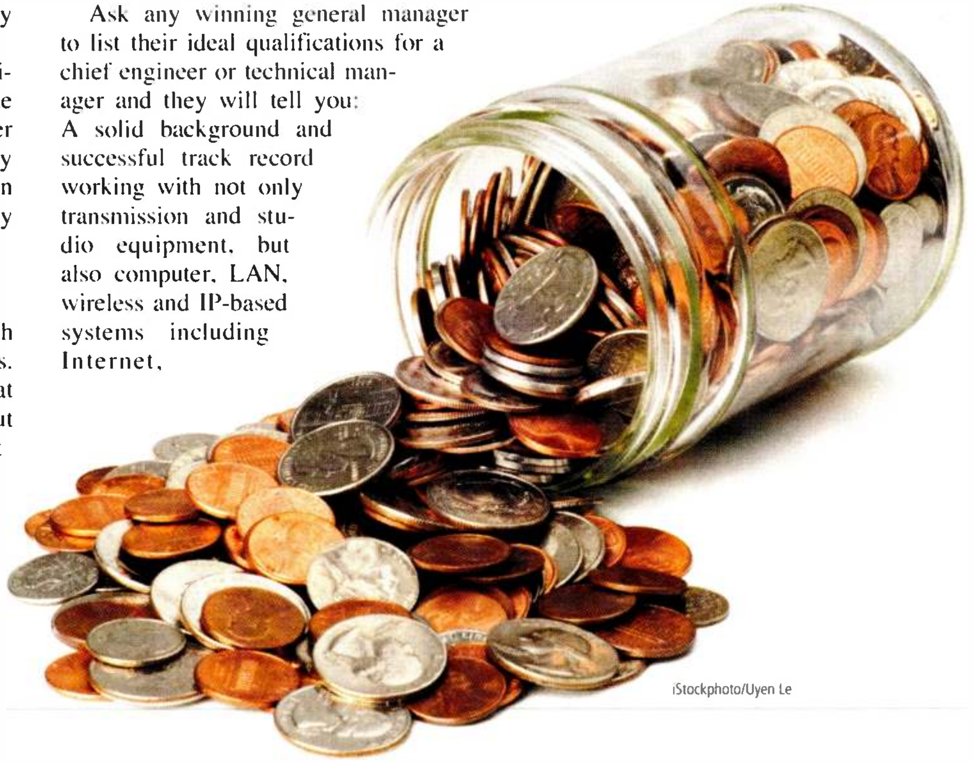

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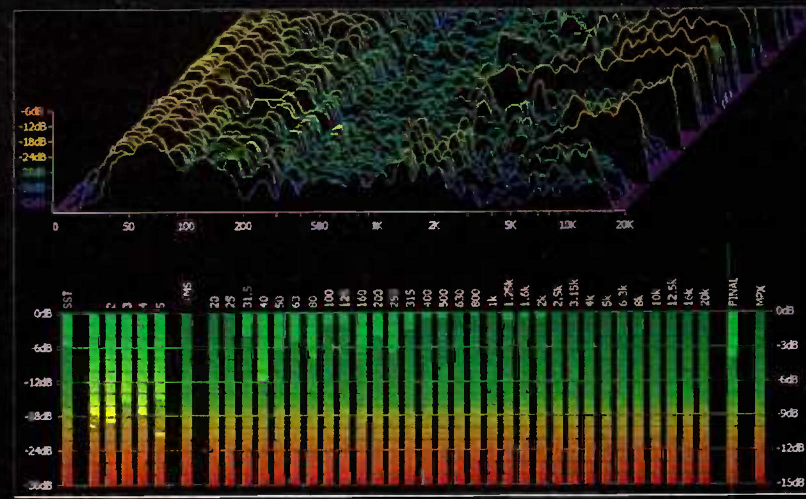
VORSIS AIRAURA DIGITAL SPECTRAL PROCESSOR



"I am giving the Vorsis development team a BIG thumbs up as this product stands out as a very SUPERIOR audio processor design."

"This processor is amazing!"

"I have the HD output feeding our web stream encoder, and two national program hosts at remote locations in the US have told us 'your audio stream sounds incredible!'"

"I can say that the Vorsis processor does NOT sound like the "O"ther guys! It sounds far better and has a very unique 'signature'. I really, really like how this processor sounds! Every other station in the market sounds like crunched up FM radio while our station is loud now and yet it still has "life" with CD quality dynamics and punch."

"I've listened to the station since the first few days after the format flip (which was a month ago yesterday), and the one thing I notice most is that the new Vorsis processor's audio quality is always terrific, regardless of the source material."

"If the Vorsis that I heard while you were testing processors last night is your final air chain (it was) it might just be the cleanest and best sounding FM I've heard since...well, forever. Great work!"

