ENGINEERING EXTRA

A CHAT WITH JOHN WARNER
Michael LeClair interviews Clear Channel's VP of engineering for AM. Page 4

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Report to the FCC on the Advanced IBOC Coverage and Compatibility Study

Study Details Levels of Predicted Interference to Analog With Increased Digital Power Using Field Measurements and Actual Automobile Listening

BY JOHN KEAN

The author is senior technologist at NPR Labs in Washington. Due to space constraints this report was substantially condensed from the original. The entire report can be viewed online at: http://www.rwonline.com/uploadedFiles/Radio_World/Resources/FCC_IBOC_report.pdf.

WHITEPAPER

The Advanced IBOC Coverage and Interference Analysis (AICCS) project was developed by NPR to further examine compatibility of in-band, on-channel digital audio broadcasting (IBOC DAB) with analog FM broadcast services in the United States, when elevated IBOC power was introduced.

A previous study of IBOC by NPR, completed in mid-2008, indicated that there was a "substantial" potential for interference to mobile FM reception and some indoor FM reception, and illustrated this potential with computer-predicted maps and population studies of a sample group of 75 public radio stations.

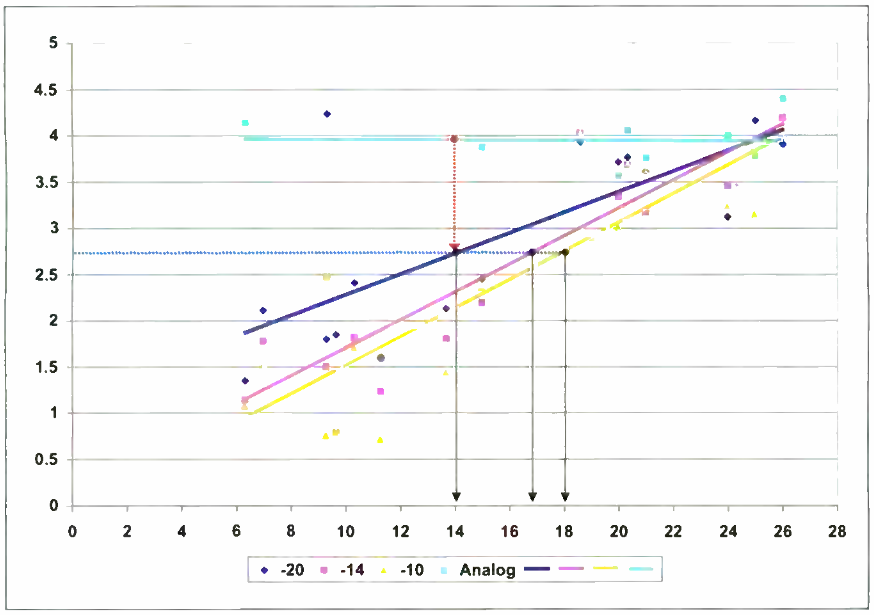

Chart of the listener test data, with regression analysis and conversion to median D/U ratios, provides the study's core evidence of harmful interference thresholds with IBOC at –20, –14 and –10 dBc IBOC, relative to analog-to-analog interference.

To help resolve conflicting reports on the potential negative impact of high-power IBOC impact on analog FM, to understand the impact of mobile impairments, which was heretofore never studied, and to involve a range of participants in the study process, NPR proposed the AICCS project to CPB. Funding was approved in April 2009.

By the project's official start date, a Working Group had been established with iBiquity Digital Corp. and CPB's engineering consultant as initial members. Soon, the Working Group included representatives from CBS Radio, Clear Channel and Greater Media (the commercial radio groups involved in the iBiquity study), as well as the Consumer Electronics Association and manufacturer Harris Broadcast. This group had the primary role of developing and approving the study procedures and test data.

A Peer Review Group was established in parallel with the Working Group to allow members of the greater broadcast industry an opportunity to review and comment on the study in process. This group eventually numbered 52 members, including public and commercial radio stations, manufacturers, engineering con-

(continued on page 10)

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FROM THE TECH EDITOR

We Want to Give You The Full Picture on IBOC

And Keep Those Cards and Letters Coming

BY MICHAEL LECLAIR

I got a lot of feedback from readers on our previous issue.

First, I want to address comments that our coverage was biased in favor of the proposed HD Radio power increase.

In the Oct. 14 issue of RW Engineering Extra we printed a lengthy article that detailed the possible benefits in digital coverage that could be obtained by increasing digital power beyond the currently authorized 1 percent average power level. This article provided detailed measurements and observations and clearly was supportive of the plan.

I consider the proposal to allow such a large increase in digital power to be the most important technical story of the last couple of years and the culminating technical question about the future of the HD Radio system.

If we go forward along this path, it is clear this will be the final chance for HD Radio to prove itself as a means to transition the radio industry to a digital transmission medium.

To give you the best possible understanding of what this proposal means, we are presenting in this issue a condensed version of the NPR Labs study on the interference effects of a digital power increase.

Their study considered for the first time the effects of digital power increases on mobile receivers. It offers a proposal for a regulatory framework that would allow power increases, but suggests that the potential for interference be evaluated on a case-by-case basis to ensure protection of existing analog FM service.

In printing both the iBiquity and NPR Labs studies, it is my goal to provide a balanced picture of the technical proposal to increase digital power.

One study points out the possible advantages in coverage area from a power increase. The other cautions that there may be a corresponding cost in analog coverage to weigh against the benefits.

Taken together, the two provide a detailed, empirical basis on which to decide whether such a power increase is warranted. I want to make clear that RW Engineering Extra does not endorse either position in this debate or lean toward either in our news coverage; rather we seek to provide fair coverage to both sides of the debate and to others. I urge you to read these studies carefully and understand their ramifications.

In November, NPR and iBiquity together urged the FCC to recommend a compromise that would allow FM stations to increase power by 6 dB and allow even higher power in many circumstances. Many major broadcasters and transmitter makers support the compromise (see Radio World's Dec. 2 issue). A decision on this proposal is expected from the FCC in the near future.

THAT DURNED ATU

I received just as much mail from readers about my column in that issue, in which I described trying to mount a toroidal current transformer in an antenna tuning unit without the benefit of an extra pair of hands. Taking a cue from the title of the column ("Who Designed This Thing Anyway?"), I got some great ideas on how to rebuild the transformer mount so that it could be done easily from the inside. Another reader suggested an excellent general method for doing the job solo. Please see the letters below. I know that you will enjoy reading the creative solutions that our readers offered.

Finally, concerned reader Dave Wigfield pointed out that I might want to be sure that I did not mislead anyone into working under unsafe conditions while alone at the transmitter site. So a reminder is in order: I *never* do work like this, alone or even with an assistant, without first making sure that someone at the studio knows where I am and what I am doing. This kind of communication is essential to prevent someone from trying to turn the transmitter on by accident while you have your head and arms inside the ATU where dangerous voltages run on exposed lines.

Please take this to heart and don't forget the importance of keeping yourself safe, even if you are in a hurry to get the job done.

I want to thank everyone who sent in their comments and suggestions on my ATU puzzle. If you have similar stories to share, please drop me a line at *rwee@nbmedia.com* and we'll try to print some of your favorite repairs.

READER'S FORUM

THREAD THAT THANG

Regarding Michael LeClair's column "Who Designed This Thing Anyway?":

Thread a piece of threaded rod (all-thread) into one bolt hole, long enough to reach through your case. Once it is inserted through the hole, the transformer should stay happily in place while you start the second bolt. It's then quite easy to remove the threaded rod from the outside and install the second bolt.

Mechanics use this approach in assembling heavy assemblies such as transmission housings on tractors. It's common enough that most shops have threaded dowel rods in every size ever needed.

A broadcast technician can keep a couple of pieces of threaded rod hiding in a tool box for just such a use.

Guy Berry
Potomac Instruments Inc
Frederick, Md.

PLATE POWER

I've gone through this before also and have the permanent solution, if the back mounting wall is thick enough.

At least one phasor manufacturer makes an aluminum mounting plate for these toroids. It has four holes, two for the toroid, with flat-head 1/4-20 short screws, and two more that are in an extended area of the plate. The back panel that I had was about 3/8-inch aluminum, and I just drilled and tapped two new holes, used the old bolts and now the toroid and plate are removable from the front.

Al Hajny, P.E.
Milwaukee

THIS ISSUE

DECEMBER 9, 2009

AM Man: Clear Channel's John Warner

VP of Engineering for AM Talks About Recent Projects and AM Engineering

BY MICHAEL LECLAIR

This is one of a series of articles about AM radio, its challenges and successes.

When it comes to AM radio stations in the United States, perhaps no engineer has quite the number of sites to worry about as does John Warner.

Warner is vice president of engineering for AM for Clear Channel Radio and has responsibility for maintaining and improving literally hundreds of AM stations.

With that many stations, there are always interesting projects in various stages of completion. RWEE spoke recently with Warner to hear about his latest and to learn from him how he ended up working in AM.

When did you first develop an interest in radio?

I had an early interest when I was about 8 or 9 years old. I owned a crystal set when I was young. My father was interested in radios, and I built a small radio as a scouting project. My mother actually taught me to solder. During World War II, she worked at Bendix Radio in Baltimore, which manufactured aircraft and tank radios for the war.

We lived on a farm when I grew up, and I became interested in antennas so that I could pick up different kinds of radio signals. I used to listen to all the European broadcasters via shortwave, and I experimented with long-wire and curtain array antennas. My father encouraged my interest in radio, and for one of my birthdays he gave me a telephone pole, which he then helped me to put in the ground to use as a tower that I could use to make experiments.

Did you attend any formal engineering school?

I attended the University of Maryland for two years in 1966 and 1967 and studied defense electronics and electrical engineering. I did not get a formal degree because my family did not have enough money to let me complete college, but I later went back to school and took further engineering courses at Johns Hopkins.

Where did you first begin working in radio?

My first job in radio was at station WBAL in Baltimore in 1979. I had a First Class radio license, and that allowed me to be a transmitter engineer for them. WBAL is a 50 kW clear-channel AM on 1090 kHz that began broadcasting in 1925. As a high-power directional array, WBAL was required to have an FCC licensed operator on duty at all times.

At WBAL I met Harrison Brooks, who had just retired before I started working there. He was the engineer who helped build the current transmission plant in 1940, which uses a directional array at night. Harrison was actually an electrician on that project, but he became so enthused about radio from working there that he became the chief engineer of WBAL after it was built.

Harrison taught me a lot of the history of WBAL and about broadcasting in general in the Baltimore area. He lived nearby and used to drop by to visit the station and keep an eye on any changes or new technology that we installed.

Do you have other mentors who have helped you in your career?

I also learned a lot from Ron Rackley, whom I met in 1986. We were installing a new Continental 317C at WBAL, and to improve the stability of the array, we also replaced the sample system at the same time and did a full proof. Ron and I struck up an immediate friendship while working on that project and we've stayed in touch ever since.

Ron gave me my first copy of the MiniNEC code, which is used to model the behavior of antennas. In those days it ran on an 8086 class computer, and it would take hours to do a tower model. I remember that you could start a model in the morning and let the computer run all day while working, and come back to find that it had just finished around 5 p.m. With the enormous improvement in computer power, modeling for AM has become so much simpler and much more important.

What kind of work do you do as VP of engineering for AM for Clear Channel Radio?

I joined Clear Channel about 10 years ago when Jacor was acquired by them in 1999. I am responsible for overseeing the design and construction of new AM facilities and the maintenance and refurbishing of existing AM stations. At any given moment there are approximately 250 to 300 AM stations that are in the Clear Channel portfolio.

For some of the projects I do the design work myself, and I always have some design work with me. I often do this kind of work while on airplanes, traveling around the country to different sites. I actually still use a slide rule for some of my designs rather than using a keyboard. It's easier sometimes to calculate on the slide rule when looking at combiner systems. There is a tradeoff between isolation and bandwidth, and you need to iterate component calculations to adjust between these two. The slide rule makes you think rather than just using a computer program to plug in numbers until it works.

With so many stations to maintain, I generally have between 15 to 20 projects going on all the time, involving site refurbishment, combining stations into a common antenna system to improve coverage and station moves.

You recently completed an interesting project in the Boston area that brought three stations together into one site.

The project was begun by Fairbanks Communications, which owned station WKOX. Originally in Framingham, WKOX operated at 10 kW daytime and used a two-tower directional array at night at a reduced power of 1 kW. WKOX was bought by AM/FM, which then later merged with Clear Channel.

By moving 10 miles closer to the city of Boston, WKOX was able to upgrade

(continued on page 8)

Photos from the Boston area triplex project. This is the WKOX phasor. 'The building footprint couldn't be enlarged,' Warner said, 'so I specified canteliver trusses to create a cathedral ceiling so we could make the phasor two stories high.'

Pre-cast tuning houses were 14 by 20 feet and each weighed 60,000 pounds. To keep them up out of the flood plain they were set on caissons that were 3 feet in diameter below grade and 1-1/2 feet diameter above grade. Temporary roadways were built to support the crane and trucks carrying the buildings; the roadways had to be removed after construction to restore the wetlands.

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Transconductance, Anyone ?

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

Development of anything in new and uncharted areas usually takes an unusual path. Most often we do not know where we are going, where our work, our experiments will take us — the unexplored country.

Transistors were no exception. The FE of our question (the Field Effect principle) was recognized by Austrian-Hungarian physicist Julius Edgar Lilienfeld, and a generalized patent was filed in Canada on Oct. 22, 1925. Oddly, Lilienfeld didn't follow up with any research articles about his work. In 1934, a derivative device was patented by German physicist Dr. Oskar Heil.

