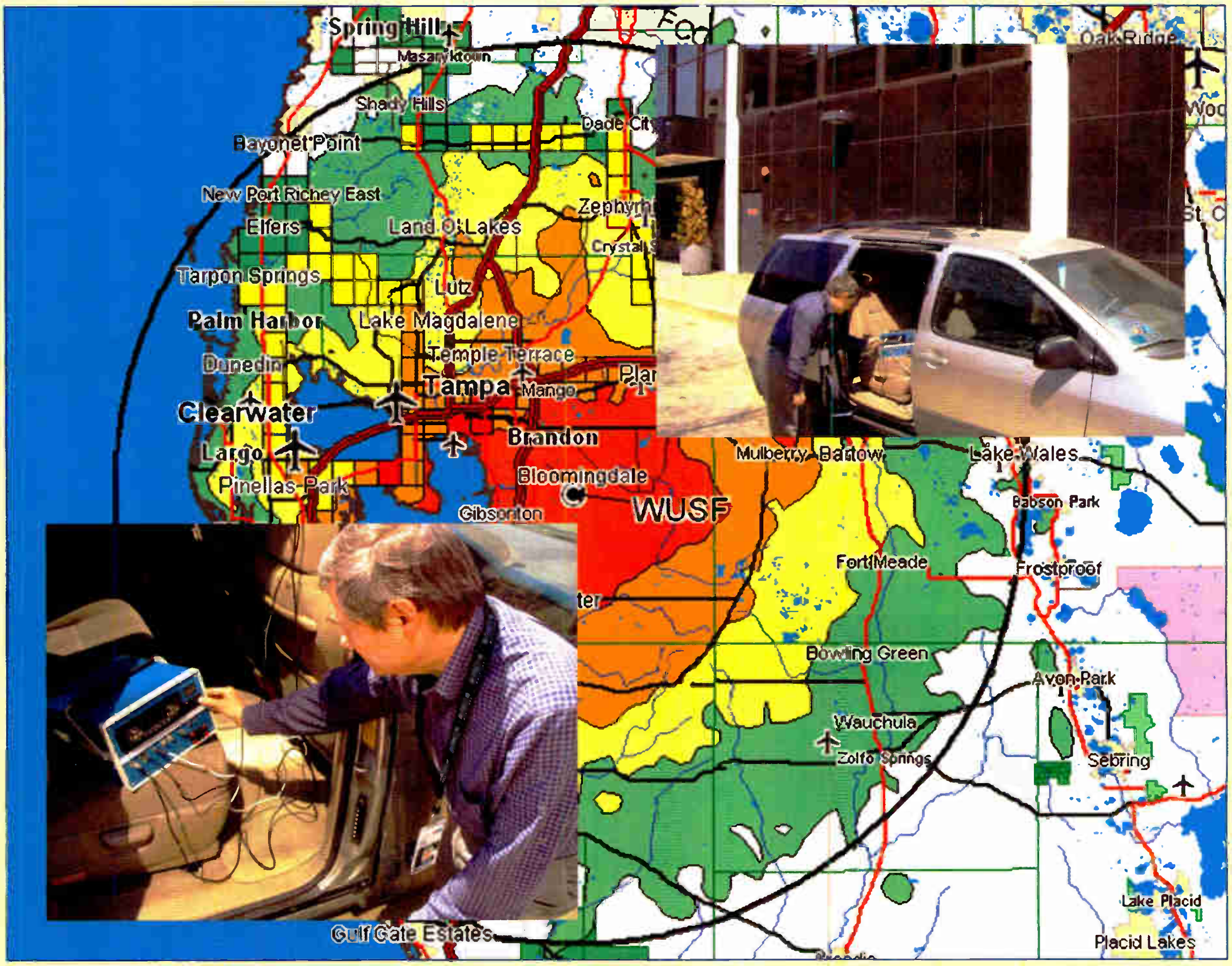
Radio Guide

Radio Technology for Engineers and Managers April 2006

Digital Radio – Evaluating the Coverage



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Volume 14 – Issue 4

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Radio Guide, ISSN 1061-7027, is published monthly, 12 times a year, by Media Magazines Inc., PO Box 20975, Sedona, AZ 86341.

Radio Waves

by Barry Mishkind – Editor

Going Down the Path Together

It is the yearly race. With NAB 2006 fast approaching, manufacturers have been feverishly preparing their exhibits – including their newest products and exhibits. The speakers have been polishing their presentations, the NAB staffers have been scrambling to bring all the logistics together, and about a zillion crates of gear is about to land in Las Vegas.

The net result will be the "Big Show" of the year – a chance to measure the state of the industry and what is ahead. Probably the most sought after information will be related to digital transmission gear and its operation.

With the number of stations converting to digital operations passing 700, data is starting to accumulate on the various aspects of installation and transmission. Among the sessions will be some reports, direct from the field, of the experiences of installation and operation.

In the months ahead, we plan to share some of the information presented with you, along with other reports directly from the field.

For example, our Digital Radio Crash Course continues on Page 8 with some comments and tips for AM installations. And on Page 4 you can find some analysis of the NPR project to compare digital versus analog coverage. Wondering if there are any special things to take into consideration in terms of processing audio for IBOC? The Processing Guide series, this month on Page 12, will help you handle it.

Of course, there might be one or two folks out there that are not deeply involved with digital transmission issues. We plan to continue to serve you as well.

If you make it to Las Vegas, please take a moment to say "hello!" Let us know where we can improve ***Radio Guide***. And don't forget the Tuesday Lunch Gathering at Noon (info at http://www.oldradio.com/nab.htm). – *Radio Guide* –

Comparing Digital to Analog Coverage Contours

Part 2 – Analyzing the Data

By Kyle Evans, NPR Labs

As more and more stations add digital transmission systems, real world data on received signal quality is starting to accumulate. Last month, Kyle Evans described the leading role NPR Labs has taken in gathering the data, using various stations from around the country. He returns this month to share some analysis of the data.

Welcome back! As we continue our discussion of NPR Labs' HD Radio Coverage Measurement Initiative, we are going to take a sample station and walk through the analysis process. Then we will be looking at the resulting drive-test maps and an HD prediction map NPR Labs is developing.

TEST CASE

WUSF, a C1 in Tampa, Florida, will be our test case in this exercise. WUSF was the first public radio station to light up their primary HD channel in early 2003 – they began multicasting in October of 2005. As a leader in HD Radio implementation, WUSF seemed a logical choice to be test case for this article; their long history, combined with straightforward results, makes it a great example.

I conducted the drive-test measurements around the Tampa area in early summer 2005, over a day-and-a-half period. My chariot was a Dodge Caravan with the same setup described in the last month's article.

Before I arrived in Tampa to take the measurements I did several coverage studies using the RF tools ComStudy (Radiosoft) and Probe 3 (V-Soft). After examining these simulations and talking with the chief engineer about listener complaints and problem areas, I planned a drive route. During the day and a half of driving, I covered what I had planned and returned to Washington to analyze the collected data.

DATA ANALYSIS

One of the first things we noticed when we began looking at data collected during drive-testing was the sheer volume of it. Our data logger collected information at a rate of around four times per second, giving about 250 samples for any one minute of data logging – a volume of data that quickly proved overwhelming when the vehicle was not traveling at highway speeds.

To compensate for this glut of data, we developed the binning technique that you see in the maps on this page. Geographic areas were divided into smaller sections (or bins) and given the average value of the points that fell in that area. This served the dual function of making our data both easier to process and to visualize; on a map of WUSF's area, 87,000 data points were synthesized into 106 bins.

The bins were further sorted into 32 different categories. The table we got after analyzing the data from WUSF is shown in **Figure 1**.

As was discussed in the previous article, global Land Use/Land Cover (LULC) adjustments were not providing the nuanced results we were expecting from our logging, so we wrote a program in MATLAB to match drive data to corresponding bins containing LULC information and predicted signal levels.

By comparing the measured and predicted signal levels by LULC bins, we came up with a table of market-specific adjustments to apply to a Longley-Rice model. After we input the data back into the original Longley-Rice study, we found our predictions more closely matched what we were observing.

As you can see, drive-test points fell into a variety of different LULC categories, with different categories exhibiting (at times) wildly different values between predicted and observed signal levels.

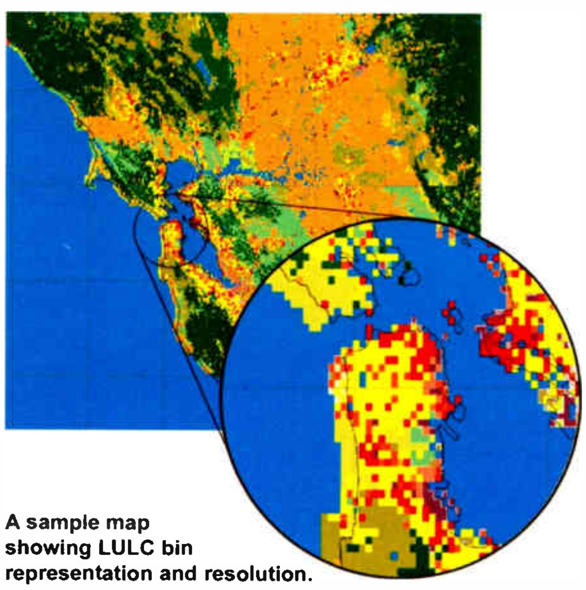
WUSF			
LULC	Description	Adj.	σ
1	Water	-7.1	9.3
2	Residential	-7.3	6.1
3	Commercial		
4	Industrial	-11.6	4.3
5	Transportation		
6	Urban Complex	-6.0	2.6
7	Mixed Urban	-1.7	10.3
8	Other Urban	-12.9	13.3
9	Cropland	-10.3	14.4
10	Orchards		
11	Feed Lots		
12	Agricultural	-15.7	14.7
13	Herb Range		
14	Shrub Range		
15	Mixed Range		
16	Deciduous	-4.6	18.0
17	Evergreen		
18	Mixed Forest	-9.6	11.8
19	Forest Wetland	-1.9	12.7
20	Wetland		
21	Sand		
22	Beaches		
23	Bare Rock	-22.7	10.9
24	Quarries	-6.4	15.1
25	Transitional		
26	Mixed Barren		
27	Shrub Tundra		
28	Herb Tundra		
29	Bare Ground		
30	Wet Tundra		
31	Mixed Tundra		
32	Ice		

Figure 1

DATA CORRECTION

The categories that are shaded yellow were discarded as either having a high standard deviation or of being intuitively unreasonable. Errors like this tended to be caused by disparities between LULC bin resolution and drive-test GPS precision.

For example, we tried to avoid driving through water. However, if the road we drove on was somewhat near water and we rounded a sharp curve, the LULC bins (at three-second resolution) often were too coarse to exactly correspond to our GPS logging (at approximately 100-foot resolution). Hence, some data tables show water adjustments – which obviously do not make a lot of sense and were discarded.



A sample map showing LULC bin representation and resolution.

The data analysis process drastically improved the quality of our data. With our correction factors we ran a new Longley-Rice study, assigned and shaded iso-contour regions, and aggregated and mapped the data (as described in Part 1).

RECEIVED SIGNAL AND HD RECEPTION MAPS

Figure 2 and Figure 3 show the maps that resulted from the data analysis process for WUSF. **Figure 2** has the bins colored to match the iso-contour regions, giving a Received Signal Level Map.

As you can see, the binning allowed the large amounts of data collected by each station to be viewable on a large scale map, and offered viewers of the maps a better characterization of regional service.

These bins are represented by the little square boxes in the upper-left quadrant of the maps. These squares do not, of course, cover the entire mapped area, but only those areas where we took the actual measurements.

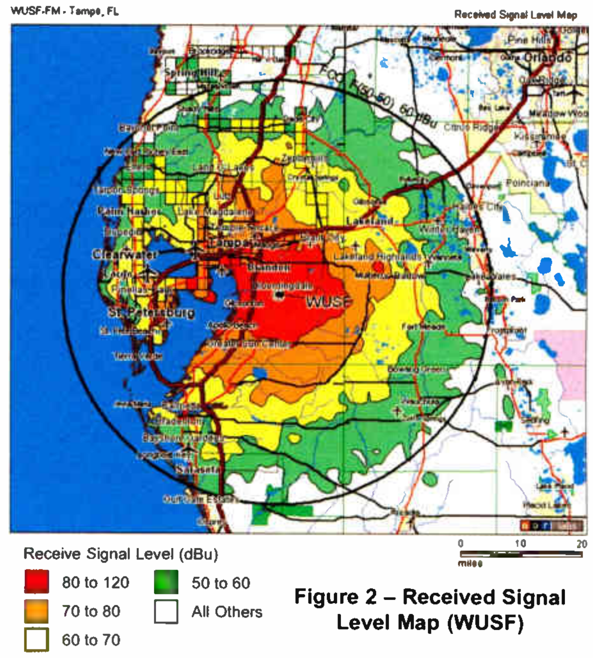


Figure 2 – Received Signal Level Map (WUSF)

Things get more interesting in the HD Receive Status Map, shown in **Figure 3**. The bins are now shaded based on the percentage of availability, computed by dividing the total number of drive points in a bin who logged an HD On signal by those that logged an HD Off signal. As you will remember from Part 1 of our discussion, the bins were shaded:

- White – Greater than 97% Availability
- Grey – 90 - 97% Availability
- Black – Less than 90% Availability

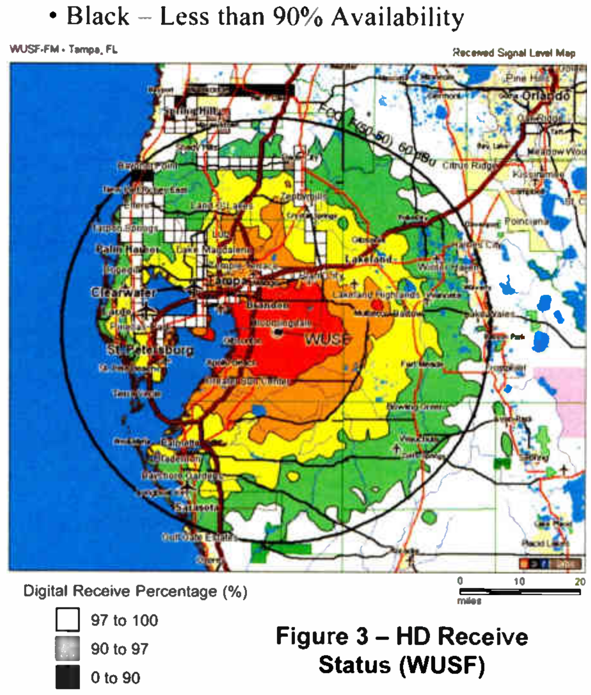


Figure 3 – HD Receive Status (WUSF)

The shading allows engineers to get a good idea of their HD Radio performance from a local drive-test perspective. However, a better representation was needed to provide a global perspective of performance – so we created an HD Prediction map that synthesized all previous information into one predictive tool.

HD RADIO PREDICTION MAP

To make a map that broadly described a station's HD performance, we had to come up with an effective method for integrating the large amounts of data we collected for each station.

We did this by writing a program in MATLAB that analyzed HD Receive Percentage as compared to measured field strength intervals.

(Continued on Page 6)

Comparing Digital to Analog Coverage Contours

Part 2 – Analyzing the Data

– Continued From Page 4 –

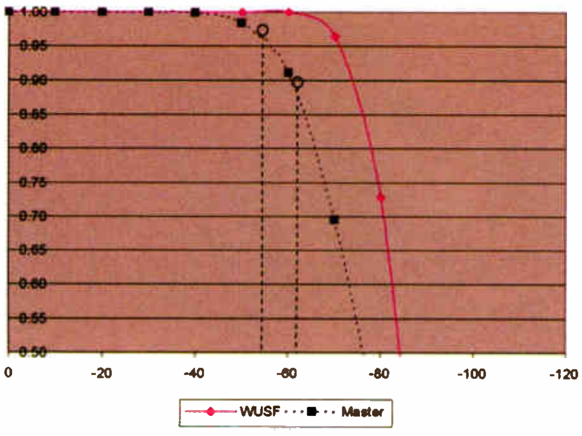


Figure 4 – HD Receive Percentage vs. Field Strength

When this information is taken into Excel, as shown in **Figure 4**, we calculated field strength levels required for percentages of HD Radio reception, and compared them with a master curve that was equivalent to the average of all our measured stations' HD performance.

We then generated a map with the same intervals used in the HD Receive Status Map discussed previously. As shown in **Figure 5**, the HD Prediction Map provides a clear picture of what to expect from an HD Radio implementation.

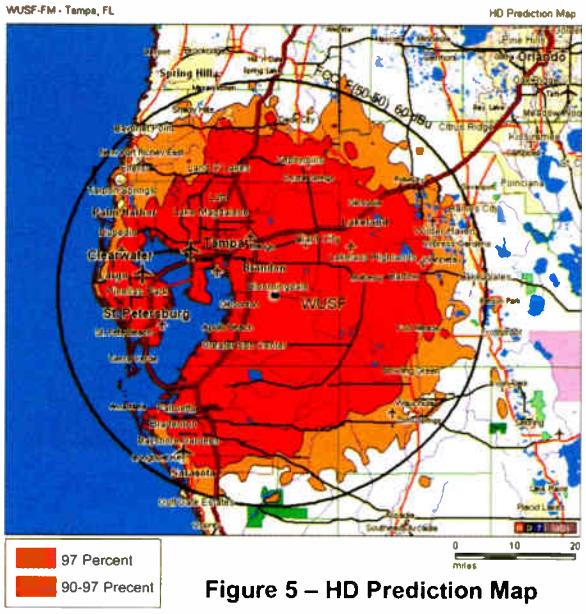


Figure 5 – HD Prediction Map

CONCLUSIONS

After completing data collection, analysis and visualization on over 30 public radio stations broadcasting in HD, we came up with several answers, but far more questions about digital radio propagation. The following hold true in most implementations:

- Stations in flat areas can expect coverage to around their 60 dBu contour 97% of the time
- Stations in hilly areas can expect coverage to around their 65-70 dBu contour
- Stations with lower ERPs can expect disproportionately less coverage than stations with higher ERPs.
- Mobile coverage is affected by the vehicle's antenna location and type (e.g., fender mounted whip, roof whip, in-window wire, etc.), vehicular noise from on-board electronics, and possible adjacent-channel interference.

AREAS FOR FURTHER RESEARCH

While we learned much, our coverage initiative also gave us many questions to further research. Some of the many:

- Why is digital coverage sometimes non-linearly related to station power?
- How do non-traditional (i.e. multiple antennas, boosters, etc.) implementations work practically?
- How do channel adjacency concerns affect coverage?
- Can indoor and portable reception be accurately predicted for IBOC DAB service (which is affected by antenna type and building construction)?

