ENGINEERING EXTRA

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NewBay Media

GET IN THE ZONE

Tom McGinley discusses ZoneCasting with the technology's key players. Page 8

Intermodulation Control for Your FM Transmission System

Know your site well to determine the best solution

WHITEPAPER

BY RANDY MULLINAX

The author is senior vice president of engineering, Southeast Region, for Clear Channel Media + Entertainment in Gainesville, Ga.

Filters have been used for the con-trol of intermodulation products caused by "mixing" with other collocated or nearby FM stations virtually since the ption of FM broadcasting. The need ntermodulation control has been on increase due to recent changes in regulatory environment, resulting wer-power (translator and LPFM) ms that are sometimes located near collocated with) high-power FM mission systems with frequency ng as close as 400 kHz in some nces.

LIMITS ON INTERMODULATION

FCC rules require that "spurious and harmonic" products, which include intermodulation products, be attenuated by specific amounts based on the output power of the transmitter as shown in Graph 1. For transmitters operating with an output power of less than 159 watts, the products must be attenuated to 65 dB below the unmodulated carrier level. The required attenuation must be calculated for transmitter powers between 159 watts and 5000 watts using the formula:

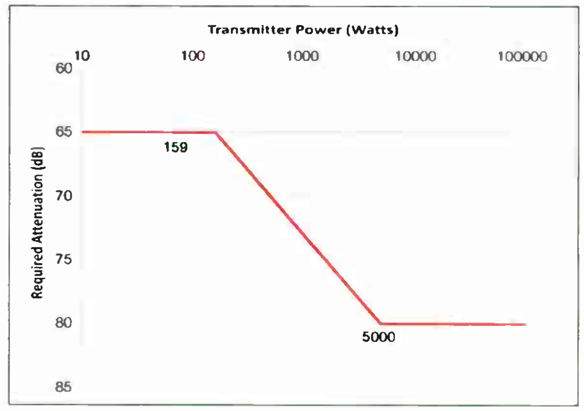
A = 43 + (10logP)

Where:

A = the required attenuation in dB

P = transmitter power in watts.

For transmitter powers greater than 5,000 watts, the required attenuation shelves at 80 dB below the unmodulated carrier level.



Graph 1: FCC limits on spurious emissions as a function of transmitter power.

NOTCH FILTERS AND THEIR LIMITS

In the early years of FM broadcasting, notch filters were most commonly used for intermodulation control, as they required fewer filter sections and were therefore less expensive. Later, bandpass filters came into vogue and continue to be the most common devices used to resolve intermodulation issues. In recent years, primarily due to HD Radio isolation issues, there has been a "newcomer" on the block: the ferrite circulator.

While there is nothing really new about circulators, only in recent years have they become available with power ratings high enough to be useful in FM transmission system intermodulation control.

Notch filters continue to be utilized in some cases but suffer from a significant disadvantage: they protect your transmission system from only one frequency. In addition, they can exhibit significant asymmetrical group delay along with input impedance matching and amplitude variations if the spacing between your frequency and the "notch" frequency is small (generally less than 800 kHz). See Fig. 1.

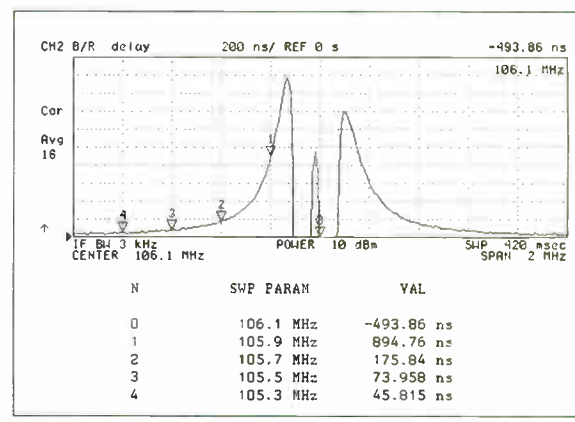


Fig. 1: Group delay measurements on a high-power two-pole notch filter. Note the sharp rise in delay near the notch frequency.

(continued on page 18)

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READER'S FORUM

YES TO INTEROPERABILITY

Regarding Tom McGinley's interview with Kevin Gross in the Oct. 17, 2012, issue of Radio World Engineering Extra:

Thanks for covering this very complex, often misunderstood subject. We couldn't agree more: There is a correlation between QoS and 1 gig infrastructure. That's an important point that is often overlooked in the AoIP interoperability discussion.

As a member of the AES-X192 taskforce, Wheatstone is very much in favor of interoperability standards. In fact, full interoperability is our goal. WheatNet-IP is not interoperable with every studio product yet, but we've come a long way in getting the broadest number of functions to interoperate in a fully integrated way. We've developed enough infrastructure and devices and alliances that make across-the-plant interoperability possible today. We recognize the need for interoperability standards, not just for the stations we serve, but for our own business model as we extend the broadcast network beyond the four walls of the studio.

Thanks for shining a very bright light on this important subject.

Dee McVicker
Marketing and Communications
Wheatstone Corp.
New Bern, N.C.

OTHER COMPUTER TOOLS

I agree that Wireshark is a valuable no-cost tool ("The Power of Wireshark," Dec. 12, 2012). Some readers may know Wireshark as "Ethereal," which is what it was called on release prior to 1.0.

I would like to also recommend another useful free software tool called "Ping tool." It can be downloaded at *www.colasoft.com*. There are additional free tool on the colasoft website as well.

Rolf Taylor
Telecom Engineer
NPR
Washington

GUY WIRE AND 'NATIONALIZATION'

Two visions? Nationalization vs. localization (Dec. 12, 2012)?

Perhaps you have missed the real question so you can't reach a legitimate answer. It's really "plastic" vs. real. Whether a conglomerate is local or regional it is all the same. Same songs, same cue cards DJs, same branding, same teasers, same long stopsets, same computers, same fascination with social media, hence same boredom.

Nothing fresh. Nothing spontaneous. Nothing real. Today is just like yesterday and tomorrow, and you will show me no new music or reason to stay tuned.

Then you talk of "leveraged." Fancy word for "you paid way more for this than the ads can support and you figured some fool would come along and be even more foolish." You can only cut so much, and then you have nothing. Once the candy bar is down to "funsize," you have to raise the price or you can't have paid too much to start with.

What will happen? Nothing. Why? Because you have to trust your staff to do the right thing. No one does, so it becomes computer-controlled like fast food. Because they are so leveraged, top brass is scared to death to make a non-focus group decision. Can't take a risk like that with a $25 million property.

Yes, there was a lot of bad local radio. But not all counties were "dry," so to speak. And you could find some good stuff with a good antenna. Now it's like Prohibition. All the local beers are gone. The conglomerates are like the G-Men, and the listening public is working up a powerful thirst.

When radio becomes interesting companionship again, the thirst will be quenched. The Internet and smartphones can't do that even if they wanted to. We just need to want to.

Jim Jenkins
Owner/General Manager
WAGS(AM)
Bishopville, S.C.


RADIOWORLD ENGINEERING EXTRA

GUY WIRE

Nationalization vs. Localization

Two views duel for the future of radio

BY GUY WIRE

What we have shaping up is a battle of two very different operating philosophies. Which one will better allow radio as a business to survive and prosper in the future?

ADVERTISER INDEX

THIS ISSUE

FEBRUARY 20, 2013

Time to Look Our Best

Adoption phase over, broadcasters need to show off HD Radio system

BY MICHAEL LECLAIR

Just since December, when I last wrote about HD Radio, it seems that new energy is being breathed into the format. The technology had a significant presence at the Consumer Electronics Show, and sales figures continue to climb: 4.5 million radios in year 2012 alone, according to Bob Struble of iBiquity. This is especially encouraging because these increased sales are being driven by a resurgent automobile industry. HD Radio needs car receivers to move consumers to adopt this technology.

HD Radio's Booth at the 2013 Consumer Electronics Show

Photo courtesy of iBiquity

It also appears that multicasting, the ability to offer extra radio channels with one license, is finally beginning to develop traction with niche broadcasters. This is an ideal technology for foreign-language broadcasting, for example, a large portion of which has been confined to the greatly inferior SCA systems developed 50 years ago. For a modest investment, it is now possible to reach millions of people with programming that might not be popular enough to justify the huge investment for an analog FM service, and at an audio quality to be proud of. Many stations such as NPR affiliates have shown that if people want a particular niche format, they will buy the radios to get it.

WHY PUSH NOW?

Here at RWEE, we have covered every aspect of the HD Radio system and followed the technology as it has improved over the years. HD Radio has improved in every aspect of deployment from its early days, including cost, efficiency, simplicity and reliability. This is especially true of the FM version, which always held more promise than the AM version.

Reasons to avoid investing in HD slowly have been disappearing. Over the last four years, when capital investments in radio hit a low point due to the recession, technology improvements continued to be introduced, but few stations had the budget to upgrade. As we are exiting a recession and capital budgets are being restored, it is a good time to look at HD Radio again.

The first wave of digital investments began in about 2003, so it has actually been about 10 years since the introduction. If you are one of those stations that jumped in at the beginning, it is time to update. There are lots of new features and capabilities now.

Most important, growing numbers of listeners and radio dealers are watching us closely at the moment. It is important to impress this group or they will lose interest and set the whole process back again. And that could be the end of radio's dominant position in media, which we have enjoyed for so many years.

DASHBOARD COMPETITION

While many in our industry feel that analog is and always will be good enough, it is hard to for me to continue to believe this.

It is in response to the weakness of the radio industry that so many new technologies have come to pass and been accepted enthusiastically by consumers. Digital music storage and transmission, portable music listening devices, satellite radio and now Internet radio have all developed as ways to pull apart the dominance of the old radio system, which is mostly a memory at this point. These new technologies offer consumers more choices and more control over what they hear and when. If the radio industry does not evolve to meet this competition, it eventually will lose its audience. The slow erosion is staring us in the face already.

> **Growing numbers** of listeners and radio dealers are watching us closely at the moment.

Perhaps the most important battlefield for consumers is in the automobile dashboard. Radio had an incredible advantage over other technologies for many decades, as it was the only way to get to mobile listeners with new or fresh content. This isn't true any longer. In my opinion, it is the car listeners that will decide the winner from amongst the mobile options that are now proliferating in the latest autos. This will then move the home market.

DRESS TO IMPRESS

So let's put on our best and show our new audiences just what we can do with digital. It's time to improve your digital coverage with higher power HD — with the new car radios, you can get further than your existing analog. Get that time alignment into shape, for goodness sake. Think about ways that messaging, and even graphics, might add to your station. Buy some new radios for the staff and maybe play around with some new formats on that multicast channel. Check out the interactive radio software that can make a direct connection to your listeners.

To help this effort, we plan to offer a regular column of HD Radio tips and tricks for the 2013 year. I hope that you enjoy them, and we welcome any tips and suggestions that readers wish to offer. Since this is an engineering publication, we will tend to concentrate on the technology side of HD, but all submissions are welcome. If I get enough of them I can build a column from just reader suggestions. Write to me at *rwee@nbmedia.com*.

Michael LeClair is chief engineer for radio stations WBUR(AM/FM) in Boston; he has been technical editor of Radio World Engineering Extra since its inception in 2005.

READER'S FORUM

DILIGENCE IS GOOD

I thought Cris Alexander wrote a comprehensive article on due diligence, definitely using a lot of good techniques ("Due Diligence Heads Off Acqusition Surprises," Dec. 12, 2012).

