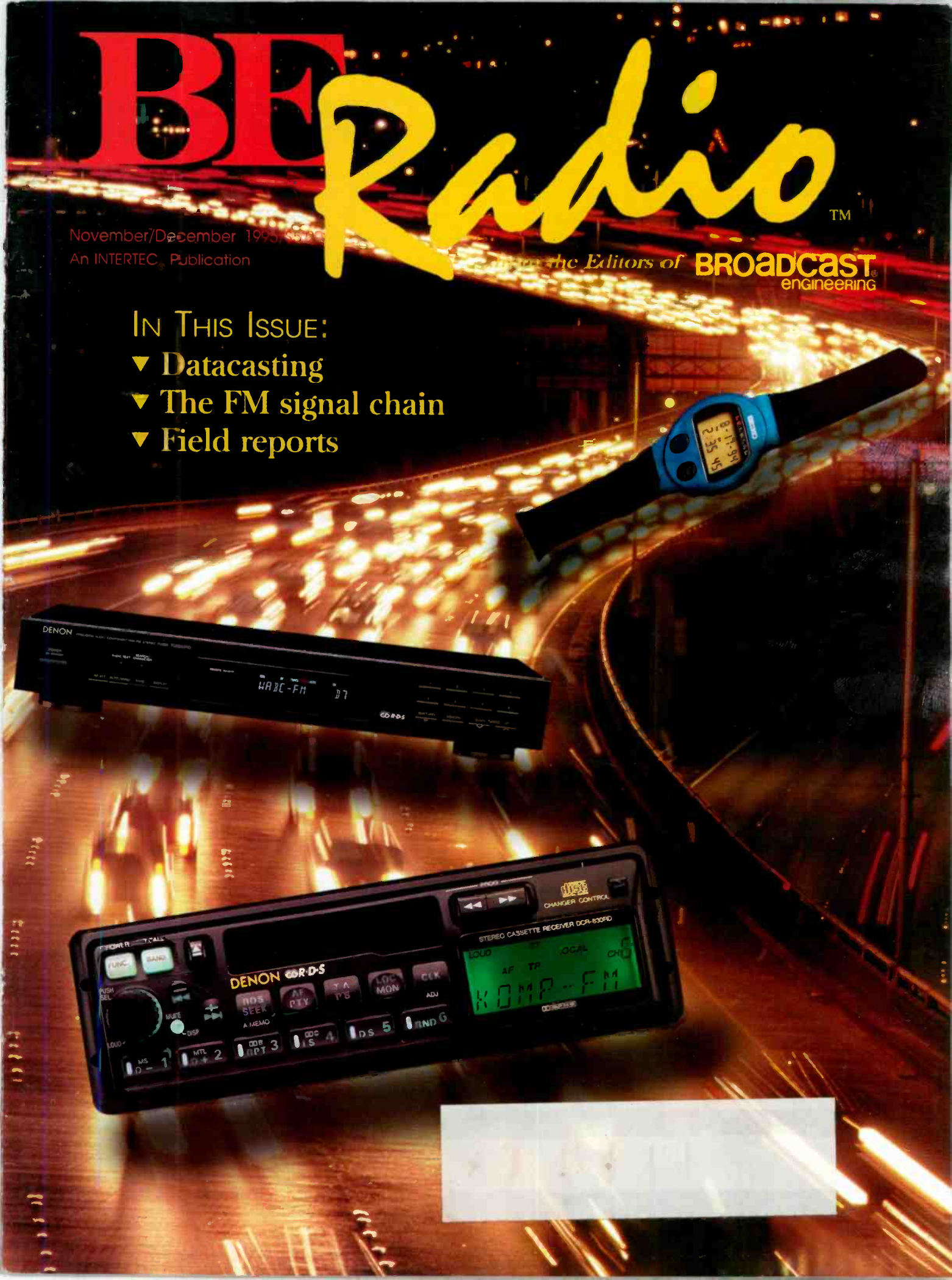
BE Radio™

November/December 1995
An INTERTEC Publication

From the Editors of BROADCAST ENGINEERING

In This Issue:

- Datacasting
- The FM signal chain
- Field reports



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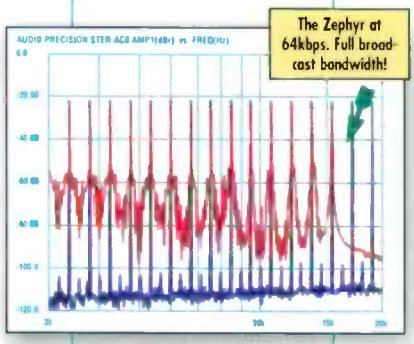

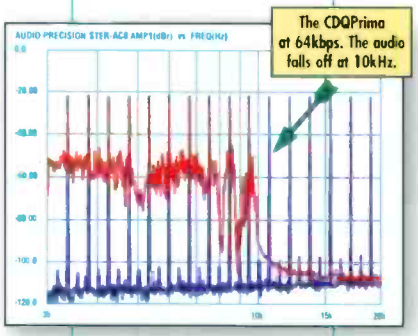

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36.
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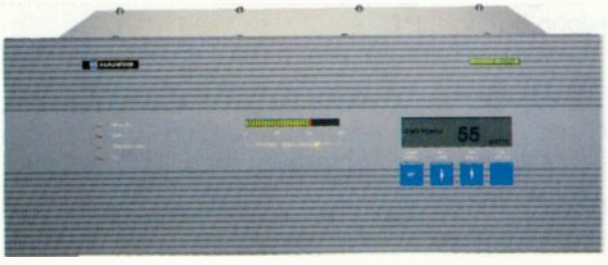

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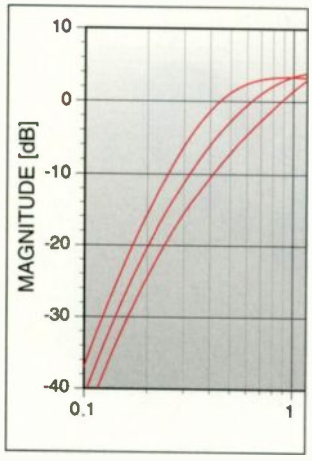
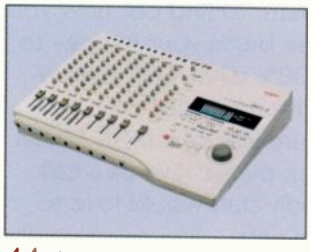
24 Data Broadcasting: The Next Frontier

This month...



34 The Signal Chain

Departments...



44 New Products

ON THE COVER: Data broadcasting via FM subcarriers may kick the radio business into high gear, as products like the Seiko Messagewatch and RDS receivers for car and home begin to reach the consumer marketplace.

[The DSE 7000 Version 5.0]

With a workstation this fast, nothing can slow you down.

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John Frost...Creative Director
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Debby DeLuca...
Commercial Production Director
HOT-97, WQHT-FM, New York

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Peter Belt...Chief Engineer
Radio 10, Amsterdam

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Russell Kerr...Planning & Development Manager
IBC, Auckland, New Zealand

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Editorial:

You say you want a revolution?

The holiday season is always a good time to take stock, give thanks and reboot for another go-round. This time, as we make a final turn toward the millennium, the broadcast industry finds itself in the middle of something big, although it's hard to say just what it is. The conversion to digital technology is certainly behind it, and while some call this trend a revolution, that may not be quite what's happening in radio.

A revolution indicates some radical departure from past practice, and on a pure technology level, digital systems certainly meet this spec. But by way of applications, the digital systems employed in radio today are performing the same functions as the analog equipment they replaced. This is simply incremental or *evolutionary* change. Even DAB will follow this same trend — or will it?

Close inspection of past changes points out some interesting distinctions. For minor enhancements to broadcast service, backward compatibility has always been paramount, and this requirement often limited the performance of the improvement; FM stereo and color television are good examples of this. On the other hand, when FM broadcasting first appeared, it was treated like a wholly new service, without any backward compatibility requirement. So, just how big a change does DAB represent? Should it be considered simply incremental change, or is it really a new service?

The IBOC camp inevitably sees DAB as an enhancement, while the Eureka 147 faction takes a new-service approach. Given this, we can conclude that the enhancement model will intrinsically underperform (relative to the new-service model) due to its need to maintain backward compatibility. That qualifies IBOC as evolution and Eureka 147 as revolution.

This could be IBOC's greatest advantage from a business perspective, however, allowing broadcasters and consumers to upgrade compatibly and at their own pace over an extended period — a *laissez-faire* approach to technological progress, with minimal upheaval to the established environment. After all, a revolution usually implies extreme dissatisfaction with the status quo, and that's not the case here. In fact, it's just the opposite, and broadcasters should be concerned with killing (or even wounding) the goose that lays those golden eggs ("If it ain't broke..."). The more compulsory and proactive requirements of Eureka 147 involve wholesale changes (and investments) by broadcasters, listeners and regulators — more pain, more gain — but also more risk to all parties, particularly to those at the top who have more to lose.

Yet, terrestrial DAB is not the only venue in which these changes are at play. The real radio revolution may be a two-pronged attack that comes from outer space and from underground: *satellite DAB* and *on-line radio*. The electorate of the marketplace will ultimately decide if either or both of these movements catch on. If they do, who will be the providers of service that share the spoils of such success? Clearly, the potential benefits to existing broadcasters from either of these businesses are likely to be restricted (in opposite ways) by the number of players involved. Satellite DAB will probably include few providers and on-line radio will probably involve too many. Therefore, there will either be little opportunity to get a piece of the action, or the benefits will be sliced so thinly that no one will get very much. Interestingly, both systems also have service ranges that greatly exceed broadcasters' reach (everyone's a "superstation"), but each new service is also limited in ways that broadcasters aren't. Consumers will weigh all these parameters and make decisions, basing their assessment on perceived benefit vs. perceived effort/expenditure.

As with any mass movement, there will be wild cards and unintended results, and the longevity of the process will also play a role: The longer this revolution continues, the greater its overall effect — like an earthquake. Some say this current course of change will *never* end. But if it's a truly continuous function, then it can't be considered a revolution. By its nature, a revolution is a pronounced and definable *point* of change. And by another definition, completing a revolution puts you back in the same place you started! Amid such semantics and conundrums, only a few things are certain about what's ahead:

1) Change: Broadcasters are moving away from analog modulation and toward "bit radiation" (the delivery of digital signals). The fungibility of this bitstream can allow delivery of many forms of communication besides the audio that radio stations are generally limited to today. (Of course, this theoretical flexibility is still subject to the need for standardization in the marketplace, without which decoders cannot recognize the transmitted bits — hence, the current EIA/NRSC process.) This is the essence of a fundamental change, the threshold of which radio broadcasting is now poised to cross. How much and how fast remain uncertain. (See this month's cover story for more.)

2) Stability: No matter what else changes, human nature is relatively constant. People will never tire of hearing stories well-told and songs well-sung — a tradition that predates radio by several millennia. As the century in which broadcasting first appeared comes to a close, it's helpful to recall that the real business of radio is (and will remain) about satisfying those basic communal needs. That's a good touchstone to help you weather the trying technical times ahead.

Meanwhile, here's hoping your holiday season is refreshing and joyful, and that *your* next revolution (around the sun) will be peaceful and prosperous.

By Skip Pizzi, radio editor

P.S.: Thanks to all our readers and advertisers for your support of *BE Radio* this year. We look forward to working and growing with you in 1996!

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Circle (8) on Reply Card

Contract Engineering:

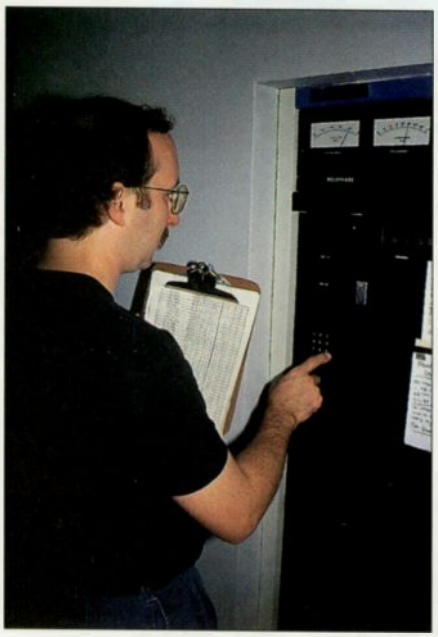
Handling multiple clients

By Chip Morgan

Question: How many engineers does it take to screw in a light bulb? *Answer:* One-fifth (i.e., one engineer must be able to screw in five light bulbs at a time), and that's no joke.

If you run a contract engineering business and you want to expand to handle more clients, you'll probably need to restructure your entire business. Your costs change due to travel, phone calls, extra personnel, insurance, less knowledge of each particular station and a myriad of other overhead obstacles. This article covers some of the considerations in expansion, and shares some lessons learned by those who have ventured into an expanded service area.

One of the most difficult issues in expansion is the psychology. No longer can you have the intimacy you get with a single station. You have many clients, and they are all different. Each one of them wants all of you, but they won't pay enough to make it worth your while.



That's OK, because that's why you're in business. In fact, you're in demand because you're good. But it's really hard to get past the first few clients because you're already extremely busy, and you don't know how you're going to get more hours in a day. The answer is to *leverage yourself* by hiring help, by raising your rates and by working with stations that have their act together.

> If you want to expand, you'll probably need to restructure your entire business.

Restructuring

• ***Your rates:*** The reason you need to raise your rates is because you're giving your time away. There are only 24 hours in a day. You can't expand because you're already busier than a one-armed paper hanger. The secret is to eliminate the bottom 10% or 20% of your clients – the ones who don't pay their bills; the ones who are extremely demanding, but don't give anything back; or the ones you just don't enjoy working with. Replace them with new accounts at a higher rate.

• ***Hire help:*** You can't do it all alone. Raise your rates to get more cash flow, hire help to handle your old accounts, and get out there and hustle some new business.

> Don't count on subcontractors for emergency response; you won't be their top priority.

• ***Work with stations that have their act together:*** If you put your new help at the stations that have their act together (i.e., the ones you kept after eliminating the bottom 10%), you must still maintain a good relationship with them. You can do this by working with the general managers and owners while your new help does the hands-on work.

Staffing

• ***Subcontractors or employees?*** Depending on the nature of your business, you may use subcontractors, employees or a combination of both. For project work, or work that is beyond your normal capabilities, outsourcing staff makes as much sense for you as it does for your clients. There are many freelance engineers available in the industry today. They are working in audio for television, doing maintenance for recording studios, running transmitters in the military, serving as technicians for paging companies or 2-way radio shops, among others.

The trick is to use specialists instead of generalists. The old saying about broadcast engineers knowing a little about a lot doesn't apply to today's business. Clients who are paying for a contractor expect specific knowledge, especially if they are paying high rates. It's expensive for you to teach on the job. Besides, it's illegal to teach if you use contractors. If you use employees, you can use on-the-job training, but if you're doing a project, don't expect to be able to charge as much for these employees.

• ***Interns:*** Who says that only programming people should have interns? If you have the time and resources for an internship program, do it. The industry needs all the new engineers it can get, and training grounds are few nowadays. Local institutions of "hire learning" can provide enthusiastic helpers who can become future employees for you or your clients. Can you think of a better low-cost solution to your needs for more bodies to do basic engineering work such as cleaning, carrying and meter readings?

• ***Emergencies:*** Don't count on subcontractors for emergency response; you won't be their top priority. You need a long list of subs to handle emergencies, plus a group of dedicated people (you, your spouse and

Chip Morgan owns Chip Morgan Broadcast Enterprises (CMBE), a broadcast design, systems management and engineering firm based in Sacramento, CA.

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your client's employees) who will do whatever it takes to solve a problem. Be sure to have enough people to handle the unlikely event of all of your clients having an emergency at the same time. If you're the main contractor for an entire market, what's your plan for a natural disaster? If you don't have one, you'd better plan on losing a lot of business if something happens.

Business issues

• ***Salesmanship:*** When you start marketing yourself and your firm to multiple clients, you won't be able to spend as much time with each client. Much of a contractor's work is "handholding," and it's an important part of what we do. If you can develop clones of yourself who can do the handholding, you're ahead of the game.

