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Radio World

ENGINEERING EXTRA

October 18, 2006

Dodge Common Snafus With Rules of Thumb

Secure Ground Connections, An Eye on the Supply Can Minimize Technical Difficulties

by Rolin Lintag

The author is chief RF engineer for Victory Television Network in Little Rock, Ark.

If you think most of the technical problems we encounter at the station require rocket science, think again. There are a few basic principles that explain most of the problems we experience. Remembering these basics can actually save our day and keep us from missing our lunch.

SECURE A GOOD GROUND

The ground system is either a path that sinks unwanted signal currents, a safe diversion for lethal currents or a return path to complete a circuit. Problems arise every time the ground system is dysfunctional.

Unwanted signal currents can be sources of RFI that get bypassed by a capacitor, as shown by Fig. 1a. The rule of thumb for the bypass capacitor to work is that its impedance should

SEE BASICS, PAGE 12

WHITE PAPER

An Approach to Common Radiator Implementation of Digital Radio

Dielectric's Fully Symmetrical Antenna Optimizes Isolation, Digital and Analog Impedance Matching

by John L. Schadler

The author is the director of advanced antenna development for Dielectric Communications.

As digital FM broadcast begins to take hold, the most efficient implementation options involve new antenna design technology. Separate radiator systems, such as interleaved, right-hand-polarized analog bays within left-hand-polarized digital bays[1], have proven to exhibit excellent performance for narrow band operation.

For broadband, multichannel operation, common analog/digital radiator solutions offer a suitable method of implementing digital IBOC FM radio, but inherent problems limit the performance of the antennas. This paper will describe the design criteria necessary to achieve equal and superior VSWR performance for both analog and digital operation in a common radiator HD Radio antenna design.

Also discussed will be the requirement for high isolation, which can only be achieved through the reduction of element cross-coupling and radiator mutual coupling. Finally, a unique antenna design will be presented using TQT, Transverse Quadrilateral Technology, to solve inherent issues associated with common radiator antennas.

Initial designs of common radiator IBOC implementation fed the digital signal into the fourth port of a hybrid feeding a pair of crossed dipoles[2] (see Fig. 1). This technique space-combines the digital and analog signals into isolated right-hand and left-hand polarized radiation. The concept allows for field conversion of existing antenna systems, by replacing the three-port hybrids with four-port hybrids and adding a second feed system for injection of the digital signal.

The approach was logical, but there were problems. There was less than ideal isolation, caused by the inherent dipole cross-coupling within the antenna elements and the mutual coupling

> The radiator must minimize the bay-to-bay mutual coupling in order to allow for a symmetrical element design. Without a symmetrical element, balanced digital and analog VSWR performance along with acceptable system isolation cannot be achieved.

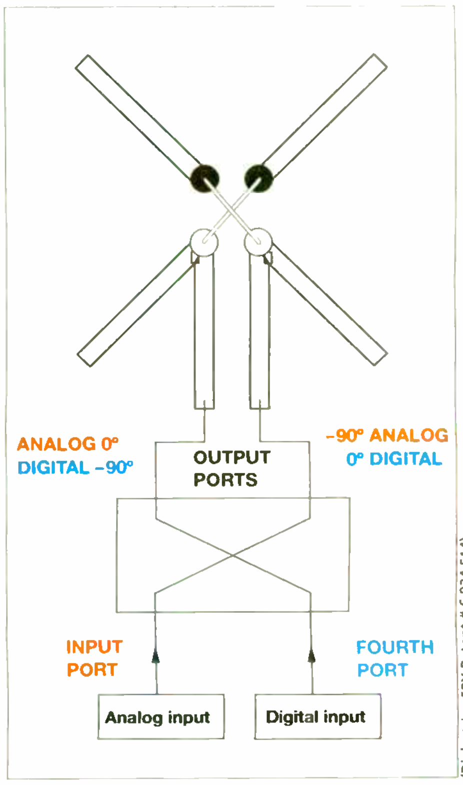

Fig. 1: Common Radiator IBOC Implementation

SEE TQT, PAGE 6

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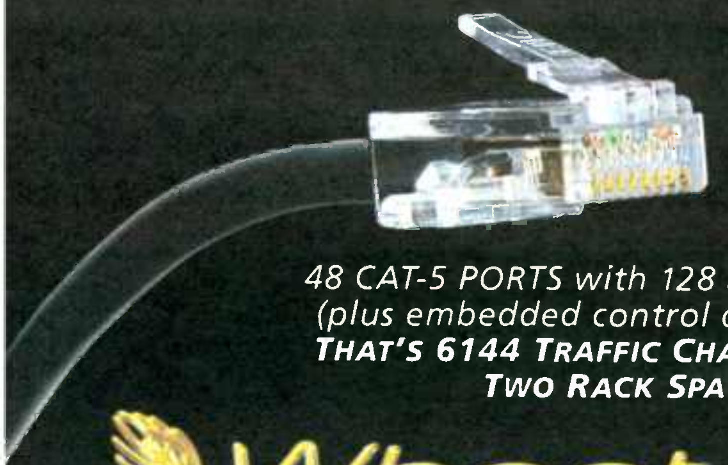

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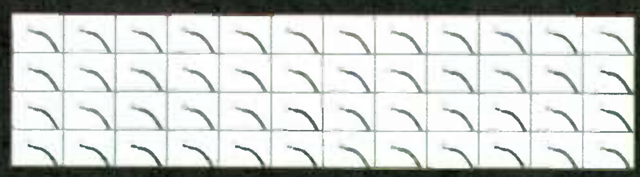

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FROM THE TECH EDITOR

by Michael LeClair

Of Tape Machines And Diversity Delay

How an Old Trick Might Work in a New World

In my August column I talked about adjusting the diversity delay on an FM station to an exact match. Apparently this subject touched a chord in many of you because I received a number of comments from readers about their experiences and techniques.

I used my ears to make the diversity delay fairly close, but it turned out to be quite difficult to get the adjustment perfect in a noisy transmitter room. The final adjustment was made using computer software to measure the time difference between the signals and then using the calculated value to precisely set the analog channel delay. From what I understand, the specification for delay is accurate to around 100 microseconds at the receiver so that is about the best you can do. Matching the analog and digital signals down to this level permits quite seamless transitions between analog and digital signals.

AN OLD TECHNIQUE

It has also been proposed to use an oscilloscope and Lissajous pattern to set the analog delay, a return to an old technique that will be familiar to those who used to maintain analog tape machines. I used to use it on cart machines when I was a young contract engineer.

For the newcomers in the field who may not be familiar with the Lissajous technique I'll explain how it works. It takes a dual-channel oscilloscope with the ability to turn off the horizontal scan and direct inputs to the vertical and horizontal deflection amplifiers. By connecting left and right channel audio to vertical and horizontal inputs respectively, it is possible to produce a display that shows the phase relationship between them.

Tape head adjustment was left to field technicians to maintain as it was impossible to build tape head mounts that were accurate and stable enough without manual compensation.

This was useful when setting up analog tape machines as the tape heads had to be horizontally aligned to within a few microns in order to achieve perfect left and right channel phase on a 20 kHz sine wave. Tape head adjustment was left to field technicians to maintain as it was impossible to build tape head mounts that were accurate and stable enough without manual compensation. By setting up an oscilloscope in the manner described above, a technician could adjust the exact tape head azimuth until the left and right channels were perfectly in phase, even at high audio frequencies.

Perfect phase alignment can be observed on the scope when the trace becomes a diagonal line from the lower left corner of the display to the upper right. A perfect circle on the display means there is a 90 degree difference in phase between channels. A diagonal line running in the opposite direction (upper left to lower right) means that the two channels are 180 degrees out-of-phase.

A perfect circle on the display means there is a 90 degree difference in phase between channels.

So how can this be applied to time diversity? First, the analog and digital signals are closely aligned by ear so that the time difference is less than 180 degrees at audio frequencies. It should then be possible to set the analog time delay to exactly zero degrees by watching the Lissajous display on the oscilloscope. After all, time delay is the same thing as phase shifting an audio signal.

That's the theory. I decided to take a look at how it works in practice so I set up a test of our FM signal. The program material was studio and telephone voice. I knew that the delay was exactly correct so it would be a good test signal, at least as far as time delay was concerned. Unfortunately, what I observed wasn't that useful.

Instead of a nice, clean diagonal line I got an inchoate mess of traces in a kind of circular clump. For those familiar with symphony recording, it looked like what you would see if you observed the phase of a recording that has too much stereo separation and lots of room reverberation.

Interestingly, if I adjusted the time delay off by about 40-50 milliseconds I could see the time delay causing the leading signal to generate a purely vertical trace just before the horizontal trace began to form on the delayed digital audio during the pauses between words. But this was far less accurate than I could do with my ears alone so I don't think using this way of measuring is that effective.

So what happened? I think that the problem was caused by the fact that we are using two different audio processors on our analog and digital audio streams. These different audio processors produce subtle differences in amplitude and phase which show up on the sensitive oscilloscope display as out of phase components.

Additionally, the high frequencies undergo very different processing between the analog and digital signals due to the fact that 75 microsecond pre-emphasis is used on the analog FM side only. The problem was caused by trying to use program audio.

A possible solution to this would be to try pure sine waves. I wasn't able to take the station off the air for that kind of test during the day so I can't comment yet as to whether this would work. I'll have to try tones next.

MORE HD INSIDE

We've got two more white papers in this issue that concern HD radio for FM. Dielectric explains their new FM antenna with improved isolation for dual analog and digital operation. The antenna symmetry concepts are quite interesting. From Ted Nahil at Harris we have an overview of the challenge of building an STL for stations now running two, and even three program streams on HD.

On top of our regular columnists we have an interview with Ron Nott, of Nott LTD, the manufacturers of folded-unipole antenna kits. And we hear again from Rolin Lintag on the basics of maintaining and trouble-shooting a radio station technical plant.

As always, please send your comments and questions at *rwee@imaspub.com*. ■

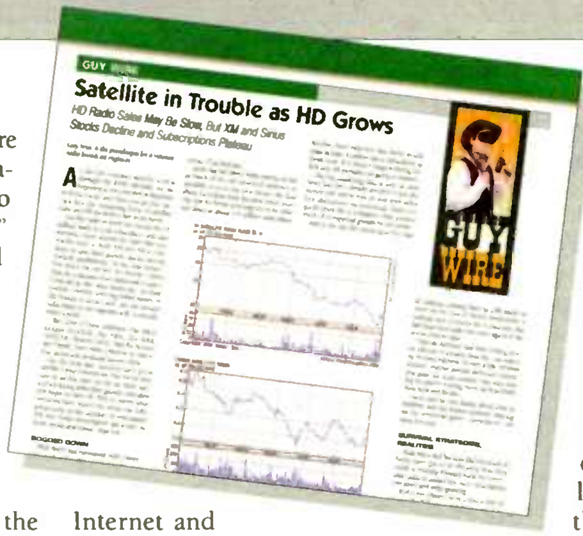
IN THIS ISSUE

Guy Wire

Gentlemen, I now see why Guy Wire doesn't use his real name. His latest diatribe against the future of satellite radio ("Satellite in Trouble as HD Grows," Aug. 23) is complete nonsense and NAB propaganda. Sad, very sad.

In the future can we have a more balanced and unbiased debate?

Jim Tracey
Berkeley Heights, N.J.



The article "Satellite in Trouble as HD Grows," is by far the most comprehensive and fact-filled report on the state of both our industry and satellite radio I've seen in all the stories that have been written over the past two years. Guy Wire, the anonymous writer, has hit a home run.

But the lament that I continue to have is that, once again, we are telling *ourselves* the story, instead of the wider marketplace. Those of us in the industry know we have challenges, but we are beginning to face them. We know it's harder than ever to make a profit, but none of us are starving. In fact, most of us are doing quite well.

And we know that radio will continue to be a primary medium for the American consumer, just as it's been since the 1920s. Remember? Movies were going to doom us. Then it was television, the Internet and the iPod. And if you only read about radio vs. satellite radio in the country's mainstream media, it was only going to be a matter of time before satellite trumped us, hands down.

Every poll I've seen over the past year, including two of our own, has indicated that Americans are listening to commercial radio as much as, or more than, they were five years ago. And in our latest AMS Radio Index conducted in August, an astounding 87 percent said that, looking ahead five years, they expect to be listening to commercial radio *as much as, or more than,* they are now. Only 10.8 percent said they thought they'd be listening less.

You would never know that from reading the Wall Street Journal, New York Times, USA Today or any national consumer publication writing on the state of radio today. All you read there is what Wall Street is saying about our public companies and what's happening with the stocks.

We've got a good story to tell, and we need to start telling it far and wide. At American Media Services, we have been working with national media, telling radio's story a little at a time with a number of these publications. Believe me, they're interested. But every time they turn around, the satellite PR machine is right there in front of them. It's time we, collectively, begin doing the same thing.

Ed Seeger
President/CEO
American Media Services
Charleston, S.C.

The CFA and Maxwell's Theory

In response to Maurice Hately's letter (*Reader's Forum*, Aug. 23), the Crossed-Field Antenna is an array of two tightly coupled short monopoles, one with the disk as its top load. In our analysis ("Crossed-Field Antenna Performance," April 5), the addition of the fields produced by both monopoles separately is an application of the Superposition Theorem, which is widely used in Antenna Theory.

In our paper, the phase difference between both generators has been varied from 0 to 360 degrees, and we found that 90 degrees is the worst value in order to tune the antenna.

It seems that CFA's inventors forgot that Maxwell's 4th equation and his other three equations form a set of partial differential equations subject to the boundary conditions of the problem, and it can be proved that our solution is correct by performing the appropriate derivatives.

We demonstrated that there is no Poynting Vector Synthesis by computing the E and H fields and the wave impedance, which has a high imaginary part close to the CFA. Therefore E X H has also a high reactive component in the near-field zone. We concluded that the CFA's performance is a little worse than that of a standard short monopole of similar height. Measurements in Australia, Italy, England and Brazil support this conclusion.

Maxwell's Theory is still a pillar of human knowledge and the CFA is part of it. Its behavior can fully be explained within this theoretical frame; it is not an exception. The good agreement between theory and experiments has demonstrated this fact and that the CFA is not some kind of exotic technological device.

Valentino Trainotti and Luis A. Dorado
University of Buenos Aires
Buenos Aires, Argentina

More letters on page 3

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between the radiator bays (Fig. 2). Poor isolation placed strains on the power-limited digital feed system and circulators (Fig. 3). It also limited the VSWR performance of the analog and/or digital system by only allowing one of the two to be optimized.

It will become evident through discussions presented in this paper that the only way to achieve equal and superior performance for both the analog and digital systems, and isolate the systems without the use of "high-power" circulators, is to provide an antenna design that minimizes cross-coupling and mutual coupling.

HISTORICAL SOLUTION TO MUTUAL COUPLING COMPENSATION

Historically, crossed-dipole antenna designs used a single input to the hybrid. Because the fourth port, as defined by Fig.1, was not used, it was typically capped off with a short circuit. The input performance of the fourth port was irrelevant. The effect of the mutual coupling can be seen in the input impedance of each dipole. Both the magnitude and phase of the coupling affects how the impedance is changed.

The examples shown in Figs. 4a and 4b illustrate the effect on the fourth port input impedance if conventional tuning techniques are used to compensate for the mutual coupling. The fourth port of the hybrid feeds the dipoles with opposite sense relative to the input port, so a "flipped" effect in the input impedance at each port of the hybrid is created.

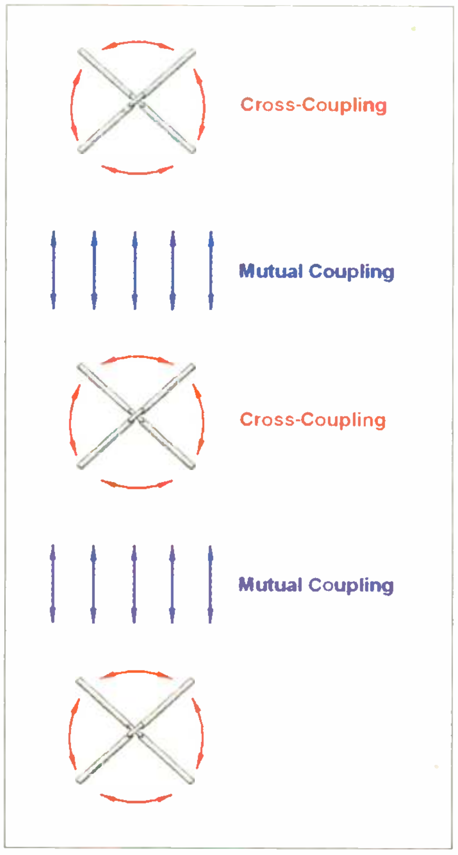

Fig. 2: Cross-Coupling and Mutual Coupling

To compensate, it has been common practice to make asymmetrical dipole adjustments to correct the impedance into one port of the hybrid. This type of compensation only works at the expense of making the input match worse into the fourth hybrid port. (See Fig. 5.) This was an acceptable solution, as the fourth port was terminated in a short circuit and its input impedance was irrelevant.

This is not an acceptable solution when broadband-balanced, optimum VSWR performance into both ports is desired. This leads to a basic design criterion: The radiator must minimize the bay-to-bay mutual coupling in order to allow for a symmetrical element design. Without a symmetrical

SEE TQT, PAGE 8

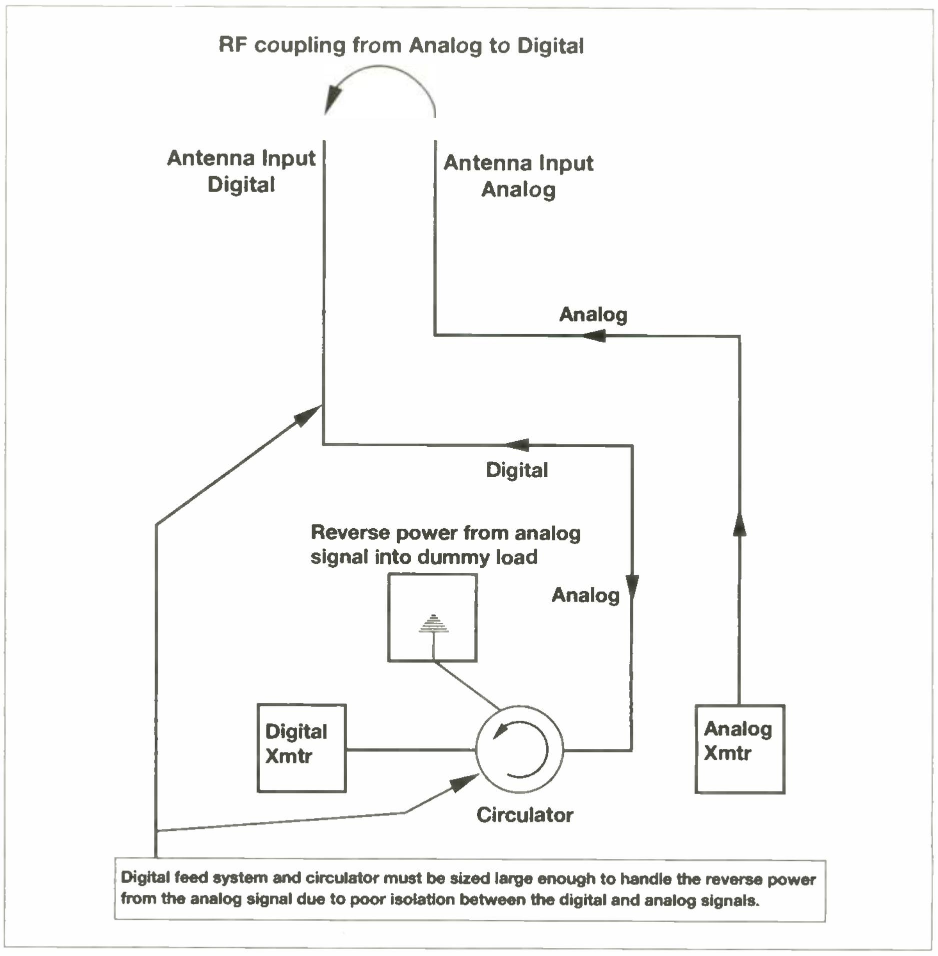

Fig. 3: Poor isolation can overload the digital feed system and circulator.