As our research progresses, we will be sure to let you know what we find. But for now, I hope you have found our discussion about HD Radio modeling and prediction useful.

Kyle Evans is an Engineering Technology Research Associate at NPR Labs in Washington, DC. Kyle can be contacted at kevans@npr.org

Digital Guide

by Jeff Welton, Nautel, Ltd.

Digital Radio Crash Course

Part 5 – AM Digital Installation

In previous installments of the Crash Course, we have looked at the hardware requirements and terminology for HD Radio™. This time out, Jeff Welton continues his discussion with some tips and tricks picked up over several upgrades and installations at both AM and FM stations.

This month our goal is to share information on the installation of AM HD Radio systems and some of the pitfalls and pratfalls I have encountered over the past few years. Hopefully, this will allow you to avoid falling into some of the same traps.

TAKING INVENTORY

We will assume you have received your shipment of equipment, perhaps some pieces to upgrade your transmitter – definitely the HD generator and associated parts, and hopefully some instructions on what to do with it all.

As soon as you get these packages, open them and check the contents (check them against the packing slip by all means, but also check them against any other paperwork you may have) invoices, quotations, emails from the manufacturer, whatever. There is nothing worse than getting the station shut down and the transmitter disassembled, then discovering the instructions on how to configure any new boards that go in it are missing.

Tech support will probably be able to walk you through it over the phone, but it is a lot less stressful to discover any anomalies before the parts are spread all over the floor – or before the transmitter is shut down and in pieces.

CHECK OUT TIME

If you have a couple of days between receiving the equipment and actually performing the upgrade, remove the HD generator and any related items from the packing and follow the start-up procedures in the HD generator's technical manual to be sure it appears to function properly.

If you can apply audio to the generator, do so at this time. I find the majority of problems that occur between our door and yours will be in this area. This is basically a computer we are shipping and it is not unknown for boards or connectors to vibrate loose during shipping.

You do not need to perform a full configuration and test nor do you need a transmitter. We are only interested in the basics: if the unit is powered up, do the lights come on? Does it settle down and appear to be working without any unexpected alarms? If you apply audio, do the equipment's audio monitors indicate that it is passing through the system properly? There may be some alarms depending on what we are testing, but a quick call to the factory can sort that type of thing out.

These are things that can easily be checked in the comfort of your office, well in advance of installation time. An important note: equipment that has been configured for installation at the transmitter site may have shipped from the factory set to operate from a 220 V power source. Confirm this before applying AC to the unit!

PUTTING IT ALL TOGETHER

Now that we know we have all the right pieces and we are reasonably sure it seems to have survived shipping, we can lug it out to the transmitter site.

At this point, we need to figure out where to start first. If you have to perform any upgrade to the transmitter, this would be the time to do that – leave the HD generator and related items in the crate(s) until the transmitter upgrade is complete.

Once the transmitter has been upgraded as required, give it a quick power up test and confirm that it still functions properly in analog mode. If there is a problem with any of the upgrade pieces, it is best to discover it at this point and get started on whatever steps are required to rectify the situation. My recommendation would be to start with a call to your friendly Customer Service Department.

Once you are reasonably certain that the transmitter has survived the upgrade process, it is time to take the plunge; install and connect the HD generator and equipment in their final resting places.

Something else you may want to consider: you will be running Cat-5 cables from the HD generator to the transmitter exciter and possibly from a site Ethernet connection to the generator. Nautel provides ten-foot cables for the transmitter connections with every shipment, but other manufacturers might not – or you may need more. A length of cable, some RJ-45 connectors and a crimp tool can save a lot of grief at this point.

Install the connectors using the T-568B standard, noting that in some cases, you may need to configure the cable as a crossover. This should be identified in your technical manual.

GETTING READY TO ENERGIZE

Now that everything is installed, connected, and appears to be functioning, it is time to get to the real fun part – the button pushing!

For AM systems, setup is somewhat more involved than for FM; my tongue-in-cheek comment to customers is that the system takes 15 minutes to install and 15 hours to configure. It is not quite that dire, but care does need to be taken to ensure the mask is met, acquisition/lock times on the receiver end are minimized and range of the digital signal is maximized.

As strange as it may seem, these three factors do not necessarily occur at the same point of adjustment and some compromise may be necessary. Furthermore, the setup of the unit will have a significant affect on the amount of potential adjacent channel interference that is created; in some cases, intentional mis-adjustment to decrease spectral regrowth in the direction of an adjacent signal may be necessary.

BASELINE TESTS

In all installations, it is best to perform the initial tests into a dummy load.

Not much adjustment will be required normally if you have purchased a complete system, transmitter included, since the HD generator usually would have been set up and tested into your transmitter at the factory, as a rule, anyway. However, there may be some adjustment required if you are upgrading an existing transmitter and adding HD.

Do not spend a lot of time worrying about the sideband levels or spectral regrowth into the dummy load – your primary interest here is that the system functions, produces the digital carriers and passes both digital and analog modulation, as well as performing the initial setup of analog and digital modulation levels.

AND ONTO THE AIR ...

Once we are certain that the system is fully operational, it is time to connect it to the big lightning rod and configure for the optimal settings into the antenna system.

A couple of things you will need to think about during this process: first, the settings as measured from the transmitter monitor point will almost certainly *not* match the settings as measured in the field – especially for directional arrays – and secondly, almost every adjustment you make will have an affect on another adjustment further down the chain.

For example, in a Nautel HD-AM system made of up an XL12 transmitter and NE-IBOC HD generator, you will have four controls in the audio line. Three of them affect audio and output power and one that only affects output power. This does not include control of the digital power, the analog and digital audio levels in the NE-IBOC, nor the front panel power control of the transmitter.

Which of these you will need to adjust will be determined specifically through the end result desired. Need to increase power without affecting the audio level? Adjust the audio gain (as counter-intuitive as that may seem), the carrier gain control, or the transmitter power control.

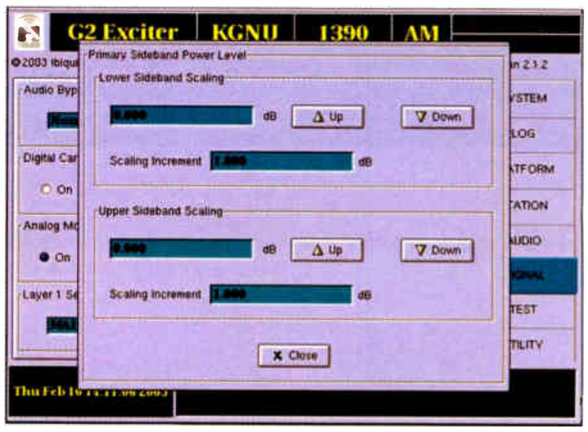
If the transmitter power control is maxed out (at its limit), increase the DAB offset some more and bring the transmitter power control down a bit, to leave some headroom. But before you start adjusting anything, it is smart to get a sort of picture in your head of the various adjustments that could have an affect on the parameter that needs changing.

TWEAKING TIME

Okay, now it is time to start tweaking for optimum operation.

The first thing you are going to want to do is to set the primary sideband levels. Into an antenna with less than optimal pattern bandwidth, it will most likely be necessary to increase or decrease one or the other digital sideband – both should be at -28 dBc from the analog carrier. These are best measured with digital carriers on and analog modulation off, at least for the moment.

To get an accurate representation on the spectrum analyzer, we recommend a minimum of 100 samples of averaging at a resolution bandwidth of 300 Hz. If there is any doubt about the results, there is an IF/AM output on the HD generator that can be used as a reference. Lesser amounts can be used when minimizing spectral regrowth in order to reduce adjustment time, but for the sideband levels a longer averaging period is better.



Primary sideband level control screen.

In the NE-IBOC, there is a specific primary sideband level control under the signal menu, as shown. Once the primary sidebands are balanced at -28 dBc, we can look at the spectrum – initially we will probably see something like this:

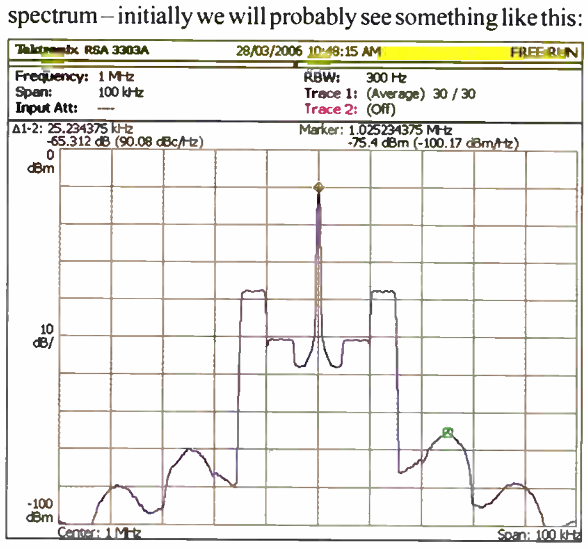


Figure 1: Unbalanced spectral regrowth.

CLEANING UP THE SIDEBANDS

We have two main ways to minimize the spectral regrowth: Magnitude DC Offset and Mag/Phase Delay.

Magnitude DC Offset will typically minimize both sidebands at the same time and you will want to make very small adjustments until you pass through the null (minimum) point and start to see the sidebands increase again – then go back to the null setting. *Notice that the Mag DC Offset will also affect output power* (and modulation depth); it may be necessary to tweak the transmitter power periodically while making this adjustment.

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Digital Guide

by Jeff Welton, Nautel, Ltd.

Continued from Page 8

I find it is best to start with the transmitter power at about 60% of its nominal operating value while I make the initial round of adjustments, then complete another round after the power has been set to the licensed value.

Magnitude DC Offset adjustment screen.

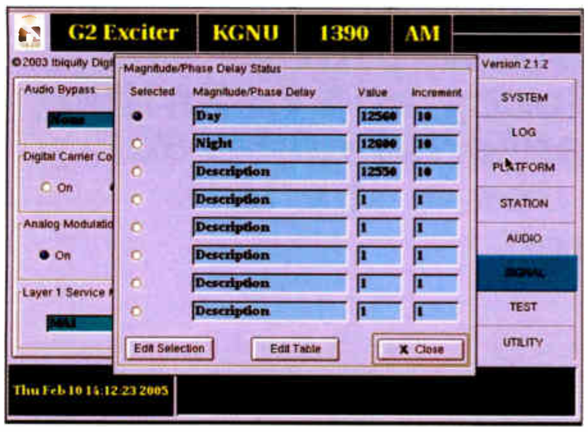
MAGNITUDE/PHASE DELAY

After adjusting the Mag DC Offset, the Magnitude/Phase Delay will tend to adjust the relative levels of the upper and lower regrowth with respect to each other.

This leads to a cycle of adjustments. Once you null the regrowth with Mag DC Offset, then match the levels with the Mag/Phase Delay, you will need to go back and reset the offset, then adjust the delay again.

Again, be aware that changing the Mag DC Offset will affect power level. Also, as you approach the top end of the setting range (+2.0000) you will find that you run out of headroom for analog modulation – a typical setting will end up with a Mag DC Offset between -0.3 and +0.3 or less.

The Mag/Phase Delay adjustment is easier to accomplish if you have the ability to periodically save the waveform on your analyzer and display it in a different color, comparing the freshly sampled waveform to the saved one as you make adjustments – this makes it quite simple to observe if your change resulted in an improvement or not.



Magnitude/Phase adjustment screen.

ACHIEVING RESULTS

This may need to be repeated two or three times before the best compromise of minimal regrowth and balance between the upper and lower is achieved. When you are finished, you should see your spectrum looking something like **Figure 2**.

One thing you may notice in the waveforms shown here is that the averaging, although on, is at a much lower rate than it should be for the final adjustments; this was done in the interest of time.

Ultimately, spectrum averaging should be done over a 30 second period. So, for the final measurements to be recorded for your records, the spectrum sweeps would require the average to be set to 106, based on 30 seconds at 0.2826 seconds per sweep.

INTO THE HOME STRETCH

Now you have gone through all the adjustments and everything looks good, so it is time to pack up the gear and go home, right? *Wrong*. Actually, the really interesting part now begins if you have a directional station, and to some extent if you do not.

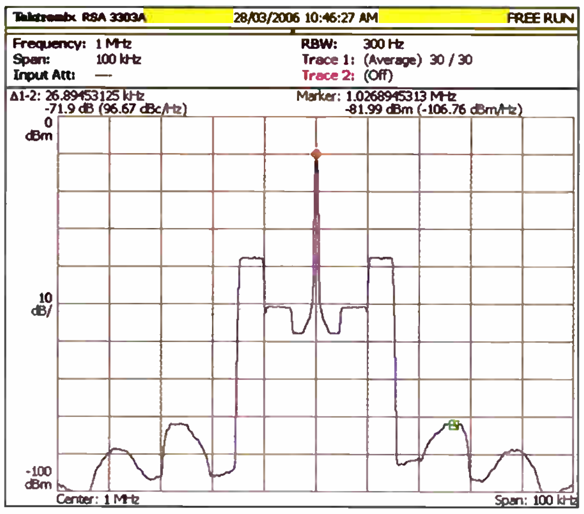


Figure 2: Spectrum plot showing balanced regrowth.

At this point, you will want to take a field measurement of the signal, again with the spectrum analyzer. My recommendation for this is similar to performing an on-air NRSC-2 proof: do it at one kilometer from the tower – in the main lobe for directional arrays.

You will probably find a marked and significant difference in the waveform – especially if you have any pattern bandwidth issues with the array. In the following example, note the unbalanced regrowth and the difference in the levels of the primary sidebands – this signal meets all aspects of the mask at the transmitter output connection, operating into the same antenna system.

Spectrum plot from the far field.

Please understand that I am *not* advocating making additional adjustments to the IBOC generator based on this waveform. Assuming everything meets the NRSC-2 and NRSC-5 limits at the transmitter output connector, then the far field measurement is what it is, based on the pattern bandwidth restrictions of the antenna system.

However, it is a good thing to have on file – it may also indicate a need for improving the symmetry or phase rotation of the antenna system.

MORE USEFUL DATA

While you have someone in the field, have them listen with a receiver capable of decoding the digital carriers. Check the acquisition time – that is, the time it takes the receiver to lock onto the digital signal after your station is selected. In that mythical perfect world, this will only take two to three seconds, although you may find that it takes longer.

If it takes noticeably longer, there may be an issue with the Bit Error Rate being too high. In that case, have the field person drive around a bit and compare the range of the digital signal vs. the field strength of the analog signal.

Ideally, the digital signal will be receivable out to near the limited of the protected contour for the analog. You should find that some adjustment of the Mag/Phase Delay and the Mag DC Offset will help to achieve this; strive to achieve the best coverage, followed by the shortest lock time. If you have to sacrifice one over the other, I would suggest going for coverage.

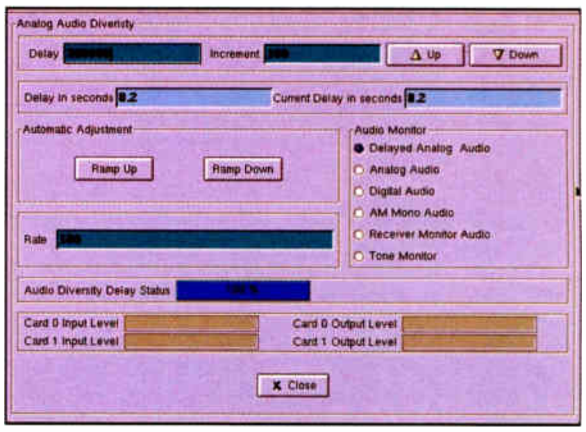
Once this is completed, recheck the signal at the transmitter output; it should not have changed noticeably. Although there may be some slight imbalance of the regrowth as a result of the field tuning, the entire signal should be within the mask.

A DIFFERENT DELAY

Now that everything else is done as far as the RF chain is concerned, it is time to set the audio delay.

Audio takes longer to travel through the digital circuitry – not only is there somewhat more circuitry to travel through, delay is added to allow buffering for signal reliability on the receiver end. Therefore, it is necessary to delay the analog audio so that when the receiver switches between analog and digital there is not a period of missing or repeated information.

There are two ways to do this, depending on what is available. The first, and most time consuming is to do it by ear; however, it is also much less accurate.



The analog delay (diversity) screen.

If you can switch the receiver between analog and digital mode, do so and adjust the delay slowly (remember there is a buffer that must be built up after each change). Listen until there is no discernible "hiccup" observed during the transition between digital and analog. On the other hand, if the receiver does not have a manual switch, just turn it off or select a different frequency, then go back to your own station and listen as you watch for the receiver to lock on to the digital signal.

The second – and by far more accurate – method works with a receiver that has a "maintenance mode" where the digital signal is played on the left speaker and the analog on the right (or vice versa). Simply put a 1 kHz tone on the air and monitor left and right channels with an oscilloscope. Set the oscilloscope to display the X-Y (Lissajous) pattern and adjust the delay until you are looking at a diagonal line, as opposed to a loop.

FINAL ADJUSTMENTS

Once the delay is set, you are pretty much ready for prime time, with the exception of setting the audio bandwidth and writing down the settings for the Mag DC Offset, Mag/Phase Delay and Analog Audio Diversity.

If you ever need to reload or upgrade the NE-IBOC software, these values will be rewritten to the defaults so, should that occur, having the final readings noted will save you repeating the above procedures.

Furthermore, some exciters, including the Nautel NE-IBOC, have the ability to handle different presets. When night-time operation is authorized, you will be able to select the night mode of operation and perform the above alignment tasks to optimize performance into the night array. (The same would apply for Critical Hours operations.)

ADDITIONAL INFORMATION

There are many resources on-line to provide additional information. One of the best with respect to the Rules involved has been set up by the FCC themselves, at: http://www.fcc.gov/mb/audio/digital/.

Other sources of information may come from the various consulting firms, manufacturer websites, and your equipment manufacturers.

That covers the basics on HD setup for an AM site. Next month we will conclude the series with a look at FM installations. As always, if there are any questions please feel free to contact me.

As the senior Customer Support Technician at Nautel, Jeff Welton has assisted in a variety of digital transmission installations. He is happy to hear from you at jwelton@nautel.com

Processing Guide

by Cornelius Gould

Audio Processing for HD Radio

Part 2 – Bit Reduction

Getting the best sounding audio from digital transmission requires learning some new techniques. Cornelius Gould continues laying the groundwork for understanding the new generation of audio processors.

We are living in a unique time in communications history. For better or worse, mass entertainment continues to change from what was to what will be – and most of these changes revolve around the word "digital."