Expanding further on his AM station with a night signal "too good to be true," I would recommend any person performing due diligence on an AM station perform a detailed inspection of the station. Make sure the antenna current/common point matches licensed values and impedances, verify both daytime and nighttime operation and patterns. Observe timely pattern switching like Cris did at night. And, with cooperation of the prospective buyer, for directional stations make sure all phase, loop and monitor points are measured and in compliance with the most current license on file with the FCC.

Doing this homework ahead of the purchase can save the future licensee a lot of headaches and possible fines for violations once the FCC has approved the transfer of control.

Alan Jurison
Senior Operations Engineer
Clear Channel Media + Entertainment
Syracuse, N.Y.

The author is a contributor to Radio World.

STL Antennas — Too Much Height?

BY JEFFREY GEHMAN

Did you know that microwave STL antennas can be too high?

A microwave signal can reflect off of water, as shown in the exaggerated drawing in Fig. 1.

If both antennas are within line of sight of water, and the water is in an unfortunate location, two signals can arrive at the receiving antenna — one from the transmitting antenna and one from the reflection off the water. If the reflected signal arrives out of phase with the direct signal, it can cause the received signal to be severely degraded or even unusable.

This problem can be solved by intentionally blocking one of the antennas from the over-water reflecting path. Trees are often a good source for intentionally blocking a path, but terrain and taller buildings can also serve the purpose. In Fig. 2, we simply lowered the height of the transmit antenna to cause the trees to block the path towards the water, which will eliminate the reflected signal.

The reflective medium does not have to be water. A swamp, a marsh or even a flat pasture might cause a reflection. Make sure you have enough height to clear the Fresnel zone, but don't install the antennas higher than necessary without investigating reflections.

Jeffrey Gehman is engineering associate at Kessler and Gehman Associates in Gainsville, Fla.

Send your story ideas or tips to rwee@nbmedia.com.

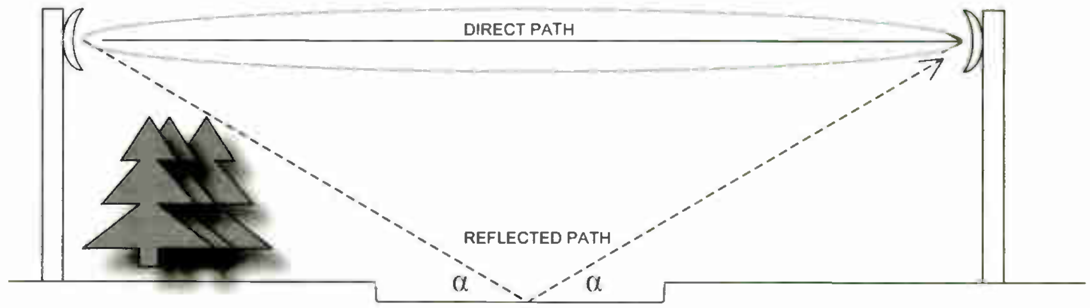


Fig. 1: An STL path with water reflection.

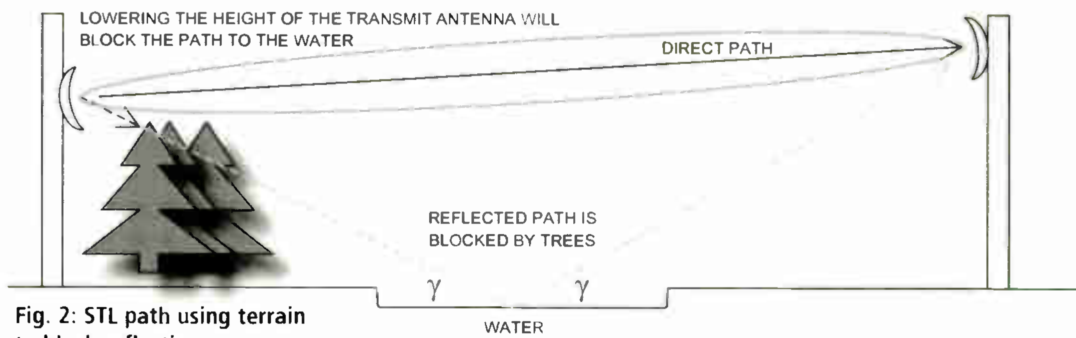
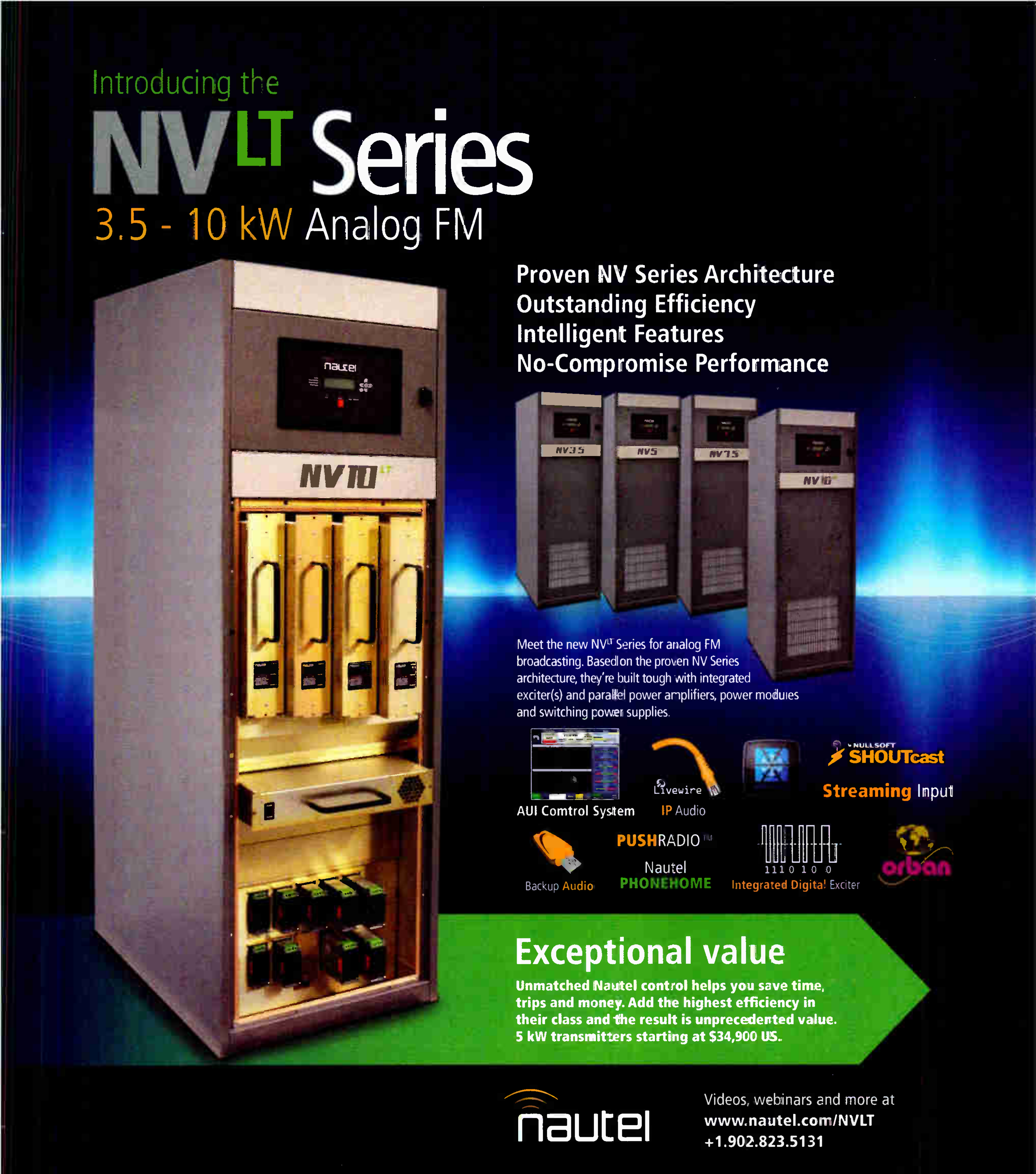


Fig. 2: STL path using terrain to block reflections.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ZoneCasting Offers New Techniques In Localized Broadcasting

Principals discuss system design and future tests with RWEE

BY TOM MCGINLEY

The industry first heard about ZoneCasting at the 2012 NAB Show. Radio World has been covering the developing story since, and a lot has happened over the past 11 months.

Most engineers are familiar with on-channel FM boosters and repeaters using Harris SynchroCast and other systems. ZoneCasting has evolved from that technology but is also able to geo-target areas inside a station's coverage area with replacement commercial and other programming content.

Harris's recently unveiled cousin, "MaxxCasting," does not broadcast different content to the geo-targeted areas, but uses many of the same innovations and techniques.

GeoBroadcast Solutions invented ZoneCasting and has worked with Harris Broadcast to fine-tune optimal implementation of this technology. The expertise of NPR Labs has also been enlisted to assist in this effort.

We recently talked with the key players from GBS, Harris Broadcast and NPR Labs who are working to bring this innovation to market. Their plan includes more real-world testing and eventual FCC acceptance.

GeoBroadcast Chief Executive Officer Peter Handy and Chief Technology Officer Bill Hieatt answered our questions about their latest developments. Also participating in our email interview were Aaron Shainis of Shainis and Peltzman, legal counsel to GBS; John Kean, senior technologist of NPR Labs; and Rich Redmond, vice president of strategy and product management for transmission systems at Harris Broadcast.

RWEE: *The promise of ZoneCasting will deliver targeted over-the-air ads or messages with different content into segmented zones within the overall coverage area of a given radio station. Explain the advantages of this technique and what it potentially means for the overall radio industry.*

Peter Handy, GBS: The advantages that the ZoneCasting technology will deliver to FM radio stations are, but are not limited to, the following: Commercial content will be more relevant to the listener. FM radio stations will have more inventory to sell while delivering the same amount of non-commercial content. Local retailers and advertisers will have the opportunity to be more efficient with their ad spend. FM station owners will have more potential advertisers by as much as two times their current customer base.

The potential for the overall radio industry is exceptional. Stations that implement the ZoneCasting system could grow their top line revenue by 20 percent or more per year. Listeners may be more inclined to listen through a commercial if it is more local (relatable) in nature. FM stations may reverse the oversupply curve by creating more demand due to the increased number of customers and local advertisers may see an increase in the results produced by their radio ad schedules.

RWEE: *The industry first heard about ZoneCasting at NAB 2012. Tell us in a nutshell how it works.*


Peter Handy


Rich Redmond

Rich Redmond, Harris: The successful use of synchronous on-channel boosters requires a combination of advanced technology for transmission of a signal and careful network design to ensure the desired area of coverage is achieved while at the same time mitigating any undesired interference to the primary station or others. The ZoneCasting family of solutions takes this technology to the next level to allow for the delivery of different localized content to specific geographic areas using a network of on channel boosters.

If we were to compare this to a lighting example, you might think of how you would light up a stadium for a night game — you ring the field with focused high-intensity lights focused on the field. All the energy is direct to the playing field; you are not trying to light up the parking lot. A traditional broadcast approach to lighting would be to put a high power omnidirectional light high above the field, as you end up lighting up the field plus everywhere else.

John Kean, NPR Labs: The system's potential success depends most on a thorough understanding of synchronized repeater operation and its capabilities: Its operation relies on sound physical principles that are better optimized than previous on-channel designs.