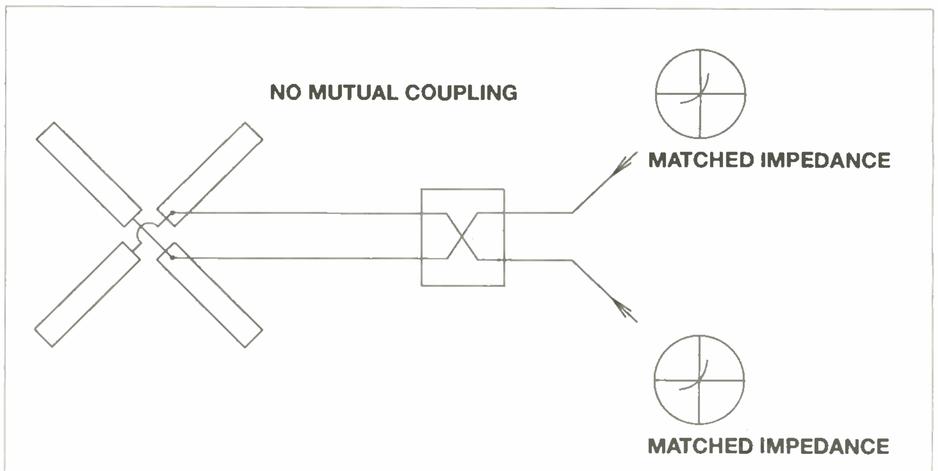

Figure 4a: When no mutual coupling is present, the input impedance is the same into both input ports of the hybrid.

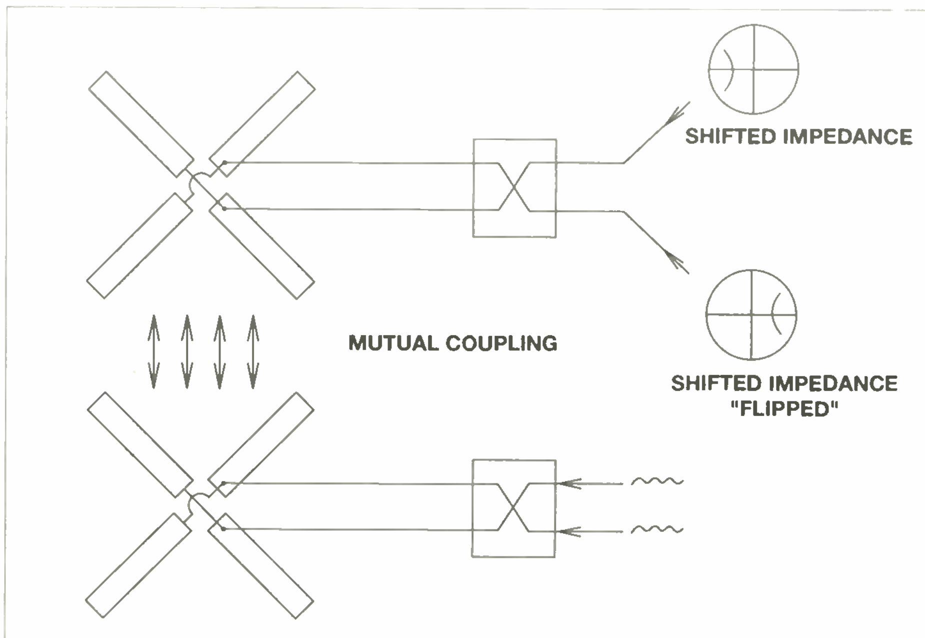

Fig. 4b: The effect of mutual coupling on the port impedance of the hybrid. Note the opposite impedance shift.

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element, balanced digital and analog VSWR performance along with acceptable system isolation cannot be achieved.

CROSS-COUPLING

As defined in Fig. 6, cross-coupling is simply the RF energy transmitted to the right-slant dipole from the left-slant dipole. This is an important parameter in the design of a hybrid-fed common radiator antenna, as by definition the VSWR of the individual hybrid inputs can only be as good as the isolation between the outputs, assuming the output loads (in this case the dipole elements) are perfect matches.

This leads to the second basic design criterion: Cross-coupling between the elements of the radiator must be minimized in order to realize acceptable impedance into both the analog and digital hybrid ports as well as achieving acceptable system isolation.

MEETING THE CRITERIA

Dielectric has developed an innovative radiator element design, which meets these basic, but formidable, design criteria. The symmetrical element design virtually eliminates cross-coupling and minimizes the bay-to-bay mutual coupling which allows for extremely high isolation and superior VSWR performance for both the analog and digital systems.

The solution incorporates pairs of crossed, right-angled equilateral dipoles referred to as TQT or Transverse Quadrilateral Technology. The TQT radiator element is shown in Fig. 7.

THE ELIMINATION OF CROSS-COUPLING

Non-crossover hybrid coupler theory can be applied to understand how the TQT geometry eliminates the coupling from the right-slant dipole pair to the left-slant dipole pair. Fig. 8 depicts a typical parallel transmission line coupler.

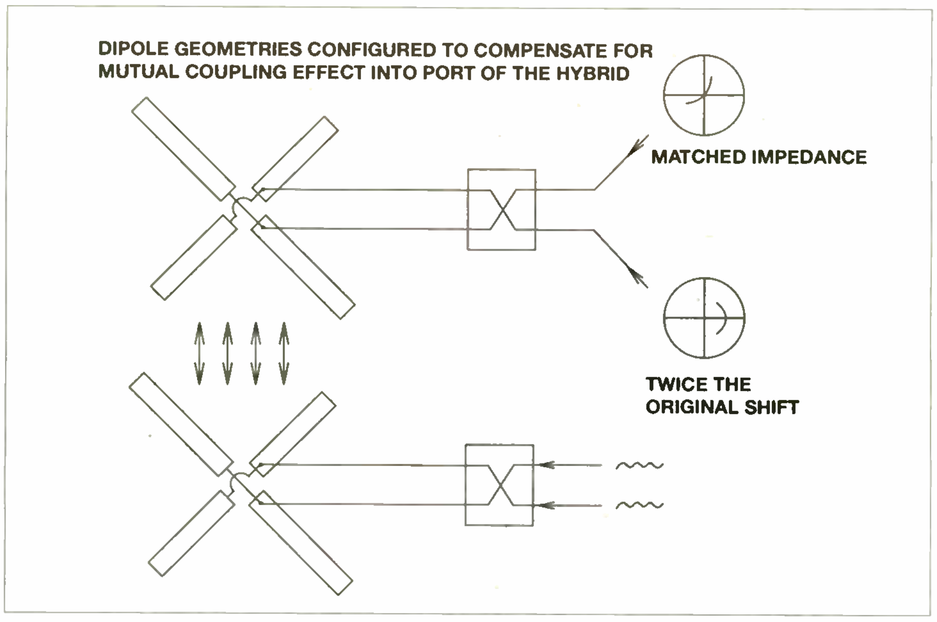

Fig. 5: Radiator adjusted to match the impedance into one port of the hybrid at the expense of twice the mismatch into the other port.

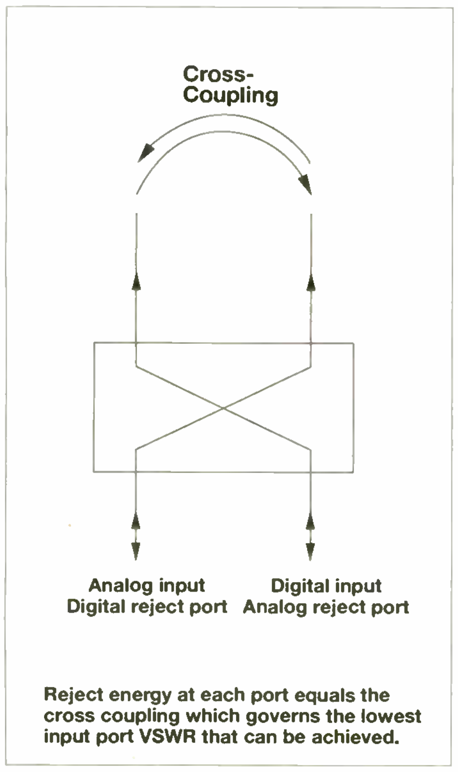

Fig. 6: The Relationship Between Hybrid Output Port Isolation and VSWR

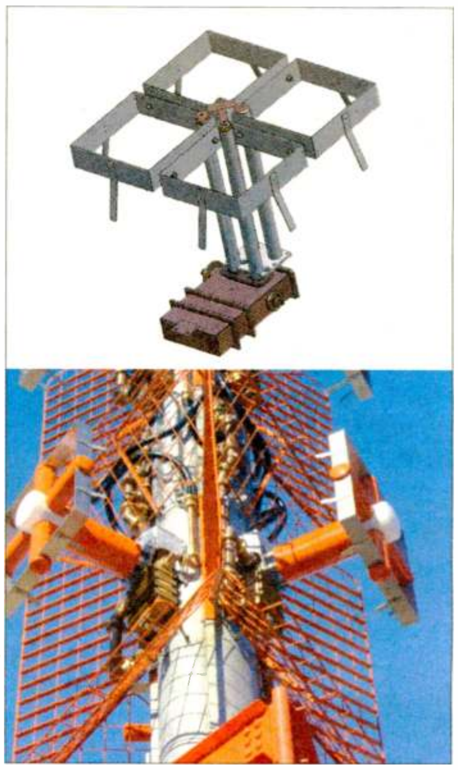

Fig. 7: TQT Transverse Quadrilateral Technology

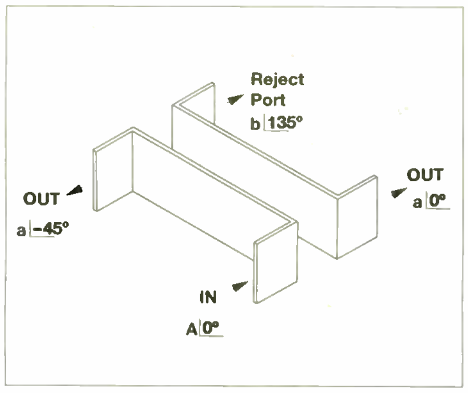

Fig. 8: Non-Crossover Hybrid Coupler

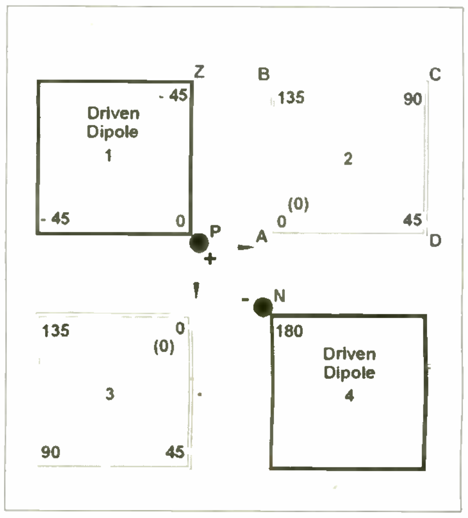

Fig. 9: Hybrid Coupler Analysis Applied to the TQT Element

This model can be used to illustrate the following operation: The adjacent square radiator sides act as four hybrid couplers with the reject port at 135 degrees relative to the input port and the phase length of the hybrid 45 degrees.

In Fig. 9, the left-slant dipoles are driven at points P and N, 180 degrees out of phase with respect to each other. Point P represents the input to the hybrid coupler with points A and Z representing equal amplitude output ports with 0, and –45 degree phase respectively. Point B is the reject port with differing amplitude and 135 degree relative phase.

Following the reject port signal from point B to point C to point D and back to point A, it can be seen that the signal from the reject port is back in phase (0 degrees) with the input port. There is no phase difference between point P and point A, so no potential difference exists and no voltage is induced between feed points, thus eliminating any cross-coupling. Similarly, this relationship holds for all four hybrid couplers created between the square dipole elements.

This analysis leads to the understanding that the TQT radiating element is driven by loop currents, as opposed to linear currents that would be found on a typical crossed-dipole configuration (Fig. 10).

MINIMIZING MUTUAL COUPLING

Given the loop nature of the element, loop antenna theory can be applied to understand how mutual coupling is minimized from one radiator bay to the next. In Fig. 11, a two-layer antenna array is depicted as a series of loop elements lying

SEE TQT, PAGE 10

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TQT

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in the XZ plane.

The vertically polarized signal propagates in the YZ plane, which is perpendicular to the loops and is in the loops' neutral plane. Therefore, none of the vertically polarized energy is mutually coupled. The only wave component that can couple from loop A to loop B is the horizontally polarized component, as the loops lie in the XZ plane.

Further, because loop faces 1 and 3 lay orthogonal to the horizontally polarized wave component, no voltages are induced on these sides.

The only voltage difference that can cause current to flow occurs between faces 2 and 4. This is due to the incoming wave reaching side 2 before it reaches side 4, thus creating a 45 degree phase difference between the faces and inducing a potential difference. The total voltage induced between sides 2 and 4 is proportional to the distance between them.

The area of the loop is the controlling factor in the mutual coupling between bays. Because the loop size is relatively small compared to the wavelength, the mutual coupling is held to a minimum.

MEASUREMENT RESULTS

The TQT radiator element design optimizes cross-coupling between the elements and mutual coupling between the radiators, so it has opened the door to a superior product line of broadband common radiator analog-digital FM antennas. Both the HDFMVee and HDCBR antenna types take full advantage of this new technology.

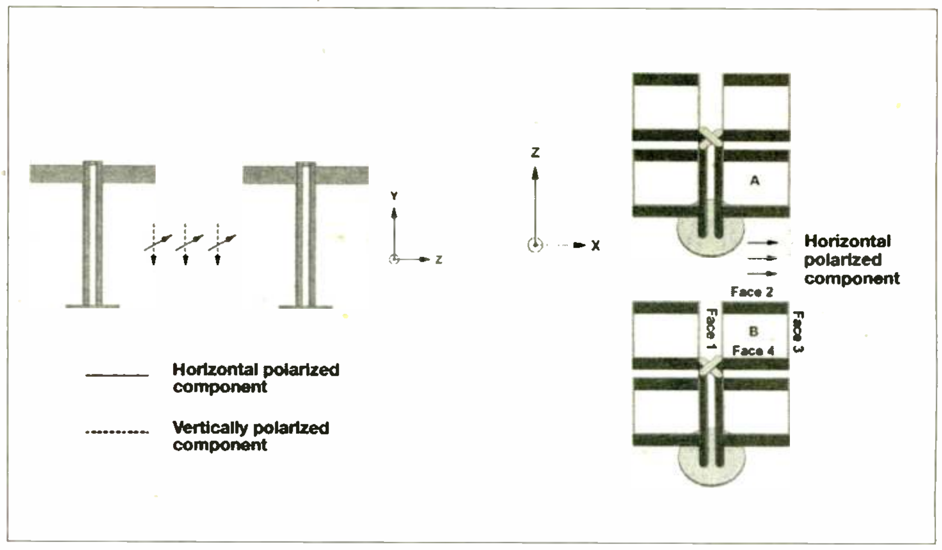

Fig. 11: Minimal Mutual Coupling

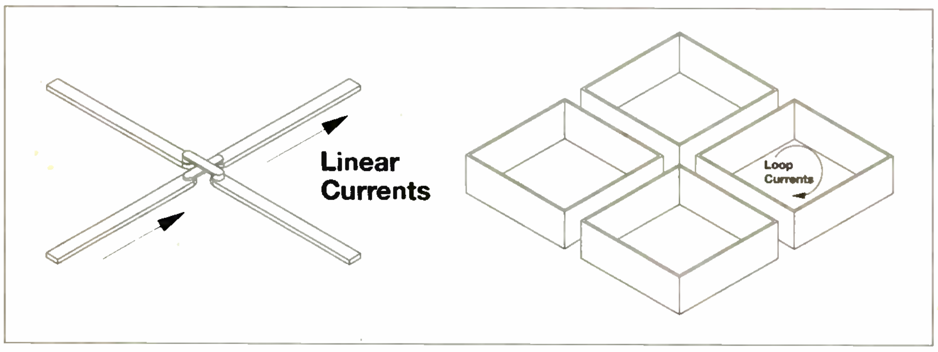

Fig. 10: Linear Currents vs. Loop Currents

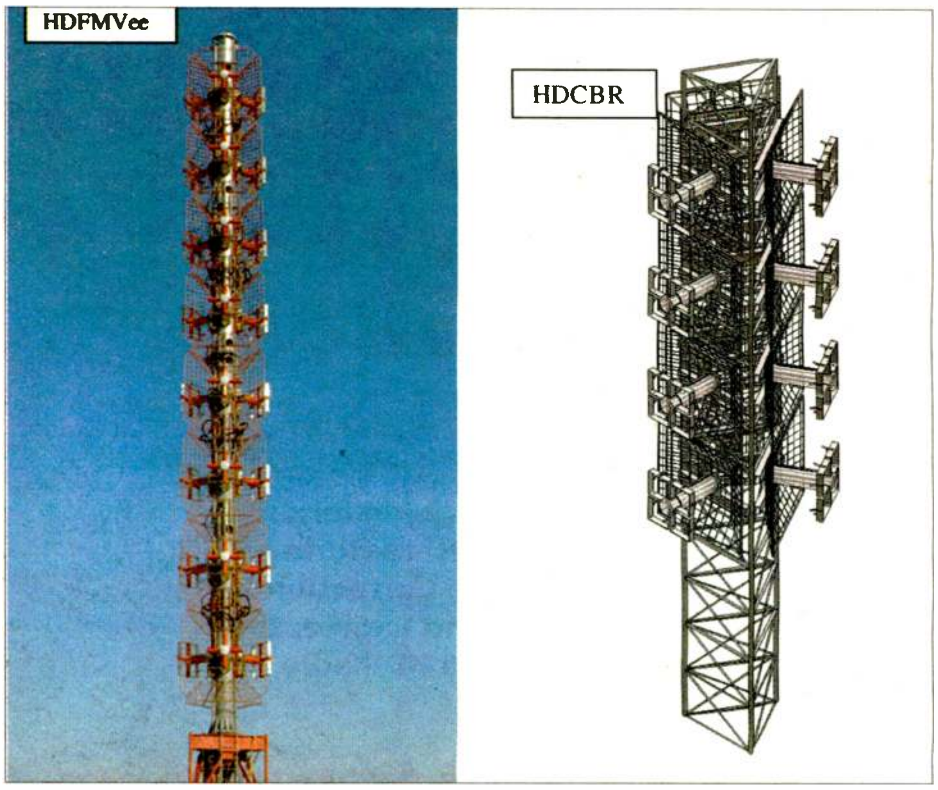

Fig. 12: TQT is used in both the top-mount HDFMVee and the top- or side-mount HDCBR.

