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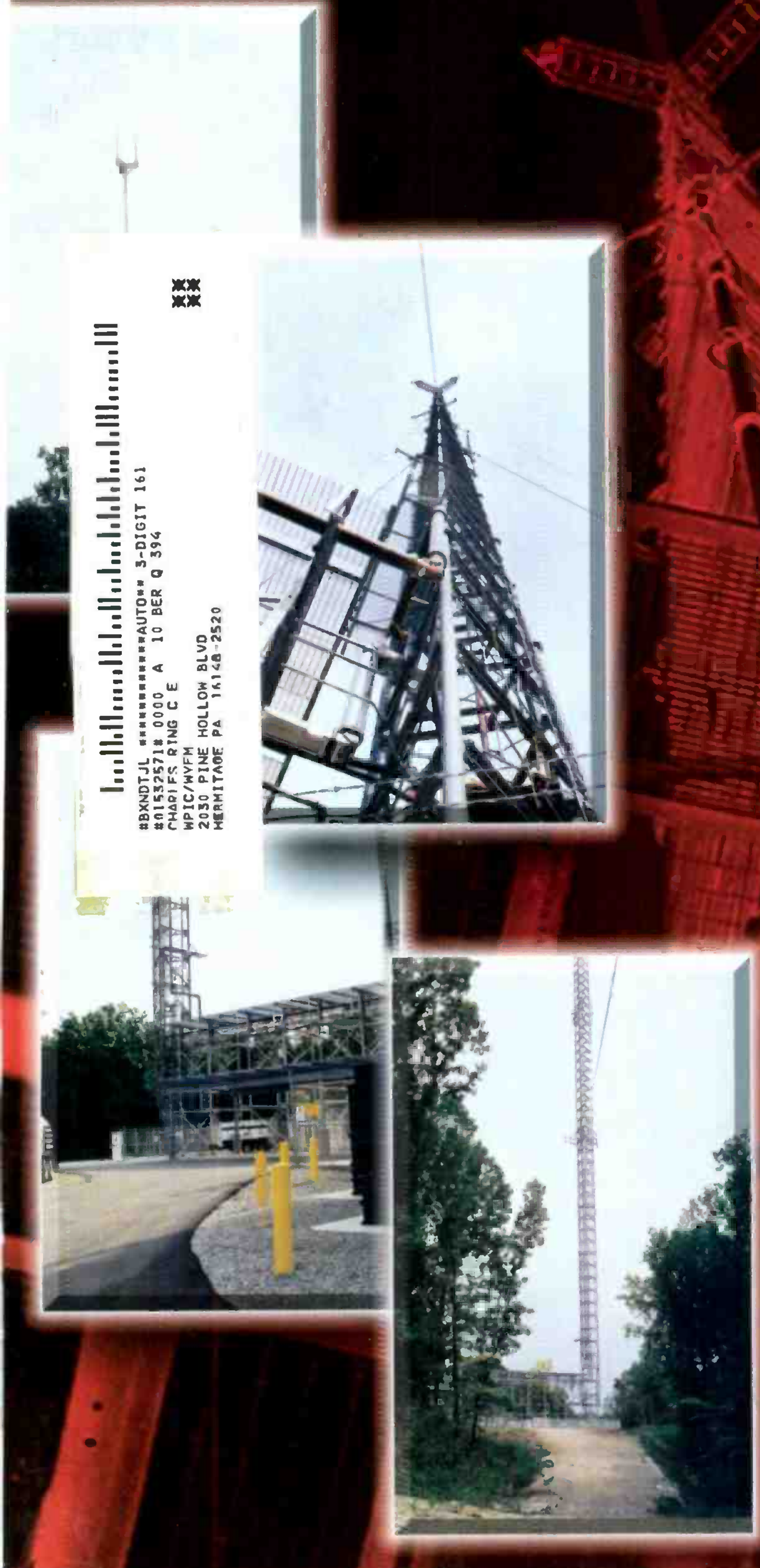

IBOC
A Look from Every Angle

ALSO:
Capturing the Aural Moment
Inside XM Satellite Radio

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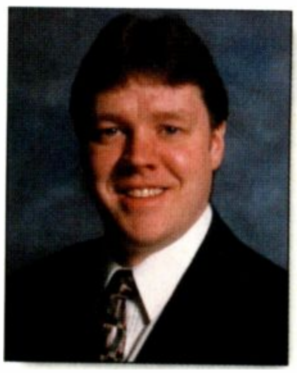
DEPARTMENTS

ON THE COVER: As the final steps for the start of the IBOC transition begin, stations must evaluate and consider several issues and concerns. Tower photos by Chriss Scherer. Cover design by Michael J. Knust.

Service provided

When a major historical event takes place, we often remember, and are usually asked repeatedly, "Where were you at that time, and what were you doing?" September 11 is one of those days. Personally, I was at home that morning. I was packing my suitcase, preparing to leave that afternoon for the Syracuse SBE Convention and National Meeting. I heard about the event on the radio and then turned on the TV to see what was happening. I stopped packing almost immediately and sat and watched the subsequent events occur.

This tragedy produced many heroes and victims. I commend the heroes for their efforts and offer my condolences to the families of the victims. The discussion of the aftermath of this disaster, however, is better left to other forums that are better suited and more appropriate for that discourse.



What is relevant to broadcasting is that my media experience is not unlike that of most people who watched or listened as the news was delivered. As information was delivered over the airwaves, the Internet, typically a space full of timely information, fell short of its up-to-the-minute reputation. The Internet was worthless as an information source. If you could connect to a news website at all for text information, there was so much traffic that data was barely able to move through the system to provide any level of acceptable quality for a streaming source. This e-bottleneck lasted through the morning and into the early afternoon.

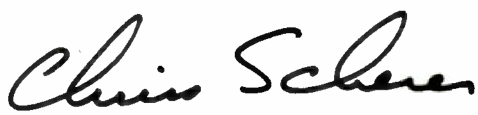
When the public wanted to learn about the events unfolding, the most reliable system was one that was based on technology nearly 100 years old. Conventional radio and television were able to reliably deliver the information to the masses without regard to the number of receivers in use. While Web servers choked trying to respond to all the connection requests and Internet pathways were brimming with data packets trying to be sent, the airwaves were reliable and clear.

This should really come as no surprise. One of the drawbacks to streaming media is the net congestion that occurs on a typical day. In a situation where the system is pushed to its capacity, the limitation is obvious. With shortcomings such as this online, the ether shows itself to be a system capable of reliably delivering information in a crisis. Short of jamming transmitters or severe atmospheric interference, the radio waves would continue to provide the information in a reliable fashion.

During the days following the attacks, the Internet showed its value in another way. While radio and TV continued to cover the story in an ongoing process, the online medium was able to provide audio, video, animations and analysis on demand from the events. This complimentary coverage in addition to the "legacy" media delivered a greater depth and broader reach than either could accomplish alone.

Once again, we have an example of how traditional broadcast can work well in tandem with the online offerings. The airwaves can provide an uninterrupted information path to a mass audience through its one-to-many infrastructure. The Web can deliver niche information to smaller segments or individuals in its one-to-several or one-to-one models.

There are those who believe that the Internet will be the delivery platform of radio's future. This may be the case one day, but it is certainly not the case now.



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Management and engineering as allies

by Jim Paluzzi, CBT

The old joke goes: How do you make sure that you never get trapped in management? The punch line follows: become an engineer! Not long ago, this joke was dead-on accurate. Even today, while many engineers have risen in the ranks of broadcast radio, many in our field still hold on to the sentiment that engineers are generally ill-suited to working amiably with senior management.

The stories of about engineers toting pocket-protectors notwithstanding, most of the stereotypical images of broadcast engineers have a basis in fact. Many engineers spent their time learning about electronics instead of working on their communication skills. It is easy for engineers to resent the long hours, the pressures of being on-call around the clock, and the relatively little appreciation received for keeping the station on the air. Passive aggression thrives in this climate of resentment, and passive aggressive personalities are hardly to be considered allies in management.

Why does broadcast management need to be integrated with broadcast engineering? Radio is a complex industry, combining seemingly disparate departments to make great programming emerge from those radio speakers. The greater the diversity of staff members who see the *big picture*, the greater the probability of success.

Every general manager has his strong suit. For some GMs, programming is everything. Other general managers cut their eyeteeth in broadcast sales. Still others come from news. Since most general managers come from fields other than engineering, it is logical that these managers will place a higher priority on the issues they understand, rather than deal with strange and unfamiliar scenarios coming out of the engineering department. In short, we tend to play to our skill set, minimizing the importance of those areas where we have little experience.

Minimizing the importance of any segment of broadcast radio can be serious. However, when engineering investments are minimized, the results can be costly. Failure to invest in spare parts, for example, can often result in even higher costs to air freight the needed part in an emergency. Furthermore, since many critical broadcast components are unique (often custom fabricated), the lag time needed to secure and ship those parts can result in extended outages that can be both painful and expensive. The resentment in engineering that can result from ignoring a reasonable request for spare parts continues the downward spiral that makes it feel like engineering and management are adversaries, rather than allies.

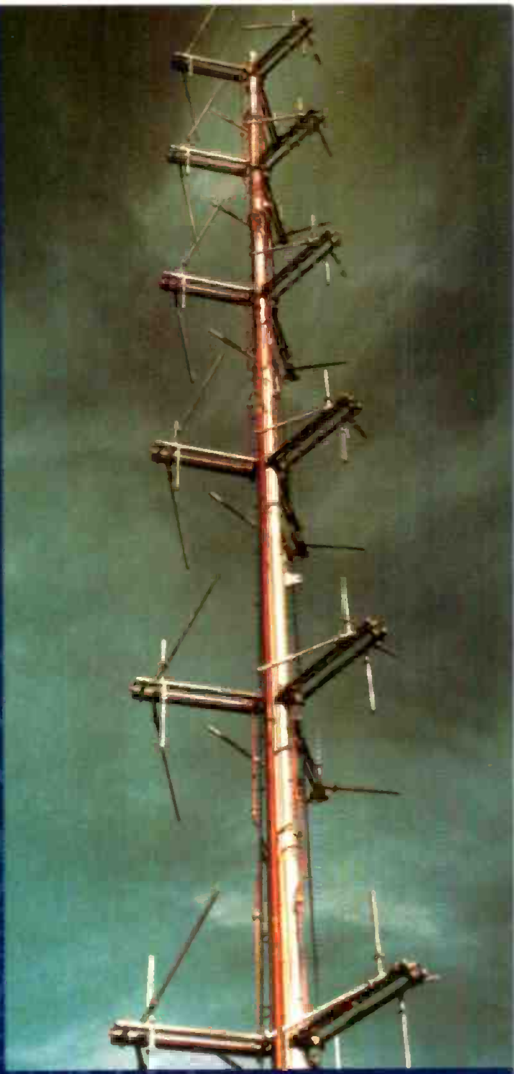
Working together

Management and engineering can develop a tight, integrated team—but it takes work. Here are four steps that both managers and engineers can take to build an alliance:

Take time to ask questions. Since engineers and managers often come with vastly different backgrounds, neither party can know with certainty whether the other side is pulling a fast one. As a result, many managers fear the worst and assume that they are about to become a victim of their own ignorance—and the engineer's questionable intent. Little good can come from this environment of mistrust. That is why radio stations must create an environment where both managers and engineers are encouraged to ask questions whenever there is a possibility of misunderstanding.

. . . we tend to play to our skill set, minimizing the importance of those areas where we have little experience.

There are few issues in broadcast engineering that are so complicated that they cannot be expressed in terms that a competent manager can understand. The key is for managers to be persistent in asking follow-up questions until they are confident that they understand the issues.



Likewise, when management makes a decision that makes little sense to the engineering staff, the engineers must take the responsibility to ask questions of management until the reasons behind the decision are clear. Both managers and engineers must learn how to ask non-threatening questions.

Kick the tires. Nothing impresses engineers like managers who care enough to get their hands dirty. One way to get into the engineering camp is to spend time inspecting engineering projects. Whether it's a new studio, a new antenna site, or simply an old transmitter that has seen better days, managers gain a better understanding of an engineering problem by seeing the problem firsthand.

Share the suffering. Broadcasting rarely has genuine emergencies in the areas of sales or accounting. However, the business is full of engineering emergencies. These problems rarely occur during standard working hours (broadcast equipment prefers to fail on weekends, nights, and holidays). The simple act of having management present during a weekend repair session—or even during those Sunday night preventive maintenance drills—could go far in convincing engineering that management gets it.

