Evolution of the STL
Bob Band of Harris explores scenarios in the age of FM+HD Radio.
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Dust Off That Workbench
Your rusty technical skills can be a potent weapon on the job, particularly now.
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Radio World
ENGINEERING EXTRA
April 15, 2009

WHITE PAPER

New Options: Deploying IP Audio for Professional Broadcast Networks

A Discussion of the Use of Private IP Links

by Rolf Taylor

Rolf Taylor is applications/support engineer for APT North America, Boston.

By now, most readers will have heard about IP audio and many are beginning to deploy it in various ways. The majority of deployments so far have accepted compromises in order to achieve specific goals, such as better remote access (for remotes), or to achieve connections at the lowest possible cost (for backup or repeater STLs). However, when you have read about audio over IP, a frequent caveat is that circuits with proper Quality of Service (QoS) are recommended for pro-grade applications.

So, just what are these services and do they work? In this paper we will look at private IP links, Metropolitan Ethernet links and the first wide-scale North American deployment of MPLS virtual network links for IP audio distribution.

The application of these network technologies for high-quality, compromise-free distribution of audio will be explained in detail. In addition, we will contrast these technologies with the IP techniques designed to work over compromised networks and discuss the advantages and disadvantages of each approach.

WHAT IS 'IP'?

Of course, IP stands for Internet Protocol. Strictly speaking, it is a suite of protocols, such as TCP/IP (Transmission Control Protocol over IP), and UDP/IP (User Datagram Protocol over IP). A "protocol" can be described as a standard language or syntax that is used for interaction and communication between devices. Incidentally, the protocol most often used for pro audio over IP is RTP/UDP/IP (Real-time

SEE IP AUDIO, PAGE 8

SBE CERTIFICATION CORNER

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

A Power Problem

Question posed in the last issue
(Exam level: CBRE)

Your AM broadcast station is authorized 25 kW nondirectional day and 1 kW with a highly directional antenna at night. At nighttime pattern changing time, the remote control cannot effect the change or reduce power. How long do you have to correct the problem before you must cease radiating?

a. 3 days
b. 3 hours
c. 3 minutes
d. The length of time it takes to drive to the transmitter
e. As long as it takes, provided you make note of corrective action you've taken in the station log.

Turn to page 6 for the answer

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FROM THE TECH EDITOR

by Michael LeClair

Time to Build for the Future

Stations With an Eye on the Future Should Prepare To Grow When the Downturn Ends

Recent news stories about the radio industry have highlighted the difficulties we are facing due to the economic downturn in the United States. Ad revenues declined about 8 percent for the year 2008, which has put pressure on the largest radio groups, particularly those that are carrying the most debt. If stock prices are any indicator, belief in the future of many groups is at a dangerously low point: as of this writing Citadel Broadcasting, Emmis Communications, Entercom Communications and Cumulus Media — about 700 radio stations combined — are all trading at a share price around or below one dollar. It seems that just about every week another headline announces continued layoffs at stations all over the country. Current projections call for a continued decline in ad revenue for 2009, according to a recent report from BIA Advisory Services. A recovery in advertising revenue for radio is not forecast until 2011.

Engineering departments everywhere are facing this pressure relatively well. Although there have been some layoffs, the average staff size for engineering has been carefully limited at most groups. When a sole engineer is already responsible for several stations, there is little room to cut back the one-man band without causing the music to stop. Having technical staff to keep stations operating is as important as having someone to handle payroll or sales.

However, in my conversations with other engineers I hear of capital projects that are being cut back or eliminated until conditions improve. That means engineers have to keep equipment running longer while maintaining the high reliability and consistent quality that listeners and station owners have come to expect.

The constant drum beat of bad news has convinced many owners to wait for a sign of good news in the industry. And that creates a host of opportunities for those stations and groups that have the financial means to invest or expand their business this year, anticipating the turnaround that is almost certainly ahead.

GOOD TIME TO BUY

The downturn in the radio market is precisely the reason why now is such a good time to make capital investments in station facilities and keep those engineering staffs busy. There are good deals to be made on real estate leases, transmission equipment and even on tower rentals. If you have the money, you can get better quality and higher performance on just about anything you buy for less than you could a few years ago. Locking in those savings now means that when industry conditions improve you can hold a competitive advantage over the competition.

If you have the money, you can get better quality and higher performance on just about anything you buy for less than you could a few years ago.

Why do I have this much confidence? Because the core place that radio holds in the marketplace has held up quite well under competitive pressures from other media. The overall pool of advertising dollars in the market is shrinking but radio is holding its place.

For the last five years or so the most dangerous competitor to the traditional radio industry has been satellite radio, which took off on a debt-fueled expansion that initially seemed unstoppable. By giving away their services, the satellite radio companies were able, for a while, to make their success seem inevitable at the expense of terrestrial broadcasting. But this is no longer the case. The remains of the two merged satellite radio companies have been lurching along from financial crisis to crisis for the last year, narrowly avoiding in March the complete dismantling of a system that now appears to have no potential to ever make a profit. Sirius XM Radio stock price today? Thirty-four cents. While it's not dead, the satellite radio business model seems irrevocably broken and faces at least several years of restructuring just to survive.

In other advertising media, newspapers are suffering more with revenues down 17 percent for 2008, according to the Newspaper Association of America. And, even in a year with both the summer Olympics and a presidential election, television revenues were down 7 percent according to BIA. Radio remains a good value compared to these more expensive alternatives. Even Google is now announcing layoffs.

Stations with their eyes on the future have learned to maintain and improve their Internet services, particularly streaming, as a way to offer more localized and personalized services to their listeners. Once seen as a threat, the Internet is now an asset for terrestrial radio stations that have developed a large listener base amongst the online community in the workplace. Digital advertising may well be the area of growth that will lead radio out of the recession.

Even the scary prospect of a massive technical change in delivery systems, as forecast by the proponents of mobile subscription data services (via WiMax wireless broadband technology), seems to have receded somewhat as rollout plans for the service have slowed due to difficult financing conditions. It appears that radio still has some years of life left to it.

GOOD TIME TO HIRE TOO

While I'm at it, I would also like to point out that this is also a good time to consider strategic hiring. A number of industry veterans with excellent skills have found themselves looking for new work. A skilled staff is a competitive advantage and essential to the highly localized services that will keep listeners loyal in the future. This might be the time to pick up that person who brings the expertise or attitude that can make your radio station better. And the ranks of recent college graduates are also a good source of well-educated workers who are willing to accept employment on terms that have been unthinkable since the dot-com boom of the late 1990s. Those of us responsible for technical hiring can now consider bringing in staff with better education and training than before. These younger workers bring with them an excellent IT background, now an essential component of radio engineering. We can train them on the RF part.

In short, it is when the situation looks the worst that the best opportunities arise. Radio remains a good business that has a future for those owners who will commit to providing the best possible service to their listeners.

Think I'm crazy? Drop me a line at *rwee@nbmedia.com* and tell me why. ■

IN THIS ISSUE

Hug Your Radio

All Is Not Lost: At Least We Still Have Listeners

When a once-proud and highly valued company like ABC Radio was selling for one penny a share, you knew things had truly run amuck.

You can buy a share of many radio companies for less than the cost of an ATM transaction. But no matter what the stock market might think, our industry is still a helluva lot better off than many others.

Radio is down about 15 to 25 percent from a year ago. Yet many companies are still flowing cash and making money, thanks to ongoing belt-tightening. To be sure, they aren't making the lofty margins they've been used to, let alone making budgets.

Be very glad you don't work for a car company. Automotive is down over 50 percent, with our Big Three essentially bankrupt. I won't even mention the banking and brokerage business, or what's left of it.

There's no sense banging away on the same old drum that times are tough and may get tougher. It's time to hug our radios and count our blessings. We had it very good for a very long time. And consumers are still counting on us.

THEY ARE LISTENING

A comprehensive study released in December by the Consumer Electronics Association entitled "Evolution of Audio ... Is Anyone Listening?" confirms that if consumers could only pick one device to use for the day, traditional radio is still the #2 choice behind television. IPods and MP3 players were roughly tied with desktop PCs and laptops for third.

This quantitative study was administered via a Web form to an online national sample of 947 U.S. adults last September. The margin of sampling error at 95 percent confidence for aggregate results is +/– 3 percent.

According to the study's summary results, audio consumption for all sources has decreased slightly from last year but remains at very substantial levels. The study lumps together listening on all devices including radio. Some 73 percent of respondents had listened to music in the last 12 months, down from 81 percent the previous year. Sixty-eight percent listened to news and information, down from 72 percent. Forty-five percent listened to sports programming the past year, down from 47 percent in 2007. And talk radio, which is 100 percent radio station listening, pulled 40 percent of all respondents, down only 2 percent from 2007.

The same study reports that while the majority of projected consumer spending on new devices will go to big-screen TVs and home theatre, there is a growing interest in extending home entertainment systems to include surround sound and built-in speakers throughout the home. Various respondents mention the desire to have the convenience of tuning in a program or music selection and having it play in every room on demand.

In spite of the influx of portable audio players that can go anywhere, most audio consumption is reported to still occur in the home. The leading audio device consumers intend to buy in the next 12 months is a new set of earbuds (11 percent). MP3 and portable digital player devices are second at 10 percent. Down the list a little farther are surround sound and stand-alone A/V receivers at a combined 6 percent. Folks still intend to buy radios for the home and their A/V systems. Sadly there is no mention of any HD Radio interest in this study.

Car radio usage is highlighted as a key component of audio consumption throughout this study. Commuters depend heavily on news, traffic and weather reports that affect their local areas. The companionship of music stations and the engagement of talk radio come up often in respondents' comments.

© iStockphoto.com / Monika Adamczyk

During all past recessions, including the Great Depression, radio listening remained steady or increased. In times of stress and uncertainty, folks need, and depend even more on, the reassuring companionship and wisdom of the personalities they have trusted for a long time via their local radio dials.

In times of stress and uncertainty, folks need, and depend even more on, the reassuring companionship and wisdom of the personalities they have trusted for a long time via their local radio dials.

IF YOU SERVE THEM THEY WILL LISTEN

A recent Radio World editorial talked about serving the audience and surviving the Meltdown. The real lesson of this era of smaller staffs and slashed budgets is that we have to concentrate more than ever on maintaining and even improving our core strengths to remain viable and successful. It always comes down to the content ... the offerings and attributes of our product that attract listeners and keep them coming back day in and day out.

The challenge for programmers is to find creative new ways to enhance that personalized link listeners discover and embrace in their favorite stations. Listeners seek out programming that makes them feel more connected to their communities, their friends and family, their careers and their avocations. Living successfully in an ever-changing and inter-dependent world demands good connectivity.

Staying on the cutting edge with innovations that enhance the radio product to attract, expand and hold their audiences is a top priority for good program directors. The Internet has become a resource for many of those innovations that are finding their way into radio. Texting, Instant Messaging and social networks like MySpace, Facebook and Twitter have reinvented the way folks connect and stay connected with the most important relationships in their lives. Radio stations that are adapting these innovations into their programming are gaining an edge.

For engineers, your job has become more than just keeping your stations on the air and sounding good. Engineers who expand their knowledge base and skill set beyond the hardware focus can become more valued team players for all departments in their stations. Become the enabler and the go-to-guy of technology of all kinds, whether it be studio equipment, computers, software apps, audio editors, cell phones, BlackBerrys and even the copiers and printers. One-on-one help for needy staffers takes time but makes you more valuable.

Perhaps even more important nowadays, station engineers should align themselves with the interests of their program directors. Ratings and revenue, and ultimately whether the station succeeds or fails, depends on how well the PDs do their job. They can't deliver the best possible version of the on-air strategy and product they have developed without you being fully invested.

These demands and expectations are (to be sure) becoming more difficult to fulfill, especially if you have lost part of your engineering and IT staff to layoffs and cutbacks. The industry is running out of competent and qualified engineers. Extraordinary times need extraordinary people to hunker down and work smarter in multiple roles. You'll find more of those people at the stations that perform above their market averages.

MORE CONSOLIDATION

As the recession grinds on and stations everywhere struggle to hit ratings goals and make budgets, I'm predicting we'll see more consolidation at several levels. We've all seen many instances in which a PD, GSM, promotions director and, of course, engineering position is eliminated at one station with a stronger sister station's personnel taking over those roles.

The media advertising money that is still out there will land on the best-rated stations. Few buyers or agencies are buying three or four stations deep anymore. As revenue and ratings shares drop on their weaker stations, cluster managers will be compelled to consider moving their strong formats onto their best signals and even creating AM/FM combo simulcasts to increase total ratings performance.

Witness a number of legacy news-talk AMs adding an FM or HD2/HD3 simulcast in quite a few major markets, such as New York, Philadelphia, San Francisco and Washington over the past year to increase their under-35 demo returns.

Carrying a marginal format, especially on a marginal AM facility that doesn't pay its own way and hasn't for a long time, doesn't make financial sense. Even in decent-sized markets, quite a few of these stations have become devalued to levels that don't justify keeping them on the air. Selling them at even fire-sale prices is difficult with the credit markets frozen.

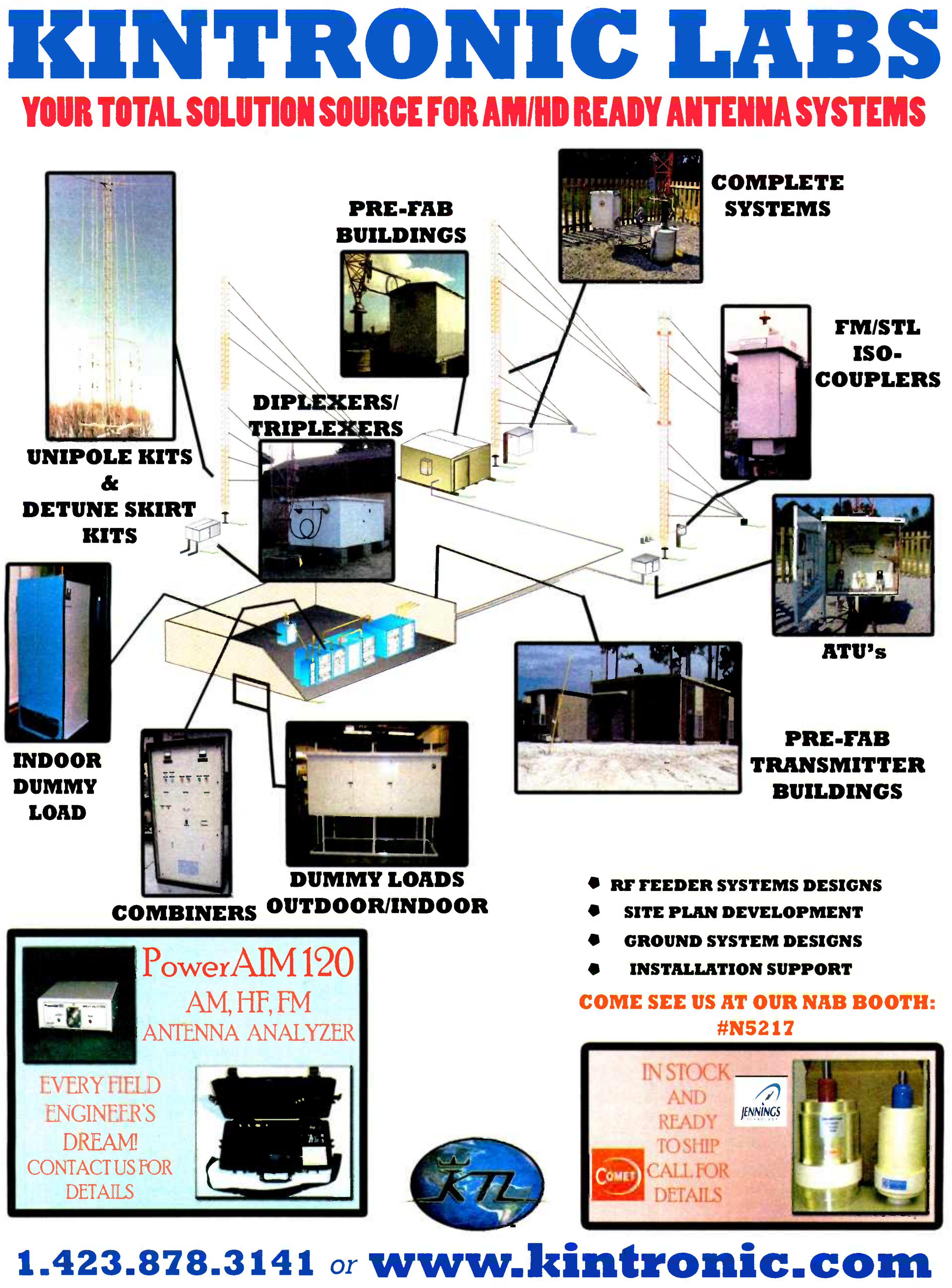
Maybe the National Association of Broadcasters should press our congressional bailout barons to offer such licensees their slice of the bailout pie or at least a tax credit to make these stations go dark forever. After all, we shouldn't waste the opportunity of a financial crisis to get the relief we've wanted for a long time.

TUNING IN THE FUTURE

The fate of HD Radio will not be known for some time. If it survives the Meltdown, that should be a reasonable indicator of its longer term efficacy.

I'm betting FM-HD will survive and succeed, mainly because it's the only game in town and the technology offers con-

SEE HUG YOUR RADIO, PAGE 6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by Charles S. "Buc" Fitch

Know How Long Before Shutdown

The correct answer to the question posed on page 1 is **c**.

The interference generated by an AM station in the United States, when it cannot reduce power by 24 kW at night, will be notable.

For decades the FCC has been allocating AM stations to communities, reviewing and approving facilities utilizing a criterion of acceptable interference. The goal (in a perfect world) is for the primary service area of the community of license and sometimes the surrounding region to enjoy interference-free, reliable service.

The calculations to estimate and evaluate the interference given and received by stations (co-channel and adjacent) use ground-wave values for daytime review. However, mainly skywave propagation is considered for critical hours and nighttime operation.

During daylight hours the ionosphere layer of the earth's atmosphere is ionized by the sun and medium-wave signals pass through into outer space. At night, without solar heating, the atmosphere "hardens up" and reflects back to earth a portion of the broadcast signal, essentially bouncing the signal a great distance.

Because of the oblique angle of the signal arriving from above (the skywave), a portion of that signal can bounce again, taking off towards the atmosphere, continuing the signal even further.

The notable reduction in field strength by reducing from 25 to 1 kW antenna system input power, and frequently also narrowing the directions in which that signal is propagated by using a directional antenna, are legally required to limit skywave interference to other stations at night.

With an omnidirectional signal and an antenna input power of 25 kW, the area of nighttime interference could cover entire states or even a large portion of the continental United States.

Over the last 90 years or so of broadcasting, federal regulators have been asked on many occasions to clarify and quantify the circumstances when a station needs to go off the air or reduce power to avoid interference as well as the latitude they have to stay on while correction takes place.

SIGNIFICANT DISRUPTION

One of their most recent visits to this subject was started in 1997, and after much reflection and exchange, culminated in the issue of the Report and Order in MB Docket 03-151, FCC 07-97, released May 25, 2007, which you can read in PDF form at *http://tiny.cc/FCC703.*

Since the text that came out of this R&O is the current applicable regulation, let's quote from the commission's own Web site commentary on the subject (which you can see at *http://tiny.cc/fcc72*):

Within question 5:

*In general, the licensee or permittee must correct any malfunction which could cause interference or turn the transmitter off within **3 hours** of the malfunction. Some malfunctions, however, must be corrected within **3 minutes**. Examples of situations requiring termination within 3 minutes are operations posing a threat to life or property, or that is likely to significantly disrupt operations of other stations (such as spurious emissions or operations substantially at variance from the authorized radiation pattern), unless the power is sufficiently reduced in that period to eliminate any excess radiation. See Sections 73.62 for AM stations and Section 73.1350 for AM, FM, and TV stations …*

The circumstances outlined in the certification question annotated above definitely require terminating operation within 3 minutes.

As of this writing, broadcast station owners are immune to license renewal challenges in the main if they are "good actors." This includes not being found in violation of the FCC rules. The goal is to expend the effort to be and remain *compliant* to avoid any risk to the next license renewal.

The beginning of any effort to achieve the highest level of compliance should be to meet or exceed all the areas of concern addressed in the FCC's station self-check lists. You should use these as your roadmap to compliance. The Broadcast Station Self-Inspection Checklists can be found at *www.fcc.gov/eb/bc-chklsts.*

THINK BIG

Not to confuse issues, but when could you stay on without having to correct such an egregious operating problem as this 25 kW non-directional at night?

Well for instance … imagine the unspeakable horror of a Category 5 tornado passing through your county, cutting a swath of destruction and taking down communications towers, power and phone lines.

You find that obviously something is wrong out at the transmitter site as you cannot change pattern directly. You're lucky your station is still on the air.

Should you go off? While I'm no lawyer, I tell my clients that they should stay on in such situations until the emergency has stabilized. Without reliable communications, the local authorities may need to dispatch and organize their professional and volunteer members using your transmission facilities. *Everyone* has an AM car radio and more than likely you'll have the interview mic in your studio taped on the speaker of your ham 2 meter walkie so that the police, fire or public service dispatcher on the other end can route vital personnel to where they are needed.

In between, you'll read the list of the dead and living … reunite families … steer people to aid stations … organize supplies … warn of bad water … calm the community … ask for neighbors to check on the elderly and sick who need immediate attention … and generally let the people of your community know what's going on.

Frankly these times are broadcasting's finest hours, when we are needed and really come through. Interference to a 20 minute music sweep 1,000 miles away just doesn't matter.

Stay on and do your job. When it safe to go out to the transmitter, then you can get out there and fix the problem.

A comment about answer (d). In SBE exams and any other test of this ilk, logic is an important factor in eliminating answer choices. Not every station's transmitter location requires you to drive there. The transmission system in this question could have been in the same building or across the yard.

The SBE Certification exam at the CBRE level is open book. Up to a third of the exam could be on FCC regulations so one should take a recent copy of Parts 73 and 74 of CFR 47.

However, the consensus of most recent test takers is that the exam room is not a place to begin acquainting yourself with FCC regulations and that a thorough and comfortable knowledge of FCC regulation is desirable before you take the test. Having the "book" allows you more to confirm your answer, not search to find it.

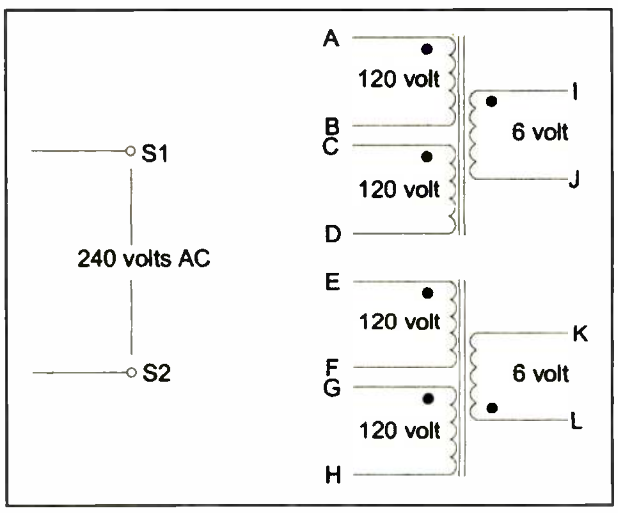
Please note that the deadline for signing up for the next cycle of SBE certification exams is April 17 for testing that will be given between June 5–15 in the local SBE chapters.

Missed some Certification Corners or want to review them for your next exam? You can find back stories under Columns at *radioworld.com.*

★ ★ ★

For the next issue, a CBT level question:

You have an immediate need to create 12 volts of AC for a power tube filament using two available, identical 6 volt secondary transformers. Referring to the drawing shown, how would you connect them together to make 12 volts from a 240 volt AC supply?



a. There is no combination that will work because the cores are not common.

b. A tied to S1, H tied to S2, B & C tied together, D & E tied together, F & G tied together, J & K tied together and then connect the 12 volt load across I & L

c. A, C, E & G tied to S1; B, D, F & H tied to S2; J & K tied together and then connect the 12 volt load to I & K

d. A & E tied to S1, D & H tied to S2, B & C tied together, F & G tied together, J & K tied together and then connect the 12 volt load across I & L

e. A & E tied to S1, D & H tied to S2, B & C tied together, F & G tied together, J & L tied together and then connect the 12 volt load across I & K

Buc Fitch, P.E., CPBE, AMD, is a frequent contributor to Radio World. ■

Hug Your Radio

CONTINUED FROM PAGE 4

sumers important and attractive enhancements over analog. Adding extra format opportunities almost for free in the HD2 and HD3 channels will eventually pay off. But the power increase will be needed to ensure HD Radio's ultimate success.

I'm feeling a lot less sanguine about AM-HD. Making it successful was always going to be a long uphill climb. For many of the same reasons AM stereo did not succeed, AM-HD may very well meet the same end. Increasing the FM-HD power will unwittingly hasten that end. Successful AM formats will eventually either wind up on FM or an HD2 or HD3.

It's tough to admit, but AM as a service is simply running out of time. It doesn't need the digital enhancements to make its core talk format listeners become interested in it or embrace it at any level.

As more news and talk formats find their way to the FM dial and AM/FM simulcasts are created during the next consolidation phase, the days of the AM service become numbered.

The big 50 kW blowtorches will be the last sticks standing. As WiMax ramps up and Internet radios start appearing in all new cars, the AM component of their combo ratings will start falling. When it reaches levels that don't justify paying the power bill and other direct expenses, even those stations will eventually hit "plate off" one last time. I sincerely hope I'll be pushing up daisies instead of pushing the plate off buttons when those days arrive.

Fortunately, it's going to be many years before AM has to worry about becoming extinct. It might be an endangered species in some areas but as long as Americans stay in love with their cars, AM radio will always be one easy button push away. With over a billion AM radios in the hands of consumers and so much sparsely populated area in this country that will not get WiMax for a very long time, AM still has a long stretch ahead. ■

The Metropolitan Opera sets the standard for great sound.

And it's chosen ACCESS to let the world listen in.

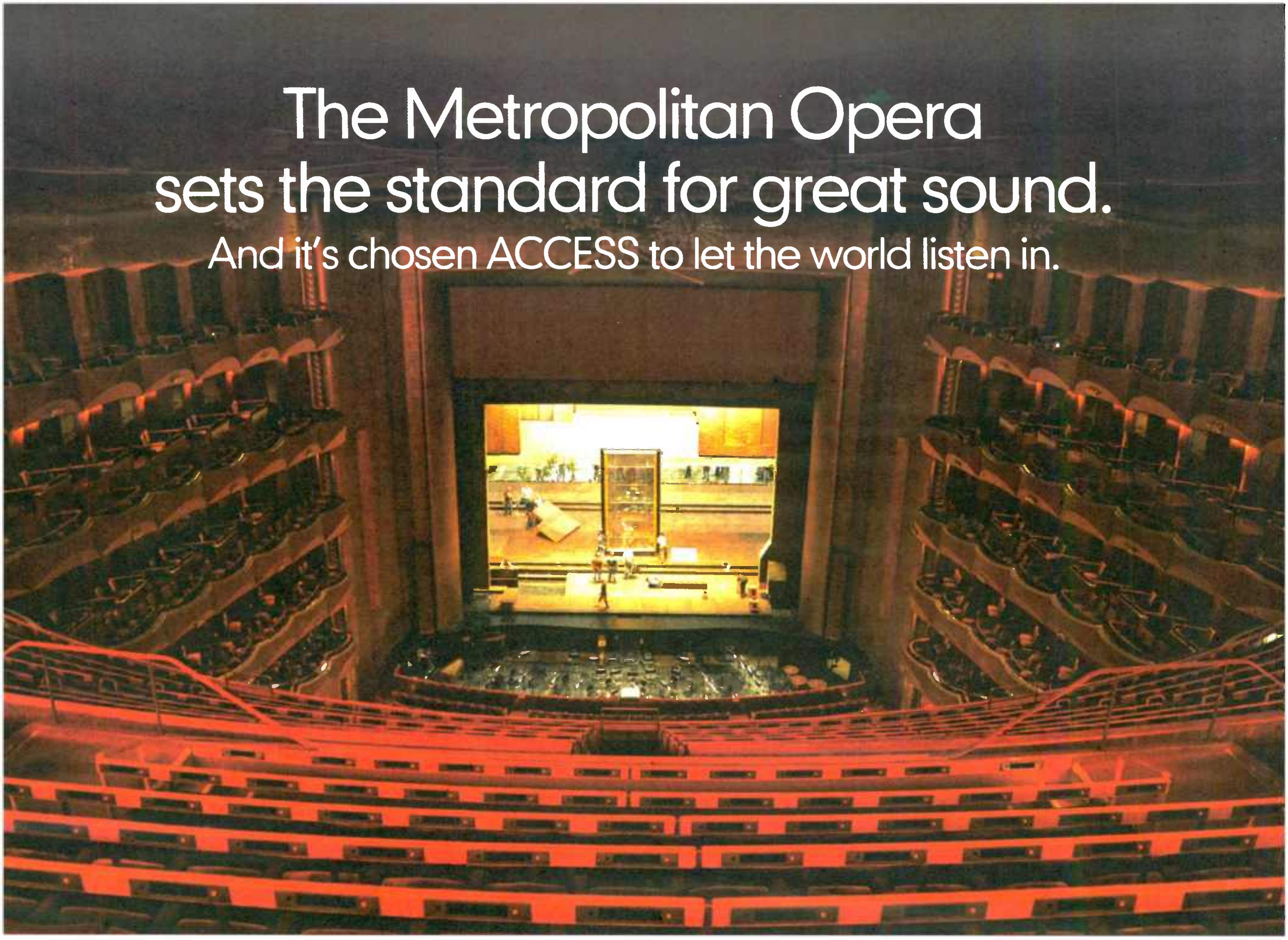


Photo: *Jonathan Tichler/Metropolitan Opera*

"Opera is one of the most challenging musical genres to do complete justice to in a broadcast, but ACCESS makes it easy."

—Matthew Galek, Broadcast Engineer for The Metropoiltan Opera

The Met's Matthew Galek is a Real-World Super Hero

Not content to rest on its laurels, the most renowned and respected opera company in the world is determined to connect with the widest possible audience—in the highest audio fidelity. With engineer Matthew Galek at the transmission helm, the Metropolitan Opera broadcasts its Saturday matinee to an ever growing number of affiliates using ACCESS (and the optional AAC suite) in multistreaming mode. With ACCESS, the Met's broadcasts offer all the sonic richness it's famous for—over the most challenging IP networks.