RWEE: *Engineers who have worked with boosters and repeaters know that terrain shielding is needed to make single-frequency networks work well. While ZoneCasting does not depend on terrain shielding, the areas where signal strengths of the on-channel transmitters are about equal will create interference or "mush zones." ZoneCasting has developed some new and unique methods to reduce mush zone interference. One apparently involves reducing or muting the booster transmitter's power during common programming periods. Please tell us a little about this.*

Redmond: Boosters within the ZoneCasting network operate in a combination of full-time and part-time modes. Boosters that are full-time operation

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Radio Automation...

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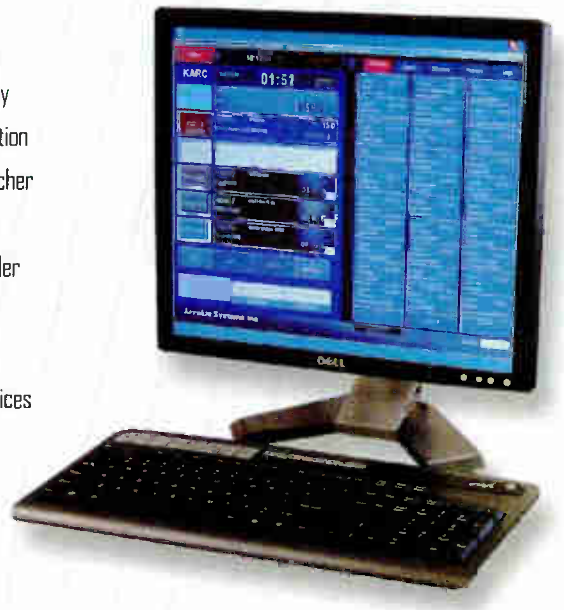

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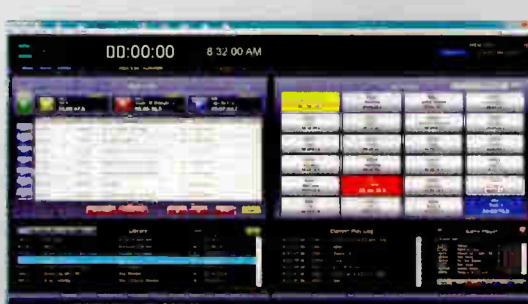

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ZONECASTING

(continued from page 8)

serve to both maximize coverage of the primary signal and support the localization of content. These full-time boosters carry the same content as the primary station most of the time, and then switch programming to the local content during segments of localization.

Other boosters only operate during the times of local content insertion to cover a certain area with the local content, and then turn off once that content is completed. This operation is interfaced with the station's digital audio system and controlled by the GBS ZoneCaster issuing commands over the Harris Intraplex SynchroCast system, and is time-aligned along with the audio content typically over an IP network.

John Kean

RWEE: *What role do NPR Labs and John Kean play in this partnership?*

Kean: NPR Labs has several roles with GeoBroadcast Solutions. The first is to determine the optimal parameters for ZoneCasting and MaxxCasting network design, including coverage design parameters for the network nodes. NPR Labs has extensive experience with signal propagation models, mapping and field verification, and is providing technical information on its own geographic mapping tools for designing a multimode network in all types of terrain.

An equally-important consideration is compatibility of the network with the primary transmitter signal, which shares within the station's authorized service contour. The NPR Labs team has conducted carefully-designed listener tests to determine the threshold time-of-arrival and signal ratio parameters for the "mush zone" resulting from synchronous transmitter operation. The testing covered mobile and fixed FM reception, and included combinations of primary-to-node and node-to-node signal propagation.

A third role for NPR Labs is to integrate the performance and compatibility data into computerized models to optimize system designs. We use the ESRI ArcMap system for its versatility in building geomathematical models and its wide range of GIS data for mapping and demographic analysis. For each minute grid-point on the study map, our terrain-sensitive model considers the arrival of signals from multiple nodes as well as the primary transmitter to compute the reception quality. This system allows us to reliably predict where "mush zones" will occur and adjust the design for the best integration with the primary station's signal, population served, etc.

NPR Labs has developed a calibrated FM signal measurement system for mobile field verification of signal coverage. Our fourth role will be to collect performance data and received audio from working systems and analyze it for system improvements. [See Figs. 1 and 2.] We may also conduct listener testing experiments to provide scientific verification of operating systems.

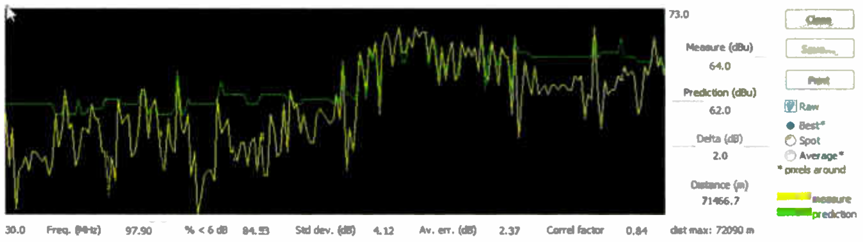

Fig. 1: WRMF's signal measurement is seen in yellow, with green showing what has been predicted before signal correction.

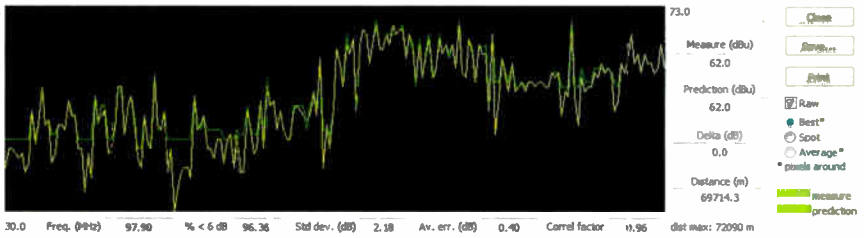

Fig. 2: Following the collection of field data, propagation parameters including diffraction factor, clutter heights and clutter absorptions are collected. This makes the measured vs. predicted correction a much more accurate model when matching the field data, and provides a highly accurate model for use in booster design and placement.

RWEE: *ZoneCasting adapts the cellular telephone model of using low-power repeater transmitters that cover defined limited coverage areas. What power levels and antenna heights will be suitable for a typical large market that may want to deploy this?*

Kean: The techniques developed for cellular telephone network site selection serve ZoneCasting and MaxxCasting networks, as well. Using moderate antenna height and power, many commercial rooftops and tower sites used in cellular industry are candidates for the nodes. Because of the number of nodes required, and because site selection requires interaction with the RF designer, "site acquisition" is handled by GBS' real estate specialists as part of a turnkey implementation. This ensures that the optimal sites are selected efficiently and cost-effectively.

ZoneCasting and MaxxCasting network design varies with each station, depending on its environment and the station's objectives for service. While the power, antenna height and site density can vary widely there are some general parameters for design. For example, network nodes should be easy to site, using existing commercial buildings and towers. Radiated power should be low enough to avoid restrictions for human exposure to RF, which, with moderate elevations tends to limit ERPs from 500 to 5000 watts.

Using highly directive antennas, GBS is able to use sites with only standard mains power and minimal equipment space. Antenna heights are typically only 25 to 40 meters above ground, to control the coverage of each node and avoid spilling signal across distant nodes or into areas to be served by the primary transmitter. GBS is developing an antenna with much higher front-to-back ratio than currently-available models as a tool for efficient designs.

Node-to-node spacing may range from one to five kilometers, depending on terrain and building density. Although the area of a network "zone"

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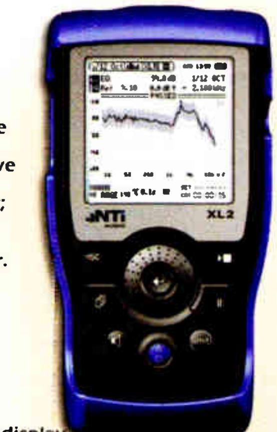

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ML1 Minilyzer
Analog Audio Analyzer

The ML1 Minilyzer is a full function high performance audio analyzer and signal monitor that fits in the palm of your hand. The comprehensive feature set includes standard measurements of level, frequency and THD+N, plus VU+ PPM meter mode, scope mode, a 1/3 octave analyzer and the ability to acquire, measure and display external response sweeps generated by a Minirator or other external generator.

Add the optional MiniLINK USB computer interface and Windows-based software and you may store all tests on the instrument for download to your PC, as well as send commands and display real time results to and from the analyzer.

- Measure Level, Frequency, Polarity
- Automatic THD+N and individual harmonic measurements k2 – k5
- VU + PPM meter/monitor
- 1/3 octave analyzer
- Requires optional MiniSPL microphone for SPL & acoustic RTA measurements
- Frequency/time sweeps
- Scope mode
- Measure signal balance error
- Selectable units for level measurements

MR-PRO Minirator
High performance Analog Audio Generator + Impedance/Phantom/Cable measurements

The MR-PRO Minirator is the senior partner to the MR2 below, with added features and higher performance. Both generators feature an ergonomic instrument package & operation, balanced and unbalanced outputs, and a full range of signals.

- High (+18 dBu) output level & <-96 dB residual THD
- Low distortion sine waves
- Programmable stepped or glide sweep
- Pink & white noise
- Polarity & delay test signals
- User-generated custom test signals & generator setups
- Impedance measurement & speaker power calculation
- Impedance measurement of the connected device
- Phantom power voltage measurement
- Cable tester and signal balance measurement
- Protective shock jacket

MR2 Minirator
Analog Audio Generator

The MR2 pocket-sized analog audio generator is the successor to the legendary MR1 Minirator. It is the behind-the-scenes star of thousands of live performances, recordings and remote feeds. With its new convenient thumbwheel control system and ergonometric package design, the MR2 is the compact and economical choice for a high performance analog source.

- Intuitive operation via thumbwheel and "short-cut" buttons
- New higher output level (+8 dBu) & low distortion
- Programmable Swept (chirp) and Stepped sweeps
- Sine waves
- Pink & White noise
- Polarity & Delay test signals
- Illuminated Mute button
- Set outputs in Volts, dBu or dBV
- Hi-res backlit display
- Balanced and unbalanced outputs

DL1 Digilyzer
Digital Audio Analyzer

A handheld digital audio analyzer with the measurement power & functions of more expensive instruments, the DL1 Digilyzer analyzes and measures both the digital carrier signal (AES/EBU, SPDIF or ADAT) as well as embedded digital audio. In addition, the DL1 functions as a smart monitor and digital level meter for tracking down signals around the studio. Plugged into either an analog or digital signal line, it automatically detects and measures digital signals or informs if you connect to an analog line. In addition to customary audio, carrier and status bit measurements, the DL1 also includes a comprehensive event logging capability.

- AES/EBU, SPDIF, ADAT signals
- 32k to 96k digital sample rates
- Measure digital carrier level, frequency
- Status/User bits
- Event logging
- Bit statistics
- VU + PPM level meter for the embedded audio
- Monitor DA converter and headphone/speaker amp
- Audio scope mode

DR2 Digirator
Digital Audio Generator

The DR2 Digirator not only generates digital audio in stereo & surround, it is a channel transparency and delay tester as well, all condensed into a handheld package. Delivering performance & functionality challenging any digital audio generator made today, it produces all common audio test signals with sampling frequencies up to 192 kHz and resolution up to 24 bit. The Digirator features a multi-format sync-input allowing the instrument to be synchronized to video and audio signals. In addition to standard two-channel digital audio, the DR2 can source a comprehensive set of surround signals.