PERCEPTUAL CODING

Virtually all "digital" entertainment media use bit-reduced or perceptual coding; such delivery to the general public will be a fact of life for radio and TV, as well as those new forms of mass communication that have yet to be invented.

It has been shown in studies that the use of perceptual coding is "acceptable" to the vast majority of the population simply because very few people pay attention to things they are not supposed to hear. And that is the trick behind how these systems work!

A basic understanding of how this all works is key to knowing the best way to pre-condition your program audio for HD Radio and web streaming. To gain this understanding, we will look at some of the common components used in today's audio bit-rate deduction schemes used such as HE-AAC, and MP3.

Of course, a complete discussion on these processes is quite complex and beyond the scope of this series. Our purpose here is not to be so much an "all encompassing guide to codecs" as to help anyone new to audio processing for coded audio to understand how to best use their processing tools to gain impressive results from HD Radio, web streams, and podcasts.

WHY PERCEPTUAL CODING IS NEEDED

Since it is impossible to broadcast *all* of the digital information available in linear digital audio due to strict bandwidth restrictions, much of the data has to be selectively discarded in order to make it "fit" in a manner that is as transparent as possible to the majority of "listening ears."

There are, of course, definite limitations as to how far you can take this data reduction idea. Anyone who has listened to a dialup quality Internet stream can attest to this!

Since the exact nature of the codec used for HD Radio is unknown due to the proprietary nature of the system, we will need to focus on a coding scheme that can best mirror the performance of HD Radio. That is why I have decided to focus on the HE-AAC codec, since its performance does indeed comes closest to what we get from HD radio. For simplicity's sake, I will have to describe this all in what appears to be a step-by-step process. It is far from it.

HUFFMAN CODING

The first and most basic step of almost all bit-reduction schemes is something called Huffman coding. Welcome to our Department of Redundancy Department.

Originally developed by an MIT student in 1952, Huffman coding looks for repetitive information and replaces it with a much smaller, simpler "description." It is the most common means of data reduction for generic computer data, and we all use Huffman coding every day in the form of ".zip" files.

As an example, consider a digital audio file that contains a 60 Hertz hum component at -20 dB. This hum in our recording never changes. It is just there in the background as a constant.

Now this hum can take up awful lot of repetitive data just to reproduce it digitally, especially if it is a really long file. What the Huffman coding scheme for digital audio basically brings to the table is the ability to replace all that with a simple descriptor.

HUFFMAN IN ACTION

What this descriptor does is to tell the decoder: "In the background of this entire file, there is a 60 Hertz waveform; you need to re-create this." It would also relay to the decoder that this 60 Hertz hum is -20 dB down, and to keep generating the "hum audio" until told to stop.

The decoder would then generate the appropriate hum at the prescribed specifications as part of the background of our recording. The encoder does not necessarily send the actual "hum audio" data.

All that is sent in our case is a description of the "hum audio" for the decoder to regenerate locally. Bam! – An awful lot of the data is removed and we have now made the audio file much smaller.

LOOKING AT IT VISUALLY

Whenever I talk to anyone about bit-reduced audio, I inevitably fall back to describing bit-reduced video.

This is because our western society is so visually oriented that there are lots of descriptive words for things we see, but very few to describe what we hear. In fact, most of us in western lands will typically notice strange things visually before we notice things aurally.

I can use this to advantage as an illustration in terms of bit-reduced audio vs. video, as there are a lot of parallels with video bit-reduction. Visually, I can describe an entire series of phenomena (*including* the exact visual parallels with audio) in a couple of paragraphs and the majority of individuals will understand what I am talking about. On the other hand, I could write an entire book on just one coding phenomena using audio terms and very few would even have a clue as to what I am talking about even after reading the entire book!

Therefore I will describe how Huffman coding is used for video in a visual way and we can go on to draw parallels with audio from there.

A DAILY DISPLAY

A form of Huffman coding can be seen every day on digital cable services including the popular cable services over "dish" type systems.

A JPEG picture with some artifacts from data reduction.

In these systems, the need to give the consumer more and more channels has resulted in removing more and more data from all the existing channels to "squeeze" additional things into the existing bandwidth. The side effects of doing this are subtle to most people as they happen outside their normal realm of perception.

This is also true for audio coding. It can be heard, but you need to know *where and how* to listen in order to hear the side effects. More on that later. For now, to see Huffman Coding in action on video, it is simply a matter of knowing where to look. These systems are called perceptual coding for the way they use "kind-of a slight of hand trickery" to accomplish their goal.

DO NOT LOOK BEHIND THE CURTAIN

In video services, the bit reduction can be observed best by watching *background images*. Most of what we see on TV is static, with only a small portion of the TV screen containing actual changing (moving) images. Since our brains are wired to pay attention to moving things, we will typically concentrate only on the moving parts of the picture.

For example, a person is talking on the TV screen. We, as humans, immediately focus on the fact that his mouth is moving, then read the person's facial expressions and listen to the words to tell the rest of the story. Very few people even notice what is happening around the actor on the screen.

Huffman coding schemes for video are quite interesting. It all happens with managing background images. The Huffman Coding part of a bit-reduced video encoder scheme communicates with the decoder in this way: "Here is the data that makes up the background of this scene. Paint it once, and keep repeating it until I send an update for it ..."

The description conversation continues: "If the change in video is small, then I will only send the data that makes up that specific moving image and the portions of the background that need to be updated." From there, the decoder makes the appropriate changes.

NOW YOU SEE IT

There are limitations here. For example, think about what happens to video when the entire screen has to change (update) rapidly, such as when the camera is panning around quickly, or is shaking around a lot. Just try to make out any kind of details in the pictures. You typically cannot. It is usually a jumble of blocky images and bright jagged pixel squares for any bright images that zip across the screen.

When large changes happen, the artifacts become very apparent.

If you were to compare this to the original, you would most likely notice that the original does not have these annoying *artifacts*. It is highly likely that you could easily see all the images clearly on the original, even though there is a lot of camera movement. Now please remember this as we go along with our discussion on digital audio bit reduction.

ARTIFACTS

I highlighted the word "*artifacts*" above. In the bit-reduced audio/visual world, *artifacts* refers to the side-effects incurred from throwing away so many bits, that what is left can no longer be reproduced in a transparent manner.

The same thing can be observed when taking images from your digital camera and, for example, manipulating these images to make the file size smaller for use on web site pages, or for e-mail.

The JPEG (.jpg) image format is the still picture equivalent to perceptual audio/video coding. You

(Continued on Page 14)

Processing Guide

by Cornelious Gould

Audio Processing for HD Radio

Continued from Page 12

can remove an amazing amount of data from a picture and have it still look the same – or at least very close to the original. Remove too much data, and the image starts to have strange looking things happen with color transitions, and with sharpness.

These "strange things" are the still-frame version of the audio/video artifacts I will be referring back to repeatedly in this series.

As you have seen, the two JPEG compressed images show a visual parallel to audio artifacts. The first picture shows the typical quality of an image ready to post on a website. The second is the same picture at the same size, but with more data compression, which results in lots of visual artifacts.

The more data you force the bit-reducing algorithm to throw away, the harder it is for the decoder to hide what it is removing from the original.

Audio can also contain just as much "artifacting," resulting in many strange sounds and noises that were not part of the original recording.

A KEY CONCEPT

In the descriptions above I mentioned something very important. I stated that if the individuals directly compared a copy of the program material that was *not* encoded with the results of the encoded material, the changes would be more obvious.

With that in mind, let us return to our audio recording. What we described in that example is an unrealistic picture to present to a Huffman encoder. Using Huffman coding alone on any audio material would not work very well.

The reason it would not work is because Huffman coding alone would not remove enough information to make any appreciable reduction in the amount of data needed to reproduce this audio file. This is why we cannot simply zip our audio on the fly to a decoder to unzip it back to normal.

The reason? Because there are a *lot* of other things going on in the recording, such as the principal audio we are really trying to catch in the recording, room noises, etc. All of these other elements are random in nature and do not lend themselves easily to Huffman coding technology. Other techniques will have to be exploited to make Huffman Encoding a more effective tool.

As we will see, the audio must be broken up into smaller pieces, which allows the use of other data reduction tools – and in some cases, cascading these tools. This will allow us to effectively remove enough data to create a smaller file, all the while leaving a trail of vitally necessary "digital bread crumbs" behind for the decoder to reconstruct something that sounds pretty close to the original audio.

IT IS ALL UP TO THE CODEC

What makes perceptual coding possible is the relationship between the bit-reducing COder and the DECoder (codec).

The Encoders job is to decide what information to throw away, what information to simplify, and what information to keep. The Decoders job is to take this information, and present it to the end user in a way that the processes used by the encoder is as inaudible as technically possible.

As we move deeper into what is going on between the encoder and decoder, it should become a bit clearer how to – and how not to – process your audio for bit-reduced media.

The Senior Staff Engineer at CBS in Cleveland, Cornelius Gould has helped stations throughout the region implement digital transmissions. He is also getting more sleep these days. Questions and comments should be sent to him at cg@cgould.com

Field Guide

by Bob Newberry

Solving STL Problems with the Axia IP-Audio System

We have been using two Moseley four-channel Starlink STL systems to provide program audio to the four transmitters at our master FM transmitter site. Remote control and RDS data is sent to the site on a companion Moseley LanLink system.

While this arrangement has worked fine for several years we recently ran into a pair of "opportunities" that set us on a search for a better system.

URGENCY FOR SOLUTION GROWS

Then, this past summer, a pair of our stations were silenced for 30 minutes when another company in town tuned up on the wrong STL frequency. That unfortunate accident set the planning in motion for a redundant audio path on a completely different frequency band.

We were also planning to add SPS (Supplemental Program Service) to our HD stations. The HD-2 channels are encoded at the studio into TCP/IP streams. While these streams are fairly small, we thought that three of these streams with remote control and RDS data might be too much for our existing LanLink system to handle.

GETTING FROM POINT A TO POINT B

The search was on for a new wireless system that could handle our audio and data needs. I started out examining equipment for the popular 5.8 GHz band. A little too popular, for I quickly found out a wireless Internet Service Provider was transmitting from the roof of our own studio building using several links in all directions. That kicked my frequency search up to the 14, 18, 23 and 24 GHz bands.

My search began with TDM or time slot-based radios where most of the slots would be dedicated to conveying digital audio. Surplus time slots ferry IP data using added hardware. Then my thought was, "Why not start with a pure IP radio to begin with, and find a way to get uncompressed audio over IP?" That seemed logical because there is so much standardized Ethernet equipment from which to choose.

I had been familiar with the Axia products and knew sooner than later I would have a chance to try them out. The Axia Audio Node is a product with eight stereo audio pairs in and out. The one-rack-unit box can be purchased in either analog or AES form.

Axia Livewire Audio Node

The audio is sampled 24 bits deep at a 48 kbps rate and converted to extremely low latency packets they call "Livewire." The latency delay of an Axia node is less than one millisecond per network hop. The rear panel has 16 RJ-45 connectors for AES audio in and out and an additional one for your Ethernet network connection; it cannot get any simpler than that.

Now I had to find a wireless link up to the task. My research led me to a carrier class radio that could send and receive 100 MB/s in both directions at the same time. Many wireless systems can transmit in only one direction at a time. This full-duplex operation is important to keep latency and stream jitter to a minimum.

A Dragonwave Airpair 18 GHz link got the data stream to the transmitter.

We zeroed in on the 18 GHz band for the lack of potential interference. Wal-Mart is not selling anything in the 18 GHz band, yet, so I checked with the Axia folks about my radio selection. They thought the radio I had chosen might be up to task and gave me their "thumbs up" on the project.

good source of processed audio for the announcer's headphones.

The one rack-unit Axia node has now become our primary STL for all transmitters at this site. The FM and HD-1 audio sources delivered by Axia are backed up now by the Moseley Starlinks.

I feed the main and backup audio sources through automatic A/B AES switches that switch instantly to the backup audio source upon a missing AES WORD clock. These switches are manufactured by BDI and have a handy built-in DA for four outputs on each switch.

The original firmware in the Axia switch preserves the AES WORD clock in the event of a communication loss. This is fine for studio work but not when you are trying to detect a communications problem automatically.

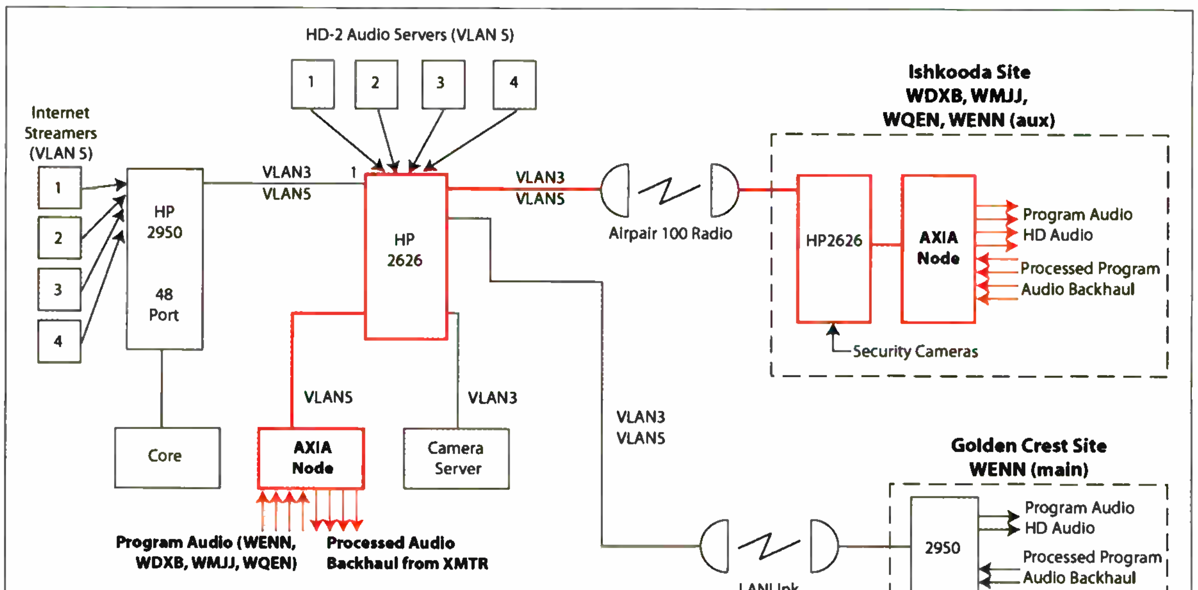
I explained this problem to Kirk Harnack of Telos/Axia one afternoon and he had a firmware revision emailed to me that evening. Problem solved.

THE FUTURE AND BEYOND

My original testing was with all eight audio channels of the Axia Audio Node enabled in both directions. After several days of good results we cut back to four audio streams up and down, confident that if we ever need more audio sources to or from the transmitter site they can simply be switched back on in the Axia software.

Since going on-line with this system in mid November it has been performing to our great satisfaction. What about rain fade at 18 GHz? With our four-mile hop and two-foot dishes, it takes a seriously heavy rain to take it down.

And when there is rain fade, the BDI AES switches instantly switch the audio back to the 950 MHz links without missing a beat. The HD-2 streams do go down for now, but the longest it has been out has been two minutes at any one time. The remote control and other slow speed data requirements continue to be met on the LanLink.



Signal Flow

TWO DIRECTIONS FOR THE PRICE OF ONE

Like other broadcasters transmitting digital radio, we had to delay our FM audio almost eight seconds to properly "blend" it with our HD-1 stream.

At the same time, since the Axia nodes and the wireless path are both bi-directional, I realized I could bring low-latency audio back from the non-delayed but otherwise processed HD audio stream. This would be a

I see the future of audio transmission belonging to Internet Packet data. There is no end to the wealth of reliable products to get the broadcaster's job done economically using the consistent protocols and connections of the Ethernet standard.

Bob Newberry is Chief Engineer for Clear Channel Radio in Birmingham Alabama. He can be reached at bobnewberry@clearchannel.com

by Bob Burnham

Thomas Edison

A Broadcast Engineer at Heart

Thomas Edison is not a name most people associate with radio – or broadcasting in general.

We immediately think of the phonograph and electric light as the Edison inventions that made him famous and (rightfully so) very wealthy as well. But this hardly tells the story of more than a thousand patents, his relentless pursuit of success, and how his very nature affects everyone alive today – whether they work in broadcasting or not.

FOLLOWING THE INTEREST

I have always been curious about Edison's work and his products. A recent renewal of this interest led to further research. Although some historians may dispute this, I soon realized that had Edison lived an extra ten years, as far as radio was concerned, de Forest, Faraday and Marconi might well have been left completely in the shadows of Thomas Alva Edison (1847-1931).

To learn more about Edison, I visited a large collection of historical buildings and artifacts – including "The Edison Institute," also known as "Greenfield Village" – assembled originally by Edison's good friend, Henry Ford. Located in Dearborn, Michigan, the museum and "village" today are well known simply as "The Henry Ford."

In the past, the Museum area had a fine collection of old radios and early transmitting apparatus. However, the most interesting part today is the "village" area.

MENLO PARK WEST

Edison's original Menlo Park laboratory buildings stand fully restored and maintained. Henry Ford painstakingly moved the Edison buildings to the site in 1929.

Some of the Edison buildings at Greenfield Village, Dearborn, MI

Also included, among many other buildings, is Edison's early generating plant. The restored buildings contain most of the original equipment also moved from the original New Jersey site.

Employees (or "Presenters") at The Henry Ford provide a wealth of knowledge on Edison and other topics applicable to the buildings in which they are stationed.

All this re-ignited my interest in Edison and led to reading Paul Israel's extensive 560-page biography on the man: "Edison: A Life of Invention." The front cover of Israel's book shows Edison clutching his "Edison Effect" tube.

This is in fact, Edison's patented device, upon which Lee de Forest based his development of the vacuum tube. A few radios were actually later manufactured with Edison's name prior to his passing away in 1931.

Thomas Edison and the Edison Effect Tube

LESS THAN SUCCESS

Edison himself, however, felt the latest perfections to his *phonograph* would become the leading home entertainment source. He thought radio would never catch on, but reluctantly agreed to produce an Edison combination radio-phonograph in 1928. It was not, however, a successful product.

Competition from other manufacturers forced production to be discontinued a year or so later, but apparently not before he gave one away!

In 1929, he held a national contest in which the prize was the scholarship to the University of one's own choosing *and* an Edison console radio (and toaster!). If that radio still exists somewhere, you can be assured it is worth more than most of us who work in radio today could afford.

