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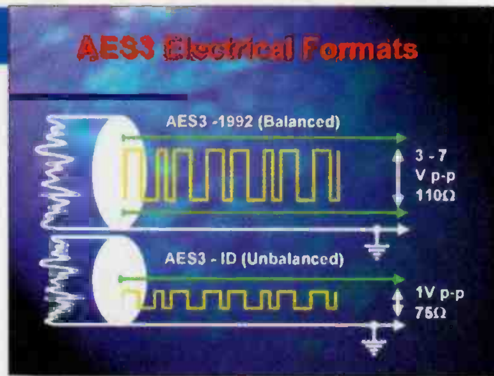

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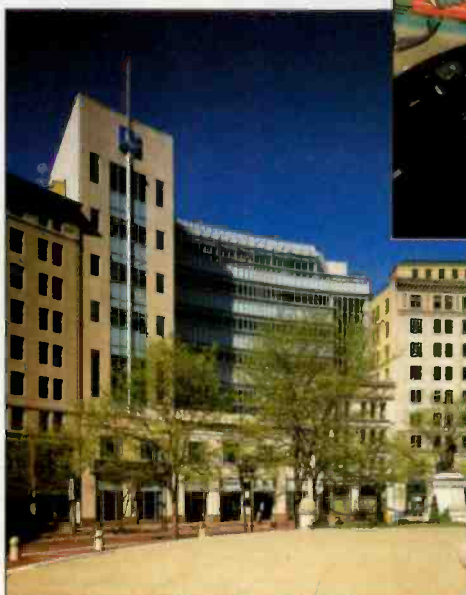

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ON THE COVER: Seacomm Erectors Inc. nears completion of the American Tower Corporation's West Tiger Mountain site in Washington. The twin 304' truss-Leg self-supporting towers and Cog Wheel Master FM Antenna were supplied by Electronics Research Inc. of Chandler, Indiana. Photo by Soundview Aerial Photography, Arlington, WA. Courtesy of Seacomm Erectors.

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DAB alternatives

Someone whose only involvement with radio broadcast is his car stereo recently asked me this question: "So, when can we expect to see IBOC DAB happen?" He wanted a specific date. I couldn't give him one because there isn't one to give. He then asked for an estimated timeline. Again, I had no specific answer.

The three IBOC proponents are all working on their systems. At the recent IBOC DAB panel at the NAB Radio Show, each company expressed that its system was either complete or nearing completion. That's the easy part. Taking IBOC to the next step is a little more difficult.

Depending on how matters are handled by other parties, including the FCC, the NRSC and the proponents themselves, the process may be swift and efficient or long and drawn out. I'll bank on the latter.

Now, there is a new item in the works to allow consumers to receive digital media. CEMA, the Consumer Electronics Manufacturers Association, filed comments with the FCC in July concerning the creation of a new broadcast service.

MMBS, Mobile Multimedia Broadcast Service, is a proposal that outlines a new application for some of the soon to be abandoned TV spectrum. With the channel reallocations for DTV, some spectrum in the upper TV band will be available for new use. The frequency range covered by the comments is from 746MHz to 764MHz and 776MHz to 794MHz. This spectrum is currently occupied by TV channel 60 to 62 and 65 to 67. The total available spectrum covers 36MHz. The spectrum will not be fully available until 2006, when all of the TV stations have completed their channel transitions.

CEMA proposes that MMBS provide free, high-quality multichannel digital audio, information and high-capacity data services for a new broadcast service to mobile receivers. One of the goals of the new service is to provide a service that is at least as good as CD quality. IBOC proponents share this wonderful goal.

It has appeared that CEMA has never fully supported IBOC. This new service proposal furthers this assessment. It seems strange that the organization that represents manufacturers of consumer radios does not want to promote the sale of new radios for IBOC but is interested in promoting new radios for MMBS.

There's even more alternate DAB activity.

UK-based Virgin Radio and Ericcson are testing technology for wireless Internet terminals. These wireless terminals — basically enhanced cell phones — will use the wireless communications network originally built for telephone calls. This mobile medium has a head start, with existing technology moving into its next generation and an established user base behind it. Currently, no timeline has been established on when this new service will be available.

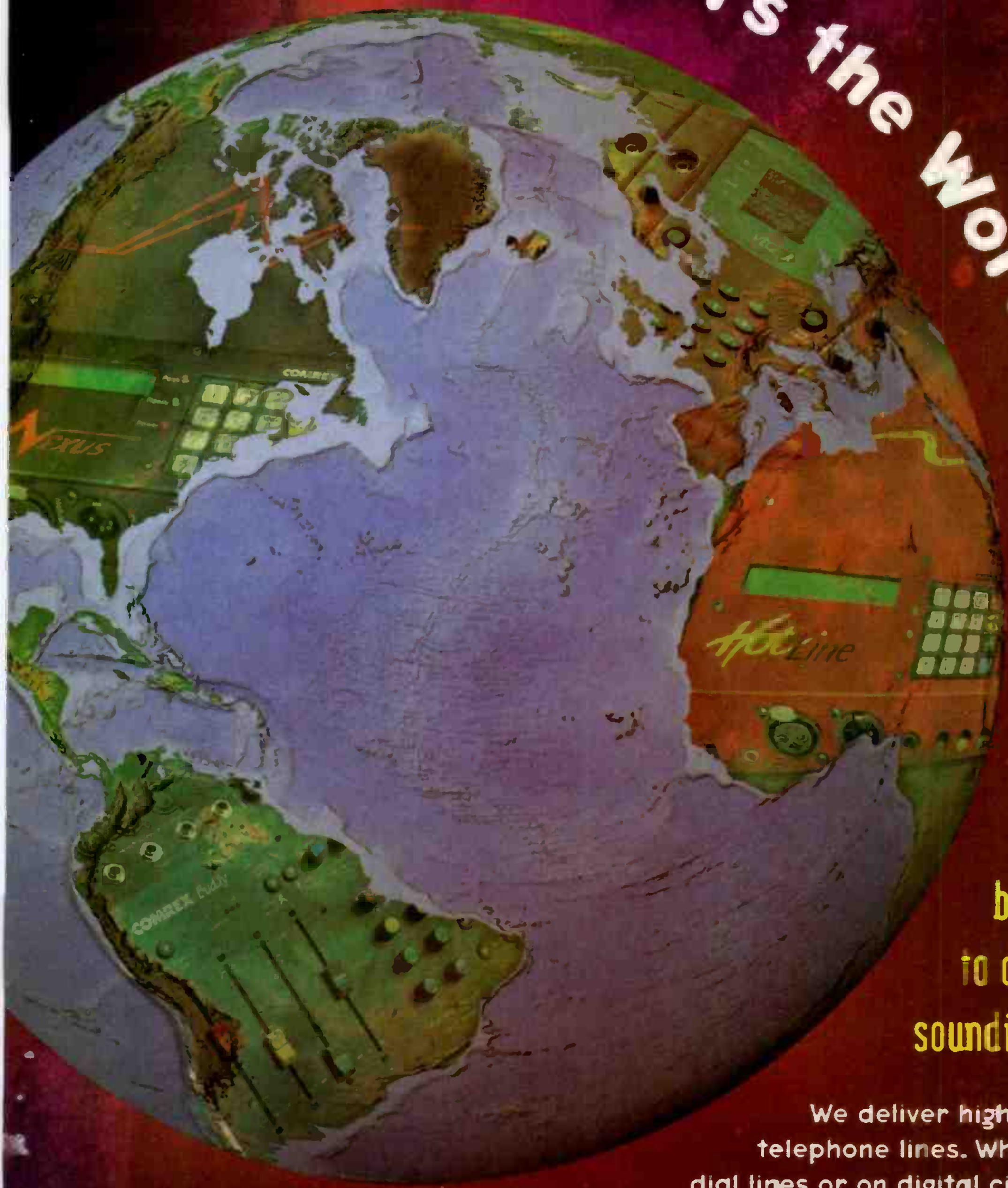
You are also aware that CD Radio and XM Satellite Radio are preparing to launch their multichannel services near the end of next year. Both plan to offer at least 100 channels of programming, primarily for mobile audiences, but there are also plans in place for terrestrial repeaters.

One point of concern with IBOC is that the FCC will not take a firm stance on a system. In some ways, we will be presented with a situation similar to the AM stereo decision. To turn this around, what if one system is chosen as a standard? Will the other two proponents simply walk away, consoling each other on their own nice-try efforts? I doubt it. The resulting legal action could further detain IBOC from becoming a reality. (By the way, the FCC is due to issue a rulemaking on digital radio on October 21.)

Before these newer technologies have a chance to upset the IBOC work being done so far, it may be a good time for the three proponents to begin working together and form a grand alliance. Each has something to offer to create a complete, final system. Between RF transmission, audio coding, data subcarriers and data transmission, each camp can still walk away with a significant piece of the pie.

The original work on IBOC began more than 10 years ago and is ongoing. We are seeing real-world demonstrations and tests on the systems. We are getting closer. However, the recent flourish of activity doesn't answer the original question: When will IBOC be ready in the U.S.?

Chriss Scherer, editor



COMREX
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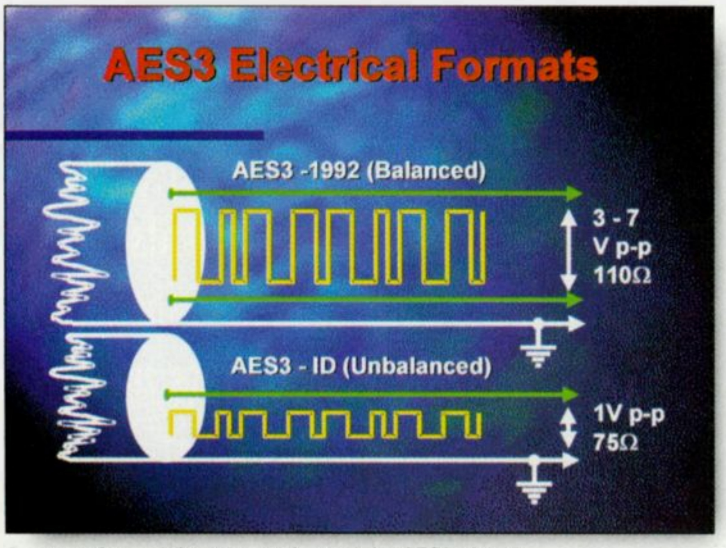
HotLine

The digital air chain

By Russ Mundschenk

Interconnecting the digital components of a broadcast air chain is easier than you might think. After a slow start, manufacturers are finally providing equipment that is not only easily installed but also enables a digitally recorded source to remain so all the way to the transmitter. The caveat is that digital audio resembles RF or video more closely than does its analog counterpart.

The AES/EBU digital transmission format surrounds each right and left sample of audio with synchronization and status information. These *packets*, or *frames*, of data are sent as a serial bitstream similar to RS-232. The bit value is determined not by amplitude but by timing, and a waveform of all digital "ones" has twice as many zero crossings as a waveform of all "zeros." Since AES3 digital audio can carry data at bit rates in excess of 6MHz, it is imperative that cable and interconnections maintain the system impedance. If they don't, reflections and capacitive roll-off can reduce a sharp square wave to unrecognizable noise.



A comparison of the two versions of the AES3 signal.

There are two AES3 transmission formats that differ electrically. The first and most common is the 110Ω standard, called AES3-1992. This standard specifies balanced transmission lines and peak-to-peak square wave voltages of from 3V to 7V. This format uses special 110Ω (±20 percent), low capacitance cable. Some manufacturers are advocating the use of standard category-5 LAN cable for balanced digital audio. CAT-5 cable has an impedance of 100Ω. The advocates claim good performance, despite the small impedance mismatch. The second AES3 format takes advantage of the bitstream's similarity to video. The AES3-ID standard sends 1V peak-to-peak square waves over unbalanced 75Ω coaxial cable. This method is handy because it allows the use of video hardware, such as patch bays, distribution amps and switchers. If necessary, a balun can convert AES3-ID to AES3-1992.

The digital steps

Usually, the first link in a digital air chain is analog, unless your facility uses all-digital sources. Set your microphone's gain structure carefully. The wonderful device that converts sound pressure to alternating current has a terrific dynamic range — in excess of 120dB. For years, good mic pre-amplifiers have been designed with large amounts of headroom, and announcers take advantage of it. Uncontrolled live audio must be given its freedom — and an analog-to-digital converter can easily run out of numbers to assign to a waveform. Unless you introduce some type of analog limiting, you must allow a full 30dB of headroom at the input to the analog to digital converter. Unfortunately, this causes a level mismatch with the rest of the sources, which have been recorded with only 15dB or 20dB of headroom. The solution is to use digital limiting and subsequent make-up gain to increase the overall level and limit the peaks of your live sources. Some digital consoles include onboard compressor/limiters that can be used for this purpose.

Other analog sources such as reel to reel and cassette decks are self-amplitude limiting because of tape saturation. Leaving 20dB of headroom should suffice.

Digital sources such as CDs, DAT tapes and some hard-drive storage systems provide digital audio feeds to the console. If no digital gain change is performed within the console, the source should come out with about the same numbers it went in with. Be wary of any digital equalization or expansion — a boost of a few decibels at the wrong frequency can cause clipping.

If it is not provided internally, a synchronization input is required for digital consoles. If all of the devices in a broadcast facility can be synchronized to one stable AES3 generator, then the audio frames and subframes can be easily mixed. Otherwise, the console will have to rate convert the incoming signal to keep step with the rest of the inputs. Rate conversion and synchronization always involve some interpolation and low-pass filtering, and they should be avoided whenever possible. Unfortunately, a lot of playback gear lacks synchronization inputs, but many record/playback devices automatically synchro-

nize to their inputs. Some devices provide a bridging input for the synchronization signal. The sync signal sent to these units may be daisy-chained as long as it is properly terminated at the end. As with any type of bridging configuration, there is no isolation between inputs. Further, disconnection of a device's internal looping input will result in loss of sync to all downstream equipment.