- AES3, SPDIF, TOSLink, ADAT outputs
- 24 bit 2 channel digital audio up to 192 kHz SR
- Sine wave with stepped & continuous sweeps; White & Pink Noise; Polarity & Delay test signals
- Dolby D, D+, E, Pro-Logic II, DTS and DTS-HR surround signals
- Channel Transparency measurement
- I/O Delay Measurement
- Sync to AES3, DARS, word clock & video black burst
- User-generated test signal files

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This simple setup runs rings around any other AoIP network - at any price...

Our BLADES carry out your orders network-wide at Gigabit Ethernet speeds - no bottlenecks

As an integral part of the WheatNet-IP Intelligent Network, BLADES interface, move, bend, shape, route and control everything you want to do with your audio. If it's audio, a BLADE will handle it - at lightning speed.

Use them organically with our control surfaces, run them from our Glass-E software wherever you have internet access, or control them from the front panels. BLADES make your life incredibly easy and secure.

As you need more functionality, just plug in more BLADES - they come in configurations to handle whatever you need (analog, digital, a/d, mic, MADI). Each BLADE is self-configuring and has the DNA of the entire self-healing network.

With BLADES, you can do everything from a simple (or complex, if you like) snake to STL-over-IP to full-on multi-studio/facility networking - even processing. And because of Wheatstone's partnership with the top suppliers of automation and remote gear, you'll have control over your entire system right from WheatNet-IP. Ruling the world has never been easier.

And this is ALL the extra stuff you need to wire-up the Intelligent Network:

Four CAT-6 cables and a low-cost switch that handles the gigabit speed WheatNet-IP runs at. Let's do the math - plug in eight connectors, power up a console and three BLADES, add your audio and you are ready to rock, roll and rule the radio world. Brilliant, you ask? Nah - just really, really intelligent.

Want to know more?

WheatNet-IP outperforms the other AoIP systems exponentially and is, by far, the most reliable network you can get. Log onto wheatip.com. There is a world of real information there. Or, give us a call. There's nothing we like better than talking about this stuff.

EVERY BLADE FEATURES

Two 8x2 stereo virtual Utility Mixers that can be used for a wide range of applications; for example, using Wheatstone's ACI Automation Control Interface, your automation system can control the mix for satellite or local insertion switching

Front panel bar graph meters switchable to display source input level or destination output level after gain trim

Front panel routing control — any system source to any destination on that BLADE

Front panel headphone jack with source select and level control — monitor any system source

Flexible GPI logic — 12 universal logic ports, programmable as inputs or outputs, routable throughout the entire system

Built-in web server
so you can configure and control locally or remotely without having to run dedicated software

SNMP messaging for alerts

Silence detection on each output that can trigger alarms or make a routing change

Silent — no fans — can safely be located in a studio with live mics

phone 1.252.638-7000 | wheatstone.com | sales@wheatstone.com it's called The WheatNet-IP Intelligent Network and it absolutely rules.

Meet the LX-24...Wheatstone's flagship, multi-award-winning advanced modular networkable console control surface

The design initiative behind the LX-24 was to create the world's finest control surface. The result is a console that redefines the entire genre. The LX-24 is an intelligent surface that can store and recall all your settings. Its totally modular design lets you configure it exactly as you like – you can even hot-swap modules at any time without having to reconfigure.

Assign any source of any type anywhere on your network to any fader. Each input channel can be assigned to four stereo busses, plus four pre/post-selectable aux sends, a stereo CUE bus, four mix-minuses and the panel's own bus-minus. Full Vorsis EQ and Dynamics let you sculpt and control your sound with the quality of the finest dedicated outboard processors. The visually-stunning meter bridge features up to four sets of bright, high resolution LED meters, as well as circular LED displays for auxiliary send levels and pan control. A digital count-up/count-down timer is also included.

The LX-24 is advanced in ways that can make a HUGE difference in your capabilities. But it's also immediately familiar to anyone who has ever sat behind a board at a radio station. Use it to make your programming the best it can be. Just plug it into your WheatNet-IP Intelligent Network – with it, and the BLADES across the page, you can, dare we say it, rule the world.

THE LX-24 CONSOLE CONTROL SURFACE FEATURES

Low-profile table-top design - no cutout required

Meter bridge with up to four bright, high-res LED meter sets

Control room and headphone outputs with level control and source selection

Two independent studio outputs

Stereo cue speakers and amplifier, built-into meter bridge

Onboard VGA and USB-Mouse connectors

Event storage (snapshots) and recall

Each input channel features:

- Four stereo bus assigns
- Four pre/post-fader aux sends
- Four mix-minuses
- Bus-Minus
- Source name display
- A/B source selector
- 2 programmable buttons
- Vorsis EQ and Dynamics including 4-band parametric EQ, High- and Low-Pass filters, Compressor and Expander/Noise gate

Wheatstone

ZONECASTING

(continued from page 10)

is almost unlimited, a typical zone serving a community may require from five to 20 nodes.

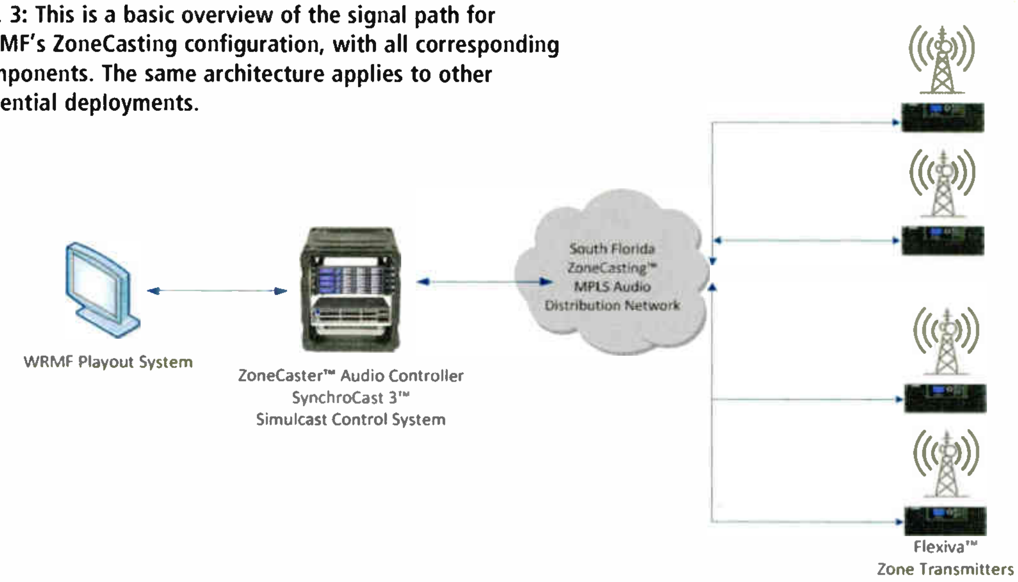
RWEE: *How will ZoneCasting networked transmitters be linked together and fed with both common and different programming?*

Redmond: The Harris SynchroCast system used in the ZoneCasting solution has the flexibility to work over a variety of networks. In North America T1 circuits (similar to E1 circuits in the rest of the world) have been the most popular for building single-frequency FM network connectivity. Recently Harris has introduced SynchroCast3 to support the use of IP networks. All of these network types can be used over wired or wireless networks to allow for the maximum flexibility in system design.

RWEE: *How will the different program content intended for specific zones be inserted and conveyed to their respective transmitters?*

Redmond: The content for both full-time and part-time boosters will originate at the studio and be distributed over the SynchroCast network. Content targeted for full-time boosters in an area of localization will switch from a simulcast of the main transmitter to locally targeted content. The part-time boosters will only be sent content during the periods of local content insertion. [See Fig. 3.]

Fig. 3: This is a basic overview of the signal path for WRMF's ZoneCasting configuration, with all corresponding components. The same architecture applies to other potential deployments.



The control of timing is a critical factor in any SFN network of boosters. Over time many have attempted to use a variety of fixed delays to adjust the network for proper time alignment, only to find that changes in the link, either wired over a public network, or wireless over a microwave, vary in actual operation, turning the once aligned network into a series of transmitters causing interference.

Only the Harris SynchroCast system supports real-time adaptive delay to ensure the critical SFN calibration is not affected by changes in performance of the network. Transmitters and the studio location are all referenced to GPS. This reference both time-stamps the audio and control signals carried on the SynchroCast system, as well as the frequency of the transmitters, pilot and pilot phase of the integrated stereo generator. By using the GPS reference, we can be certain that all the transmitters operate on the exact same frequency along with the stereo generator located at each transmitter site, a critical first step for a successful booster.

The second use of the GPS reference is to power the real-time adaptive delay. The important part of delay control is to align the time the audio arrives at a listener's receiver in an area of overlap between transmitters with the same content. The delay of each transmitter is different based on location, terrain, building density and total time it takes the audio to travel from the studio to the farthest transmitter site. Proprietary software is used to calculate the exact delay required for each transmitter in the network to optimize overage. Once installed, the system is adjusted based on field measurements to dial in system performance.

RWEE: *A ZoneCasting announcement last spring indicated that system testing had been conducted in Utah and that additional testing would be done during the summer in Sebring, Fla. Tell us more about the results of those tests.*

Bill Hieatt, GBS: The two tests conducted represented two different ends of the variety of conditions that we anticipate for ZoneCasting implementations.

Our initial tests in the Salt Lake City region consisted of four zones, each covered by an autonomous booster. This FM broadcast region had already been in place for a reasonably long time and interference between the zones had been minimized through the use of terrain shielding as well as Intraplex SynchroCast synchronization. We found that it was not necessary to modify any RF broadcast parameters, at any booster site, to implement and test the ZoneCasting concept.

Bill Hieatt

Conversely, the system in Sebring, Fla., was built from the ground up as no boosters or zones initially existed. And because terrain shielding was not available, it was obviously more difficult in terms of engineering and implementation. It became invaluable with respect to developing our simulation models and understanding what we needed going forward in such an environment.

In both tests, we initiated the engineering design based on published standards for synchronized audio in SFNs such as those from the ITU, but in Sebring, we found we needed to make our own modifications. The design includes typical RF engineering parameters such as radiated power, antenna array azimuths, downtilt and simulcast differential time delays. By using considerable field data measurements we optimized the mathematical modeling of our computer simulations. We were then able to "predict and move" our transition areas (from the main coverage to the ZoneCasting zone) to areas with little population or automobile traffic.

Once we were comfortable with our modeling of the ZoneCasting System, we were subsequently able to experiment with different techniques such as switching to monophonic transmission during a ZoneCasting advertising spot.

During the tests we found it important to use an FCC-approved calibrated receiver with a calibrated antenna and GPS receiver to log the audio samples. The transition area that exists between the ZoneCasting region and the main broadcast transmission area appears as multipath noise to the FM receiver. Most car audio manufacturers will compensate for channel conditions such as multipath fading by reducing stereo separation and/or changing the audio processing, and it was important not to be biased by any particular FM car receiver. This subsequently prompted us to fund truly pioneering additional research that has been conducted by NPR Labs.

The most difficult challenge that we faced in terms of implementation was the distribution of the localized audio content to the ZoneCasting boosters. Because we send linear uncompressed audio to each booster, QOS issues such as delay and jitter are crucial, and very close cooperation with the WiMAX service providers was required. Although versed in Quality of Service requirements due to their other user's applications, such as VoIP and gaming, careful examination of the audio distribution should be done. Depending on the area, a permanent installation may be better suited using licensed RF or copper/fiber connectivity.