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ACCESS delivers mono or stereo over DSL, Cable, Wi-Fi, 3G cellular, satellite, POTS (yep, ACCESS is a full featured POTS codec and works seamlessly with Matrix, Vector and Bluebox)—plus some services you may not have even heard of. Given the challenges of the public Internet, it's no small boast to say that ACCESS will perform in real time over most available IP connections.

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IP Audio

CONTINUED FROM PAGE 1

Transport Protocol over User Datagram Protocol over IP).

Devices connected to the Internet *must* use IP since that is the Internet's native protocol. The same protocol could be used directly between two devices even though they are not on the Internet. Or an entire dispersed network of routers and computers could use IP without being connected to the Internet.

Because of the huge growth and popularity of the Internet, IP has come to be the default protocol for any computer/device networking. This is a good thing, but it certainly causes a lot of confusion.

In the United States, when I am asked about "IP audio," I find that 80 percent of the time the question is in reference to IP audio over the *Internet*. I believe that this is because the widely exaggerated death of ISDN means that ISDN users are looking for a replacement, preferably something generic enough that it will be around for a long time to come. Generic Internet access fits this requirement well, and also comes in a variety of forms including various wireless technologies.

There is also cost sensitivity. Users are well aware of the pricing for ISDN and T1 access, and they know that "Internet access" is cheaper.

There are a number of papers about using the Internet for audio over IP (see the references at the end of this article). Invariably, these papers warn that the Internet (or other networks with a high degree of sharing/contention) have their limitations and then offer ways to make the most of these limitations. These papers also generally allude to "IP networks with proper Quality of Service (QoS)" and how these are recommended for pro-grade applications such as studio-to-transmitter and other similar links.

We will assume the reader has read one or more of these papers and understands the limitations of audio over the Internet. In this paper we will bridge the gap and describe these other networks, including case studies using these "private IP networks" for audio over IP. We will also briefly compare the results using these links vs. the Internet approach.

Exclusive IP Links

Any IP link that is yours exclusively and is used for audio *only* falls in this category. IP bandwidth providers can provide such dedicated bandwidth offerings. This category would also include using fiber optic cable or using IP Radios to build a network. Another option is to take a point-to-point T1 and convert it to IP at either end (see Fig. 1).

QoS-capable Exclusive IP Links

If you take an exclusive link and use it for both audio and other data, the link will need a mechanism to establish QoS. In other words, it must be designed to give priority to the audio stream even if that means dropping packets from non-audio data. The network will need to be built with this in mind.

For example, the router or switch at the two ends of an exclusive link can be programmed to provide this function. You might tag the audio data with the Differentiated Services Code Point (DSCP) of EF (Expedited Forwarding) for the audio, leave the other data untagged (best effort) and have this honored by the router or switch. In many cases the carrier can provide this function, but you can add this function yourself using appropriate equipment, assuming, of course, an exclusive IP link.

Metro Ethernet (Ethernet-based Metropolitan Area Networks)

Metropolitan Area Networks (MANs) are networks covering an area from a few blocks to the size of a city (within a Telco Local Access and Transport Area). By far the most popular technology is based on Switched Ethernet, making it possible to treat such a MAN as if it were simply an extension of the Ethernet LAN.

It is worth noting that Ethernet is not an IP technology, and has its own suite of protocols. An advantage is that it can accommodate protocols apart from IP; for example the old Appletalk protocol can be passed over an Ethernet network. While the proper use of Ethernet switches and Virtual LANs (VLANs) will give a routing-like function, unless the user adds IP routers it won't be a true IP network. Also, since there are no IP routers in the

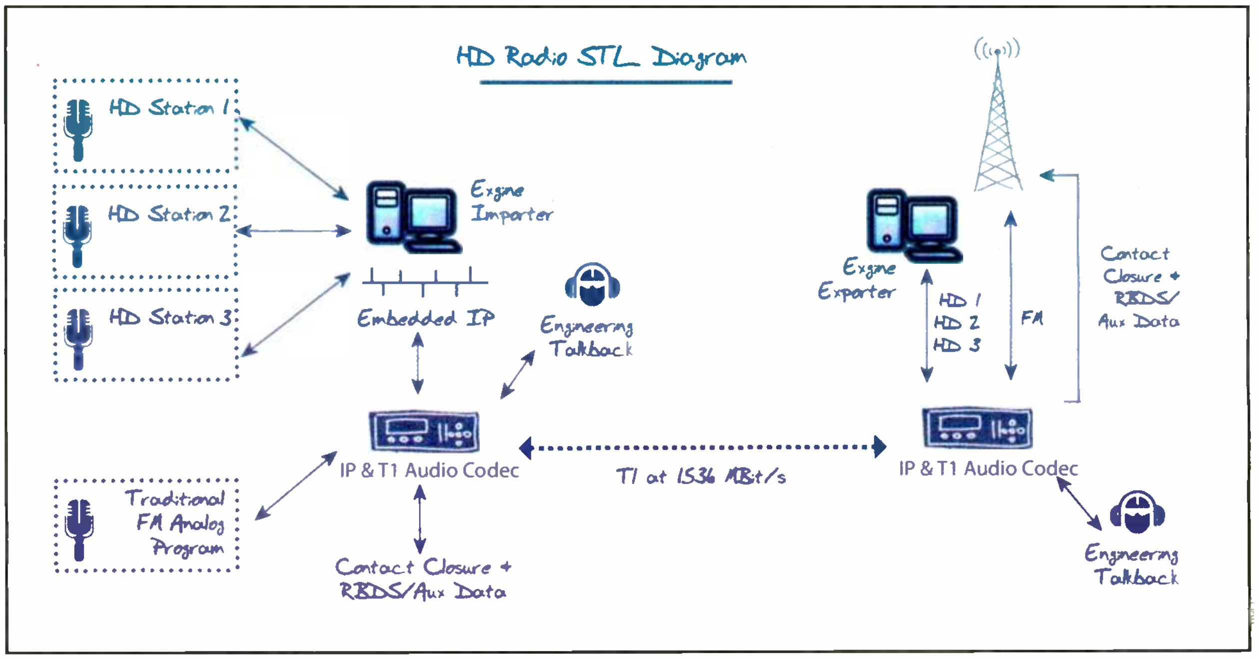

Fig. 1: Converting a point-to-point T1 to IP allows considerable flexibility, such as this application where the HD Exporter data is mixed with IP audio codec data for transmission. This requires only an Ethernet Switch, which in this case is integral to the codec.

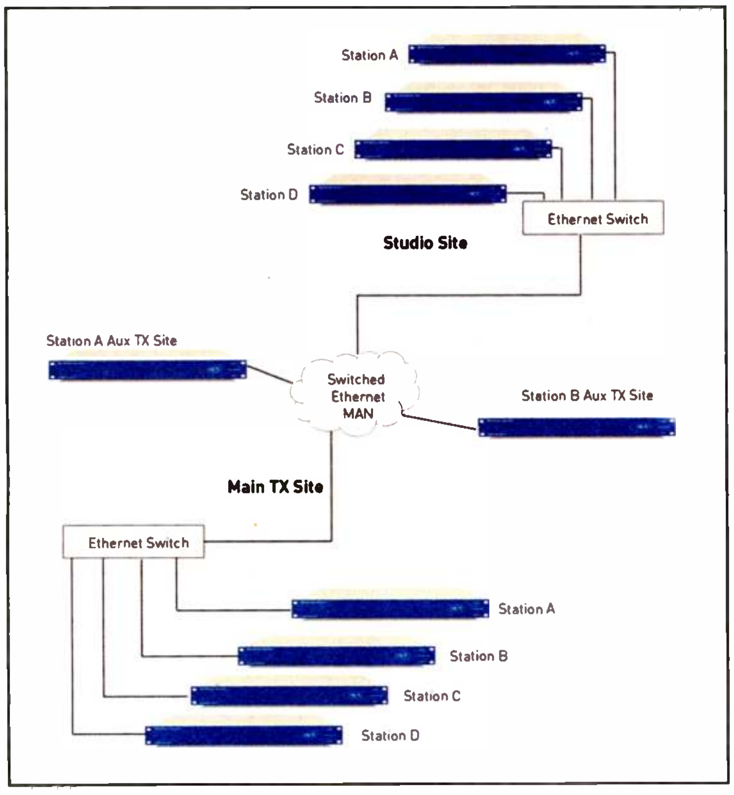

Fig. 2: Network Topology for the Linear-Audio Over Switched-Ethernet Net

network cloud, this type of network cannot take advantage of certain IP features, in particular IP Multicast.

Corporate IP departments appreciate switched Ethernet networks because they have complete control, as opposed to other options where their control ends at the network's edge.

Recently, switched Ethernet-based Wide Area Networks have become available with global footprints and tend to be a particularly cost-effective option.

Multi-Protocol Label Switching (MPLS)-Based IP Networks

Multi-Protocol Label Switching is a technology that is being used to replace ATM for network transport. MPLS operates between Layer 2 and Layer 3 in the OSI model and can transport Ethernet, IP or other packets. For our purposes we will consider IP networks implemented with MPLS.

The MPLS "Label Edge Router" attaches (pushes) small (32 bits) labels onto packets at the edge router as they enter into the network. These tags identify packets with regard to their routing characteristics within the MPLS IP network. At the final destination router, the labels are removed (popped) before being passed to the customer's IP network.

The MPLS network is a special type of managed IP network. Management of these networks is sophisticated and is more like the management of a circuit switched network (like the synchronous traditional telephone networks) than a typical packet network. Just as with a circuit switched network the carrier must provision the network for new traffic before it is added. Provisions for backup routes are also a concern.

MPLS is path-based. When the first packet with a particular combination of attributes enters the network, a path is determined for the packet and all subsequent packets will follow this path. There are also provisions for re-routing rapidly in the case of a network failure. Fully meshed private IP networks can be established where multiple sites all have access to each other.

The labels include a QoS field that allows providers to offer customers multiple classes of service. Unlike switched Ethernet, MPLS is generally IP-based and therefore IP Multicast can be available as an add-on and can be useful for efficient program distribution to multiple sites. Each path is separate, so when packets with different attributes (for example, class of service) pass between the same two points, multiple paths would be established.

CASE STUDY: MULTIPLE STLS OVER ETHERNET MAN

In this case, the customer has four stations at a common studio location. All four stereo program channels need to be delivered to the common transmitter site, plus two of the four channels need to be delivered for backup purposes to backup transmitter sites (see Fig. 2).

The customer required linear (uncompressed) streams, so the bandwidth requirements were high at 1.602 Mbps per stereo pair.

Due to the proximity of the sites, the carrier proposed an Ethernet-based MAN. The customer involved us early and we determined that since the network was Ethernet-based, we would not be able to take advantage of IP Multicast to handle the two IP streams that would be going to multiple locations. Therefore a multiple unicast topology was approved; meaning that bandwidth at Site A was required to handle both streams for the streams going to two locations. Despite this limitation, the cost still met the customer's targets. Details of the network are shown in the table below:

Site	MAN bandwidth	Streams
Studio	10 Mbps	A, A', B, B', C, D (9.6 Mbps)
Main TX Site	10 Mbps	A, B, C, D (6.4 Mbps)
A Aux TX Site	2 Mbps	A' (1.602 Mbps)
B Aux TX Site	2 Mbps	B' (1.602 Mbps)

IP Bandwidth Provisioning for the Linear-Audio Over Switched-Ethernet Network

In this situation, deployment was extremely simple given that the IP codecs were, for all practical purposes, on the same LAN.

SEE IP AUDIO, PAGE 10

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IP Audio

CONTINUED FROM PAGE 8

CASE STUDY: INTERNATIONAL PROGRAM DISTRIBUTION VIA IP MPLS

WorldBand Media LLC's goal is to be "North America's leader in ethnic content and delivery." Its media interests enable ethnic North Americans to have access to quality content while at home, in the car or on the move, a growing and largely untapped market. At this writing, WBM is on the air in four cities and has plans to add another 11 stations over the next two years, all geared towards the ethnic market. Stations on air at this time are:

Emmis:
New York - WQHT(FM) 97.1-HD3
Los Angeles - KPWR(FM) 105.9-HD3
Chicago - WLUP(FM) 97.9-HD3

Bonneville:
Washington - WTOP(FM) 103.5-HD2

Next Media:
San Jose - KEZR(FM) 106.5-HD2 (Coming soon)

WBM's main production studio facility is in Toronto, Canada.

Network

The network consists of a hub and spoke network with each site connecting to the MPLS network cloud.

All remote cities have T1 lines; access into the MPLS cloud is at 512 kbps on these lines with a restriction of 70 percent of traffic (358 kbps) at the high class of service required for audio data. The remainder of the capacity can be used for non-audio connectivity. As long as this 358 kbps limit is not exceeded, the audio data is guaranteed to meet the performance objectives of the Telco's Service Level Agreement (SLA). The audio streams are encoded at 256 kbps with a packet size of 512 bytes. After Ethernet encapsulation and IP packetization, the audio streams use 322 kbps per second for 16-bit 15 kHz Enhanced apt-X audio.

The Ontario headquarters has a DS3 into the cloud. This is provisioned as 2.5 Mbps for the audio streaming and a separate partition of 5 Mbps for corporate Internet access.

Equipment Management and Rollout

The telco is providing WBM a fully managed network including the carrier-provided edge routers at each site. This means they handle all programming and long-term monitoring, support of the routers and are available 24/7 for support.

Management of the codecs is, of course, the responsibility of WBM engineers. At the time of writing, management was via the APT Network Management System software, though WBM is considering using SNMP in the future.

Each codec provides performance monitoring statistics including:

- Packets transmitted
- Packets received
- Out-of-sequence incoming packets
- Lost incoming packets
- Corrupt incoming packets

As the first five sites were brought online we found the network maintained the SLA in all cases but the Chicago route. From the NMS we knew that this route was only achieving about 99.6 percent packet delivery. Had it not been for the performance monitoring on the codecs, the problem might have gone unnoticed for some time as the error concealment meant the audio sounded fine. Armed with several days of data, WBM's engineers contacted the telco and the problem was found to be a bad DS3 circuit and was fixed.

COMPARING PRIVATE NETWORKS WITH THE INTERNET

Private networks provide security and reliability as compared to the Internet. Here is a summary of the problem experiences with the Internet that are addressed by using a private network:

Delay. Transit delay over the Internet is highly variable and there are no guarantees.
Result: This delay adds to the overall delay budget.

Jitter. Short-term variability in delay is considerable and varies over time when using the Internet.
Result: IP codecs using the Internet must use worst-case buffer settings (adding to the delay budget) or variable buffers, which can at times be longer than ideal, and changes in delay during a connection can be unnatural for talent.

Packet Loss. Internet connections generally have continuous loss of some packets. Several lost packets a minute are common and as many as one per second is not unusual.
Result: pops, clicks, garbles or dropouts if system does not support error concealment. Even with effective error concealment, this represents a lossy process best avoided.

Service Level Agreements and Metrics

When Pro-grade IP networks are used, the network provider will guarantee the performance with a written contract called a "Service Level Agreement" (SLA). Worst case, they will offer the following performance, often better:

Metric	Typical Values	Notes
Availability %	99.9 – 99.999	Circuit up time
Latency (round trip delay)	50 – 300 msec	Distance dependent
Packet delivery %	99 – 99.999	
Jitter	10 – 50 msec	
Mean time to restore service	2 – 5 hours	

An important feature is a Service Level Agreement where the circuit performance is specified in advance.

It is worth noting the difference between % packet delivery vs. % availability. Availability is the percentage of time the circuit is up and working. When the circuit is up and running, the other metrics (such as packet delivery) are to be maintained as agreed. When the circuit is down this does not affect the other metrics, only the availability metric.

Therefore, the availability metric is the first to consider. It is given in a percentage, and is often described as a number of "nines." For example, if the SLA specifies the circuit availability as 99.999 (e.g. 0.001 percent down time) this would be called "five nines." Let's look at what this means over the course of a year.

525960 minutes per year * 0.001 % outage
= 526 minutes outage per year (8.8 hours of down time per year).

If we go to seven nines:
525960 minutes per year * 0.00001 % outage
= 5 minutes outage per year.

PRO-QUALITY EQUIPMENT

So far we have covered pro-grade networks. What about the codec? What attributes will complement the pro-grade network? A professional approach to audio transport over IP requires mastery of not just the network, but also the suite of hardware and software tools which allow control, supervision and operation of IP audio delivery.

These tools enable not only network and equipment monitoring, but the implementation of remedial action, hardware redundancy and error alleviation. Where possible, you should seek to source an integrated solution which delivers all these services in a single product, specifically the audio codec. This integrated solution allows the administrator to manage both audio AND data services from a central location either by a unified control software or on a higher level by SNMP.

Design Philosophy

The design philosophy behind products is a key factor to consider when purchasing equipment for use in a professional broadcast environment. There are two key approaches: DSP-based, or PC-based, product development.

PC architecture uses off-the-shelf motherboards, which are generic, low-cost platforms not designed for use with audio or 24/7 operation. Instability and memory leaks within the operating core can lead the system to "hang," as a PC is prone to do. DSP-based systems, on the other hand, are designed from the outset for high-quality audio delivery and signal integrity. They typically offer faster boot-up time, greater stability and greater operating resolution (bit depth).

While it may be acceptable for a user to reset their PC, it is definitely not acceptable for professional broadcast applications. PC-based architecture should be approached cautiously for critical applications.

Hardware Redundancy

For mission-critical STL applications, hardware redundancy is vital to ensure backup in the case of network or equipment failure. You will need to consider the importance of each link and determine the complexity of backing it up as necessary. Equipment that conveniently provides the necessary fail-safe options can make life easier.

For example, features such as hot-swappable audio modules, redundant power supplies and automatic backup functionality are some of the features that should be considered.

Configurability & Quality of Service

There are many variables in how QoS can be implemented. Therefore, it is vital that the audio codec selected provides flexibility and control to implement them easily with the method offered by the network provider.

This will typically include audio setting configuration, control of packet size, ability to buffer audio to compensate for jitter, error concealment to disguise packet loss and the ability to set the Diffserv Quality of Service tagging in the audio codec.

The codec should also provide maximum flexibility with regards to network configuration, allowing the broadcaster to implement unicast, multiple unicast and multicast applications.

Audio Algorithms

When designing your IP network for audio transport you will need to evaluate the cost of bandwidth vs. the audio quality required. Restrictions in available bandwidth will often rule out linear/PCM audio and some form of compression will often be required. There are two main types of compression techniques: ADPCM and Perceptual algorithms.

Perceptual-based algorithms (such as MP2, MP3, AAC and their many derivatives) use psychoacoustic-based principles that analyze audio content and determine what is audible to the human ear. The algorithm will remove all inaudible content and is therefore, by definition, "lossy." Using multiple passes of a perceptual codec (for example, consider the broadcast chain for HD Radio or DAB) can easily result in content heavy with artifacts. Ultimately this will cause "listener fatigue," swiftly followed by tune-out to a station offering higher audio quality.

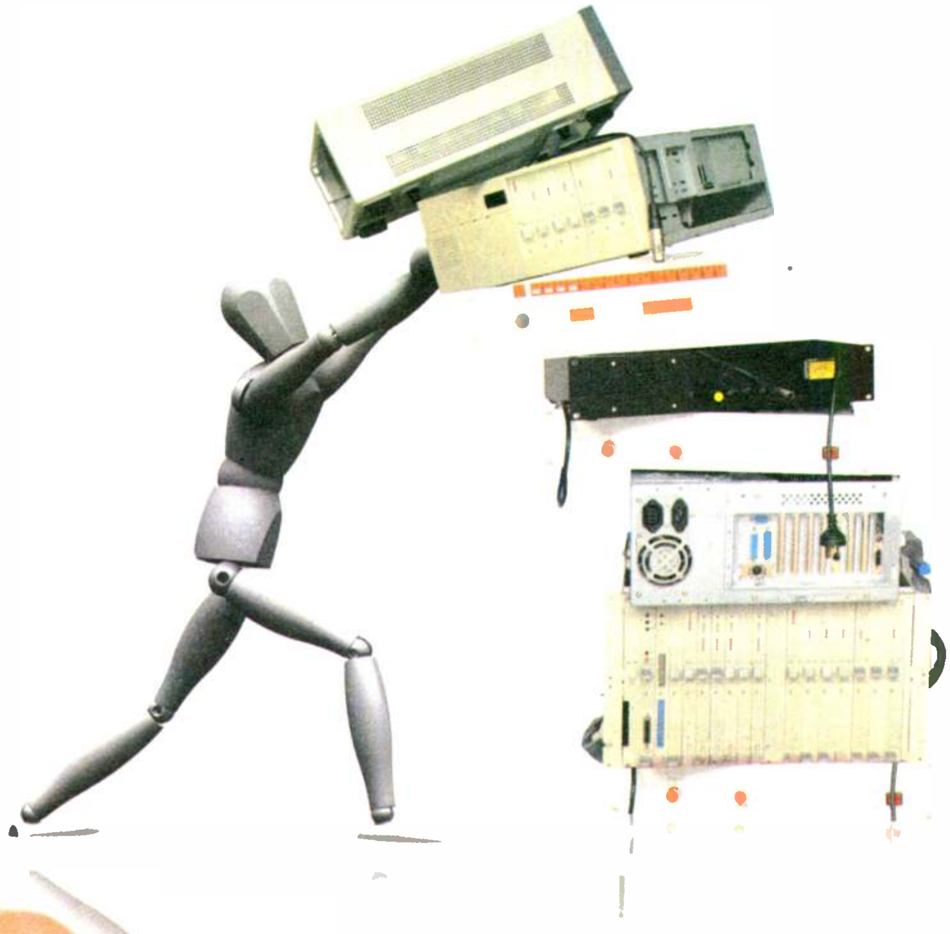
Additionally, perceptual coding introduces a coding delay of 60 to 500 msec that will be added to the packetization and buffering delays inherent to IP transport. Therefore, is important to consider the latency of the compression algorithm employed in order that sufficient buffering to achieve reliability can be achieved without exceeding the delay expectations for the system.

ADPCM algorithms offer a more attractive alternative given their gentler, minimally-destructive approach to coding. ADPCM-based, Enhanced apt-X technology delivers both exceptional audio quality and ultra low delay (under 10 msec), making it particularly suited for audio over IP applications. Enhanced apt-X overcomes the problems associated with multiple psychoacoustic coding passes in the broadcast chain as it is extremely resilient to tandem coding, retaining acoustic integrity up to and beyond 10 encode-decode cycles.

As a non-frame-based algorithm, Enhanced apt-X allows for smaller packets (as small as 64 bytes) contributing less delay and enabling quicker synchronization. The ability to start synchronization on receipt of the next valid sample and to achieve full synchronization

SEE IP AUDIO, PAGE 12

How do you fit an entire remote broadcast truck in a single box?



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ANTENNA TROUBLE

Hello Michael,

It is no surprise that someone trying to use a single bay for IBOC and a 10-bay for analog would have problems with the 10 dB increase. Not understanding the physics of gain antennas is the reason.

I could not give accurate figures, but something between 2–3 dB is the typical capture ratio of a decent analog FM receiver. Ten dB down would work fine with HD as long as the characteristics of the antennas are thought of before the increase, not after.

The problem is very simply that the two antennas chosen for the "Looming Danger of Digital Host Interference" article (Feb. 18) are absolutely the wrong antennas for the job, no matter where the antennas are on the tower.

There was a presentation to the Tennessee Association of Broadcasters in January by Bob Surette at Shively Labs that outlined this exact problem very well. The PowerPoint presentation is available for download at *http://tiny.cc/Shively*. An overview can be found at *http://sbenashville.org/pages/tab-2009.php* in the "Afternoon Sessions" section.

A single bay for HD Radio along with a 10-bay antenna for analog is asking for trouble on many different levels.

— David R. Wilson

HD Radio at 10 dB down from the carrier power will work fine; it does have its challenges and they can be overcome. HD using high-level combining is not going to work at the higher power levels. Low-level combining and possibly for those already running IBOC with separate antennas it might be possible to use a very clean amplifier with current IBOC hardware.

A single bay for HD Radio along with a 10-bay antenna for analog is asking for trouble on many different levels. Depending on physical isolation, intermod products are possible. There will be many areas where the IBOC RF will be well above the analog signal.

To me, the article was well done, but it illustrated a problem with not knowing the physics and related patterns of the antennas.

David R. Wilson, KU4B
Engineer
The Cromwell Group
Nashville, Tenn.

DEFECTIVE AND UNWANTED

I feel compelled to respond to Guy Wire's "Power Boost or Bust for HD Radio" (RWEE, Feb. 18). I fear that Mr. "Wire" may be inhaling too many flux fumes from his trusty Weller soldering gun.

First of all, "Guy" reiterates the tiresome, unsupportable contention that "radio needs digital to survive" in today's world.

Really? Maybe somebody can point to a credible marketing study that persuasively makes the point that people would listen to radio a lot more "if it were only digital." Actually, all the evidence I've seen indicates that (a) radio listeners are perfectly satisfied with the existing analog radio system and (b) don't care about HD Radio — among the very few who are even aware of it (and, yes, I know iBiquity has cobbled some alleged poll that purports to indicate otherwise).

I would make the case that, far from being the savior of radio, HD could actually accelerate its decline as self-anointed industry "leaders" try to force a defective and unwanted "innovation" on consumers.

Want proof? Look at the interference debacle of HD-AM. The vastly increased noise floor from adjacent-channel IBOC carriers has certainly done nothing to reverse AM radio's fortunes. Actually, in the northeast, it's turned the nighttime AM dial into an unlistenable bog of offensive noise.

Now, "Guy" insists we need to repeat the AM IBOC disaster on FM. Great! Here comes more make-it-up-as-we-go-along alchemy from the dwindling HD Radio crowd.

So "Guy" thinks a 10 dB digital increase "for stations with no interference issues" is just the ticket to save HD? Riddle me this, Mr. Weller-wielder: Who determines whether there are "interference issues?" The HD interferer? The alliance/iBiquity? Will adjacent-channel victims have any say in the matter?

(By the by, don't expect the FCC to actually do its job and enforce IBOC interference mitigation. WYSL has seen what level of interest the commission has in resolving HD interference issues: that would be *zero*.)

Notwithstanding the hype from HD Radio proponents, the destructive interference potential from the proposed increase is enormous. Doesn't anyone remember how HD-pumpers predicted AM-IBOC at night wouldn't be a problem? Haven't we learned anything from their endless technical deck-stacking and blind dismissal of legitimate concerns?

Behold the endless parade of inconsistent and implausible arguments from the pro-HD faction. Four years ago they insisted (notwithstanding recent lies repeated by "Guy" that the alliance "always had concerns" about it) that –20 dBc injection would work just fine.

After field experience forced a retreat from the false insistence that digital coverage absolutely equaled the analog, HD-pushers suddenly discovered that they *needed* 10 dB more for the digital to work acceptably.

Now we're hearing the suggestion that, since 10 dB more will likely produce serious interference problems, that maybe 6 dB might be okay "in some cases" (see above query about who would determine this, and how.)

So, HD-types, what's your story? Does the system need –10 dBc or doesn't it? Pick one and stick with it. Or is this a tacit admission that once again, you're fearful that the adjacent-channel problems will be horrible and you're hedging your bets?

HD Radio: Trying to have it both ways. At the expense of others. As usual.

Let's step back on Planet Earth here for a moment: To say that the hybrid-digital radio train has left the station is somewhat of an understatement. Have you talked to anyone lately who gives a flying rip about HD Radio, other than engineers and industry columnists and bloggers? Have you actually tried to purchase an HD Radio at retail recently (never mind about getting the freaking thing to work when you get it home)?

Not only has the train left, the station has been torn down, the rails have been ripped up and they're building a Walgreens on the site.

What radio needs is to stop endless squabbling and analysis of this deader-than-dead digital disaster and focus on the basics — starting with restoration of quality programming which once made radio, ahem, "ubiquitous" among media consumers.

"Phil E. Strann"
aka Bob Savage
President/CEO
WYSL NewsPower 1040
Avon/Rochester, N.Y.

IP Audio

CONTINUED FROM PAGE 10

within 3 ms @ Fs = 48 kHz ensures faster recovery from packet loss, making dropouts nearly inaudible.

Management & Monitoring

As with any pro-grade solution, the ability to control and monitor the equipment remotely is vital. This can be achieved either by front-panel control, SNMP or a dedicated management software package.

Whichever option is selected, the user should ensure that it provides the following capabilities:

- At-a-glance status of all codecs throughout network
- Ability to configure of audio (codec) settings.
- Flexible configuration of transport link. For example, packet size, jitter buffers and IP unicast and multicast routes. It also encompasses the configuration of automatic back-up to either a secondary IP port or synchronous links.
- Performance Monitoring providing statistics on packets transmitted and received, error counts, sequence errors, etc.
- Ability to set critical, major and minor alarm conditions relating to issues such as silence detection, loss of connection, loss of sync & exceeding jitter buffers
- Ability to set conditions that are triggered on alarms; i.e. switch to automatic backup and revert after *n* seconds of stable audio stream.
- Alarm and Event Logs to enable analysis of recurring errors and conduct accurate network diagnostics.