The HDFMVee shown in Fig. 12 was the first full antenna to incorporate the TQT radiator design. Superior and balanced analog and digital system performance was demonstrated through measurements. The measured, full-band VSWR of the antenna into both the analog and digital inputs located at the base of the antenna was under 1.07:1, and the measured isolation between the two inputs was greater than nearly 30 dB across the entire FM band, with most if it better than 35 dB. (See Figs. 13 and 14)

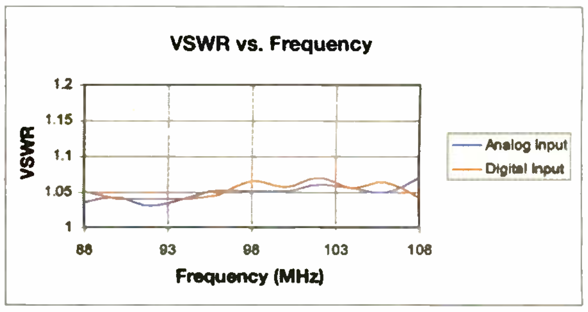

Fig. 13: Measured VSWR of full HDFMVee antenna shown in Fig.12. Note the equal performance for both the analog and digital inputs.

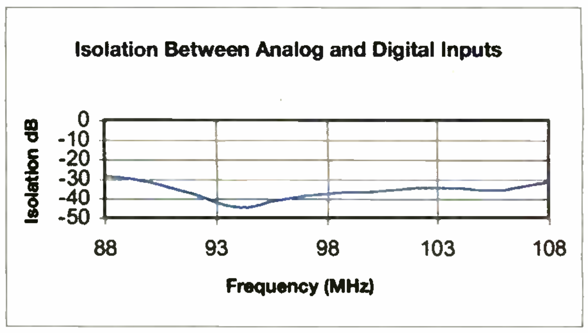

Fig. 14: Measured isolation between the analog and digital inputs of the full HDFMVee antenna shown in Fig. 12.

CONCLUSION

The TQT radiator and its benefits to HD Radio implementation have been discussed, analyzed and supported through measurements. Its geometry optimizes mutual and cross-coupling, paving the way to balanced VSWR performance as well as a high isolation between the analog and digital systems.

The author thanks the Development Team at Dielectric for its dedicated support, encouragement and creative influence. Products discussed in the paper are subject to patents and pending patents in the United States. ■

ENDNOTES

[1] Dielectric – SPX Patent # 6,914,579
[2] Dielectric – SPX Patent # 6,934,514 "System for Transmitting Digital Signals with FM Signals"

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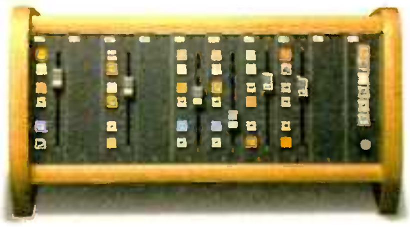

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only be 1/10th the impedance of the protected input at the frequency of the RFI. A faulty ground, or an open capacitor as shown by Fig. 1b, allows the full current of the RFI to appear at the input of the circuit.

The same goes with the tuning network of an AM antenna system. The tuning network also acts like a filter, bypassing to ground all harmonics that can otherwise go out to the antenna. Make sure that the capacitor of the T-section shown on Fig. 2 is securely connected to the ground by a copper strap. A loose connection to ground will not only cause an arc that may destroy the vacuum capacitor but also can be an intermittent source of spurious signals.

A lightning rod or a static dissipater is only as good as its ground system. A low-impedance path to earth ground is essential to guiding excessive magnitude currents down to where they should go. The wires, lugs and ground rods can deteriorate in due time and therefore need to be inspected on a regular basis for integrity.

High-voltage interlocks are tools to short HV currents to ground. They serve as safety apparatus for personnel working on the equipment. The purpose is to divert lethal currents directly to ground instead of finding its path across the heart of a person. Make sure that you inspect the grounding stick for resistance to ground especially if the insulation of the wire is not clear. It is possible that you are betting your life on a grounding stick that is not grounded.

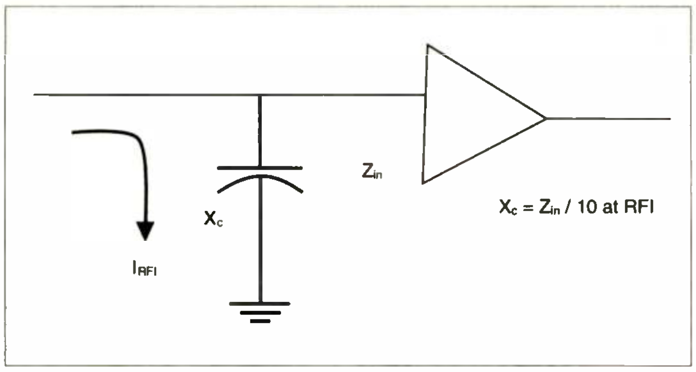

Fig. 1a: The bypass capacitor is a short circuit to the signal you want to go to ground.

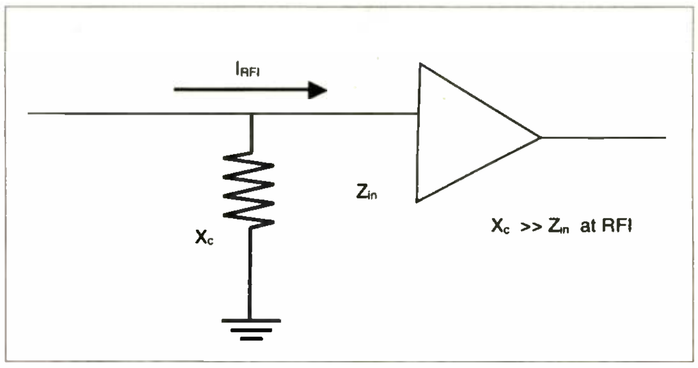

Fig. 1b: An open capacitor causes the unwanted signal to appear across the input of your circuit.

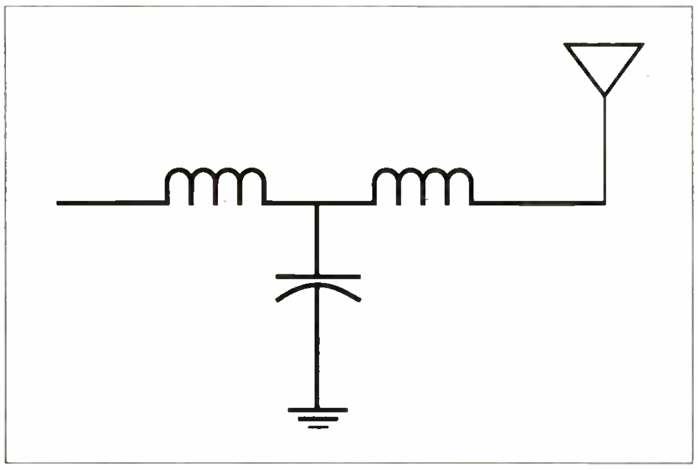

Fig. 2: A T-section is commonly used on tuning sections for AM towers. The shunt capacitor should have a good connection to the ground.

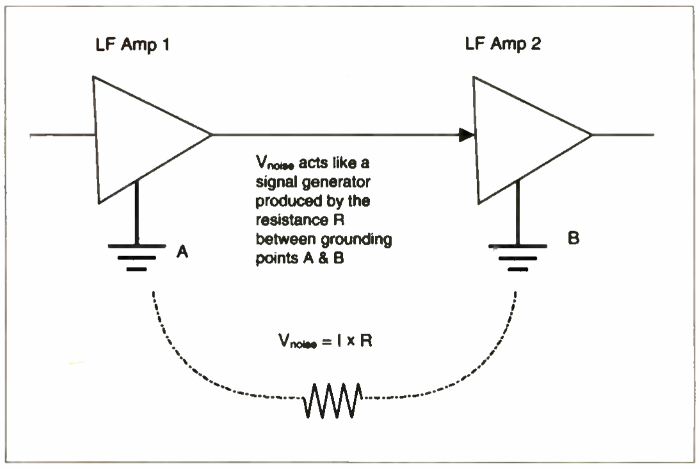

Fig. 3: How a Ground Loop Happens

Balanced audio circuits require a good ground to complete a noise-free signal path. A microphone Cannon or XLR connector can have an open ground, causing hum on your amplifier. On the other hand, multiple grounds for an analog audio circuit can cause a problem called a ground loop. The problem is not having a ground but the introduction of a noise source due to the difference in the impedance of the grounding points. Refer to Fig. 3 for an electrical diagram on how this happens.

MAKE A GOOD CONNECTION

Circuits need to have a complete path in order for current to flow. If there is an additional resistance along the path that is not intended in the design, the desired signal gets attenuated or altogether decimated depending on how big the resistance is compared to the signal. The "resistance" also can diffuse energy in the form of heat and cause secondary problems.

Fig. 4a shows the electrical equivalent of a good connection while Fig. 4b shows an additional resistance producing a voltage drop across it. Depending on the voltage and the current flowing through the connection, a loose bolt and nut on the transmitter can warm up or cause an arc if there is HV at that point.

This is why it is imperative to secure good mechanical connection on the fingerstock of a vacuum tube. If the fingerstock loses its temper, resulting in a poor connection, there will be an uneven current distribution through the fingers burning parts of the fingerstock until the tube itself is damaged.

A good mechanical connection also is important in attaching a power transistor to its heatsink. Replacement of the special heat conductive foil between the transistor and the heatsink is as important as replacing the transistor. It is tempting to cut corners in the repair of equipment just to put it back into operational condition. However, remember that if it won't stay operational over a period of time, then the repair work is a failure.

Ever wondered why there are "too many" screws on FM oscillators or the FM

SEE BASICS, PAGE 14

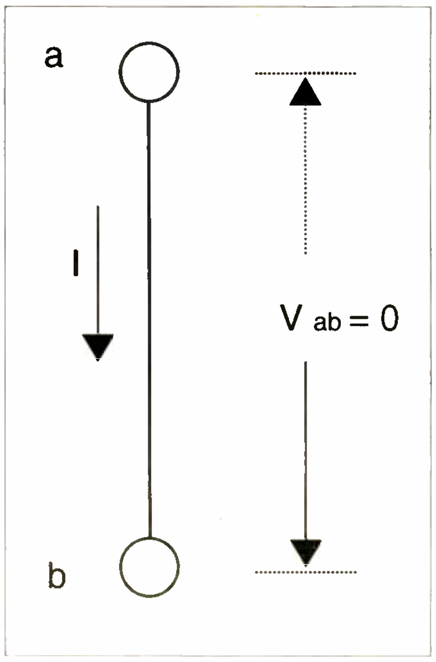

Fig. 4a: A good connection is an electrical short.

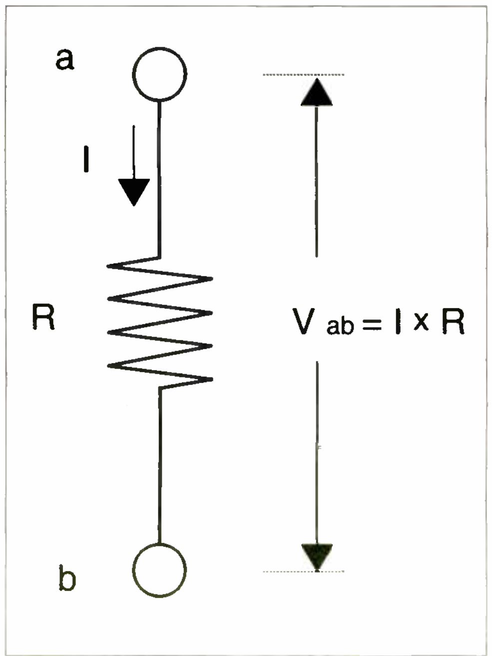

Fig. 4b: A bad connection is electrically an unwanted resistance or worse, an open circuit.

CONTINUED FROM PAGE 12

cavity? Believe it or not, all these screws need to be put back in their places, as they are part of completing the circuit. The outer metal enclosure of the FM cavity, for example, acts as the outer conductor of a coaxial transmission line and therefore should be flawless as seen by the VHF signal.

A good connection on any electrical equipment is as important as the many arteries and veins that connect our body to the heart. Anytime any of these bloodlines are blocked or disconnected, our body will not function as it should.

WATCH THAT POWER SUPPLY

A large percentage of electrical equipment problems can be traced back to a malfunctioning power supply, or poor quality source of AC voltage for that matter. There are just so many "impurities" on the AC power that comes from the electric utility that we need to shield our equipment against their adverse effects. Some of these AC power anomalies can cause a glitch or even catastrophe on digital equipment, so much so that an uninterruptible power supply is a standard peripheral in our stations.

The choice of a UPS can become a concern to most of us, as we can still experience power supply-related problems even if we have a UPS in service. Understand that some UPSs are not "true online" in their protection. I'm not referring to a particular advertisement with the term "true online." I simply mean that Fig. 5a is a better UPS compared to the one in Fig. 5b, which is how most UPSs we buy in department stores are designed to work. It will be fun for you to work out the difference between the two set-ups.

Control circuit problems on your transmitter may not be due to faulty digital circuits. Check your power supplies to make sure the ripples are not excessive and the output is indeed regulated at different switching conditions. You'll need an oscilloscope for this purpose and not necessarily an elaborate digital troubleshooting tool or computer troubleshooting degree. Digital circuits tend to be confused with its 1s and 0s if the DC powering it is not stable in operation.

Note that if your remote monitoring equipment is on UPS, include all the relays associated with it on the UPS as well. There are still remote monitoring and control systems in use at stations that use the

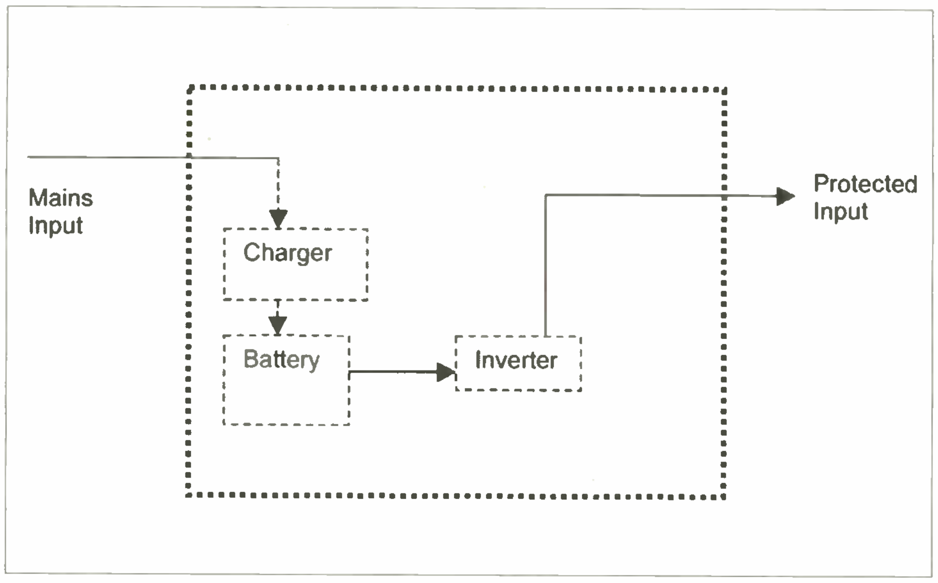

Fig. 5a: Simple Block Diagram of a True Online UPS

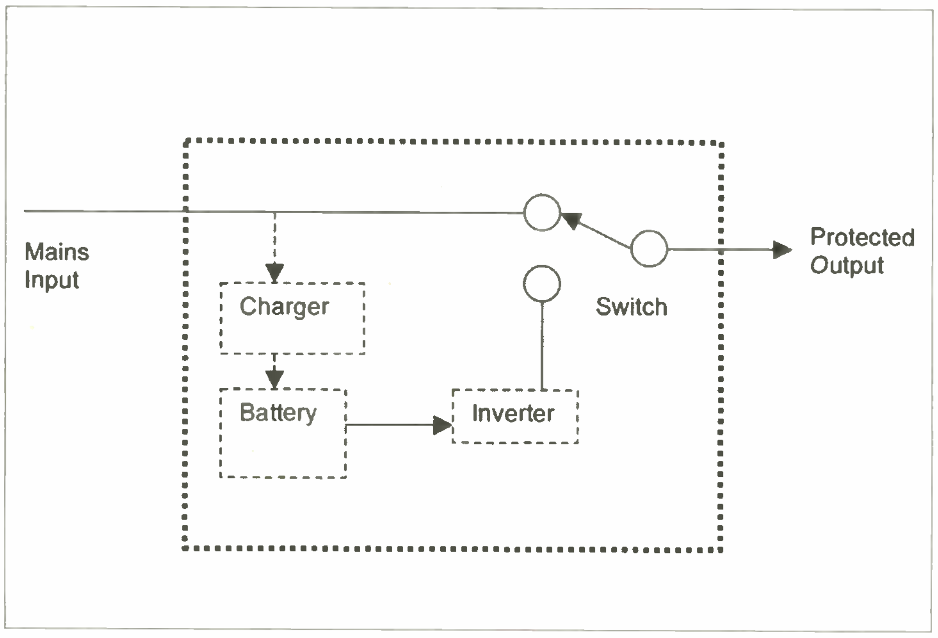

Fig. 5b: Simple Block Diagram of an Ordinary Department-Store Type of UPS

old mechanical relays for control and status indicators. The interface and the PC (or processor) may already be on UPS but if the relays are not, there can be control malfunctions.

AC power problems can manifest in different ways. I recall a time when a HV transformer was overheating in operation. The usual temperature shown on the thermometer was just 60 degrees Fahrenheit, but that day showed it was 90 degrees. The top cover of the transformer was bloated, suggesting that there was excess gas trying to escape. The container itself was hot to the touch.

We saw the problem after signoff, when we inspected the 480 VAC primary connections. One of the three-phase connections was loose, causing the other two phases to take up more current and overheating the coils. From then on, we have included in our routine maintenance to check all high-current and high-voltage connections with the use of an infrared thermometer, comparing the temperatures of the connections. Needless to say, we observe all applicable safety precautions in these activities.

Another instance of a power supply problem occurred when we could not keep a transmitter in operation after a storm. All the interlocks were okay. All our inspections of the transmission lines and the antennas showed no problems. We later found out that the substation transformer on the pole owned by the local electric cooperative has an arcing connection on the primary.

I happened to be standing in front of the pole, exasperated at what was going on, when I saw and heard a spark on top of the pole. An emergency call to the power company and consequent repair got us back on the air. So if your transmitter won't stay on the air, remember that the AC power can be one of the culprits.

