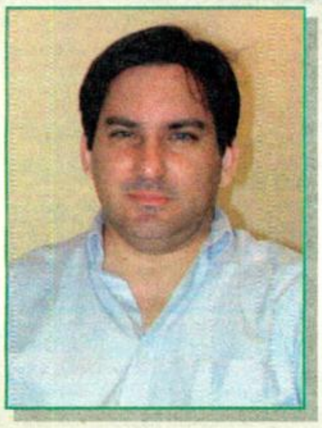
Radio World
ENGINEERING EXTRA

December 14, 2005

DESIGNER INTERVIEW



Derek Kumar

FMeXtra: Another On-Channel Solution

Derek Kumar of Digital Radio Express Explains the Development of a Digital System Using Subcarriers

By Michael LeClair

At the NAB Broadcast Engineering Conference in April, a new digital radio system debuted on the show floor from Digital Radio Express.

Offering a simple implementation and relatively low costs, DRE demonstrated working digital transmissions

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The Design of a Linearized Tube Amplifier

High-Power Common Amplification for FM and Digital IBOC Signals

by Daniel L. Dickey

The author is vice president of engineering for Continental Electronics Corp. in Dallas.

The IBOC system is based on Orthogonal Frequency Division Multiplexing or OFDM, which produces a complex RF waveform having continuously varying envelope and phase. In contrast, FM is a constant envelope signal with only time-varying phase. Therefore many FM transmitters employ class C or E final amplifiers to obtain higher efficiency because the higher the efficiency the lower the total cost of ownership owing to lower purchase and operating costs.

However, these high-efficiency amplifiers exhibit severe intermodulation when presented with input RF that contains a time-varying envelope component because they almost totally ignore the input level variations. Therefore the challenge is to design an amplifier that is able to reproduce the time-varying envelope component of the IBOC signal whilst giving up as little efficiency as possible.

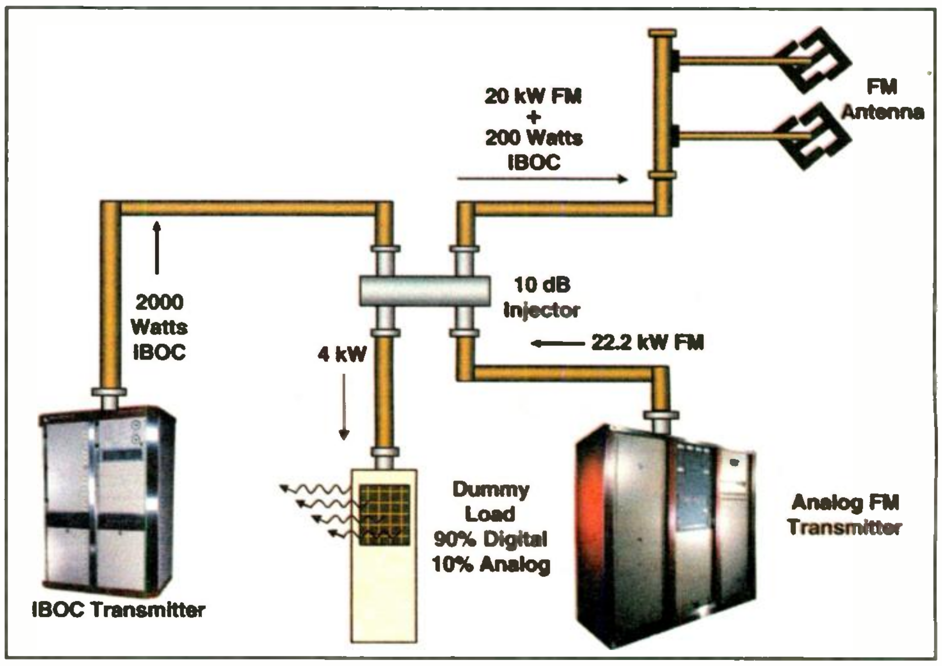

Fig. 1: High-Level Combining System Diagram

DESIGN PROCESS

The design process we followed consisted of a requirements phase, followed by paper design and finally design validation by measurement. The first step was to define the requirements.

The primary requirements were the desired maximum power output of the transmitter and desired efficiency. Other system requirements for digital radio transmission are specified by the IBOC system specifications [see Footnote 1]. Another important requirement was that the analog FM performance of the transmitter should be consistent with current analog-only designs and preference should be given to analog improvements where practical.

REQUIREMENTS

The next step was to complete a paper design and calculate the expected performance. This step will often indicate if the original requirements are realistic or not. If not, revisions to the requirements may have to be made. The final step was to actually build the transmitter and verify measured performance against the finalized requirements.

The power output requirement was specified as 20 kW minimum. This power level was deemed adequate for a significant population of FM transmitter systems already in the field based on available market data. It also appeared that this requirement could be met using an existing design with certain modifications. By using an existing design we could eliminate many of the "teething" problems a totally new transmitter design would inevitably entail.

Based on an analysis of existing solu-

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FROM THE TECH EDITOR

Michael LeClair

Two Fall Engineering Conferences Worth a Visit

This fall I had the pleasure to attend not one but two worthy conferences devoted to broadcast engineering. Both featured great papers and some of the latest information on technology trends; both were more manageable in scale than the large NAB shows.

AN INTERNATIONAL FLAVOR

First was the IEEE Broadcast Engineering Symposium, held in Washington, D.C. Sponsored by the Institute of Electrical and Electronic Engineers, the symposium is a forum for new research in the field of broadcast engineering.

Listening to the presentations it is hard not to be overwhelmed at the range of topics and the technical depth that underlies each one. Many presenters described initiatives in nations that take different approaches to broadcasting than does the United States.

The varied perspectives are a learning experience for a U.S. resident. Sometimes we forget that not everyone is working on the same digital broadcasting systems we are just beginning to deploy. The experiences of others in the digital realm can be a powerful guide to our own changing technology.

Presentations included papers on DRM, AM antenna design and multichannel audio broadcasting. For those who like hard engineering and basic research, this is a place to find it. No, you don't have to pass a test to go, but be prepared to pay attention; the information is very technical.

We are fortunate to be able to include in this issue a paper from the Symposium. It was presented by Dan Dickey of Continental Electronics and describes the design and performance testing of its tube-based HD Radio transmitter.

While this paper was being presented, I found myself looking at tube load lines for the first time in many years and enjoying myself immensely. It was fun to see the familiar tube at the center of the action; these days so many technical developments center on the ways that computers and digital transmission are changing broadcasting.

The paper also provides a look at the engineering processes and tradeoffs that go on behind the scenes during the development of a real-world transmitter.

I hope to be able to feature more useful information and papers from the Broadcast Engineering Symposium in the future.

THE LOCAL SCENE

Just a few weeks later I was at Boston, a Society of Broadcast Engineers-sponsored trade show and workshop now held every fall in the Boston area. The SBE has been organizing such shows across the country to provide broadcast engineers an opportunity to attend both a regional trade show and an informative Ennes Workshop.

The cost of these shows is only $25, which can fit into pretty much anyone's budget, even if you work for the stingiest of employers. The SBE Web site says there are shows scheduled this year for Seattle, Pittsburgh, Dallas, Michigan, Wisconsin and Oklahoma, as well as Boston. For most readers, it should be possible to attend one within a day's drive.

Topics at this year's Ennes Workshop included a presentation on many of the unique properties of wire and audio cable by Steve Lampen of Belden, demonstrations of different types of surround sound technologies by Frank Foti of Telos Systems and an overview of the problem of transmitter spectral regrowth with HD Radio by Bob Surette of Shively Labs.

These presentations were informative and gave information that can help you stay ahead of technological change. There was a trade show on the following day, which featured more than 100 manufacturers booths and some of the latest technology on display.

A large part of our job is just knowing what kinds of products and equipment are out there for those times when a project needs to be done right away. The chance to see new products before being asked to budget, design and order equipment for a new initiative (before 5 p.m.) gets you ready for fast-paced opportunities.

These workshops are valuable events and should be on everyone's calendar, especially if you are not one of the lucky ones who get to go to the big NAB Broadcast Engineering Conference in the spring. SBE members should also note that Ennes Workshops count for valuable recertification points you may have to scramble to come up with every seven years.

For me, broadcast shows and conferences are an important part of my career and I can't imagine how I could carry out the daily engineering or long-term planning I do without these valuable resources. Every year I seek out and schedule these kinds of events for my staff and myself because we need to keep up with the technology or we lose our value as broadcast engineers.

All professions, such as medicine, law or architecture, have similar industry events that serve the same purpose — keeping on top of how their industry changes. While you may feel you don't have the time to attend everything, it is still important to make the time to go to a broadcast engineering conference on a regular basis to keep up your skills.

IN THIS ISSUE

Of course, another of the most valuable resources for keeping up on the latest in broadcast technology is in your hands — the latest issue of Radio World Engineering Extra.

In the last 10 years it has become more common for stations to combine operations into a shared antenna. With new tower space difficult to build, and the mandate for digital TV eating into the inventory of available support structures, many engineers now find themselves maintaining one or more stations that feed into a large combiner.

To learn more about these essential devices we have a new paper from Bob Surette on combiner design. Even if you aren't the one responsible for maintaining the entire system, this paper will explain how combiners work, the latest designs and their use with HD Radio.

We also have an in-depth interview with Derek Kumar of Digital Radio Express on its new digital radio system that utilizes the subcarrier region of the FM broadcast channel. The article has interesting history about where this idea came from and inside information on the technical details of the system. I know a lot of readers want to know more about this system; here is your chance.

We've also got Guy Wire on the technical siege radio is facing and Barry Blesser with another perspective on how technical change comes about.

You too can be a part of the technology discussion. We have been getting wonderful letters from our readers and we print as many as we can in Engineering Extra. Please keep sending us your comments, suggestions and insights to me at *rwee@imaspub.com*. ■

For me, going to broadcast shows and conferences is an important part of my career; I can't imagine how I could carry out the daily engineering or long-term planning I do without these valuable resources.

IN THIS ISSUE

Kumar

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and receivers.

In this issue's interview we speak with Derek Kumar, vice president of engineering for Digital Radio Express. Kumar received his BSEE and MSEE from the University of Illinois at Urbana-Champaign in the 1980s. He has been active for many years in the development of digital radio systems.

What drew you to broadcasting?

While I was a National Science Foundation graduate fellow at the University of Illinois, I met Professor Bill Hunsinger. He had invented a new microwave signal processing technology called acoustic charge transport [ACT]. Professor Hunsinger was already well known in the field for his contributions to surface-acoustic wave [SAW] filter theory.

SAW filters are used extensively in satellite and mobile phone systems. ACT technology allowed for a digitally programmable SAW filter. It had all sorts of applications that were previously thought to be too complex or too power-hungry to implement by conventional circuits.

The professor spun the research group out of the university and founded the company Electronic Decisions Inc. We were funded by the then-largest single grant from the Defense Advanced Research Projects Agency.

It was an incredibly exciting time. We had a generous equipment budget, and we were researching both fundamental technology issues and high-level system applications, which is a rare opportunity today.

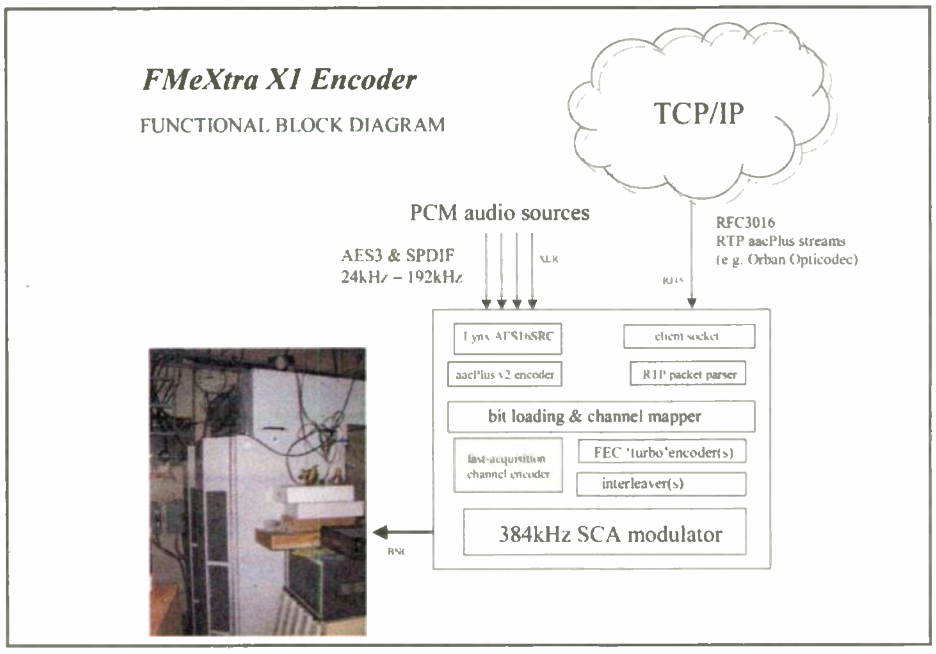

Fig. 1: FMeXtra System Block Diagram

How long have you been working on the digital radio system that is now being offered as FMeXtra?

In the late '80s, a group of broadcasters approached EDI to see if there was any way to use ACT technology to make an FM IBOC system. That was my first encounter with Tony Masiello of CBS, Paul Donahue of Gannett and Glynn Walden of Westinghouse.

They had formed a consortium, eventually named USA Digital Radio, to come up with an alternative to Eureka-147. The objective was to come up with a system that preserved the existing transmitter infrastructure, relative signal coverage and station branding.

EDI built the first workable FM IBOC system. At that time, the receiver was a large rack of equipment, and it took a gasoline-fired generator to keep the whole thing running.

I have many road warrior stories, most of which involve sitting in the back of rental vans with Tony, rambling through downtown Chicago expressways at midnight with a homemade aerial tied to the front bumper, and the generator mounted and running on the lift gate. When we'd stop for gas, the locals thought we were federal agents.

Bottom line, the system worked, and it didn't rely on blend-to-analog. Unfortunately, the audio codec technology, MPEG Layer 2, was inefficient compared to what's available today, so we were trying to achieve data rates well over 200 kbps in the IBOC "shoulder" sidebands. You can't do this without going into the adjacent channels or causing compatibility problems with the analog host.

There is no significant difference in spectrum occupancy between the "extended hybrid" mode of IBOC today and these earlier systems, which were deemed by the NRSC and others to be incompatible with the host analog FM signal.

After the initial industry rejection, USA Digital Radio basically went into hiatus for several years until the audio compression technology improved. I had left EDI and gone to National Semiconductor for a short time, but I preferred to be an independent consultant.

Soon I recognized that new, more efficient audio codecs like AAC could be combined with redundant IBOC sidebands, and the combination could overcome the objections to the earlier IBOC systems. So I filed a series of patents and teamed up with my former manager at National Semiconductor, Norm Miller, and Mr. Dwight Taylor, to form Digital Radio Express. We founded DRE in the heart of California's Silicon Valley to have access to the latest technologies and the region's tremendous engineering talent.

Eventually DRE asked the NRSC to reactivate the DAB subcommittee. Early on, we

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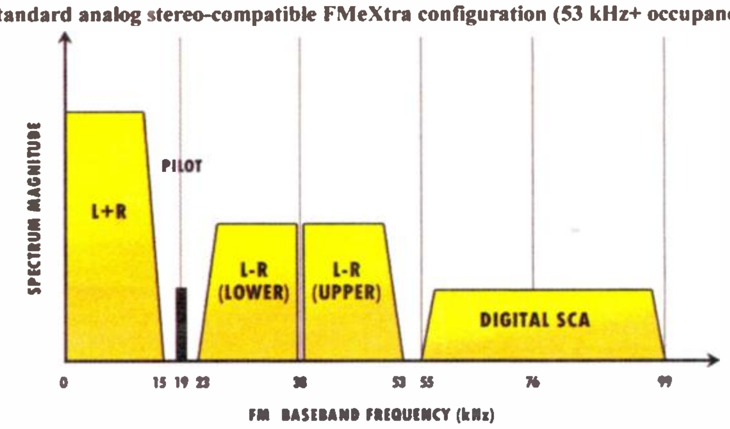
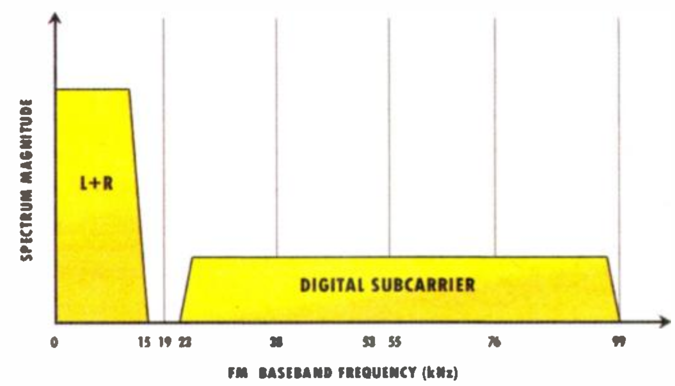
Standard analog stereo-compatible FMeXtra configuration (53 kHz+ occupancy)



	QPSK	8-PSK	16-QAM	32-QAM*
Density A	52 kbit/sec	77	102	126
Density B	58	86	115	143
Density C	64	95	127	159

Extended analog mono-compatible FMeXtra configuration (20 kHz+ occupancy)



	QPSK	8-PSK	16-QAM	32-QAM*
Density A	92 kbit/sec	138	183	226
Density B	103	154	205	256
Density C	114	171	228	285

*32-QAM recommended for stationary use only

Fig. 2: Data Rates for FMeXtra and Bandwidth Occupancy

Kumar

CONTINUED FROM PAGE 4

saw that IBOC was going nowhere as long as there were multiple proponents, and even in the best estimates, it would be many years before there would be any return on investment.

