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RF Safety Imperative for Multi-Use Sites

by John M. Lyons and Richard A. Tell

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This paper was adapted from one presented at the NAB Broadcast Engineering Conference in April 2006.

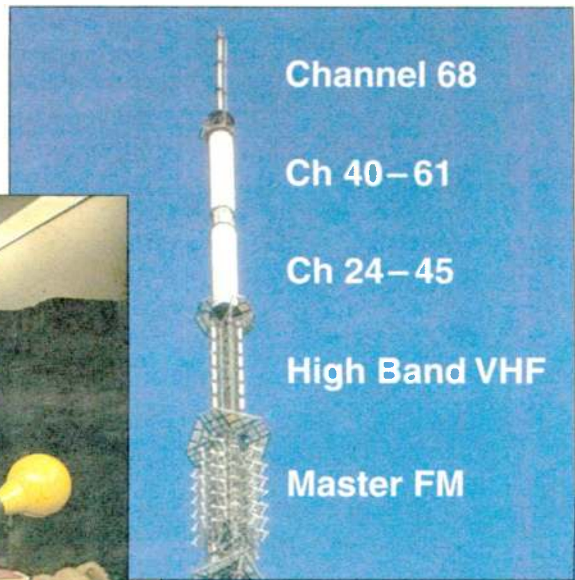

Fig. 1: Photo of the antenna mast at 4TS showing the different master antennas for FM radio and VHF and UHF TV.

Fig. 2: Richard Tell uses the Narda SRM-3000 portable spectrum analyzer and isotropic antenna to document RF field level in a building adjacent to the 4TS site.

The Condé Nast Building at 4 Times Square (4TS) was completed in 1999 and is a 48-story building comprising 1.6 million square feet of space located at Broadway and 42nd Street in Manhattan. The height to the top of the antenna mast is 1,118 feet (356 meters) above sea level. In keeping with the environmentally responsible design of the building, the rooftop construction of a main antenna tower with various broadcast antennas and their operation was done with great care to insure safety and compliance with applicable regulations of the FCC.

Prior to the Federal Telecommunications Act of 1996, New York City had in place city-specific limits on RF fields, but after 1996 these local limits were pre-empted by FCC regulations specifying maximum permissible exposures (MPEs) for members of the general public and occupationally exposed workers.

The antenna tower is situated in the center of the building roof starting at 733 feet 9 inches in height, and provides master antenna facilities for FM radio broadcasting (994 feet) and VHF (1,039 feet) and UHF television broadcasting (lower UHF at 1,076 feet and upper UHF at 1,105 feet). Fig. 1 illustrates the overall physical layout of the master antenna systems at 4TS.

The 4TS site has become a major primary/backup facility for broadcasters with their main/backup facilities located elsewhere, such as the Empire State Building, and the site continues to expand its operations to include more stations. Currently, ten FM radio stations, one VHF TV station and four UHF TV stations use the site, as summarized in Tables 1 and 2.

A challenge associated with development of the 4TS site was providing transmitting facilities for new tenants while, at the same time, insuring that all operations would be safe from an RF perspective and in compliance with FCC rules on human exposure. From the beginning, RF safety was incorporated into the overall building operation plans and this effort required cooperation and support from building management.

These efforts resulted in an evolution of RF safety protocols and work practices that, ultimately, formed a comprehensive and multifaceted program that conforms to a recently published IEEE Recommended Practice on RF

SEE RF SAFETY, PAGE 6

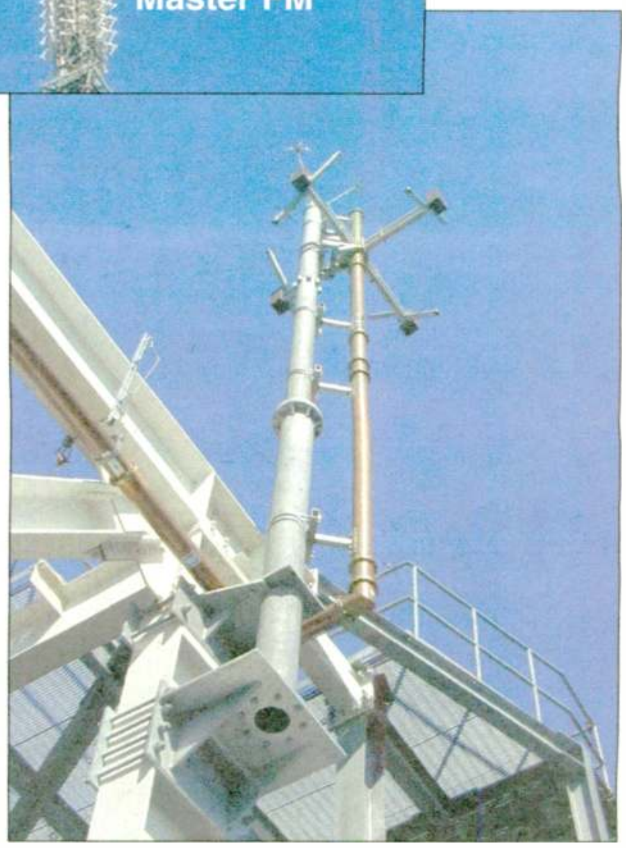

Fig. 3: Close-up photograph of the Lindenblad FM backup antenna at the 4TS facility mounted to the steelwork of the eastern-facing 4TS sign.

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FROM THE TECH EDITOR

by Michael LeClair

Election Season Brings On the Remotes

Talented Technicians, Synergy Between Engineering, News Departments Necessary for Live Coverage

One of the regular but infrequent joys of working for a group of stations with an all-news format comes during the even-numbered election years. In the political season, we have to gear up and be ready for live coverage at major media events.

A couple of years ago we went live from both the Democratic and Republican National Conventions. Those events required us to build a small radio interview "studio" on the fly to support two of our regular news shows in the field. At least in those cases we had a couple of days between when the venue was opened to the media and the event began, although you have to be prepared for the FBI bomb sweeps that run through just before the political types show up.

For pure stress, nothing beats going live on primary or election night from a hotel ballroom that was not selected until four days before the event. This fall was no exception as there was a hard-fought primary for governor in our state with a subsequent closely watched election.

We ended up covering four sites live during the primary and then three on election night.

This year's coverage plans were developed in the last couple of days before the events came off, mostly due to the candidates not making final decisions on where their campaigns would celebrate (or concede) until just a few days before primary and election night.

OUT OF THE ORDINARY

Working the remote side of one of these broadcasts is a different test for broadcast engineers. The technical aspects of the remote are quite easy: we use ISDN or POTS codecs to backhaul live reports and a press feed from a mult box that contains the important speeches from the candidates. The difficult part is dealing with the challenge of working in a dynamic environment where nothing planned can ever be counted on. Having a backup plan for just about any imaginable problem is essential to avoid losing a part of the broadcast. But there are other, non-technical challenges as well.

First is locating the phone line or ISDN line that has been ordered as backhaul for the event. In most cases, the ballroom is in use until the morning of the remote broadcast so it isn't possible to visit the site in advance to test these circuits. Once you get on-site, it is often necessary to locate the local telecommunications contact, who is ridiculously busy, to help locate your circuits so you can make a first test with enough time to respond in case there is a problem. The skills required aren't exactly technical but rather just a sense of doggedness and determination.

In fact, at one site this year the room wasn't opened until 45 minutes before we were scheduled to go live. As it turned out, our ISDN line was hidden in a stairwell on the wrong side of the room and we had to move the site in the middle of the broadcast.

A second challenge is finding a place to set up amongst the many other broadcasters who have staked out their space on the press risers. If you set up your equipment and don't stay around to defend it, don't be surprised if when you come back someone has moved in and taken your perfect spot, and you will be scrambling to find a place where you can see. It helps to make the acquaintance of other technicians on-site and let them know you are there so they will respect your needs while you run off to another setup at a different hotel.

The third challenge is then working with a reporter who will be going live, possibly for the first time from an event, and is counting on you to handle everything but talking on microphone. Sometimes this aspect involves acting as a bit of a therapist as well as a technician.

These challenges all involve working with people, as opposed to equipment, to solve problems. It is important to remember that people skills are the key to these broadcasts, rather than technical knowledge. Getting technicians in the field who are good at working with people is a key to success at live events. At the same time, the field technicians have to be prepared at a moment's notice to troubleshoot technical problems and get the job done because there isn't a second chance to get the broadcast when you are live.

TEAM EFFORT

Back at the studio, the key technical challenge is in creating enough mix-minus feeds so that each individual site can have its own custom mix without feedback. In these days of HD Radio it is no longer possible to rely on off-the-air monitoring for handoffs to remote sites — the delays are much too long. For our older analog plant, this can mean a maze of patch cords and a planning sheet for each feed to make sure that it all works. The newer digital consoles with the ability to download a custom mix-minus plan from a laptop computer definitely have the edge when it comes to this kind of custom setup.

Although live events can be difficult, and 12-hour days are routine for this type of event, there is a compensating reward in the knowledge that this is a team effort that really pays off when it is done right. Sure, my technicians may not be able to strike their gear and get back before midnight, but when they get there they will find producers and journalists still going strong all night long, preparing stories for the next morning and delivering updates on the election returns.

Election coverage is one of those few times when everyone in engineering has to work closely together with news, putting in an extra effort to achieve something extraordinary. I always try to keep that in mind, especially when it's 15 minutes to air and one of our sites is still searching for the all-important phone line.

Although live events can be difficult, and 12-hour days are routine for this type of event, there is a compensating reward in the knowledge that this is a team effort that really pays off when it is done right.

PROJECT PROFILES

We have a new kind of feature in this issue of RWEE that I am calling a "Project Profile." These stories are about difficult or complex projects that come up occasionally at radio stations and how they are solved. Broadcast engineers as a group are very project-oriented and this is one of our major skills. In fact, outside of engineering, there are few employees in the average radio group or station who have any experience at project planning. In this issue we talk about the replacement of a computer audio system that is at the heart of a group of radio stations, similar to most radio groups today.

We are interested in your stories as well. If you have a story about a complex project and want to tell it to our readers, please send me your ideas at *rwee@imaspub.com*. ■

IN THIS ISSUE

by Dave Hershberger

A Fourth Method for Digital Radio Broadcasting?

Advanced Television Systems Are Capable of Mobile Reception, Presenting a New Technology for Radio

Dave Hershberger is senior scientist for Continental Electronics Corp.

There are three widely deployed methods for terrestrial digital radio broadcasting: the Ibiquity "HD Radio" systems for AM and FM, Eureka-147 and the Digital Radio Mondiale (DRM) system. HD Radio has many advocates and critics. DRM, used primarily for shortwave broadcasting, has otherwise found little application in the United States. But there are proposals to use DRM at 26 MHz for local broadcasting. Eureka-147 is in use in Canada, Europe and elsewhere with mixed results.

A fourth possibility for digital radio broadcasting is just now emerging from an unexpected direction: digital television broadcasting. It might soon be possible for robust radio streams to be encoded into ATSC 8-VSB (8-level vestigial-sideband) signals, which can be received in a low signal-to-noise ratio (SNR) mobile environment.

HISTORY AND BACKGROUND

Historically, television and radio broadcasting services have been separate, using different frequencies. This distinction has existed for technical reasons. Radio is intended to be received mobile, but only recently have there been serious attempts to add mobile reception capability for television. Also, television is a wider-bandwidth service, required to transmit pictures as well as sound.

The technical advances that allow mobile TV reception can now also be applied to radio, or audio-only services.

After the FCC approved the basic 8-VSB transmission system for digital TV back in 1996, the Advanced Television Systems Committee (ATSC) did not simply disband itself. Instead, ATSC has been promoting enhancements and improvements to the basic system. In the last few years there have been developments that allow improved reception under conditions of increased multipath, dynamic multipath and low signal strength. The ATSC Distributed Transmission standard also allows use of multiple synchronized transmitters to cover an area.

Television's wide bandwidth can be an advantage for radio — a certain amount of inherent frequency diversity will result if radio signals time-share the same 6 MHz channel with television content. The technical advances that allow mobile TV reception can now also be applied to radio, or audio-only services. In other words, there may be a convergence of transmission facilities for radio and television.

THE MODULATION WARS

To an extent, ATSC's improvement efforts have stemmed from the "Modulation Wars." Shortly after 8-VSB was approved, there were some dissenters who claimed we should have used a COFDM (Coded-Orthogonal Frequency-Domain Multiplexed) system rather than the 8-VSB system. At that time, COFDM outperformed 8-VSB in one important area: strong signal (urban) multipath. 8-VSB was (and still is) superior in terms of weak signal performance and peak-to-average ratio. In other words, the reception threshold for 8-VSB signals was about 2 dB less than that for COFDM.

Additionally, the higher peak-to-average ratio of COFDM signals reduces overall transmitter efficiency compared to 8-VSB. Given that transmitter size (in solid-state technology) is determined mainly by the peak power, rather than the average power that needs to be transmitted, COFDM transmitters had to be as much as four times larger than VSB transmitters to cover the same area.

ATSC set out to develop enhancements to the 8-VSB system, working to improve its SNR threshold, its adaptive equalizer technology and coding technology. Systems were developed that did just that, and one was approved and standardized — the E-VSB system (Enhanced Vestigial Sideband).

In 2002, the modulation warriors were pacified by the introduction of new receiver technology from Linx Electronics, and later by others. Linx developed a new 8-VSB receiver, which greatly improved multipath performance. In fact, multipath performance of the 8-VSB system suddenly became superior to COFDM, for both strong and weak signals. The Linx receiver required no changes to the transmitted 8-VSB signal.

Tests showed that when a COFDM receiver had a multipath reflection added, that its receive SNR threshold went up. In other words, multipath meant you needed a stronger main signal component to get reception.

Interestingly, the opposite happened with the Linx receiver technology. When a reflection was added to a signal, the "main" part of the signal (the unreflected part) could actually get weaker. In other words, the Linx receiver technology uses the reflection's energy to improve reception. Earlier reception methods tried to cancel the reflection. The Linx receiver used the reflection's energy to aggregate the received signal strength. Third-party tests conducted by the CRC (Canadian Research Centre) confirmed this improvement (see *www.tvtechnology.com/features/news/n-casper-06.26.02.shtml*).

Fig. 1 shows the spectrum of an 8-VSB signal without any multipath reflections.

The spectral tails have a square root, raised-cosine shape, and a pilot carrier is transmitted about 309 kHz in from the

SEE ADVANCED RADIO, PAGE 14

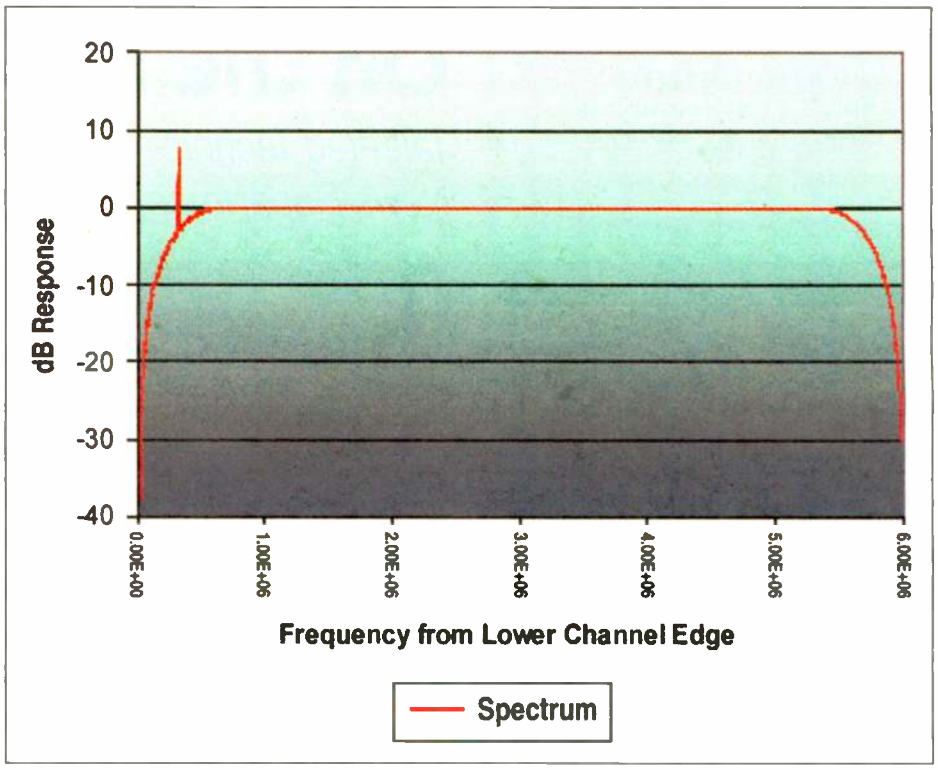

Fig. 1: 8-VSB Spectrum Without Multipath

RF Safety

CONTINUED FROM PAGE 1

Safety Programs known as C95.7-2006 (IEEE, 2006). This new recommended practice outlines the application of numerous elements that can comprise an effective RF safety program and this paper summarizes a number of these elements as used in the RF safety program at 4TS.

GENERAL SITE DESIGN CRITERIA AND RF SAFETY OFFICER

It is important to note that the collection of these elements as a whole form the 4TS RF-safety program. An in-house RF safety officer administrates the program, and has the responsibility and authority from building owner/management to insure that all aspects of the program are observed on a continuing basis and that the program is changed when it becomes necessary to accommodate changes in broadcasting and telecommunications operations at the site.

Attempts to implement an RF safety program without clear-cut administrative responsibilities and solid backing by management usually fall short of the goal of keeping the public and personnel safe. The RF safety officer is the site point of contact for any and all questions regarding RF safety, and it is imperative that personnel who work at the facility are made aware of how to contact this person.

As the 4TS site continued to develop, the RF safety officer directly participated in discussions and planning pertaining to the design of the building and transmitter support facilities. Outside experts were brought in, from time to time, to assist in providing guidance on various aspects of how to best achieve an overall effective safety program related to RF exposure.

RF SAFETY AWARENESS TRAINING AND INFORMATION

A crucial aspect of the 4TS program has been the development and presentation of an RF safety awareness training session that is presented annually. This session explains the technical basis for concerns over RF exposure, how federal standards have been promulgated to control exposure to safe levels, the concept of MPE and how these relate to potentially hazardous exposure. The RF safety awareness training also describes where and when personal RF monitors should be used and what to do if a monitor alarms.

Fig. 4: The 4 Times Square building showing the antenna mast with master antennas for FM radio and VHF and UHF TV broadcasting.

Table 1. Summary of FM radio stations operating from the 4TS facility.

Call	Freq (MHz)	ERP (kW)	TPO (kW)
WKCR	89.9	0.65	0.394
WPAT	93.1	7.50	4.250
WNYC	93.9	10.80	6.223
WSKQ	97.9	12.40	6.806
WHTZ	100.3	13.50	7.338
WKTU	103.5	13.50	7.203
WAXQ	104.3	13.50	6.844
WWPR	105.1	13.50	6.942
WCAA	105.9	1.00	0.715
WLTW	106.7	13.50	6.669

Also covered are descriptions of the building RF safety systems, including signage, warning light system and door enunciator system. Finally, information is presented on what is known about restricted access areas at the site, what areas to avoid, how the RECON monitoring systems works to help personnel stay safe.

RF safety awareness training is given each year to accommodate new workers at the 4TS site, as well as a refresher course to those who have previously attended the training. Relevant building personnel and subcontractors who provide services to the building are required to attend. This includes employees from the building security and engineering departments, personnel management and others designated by the RF safety officer.

Table 2. Summary of VHF and UHF TV stations operating from the 4TS facility.

