Radio Technology for Engineers and Managers

Radio Guide

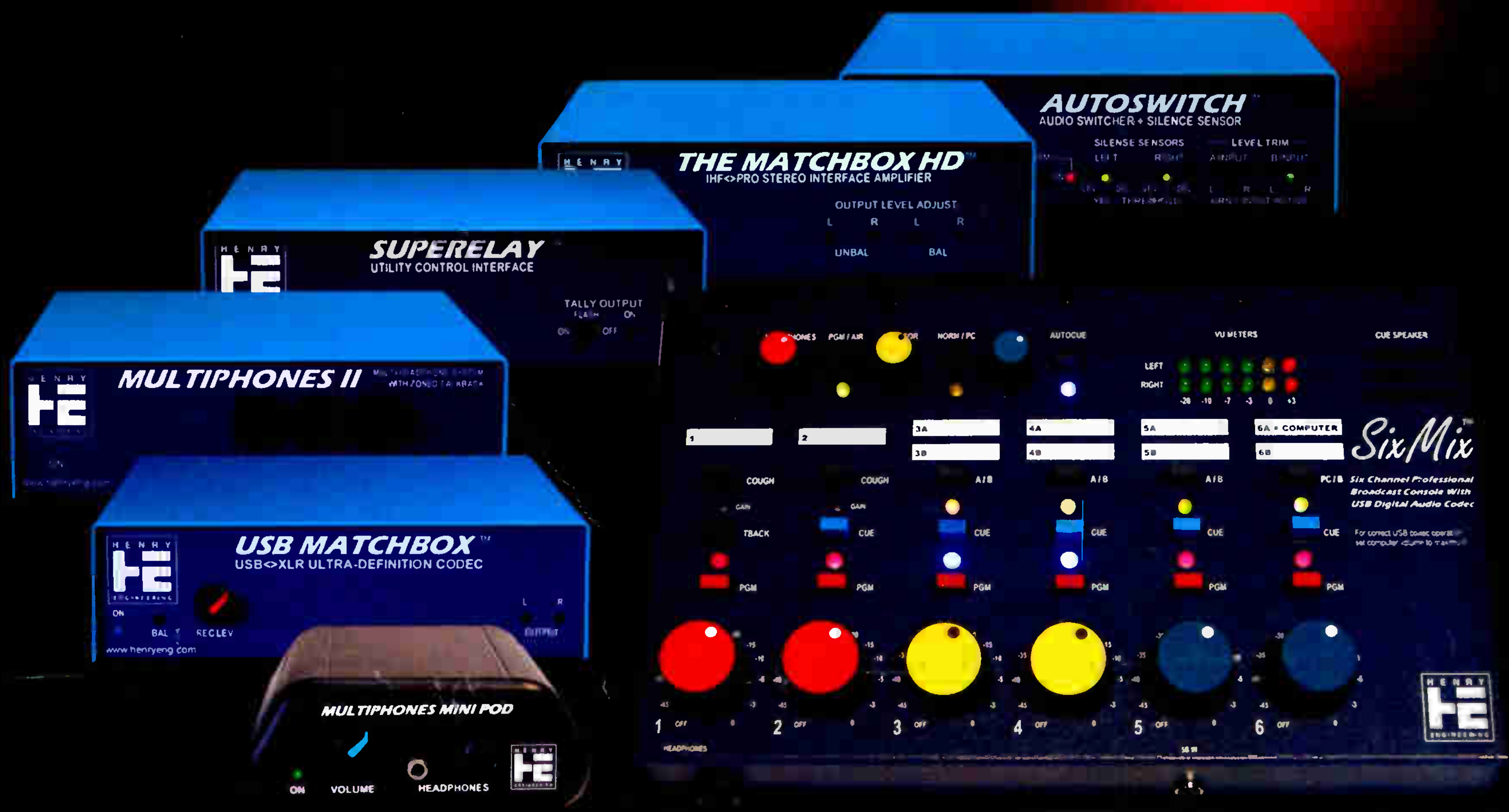
www.radio-guide.com

November-December 2008 – Vol. 16, No. 6

Solar Power Solutions Provide New Options

Inside Radio Guide

YOU MAY FIND YOURSELF CREATING PROBLEMS JUST TO USE OUR COOL STUFF...



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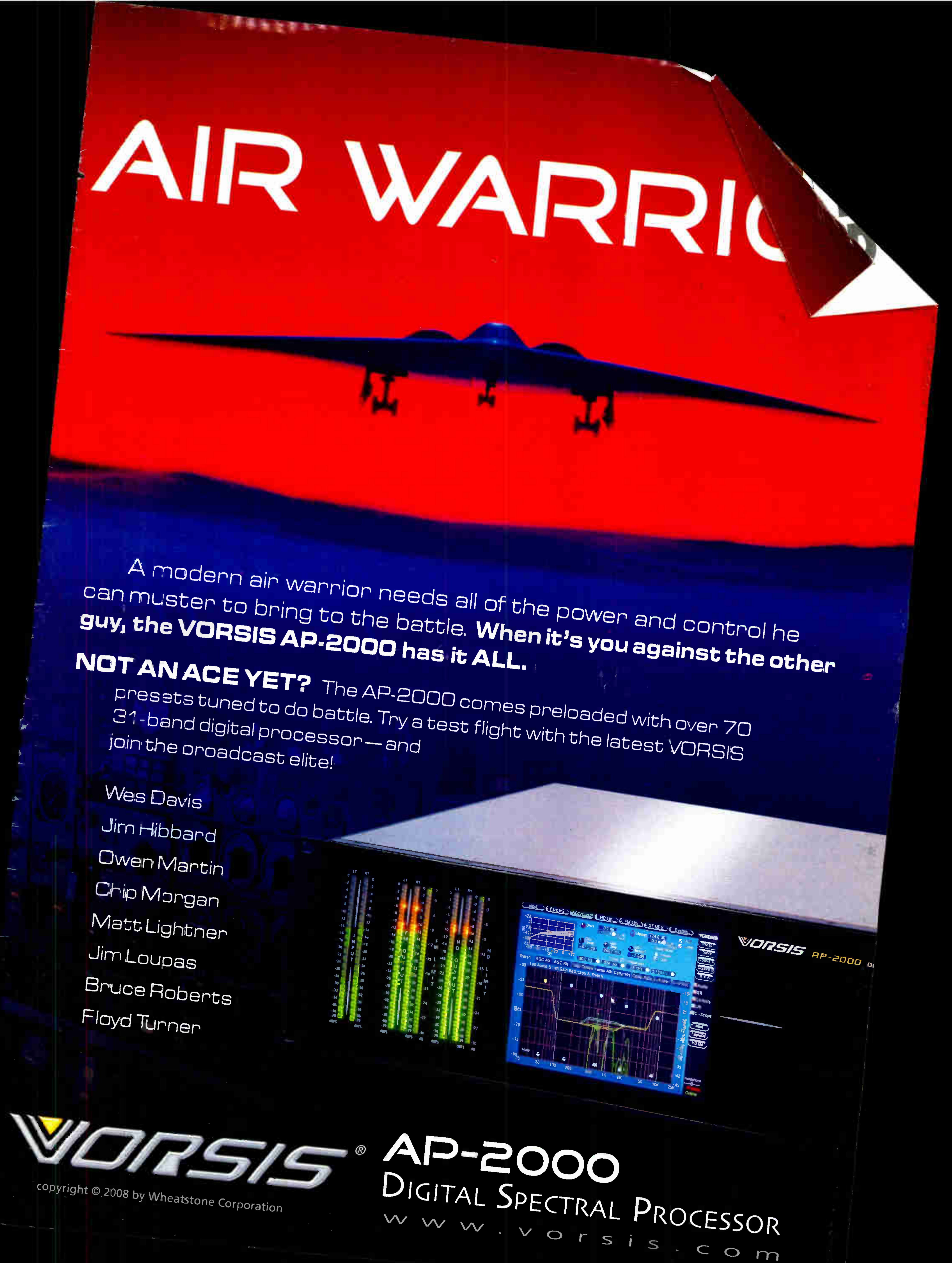
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Cover Photo:

Bill Sepmeier with an iPowerPV solar power system. It has been operating for several months with no downtime, thanks to sufficient battery capacity.

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PO Box 20975, Sedona, AZ 86341
Phone: 928-284-3700 Fax: 866-728-5764

Ray Topp *(Publisher)*
radio@rconnect.com

Barry Mishkind *(Editor)*
editor@radio-guide.com

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Radio Waves

by Barry Mishkind – Editor

For those returning from vacationing on Mars, the radio industry, along with many others, is under great pressure. A year ago who would have thought that you could buy shares in four or five major radio groups, and still have change left from a dollar?

Among the many reasons for this state of affairs, debt service has become a millstone around the necks of the companies. To compensate, some managers who are adequate in good years, seem to find the technical budget an easy target in more difficult times.

Where does that leave the engineering community?

There is no question that it can be difficult to defend a budget these days. However, broadcast engineers can rise to the challenge and show not only that they are good stewards of the station's money, but they actually save money by doing their job.

Keeping abreast of new technologies and ways of doing things is important. So is locating and eliminating single points of failure that could rob your station of air time – and income. But a crucial part is learning how to communicate your successes with your GM in language he or she understands. Showing how preventive maintenance and sharp attention provide year-over-year savings will always get their attention.

That is why one of the most gratifying parts of the *Radio Guide AM Transmission Seminars* has been comments from attendees on how the program has helped them be more effective. One attendee said he realized he was going to save hundreds to thousands of dollars from what he learned the first day.

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More details on page 36 or visit www.radio-guide.com for more information and registration.

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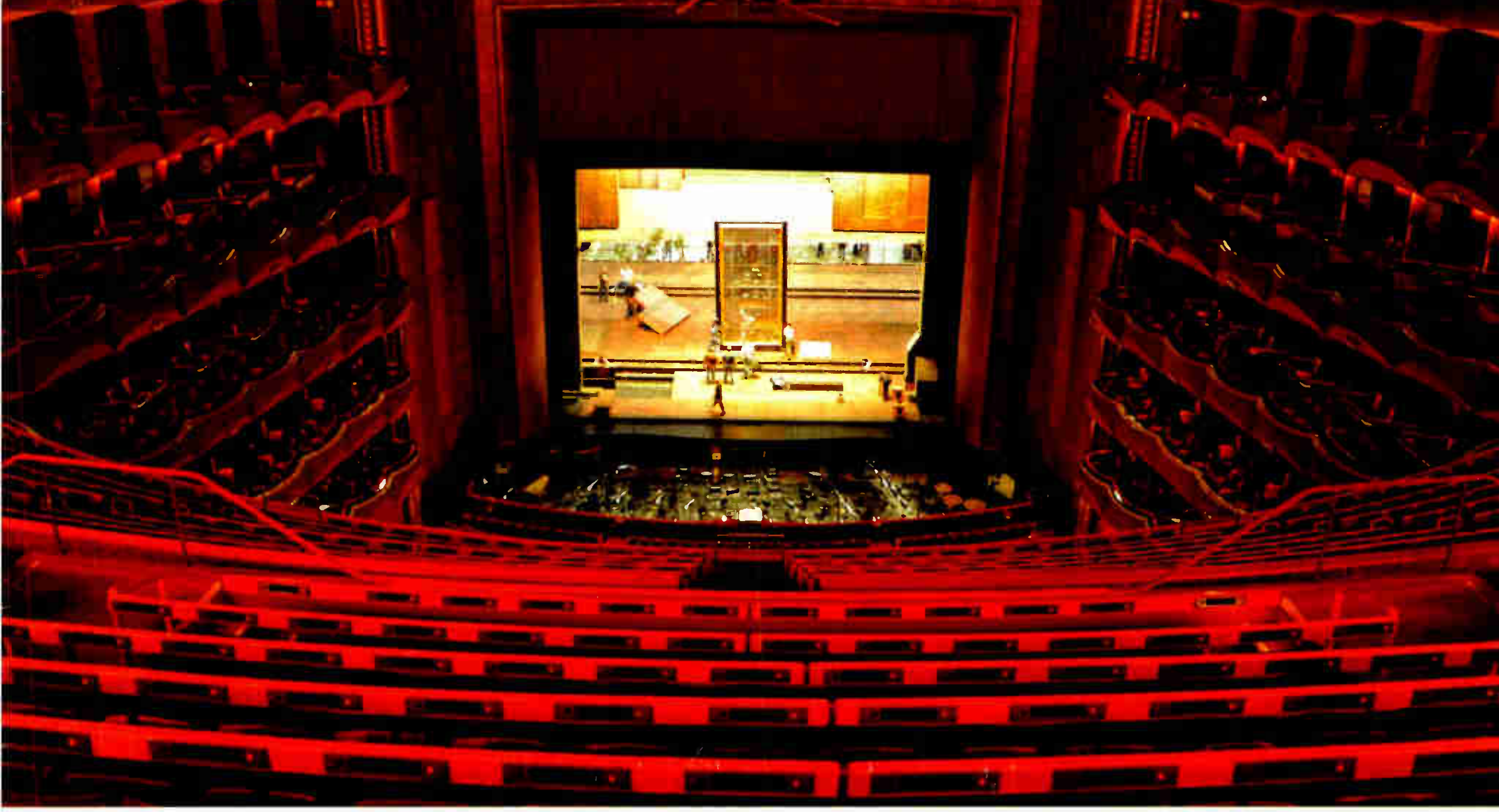

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Designing Solar Power Systems for FM Translators

by Bill Sepmeier

Generally speaking, most translators are common enough, used to provide FM service where reception is poor and to expand a station's reach. Generally translators usually are located at sites which receive commercial power.

OFF-THE-GRID DESIGN

However, with many translators running 40 Watts of RF output power or less, solar power has emerged as a reasonable option that allows their placement anywhere service is desired, regardless of power availability.

Station engineers can design their own solar systems or choose from new lines of mostly pre-assembled systems, such as the Satcom Resources' iPowerPV™, a fully-integrated solar power plant designed to deliver "plug and play" solar energy for many types of telecommunications equipment in the most remote of remote locations.

Solar modules after installation on a three-module iPowerPV.

As a bonus, the system not only catches the sun, but also shades the system.

For example, the US Naval Research Lab chose an iPowerPV to power a "plug and play" high-speed satellite and WiFi Internet connectivity setup for a genetics lab in Sierra Leone, part of an effort to cut the time required to identify dangerous new diseases.

LOCATING A VIABLE SITE

The design of any off-grid power system begins with the collection of some basic data. Among the things it is important to know are:

- if the site is generally sunny all day long.
- how severe the shading of the site is during the day.
- the load in Watts presented by the translator.
- the "peak insolation time," or number of "peak sun hours" available at the site.

("Peak Sun" is the number of hours each day that the site receives energy from the sun at roughly 1 kW per square meter, averaged over a year's time. This information has been gathered over many years by NOAA and other climate monitoring agencies around the world.)

CALCULATING THE LOAD

We wanted to place a Tepco J-340 translator on a mountaintop overlooking Vail, Colorado. In order to know how many photovoltaic (PV) modules we will need, we have to determine how many Watt-hours of energy the translator will draw.

According to the documentation, the J-340 draws 2.8 Amperes when powered by 28 Volts DC, which equals 79 Watts from the battery, so we multiply 79 Watts by 24 hours to find that the daily load is 1,896 Watt-hours. (If you have the tools to measure the current yourself, it is a good idea to do so – the actual draw is often less than specified.)

From this point, solar array design can be performed two ways. We can stay in Watts and Watt-hours or convert to Amperes and amp-hours. When all solar modules delivered 12 VDC, most designers used amp-hours. Today's solar modules often deliver much higher voltages which, though the use of a "Maximum Power Point Controller," can be converted to any battery voltage required. For purpose of illustration, we will stay in Watts for the moment.

FACTORING THE SUN YIELD

In any solar off-grid application, the battery actually powers the load, not the solar modules. Thus the solar modules must provide the battery with enough energy to power the translator 24 hours a day, recharge the battery while to translator is operating, and do this all while the sun is shining.

During the conversion from electricity to chemical and back, batteries lose about 20% of the energy input to them. Because of this loss, we multiply the 1,896 Watt-hours of actual load by a factor of 1.2, which makes the effective energy requirement 2,276 Watt-hours.

Since according to NOAA the sun averages 5.5 hours of 1000 W/m insolation at our proposed site above Vail, this is the length of time the PV modules will have, on average, to produce the 2,276 Watts the battery requires to recharge. By dividing the energy needed over 24 hours by 5.5 we learn that we need 414 Watts per peak sun hour. ("Always Round Up" is the cardinal rule of off-grid solar design – remember, winter days are shorter than average days!)

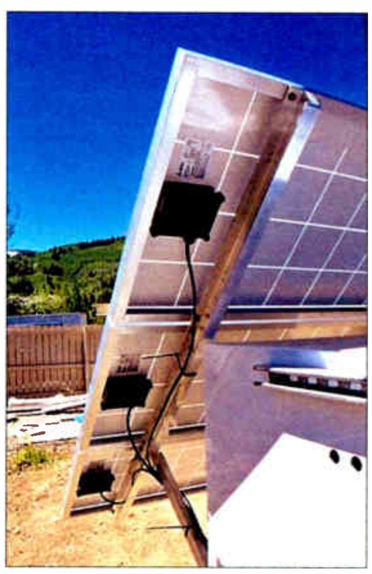
BUILDING THE SYSTEM

It is time to choose among solar modules, which vary in power output, to find out how many we will need to maintain our battery.

In this example, we will choose a relatively inexpensive module that happens to provide 12.5 VDC, a Mitsubishi 125-Watt module. Dividing the effective load per peak sun hour (414 W) by the module's power (125 W), we find that four of these modules will operate this load and charge the battery each day to float voltage of 12.5 VDC.

Powder coated aluminum iPowerPV solar shelter with an integrated solar module rack in place.

Since we are running a 24 to 28 Volt load and battery, we have to wire two modules in series. Therefore, eight of these 125-Watt modules, four strings of two, will deliver the energy the load and battery require.



Wiring the solar PV modules after they are mounted on integrated aluminum rack assembly.

Of course, solar modules today can deliver a lot more than 125 Watts per module – 185 to 210-Watt modules are common, but they operate at higher voltages and require the use of a "Maximum Power Point" (MPPT) charge controller that can output proper battery charging voltages. These controllers cost less than one PV module, though, and by using one we could use three of these newer 30 Volt, 185-Watt modules instead of eight 125-Watt units, (though four, in two series/parallel strings, would be recommended for optimal charge controller operation), saving far more than the cost of the charge controller.

RESERVE CHARGE

Since every day is not sunny, the battery must provide energy for operation during cloudy weather. Again, we need some information. How many "cloudy days" or days of autonomy are needed? Conservative designers generally prefer a week of autonomy, so let us choose seven days as our autonomy goal.

Unlike starting batteries used in vehicles, solar system batteries are designed to be discharged and recharged many times, and are called "deep cycle" batteries for this reason. Battery manufacturers, however, do not design them to be run all the way down all of the time. 50% of a full charge is typically the most discharge these batteries expect to see on a recurring basis.

"Less (discharge) is More", as someone once said, and you can run them into the ground occasionally without too much damage, but they will live their expected lifetime and resist freezing in the winter if 50% discharge levels are their regular diet.

SIZING UP THE BATTERIES

At this point we need to convert the load from Watt-hours to amp-hours using Ohm's Law. To be conservative, we use the current drawn at the 50% battery discharge level of 24 Volts instead of the manufacturer's specified load at 28 Volts – the float voltage.

Rounding up as we go, the effective load becomes about 95 amp-hours; multiply 95 amp-hours by 7 days and the effective solar autonomy load is 664 amp-hours per week at 24 VDC. Since we do not want the battery to deliver more than 50% of its storage capacity, this site will require a battery with a minimum total reserve capacity of 1,328 amps.