Routing flexibility

You may want to run all of the interconnections to the console through some sort of physical patch bay. Unfortunately, no one has come up with a standard for patching the 110Ω balanced format. Currently, the best option is to use high-quality TRS audio patch bays. The bays should be wired to terminate an output when its normalled input is patched. Loss of load causes a peak-to-peak voltage rise that can damage some system components, especially those originally designed for video. Half-normalling of outputs is not acceptable, since there are no high-impedance inputs for them to feed. Design your facility to reduce the number of interconnect points. Standard 66-type connection blocks are not designed to carry 6MHz square waves. An alternative is to use CAT-5 rated blocks or those specifically designed for AES3-1992. A typical video patch bay (especially the self-terminating type) works well with the AES3-ID 75Ω format, but care should be taken in patching so as to not unterminate a source.

Splitting the AES3 signal is easily done with a distribution amplifier. Resistive splits should be avoided because of the inherent attenuation. The 110Ω AES3-1992 format requires a specially designed balanced digital DA. The 75Ω format can use either AES3-ID or video DAs.

Mixing AES signals requires a great deal of number crunching. This process requires a digital mixing console or a stand-alone microprocessor-based mixer. These devices calculate the instantaneous products of each mixed sample.

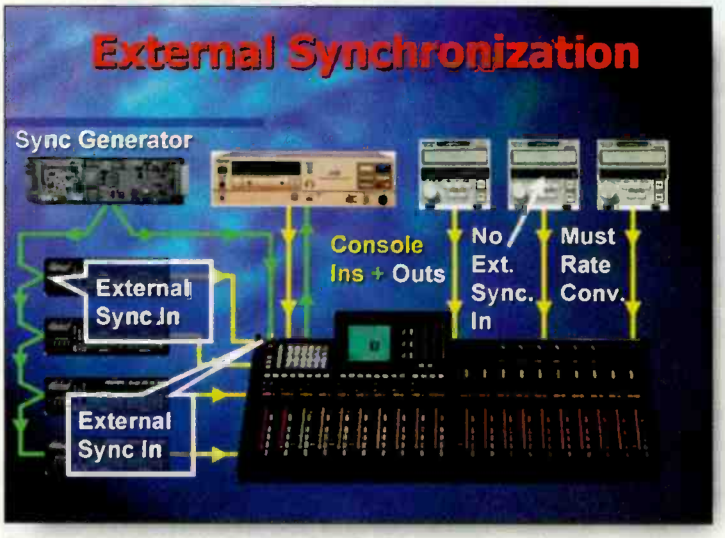
Switching AES3 signals may be done with specialized AES3-1992 110Ω balanced switchers — the unbalanced AES3-ID format can use both AES and video switchers — as long as they are nonclamping. AES switchers are synchronous and change assignments at the beginning of a frame to remove pops and clicks. This also relieves any downstream equipment from having to resynchronize to the new selection.

Studio-transmitter links (for nonintegral facilities) can degrade the signal, especially those that use digital compression. Production of spurious artifacts and delay increases dramatically as different compression schemes are daisy-chained.

On to processing

After having been gain changed, mixed, split and switched, the signal enters the digital audio processor. There are only a handful of digital processors available (see

"Digital on-air processors" September 1999, p. 38), and they all are capable of receiving and sending AES3 digital audio. Most modern analog and digital processors provide an analog composite output, but there is no digital composite standard. AES/EBU is designed to carry two-channel audio with a bandwidth equal to half the sampling frequency or Nyquist frequency, which certainly is not an efficient high-bandwidth single-channel composite transmission format. If AES/EBU is used to interface the digital audio processor to a digital exciter, the exciter must accept a processed discrete left and right input. It is then necessary to use the exciter's internal stereo generator. Even if the sampling rates of the processor and exciter are the same (in round numbers), the exciter will still have to rate convert to synchronize the units. This causes modulation overshoots and added propagation delay.



Sources and feeds can be synchronized or unsynchronized.

Determine what additional processing functions the digital stereo generator in the exciter may add to the signal. These can take the form of added low-pass filters, a look-ahead limiter or a composite limiter. Each exciter manufacturer offers different functions. These added functions may affect the sonic and modulation performance. To date, there is no digital equivalent of the analog composite input to a digital exciter, where the stereo-encoded signal from the audio processor is tightly coupled to the modulator stage. It might be wise to make an analog connection between the processor and exciter, at least until a digital composite standard is adopted.

Compression algorithms, audio processing and even the acquisition of the AES signal introduce delay. The compound group delay of an entire transmission system can cause unacceptable psychoacoustic effects in the air talent's headphones. A small amount of delay (<10ms) manifests itself as a perceived loss of high frequencies. The mixing of spoken audio as conducted through the bones in the announcer's head and the delayed headphone audio acts as a low-pass comb filter. More delay means more disorientation. One solution is to use your backup analog air chain to feed the headphones. The air signal should still feed the speaker monitors to detect any transmission problems. It is possible to use the microphone tally to switch headphone monitor feeds so that a low-delay signal is heard when the mics are on and an off-the-air signal is heard when the mics are off.

Russ Mundschenk is chief engineer of WBEB, Philadelphia.

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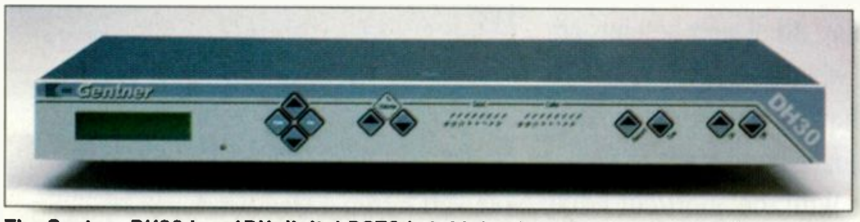
Polishing your POTS

By Skip Pizzi, Executive Editor

The analog dial-up telephone system, affectionately known as POTS ("plain old telephone service"), simply won't go away. Radio broadcasters continue to deal with POTS audio as a common component of their on-air sound, and this isn't likely to change for some time. POTS is a constant reminder of legacy audio from the earliest days of aural transmission. In today's sonic environment, if the range of audio quality that we're exposed to were equated to fine art, POTS would be Elvis on black velvet.

To be fair, POTS is a communications system. "Voice-grade" quality is really all that's necessary, and it keeps the channel's costs down. Radio broadcasting itself didn't sound much better in its early years, but audio technology has vastly improved in intervening years, and radio has come along. POTS alone remains back nearly where it was in the bad old days. Nevertheless, incremental improvements continue.



The Gentner DH30 is a 1RU digital POTS hybrid that includes a unique built-in speaker with front-panel volume control, AES3 I/O and highly adjustable operation.

Digital hybrids

One of the biggest difficulties with putting POTS on the air has been the physical interfacing of the two-way phone system into an otherwise one-way audio system. In other words, while most audio uses a pair of wires to send a single audio signal from point A to point B, POTS can put a bidirectional signal on that same pair.

Technically speaking, the POTS scheme is called a "two-wire" system, while the rest of audio uses a "four-wire" approach. This terminology refers to the fact that most audio systems require two separate circuits (each occupying a pair of wires) to establish a bi-directional communications path, but POTS does it on a single pair. To put it in familiar ms, POTS is a two-lane highway, while the rest of audio uses a divided, four-lane system.

Advances in this space during the early 1990s applied digital signal processing (DSP) to the telephone interface, resulting in substantial improvement over previous analog hybrid technology. The most notable change came from the ability of the "digital hybrid" to intrinsically adapt itself to the conditions of the current phone call, thus optimizing the studio-to-telephone interface each time the hybrid was used.

But the audio quality of the caller wasn't greatly improved by these devices. The digital telephone hybrid primarily improved isolation between the studio and the telephone, which generally made the *studio* voice sound better, and kept it more independent of the audio processes and gain applied to the caller side.

Many frequent POTS-audio users learned that a little audio equalization and compression can go a long way in improving POTS audio quality downstream of the interface. Therefore some POTS hybrids incorporated such audio processing into their DSP functionality, making both the caller and the studio host/reporter sound better. Nevertheless, these devices were still limited by the delivered quality of the audio from the POTS network.

The latest trends

That's how things stood until the last year or so. Now POTS hybrids are finally starting to reach out and touch something in the quality of the network itself. Because many radio stations are now equipped with digital connections to their local telco central offices (COs), the latest crop of POTS interfaces accommodate a direct digital connection on the telco side. This includes ISDN-BRI, ISDN-PRI or T-1 services, which can be directly interfaced to the (single or multi-line) POTS hybrid.

Advantages of this "digital-to-the-CO" approach include lower noise, reduced distortion and even better isolation, all due to the fact that now the four-lane highway has been extended to the caller's neighborhood. The only analog, two-wire section of the circuit is between the caller's phone and his/her CO, which is typically a small part of the overall path.

For larger stations that use multiple phone lines fairly frequently, the dedicated, multi-line capability of a T-1

connection to the CO may make more sense than the (switched) ISDN approach. Multi-line installation is also far simpler, requiring only a couple of cables to a central point rather than dozens of discrete pairs to each studio.

Some new hybrids also include AES3 digital audio outputs, so the telephone audio can remain in the digital domain as it passes into the mixing console and perhaps beyond. In some cases, backfeed inputs to callers also accept AES3. Some multi-line units also allow internal conferencing of multiple callers, thereby freeing up the console from some of its mix-minus busing duties.

Control freaks rule

Another new area involves advanced control capabilities. For example, some new digital hybrids include a TCP/IP control interface, allowing them to be managed remotely via an intranet or the Internet. This provides substantial

The Telos Desktop Director is a multi-line hybrid controller with a range of identifying icons that can be placed next to each line's select button. It can also serve as a control room telephone.

flexibility, particularly for live remotes with call-ins.

Other remote- or reporter- friendly features include auto-answer, password protection and acoustic echo cancellation, whereby auto mixminus can be extended to include the decay or reverberation time of a call that's being pumped through a sound-reinforcement system at a large remote venue.

Control can be performed from a PC (direct or via a network connection) or on dedicated multi-line telephone devices with LCD displays. These new systems also allow flexibility in allocating telco-line resources. The same set of lines can be controlled from any one of several different locations throughout the facility or remotely. This means a consolidated site can maximize the use of multiple incoming phone lines across several stations' programs and studios, with duplicate (or portable) control terminals and audio I/O in two or more studios of the facility.

Since POTS seems here to stay, stations that put a lot of telephone audio on the air are wise to consider this new class of devices, for both qualitative and quantitative reasons.

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Care of solid-state transmitters

By John Battison, P.E., technical editor, RF

Solid-state transmitters require careful attention to proper operation and maintenance procedures. Dirt and excessive heat are their greatest enemies; poorly regulated and contaminated primary power supplies come in a close second.

Heating and cooling

Many transmitters are located in remote places, often in less than pristine, even ramshackle, buildings that are neither heatproof nor dust-proof. Concrete-block buildings with properly installed doors and cable entryways are usually easier to keep relatively clear of dust and dirt as well as small animals and insects. Nevertheless, these pests usually manage to find their way inside.

Fan blades and cooling fins must be kept clean and clear of dust and dirt. (Courtesy of Continental.)

In the few instances of co-located studios and transmitters, sufficient air conditioning is usually included in the building plans. Yet, in cases where a plant has grown beyond the original size and capability of the A/C system, supplementary A/C is often needed in transmitter rooms. Treatment can be the same as at remote locations, taking precautions that any hot vent air does not feed back into the system.

Block buildings can absorb and retain heat for quite a long period, with the temperature inside increasing all the time. For this reason, A/C is not a luxury; it is a necessity. When planning a new transmitter building, it is essential to be guided by the builder's recommendations regarding wall heat transfer, available insulation and equipment heat load.

To reduce dust, paint and seal all walls and floors. It seems that concrete usually manages to rub off and produce a little dust that collects in hot spots and settles in vents and blowers.

Do not forget the many small black boxes that seem to end up inside a transmitter building in addition to the transmitter itself. They all add small doses of heat, 50W or more at a time. In some cases, in cooler regions, merely exhausting the heat may suffice. But it is a dangerous condition to enter into deliberately when a little foresight can prevent loss of airtime caused by heat buildup. Unexpected periods of high heat must also be allowed for.

Check the operating temperature range of the intended transmitter and plan enough A/C capacity to cover it with an adequate safe load. Include this load in your plans for a backup generator.

Arrange air vents so that rain cannot enter. One transmitter I worked on was beautifully installed. It had a direct vent to the outside air located directly over the final, vertical hot-air vent on top of the transmitter. When it rained, the rainwater entered the final cavity, cracked the glass of the tube and made an unholy mess of the inside of the transmitter. This was not a solid-state transmitter, and water doesn't usually crack hot transistor housings, but the principle is sound: Any air vents close to the transmitter must be designed so that rain cannot enter from any direction.

Maintenance

Small ducts are attractive places for small animals and birds to nest. For this reason, it is better to use large-area filtered air vents. Although wire guards can be fitted over such vents, a nest built on the outside can stop as much airflow as one built inside! In short, be careful to ensure that the cool air supply that you planned actually operates as planned.

Where heat conduction by means of close, face-to-face contact is used, it is important to use the heat-sealing compound recommended by the transistor manufacturer. Small imperfections often occur on supposedly flat faces and detract from heat transference due to heat sinks. Be sure to clean old paste before reinstalling.

Fans have the habit of failing without being noticed. In many cases, muffin fans are used for spot or local cooling. Some fans operate quietly, and their presence may not be noticed — until they fail.

Sometimes engineers may have noticed hot spots and installed an unspecified fan without noting it on the station records or schematics. Subsequent engineers who didn't know about this fan might experience overheating troubles if this fan fails. It's always wise to take time to go over a new transmitter with a fine-toothed comb to look for little additions that made life easier for someone else.

Solid-state equipment can be sensitive to the temperature of its environment. It is necessary to move more air to

cool a solid-state transmitter than a tube transmitter of similar power. High power in solid state is necessarily achieved by use of multiple RF modules, and often by individual power supplies. Thus, more components and a higher power-supply capability are required for a solid-state transmitter than for a tube transmitter of similar power.

Because of the increased sensitivity of solid-state equipment to temperature boundaries, errors can be made by allowing the RF power level label to govern the anticipated cooling requirements. This can result in an inadequate volume of air and consequent overheating. As improvements are made in *Mosfet* design and construction, and possibly new high-power solid-state devices, cooling requirements could drop below equivalent tube transmitters.