Call	Channel	Freq (MHz)	ERP (kW)
WABC	7	174-180	205
WABC-DT	45	656-662	225 (STA)
WXTV	41	632-638	1,400
WFUT-DT	53	704-710	150
WFUT	68	794-800	3,000

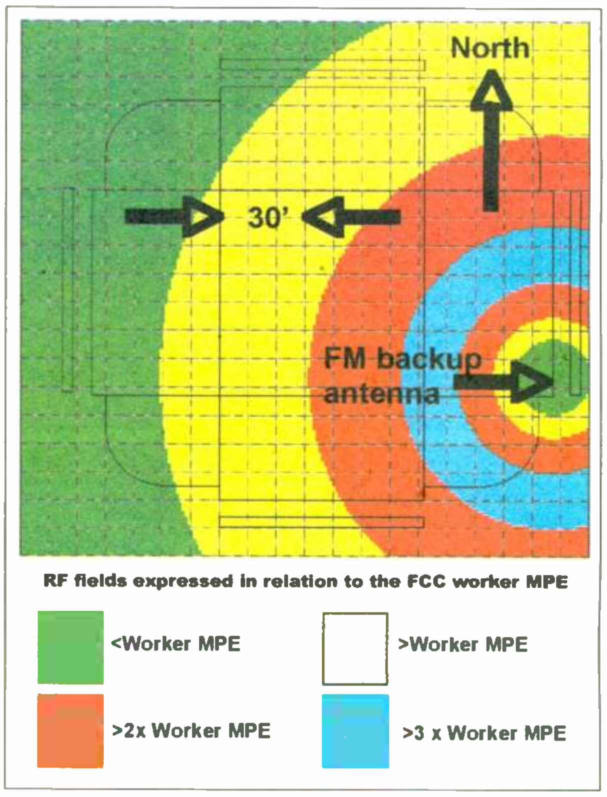

Fig. 5: Calculated RF field at main roof level at 4TS for a total of eight FM radio stations operating simultaneously from the Lindenblad backup antenna. The total effective radiated power in vertical and horizontal polarization planes in this example is 64 kW.

Beyond the more formal RF safety awareness classes, personnel who have to access the roof of 4TS are provided a succinct RF safety information sheet to read. This information sheet is a one-page description of the hazards associated with over-exposure to RF fields and includes descriptions of how signage, personal monitors and avoidance of restricted access areas on the roof and tower can control personnel exposures.

The sheet has a place for the reader to sign acknowledging that they have read and understood the message on the sheet. The sheet affords the worker one way to become aware of the critical RF safety issues relevant to the 4TS site.

ON-SITE RF FIELD MEASUREMENTS AND ANALYSIS

As a part of the 4TS RF safety program, RF field surveys are performed from time to time, based on changes that are made in the transmitting environment. For example, when a new station initiates operation at the site, measurements are conducted to verify that the RF fields on the roof do not exceed the applicable MPEs set by the FCC. Keeping an updated survey of ambient RF field levels is helpful when considering the potential need for changes to RF safety protocols at the site.

RF field measurements are routinely performed with Narda Model 8742 broadband RF field probe and Model 8718 meter whenever changes in the operational environment occur. In some cases, more detailed field measurements may be performed using a portable spectrum analyzer (see Fig. 2) equipped with an isotropic type of antenna.

In some cases, detailed analysis may be performed in concert with measurements to identify potential restricted areas for certain operational scenarios. When the FM

SEE RF SAFETY, PAGE 8

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RF Safety

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backup antenna is used, a region near the southeast corner of the roof can exhibit RF fields above the lower tier of the FCC MPEs and this region can be mapped to assist workers in understanding which areas must be avoided during backup operation. Fig. 5 is a representative illustration of an RF field map resulting from analysis of the FM backup antenna when simultaneously driven with eight FM stations.

Fig. 6: The Nardalert personal monitor detects RF emissions and weights the field intensities in accordance with the FCC MPE. The alarm threshold may be set at user selected values as a percentage of the MPE. The device also indicates the greatest field to which it has been exposed and a history of the monitor field readings can be downloaded to a personal computer for further analysis. The Nardalert unit detects RF fields across the frequency range of 100 kHz to 100 GHz, expressed as a percentage of the MPE. The Nardalert unit allows for downloading of a historical picture of RF field levels over a long period of time, such as an entire workday. This feature provides a way to document personnel exposure when workers may have need to access areas with suspected high fields.

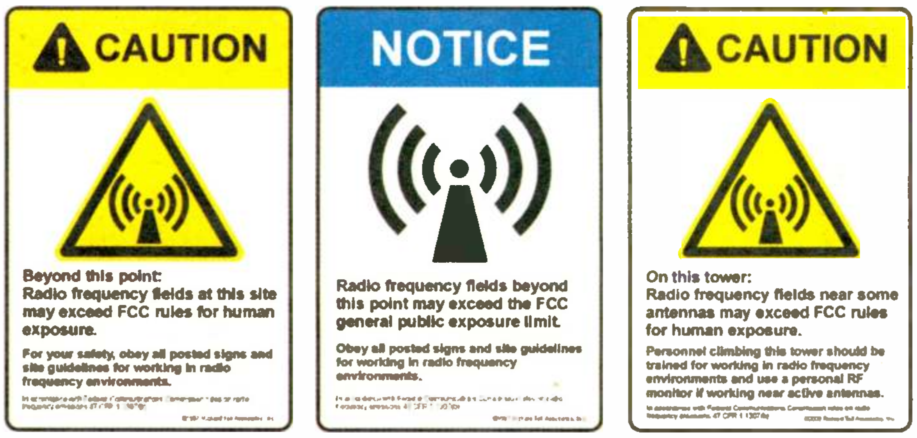


Fig. 7: Signs posted at the 4TS broadcast site.

USE OF PERSONAL RF MONITORS

The policy at 4TS is to always wear a personal RF monitor when working near active antennas. Generally, this means when work at any point on the tower is required. Personal monitors, similar to that shown in Fig. 6, provide a ready means for the individual worker to monitor his/her own exposure and, if need be, take corrective actions to reduce exposure.

Personal monitors used at 4TS include the Nardalert unit from Narda Microwave, which possesses a frequency-shaped response wherein field intensities on different frequencies are weighted in accordance with the FCC MPE so that the unit can be set to alarm when the aggregate RF field exceeds a user-specified threshold.

POSTING OF RF SAFETY SIGNAGE

The 4TS broadcast site is posted with RF-safety signs at appropriate locations to alert personnel to the fact that active antennas exist at the site and caution should be used when working near these antennas. Three different kinds of locations, relative to signage, exist at the site: points of main roof access from inside the building where RF Notice signs are used; the southeast corner of the main roof level in the vicinity of the FM backup antenna where RF Caution signs are posted; and at the base of the antenna tower where Tower Caution signs are installed to remind tower workers of the fact that intense RF fields exist near the master antennas if the 4TS stations are active. These signs are illustrated in Figs. 7, 8 and 10.

Fig. 8: RF Tower Caution sign installed on tower access hatch.

RECON TRANSMITTER MONITORING SYSTEMS

An important component of the overall 4TS RF-safety program is a system designed to monitor the status of each of the transmitters operating into the various antennas. This system, the Harris RECON system, is based on signals obtained from power sensors connected to each of the transmission lines leading to/from the various FM diplexers and the inputs to the VHF and UHF combiners.

Fig. 9: CRT display of the Harris RECON system used for continuous monitoring of the status of each transmitter at the 4TS facility. Trip points may be set to cause activation of alarms based on transmitter power levels.

The system-monitoring screen, illustrated in Fig. 9, has the capacity to indicate the forward- and reflected-power levels of each transmitter. Based on user-selected power thresholds, the RECON system continuously measures and compares transmitter power levels against the various thresholds and permits the switching of other devices, such as the RF safety lighting system described below.

The ability to log into the system remotely from any computer connected to the Internet, and observe transmitter status, is a unique and highly useful aspect of the RECON system. This is particularly helpful during times when transmitters may be active at the 4TS site and coordination is necessary to accomplish certain kinds of tower work.

By observing the operational status and power level of various transmitters, the system provides information on the likelihood of high RF field levels at the site and, thereby, assists in determining the level of control necessary to insure compliance with the MPE rules. Being able to remotely interrogate the system means that transmitter operation may be verified from another location such as the Empire State Building where many stations have their main operations.

RF SAFETY LIGHTING SYSTEM

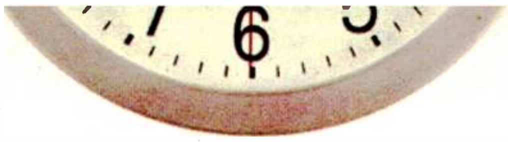
Outputs from the RECON are used at 4TS to control the status of a series of RF safety alerting lights that are installed at each of the three main roof-access doors, at two points in the southeastern corner of the main roof near the location of the FM backup-antenna and at the hatch and door access points to the base of the antenna tower.

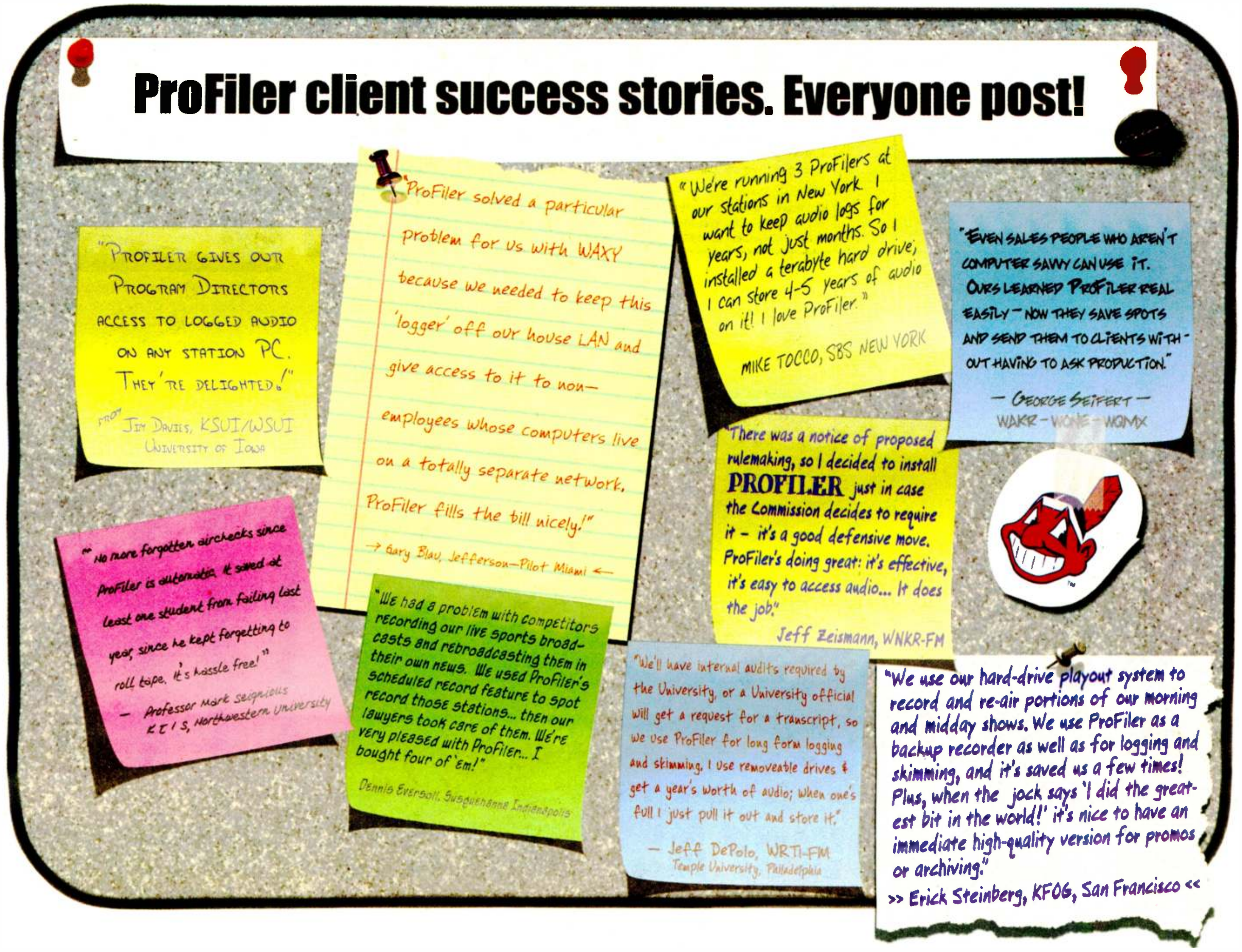
These lights include a green, amber and red lamp assembly at the main roof doors and at the southeast corner of the main roof; and a green, amber, red, white and blue lamp assembly located at the tower base. Chart 1 summarizes many, but not all, of the meanings of the various lamp conditions.

RF SAFETY DOOR ENUNCIATOR SYSTEM

Coupled with the RF safety lamps is an RF safety door enunciator system. This system provides customized verbal announcements at the main roof access doors, at the southeast corner of the roof near the FM

SEE RF SAFETY, PAGE 10





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RF Safety

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Location	Color	Meaning relative to RF fields
Main roof access doors	Green	Main roof less than public MPE
	Amber	FM backup antenna energized, use caution in that area
	Red	An emergency condition exists on the roof, use caution and observe all posted signs and verbal announcements.
Southeast corner of roof	Green	FM backup antenna not energized
	Amber	FM backup antenna is operating at low power. Fields on roof and eastside cooling towers and 4TS signs may exceed public MPE.
	Red	FM backup antenna energized at full power, fields may exceed worker MPE on the eastside AC cooling towers and the 4TS signs.
Tower base access hatch and door	Green	FM master antenna is operating at very low power but is safe to climb.
	Amber	FM master antenna is operating at medium power, do not enter FM aperture.
	Red	FM master antenna is operating at high power, do not enter aperture.
	White	VHF antenna is on. Use caution when working near the VHF antenna.
	Blue	UHF antenna is on. Use caution when working near the UHF antenna.

Chart 1

backup antenna and at the tower base hatch and access door, based on the status of the various RF safety lamps. The TowerSwitch devices become operative when a door or hatch is opened, or a button on the unit is pressed to obtain RF-safety-related information.

Fig. 10 shows one of the units installed at one of the main roof access doors. A total of 16 different RF safety messages are contained in digital memories of the various units. The particular message that is played depends on the specific lamp status of the associated RF safety lighting system. Here is an example message developed for the TowerSwitch units installed near the FM backup-antenna when the red lamp is on:

"Your attention please! The FM backup antenna is on and operating at high power. Enter this area of the roof with special caution and always use a personal RF monitor. Also, be aware that RF fields may exceed the occupational exposure limit for safe exposure on the east side A/C cooling towers and on the 4 Times Square sign supports. Do not climb on the east side cooling towers or sign supports. Remain out of this area of the roof if you have not received RF safety awareness training."

This message plays when the RF-safety info button is pressed (see Fig. 11). The various units play other messages, customized for each of the different transmitter conditions that can exist at the 4TS facility. The combination of signal lights with verbal messages enhance the RF safety program by providing reinforcement of the do's and don'ts of working in RF fields at the 4TS broadcast site.

Fig. 10: Alerting light system is installed at each roof access and tower access point at the 4TS facility. The lamp status controlled by the RECON system controls the message that is played by the TowerSwitch enunciator system located adjacent to the alerting light.

In addition to the warning lights and enunciators, an access card reader and logger controls access to the tower base through the tower access hatch. Only those licensees who have attended an RF safety seminar and are on record with the building will have their access cards coded for this portal. All others must be escorted by the RF safety officer or other designated "certified" building official.

Fig. 11: Close-up photograph of the TowerSwitch RF safety door enunciator unit that is mounted at main roof-access doors, outside on the main roof, and at the hatch and door access points for the antenna tower.

LOCK-OUT/TAG-OUT PROCEDURE

As a part of the 4TS RF safety program, lock-out/tag-out procedures are used when FM transmissions are switched from the main master antenna to the FM backup antenna. In this scenario, the main combiner output feed is locked out/tagged out before the manual patch is moved to the backup antenna. This is a manual switchover to protect workers who may already be within the restricted area of the main roof. This procedure insures that safety concerns are addressed and that areas are cleared before

SEE RF SAFETY, PAGE 12

RF Safety

CONTINUED FROM PAGE 10

the backup antenna is energized.

Fig. 12 shows the manual patch and the lock-out/tag-out switch. Similar lock-out/tag-out switches are in use in the VHF and UHF transmission paths, between the combiner outputs and antenna feed systems.

MEDICAL DEVICE CONSIDERATIONS

There are no federal regulations that prescribe field strength limits for avoiding adverse interference with implanted medical devices such as cardiac pacemakers or defibrillators. Nonetheless, the issue of potential interference with medical devices is included in the RF safety awareness training sessions described above. Persons who may rely on such devices are directed to consult with their physician prior to entering work areas on the roof.

ANNUAL PROGRAM AUDIT AND RETRAINING

An effective RF safety program must include some way of auditing its performance. This is accomplished at 4TS through a continual appraisal of how well the procedures seem to work and maintaining a record of any over-exposure incidents that may occur. This facet of the program can provide important feedback on aspects of the program that may need to be changed or strengthened, or suggest features of the program that may, ultimately, prove unnecessary.

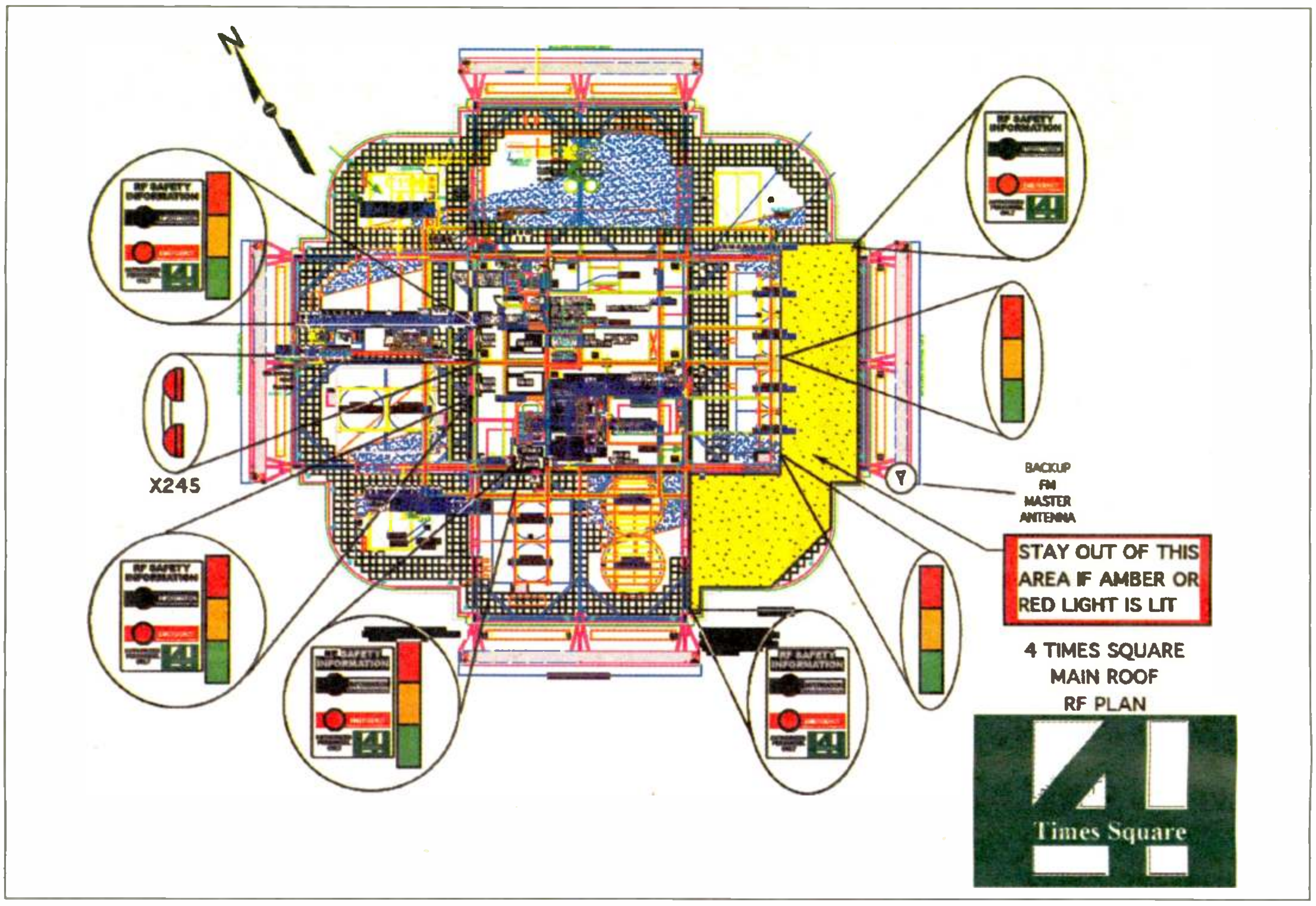

Illustration of the main roof level showing locations of RF-safety signage, RF alerting beacons, and RF safety enunciators and the telephone. A similar drawing for the tower access level is provided at the tower access hatch and door.