Battery storage capacity is generally specified at various rates of discharge, the most common being the 100 and 20-hour discharge rates, which imply the current drawn to discharge the battery over these lengths of time. Without conversion loss, the J-340 translator's 2.8 amp per hour load will actually take about 475 hours to fully discharge a 1,328 amp-hour battery, or about 237 hours to run it halfway down.

Real-world conversion loss subtracts about two days of reserve power a perfect battery could deliver. But since batteries are generally sold assuming higher current loads, you still can buy too many, since in low-power load applications they will be under-rated even at the 100 hour rate.

SOLAR BATTERY TYPES

There are three basic types of deep-cycle solar batteries: flooded wet cells that use a water and sulphuric acid electrolyte (which requires regular maintenance but provides a large storage capacity), AGM "glass mat" cells in which the electrolyte is held in a sponge of fiberglass, and gel cells in which the electrolyte is in a gel form.

Most off-grid applications today use sealed, "maintenance-free" AGM "glass mat" batteries, since the electrolyte solution is suspended in a fiberglass mat between the plates and does not stratify like "flooded wet-cell" battery water does. This eliminates the need for most battery service, such as adding distilled water and regular equalization charging to break down sulphates on the plates.

The iPowerPV solar plant is the only pre-fab power station that uses modular AGM batteries designed to provide primary power for telephone company central offices instead of the typical solar site's large series-parallel arrays of "8D" AGM batteries. The iPowerPV also includes a temperature-compensated battery charge controller, DC and AC circuit breakers, and dual 125W pure sine wave inverters (a "cold-spare" is standard).

There are many reasons to incorporate these types of modular batteries. First, they store a lot more energy in much less space. They use nickel-plated copper buss bars to connect their modular cells in series and parallel instead of bulky 4/0 jumper cables. And they are racked

(Continued on Page 8)

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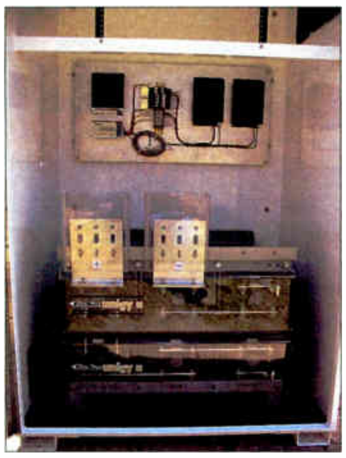
Designing Solar Power Systems for FM Translators

by Bill Sepmeier

– Continued from Page 6 –

in enclosed steel cases to prevent battery damage, especially in seismic areas. They do not off-gas nearly as much corrosive vapor or hydrogen since they do not have to be equalized.



The 12 VDC, 1470 amp-hour modular AGM battery iPowerPV batteries and pre-assembled solar electronics. The 19" rack for customer equipment is located at the top of the enclosure.

If we were "home brewing" though, we might use the more "conventional" design – the largest capacity battery available in a 12-Volt AGM format, the MK or DEKA "8D." These batteries are rated for 245 amp-hours at their 100 hour rate to full discharge. Using the published 100 hour rate, 245 amp-hour capacity per battery to obtain the 664 amp-hours (to a 50% discharge) that our effective load needs for a week's autonomy, it will require 12 of these batteries connected in series-parallel, since we need 24 to 28 Volts.

A DESIGN PROBLEM

This battery bank would require six batteries in parallel, twice in series, to deliver the 24 to 28 VDC and storage capacity needed. Off-grid solar operators have found that it is risky to go more than three batteries "deep" – or in parallel – since, over time, small discrepancies can appear in terminal connection resistance.

These irregularities cause imbalances between the batteries when they are recharged and lead to less battery bank capacity than expected – or even to premature battery failure. This is why telephone companies went with large capacity modular-buss batteries 100 years ago, still use them, and why they are well suited today for off-grid solar power systems.

We can perhaps get around this problem by calculating the battery's reserve capacity at 2.8 amps, the actual current our load will draw. A 245 amp-hour battery literally can provide energy for 245 hours if the load is 1 amp. At 2.8 amps it will last 87.5 hours, or 43.75 hours to 50% discharge. That is 1.83 days of backup time. Four batteries in parallel, in series-strings of two batteries will get the 24 to 28 Volts the translator needs. Thus eight 245 amp-hour batteries will back up our effective load for seven days.

Four deep is better than six, but still above the "three deep" parallel rule established by years of off-grid solar power users. If you use the sealed, modular Telco-grade system, these problems are eliminated.

AVOID GAMBLING ON THE SUN

Of course, the PV modules will generate some power during "non-peak" morning and evening hours – even on cloudy days.

The "cloudy day power" of about 30% of our 125-Watt module's rated output current of 7.23 amps is 2.17 amps. At 30% output four 125-Watt PV strings in parallel will make about 8 amps, depending on cloud density – which is more than the translator requirement of 2.28 amps. So on a cloudy day the array will operate the load for a few hours and still send some power back to the battery.

You can gamble and reduce the battery bank to two series strings of three in parallel. However, I would not give odds regarding whether you will win every time, or if your batteries will last their expected life of eight or nine years, since they may be discharged more than 50% far more often. Not as long as Murphy's Law is still on the books.

CHARGE CONTROL

Overcharging is the most common reason batteries fail in off-grid solar systems – or used to be, before the development of reliable charge controllers. Instead, keeping the solar modules within their optimal power window while optimally adjusting the voltage and current to the battery can produce 20% to 30% more power.

Today's charge controllers come in two flavors, standard PWM (pulse width modulation) and MPPT (maximum power point). PWM controllers are less expensive and provide the proper voltages needed to charge and protect the battery. MPPT controllers can utilize higher voltage PV modules and match them to lower voltage battery banks.

Such controllers optimize the recharging requirement of the battery against the varying power input solar panels generate with varying levels of insolation throughout the day. Voltage and current are optimized to the battery while the solar modules are allowed to remain in the range of voltage and current that is optimal for solar cell power production, instead of being "locked" to the battery bank's voltage – this is how they can provide up to 30% more energy to the battery and load.

TOTAL SITE LOCATION FLEXIBILITY

Solar energy provides complete flexibility in choosing translator and other low-power communications sites at reasonable costs, especially when compared to bringing in commercial power.

In this example we have used a DC powered load, but pure sine wave inverters are inexpensive, reliable and can operate standard 120 VAC devices with negligible overhead power consumption. This makes the user's choice of equipment very simple. You easily can design a system to meet your site's needs, though there are a lot of choices for mounting hardware and parts that we have not covered here.

Or purchase a system that will arrive ready to build and run in less than a day, including up to six PV modules (125 to 225 Watts each), the racking assembly needed to mount the modules integrated on a weatherproof aluminum enclosure that holds the Telco-grade modular battery, solar electronics, redundant inverters, and even provides standard 19-inch rack space for your translator.

Bill Sepmeier is the managing partner of DC Power and Light Company, LLC, a renewable energy operating company based in Sweetwater, Colorado and is also CTO of Satcom Resources. Fittingly, he composed and transmitted this article using on-site solar & micro-hydro-electric energy. Contact him at bill@dcpowerandlight.com

Operations Guide

by Stanley B. Adams

Avoiding the Single Point of Failure in our Studios

Part 2 – Building a Studio Checklist

Identifying and resolving Single Points of Failure (SPFs) is an important part of a broadcast engineer's job. In this follow-up article, Stan Adams shows how to start a studio checklist for cover each part of the audio chain.

Finding and getting rid of Single Points of Failure may not be on the top of your To-Do list, but it should not be far from the top. A regular program to attack SPFs is essential to keep any facility running smoothly over the long haul.

We want to share some ideas and solutions that have worked for others. In this series, I have the favor of a number of engineers who have offered supportive suggestions – even a manufacturer chipped in with some helpful tips from experience.

FAILURE, REDUNDANCY, RESTORATION

The concept of a Single Point of Failure is summed up in the following questions: How likely is any component in the program chain to fail? If one does fail, how likely is it to interrupt your programming – and how long will it take to restore service?

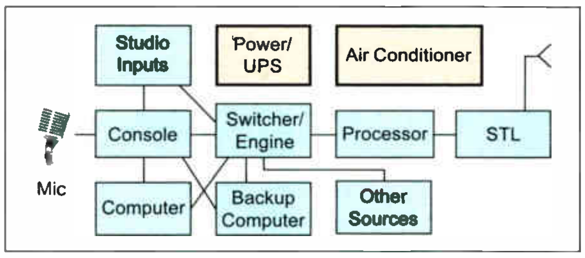
Components with a "soft failure" mode are best – keeping you on-air, even at a reduced capability. This is similar to "run flat" tires, which contain a solid rubber core that prevents a complete flat if the surface is punctured. They can only be used for a limited time at a reduced speed, but at least they still roll.

In evaluating the system, we also consider **Redundancy**. This means having backup components which automatically "kick in" should one component fail. For example, large cargo trucks can lose a tire – except for the front tires, which are used to steer – without major consequences. Of course, in many cases, cost becomes a significant factor in how much redundancy can be afforded.

And lastly, we consider **Restoration**. This word is, in a sense, contrary to our theme. But all engineers and even other operational people must know what to do when you have an actual failure along any point in your system.

A SYSTEMIC APPROACH

The best way to start is to look at the signal flow of your facility in a block diagram format. This sort of linear "picture" will help identify many of the SPFs you want to avoid.



A generic signal flow diagram.

If you start, as they say, at the beginning, there is at least one microphone. It is not often a microphone will fail in a studio, but it can happen. For example, what is your plan of action if your morning show gets silly and shoots it with a fire extinguisher or a stun gun? Then, too, microphone cords can and do fail from constant handling.

If either situation happens, how would you get audio back on the air? And how quickly?

Some announcers might think fast enough to grab a cord from the Production Room, but only if the cord were accessible and easy to move. And, there is no reason for the chief engineer to have to come in at 3:00 AM when a competent board operator/announcer can do it with some preliminary training.

What is the best solution? A spare cord – or a spare microphone wired in the Control Room? Or, perhaps an "emergency bag" with a variety of cords and adaptors in a convenient place is the answer. As I said, each situation is different.

HUB AND SPOKE

Moving along the chain, not only the microphones but virtually every audio source filters through the console – or the engine in digital systems, where servers and hubs have matrix switching so any input may go to any output. With such a digital environment, we no longer think solely in terms of broadcast engineers but also of IT people being involved in the construction and operation of the studio gear.

Fortunately, like microphones, consoles are usually reliable. But one lightning strike could reduce the hub of your audio chain to a dead end.

One way to keep this SPF from knocking your station off the air is to pay special attention the connections with the outside world. Filtered power from a UPS and surge suppression on the audio or Ethernet cabling goes a long way to protect the electronics.

SPARE HUB

Some stations wire the production console so that it can be switched quickly to the air chain. Sometimes the Production Room is laid out exactly as the Control Room to make things easier. Analog systems may feature a patch bay to connect or bypass parts of the system. (Make sure patch cords are available!)

On the other hand, with the new digital systems, it is even possible for the engineer to use an Internet connection to bypass a dead console and switch another studio – or even a single source – directly to the program chain. Even a mono signal is better than nothing.

Some stations will have a mix of analog and digital equipment because they add equipment as they can afford it. Patching around some equipment may present the problem of matching the analog to the digital. Perhaps using a Tieline, Henry or some other A/D will help you recover.

No matter what plan you have in mind, this is a place where proper documentation is crucial. It might be years before you need to activate a backup plan. Will you remember where each input and output are located? A posted Assignment Log (inputs, outputs, direction, purpose) will save a lot of time during an emergency.

... AND THOSE OTHER SPOKES

Each audio input presents its own set of potential concerns. If a computer provides the majority of your audio, there ought to be a plan for what to do in case of failure of a hard drive, sound card, power supply, etc.

A CD player or two in the control room might get you back up with "something" – sort of like the solid core spare tire, but to restore normal operations might well require more. A second, mirrored computer that can be brought on line and control all the program elements might be a better plan. More than a few stations are now setting up such a computer out at the transmitter, as a way to withstand a compete loss of the studio.

What about IT security? Is it possible for internal or external damage to disrupt all programming? This is receiving more attention daily because of outside links. Programming equipment really has no need to be on the Internet. But if it does have such a connection, a secure firewall is critical.

Depending upon the format, other spokes that feed the console hub might include telephone lines, digital editors, program loops, RPU receivers, satellite receivers, etc. Each of these needs to be evaluated for dealing with SPF issues. While some stations rely on a single satellite receiver (perhaps as they have but a single transmitter), it only takes that one lightning strike, for example, to cause a lot of dead air.

HANDLING PHONE WOES

Talk stations should consider what happens if a phone cable is cut. If all the incoming lines are on one cable, anything from a backhoe to a fire could change your format in an instant.

Should something happen, do you or your staff know whom to call at the phone company to get a quick response from the repair crews? Meanwhile, recovery options range from separate cables to VoIP, or even a lash-up to get a cell phone or two into the console. Avoid putting all your eggs in one basket, so to speak. In a major power outage, you could lose VoIP – or a drained cell-tower battery could end that input source.

And how about your remotes and sports events? The equipment at some stations I know is generally thrown into a tote bag and forgotten about until the next time it is needed. Not only can you lose a lot of money (and maybe the client) from a "blown" remote, but it sure makes the station look bad to the listeners.

BATTERIES NOT INCLUDED

One thing is certain: without power, you will have a hard time getting any audio anywhere. Power and UPS systems cannot receive too much attention.

This is why many stations have a flock of little UPSs, hanging off all the mission critical stuff. But how would you know if they will keep you on the air if Mains power were to fail? For some stations, the SPF might be a battery in an old UPS. These batteries have a definite lifespan. So they need periodic checking and replacement.

Perhaps a better question: Will they last until the generator kicks in? Maybe even a better question: is there a generator available should the power fail? Or do you have a contract with a company to provide power generation upon demand?

If you are considering a small UPS system, what type of backup reserve time in hours are you planning to have ready? Time equals battery amp-hours divided by the load. As you do the calculations, you will want to be conservative and think in terms of about 80% of the rated capacity to supply your maximum use time.

Either way, once again, having the appropriate contact numbers at the local utility can save a lot of down time.

GET THE CHECKLIST STARTED

As you can see, we are only part-way through the studio evaluation; we have only considered the various program source originations. Once you start thinking about each component of the program chain, all sorts of things to consider pop up.

Since the goal is to help you develop a useful checklist that you can adapt to your specific needs, begin it with brief notes on the items discussed here. As you build your list, you can add points and comments to each item – documenting everything as you go.

Next time we will move further along the program chain and consider some additional studio issues that might come into play during an emergency. If you have some ideas, or thoughts on aspects we have missed, please send me an email with your comments. As we pool our knowledge and experience, everyone benefits.

*Stan Adams is a frequent contributor to **Radio Guide**. Contact him at stanleybadams@yahoo.com*


NX50


32000W
32W
Meters
Select
RF On
RF Off
Menu
Status
Remote
Help


NV40

Transmission Guide

by Phil Alexander

Taming the AM Workhorse – RF Networks

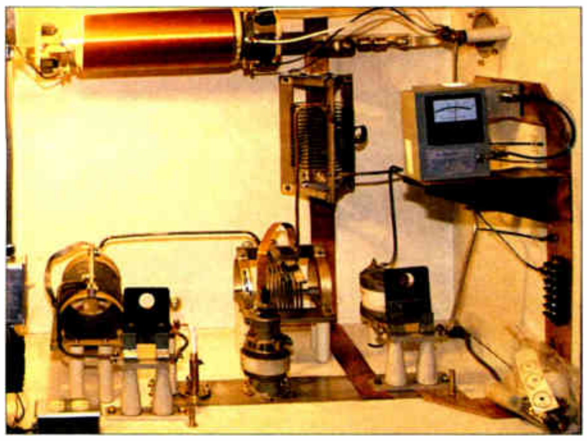
While lightning can be pretty to watch, radio engineers grimace as the storms approach their antennas. Although he cannot prevent the storm, Phil Alexander can show us how understanding RF networks can help us design better replacements when a bolt from above has blown one of our ATUs to bits and pieces.

Connecting a transmitter's energy to the steel that radiates the signal is a series of transmission lines and networks. Understanding how they channel and affect the stations' signal is essential to getting the best possible transmission to the listening public.

These networks are not some mysterious "black art" needing a consultant for solving every problem, especially those caused by component failures. In fact, the only network mystery is why so many AM engineers do not seem to understand the one part of our business that has not changed for nearly eighty years.

THE ATU

When used for matching the energy delivered by a transmission line to a tower, the networks are known by several designations. The most common names seem to be the Antenna Tuning Unit (or ATU), the Line Tuning Unit (LTU), or the Antenna Coupling Unit (or ACU). Generally, ACU is most often used by those purists who dispute the idea that an antenna can be "tuned."



A typical ATU

Strictly speaking, there is no way a vertical radiator can be tuned. However, from a practical standpoint, the network is tuned or adjusted for optimal power flow from the transmission line to the radiator, or antenna.

The same networks are used in directional antenna phasors, where we need to adjust the phase and power sent through the transmission line for each radiator in the antenna array.

COILS AND CAPS

Regardless of their use, networks are simply combinations of coils and capacitors. The basic understanding of these networks has not changed since the 1930's, when vertical radiators and directional antennas became a standard part of medium wave transmission.

These "lumped-constant" networks are called that because their inductance and capacitance is lumped together in a few clearly identifiable components. Using standard formulas for designing these circuits allows very precise impedance transformations and phase adjustments.

UNDERSTANDING THE "j" IN IMPEDANCE VALUES

Before we dive into networks themselves, we need to stop for a moment and look at the common way we measure impedances in RF circuits – because this affects the way we look at networks.

We use something called the "j" operator, which is a math term for the square root of -1. For our purposes here, we do not need to explore the effects of j – it is enough to understand that the operator puts reactances into a form we can conveniently use. Using j, all inductances become positive reactance values and all capacitances become negative reactance values; it is unnecessary to consider the actual component values in micro-Henries and micro-Farads until we are ready to select the parts we must buy.

While there are several ways of characterizing the reactive part of a complex impedance, such as vector angles, polar notation, or, in AC power circuits, power factor, we will use the familiar rectangular or Cartesian notation most of us have seen used for RF impedances.

The key point is that we need to understand that every complex impedance has a resistive component and a reactive component.

RESISTANCE AND REACTANCE TOGETHER

For example, consider a tower base impedance with a resistive component of 138 Ohms, combined with an inductive reactive component of 220 Ohms.

Using the "j" operator, the inductive reactance can be represented simply as "+j220." In this way we can state the entire complex impedance as 138 +j220 Ohms and everyone familiar with RF impedances will know exactly what we mean. Not only that, we can combine other reactances with this number and predict exactly what will happen.

For example, if we add a capacitor in series with the base of the tower described above, and that capacitor has a capacitive reactance (Xc) of 220 Ohms at the station's operating frequency, by using the "j" operator that converts to -j220. Using simple addition, adding the reactive value of the tower (+j220) and the reactive value of a capacitor selected to have Xc = 220 Ohms (or -j220), the complex impedance at the input terminal of the capacitor connected to the tower base is 138 j0 Ohms, or non-reactive at the operating carrier frequency.

This is only an example and, as we will see later, may not be the best way of correcting a tower's reactance. However it is one way that will accomplish the job, and we will see that other methods depend on the same sort of simple addition of negative and positive numbers.

At this point all we need to understand is that +j is an inductive reactance and -j is a capacitive reactance – and that we can simply add them, using one to offset the other.

When we are done and ready to buy parts we can convert the j value into micro-Henries or micro-Farads (or any other physical value) using the formulas for inductive and capacitive reactance. Later we will see how understanding this basic idea points the way toward making fixed capacitors behave as if they were variable, and increasing the effective size of small capacitors to a useful size.