AT&T's Bell Labs history indicates that John Bardeen and Walter Brattain actually set out at first to determine if they could use the very high-impedance input of these FET devices to create an amplifier with a voltage to current transfer function exhibiting transconductance similar to tube amplifiers. While working to this end, they experimentally observed that when electrical current was introduced into a junction contact attached to a crystal of germanium, the output power was larger than the input. This event was the birth of the bipolar junction transistor, BJT. This current amplifier arrangement satisfied their need and the BJT generation was born, placing the FET on the back burner.

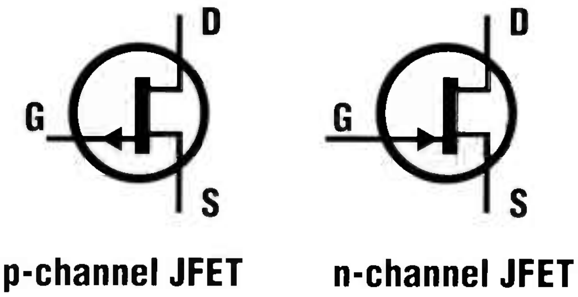


Fig. 1: Electronic symbols for the junction field effect transistor. G stands for gate, the normal input terminal, D stands for drain and S stands for source.

Two fellows named Kahng and Atalla built the first MOS (metallic oxide semiconductor) transistor at Bell Labs in 1960.

The earliest workable FET application that appeared was a MOSFET (metal oxide semiconductor field effect transistor) but their cause célèbre, the best application of this technology, was an integrated circuit where gas deposition and other fabrication concepts allowed CMOS (complementary metallic oxide semiconductor) techniques to be easily implemented.

The high impedance of CMOS means little power is needed from the source, minimizing loading of the previous stage. High gain and relative high output power are achievable and make FETs ideal for certain uses. This small power demand of the input and the small quiescent power consumption of the device are reasons FETs usually are more power efficient than other transistor types. Power efficiency is an important concern in IC development where an LSIC or VLSIC can have over 1 million individual active transistors (as in a Pentium microprocessor) and inefficiency is translated directly into destructive heat.

At the other end of the complexity spectrum, one simple application for a FET is the gain and impedance conver-

My, You Look FETching

Question posed in the Aug. 19 issue
(Exam level: CBRE)

About FET transistors, which of the following is most accurate?

a. The drain is the normal input element akin to a grid in a tube
b. The gate is the normal input element akin to a grid in a tube
c. The source is the normal input element akin to a grid in a tube
d. The screen is the normal input element akin to a grid in a tube
e. None of the above because an FET is a transistor and so a current amplifier unique to itself.

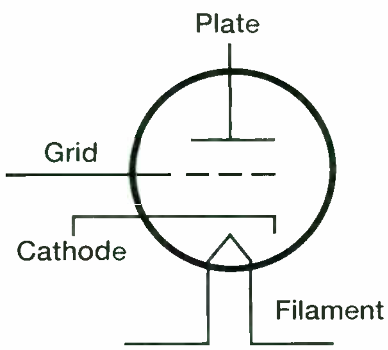


Fig. 2: A triode, three-element tube showing the input grid connection to the left. The grid in a tube is analogous to the gate on an FET.

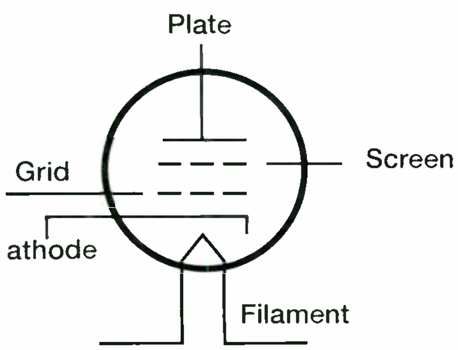


Fig. 3: A tetrode, four-element tube showing the additional 'screen' control input between the grid and plate.

sion needed in condenser microphones. A small change in reactance is created when acoustic pressure waves deflect a capacitive element surface (e.g., when your air talent speaks into the condenser microphone) which is differentiated into a tiny voltage change with negligible energy. A FET stage amplifies this tiny signal and produces enough voltage gain to feed a microphone cable with a standard level. When you place "phantom power" on your console microphone channel this little circuit is what you are powering.

Fig. 1 shows two common FET configurations in schematic representation and similarly, Fig. 2 is a triode tube that in function is similar to the FET. The gate then is functionally similar to the grid of the tube, so answer (b) in the question on page 6 is correct.

A screen is an additional control element in a tube, such as a 4CX1000A or 5CX1500B, both of which are used extensively in FM transmitters (Fig. 3). This "red herring" choice, (d), has nothing to do with the construction of an FET, and so is incorrect.

As noted above the BJT and FET are both transistors but only the BJT is normally considered a current to current amplifier.

HOW DOES IT WORK?

In ultra simple terms, a voltage applied to the gate (relative to the source), alters the current flow from source to drain. In the most ordinary "N" channel type FET, a negative voltage pinches off the current flow between source and drain, the depletion mode. Conversely a positive voltage increases the current flow between source and drain, the enhancement mode.

Since the first FET came to market, at least a dozen different special-use FETs are in current manufacture for applications as varied as microwave receive pre-amps and high-speed, high-current switching.

In 2006, more than 1.7 billion MOSFETs were vended (mainly in LSI and VLSI ASICs), nearly 60 million for every person on the planet.

Where would we be without them?

By happy coincidence, Mario Orazio, the Masked Engineer in our sister publication TV Technology, explores the universe of MOSFETs more fully in the Oct. 21 issue of that publication, for those who would like some more background. Read the article online at *http://tvtechnology.com/article/88622*.

Note: The deadline for signing up for the next cycle of SBE certification exams is Dec. 31, 2009 for exams given in local chapters between Feb. 5 and Feb. 15, 2010.

The question for next time is shown in the box below.

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

Protect Me, CB!

Question for next time (Exam level: CBRE)

When is a fuse more desirable than a circuit breaker as an overcurrent protection device?

a. A fuse is never more desirable in a circuit
b. A fuse is always more desirable in a circuit
c. A fuse is more desirable when the current is over 100 amps for economic reasons
d. A fuse is always more desirable because it means you get a service call
e. A fuse is more desirable when instantaneous interruption is needed

WARNER

(continued from page 4)

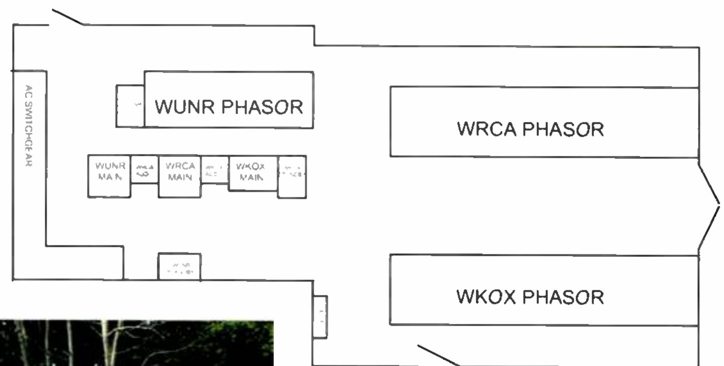
to a full 50 kW signal for both day and night and put a full-time signal over the entire metropolitan Boston area. The site they moved to was a new five-tower array at the old WUNR transmitter site in Newton, owned by Herbert Hoffman.

WUNR originally operated at 5 kW unlimited using a two-tower array. WUNR upgraded to 20 kW night and day as part of the project. Station WRCA, which is owned by Beasley, was also part of the move and was able to achieve an upgrade from 5 kW directional day and night to 25 kW day and 17 kW night time power by using the new five-tower antenna array.

You can see that this was a complicated project but the substantial increases in power made it attractive to all the owners.

I began working on this project in 1999. It took about eight years to get the necessary approvals to start construction. The local zoning and environmental approvals were particularly hard to obtain due to opposition from the local community.

The three phasors are placed in the building and assembled.



Equipment layout. 'There was just enough room in the building to install the equipment with minimum safety clearances.'

The original WUNR transmitter building had a flat roof. Clear Channel had to make the building look like surrounding houses. The windows are fakes.

What kinds of unique challenges were involved?

To start with, the extended time required to get local approval means extra work with the FCC. Before you can commence the zoning and approval process, you must first obtain the construction permits for the proposed facilities. But because of the delay in local approvals, we could not complete this project within the typical window of three years, so we were forced to file numerous extensions with the FCC explaining that the delays were out of our control. Every six months, we had to file a report on the progress of the project in order to keep the construction permits alive.

Once construction began, it took a little over two years to complete. We built this site around an operating radio station that needed to stay on the air while we took down two towers that were 353 feet tall and replaced them with five towers. The new towers were less than 200 feet tall, which was an advantage because they no longer would require FAA marking and lighting.

The tower site is a wetland area that is adjacent to the Charles River, and the water table runs about 3 feet below grade. In order to put conduit below the frost line we had to go below the water line, so we ended up using PVC conduits where all the joints had to be sealed.

Due to the wetland site, we used helical screws at the anchor points rather than conventional concrete anchors. The tower bases were of conventional concrete pier construction.

But the most difficult part was the environmental restrictions placed on the project. We had to interrupt construction several times during the breeding cycle of the blue spotted salamander, which is classified as an endangered species. There could be no open trenches on the site between Feb. 15 and May 15, and trenches could not be left open at night over the weekend. We had to leave a clearance of 4 inches at the bottom of our tower safety fences to permit animal movements.

All told, there were over 60 different conditions we had to meet to satisfy the local zoning, including the requirement that the stations hire an environmental consultant to work for the city and monitor the project for compliance.

During the project there were no stop work orders and no violations of the zoning requirements. At the end of the project we had to appear before the local conservation commission, and they actually commended us on doing careful construction.

I want to point out one other unique aspect to this project from an engineering standpoint: These were the first three stations to use Method of Moments modeling to license a directional array.

Were stations in the triplex going HD?

No. In a triplex with nine filters and their component stray reactances it can become very difficult to get all of this to work with HD so we decided not to pursue that at this time.

Do you have any other interesting projects in the pipeline right now?

We are just finishing up an eight-tower directional array in the St. Louis area. This one will also be licensed using Method of Moments.

Are there differences in a project when using Method of Moments?

What I am finding is that when using Method of Moments there are some tricks and techniques that you learn. It is necessary to build the towers first and then build the model after construction. The model needs to be calibrated due to the velocity of propagation of the tower system not being equal to 100 percent.

With an eight-tower array there is a lot of measurement work involved in calibrating the model too. You have to measure the base resistance and reactance of all the towers with each one grounded and the others floated and make up a matrix of all these measurements.

We used the Rackley network analyzer and directional coupler method to make the measurements faster. To keep from having to haul a network analyzer all over the tower site and provide power at each tower base, we used the sample lines to measure the tower impedances one at a time. By calibrating the network analyzer to compensate for the sample line we were able to do all the measurements from inside the transmitter building.

The model has to be compensated for differences in tower heights and tower variations, such as if the site terrain is not completely level. Note that towers toward the interior of the array will have different impedances from towers on the outside due to the mutual coupling between the towers.

Once you calibrate the model to actual conditions, you can figure out the operating parameters for the array. These calculations have to be iterated back and forth until it all converges into the correct values for the system components.

It has been an interesting and valuable experience.

On FM translators for AMs: Do you find this a helpful development?

We do have a few translators repeating AMs. I haven't been involved. The last time there was a translator filing window we licensed a bunch; at that time, AM on FM wasn't allowed. Since that is now the case, I can see translators becoming more valuable but I'm not aware of a company-wide effort in that direction. I would think a translator would be beneficial to an AM having a high NIF (nighttime interference-free contour) limit.

IBOC

(continued from page 1)

sultants, and research organizations from three other countries.

AICCS was led by project investigators John Kean, senior technologist for NPR Labs, and Dr. Ellyn Sheffield, Towson University assistant professor of psychology specializing in cognitive testing. The two project investigators developed and performed detailed listener tests under carefully selected field test conditions. The interference testing used a production automotive receiver to receive over-the-air signals from an interference test FM station and an associated first-adjacent station operating various levels of IBOC transmission power.

Tests were performed by broadcasting carefully selected audio samples over the Interference Test Station and recording the stereo FM reception of this station from the mobile receiver in a test vehicle, as the digital power levels of the IBOC test station were changed from –20 dBc to –14 dBc, and to –10 dBc (1 percent, 4 percent and 10 percent of analog FM transmission power). At three of the four interference field tests, analog-only transmission was added, thereby providing baseline data on analog-to-analog interference.

The audio quality was evaluated by a group of listeners who graded the reception quality of audio samples and decided whether they would continue to listen, based on the audible quality of the test material. The over-the-air recordings from the four test stations were played back through the standard sound system of a Nissan Altima being driven at speeds of 35 and 60 miles per hour. Audio material was evaluated with measured D/U ratios from 0 dB to 26 dB, all located within the 60 dBμ contours of the Interference Test Stations.

Evaluation of the listener ratings of speech and low-density music material recorded over-the-air from actual stations indicated a reduction of the mean opinion score from 4.0 ("good" on the 5-point MOS scale) for analog-to-analog interference to 2.7 (below "fair") at the *present* –20 dBc IBOC power. These ratings were determined at a D/U ratio of 6 dB, as provided (by the FCC in 47CFR73.215 and 47CFR73.509) for a first-adjacent analog station that is minimally (but legally) spaced to a hybrid FM station. For –10 dBc IBOC transmission at the same D/U ratio the listener rating of this material dropped to MOS 2.1 (close to a "poor" rating of 2.0).

INTRODUCTION

The main test goal is to understand consumers' reactions to analog radio broadcasts in a mobile environment when digital power is increased. This is significant since the IBOC subcarriers of an adjacent-channel hybrid FM station occupy the same RF spectrum used by a desired FM channel, as shown in Fig. 1. As a result, first-adjacent channel compatibility is one of the more significant considerations for an increase in transmission power for the FM-band IBOC system.