Broadcasting rarely has genuine emergencies in the areas of sales or accounting.

Seek out positive interaction. Look for multiple opportunities for management to talk with engineering staff when technical support is not being requested. This means taking time to engage engineers in discussions about general subjects. Topics can range from simple small talk to in-depth discussions of management's strategic vision for the station.

Task management

At some stations, the only contact some engineers receive from other staff members is a request—or a demand—to fix something. Often, that "fix it" request does not even require engineering skill. Amazingly, many engineers get routine requests to repair refrigerators, desk drawers, toilets, and slow-draining sinks. Some engineers are even called upon to render routine janitorial service.

No job should be too menial for any member of a successful broadcast team. Most engineers are more than willing to go the extra mile to do whatever needs to be done at a station. Nevertheless, management will find engineering a reliable ally in getting the job done only if the engineers believe that they are respected professionals on the broadcast team.

Jim Paluzzi is general manager of KBSU in Boise, ID, and professor of broadcast technology at Boise State University.

Impedance matching

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

We have all been taught that the load impedance must match the generator impedance in the case of non-DC voltages in order to obtain the most efficient transfer of power.

In DC work it seems that loads with an improper resistance fail to work because the supply voltage is too low, or else burn out because their resistance is too low for the applied voltage, and simple Ohm's law applies.

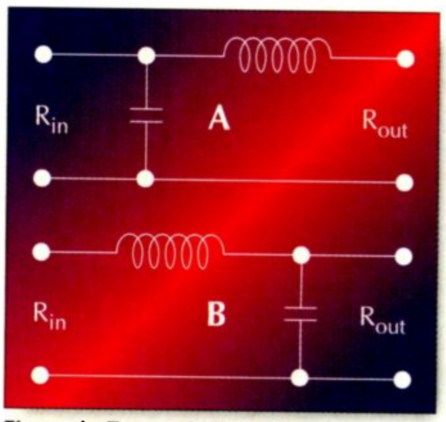


Figure 1. Two variations of an L network. Version A has a higher input impedance than the output. Version B has a higher output impedance than the input.

In RF work, the impedance of the load must match the generator impedance, otherwise standing waves develop, which can waste power, cause transmission line burnout, damage the generator, result in spurious radiation, damage matching components and ruin audio quality.

The problem is caused by the imaginary term in the expression for impedance:

$$Z = \sqrt{R^2+(X_l - X_c)^2}$$

Where Z = impedance
X_l =inductive reactance
X_c =capacitative reactance

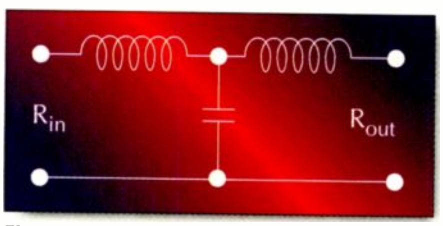


Figure 2. The T network provides a larger transformation ratio than an L network.

Fortunately, AM and FM transmission systems have standardized on transmission line impedances of 50Ω, and it is only rarely that we encounter transmission line of a different value, regardless of whether the line is 1/4 inch or 8 inches in diameter.

It has been found that 50Ω provides a convenient impedance to keep line voltages and currents within reasonable limits. Higher line impedance results in higher operating voltage and lower line current, and lower impedance results in the opposite effect.

Load matching

Engineers sometimes lose sight of the fact that the networks we use to feed antennas are really transformers, although they do not have separate primary and secondary windings. Nevertheless, there are four terminal transmission networks even though one input and output terminal is grounded. We are transforming the impedance of the antenna to match that of the transmitter output circuit.

A network is tuned to a specific frequency and requires readjustment if the operating frequency is changed. It also has a distinct advantage in that it provides a simple transformation from a complex impedance to a purely resistive load. Although a transformer can work over a wider bandwidth in audio, it is very difficult to operate over a wide RF bandwidth.

When properly tuned, the network will present a load of 50Ω resistance with zero reactance, i.e. Z=50±j0, to the transmitter.

The simplest form of network is the L network shown in Figure 1. Notice the different signal flows.

These networks will work in either direction and transform inversely, provided the frequency is kept the same.

It is important to note several points. In both figures the output voltage will lag. The amount of phase shift is determined by the angle of impedance produced by the combination of load and reactance element closest to the output terminal. The transformation ratio is determined by the same components. This leads us to the conclusion that the phase shift and transformation ratio are not independent of each other.

This feature makes L networks suitable only for simple antenna matching requirements. Therefore, we have to look to the TEE network to provide independent phase and ratio values.

The TEE network in Figure 2, found in most phasors, is a useful and interesting network. Some foreign broadcast systems take advantage of transmission line length to obtain the desired phase shift, which is not allowed by the FCC. Such methods do not provide any control of phase shift, although they do work after a fashion.

In the case of a simple non-DA radiator, we are not usually concerned with the amount of phase shift in the network, so an L generally suffices. For a DA where all elements in the feeder system contribute to the achievement of the desired phase shifts, it is essential to use a TEE network.

Engineers need to be able to specify phase shift independently of the transformation ratio. This cannot be done in an L network. Theoretically, a TEE network can have any ratio from zero to infinity and a phase shift from zero to ±180 degrees. However, operational considerations limit this range. The TEE is noted for its easily obtained 90° phase shift and reasonable range.

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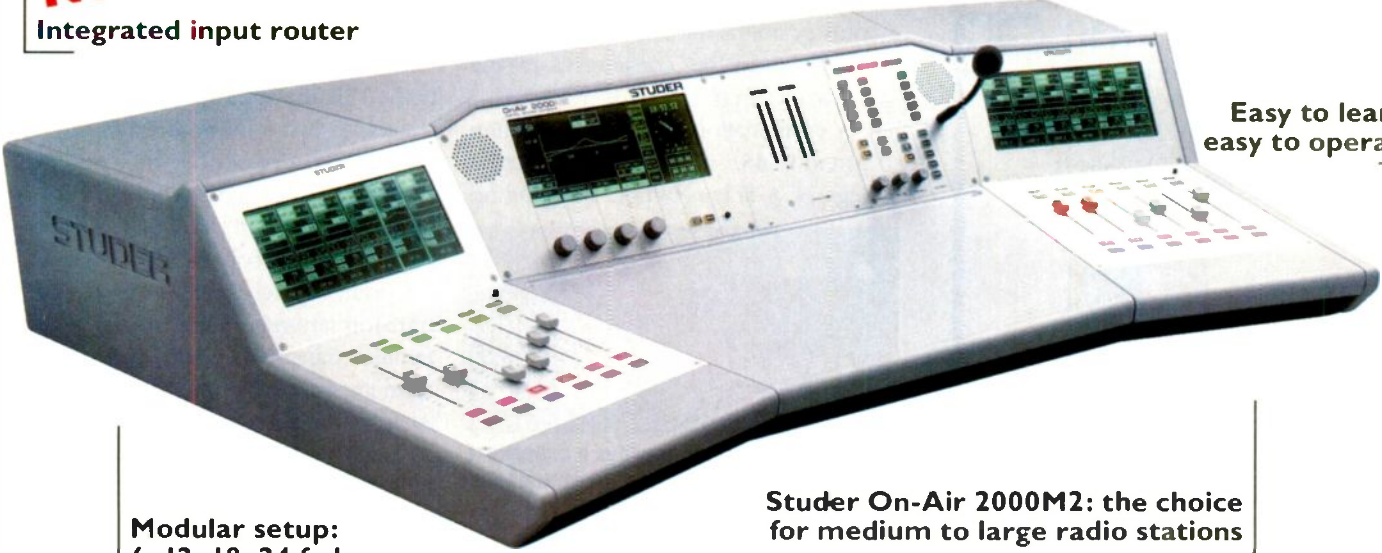

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The TEE may be considered as two L networks connected together with a common shunt leg, which has a higher impedance than either end. The overall phase shift is the total of the phase shifts of the two L networks. It also has good harmonic rejection.

When building an ATU, the total output leg reactance is that of the leg plus or minus the antenna reactance, which must be considered in the network circuit.

A combination of L and C is often found in the shunt, input and output legs of a TEE network. This has no

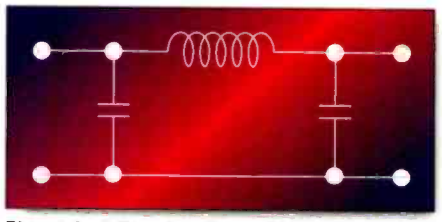

Figure 3. A Pi network provides independent variation of phase shift and transformation ratio through the circuit.

circuit significance, but it is an easy way to obtain a desired capacitative (negative) reactance that has a nonstandard value.

Coil taps are adjusted until the desired negative reactance is obtained. This is not the ideal method of obtaining the required reactance—it can effect signal quality. The preferred way is to use a variable vacuum capacitor.

In this discussion we have considered all components to be lumped, that is, as discrete units. Coils have capacitance that varies from turn to turn. Often this will antiresonate the coil at some odd frequency. Capacitors also have inductance associated with their leads, which can produce series resonance at some frequencies and cause capacitors to act like inductors at odd frequencies.

It used to be easy to obtain vacuum capacitors on the surplus market, but the supply seems to have dried up in recent years. However, in critical cases the extra expense is worthwhile.

The PI network is a natural follow on to the TEE and is shown in Figure 3. It resembles two L networks connected with a series reactor in lieu of a central shunt leg. The PI network is more commonly used in transmitter output circuits and is not often found in ATUs.

A point of interest while discussing transformation devices is that the familiar transmission line can transform impedances in a limited fashion. At low frequencies this effect is not normally perceived, but as frequency increases so that the line length is an appreciable part of a wavelength or more, we find that impedance transformation occurs in the same way a TEE or similar network would work.

The line becomes a distributed, instead of a lumped, constant network. The voltage at the receiving end can be higher or lower than the sending end; this is not caused by I^2R losses. Calculations of this nature call for calculus and differential equations, so we'll leave the subject purely as matter of interest because it currently has no general application in AM work.

E-mail John at batcom@bright.net.

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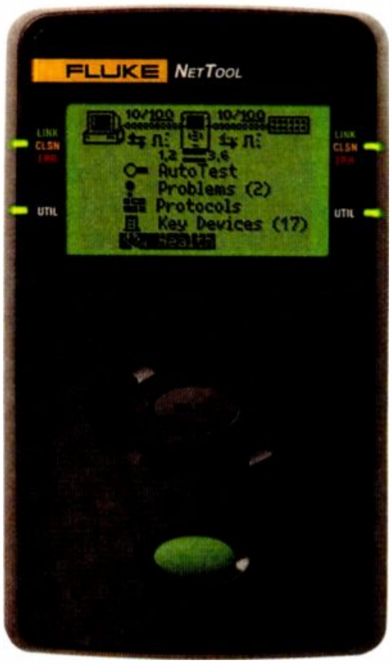
Network diagnostic tools

By Kevin McNamara, CNE

Remember when creating a PC-based network was relatively simple (except for spending countless hours fighting with the operating system software)? Thankfully, most of those problems have been eliminated. Of course, we're not just transferring files or sharing printers anymore. Network servers handle application and resource sharing, manage connections to the Internet and/or company network, control e-mail, provide security and handle audio/video information.



Handheld diagnostic tools are useful in quickly finding network problems.

Proper installation and setup of the physical layer portions of a LAN, including cabling, cable terminations, NICs and hubs, are critical to maintaining proper performance. With throughput speeds for Ethernet networks moving into the gigabit-per-second region, these issues take on new meaning. Hardware devices are also more sophisticated. The basic network hub doesn't cut it anymore for the new high-performance flavors of Ethernet. Network switches functionally replace the hub, but provide a high level of intelligence for the efficient switching of high-speed data—think hub on steroids. Network routers are essential devices for any LAN that is connected to another network. LANs connected to the Internet, or perhaps a private company network, require a router. Routers are intelligent devices that can perform wide range data routing based on a set of defined rules. By definition, properly configured routers will deliver an effective level of security.

The point here is that not only do we need to make sure that the path on which the data travels works properly, but also that it travels through the various hardware devices in the most efficient manner. When everything seems to be working OK, we probably don't pay a lot of attention to data throughput issues; however, when the network mysteriously slows down, acts intermittently or passes too many errors, the formidable task of determining the problem begins. The problem may lie in software or hardware, cabling, improper configuration or device failure. These and other questions will arise. Fortunately, network diagnostic tools are available that will help identify even the least apparent problem.