So we decided to license our patent portfolio for use in IBOC to USA Digital Radio, which eventually merged with Lucent's IBOC group to form Ibiquity. We are an Ibiquity shareholder.

We decided to turn our attention to the FM SCA because it didn't have the long political process of IBOC, so we felt it had a much better near-term return on investment. The FM SCA also is applicable worldwide, and it appeared that IBOC would have uncertain international acceptance in view of competing open-standard digital radio systems.

We decided to call our new digital SCA system FMeXtra to emphasize its connection to the existing analog FM signal — the "FM"— and to emphasize the new content our technology made possible — the "extra."

How do you see FMeXtra in relation to the HD Radio system from Ibiquity?

We view the only NRSC-tested and FCC-approved form of IBOC, which is "hybrid" mode IBOC, as a complementary service. Bits are bits. More bits are better. However, our business plans diverge when

Reps from BEXT Inc. and BEL Music at the BEL Music transmitter site. Its FMeXtra system installation is the first for Belo Horizonte, Brazil.

it comes to utilizing the bandwidth closer to the main channel signal, and broadcasters will ultimately make that choice.

Our vision of the future is the transition from analog stereo to analog mono main channel with a corresponding increase in injection and bandwidth for the digital subcarrier. There is a certain naiveté that digital signals need very low power levels for proper operation, but in other digital radio systems such as Eureka-147 and Digital Radio Mondiale, significant increases in the recommended power levels over the original designs were required in order to achieve reasonable coverage.

We want to transform the existing high-power analog FM transmitters into high-power digital FM transmitters. There is nothing inherently digital or analog about a transmitter. They are simply either class-C or linear transmitters. Digital modulation methods can be made to work efficiently with class-C amplifiers. GSM mobile phone technology, which represents more mobile phones than any other competing technology, is an excellent example of a successful class-C digital transmission technology.

Are there ways in which your digital system is superior to that offered by Ibiquity?

Performance-wise, I think all in-band systems that inherently have to coexist with existing signals in a relatively narrow bandwidth, including both IBOC and FM SCA, have certain limitations when compared to clean-slate designs.

Talk about the basic technology concepts underlying FMeXtra.

The FMeXtra system implements best-in-class across many technologies. We use a multicarrier modulation like COFDM to achieve tight spectral shaping and minimize intersymbol interference. Each of the carriers in the multicarrier composite is modulated using hierarchical modulation (HM) to provide a variable information throughput.

Our error correction is based on "turbo" iterative decoding, the most powerful form of error correction known. We incorporate an adaptive RF channel equalizer based on waveform properties to mitigate multipath, and IF digital filtering for adjacent-channel rejection.

The channel equalizer is a crucial part and is one of the big advantages over previous SCA receiver implementations. It is similar to the adaptive equalizers used by Motorola — now Freescale — in its Symphony digital radio chipset and the Blaupunkt Twinceiver.

A side benefit of all of this processing is that it cleans up the received analog FM signal as well. We use the latest audio compression technology, aacPlus version 2, which I'll discuss later. When MPEG surround sound implementations are available, we'll offer that as well.

What is the payload data rate for FMeXtra?

The payload depends upon the FMeXtra encoder configuration. Our system is very flexible. Almost everything is controlled by software switches, and we let broadcasters make their own choices about important parameters like delay and data rate.

There also are three different signal constellations, from QPSK to 16-QAM, and four different code rates, so there many combinations. Minimum payload is around 20 kbps for a partial subcarrier, up to 64 kbps for a full subcarrier with stereo main channel, and well over 128 kbps when the main channel is mono.

Everything is implemented in a single 1U rackmount server with custom PCI interface cards. Connect your audio sources to the PC and connect the PC to your existing FM exciter. Plug and play. You can be on the air with FMeXtra in only a few minutes.

FMeXtra system can be used for a variety of multicasting applications. We provide good stereo audio quality with 15 kHz bandwidth and 90+ dB dynamic range at bit rates as low as 20 kbps. Our system supports arbitrary sample frequencies and does not have strong synchronization requirements, so we have a lot of flexibility for incorporating alternate audio and even video codecs specifically optimized for low bit rates, unlike other digital radio systems.

We also support closed or subscription services with built-in conditional access. Foreign language clients, reading services for the visually impaired and other private radio networks are natural candidates, and we've seen tremendous interest from them. Some public radio stations have expressed an interest in having member-only FMeXtra channels, immune from pledge breaks.

The ability to partition the bit capacity into arbitrarily small slices makes it possible to service a lot of niche interests that simply weren't economically feasible before, and we are just now starting to see the entrepreneurs emerge. But we also have a lot of interest from existing broadcasters who simply want to multicast in the most economical manner.

Foreign language clients, reading services for the visually impaired and other private radio networks are natural candidates, and we've seen tremendous interest from them.

What about the legal aspects of using your system, with regard to how it is regulated by the FCC. Are there any STAs or special permissions required?

FM SCAs, both analog and digital, are not regulated by the FCC. Provided the SCA system complies with the bandwidth and injection limits, any form of modulation is permissible without any additional authorization. No paperwork, no hassles.

However, we certainly see a future path to using more bandwidth and more injection than the current rules allow, and when the time is right, together with broadcasters, we will approach the regulatory authorities. Similarly, we don't charge broadcasters license fees when they use our technology. You simply buy our box as you would any other piece of broadcast equipment.

Can you discuss the results you have from field-testing FMeXtra?

Coverage is a complex topic and we don't have all the answers yet. The number one issue is injection, which is limited by antiquated FM SCA rules.

The biggest issue is peak-to-average power ratio. Since we use a COFDM-type signal, this ratio is significantly higher than a single-carrier system, and the current rules penalize us even though there is no interference. We believe we can get coverage at the 60 dBu contour within the existing rules and our tests to date support that.

We've had the system on the air in the San Francisco Bay area, Los Angeles area, San Diego, New York, Minnesota, multiple states in Brazil and, by the time this interview is published, Israel. We can do much better than that with higher injection, what we call a "superinjection" subcarrier, which causes only a minor increase in the occupied bandwidth, much less than the bandwidth occupied by IBOC signals.

By superinjection, we simply mean SCA injection levels well beyond current FCC SCA limits. We have tested our SCA in the laboratory environment with the injection set at over 50 percent peak modulation, and the increase in interference is very small, much less than the interference measured by the EIA and NRSC in the first-generation IBOC configurations. The next step will be experimental testing with an STA.

What type of audio coding is used in FMeXtra?

We use Coding Technologies aacPlus version 2, which is an open MPEG4 standard, selected by 3GPP [Third Generation cellular Partnership Project], XM Radio, Digital Radio Mondiale and many others. We believe it is the best audio codec at these data rates.

Greg Ogonowski of Orban has posted a large variety of audio samples on Orban's Web site in the Opticodec product section, and I would encourage your readers to have a listen. We are currently working on a data link between our FMeXtra encoder and the Orban Opticodec. When that is finished, you'll be able to ship compressed aacPlus streams directly into our system over TCP/IP from anywhere.

This is powerful because it eliminates transcoding artifacts, dramatically reduces STL costs on the transmitter end and it opens the door to all sorts of interesting DVR-like devices on the receiver end. Millions of cell phones today already have an aacPlus decoder in them and that number is going to increase dramatically in the coming years. Free PC-based aacPlus players like Winamp are readily available on the Internet. We don't believe there is room for another audio codec at this point.

Are receivers available that will work with FMeXtra?

Regarding receivers, right now we are concentrating on specialty receiver markets as a replacement for analog SCA receivers and other niche markets. It's a long road to get any significant consumer acceptance for general-purpose digital radios; just look at the IBOC radio sales.

Rikei Corp. of Japan is overseeing the manufacture of several different model types — tabletop, car and boombox — for low-cost FMeXtra radios. The simplest radio is less than $100. We are working with IBOC radio manufacturers too. For implementations that use the TI IBOC chipset, which is just a re-badged general purpose DSP, there is no additional hardware cost to add FMeXtra, and we expect to see multiple models of FMeXtra/IBOC combination radios.

However, we believe few IBOC radios will be sold at the current IBOC receiver price point.

Our vision of the future is the transition from analog stereo to analog mono main channel with a corresponding increase in injection and bandwidth for the digital subcarrier.

Some analysts have criticized the DSP implementations of IBOC receivers because of their excessive power consumption, but we've implemented FMeXtra on these DSPS using only about 100mA, which makes battery operation feasible.

In closing, how do you see the future of FM broadcasting over the next couple of decades? Is the conversion to digital inevitable?

We strongly believe that digital conversion is essential to long-term survival of the radio industry. We see competitive pressure coming from alternatives such as SDARS, 3GPP, WiMax; you name it, the list goes on and on. It has nothing to do with CD-quality audio, though; it's all about the content choice. We believe our system accomplishes the goal of digital conversion to increase content choice without making hundreds of millions of radios obsolete.

FM radio is one of the few true worldwide communication standards, and we'd like to see it stay that way. Our roadmap from the existing stereo subcarrier today to a wideband digital "superinjection" subcarrier, while preserving analog mono indefinitely, with or without IBOC, is seamless.

Comment on this article by writing to rwee@imaspub.com.■

Amplifier

CONTINUED FROM PAGE 1

tions for combining OFDM and analog FM the efficiency of the final power amplifier was specified at greater than 60 percent. We would be reusing a well-understood design so we could expect the analog performance of the new design to be comparable. Also, the transmitter size should be no larger than necessary, with the design goal that it fit in the same footprint as an analog-only transmitter of current design.

The IBOC system specifications are found elsewhere as previously noted. The requirements for this application involve strict third- and fifth-order intermodulation limits. The third-order products should be less than –55 dBc and the fifth-order products must be less than –75 dBc. These requirements help ensure that stations operate within the already existing spectral mask specified by the FCC.

COMPARISON OF COMBINING METHODS

There are two fairly common methods for combining OFDM and analog carriers for IBOC for transmission with a single antenna. One is known as high-level combining. This system requires a separate OFDM transmitter in addition to the existing FM unit. The two transmitters are combined, typically by using a 10 dB directional coupler, as shown in Fig. 1 (see page 1).

In high-level combining, the existing analog transmitter must be increased in power about 1 dB to make up for the inherent losses in the coupler. We know that a typical tube-type FM transmitter will have a final plate efficiency of about 78 percent. The efficiency of the digital transmitter will be typically 35 percent.

From these assumptions it is fairly straightforward to calculate the final amplifier efficiency of a 20 kW TPO system using high-level combining.

$$eff = \frac{TPO}{Pfa + Pfd} * 100\%$$

Where:
Pfa = Input power to analog final amplifier
Pfd = Input power to digital final amplifier

In this example, the output of the 10 dB coupler must be 20 kW analog and 200 W digital. The inputs to an ideal 10 dB coupler will need to be 22.2 kW analog and 2 kW digital to achieve these output levels. The extra 2.2 kW of analog power and 1.8 kW of digital power are dissipated in the reject load of the 10 dB coupler.

At 78 percent efficiency the FM final amplifier input power will be about 28.5 kW. The digital final amplifier input power will be about 5.7 kW. We would expect the typical final amplifier efficiency for the high-level combined system to be no greater than 58.5 percent.

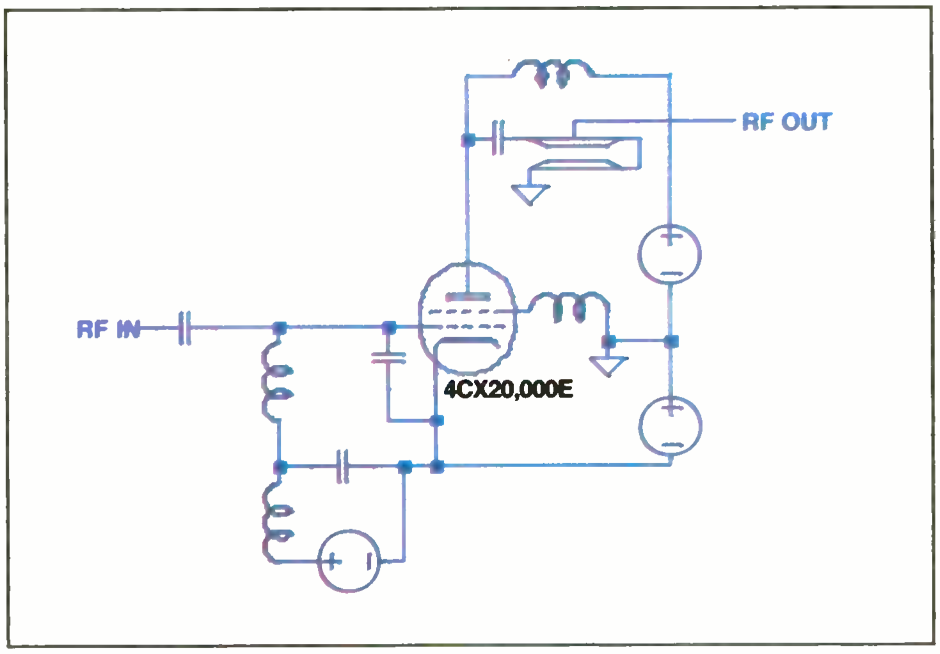


Fig. 2: Class C Tube Power Amplifier Schematic

This analysis ignores the insertion losses in the 10 dB coupler as well as the losses in the circulator needed by the digital transmitter to improve the isolation of the coupler. Thus it appears that our design requirement for a low-level combined amplifier with final amplifier efficiency of 60 percent will be an improvement over high-level combining.

In addition to efficiency there are other advantages to using a single amplifier for the combined analog and digital signal. A single amplifier is simpler from a system integration perspective. The new transmitter's interface to the broadcast site power and remote control is the same as most existing high-power analog transmitters.

There will be more heat generated by the new transmitter, owing to the reduced final amplifier efficiency (60 percent vs. 78 percent), but there is still only a single exhaust required, as opposed to combining methods that use multiple combined transmitters.

TRANSMITTER DESIGN

After evaluating all the requirements, our engineering team felt the Continental Electronics 816R series transmitter that employs the CPI 4CX20,000E vacuum tube as the final amplifier could be modified to meet the required specifications.

This transmitter design and tube type is already field-proven. The amplifier is particularly suited for operation as a linear amplifier. As previously discussed, the OFDM waveform has a time-varying envelope component. Thus, the entire RF amplifier chain must be linear enough to meet the out-of-band emission limits. Out-of-band energy will be produced due to intermodulation distortion products that are introduced by any nonlinearity.

The 816R series has a few distinguishing design elements that make it particularly suitable for operation as a digital transmitter. The final amplifier is designed as a common cathode with DC-grounded screen. There are several inherent advantages to the grounded screen topology.

The absence of a screen bypass capacitor eliminates a potential source of

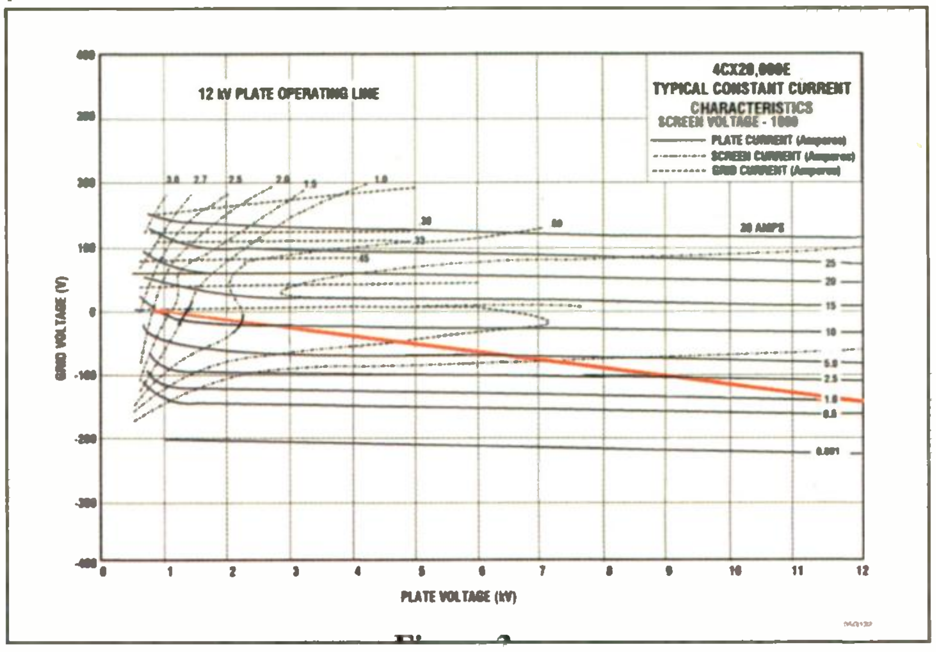


Fig. 3: Constant Current Characteristic Curves for 4CX20,000E

unwanted resonances, which improves amplifier stability. A simple inductor arrangement connecting the screen to the cavity ground plane provides neutralization. Good neutralization further enhances stability. Stability is important because the amplifier will need to operate in a linear mode with fairly high gain. The basic RF schematic of the amplifier is shown in Fig. 2.