Although the undesired FM carrier does not overlap the desired channel, practical receivers are limited in their discrimination against adjacent-channel analog interference. Thus, the FCC established a minimum 6 dB desired-to-undesired (D/U) ratio to avoid harmful interference at the service contour of the protected station, as shown in the vertical offset in the FM carriers in Fig. 1. These protection standards are codified in 47CFR73.207 of the commission's rules for non-reserved channels and in 47CFR73.509 for reserved (non-commercial educational) channels. The addition of IBOC transmission to a first-adjacent station changes the amount of interfering energy intercepted by the desired channel receiver. The technical question, then, is: At what D/U ratio does a first-adjacent hybrid FM signal produce harmful interference to reception?

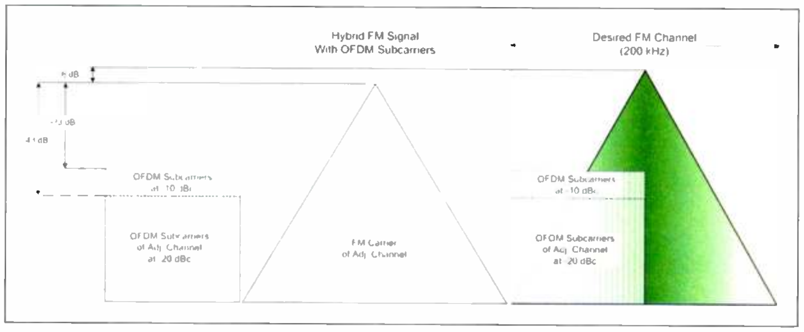


Fig. 1: Simplified drawing of frequency relationships between Desired FM Channel (right) and IBOC OFDM subcarriers of adjacent-channel station, which are transmitted in two frequency bands that extend (for mode P3: Primary Main and two Extended Partitions) from 114 kHz to 198 kHz above and below the host FM channel center frequency. (The relationship is mirrored for an upper-adjacent hybrid station). IBOC subcarrier levels are shown in a 1 kHz power bandwidth.

Fig. 3: Calibrated vertical ground plane antenna on the vehicle used for Rhode Island testing

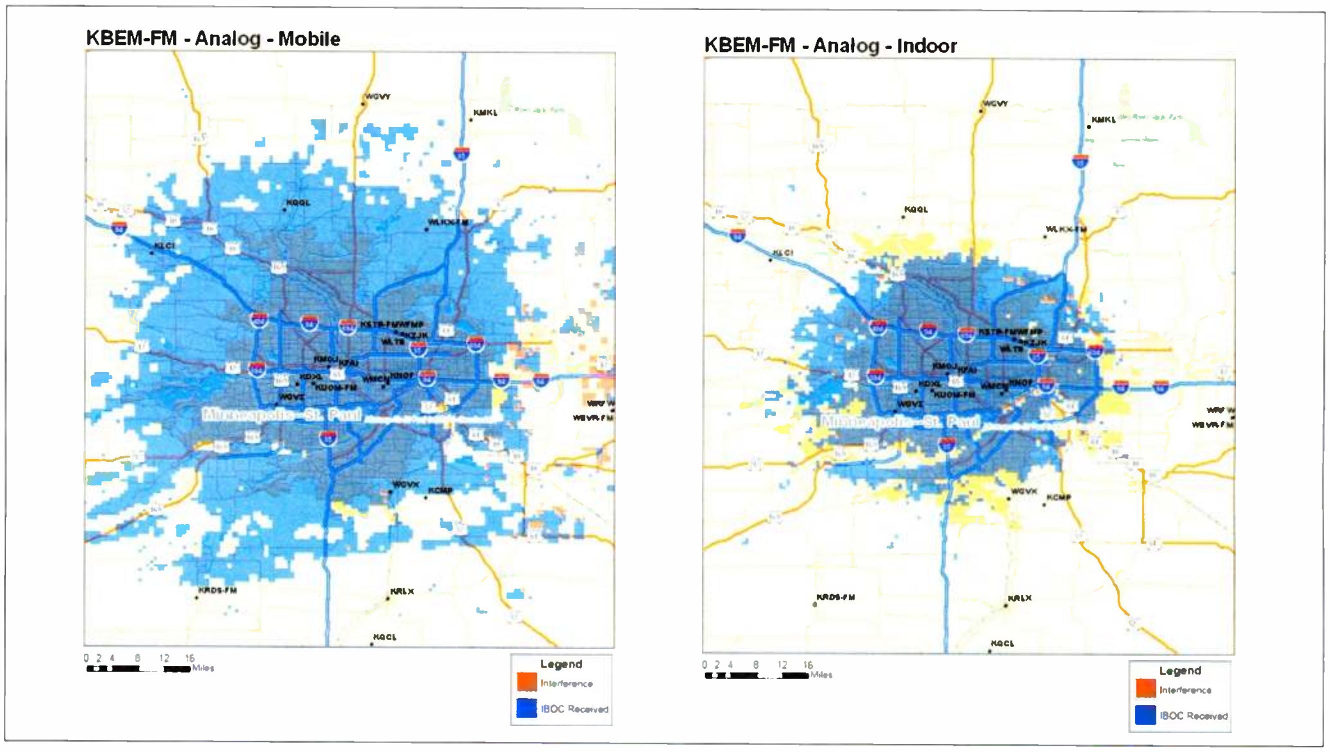


Fig. 2: Maps illustrating the difference between analog mobile coverage (left) and analog indoor coverage (right) for stereo FM reception.

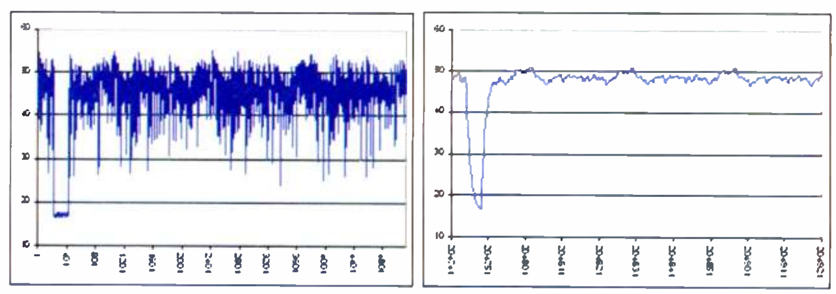


Fig. 4: Example of mobile field strength data captured without Rayleigh filtering (left) and with real-time Rayleigh filter (right)

BASIS FOR A POWER INCREASE STUDY

The need to increase IBOC transmission power is prompted by reports of inadequate coverage, particularly for indoor service. The coverage area of mobile FM service is substantially larger than the area of indoor service, due to an absence of building penetration loss and the typically higher efficiency of antennas on vehicles, compared to average indoor antennas. The size of predicted mobile coverage, relative to indoor coverage, for a sample station is illustrated in Fig. 2 for

(continued on page 12)

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- I/O Delay Measurement
- Sync to AES3, DARS, word clock & video black burst
- User-generated test signal files

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Analog Audio Generator + Impedance/Phantom/Cable measurements

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- Impedance measurement of the connected device
- Phantom power voltage measurement
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- Protective shock jacket

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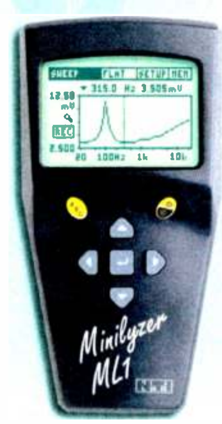
Analog Audio Analyzer



The ML1 Minilyzer is a full function high performance audio analyzer and signal monitor that fits in the palm of your hand.
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MiniLINK

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- VU + PPM meter/monitor
- 1/3 octave analyzer
- Requires optional MiniSPL microphone for SPL & acoustic RTA measurements
- Frequency/time sweeps
- Scope mode
- Measure signal balance error
- Selectable units for level measurements

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IBOC

(continued from page 10)

KBEM(FM), Minneapolis. The outer region of an FM station's coverage presents opportunities where the distance to a first-adjacent channel station may be reduced, thereby increasing the ratio of potentially-interfering IBOC sidebands to the desired signal. Mobile service has also become the leading mode of reception by radio listeners in North America. Consequently, mobile service was chosen for interference testing.

Subjective tests by both NPR Labs and iBiquity have been conducted in acoustically-treated laboratory environments with samples created on laboratory test beds or with fixed field reception. By testing exclusively in a laboratory environment (i.e., either on headphones or in an acoustically treated studio with professional field monitors) we believe that it may not accurately predict consumer behavior in *mobile situations*, for two important reasons.

First, testing participants in a laboratory environment does not replicate the way consumers listen to audio in a vehicle. Issues include the consumer's physical position between the speakers and diverted concentration due to other visual stimulus. Perhaps most important, listeners experience environmental "road" noise (e.g., tire noise, outside environment, air conditioner and/or heating fans, whining engine) in the mobile environment that affects their perceptions of audio quality.

Second, there are special acoustic properties of multipath interference impairments that we have heretofore not considered in subjective testing. In developing the test methodology, it was believed that consumers may rate signals with undesired multipath impairment in a different way than they rate signals with steady-state noise, as is found in stationary environments. Testing consumers in automobiles is the only practical way to account for the acoustical environment of automobiles and multipath impairments, critical variables that may dramatically alter our understanding of acceptable audio quality for the majority of listeners.

NPR proposed that a Working Group be established to discuss methodology, guide the test procedures and review test data. The Working Group comprised the representatives in Table 1.

A member of the Working Group, Greater Media, had an FM station serving Boston, WKLB(FM), that had an FCC Experimental Authorization for high-power IBOC transmission, and that WKLB had a first-adjacent channel neighbor, WRNI(FM), in Rhode Island, that was an NPR member station. This ready-made opportunity became the first station pair to be tested. In June, NPR added a second pair of stations to the pilot test with Minnesota Public Radio, which was scheduled to support a high-power IBOC test for indoor coverage measurements. This led to the choice of KBPN(FM), Brainerd, and KCRB(FM), Bemidji, as the interference test and IBOC test stations.

Two more station pairs were added. The reports on the test station selections and the listener test results are contained in the following sections.

FIELD TEST PROCEDURES

Drive-Test Route Selection and Recording

All of the test routes were located within the F(50,50) 60 dBμ service contour of the analog interference test stations. The routes were selected for uniform speed at or near the limit posted for the roadway, with no stops required during the 80 seconds required to record the audio stream to be broadcast by the interference test stations. The field strength of both the interference test station and the potentially-interfering IBOC station were

(continued on page 14)

Affiliation	Participant	Title
CBS Radio Inc.	Glynn Walden	SVP Engineering
The Corporation for Public Broadcasting	Doug Vernier	CPB Consultant
Clear Channel Communications	Jeff Littlejohn	Executive VP - Distribution Development
Consumer Electronics Association	Dave Wilson	Senior Director, Technology & Standards
Greater Media Inc.	Milford Smith	Vice President, Engineering
Harris Broadcast Communications	Geoff Mendenhall	VP, Transmission Research & Development
NPR Labs - National Public Radio	John Kean Ellyn Sheffield	Co-Project Investigator Co-Project Investigator

Table 1: AICC5 Working Group Participants

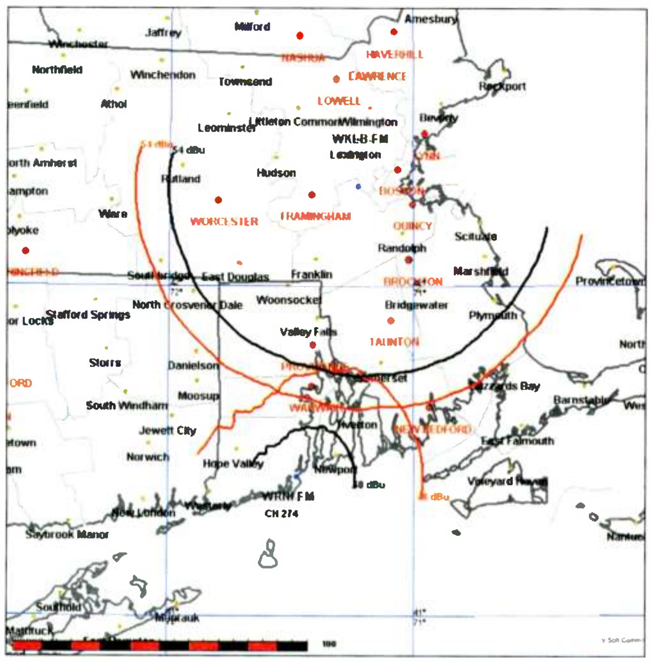

Fig. 5: Map for interference test station WRNI (below), and IBOC test station WKLB (above) showing the 60 dBμ and 54 dBμ service contours (black), and the 54 dBμ and 48 dBμ interference contours (red), respectively, of WRNI and WKLB.