Cable tester

No toolbox should be without some type of cable tester. Most networks rely on *unshielded twisted pair* cable (UTP) as a means to interconnect devices. The UTP cable comprises four individual twisted pairs of wire within a common outer sheath. Since the UTP cable uses copper conductors, it is subject to the usual electrical characteristics, notably signal (attenuation) and frequency losses that vary directly with its length. The current generation Ethernet networks operate in *full-duplex*, which means that transmitted and received data is carried simultaneously. Two of the four pairs within the UTP cable are used to transmit and receive. The problem with this arrangement is that the signal levels for transmitted and received data at any given termination point may have extremely different levels. This imbalance could create a problem known as *near-end cross talk* or NEXT.

To fully understand NEXT and its potential effects, consider that network devices are designed to send signals over fairly long lengths of UTP. The network device transmits a signal at a level that is high enough to overcome the predicted attenuation of the UTP cable. In contrast, the receiver in the network device is designed to be sensitive enough to hear and properly decode most levels of signals. NEXT is created when the transmitted electrical signal (current) on one pair of wires forms a magnetic field, which couples to the pair carrying the received signal. This problem generally occurs at the UTP cable end because this is where the transmitted signal is highest relative to that measured on the received pair, and because the cable pairs may be untwisted in order to facilitate attachment to the RJ-45 connector, promoting more efficient coupling.

The interference created as a result of NEXT can have severe effects on the performance of the network. For higher performances, Category 5e (CAT5e) cabling or higher variations of the NEXT measurement are specified. These measurements include *equal-level far-end crosstalk* (ELFEXT), *power sum near-level crosstalk* (PSNEXT) and *power sum equal-level crosstalk* (PSELFEXT), which are derived from calculations, not a specific measurement.

The Electronics Industry of America and the Telecommunications Industry Association (EIA/TIA) are charged with and have produced detailed specifications related to the manufacture, installation and certification of network

Multifunction testers can diagnose a variety of network problems.

cabling systems. These specifications, also known as TSB-67, provide a baseline from which the performance of installed network cabling can be measured.

Cable testers range from basic units that do little more than check the electrical integrity of the UTP and its connections, to sophisticated analyzers, which provide measurements such as attenuation, cable length, and NEXT. The current generation of high-end testers can perform virtually every test and performance measurement specified within the most recent version of TSB-67 with a single command. It is recommended that detailed measurements be performed on every UTP cable in a facility, particularly upon installation, for many reasons.

1) Proper installation can be verified and/or corrected prior to operation.

2) Initial performance measurements for each segment of UTP cable can be retained and used as a basis to compare with future measurements.

3) Will aid in determining the adequacy of existing cable for use with emerging networking technologies.

If you outsource the installation of cabling, be sure to require certification (hard copy and/or exportable data format) that each segment of cabling meets or exceeds current EIA/TIA specifications.

Thus far, the discussion has been limited to UTP cables; testers are also available for coaxial and optical fiber cables. Many of the high-end test systems discussed can perform specified tests unique to these cable types either as a standard feature or using optional hardware and software.

Network Analyzers

A network analyzer is a useful, albeit expensive, tool for documenting and troubleshooting LANs and WANs. These tools allow a network engineer to perform the cable testing functions previously discussed and to monitor and quantify the packets of data traffic moving across the network. These testers provide a comprehensive suite of tools that give several views of a network, including discovery of network devices attached to the network; detailed information about those devices including network addresses, names, type of device and protocols used; logical mapping of all devices and connections within a LAN or WAN; detailed IP information; network usage statistics; data performance measurements; and network error information.

Kevin McNamara, BE Radio's consultant on computer technology, is president of Applied Wireless Inc., New Market, MD.

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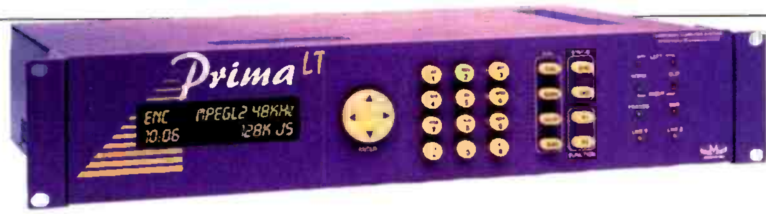

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Webcasters must pay royalties

By Harry Martin

In another victory for the record companies, the United States District Court in Philadelphia has affirmed the Copyright Office's December 2000 ruling holding that AM/FM broadcasters simultaneously streaming their signals on the Internet are responsible for royalty payments to ACSAP, BMI, and SESAC, and to record companies.

Last December, the Copyright Office issued a final rule stating that AM/FM broadcast signals transmitted simultaneously over the Internet are not exempt from paying royalties to record companies for their limited public performance rights in sound recordings. In response to this final rule, the National Association of Broadcasters and several large broadcast groups filed suit against the Registrar of Copyrights to overturn the Copyright Office's final rule.

In March 2000 the Copyright Office initiated a rulemaking and sought comments on whether a broadcaster's transmission of its AM or FM radio station over the Internet is exempt from copyright liability under the Copyright Act, and whether such transmissions should either qualify for the compulsory license or be authorized by the individual copyright owners. The record companies and the broadcasters looked to the Digital Performance Right in Sound Recording Act of 1995 (DPRA) and the Digital Millennium Copyright Act of 1998 (DMCA) for guidance.

The DPRA created an exclusive, but limited, right for copyright owners of sound recordings to perform their works publicly by means of digital audio transmissions. Among the limitations on such performances was the creation of a compulsory license for nonexempt, noninteractive, digital subscription transmissions and an exemption for certain nonsubscription transmissions, the scope of which has been the subject of dispute between broadcasters and copyright owners since the DPRA's inception.

With the passage of the DMCA, Congress amended the Copyright Act to clarify that the digital sound recording performance right applies to certain nonsubscription digital audio transmissions over the Internet, such as Internet-only webcasting. Specifically, the DMCA created a statutory license for nonexempt eligible nonsubscription transmissions (e.g., webcasting) and nonexempt transmissions by preexisting satellite digital audio radio services to perform the sound recordings publicly in accordance with the terms and conditions set forth in the new statutory license. The parties disagreed, however, over whether a broadcast transmission, which is defined as a transmission made by a terrestrial broadcast station licensed by the FCC, is a non-subscription transmission within the scope of exemptions provided in the Copyright Act.

The District Court in Philadelphia sided with the Copyright Office in its interpretations of the Copyright Act. Thus, any entity that transmits an AM/FM radio signal via the Internet is subject to the terms of the statutory license in the Copyright Act is law, and AM/FM broadcasters must comply with it or face sanctions.

The Copyright Arbitration Royalty Panel (CARP) is in the process of establishing rates and terms for statutory licenses to webcast public performances of sound recordings. The CARP rates are not expected to be established until the end of the year at the earliest *and will be retroactive.*

FM Auctions Cancelled

The FCC has indefinitely cancelled its December 5, 2001 FM auction. The agency was scheduled to accept short-form auction applications (Form 175) for 352 vacant FM allotments between September 24 and October 5 and proceed to auction them beginning December 5.

The delay is a result of a decision by the U.S. Court of Appeals for the D.C. Circuit, which held that auctions would not be permitted for any applicant group that includes one or more noncommercial (NCE) applicants. It was expected that many of the available frequencies would attract NCE applicants because such applicants would have a better opportunity under any selection criteria other than auctions.

It is likely the FCC will seek help from Congress to resolve the question of how to select among NCE and commercial applicants. A good argument could be made that the law should be changed to provide that NCE applicants be required to participate in auctions when they apply for commercial channels.

If Congress does not act, the FCC will be left with little choice but to come up with a point system to decide among mutually exclusive applicants. Such a point system, which favors locally-based groups and those with the fewest existing broadcast interests, is already in place for NCE-only application contests.

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 or before December 3, 2001: Alabama, Colorado, Connecticut, Georgia, Maine, Massachusetts, Minnesota, Montana, New Hampshire, North Dakota, Rhode Island, South Dakota and Vermont.

IBOC A Look From Every Angle

By Doug Irwin

As DAB development continues, stations need to look ahead and prepare for the coming changes.

It's a cool Monday morning; the first in October, in fact. After opening your office, and after downing the requisite two cups of coffee, you turn on your computer and open them: The dreaded capital budget spreadsheets.

But there is more to the story this year than you realize. Your office phone rings. It's the boss. "Chief", he says, "I know the capital budget is due this Friday, so it's important that I tell you now. I've decided that we'll start broadcasting IBOC at the end of next year, on the FM and the AM. I've been following the trades, and it's just something I want to do this time. So make sure you figure out just how to do it and just how much its going to cost us." Click. You didn't even have a chance to get a word in. In fact, you sit there, stunned and slack-jawed.

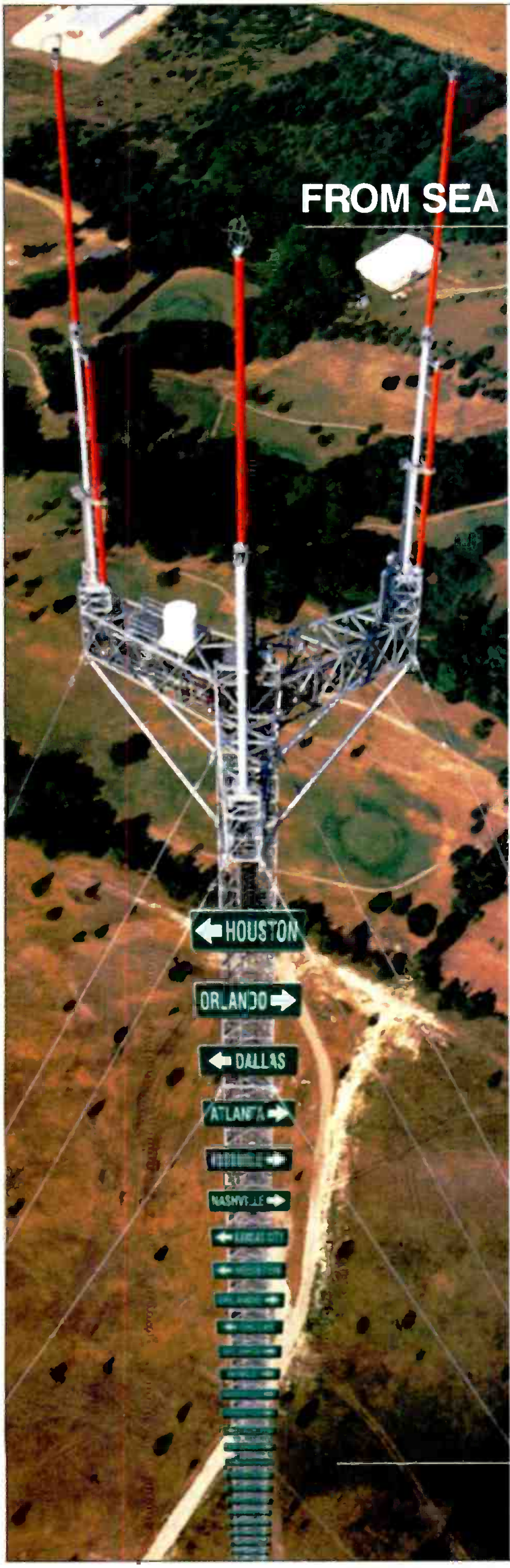
After a few minutes, and a quick mental review of what you've learned in the trades and at the NAB convention, a plan starts to settle in your mind. According to what you have read in the press, the gear will be available next year. For purposes of planning this far ahead, it's possible to ignore regulatory difficulties; in fact, in order to carry out the boss' plan, you've got to assume everything is a go.

With a little help from your friends at iBiquity, you obtain a block diagram of the IBOC system for both AM and FM. (See Figure 1 for the AM and FIgures 2 and 3 for the FM.)

The FM side

Delivery: If you deliver your program audio to your transmitter site as analog discrete or analog composite, you are going to have to convert that audio to the AES/EBU format prior to hitting the input of the IBOC exciter.

Processing: Ibiquity has always assumed that a station would want to process audio for the analog transmission differently than for the digital transmission. Since the



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United We Stand

digital system does not make use of pre-emphasis, there is no need for HF limiting, as there is on the analog path. However, since the point of this article is budgeting, it does seem reasonable to point out that the same processing device could be used to feed the IBOC exciter as well as the analog exciter. One caveat: it is likely that the engineer will be able to get away with far more processing on the analog path than on the digital. PAC is not friendly to high amounts of equalization to the program audio. There is also some question as to the character of clipped audio after it passes out of the PAC decoder. Although one could use the same processor for both the analog and digital, compromises will need to be made between adjusting a single processor for best analog sound or for best digital sound.