The smart contractors only hire or subcontract to engineers who are good with people. Bedside manner is critical when you have a limited number of hours to make a good impression. The client's confidence is influenced far more by *your* confident manner than by his belief in your technical skills. Your ability to do the job is assumed – until confidence is lost. Engineers who can't impress clients should work at transmitter sites or behind the scenes. They aren't good for business.

> If you're the main contractor for an entire market, what's your plan for a natural disaster?

• ***Conflicts of interest:*** Once you start taking on multiple clients, you are bound to run into situations where your actions with one client could affect the success of another. Owners and general managers are well aware of this, and if you don't handle it well, your business will suffer.

You need to develop your own ethics, but a good place to start is to decide to not take on any work that could be considered a conflict of interest without disclosing the potential conflict to all affected parties. Get them all to agree that they can work with you under those conditions. This becomes more important when you serve as a *consultant* to your client.

In pure contracting, there's rarely a conflict, but in your dealings as a purveyor of wisdom and experience, you may well be in a position to affect the success of one client at the expense of another. It's not uncommon for a consultant or contractor to identify such areas and recommend an outside firm to handle that portion of the work. Greed in conflict-of-interest situations only results in short-term success.

> Much of a contractor's work is "handholding," and it's an important part of what we do.

• ***Service department:*** If you do a lot of bench work as part of your company's value-added service, you may want to consider a central service department where you take all the machines that need heavy repair. This is a way to reduce the cost of test equipment by using the "hub and spoke" system. Organize your repairs around a single shop schedule instead of several.

• ***Systems management:*** As your firm gets bigger, you may want to eliminate the headache of doing repairs entirely. You'll be so busy with scheduling and project management that the repairs will tend to be lower profit. Once again, outsourcing may be the answer. Consider making arrangements with factory techs or with other firms that have skilled technicians who can do repair work quickly and easily. Remember, your client doesn't care who does the work as long as it is done quickly and cost-effectively.

• ***Brokering:*** There is great merit in the concept of using subcontractors to start your expansion in this business. The ebb and flow of work is so great that the risks far outweigh the benefits of using employees for short-term employment. You also can set up reciprocating relationships with other contracting firms to help one another with project work.

• ***Cost of business:*** It costs more to work with multiple clients. You need to have extensive systems in place to deal with the complexities of working with different stations. Sometimes you can get stations to adjust to your systems, and other times you can't. The costs of getting familiar with a new client and putting out the inevitable fires that you inherited are not cheap. Consider getting the station up to your standards as a one-time project (for extra cost), not part of the ongoing maintenance package.

• ***Expenses:*** If you start working across a large geographical area, the costs of phone calls and travel expenses become an important part of your finances. That added cost also makes you less competitive with the local engineers. You must increase your value to the client to compensate, and/or find a way of recouping these added costs.

• ***Safety:*** You already know not to touch a transmitter capacitor without removing power *and* discharging it. As you expand, more engineering work at your client stations can be done by station employees and less experienced workers in your company. Make sure they know the basics.

• ***Preventive maintenance:*** As a small contractor, putting out fires and dealing with emergencies adds a little spice to your life. If you have 20 or more client stations, each with multiple sites, you don't need any more excitement. It's time to put together a preventive maintenance plan. This plan also serves as a training syllabus for new employees, and removes the minute-by-minute coaching of new engineers that is sometimes required.

> Engineers who can't impress clients should work at transmitter sites or behind the scenes.

• ***Future growth:*** How big should you be? The best working groups are from 7 to 10 people per project leader – big enough to support a strong leader, but small enough for each person to make a difference and have a personal loyalty toward the leader. Groups of this size also have the highest profit margins. Under this theory, the size of the firm is determined by the number of project managers you can get who can run a fun group of 10 people. The rest is up to you.

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Circle (6) on Reply Card

Managing Technology:

Using computers

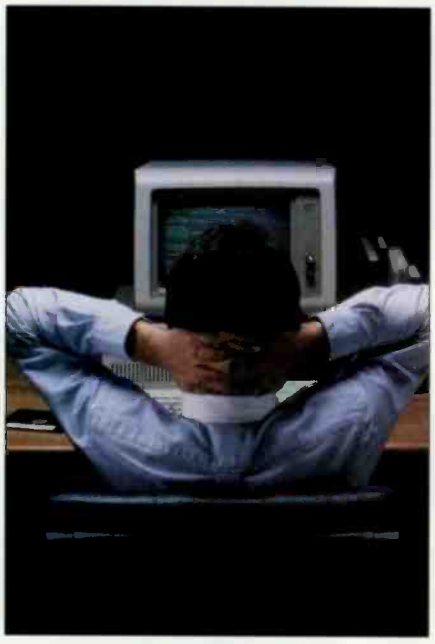
By Kirk Harnack

Most broadcast trade magazine articles about computers consider their uses in control, production and automation applications. This article will instead consider computers and their use by broadcast managers as management tools. You'll find an explanation of some basic office-computing principles and some details about helpful software programs that today's managers will find beneficial.

First, note that departmental and general managers in broadcasting use computers in essentially the same ways that managers do in other professions. Bookkeeping, employee scheduling, personal time management and word processing comprise the bulk of managerial computer use. But before looking at applications, a quick check of system hardware is in order.

Platform overview

While some offices make use of Macintosh or Unix-based computers, the prevailing computing platform for business is the IBM-compatible PC.



PCs are usually ranked by the type of processor employed. Early PCs used the Intel 8086 and 80286 processor. The late 1980s saw the debut of the Intel 80386 processor. Today, however, the typical office computer will be limited in usefulness if it does not contain a fast 80486 or Pentium processor. (A "fast" 486 processor is one with at least 50MHz clock speed.) At most stores and computer outlets, a 486DX2/66 is frequently the minimum processor configuration available. Mid-range computers are usually 486DX4/100 units or Pentium 60s or 75s. The top-shelf Pentium-based computers, usually Pentium 133s, are wonderful performers, but are currently the most expensive and probably have more horsepower than is really necessary for today's office applications.

What about RAM and hard-drive size? Most computers sold these days come with just barely enough of both to work reasonably well. A good, practical minimum amount of RAM is 8MB (4MB used to be the norm, but 8MB works much better). With Windows 95, a 12MB or 16MB minimum is suggested. Most computers will come with at least a 540MB hard drive. This is a practical minimum. If your needs outgrow this size, adding a larger hard drive is getting cheaper every month.

If your office doesn't have at least a 486 or Pentium-based computer, then a large percentage of the best-performing and most capable software is unavailable to you. Many radio stations are able to trade for all or part of their computer requirements. If a trade agreement is used to obtain computers, be sure someone who is knowledgeable about your computer requirements is involved with the negotiation. Too many radio stations have unwittingly traded advertising time for used, inadequate or outdated computers.

Many of the industry-specific applications used by the traffic department, engineering department and programming department are still DOS-based programs. The majority of these will run "under" Windows. However, most of the more general business software packages are Windows applications, making it imperative that the station's computers be Windows-capable.

What follows is a look at some of the more interesting and productive software offerings from this general business management category.

Personal time management

What if you could have your day-timer or other calendar in your computer? There are certain advantages to this. You can easily enter recurring appointments, maintenance schedules, employee meetings, birthdays and anniversaries. You can schedule an alarm to sound just before important meetings. You can easily track to-do lists and block out time in a long-range planner.

Programs that do these tasks are generally called *Personal Information Managers* or PIMs. There are many PIMs on the market, and choosing the one that is best suited to you is a little challenging. They all work in roughly the same way, but some seem to be organized better than others. One of the most popular is *Lotus Organizer*. Another one is published by the same folks who make *Day-Timers* pocket calendars. A particularly neat PIM is *PlanIt Adrenaline*. It features Warren Miller action photos and video clips to help motivate you to "take on the day."

If you already have a database of contacts with names, addresses and phone numbers, you may want to look for a PIM that can import this data. If you use a laptop computer, look for a PIM that allows easy updating of its files between the laptop and your office computer.

After using it for a short while, you'll soon find yourself in the PIM habit and your life might become altogether too organized. This author's PIM recently reminded him of his wedding anniversary and his mother's birthday, thus averting certain catastrophe.

One outgrowth of the PIM is the personnel scheduler. If your computer has Microsoft *Windows for WorkGroups*, then you already have a basic people-scheduling program called *Schedule+*. More sophisticated personnel schedulers can match employee talent and resources with tasks and their schedules for completion. One such program is *People Scheduler Plus* from Adaptiv. Individual employee schedules can be printed and handed out. Overall scheduling reports let the manager know what everyone is supposed to be doing and when.

Another interesting management tool is paging software. This type of program can page one person, a group or everyone with text messages (assuming they have alphanumeric display pagers). Some programs, such

Kirk Harnack is president of Harnack Engineering, a contract engineering firm based in Memphis, TN.

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as *Pager Power* from DSR Software, can even send pages on a predetermined schedule. For example, if you've ever forgotten to pick up your kids from school or from Cub Scouts, you can easily schedule the software to page you at the appropriate time.

Pages can be set up for years in advance if desired. This capability could also be used to excuse yourself from useless meetings or other unpleasant situations. Because pagers are easily grouped, a sales manager could page all the sales people at once to inform them of commercial avails, and engineering managers could page a remote crew regarding changes in schedule or venue.

Employee management

Modern software applications really stand out in the area of employee management. Sometimes you can be so overwhelmed by employee management paperwork that you do not have time for training and hands-on work.

One leading software company in this field is KnowledgePoint. Managers can begin by using this company's program, *Descriptions Now*, to generate accurate job descriptions. *Policies Now* helps managers write company or departmental policies.

Entering data into these programs is mostly a matter of answering questions about your company or department. The software then generates appropriate forms and text for you to print.

Performance Now assists with evaluating employees (or preparing yourself for an evaluation) and giving accurate employee performance reviews. Each software package contains forms plus pre-written and formatted text that you customize for your company.

Research

Need a phone number? Want to know all the radio stations in Dubuque? Looking for a tower company in Florida? How about all the welding shops in your zip code? Then one of the many CD-ROM phone books will come in handy. Two popular packages are *American Yellow Pages* from ABI and *PhoneDisc* from Digital Directory Assistance.

Most of these CD-ROM software packages come with a search engine to help you find what you're looking for quickly. One interesting use is to simply type the call letters of any radio station in the "search for" box. Within one or two seconds, the software will bring up the phone number and address for any of more than 10,000 radio stations. Other businesses are just as easy to find.

Some packages offer a search by industry-standard SIC codes. If you'd like to target all the chiropractors in your city, for example, these CD-ROM phone books can give you a list in seconds. Some, like PhoneDisc, can even print mailing labels or export the selected names to your word processor for writing personalized letters.

The National Association of Broadcasters (NAB) also has entered the CD-ROM publishing and distribution business. CD-ROMs have been distributed to attendees at the last two NAB conventions. These discs are full of advertising brochures from exhibitors, text and copies of speeches and papers given at the convention, and other useful information about the products and services available from vendors at the shows.

Office suites

The most common applications used in today's radio station offices are found in "suites" of programs offered by the major software publishers. Microsoft *Office*, Claris *Works* and Lotus *Office Suite* are popular "bundled" packages of different programs that can work together. The packages usually consist of a word processor, a spreadsheet program, a database program, graphical sales presentation software and some form of communication or "mail" program.

The level of sophistication in these applications has increased dramatically from similar programs of several years ago. Today's word processors can correct spelling on the fly. Spreadsheet applications often have "wizards" or other utilities to walk you through their setups. Moreover, these programs often feature templates for just about any form or report imaginable. The text and graphics can be formatted automatically to make documents look professional.

Moving on

Seeking a new management position? Look to a big selection of software to assist you in writing a good-looking resume. A quick check of an office-supply discount store revealed *Instant Resume* by SoftKey, *Perfect Resume* by Davidson, *PFS: Resume* by PFS and *WinWay Resume* with interview simulation and salary negotiation. These software applications run circles around what a job seeker can do with a typewriter.

Discovering how to use a computer as a genuine tool rather than a crutch is important. Define the kind of productivity and work flow you want to see from your company or department. Then, see how computer technology can help you get there. With a good computer, the right software and a little training, a station or department manager can become more productive and increase his or her professional image.

COMING IN THE NEXT ISSUE . . .

COVER STORY: *Transmission*

The RF side of the radio facility gets the spotlight in this issue. Our main article covers transmitters, antennas, transmission line and related systems for AM and FM radio broadcast. Related articles consider tower leasing and FM translators.

Audio Control Systems

The growth of multistation facilities creates the need to manage more audio inputs and outputs under one roof, without sacrificing audio quality or flexibility. Many single-station shops are expanding their audio-path capacities, too. Today's mixers, switchers and routers are handling these increased requirements in a cost-effective fashion.

Managing Technology: *Managing Multiple Stations*

"Competing with yourself" is a new phenomenon facing an increasing number of duopolized station managers, and it requires a new set of skills.

Contract Engineering: *The Engineering Professional*

What constitutes professionalism in the contract engineer? One experienced pro presents his credo.

RF Engineering: *Power Tubes*

The last vacuum tube at the station is probably in the transmitter's final section. Its care and feeding are discussed by John Battison.

FCC and EAS Updates:

The effects of EAS on unattended operations and other regulatory news.

Plus, BE Radio's roundup of product reviews, industry news, business happenings, new product announcements and more.

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RF Engineering:

Proofs of performance

By John Battison, P.E.

Sooner or later, there comes a time when a station is faced with making a full or a partial proof. The need for a full proof generally arises when:

1) The FCC inspects your station and is unhappy, or a competitor complains about your operation (probably because you have a better signal than his);

2) You have a directional antenna (DA) that is about 30 years old or older and you are having major problems with it, for which the only solution is a thorough overhaul; or

3) You have just walked into a new operation that has to be proved to the commission for its license application on Form 302. There are a few other reasons, but these three cover the vast majority of cases.

A full proof consists of a nondirectional and a directional set of measurements, both made at exactly the same place. It is not always easy to go to exactly the same spot, and sometimes successive measurements are made by different engineers. So it is best to make your directional and nondirectional measurements at the same time.

The full proof requires attention to detail during preparation and the use of certain specialized tools.

Preparation for a full proof

Be sure that you have a corrected current copy of Part 73.2 *et al* (starting at Subpart A), and read it several times. If you see anything you don't understand, ask another engineer or, better yet, call the FCC. Also, obtain several copies of FCC Form 302, *Application for a License*. Read the technical instructions for Form 302 carefully, and re-read any referenced rules in Part 73.2.

If you are making a full proof for an existing station, first find the original or the latest full proof. It's extremely important to have this, because without it, you may have to make a new full proof from scratch. This involves establishing new measuring points and taking close-in measurements. It also gives you no reference for comparison with your current results.

If you can't find a copy in the station's archives, and the former chief doesn't have one stashed away somewhere, obtain a copy from the FCC's archives. Probably the easiest way to do this is through Dataworld in Washington, DC (800-368-5754). In most cases, this will cost you around $55, and it takes about a week.

While waiting for the copy of the proof to arrive, you can check out your map situation. (If you can't find the proof, odds are that your maps have disappeared too.) Remember that you will have to go out about 20 miles in all directions, so order the necessary maps in good time. If you are in a county seat, you can often get the maps from the county engineer's office. If this is not possible, try the International Map Service in Denver (800) 426-8676, which can usually provide next-day delivery. Specify a radius of *x* miles with the station coordinates as the center, and the company will determine the maps needed and send them. You will need "one in twenty-four thousand" scale (1:24,000) topographic maps.

When you get the maps, look at the section containing the antenna's coordinates. For FCC purposes, the array center is taken as the central point between all towers. For a 2-tower array, this is simple, but for multitower arrays it can be more difficult. Be sure to verify that your start point agrees with the FCC's recorded coordinates and refer to the Part 73 rule on how to determine the correct figures. If you come up with something different, you will have to explain it in your engineering report, and it could slow down the process.

Having determined your start point on the central map, clearly mark it. Then commence laying out your radials. Start with the zero radial at *north* (this is cartography, not mathematics) and move clockwise, marking a radial every 45°.