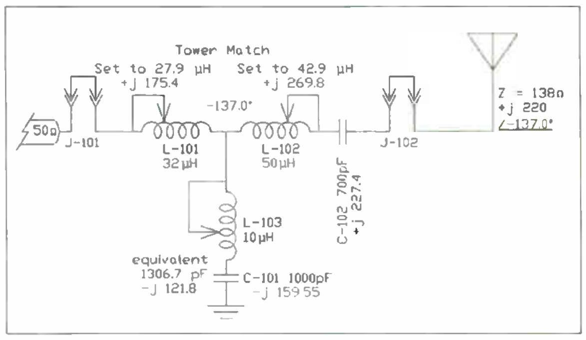
PUTTING j TO WORK

Understanding the j operator use and a few formulas allows designing networks for specific purposes. For example, consider the tower base impedance mentioned above of 138 +j220 Ohms. Designing a network to match it to a 50-Ohm transmission line with a built-in phase delay of 137° requires solving just a few equations, installing the components, and adjusting them to the values indicated by the equations.

The replacement of failed components – such as those caused by lightning damage – is accomplished in the same way.

GRASPING NETWORK TOPOLOGY

Of course, understanding how to repair and adjust a network can be difficult without some basic understanding of how common lumped-constant networks are designed. This is especially true when one of the phasor controls in a directional array network "runs out of room" for correct adjustment, possibly because one of the components of an ATU has failed and a replacement is no longer manufactured in the original value.



A "T" Network with 50 j0 Ohm input, 138 +j220 Ohm output, and 137° phase delay.

Understanding network design begins with knowing several of the common network types and understanding what they can do. By following the mathematics, a station engineer can solve many problems in a short time.

There are many special purpose networks for purposes such as for matching high power antennas, for improving pattern and impedance bandwidth, or for multiplexing several signals on a single tower. However, the common types of networks we use every day for ordinary purposes are the "L," the "Pi," and the "T" (or "Tee").

The common networks have either two (in L's) or three variable elements (Pi's and T's). While fixed capacitors are generally used in circuits handling less than 5 kW RF power, a series coil can make the effective circuit value variable from the inherent value of the capacitor itself to a lower reactance value that can make the capacitor appear up to 50% or 75% larger and allow the lumped constant LC value to be set at exactly the desired value for the circuit design requirement.

CONTROLLING VARIABLES

A network of three adjustable values can control up to two independent variables while one with two adjustable values can control only a single value (phase or impedance, but not both).

Where impedance and phase must be adjusted to specific values the three-variable network will do the job. On the other hand, if all we need is an impedance transformation, a network of two values is less expensive and often more rugged, plus it often has a greater safety factor.

Networks can be designed in two basic configurations: lagging (or low-pass) networks and leading (or high-pass) networks. A lagging network retards or delays the phase of the energy passing through it, and a network designed for delaying phase also inherently has the characteristics of a low-pass frequency selective filter. A leading or phase advancing network acts as a high-pass frequency selective filter.

Forty or fifty years ago, when suppressing transmitter output high-order harmonics in those older transmitter designs was more critical than it is for modern, well-behaved transmitter designs, the inherent filtration of the impedance matching networks was more important than it is today. This may be where the American industry practice of using a low-pass, or delaying Tee network for most ATU's began.

L NETWORKS

L networks may be used either as impedance transformers or as phase advancing or retarding networks where the alternative aspect essentially is a function of the desired change.

In other words, the phase effect of an L network will depend on the impedances being matched or the impedance transformation will be a function of the phase change. The practical effect of this fact limits L networks strictly to the role of impedance transforming devices where phase change is not a critical objective.

While the network that follows is not drawn conventionally, it is a true L network of the lagging or low-pass type. The connection between input series inductance and shunt capacitance is the clipped tap going to the load. A small amount of the coil to the right of the clip is series inductance for adjusting the effective working value of the capacitor.

(Continued on Page 14)

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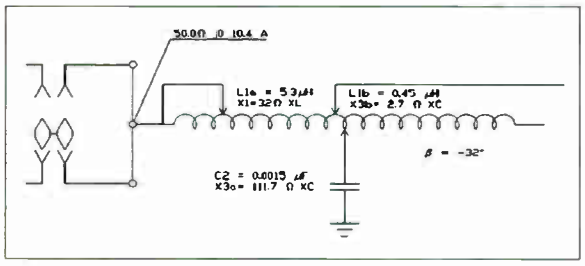
Transmission Guide

by Phil Alexander

– Continued from Page 12 –



An L network can be used for matching a new transmitter to an older system.

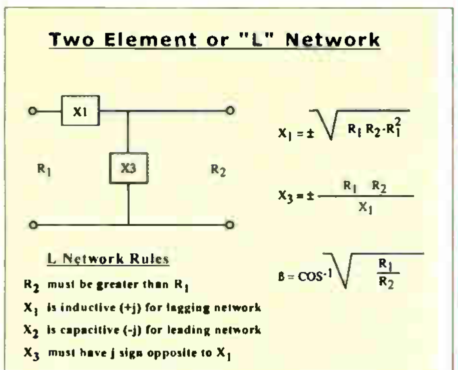
Before toroid/linear scale RF ammeters became popular, an L network was frequently used to match transmitters to a calculated common point impedance so as to produce a current that could be easily read on an exponential scale, thermocouple meter.

For example, in an older 5 kW DA array the common point impedance might be set to 74.7 Ohms, resulting in a common point meter reading of 8.50 Amps, or 70.5 Ohms for a common point current of 8.75 Amps, at the standard DA common point power input of 5.4 kW.

MATCHING OLD TO NEW

Not all phasor designs convert easily from 70 or 75 Ohms to the 50 Ohm impedance required as a load by a modern transmitter. It is often simpler to use a common L network to make the transformation.

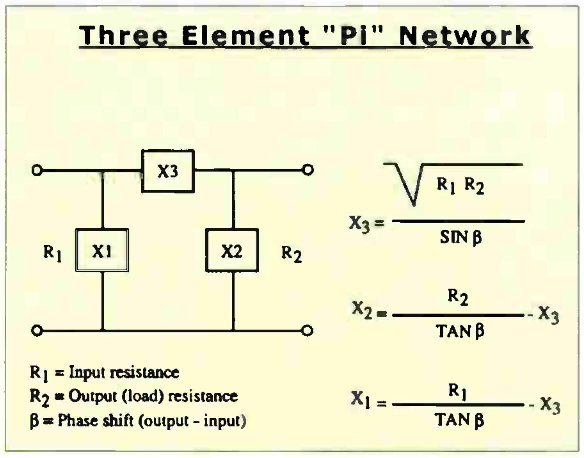
Furthermore, keeping the original plant common point may be very important if the old transmitter is used as an auxiliary. You may have a choice: re-tuning the old transmitter to match 50 Ohms, reworking the phasor from a 70 to 75 Ohm to a 50 Ohm input design, and processing a common point impedance change with the FCC – or perhaps a much less complex solution: simply installing an L network between the new transmitter and the RF source selector switch feeding the phasor's common point.

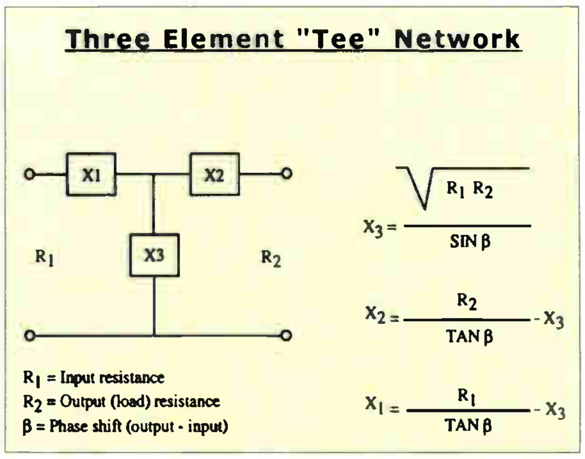


Although the first Rule seems to say L networks cannot reduce impedance, this is not true because an impedance increasing network can be used in reverse. Reversing the schematic by placing the X1 reactance on the right side of the X3 connection and reversing the "R" signs effectively inverts the network function without violating the Rules. Thus, a 50 Ohm in/100 Ohm out network can be used backwards as a 100 Ohm in/50 Ohm out impedance transformation.

PI AND T NETWORKS

Three-element networks are called T's and Pi's because their schematic configuration resembles one of these forms.



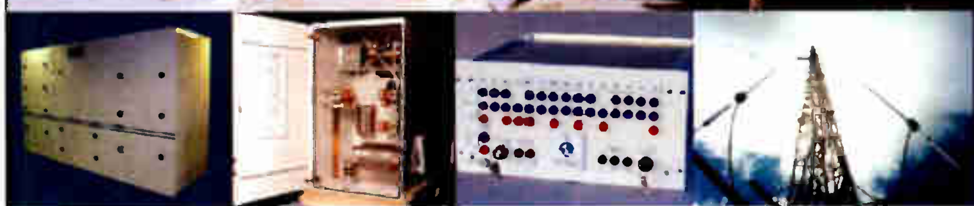


These three-element networks have a beta (ß) – or phase-function that is independently variable from their impedance transformation. It is this dual ability that makes them the true workhorses of AM transmission.

Also, if you look carefully at the mathematical formulas, you will see there is no difference between the calculations for Pi networks and Tee networks. The only difference is in component location on the schematic.

(Continued on Page 16)

AM Directional Systems...



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CHOOSING THE RIGHT NETWORK

Practically speaking, T's are usually less expensive than Pi's, especially for manufacturers who make their own coils. Even though other designs may offer technical advantages, it is the "lagging" or phase delaying T network that is commonly found in many systems, especially in older designs.

However, it is also true that for large ratio impedance reductions, such as were common in tube-type AM designs, the least expensive network is the Pi configuration. Additionally, the equipment builder's costs of fixed transmitting capacitors (generally the mica type) were a strong network design influence – and one of the main reasons these networks became so popular.

ANALYZING THE NETWORK

An all too prevalent idea is that there is some "magic" in the 90° lagging network. Since these are very common and are often the network of choice for ATU's, it is easy to understand how the idea originated.

Look at the formula for the X3 reactance element of a three-element network. The mathematical simplification shows the real reason for choosing a 90° phase shift. Before computers, most of these network calculations were done using a slide rule, paper and pencil. Anything that would simplify that work was welcome in an engineering office.

If you studied Trigonometry before pocket calculator prices fell to an affordable level you probably still remember some of the functions and can see the answer. If not, knowing that the sine function of a 90° angle is 1.000 helps understand the real reason we see so many 90° ATU's – it is the selection of 90° that simplifies the math.

However, computers are a *good* thing because, for some modern transmitters, 90° ATU delay plus 80° or 90° delay in the transmission line can be a very bad choice, especially if impedance bandwidth is an important consideration.

CORRECT CALCULATING

Notice that the calculations must be done as shown, in the correct order.

After selecting the network phase shift (ß), X3 is calculated first because this answer is used in both the X2 and X1 calculations. Also, notice that the sign of ß determines the reactance sign. Since the reactance values are measured in Ohms (either inductive or capacitive), using the j operator notation is the easiest way of tracking the component types.

Using this method, if X values are negative (-) the effective value of the component will be capacitive, or -j, and if positive (+), inductive, or +j with the values in Ohms at the operating frequency. This avoids the complication of converting back and forth between reactance values and actual component values until the final component selection process.

RUNNING THE NUMBERS

Now, we have enough information to design a network for matching the 138 +j220 Ohm tower to a 50-Ohm transmission line with a built-in phase delay of 137° – although we still will need some additional basic facts for its construction.

First, we know the ß = -137° because we need a phase shift *delay*, so the formula for X3 is:

(SQR(50 * 138)) / SIN ß
or 83.06624 / -0.681998 = -121.798
which rounds to -121.8.

Thus, X2 and X1 respectively are: (R2 / TAN ß) - 121.8 and (R1/TAN ß) - 121.8, or 147.98688 - (-121.8) = 269.78688 and 53.6184355 - (-121.8) = 175.4184355 which rounds to X2 = +269.8 and X1 = +175.4

Therefore, this is the table of values for our 50 j0 to 138 +j220 matching network:

X1 = +j175.4 X2 = +j269.8 X3 = -j175.4

FINISHING THE TRANSFORMATION

However, this network needs a vital component before it will work. While it matches the line resistance to the resistance of the tower, it does not correct the +j220 found in the tower base impedance. For simplicity we will call this load reactance correction value X4

Although simply inserting -j220 at the output of the network – canceling the +j220 of the tower to give us a 50 j0 Ohm match at the network input – may work in a pinch, it also may be a bad idea. We will explain why in our next installment.

Also we will look further into these calculations and the corrections needed to make this a practical and useful ATU network, and explore how we adjust "fixed" capacitors. As we explore these and other topics about resonant and near resonant circuits we will discover some other things we need to know about LC circuits operating in a network and their effects on operations of both standard and directional stations.

*A regular contributor to **Radio Guide**, Phil Alexander has long experience in building, maintaining and repairing RF networks. He is also one of the instructors at the **Radio Guide AM Transmission Seminar**. Contact Phil at dynotherm@earthlink.net*

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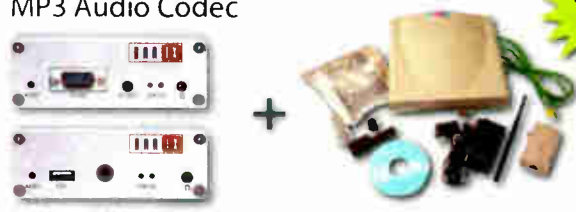

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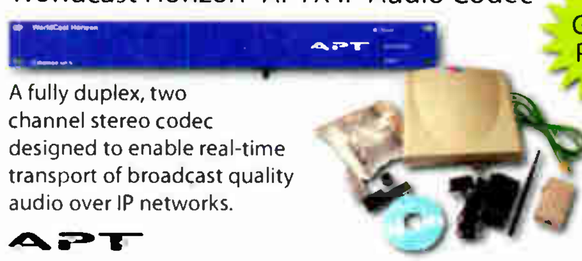

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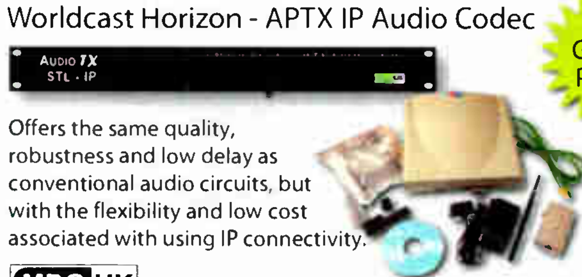

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FCC Makes Important Changes to AM Rules

This is an historic time in the history of AM "Medium Wave" standard broadcasting in the United States.

On Friday, September 26, 2008, the Federal Communications Commission released the Second Report And Order concerning changes to the FCC Rules Regarding the AM Radio Service and Directional Antenna Performance Verification (MM Docket No. 93-177).

NINETEEN YEAR EFFORT

The Report And Order was then published in the Federal Register, making the Rules effective on December 1, 2008. However, until the Office of Management and Budget signs off on the forms, there is no way to actually file one right now.

The initial Rulemaking proposing that AM directional proof of performance standards should be updated was filed with the FCC on December 15, 1989 by a consortium of five broadcast consulting engineering firms. In recent years, it was referred to as Docket 93-177

The successful conclusion of this 19-year approval process came through the participation and cooperative efforts of the industry as a whole: FCC staff, NAB, consulting engineers, manufacturers, attorneys, and group owners who participated in the final filing efforts.

SOME KEY POINTS

Among the new Rules for Directional Antenna Performance Verification, two aspects in particular will impact broadcast engineers and station owners.

The first is approval of the use of Method of Moments (MoM) analysis, such as the Numerical Electromagnetics Code ("NEC") or MiniNEC to accurately predict the relationship between pattern shape and internal array parameters. The second is an off-shoot – to make sure the MoM works, accurate measurements of the installed towers and components are required.

The thrust of the new Rules is that the calculated values need to match the measured values within a very close tolerance to prove proper pattern adjustment. This places a high burden on the field and/or chief engineer making system measurements.

MEASUREMENT DATA COLLECTION

Among the data that should be part of any installation are:

• The matrix of impedances at the base (feed point) of each radiator in the array, with all other radiators elements shorted and/or open circuited.

• Measurement of the lumped series inductance of the feed system between the output port of each radiator tuning unit and the associated radiator.

• Measurement of the shunt capacitance of each tower base.

• Verification of the sampling line impedance to confirm that all lines are of equal impedance within two Ohms.

• Verification of the sample line electrical length to confirm that lines are within one electrical degree.

Modern vector network analyzer (VNA) equipment allows measurement of components, networks, radiators and transmission lines with high levels of accuracy not previously attainable. Using the gear and developing useful field measurements is our focus in this article. The next issue of ***Radio Guide*** will focus on MoM analysis.

THE IMPEDANCE BRIDGE

Before we discuss measurement procedures, a brief survey to compare the impedance measurement equipment used in past decades with current technology is appropriate.

For many decades General Radio Company in Cambridge, Massachusetts was the prime supplier of antenna impedance bridges. The 916 and 1606 models have been primary tools for several generations of engineers.

The Model 916AL was first sold in 1942 and was often used for broadcast impedance measurement reports submitted to the FCC well into the 1980s. The frequency range covered 50 kHz to 5 MHz and could read resistance from 0 to 1,000 Ohms and reactance up to 11,000 Ohms at 100 kHz.

The General Radio Model 1606-B was first manufactured in 1967 and is still in use today. The frequency range covered 400 kHz to 60 MHz, and it could read resistance from 0 to 1000 Ohms and reactance up to 5,000 Ohms at 1 MHz. Basic accuracy for the 1606 versions was specified at plus or minus 2%

General Radio Type 1606-A RF Bridge

THE OPERATING BRIDGE

Delta Electronics revolutionized the process of measuring impedance in broadcast antenna systems with the introduction of the operating impedance bridge.

The OIB-1, and extended range OIB-3, can be inserted in-line in an operating transmission system so that an external generator and detector are not required for carrier measurements. They also may be fed with a signal generator, and an external detector employed, for non-directional or common point impedance measurements.

The OIB-3 extended range bridge is designed for operation between 500 kHz and 5 MHz with a resistance range of 0 to 1000 Ohms and a reactance range of -900 to +900 Ohms. Basic accuracy is plus or minus 2% plus or minus 1 Ohm. These instruments are used regularly in broadcast applications where driving point impedance and network input impedances are required in directional antenna systems.

Delta OIB-1

In my opinion, a Delta bridge should not be used except for driving point impedance measurements in a directional array as the bridge introduces stray reactance which can significantly affect impedance readings, especially for towers between 110 and 190 degrees in height.

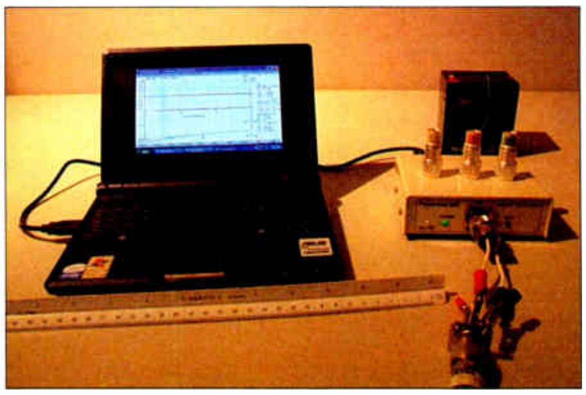
VECTOR NETWORK ANALYZERS

Numerous manufacturers produce vector network and impedance analyzers that can be used for circuit and antenna measurement work.

One high-end example is the Agilent E4991A, with a basic accuracy of 0.8%, retailing at $50,000.00. Equipment of this nature is not cost effective for field use and is not designed for direct connection to broadcast towers where high RF voltages impressed by other nearby radiators can damage the analyzer input circuits.

In 2008, Kintronics Labs introduced a new VNA to the broadcast industry designed for the rigors of field work but with high accuracy, battery power, and computer control – the PowerAIM 120.

The PowerAIM 120 covers 0.1 to 120 MHz employing an internal RF generator using step sizes from 1 Hz to 10 MHz. It has an impedance range of 1 Ohm to 2,000 Ohms with an accuracy of 1 Ohm, plus or minus 5% up to 60 MHz, at phase angles to plus or minus 90 degrees. The maximum safe RF input is 50 Volts peak-to-peak.