Proper ventilation is still important for solid-state transmitters.

Power quality

Attention should be given to power-supply quality. Transient suppression in power supplies is extremely important. Lightning transients are a reality in broadcasting, and much has been accomplished to control their effects. Proper power-line input treatment and surge protection are a necessity. Sometimes the nature of switched power supplies for large solid-state transmitters can reflect badly into the primary source and affect the power factor. Most power companies expect users to achieve a power fact as close to 1.0 as possible. High harmonic content that is allowed to develop across the power line can produce interference to other circuits and degrade the power factor.

This article has emphasized temperature control because disregarding it can lead to trouble in solid state. Although solid-state devices usually operate with low voltages, the power supplies are usually very low impedance and are capable of storing a tremendous amount of energy. From the viewpoint of high voltage, there appears to be little to fear; however, this in not necessarily the case.

The amount of power that can be stored in a non-discharged circuit can easily raise a metallic short almost to incandescence and can result in serious burns to personnel in contact with the shorting material. It behooves engineers to use as much care with low-voltage solid-state transmitters as with high-voltage tube transmitters.

E-mail John at: batcom@bright.net.

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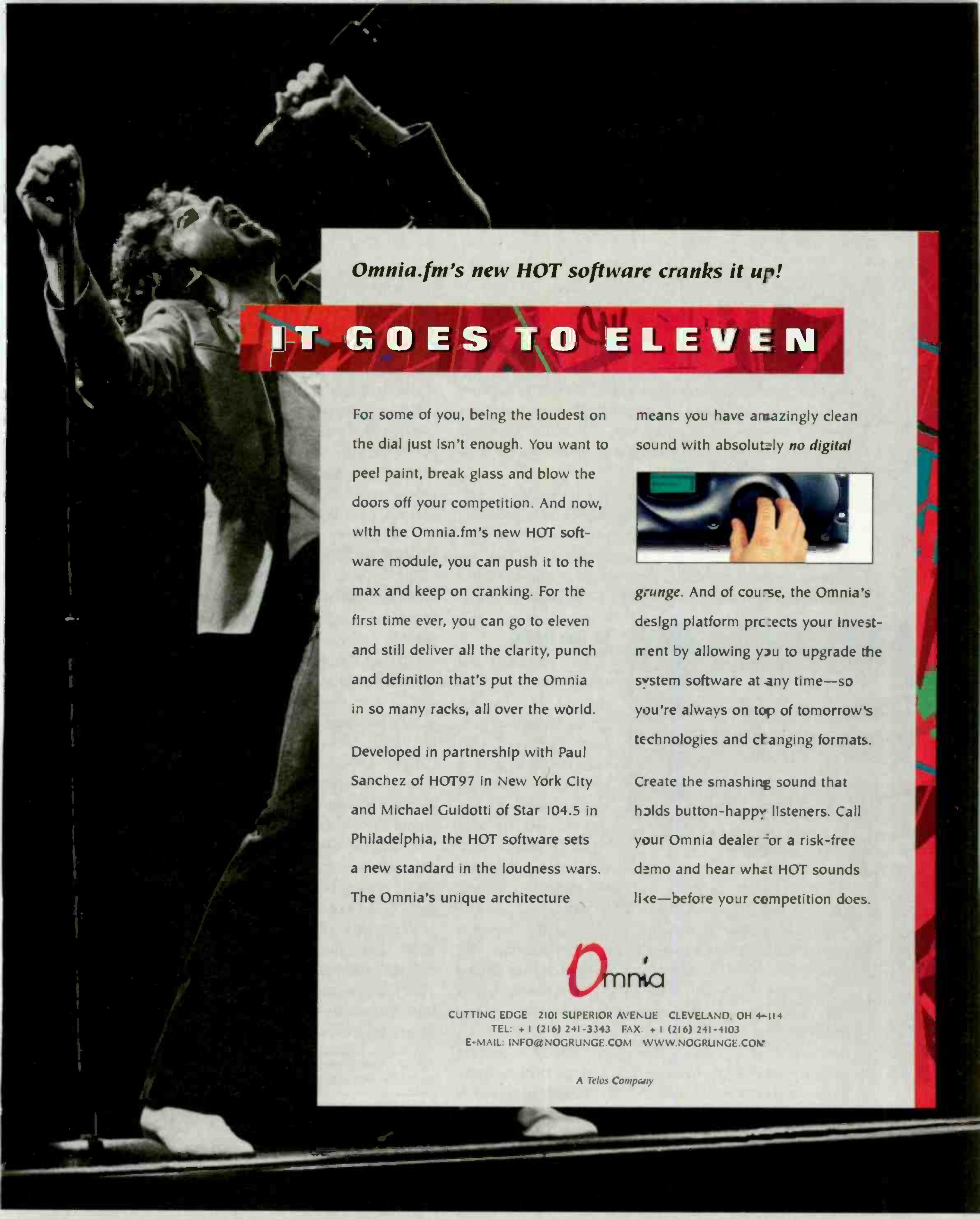

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Datacasting update

By Chriss Scherer, editor

FM stations have long used subcarriers as a means of supplemental income. Though the technology itself is not new, there has been recent work on setting some standards for data applications.

So far, data subcarriers have lacked standards for their use or protocols, except for RBDS (Radio Broadcast Data System), introduced in 1993. The new standards allow manufacturers to create products that are compatible with the specific technology.

The Consumer Electronics Manufacturers Association (CEMA) Mobile Electronics Technology Standards Setting Committee recently met and approved two new standards on two different data subcarrier formats. The two systems covered are called *Data Radio Channel (DARC)* and *Subcarrier Traffic Information Channel (STIC)*.

Service	Subcarrier Frequency (kHz)	Data Rate (kb/s)
RBDS	57	1.187
STIC	72.2 87.4	18.05 21.85
DARC	76	16

Table 1. The frequencies and data capacities of various subcarrier services.

In the DARC

The standard for DARC has been approved as EIA-794. The system has already been deployed outside the U.S. and is extensively used in Japan, since it was developed by the NHK. A similar standard was already passed in Europe in 1997. The CEMA standard is almost identical and serves mostly as a formality.

DARC is similar in function to RBDS. The signal is transmitted on a 76kHz carrier and a 16kb/s data rate. The modulation is a *Level Minimum Frequency Shift Keying (LMSK)*. The bandwidth of the subcarrier is 35kHz, which yields an occupied spectrum of 60kHz to 95kHz. Compare this range with the RBDS standard of 57kHz and a data rate of just less than 1.2kb/s (see Table 1). According to data posted online from the ITU and the DARC Forum, measurements have shown that the DARC subcarrier is fully compatible with the RBDS subcarrier.

On the STIC

The October 1998 issue of *BE Radio* (Next Wave, p. 26) examined the Minnesota Department of Transportation tests on a system being developed for the Intelligent Transportation System (ITS). This system was being considered for a mobile traffic-management system to better inform motorists of traffic conditions. MITRE Corporation developed STIC, and so far it has only been used in tests and pilot programs. The system is now ready for primetime and commercial deployment.

The adopted CEMA subcommittee standard for STIC is shown in the table. The Federal Highway Administration (FHWA) is supporting STIC for their efforts.

Both technologies offer increased data capacities compared with the RBDS standard. Even when the RBDS standard was introduced, it was felt that further enhancements would be needed, since consumers would have access to more data information services at higher data rates.

Future of datacasting

The National Radio Systems Committee (NRSC), a joint effort between the NAB and CEMA, has a High Speed FM Subcarrier Committee (HSSC) that had its actions suspended in 1998 when agreement on a single standard could not be reached. At that time, the HSSC was evaluating three different systems: DARC, STIC and a third system, the High Speed Data System from Seiko. The testing for these systems was continued and has lead to the established standards from the ITU. Where the joint CEMA/NAB subcommittee could not agree, the CEMA-only subcommittee has reached a decision. Their standard furthers the effort for DARC and STIC by establishing guidelines for their application in the U.S.

With IBOC on the horizon, there is some skepticism about further evolution of datacasting. Currently, the IBOC testing being done is for main channel performance. By occupying more of the available spectrum (and pushing subcarriers out of the way), a more robust IBOC signal can be delivered. Another possibility is to encode additional data into the main channel data stream. There is also the obvious apathy from consumers and broadcasters toward RBDS, which may be assuaged with higher data rates and capabilities.

Some information was obtained from the August 2, 1999 issue of Radio TechCheck, *published by the NAB.*

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FCC issues heavy fines

By Harry Martin

In August, the FCC issued several notices to radio broadcasters that assessed fines, in the aggregate, of more than $60,000. Broadcasters should be aware that FCC inspectors still make unannounced visits to studios, and audience and competitor complaints can lead to FCC forfeiture proceedings. The following fines were imposed:

$35,000 indecent broadcast. An AM licensee was fined for comments radio personalities made during a week of broadcasts on a midday show. A listener's complaint, accompanied by recordings of the show, initiated the investigation. Indecent material continued to be broadcast, even during the investigation. In issuing the fine, the FCC reiterated that it has a statutory duty to prosecute licensees that broadcast obscene, indecent or profane language. The FCC's standard for determining indecency is "offensive language or material that depicts or describes sexual or excretory activities or organs."

$14,500 unauthorized operations and main studio location. The FCC fined an FM licensee $7,500 for constructing and operating its station on the wrong channel. In addition, the operator was fined $7,000 for locating its main studio outside the station's city-grade contour. Although the FCC has recently relaxed restrictions on main studio locations, violations are not mooted by a subsequent change in the rules.

$7,000 main studio staffing. While noting that noncommercial educational stations may seek a waiver of the main studio rule, the FCC fined a noncommercial station for failure to comply with the rule absent such a waiver. FCC agents attempted to enter the main studio of the station on three different occasions. Each time, they found a locked building with two contact telephone numbers posted on the door. During its investigation, the FCC determined that the station occasionally employed one person or was staffed by volunteers. The FCC's rule for main studio staffing requires, at a minimum, that a managerial or a full-time staff person be present during normal business hours. Part-time and volunteer staff do not satisfy this rule.

$4,000 broadcast of telephone conversation. Based upon a complaint from a listener, the FCC fined an FM licensee $4,000 for broadcasting a telephone conversation simultaneous with its occurrence but without the consent of the other party to the call. On-air personalities should take great care to ensure that they comply with the FCC's rule requiring advance consent to the broadcast (or recording for later broadcast) of telephone conversations.

Broadcast ownership attribution

The FCC has revised its broadcast ownership "attribution" rules. The attribution rules define what constitutes a cognizable interest for purposes of applying the ownership rules. Essential elements of the FCC's order include the following:

- Adoption of a new "equity/debt plus" standard, which will function in addition to the current attribution rules. Under the new rule, a holder of a financial interest, whether equity or debt or both, in excess of 33 percent of a licensee's total assets will have an attributable interest in that licensee if it is either a major program supplier to that license (supplying more than 15 percent of the total weekly broadcast programming hours) or if it is a same-market media entity (including broadcasters, cable operators and newspapers). All stock, both common and preferred, both voting and nonvoting, will be counted toward the 33-percent threshold.
- Retention of the 5-percent voting stock benchmark, while raising the voting stock benchmark for passive investors from 10 percent to 20 percent.
- Elimination of current aspects of the cross-interest policy (*i.e.*, key employee relationships, nonattributable equity interests, joint venture agreements).
- No change in treatment of joint sales agreements (JSAs).
- No change in treatment of limited partnership interests as distinct from corporate voting equity interests.
- Application of limited partnership insulation criteria to determine attribution of limited liability companies (LLCs).
- Application of revised broadcast attribution criteria to broadcast/cable cross-ownership rules.

Except for television LMAs, any interests acquired on or after November 7, 1996, the date of FCC adoption of the Attribution Further Notice of Proposed Rulemaking, are subject to the new rules. If the interest was acquired before that date, it is grandfathered.

Harry Martin is an attorney with Fletcher, Heald & Hildreth, PLC., Arlington, VA. E-mail martin@fhh-telcomlaw.com.

Dateline

Radio stations in the following states must file their biennial ownership reports on new Form 323, or Form 323-E for NCE stations, on or before December 1: Alabama, Colorado, Connecticut, Georgia, Maine, Massachusetts, Minnesota, Montana, New Hampshire, North Dakota, Rhode Island, South Dakota and Vermont.

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THE Self-Resonant Folded Unipole Antenna

By Sylvio M. Damiani, P.E.

A new variation on the folded unipole

The view from tower's base. The metal ring is part of the ground system.

The limiting presence of a strong reactance component in an antenna input impedance has caused problems for the broadcast antenna design engineer. This problem can occur even when engineers opt for models that theoretically rid themselves of this inconvenient ±j component by attempting to determine, at the design level, a resonant height for the tower.

We refer, of course, to MW broadcasting in which the field and/or consulting engineer has to develop the mechanics of the antenna (or antennas) of a radiating system. Years of work in the field have resulted in the development of a new type of antenna in which a self-resonant condition is reached by the easy and continuous tuning of a lumped reactive component installed at the antenna itself.

The regular folded unipole

The commonly used folded unipole (or monopole) antenna for MW broadcast basically comprises a grounded support tower and a set of skirt fold-wires that run vertically and parallel to the tower, making electrical contact at the top and usually at a movable point determined empirically. The fold-wires are uniformly distributed around the support towers to maintain an omnidirectional radiation characteristic when standing alone. The feed point of this antenna is a copper tube formed into an O-ring installed concentrically around the tower, near the ground, connecting all the fold-wires together. A large amount of mechanical hardware is involved (e.g., compensating springs, anchors and insulated spacing bars) to keep the fold-wires stressed enough to avoid touching the steel structure of the support tower, even when buffeted by strong winds.

Electrically, this antenna presents a higher input impedance when compared with that of a simple tower of the same height isolated at its base. When properly designed, one can arrive at more than 100Ω input resistance, associated with a moderate reactance value, which turns the antenna into a relatively low-Q radiating device. Its relatively good bandwidth also makes it suitable for broadcasting music.

This technique has also been employed with directional antenna arrays. Its highly desirable, inherent high-input impedance will certainly be loaded down by the influence of other towers composing the array.

Even so, the I^2R losses drop to a lower value because of the relatively low RF currents circulating in the antennas and their associated radial wires.