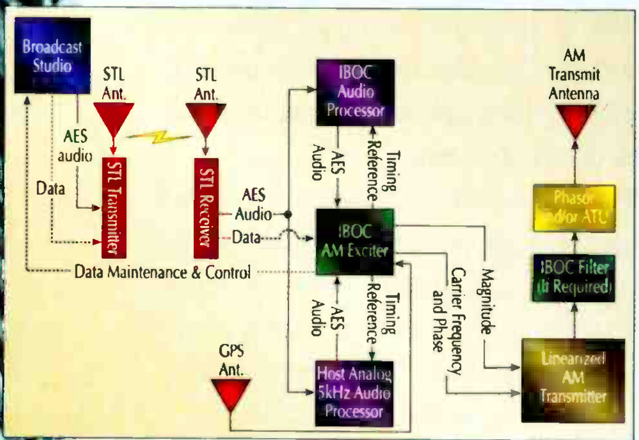

Figure 1. An IBOC transmission system will contain several new elements. Shown here is an AM tranmission chain.

RF stages: All of the major transmitter manufacturers will have linear amplifiers designed to work with the IBOC signals by NAB next spring. In the not-too-distant future, the same manufacturers will market transmitters that combine the low level IBOC carriers with the analog FM carrier, followed by high-power, linear amps that will amplify the IBOC carriers and the FM carrier alike. This *common-amplification* approach is a bit too far ahead for year 2002 budgeting.

At this point you have two options. The first is the high-level combiner that has been shown at the last two springtime NAB conventions. This combiner has four ports: one input for the analog transmitter and one output that feeds the antenna; one that accepts the high-level IBOC carriers, and finally one for a dummy load. The obvious advantage of this approach is that you use the same antenna for radiation of the IBOC carriers as you do for your analog FM carrier. There are several things to consider, though. The high-level combiner has about a .46dB insertion loss for the analog carrier throughput. You'll need about an additional 10% RF output from your analog transmitter. Don't neglect to consider the additional power needed by your transmitter, along with a larger heat

load. The second input of the combiner accepts the IBOC carrier RF signals, but only couples 10% of their energy to the output port connected to the antenna. The rest is dumped into the dummy load.

What does this mean in terms of the size of the IBOC amplifiers? Well, let's take, for example, an FM with an ERP of 100kW, and an antenna input power of 33.3kW. Since the average power of the IBOC carriers will be 20dB below the analog carrier power, in this example the antenna input power for the IBOC carriers is about 333W. Neglecting all transmission lines losses for simplicity's sake, we need the IBOC carrier level going in to the combiner to be 3,330W. It is important to note that the linear amplifiers for the IBOC carriers will need to be able to handle at least 5.5dB above the average power level (albeit on a short duty cycle). So, neglecting transmission line losses, you need to purchase and install an amplifier big enough to put out 11,815W, just so that you can get 333W at the antenna input. Keep in mind the need for extra power from the AC mains, along with the extra heat load. In this example, you would probably need at least one full rack to house the amplifier for the IBOC carriers, and you'll need space for the high-level combiner itself.

The second method would be to use a separate antenna solely for the purpose of transmitting the IBOC signals. This antenna should be optimized to closely match the main antenna pattern. Using a similar antenna design and paying attention to maintaining the same relationships to tower structural members can produce patterns within a few decibels of each other. Taking the same 100kW example as above, and using another antenna with the same amount of gain, (neglecting transmission line losses again) 333W would be required at the input of the antenna, and an amplifier that could put out 5.5dB over 333W, or about 1,181W. An amp this size will fit in a rack comfortably. No need to buy or install the high level combiner.

Of course, the right choice will depend upon the circumstances. You could use the same antenna, and sink money in to a larger amplifier and combiner, and face larger electricity bills (and maybe even site rental), or you could buy smaller gear and install another antenna and transmission line. Obviously you'll need to consider the cost of that on a monthly basis as well.

The AM side

Delivery and Processing: The requirements for AM IBOC are similar to that of the FM system. The audio that arrives at the transmitter site will need to be digitized into the AES format. The audio bandwidth of the analog portion of the transmission will be limited to 5kHz. Since this is not a requirement for the digital portion, it is desirable to use separate audio processing for the separate AM and digital portions of the transmission.

Transmission: Several transmitter manufacturers have already shown products at the NAB convention that can pass the IBOC carriers along with

the normal AM carrier. Unless your transmitter is less than five years old, it is highly unlikely that it will pass the IBOC carriers, so if the boss is really serious (indeed this is the way to find out for sure) than make sure to budget for a new transmitter for the AM side.

Don't neglect the antenna itself; the characteristics of the system, as seen by the transmitter, will need to be symmetrical ±5kHz from center frequency. The frequency response of the antenna system will need to be symmetrical over the same bandwidth. If you had previously optimized your antenna system for stereo, then it will be optimized for IBOC as well.

Doug Irwin is director of engineering for Clear Channel San Francisco.

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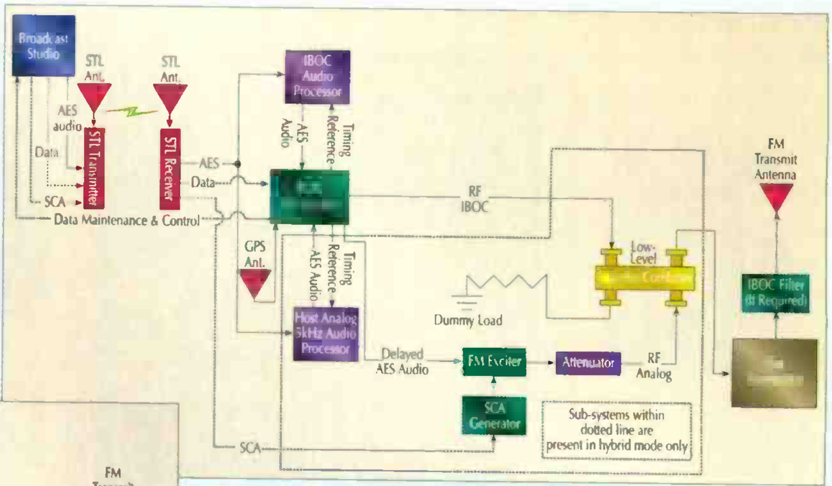


Figure 3. Newer transmitters, possibly with minor modifications, may be capable of passing the IBOC signal. In this case, a low-level combiner can be used.

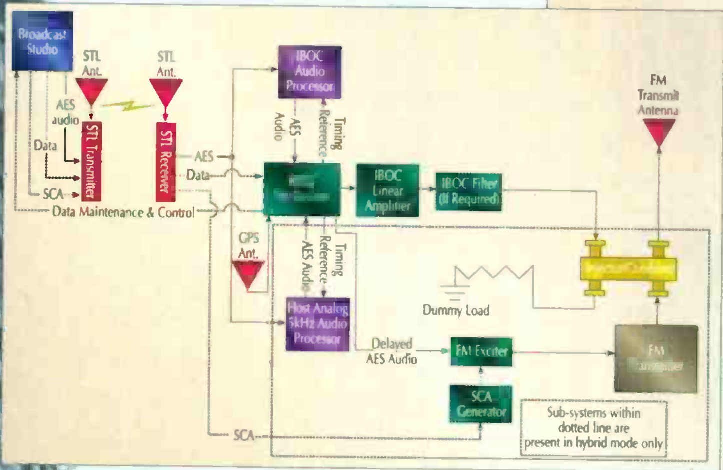
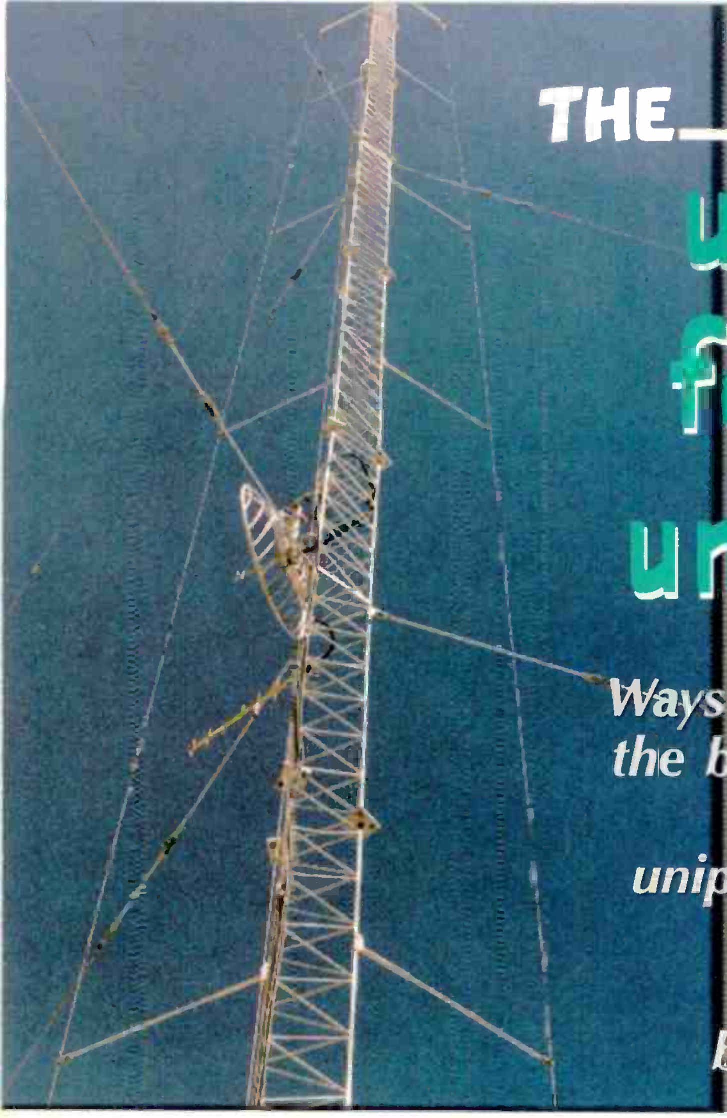


Figure 2. If an analog FM transmitter is incapable of passing the IBOC signal, a high-level combiner system must be used.



THE useful folded unipole

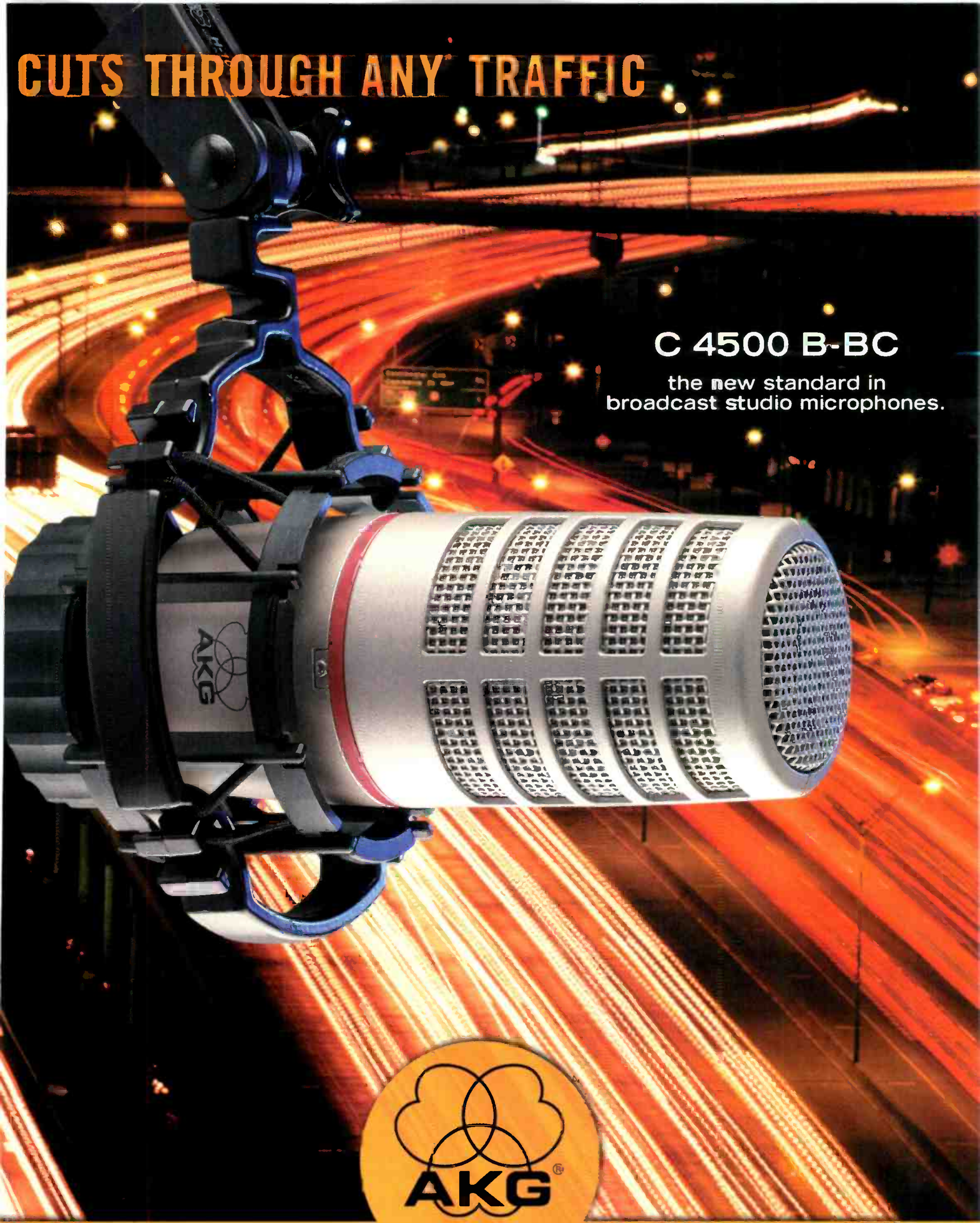
Ways to optimize the bandwidth of the folded-unipole antenna for stereo and digital broadcasting