RWEE: *Your recent press release identifies WRMF(FM), Palm Beach Broadcasters in West Palm Beach as the next station that will install ZoneCasting for more extensive testing early in 2013. Can you share the details of that effort and partnership?*

Handy: The proposed partnership with Palm Beach Broadcasters in West Palm Beach is currently in the design phase for a network for WRMF(FM). The system we are designing is somewhat complicated, as the zone we are looking to cover is relatively large. WRMF may be one of the best stations in the state of Florida and it certainly has one of the best signals. The design we are working on has been modified several times, and we believe the latest schematic will accomplish the needs of our client. If we are correct, we would hope to begin the build out of this network within the next six weeks. [See Figs. 4, 5 and 6.]

RWEE: *How many zones will be needed and at what power levels to achieve the WRMF coverage objectives?*

(continued on page 16)

Fig. 4: This graphic shows the FCC-defined service contour for WRMF. It is a graphical representation of where the ZoneCasting tests will happen in southern Florida.

ZONECASTING

(continued from page 15)

Handy: Our first buildout for WRMF will be one zone, which covers a portion of Broward County. Ultimately, WRMF will have ZoneCasting coverage of all of Broward County. However, this in all likelihood will be a two-step process. The first zone will have approximately 30 transmitter sites with each transmitter site broadcasting at power levels of less than 1,000 watts. The multi-site low power design creates minimal interference while at the same time delivering signal coverage that not only covers the listening area, but does so with a cleaner signal than what the listener currently gets from the main transmission site. In other words, the station will now have the ability to run geo-targeted content, delivering more relatable content and will be doing so with better audio quality.

RWEE: *ZoneCasting deployment will require special FCC approval, rules modification and licensing. What is the status of the petition with the FCC to allow booster stations to transmit programming that is different from the main channel?*

Aaron Shainis, GBS: Shainis & Peltzman, Chartered is the principle regulator counsel to GeoBroadcast Solutions. At present time, ZoneCasting has requested pursuant to a rulemaking filed with the FCC to make a minor modification to the FCC's rules to allow origination of programming on booster stations. That rule making has been pending for about six months, which is not unusual.

It is anticipated that a Notice of Rule Making will be issued sometime during the first half of 2013. That notice will seek comment from the public on the proposal, but it is generally thought that the matters contained in the petition are not controversial, so adverse comments are unlikely. The preliminary comments files shortly after the request for rulemaking was filed were supportive.

With respect to the experimental authorizations for the WRMF tests, the engineering for the applications for the boosters are currently being finalized. The applications for permanent booster facilities will be filed and those are generally granted within two months. Once they have been granted, built and licensed, the commission will entertain the request for experimental authorization. Our experience in obtaining other experimental authorizations relative to ZoneCasting is they generally are granted within a matter of weeks after filing. I believe that WRMF will be treated no differently.

RWEE: *Broadcasters interested in ZoneCasting are all wondering what the ball-park costs of adding this enhancement to their markets might be, on a per installed booster site basis.*

Redmond: There are three major areas of costs associated with the ZoneCasting system.

The first is the licensing and network design costs. Part of the key to the success of ZoneCasting is the use of special planning tools to create a targeted zone of transmitters to cover a certain area while at the same time minimizing any impact to other zones or the main signal. These costs are variable depending on the number of zones a station wants to target, and the number of sites needed to cover the zone. These costs are part of an upfront licensing fee that will vary by market size. In addition there is a small revenue share associated with the use of the GBS patented technology, which is similar to an agency commission for the incremental revenue the systems generates.

The second portion of costs is related to the distribution of audio to the various sites, and the actual transmitters and antennas needed. While these too vary based on the power needed at each site, a basic site of equipment is about $39–55K plus installation. There would also be some equipment needed for the studio location, and is similar in cost to that of the transmitter site.

The third area of cost is the ongoing tower rental, data circuit charges and electricity needed to run the sites. The costs here are related to the number of sites and the part of the country you operate in, but as these are low tower sites they are typically in the hundreds of dollars per month range.

Tom McGinley is a longtime radio broadcast engineer and technical adviser to Radio World.

Comment on this or any other story to rwee@nbmedia.com.

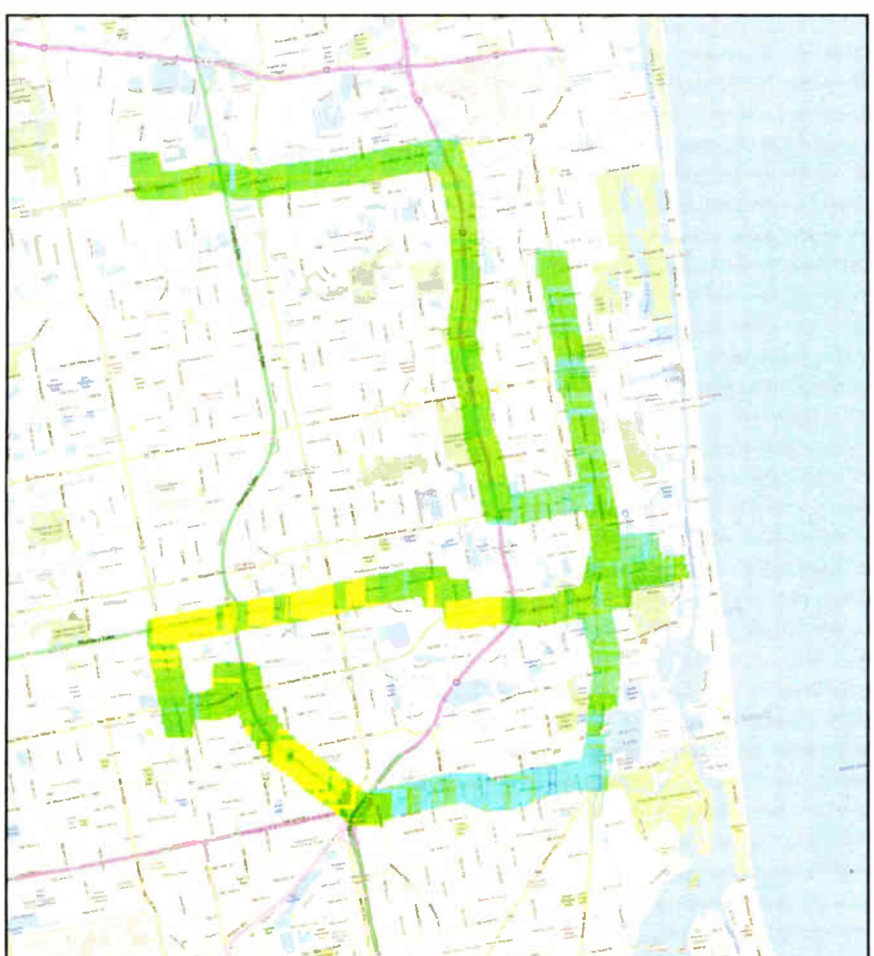


Fig. 5: This map shows a sample of a drive test to show data of the measured RF signal. This represents the southern portion of the market where the initial tests will happen.

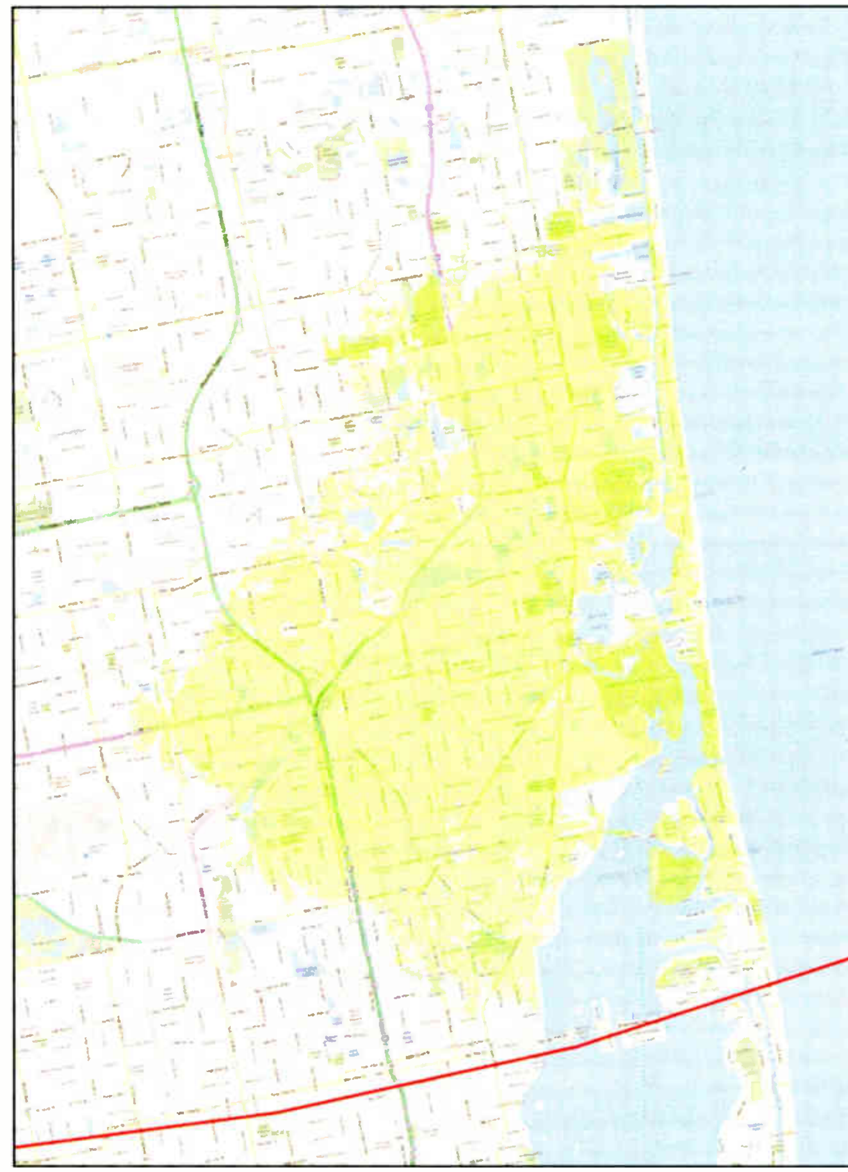


Fig. 6: This map highlights the total coverage area of the ZoneCasting trials for WRMF, covering the Miami, Fort Lauderdale and West Palm Beach areas.

Fins 'n Fire: The 5671 Broadcast Transmitter Tube

BY JIM HAWKINS

I first saw these glowing giants, below, as a young ham on a visit to WNEW(AM) 1130 kHz in New York in 1966.

During World War II, these tubes were used to create RF power for induction heating, hardening engine parts for military vehicles. After the war, these proven amplifier tubes were put to widespread use in 50 kW AM transmitters by RCA and Westinghouse.