You may have more than eight radials to draw, however. If it's a new station, look at the construction permit to determine which radials the FCC requires to be measured in addition to the basic cardinal and quadrantal azimuths.

If the original proof is available, but the maps are not, find the reduced-size master maps in the old proof. It will show all the radials with measuring points marked and numbered. Examine this map and arrange the extension maps suitably.

Having assured yourself of the correctness of your DA location, proceed to copy the original points onto the appropriate radials on your new maps. While doing this, verify the correctness of the mileage measurements. Mark your points exactly as shown on the original, unless there are some obvious reasons for not doing so, such as flooding or similar map indications that show it to be impossible. In this case, select new points as close as possible to the original.

If you're in luck, the original engineer will have accurately described the measuring points on the measurement sheets. You should then be able to identify your new points easily. Often, however, measuring points are not described, so all you can do on subsequent runs is hope you've found the same point as the original measurer.

Ideally, every point should be clearly described, such as "center of driveway between gate posts, house number XXX on YYY Road"

John Battison, *BE Radio's* consultant on antennas and radiation, owns John H. Battison and Associates, a consulting engineering company in Loudonville, near Columbus, OH.

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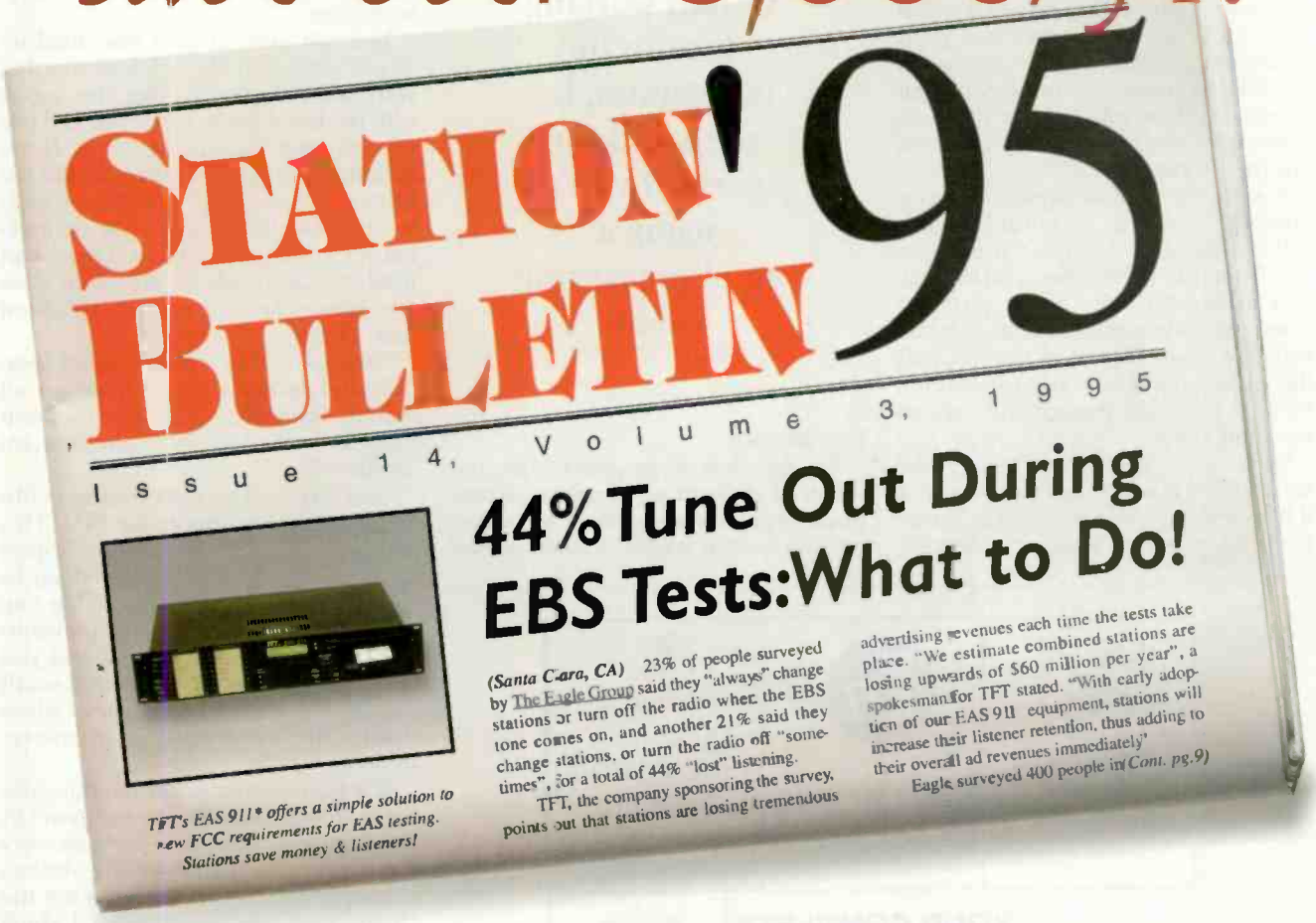
STATION BULLETIN '95

Issue 14, Volume 3, 1995

44% Tune Out During EBS Tests: What to Do!

(Santa Clara, CA) 23% of people surveyed by The Eagle Group said they "always" change stations or turn off the radio when the EBS tone comes on, and another 21% said they change stations, or turn the radio off "sometimes", for a total of 44% "lost" listening.

TFT, the company sponsoring the survey, points out that stations are losing tremendous advertising revenues each time the tests take place. "We estimate combined stations are losing upwards of $60 million per year", a spokesman for TFT stated. "With early adoption of our EAS 911 equipment, stations will increase their listener retention, thus adding to their overall ad revenues immediately"

Eagle surveyed 400 people in (Cont. pg.9)

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or "10 feet east of pole number ZZZ." This way, anyone who comes after you will be able to repeat your measurements. Don't write "in front of white house" – a new paint job can minimize the value of that description.

Difficulty is often encountered in determining the exact angle of a radial when close to an antenna and good landmarks are lacking. A compass is the obvious answer, but be careful when using one. Remember that a compass shows the magnetic north direction, not true north.

A little error called *variation* comes into play. The magnetic north pole also shifts somewhat. Magnetic north can vary from true north either east or west. You can obtain the current variation from aeronautical charts that show the variation when they were printed, and the annual change. Or you can call the local airport and request the current variation figure.

Variation is applied by *adding* the correction if it is west and *subtracting* it if it is east. A good mnemonic is: "variation west, magnetic best; variation east, magnetic least."

Having laid out the close-in radials, check their accuracy against their continuations on the extension maps. Extending a radial from one map to the next can be tricky. Make sure your radials' directions are accurately transferred.

> When working close to the transmitter, be prepared for sparks if you're using a metal measuring chain.

Equipment

For the close-in measurements, you will need an accurate measuring device. Many engineers use a chain accurately cut to a specific length. A chain is used because it will not shrink or stretch. Plant several strong stakes to mark off the points as you depart from the antenna.

When working close to the transmitter, be prepared for sparks if you are using a metal measuring chain. Sometimes it is necessary to reduce transmitter power in order to eliminate this problem. If you do so, be sure to make the necessary corrections to your measurements.

You will need at least one *field intensity meter* (FIM). Before starting your measurements, take the meter with the latest calibration date and use this as your master monitor. If no meters have been calibrated within the last two years, send yours to be calibrated, and do this while you are making all your preparations. Don't wait until you are ready to start, otherwise you may delay the process by about four weeks.

Take all the meters to a good location and measure your signal on all meters. There should be little variation between meters. Discard any that are too far off.

Don't try to make your readings without a tripod to support the FIM. This can be a simple photographic tripod that is strong enough to stand up to rough field work. I like a wooden one best. You may have to make transmitter changes while measuring, and you need to be able to observe the small changes. This is especially true when doing the DA/non-DA measurements.

It is best to arrange for the transmitter to change between DA and non-DA at convenient intervals – perhaps every three minutes. Apart from the obvious change in field strength following the change-over, you can always tell which transmitter mode is in use by looking at the time and determining which 3-minute period is in use.

A number of forms of communications back to the transmitter site can be used. If you don't have a CB system available, a cellular phone is often a good substitute, although air time can be expensive. Also, remember that ham walkie-talkies can't be used for business purposes.

Making a full proof is never easy, but if properly done, it provides a real sense of the actual coverage of an AM station, along with a sense of accomplishment for the engineer(s) involved.

For more information on equipment used in proofs of performance, circle (100) on Reply Card.

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FCC Update:

AM expanded band allotment plan

By Harry C. Martin and Andrew S. Kersting

In a reprise of the "Gang that Couldn't Shoot Straight," the FCC granted several petitions for reconsideration and review of the AM expanded band allotment plan that identified stations that were eligible to apply for authorizations for specific expanded-band frequency allotments.

In denying an application for review of a Mass Media Bureau decision finding a licensee ineligible to migrate to the AM expanded band, the FCC rescinded its Oct. 14, 1994 public notice announcing the allotment plan for the expanded AM band. On reconsideration, the petitioners advised the FCC that there were errors in its AM engineering database, which was used to generate station interference improvement factors and the resulting allotment plan. The petitioners also raised questions concerning the proper definition of the Canadian border and other aspects of the processing procedures in generating the allotment plan.

Upon review, the FCC verified the existence of certain errors in the database. The commission also acknowledged that every correction to database information had the potential to affect each of the improvement factors and station allotments that were accorded the migrating stations. The FCC rescinded the improvement factor ranking of stations, as well as the allotment plan. It also reconsidered the definition of the Canadian border used in the preparation of the first allotment plan and found that, consistent with the definition in the U.S. Canada Working Agreement, the border is defined by land mass.

The agency also identified and clarified the standards used to implement the allotment plan. The FCC noted that interested parties will be given the opportunity to comment on these matters and after the comments have been considered, it will take any further action deemed appropriate. The commission will then execute the relevant computer programs and revised improvement factors and issue a revised allotment plan.

After the allotment plan is finalized, the FCC will notify each licensee that was allotted a frequency, and call for construction permit applications to be filed pursuant to the application procedures announced in the rescinded Oct. 14, 1994 public notice.

FCC waives settlement caps

Faced with a continuing delay in developing criteria for deciding comparative hearings, the FCC will waive two of its rules that limit terms for settlement. The waiver will lift the rules for settlement for competing applicants for new broadcast facilities and in contested renewal cases for a period of 90 days until Dec. 14, 1995.

The waiver will allow competing applicants for new broadcast facilities, either already designated or scheduled for comparative hearings, to settle for any amount. For contested renewals, settlement will be limited to out-of-pocket expenses.

The FCC is trying to clear the backlog of cases caused by an FCC freeze on mutually exclusive proposals for broadcast facilities and comparative renewals. The freeze was prompted by a U. S. Court of Appeals decision that struck down the criteria set by the commission for deciding among competing applications. The situation was made worse by a recent Supreme Court decision calling into question policies that provide preferences for minorities.

The FCC hopes the waiver will result in resolutions of various proceedings that are subject to the freeze. The agency emphasizes that the waiver is temporary and affirms its support for the rules limiting payments in application settlements. The FCC explains "that many of the applications...were filed during a lengthy period of time when the applicants could have had no reasonable expectation of profiting from their proposals."

Commissioner Andrew C. Barrett dissented with the FCC announcement, referring to the action as a "bandage approach for dispensing these mutually exclusive applications." He believes that the FCC should directly address the criteria problems cited by the court's decisions. Barrett fears the waiver will serve the interests of a few individuals and not the general public.

FCC refuses to reduce EEO fines

The rejection of requests to reduce EEO fines shows that the FCC is examining these requests with an eye toward rejecting them. The withholding of any financial information that the commission deems relevant will result in a denial of the request.

With every Notice of Apparent Liability, the FCC must take into account a licensee's ability to pay when assessing a fine. The decision to allow the reduction, however, is made by the FCC. It requires extensive disclosures, which include statements of income from broadcast operations, expenses and payments to principals.

In one decision, the agency found that financial disclosures, which included one station, are insufficient for a group owner. The licensee had provided properly prepared statements, which showed that the station had no assets and that its liabilities exceeded its ability to pay. However, the licensee failed to include information about its other stations, particularly about the proceeds of a recent sale approved by the FCC.

Such information being absent, the commission found that the financial statements were not sufficient to show that the company was unable to afford the fine.

Dateline: On or before Dec. 1, 1995, radio stations in Alabama and Georgia must file their renewal applications. Also by Dec. 1, stations in the following states must file their ownership reports: Alabama, Georgia, Colorado, Minnesota, Montana, North Dakota, South Dakota, Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island and Vermont.

Harry C. Martin and Andrew S. Kersting are attorneys with Fletcher, Heald & Hildreth, P.L.C., Rosslyn, VA.

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EAS Update

The impact on operators

By Paul Montoya

Many stations are running the EBS/EAS test message to alert listeners to the fact that a new system is coming. But do owners and operators really know what is coming? This article will explore configurations of the EAS to best fit your station's operations and the role the operator may play in activating the system.

The deadline for implementing EAS has been moved to Jan. 1, 1997. This means more time for manufacturers to gear up, more time for the states to put together their plans and more time to implement the system. Let's explore the possibilities of an installation based on criteria mandated by the EAS rules.

Common criteria

All decoders will have the capability to monitor more than one source. In some areas, and with some equipment, you may monitor up to six different information sources. Decoders will also have the ability to interpret alert levels and handle them in specific ways through relay closures. The decoders should also have means to direct text information to different external devices.

Because of the automation capabilities of the EAS, much of the burden will be lifted for stations running under the new unattended operations rules. If set up properly, the EAS can take care of itself.

A sample system

Station KXYZ gets its programming from one of the national satellite-delivered radio format companies. It uses a hard-drive-based system for control of the operation and for playing commercials, promos and jingles. The morning show, however, is live.

All audio is routed, allowing one or more sources to be on the air at any one time. This is controlled by the main computer tied into the system. Input 1 of the router may be the satellite music format; input 2, the national network news channel; input 3, the hard disk itself; input 4, the board output from the studio; and input 5, the audio output from the EAS decoder.

Much of the format control is handled by six different satellite system closures provided by the satellite company via 25Hz and 35Hz tones, which are fed into the computer and are interpreted to play commercials or play a station ID or promo. These closures, with proper software design, can provide seamless operation of the particular format.

EAS decoder relay closure outputs could also be tied to the computer system's control system, providing information to the computer on the type of alert status received. The automation software would be set up to handle these closures in specific ways.

Three closures are provided from the EAS decoder: one for a test level alert, one for a watch level emergency and one for a warning level emergency. Through the design of the software by the automation system manufacturer, customization of the handling of the alert could be set specifically for any individual operation.

A test level alert would log the information onto the program log. It might also light a status line on the computer screen to show that an EAS test had been received.

A watch level alert would be handled by the computer, tying the EAS audio output into the hard-disk recorder audio input, with the computer system recording no more than two minutes of information onto the hard disk, and playing the file at the next break or calling or paging an operator to make a decision on how to handle the alert.

A warning-level emergency could have its audio directly placed on the air and upon receipt of the End of Message (EOM) code, return the system to normal operation. This, in turn, could also be logged.

Most of these operations could be handled without any human intervention. During the live morning show, however, the on-air operator needs to make decisions on handling the emergency.

In this case, the station is operating in a "live-assist" mode. The operator has control of the system, and decides when to start commercials on the system, play music off of CD, or drop live banter into the morning programming. Because commercials are still played off of the hard-disk-based system, the operator still uses the computer terminal for control of audio routing and logging.

Should any alert come into the station via EAS, the operator can be alerted immediately through the computer terminal as to the type of emergency. Any text information could also be displayed on the terminal screen or audio could be listened to through the console's cue channel. Decisions can then be made on how to handle the alert.

A warning-level alert can be wired to sound an alarm through the station paging system, should the operator be out of the studio. The possibilities are only limited by the imaginations of the owners and operators of the broadcast facilities.