The study of the technology and tube types used in the late 1920's that may have been used by "Edison Industries" is another subject altogether, as the technology at that time was so very new. The de Forest patent for the electronic tube, for example, had just been issued on January 29, 1929, a month *after* the Columbia Broadcasting System was already incorporated!

SETTING THE STAGE

In any event, it is evident that Edison knew long before his death that his early work was, in fact, leading to the development of an industry then in its infancy. He just did not expect it to be radio!

Indeed, much of his work actually led to several industries *other than* radio. One of the many spin-offs of Edison's original company – General Electric – is, of course, legendary for its development of commercial radio.

It is fairly common knowledge that the vacuum tube and other concepts all crucial to practical broadcasting were all developed based on Edison's earlier work. However, there are some notable though less obvious comparisons to Edison's work and ethics as well as his approaches to inventions that are identical to a typical broadcast engineer of today.

SIMILAR QUALITIES

In order to understand, design, build or troubleshoot a complex studio or a complex piece of equipment, one must first understand each individual component. There must be a practical reason for each stage to exist and a functional or user-oriented need for the device or combination of devices (as in a single piece of equipment) to exist as a whole.

Edison also thought about his individual inventions or devices as part of larger systems. He invented the first practical electric light bulb (1879), but realized it was of no value if it was not practical for everyone to use. He spent years developing methods to generate and distribute electricity.

As part of his commitment to bring electricity to the country, Edison's company was the first to construct power generating plants in the U.S. and other parts of the world (1883/4). To this day, southeastern Michiganders are still writing checks every month for their energy needs, payable to Detroit Edison.

ON-AIR EXPERIENCE

Edison developed a reputation in his youth as a master telegrapher (a form of "broadcasting" prior to radio). Many of us in broadcast engineering today began our careers as on-air "jocks" before becoming Chief Engineers.

Building on the technology of the time and having a keen understanding of the building-blocks, Edison would soon develop devices that would allow multiple transmissions to be conveyed over fewer wires, a means of printing telegraphy, and various repeaters that allowed transmissions over very long distances.

Thomas Edison's Desk

Think about how many satellite transponders exist in a single channel off a "bird." Or how many channels can be carried in a single fiber optic or in an ISDN or T1 connection from a remote broadcast or to a transmitter site – all on a single carrier or a single pair of copper wires. For that matter, think about how many channels are available on your television through a single piece of coaxial cable.

Edison patented the conceptual methods of doing these types of things with telegraphy (the communication method of the era with which he was already an expert) over copper long before radio or television. He was no slouch in business or self-promotion either. He gained respect and a powerful reputation early in his career. This meant major businesses of the era financed *his* work.

Among his 1,093 patents included the carbon transmitter that made telephones work (1876), the Vitascope (leading to motion pictures – 1890), the dictaphone, mimeograph, storage batteries (all around 1900), and many more.

WIRELESS TELEGRAPH

One of his more interesting efforts was a means to transmit wireless from a moving railroad car. A reed vibrating at 500 Hertz (or cycles per second as it was called then) was turned off and on with a telegraph key at the appropriate dot and dash interval. The "antenna" was the metal roof of the railroad car.

Existing telegraph wires about thirty feet away served as a receiving "antenna." While this could probably best be described as a form of capacitive/inductive coupling, it was probably one of the very first successful wireless transmissions.

Like Edison, a broadcast engineer by necessity must know a little about *everything* in the plant as well as the broadcast business itself. Of course, we can specialize in various areas, but among them we had better be able to know how to keep the station on the air.

(Continued on Page 20)

All talk and no action? That certainly doesn't describe any radio station we've ever seen. With guest interviews, news and traffic feeds, live reports and listener calls to juggle, a talk studio is one of the most active places on the planet. Seconds count, and there's no room for mistakes.

That's why we created Status Symbols® for the Telos TWOx12 Talkshow System. Instead of flashing lights to decipher, there's easy-to-understand picture icons that give talk pros the information they need with just a glance. What caller's next? Who's screened, and who's just holding? With Status Symbols, you'll know instantly. And only Telos has them.

TWOx12 has lots more benefits. Like Digital Dynamic EQ, for uniform caller audio despite less-than-perfect lines. Twin DSP-powered hybrids for quick, no-hassle conferencing. A unique Dual Studio Mode that lets you use your 12-line phone system like dual six-line systems for extra flexibility. And TWOx12 is the world's only talk show system that can work with either POTS or ISDN lines to deliver exceptional caller clarity. Impressive? You'd expect no less from the company that *invented* the digital broadcast hybrid.

Is TWOx12 the perfect union of word and deed? Thousands of broadcasters worldwide think so. Why not see for yourself?

Telos
AUDIO | NETWORKS

12 lines, two digital hybrids, and superior audio performance. Desktop Director controller features handset, speakerphone and headset jack. Drop-in controls available for popular consoles.

New Call Controller has Status Symbols, DTMF pad and recorder controls (like Desktop Director), but lets talent use their favorite wireless phone or any standard handset for call screening.

Status Symbols show exactly what's what. Intuitive icons show calls locked on-the-air, which hybrid they're on, who's next in queue and more. So much better than a panel of blinking LEDs.

Assistant Producer enables talk show production via LAN or WAN. Status Symbols, Caller ID support, instant messaging and caller database are just a few benefits. Supports touchscreens, too.

Radio History

by Bob Burnham

Continued from Page 18

ASSEMBLING AN A-TEAM

Anyone who worked for Edison in later years had to pass an extensive test. It was comprised of many questions about the United States government and other seemingly unrelated issues to the job itself. It is said that Edison's own son could not pass the test.

Among the 150 questions each applicant needed to answer were special ones tailored to the job being filled. Magazines often did stories on the tests, quoting questions such as:

- What city in the United States is noted for its laundry-machine making?
- Who was Leonidas?
- Who invented logarithms?
- Where is Magdalena Bay?
- What is the first line in the Aeneid?
- What is the weight of air in a room 10 by 20 by 30 feet?
- Who composed Il Trovatore?
- Which countries supply the most mahogany?
- Who was the Roman emperor when Jesus Christ was born?
- How many cubic yards of concrete in a wall 12 by 20 by 2 feet?

I could not answer even half the questions correctly, but if you wanted to work for Edison in the early 1900s, you had better be the absolute best in your field and know a little of everything about everything.

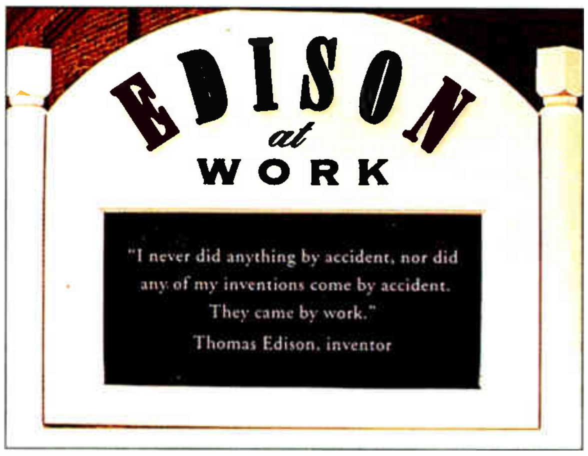
This allowed Edison to be very selective of those whom he hired. He was quoted as saying "Only 2 percent of the people think, as I gather from my questionnaire." Those who managed 90% correct effectively demonstrated an IQ of about 180.

As to work ethics, Edison was known as a scrappy, competitive individual. He would work around the clock when certain projects were in a critical developmental stage.

GET IT DONE WORK ETHIC

Who among us has not pulled many an "overnighter," building a studio or working on a particular installation with absolutely no regard to time? Sometimes we even forgot to eat!

The reward is seeing everything *work* just as designed and seeing others benefit from that work. Hearing a morning show on the air the next day in a studio you just labored in for a dozen hours or more is a cool thing.



Edison was clear about the road to success.

Thomas Edison was no different. He was a workaholic. Even Edison's own health was a scientific experiment. He would eat only foods that completely agreed with his digestive system. Having lived to the ripe age of 84 in 1931, he must have been on the right track.

One favorite Edison quote, paraphrased and modernized: "None of my inventions were accidents – they were the result of hard work" could probably also serve as a motto for broadcast technical personnel – just replace the word "inventions" with "projects."

Think of someone (or a group of someones) who designed, licensed, built, and then successfully operated a complex directional AM array – when others thought it was not possible at that location. An audience was served, people were delighted, and the owner made profit ... eventually. But it took a lot of steps and investment of blood, sweat and an especially large quantity of money.

But mostly it was hard work, very hard work.

GOOD ENGINEERING TAKES FOLLOW-THROUGH

Have you ever installed an AM ground system, erected towers, and done the footwork necessary to prove to the FCC that your equipment was operating as designed and not interfering with co-channels?

While a jock may delight in a shiny new studio, but perhaps takes it for granted, only a broadcast engineer knows what it took to make it work as it does: hour upon hour of tedious wire stripping, drilling, crimping, soldering, pulling wires, etc.

Our personal technical successes in radio are never, ever by accident! They are *always* the result of our hard work. And that was the same quality that drove – and rewarded – Thomas Edison.

COMPLEX PERSONALITY

Edison did have a soft side. He was deeply saddened by the death of his first wife. Having spent so little time at home, he actually felt guilty of his passion for his work. Perhaps arising out of this guilt, his daughter, then only 12 years old, became his laboratory assistant.

Right up to the end of his life, even as his health was failing, Edison remained a hard worker and thinker. During and after World War I, for example, he developed many defensive systems for ships and submarines, as well as inventions that brought about new uses for things like rubber, concrete, and ethanol.

Two smart guys pondering great thoughts.

While there are plenty of us today who know the meaning of hard work, and some people in our industry who even approach the "genius" status, it is highly unlikely any might ever hope to have the profound effect Thomas Edison had on communications and the world.

I am grateful to The Henry Ford for the inspiration for this curious journey and to Paul Israel, author of the afore mentioned book: "Edison: A Life of Invention." This volume provides a wealth of insight and little-known information about the famed inventor. If you are in the Detroit area, a visit to The Henry Ford should be on your list of must-see destinations. Hours are limited during the winter, but find the details at: www.thehenryford.com, where you can also order the book.

By age 10, Bob Burnham was already playing with dry cells, knife switches and flashlight bulbs. Today, he lives and breathes broadcast gear at the Specs Howard School of Broadcast Arts in Southfield, MI. Contact him at bburnham@specshoward.edu.

The Worst I've Ever Seen

A Visual Display of the Good, the Bad, and the Plain Hard-to-Believe

Surviving a Tornado – Barely!

It was quite the stormy night. In fact, the weather front generated a tornado as it blew through the area. Dave Riddle (WD4KBP) said it was one of the worst storms he had experienced. "The tornado was vibrating the floor, like a diesel engine," he recalled. One tower (an LMR repeater tower) was toppled, hitting a second tower's guy wires.

The top three guy wires popped off and the winds whipped the top 100 foot section of tower from side to side.

When Riddle first stuck his head out to look at the resulting damage, he saw the top section of the tower pictured here. "It was waving in tornado winds back and forth and bending down to a 90 degree angle on the tied side. I just knew it was going to fall, but somehow it didn't."

A couple of workers struggled to grab the loose guy wires. By the time a camera was found, they had managed to get the tower in a position somewhat closer to "normal."

As we can see after these storms pass through, it is hard to protect towers from tornado-strength winds. Nevertheless, any time there are multiple towers on a site, giving regular attention to the condition and tensioning of the guy wires and anchors might well save an adjacent stick.

... and this is *after* they tied off the tower

Thanks to Dave Riddle of Dave Riddle Engineering in Elizabethtown, KY, for sharing this picture.

"Some people don't like change. Change doesn't much care."

"I guess being the very first station to use Ethernet for audio routing has made WEGL a little famous! Someone's always on the phone: 'Tell me about your Axia system. What's the real story?'

"The real story is that two years ago, when our our old analog consoles began to fall apart, we put in an Axia IP-Audio network and SmartSurface. And I've never had a single reason to regret that decision.

"Sure, I was skeptical at first. But audio-over-Ethernet technology is compelling! Other companies just use CAT-5 to carry audio using proprietary protocols. Axia uses standard Ethernet to build a true network with uncompressed digital streams *plus* machine logic and program-associated data. No one else does that! I was a little concerned about dropouts and QoS problems, so we went to the Axia factory and assembled a network ourselves. It was easy to do, and it just *worked*. We were sold.

"The jocks took to the new board like fish to water. Show Profiles are their favorite part, since they can all have custom board setups. Some like their headphone levels blasting, some don't. Some like the mic on the left side, others on the right. I've got one guy who brings in his vinyl records every week for an oldies show; he's the only one who uses the turntables but when he loads his profile, they're ready to go.

"There were a few little bugs, but we had the very first surface! Axia support gave us new software right away and our problems were solved. Two years later, I'm more impressed than ever. I recommend Axia one-hundred percent.

"Since the first studio was installed, we've added a new production and interview studio, and we plan on building three more studios. It'll be all Axia — all the way to the transmitter."

— *Marc Johnson, Chief Engineer, WEGL-FM*
Auburn University, Auburn, Alabama

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by Goran Tomas

Streaming Audio

Part 3 – The Optimod PC

To have a great sounding web stream you not only need a good codec, but you also need quality audio dynamics processing. Users have been accustomed by terrestrial radio broadcasting to set the volume at a certain level and not have to adjust it for every song. They expect the same from radio delivered through the Internet.

DELIVERING CONSISTENCY

Web streams with ever-changing audio levels are, plain and simply, irritating. Inconsistent frequency balance does not help either, making audio dull and thin on one song and overly shrill on the next. Then there is the problem of significantly exaggerated codec artifacts.

We need all the tools from FM processing to achieve that level of consistency and major market sound: levelling, compression and limiting. Furthermore, absolute peak control is a must, but for a different reason: overdriving digital systems produces a very, very nasty distortion.

Although FM processing produces a tightly peak-limited signal, it is not really effective for web streaming. To repeat: codecs really, really do not like high-end density caused by pre-emphasis and they also really do not like clipping! So, to achieve good sound with bit-reduced audio, you need processing specifically designed for the application.

OPTIMOD-PC

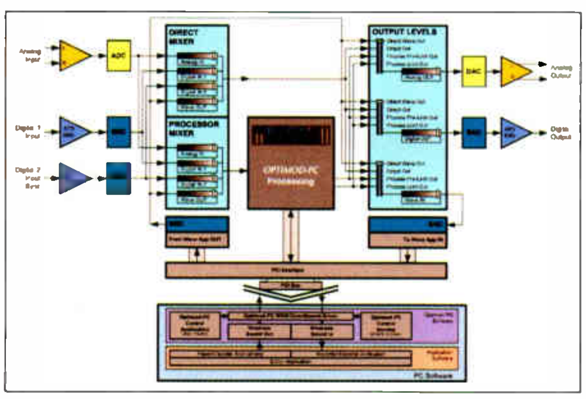
Orban introduced a perfect solution for digital stream processing in 2003 – the Optimod-PC 1100 – perhaps one of their most innovative products.

The Optimod-PC is a 9" by 5" PCI-card boasting three on-board Motorola DSPs. In essence it is a soundcard with a built-in hardware dynamics processor. Audio can be dynamically processed in real-time without using any resources from the host PC; in fact, the Optimod-PC uses the host only for power and to adjust inputs, outputs, and processing parameters – audio continues to be processed even if the operating system crashes.

There is a stereo balanced analog input and output with provisions for either +4 or -10 dBu gain setting. In addition, the two digital inputs can be used with different sample rates and bit depth or one of the inputs can be used for synchronization.

FLEXIBLE AUDIO HANDLING

The card also talks directly with Windows via WAVE drivers. That means you can output audio from the PC directly to the Optimod-PC and get it back without using any of the analog or digital inputs. In fact, there are two separate mixers at your disposal – processor mixer and direct mixer.



Optimod PC block diagram.

Any input (analog, digital 1, digital 2, or WAVE from the PC – or a mix of them) can be sent to the on-board dynamic processor and separately send any input (or a certain mix of them) to the direct mixer. The outputs are also configurable, meaning any of the three outputs (analog, digital or WAVE to the PC) can be assigned to the output of the direct mixer, direct WAVE audio from the PC or processed audio, pre or post look-ahead limiting.

Two built-in API- or GUI-controllable mixers and an array of input and output options means Optimod-PC will be all you will need for your "streaming studio" in most cases, probably saving you money you would spend on an external mixer. Meanwhile, all your audio stays in the digital domain.

To illustrate the possibilities: we used a Optimod-PC to play audio from the PC, sent it to a stand-alone processor under test and then directly switched and compared the processing of the Optimod-PC, the HD output of the test processor, and the FM output of that processor (after decoding with a modulation analyzer), while recording it on the PC and sending it to active speakers for monitoring.

VERSION 2 SOFTWARE

But the heart of this "sound-card" is the built-in Optimod processing. We had an opportunity to try an early build of Version 2, now available for release. A quick glance over the new features makes it clear this is not just a "brush-up" release, but a major developmental step-up from version 1.

In fact, Orban re-wrote the entire DSP code for this version to be able to squeeze all the new features in a limited number of cycles available from the on-board DSPs. The new algorithm now offers the same power and features of HD processing found in Orban's flagship 8500. And all this on a $1,500 PCI card!

The first dynamic stage is AGC, which has gone through a major transformation. It is now fully dual-mono independent and window-gated. Starting with the 8400, Orban has gone with window-gated AGCs, and for a good reason: by freezing the audio gain within a pre-determined window size, this type of AGC does not further process audio that is already tightly dynamically controlled.

It also allows a use of faster attack and release times as most of the time the AGC is frozen. The result is a much better "grip" on incoming levels and a more consistent output which keeps the following stages in the "sweet spot" – sufficiently driven, but not overdriven.

With the new AGC come several crossover options: linear, all-pass or no-delay linear. The purist choice here is linear, which has no dips or peaks at crossover frequency and exhibits smooth phase response; we preferred the all-pass type. Among the huge array of other AGC parameters, there is the ability to use compression ratios of 4:1, 3:1, or 2:1 in addition to inf:1.

NEW EQ CHOICES

Following the AGC is a revised EQ stage that now offers more options for tailoring the bass and high-end. Three fully parametric EQs in addition to a low-frequency shelving equalizer and a dynamic high-frequency enhancer are complemented with low-pass and high-pass filters. The latter is particularly important as it provides the ability to filter out high frequencies that the bit-reduced codec either cannot reproduce or can, at expense of increased artifacts.

The high-end is an Achilles' heel for every codec as this is the part of the spectrum with which codecs have most problems. It is also the part of the spectrum where codecs exhibit most of their artifacts, particularly at lower bitrates. By band-limiting the audio, these artifacts can be avoided or at least significantly minimized.