Besides a written record of the program's activities during a year, personnel are provided with retraining each year to freshen workers' memory of the established protocol for maintaining RF safety at 4TS and strengthen each person's awareness of and appreciation for RF safety. Each person present at the RF safety awareness training is provided with a certificate, and a record of their participation is made for retention by the RF safety officer.

DEVELOPMENT OF AN RF SAFETY PROTOCOL

A so-called 4TS RF safety protocol lays out the basics of staying safe at the facility and is similar to the RF safety information sheet discussed earlier, but with more detail. This protocol includes guidance on safety procedures, such as:

- All personnel should be trained for RF safety awareness or escorted by a person who is trained.
- Obey all posted signs.
- Obey light beacons for roof access.
- Listen to and obey verbal instructions.
- Always assume antennas are active.
- Use personal RF monitors when working near active antennae.
- Follow procedures established by RF safety officer.
- Remain out of restricted access areas designated by the RF safety officer.

This protocol is made available to all personnel who need access to the roof and tower areas. In addition to the guidance provided within the protocol, descriptive drawings of the 4TS roof are posted at each of the main roof access doors and the entry points to the antenna tower. These drawings, such as that for the main roof level shown in the illustration above, identify the location of telephones and alerting-light beacons.

The protocol is changed as warranted by changes in usage of the 4TS facility but in all cases, the intent of the RF safety program at 4TS is to maintain a main roof level that is, except for certain limited conditions, free of exposures that would exceed the FCC's public MPE.

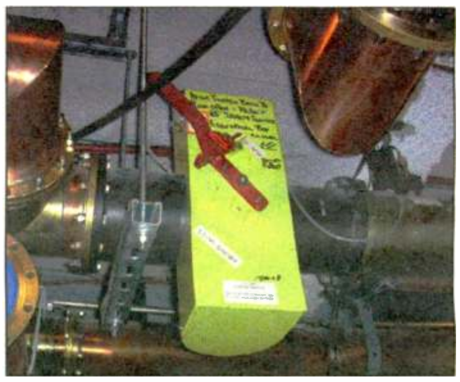

Fig. 12: A manual patch is used to isolate the main combiner feed from either the main or backup antenna. The lock-out/tag-out switch preceding the patch assures that there is no RF energy present, before the patch can be pulled and moved.

CONCLUSIONS AND RECOMMENDATIONS

Implementation of a robust and effective RF safety program is best accomplished through design from the very beginning of development of high-power facilities. The RF safety program at the 4TS building continues to evolve as the number of broadcasting and non-broadcasting licensees increases and new technology provides enhanced ways of insuring safety. The various elements discussed here may prove effective for managers and operators at other multi-use facilities elsewhere.

While the technical and procedural details of an RF safety program are important, real success at complex sites is crucially dependent on a strong commitment to supporting the RF safety program by facility management and the day-to-day oversight provided by an on-site RF safety officer. Engineering personnel charged with the development of RF safety programs at other multi-use broadcast sites are encouraged to work carefully with their building and/or site managers in the overall design and support of their programs. ■

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Advanced Radio

CONTINUED FROM PAGE 4

lower channel edge. The signal is mostly upper sideband.

When a time-delayed reflection is added to a signal of any kind, it produces a comb filtering effect. The frequency response becomes bumpy or ripply. At some frequencies the interference is destructive, creating nulls. At other frequencies the interference is constructive, creating peaks. Fig. 2 shows a multipath example. The spectral shape is the reason for the "comb filter" term — it looks like the teeth of a comb.

As the reflection amplitude gets bigger, the peaks and nulls also get bigger. When the reflection amplitude equals the direct signal, then the signal nulls go all the way to zero. This is called a "0 dB reflection." Fig. 3 shows such a difficult channel response.

Early 8-VSB receivers, which tried to cancel the reflection, could not deal with this situation, because it would require infinite gain to be applied to the received signal at the nulls. But newer receiver equalizers from Linx, Zenith and possibly others work in the presence of 0 dB echoes, and the resulting infinitely deep (in decibels) spectral notches.

The development of improved receiver technology changed the game. 8-VSB suddenly became equal or superior to COFDM in all major areas — strong and weak signal multipath, weak signal performance, transmitter efficiency and transmitted bit rate. The modulation wars are over for television, and 8-VSB won.

But one obstacle has remained, and that is mobile reception. The 8-VSB system was not originally designed for mobile receivers, which experience fast-changing dynamic multipath and Doppler shifts. A Doppler shift is a slight change in the received frequency caused by relative motion between the receiver and transmitter. At channel 14 or 473 MHz, Doppler shift is about 0.705 Hz per mile per hour. At 75 MPH, a 473 MHz signal will shift about 53 Hz. Doppler shift can introduce different speed-related frequency shifts to each multipath component of the signal.

The receiver developments made by Linx, Zenith and others do not provide mobile reception. However, new developments have mitigated these problems, making mobile reception of modified 8-VSB signals possible.

As the ATSC system and especially its receiver technology has been improved, it has been moving in the direction of becoming more suitable for what radio needs — robust mobile reception in the presence of dynamic multipath propagation and Doppler shift.

A-VSB ATSC DEVELOPMENTS

As part of this ongoing effort to improve the basic standard, a new and relatively comprehensive set of further improvements has been proposed. Rohde & Schwarz and Samsung have joined forces to develop a system called A-VSB, which stands for Advanced Vestigial Sideband.

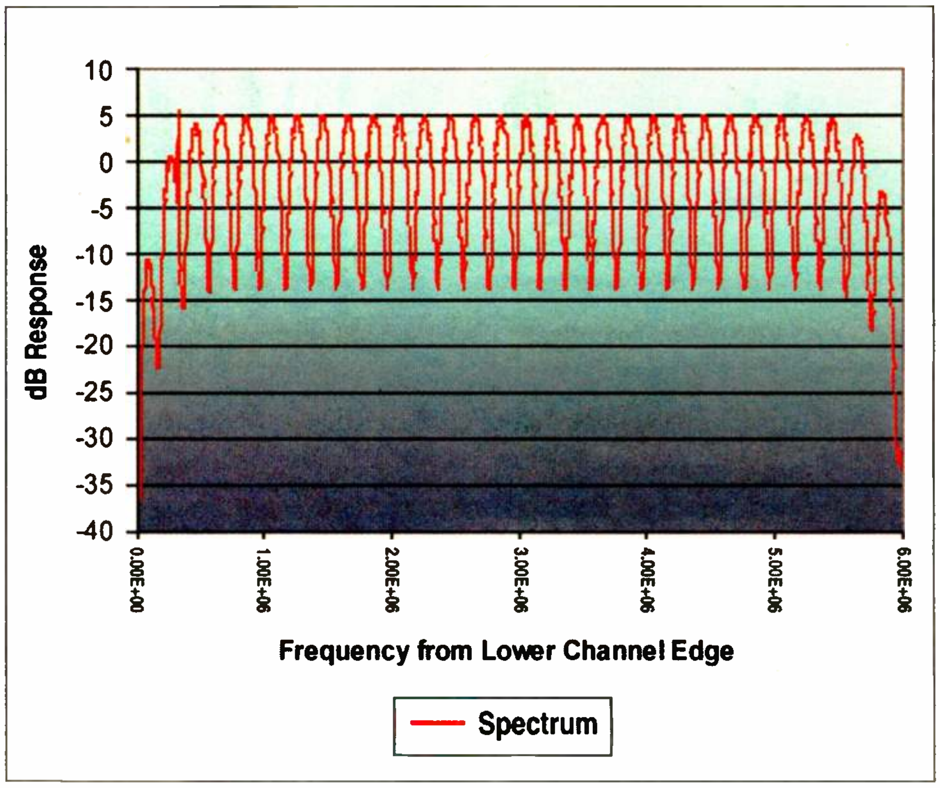

Fig. 2: –2 dB Reflection, 5 Microsecond Delay

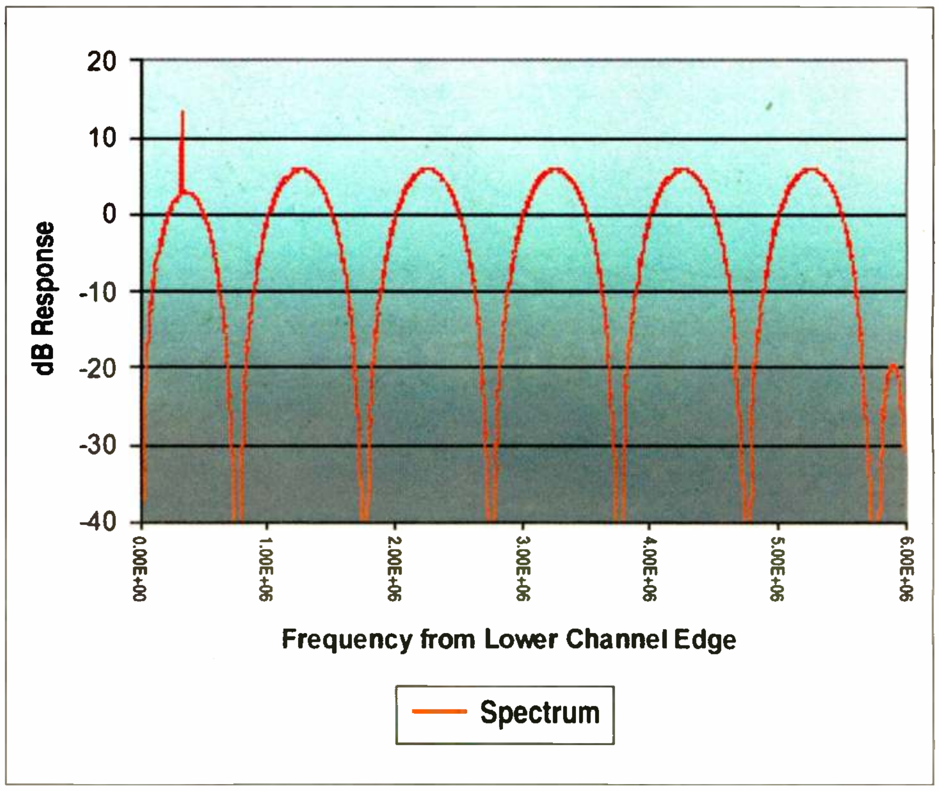

Fig. 3: 0 dB Reflection, 1 Microsecond Delay

A-VSB takes a portion of the normal 19.39 megabit payload of a conventional 8-VSB signal and applies additional coding and equalizer training sequences. These enhancements make these parts of the 8-VSB signal receivable at lower signal-to-noise ratios and in mobile applications. Only the packets with the additional A-VSB coding are more robust. These packets may be received by mobile receivers, at locations and speeds where the conventional VSB packets are lost. Legacy ATSC receivers ignore the A-VSB packets, and receive only the conventional 8-VSB packets.

The additional coding allows reception even in the presence of rapid mobile flutter, poor SNR and Doppler shift.

Another component of the A-VSB signal is an improved "training sequence," an essential component of a mobile transmission system. A "training sequence" is a known bit-pattern that is transmitted at regular intervals to allow receiver equalizers to "train" themselves to correct linear distortions in the channel. The receivers use an adaptive equalizer, a digital filter that changes its coefficients, and therefore its frequency response, "on the fly" in response to changing channel response.

Once the spectrum is restored to a flat response, the bits can be demodulated. The filter is adjusted until the expected "training sequence" is produced. Once that is achieved, the payload data can be recovered, until the channel changes enough that the equalizer no longer works.

In the legacy 8-VSB system, the training sequence occurs at the field rate, which is approximately 41.3 Hz. So every 24.2 milliseconds, the equalizer may update itself. That is not fast enough for mobile reception, where the flutter rate may be considerably faster. A-VSB solves this problem by inserting a supplementary reference sequence (SRS) into the MPEG packet's adaptation field.

The data rate that is assigned to create these training sequences is variable. Under severe Rayleigh fading, more training sequences appearing more frequently in the VSB frame is desirable. At present SRS training sequences to compensate for severe Rayleigh fading will require 2 megabits per second and may change as

SEE ADVANCED RADIO, PAGE 16

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Advanced Radio

CONTINUED FROM PAGE 14

Transmission Mode	*Conventional 8-VSB*	*A-VSB ¼ Rate*
Threshold	15.1 dB	4.5 dB
Mobile reception speed (channel 14)	1.4 MPH	171 MPH
Channel capacity	19.39 Mbps	4.8 Mbps

Table 1: Conventional 8-VSB and A-VSB Comparison

ATSC Payload	*A-VSB ¼ rate payload*	*Stereo programs*
17.4 megabits	0	0
16.4 megabits	250 kilobits	4
15.4 megabits	500 kilobits	8
14.4 megabits	750 kilobits	12
13.4 megabits	1 megabit	16
12.4 megabits	1.25 megabits	20

Table 2: ATSC and A-VSB Payloads and Radio Capacity with 2 Megabits of SRS

the technology matures. The presence of SRS allows receivers to continuously adapt their equalizers, making it possible to equalize signals corrupted by fast dynamic multipath. SRS may also be used to improve reception of legacy 8-VSB packets under dynamic multipath conditions.

A normal 8-VSB signal can be received in fixed locations (no Doppler shift) at a signal-to-noise threshold of 15.1 dB. A-VSB packets at the 1/4 rate can be received at an SNR of only 4.5 dB — and at speeds up to 171 MPH on channel 14 (473 MHz channel center).

A 1/4 rate code means when you start with 4 bits of channel capacity, you can transmit 1 bit of payload. In return for the bit rate you give up, you get a more robust channel that works at a lower SNR.

Table 1 shows how 8-VSB and A-VSB compare. A-VSB is better than conventional 8-VSB by 10.6 dB. Conventional 8-VSB only compensates for a small amount of Doppler shift, only enough to allow for tropospheric effects, some slow dynamic multipath and tower sway in high winds. The price for the better performance of A-VSB is the lower payload. Conventional 8-VSB transmits 184 bytes of payload per packet where A-VSB only transmits 46.

Many broadcasters already own digital TV transmitters. The only additional investment would be for an A-VSB encoder and modulator — a relatively low expense.

Let's do the math. Let's say a television broadcaster has an improved HDTV encoder, and can afford to give up 7 megabits (2 Mbps SRS plus 5 Mbps for radio services) of his 19.39 megabit payload without significantly affecting HDTV picture quality. What could we do with 5 megabits of 8-VSB and A-VSB coding?

Five megabits of 8-VSB payload translates into 1.25 megabits of A-VSB payload with the 1/4 rate coding. These 1.25 Mbps are more robust than the digital television data, and can be received in cars. With the best audio coding methods now in use, let us assume we can pack a stereo audio program into 64 kilobits per second. The 1.25 megabit capacity means we can transmit at least 19 stereo audio programs to cars and homes. If some of the channels are monaural we can transmit even more programs. Variable bit-rate statistical multiplexing may further increase this capacity.

Table 2 shows how the ATSC payload could be allocated between legacy ATSC packets and A-VSB packets, the A-VSB payload and the number of stereo programs that could be supported at approximately 64 kilobits/second. Two megabits have already been subtracted from the numbers in the left column for SRS.

Mobile video reception has been demonstrated with A-VSB. So the automobile of the near future may include an ATSC receiver in the car "radio." In the back seat, there would be a video screen so the kids can watch TV while riding. In the front seat, the same tuner could decode audio-only A-VSB programs — radio!

A-VSB's mobile capabilities are attractive to broadcasters for several reasons. First, the broadcaster may program directly to mobile viewers and listeners, without having to rely on middlemen cell-phone providers and sub-providers such as MediaFLO. Second, a subscription fee will not necessarily be required to receive the mobile TV and/or radio broadcasts.

Third, many broadcasters already own digital TV transmitters. The only additional investment would be for an A-VSB encoder and modulator — a relatively low expense. Adding radio signals to the DTV signal would be a no-brainer. Fourth, the local content available via terrestrial broadcasting provides powerful competition against satellite radio providers; weather, traffic, news and commercials would all be local. Fifth, the capacity of A-VSB allows many program streams, which provides another way to compete with satellite radio.

A-VSB may be implemented with "time-slicing," a technique that also exists in DVB-H (a COFDM-based mobile video transmission system). Time-slicing allows the robust packets to be bunched into short bursts at regular intervals. This allows battery-powered receivers to power down between packet bursts, thus saving power. The receiver buffers enough signal to provide continuous programming between packet bursts.

Mobile reception, particularly in areas with terrain shielding, can be difficult with a traditional single transmitter system. However, ATSC standard A/110 describes a system for distributed transmission, using multiple transmitters to cover an area. Use of synchronized gap-filler transmitters will help not only mobile reception of A-VSB, but traditional fixed reception of ATSC television signals too. The first ATSC distributed transmission system went on the air in July of 2003. The A-VSB system includes an alternate method of synchronizing distributed transmitters.

POSSIBLE ENHANCEMENTS FOR RADIO-ONLY

If there are applications for A-VSB where the transmitter does not need to be shared with television broadcasting, then all of the packets may be A-VSB encoded. There would be no data that an 8-VSB legacy receiver would recognize. But in that case, there is no longer any need to maintain compatibility with ATSC standard A/53 (the 8-VSB television broadcasting standard).

Rohde & Schwarz and Samsung are thinking about improving the impulse noise rejection coding for the system for use on VHF low-band channels 2-6 (54 to 88 MHz). Although low-band propagation in hilly areas is better than it is on UHF, low-band also suffers from more impulse noise. If and when television vacates these channels, this spectrum could be used for A-VSB broadcasts.

A further modification would be to scale the bandwidth down from 6 MHz to 1 MHz or less. A 6 MHz channel might support as many as 100 audio programs, so this might be too much capacity to bite off in one chunk. A lower bit rate, scaled-down A-VSB channel at 1 MHz or less would provide fewer audio channels (12-18) and would provide much more allocation flexibility. Instead of accommodating just five 6 MHz channels, VHF low-band would have 30 slots if a 1 MHz wide variant of A-VSB were used for radio-only services.

One simultaneous strength and weakness of the Eureka-147 system was its leveling of the playing field for all broadcasters. Broadcasters would have had to share transmitters, and would have gotten the same coverage area. There is some similarity here between Eureka-147 and A-VSB radio broadcasting.

A-VSB provides the capability for multiple program streams, but that does not necessarily impose a requirement that broadcasters must share transmission facilities. Just as conventional television broadcasters are now providing multiple program streams on their DTV channels, radio broadcasters could do the same. So instead of sharing program capacity, a radio broadcaster could increase the number of program streams. What could traditional single-program broadcasters do with a dozen program streams?

Streams could carry specific programs such as traffic reports, weather, time-shifted rebroadcasts of popular talk shows, local "Swap Shop" shows or business reports. This kind of multiple-stream capability will help traditional broadcasters compete with iPods, internet niche programming, etc.

CONCLUSIONS

The notion of providing audio-only services is already being considered by mobile video providers. In other words, they already contemplate radio on cell phones as well as television. Let's not let them beat us broadcasters to the punch at our own game.

The distinctions between radio and television are becoming blurred. Low-resolution mobile video could be considered "radio with moving pictures." Radio also could be transmitted with still images — advertising, or program-related pictures. All of this is possible with A-VSB.

With the development of A-VSB, there is no technical reason why radio broadcasting could not be migrated to ATSC signals. There is no economic reason why this could not be a free, no-subscription service. No new spectrum allocations are required. Unlike HD Radio, there is no interference penalty, oppressive royalty payment, limit of just one or two program streams or a major impact on the transmitter system. Broadcasters, and not cell phone service providers, are in control of the ATSC transmitters. Let's look at use of this new technology for radio.

Comment on this or any article. Write to rwee@imaspub.com. ■

A-VSB Demonstration at NAB 2006

This photo shows a hardware demonstration of A-VSB reception in the ATSC "Hot Spot" at NAB2006. A path simulator produced dynamic multipath and Doppler shift. The two spectrum analyzers show horrible multipath, yet the two Samsung prototype mobile A-VSB television receivers are still making pictures. The sign says the threshold of visibility is only 4.5 dB, and the path simulator was simulating mobile reception on channel 14 (473 MHz) at 171 MPH. Although the demonstration showed mobile television reception, it could just as easily be used for mobile radio.

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Charles S. Fitch is a frequent Radio World contributor.

