ENGINEERING EXTRA

HEAT IS YOUR ENEMY
Poole and Guzina offer insight on how to keep things cool. Pages 12–16

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Sustainable Facilities and LEED Certification: A Broadcaster's Guide

Green Design Principles Form The Core of Rating System and Offer Long-Term Benefits

BY ANTONIO ARGIBAY

The author is with Meridian Design Associates, Architects, P.C.

"How will green and sustainable building construction requirements affect my facility development plans?"

WHITEPAPER

This is a question all broadcasters should be asking themselves right now. There exists an amalgam of codes and regulations that have been separately administered by a variety of governmental agencies, which address energy efficiency, water conservation, toxic materials, transportation, waste management and even historical/cultural factors.

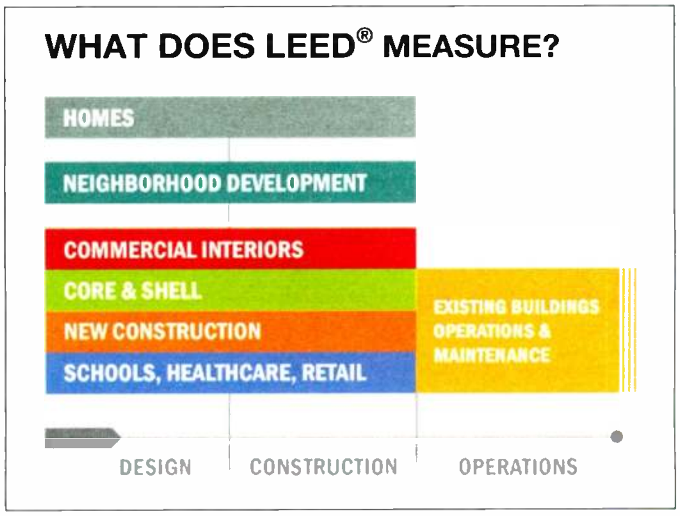

Fig. 1: LEED Systems and Areas of Measurement

Sustainable Design has emerged as a cohesive strategy and a unifying concept for all of the above. The trend is toward a mandated solution under the umbrella of Sustainability, bundling the environmental, energy and occupant regulations under it.

Today the evolution of Sustainable Design has matured to the point of codification. States, municipalities and government agencies are mandating a standard of "Green" design for the construction projects in their jurisdictions. Legislative bodies have been busy at all governmental levels framing this type of legislation.

While many of the drivers are of a sociopolitical nature, Sustainability has behind it an unprecedented economic force. The economic drivers of energy savings are obvious: at the individual consumer/user level, lowering consumption provides a direct benefit — lower cost. Sustainable design focuses,

(continued on page 4)

Modern VHF Signal Measurement Techniques At NPR Labs

BY JOHN KEAN

The author is senior technologist at NPR Labs in Washington.

Field strength measurements are almost as old as radio itself, as engineers have endeavored to test and

WHITEPAPER

improve their RF transmission systems. Despite generations of advancement in radio, however, the principles applied to field strength measurement for broadcast have not changed much.

Today's requirements of receiving antennas, detection and filtering, recording and statistical analysis have their basis in principles developed almost three quarters of a century ago. This article discusses some techniques developed by NPR Labs to make FM broadcast field measurements faster, easier and potentially more accurate.

VHF field strength measurements were commonplace at the dawn of television: Every new TV station had to conduct "license proof of performance"

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RADIOWORLD
ENGINEERING EXTRA
3 No. 10 April 14 2010

Next Issue of RADIO WORLD April 21, 2010
Next Issue of ENGINEERING EXTRA June 9, 2010

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adio World Founded by Stevan B. Dana

adio World (ISSN: 0274-8541) is published bi-weekly with dditional issues in February, April, June, August, October and ecember by NewBay Media, LLC, 810 Seventh Avenue, 27th Floor, ew York, NY 10019. Phone: (703) 852-4600, Fax: (703) 852-582. Periodicals postage rates are paid at New York, NY 10079 nd additional mailing offices. POSTMASTER: Send address changes) Radio World, P.O. Box 282, Lowell, MA 01853.

EPRINTS: Call or write Caroline Freeland, 5285 Shawnee Rd., te. 100, Alexandria, VA 22312-2334; (703) 852-4600; ax: (703) 852-4583

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Blesser and 'The Last Word' Go to Vegas

Also: We Start a New Feature on Information Technology With Stephen Poole

BY MICHAEL LECLAIR

As we come to the end of a long winter, I feel a sense of renewal in the industry. The economy appears to be recovering, and with it we should soon experience a recovery in the radio industry. This spring brings with it an extra sense of rebirth beyond the seasonal changes.

I am pleased to introduce a new feature in this issue of Radio World Engineering Extra. Stephen Poole of Crawford Broadcasting will begin a regular column on Information Technology for Broadcast Engineers. This month's topic will be on maintenance of personal computer hardware and how to tell when hardware or software causes a problem with your computer (see page 12). Future topics will include all aspects of IT, such as computer security, software viruses, software maintenance and computer networking.

Regular readers of Engineering Extra will recall that Stephen has appeared in these pages from time to time, offering useful tips and tricks on a range of broadcast engineering topics in an entertaining and easily readable style. With information technology now a regular part of the responsibilities of most radio engineers, we feel this column is timely and will be helpful to you in your daily work. We welcome Stephen to Engineering Extra.

If you have suggestions for topics for his column please feel free to drop me a note at *rwee@nbmedia.com*.

THE ENVELOPE PLEASE ...

It is also my pleasure this month to note that our very own Barry Blesser, regular author of the *The Last Word* column since the very first issue of Engineering Extra, was chosen to deliver the keynote address at the NAB Broadcast Engineering conference in Las Vegas.

His speech will consider the role of engineers in today's broadcast systems, and how their role and stature can be enhanced by augmenting their technical skills with non-technical expertise. Barry is a passionate advocate of the career value of enhanced emotional intelligence and soft skills. His talk will emphasize this hidden asset.

Barry has been writing provocative and challenging columns in Engineering Extra for more than five years now. It is hard to summarize in just a few words the wide range of ideas and concepts that he has covered in that time.

Dr. Blesser has written about the need for lifelong learning, technological scarcity and surplus, the techniques of negotiation, the psychology of schedules, the psychology of technical quality, Chaos Theory, head-space farming, the illogic of logical reasoning, HD Radio, the development of the compact disk, audio villages, aural architecture, engineering listservs, the Long Tail phenomenon, Word of Mouth marketing, management and decision-making, corporate cultures, understanding people to become a better engineer, and businesses based on a model of delivering products to consumers for free, just to mention some of the topics.

In the process, Barry has at various times quoted Plato, Peter Jennings, Malcolm Gladwell, Marshall McLuhan and Gordon Moore, along with many other writers of current interest.

Blesser is considered one of the grandfathers of the digital audio revolution. He invented and developed the first commercial digital reverberation system, the EMT-250 in 1976, helped start Lexicon in 1971, published the landmark paper, "Digital Processing of Audio Signals" in 1978, co-chaired the 1st International Conference on Digital Audio in 1980 and was an unpaid adviser to the U.S. Justice Department on the Watergate Tapes in 1974.

He was president of the Audio Engineering Society in 1980, the AES awarded him their Silver, Bronze and Governors Medals, both Publication Awards, and made him an AES Fellow. He has been on the AES editorial review board since 1975, and currently serves as its consulting technical editor. He also has published numerous papers in professional journals and has been awarded many patents on audio and signal process.

After receiving his S.B, S.M and Ph.D. from MIT in Electrical Engineering in 1964, 1965 and 1969, Barry served on the MIT faculty from 1969 to 1978 as an associate professor of electrical engineering and computer science. He taught courses on electronic, instrumentation and audio technology while conducting research in the Cognitive Information Processing Laboratory.

After leaving academia in 1978, he has been a technical and management consultant, working with more than 50 companies, including AKG, Orban, Harmon and Studer. He often functions as a "change agent," using the principles of risk engineering to maximize productivity and profitability. In addition, he has been an expert witness on patents cases, a director of engineering, and chief technology officer, and a founding officer of several startup companies.

Our own Barry Blesser, regular author of the *The Last Word* column since the first issue of Engineering Extra, was chosen to deliver the keynote address at the NAB Broadcast Engineering conference.

As Barry's long-time editor, I find it amazing that such a range of topics could emanate from one writer, informed by his unique perspective on the inside of the engineering world. I always learn something from his columns. And countless times while reading I have found myself nodding slowly as I recognize myself in his descriptions and the wisdom of his observations.

In honor of his selection to be the keynote speaker at the NAB Broadcast Engineering Conference, we have an extra-long column from Barry this month. I hope you find it as thought-provoking as I did.

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additionally, on the economies of the region, highlighting the impact of individuals' planning on the overall building environment, especially in areas of high municipal costs of infrastructure and energy generation.

As we look at the move toward a cohesive — and mandatory — degree of Sustainable Design compliance for projects, it is less important for broadcasters to know the ever-evolving details and more important that they concentrate on the concepts driving the requirements.

So as we begin this road to codification of what have been separate requirements by various agencies, what can we expect?

We can expect requirements that are very similar to what LEED certification entails. Unlike building and zoning codes, which painstakingly spell out what you may or may not do, technology and socioeconomic issues. It is the most popular and recognized rating system — up to the 2009 version 3.0, almost 28,000 projects totaling over 6 billion square feet of gross area had been registered. [Ref. 3] It is important to note that only a fraction of all those projects actually end up being certified (about 20 percent).

There are several versions of the LEED green building rating system according to building/project type. The three that are applicable to broadcasters are **New Construction** for new buildings and major renovations, **Existing Building, Operations & Maintenance** for certification of ongoing facilities providing entry level certification and **Commercial Interiors** for tenant-type work where the applicant does not control the whole building.

At its core, LEED measures performance, then rates it into four levels: **Certified**, 40–49 points; **Silver**, 50–59 points; **Gold**, 60–79 points; and **Platinum**, 80 points and above.

Fig. 2: LEED Categories

It is estimated that Americans spend about 90 percent of their day indoors, where adhesives, sealants and lack of fresh air conspire to create a toxic 'soup' that has been directly linked to absenteeism and other workplace maladies.

Sustainability will have a few obligatory requirements and then a broad range of choices in a few environmental categories with very specific requirements to achieve certification for each.

"Various LEED initiatives — including legislation, executive orders, resolutions, ordinances, policies and incentives — are found in 45 states, including 201 localities (137 cities, 36 counties and 28 towns), 34 state governments, 14 federal agencies or departments, 17 public school jurisdictions and 41 institutions of higher education across the United States." [Ref. 1]

WHAT IS LEED?

"LEED green building certification program is a voluntary, consensus-based national rating system for buildings designed, constructed and operated for improved environmental and human health performance." [Ref. 2]

This is the definition provided by U. S. Green Building Council, a non-profit organization comprising 18,000 organizations from all aspects of the building industry.

USGBC developed the LEED rating system. It was introduced about 10 years ago, and its latest version, v3.0, was released in 2009. It is an evolving system based on feedback from implementation and refinement based on evolving

WHAT DOES LEED MEASURE?

Think of the LEED rating system as a label that immediately lets anyone know the "ingredients" that make up a building's or leasehold's content and its performance.

There are seven areas or categories that it measures, and within these there are a series of *credits*, which are awarded *points* according to success in fulfilling the requirements. Two categories are, in my mind, the underpinning of the five environmental categories.

The first, **Regional Priority**, is the newest category, and addresses issues that are most important locally for each region of the country as prioritized by USGBC chapters and members. Thinking locally is at the core of sensible building, and this category encourages that by providing up to 4 bonus points.

The second, **Innovation in Design**, provides up to 6 bonus points for projects that use creative technologies and strategies to provide performance solutions that are more than those required by other LEED credits or new strategy solutions not found elsewhere in LEED. This credit category also rewards projects for including a LEED Accredited Professional on the team to ensure a synergistic, integrated approach to the design and construction phase.

The five *environmental categories* are the core of the performance criteria, and like branches of a tree, different credits are closely related between the categories in such a way that gaining points in one credit will make a contribution towards another. There is a maximum total of 100 points, which can be achieved in the environmental categories. The breakdown per category varies slightly depending on the LEED system applied. For the sake of simplicity, the points per category provided are for the New Construction and Major Project (NC) system. Every LEED category credit is followed by a set of *options*; these provide great flexibility by allowing a variety of approaches to achieve the desired points for a credit.

Sustainable Sites (SS):

Choosing a broadcaster's building site — whether a new building, existing or a tenant space — is the first step toward a "green" project. The Sustainable Sites category discourages development on previously undeveloped land; minimizes a building's impact on ecosystems and waterways; encourages regionally appropriate landscaping; rewards smart transportation choices; controls storm water runoff; and reduces erosion, light pollution, heat island effect and construction related pollution. This category has a total of 26 points available. It is important to note that this category also applies for Commercial Interior (CI) LEED system candidates (21 possible points), and it both makes sense and is a simple and economical way to achieve points. All you have to do is make sure that the criteria for SS are part of your search for a new leasehold.

Water Efficiency (WE):

Buildings are major users of our potable water supply. Broadcast buildings face typical consumption issues, and can achieve water reduction through more efficient faucets, fixtures and fittings inside and water-wise landscaping outside. Additionally, many larger facilities have cooling towers for chilled water air conditioning systems, which consume proportionally more water than an office building occupancy. A system of reclaiming "grey" water to provide make-up water is a good example of how additional savings opportunities can be developed. This category has a total of 10 points available.

Energy and Atmosphere (EA):

Broadcasters, perhaps even more than general consumers, equate Sustainability with cutting back on energy consumption — and perhaps with good reason. Broadcast facilities are very dependent on power; whether it is for lighting a TV production studio, a room full of racks or a transmitter, you need power. Buildings use 39 percent of the energy and 74 percent of the electricity produced each year in the United States. [Ref. 4] This category encourages many varieties of energy strategies that will appeal to broadcasters: commissioning; energy use monitoring; efficient design

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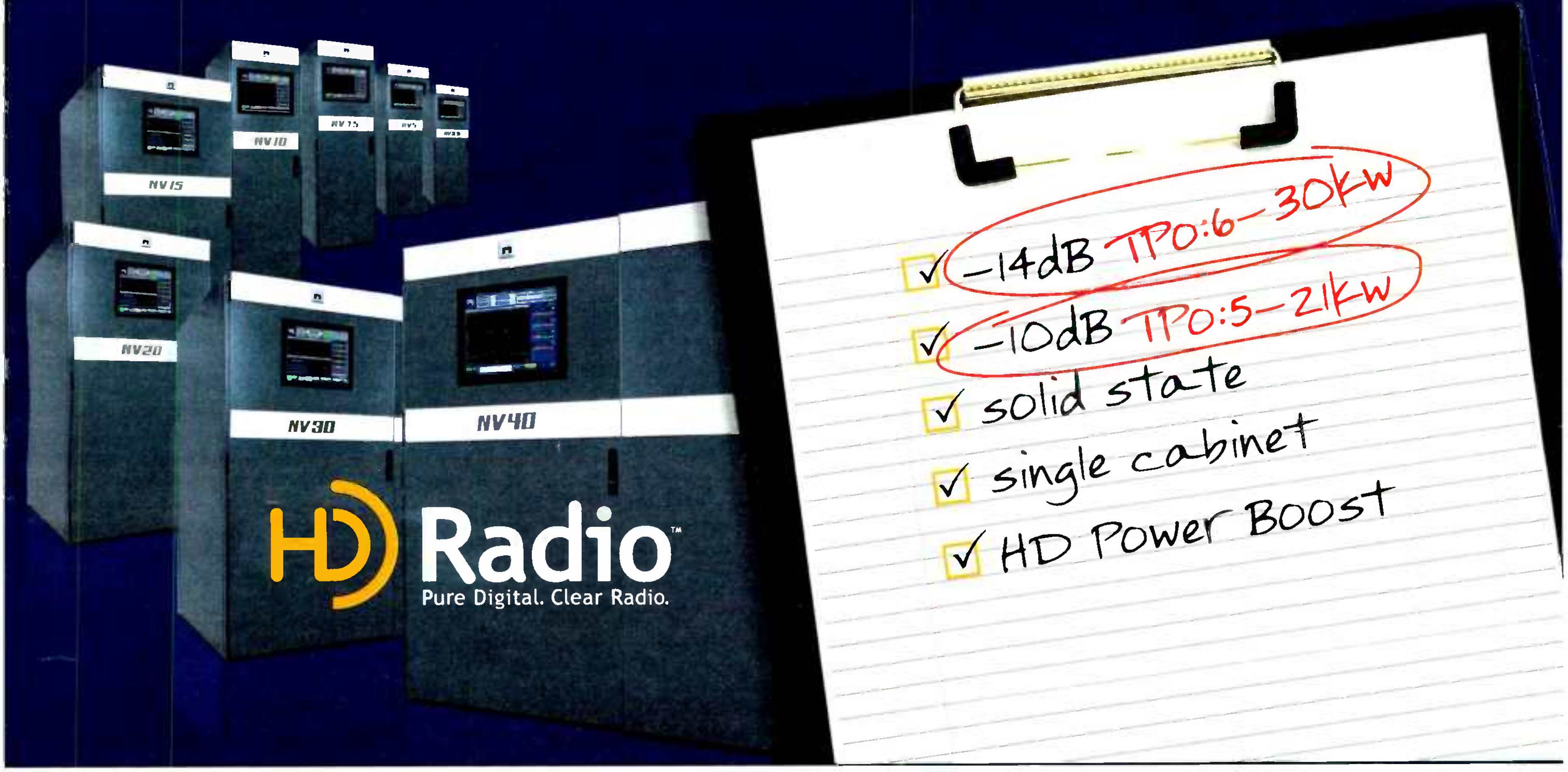

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and construction; efficient equipment, systems and lighting; the use of renewable and clean sources of energy, generated on-site or off-site; and other innovative strategies. We will come back to this category later on as it is very important; however, note that this category has 35 possible points — the most of any category — yet it's only about one-third of the possible points.

Materials and Resources (MR):

The process of building and operating a building uses a lot of materials and resources, and it creates waste. This is something that is painfully obvious to broadcasters who have to upgrade facilities because of changes in technology and the evolution of the industry. At the same time, they have been pioneers in repurposing buildings to suit their needs. This credit category encourages the re-use of existing construction, selection of local materials, use of renewable materials and mandates collection of recyclables. It promotes the reduction of waste, and it takes into account the reduction of waste at a product's source. This category provides 14 possible points.

Indoor Environmental Quality (IEQ):

The quality of our indoor air is something that affects all of us across all occupancies and pay scales. It is estimated that Americans spend about 90 percent of their day indoors, [Ref. 5] where adhesives, sealants and lack of fresh air conspire to create a toxic "soup" that has been directly linked to absenteeism and other workplace maladies. Another part of IEQ has to do with thermal comfort and day lighting issues that, when solved correctly, have the potential to contribute toward energy savings. The Indoor Environmental Quality category promotes strategies that in general control every aspect of the interior environment. This category has 15 possible points (17 for the LEED System for Commercial Interiors).

WHAT DOES LEED DELIVER AND HOW?

Third-party certification through the Green Building Certification Institute is the result. GBCI is an independent party that guarantees, along with its ISO compliance certifying partners, that a rigorous process has been followed, ensuring the "consistency, capacity and integrity of the LEED certification process." [Ref. 6]

GBCI was specifically organized to provide ANSI/ISO/IEC 17024 in 2009, and is therefore a new development in the LEED process. Additionally it provides professional accreditation and manages the Credentialing Maintenance Program for professionals.

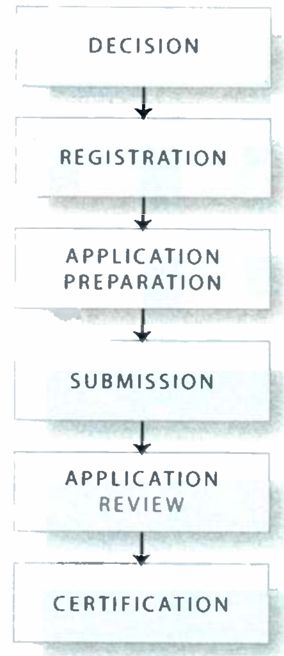

Fig. 3: LEED Process Overview

The procedure to achieve Project Certification is simple, easy to follow and heavily supported by online tools. The first step is to make sure your project meets the Minimum Program Requirements (MPR) for acceptance as a LEED project. This will become important as Sustainability grows into a coherent mandated set of requirements. Once certain of meeting the MPR, it is recommended that you carefully articulate the reasons (whether mandated or voluntary) why LEED certification is sought, first by the system type (New Construction, Commercial Interiors, etc.), and then initial performance level (Certified, Silver, Gold or Platinum).

LEED is definitely a team effort; it is a collaborative process, requiring the coordination of all the stakeholders in the project in order to reach the most preliminary LEED **Decision**.

Broadcasters as a user group have a unique advantage insofar as most of their significant projects require substantial collaboration teams. These teams include owners, designers and builders working together with well-defined success criteria and, many times, the experience of working together to deliver projects. This integration of needs and expertise, when led correctly, will yield a systems-oriented approach to design solutions that will capitalize on the synergies and improve the overall performance of the project.

The first tool the project team will use is the Credit Checklist, which is one of the tools provided for download as a preformatted spreadsheet (see sample in next page). This list provides three categories for each achievable point: "yes," "?" or "no." In the checklist of

LEED 2009 for New Construction and Major Renovation
Project Checklist
Project Name New Building Urban low-rise
Date: April 2010

Y	?	N			Possible Points	Comments
17	4	0	**Sustainable Sites**		Possible Points: 2	Comments
Y			Prereq 1	Construction Activity Pollution Prevention		
1			Credit 1	Site Selection	1	It s an appropiate site by definition
5			Credit 2	Development Density and Community Connectivity	5	site meets Option 2 of Req
	1		Credit 3	Brownfield Redevelopment	1	we will have to verify
6			Credit 4.1	Alternative Transportation - Public Transportation Access	6	we meet Option 2 for Bus stop proximity
	1		Credit 4.2	Alternative Transportation - Bicycle Storage and Changing Rooms	1	We may be able to work into plan
		0	Credit 4.3	Alternative Transportation - Low-Emitting and Fuel-Efficient Vehicles	3	Parking is problematic
2			Credit 4.4	Alternative Transportation - Parking Capacity	2	We meet this requirement because our parking is less than the minimum zoning allows
		0	Credit 5.1	Site Development - Protect or Restore Habitat	1	This will be very difficult at this location even with a green roof
	1		Credit 5.2	Site Development - Maximize Open Space	1	We may be able to achieve this by applying pedestrian oriented hardscape areas at 25%
1			Credit 6.1	Stormwater Design - Quantity Control	1	We can achieve this because the area had exisitng impervious greater than 50%
	1		Credit 6.2	Stormwater Design - Quality Control	1	Conduct cost benefit of treating run off for make up cooling tower water.
		0	Credit 7.1	Heat Island Effect - Non-roof	1	We will nor be able to achieve this
1			Credit 7.2	Heat Island Effect - Roof	1	Roofing material with SRI acceptable material
1			Credit 8	Light Pollution Reduction	1	We can fullfill requirement
6	0	0	**Water Efficiency**		Possible Points: 1	Comments
Y			Prereq 1	Water Use Reduction - 20% Reduction		
4			Credit 1	Water Efficient Landscaping	2 to 4	
				[ ] Reduce by 50%	2	
				[x] No Portable Water Use or Irrigation	4	We don't plan on irrigating

Fig. 4: Sample LEED Process Checklist

credits there will also be *Prerequisites* for each of the five environmental categories measured by LEED. These are all mandatory and must be complied with in order to obtain certification; failure to follow any one of them will exclude your project in its totality.