KEEP THE COOL

Any equipment operated beyond its temperature specifications will malfunction. This is true for both mechanical and electrical parts. Semiconductors suffer from thermal runaway resulting in the breakdown of their PN junction. Vacuum tubes get damaged when their internal components melt and get shorted inside due to lack of cooling.

Remember to allow enough time for the blowers to cool the tube during shutdown before opening any interlocked doors. Prematurely aborting the cooling process can damage the tube enough to shorten its useful life.

It is not enough to have normally operating fans. Ensure that there is enough cooling air available and that cooling is directed to where it is needed. Solid-state transmitters can be more sensitive to lack of cooling due to their small footprints, hence less surface area to diffuse heat. The efficiency of the cooling system (whether liquid, air only or both) should be maintained at all times to ensure a reliable and normal operation.

Some intermittent problems on equipment can be due to inadequate thermal dissipation of components. They show up either some time after the equipment was turned on or under higher-power operation.

SEE EVIL, HEAR EVIL AND SMELL EVIL

Fault-finding skills are good when used on equipment (rather than on people). Engineering personnel should develop the skill of observing abnormal operation, hearing undesirable sounds and smelling smoke from burning components. Indifference or lack of concern can be dangerous or result in life-threatening conditions in the station. Remember that equipment failures or fires give out prelimi-

SEE BASICS, PAGE 16

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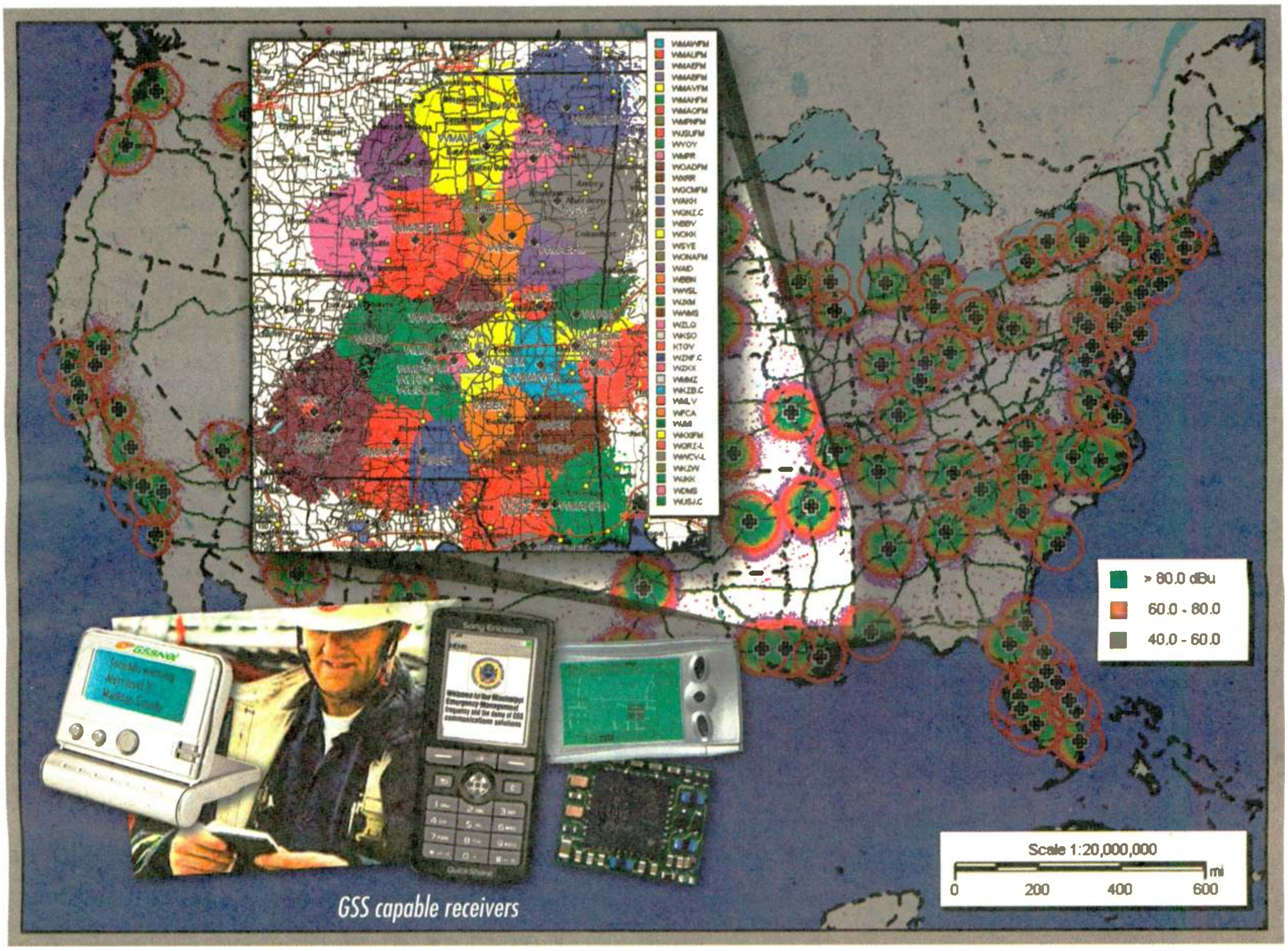

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Racks Are Radio Facility Building Blocks

Rack Layout Preparation and Floor Space Drawings Are Keys to an Efficient Broadcast Studio Build-out

Some rack furniture manufacturers have designed workstations to directly accommodate computer gear, for example this Winsted item.

James E. O'Neal is a retired broadcast engineer and current technology editor for TV Technology magazine.

When a new control room or master control facility is being planned, many things must happen. First thoughts are given to defining the room's function. The next item of business is selecting equipment to perform the required tasks. Somewhere on the long checklist is selecting "furniture" for the facility. And as most everyone reading this knows, "furniture" in a broadcast facility is a bit different that what you'd shop for in your local "Rooms-Are-Us" store.

Tables and file cabinets are important, but satisfactory items can be located at office supply companies. It's the racks and console units that have to be "sent away for."

THE ORIGIN OF THE RACK

"Rack" is an interesting word. It can refer to meat, a place for putting things or an ancient instrument of torture. It's a triangular device found for grouping billiard balls, part of a gear assembly or even a place to sleep. It refers to the set of antlers on a deer. Other examples come to mind, but it's probably safest to stop with the deer.

So how did the term get into broadcasting and become a fairly large budget consideration in most any sort of engineering project?

It appears that the phone company was the first large user of equipment racks — they were initially called relay racks, due to the widespread use of relays in early phone systems.

Racks have been part of electronic installations for the better part of a century now and are available as off-the-shelf items from scores of suppliers.

The most common rack "size" or rail spacing is 19 inches. Another "standard" associated with equipment racks is the spacing of mounting holes (drilled holes for inserting clips to receive mounting screws, or tapped holes for directly accepting screws). These spacings reflect standardization in height of equipment designed for rack mounting, as well as the position of mounting holes machined into the device panels. All rack-mount broadcast gear is vertically sized in multiples of 1.75 inches (approx. 44.5 mm). The 1.75-inch height is termed a rack unit or "RU."

LAYOUT PLANNING IMPORTANT

Preparing rack layouts in new installations is one of the more important parts of the project. A great amount of study

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Basics

CONTINUED FROM PAGE 14

nary signs that, left unheeded, can develop into an emergency within a matter of months or even just a few minutes.

Training a newcomer what to normally expect to see, hear and smell within the station is an important part of being a good employee. Accidents or emergencies can be avoided if problems are addressed early enough.

Remember that problems that are left unattended will only get worse and never get better by themselves over time. This is what physicists call the Law of Increasing Entropy. Equipment and systems will fail unless an appropriate effort is expended to keep it in operation.

PASS THE WORD

Do you have a whiteboard where the next shift operator will see that the generator set is still running?

Is it a Standard Operating Practice in the station that engineers are informed of problems that happened and how they were rectified?

Oftentimes, problems recur simply because other personnel are not forewarned of what could happen when the Standard Operating Practice is not observed. Worse is if there is no agreed-upon SOP. This applies to turning on and off the transmitter, operating the generator, whenever there is a power failure and other contingencies. Every person on the station should be on the same page on procedures in order for them to act accordingly.

I hear complaints from chief engineers about how master control operators fail in the performance of their duties. The question in my mind is, were the operators trained on how to perform the expected duties in the first place?

Training a newcomer what to normally expect to see, hear and smell within the station is an important part of being a good employee.

Do they know that the generator may fail if it is operated for an extended time without load? Do they understand that there is a time delay from the moment they press the command buttons to the actual switching at the transmitter site, and therefore should wait awhile for the cycle to complete instead of pushing the button multiple times?

Expectations that are not communicated and explained are unreasonable. Poor performance of employees due to lack of training and proper communications is the failure of the leadership. One sign that this is happening is if technical problems occur, continue to recur and people just pass the buck around, looking for whose head should roll.

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- 1/2" precision measurement microphone
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- Omni-directional reference microphone for acoustical measurements
- Required for the Acoustilyzer; optional for the Minilyzer

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- USB interface fits any ML1 or DL1
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- Enables data storage in analyzer for later upload to PC
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- Control the analyzer from the PC
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by Cris Alexander

Transmitter Security Is a Challenge For Engineers

Cris Alexander is director of engineering for Crawford Broadcasting Company in Denver and a regular contributor to RWEE.

In last month's column I made the point that a typical day in the life of a broadcast engineer can consist of … well … just about anything. We may find ourselves in suit and tie attending meetings, at the keyboard writing scripts for the automation or remote control systems or changing the oil in the generator. Occasionally our activities can extend well beyond even that.

Engineers have responsibility for the security of the transmitter sites under their care, and we sometimes have to deal with break-ins, theft and vandalism. In this month's column we'll deal with one of the site security issues that engineers are facing nationwide.

We'll also take a peek at some new technology. From time to time there are significant changes or advancements in technology that completely revolutionize the way we do things.

Over the past few years, many stations have been reworking the infrastructures of our facilities, replacing analog and digital audio carried in multi-conductor and individual cables to Ethernet and fiber-optic backbones wherein everything is carried on high-bandwidth CAT-5, CAT-6 or fiber cables. In Crawford's Chicago, Denver and Detroit markets we have installed router-based systems and I'll share some of our experiences.

TOWER SITES ATTRACT VANDALS

Over the years, I've seen a lot of criminal activity around radio stations, at transmitter sites in particular. Most of it has come in the form of vandalism or criminal mischief, but from time to time something more serious has happened.

Thirty years ago, someone set the dumpster on fire outside the rural studio/transmitter site for the FM station I was working at. Aside from the paint on the dumpster (they really built 'em in those days), no real harm was done.

In the early 1980s, we had a rash of base jumpers on our 1,549-foot candelabra tower in Dallas. Those folks would cut the fence, cut locks and do whatever they could to gain access to the tower. On one occasion, one pulled the main disconnect for the transmitter building on the way out — a little "thank you" to us for trying to make the site secure.

Fig. 1: Missing tower base ground wire makes a site vulnerable to lightning damage.

At our five-tower directional array in Dallas in the early 1990s, someone cut several guy wires, leaving the top 100 feet of one of the towers leaning over about 15 degrees and swaying in the wind.

I found it strangely coincidental that the person who notified me of the damage was a local tower rigger who just happened to be driving by. That happened twice in a month's time. The second time, I found someone else to fix the damage.

TARGET PRACTICE AND MORE

Tower lights are almost irresistible targets for certain individuals with long guns, particularly in the South, it seems. Over a five-year period at an FM site in Birmingham, Ala., we had four or five episodes of bullet holes through the transmission line, all adjacent to beacons or obstruction lights.

I found myself wishing that "Bubba" was a better shot. I'd rather fix a tower light than a transmission line. A busted tower light won't take the station off the air.

There have always been partiers at transmitter sites, usually teenagers drawn to the remote locations for their beer busts and back-seat activities.

Recently, some college-age guys (as determined by a neighbor's sighting) reached a sufficient level of intoxication to feel that they could easily scale our FM tower in Buffalo, N.Y.

Fortunately, they couldn't get through the fence with what they had on hand and gave up, but not before leaving a "love note" for our chief engineer in spray paint on the side of the transmitter building.

Transmitter sites and their access roads seem to be inviting dumping grounds. I can't count the times that our engineers have driven up to the gate and not been able to get in because someone had dumped a load of old roofing materials or other trash in the way. And we have to clean that up, too. In most cases, we're held responsible for dumping on our property and for removing any hazardous materials.

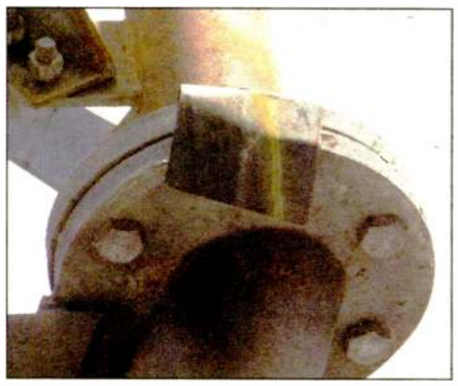


Fig. 2: Only the end of the strap remains.

At one of our mountaintop sites in Alabama several years ago, someone dumped the body of a murder victim almost at the door of the building. *That* was pretty scary. I don't know if that murder was ever solved.

And then there are the "taggers," graffiti artists who find big transmitter buildings to be excellent canvases for their masterpieces. I haven't quite figured this out. Isn't the point to have others see your work? Most of our transmitter buildings, particularly at the AM sites, are located remotely so that they aren't readily visible from nearby thoroughfares.

Last spring, our Colorado Chief Engineer Ed Dulaney had a running battle going with some local "wanna-bes" that liked to tag the transmitter building and barn at the KLZ(AM) site in Denver. Ed spent some nights at the site and caught the little #$%^s almost in the act, running them off before they could do any damage.

But they eventually had the last word. They tore every picket off one of the tower base fences and scattered them over five acres, and they took some of them and spelled out a personal "love note" for Ed on the ground in 16-foot letters.

When I saw it, I couldn't help but laugh; Ed wasn't one bit amused.

COPPER IS THE NEW GOLD

But perhaps the most expensive damage over the years involves copper, and radio stations by nature use a *lot* of copper.

Even the simplest non-directional AM station's ground system is likely to include more than five miles of No. 12 copper wires. A multi-tower directional AM station can employ many times more wire plus a lot of strap.

Ten years ago, the company maintaining an agricultural ditch that bisects one of our four-tower directional sites snagged a transverse strap with its dozer blade. This is a 4-inch copper strap that terminates intersecting ground radials between towers in a directional array. Before the operator saw what he had done, a large portion of the ground system had been unearthed and destroyed. The damage amounted to tens of thousands of dollars. Likewise, "beer bandits" stealing copper for booze money can convert a $50,000 ground system to $26 cash in just minutes.

The problem now is that copper prices have risen sharply, to the point where an old all-copper penny is worth a lot more than one cent. Here in the Mile-High City where I live and work, copper thieves raided a closed Gates Rubber plant for all

SEE TX SECURITY, PAGE 22

You think *we* have a lot to say? You should hear our clients.

When we asked our clients which Element features they liked best — well, you see the results. And this is the *edited* version. (Good thing we bought two pages.)

Go (con)figure • The folks at MPR say they really love being able to configure their Elements and keep tabs on their entire Axia network using standard Web browsers. You can set up and administer an entire building full of consoles from the comfort of your own office (where there's plenty of Cheetos and Pepsi). Put an Internet gateway in your Axia network and you can even log into Element remotely, from home or anywhere else there's a Net connection. Great for handling those 6 P.M. Sunday "help me!" phone calls from the new weekend jock.

Who are these guys? • Why buy a console from Axia? Element was designed by Mike Dosch and his team of ex-PR&E renegades (who know a bit about consoles). And Axia is a division of Telos, the DSP experts.

Screen play • Element lets you use any display screen you choose, to suit your space and décor. Get a space-saving 12" LCD, or go for a big 21" monster. (This is Dave Ramsey's favorite Element feature, by the way. Anyone wanna bet he bought his monitors on sale?) Hook up a VGA projector and make a Meter Wall!

Perfect timing • You can't have too much time. That's why Element's control display contains **four different chronometers** to help keep talent in sync: a digital time-of-day readout that you can slave to an NTP (Network Time Protocol) server, an elapsed-time event timer, a countdown timer talent can set for any interval they choose... and there's also that big, honkin' analog clock right in the center of the screen (Big Ben chimes not included). We wanted to make it even bigger, but our screen designers charge us by the pixel.

Where's Waldo? • Hide-and-seek is a pretty fun game. But not when when you're in a hurry, and definitely not when you're on the air. So every Element fader comes with a big, **bold** 10-character LED display right above it to show talent, at a glance, exactly what source is assigned to that fader. If it's music from a digital playout system provided by one of our partners, the display can even show the title or artist of the song that's active. Talent tells us that these displays are at the perfect angle for either sit-down or stand-up studios.

Options • Clients say they love Element's uncluttered worksurface. We kept it clean by placing an "Options" key over each fader to give instant access to all the advanced goodies. It makes customizing settings easier than selling fudge cake to Dom DeLuise.

Black velvet • What's 100 mm. long, silky smooth, goes up and down all day and **lasts forever**? Our super-quality conductive-plastic faders, of course. (You have a filthy mind, mister. Shame on you.) We sourced the most durable, reliable, premium faders and switches for Element. And we added extra touches, like the custom-molded plastic bezels that protect on/off switches from accidental activation and impact. Because we know how rough jocks can be on equipment — some of us were (jocks, not rough). And because we also know there's nothing more embarrassing than a sudden case of *broadcastus interruptus.*

Audio cards • Well, *um*, there actually aren't any. Not in Element, or anywhere else in an Axia network. Why not? Think about this: your production guy spends hours crafting exciting, finely-tuned bits of broadcast magic, only to filter them through a card sitting in a noisy, RF-filled PC. It's like washing a wedding dress in the Hudson River. Not only that, broadcast audio cards are *expensive*. And they only work in *PCI slots*... how many of those are you seeing on new PCs? The **Axia IP-Audio Driver** installs on any Windows® PC to send and receive pure digital audio right through the PC's Ethernet port — no sound card required. You get better, cleaner PC audio that's sharable right to the network. And you save tons of cash on sound cards, and on the audio inputs you would have needed for that PC card audio — more than enough to buy that cool new network tester you've been lusting after.

Great Phones • We wanted the phones on Element to work like an extension of the board-ops themselves. Unfortunately, talent objected to having Ethernet ports implanted in their skulls, so we came up with the next best thing. With Element, jocks never have to take their eyes or hands off the board to use the phones. Element works with any phone system, but it really clicks with the Telos Series 2101, TWOx12, or the new NX-12, which connects four hybrids plus control with a *single Ethernet cable*. Status Symbols™ (those cool little information icons) tell talent at a glance whether a line is in use, busy, pre-screened, locked on air, etc. You can even dial the phone right from the board using the integrated keypad.

Fried Chicken • Conductive aluminum bullnose is connected to a 40 kilovolt storage capacitor* that can be activated with a GPIO closure. Set up a hotline remote trigger for the PD to give the jocks a little "positive feedback!"