The EQ stage is buffered by a multi-band compressor/limiter. The main news here is that the multi-band is now fully dual-mono independent. As with AGC, you can set the maximum difference in gain between channels for each band. Crossover points are fixed, apart from B1/B2 crossover point, which you can choose to be either 100 Hz or 200 Hz.

LIMITER BALANCING

Also new is a limiter attack control that gives you an opportunity to trade how much work will be done by the compressor part and how much by the limiter. The trade-off is a bit more volume and depth in sound at the expense of loudness and less punch; in streaming absolute loudness is not the most important thing and lower settings can give an interesting effect

The look-ahead limiter is also significantly improved upon in version 2 and is now capable of creating substantial loudness – *if* you really need that. As with all look-ahead limiters, overdriving it produces gain intermodulation that does not sound nice. It is best to use final limiting very sparingly, just to tighten up the whole sound.

Among the clipper controls are bass clipper threshold and a "hard bass clip shape," a very useful control allowing you to have tighter, more punchy and controlled bass or a smoother, more "round" one.

TAKING STOCK

The version 2 software takes the Optimod-PC processing to a new level. Cut-to-cut consistency is notably improved, thanks to a new, much more capable AGC. It rides gain over much wider range and manages to stay inconspicuous most of the time. The dual-mono architecture in AGC and multi-band also helps to maintain absolute cut-to-cut presence.

The ability to adjust processing to your taste is vast. We did not count all the parameters, but there are a lot of them! Practically everything is adjustable, but there is also a simple less-more control for those who do not have time and/or would rather leave tweaking to experts.

The Optimod-PC's AGC screen.

A lot of factory presets are available, mostly resembling those found in 8500. There are some specialized ones like protection limiting only, which can be used for dubbing music and AGC plus protection limiting (with or without pre-emphasis) that can be used for driving discrete STLs.

There are quite a few controls for tailoring the high-end, which is especially important when you are trying to minimize codec artifacts. Two WMA factory presets exploit these controls trying to get the best out of the notorious Windows Media codec.

Those who want to get that "signature sound" will find it easy to do as the EQ section is more elaborate, plus all multi-band thresholds and timings are also available for tweaking. Finally the look-ahead limiter is more capable and more "serious" than in the previous version.

There really is not much to criticize, but if I must I would like the gate action to be perhaps just a bit smoother. All in all, Optimod-PC is currently the most powerful and versatile digital-only processor. It matches the power and flexibility of 8500 on a single PCI card, which speaks for itself.

There is a word Bob Orban uses to describe the goal of the processors: the flow. Well, Version 2 delivers on that promise, wrapping your radio program in one seamless, equalized, consistent sound flow that, nevertheless, keeps the music live and exciting.

Goran Tomas is a radio engineer and audio consultant based in Zagreb, Croatia. His passion is audio processing. You can contact Goran at goran.tomas@post.htnet.hr

– Techie Stats –

1. Balanced analog inputs and outputs.
2. Two digital inputs and one digital output.
3. Direct I/O communication with OS via WAVE drivers.
4. Three on-board Motorola DSP56362 DSPs run independently of computer's OS.
5. Five-band Optimod processing almost identical to 8500's HD processing path.

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SS 16.16

The SS 16.16 provides audio routing of 16 stereo inputs to 16 stereo outputs. This type of routing allows any one stereo input to be assigned to any/or all stereo outputs. The SS 16.16 may be controlled via front panel encoder controls and/or a multi-drop RS-232 serial port. A 40 x 4 LCD back lit display provides for input descriptions and macro setup. Additional features: headphone amplifier with front panel jack and level control, front panel monitor speaker with mute switch and level control, internal audio activity/silence sensor with a front panel ACT indicator and rear panel open collector, and a 16 GPIO port. FREE Windows NetSwitch remote control software, which supports Serial, USB and Ethernet with the optional ESS-1 Ethernet to serial converter, is available for download. Installation is simplified with plug-in euroblock screw terminals.

ACS 8.2

The ACS 8.2 provides matrix audio switching of 8 stereo inputs to 2 stereo plus 2 mono outputs. Any input assigned to output one has fading capabilities. Matrix switching allows any/or all inputs to be assigned to any/or all outputs. The ACS 8.2 may be controlled via front panel switches, contact closures, 5-volt TTL/CMOS logic and/or the multi-drop RS-232 serial port along with 16 GPI's, eight relays, eight open collector outputs, and input expansion port. Installation is simplified with plug-in euroblock screw terminals.

SS 4.2

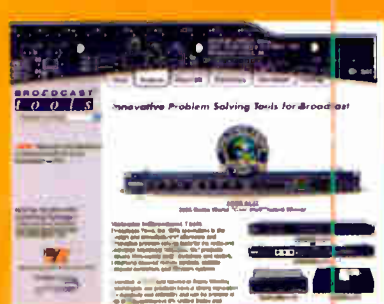
The SS 4.2 provides matrix audio switching of 4 stereo inputs to 2 stereo plus 2 mono outputs. Matrix switching allows any/or all inputs to be assigned to any/or all outputs. The SS 4.2 may be controlled via front panel switches, contact closures, 5-volt TTL/CMOS logic and/or the multi-drop RS-232 serial port along with 16 GPI's, eight GPO's, and input expansion port. Installation is simplified with plug-in euroblock screw terminals.

SS 16.4

The 16.4 provides matrix audio switching of 16 stereo inputs to 4 stereo plus 4 monaural outputs. Matrix switching allows any/or all inputs to be assigned to any/or all outputs. The SS 16.4 may be controlled via front panel switches, contact closures, 5-volt TTL/CMOS logic and/or the multi-drop RS-232 or RS-485 serial port along with 24 GPIO's and input expansion port. Installation is simplified with plug-in euroblock screw terminals.

SS 8.2

The SS 8.2 provides crosspoint switching/routing with 8 stereo inputs, 2 stereo plus 2 mono outputs. 3 switching modes, I/O trimmers, internal silence sensor, selectable headphone and powered speaker level controls and outputs. LED VU meters, 16 GPI's, eight relays and eight open collector outputs. Multi-drop RS-232 and RS-485 serial ports, plug-in euroblock screw terminals and input expansion port.



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Tech Tips

by Chris Arnaut

Cheap is Good!

Eighteen or so years ago, my instructor in electronics school informed us that "Cheap, is good."

While I thought that was amusing at the time, as I have progressed through almost two decades of being a broadcast engineer, his words still ring true – although I have to admit that I have repeated his teachings to others a little more eloquently using the famous quote: "Simplicity is the hallmark of genius."

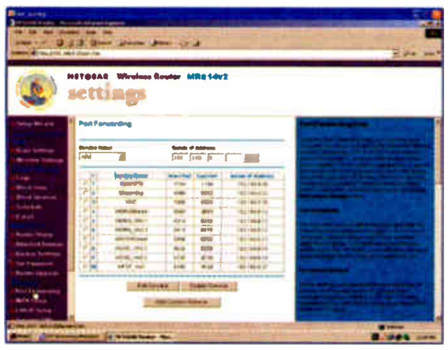
In fact, there is no better education than being in the trenches, so to speak, having to come up to a simple solution to a complex problem with no budget.

"FREE" LISTEN LINE

Recently, a close friend of mine achieved his dream by purchasing his own station: a 5 kW directional in a small town, and an even smaller operating budget. He frequently traveled on weekends to a location directly on one of the major nulls in the pattern. Yet, he still needed a cost-free way to monitor the station.

Digging through the equipment in the transmitter room/workshop, I was able to come up with a way of achieving this without having to resort to a phone coupler.

Resurrecting an old Pentium II with just enough RAM, I installed an old sound card and Windows Media Encoder (a free download from Microsoft). A few minutes later I had his DSL router configured to forward the appropriate port requests to the new "encoder."



Port Forwarding Enables No-Cost Station Monitoring

Now my friend is able to monitor the station during his weekend travels from any location with an Internet connection.

AFFORDABLE ROUTER

Not too long ago, I spent much of my time replacing old electrolytics and aligning the heads on ITC SP's, Ampex 350's, and the occasional ATR-700. Now I am a glorified IT manager that understands RF: nearly all new equipment I handle comes out of the box with an Ethernet jack on it.

Our facility operates four stations out of one location. We maintain multiple transmitter sites with transmitter remote control systems, RDS encoders, HD generators, audio processors, off-site servers and many more devices that all need to communicate with the studios using IP communications.

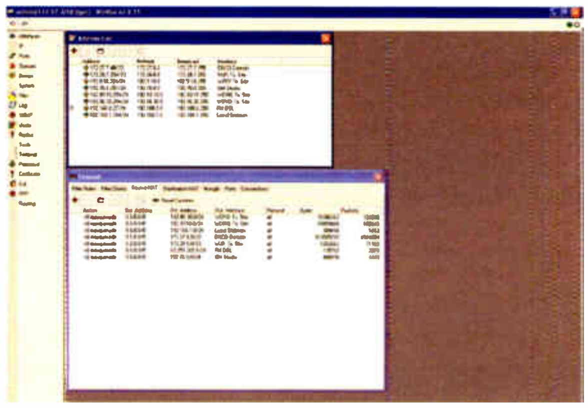
Managing all of this IP traffic necessitated the use of static IP addresses using different subnets for each location. Those subnets, plus two independent DSL circuits at the studio, not to mention the corporate WAN made me realize that we had built the proverbial boat in the basement. How will we manage all of this ... affordably?

My answer was found on the Internet – a company called MikroTik (http://www.mikrotik.com). They have a variety of wireless and IP routing solutions, one of which is called the Instant Router. It is an IDE flash module with a Linux operating system and MikroTik's router software installed.

I bought this product and installed it on an old PII. With this little flash drive installed, the only moving part is the cooling fan on the power supply. No keyboard, no mouse, no monitor – no nothing! Just the motherboard, the IDE module and a few NICs.

The IP traffic on eight different subnets now is managed easily through an intuitive HTML interface. Total cost was under $100 for a router with a 450 MHz processor, ten Ethernet connections and 128 MB of memory. Try getting *that* from Cisco at an affordable price!

The personal satisfaction of coming up with a clever device or solution using only parts lying around the workshop is incredible. I think that as engineers, there is a little "Gilligan's Island Professor" in all of us.



MicroTik configuration screen makes it easy to manage multiple sources from afar.

Looking back, I realize how accurate my instructor's words really were. Cheap is good!

The Director of Engineering for ABC Radio - Detroit, MI, Chris Arnaut loves to find neat, inexpensive solutions for solving problems. He can be reached at: chris.m.arnaut@abc.com

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The USB Matchbox is a basic USB (digital) to XLR (analog) interface that provides stereo inputs and outputs at professional levels on XLR connectors. The USB Match Plus is similar; it also includes LED peak level meters to accurately monitor input and output levels, and a high-performance headphone amplifier for critical aural monitoring. Both units also include a Speaker output to feed a monitor speaker system, and a Mute control port to mute the Speakers with an external contact closure.

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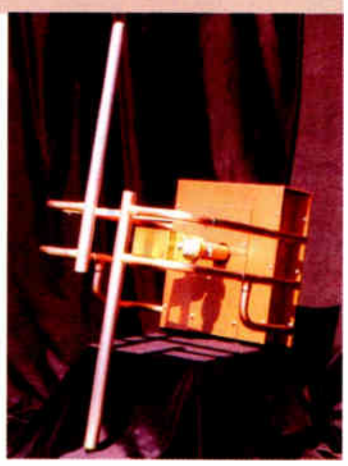
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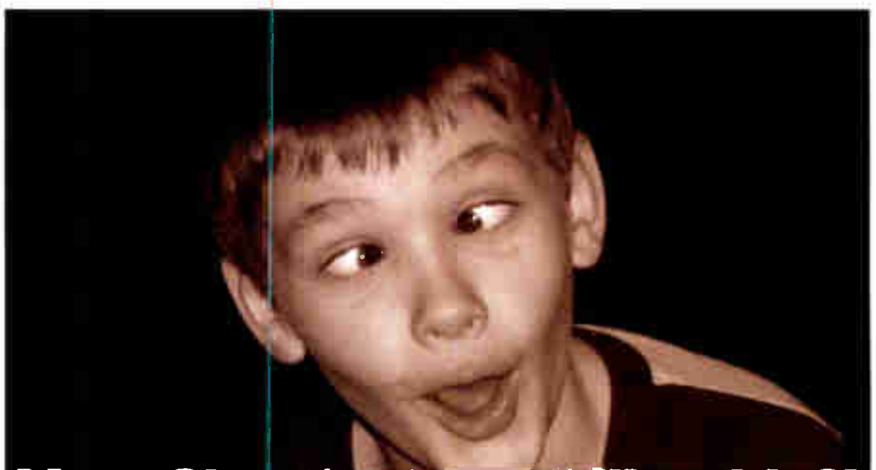

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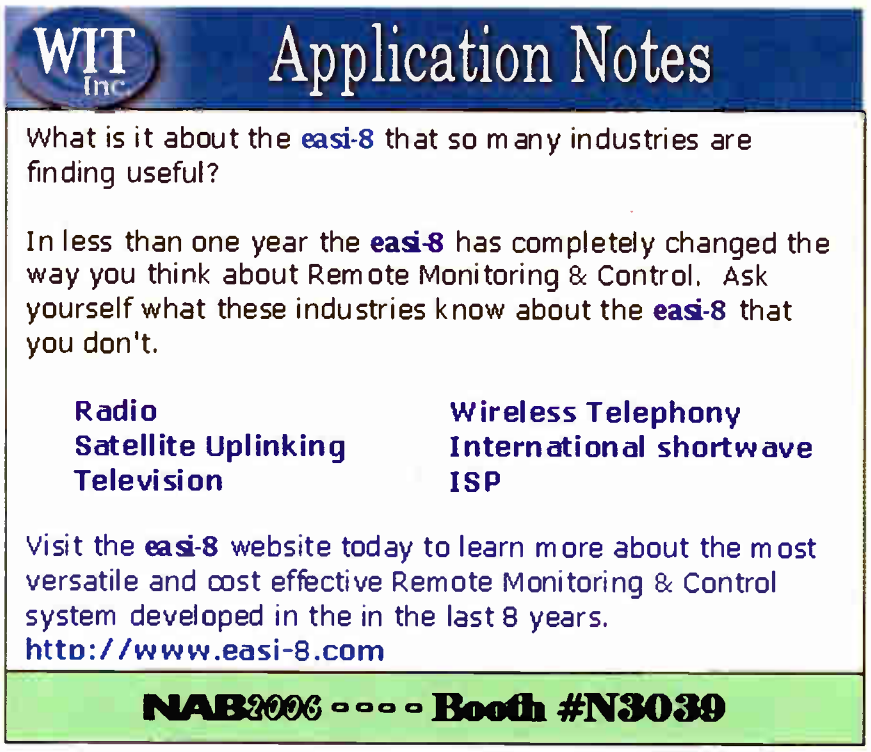

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Strange Ruling on International Issue

In a stunning decision, the FCC has swept aside the voluminous engineering material submitted in the XHBCE-FM proceeding and has granted the request of Broadcast Company of the Americas for Section 325(c) authority to electronically deliver programming to Class C1 Station XHBCE-FM, Tecate, Baja California, Mexico.

An objective observer might be understandably confused on how the Commission came to this decision, one that should have the attention of every station close to the international border.

The Commission's Order and Authorization (O&A) granting the 325 authority is available at http://hraunfoss.fcc.gov/edocs_public/attachmatch/DA-06-473A1.doc

LONG-RUNNING PROBLEM

The case involves FM station XHBCE-FM, and AM stations XESS, XESDD and XEKTT, in Baja North, Mexico.

Aerial photographs taken by Lazer Broadcasting in May 2005 uncovered evidence of apparent massive violations of international broadcasting agreements – from AM stations that should have been built with multiple towers (but were not), to XHBCE-FM's Class B facility that was apparently operating from the wrong location (and 1,700 feet too high), to a Class C1 antenna that apparently cannot protect the U.S. (This antenna was built to handle 100 kW ERP, far above the 8.2 kW value ultimately allowed by the SCT.)

While the operators of the stations have repeatedly and vehemently denied any wrongdoing, Lazer Broadcasting along with Emmis Communications filed information with the FCC that appeared to have shattered the heart of the Baja stations' defense.

According to the Lazer/Emmis attorneys ("Lazer"), the document provides, "....conclusive evidence that BCA and Quetzal have been engaged in a high-stakes game of fraud on the FCC" in order to save their Section 325(c) permits.

DOCUMENTED FACTS

Maps, color photos and engineering drawings accompany Lazer's easy-to-read pleading and show how the alleged misdeeds were accomplished. You may read the Lazer/Emmis filing (3.3 MB) at http://earthsignals.com/add_CGC/Reply_BCA_Opposition.pdf

Color photos illustrating the situation are posted separately at this URL: http://earthsignals.com/add_CGC/Reply_BCA_Oppose_Photos.pdf

If you read nothing else, download the first document and read "pdf" pages 28 thru 33, starting with the title, "The True Location of XHBCE's Class B Plant is Revealed." It would help to print the Exhibit E-2 map beforehand ("pdf" page 39) as a guide.

It is fascinating to see the step-by-step process that Lazer claims was used to obscure the true location of a valuable broadcast property. How do you move coordinates from one place to another anyway? Once you have read that, you will probably want to read more.

A PUZZLING DECISION

In many ways, this O&A is incredible. It goes to great lengths to avoid deciding the most basic issues raised – including the allegation that the XHBCE Class B facility was built on a mountaintop far from its authorized location (a ravine).

The O&A also caves in regarding a directional antenna pattern issue for XHBCE's Class C1 site by simply saying, "In matters such as this, we rely on the responses of SCT (Mexico's FCC), since it has the authority to regulate XHBCE-FM" (para. 12).

The FCC failed to take into account that XHBCE's own range-measured pattern violates the SCT-stipulated pattern and that Lazer Broadcasting's engineering report, which relied on data from ERI's NEC modeling of the XHBCE antenna, showed the same thing.

IS ANYONE PAYING ATTENTION?

It is amazing that the Commission did not see fit to take a single field strength measurement on XHBCE's Class C1 operation – or tell us about it if they did.

Perhaps aware that this lack of oversight could encourage lawlessness in the U.S./Mexican Border Zone, the Commission stated in footnote 36 that, "We will, however, periodically monitor transmissions to ensure that the transmissions are in accordance with the 1992 USA-Mexico FM Broadcasting Agreement."

This hotly contested case was a golden opportunity for the Commission to strut its stuff and take a measurement – but it apparently did nothing.