Other options

Any full-time live operations can handle emergencies adapted to their own technical operation through the relay closures and text message outputs provided by the different EAS manufacturers. A large newsroom operation could take advantage of encoder relay closure functions and direct text into word-processing equipment to efficiently handle almost any type of alert.

How the operator responds to an alert can be adapted to how the system is set up in your facility. The EAS can be used as an independent device that can automatically route alert information where needed. Or, the system can be used to alert and disseminate information from many possible sources to the operator on duty.

In the coming years, it will be exciting to see the capabilities provided by EAS decoder manufacturers and hard-disk-based automation system companies in providing innovative ways to handle EAS messaging.

Paul Montoya is president of Broadcast Services of Colorado, a contract engineering firm in Lakewood, CO.

Eureka 147 vs. IBOC

Reader Feedback:

Hats off to you! You are the only one I have seen with the intestinal fortitude to state the facts clearly (*Editorial*, "How good is good enough?" p. 4, September/October 1995).

Eureka 147 is not perfect, but it is substantially better than IBOC. The broadcasters that are pushing this IBOC are only fooling themselves by pushing so hard. Maybe down the road, we can improve the signal purity and concentration, but there will be holes. Reception will be more erratic than our existing analog system. And think of the potential additional revenue sources that will come from data transmissions.

I believe Bob Culver summed it up best after the tests in Montreal, "The future is here and America is waving it good-bye."

Richard L. Edwards
Ft. Lauderdale, FL

What a marvelously diplomatic DAB piece in the September/October *BE Radio* (*Editorial*, "How good is good enough?" p. 4). DAB is such a politically hot potato, I guess you need to be a master of diplomacy. It really is too bad, because Eureka 147 is clearly the superior technology and already on the air in England.

The NAB is surely backing itself into a hole on this one. Its reaction to the likelihood of Eureka 147 Satellite DAB at the radio convention last month (October) was nearly hysterical.

Here's the scenario from hell. Satellite DAB gets up and running with a significant number of terrestrial gap filler transmitters to make the service ubiquitous and spontaneous — just like AM and FM. It is bulletproof Eureka 147.

Through some serious compromises (as you pointed out in your piece), the NAB finally gets some crippled persuasion of IBOC to work on FM.

Therefore, terrestrial broadcasters are condemned to compete with the satellite folk using a technically inferior IBOC system that is probably no better than FM on a good day and probably worse. All of this in the name of preserving the asset values in the industry.

Just in case you hadn't heard the old IBOC jokes:

- IBOC works! But it ruins FM.
- IBOC works! But the receivers cost $10,000 each.

Julian H. Breen
Pennington, NJ

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Data broadcasting: The next frontier

By Miles Beam

Data broadcasting could be your station's on-ramp to the information skyway.

The time may finally be right for data transmission to become an integral part of the FM broadcasting business. Although it was included in Edwin Armstrong's original concept for FM radio, non-aural service has never been much more than a small sideline for most stations. The info-highway revolution could change all that, but only for stations that seize the opportunity.

Congratulations! Your station just signed up subscriber number 100,000 to your data services. Sure, the $50-per-year subscription fee generates more than $5 million each year, but it's really the extra $20 million annually in advertising revenues that you see as the motivating factor for these services. Probably the most interesting part of this venture is that the services you provide were created by your staff and based largely on off-the-shelf technology.

Although this may sound a little far-fetched today, it could easily be tomorrow's reality. The surging interest in data services, especially wireless data services, is revolutionizing the way that information is being distributed. Data broadcasting is getting a tremendous amount of attention these days in the general press, and local FM radio stations may yet prove to be the largest untapped resources for distributing data.

In this article, the possibilities for how your station can become involved in data broadcasting are explored. The two basic approaches include the traditional method, where a station leases its subcarriers to a third party for a monthly fee, and an exciting alternative approach in which a station can implement its own data broadcasting services.

Getting involved in data broadcasting

For many years, a station could generate additional revenue by leasing its subcarriers to third parties. Some of these companies, which can be thought of as "information distributors," specialize in transmitting time-sensitive data. In a typical arrangement, after an FM station agrees to lease a segment of its space, the third party installs a local computer that receives its signal from a satellite then forwards it on to the station's subcarrier generator. Traditionally, radio stations pay none of the equipment costs needed to process such a third party's subcarrier data feed.

More companies are now approaching FM stations regarding the possibility of leasing their subcarriers for a host of new applications. Some of these services rely on the station's *radio broadcast data system* (RBDS) subcarrier. Companies that provide RBDS paging or *differential global positioning system* (DGPS) data may offer to install RBDS equipment in a station for free to support their application and then offer a percentage of revenues as ongoing compensation. This may sound like a good idea, but a station manager should carefully investigate how much money can be generated with this approach before committing to a long-term contract.

This is an exciting time in the evolution of technology because all of the hardware and even much of the software needed by a radio station to launch a data broadcast service are now available as off-the-shelf solutions. It is possible to broadcast data on an FM station's subcarriers today at 67kHz or 92kHz using data rates of up to 28,800 bits per second (b/s). It is also possible to use RBDS to broadcast third-party data services (*transparent data*, in RBDS terminology) at rates between 100b/s and 200b/s.

A radio station either can set up a data broadcast system on its own, or it can partner

Seiko presented its datacasting system to FM radio broadcasters at the 1995 World Media Expo in New Orleans.

with another firm that provides the content. For example, one possible marriage is a joint effort between a radio station and a local newspaper. The newspaper can provide the content (text and/or graphics) while the radio station provides the transmission capabilities. For stations that are interested in data broadcasting but don't have the staff or time to research how to begin, help is available. Hardware and software manufacturers are often willing to lend a hand to help you get going. They also may offer special assistance, such as loaners, low-cost evaluation units and free advice.

Datacasting advantages

Before getting into the nuts and bolts, it may help to review some basics. Data broadcasting (or *datacasting*) is the transmission of data over a simplex (one-way) data link from a single point to multiple receiving locations. Datacasting can take place via direct broadcast satellites (DBS), over terrestrial TV's vertical blanking interval (VBI), through cable TV systems and, of course, on FM subcarriers, to name but a few of the more well-known methods.

Datacasting has many advantages over conventional 2-way, point-to-point communication methods. Perhaps the most important is the ability to send data to an unlimited number of sites simultaneously. This has proven to be of great value to corporate franchises and chains that have many locations nationwide and to information providers who offer subscription-based services. Small companies with only a few locations can transfer data via modem and dial-up phone lines fairly easily. Once the amount of data increases to several megabytes each day and the number of remote sites increases to 50 or 100, it becomes time to look for alternatives, however. If it takes 9.5 minutes to transfer a 1MB file to each location, then to reach 100 locations is going to require at least 158 hours of transmission time, and that assumes everything goes perfectly. Compare that to only 9.5 minutes to reach all 100 sites, or 10,000 sites for that matter, and the appeal of datacasting becomes obvious.

Another advantage of datacasting relates to the issue of controlled transmission costs. Many 2-way communications systems are priced by the minute or by the byte . This is not so for most datacast applications. Typically, an FM radio station will make the data channel available to the information provider for a fixed fee per month or year regardless of usage. Many DBS services also charge in this same usage-insensitive

way. The information provider's communication costs are thus controlled, and the cost is the same whether the channel is used for five minutes or 23 hours each day. This also means that because the data channel is available all day (or nearly so, depending upon the FM station's operating practices), a tremendous volume of data can be moved in a 24-hour period, even at relatively low data rates. At 19,200b/s, it is possible to transfer more than 165 million bytes of data each day. That's the equivalent of approximately 33,000 pages of plain text.

Competing technologies to FM subcarriers

If the concepts of local datacasting services via FM subcarriers do catch on, it is only natural to ask what technologies the FM station may be competing against. TV stations have the capability to broadcast data using the VBI at speeds up to 57,600b/s, which is considerably faster than an FM subcarrier channel. The VBI transmission and encoding equipment is more expensive than that required for FM, but VBI data receivers are becoming cost-competitive with high-quality FM receivers. In spite of what appear to be obvious advantages, however, VBI is not a technology that has been in widespread use in the United States.

For nationwide applications, DBS-based services generally have a cost advantage over FM subcarriers, but a DBS application is usually not feasible for a *local* data service.

Meanwhile, a host of new wireless technologies are rapidly emerging. Most of these are personal communications systems (PCS) services that are not designed to deliver a large amount of data to numerous sites in a cost-effective manner.

The cellular telephone industry is also developing standards for data transmission, but it is unlikely that this technology will be cost competitive for use in a dedicated datacast application.

The capability of a terrestrial cable TV network to pipe high-speed data into homes has been discussed and examined for several years. It is theoretically possible to broadcast data into all of the homes on a cable TV system at multi-megabit/second data rates. Cable modems that provide the interface to a PC are already available. The capabilities of this infrastructure are tremendous if the right combination of technologies and applications can be assembled. The potential of any of these technologies to compete with FM subcarriers depends largely upon the application adopted and local market forces.

FM subcarrier technology has several unique advantages over possible competing technologies: The receivers are generally available at relatively low cost; data can be received reliably even in a mobile environment, which is something that today's low-power DBS systems or VBI systems cannot do reliably, if at all; and the FM receivers require only a small antenna.

Emerging datacasting standards

RBDS has been standardized in the United States for several years and is slowly becoming accepted. The EIA and several encoder and decoder manufacturers are seeding the marketplace with systems in an attempt to stimulate this acceptance. Three factors are involved in this growth: radio station use, receiver availability and consumer awareness/demand.

RBDS uses a 57kHz subcarrier to deliver approximately 1,200b/s of data. The RBDS standard includes about a dozen different features, but not all receivers will implement all features, nor will every radio station employ them.

Most of this data is designed for *station-* or *program-related* use, which makes RBDS unique. For the first time, an FM station's subcarrier data can be received by its regular listeners (assuming they are equipped with RBDS radios) for the reception of auxiliary information. This differs significantly from the traditional use of subcarriers for the broadcast of data to users who have no connection to, interest in or knowledge of the host radio station's main audio signal. Nevertheless, RBDS does allow a small amount of this third-party data to be carried along with its program-related offerings, as noted earlier.

However, serious future datacasting will require higher speeds than RBDS can provide. For this reason, the NAB and EIA have jointly established the High Speed Subcarrier Subcommittee of the National Radio Systems Committee (NRSC). This group has been assigned the challenging task of developing a national standard for high-speed datacasting. The committee has taken the approach of developing a set of requirements and is reviewing existing systems that may fit the bill. Three systems are currently being evaluated by the committee as the basis for possible standards. These systems come from Seiko, the Mitre Group and Digital DJ.

The work of this committee is not designed to supersede the functionality of the recently adopted RBDS standard. On the contrary, the goal is to develop a system that will not interfere with existing RBDS systems. The committee expects to complete develop-

ment of a standard in 1996. (The U.S. Transportation Department is also studying these same systems, along with others, for possible use in its *Intelligent Vehicle/Highway System* [IVHS], a future "smart-driving" technology that might involve FM subcarriers to deliver data to fixed and mobile receivers.)

The development of a national standard also might increase opportunity for the radio industry to offer direct datacasting services to personal computers in the consumer and commercial arenas. Services could be established in which either the subscriber pays to receive a data service or where the data is provided free and sponsors bear the costs.

Not everyone is thrilled with the prospect of a national standard for datacasting, however, and some even insist that it is a step backward. A number of datacast systems are in use today with data speeds that range from 4,800b/s to 28,800b/s.

The adoption of a standard, even a voluntary one, has raised questions about the long-term viability of those systems that are currently in place and in which millions of dollars have already been invested. There is also the issue of whether the adoption of a standard would hold back the development of more capable systems based on proprietary technology, because standards often tend to establish the lowest acceptable level for a particular technology. The specter of antitrust has also been raised by critics of high-speed datacasting standardization.

Seiko's datacasting plans extend beyond its current wristwatch pager to include a line of "smart-radios" that incorporates numerous interactive features.

Technical features of datacast systems

From a hardware standpoint, an FM radio station only needs a few more black boxes to set up a datacasting system. At the station, the main components required are a subcarrier generator (if the station does not already have one) and a data encoder. Each receive site will, of course, need an FM subcarrier data receiver. Several systems on the market are widely used, and they vary in cost, sophistication and capability. Here is a look at the basic characteristics and common features of datacast systems on the market today.

- *Subcarrier frequency:* Most datacast systems that are available off-the-shelf from manufacturers today can operate at either 67kHz or 92kHz.
- *Forward error correction* (FEC): Some systems use FEC algorithms, such as Reed-Solomon codes, to help correct minor errors that may occur during transmission of the data. Other systems provide a completely transparent channel and offer no error correction at the hardware level.
- *Data rate and interface:* Standard RS-232 asynchronous I/O is used by most hardware. The data rates available typically vary from 4,800b/s to 19,200b/s, depending upon the manufacturer. Systems that use built-in FEC usually have two data rates assigned. The first is referred to as a total or aggregate throughput, which includes the overhead required by any FEC algorithm. The available data rate may be significantly less, and it's the value that determines how much information you can move across

Active billboards and other signs can be programmed via FM datacasting.

a particular system. For example, a system may boast a 19,200b/s data rate, but it may only make a data rate of approximately 14,000b/s available for your data.

• *Addressability:* Receivers may each have a unique ID or serial number assigned at the factory that allows them to be individually addressed. Some designs also allow for one or more group codes or group IDs to be assigned to the receiver. This greatly increases the flexibility and potential applications of a system, but at the expense of somewhat reduced throughput due to the additional address data required.

• *Encryption:* Some systems have the capability to automatically encrypt the datastream so that only authorized receivers can correctly interpret the incoming datastream. This may also reduce net throughput of the system to some extent.

• *Data buffers and flow control:* Often a PC may be used to receive data in the background while performing other tasks in the foreground. Some data receivers use a small buffer that can hold incoming data for short periods of time. This gives the receiving PC a chance to get the data from the buffer during idle CPU cycles. A data buffer is only useful if some type of flow control is also implemented.

• *Compatibility:* The systems on the market today all use technology proprietary to the manufacturer. Therefore, you will need to make sure that you buy the data encoders and receivers from the same company, unless the manufacturer specifically tells you otherwise. This situation may change in the future if the NAB adopts a standard for high-speed datacasting.

These are only the most basic characteristics, but they must be understood before any system can be considered for a datacasting application.

Software for data broadcasting

Just as you need communications software to make your modem useful, you will need some type of communications software for your datacasting applications. The degree of sophistication required depends on a variety of factors, not the least of which relates to the type of data being broadcast.

Software has the potential to perform two primary functions. In addressable systems, the software is used to send control codes that identify which receiver or group of receivers are intended to receive the data that follows. This software will generally be provided by the hardware manufacturer where applicable.

Software may also be required to perform such functions as reliable file transfers. Off-the-shelf software solutions are now available for transferring binary files reliably over a broadcast network. This software is compatible with today's FM subcarrier data hardware and can even be used to broadcast data files over RBDS.

Potential datacasting applications

A number of potential and emerging applications for datacasting technologies have been identified. Some relate specifically to the journalism and broadcast industries, while others are more widely applicable and can play a role in consumer-oriented services and advertising methods. Multimedia applications also could be involved in the development of these services:

• *Updating kiosks and broadcast of digital audio files:* Multimedia kiosks in various forms are springing up in cities across the United States. Hundreds or even thousands of kiosks may be placed in one city. These kiosks are usually PC-based and contain software that must be updated. Some kiosk providers are still traveling to each site or dialing into each kiosk PC to upload new information. Datacasting provides an ideal means for kiosk-network operators to distribute data.

Advertisements can be delivered via satellite to radio stations in the form of compressed digital audio files. That data could be distributed locally to stores or businesses using FM subcarriers. Future software developments will make

it possible to provide additional features, such as addressability, remote turn on/off of a particular site, and to allow multiple services to be distributed through a single FM subcarrier channel.

• *Newspapers, magazines and new services or methods of delivery:* The time may have come for newspapers, magazines and news services to consider the advantages and potential market for development of new services based on datacasting technologies. This service could take on a variety of forms, not simply limited to the delivery of news electronically. There is potential for the development of services for businesses and the home PC user. Radio stations could consider providing local news to area BBS operators, including digital photos and even digital audio or video clips of recent dramatic events.