The 816R topology is proven as a class C high-efficiency amplifier, but the challenge now is to determine how much power can be obtained as a linear amplifier and at what efficiency. The required power supply voltages can be calculated using the venerable "EIMAC Tube Performance Computer" [2].

This method uses a graphical technique for determining performance and operating conditions for most types of broadcast power tubes. The technique involves determining a few key operating points, and then, by using a constant current graph, other tube element voltages and currents are found.

From these data points the amplifier performance can be computed. The computation will provide RF output power, DC plate efficiency, drive power and grid currents. Once these are known the power supplies can be specified. A set of constant current curves for the 4CX20,000E is shown in Fig. 3.

The operating line is plotted between two key points. The first point is from the plate voltage at the quiescent operating point. CPI recommends this tube be operated with 1A of static current for best linear performance. The maximum rated plate voltage is 12.5 kV but we limited our analysis to 12 kV to give a reasonable safety margin.

The second point is found from the intersection of 0V grid and the maximum desired screen current. The line between these two points forms the so-called "operating line." This particular choice of operating line describes the mode of operation known as class AB1. The plate current has a conduction angle slightly greater than 180 degrees but the grid current is zero at all times. Data points are taken graphically from this load line and used to compute the expected amplifier performance.

Because the 816R transmitter can use either the 4CX15,000A or 4CX20,000E, we computed the expected performance for both tubes before deciding which configuration would best meet the system requirements. Table 1 shows the results for three different scenarios.

The first two columns show the expected performance of the 4CX15,000A with its screen set to 750 V. It is necessary to compute the performance at two RF drive points. The first of the two columns represents the performance at maximum drive, which occurs when the digital signal is at maximum envelope. The second column gives us the performance when operating with just the analog CW signal.

The difference between these represents the peak-to-average ratio, or crest factor, of the analog plus digital signals. For IBOC this ratio is approximately 1.2 dB so we selected 1.5 dB as a conservative crest factor for our analysis. The last two column pairs represent the expected performance of the 4CX20,000E at two different plate voltages. In both of these cases the screen voltage is set to 1 kV.

The maximum expected power from the 4CX15,000A computes to be slightly less than 11 kW. This is well short of our previously stated requirement so this tube cannot be used except in very limited lower-power cases.

The 816R uses a 10 kV plate power supply so we were interested in the amount of power we could expect from the 4CX20,000E with this configuration. The maximum expected power is about 18 kW, which is slightly less than our design goal. But because the transmitter's normal configuration is with this plate voltage it was fairly simple to make laboratory measurements to validate the results obtained by the graphical computation method.

Our measurements found the maximum power output to be about 17.5 kW, which is close to the prediction. The final pair of columns shows that by increasing the plate voltage to 12 kV we could expect the maximum output power to be about 22 kW, which is about 10 percent higher than our design target of 20 kW. Therefore we selected this as the optimum configuration for this application.

Having selected the final amplifier operating conditions we then turned our attention to the RF drive section. The RF drive also must be a linear amplifier to meet the required out-of-band emissions. In this case we selected an existing solid-state linear amplifier previously used for low-band television service.

The RF frequency range and linearity requirements are similar for both applications and having more than one application for the RF driver should help reduce cost and make it more likely that

AMPLIFIER, PAGE 10

	4CX15,000A		***4CX20,000E***		***4CX20,000E***	
	Plate at 10 kV		Plate at 10 kV		Plate at 12 kV	
RF Power Out (kW)	15.56	10.75	25.12	17.97	30.93	22.33
Plate Dissipation (kW)	6.09	7.22	10.29	11.85	12.05	14.1
Plate Efficiency (%)	72	60	71	60	72	61
Plate Current (Adc)	2.16	1.8	3.54	2.98	3.58	3.04
Screen Dissipation (W)	24	4	238	119	230	108
Screen Current (Adc)	0.03	0.01	0.24	0.119	0.23	0.11
Drive (V)	200	168.3	139.7	117.5	145	122
Drive (dB)	0	-1.5	0	-1.5	0	-1.5

Table 1: Comparison of Operating Parameters

Amplifier

CONTINUED FROM PAGE 9

spare devices would be readily available.

Because the final amplifier is operating with no grid current, there is no net power going into the tube grid circuit from the driver, except for small losses in the input grid capacitance. However, there is a grid-swamping resistor to increase the bandwidth and therefore approximately 200-250 watts of peak drive power is necessary to achieve full transmitter power.

PERFORMANCE RESULTS

Having selected the operating conditions and components, we then turned to the task of actually building the transmitter and making the necessary performance measurements. We had at our disposal an 816R analog transmitter. We modified the power supplies to the required voltages and replaced the original class C driver with the new linear amplifier.

The most interesting question was whether or not the transmitter would have sufficient linearity to meet the IBOC system specifications for out-of-band performance. Fig. 4 shows the measured out-of-band emissions when compared to the IBOC system specifications.

Fifth-order intermodulation products, seen approximately 350 kHz on either side of the FM carrier, are −75 dB below carrier or better. Third-order intermodulation products are partially masked by the OFDM carriers. These measurements were made without the benefit of any pre-correction from the low level stages.

The efficiency of the amplifier turned out to be close to the predictions based on the graphical tube performance computer. At 20 kW we measured 57 percent plate efficiency, which is very close to the computed results for that power level.

One unexpected problem arose when

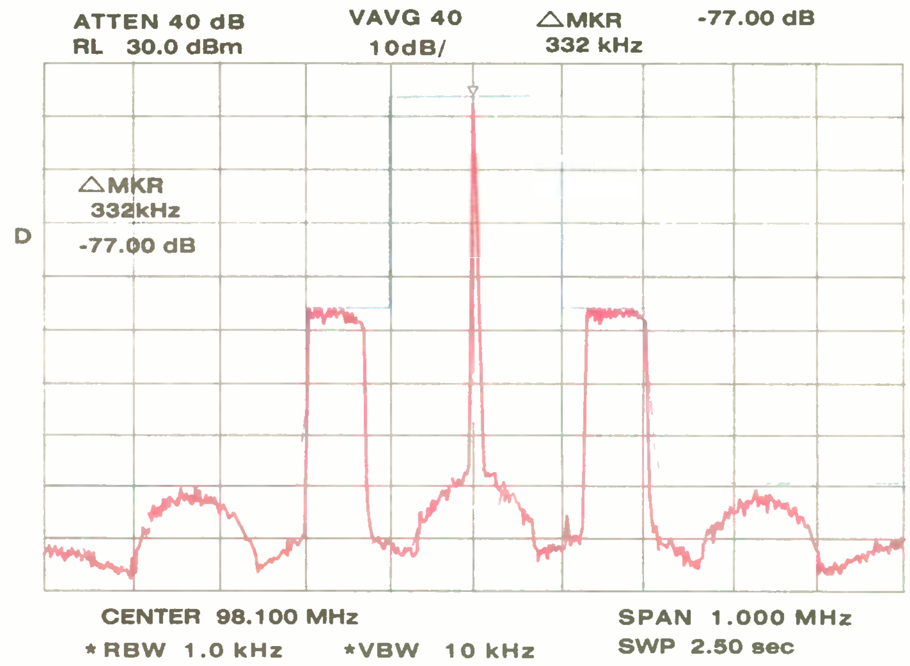


Fig. 4: Measured Out-of-Band Emissions Without Pre-Correction

measuring the analog performance to make sure there was no degradation from the original transmitter specifications. The asynchronous AM noise was slightly higher than the unmodified transmitter. This was caused by AC ripple in the grid bias power supply and the AC filaments.

These noise components were not as critical when the amplifier was operated in saturated class C mode. But when the amplifier operating point was moved to class AB1 these noise sources had a much greater effect on envelope hum. The bias power supply needed extra filtering and the filament circuit was fitted with a classic hum-nulling circuit. These modifications brought the synchronous noise down to about the same levels as the original transmitter.

CONCLUSIONS

This paper described a transmitter design that can produce significant amounts of IBOC power without the need for a separate digital transmitter. At maximum power output the efficiency is actually better than a conventional high-level combined system. In the future this transmitter could make beneficial use of low-level pre-correction. Pre-correction would probably increase the available power output, plate efficiency or some combination of both. The measured performance meets all the IBOC system specifications.

The transmitter has the same footprint and system interfacing as a typical analog transmitter. It does not require complicated external RF plumbing found in many other designs. It does not require any modifications to the antenna or feed line system. Overall it represents an attractive alternative to most other high-power IBOC solutions.

ACKNOWLEDGMENTS

I would like to express my appreciation to my fellow engineers at Continental who made a significant contribution to the research for this project.

Dr. Vic Mason performed the detailed analysis of the expected amplifier performance using the graphical tube performance computer. Alan White implemented the design changes required to convert the 816R into a digital transmitter that meets the IBOC system requirements.

REFERENCES

[1] Ibiquity Digital Corp., HD Radio FM Transmission System Specifications Rev. D, Feb. 18, 2005

[2] Eimac division of CPI, Application Bulletin #5 "Tube Performance Computer for R-F Amplifiers," 1969.

This paper was originally presented at the IEEE Broadcast Symposium, October 2005. ■

MARKETPLACE

Harris HDX-FM Has Adaptive Group Delay EQ

The Flexstar HDX-FM from Harris Corp. features real-time adaptive correction technology, which enables noise reduction and transmitter/antenna linearity. It is part of the company's Flexstar line of HD Radio equipment.

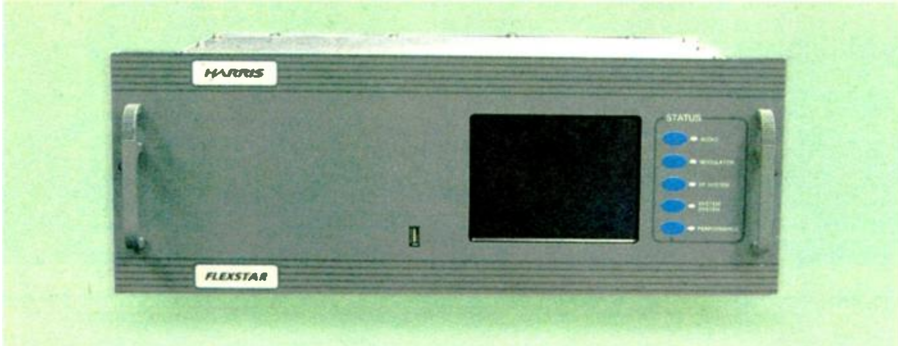
Highlights include adaptive group delay equalization, secondary auto-switching of AES3 and composite inputs and hybrid/straight FM outputs for Harris' Split-Level Combining method, which the company says enables a power-efficient implementation of FM HD using a station's existing FM transmitter and antenna and offers up to 10 percent reduction in operational costs over high-level combining.

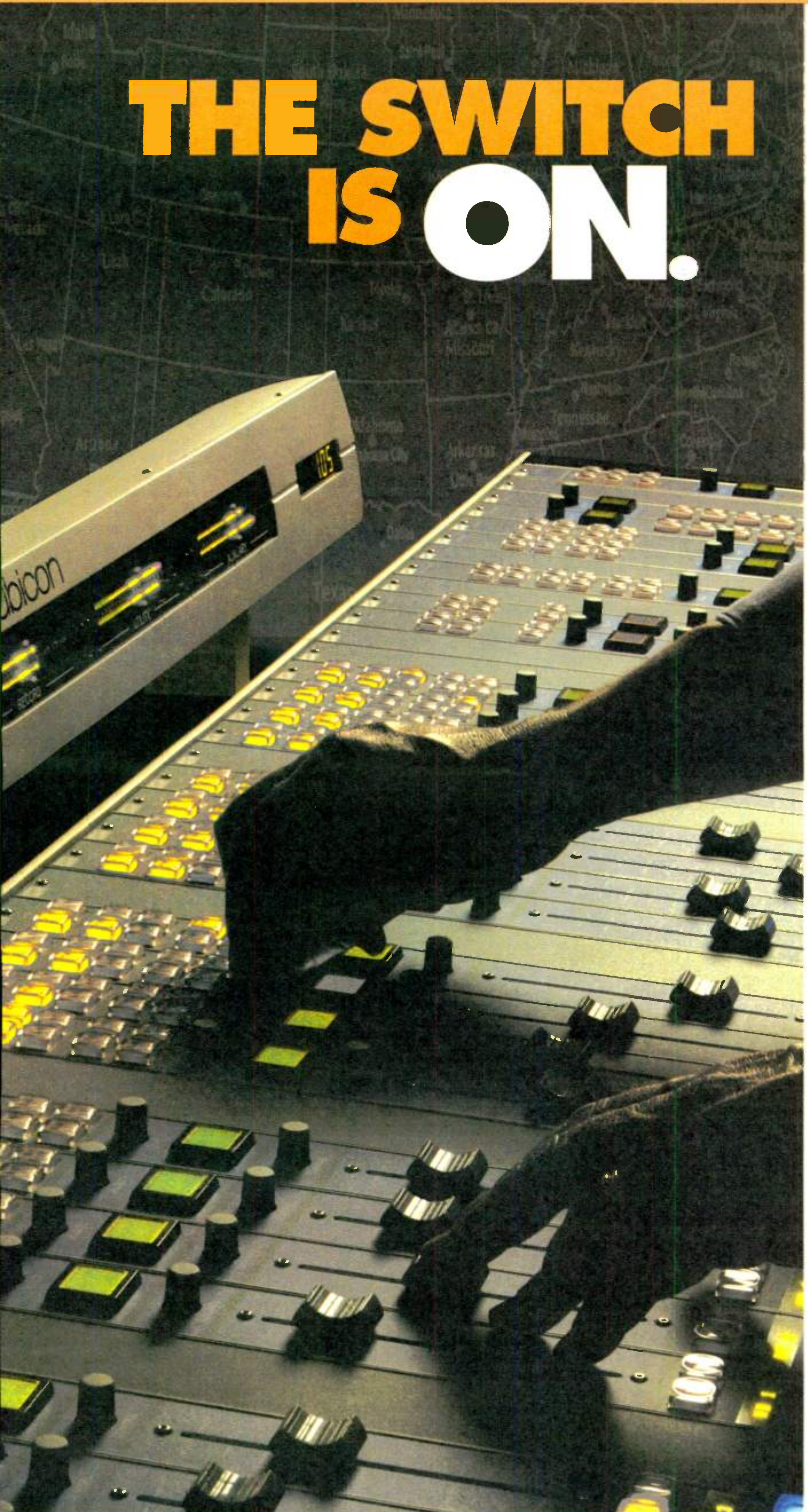
The HDX-FM exciter also features diagnostics and real-time monitoring.

"Non-linear adaptive correction will enable transmitters to develop higher power levels for an equal number of output transistor devices," said Rich Redmond, director of strategic management for Harris' BCD Radio Broadcast Systems business unit.

"In many cases, it allows for lower initial capital expense, and offers superior math compliance and stability over wide temperature, AC power line and load variations."

For more information, contact Harris Corp. at (513) 459-3400 or visit www.broadcast.harris.com.





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WHITE PAPER

By Bob Surette

The Basics of Modern Combiner Design

With HD Radio and Other Factors at Work, Balanced Combiners Become Increasingly Complex

The author is manager of RF engineering for Shively Labs.

The FM spectrum is becoming an increasingly crowded and complex environment. In addition to the steady increase in station allocations that began in earnest with Docket 80-90 in the 1980s, each allocation is becoming home to more and more transmitters as stations add auxiliary, booster and digital services. At the same time, the station ownership consolidation that began in the 1990s has made it both desirable and easier to consolidate transmission sites.

Until recently, low equipment and leasing costs generally made it more desirable to operate over separate rather than combined antennas. Facilities combining more than two or three stations were generally limited to the largest metropolitan areas and were almost always limited to 12 stations or less, all analog of course. Manufacturers also generally had the advantage of knowing in advance all the stations that were ever likely to operate on the system, and reconfiguration for new frequencies and power levels was seldom ever required.

Today's reality is different. Modern sites must be expandable, with 20 or more stations a realistic design goal. Frequencies and power levels can be expected to change throughout the life of the system. Combined facilities routinely house both primary and auxiliary services, making cold-start capability and minimal reconfiguration times a basic requirement. And, into the foreseeable future, sites will need to support a combination of digital and analog services.