Shown: 20-position Element, nicely equipped, $16,557.00 U.S. MSRP. Not shown but available: 4-, 8-, 12-, 16-, 24- and 28-position Element. Dual exhaust and whitewalls optional at extra cost

Element

Meter reader • LED program meters? How very 1990's. Element's SVGA display has lots of room for timers, meters, annunciators (*there's* a five-dollar word) and more — enough to show meters for all four main buses at once. Reboot the console to 5.1 surround mode and the light show is even cooler. Any more bling and those fast 'n furious types'll want it for their dashboards.

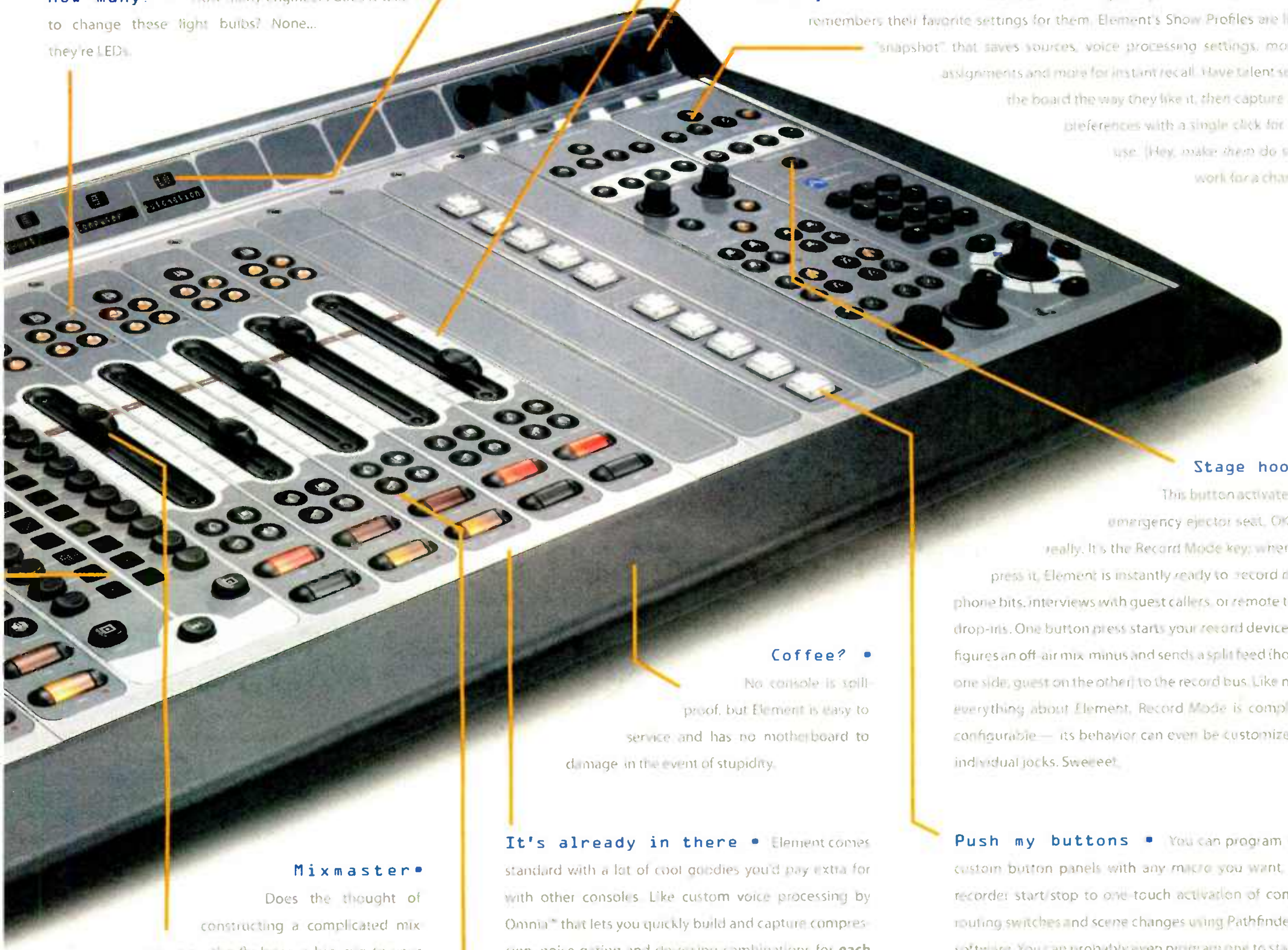
Status Symbols • There are those icons again. (We're in love with icons. It's the Telos way.) These Status Symbols alert talent to phone lines ringing, mix-minuses minusing, talkback channels talking, etc. They can even display fader numbers, like you see here. Just one more way Element makes it easy for talent to do a fast, clean show.

How many? • How many engineers does it take to change these light bulbs? None... they're LEDs.

Swap meet • Element modules are easy to hot-swap. Remove two screws and a cable or two, and they're out. In fact, you can hot-swap the **entire console** — unplug it and the audio keeps going, because mixing is done in an external Studio Engine.

Can I play with your knobs? • Twist 'em, push 'em, make 'em click. Element comes standard with some pretty powerful production features, like per-fader EQ, voice processing and aux sends and returns. Context-sensitive SoftKnobs let production gurus easily tweak these settings, while simultaneously satisfying their tactile fixations. (Don't worry: for on-air use, you can turn off access to all that EQ stuff.)

Memory enhancer • We know how forgetful jocks can be, so Element remembers their favorite settings for them. Element's Show Profiles are like a "snapshot" that saves sources, voice processing settings, monitor assignments and more for instant recall. Have talent set up the board the way they like it, then capture their preferences with a single click for later use. (Hey, make them do some work for a change.)



Stage hook • This button activates the emergency ejector seat. OK, not really. It's the Record Mode key; when you press it, Element is instantly ready to record off-air phone bits, interviews with guest callers, or remote talent drop-ins. One button press starts your record device, configures an off-air mix-minus and sends a split feed (host on one side, guest on the other) to the record bus. Like nearly everything about Element, Record Mode is completely configurable — its behavior can even be customized for individual jocks. Sweeeet.

Coffee? • No console is spill-proof, but Element is easy to service and has no motherboard to damage in the event of stupidity.

Mixmaster • Does the thought of constructing a complicated mix-minus on-the-fly bring a big grin to your face? If so, you're excused (Masochism 101 is down the hall). But if you hate building mix-minuses manually as much as we do, you'll love the fact that Element does them for you. No more using all your buses for a four-person call-in; no more scrambling to set up clean feeds for last-minute interviews. When you put remote codecs or phone calls on-the-air, Element **automagically** figures out who should hear what and gives it to 'em — as many custom mix-minuses as you have faders.

It's already in there • Element comes standard with a lot of cool goodies you'd pay extra for with other consoles. Like custom voice processing by Omnia™ that lets you quickly build and capture compression, noise gating and de-essing combinations for **each and every jock** that load automatically when they recall their personal Show Profiles. (There's even a secret "Big Balls" setting that makes wimpy interns sound like John Leader. A fifth of Chivas to the first guy who finds it.)

Talk to me • Need some one-on-one time with your talent? Talk to studio guests, remote talent, phone callers — talk back to anyone just by pushing a button.

Push my buttons • You can program these custom button panels with any macro you want, from recorder start/stop to one-touch activation of complex routing switches and scene changes using PathfinderPC™ software. You can probably even program one to start the coffee machine (black, no sugar, thank you).

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CONTINUED FROM PAGE 18

the copper they could get their hands on. The demolition contractor, which had based a good bit of its price on the salvage of the copper and fixtures inside the plant, took quite a hit when it eventually got in there to tear the place down.

Then last summer, a copper thief was killed when he broke into a pad-mounted utility transformer to steal the copper wiring and grabbed a 13 kV primary wire. Thieves are desperate to get at the copper. You'd think it was gold.

I was in Alabama not long ago, making the rounds of our five-station operation there. As I was eyeballing the base area under the 1,300-foot tower and thinking about the cool, conditioned air inside the transmitter building, I noticed something missing. The ground wires connecting the tower to the array of ground rods around the base were gone.

Copper thieves had struck, taking all the large-diameter copper ground wire and the external copper strap providing the RF ground connection. (See Figs. 1 and 2)

What were the indications of the missing grounds? There were none. No changed parameters, nothing. If it had been an AM site, there might have been some parameter shift, depending on what copper was taken; but here, nothing.

And had the 1,300-foot tower taken a lightning hit with the *only* path to ground being down the FM and STL transmission lines and through the equipment to the power lines, the damage would have been catastrophic.

At that same site, we found that a portion of the poly jacket on the Andrew 5-inch air-dielectric transmission line had been slit open, exposing the shiny copper within. Had the thieves hacksawed through that line, the station would have been off the air, maybe for a long time.

I later found that the ground wires and straps had been stolen from several of our Alabama tower sites, leaving them completely vulnerable to lightning damage. Thank God we made the discovery before any storms rolled through. Given the propensity of the sky in Alabama to open up at any given time between March and November, that really was a miracle.

What are the lessons here?

First, forewarned is forearmed. We know that our tower sites are vulnerable to copper theft, so we've got to take measures to reduce the risk. Keep exposed copper covered up. Keep dirt on top of the ground radials. I've also heard it suggested that exposed straps be painted primer gray as a means of disguising them.

At my Birmingham sites where the copper was stolen, we replaced the copper ground leads with larger-diameter aluminum ground wires — not as good as copper, but not likely to be stolen.

The other lesson is that broadcast engineers must inspect *all* the exposed ground connections during *every* site visit. This isn't something you would normally look at. Again, had our chief engineer and I not stumbled upon the missing copper, it likely would not have been noticed until the transmitter was a pile of smoldering ashes on the transmitter room floor.

Fig. 3: Wheatstone G5 Control Surface in Denver

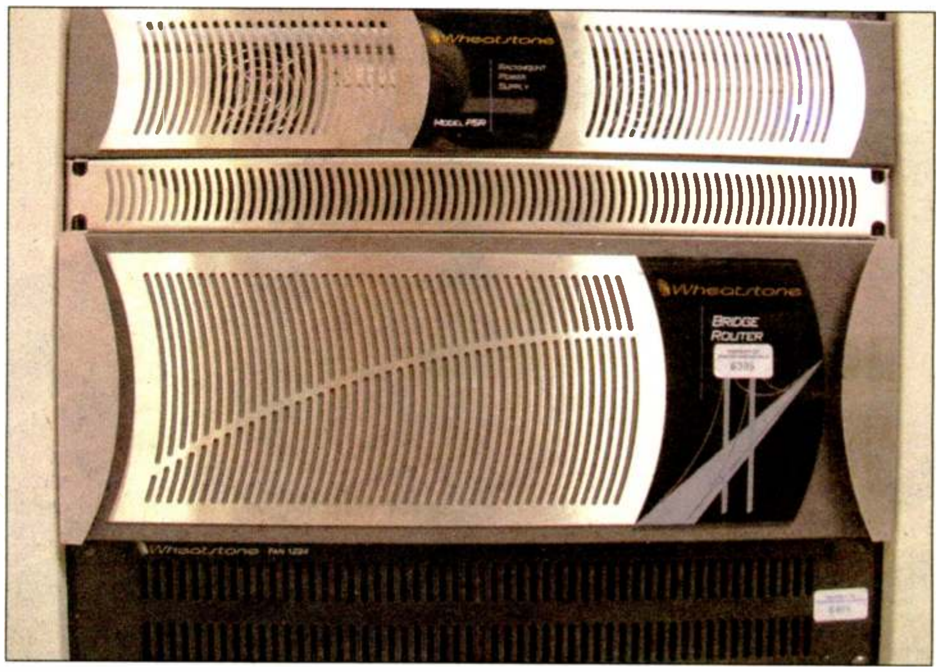

Fig. 4: G5 Router Cage Installed

THE NEW WORLD OF DIGITAL

I'm admittedly an old "tube-and-iron" guy. When I came into this business and did my electronics training, transistors were relatively new. Tube theory primarily was taught, with just a passing nod to solid-state semiconductors. And transformers were king.

Forget "active balanced" inputs and outputs. No such thing. Forget about op-amps and logic gates. Transmitters were "walk-in"; mixing consoles were big with rotary step faders; and wiring was done on "Christmas trees." That was a long time ago, and thankfully, we've come a long, long way.

My company tends to stay close to the leading edge (sometimes the "bleeding edge") of developed broadcast technology; but in most cases the timing of our adoption of new technology is driven by capital equipment rotation schedules.

In other words, we wouldn't normally make a jump and replace a bunch of perfectly serviceable equipment that was otherwise within its planned useful life. We wait until the existing equipment reaches its normal scheduled replacement date and then make the jump. That means, depending on the timing, we can either be right on the leading edge or a few years behind it. And sometimes being a little behind the curve isn't such a bad thing. Let someone else be the "test pilot" for a change.

I'm admittedly an old 'tube-and-iron' guy.

A number of years ago at the spring NAB convention, I began seeing some of the router-based studio systems that use "control surfaces" rather than "boards" with audio and control logic connections made at the central or satellite router cages. Control surfaces are connected via CAT-5 cables instead of fat multi-pair cables.

I remember being intrigued and thinking that this was the future of broadcast studio infrastructure. Indeed it was. A lot of facilities now use such systems, and those that jumped in early have helped "debug" them so the technology is now more or less mature.

Because of the timing of things, my company was just a little late getting aboard with the streamlined infrastructure. But we are now getting aboard and in a big way, converting Chicago last year and three additional big markets this year. This has been quite a leap for this old tube-and-iron engineer, but I'm not sorry to see us entering the new world it represents.

We installed a Wheatstone Bridge Router and Generation 5 control surfaces in our Chicago facility in 2005, and I configured and ordered the system. But it wasn't until last summer when we installed a four-station system in our Denver hub that I got to really *see* one of these things go in.

I wasn't directly involved in the installation (other than standing around and getting in the way), but I did get a good look at the system and its installation and configuration. (See Figs. 3 and 4)

Without a doubt, this is a huge improvement over even recent analog and discrete digital studio systems. Once the infrastructure is in place, the possibilities are limitless. Configuration changes are done with mouse and keyboard instead of cross-connect wire and punch blocks. Board configuration can be changed from day-part to day-part with a push of a button. Even EAS integrated into the system, without those downstream program-interrupt relay boxes.

Interface with digital automation is via Ethernet connection, greatly simplifying the physical connection and opening up a whole world of possible commands/instructions that can be sent.

Cutting in such a new infrastructure within an existing operation takes a lot of thought and planning, especially if the stations must stay on the air during the change, but it can be done. The secret is threefold: First, careful planning; second, temporary facilities (production rooms configured as temporary on-air studios); and third, long hours (i.e. "git-r-done").

Holiday Inn used to have an ad slogan: "The best surprise is no surprise." That bit of Madison Avenue "wisdom" holds true in big studio projects as well. Plan, plan and plan. Plan for what you know, plan for what you think may be the case and plan for contingencies. Make sure you have everything you need on hand.

A case in point was that we needed an external headphone amplifier in each control room for the new system. Surprise! That should have been caught in the planning.

Production rooms don't often lend themselves very well to on-air use. Often there is no provision for mix-minus and there is no multi-line telephone interface. But those things can be overcome. The air and production staffs will complain, but "no pain, no gain." A few days of inconvenience will yield a big improvement in the overall facility. They can get over it, but you will have to *sell* it to them.

I have found over the years that immersion is the way to go with projects such as this. Don't start and stop. Don't drag the project out over weeks. Get in there and get it done. Work long hours. Focus. Enlist the GM and other department heads to help you alleviate the inevitable sleeve-tugging so you can stay focused on The Project without getting sidetracked. The result will be a job completed in a much shorter time with much less inconvenience to the rest of the staff, to clients and yourself.

The good news is that once you are in the new world of digital studio architecture, your life will get a lot easier. Format change? No problem. Ten minutes okay? Move Station A to Studio C? No problem. Give me two minutes. Change the source on Fader 6? 30 seconds. You're going to love it, *especially* if you're an old tube-and-iron guy like me.

Send comments on this or any article to rwee@imaspub.com. ■

by Ted Nahil

Delivering HD Stream to Transmitter Requires More Bandwidth

The Latest-Generation HD Implementation Requires Extra Bandwidth or Careful System Design

Ted Nahil is the domestic broadcast channel sales manager, networking, for Harris Corp. Broadcast Communications Division in Mason, Ohio.

There was a time not long ago when a broadcaster's only requirement for connectivity to the transmitter site was a stereo audio pair and some form of data link to operate a remote control system. The audio was unidirectional and the "data" link consisted of a two-wire circuit over which the FSK data from the station's remote control system passed. It wasn't uncommon that the data circuits were provided and maintained by the telephone company with the audio moved over a conventional 950 MHz STL system.

For anyone now implementing or considering HD Radio technology, those simple circuits or paths are no longer viable as an STL solution.

This paper will start with a review of the components of the two Ibiquity HD Radio generations and describe the various configurations possible for placement of these components. We'll then look at the STL options available to deliver this data to your transmitter site.

Finally, we'll talk about what the future holds and why you should plan for it now, regardless of the implementation you choose at the onset of your digital conversion.

I. HD RADIO ALTERNATIVES

Ibiquity's Gen 2

The original HD Radio implementation in the United States requires that a 20 kHz stereo audio channel and a 400 bits per second (bps) data channel be delivered to the transmitter site. The audio can be linear or compressed, with the critical requirement that it be sampled at 44.1 kilo samples per second (ksps). This configuration, still available for the simplest HD implementation, is called Gen 2.

The audio is delivered to the transmitter where it feeds the Gen 2 exciter. The exciter does two things. It generates the HD data stream for the digital transmission, and produces a delayed analog audio output to feed the conventional analog transmitter. The audio for the digital transmitter is called the main program service, or MPS.

Along with the MPS, we also have the capability to transmit data that accompanies this audio and contains information about its content. This data is called Program-Associated Data, or PAD, and it is transmitted with the MPS signal throughout the HD process. It is used to display title, artist and album information for the listener to see on the display of an HD radio. This data is serial in form (RS-232) at a very low rate of 400 bps. Fig. 1 illustrates the basic Gen 2 HD system.

Ibiquity's Gen 3

The second commercially available HD Radio iteration introduces the Importer to the mix. The purpose of the Importer is to produce a second (or third) digital audio channel. The Importer is a Windows XP-based PC with a high-quality, multichannel audio card.

The Importer creates all of the digital services except the main program service (MPS) audio channel. These services include Advanced Application Services (AAS) and Supplemental Program Service (SPS), which is a second audio channel transmitted along with the MPS channel, allowing the broadcaster to have a second audio service that is different from the MPS (and analog, or host) channel.