CONCLUSIONS

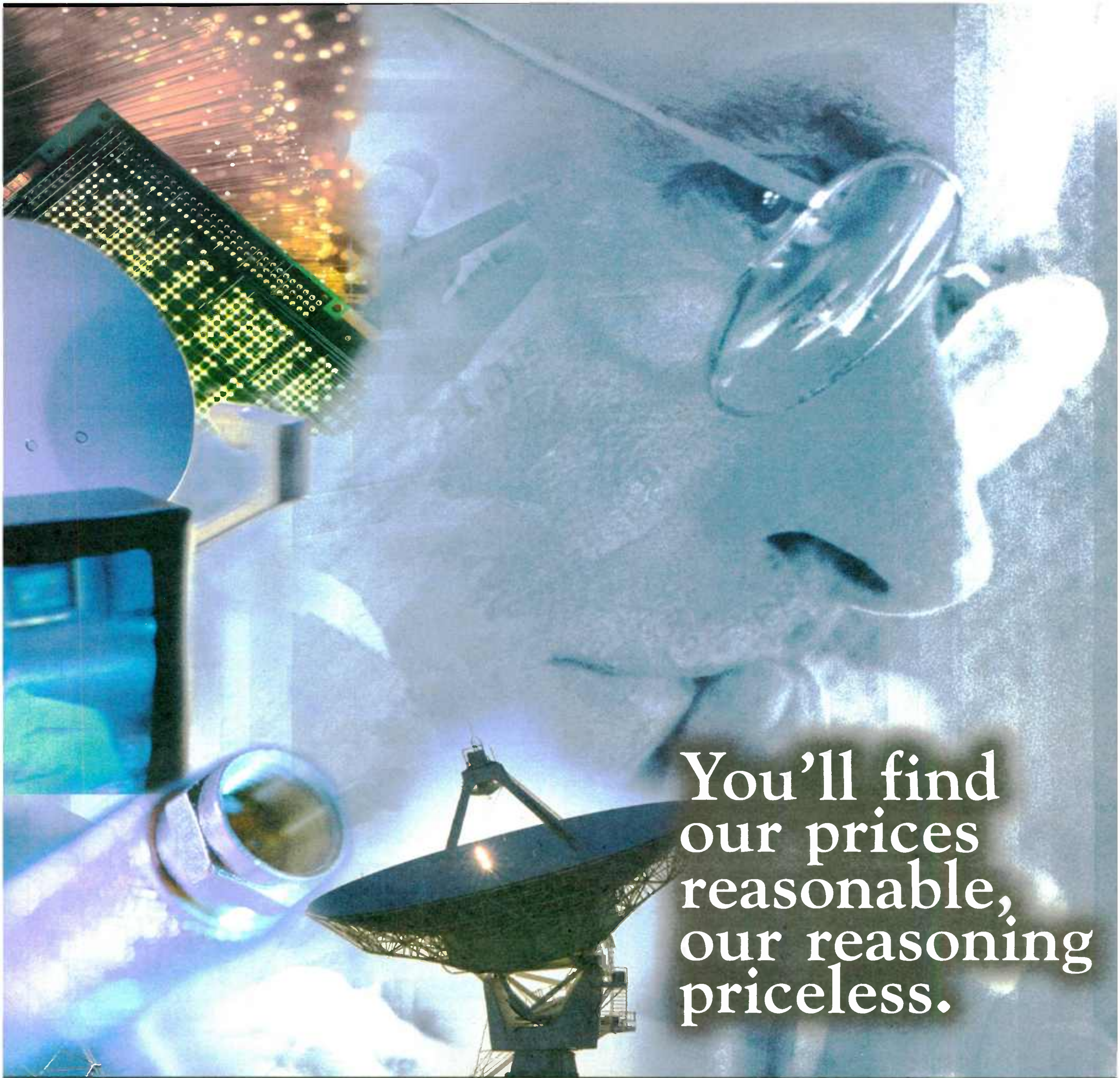
The developments in IP technology for remotes and ad hoc applications are exciting and useful. However, when planning primary studio-transmitter links, program distribution (satellite replacement) and other pro-grade applications, IP networks other than the Internet offer serious alternatives to dedicated synchronous (e.g. T1) and satellite networks. These IP network options will continue to expand and will likely drop in price. In particular, the fact that these techniques allow mixing high-priority audio data with lower-priority general-purpose data will allow broadcasters considerable flexibility to move into the future without the compromises of the Internet.

REFERENCES

"A Practical Guide to Audio Over IP for Broadcasters," by the staff of APT

EBU Tech 3326. "Audio contribution over IP: Requirements for Interoperability." Source: N/ACIP Status: Technical Specification, revision 3, European Broadcast Union, Geneva April 2008 http://www.ebu.ch/CMSimages/en/tec_doc_t3326-2008_tcm6-54427.pdf

EBU Tech 3329. "A Tutorial on Audio Contribution over IP." Source: European Broadcast Union N/ACIP, Geneva May 2008. http://www.ebu.ch/CMSimages/en/tec_doc_t3329-2008_tcm6-59851.pdf ■



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by Bob Band

The Combined FM/HD Radio STL

Bob Band is business development manager for Intraplex Products, Harris Corp.

Not so many years ago, a studio-transmitter link meant one of two things: an analog RF link at 950 MHz, or an analog conditioned line leased from the telco.

While many analog 950 MHz links are still in use, conditioned leased lines have almost completely disappeared as the telco world has moved to digital networks, and the old-school technicians needed to maintain them have retired and been replaced by IT techs more familiar with protocols than impedances.

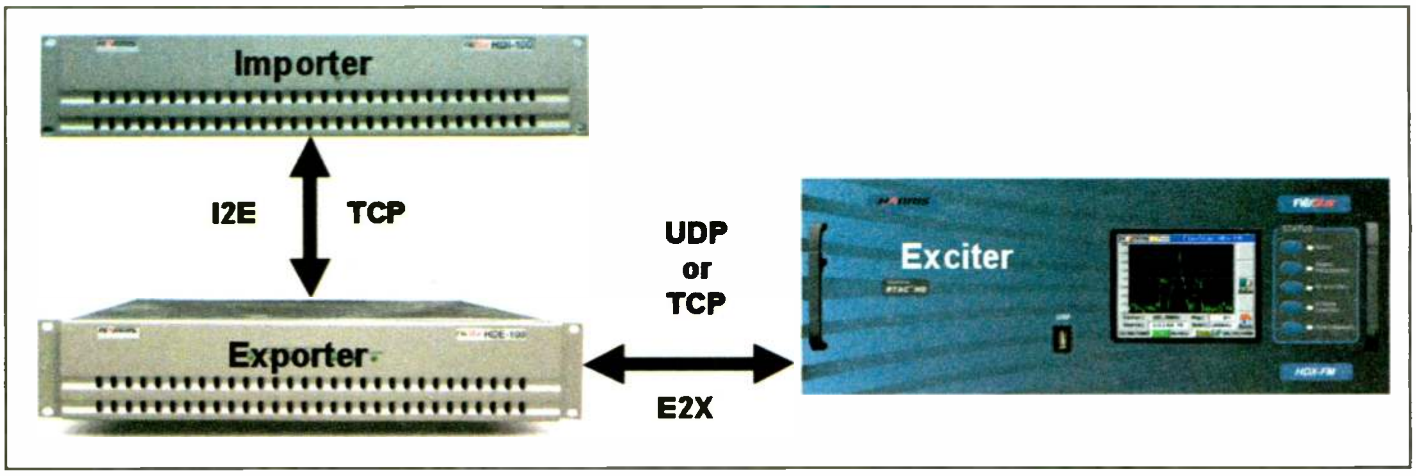

Fig. 1: HD Radio Components

THE EVOLUTION OF THE STL

STLs began moving from analog to digital long before the advent of HD Radio, taking advantage of the higher fidelity and greater flexibility the digital world offers. First to move were land lines, as the conditioned analog circuits were replaced by T1 digital links. As far back as the late 1980s, digital pioneers were installing T1 multiplexers, which were capable of combining multiple services such as STL and TSL audio, telephone circuits and control data over a single digital service.

One decade later, 950 MHz radios also moved into the digital realm. This trend was started with the Harris CD Link in 1997, followed by several other manufacturers, including Moseley and TFT.

The move from analog to digital opened up a host of new possibilities. Anything that could be converted into ones and zeroes could be carried across these new digital media, subject to the total capacity of the link.

For example, T1 operates at a fixed rate of 1.544 Mbps. The conversion of a 15 kHz FM stereo broadcast signal to digital using linear PCM encoding with 16-bit samples provides a data rate of 1.024 Mbps.

While this fits comfortably within the confines of a T1, the desire to fit more channels onto one link led to the development of a number of audio compression algorithms, including apt, Dolby, the various flavors of MPEG (up to and including AAC), and ITU-T standards such as J.41 and G.722.

While each of these has its plusses and minuses, taken together they enable us to carry anywhere from two to a dozen or more stereo channels across a single T1 circuit.

In the 950 MHz realm, digital carrying capacity is limited by a combination of factors, including how much RF bandwidth is available (typically 300 kHz, but sometimes more or less) and what kind of modulation you can perform on the signal, which is itself influenced by the distance, terrain and other elements affecting RF transmission. In an ideal case, a well-designed, robust system can manage up to about 2 Mbps of throughput across a 950 MHz link.

One big difference between the two technologies is that 950 MHz radios typically operate one direction only. T1 is inherently duplex, with the same amount of bandwidth on the TSL path as on the STL. Thus, the return path can be used for monitoring audio and for backhauling downlinked satellite programs, as well as for two-way traffic such as intercoms, off-premise telephone extensions and LAN interconnectivity.

Today, T1 has begun to give ground to IP, as digital networks move from TDM (time division multiplexed) links with fixed bandwidth to the greater efficiency of packet-based services. But packet networks, which were not originally designed for transport of real-time services such as broadcast radio, present their own challenges for use as STLs.

In the wireless world, license-exempt radios, particularly in the 2.4 GHz and 5.8 GHz bands, have begun popping up with ever-greater frequency. This is tied to the increasing difficulty of obtaining 950 MHz licensed frequencies, particularly in more crowded urban areas. Here, the leased-line and wireless formats begin to merge. These new types of radios typically have telco-standard interfaces such as T1, E1 and Ethernet ports, allowing the same equipment that is used on digital land lines to be used in wireless installations.

THE CHALLENGE OF HD

The HD Radio system is designed to carry multiple programs and services, including:

- Main Program Service, also known as HD1, which by current FCC regulations must be a simulcast of the analog FM broadcast signal.
- Main Program Service Data (MPSD), information about the artist, song title, etc., that is displayed on the HD Radio receiver.
- Supplemental Program Services (SPS), the secondary audio programs. Currently the HD Radio protocol supports up to two SPS programs, generally referred to as HD2 and HD3.
- Supplemental Program Service Data (SPSD) for each SPS, similar to the MPSD.
- Advanced Application Services (AAS), data services that may include such things as stock market, traffic or weather updates, e-commerce and many other possibilities.

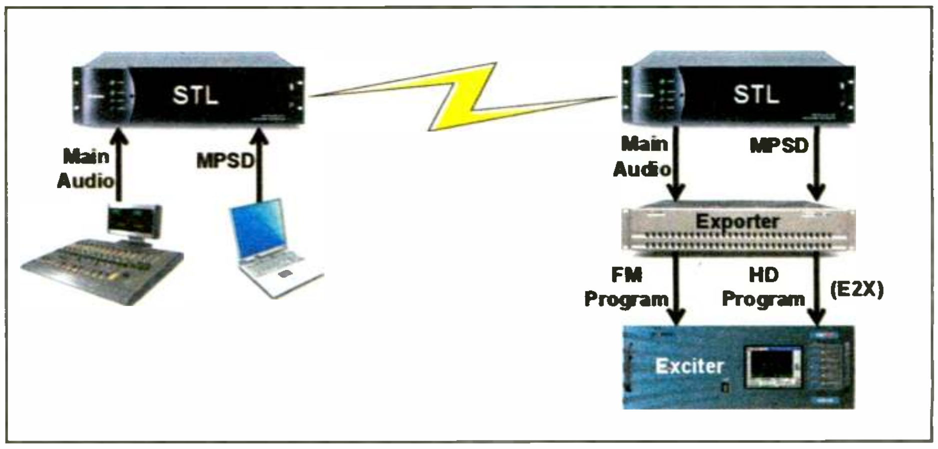

Fig. 2: No Importer, Exporter at Transmitter (Scenario 1)

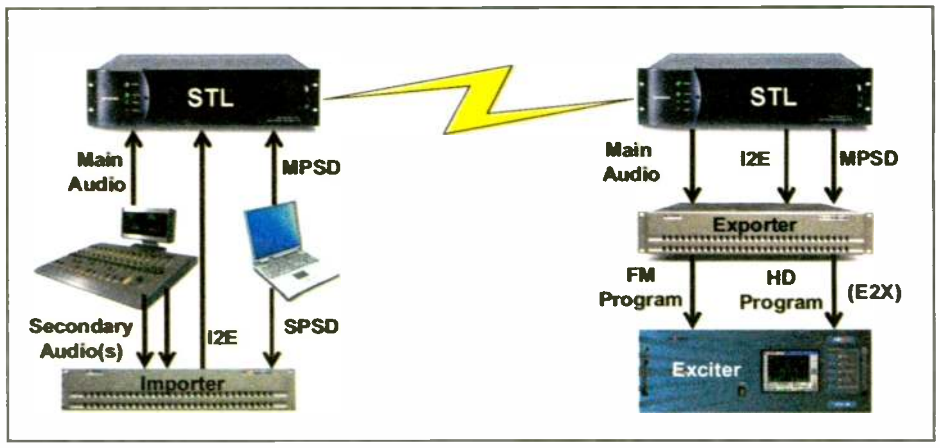

Fig. 3: Importer at Studio, Exporter at Transmitter (Scenario 2)

Physically, from the broadcasters' perspective, the HD Radio system consists of three main components: the Importer, which encodes and formats secondary audio programs and their associated data, as well as any AAS services being offered; the Exporter, which takes in and encodes the main audio program and its associated data, as well as the output of the Importer, to create the multiplexed HD signal; and the Exgine Exciter, which receives the formatted output of the Exporter and creates the HD Radio signal.

In HD terminology, the data connection between the Importer and Exporter is referred to as the I2E signal, and that between the Exporter and Exciter is the E2X signal. The I2E signal is a TCP data stream, while the E2X signal can be either UDP or TCP (see Fig. 1).

The STL bandwidth requirement of the HD Radio signal depends on two basic factors: where the physical components of the system are located, and which Service Mode is in use.

PLACEMENT OF THE COMPONENTS

While the Exciter must be located at the transmitter site, there are four possible scenarios for the placement of the Importer and Exporter, as outlined below. Each has its advantages and disadvantages.

Scenario 1: For those who do not plan to add any secondary programs to their HD broadcast, no Importer is required, and it can make more sense to place the Exporter at the transmitter site, thus eliminating the need to carry either the I2E or the E2X signal across the STL. In this configuration, we need only transport the main program audio in AES/EBU format at a 32 kHz or 44.1 kHz sample rate, plus the associated MPSD data channel as a low-bit-rate (< 400 bps) UDP channel with no duplex connectivity required (Fig. 2).

Scenario 2: Placing the Importer at the Studio and the Exporter at the transmitter site means we need to add I2E transport to the above. The I2E is a TCP data signal that can run as high as 156 kbps — not a huge amount of additional data, but being TCP, it requires duplex connectivity (Fig. 3).

Scenario 3: Positioning both the Importer and Exporter at the transmitter site places heavy demands on the STL (unless, as previously mentioned, only the Main Program is being broadcast, in which case the Importer is not required) as we would then need to transport all of the audio programs across it, plus all their associated data channels, plus any additional data

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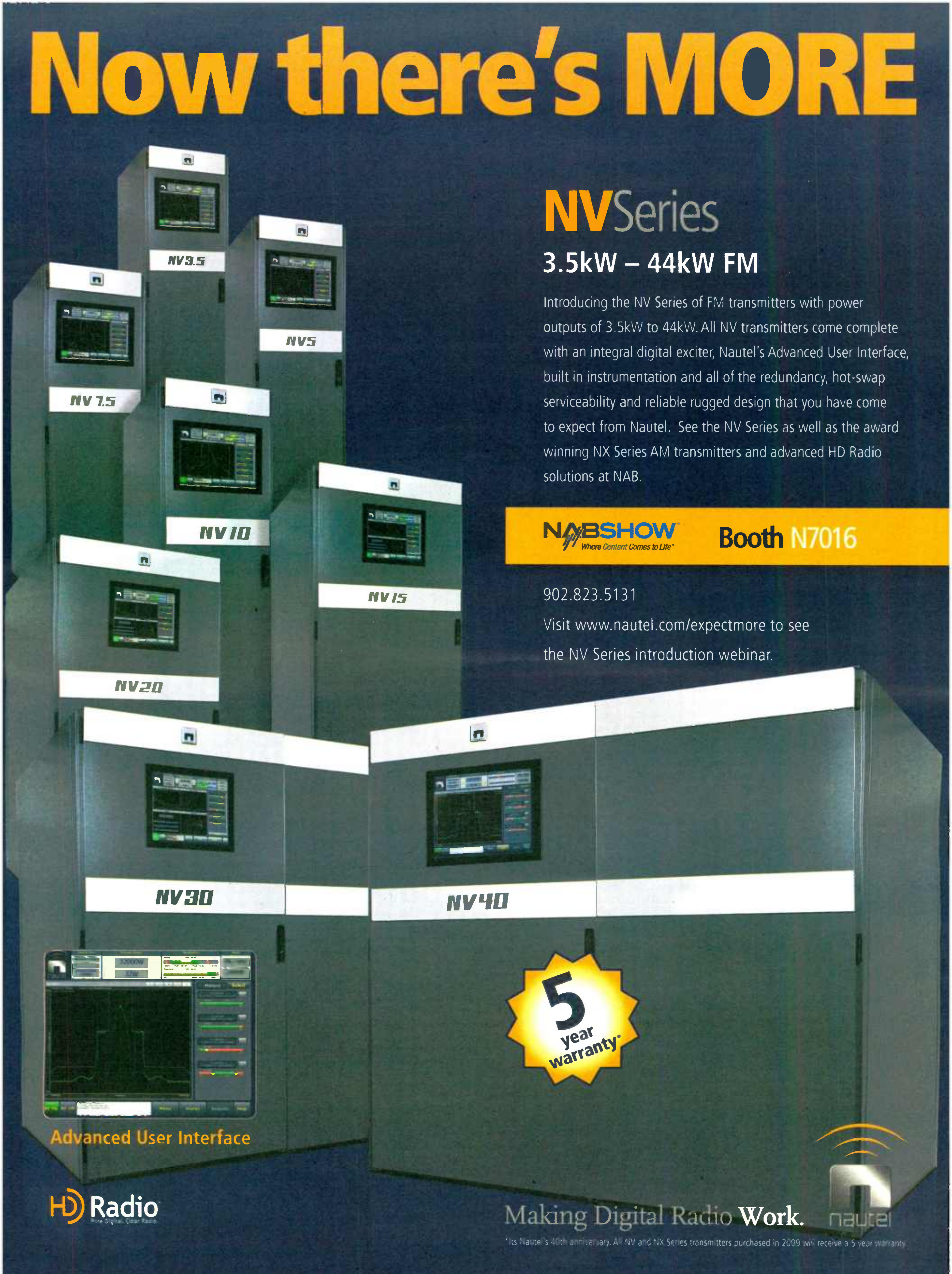
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Introducing the NV Series of FM transmitters with power outputs of 3.5kW to 44kW. All NV transmitters come complete with an integral digital exciter, Nautel's Advanced User Interface, built in instrumentation and all of the redundancy, hot-swap serviceability and reliable rugged design that you have come to expect from Nautel. See the NV Series as well as the award winning NX Series AM transmitters and advanced HD Radio solutions at NAB.
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Advanced User Interface
HD Radio
Making Digital Radio Work.
nautel
*It's Nautel's 40th anniversary. All NV and NX Series transmitters purchased in 2009 will receive a 5 year warranty.

STL

CONTINUED FROM PAGE 14

channels we're using for AAS. Of the available STL options, only wideband IP has the capacity to support this without using audio compression (Fig. 4). Some engineers like this scenario because it allows them to use local audio sources at the transmitter site to keep all the HD programs on the air in the event of a catastrophic STL failure.

Scenario 4: In most cases, the most effective and bandwidth-efficient solution is to place both the Importer and the Exporter at the studio and feed the E2X over the STL to the transmitter site, and we find that iBiquity Digital recommends this configuration for most HD installations (Fig. 5). Yet, it is precisely this transport requirement that presents the greatest challenge in the design of the STL. Many implementations of the E2X use UDP, a one-way protocol that does not allow for the resending of lost or errored packets. IBiquity Digital reports from their lab testing experience that IP packet loss must be less than 10^{-5} for successful performance.

The latest version of the iBiquity Digital standard for HD Radio allows the use of TCP, which increases robustness by allowing missing packets to be retransmitted. With TCP in place, the signal remains usable under severely impaired conditions with bit error rates up to 0.03 percent. However, TCP requires two-way communications to operate, and thus presents a problem for traditional 950 MHz STLs. Some manufacturers have tried to find ways to work around this by creating a backhaul channel to enable TCP.

T1 and IP links, whether as land lines or over microwave radios, are inherently duplex and thus well-suited to handling TCP traffic.

An additional consideration when transporting the E2X signal is the fact that both the Exporter and Exciter must be kept in close synchronization to prevent overflows and underflows in the Exgine buffer, which can cause audio dropouts. The simplest method of achieving this is to use GPS clocks at the studio and transmitter, which provide 10 MHz reference clock outputs. Lacking this, a well-designed exciter can, over time, synchronize to the Exporter, but only if there is a solid STL connection with plenty of bandwidth — typically at least 500 kbps to ensure reliability.

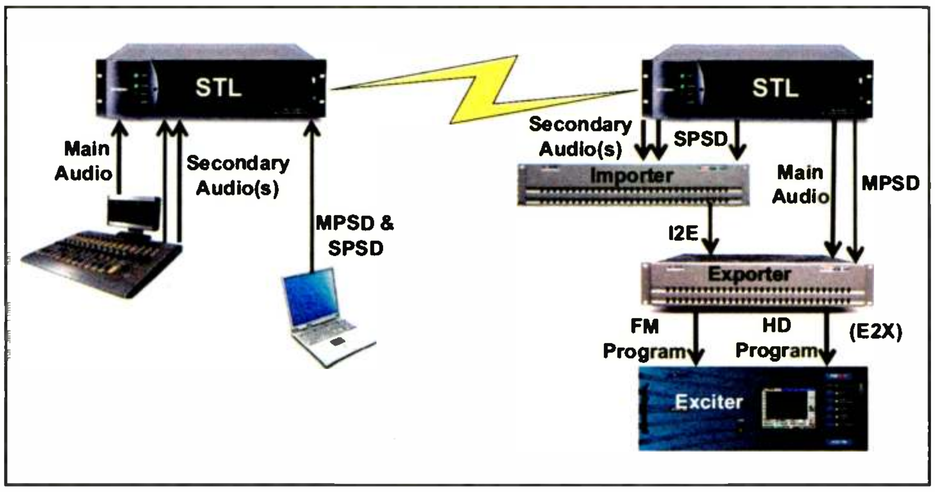

Fig. 4: Importer and Exporter at Transmitter (Scenario 3)

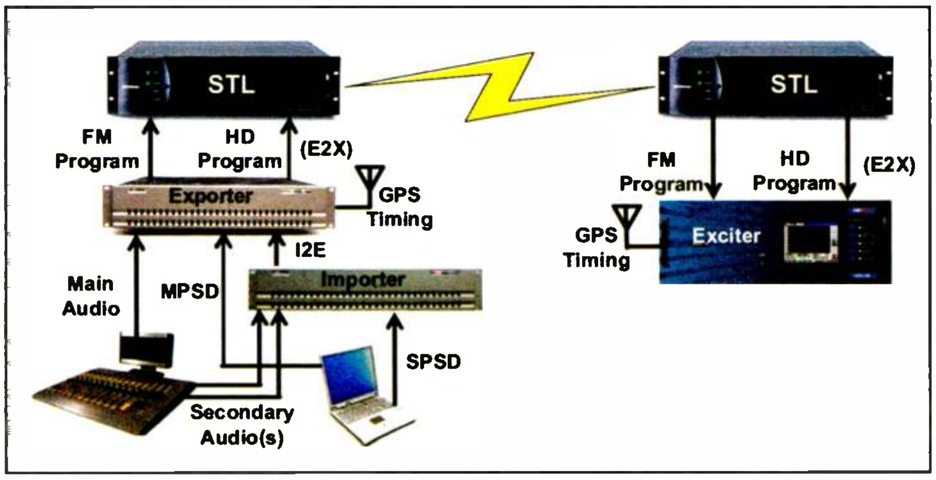

Fig. 5: Importer and Exporter at Studio (Scenario 4)

SERVICE MODE

The other major factor in determining the bandwidth required for HD Radio on the STL is the Service Mode. In the hybrid broadcast of an FM analog signal combined with HD Radio, the digital signal travels in the side lobes of the analog FM within the limits of the FCC mask. The Service Mode determines how many bits are used and where in the side lobes they are placed.

That subject is worthy of an article all to itself, but suffice it to say that there are currently three modes available, referred to by the acronyms MP1, MP2 and MP3. Within each Service Mode, the available bandwidth is broken up in different ways depending on the type and number of services being offered (Fig. 6).

MP1 mode provides 96 kbps of bandwidth that can be divided into multiple channels. The minimum requirement for the Main Program Service is 32 kbps, which leaves 64 kbps for the other program and data services. The minimum bandwidth for an SPS audio service is 10 kbps; however, any audio service running at less than 32 kb is going to be mono and anything less than 24 kb is not likely to sound terribly good, though there is a lot of work being done with very low-bit-rate codecs for speech.

Data Rates and Provisioning Required for Modes and Services

HD Protocol	Direction	IP Protocol	Service Mode	Avg. Bandwidth Kb/s	Provision Kb/s
I2E	Duplex	UDP	MP1 SPS 12Kb	13.0	17.3
			MP1 SPS 32Kb	34.9	46.6
			MP1 SPS 48Kb	43.5	58.0
			MP2 SPS1 12Kb	21.5	28.7
			MP2 SPS1 32Kb SPS2 12Kb	57.0	76.0
			MP2 SPS1 48Kb SPS2 12Kb	65.2	87.0
			MP3 SPS1 24Kb	36.5	48.6
			MP3 SPS1 32Kb SPS2 24Kb	69.4	92.5
			MP3 SPS1 48Kb SPS2 24Kb	77.7	103.6
		TCP	MP1 SPS 12 Kb	16.3	27.2
			MP1 SPS 32 Kb	37.6	62.7
			MP1 SPS 48Kb	53.8	89.6
			MP2 SPS1 12Kb	29.8	49.7
			MP2 SPS1 32Kb SPS2 12Kb	65.2	108.7
			MP2 SPS1 48Kb SPS2 12Kb	80.6	134.2
			MP3 SPS1 24Kb	42.3	70.4
			MP3 SPS1 32Kb SPS2 24Kb	78.2	130.3
			MP3 SPS1 48Kb SPS2 24Kb	93.3	155.5
E2X	Simplex	UDP	MP1	119.7	159.5
			MP2	132.1	176.1
			MP3	149.3	199.0
	Duplex	TCP	MP1	139.3	232.0
			MP2	155.6	259.2
			MP3	167.8	279.5

Fig. 6: Service Modes

Typically, stations use 48 kbps for the main program service, and the remaining 48 kbps for SPS services. This whole 48 kbps can be dedicated to just SPS1, or it can be further subdivided to a 24 kbps SPS1 and a 24 kbps SPS2. Alternatively, the original 96 kbps in MP1 mode could be divided up 32/32/32 or 64/32 or 64/16/16, or even further subdivided if AAS data services are in use. We expect that next year SPS3 will be introduced, giving the broadcaster even more options from which to choose.

MP1 requires ~232 kbps of TCP E2X transport bandwidth or 160 kbps UDP, no matter how it is divided up.

MP2 is an extended mode that provides an additional 12 kbps for services. Unfortunately, this extra bandwidth cannot be combined with the 96 kbps available in MP1, so it's not very useful except for data services. The E2X transport bandwidth requirement for MP2 is ~260 kbps TCP or 176 kbps UDP.

MP3 is a further expanded mode which provides 24 kbps of bandwidth on top of the MP1 allotment. As with MP2, this extra 24 kbps can't be combined with the original 96 kbps, but it can be used as a single extra 24 kbps channel, and thus could support a mono audio program. Stations might use this mode to run two audio programs at 48 kbps and one at 24. MP3 requires ~280 kbps of TCP transport bandwidth for its E2X signal, or 200 kbps in UDP mode.

This is the maximum that we have to be concerned with today, but we expect that an upcoming revision of the HD Radio standard will bring MP11. This will provide yet another 24 kbps data block in addition to the 96 in MP1 and 24 in MP3. Estimated transport requirements for MP11 are approximately 330 kbps in TCP mode and 240 kbps UDP.

Finally, a recently introduced transport layer protocol called HD Protocol (HDP) adds error correction and other techniques to further enhance the reliability of I2E and E2X transport, and provides support for IP distribution from a central studio to multiple transmission sites.

TRANSPORT TECHNOLOGIES

As previously discussed, there are several methods available for establishing an STL, each with its particular strengths and weaknesses. The 950 MHz microwave band is reserved for radio STLs in the U.S., but to use it you need both an available frequency and a clear line-of-sight path. T1 needs no line of sight or license, but it must be available from a local service provider and brings with it recurring lease costs. IP may be less expensive than T1, but high-reliability IP circuits such as MPLS may not be available. And using either T1 or IP over unlicensed microwave radios requires not only line of sight but also careful planning to minimize the chance of interference from other users.

We'll look more closely at each of these options below.

T1

The T1 bandwidth of 1.544 Mbps is subdivided into 24 time slots (sometimes referred to as channels or DS0s) of 64 kbps each, plus 8 kbps of overhead. The digitized but uncompressed FM stereo signal occupies 17 time slots, leaving seven

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Using the HD Radio Signal As an FM Feed

Since the introduction of HD Radio, some have asked why the digital HD audio signal could not be used to feed both the HD and FM exciters.

This can be done, but only by introducing a compromise that many find unacceptable.

The technology to extract the HD1 audio from the existing multiplexed E2X transport stream and feed it directly to the analog FM exciter is available today from some manufacturers; however, it means using a digital audio signal that has been highly compressed (typically to 48 kbps) for the FM signal, which is anathema to many broadcasters.

Another approach would be to digitize the FM signal separately from the HD1 using less compression and multiplex it together in the Exporter with all the rest of the HD programs into the E2X signal, so that only one IP stream needs to be sent across the STL.

This is in the long-term plans at iBiquity Digital, the developer of the HD Radio standard, but at this time there is no release date scheduled. As things look today, this would be a compressed 128 kbps low-latency channel using a form of Dolby compression. It will, of course, not be a requirement, as many broadcasters will still not be willing to give up the fidelity of uncompressed audio (or the ability to choose their preferred method of compression, if compression is to be used) for their primary program signal.

STL

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for other purposes.

Of the four scenarios described earlier, in Scenarios 1 and 2 (Main Program only with no Importer, or Importer at the studio and Exporter at the transmitter site), only a relatively low-speed digital signal (MPSD or I2E) needs to be carried alongside the FM signal, using at most three time slots.

Scenario 3, placing both the Importer and Exporter at the transmitter, requires carrying multiple audio programs and multiple data signals. This is achievable by using compression on the audio signals. With a high-quality audio compression algorithm such as Enhanced apt-X, all three audio programs (HD1, HD2 and HD3) can easily co-exist on a T1 line with their associated data.

For Scenario 4 (Importer and Exporter at the studio), we need to carry the E2X signal beside the analog FM. As we see from the numbers in the previous section, depending on the Service Mode (MP1, MP2, MP3, or MP11) and transport format (UDP or TCP), the E2X signal can range from 160 kbps to just over 330 kbps. This translates to three to six time slots in T1 terms, meaning it can fit comfortably alongside the uncompressed FM signal as long as the hardware allows that portion of the T1 to be configured as an Ethernet bridge.