A great common denominator between broadcast and communications operations is that they consume electric power. The great constant between them is that they must struggle to overcome power quality (PQ) problems. Our power is perfect when it leaves the generator. It's in what we do to it after that, in how we use and distribute the power, that we electric consumers create PQ problems.

PQ difficulties take the form of less-than-perfect sine wave, voltage regulation variations, waveform noise, supply reliability, phase unbalance and differential ground problems, just to mention a few deficiencies. Sometimes PQ becomes so poor that the only option to stay on the air is to go over to an alternative, standby source.

In the past, in the classic broadcast operation, that source was the standby generator. The power picture today is a little more complicated as we add in such factors as co-generation, power conditioning, harmonic currents, demand factor reduction and the absolute need to equip some mission-critical equipment with uninterrupted power supplies (UPS).

GETTING DOWN TO BASICS

Every standby supply is made up of three elements.

The first is a recognition system that detects when PQ has gone out of tolerance and initiates the standby power generation. The second element is a source of standby energy (fossil fuel in an engine-powered generator, batteries in most UPS, etc.). Finally, you must have a power generator — an alternator in an engine-powered generator, an inverter in an UPS, a solar array, etc.

The sophistication of the recognition circuit determines how many factors of the PQ picture the standby unit can handle. A simple drop-out relay can detect a loss of power. At the other extreme, several networked microprocessors, each viewing a different monitoring point and factor, can be ganged to make the decision to initiate a switch to backup supply.

The source of power determines the duration that can be supported and the capacity of supply. The choice of power generator type and its output capacity limits the load level and load character that can be supported.

The recognition system generally looks at one or more of these six factors of PQ:

1. Phase loss in a three-phase electrical supply system, the most ordinary outage in broadcasting.
2. Phase reversal in a three-phase electrical supply system; very rare and normally encountered only when utility work or generator switching has just occurred.
3. High line voltage, encountered when local voltage regulators have gone out of range or when a large, heavy user has suddenly disconnected.
4. Low voltage; proportionately set to match the load but typically the recognition circuit calls for action between 90 and 105 volts on a 120-volt circuit.
5. Loss of supply voltage, which is low voltage taken to an extreme.
6. The more esoteric — the utility would like you to think picayune — PQ factors as noted above.

Regardless of the decision points made by the recognition circuit, the user must make a larger, more basic decision first. Can the load and mission tolerate a loss of power while the standby source comes online, or must those loads have uninterruptible power supplies to ensure that they never lose power?

As a practical matter, in the typical broadcast plant the answer is often yes to both questions. Some loads absolutely will need to be supplied by UPS power and then supported again for the long haul by a fuel-powered generator once the generator has started. The balance of the plant can wait for the generator to come online.

WHAT'S IN THE BOX?

Most UPS units have the three basic elements described above where the power source is a battery and the power generator is an inverter.

The less expensive versions normally feed through the incoming AC power and simultaneously switch on the inverter and switch over to the inverter output when a PQ problem appears.

Generator for Backup Power Shown Installed in Outdoor Enclosure

More expensive versions send the incoming AC power to a large rectifier/regulator that sends DC power to the battery bank, and this DC is then constantly inverted to create a new (and hopefully nearly ideal) AC supply, free of PQ deficiencies. The upside of this design is seamless operation and isolation from the incoming line as the inverter supply is constantly online. The downside is that the rectifier must be capable of supplying all the power needed for the "re-conversion" back into AC, instead of just the trickle-charging present in a low-price UPS.

Typically, UPS supplies are designed to support rated loads for 20 minutes, for cost, size and maintenance reasons. The Edison Institute, which keeps track of such matters, says the vast majority of power outages (67 percent or so) are weather-related. Other causes are animals (squirrels cavorting on insulators much to their chagrin), car accidents ("I swear the pole jumped at my car"), maintenance on utility lines and human error. According to the Electric Power Research Institute, roughly 2 million businesses have lost $46 billion per year in lost production due to power outages.

From my own observation in New England over the last 20 years, most outages are under six minutes; the handful of longer outages have averaged six hours. Under this circumstance, a properly sized and maintained UPS should cover most of those six-minute outages.

The above numbers are probably typical. The most important numbers are the past decade's outages at your location. Check with your utility or state Public Utilities Commission to get a realistic statistical analysis on which to base your decisions.

The quest for efficiency and capacity has brought a number of alternative UPS systems into vogue. The most prominent of these for larger loads is the "flywheel UPS." Essentially an electro-mechanical device, the flywheel UPS has an electric motor, a large mass flywheel and an alternator connected on a common shaft. The motor drives the alternator in normal operation precipitating two desirable features: isolation from the utility power source and power factor (PF) correction if desired.

When utility power is lost, the energy stored in the rotating mass of the high-speed flywheel is converted into electric power by the alternator. Depending on design, load and other factors, this UPS can

See POWER, page 20 ▶

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With the addition of the optional MiniSPL measurement microphone, the ML1 also functions as a Sound Pressure Level Meter and 1/3 octave room and system analyzer. Add the optional MiniLINK USB computer interface and Windows-based software and you may store measurements, including sweeps, on the instrument for download to your PC, as well as send commands and display real time results to and from the analyzer.

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- VU + PPM meter/monitor
- 1/3 octave spectrum analyzer
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- Measure signal balance error
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DL1 Digilyzer
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- Measure digital carrier level, frequency
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- Bit statistics
- VU + PPM level meter for the embedded audio
- Monitor DA converter and headphone/speaker amp

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

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- Reverb Time (RT60)
- High resolution FFT with zoom
- Optional STI-PA Speech Intelligibility function
- THD+N, RMS Level, Polarity

MR1 Minirator
Analog Audio Generator

The MR1 Minirator is the popular behind-the-scenes star of hundreds of live performances, remotes and broadcast feeds. The pocket-sized analog generator includes a comprehensive set of audio test signals, including sweep and polarity signals which work in conjunction with the ML1 Minilyzer.

- Sine and square waves
- Pink & white noise
- Polarity test signal
- Stepped sweep for response plots
- Balanced and unbalanced outputs

MiniSPL
Measurement Microphone

The precision MiniSPL measurement microphone (required for the AL1 Acoustilyzer and optional for the ML1 Minilyzer) is a precision reference mic for acoustics measurements, allowing dBSPL, spectrum and other acoustical measurements to be made directly.

- 1/2" precision measurement microphone
- Self powered with automatic on/off
- Omni-directional reference microphone for acoustical measurements
- Required for the Acoustilyzer; optional for the Minilyzer

MiniLink USB interface and PC software

Add the MiniLINK USB interface and Windows software to any ML1 or DL1 analyzer to add both display and storage of measurement results to the PC and control from the PC. Individual measurements and sweeps are captured and stored on the instrument and may be uploaded to the PC. When connected to the PC the analyzer is powered via the USB interface to conserve battery power. Another feature of MiniLINK is instant online firmware updates and feature additions from the NTI web site via the USB interface and your internet-connected PC.

- USB interface fits any ML1 or DL1
- Powers analyzer via USB when connected
- Enables data storage in analyzer for later upload to PC
- Display real time measurements and plots on the PC
- Control the analyzer from the PC
- Firmware updates via PC
- MiniLINK USB interface is standard

NTI Americas Inc

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americas@nt-instruments.com

Power

CONTINUED FROM PAGE 18

deliver power from 20 seconds up to a few minutes, which is more than enough time to bring online a standard fossil-fuel generator.

Most of these more exotic UPS schemes support large segments of the station's power loads and hence are major capital purchases. Station personnel in this circumstance would be wisest to acquire the services of a qualified consulting electrical engineer to guide their decisions in these instances.

At one time, separate feeds from two different power plants were the norm in larger operations. With the move to "area grids," which tend to regionalize power problems, and the fact that utilities now look to the user to pay for these extremely expensive systems, there is now little gain in this arrangement. A cost/gain/benefit economic study normally emphasizes that the money is better spent on local standby power instead of second service.

BLACKOUTS, BROWNOUTS, CO-GENERATION AND PEAK SHEDDING

There are many ways that we can lose utility power. Simply put, power is not always available in the quantity, quality and location we want it. In periods of high demand — such as summer air-conditioning or the heating demands of extremely cold weather — utilities, even with regional power sharing, often come up short in generation. Blackouts, wide-area power outages, are the result.

Rolling blackouts occur when the utility moves the locus of the blackout periodically. Their goal is to even out the pain by shutting off the power supply to an area large enough to bring the total remaining load connected and the available generation into equilibrium. Once they strike that balance, usually about every three hours (just long enough for your ice cream to melt), they turn the blacked-out area on and then turn off another area of comparable consumption. The first might be your studio's area, the next your transmitter.

Brownouts are periods of voltage reduction such that, again, power load and supply are brought into equilibrium. At one time, the national standard for voltage supply was the nominal voltage (say 120 volts at an outlet) plus or minus 5 percent.

At the moment, the supply contract of many utilities stipulates a voltage variation that is as much as plus and minus 10 percent. Their definition of a brownout begins below minus 10 percent or below 108 volts at the outlet and runs down to zero volts. Much broadcast equipment will not run reliably below 110 volts and some equipment (anything with a motor usually) is actually damaged at low voltage.

The installations of standby generation decisions are difficult because of the capital costs involved. In my own design work, pricing has never been lower than 50 cents per watt for a generator with a cord set, and can run as high as $4 a watt installed for a unit that required special support structural and cooling system designs. With these costs in mind, a fundamental question is whether the station just wants to stay on the air during a power outage or continue doing business. If the latter is desired, nearly the entire studio and business office must be supplied power.

To postpone or in some cases prevent a blackout, many utilities will compensate a user with enough generator capacity to generate their own power. A maximum-size cluster of radio stations running both studio and transmitters on a generator could potentially shed half a megawatt of peak demand from the utility load.

In the case of a facility with large generation capability, the utility views and configures the station as a co-generator where the station generator is synchronized to the commercial power feed and excess station power is fed back into the power grid. Advanced financial and engineering arrangements are made for this configuration. Often the generator is remote controlled by the utility so it can be started on demand.

Generators vary tremendously in quality (especially sine wave purity) from model to model and from manufacturer to manufacturer. Especially important is the generator's ability to power highly reactive loads (high PF) such as the switching power supplies that are ubiquitous in broadcast stations.

Further, when presented with the less-than-perfect AC output of a generator, many UPS units will determine that the noise on the waveform is excessive and will not switch to the generator power. To avoid these latent problems, once again review specifications carefully, work with the manufacturer for compatibility and when in doubt, acquire the services of a professional engineer to guide your decisions.

Whether it is for your own use, for an electrical installation contractor or for the review of your PE, gather and arm yourself with accurate data. Most stations have a "walk around" log; the tech staff periodically notes the reading on every gauge or display in the plant to keep a record of baseline information. In the past, most station engineers installed meters on the incoming line for both voltage and current, and these were noted at the same time you read the broadcast equipment meters.

Today, with ultra-high power costs, an intelligent investment is your own kilowatt-hour meter installed near your utility meter or main CB. The latest models will record the highest peak current, the highest peak kWh following your utility's demand factor specification and the total kWh. You can even have the meter periodically send this information to your computer. The meter also displays line voltages and power factor. The more you know, the better your decisions. These meters are cheap for what they do and serve as a double-check for your electric meter to keep the utility honest.

REGULATIONS FOR STANDBY POWER

Most inspections of standby-power installations, primarily during construction and installation, are performed by the electrical inspector of the municipality in which the actual standby-power installation is located, or by an independent electrical inspector/underwriter who issues a compliance certificate.

Most use the overall National Electrical Code as the standard for a safe installation. The NEC section 702, for optional (not legally required) standby systems, addresses most of the details of a broadcast generator install. In simplified terms, section 702 covers standby where no one will die if the backup power doesn't come on.

As discussed at length in our past Radio World series covering the NEC, section 701 is for mandatory, sometimes legally required power systems that provide life safety power to a facility. Services as serious as power to hospital operating rooms, emergency exit lighting and the elevators in your building are covered by section 701.

Be extremely careful when connecting your station loads to a section 701 power system. This issue is not one of cavalier indifference, no matter what anyone tells you. Every connection requires a load study, and as a user you are a participant in its successful operation and share in any liabilities if there are problems.

It's best to avoid putting anything but life-safety loads on a 701 system.

STANDBY SYSTEMS MAINTENANCE

A huge, almost universal fallacy is that electrical power systems require no maintenance. The reality is they require little maintenance, and that modest amount has to be professionally executed, properly directed and done in a timely manner.

In a broadcast station, where ready reliability is most important, there is no substitute for regular testing under load. Fossil-fuel generators have to be exercised at least once a week under full load for a duration that brings them to operating temperatures. Thirty minutes supplying those loads is considered typical. Uninterruptible power supplies should be exercised by requiring them to supply their connected loads for 80 percent of the projected run time at least once a month.

Follow the manufacturer's maintenance recommendations religiously. Typical maintenance cycles include full service and testing of a fossil-fuel generator every six months, and battery checks every quarter for critical and every year for non-critical UPS.

If you use a battery bank, most are lead-acid and that includes the deep-discharge marine-type batteries used when long operation is desired. Gel cells and calcium-type sealed automobile batteries are ubiquitous; most of us have forgotten that we have to keep lead-acid batteries topped off with distilled water.

I've encountered at least two lead-acid batteries that were completely dried out. I pushed the test button and the system went dead. Top off lead-acids at least once a month.

As with your entire power distribution system in the broadcast plant, standby systems should have periodic inspection and maintenance, performing such work as re-tightening termination connections that hold wires, normally just a check for copper but definitely necessary where large aluminum conductors are used. Items such as outlets and plug connectors should be inspected and replaced as needed.

Finally, critical circuit breakers should be exercised and tested. Many broadcast plants have ground-fault type main breakers or motor driven circuit breakers because of the service size. These somewhat complicated circuit breakers should be tested and operated to confirm that they can actually interrupt (disconnect) the utility power supply.

As in all other parts of the broadcast universe, little good happens by accident. The best, most useful and most reliable standby-power systems come from a thorough and thoughtful design and maintenance process. No detail in this area is too small or unworthy to be completely reviewed, evaluated and decided. ■

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by Cris Alexander

Old Meets New in AM HD-R

Old Technology (Coils, Capacitors), New Technology (The HD-R Generator) Come Together in HD Radio

Cris Alexander is director of engineering for Crawford Broadcasting Company.

I've heard it said that the more things change, the more things stay the same. This seemingly contradictory statement heralds an underlying truth that the underpinnings of the physical world and of human behavior don't change even though the "wrapper" or veneer that we see and deal with every day changes radically.

For example, I was at one of our Detroit transmitter sites recently. With me was Tom Gardull, our Detroit market CE, and Larry Foltran, our corporate IT guy. Tom had been at that site on a regular basis since the early 1990s. He had seen it transition from glowing tubes to bipolar transistors to MOSFETs to HD Radio.

Larry had never seen an AM transmitter site before, and yet he found himself at home at the site with computer screens, keyboards and mice (or is it mouses?). The exciter even had a CD-ROM drive in it, something Larry instantly recognized. A lot of change had occurred over the previous few years to transform the site from something that only a seasoned AM radio engineer would be comfortable with to an environment of IP addresses and CAT-5 wire.

The challenges of that transmitter site have shifted over the years. These days they have to do with GPS lock, AES sync and VNC connections into the various pieces of equipment. Even the audio processing, remote control and monitoring have shifted into the world of ones and zeros. And yet beneath it all is the transmitter pumping out a modulated carrier, a phasing and coupling system dividing up the power and the towers radiating the E and H fields. Without that underlying structure, the more glamorous and cutting-edge technology of ones and zeros would have little purpose.

AM DIGITAL MEETS THE ANTENNA

And this brings me to one of the bigger challenges I have faced in the course of entering the AM HD-R world: getting the load properly configured for HD-R transmission. Certainly we have had to do a lot of modifications to our transmitters, STL systems and audio chains to get HD-R on the air, but the hardest part in most cases has been the antenna, arguably where old meets new.

What does it take to get an HD-R signal through an AM antenna system? A good bit has been written about this. Transmitter and antenna system manufacturers have done studies, and these studies have yielded some useful information. The general specification that I have been operating on is symmetrical VSWR below 1.035:1 on frequencies +/-5 kHz removed from carrier, VSWR below 1.20:1 on frequencies +/-10 kHz removed from carrier and VSWR below 1.40:1 on frequencies +/-15 kHz removed from carrier.

In some systems these specifications are attainable. In three situations within my company's stable of AM antennas we found the spec to be met without further modification — surprisingly, all three were directional arrays. But with most AM antenna systems, some work has to be done to even get close.

To further complicate things, the cusp orientation of the load has to be right for AM HD-R to work. This is simply the orientation of the impedance plot on a Smith chart. Most power amplifiers want to see a 9-o'clock orientation to work properly. That means a matched, non-reactive load on the carrier frequency with lower resistance and rising reactance of opposite signs on either sides of carrier.

Without getting too deep into the theory and underlying physics, an AM antenna system really works right on the carrier frequency only. It is only on that frequency that the radiating element(s) along with the matching and phasing networks produce the desired results. Move a few kHz off the carrier frequency and the radiating element itself has a different complex impedance and each inductor and capacitor in the system has a reactance different from that on the carrier frequency. So achieving the HD-R bandwidth specification is like hitting a moving target — no easy task.

To get there, we have employed a number of tricks and tools. We usually start with a General Radio impedance bridge and synthesizer/detector. With this we sweep the antenna input or common point to see where we are. Then we often sweep the radiating element itself or the common point to see what we have to work with. In some cases, we get out the network analyzer, power amplifier, attenuators and directional couplers and look at the antenna system with that rather complex (but way cool!) tool. But regardless of the tools we employ, the idea is the same — to get from where we are to where we need to be. (See Figs. 1 and 2.)

In some cases, we found that we had to design, build and install a phase rotation network between the antenna input and transmitter to rotate the cusp around to the proper orientation. In others, we found we had to do some work on the common point or ATU network first to get the VSWR values and symmetry in shape. In other cases we found we had to go through the entire directional antenna system, tuning out reactances and matching transmission lines. I'm sorry to disappoint you; there is no hard and fast (or easy) answer.

One bit of hope I can share is that in my experience (and don't take this as gospel; some may argue this point), the cusp shape and orientation are more important to good HD-R operation than absolute sideband VSWR figures or perfect symmetry. We have some antenna systems that because of array geometry, diplexer bandwidth or other factors, the VSWR values far exceed the "HD-R spec," and yet those antenna systems work just fine for HD-R once the load cusp orientation is correct.

One such array is KLZ(AM) in Denver, a two-tower wide-spaced array on 560 kHz. The towers are just over a quarter wavelength. All this sounds like it should be a pretty good load, right?