By environmental category the credits are:

1. Sustainable Sites
   a. Construction Activity Pollution Prevention

2. Water Efficiency
   a. Water Use Reduction

Energy and Atmosphere
   a. Fundamental Commissioning of Building Energy Systems
   b. Minimum Energy Performance
   c. Fundamental Refrigerant Management

Material and Resources
   a. Storage and Collection of Recyclables

Indoor Environmental Quality
   a. Minimum Indoor Air Quality Performance
   b. Environmental Tobacco Smoke Control

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The team will conduct an initial pass to identify the readily achievable (yes) and the maybe achievable (?) and the points that in their opinion are difficult for the project to achieve (no). Each point should have comments to clarify the reasons. The Project leader should organize a working meeting to discuss the Credit Checklist with the whole team and make final determinations on the achievability of a particular number of total certification points. These final recommendations for approval to ownership of the project should be conservative in the likelihood of achieving the necessary points and should be the result of the synergistic input of the whole team including Administrative, Design, Budgeting and Implementation.

Registration is the next step, and it is the process by which the project ownership officially requests certification and the team establishes contact with GBCI and receives access to the online tools. The project is registered by an individual who becomes the Project Administrator to GBCI. All other team members have access and can enter information; however, they are listed as users and their capacity to administer is limited. The Project Administrator can be changed at any time. To register the project, two fees must be paid up front. The fees are a Project Registration Fee (USGBC Members: $450; Non-Members: $600) and a Project Certification Fee. Preparing the Application involves providing basic project and team information.

Application includes the documentation required to fulfill the Prerequisites and each individual credit in the Project Checklist. As each of them is different, for the sake of this paper the important point is that there are many tools including templates, off-line calculators with formulas, forms and guidance to make the process efficient, standardized and simple. These documents are to be reviewed for completeness and are uploaded by team members.

Submission of the Application can only be done by the Project Administrator and requires payment of the Certification Review fees.

The Certification fees vary by the rating system and the size of the project. For example, for New Construction or Commercial Interiors, non-members pay $2,250 for projects under 50,000 square feet and ten times that for projects over 500,000 square feet, with projects in between paying $0.45 per square foot. We refer to them as fees (plural) because there is a Design Review fee and a Construction Review fee.

The **Review** process has two options: one whereby the Design Review and Construction Review are split and the other where they are combined. A split Design and Construction review allows for four review phases (a preliminary and a final for each). When they are combined, the review is done in two phases — one for Design and the other for Construction. Splitting the Design and Construction has the advantage that you get the value of preliminary feedback in the form of technical advice in a way that can be adjusted with the least amount of turbulence. The result of Preliminary Review is that each point submitted is evaluated and ruled as "anticipated," "pending" or "denied." Final reviews result in "awarded" or "denied," with only the Appeal Review process at the team's disposal — at $500 for each credit.

The final step is **Certification**, and you will receive a certificate.

LEED FOR BROADCASTERS?

Broadcasters as a "use group" for a building use are much less definable than say Retail or Office uses. A broadcast use will be typically composed in varying proportions of three space types: **office**, **technical** and **content creation**. The proportions of which can vary wildly depending on the project, the media and even the business plan. While the LEED energy related points are about 1/3 of the total, their potential operational cost benefit is a big driver. LEED as a performance measuring tool is a great way to guarantee your project is built to a consistent yet flexible level across the board regardless of your mix or scale of project. It is also a safe bet that it will be performing at substantially higher level than a comparable building designed without LEED.

Broadcasters with projects involving **office** space should be implementing some of the tried and true solutions available, while at the same time making sure those solutions are in keeping with long terms goals and objectives. For example under-floor air distribution has been shown to cut down on cooling energy costs by 20 to 30 percent [Ref. 7], at the same time you are buying flexibility for future modification of a space. The cost delta between overhead air distribution and under-floor can vary by region, ratio of open to enclosed spaces and scale; however once you factor in all the costs including electrical distribution, it is very close. The first time you reconfigure the space it will be like cashing a check — and no sheet metal will go into a dumpster.

The **technical** space aspect of a broadcast operation is heavily dependent on good quality, reliable energy. Whether the area is a peopled tech space such as a control room or a largely unoccupied space as a rack room, it is a heavy consumer of power and therefore cooling — which requires power. As far as power is concerned, evaluation of project sustainability will be based on ANSI/ASHRAE/IESNA Standard 90.1-2007. The Prerequisite for Minimum Energy Performance is best fulfilled by Broadcasters with *Option 1 — Whole Building Simulation* and you have to demonstrate that the building is 10 percent more efficient if new and 5 percent if existing. The baseline is the key in this comparison and as there is no ASHRAE defined "Broadcast Building" type, the baseline is a measurement of an existing facility or your own comparable occupancy. This measurement is done through energy modeling. It should be noted that, like broadcasters, occupancies such as data centers lack a defined LEED system; however in 2009 Citigroup inaugurated a "Platinum" rated data center facility. [Ref. 8]

> **Content capture** spaces are unique to media facilities, and also play a substantial role in the energy profile for modeling.

Beyond the Prerequisite the largest single point amount is in the Optimize Energy Performance credit with up to 19 points, or about 20 percent of the credits. This is done by additional percentages of savings being matched proportionally with points.

Content capture spaces are unique to media facilities, and also play a substantial role in the energy profile for modeling. These types of spaces can vary greatly, from large TV Studios to Radio Studios. Yet they share a common factor; that the lighting generates either a significant or the most significant load. To achieve substantial savings, broadcasters will have to commit to modern lighting design solutions that lower the watts / sq. ft. for the space and therefore the dissipated heat load upon which the cooling will be based.

CONCEPTS VS. DETAILS

There is a substantial amount of detail involved in a broadcast project. Many will view participation in the design of Sustainable Facilities with trepidation — whether required by corporate or mandated by the state. It is unfamiliar and adds another layer of details to what is already a challenge. Sustainability, however, should be approached as a *concept* first, to which a variety of solutions can be applied to suit your project needs. Therefore "think," and Sustainable Design will be a process you will come to value.

Think *long-term:* Do cost benefit analysis, life cycle analysis.

Think *holistically:* Interdependency of systems is the key to success.

Think *collaborative:* Team solutions translate to better designed facilities.

Think *innovation:* Every project has it challenges — and opportunities.

Think *engineering:* Start with calculations such as dissipation and diversification of loads.

Think *economic:* The rebate incentives are very attractive beyond the mandated performance.

Think *innovatively*: Be guided by the "think" concepts above.

This paper was presented at the 2010 NAB Broadcast Engineering Conference by Antonio Argibay, AIA, LEED AP Meridian Design Associates, Architects, P.C.

REFERENCES

1. LEED Public Policies (December 9, 2009) publicpolicies@usgbc.org
2. From U. S. Green Building Council Web site *http://www.usgbc.org/*
3. LEED Project List — Public USGBC December 8, 2009, excludes projects registered under 2009 version.
4. U.S. Department of Energy. Buildings Energy Data Book 2009. *http://buildingsdatabook.eere.energy.gov/*
5. The Inside Story: A Guide to Indoor Air Quality. U.S. EPA/Office of Air and Radiation. Office of Radiation and Indoor Air (6609J) Cosponsored with the Consumer Product Safety Commission, EPA 402-K-93-007.
6. From U.S. Green Building Council Web site, What LEED Delivers *http://www.usgbc.org/*
7. David Stenftenagel, York International for U.S. Department of Energy, EERE. Assessment of savings can vary widely, by system, location and several other parameters.
8. *http://www.inhabitat.com/2009/08/04/citi-datacenter-leeds-germany-to-a-green-future/*

'Gauge' the Information With Care

Wire Question Tests Practical Knowledge

BY CHARLES S. FITCH

To help you get in the SBE certification exam frame of mind, we pose a typical question in each column. Although similar to actual questions, these are not from past exams nor will they be on future exams in this exact form.

Besides the technical side of the instructional questions poised in this column, we've often discussed the nature of test taking and the style of questions as well.

In general, questions can be categorized at the extremes as "too much information" or "minimal information" questions. The question we asked last time, repeated at right, is an example of the former. Stripping out the extraneous (too much information), what remains is this:

— We need to limit the voltage drop to less than 5 percent of the supply voltage.
— The considered current load is 62 amps.
— The supply voltage is 240 volts.
— The length of the cable is 250 feet.
— Only one answer is correct.

Overall, the purpose of these SBE certification exams is to confirm your practical and formal knowledge of the technology and regulations that make up the core of our industry. The precise purpose of this question, although buried in rhetoric, is to test your general knowledge about wire sizes and their capabilities.

I've always felt that the way wire sizes are numerically described is counterintuitive. One would logically think that the bigger the wire, the bigger the associated number should be for that wire size. The reality is the reverse.

To bring order, near the turn of the last century the Brown and Sharpe Company standard became the standardized American Wire Gauge.

In the early days of wiring America, competing firms and technologies had unique and varied ways and numerology to describe the sizing of wires. To bring order from chaos, near the turn of the last century, the Brown and Sharpe Company standard became the standardized American Wire Gauge (that's the AWG you see on wire boxes such as the 12-2 with ground romex you buy at Home Depot). B&S's system essentially doubled the volume of the wire every three numbers and defined precise cross section dimensions for each size. Most wire was solid at that time and made from molten copper pulled through a die (extruded).

The question-level is CPBE level, so we can assume that the person taking the exam has at least 20 years of quotable, employed industry experience. Wires make up a major part of our systems and installations. A practitioner at this stage in his or her career without knowledge of wire types, sizes and use deserves to fail.

A quick glance at the answers would indicate that answers (a) through (c) are incorrect on their faces, as their

Table 5-1. Table of Standard Annealed Bare Copper Wire Using American Wire Gage (B & S)

Gage (AWG or B & S)	Diameter	Area	Weight	Length	Resistance at 68° F	
	Inches (Nom.)	Circular Mils	Pounds per M'	Feet per lb	Ohms per M'	Feet per Ohm
0000	.4600	211,600	640.5	1.561	.04901	20,400
000	.4096	167,800	570.9	1.968	.06180	16,180
00	.3648	133,100	402.8	2.482	.07793	12,830
0	.3249	105,500	319.5	3.130	.09827	10,180
1	.2893	83,690	253.3	3.947	.1239	8,070
2	.2550	66,370	200.9	4.977	.1563	6,400
3	.2294	52,640	159.3	6.276	.1970	5,075
4	.2043	41,740	126.4	7.914	.2485	4,025
5	.1819	33,100	100.2	9.980	.3133	3,129
6	.1620	26,250	79.46	12.58	.3951	2,531
7	.1443	20,820	63.02	15.87	.4982	2,007
8	.1285	16,510	49.98	20.01	.6282	1,592
9	.1144	13,090	39.63	25.23	.7921	1,262
10	.1019	10,380	31.43	31.82	.9989	1,001
11	.09074	8,234	24.92	40.12	1.260	794
12	.08081	6,530	19.77	50.59	1.588	629.6
13	.07196	5,178	15.68	63.80	2.003	499.3
14	.06408	4,107	12.43	80.44	2.525	396.0
15	.05707	3,257	9.858	101.4	3.184	314.0
16	.05082	2,583	7.818	127.9	4.016	249.0
17	.04526	2,048	6.200	161.3	5.064	197.5
18	.04030	1,624	4.917	203.4	6.385	156.5
19	.03589	1,288	3.899	256.5	8.051	124.2
20	.03196	1,022	3.092	323.4	10.15	98.5
21	.02846	810.1	2.452	407.8	12.80	78.11
22	.02535	642.4	1.945	514.2	16.14	61.95
23	.02257	509.5	1.542	648.4	20.36	49.13
24	.02010	404.0	1.223	817.7	25.67	38.96
25	.01790	320.4	.9699	1,031	32.37	30.90
26	.01594	254.1	.7692	1,300	40.81	24.50
27	.01420	201.5	.6100	1,639	51.47	19.43
28	.01264	159.8	.4837	2,067	64.90	15.41
29	.01126	126.7	.3836	2,607	81.83	12.22
30	.01003	100.5	.3042	3,287	103.2	9.691
31	.008928	79.7	.2413	4,145	130.1	7.685
32	.007950	63.21	.1913	5,227	164.1	6.095
33	.007080	50.13	.1517	6,591	206.9	4.833
34	.006305	39.75	.1203	8,310	260.9	3.833
35	.005615	31.52	.09542	10,480	329.0	3.040
36	.005000	25.00	.07568	13,210	414.8	2.411
37	.004453	19.83	.06001	16,660	523.1	1.912
38	.003965	15.72	.04759	21,010	659.6	1.516
39	.003531	12.47	.03774	26,500	831.8	1.202
40	.003145	9.888	.02993	33,410	1,049	0.9534
41	.00280	7.8400	.02373	42,140	1,323	.7559
42	.00249	6.2001	.01877	52,270	1,673	.5977
43	.00222	4.9284	.01492	67,020	2,104	.4753
44	.00197	3.8809	.01175	85,100	2,672	.3743
45	.00176	3.0976	.00938	106,600	3,348	.2987
46	.00157	2.4649	.00746	134,040	4,207	.2377

A portion of a table of wire characteristics, descending from the very large '0000.' Notice caveats that resistance is at 68°F and wire is bare (not coated and not insulated). This is from Dr. Key's 'Principles of Electricity.'

current carrying capacity in power handling applications is under 30 amps. Also, the National Electrical Code, which governs electrical power wiring in the United States for approval and insurance purposes, will not allow a conductor smaller than a #14 to be installed in a power supply application such as this in a commercial installation.

The NEC allows the use of both copper and aluminum wiring for most power purposes with the current rating of a comparable-sized aluminum conductor proportionately less than copper (aluminum has less free electrons). So answer (d) could possibly be dismissed because the smaller size of this wire limits the answer to the single and last selection, (e).

Although the question appears to be complex, your practical knowledge should take you quickly to the probable answer.

LET'S DO THE NUMBERS

However, suppose that the choices were all quite similar-sized wires. Then the question would become a calculation exercise.

Besides the "The National Association of Broadcasters Engineering Handbook," "The ARRL Handbook for Radio Communications," "ITT Radio Engineer's Handbook," "Electronic Communication" by Robert Schrader and

Watch That Drop

Question posed in the Feb. 17 issue
(Exam level: CPBE)

You are preparing an executive summary for management outlining the projected cost of various aspects of new facilities at your station. You need to calculate the wire size for the main power feed to the remote truck.

This truck will be used as the ultimate studio backup in the event of a long-term utility power outage. The HVAC and terminal equipment in the truck make this a notable load, so the wire is a large part of the cost. An NEC requirement is to limit voltage drops at the load to under 5 percent of the nominal supply voltage.

The worst-case load, with both HVAC units running on a 95 F day and all lighting and gear running, is 62 amps at 240 volts. The wire distance to the trucks reserve parking space is 250 feet.

Ignoring power factor (PF) and incidental issues, from the panel CB to the local disconnect supplying the truck, which size wire will limit the voltage drop to under 5 percent?

a. #18 copper TW
b. #16 copper TW
c. #12 copper THHN
d. #8 aluminum USE
e. #4 copper THHN

maybe "Radio Handbook" by William Orr, you should also have a copy of the National Electrical Code, published by the National Fire Protection Association, or Dr. Eugene Key's "Principles of Electricity" that we all used in undergraduate or tech school.

Since we can ignore all other factors, the wire resistance becomes the limiting dynamic in our calculation. Since we have a probable answer on its face, let's consider the #4 THHN copper conductors. We have 250 feet out and 250 feet back of #4 copper. From Table 8 in the 2008 edition of the NEC, we have a per foot resistance of 0.000321 ohms (0.321 ohms per 1000 ft) for typical coated wire as you usually find in THHN manufacture.

Calculating the exact answer:

500 ft times × 0.000321 ohms per ft = 0.1605 ohms total wire resistance for 500 ft

62 amps × 0.1605 ohms = 9.951 volts drop

9.951 volts drop divide by 240 volts = 0.0415

Converted to percentage = 4.15%
(which is under 5%)

Our distinguished and super-punctilious editor has noticed that various tables for wire resistance often differ. The values in the NEC tables are calculated to reflect the anticipated operating temperatures, wire coating (if present which attenuated cooling) and the environment inside of the usual insulation encountered in these conductors based on values supplied by the National Bureau of Standards.

The table that accompanies this article is for bare wire

(continued on page 12)

MINSTRUMENT MATRIX

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

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- Monitor DA converter and headphone/speaker amp
- Audio scope mode

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

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- 24 bit 2 channel digital audio up to 192 kHz SR
- Sine wave with stepped & continuous sweeps; White & Pink Noise; Polarity & Delay test signals
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- Channel Transparency measurement
- I/O Delay Measurement
- Sync to AES3, DARS, word clock & video black burst
- User-generated test signal files

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The AL1 Acoustilyzer features extensive acoustical measurement capabilities as well as analog audio electrical measurements such as level, frequency and THD+N. With both true RTA and high resolution FFT capability, the AL1 also measures delay and reverberation times.
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Analog Audio Generator + Impedance/Phantom/Cable measurements

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- Cable tester and signal balance measurement
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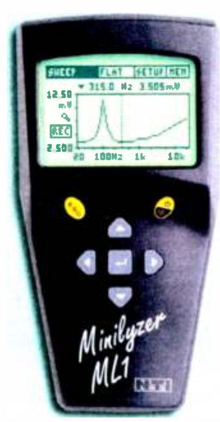
Analog Audio Analyzer



The ML1 Minilyzer is a full function high performance audio analyzer and signal monitor that fits in the palm of your hand.
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Let's Start With the Hardware

PC Problems Aren't Always in the Software

BY STEPHEN M. POOLE

When you think of a computer professional, you probably imagine someone who sits at a terminal screen entering cryptic commands. This is part of it, but I want to start with the fundamentals. In this article, we'll look at some ways to determine whether a computer problem is being caused by software, or by hardware.

In the digital age, we sometimes forget that power supplies get old, cables become intermittent and hard drives fail. These problems can be surprisingly difficult to track down too. The PC will appear to work fine for a while, then suddenly shut off or reboot for no obvious reason and with no warning. I know from browsing the community forums online that this can throw even the most experienced professional. They'll spend hours reinstalling the OS and tinkering with configuration settings … when the problem could be as simple as a dirty heat sink.

Here's the rule: Unless you have made a change in software or system settings *immediately prior to the problem appearing*, it's probably the hardware.

Now, you should do regular backups (e.g., in Windows, you can use "restore points") to keep a "known good" configuration to fall back on to verify the software. Remember, "software changes" could include malware that was installed without your knowledge. You should regularly scan any Windows PC for viruses and trojans, especially if it accesses the Internet. But that rule will save you a lot of grief in the long run. Don't overlook the hardware!

To lay the groundwork, let's review what a PC needs in order to work reliably:

- A clean, reliable AC power source
- Plenty of cooling air
- Good electrical connections on all plugs, peripherals and hardware

GOOD AC POWER

You'd think this was obvious, and it should be. Unfortunately, with computers becoming ubiquitous in the typical broadcast facility, we're just plugging them in wherever there's an available outlet. As a result, you'll find PCs on the same AC branch with vending machines, air conditioners and worse. This may work at first, but as the computer ages, the power supply becomes less able to smooth out noise on the AC line and you'll start having problems.

If you're fortunate enough to be doing a new installation, don't pass up the opportunity to do it right to begin with. You should specify dedicated, single-outlet-per-breaker runs for all digital equipment, with big UPS units on all critical systems.

In an existing building, it's not so easy. If your budget won't allow hiring an electrician to install a dedicated outlet, you may have to become creative. You may actually find yourself running a heavy extension cord from a known-good source of AC in some cases. However you do it, the AC power to a PC must be clean and reliable.

Of course, "reliable" is a relative term. You must also make sure that your UPS units are working and have fresh batteries. Ironically, the power companies have gotten better at switching to backups during maintenance, which introduces a new issue: You may not even notice the lights flickering, but your PC will. The first sign of a problem might be someone shouting, "My computer just locked up!" You should also keep a known-good UPS handy as a spare for testing.

From my experience, the batteries in most UPS units last only a couple of years at most. The better ones have a "test" button that should be used regularly. Make this part of your regular maintenance schedule. When you install a UPS, make sure it's well-ventilated, because heat is the number one killer of batteries — and on that subject in general …

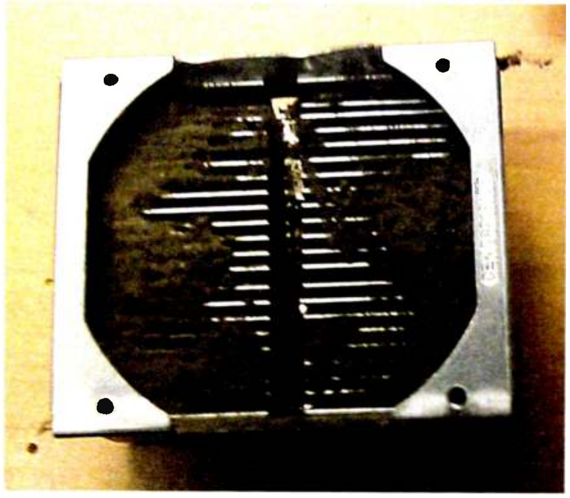

Fig. 1: This clogged heat sink was obscured by the fan.

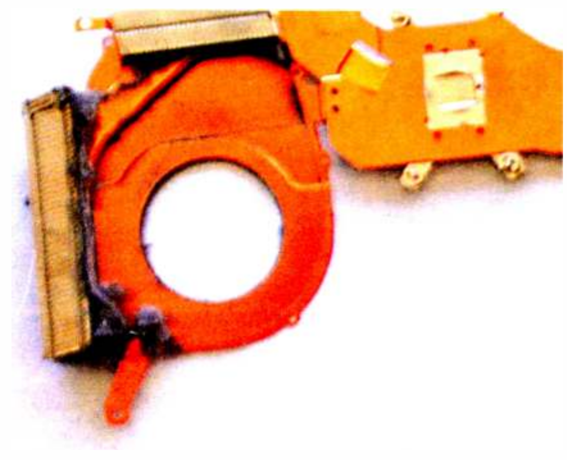

Fig. 2: This laptop suffered a complete processor failure due to dust on the heat sink.

HEAT IS YOUR ENEMY

This rule applies to all electronics, and the figures shown here were the inspiration for this article.

Most of us wouldn't think of running a transmitter with the same air filters for years, but we tend to forget that dust collects in computers too. A layer of dust acts as an insulator, trapping heat. This can cause components to become dangerously warm, ultimately resulting in failure.

This is especially true of microprocessors, which concentrate a lot of heat into a relatively tiny core area. Without a sink and a fan to draw out and dissipate that waste heat, a dangerous CPU temperature rise can result in a matter of *seconds*. Modern PC processors usually include a protection circuit that will do an immediate, emergency shutdown if the processor core becomes too hot. The symptom is that the PC will run for anywhere from a few seconds to several hours, then suddenly (and usually without warning) shut off — just as if someone flipped the power switch.

When you run across this, assuming that it's not something obvious (like a loose power cord), it's likely heat buildup. Open the PC case and start cleaning. The fans should turn smoothly and without noise.

Dust can hide where you won't notice it. Fig. 1 shows a typical Pentium-class heat sink that appeared

(continued on page 14)

GAUGE

(continued from page 10)

resistance at 68°F. Wire resistance increases with temperature essentially at a proportional value of very nearly 0.00218 per degree F for this bare wire.