However, as T1 systems are often used for additional purposes beyond the pure STL audio, it may be desirable to use compression to free up extra bandwidth. This can allow transport of multiple audio programs, provide telephone connectivity and enable remote control over the same T1 link. Many broadcasters find it expedient to establish two distinct Ethernet bridges across the T1: one to carry the E2X signal and one to carry all other Ethernet traffic, such as remote control data and LAN bridging. This ensures that nothing can interfere with the critical E2X packets.

All in all, T1 provides an excellent, versatile and highly reliable medium for an STL.

950 MHz

As with T1, digitization of the 950 MHz STL brings the ability to multiplex different types of programs together, and its capacity is thus, in many ways, comparable to that of a T1 circuit. But, unlike T1 with its fixed 1.544 Mbps capacity, the total bandwidth available on the 950 MHz STL is, in part, determined by geographic and environmental conditions, as well as differing technical implementations. In some cases it may be capable of transporting more data than a T1, and less in other cases.

The major difference is the lack of an inherent return path, which means that a basic 950 MHz radio link is unable, for example, to support TCP traffic. It also makes the traditional 950 unsuitable for STL use where intercoms, telephones or other two-way services are desired.

Typically, these digital radios use quadrature amplitude modulation (QAM) as a means of getting more carrying capacity over a given amount of RF bandwidth. QAM data is sent as binary symbols in a grid with the number of points in the grid being a power of 2 (2, 4, 8, etc). Common QAM forms are 16-QAM, 64-QAM, 128-QAM and 256-QAM. By moving to higher-order symbols or constellations, it is possible to transmit more bits in the same RF bandwidth (see the table in Fig. 7). However, in doing so the mean energy between points in the QAM constellation must be closer together and thus more susceptible to noise and other corruption. This results in a higher bit error rate (BER) so that all other things being equal, a higher-order QAM can deliver more data than lower-order QAM — but it does so with less reliability.

With the advent of HD Radio it is worth rethinking the whole design concept of the 950 MHz STL.

New, more powerful processing chips enable the introduction of more efficient error correction schemes such as low-density parity-check (LDPC) codes or turbo codes. In contrast to less-efficient error correction schemes, such as Reed-Solomon, LDPC can offer a clear advantage in terms of performance for a given signal-to-noise ratio.

QAM Order	Spectral Efficiency, Bits per Second per Hz	Raw Data Bandwidth (Mbps) with a 200 kHz RF bandwidth	Raw Data Bandwidth (Mbps) with a 300 kHz RF bandwidth	Raw Data Bandwidth (Mbps) with a 500 kHz RF bandwidth
4	2	0.4	0.6	1
16	4	0.8	1.2	2
32	5	1	1.5	2.5
64	6	1.2	1.8	3
128	7	1.4	2.1	3.5
256	8	1.6	2.4	4

Fig. 7: QAM and Spectral Efficiency

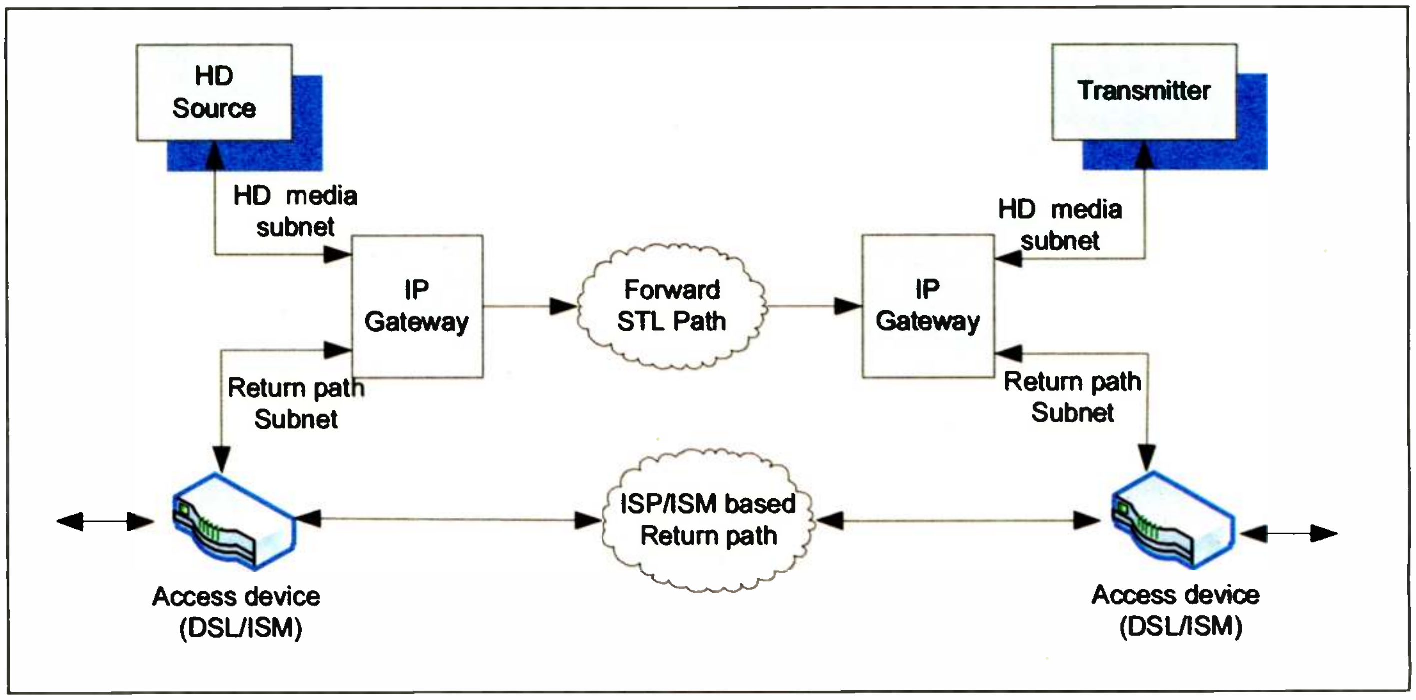

Fig. 8: Network Topology With Return Path

Specifically, for equal amounts of FEC overhead, LDPC requires 3 dB to 5 dB less signal for the same BER performance than does Reed-Solomon. In the real world, this can translate into using the next-higher QAM order while maintaining the same BER and RF power level.

Since the 950 MHz paths are generally assigned only in the forward STL direction, a combined FM/HD STL offers maximum flexibility when it supports duplex data traffic such as TCP. It behooves us to find a means of establishing a reverse or backhaul data path from transmitter to studio that integrates smoothly with the outgoing 950 MHz path.

This reverse link can be achieved in any of several ways. It can employ radios in other bands, such as the license-exempt 900 MHz ISM band, which is close enough to the licensed 950 MHz band to "piggyback" on the same antennas and cabling; other license-exempt radio links that may be in use for LAN/WAN traffic; an inexpensive DSL link from a managed IP service provider, as shown in Fig. 8; or via a corporate WAN.

Sometimes overlooked in current 950 MHz digital STLs, however, is the fact that for this to work well the STL should contain an IP gateway architecture that allows the effective integration of any of these sorts of return paths. This integrated IP gateway needs to manage the available bandwidth and allocate it appropriately among the various traffic types: audio for the FM and, depending on the component locations, the HD program(s); IP data for the I2E or E2X HD Radio signal; and other IP data, such as control and management, and even LAN traffic.

It is imperative that the gateway's architecture supports features such as filtering of unwanted Ethernet traffic, policing and shaping of the incoming Ethernet traffic, and prioritization of all traffic so that the low-priority traffic does not interfere with the media related traffic. It also needs to address the fact that the HD Ethernet traffic may be "bursty" or variable in rate, and thus requires smoothing.

Another thing to consider is that when a low-speed data path such as a DSL is available alongside a 950 MHz STL, the same management mechanism that handles TCP return traffic under normal circumstances may be used to switch all traffic, both FM and HD, to the alternate data path in the event of catastrophic STL link failure. While less reliable and often lower capacity than the main STL, this at least would provide some degree of backup during an emergency.

Harris Corp., under the aegis of its Intraplex products line, is introducing a new 950 MHz STL product, HD Link, specifically designed to incorporate these new types of features.

IP

Internet Protocol (IP) is a packet network protocol originally designed for data transport, and as such presents particular challenges in carrying real-time, mission-critical signals such as are required by STLs.

Some of these issues, such as network jitter, are eliminated by using dedicated point-to-point services such as microwave radios. But when the IP transport is provided over a shared network from a service provider, reliability becomes a serious problem.

In general, only networks that support the Multi-Protocol Label Switching (MPLS) protocol are suitable for use as STLs. MPLS allows network service providers to guarantee users a fixed amount of bandwidth at an assured quality of service level. Such services can come close to the reliability of T1 at a lower cost, and as such have become increasingly popular, where they are available. Techniques such as Forward Error Correction (FEC) can further enhance reliability, albeit at the expense of increased bandwidth.

On an MPLS network, you can get as much duplex bandwidth as you are willing to pay for, so it can easily support any of the component placement scenarios. But even here, the one-time, up-front cost of audio compression may be preferable to the higher recurring costs of greater network bandwidth.

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What's a T1?

T1 was originally developed as a means of digitizing and transporting telephone conversations. Each telephone connection became one 64 kbps time slot, so a T1 enabled 24 conversations to be carried at 1.544 Mbps over two twisted pairs of wires. It is still the standard basic building block used by telcos in the U.S., Canada and a few other places. E1 is a similar protocol that allows the transport of 30 telephone connections at 2.048 Mbps, and is the standard throughout most of the world outside North America. When connecting to radios that do not interface to the public switched telephone network (PSTN), either standard may be used, and broadcasters often prefer E1 because they can get 25 percent more bandwidth at the same price as T1.

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LICENSE-EXEMPT RADIOS

License-exempt radios (often referred to as spread-spectrum radios, though this is only one of the technologies such radios employ) are available for several frequency bands, most commonly 900 MHz, 2.4 GHz and 5.8 GHz.

While all are freely available for use by the general public, the lower two, 900 MHz and 2.4 GHz, are part of the ISM (Industrial, Scientific, and Medical) bands, originally intended for use by devices that emit electromagnetic radiation for purposes other than telecommunications, while 5.8 GHz is a communications band used by, among other things, the emerging WiMax standards.

As the radio STL bands grow more crowded, we can expect to see more attention paid to recently introduced radios in the 5.3 and 5.4 GHz bands. Although these license-exempt bands have strict power limitations that preclude their use for long-distance shots, they may prove quite useful in crowded but short-distance urban environments.

All other things being equal, the lower the frequency, the greater the distance over which these radios can operate; however, both the 900 MHz and 2.4 GHz bands are more likely to encounter interference from other devices, including cordless telephones and microwave ovens, so most broadcasters these days are opting for 5.8 GHz. These radios offer standard network interfaces on the user side, most commonly Ethernet (IP), and in many cases T1 or its higher-bandwidth variant, E1 (see sidebar on page 18).

On a well-designed microwave link, using either the T1/E1 or IP ports provides the same capabilities and carries basically the same limitations as for land-line T1 and IP described above. On the IP side, MPLS is not required, as there is no network through which the IP packets need to get routed. However, although the E2X signal is a packet stream that can be routed through the Ethernet port directly, many broadcasters prefer to use the T1/E1 ports to carry their audio. An Ethernet bridge within the T1/E1 for the E2X signal keeps the actual broadcast signals separate from LAN and other traffic that they may be transporting when using the radio's Ethernet port.

One thing that differentiates license-exempt radios is whether they use Frequency Division Duplexing (FDD) or Time Division Duplexing (TDD).

FDD radios use a pair of frequencies with a guard band between them, one for transmit and one for receive, while TDD radios use the same frequency half-duplex at alternating 0.5 mS intervals. TDD radios thus make better use of the available bandwidth, and have more flexibility when seeking out a "clean" frequency on which to operate. FDD radios also tend to be frequency-specific in their hardware, while more modern TDD radios tend to be software-tunable.

Another characteristic to look for in these radios is whether the modulation scheme they use is Single Carrier (SC) or Orthogonal Frequency-Division Multiplexing (OFDM).

SC systems use a single carrier frequency to carry all the data sequentially, while OFDM uses multiple carriers to transport the data as interleaved orthogonal signals. OFDM modulation provides greatly enhanced resistance to multipath interference, and even allows the radios to operate under near line-of-sight (NLOS) conditions, where more traditional radios require clear line of sight. OFDM also incorporates FEC for enhanced reliability.

IN SUMMARY

There are a number of ways of establishing an STL that can support both legacy analog FM and HD Radio. While T1 provides the most reliable system to support all the possible equipment placement scenarios, a digital 950 MHz link can handle most of them as well, and the newer IP and license-exempt radios open up yet more options. Which system is right for your station depends on three things:

1) Technical considerations, such as which HD services you choose to put on the air and where you decide to place the Importer and Exporter.
2) External constraints such as line of sight, availability of 950 MHz licenses and T1 access to the transmitter site.
3) Commercial factors such as the recurring costs of land lines vs. the up-front cost of wireless.

The choice is yours.

CREDITS

This article includes information from papers by the same author that were presented at the 2008 and 2009 NAB Broadcast Engineering Conferences.

The author would like to thank iBiquity Digital Corp. for their kind permission to include diagrams and information from their white paper entitled "HD Radio Data Network Requirements," by Tim Anderson *et al.*

THE ENGINEERING BLOCK

A DAY IN THE LIFE

by Cris Alexander

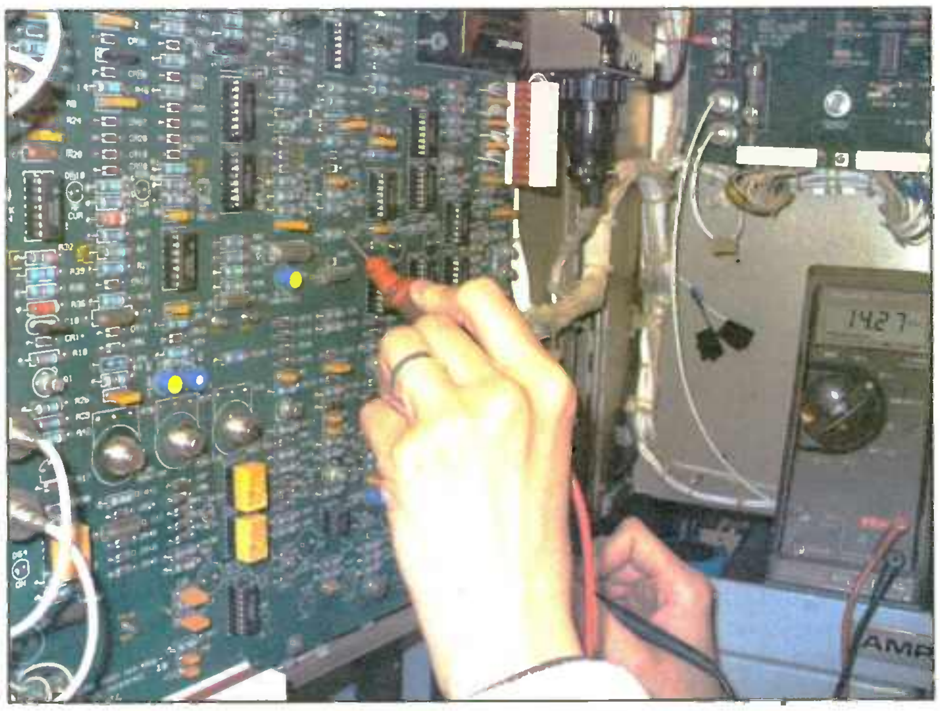
A Return to In-House Repair

With Budgets Tight, Dust Off That Workbench for Some Savings

Things have sure changed over the past year. The first few months of 2009 have not been kind to our business. Along with shrinking revenues we have seen layoffs, pay cuts and slashed budgets. We are all being asked to do more with less.

In the radio business, engineering often is viewed as a necessary evil; indeed to some degree it is. Of course we know that without a properly engineered and reliable facility, a radio station cannot successfully compete. And yet it is hard for some to make the connection between the costs of engineering and station revenues. With revenues falling, the pressure is now on to reduce those costs.

The good times of recent years, along with advances in technology, have changed the way engineers work. Think about it for a minute. In recent years, other than transmitters, how many pieces of equipment have you repaired in your shop and how many have you returned to the manufacturer or sent out to a repair depot? Why is that?



Radio engineers will have to dust off rusty troubleshooting skills.

MODULE SWAPS: EFFECTIVE BUT EXPENSIVE

Part of the issue is technology.

Much of our modern broadcast equipment is constructed in a way that makes it difficult to troubleshoot in the field, much less repair.

Manufacturers have geared themselves to swapping out modules and circuit boards rather than the traditional model of supporting the engineer in the field with repair parts.

And let's be honest here: Most engineers have enjoyed this arrangement. It has freed us from the time-consuming process of troubleshooting and repair down to the component level. From the manufacturers' perspective, it eliminates a lot of the "over-the-phone training" that often takes place when one of their customer support techs has to talk a relatively unskilled person at the station through the troubleshooting process.

Except for the expense, it's been a good arrangement for a lot of folks.

Another reality is that many of the subassemblies used in today's broadcast equipment are no longer even made at the factory where the transmitter, mixer or other equipment is assembled. Power supplies, power amplifiers and other major subassemblies are purchased by the equipment manufacturers and assembled in the equipment.

My company recently purchased a couple of new transmitters from a major manufacturer that has been around the broadcast transmitter business for a lot of years. Open the back door of these units and you'll find entire subassemblies with another manufacturer's name on them. Generally speaking, these subassemblies are not field-repairable. Even the transmitter manufacturer simply swaps them out, sending defective or damaged units back to the source for repair.

The problem with this equipment support model is that it is expensive. In recent years, I've had repair invoices cross my desk that I just about choked over. So much of this kind of thing is done at a "flat rate" or on an exchange basis.

With the "flat rate" model, the repair charge is a fixed amount no matter what, whether it involves only the change of a 29-cent resistor or a $300 DSP chip. The flat rate is set high enough that the manufacturer or repair depot will always make money.

The exchange model is internally similar. For a fixed amount, the manufacturer will swap your defective module with a ready repaired and tested module. The manufacturer then repairs and tests the defective module for the next customer.

Whichever model is used by a manufacturer, the customer pays for the convenience, and this does nothing but add to the "cost center" image of radio station engineering departments.

DIY

As we face a tightening economy, to remain financially viable we are going to have to find ways to reduce these costs, and one way has to be getting back to the in-house repair model. That's not possible with every piece of equipment, but it

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Repair

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is with a good many.

This process begins with directing our mindset away from what we have become accustomed to. Our thinking has got to be that we will make every effort to repair the device ourselves; factory repair becomes the last resort.

We're going to have to clean off our workbenches. Many times, I walk into the engineering "shops" of our station clusters and find the workbenches covered with everything; the bench is used for anything except the repair of equipment. Tools and test equipment are nowhere in sight — who needs them?

We're going to have to remedy that. Get the tools organized and the test equipment — DVM, oscilloscope, etc. — arrayed and ready to use in a hurry.

And we might do well to invest in some tools and soldering equipment (and a lighted magnifier) to work on surface-mount technology (SMT) circuits and components.

Some of this might require a "sales job" on station management, explaining that modern circuit construction techniques require specialized tools and equipment to repair. The old pencil-iron and needle-nose pliers may not be adequate for a lot of today's equipment.

Next, we're going to have to dust off our rusty troubleshooting skills.

This may be the biggest mental hurdle for many of us. Because we haven't done a whole lot of component-level troubleshooting in a while, we may think we've lost the touch, and this is probably true to some degree. But like a lot of other skills, these will return with use quickly.

I have sat at a desk for a lot of years. It's been close to 15 years since I have done any serious troubleshooting and repair work.

Early this year, one of our transmitters on the West Coast was giving us no end of grief, something in the control circuits, and at the request of the station chief engineer, I hopped a plane west to have a look for myself.

As I began probing the circuit board, I initially was apprehensive; but I gained confidence as I worked my way through the circuit, following signals through gates, comparators and logic circuits.

Before too long, I found where a signal simply disappeared. It was present on the end of a pull-down resistor on the input of an inverter but was not present on the inverter input pin. In the final analysis, a solder joint that looked perfectly good was a perfect insulator. Re-soldering the joint fixed the problem and got the transmitter running again.

Those long-unused skills quickly came back to me with a little exercise, and I found myself enjoying it.

Another consideration is a ready supply of replacement parts. In most locations, the days of running down to the local supply house and getting the needed parts are long gone.

In Denver where I make my home, good luck finding a real electronic parts supply house! I suspect the same situation exists in many other locations.

We have come to rely on Mouser, MCM, DigiKey and the like for our parts needs. These national vendors carry a huge stock from a wide selection of manufacturers; but it takes time to place the order and have it shipped in. Adding overnight freight to the order just runs the cost up.

A better solution is to maintain a ready stock of the "usual suspects." You should have a good assortment of 1/4-watt carbon resistors on hand in all the standard values from 1 ohm to 1 megohm. I would think you should also have a good assortment of SMT resistors on hand as well. A good selection of electrolytic and tantalum capacitors along with a few SMT capacitors should also be in the parts bin.

In recent years, how many pieces of equipment other than transmitters have you repaired in your shop? How many have you returned to the manufacturer or sent out to a repair depot?

That takes care of the "generic" stock.

Then you need to maintain a list of the parts that commonly fail in equipment that you maintain. "Mission critical" parts, one or two of each type of semiconductor for example, should be kept on hand for transmitters and other key pieces of equipment. When you use a part from this stock, immediately order a replacement.

Watch for parts obsolescence. Many times, production will cease on a particular key part.

I remember back in the mid-1990s, a particular voltage-controlled amplifier IC that was used in a then-popular audio console went out of production. The only replacements available were those on hand at the console manufacturer, and that stock quickly was depleted, essentially orphaning the console. Some engineers were watching and knew this was about to happen. Those individuals were able to order in a good stock of replacements, keeping their consoles running for many more years.

Finally, we have to train the next generation.

How many engineering assistants working in today's stations and clusters have primarily IT training? Do these folks, even if they have basic electronics training, know how to troubleshoot to the component level? Unless someone has taken the time to teach them the art, their troubleshooting skills are likely limited to "point and click" and wholesale equipment/module swaps.

Don't miss the opportunity to show these up-and-comers how to do it.

Unless we get back to DIY repairs of our studio and transmitter equipment wherever possible, we consign our engineering operations to becoming shipping departments rather than engineering departments, and that in turn impacts our value to our employers.

We can't fix everything in the field, but where it makes sense, we've got to try. In the process, maybe we can stretch just a little more life out of some of our equipment. That's worth something in the eyes of station owners and stockholders.

That is what we're all going to have to get back to in this tough economy. By repairing everything that we can in the field, we'll save our employers a bunch of money, increase our value to them and reduce our "cost center" image.

In the process, we just might find ourselves with a sense of satisfaction in our jobs that we haven't felt in a long time.

Cris Alexander is the director of engineering at Crawford Broadcasting Company and the SBE's Broadcast Engineer of the Year. ■

Interact

CONTINUED FROM PAGE 22

internal substrates.

The tone of voice arises from a different substrate than the rational engineering content and is received by other substrates. A logical argument may be composed by the neo-cortex, but the auxiliary emotional channel is also transmitting our internal emotional state. The listener decodes both the content and auxiliary channels. The emotional channel might hijack the content if the suggestion seems to be a threat to career advancement. However, the speaker may incorrectly assume that only the rational substrates of his colleagues are receiving the input.

All interactions with people are always taking place on two channels: rational and emotional. None of us can shut down the emotional channel regardless of our desire to do so. Emotional broadcasting is an always-on transmitter. We and the other mammals evolved that way.

RECOGNIZE EMOTIONS TO BUILD SOFT SKILLS

Engineers and scientists love to assume that professional conduct should be stripped of emotions so that a rational dialog results. Oddly enough, medical evidence now shows that emotions are even required for such simple tasks as driving an automobile. Those with injuries to their emotional substrates cannot do the most basic of tasks.

Take a simple example. You are driving along a crowded street and see a child in front of your car. Without emotions, the driver would not care if he hit the child or crashed into a parked car.

Emotions are simply the answer to the question "Why should I care?" If you do not care about anything, you cannot function. It takes many brain substrates to be a human being.

With practice, one can be proficient at recognizing the interactions between people. For those without an intuitive ability to observe such interactions, one can spend a little time learning the skill so that it eventually it becomes automatic.

During your next meeting, take a few minutes quietly to analyze the interactions, and then make a system model of what you observed. You may also notice how different stimuli produce different responses, not unlike a technical system. Devote at least 50 percent of your attention to the emotional channel.

If hard and soft skills draw upon the same system techniques, why are engineers known for not having good soft skills?

For me the answer is two-fold: (a) elements in a social system have different rules than hardware and software elements, and (b) we are each in the system that we are observing. With a little effort, an engineer can learn to adapt their skills to handle both issues. ■

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by Barry Blesser

A System Model for Human Interactions

Understand People to Become a Better Engineer

In my previous Last Word article (Feb. 18), I introduced the value of soft skills. It is now time to merge those concepts with hard skills by drawing upon our engineering training.

While people and technology skills initially appear to be unrelated, they are built from the same underlying principle: modeling complex systems and their elements to predict their behavior.

It took me 40 years to appreciate the value of soft skills. Having grown up in a household that did not emphasize them, I did not know how useful they were. My parents were trained as chemists, and were comfortable with the physical world. For us, people were unpredictable and mysterious.

While studying electrical engineering in college, I discovered that electrical and mechanical systems were easy to understand. Physical models were useful for predicting results, even with large and complex systems.

Now, after experiencing life for half a century, I realize that people in a complex organization are nothing more than elements in a system, albeit a social system with its own rules and models.

Both a capacitor and a person have states that arise from their history. When their history is combined with an input, they both produce an output. A model of a complex system has high predictive value if, and only if, the model embodies accurate rules of its elements. Rules for people and rules for hardware or software are very different, but nevertheless they are rules that can be examined and codified.

KNOW YOUR TYPES

What are the rules for people in a social system?

Each person has criteria for the kinds of transactions that will produce personal gratification and rewards. A nurturing engineer delights in helping others; a creative engineer thrives with the opportunity to push the state of the art; an obsessive engineer feels good when cataloging each detail of a project; a charismatic engineer thrives as a group leader.

iStockphoto.com / Sirin Buse

The list goes on.

Depending on the individual's personal value system, when faced with an input, he/she will produce a response based on their personal criteria for enhancing well-being and comfort. The stimulus and response are tightly coupled for each type of personality.

There are many catalogs of personality types, and it is worthwhile getting a feeling for the differences. The Web site *www.personalitypage.com/personal.html* provides a list of 16 types based on the Myers-Briggs classification system, which includes Duty Fulfillers, Guardians, Nurturers, Caregivers, Mechanics, Doers, Performers, Artists, Executives, Scientists, Visionaries, Thinkers, Givers, Protectors, Inspirers and Idealists.

Which type are you? Your supervisor, your spouse and your best friend? You can click through on the list to see a discussion of each type. Most of us are a mixture of a few with one or two dominating. Each personality type can be modeled.

The next step introduces the idea that every human interaction can be modeled as a transaction with multiple stimuli and responses — you do this for me, and I will do that for you. Your verbal output and body language are inputs to me, and I respond according to those inputs and my cognitive state. My response then becomes an input to your system.

Social interactions are feedback systems. Even the most trivial discussion can be modeled as a feedback transaction where the choice of what, when and how to speak is a component of a transaction.

Of course this becomes more complex in a group where each person is an element in a more complex system having multiple elements and a variety of transactions. But the social dynamics in a meeting are similar to a computer operating system with hundreds of modules connected to each other. There too, messages fly around giving the composite system predictable and useful results.

WATCH AND LEARN

If my analogy between a computer and human system is correct, why isn't this obvious? The simple answer is that most of us find it difficult to be an element in a system while simultaneously observing the system as an outsider would observe it. But one can learn to do both, which I call being "split-brained," by simultaneously participating and observing. The key element in playing this dual role is in slowing time so that you can observe both the system and yourself.

Without slowing time down, one is likely to simply act and react using the first choice that comes to mind without first exploring the likely consequences of actions and reactions. But if one stops for a second to compose a list of choices, one realizes that some choices are better for achieving the desired outcome than others.

Should I say something immediately or remain silent, thereby giving someone else a chance to speak? Should I ask a focused question or should I lead an open brain-storming discussion? Which choice is best given my values and personality?

Most people do not slow time down enough to engage their rational neo-cortex in making decisions. The animal brain stem is fast responding; the neo-cortex is slow. Managing time is the key to learning soft skills, which is often nothing more than creating a list of choices, picking the one that matches your values, and then acting on that choice. By managing your relationship between your responses to stimuli, you in fact change the system because you are also in the social system.

It is now time for a neurobiology digression.

While we each think of ourselves as a holistic and unified "me," in reality our head is actually composed of dozens of brain substrates each of which communicates with other substrates.

This communication is less than perfect. Our language substrate is only one of many, and it only has limited information from the other substrates.

Our consciousness is a bit like the dashboard of an automobile, providing some information about the engine's state, but not all.

For example, your language center has no input from the part of your brain that monitors blood sugar. You can observe that your stomach is rumbling, and you can infer your need for food, but there is no direct input from the substrate that regulates energy.

Nature evolved a brain system that optimized survival, not conscious awareness and rational thought. Under real or imagined pressure and threats, our fast-responding emotional substrate controls behavior. If our ancestors perceived a threat, immediate action was required; for example, choosing among the classical fight, flight or freeze response. Thinking takes too long. Activating biological readiness is entirely unconscious and virtually instantaneous.

If you are interested in what modern science knows about the system in your head, read Robert Sapolsky's book "Why Zebras Don't Get Ulcers." Even if you only browse the text, as an engineer you will come to appreciate that our brain is also a complex system composed of multiple elements each of which follow simple rules.

Let us explore the implications of our new model in the context of a meeting among engineers and their manager. Each person in the room is actually a few dozen brain substrates, each of which can and does communicate with the other substrates in the room as well as with

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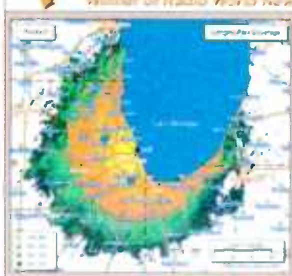

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June 10, 2009

WHITE PAPER

Tube Amplifier Ideal For High-Power IBOC

Design Offers High Efficiency and Low Operating Costs for Low-Level Combined HD Radio

by Geoffrey Mendenhall, P.E.