A PowerAIM 120 hooked to an Asus Eee running Windows XP for instrument control and data storage.

ENSURING GOOD DOCUMENTATION

What follows is a brief examination of, and a discussion of, specific field measurement techniques to obtain the most accurate readings possible.

In any project, extreme care must be taken to calibrate the test equipment to remove any ambiguity related to test lead length, routing and test equipment placement. A common reference signal needs to be used to verify that sample devices, installed at the output of the antenna coupling unit, are within the manufacturer's calibration specifications.

Copious field notes and digital pictures are very important so that the system can be fully described at any time in the future, should questions arise.

GETTING ALL THE DATA

Rule Section 73.151(1) requires that the impedance of each tower in the directional array be measured at the base, or feed point, with all other towers shorted and/or open circuited. For a three-tower array, the measured data would be as follows:

At Tower #1

1. Measure impedance with towers #2 & #3 open.
2. Measure impedance with #2 shorted and #3 open.
3. Measure impedance with #3 shorted and #2 open.

At Tower #2

1. Measure impedance with towers #1 & #3 open.
2. Measure impedance with #1 shorted and #3 open.
3. Measure impedance with #3 shorted and #1 open.

At Tower #3

1. Measure impedance with towers #1 & #2 open.
2. Measure impedance with #1 shorted and #2 open.
3. Measure impedance with #2 shorted and #1 open.

AVOIDING PROBLEMS

So, where are the traps that can get you into trouble here?

First, it is critical that the measured data makes sense to the design engineer who is constructing the NEC models to be employed in the initial proof. In fact, it would be wise to e-mail your results before leaving the site. If your role will be to recertify an installation, try to be on site to witness the original verification process.

During the process, record the leg diameter and face width of the tower. Take several photos to confirm that the tower matches the quoted specifications and design drawings. Improper construction practices such as failing to bond transmission lines to the tower at proper intervals or failing to bond the tower light conduit regularly can impact impedance readings.

Then take the open and short measurements at the feed point on each tower – and that point should be the same on all towers. Failure to do this can result in data that does not match the model. Similarly, the shorting strap must be either strap, or low inductance braid, and the same strap should be placed on each tower in exactly the same position.

GETTING SOLID DATA

It is important to consider that the tower impedance is impacted by the tower lighting circuits, static drain choke (if used), tubing between the tower feed-point and the tuning unit, and coupling between the cabinet and ground. And do not forget the potential effects of sampling lines with isolation coils or STL antennas with isocouplers.

Our recommendation is, if possible, to measure the impedance on the tower at the point where the feed is attached, with as many shunt components removed as possible.

(Continued on Page 20)

RF Guide

by Clarence M. Beverage

– Continued from Page 18 –

A second set of readings at the feed-point – which in most cases would be the output of the J plug in the tuning unit, next to the sampling device if base sampling is employed – must also be taken. This process provides a set of control data to use in estimating series and shunt reactance.

INDUCTANCE AND CAPACITANCE

Rule Section 73.151(1)(vii) requires that the series inductance of the feed system be determined. Measurement of tubing diameter, turns spacing, and the length of the interconnecting tubing on each side of the inductor should be recorded along with a photo for each tower base.

The inductance can be calculated from the standard formula: L = (N^2 * D^2)/(18*D + 40*H), where

L=microhenries
N=number of turns
D=diameter, inches
H=length(or height, hence the H), in inches.

An impedance measurement at the ATU J plug output terminal to ground, with the plug out of the circuit and the base insulator shorted, will provide a measured value of R and X that can be compared to the calculated value to establish series inductance.

Rule Section 73.151(1)(viii) requires that the shunt capacitance of the base insulator be determined. The manufacturer, make and model number should be recorded and the manufacturer contacted to obtain the base insulator capacitance. If capacitance of each base insulator can be measured before installation, that is an added bonus in terms of quantifying variables.

SAMPLE CALIBRATION

Rule Section 73.151(2)(i) requires that sample device calibration be confirmed when towers are monitored with base current or base voltage sampling devices. Such calibration can be determined by removing the sample device from service and field verifying performance.

To calibrate toroid current transformers, all of the toroids can be placed in series at a point in the RF path, near to the phase monitor, and a pair of equal length flexible heliax sample lines run to the transformers to confirm that the current ratio and phase readings agree with the manufacturer published data.

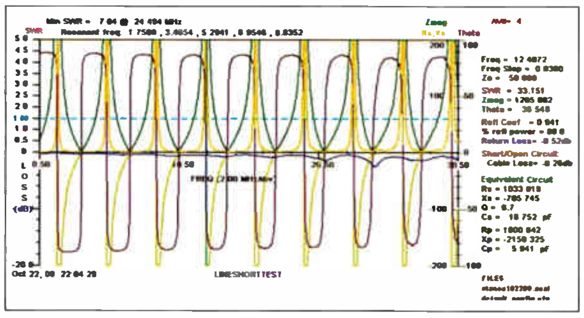
Provision to do this regularly should be designed into the RF system and could be a section of tubing mounted between insulators that is easily accessible. Voltage samples require a connection to the RF bus with the case connected to ground. The calibration process should be fully described and documented with photographs.

CHECKING THE SAMPLE LINES

This Rule section also requires that the sample lines be measured to confirm 1) equal electrical length within 1 degree at the operating frequency and 2) impedance within two Ohms of the manufacturer's published data. To make these determinations it is wise to have a copy of the cable order and know the specified length of each line in the order, as well as the manufacturer, type number, characteristic impedance and velocity factor.

From basic transmission line theory we know that an open circuit 1/4 wave line will show zero reactance at a 1/4 wave and 1/2 wave multiples thereof, whereas a shorted transmission line will show zero reactance at a 1/2 wave and 1/2 wave multiples thereof.

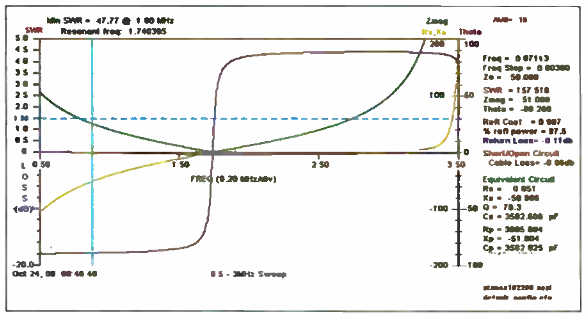
Determining sample line electrical length is a simple process when the sweep function in the VNA is employed. To illustrate, the following picture is a sweep from 0.5 to 20 MHz of a section of Andrew LDF5-50 having a factory specified velocity factor of 88% with a short across the line.



0.5 to 20 MHz sweep of a section of LDF5-50

The PowerAIM employed for this measurement identifies the 1/4 wave resonance points whether the line is open or shorted. The spool is approximately 20 years old, was stored outside in an unprotected environment and was believed to be about 120 feet in length. A general sweep such as this can provide a good estimate of the lowest resonant frequency and give us the basic information required to run a more detailed sweep with the line open as required by the Rules.

In this case the sample line is very short so we can use a narrower sweep between 0.5 and 3 MHz to determine the frequency representing the first 1/4 wave point. Running this sweep we see that Xs = -0.003 ohms at 1.74227 MHz which is a length of 124.2 feet based on a velocity factor of 88%



The same line, with sweep narrowed to 0.5 to 3 MHz.

To measure the characteristic impedance of the sample line we must move 1/8 wave from the 1/4 wave point and, leaving the line unterminated, measure the characteristic impedance in the single frequency mode.

The section of line under test exhibited a measured impedance of 50.8028 Ohms at 0.8711 MHz and 48.66 Ohms at 2.6134 MHz. It is recommended that the VNA be used to measure the impedance of the toroid transformer to confirm that the terminating resistors have not changed value. Finally, terminate the sample line with the toroid and then measure the sample line impedance at carrier frequency.

It is hoped that this information is helpful in terms of gathering the field measurement data required for initial Directional Antenna Performance Verification and subsequent Recertification. Obtaining quality data – and taking sufficient additional data to remove the "why is this behaving in this unexpected way factor" – should go a long toward achieving a successful adjustment and stable ongoing operation.

Few successful efforts are achieved without collaboration. Many thanks to William P. Weeks of Milton, New York for his tireless field engineering efforts, program planning and office engineering time directed toward preparing both of our firms to execute this work in the best way possible.

A Broadcast Engineering consultant for over 30 years, Clarence Beverage is the President of Communications Technologies, Inc., in Marlton, NJ. Contact him at cbeverage@commtechrf.com

First Person

by Jim Tonne

Meet the Crowbar

Occasionally, experienced engineers like to "initiate" younger techs by surprising them with something unexpected. Occasionally, what happens really is unexpected.

I was chatting with a group of people the other day and the subject of "crowbars" came up. This caused me to have a flashback to "The Good Old Days," circa 1987, at which time I was a newcomer to a small business firm in Dallas, Texas.

JOINING THE HIGH POWER CLUB

I was placed with the shortwave broadcasting people. This involved working with transmitters whose carrier output levels were in the range of 100 to 500 kW. Prior to that time the highest power I had worked with was 5 kW, so this was quite a step upward, power-wise.

I had been assigned to a group working on the transmitter control ladder. ("Turn it on, turn it off", etc.) At some point they were going to test the crowbar. I had never seen a crowbar before. I had not the slightest clue as to what a crowbar did.

They told me, with a lot of very serious looks on their faces, that this was a device that, after a fault was sensed, would dump the energy from the entire high voltage system in the blink of an eye. It would make a huge noise, probably shaking the floor, dim the lights, and the testing person would be at risk.

GETTING READY

The person doing the testing would take a few-inch-long piece of #30 wire on the end of a yard-long fiberglass rod and place that piece of wire between high voltage and ground at a particular place in the power supply. By creating an artificial overload this would operate the fault-sensing circuitry. That in turn would trip the crowbar and result in a Terrifying Transient.

Since I was to be "initiated into the club" they told me that I was chosen to do this dirty deed. They said they would stand behind me in case I collapsed onto the floor.

Being as naive as I was, I took all of this at face value. Holding the fiberglass rod with one hand meant that I could only cover one ear to block the sound of the explosion. This alone had me concerned.

THE MOMENT OF TRUTH

On the scheduled day I examined the wire to be sure it was the right size, this being verified by my immediate supervisor. Everyone around had this very serious look on their faces.

It was time. The transmitter was energized and brought to full power. 3 - 2 - 1. I gritted my teeth and connected that tiny piece of wire directly across the output of the power supply delivering 15 kV.

But the wire did not even vaporize. The operation of the crowbar was totally – I mean *totally* – silent. The system simply shut down without the slightest whimper.

INDUCTION!

I am sure I had turned white from stress. Everyone laughed and welcomed me to the Crowbar Testing Club.

Actually, the crowbar behaved exactly as it should have. The specifications by Eimac were that the crowbar must operate in a manner such that the #30 wire must survive the test. This way the fast fault-detector, when operated, would protect the final amplifier tube in the transmitter. Those tubes, although capable of perhaps 400 kilowatts of plate dissipation, had rather fragile grid and screen structures.

The use of a correctly-operating crowbar was the best way to save the tube from a circuit malfunction.

It turned out that the Terrifying Transient was in fact typical of earlier designs in which an ignitron actually shorted the power supply. Instead I was tripping a pulse-width modulation supply. And those shut down quite gracefully, unlike the older brute-force designs. Newcomers of course, and especially *really gullible newcomers*, did not know these little bits of history.

The man behind this huge hoax was my immediate supervisor Sam Engel. We all miss you, Sam; I surely miss your delightful sense of humor – although I suspect that at least some of my white hair is due to your crowbar joke!

Jim Tonne is a veteran broadcast engineer, semi-retired after five decades of broadcast engineering, from station-level to manufacturing. Jim would like to hear from Club Members at tonne@comcast.net

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Practical Engineering

Some More Handy Hints From An Old Timer

by Mike Langner

Whether you care for one station or a dozen, it is always good when you can benefit from another engineer's experience. By not reinventing the wheel, we can "work smarter, not harder." Mike Langner offers some pointers from his 50 years in the business.

SAFETY WHILE TROUBLESHOOTING

Personal safety has to be a first concern of any engineer who wants to live long enough to cash his next paycheck. A few simple rules will go a long way to keep you safe. A few tricks will make you even safer.

The First Rule of Safety is to make sure the power is off wherever you plan to stick your hands inside of something. Make sure the equipment is off inside any gear where you plan to stick your hands. That is: breakers down, disconnect down, and shorting stick employed anywhere high voltage might be found.

The Second Rule is, whether you have a studio-transmitter site or a remote-controlled site, a second person should be on *site*, instructed and ready to assist should trouble happen.

AVOIDING THE RF BITE

Everyone tasked with maintenance should know that when it is time to service an antenna system, the power must be turned off or you are likely to get a nasty surprise when you touch a "hot component."

This is especially important when you find yourself working alone out at the base of an AM tower. In most cases, the prudent action would be to lock the disconnect box in the de-energized position to prevent some "auto-restart" circuit – or some person arriving at the site and discovering the disconnect was off – from actually turning the transmitter on while you are out in the field.

Of course, there are times when you need to have the transmitter turn on and off in order to use a bridge or observe something in the ATU while under power. Trudging back and forth from the tower to the transmitter building for each iteration may take too long, especially if something is trying to burn. But, if you can activate the remote control, *someone else can, too!*

So here is a trick you can use: Just stick a big screwdriver in the lightning ball or horn gap. That will short out the tower. Or – and perhaps even better – use an automobile battery jumper cable to short the tower to ground. But before trying it, please read the next paragraphs.

WARNING

A very important note: AM series-fed towers can accumulate a DC charge of several thousand Volts from wind-driven dust and give you a nasty burn from the arc. Similarly, your AM tower is a great receive antenna, picking up lots and lots of signals from other nearby AM stations.

Therefore, when grounding a tower for safety, connect to the *groundside first, then to the tower*. This safety move can keep you from getting a DC arc burn – or a nasty RF burn – from what seems to be a "dead tower" but is in fact "hot" with a static electricity charge or induced RF.

STEP-START RESISTORS

While doing maintenance where you need to turn the transmitter on and off, be sure to observe the condition of any step-start resistors. These are the resistors many transmitter manufacturers have incorporated in series with the AC mains that feed the transmitter.

Because step-start resistors only conduct electricity in the brief fraction of a second between pushing "Start" or "On" and the length of time it takes the main primary contactor to start, step-start resistors in a typical 5 kW transmitter may be as small as 50 Watts.

If you start the transmitter once every 30 minutes or less, you are generally safe. But restarting the transmitter a dozen or more times in as many minutes while trouble-shooting can cause the step-start resistors to get very hot and open up. Then your transmitter is subject to excessive surge currents on startup, and the stress those excessive surge currents place on the transmitter. Through the years, they can – and do – fail, and you will not know until something does fail, stressed by "across-the-line" starting.

Checking the step-start resistors when performing periodic maintenance (like cleaning the transmitter and its filters) is a good start. And, for just a few dollars, you can place much higher wattage resistors as replacements into the transmitter. It is something the transmitter manufacturer should have done in the first place – and is a very good investment in keeping your transmitter running at top form.

Mike Langner has been a longtime engineer and station owner in Albuquerque, NM. Contact Mike at mlangner@swcp.com

Studio Guide

by George Zahn

A Time When "Feedback" is Wanted

During the course of this series, George Zahn has discussed a variety of microphones. The various families of microphones and some of the more useful models for broadcasters were covered. He has also spoken about how to use these microphones – in terms of selection and placement, for example – so stations can get the most out of their microphone inventory. This has brought comments and questions from many readers.

Last issue, I shared some reader comments on the ElectroVoice 635A, the legend of the "hammer" demonstrations, and an update on the microphone as it is available today.

While we had a number of wonderful stories on the 635A, I did not want to shortchange some of the other wonderful microphone "feedback" messages I have received in recent months from avid ***Radio Guide*** readers. As always, it is a very welcome and humbling opportunity to learn from engineers and managers and their experiences.

DOORS OF OPPORTUNITY

Another microphone that has some lore behind it is the ElectroVoice 676. Some call it the "Jim Morrison" microphone. I even found a YouTube video of a guy playing harmonica on the microphone through a Fender Bassman.

This is the microphone we once referred to here affectionately as the light saber mic, because the silver beauty with highly visible ports looks like it might have been George Lucas' inspiration for the handle of his movie swashbuckling creation.

The EV 676

An archaic microphone? That is what many may think, but some of these old ElectroVoice models refuse to die. While not nearly as prevalent as the 635A, 676's are still in use in many places.

George Portell (W8QBG) reports "I was given one and use it on a Bauer 707 [transmitter] along with a Behringer Shark [pre-amp] and a Shure EQ." George reports that the microphone does quite well for him in this application, but he is looking for the original specifications on the microphone and, while the microphone itself can be found readily on many Internet sources, the specs are difficult to find.

Therefore, we are putting out the ***Radio Guide*** "bat signal" for someone who might have a copy. So far, I have been unable to unearth one.

RIBBON AND BLUES

We have paid plenty of attention to ElectroVoice and their dynamic microphones here, but the ribbon family also has drawn some comments.

Dave Cory, the Chief Engineer of Cherry Creek Radio in St. George, Utah, was inspired by the ***Radio Guide*** interview with AEA and Wes Dooley *(**RG** September 2007, Page 20)* to bring some velocity microphones (and himself) out of retirement.

AEA's R44 ribbon microphone.

Cory wrote, "I am the proud owner of an RCA 44BX and 77DX in pretty good shape and very much would like to bring them up to factory specs. I've sat on them for years and may put them in to use, as a temporary experiment, at my present stations. After normal retirement, I find myself back in charge of eight radio stations as Chief Engineer."

In response, Audio Engineering Associates is one of the main choices for trying to restore and repair classic RCA microphones. They work to create parts as close to the original specifications as possible – and unless you notice the logo, their R44 model is a virtual clone of the 44BX.

One of the reasons Audio Engineering Associates is a bit harder to find, even on the Internet, is that apparently website names that involve the AEA letters were all snarfed up. The best way to contact Wes Dooley at his AEA website is simply to browse to www.wesdooley.com.

For those who have yet to work with ribbon microphones, a well-functioning ribbon (or velocity) microphone offers some of the smoothest and richest sound you can get. The caveats, especially in the classic older ribbons, include fragility of the ribbon element. These are not microphones to be mishandled or blown into, the old amateur way of testing a microphone.

They are also to be kept away from incredibly high Sound Pressure Levels (SPLs) as the force of high amplitude sound waves can damage the very lightweight element. This same light nature of the ribbon is what allows it to be one of the truly great fidelity microphone families. Good luck to Dave on the restoration of his historic gems!

SHURE UNCERTAINTY

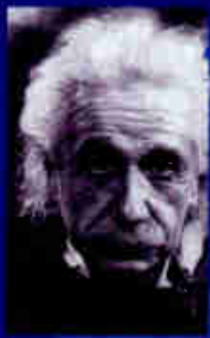
One other "bat signal" to put out there. Steve Manuel of WWJB in Brooksville, Florida had a question about a microphone pre-amp: "Have you ever used or setup a Presonus Eureka in a broadcast situation? We are NewsTalk and I have been trying one out with an SM7B host microphone in our On Air Studio, host microphone. I know the Symetrix 528E has become the standard today but wanted to give the Presonus a run."

The Presonus Eureka boasts variable impedance for the microphone inputs, as well as a three-band parametric EQ which can be set pre or post-compressor on the unit, according to the specifications. There is even a Saturate control which can simulate the audio quality of analog tape saturation. Other features include send and return jacks to allow for patching in other effects.

As many an operator can attest, more controls can be very seductive and should offer more control, but may also introduce more confusion and novel new ways to improve or mess up our sound. In my travels, I have yet to work with one of the Eureka units.