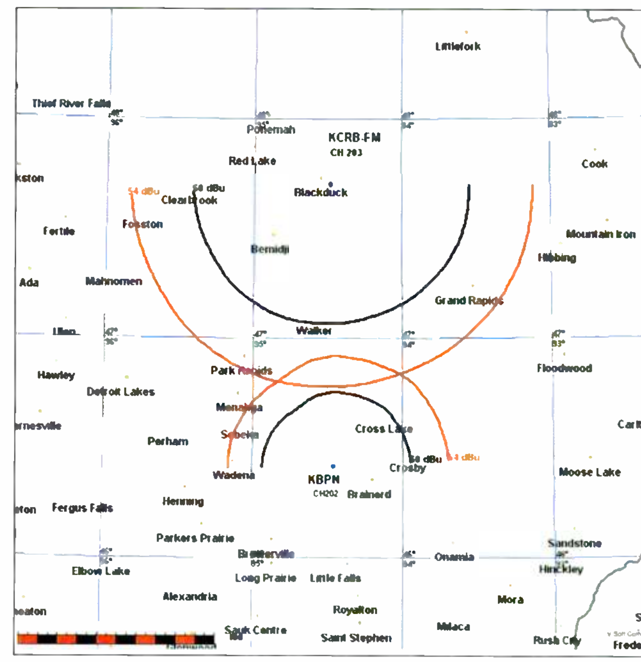

Fig. 6: FM contour map for interference test station KBPN (below) and IBOC test station KCRB (above)

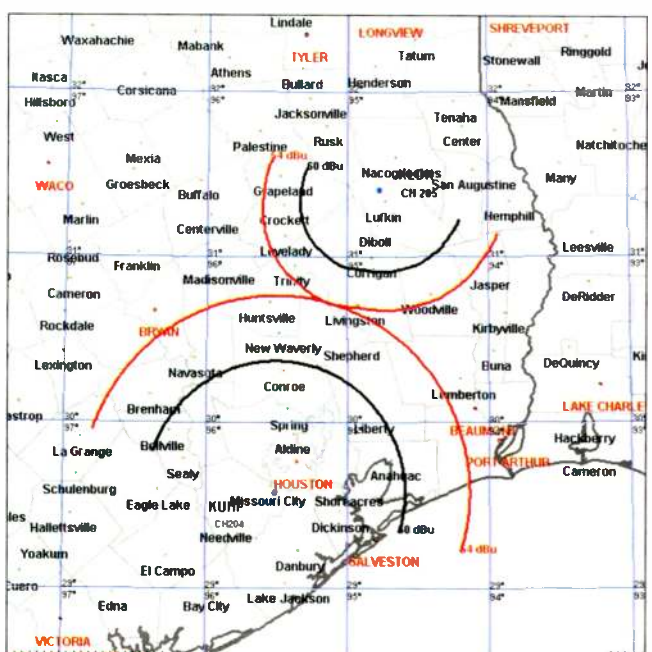

Fig. 7: FM contours of interference test station KLDN (above) and IBOC test station KUHF (below)

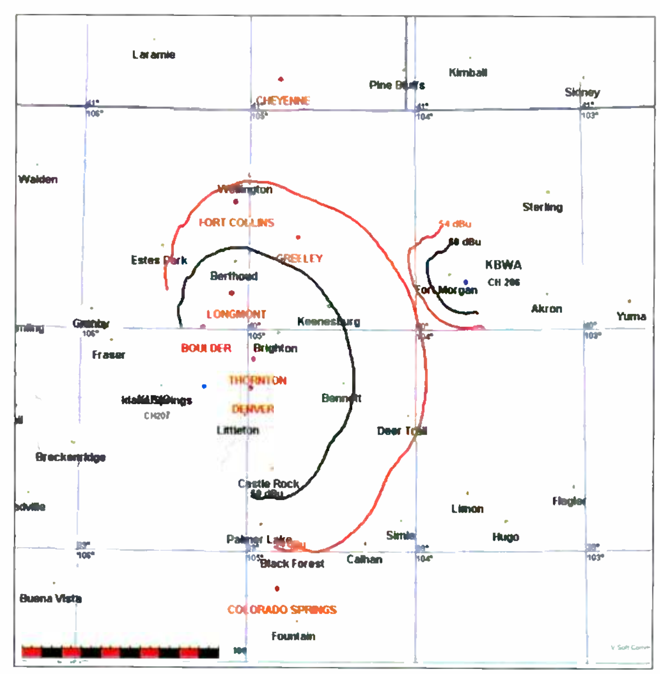

Fig. 8: Contours of interference test station KBWA (above) and IBOC test station KUVO (below)

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" When we started, we were jumping into something we knew nothing about! We called your tech support & within a day they had a solution. It was miraculous. They helped us get wired up & set up. (Tech Support) had a positive & upbeat attitude. They went above & beyond!"
David Trudrung, General Manager & Co-owner

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Scott Gray

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IBOC

(continued from page 12)

Interference Test Station and FCC Class			High-Power IBOC Test Station and FCC Class (1st-adjacent to Interference Test Station)			Number of Interference Test Locations	Average Distance to Interference Test Locations (km)
WRNI-FM	A	Narragansett, RI	WKLB-FM	B	Waltham, MA	3	85
KBPN	C3	Brainerd, MN	KCRB-FM	C1	Bemidji, MN	4	108
KLDN	C1	Lufkin, TX	KUHF	C	Houston, TX	2	167
KBWA	A	Brush, CO	KUVO	C1	Denver, CO	2	133

Table 2: Stations Used in the Over-the-Air Testing of IBOC Interference

measured with NPR Labs' calibrated ground plane antenna, shown in Fig. 3, to provide a continuous indication of local D/U during each audio stream. All of the locations used for test recordings were representative of D/U ratios found inside the 60 dBμ service contour of the interference test station; there was no "cherry picking" of unusually low D/U ratios that may cause greater IBOC interference.

Field strength measurements as well as audio reception test recordings used NPR Labs' custom vertical ground plane antenna. This antenna system provides a calibrated gain (approximating an ideal vertical dipole) to provide accurate measurements of field strength at 1-1/2 to 2 meters above ground. Its nearly omnidirectional radiation pattern helps to provide uniform reception from the desired and undesired signals, regardless of angle of arrival. This second factor is important to ensure that the amplitude of signals arriving from the interference test station and the elevated-power IBOC station are not affected by antenna pattern distortions caused by the vehicle body, which is common to "mag-mount" antenna systems.

NPR Labs has considerable experience in using the calibrated vertical ground plane antenna with its portable field test units. The field test unit (FTU) is equipped with specially designed circuitry to remove Rayleigh fading from mobile signal measurements and provide an accurate "local mean" of the field strength. Fig. 4 illustrates the field strength of KBPN, the Minnesota interference test station, recorded along one of the test routes as it is collected directly by the receiver, before and after the custom Rayleigh filter. This technique is not available from any other known instrumentation.

When in motion, the antenna was switched to the analog FM receiver, which was tuned to the interference test station ("victim"). The audio output of the receiver was recorded digitally in 16-bit PCM to a WAV file as the test station broadcasts a pre-recorded audio prepared by NPR Labs. This audio consists of series of audio samples of 15–20 seconds duration.

Due to log-normal fading effects, the strengths of the interference test station and IBOC test station varied along a test route, causing the ratio of these stations to change continuously. To properly classify the samples, the median D/U ratio was analyzed for each audio sample interval and the samples were "binned" in common D/U ranges. A large number of recordings were required to ensure that most bins contained several samples for use in listener testing. The test route recordings were performed with different levels of IBOC transmission power to enable evaluation of the audio samples by D/U ratio and various IBOC transmission powers.

These sample recordings were combined with the field strength recordings and compiled for listener testing.

Selection of Test Stations

As much as possible, the station pairs were chosen to represent a variety of FCC facility classes and terrain types. However, at the time of the study the number of stations with high-power IBOC transmission capability was limited. Two of the Interference test stations were Class A, one was Class C3 and one was Class C1, as shown in Table 2. Three of the four station pairs were selected from available FM stations with high-power IBOC transmission capability. The IBOC test station of the station pair in Minnesota was temporarily upgraded from –20 dBc operation to –10 dBc operation for this study. Details on the criteria and choice of stations are provided in the following sections.

WRNI(FM), Narragansett Pier, R.I.

WRNI is a non-directional Class A facility operating on non-reserved band Channel 274 with 1.95 kW at 69 m above average terrain. The station operates in hybrid IBOC mode through the main FM antenna, but operated in analog for the tests. WKLB(FM), Channel 273B is located 100.34 km at 12° True from WRNI, and received an Experimental Authority from the FCC on Dec. 12, 2008, to operate with IBOC DAB emissions up to –10 dBc. The IBOC upgrade was completed and WKLB has experimentally operated with high-power IBOC since January. Both stations are non-directional.

A map showing the contour relationships of WRNI and WKLB is provided in Fig. 5. The red F(50,10) 54 dBμ interference contour of WKLB does not touch the 60 dBμ service contour of WRNI, in fact leaving a gap of approximately 8.8 km. It is apparent that the 48 dBμ interference contour of WRNI overlaps the 54 dBμ service contour of WKLB by approximately 4 km, although this is not relevant to the test scenario. (A reserved band Class B station service contour is 60 dBμ, which would provide more than the minimum separation between these stations.)

KBPN, Brainerd, Minn.

Minnesota Public Radio operates 37 FM stations in and around the state of Minnesota and offered two of its stations for testing. At the time of the study, however, none of the stations were equipped to transmit high-power IBOC. It was necessary to identify one station for this study as the high-power test station with a neighboring first-adjacent station as a suitable interference test station. NPR Labs evaluated all 37 stations as high-power IBOC candidates for the study, as well as several non-MPR NCE FM stations and selected KBPN, Channel 202C3, Brainerd, and KCRB, Channel 203C1, Bemidji, shown in Fig. 6. To operate KCRB with IBOC sideband powers of up to –10 dBc, in addition to an FM carrier output of 13.2 kW, Harris Corp. supplied a model HPX40 single-tube FM transmitter.

KLDN, Lufkin, Texas

Fig. 7 shows the F(50,50) 60 dBμ contour of KLDN(FM), Channel 205C1, Lufkin, the interference test station, and the F(50,10) 54 dBμ contour of KUHF(FM), Channel 204C, Houston, which added a separate IBOC transmitting antenna to achieve –10 dBc emission. KUHF is 215 kilometers southwest of KLDN. The pertinent contours of these stations are separated more than 25 kilometers, which provided an opportunity to test IBOC interference at higher D/U ratios.

KBWA, Brush, Colo.

During the study it was learned that KUVO(FM), Channel 207C1, Denver, was installing a new transmitter, allowing IBOC transmission of up to –10 dBc. A search for first-adjacent neighbors of KUVO was conducted and KBWA(FM), Channel 206A, Brush, Colo., was selected as the interference test station, upon approval by station licensee Way-FM

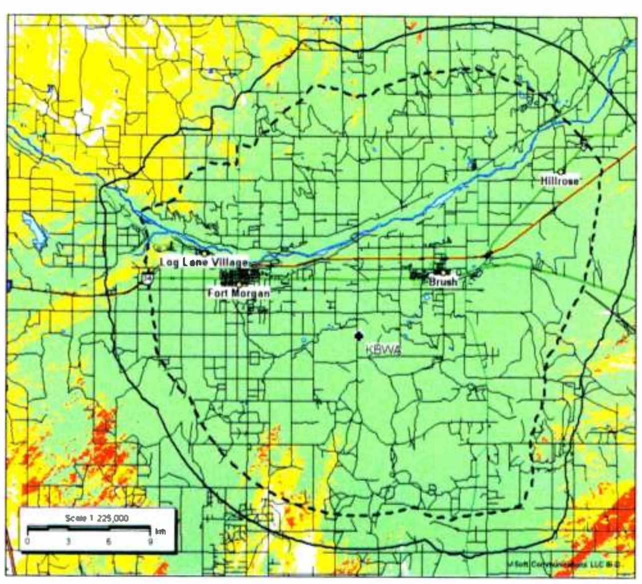

Fig. 9: TIREM interference to KBWA (full power) from KUVO in yellow, and co-channel KTLC in red. The 60 dBμ contour of KBWA is the solid line, with the half power contour as the dashed line

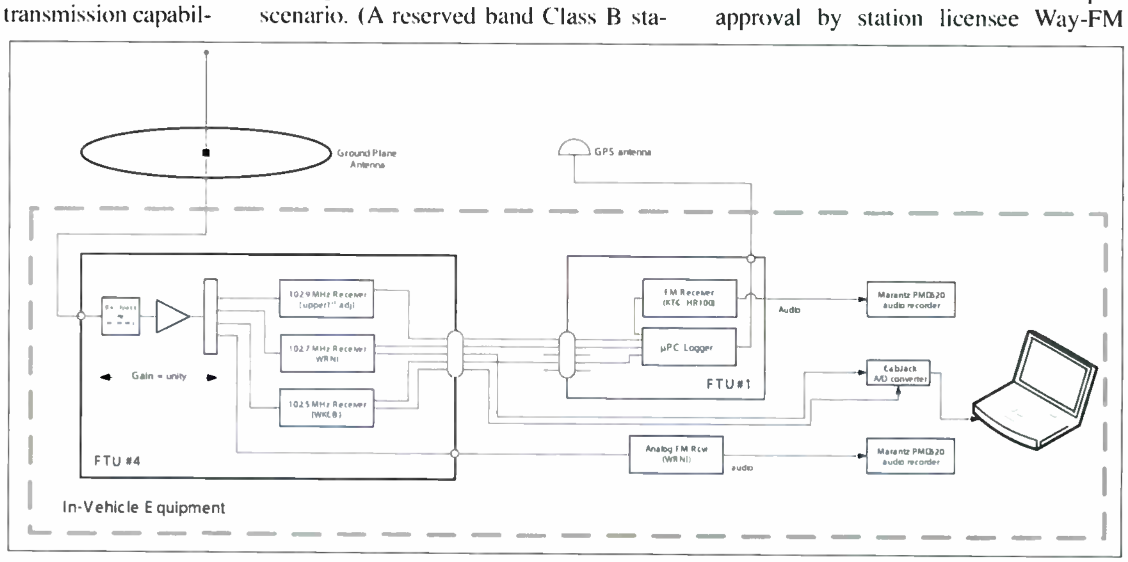

Fig. 10: In-vehicle instrumentation used to record field strengths and test audio

Media Group, Inc. Fig. 8 shows the F(50,50) 60 dBμ contour of KBWA and the F(50,10) 54 dBμ contour of KUVO. The station separation distance is 143 kilometers, which provided the opportunity to test impairment at a large distance and with higher D/U ratios.