The author is vice president of transmission research & technology at Harris Broadcast Communications in Mason, Ohio.

This paper traces the process of selecting the technology and developing a new high-power VHF transmitter for the common amplification of FM+HD signals. It also explains the application of new, high-power RF amplifier and power supply technologies to elevated HD Radio sideband transmission.

Why increase the HD Radio sidebands?

Recent interest in fully replicating analog FM coverage with HD Radio in difficult receiving locations has led to a proposed 10 dB increase in the HD Radio sideband levels that accompany analog FM transmissions.

Increasing the HD Radio sideband levels by 10 dB poses significant equipment investment, energy cost and transmitter site floor space challenges to broadcasters.

Our mission is to find transmission solutions that minimize the initial investment and ongoing operating cost for broadcasters to increase their HD Radio coverage.

There are a number of different combining methods available today, including space combining, high- or split- (sometimes referred to as mid-) level combining and common amplification of FM+HD signals. While space combining may be the most efficient means, it has its own limitations such as tower space requirements and signal level mis-tracking between FM and HD. High-level combining would not generally be considered an

SEE TUBE, PAGE 8

FIRST PERSON

Light It Up at the Mall

Early Test of WiMax Shows Potential for Remotes

by Tom Hartnett

The author is technical director at Comrex.

We've long heard rumors of a new, ubiquitous wireless data network on the way called WiMax, and we at Comrex have been longing to spec out its performance using our Access IP codecs. I got my chance recently when I received a WiMax Express card for testing.

The first widespread commercial deployment of WiMax technology is coming from a division of Sprint Wireless dubbed Xohm. They currently offer commercial

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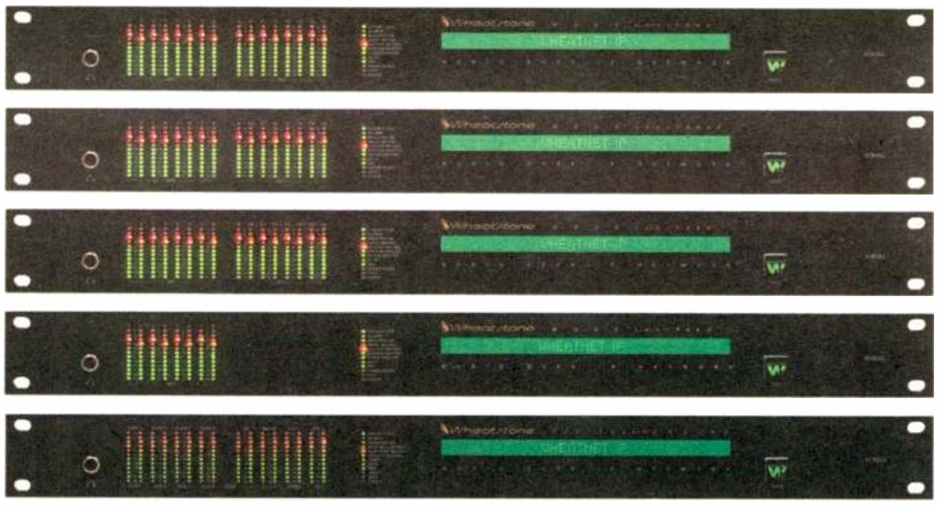


AUDIO-OVER-IP ROUTING. SOME TECHNICAL STUFF.

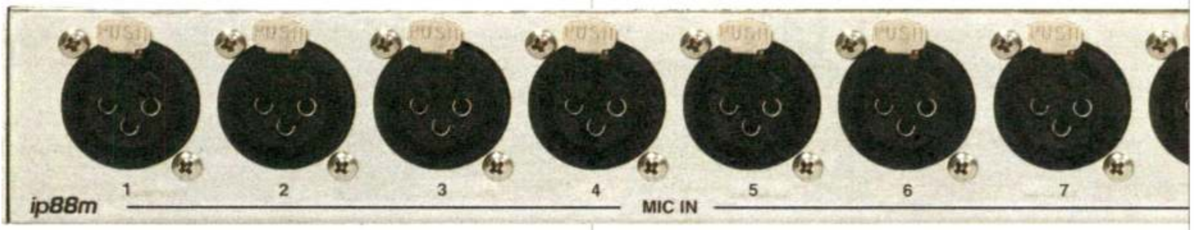
WHEATSTONE and WheatNet®-IP

WheatNet-IP is the new name for Wheatstone's Audio-over-IP networking, routing, and mixing system. First introduced at NAB 2008, it now accounts for the vast majority of networking systems that Wheatstone quotes and installs.

First, a quick overview, and then why WheatNet-IP has been so successful, not only in converting Wheatstone's loyal clients to AoIP, but also in convincing clients of the superiority of Wheatstone's technology over other choices.

WheatNet-IP BLADES

We call our I/O and mixing hardware and software "BLADEs"... way beyond the cutting edge, they're sharp and to the point (and yes, pun intended). Each BLADE is designed for a specific function—we don't cram unrelated tasks into one box making a central point of failure; we all know about "putting all your eggs in one basket."



BLADEs are access points in and out of the network. They interface seamlessly with Wheatstone's Evolution Series Console Control Surfaces, the Glass-E Virtual Console Control Surface, most of the popular automation systems, and streaming audio.

Three BLADES are line level I/O interfaces, one all analog, one all digital, and one half of each. Our newest BLADE provides mic level inputs. A fifth hardware BLADE mixes the audio for a Wheatstone console control surface. Each of the BLADEs and each Wheatstone console control surface connects to the network with a single CAT5E/6 cable.

BLADES are loaded with lots more sharp features: Each includes two 8x2 virtual utility mixers that can be used for a wide range of applications, a front panel headphone jack with source select and level control to monitor any system source, SNMP messaging for alerts, and silence detection on each output that can trigger alarms or make a routing change.

There's also WheatNet-PC, a software BLADE that you install on automation system computers, news workstations, or even the PD and GM's desk computers—to control, play and record audio on and off the network. It eliminates the expensive sound card, and replaces tons of audio and control wiring with a single CAT5E/6 cable.

EASE OF INSTALLATION

The relatively small channel count of each I/O BLADE allows you to conveniently locate it close to your equipment. In TOC/Master Control, there's no need for a back wall full of punch blocks, a BLADE (or occasionally two) in each rack keeps audio and control wiring entirely within the rack, allowing for a fast and clean build-out. In the studio, usually just one line-level BLADE is required; they're silent, so you can locate them with live mics.

FAST AND SIMPLE SETUP

Wheatstone's goal was a system that's extraordinarily easy to implement without the need for super-complicated network engineering, and where you don't need to be concerned about setting priorities to assure that those signals that are most critical are available.

WheatNet-IP setup is easy, intuitive, and takes only a few minutes until you're on the air. The front panel setup wizard in each BLADE gets you up and running in moments. Extensive front panel metering and status indicators provide quick confirmation that all is well. WheatNet-IP's web interface and WheatNet-IP Navigator software let you further customize your system, locally or remotely, with input and output names, logic associations, routing and much more.

RELIABILITY

Audio everywhere all the time, and keeping you on the air, were foremost in the design of WheatNet-IP.

Wheatstone chose Gigabit Ethernet (1000BASE-T) because 100BASE-T just can't simultaneously handle the large number of audio channels prevalent today in large broadcast plants without the very real risk of audio not being available when you need it. Gigabit protocol means all audio everywhere with extremely low latency.

WheatNet-IP is completely self-contained—no PC is required to perform any of the system functions, including routing, mixing, salvos, and logic control. The PC is needed only for configuration changes.

Each BLADE carries a complete map of the entire connected network in its onboard CPU flash RAM. Talk about redundancy, a system with 36 BLADEs has 35 backups! Need to replace a BLADE? Assign its ID number and connect it to the network—it will query the other connected BLADEs and import all the necessary configuration settings!

BLADES

ip88m ANALOG MIC I/O BLADE: 8 fully balanced reference-grade mic preamps with phantom power, 8 analog outputs, 12 universal logic (GPIO) ports programmable as inputs or outputs, routable throughout the system.

LINE LEVEL I/O BLADEs: 16 input channels, 16 output channels (switchable 8 stereo, 16 mono, or any combination), and 12 universal logic (GPIO) ports.

ip88a ANALOG I/O BLADE: 16 analog in/out.

ip88d AES DIGITAL I/O BLADE: 8 AES (16 channels) in/out.

ip88ad ANALOG & DIGITAL I/O BLADE: 8 analog in/out, 4 AES (8 channels) in/out.

ip88e WheatNet-IP MIX ENGINE BLADE: Handles all of the mixes from Wheatstone Evolution Series Console Control Surfaces and the Wheatstone Glass-E Virtual Console Control Surface, distributing the four stereo PGM, four stereo AUX SEND, per-channel MIX-MINUS, monitor outputs and other bus signals to the network. Once on the network, they are available as sources and outputs anywhere. This creates an extremely flexible system, where program outputs from one surface can be a source on any other surface; for example a news mixer's program bus as a source on the air studio surface. While the ip88e doesn't house audio I/O, it does include 12 universal logic (GPIO) ports.

WheatNet-PC BLADE: Installs on Windows PCs to replace the sound card; interfaces eight stereo audio signals in/out, plus automation control data (start, stop, etc.).

Audio Networking—Simply Evolved

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FROM THE TECH EDITOR

by Michael LeClair

Monday Was Like Tuesday

NAB Show Quieter but Still Valuable

Photo by Bob Kovacs

Monday was like Tuesday, Tuesday was like Wednesday, Wednesday was like Thursday and no one knows what Thursday was like because no one showed up. I'm talking about the NAB Show in April of course, and the common perception amongst attendees that it was smaller and quieter than usual.

According to the official numbers, just over 83,000 showed up for what is broadcast engineering's premiere conference event. That is down about 20,000 from last year.

My own impression was that the North Exhibit Hall, home of the radio and audio exhibitors, got off to a slow start, but in the end it was a productive show for most. I have to admit that it was much easier than usual to talk to many vendors about specific products for the items in my station's budget. And some booths around the edges of the exhibit floor seemed abandoned. But those manufacturers with new and innovative technology were as mobbed as ever, with lines formed around their booths to see new equipment.

> The Banners Index, or the wait to get lunch, was as long as ever during the days when the exhibit floor was open.

I have one other informal attendance metric. The Las Vegas Convention Center has a small restaurant near the North Hall known as Banners. The Banners Index, or the wait to get lunch, was as long as ever during the days when the exhibit floor was open. No signs of recession there.

On the other hand, there were a number of stalwart radio companies that simply didn't show up this year, such as QEI and TFT. Their absence was a bit disturbing.

The reason for numbers being down this year is quite obviously related to the recession that is battering the economy as a whole and radio in particular. Radio stations and groups have cut their travel budgets to the bone in order to keep other cuts at a minimum.

From my own hometown of Boston, I think that maybe three or four radio engineers went this year; in normal years that number would have been 10 to 15. These cuts have hit radio particularly hard.

Friends I have seen in Las Vegas for many years were not able to make it this year, and the ones who did travel to the show often did so on their own nickel. Happily, hotel rates were the lowest I have seen in years, so those who decided to travel on their own, and perhaps even use vacation time, were at least able to find many bargains on housing. Some rooms were going for as little as $40 per night.

For those with expertise in finding a free meal around the show (a conference art form), attending really didn't have to cost too much, especially if Las Vegas is within driving distance. For those trying to minimize all their expenses, the show became a kind of guerilla experience, some even forgoing the usual cabs to and from the convention hall for public transit on the city bus. Now that's dedication.

CONFERENCES STILL EDUCATIONAL

In spite of the smaller attendance, the Broadcast Engineering Conference, which is at the heart of the NAB Show, was just as good and as educational as always. The list of important engineering papers was as long as ever.

In my opinion, the most important topic of the show was the various approaches to building high-power digital radio stations and the effects this would have on radio. It appears likely that some form of high-power digital broadcasting will be approved within a year and there was plenty of information for those of us who will have to build

SEE NAB SHOW, PAGE 18

Photos by Jim Peck

Top: Don Hanke of the Heartland Media Group sets his watch to the NTD24S-POE clock display at the Masterclock booth. Middle: Consulting engineer Larry Will asks a question of BIA's Sid Shumate, who spoke about HD Radio reception at various power levels. Bottom: Matthew Stadtmuller of Clear Channel in Salt Lake City visits the iBiquity booth and inspects the Jensen JiMs-525i docking digital HD Radio system for iPods and iPhones, with support for iTunes tagging.

IN THIS ISSUE

A DAY IN THE LIFE

by Cris Alexander

Prepare to Model Your AM Array

Practical Tips to Guide You When Considering the Use of Moment Method Modeling

We are now several months into the new AM technical rules that permit moment method modeling of eligible AM directional arrays.

The first model proofs were filed almost immediately after the February effective date, and many (if not all) of the stations that have filed are either operating under program test authority, an STA or a new license as a result of those filings.

These months have been a time of learning for engineers throughout our industry, from consulting engineering firms, all the way to station engineers doing the field work associated with the modeling. We are learning what works and what doesn't, what policy decisions the FCC needs to make with regard to the new rules and specific solutions to special cases.

And so, with these months of experience behind us and many years of modeling in front of us, it occurred to me that perhaps this would be a good time to take a fresh and practical look at the modeling process.

In doing so, I would hope to help those contemplating this option to make the right, informed decision and get the horse before the cart as they start down the modeling path.

PRECEDENTS

There are several precedents to employing the modeling option. Some of these are in the rules and have been well-publicized (and some have been well-misunderstood!) but I won't belabor them here. Do keep in mind, however, that only series-fed arrays are eligible. If your array employs skirted or shunt-fed towers, forget it.

But beyond what's in the rules are several key prerequisites that figure heavily into the cost/benefit analysis. I have learned the hard way to look at these first!

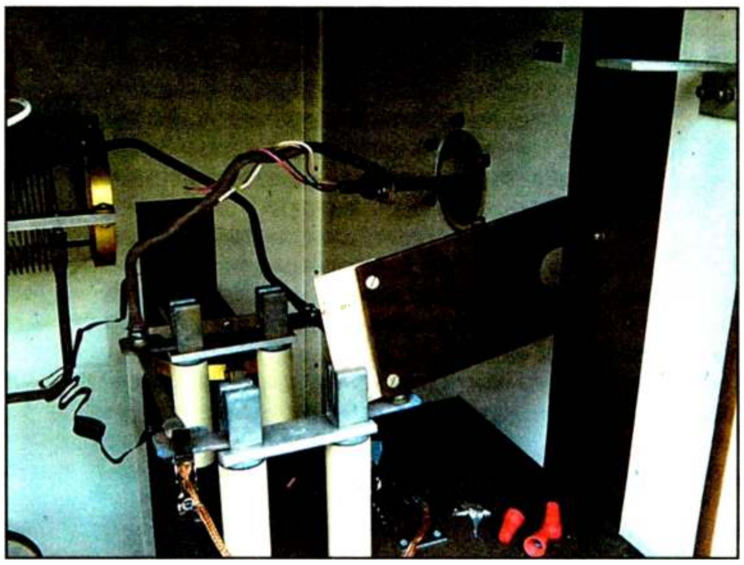
Item number one is the as-built tower geometry. The new rules require that a surveyor's or engineer's certificate be submitted showing the actual array geometry. While the rules don't specify a tolerance, the Media Bureau seems to be using 1.5 electrical degrees as the cutoff point — if each tower in the array is inside a 1.5-degree circle centered on its design position, you're good to go; if not, then your only option may be to redesign the pattern based on actual tower locations and go through the 301 application process. That adds a lot of time and expense to the process, and thus, is an important first step in the evaluation process.

So you've sent the surveyor out to provide you a sealed drawing of the array geometry and he hands you one showing the actual distances and bearings between array elements. How does one go about getting from there to the variance from the design location in terms of absolute distance? I've found that the easiest way is to convert to X-Y coordinates.

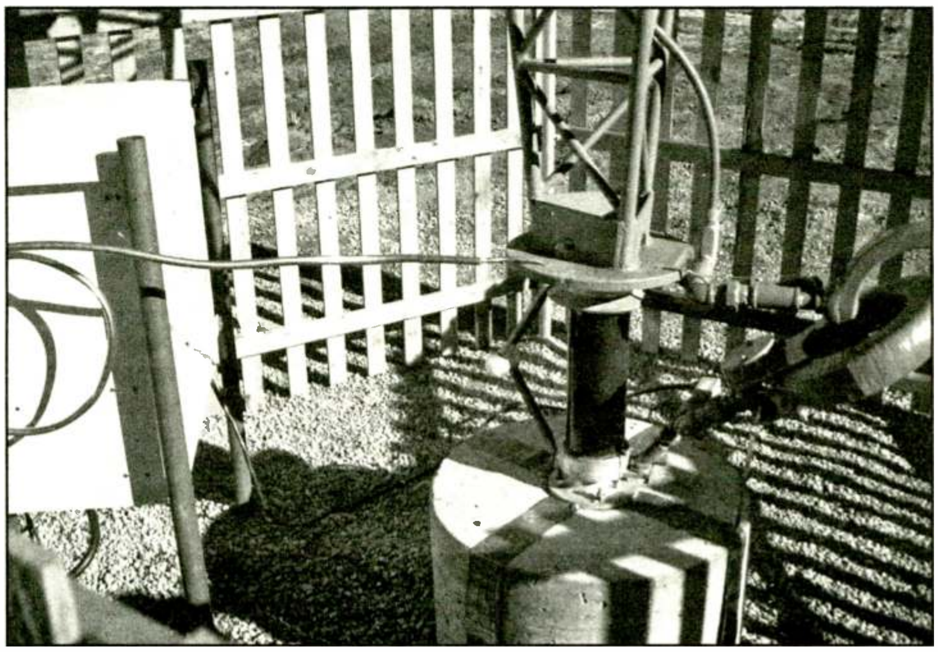
Start with the reference tower at X = 0, Y = 0 (0, 0). Then convert the design locations of all the other towers to X-Y coordinates. This is easy: X equals spacing between the towers times the cosine of the azimuth (direction angle between the towers) and Y equals spacing times the sine of the azimuth. A tower that is 75 electrical degrees in spacing and 40 degrees in azimuth from the reference tower would have coordinates 57.453, 48.209.

Next, convert the surveyor's as-built tower locations to X-Y coordinates in the same way. You will have to convert from feet to electrical degrees and from surveyor angle units to clockwise azimuth reference to true north.

Then it's a simple matter of determining the distance between the design and as-built coordinates. Find the difference in the X coordinates and the difference in the Y coordinates, and then take each difference as one leg of a right triangle per the Pythagorean theorem. Take the square root of the sum of the squares of the sides and you have your variance. Since we have calculated the variance in units of electrical degrees the answer can be used directly to determine if you are within the allowable tolerance.



Disconnect lighting chokes and their tower-potential AC wiring before measurement.



Photograph and otherwise document everything in the tower base region.

If you do this for all the towers and find that each is within the 1.5-degree circle, you're good to go. Otherwise, you have a decision to make whether to invest in a pattern redesign, allocation study and subsequent FCC filing or forget about the modeling option altogether.

Item number two is your sampling system. Many sampling systems are old and in unknown condition. Are your sample lines of equal length (within 1 electrical degree) and equal characteristic impedance (within 2 ohms)? If not, you will have to replace, adjust or repair them prior to employing the modeling option, and this can be a significant expense.

As such, sweeping the sample lines should be done very early in the modeling process. Find the electrical length on the carrier frequency and determine the characteristic impedance of each line. If the lines meet the FCC criteria you can proceed with moment modeling. Otherwise, you have another decision to make: upgrade the sample system or forego the modeling option.

In some cases — and this is something I found out in the second array that I modeled — it may be necessary to change from base to loop sampling.

GOOD MEASUREMENTS — GOOD MODEL

With those two "biggies" out of the way, the next step in the process is to measure the base impedance matrix. Using a bridge or network analyzer, measure the base impedance of each tower with all the other towers both open at the base and shorted.

If the towers are all relatively short (less than 100 electrical degrees or so), you can forego the short-circuit measurements. Otherwise, carefully measure each base impedance in turn and record the results.

Your notes should also include a notation of the type of bridge or analyzer used and whether the reactance values are corrected or uncorrected if you do not use a network analyzer.

There are a lot of caveats in this impedance measurement process. Most folks will measure at the ATU output because it is likely the last place in each tower's transmission path that you can open the circuit and connect a bridge or analyzer. But there are some issues with this location.

In every case there is a finite (and often measurable) amount of series inductance in the feed tubing between the ATU output and the tower. This must be accounted for.

There is also a finite (and usually unmeasurable) amount of shunt capacitance to ground from the feed tubing, bowl insulator and internal ATU "plumbing" between the measurement point and the ATU output. Depending on the impedance of the tower, this may be significant and we may have to account for it in a nodal analysis supplement to the antenna model.

In many installations there will be other current paths that may have to be disconnected or accounted for. Static drain chokes should be disconnected, as should lighting chokes and their associated tower-potential AC wiring (to eliminate the capacitive coupling back to the choke through the wire insulation). Sample line isocoils must also be disconnected on the tower side.

Yet another "stray" path that must be eliminated in loop-sampled towers is the sample line that often parallels the feed tubing from tower to ATU.

Next, short across the base insulator with several low-inductance straps and measure again at the ATU output. The residual reactance will be the series inductive reactance of the feed tubing.

With a tape measure, determine the

SEE MODEL, PAGE 6

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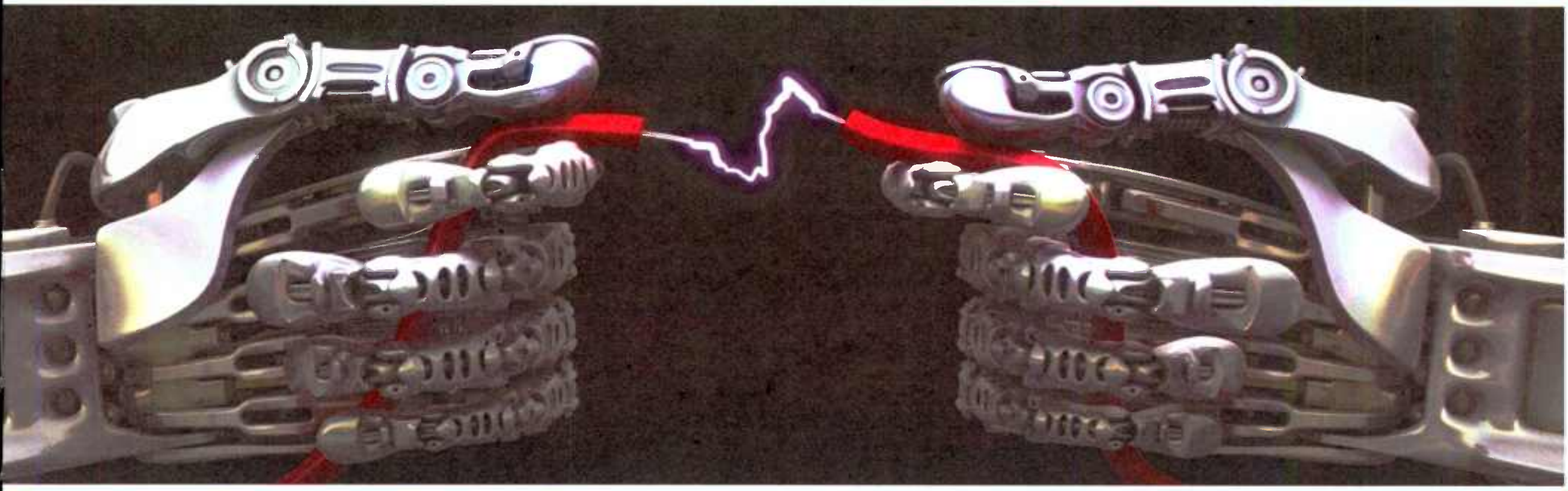

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by Charles S. "Buc" Fitch

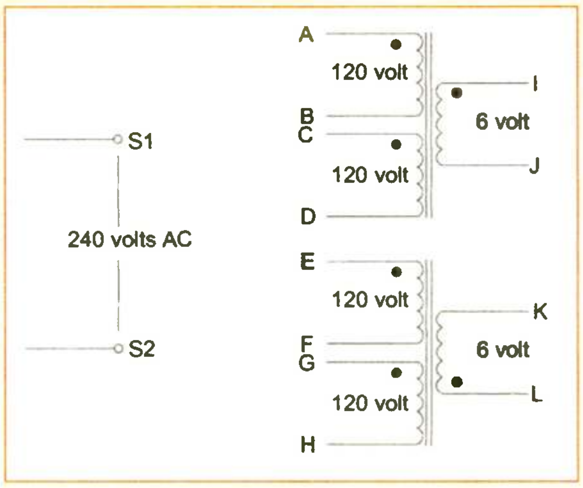
Working With Transformers? Keep an Eye on Phase

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

12 Volt Challenge

Question posed in the last issue (Exam level: CBT)

You have an immediate need to create 12 volts of AC for a power tube filament using two available, identical 6 volt secondary transformers. Referred to the drawing, how would you connect them together to make 12 volts from a 240 volt AC supply?



a. There is no combination that will work because the cores are common.
b. A tied to S1, H tied to S2, B & C tied together, D & E tied together, F & G tied together, J & K tied together and then connect the 12 volt load across I & L
c. A, C, E & H tied to S1; B, D, F & H tied to S2; J & K tied together and then connect the 12 volt load to I & K
d. A & E tied to S1, D & H tied to S2, B & C tied together, F & G tied together, J & K tied together and then connect the 12 volt load across I & L
e. A & E tied to S1, D & H tied to S2, B & C tied together, F & G tied together, J & L tied together and then connect the 12 volt load across I & K

Our question this issue is in the box at far right.

The given transformers limit the output configuration to a series arrangement in order to develop the required 12 VAC. The correct answer is the final one, (e).

Probably your first reaction would be one of incredulity; isn't the answer (d)?

Both the writer and our distinguished editor thought that our readers were getting a little complacent with the very organized, linear "Spockian logic" of the question-and-answer normally found here in the *SBE Certification Corner*. So a little curve has been introduced this episode to make a most important point about the topic, and if you got the answer correct, kudos to you.

Transformers allow us to change AC voltages in order to convert from a typical supply voltage to a desired working voltage within equipment.

When combining transformer voltages (or any voltage actually), *polarity* is important. In AC circuits polarity is really the relationships between the phases of the voltages involved. Dots are used to indicate these relationships in drawings where the polarity phasing of transformer windings is important. If you introduce a positive swing into the lead marked with a dot on the primary, secondary leads marked with a dot will similarly experience a positive polarity.

Notice in the drawing that the phasing dots on the secondaries are at leads I and L. If the primaries of the two transformers are configured and the input voltage applied identically, then the voltage at the secondaries will be identical hence "in phase" at leads I and L.

Intuitively, the way the drawing is laid out, one might think the relationships described in (d) are correct but the dots set the actual phasing.

Similar to stringing batteries together, series sources properly polarized (plus to minus in batteries) will *add*. If connected in series but out-of-phase, the source voltages will *subtract*.

Although in answer (d) the primaries are configured properly such that with 240 volts primary input each of the two secondaries will have 6 volts on them, the secondary connections as described would essentially *cancel* the voltage between I and L as the connections are out of phase. Thus (d) is incorrect.

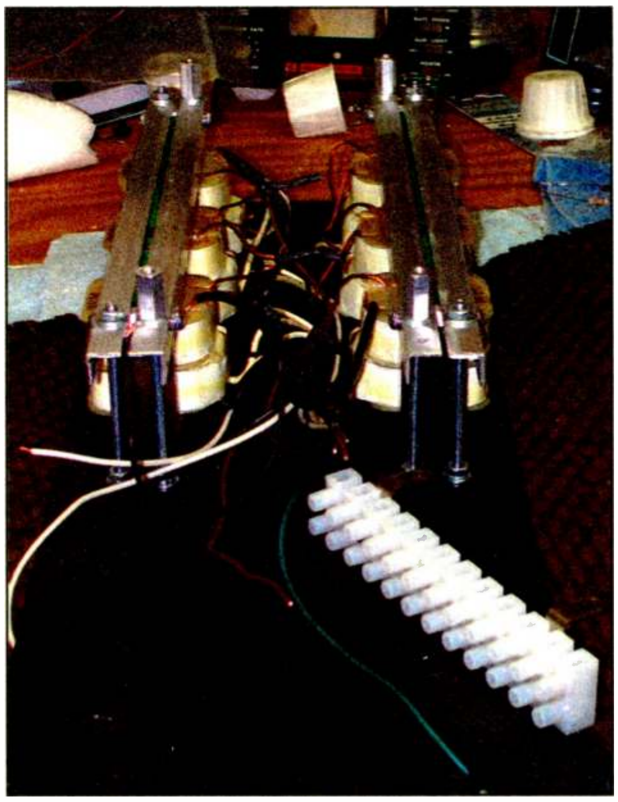
MIX AND MATCH

Let's look at the primaries for a moment and address a second concept: conversion ratio.

This problem is a good example of how combining a number of standard transformers can create a custom voltage conversion. Transformers designed for AC conversion can maintain, increase or decrease the voltage between primary and secondary. The relationship is set by the "turns ratio," which is the ratio of coil winds in the primary to those in the secondary.

The ratio in each of the 120 volt primaries to the secondary in these transformers is 20:1. There are 20 winds on the primary to one wind on the secondary. As a practical matter in the design of an efficient transformer, the primary could be 60 winds and the secondary three but the *ratio* would remain the same. The secondary voltage is the primary voltage divided by the turns ratio. In this example, 120 VAC on the primary divided by 20 equals 6 VAC on the secondary of each of the transformers.

Paralleling the primaries in phase maintains that 20:1 ratio so that 120 volts applied produces 6 volts on the secondary. When a pair of 120 volt primaries are placed in series the ratio increases to 40:1 and thus 240 volts input is needed to produce 6 volts on the secondary.



A home-made panel using a set of standard transformers interconnected to create a high-current filament supply.

Answer (b) is incorrect as we are putting all four of the primary windings in series, essentially creating a 480 volt primary. We would need 480 volts on the primary to achieve 6 volts on each of the secondaries and since we only have 240 volts available, that 6 volts could only be 3 volts.

Answer (c) is incorrect as the primary configuration would present a short to the 240 volt AC source because both legs feed lead H.

Answer (a) is incorrect on its face as the cores of the two transformers are separate.

CLOSE ENCOUNTERS OF THE TURNS RATIO KIND

For most of us broadcast types, the need to understand transformers comes when we must set or adjust taps in our transmitter high-voltage supply on the primary of the high-voltage transformer. Because of the various supply voltages available from the utility, or when your site has a continuous high or low line voltage from the nominal, we sometimes need to make these adjustments manually.