Low-cost FM subcarrier data receivers have made it practical for home users to receive information right at their desktop. For example, home PC users might enjoy the capability of looking at a map of the latest traffic jams on their PC just before leaving for work. In the winter, a complete list of all closings and cancellations could appear on the PC at the click of a mouse. Visually impaired individuals have the capability to use low-cost speech synthesizers installed in their PCs to read these text files to them. It is conceivable that this same technology could be adapted to provide a valuable service to the busy, non-sight-impaired person who simply wants to be able to click on an item and have the PC read the file while he or she gets ready for work or performs other tasks.

Radio Rock-It from Advanced Digital Systems is a virtual radio for a multimedia PC that uses an FM/RBDS receiver on an internal card with accompanying software to extract RBDS data for the screen display while routing audio to the PC's speakers.

One significant advantage of services delivered via subcarrier is that they do not tie up a phone line. In households where a family member may spend an ever-increasing amount of time online, the ability to receive information without dialing out to get it could become an important advantage.

Mobile laptop users are becoming familiar with the concept of receiving information through a wireless network. These users should easily adapt to the concept of receiving information via a data receiver attached to their PC. The concept of receiving information relevant to the local area may be well received today, especially in large metropolitan areas. It

Continued on page 33

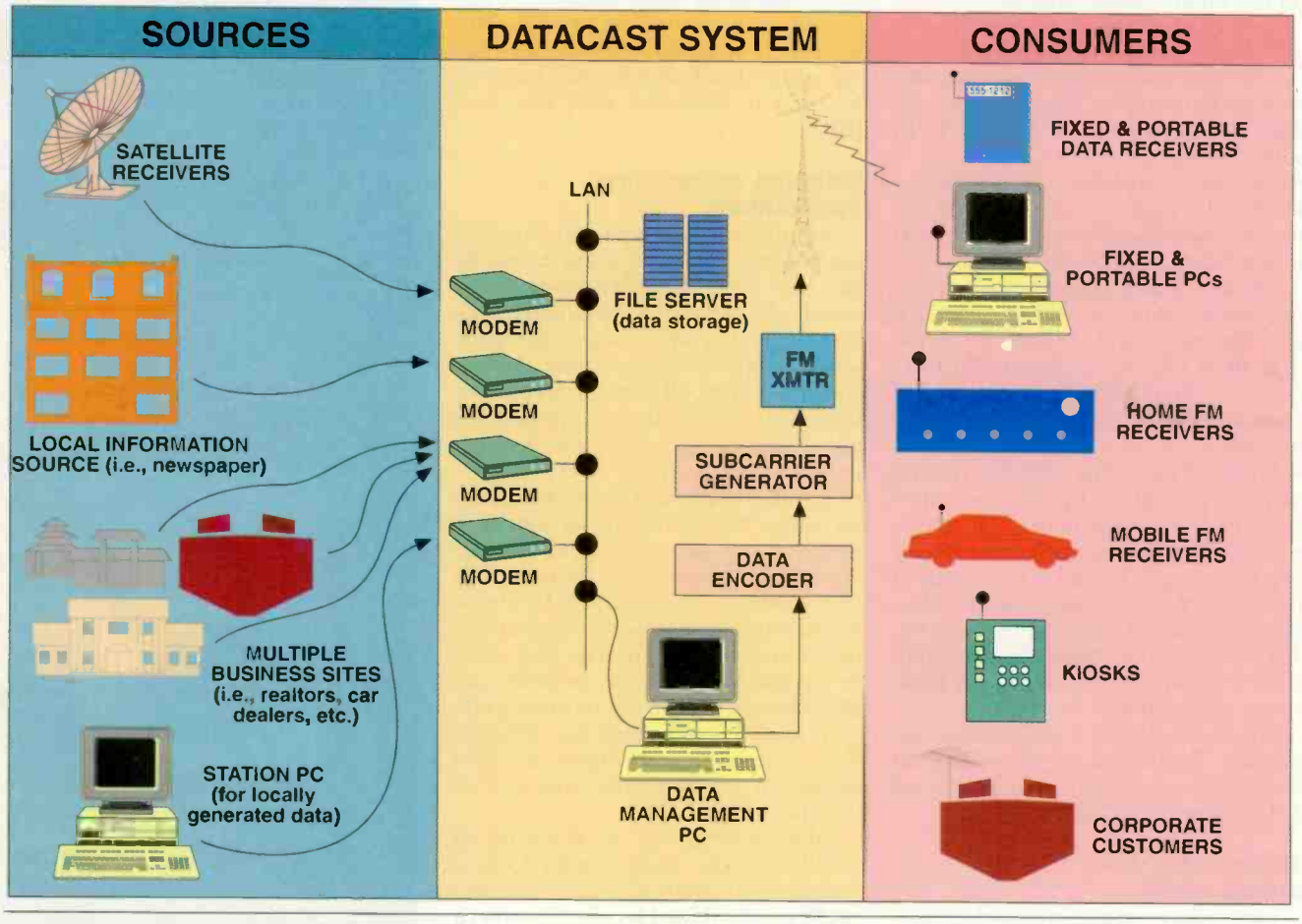


Figure 1. The FM radio station can collect data from many providers (or create its own) and distribute it to consumers via subcarrier transmissions.

Continued from page 30

also provides an opportunity for local information providers to deliver content to consumers who are not adequately served by nationwide information services.

Newspapers already collect information on real estate listings, automobiles, auctions, construction equipment, office equipment and so forth. Imagine the power and flexibility of having this type of information in electronic form and broadcast to realtors, car dealers, businesses and others who may want daily updates in an easily searchable form.

In fact, it is possible to set up a variety of information services in many different categories and let the subscribers only choose the ones that interest them. Addressability in the datacast software will allow the newspaper to deliver messages to a specific subscriber, turn off a particular subscriber's service and to even add additional services if the subscriber requests them. Some of this information would be useful to individual consumers as well.

> One advantage of services delivered via subcarrier is that they do not tie up a phone line.

Many newspapers are beginning to offer electronic or on-line versions. It would be a relatively easy transition for these papers to employ datacasting technology for their subscriber base. On-line papers typically employ a graphical interface and deliver data through dial-up phone lines. Unfortunately, this system often results in forcing the user to spend most of his or her time waiting for the next screen to be drawn as the data slowly comes in over the phone line. A datacast system would deliver the entire day's content to the local PC, allowing for nearly instant access to the desired data.

• *Advertising possibilities:* In some cases, the cost for such networks should not be born by the subscribers alone. There is room for creative development of advertising to be included in some local information services provided that it also serves a useful purpose for the consumer. Perhaps a list of specials, electronic coupons that have been downloaded or special incentives provided only to subscribers of the service would be included in the information provided. Advertising in a consumer-oriented datacast information service would need to provide valuable and desired information. Although this is a challenge, it is an achievable goal.

• *Educational opportunities:* Universities, technical colleges and even public schools could set up networks to provide data to students who are currently enrolled. Updated class schedules and even class materials could be distributed to students via datacast networks. The university or school paper could be distributed to students in electronic form, perhaps using the FM subcarrier capabilities of the local campus radio station. Such a tool would not only help to distribute information, but help to educate tomorrow's leaders about the capabilities of these technologies.

The next step

If you are interested in pursuing the development of your own, more full-fledged (and potentially lucrative) datacasting services, then you should become familiar with the hardware and software available. The next step is to consider your location and identify what types of projects might work well in your area. If you want to partner with a local information provider, then you will need to identify your prospects and be prepared to educate your potential customers.

Meanwhile, RBDS is here today. Stations that haven't already established their RBDS service should explore its offerings to see if they are appropriate and desirable.

Launching your own datacast service can be done today. The potential rewards are great to those who find the right application for their area. These stations will also be poised on the vanguard of radio's future and well-positioned to compete — and succeed — on tomorrow's information battleground.

Acknowledgments: Special thanks to Modulation Sciences, Seiko Communications Systems, Mainstream Data, EZ Communications and New City Communications.

Miles Beam is president of Milestone Technologies Inc., Raleigh, NC, developers of SATX, a file-transfer program for use with FM subcarriers.

For more information on data broadcasting systems, circle (101) on Reply Card. See also "RDS Encoders, Monitoring Equipment," pg. 84 of the BE Buyers Guide.

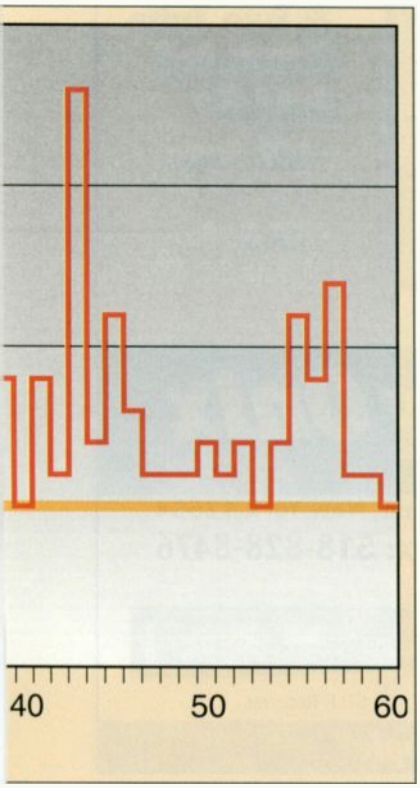
Feature:

The signal chain

There's many a slip twixt the console and the transmitter.

By Greg J. Ogonowski

Bottom Line: *A radio station's signature sound is a combination of its format and its signal chain, and it represents the licensee's greatest asset. Some of the signal chain's effects may be unintentionally altering a station's sound in negative ways. Keeping up with the competition—and the FCC's requirements—requires complete understanding of this important set of components.*



The overall sound of a radio station is greatly influenced by the performance of the devices in its signal chain. These typically include the station's audio processor(s), studio-to-transmitter link (STL) and exciter. This article will first review the nature of this chain, then move on to examine some of the FM signal chain's lesser-known difficulties and their potential solutions.

An understanding of both the basics and the details of a signal chain is required by broadcast engineers to ensure that the sonic effects of the air chain on their stations' sounds are intended and not inadvertent.

Air chain basics

A typical audio-processing system today consists of a slow AGC followed by a multiband compressor with moderate attack and release times. Correctly designed multiband processors have these time constants optimized for each frequency band (low-frequency bands have slower time constants than high-frequency bands). This multiband compressor usually does most of the work in increasing program density and, therefore, loudness.

The loudness of soft passages will be increased in direct proportion to the amount of gain reduction that is applied. This amount of gain reduction will also affect the consistency of the air chain's overall loudness. Such a broadband AGC is used for controlling average levels, and may also help in correcting a certain amount of level-setting error on the part of the board operator. The AGC isn't intended to greatly increase loudness – that is the role of the multiband compressor and peak limiter(s).

Additional processing in the form of equalization is also added in many of today's radio air chains. The equalizer is usually placed after the AGC and before the multiband compressor. Any multiband gain processing is actually a form of equalization, as well, in that it applies frequency-selective gain processing. These spectral adjustments can greatly influence the "signature" sound of the air chain's processing.

Toward the end of the processing chain, peak clippers decrease the peak-to-average ratio, thereby increasing loudness within the peak modulation constraints of the channel. To decrease clipping-induced distortion, some processors use sophisticated distortion-canceling schemes that remove distortion in the frequency bands most likely to be audible to the listener.

Finally, low-pass filters are generally included in the chain to limit its high-frequency response to 15kHz for FM or to other bandwidths as required by the local regulatory authority. It is common that the last low-pass filter of the system includes overshoot compensation so that it does not generate spurious modulation peaks.

STL issues: Where's the processor?

When processing is applied at the transmitter site, the signal-to-noise ratio (SN) of the STL must be high enough to pass the full dynamic range of the unprocessed audio. The STL must also exhibit excellent frequency and phase response. When processing is applied ahead of the STL, pre-equalization at the studio end of the link to compensate for the intrinsic rolloffs of the STL path

may be helpful particularly on the low end. Poor AFC-loop design in STL transmitters is the most common cause of these low-frequency response problems, and pre-EQ is the best solution to the overshoot problems it creates. (More on this later.)

On the other hand, new digital STL systems using lossy bit-rate-reduction schemes are inappropriate for passing audio that has been processed at the studio. For example, studies have shown that ISO/MPEG Layer 2 at 384kb/s introduces approximately 1 dB of overshoot with processed audio.

Overshoots increase markedly as bit rate is reduced (most digital STLs use 256kb/s or less). Although these overshoots can be clipped or limited, such processing can cause audible side effects. If the audio processor is located at the transmitter, however, its input can be fed without difficulty from an STL using a lossy bit-rate-reduction scheme because it is unnecessary to preserve the waveshape of unprocessed input audio.

The latest digital systems allow such a configuration, and even include the ability to use AES/EBU interconnection between digital STL, digital audio processor and digital exciter, allowing the signal to remain in the digital domain from the output of the console to the first RF stage of the transmitter.

Peak modulation control

The audio processor must control the peak modulation of the RF carrier to the standards required by the governing authority, such as the FCC in the United States. In FM, the peak deviation of the carrier must be controlled so that the modulation monitor specified by the governing authority does not indicate overmodulation. Because the rules often permit the modulation monitor to ignore extremely brief overshoots, the instantaneous peak deviation might exceed the peak modulation as indicated on the modulation monitor.

The requirements for peak control and spectrum control tend to conflict, which is why sophisticated non-linear filters are required to achieve the highest performance. Applying a peak-controlled signal to a linear filter almost always causes the filter to overshoot and ring because of two mechanisms: spectrum truncation and time dispersion.

You can build a square wave by summing its Fourier components together with correct amplitude and phase. Analysis shows that the fundamental of the square wave is approximately 2.1 dB higher than the amplitude of the square wave itself. As each harmonic is added in turn to the fundamental, a given harmonic's phase is such that the peak amplitude of the resulting waveform decreases by the largest possible amount. Simultaneously, the rms value increases because of the addition of the power in each harmonic. This is the fundamental theoretical reason why simple clipping is such a powerful tool for improving the peak-to-average ratio of broadcast audio.

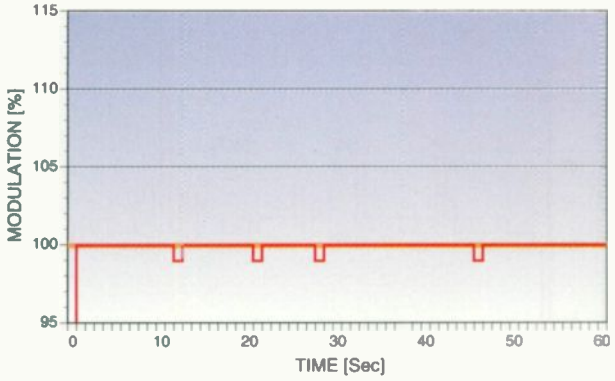


Figure 1. Peak modulation at output of audio processor (as measured on Belar *Wizard*).

Clipping adds spectral components to the audio waveform with phase and amplitude characteristics that are precisely correct to minimize the waveform's peak level while simultaneously increasing the power in the waveform.

If a square wave (or clipped waveform) is applied to a low-pass filter with constant time delay at all frequencies, the higher harmonics that reduce the peak level will be removed, increasing the peak level and with it, the peak-to-average ratio. Thus, even a perfectly phase-linear low-pass filter will cause overshoot. There is no sharp cutoff linear low-pass filter that is overshoot-free; overshoot-free spectral control to FCC or CCIR standards must be achieved with filters that are embedded within the processing, such that the non-linear peak-controlling elements in the processor can also control the overshoot.

If the sharp-cutoff filter is now al-

lowed to be minimum-phase, it will exhibit a sharp peak in group delay around its cutoff frequency. Because the filter is no longer phase-linear, it will not only remove the higher harmonics required to minimize peak levels, but will also change the time relationship between the lower harmonics and the fundamental. They become delayed by different amounts of time, causing the shape of the waveform to change. Therefore, this time dispersion will further increase the peak level.