If any of our readers have ideas on the Presonus Eureka versus the Symetrix 528E, especially in relation to using it to process an SM7B for a NewsTalk AM station, feel free to share them and together we can help Steve out. As I have stated before, the collective expertise of ***Radio Guide's*** readers is astounding. Thanks, as always, for your questions and comments which help us all learn more and make us better broadcasters!

George Zahn is the Station Director at WMKV-FM in Cincinnati, OH. He enjoys discussing new and different techniques to help stations improve their sound. Let him know what works for you at gzahn@mkcommunities.org



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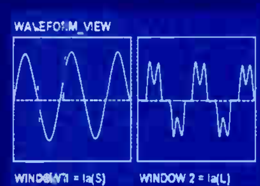

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Protection Guide

by Gary Minker

Protect Gear By Understanding Grounding Methodologies – Part 2

Whether it is an existing facility or one in the planning stages, a careful evaluation of the system ground is essential for safe and controlled dissipation of lightning strikes and other circulating currents. Gary Minker continues his discussion on how to protect your facility.

We left off in our discussion by presenting the concept that while it is not always possible to prevent lightning strikes and other surges in an electrical or RF system, effective control over where and how the strike current flows can go a long way to prevent damage.

This time, we want to take a look at some real life examples of how to implement such control.

THE THEORY

By way of quick review, our goal is to remove the circulating current paths. Then, when an event occurs, everything in the room stands up with a potential rise and, once dissipated milliseconds later, it all sits back down untouched.

Without circulating paths, there is no current flow. With no I/R losses there is no voltage drop. With no voltage drop, there is no dissipation of current. With no dissipation, there is no heating, arcing, or burning.

Because we are dealing with two energy sources, lightning strike potential and AC mains issues, two methods of control must be considered.

SOME EXAMPLES

We will start by showing how this was accomplished at two real stations. Figures 1 and 2 depict the sites of WEAT-FM and WKTK-FM. They are shown in graphic representation of an electrical circuit equivalent in three dimensions, subject to the limitations of my drafting program.

In these representations, resistive and inductive components are considered. Any capacitive features would be considered to be a part of the insulation barrier against the break down of the difference of potential and are not a part of this discussion.

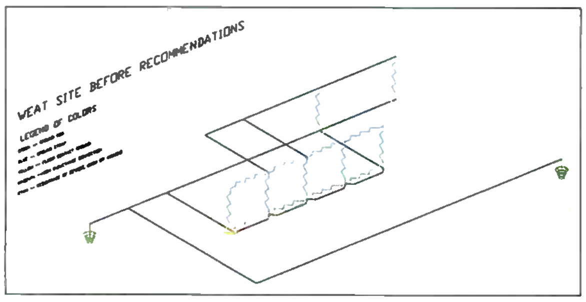


Fig. 1 – WEAT site before recommendations.

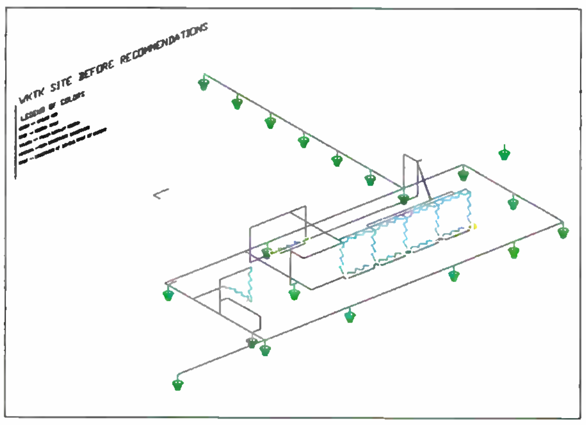


Fig. 2 – WKTK site before recommendations.

Figures 3 and 4 show the same sites after modifications were made or proposed (such changes may or may not have been implemented as yet). By giving attention to detail, one can see that the elimination of circulating paths has largely been accomplished. Of course, it is impossible to eliminate all paths due to electrical codes or physical layout requirements in the conduit and wiring systems.

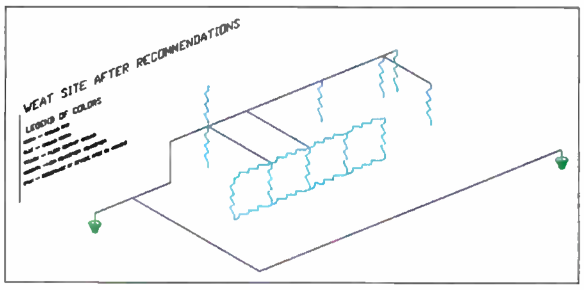


Fig. 3 – WEAT site after recommendations.

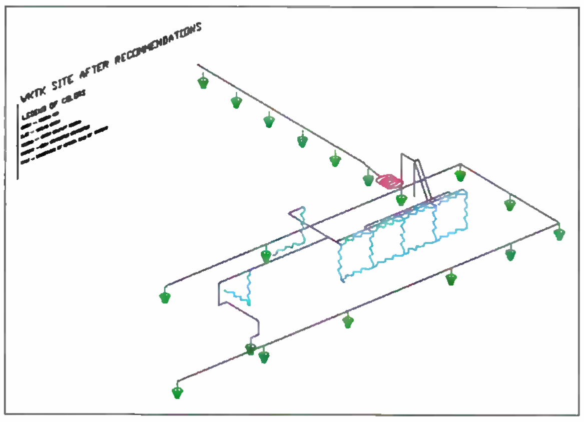


Fig. 4 – WKTK site after recommendations.

What follows is a discussion of the issues considered in the course of making the recommendations depicted.

AC MAINS PROTECTION

First off, it is essential to control the energy impressed on to the AC mains, regardless of the source. Assuming that the spike energy is controlled by either keeping it out of the plant and/or clamping if it is generated by an errant machine in the plant, this topic is easily dealt with. There are many devices on the market, sold through their claimed contributions to peak voltage limiting of the mains. These largely will be ignored.

Suffice to say, regardless of the spike source, limiting of the spike voltage is essential to minimizing the damage to the equipment in the shelter. Surge arresting is typically accomplished via devices situated across the line to neutral, line to ground, and neutral to ground. The two basic types of mains surge arresting are series-inserted devices and parallel devices.

Series devices are substantially more effective at spike control in the use of inductors, as those devices often also contain a method of sine wave tracking – which minimizes the spike to a low RMS average value, as opposed to peak value – regardless of the position or location on the sine wave. Parallel devices usually only clamp the spike voltages to a prescribed value regardless of the location (time, and angle) on the sine wave.

HANDLING STRIKES

This is the tough one. As we discussed last time, the strike needs to be diverted. Entry of the strike energy into the shelter must be avoided.

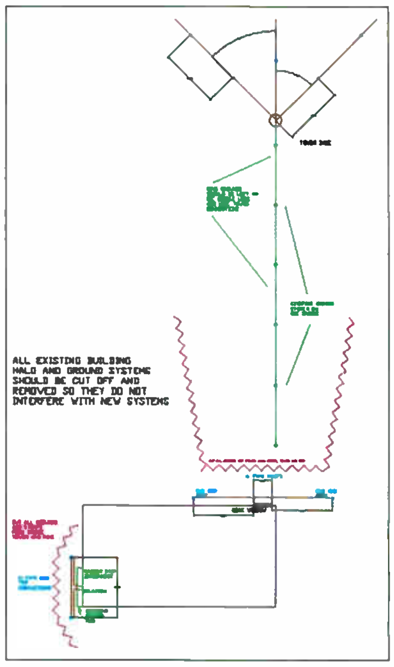
The entry of strike energy into a shelter system through the grounding system and devices in mechanical contact with the floor causes another significant source of damage and is called the Reverse Burst. This is the crux of the requirement to insulate devices from the floor in the shelter. The rest of the diversion is left up to effective fire walling of the energy at a machine location.

The AC mains protective system can assist with this imparted energy – but only if it is impressed onto the mains conductors or attempts to breach the conductors insulation value, if entry is achieved on the grounded or neutral conductors side of the shelter devices.

Enter the Single Point or Star ground.

SINGLE POINT GROUND

In a physical plant the size of any transmitter facility, whether simple cellular or broadcast, a true ground at a single point is problematical, if not almost possible. A more realistic approach is introducing the design called the Distributed Single Point System.



A proposed grounding design for the WKTK site.

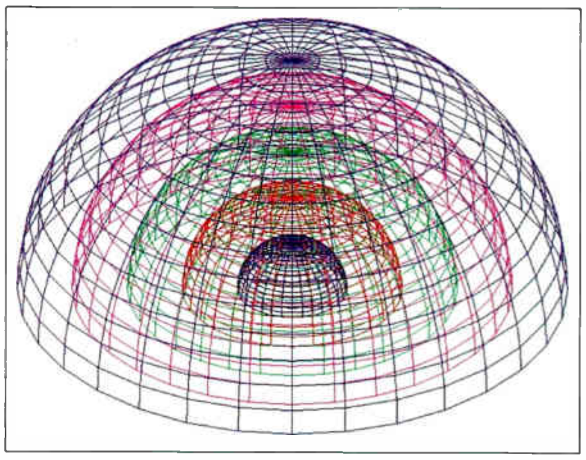
This theory involves the creation of single point entities unto themselves, acting upon and by themselves, and minimizing electrical contact (conduction) to the other members of the quantity. For example, consider this design for a grounding system for the WKTK site.

In this design four distinct areas of concern - which we shall term "entities" – are created: The Tower entity, the Cable Portal entity, the Mains entity, and the Shelter Systems entity. We shall consider each in turn.

THE TOWER ENTITY

At the top of the drawing is the tower entity. You will notice a dissipative array called the "Crow Foot" is applied to promote the "throwing" of the charge away from the shelter. This is accomplished by installing this geometry of the array outwardly, away from the shelter and downwardly via 40-foot driven rods (the physical design may be modified according to local conditions).

It is important to accept that the energy from a lightning strike onto untreated soil imparts energy that is half-spheroid in shape. Essentially, the energy will radiate downward as well as circumferentially outward – except in cases where gradient moisture changes the geometry which cause a cardioid emanation downward.



Energy from lightning moves down and outward.

Strike energy imparted into a single ground rod of sufficient length and construction changes the geometry of the imparted energy into an ellipsoidal or conical expression with minimal horizontal radiation. The energy will prefer to travel on the metallic conductor rather than radiate outwardly into unknown soils.

STOPPING UNWANTED ENERGY TRANSFER

This Tower array Single Point entity exists singularly. To maintain compliance with the NEC, this array is allowed to be contiguously connected to the shelter – only – via the descending cables from the tower.

While these cables are also treated as a part of the tower entity in strike management, there is some remaining energy transmitted via these conductors. This haphazard conduction into the structure needs to be addressed in a secondary way. (Continued on Page 28)

Seek and Ye Shall Receive

DSC-32/64 Dual Satellite Remote Control

The DSC-32/64 allows the remote control of any combination of TWO X-Digital Systems XDS, IDC "MAX", StarGuide II / III, Wegener Unity 4000 or ComStream receivers. A front panel encoder control with a 16 x 2 backlit LCD display provides local control and program descriptions, while external control may be in the form of RS-232 (Optional USB or ETHERNET) serial and/or contact closures.

PS-99 Programmable Scheduler-99

The Programmable Scheduler can store and control up to 99 events. Events may be programmed with Hour/Minutes/Seconds and Day/Month/Year or Day of Week.

TimeSync Plus

The tiny TOOLS Time Sync Plus provides four separate GPS time referenced outputs. The Time Sync Plus would be a great companion for the PS-99.

COA-37 XDS Connect 'O Adapter

Here's another problem solver from Broadcast Tools for the X-Digital Systems XDS, StarGuide II / III satellite receiver! The Connect O' Adapter 37 XDS provides an effective way to convert the DB-37 connector to the euroblock removable screw terminals.

COA-9 XDS/MAX

The Connect O'Adapter-9 allows you to convert the DB-9 connector on your X-Digital Systems XDS,IDC "MAX" and StarGuide II / III receiver to the euroblock removable screw terminals.

COA-15 MAX

Need to convert the DB-15 connector to the euroblock removable screw terminals? The Connect O'Adapter 15 MAX will do the job. The COA-15 MAX is designed to plug into the male 15-pin D-Sub connector on the IDC "MAX", StarGuide II / III.

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* *New products available June 2008.*

Protection Guide

by Gary Minker

Protect Gear By Understanding Grounding Methodologies - Part 2

– Continued from Page 26 –

Bonding descending cables to ground.

The geometry of departure of the conductors that go toward the shelter determines the amount of energy imparted. A simple 90-degree bend offers some change of impedance to the strike energy. Creating a dip in the conductors in excess of 90 degrees, if not a full circle, offers substantially more inductance.

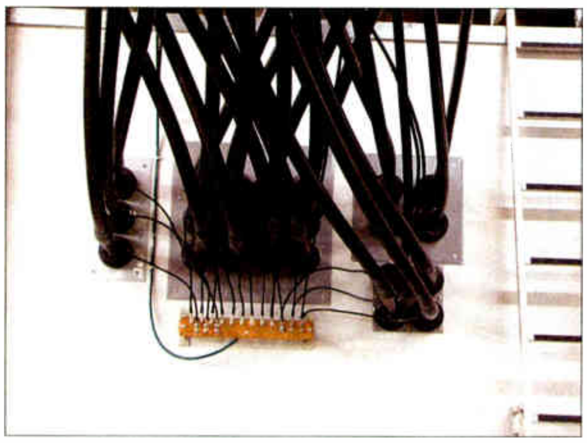
Coiling conductors provides an inductance path against strikes.

Where possible, one or two turns in a rigid loop formation offers the greatest rise in the inductive path value and creates the highest impedance to this energy which can be bled off to the tower ground before heading for the shelter. This is especially effective when the conductors are appropriately grounded and bonded to the tower ground entity – not the structure itself, as this a common mistake in order to bleed the charge off of the lateral run. Cables that cannot be coiled can be sleeved in rigid conduit to simulate a torroid.

CABLE PORTAL ENTITY

The cable portal can be a major source of energy imparted to the shelter.

This portal entity is controlled by the proper application of various devices and methodologies such as grounding straps and surge arresting coaxial devices to the cables entering the shelter. Energy from these cables may be arrested and controlled by the driven array curtain as shown in the WKTK ground design drawing on the previous page ("Cable portal curtain") – if it is properly applied.



The array curtain for the cable portal.

The grounding entity in the drawing is in compliance with the NEC in the requirement of a contiguous connection, if only via the cable conductors. This brings us to one of the keys to understanding the system: the connection of the tower and portal arrays are indeed contiguous, but they also are highly inductive. It is this high inductance value and low curtain-array resistance that creates a substantial barrier to strike energy – in effect, an RF shunt network.

It should not be debated that unlike a standard Fall of Potential grounding system test which measures the effectiveness of non-RF wave fronts, high inductance values pose significant impedance figures to any imparted strike energy due to the high rise time (high frequency) emulation of the strike.

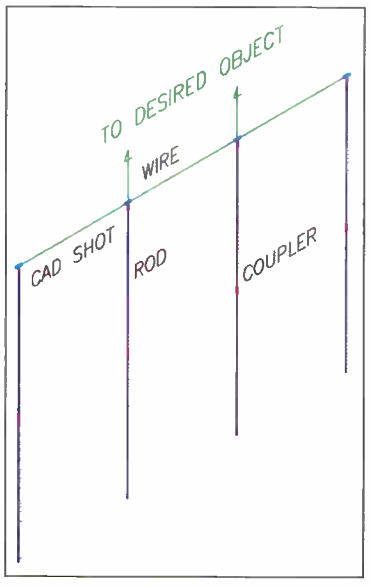
This ground strap, on the last Ice Bridge before the building, should be cut.

The tower entity is inductively separated from the portal entity via this high inductance. This high inductance is insured by the cutting of the traditional convention of the connected ground strap to the tower system and the portal/shelter entities. The strap is a low inductance throw back to the early days of AM broadcast and has no place in modern grounding considerations.

MAINS ENTITY

The mains entity incorporates a similar curtain array as does the portal. This driven array bonds the AC mains to earth, thus enhancing the NEC requirement of a driven stabilizing ground conductor.

It should be understood that the driven ground conductor at the base of the supply pole or ground-mounted transformer is placed *to protect the Power Company assets and stabilize their device.* The mains array only has contiguous connectivity to the Power Company via a relatively small conductor which is very high in impedance and inductance above 60 Hertz. This is fortunate, since the Power Company grounding conductor is tied to *another lightning rod that is many miles long.*



The array curtain for the AC Mains.

The mains entity also has contiguous connectivity with the shelter electrical distribution system via a much lower impedance conductor due to the multiplicative paths of grounds, neutrals, and the Neutral bonding screw (or bolt, on larger systems). Sufficiently sized neutral conductors, and the added use of segregated grounding conductors in both insulated dedicated conductors (green) and the related metallic conduit systems, augment this low impedance.

Rather than focusing on any claim that the NEC is designed to damage systems in the shelter, let us instead note that attention paid to conductor size, bonding, and conduit layout and assembly during site design or re-work which facilitates the Distributed Star Point construction within any shelter.

SHELTER SYSTEMS ENTITY

The Shelter entity Single Point design often is the most corrupted. While attempting to maintain the Single Point design inside the shelter the occasional crossed-connections cannot be avoided. Poor connections to the outside world can further frustrate implementation of any ground design.

Simply stated, this is not a ground.

At the same time, the installation of inter-device conduits and control circuits often inadvertently destroys the Single Point design and cannot be avoided. These problems can be minimized on a best-effort basis by more careful design of the conduit systems and subsequent bonding of these systems.

BAD CONVENTION

The shelter system itself has long suffered from conforming to the antique convention of running the tower ground bonding straps from the tower entity invasively inward to the floor of the shelter. This strap usually also picks up the building steel, floor reinforcing bar systems, and the bases of all metallic machinery in the shelter, and then heads for the AC mains system.

Then, when strike energy enters the shelter, a circulating current flows in an inductively induced, fly-wheeling manner throughout the shelter one or more times before dissipating. In turn, this flow of current treats the fall of potential from the top to the bottom of a metallic device as a fuse. In fact, sufficient energy in this fall of potential turns *everything* in the rack into a fuse. The result is seen in arc-overs and other damage.

This strap system creates a dynamic circulating current loop not only for AC mains stray voltages and currents, but also for distribution of strike potentials from both direct conduction and antenna-like inductive pick-up of EMP magnetic waves. It is exactly the installation of this strap system on the *bottom* of each metallic device that causes the "Fuse Effect."

GROUND SYSTEM STRAPS

Of course, an exception must be mentioned which involves methods of integrity for AM Radio Stations regarding the connectivity of the transmitter, Antenna Phasing Equipment, and the Antenna arrays. The incorporation of the large strap system has been considered a key component to the proper installation of these systems.

However, a debatable theory maintains that treating the bonding strap with a substantial curtain array at the entrance to the shelter will assist in the control of incoming energy to the Shelter. It has been my experience that the straps' entry into the building is unnecessary and may be inductively segregated or eliminated as suggested here while still maintaining the RF integrity of the system, unless required by phasing equipment.

PROTECTING SHELTER CONTENTS

Again, the goal is to eliminate circulating paths. For that reason, we recommend an installation method that utilizes not only the top-of-device connectivity convention, but also insulates metallic devices from the floor.

The removal of the strap system from the bottoms of the shelter devices is key and critical. Wood, plastic, or other insulation can be used, but to avoid any circulating currents working their way through the equipment, it should not rest on the floor.