The signal ratio of KBWA and KUVO is shown in the map of Fig. 9. This TIREM point-to-point prediction shows areas that are predicted to receive interference at 20 dB D/U (−10 dBc) in yellow. Co-channel interference from KTLC, Class C1, Canon City, Colo., at 34 dB D/U is shown in red. Areas in the D/U map that were expected to receive minimum field strength of 40 dBμ (at vehicle height) are shown in green, representing the approximate limit of mobile stereo reception.

Field Measurements

A diagram of the vehicle measurement and recording system is shown in Fig. 10. This shows, on the left, the calibrated ground plane antenna and FTU #4, which contains: a custom bandpass filter for 88–108 MHz, a low-noise high dynamic range preamplifier, a four-output signal splitter and three Kenwood KTC-HR100 "black box" mobile tuners. The Kenwood tuners were modified to provide a DC voltage output that is a logarithmic representation of its RF input power. The tuners also have new ceramic IF filters to provide a discrimination of approximately 30 dB against adjacent-channel FM signals, to support the meas-

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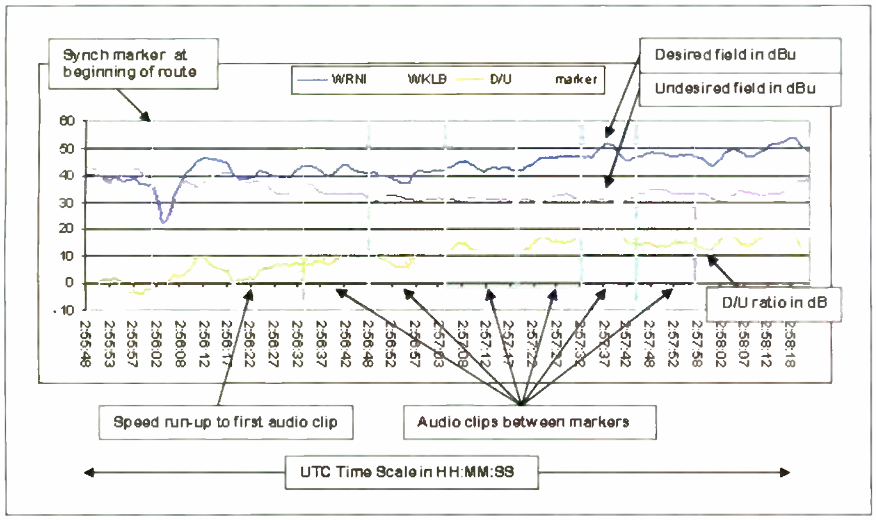


Fig. 11: Sample of field strength time profile for one of 164 routes in the study, showing key elements of a mobile run. Overall duration is approximately 2-1/2 minutes

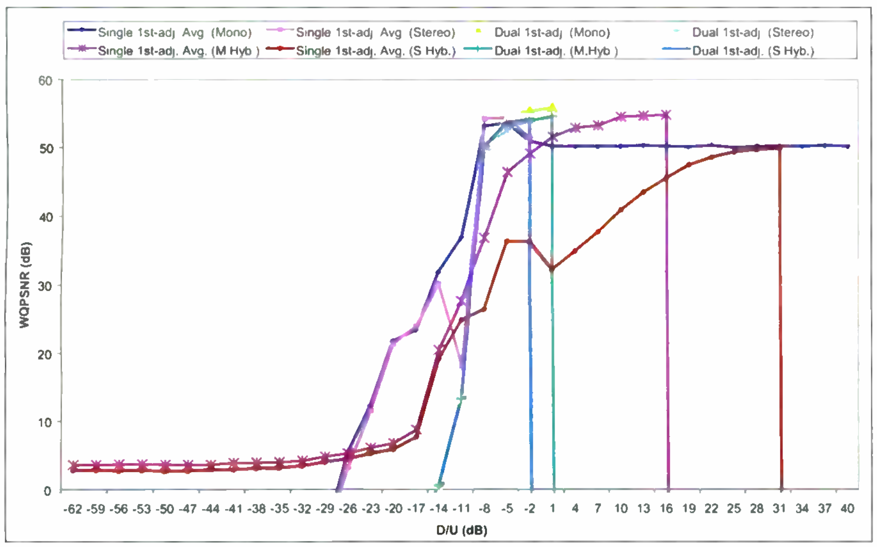


Fig. 12: Chevrolet Suburban selectivity at −70 dBm with analog and IBOC first-adjacent signals

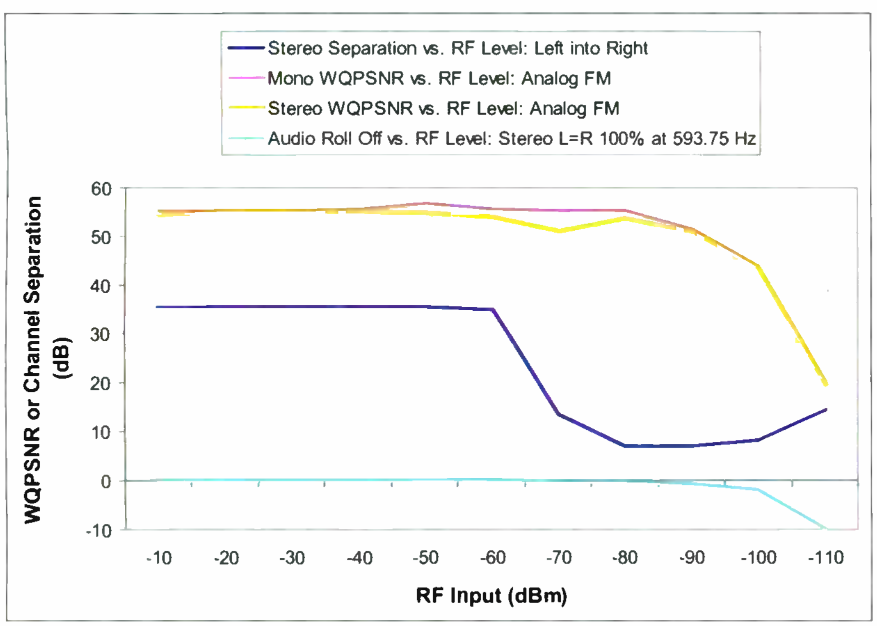


Fig. 13: Audio SNR, stereo separation and audio level vs. RF input level

IBOC

(continued from page 15)

urement campaign for this study. The DC lines carrying the three field strength measurements were cross-connected to FTU #1, which houses the micro-computer data logger and GPS antenna input. One RF output of FTU #1 is connected to the mobile FM receiver, which is connected to a Marantz PMD620 Professional Handheld Recorder, which stores 16-bit, 44.1 kHz WAV files of the FM stereo mobile audio.

The three tuners in FTU #1 were tuned to the desired channel frequency, the adjacent-channel IBOC test station frequency and the alternate adjacent channel frequency. The alternate adjacent channel frequency is logged as a check for environmental RF noise and interference that might reduce the accuracy of measurements on the other two channels. The data logger in FTU #1 records at a rate of 4 Hz on up to six A/D channels and four digital input channels.

The laptop PC is connected to a LabJack U12, providing eight 12-bit analog inputs for high speed sampling of the unfiltered DC signal strength lines from the three tuners in FTU #4. The LabJack PC software is operated in the streaming mode at a minimum rate of 50 samples per second. The software logs the voltages received by the A/D converters and a time since the start of the file with a resolution of 0.01 seconds.

Logging of Signal Ratios on Routes

Each drive-test measurement (as many as 16 passes for a single route) was recorded and the field strength data was processed for classification of the audio material. The charts provide a wealth of information about the RF signals along the drive test routes. Fig. 11 points out some key features. On the left, the vertical scale displays the lognormal field strength in dBμ (relative to 1 μV/m), while the horizontal scale displays the time in hours, minutes and seconds, recorded from the on-board GPS receiver. Time runs from left to right on these charts.

Three graph lines are displayed: the field strength of the Desired (interference test) station, the Undesired (IBOC test station) and the instantaneous D/U ratio of the two. The simultaneous recordings of the audio and RF levels were synchronized with a sharp drop in the signal levels near the left, after which the vehicle starts and gains speed, which is held as constant as possible over the remainder of the route. The first of a sequence of audio clips were broadcast by the interference test station as the vehicle passes a road marker. The audio clips, lasting 10–15 seconds, are marked on the chart to determine each clip's mean D/U ratio. Clips with D/U ratios that were unusually high or low, relative to the 6 dB target D/U ratio, were excluded from listener tests. This technique allows us to "bin" the clips by D/U ratio, ensuring that the reception conditions heard by listeners are known and the data can be analyzed more consistently.

Mobile Test Receiver Performance

The receiver used to provide audio recordings for the listener testing was selected carefully from a group of

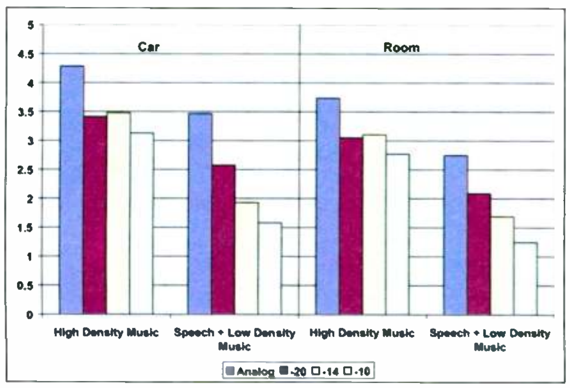


Fig. 14: Difference between car and room listening at 60 mph

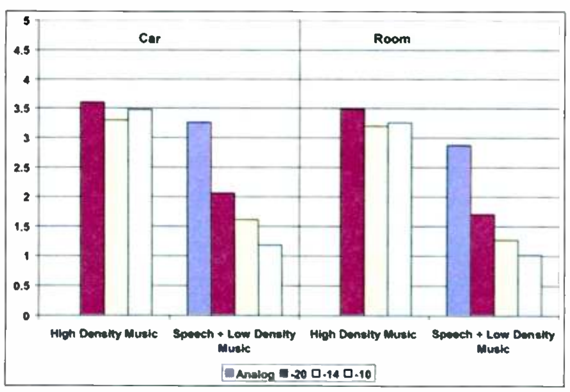


Fig. 15: Difference between car and room listening at 35 mph

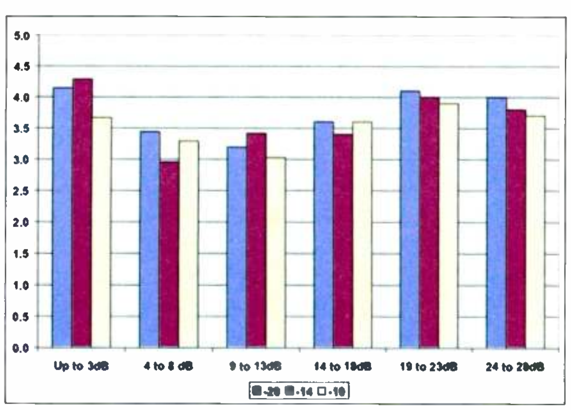


Fig. 16: High-Density Music at –20, –14 and –10 dBc

D/U (dB)	Genre	Location Recorded	IBOC Levels	Number of cuts (IBOC x Genre)
	Test 1 - 60 mph			
< 3	Speech - Female and Male	Minnesota	-20,-14,-10, analog only	8
	Music - high and low density	Minnesota	-20,-14,-10, analog only	8
4 to 8	Speech - Female and Male	Rhode Island	-10,-14,-10	6
	Music - high and low density	Rhode Island	-10,-14,-10	6
9 to 13	Speech - Female	Minnesota	-20,-14,-10, analog only	4
	Speech - Male	Rhode Island	-20, -14, -10	3
	Music - high and low density	Rhode Island	-20, -14, -10	6
CD Source				12
	Test 1 - 35 mph			
Under 3	Speech - Female and Male	Minnesota	-20,-14,-10, analog only	8
4 to 8	Speech - Female	Minnesota	-20,-14,-10, analog only	4
	Speech - Male	Rhode Island	-20, -14, -10	3
	Music - high density	Rhode Island	-20, -14, -10	3
	Music - low density	Minnesota	-20, -14, -10, analog	4
9 to 13	Speech - Female and Male	Rhode Island	-20, -14, -10	6
	Music - High Density	Rhode Island	-20, -14, -10	3
CD Source				9
Test 1 Total				**93**
	Test 2 - 60 mph			
14 to 18	Speech - Female	Rhode Island	-20,-14,-10	3
	Speech - Male	Colorado	-10,-14,-10,analog only	4
	Music - high density	Rhode Island	-20,-14,-10	3
	Music - low density	Rhode Island	-20,-14,-10,analog only	4
19 to 23	Speech - Female and Male	Texas	-10,-14,-10,analog only	8
	Music - high and low density	Texas	-10,-14,-10,analog only	8
24 to 28	Speech - Female and Male	Texas	-20,- 14,-10,analog only	8
	Music - high and low density	Texas	-20,- 14,-10,analog only	8
CD Source				6
	Test 2 - 35 mph			
14 to 18	Speech - Female	Rhode Island	-20,-14,-10	3
	Speech - Male	Colorado	-10,-14,-10,analog only	4
	Music - high density	Rhode Island	-20,-14,-10	3
	Music - low density	Rhode Island	-20,-14,-10,analog only	4
19 to 23	Speech - Female and Male	Texas	-10,-14,-10,analog only	8
	Music - high and low density	Texas	-10,-14,-10,analog only	8
24 to 28	Speech - Female and Male	Texas	-20,- 14,-10,analog only	8
	Music - high and low density	Texas	-20,- 14,-10,analog only	8
CD Source				6
Test 2 Total				**104**

Table 3: Samples used in Mobile Tests 1 and 2

more than a dozen automotive receivers. The group, which includes both OEM and aftermarket models, was tested extensively for performance as part of the DRCIA project. The chosen receiver, a 2003 Chevrolet Suburban, exhibited better-than-average sensitivity and selectivity. The Suburban receiver's selectivity tests are shown in Fig. 12 for a received signal power of –70 dBm, which is close to the signal levels encountered in the field recordings. This chart shows the weighted quasi-peak audio SNR as the ratio of desired-to-interfering signals range from –62 dB to +40 dB.