Several options exist for simple combinations of FM signals, especially if the frequency spread is relatively large. However, for complex combining environments, balanced combiners are used almost exclusively. As sites become increasingly complex and crowded, balanced combiners are evolving to become increasingly complex as well, and today's combiners are different from systems designed even five years ago.

COMBINER BASICS

When more than one signal is broadcast over a single antenna, the signals must be combined in such a way that no chance exists for the signals to feed back into each other's transmitter. Failure to do so would allow spurious intermodulation products (spurs) to be generated within the final amplifier stages of the transmitter, which would then be broadcast over the antenna.

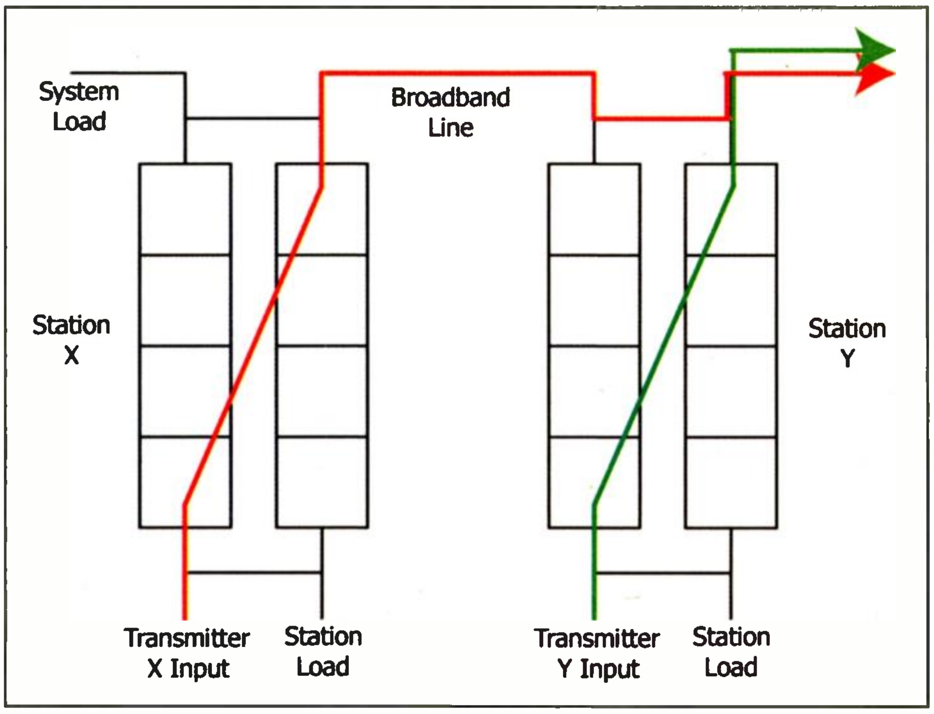


Fig. 1: Standard-Feed or Single-Feed Configuration

Spurs created between FM stations can occur not only in the FM band, but also in the low-band VHF and aviation bands. In addition, FCC Rule 73.317(d) specifies that spurs more than 600 kHz removed from the carrier must be attenuated below the carrier frequency by 80 dB or by 43 + 10log10 (power in watts) dB, whichever is less.

In practice, stations operating transmitter output powers of 5 kW or greater must usually meet the 80 dB requirement, while stations running lower TPOs fall under the computational method.

Experience has shown that to prevent spurs, each transmitter must be isolated from all others in the system by a minimum of 40 dB, with 46 to 50 dB ensuring regulatory compliance. Spur attenuation is accomplished by a combination of transmitter turn-around loss and filtering. Turn-around losses affect the way spurs are created in the transmitter. These losses typically run in the 6-13 dB range for tube-type transmitters, while 15-25 dB is typical for solid-state units.

An off-frequency signal is attenuated 40 dB as it passes through the bandpass filters of the combiner module toward a transmitter. The spur it creates exiting the transmitter is an additional 6-25 dB below the level at which the signal entered due to the turn-around loss. This spur is then attenuated an additional 40 dB as it passes back through the bandpass filters. The result is spur attenuation of at least 80 dB, with 100 dB or more possible.

Transmitting signals on the same frequency, as occurs in combined digital and analog systems, has its own set of problems. Transmitters broadcasting on the same frequency must be isolated not only from other transmitters in the system, but also from each other. Bandpass filters will not attenuate on-frequency signals and isolation is provided primarily by the directivity of the modern hybrid.

Technically, the digital portions of a hybrid HD Radio signal are not on the same frequency as the analog. However, because of the very close spacing and the fact that the digital signals bracket the analog, they are beyond the isolation capability of conventional filters and for the sake of combiner design are considered to be the same frequency.

THE STATION MODULE

The two most popular methods of combining FM signals are the branched combiner, also known as a starpoint, and the balanced combiner. In a branched combiner, each station's transmitter feeds through a bandpass filter into a combining tee. The combining tee is designed to appear as a quarter-wave open circuit to other signals feeding into the system, and provides the fundamental isolation between stations.

Because the design of the matching tee, or starpoint, becomes more complex as stations are added, the practical limit for combining stations this way is limited to about four stations.

The alternative to the branched combiner is the balanced combiner. In a balanced system, each station generally feeds a station module. The heart of the station module is a hybrid ring, supplemented by either band-reject (notch) or bandpass filters. Additional components such as directional couplers, isolators, patch panels and station loads are added to the module as required. Like branched combiners, balanced combiners built with notch filters

COMBINERS, PAGE 14

Case Study

Simple EAS Switching

Solution developed for numerous Logitek customers

THE ISSUES:

- Analog EAS system, digital transmission chain—how do you route the audio?
- Analog AUX audio source also needs to be switched
- Switching needs to happen automatically when EAS relay activates

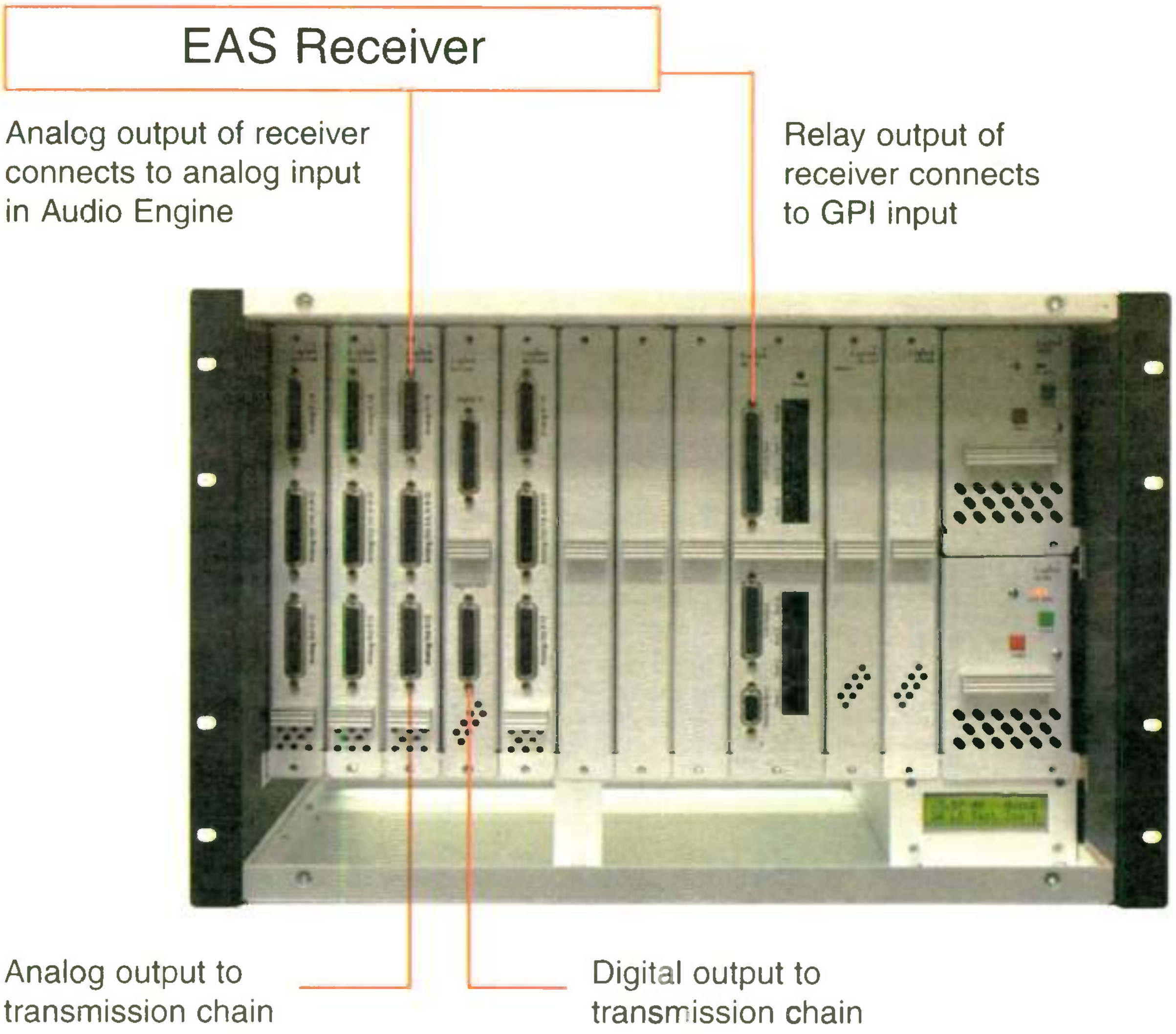
It's a common problem: *You have an analog EAS system located somewhere in your facility, and when it activates, you need to switch all of your program output channels (for all stations under your roof) to the EAS output.*

When you have a digital transmission chain, the problem is compounded: *How do you get that analog input to your digital output without a lot of trouble?*

THE LOGITEK SOLUTION:

Logitek's full featured digital audio router, the Audio Engine, is used along with a trigger set in the Logitek Supervisor software for the Audio Engine. The EAS receiver is connected to the Audio Engine as shown. Analog and digital outputs from the Audio Engine are set up for automatic switching to the EAS signal when the EAS relay activates. With multiple stations, a networked Audio Engine system will accommodate switching for everyone. When the relay releases, another trigger automatically reverts audio to the designated program and auxiliary sources.

With the Audio Engine as your audio routing source, you can provide a clean program feed to yet another auxiliary output so the EAS signal isn't included in program recording.



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Combiners

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and round bandpass filters require carefully phased lengths of coax between the filters to achieve fundamental isolation and impedance matching.

Balanced combiners employing bandpass filters do not require these phase-optimized matching sections to achieve fundamental isolation. In a properly designed balanced module using bandpass technology, all the isolation required by a given station is contained within that station's module. This allows stations to be added in any frequency order. It also eliminates the need for retuning when stations are added, removed or change frequency.

Being able to isolate a station's transmitters from off-channel power depends on more than just bandpass filter technology. The combiner module components must be balanced and configured to look the same electrically to energy moving in multiple paths across the module. Achieving this electrical balance and symmetry under varying power loads requires attention to subtle electrical details, tuning and thermal considerations. Indeed, the computer models on which these designs rely have only recently been developed.

THE TRADITIONAL BALANCED COMBINER SYSTEM

Until a few years ago, virtually all balanced combiner systems of any size were configured in a "standard" or "single-feed" configuration. In a single-feed configuration (see Fig. 1) the transmitter outputs of all stations travel through the broadband line in one direction and exit through a single wideband port.

The broadband line is the combination of output hybrids and interconnecting coax that carries the combined transmitter outputs to the antenna(s) and is so named because it carries all the signals extant in the system, regardless of frequency. This includes spurs and signals coupled in from other antennas. Broadband lines are completely bi-directional, making each end both a potential input and output.

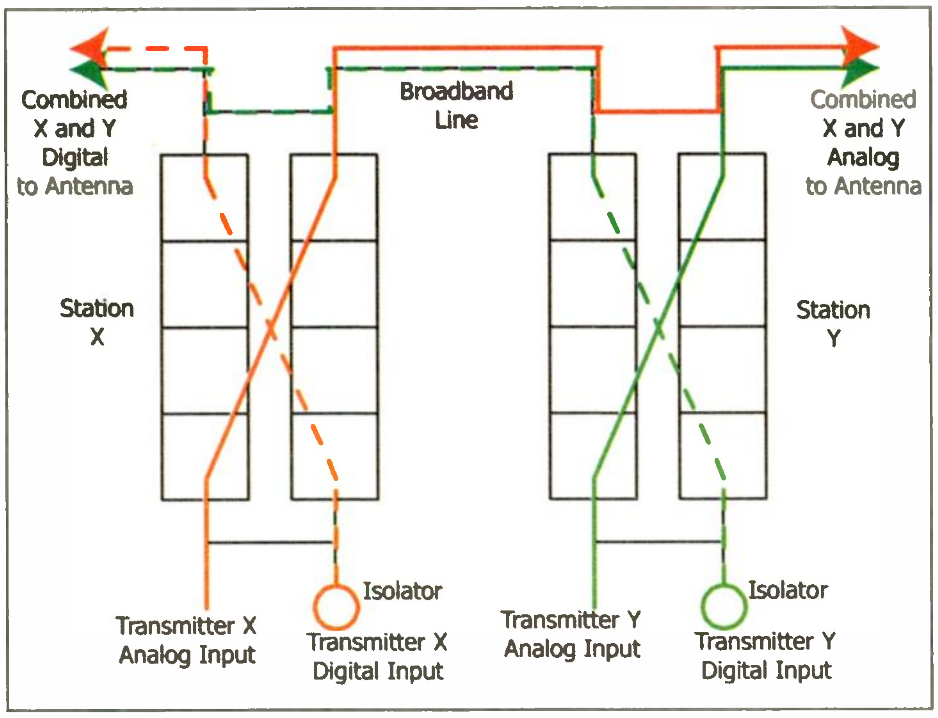


Fig. 2: Back-Feed Configuration

The single-feed configuration is limited to a single input per station module, though this input can handle analog, digital or a combined signal. The transmitter feeds for each station travel in the same direction along the broadband line. Therefore, the broadband line components at the wideband output must be large enough to handle the total average and peak power of all the transmitters in the system.

This increases the likelihood that nine-inch components will be required for large systems, even if a splitter will be used to split the signal into dual six-inch feeds.

Single-feed combiners are the easiest to tune because a few marginally tuned modules can be isolated in the slots farthest from the antenna where they have the least impact on the balance of the system.

In a balanced combiner system, it is possible to tune a module to optimize the performance of the whole system at the expense of the individual station's module. Unlike back- and cross-feed combiners, only one wideband output is used for an antenna feed. This allows a system reject load to be attached to the wideband output farthest from the antenna where it can dissipate any energy not attenuated in the bandpass filters of the system. This load also absorbs primary transmitter power not directed to the output leg of the hybrids in each module.

When module components are well balanced, this extraneous transmitter power is approximately –35 dB below the combined primary transmitter powers. This is a small amount of power for even the largest combiner chains. However, the amount of extraneous power rises rapidly with even small inefficiencies in the balance of the modules, doubling for every 3 dB decrease in efficiency.

The size and operating temperature of the system reject load is not only an indicator of how well balanced the individual modules are tuned, they also are indicators of how difficult it will be to add digital transmitters to the system using back- or cross-feeding because the increased extraneous power will quickly overwhelm the ability of the digital port isolator to deal with it.

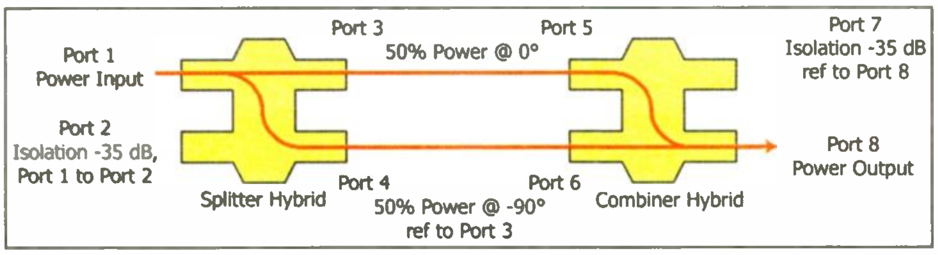


Fig. 3: Hybrid Ring

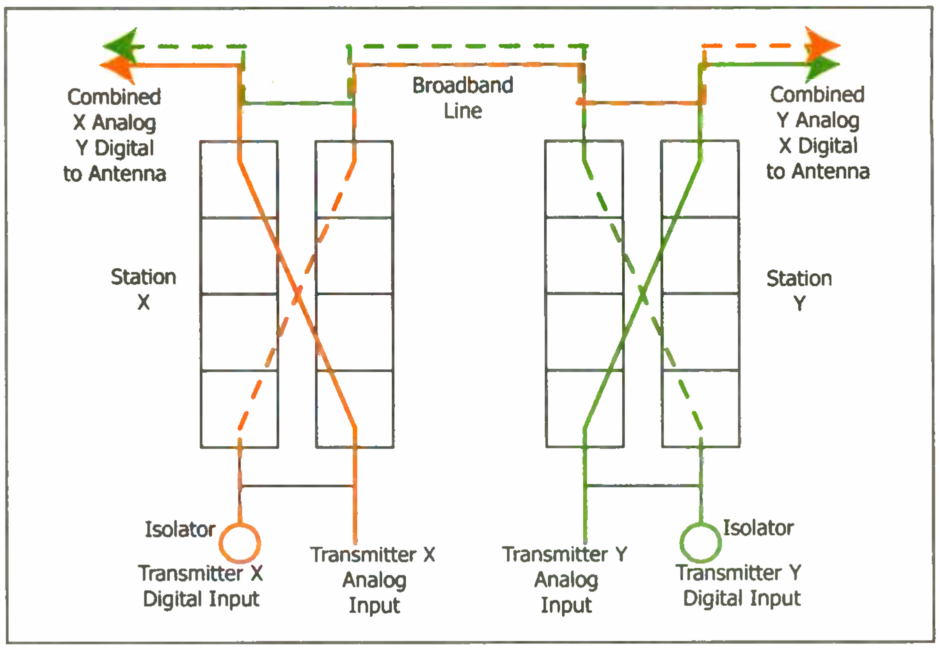


Fig. 4: Cross-Feed or Split-Feed Configuration

Single-feed combiners are sometimes configured so the transmitter for the last station in the chain is fed into the wideband input port of the broadband line, thus avoiding a full module. This method is used with frequency-agile transmitters to provide an emergency backup for any station in the system with a single transmitter.