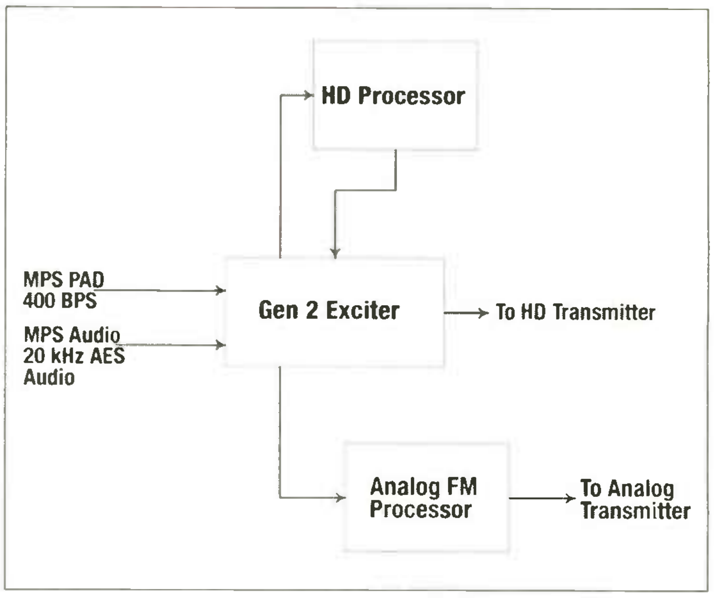

Fig. 1: Gen 2 HD System

Gen 3 also breaks the components up further. The Gen 2 exciter is split into two parts: the Exporter and the Exgine exciter. The Exporter creates the digital MPS channel, incorporates the MPS PAD and can generate the delayed analog audio feed. The Exgine exciter generates the digital HD Radio subcarriers.

Gen 3 consists of three distinctive parts. The configuration of these parts and how we deliver audio and data to them is the main focus of this paper.

II. THE BANDWIDTH PROBLEM SURFACES

Goodbye, old STLs

To implement a Gen 2 HD Radio system, we need to deliver 20 kHz audio, preferably linear, and the PAD that accompanies it to the transmitter. The Exporter function is built into the exciter in a Gen 2 system, so we have no alternative but to deliver 20 kHz audio to the transmitter site if we want full-fidelity digital audio. This means that older STL systems, and certainly telco program loops, are inadequate for this task.

Although it is not usually mentioned as part of the description of Gen 2 exciters, these exciters are performing two distinct functions: producing the digital data stream and generating the digital carrier.

The audio destined for the digital transmitter exits the exciter, where it can be processed, and then is fed back to the exciter where the digital signal is created. In this process, an analog feed delayed to time-align with the digital audio exits the exciter as well, where it is processed and fed to the analog transmitter. Mechanisms exist within the system to "tweak" the time relationship such that the analog and digital audio is always in time alignment.

The latest versions of popular audio processors have the ability to produce this delay when they are locked to the action occurring in the digital exciter, an alternative method of producing the delayed analog audio. A benefit to this approach is that the processor can then resample the analog audio output (at 32 ksps) to produce a 15 kHz signal. This 15 kHz audio is then fed to the analog transmitter. This ability will come in handy in a Gen 3 implementation.

Therefore, for an HD system employing a Gen 2 exciter, we need an STL capable of transmitting 20 kHz audio and low-speed (400 bps) data to the transmitter site. Fortunately, this is not a heavy requirement for today's STL systems. All the digital magic takes place at the transmitter site, so we need only to deliver audio and some very slow data.

Meeting these bandwidth requirements is not difficult, whether you chose a 950 MHz STL system like the Moseley Starlink 9003Q or a T1 STL like the Harris Intraplex STLHD. Delivery of 20 kHz linear audio and the PAD data is easily accomplished with either of these STL systems.

The bandwidth limitations of these systems become an issue when we move to Gen 3.

Need more bandwidth, please

To move the audio and data using a Gen 3 Importer/Exporter/Exgine exciter configuration, we have to make some decisions on equipment placement, decide on the

SEE BANDWIDTH, PAGE 26

This boring ad can save your butt, make your job easier, and keep the boss happy.

Interested? Good. Now let's get down to the business of keeping your radio station reliably on the air.

Does your transmitter go off the air during lightning storms? Does the breaker trip for no apparent reason? Do you waste time driving to the site to reset it, and try to figure out why it tripped? Do your studio computers sometimes lock up or do other weird things? These failures are often caused by spikes and transients on the AC powerline. They're a fact of life. They cause damage and unreliability **and make you look bad.**

Now the butt-saving, keep-the-boss-happy part: Henry Engineering's ***PowerClamp*** Transient Voltage Surge Suppressors (TVSS) units **will solve these problems.** Instead of making excuses about why you're off the air (again), you can brag about your station's on-air reliability and lack of transmitter failures. **Now you're a hero.**

PowerClamp surge suppressors are the best performing TVSS units in the industry. They were originally developed for use by the U.S. Department of Defense, to protect the computers on Uncle Sam's military test ranges. PowerClamp TVSS units are used at hospitals, airport control towers, banking data centers, and hundreds of mission-critical installations across the country. They'll work just great at your radio or TV station.

Now let's get down to some solid engineering. No advertising hype, just verifiable facts and figures. Why do PowerClamp TVSS units work so well? How do they work? Here are the answers.

PowerClamp TVSS units have some very significant advantages over virtually any competing product:

1. **Extremely low clamping level.** ***PowerClamp*** uses a *hybrid of multiple clamping circuits* to achieve an extraordinarily low clamping level. Our advanced technology attenuates spikes and surges to within *a few volts* of the AC sinewave. The circuitry detects the *amplitude and risetime* of the offending transient and responds accordingly. PowerClamp's multi-stage hybrid design is the secret to its incredible performance. It works.

2. **Non-degrading operation.** ***PowerClamp*** performance *does not degrade*. Unlike TVSS units that rely solely on MOVs, PowerClamp's attenuation level remains consistent even after years of service. The ultra-low clamping level results in minimal power dissipation in the suppression components, so there's no degradation. Hundreds of PowerClamp units that were installed in the 1980s are still working today. So will yours.

3. **Guaranteed performance.** ***PowerClamp*** spec sheets quote accurate engineering data. We *guarantee* our clamping levels under real-world conditions. Compare our specs to any competitor (assuming they actually publish their clamping levels) and see for yourself. No smoke-and-mirrors, just performance and results.

For more detailed engineering data and broadcast-user Case Histories, please visit www.henryeng.com. Be sure to view the PowerClamp **Theory Of Operation**.

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Bandwidth

CONTINUED FROM PAGE 24

type of audio feeds we will use and possibly deal with some perceived trade-offs.

If we place all of the HD equipment at the transmitter site, we have a dilemma. We now need to deliver two 20 kHz audio channels (one main, one supplemental) plus two PAD data streams from the studio to the transmitter. If we want linear audio for both audio feeds, we've run into a bandwidth dead end.

There is no single "conventional" STL system available that can deliver two 20 kHz linear audio channels from point A to point B. The technology simply does not exist on a 950 MHz link or a T1 link. There are some "non-conventional" alternatives described below, but choices must be made if only a 950 MHz or T1 STL is being considered.

It is possible to connect an Importer directly to a Gen 2 exciter as well. However, we face the same dilemma we face if we locate the Importer at the transmitter site. Two 20 kHz audio feeds and PAD for both program channels need to arrive at the transmitter site.

III. EQUIPMENT PLACEMENT IS THE KEY

How is it all connected?

The Importer communicates with the Exporter through a UDP (User Datagram Protocol) connection. Note that the long-term objective is to use TCP (Transmission Control Protocol) for this connection. When the Importer and Exporter are co-located, the connection is made with a CAT-5 cable.

The output of the Importer is a 48 kbps stream (with some packetizing overhead) that contains the AAS information (including PAD). Consequently, if the Importer is separated from a Gen 2 exciter (placed at the studio, for example) or an Exporter, a 128 kbps link should be sufficient for this connection.

The Exporter communicates with the Exgine exciter through a UDP connection. The output of the Exporter is 96 kbps plus overhead, resulting in a data rate that is approximately 109 kbps. Under ideal conditions, a 128 kbps link is sufficient for this connection.

Practically speaking you should plan to allocate 192 kbps for this connection. This is because the data from the Exporter is sent in bursts. There should be enough bandwidth available so the exciter does not time out waiting for packets from the Exporter.

Fig. 2 shows the components of a Gen3 HD Radio system. One main (MPS) channel and one secondary (SPS) channel are shown, along with the PAD data.

Exporter and Exgine exciter only

There are a limited number of possibilities for arranging our HD equipment in a Gen 3 system. The Exporter can still go either at the studio or at the transmitter if we have no desire to do an SPS channel. Locating the Exporter at the transmitter site puts us in the Gen 2 arena — we need to deliver 20 kHz linear audio and PAD to the Exporter input. This also means our processor has to be located at the transmitter. Nevertheless, this implementation is easy using either a 950 MHz STL or a T1 STL.

Placing the Exporter at the studio, however, now means we need to transport audio for the analog transmitter, PAD and the Exporter's UDP data stream to the transmitter. The benefit of using the audio processor to create the delayed analog audio feed is now evident: Because we use the processor to resample the audio output at 32 kHz, we've reduced the audio bandwidth we need to deliver to the transmitter from 20 kHz to 15 kHz.

We only need audio for the analog transmitter so there is no reason to feed it audio with a frequency response beyond 15 kHz.

Adding the Importer

When we add the Importer to the system, again, we have two choices for placement. If the Exporter is at the transmitter site, the Importer can be placed there and connect to the Exporter with a CAT-5 cable. As we have discovered, this now means we need to deliver two 20 kHz audio signals to the transmitter: one for the Importer and one for the Exporter.

The Importer also can be placed at the studio, feeding an Exporter at the transmitter site. Now, we need to deliver 20 kHz audio to the input of the Exporter, the MPS PAD and 128 kilobits of TCP or UDP data — the connection between the Importer and Exporter — to the transmitter site. One caveat with this approach: Both the Importer and Exporter need the same clock reference. This is achieved easily with a properly configured, accurate GPS system.

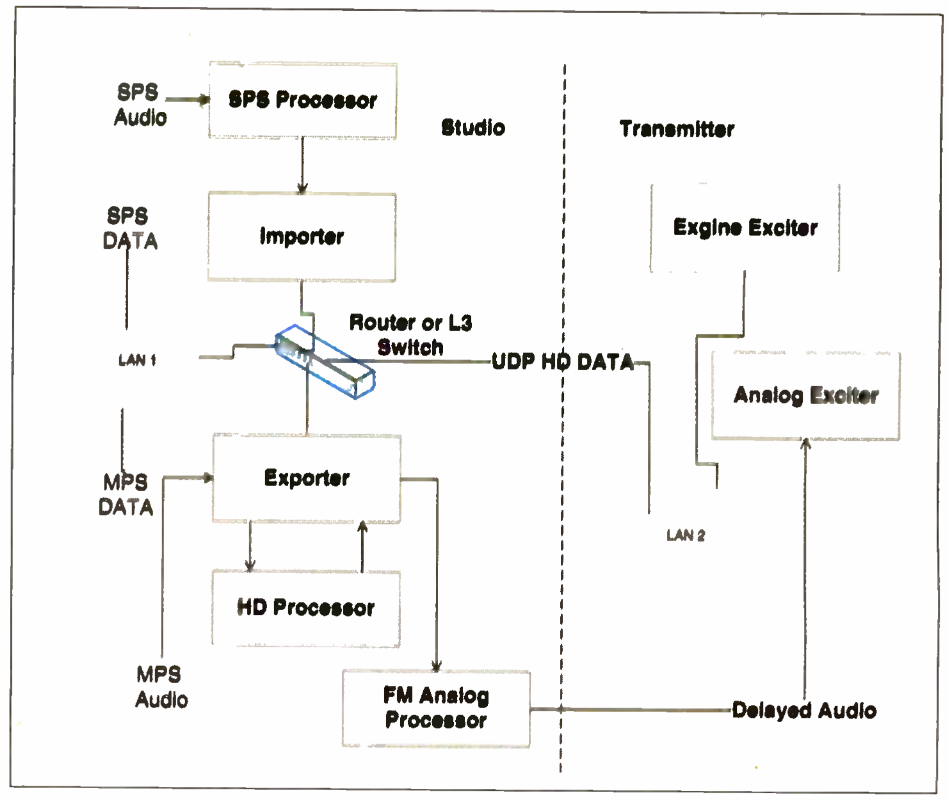

Fig. 2: Gen 3 HD System

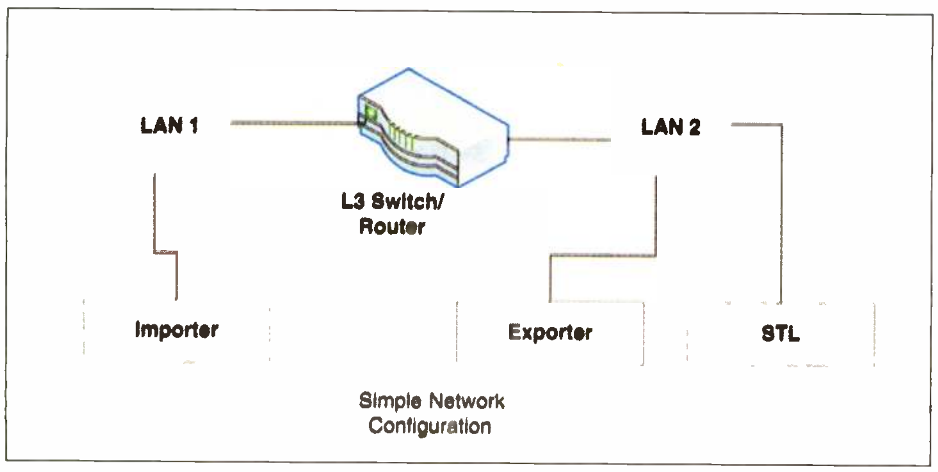

Fig. 3: Simple Network Routing

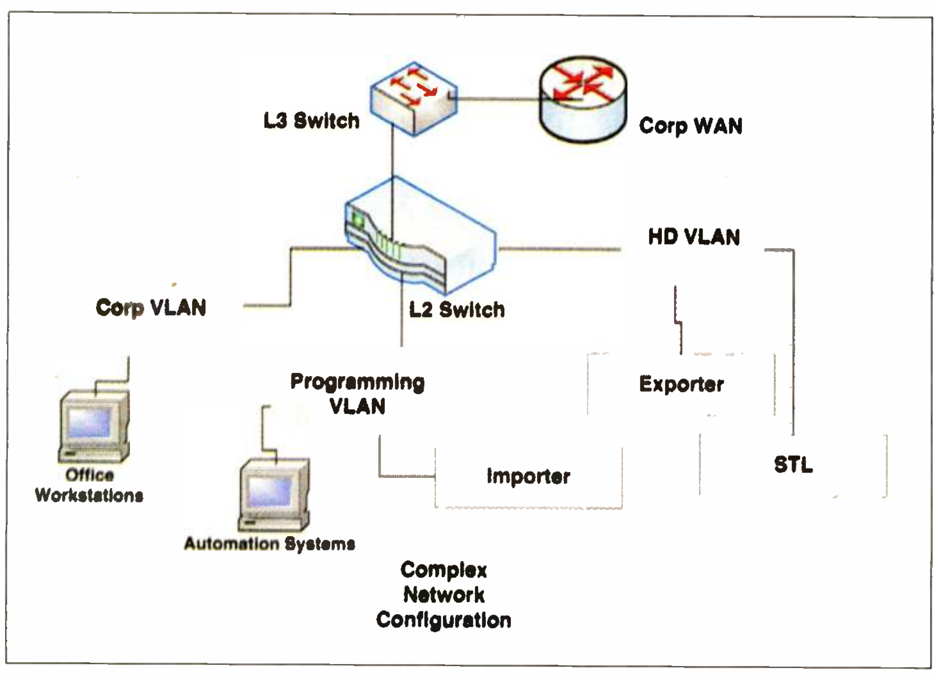

Fig. 4: Complex Network Routing

Importer and Exporter at the studio

We need to weigh some options when considering placement for a complete Gen 3 system. Placing the Importer and Exporter at the studio has many advantages. As we have seen, the Importer connection to the Exporter is a simple CAT-5 cable. Audio feeds to each come directly from the program outputs of the individual sources, through the appropriate processors. The STL needs to transport only 15 kHz audio (for the analog transmitter) and the Exporter's UDP data stream.

Locating these components at the studio means the audio processing must also be located at the studio. This is generally not an issue; in fact, it is the generally preferred method. Facilities replacing an older (i.e., limited to 15 kHz) composite STL have an added advantage, as this system can function as a backup for the analog transmission system.

For anyone starting from scratch planning an HD system, locating as much of the equipment as possible at the studio requires the least amount of studio-to-transmitter bandwidth.

Split Importer

One last configuration is in use by some facilities that have Gen 2 exciters and Importers located at the studio. This configuration involves a split Importer — two computers functioning as a complete Importer. The two parts communicate using TCP and the remote Importer has a second network interface card (NIC) that communicates with the exciter using UDP.

This saves some bandwidth in that the audio for the Importer is delivered at the studio and the connection between the two Importers can run at 128 kilobits.

IV. MPS, SPS AND PAD SOURCES AND NETWORKING CONSIDERATIONS

Before we examine STL alternatives, it is important to discuss the various IP connections and how we should isolate them. The first objective is to reduce greatly or totally eliminate any congestion on the IP networks associated with any source. The second objective is to take steps to guarantee that the TCP or UDP packets arrive at their destination on time.

Subnets and routers

The details of creating subnets are beyond the scope of this paper. However, it is important to understand how we isolate the components of a Gen 3 system so they are as immune from interaction as possible. We achieve this with subnets and VLANs (virtual LANs).

Assuming our devices are using reserved IP addresses, we want to put the Importer on a different subnet from the Exporter. We want the Exporter and the STL IP components on the same subnet.

Fig. 3 illustrates a simple network scheme. Notice that the Importer is on a different subnet from the Exporter and STL. To make this work, we need a router or a Layer 3 switch between the Importer and the network components it shares, and the rest of the HD components and STL.

Fig. 4 illustrates a network topology that

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allows a corporate network, an automation network and an HD network to communicate with one another without causing congestion or collisions on any network segment.

Dedicate an IP connection for HD

When we are ready to move the HD IP data from the studio to the transmitter, we must take care to limit the traffic on those IP links to only the HD data stream. Although it is practical to have an extension of the station's LAN at a transmitter site, always use a separate IP link, and separate subnet as well, for any non-HD IP connection from the studio to the transmitter site. Never attempt to move your HD data, PAD, RBDS and station LAN information across a single LAN connection.

V. STL ALTERNATIVES

'Conventional' STLs

The STL we use depends on the equipment placement we have chosen. Our bandwidth requirements are greatly reduced with the Importer, Exporter and processing located at the studio. We need only move 15 kHz audio (delayed, for the analog transmitter feed), the MPS data stream and PAD from the studio to the transmitter.

With this approach, a conventional 950 MHz STL link will work as an STL. For example, the Moseley Starlink SL9003Q with the LAN package has enough bandwidth to move the audio and data we need to deliver to the transmitter. We have no ability to retrieve any information from the transmitter site, as a 950 link is unidirectional, but we don't need to because the HD data stream is a unidirectional UDP stream.

Similarly, a conventional T1 STL like the Harris Intraplex STLHD-15 provides 15 kHz linear audio in both directions and a LAN circuit operating at 448 kilobits. We only need to move 128 kilobits for the HD stream, so we can reduce the LAN to that rate and have room for additional payload like telephone extensions, serial data and even another LAN circuit. The advantages of a T1 STL link are the additional payload capacity and the fact that the link is inherently bi-directional.