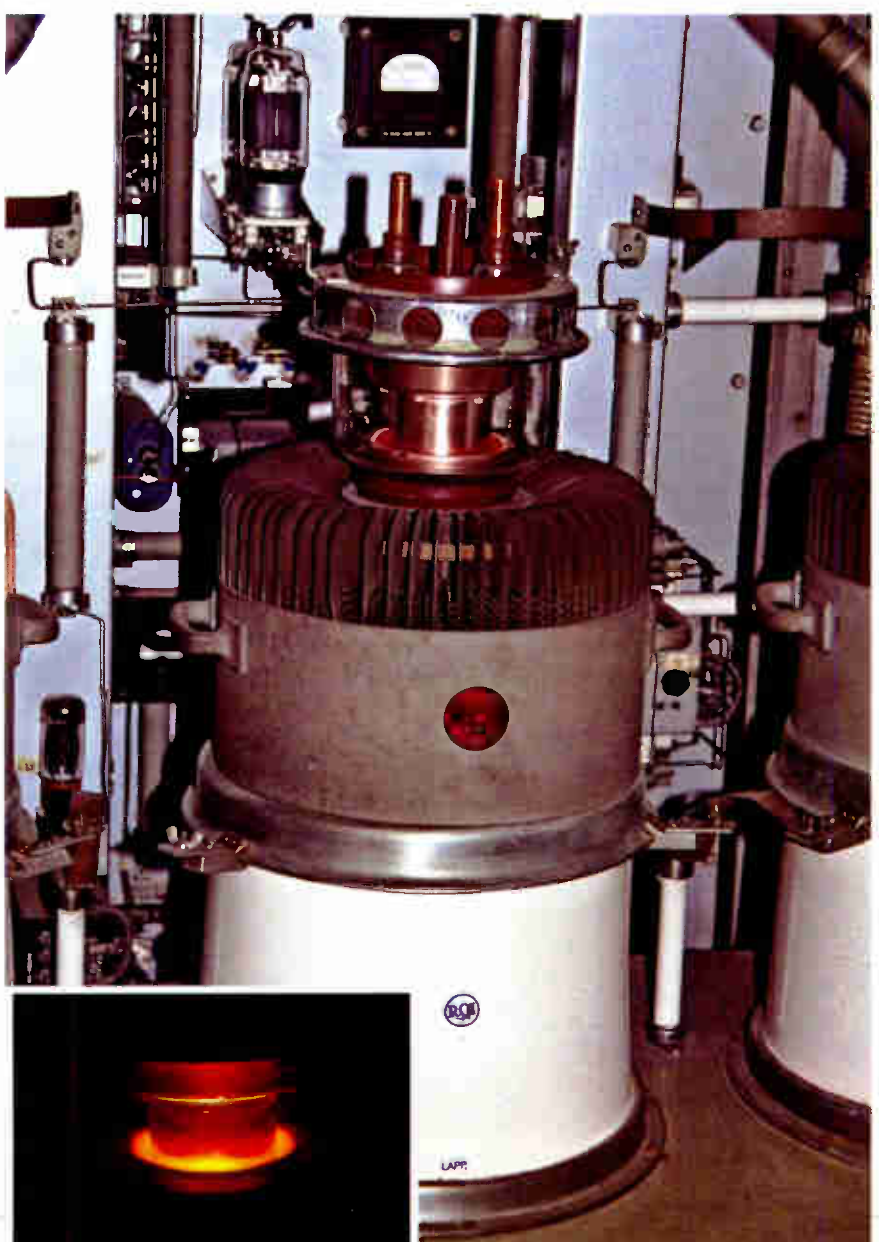
Derived from the earlier water-cooled 9C22, the first generation of 5671 tubes weighed about 350 pounds. They were redesigned with half as many cooling fins, reducing the weight to 225 pounds by perforating the fins (visible in the photo). The 5671 is removed and replaced using a custom manual forklift.

The photo shows a "hot" spare sitting in a porcelain air cooling chute in an RCA BTA-50F at WKNR(AM), Cleveland, taken during a 2001 visit. The inset image shows the glow in the dark.

By the 1970s AM broadcast transmitters evolved with more efficient designs, eliminating the need for these tubes.

Some of these tubes found a home in museums and private collections. (See Tube Collector magazine, February, 2001, "The 5671" by Ludwell Sibley; visit *www.tubecollectors.org*.)

Jim Hawkins is a radio enthusiast. Visit his home page hawkins.pair.com *for images of broadcast technology, ham radio and more.*



INTERMODULATION

(continued from page 1)

When using notch filters, you should avoid the temptation to "treat the symptom" as opposed to "curing the disease." Even though it may take an additional stage of filtering, it is important to remove the source of the intermodulation (notching the frequency of the station that is causing the IM) vs. trying to notch out the product frequency that is coming from your transmitter(s).

An example where this was unsuccessfully tried is shown below. Two stations were being combined using a single "constant-impedance" combining module. I assume it was initially believed that due to spacing between stations, which was greater than 4 MHz, the 30 dB or so of isolation provided by this arrangement would be sufficient. However, a spur was being produced at 90.3 MHz and a single-stage notch filter was installed to "notch out" the product.

I'm sure that if intermodulation measurements were done with both of the transmitters unmodulated, no problem would have been detected. However, when both were modulated, the calculated "carrier" frequency of the product was notched out, but the modulation products remained at a level that was not in compliance with FCC rules. The stations involved shall remain nameless and the problem has since been corrected. See Fig. 2.

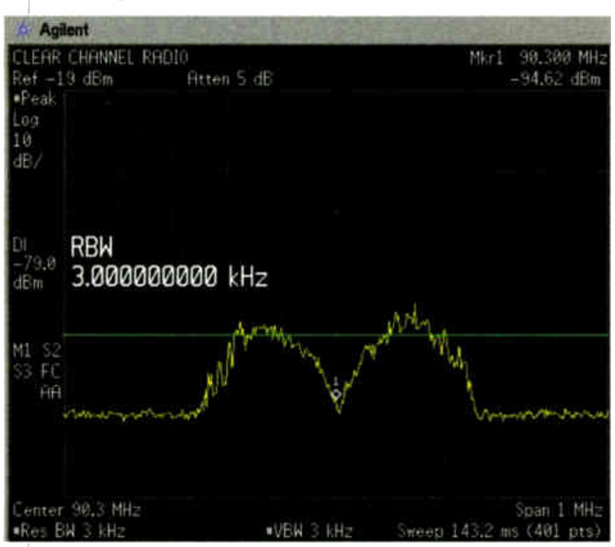


Fig. 2: Spectrum analyzer display of intermodulation products generated by two carriers under full modulation. Note how the intermodulation products extend to both sides of the 'notched' carrier, creating illegal spurious components.

BANDPASS BETTER

Bandpass filters provide isolation over a wide range of frequencies but have limitations when the "interfering" frequencies are closely spaced. As can be seen in the response characteristic of a low-power three-pole bandpass filter (Fig. 3), isolation is poor for frequencies closer than about 800 kHz. While the purpose of this measurement was to show the amount of isolation (65 dB) at 4.8 MHz above the frequency of operation, it is easy to see that significant isolation is available closer to the transmitter frequency. The approximate values of isolation based on frequency spacing are as follows:

1.0 MHz	25 dB
2.0 MHz	42 dB
3.0 MHz	53 dB
4.0 MHz	60 dB

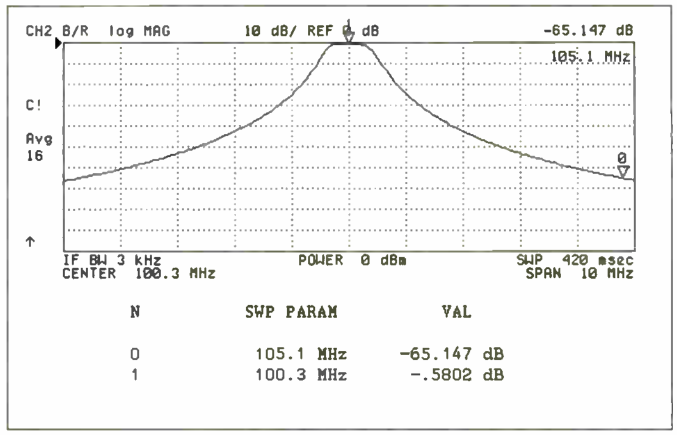


Fig. 3: Low-power three-pole bandpass filter response.

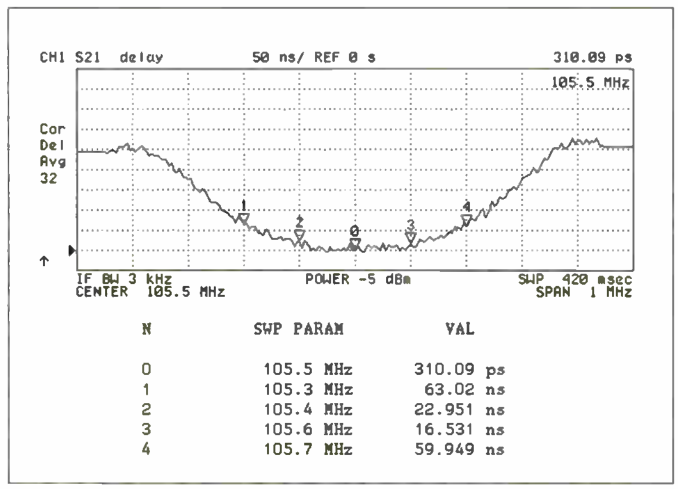


Fig. 4: High-power three-pole bandpass filter group delay.

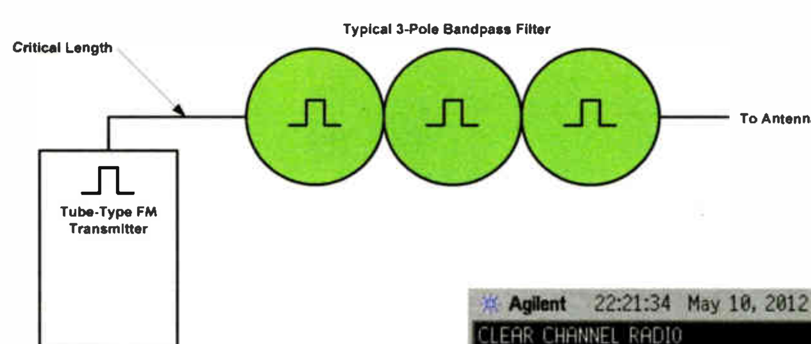


Fig. 5: Diagram of transmitter connected to three-pole bandpass filter showing critical length.

A larger number of bandpass cavities, cross-coupling (also referred to as non-adjacent coupling), or a combination of bandpass and notch cavities are sometimes used to provide steeper filter skirts to improve isolation at the more closely spaced frequencies.

Bandpass filters typically exhibit symmetrical group delay characteristics. Fig. 4 shows the group delay of a high-power three-pole filter. The symmetry is excellent within the desired pass band with the group delay rising to a value of approximately 60 ns at 200 kHz on either side of the center frequency.

PING PONG PROBLEM

Beyond low isolation for closely spaced frequencies, the major disadvantage of "single-ended" bandpass filters is possible interaction between the resonant output circuit of a tube-type FM transmitter and the filter. This interaction or "secondary resonance" is often referred to as a "critical length" issue since it is a function of the length of the transmission line between the output of the transmitter and the input of the filter. See Fig. 5.

There are several ways to describe how this interaction occurs; I often refer to as a "ping-pong" issue.

A class-C amplifier creates a great deal of RF noise over a wide range of frequencies. One function of the output cavity in a tube-type transmitter is to attenuate the noise, but some noise energy will be coupled into the transmission line at the output of the transmitter. For the purpose of this discussion, let's assume that this RF noise is removed from the transmitter frequency by about 1 MHz.

When the transmitter is coupled into a "single-ended" bandpass filter, the noise will travel down the transmission line, but since it is outside the pass band of the filter, it will be reflected back to the transmitter. Since the noise is also outside the pass band of the transmitter cavity, it will be reflected again. If this reflection is in-phase with a component of the noise being produced by the transmitter, it will increase in amplitude and the process will repeat continuously resulting in a spurious signal of considerable amplitude. This spurious signal will "mix" with the original transmitted frequency producing additional products in the typical "Christmas Tree" fashion (see Fig. 6).