"Thanks for a great sounding box that makes us sound bigger than the so called big stations!"

"Your Sweet Spot Technology AGC has the most invisible gain correction that I have EVER heard in ANY on air processor. Listeners have been calling to compliment us on the improvement in our on air sound."

"We've used your product close to a year now and it's just out of this world. When we put the Vorsis box online our audience noticed the difference instantly and started calling asking questions like 'What's going on? What did you all do? Your sound is clear, crisp, and bright and the audio sound level is great now!!!'"

"The music sounds great, and this box can be tweaked to anyone's preference. There is a lot to discover in this machine.....but our single biggest achievement has been achieving the clearest, cleanest 'voice' I have ever heard come from an FM processor."

"I am extremely impressed with the unit's capabilities and how well it performs with our NPR talk/Classical format."

Real Comments From Real Users About Vorsis

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IT'S TIME YOU WON THE RATINGS WAR

"What an amazing difference in sound quality!!! This is a brand new FM station and comparing it to the other new station in town using the Other brand of processor our client is louder, clearer, and even legal. Wheatstone definitely has a winner here with Vorsis."

"This is a great sound and we are so, so pleased with our new Vorsis on-air processor. You just threw down the gauntlet to the processing industry with this new unit! Nobody can match a sound this loud, this clean, and this unique! Now everybody gets to chase after us for a while. Thanks Vorsis!!"

"Our signal used to virtually disappear in downtown New York when we went on night pattern because of the extremely high level of man-made noise. Now when we're on night pattern our coverage in downtown is actually better than when we are on day pattern, the other brand of audio processor and a 10X higher powered transmitter! We're buying a second one to put on our daytime transmitter!"

"You have to be kidding! I have NEVER heard FM audio sound this good, this detailed, this smooth, this clean, and this loud (how did you do it???). Very nice work!"

"Love the box!!! Overall the sound of the station is vastly improved. It's loud, wide and clear."

"I guess the only word for Vorsis is 'WOW.' It's got some great bottom end, and it's more transparent than any processor I've heard."

"The AGC/Compressor/SST combination is simply amazing. We play classical CDs. Older classical CDs were mastered at a much lower level than current ones. Announcers don't compensate and never will. Your processor is able deal with what amounts to probably 40-45dB (or more) *average* level variations and hold them perfectly in the sweet spot with virtually no squashing, pumping, sucking, or other usually audible artifacts of such wide range level control. In short it does its job perfectly every time."

"This box sounds much better than any other processor I have ever tried. Ever!"

"I love classic rock and it's the program format on the station that I own. No other processor that I've tried (and I think I've tried them all!) sounds as good on this format. We're nice and loud and still cleaner than the other stations in the market. We were surprised to hear the intentional dynamics of songs actually get on the air – other processors just flatten them out or turn them into a sea of mush. For the first time ever we're also hearing subtle nuances in songs that we used to think we knew every single note of. What an amazing air sound! No.... What an amazing processor!!"

"The SST algorithm is the least audible of ANY processor I have ever had experience with. I'm not sure how you did it or exactly how it works but its automatic "leveling" is excellent – no pre-processing whatsoever is necessary with SST."

"The high end of this processor is very open sounding – there is no fake "sparkle" with the HF EQ either. Perfectly clean and natural sound. And did I mention LOUD?"

"Your equalizers are actually useful and unlike other processors do not grunge-up the sound merely by enabling them."

"Finally! A processor that deals effectively and transparently with overly-sibilant announcers and audio levels that usually go all over the place! (I especially love the tweak-able multi-band thresholds!)!"

"Why haven't the other audio processor companies been able to make an AM box that sounds this good? I can't think of a positive superlative that is big enough to describe how pleased I am with our AM sound now. Our coverage seems to have increased by quite a bit too!!"

"Our multipath is Gone! GONE! As an engineer I have difficulty believing a processor can make this much difference in apparent coverage area but the listening is the proof. We've had several listeners call and comment that their reception has greatly improved and even I've noticed vast improvements when driving through what were previously horribly multi-path prone areas. I'm not sure why, but it sure does work!!"

"This box has great metering and excellent analytical tools – you get good visual indication of everything that is happening inside."

"The unit's stability has been flawless, not even a tiny glitch. We have it set up to time-sync and it works great. The scheduler-based (and SILENT!!) preset switching is perfect! Unit sounds very accurate sonically and is very easy to set-up."

"We are now VERY unique in our audio. Compared to other stations in the market, we are as loud yet maintain legal modulation (at least 4 stations in our market run with 130%+ modulation). We're not "squashed" sounding at all and if you compare us with the other stations (all formats) we're clearly a dynamic and clean stand-out signal on the dial now."

NOTE: We aren't naming names because everyone who is reaping the rewards of sounding better appreciates their anonymity (with respect to the competition). We won't blow your cover, either.