A piece of electrical trivia most practitioners do not know is that electrical wiring has to be made from virgin copper. Other copper products such as motor cores, radiators, house flashing, etc. can be made from reclaimed copper, as the wide variation in electrical conductivity found in reclaimed copper is not important.

I'll leave you to do the calculation for the #8 aluminum.

The deadline for signing up for the next cycle of SBE certification exams is June 4 for exams given at the Local Chapters between Aug. 6–16.

Missed some SBE Certification Corners or want to review them for your next exam? See the "Certification" tab under Columns at radioworld.com.

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

Do You Measure Up?

Question for next time

(Exam level: CBRE)

This Sunday night you are going to install a new HDFM exciter, which also generates the composite stereo signal. Are you required to do performance measurements?

a. No, as long as there is no change in modulation level.

b. Yes, because you're a professional and you want to know that the station is measured perfect no matter that the program director says his "golden ears" are better than your test gear.

c. No, there is no FCC mandate to do this, and anyway performance is set by the manufacturer's checkout.

d. Yes, under the general guidelines of 77.12966 b.3 any equipment change requires performance measurements.

e. Yes, 47CFR73.1590(4) requires performance measurements when a stereo generator is first installed.

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Thermal Management of Studio Installations

Some Basics of Heating and Cooling Systems

BY BLAŽO GUZINA

The heating, ventilating and air-conditioning (HVAC) requirements of employees and equipment in a sealed space are important considerations in designing a radio or TV station.

The exact air-conditioning load for studio and control room depends on the equipment power consumption and the rate of airflow into the room for a given outside air temperature. Other adverse environmental conditions, such as humidity, also should be factored in.

The design goal of ensuring comfort and safety for employees, along with specific operational challenges such as 24-hour cooling, requires an HVAC system that delivers conditioned air to the studio at a low velocity and distributes it according to convection and diffusion principles.

Good air distribution is also important to ensure that equipment operates at the proper temperature.

THERMAL MANAGEMENT

In the HVAC system design, special attention should be paid to the issue of thermal management within a studio installation.

Thermal management is not just a matter of introducing cool air to a facility, but also removing the heated air. Simply injecting cooler air does not assure that heated and cooled air will merge and create a desired average temperature.

Due to the laws of physics, pockets of hot air will develop, isolating the cold air from where it is needed and concentrating the heated air into areas where it can do the most harm. These areas are most frequently the equipment racks. Therefore, try to manage a thermal environment, not to fight it.

Simply injecting cooler air does not assure that heated and cooled air will merge and create a desired average temperature.

The issue has gained special importance over the past two decades, with the introduction of personal computers and other digital equipment sensitive to dust and humidity. Consequently, air filters are now found not only within the air conditioning system, but also at the air inlets of sensitive units of equipment.

PASSIVE OR ACTIVE

There are two primary approaches to thermal management: passive and active. Passive solutions make the most out of venting and understanding the behavior of heat to maximize the efficiency of vents. Active solutions are based on designing fans to move air in a predetermined path.

A good approach to thermal system design means resolving two airflows: 1) the way heated air travels through the equipment rack and 2) the path of the air throughout the room. These two airflows will interact.

It is up to the design of the thermal management system to assure that all heat generated by equipment is first removed from the rack and eventually from the room.

Knowing that there are many radio stations around the world that do not have air-conditioned environments, it is important to fulfill at least the minimum requirements for venting the rooms to assure that heat from the racks does not raise significantly the ambient temperature.

Many radio professionals believe that studios and control rooms should be no hotter than 24°C (75°F), while internal rack temperature should not exceed 30°C (86°F). The latter figure is important to assure proper equipment function and longevity. For every 10°C (18°F) increase above 20°C (68°F) long-term reliability of studio equipment is reduced by 50 percent.

HOT SPOTS

Proper planning of airflow inside a rack ensures that the waste heat is effectively removed and no hot spots occur.

When the cooler air is taken from the front and the heated air exhausted toward the rear or sides of the cabinet, this is known as front-intake equipment. In opposite case, when the cooler air is taken from the rear and the heated air exhausted toward the front of the cabinet, this is known as rear-intake equipment.

In both cases, the largest heat load will come from power amplifiers. Hence, the amplifiers and other hotter equipment should be placed in the lowermost part of the rack. This approach helps the natural convective rise of heat.

Experience shows that moving air through a rack from bottom to top results in the lowest internal temperatures.

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HARDWARE

(continued from page 12)

to be fine at first glance. But once the fan was removed, it became obvious that it was essentially useless due to a thick blanket of dust.

Don't assume that this only happens to big desktop PCs, either. Fig. 2 is an example from a laptop. In this case, this user kept restarting the computer over and over, and the processor was finally destroyed by overheating. The moral of the story is to *train your employees*: If a PC cuts off for no apparent reason, they can check for loose power plugs or a flaky UPS. But tell them not to keep pushing the power button! If the problem doesn't clear up, they need to leave that PC alone until you can investigate.

One other tip: While you've got the PC opened for routine cleaning, examine the motherboard. Power it up and use an infrared thermometer to check for unusual hot spots. Nothing inside that box should show more than 140 degrees Fahrenheit (and the lower, the better). Look at the capacitors. Are they starting to bulge and look "swollen" on top? If so, replace that motherboard or plug-in card ASAP. It's a failure waiting to happen.

BAD CONNECTIONS

The symptoms in this case will be random hangs, missing or blank screens and other weirdness. Here you really will wonder if it is the hardware or software. But remember the rule that we stated above: *If you haven't changed the software or system settings*, it's most likely a hardware issue.

The connections to, from and inside your PC must work at very high (or even UHF) frequencies. You wouldn't dream of doing a sloppy job on a Type N connector for an STL link. Equivalent care should be used when you crimp an RJ-45 plug onto CAT-5e for your 10 or 100 Base-T network. (Note: if it's Gigabit Ethernet, you may need to hire a pro and/or use special test equipment to build and maintain the cables.) Take your time and do it properly. Buy one of those inexpensive cable testers and use it. Wiggle the cable at both ends and make sure the indicator lights remain solidly lit.

These problems can be quite difficult to run down as well. One obvious clue is if you move the PC to a different network connection and it starts working properly. I have mixed feelings about network patch panels and wall jacks too. While they can make your installation a lot neater-looking, they also add additional points of failure. Speaking from experience, punch-type wall jacks are notorious for becoming intermittent over time. Every engineer should keep a 100–200-ft known-good CAT-5 cable handy for troubleshooting. If the PC seems to work properly on that cable, you've got a bad connection somewhere in the existing run.

Inside the PC, corrosion and loose connections can be a problem as well. If a RAM stick isn't making good contact with its socket, you can get random hangs. Remove the cover on the PC and gently push on the RAM while it's running. Because this can also cause random reboots (less likely than a hang, but still possible), you should always check the RAM and all motherboard connections whenever you're cleaning the innards of a PC.

OLD, WORN HARDWARE

The most common failure, of course, is with disk drives. There are some free utilities online that will help you to troubleshoot these issues; those rate a separate article of their own in the future. For now, don't forget that peripherals and plug-ins won't last forever, either — sound cards, network cards and USB "sticks" will all fail in time. The best idea here is to keep some known-good spares handy for troubleshooting, or to swap a known-good unit from one PC into the one that's giving trouble.

A lot of this is just common sense and standard troubleshooting techniques, but I'll repeat the key point in closing: if your PC hasn't had major software upgrades or configuration changes made recently, but is shutting down for no apparent reason, crack the cover! It's probably the hardware.

Stephen M. Poole, CBRE-AMD, CBNT, is market chief engineer at Crawford Broadcasting in Birmingham, Ala.

THE OFFICIAL WHEATSTONE NON-TEASER NAB TEASER AD

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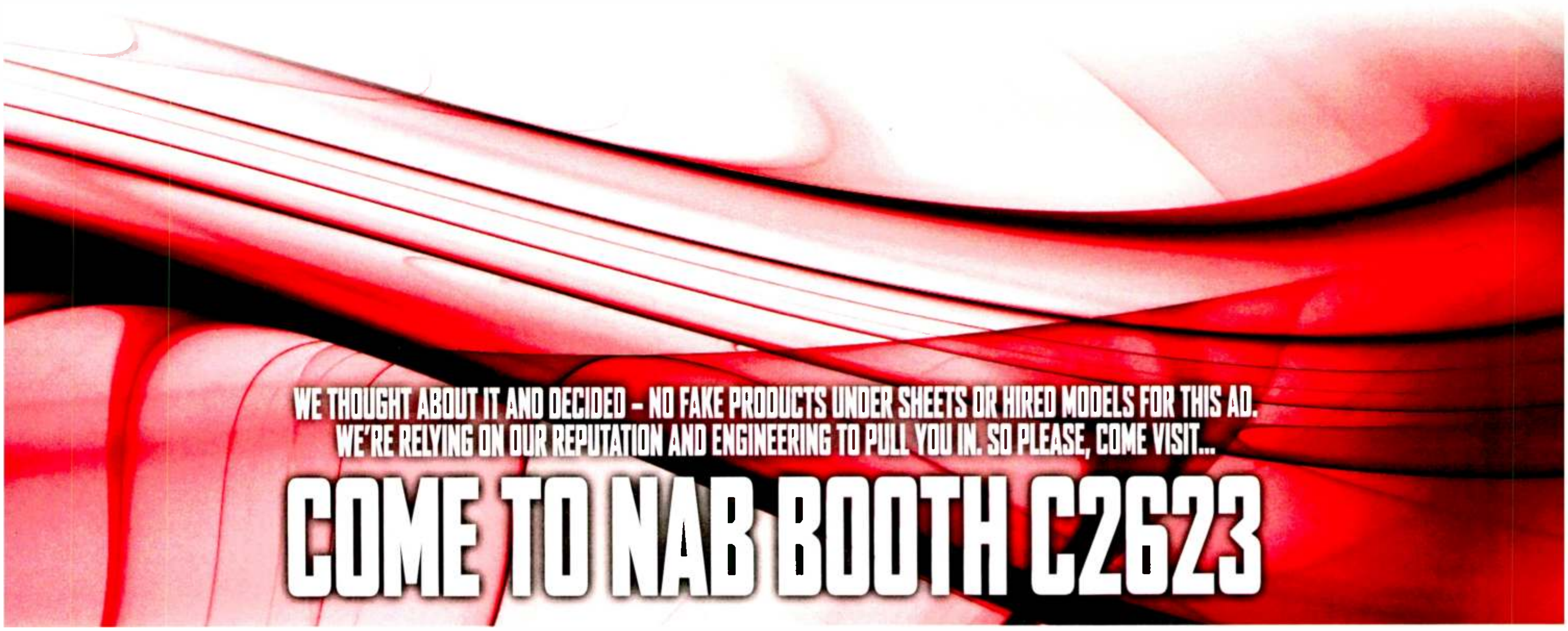

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HVAC

(continued from page 14)

Passive convection of heated air (without fans) will benefit also from the largest racks. Wider racks assure a good chimney effect by drawing heat upward more effectively.

To create an unimpeded airflow inside the rack, the vent openings should be at the bottom and the top of the rack, never at the middle. Also, care should be taken when equipment is stacked directly on top of one other, in order not to block the intake vents on the bottom and the exhaust vents at the top of the unit.

A lot of equipment has internal fans. The air exhausted by internal fans will cause the recirculation of the rack air and may disturb the natural convective rise of heat. A similar problem may arise if the rack is placed directly under supply ductwork. Cold air falls and goes in the opposite direction to the natural convective rise of heated air.

When too many pieces of hot equipment are within a rack, passive thermal management is not a solution, and it becomes essential to force heated air from the rack. This is active thermal management. It means that fans are used to remove heat from an equipment rack.

The best spot for fan placement is in the top of the rack, where the hot air is concentrated and needs to be removed. Vertical placement of fans is appropriate where there is possibility of contaminants falling into the rack.

The use of multiple fans requires that they be checked regularly for proper operation. If one fan stops functioning, it acts as a passive vent, i.e., a short-circuit path for the airflow. A nearby fan or fans which are still functioning will not effectively remove heat from the rack due to this short-circuit path.

Similarly, place vent blockers over all intake points close to the fan and at other positions except at the top of the rack.

Proper fan and vent placement helps force more air into the rack, and assures correct airflow to break up eventual hot spots.

The same approach applies for shelves within a rack. Shelf surfaces are an obstruction to airflow. To prevent a temperature rise in the lower parts of the rack, shelves have to be vented. In general, more open area in the form of slots or perforations on a shelf surface is always better.

FAN PERFORMANCE

When it comes to the choice of fans, two terms are essential for describing and understanding their performance: airflow rate and static pressure.

Airflow rate is the volume of air (in cubic meters) moved per minute. The airflow rate of fan (or fans) at the top of the rack has to be greater than the sum of airflow rates of all the fans built into the equipment within the rack.

Static pressure is the pressure or suction the fan is capable of developing. As the air travels through intake vents, the air pressure drops. The fan selected must be capable of operating at a given static pressure, as a measurement of resistance to airflow. Otherwise, the airflow rate will drop.

A proper use of fan(s) at the top of the rack, in combination with the equipment's built-in fans, will increase the static pressure. The air will be pulled through the vents more effectively when both the rack and units' fans work together as a team.

DUST AND HUMIDITY

In a humid environment, generally an area with a relative humidity of 70 percent or greater, dust will absorb the air moisture. The result is increased accumulation of dust on equipment circuit boards.

All sensitive digital equipment and PCs will be affected unless proper air filtration is used. Filters on the air conditioning system and within the equipment have to be cleaned regularly.

Along with filters, another systematic measure will help prevent equipment failure: the proper use of the fan's speed control. A general rule is that the lower fan speeds have the effect of decreasing the amount of deposited dust. If dust is deposited on circuit boards inside the equipment, it will further reduce its thermal transfer, resulting in shorter life-time and potential malfunctioning of sensitive equipment.

NOISE ASPECTS

Noise is another important consideration with air-conditioning and active thermal management of studio installations.

Structure-borne noise is produced by the vibrations of the HVAC motor, fan and compressor — the same as from any machine. Aerodynamic noise is produced by the air flow in the ducts and through grilles and diffusers.

Transmission of these noises from air-conditioning system via the ductwork to all studio facilities is a major problem. Hence, correct planning at an early stage will save costly modifications later on.

The designers of an HVAC system should cooperate closely with the acoustics consultant and provide sound silencers and acoustical lining in the ductwork, if necessary, to meet studio noise criteria.

Noise transmitted through air-conditioning ducts must be attenuated before it enters critical studio areas, i.e., the passage of sound from one place to another must be prevented or at least reduced to an acceptable level.

The use of fans with the capability of precise, dynamic control of the variable-frequency drive allows us to vary the fan speed and the air velocity in order to minimize the transfer of sound and vibration.

Furthermore, to meet noise criteria, the required slow-speed airflow is achieved by increasing the cross-sectional area requirements for ductwork and grilles, while the exit velocity at the diffuser of the air-conditioning system is reduced. Low-velocity air supply helps to eliminate noise caused by turbulence in the duct and grille.

Typical design requirements are 1 meter per second for grille velocity and 10 changes of air per hour for medium-sized studio facilities.

Some radio and TV broadcasting studios and control rooms have additional, separated technical equipment facilities, called machine rooms or central technical areas.

Good air distribution and thermal management are also important for these facilities to maintain the equipment at the proper temperature.

Blažo Guzina, M.Sc., Dipl.-Ing., is a senior engineer within the Technical Department of Radio-Televizija Srbije. He is the author of the Serbian-language books "Sound Recording Technique" and "Audio Techniques in Radio and Television." Contact him via e-mail at blazo_guzina@yahoo.com.

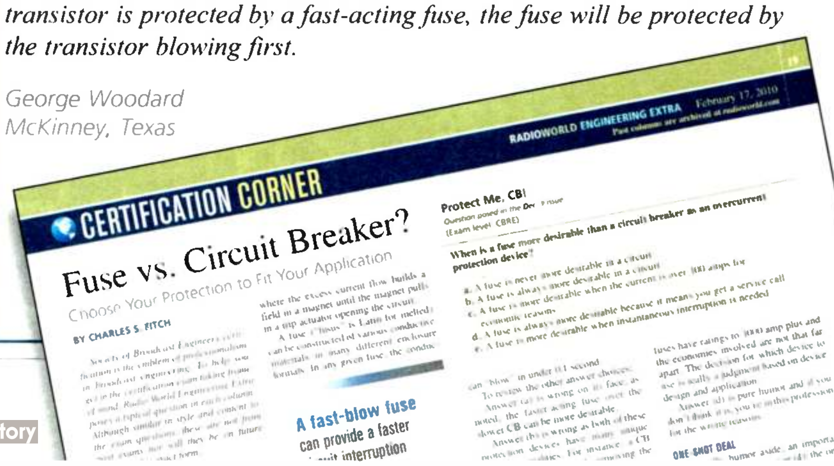
READER'SFORUM

COROLLARY #18

Michael, in response to Buc Fitch's article on fuses and circuit breakers (Feb. 17), I offer the following:

Corollary #18 to Murphy's Basic Law: In any electronic circuit where a transistor is protected by a fast-acting fuse, the fuse will be protected by the transistor blowing first.

George Woodard
McKinney, Texas



RADIOWORLD ENGINEERING EXTRA February 17, 2010

CERTIFICATION CORNER

Fuse vs. Circuit Breaker?

Choose Your Protection to Fit Your Application

BY CHARLES S. FITCH

Protect Me, CB!

A fast-blow fuse can provide a faster circuit interruption

MEASUREMENT

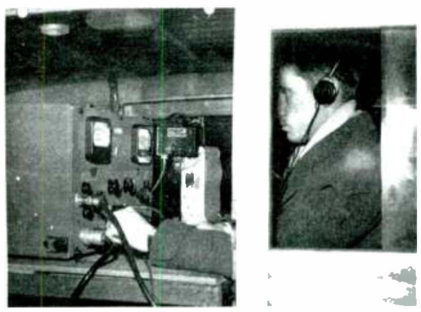
(continued from page 1)

tests for their transmission system, which included field measurements to demonstrate that their radiated signal strength was as expected.

In the 1940s and 1950s, station engineers, or their consultants, carried out extensive measurement programs and filed the results with the FCC. This often required equipping a vehicle with a tall mast and dipole antenna (FCC field strengths are specified at 30 feet above ground) and heavy equipment.

Top: Fig. 1: A 1948 Ford 'woody' station wagon used for the antenna proof of WJZ(TV), Channel 4, Detroit, taken in the winter of 1950-51.

Bottom: Field engineer working in the wagon with the field strength meter (left) and chart recorder (center).



An example is the photo in Fig. 1, taken from the proof for WJZ(TV), Channel 4, Detroit, filed Feb. 13, 1950, of a 1948 Ford "woody" station wagon with the dipole mounted above the rear roof. The inset photo shows the interior of the wagon, equipped with a RCA field strength meter and paper chart recorder in the background, operated by an unnamed engineer from William L. Foss Inc. in Washington. Taken in the winter of '50/'51, that's Michigan snow under the wagon.

Fig. 2 shows the equipment in detail: The RCA Type 301-B field strength meter contained a step attenuator, tunable band pass filter, RF amplifier and detector/filter, which produced a DC

(continued on page 18)

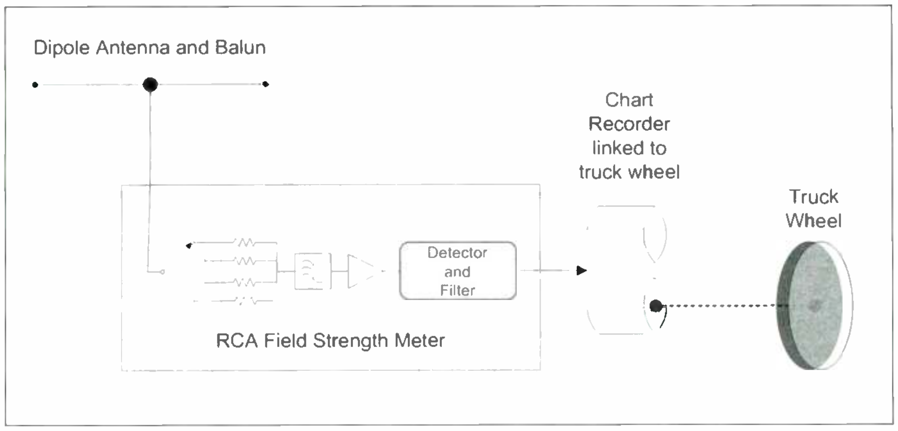


Fig. 2: Details of the 1950 measurement system, using a RCA Type 301-B field strength meter containing an attenuator set, tunable RF filter and amplifiers, and detector with DC output; the chart recorder's movement was linked to the vehicle's motion, to ensure correlation to the distance traveled in each mobile run.

MEASUREMENT

(continued from page 17)

output voltage that was proportional to the RF signal voltage. The DC voltage was applied to the chart recorder's galvanometer, which moved a pen across the paper proportional to the voltage, at right angles to the motion of the paper as it rolled through the recorder. Typically, the winding of the paper was synchronized by speedometer cable to a wheel on the vehicle, so the recording speed was made at a uniform rate of wavelength travelled per second.

Early field strength measurements required numerous (at least a dozen) field strength measurements along a radial from the transmitter. At each location, the vehicle slowly drove a 100-foot mobile run, continuously recording the field strength on the chart paper. Later, the charts were analyzed by hand to determine the median field, and the group of measurements was then plotted as a cluster of points on a chart of distance vs. field strength, as shown in Fig. 3. Taken as a curve through the points, individual variations were minimized and the effect of the antenna's radiation efficiency could be determined. This process was repeated on numerous other radials to develop an antenna radiation pattern and coverage map. Clearly, this was a laborious and costly process, but it was capable of providing remarkably accurate and repeatable measurements.

Moving to the present, beginning in 2004, NPR Labs needed to collect field strength data from FM radio stations along with reception performance of mobile HD Radio receivers. Instead of 100-foot mobile runs, we needed to gather the signal strength along roadways extending over wide areas of an FM station's coverage. Rather than estimating the radiation pattern of the station, the purpose of these measurements was to examine the digital receiver's behavior as a function of field strength, which was valuable in developing a model for predicting HD Radio coverage.

As shown in Fig. 4, NPR's mode of transportation is more modern, and considerably more comfortable for its field measurements than the 1950-era example. Typically, we use small sedans or crossover SUVs, since the measurement equipment had shrunk to a small box or two that could ride on the back seat, as shown on the inset to Fig. 4; but more on the design of the measurement instrumentation later.

MODERN REFERENCE ANTENNA

Based on years of earlier testing with a magnetic mount antenna on the roof of vehicles, we realized that the gain of the antenna seemed to vary from one vehicle to another. This was understandable, since the size, shape and flatness of vehicle roof, which becomes the ground plane of the antenna, differ considerably from one vehicle to another. Equally important, we needed to know the absolute gain of the antenna, to correctly convert received signal power into an ambient field strength.