Irregularities in the slopes of the curves are due to the stereo blending action of the receiver. This a common technique in mobile receivers to reduce audible noise under interference and fading conditions that occur as the vehicle moves along a roadway. This is an important performance characteristic for a mobile test receiver that was considered in this study. Fig. 13 shows that the chosen receiver exhibits a stereo SNR that nearly equals the monophonic SNR until the failure point of reception, below –90 dBm. This is due to stereo separation curve (blue line), which begins blending at a signal power below –60 dBm. This high stereo SNR performance reduced the effects of IBOC interference in the listener testing.

SUBJECTIVE TEST METHODOLOGY FOR MOBILE LISTENER TESTS

Audio Sample Selection

Audio was selected from the field samples that were collected in Minnesota, Rhode Island, Colorado and Texas. The RF D/U ratios of all individual audio samples were determined, and the audio cuts that were used in the testing are listed in Table 3. For Test 1, there were a total of 93 different samples that were presented across all of the genres. For Test 2, there were a total of 102 different audio samples presented across all of the genres.

The samples were screened to avoid anomalies, including unusual atmospheric signal propagation conditions that cause deviations in signal strength from the distant IBOC transmission station, terrain shadowing effects that cause excessive swings in signal strength during the time of individual audio samples (determined by the standard deviation of the field strength), audible interference from other stations (co-channel or first-adjacent channel) that may affect the accuracy of listener assessments, sporadic noises that were not part of the signal tests (ignition noise, power-line noise, etc.). After all of the anomalous samples were eliminated, we randomly chose samples from lists. Sample triads were selected carefully so that direct comparisons between –20 dBc, –14 dBc and –10 dBc samples could be made.

Participants

Participants were recruited through a notice placed in an electronic newsletter disseminated among Towson University staff, faculty and students. Data from 24 men and women between the ages of 18 and 65 were collected towards the completion of this study. Participants were compensated $150 for the first session and $75 for the second session.

Test Procedure Overview — Studio and Mobile Testing

Participants rated audio samples in a studio and a car setting. The order of these settings was counterbalanced among participants, thus half of the participants listened to the samples first in the auto and half listened first in the studio. All participants arrived at the predetermined parking lot on the campus of Towson University. They were then escorted to the test automobile or the studio where they were given a simple introduction and overview of the testing procedures. They were asked to read and sign an informed consent form. Once this had been completed, the experimenter script was read to the participants. The experimenter script explained the instructions for the testing procedure. Testing was conducted one participant at a time. Table 3 shows audio sample types for each testing round.

Car vs. Studio

Fig. 14 and Fig. 15 show the difference in participants' ratings when listening in the car and the studio. Notice that at 60 mph listeners rate samples better overall when listening in the car, presumably due to masking road and cabin noises, while at 35 mph this effect dwindles significantly.

Differences between –20, –14 and –10 dBc

Different patterns emerged for High Density Music and Speech and Low Density Music. Fig. 16 shows participants' ratings of High Density Music. Notice that there is no significant difference between IBOC levels, with the exception of –10 being lower in the category "Up to 3 dB." However, as Fig. 15 and Fig. 16 show, participants were more likely to discern differences in speech and low density music, particularly in the 0 to 9 dB range. Thus, we show participants' ratings of Speech and Low Density Music in two ways. Fig. 16 shows ratings from 0 to 28 dB as originally grouped.

Notice that from 0–3 dB the ratings are higher than 4 to 8 dB. Although at first counterintuitive, we believe this phenomenon occurred because the receiver was blended to monophonic at low desired signal strength. As the desired signal strength rose, the receiver went into stereo, allowing participants to hear more interfering noise.

We wanted to explore more carefully the region between 6 dB and 28 dB, which are typical D/U ratios found within the protected contour. We took each triad, plotted the mean opinion scores for each sample within the triad, and drew a regression line to highlight trends for the three IBOC levels. These results are plotted in the last chart of Fig. 17.

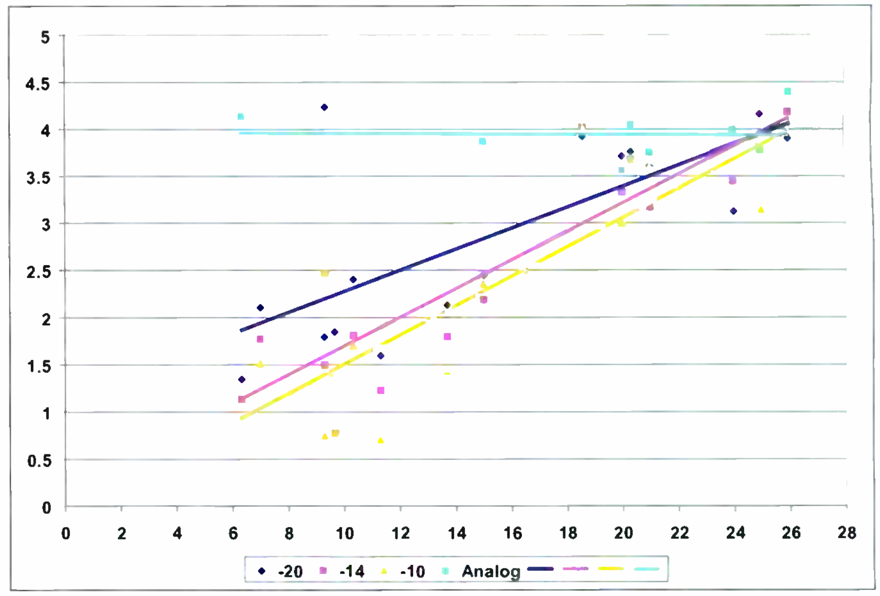


Fig. 17: Listener data points for speech and low-density music, plotted by MOS score vs. D/U ratio. Regression lines for results at –20 dBc (blue), –14 dBc (magenta) and –10 dBc (yellow) IBOC powers

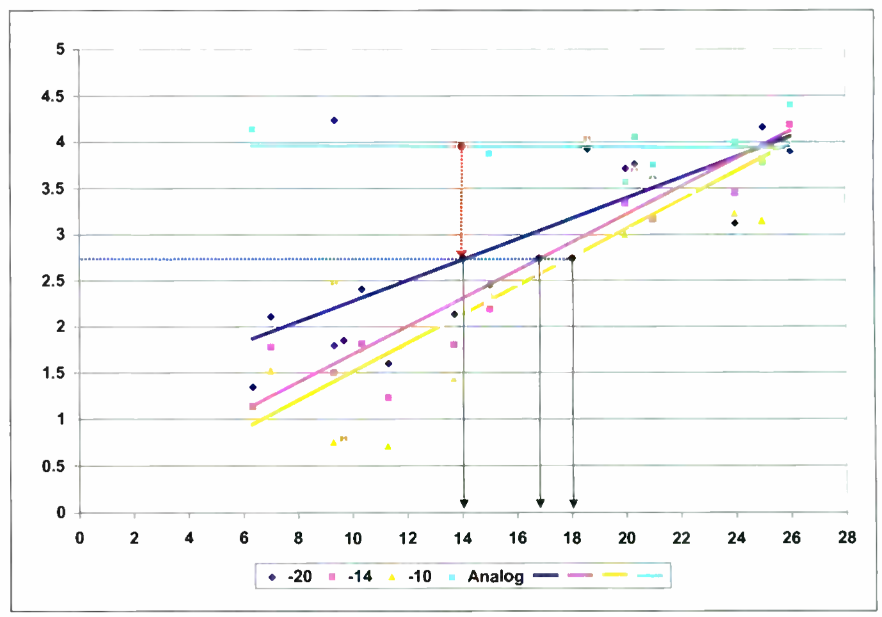


Fig. 18: Regression of listener data converted to D/U ratios

INTERFERENCE PROTECTION METHODOLOGY

Once the listener data was plotted on a D/U scale and reduced by regression analysis, it was possible to produce RF protection ratios that may be used in allocations policy. Fig. 18 is a reproduction of the listener data from the previous section of this report, to which several lines have been added to illustrate the methodology. The horizontal blue dashed line at a mean opinion score of 2.7 is added to represent the onset of harmful interference. As justification, this value is approximately 1.5 units below the regression line for analog-to-analog FM interference in the testing, at a MOS of 4 ("good"), as shown by the red arrow line. The 2.7 score is below a MOS of 3 ("fair") and only one-half unit above the MOS recognized from listener data as a major turn-off point (at which approximately 80 percent of listeners would decide to stop listening). At MOS 2.7 a substantial percentage of listeners would be expected to turn off, as well.

At the point where the –20 dBc regression line (dark blue) intersects the 2.7 MOS line, a black arrow line is dropped to the D/U scale, at a value of 14 dB. This establishes the field strength ratios (desired FM to hybrid IBOC) for the onset of harmful interference. Similarly, the arrow lines are dropped from the intersection of the –14 dBc (magenta) and –10 dBc (yellow) regression lines. These touch the D/U scale at ratios of 16.8 dB and 18 dB.

(continued on page 18)

IBOC

(continued from page 17)

The field strength ratios collected for each mobile run are based on the median field strengths. To apply these ratios to the FCC's methodology, which consider median time availability for the desired signal, using the F(50,50) curves, and the 10th percent time availability for the interfering signal, using the F(50,10) curves, conversion of the measured D/U ratios is required. The procedure for this conversion is detailed in the FCC's Report No. R-6602. This report includes a graph, as Fig. 19, which indicates the "fading ratio" adjustment values as a function of distance and transmitter height.

In this case, the distance is from the IBOC proponent transmitter to the potentially affected listener, near the protected service contour of the FM station. Although distances vary for every station and every listener, a study of probable distances from IBOC transmitters to first-adjacent service areas indicates a fading ratio adjustment of 8 dB is appropriate. This would accommodate separations of up to 110 kilometers (68 miles) and antenna heights up to 1500 meters (5000 feet) above average terrain.

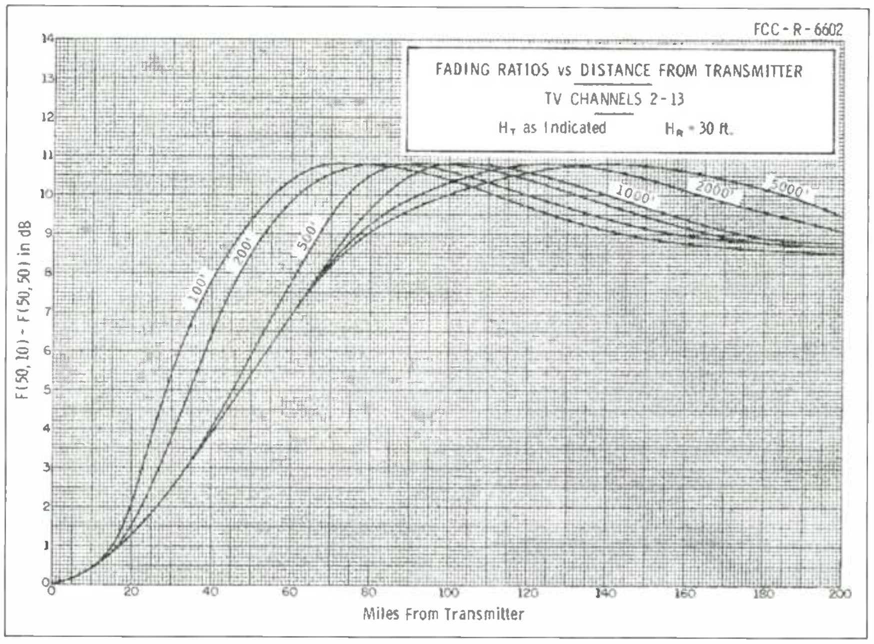


Fig. 19: Fig. 10 from FCC R-6602, showing the adjustment between the median and the field strength exceed 10% of the time.

Using this adjustment, the F(50,50) – F(50,10) ratio becomes 6 dB (14 – 8) for –20 dBc IBOC, and 8.9 dB and 10 dB for –14 dBc and –10 dBc IBOC, respectively.

The above ratios are added to the graph of Fig. 20 as blue dots. A best-fit slope to the listener data is added as the blue line.

worsen as the D/U ratios decrease, until a median ratio of 6 dB is reached; between 6 dB and 0 dB, the ratings flattened (no further degradation was indicated). This effect was due to the stereo blend system in the test radio, which is common to mobile FM receivers, and should occur well outside the 60 dBμ contour of station pairs with standard first-adjacent contour protection. However, so-called "super-powered" Class B FM stations (which may be defined as stations with contour distances exceeding the reference power-and-height of a Class B by more than 10 percent), can produce low D/U ratios within the 60 dBμ contour of a first-adjacent FM neighbor.

SUMMARY

Our results indicate that increased IBOC digital power has the potential to cause interference to the analog reception of first-adjacent stations with low desired-to-undesired signal ratios at their protected 60 dBμ contour, relative to the field strength of the IBOC station. The study found that digital interference to analog FM reception would cause listener tune-outs if D/U ratios are between 6 and 10.4 dB, depending on the specific IBOC injection level. However, the study found that many stations may upgrade IBOC power with minimal problem if the prescribed ratios are met. Also, techniques such as asymmetrical digital sideband transmission, separate digital transmitting antenna pattern, and digital repeaters may be used to expand IBOC coverage without increasing digital interference to neighbors. Therefore, the study recommends that digital power increases should be considered in connection with the allowable D/U ratios to avoid harmful interference.