Self-resonant folded unipole

From the basis of the folded unipole, we can make a few modifications and add a few items to acquire a self-resonance capability. These include the following:

1. Substitute the base O-ring, mentioned earlier, with a C-ring, or, to better describe it, with an open polygon that interconnects all the fold-wires at the antenna base at the same height from ground (as shown in the photo above left). For example, for a three fold-wire antenna, the open polygon is a two-sided triangle, or a V-form device. For a six fold-wire folded unipole, an open hexagon (or a hexagon minus one side) is applied. For a nine fold-wire antenna, an open eight-sided polygon is installed at the electric closure of the fold-wires at the antenna base. Regardless of the total number of fold-wires, all must be interconnected through a *conductive open polygon*, generically referred to as a C-ring.

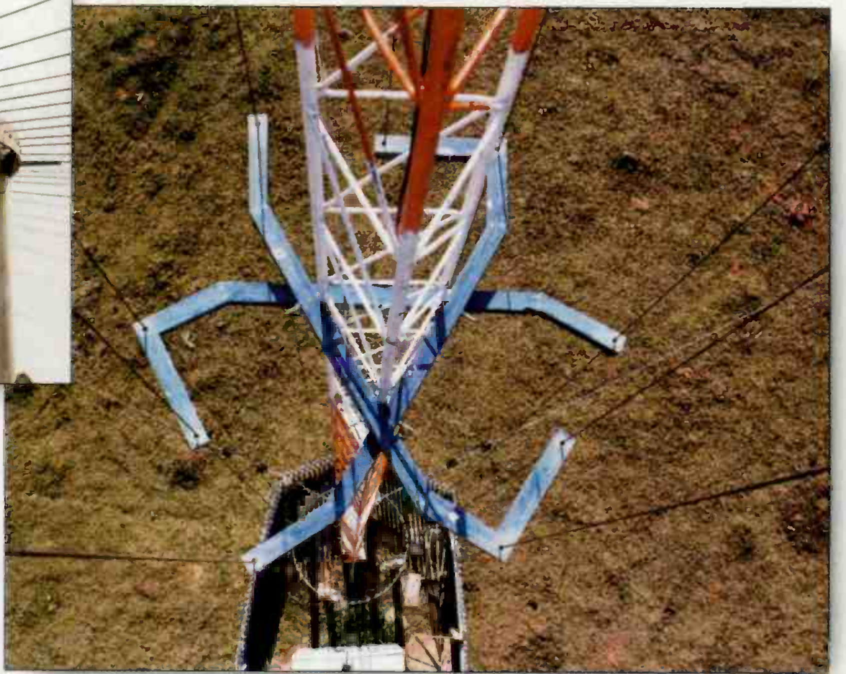
2. Install a *corrective lumped reactance* component in series with the C-ring, between two adjacent fold-wires, its position and value having been correctly established.

The base detail. Each fold-wire has a tension spring, two porcelain insulators and the horizontal C-ring.

This process is time-consuming, calling for several iterations to calculate the reactance value and its location on the C-ring. When running the RF design program EZNEC2 (a calculation program that uses the Numerical Electromagnetic Code 2, also called NEC2) without the self-resonant load, the input impedance will have a ±j reactive component. The corrective self-resonance lumped reactance will have an opposite sign.

Unfortunately, the calculation of the self-resonance of the folded unipole is not so simple. Actually, I discovered this antenna when dealing with a similar problem and running the calculation program EZNEC2. At that time, under certain initial conditions, the input impedance of a regular folded unipole seemed to present a very low reactance. This in turn was an interesting feature, since it would provide, at least theoretically, for excellent bandwidth and very good audio quality in AM broadcasting.

Further calculations confirmed the conditions required for self-resonance for this specific antenna. As many readers may know, the *Code Technique* is based on modeling the antenna and metal structures near it with wires. The model has to be carefully prepared, obeying all the criteria the EZNEC2 manual recommends, to obtain the correct antenna characteristics and its resulting radiated E-field.

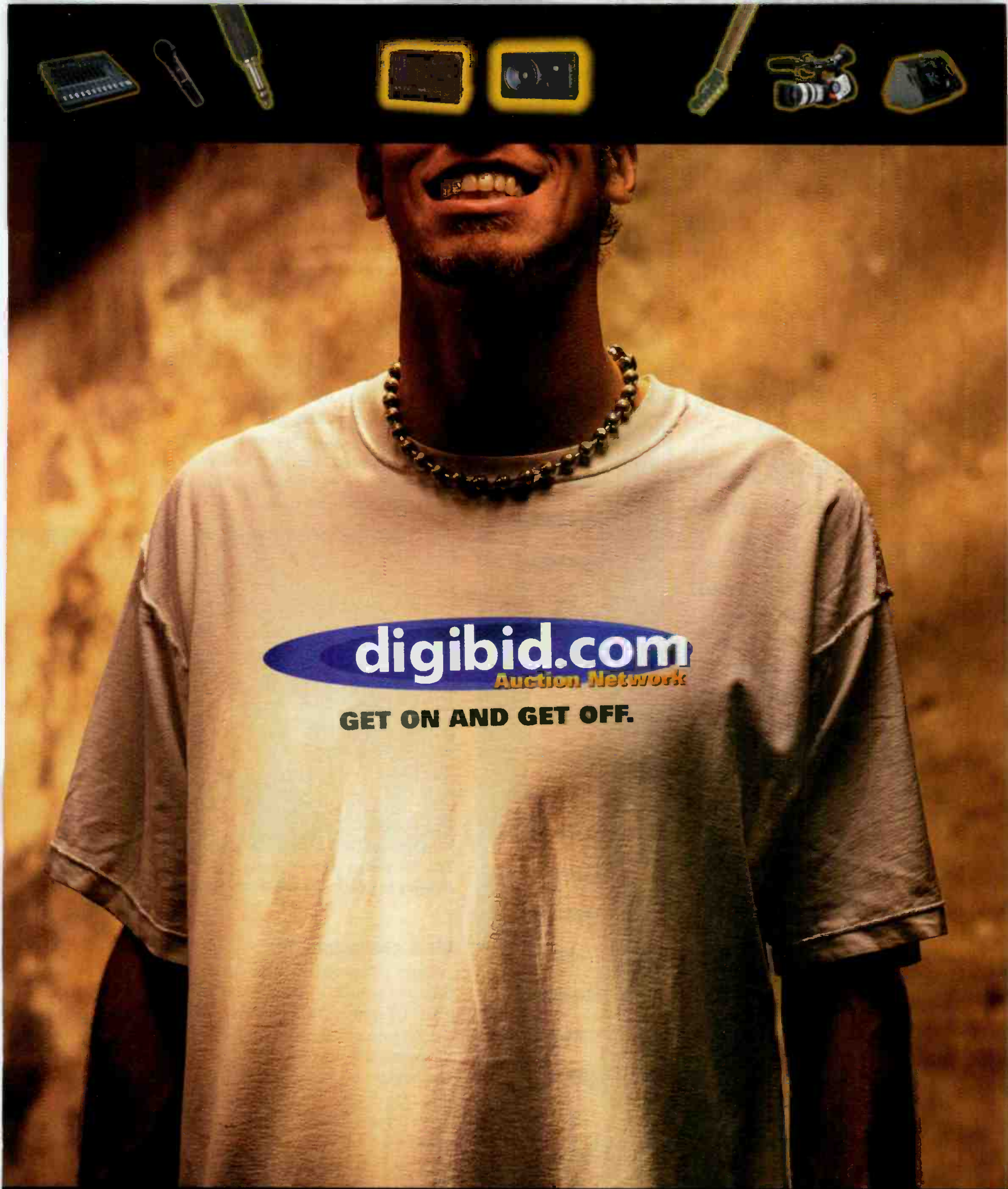


A view from above. The blue arms are insulating spacers.

Tuning to self-resonance

The corrective reactance is tuned to its expected value. In practice, at the transmission site, the reactance is tuned while the antenna input impedance is simultaneously checked through an operating impedance bridge. Remember to place the bridge's *X dial* to the zero position. Once this simple field operation is done, one has an antenna with a purely resistive input impedance. Obtaining a self-resonant folded unipole antenna is that simple, almost.

Once the required circuit conditions are known and modeled by the NEC2 engine, the subsequent tasks are determining the specific point at which to feed the antenna on the C-ring, deciding where to install the reactive load in series with the C-ring (i.e., between which adjacent fold-wires), and determining the proper



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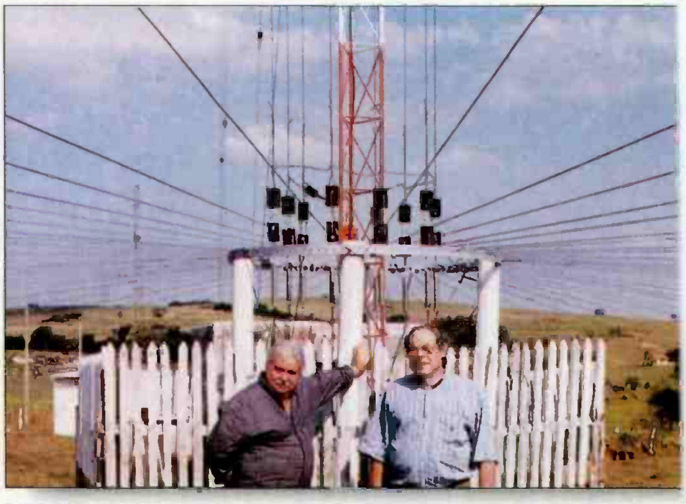
Folded Unipole Antenna

reactance value in ohms at the operating frequency. All of this is related to the specific antenna under study. It is not within the scope of this article because it is part of a pending U.S. patent.

The reactance load changes the forward RF current phase into the fold-wires that are located after it. This opposes the direction of the source or feed point as well in respect to the remaining wires in such a manner as to produce zero reactance at the input point. That is why it is necessary to connect all fold-wires to the C-ring or open polygon in order to allow this phase difference between currents on the fold-wires, which in turn are the wires responsible for the radiation phenomena. Another characteristic observed at the end of the calculation is the current phase at the top of the tower area, which is also the point where the fold-wires are connected to the tower: There are no abrupt phase differences between currents flowing into the fold-wires and the current flowing in the tower top itself when the resonance occurs at the antenna input point.

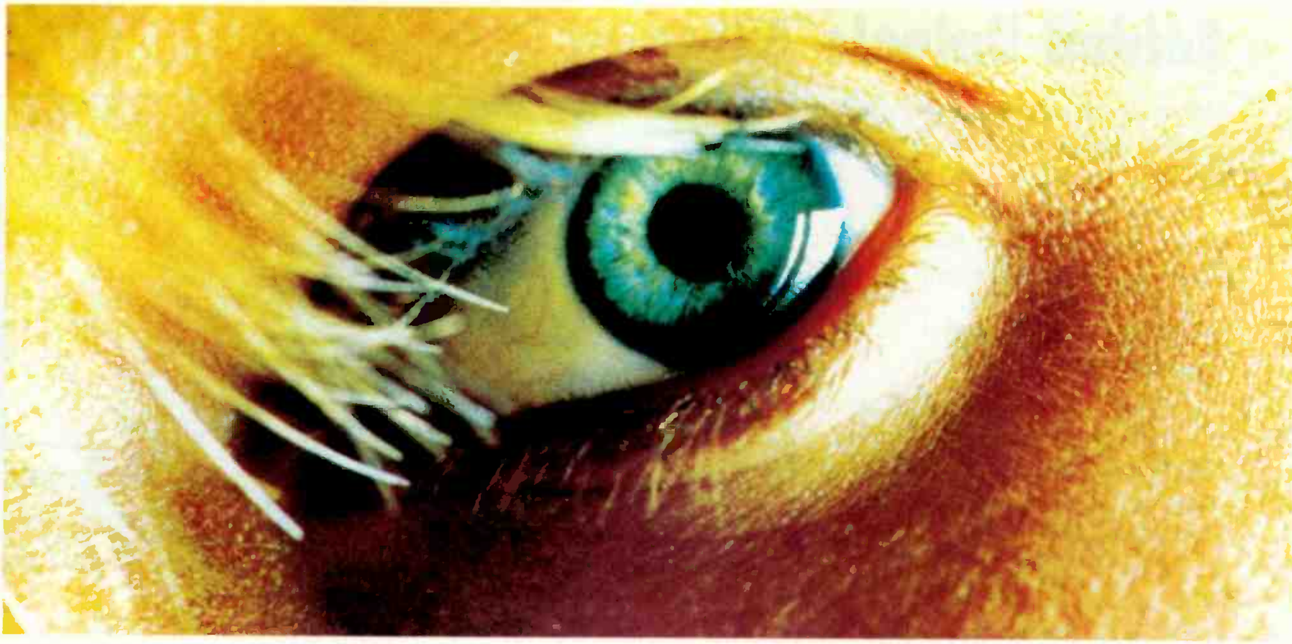


ZYK-767 station owner Camillo C. Perez (L) and the author standing in front of the self-resonant unipole.

Main characteristics

Figure 1 shows an SWR plot of one self-resonant model that was installed recently and has been in operation since December 1998. Observing the SWR throughout the frequency band under analysis, this antenna appears to approach a theoretically ideal antenna. It has a wide bandwidth never seen before for an AM-type transmission. At ±16kHz, referenced to the center (carrier) frequency it presents an SWR of 1.12:1. At ±12kHz, the SWR is less than 1.1:1.

Careful observation of its symmetry shows that the plot is symmetrical when viewed from the carrier frequency. Both of these characteristics are essential for an optimized AM transmission, which certainly will result in good music quality with very low harmonic distortion, and no locally generated intermodulation between sideband tones. If the audio frequency response were not purposely limited to some low value as it is



Folded Unipole Antenna

commonly done, this antenna would provide a detected audio response comparable to a mono FM station — and at least up to the definitions of the AM IBOC DAB systems currently under development.

Practical results and comments

There are two self-resonant antennas in regular operation in Brazil. The first, ZYK-767 Radio Cidade in Boituva, in operation since mid-December 1998, is a nine fold-wire model at 1490kHz, running 1.0kW of power. The SWR plot in Figure 2 is the calculated characteristic for this antenna. In practice, its transmission seems limited only by studio-related audio-quality problems. Even so, it presents superb music quality and excellent area coverage.