Unfortunately, because of the broadside pattern geometry, the sideband VSWR is over 2.1:1. We tried every trick in the book to get it down without success. While we could get the absolute VSWR values down to 1.4:1 at +/-15 kHz, the network analyzer showed a "knot" in the load plot, a place where the

SEE AM HD-R, PAGE 24

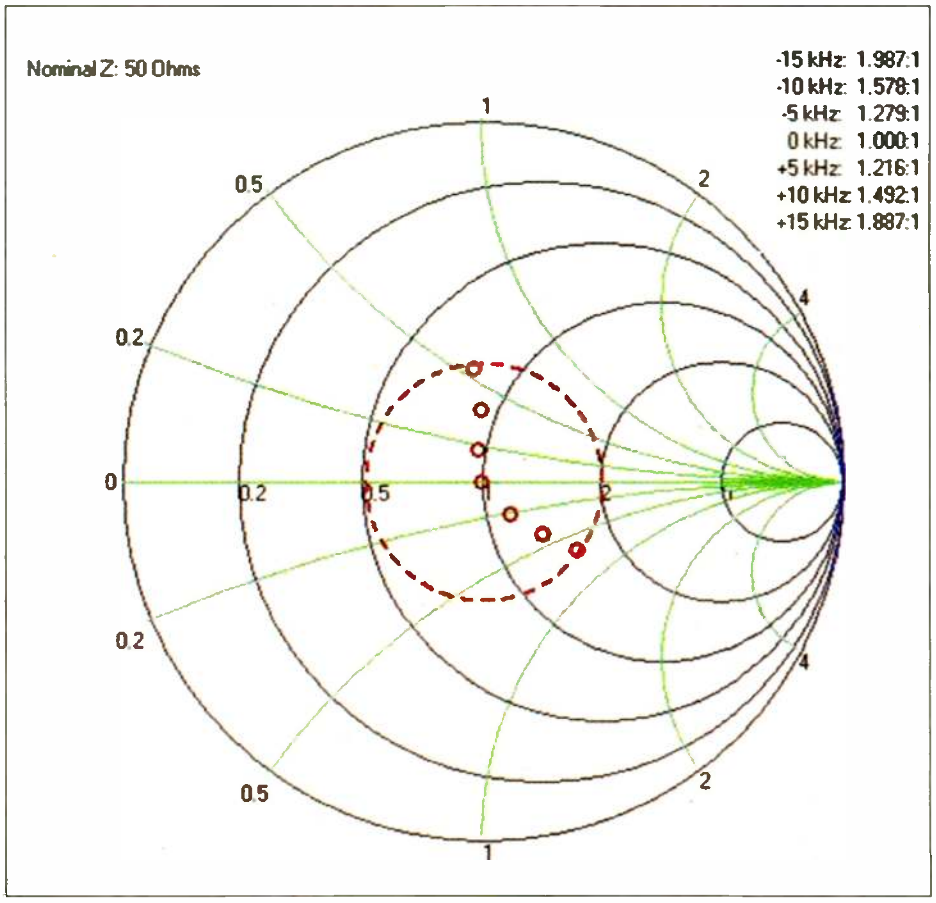


Fig. 1: Smith Chart of station common point impedance at WEXL before HD-R conversion

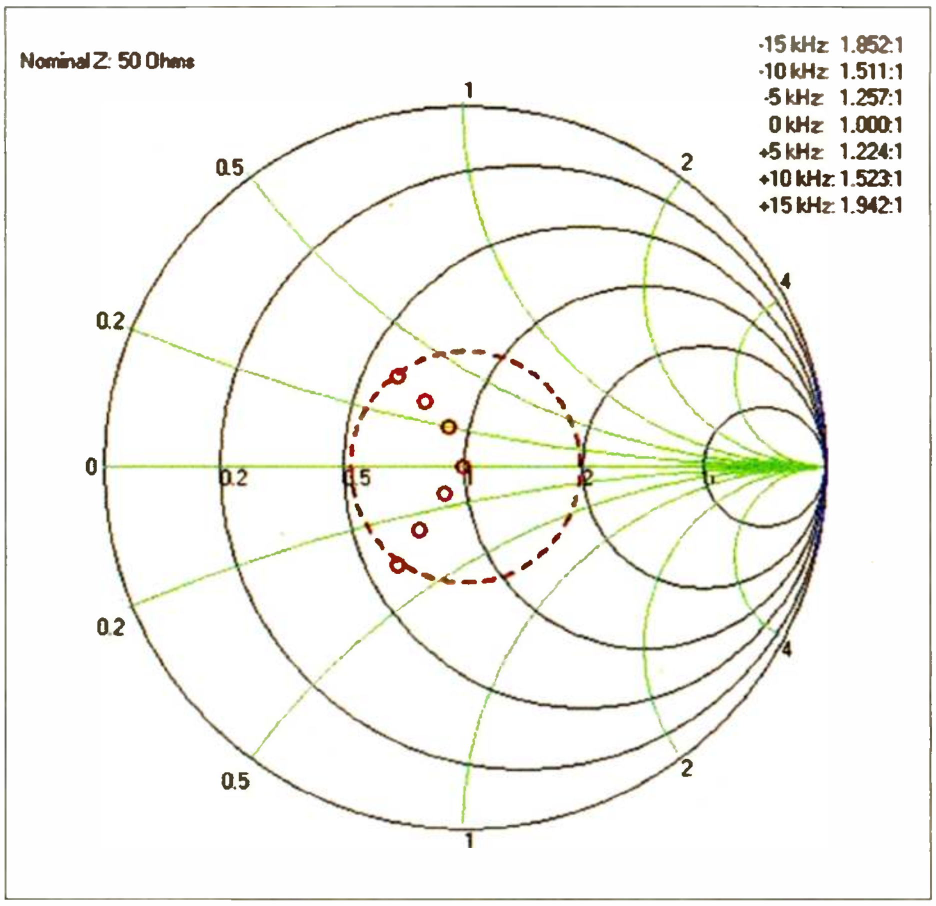


Fig. 2: Smith chart showing WEXL common point after installation of phase rotation network

AM HD-R

CONTINUED FROM PAGE 22

impedance line crossed back over itself. HD-R wouldn't work at all into this load. But we found that if we went back to the uncorrected load and focused on cusp orientation, the HD-R operation would work just fine.

Lock times are a little slow, but once locked the digital performance is solid and robust. When digital reception finally gives out, the underlying analog signal is usually audibly noisy. While we haven't made field strength measurements to try and quantify this, the bottom line is that the digital signal covers the market and a whole lot more.

Isn't it interesting how things like digital lock time, robustness and bit error rates are, in the final analysis, dependent on such antediluvian items as coils, capacitors and plated copper tubing? Which brings us back to my original point: No matter how far we go with new technology, in the end it's still the same physical laws that make it work. It may be ones and zeros and OFDM, but underneath it's still volts, amps and ohms. As an old tube-and-iron guy, somehow I find that comforting.

DIGITAL INTERFERENCE

I was recently asked to speak at an educational event put on by our local SBE/SMPTE chapter. This "Audio Boot Camp" featured speakers on a variety of audio topics for both radio and television. I learned a great deal. Our chapter puts on these events at least once a year. I find that they are worthwhile; a mini broadcast engineering conference without the trip to Las Vegas.

My topic was "HD Radio Update." I gave a brief overview of where we were three years ago (some were still calling

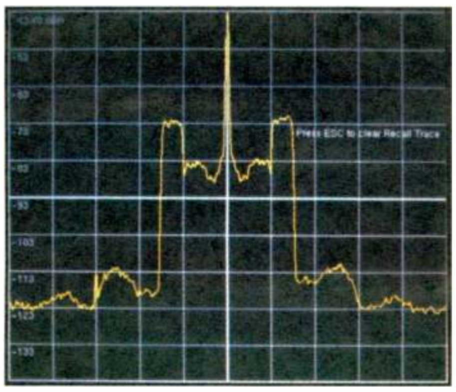


Fig. 3: Spectrum analyzer plot of HD-R station showing performance within the proposed HD mask. Note the spectral regrowth 'humps' at approximately 25 kHz and 37 kHz from center frequency on either side of the plot.

HD-R "DAB"), what progress has been made (1,000+ stations converted) and where we may be headed. I'm no prognosticator, but I did make some guesses based on our track to date and industry trends.

One item I spent some time on is the frequent criticism of HD-R that we see in the trade press and online. A good bit of the criticism (which never seems to include any practical, real-world, workable alternatives) has to do with interference caused by the AM and FM HD-R systems. I may have surprised some in the audience when I acknowledged that HD Radio does cause interference for both AM and FM stations. There's no way around it.

In the vast majority of cases, the interference is limited to areas beyond the protected contour, out where there is no entitlement to coverage in the first place. But that doesn't make things any better for the stations — particularly the "exurban" rim-shots — that count on that outside-the-contour coverage for the bulk of their revenue.

Another HD-R interference issue I mentioned has to do with third-adjacent-channel AMs. All the focus has been on first- and second-adjacents, but the interference in those cases is typically outside-the-contour interference, as mentioned above. But there are third-adjacent channel stations in many markets.

Paragraph 73.37 of the FCC Rules prohibits 25 mV overlap of third-adjacent-channel stations. That normally keeps such situations from occurring, but there are quite a few waivered and grandfathered stations around with overlap. If power levels are low, it's no big deal, but sometimes the third-adjacent HD-R station operates with high power. In that case, the 25 kHz spectral regrowth, which should be down at least –65 dBc and well within the NRSC/§73.44 emission mask, pokes a "hole" in the other station's coverage. (See Fig. 3.)

I've dealt with this myself. A 50 kW third-adjacent HD-R station in Los Angeles was poking a six- or seven-mile hole in my 5 mV "city grade" coverage. That –65 dBc "grass" was producing a field strength of 2-3 mV/m in the area, sounding like electrical noise and making it impossible for listeners to hear my station.

Thankfully the licensee and engineering crew at the other station were very cooperative, reducing its upper primary digital carrier levels by a couple of dB. This resulted in a considerable reduction in the intermodulation products around +25 kHz, pulling the interference area in to essentially the other station's blanketing contour. That reduction does not seem to have affected their HD-R coverage a bit.

I think this is going to happen time and again in other markets. Engineers, managers and owners should take a lesson from what happened in the Los Angeles case and be prepared to cooperate and resolve the situation.

If there's one thing I've learned over the years, it's that any practical implementation of technology is a compromise. Charlie Morgan said as much in a recent article dealing with the NRSC. HD Radio is a pretty big compromise, particularly on the AM side. We would do well to remember that it is the distillation of years of work by the best minds in our industry. A better system is not going to come along, and twice-burned receiver manufacturers are not going to follow a new path. Critics had better get used to that idea.

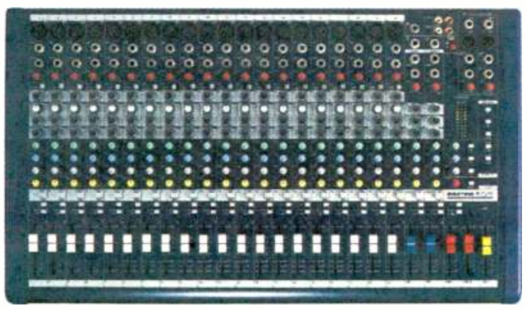
If we're going to make this thing work — and we will — it's going to take cooperation and compromise.

Comment on this or any article. Write to rwee@imaspub.com. ■

In my experience (and some may argue this point), the cusp shape and orientation are more important to good HD-R operation than absolute sideband VSWR figures or perfect symmetry.

MARKETPLACE

Soundcraft Debuts MPM Series Mixers



Soundcraft debuted its compact MPM Series of multipurpose mixers, which it says are suitable for live sound and recording. The MPM is available in two standard frame sizes, offering either 12 (MPM12/2) or 20 (MPM20/2) mono inputs, with each model featuring two additional stereo input strips.

The MPM's transparent GB30 mic preamp, also used on Soundcraft's larger LX7ii and GB Series desks, features high-resolution adjustment over a wide gain range of 55 dB, and provides +22dB headroom through the console. The company says true 48-volt phantom power accommodates for condenser microphones of all types.

Both the MPM12/2 and MPM20/2 are equipped with three auxiliary busses, configurable for use as effects or monitor sends, and main connectors are XLR-type and 1/4-inch metal jack sockets. RCA phono connectors are additionally provided for disc and stereo playback inputs and record outputs.

Equalization on the mono inputs is three-band with a swept mid (fixed mid on stereo inputs). All mono input channels have TRS insert sockets, and inserts also are provided on the mix output. The MPM feature set also includes 60 mm faders for accurate channel control, an intuitive and comprehensive solo system and ten-segment LED output metering.

The MPM's monitor output and headphone output work in parallel so performers can still listen on phones while an engineer is listening on studio monitors.

The MPM12/2 and MPM20/2 also can be converted for rack-mounting by adding optional rack rails, although only the MPM12/2 will fit in a standard 19-inch rack.

The MPM12/2 retails for $689, or $722 with optional rackmount kit. The MPM20/2 retails for $969.

For more information, contact Soundcraft USA/Harman Pro North America in California at (818) 920-3212 or visit www.soundcraft.com.

Goldeneagle HD Has Updated Firmware

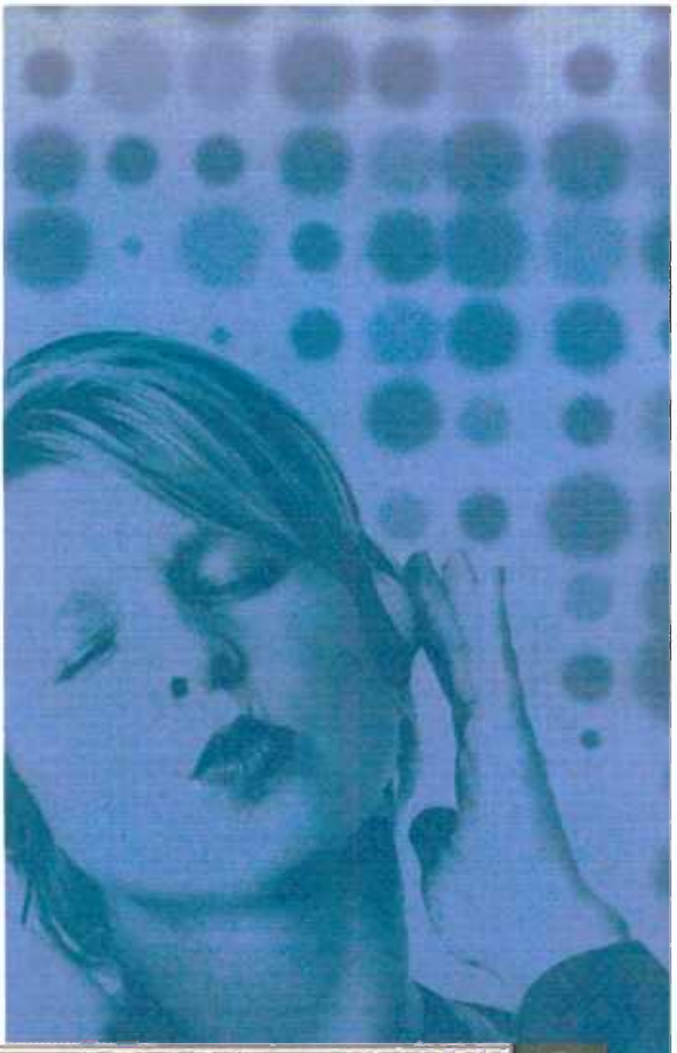
Audemat-Aztec says it has released firmware version 1.4 for its Goldeneagle HD receiver, which continuously monitors analog and HD signals measuring parameters from a single station or multiple stations. The company describes the unit as a smart modulation monitor with optional spectrum analyzer/digital demodulator and transmitter remote control capabilities.

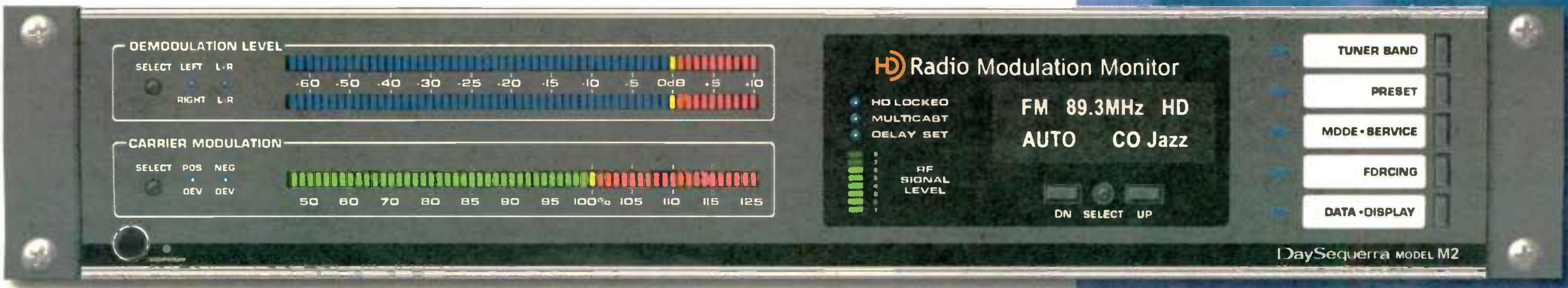
V1.4 features time and level alignment monitoring as well as RF mask monitoring, and the ability to send an alarm when detecting out of tolerance conditions on specific parameters. The digital demodulator for FM analog modulation monitoring now measures 67 and 92 kHz SCAs.

Existing features of the Goldeneagle HD include balanced analog and digital audio outputs; touchscreen display for selection of preset stations and visualization of readings, spectra and bargraphs; embedded Web server and software for remote monitoring; and RDS data display and monitoring, as well as program service data display.

For more information, contact Audemat-Aztec in Miami at (305) 249-3110 or visit www.audemat-aztec.com.

Multicast Ready





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by Dan Rose

Don't Give Murphy the Satisfaction

Facilitate Upgrades by Planning for Unforeseen Troubles, Brainstorming Ways to Prevent Them

Dan Rose is audio and transmission engineer for WBUR Group, Boston.

Any large project can have unexpected pitfalls. The key to success is in recognizing potential obstacles and taking steps during planning to prepare for them. The oft-cited Murphy's Law states that whatever can go wrong, will. But the more important corollary is, if you plan for all eventualities everything will work out fine.

WBUR recently underwent a large-scale upgrade of our Broadcast Electronics' AudioVault hard-drive playback system. This upgrade was more complex than a typical project.

The system spans two studio locations, which are located about an hour drive from each other. Along with new software installation for 30 computers at reporter desks, there were nine studio workstations, two automation computers and five servers that needed to be either replaced or rebuilt. Because these systems are in use and on-air 24 hours a day, downtime had to be minimized — and even then, only one server could be worked on at a time.

Finally, while the station could set aside as much time as I wanted for planning and preliminary work, the actual upgrade had to be finished over a single weekend. And there was another wrinkle: because the newer software was incompatible with the old software, upgraded machines couldn't talk to non-upgraded ones. The installations had to be completed in one session, in time for Monday morning's news operation to start unimpaired.

In many cases, ordering entirely new systems from the manufacturer and hiring a field service group to install them would be the preferred route. However, the station didn't have the budget for that. I had to reuse as much hardware as possible, spending less than a tenth of what the alternative would cost, relying on the two backup computer audio cards we had for configuration and testing of the new servers.

With such a complicated project, and the even more complicated restraints, a lot could have gone wrong: I could have discovered halfway through the rebuild that the servers couldn't communicate with each other over our T1. I could have found that a critical connector had changed from a 15-pin to a 25-pin and have had to rebuild it in a hurry. I could have had to stop halfway through, patch things together, and start up the week with a system held together with duct tape and prayers. But I didn't; not that things didn't go wrong and unforeseen problems didn't pop up, but rather I ran into them at a time that was convenient for me.

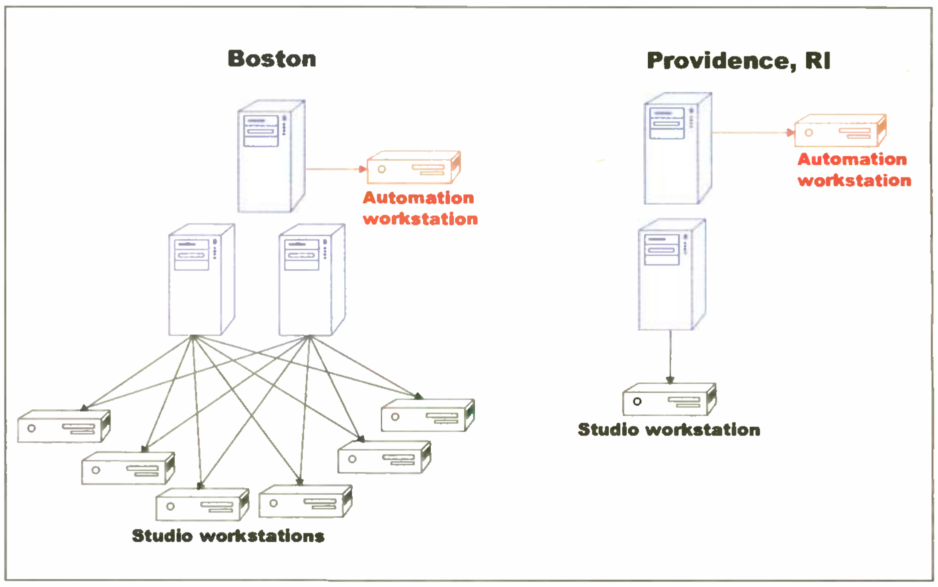

Fig. 1: One server in Boston and one in Providence handle long-form recording and automation. Separate servers connect to studio workstations for music, news and promo playback.

When you're preparing a major project, you can brainstorm and prepare for everything that can happen to stall it, whether it's running out of software licenses, or having the person in charge get hit by a bus the day before. Murphy's Law is partly a cynical joke and partly a statistical certainty — some time, some project, something will go wrong — but mainly it's a warning to find the weakness before it happens and save the day.