However, the wideband input port of any combiner chain will have some energy flowing to it — both small amounts of primary transmitter power as well as off-channel energy flowing back from the antenna. Without the system reject load to attenuate this energy, it will feed directly into the transmitter. Therefore, this technique is usually employed at lower power and a supplementary bandpass filter is generally used for fixed frequency applications.

BACK-FEED CONFIGURATION

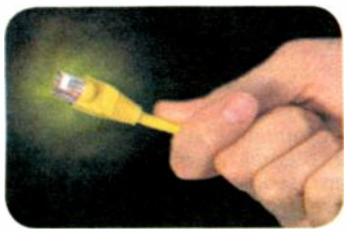
The back-feed configuration (Fig. 2) was developed as a low-level combining

COMBINERS, PAGE 18

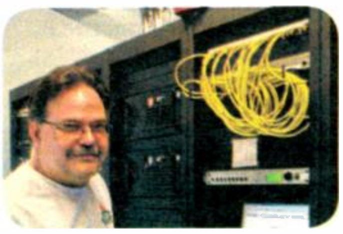
"Showcase studios take time, right? Not this time."

"'Challenging' didn't begin to cover it. Our showcase studios were to be located in the high-visibility West Edmonton Mall. With only six weeks 'til our on-air date, our challenge was finding a manufacturer we could trust to deliver on our timeline.

"We'd almost decided on one of the traditional console/router companies; working 25/7, we could *barely* make our deadline. Then we found out about Axia IP-Audio networks.



"Axia gear goes together with RJ-45 connectors, so adding sources to the network takes almost no time. A few clicks and you're done! That produces a substantial cost reduction in terms of wiring from room to room.



"And because the Axia system routes audio using ordinary Ethernet instead of expensive mainframes, the ease of adding to the network allows it to grow and change dynamically with our operations.

"When we decided to go with Axia, the router guys had a fit. They actually tried to tell us that the IP-Audio network would catch viruses! We laughed for days about that one.

"Our studios were finished with time to spare. The installation came together really well, and since going on the air we've been trouble-free.

"We've had several announcers tell us how much they love working with the Axia surfaces and how easy they are to operate. It's great to be able to setup and save multiple configurations that can be recalled at a moment's notice.

"Our experience with Axia has been all positive; we've had no audio glitches or dropouts whatsoever. I don't know why we hadn't gone this route earlier. Where we're installing new equipment, we're onboard with Axia."

— Owen Martin, Director of Engineering, Newcap Radio, Alberta, Canada

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Axia saves you money by using open Ethernet technology to replace expensive proprietary mainframe routers. Not only is Ethernet less expensive, it's simpler and more reliable — perfect for critical 24/7 operations. The Axia IP-Audio solution eliminates sound cards, DAs, punch blocks and cumbersome cables, so it reduces installation and maintenance costs.

And now, Axia has a cool new modular control surface: Element. Scalable from four to forty faders, you can build the ideal surface for every studio. Element's abundant outputs and flexible architecture can be switched between stereo and surround mixing. Its info-rich user display, built-in router control, and integrated phone and codec support simplify the most complex shows. You'll never outgrow it.

Like all Axia products, Element does more and costs about half what others try to charge for their *"Trust us, this is better than Ethernet, would we lie to you?"* stuff.

Element. Worth its weight in... well, you know.

HD Multicast, HD Surround, conventional stereo — Element handles them all. Upgrade your studios with confidence; you're ready for anything.

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Combiners

CONTINUED FROM PAGE 14

method for analog and digital signals.

When two hybrids are used in a ring configuration (Fig. 3) to both split and combine a single input signal, virtually 100 percent of the signal exits the ring through the hybrid leg opposite the input. Signals can be fed into both input hybrid legs without the signals mixing.

In a back-feed system, digital transmitters are fed into the hybrid ports opposite the analog transmitters and a combined digital signal exits the wideband port normally occupied by the system reject load in a single-feed combiner. The combined digital signals can then be broadcast through a separate antenna, or recombined in the antenna radiators using a hybrid. The digital-only transmission line is generally smaller than the analog transmission line. Isolators are used on the digital transmitter inputs to prevent analog on-channel signals from feeding back into the digital transmitter.

CROSS-FEED CONFIGURATION

The cross-feed, or split-feed, configuration (Fig. 4) is a variation of the back-feed. Rather than segregating digital and analog signals into separate lines, it combines the analog signals of some stations with the digital signals of others. Usually, the analog power is split as evenly as possible, thus minimizing both the average and peak power any broadband line component carries.

The advantage to this technique is that nine-inch components are eliminated in all but the largest systems. Using equal-sized transmission lines also provides redundancy. A failure in a transmission line or portions of the antenna feed system can be overcome by directing a station's primary transmitter, either analog or digital, over the remaining transmission line.

HYBRIDS

The heart of the modern balanced combiner system is the quadrature hybrid. Each station module employs two hybrids, one on the transmitter input(s) of the module and one on the output/broadband portion of the module. These two hybrids operate in three different modes in a balanced module, as illustrated in Figs. 5A, 5B and 5C.

In Figure 5A, a signal enters the input leg of a splitter hybrid (Port 1) and is split into two equal signals. Because of the electrical length of the hybrid, the signal exiting Port 4 is 90 degrees out of phase with the signal exiting Port 3. When a hybrid is used as a combiner (Figure 5B) the exact opposite happens and two signals 90 degrees out of phase are recombined into a single signal. When two hybrids are used simultaneously as splitter and combiner, the system is called a hybrid ring.

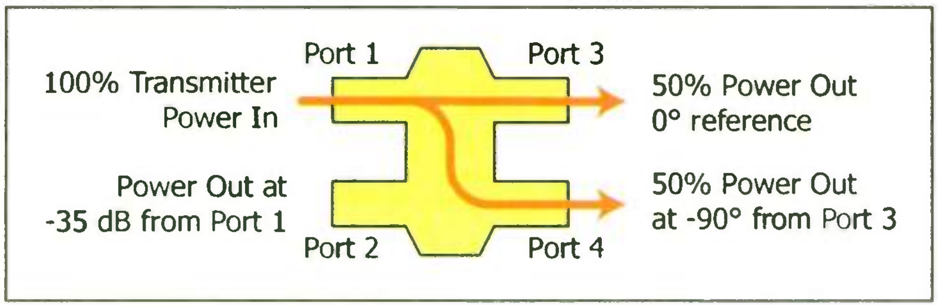

Fig. 5A: Hybrid Used as a Signal Splitter

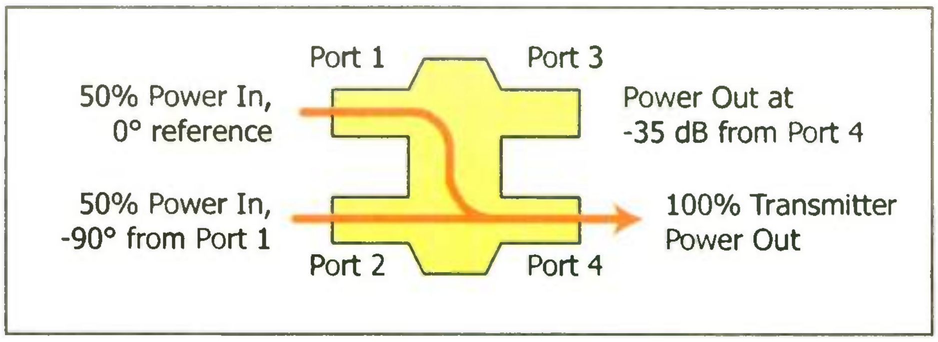

Fig. 5B: Hybrid Used as a Signal Combiner

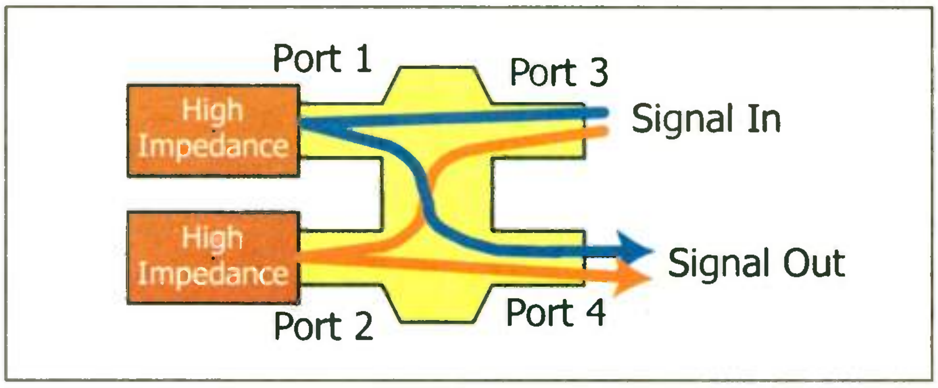

Fig. 5C: Hybrid Used as a Signal Reflector

Each hybrid in a complex balanced combiner system operates in all three modes simultaneously. In older combiners configured for a standard feed, the amount of mixed-mode operation is minimal because the majority of the energy is moving in one direction from a single transmitter input, through the combiner module and down the broadband line to the antenna.

While some reflected energy from the antenna and extraneous energy from the transmitters moves in the other direction on the broadband line, only a small amount of reflected on-channel energy passes back through the system into the transmitter, causing the output hybrid to operate in splitter mode and the input hybrid to operate in combiner mode.

When combiners are configured for cross- and back-feed operation, on-channel power is coupled from one transmission path into the other via the antenna elements and feeds back into the module through the opposite leg from which it exited. If two transmitters are operating into a single module, power will be exiting and returning through both legs simultaneously.

While an efficiently operating antenna will minimize the energy coupled between paths, there will still be sufficient energy returned to require a dummy load for the port opposite the analog transmitter input. If a port is not occupied by a transmitter — for example, if a station runs an analog-only or high-level combined analog/digital signal — a standalone dummy load is used on this port. When the port is occupied by a digital transmitter, the dummy load becomes part of the isolator assembly.

In cross- and back-feed operation, the signal reflector mode of operation of the broadband hybrid is also much more complex, as primary transmission power and reflected power travel in both directions along the broadband line.

With power moving in so many different directions at once across these hybrids, it is imperative that they have good VSWR characteristics, and are as balanced and symmetrical as possible. Balanced and symmetrical hybrids show the same VSWR characteristics through each port, even as the hybrid increases in temperature. The more identical the electrical paths through these ports are, the greater the isolation that can be achieved. Fig. 6 shows the performance curve of a well-balanced and symmetrical hybrid.

THE BANDPASS FILTER

Modern balanced combiner station modules employ two bandpass filter sets between the input and output hybrids. In complex combiner systems it is imperative that the bandpass filters of all modules be tuned to have as close to the same response characteristics as possible.

The goal is to have the hybrids react identically to the filters. Small differences in electrical length through the hybrids quickly add up to an increased VSWR. For example, a phase difference of ± 2 degrees in the legs of a hybrid produces a VSWR of 1.07:1 (–29 dB). If that phase difference degrades to ± 4 degrees, the VSWR deteriorates to 1.15:1 (–23 dB).

TYPES OF BANDPASS FILTERS

Balanced combiner bandpass filters come in three designs: loop-coupled, iris-coupled and interdigital. The designs refer to the method used to couple electrical energy between the individual cavities of the filter.

Loop-coupled cavities are generally round and rely on interconnecting coax to obtain a quarter wave of electrical length between the center probes of adjacent cavities. As the size of the cavities increases in proportion to their required power handling capacity, and/or the spacing that needs to be maintained becomes shorter at higher frequencies, mechanical interference becomes a problem. When this occurs, the input and output coupling loops of the cavities are altered to compensate.

Ideally, the input and output coupling loops should be as close to identical as possi-

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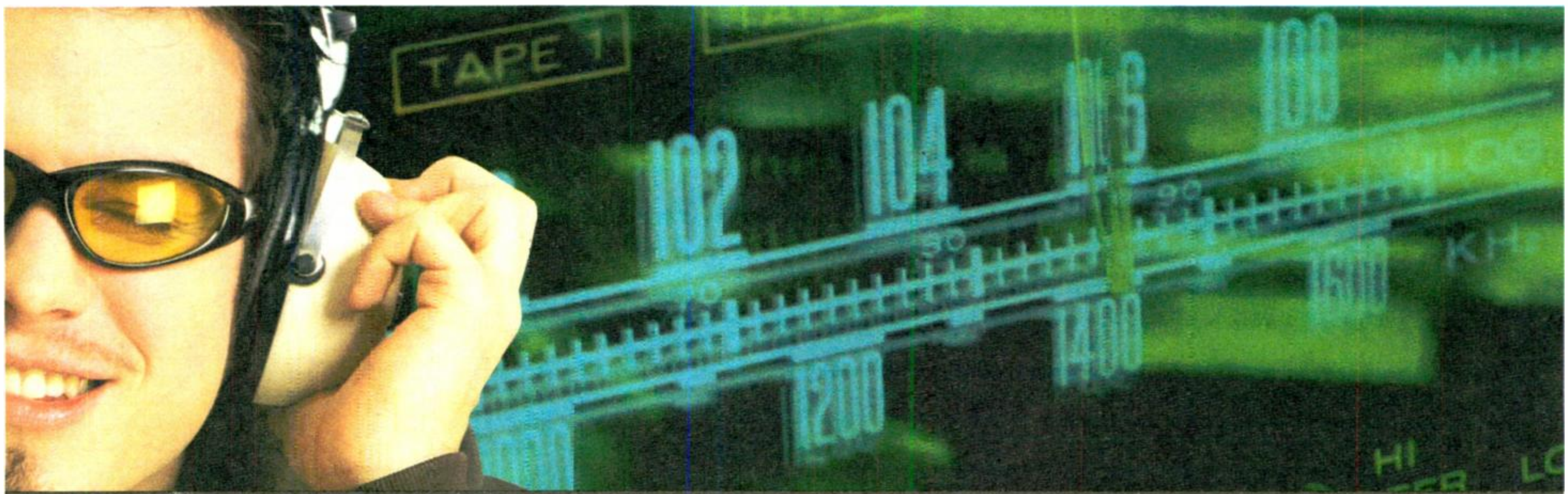

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Combiners

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ble to ensure the phase and amplitude of the energy entering and exiting the cavity are as close to identical as possible. Loop-coupled filters typically provide a large number of tuning points allowing compensation of phase and amplitude discrepancies.

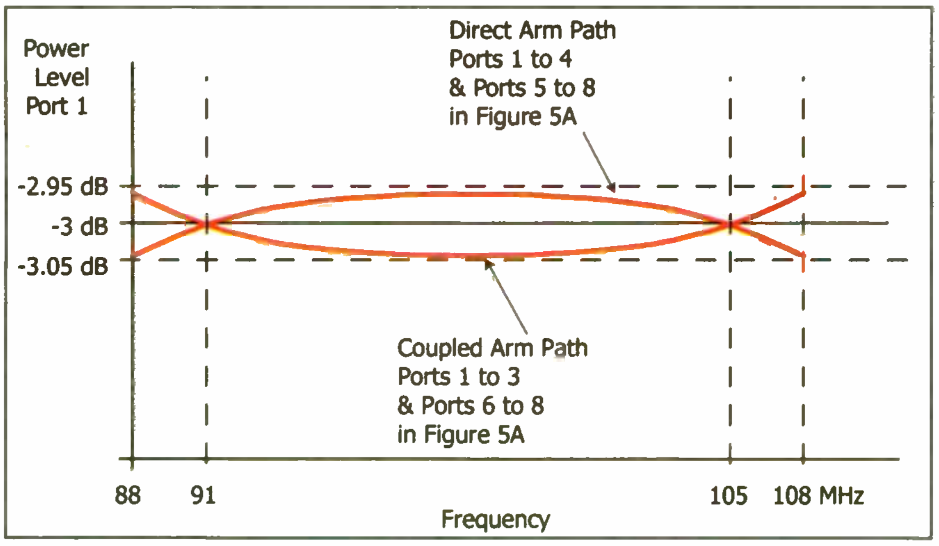

Fig. 6: Hybrid Frequency Response

However, as stations are added to the combiner and the number of (different frequency) bandpass filters that must be identically tuned increases, the sheer number of parts and adjustment points moves from being an asset to a hindrance. This is because the chances for mechanical, electrical and thermal asymmetry increase with the square of the number of filters, as the relationships between pairs of stations must be taken into account.