The solution was the design of a calibrated monopole antenna with a ground-plane that "floated" above the roof of the car, helping to isolate it from the car body's influence. Built by Kintronic Labs, the finished antenna is shown in Fig. 5. It has a circular frame 60 inches in diameter, with an expanded metal mesh ground plane. The ground plane is segmented into four pie-shaped sections that are held together with captive bolts and wing nuts, allowing the antenna to be dismantled quickly and packed in a box for shipment. The ground plane is clamped to roof rails with standard mounts to fit almost any vehicle. We've used this antenna on stations from coast to coast, measuring thousands of miles, without a bit of mechanical or electrical

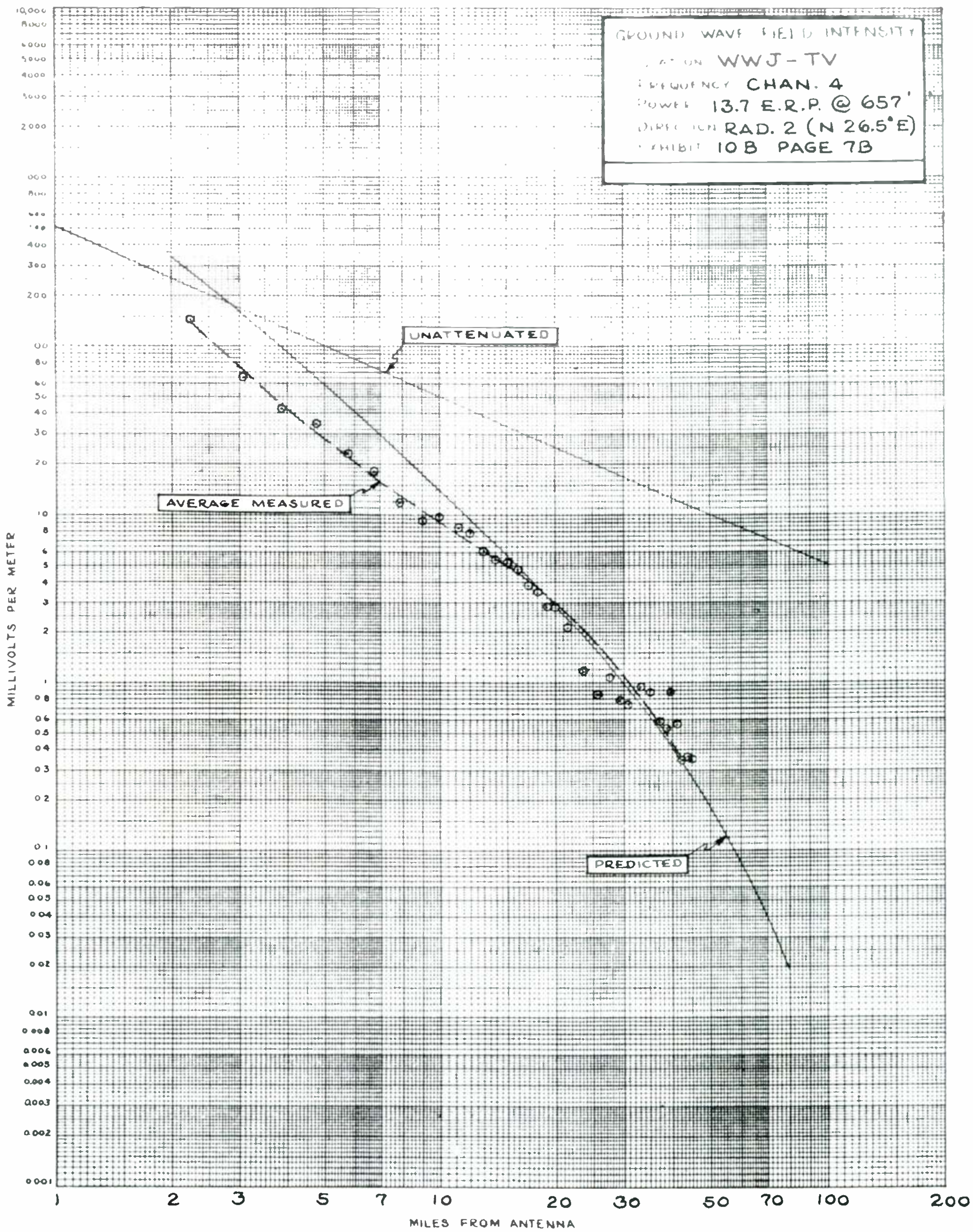


Fig. 3: A chart of one of the radial measurements from WJZ(TV)'s 1950 proof, showing the field strength (vertical scale) vs. distance of many measurement points, with a curve-fit for comparison to the FCC's (then) field strength prediction curve.

trouble. To some, however, it resembled a "flying saucer" hovering over the car, and we've received many puzzled looks from other drivers, and even had a few curious police officers ask what we were doing (although, so far, only while we were parked!).

The FM band is covered with a set of four monopoles sized to approximately 1/4 wavelength for each sub-band. The stainless monopoles attach to the center groundplane connector through an insulated base with a series capacitance that counteracts inductive reactance. Kintronic measured each monopole with a network analyzer and trimmed the lengths and capacitance for the best match.

The antenna was calibrated at the Table Mountain Test Range, near Boulder, Colo., operated by the Institute for Telecommunications Science (part of the U.S. Dept. of Commerce). Table Mountain is like the name implies, an eerily flat mesa rising above the Colorado plains — perfect for conducting signal measurement tests without the reflections of buildings, trees or even bushes. As Fig. 6 shows, Table Mountain has a turntable capable of rotating the entire car, which was used

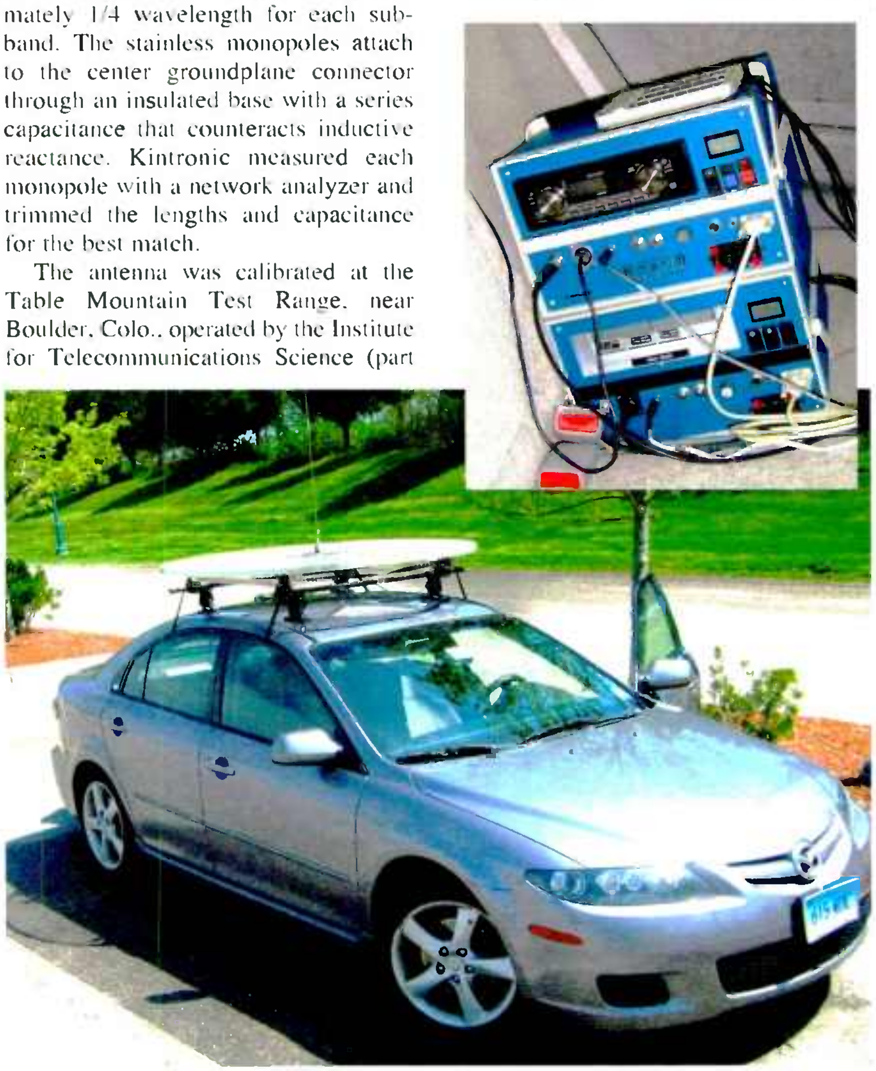


Fig. 4: A rental car equipped with NPR Labs' calibrated ground plane measurement antenna, taking signal and interference measurements near Brush, Colo. Inset: A backseat view of the Field Test Unit, configured for three-signal field strength collection (lower unit) plus HD Radio tracking and data logging (upper unit).

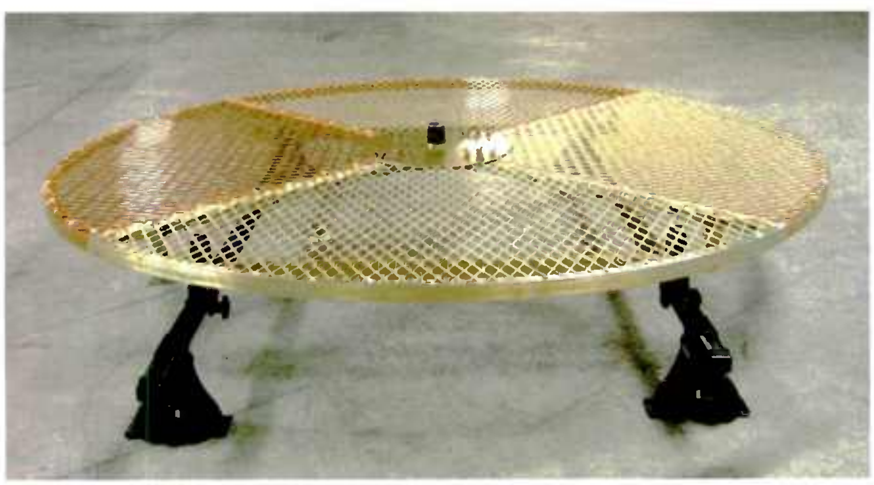


Fig. 5: The modular design of the ground plane antenna is visible in this photo, taken after assembly at Kintronic Labs. A set of standard roof rails attaches the antenna to any vehicle.

Fig. 6: The ground plane antenna undergoing calibration on the 30-foot turntable at Table Mountain Test Range, north of Boulder. The horizontal pattern uniformity on the vehicle was performed by rotating the entire vehicle, which contained a reference signal generator, and measuring test signals from a calibrated receive antenna near the measurement van, visible in the background.

for pattern measurements. The inset shows the reverse direction, looking past the test vehicle to the measurement truck and calibrated antenna tower. Fig. 7 shows that the antenna provided good pattern circularity: ±1 dB at 87.9 MHz and ±2.5 dB at 100.6 MHz. Pattern uniformity helps ensure that the gain of the antenna, and its related field strength measurements, are consistent no matter which direction the vehicle is driving, relative to the direction of the transmitter. The RMS gain of the antenna on 72 azimuths was very close to a vertical dipole across the FM band.

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The Human Wonderland of System Complexity

Technological Systems and the People Factor

BY BARRY BLESSER

In the 1970s, a few of us realized that signal processing could be used in commercial products for the audio and broadcasting industries. We had the knowledge and skills to be successful, and the world viewed us as technical wizards, awarding us high stature and monetary compensation.

My high point was the development of an electronic concert hall in a small box (the EMT-250), thereby replacing large and inflexible reverberation chambers. We rode the wave.

Almost half century later, products that use digital signal processing are ubiquitous, inexpensive and magically powerful. The high art of yesterday's engineers is now the accumulated wisdom of today, repackaged in inexpensive chipsets. Sophisticated technology is now a commodity. For an engineer, system design replaces component design.

So what do we now mean when we describe something as a "system?"

A system is a collection of elements that interact with each other such that its properties cannot be found in any of the individual pieces. Now more than ever, technology is just one of the elements in broadcast systems that also include many different types of people: investors, managers, listeners, colleagues, advertisers, competitors, journalists and, of course, engineers. To survive, engineers must have, or acquire, the necessary skills to design and maintain systems that include the behavior of people.

How then can an engineer in the 21st century regain the stature and compensation of his earlier counterpart in the 1970s? The answer is to redefine the scope of a system such that people are now included as a major element. Human behavior and psychology follow well-defined rules, but they are definitely not the same rules as those for hardware and software.

AUDIENCE MEASUREMENT IS A SYSTEM

Over the decades, new elements have been continuously added to systems. The 1960s hardware engineers had to retool their skills in the 1980s with the advent of software. Electronic processing was added to mechanical systems; user-interface design was added to computer systems; digital signal processing was added to audio systems; and currently, people have been added to almost every type of system. But the idea of thinking about people as being *in* the system is relatively new.

> **During the first half** of 2009, executives at our company, 25-Seven Systems, were approached to help investigate why the shift from paper diaries to the PPM system had adversely affected particular radio shows.

People have properties that never become obsolete, unlike specific technologies. Evolution works on a long time scale, and our biological brain has not changed much over the centuries. In contrast, my technical skills of the 1960s became obsolete in the 1970s, and my skills of the 1970s became obsolete in the 1980s. But my understanding of human psychology, which I have been acquiring for the last 40 years, continues to become more sophisticated as I gain more experience. Wouldn't you like to have some skills that, like fine wines, got better with age?

While there are many examples of this new kind of system in the 21st century, I will focus on one particular broadcast system as an illustration. It also happens to be a hot topic. Audience measurement technology provides a perfect illustration of how people determine the personality of the system.

When the audience measuring system in the radio industry used paper diaries, our industry was using the technology of our ancestors: paper and pencil. Since there was only one technical solution everyone accepted its properties, good or bad.

Beginning in the 1980s, research scientists began to consider using signal processing technology to embed digital codes into an audio signal without producing any audible degradation. These codes (watermarks) could be used by a broadcast station to label audio as having originated from their station. Monitoring equipment carried by a listener then detects the presence of these codes, thereby connecting the listener to the station. Sophisticated technology could now replace primitive paper.

Arbitron and many other companies considered the problem of watermarking to be a difficult technical challenge. Eventually, after a few decades of research and development, engineers created a system that worked well in laboratories and pilot studies. After successfully testing and adjusting the system, Arbitron has been replacing the paper diary method with its new automated electronic solution, the Portable People Meter, in an increasing number of markets. From a technical perspective, the design is elegant.

During the first half of 2009, executives at our company, 25-Seven Systems, were approached by friends and colleagues to help investigate why the shift from paper diaries to the PPM system had adversely affected particular radio shows. Evidence was building that something was not right. There were suspicions that there might be a technical explanation for changes in ratings.

ADVERTISER INDEX

TECHNICAL VS. HUMAN PROPERTIES

As inquiries continued to arrive at our main office, I decided to examine PPM as a complex system. After analyzing Arbitron's patents and talking to many knowledgeable people who had experience with PPM, I wrote a white paper, "Technical Properties of Arbitron's PPM System," which summarized everything that I understood about the PPM systems at that time.

I wanted to share my understanding of how the PPM system might actually behave in the real world of imperfect people listening to a wide variety of audio. If you have not read the paper, you can download a copy at *www.25-seven.com/blesser.html*.

I was not the only one interested in the implications of PPM. In November I was invited to speak with the Congressional Committee on Oversight and Government Reform in Washington. This committee was researching the PPM system in preparation for a congressional hearing on the potential impact of PPM on minority stations.

While I had been primarily focused on the technical properties of PPM, the committee was concerned with an entirely different side of the story: people. It is well worth your while to view at least some of the hearing using another link on the same page of our Web site.

The designers of PPM, while focusing on technical challenges, appear to have underestimated the relevance of the "people" part of the system: listeners in specific sub-cultures with unique attitudes, values and life styles. People are not electrons with identical properties; they are all different. Furthermore, the behavior of listeners in some cultural groups can collide with the inflexible technical properties of PPM to create unanticipated side-effects that degrade the reliability of the system. Apparently, the designers of the system had not realized that the skills of psychologists, sociologists and anthropologists were also needed as part of the system design process.

Before we explore how technology and people together create a complex system, I need to explain a few basic aspects of the PPM encode-decode algorithm.

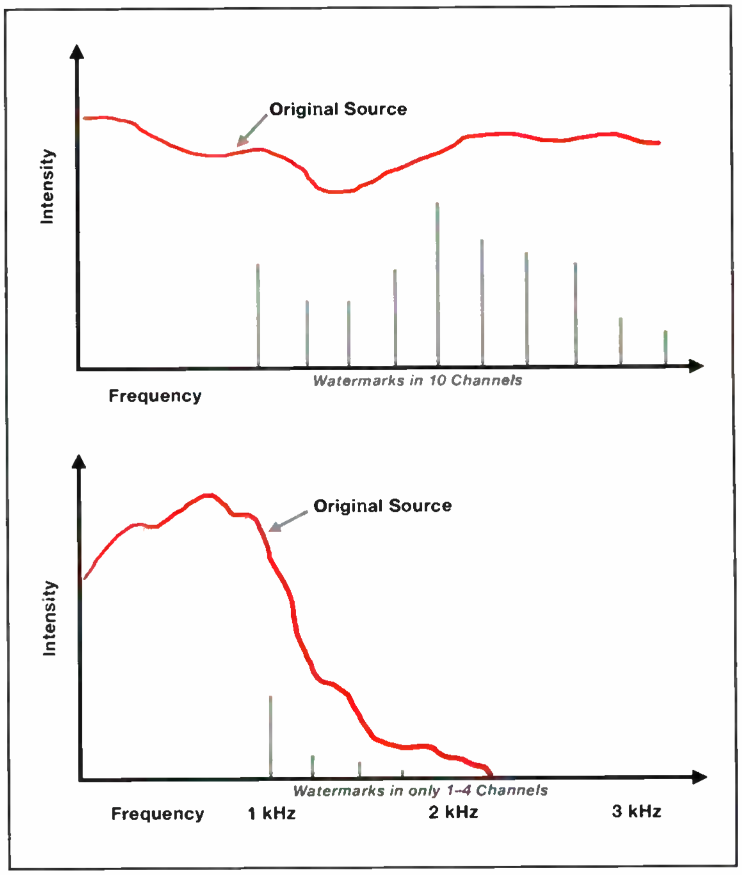
Watermarking energy, which contains the digital codes identifying a station, is injected in the spectral region from 1 to 3 kHz at a level well below the audio energy in this band. Because of the psychoacoustic property of masking, these watermarks are inaudible to the ear if their energy is significantly lower than the corresponding energy in the original source. Sounds that have strong energy in this spectral band can mask strong watermarking signal strength. Sounds with weak energy can only mask weak watermark energy, and faint sounds with little or no energy cannot mask any watermarking energy. Watermarking energy is thus dependent on the source audio.

There are many examples of how technology and people interact in unanticipated ways.

Consider the real-life situation of a family living in an apartment with open or acoustically porous doors. Assume that a teenaged son is listening to a hard-rock station in his bedroom, and that his father, wearing the PPM device, is listening to a talk-radio program in the living room. The PPM device hears two watermarks from two programs, and it will decode the stronger one.

But watermarking energy at the PPM device is determined by two factors: (a) proximity between the radio and the device, and (b), the amount of watermarking energy in the source. The watermark energy for the son's program might be 40 dB stronger than that of the father's program, which would be enough to overcome the extra attenuation of a longer distance to the device.

In such an environment, the talk-radio program does not get credit for having a listener in this household. And if both the son and father were independently participating in the Arbitron listener panel, the hard rock program gets credit for two listeners.



Top: High watermarking energy when the audio is full energy over the spectrum

Bottom: Weak or missing watermarks for audio that is mostly low frequencies.

UNEXPECTED SYSTEMATIC BIASES

Another example of unintended consequences arises from the assumption that any system will produce random errors, and such errors will average out. In contrast to random errors, systematic errors become strong biases in audience ratings. Consider an example of a systematic bias.

For fashion-obsessed youth and young adults, wearing the PPM dongle would not be "cool" today as it might have been in the 1990s when a pager was a status symbol. On the one hand, a cell phone evokes connectedness, social relevance, and can be customized to individual tastes with apps, skins and ringtones. On the other hand, the larger PPM dongle has become a symbol of an electronic dog collar worn by people tied to a job.

Attitudes towards devices depend on social status, and those with a cool image are likely to refuse to participate in Arbitron's audience panels if it means carrying around a visible dongle for 8 hours a day week in and week out. Had the PPM technology been incorporated into a cell phone, the story might have been different.

Those who are suspicious of governments and organizations might have been willing to fill out a paper diary for a couple weeks, but may fear that the dongle is an electronic tracking device. Dongle symbolism can result in under-counting of some cultural groups. A pencil and paper diary gives participants full control of what is happening, while a dongle demands hidden (mysterious) interaction with a command center. This may evoke fears that "big brother is watching" for a segment of the population intent on staying hidden. Even to a knowledgeable engineer, the unverifiable nature of a sealed dongle becomes a psychological problem.

Knowing what I know about technology, computer viruses, corporate machinations and newspaper reports of unethical behavior, do I really want to trust a corporate spokesman who tells me to blindly trust them?

Using myself as an example with my life style and value system, I would never participate in any audience measuring activity that required me to wear a dongle week in and week out for months or years. But I might have been willing to fill out a paper diary in the evening for a few months. I, and others like me, represent a sub-culture that remains inaccessible to the new audience measurement process. But we might be a critically important group to advertisers.

PERVERSE CONSEQUENCES

To combat people's resistance to participate in audience panels, Arbitron offers a modest payment per month. A minimal payment produces a motivational incentive for those lower income people in desperate need of additional cash. Those with wealth, who may be an important segment for advertisers, are very unlikely to be motivated by an additional $10 per month.

From a purely economic perspective, even though the PPM can be fully automated, it is now proving to be expensive to train and retain panel participants. The additional cost of managing participants pushes more cost on to the broadcast industry. Automated technology can actually have a high human maintenance cost.

As a final example of unintended consequences, consider: What if many radio stations discovered that specific programs have sounds that only weakly encode the watermarking, namely certain types of jazz and male talking heads?

Because radio stations have no way to influence the encoding process, their only choice is to modify their programming to better match the design assumptions made by PPM developers more than 15 years ago. Programming decisions are now driven by the technical properties of PPM, not by listener preferences. Without realizing it, designers in 1994 sitting in their laboratory were actually changing listening options in the 21st century and perhaps for decades.

Combining these issues leads us to the conclusion that audience ratings may have a bias towards those who are poor, uninterested in being cool, and enjoy full-bandwidth music. Biases are systemic errors unique to particular scenarios, sub-cultures and broadcast preferences.

In contrast, random errors assume sampling a uniform population with a large sample size. Human populations are seldom uniform. In fact, averaging as a statistical technique assumes that all errors arise only from additive random noise. An engineer without a background in population sampling might not realize that a measure from a particular population in a

(continued on page 22)

SYSTEMS

(continued from page 21)

particular scenario does not predict performance with other scenarios.

REAL-WORLD BETA TESTING

Notice that these systemic biases could all arise from how people interact with the technical properties of the PPM design: packaging symbolism and varied watermarking energy. I have no doubt that the design would have turned out differently if the developers had had the foresight to consider what they didn't know, and to recognize that a complex system, which includes human behavior across multiple subcultures and shifting social norms, cannot be solved only with technical wizardry.

Are my descriptions of biases real or just hypothetical possibilities? What is truth in audience measurement?

Unfortunately, a methodology to establish truth, even for one week in one city, is pragmatically impossible. However, because there is data for two methodologies, PPM and paper diary, and to the extent that they differ, one or both must be in error.

If one reports an audience size of 10,000 and the other reports 20,000, then at least one of the two must be off by at least 5,000 listeners. In other words, the existence of a second method automatically highlights biases that produce winners and losers. Each station will prefer that system which provides the most favorable ratings. The difference in ratings now becomes political and economic, not technical. The congressional inquiry arose because a significant number of losers were minority-owned stations.