Since the reflected power metering circuits of the transmitter are not frequency-specific, these spurs cause an increase in

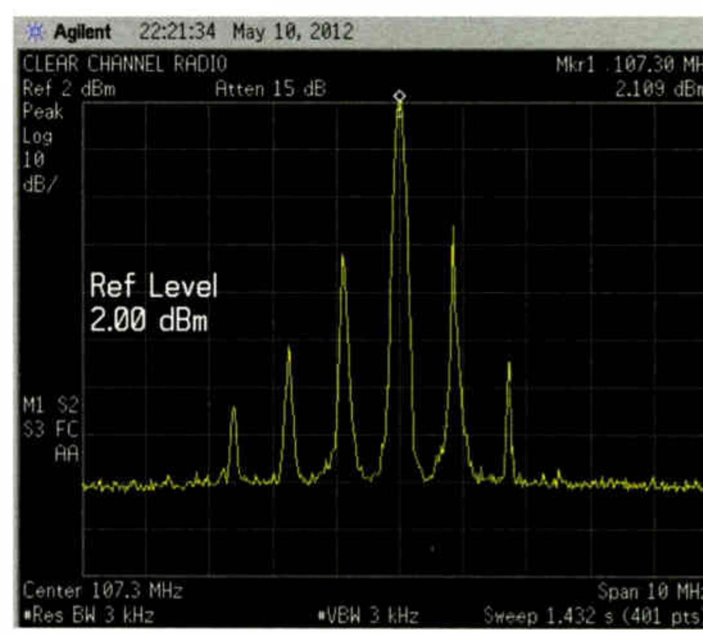


Fig. 6: Spurious products produced by a tube-type FM transmitter operating into a 'single-ended' bandpass filter ('Ping-Pong' issue).

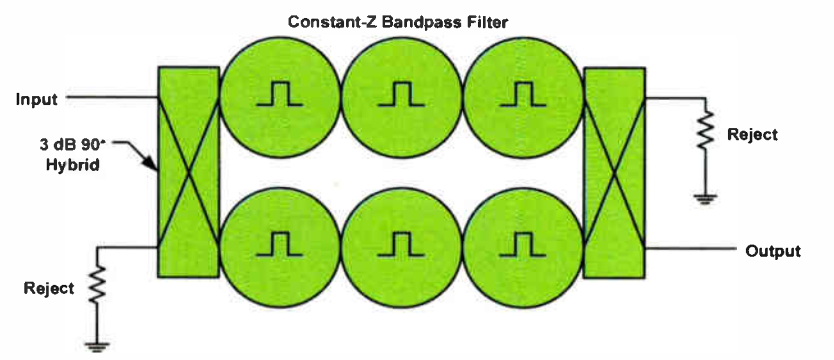


Fig. 7: A constant impedance bandpass filter requires twice the number of cavities of a conventional bandpass filter and the addition of two four-port hybrid sections.

Fig. 9: Circulator installed in an FM broadcast facility.

Fig. 8: 'Trombone' line ahead of a bandpass filter.

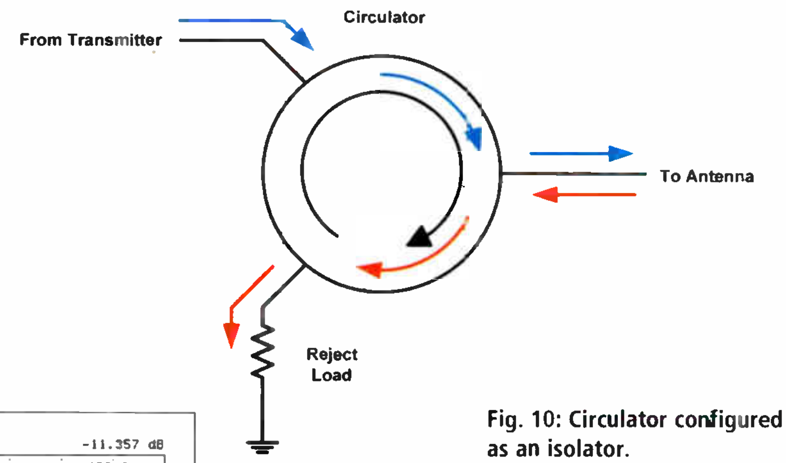
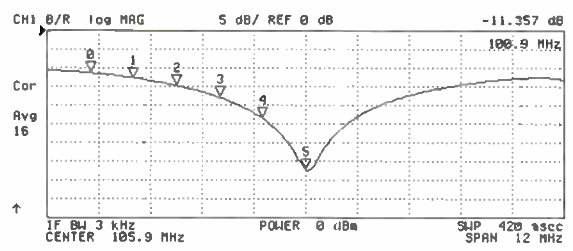


Fig. 10: Circulator configured as an isolator.

the reflected power reading of the transmitter and often cause VSWR trips or foldback to occur. One way to avoid the problem is by utilizing a broadband solid-state transmitter that does *not* incorporate a resonant output circuit that rejects out-of-band energy. Another solution is to use a "balanced" or "Constant Impedance" bandpass filter (see Fig. 7).

While the Constant-Z arrangement is common in high-power combiner applications, it is seldom seen used just as a bandpass filter due to both cost and the amount of space required. As opposed to the single-ended type, this arrangement requires twice the number of bandpass cavities plus two 3-dB 90-degree hybrids and two reject loads.



N	SWP PARAM	VAL
0	100.9 MHz	-11.357 dB
1	101.9 MHz	-12.686 dB
2	102.9 MHz	-14.74 dB
3	103.9 MHz	-17.943 dB
4	104.9 MHz	-23.562 dB
5	105.9 MHz	-37.301 dB

Fig. 11: Circulator isolation vs. frequency.

LEARN THE TROMBONE

The most common solution to the "critical length" problem seems obvious: Change the length of the transmission line between the output of the transmitter and the input of the bandpass filter. While it *sounds* like a simple solution, it often takes quite a bit of effort to accomplish. To make it a little easier, I typically install a trap or "trombone" line at the input to the filter as shown below (see Fig. 8).

The total length of the line should be changed in increments of about 4 inches until the "ping pong" products disappear. The transmitter loading control will have the greatest impact on these products and can be adjusted on either side of its optimal setting to make sure there is some range over which the products do not reappear. I typically fabricate two line sections at each of the following lengths: 4, 6, 8 and 16 inches. These can be ganged together using unflanged couplers.

Once the optimal length has been determined, single pieces of line can be cut to replace the pieces that were ganged together, producing a more professional looking installation.

A CIRCULATOR IS AN ISOLATOR

When the frequency spacing is close, a ferrite circulator configured as an "isolator" may be the only way to achieve good performance (See Fig. 9).

Circulators can be used in a number of different applications. When one is installed with a reject load on one port and is used to "isolate" a transmitter from energy entering through the transmitter's output port, the correct term is "isolator" (see Fig. 10). In this configuration the majority of any energy directed back toward the transmitter from the antenna will instead be routed to the reject load as shown in the diagram below.

Isolators typically provide 30 dB or greater isolation at their operating frequency but as can be seen below, the isolation drops off quickly as the frequency changes (See Fig. 11). In this case, the isolation has dropped by almost 14 dB at 1 MHz from the center frequency. As

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INTERMODULATION

(continued from page 19)

devices that are relatively new to FM broadcast, there are a number of "dos and don'ts" to get used to. It is commonly known to make sure the device has adequate power handling capability, but some requirements are less obvious.

When an isolator is being used, it requires some type of reflected power monitor at the output of the circulator (see Fig. 12) to monitor the condition of the antenna and transmission line. The reflected power monitor in the transmitter will be unable to detect an increase in antenna or transmission line VSWR due to the isolation provided by the circulator (the reflected energy is routed to the reject load).

Ferrous metal can interfere with the magnetic properties of a circulator, so follow the manufacturer's recommendations for mounting the device. Stainless steel and aluminum mounting hardware are typically recommended and most manufacturers provide some means to adjust the "magnetic circuit" of the circulator, but specialized test equipment may be required.

One final and often ignored issue is that circulators may under certain operating conditions create harmonic energy. At the very least, each installation should be tested to ensure that any harmonics at the output of the circulator are below the maximum allowed by FCC rules. Typically, only the second harmonic is produced, which can be "trapped" out with a quarter-wave shorted stub located after the circulator (Fig. 13). While the stub is usually the less expensive solution, a number of manufacturers can also provide low-pass or harmonic filters to resolve the problem.

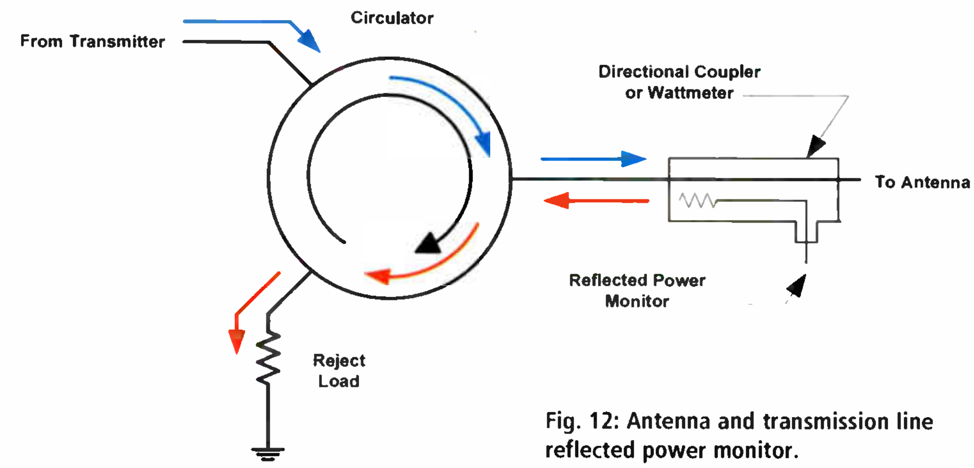

Fig. 12: Antenna and transmission line reflected power monitor.

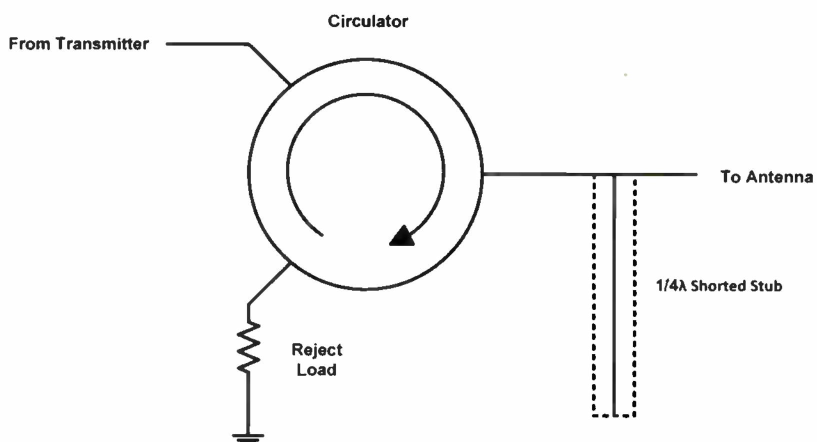

Fig. 13: Isolator with quarter-wave shorted stub at output.