When a square wave is applied to a linear-phase filter, overshoot and ringing will appear symmetrically on the leading and trailing edge of the waveform. If the filter is minimum-phase, the overshoot will appear on the leading edge and will be about twice as large. In the first case, the "overshoot and ringing" are caused by spectrum truncation that eliminates harmonics necessary to minimize the peak level of the wave at all times. In the second case, the overshoot and ringing are caused by spectrum truncation and by distortion of the time relationship between the remaining Fourier components in the wave.

Overshoots in composite STL systems and FM exciters

It is well-known that processed, peak-controlled program material causes most composite STL systems and FM exciters to produce overshoot in FM composite baseband signals. The heavier the processing, the more they overshoot. This overshoot occurs even in properly band-limited systems that use STL paths without multipath. Accordingly, loudness is compromised because average modulation must be reduced to prevent illegal peak overmodulation caused by this overshoot. Previous attempts to eliminate this overshoot have degraded system performance. A new approach minimizes this overshoot without compromise.

A Belar Electronics *Wizard* FM modulation analyzer was used to plot peak modulation vs. time on the output of an aggressive audio-processing system and several contemporary STL systems and FM exciters. The results reveal the extent of the problem. The same program material and time segment was used for all plots.

Figure 1 indicates the audio processor output peak modulation directly. Figures 2 and 3 indicate the peak modulation of a popular STL system and an FM exciter respectively. Note that the STL and exciter suffer from overshoot causing overmodulation. To prevent the resulting overmodulation, the modulation level must be reduced more than 13%, losing almost 1.5dB of loudness.

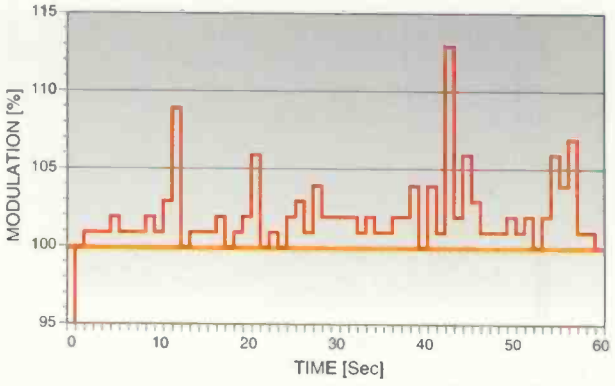


Figure 2. Peak modulation of a popular STL system (before modification).

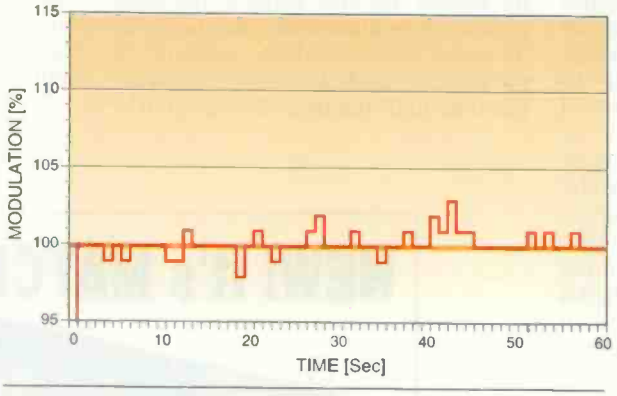


Figure 3. Peak modulation of a popular FM exciter (before modification).

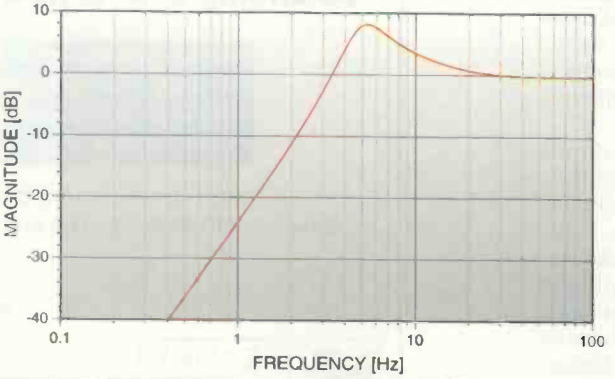


Figure 4. A popular STL system's infrasonic frequency response.

The FM stereo system

The world-standard FM stereo *pilot-tone* system encodes the sum of the channels (L+R) in the frequency range of 30Hz to 15kHz in the stereo baseband — the *stereo main channel*. The system encodes the difference between the channels (L-R) on a double-sideband suppressed-carrier subchannel centered at 38kHz and occupying 23kHz to 53kHz in the stereo baseband — the *stereo subcarrier*. A pilot tone at 19kHz tells the receiver that a stereophonic transmission is being received, and provides a phase and frequency reference to permit the receiver to regenerate the 38kHz subcarrier to use in its stereo demodulator.

Any energy that appears in the baseband's frequency range from 30Hz to 19kHz that is caused by a signal in the stereo subcarrier is termed *subcarrier-to-main-channel crosstalk*. Any energy that appears in the baseband's frequency range from 19kHz to 57kHz that is caused by a signal in the stereo main channel is termed *main-channel-to-subcarrier crosstalk*.

When the stereo encoder is driven by a pure right-only or left-only signal, *stereophonic separation* can be measured at the stereo decoder as the ratio between the desired and undesired signal levels. The desired signal is the signal appearing in the decoder output channel corresponding to the channel driven at the encoder. The undesired signal is the signal caused by the desired signal that appears at the remaining output.

Ideally, crosstalk is non-existent and stereophonic separation is infinite. In practice, both linear and non-linear errors cause these characteristics to deteriorate.

In the linear domain, separation and crosstalk are mathematically orthogonal. Phase and frequency errors that cause one to deteriorate will not affect the other. For example, phase or frequency errors in the composite signal channel will cause separation to deteriorate, but cannot affect crosstalk. This is because the stereo main and subchannels are already separated in frequency, and changes in phase or amplitude response in the composite channel cannot affect this

frequency separation. Conversely, mismatches between the linear response of the left and right signal paths prior to the stereo encoder will cause crosstalk, but cannot affect separation.

Non-linearities in the composite channel can cause separation and crosstalk to deteriorate because such errors cause harmonic and intermodulation distortion that introduce new frequencies into the baseband. These new frequencies are likely to inject power into a part of the baseband spectrum that will be decoded by the stereo decoder in spatial locations different than the locations of the original sound sources. Furthermore, these new frequencies are perceived by the ear not as changes in spatial localization, but as highly offensive distortion.

This is somewhat analogous to *aliasing* distortion in a digital audio system. In such a system, any input frequencies greater than one-half of the sampling frequency (the Nyquist frequency) are encoded with the wrong frequency. They "fold around" the Nyquist frequency and appear at the decoder as frequencies unrelated to the program material that produced them. The ear perceives this aliasing as offensive distortion.

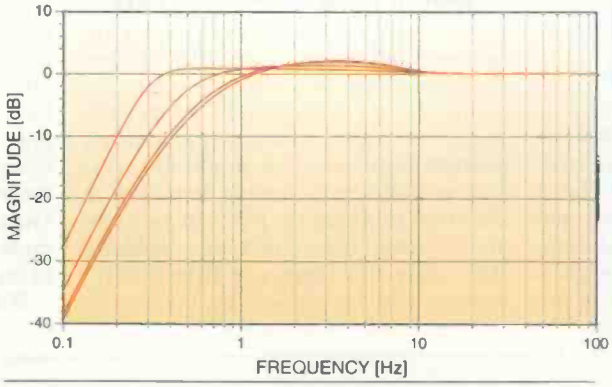


Figure 5. A popular FM exciter's infrasonic frequency response, plotted with the unit operating at four different RF frequencies.

A previous non-linear solution

The most common technique for reducing FM composite baseband signal overshoot has been composite baseband clipping. Composite clipping has been disparaged because it causes signal degradation and because early implementations that clipped the pilot could violate FCC rules. No implementation prevents dynamic signal degradation.

The composite baseband clipper is a non-linear device. Thus, it generates distortion and aliasing products that contaminate the composite baseband signal, degrading dynamic stereo separation and causing audible dynamic distortion. It also produces distortion products in the upper subcarrier (SCA) region, reducing or destroying the subcarriers' market value and reducing revenue potential.

Although it is possible to low-pass-filter the clipped baseband (thus protecting the subcarriers), such filtering does nothing to eliminate intermodulation distortion in the stereo baseband region below 57kHz. This will also tend to increase peak modulation, partially negating the peak control provided by the composite clipper. Such filters do not protect the 19kHz pilot tone from interference caused by the clipper-induced distortion, which can cause problems in receivers' stereo decoders.

If the FM exciter is the source of overshoot (as opposed to the STL), or if the clipper precedes the STL, then the composite baseband clipper cannot control overshoot. Instead, it can actually increase overshoot because the clipping process produces increased amounts of infrasonic intermodulation distortion products.

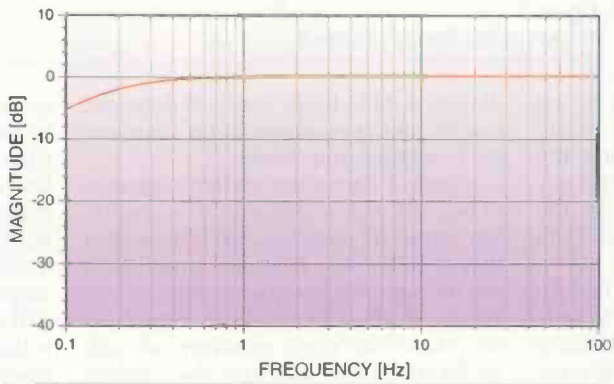


Figure 6. Minimum low-frequency response requirement for the audio chain to be free from overshoot.

Some have argued that composite baseband clipping increases loudness more than audio clipping in the left and right channels. But this loudness increase is accompanied by degraded dynamic stereo separation and crosstalk. To preserve dynamic stereo performance, the spectra of the stereo main channel and subchannel must be completely isolated. The main channel must not have any energy above 19kHz, and the subchannel must not have any energy below 19kHz.

One consequence of such frequency separation is this: In a system that achieves high dynamic separation and low crosstalk, it must be impossible for the system's final filter/limiter to reproduce any approximation to a square wave if the square wave's fundamental frequency is higher than one-third the cutoff frequency of the low-pass filter prior to stereo encoding (typically 15kHz). This is because the first harmonic of the square wave is three times the frequency of the fundamental, so the low-pass filter removes it (and all higher harmonics too). Any square wave above 5kHz will emerge from the receiver as a sine wave. Because they generate spurious harmonic and intermodulation products, composite baseband clippers do not meet this criterion and, thus, compromise dynamic stereo performance.

Composite clipping has one potential advantage. Conventional wisdom holds that the peak modulation of the composite baseband is the greater of

the left or right channel levels, plus the pilot. However, this is only an approximation because the pilot is correlated in phase with the 38kHz suppressed subcarrier. This causes the total composite modulation to decrease slightly when the left and right channels are unequal in level. Assuming 10% pilot injection and holding the left channel at 100% modulation, decreasing the right channel from 100% to 0% modulation will cause the composite modulation to decrease by 2.8% (*interleaving error*). Perfectly accurate peak limiting in the audio domain, prior to stereo encoding, can only control the composite modulation to an accuracy of -2.8%/+0%. Only a process that is aware of the total peak composite modulation (including the pilot and any subcarriers) can control composite modulation accurately.

Because composite baseband clipping controls the peak deviation of the composite signal precisely (assuming the pilot is also clipped), it can theoretically be louder than peak limiting in the audio domain. But this "advantage" is an imperceptible 0.24dB, at best.

Composite baseband clippers that do *not* clip the pilot (which are the only clippers legal for use in the United States) do not eliminate the interleaving error and, therefore, produce no loudness advantage at all.

In these digital times, bad audio quality has become unacceptable to formerly unsophisticated consumers. It is absurd that composite baseband clippers are being used to degrade system performance below that of some of the least-expensive receivers. Composite clipping is an easy, unsophisticated method of increasing apparent loudness of the broadcast signal, but it compromises quality in a way that is unacceptable to any broadcaster trying to compete with CD or the newer recordable digital media.

Source of overshoot

Extensive computer modeling and analysis of several current-generation composite STL systems and FM exciters has revealed that the overshoot problem is not in the high-frequency domain (as previously assumed), but instead at infrasonic frequencies.

Most of the systems modeled have infrasonic peaks in their frequency response, and/or have insufficient low-frequency response to accurately reproduce a processed composite baseband signal. Some of the systems even suffer from marked non-linearity, having different frequency response at different modulation levels at very low frequencies, aggravating the problem. This poor low-frequency transient response can be caused by incorrectly designed AFC loops and/or deficient low-frequency response of the composite baseband amplifiers.

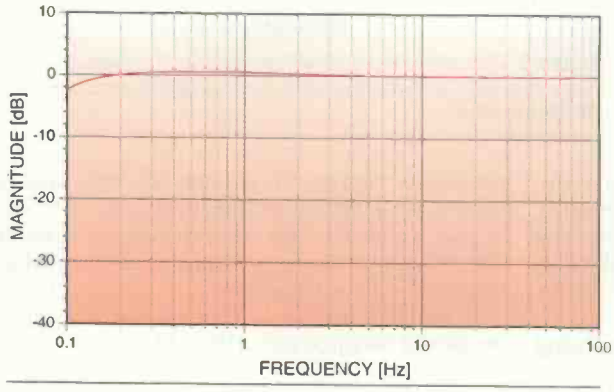


Figure 7. Optimized response of the same STL system shown unmodified in Figure 4.

Figure 4 shows the system response of one popular composite STL system. On some STL systems and FM exciters tested, infrasonic response varied with the RF operating frequency selected, as Figure 5 illustrates. These variations are part of the "sonic signature" of each audio chain, and they may also explain the widely held myth that certain FM channels intrinsically sound better than others. Among the STLs and exciters evaluated, newer systems did not necessarily have better performance than older designs.

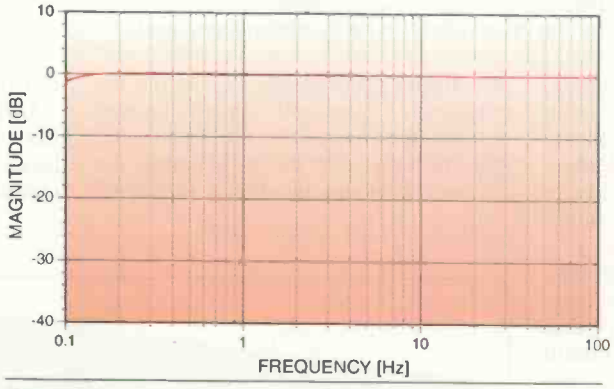


Figure 8. Optimized response of the same FM exciter shown unmodified in Figure 5.

Another important consideration is the overall system performance of the various components in the composite signal path. When these components are cascaded, the system response deteriorates. The amount of degradation depends on input and output impedance interactions in the composite baseband amplifiers and how many systems are cascaded. The audible performance of a system is not always simply the sum of the performance of its parts. Once again, this might explain why legends contend that certain combinations of equipment sound better than others.

If the overall system response is modeled as a high-pass filter with a single dominant pole, the percentage of overshoot can be easily calculated for any given frequency applied to the system input. This overshoot will occur regardless of whether the low-frequency rolloff described earlier is in the composite channel or in the left and right audio channels after peak limiting.

In the former case, the rolloff can also compromise low-frequency separation. To achieve less than 1% overshoot with a 50Hz square wave (a reasonable criterion for good peak control), the dominant pole must be located at 0.16Hz or lower with no peaking. Good 10Hz square wave response does not predict low overshoot because a peak in the region below 10Hz can phase-equalize the 10Hz fundamental while simultaneously distorting the phase and amplitude of the components below 10Hz. If more than one low-frequency rolloff element is cascaded in the composite path, each element's cutoff frequency must be substantially below 0.16Hz. Figure 6 shows the minimum required low-frequency response.