Other good practices to implement include insulation for support hardware and poles, as well as for the operator when on site. In high lightning areas, even a rubber doormat can provide useful protection. *(Continued on Page 30)*

Protection Guide

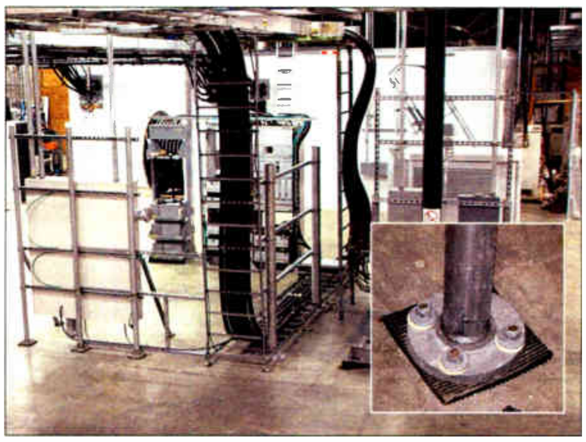
by Gary Minker

– Continued from Page 28 –

All connections are made at the top of the equipment.

Even a doormat can be used to keep equipment from contacting the floor.

Wooden blocks insulate the equipment from the circulating currents.

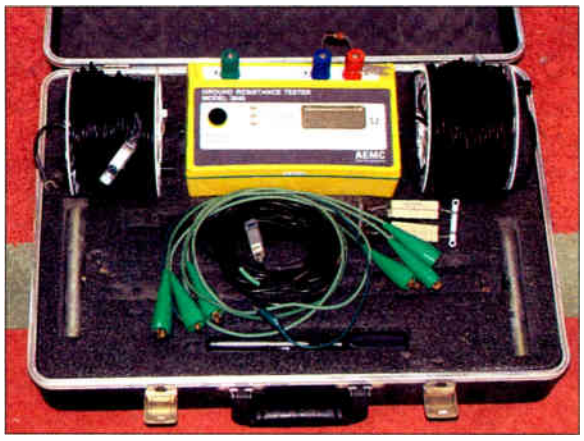


Whenever possible, avoid providing a straight path for strike current.

IMPLEMENTATION AND TESTING

Once a site or design has been reviewed and the recommended design is accepted, the construction or modification of a site should commence.

During construction the testing of the various conductor paths to be removed or observed may be done by using test instruments. A three-point resistance testing set will give reliable readings.



A ground resistance tester.

Small isolated two-Ampere power supplies or AC voltage sources with an ammeter may be used with a variac to determine the resistivity of a conductive path where stray currents or voltages may exist either due to leakage or induction.

You can also use a Volt-Ohm meter, although Ohm meters are subject to errant readings due to small stray circulating currents in the Shelter Entity. This can be confirmed by the careful removal of one end of a grounding conductor and noting that a voltage exists on this now free wire. This is likely indicative of another potential (no pun intended) problem in the plant.

Outside, clamp-on meters may be well-suited for measuring, tracking and routine maintenance of rods by recording the stray currents and resistance of a given single-ended entity such as a rod in an inspection well once or twice per year. A spreadsheet is helpful in tracking any changes to these systems.

Clamp-on meters will measure currents in ground wires and rods.

It is the goal of a conductor to have a very low resistance within the entity in which it exists and to have a low resistance toward the grounding array to which it belongs. In order to comply with the requirements of the electrical code there needs to a high inductive coupled impedance value between the different entities.

Examples of highly inductive couplers could include the outer conductors of RF related cables or the shields of signal cables between one entity and another. Where these casual conductors do not exist, a coil of wire of an appropriate gauge may be created and contained within a steel enclosure of sufficient size with a removable cover to hold and protect it.

This coil of wire will allow reasonable amounts of lower frequency currents to pass when needed during a 60 Hertz fault so that the distributed aspect of the large footprint grounding system may come into assistive play but the tightly affixed coils of wire will present a very high inductance/impedance to a high frequency strike whether direct conduction or EMP.

This coil of wire can also be used as a gauge of effectiveness after a known strike to see if the coil has blown open or burned in any way, or if the method of securing the coil such as nylon tie wraps has been damaged. The integrity of the system is totally dependant on the methods of connection, whether bolted, clamped or preferably exothermic. Once abnormal conductors have been identified as either removable or repairable, the system can be fixed.

The integrity of each entity is dependent upon its ability to stand alone in its function and to not affect, or rely on, the entities adjacent to it.

INSPECTION

In the design of the various entities of the grounding system, it is important to be able to inspect, log, and repeat testing and verification of the effectiveness of the design along with certain components. The use of large, deep, plastic valve boxes or inspection boxes at the location of each driven rod is very important.

At regular intervals, use of a device such as the clamp-on ground component tester may be utilized to verify the continued resistivity of a driven or planted-rod system. This device is simply clamped around a singled-ended entity such as a ground rod or a wire singularly leading to a ground rod. This resistive value should be logged and maintained for future use and testing.

What you are looking for is evidence of "glassification." Glassification happens when the earth surrounding a driven ground rod is turned into a glass-like material from extreme heat in proximity to the rod. Glassification of a ground rod renders it useless as a conductor of strike energy – and may raise the resistive value by a magnitude of several hundred times the initial driven value. Contact with a glassified rod during a strike condition may be fatal as it does not flow current to minimize voltages in I/R losses.

Upon finding that a particular rod may have "glassified" from the observance of an elevated resistivity, corrective replacement action may be taken.

MAINTENANCE

We have seen various points of view leading to a new cohesive thought of designing, constructing, repairing, and managing a ground system. Nevertheless, in this care and feeding we see that it is possible for even the best design to fail at some point either through the application of overwhelming energy or in the performance of its duty.

Like any electrical or mechanical system it is important that a maintenance and inspection program be designed for the various entities in the facility which is unique to that facility. Hopefully it is this electrical and visual inspection regimen that will expose any deficiencies before they become issues during the next strike event.

It is often noted that simple decay will deteriorate any grounding system. However it is usually the damage that is developed in the performance of its duty that brings most of the damage to light. Hopefully this damage is the sacrificial anode, so to speak, of the system and that the integrity of the apparatus and personnel at the site were spared.

THE BOTTOM LINE

It is not as important what you tend to believe, or even what is fact or fiction. The proof of the matter is that certain techniques work and others are simply ineffective or downright dangerous to materiel or personnel.

As mentioned earlier, as each site is different, each site is the same. The commonalities of installations are the backbone of most system designs. It is the small esoteric differences that require us to apply the element of not only common sense but practicality in the effective design of grounding and electrical systems.

Proper application of the various conventions to each identifiable entity in a physical plant is critical to the longevity and trouble free aspects of survival. Simply because we as a group have done "it" a certain way forever is not a good reason to continue to do this type of thing, especially if there is conclusive proof (if not reasonable conjecture) that there is a better or safer way. Effective application of the numerous grounding conventions needs to avoid the pitfalls of patent infringement or legalities and rights indemnification.

Bold steps need to be taken to create a more unified and appropriate convention that allows the designers and ultimate users the assuredness that a system was specifically and appropriately designed for them and favors none other than them.

In the end, lightning suppression is about control. The best way to control the bull in the china shop is to keep him out all together. Mega Joules of energy will go pretty much where it wants, but with a little creative help, it can be harmlessly diverted.

Gary Minker has analyzed hundreds of electrical and transmission systems. The owner of Radio Works R.F. Consulting (www.radioworksrfconsulting.com) in Lake Worth, FL he can be contacted at gary@radioworksrfconsulting.com

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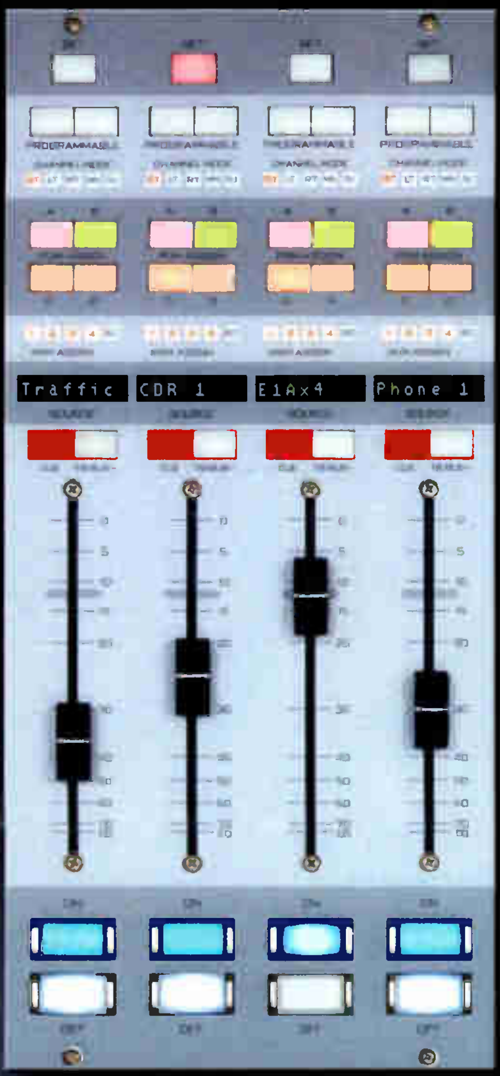
EVOLUTION-6

The E-6 is a powerful, compact and cost-efficient networked audio control surface with buil and a powerful set of PRODUCTION TOOLS for each input channel, allowing a single surfa reconfigured for different talent, studio and format requirements.



E-6 INPUT CHANNELS can access networked audio sources with the press of a button. All sources are displayed right above the fader. Each fader has its own mix-minus output (in addition to the console's own 4 MXM busses). SET buttons at the top of each channel can access a powerful array of production tools individually tailored for each input strip. These include four bands of parametric EQ, compressor/limiter, expander, pan, mode, HPF, LPF and phase reverse. These EQ/DYNAMIC functions allow powerful per channel mic processing. The console has four output busses (can include 5.1 surround), 4 mix-minus busses and 4 aux mixes (all with TB). Each input channel also has two programmable buttons for customized functions, as well as ON/OFF switches with built-in machine control (logic follows source).

The Wheatstone Evolution-6 Digital Audio Control Surface

in EVENT RECALL
e to be instantly

THE REALTIME HI-RES GRAPHIC DISPLAY keeps operators up to date and completely informed concerning all surface functions. Metering, bus assignment, channel status and sources, event recall, monitors, EQ and dynamics—all appear here via the mouse/trackpad driven GUI. Note the surface drives the VGA monitor with built-in circuitry (no external PC required).

THE MONITOR/SET PANEL (right) has Control Room, Headphone, and two independent Studio outputs. It also allows the operator to program input channels via the SET function: aux mix and mix-minus assign (4 each; all with talkback), input source select, and pan. The panel also has fourteen programmable buttons which can initiate custom functions like remote setups, intercom, machine commands and salvos.

Available in 4, 8, 12, 16, 20, or 24 channel mainframes

The E-6 audio control surface interfaces directly with Wheatstone's E-Series network switch and associated studio satellite I/O cages. Wiring between components is via single CAT-5 cables, eliminating point-to-point multi-pair runs. **Each studio surface operates independently, yet can share all network sources and mixes with others.**

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Heavy Metal

by J.S. Sellmeyer, P.E.

RCA's Transition to Design & Manufacturing

Part 3 – The RCA BTA-50F Series

During World War II, most transmitter deliveries were put on hold. Lessons learned from the war effort by the manufacturers in every industry led to improved designs and production standards for many products, including radio transmitters. As the War ended, RCA was active on several fronts, and brought to market some venerable products. Jack Sellmeyer continues his look at RCA's evolution.

After only four RCA 50-E transmitters *(see **Radio Guide**, July-August 2008)* were delivered to the domestic market, World War II intervened and diverted most all commercial electronic production to support the war effort. It has been reported that several RCA 50-E transmitters were delivered to foreign governments to support the psychological war effort, but none of the deliveries or quantities have been confirmed.

In the latter years of the war, RCA began to devote some planning and preliminary design effort to the direction the company would take in the post war years. To that end in late 1943 RCA began the efforts toward improvements to the 50-E design.

Information was compiled about problem areas in the 50-E radio and a newer model, the "50-F" design was begun. This radio was evolutionary in that it retained much of the circuitry of the 50-E and many of the individual cabinets, with only minor updating to the circuitry to take advantage of newer tubes and different circuit topology in some cases.

EXPANDING THE PRODUCT LINE

In the post-war years, RCA expanded its broadcasting offerings in an exponential manner, offering complete product lines for the Broadcast Audio Systems, Standard (AM) Broadcast Transmitters, FM Broadcast Transmitters, Television Broadcast Transmitters and Television Broadcast Studio Equipment.

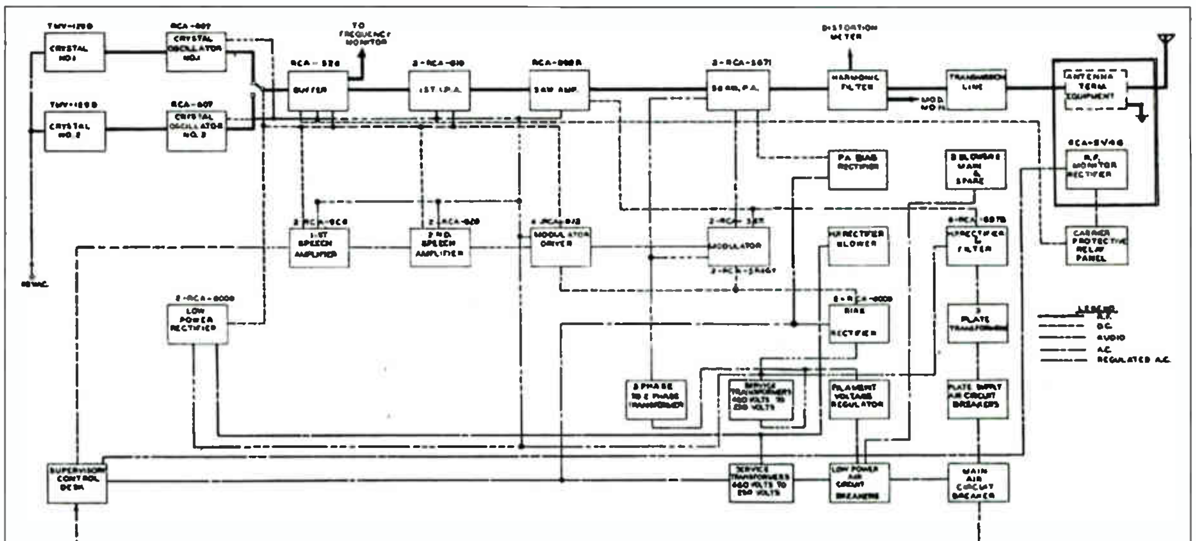
With this major increase in the broadcast product line, a new product numbering system was needed to distinguish between the different product areas. For transmitters, a prefix was added to the power level to differentiate between the AM, FM, HF Broadcast and Television Broadcast transmitters. The following table illustrates the various prefixes, power levels and series numbers.

RCA Transmitter Model Numbering Sysytem

Product	Pwr Level	Series	Rev	Notes
BTA	Watts (< 1 kW) kW (> 1 kW)	F	1	AM Broadcast
BTF	kW	B	-	FM broadcast
BHA	kW	-	-	HF broadcast
TT	kW	AL	-	TV CH 2-6
TT	kW	AH	-	TV CH 7-13
TTU	kW	B	-	TV CH-14-83

Thus the next 50 kilowatt AM transmitter in the line would have BTA-50F on the nameplate.

The BTA-50F series began production in early 1947 and ceased production about 1954, producing one of the best sounding and most popular 50 kilowatt transmitters ever produced. At least fifteen units were produced and installed in the US and Canada in what was primarily a replacement market at that time.



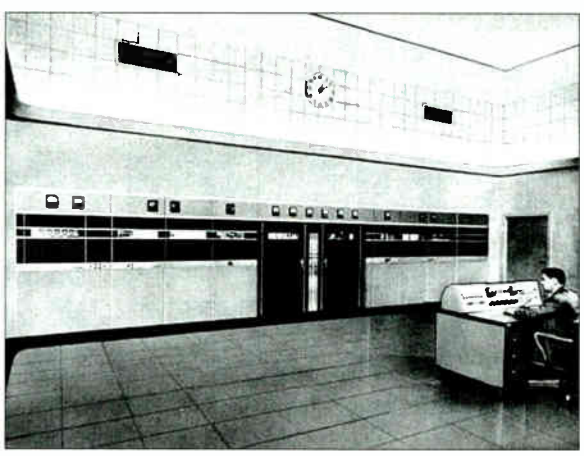
The Block Diagram for the BTA-50F

FRAME CONSTRUCTION

RCA continued with the Art Deco styling first incorporated in the 50-D and the 50-E. This arrangement, when combined with an overall "drape wall" atop the transmitter and side walls at the ends of the transmitter, presented a very attractive appearance. RCA would retain this approach to transmitter housings for several generations of AM, FM, and television transmitters.

The BTA-50F transmitter was constructed from functional units contained in free-standing steel frames which were placed behind the RCA "unified panel arrangement." The "unified panel" consisted of a series of Art Deco styled, painted steel panels which together formed the front panel of the transmitter. The individual panels were joined together on a steel rail, bolted to the floor of the building and attached to the front of each of the individual assemblies.

The transmitter was 33 feet wide, 7 feet high and 17 feet deep, including the high voltage and modulation transformers, their associated reactors, and the required safety fences or transformer vaults where required.



The original RCA BTA-50 installed at WGAR.

The first BTA-50F was delivered in early 1947 to Station WGAR, Cleveland, Ohio – a Class II station.

A second BTA-50F was ordered for Station KMPC, Los Angeles, California, then co-owned by the G.A. Richards Group, headquartered in Detroit, Michigan; it was installed about a year later. At that time, Mal Mobley, the Field Engineering Supervisor for the Richards Group, was transferred to Los Angeles to oversee an addition to the KMPC transmitter building and the installation of the new 50 kW transmitter.

LOOKING INSIDE THE BTA-50F

Comparing the block diagram of the BTA-50F series with the one for the 50-E shows some of the design changes, especially in the exciter and low level audio sections. The BTA-50F had a total of 29 tubes of nine types in the basic transmitter, ten fewer that the 50-E. Of these, ten were mercury vapor rectifiers.

An interesting feature of the BTA-50F documentation was that the transmitter schematic was printed on high quality linen cloth using colored ink to highlight the different circuits.

IMPROVED EFFICIENCY

Some of RCA's built-in redundancy was carried over from the 50-E series.

For example, the BTA-50F had built-in backup in the event of a serious fault in the high power stages. Also retained was the in-place spare high voltage rectifier tube which could be rapidly inserted into the faulty position in the event of a tube failure. A third tube position was added to the modulator cabinet for a spare tube, and the two now excess sockets in the RF PA were used for in-place spare tubes.

Although the BTA-50F series initially maintained the overall AC to RF conversion efficiency of the 50-E, RCA was able later to improve it by more than ten percent.

Overall Power Consumption at 50 kW RF Output

Model	0% Mod	25% Mod	100% Mod	Efficiency
50-D	140 kW	Not Spec	175 kW	43%
50-E	110 kW	120 kW	156 kW	48%
BTA-50F	116 kW	124 kW	158 kW	47%
BTA-50F1	96.5 kW	105 kW	138 kW	54%

The higher efficiency reached by the F series allowed for even better reliability through redundancy. An in-place spare modulator tube was provided as well as *two* in-place spare tubes for the RF power amplifier. These could be quickly placed in service by moving the appropriate wires.

To change the RF power amplifier tube simply required changeing the two filament connections and the grid connection. To put the spare modulator tube on line, it required changing the filament, grid, and the proper plate connections.

Warm-up time for the high power tubes was only 15 seconds, and the system warm-up time was limited primarily by the mercury vapor rectifier and low-level tube warm up times. If the tubes were already warm, a time-delay bypass pushbutton was available to rapidly restore service after the low level tubes had about 30 seconds to warm up.

(Continued on Page 36)

Can a radio console be over-engineered?