By Ron Nott

One of the advantages claimed for the folded unipole is its broad bandwidth. However, years of experience have shown that this can vary greatly depending on several factors, mainly overall tower height.

Fifteen years ago, a station installed a unipole with bandwidth that was almost unbelievably broad. The engineer told me that he fudged the impedance measurements slightly because they were so good that he was concerned that the FCC might question them. It was then realized that the bandwidth of the unipole could be extremely good under certain conditions and poor under others. Determining these conditions can be elusive.

The late John H. Mullaney was the pioneer of this antenna, and he had Dr. Jerry Raines write a computer program specifically for its design. While this program is now old in terms of computer technology, it is still valuable and reveals how an antenna may be designed to optimize the bandwidth.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folded unipole

One advantage of the folded unipole is that is can provide a higher value of resistance than a conventional series-fed antenna when the antenna must be electrically short, i.e., less than one-quarter wavelength (90°) in height. For antennas around 60° in height, an adequate resistance can be obtained with a unipole, but the bandwidth is usually narrow. There are modifications that can be applied to broaden it, but it is normally not ideal.

Alternatively, when a folded unipole is installed on a tall tower that approaches one-half wavelength (180°), the bandwidth may also become a problem, and modifications must be applied to obtain reasonable values of both impedance and bandwidth.

A folded unipole antenna may be loosely described as a length of coaxial cable stood on end with the center conductor grounded and the wire skirt simulating the outer conductor. The radiation from it makes it look like a lossy length of line, but several characteristics are similar to a transmission line.

The tuning stub height is analogous to a short across a length of transmission line some distance away from the generator or drive point. Moving it up or down affects both the resistance and the reactance seen at the generator.

Normally, the stub is adjusted to present the desired value of resistance (usually 50Ω). The reactance is usually inductive, and a series capacitor may be placed in series with it to resonate the antenna.

The industry standard

The series-fed, quarter-wave antenna has become the standard of the industry because it has the minimum height at which a reasonable value of resistance with low reactance can be obtained. This means that the antenna tuning unit can consist of a simple Tee network, and the radiation efficiency will be reasonably good. There is nothing magic about a quarter-wave antenna, it merely makes for a convenient antenna treatment.. Referring to FCC Rule 73.190, fig. 8., you will not find a sudden rise in field intensity or any other advantage. Taller antennas have higher gain, but at the cost of a taller tower.

While the above discussion pertains to the conventional series-fed antenna, in general the same principles apply to the folded unipole except for the impedance values. An untuned quarter wave unipole would have high values of resistance and inductive reactance at its impedance. Fortunately, the antenna is easily stub tuned to present a better resistance value such as 50Ω, but there will normally be a value of inductive reactance that may be cancelled by a series capacitor to resonate the antenna.

Best height for broadband

Much experience has shown that while the quarter-wave folded-unipole normally has fairly good band-

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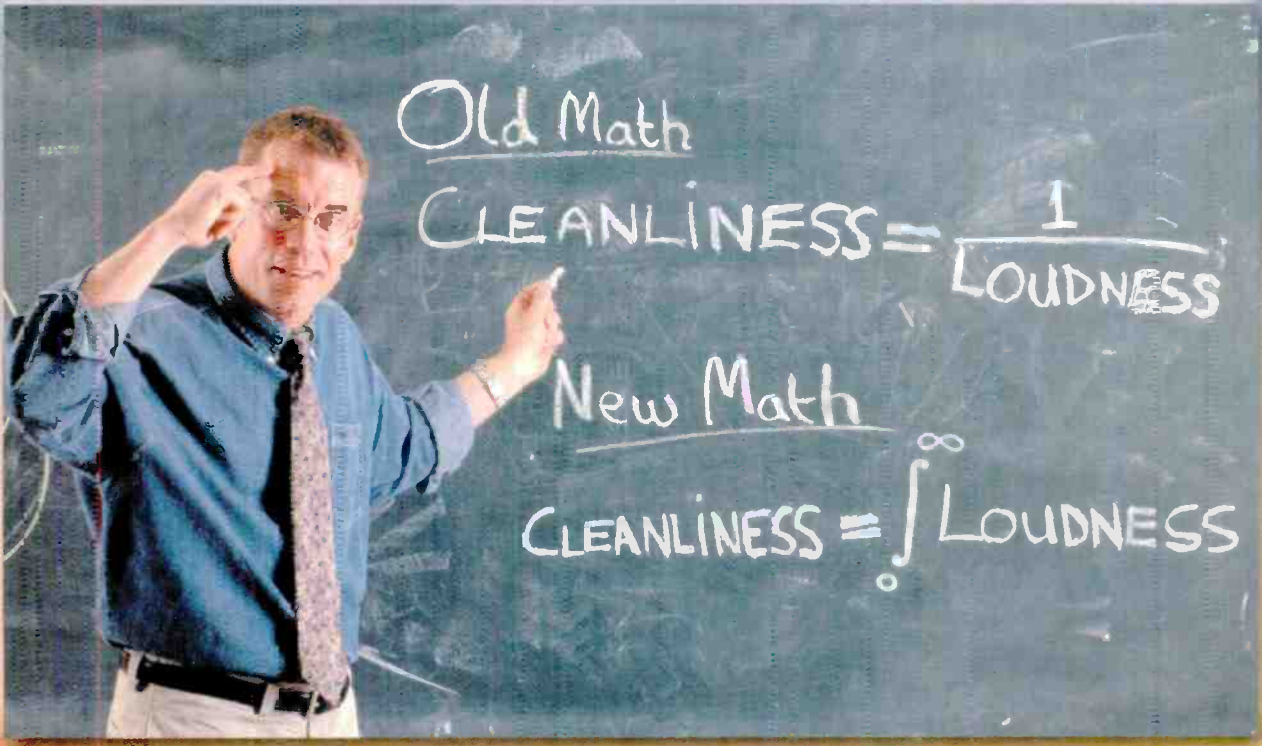

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Physical parameters of the tower and its surrounding can influence the antenna's performance.

width, it becomes extraordinary when the antenna is slightly taller. This is confirmed by the Mullaney Engineering program and several cases of actual field experience. While there are variables that must be considered, if the antenna height is between 105 and 115 electrical degrees tall, the bandwidth is extremely broad. Other factors are tower cross-section, spacing of the skirt wires from the tower, the number of skirt wires and the skirt wire diameter. Variables more difficult to deal with are found in the environment around the antenna, such as metal structures, power lines, ground characteristics, etc.

Using the Mullaney program and applying years of experience, an antenna can be designed and built with excellent bandwidth for AM stereo or digital (IBOC) transmission. In the expanded band where tower height is relatively short, adding a small amount of height can result in a real improvement in bandwidth over a quarter-wave antenna. This height increase becomes proportionally greater at lower frequencies, but in the upper portion of the AM band, it may be practical to increase tower height slightly and install a bandwidth-optimized folded-unipole antenna to realize the full advantages of stereo or digital transmission. On a taller tower, the upper portion of the tower may be detuned, leaving an optimum height antenna below it.

Impedance matching can be as simple as setting the antenna tuning stub for 50Ω resistance and then resonating the antenna with a series capacitor at its input. There was a time when it was desireable, and often necessary, to use a Tee network at the input to an antenna to attenuate harmonics, but all AM transmitters accepted since 1960 are required to have adequate spurious-emission attenuation built into the output network. It is no longer necessary to use a Tee network for harmonic attenuation. In fact, unless it has been specifically designed and tuned for broad bandwidth, a Tee network may function as a bandpass filter, which can attenuate sideband energy, defeating the broadband characteristic of a bandwidth optimized folded-unipole antenna.

The entire tower does not need to be used as the radiator, particularly if the tower is very tall.

Tall towers

In many cases, an existing or new tower for another service may be used as an AM broadcast antenna, even if it is too tall for the AM frequency, as is often the case with an FM tower. In this case, the upper portion of the tower below the FM antenna may be detuned to produce the optimum height for the AM antenna. This allows the AM antenna to be bandwidth-optimized, while the detuning skirt makes the tower above it effectively disappear.

This method allows consolidation of the AM and the FM transmitter sites using a grounded tower, which eliminates the need for isocouplers. Bear in mind that if an existing tower is to be considered for AM service, the guy wires must be segmented with insulators, as is the case for any guyed tower used for AM. Unfortunately, this may cost more than the folded unipole antenna and detuning skirt.

While the advantages of a folded unipole antenna are well known, optimizing one for bandwidth is frosting on the cake. If your station is considering either stereo or IBOC digital broadcasting, you should take a hard look at the bandwidth optimized folded unipole antenna. The system bandwidth of an AM transmission system includes the transmitter, the transmission line, matching network and antenna. The transmission line becomes important if any sideband energy is reflected from the antenna and/or tuning unit. A Smith chart shows what happens to this energy if you don't have an adequately broad bandwidth for the transmitter load. It can have a negative effect on your signal.

The RF system must be considered as a whole, and if any part of it has limited bandwidth, the quality of your transmission may suffer. Stereo and digital AM broadcasting require greater bandwidth than mono AM. Even if your system seems to be good now, it may not perform well with more complex methods of modulation in the future. If you want perfection for your transmission, consider the bandwidth optimized folded unipole antenna.

AM does not have to take a back seat to FM in quality of sound. All it needs is good bandwidth from the audio sources to the antenna.

Ron Nott is president of Nott Ltd., Farmington, NM.

The Mullaney Unipole program, copyrighted by Mullaney Engineering Inc., is available through the company by calling 301-921-0115.

Thom Mohrman, Broadcast Engineer and Jake Glanz, Manager of Broadcast Maintenance for Sirius Satellite Radio

Paradigm digital console in Sirius Satellite Production Room

Klotz Helps Sirius Fly

Sirius Satellite Radio began its flight into the world of new technology eleven years ago, pioneering the concept of digital satellite radio. Located in the McGraw-Hill building in midtown Manhattan, the Sirius national broadcast studios will begin transmission of Sirius' audio entertainment service to vehicles later this year.

A unique tri-satellite system will broadcast up to 100 channels of digital-quality radio to listeners, including 50 channels of 100% commercial free music and up to 50 channels of news, talk, sports and entertainment programming. This wide range of programming will be delivered to specially designed satellite band receivers to be offered in vehicles by Ford, DaimlerChrysler and BMW, as well receivers to be sold at retailers nationwide. Sirius will broadcast throughout the continental United States for a monthly subscription fee, allowing listeners to enjoy uninterrupted programming as they travel across the nation.