Placing the Importer, Exporter and processing at the transmitter site requires that we now move two 20 kHz audio channels — one for MPS, one for SPS — and PAD for each from the studio to the transmitter. We no longer need to move an IP stream, but we have a lot of audio to move.

Neither a 950 MHz nor T1 STL can deliver two linear audio channels to the transmitter. There just isn't enough bandwidth. The only choice is to introduce some compression. Alternatives include using MPEG Layer II or APT to gain the necessary bandwidth.

The Moseley Starlink system offers MPEG only as a choice for compression. The Starlink can be coupled with the Moseley Lanlink, which operates in the 902–928 unlicensed ISM band through the same antenna using a built-in combiner. This allows duplex LAN connectivity between the studio and transmitter, and reserves the Starlink bandwidth for both audio channels.

The Harris Intraplex STL systems offer MPEG as well, plus Enhanced apt-X that can operate in the 16-, 20- or 24-bit mode, greatly reducing the required bandwidth. For example, two Enhanced apt-X stereo channels operating at 20 kHz response in the 24-bit mode can easily fit in a T1 channel, leaving 384 kilobits available for other data, like a LAN, serial or telephone connection.

It is important to note that neither a 950 MHz RF link nor a T1 link can fit one 20 kHz linear and one 20 kHz compressed channel in the available bandwidth. Choosing to place the HD equipment at the transmitter site creates a situation where we either have to compress both the MPS and SPS audio, or get creative.

> **Broadcasters must plan their installations carefully and account for the added STL bandwidth they need to implement HD and HD2 radio services to the public effectively.**

Installing two T1 circuits to a transmitter site is a clean alternative for stations that can afford the expense. Now, both the MPS and SPS audio channels can be linear with a small amount of bandwidth left over for either LAN, serial or telephone links. This approach is being adopted by some larger group facilities in major markets.

In the 950 MHz world, the alternative is to procure two STL licenses. This is unlikely to occur, as the 950 band in almost every U.S. market is filled.

'Non-conventional' STLs

There are other choices available to broadcasters that do not fit into the conventional STL model. These alternatives include unlicensed spread spectrum T1/E1 links, unlicensed spread-spectrum IP links and large-capacity DS3-based systems.

The benefits associated with choosing an unlicensed RF link usually far outweigh the risks. Although radios in the unlicensed band are, by definition, unregulated as far as frequency coordination is concerned, it is never a bad idea to work with other broadcasters and users to maintain some updated information data on what systems are being used in the field.

For example, a 2.4 GHz link may work well until an ISP decides to use that same band to deliver high-speed Internet service to customers who have no other means of obtaining it. One advantage of spread-spectrum technology is that under most circumstances, changing antenna polarization or spreading codes can eliminate mutual interference when two links must coexist in the same band.

Spread-spectrum links also offer the benefit of multiple channels on the same link. It is possible to purchase radios in the 2.4 or 5.8 GHz band that can carry four or eight T1 or E1 circuits, for example. These links are privately owned (by the broadcaster), so once the initial capital investment is made there are no recurring costs associated with leased lines that would be provided by a telephone carrier.

Many manufacturers, including Harris, Proxim and Adtran, offer multiple T1 or E1 radio links that operate in the 2.4 or 5.8 GHz unlicensed ISM band. These radio links perform much differently from conventional 950 MHz links. It is important to have path studies completed on any spread-spectrum link to ensure that the path is clear. Fresnel clearance in these bands is different and much more critical.

Operating in the same bands, spread-spectrum IP links offer another choice for the broadcaster. Manufacturers familiar to the broadcaster include Proxim, Adtran and Motorola. IP-based radios usually offer 10 or 100 Mbps data rates, more than sufficient to accommodate the bandwidth required for HD. These radios, coupled with an IP multiplexer, can provide a reliable alternative to a conventional STL.

There are a number of large-capacity systems available to the broadcaster as well. Broadcast Electronics offers a product called Big Pipe that can provide up to 45 Mbps of bandwidth and can operate on an unlicensed spread-spectrum link or a dedicated DS3 circuit, usually obtained from a telco provider.

Radio broadcasters who have facilities collocated with an HD TV facility may be able to use some of the TV station's bandwidth to install a T1, E1 or IP-based STL. Consider this approach if it is available, as there is almost always some bandwidth available on a DS3 in use by an HDTV facility.

VI. CONCLUSION

HD Radio technology and its multicasting opportunities offer broadcasters the first major advance in broadcast technology in years. As with any emerging technology, we have only just begun to realize the potential this service will afford broadcasters and listeners as well.

Broadcasters must plan their installations carefully and account for the added STL bandwidth they need to implement HD and HD2 radio services to the public effectively. The technology in its current state is dynamic, and broadcasters must remember this as they introduce these services to the radio audience.

The burden on a station's STL will continue to increase. With correct planning and equipment location, the broadcast engineer can reduce the station's bandwidth requirements and accommodate the additional audio and data requirements brought on by an HD Radio implementation.

E-mail comments on this or any other article to rwee@imaspub.com. ■

by Steve Callahan

Tales of a Lifetime in AM Antenna Design

Ron Nott Discusses His Career Muse, Folded Unipoles And Support for Elevated Ground Systems for AM

Steve Callahan is assistant chief engineer for the WBUR Group in Boston and is a regular contributor to RWEE.

Some people think AM radio is terminally ill. Not so, says Ron Nott, who has been involved with AM antenna improvements since the 1960s. Chances are you've heard of Ron or his company, Nott Ltd., as the manufacturer of folded unipoles for AM stations. Ron has helped a number of AM stations since forming Nott Ltd. in 1982 in Farmington, N.M.

In this interview, we get a look at Ron's interesting personal history and his years of experience with John Mullaney's unipole design. (While Mullaney did not invent the unipole, he put it into practical application and did virtually all the early development.) He explains the theory behind the folded unipole and his newest product, elevated AM ground systems. Nott also has been a ham operator for 47 years.

Where were you born and where did you go to school?

I was born in Oklahoma City in 1934 and went through its school system. I attended a total of six colleges and universities but never graduated from any of them. My health has always been inconsistent, along with an incredible degree of inherited laziness, so I am virtually self-educated.

Incidentally, I observe that many broadcast engineers have done the same thing. They just buckle down and dig in to learn. The SBE is aware of this and its certification program in many areas of broadcasting provides opportunities for a person to become certified and recognized for his or her own efforts, regardless of formal education.

What do you do when you're away from work?

Away from work I am a train and railroad nut. My wife and I own about 15 acres of New Mexico desert and I have been building a riding railroad on it. The scale is 1.5 inches = 1 foot-0 inches for standard gauge and 2.5 inches = 1 foot-0 inches for narrow gauge. I have one locomotive, which is a model of a 1932 box cab diesel. It weighs 500 pounds and is powered by deep-cycle RV batteries.

Ron Nott and His Dog Charley

I am slowly constructing a steam locomotive to the narrow-gauge scale. It will burn coal, boil water and the steam will drive the wheels like the engines of more than a century ago.

What inspired your broadcast career?

It was the Russians. You may recall that they placed a satellite in orbit in 1957 called the Sputnik. I was called into Army active duty in early 1958 and wound up teaching electronic fundamentals in the Officer Training Division of the Ordnance Guided Missile School at Redstone Arsenal, Ala. At that time, Werner von Braun and his German rocket scientists were there, so it was a very exciting place to be. Congress threw millions of dollars at the place to try to catch up with the Russians so it was the center of attention for a while.

When I got out of the Army in 1960, I intended to go back to school to get a degree in electron physics, but was short of funds because our Congress forgot those of us who served at that time. Someone told me that there was a radio station nearby that needed someone with a license, so I went and talked with the chief engineer. He said that if I got my FCC First Phone ticket I had a job. I had been teaching electronics and had become interested in amateur radio, so all I had to do was cram for the rules part of the test and I had my license in about two weeks.

So I went to work for WAIL(AM) 1460 kHz in Baton Rouge, La. They had a nighttime directional array but the FCC exam did not cover this, so I asked, "Duh, what's a DA?" The CE said, "Well, we have a four-tower parallelogram with unequal height towers."

This was the deep end of the pool, so it was cramming time again. I did a repair job on the phasor and other antenna equipment and within a few months I also was employed at a second station, this one

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Unipoles

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with a three-tower directional array. I became the directional antenna guy in town because nobody else wanted to know about these things.

Who did you have as a mentor early in your career?

When I started my antenna manufacturing business in 1982, the late John H. Mullaney became my only, but totally invaluable, mentor. This gentleman was a professional engineer in every sense of the title. His teaching, suggestions and assistance were of golden value to me and I treasure the memory of this fine man.

What inspired you to form your own company?

I had an extremely interesting experience with a folded unipole and could not get it out of my mind. I got a job at a power generation station, but I still liked broadcast engineering much more than power generation. I managed to get on the night shift, and for the next eight years I worked for myself from 8 a.m. to 3 p.m., and from 4 p.m. to midnight for the electric company. At that time I had the opportunity for early retirement, which I took so I could devote myself full-time to my business.

When it comes to running a manufacturing business, my wife says there are three problems — employees, customers and vendors. Everything else is great.

Your company is known for providing folded unipoles for AM stations.

We have specialized in folded unipole antennas because they are versatile in many ways. The grounded tower eliminates the cost of the base insulator and allows installation of VHF and UHF antennas on the tower without isocouplers. Using the Mullaney Unipole design program, we can provide an antenna with extremely broad bandwidth for digital AM radio.

By using this program, we also can provide a 50 ohm drive-point impedance on an antenna that is very short electrically. If a tower is too tall for an AM frequency, we detune the upper part of the tower and design an optimized bandwidth antenna to install below it.

Some people say that a folded unipole will increase a station's coverage. Is this true?

The only dramatic improvements we have experienced were when an existing series antenna was retrofitted as a unipole, but only if the series antenna already had serious problems. Assuming that a series antenna is operating properly, and then retrofitted as a unipole, the effective diameter of the antenna is increased by the skirt and there may be a small gain on the order of a fraction of one decibel. This is because the propagation velocity within the now "fatter" antenna is slightly decreased, making the formerly thin antenna appear to be slightly taller than it actually is. This is an old principle based on the length-to-diameter ratio.

As a side note, some time ago a person claimed to have invented a folded unipole that had circular polarization. Considering the design of FM CP antennas, I do not believe this would be possible with a folded unipole and, if so, the FCC would certainly want to set standards for it. There is just no free lunch.

Shop Foreman Ron Walton, Ron Nott and Shop Hand/Master Welder Ray Toledo talk about the folded unipole and examine a demo.

Nott, a self-proclaimed 'railroad nut,' shown with his 'reefer' car, a reproduction of a refrigerator car. He built the car from scratch and lined it with Rhino Lining. The top lifts up, and it is going to be used to hold drinks when his family has parties.

Building a tall tower these days is difficult and expensive due to community opposition, but electrically short towers are a problem in AM service. Can a folded unipole be effective with electrically short towers?

The most commonly used short antenna — even in broadcast service — consists of a vertical radiator with a "loading coil" placed near its base, or sometimes its center, the latter being more efficient. However, as a vertical antenna's height is decreased, its radiation resistance decreases approximately inversely as the square of the height.

For example, in theory a quarter-wave vertical has a radiation resistance of about 36 ohms. But a one-eighth-wave vertical has a radiation resistance of about 9 ohms. A 1/16th-wave antenna then has a radiation resistance of about 2.25 ohms. However, the loss resistance remains constant regardless of height. If we assume a loss resistance of five ohms added to a radiation resistance of 36 ohms, the total is 41 ohms. This is a fair match to 50 ohm coaxial cable and a reasonably efficient antenna. But take a look at a 1/16th-wave antenna. Add 5 ohms loss to 2.25; you get about 7.25 and more than two-thirds of the RF energy is lost as heat resulting in very poor efficiency.

However, in the case of the short, folded unipole, the input impedance can be transformed upward as described previously so that even a 1/16-wave antenna can have an input impedance of 50 ohms plus j zero. If you do the heavy math required to determine the radiation resistance, it will result in a relatively small value, but the overall antenna efficiency can be greatly increased.

When a series-fed vertical antenna height is decreased, the input reactance becomes capacitive. That is why the inductance of a loading coil is required. However — and this is extremely important — when the height of a folded unipole is decreased, the input reactance becomes inductive. This means that a "loading capacitor" is needed at its input instead of a loading coil.

A capacitor is inherently a much lower loss device than an inductor, even an edge wound, silver-plated inductor. We always recommend that a vacuum-variable capacitor be used at the input to our folded unipoles intended for broadcast use. A vacuum-variable capacitor is an almost totally lossless device. An old ham once told me that L stands for loss.

Now, concerning its use as an electrically short antenna. We built and tested an experimental antenna that was only about 25 degrees tall; but the base must be insulated and an inductance placed across it. This provides an antenna with only two tuning components that will provide 50 ohms plus j zero. It also had a capacity top hat and many wide-spaced skirt wires.

Having too many irons in the fire at the time we did not develop this antenna further. The bandwidth was narrow, but by proper ATU design it could have been a reasonably broadband antenna system.

You also are a proponent of elevated ground systems for AM stations. Could you explain the benefits?

It may be appropriate to review the history of AM ground systems.

Going way back, some broadcasters used a "counterpoise" for the ground image required below a vertical radiator. However, by the 1930s, many stations were using buried radials so when the FCC had G. H. Brown and his associates set up standards for AM antennas, this is what they used. It is noteworthy that the FCC rules state that 90 radials are acceptable, but for some reason the industry has adopted 120. Note that both these numbers conveniently divide into 360 degrees for locating the stakes when laying out a new ground system.

A quarter-wave vertical antenna over a buried radial system of quarter-wavelength copper wires became the standard of the AM industry. The buried wires are somewhat protected by the dirt on them. However, this introduces several unknowns. You don't know the condition of an old buried radial system. Corrosion, trenching machines and farmers' plows can all do their damage.

Placing ground radials in dirt does two other things. One, the radio signal is attenuated by the dirt. The deeper they are buried the more they are attenuated, but even six inches of dirt costs signal. Two, soil and water have varying values of permittivity. The FCC assumes 15, but this can vary depending on soil chemistry, moisture, etc. The permittivity of water is about 80. Both of these increased values mean that the RF propagation in the buried wires is less than in air, so your buried wires are no longer a quarter-wavelength.

So now along comes Numerical Electromagnetic Computation — NEC. Some guy does some predictions and determines that an elevated-radial system of only four wires will perform as well or better than a 120-wire buried system. There will be some scalloping causing a slightly "four-leaf clover" pattern, but this can be resolved by using six wires in the system.

There are some design requirements, such as the radials must be insulated their full length after they leave their attachment to ground at the base of the tower and they should be a bit longer than a quarter-wavelength. For high-powered stations, radio frequency radiation limits must be considered around the wires, but this is resolved by placing them high enough above ground.

Assume we are going to build an elevated radial system of six wires. You place posts (wood or metal) at a distance away from the tower so that the wires will taper upward at about 30 degrees. Farther away, you place more posts to support the radials and at the outer posts, you install back guys. These require a ground anchor and a guy cable up on the post with a turnbuckle in it. A farmer could cultivate crops below the elevated radials and trenching machines for pipelines and telephone cables are not a concern.

You also manufacture the Gila Stat, a static discharge device. How does it work?

Multipoint dissipation, or charge transfer, works by slowly dissipating the electric field associated with a thunderstorm. A lightning discharge needs an electric field approaching 100 million volts to be initiated. If this field voltage can be decreased below the point where lightning is triggered, then a strike won't occur.

So I went to work for WAIL(AM) 1460 in Baton Rouge, La. They had a nighttime directional array but the FCC exam did not cover this, so I asked 'Duh, what's a DA?'

It was once believed that a lightning strike lowered a charge in the thousands of Joules, but current thinking is that a lightning strike is only some 10 to 50 Joules. This is not really a massive amount of energy, but because a strike occurs in a few microseconds the current can be thousands of amperes. If the same energy is discharged over several minutes of time, rather than a few microseconds, the current is typically from a few milliamperes to a few amperes and damage does not occur.

An excellent book on this subject is "The Electrical Nature of Storms" by MacGorman and Rust.

We never guarantee 100 percent elimination of strikes, but experience indicates that they can be reduced 95 to 99 percent by proper design and application of dissipation. Bear in mind that it is not a magic wand and that a single dissipator atop a tall tower will solve the problems. I believe that this method is prevailing over the egos and closed minds that obstructed it in the past.

You also provide AM detuning systems.

Concerning detuning systems, we also do this because the business is there and is closely related to folded unipole antennas.

SEE UNIPOLES, PAGE 32

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Unipoles

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Cellular telephone service continues to grow and we provide detuning systems for cell towers that are very stable and have long life expectancy by using quality materials and design.

Demand for AM detuning systems comes and goes depending on the growth rate of cellular phones. While it is unpredictable, the continued growth of cellular as well as other communications towers tells us it will continue for a considerable time. We have detuned water tanks, smokestacks and other tall metallic structures. Anything that distorts the pattern of an AM station by re-radiation can be detuned including steel buildings and bridges.

What are some of your more memorable projects?

We have many memorable experiences, one of which is furnishing a three-frequency detuning system for a 200 meter self-supporting tower in Kuwait shortly after the big battle there in 1991. Harris Broadcast did this project and Mullaney Engineering provided the design. They wanted to do field-intensity measurements before and afterward, but there are so many land mines that nobody would get off the traveled roads to do the measurements. We assume that the systems worked.

New products in the future for Nott Ltd.?

We hope to work with the Sandia National Laboratory to develop a device that will eliminate lightning pulse energy from traveling down power lines into buildings, damaging station equipment, appliances, etc. Stay tuned for that. ■

Racks

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and consideration has to be given to "human factors," even if the facility being designed is not normally staffed. Some of this should be incredibly obvious — you do not want to encounter a patch panel mounted 10 inches above the floor — yet mistakes in judgment do happen.

Once everything is racked up and wired, it's usually too late to bring the train back to the station. Even before the gear gets connected, installers are going to get upset over having to rearrange things. It's not fun moving an 80-pound piece of equipment up 14 inches just because you realized too late there was no room for the control panel that was supposed to go with another piece of gear.

Proper planning is easier than having to explain to the big boss that you need 20 hours of overtime approved for re-arranging racks.

CAD TO THE RESCUE

Fortunately, the computer has made rack layout much easier. Programs such as VidCAD and Winsted's WELS even allow you to create three-dimensional representations of equipment, racks and consoles. You are instantly alerted to the fact that the new router is going to hang out the back of the rack and not allow the door to close.

Even without the sophistication of 3-D CAD, it's relatively easy to generate a 2-D rack layout for your facility. Moving things around for best fit and ergonomics is a breeze compared with the good old days when everything was hand drawn. Part of facility planning involves a floor space drawing to ensure that everything

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Products & Services SHOWCASE

Racks

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is going to fit, that rack doors can be opened and that equipment on slides in facing racks can be installed and removed without problems.

Early computer programming instruction stressed plenty of "no-op" steps in the program, as there might be changes later.

The same goes for rack layout too. Don't try to squeeze the maximum amount of gear into the rack, for two reasons. First, you have absolutely nowhere to go if another piece of equipment has to be added later on. (And it always will!)