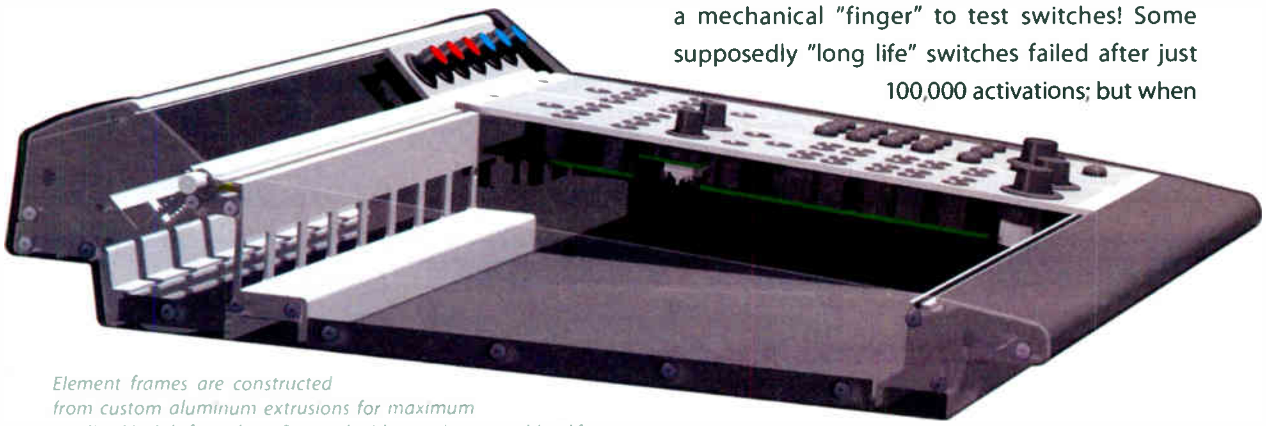
(Only if you think "good enough" really is good enough.)

The radio console, redefined.

Building a great console is more than punching holes in sheet metal and stuffing a few switches in them. Building a great console takes time, brain-power and determination. That's why Axia has hired brilliant engineers who are certified "OCD": **Obsessive Console Designers,** driven to create the most useful, powerful, hardest-working consoles in the world.

Beneath the surface

There's more to a great board than just features. **Consoles have to be rugged,** to perform flawlessly 24/7, 365 days-a-year, for years at a time. So we literally scoured the globe for the absolute best parts — hardware that will take the torture that jocks dish out on a daily basis.



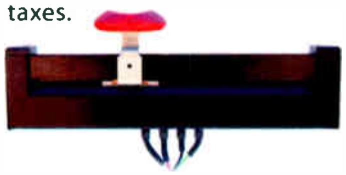
Element frames are constructed from custom aluminum extrusions for maximum rigidity. Module face plates & console side panels are machined from thick plate aluminum. Even the hand rest is a beefy extrusion. All this heavy metal means even the most ham handed jock can't dent it.

First, Element is fabricated from thick, **machined aluminum extrusions** for rigidity and RF immunity. The result: a board that will stand up to nearly anything.

With so many devices in the studio these days, the last thing anyone needs is gear with a noisy cooling fan. That's why Element's **power-supply is fanless**, for perfectly silent operation inside the studio.

Element modules are **hot-swappable**, of course, and quickly removable. They connect to the frame via CAT-5, so pulling one is as simple as removing two screws and unplugging an RJ — no motherboard or edge connectors here.

Faders take massive abuse. The ones used in other consoles have a big slot on top that sucks in dirt, crumbs and liquid like the government sucks in taxes. By contrast, our silky-smooth conductive-plastic faders actuate from the side, so that **grunge can't get in**. And our rotary controls are high-end optical encoders, rated for more than **five million rotations**. No wipers to clean or wear out — they'll last so long, they'll outlive your mother-in-law (and that's saying something).



Element's **avionics-grade switches** are cut from the same cloth. Our design team was so obsessed with finding the perfect long-life components that they actually built a mechanical "finger" to test switches! Some supposedly "long life" switches failed after just 100,000 activations; but when our guys found the switches used in Element, they shut off the machine after **2 million operations** and declared a winner. (The losers got an all-expense-paid trip to the landfill.)

Element's individual components are **easy to service**. Faders come out after removing just two screws. Switches and rotary volume controls are likewise simple to access. And all lamps are LEDs, so you'll likely **never need to replace them**.

Engineers have said for years that console finishes don't stand up to day-to-day use. Silk-screened graphics wear off; plastic overlays last longer, but they crack and chip — especially around switches and fader slots, where fingers can easily get cut on the sharp, splintered edges. We decided that we could do better.

There's a reason these board-ops are smiling. Axia consoles are in more than 1000 studios worldwide

Element uses high-impact Lexan overlays with color and printing on the back, where it **can't rub off.** And instead of just sticking the Lexan to the top of the module like some folks do, our overlays are **inlaid on the milled aluminum module faces** to keep the edges from cracking and peeling — expensive to make, but worth it. For extra protection, there are **custom bezels** around faders, switches and buttons to guard those edges, too. Which means that Element modules will **look great for years.**

By the way, those on/off keys, fader knobs and bezels are our own design, custom-molded to give **positive tactile feedback**. The switch is flush with the top of the bezel, so it's easy to find by touch. But if something gets dropped on it, the bezel keeps the switch from being accidentally activated.

More than just products

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Consoles

Heavy Metal

– Continued from Page 34 –

THE RF EXCITER

The RF Exciter stage was located at the left end of the cabinet.

This unit was, effectively, the RF section of the BTA-250L, a 250 Watt AM transmitter. It consisted of two UL-4392 crystal-controlled oscillators – an updated version of the UV-4292 oscillator which was used in all of the RCA AM transmitters beginning in the early to mid-1930's. The only significant differences in the two units were a tube change to the more modern 807 and the replacement of the output inductors with a single tapped Litz wire coil. The two units were interchangeable.

A front panel changeover switch was provided for selection of the active oscillator. The crystal ovens were powered from a 110 Volt circuit separate from the 460/480 Volt AC mains supply.

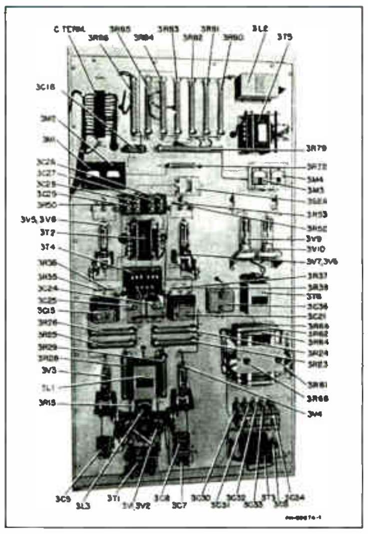
The exciter consisted of only four stages to arrive at the five kilowatt level. These were the oscillator stage (an 807), a buffer stage (an 828), and parallel 810's operating as the driver for the five kilowatt power amplifier stage. The identical circuitry was used in the BTA-5F and BTA-10F transmitters.

All of the tubes and components except those associated with the 892R five kilowatt amplifier were mounted on the front of the RF Exciter unit and were accessible through the left door. The meters above this door were associated with the five kilowatt amplifier stage displaying grid and plate currents for the stage.

The five kilowatt driver stage was located inside the cabinet on which the RF Exciter was mounted. It was accessed through a pair of rear doors. The circuitry was basically the same as the 50-E Exciter.

THE AUDIO DRIVER

The audio driver circuit for the BTA-50F modulator is virtually identical to that of the 50-E. This circuit was carried forward intact to the BTA-50F, mounted on the hinged rear door of the modulator cabinet as shown.



The audio driver on the rear of the modulator cabinet.

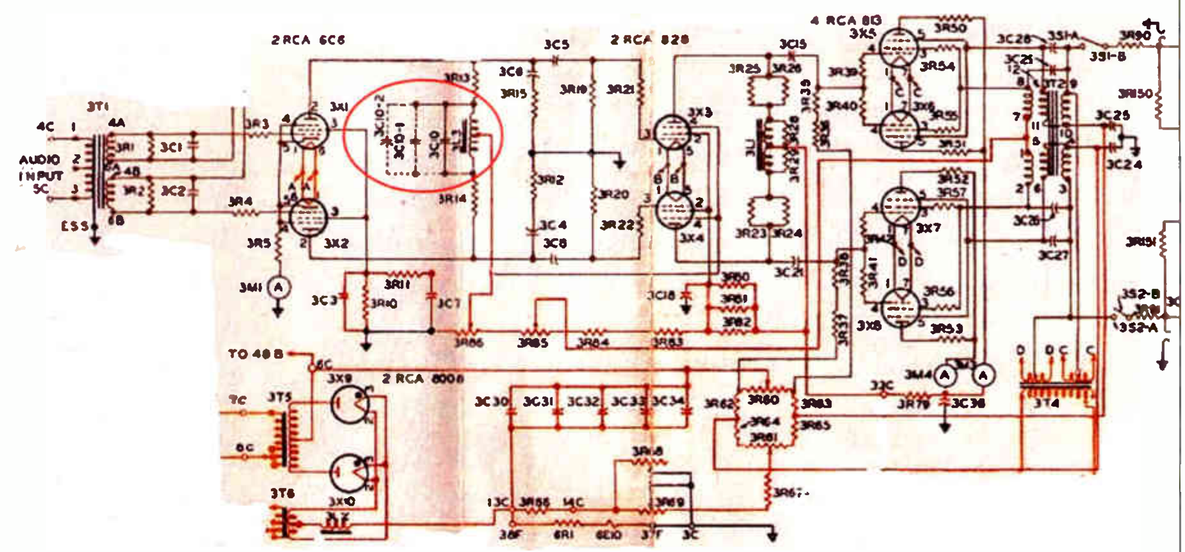
The modulator consisted of a pair of newly developed 9C22 forced-air cooled triodes operated in Class B, driven by four 828 beam power tetrodes operated as Class A cathode followers, configured in push-pull parallel.

The four 828's were coupled to the 9C22's through a novel arrangement using a six-winding, tightly coupled iron-core choke arrangement. The cathode follower stage was driven by a pair of 828's in push-pull, operating as a Class A amplifier stage.

The intermediate amplifier stage was driven by a pair of 6C6 pentodes. Overall feedback taken from the primary of the modulation transformer was applied in series with the split secondaries of the audio input transformer to the 6C6 input stage.

Hum originating in the high power amplifier filaments continued to be a problem in the early days. This was due to modulation of the electron stream by the AC powered filaments. Early transmitters used DC motor-generator sets to produce the high current, low voltages required to heat the filaments of the high power RF and audio stages.

(Continued on Page 38)



The BTA-50F audio driver schematic.

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A handheld digital audio analyzer with the measurement power & functions of more expensive instruments, the DL1 Digilyzer analyzes and measures both the digital carrier signal (AES/EBU, SPDIF or ADAT) as well as embedded digital audio. In addition, the DL1 functions as a smart monitor and digital level meter for tracking down signals around the studio. Plugged into either an analog or digital signal line, it automatically detects and measures digital signals or informs if you connect to an analog line. In addition to customary audio, carrier and status bit measurements, the DL1 also includes a comprehensive event logging capability.

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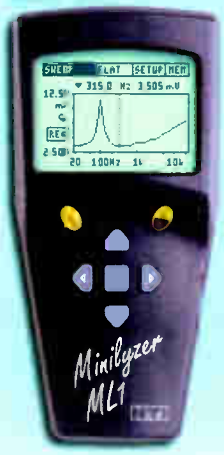

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Heavy Metal

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With the advent of newer tubes, the filaments were powered by center-tapped filament transformers, sometimes operated from three-phase power and sometimes from single-phase power. Use of the center tap in many cases reduced the hum contribution significantly by balancing out most of the hum caused by the application of AC power to the filaments.

While this was generally effective it was not sufficient to fully suppress the hum caused by the high power filaments required for the 9C22 tubes used in the modulator and RF power amplifier. This led to some innovations and novel use of negative feedback to aid in further suppression of the predominant hum frequencies.

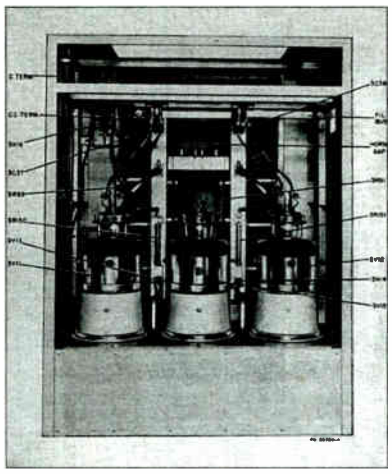
In the first audio stage plate circuit a parallel-tuned circuit consisting of inductor 3L3 and 3C10 was tuned to 120 cycles. The circuit presents a very high impedance load on the 6C6 input stage plate circuit resulting in a sharply tuned peak in the open loop frequency response of this stage. When the feedback loop is closed, the response is flattened and the hum frequency generated within the modulator system is suppressed by the amount of the applied feedback.

Thus, the resulting frequency response was essentially flat. The overall hum contribution of the modulator was significantly reduced.

MODULATOR SECTION

The modulator was located to the right of the RF driver cabinet. The modulator stage used a pair of 9C22 tubes in push-pull operating in Class B. As mentioned, a spare modulator tube was included in the modulator compartment.

This stage improved the efficiency over the Class AB-1 mode used in earlier five and ten kilowatt transmitters by reducing the idling current of the modulators and driving the grids into the positive grid region.



The BTA-50F modulator compartment included a built-in spare.

Achieving this required a very low source impedance from the audio driver to deal with the relatively high currents due to the abrupt drop in grid resistance when the grid is driven into the positive grid region. This is readily achieved by the tightly coupled cathode follower stage. The circuit is easily capable of dealing with the abrupt drop in load impedance due to the Class B operation of the modulator tubes, while introducing very little distortion of the waveform.

THE HEAVY METAL

The "Big Iron" in the BTA-50F series was not changed greatly from the 50-E series. As with the 50-E, the modulation transformer was an oil-filled rectangular tank just over six feet high, 40 inches wide, and 25 inches deep – weighing 6,100 pounds, including the 190 gallons of 10C mineral oil weighing 1,400 pounds. The 50-F modulation transformer was rated at 37.5 kVA, an increase of 6 kVA over the 50-E.

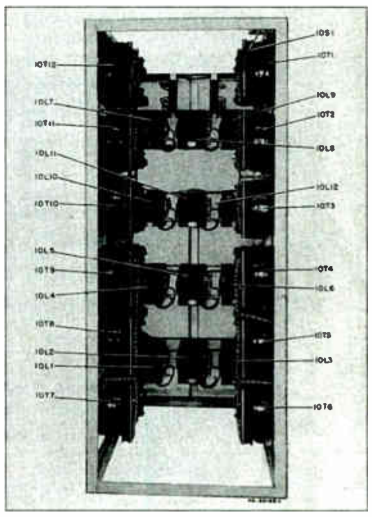
The modulation reactor was an oil-filled round tank about five feet in height using 135 gallons of 10C oil weighing 1,000 pounds. The reactor current rating was increased to 7.5 amperes, versus 6.0 amperes for the 50-E. It is probable that core saturation resulting from high level, low frequency program material was a problem for the 50-E series. The BTA-50F series had no such problems.

The three 50 kVA plate transformers were "pole pig" style tanks about four feet in height, each weighing 1,350 pounds and containing 60.5 pounds of 10C mineral oil.

THE HUM FREQUENCY FEEDBACK AMPLIFIER

The Hum Frequency Feedback Amplifier, a rack-mounted assembly connected between the peak limiter output and the audio input to the modulator, was another 50-E section carried over to the BTA-50F.

The Hum Frequency Feedback Amplifier was needed because the very high currents required by the four high level tubes caused a certain amount of hum. Each of the tubes required 375 Amperes of current at 19.5 Volts. This was supplied by three individual 19.5 Volt transformers, with their secondaries connected in parallel, for each of the four active tubes.



The BTA-50F Filament Supply Cabinet.

The photograph shows the cabinet containing the reactors and transformers. It was located between the modulator and the RF power amplifier cabinets and weighed 2,500 pounds.

(Continued on Page 40)

Heavy Metal

by J.S. Sellmeyer, P.E.

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Four copper busses exited from each side into the associated cabinets to supply filament power to the four active tubes. The busses were one and one-half inch wide by 15/16 of an inch thick.

Each of the transformers included a tapped iron-core reactor in series with the primary of its associated transformer. The reactors were used to limit the peak current to the tube filament during startup and to set the operating voltage. The primaries were fed from a regulated voltage source.

GETTING THE HUM OUT

The unit took an RF sample of the output line current, demodulated it, and removed most of the predominant hum frequency components from the signal. The unit consists of a high gain, two-stage audio amplifier with negative feedback from the plate of the last stage back to the cathode of the first stage. The amplifier also contains a tuned, positive feedback circuit from the plate of the last stage to the grid circuit of the first stage.

Detected audio from an RF sample of the current flowing in the output transmission line to the antenna system was added to the audio output from the peak limiter. The positive feedback loop was carefully tuned to the predominant hum frequency of the RF power amplifier stage by use of a phase-shift network inside the loop. The frequency was adjusted to that of the predominant hum frequency, and the envelope feedback is then adjusted to flatten the frequency response of the overall system.

The hum frequencies are suppressed by the amplitude of the regenerative peak at the hum frequency. Thus the hum in the entire transmitter is reduced considerably, to the extent that the specification of 60 dB below 100 percent modulation could be achieved.

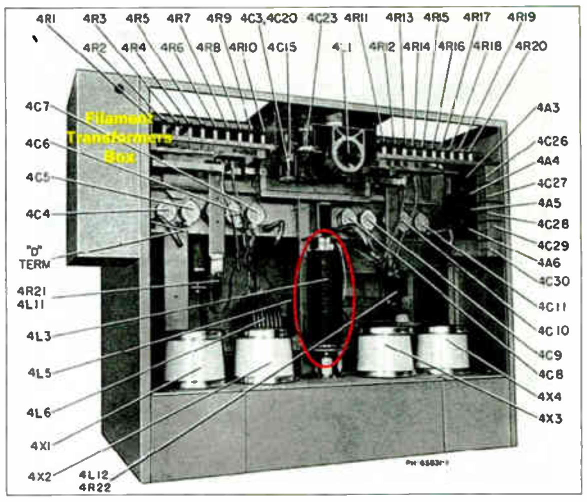
The Hum Frequency Feedback Amplifier would disappear with the BTA-50F1. About 1949, the BTA-50F1 was introduced using new RF PA and modulator tubes with drastically reduced filament power requirements. The filament cabinet would go away and be replaced by a small box attached to the left side of the RF PA, which now contained the reactors and transformers.

With this change, the primary power input requirements would be reduced by about twelve percent. This resulted in overall AC to RF efficiency above 50% for the first time!

50 KW RF POWER AMPLIFIER

The 50 kilowatt RF power amplifier contained in the center cabinet of the transmitter cabinet was nearly identical to that of the 50-E. (The filament cabinet used in the BTA-50F1 may be seen attached to the upper left side of the cabinet.)

Two 9C22 triodes were used in parallel for fifty kilowatt operation. The heavy copper busses from the filament supply cabinet were connected through heavy, flexible copper straps from the filament bypass capacitors to the filament connections on top of the tube envelope.



The RF power amplifier cabinet.

Front panel meters were provided to indicate total grid and plate currents, and individual cathode currents.

Individual parasitic suppressors were installed in the grid and plate connections for each tube and were supported by heavy copper straps. The stage was neutralized by parallel-resonating the grid to plate capacitance and the associated stray capacitance of the wiring. A very long, fixed inductor, 4L3, was made adjustable by the addition of taps to the copper wire which formed the winding

THE OUTPUT NETWORK

The output network was a conventional Pi network using air variable capacitors, rated at 15 kilovolts peak. The capacitors were contained in high pressure tanks, operated at a pressure of approximately 180 psi using dry nitrogen as a dielectric.

The tanks were mounted in an inverted position from the top of the cabinet. Each capacitor was driven from a reversible low speed motor. Front panel pushbuttons controlled the motors. A portion of the tuning capacitor, 4C16, is visible on the following page.