Currently housing 76 studios and four live performance studios, the Sirius broadcast center completed its initial build out in the fall of 2000, further expanding its fully digital facility with eleven additional production and on-air rooms. Sirius engineers commenced building four talk-interview studios alongside seven production-only control rooms, envisioning self-sufficient production and air rooms all with a specific focus and zero limitations. Then came the seemingly routine task of equipping the rooms with consoles. Seemingly routine.

The four talk-interview studios posed a unique challenge; each had to operate as a multi-function room within a limited amount of space. Jake Glanz, Sirius Manager of Broadcast Maintenance, and Thom Mohrman, Broadcast Engineer, spent months trying to find a console that could not only provide the flexibility and power of a major digital console but could also be retrofit into existing talk studio furniture positions. They had envisioned what Glanz calls "little fader pods."

"We found that we had actually hit a niche in the market that nobody fills," says Mohrman, "There are all these broadcast users that are out there building small rooms, all digital, and there are no small format digital consoles. We ran into the fact that there was nothing in a digital console smaller than eight faders, we were literally wondering why we couldn't buy a 12" x 8" box and have the capability of a digital broadcast console."

Klotz Digital offered the solution by providing VADIS four-fader modules CB201 in a mini console frame for each of the four talk-interview studios. These four fader units allow operators flexibility to control the parameters of live show segments through to typical voice tracking for music bed. Each studio can connect to various of the combo control rooms to create host/guest interviews, talk shows, morning shows and post production/engineering work. All fader units are connected serially to the VADIS Platform in the rackroom allowing individual users to capture audio sources required for the task at hand. "It made it very efficient for us, because we could put everything into one small frame and define its use for what we specifically need," says Glanz, "VADIS was the only thing that fit our need, it is the only thing that fit the bill."

Installation Specs

8 Paradigm Digital Radio On-Air Console
1 VADIS 880 frame
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The Vadis D C. four-fader mixer delivers considerable control in a minimal space.

The Vadis 88C frame sits at the heart of the platform and is serially connected to all the fader units, allowing individual users to capture audio sources required for the task at hand.

The remaining seven production rooms required straightforward digital on-air consoles that could act as a stand-alone unit. "The Paradigm consoles, in terms of price and performance, were exactly what we were looking for," comments Glanz, "They fit into the holes we cut for them and they work. And the voice talent seems to love them!"

The Klotz Paradigm digital on-air consoles allow Sirius operators the ease of specifically defining their individual settings and recalling user presets by the touch of a button. Mohrman explains, "There are more than 40 air talent people going through these studios every day. There's a lot to be said from the engineering point of view when you can push one button and it changes the configuration so that you are set up the way you want to be. All you have to do is put a label under each button that says 'push for interviewing' or 'push for voice tracking.'"

Though faced with a unique challenge, Sirius was able to efficiently and economically expand its facility and remain on the cutting edge of technology by installing Klotz Digital's VADIS Platform and innovative digital consoles. With broadcast technology moving rapidly forward, Sirius and Klotz Digital remain on the forefront of radio's new horizons. ■

RECORDING SOUND

Capturing the aural moment, while leaving the past behind, couldn't be easier

By Steve Fluker

If you have a storage room full of old cart machines, portable cassette decks for news, and reel-to-reel machines collecting dust, you are not alone. Seasoned broadcasters may find it difficult to let go of the past, but welcome the new choices of the digital recording machines on the market today, which have replaced their old analog counterparts. Digital technology is changing on a daily basis, bringing out new ways to record audio using better and smaller devices. Unfortunately, new recorders mean new formats and new storage media. Standardization across the business is fading. Each recording house, voice talent, home studio, and advertising agency has a favorite format to record in and assumes that the broadcaster will have a compatible machine to play it on. Production directors can find themselves scrambling for a way to play back a spot mailed to them.

When outfitting a production room, it's important to have all of the major types of audio recorders and players. Yes, you should still have an open reel machine somewhere in the facility just in case an agency sends out a spot on tape, and to play those stacks of old tapes on the shelves. You should also keep a cassette deck in the studio as well. Many times a client will still ask for a dub of their spot on cassette to review and keep. Prospective announcers may also send their air check tapes on cassette still.

Understanding digital recorders

When looking at digital recorders, there are a few key terms with which you should be familiar: *sample rate*, *bit rate*, and *data compression*. Basically, a digital recorder is taking repeated pictures or snapshots of what the audio looks like. Like a movie, if you have a large number of pictures taken in a short period of time, and then flip through them, you will see the picture move. Similarly, if you take multiple snapshots of the audio waveforms and play them back rapidly, you will be able to recreate the audio. The sample rate refers to the number of these snapshots taken of the audio every second. CDs, for example, sample at 44.1kHz, or take 44,100 pictures per second. Like a movie, the more pictures you take (the higher the sample rate), the better the quality will be.

What the recorder is measuring at each sample point is the voltage or amplitude of the audio waveform. The

resolution and sample rate refer to how accurately that measurement is taken. Just like with digital cameras, the higher the resolution or sample rate, the better the quality. Figure 1 shows an audio sample with a 32-bit resolution and a sample rate of 20 samples per second. CDs are recorded with 16 bits, which translates to a resolution of 65,536. A 24-bit rate audio expands that resolution to 16,777,216.

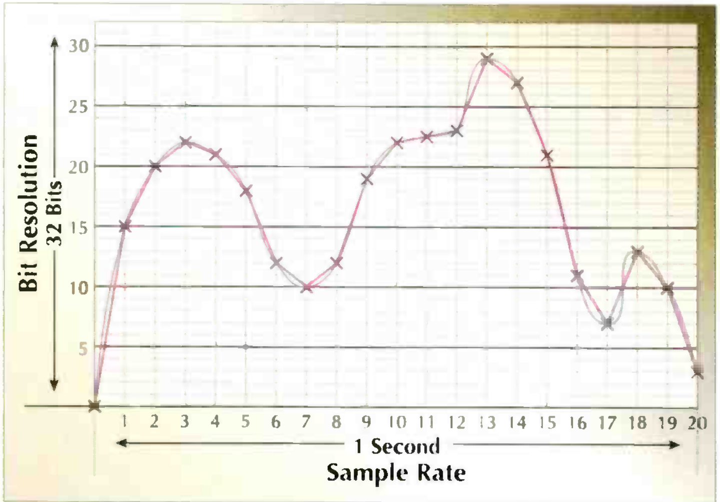


Figure 1. The blue line represents the original waveform, the Xs represent the sample points, and the green line represents the reproduction of the digitally sampled waveform. This example shows a 32-bit resolution and a sample rate of 20 samples per second.

The third important term to understand is *data compression*. Digital recorders have a limited amount of storage space. It's the same as the hard drive on your computer. The more data you put on the drive, the faster you will fill it up. Digital audio in its pure or linear form will require about 10MB of storage space for one minute of stereo CD quality audio. This adds up quickly as you continue to record. Complex algorithms were developed to analyze the audio and find pieces that can be eliminated without being noticed by the human ear. As you reduce the data more and more (increase the compression ratio), you will begin to hear some of the side effects. The trade-off is higher recording time capacity but at a lower audio quality. When the proper compromise is found, you can achieve a dramatic increase in recording time, with virtually no audible quality loss.

New standards

Digital recorders are no longer just on a wish list, they have become a necessity to keep up. In today's studios, the new recorders are now becoming the new "old standards". Introduced in 1987, Digital Audio Tape (DAT) was the first type of digital recorder to become widely

With so many legacy formats to choose from, it may be wise to maintain at least one playback machine per potential format.

used by radio stations. Mechanically, a DAT machine is like a miniature VCR, using a small cassette tape, which is pulled out of the cartridge by the machine and wrapped around a high-speed rotating head. One tape will hold up to two hours of audio. As long as the machine is kept in good operating condition, the DAT will produce excellent quality recordings. The audio is kept in its purest form by recording in a linear format, rather than using data compression with bit rates as high as 24. Typically, the user can select sample rates of either 44.1 or 48kHz for better than CD quality recordings. Most machines can automatically step down to a lower 32kHz rate when necessary to be compatible with some other digital formats. The down side of the DAT is that it is still basically a tape format with a lot of moving parts. The tape transports are mechanically complicated. Heads will still wear in time, and if they are out of alignment, tapes recorded on one machine might not play back in another. The old complaint of a machine eating a tape is still common with DAT. I suggest that you always rewind the tape before trying to eject. While the use of the DAT format is fading, it's still advisable to have the ability to play these tapes in the studio.

The next type of digital recorder replaces the tape with a disk. Some of the early replacement cart machines were called digital carts. Attempts to use standard floppy disks were close, but didn't quite make it due to the limited record time per disk. Even at a lower 32kHz sample rate, these recorders could only muster about 50 seconds of record time. To overcome this, manufacturers moved to the higher capacity magneto-optical (MO) disks. While the blanks are more expensive, they can record several hours of stereo high quality audio on each disk. Some machines will also record on Zip disks, which will provide more than 30 minutes of record time.

Another more commonly used disk recorder on the market is the mini-disk. Through the use of the data compression algorithm called ATRAC, a small disk can hold up to 74 minutes of audio. With a sample rate of 44.1kHz and bit rate of 16, it's difficult to tell the difference between a mini-disk and a CD. Mini-disks are also readily available in portable models and are great for field recording and news gathering. Small consumer recorders and blank disks can be purchased at local electronic stores for less than $200. These inexpensive recorders even have some basic editing functions on them, allowing a reporter to record, edit, and send an actuality on the fly. Keep an eye on the machine, however, as they are getting so small that it's easy to set one down and lose it.

Since the mini-disk is a popular format, it's a good idea to have them

Recorder	Media	Record Time (Stereo)	Compression	Sample	Bit Rate	Portable
DAT	Cassette Tape	2 Hours	Linear	32, 44.1, 48kHz	16 or 24	Yes
Mini-Disc	Removable Disk	74 Min	ATRAC	44.1kHz	16/18	Yes
Digital Cart	Zip Disks MO Disks	Up to 38 Min Up to 3 Hr 23 Min	Linear or AC-2	44.1 or 48kHz	16	No
CD Recorders	CD-R Disks	80 Min	Linear	44.1kHz	16	No
Memory Card Recorders	Memory Cards Vary depending on Memory	Up to 102 Min Up to 204 Min Up to 19 hours	MPEG1 Layer 2	48kHz or 24kHz	16	Yes

Figure 2. A comparison of various formats, their media type, and key operational parameters.

Removeable media recorders, such as these from Sony, Marantz and Denon, look and feel like conventional cassete decks.

available in your studio. There's a wide range of choices with rack mount models starting at just under $600, and costing as much as $4,000. You should chose a model based on your demand and needs. For the occasional use, the lower end model is all you need. For a station with high demand use in production and on-air studios, you should consider the professional high-end models. These recorders offer more features, such as the ability to remote start from a console, balanced analog and AES digital inputs and outputs, more precise cueing, more robust mechanics, hot key instant starts, and more. Just keep in mind that even the less expensive models will still give you excellent audio quality.

Most people compare the quality of a digital recording to the quality of a CD. Since CD quality is highly desired, and because CDs are used everywhere, from homes to cars to offices to the control room, easy to use recorders have been desired for some time. The biggest problem has been the "write once" limitation of the CD. A small mistake while recording meant starting over with a new blank disc. This added to the popularity of the mini-disc with its record and erase capability. With CD recorders becoming almost standard in today's PC's though, the format is now starting to take off in studios and at home. You can load your music onto the hard drive of your computer, then correct any mistakes before dubbing the final copy to the CD. Blank discs have also come down in

RECORDING SOUND

price to under a dollar each, and with their 80-minute audio capacity, they have become one of the most economical ways to archive old spots and files. While great for studio use, the CD is still not practical for field recording.

Portable recorders

Field recording has always been a challenge. Portable DAT and mini-disk machines have given us excellent quality far exceeding the older cassette machines, but both still have complex mechanical transports, which can wear out and break down from being tossed around in cars and briefcases. Nothing is more frustrating than stumbling onto the perfect interview then having the recorder not work properly.

The latest wave of portable digital recorders is now available. These recorders have no moving parts to wear out or

Handheld recorders rely on solid-state media, which is sometimes removeable.