A new linear solution

Because composite baseband overshoot is caused by poor infrasonic frequency response, it can be eliminated by the proper design of the AFC circuitry and composite baseband amplifiers. It can also be corrected (although not as accurately) by an infrasonic equalizer that flattens the very low-frequency response of the composite signal path. Both methods are linear solutions to linear problems. The first method is preferred. Unlike composite baseband clippers, linear correction produces no distortion or aliasing products, ensuring maximum loudness without side effects.

Highly optimized modifications to most current-generation FM exciters and STL systems permit these units to pass the most highly processed composite baseband signal while adding

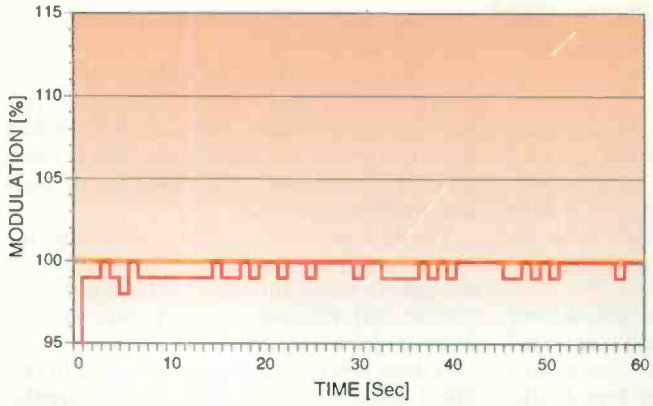


Figure 9. Peak modulation of the same STL system shown in Figure 2, after modification for improved infrasonic response.

less than 1% overshoot. This is often an improvement of 10:1 or more, resulting in a 1dB loudness advantage with almost any audio processing. This can be a cost-effective solution, offering potentially better sonic performance than some digital alternatives because there is no data compression involved. These modifications will certainly offer better performance than all known unmodified analog equipment.

Figure 7 shows the optimized infrasonic response of the same STL system shown in its unmodified form in Figure 4. Figure 8 presents the optimized response of the same FM exciter shown in Figure 5. Figures 9 and 10 show the

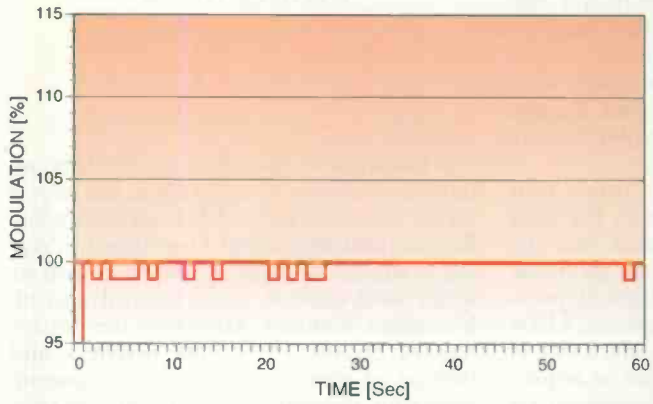


Figure 10. Peak modulation of the same FM exciter shown in Figure 3, after modification for improved infrasonic response

improved peak modulation control resulting from this same optimization on the STL system and FM exciter respectively. (Compare this to the peak modulation shown in Figures 2 and 3.)

Getting a signal as loud as possible under existing government regulations requires attention to every link in the audio chain. One or more weak links can noticeably decrease the loudness and competitiveness of the signal. In broadcast audio, as in most other endeavors, attention to detail separates the winners from the losers.

Greg Ogonowski owns Modulation Index, a broadcast consulting engineering firm in Diamond Bar, CA.

For more information on FM signal chain equipment, circle (103) on Reply Card. See also "Dynamics Processors," p. 54, "Exciters, Generators," p. 82 and "STL Components and Electronics," p. 84 of the *BE Buyers Guide*.

Field Report:

Lexicon Alex and Vortex audio processors

By Christopher H. Scherer, CBRE

Features at a glance:

- Good-sounding, general-use effects devices
- Low cost
- Simple operation
- Small size
- External control of some functions
- Wide range of imaginative, dynamic settings

Many changes are going on in radio stations today: digital editing, hard-disk storage, computer automation, and so on. With so much attention given to large plans and high-budget items, it is easy to overlook some simple ideas that can add some sparkle to your audio productions and do so without digging too deeply into your resources. Along these lines, Lexicon has introduced two new audio effects processors, the Alex and the Vortex.

Both units are designed for time-based effects, such as reverb, echo, flange and delay. Each occupies one rack space, and they are both only 4 1/4-inches deep (without connectors, the front-panel knobs stick out an additional three-quarters of an inch). Other similarities between the units include a 2-digit, 5/8-inch LED display, effect-select control, value control and input level control. Both units are built around basic preset sounds, and they have somewhat similar appearances, but the functional differences between them are significant.

Alex

Rotary pots are on the front-panel control input level, wet/dry mix and output level. There is also a 2-color LED for input level display. The 16 preset effects are titled Large Hall, String Hall, Recital Hall, Chamber, Guitar Room, Tiled Room, Inverse, Gate, Gold Plate, Vocal Plate, Brass Plate, Perc Plate, Chorus, Flange, Echo and Delays, which are selectable via a front-panel rotary switch.

The *Value* control (another rotary pot) changes any of three parameters for each effect: Decay, Delay and FX level. Pressing the *Parameter* button first shows the value being adjusted and each additional press toggles through the three parameters. LEDs in the display window indicate which one is currently active. Each parameter is adjustable in 16 steps. The FX level defaults to 16 (max) for all the presets, and I found no need to change this because the mix control provides easier access to the same function. A *Register/Preset* button toggles between two memory modes with an LED to indicate which is active. In the Preset mode, the factory settings are active, while the Register mode provides a memory address to store a modified version of the preset. A *Store/Clear* button is used to save a modified preset into the register. You can modify each preset and save one version of each in the register.

The rear panel has 1/4-inch TS connectors for unbalanced inputs and outputs, the coaxial power connector for the wall-wart supply (9VAC, 1A) and a 1/4-inch TRS footswitch connector. The footswitch connector allows remote control of the bypass function and a step function for scrolling through a list of effect presets. This is one feature that adds some versatility to the Alex. Switches can be selected by the user to operate in either a momentary or a latching (default) mode. This is changed via a power-up software setting.

A chart in the manual fully details each parameter for each effect. The actual timings in milliseconds may be more detail than is needed by some users, but it does help to give a better understanding of each parameter's operation.

The Alex sounds good for a unit of its size and price. It is reasonably quiet, and even though there are limits as to the number of effects and variables to each, for what it does, it does it well.

It does not have a true stereo path in the effect chain. Although there is some spatial fullness to the effect signal, it derives its input from a mono sum. (Stereo signals passing through the unit in "dry" mode remain in stereo, however.)

> These processors could be easily used again and again without getting tired.

Vortex

While most of the effects on the Alex can be categorized as reverberation, the effects on the Vortex are more delay-oriented (echo, flanging and chorusing). Operating the Vortex is similar to running the Alex, with its input level control, value control and effect-select features. However, the Vortex has 32 presets, 32 storage registers, and instead of controlling only three parameters with 16-step precision, you now have control of 16 parameters with 64 discrete steps to each. Again, one modified setting of each preset can be stored in any of the 32 associated storage registers. On the Vortex, the presets/registers are set up in two banks (A and B) of 16 apiece, for reasons to be discussed later.

The rear panel has the input, output and power connections and four 1/4-inch TRS connections for various control functions: bypass switching, the Step function (for stepping through preset chains), Tap setting and switching between the A or B registers. An A/B connection is intended for switching an external device, such as the channels on a guitar amp, to follow the A and B registers. A use could be found in the production studio if needed. A foot pedal connection is also provided for continuously variable remote control of the front-panel-selected parameter. A 10K to 50K pot is used to vary the parameter. If your hands are busy holding a guitar, this would be useful. In a radio station, again, use your

Chriss Scherer is chief engineer at WMMS-FM, Cleveland.

imagination.

Two features are unique to the Vortex. One involves the Pedal/Tap function. This allows you to set the delay time by pressing a footswitch button in time with the music, thereby setting the delay time. This is useful for trying to match a delay or echo in time with the music, instead of listening and tweaking until you get it just right. Tap the button once to start the interval, then tap it again to end it. This is ideal for getting the echo to fit the beat of the music.

The other unusual feature is called *audio morphing*. This function crossfades one effect into another at the press of a button. The two effects must be in an A and a B bank of the same register, for example, 1A and 1B. Setting the morph A/B value determines the rate of the morphing effect (i.e., the length of the crossfade).

> Live production-on-the-fly programs may find the Alex or Vortex particularly useful.

Hearing a morph between two effects on a guitar and drum machine was interesting, especially while changing the morph rate between two effects during the morph. Again, the value of this processor to live performance is obvious, but in an audio production setting, some creativity is in order. Morphing can be used to crossfade between two different-sounding algorithms or to change the settings on a single algorithm. By setting the A and B effects to the same algorithm with different settings, you can clearly hear the parameters change (short echoes to long or quick rate to slow rate, for example).

The Vortex manual includes a description of the various algorithms that lend a greater understanding as to what each effect is actually doing. Given the amount of control over each of the numerous parameters, this helped me quickly get an idea as to how to manipulate each one. Some of the names given to the algorithms are odd (e.g., Fractal, Cycloid, Bleen, Aerosol), but after hearing them, they seem somehow appropriate.

Applications

I was able to try both units on some individual instruments and on mixed program material. The effects on guitar and drum machine were impressive. I believe Alex and Vortex would be most at home in a small project or practice studio. If some of your production includes in-house jingles or song parodies, these processors could be easily used again and again without getting tired.

Because of the lack of MIDI control, and with some of the options of the Vortex, it is obvious that these units were primarily designed for a musician's use, but don't let that stop you from considering its use in production. (In fact, the many ex-musicians with radio production gigs today will be quite comfortable with these devices.) "Morning Zoo" or other live production-on-the-fly programs may also find the Alex or Vortex particularly useful because of their performance-based design. Keep in mind that these units' unbalanced connections may require external interfacing in some studios.

The true stereo path of the Vortex does allow for some interesting effects. The Alex, although not as complex, offers some fantastic-sounding reverbs, a nice fat chorus and flanging that is easy to set up. Because of its limited controls, it lends itself to quick setups.

The Vortex gives you more control over its rather complex algorithms and, because of this, seemed to require more time to understand how each one works and to experiment with its adjustments. Once that is accomplished, some good – and distinctive – sounds can be found.

> If your producers want straightforward effects units that won't break the bank, keep these two in mind.

If your producers want straightforward effects units that won't break the bank, keep these two in mind. Because they are also available through music retailers, you can probably testdrive one of them at a music store near you.

Editor's note: Field reports are an exclusive *BE Radio* feature for radio broadcasters. Each report is prepared by well-qualified staff at a radio station, production facility or consulting company.

These reports are performed by the industry, for the industry. Manufacturer's support is limited to providing loan equipment and to aiding the author if requested.

It is the responsibility of *BE Radio* to publish the results of any device tested, positive or negative. No report should be considered an endorsement or disapproval by *BE Radio* magazine.

For more information on Lexicon's Alex and Vortex, circle (102) on Reply Card.

News:

EBS replacement deadline postponed

The FCC has given broadcasters another six months to replace EBS equipment with the new EAS system, with Jan. 1, 1997 as the new deadline. NAB, which has asked for a full year delay, is still concerned whether enough equipment will be available in time.

Station trading heats up

Research conducted by BIA Publications shows that in a survey of all radio stations in the top 50 markets (1,296 stations), 497, or 38.4%, are in duopolies, a number that has increased by 44.9% since March 1995. Also showing a substantial increase are the number of stations involved in LMAs, which is up 43.8% since March 1995.

Additional research by BIA shows that 899 or 9% of all radio stations have been sold or have announced a change in ownership during 1995.

Many of the radio station transfers are part of group sales. The groups that acquired the most stations are: Evergreen Media (25 stations), Group W (21 stations), Park Communications Inc. (21 stations), Walt Disney (21 stations) and River City Broadcasting (20 stations).

The majority of the activity is in the top 100 markets, which account for 448 or nearly 50% of the sales. One quarter of the sales occurred in non-metro markets. This research is based on radio stations with sale dates between Jan. 1 and Oct. 6, using BIA's database of 10,501 radio stations.

Top FM broadcasters join EIA's RDS campaign

More than 60 top FM broadcasters have joined the Electronic Industries Association/Consumer Electronics Group's (EIA/CEG) Radio Data System (RDS) promotional campaign since its launch in April. These stations, located in 16 of the top 25 radio markets, constitute a 20% increase in the number of stations using RDS.

Noble Broadcast Group also has signed agreements for its FM stations in the top 25 U.S. markets. Noble is the first broadcast group to make an RDS commitment for its stations nationwide.

The EIA campaign provides RDS capability virtually cost free to any FM broadcaster in each of the top 25 U.S. radio markets. RDS technology allows broadcasters to send an inaudible stream of data to RDS-equipped home and car radios in their listening areas. This stream of data can include the station's call letters and programming format; traffic, weather and emergency messages; any other text information; and instructions to automatically tune car radios to other frequencies as the car leaves the station's listening area.

In exchange for the RDS equipment, software and training, the EIA seeks advertising or underwriting credits to be used in concentrated consumer-awareness promotion periods predetermined for each market. As an additional incentive for broadcasters to join the campaign, EIA is providing stations with music board software from Specialized Communications Inc., along with RDS encoders and technical training from RE America.

The EIA program will run through April 1996 and will eventually put RDS broadcasts in reach of 85% of the public.

NAB study shows radio employee compensation increased in 1995

The average total compensation for radio station personnel in 1995 has increased 7.4% over 1994, according to results from the NAB publication, *Radio Station Salaries: 1995*. This report contains results from a survey conducted by the accounting firm Miller, Kaplan, Arase & Company of stations in the top 150 markets. Operators responsible for more than 1,000 stations responded to the survey.

The report provides salary and compensation information for 40 different positions. Results are presented for stations of different revenue size, market size, regions of the country and for different formats.

Radio Station Salaries: 1995 is available from NAB Services for $100 for members and $200 for non-members. NAB Services can be reached at (800) 368-5644.

FCC waives rules on unattended operation

Broadcast stations may now operate unattended thanks to a recent FCC action. The commission has waived the requirement for duty operators at broadcast stations. It also has eliminated the need for station operators to hold the Restricted Radio Telephone Operator Permit.

The FCC has updated the rules relating to transmitter monitoring in order to bring them up to date with respect to the capabilities afforded by modern electronic technology.

In many areas of broadcast operation, automation is seen as affording more accurate and controlled operation than that performed by humans. Such operation, the FCC stated, is seen as potentially improving the viability of financially marginal stations.

Tower light monitoring rules will still apply, and EBS activation rules will apply until the EAS system becomes official.

Radio Satellite Corporation receives patent for car radio

The U.S. Patent Office has awarded Radio Satellite Corporation Patent No. 5,455,823 for its Radiostar integrated 2-way communications and navigation system. An on-line simulation of a futuristic car radio based on Radio Satellite Corporation patents is available on the Internet's World Wide Web at http://www.radiosat.com/radiostar.

The Radiostar system will add a new dimension to car radios, providing consumers with direct response to advertisements, interactive digital audio entertainment, integration of precision navigation with 2-way communications and integration of data and voice communications.

A pair of anniversaries

KDKA radio in Pittsburgh, the world's first commercial broadcasting station, is celebrating 75 years of commercial radio. KDKA went on the air with Harding-Cox presidential election returns on Nov. 2, 1920. The station also made the first documented commercial broadcast and held the first FCC license.

The first station was located in a small garage in Wilkinsburg, where amateur radio operator Frank Conrad conducted broadcasting experiments. When he got tired of talking, he played records, making him the first DJ. Conrad's employer, Westinghouse Electric Corporation, saw the potential for the medium and established a broadcast laboratory.

The International Telecommunications Union (ITU) is also celebrating an anniversary. In October, The ITU celebrated the 100th anniversary of radiocommunications, marked by a function at the Geneva International Conference Centre. The event included an exhibition of the origins of radiocommunications, showing the first equipment built by Marconi and Popov, a presentation on Nikola Tesla and a Japanese-developed radio-telephone, which was used for the world's first public telecommunications.