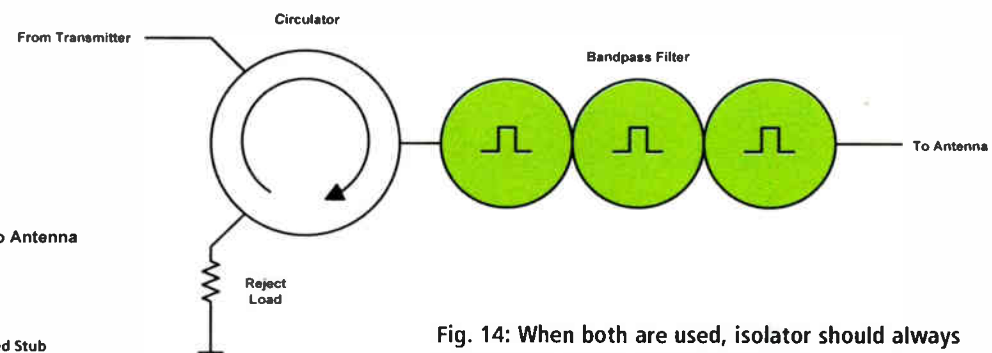

Fig. 14: When both are used, isolator should always be installed ahead of bandpass filter.

THE WHOLE ENCHILADA

In cases where protection is needed from frequencies both close to and farther away from your transmitter's operating frequency, the use of both a bandpass filter and an isolator may be the best solution. If this is done, the bandpass filter should always be installed after the isolator as shown in Fig. 14.

In this configuration, you get the best of both. The bandpass filter will provide attenuation of any even-order harmonics produced by the circulator and the circulator will resolve any critical length (or ping-pong) issues that might exist from the use of a single-ended bandpass filter.

While the need for intermodulation control in FM transmission systems is undisputed, there are a number of hardware options to consider, and each type has strengths and weaknesses. The manufacturers of filters and related products can provide a wealth of assistance. To determine the optimal configuration a thorough knowledge of the specific site conditions is needed.

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SINE

(continued from page 22)

A brute force method of calculating the value is to take an estimate of the value using known samples at even intervals. For example, if we choose nine values (see Fig. 1 again) we get that the RMS value for a triangle wave equals approximately:

$$\sqrt{\frac{0+\frac{1}{16}+\frac{1}{4}+\frac{9}{16}+1+\frac{9}{16}+\frac{1}{4}+\frac{1}{16}+0}{9}} = 0.5528$$

By increasing the number of samples, we would find that the value converges to 0.577 (try this and see if you are curious). Fig. 1 shows how the above values are derived.

This reduced effective value makes logical sense as there is less area "under the curve" for a triangle wave when compared with a pure sine wave.

So answer (c) was the most correct.

If you'd like to explore sine and triangular waveforms more, one of the better explanation explorations from an infinite number of Internet locations is a paper by Kenneth B. Cartwright; we've posted the link to it at *radioworld.com/links*.

Once again, "Schaum's Outline of Electric Circuits" and Dr. Frederick Terman's multitude of textbooks thoroughly cover the subject.

CLASSIC BUC BOGUS

Our two excellent editors (and managers) let me have some fun cooking up these bogus answers. Your humble author really got out of control on this issue; all answers but the correct entry were really bogus.

Answer (a) is wrong as peak and RMS are very different values. Answers (b) and (e) read well but are gobbledygook.

Answer (d) is a super bogus entry made up of pieces and parts from the "equation" section of my Microsoft Word program. Doesn't this equation have that official and scholarly patina? It looks devastating, but means nothing.

The next SBE certification exams will be given at NAB on April 9. Closing date for signing up for the exams is March 22. If you are interested and ready to take the exams, we strongly suggest that you sign up soonest as the next following exams are scheduled for June in the local chapters.

Remember a dream is just a dream … a goal is a dream with a plan and a deadline. So get yourself and your confreres motivated to become certified or advance a grade today.

Charles "Buc" Fitch, P.E., CPBE, AMD, is a frequent contributor to Radio World. Missed some Certification Corners or want to review them for your next exam? See the "Certification" tab under Columns at radioworld.com.

You Impede Me, Coaxially

Question for next time

(Exam level: CPBE)

What factors determine the characteristic impedance of coaxial transmission line?

a. Diameters of the inner and outer conductors.

b. The speed of light divided by the wavelength of use, all over the square root of the unit ratio areas of the surface of the inner and outer conductors, if you want to be *really* exact.

c. The square root of the individual diameters of the inner and outer conductors multiplied together, divided by the constant K, which is the velocity factor of the manufactured material.

d. 0.707 times the equivalent impedance of a waveguide of comparable area as the outer conductor; this is an important relationship for circular to rectangular waveguide converters.

e. The fine impedance value is factory-set by the density and spacing of ceramic spacers.

Just Sine Me in, Scotty

A Question of Peak Performance

Question from the Oct. 17 issue

(Exam level: CRBE)

What is the mathematical relationship of the peak voltage and the RMS voltage value of a uniform triangular waveform?

a. The peak value and the RMS value in volts are numerically equal

b. The peak value is the sine value and the RMS value is the cosine value of the square root of 12 times Vp to p in volts

c. The RMS voltage value is the peak voltage value divided by the square root of 3

d. $\text{RMS E} = \sum_{k=0}^{n} \binom{n}{k} Vp^{n-k}$

where n is the number of cycles considered (normally based on a nominal 1 second or the waveform frequency) and k is Boozeman's constant (after Victor Boozeman) normally rounded to 1.57 or $\pi/2$

e. RMS E = Vp times the square root t divided by T where T is the duration of the waveform (nominally ¼ of the cycle) and T is the total count of cycles or the frequency of the waveform

BY CHARLES S. FITCH

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

In our attempt to kindle interest and involvement in the Society of Broadcast Engineers' certification process, we have been moving methodically through a selection of topics highlighting the grades and specialty certificates offered in the program. We hope this has provided our readers with the confidence that one can be successful and stimulated the desire to obtain certification.

This issue's column is a return to basics, designed to focus and strengthen your grasp of fundamentals. Mastery of them is a notable element of the SBE CRBE exam.

VOLTAGE MEASUREMENT

Of the two voltage universes that we have at our disposal, alternating current (AC) is undoubtedly the dominant. Direct current (DC) is sort of a stepchild and is used mostly in the broadcast realm for device power and control.

The measurement of DC essentially is just one parameter, an instantaneous peak voltage, plus or minus, normally from the reference point of zero volts or ground.

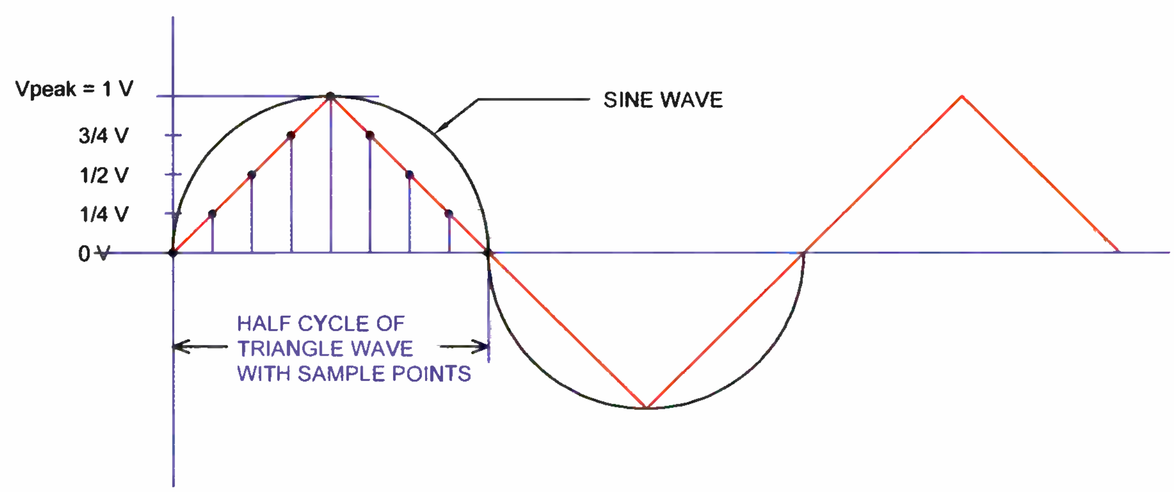

Fig. 1: RMS Value of Uniform Triangle Wave

In contrast, AC waveforms can only be described by mathematical analysis. It usually requires trigonometry for pure sine waves and functional derivatives for more complex, non-sinusoidal waveforms. For discussion purposes, let's focus on pure sine waves for a moment and leave the complex waveforms for a CPBE question.

In the meantime, we'll look around nearby for a pure sine wave to study. Let's put our fingers in the outlet on the wall for a 60 Hz sine wave (just kidding). Fig. 1 is a drawing of a single cycle of a pure sine wave such as you would find on the power line with related proportional voltage levels. Since this wave is symmetrical (equal +/– potential) around a zero voltage axis, we could measure its peak value in one polarity only, or its peak-to-peak value.

Another way to consider it would be its average voltage. If we took the average of the entire envelope, that would be zero as the positive and negative polarities cancel out. So let's take the average of half a cycle. A statistical iteration of a nearly infinite number of evenly phased spaced (say 1 degree of advancement) would give us an average value of 63.7 percent of the peak instantaneous value.

Already you can see that AC voltage measurements are somewhat more complex than DC, and for most of us to keep it simple, we perform our measurements with a meter that does the math for us. What most meters are actually measuring is this average value.

POWER EQUIVALENCE

But is there a numerical value that would be more useful and universal to us than this average value? A common thread between AC and DC is equivalent power.

Humans receive most of their information visually, so let's use a visual analogy. Power up a suitable incandescent light bulb with DC and achieve a reference luminosity of, say, 10 candelas. If that bulb requires 100 volts DC to reach this point, then substituting an AC voltage we discover that a peak value of 141.4 volts would be needed to reach that same 10 candela level. The average AC value turns out to be 90 volts (141.4 x 0.637). This is problematic because if we are measuring equivalent levels of power (luminosity), we would expect to measure equivalent voltages.

To rationalize the numbers at 100 volts between DC and AC, we create a new value of 100 volts AC which, by convention, we call the "effective value" or 0.707 times the peak value. As previously mentioned, although your trusty Simpson 260 might be actually registering average voltage, the AC scales are calibrated in this effective value.

Now we can work backwards, and in doing so, we identify that an infinite number of voltage samples of the sine wave added up to the 0.707 relationship indicates the RMS value of the sine wave. The RMS value is not quite the same as the average value; it is the square root of the mean of the squares of the sample values, sometimes called the *quadratic mean*.

OK, SO THIS WAS A HARD ONE

In previous discussions of exam-taking strategies, one caution we urged repeatedly is to always read the question and identify what is actually being asked. In this case, our question is asking for the RMS value of a triangular wave. If we were to repeat the RMS calculation on a uniform triangular wave, we would find that effective value would be 0.577 as a multiplier or approximately 1.73 as a divisor (actual value is the square root of 3). To solve this exactly requires the solution to something called a Taylor series equation.

(continued on page 21)

WHEATNET IP

THE INTELLIGENT NETWORK

follow the gigabit road

Somewhere in this, the Emerald City, there is an Intelligent Network with more than a million crosspoints connected through a 1,232 x 1,232 audio matrix shared between 21 studios and seven stations, all via AoIP running at gigabit speed. The equipment tally so far: 77 Wheatstone IP88a BLADE access units with 15 Wheatstone control surfaces, 12 crosspoint controllers, three Producer Turrets, 43 Headphone Panels, 23 Mic Control Panels and 45 Mic Processors. Still to come are at least seven more IP88 Blades, 17 mics, 17 headphone panels and 17 mic processors.

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