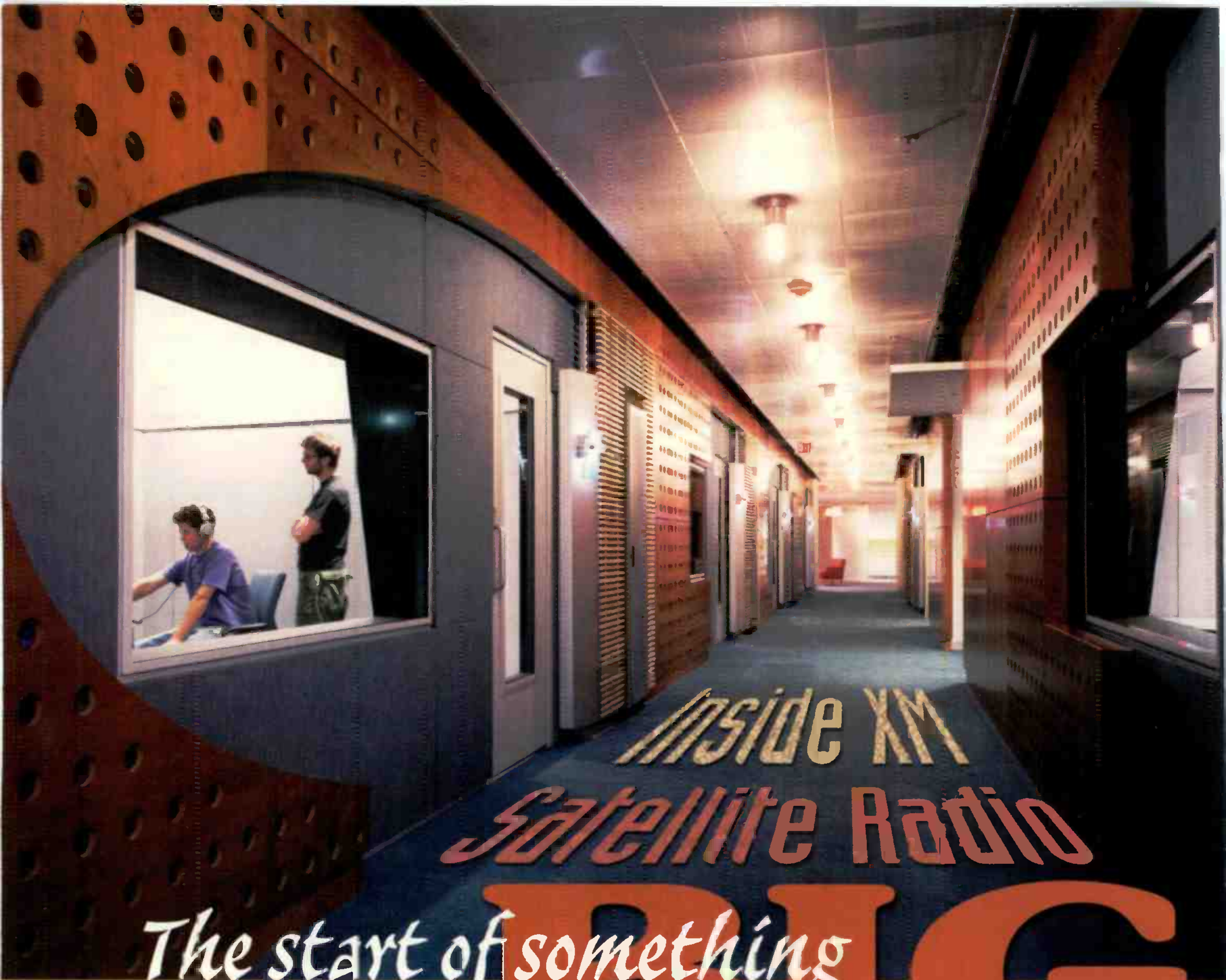
break, no tapes to eat, no disks, no heads to be jarred out of alignment, and no motors. They use the new plug-in memory cards. These are the same cards used in digital cameras and portable MP3 players. There are several different types of memory cards available, such as Flash Cards and Memory Sticks, and they are available in standard values of 64MB and 128MB, with some available up to 1.2GB on a single card. These professional recorders typically offer both linear and some form of data compression to give extended record time. An example is a model that uses the MP2 data compression method and allows various quality selections. Again, the trade-off for quality is an increased record time. On an off-the-shelf 128MB flash card, you can expect get about 1.5 hours of CD quality audio, or as much as 6 hours of record time if you reduce the quality to the "FM radio" mode.

Perhaps the best feature of these recorders takes place when you get back to the studio. You can eject the memory card out of the recorder, and plug it into a USB adapter connected to your computer. Files can then be instantly transferred to your hard drive, where they can be edited with a software package. With a CD-R drive in your computer, the final edited copy of your interview, as well as the original raw unedited audio can be burned and archived to a compact disc. If you take a laptop computer with you, your car or station van can become a complete field production facility. The only down side to these recorders is the cost, although prices are already starting to drop. If budget is a factor, the portable mini-disk recorder may be your best option for now.

These are the main types of recorders used today, although there are still others in use both in the studio and the field. Recorders, which use internal hard drives, are typically associated with digital editors and workstations. There are some portable recorders on the market that use a removable SCSII drive. This allows the reporter to record audio directly onto a drive, which can then be inserted into a studio computer for editing. Even DVD recorders are starting to appear on the scene. These are similar to CDs, but expand the recording time of the audio from 80 minutes, to about 8 hours of CD quality audio. These will undoubtedly become a popular method for backing up and archiving production work in the future.

As technology advances, it's safe to say that we will see new and better ways to record and store our audio. Data compression schemes are also improving rapidly, allowing us to store more and more audio on one disk or flash card. The improvements are exciting, but you must be prepared to stay up-to-date, and be prepared to train your staff on operating these newer machines.

Steve Fluker is the director of engineering of Cox Radio, Orlando.



The start of something BIG

by Chriss Scherer, editor

You have seen several large radio facilities in the pages of *BE Radio*, including those for Clear Channel Denver and Sirius Satellite Radio. When they were completed, those facilities were the largest radio facilities in existence in North America. As is usually the case, once a milestone is achieved, the challenge to exceed it is made. The new facilities for XM Satellite Radio are a showcase indeed, combining practical function with cutting-edge form. To top it off, this facility is now the largest radio facility in North America.

The new facility, located in the technology corridor of Washington, DC, occupies 155,000 square feet of space on two floors of its building. In all, there are 82 studios in the facility. The building has a history of delivering information to the masses. For many years, the building at 1500 Eckington Place was the home to the printing presses for *National Geographic* magazine. The heritage of delivering a leading media of its day is continued with XM.

Take the tour

The satellite service-provider's headquarters occupy two floors in the building. The third floor houses the administrative, marketing and programming departments, the satellite control team and a café. While it has become common in consolidated radio facilities to see two or three program directors, it's a very different sight to see scores of program and


The stylish, quiet and efficient studios are a benchmark of radio high-tech.

music directors. Programming 100 channels requires the necessary talent to make all the programming decisions.

The second floor has 60,000 square feet of space dedicated to the broadcast and satellite operations. In this space are 14 production studios, 38 on-air studios, 24 assembly booths, four voice-over booths, one performance studio (with 2,600 square feet alone), the broadcast operations center, the network operations center, the enterprise control center and the technical operations center.

The key design elements for the facility combine the functions of routing audio, data and control information all at one time. In may ways, the facility design looks more like an IT installation than a radio installation.

The heart of the system is the Klotz Vadis platform, routed through a backbone provided by fiber opitc cable and Radio Systems' StudioHub+ CAT5 wiring system. There are more than 200 Vadis frames, 1,650,000 feet of CAT5 cable and 630,000 feet of fiber optic cable in the facility. This network ties all the functions of the Klotz and Dalet systems together with all the other audio and data sources.

The Broadcast Operations System (BOS) keeps track of all audio sources and events being used. The foundation of this system, provided by Encoda, contains various software modules used for show scheduling, traffic scheduling, material management (to assign production duties and file names), and digital transmission control (to permit access to shows and set bit-rates for transmission). The BOS also supervises the Drake automation system that oversees the Dalet workstations.

From the beginning

The studios are all designed from a similar base. Each studio is actually an Acoustic Systems isolation booth. With so many studios being built, traditional

From program origination (top) in one of the 82 studios to enterprise control (bottom), audio and data are routed throughout the facility.


Enterprise control, which oversees the operation of the business enterprise, includes an operator's chair that resembles Captain Kirk's.

studio construction—building a room from the ground up—did not make sense. Despite the modular approach, the studios do not feel like modular booths. This method also provided an easier means to achieve the desired noise rejection than would have been possible by building the rooms individually.

Each room has furniture from Studio Technology, a Klotz control surface, Dalet workstation, Denon CD players, Genelec monitors, Omni-mount speaker mounts, Tascam cassette deck, Sony DAT deck, Telos phone system, ESE and Leitch clocks and Audio Technica or Rode mics. Some studios have additional equipment for specific applications, such as a 360 Systems ShortCut, ProTools DAW or Eventide broadcast delay. There are even a few Fidelipac cart machines in use.

The technical operations center houses nearly 300 racks and supports the shared and behind-the-scenes equipment, including 120 Omnia Audio Omnia3 audio processors and 22TB (terabytes)of storage space on a storage-area network. There are multiple rows of racks—one serves the needs of the office computer network. The rest are dedicated to the studio facility.

Keeping it straight

Monitoring the 100 channels is a major task. To do this, the broadcast operations center (BOC) monitors the audio and data being sent to the satellite delivery system, which is monitored by the network operations center (NOC). The entire facility is under the supervision of the enterprise control center (ECC), which is appropriately named. It is not only the final supervisor position for the technical business enterprise, it looks like the bridge of the Enterprise, complete with Captain Kirk's chair.

The supervisor in the captain's chair has intercom access to

Above: One of the news workstations. Below: There are two satellite uplink antennas on the building rooftop.

Facility Specifications

Audio files	2,000,000
Audio workstations	320
CAT5 cable	1,650,000 feet
Computer storage space	26TB (terabytes)
DAW systems	14
Digital control surfaces	288
Equipment racks	279
Fiber optic cable	630,000 feet
News preparation stations	24

every operator in the facility. The button panels on the chair's arm select the station. A gooseneck mic picks up the supervisor's commands. Above the chair is a parabolic speaker reflector, so any communications back to the supervisor are only heard by the supervisor without disturbing anyone in the BOC.

The large displays in the BOC show satellite status and audio levels at a glance. Individual control stations monitor the status of the automation systems, the audio and data control systems, and program scheduling.

In addition to the Washington facilities, XM also has studios in New York and in Nashville at the Country Music Hall of Fame. These other locations have similar designs and are fully integrated with the Capitol facility. The integration is so complete that audio files are stored in Washington and accessed remotely. The design is such that it doesn't matter that the studios are not down the hall but are instead across several state lines.

Radio history is about to witness the creation of a new chapter as the satellite radio services begin commercial delivery. XM is a part of that history, and its facilities have already made radio history because of their magnitude of scale.

Above: The technical operations center is a stockpile of behind-the-scenes equipment. Below: Another look at the ECC and BOC.

Equipment List

- 360 Sytems - Instant Replay
- Acoustic Systems - Modular Studios
- Audio Technica - AT808G, AT857QMAL
- Broadcast Store - Mic arms
- Encoda/DAL - Automation system
- Dalet - Dalet 5.1 workstations, Team Newsroom
- Denon - DN-961FA
- ESE - ES-3242, ES-324B12, ES-3244S, ES-3244F2
- Eventide - BD500-100
- Fidelipac - CTR14, ES310
- Genelec - S30D, 2029B, 1091A, 1030A
- Harris - Netboss Network Management System
- Klotz - Vadis, DC-2 controllers
- Leitch - Clocks
- Northeastern Communications Concepts - Studio Planning, Acoustics, Furniture Design
- Omnia - Omnia3
- Omni-mount - Speaker mounts
- PowerGold - Music Scheduling software
- Prolite - On-Air lights
- Radio Systems - StudioHub+
- Rode - Mics
- Sony - MDR-7502, MDR-7506, MDS-E11, PCM-R500, SMS-1 F/B
- Studio Technology - Studio Furniture
- Tascam - 122 MKII
- Technics - SL120 MKII
- Telos - 2101

How It Works

RF Combiners

By Bob Surette

Transmitting several frequencies from a single broadband antenna system requires the use of a combining system, or combiner, composed of RF filters and interconnecting transmission line. Generally, a combiner can be categorized as *branched* (star point) or *balanced* (constant-impedance). These types may use *band-reject* (notch) or *band-pass* filters.