Also, more than likely, some of the equipment will overheat from being in such proximity to its similar heat-producing brethren. Moral: leave a lot of empty space and buy blank panels to cover it. Your equipment will run cooler and last longer and you'll be a hero later on when management wants one more "what's-it" installed as soon as it shows up on the loading dock.

A CATALOG FULL OF OPTIONS

Racks and consoles can be ordered with a number of accessories and options. At minimum are secondary rail sets (needed for rear support of deep and/or heavy equipment), power strips (two separately powered strips are recommended), lacing bars and grounding bus bars.

Rack tops, rear doors, sides, accessory drawers, ventilating fans, writing surfaces, blank panels and console work surfaces should be considered when the order is being prepared. Most companies also can provide caster sets if the rack or group of racks needs to be somewhat mobile.

A word of caution is needed here. It is always possible to load a rack in such a way that it becomes top-heavy. A top-heavy rack is not something that should have wheels under it. Bolt it securely to the floor and rethink the mobility idea to encompass lighter gear, or at least place the heavy stuff at the very bottom.

APW/Mayville offers the Stantron E-Rack, a 22-inch-wide system with horizontal lacing brackets, spread cables from front to back.

When placing racks, the matter of static floor loading should be more than a passing thought. While this should not really be a consideration in a new facility specially designed for broadcast installations, it could be a big issue in an older structure. If there's any doubt at all, bring in a qualified structural engineer and have some numbers run to see if the floor will take the load. This is a potential life-and-death matter and should never be left to guess work.

Also get shipping costs quoted up front for the racks and console units selected. Moving a lot of steel across country is not cheap and needs to be part of the project budget. Surprise big-buck "collect" express charges are not going to put anyone on good terms with upper management.

CLIPS VS. TAPPED RAILS

As mentioned, racks provide for mounting gear in two basic ways, clips that snap into pre-formed rail holes, and rails that have threaded holes to directly accept bolts. Both have advantages and disadvantages.

Clips are handy, but require careful planning in order to line up with equipment mounting holes. It's no fun hoisting that 65-pound chassis two-thirds of the way up the rack only to find that two of the clips are in the wrong place. It's also no fun to discover that you don't have enough clips to mount everything. Order several hundred more clips and matching screws than you think you'll need — they're cheap.

Tapped holes have the advantage over clips in these situations, but can sometimes necessitate extra work. If the holes weren't cleanly tapped by the manufacturer, or if they caught some of the rack's paint coat, you can only screw in a bolt with the greatest difficulty. Trying to drive bolts into partially occluded holes is not fun, and it's all too easy to strip both threads and bolt heads. The purchase of a couple of appropriately sized taps and tap wrenches is a good idea when using racks with threaded rail holes. ■

READER'S FORUM

Diversity Delay

Michael, thanks for your great article on diversity delay on HD Radio ("The Final Step in HD Setup Takes Using Your Ears," Aug. 23). I have not tried this but I wondered if you could send both speaker outputs to a dual channel scope and set it for a Lissajous pattern. As you adjusted to the proper delay the display would become a narrow 45 degree line. Have you ever tried that?

Randall F. Miller Jr.
Senior Engineer
WITF-TV/FM Radio Pennsylvania
Harrisburg, Pa.

Tech Editor responds: Your question got me curious to see if using a scope will work. See my column on page 3.

Our HD Story

When we made our first HD transition, all we had was our Kenwood HD tuner connected to the Kenwood receiver head system. No DaySequerra Monitors at that time.

After finishing the installation, we had the PD program a 400 Hz tone burst WAV file into the automation system to play for 10 seconds at 3:00 a.m. that morning.

We placed the Kenwood head unit in the PD's vehicle to split mode. We then connected a MD recorder to the RCA outputs on the HD tuner and recorded the tone burst.

We loaded the audio into the Cool Edit program and measured the time difference between analog and HD. We took that figure and added it to the Optimod 8500 delay time — perfect time alignment.

Keep up the good work. We love Engineering Extra.

Harry Bingaman,
Chief Engineer
Andy Kauffman,
Program Director
Sunbury Broadcasting Corp.
Sunbury, Pa.

Products & Services SHOWCASE

Let's Have AM Improvement With Clout

The NAB's Translator Proposal Will Provide AM With Some Long-Overdue Relief. Even More Should Be Done

Guy Wire is the pseudonym for a veteran radio broadcast engineer.

It's been a long time coming, but we finally have a proposed rule making initiative that will give the AM service some long overdue help of real significance. The NAB submitted an NPRM in July to allow AM stations the ability to augment and improve service within their primary coverage area using FM translators. The proposal may pose various technical challenges and could have gone farther by offering more far-reaching options, but at least it gets the ball rolling in the right direction.

The commission has dealt with similar proposals in the past, going back as far as 30 years, but each time the idea has been rejected. Only a few unique cases in Alaska and one in the southeast involving Cuban interference have won special FCC authority to translate AM over FM.

FIGHTING UPHILL

For years AM stations in many parts of the country have battled poor ground conductivity and nighttime interference, making it difficult to cover their markets properly. Before FM became dominant, translators for such stations certainly were justified and could have helped a lot, especially at night. In those days the commission was much more interested in advancing FM than protecting AM.

It rejected the previous petitions by citing the notion that "AM propagation suffers no gaps in coverage," like those found with FM. That idea may have had some justification in the good old days before noise pollution and increased interference of all kinds rendered acceptable and consistent AM reception a major struggle within the service areas of all AM stations.

For too many reasons we hate to think about, the vitality of the AM service has slowly deteriorated with every passing year. Unless an AM station adequately covers a market of decent size with a good signal both day and night, its chances of success and survival are severely compromised. The few FCC rule changes aimed at AM improvement that have been implemented have done little to slow the advancing decay.

The NRSC mask filter reduced sideband splatter and did help second adjacencies. The "ratchet" clause reduced a small amount of nighttime interference from modified facilities. And the expanded-band initiative moved a few stations off cluttered channels.

However it appears that most stations getting an expanded-band frequency have not been all that interested in retiring their old channels. A group of them are petitioning the commission to keep both, completely undoing the intent of the original initiative. It seems giving up something for AM improvement is not all that appealing. Real relief, as contained in the NAB NPRM, is needed.

FROM BAD TO WORSE

AM stations everywhere continue to lose audience to increasing noise interference, FM and satellite radio, the Internet and other alternative media delivery services. The plight of daytime-only AMs has worsened considerably in the face of such challenges. It will only get worse next year when the country adopts four additional weeks of extended daylight savings hours from March to November.

> **The commission should adopt the use of terrain shielding and computer-generated Longley-Rice terrain profiles to determine real coverage in all FM allocations issues.**

Clear-channel blowtorches expand their coverage at night dramatically but most all other AM stations have forever suffered the penalty of restricted nighttime primary coverage because of skywave interference. Most lose a considerable percentage of their daytime service area at night, especially the 1 kW local channel Class C stations, some of which lose up to 90 percent. Clearly these stations, which account for almost a quarter of the entire band, need help and they need it now if they are to endure and survive.

The NAB proposal calls for daytime-only stations to finally get the equivalent of full-time service by allowing them to operate their new FM translators on a 24/7 basis. That part of the NPRM will require additional rule changes. This is a huge improvement and represents their only opportunity to finally be granted effective full-time status. For the first time, daytimers in many markets will be able to fully serve their communities like other stations.

PROBLEMS AND SHORTCOMINGS

The proposal also calls for the new FM translator 1 mV/m contour coverage to be limited to the lesser of the existing AM 2 mV/m contour or a 25 mile radius from its transmitter site. Translator power output and ERP levels would presumably only be limited to meet those constraints. This seems reasonable for stations in populous areas but doesn't allow those in more isolated markets enough reach to serve listeners in outlying areas. Hundreds of stations in the midwest and west fall into that category and deserve perhaps a 0.5 mV/m contour and 50 mile limit.

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AM

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Translator antenna designs and site selection for stations using AM directional antennas may present complications under this proposal. There also may be problems for those who propose significantly elevated translator locations under the existing archaic method of predicting FM coverage for licensing using the 2 to 10 mile HAAT profile.

Consider the case of a station wanting to better serve a suburb 20 miles from its AM transmitter with an FM translator from a tall ridge. The area is in an adjacent valley on the fringe of the 2 mV/m AM contour. Determining the translator's optimum location and antenna design to be able to keep its theoretical 1 mV/m coverage completely within the AM 2 mV/m contour will be challenging.

The NAB NPRM makes no specific mention of how AM stations filing for FM translators will demonstrate, let alone verify, that the 1 mV/m translator contour will not exceed their AM 2 mV/m contour in any direction. Presumably the AM contour mapping will be based on theoretical antenna efficiency and M3 ground conductivity values, or by AM directional Proof of Performance measurements where available.

As any radio engineer knows, predicting FM coverage contours using the present 2 to 10 mile HAAT profile-licensing rule is fraught with error and in many cases is not even remotely accurate. Determining a more realistic 1 mV/m FM contour for this proposal would certainly seem appropriate. The commission should adopt the use of terrain shielding and computer-generated Longley-Rice terrain profiles to determine real coverage in all FM allocations issues, including this proceeding.

A FAIR ADVANTAGE

The basis of the NAB proposal is fairly drawn to establish the FM translator option only to enhance AM coverage within existing AM service areas. Extending service beyond that into unserved areas would be prohibited. Existing FM services including translators and LPFM stations would be protected.

However in the larger markets, few open FM channels exist to afford AM stations this opportunity. The NAB should have included the provision to allow any local AM station desiring an FM translator to trump any existing translator that imports a distant signal where no open FM channels are available. Enhanced local service should always take precedence and be awarded the advantage in contested proceedings.

LOOKING FORWARD

Except for the clear-channel powerhouses and legacy stations with solid full-time coverage, the AM service is under siege, including far too many marginal stations with dwindling audiences and revenues. If AM is going to be competitive in the digital era and make the best use of the burgeoning HD opportunity, the present inventory of stations populating the AM band will simply have to be reduced.

In previous discussions, I've advocated the FCC consider creative proposals to allow a reasonable and equitable method for current owners of marginal AM stations to retire their licenses and get something of value in return. Those include trading them for LPFM replacements where allocations rules permit and/or selling their allocated protection to an existing AM station that wishes to expand service and implement HD.

Assuming the NAB NPRM for AM translators on FM is adopted, we predict that quite a few of the AM owners who add FM translators to replicate most of their AM coverage will soon realize their AM facility has become expendable. The translators will essentially become low-power FM stations that can stand on their own. The AM transmitters can be shut off and the licenses surrendered.

If AM is going to be competitive in the digital era and make the best use of the burgeoning HD opportunity, the present inventory of stations populating the AM band will simply have to be reduced.

The FCC should anticipate such a development in this rule making and consider including an incentive for candidate AM station owners to move in this direction. You could call it a new kind of AM improvement that reduces clutter and interference so those facilities that remain can better leverage the advantages of HD with improved coverage and reduced interference. The more I think about it, the more I'm convinced it's a win-win proposal for the industry.

LONG LIVE AM

The present AM service is predominately made up of news, talk, sports and religious formats that continue to provide valuable local service to their communities. When civil and natural emergencies strike an area, AM radio has always risen to the occasion as the first choice for the majority of listeners. Many will be able to do a better job of serving those communities with the addition of FM translators. Others may find that converting their AM operations to FM translators or LPFM services in the years to come will serve their interests much better.

Allowing AM stations a more level playing field with their FM brethren is now more than ever fully justified. While the NAB proposal will provide AM some long overdue relief of real consequence, more will have to be done to enhance and preserve the AM service as the HD rollout moves forward. Some of the allocations and design issues may be challenging, but the effort will be well worth it. The commission and the entire industry need to embrace this proposal and expedite its adoption.

Send comments on this or any article to rwee@imaspub.com. ■

Villages

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feedback such that each individual can rapidly respond to the behavior of other individuals. The group then manages itself without a recognizable structure or appointed leader.

When we examine traditional radio broadcasting, we see the reverse situation. Executives and powerful personalities at the top control the listening experience of individuals at the bottom. There is limited communication among individuals at the bottom. As a result, a radio audience, however large, seldom becomes a dynamic and organic entity; it remains the passive, hierarchical and ballistic recipient of what it is given (ballistic missiles have no feedback: it's shoot and pray). Market research is too crude and slow to create real-time communications.

My son and his peers almost never listen to radio, and they are rapidly losing interest in television and newspapers, all of which are based on a ballistic social structure. The current generation values the organic experience of electronic towns. In fact, that is their dominant experience.

What does that mean for traditional radio? The answer is that its social structure must evolve to provide for the needs and expectations of the next generation, who value the organic and dynamic aspects of electronic villages. Thirty years from now, historians will observe the Internet produced the same kind of social revolution as improved agriculture did in the 10th century, and advanced industrialization did in the 20th century. In each case, technology changed the social density, which then changed the number of bilateral communication links within the group.

By embracing technologies that are bidirectional, "broadcasting" becomes the name for a new communication system that just happens to include RF radiation as one of its components. There is no reason why terrestrial broadcasters cannot become meta-broadcasters — audio village enablers. The old model is dead even though its technology still has value within the new model.

Similarly, if HD Radio provides a large number of new channels, broadcasters can create audio street corners inhabited by such communities as guitar players, Chinese immigrants, political activists and so on. HD Radio, by breaking the old model, allows new programming models to be invented. Radio could become a "nation of audio villages."

While we are discussing feedback as a means of sustaining a community, during the last two years I have only received a few comments from readers about these *Last Word* articles, not unlike ballistic radio. If you want Radio World to become a village, readers must participate by influencing what authors write. Send us your comments and create a collective voice.

Contact Barry Blesser with comments and topic suggestions at barryblesser@25-seven.com. ■

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by Barry Blesser

New Audio Villages Challenge Radio

Dr. Barry Blesser is director of engineering for 25-Seven Systems.

Ever since I first witnessed lightning destroy a power transformer at the age of three, I have been fascinated by electronics. Like those of many broadcast engineers, my career evolved to focus on the magic of electro-acoustic wizardry.

During the 20th century, audio technology was novel and exciting just because sound, which had always been ethereal, fragile and ephemeral, became a tangible commodity that could be stored and transported. This change parallels the progression of printing five centuries earlier. In both cases, technology produced a social paradigm shift.

During the later stages of these shifts, when technology and knowledge are in abundance, inventiveness no longer dominates progress and change. But if technology no longer controls the destiny of audio and radio, what then drives market choices? The answer is the social attributes of a technology. Engineers, companies and industries that ignore the social meaning of their technology do so at their own peril.

SOUND CONNECTS PEOPLE

If one examines earlier cultures, one observes that sound played the dominant role in social cohesiveness. Sound connects people together. Our sensory biology of hearing, which existed long before our technology, evolved to link people to each other. Radiating sound waves enable the voice of one individual to appear inside the head of another, which is nothing other than sonic broadcasting.

Although radio broadcasting changed the scope and geography of how people were aurally connected, sound's basic function remained otherwise unchanged. Terrestrial broadcasters are caretakers of a particular social connection technology. The nature of broadcasting (be it by way of sound waves, radio waves or digital networking) has changed, but people are still people — sound connects individuals within real or virtual towns.

By accepting the premise that communications are central to supporting social cohesiveness within groups, we are left with questions such as how such groups come into existence, how they acquire their cultural values and how they grow. History provides some insight into the dynamic that creates communities.

Cities and towns first appeared in Europe during the Dark Ages. After the Visigoths conquered Rome in 476, Europe became an unstable mix of migrants and tiny villages, the largest of which had no more than a thousand inhabitants. The population remained dispersed and at a low density for some 500 years. Suddenly, without any obvious explanation, large towns and cities sprang up across the continent as if by magic, often with a hundred thousand inhabitants.

What produced such an instantaneous transformation in the social structure of an entire continent?

After the 10th century, there were a series of technical advances involving the management of energy, especially as applied to food production. More productive farms (i.e., improved technology) could sustain denser populations. Cities were created by thousands of independent, individual decision-makers, each of whom saw the advantages of living in a dense community. There were neither city planners nor political figures managing the process, and nobody instructed people on how to form large social units.

In his book "Emergence," Steven Johnson explores numerous examples of how individual organisms, when living in a dense community with good communications and feedback, can create recognizable social entities that display intelligence.

IT TAKES A VILLAGE

In contrast to these examples, radio communications have been viewed as being intrinsically unidirectional. Without an ability to communicate to others, listeners are unlikely to coalesce into audio villages. Recently, however, broadcasters have been exploring alternative programming and technical models, explicitly designed to create virtual communities. The announcer-producer becomes the facilitator-coordinator rather than autocrat-king.

There are numerous examples. Chris Lydon's "Open Source," which is distributed by Public Radio International, uses the "people formerly known as the audience" to produce the show by contributing topics and ideas. WEEI(FM)'s call-in sports program has top ratings in its local market. Big D and Bubba on Clear Channel Radio make liberal use of e-mail and instant messaging to make their listeners part of the show. Opie & Anthony on satellite and terrestrial radio encourage fans to submit production fragments, crediting them on national air.

> **Sites such as MySpace, Facebook and Friendster allow kids to share ideas, videos, audio, TV clips and pictures. Communication is one-to-one, one-to-many and many-to-one.**

In almost all cases, these program models make liberal use of the Internet and telephone to augment unidirectional terrestrial broadcasting.

A new generation of kids is growing up with Internet technology that supports real peer-to-peer feedback and communications. In contrast, terrestrial radio looks tired and obsolete. Using my teenaged son as an illustrative example of this new dynamic, we see a critical need to upgrade the social model of radio.

His is the first generation to grow up with the Internet, which he describes as a social enabler, not as a technology. For his generation, the Internet was at first the AOL Chat room, but rapidly evolved to become such Web sites as MySpace, Facebook, Friendster, xPeeps, YouTube and numerous others. These sites allow kids to share ideas, videos, audio, TV clips, pictures, drawings, poems, opinions, dress styles, troubles and even pornography. Communication is one-to-one, one-to-many and many-to-one.

Like early towns in ancient Europe and 1950s street corners in Peoria, groups of individuals now spontaneously coalesce at virtual locations, creating electronic villages. There is no mastermind or leader conducting the process. And as time goes on, villages change and evolve; some grow to be very large, while others disappear. They are organic and dynamic, just like a neighborhood. Each village has its own personality, morality, value system and interests.

In a similar way, adults use eBay, Craigslist, blogs and other sites for selling, buying, advertising and disseminating points of view. They too are electronic villages. Advertising is not necessarily unwelcome if it fits within the village ambience, which is the model being used on many Web sites.

By connecting the world's population, globalization transformed isolated social groups into a single world city, and young adults are now sub-dividing this global city into many small, ad hoc virtual villages, each with its own personality. The radio industry needs to understand the importance of audio villages if it is to provide something of value to this generation.

Kids today cannot conceive of the pre-Internet world we grew up in. As any good anthropologist will tell you, to understand a foreign culture you must live among them, learn to speak their language and live as they do. Only then will you appreciate their way of organizing life. From the perspective of pre-Internet adults, the post-Internet generation is a foreign culture. If you want traditional radio to survive, talk to a young adult; or better yet, spend time with them.

CHANGING THE SOCIAL DENSITY

In analyzing how organic communities emerge, Johnson observes that two critical elements must always be present: efficient communications among individuals, and

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