3rd Radio Montreux scheduled for 1996

The 3rd Montreux International Radio Symposium and Technical Exhibition is scheduled for June 6-9, 1996, in Montreux, Switzerland. Preceding the show is the 3rd International Symposium on DAB on June 4-5. It is organized and coordinated by the EBU.

BUSINESS

Harris Allied, Richmond, IN, has been named the exclusive distributor of **Oktava** microphones in the United States and Canada. Two Oktava condenser mics — the MK012 and the MK219 — have been added to Harris Allied's product line. Both of the mics, manufactured in Russia, provide performance and value to the broadcast and recording industries.

Kwikstar Communications, Vancouver, British Columbia, has entered into a letter of intent with **MPR Teltech**, owner and sole shareholder of Digital Courier International (DCI), and an investor group, to acquire all outstanding shares of DCI in exchange for common and preferred shares of Kwikstar.

Otari's representative in South Africa, **Tru-Fi Electronics**, has sold 41 MR-10 minidisk recorders to the **South African Broadcasting Corporation** (SABC).

MPR Teltech, Vancouver, British Columbia, is licensing its MPEG Audio Layer II compression technology to **Scientific-Atlanta** for use in its satellite digial audio products.

Dolby Laboratories, San Francisco, will offer its DSTL digital studio-transmitter link system at a reduced price. The 2-channel DSTL system will carry a new list price of $9,900, with 4-channel systems at $10,900.

AT&T and **Audio Processing Technology** (APT), Belfast, Northern Ireland, have formed a strategic partnership to develop new technologies for the economic acquisition and distribution of high-quality audio over direct dial digital networks.

Spectral, Woodinville, WA, has formed a strategic alliance with **Broadcast Electronics**. The alliance will allow Prism editing systems to produce sound files for use with Broadcast Electronics' AudioVAULT hard-disk-based digital audio storage system and transfer the files seamlessly via a wide area network.

Sonic Solutions, San Rafael, CA, has entered into an agreement with **National Public Radio** (NPR) to equip NPR's headquarters in Washington, DC, with a radio workgroup system that will bring the NPR program production and on-air into the digital age.

PEOPLE

Bill Wolfenbarger has joined the radio field sales staff of Harris Corporation's Broadcast Division in the Pacific Northwest.

Also, **Mary Ann Seidler** has been appointed sales director in Europe.

Anton Thimet has been named technical director of Telos Systems' new office near Munich, Germany.

John Carey has been named vice president, marketing, for Euphonix, Palo Alto, CA.

Also, **Andrew Wild** has been named vice president, market development; **Benn Carr** has been promoted to product manager; and **Peggy Blaze** has been promoted to marketing communications manager.

Alex Welti has been promoted to product manager for Harman Pro North America, Northridge, CA.

Joe Bean has been promoted to national sales manager for Studer in the United States.

New Products:

Reproduction of classic headphone

Sennheiser

◀ HD414 Classic: limited-edition headphone offered in celebration of Sennheiser's 50th anniversary; Dr. Sennheiser's signature is featured on the headband; the HD414 Classic is modeled after the original HD414 that was developed in 1967 with black headband and yellow ear cushions; the transducers have been updated, and the model weighs 2.8 ounces; the HD414 Classic comes with a 10-foot oxygen-free copper signal cable that terminates in a 1/8- to 1/4-inch gold-plated stereo phone plug.

Circle (152) on Reply Card

Windows interface for remote transmitter control

Gentner Communications

• VRC-WIN: a Windows interface for the Gentner VRC-2000 remote-control unit for broadcast transmitters; a VRC-1000 that is equipped with VRC-2000 firmware can also be used with the new software; all VRC operations previously available in the DOS-based program SETUPVRC can be accomplished with VRC-WIN, including logging, time-of-day, mute, clock, terminal mode and setup functions; users can dial and connect to any of six sites by clicking on the desired site icon; users can also obtain metering readings with both analog and numeric displays; graphic representations of analog meters are user definable and meter scale length and color can be adjusted.

Circle (153) on Reply Card

Digital multitracker

Fostex

▶ DMT-8: an 8-track hard-disk recorder/mixer/editor; the DMT-8 features CD-quality 16-bit recording to an internal hard drive, fluorescent metering, dedicated non-destructive cut/copy/paste editing keys, user-friendly interface, a jog/shuttle wheel, two bands of sweepable EQ and 16 channels of mixdown to analog and digital outputs; a 540MB hard drive provides 12.5 minutes of recording across all eight tracks; the drive is easily archived or restored from a DAT machine, such as the Fostex D-5, via fiber-optic S/PDIF transfer; an 8x4x2 analog mixer features a unique 4-bus architecture with two aux sends, two stereo returns, dual parametric EQ, and in-line monitoring that allows the user to mix the eight digital disk tracks with an additional eight inputs; the DMT-8's digital output allows direct mastering to DAT, as well as complete MIDI time code (MTC), MIDI machine control (MMC) and programmable tempo maps and click tracks.

Circle (150) on Reply Card

AES/EBU interface for Zephyr

Telos Systems

• AES/EBU input/output option for Zephyr: an AES/EBU interface for the Zephyr digital network audio transceiver (Zephyr integrates in a single unit an ISO/MPEG Layer III and Layer II codec with an ISDN terminal adapter and can transmit 20kHz stereo duplex audio on a single dial-up ISDN phone line virtually anywhere in the world); the AES/EBU interface, available as a plug-in card, provides maximum flexibility for connection to digital studio equipment; sample rates of 32, 44.1 and 48kHz are supported, and the interface accepts clock from an external source or provides clock that is locked to telco clock when required.

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FM exciter

Harris Allied

• DIGIT: a digital FM exciter featuring a 3-year warranty; DIGIT uses direct digital synthesis technology to generate a CD-quality FM signal; DIGIT is available with an analog or an AES/EBU input module; once a digital signal to the transmitter becomes available, the analog input module can be replaced with a digital input module in minutes; the digital input module provides a DSP-based stereo generator for stereo separation over 65dB and inaudible noise and distortion; the digital input module also provides a digital composite limiter that uses proprietary "look-ahead" circuitry to anticipate and eliminate overmodulation peaks.

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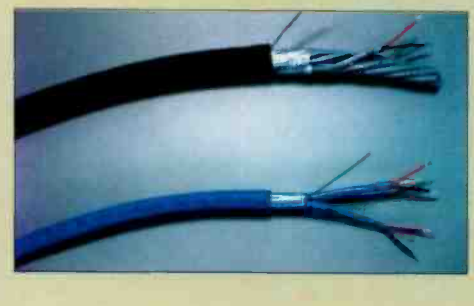

Outer jacket compound for multipair audio cable

Gepco

◀ GEP-FLEX: a highly flexible outer jacket compound for the 618 (22 gauge) and 724 (24 gauge) series multipair audio cable for indoor and remote use; GEP-FLEX is designed with an increased temperature range with cold weather properties to minus 60°C; GEP-FLEX features a matte finish that retains the UL listed-type CM rating required for permanent installation; GEP-FLEX multipair cable is available in bulk or customized lengths; Gepco will terminate GEP-FLEX cable to connectors, patchbays, etc.

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Continued on page 46

The Aphex Air Chain has given stations throughout the world more listeners by increasing fringe area coverage and reducing multipath distortion. After installing the Air Chain, WDRE-FM, a suburban New York City station, is reaching over *one million* more people! And their listeners are staying tuned in longer. Why? Because the Aphex Air Chain is the cleanest, most natural sounding processing available–regardless of music format–while still maintaining competitive loudness.

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Multitrack USP
Sonic Solutions

Multitrack ultrasonic processor (USP) system: a wide-channel, high-resolution digital audio editing and mixing workstation, offering up to 64 channels of input and output and 80 to 100 separate simultaneous disk playback tracks; the USP card includes four Motorola 56002 DSP processors clocked at 66MHz, as well as a high-speed SCSI controller, four serial/SMPTE ports and a digital audio interface capable of I/O of up to 16 channels of audio in digital or analog formats; the Multitrack USP links individual USP cards using a high-speed board-to-board bus; Multitrack USP is capable of recording, editing, filtering and mixing audio with full 24-bit resolution.

Circle (155) on Reply Card

Instant Replay software upgrade
360 Systems

Software version 1.2 for Instant Replay: Instant Replay is a professional digital audio recorder featuring immediate access to 1,000 individual audio cuts of any length; the software upgrade features follow-on mode playlists, remote triggering via GPI and the ability to backup selected banks of audio cuts; with version 1.2, users can build playlists in manual mode (where each cut in the list is triggered by successively pressing PLAY) or in follow-on mode (where cuts play sequentially one after the other until the list is complete); using the built-in GPI port, Instant Replay can now be triggered remotely.

Circle (159) on Reply Card

R-DAT recorder
Otari

• **DTR-8:** an R-DAT recorder featuring enhanced facilities for recording user-entered ID characters and accessing other subcode information; the DTR-8 allows users to record and erase up to 60 characters at the beginning of each track; the characters are displayed on the DTR-8 front-panel display on playback, and can be read by other compatible machines; various subcode time information, such as start ID, end ID and skip ID, can be written and erased; all TOC information is available for editing and archiving.

Circle (160) on Reply Card

Software upgrade for DSE 7000
Orban

Software version 5.11 for DSE 7000: software for the DSE 7000 digital audio workstation designed for ergonomic, easy-to-learn, lightning-fast editing of commercials, announcements and news; version 5.11 supports hardware-based MPEG sound file export to popular on-air systems (network adapter required); DSE 7000 users with network links to audio delivery systems, such as the Enco DAD-486 and the Broadcast Electronics AudioVAULT, can now export sounds or mixes from the DSE 7000 using MPEG compression; version 5.11 also provides new locate marking functions, allowing users to set, name, display and recall 24 locate points or go to any time location instantly; the upgrade incorporates all changes made with 5.0; version 5.11 is free to all DSE 7000 users.

Circle (161) on Reply Card

MiniDisc recorder
Denon

• **DN-1100R:** a MiniDisc recorder featuring a "Hot Start" function that allows up to 10 different MiniDisc tracks to be assigned to the unit's 10 independent "Hot Start" buttons for instantaneous track playback; a cue detect function can cue to the point where the sound actually starts, rather than the beginning of a track, or to any desired point within a track.

Circle (157) on Reply Card

Transmission system
Lightwave Systems

• **Fibox DATI-SL & DATO-SL:** data transmitter and receiver modules that provide a flexible interface capable of moving unidirectional control signals through Lightwave's Fibox digital fiber-optic transmission systems; each system requires at least one set of master controls; the DATA modules operate in slave mode only and require a minimum of one set of master I/O modules to form a functional transmission system; signals that can be input or I/O to the data modules include RS232, RS422, RS485, MIDI, SMPTE time code and switch closures.

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Advertising rates in ***BE Radio*** Classified Section are $45 per column inch, per insertion. There is a one inch minimum.

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FOR SALE

Nautel Ampfet 25, 25 kw AM Transmitter at 1200 KHz. Recently removed from service this unit is complete, and comes with a small selection of spare parts. It was in service for only 5 years prior to the station switching to the FM band. Also available 25 Kw Electro Impulse Air Cooled Dummy Load. Both units are in excellent condition and will be sold separately or as a package.

For details contact:
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Complete 50 kilowatt AM RD site including the following:
- 1 Harris MW 50 transmitter installed in 1976.
- 1 RCA Ampliphase 50KW transmitter 1950's vintage
- 2 LR 24" towers only 6 years old, 320 feet in height
- 1000 feet of recoverable 4in Andrews feed line
- various 50 kilowatt phasing components
- water cooled 50KW dummy load and transmitter switch
- 3 complete 450 STL systems, 2-Moseley PCL 101's, 1-Marti STL-10
- Optimod model 6000, three years old

In addition:
- 1 Katrein12 panel wide band FM antenna model #K523417 horizontal polarized only three years old
- 1 Dielectric 6 bay CP antenna complete with Radomes model DCVS 6B

The AM equipment will be available early in 1996, while the FM equipment is ready by the end of this year.

Call or fax Dick Cleveland or John Eddy at Radio (RSL) Inc.
206 Rookwood Ave., Fredericton, N.B.
Phone (506) 451-9111
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HELP WANTED

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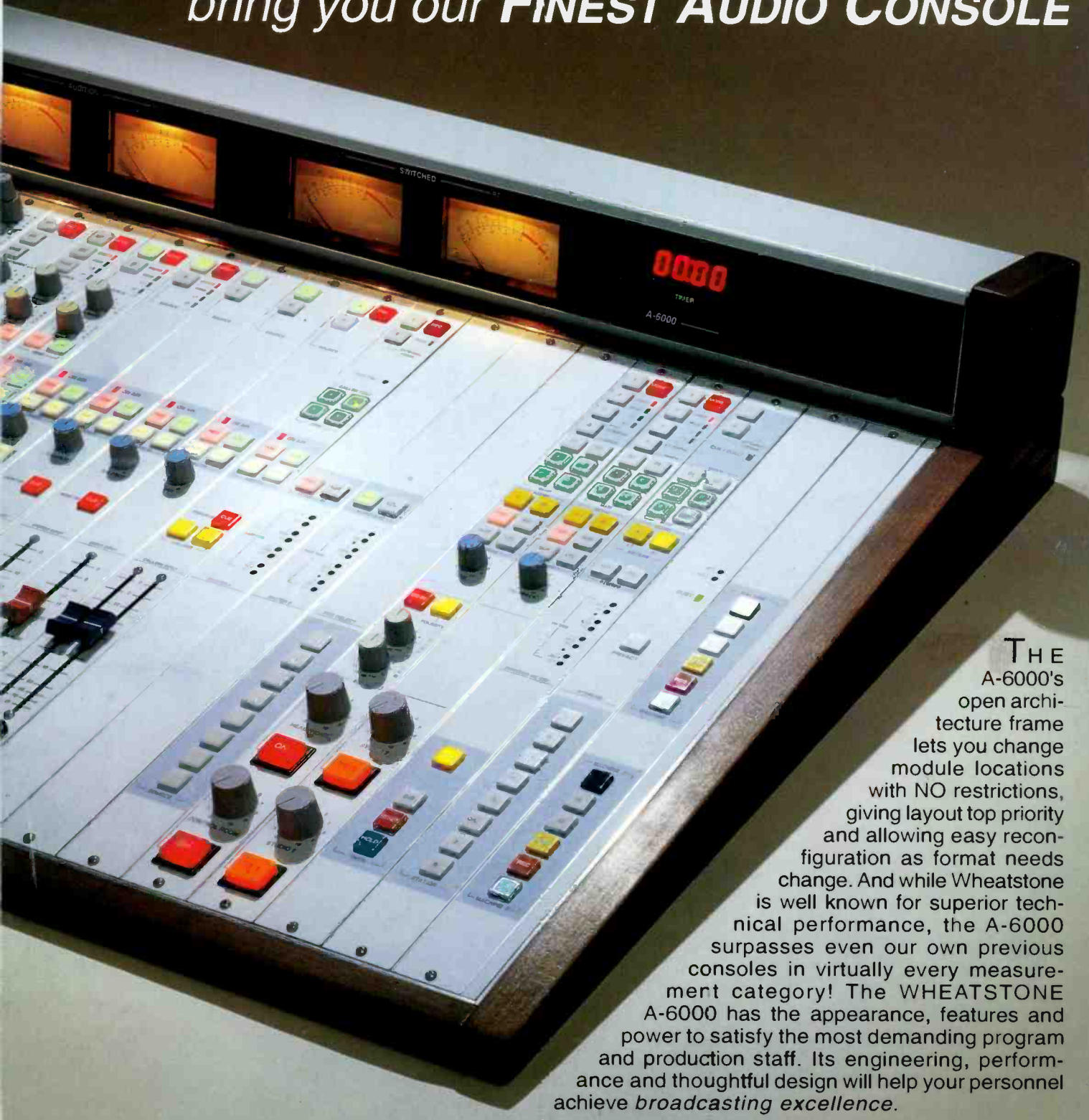

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