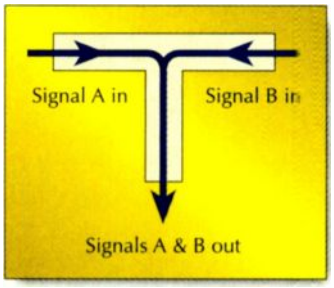


Figure 1. Tee Junction Schematic.

Components of combiners

There are several ideas to know when discussing combiners.

Tee or Star-Point Junctions. A tee junction, shown in Figure 1, is a coaxial component that provides for two RF signals to flow into a common path; a star-point junction is a tee with more than two input paths. This basic coaxial component is one of the building blocks of a branched combiner.

Filters. Filters sort RF frequencies, attenuating some while allowing others to pass readily. Depending on the design, a filter may either *attenuate* (band-reject type) or *pass* (band-pass type) a narrow bandwidth.

Frequency Response. Energy transfer through the band-pass filter is highest, or least attenuated, at the resonant frequency, and drops off at frequencies above and below that frequency. This *frequency response* is the fundamental property that enables a filter cavity to sort frequencies.

Group Delay. The signal takes a finite amount of time to pass through the cavity, and just as more energy is lost, so more time is taken at nonresonant frequencies. This is termed *group delay difference*, or group delay for short. Excessive group delay within the pass band results in signal distortion.

Branched or Star Point Combiners. A branched combiner is a simple combination of a specially tuned tee or star point junction and the required number of filters to ensure a sufficient amount of isolation. For example, an FM branched combiner containing a three-cavity bandpass filter in series (Figure 2) may be used to provide the high-quality isolation required for two frequencies more than 1.6MHz apart.

The three-cavity filter system in Figure 2 is tuned for one of the channels in a two-station branched combiner and forms one leg of the combiner. The second leg is a similar combination of filters tuned for the other frequency. Figure 3 shows the basic combiner configuration.

TX1 and TX2 are the signals from transmitters 1 and 2 as they enter the combiner. The length of the coaxial line between each set of filters and the tee junction is adjusted to provide a high impedance (approaching an open circuit) to the other frequency, so that the power flow of each signal is through its own filter, out of the tee junction, and up to the antenna.

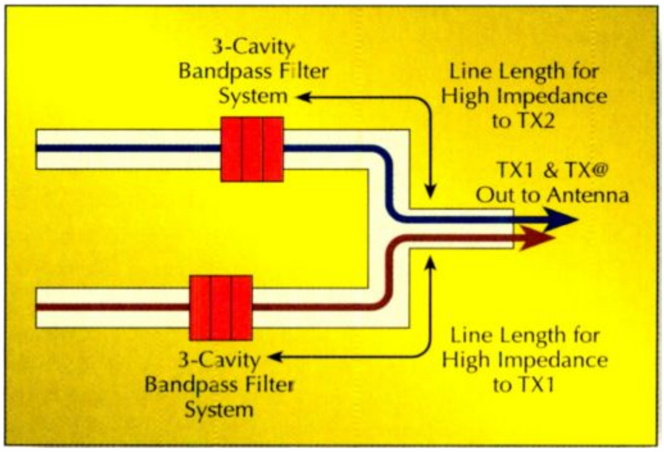


Figure 2. Branched Combiner Schematic.

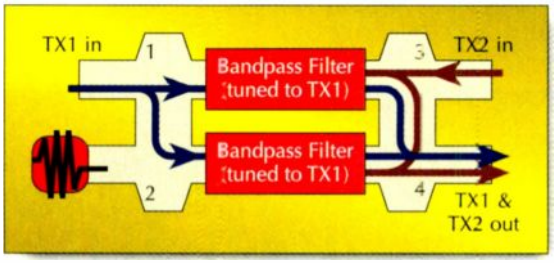


Figure 3. Band-Pass Filter Balanced Combiner.

Balanced combiners

In a band-pass balanced combiner system, band-pass filters are used within the hybrid ring. The basic system layout is similar to that of a notch combiner.

The power flow is shown in Figure 3. In the notch system, the filters reflect signal TX1 entering port 1. In the band-pass system TX1 also enters port 1, but passes through the hybrid ring's band-pass filters and out port 4, while signal TX2, entering at port 3, is reflected by the filters and exits at port 4.

Bob Surette is manager of RF engineering of Shively Labs, Bridgton, ME.

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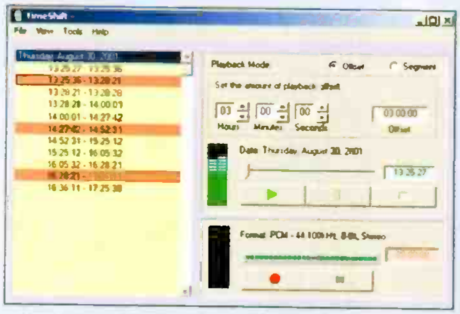
Audio time shift program
Broadcast Software International



◀ **TimeShift:** This program will continuously record an incoming signal that then can be either randomly accessed or played back with a time-offset. Broadcasters in any time zone can continuously delay satellite feeds. TimeShift can be used to effortlessly and instantly create "best of" shows. TimeShift will interface seamlessly with Simian to combine satellite programming with live broadcast or hard drive automation. The program is capable of storing a year's worth of network programming, including all cue tones, so that broadcasters can insert local spots. This will eliminate the need to "dub the network feeds" for sports, business or other features.

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Tracker: This audio logging system can record up to 8 stations while simultaneously playing back audio. RCS Tracker operates as a self-contained unit. A single off-the-shelf brand name computer stores and plays back all audio from standard multiple-channel audio cards that are supported worldwide. The user selects the audio fidelity desired, and RCS Tracker shows the user the impact of those choices on hard drive resources. The Tracker allows audio to be recorded from a telephone, radio, TV or microphone, and played back from the computer or over a network, over the telephone or over the internet. Audio stored in RCS Tracker can be retrieved and monitored at any time, from a variety of locations, without disrupting the ongoing Logging process.

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Audio switcher
Henry Engineering

▼ **MoniSwitch:** Digital audio processors often introduce time delay into a radio station's transmitted signal, which creates a distracting echo to the DJ monitoring the station using headphones. MoniSwitch is a specialized audio switcher that automatically switches the DJ's headphones from air to local when his mic is on, so that the DJ doesn't hear the delay artifacts caused by the station's digital audio processor. The bizarre echoes and flanging effects disappear, because he hears himself pre-processor when the mic is on. At all other times, the off-air signal is monitored as usual. MoniSwitch is easy to install and works with all audio sources. Individual gain adjustments allow matching the air and local audio levels.

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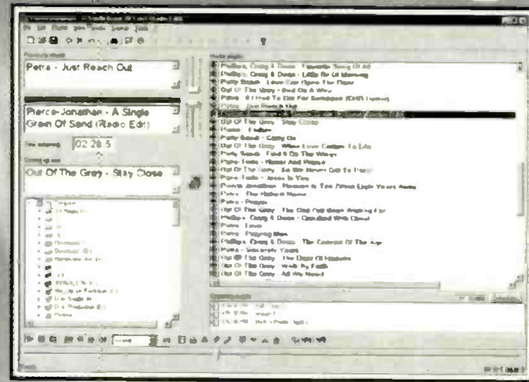

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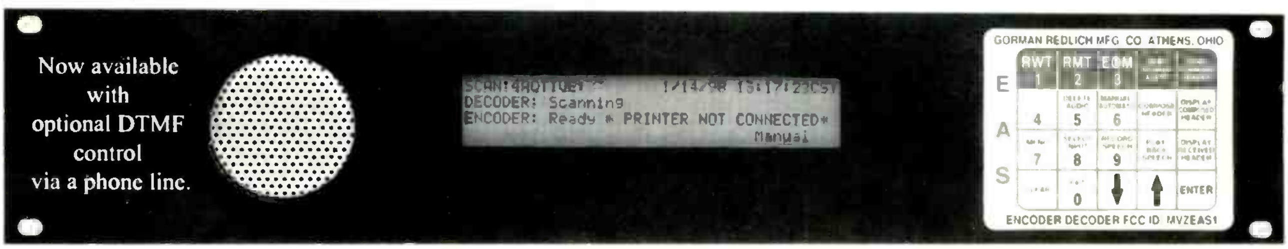

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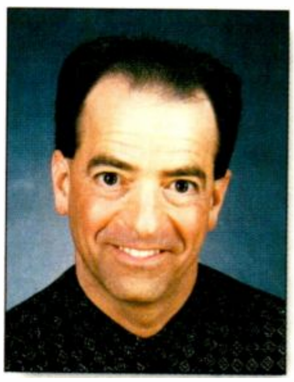
Let your light shine

By Skip Pizzi, contributing editor

The events of recent days have brought much attention to the broadcast media, as is often the case in periods of crisis. It is times like these when the true value of broadcasting shows through, and the routine, day-to-day priorities of the business fade in importance. The nation huddles to stay informed via news broadcasts, or to discuss issues on talk radio, and eventually to escape and return to normal with sports and entertainment programs.

Like most of American enterprise, our industry is at its best in a crisis, and new ideas are spawned as broadcasters struggle to find more ways to provide service. But unlike many U.S. businesses, broadcasters are not suffering downturns in usage at present, nor do they have to dramatically alter their offerings to remain viable in a changed world. Consumers simply want more of the same from broadcast services. For radio in particular, therefore, this is a timely moment to explore extension of services that might properly fulfill the current imperative.



Like most of American enterprise, our industry is at its best in a crisis, and new ideas are spawned as broadcasters struggle to find more ways to provide service.

More ways to help

Online services are the most obvious venue for these extensions today, allowing broadcasters to provide audio and non-audio (i.e., text, photos and graphics) plus two-way communication and personalization to the wired PC environment. Wireless data is waiting in the wings as the next act, providing an opportunity to feed lighter-weight versions of such enhancements to portable devices. DAB may offer similar opportunities in upcoming years, and it is likely that other technologies not yet identified will continue the trend in the long term.

Perhaps best of all, such growth comes without any corresponding losses to the medium's core service and competency: over-the-air broadcast audio. This means that development of skills, services and revenues in the new areas can occur incrementally and grow at a natural and pragmatic pace, without undue risk or speculation. It also allows broadcasters to identify the unique values of many services and maximize their respective potentials. Broadcast and online services are complementary in this respect, as recent events have underscored. For example, when many listeners want to hear the same thing, broadcasting fills the need perfectly. When the opposite is true (i.e., listeners each want something different), online service excels.

The key to cultivating new services is properly multipurposing content and extending the broadcast channel's established branding. Broadcasters have already had some experience with multipurposing in the consolidation process, where facilities, talent and, in some cases, content have been shared among colocated operations for multiple broadcast services. The difference between that process and the broadcast/online variant involves the divergent service profiles between broadcast and online media, so the content offered on each must be optimized in distinct ways. Radio professionals across the industry are learning and developing this expertise today, and audiences' current needs can help refine this process.

Optimizing design

I once attended the dedication ceremony for a newly constructed house of worship and heard an apropos story from one of the clergy who spoke at the event. He recalled a similar opening event at another new facility, which its congregants had anticipated greatly as they watched the building's construction progress over many months. They had marveled particularly at the huge and beautiful windows featured in the edifice's design, but all were shocked and dismayed when they at last entered the completed structure and saw how *small* the windows' surfaces appeared from the building's interior. "How can the windows be so big and beautiful on the outside, and yet so tiny on the inside? Why are they designed like that? They hardly let in any light at all," the congregants complained. Their prelate answered, "You misunderstand the purpose of these windows. They are not intended to let *in* light, but rather to allow the light generated within these walls to be better shed upon the community outside."

Broadcasters should design their services accordingly—and not just with a single "window" to their communities, but multiple ones. In this way they will maximize the beneficial service they provide to the public, and reap corresponding rewards.

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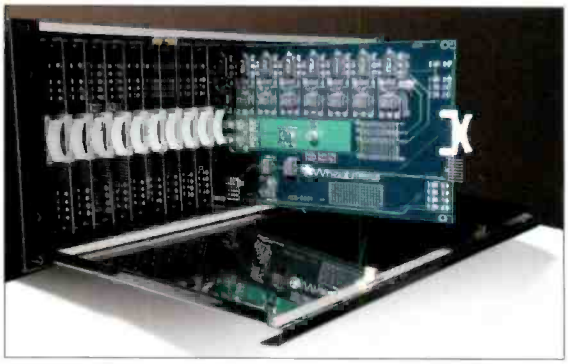

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