The second, ZYK-563, at Radio Ciuibe de Birigui in São Paulo, is a three fold-wire model installed in mid-February 1999, at 850kHz and 1.0kW of output power. This installation presents a much better set of on-air characteristics than the first installation. It is also transmitting in C-Quam stereo.

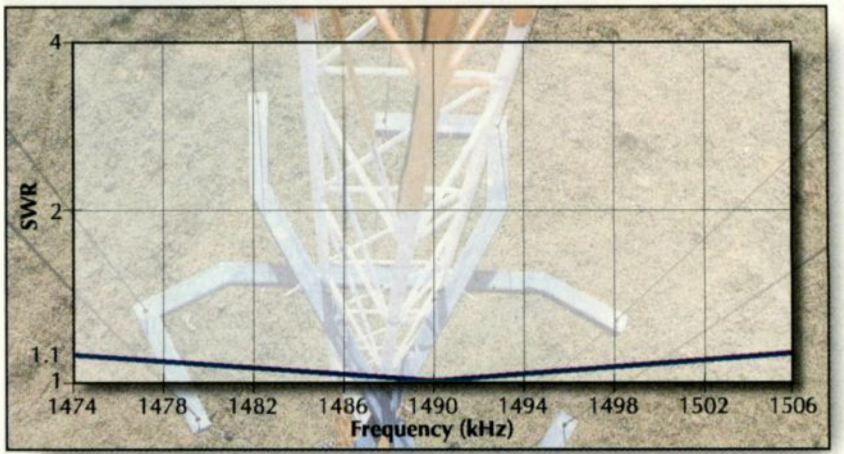


Figure 1. The SWR plot of a working self-resonant folded unipole antenna operating at 149kHz. Total bandwidth shown is 32kHz.

Note: The method described here has been filed with the U.S. Patent Office and has a patent pending.

Sylvio M. Damiani, P.E., is an consulting electronics engineer and coauthor of the Brazilian National Plan for MW Radio Stations. *He is based in São Paulo, Brazil.*

For more information on folded unipole antennas, see John Mullaney's article on our website:

www.beradio.com/features/tech/tech.cfm

Unexpected RFR

By Robert D. Lambert, Jr., P.E.

Isocouplers are often installed and then forgotten — until they're the source of trouble.

Much attention has been given to the problem of RF exposure and radiation around tower bases. Monitors are now available for checking RF levels. With one of the monitors, an unexpected source of *radio frequency radiation (RFR)* was discovered: an isocoupler.

In the 1940s, there was considerable interest from AM licensees interested in getting CPs in the new 88MHz to 108MHz band. One of the first questions regarded the use of a series-fed AM tower to support the FM antenna. Western Electric and RCA solved the matter of getting the FM signal to the FM antenna without shorting the AM signal to ground. Western Electric presented its cylindrical 730-A Filter and RCA its boxlike FM-AM Isolation Unit, later given the number BAF-14-A. In listing the desired characteristics, Western Electric stated, "The ideal bridging element would look like a low-loss 1:1 transformer at the FM frequency. It would present an infinite impedance to the AM frequency. It would be weatherproof and gas-tight. It would be nonradiating." The company further stated that "the coaxial construction employed prevents radiation which might assume troublesome proportions if other arrangements were used." Both manufacturers also pointed out other means for AM/FM isolation, such as the cylindrical and boxlike isocouplers (as we now call them), introduced by each company and now in common use.

Diagnosing trouble

Many isocouplers function properly, but some have been found to radiate FM strongly. Because they are usually installed near the tower base, this could pose an unexpected hazard to station personnel. It is recommended that every station check its isocoupler for such radiation. This should be done when the AM transmitter is off, and preferably at night if a visual indicator like a neon bulb on an insulated stick with a short pickup wire attached is used. A fluorescent tube can also be used, but will require a minimum voltage to fire and therefore may not be sensitive enough in some cases.

Be careful. You may be surprised by the amount of RF present. At one station, vicious bright blue ½-inch to ¾-inch arcs could be drawn from the isocoupler housing with an insulated screwdriver. A fluorescent tube was brilliantly lit when brought in proximity. In this instance, the TPO was 20kW and the isocoupler had a maximum FM insertion loss of 0.2dB, for a total loss of 900W. Therefore, its power loss through radiation could be estimated as half of the total, or 450W.

Once a station finds that its isocoupler is hot, the next step is to correct the problem. After all, it is neither easy nor inexpensive to replace a unit handling 20kW FM and the same or more AM power. Also, there may still be some doubt as to the source of the RF. It could be suggested that the RF on the isocoupler is due to the strong downward radiation from the stacked in-phase FM antennas overhead.

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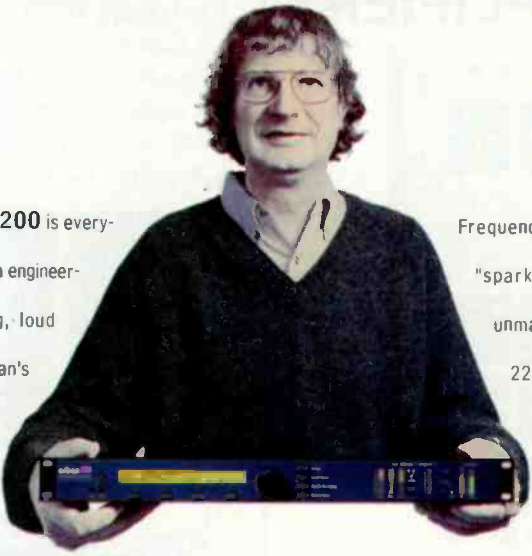

THE OPTIMOD-FM 2200 is everything you'd expect from Orban engineering: superior design, a big, loud OPTIMOD sound, plus Bob Orban's proven processing know-how. In fact, about the only thing unexpected is the price. Around half what you'd expect to pay for 100% Orban performance.

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The 2200's two key processing structures come directly from Bob's evolutionary work on the OPTIMOD-FM 8200. In the Two-Band structure, Bass EQ lets you selectively add punch, while a High Frequency enhancer automatically adds "sparkle." Protection mode maintains unmatched transparency and makes the 2200 an ideal upgrade for stations using Orban's classic 8000A. Both structures tightly limit peaks while providing superb baseband spectrum control. This guarantees highest loudness by protecting the stereo pilot tone and preventing overshoots in any uncompressed digital STL.

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Unexpected RFR

After studying the matter for some time, circumstances arose that caused the station discussed above to take its AM station off the air and replace the isocoupler with a suitable length of coaxial line. Upon resuming FM operation, it was found that all the stray RF was gone. A replacement isocoupler of a different design was then installed so that AM operation could resume. The new isocoupler ran cool and could be touched without fear.

Isocouplers like the one shown here are commonly used to mount grounded antennas on hot towers. This isocoupler is operating properly.

A similar situation was found at a Class A FM station, where the TPO was slightly less than 5kW. The isocoupler was about 4 feet above ground level and was not far from the entrance to the transmitter building. FM leakage was found on the outer surface of the isocoupler, though much less than in the previous example. Nevertheless, a standard fluorescent tube would glow brightly when brought near the isocoupler. As before, a replacement isocoupler cleared up the problem completely. In this instance, the station owner declared that his station's coverage improved after the change.

Verifying performance

Several experiments were conducted with the Class A station's original isocoupler. Using a 25W exciter, measurements were made of the insertion loss using two wattmeters and a 50Ω dummy load. The input impedance was measured with the isocoupler terminated in the 50Ω load using a Hewlett-Packard Vector Impedance Meter. This figure was used to determine the VSWR. The operation of this isocoupler was essentially within the listed specifications, which did not specify the permitted maximum level of radiation.

Anyone purchasing an isocoupler should obtain a statement from the manufacturer of the maximum permitted level of radiation from the unit.

Note: The exact reasons for the isocoupler failures were never fully determined. Possibilities include lightning, an over-power condition, or even excessive harmonics from spurious emissions.

Thanks to M. Fayne Anderson and Milton Holladay Jr. for their help with this project.

Robert D. Lambert is a consulting engineer in Columbia, SC.

Citadel Selects Scott Studios as "the Best" Digital System

Larry Wilson (at right), CEO of Citadel Communications Corp., shakes hands with Dave Scott as Citadel standardizes on Scott Systems for its 124 stations and future aquisitions.

Citadel Communications Corp., one of America's top 10 radio groups in 1998 revenues, selects Scott Studios Corp. as its sole supplier of on-air digital audio delivery systems for its 124 radio stations and future acquisitions.

"We thoroughly investigated all of the competitive digital air studio systems and decided upon the best one," says Larry Wilson, CEO of Citadel Communications. "Our regional Presidents and Vice Presidents of engineering and programming spent nearly a year analyzing different options. While no system or manufacturer is 100% flawless, it became obvious to us that Scott Studios is the very best. Their long history of excellent service commitment, the quality of their digital studio products and competitive pricing were our primary reasons for selecting Scott Studios."

Dave Scott, CEO of Scott Studios Corp. says, "It's an honor to be Citadel's sole digital audio vendor and take their other brands as trade-ins on our new equipment. Our systems are designed by announcers, for announcers.

"Of Scott's 61 employees, 43 are former jocks and PDs with 700 years collective radio experience. Competitors work more from the engineer's perspective, although we have 20 former chief engineers on staff also. Scott Studios' digital fits DJs like a glove."

After adding five Oklahoma City stations and other pending transactions, Citadel will own or operate 124 radio stations in 23 mid-sized markets such as Providence, Salt Lake City and Albuquerque.

Citadel is well known across the country for attaining topnotch competitive programming success, and the addition of Scott Studios announcer friendly technology will help Citadel announcers deliver superior information, entertainment and service to their 8,000,000+ weekly listeners.

Citadel's stations are not the only ones who choose Scott: *More* U.S. radio stations use Scott Studios' than *any other* digital system, with 5,046 Scott digital workstations in 2,202 U.S. stations. Nine of the ten *top-billing groups have Scott Systems*.

Scott Systems are the ***easiest to use!*** They're intuitive, straightforward, simple, yet the ***most*** powerful!

The Scott System is radio's most user-friendly. You get instant airplay or audition of any song simply by spelling a few letters of its title or artist. You see when songs played last and when they'll play next. You also get voice tracking while listening to music in context, hot keys, automatic recording of phone calls and graphic waveform editing, all in one computer!

Scott Studios is famous for our ***uncompressed*** digital systems at a compressed price, (but we work equally well in MPEG and MP3). Scott Studios' audio quality is the ***very best*** and plays on laptops or PCs with ordinary sound cards. We pre-dub your startup music library free. Your PD can auto-transfer songs digitally in ***seconds*** with a CD-ROM deck in his or her office.

Scott gives you industrial quality 19" rack computers, but ***nothing*** is proprietary: functional equivalents are available at computer stores. You also get 24 hour ***toll-free*** tech support! Scott also lets you choose your operating system: Linux, Novell, NT, Windows, DOS or any combination. You also choose from ***three*** systems: Good, Better, Best. One's right for ***you!***

The Scott System 32 (pictured at the upper right) is radio's most powerful digital system. Your log is on the left side of the LCD touch screen. Instant access Hot Keys or spur-of-the-moment "Cart Walls" are on the right with lightning-quick access to ***any*** recording. Phone calls record automatically and can be edited to air quickly. You can also record and edit spots or voice tracks in the air studio or go on the air from production.

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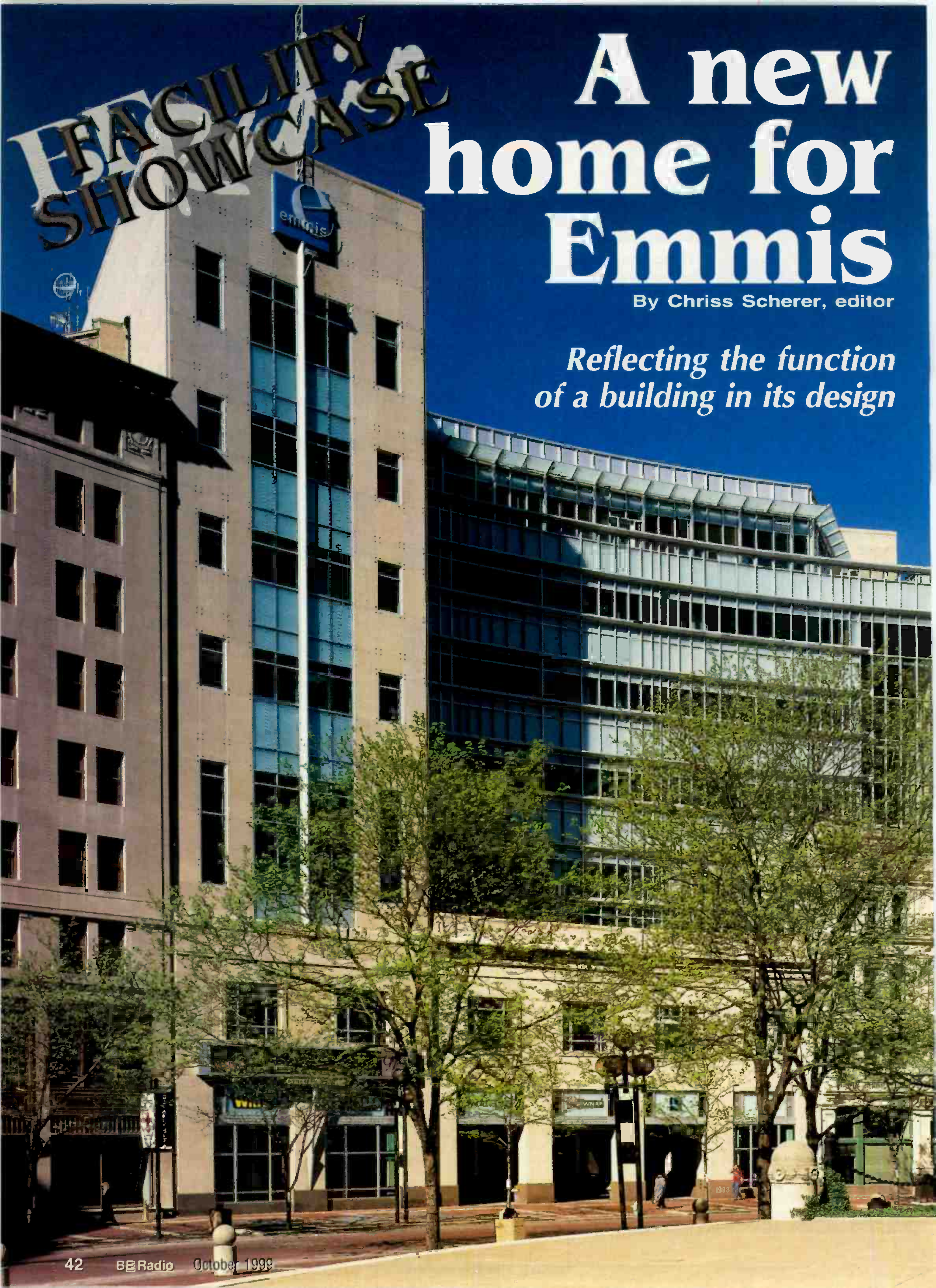
FACILITY SHOWCASE

A new home for Emmis

By Chriss Scherer, editor

Reflecting the function of a building in its design



In the September 1998 issue of *BE Radio* (p. 48), we gave you a sneak preview of the Emmis facility when it was under construction. The facility, located in the center of downtown Indianapolis on Monument Circle, was recently completed. The stations have moved in and begun operations.