For this reason, large loop-coupled combiner systems typically require large amounts of final tuning after the modules have been moved into place and each time a new module is added. Loop-coupled bandpass filters also have the disadvantage of being much larger than their iris-coupled counterparts, often as much as twice as large.

In iris-coupled filters, cavities are square and physically joined together in rectangular boxes. Adjacent cavities share an iris wall. Currents circulating around the center probe of one cavity induce alternating currents in the adjacent cavity, providing 90 degrees quadrature without manipulation of the physical spacing. The elimination of the intercavity connecting coax and coupling loops not only eliminates the chance of phase and amplitude distortion, but also reduces the parts count of the cavities significantly. This, in turn, makes iris-coupled cavities less susceptible to thermal detuning and easier to thermally stabilize.

Iris-coupled cavities rely on the cavity being designed and fabricated to very tight mechanical and electrical tolerances, something that was difficult before the advent of modern computer design programs.

Interdigital filters have only recently been introduced as an alternative to loop- and iris-coupled filters at FM frequencies. Interdigital filters do not employ individual cavities that must be coupled together. Parts counts are minimized and interdigital filters are significantly smaller than even iris-coupled filters. Because of their smaller size, interdigital filters have higher insertion losses than either loop- or iris-coupled filters of the same power rating, and careful attention must be paid to the thermal properties of the filter.

Interdigital filters have better out-of-band frequency rejection than cavity-style systems and are ideal for balanced combiners because of the ease of maintaining identical tuning across the system.

Combiners with stations that are close in frequency, or where future close-spacing is possible, generally utilize four-cavity/resonator bandpass filters. Adding resonators or cavities to a bandpass filter increases rejection (isolation) and the size of the passband (see Fig. 7).

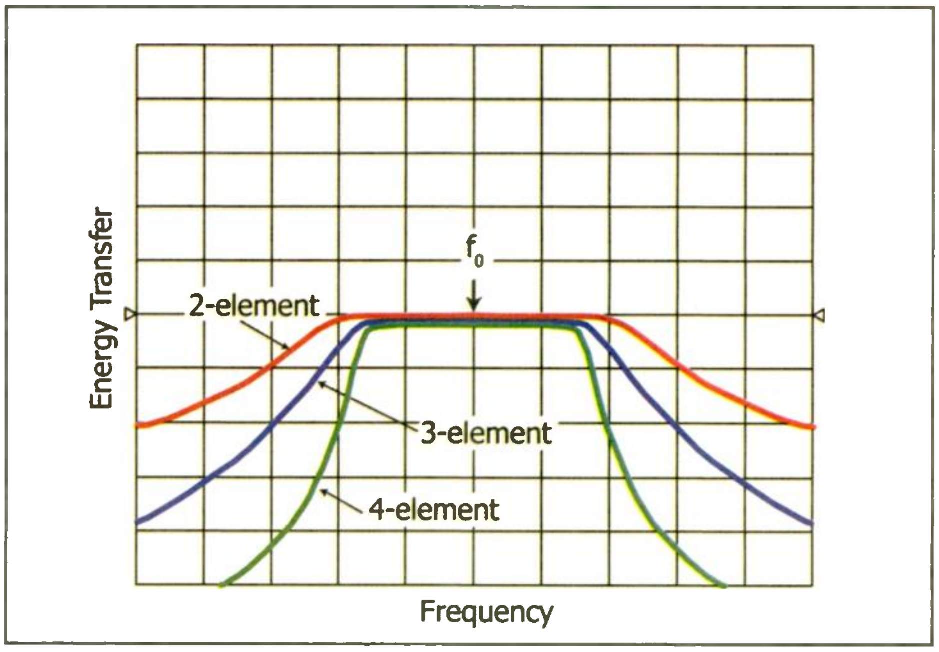

Fig. 7: Frequency Response for 2-, 3- and 4- Element Bandpass Filters

Improved passband width is becoming increasingly important for digital operation. However, it also increases group delay, insertion loss and physical size of the filter. Optimizing the tuning of a filter for any one of these characteristics tends to degrade the others. In complex systems, isolation is the most important characteristic of a filter. Group delay can be overcome with equalizers and insertion loss is compensated by increasing transmitter power.

For combiners with relatively large frequency spreads, two- and three-cavity bandpass filters are sometimes used to save cost and space. Occasionally, frequency spreads between stations in the combiner chain are artificially increased by splitting the combiner into two separate combiners and assigning adjacent frequencies to opposite chains. Each combiner then feeds the antenna through a separate transmission line. This system is particularly common in countries where frequency spreads of less than 0.8 MHz can be found in a market. This method of combining makes incorporation of separate digital transmitters difficult, if not impossible, depending on the frequency spread.

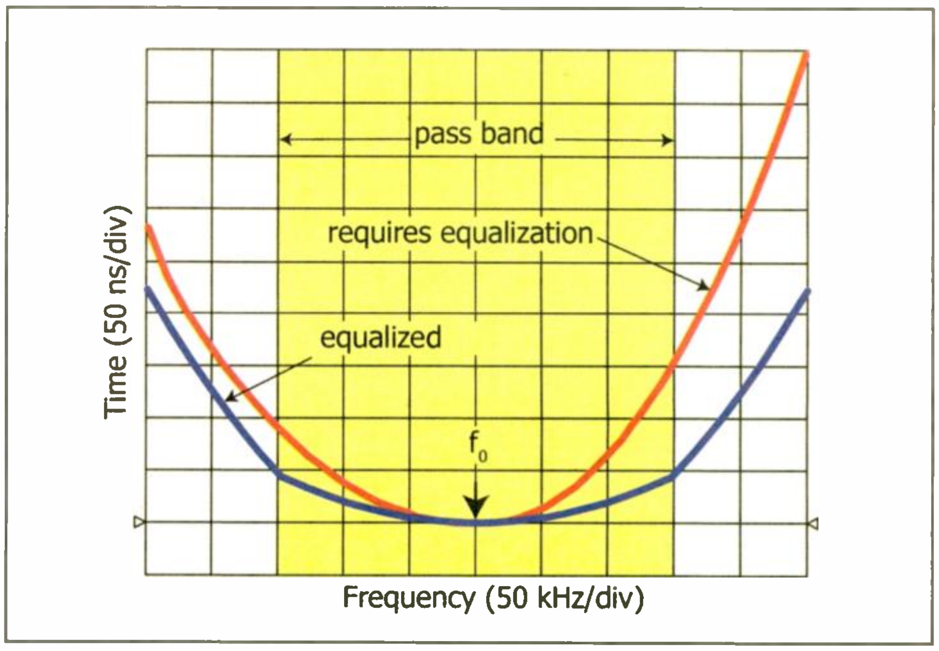

Fig. 8: Group Delay Equalization, Before and After

INPUT HYBRID LOAD

When only one port of the input hybrid is being used, the other is normally occupied by a reject load. The size of this load depends on the isolation between the input ports of the input hybrid, typically about –35 dB for a modern hybrid. In a standard-feed combiner, all unattenuated power reflected from the antenna is shunted back through the station module to the transmitter input port. In back- or cross-feed combiners, the isolation inherent to the radiator design or the isolation between the two antennas must be taken into account.

In a well-balanced radiator design, this antenna isolation will typically run in the 15–20 dB range. The unattenuated power in a back- or cross-feed combiner returns to the hybrid port opposite the transmitter input. Therefore, in these configurations the load must be sized to handle 15–20 dB more reject power than in a standard-feed configuration. If the radiator is poorly balanced and the isolation is lower, the size of the input hybrid load will need to be increased accordingly. The same considerations and calculations used to compute the size of this load are used to size the isolator load if one is employed for digital combining.

DIRECTIONAL COUPLERS

Precision directional couplers are commonly found on each broadband output of balanced combiner systems. This directional coupler is a convenient port for taking FCC-

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for Automation and Switching Solutions

SS 16.16

The SS 16.16 provides audio routing of 16 stereo inputs to 16 stereo outputs. This type of routing allows any one stereo input to be assigned to any/or all stereo outputs. The SS 16.16 may be controlled via front panel encoder controls and/or a multi-drop RS-232 serial port. A 40 x 4 LCD back lit display provides for input descriptions and macro setup. Additional features: headphone amplifier with front panel jack and level control, front panel monitor speaker with mute switch and level control, internal audio activity/silence sensor with a front panel ACT indicator and rear panel open collector, and a 16 GPIO port. FREE Windows NetSwitch remote control software, which supports Serial, USB and Ethernet with the optional ESS-1 Ethernet to serial converter, is available for download. Installation is simplified with plug-in euroblock screw terminals.

SS 16.4

The 16.4 provides matrix audio switching of 16 stereo inputs to 4 stereo plus 4 monaural outputs. Matrix switching allows any/or all inputs to be assigned to any/or all outputs. The SS 16.4 may be controlled via front panel switches, contact closures, 5-volt TTL/CMOS logic and/or the multi-drop RS-232 or RS-485 serial port along with 24 GPIO's and input expansion port. Installation is simplified with plug-in euroblock screw terminals.

ACS 8.2

The ACS 8.2 provides matrix audio switching of 8 stereo inputs to 2 stereo plus 2 mono outputs. Any input assigned to output one has fading capabilities. Matrix switching allows any/or all inputs to be assigned to any/or all outputs. The ACS 8.2 may be controlled via front panel switches, contact closures, 5-volt TTL/CMOS logic and/or the multi-drop RS-232 serial port along with 16 GPI's, eight relays, eight open collector outputs, and input expansion port. Installation is simplified with plug-in euroblock screw terminals.

SS 4.2

The SS 4.2 provides matrix audio switching of 4 stereo inputs to 2 stereo plus 2 mono outputs. Matrix switching allows any/or all inputs to be assigned to any/or all outputs. The SS 4.2 may be controlled via front panel switches, contact closures, 5-volt TTL/CMOS logic and/or the multi-drop RS-232 serial port along with 16 GPI's, eight GPO's, and input expansion port. Installation is simplified with plug-in euroblock screw terminals.

SS 8.2

The SS 8.2 provides crosspoint switching/routing with 8 stereo inputs, 2 stereo plus 2 mono outputs. 3 switching modes, I/O trimmers, internal silence sensor, selectable headphone and powered speaker level controls and outputs. LED VU meters, 16 GPI's, eight relays and eight open collector outputs. Multi-drop RS-232 and RS-485 serial ports, plug-in euroblock screw terminals and input expansion port.

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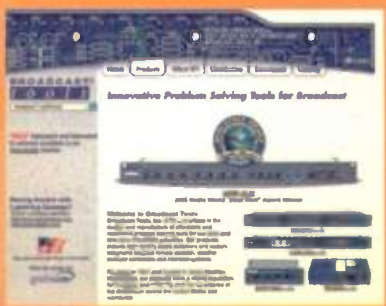

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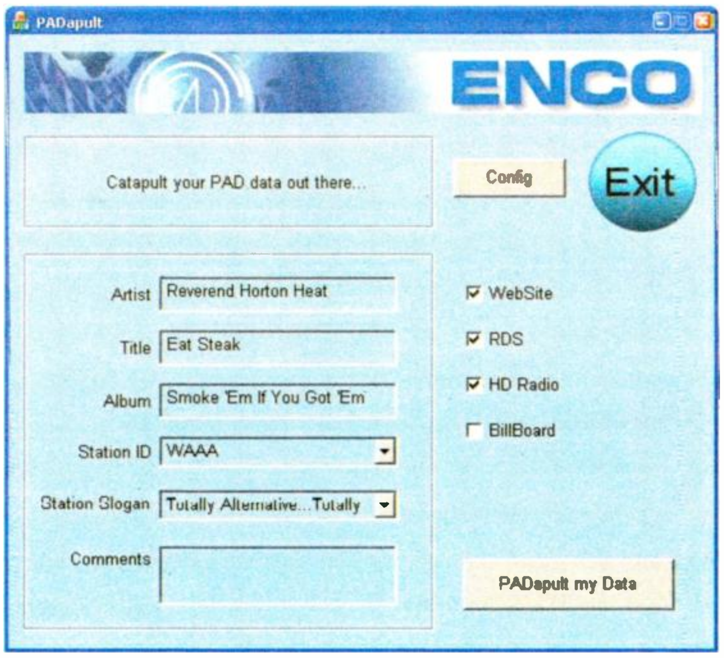
INNOVATIVE PROBLEM SOLVING TOOLS FOR BROADCAST

Manufactured with Pride in the USA

ENCO Debuts PADapult, Ships DAD with Surround

Program-associated data gives land-based stations capabilities similar to satellite radio services, such as text scrolls across the front of the receiver's LCD panel; and song and artist information and station ID as standard content. PAD also can include traffic and weather updates or other information the station provides, including commercials.



ENCO Systems says it has a new method for broadcasters to get program-associated data out on their HD Radio transmission.

The company says PADapult enables broadcasters to easily encode and transmit PAD data on the fly, and is suitable for live news/talk and sports formats where standard data may not be available from their audio library. It also is suitable for broadcasters who play CDs from traditional devices and who wish to create and send PAD data to their HD Radio audience.

PADapult is available as an add-on module for DAD users, or as a stand-alone version for users without DAD systems.

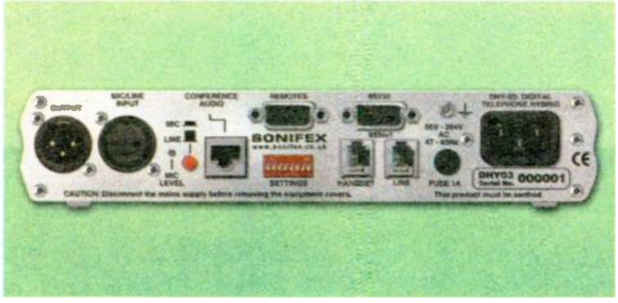
Also, ENCO says its DAD and DADtv systems are shipping with integrated multichannel sound, configured as either 5.1 or 7.1.

ENCO Systems online at www.enco.com.

Sonifex DHY-03 Has Universal Line Compatibility

Independent Audio has debuted the Sonifex DHY-03 DSP-based digital telephone hybrid, which the company says is a redesign of the current DHY-02.

The DHY-03's feature set includes universal line compatibility, input and output gain adjustment, input and output metering and conferencing.



Additional highlights include RS-232 serial control, local/remote line hold switching, integrated auto-answer, automatic call disconnection, auto-ducking, DTMF tone recognition, a balanced mic/line input and balanced line output.

For more information, contact Independent Audio in Maine at (207) 773-2424 or visit www.independentaudio.com.

Combiners

CONTINUED FROM PAGE 20

required test measurements, enabling diagnostics and as a port for any protection and monitoring system the combiner may employ. Its versatility is further enhanced when it is used with directional couplers located on the inputs to each module. Couplers must be of high quality to ensure proper operation in the complex combined environment.

GROUP DELAY AND EQUALIZATION

When the entire 200 kHz-wide group of frequencies that compose an FM channel passes through a filter, it doesn't do so at the same time. The portions of the signal (or frequency groups) farthest from the center frequency (represented by f_0 in Fig. 8) are delayed. It is desirable to have the delay as symmetrical as possible.

When two frequencies in a combiner chain are located close together (generally 1.0 MHz or closer), their bandpass filters interact causing an asymmetry in the frequency response of the filters, which in turn causes the frequency groups in portions of the signals to travel through the filter at different rates. These resulting asymmetries in signal speed are referred to as group delay.

It is possible to correct for group delay by asymmetrically tuning the filters to compensate for the differences in frequency response. However, this has the effect of unbalancing the station module, decreasing the isolation and increasing the amount of power to the reject load.

Instead, modern combiners use additional, specially tuned cavities to return the group delay across the channel to a more symmetrical pattern. The equalizer is needed only for the station in a closely spaced pair that is located farthest from the wideband output. Group delay correction is only used on the analog portion of signals. In back- and cross-feed combiners that allow feeds to be reversed, the group delay equalizer must be tuned in the position the station module will normally occupy and it must be removed from the transmission chain if the feed is reversed.

Modern combiners normally employ low-level group delay equalizers positioned between the output of the station's exciter and the input of the IPA of the transmitter. Older systems generally located the equalizers between the transmitter and the input of the station modules.