BACKGROUND

The WBUR group operates four stations in Eastern Massachusetts and Rhode Island, providing National Public Radio news and talk radio service to the greater Boston and Providence metropolitan areas on separate program streams (frequently, though not always, the same shows, but with different legal IDs, promos and local underwriting announcements). Though our Boston stations are staffed 24 hours, our Rhode Island operation is automated overnight and on the weekend.

Three AudioVault servers in Boston and two in Providence control audio playback and automation. All underwriting, promos, news actualities and delayed shows — either locally produced or satellite-delivered — are fed from these servers to the studios. For unattended operation, a workstation in Providence and a backup in Boston (in case of server failure) handle switching and playback of breaks. (See Fig. 1.)

For reliability, two of the Boston servers and one of the Providence servers mirror each other's inventory, and each air studio has outputs from each server. A complete loss of one server results in a little more work for the operator, juggling audio cuts during breaks, but with no loss of inventory or accessibility. For long-term outages, we can move resources from one studio to another with patch cables, and restore full capabilities to a room within minutes.

The other two servers, handling hour-long recording and playback of shows, have multiple hard drives in a mirrored RAID configuration. The death of a drive is not fatal, and can be replaced in less than an hour with no data loss. (See Fig. 2.)

The Boston and Providence servers communicate via a T1 that bridges the two locations while keeping them on one network. Audio files and GPS clock synchronization all pass over the T1, along with audio from the backup automation machine.

PLANNING

Prior to the upgrade, four of the servers were running Windows NT, with the fifth on Windows 98. Studio and automation workstations were on Windows 98, and much of the hardware was between three and seven years old. All systems were working but nearing the end of their useful lives, with hardware starting to wear out and software patches becoming tougher to find. Planning an upgrade was easier at this stage than it would have been if systems were failing. Without the pressure of an impending collapse, we could plan at leisure and focus on cost, performance and reliability instead of getting new servers out as soon as possible.

Strange as it may seem for a computer-based system, performance wasn't the most important goal. Although the software was being upgraded to a new version, the user interface was identical. Most of the changes were under the hood. But with higher performance comes heat, which sacrifices long-term reliability.

I learned this intimately when one of the new servers failed a month post-upgrade. One of the small form-factor CPU fans died and the processor, a 2.4 GHz Pentium IV, immediately overheated and burned itself out. Even before the fan stopped running, the CPU core temperature was regularly over 60 degrees Celsius. I replaced the CPU with a lower speed 2.0 GHz Pentium and saw a 10 degree drop in temperature, and CPU usage hardly ever goes over 50 percent because most of the processing is handled by the audio cards.

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Murphy's Law

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A clear lesson to take away from this is that the "newest and fastest" option doesn't always help achieve the end goal. Whether it's a server that's wasting heat and CPU cycles, a multi-thousand dollar laptop that's just used for e-mail or an eight-cylinder engine in a car that does a five-mile commute each day, an overpowered solution can be just as bad as an underpowered one, when cost and reliability are factored in.

Two of the servers and all of the workstations were completely new. I was able to assemble them and install the operating system and software in advance, allowing plenty of time for testing. I used new desktop computers for the studios but for the servers we purchased the individual components and assembled these in-house.

Even under the best conditions, a Windows install can take hours, especially with large drives to format. But in almost any computer upgrade, this can be done weeks or even months in advance. With the testing and configuration complete, the work on upgrade day could be reduced to just physically replacing the machine, a matter of minutes instead of hours.

However, the other three servers had an additional complication. We were reusing all of the hardware, but completely upgrading the operating system and software. With the best of luck, I could format and upgrade those three machines over a couple of hours during the upgrade, but that's still several hours of downtime with me just sitting and watching a progress bar.

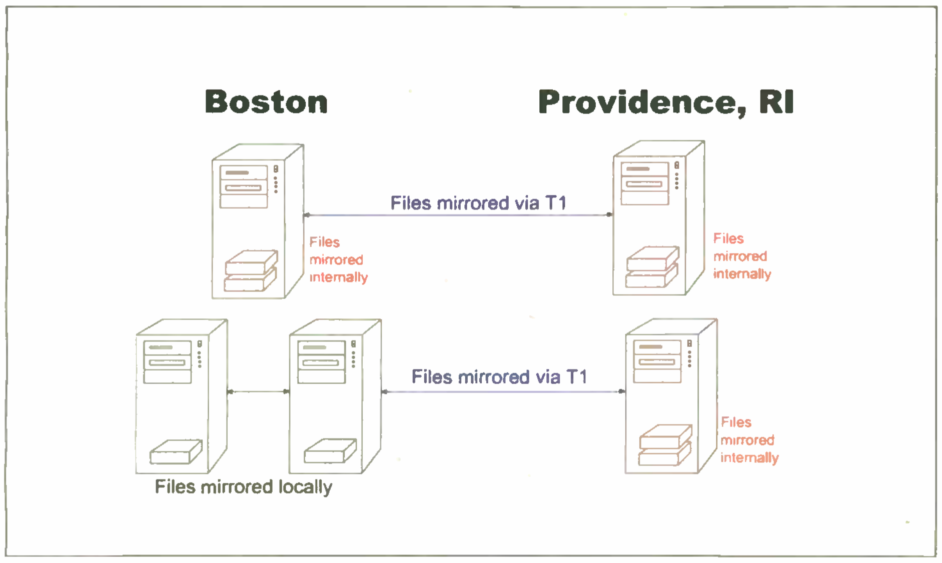


Fig. 2: For reliability and safety, servers mirror each other's inventory. Most servers also have internally mirrored RAID drives.

We allowed generous amounts of time for each task. By building this additional room into the schedule, we were planning to get ahead of where our hypothetical task times would fall.

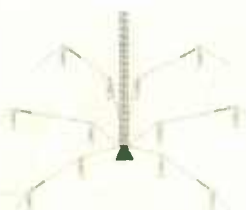
Also, what if there was a problem? What if I ran into some complication halfway through and had to abort? With the workstations and other two servers, I could always reinstall the old ones and walk away with no changes, but if I formatted the hard drives in these three, there was no looking back.

Both of these potential issues had one easy solution: new hard drives. Several weeks in advance, carefully coordinated with the on-air staff in Providence, I temporarily replaced the system drive in each server and installed the new operating system and software. Then, I removed and labeled them and reconnected the original drive. The servers could keep running on their original systems and software configurations until the final upgrade weekend, at which time I would just replace each hard drive, moving them to the new system in minutes.

Upgrading an in-use system always adds another challenge. Testing is highly important, but how do you safely work on something that is in use every day? This particular project involved some new hardware, a new operating system, new software, and a new communications protocol, and it had the ability to interfere with our current servers. One of the new machines and one of the old wanted to be the master source for network time synchronization, and having them fight would quickly crash the studio workstations. Even if they could happily coexist, any one of a number of potential conflicts could occur.

With the possibility of file transfer rules getting confused and deleting our inventory, it just wasn't safe to connect our new servers to our old network, but I still had to test everything, including network communications. Working with our IT department, I set up an independent internal network in our shop for testing. The new servers and new workstations could send data back and forth happily, with no ability

SEE MURPHY'S LAW, PAGE 29




CircuitWerkes
Sicon-8

Murphy's Law

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to talk to our production system. Everything was contained.

Security is always a challenge, particularly with a mixed network of business and audio workstations. Between Internet worms and viruses, having a computer accessible to the outside world drastically reduces reliability. However, our reporters and producers need to have access to e-mail and Web browsers on the same machines that they use to edit audio clips. To get a good compromise between security and convenience, I worked with our IT department to set up IP Security (IPSEC) protocols, which are like an advanced firewall.

For example, none of the studio workstations needed to talk to each other. In fact, each one could live independently of the other studios and most of the servers. By setting their IPSEC rules so they only could speak to the server, all but one vector for infection was eliminated. Likewise, only one server needed the ability to see the reporters' computers, only through one port, and only if they were on our internal network. By preventing other communications, we could stop the spread of all worms that didn't use that particular unusual port. In this age of computer insecurity, we shouldn't ask what we should lock down, but rather what should we open?

Finally, for remote administration we used Virtual Network Computing (VNC), which gave us desktop access and control of the servers over the network. This was secured through IPSEC by making it only accessible from our in-house Remote Terminal Server, using an encrypted and secure channel. The added ability to check logs, make automation changes and restart services in Providence from my desk in Boston or even at home was an important part of the upgrade.

Like any firewall, IPSEC filters are complicated and prone to setup errors, which again, we ran into well in advance. We were able to adjust the filters without worrying about security or affecting the rest of the WBUR network because none of the machines were physically connected to it. By the time upgrade day arrived, we knew every port and service that would be used and had locked all the others up.

UNEXPECTED DIFFICULTIES

Very early on into the project, I found that the Pentium IVs we would be using needed larger heat sinks and fans than our old systems had required. That would normally be fine, but with the particular backplanes I had to use (sized to allow for multiple ISA and PCI cards), the heat sink ran into the drive bay above it. If this had been discovered during the final weekend, I'd have been stuck. But instead, I was able to order small form-factor heat sinks and fans well in advance.

Another unusual problem involved fitting new, smaller ATX power supplies into old server cases, sized for the large AT power supply. The new one only took up half the space of the old supply, which was great except that I was left with a four-by-three-inch hole in the back of the server, wide open to dust. Again, I was saved by having the luxury of time for pre-planning. We built a custom plate for the back of the server, with proper openings for the fan and power cord, sealing off the unused area.

Both of these particular issues, and many others, were discovered and planned for during the pre-building and testing phase. By taking adequate time to prepare, hardware can be measured and laid-out, cables can be run for length weeks in advance, software can be tested long before it is needed and contingency plans can be made for even the most unforeseen circumstances.

EXECUTE

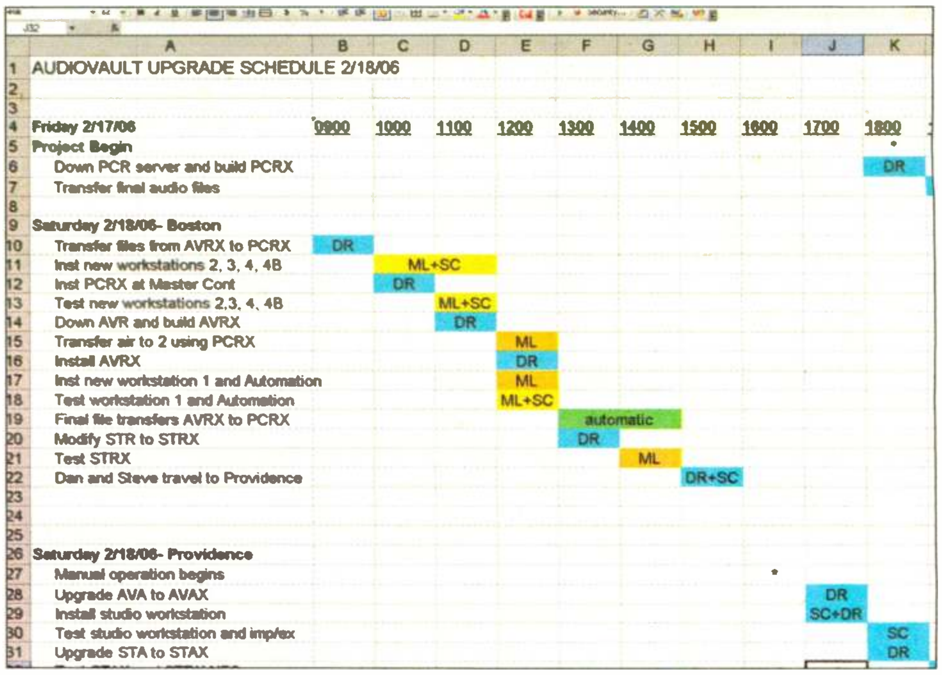
Prior to the upgrade, inventory was copied from the old servers to the new ones during an overnight session. I took down one server on a quiet weekend and moved its data drives, containing upwards of 5,000 cuts of music, promos and news, to one of the new servers. I then set it up to transfer its total inventory to the new server, in a slow and time-consuming process.

One of the limitations I couldn't get around was the data bus speed of the older AudioVault hardware. Though I could get new high-speed SCSI drives, the Ultra SCSI interface they use to connect to the card is limited to 20 MBps, a small fraction of the 320 MBps possible. Any data transfer is limited by the speed of its slowest member, in this case the SCSI interface on the audio cards. A long 24 hours later, our audio inventory was in one of the new machines.

Murphy's Law is partly a cynical joke and partly a statistical certainty, but mainly it's a warning to find the weakness before it happens and save the day.

I then returned the old server and its drives to service, and put blank drives in the second of the new audio servers and started transferring files again. After another 24 hours both new servers had the complete set of cuts. This was an area where planning and pre-production really paid off. By moving everything over in advance, I took 48 hours of waiting out of our upgrade-day schedule, turning it from a long weekend with no room for unexpected errors into a short one.

A total of six engineers were scheduled to help out on the upgrade day, including three audio and three IT personnel. Audio engineers were assigned to replacing the AudioVault system equipment and IT staffers would handle the reporter desktop upgrades. To ensure that our other engineers and I would be on the same page, we created a timeline for the upgrade day. (See Fig. 3.)



	A	B	C	D	E	F	G	H	I	J	K
1	AUDIOVAULT UPGRADE SCHEDULE 2/18/06										
2											
3											
4	Friday 2/17/06	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800
5	Project Begin										
6	Down PCR server and build PCRX										DR
7	Transfer final audio files										
8											
9	Saturday 2/18/06- Boston										
10	Transfer files from AVRX to PCRX	DR									
11	Inst new workstations 2, 3, 4, 4B		ML+SC								
12	Inst PCRX at Master Cont		DR								
13	Test new workstations 2,3, 4, 4B			ML+SC							
14	Down AVR and build AVRX			DR							
15	Transfer air to 2 using PCRX				ML						
16	Install AVRX				DR						
17	Inst new workstation 1 and Automation				ML						
18	Test workstation 1 and Automation				ML+SC						
19	Final file transfers AVRX to PCRX					automatic					
20	Modify STR to STRX					DR					
21	Test STRX						ML				
22	Dan and Steve travel to Providence							DR+SC			
23											
24											
25											
26	Saturday 2/18/06- Providence										
27	Manual operation begins										
28	Upgrade AVA to AVAX									DR	
29	Install studio workstation									SC+DR	
30	Test studio workstation and imp/ex										SC
31	Upgrade STA to STAX										DR

Fig. 3: With its built-in grid, a spreadsheet program is a handy way to organize tasks and time.

We allowed generous amounts of time for each task. For example, one hour to take down a server, replace its hard drive and reboot it, or half an hour to physically replace one desktop machine with another. By building this additional room into each task in the schedule, we were planning to get ahead of where our hypothetical task times would fall (starting a task at noon instead of the 2 p.m. time we had scheduled). If we hit any snags, such as having to move around power cords or needing to install a critical software patch, we'd still manage to hit our original time goals.

The alternative to this would be to have much stricter times for each task, and then schedule time at the end for fixing any problems encountered, but this method has a psychological flaw: from the very first thing that takes longer than you predict, you're behind your schedule. When pressured by being behind deadlines it is tempting to try to rush, which causes more

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Guy Wire

I am not always a supporter of the masked Guy Wire, but on this issue he makes good sense. It is high time we truly improve AM with the use of FM translators. But as the owner of a 1 kW daytimer, WGTO(AM), I can say we mom-and-pop operators are deathly afraid that when the rules come out the wrong people will get the help.

Unless the rules are biased heavily to favor rural standalone stations where the owners have no FM interests, the deck may be stacked by group owners who come in and buy up daytimers then move them to other cities and apply for FM translators. The result would be *no* local service to communities whose owners sell out. Or worse yet, the well-bankrolled Big Boy group-owned AMs get the translators and the little guys are still out in the cold.

Yes, translator space will be tight in some areas, but as Guy states those translators that are supplied programming from stations hundreds and even thousands of miles away should be allowed only as a secondary service. What sense does it make to allow stations in California to use translators in Michigan when the local AM cannot find a translator channel? Standalone AM stations rarely have deep pockets and winning by auction is impossible, so my suggestion is to start by having the FCC run a software program and assign FM channels to AM daytimers where possible.

The easiest way would be to use the tower location as the default translator site. Of course some adjustment would be needed for stations that are highly directional but it is possible to do such a global program, just like the FCC did to figure out the flea power levels assigned to daytimers for night operation many years ago. If the program required bumping out of town supplied translators then so be it.

It is time for real change because very soon it will be too late.

Larry Langford
Owner, WGTO(AM)
Cassopolis, Mich.

As the owner of a 1 kW daytimer, I can say we mom-and-pop operators are deathly afraid that when the rules come out the wrong people will get the help.

— Larry Langford

Diversity Delay

Michael, I've gotten diversity delay spot on for my AM IBOC station ("Of Tape Machines and Diversity Delay," Oct. 18). Don't laugh, it is important to do so to minimize, although obviously not eliminate, the audibility of switching in and out of digital. It would be interesting to try your oscilloscope method on an HDFM with the processing removed from both analog and digital to see if that indeed was the prime cause of dancing phasiness.

You really need to use a trained pair of ears, listening for the in phase sound quality when you've got the delay really close. It can be done! It took me some experimentation as one can set it on a false impression of in phase especially when dealing with divergent processing and the phasiness that may be inherent in the psychoacoustic compression scheme. There is no apparent reverberation when the signals blend. I wish I could say the same for most of the other IBOC stations I can monitor.

Ira A. Wilner
Putney, Vt.

Michael, I enjoyed your article. Honestly I don't think we have a scope that still works.

I did time alignment a little differently. I used two identical radios — one in HD, one in analog — and a laptop. The left channel of the radio in HD was connected to the left channel of my laptop and the left channel of the analog radio to the right channel. Then I made a stereo recording in Adobe Audition. Then I zoomed in to the sample level and it was easy to see the error and measure the time difference.

What's nice about this technique is that it can be done in the comfort of one's living room. As I remember I made the delay adjustment on the exciter over the web.

I also tried this with a Kenwood in split mode. It works well, but one has to adjust the channels to match levels.

Mark Manuelian
Boston

What Price New Media?

Just being a consumer and interested in HD Radio, I am trying to find out more about it ("Satellite in Trouble as HD Grows," Aug. 23). From my angle, it looks like we are just being sucked in by a greedy industry with no consideration for the consumer, other than the dollars they can pull out of our billfolds. It will be a lot of hype and a slow, costly build-up that really doesn't add anything.

Then there will be the changes in the system that we will need to upgrade to in order to receive the benefits of the new technology. Think computers; it's impossible to keep up with all the new stuff and we're limited to the amount of money we can spend. New media is driving us crazy. Guess there are enough fools out there who want it bad enough to pay for it.

The Who was wrong. We will be fooled again and again and again.

Rich Grant
Wood River, Ill.

Clips vs. Rails

The article on racks ("Racks Are Radio Facility Building Blocks," Oct. 18) gave a comparison of clips vs. tapped rails. If you inherited a rack that requires clips, throw away the clips and mount Middle Atlantic rack rails behind the mounting rails. They come in a wide range of lengths and make mounting equipment a lot easier than fooling with clips.

Stanley Swanson
Yuma, Ariz.

More to Nott

That was a great article on Ron Nott ("Tales of a Lifetime in AM Antenna Design," Oct. 18) but you missed a product. He makes a ham radio mobile screwdriver antenna that is awesome. I have one and it is the toughest best-made mobile antenna I have ever seen. Ron makes them to last forever and it works much better than the competition.

Not every Ham's wife would approve of one of these hanging on the family minivan, but it is made for performance not for appearance.

Jack Davis
K6YC
Chief Engineer
KTXL(TV)
Sacramento, Calif.

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errors as you overlook things, forcing you even farther behind. Even if you finish at the same time as you would otherwise, a high-stress project never works quite as well as a low-stress one.

Work on the Saturday of the upgrade started at a relaxed 10 a.m., replacing workstations not in use at the time, and shutting down and replacing the servers one at a time. By mid-afternoon, we traveled down to Providence, and completed the installation there by 5 p.m. Five servers, nine workstations and thirty desktops in two locations, fully upgraded in less than seven hours, with almost a day and a half of time to go before they would be needed.