Normally two sets of tap adjustments are made available in your typical 1 kW tube-type AM transmitter such as the one shown in the schematic (on page 8) from the classic CCA (see RW article on this rig at *http://rwonline.com/article/2806*).

If your site had single-phase power with a nominal 240 volts on the line, you would set the taps as shown with one phase line on the 230 volt tap and the other phase line on the +10 volt tap.

If your site had a three-phase wye supply (120 volts phase to neutral and 208 volts phase to phase), then you would set one phase line to the 208 volt tap and the other to the 0 (zero) tap.

What we're doing here in each of these cases is adjusting the turns ratio such that we obtain the desired

SEE TRANSFORMER, PAGE 8

Model

CONTINUED FROM PAGE 4

height of the tower base pier above ground. Measure the height of the base insulator and obtain any and all other information you can about it. Measure the tower face width and note the number of sides. If the tower base section tapers, measure the face width at the base, the face width at the top end of the taper and the length of the taper. Note the location where the feed tubing connects to the tower itself. Take a photo of each tower base, including base pier, insulator and feed tubing. Also photograph the location where the bridge or analyzer was connected.

The more information you can give to the engineer doing the model, the better the model will be. He will likely construct not only a calibrated tower model but also a couple of circuit models accounting for the series and (estimated) shunt reactances in the base region, including base insulator, Austin transformer, lighting choke, static drains, isocoils and isocouplers.

With good and complete measurement data the engineer can quickly construct and calibrate the model to determine whether the array can likely be adjusted to the model parameters with the existing phasing and coupling system, or whether modifications will be necessary.

In some cases — and this is something I found out in the second array that I modeled — it may be necessary to change from base to loop sampling.

In the months since the new modeling rules went into effect, we have learned that the modeling process isn't a simple matter of "just do it." Rather it is an information-gathering and decision-making process that in some (most) cases will lead to a successful filing. In those cases, folks are finding out that it is well worth the time and effort.

Cris Alexander is director of engineering at Crawford Broadcasting Co. For more on this topic also see the article on page 18 of the June 3 issue of Radio World. ■

Tube

CONTINUED FROM PAGE 1

efficient method of elevating HD Radio sideband levels. Split-level combining efficiency gains are lost after only a 3 dB increase in elevated sideband levels.

This paper will focus on a new solution for more efficient common amplification of high-power FM+HD signals in the 10 kW to 40 kW RF power output range.

The linearity challenge

The proposed 10 dB increase in HD Radio sideband levels presents a significant linearity challenge to common amplification of FM and HD Radio signals through a single transmitter. The common amplification linearity must be improved by 20 dB to accommodate a 10 dB increase in HD Radio sidebands while still meeting the original NRSC-5B RF emission mask. See Fig. 1.

The desired transmitter solution is focused on optimizing four key parameters. The goal is to minimize purchase and operating cost while providing a maximum power output and operating efficiency.

The transmitter should be capable of at least 40 kW analog FM power, 30 kW FM+HD at –20 dB sideband level and at least 15 kW FM+HD at –10 dB sideband level.

In addition, the ability to change operating modes from FM+HD to HD only or FM only on the fly is a key part a flexible transmitter back-up strategy.

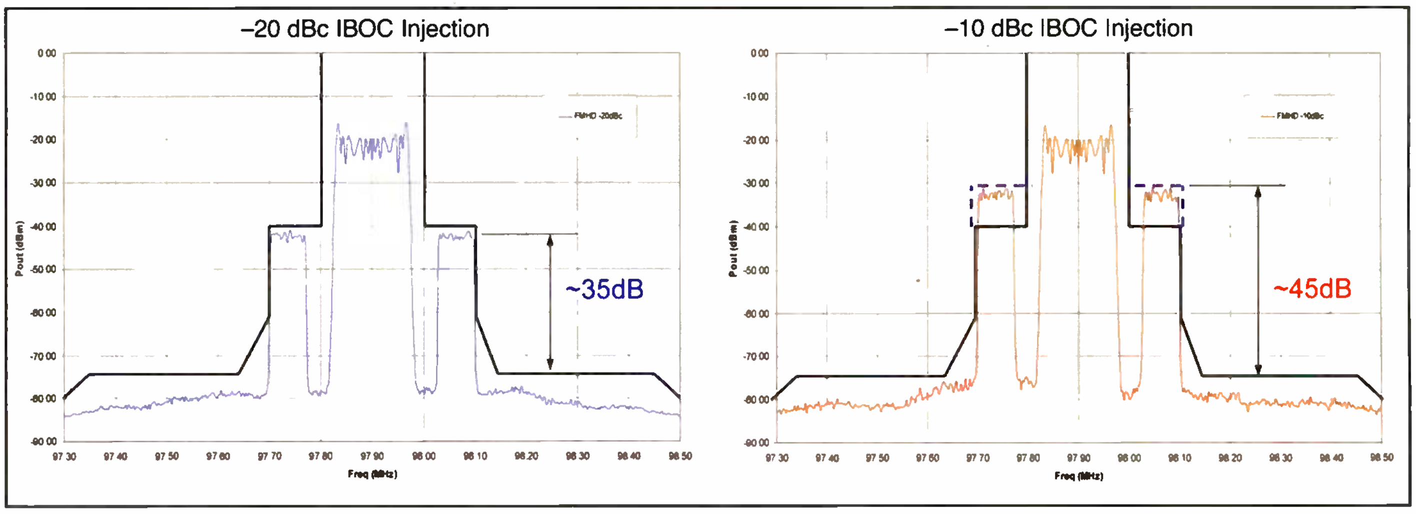


Fig. 1: Increased digital sideband power means that transmitter linearity must also improve by 20 dB to meet NRSC mask.

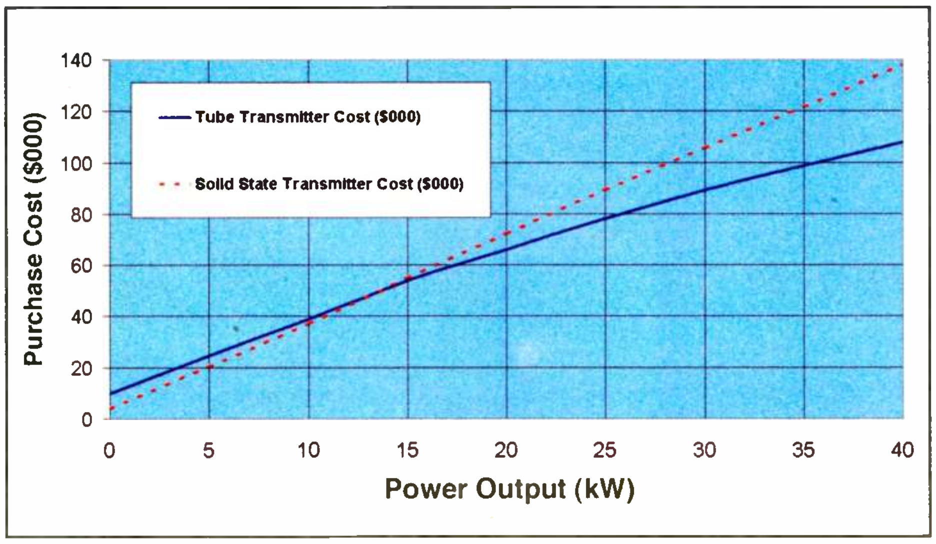


Fig. 2: Comparison of Purchase Costs for Tube vs. Solid-state Amplifiers

THE TECHNOLOGY SELECTION PROCESS

Harris Broadcast is a leading supplier of HD Radio transmitters that utilize both solid-state and vacuum tube technology. In an effort to find the lowest-cost solution at power levels above 20 kW, the current state of both of these technologies was carefully investigated.

Purchase price

Although solid-state technology offers several advantages, it carries significant purchase cost and operating efficiency penalties at RF power output levels above 20 kW, using currently available solid-state device technology.

Fig. 2 graphically shows the purchase

SEE TUBE, PAGE 10

Transformer

CONTINUED FROM PAGE 6

1700 volts on the hi-voltage secondary.

The nature of this question brings us to a general comment on technical test-taking and question-solving. There are two ways to approach this genre of question: work to the solution or work from the answers.

If you know for certain how to work the problem, solving for the solution and then looking for the correct answer is probably best. If you do not completely understand the question or have a full grasp on the concepts and issues involved, working from the answers usually will increase the probability of a correct response.

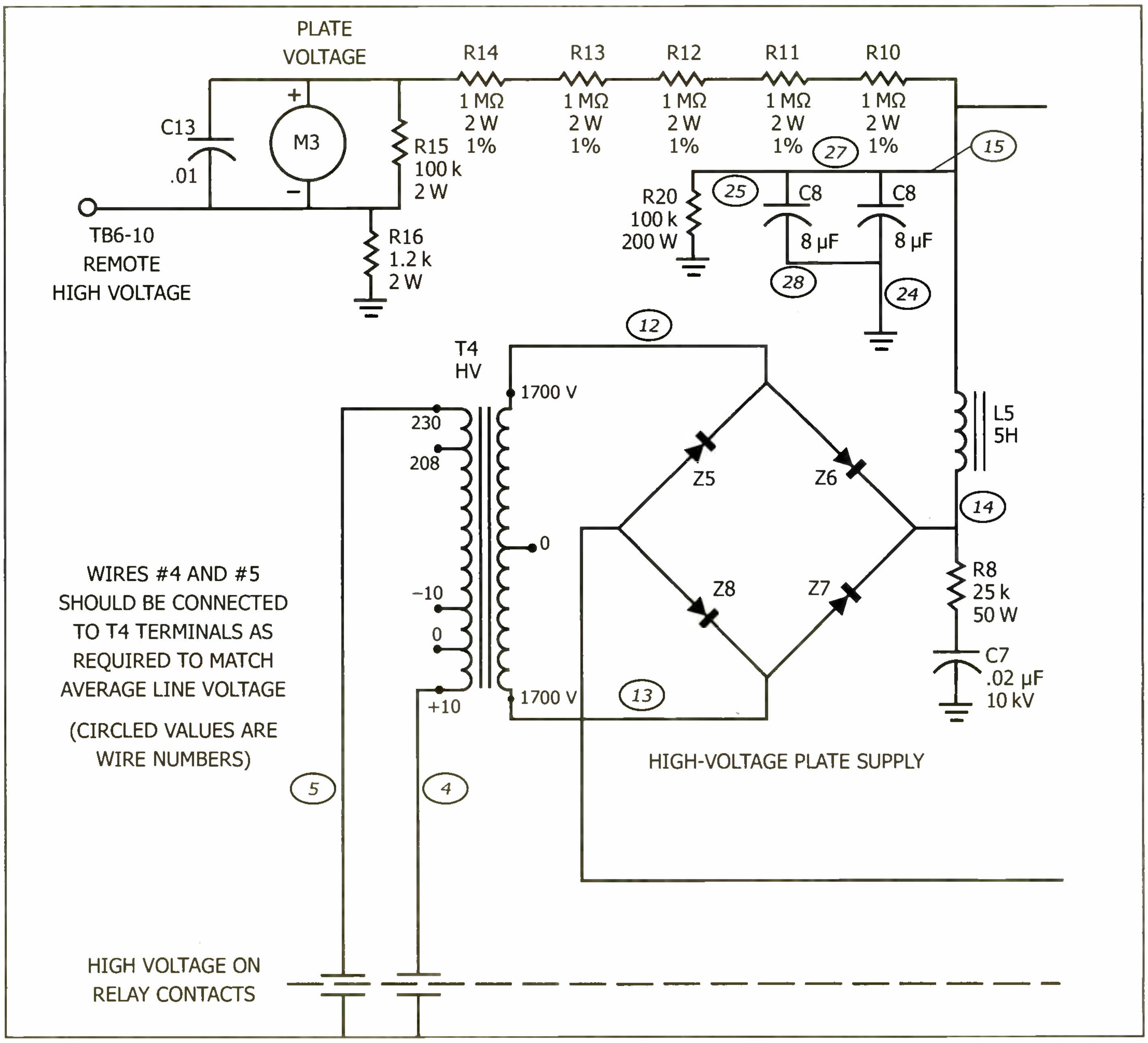
* * *

For the August issue, a CBT-level question: *What are the advantages of a solid-state bridge rectifier over a solid-state full-wave rectifier?*

- **a.** Reduced peak inverse voltage rating requirements for the rectifiers
- **b.** Better utilization of the power-handling capacity of the supply transformer
- **c.** Reduced voltage drop
- **d.** b. & c. above
- **e.** a. & b. above

The deadline for signing up for the next cycle of SBE Certification exams is Sept. 18 for testing that will be given between Nov. 6 and 16 in the local SBE chapters.

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



The high-voltage transformer taps are set to adjust the amplifier high-voltage supply based on the provided utility voltage. The taps can be set to either add or subtract from nominal supply voltage as required.

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Tube

CONTINUED FROM PAGE 8

cost vs. power output (dollars per kW) comparison of solid-state to vacuum tube-type transmitters. Notice that while the cost of solid-state tracks more or less linearly with power output, the cost of vacuum tube technology tends to flatten out at higher power levels.

The reason for the difference in the shape of the curves is due to the differences in the transmitter architectures. As the power of a solid-state transmitter is increased, the number of RF amplifier modules, power supplies, cooling fans, combiners, combiner ports and span of the control system increases in direct proportion to the power output level. For example, every time the power output level of a solid-state transmitter is doubled, the number of RF amplifiers, power supplies, combiner ports, etc. is exactly doubled in cost.

A high-power, single-tube, transmitter will have some proportional changes in the size of the vacuum tube and associated power supplies as power is increased, but they are not in direct relationship to the output power level. For example, the cost of a 40 kW tube amplifier cavity is not twice the cost of a 20 kW cavity and the cost of a 5.0 ampere, high-voltage power supply is not twice the cost of a 2.5 ampere power supply.

Ongoing energy consumption

The long-term energy consumption of a transmitter is now more important than ever, not only to save electrical power costs, but to provide a "green," reduced carbon footprint. Depending on the power output of a tube-based transmitter, the broadcaster could save as much as $6,000 to $10,000 a year in energy consumption over a solid-state transmitter. This is due to the solid-state RF combining power losses, which increase at higher power levels, as well as the lower transistor efficiency when compared to a single-tube power amplifier.

PA efficiency over a range of power levels

Another key consideration in the selection of high-power FM+HD transmitter architecture is the operating efficiency of the RF amplifier technology and the ability to achieve high operating efficiency over the full range of output power levels required. A vacuum tube amplifier can achieve over 80 percent operating efficiency in FM mode and over 68 percent operating efficiency in common amplification mode over the full range of power from less than 10 kW to over 40 kW.

On the other hand, a solid-state amplifier could achieve only about 60 percent efficiency in common amplification mode and only at its full rated power. As the power output is decreased, the efficiency will drop, because the solid-state amplifier, unlike the tube amplifier, typically lacks the ability to have its load line changed for optimum efficiency at reduced output power.

Air cooling temperature drop

Cooling efficiency is another key consideration for a high-power transmitter design. Air cooling is most efficient when the heat sink surface being cooled has a high temperature drop compared to the ambient air temperature. Due to the thermal resistance from the silicon junction to the heat sink, the maximum heat sink temperature in a solid-state transmitter is limited to about 85 degrees Celsius in order to maintain a semiconductor junction temperature of less than 150 degrees C. A high-power vacuum tube anode heat sink does not have the multiple thermal interface resistances like a solid-state amplifier and can operate at up to 225 degrees C; therefore less cooling air volume is required to remove the same amount of heat from the tube-type transmitter.

As the HD Radio sideband levels are raised, the amplifier has to be biased into a more linear operating point, which reduces the PA efficiency. Ultimately, the ability to remove heat from the amplifying device places the upper limit on power output available at –10 dBc HD Radio sideband levels.

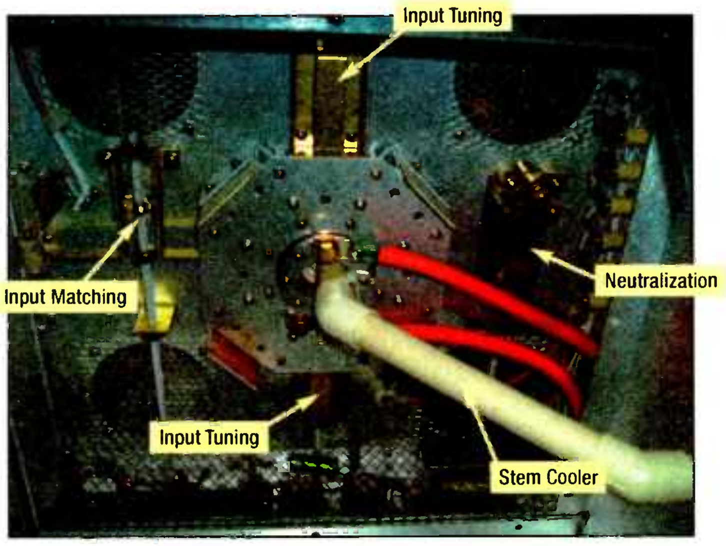


Fig. 3: View Below Tube Socket Showing Input Tuning, Matching and Neutralization

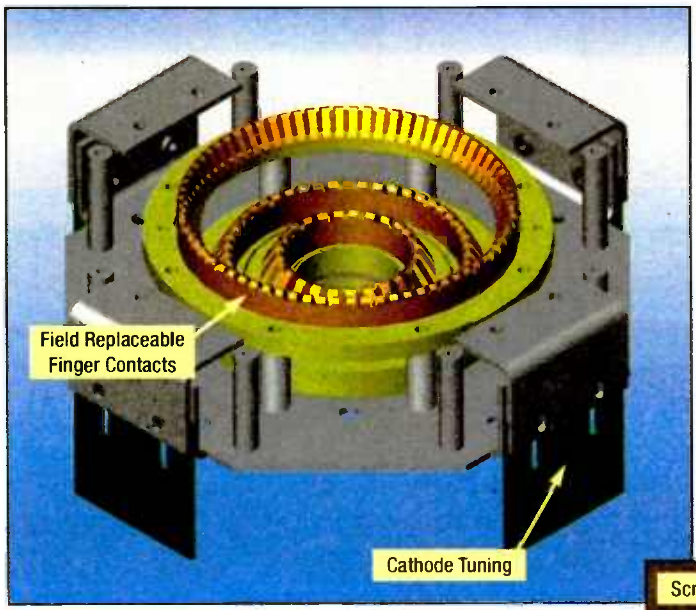


Fig. 4: Integrated Tube Socket

THE TECHNOLOGY IS SELECTED

After a thorough evaluation of currently available solid-state and vacuum tube technology, Harris conducted a series of "Voice of the Customer" (VOC) meetings with key customers to get feedback on the choice of high-power RF power amplifier technology to be used in a new transmitter architecture. After considering all of the trade-offs discussed above, the decision was made to develop a new, high-power, high-efficiency, FM+HD Radio transmitter architecture based on a single vacuum tube output stage, driven by redundant solid-state intermediate power amplifiers.

Vacuum tube selection

A number of different vacuum tube technologies from several manufacturers were evaluated for cost, HD Radio performance and reliability.

Although there are some alternative vacuum tube technologies available, the customer feedback drove the design engineers to see how much power and performance could be obtained from the familiar 4CX20,000 series of RF power tetrodes. This family of tubes has a well-established operating life and reliability record. The directly heated cathode used in these tubes shorten the warm-up time to less than 10 seconds, allowing near "instant on" operation as requested in our VOC meetings.

What can be learned from vacuum tube DTV amplifiers?

Although solid-state technology dominates DTV transmitter architectures at power levels below 30 kW, vacuum tube, MSDC-IOT technology offers the highest operating efficiency and has become the preferred technology at power levels above 30 kW. The primary issue with the more limited bandwidth of vacuum amplifiers is minimizing the non-linear, "memory effects," so that the amplifier non-linearity can be digitally pre-corrected in the exciter. The experience gained in input/output bandwidth enhancement, adaptive pre-correction and power supply de-coupling can also be applied to an FM+HD power amplifier.

CAVITY DESIGN FOR HD RADIO

The customer-desired attributes for the tube power amplifier cavity included:

- Maximum HD power
- Non-interactive tuning
- Tube change in less than 10 minutes
- Field-repairable tube socket
- Neutralization from outside cavity
- Minimization of discrete, frequency selected, components
- No vacuum capacitors
- Ability to change transmitter frequency quickly in the field
- Resistance to lightning

A new power amplifier cavity needed to be designed to optimize the performance of the 4CX20,000C tetrode.

Successful FM+HD operation requires significantly more transmitter operating bandwidth than FM analog operation. In order to improve HD Radio power output, RF mask compliance and efficiency, several innovations were implemented in the new cavity design.

Inductive input matching

The primary bandwidth limitation in a linearized, non-saturated, high-power, vacuum tube power amplifier is the input capacitance of the tube. The input capacitance of the 4CX20,000C is about 195 pF, which presents a very low capacitive reactance in parallel with the reasonably high input resistance. This produces an input "Q" approaching 20.

One way to reduce this "Q" and improve the bandwidth is to use an input matching technique that uses part of the tube's input capacitance to make the impedance transfor-

SEE TUBE, PAGE 12

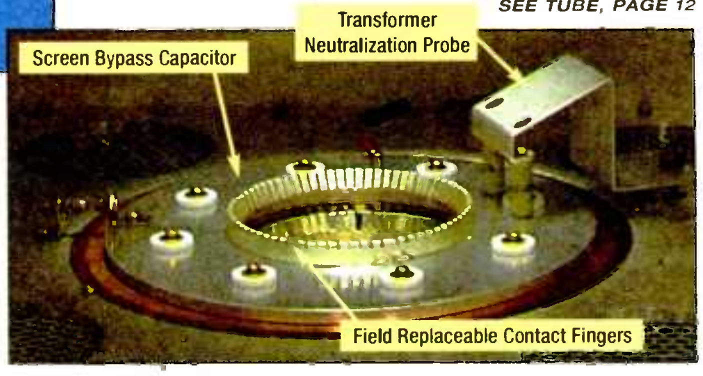


Fig. 5: View of Tube Socket Showing Neutralization Sampling

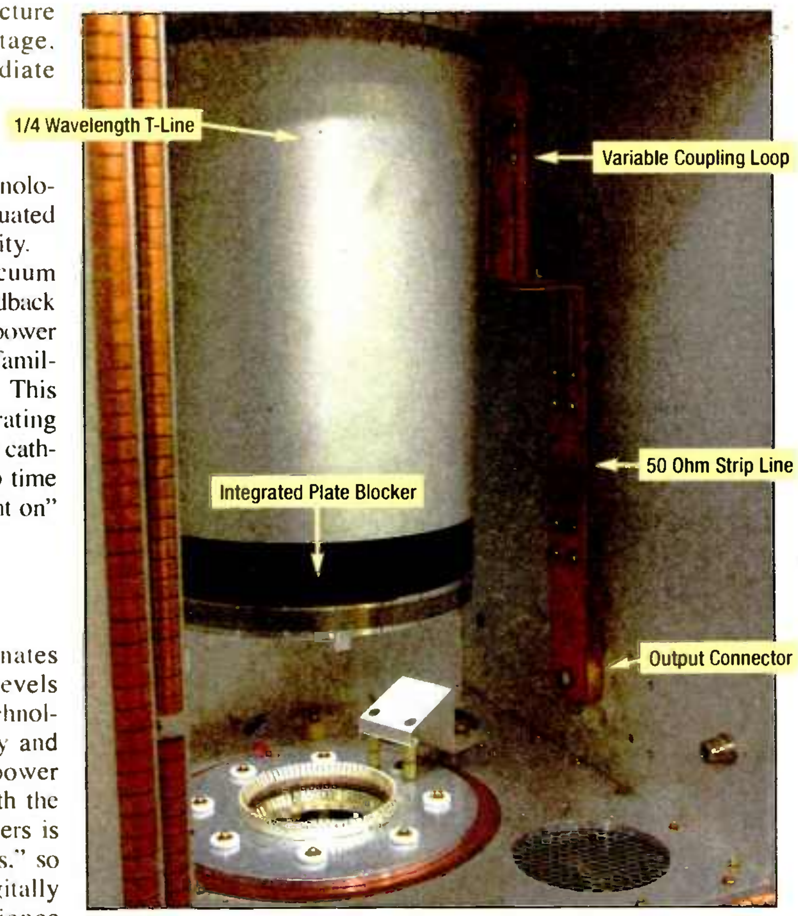


Fig. 6: View of Tube Cavity Showing Output Coupling Loop

MINSTRUMENT MATRIX

Sophisticated Minstruments from NTI give you comprehensive test capability... and these flexible audio instruments fit in the palm of your hand

DL1 Digilyzer
Digital Audio Analyzer

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

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

DR2 Digirator
Digital Audio Generator

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

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

DIGITAL

AL1 Acoustilyzer
Acoustics, Audio & Intelligibility Analyzer

The AL1 Acoustilyzer features extensive acoustical measurement capabilities as well as analog audio electrical measurements such as level, frequency and THD+N. With both true RTA and high resolution FFT capability, the AL1 also measures delay and reverberation times.
With the optional STI-PA Speech Intelligibility function, rapid and convenient standardized "one-number" intelligibility measurements may be made on all types of sound systems, from venue sound reinforcement to regulated "life and safety" audio systems.

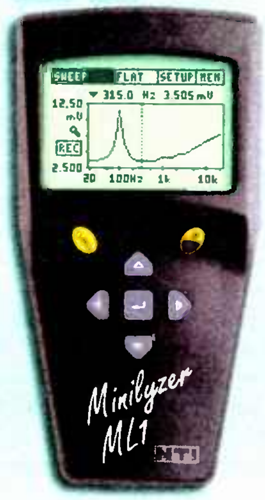
- Real Time Analyzer
- Reverb Time (RT60)
- Delay measurements
- High resolution FFT with zoom
- Optional STI-PA Speech Intelligibility function
- Automatic Distortion analyzer (THD+N)
- Frequency, RMS Level, Polarity measurements
- Requires optional MiniSPL microphone
- Includes MiniLINK USB interface & Windows PC software for storing tests and PC transfer

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

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

- High (+18 dBu) output level & <-96 dB residual THD
- Sine waves & programmable swept (chirp) and stepped sweeps
- Pink & white noise
- Polarity & delay test signals
- User-generated custom test signals & generator setups
- Impedance measurement of the connected device
- Phantom power voltage measurement
- Cable tester and signal balance measurement
- Protective shock jacket

ML1 Minilyzer
Analog Audio Analyzer



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

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

MiniLINK

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

MR2 Minirator
Analog Audio Generator

The MR2 pocket-sized analog audio generator is the successor to the legendary MR1 Minirator. It is the behind-the-scenes star of thousands of live performances, recordings and remote feeds.

- Intuitive operation via thumbwheel and "short-cut" buttons
- New higher output level (+8 dBu) & low distortion
- Programmable Swept (chirp) and Stepped sweeps
- Sine waves
- Pink & White noise
- Polarity & Delay test signals
- Illuminated Mute button

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Tube

CONTINUED FROM PAGE 10

mation to the 50 ohm transmission line from the solid-state driver stage. This is accomplished by using a series, adjustable strip-line to form an "L" network with the shunt "C" element being provided by a portion of the tube input capacitance. The rest of the tube input capacitance is parallel resonated at the operating frequency by two, parallel, adjustable, strip-line inductors.

The physical arrangement of the input matching is shown on the left side of Fig. 3, while the grid tuning strip-lines are shown in the upper and lower center.

Cathode tuning for efficiency

In order to achieve peak efficiency, the phase angle of the RF voltage on the tube cathode must be adjusted with respect to the phase angles of the RF voltages on the control grid and screen grid of the tube. When the optimum phase relationships exist, the conduction angle of the tube is shortened, which in turn improves efficiency.