These issues have come to light only after PPM was deployed on a wider scale; designers call this a Beta-test. Until a design has been exposed to a large number of people in the real world, one will never know what scenarios will prove to be relevant. When Arbitron says that the system was tested extensively, they are correct, but controlled tests with specific scenarios do not represent the world as it is. It is impossible to discover all of the scenarios by thinking.

KEEP PEOPLE IN THE EQUATION

Given the complexity of the issues discussed, Arbitron has taken the position of using secrecy, rather than an open discussion, as a way of responding to challenges to their system. In many private conversations, I have been told that secrecy is required to prevent stations from "gaming" the system.

Paradoxically, secrecy actually creates a situation where a smart advertiser could successfully take advantage of defects in the system. Given that ratings have biases, with the appropriate research, an advertiser could estimate the size and nature of the bias for a particular program.

For example, the reported audience size might be 10,000, but by including the bias, the actual size might be estimated as being 15,000. The advertiser pays for air time on the smaller measure and gets 5,000 extra listeners.

Combining these issues leads us to the conclusion that audience ratings may have a bias towards those who are poor, uninterested in being cool, and enjoy full-bandwidth music.

Audience ratings are a current topic, but in the context of this discussion PPM is just one example of how 21st century systems are now dominated by the properties of humans. Applications where human beings and technology fuse together to become a single system are distributed throughout our daily life. The user interface of your favorite word processor is a connection that creates a system with you in it. Similarly, executives participating in a remote audio-video conference are also a system with people and technology.

Engineers who are comfortable with technology need additional skills besides their technical wizardry. People are part of the system, and people are not black boxes that follow the rules of hardware or software. People are the ultimate challenge for engineers who design, deploy and maintain systems. And finally, whatever skills you acquire in understanding people, be they listeners or executives, those skills will never become obsolete. Ignore people at your peril.

Barry Blesser is director of engineering for 25-Seven Systems. Opinions are his own. Comment on this or any article to rwee@nbmedia.com.

MEASUREMENT

(continued from page 21)

Now that an accurate transportable antenna was available, we needed to upgrade our signal measurement instrumentation. The requirements were: (1) a signal meter with wide dynamic range, (2) high selectivity (capable of accurately measuring

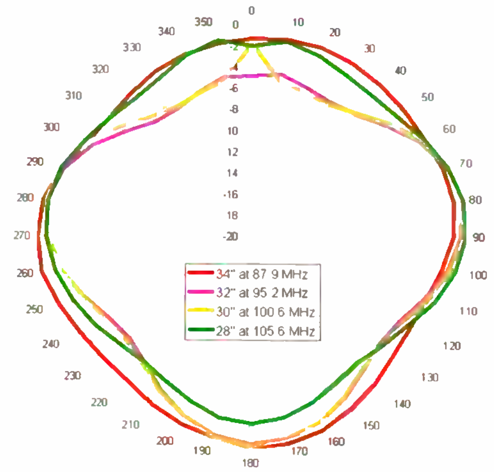


Fig. 7: The ground plane antenna performance as measured on-vehicle at Table Mountain for 87.9, 95.2, 100.6 and 105.6 MHz. The 0-degree reference at the top is the front of the vehicle. An RMS of each pattern was used to determine the calibrated gain for each frequency sub-band.

a desired channel in the vicinity of an undesired first-adjacent channel station), (3) ability to log HD Radio reception (digital/analog blend decision) from the same antenna used for field strength, (4) ability to record field strength on up to three separate channels simultaneously (such as desired channel and upper and lower first-adjacent channels).

This was a tall order, and there was no commercially available unit that met our requirements, so in NPR Labs tradition, we built our own field test unit.

We'll report on the design, operation and results of the field test unit with the ground plane antenna system when we conclude the story next issue.

TECHMART

FINALLY...FAILSAFE NETWORKED AOIP.

W EATST P ARE Y RB ST CE BY A LONG S

When it comes to networking your facilities, there's only one best choice. Wheatstone. For years, we've been the network/control surface choice of top broadcasters. And with good reason – we care.

Wheatstone's Audio-Over-IP product is the best in the business. Here's why:

1. WheatNet-IP is easiest for a station to implement and configure. It is, hands down, the easiest in the industry. No need for Wheatstone to provide factory on-site assistance unless you really WANT us there. The manual and app notes will have you up, running and stable in less time than any other system.

2. WheatNet-IP is a natural for large facility multi-station networking (and for smaller facilities too!). It uses the IGMP features of Ethernet Layer 3 switches to identify a multicast packet, see which ports are requesting that packet, and send it only to those ports. Traffic control is maintained and system bandwidth is optimized.

3. Redundancy is critical. A typical WheatNet-IP installation has multiple levels of redundancy. Each BLADE holds the complete map of the entire system within its onboard memory – we call it distributed intelligence – a system with 50 BLADEs has 49 backups with failover in the event of a failure. Cisco Stackwise technology provides redundancy in the central core TOC switch. A WheatNet-IP/E-Series console studio complex can stand alone, even if the TOC goes down, with backup analog or digital program audio feeding a back end router independent of the core Gigabit infrastructure.

4. Modular is better. Why would you want to combine your switch, mix engine and I/O into one box? Beats us. With WheatNet-IP, you install only what you need, where you need it. We believe in not overselling.

5. Manufacturing quality is very important. Wheatstone is proud to have the best track record in the business for build-quality, reliability and intelligent functionality. With far more up-and-running installations than anyone else, this is where we really shine. An investment in WheatNet-IP and E-Series control surfaces today will reward you with a future-proof, failsafe networking/control environment that's infinitely updatable and in for the long run.

6. WheatNet-IP has an advantage. Take a look at your entire environment. Wheatstone is a perfect partner because we are always there, always innovating. Built into every WheatNet-IP BLADE are features others just didn't think of – handy utility mixers, silence detection, crosspoint routing control, headphone monitoring of any source, lots of logic GPIO, and comprehensive metering of audio I/O, not just signal-presence indicators. And, in the hugely unlikely event that a BLADE needs to be replaced, you just plug in a new one and enter the BLADE number. That's it.

7. Wheatstone is local. WheatNet-IP and the E-Series, just like ALL Wheatstone products, are designed, engineered and built from start to finish in our New Bern NC USA facility. Everyone who works on our products is 100% knowledgeable and immediately available. You can relax – as with the famous insurance company, you ARE in good hands.

With WheatNet-IP, we think we've done our homework. In fact, we know we have. And we're happy to say that we've got the best product on the market. To learn more, and there's a LOT more, get us on the phone or visit us on the web. We'll be happy to meet with you and get you everything you need.

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NewBay Media

Modern VHF Signal Measurement Techniques at NPR Labs, Part II

A Measurement System to Measure HD Coverage Accurately

BY JOHN KEAN

The author is senior technologist at NPR Labs in Washington.

In the first half of this paper (Engineering Extra, Apr. 14), I discussed the need for an accurate antenna

WHITEPAPER

capable of repeatable measurements and presented the design of NPR Lab's transportable ground plane antenna. The article also described some early measurement techniques for VHF FM that set standards for quality, worth emulating today some 60 years later.

However, the old techniques used a series of local spot measurements that were collected along a common transmitter radial. These separate measurements were plotted on a signal strength vs. distance chart and fitted with curve.

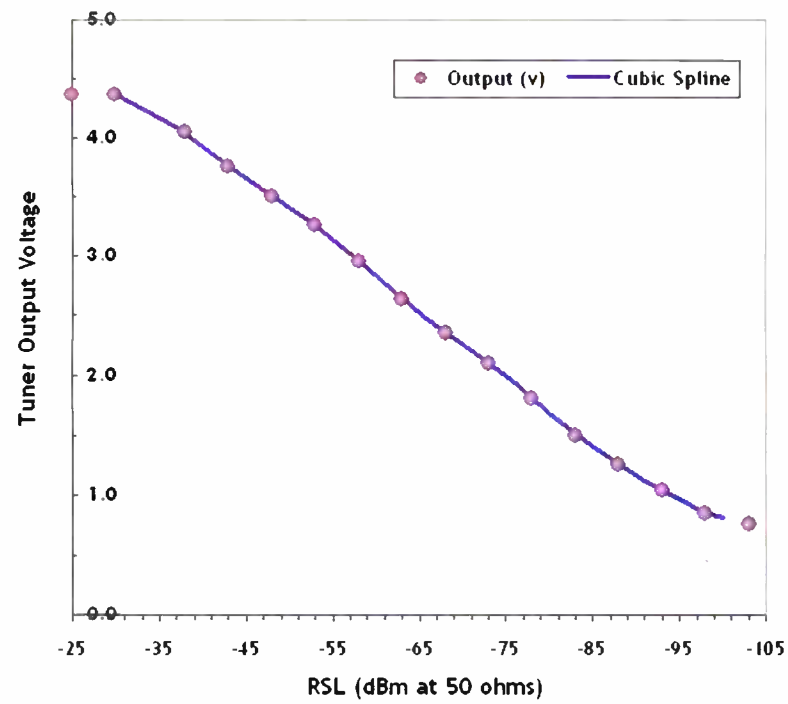

Fig.1: This chart shows Kenwood tuner DC output vs. RF signal input. With the calibrated groundplane antenna, a maximum input of –30 dBm is more than 80 dBu field strength. Signals or channel noise as low as 10 dBu are measurable.

The position and shape of the curve, relative to the FCC's signal propagation curve, indicated antenna radiation performance in a given direction and terrain effects at the coverage fringe. This approach though wasn't suited to "drive-test" studies over wide areas, which NPR needed in order to evaluate and compare HD Radio coverage to analog FM service.

Fortunately, we now have computers and software tools to help continuously collect and process the volume of data along hundreds of miles of roadway.

NPR Labs needed to carry out measurements of HD Radio signal coverage, specifically to determine how interference received from stations on first- and second-adjacent channels would affect digital reception. This required a customized measurement system. Drive test measurement adds some requirements that were not necessary in the original systems, especially in view of a tight schedule and limited budget. (See chart on page 8.)

The requirements were a tall order, as the middle column entries show. There was no commercially-available unit that met our requirements, so in NPR Labs tradition, we built our own field test unit. This unit provided all the features and performance summarized in the right column.

The following will describe how we set up the units for measurement, calibrate them and use them for field strength measurement.

NPR Labs had some early experience with the Kenwood KTC-HR100 "black box" tuner, as it was the first commercially-available HD Radio receiver.

(continued on page 8)

WHEATNET IP

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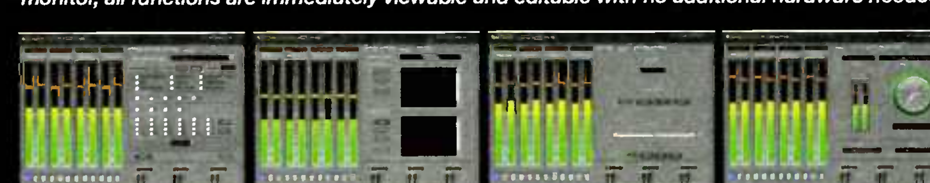
The compact E-1 Control Surface Console and associated ip88cb Console Audio Blade provide all the networked control, mixing, and I/O needed for small to mid-sized studios at a price comparable to similar sized standalone analog consoles. The E-1 features an integrated LCD Monitor for metering and control, a streamlined user interface with password protected access to complex functions via LCD display and touchpad, and 4 Main Mix busses as well as Control Room and Studio Monitor outputs with selectable sources from the audio network. Complex Mix Minus setups are made simple thanks to per channel Mix Minus outputs with selectable reference mix and talkback interrupt. You also get auto switching between off line Mix and on line Mix Minus per channel. The E-1 features 99 show presets and a programmable per-channel A-B Source/Select switch which emulates traditional broadcast consoles. Of course the E-1 will work just fine with Wheatstone TDM products, too! Completely made in the USA and available TODAY!

- **Digital Control Surface in new compact frame**
- **Integrated LCD Monitor for metering and control**
- **Monitor / Channel Display area is angled for better ergonomics and display view**
- **Streamlined user interface with password protected access to complex functions via LCD display and touchpad**
- **4 Main Mix Busses**
- **Control Room and Studio Monitor Outputs with selectable sources from Audio Network**
- **Per Channel Mix Minus Output with Selectable Reference Mix and Talkback Interrupt. Complex Mix Minus setups made simple.**
- **Auto Switching between Off Line Mix and On Line Mix Minus per channel**
- **99 Show Presets**
- **Incredible new price!**

With the brand new ip88cb Console Audio Blade, a complete standalone/IP-Networkable Wheatstone console is well within the reach of any studio. And with the E-1's integrated LCD monitor, all functions are immediately viewable and editable with no additional hardware needed.



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RADIOWORLD
ENGINEERING EXTRA

L 34, No. 15 June 9, 2010

Next Issue of RADIO WORLD June 16, 2010
Next Issue of ENGINEERING EXTRA August 18, 2010

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radioworld@nbmedia.com.

dio World Founded by Stevan B. Dana

dio World (ISSN: 0274-8541) is published bi-weekly with ditional issues in February, April, June, August, October and cember by NewBay Media, LLC, 810 Seventh Avenue, 27th Floor, w York, NY 10019. Phone: (703) 852-4600, Fax: (703) 852-82. Periodicals postage rates are paid at New York, NY 10079 d additional mailing offices. POSTMASTER: Send address changes Radio World, P.O. Box 282, Lowell, MA 01853.

PRINTS: Call or write Caroline Freeland, 5285 Shawnee Rd., . 100, Alexandria, VA 22312-2334; (703) 852-4600; x: (703) 852-4583

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CAP Implementation Guide Gives Glimpse to Future System

Greater Flexibility of Data Transmission Offers Possibility of Improvements

BY MICHAEL LECLAIR

Just before press time, I found myself scanning through the CAP Implementation Guide, an interesting document prepared by EAS equipment manufacturers. The group is known as ECIG — EAS CAP Industry Group. CAP, of course, stands for the Common Alerting Protocol, which has been adopted as a standard data protocol for a revised emergency notification system currently in the works.

The guide is being developed to assist manufacturers in developing equipment that can operate compatibly. The goal is to have CAP equipment that will deliver the right messages to the public no matter which manufacturer's system is used to send or receive messages. This is a worthy goal.

The new Emergency Alerting System under development is constrained by the need to operate within the existing EAS rules and SAME codes. CAP is a far more flexible and powerful system as it is based purely on data transmission, but ultimately it has to translate to something that works under the EAS system.

For example, the final "payload" of a radio emergency messaging system is an audio message. Under CAP, this audio message can be created from a text message using text-to-speech conversion, rather than relaying an analog audio file from sender to receivers, often over multiple generations. By generating the audio message from data, the quality can be maintained at a reasonable level even as the message is disseminated multiple times.

In my home state of Massachusetts, the Primary Entry Point for emergency alerts and monthly tests is an AM station with very broad reach, but the audio fidelity is noticeably lower than is typical on the many FM stations that then relay this alert. So this is a potential improvement. Done correctly, it also allows understandable messaging without having to find "announcer talent" amongst the state emergency management agencies.

ENCOURAGED BY POSSIBILITIES

The Guide provides the outlines of what could be possible in a new Emergency Alerting System. One of my pet peeves about the current EAS is its reliance on a daisy-chain of transmission. Typically, a single entry point station is used to generate the original alert or test, which is then relayed by other stations out to the public. In larger states, this can mean a significant delay before a message reaches the last radio station in the chain.

The capability of distributing emergency messaging via pure data transmission offers the possibility of building a system that does not require a daisy chain.

For example, the distribution of an emergency alert could now be accomplished via a relatively inexpensive path, such as the public Internet. All affected stations would receive the alert simultaneously, greatly speeding the distribution of an emergency alert at a fairly modest cost. An audio alert message could be placed at a website and downloaded automatically for playback from the receiver. A more hardened distribution system, such as satellite, would be an option where a higher reliability backbone is desired to supplement some or all of the chain.

One of the other great advantages of using alert distribution by a data path such as the Internet is the ability to conduct a "closed circuit" test of the system. Receivers can log all the relevant information, alert local engineering personnel and even respond back to the test sender with acknowledgement messages. To me, this offers the means to a large reduction of over-the-air testing, which we all dislike.

It may still be necessary to do the occasional "instructional" test to keep audiences educated on what an alert sounds like as well as to monitor actual system performance (similar to the existing Required Monthly Test) but weekly on-air tests potentially could be eliminated. That's an improvement that broadcasters could get behind.

KEEP IT SHORT

The CAP Implementation Guide also endorses a strict limit on message length of 1,800 characters maximum. This is important to make emergency messaging workable, both for direct display of the text message on advanced receivers or television systems and to keep the audio message within a two-minute length. Enforcing an efficient alert will contribute to the effectiveness of the system and reduce audience tune-out. The industry group recommends truncating audio messages of greater than 120 seconds, including those generated using text-to-speech conversion.

While the standard language for alert distribution is English, the CAP system supports audio messaging in multiple languages where this is desired. If a second, or even third, language version of an audio message is desired, the recommended operation is to have the receiver play the message in English, send the end-of-message data burst, and then play out any additional language messages immediately after the test concludes. This allows stations to select whether or not they wish to air alerts in more than one language based on their demographic service area, or to just stick with the English version.

STATE ACCESS

A new feature of CAP is a class of alerts known as "Governor's Must Carry." By creating a new class of messages that can be generated by local state agencies, the system has an input for local emergencies. That's an important feature of any new alerting system.

As most of you are aware, the EAS system is getting long in the tooth and is in need of updating to something more flexible and reliable. Discussions by government agencies have been under way for some time now, but many of the elements of the "new EAS" seem to be coming into place. From what I read in the Implementation Guide, some very good thinking has already taken place about how the future system could operate.

It's important for all of us to stay aware of these discussions and to help to develop a system we all can live with. We can even hold out some hope that it will provide a useful public service and possibly save lives. That's also a worthy goal.

THIS ISSUE

JUNE 9, 2010

Careful Planning Comes First in a Studio Move

A Cable Ladder Can Make Wiring Much Faster and Easier

BY CRIS ALEXANDER

In case you didn't know it, there is a recession on. With reduced top lines, radio station owners and managers are looking for ways to save money to preserve as much of their bottom lines as they can.

With rents down considerably in many markets, it can make a lot of sense to look for a new leasehold. Of course, the costs of relocation, including the often costly tenant finish of the raw space, must be factored into the move equation; but in these lean times, with landlords eager to fill their empty space with tenants, it's often possible to make a sweet deal.

I've observed several stations in my home market making such moves of late. Four of those stations are my responsibility, and at this writing we are well on our way to getting the new space ready to move the stations into. It's been awhile since I was personally involved in a new studio buildout, so the process has been a (re)learning experience for me.

This particular project is of a type that I have not undertaken in 23 years. In every other studio move I have done since 1987, we have built out the new space, purchased new cabinets and equipment, built out the new studios and moved into them.

This time, the cluster's studio equipment and cabinets are all too new to even consider replacing (and don't forget that there's a recession on!), so my challenge is to somehow move all the studio equipment from the old leasehold to the new in the shortest amount of time while keeping all four stations on the air. Piece of cake. Or maybe not.

PLAN TECHNICAL DETAILS

The key to any successful relocation project is careful planning.

The planning for our new Denver facility started last fall. We sat down with the architects and discussed every detail of our proposed space. Within a few months, we had a final floor plan and a set of construction drawings that were approved in short order by the city's building department. Bids were solicited, a contract was awarded and walls started going up.

By late April, the tenant finish was just about complete. That meant it was time for the technical infrastructure buildout to start.

A lot of planning went into that part of the project as well. Conduit runs, NEMA box placement, power distribution, telephone and Internet wiring were carefully thought out. A "home run" of 2-inch EMT conduit was installed between each control room and the TOC, the "Technical Operations Center" (we used to call it the engineering room). A run of 2-inch EMT went to the telephone/electrical room, and a run of 4-inch EMT was installed to provide roof access for coax cables and the like.

Space is tight, so the rack budget was critical. We are downsizing from seven racks to four. The racks selected were Middle Atlantic WRK-series open-frame units. Side panels were purchased for the two end racks, and each rack has a locking back door. A top plate containing a thermostatically-controlled fan and a removable wiring access plate was provided for each rack. The four units were bolted together and to the floor. A 1.25 kVA rack-mount UPS will

(continued on page 6)

Patch panels were used to terminate all phone and LAN wiring.

			ADI-2001 Slot #3		Block #1	SDI-2001 Slot #4			
Source/Destination	Pos#	Wire	Signal	Color	Color	Signal	Wire	Pos#	Source/Destination
KLTT ASERV-1 L	1A	H	Channel 1 (Stereo 1 Left) In	Brn	Brn	Channel 1 (Stereo 1 Left) In	H	26A	KLTT ASERV-2 L
D9M	1B	L					L	26B	D9M
	2A	S					S	27A	
KLTT ASERV-1 R	2B	S	Channel 2 (Stereo 1 Right) In	Red	Red	Channel 2 (Stereo 1 Right) In	S	27B	KLTT ASERV-2 R
D9M	3A	H					H	28A	
	3B	L					L	28B	D9M
	4A	H	Channel 3 (Stereo 2 Left) In	Org	Org	Channel 3 (Stereo 2 Left) In	H	29A	
	4B	L					L	29B	
	5A	S					S	30A	
	5B	S	Channel 4 (Stereo 2 Right) In	Yel	Yel	Channel 4 (Stereo 2 Right) In	S	30B	
	6A	H					H	31A	
	6B	L					L	31B	
	7A	H	Channel 5 (Stereo 3 Left) In	Grn	Grn	Channel 5 (Stereo 3 Left) In	H	32A	
	7B	L					L	32B	
	8A	S					S	33A	
	8B	S	Channel 6 (Stereo 3 Right) In	Blu	Blu	Channel 6 (Stereo 3 Right) In	S	33B	
	9A	H					H	34A	
	9B	L					L	34B	
	10A	H	Channel 7 (Stereo 4 Left) In	Vio	Vio	Channel 7 (Stereo 4 Left) In	H	35A	
	10B	L					L	35B	
	11A	S					S	36A	
	11B	S	Channel 8 (Stereo 4 Right) In	Gry	Gry	Channel 8 (Stereo 4 Right) In	S	36B	
	12A	H					H	37A	
	12B	L					L	37B	
	13A	H	Channel 9 (Stereo 5 Left) In	Brn	Brn	Channel 9 (Stereo 5 Left) In	H	38A	TRN-1
	13B	L					L	38B	(From DA 1 L)
	14A	S					S	39A	
	14B	S	Channel 10 (Stereo 5 Right) In	Red	Red	Channel 10 (Stereo 5 Right) In	S	39B	TRN-3/WW
	15A	H					H	40A	(From DA-1 R Bridged)
	15B	L					L	40B	
CRC-1	16A	H	Channel 11 (Stereo 6 Left) In	Org	Org	Channel 11 (Stereo 6 Left) In	H	41A	
(From KLZ Intraplex)	16B	L					L	41B	
	17A	S					S	42A	
CRC-2	17B	S	Channel 12 (Stereo 6 Right) In	Yel	Yel	Channel 12 (Stereo 6 Right) In	S	42B	
(From KLZ Intraplex)	18A	H					H	43A	
	18B	L					L	43B	
Sangean Receiver L	19A	H	Channel 13 (Stereo 7 Left) In	Grn	Grn	Channel 13 (Stereo 7 Left) In	H	44A	
	19B	L					L	44B	
	20A	S					S	45A	
Sangean Receiver R	20B	S	Channel 14 (Stereo 7 Right) In	Blu	Blu	Channel 14 (Stereo 7 Right) In	S	45B	GABNET
	21A	H					H	46A	(KLZ Intraplex)
	21B	L					L	46B	
	22A	H	Channel 15 (Stereo 8 Left) In	Vio	Vio	Channel 15 (Stereo 8 Left) In	H	47A	
	22B	L					L	47B	
	23A	S					S	48A	
	23B	S	Channel 16 (Stereo 8 Right) In	Gry	Gry	Channel 16 (Stereo 8 Right) In	S	48B	Ramsey
	24A	H					H	49A	(From DA 5 L)
	24B	L					L	49B	
	25A							50A	
	25B							50B	

Color-coded documentation helps to keep things organized during installation and provides a record of the baseline installation.