CONCLUSION

A quick search on the Internet will quickly turn up dozens of upgrade horror stories; projects gone bad when they encountered the unexpected. However, with sufficient time for planning and testing, any difficulty can be foreseen and avoided, or at least countered. An important task during the planning stage is to figure out what could go wrong, and brainstorm ways to either prevent or fix it if it occurs.

We had contingency plans for our upgrade day that covered a range of possibilities, not just for overlooked items (necessary drivers and configuration files were kept on a portable flash drive) but for catastrophic failures. Pre-formatted drives were on hand in case of crashes, and we had the ability at any point — even after finishing — to restore everything to the way it was the previous day.

This can apply to any project, hardware or software, digital or analog. Transmission line lengths for new transmitters can be measured, and some extra lengths can be ready at installation, just in case. Remote broadcasts can have primary ISDN connections and a hot spare ISDN, connected in case the first goes down.

Our upgrade could easily have taken the entire three-day weekend we had available, or we could have had to abort and patch things together in a stop-gap measure to keep them running until problems had been solved. But through exacting planning, almost to the point of paranoia, it was an easy seven hours. Since then it has run almost seamlessly, rewarding our hours of planning with reliable and efficient performance.

The lesson is straightforward: if you look out for Murphy's Law with your proverbial fire extinguisher, even a fire doesn't have to be an emergency. ■

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Radio Makes Room for WiMax

Developments May Alter the Broadcasting Landscape, But Radio's Strengths Will Keep It Viable

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

It would seem that quite a few engineers in our business are giving up on any future for radio. To them, WiMax is a torpedo dead ahead that is poised to sink radio broadcasting and its 90 years of legacy service. The following letter from Mark Krieger, responding to my support for AM translators on FM, is typical of the sentiments we often hear on this topic. He has already written radio's epitaph:

Just read your article regarding supporting FM translator grants to AMs and I confess it evoked a couple of laughs.

I too am a veteran radio engineer of 31 years, and an SBE officer and senior member as well. During that time I've had a variety of AMs and FMs under my watch, including a 50 kW AM with a five-tower DA. I used to love sending out QSL cards to Europe, just as I used to love listening to international broadcasting on my trusty Hallicrafters when I was 12 years old. I still have a basement full of every type of broadcast and utility receiver imaginable, the leavings of a lifelong love affair with radio.

Even so, here's how the thesis of this article strikes me: In a nutshell, what's being proposed is that AM operators be allowed to leave their sinking ships to board lifeboats that are already overfilled and also sinking, albeit more slowly.

This may be an unpleasant analogy, but we need to come to grips with the reality that the way Americans use media, including radio, is being irretrievably transformed by broadband technology. The fact of the matter is that AM has had a long and venerable life, as have FM and analog TV. But we're nearing the end of that era. Broadcasting as a conduit for OPC (Other People's Content) is drawing to a close. As the "pull" model takes over, the use of large chunks of bandwidth for carriage of dedicated programming makes less sense. In fact, I believe we'll begin discussing turning off dedicated broadcast signals (FM and TV) and repurposing that spectrum to broadband in just a few years. And broadcasters will be powerless to stop it, because we've never owned the spectrum we operate on. That resource has been on loan to us by the American people.

The harsh fact of the matter is that unless you are in the business of creating content, you probably ought to cash out of broadcasting now, while you can still get a decent buck for the station. The public soon won't need you to listen to Rush, Dr. Laura, Westwood One, the NFL, MLB, ad nauseam. Even now, they can get much of that programming right from the source.

Presuming, for a moment, that a local broadcaster does produce a quality localized product that has real value, he or she had better focus on developing their broadband delivery, promotion and business model rather than thinking about how to survive economically as a low-power FM — that really is the ultimate in futility. The only thing I've read lately that made me chuckle more was the article by a gentleman proposing the creation of a new FM band for AM owners. Now that was a hoot!

I could go on about studies that reveal that people under 30 have little or no affinity for the radio medium, how the NAB's clout on Capitol Hill is waning, how WiMax is going to present a huge blow to major market radio, etc., but it's all too grim. Let's just say that we're all working in a legacy industry, and that those of us who wish to continue working in electronic media ought to be about the business of getting our broadband pipelines in order with the knowledge that quality content, not a piece of paper from the federal government, is where our collective fortunes lay.

Mark Krieger
Director/General Manager
WJCU(FM)
A Service of John Carroll University
Cleveland

There is no question that broadband technology is beginning to change broadcasting as we know it. The eventual deployment of widespread WiMax availability also will change it. Mark may be laughing now but to suggest these developments will soon render the broadcast service essentially useless, and that we should "begin discussing turning off dedicated broadcast signals (FM and TV) and repurposing that spectrum to broadband in just a few years," is downright hilarious.

Mark's observations and advice seem to misinterpret or ignore important realities on a number of issues, and presume the following statements are true or will soon become true:

1. Most consumers will clamor for WiMax services and will prefer to engage and manage its "pull model" over broadcast services.
2. WiMax-based devices that replace radios (and even TVs) will be just as easy to use for average consumers and just as affordable.
3. WiMax will need the scarce spectrum now used for broadcast to be effectively deployed.
4. The FCC can and will likely take existing channels away from broadcasters and award them to WiMax operators.
5. Most folks under 30 do not need nor use radio anymore, suggesting they will not use it as they grow older.
6. Most radio stations do not create useful or compelling content on their own and merely play tunes or OPC via networks and nationally syndicated shows.
7. Most radio stations are not yet Webcasting over the Internet or are not gearing up to do so.
8. Broadcast radio and TV are close to the end of their life spans and will completely give way to broadband and WiMax in the near future.

It's not too surprising to hear comments like Mark's coming out of a university environment where MP3 players, cellphones, laptops and WiFi internet are the mass media staples. Any university campus is a bubble wherein everyone is exposed to new technologies and hi-tech ways of doing things. In most cases, mom and pop paid for their student's hardware and the tuition that provides the university Internet connections.

Furthermore, students and teachers alike generally have little interest in the affairs of their surrounding communities and are narrow-focused on their own pursuits.

When students move out of such isolation and into the real world on their own, they discover a whole new set of priorities that compete for their time, attention and money. The Internet and wireless communications devices will still be important of course, but they also will find devices that are free and easy to use that connect them with resources of relevance and importance in their local surroundings. That's where local radio has always shined.

I wonder if Mark has considered how many "blinking 12:00" displays are still lurking on home recorders, and what percentage of the population actively uses TiVo and similar features with their home TV services. Pull technology has been around for a long time and still befuddles far too many folks who try to use it. Consumers want their information and entertainment services to be simple, convenient and easy to use. Finding and using Internet-based content, especially on mobile devices, has a very long way to go before it qualifies in that category.

Radio is the winner in delivering 'free and easy to use,' entertaining personalities and the best local connection. These attributes should be our battle cry in the face of other media that attempt to lure away our listeners.

WHAT BAND FOR WiMAX?

The FCC regulates the use of the currently allocated electromagnetic spectrum in the U.S., based for the most part on rules debated and passed by Congress. Existing stakeholders, represented by lobbyists, affect the process heavily. Any effort to displace existing licensed broadcast channels with broadband services would most certainly be subjected to a long battle taking years to resolve. But that's probably not going to happen anyway.

The commission has seen the need for WiMax and its challenges coming for quite a while. Finding the appropriate spectrum for it may not be the big problem however. The battles over net-neutrality, priority access and of national vs. local distribution promise to be huge. As it turns out, there is quite a bit of underused and even "white" spectrum out there identified by an FCC Task Force study. Let me quote from former FCC chairman Michael Powell's paper of Oct. 30, 2002 entitled, "Broadband Migration III: Directions in Wireless Policy":

"The Commission has recently conducted a series of tests to assess actual spectrum congestion in certain locales. ... The results showed that while some bands were heavily used, others either were not used or were used only part of the time. It appeared that these 'holes' in bandwidth or time could be used to provide significant increases in communication capacity, without impacting current users, through use of new technologies. ... Although not dispositive, these results call into question the traditional assumptions about congestion. Indeed it appears that most of spectrum is not in use most of the time. ... There is a substantial amount of 'white space' out there that is not being used by anybody."

WiMax will work best in the UHF spectrum between 300 MHz and 3 GHz. That would exclude AM, FM and VHF TV. Most of the present broadcast UHF TV spectrum was already re-purposed for HDTV within the last 10 years. Rather than blowing up heavily used existing broadcast channels and converting them for use by WiMax, it makes much more sense to carve out a new band or group of bands for wireless broadband distribution from lightly used spectrum, as was done to launch the cellphone services.

CONTENT, CONTENT, CONTENT

Nobody would disagree that quality content is where broadcasters' collective fortunes lie. But content has always been king and has driven every station since KDKA(AM) signed on the air.

Almost every time a station decides to turn its back on the importance of content, especially locally produced content, the results are predictably disastrous. When stations flip formats from "live and local" to satellite-delivered and time-shifted automation, they usually lose. I have no argument with Mark's suggestion that stations operating in this manner will have problems when WiMax starts gaining a foothold.

On the other hand, Mark disregards the reality that virtually all successful stations have long produced and showcased familiar local content of value that attracts significant audiences in all-sized markets. That's something that WiMax resources are not likely to displace unless they are clearly better and more compelling, and they are easier

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and more convenient for the majority of listeners to access.

Perhaps the most underestimated aspect of broadcast radio that Mark overlooks is the burgeoning commitment to develop Web site and streaming resources to extend its reach and appeal to broadband and Internet users. Almost all stations now have Web sites even in small markets. Most have added or are in the process of adding "Listen Now" buttons for live streaming as well as podcast download libraries.

Quite a few have been at it since the late 1990s and have integrated their Web presence as an important part of their sales and marketing efforts. It appears Mark is a little late realizing radio has been "getting our broadband pipelines in order" for some time now.

Broadcast radio is not operating in some kind of isolated vacuum, oblivious to the need for creating quality content and leveraging its distribution, whether over the air, over satellite networks or over the Internet. Where does Mark think folks like Rush Limbaugh, Dr. Laura and virtually all syndicated hosts come from? Why, local radio stations of course!

Beyond the Internet mega-content providers like AOL, Yahoo and MSN, a lot of the programming you hear over the Internet now and will hear on WiMax will come from radio stations and their parent companies.

Clear Channel Radio and Premiere Networks develop content for cellular radio and have a deal with Motorola right now to include some Clear Channel programming on *i*Radio phones. The Clear Channel Format Lab also is developing content for the Internet, and programming deals for more cellular systems and in-vehicle systems are in the works. Other major radio groups are hard at work inventing and growing their versions of similar resources.

THE MERCURY RADIO WAKE-UP CALL

One of the highlights for me at September's NAB Radio Show in Dallas was the unveiling of the Mercury Radio study, a comprehensive and realistic look at where radio is today and what it needs to do to remain relevant and successful. It debunks the myth that nobody under 30 uses radio. They may be using it less than in the past since the introduction of MP3s and iPods, but in fact there is a large percentage of folks under 30 who still enjoy and depend on radio as their primary source for music.

The bottom-line conclusion of this study: we still have many strengths to keep us going but also many challenges in the digital era and transition to HD. When measured against all other media, radio is the clear winner in delivering "free and easy to use," the most entertaining personalities and the best local connection. These attributes should be our constant battle cry in the face of other media that attempt to lure away our listeners. Everyone who cares about our business should give this 45 minute slideshow their utmost attention: *www.mercradio.com/free.htm.*

Radio companies everywhere are adapting to the forces of change as they diversify and re-purpose assets to better support their business models going forward. Market forces will reshape the present AM and FM bands according to how well station owners manage those assets. Smaller AM stations may go away or morph into LPFMs and translators, while larger ones step up to improve their coverage and service areas. Successful AM and FM stations alike should all look forward to being part of tomorrow's WiMax landscape.

I would not advise engineers like Mark to forget about dealing with transmitter plants as they turn more attention to Internet operations anytime soon. WiMax may eventually supplant some of the broadcast service way down the road sometime, but not in his lifetime or in the foreseeable future. ■

MARKETPLACE

USB Matchbox, Match Plus Add InGenius Input

Henry Engineering says its USB Matchbox and USB Match Plus USB-to-XLR interface units have been enhanced with the addition of THAT Corp.'s InGenius servo-balanced input stage.

The units are used instead of a PC sound card. THAT Corp.'s InGenius servo-differential input amplifiers enhance the products by providing CMRR noise rejection performance that is equivalent to that of a transformer. The company says this eliminates common-mode hum or noise from affecting recordings made with the units.

Because of their servo input design, the InGenius IC's CMRR performance is not affected by the balance or symmetry of the source. CMRR performance remains constant over a wide frequency range and under even drastic cases of asymmetry, such as an accidental ground. This makes the USB Matchbox and USB Match Plus suitable for use where the analog inputs are fed from a long cable run, such as a broadcast facility.

The USB Matchbox is a basic unit; the USB Match Plus adds accurate level metering and a reference-grade headphone amplifier for critical monitoring. Both units are USB-powered. The new versions are identified with the InGenius logo on the front panel.

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

Harris Has Transmitter, Exciter for Small Market

Harris ZX1000

Harris Corp.'s ZX low-power transmitter is based on its Z-Series of FM solid-state transmitters. It is suitable for use at small-market stations requiring 3.5 kW or less of analog power, or in major-market stations needing a low-power HD Radio system.

The ZX is available in 500 watt, 1 kW, 2 kW and 3.5 kW power levels for FM broadcasting. The company says the 2 kW/3.5 kW versions can be driven to full power using a standard 55 watt exciter, with the lower-power units requiring even less drive. Upgrades to HD Radio are achieved when driven by the Flexstar HDX-FM exciter, either as a hybrid analog/digital system (known as common amplification) or in digital-only mode.

The HDX-FM exciter allows tri-mode operation — analog, digital or hybrid mode — with a slight power derating in digital modes for broadcasters seeking a more economical digital transition. The HDX also adjusts the bias of the ZX transmitter's amplifier for optimum efficiency as modes are changed on the fly.

Harris also offers the MicroMax FM exciter for small-market broadcasters. The 30 watt 1 RU exciter is suitable for use with the ZX line of FM transmitters, and begins shipping late December.

For more information, contact Harris Broadcast Communications Division at (408) 782-1201 or visit www.broadcast.harris.com.

Products & Services SHOWCASE

by Randy Hoffner

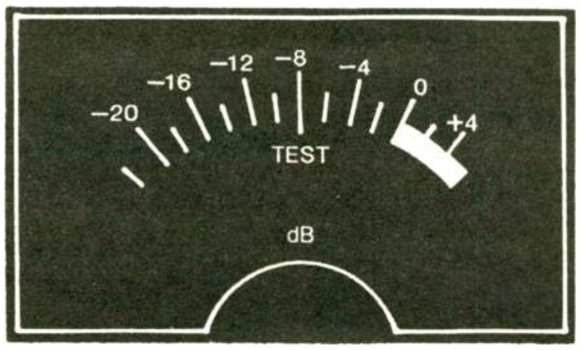
Digital Audio Metering Not as Easy as It Looks

Randy Hoffner is a veteran broadcast engineer.

Most of us have long since discovered that the presumption "if it's digital, it's perfect" is not necessarily accurate.

The digital domain gives us many advantages, but it offers at least as much room for error, as does the analog domain. Thanks to some recent work of the standards committees of the International Telecommunications Union and the Audio Engineering Society, some interesting problems concerning the metering of digital audio have come to our attention.

And we thought there were complexities in the metering of analog audio.



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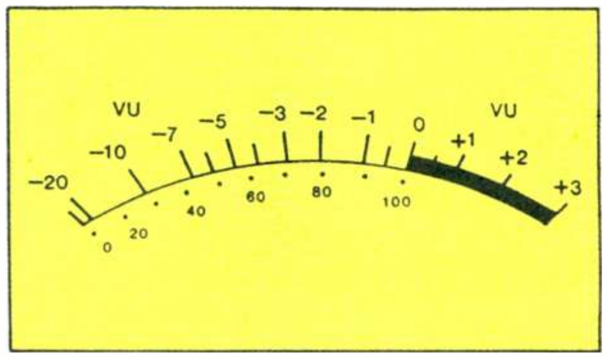
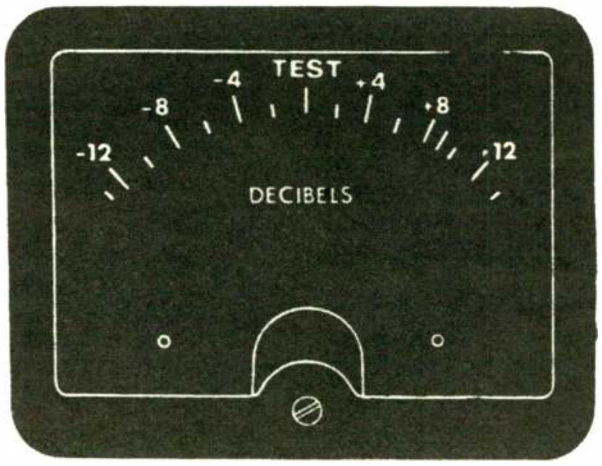


VU Meter



EBU PPM

ROOT CAUSE

The root cause of digital audio metering problems is the very fact that digital audio is sampled and quantized (and, because of this, we might infer that similar problems could arise in the metering or monitoring of digital video, but that is a subject for another publication).

The digital audio meters we use today give rise to some perplexing anomalies, according to the background research of the committees.

It has been frequently noted that if an analog audio recording is repeatedly played into a system that digitizes it and meters it in the digital domain, or if a digital recording is repeatedly played through a sample rate converter before metering, significantly different peak readings may be noted on each play. It also has been noted that overloads may be encountered from digital audio signals containing no samples that even approach digital full scale. Finally, when constant-amplitude pure tones are played through digital audio systems, digital audio meters may under-read them, or the meter indications may continuously waver and vary.

The cause of the above anomalies may be traced to the sampled and quantized nature of digital audio. Although we do not often think about it in practice, it is well known that a digitized audio signal (or any other digitized waveform, for that matter) does not contain the entire waveform that was present in the analog domain; it contains only periodic samples of that waveform.

We trust that such signals yield accurate representations of their original analog waveforms because they were digitized, and later converted back to the analog domain, while applying the "rules" of sampling and digitization, notably the Nyquist rule.

Put simply, the Nyquist rule states that in order to perfectly reconstruct a sampled waveform, at least two samples of the waveform must be taken each cycle. Another way of saying this is that no frequency greater than half the sampling frequency may be permitted into the sampler.

ALIAS FREQUENCY

If a frequency higher than half the sampling frequency is permitted to enter the sampler, it will appear at the output of a digital-to-analog converter not as the frequency that went into the sampler, but as an "alias" — a lower frequency component, within the range of zero to one-half the sample frequency, that was not present in the original signal; i.e., a distortion component.

If we follow Nyquist's rule about filtering the analog signals that are input to the sampler, the sin x/x function that is applied when the digitized signals are converted back to the analog domain will perfectly reconstruct the input waveforms, although the digitization process did not record what happened between samples.

If we do not follow Nyquist's rule, the D/A converter will not output a perfect analog of the signal that went into the sampler. This is the rock-bottom foundation of digital audio, and any other process in which an analog waveform is sampled and digitized.

AMPLITUDE PEAKS

The first two anomalies mentioned are caused by the fact that when an analog audio signal is sampled, its highest amplitude peaks frequently occur between samples. However, digital audio meters, as currently implemented, simply measure the amplitude of each sample without regard to what happened between samples.

Thus, when an analog audio signal is repeatedly played through a sampler/digitizer, the samples are taken at different points on the analog waveform each time the signal is played, causing the peak indications of the meter to vary from play to play.

Further, because the peaks often occur between samples, output overloads can result although we cannot see a single sample that is at digital full scale.

Short of converting the signals back to the analog domain before metering, these problems may be overcome by oversampling the digital signal; generating, by interpolation, additional samples that fall between the original samples. We know that this will work, as long as we have followed Nyquist's rule in the first place, because it will restore the apparently "lost" information between samples. In fact, almost every CD player does just this prior to D/A conversion.

The oversampling process permits us to solve the third anomaly as well: the under-reporting of the levels and the wavering indications of some pure tones. These phenomena occur because such tones beat with the sampling frequency. The relative phasing of these tones and their beat products can reduce the tone levels or cause them to vary.

UNDER-INDICATION

Tones that are close to low-integer factors of the sampling frequency generate beat frequencies low enough to visibly interact with the decay rate of the meter. According to the research, it is not difficult to encounter a 3 dB under-indication for a tone at one-quarter of the sampling frequency, and the under-indication of a tone at half the sampling frequency can be almost infinite, depending on relative phasing.