Finally, the Commission faults Lazer Broadcasting for not providing sufficient evidence that XHBCE is causing actual interference to the reception of Lazer's co-channel station KXRS-FM in Hemet, CA. The demand for an expanded showing – whereas the real focus should be on the correct operating parameters and antenna pattern – is an invitation for chaos in the Border Zone.

BAD SITUATION FOR BORDER STATIONS

Now, a situation may develop that every unscrupulous operator will be tempted to crank up the power, move to an unauthorized site or broadcast on any desired frequency (this happened recently), until proof positive of interference arrives. The burden of proof should not be on the victim station.

In summary, the Commission's mishandling of this case has sent the wrong message across the U.S./Mexican Border Zone.

Then again, some feel the Commission is but a ghost of its former self. The agency has been paying less and less attention to Rule compliance for broadcast stations and has no genuine interest in conducting the type of field measurements that it says in the O&A are needed. But worse, the Commission has, in this case, thrown a colossal canister of cold water on efforts by private parties to take up the slack.

Much of the material for this story was drawn from articles written by Robert Gonsett, president of Communications General Corporation, consulting radio engineers, Fallbrook, CA.

Over the years, Bob has dealt with many cross-border situations, but has never seen apparent Rule violations as egregious as those portrayed here. Bob can be reached at <r.gonsett@ieee.org>.

Practical Engineering

Springtime at the Tower

by Scott Cason

Spring is upon us again and as the saying goes, "a young man's fancy turns to romance." However an engineer's thoughts should be turning to the transmitter site.

It is very easy to neglect a remote site when the temperature is below 40 outside on a regular basis. On the other hand, warmer temperatures signal it is time to get out and enjoy nature again, and – after all, what is more "natural" than a transmitter site?

FIRST LOOK

Start while driving up to the site. Check the power lines, telco lines and other lines on the power poles if you can.

Have icy limbs fallen across the lines during the winter? If limbs or small trees are resting across the lines, this may cause trouble; now is the time to alert the utility company to the problem.

Once the tower is in view, check to see if winter's cold winds have loosened any feed lines or other attachments to the tower like electrical wiring for lights or STL, RPU, or tenant antennas. Make sure nothing is hanging loose from the tower.

CLOSER INSPECTION

How does the paint look? Has ice or snow done any damage to the paint scheme on the tower? Cold temperatures also tend to make nylon wire ties brittle; over time, they can break from the stress of wind, ice and temperature extremes.

Another temperature-based item: check that the guy wires look "normal" and are not sagging; freezing water in the ground has been known to push guy anchors around, especially if the anchors were not installed properly in the first place.

Take note of the access road; wintertime visits inflict wear and tear on the road. If there are deep ruts, it is time to arrange for placing some suitable gravel on the road.

THE TRANSMITTER BUILDING

Has falling ice damaged the roof or any other part of the transmitter building, including the ice bridge between the tower and building?

A piece of ice may not seem like much, but after falling 400 feet from the tower, it becomes a missile capable of an amazing amount of damage. I have seen ice take out security lights, heat exchangers, and vehicles – even pierce roofs. Binoculars are handy in checking for possible tower damage from falling ice.

How do the power leads from the utility company look – has icing pulled any of the anchors away from the building or stretched the wiring? The same goes for telco and other cables that are flown to the building from poles; such wiring is not designed to support much weight.

Use binoculars and check the messenger cabling (used between poles and other supports) holding up the signal wires for damage or breaks. If the messenger cable is damaged, there is a problem waiting to happen at the worse possible time. Now is the time to alert the utility company.

EVICT THE UNWANTED

Once inside, check for evidence of rodents or other furry friends that used your transmitter building (including raceways, conduits and floor troughs in older buildings) – and more specifically your transmitter and/or high voltage supplies – as their winter home.

At AM sites, also check the phasors and ATUs. This is the perfect time – before wasp season. It is amazing how fast mice can set up housekeeping in the smallest of space. I have seen them even within the confined spaces of loading coils at the top of AM transmitters.

I suppose they enjoy the warm feeling they get with all the RF around them. However, nests like this can cause all sorts of problems. Over time, their excrement can corrode copper connections and throw a pattern way out of tolerance, if not taking you off the air all together

As you go to your various towers checking ATUs, also check to make sure no other buried cabling has been pushed to the surface by water freezing and thawing underground. This includes AM ground radials.

CHECK THE ENTIRE PLANT

Do not forget the backup transmitters. I was recently surprised at a client's site when I fired up his backup AM transmitter: leaves, twigs, grass and other rubbish started spewing out of the top of the cavity when the blower came up to speed. Surprise turned to fear as the rubbish that remained in the cavity started to smoke once the filaments started heating it up!

Rodents had built nests in the bottom of the transmitter, in the cavity and even inside the impellers of the blower! Because this site had not been well maintained for over five years, work on his main transmitter had to wait another two days while we cleaned out the backup transmitter and it cost him an additional $2,000 in time and parts.

KEEPING THE GENERATOR HAPPY

Another critical part of your facility is the generator. Springtime in the Southern United States means thunderstorms. Thunderstorms produce lightning – and lightning tends to produce power outages.

It is wise to have an annual maintenance contract with the generator vendor; schedule them for early spring, so they can come out before their schedule fills up. Wintertime is the most stressful time on engines, so spring is the perfect time of year to flush and replace anti-freeze, and check the batteries

A little attention to your site during the early spring will prevent headaches and embarrassment during the rest of the summer. It will also prepare your site for the whole new set of stresses it will see when the temperature outside rises.

Scott Cason is a contract engineer based in Louisville, KY. He can be contacted at scott@lagrange-com.com by Dana Puopolo

Voice Over IP – Now Ready for Prime Time

Many of us remember applications, like Netmeeting, and Net2phone, that were in vogue a few years ago. You installed them on your computer and, using a headset or microphone, you could talk to people anywhere in the world over the Internet – without long distance charges.

The problem was: the quality was terrible! Echoes, dropped connections, and a myriad of other problems essentially turned those programs into play toys for experimenters.

Now fast-forward to today where Voice over IP (VOIP) is already used by millions every day. No longer is VOIP a toy, but a real application that is ready for use by you, both personally and in your facility.

In this first part, we will provide an overview of VOIP and its advantages and pitfalls, and give some examples of the various providers out there.

ANALOG TO DIGITAL

Voice over IP is literally phone calls where your voice runs through a codec (COder/DECoder) and is converted into digital packets. These packets then run to their destination over an Internet Protocol (IP) network. Once they reach their destination, the codec on the other end assembles the packets back to audio. That, in a nutshell, is how VOIP works.

Things like TCP, error correction, etc. are not used. Instead, the codec on the receiving end uses error concealment, which "fills in" missing data by interpolation. Of course, it is really not quite that simple, because signaling, dialing, etc., has to also be built into VOIP.

Of course, the most common IP network is the Internet itself, but many companies also have their own internal IP networks. VOIP is presently used by all the major long distance companies to route calls. Sprint, AT&T, Qwest and MCI are all in the process of converting their long distance circuits to be 100% IP based. This way, they are not limited to just using these channels for voice only.

Most cable companies also offer VOIP telephone service as an alternative to normal POTS service. Even some of the telcos themselves use VOIP instead of copper circuits. For example, Verizon FIOS is 100% IP based. Then there are the companies that offer VOIP over the Internet such as Vonage, Packet 8 and AT&T Callvantage.

USING A COMMON PROTOCOL

What changed everything with VOIP was the adoption of a common protocol for making connections. Session Initiation Protocol (SIP) is a universal standard that everyone (aside from one notable provider) uses for VOIP. The telcos have adopted it for their VOIP systems. The one holdout is Skype – and we will talk more about them next month.

SIP defines the signaling and packet setup for VOIP. Since everyone uses it, they can seamlessly interoperate between each other. Unlike Skype, where you must have a computer running a program for it to work, SIP also allows for small boxes called Analog Telephone Adapters (ATAs) that simply connect between your network connection and a standard telephone. No computer is needed.

With an ATA, when you pick up the phone you get a dial tone, just like with Plain Old Telephone Service (POTS). The phone rings the same as with POTS, too; tip and ring with VOIP act the same as with POTS. Finally, the quality can be better than a POTS call, because many codecs used with VOIP are 14-bit PCM, as compared with the 8 bits of resolution used by POTS.

MORE THAN A COST ADVANTAGE

The big advantage of using VOIP over POTS is cost. VOIP is much cheaper to deploy and use then standard POTS service. All of us have seen the Vonage ads where they offer unlimited calling to the Unites States and Canada for $24.95 a month. If you make a lot of long distance calls, this can be a bargain.

However, the advantages do not just end there. With VOIP you can choose your number's area code. For example, let us say you moved from Los Angeles to New England (as I did recently).

In California, I had an LA phone number with my Vonage service. When I got to Rhode Island, I simply plugged the Vonage ATA into my new Internet connection and still had the same LA number in Providence. Many people buy VOIP service and ship the ATA units to relatives overseas, giving them a US phone number and the ability to make unlimited calls to the US and Canada.

Most commercial VOIP providers also offer all the normal phone features such as 3-way calling, call waiting, caller ID, etc. Where they excel is in providing additional other features such as virtual numbers, simultaneous ring, advanced voice mail, etc.

WHERE THE PHONE RINGS

A virtual number is simply an additional incoming phone number that rings your main VOIP telephone number. When I lived in Los Angeles, I got a Boston area virtual number. This way my relatives and friends in Boston could dial a local number and my phone in Los Angeles rang, toll free. Virtual numbers cost a few additional dollars a month and you can have as many of them as you desire.

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IT Guide

by Dana Puopolo

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Simultaneous ring is a feature where you can tell the VOIP provider to ring an additional number when you receive a call. I have my simultaneous ring programmed to call my cell number. When someone calls my main number, it rings both at my house and on my cell phone. The first one who picks up gets the call.

This way, people have a single point of contact to get me. Since the caller ID information also carries through, I can decide if I want to take the call or let it go to voice mail. Most voice mail systems for VOIP have the option to email the messages to you as an MP3 or WMA file, so you can retrieve it when near a computer if you desire. They all also have the normal call-in type number for messages.

POTENTIAL DOWNSIDE

By now you are probably saying to yourself: "Where can I sign up?" But before you do that, there are some caveats. Many who sign up for VOIP become disappointed because they find it does not work well for them (or does not work at all). Others find that it works some of the time and not others. For example, some hotels block VOIP usage.

Remember that VOIP uses an IP network to send those packets around. If your Internet connection is not up to snuff you will have a poor VOIP experience. Many people tell me they have a 3-megabyte connection yet their VOIP breaks up all the time. With VOIP, bandwidth is not all that matters.

As mentioned earlier, VOIP does not use TCP/IP for transmitting voice packets. To minimize latency, it uses the UDP protocol. To quote the RFC768 standard: "This protocol (UDP) provides a procedure for application programs to send messages to other programs with a minimum of protocol mechanism. The protocol is transaction oriented, and delivery and duplicate protection are not guaranteed. Applications requiring ordered reliable delivery of streams of data should use the Transmission Control Protocol (TCP/IP)."

Simply stated, unlike TCP/IP (the normal Internet protocol used for web browsing, downloading, etc.), UDP offers no error connection for lost packets. While the codec on the receiving end can conceal some errors, if the lost packets exceed a certain threshold, the audio will begin breaking up. So, an Internet connection with low packet loss is essential for good call quality with VOIP.

UPLOAD SPEED CRITICAL

Furthermore, you must take into account the packet loss and bandwidth going both ways. The most common VOIP complaint is that: "I can hear the caller fine, but my voice breaks up." Usually this is because most Internet connections in the United States are asymmetrical; that is, they have much lower upload then download speeds.

It is not uncommon for these to be unequal by a factor of ten or more. Indeed, the most popular Internet connection recently in use in the USA was a 1500/128 kbps connection. This connection is actually marginal for VOIP because the best quality codec will use about 84 kbps itself.

If fact, if you try talking on the phone while surfing the web with this connection, your voice would likely break up on the caller's end. One option to cope is a lower quality codec, which might sound like a cell phone call.

COMPATIBILITY CHECK

Fortunately, there are on-line tests that can quickly tell you if your connection is good enough for a quality VOIP experience. Here are two of my favorites:

http://myspeed.visualware.com/voip/index.html This test tells you the upload and download speeds of your Internet connection. Since the upload is usually less, that is the key parameter. This site will also tell you how many connections your Internet will also support.

http://www.testmyvoip.com/ This java based test makes an actual VOIP call to a number of selectable destinations. It measures everything including packet loss, jitter, latency, etc. and gives you a 1-5 rating of quality. The best you can get is 4.4, because all codecs use perceptual coding (bit-rate-reduction). For VOIP, the best codec available at this writing is g.711.

If these two tests give good results, there is an excellent chance that VOIP will work well for you. Now you have to choose which carrier to get, whether you want to buy an ATA device pre-programmed or program one yourself, etc.

THE 911 ISSUE

But before considering specific VOIP providers, we need to mention an undesirable feature of VOIP 911 access.

Most VOIP providers offer 911 calling, but frequently it is not as good as that offered by POTS service. As this article is being prepared, I am reading about someone whose house burned to the ground because when they called 911 using Vonage, they were put on hold by the emergency center, delaying the fire department's response by several minutes.

Here is what happened: when you call 911 using POTS, your call gets routed to the local 911 center automatically. With most VOIP providers, you tell them (when you sign up) your address, so they can set up 911 calling for you. Unfortunately, sometimes the call gets routed to a routine number at the emergency center because the VOIP provider can not directly access the 911 emergency number directly.

In the case above that is what happened – the center put the caller on hold. For this reason, I recommend that VOIP not be used as a replacement for POTS. Instead use it as a supplement. Buy minimum POTS service and use that for calling 911. Or ask your phone company if they allow for 911 calls on dead POTS lines; some do.

Next month we will discuss some of the VOIP providers, including one that offers free calls, Skype, and a free SIP VOIP network that has almost a million users.

Dana Puopolo is currently doing contract engineering and projects from his base in Providence, RI. Or is he? As with email, you cannot always tell where someone is with VOIP! Speaking of email, Dana is at dpuopolo@usa.net

Multicasting.

It's like trying to fit —

well, you know.

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EAS Watch

by Ken Evans, WMDT, Salisbury, MD

Maryland's EAS Plan – New and Improved

It has been a long wait, but finally on Wednesday February 22, 2006 at Maryland Emergency Management Headquarters (MEMA) in Reisterstown, MD., the new Maryland State EAS Plan was released. All I can say is that it was a long time coming.

MAJOR OVERHAUL

The new plan is written with revisions in mind, having a main text and 13 annexes, divided by topic. To put it mildly, the plan was the work of many people and highly scrutinized by the SECC and other experts.

As the one responsible for constructing the annexes, I used many of the ideas gained from other State Plans and suggestions via the SBE EAS remailer. From the web and the FCC's EAS web page I printed out and read through as many State EAS Plans as possible. And I came up with lots of suggestions, not all of them made the final plan.

In the end, the plan is significantly different from the old interim plan released in 1996-97. Here are some of the biggest changes.

STATE RELAY NETWORK

With the addition of a State Relay Network, based on EMnet EAS, we established a means of linking Emergency Managers and Broadcasters (especially LP stations and TV Stations) in and around Maryland.

For those of you who do not know about Comlab's EMnet, it is a satellite/Internet based messaging communications system for Emergency Managers. Adapted to carry EAS messages to broadcasters, you get a crisp clear EAS message at each broadcast node (unlike the old static filled messages via the daisy chain method).

To help TV Stations comply with all of the FCC Rules these messages also include the full vocal text. This text can be instantly inserted (or almost so) into the EAS crawl or Closed Captioning to get an emergency message out. No more listening to the vocal, writing it down, typing it up and then crawling it. It can be totally automatic or at most a quick copy and paste to get the message on air.

Furthermore, EMnet can send along pictures for Amber Alerts, maps of affected areas, and background information about an emergency situation. Having a connection monitoring the State Relay Network makes each station like an LP station – it means everyone gets the State and Local EAS messages directly.

Note however, the LP assignments have not changed. We still need the daisy chain to carry the EAN messages. It also serves as a backup method for the State relay should that ever fail. The State Relay Network Annex explains the network and how it works, including setup diagrams.

ENHANCED MONITORING

Aside from one exception, we did not change the old Local Primary assignments; but we did add a recommendation that broadcasters listen to as many EAS sources as possible.

The assignment order after the two LPs assigned is the state relay network (which is EMnet EAS where available) and then NOAA Weather Radio. Also we recommend monitoring any nearby state's EAS messages.

EMnet is in 11 States and makes this very easy, as Pennsylvania, Delaware, Virginia, and the District of Columbia all have and use EMnet for EAS messaging. Knowing how much of Maryland is surrounded by these states (and West Virginia), and that broadcast signals do not stop at state boundaries, the Salisbury MD TV station where I work can receive and relay EAS messages affecting our viewers in neighboring states.

Encouragement for everyone to participate by doing EAS messaging for their broadcast area was purposely written into this plan. Although we cannot require it, we want broadcasters to follow the other state's EAS plan when carrying out-of-state messages. The hope is more lives can be saved by carrying all the EAS messages for the station's broadcast area.

We also added an Amber Alert annex with an understanding of the Maryland Amber Alert process and what coverage is asked for when a Child Abduction Emergency (CAE) occurs.

REGIONAL PLANS ENCOURAGED

The Local (Area) Emergency Communications Committee Annex suggested that our EAS Regional Areas each form a committee and work out their own regional plan. We included a suggested local area plan as a guide. We hope to include additional plans in this Annex as they are produced and submitted.

I personally hope some consideration is given to considering an area-wide plan. We already have an

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EAS Watch

by Ken Evans

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Emergency Manager's group that work together on Delmarva issues. (Delmarva is a combination of state names used locally for the peninsula made up of Delaware, Maryland's Eastern Shore area and Virginia Eastern Shore). Ultimately, it may be more effective to develop an area wide plan for a region which shares many broadcast contours that overlap state boundaries than to have many individual plans.

FOSTERING BETTER COMMUNICATION

Our Plan has listings of State EAS Regions or Local Areas, a complete list of SECC Committee Members, and the Emergency Management (EM) contacts.

We also took steps to enable easier mutual aid requests for EAS messaging from one EM office to another when needed. Then, if one EM office or Emergency Communication Center is inundated with too much work, another local operations center or the State EOC at MEMA Headquarters can issue the needed message(s) if requested. This is called using your resources.

The Plan also sets up areas for planning and local testing if needed in the future.

ADDITIONAL INFORMATION

The 2006 Plan includes a complete listing of FIPS codes, including marine FIPS for coastal waters, the Chesapeake Bay and Tidal Potomac River. We also adopted a listing of definitions for EAS events and how they would be used in Maryland. The original list came through work of the NWS.