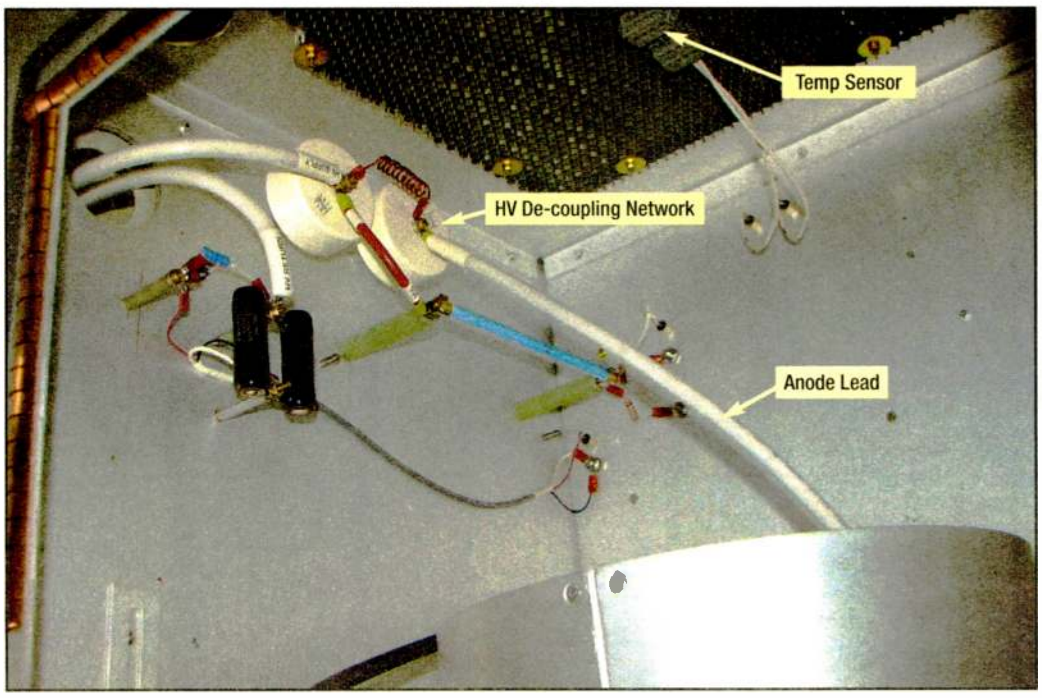

Fig. 7: Decoupling Components in Plate Supply Line

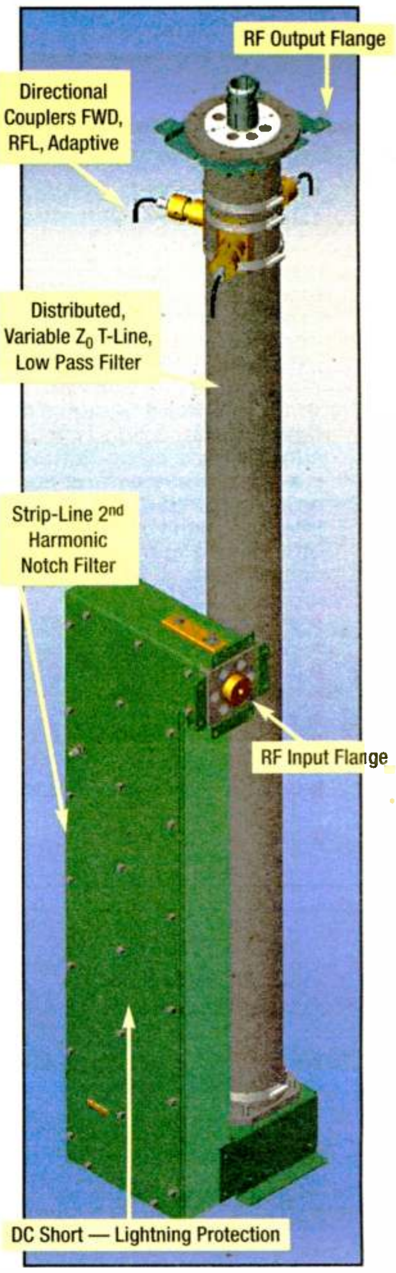

Fig. 8: Internal Low-Pass and Second Harmonic Filter

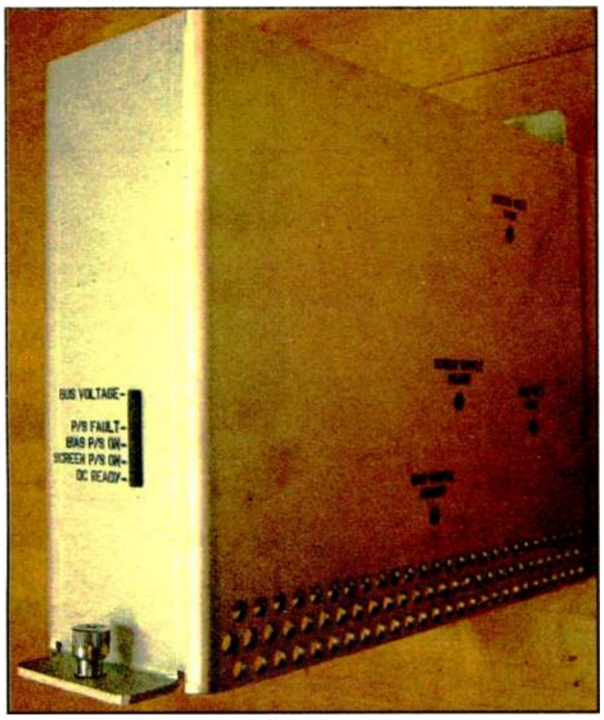

Fig. 9: Switch Mode Power Supply for Screen and Bias Supplies

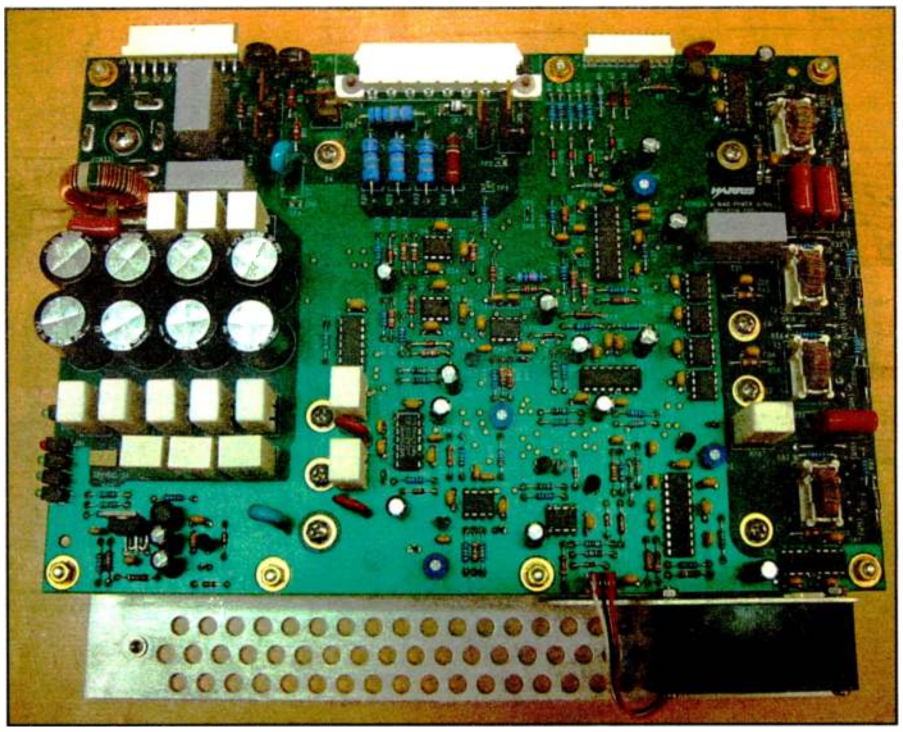

Fig. 10: Switch Mode Power Supply Circuit Board

A new tube socket was developed with integrated film blocking capacitors and integrated cathode voltage phase adjustment inductors. Fig. 4 is an illustration of the integrated tube socket assembly.

Transformer neutralization

Neutralization reduces the feedback from the amplifier output circuit to the input circuit and is important to maintaining the stability, efficiency and linearity of the power amplifier. The reduction of non-linear, memory effects on the digital HD Radio signal requires wide bandwidth neutralization instead of the narrower bandwidth self-neutralization techniques previously used in analog FM transmitters.

A new, wide-bandwidth, RF transformer neutralization technique at VHF/UHF frequencies was developed. A capacitive sample of the RF voltage on the plate (anode) of the tube is fed to a broadside coupled, adjustable, strip-line transformer where it is scaled, inverted in phase and fed to the grid circuit of the tube. The right-hand side of Fig. 5 shows the plate voltage sampling device and the right-hand side of Fig. 3 shows the strip-line transformer.

Inductive power output coupling

In order to maximize the bandwidth of the output matching circuit, the capacitive end loading on the 1/4-wavelength cavity resonator center conductor needs to be minimized. This was accomplished by designing a novel method to inductively couple the output power from the shorted end of the cavity center conductor where the RF current reaches its maximum value. The output coupling loop had to be placed at the shorting plane, but still allowing the shorting plane to be moved to the desired operating frequency in the FM broadcast band. A short section of 50 ohm suspended strip-line, which can be adjusted in length, provides the connection from the output coupling loop to the cavity's RF output connector. The output coupling loop and suspended strip-line can be seen on the right side of Fig. 6.

The use of inductive output coupling at the low-impedance end of the resonant line not only reduces the amount of end loading capacitance at the high-impedance end of the resonant line, but also eliminates interaction between the plate tuning and output loading of the amplifier. Adjustable output loading is essential to maintaining maximum operating efficiency over the full range of power output levels from less than 10 kW to more than 40 kW. The ability of this vacuum tube amplifier to also change the load line to match into the complex impedance presented by the transmission line is helpful in maintaining peak efficiency into an elevated VSWR on the antenna.

Power supply de-coupling

Effective de-coupling and bypassing of the power supply wiring to the various tube elements from RF down to audio frequencies is essential to reduce time variant, non-linearity in the RF power amplifier so that it can be digitally corrected by the HD Radio exciter. This is accomplished by locating appropriate bypass capacitors close to the tube connections with a minimum of inductance between each bypass capacitor and tube element. Fig. 7 illustrates how the plate power supply is bypassed for HD Radio operation.

Internal low-pass filter and harmonic notch filter

The power amplifier operates in high-efficiency class C, non-linear, mode for FM analog-only operation and operates in a moderately high-efficiency, class AB, quasi-linear, mode for FM+HD operation. Both of these operating modes produce harmonic energy. An internally mounted, integrated low-pass and even-order harmonic notch filter was designed to provide the necessary attenuation of harmonic energy leaving the power amplifier cavity.

The harmonic notch filter is implemented using suspended strip-line techniques in a rectangular, aluminum housing and provides a DC short to lightning. The low-pass filter uses folded, distributed, non-constant impedance, coaxial transmission line sections to reduce the size so that it can be mounted internal to the transmitter. Fig. 8 is an illustration of the filter.

Switching power supply technology — electronic control of tube operating point

The ability to make the RF amplifier multi-mode with optimum HD Radio performance requires a new approach to the grid bias and screen bias power supplies.

Traditionally, the grid and screen bias power supplies were unregulated, linear power supplies with large filter components. The ability to switch modes on the fly, from FM+HD to FM analog only or to change the HD Radio sideband injection level may be a part of the back-up strategy for the broadcaster. In order to optimize the operation of the amplifier for any of these operating modes, a dual switching, grid/screen bias power supply was developed.

These two electronically programmed and regulated power supplies allow the system controller instantly and precisely to change the grid bias and screen voltages as required. The VOC feedback was positive towards the use of regulated, switching, power supplies if there is

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A Critic Lashes Out At HD Radio, Again

But Guy Says He And Other Opponents Need to Be Realistic

Usually I would not devote an entire column to respond to a reader's letter. But Bob Savage's attack on HD Radio (RWEE, April 15) and most of his misconceived arguments against it as well as his misrepresentation of much of my February installment simply pushed me over the edge. I guess Bob (a.k.a. Phil E. Strann) forgot to clamp bumpers on his plastic imitation guy wire.

Savage owns and operates WYSL(AM), a Rochester, N.Y., rimshooter licensed to Avon, N.Y., on 1040 kHz. Understandably, WYSL has problems serving Rochester with first-adjacent interference from WBZ on 1030 kHz during critical hours and nighttime operations, especially during the long Northeastern winters.

Ya gotta feel a little sorry for Savage and stations like WYSL. A life-long radio guy has a dream and sinks a big chunk of his personal wealth into building a shoehorned AM station that he hopes will be successful serving a larger market from his tiny suburban city of license.

There are perhaps similar stories like WYSL in every decent-sized market. Radio has seduced lots of folks like Bob Savage into challenging ownership positions.

Savage doesn't like HD Radio because it adds another order of interference to his already compromised signal. Every piece of his diatribe, whether accurate or not, denigrates HD Radio as unnecessary and defends the analog status quo as good enough for radio.

MAD AS A BUZZING HORNET

What he doesn't tell us or like to admit is that much of WYSL's Rochester coverage was already getting clobbered by WBZ's analog upper sideband skywave signal.

The more important legal issue here is whether the WYSL protected primary contour is receiving new and bona fide interference from WBZ's HD Radio transmissions.

Savage purportedly supplied the Federal Communications Commission with field measurements showing that was the case. I am told that WBZ engineers performed the same set of measurements and concluded that Savage's data or his measuring methodology was flawed.

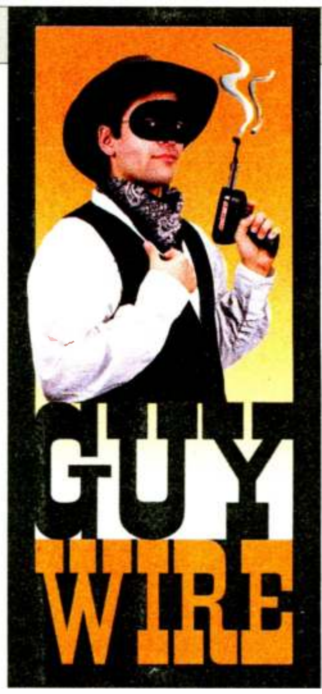
The FCC apparently agreed with WBZ and did not grant WYSL any relief. Under these circumstances, WYSL's coverage into much of the Rochester metro area is not afforded protection under the rules. Had Savage's showing been accepted by the commission, they could have ordered WBZ to work with him in reducing HD Radio power to acceptable levels or even cease such operations at night altogether.

Whatever useful coverage WYSL had in the areas now subjected to higher interference from WBZ was simply bonus coverage he was getting for free. It's just a cold fact of life that any rimshot owner is going to have to accept.

Savage claims that "the vastly increased noise floor from adjacent-channel IBOC carriers … in the Northeast … has turned the AM dial into an unlistenable bog of offensive noise."

Earth to Bob: Other than a handful of stations like WBZ and WOR, there really aren't that many AM-HD stations on at night in the Northeast. A few still run HD daytime only for a number of reasons.

The reality is, the number of HD Radio stations causing increased noise on the AM band at night is minor, compared to the already elevated noise floor caused by analog skywave and the myriad of power lines and other noise-generating sources. That has been the rather sad case for AM



listeners almost everywhere for a long time. It's one of the many reasons AM's use and popularity have waned over the years. Only AM stations with solid primary contour coverage of their markets both day and night have a shot at being fully competitive, almost always with some kind of news, sports or talk format.

CALLED OUT THE PROBLEMS

In spite of Savage's insinuations that I'm in the tank for HD Radio and iBiquity, I've closely followed the evolution of the

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Tube

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optional redundancy.

Fig. 9 and Fig. 10 are photos of the dual switching power supply.

Specialized transmitter control system requirements

The ability to change the transmitter operating mode on the fly requires a next-generation control system to synchronize any of three operating modes of the solid-state driver stage with the final amplifier operating bias for the grid and screen elements. Automatic power control uses two different methods depending on the operating mode. The FM analog mode uses a fixed level of RF drive to saturate the final amplifier while changes in screen voltage control the power output. The FM+HD mode uses a fixed screen voltage and variable RF drive to control the power output. The control system graphical user interface can be accessed via an Internet connection. Fig. 11 shows the control system user interface and Fig. 12 shows the overall block diagram of the transmitter.

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Fig. 11: Transmitter User Interface

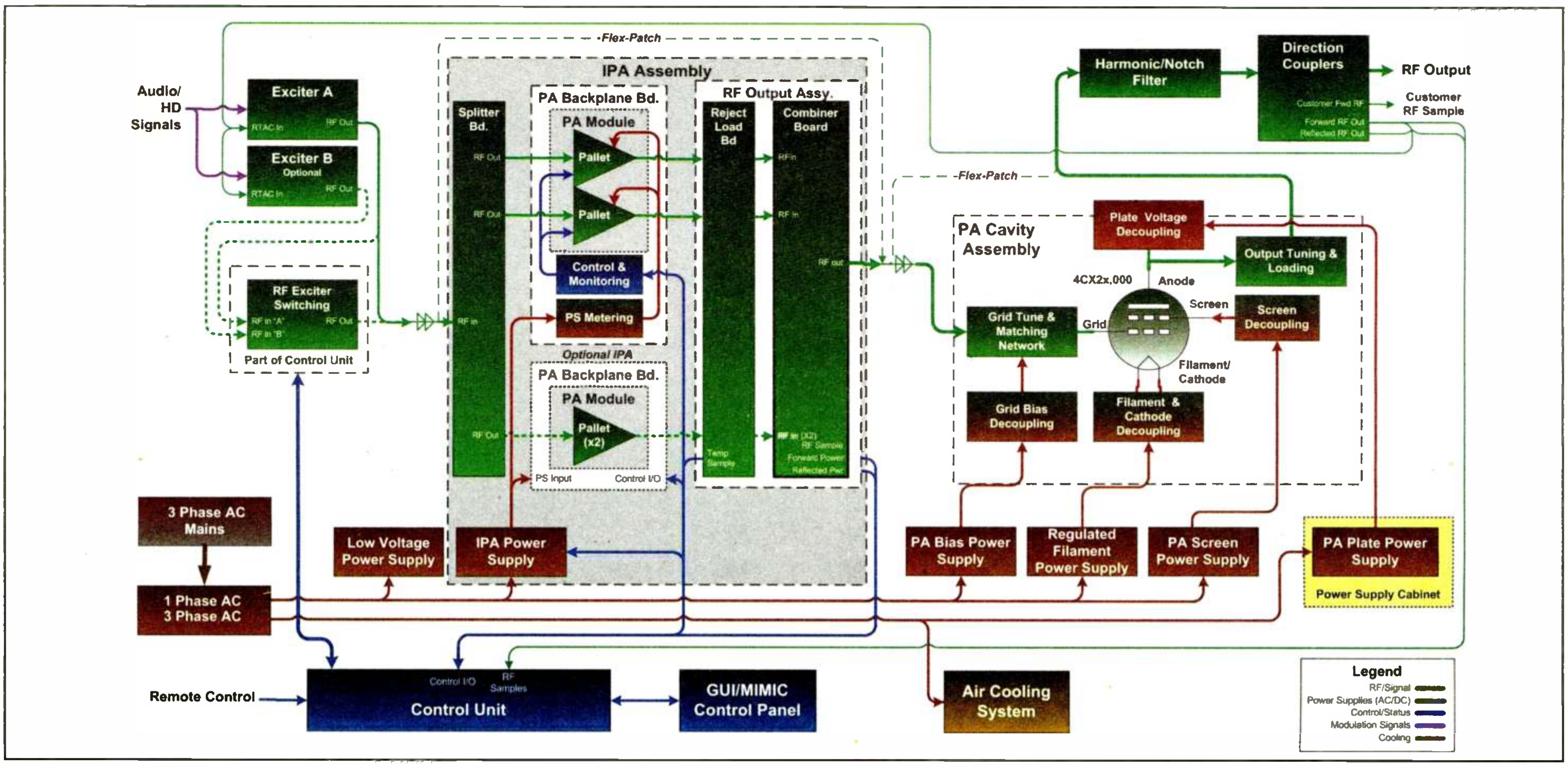

Fig. 12: Transmitter Block Diagram

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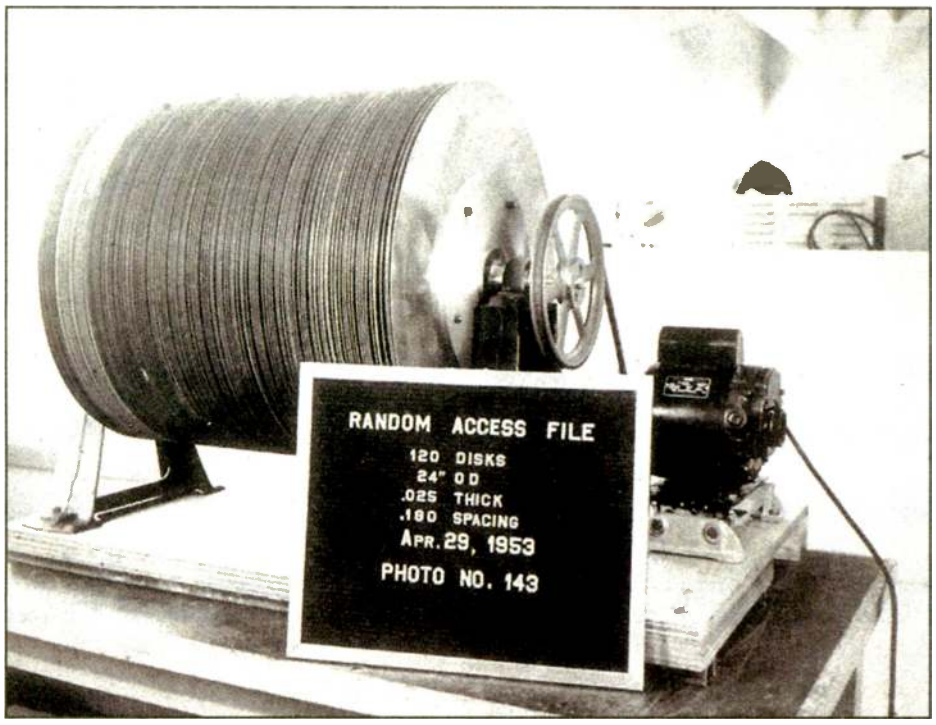
by Karl Paulsen

Sources of Hard-Disk Latency

Increased Spindle Speeds Offer Faster Access Times

The year 1956 marked the beginning of an era that would dynamically and dramatically alter the landscape of technology forever. It was in San Jose, Calif., where the first hard-disk drive (HDD), called the IBM 350, was invented by a group of by IBM scientists under the direction of Reynold Johnson. The 350 HDD would accompany the IBM 305 RAMAC (Random Access Method of Accounting and Control) computer and had a total capacity of 5 million seven-bit characters. A single head assembly with two heads accessed all 50 24-inch diameter platters, and the average access time was just under one second.



Early laboratory assembly of a disk drive that would become part of the RAMAC computing platform.

THE PRICE ON PERFORMANCE

Early HDDs had an areal density of only 2,000 bits per square inch and produced a data throughput of only 8.8 kbps. The pre-dawn era of massive HDD devices employed a spindle speed of less than 1,000 rpm, yielding a latency of 30 ms.

Disk drive improvements often appear as statistics, the most prominent advances clearly defined by the consistent growth in storage capacity and the steady increases in rotational (spindle) speeds. History has shown that rapid price reductions are often realized within the first six to nine months after the introduction of the next leap in capacity. Today, terabyte (TB) capacities are common. The first 1 TB drives being introduced at CES two years ago went for nearly $1,000. Now the price for an external USB/FireWire 400 drive is well below the $200 mark.

While capacity and reduced costs are both important factors for the storage industry, the rotational speed of the spindle (i.e., platter assembly) is another important performance specification that influences the specific applications for some drives compared to others. Spindle speed statistics seem only to take modest jumps and are far less dramatic than the increasing number of gigabytes of storage.

Spindle speed is a measure of how fast the HDD platters spin during normal operation. The spindle speed affects, on average, how fast data can be recovered from the hard drive when requested by a controller. Spindle speeds directly determine rotational latency, a metric that affects the average seek time and, in turn, impacts read and write times as well as accessibility. Seek time is the time required for the head to move from a worst-case position to the requested track (or cylinder) where the data to be retrieved is located. Once the head moves to the proper track, it must then wait for the platter to rotate until the data is positioned below the head. The sum of these times becomes the "seek time."

The spindle speed affects, on average, how fast data can be recovered from the hard drive when requested by a controller.

SPINDLE SPEED

From the 1960s forward, spindle speeds crept upwards until, by the 1980s, spindles for most HDDs were powered by a DC motor and spun at a constant speed of 3,600 rpm or less. By the 1990s manufacturers began to realize the improvement benefits of faster spindle speeds and the rpms began to rise from 3,600 rpm to 4,500 rpm. Eventually the high-end IDE/ATA drives and low-end SCSI drives reached 7,200 rpm.

Latency is directly proportional to the rotational speed of the spindle and can easily be found when it is not stated in a specifications table. The value for latency can be calculated as: 30,000 divided by the spindle speed, expressed in milliseconds. Ironically, the incremental decreases in seek time are not nearly as impressive as the increased numerical figures associated with the rotational speeds of the spindle. For example, the step from 5,400 to 7,200 rpm drives only shaves 1.4 ms off the average latency. The jump to 10,000 rpm drives only reduced the latency by another 1.16 ms.

THE LATENCY FACTOR

Seek time and latency are most relevant to certain types of data accesses. For media-centric operations, latency becomes a true performance factor for such operations as nonlinear editing. When HDD operations require multiple frequent reads from random sectors on the disk, the seek time and latency become performance-limiting factors. For media servers, clip players or digital cinema servers that read large contiguous blocks of data, latency is a relatively minor factor because the speed impact only occurs while waiting to read the first sector of a file — after which the heads don't reposition much except at the end of a track. For nonlinear editing there are other factors, such as disk fragmentation, that further impact latency and seek times to a different degree.

Manufacturer cut sheets express rotational latency in terms of an average time. For newer 15,000 rpm SCSI drives, this average is about 2.0 ms. Accompanying that spec are the seek times, which should be shown from two perspectives.

First is the read/write time for a single track. Functionally, once the track is found and the actuator is positioned, a single seek time becomes the time it takes for the head to identify and settle on the precise spot where the data will be read from or written to. The second spec is the average seek time (which will be stated separately for both a read and a write), followed next by a maximum or worst-case average seek time which is at least two times the average seek time for a read.

Typical specifications for a 300 GB SCSI drive with a rotational speed of 15,000 rpm will have a rotational latency average of 2.0 ms. The seek time for a single track read/write operation is 0.45 ms, with an average seek of 3.5 to 4.0 ms. The maximum seek time is 7.9 ms.

WEIGH THE SPECS

Another benchmark test for drives is based upon tabulating the average number of input/output requests per second.

A request will consist of both actuator (the arm that the head is attached to) and rotational positioning, followed by a block read or write. The block size is 8k for a workstation or database instance, and anywhere from 0.5k to 64k for a file server pattern. As a benchmark comparison between drive rpms and the number of I/O requests per second — the 15,000 rpm drive benchmarks at 140 I/Os per second compared with 84 I/Os for 7,200 rpm drives and 105 for 10,000 rpm drives. Summarily, a 15,000 rpm drive delivers a 33 percent increase in I/Os per second over 10,000 rpm drives, which equates to a 28 percent improvement in "time-to-data" performance.

For professional broadcast server applications, these specs are carefully analyzed during the product design, development and HDD qualification period. This is why media server manufacturers prefer to provide the storage systems that are married to their specific software and hardware controller, I/O and media managers. However, if you're adding drives or arrays to server platforms that are used for non-linear editing, transcode engines or graphics workstations, understanding these specifications and knowing where or how to employ the growing variety of eSATA, SAS, iSCSI and Fibre Channel drive arrays in your system is valuable indeed.

Karl Paulsen is chief technology officer at Azcar Technologies.

This article appeared originally in TV Technology magazine. ■

Tube

CONTINUED FROM PAGE 14

SUMMARY

The efficient, common amplification of FM + HD Radio signals requires a new RF amplifier design approach.

Vacuum tube RF amplifier technology offers the lowest purchase cost and highest operating efficiency at output power levels above 20 kW. It is now possible to offer FM+HD power output levels above 30 kW from a single transmitter. There is still work to be done on additional new vacuum tube technology to push to even higher power output levels. Further advances in the HD Radio exciter's adaptive pre-correction and peak-to-average power reduction techniques offer further upside power output possibilities through exciter software updates.

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Dave Danielsons, Principal RF Design Engineer
Ky Luu, Senior Scientist
Kerri Harris, Engineering Assistant
Monica Collins, Administrative Assistant

This paper was presented at the 2009 NAB Show in Las Vegas.

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


Fig. 1: Xohm-Supplied WiMax Express Card With PC Card Adapter

Fig. 3: This will be easier than I thought!

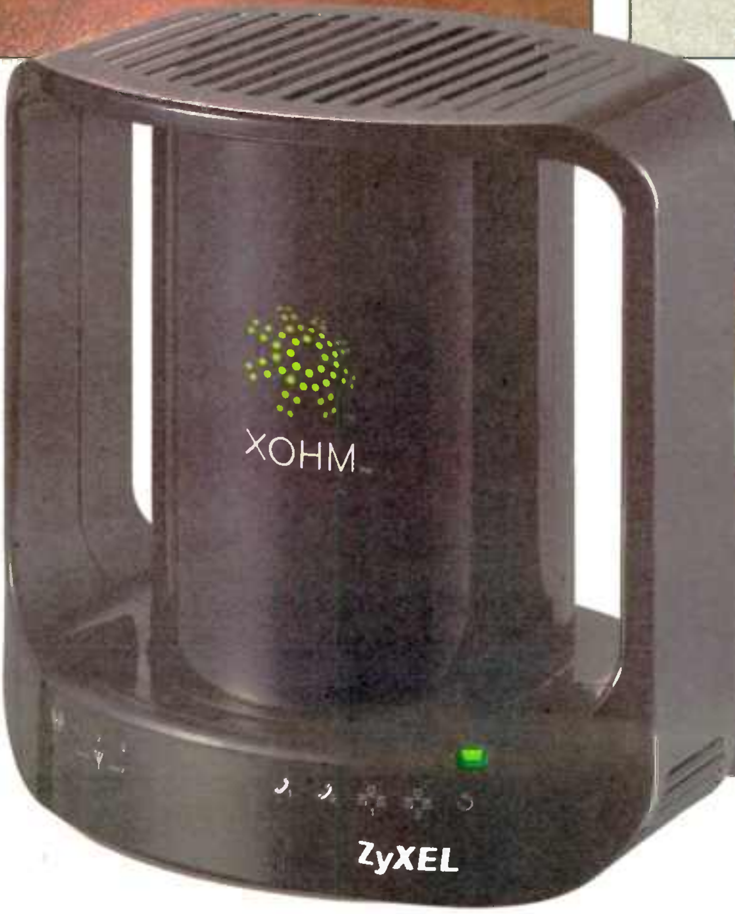


Fig. 2: The Xohm External Modem

Fig. 4: Scene of the Crime

WiMax

CONTINUED FROM PAGE 1

service in the Baltimore market only, with several other cities coming online around the end of 2009. After enough begging, we got hold of a sample card, shown in Fig. 1, with intention of finding a way to have Access Portable utilize the card, and then finding a friendly broadcaster in the Baltimore area to help us try it out.

As it turns out, the card offers literally no Linux support at this time, so the project of including direct support for it was shelved for a different day. For future tests, I recommend using the available external modem, shown in Fig. 2, which should theoretically have no such interface issues. It may have an advantage as well, since building penetration at the 2.5 GHz frequency used by Xohm can sometimes be challenging. Utilizing the external modem would allow you to position it near a window, and run an Ethernet cable to where the action is.

Before I booked my flight to Baltimore, a little Googling produced some reports that Baltimore WiMax users have migrated to some other "soon to be covered" cities and had success with their Xohm hardware there. Since one of the reported cities was Boston, I ventured out on a little site survey to see if I could conduct the testing closer to home. Lo and behold, the card in my laptop lit up in various areas in the city and around the Route 128 technology corridor (Fig. 3).

So I found a convenient location to our office in Devens, Mass., which turned out to be the shopping area in Burlington. I went back a few days later, staked a location in a shopping center parking lot (Fig. 4), and began testing.

First, I did a round of speed and ping tests. The Xohm Windows client has a built-in link to Speedtest.net, so I ran a couple of tests there. A typical result is in Fig. 5.

The tools at *DSLreports.com* weren't quite as charitable on the downlink side, but we really care more about uplink speed for codecs, and it still appeared to be plenty (Fig. 6).

But bandwidth is only half the battle, since the IP codec application is so reliant on low network delay. This has been an issue with 3G networks, which can often instill a large fraction of a second of delay in each direction. So some ping tests were performed (Fig. 7).

The results, an average of 80 msec delay, were pretty respectable.