MOVE

(continued from page 4)

be installed in each rack with the UPS feeding two full-length power strips, one on each side.

I decided early on to use a cable ladder system for all the wiring within the TOC. We did this at a transmitter site installation last year and it made a believer out of me. The cable ladder system eliminates at least one insulation displacement block in each rack and greatly simplifies the facility wiring. The cable ladder provides a neat, secure and convenient path for all the wiring between each rack, the blocks feeding the studios, the telephone/LAN rack and the conduits feeding electrical room and roof.

For this type of work, a CAD program is a must. For years I used AutoCAD, but over a decade ago switched to TurboCAD, a feature-packed program that does everything I need it to. All the rack and cable ladder system were laid out in TurboCAD and the plotted plans were given to the general contractor. From those he had no issues putting everything together exactly as we wanted.

In fact, we used TurboCAD to plan the entire facility. Because it will import and export AutoCAD files, I was able to swap drawing files with the architect seamlessly.

Cable ladders greatly simplify the wiring task.

The CBC-Denver facility has at its core two vital organs: a Wheatstone bridge router and an RCS NexGen digital media system. The bridge router is the audio "engine" for the entire facility, and NexGen provides virtually all the audio and programming. These elements are common to all four stations, so there will be no moving one station at a time — it's all or nothing!

And so it is that we have to have the TOC ready for all the equipment. There won't be time to move the equipment, install it in the racks at the new location and then wire it up. The wiring has to all be in place on moving day so that we can move each item, put it in the racks, plug it in and turn it on. The Wheatstone bridge router and NexGen system have got to be working at the new locale within hours of their removal at the old location.

When we first installed the Wheatstone bridge router system a few years ago, we had to integrate it into the existing analog audio scheme, converting to AES to the degree possible at the time and slowly evolving into a nearly all-digital facility since. This was a learning process, and while I won't say that big mistakes were made along the way, we certainly could have done a few things better.

Starting fresh in a new location would

seem to be the ideal time to fix these things, but after much consideration I decided that we simply don't have time. We will, in essence, relocate the bridge router system configured exactly as it is now. That way we know that it should work, we know *how* it should work and we will not have to spend a lot of time troubleshooting configuration issues within the system.

If we don't make any wiring errors we should be able to unplug the system at the old facility and plug it in at the new and be off to the races. I'll have to let you know how that works out.

THE RIGHT TOOLS

There are lots of project planning software tools on the market to help with projects like this, and I have some in my library. In this case, however, I opted to use a tried-and-true software tool, Microsoft Excel, to plan the project.

A color-coded spreadsheet was created for each wiring block in the facility. Each line contains the signal source or destination, block location, wire designation (high, low or shield) and signal name. The individual block spreadsheets were assembled into a single workbook with a tab for each block.

From these spreadsheets we created wires with the proper termination on one end along with a Kroy wire label under clear heat shrink tubing. The other end of each wire was left unterminated and was marked with a piece of painter's tape with the signal name written on it. As each wire was installed from the proper location in the designated rack, it was routed through the cable ladder system to the correct Krone block, cut to length, affixed with a label under heat shrink and punched down.

We're using hook and loop fastener wire ties to bundle the wires and secure them to the cable ladder. This will allow for future wiring changes while keeping things neat and secure. We actually got this idea from our phone guy, who used the ties to bundle the huge trunk of Cat-5e wires coming from all over the facility to the bank of patch panels we'll use to route phone and LAN signals.

We're going to follow a similar plan for each of the studios. With the bridge router system, there's not a lot of signal wiring in the studios, but we still have to tie local sources and destinations — CD players, NexGen workstations, phone hybrids, mics and headphone amps — to the "satellite" router located in each studio (called a "satellite" router because it operates as a "satellite" to the main bridge router). All the signal cables will be pre-made with connectors and wire labels installed. When the cabinets and equipment are installed in each studio, wiring will be a simple matter of plugging in each device, routing the wire, cutting it to length, affixing a label and punching it down.

Amanda Alexander terminates a studio 25-pair cable.

When the time for The Big Move comes, I plan to bring in the troops, market CEs from some of our other facilities who are proficient with Wheatstone, NexGen and other systems. I can hand each the wiring spreadsheets for their assigned rooms and they can complete those rooms without supervision.

We're about done with all the TOC wiring and we're starting now on all the studio pre-wiring. I am confident that we will make our move date in July.

Cris Alexander is director of engineering at Crawford Broadcasting Company and a past recipient of SBE's Broadcast Engineer of the Year Award.

MEASUREMENT

(continued from page 1)

Although a complete tuner, the box required a Kenwood in-dash head unit to provide the tuning controls, display and loudspeaker amplifier. We used one in NPR's "Tomorrow Radio" drive test work in 2002, to record coverage in a number of cities around the country. We used a proprietary computer interface to connect to the tuner, and the interface required proprietary software to record the data. While it worked well, the reception status and GPS data logs were kept in separate files, and no information was available for field strengths, which we determined was necessary to build a model for HD Radio coverage prediction.

Fortunately, a little "reverse engineering" of the black box yielded a breakthrough. The voltage at a certain point on the receiver board provided a near-linear presentation of the input signal power over a 70 dB range! Fig. 1 shows the DC output voltage vs. FM RF input referenced to 50 ohms, from –25 dBm down to –104 dBm.

> **There was no commercially-available unit that met our requirements, so in NPR Labs tradition, we built our own field test unit.**

It's apparent that the signal voltage flat-tops above –30 dBm, and there is a slight curve at the lowest signal powers. The voltage would be fine as is, but we extend the range of accuracy by using a cubic spline formula to track the curves. When attached to our ground plane antenna, this results in an accurate measurement from approximately 80 dBuV to nearly 10 dBuV. While the upper limit would prevent measurement at higher field strengths closer to test stations, we have focused on lower field strengths that are pertinent to station interference and which correlate nicely to the native range. If we needed measurements at higher signal levels, we inserted a fixed 50-ohm pad into the antenna line.

The Kenwood tuner provides only the signal strength of the analog host FM station, but the frequency difference between the FM carrier and each digital subcarrier group is less than 150 kHz. At FM Band frequencies this difference is less than 0.17 percent (0.15/88.1 = 0.0017), which causes a high correlation of fading between the analog and digital signals. Consequently, a station's analog FM field strength is an accurate "proxy" for the station's digital field strength. This condition would not apply to stations that have different analog and digital antenna radiation patterns, but we avoided this type of station in our nationwide measurement campaign used to develop a prediction model for HD Radio reception.

Comparison of Available Systems and NPR Labs' Requirements

REQUIREMENT	'OLD' SYSTEM APPROACH	SYSTEM SOLUTION
Continuous recording of RF signal strength	Strip charts may record for long periods, but manual derivation of local median signals (every 100-200 meters) over long distances would be grueling	Digital sampling with large storage direct to memory card, permitting hours of non-stop recording
Large RF dynamic range from the signal recording system, to support variations in distance as well as log-normal fading effects	Common field strength receivers have wide range capability by changing the input RF attenuator, but this interrupts the signal and attenuator settings must be tracked	Selection of a receiver with >60 dB of linear signal measurement range (70 dB with slope compensation); a 12-bit A/D converter providing >70 dB of recording depth
Ability to simultaneously record field strength on multiple channels	Achieved by building multiple systems	Compact receivers that fit into one cabinet
High selectivity (ability to simultaneously record a desired channel a nearer first-adjacent channel signals)	Usually not a consideration for spot measurements	Upgraded 10.7 MHz IF filters to support measurement of desired signal >25 dB below a first-adjacent station signal, based on analog-to-analog interference
Ability to log HD Radio reception	All field strength receivers at the time were analog-only	Receiver provides digital/analog Blend Line to digital recorder, sharing tuner for signal strength
Compact and portable	A challenge for a multiple-channel system with separate cabinets	Two boxes fit in the backseat of any size vehicle; GPS interface for latitude, longitude and time integrated to digital logging

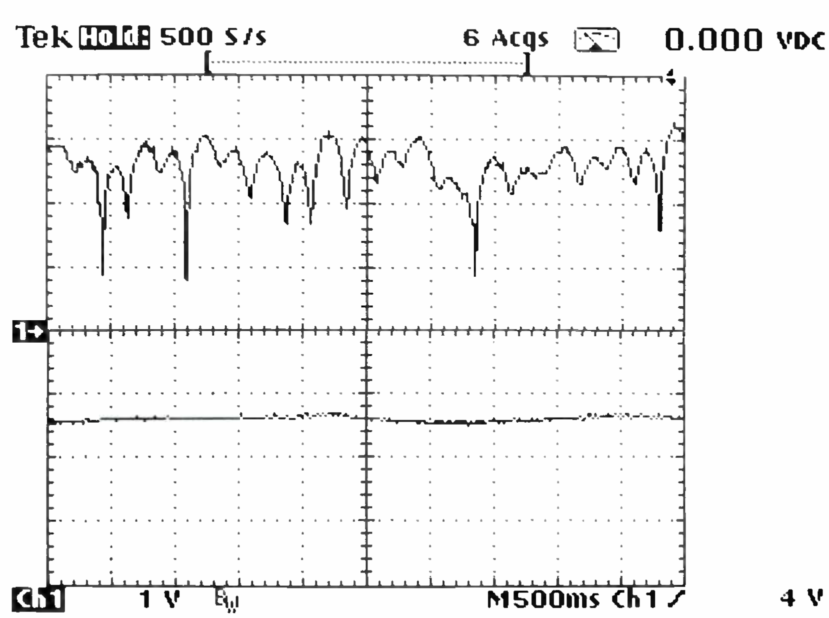

Fig. 2: Dual-trace oscillograph of the tuner's unfiltered output voltage (upper half) with fast fading from lab's Rayleigh simulator. Peak-to-peak RF range is approximately 25 dB. The lower trace shows the DC output after low-pass filtering. The average voltage is preserved, but the variations are greatly reduced.

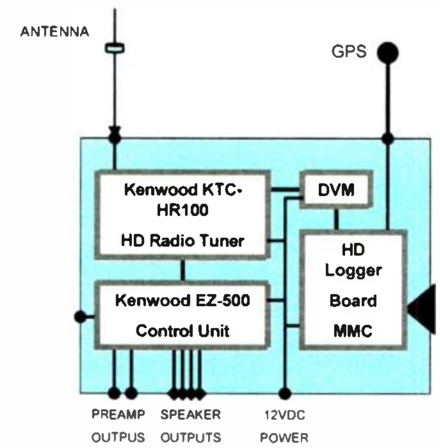

Fig. 3: Simplified diagram of the NPR Labs Field Test Unit, containing the Kenwood KTC-HR100 FM/AM/HD Radio tuner and EZ-500 control unit. The G-Dyno logger board with its MMC card socket is connected to the tuner through the low-pass filter (not shown). A digital voltmeter displays the DC signal line. A 12 volt sealed lead-acid battery, also not shown, provides backup against power interruptions and portable operation.

FAST FADES

Another important consideration in drive-test measurement of VHF signals is fast fading, which is caused by reflections from the foreground surface near the vehicle, distant hills or mountains, buildings, etc. The multipath causes the mobile signal to vary large amounts, often more than 20 dB, within the span of one wavelength (about 3 meters at FM frequencies). This effect dominates the variation in field strengths over the short distances that we refer to as the "local mean field strength." These distances for "local mean field strength" may be 100 to 300 meters, and correlate to the cell sizes we use in our computer predictions of field strength. While we could potentially sample at high rates to quantize this fast fading, then average the results, this process requires a lot of data storage and post-processing, which is wasteful when the local mean field is what we want.

To reduce the sampling rate and storage of fast fading, we filter the signal in real time, using a four-pole low-pass filter having a 1 Hz cutoff. This is imple-

(continued on page 10)

No one else builds single-cabinet, solid-state transmitters with power outputs of 6kW – 30kW in -14dB hybrid mode and 5kW - 21kW for -10dB. And only Nautel gives you an option for even more power in the same cabinet with HD Power Boost. That means more flexibility in planning for higher injection levels. Expect more; more engineers, more innovation, more -14db and -10dB power.

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MEASUREMENT

(continued from page 8)

mented with conventional op-amp ICs with a Butterworth characteristic. Fig. 2 shows a dual-trace oscilloscope photo of the DC voltage before filtering, using a mobile signal generated by the lab's HP-11759C RF channel simulator. In the upper trace, familiar rounded peaks and sharp signal drops are representative of fast fading, which is also termed Raleigh fading, from the statistical probability distribution of fast fading. In the lower trace of Fig. 2, after the low pass filter, fast fading is almost gone and only the slower fading is left. The slower fading would reveal the effects of terrain shielding and land cover on signal strength that we are attempting to measure. The slow fading is referred to as log-normal fading, again getting its name from the statistical distribution of the signals over large geographic areas.

① Digital Volt Meter (for real-time Received Signal Level and power supply status)
② Controls and Indicators (from left to right) Main Power Switch, Logger Power Button, Logger Start/Stop Button
③ 1/4" Headphone Out
④ 1/8" Headphone Out
⑤ Terminal Block for External Loudspeakers (4 x 20W)
⑥ Headphone Level Control
⑦ Preamp-Level Stereo Output Jacks
⑧ Power Input Jack
⑨ MMC Card Slot
⑩ Global Positioning System (GPS) Jack
⑪ FM Antenna Input Jack
⑫ Kenwood EZ-500 Receiver Head Unit (controls internal KTC-HR100MC tuner)

Fig. 4: The main Field Test Unit's features.

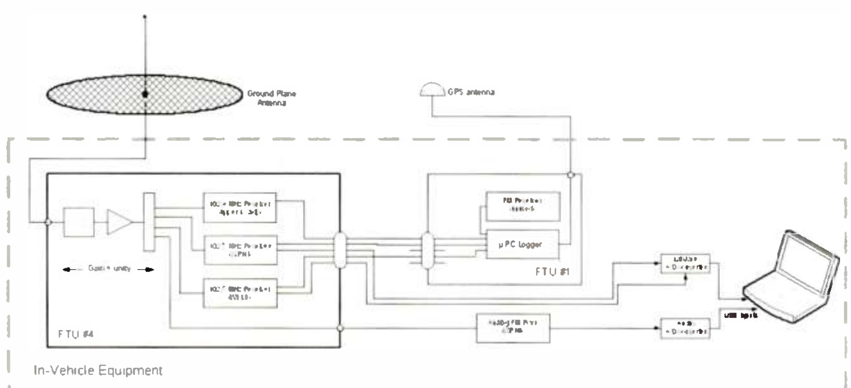

Fig. 5: The multichannel RF logging system used a standard Field Test Unit (FTU #1), equipped with a triple-input connector to interface with a second unit (FTU #4), modified to contain a total of three KTC-HR100 tuners. This unit also contains an 88–108 MHz bandpass filter, high dynamic range RF amplifier and four-port RF splitter. For NPR Labs' recent HD Radio interference field tests, the three tuners were set to the desired channel and upper and lower first-adjacent channels, while the fourth RF output was fed to an OEM car radio, tuned to the desired channel, for analog audio recordings.

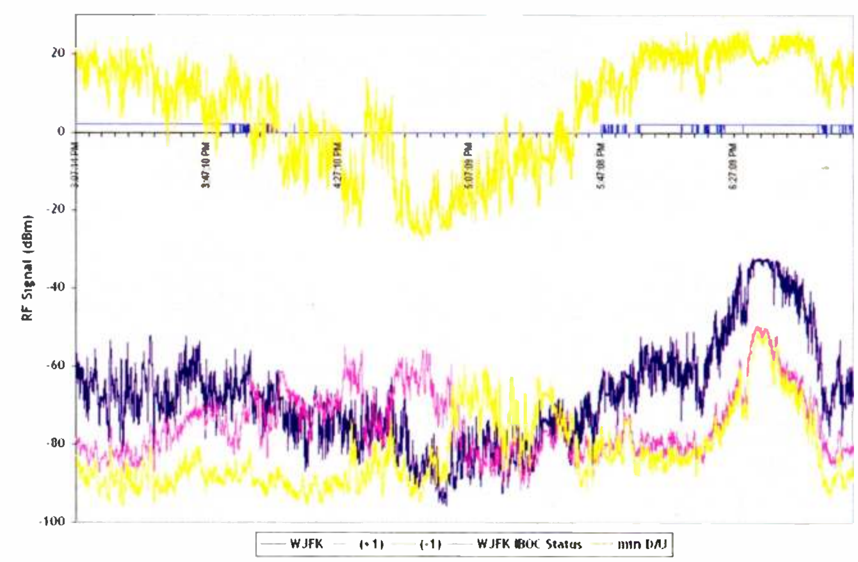

Fig. 6: Signal power measurements in dBm from four hours of drive-testing outside Washington and in Maryland and northern Virginia for station WJFK(FM), a Class B on 106.7 MHz in Manassas, Va. WJFK's signal is shown in dark blue trace along the bottom. Signals from WWEG, a Class B on 106.5 MHz in Myersville, Md., and WWMX, a Class B in Baltimore on 106.9 MHz are recorded in yellow and magenta, respectively. A desired-to-undesired signal ratio between WJFK and WWEG or WWMX, whichever is higher, is calculated and displayed as "min D/U" in gold, near the top of the chart. IBOC digital reception status is shown as the lighter blue trace near the 0 dB line; a "high" indicates digital reception and a "low" indicates no digital reception. Over most the route, the station signals vary independently, with WJFK's digital reception dropping near the middle portion of the route. While the "min D/U" is an approximate indicator of successful IBOC reception, computer analysis of the numeric data presented here showed that a more complex relationship between the absolute level of WJFK and its ratio to both station signals was needed to determine whether IBOC would be received.

The log-normal fading, representing the local mean field strengths we wish to capture, is sampled by a microcomputer logger inside the Field Test Unit's cabinet. We wanted a logging device with removable flash memory storage, to provide a simple, self-contained measurement system and to avoid connecting laptops and running custom software. Finding the right logger wasn't easy, when it had to combine a compact analog-to-digital sampler with integrated GPS capability. We finally located a company based in Scotland that makes a computer logger for race cars, called the "G-Dyno Plus." The logger is only 3 by 6 inches and has seven A/D input channels. It also has four binary digital input channels, which made it perfect to record the Kenwood tuner's digital blend line. The G-Dyno logger required software modifications by the manufacturer to change the sampling rate (we chose 4 Hz) and the output data format to we needed for signal post-processing.

The logger stores the RF signal values, digital receive status, UTC time stamps and GPS latitude and longitude to an MMC memory card (similar to SD cards).

A simplified diagram for the field test unit is shown in Fig. 3. Inside the field test unit cabinet, the logger board is connected to the Kenwood KTC-HR100 "black box" tuner, which supplies the RF level and digital receive status signals. The connector for the external GPS unit and control buttons are brought to the front panel of the cabinet. The Kenwood EZ-500 control unit, mounted on the cabinet front, is connected to the tuner and provides a variety of audio outputs. Fig. 4 is a photo of the basic field test unit, pointing out the front-panel controls and connections.

MULTIPLE CHANNELS

To develop a model to predict the coverage of HD Radio (NPR Labs completed this model and has a patent pending), we realized that the original field test units' single channel wasn't enough.

We were estimating the field strength of the HD Radio signal by measuring the FM Host carrier (something that is well-correlated with the signal level of both sidebands, due to their close frequency adjacency). However, HD Radio employs two separate sidebands approximately 100 to 200 kHz from the FM carrier, squarely in the channels of upper and lower first-adjacent stations. To understand the behavior of HD Radio in the real world, we needed four receivers: one to provide field strength data on the desired host FM channel, one to determine the digital reception status and two to capture signal strength data on the lower first-adjacent channel and the upper first-adjacent channel.

The small size of the Kenwood black box tuners offered the opportunity to combine the three tuners, which collect the signal strengths of the host FM and upper and lower channels, into one separate cabinet. Rather than use three bulky head units, Kenwood offered a small tuner control that was no larger than a candy bar. (The auxiliary cabinet containing three tuners with the small tuner controls can be seen in the inset photo in the first article.)

Fig. 5 shows an actual diagram of the in-vehicle system used in 2009 for a series of over-the-air interference studies involving first-adjacent digital stations with analog FM reception. The left box is a field test unit containing a high-performance 88–108 MHz bandpass filter, a low-noise high dynamic range amplifier, and a precision four-port RF splitter. Three of the ports feed the three receivers in the auxiliary cabinet, which are connected through a multi-wire cable to the logger in basic field test, shown in the center. The fourth RF output was fed to an analog mobile FM receiver in this particular test for audio recording of off-air reception.

Returning to the system's use for IBOC reception studies, a drive-test of WJFK(FM), Manassas, Va., a Class B commercial station on 106.7 MHz near Washington, is shown in Fig. 6. The graph illustrates approximately four hours of drive-test measurement on highways and arterials in southern Maryland and northern Virginia. This figure shows the signal power in dBm for WJFK (which operated in hybrid digital at –20 dBc at the time) as the dark blue line near the bottom of the chart. Note that even with the low-pass filtering, the log-normal fading causes substantial signal variation when viewed over longer periods.

WJFK has a first-adjacent neighbor, WWMX, a Class B on 106.5 MHz in Baltimore, and another first-adjacent neighbor, WWEG, a Class B on 106.9 MHz in Myersville, approximately 60 miles west of Baltimore and 50 miles northeast of WJFK.

WWMX's signal is shown in yellow (–1 channel) and WWEG is shown in magenta (+1 channel). It's apparent that the three signals can track differently in strength along the routes, depending on the distances and various terrain effects from each station. Signal powers varied from a high of approximately –30 dBm, where WJFK's signal began to flat top, to lows close to –100 dBm. Where WJFK's signal rises significantly, WWMX's and WWEG's signals rise too. This is due to 25 dB crosstalk from first-adjacent signals in the tuners. However, this level of measurement isolation was sufficient to collect all the data we needed to develop the HD Radio coverage prediction model.

Two more traces of data are presented on Fig. 6. A "max D/U" is shown in gold, representing the worst (lowest) desired-to-undesired signal ratio between WJFK and WWMX or WWEG are shown. It's apparent that during the middle of the drive that WJFK's signal becomes weaker than both stations' signals, putting the gold trace below –20 dB. Near the beginning and end of the drive, the D/U ratios are nearer to +20 dB.

The last trace to view is in bright blue, near the "0 dB" level, presenting the digital receive status of WJFK's HD Radio signal. A "high" line state indicates digital reception and a "low" (0) state indicates no digital reception. There is a rough correlation between the signal level of WJFK and its D/U ratio, to WJFK's digital reception. However, our analysis of thousands of miles of signal reception data revealed that a more complex relationship was involved with these three signals for a prediction model of HD Radio reception. While we can't reveal the details while the patent is pending, at any given location the model considers the field strength of the digital signal as well as the ratios of the digital signal to each first-adjacent channel analog FM signal. The effects of second-adjacent channel FM signals are considered as a secondary factor.