A list of Maryland Event codes includes the events we hope will be set up for automatically forwarding by stations using automation. This one includes Tsunami Warnings for coastal and bay areas. There was quite a discussion on this one by the committee; it really appeared unlikely to be ever used.

But then the Tsunami of Dec. 26, 2004 happened in the Indonesia region. And more recently was the news release that the West Coast/Alaska Tsunami Warning Center would implement a new suite of event-driven tsunami text products for the coastal areas of Alaska, Canada, and the US. This became effective as of January 27, 2006. So now we have a means of warning, not just an event code, all coming from seeing what happened half a world away.

IMPROVED ALERTING

Not all of the ideas presented were used. One suggestion was that the Required Monthly Test (RMT) start-point rotate through all the state EAS message origination points where EMnet is available.

I firmly believe that the RMT is designed to show our connectivity with the Emergency Management community and that as a test, it should allow those who will have to start the actual emergency messages an opportunity to practice sending messages. This is a way to help promote familiarity with the equipment and efficiency of operation. Remember it might be good to test via multiple means of communication to assure good connectivity.

In the end, the rotation suggestions have been pulled for now; MEMA will carry the burden and conduct the tests. But perhaps we can do the rotation in the future as the various agencies install gear designed to work properly with the EMnet system.

Our daisy chain, as well as NWS, can be included in these methods by plan, even though EMnet will be the primary or usual method. Although not all tests will always work every time – we have the human factor to overcome – only one RMT is sent each month so stations can check that these tests are received (and log what happened if not) to comply with FCC Rules.

GETTING THE BENEFITS

Now that the new State EAS Plan is in release I look forward to the improved messaging features which allow us to get better message quality and the full text when an Emergency Alert comes. Then the speed of forwarding those vital messages will be fast enough to know we have helped save lives – and that is the whole purpose of using EAS, is it not?

If you would like to review the Maryland State EAS Plan, it is available on-line at the following addresses: http://memaportal.mema.state.md.us/portal/server.pt/gateway/PTARGS_0_2_898_0_0_18/md_eas_master_plan.pdf and http://www.mdcd.com/

By the way, the turnout at the meeting on February 22nd was large. Despite it being rescheduled several times, there was a lot of interest, making this a successful culmination of a long process to get the new Plan established.

Of course, with the recent EAS proceedings at the FCC, we are reminded that EAS is in a state of flux; more changes can be expected. What changes will reorganizing EAS under the Department of Homeland Security bring? Now I am wondering how soon our Plan will have to be updated changed.

Ken Evans is the Master Control Supervisor at WMDT, Salisbury, MD, and a member of the Maryland SECC. Contact Ken at ken_evans@wmdt.com

Radio War Stories

by Phil Alexander, CSRE, AMD

Adventures in the AM Field

(Confessions of an AMD in the Trenches)

Part 4 – Whatever Must Be Will Be

Our semi-fictitious account of what can confront an engineer brought in to fix a directional antenna problem continues. Phil's story has reached the point where he and the GM have had a "meeting of the minds" and are ready to solve the problem, not just stick on another band-aid.

Simple "cranking" on a phasor is not something I like to do because it is essentially trial and error without much understanding of rhyme or reason. However, there are times when there is no good alternative.

As "Mr. Carpet" wanted us to get the power back up as high as possible, this appeared to be one of those times. So I sent my assistant to a location in a minor lobe and sent the CE to the monitor point that started the exercise.

Meanwhile, I placed a comfortable chair where I could adjust the phasor and operate the phase monitor as best as was possible in its condition.

SEEKING A STARTING POINT

I started by working to get the phase monitor indications as close as possible to the licensed values, taking careful notes of the phasor settings each time I moved one, along with the phase monitor result.

I was very careful to move only one adjustment each time so we would have a useful guide to the actual effects of the phasor controls.

As is often the case, the controls on the phasor were labeled with their functions. As is also often the case, the phasor seemed to have other ideas. This is a common failing of many phasors, but this one seemed much worse than most. For example, tower three phase affected tower one and tower three *power* but had almost no phase effect. Tower three power changed the ratio of tower one about half as much as it affected tower three.

Finally, I made a chart based on the moves I had made, and made a few more moves, experimenting to fill in the blank spaces of the chart.

WALKING THE PATTERN IN

The fellows arrived at their posts and called in, so I started "cranking" to "walk" the pattern. Once again, I moved a single control each time and logged all effects including the result shown by the FIM's at the distant points.

Little by little, we were able to move the correct null over the problem monitor point and move the adjacent minor lobe over its intended azimuth. At full nighttime power, the pattern was within limits, although the monitor indications showed one tower outside the three degree phase tolerance limit. Hooray! Enough for one day.

It was lunch time, and time for us to depart for home. My assistant and the CE returned to the transmitter after about 20 minutes and we began securing equipment in the vehicle for the return trip.

WHAT TO CHANGE

While we were doing this the CE had a question: "How do you know if you need to change phases or change ratios to get a pattern aligned?"

I explained that we did not really "align" it in the true sense of the word; that would come later. But, to answer his question: phase – and only phase – affects the azimuths of nulls and lobes while the field ratios, as indicated by the tower current ratios, affect the depth of the nulls.

A good way to remember that is phase is an angle, and angles affect angles. Ratio means relative strengths of the fields generated by the towers, and strength of field affects field strength.

"You mean you didn't have to adjust the power going to the towers?" he asked.

HOW DOES THIS ARRAY REALLY WORK?

I told him, "No, it is never that simple. Usually, when you adjust one operating parameter, others change because the towers affect each other. It is called mutual coupling which is an effect of changing mutual impedances."

He was beginning to look a little bit bewildered so I continued, "Think about two towers near each other. Both are generating fields, however both are receiving those fields. We think receiving involves almost no power. Usually, that is correct, but if we "float" or completely disconnect one of the towers in your array are you going to touch that tower with your bare finger while we are sending full power to the others?"

The CE looked at me like I had marbles running from my ears, made a wry face and said, "No way," and I agreed. "However, that tower you won't touch is merely a receiving antenna for the detector, which would be your finger if you touched it." That startled him, and I could see the wheels begin to turn. "So, you see, some receivers do receive quite a bit of power if they have a very good antenna located very near a transmitting antenna."

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World Radio History

Radio War Stories

by Phil Alexander

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IT ALL DEPENDS UPON THE PHASE

I continued: "RF is high frequency AC, so it has a phase. Suppose we have two AC signals connected to either side of an AC ammeter. If those signals are perfectly in phase, no current will flow through the meter. If there is no load current, we say the circuit is "open," meaning the resistance is infinite, right?" He nodded. "OK, take the same circuit and reverse the phase of one signal so it is 180 degrees out of phase with the other.

"But if we do that it will blow out the meter!" By now, I could almost hear the wheels spinning in his head.

"Substitute base current meters for the AC ammeter and the coupling of power directly from one tower to another and you have the circuit we have been discussing. Think about varying the phase of the field or signal of one tower between 180 degrees and zero at the time it arrives at the other tower."

That triggered: "Wow, both towers could appear to have a base resistance between infinite and zero as you change the phase." "Not exactly," I replied, "because all the power from one tower cannot appear at the other tower because most of it is radiated in other directions, however your idea is correct."

THE LIGHT GOES ON

"Let me see if I understand this. If we change the phase of one tower some of its power is received by the other towers and, depending on the phase that is received, the base resistance of each of the other towers might be changed from a very high value to one much lower, or vice versa, so if you make one change in phase or power, everything changes to some extent. Can that be true?"

It was clear that he was beginning to understand what we call mutual coupling, or mutual impedance between towers, so I smiled and said sometimes it was a little more complicated, but basically he was correct, and that was a good start.

"Of course all this happens the instant you move the adjustment, but what you are seeing is the effect of one small change on the entire system, not just on the phase of a single tower."

BACK TO THE OFFICE

We said our goodbyes and told the CE to watch for the arranged loaner phase monitor and toroid coils. We would be back in three or four weeks and I would try to show him as much as I could about how his array worked while we were making it behave.

We arrived at our office early that evening and I e-mailed a short confirmation of our morning discussion including the details of the toroids. Then I started outlining the formal report of our trip to "Mr. Carpet's" wayward directional array.

Looking at the maps, it was obvious that the phase monitor indications were simply not correct – not far off – but not close enough to maintain the nighttime pattern within monitor point limits even with the correct ratios.

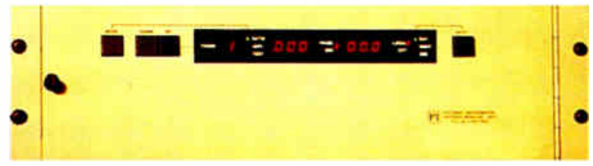
IMPATIENCE, THY NAME IS GM

About two and a half weeks later Mr. Carpet's CE called me to say he had the loaner phase monitor and four toroids, and his boss was "chomping at the bit" for me to get back there.

Five minutes after I had explained that we were booked solid for the next week, the expected call from "Mr. Carpet" arrived. After several parried attempts to reschedule our business, he relented we agreed that we would return a week from the following Monday.

We returned late on the scheduled afternoon because we knew we would have a long night ahead. The first order of business was installation of the loaner phase monitor, followed by a quick check of night monitor points and phase monitor logging.

There was a slight change for the better, but the problem still remained. We decided the best course was meeting at the transmitter at 11:30 PM to change the sampling from loops to toroids. Mr. Carpet had agreed we could have the station after the midnight headline news break until 5:00 AM, so we intended to take full advantage of the time.



A calibrated monitor makes knowing what the phasor is doing much easier.

ONE OF "THOSE" NIGHTS

By 4:00 AM we had all four toroids installed in the antenna coupling units and connected to the sampling lines. We fired up the transmitter on night power and pattern – and *nearly every indication had changed.*

After letting the CE try his hand at adjusting the phasor to get a feel for the problems caused by the interaction, with frustrating results, I tried to return the system to the licensed operating values. A couple of hours of dealing with the interactive monster managed to bring the phase monitor readings almost exactly to the licensed values. We delayed the switch to daytime power and pattern while the CE took a reading at the troublesome monitor point.

I would like to say it was well below limits and everyone lived happily ever after – but that was not the case. It was right at the limit and someone sneezing at the transmitter would probably send it above. Clearly, there was more work to be done. We switched to daytime and called it a day.

MAKING SOME PROGRESS

One of the most troublesome problems was the interactivity of phasor controls and the poor action of some of them. After sign-off for maintenance the next evening,

(Continued on Page 44)

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Radio War Stories

by Phil Alexander

Continued from Page 42

we checked the phase monitor readings for both patterns. Minor adjustments to both patterns took over an hour, but we achieved the licensed values.

After reducing power to about 250 watts, we spent the remainder of the night taking operating impedance bridge (OIB) readings at both the inputs and outputs of the antenna coupling units for both day and night patterns.

While a perfect match between transmission line input and coupling unit input is seldom achieved – and not essential except for high power sections of an array – a severe mismatch may not load the phasor properly. This often causes poor phase or power control during adjustment, compounding the problems from the mutual coupling between towers, and makes adjustment a very frustrating exercise for even those who have long experience adjusting arrays.

CHECKING THE NETWORK VALUES

After the station signed on for the day, we reviewed the measurement results, calculated the correct coupling network values for matching the measured operating impedances of the towers, and compared them with the actual strapping of coils and capacitor values in the networks.

There were several differences in the coils and one of the capacitors appeared to be the "wrong" value, about 30% less than our calculations. The antenna coupling units were prone to lightning damage according to the CE and the "incorrect" capacitor was installed following a storm a few months earlier. I asked if any adjustment was made to compensate for the capacitor value and got a puzzled look in return.

After explaining the purpose of a series capacitor in the output leg of a coupling unit, I plugged the measured values of operating impedance for that tower into a spreadsheet I wrote for designing coupling networks. The phase delay of that network was near 90° so we set the delay to 90° and entered the input and output impedances. The computer gave us reactance values for the network components.

Then, I reminded the CE that inductive and capacitive reactances, in effect, cancel each other and showed him how the output series capacitor shifted the load on the matching network from inductive to capacitive. "But, don't we want to cancel the reactance?" he asked.

I suggested he take a hard look at the computer results and remember that both the input and output inductors in a 90° delay network have the same values – but this one had more turns on the output leg than on the input.

SMARTER THAN THE AVERAGE BEAR

"It looks like you cancelled the tower inductance with a capacitor and, since the capacitor has a larger reactance than the tower, extra coil was used to bring the reactance value to zero before the coil acts as the output leg of the matching network. It seems like the output leg acts like two coils in series, with each one there for a different purpose. Is that the way it works?" he asked, giving me the chance to say, "*Bingo!*"

The local engineer was beginning to understand the way practical coupling networks are constructed. I explained the other function of the input and output legs of the network controlled phase delay and showed him that greater delay required more turns in the input and output legs while changing the impedance meant changing the reactance in the network's shunt arm.

"But that is a fixed capacitor, so how do you ... Oh, I get it. You use the series coil to cancel some of the capacitor's reactance," he said, answering his own question.

CLOSE IS CLOSE ENOUGH

I told him the impedance match would change a little with phasor adjustments because the operating impedances of the towers would shift.

"However," I said, "it's not necessary to have an exact match as long as the phasor controls are not affected too much. If that happens, you will know it because you may wear out your arm cranking before you get much change from a phase control that is loaded by the wrong impedance."

"On the other hand," I continued, "a good match is more important when the power input to a tower is high because VSWR can cost power you should be radiating. Remember, power is measured at the common point of the phasor. If you waste it, heating a transmission line, the array efficiency is lower."

The CE commented that he did not see a good reason for replacing the capacitor with the "wrong" value if we adjusted the coil in the output leg of that network and I agreed. He asked if we would be adjusting the coupling units that night and I told him that was the plan.

WILL WE EVER SEE THE SUN?

We again agreed to start at midnight and re-adjust the coupling networks according to the design values needed for matching the operating impedances of the towers while giving the correct phase delay.

The CE met us and expressed surprise as we drove our service vehicle to the first tower base, opened the coupling unit, and unpacked the RF generator, my old, reliable General Radio impedance bridge and a field intensity meter. He thought we would use the OIB again.

"What is that thing?" the CE wanted to know, pointing at the bridge. When he said, "I saw something similar in the station's junk pile when I arrived here," my heart jumped a few beats and I asked if it was still there. "Uh, I don't know if we threw it out or not. But we can check," he said.

At the tower, we checked the bridge calibration with non-inductive standard resistors at 10, 50, 100 and 600 ohms and also checked the reactance range with a standard capacitor that gave us a 210 ohm reactance reading at the frequency we were using. I explained we were going to do these measurements the old fashioned way (since the one tool I did not have was a RF network analyzer).

(Continued on Page 46)

Radio War Stories

by Phil Alexander

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MORE MEASUREMENTS

"We should start on the easy one first," I said, as my assistant started disconnecting the shunt branch of the daytime antenna coupler. Fortunately, the coupling units had "J-plugs" at the inputs and outputs which meant we had less to disassemble.

First, I marked the present location of all the shorting straps and counted the number of turns called for by the design sheet we had made the day before. Next I connected the bridge and adjusted each leg for the design reactance and we reassembled the network. As my assistant grabbed the 50 ohm calibrating resistor, the CE asked me about the connection to the field intensity meter, saying he had never seen anyone use the BNC connector and always wondered about its purpose.

I quickly explained it was acting as an RF detector and nothing more – the object was adjusting the bridge to read the lowest possible value which told us it was balanced and the readings of the dials were accurate.

ACCURATE NETWORK MEASUREMENTS

I connected the standard resistor across the network input while my assistant set up the bridge on the output. I told him, "The tower was about 25 ohms plus j32, so look for 25 minus 32."

"Hey," he said, "I'm getting 26 minus 30 if I correct the reactance for frequency. I don't quite believe that."

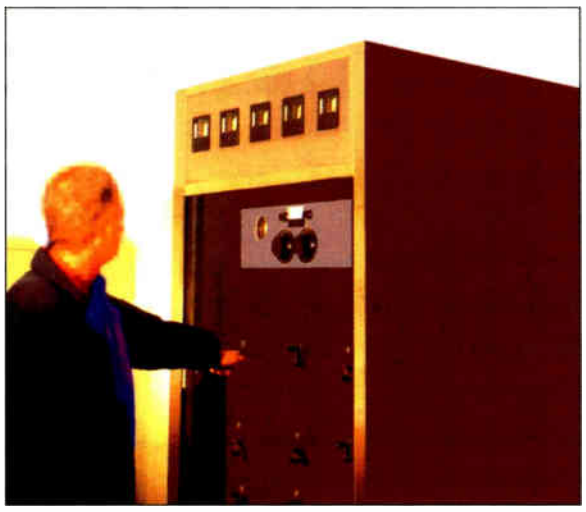
I chuckled saying, "More often the bear gets you, but sometimes you get the bear, and it looks like this is one of those. That is close enough, but tweak the shunt a hair higher if you want."

He put two "s" bends in the strap of the shunt coil and re-read the impedance saying it was as close as he could get it. We moved on to the next tower, hoping our luck would be half as good."

PROOF OF THE PUDDING

We repeated the process two more times on the other daytime networks, returned to the transmitter building and signed on the daytime operation with a dead carrier. The phase monitor was out of tolerance on every reading.

The CE turned a bit green at that point, but I told him it was not quite time to begin worrying. Once again, we logged the position of the phasor index counters and the phase monitor readings, then I stepped up to the phasor and began adjusting with what appeared to be wild abandon.



"It seems to work. It never did that before."

In less than 10 minutes, the phase monitor agreed exactly with the license. "You try it," I said to the CE, "but remember that number three power works backward. A larger counter reading will give you a smaller ratio. Just move slowly until you get a feel for the way it will react."

He was amazed. The phase controls moved the phase of their respective towers, and the power controls rolled power up and down with minor phase changes. He reset the readings to the licensed values.

SUCCESS AT HAND?

At this point, I must say we were very fortunate. Many of the problems with phasor adjustment had apparently been the results of serious mis-matches.

Often, the problem is mutual coupling and that makes the array harder to adjust even though the matches are good. However, in this daytime array, it appeared the mutual coupling effects were relatively mild. While there was some interaction, the controls performed more or less as expected, similar to their indicated functions.

We adjourned for breakfast, and then toured the daytime monitor points. As expected, they were within limits, and I was sure keeping them that way would be a task the CE could handle in the future.

TREASURE HUNTING TIME

On the way back to the transmitter, he asked if I still wanted to look for the old bridge in the back room junk. I said, "Sure."