These older group delay equalizers were larger in order to handle more power, and took up significantly more space. However, they had the advantage that the spacing between the group delay equalizer and the combiner module could be optimized to maximize VSWR bandwidth.

LOCKOUT/TAGOUT

Modern combiner systems generally supply lockout/tagout capabilities. This is particularly important for systems that allow remote startup of transmitters and where the transmitters may be under the control of multiple engineers. Lockout/tagout is generally accomplished by employing a short from the outer conductor to the inner conductor of strategically placed coaxial transmission lines.

The broadband lines between the combiner output(s) and the antenna provide a logical place to lockout power from the antenna with a minimum number of switches. However, this only provides safety downstream toward the antenna.

It is becoming increasingly common to see lockout/tagout done on transmitter inputs, particularly on back- and cross-feed systems. While this requires locking and monitoring of more points, it has the advantage of allowing only some transmitters to be locked out in the event that just one broadband feed is shut down. It also provides protection when work is being done on the combiner rather than the antenna.

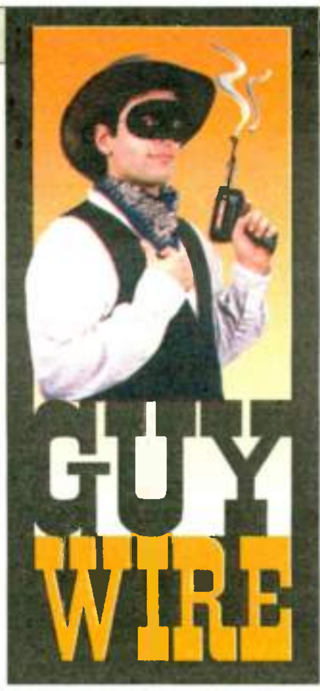
CONCLUSION

Combiners have been used for many years to allow the transmission of multiple signals over a single antenna. However, with the implementation of HD Radio, the need to keep combiners as small as possible and the desire to provide redundant transmission paths in a single antenna, combiners are becoming increasingly complex. While the fundamental components of balanced combiners remain the same, this increasing complexity requires that these components be manufactured and tuned to increasingly sophisticated standards. ■

Can Radio Fight the 'Internet Revolution'?

Let's Not Give Up on the Grand Old Medium Just Yet

Guy Wire, Radio World's masked engineer, is the pseudonym of a well-known radio veteran. Opinions are his own.



Almost every day we read and hear about the impending demise of radio. Terrestrial radio. The radio we've all enjoyed and depended on for the past 85 years.

It's about to be eclipsed and replaced by other digital wireless delivery services popping up all over: satellite radio, iPods, wireless Internet and cellphones with streaming Web content. With all these choices, radio surely will be swept away to the ash heap of antiquated technology.

If you spend time lurking around online radio listservers, you'll get a sense of the prevailing attitude. Accomplished radio vets, usually engineers, are predicting radio is not long for the modern world. Some even hope aloud that they can make it to retirement before their jobs and stations disappear.

GADGETS GALORE

Much of the apprehension grows from the gadgets spawned by the Internet revolution over the past few years. Ever since Web access became portable in a small package, the concern that radio is in deep trouble has deepened in the minds of many.

The younger generation traditionally has been quick to acquire and use the latest personal electronic devices. Many of these devices enable the user to store and play content historically provided by radio, now also conveyed through other means. Favorite songs, news, information and even talk can be delivered in a small portable device that is no longer a radio.

There's nothing new about this trend. Younger demos and techies are the first to embrace consumer electronics innovations. It happened with 45 records, 8-track tapes, cassettes, CDs, Walkmans, Gameboys, PCs, PDAs, cell phones and now iPods. The latest gizmo brings acceptance and status within peer groups.

CALL THE MORTICIAN

Ask typical 18-year-olds and they will tell you radio is passe. It's not cool, it's virtually irrelevant. What is cool is to proclaim that they never listen to radio.

They get music from file-sharing downloads and listen to it on iPods. Their main sources of infotainment are television and the Internet.

AM radio, you ask? Those who even know what it is will tell you their grandparents might still listen to it.

If you believe critics who say such mass-media consumption habits will remain pretty much the same as young consumers age, it doesn't look good for radio. May as well write the epitaph and get ready to close the book on its storied history.

Not so fast there, digithead.

Those who subscribe to this theory, and are a part of it, are too far inside the modern digital media forest to see the trees. Like trees, people grow up and branch out. Their interests become more varied as they discover other diversions and leisure-time pursuits.

They start doing other things with their free time besides cruising the Net, IM'ing and keeping their iPods freshened up. In the old days they would have cruised the drag, hung out on the phone, read books and listened to records.

To paraphrase Yogi Berra: similar but just a little different.

As young folks finish school, meet significant others, marry, get jobs, buy houses, move around and start focusing their time and attention on those priorities, they begin finding outlets for their infotainment that are more easily used, less predictable and more interesting. Radio has almost always been one of those.

EVERYWHERE FOR EVERYONE

Radio just might be the most ubiquitous electronic communication device out there, although some would argue the cellphone has caught up. Ninety-eight percent of the 12+ U.S. population has access to a radio. Every household has an average of five radios. Virtually every car has a radio. The majority of folks who commute via car turn on their radios and listen every day.

Radio is totally portable; it comes in all sizes and colors, with many personalized

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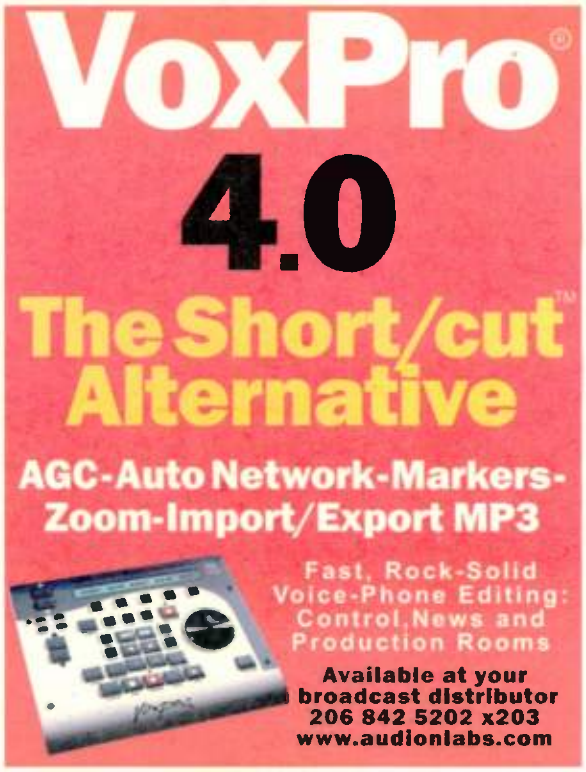
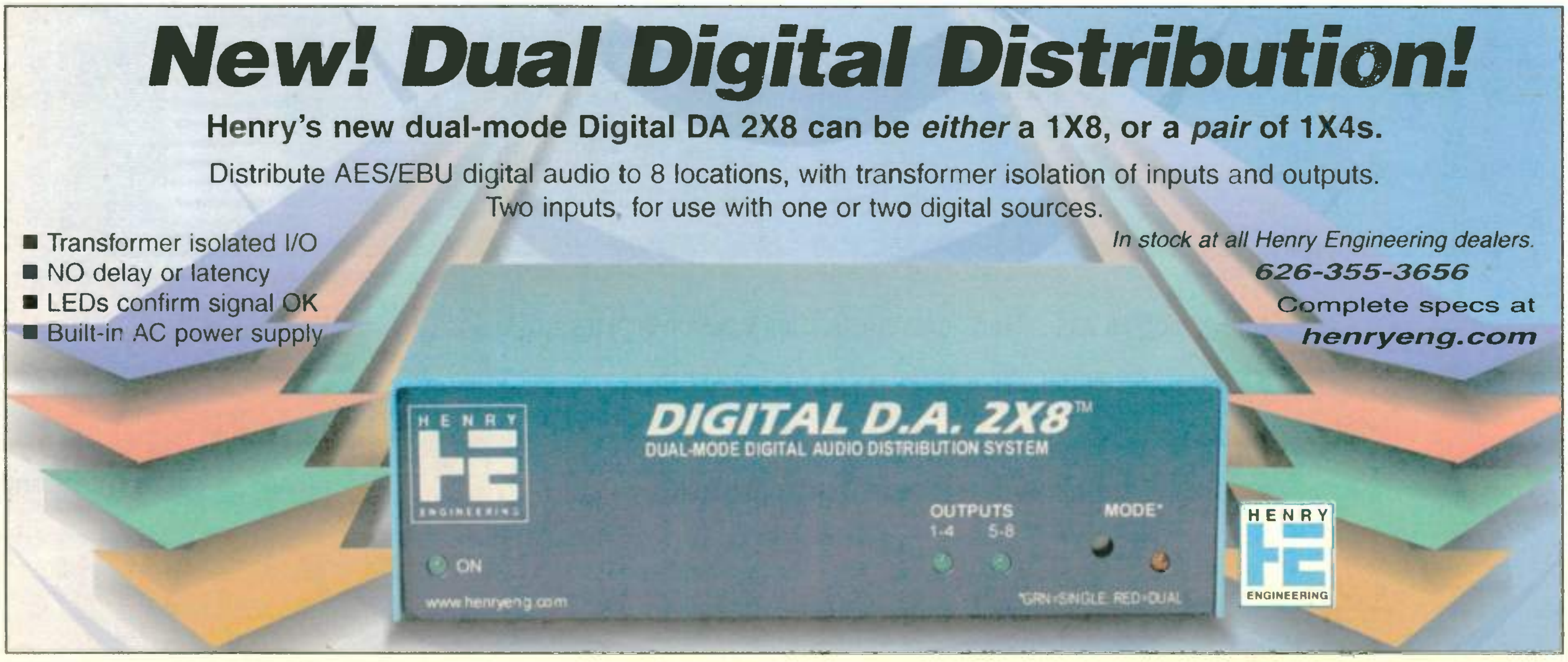
Products & Services SHOWCASE





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programmable features. Just turn it on, punch up a favorite station and go about whatever else you want to do — all hands-free without wires and without worrying about the demands of interactivity. Not having to expend much effort to be entertained or informed is one of the blessings of advancing age and wisdom.

Satellite radio may have hundreds of commercial-free channels; but it isn't local and never really can be despite adding local traffic reports in some markets. You can listen in a car, out in the clear; but reception inside buildings and among overhead obstructions too often makes satellite radio unreliable.

And of course there's that pesky monthly subscription fee.

BE COOL

The challenge for terrestrial radio for some time has been to find new ways to be cool again, to be more relevant and competitive in a crowded field of electronic mass-media choices.

We simply need to keep up with advancing technology so the perceived quality, reliability and attractability of our product compete on a level playing field with all the others.

That's where HD Radio comes in. Yet many of our doomsday friends have decided HD comes with too little, too late. The complaints include all their familiar talking points: HD causes adjacent-channel interference and wipes out AM fringe area and skywave coverage. It offers marginal improvement over analog and lacks a "true killer app." And the compression codec degrades the audio quality.

Complain all you want about digital compression, but the public decided long ago that MP3s sound like CDs and are judged as having higher quality than radio, even FM radio. Noise and multipath are responsible for that, not codec artifacts.

If we as an industry don't bridge that gap, those who claim to be hearing radio's death rattle might have a shot at being right.

Apart from engineers and purists, the mass audience doesn't care much about maintaining pristine audio quality. Entertainment quality is perfectly acceptable. HD Radio easily provides that, even at bit rates well below 96 kbps.

And complain all you want about bad content and too many radio stations sounding the same. HD brings multi-channel capability that creates additional channels of variety and specialty formats along with the main channel.

In the past, most owners couldn't succeed doing narrowcast formats on stand-alone, full-signal stations. This opens up a new offensive front for traditional radio.

MEASURING SUCCESS

We mustn't forget that radio is more than just a delivery platform for content. Our business has always been about developing and showcasing the best entertainment and information programming we can find that appeals to the largest audiences. We are continuously measured by how well we do that every quarter.

Radio is blessed with the distinct advantage of being able to deliver content efficiently over a wide area from a single point. Simple, low-cost, portable receiving devices along with those built into cars have enabled any consumer to use and enjoy radio with ease.

The new technologies so many see as threats to radio mostly employ a cellular topology with streaming content via the Web and other sources. They certainly want to mimic radio's delivery capability but are climbing a much steeper path in providing the same quality of user experience.

The new generation of cell phones with Net-enabled audio streaming are a prime example. They offer limited and less reliable coverage along with a more complicated interface and expensive access. Thus the product appeals to a smaller and more select audience.

Imagine the average consumer using the highly anticipated multifunction, high-fidelity cell phone with Internet, e-mail, PDA, iPod and camera all in one small, handheld package. Some will eventually include radio and TV reception. Talk about feature overload and, probably, an incredibly confusing control interface.

Radio will counter this by integrating Internet resources and download links into its HD datastream. Various kinds of new interactive services are poised to team up with simultaneous automatic cell phone uplink communications. When the hybrid period gives way to all-digital, a multitude of new offerings and innovations will appear.

DRIVING IN TRAFFIC

Until wireless broadband and cellular telecomm services become extraordinarily cheap and saturate all population centers, the new technologies that want to replace radio will struggle to attain wide-area seamless coverage and overcome a variety of other unique challenges to make their product more user-friendly and attractive to the mass audience.

Until that happens, radio has at least several opportunities for continued success, doing what it does best as well as some new tricks.

Radio stations everywhere are ramping up development of their own interactive Web sites. With podcast downloads, links to lots of other valuable resources, plus the live streams of their air product, radio simply adds another delivery platform and merges itself with the Internet.

Even if wireless Web streaming devices manage to displace the traditional radio receiver someday, radio will have completely integrated itself by then as part of a new mass-media world in which most all communications flow through the Internet.

Maybe you're still skeptical; but I'm feeling pretty good about radio. Stay tuned and don't give up on the grand old medium just yet.

How to ...

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MARKETPLACE

CEC 811HD Transmitter Features IBOC Exciter

Continental Electronics has highlighted its 811HD IBOC transmitter, a cabinet-mounted low-power HD-only linear transmitting system that includes an IBOC exciter. Additional options include a CEC IBOC importer for multicasting and surround sound broadcasting, and the Audemat-Aztec Goldeneagle IBOC monitoring system.

The company says the 811HD is a 250-watt HD Radio transmitter for separate, special combined antenna systems, or for use in common antenna systems. It is suitable for use with an analog transmitter up to 25 kW analog TPO.

The 811HD shares many of the same features of CEC's new 815D5 transmitter. LEDs indicate operational status, and AC power recycling facilitates operation.

For more information, contact Continental Electronics in Dallas at (800) 733-5011 or visit www.contelec.com.

GUY'S SPLIT PERSONALITY

The continuation of Guy Wire to present an argument for digital broadcasting is a study in multiple personality behavior.

There is one side of Guy that is trying to promote HD for obvious reasons. Then there is the other side that will not permit him to tell a lie.

The newest article on defending the thinning of the "heard" is another classic ("The Great AM Debate," Aug. 24). For the first time I understand the words of my favorite English professor when she declared that great "lit" was written to be digested and dissected. Guy's comments, if carefully read, would show the inward struggle.

Guy needs to take a travel vacation. HD Radio itself will eliminate first-adjacent contours on FM. HD Radio on AM, using the proposed system owned by the 21 gunners pointed at the head, will eliminate any broadcaster within 20-30 kHz of each side of the HD blaster. Any new FM LPs offered to drop-dead AM guys would get killed by the nearby digital adjacencies. The cost of going digital for the LP guy would be higher than the cost of the LP basic analog gear alone. Perhaps Ibiquity could donate the royalty fees to the little guys.

The adjacent jamming applies to present market conditions, not just small towns of America. The facts are not mine, they are the facts of life as currently playing at the local theatre of the mind (broadcast spectrum).

This is well calculated in Guy's comments advising the narrow-casters to exit AM via a tax break. The idea is great. It will require power increases for the survivors to restore the contours lost to digital.

I don't expect the extra compressed spare channel idea to fly on FM, given that the blind population, most likely candidates for the secondary channel, also possess the finest hearing in our midst and will not tolerate anything that sounds distorted and irritating, such as the channels proposed in the first and second rounds of the selling of digital stuff to the broadcasters.

As for the idea that HD sounds better on either the FM or AM channels, that too is proving to be a relatively false prophesy.

There just ain't enough bandwidth on either spectrum (even if you consider the stolen component already in the mix such as the neighbor's territory on AM and FM) to deliver better audio. The term "amelioration" from Guy's article is another double-meaning word, normally written suggesting that one find another word to "amend" the real meaning of the discussion.

I submit the entire article is an amelioration of the debate by spinning the blame backwards. He is a smart fella for sure. We kill off the little guys and those religious stations and we wipe out the only remaining locally active broadcasters giving them a real estate sale and a tax certificate and leave the channel space to the 21 players with 100 million investors watching them grow more hard drives.