We used this instrumentation for extensive drive-test measurements with 10 other public radio stations across the United States. The additional data led us to the development of a comprehensive model for HD Radio coverage that considers the digital signal level and the levels of upper and lower first- and second-adjacent signals. We are grateful to have the opportunity to develop the multichannel FM signal measurement system, which has provided public radio with a great deal of information on signal propagation and station coverage.

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

Tower Lighting Options Grow

New Solar-Powered, LED Lights Help Save Costs While Meeting Aviation Obstruction Rules

BY MEENAKSHI SINGHVI

Aviation obstruction lights are high-medium-, or low-intensity lighting devices installed atop high-rise structures, buildings and towers and used as collision avoidance measures.

The governments of most countries require aviation obstruction lights on all high towers and on low towers near airports, because towers are hazards to aircraft. Such devices make the structure much more visible to passing aircraft, and are usually used at night, although in some countries they are used during daytime, too.

Aviation lights need to be of sufficient brightness in order to be visible for miles around the structure.

For broadcasters, high-rise towers are a vital part of the transmitting system, so proper understanding of tower lighting system is essential.

In general, tower lighting systems require several sets of lights, depending on the height and location of the tower, along with connection to the mains power supply. In addition, medium-wave broadcasters require some form of isolation system, such as an Austin transformer, on self-radiating towers.

Earlier, incandescent filament bulbs were standard for tower lighting, but nowadays LED-based and solar-powered LED-based aviation obstruction lights are very popular.

These lights have replaced older incandescent filament and neon bulbs for several reasons. An additional benefit for broadcasters is that solar-powered LED aviation obstruction lights can eliminate the need for power cabling and Austin transformers on self-radiating towers.

CATEGORIES OF LIGHTS

Aviation obstruction lights are broadly divided into three types: aviation red obstruction lights for structures less than 200 feet (61 meters) above ground level (AGL); medium-intensity flashing white obstruction lights for structures between 200 feet and 500 feet (153 meters) AGL; and high-intensity flashing white obstruction lights for structures with a height exceeding 500 feet AGL. A mix of these types of lights may be required, depending upon the tower.

Aviation obstruction lights must meet all specifications of the International Civil Aviation Organization (ICAO). Since rules can vary from nation to nation, additional approvals from other organizations may be required. In the United States, the Federal Aviation Administration is responsible for implementing aviation safety regulations.

Any structure that exceeds 200 feet AGL generally needs to be marked/lighted according to FAA regulations. There are many factors that can affect obstruction marking requirements, such as weather, terrain, proximity to airports, etc.

Tower lighting can be red or white; specific colors may be mandated based on the tower size and location.

For red lighting systems, the tower must be painted in alternating sections of orange and white paint to provide maximum daytime visibility; red lights are for night-time use only. In the case of white or dual (red-white) lighting systems, the need for painting the tower may be eliminated.

A tower or any high-rise structure may be lighted by low-, medium- or high-intensity obstacle lights or a combination of such lights.

Multiple light units may be used to achieve a horizontal coverage of 360 degrees around the tower or structure. The "beam spread" of a light is defined as the angle between the two directions in a plane for which the intensity is equal to 50 percent of the minimum specified peak beam effective intensity.

Towers taller than 200 feet may also require lighting at intermediate points along the tower. The color and placement requirements can vary based on tower height. The presence of guy wires may also affect how a tower must be marked.

In addition to structure size, the type or combination of types of lights that must be used can vary based upon the time of day. Their type of signaling (fixed or flashing) and brightness also can vary. FAA Advisory Circular AC 70/7460-1K outlines the specific obstruction marking requirements.

TYPES OF LIGHTS

Traditionally, red lamps use incandescent filament bulbs or neon bulbs, which have a relatively short lifespan.

Nowadays, LED-based and solar LED-based lights are becoming quite popular.

Advances in light-emitting diode technology are creating new applications and increased acceptability of LEDs for mainstream applications. Until recently, LEDs were considered appropriate only for indication or decorative purposes, but LEDs are now gaining acceptance for signaling, down lights, floodlights, street lights and aviation obstruction lights.

LED light is increasingly superseding incandescent bulbs and neon lights, particularly for applications where the bulb can be difficult to replace, because an LED light source can offer a longer life, energy savings, equal or better light characteristics and years of maintenance-free operation and a quantifiable return on investment.

LEDs are common on broadcasting towers, mobile towers, wind turbines and high-rise buildings. Technical specifications of these lights are based on the number and type of LEDs used, and are usually defined in terms of lux produced. LED-based obstruction lights are available for all intensity types and categories.

In addition to being long lasting (LEDs can remain in service for a decade or more), LED technology is quite efficient at converting electrical energy into light energy while generating very little heat. LEDs are 90 percent more energy efficient than the incandescent bulb.

Also, since LEDs give off hardly any heat, they are safe to handle and there are no UV or infrared rays. They also are clearly visible in sunlight, without any time lag.

Unlike conventional light sources such as fluorescent and high-intensity discharge bulbs that use mercury to generate light, LED lighting uses no mercury, thus eliminating issues surrounding disposal of hazardous substances.

(continued on page 14)

	AOL Using Filament Bulbs	AOL With Neon Spiral	AOL With LED Lights	AOL With Solar Panel & LED
Original Equipment Cost	Very Low	Medium	Medium	High
Cabling Costs	High	High	High	None
RF Isolation	Required	Required	Required	Not Required
Power Panels	Required	Required	Required	Not Required
Maintenance	Bulb Replacement Required	Bulb Replacement Required	None	Battery Replacement Required
Bulb Life	1,000 hours	5,000 hours	100,000 hours	100,000 hours
Power Consumption	Very High	High	Low	None External

Table 1: Comparison of Various Lights for Aviation Obstruction Lighting

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DMS Broadcasting, San Francisco, CA
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David Trudrung, General Manager & Co-owner

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LED LIGHTS

(continued from page 12)

LEDs are also reliable and rugged; they contain no fragile filaments or glass. LEDs are solid-state devices and are less affected by the demands of harsh and hazardous environments. Finally, the usable life of LED bulbs is limited by lumen depreciation, not failure.

Lumen depreciation is the main concern with LED bulbs as their luminous intensity can significantly decrease over time. However, many manufacturers compensate for this by offering lights with initial luminous intensity much greater than required by FAA and ICAO specifications.

LEDs can also be heat-sensitive, and excessive heat buildup can shorten their usable lifespan.

SOLAR LED-BASED LIGHTS

The combination of a new generation of LED lights with very low power consumption and the falling costs of solar panels made it practical for LED-based obstruction lights to work on solar energy. This kind of system consists one solar panel, a backup battery, high-intensity LED lights and a control circuit.

In fact, this arrangement is very economical compared to other aircraft obstruction lighting (AOL) systems (see Table 1, page 12). These lights are suited for all types of tower, and avoid the necessity of laying mains power supply cables on the tower. Also, in case of self-radiating medium-wave towers, the costs of Austin isolation transformers are also saved.

Among the other benefits of solar-powered LED-based obstruction lights are that each light operates independently; and accident or failure may affect one light, but it will not affect the others.

Also, with automatic sensors no manual intervention is required to turn the lights on or off. Solar lights can be designed to provide illumination automatically from dusk to dawn. Each system can charge itself, storing and producing electricity even on overcast days.

In addition to the light itself, solar-powered LED-based obstruction lights do require a few additional basic "modules" for operation.

A solar, or photovoltaic to use the formal term, module converts sunlight into electricity that can be used immediately or stored in a battery for use during the night. The type of battery being used is lead-acid, maintenance-free type, which is designed to be fully charged and discharged over and over again without causing damage.

Also necessary is a DC-to-AC inverter to convert direct current from the battery into alternating current to run AC appliances. If the LED lights are able to work on DC, then there is no need for converter.

Setting up a solar-powered LED-based obstruction lighting system does require some care, especially in positioning the solar panels to ensure maximum power generation.

Also, if a DC-to-AC inverter is used, remember that a 240 V inverter loses about 30 percent of the power during the conversion process. Using 12 V DC-based systems eliminates this power loss.

It is also important to check the life of the batteries, number of batteries and their charging capacity.

Meenakshi Singhvi is station engineer for All India Radio in Ahmedabad, Gujarat, India.

This article was adapted from a piece published in the June 2010 international edition of Radio World.

READER'S FORUM

OFF BY A DASH OR TWO

I enjoy the "Radio World Engineering Extra" and found the article on Page 1 of the April 14 issue ("Modern VHF Signal Measurement Techniques at NPR Labs") to be most interesting. But your broadcast history is off a bit.

The Detroit station where the measurements were done in 1950 is WWJ-TV, not "WJZ(TV)". In 1950, WWJ-TV was the station using Channel 4 in Detroit. WJZ-TV operated on Channel 7 in New York City at the time. It is now WABC-TV, having adopted that call sign in March, 1953.

Also, the call sign has a hyphen in it. The use of "(TV)" or "(FM)" is for call signs that do not have the -FM or -TV suffix as part of the call sign. Hence, in New York, WJZ was the AM station on 770 kHz (now WABC), WJZ-FM was the FM station on 95.5 MHz — now WPLJ(FM) — and WJZ-TV was the television station on Channel 7. But WGHF(FM) was the FM station on 101.9 MHz and WQXR-FM was on 96.3 MHz. The latter station had the suffix because there was a WQXR on the AM band. The historic WJZ call letters now reside in Baltimore. Westinghouse changed the call letters of WAAM(TV) to WJZ-TV in 1957 upon acquiring that station. CBS, which now owns WJZ-TV, changed the call letters of its WJFK and WQSR(FM) to WJZ and WJZ-FM, respectively.

Philip E. Galasso
Chief Engineer
Citadel Wilkes-Barre/Scranton
Wilkes-Barre, Pa.

Ed. Note: Some years ago, after debate, Radio World adopted an editorial style rule of identifying all broadcast licenses on first reference with the suffix AM, FM or TV in parentheses. Thus the station licensed as KIIS-FM is written here as KIIS(FM) on first reference and KIIS subsequently. We acknowledge that this was heresy to some devoted radio call sign fans.

SOLAR-POWERED LEDS IN INDIA

AHMEDABAD, INDIA — In July 2008, while attending to a fault of cabling and lights on the medium-wave mast at All India Radio Ahmedabad's Bareja high-power transmission site, it was observed that the Austin transformer at the site was also faulty.

IN THE FIELD

Looking at the exorbitant replacement cost of this transformer and cabling, the station decided to explore the other alternatives for obstruction lighting on the tower.

During its search, AIR Ahmedabad came across an excellent option: compact solar-powered LED aviation obstruction lights.

The solar-powered lights consist of a backup battery panel, high-intensity LED lights and control circuitry — all enclosed in a suitably designed compact iron-clad box.

The solar panel is rigidly attached to the box, making it a single module. With the help of clamps, the entire unit can be mounted on the mast or tower.

A setup like this had not previously been used on a live mast carrying RF voltage in excess of tens of thousands of volts. Some personnel were skeptical that the systems might burn out due to the high RF field, and the effect of a high-intensity RF field on the storage batteries was also not known.

As an experiment, one solar-powered LED aviation obstruction light was mounted on the mast at 3 meters above ground level (10 feet AGL); utmost care was taken to observe various safety precautions. This exercise was done during daylight hours.

When the transmitter was switched on, no abnormality was noticed in the lighting unit, and all the parameters of the transmitter were also found to be normal.

We waited until dark to see the working of solar switch, which was included for automated dusk-to-dawn operation.

It was a happy moment for the staff to see that lamp easily switched on. All parameters of the transmitter, again, were found to be normal.

After the transmission, the module was inspected thoroughly for any arcing or other signs of damage; all of the components were found in healthy condition.

The working of the test unit was closely monitored for about one month before it was moved to its permanent location atop the 175 meter (575 foot) mast.

Subsequently, four more solar-powered LED lights were installed on the medium-wave mast, and one on the STL towers. These lights have worked satisfactorily since their installation.

— Meenakshi Singhvi

The Advance That Has Led Us Backwards

We've Become Slaves to Our Automation System Technology in Too Many Ways

BY GUY WIRE

The 2010 NAB Show has come and gone. By most accounts, this year was a significant improvement over the past several conventions. Traffic was up, buyers were serious and vendors were busier. The industry appears to be turning around with renewed hope of better things yet to come.

I usually do an NAB recap piece after the show each year, citing all the Cool Stuff and promising new products and technologies that caught my eye. My colleagues at Radio World have already handled that pretty well. After leaving NAB this year, I kept thinking about one particular paper given during Monday's afternoon radio tech session that exposed a largely unacknowledged reality, one that has literally crippled the product of radio and our business.

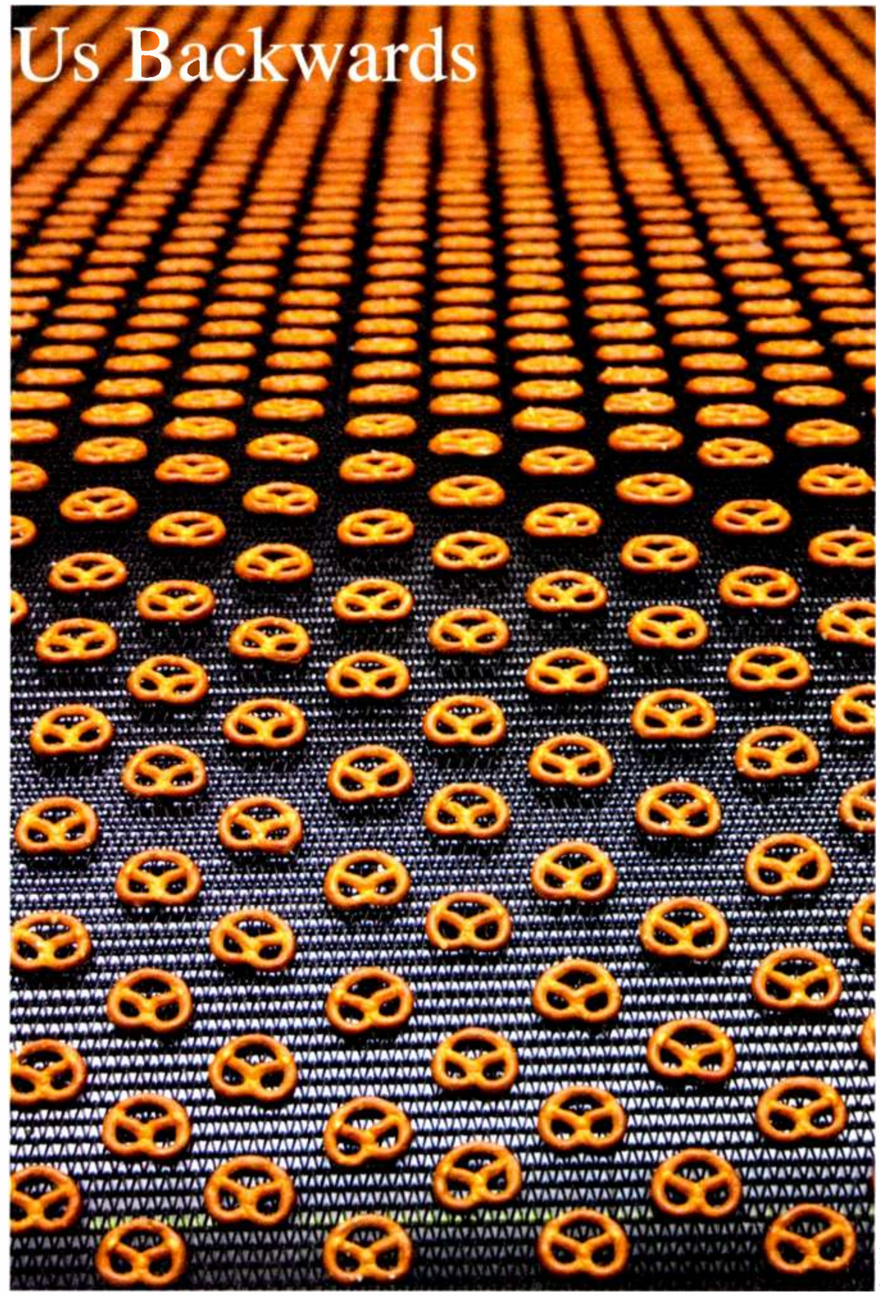
RADIO'S MALAISE

Pat Campion, director of product development for ENCO Systems, presented a discussion titled "Beyond Automation: Intelligent Software Design for Live-Assist Applications." He started by warning the audience he was taking great risk that he might not have a job after saying what he wanted to say about radio automation systems. Not just about his own company's products, but about those of all his competitors. That quickly got everyone's undivided attention.

Campion asserted that computer-based automation systems should be blamed for a part of what is wrong with radio today. Without reservation, I totally agree.

Twenty or thirty years ago — before consolidation, computers and the Internet changed our business forever — only the background music stations dared to use clunky automation systems. They all featured various kinds of Rube Goldberg-inspired tape rotation and play-out systems. Virtually every popular station with live announcers used carts and CDs to deliver their recorded content.

I can remember many top-rated jocks and morning shows of that era having huge walls and carousels filled with carts, carefully categorized and labeled. When they wanted a special bit or effect, they knew right where to grab and load it for quick execution. Dead air was practically nonexistent. Real live jocks knew how to fill and buy time cleverly without liner cards when they had to. Radio still had a sense of fun, impulsive creativity and unpredictability back then.



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Automation is a cost-saver, in radio and most businesses. That's great if the goal is to produce a homogenized product in large quantities, but Guy Wire says automated and live-assist technology has had unintended consequences.

Then came the big technology advancement. PCs and networks brought a promising and seductive amount of flexibility and efficiency to both production and on-air execution. As user interfaces, digital audio platforms and drive storage capacity all improved, loading everything destined for the airchain became easy if not preferable.

GIVE WAY TO THE 'BETTER WAY'

Fewer people could now do more of the work. Shows could be fully automated with voice-tracked announcers making it all sound "live." The game became how well we could fool the audience.

Consolidated owners and managers figured out the financial advantages of this marvelous new way of doing radio even faster than programmers. Except for drive times, live announcers were jettisoned. Radio quickly became more sterile, homogenized and predictable. I don't have to belabor the fine points of that ugly little truth.

Today's radio automation systems admittedly do a lot of things pretty well. But they also inflict a lot of unintended consequences.

Playing a log of events in sequence and reliably stopping and restarting on command is not too hard. Implementing a good search and change function for live-assist operators to quickly find and swap or add elements on the fly is more challenging.

Some do this chore better than others. Those that don't measure up frustrate the jock and degrade his performance. It's probably why we see many stations still hanging onto Instant Replays and similar external devices to handle quickly-needed audio clips.

Every system out there has its own unique strengths and weaknesses. If operators don't learn how to properly use all of the features and also how to overcome all of the foibles of their system, the air sound suffers.

TECHNOLOGY SEDUCTION

Automated live-assist radio has lulled a lot of jocks out of being creative and compelling, into a less effective frame of mind. Either they become lazy and inattentive, letting the machine do most of the work as programmed, or they spend most of their mental energy just feeding the monster and tracking the system, making sure all the spots play and the songs and sweepers segue properly.

Shouldn't they really be concentrating on making their next live break the best and most engaging it can possibly be for their listeners?

Too many programmers have been seduced by the power of automation giving them "more control and consistency." Too many capable and creative jocks have been largely muzzled into liner card readers and generic voice-trackers. Programmers using the smothering control of automated air content have squeezed the life out of the people who talk to us over the radio every day. Most have no real choices of what to air or even what to say. The PPM imperative to play the tunes and shut up is only making it worse.

There is no honest way to spin this into something positive. It's been literally devastating to the radio music industry. Air talent that doesn't cooperate can be easily replaced with a voice-tracked box. The pendulum has swung too far in the direction of control and away from creativity. We've lost perhaps an entire generation of great live jocks who might have been, save for the damage inflicted by automation systems.

A sage and venerable icon jock recently told me his show would immediately improve if we got rid of the automation and brought back only carts and CDs. If only we could resurrect those triple-stack cart decks tossed into a dumpster years ago. But I digress.

REGAINING CONTROL

Campion's paper takes on the inadequacies of radio automation headfirst, identifying unexploited opportunities and areas needing improvement. His current focus at ENCO is developing enhancements that make the job of the live-assist jock easier and more efficient, so that person *can* concentrate on doing a better show. That means spending a minimum amount of time and effort finding and preparing his chosen content. It also means harnessing the resources of the Internet to enrich that content.

Good live-assist automation performance depends not only on flexible, well-written and resilient programming but also on smart execution by the operators. Any system can only do what those who design it, set it up, program it and run it, expect it to do. An expensive, fully developed feature-rich system that is misused will sound just as clunky or defective as a more limited, less developed or buggy system.

Pat ended his presentation by challenging every station programmer and engineer to evaluate how well their automation company is delivering everything they need to achieve the air sound they want. If it's missing key ingredients or not executing their needs reliably, they should be all over that automation company to correct the flaws and make it acceptable. If that doesn't happen, fire that company (even if it's ENCO) and find one that can and will deliver.

Congratulations, Pat Campion. That's refreshing and courageous. If we ever needed something to jump-start better programming and air sound execution in radio today, this is it. We've become slaves to our automation system technology in too many ways, letting it dictate what we can and cannot do in an increasingly demanding and competitive media space. It's time we retake full control and insist that it deliver the results we truly want and deserve.

As an engineer, I do admire the engineering genius and beauty of these machines and realize that computer-based digital audio playout systems have been one of the most important technical innovations for our business in my lifetime. They have made radio technically more reliable and higher quality in many ways that were impossible before.

But in my heart, I worry that when I install one of these systems to automate a station, I am cutting out another piece of the soul of our industry and throwing it in the trash. We could end up like Neo in the Matrix. The dark side of this technology is that the patient dies in the real world. We might just need an Oracle to save us.

Guy Wire is the pseudonym for a veteran broadcast radio engineer.

The Equipment Measurements Question

When Must You Show Compliance of Your Transmitter to Technical Standards?

Do You Measure Up?

Question posed in the Apr. 14 issue
(Exam level: CBRE)

This Sunday night you are going to install a new HDFM exciter, which also generates the composite stereo signal. Are you required to do performance measurements?

a. No, as long as there is no change in modulation level.
b. Yes, because you're a professional and you want to know that the station is measured perfect no matter that the program director says his "golden ears" are better than your test gear.
c. No, there is no FCC mandate to do this, and anyway performance is set by the manufacturer's checkout.
d. Yes, under the general guidelines of 77.12966 b.3 any equipment change requires performance measurements.
e. Yes, 47 CFR 73.1590(a)(4) requires performance measurements when a stereo generator is first installed.

BY CHARLES S. FITCH

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

Today's question, shown in the box, serves two purposes: First, to once again remind you that the SBE exams are open book. You are allowed to take related reference material with you. Second, to remind you that you should carefully select and be acquainted with your reference choices before the exam. The exam room is no place to familiarize oneself with material that is several hundred pages long.

Questions on operating practices and the related FCC regulations make up around 25 percent of the usual testing content of the Certified Broadcast Radio Engineer exam, and this proportion reflects the importance that compliance to these regulations represents as a part of our professional performance. Questions on safety, technical problems and related theory round out the question areas on the CBRE exam.

In the main, the FCC regulation questions you'll encounter test you for two qualities: Are you familiar with the structure and organization of these regulations? And do you know, or can you readily access, the specific information in them?