See the September 1998 article to get a feel for the complete transformation of the building in just under one year.

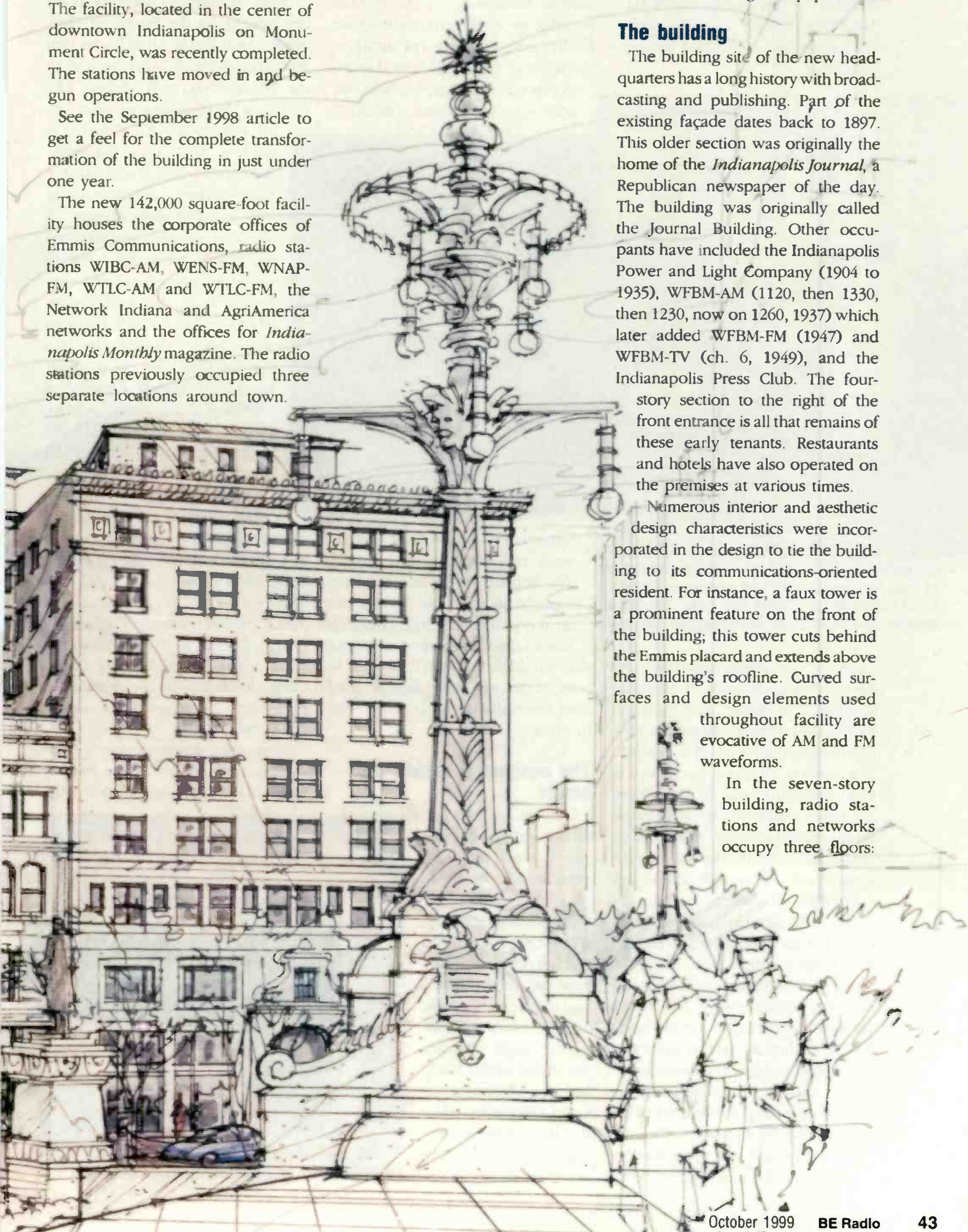
The new 142,000 square-foot facility houses the corporate offices of Emmis Communications, radio stations WIBC-AM, WENS-FM, WNAP-FM, WTLC-AM and WTLC-FM, the Network Indiana and AgriAmerica networks and the offices for *Indianapolis Monthly* magazine. The radio stations previously occupied three separate locations around town. Moving these discrete operations into a single facility presented some advantages as far as sharing of resources and networking of equipment.

The building

The building site of the new headquarters has a long history with broadcasting and publishing. Part of the existing façade dates back to 1897. This older section was originally the home of the *Indianapolis Journal*, a Republican newspaper of the day. The building was originally called the Journal Building. Other occupants have included the Indianapolis Power and Light Company (1904 to 1935), WFBM-AM (1120, then 1330, then 1230, now on 1260, 1937) which later added WFBM-FM (1947) and WFBM-TV (ch. 6, 1949), and the Indianapolis Press Club. The four-story section to the right of the front entrance is all that remains of these early tenants. Restaurants and hotels have also operated on the premises at various times.

Numerous interior and aesthetic design characteristics were incorporated in the design to tie the building to its communications-oriented resident. For instance, a faux tower is a prominent feature on the front of the building; this tower cuts behind the Emmis placard and extends above the building's roofline. Curved surfaces and design elements used throughout facility are evocative of AM and FM waveforms.

In the seven-story building, radio stations and networks occupy three floors:



WENS-FM and WNAP-FM on the third; WIBC-AM, Network Indiana and Agri-America on the fourth; and WTLC-AM/FM on the fifth floor. The corporate offices are located on the seventh floor.

The main lobby spans more than three stories and can be used for special events and receptions. (Shown R under construction). Photos this page: Jon Miller, courtesy Hedrich Blessing Photographers, Chicago.

One of the design goals was to keep as many common elements as possible. The studios and, to some extent, the technical operations/rack rooms are similar in their design, and much of the same equipment is used throughout the facility. There are two basic room layouts, based on the station's format: news/talk or music. Although no two studios are clones, certain considerations are common to all of them, regardless of format. The pictures included in this piece will give you a general feel for the facility's design.

Any facility relocation project is a time-consuming effort. For many stations, the demands are too great for the technical staff to supervise the entire design and installation project and keep the stations on the air and operating at the peak. This facility was no exception. Though the entire project was controlled by the station staff, much of the work was outsourced. This not only helped the station's staff maintain a realistic workload, but also it made possible an earlier completion time for the entire project. For instance, the miles of cable and wire that are in place were prepared, and one end was terminated, before it arrived in Indianapolis. When the walls and conduits were placed, the half-prepared cables were brought in, run and terminated on the unfinished end. This step alone saved several weeks of time that would have been lost if cable runs could not have begun until after the wall and cable trays were in place.

The equipment behind the sound

Each studio is built around an Integrity console (20 total throughout the facility) and furniture from PR&E. All the twisted-pair wiring is AES3-compliant Belden cable. Cable runs between studios and tech centers are on 12-pair cables. Not all of the audio sources are digital at this time, but one advantage to using AES3 cable is that it makes excellent analog cable as well because of its lower capacitance and tighter manufacturing specification.

On-air storage and playback is accomplished via the Broadcast Electronics AudioVault. All of the servers and workstation PCs are housed in the fourth-floor tech center. The monitors, keyboards and mice are all extended with Cybex extenders. All PCs are industrial-duty and consist of eight AudioVault servers, one Net delay server and 25 workstations. All the servers and workstations are monitored by AutoView so each can be accessed and controlled from the tech center. There are three 23GB drives on six of the servers; the other two servers have six 18GB drives for a total storage capacity of 630GB for the entire system. There are more than 18,000 audio files on the system. All drives are mirrored for complete redundancy.

The original plan for audio storage called for 6.4:1 compression at a 32kHz sampling rate on all the audio files. Later, all the music was switched to 3.2:1 compression at 32kHz for better quality. Though this provided better quality, the programming personnel still did not find it quite satisfactory, so the music sampling rate was changed to 44.1kHz at 3.2:1 compression.

None of the stations shares a common transmitter site. All the stations have dual T1 circuits in place from

Looking into the studio of WENS from the hallway.

The control room for WIBC has room for five guests and a co-host. The newsroom doors are on the right. Photos this page: Jon Miller, courtesy Hedrich Blessing Photographers, Chicago

the studios to the transmitters for telemetry and STLs. All the tower sites except WTLC-FM can be seen from the roof. These stations use a microwave STL as their primary and T1 as a backup. Only WTLC-FM uses the T1 for its primary STL. The roof also has two Ku-band uplinks for the networks, RPU antennas and a diesel generator.

A 200kVA UPS in the penthouse covers critical systems during the switchover to and from the generator.

The production rooms can serve as back-up air studios and have similar layouts to them, with the addition of a SADiE DAW. Currently, the editors are not networked together.

The WIBC production studio.

Lookouts

There are two showcase studios on the ground floor that look out to Monument Circle. The studios are accessible by any of the stations or networks. All of the operational functions, including access to call-in telephone lines, complete control of the on-air playback system, EAS, audio routing and monitoring, can be switched to either showcase studio. One studio is slightly larger than the other. Both can be used for any format, but one is tailored for a music format and the other for a talk format.

A video-quality electronic variable message board, located above one of the showcase studios, provides news and information about special events to passersby on the street. There is also a camera that can display images of pedestrians walking by the headquarters on the message board. The

The news workstations are compact but still flexible. Notice the auxiliary audio jacks on the clock/timer panel.

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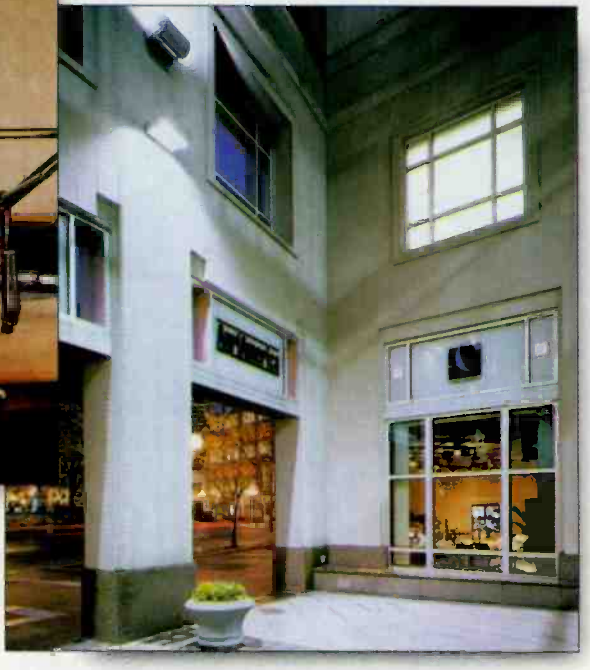
showcase studios use double-paned, bulletproof glass for soundproofing and safety. These studios are also equipped with a flexible, two-way video-monitoring system. The showcase studios will enable greater interaction between the on-air personalities and the community.



Above: A view of the larger showcase studio on the first floor. Right: Outside the same showcase studio standing in the forecourt entry looking out to Monument Circle. Photos: Jon Miller, courtesy Hedrich Blessing Photographers, Chicago

Sound quality and characteristics have been standardized across the stations with Symetrix 528E microphone processors, ElectroVoice 807 microphones for the news/talk stations, and Shure SM-7 and ElectroVoice RE-27 microphones for the music-format stations. JBL 400-series monitors are used throughout.

Behind the scenes

Three technical centers, using 32 Stantron racks, provide transmission equipment (including satellite, ISDN and T1 transmission facilities) and technical support. Facilities are spread between the three technical centers, which are stacked on three separate floors. The fourth floor supports WIBC-AM, Network Indiana, AgriAmerica and the SAS64000 dual frame 2563256 stereo router. The fifth-floor tech center provides support for WTLC-FM, WTLC-AM and the AudioVAULT storage unit. The sixth-floor tech center supports WNAP-FM and WENS-FM, the Emmis flagship station. Intraplex T1 primary and Moseley Aural backup STLs round out the systems. Inter-room wiring connections consist of

Project-at-a-glance

Facility: Emmis Communications
Location: Indianapolis, IN
Stations/networks: Five stations, two networks
Number of studios: 25
Architect/project manager: Ratio Architects, Indianapolis
Equipment installer: Pacific Research and Engineering, Carlsbad, CA
Acoustician: Northeastern Communications Concepts, New York
General contractor: Shiel Sexton, Indianapolis
Design approved: July 1996
Construction start date: Jan[illegible] 1997
Move-in date: December 1998

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approximately 12,000 feet of Belden 1806A AES3 multipair cabling.

Time throughout the facility is kept in sync with an ESE 185 GPS-based clock. The time signal from the ESE feeds the Integrity consoles, ESE analog wall clocks and PR&E digital clocks in every studio. Sine Systems LED message boards and controllers in each on-air studio are triggered by a variety of conditions to indicate alerts and open mics.