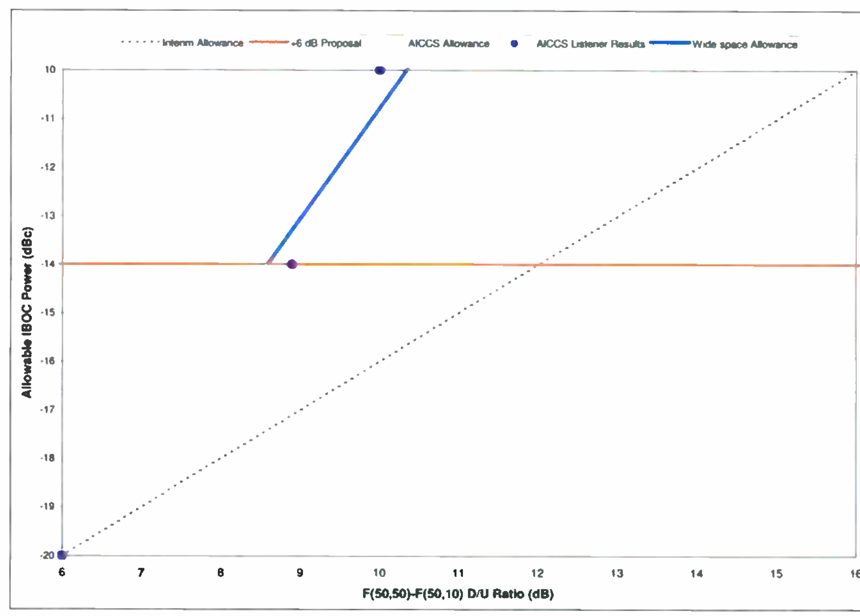


Fig. 20: Allowable IBOC power vs. D/U ratio at the protected 60 dBμ contour, based on listener ratings of IBOC interference degradation (dotted blue line beginning at 6 dB D/U and –20 dBc). The orange line shows a 6 dB blanket increase, while the power allowance for wider separations is solid blue. NPR's interim allowance is included as the dashed black line.

Assuming a blanket increase of 6 dB in IBOC power on a non-interference basis, the portion of the line below –14 dBc is shown for reference as a dotted line. The portion above –14 dBc is shown in solid blue as the "Wide-space Allowance" for stations with a D/U of at least 8.6 dB. This line extends to –10 dBc at a D/U ratio of 10.35 dB.

The D/U ratios may be applied to a simple contour protection method to determine the allowable IBOC powers, similar to the "Prohibited Overlap" requirements for NCE-FM stations in 47CFR73.509 and "Contour protection for short-spaced assignments" in 47CFR73.215.

Noise degradation and listener ratings

How Computers Find One Another

DNS, Netmasks & Gateways: The Keys to IP Networks

BY STEPHEN M. POOLE

Consider this another installment in the endless series of "things that you need to know nowadays, but for which simplified and practical information isn't readily available."

Imagine a typical workday. You might enter the IP address of a Web-capable remote control in your browser. Up comes the remote screen. You might then type in "www.digikey.com" to look up some parts. (You'd never enter "youtube.com" or something like that, of course, because you're a conscientious employee who doesn't goof off. Ahem.)

Have you ever wondered how the network knows whether an address is local or remote? How does it know that the remote control is on the local network, but that digikey.com's server isn't?

It's not just the fact that you've entered "www.digikey.com." If you enter the "raw" IP address yourself — 204.221.76.6 at this writing — you'll still go to their main page. Likewise, on some networks, you could enter a local specifier such as "//localserver//foldername" to connect in a file browser. The fact that you've used text instead of an IP address obviously doesn't tell the computer whether that address is local.

Understanding how computers find each other will aid in troubleshooting common network problems. Unfortunately, most of the documentation for this falls into two categories: It's either way too detailed and geeky, or it's a joy-joy feel-good overview that doesn't really tell you anything.

I'll try to cover the key points. To keep this short and sweet, I'll focus exclusively on ARP, DNS and network routing with TCP/IP and IPv4 addresses. While more complex setups certainly are possible, the base example will be a local network that's based on a DSL router/modem for shared Internet access.

THE DOMAIN NAME SYSTEM (DNS)

You're familiar with this, so I'll only mention a few extras and highlights. In essence, DNS is what allows you to use an easy-to-remember name like "digikey.com" instead of the raw IP address. If DNS is working properly on your computer, you can use that text as a synonym for the IP address.

Many years ago, everyone had a file on his or her computer with a name like "hosts." This contained the mappings for host names to IP addresses (or whatever that particular network used). This legacy still lives with us. On a typical Windows system, see "/windows/system32/drivers/etc/hosts." On a 'nix system (including Linux), the file "/etc/hosts" is used.

What many network administrators don't know (or have forgotten nowadays) is that the computer usually refers to these files *first*, before querying DNS. If you were to put "digikey.com" in the host file with a made-up IP address, you could get an error in your Web browser when you tried to go to Digikey's site. Likewise, a Bad Guy (capitalized out of irreverence) might tamper with the "hosts" info to force someone to a bogus site. Some viruses have exploited this in the past.

IP ADDRESSES: NETMASKS, THE PREFIX AND THE HOST NUMBER

Attempting to explain network masking in great detail requires converting to binary and using the logical "AND" function. Do a Web search on this for more info (put on your foil hat to protect your brain from implosion first). Again, I'll just hit the need-to-know highlights.

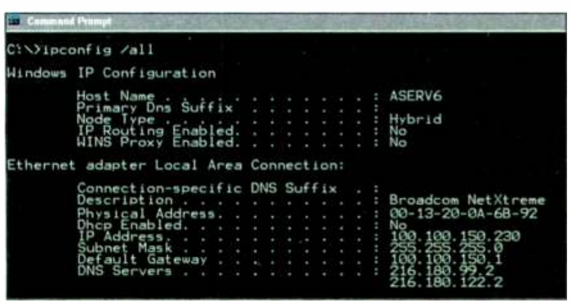


Fig. 1: Typical 'ipconfig' Results in Windows

Standard 32-bit IPv4 addresses are written as a group of four octets, each representing a single 8-bit byte. Each octet can thus have a value from 0 to 255, which represents all "0's" or all "1's," respectively.

The 32-bit netmask, which is written the same way, is used to break this IP address into two parts: the *prefix* and the *host number*. Here's a typical example from a small Class C network.

Netmask:	255.255.255.0
IP Address:	192.168.1.200
Prefix:	192.168.1
Network Base:	192.168.1.0
Broadcast Address:	192.168.1.255
Host Number:	200

This IP address refers to host number 200 on the subnet (network base) 192.168.1.0.

With the standard Class A, B and C netmasks — 255.0.0.0, 255.255.0.0 and 255.255.255.0, respectively — it's easy to understand what is going on:

1. If there's a "255" in the netmask (all 1's in binary), the corresponding octet in the IP address is part of the prefix.
2. The network base will be host number 0 and isn't directly addressable.
3. The broadcast address is the last possible host number — 255 in this example. It's reserved for sending messages to all local hosts at the same time.

The above values can be calculated by your PC from its own IP address and the network mask. Once the calculation is complete, a simple rule is applied when you try to contact any other host. *If the IP has the same prefix, it's considered part of the local network.*

Unless you're doing some esoteric (read: weird) subnetting, all hosts on the same network should have the same network mask, or they'll calculate different values. If we were accidentally to configure this host with a Class B instead of Class C netmask, we'd get this result:

Netmask:	255.255.0.0 (wrong!)
IP Address:	192.168.1.200
Prefix:	192.168 (nope!)
Network Base:	192.168.0.0
Broadcast Address:	192.168.255.255
Host Number:	1.200

You're now using the wrong broadcast and base addresses. This particular host won't work properly. Another fact that should be obvious is that all hosts on a local network should use the same prefix — 192.168.1 in this case.

Try this: Take two PCs and give them static IP addresses 192.168.1.100 and

(continued on page 20)

ADDING A STATIC IP ADDRESS TO AN UNKNOWN NETWORK

Most small networks nowadays use the Dynamic Host Configuration Protocol, DHCP, to allow users to connect on the fly. The computer sends a request to the DHCP server, which provides everything it needs to connect: an IP address, netmask, default gateway and the location of the DNS servers. An employee can bring in a new laptop, plug it in and start browsing the Web without having to worry about entering network details.

But you, on the other hand, may need those details! Two useful commands that every engineer should know are "ipconfig /all" for Windows and "ifconfig -a" for Linux and MacOS. You can use these at a command prompt or terminal window to obtain critical information.

Fig. 1 shows a typical result for Windows (the MAC address is referred to as the "Physical Address"). This particular machine has a statically assigned IP ("DHCP Enabled" returns "No"). The address is 100.100.150.230, with a netmask of 255.255.255.0 and a default gateway of 100.100.150.1. The IP addresses of the DNS servers are shown at the bottom of the image.

Now suppose that you need a static, unchanging IP for a Web-capable remote control. You can't just make up a value, not even if it's in the correct subnet. Using Fig. 1 as an example, you can't just choose "100.100.150.123" off the top of your head. You have to choose a static IP address that isn't within the range that the DHCP server would assign.

How do you do this, especially on an unfamiliar network? With most small networks, particularly those with Internet access, the DHCP server is simply part of the modem/router. In that case, the default gateway address obtained from Fig. 1 should take us straight into that modem or router.

Open a Web browser and enter the default gateway and you should see a configuration screen (see Fig. 2). If need be, find the owner's manual for the unit online and try the default login information; worst case, you'll have to reset the unit and start over, but at least you'll be in control from that point on. Look for the DHCP configuration screen. It will typically assign a range of IP addresses; in this case, from, say, 100.100.150.100–100.100.150.200. Pick an IP address that's not within that range for your remote control.

By the way, this would also be a great time to start a detailed record of assigned IPs, passwords and other key information. We use ordinary spreadsheet software for this.

You're almost there; you can now enter the network information in that remote control unit. Use the static IP address that you've chosen. The rest of the information comes from the "ipconfig" or "ifconfig" and "cat /etc/hosts" command(s) that you ran earlier — default gateway, netmask and DNS information. Test the remote control, confirm that you can get into it with your Web browser, and you're good to go!

NETWORKS

(continued from page 19)

192.168.2.101. Hook them together with two standard cables and a small network switch. Start a command prompt and use the "ping" command to see if they can communicate: for example, from 192.168.1.100, enter "ping 192.168.2.101." With a netmask of 255.255.255.0, the ping won't work. But if you change the netmask to 255.255.0.0 (meaning that prefix is only the first two octets), it will.

You might want to become familiar with so-called "classless inter-domain routing," or CIDR, notation. This is commonly used by Internet Service Providers when assigning a small block of static IP addresses. Basically, with CIDR notation, the base address is followed by a value that specifies the number of "1" bits in the netmask: for example, 192.168.1.0/24 for a standard Class C network. The "/24" means that there are 24 "1" bits in the mask, or

In Binary: 11111111.11111111.11111111.00000000
Netmask: 255.255.255.0

CIDR notation is possible because netmasks follow a simple rule: "1" bits are always written to the left, and any "0's" go to the right. You can't intersperse "1's" and "0's." There are CIDR calculators online that will derive these values for you. One good one is at *http://grox.net/utils/whatmask/*.

ARP – THE ADDRESS RESOLUTION PROTOCOL

OK, you've entered the IP address of that remote control in your browser. The netmask is applied and your PC determines that it's local. It now does what's called an *ARP broadcast*.

If you have a packet sniffer such as Wireshark on your computer, you can actually watch this process (see Fig. 3). In the illustration, I've pinged our mail server at local IP address 192.168.50.3; I'm at 192.168.50.101. My machine broadcasts a request to the entire network: "who has this IP?" The mail server responds with its MAC address (00:22:19:0b:b7:0f). Now the Ethernet hardware, which always communicates from MAC to MAC at the local level, knows where to reach the mail server. The ping works (see the lower half of the picture).

If no machine responds to an ARP after a timeout (typically 30 seconds), or if more than one responds, you get an error. Also, once your PC has done an ARP, it will cache the results for a time; you might not see what I've shown in Fig. 3 if you repeat the experiment. But now let's see how non-local addresses are handled, using a …

GATEWAY

By definition, this is simply an interconnection between different networks (i.e., those with different prefixes). Very complex routing is possible with large networks (such as the Internet itself), which could have many gateways. But if any communication will be done beyond the local network, there will always be at least one *default gateway* to the outside world.

In a small Class C network anchored on a DSL router/modem, this is easy to follow. All addresses will either be local or on the Internet, so we only need one gateway to the outside world: the DSL modem itself! Its IP address is provided as the "default gateway" to all hosts on the local network that will require Internet access.

Now suppose you enter "www.digikey.com" in your Web browser. The browser will query DNS to obtain the IP address (you'll see something like, "looking up digikey.com" at the bottom of the browser window). Using the values from Fig. 1 for this example, a DNS query will go to 216.180.99.2, the first DNS server listed. This is a non-local address; the netmask is applied and your computer actually routes the DNS request itself through the default gateway. The distant DNS server (typically a machine at your local ISP) will respond with the IP address.

This is why, if your default gateway is set incorrectly, your browser will hang at "looking up digikey.com" and eventually time out with an error. If the first DNS server doesn't respond, a query could be sent to 216.180.122.2, the alternate.

Some DHCP servers return the default gateway address for DNS; this means that the DSL router/modem takes care of the lookup.