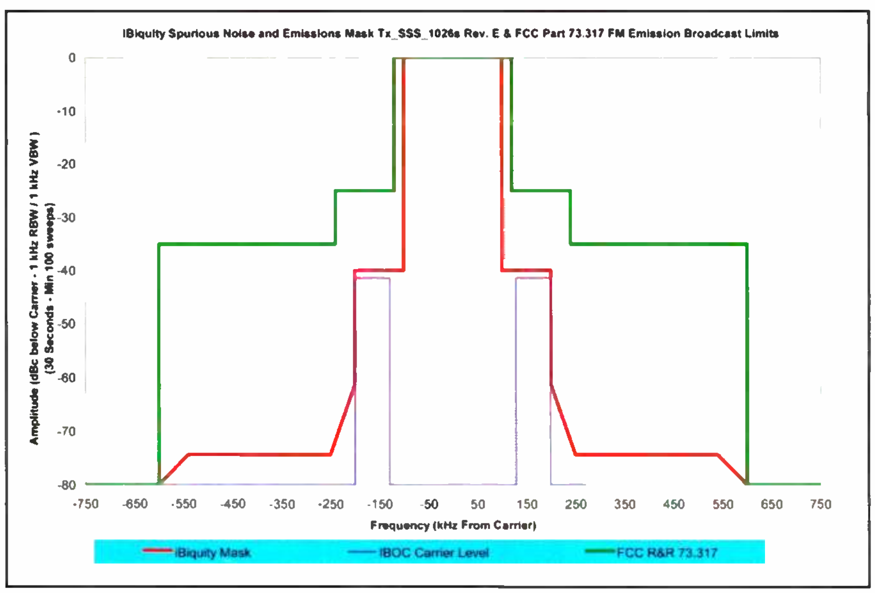

Image courtesy iBiquity

Emissions mask for FM showing both the standard FCC mask in green and the HD Radio mask in red. Equipment performance measurements check for signal emissions outside these limits which can potentially interfere with other stations.

We've discussed effective general test-taking strategies and how you can quickly dismiss many answers on their face. Even a general knowledge can eliminate many of the choices, so use this to your advantage.

Quickly reading over the possible answers for the question we've posed this issue should make you jaundiced of answer (d) immediately. Overall, the focus of the FCC is to enforce rules and regulations unique to this agency, which mainly is contained in 47 CFR (Volume 47 of the Consolidated Federal Regulations) and, if you've been at this long enough, you know there is no Part 77.

All of 47 CFR, even in tiny print, covers an entire bookshelf. Most of the specific regulations for broadcasting are contained in Part 73 for what used to be known as "main station" and Part 74 for what had been known as "auxiliary support services" such as translators and remote pickup links. The two sections have become blurred now as LPFM and translators for AM stations compete on an equal basis with more traditional "main stations."

For instance, here in Hartford, there is a fill-in translator (Part 74) with a signal better than most Class A FMs. Since it carries the HD2 signal of the Class B main station, most listeners think that it's just another full-power FM station (like those in Part 73).

Since only one choice has a specific reference in Part 73 for a main facility issue, a quick check of the rule shows its perfect relevance to the question, and there is the answer. Answer (e) is correct.

1590 (a) The licensee of each AM, FM, TV and Class A TV station, except licensees of Class D non-commercial educational FM stations authorized to operate with 10 watts or less output power, must make equipment performance measurements for each main transmitter as follows:

(4) Installation of FM subcarrier or stereophonic transmission equipment

Gone are the days of hauling all that backbreaking test equipment up to the transmitter site such as this classic total harmonic distortion analyzer.

pursuant to § 73.295, § 73.297, § 73.593 or § 73.597.

A mea culpa: Careful readers of this column will probably have noted that the regulation overall paragraph identifier "a" was missing in last issue's question printing. We printed 47 CFR 1590(4). I'm certain this probably caused our sedulous editor many sleepless nights as he tried to conjure up from the gray cells what was wrong with the answer selections.

Performance measurements should also be conducted for the following:

- The initial installation of a new or replacement transmitter
- Any modification made under 73.1690
- Installation of an AM or FM basic/standard and/or a new HD generator/exciter
- When specifically instructed by other rules or as a function of your FCC authorization.

In general, just about any component change in the system that could affect frequency stability, modulation envelope or adherence to regulation standards needs to be "proofed."

The elaborate proof of performance requirements of the past covering audio

response and distortion have been eliminated from Part 73. The common logic at present is that the competitive environment will take care of these issues. If a station really wants the most audience, the best sound, the greatest coverage, they will maximize the related technical performance because operating optimally is in ownership's best interest.

The remaining "proof issues" are spectral purity concerns. Your quest to be the best should not take you outside of your assigned channel either from over modulation and/or from spurious signals caused by non-linearities in your plant's operation. For the most part, these tests take on the form of spectrum analyzer reviews of occupied bandwidth.

The one and only occupied bandwidth test that must be made periodically within a mandated period of time is the AM occupied bandwidth measurement required annually. Each test must be made within 14 months of the previous. Overall the specifications for this are in 73.44 but if you're running HDAM, you'll need to at least meet the spurious requirements as well as staying under the HDAM IBOC mask that includes the adjacent channel digital sidebands.

FM occupied bandwidth is described by specifications in 47 CFR 73.317 for "traditional" FM but, as above for AM, you'll use the HDFM IBOC mask for the sidebands in the adjacent channels on either side.

Missed some Certification Corners or want to review them for your next exam? See the "Certification" tab under Columns at radioworld.com.

What's the Ratio, Kenneth?

Question for next time

(Exam level: CBRE)

At 100 percent AM modulation, what is the ratio of peak antenna current to unmodulated current?

a. 16 to 1
b. 8 to 1
c. 4 to 1
d. 2 to 1
e. 1 to 1

Fundamentals of Digital Audio

Long Theorized, Digital Now Dominates the World of Audio

BY BLAŽO GUZINA

The process of digitization of audio, video and film techniques is unstoppable.

Recording, production, storage, distribution, transmission, broadcasting and reproduction of sound and image are much more effective and allow better quality when performed in digital than in analog.

Working in the digital domain means virtually noise-free, crystal-clear sound. Also, multiple copies of the initial recording can be produced without loss in sound fidelity.

THE WORLD IS ANALOG

However, audio itself is analog in nature and the world around us remains analog. The most-used audio transducers — the microphone and loudspeaker — are analog devices, as is the biological hearing mechanism.

The microphone, as an analog electromechanical transducer, produces a signal that resembles the waveform of the recorded sound. The waveform of the signal and the original sound are analogous. The output signal is amplified before further processing, in order to reach a safe signal level, i.e., sufficiently higher than the noise floor.

However, signal processing may add electrical and electronic noise. Hence, an audio signal is analogous to the original sound plus additional noise.

At a radio station, processing an audio signal means mixing, recording, transmission and reproduction. Many analog signal handling difficulties and impairments, such as linear distortions, nonlinear distortions and noise, can be avoided if the analog signal is digitized before the step of modulation and transmission.

Digital systems employ time sampling and amplitude quantization, the twin pillars of audio digitization, to transform the audio information by encoding the infinitely variable analog waveform as discrete values in time and amplitude.

BINARY SIGNALS

In a digital audio system, digitization actually starts with the conversion of the analog signal to digital. This is done by the analog-to-digital converter (A/D). Analog-to-digital conversion consists of two processes: sampling and quantizing. At the output of the A/D converter the signal is in binary form, composed of two types of digital pulses: zeros (0) and ones (1).

Those convinced that the digitization is something new and modern, are mistaken. The idea of converting information into a binary form, two types of digital pulses, came about early as in 1835.

Samuel F.B. Morse, an American professor of painting and sculpture, invented what is today known as the Morse code alphabet, consisting of dashes and dots. Morse realized that it would be useful to represent the English-language alphabet, numbers and some punctuation marks with only two states: dit and dah.

Morse didn't know the term digital, nor did he think of analog and digital signals, but his dashes and dots were actually the first example of some kind of pristine binary system, in the same way as today's digital ones and zeros.

It was also an example of encoding — replacing the 26 letters of English alphabet, plus the numerals from 0 to 9 and punctuation marks, with a series of easily transmitted dashes and dots.

In 1928, the American engineer Harry Nyquist published his theory of sampling, which is considered the basis of digital technique in general.

Number of bits per sample (binary word length) (n)	Number of discrete sampled signal values (2^n)	SNR (dB)	Maximum quantizing error (%)
10	1,024	60	0.0488
14	16,384	84	0.00305
16	65,536	96	0.00076
20	1,048,576	120	0.0000475
24	16,777,216	144	0.0000029

Then, in 1930, Russian physicist V.A. Kotelnikov established the basic principles of digital processing and signal transmission. Kotelnikov determined a mathematically exact system of analog-to-digital conversion. The Soviet Union declared Kotelnikov's theorem a military secret and classified it.

Alec Harley Reeves, an English engineer, invented pulse-code modulation (PCM) and a system for error correction, considered a foundation of the digital process. PCM was patented in 1938.

After World War II, American mathematician Claude Shannon published a theorem of sampling, which came as the jewel in the crown after the ideas of Nyquist and Kotelnikov.

Finally, in 1948, Shannon with fellow American scientists Bernard Oliver and John Pierce introduced a complex theory of digital signal encoding and realized the final shape of PCM based on the foundations laid in the 1930s.

In 1977, British companies Decca and Denon introduced the digital audio tape recorder, and, in 1982, electronics giants Philips and Sony started mass production of the compact disc player. Everything that followed is history.

Despite being theoretically possible years earlier, the commercialization of digital audio was delayed for decades as technology caught up with the theories.

DIGITIZATION OF AUDIO SIGNALS

Sampling is the first step in the process of digitization of audio signals. The amplitude of the analog audio waveform is measured at periodic intervals, and the measurement accuracy depends on the sampling frequency.

Nyquist stipulated that the sampling frequency has to be at least twice the maximum desired audio frequency. For this reason, if the audio bandwidth is 20 kHz one has to apply a sampling frequency of greater than 40 kHz. For technical reasons, 44.1 kHz for commercial and 48 kHz for studio operations became standards.

The sampling rate is defined as the number of samples recorded per second. Its reciprocal, sampling time, is the time between each sample.

For example, a sampling time of 1/48,000 second corresponds to a rate of 48,000 samples per second.

The choice of sampling rate is one of the most important design criteria in the digitization process. It determines the bandwidth of the digital system.

The samples are further processed by assigning them a binary number approximating their sampled value. The process is known as quantization. Early digital audio equipment, such as the CD, used 16-bit quantization.

A bit is a useful contraction of the terms binary digit. Sixteen-bit quantization means that the sampled voltage range is divided into 2^{16} = 65,536 discrete sampled signal values, i.e., 65,535 quantizing intervals.

High-quality studio equipment uses a 20-bit technique (1,048,576 discrete sampled signal values, i.e., 1,048,575 quantizing intervals) and 24-bit (16,777,215 quantizing intervals) per sample.

Quantization is thus the measured value, assigned the appropriate bits, of the analog signal at sample time.

SYSTEM RESOLUTION

Quantization accuracy is limited by the system's resolution. Because of final binary word length, a limit of 16 ones and zeros within a 16-bit system, a digital systems' resolution is limited and measuring error is introduced (see table, above).

This error is similar to noise in an analog system, but at the same time it differs because its character changes with signal amplitude.

The greater the number of bits per sample as well as the sampling frequency, the lower the quantizing error. Lower quantizing error means greater signal to noise ratio (SNR) and lower distortion (see table).

This is the reason audio processing within a studio uses the technique of oversampling (sampling frequency of 96 and 192 kHz) and word lengths of 20 bits and 24 bits.

However, it is important not to forget that, at some point, the quantizing error becomes audibly indistinguishable. This is the explanation why most manufacturers have agreed that a minimum 16-bit system provides an adequate and faithful representation of the signal at the place and time of recording.

As can be noticed from the table, the approximate formula for calculating the signal-to-noise ratio (SNR) is:

$$SNR\ (dB) = 6n$$

For instance, if n = 20 then SNR (dB) = 6 × 20 = 120 dB. The mathematically exact formula consists of the logarithms of the sampling frequency and the maximum signal frequency and yields somewhat greater values in dBs. However, further discussion of the exact formula is beyond the scope of this article.

SIGNAL FIDELITY

In general, a sampling rate of 44.1 kHz (consumer) and 48 kHz (professional), with a digital word length of

16 bits, yields signal fidelity comparable to or better than the best analog systems.

For instance, an analog audio mixing desk and analog audio tape recorder have an SNR of the order of 60 dB, while the approximate theoretical value for the 16-bit digital is 96 dB, with actual practice achieving a value a few decibels lower.

In addition, the digital technique has advantages, such as longevity and fidelity of duplication.

If we summarize the process of transforming audio information from analog to digital and then back to analog, the audio signal in a radio station is sampled, quantized, converted to binary form, and encoded for recording, storage, distribution or transmission. Reversing the process produces a replica of the original signal.

Just as the discrete frames of a movie create a moving picture, the samples of a digital audio recording create music or speech. If we increase the film speed, using more frames per second, we would capture quicker movements. In the same manner, the greater the sampling frequency the better quality of recorded sound.

But, at the same time, this means the greater storage demands — in the form of more megabytes, gigabytes, terabytes, etc. — as well as larger bandwidth requirements for the transmission channels.

Therefore, distribution and transmission of the signal over a telecommunication channel with restricted bandwidth often requires compression.

Digital audio signals are efficiently compressed thanks to the MPEG techniques. The MPEG compression algorithms are used to remove redundant data from the transmitted signal in order to considerably reduce the bitrate expressed in Mbps. This is another advantage of digital audio. Also, this allows digital audio to be widely used across multimedia systems, a convenience not possible when different media were in their analog form.

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EMOTIONS

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ment. If you want to make a group of engineers function as a well-oiled machine with strong interpersonal cohesion, everyone in the group must be paid in their personal currency. And that requires everyone to understand everyone else's currency. A friendly chat over a cup of coffee is the easiest way to share currencies. Not only will a group that pays each other in personal currencies be more efficient and productive, but everyone will also enjoy their work. Group cohesion is a win-win.

WHY DO YOU CARE?

As an exercise, ask yourself why you have bothered to read this article? You could have stopped at the first paragraph. Why do you care about what I am saying? What is your currency? How do my ideas provide you a payment in your currency?

I can use myself as a teaching example. Why have I bothered to write this article? Yes, I am paid to write but the amount of money that I receive is embarrassingly small and by itself that amount would not motivate me to spend hours on each article. Another possible answer is that I enjoy the stature and fame that public exposure brings. While such rewards are real, they are not my driving motivation. The core reason is that I want to have a positive influence on my friends, family and colleagues, leaving some kind of legacy before my 67-year-old body eventually gives out. My personal currency is nurturing. It wasn't always so, but it is now.

I also have a long-term secondary currency: creating new fields and markets, such as digital audio in the 1970s, character recognition in the 1980s and aural architecture in 1990s. Recently, I have been developing new methods to teach soft-skills to executives, engineers, therapists, immigrants and young students. This new activity could be motivated by my desire to earn more money. I provide most of these services pro bono, free to those who cannot pay. My primary and secondary currencies are actually merged: creating a new field that directly and indirectly provides nurturing to others. I get paid in two currencies at the same time. While I might eventually make real money teaching soft-skills, that is not my motivation.

THE PAYOFF

The same model of currencies works in all kinds of social interchanges. Consider coming home and having a fight with your teenager about staying out late at a party. You need to figure out the kid's currency, which might be nothing more than having a cool image. Together, you might be able to invent a better way of paying the kid in a safer form of the same currency. Everybody wins.

The difficulty is that you cannot discover a person's currency by simply asking him what he wants. You are likely to get a socially acceptable answer but not one that is real.

Instead, while at lunch, ask a colleague what aspect of their job or hobby he really enjoys. What makes life fun? The answer will reference their currency. Now the payoff: during an engineering meeting, indentify a useful task that has elements of this currency and publicly recommend that this colleague be encouraged to do that task. You are likely to get enthusiastic support and appreciation. This is *leadership*! People will follow those who pay them in their currency. I have used this method for more than 40 years, and trust me, it really works like magic.

Barry Blesser is director of engineering for 25-Seven Systems. Opinions are his own. Comment on this or any article to rwee@nbmedia.com.

Emotions as Engineering Glue

Would the World Really Turn if We Were All Like Mr. Spock?

BY BARRY BLESSER

iStockphoto/Mark Stay

For most professionals, the idea of emotions in the workplace is viewed as a disrupting influence on the ability to get work done efficiently.

We have all observed angry voices, fist pounding, abrasive augments, passionate rigidity and even sexual flirtations. I have never heard anyone argue that these manifestations of emotions should be tolerated in the workplace. One executive once told me that emotions and psychology should be left at home.

Engineers are especially hostile to the idea that emotions have utility in the workplace, believing instead that this profession must be based on logic, reason, inference, deduction and the hard cold facts of observable reality.

In the 1960s, the science fiction television series "Star Trek" introduced us to the character Mr. Spock, who was half human and half Vulcan. He continued in the more recent feature movies as the prototype of a typical engineer. The character embodies the essence of logic, literalness and reasoning, thereby becoming the most famous symbol of what I call "anti-emotionalism." As if to highlight the weakness of human emotions, Mr. Spock said: "Nowhere am I so desperately needed as among a shipload of illogical humans."

Could this view of emotions be totally wrong? I will attempt to demonstrate that life as we know it stops if emotions are removed. Fortunately, people cannot suppress emotions.

NO EMOTION, NO FUNCTION

To begin, we need to look at what neuroscience research tells us about emotional substrates in the brain.

Emotions have been said to exist as part of the limbic system, which includes the amygdala and other connected substrates. Occasionally, a patient shows up for medical treatment with those parts of the brain having been damaged by accident or disease. These cases illustrate what happens to a person without emotions. On the one hand, they appear normal but when examined more carefully, the consequences of the injury become clear.

Such people have difficulty driving a car, but not because they lack the cognitive and motor skills to control the vehicle; rather they simply do not care if the car is heading towards a child playing in the middle of the road.

In one case a scientist reported that it took him more than four hours to get dressed in the morning. He could see all of his choices in the closet but he had no means to make a decision. Should he wear a blue sock on his right foot and a red sock on his left foot? He simply did not care because all of the choices were equivalent without emotions. Every possible combination of clothing could be considered as a choice. This is the real Mr. Spock: non-functioning.

How then can we reconcile the common view of emotions as being negative with the medical reality that we cannot do even the simplest task without them?

Consider first that the word "emotional" is reserved for those cases where the emotions are inappropriately intense and correspondingly destructive, like an adult tantrum. I call such extremes emotional hijacking; too much of a good thing becomes destructive.

Because emotions are like water to a fish — all around us — we lack a vocabulary for the emotional water that we swim in. Ordinary emotions are simply the answer to the question: "Why do you care?"

PERSONAL CURRENCY

Let us consider an engineering meeting discussing a particular technical problem that needs to be addressed. Everyone has an opinion, and each of these opinions is an individual's unique answer to the previous question. "I care because...." Publically, everyone may state that we all care because it is good for the broadcast station to have the issue addressed. However, each individual has a private reason for caring.

Here are some possible reasons why an individual might care. He wants to prove to his father that he made the right career choice. He wants to show he is intelligent because he is trying to raise his self-respect. He wants recognition to get a raise so that he can send his daughter to college. He wants the younger engineers to see him as still having value. He wants his choice to dominate the discussion as retribution for a previous insult. He is trying to compensate for an inferiority complex because he never went to college. He views life as a competitive sport with winners and losers. He wants to impress the cute new female engineer so that he can ask her out on a date.

Engineers are especially hostile to the idea that emotions have utility in the workplace.

These answers can dominate each individual consciously or unconsciously. I call the answers a person's personal currency. We get paid in emotional currency in addition to our regular paycheck. Management studies have consistently shown that financial compensation is rather low on the criterion for job satisfaction even though many of us think that is the largest motivator. It is not. Our personal currency is the driving force because it answers the question about why we care about something.

This discussion is not intended to be academic. There are meaningful implications to your engineering depart-

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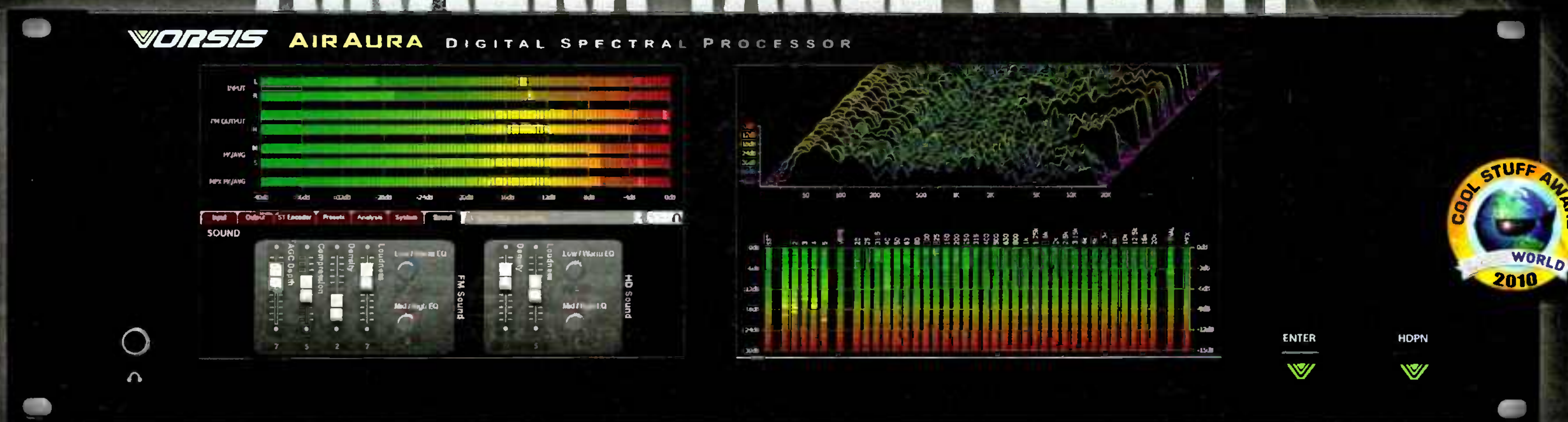
ADVERTISER INDEX

AIRAURA TAKES FLIGHT!



The new AirAura™ audio processor features proprietary "AirAura" final clipper technology for cleaner, clearer, more natural mid and high end detail without smearing, dulling and other artifacts commonly associated with managing the FM pre-emphasis curve. Its advanced multiband AGC/SST (Sweet Spot Technology) delivers incredibly smooth and unobtrusive gain and spectral control during widely varying incoming program levels, and the AGC boasts separately adjustable low and high inter-band coupling algorithms for serious sonic sculpting. AirAura also offers the latest Vorsis Bass Management System (VBMS) with new Texture control for fine-tuning on-air bass. Dual front panel 'widescreen' displays show extensive detail about the processor's operation. In addition to real-time measurement of input, output, and RMS (loudness) output levels, its comprehensive metering also shows all gain reduction activity. Specialized analysis functions exclusive to Vorsis offer an astonishing overview of input or processed audio. And for ultimate flexibility, AirAura gives you remote processor control via wired Ethernet or integrated WiFi connectivity. Completely made in the USA and available TODAY!

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- **Specialized audio analysis functions, including FFT and oscilloscope analysis of input or processed audio, Energy vs Frequency display of input or processed audio, 3-D plotting of audio spectral content vs. time, Spectral Dynamic Range metering, and activity display of clipper's distortion masking algorithm**

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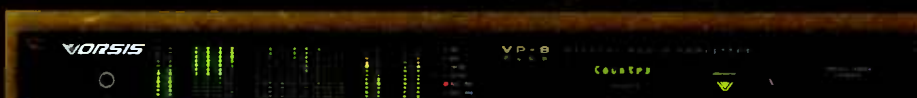

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