The last factor that will affect delay is the overall jitter performance of the network. Since the decoder needs to buffer the incoming packets to account for late

SEE WIMAX, PAGE 18

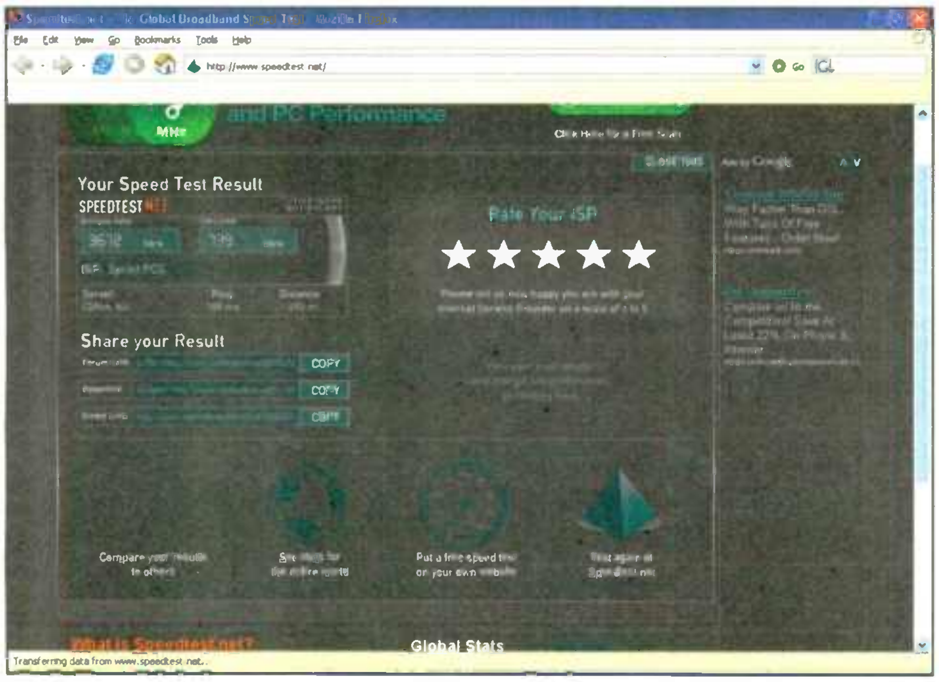


Fig. 5: 3.6 Mbps downlink! 740K up! Very nice.

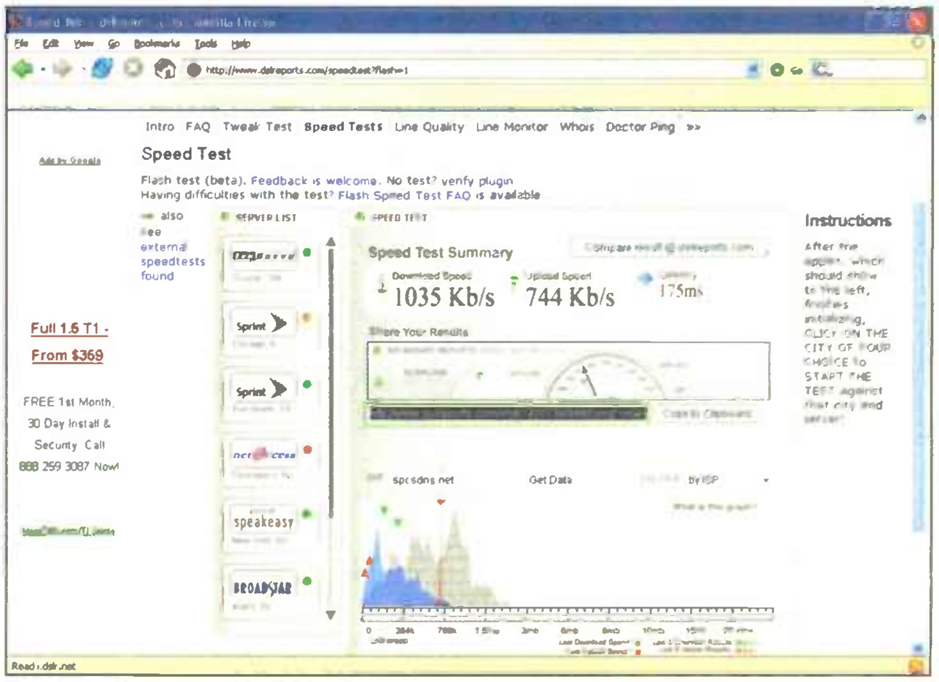


Fig. 6.: Still Not Too Shabby

WiMax

CONTINUED FROM PAGE 17

arrivals, this buffer will add to the overall delay. Now keep in mind, the network I was using was purely in its test phase, and I'm pretty sure I was sharing it with virtually nobody else. So the final results will probably vary from mine.

As mentioned, attaching the card directly to the codec was a non-starter, so I needed to lash up a laptop running the card to a portable Access. This is done via the Windows utility called Internet Connection Sharing (ICS). I ran an Ethernet crossover cable to the Access and that resulted in the mess shown in Fig. 8, below, but voilà! It works!

Because the Access rack back in my lab has online statistics available, I was able to monitor the network quality and jitter rates on both ends simultaneously. I was very impressed.

I was running the AAC-ELD stereo option, which utilizes around 80 kbps in each direction. The network jitter on the return link, as read on the portable, required a jitter buffer of about 60 mS for stable operation. And stable it was, without so much as a packet drop over the hour-long testing (Fig. 9).

But of course, the real test is what was getting back to the lab, since that would be the "over-the-air" link. Luckily the WiMax link had plenty of extra bandwidth for me to log into the Web page of my lab unit to check that (Fig. 10).

So the test "broadcast" was perfect. Sounded great in my car, and the remote stats page showed it sounded perfect in the lab as well. What was the overall delay? The numbers:

1) AAC-ELD coding and decoding cycle: 50 mS
2) 1/2 Ping time transmission delay: 40 mS
3) Decode jitter buffer: 60–80 mS

Total one-way delay of this system was around 170 mS. That's in the same range as some digital mobile phones. Given a mix-minus feed, it should be quite manageable on an interactive basis.

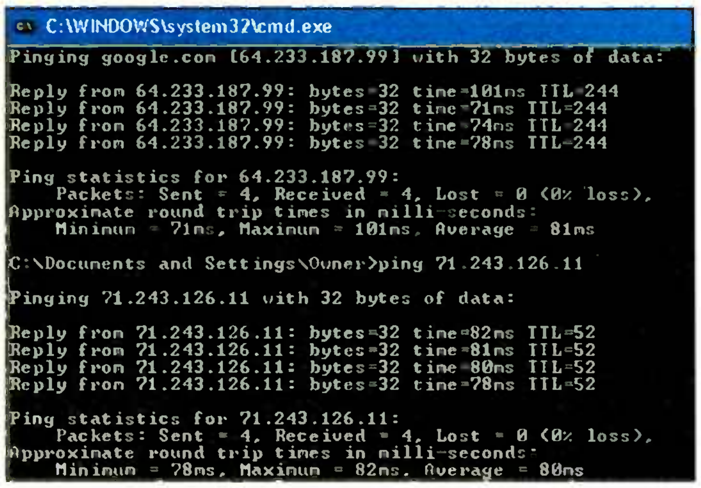


Fig. 7: Ping Test to Google (81mS avg) and to My Lab Codec (80 mS avg)

Fig. 8: Ugly but Effective

Fig. 9: Portable RX stats — holding up very well.

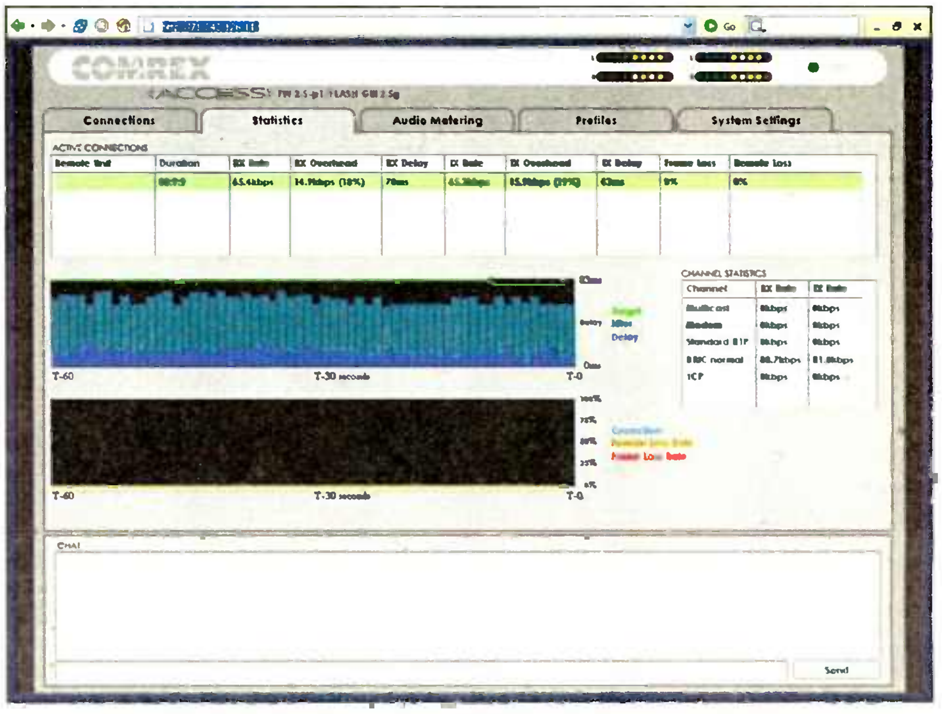


Fig. 10: Perfect Transmission With Jitter Buffer Around 80 mS

SUMMARY

While I must add a couple of caveats in that the Xohm WiMax system is not heavily deployed or used, early tests are extremely promising for use of this technology for remote broadcasts using Access IP codecs. We'll gather more info as customers get subscriptions (and hopefully support the card directly) and will update our Web site (*www.comrex.com*) with the latest details. ■

NAB Show

CONTINUED FROM PAGE 3

new transmission plants. There were many good papers and presentations to be seen, including one we are publishing in this issue from Geoff Mendenhall of Harris Corp. (see page 1).

A favorite moment for me this year was seeing David Rehr interview author Malcolm Gladwell during one of the show's events. Gladwell is one of my favorite writers right now, and it was a treat to see him in person and hear more about his latest work.

For me, the most important reason to attend the NAB Show is to keep up on the latest in technology so that my knowledge and skills can stay up-to-date with changes in the broadcast industry. Even the smaller show this year was able to fulfill that goal, both in the conference sessions and in the exhibit halls.

AT SBE EDUCATION IS NUMBER ONE

Speaking of education, in the April 2009 issue of the SBE Signal, the Strategic Planning Committee released the results of its member survey. It showed that members consider education to be the most important concern of the Society of Broadcast Engineers; almost 99 percent of respondents were in agreement.

Our very own Cris Alexander, who authors the *Day in the Life* column for Radio World Engineering Extra, also serves as the chair of the Education Committee for the SBE. So in addition to reading his regular columns, you should look into what Cris has been doing over at the SBE.

Recent efforts have resulted in a new educational opportunity in the form of SBE University. Three radio-related courses are currently available: AM Antenna Modeling, FM Transmission Systems and Matching Networks and Phasing. The courses are available to both members and non-members and are taken online, on-demand for a modest fee. No travel is required.

Many of us talk about the need to bring new talent into broadcast engineering, and the SBE University can help. With expenses cut all across the board, are you hiring part-timers and recent graduates with no experience to help out with engineering? Here's a way to get them the background education they need. What better way to start someone out as a new engineer?

I like to promote the efforts of the SBE because it exists to support broadcast engineers in their careers. I am a longtime member of the SBE and am a Certified Professional Broadcast Engineer. Note that it takes 20 years of professional experience to achieve the highest certification level, in addition to passing exams.

The recertification requirement every five years forces engineers to keep their skills current. I chose to get certification because this is the industry-accepted method of proving that I have the skills and experience as a broadcast engineer.

Finally, to get into that certification "frame of mind," please don't miss our regular feature, the SBE Certification Corner in Engineering Extra. We present in each issue a challenging question that addresses a topic that might be covered on an SBE certification exam.

Author Buc Fitch and I try to come up with representative questions, which allow us to explain in detail a technical topic related to broadcast engineering, such as FCC rules, basic electronics or AM transmission systems. Our answers take a broad view of the topic so that in addition to just answering the question, we try to present background explanation that hopefully helps you to understand the engineering involved just a bit better. ■

READER'S FORUM

That's How It Bounces

If you are going to describe propagation for SBE certification question (RWEE, April 15), at least do it correctly. Your description on page 6 for the power question states: "During the daylight hours the ionosphere layer of the earth's atmosphere is ionized by the sun and medium-wave signals pass through into outer space. At night, without solar heating, the atmosphere 'hardens up'..."

Quite the opposite occurs: During the daytime the D layer thickens and absorbs LF radio waves so they can't reach the E and F layers to be reflected. At night without the presence of as many solar particles (not so much heat), the D layer *thins* or goes away altogether to allow the low-frequency waves to reach the E and F layers to be reflected.

I realize the question was about FCC rules, but nonetheless, if we are helping future CEs learn, let's not feed them misinformation.

Paul A. Litwinovich
Director of Engineering
WSHU(AM/FM), WSUF(FM)
Fairfield, Conn.

Technical Editor Michael LeClair replies: Your description of ionospheric reflection is much better than ours so we are reprinting it in full.

by Charles S. "Buc" Fitch

A Proportionate Heater Replacement For Marti Crystal Cans

Restore Your Remote Gear's Stability and Performance

Ever since my affectionate *Milestones* column about Martis appeared in Radio World back in 2005, an endless parade of Marti remote pickup receivers and transmitters has passed across my workbench. Marti users near and far have sent me their gear in the hope that I can either resurrect it back to functionality or peak it up to new performance.

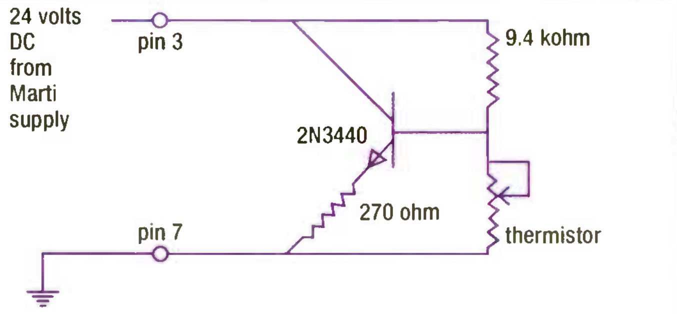
One troublesome item in those Marti units since day one were the heaters in the crystal ovens. At this point almost all ovens of one particular brand are non-functional.

Most Martis will run adequately without a functioning heater in a room temperature environment. However, to achieve peak stability performance and in locations subject to very low temperatures, a heated can is needed.

My solution is to build a replacement heater for single-frequency applications (two crystals and this heater circuit will not fit easily in a standard Marti crystal can). Most crystal oven heaters are of the thermostatic variety; the heater element heats up the inside of the can and at a fixed point a thermostat element opens the circuit. After cooling, that thermostat closes, current flows again and that starts to pick up the heat. The range of temperature is set by the make and unmake points of that particular thermostat.

The schematic (Fig. 1) is of the somewhat different "proportionate" type. Proportionate temperature controllers forego the abrupt on-off control and use a sort of dynamic feedback loop varying the heat generated by the oven element to maintain a predetermined set point. The goal is to balance the heat generated with the temperature needed and, if properly designed, these ovens can maintain that temperature quite closely.

The collector of an NPN transistor is connected to 24 volts as in a Marti STL-8 receiver or an RPU "R" series receiver. The emitter goes to ground through a 270 ohm 0.5 watt resistor. The nominal design current flow is about 40 mA with 12 volts across the resistor. That brings the 270 ohm resistor to near maximum heat handling capability, making it essentially a 0.5 watt heater. Twenty-four volts also feeds a resistive voltage divider made up of a fixed 9.4 kohm resistor and a thermistor to ground. At room temperature of about 68 degrees Fahrenheit, the thermistor has about 10 kohm resistance. If the heat goes up the thermistor resistance goes down, dropping the voltage at the junction point of these two resistors. This lowers the voltage at the "pass" transistor's base, dropping the voltage applied to the heater resistor and hence lowering the heat generated.



Parts List
Transistor = 2N3440 or equivalent
Thermistor = RadioShack 271-110 or equivalent
Resistor 270 ohm = RadioShack 271-1120 or equivalent
Resistor 9.4 kohm = made up from two series
4.7k 1/8 watt resistors RadioShack 271-008 or equivalent

Fig. 1: Basic schematic for the proportional crystal oven heater. See text for assembly details.

Fig. 2: The proportionate crystal heater undergoes bench test prior to final assembly.

At just about 90 to 100 degrees Fahrenheit, equilibrium is obtained (component value dependent) and with slight proportional adjustments, the crystal is kept at a stable temperature.

CONSTRUCTION FINE POINTS

Here are the practical details. Since the temperature of the crystal is what is important, the 270 ohm resistor and the thermistor are pressed directly against the crystal on opposite sides under shrink wrap. The heat of the resistor on one side migrates through the crystal can to the opposite side providing a sort of control hysteresis.

A 2N3440 NPN (basically a 2N2222 on steroids) was chosen as it has a good power rating, it remains stable at temperatures over 100 degrees Fahrenheit and is in a metal can. Most important, my good friend Bill Rosenfeldt gave me 60 of them for my 60th birthday present! That's a lot of transistors to find applications for, and this is a perfect use.

The thermal qualities of this transistor are important as we have chosen to keep the transistor inside the crystal can. The IR drop across the transistor is also given up as heat and so we really have two heaters: The 270 ohm resistor is heating the crystal directly and the 2N3440 is heating the interior of the closed can. So the transistor has to be stable and tolerate high temperatures otherwise you'd probably have thermal runaway.

Assembly is straightforward. Open the can (small screws on the sides) and mark the position used by the active crystal. Unsolder and remove the old heater (usually looks like a ceramic capacitor) and the redundant second crystal socket.

Take the crystal and swab a little "stiff" aluminum heat sink compound. Cover the leads on both the 270 ohm resistor and the thermistor with small shrink wrap so they will not short out on the crystal walls. Now shrink wrap the entire crystal with the thermistor and the resistor on opposite sides.

Solder two #20 tinned solid bus wires into pins 3 and 7 (99 percent of all Martis use pin 3 for the high side of the voltage and pin 7 as ground, but double check this before you start). Assemble the circuit as you like using these stiff posts as mounts such that the top of the transistor is even with the top of the can when it is placed over this new assembly.

Remove the insulation found in the top of the heater can and then fill the top with a little more than 1/8-inch of stiff aluminum heat sink compound. This paste will bond with the top of the transistor when assembled and allow the heat to run off onto the skin of the can.

Put the can top on once and see if you have even paste on the top of the transistor and if so, then rotate the can 180 degrees and screw back together if the can has just two screws. If it's the more rare three-screw variety, dab a little more on top of the transistor and put it back together.

Fig. 2 shows the assembly just after the heat paste check and just before the can was put on permanently.

Thus far this little circuit has proven to be reliable, durable, stable and effective.

Although I have not made one of these for another voltage, it would seem to me that for 12 volt cans you could use a 120 ohm resistor instead of a 270 and the performance results should be about the same.

Total cost: About $10.

You can read our earlier Milestones column about Martis under Columns/Milestones at radioworld.com; *it also appears at* www.martielectronics.com, *keyword Fitch.* ■

Savage

CONTINUED FROM PAGE 14

technology from the beginning and have often been critical of its shortcomings. I've gone on record as saying AM-HD has a tough uphill climb to achieve success. HD-R just doesn't add enough compelling value to make AMs more successful or appealing. (OK, I will concede that at least ballgames do sound better on HD.)

I'm becoming convinced that the industry will conclude the hybrid mode for AM is too expensive and too much of a compromise to win over enough stations and consumers to make it viable during the hybrid transition. Except in sparsely populated regions, WiMax Internet-enabled mobile devices, including the new breed of multi-mode car receivers, will drive a lot of "radio listening" in the not too distant future.

But I wouldn't count AM-HD down and out just yet. As more AM stations go dark and/or switch to LPFM or FM-HD supplemental channels, at some point in the future surviving stations may eventually decide that a switch to all-digital will serve their interests better. The advantages of all-digital are impressive. But it's not going to be easy for the stakeholders of a proud 90-year-old legacy tradition to turn their backs on more than a billion analog AM radios in the hands of consumers.

FM-HD is a completely different animal with so many more attractive stripes and features. It has two critically important advantages AM never had. The FM band's founding fathers created channel spacing rules that actually prohibit any station from spilling energy into its first-adjacent neighbor's allocated channel. Not having to deal with skywave propagation is the other.

HD on FM has proven itself a worthy innovation that does not cause interference to its neighbors when properly installed and maintained. Very few real interference cases have emerged on FM in which protected contours of first-adjacent channels received interference from HD subcarriers. The Savage claim that "Guy insists we need to repeat the AM IBOC disaster on FM" just doesn't hold water.

HD POWER BOOST BASICS

The proposed 10 dB power increase for FM-HD does introduce the possibility of some increased interference, both to the host station's analog listeners and to some first-adjacent neighbors, mostly short-spaced stations. During the initial rounds of IBOC testing in the early 1990s, a few test receivers exhibited elevated analog white noise levels at digital injection above –20 dBc. For that reason, along with field evaluations that revealed the edge of HD reception was roughly equivalent to the analog 1 mV/m contour, iBiquity engineers chose the –20 dBc power level as the starting point for FM hybrid transmission.

As time has gone by, receiver manufacturers have made a better effort designing tighter IF filter response characteristics and smarter demodulators to minimize the leaking white noise problem. Increasing HD power from –20 dBc to –10 dBc in today's environment does not appear to degrade analog performance for the vast majority of installed consumer receivers. A real-world test case confirms that. Over two years ago, KROQ(FM) in Los Angeles, received and implemented an STA to operate HD at –10 dBc. I've checked with CBS and other L.A. engineers who cite no instances of reported or even anecdotal interference complaints.

Using –10 dBc HD power may result in increased interference to first-adjacent stations, especially in short-spaced situations. This is going to be tricky to evaluate properly since most such scenarios already exhibit significant analog interference to each first-adjacent neighbor at their fringes. A lot of it is the result of front-end overloading where the D/U ratios collapse. Nonetheless, additional field testing is now under way in a number of markets to give all stakeholders a better reading of the issue.

It's probable that most stations with first-adjacent short-spaced limitations will not be able to increase HD power the full 10 dB. A lesser amount of increase should be permissible for many. A few may not be able to increase HD power at all. The rules will need to be specific and enforceable to protect all interests.

The proposed HD Radio power increase is an important step forward in FM-HD's maturation process. It will allow HD reception to more closely match the consumer's expectations of a traditional "radio experience" when capturing and holding HD Radio stations on the dial with any radio in typical listening venues.

Savage is calling HD Radio a "defective and unwanted innovation" that has already failed since consumers aren't buying HD radios and are perfectly happy with their old analog sets. Only iBiquity, industry "leaders" and supportive engineers want it to succeed and the public could care less, he says.

STATUS QUO CRUSADE

Yes, the rollout has been painfully slow for those of us working inside the industry. I completely agree that right now, there is little public demand for HD Radios or the additional services on supplemental channels. Better programming, better marketing and cheaper receivers are all needed to push it along more effectively.

Consider this: If the history of major technology advances implemented on broadcast services teaches us anything, it confirms that it simply takes many years for even nuanced improvements to catch on and become mainstream. Witness the adoption of FM stereo. Introduced in 1959, the innovation didn't truly come of age until some 20+ years later. By comparison, HD Radio as an authorized service has only been around for less than seven years.

Bob Savage and all other broadcast brothers who oppose HD Radio need to realize where we are as an industry and where all other electronic media are headed, taking much of our audience with them. Radio is the last major player doing analog. The other services aren't doing digital just because digital is new and glitzy. They've converted to digital delivery because of its superior scalability, manageability and problem resolution capabilities in creating a higher-quality product for the consumer.

And don't lose sight of the eventuality, when analog carriers give way to all digital. We can only wonder what additional roles radio will then be able to play as part of tomorrow's vast array of electronically delivered consumer multi-media choices.

HD Radio has just left the starting blocks. Don't keep insisting on the status quo for our industry, Bob. Buggywhip salesmen did the same thing over a hundred years ago and let the world's travelers pass them by … in their new automobiles.

RW welcomes other points of view to radioworld@nbmedia.com. ■

Stress

CONTINUED FROM PAGE 22

lem if activated for only a short interval. But the body falls apart if they continue indefinitely.

RESPONSE TO STRESSORS

I strongly recommend taking a look at Robert Sapolsky's book, "Why Zebras Don't Get Ulcers." It explores the consequence of stress: stress-related diseases. He also proposes coping mechanisms. Managing stress is yet another of the soft skills that are critical for survival.

Sapolsky's simple recommendation is to experiment with yourself until you find a technique that reduces the "experience" of stress. It can be meditating, taking long walks, playing with a grandchild or whatever. But if you do not find some way to throttle back your response to stressors, you will destroy your internal organs.

None of us can change the world, but we can and should change our response to it. Reinhold Niebuhr wrote a famous prayer: "God grant me the serenity to accept things that I cannot change, courage to change the things that I can, and the wisdom to know the difference." Alternatively stated, you can rarely change the external world, but you can always change your inner world.

My personal method of reducing stress is spending time with close friends, colleagues and family. This is more than just socializing with the gang. I get the benefit of the comfort from being connected to a supportive community with sympathy, empathy and a shared view of mutual assistance and caring. People are social animals that gain from cohesion. Also, I am an executive of an equipment manufacturer that was created entirely on the basis of enhancing the well-being of the staff as the only currency.

It really does work.

The author is director of engineering for 25-Seven Systems. ■

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by Barry Blesser

The Biological Cost of Stress in Broadcasting

Our Systems Are Not Designed to Operate In a State of Constant High Alert

Even if you do not read the newspaper or listen to the radio, you know that there is uncertainty in the broadcast industry.

While you may still have a job, you are experiencing the consequences of broken business models and economic meltdown. This article does not promise yet another self-help solution. We do not choose the decade we live in, and there is usually little that one can do to bring back the "good old days."

Nevertheless, it is useful to consider some of the hidden consequences of the environment that we find ourselves immersed in.

In the previous *Last Word* article (RWEE, April 15), I introduced two concepts: a human being as an element in a social system, and the need to acquire the soft skills to manage that system.

In addition to being in a social system, we are each a biological system composed of thousands of elements that have evolved to work together. Your foot, your stomach and your eyes are obvious examples of elements with specialized function in you as a system. But there are also thousands of hidden elements that are critical to your ability to function. Although you cannot see these components, they are there and critical for survival.

While we may experience ourselves as a "holistic" me, this is not a useful model when trying to survive in a hostile environment. You are a system. In the same way, an automobile, a broadcast station and an RF transmitter are systems. A good engineer understands the difference between an element and a system. Recent research is now showing how the biological elements in you as a system respond to the dynamics of life.

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INSTRUCTION MANUAL

When you purchase a transmitter, the manufacturer provides a user's manual and literature on how to maintain and repair it. The designer of the system makes assumptions about how it should function, and ideally, its properties are articulated as limitations in performance under various conditions. Run the final stage of a transmitter at 50 percent over its power rating for a day and it is likely to burn out. Standard 14/2 electrical wire can handle 100 amps for a short time, but if the current continues, your house will burn down. Run your heart at 100 percent over its normal rating for a week, and it may also burn out.

During the trailing days of World War II, afterburners were installed in jet airplanes. These devices injected excess fuel into the exhaust to provide a short-term boost in power, like the boost required for an animal running for its life from a lion. In effect, the engine was run beyond its rating, and continuous use of the afterburner would destroy the engine.

Similarly, if you run a 26.2-mile marathon, you will need weeks of rest to allow for healing in the overloaded muscles and heart. Legend has it that in 490 B.C. the original Marathon runner, who carried the news of the Greek victory over the Persians, died shortly after reaching his destination. Overload has a cost.

Over the centuries, intuitive wisdom has created a set of ad hoc rules for the limitations of the biological elements in the human system. These rules are constantly in flux, and history usually showed that they were wrong. But during the last decade, rapid advances in cognitive science, evolutionary biology and medical technology are now providing reliable data about the dynamics of the elements in our biological system.

STRESSOR EFFECTS

What happens when our biological system is placed into an engineering laboratory in a broadcast station in the 21st century? Obviously, the system did not evolve for that purpose. Your body does not necessarily distinguish between an ominous lion and a pending layoff; both are experienced as danger.

In simple terms, all species evolved a unique mechanism for avoiding danger. To one degree or another, every animal has one of three choices for handling a threat: fight, flight or freeze.

Your body does not necessarily distinguish between an ominous lion and a pending layoff; both are experienced as danger.

Human beings also respond in this way. We fight to keep our jobs or for a promotion. Or, when times are tough, we take flight to another industry or a different life style, or hide with our head in the sand avoiding any actions that might attract attention. We can now look more carefully at how our biological system responds to threats and stressors.

Nature used one critical idea in designing biological systems. If you are being chased by a lion, activate all elements beyond their ratings in order to avoiding being the lion's lunch. It does not matter how much that overload damages elements in the system because the alternative is far worse. Better to allow a week for recuperation than to be eaten.

At this point, you might be wondering why this discussion is relevant to those of us who are working in the broadcast industry. The answer is that for many (most) of us, our work environment has stressors, which produce a stress response to protect us from real or imagined danger.

We may experience 21st century dangers on a 24/7 basis, though we were not designed to handle continuous stressor threats. You may be lying in bed at 2 a.m. trying to plan how you will avoid the impending layoffs. This is biologically equivalent to being chased by a lion. However, with a real lion, after a short time, you are either safe or dead. The threat is short-lived, overloading our internal components for a short time, like the afterburner. But we are not designed to handle threats for weeks, months or years.

Like all mammals, many of our biological elements respond to stressors. I will take an example of a single organ — the heart.

Under stress, your sympathetic nervous system signals to all organs to enter survival mode, releasing a special hormone, glucocorticoid, to communicate urgency to the other organs. Your heart shifts into high gear, beating faster with increased pumping pressure. Your veins constrict and arteries expand to feed blood to muscles while shutting down blood to non-essential organs. Your kidneys are told to stop extracting water to avoid dehydration due to a loss of blood. Digestion stops, the immune system shuts down, memory is impaired, sleep becomes impossible … the list goes on.

These stress responses are not a prob-

SEE STRESS, PAGE 21

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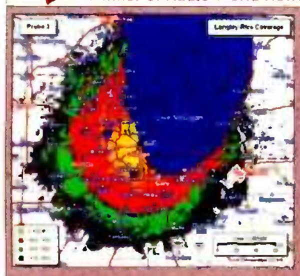

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