An eight-station news workroom provides eight workstations for WENS-FM, Network Indiana and AgriAmerica news support. Two lighter workstations provide local traffic/road condition services for all of the stations.

WTLC-AM, WTLC-FM and WIBC-AM also stream audio over the Internet. The Web servers for the Real Audio streams are kept in the tech center.

Preparing for digital

The digital consoles were installed in preparation for the ongoing upgrade to a completely digital studio. Only WENS and WNAP are fully running digital paths from the console out to the transmitter input at this time. The system delay from console input to an off-the-air receiver is not significant, and operators are able to monitor directly off the air. A few announcers are aware of the slight delay, but it is not significant enough to be a problem for them.

Though only a limited amount of digital audio is being routed through the facility, the wire and cable used will support the future changes.

This article focuses on the technical side of the operation, but there is much more in the building that also warrants considerable attention, such as the general office area, several atriums, and the individual station reception areas. The Emmis headquarters is more than just showcase studios — the entire facility is a showcase.

Thanks to Anita Gambill of Ratio Architects, Bob Hawkins, chief engineer of WENS and WNAP, Jeff Dinsmore, chief engineer of WIBC-AM, Network Indiana and AgriAmerica, and Dave Hood, chief engineer of WTLC-AM/FM and AudioVault administrator for their help in preparing this article.

FOR MORE INFORMATION
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Equipment lists

Air studios

PR&E Integrity consoles
Panasonic SV-3800 and SV-3700 DATs
JBL 4412A monitors
Electro-Voice RE-27 or Shure SM7 mics
Shure SM7
AKG K141 headphones
Hafler P1000 and P3000 power amps
Audiometrics CD-10 CD players
Tascam 122 MKII cassette
Telos 1A2 telephone interface and Delta 100 hybrids
AKG K141 headphones
360 Systems Instant Replay
360 Systems ShortCut
Sony MiniDisc recorder/player

Production

PR&E Integrity consoles
SADiE DAWs
JBL 4412A monitors
Auratone Soundcube monitors
Marantz CD recorder deck
Audiometrics CD-10 CD players
Electro-Voice RE-27 or Shure SM7 mics
Hafler P1000 and P3000 power amps

Tech center

AudioVault servers and workstations
TFT and Sage EAS units
Intraplex TDM-160 T1 multiplexer
SAS 64000 256x256 stereo router
WireReady servers
Moseley 6010 and 606 STLs
Telos Zephyr and ZephyrExpress ISDN codecs
Comrex Vector and Hotline POTS codecs
Marti RPUs
CircuitWerkes TeleRadio
Belar modulation monitors
Dorrough audio test sets
Cisco hubs

News Workstations

Electro-Voice RE-27 mic
AKG K141 headphones
SAS IFB and router controller
Tascam 122MKIII cassette
Sony MiniDisc recorder/player
Telos 1A2 interface module
Symetrix 528E mic processor
Fostex 6301B powered monitors

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ANTENNAS

FM Antenna Concepts

By John Battison, P.E.,
technical editor, RF

A further explanation of the operational characteristics of FM

This is part eight of a nine-part series on broadcast antennas.

The inventor of our FM system, Major Armstrong, used simple dipole antennas in his original experimental laboratory work. These antennas bear little resemblance to the FM antennas used today. As Armstrong's invention worked its way into commercial use, antennas became more complex with the need for increased power.

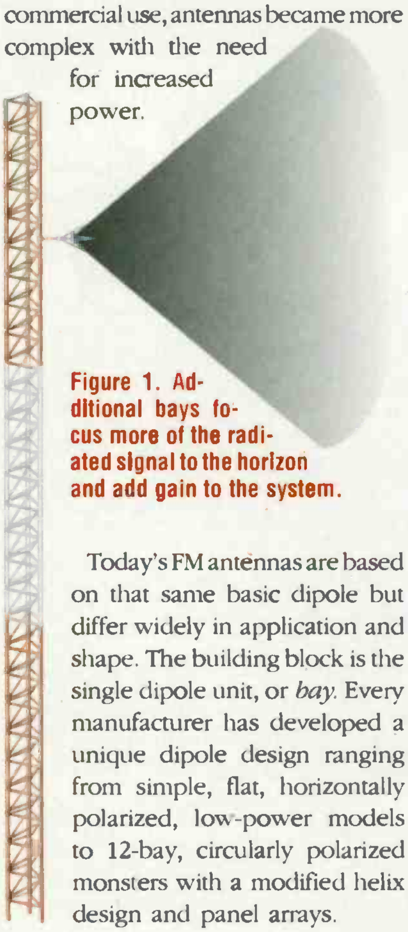


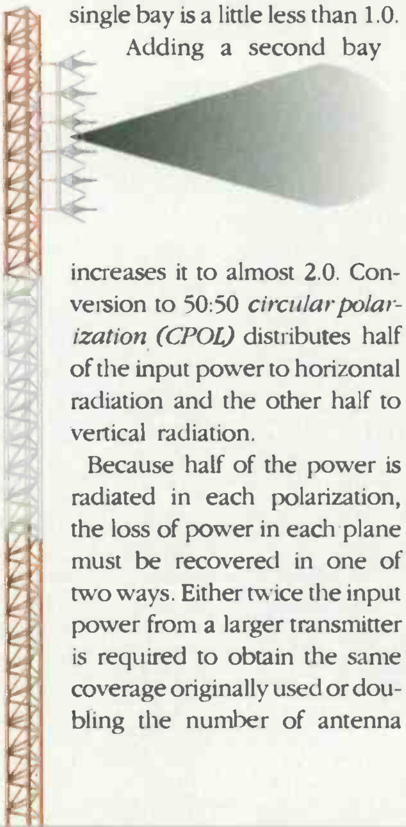
Figure 1. Additional bays focus more of the radiated signal to the horizon and add gain to the system.

Today's FM antennas are based on that same basic dipole but differ widely in application and shape. The building block is the single dipole unit, or *bay*. Every manufacturer has developed a unique dipole design ranging from simple, flat, horizontally polarized, low-power models to 12-bay, circularly polarized monsters with a modified helix design and panel arrays.

Antenna gain

To increase antenna power gain, more bays are added. Each additional bay narrows the transmitted beam vertically and increases the antenna's horizontal radiation. In the absence of tower-induced distortion, this radiation will typically be omnidirectional. It is easy to see how the compression of the vertical beam increases the horizontal power.

In *horizontally polarized antennas (HPOL)*, the power gain for a single bay is a little less than 1.0. Adding a second bay

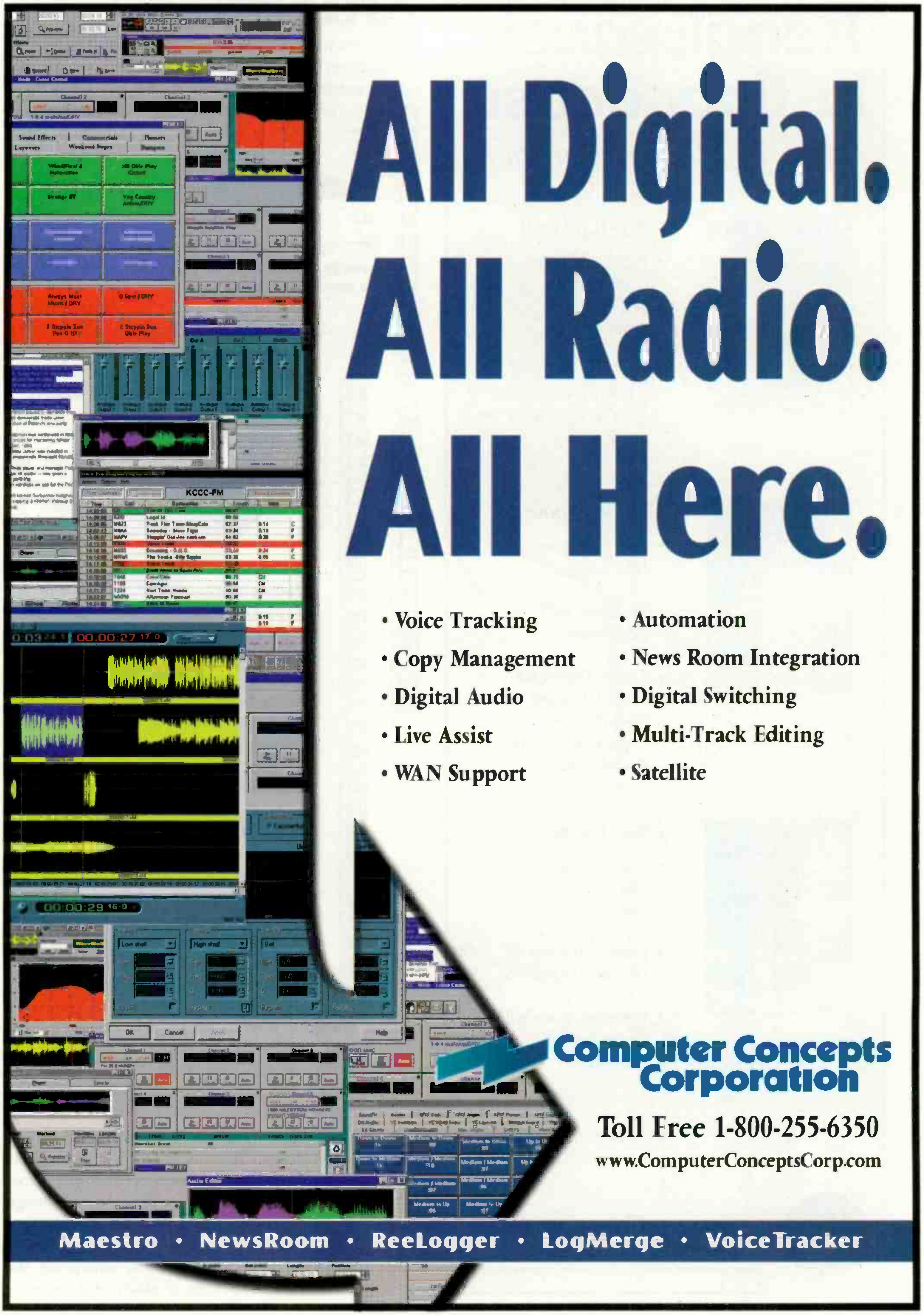


increases it to almost 2.0. Conversion to 50:50 *circular polarization (CPOL)* distributes half of the input power to horizontal radiation and the other half to vertical radiation.

Because half of the power is radiated in each polarization, the loss of power in each plane must be recovered in one of two ways. Either twice the input power from a larger transmitter is required to obtain the same coverage originally used or doubling the number of antenna bays, for example, from three HPOL bays to six CPOL bays, is necessary.

There is considerable argument among engineers concerning the pros and cons of high-gain antennas with lower-power transmitters versus low-gain antennas and higher-power transmitters. The pros say that the narrow antenna beam tends to pass over the receivers closer to the transmitter and perhaps illuminates distant areas where there are no listeners. The cons maintain that, by virtue of the lower-gain antenna's broader vertical beam, close-in listeners will be properly served. It seems that, out to about four miles or so, signal strength is better. Past this point, however, there is usually no difference. Probably the best method of determining which way to go is to balance the initial costs of a high-gain antenna and perhaps a stronger tower against the long-term cost of electric power.

As public concern about the possible danger posed by non-ionizing radiation has grown, attention has increasingly been paid to end and downward radiation. In general, 180 to 225 vertical degree spacing between antenna bays controls downward radiation. Half-wave spacing (180 degrees) seems to be most effective. As the spacing is increased toward a full-wavelength antenna, gain tends to diminish as null fill changes.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With FM's rise in popularity, HPOL antennas were often mounted on poles on the top or side of existing AM radiators and fed via quarter-wave isolating stubs, isocouplers or isolating transformers. The additional tower height produced by the addition of a vertically mounted FM antenna increased the AM radiation and could result in interference, requiring a modification of the AM license. To save this re-engineering cost, FM antennas were often side-mounted on AM transmitters.

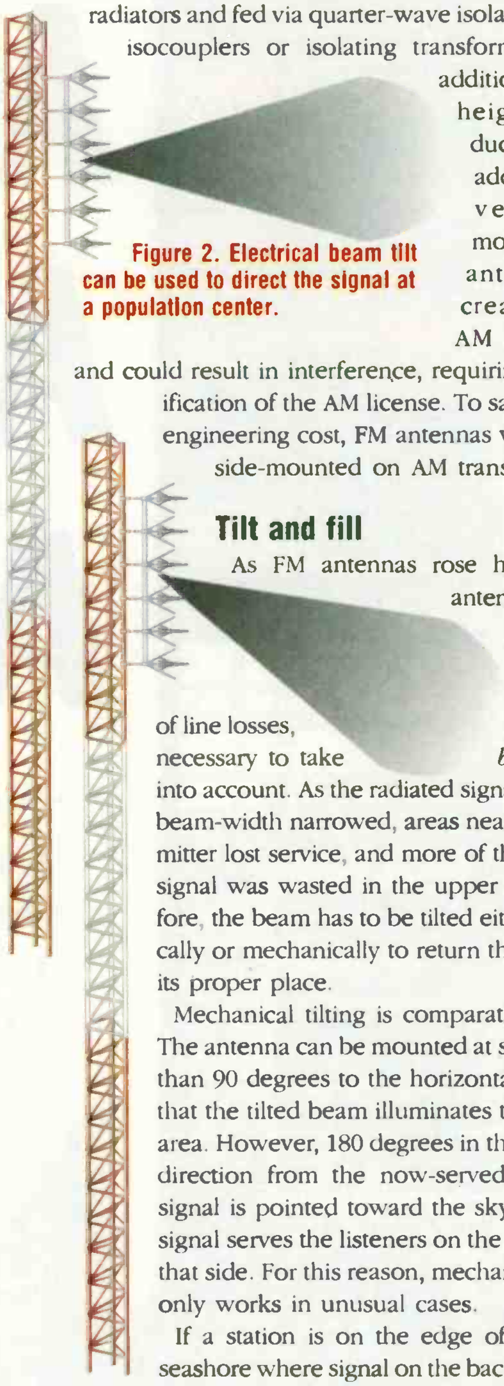


Figure 2. Electrical beam tilt can be used to direct the signal at a population center.