These effects apply to audio program material as well as tones, of course, but are not usually serious problems because program material does not typically contain sustained high-frequency content, and content at half the sampling frequency is largely removed by the sampler's anti-aliasing filters.

OVERSAMPLING

The degree of oversampling required to prevent under-indication in digital audio metering depends on how much under-indication is tolerable, of course.

Some mathematical calculations, not subjected to real-world testing, show that a 10-times oversampling ratio results in a maximum under-indication of about 0.1 dB, while 32-times oversampling reduces the under-indication to about 0.01 dB.

It is possible to implement oversampling filters for metering that are simpler and have less precision than those required for listening, so long as they don't degrade the metering beyond the required tolerance.

High-precision over-sampling chips are readily available at low cost, and will serve the need nicely. It would be well to see this work result in an international digital audio metering standard that produces highly accurate level indications. ■

MARKETPLACE

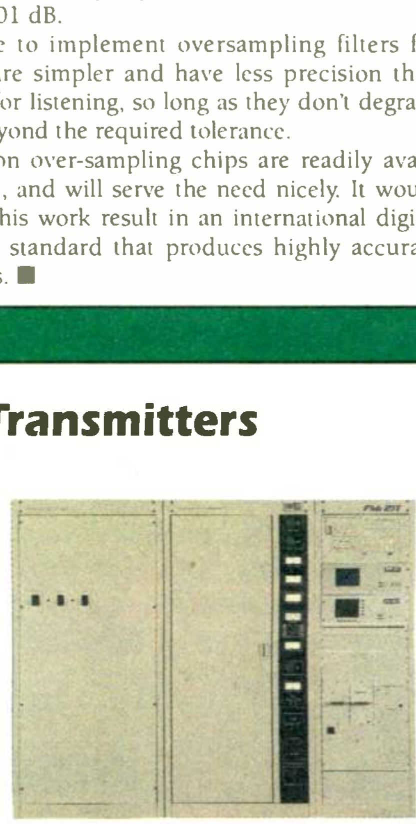
BE Ships FMi T Series Tube Transmitters

Broadcast Electronics is shipping its line of tube transmitters for HD Radio, the FMi T Series, which offers efficiency and power levels for low-level combined operations. The series consists of three models — FMi 17T, FMi 21T and FMi 25T — with up to 25 kW FM+HD Radio operation and more than 55 percent overall efficiency. Additionally, it includes BE's ESP correction technology and folded half-wave cavity, which BE says eliminates troublesome and unreliable DC plate blocking capacitors and sliding RF contacts.

The first FMi 21T transmitter went on the air in August at WGAR(FM) in Cleveland.

BE FM 25T, FM 30T and FM 35T transmitters now operating as analog FM can be updated for HD Radio operation.

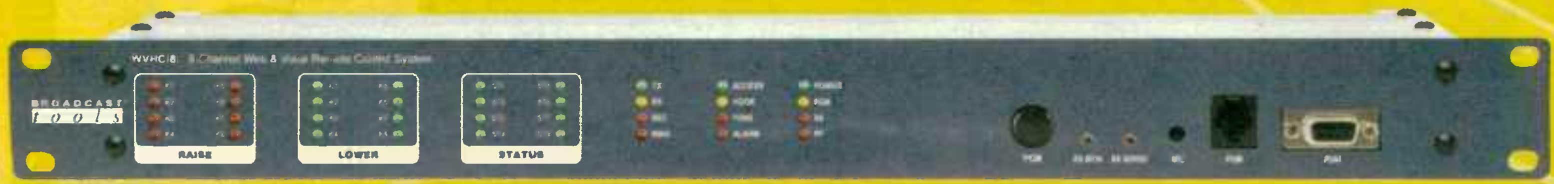
Be also makes a line of transmitters for analog as well as HD Radio conversion options, including its solid-state FMi transmitter line providing low-level combined power levels of 16 kW or less, non-combined.



Broadcast Electronics FMi 21T

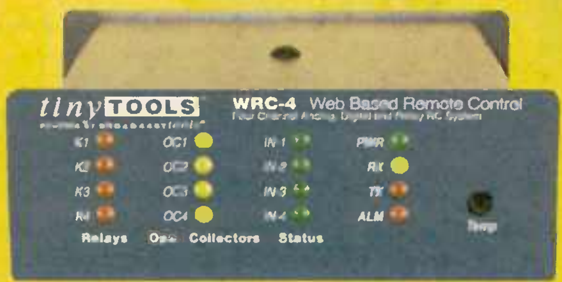
For more information, contact Broadcast Electronics in Illinois at (217) 224-9600 or visit www.bdcast.com.

Remote Control



WVRC-8 8 Channel Web & Voice Remote Control System

The WVRC-8 provides a cost-effective, one rack-unit solution for web based and/or recordable voice response dial-up transmitter site control. The WVRC-8 was designed from a user point of view, so all of the basic functionality you need is included to control your site equipment, while including the accessories other manufacturers consider optional. The WVRC-8 is equipped with a browser based 100 event function program scheduler and 8192 event alarm logger, while the user may select from four email recipients and a sound effect to play when an out of tolerance alarm is generated. The WVRC-8 is equipped with eight high-resolution analog (telemetry) channels, while each of the eight optically isolated status channels may be configured for 5 to 24vdc wet or dry (contact closures) status monitoring. The eight control channels are equipped with independent SPST one-amp relays for each raise/on and lower/off function. These relays may be latched, unlatched or momentarily closed. The WVRC-8 is supplied with spoken words and phases in English, while the user is free to record words and phases in their language. In addition, the WVRC-8 may be programmed for dial-up operation via HyperTerminal, while the Java applet programming can be performed using your favorite web browser. System expansion may be accomplished by cascading multiple WVRC-8's on the same telephone line and/or Ethernet switch. Future external add-on products such as X-10 modules, Zig-Bee hubs, and AC power controllers may be attached via the BT-Link expansion port. The WVRC-8 is supplied in a 1-RU chassis.



WRC-4 Web Based Remote Control

The tiny TOOLS WRC-4 is a fresh approach to remote site monitoring and control or providing an inexpensive solution to Internet enabling your present remote control system. The WRC-4, combined with web access and your favorite web browser, brings you the following features, all available in this small, but powerful tiny TOOL: A powerful built-in web-server with non-volatile memory; 10/100baseT Ethernet port; four channels each of high resolution telemetry inputs with a large monitoring range; optically-isolated status (contact closures or external voltages) inputs; normally open dry one amp relays; open collector outputs; front panel status indicators, a single front panel temperature sensor and 4-email notification addresses. The WRC-4 is also SNMP enabled. The WRC-4 has been carefully RFI proofed, while including the accessories other manufacturers consider optional. The WRC-4 is supplied with plug-in euroblock screw terminals and loaded with a generic web page that may be edited by the end user. The WRC-4 works with either dynamic or static IP addresses (when used with a dynamic IP, an inexpensive cable or DSL router may be required). Multiple WRC-4s may be used with a user provided Ethernet hub. The WRC-4 may be set on a desktop, mounted on a wall or up to four units mounted on the RA-1, Rack-Able mounting shelf.

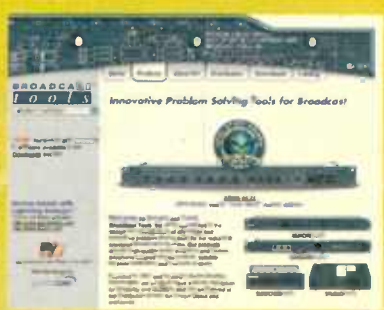
AVR-8 Voice Remote Control

The AVR-8 is a voice remote control system that automatically reports changes detected on any of its eight digital inputs to a remote telephone and/or pager. After speaking a greeting message that may identify the source of the call, the AVR-8 then speaks a unique message for each input change. Each message comes factory programmed, but may easily be re-recorded with your own customized messages. After reporting, the AVR-8 allows you to give it commands through your telephone keypad. Functions include telling the AVR-8 to report on the input state of any of the eight digital inputs, commanding the AVR-8 to pulse any one of its four relays for 750 ms and/or turning any one of the relays on or off. When a relay command is given, the AVR-8 speaks the relay 'name' followed by the 'on' or 'off' message. For instance, commanding relay 4 ON causes the AVR-8 to turn the relay on and then report "Relay 4 ... is on." As with the greeting and input messages, the relay 'name', 'on' and 'off' messages may be re-recorded if desired.

In addition to initiating a call out when inputs change, the AVR-8 monitors its telephone line to receive a call-in from a remote location. When a call is received, the AVR-8 speaks a greeting message, and is then ready to receive and execute commands to report on its inputs, change to its relay outputs or turn on an audio input to the telephone line.

VAD-2 Voice/Pager Auto Dialer with Silence Sensor

The tiny TOOLS VAD-2 is a user programmable two-input with integrated stereo silence sensor, multi-number voice/pager auto dialer, designed for dial out voice message notification. The VAD-2 has two dry contact inputs and stereo silence sensor, which, when tripped, will sequentially dial up to four different phone numbers and play back a user recorded message corresponding to the tripped input. The VAD-2 is also equipped with two SPST one amp relays for the control of external equipment. The VAD-2 can store up to four 32 digit phone numbers and one 32 digit pager phone number which may be associated with any of the two inputs and/or stereo silence sensor. The VAD-2 is capable of remote or local configuration and message recording with a total recording time of 16 seconds. The two SPST relays may be programmed for momentary, latching or tone duration operation. The VAD-2 may be set on a desktop, mounted on a wall or up to four units mounted on the RA-1, Rack-Able mounting shelf.



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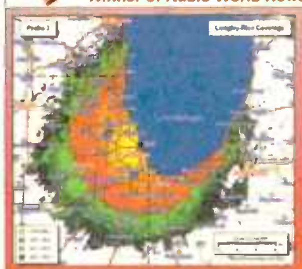

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Burk Technology Shipping AFD-1

Burk Technology's AFD-1 arc and flame detector is shipping. It detects arcs and flame, and connects directly to the Burk ARC Plus, ARC-16, GSC3000 and VRC2500 broadcast facility remote control systems. Applications include transmitter enclosures, antenna-tuning units and transfer switches. The company says the device is small enough for mounting inside equipment cabinets.

"The AFD-1 provides immediate warning of electrical arc problems that can lead to significant damage later on," said Anita Russell, general manager of Burk Technology. "It will reliably detect a pilot light or arc from 15 feet, even in broad daylight."

For more information, contact Burk in Massachusetts at (978) 486-0086 or visit www.burk.com/afd-1.

ERI Has FM Band-Pass Filter for IBOC

Electronics Research Inc. debuted an FM band-pass filter line for IBOC and low-power analog FM applications. The company says the 955 Series is suitable for use as a band-pass filter for protection from undesirable cross modulation products, and also can be configured as a branch combiner for combining two or three analog or IBOC transmitters into a single antenna. The filters are rated at 3 kW average power and can be tuned for FM operating channels between 88 and 108 MHz.

ERI also has a constant impedance-combining module available in the 955 Series.

The filter cavities are sized to provide low insertion loss resulting in minimal temperature rise and reduced transmitter power loss. The individual cavities are loop coupled so that each filter back can be optimized for the particular application required and can be retuned in the field if necessary. The filters are provided with an integrated floor-mounting frame, which can be suspended from a ceiling or wall mount with optional mounting hardware.

The 955 Series filters are available for shipment within four to six weeks after receipt of order.

For more information, contact ERI in Indiana at (877) ERI-LINE (374-5463) or visit www.eriinc.com.

The Last Word

CONTINUED FROM PAGE 38

Walk through your home while listening to loud music through headphones. Then, do it again without headphones. Notice how the clear sounds of hard shoes on wooden stairs provide navigational confidence, especially when the eyes are focused elsewhere. When crawling through underground caves, spelunkers can gauge the depth of a dark passageway by its resonances. Auditory spatial awareness, while relatively unconscious, is available to all of us.

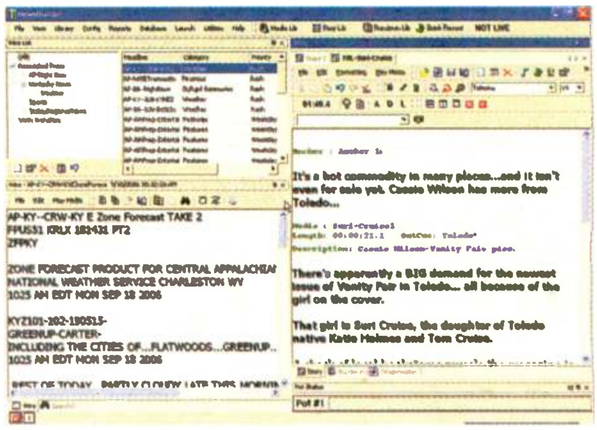
In "Spaces Speak," I have developed the concept of aural architecture. It is the auditory equivalent of visual architecture, but it is far more complex that its visual counterpart.

To understand the aural experience of space, I took an interdisciplinary perspective, using concepts borrowed from music, acoustics, perception, psychology, anthropology, engineering, theology, archeology, evolution, neuroscience, history, architecture and the accumulated traditions from diverse cultures and subcultures over thousands of years. When using the broad view, we find at least four components to aural architecture: social, musical, navigational and aesthetic spatiality. Social spatiality belongs in radio broadcasting.

Long ago, hearing was king of the senses, and it is time to restore it to its rightful place in the sensory world. It is time to reexamine "modern" assumptions, most of which originated from historic accidents. The status quo of radio broadcasting during a long period of stability in the 20th century was comfortable, but social and communication changes invite us to reconsider those assumptions that are taken as predetermined givens.

While tradition provides stability and predictability, it can become like a claustrophobic prison. Some of radio's traditions are at odds with the sensory norms that evolved across the centuries and in a wide range of cultures. Our technology changes rapidly, but as a social animal, we are very similar to our ancient cousins. ■

NewsBuilder Adds Hot Key, Layout Creation



Created Date, Created User, Length and Media Length columns have been added to the Story Library.

Prophet Systems changed the name of its NewsGen automation software to NewsBuilder, and says new features have been added as well, such as a newsroom's ability to create its own hot keys or set up its own layouts. The standalone software enables reporters to write newscasts, receive and revise wire copy and digitally record, edit and playback audio. It is scalable from an enterprise-wide deployment to a server-based system.

NewsBuilder 2.0 will update the erase date to reflect the new category's settings after a media file or story is moved to a new category. Additionally, Created Date, Created User, Length and Media Length columns have been added to the Story Library.

Other highlights include the Quick Record button, which allows immediate recording of audio when there is a breaking news story; and the Teleprompter, which lets users scroll their news stories while reading them, and play back news audio files. This feature can be tailored to the reading speed and the on-air delivery of each anchor or reporter.

NewsBuilder also allows the assigning of stories to specific anchors, and eases the timing of newscasts by calculating the time based on the assigned reporter for a story.

For more information, contact Prophet Systems in Nebraska at (877) 774-1010 or visit www.prophetsys.com.

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by Barry Blesser

Social Spatiality Belongs in Radio Broadcasting

By Nixing Ambient Soundscapes, Broadcasters Hinder Radio's Ability to Transport the Listener Audibly

Barry Blesser is director of engineering for 25-Seven Systems.

During the last five years, I have been researching and writing a book called, "Spaces Speak, Are You Listening? Experiencing Aural Architecture." MIT Press has just released it, and among other things, it explains how radio broadcasters ignore important aspects of the aural experience. I have extracted a few highlights to support the argument that the ambient environment could, and should, be part of broadcasting, which extends ideas recently introduced here in The Last Word ("CDs Prove Secondary Features Matter," Aug. 25, and "New Audio Villages Challenge Ballistic Radio," Oct. 18).

Radio broadcasting, which is a subset of audio, which is a subset of the aural experience, can only be understood by examining the historic role of hearing. Unlike the other stimuli, sound originates from dynamic events; a static world never produces sound. Sonic events can originate from sticks banging against each other, strings made to vibrate, vocal cords under lung pressure or children playing in the fields.

Our ancient ancestors viewed hearing as the means of connecting those animate and inanimate objects that were producing sonic events into their consciousness. One does not need to understand anything about sound to recognize its importance in sensing events. Even today, the average person has little understanding of sound, which remains ethereal and illusive. From this perspective, radio broadcasting is nothing more than a super-efficient way of transporting sonic events over long distances. Ignoring scientific explanation, hearing allows us to become aware of events.

BEING THERE

But sound never exists in isolation. Sonic events always take place in a space, which itself contributes a social and physical context to the aural experience. For example, sports programs almost always include the ambient sounds of the arena, thereby transporting listeners into the soundscape of the sports event. You are there in the stadium, not sitting in your den or automobile.

One of the earliest examples of transmitting spatial ambience was NBC's broadcast of the New York Metropolitan Opera, hosted by the famous Milton Cross. These broadcasts, which began in the 1930s and continued for more than 40 years, explicitly transmitted spatial acoustics and background of audience activities.

Unlike the sanitized spacelessness of studio announcers, elevated microphones at these live performances provided remote listeners with the same aural experience as the audience, which included the sounds of shuffling feet, muffled coughs, premature applause and even rattling candy wrappers. Listeners, sitting in their farm kitchens, were part of the live audience in New York, which provided an emotionally charged social context.

Contrast these two examples with the more typical announcer in his dead studio with a microphone at his mouth. He is injected into the isolated space of an automobile stopped in rush-hour traffic. Neither the studio nor the automobile is like a street corner where people congregate. Unintentionally, and perhaps in the name of audio quality, the aural experience is stripped of its spatial and social context, which often has as much emotional impact as the content. We are all social animals, and through historic accidents, the social part of listening has been removed from radio broadcasts and reproduced music.

In contrast, even sanitized television uses a live audience when possible, or alternatively, canned laughter and applause to artificially create some kind of social context. News reporters are shown on location where events are happening. If radio broadcasting seeks to create audio villages, as I previously argued, this important part of the aural experience cannot be ignored.

> **We are all social animals. Through historical accidents, the social part of listening has been removed from radio broadcasts and reproduced music.**

Transporting listeners into a new space is different for radio than for television. With vision, it is easy to create an external world, just point the camera. We never see anyone on television framed against a neutral gray background. Television always includes space, whereas radio has drifted away from placing sonic events in a soundscape. There are important exceptions, such as "Morning Edition" on NPR radio. Ambient sounds are social context, not noise.

AURAL ARCHITECTURE

Radio should be the high-impact media. The media guru of the 1960s Marshall McLuhan argued that the imagery of radio is intrinsically "hot" because it requires the listener to actively engage in creating the aural experience. In his view, television is "cold" and passive. Even though radio has this unique advantage, broadcasters ignore the importance of creating social cohesion by removing the soundscape, which is the location for an audio village.

Sadly, we have thrown the baby out with the bathwater. Early radio was always fighting against noise, and in 1920s all forms of ambience were treated as noise. Without thinking, we currently accept an odd tradition that originated a long time ago.

In the early days of broadcasting, soundscapes were a critically important part of radio theater. The special effect rooms at NBC were designed for the purpose of artificially creating the acoustics of a specific environment, such as caves, haunted houses and open plains. The first synthetic reverberation, albeit primitive by modern standards, was one of these effect rooms.

Today, there are sophisticated spatial synthesizers that can be used to select any kind of artificial space. While these devices are mostly used in music production as an effect or as a means for replicating the acoustics of a performance space, they also can be used as tools for creating the illusion of a social soundscape.

Two aural components contribute to a listener's associations to a particular space: its unique sounds and its characteristic acoustics. For example, forests have the sounds of birds and rustling leaves. And forests have particular acoustics resulting from the movement of reflecting surfaces, air turbulence and thermal refraction. Both its sounds and its acoustics contribute to perceiving the space as a forest; and either aspect can dominate or complement the other. The same is true for other environments, such as an urban city, an automobile tunnel or a school classroom.

The notion that we can hear the passive material and geometries of a space is not obvious in our visually oriented culture. Sensing spatial attributes does not require special skills — all human beings do it — because a rudimentary ability is wired into the brain as part of our genetic inheritance.

For example, when blindfolded, most everyone can approach a wall without touching it just by attending to the way the wall changes the frequency balance of the background noise. Similarly, as we walk into a room, the sounds of our footsteps hint at the location of stairs, walls, low ceilings and open doors.

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