The truth was I really wanted to see what sort of bridge he had, and if it might be salvageable. He led us to a room behind the auxiliary transmitter to a true junk pile that included what must have been the station's original Nems-Clark phase monitor and all sorts of other goodies very few under age 40 would begin to recognize.

Even that "old station" smell wafted up from the dust. It was like opening the door to a time capsule from the golden days of AM radio when hi-fi was just good mono and most transmitters said Collins, Gates or RCA in big cast chrome letters.

It begins to look like Phil has the antenna working correctly again but he seems to have gotten lost in a time-warp. Will he make it back to this century and, if he does, what will they find in that junk pile? We will find out next month!

A contract engineer specializing in RF transmission and AM directional stations, Phil Alexander is based in Indianapolis, IN. When not chasing strange lobes and nulls, he can be contacted at dynotherm@earthlink.net

2006

RADIO ROUNDUP

The Radio Guide Industry Date and Event Register

Email your information to: ***radio@rconnect.com***

National & SBE • Regional & State • FCC Applications & Deadlines

NAB 2006
April 22-27, 2006
Las Vegas, Nevada
www.nabshow.com

Broadcast Electronics HD Radio Seminar
April 23, 2006 – Las Vegas Convention Center
2:00-4:00 PM, Room N-114
www.bdcast.com

SCMS Communications Conference
June 1, 2006
Charlotte, North Carolina
SCMSConference@laurenoriginals.com

Mid-Atlantic Broadcasters Conference
June 5-6, 2006
Atlantic City, New Jersey
www.njba.com

Northern New England Broadcaster's & SBE 110
June 22, 2006
Manchester, New Hampshire
bteffner@wcax.com

AM/FM License Expiration Dates
August 1, 2006
Delaware & Pennsylvania
/www.fcc.gov/mb/audio/renewal/index.html

Email your dates to: radio@rconnect.com

BOS-CON 2006 Boston SBE Regional Convention
October 12-13, 2006
Marlborough, MA
www.bos-con.com

NAB 2006 Radio Show
September 20-22, 2006
Dallas, Texas
www.nab.org/conventions/radioshow/2006/

34th Annual SBE22 Broadcast & Technology Expo
SBE 2006 National Meeting
September 26-27, 2006
Verona, New York • www.sbe22.org

3rd Annual Broadcast Engineering Expo
October 2006
Dallas/Fort Worth, Texas
www.www.bee2005.org

2006 Broadcasters Clinic
October 24-26, 2006
Madison, Wisconsin
www.wi-broadcasters.org

SBE Certification Exam Dates

Exam Dates	Location	App. Deadline
June 2-12	Local Chapters	April 21, 2006
August 11-21	Local Chapters	June 9, 2006
November 10-20	Local Chapters	Sep. 22, 2006

Radio & Rules

Do's and Don'ts: FCC Compliance in an Ever Expanding Regulatory Environment

by Laura Mizrahi

Changes are on the horizon regarding EAS implementation and nomenclature; ANSI compliance continues to be a "hot button" topic; and tower maintenance and ASR issues keep broadcasters on their toes.

Q: We are in the process of preparing our station's license renewal application with the FCC. Our FCC attorney has advised us that we need to submit a more detailed ANSI compliance statement with this upcoming renewal than was submitted with our last filing. Have there been recent Rule or policy changes which would account for this?

A. The Commission has been taking a very "hard look" at all license renewal applications with respect to potential radio frequency exposure for some time now, and numerous and ongoing instances of apparent "willful non-compliance" in this regard (as determined by FCC inspections) add fuel to this growing fire. For example, it has only been a little over two years since a Forfeiture Order in the amount of $10,000.00 per violating station was issued in what is commonly know as "the Mt. Wilson (CA) licensees" case, an instance where on their own, no one station exceeded the permissible ANSI exposure limits but, when combined, exceeded these limits by some 160%.

Essentially (and in particular in multi-user sites where an individual licensee's transmitter may produce in excess of 5% of the power density exposure limit), the Commission considers it to be the shared responsibility of all such licensees to cooperate with each other to ensure that workers and the public are protected from RF exposure in excess of the guidelines. However, we have been alerted by a number of clients whose stations are co-located with other broadcast facilities that this "spirit of cooperation" appears to be transient, at best, and totally lacking, at worst.

All broadcast stations located at multi-user sites must certify in their license renewal RF compliance responses that it either individually complies with the ANSI exposure guidelines or that it has a worker policy and procedures plan in place to protect both workers on the tower or the public by turning off, or reducing power, in concert with other users at the site.

To not actually be implementing such a plan leaves all licensees in the "over 5%" contribution category open to the same potential fate as the Mt. Wilson licensees, not to mention the very real liability from both a moral and legal standpoint with respect to exposed individuals. Should you, as an individual licensee, find your station in such a predicament, it would be advisable to discuss the matter with your FCC attorney.

Q. We hear that there have been some recent modifications to the Emergency Alert System ("EAS") Rules. What is the most recent update and what do we need to know to stay, or become, compliant?

A. On November 10, 2005, the FCC released a "First Report and Order and Further Notice of Proposed Rulemaking" on its review of the EAS. The Report and Order portion expands the current EAS Rules to include digital audio broadcasting (DAB), broadcast cable TV providers, and satellite radio and direct broadcast satellite services (DBS).

Briefly, all DAB and DTV broadcast stations will have to share the same EAS requirements as analog stations, including installation and maintenance of the proper equipment and the conducting of EAS tests. The Commission is permitting broadcasters the flexibility to determine the method they will use to initiate the EAS message (i.e., FM stations may use subcarriers to transmit the EAS codes), as long as the public will receive the same message regardless of the mode in which the transmission of the message is conveyed. All of the above noted participating EAS stations, (with the exception of DBS), must comply with the new Rules by *December 31, 2006.*

The process is continuing with the FCC's Further Notice of Proposed Rule Making. Quite a few comments have been filed by interested parties – including new ways and technologies to distribute EAS messages and alerts – and the industry is awaiting further action by the Commission.

A complete copy of this Report and Order and Further Notice of Proposed Rulemaking (EB Docket No. 04-296) is viewable on the FCC website.

Q. Our station is going to be visited by an FCC inspector next week. Apart from the obvious review of the contents of our Public File and main studio requirements, what are some commonly overlooked enforcement violations we should be aware of?

A. Consistently, the most typical infractions that result in significant monetary forfeitures are those that pose the most serious potential threat to human life. These include ANSI and EAS violations as well as the failure to maintain and register antenna structures.

Forfeitures in amounts exceeding $15,000.00 are not uncommon when a station is found liable of having an inoperable EAS decoder or not keeping appropriate logs, failing to register or post an ASR number or properly fencing or enclosing an antenna structure.

At only one week away from inspection, it may not be possible to rectify all potential issues such as those mentioned here if they have been neglected but it will be seen as a show of good faith if steps are taken immediately to rectify any issues that become known as a result of the station's preparation for inspection. After that point, care should be taken to maintain good working equipment as well as regular monitoring of any and all ANSI compliance and tower maintenance requirements. Good luck!

Laura Mizrahi, Vice President of Communications Technologies, Inc., has been involved in broadcast consulting engineering for nearly 20 years. Questions relating to issues of a broadcast technical nature can be sent to lmizrahi@commtechrf.com.

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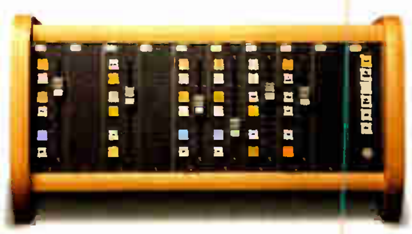

New RIOGrande Stand-Alone Mixer/Router — RIOLink, the SAS Remote I/O chassis for the 32KD, has grown into a full-featured stand-alone mixer/router, a junior version of the 32KD. Use it with Rubicons, SLs, Rubi-Ts, or simply as a powerful 32x32 analog and digital router. Connect two RIOGrandes with CAT5 or fiber for a great 64x64 mixer/router system.

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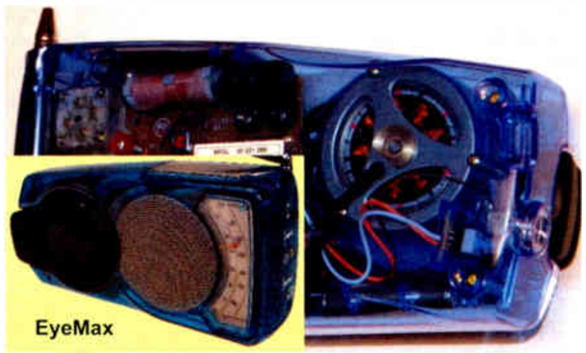
LIGHT, RADIO, EVEN WEATHER

Freeplay's EyeMax radio offers FM/AM tuning, a high performance speaker, impact recessed controls and rugged construction. The radio comes in two models – FM/AM and FM/AM Weatherband, which offers seven NOAA channels. The EyeMax also has a small flashlight, making it a perfect dual purpose companion for field work.



The alternator is the heart of the Freeplay power system, as shown in this EyeMax model.

For those of you looking for more features, the Summit radio has four wavebands (FM/MW/SW/LW) with digital tuning, LCD digital display panel with backlighting and 30 station presets. The preset capability is useful for remote broadcasts where interviewers and interviewees need to hear the home station at the remote site.

Both the EyeMax and Summit models include a high performance solar panel that provides power to the radios, as well as AC/DC adapters. Superior to the competition in terms of operating time output and per wind-up input, these radios play for approximately 30 minutes with a 30-second wind and 20-25 hours when fully charged.

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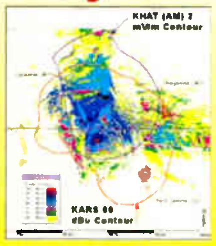

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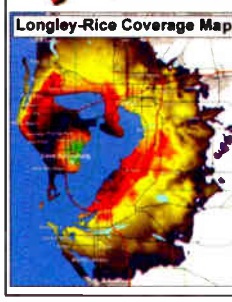

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Radio Guide Ads: April - 2006

Steve Gordoni Appointed Audemat-Aztec Sales Manager

Audemat-Aztec has announced that they have hired Steve Gordoni as North America Sales Manager. Gordoni will be in charge of developing the sales and reinforcing the relationship with dealers in the US and the Canadian Markets.

"Adding a Senior Sales Manager to our team is the next step towards our development goals," states Christophe Poulain, Executive Vice President of Audemat-Aztec Inc.

"Steve Gordoni has been working in the industry for 30 years. He is a skilled sales and broadcast engineer, and a very valuable addition to our team."

"It is an exciting challenge to join Audemat-Aztec," says Steve Gordoni, regarding his new Sales Manager position. "This company has a history of high-tech products and is listening to the needs of the market. I'm really thrilled about the new product developments and the opportunities," adds Gordoni.

Steve Gordoni was North America Sales Manager for Orban for the past 5 years.

He also worked at Aphex Systems, 360 Sysytems, Broadcast Electronics and RAM Broadcast Systems as Sales Manager. He was Director of Engineering for WOJO in Chicago.

Steve will be located on the west coast, and can be reached at gordoni@audemat-aztec.com or 805-497-4685

Audemat-Aztec
Phone: 305-249-3110
Web: www.audemat-aztec.com

Kevin Clayborn Appointed Orban/CRL Sales Manager

Circuit Research Labs, Inc., has announced that 13 year Orban/CRL veteran Kevin Clayborn has been appointed to the position of North American Sales Manager, including US and Canada.

Kevin is experienced and knowledgeable in the audio processing business. He was hired as Customer Service Manager by the late Ron Jones in 1993, and has worked within the organization in a variety of key positions for the past several years, including Orban Customer Service Support Engineer and CRL and Avocet Product Manager.

After leaving the Air Force, Kevin worked as a Chief Engineer for an AM/FM combo in Tucson, Arizona. In the year and half he lived in Tucson, he helped put two new FMs on the air and upgraded a third one from a Class A to a Class C.

Kevin comments, "I am looking forward to this new position. I hope to continue the level of support our dealers have come to expect from Orban."

He is available by telephone at 480-403-8321, fax at 480-403-8301, or e-mail at kevin@orban.com

Orban/CRL
Phone: 480-403-8300
Web: www.orban.com

BE HD Radio Seminar Held at NAB 2006 Convention

Broadcast Electronics will hold its fifth annual Las Vegas HD Radio™ seminar on Sunday, April 23, at the Las Vegas Convention Center. [www.bdcast.com]

BE's Las Vegas seminar is the largest attended of the dozen seminars BE holds around the country each year, and will continue the company's education rollout of HD Radio. Included in the discussion will be practical solutions for conversion as well as the latest in transmission and studio technology.

The seminar also will serve as a discussion forum for broadcasters interested in field-tested HD Radio conversion techniques and new developments advancing HD Radio.

BE's HD Radio seminar is free to all interested broadcasters and will be held: Sunday, April 23, 2 - 4 PM, Las Vegas Convention Center, Room N-114

Gear Guide:

April – Towers, Antennas, Phasors, RF Products

Monthly Gear Guide Categories

- **January** - AM-FM Transmitters, Exciters, IBOC
- **February** - Telco, Remote Audio, Codecs, Wireless
- **March** - Consoles, Mixers, Routers, Mics, Furniture
- **April** - Towers, Antennas, Phasors, RF Products
- **May** - Test Equipment, AM-FM-HD Monitors
- **June** - Automation, Digital Storage, Workstations

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Lynx™ – Side Mount IBOC Antenna

www.eriinc.com • 812-925-6000 **NAB Booth N2406**

LYNX™ Dual Input Side Mount Antenna for FM IBOC Operations. From the beginning, ERI has been a leader in the research and development of IBOC FM technologies.

The Electronics Research LYNX Dual Input Side Mount Antenna is designed specifically for FM IBOC applications. This new antenna is capable of transmitting both the analog and digital FM signals without requiring a high loss hybrid combiner, and maintains high isolation between the digital and analog transmitters.

The design meets the current Federal Communications Commission requirement for informal notification of implementation. In addition to the LYNX, ERI provides other solutions to broadcasters' needs including the iBOX™ low, medium, and high power Hybrid Combiners and the Mask-960 IBOC Spectral Compliance Filter.

Jampro Antennas **NAB Booth C1517**

FM Antennas – HD Radio Upgrades

www.jampro.com • 916-383-1177

Jampro Antennas/RF Systems now offers field upgrades to existing FM antennas for HD Radio™ broadcast. Panel upgrades convert many models to dual input Analog/HD inputs. Side mount arrays can be field upgraded to two input, interleaved or different height systems.

And Jampro offers new antennas for every type of HD broadcast. One of the recent HD upgrades was WERN (photo) who uses a JADP cavity back panel system.

Pro Line rigid transmission line (full systems and replacement parts) have been manufactured at the Jampro plant for years. Being on the West Coast, Jampro can ship small emergency parts orders out when many of the East Coast companies are already closed for the day.

Kintronic Labs Inc. **NAB Booth N3211**

Optimized AM Directional Systems

www.kintronic.com • 423-878-3141

WFDF in Detroit, Michigan

Kintronic Labs has invested significant internal R&D funds to develop state-of-the-art AM antenna system network optimization design software to yield maximally flat input impedance characteristics, minimal deviation pattern bandwidth and linear group delay for the current hybrid analog + digital HD radio modulated waveform.

These new design tools are enabling Kintronic Labs AM antenna systems to produce a received sound quality better than ever before. An example of this is Radio Station WFDF in Detroit, Michigan that was designed to accommodate the AM HD digital audio for Radio Disney with 50kW into separate eight-tower day and night patterns.

Kintronic Labs is making every effort to lead the way in providing top quality AM radio broadcast antenna systems for the digital revolution.

Micro Communications **NAB Booth N418**

FM Antennas, Combiners, Filters, RF Switches

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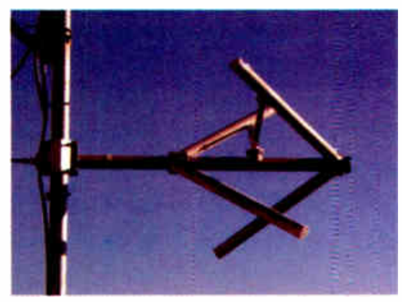


Micro Communications, Inc. (MCI) offers a complete line of FM broadcast products including FM antennas, channel combiners, filters, coax switches and coax components for complete RF systems from the transmitter to the antenna, inclusive.

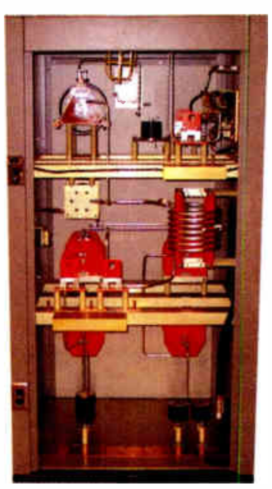
The element displayed is one of the many antennas available. These elements are available for horizontal, vertical and circular polarizations and are broadband from 87.5 to 108 MHz. Depending on the application, elements are selected for top, side or leg mounting and suitable for either square of triangular towers. Elements can be stacked and arrayed to provide various patterns and gains.

The antenna elements have been designed for the most rugged of environments. Reflectors and dipoles are hot dip galvanized steel. The operating temperature range is -40 to +80 degrees C. Fully pressurized feed systems can be provided. Beam tilt and null fill at no additional cost.

Phasetek Inc. **NAB Booth N706**

Antenna Phasing Equipment

www.phasetekinc.com • 215-536-6648



Phasetek's experienced staff of engineers and production personnel are dedicated to provide the Broadcast industry the highest quality, custom designed Antenna Phasing Equipment.

Precise and detailed systems specifications are developed to ensure maximum accuracy and the utmost efficient circuitry. Their staff is available to discuss your Phasor, Antenna Tuning Units, Diplexers, Dummy Loads, and other R.F. system needs with you and/or your Consulting Engineer.

Phasetek's manufacturing facility and components expertise are also available to design and fabricate any type of inductor or special R.F. component. Their Engineering and Production staffs' years of experience and commitment to quality are available to fill any special requirements.

Shively **NAB Booth N1517**

RF Filters and Combiners

www.shively.com • 888-SHIVELY

Shively Labs offers a complete line of filters and combiners for FM broadcasting. Recent additions to the product line include the Model 2600 Series of interdigital bandpass filters and the Model 2900 Series of low power notch and bandpass filters.

Model 2600 filters are ideal for stations with transmitters up to 8 kW in power. Model 2900 filters are designed for applications up to 1.5 kW. Both series of filters are ideal for digital radio implementation and both can be configured into branched and balanced combiners for analog and digital multistation applications. Shively also offers a complete line of patch panels and coaxial transmission line components to complete your filter or combiner installation. For complete mechanical and electrical details on all their filter and coax products, please visit their website.

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