Tilt and fill

As FM antennas rose higher and antenna power gain increased to take care of line losses, it became necessary to take *beam-tilt* into account. As the radiated signal's vertical beam-width narrowed, areas near the transmitter lost service, and more of the radiated signal was wasted in the upper air. Therefore, the beam has to be tilted either electrically or mechanically to return the signal to its proper place.

Mechanical tilting is comparatively easy. The antenna can be mounted at slightly less than 90 degrees to the horizontal plane so that the tilted beam illuminates the desired area. However, 180 degrees in the opposite direction from the now-served area, the signal is pointed toward the sky, thus less signal serves the listeners on the ground on that side. For this reason, mechanical tilting only works in unusual cases.

If a station is on the edge of a lake or seashore where signal on the backside is not needed, tilting the antenna works well. However, if the signal needs to be "bent" downward all around the transmitter, the electrical method must be used. Associated with beam tilt is *null fill*, which is often required because vertical nulls develop as additional bays are added.

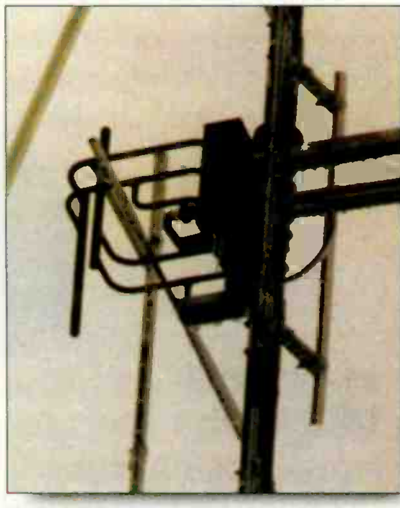
About half a degree of beam tilt is usually sufficient to take care of overshoot. This amount of beam tilt is easily produced by advancing the current phase in the upper bays and delaying it in the lower bays. During design stages, the antenna engineer determines the required degree of phase control.

When deciding on a new antenna, examining the vertical and horizontal pattern is essential. Determine

where nulls will fall, and have the manufacturer modify the antenna to take care of the problem. Many times, when a new antenna is installed, poorer reception results in some important areas because the vertical pattern was not checked.

Going directional

Directional FM antenna development and design are quite different from that for AM. The former has stemmed from the experiences of broadcasters. The first FM stations probably put their antennas on a tower or on top of a building, let the signal flow and awaited the results. It appears that not a great deal of thought was given to the effect of the antenna support until about 20 years ago. Early FM broadcasters knew that side-mounting sometimes provided good general coverage with a few areas of spotty or poor reception. When circular polarization became popular, broadcasters began to pay attention to the polar plots of vertical and horizontal radiation. Vertical and antenna plots were examined, and the often tremendous differences between the strongest signal in each polarization on the same azimuth were noticed.



Parasitic elements can be added to an antenna to give it directional qualities. Photo courtesy of Shively Labs.

Savvy engineers took advantage of the directional effect of the tower on an omnidirectional antenna. They were able to produce an FCC-acceptable nondirectional signal in a favorable direction through judicious antenna positioning. As FM close-spacing developed, directional antennas became a necessity. In FM, an antenna's planned directivity is developed by taking the tower into account and adding vertical and/or horizontal parasitic radiators to produce the desired pattern. The exact number of parasitic rods depends on the individual case.

Vertical tower sections have a strong effect on *vertical polarization (VPOL)* when the antenna is side-mounted and close-in. Similarly, horizontal sections can affect the HPOL. After a directional FM antenna is designed by the manufacturer, it is tested with either a full-scale model on the actual tower section or a scaled-down VHF or MW version.

Directional FM antennas are not usually proofed in the same manner as AM directional antennas. Only in exceptional circumstances are field strength surveys made. Aircraft, usually helicopters, are being used more frequently because they can provide extremely good coverage information. The consulting engineer either uses the antenna plot supplied by the antenna manufacturer or a plot modified to suit the engineer's requirements. If the manufacturer can meet these specs, an application for construction permit is filed.

After the CP is granted, the manufacturer designs, builds and tests the directional FM antenna. The company then ships the antenna, which is installed and put on the air. The test results that the manufacturer supplied are filed

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with the application for license in the same manner as an AM DA application is filed.

Cable considerations

It is important to pressurize coaxial cable; doing so will keep moisture out. Moisture can cause corrosion of the internal bullets that connect the center-line sections and can lead to arcing and the development of hot spots in the cable.

Skin effect can also take a toll on air dielectric cable that has developed a dirty, oxidized coating. VHF-FM experiences skin-effect conditions of travel along the surface of, rather than through, the copper center conductor. It has been estimated that as much as 40 percent of the signal can be lost in upper-band, UHF-TV frequencies from old, dirty, oxidized, unpressurized line. Even at lower-frequency FM, the skin effect can be noticeable.

Apart from preventing downtime caused by coaxial line damage, it is important to remember that unpressurized air dielectric line *could* account for unexplainable drops in coverage or signal strength.

Deicing

An important consideration for the FM engineer is deicing. Deicing can be accomplished by means of heating the elements or by using a plastic *radome*. The radome prevents ice from collecting on radiators and producing an increased VSWR that is often sufficient to knock a transmitter off the air and cause line damage.

Antenna heaters are expensive to install and run. In some FM antennas, the radiating element itself is used as a heat radiator. The heating current actually runs through it and thus heats it. Other antennas have a heater element inside the radiators.

Metal guy wires should be kept clear of FM antennas so as to not interfere with their radiation.

In most cases, it seems that radomes provide the best answer. There is no initial installation expense or continuing expense for power. If the proper material is used for the radome and it is sufficiently far from the radiator so that ice buildup cannot change the VSWR, there is no loss of signal and no expense for heating. Unfortunately, wind loading increases, which has to be considered when planning the installation.

Broadband antennas

FM antenna design has progressed from simple dipoles to today's highly efficient broadband antennas. We have seen the development of triangular loops, square loops, simple rings, ring antennas with capacity plates on the ends of the elements, various shapes of twisted and skewed antennas, helix, cylindrical and the increasingly popular panel-type antennas.

Depending on the tower shape and size, the panel antenna closely approximates a circular pattern. It also lends itself well to the multiplexing of several transmitters into a single antenna and provides good directional antenna control.

When using guyed towers for FM antenna support, ensuring that metallic guys do not pass in front of the antenna aperture is crucial. Any metallic objects close to the radiator will produce gross pattern distortion and many operating problems. If guys have to pass in front of the antenna because of antenna mounting requirements, Phillystran or another type of nonmetallic guy must be used. It can be expensive in terms of insulators and labor to break up metal guys into the extremely short sections that will not affect the radiated signal.

This is the eigth in a series of nine articles on basic broadcast antennas. Upcoming installments will appear monthly in BE Radio *throughout 1999. Once all the installments have been published, the series will be available for purchase as a single document. For more information regarding bulk orders of this series in quantities of 500 or more, contact Jenny Eisele at 913-967-1966.*

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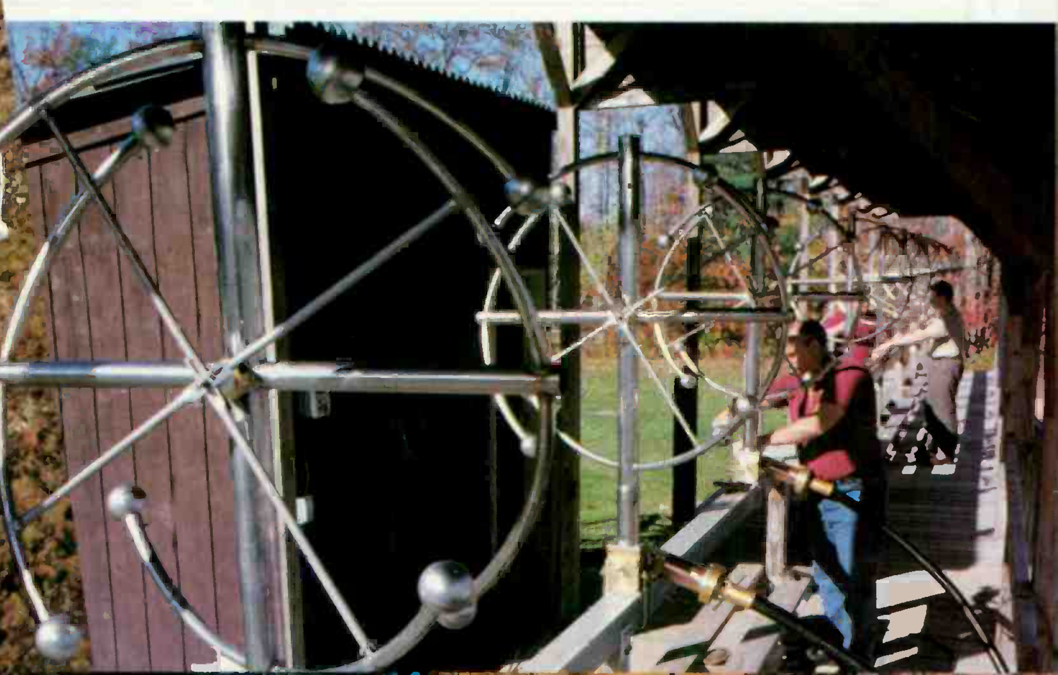

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A. Total No. of copies printed (net press run)	15,280	16,630
B. Paid and/or requested circulation		
1. Paid/Requested Outside-County Mail Subscriptions stated on form 3541 (include advertiser's proof and exchange copies)	12,920	14,034
2. Paid in-County Subscriptions (include advertiser's proof and exchange copies)	0	0
3. Sales through dealers and carriers, street vendors and counter sales, and other Non-USPS Paid Distribution	0	0
4. Other classes mailed through the USPS		
C. Total paid and/or requested circulation	12,920	14,034
D. Free distribution by mail (samples, complimentary and other free)	1018	953
1. Outside-county as stated on form 3541	1018	1018
2. In-county as stated on form 3541	0	0
3. Other classes mailed through the USPS	0	0
E. Free distribution outside the mail (carrier or other means)	480	500
F. Total free distribution (sum of D and E)	1,498	1,453
G. Total distribution (sum of C and F)	14,418	15,487
H. Copies not distributed	862	843
I. Total (sum of G, H)	15,280	16,330
Percent paid and/or requested circulation (C/Gx100)	89.6%	90.6%

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Jenny Eisele (Editorial Reprints)
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E-mail: jenny_eisele@intertec.com

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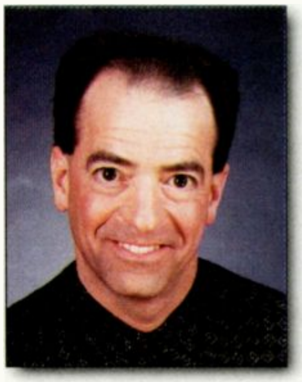
Boombox with a browser — and beyond

By Skip Pizzi, executive editor

It's time to get serious about multimedia broadcasting. Radio isn't just audio anymore. That may sound like heresy, but face it, if new media is to have a breakthrough value, it will come in its integration of content types. Old (i.e., analog) media was medium-locked, meaning radio was an aural-only medium; TV was aural and visual; and print was text and graphics.

Now the rules are changing, thanks to digital technology. The bits-is-bits axiom implies that anything you can digitize can be transmitted in a digital bitstream (including multiple media simultaneously), as long as the receiver can recognize and interpret what the transmitter is sending. The limits are set only by transmission bandwidth and the penetration of standardized content and delivery formats.



One way to deliver multimedia is via a device that converges a portable radio with a wireless Web browser.

Delivery options

One way to deliver multimedia is via a device that converges a radio with a wireless Web browser. This could work today, although it's not an elegant solution (the user has to tune the radio and enter the URL). One step better is the hyperlinked website, in which the broadcast signal automatically loads the URL into the browser (via RBDS, for example), so the station's website is automatically called up on the browser display when the station is tuned in. Nevertheless, wireless Internet connectivity is still fairly expensive and rarified.

Most of the applications discussed above could be accomplished without a return-channel, in a point-to-multipoint, one-way wireless fashion. This implies that the traditional radio broadcast model could survive, with the addition of standardized multimedia content and appropriate receivers. In this approach, the actual *content* displayed on the radio's "browser" would be delivered as auxiliary data over the air, either in real time or in pre-cached form for later display.

The over-the-air delivery is far cheaper than wireless Internet (essentially it is free, like radio), its bandwidth is potentially more plentiful, and it intrinsically allows the same portability and coverage that traditional radio enjoys today. The content could be carried on today's analog radio signals using high-speed subcarriers (again, something that's been under exploration for several years), or on future DAB channels using part of the bitstream set aside for auxiliary data. Although only a limited number of websites would be available in this case, the selection of this content would be under the station's control, so it could sell access to this premium delivery space.

A key enabler (which has yet to be developed) is a *standardized content format*, which would provide an analogous function to that of HTML on the World Wide Web. Without the standardized use of HTML the Web would never have achieved its massive popularity, and a similar common content base is required for multimedia broadcast content to succeed. It makes sense to build this format on a foundation of HTML, since substantial content and design expertise in this area already exists.

Making it happen

For such non-aural content to become popular, it has to look good on the display device. This implies that current Web pages can't simply be sent to the multimedia radio's screen. Rather, content must be customized for the display. The interactive TV industry has learned this lesson, finding that what displays nicely on a PC screen doesn't necessarily work on the TV (even though it's essentially the same display device), because the two systems are used and viewed differently. Radio has never had a visual display tradition, so there are no established norms or aesthetics. Before a successful multimedia content style and standard can be developed, some understanding of the display parameters will be required.

Easy-to-use content-creating tools will also be needed. The computer workstation that is in increasing use by radio producers today bodes well here. It won't be much of a stretch to incorporate multimedia content-authoring applications on the same platforms used today for audio-only production. Yet unless these tools are quick and user-friendly, the whole concept won't fly.

Of course, even if multimedia broadcasting becomes wildly successful for radio stations, there will still be many users who are listening to audio only. Always remember the main product while developing new ancillary services.

For more on this topic, see next month's Next Wave column; we'll look at CEMA's proposal for a Mobile Multimedia Broadcast Service (MMBS).

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