Fact is, upon closer examination, the heartbeat of real radio is still the small and medium markets where a couple of thousand stations still thrive or struggle in the midst of the Wal-Marting of the spectrum. Another oxymoron for tomorrow's trivia game: "public airways."

Perhaps the good part of the latest Guy story is the criticism of the NAB, claiming they want to keep the number of stations high. In fact that is probably a smokescreen, as NAB collects few dues from broadcasters, especially the small folks. NAB enjoys deep pockets from its annual show, and selling ad space as well. Thus, NAB supports digital stuff and has jumped for a room reservation with the digital stalkers convention long ago.

The first horse out of the chute on digital, if you recall, are the geniuses who live off our tax and donated dollars at NPR with visions of multichannel TV and multichannel FM to add more capex and budget goals to the mix. Then came the NAB with its list of former FCC lawyers and spinoffs funded by those annual radio shows.

Jerry Smith
Terre Haute, Ind.

The first horse out of the chute on digital, if you recall, are the geniuses who live off our tax and donated dollars at NPR ... Then came the NAB with its list of former FCC lawyers and spinoffs funded by those annual radio shows.

— Jerry Smith

SPECTRUM MANAGEMENT AND A BOTTLE OF BOOZE

I find Guy's ideas for reducing the number of AM stations licensed quite intriguing. It is not, however, a new idea.

Many years ago, before consolidation, and during the Great AM Stereo Wars, several of us addressed the need to reduce the number of AMs at an informal workshop at one of the SBE conventions.

I'll name no names save myself, mostly to protect the guilty. The panel consisted of myself, the chief engineer of a highly regarded legacy album rocker, a highly placed bureaucrat and a bottle of fairly good whiskey. There was no audience.

We developed the following steps for reduction of the number of licenses; and while they are to a degree arbitrary, they would have worked, and probably would work today:

1. Any station license whose antenna array requires more than three towers is revoked;
2. Any license for a power level below 5 kW is revoked.

Should these steps not result in sufficient reduction to overcome interference, the classic Roman decimation would take place, wherein licenses are lined up alphabetically, and every tenth one in the line is revoked. Successive passes are made through the line until the desired reduction is achieved.

At this point, the fairly good whiskey gave out and we all retired for the evening.

It would have worked, though, and still would.

Johnny Bridges
Chestnut Mountain, Ga.

PRACTICAL CONSIDERATIONS

I read with interest Guy Wire's thoughts on AM IBOC. While I can't say I know where AM IBOC is ultimately going, having heard it daily on several of our stations and others in the Denver market for the past few months, I am impressed.

Our AMs really do sound like FMs. But there are limitations and there are problems.

Broadband noise and static crashes kill the digital lock, and in-band, on-channel AM is really in-band, adjacent-channel. The primary digital sidebands are centered at +/- 15 kHz. Fully spaced first-adjacent stations (i.e. no 0.5/0.25 mV overlap) won't have any issues, but grandfathered first-adjacents may experience some fringe interference.

With the digital sidebands at –30 dBc or so, I don't see anyone having problems inside their own protected contour, but let's face it — a lot of stations rely on unprotected coverage beyond the 0.5 mV/m. At the protected contour, the co-channel IBOC interfering signal from a grandfathered first-adjacent channel station (no 0.5/0.5 mV overlap) would be about 15 uV, which is about 4 dB less than the 25 uV that would be permitted at that point by a real co-channel station.

The limitations and issues notwithstanding, Crawford Broadcasting Co. is investing heavily in the Ibiquity system, as are Clear Channel, Entercom, Infinity, Cox, Emmis, ABC/Disney, Cumulus, Univision and others. We see the handwriting on the wall for terrestrial radio, and AM in particular.

If we can't compete with satellite radio, online streams (particularly with growing wireless Internet coverage), iPod/podcasts and other emerging media, we're done for in a few more years.

The short-sighted naysayers insist that AM needs to do something different than Ibiquity IBOC, but the truth is, that's not going to happen; it's way too late for that. We're years down the development road on this, and if we change directions now, receiver manufacturers will be twice burned — AM stereo and now IBOC. They'll kiss AM goodbye and never go out on a limb with another new system again. And who could blame them?

So this company is aboard in a big way, for better or for worse. It's going to be an interesting ride.

Cris Alexander
Director of Engineering
Crawford Broadcasting Co.
Denver

The short-sighted naysayers insist that AM needs to do something different than Ibiquity IBOC, but the truth is, that's not going to happen; it's way too late for that.

— Cris Alexander

COLLOCATED AM/FM STATIONS

Thanks for your article about the AM/FM collocation issues ("From the Tech Editor," Oct. 19). I have had two such instances to deal with. In one case I actually moved the exciter out of a Continental 816 and mounted it in the rack right below the STL receiver. One short chunk of RG-62 between the two solved that problem.

In the other case what looked like interference was simply local receiver overload. The AM and FM signals were combining in the front end of the receivers (and spectrum analyzer) to create a signal above and below the FM frequency — spaced out the distance of the AM frequency. Once I put a band-pass filter in front of the spectrum analyzer, that blocked out the AM signal the FM sidebands disappeared.

Laverne Siemens
Director of Engineering
Golden West Radio
Altona, Manitoba, Canada

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Dielectric 700 Series Suitable for 700 MHz

Dielectric Communications offers a line of antennas for the 700 MHz Mobile Media spectrum. The 700 Series includes slotted coaxial, panel and stripline antennas that can be horizontally, vertically, circularly or elliptically polarized and customized.

The company says the 7C, 7P and 7S Series antennas are compact and lightweight. Customized azimuth patterns, elevation patterns, gain, beam, tilt and null fill are available with each model.

The 7C line features slotted coaxial antennas; the company says it offers the popular center-fed pylon style.

The 7P meets omnidirectional pattern requirements with either horizontal or vertical polarization. The panel's wide impedance and pattern bandwidth make it suitable for multiplexed channels, and the number and location of the panels can be varied to determine the azimuth and elevation patterns.

Each individual panel's input can be 7/16 DIN or type N, while the array feed system can be specified to accommodate the input size. Customized versions and circular or elliptical polarizations are available by request; a 7 PD version offers a duplet option with two layers incorporated into one panel with a single feed point.

For applications requiring a horizontally polarized, omnidirectional broadband solution, Dielectric says the 7S Series of stripline antennas has 80 percent less windload than a comparable panel antenna by virtue of its enclosure in a full radome. It is available in one to four sections, and while the input to each individual four-layer section is type N, the array feed system can be specified to accommodate any input size.

Each 700 Series antenna is supplied with necessary feed lines and power dividers, which the company says are factory-tested prior to shipping.

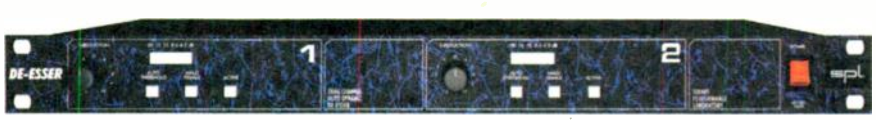
For more information, contact Dielectric Communications in Maine at (207) 655-4555 or visit www.dielectric.com.

SPL De-Esser Detects, Removes Sibilance

Sound Performance Lab says its Model 9629 Auto Dynamic de-esser removes sibilant frequencies without compromising the timbre and natural character of the voice.

The unit monitors the frequency spectrum and detects the sibilant frequencies. The bandwidth is set narrowly around the range of the sibilance so that neighboring frequencies remain unaffected. This frequency band is mixed back into the main signal phase-inverted to cancel out the sibilance.

SPL says that the processing intensity of traditional de-essers drops off with increasing distance, and compressors placed after the de-esser for signal correction tend to respond incorrectly to the changed values. The 9629's automatic threshold-adjusting function compensates differences in the input level caused by the singer moving in relation to the microphone so the selected reduction value remains constant.



Additional features include symmetrical XLR and jack plugs for the in- and outputs, internal power supply with toroidal transformer, GNDlift switch, relay hard bypass/power fail safety and voltage selector switch. Users can set a front-panel switch to Male of Female to adjust for vocal characteristics.

For more information, contact SPL-USA in California at (866) 477-5872 or visit www.spl-usa.com.

ERI Releases EBSP Software Version 7.0

Electronics Research Inc. offers version 7.0 of its ERI Broadcast System Planner software, which the company says assists in the designing of FM radio and UHF and VHF television transmission systems, and has pattern and gain information for ERI standard antenna products.

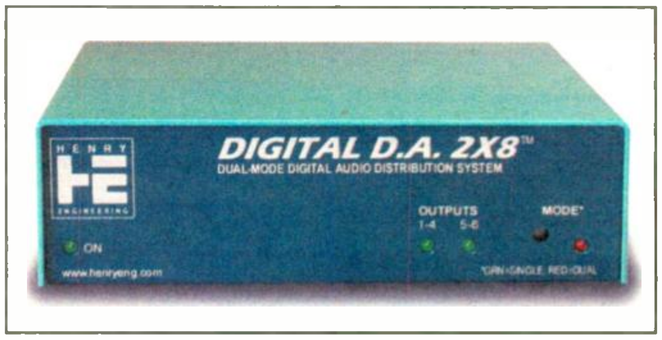
EBSP includes transmission line loss values, and allows the user to calculate transmitter power output required to achieve a given effective radiated power and effective radiated power from a given TPO. Additionally, it has plotted and tabulated azimuth and elevation pattern data for most standard ERI antenna products, such as Rototiller FM antennas.

The latest version (7.1.6) is available on the ERI web site.

For more information, contact ERI in Indiana at (812) 925-6000 or visit www.eriinc.com.

Henry Engineering Has Digital Distribution System

The Digital D.A. 2X8 from Henry Engineering is a dual-mode distribution system for AES/EBU digital audio signals, and is suitable for the routing to multiple destinations. The company says it produces outputs that are copies of the input signals, and there are no changes to data or timing, and no jitter, delay or latency is added. The unit is compatible with sample rates up to 96 kHz.



Digital D.A. 2X8 has two inputs and eight outputs. There are two operating modes, selected by a recessed front panel pushbutton. In Single mode, the unit operates as a 1-in, 8-out D.A., in that a single input signal is reproduced on each of the eight outputs. In Dual mode, it operates as two independent 1-in, 4-out D.A.s, in that each of the two input signals produce four outputs. There is no interaction between the two channels.

The presence of output signals is confirmed via a front-panel LED for each output group. Inputs and outputs are individually transformer isolated. Input termination is user-selectable. Input signals are conditioned to correct for low levels and high frequency roll-off caused by long cable runs. The output signals conform to AES/EBU standards.

Digital D.A. 2X8 is 1/3 rack-width, and can be rackmounted using the optional rack shelf or wall-mounted with optional wall/cabinet mounting brackets.

For more information, contact Henry Engineering in California at (626) 355-3656 or visit www.henryeng.com.

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Barry Blesser

Tools for Analyzing Your Future

A Look at the Shifting Forces Affecting the Radio Industry and Its Many 'Stakeholders'

Depending on whom you talk to, the future of the radio broadcast industry is black, white or any shade of gray. We live in an era in which entire industries are being threatened, revolutionized and re-invented.

While some self-appointed pundits have a clear vision of what our industry must do to survive and thrive, I am just not smart enough to predict the future and will not offer yet another opinion. I will, however, offer a set of analytic tools so you can analyze the dynamic forces that now are destabilizing the status quo.

Think of the radio industry as a loose confederation of groups, each of which has a stake in our industry; hence they are called stakeholders. Such groups include listeners, investors, advertisers, executives, employees, journalists, governments, tradeshow organizers, equipment manufacturers, networking specialists, technical consultants, and so on.

Aside from the physical infrastructure, the radio industry is nothing more than a collection of these groups.

Within each stakeholder group, we find individuals who have similar interests and a common relationship to other stakeholder groups. Compared to executives and engineers, listeners are a relatively similar group. Compared to investors and manufacturers, executives are similar.

Depending on the goal of an analysis, each stakeholder group can be further divided into subgroups. For example, the listener group includes youths with a taste for a specific music, businessmen commuting to work and immigrant families facing language barriers.

COMPLEX CALCULATIONS

While we could attempt to analyze the detailed relationships of each stakeholder group to all the others, the matrix of the combination is large indeed. However, even though the effort is large such an analysis is critical to making decisions.

As a consequence of having a relationship to other stakeholders, each group derives some benefit and contributes some value. For example, listeners benefit by receiving news and pre-packaged entertainment. In exchange, they contribute rating and headspace, and they are likely to consume goods and services advertised by sponsors. Investors contribute financial capital and expect a return on their investment. Sound engineers produce programs for salary, and sales people receive ad commissions.

Each group contributes something to the industry (cost), and in exchange, receives some benefit (gain). When the ratio of gain to cost is favorable, a stakeholder group grows; and conversely, when unfavorable, it shrinks.

Investors can move their assets to industries with higher ratios. Audio equipment manufactures can shift their product line to cinema or television. Executives can take positions in other industries. Listeners can replace radio with portable audio prepared at home. Stakeholder groups expand and contract as individuals immigrate into and emigrate out of any given group. Looking to optimize their ratio, individuals make choices to maximize their personal situation.

Complexity arises because unrelated events change the ratio of gain to cost for each stakeholder group, leading to different choices. That then changes the ratio for other stakeholders, who then shift their choices.

As listeners change their preferences in audio media because of new technology, advertisers shift their choice of delivery vehicles. Advertisers have a vast array of choices, including newspapers, television, billboards, direct mail, the Internet and so on. New technology is constantly destabilizing the status quo of every group. And society constantly is adjusting its values: personalized versus standardized, public versus private, large versus small and so on.

While the details are unique to each group, each industry, each culture and each decade, the pattern is universal.

To predict the future, one needs to identify and analyze critical stakeholder groups with their shifting choices. Consider, for example, listener stakeholders who receive any of four classes of radio programs: entertainment, information, unique personalities and local community participation. A long time ago, they had few choices for these classes. Now, however, they have exponentially increasing choices, which instantaneously changes the ratio of gain to cost.

As an illustration, we can focus on entertainment. Copying, buying and organizing portable audio players takes time and money, but this choice can be readily customized to mood, time, place and personal preferences. In contrast, broadcast programming requires no preparation effort on the part of listeners, but they give up headspace and experience the unwanted pounding of aggressive messages.

Some listeners value the fact that expert programmers can find and sort music using their skill and experience. These factors are all part of the listener's ratio.

CHANGING TECHNOLOGY AND TIME

Unlike music entertainment, there are fewer choices for news and information, especially traffic reports on a minute-by-minute basis while driving. However, at some point soon, GPS services will offer not only real-time traffic information but also recommendations for alternative routes.

Such a service will be attractive, and like all popular technologies, it will eventually become an inexpensive commodity provided as standard equipment. This is a perfect example of how a new technology changes one ratio, opening new choices, which then changes many other ratios.

Broadcasting traffic information from expensive helicopters loses its value if listeners receive the same information from a faster, more comprehensive and interactive source. Technology shuts the door on the helicopter pilot, but opens a window for the GPS operations guru.

Having hundreds, if not thousands, of available audio channels has value to listeners only if they have a strong preference for a specific kind of music, such as 19th century Polish polka. However, providing that kind of service has a production cost and requires effort to manage music libraries. And the number of listeners on each channel becomes tiny as the musical niche becomes small.

Hence, this option is only viable if the audience can be increased by broadcast nationwide or even worldwide, such as with satellite or Internet radio. Even so, the cost of niche programming often is provided by monthly subscription fees rather than just by advertising, which is yet a different kind of cost for listeners.

Finally, we come to one unique asset that is often valued highly: the magic personality of a special voice or brand.

Listeners may want to hear their favorite personality or sports team available only on one channel of one medium. By elevating a personality to mythical status, the ratio is highly skewed. Many young adults will spend a week's salary just to attend a concert of their beloved music group. For passionate followers of a highly valued person or team, cost is no object.

In this short illustration of stakeholder analysis, we immediately notice the complexity and dynamic nature of any conclusion. The problem for each group is compounded by a skew in time-scales. While listeners can switch choices daily because they have little invested capital in their current choice, investors have their resources locked in inflexible physical plants, and professionals have decades invested in narrow skill sets. Stakeholder groups are not symmetric in their relationship to temporal flexibility.

What then is the future of terrestrial radio? The answer depends on the success in creating new relationships among the various stakeholder groups, such that each group has a positive ratio of gain to cost. Easier said than done. And like a good academic, I leave the answer to the reader to discover. While the questions and framework are clear, the answers are not.

Historically, the actual outcome of such complex situations often arises from unplanned, unpredictable and unmanaged events. This is explained by chaos theory, which is definitely worth learning. As a one-sentence summary, it says that a single trivial event, out of millions of other trivial events, can eventually have profound and unexpected consequences.

With such a premise, no amount of analysis will remove the fog from radio's crystal ball.

Dr. Barry Blesser is director of engineering for 25-Seven Systems, a former associate professor at MIT and past president of the AES. Contact him with your comments at barryblesser@25-seven.com. ■

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