Fig 2: Finding the DSL Modem at the Default Gateway

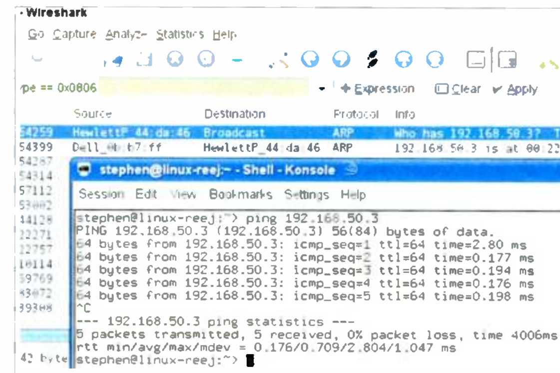


Fig. 3: Watching the Address Resolution Protocol in Wireshark

In any event, assuming success, Digikey's IP address is returned to your browser and it will attempt to establish a formal connection to Digikey's Web server. Once again, the netmask is applied. Your computer determines that it's a non-local address and sends the request to the default gateway. The router "marks" the packet (typically by using a unique port number), then sends the request out onto the Internet. Digikey's Web server responds and (assuming no errors, of course!) returns a Web page. The router sends the packet back to your PC and the page is displayed in your browser.

SUMMARY

There are many details that I've left out. But this should get you started and you'll be able to troubleshoot common network complaints with this knowledge.

If you're not familiar with "ping," play with it and learn how it works. It's non-destructive, so you won't hurt anything. It does a basic, simple host-to-host "are you there?" communication that either works or doesn't. If it doesn't, check your network settings, then check your hardware (bad cable or bad card?).

But what this knowledge implies is perhaps more useful. If you want to stop a Windows machine from accessing the Internet, simply convert it to a static IP address, and then *remove the default gateway and DNS information* in the network settings. This won't stop a skilled hacker, but it will prevent an automatic update from trying to install itself right in the middle of drive time (!). Note that turning off Automatic Updates in your Windows' settings will not stop third-party programs from trying to update themselves automatically.

Plus, it will make it much more difficult for employees to browse the Web on that machine, possibly downloading a virus or other malware without your knowledge. That alone is worth the trouble, believe me!

Stephen Poole, CBRE, AMD, CBNT, is market chief engineer at Crawford Broadcasting Company. This story is based on an article that appeared in the Crawford Broadcasting Local Oscillator newsletter.

LEASE

(continued from page 22)

offices have to be built out. It is more than a good idea to get a provision in the lease that allows for rent-free possession of the space for a period of time prior to the actual occupancy date — 60 or 90 days — for all this work to be done.

There simply is no way to build out and occupy a space as a studio operation in the same timeframe that a typical office tenant finish will take.

It is a lot of trouble to move a radio station's racks, studio cabinets, equipment and infrastructure.

Be sure to allow plenty of time for the tenant finish.

OPERATING EXPENSES

It's typical for a lease to require a tenant to pay his proportionate share of the increase in the operating expenses of the building over a certain amount established in the base year, typically the first year of the lease.

Sometimes this is spelled out in detail in the lease, but sometimes the language is vague. This can be a real "gotcha" if you're not careful.

A lease may spell out a fixed amount of power usage per square foot — four watts per square foot, for example. Is that enough to take care of your office and studio use of the space? Probably not. Leases typically are structured for office use of the space, and four watts per square foot is probably fine for that. But throw in consoles, servers, workstations and all the other equipment, and you may find you're a lot closer to six watts per square foot.

Leases often provide for a periodic audit of power usage and if the allowance is exceeded, the overage is billed at a premium. Pay close attention to this during the negotiation process. Ask if the allowance includes lighting (it usually does) and HVAC (it often does not). You may end up paying a higher rent for a higher power allowance, but that will likely be much less than the premium you pay for exceeding the allowance.

OPERATING HOURS

Office buildings often have specified hours of operation. That's not just talking about when the doors are unlocked but also what hours the HVAC system operates. If your radio station operates 24 hours a day (or even 18), this is going to be an issue with which you're going to have to deal in the lease negotiation.

Sometimes, building HVAC systems are zoned so that it can be operated at different hours in different parts of the building. Quite often, however, the whole building shuts down at 6 p.m. and there is no cooling to be had until 7 the next morning. In this case, you will have to make provisions for air conditioning your space outside those hours. One way to do this is with a separately metered auxiliary HVAC unit that services only the studio and engineering spaces.

Another consideration is how people will get into the building after hours.

Many employ a code lock or require a key card for after-hours access. Employees will be provided with a code or issued an access card, but how will your clients get in? Deal with this during lease negotiations with a provision for a video/audio intercom and some sort of remote door release, or if possible (such as in a ground-level suite), a separate entry for the radio station.

TENANT FINISH

As a rule, the costs to build out a space for occupancy by a tenant are paid by the landlord and amortized over the term of the lease and incorporated into the rent.

The more extensive the buildout and the shorter the lease term, the higher the rent will be. Soundproof walls, windows and doors and all the electrical and mechanical work to build out a studio cost a lot of money. This quickly can run up an otherwise reasonable base rent to a level that the station's cash flow cannot support.

One way to deal with this is for the tenant to fund the tenant finish himself or borrow the money from a lending institution at an attractive interest rate. Even if the money is borrowed, it is almost certain to be at a much lower rate than what the landlord would offer by way of amortization. Funding the tenant finish gives you more control over the construction as well, allowing you to hire the contractor of your choice (subject to landlord approval, of course). It is likely that the landlord will require you to use his subs for tie-ins to the building's mechanical and electrical systems, so be prepared for that.

ROOFTOP ACCESS

Don't assume that a lease for office/studio space will grant you rooftop access for your STL, RPU and receiving antennas — it generally does not. Rooftop access must be negotiated separately, and there will usually be a charge for it depending on what you intend to do up there.

Rooftops can run the gamut from simple flat membranes to complex multi-level structures complete with elevator penthouses, cooling towers and provisions for antenna mounting. What you do in terms of the lease depends to a large degree on how the roof is set up.

A simple roof with no antennas can often be dealt with simply, perhaps with a sentence or two in the body of the lease providing the tenant access to a certain number of square feet in a certain corner of the roof for mounting a fixed number of antennas of a specified size. A rooftop at the other end of the spectrum, one that is already outfitted with antenna mounts and that likely has other RF tenants in place, likely will be much more restrictive, spelling out in great detail what size and type of antennas you will install where, and there will also likely be verbiage dealing with interference as well.

You can work with either one and just about anything in between. The important thing is to think carefully through what will be needed on the roof and make sure the lease provides for that. Don't go overboard, because this can be off-putting to landlords of smaller buildings who might start to wonder what impact your rooftop antenna farm will have on his building and other tenants. It can and likely will impact your rent. If you can negotiate some excess capacity for little or no additional cost, that's good; but be careful not to go too far.

Interference language can be important, especially if your STL de-senses a 930 MHz link receiver for a paging service operating from the rooftop. You could find yourself shut down while you order and install a set of custom pass/reject filters for that other rooftop user.

On the other hand, you might find your RPU or ICR unusable due to interference from a land mobile or wireless transmitter on the roof. Interference language swings both ways, so be careful to look at it from both perspectives. And make sure that the lease clearly states that future rooftop leases will include similar interference language.

You can leave the rest of the lease to the GM or owner, stuff like base rent, escalation, floor factor, common area maintenance and the like. But you should have input on the few key items listed above. At the end of the process, you hope to end up with a tenant-friendly lease at a location that will serve well as home for your station or cluster.

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

ADVERTISER INDEX

A Good Studio Lease Requires Good Engineering

By Dealing With Key Issues in the Negotiation Process, You Set the Tone for a Successful Move

BY CRIS ALEXANDER

In the Oct. 14 issue we looked at a number of important factors for selecting a new studio location or leasehold. This time, we'll venture outside the normal realm of broadcast engineering to look at lease issues.

Why should the station engineer be involved in the lease negotiation process? After all, isn't that the purview of general managers and owners?

While for the most part the lease process is the problem of the general manager and owner, there is much in the process about which you can and should have input, things both technical and non-technical.

By bringing insights and expertise to the table, you will only increase your value to the GM and owner.

LEASE TERM

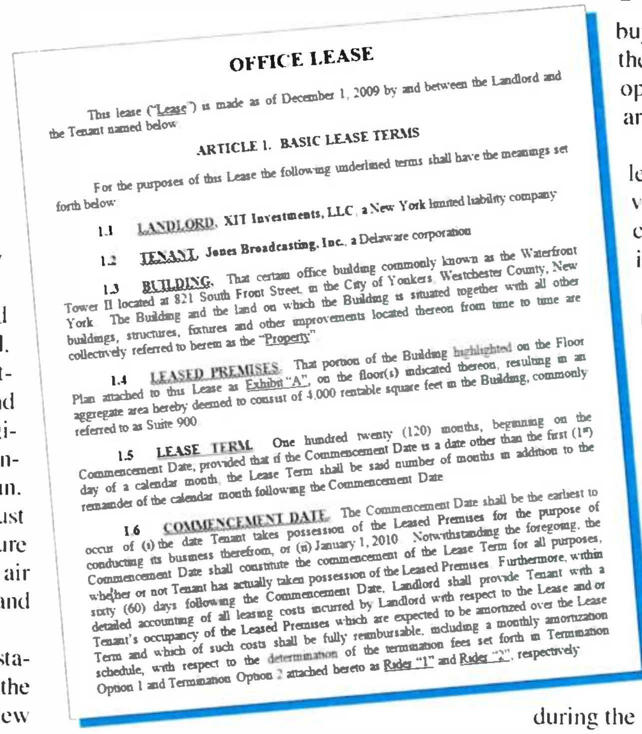
Moving a radio station studio operation is a real pain. This differentiates a radio station studio lease from most regular office leases.

It's no big deal to move desks, file cabinets and copy machines. Relocating studio cabinets, equipment racks, studio equipment and the infrastructure that ties it together — especially when you have to keep the station on the air during the move — is a very big deal.

Studio walls, doors, windows and ceilings must be treated for sound. Conduit must be run for the low-voltage wire carrying audio, control and Ethernet between studios and the engineering room. STL and satellite antennas must be installed and cables run. POTS lines, ISDN and T1 circuits must be relocated. And then you get to figure out how to keep the station on the air while you move all the equipment and studio cabinets!

It's a lot of work to relocate a radio station studio operation. For that reason, the term of the lease takes on a whole new import. If the next move can be pushed out to five, seven or even 10 years, that pushes all that trouble and inconvenience out that many more years as well.

The term of a studio lease has implications for both the tenant and landlord. If rents go up in the market, the landlord will be stuck with a below-market rent on the space locked in for the term of the lease. Conversely, if rents go down in the market, the tenant will be stuck with above-market rent until the end of the lease term.


OFFICE LEASE

This lease ("Lease") is made as of December 1, 2009 by and between the Landlord and the Tenant named below

ARTICLE 1. BASIC LEASE TERMS

For the purposes of this Lease the following underlined terms shall have the meanings set forth below

1.1 LANDLORD. **XIT Investments, LLC**, a New York limited liability company

1.2 TENANT. **Jones Broadcasting, Inc.**, a Delaware corporation

1.3 BUILDING. That certain office building commonly known as the Waterfront Tower II located at 821 South Front Street, in the City of Yonkers, Westchester County, New York. The Building and the land on which the Building is situated together with all other buildings, structures, fixtures and other improvements located thereon from time to time are collectively referred to herein as the "Property"

1.4 LEASED PREMISES. That portion of the Building highlighted on the Floor Plan attached to this Lease as Exhibit "A", on the floor(s) indicated thereon, resulting in an aggregate area hereby deemed to consist of 4,000 rentable square feet in the Building, commonly referred to as Suite 900

1.5 LEASE TERM. One hundred twenty (120) months, beginning on the Commencement Date, provided that if the Commencement Date is a date other than the first (1st) day of a calendar month, the Lease Term shall be said number of months in addition to the remainder of the calendar month following the Commencement Date

1.6 COMMENCEMENT DATE. The Commencement Date shall be the earliest to occur of (i) the date Tenant takes possession of the Leased Premises for the purpose of conducting its business therefrom, or (ii) January 1, 2010. Notwithstanding the foregoing, the Commencement Date shall constitute the commencement of the Lease Term for all purposes, whether or not Tenant has actually taken possession of the Leased Premises. Furthermore, within sixty (60) days following the Commencement Date, Landlord shall provide Tenant with a detailed accounting of all leasing costs incurred by Landlord with respect to the Lease and or Tenant's occupancy of the Leased Premises which are expected to be amortized over the Lease Term and which of such costs shall be fully reimbursable, including a monthly amortization schedule, with respect to the determination of the termination fees set forth in Termination Option 1 and Termination Option 2 attached hereto as Rider "1" and Rider "2", respectively

Also, if there is the possibility that the owner will sell the station, a long-term lease may be a big negative for the buyer, who may want to move the studio to his existing studio operation across town. So there are risks both ways.

One way to address this, at least for the tenant, is to provide "outs" under certain circumstances at specific points in the term.

For example, the landlord may agree to provide for termination of the lease at the tenant's option in Year Five with 180 days notice. You may have to pay for this with an early termination fee, probably three months' rent plus the balance of the unamortized build-out and lease expenses. If you believe that rents may go down at some point or if there is the real possibility that the station will be sold during the lease term, it may be worth it.

POSSESSION

It takes time to outfit existing or raw space for use as a radio station studio operation.

Soundproofed walls have to be built, infrastructure has to be installed and the

(continued on page 21)

FINALLY...FAILSAFE NETWORKED AOIP.

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

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

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

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

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

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

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

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

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

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

Wheatstone

Audio Networking—Simply Evolved

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