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Heavy Metal

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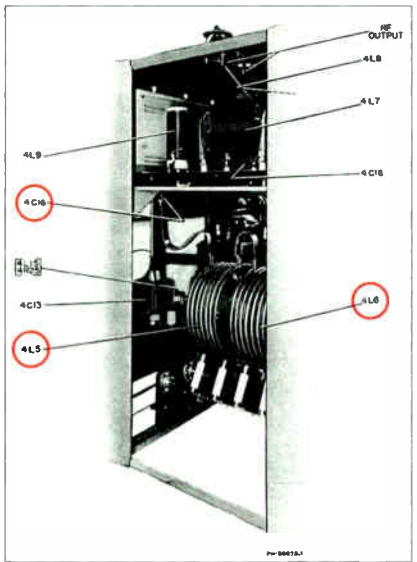
The inductor employed two large coils mounted on a pair of rails to allow adjustment of the mutual coupling between the pair for a wide range of inductance to accommodate the full band. The coils, 4L5 and 4L6 in the picture, were mounted on the floor of the cabinet, centered in the cabinet. This was another carryover from the 50-E.



The output network at the rear of the PA cabinet.

A very wide range of power control was provided by the loading control. This part of the network was contained in a copper-plated steel enclosure attached to the top of the cabinet, centered between the two capacitors.

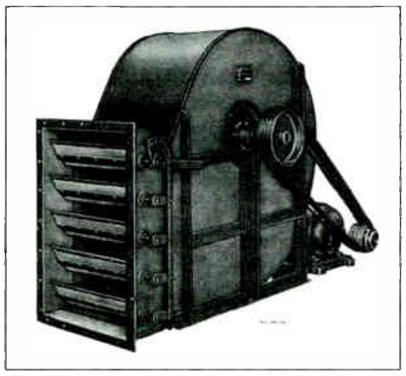
The balance of the output network was referred to in the literature as the Harmonic Filter. It took the form of a conventional "T" network and was installed in a copper-plated steel enclosure mounted to the top of the cabinet. It used edge-wound ribbon coils with conventional taps, along with large mica capacitors as vacuum capacitors were not yet readily available.

Typical transmission line impedances were on the order of 200 to 300 Ohms. Coaxial lines capable of handling the high peak power levels were not yet in common use, so most installations employed a 230 Ohm, six-wire transmission line.

COOLING SYSTEM

The cooling system consisted of a pair of blowers coupled through individual dampers to a large cooling duct, approximately 32 inches high by 48 inches wide, which ran beneath the transmitter for its full length.

The blowers were large, squirrel cage devices indirectly driven by 7.5 horsepower motors through four belts. Each blower delivered 10,700 cubic feet of air per minute at a static pressure of 2.0 inches at sea level to 13,000 CFM at a static air pressure of 2.4 inches at 5,000 feet above sea level. One blower was used to cool all of the power tubes, using individual pipes attached to the air duct to direct the cooling air through the insulators on which the anode coolers rested.



One of the two blowers in a BTA-50F.

The blowers were usually installed in a basement or room located below grade level. Separate contactors were installed in the blower room for each unit, so the blowers could be exchanged without airflow interruption while the transmitter was in operation.

The air intake was a large area, approximately 45 square feet in size, located on an exterior wall of the building. This wall was on the side of a ten-foot by six-foot shaft which extended vertically from the top of the screened intake louvers to the sub-floor grade level. The wall to the blower room was fitted with a group of replaceable air filters charged with a thin layer of oil to capture large particulates carried through the air. Normally a station would have two sets of the filters so they could be rotated and cleaned on a regular basis.

The heated exhaust air from the transmitter cabinets was normally captured by an overhead duct system. It was then either vented outside the building or included in the building heating system for use during the winter.

THE NEW HIGH POWER TUBES

The modulator and RF power amplifier tubes in the BTA-50F design were 9C22's, a tube designed in 1944 by RCA for high power operation. Two were used in the modulator and two in the RF power amplifier. These tubes were a newly designed, forced-air cooled triode rated at 20 kilowatts plate dissipation.

The tubes used a group of copper fins radiating from the core of the anode for cooling. The tube weighed approximately 225 pounds, requiring a hydraulically operated jack and dolly to remove and install the tubes.

The 9C22 had multiple filament strands made from pure tungsten connected to two pairs of posts on the top of the envelope. The strands were operated in parallel for single phase operation. The resulting filament power was 8,092 Watts per tube.

In early 1947, RCA developed a new high power, forced-air cooled triode, using thoriated-tungsten filaments, which resulted in a significant reduction of the power required by the filament. The filament was rated at 11 Volts at 285 Amps and 3,235 Watts, only 38.7 percent of the power required by the 9C22. The plate dissipation was increased to 25 kilowatts with reduced cooling requirements.

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The new tube, bearing RCA development number A-2270-A, was field tested at WGAR, Cleveland, Ohio and KDKA, Pittsburgh, Pennsylvania prior to release to the marketplace as the 5671.

One of the 5671 PA tubes in its socket.

This tube would become original equipment in later generations of both RCA and Westinghouse fifty kilowatt transmitters. The tube was retrofitted into all of the early BTA-50F transmitters as well as the KOB and KGA 50-E transmitters and probably found its way into the WCAU 50E transmitter as well, due to its proximity to RCA. It would become the industry standard for several years, with exceptionally long life – on the order of 80,000 to 90,000 hours in many cases – when the filament voltages were properly managed.

HV POWER SUPPLY & RECTIFIERS

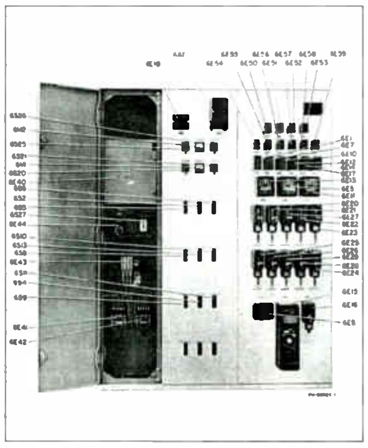
The high voltage power supply for the BTA-50F series transmitter was mechanically identical to the earlier 50-E transmitter. The rectifier rack and filter system also were carried forward to the BTA-50F series with no significant changes.

Because the BTA-50F was a Class C final amplifier modulated by a Class B audio stage, the DC plate voltage was significantly lower than the linear amplifiers which preceded it a couple of generations earlier – on the order 10,000 to 11,000 Volts. This voltage was supplied by three 50 KVA plate transformers supplied from a 460 Volt source.

CONTROL SYSTEM

Differing from the 50-E and earlier transmitters, the BTA-50F series was designed to operate from a 460 Volt three-phase power line. All of the control and protective circuits were consolidated into a single Control and Protective Circuit cabinet behind the right-hand portion of the front panel.

The 460-Volt primary circuits were brought into and distributed from a cabinet located behind the Control and Protective Circuit cabinet. This cabinet contained the main 460 Volt disconnect switch, the Low Power, and the filament contactor, the main plate contactor and the Delta and Wye contactors for the high voltage power supply primary windings. The large General Electric contactors appear on the front of the cabinet.

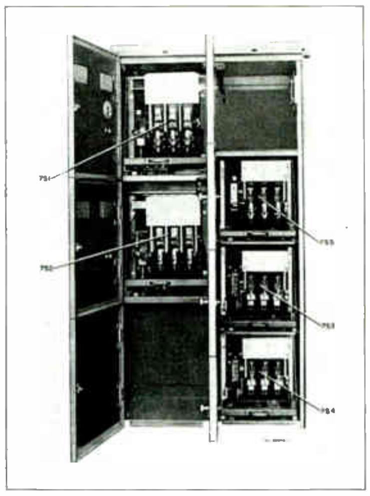


The Switchgear cabinet.

Additional access to the Control and Protective Circuit systems was from the left side and the rear door, which was not interlocked.

UPGRADE

The significant difference between the two series (BTA-50F and 50F1) was the development of the 5671 tube. This tube reduced the power consumption by approximately twenty kilowatts and extended tube life from a couple of years to a decade or more.



A side view showing the overload relays & circuit breakers.

The type 9C22 modulator and power amplifier tubes were replaced with four 5671's. For the existing BTA-50F transmitters, the four 828 tubes in the Audio Driver cathode follower stage were replaced with four 813's. The 813 had considerably higher emission capability than the 828 and provided significantly longer tube life, though not nearly as long as the 5671's.

One of RCA's ads for the 5671 tube.

The RCA Tube Plant in Pennsylvania actively promoted the 5671 in its advertising for use as a retrofit tube with long life and low operating costs.

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The company regularly advertised in Broadcasting Magazine, then the "Bible of Radio Broadcasting" from the early 1950's to the mid-1960's, with glowing customer testimonials of actual tube life.

The twelve modulator and power amplifier filament transformers were replaced with four new transformers rated for 11 Volts at 285 Amperes. The eight unused filament reactors were removed. The filament voltmeter was replaced with a 0-15 Volt meter to allow better accuracy in the ten to eleven Volt range where the 5671's were usually operated.

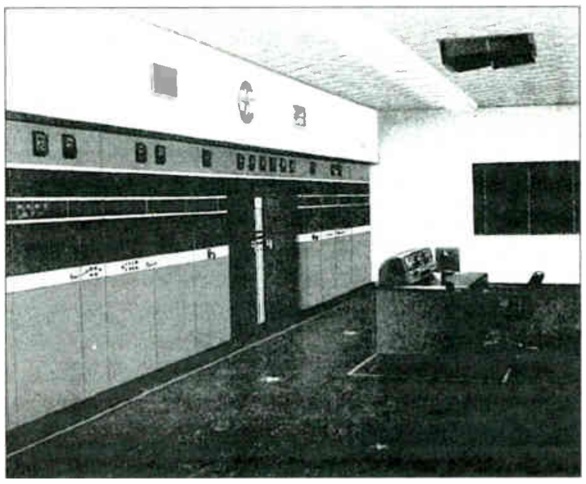
Another benefit of the new tube was the Hum Frequency Feedback Amplifier was no longer required to meet the noise specification of 60 dB below 100% modulation.

The frequency response was typically flat within one dB from 30 Hz to 10,000 Hz. While specified at three percent total harmonic distortion from 50 Hz to 7,500 Hz at 95% modulation, most well maintained BTA-50F's would do better than 1.5% at 50 Hz and 7,500 Hz dropping to about 0.5% from 100 Hz through about 5,000 Hz.

OFTEN REUSED AND VIEWED

No accurate information is available as to the total number of BTA-50F series transmitters produced, but at least fifteen are known to have been installed in the US and Canada.

At least five of them went on to serve other stations following retirement from their original purchasers. These include the original WJJD, Chicago, IL transmitter was relocated to WEEP, Pittsburgh, PA; the WFAA/WBAP transmitter installed at the Grapevine, Texas DFW sharetime operation was relocated to WGAR, 1220 kHz in Cleveland, OH as an alternate main transmitter by your author in 1972; the original WGAR transmitter was relocated to WEEP, Pittsburgh, PA in the 1980's for parts; the WGBS transmitter in Miami, FL, went to an unknown location; and the WOAI transmitter at San Antonio, TX was sold to another station following the demise of the Shelby, TX site due to a B-29 collision with the WOAI tower in April 1956.



The KMPC transmitter and site has been filmed many times.

Set in an ample-sized transmitter building, the 50-F at KMPC has been a favorite of producers and seen in many Hollywood productions over the years – from a TV series about the FBI in the 1950s to the program *24*, where terrorists were seen coming out of the right-hand door to fight with Jack Bauer. Sadly, the building (and the transmitter) will be going away at the end of the year.

There are presently at least three of the BTA-50F transmitters still installed. These are located at KRMG, Tulsa, OK, WHKW (formerly WGAR), Cleveland, OH and KOMO, Seattle, WA. The KRMG transmitter is a BTA-50F1 installed in late 1949. It is still operational and in service as a backup transmitter. I am told that the WHKW and the KOMO BTA-50F transmitters have been recently decommissioned although they remain in place. Not bad for a transmitter series manufactured fifty-nine years ago!

SUMMING IT UP

The BTA-50F and the BTA-50F1 transmitters became one of the most popular and, arguably, the best sounding and most reliable fifty kilowatt transmitter models ever built. It would be fifty years before the solid state fifty kilowatt transmitters would surpass the BTA-50F in overall audio quality.

Most were placed in service on the Class I channels in both the US and Canada. It is known that several were exported to other countries, but no records indicating the countries or specific stations were available to the author at the time this article was written.

I believe it is significant that one or two are still in service after sixty years. Only one older transmitter was known to be operational in the US in recent years – that being the Western Electric Model 7A at WLW, Cincinnati, OH. However, that transmitter has been heavily modified for high-level plate modulation and is in need of repairs which reportedly may lead to permanent decommissioning.

I would like to acknowledge the contributions of several people who provided information about the various BTA-50F transmitters, the tubes, and their histories. Among them are Tom Yingst, formerly of the RCA Tube Division at Lancaster, PA, Steve Tunwall and David Johnson of Cleveland, OH, and Walt Jamison, PE of Seattle, WA.

Jack Sellmeyer has been designing, constructing, and maintaining broadcast equipment and stations for over five decades. He can be contacted at jack@sellmeyereng.com

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Maintenance Guide

by Gary Glaenzer

The Care and Feeding of The Phasing System

When I re-joined KHMO in the fall of 2005, one of my first priorities was solving a problem that was occurring at the station every eight to ten days or so – the phasor would fail to complete its switch between patterns.

Much head-scratching and hair-pulling followed, and the end result was that I became, by default, pretty much an expert on the Harris Phasor Control Board.

DIAGNOSING THE "STALL"

KHMO is a DA-2 running 5 kW daytime and 1 kW at night. It is situated in the Salt River bottom about six miles south of downtown Hannibal, MO.

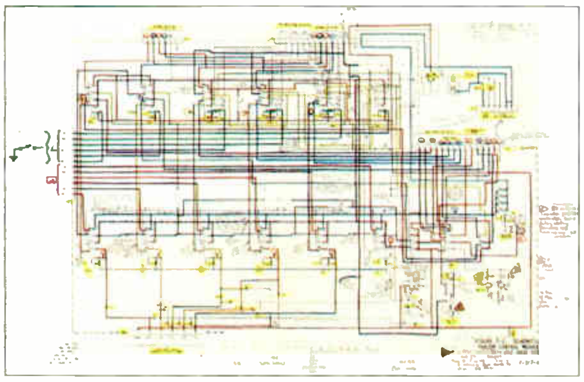
The array is made up of six 229-foot towers and was built in two lines of three towers; the towers are spaced 90 degrees apart, the tower lines are 180 degrees apart. The main lobe is pointed NNW at 344 degrees. The phasor was supplied by Harris Corp in the summer of 1982, after a fire destroyed both the BC-5P2 and the old phasor.

The first problem I had to attack was the system "stalling out," for lack of a better term, during pattern change. My initial investigation revealed that one of the NON-20 cartridge fuses on the incoming supply line to the phasor was blown. When we listened to the phasor during such an event, we could hear the motorized contactors shuttling back and forth and back and forth until the fuse blew.

At that point, we were left with a manual control system. That really was not of much use since it was designed to switch six towers and the associated phasor networks.

PHASOR CONTROL

For those of you who have never seen a Harris Phasor Control Board, the schematic shows it in all of its glory:



The schematic for KHMO's Phasor Control.

This is relay control at its ultimate. In spite of the "ball-o-snakes" diagram, it is very simple; there are five pairs of what are best termed mode set relays: Day, Night, Non-D, Main, and Aux.

There are four motorized contactors in the phasor, one for Main/Aux switching, and three to handle the Day/Night switching. Another contactor at each tower base changes the towers from Day to Night. Pushing a button ("DAY," "NITE," "MAIN," "AUX") on the front of the phasor (or its remote control equivalent) locks in what I call the "temporary latch relay" of each pair, which in turn triggers:

- Shut off the transmitter that is currently in use.
- Change patterns to the desired mode.
- Bring the selected transmitter back up at the required power for the pattern selected.
- The temporary latch relay releases and the new mode is set via the running relay of the pair.

TRACING THE STALL

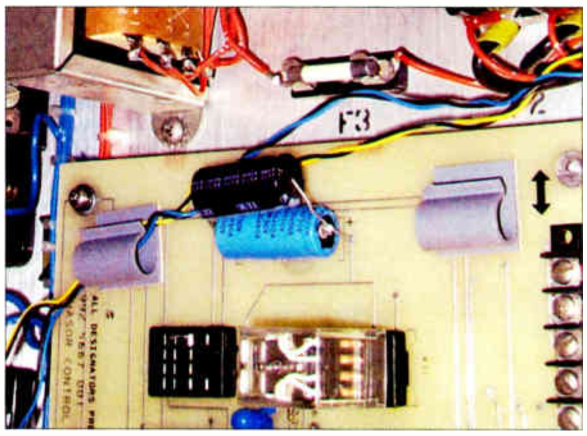
Watching it with the door open, and switching enough times, we eventually determined that the fuse blew because the relay control board was holding "on" one of the two large power contactors that feed power to the contactors at the towers.

The fuses were able to handle the normal momentary load. But the supply voltage would slump as more of the KHP relays on the board were energized, and finally there was not enough voltage to pull in the final relay that said "job finished."

After hanging up for about three or four seconds, the load exceeded what the fuses could handle and they would begin to blow.

ALMOST MISLED

Eventually, the culprit was identified; it all came down to a 100 uF @ 25 V capacitor, across the output of the power supply for the relay control board.



A replacement capacitor brought the power supply back to normal.

It was not that we had not looked there. We had checked the voltage several times, and always saw 25 Volts or more DC. Those of you who have fallen into "the trap" already know what I am about to confess: *Never* use a Simpson 260 to measure small DC voltages in an RF environment.

(Continued on Page 50)

Maintenance Guide

by Gary Glaenzer

The Care and Feeding of The Phasing System

– Continued from Page 48 –

With the transmitter on, we saw plenty of "apparent voltage" – on the order of 25 Volts DC. With the transmitter off, however, we saw it dip from a high of 23 Volts, to 21, and to 19, at which point it failed to function. After replacing the capacitor, this part of the circuit now worked as advertised. The hair-pulling could stop.

CONTACTORS AND MICROSWITCHES

With the power supply for the control board fixed, I went on to tackle the next issue: Each pattern is permissioned by a series string of micro-switches at the towers; if a contactor fails to make the switch completely, the tally light does not come on and the transmitter stays off.

When a contactor and/or its associated micro-switch failed, it took a lot of slogging through the grass to find the offender. As I started solving the control system problems, we found out that several contactors were already at the end of their useful life – but more about that in a moment.

To provide easy indication as to which tower was creating a problem, I constructed a "Box-o-Relays."

I was fortunate that Harris included an extra coil and vacuum capacitor tuning network that was never hooked up. I removed those and had plenty of room for my box; the 24 Volt at 5 Amp power supply for the relays is inside.

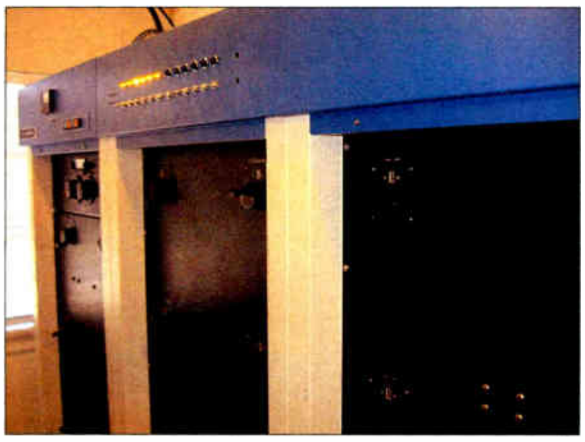
NOW I CAN SEE THE PROBLEM

Each relay is energized by the micro-switch at the associated tower. One set of contacts per relay makes the series string to allow power-up. A second contact turns on a lamp on the front of the phasor.

The "Box-o-Relays"

The switches below the lamps have two functions:

1. Downward is a spring-loaded position, to do a lamp test. This ensures the bulb is working.



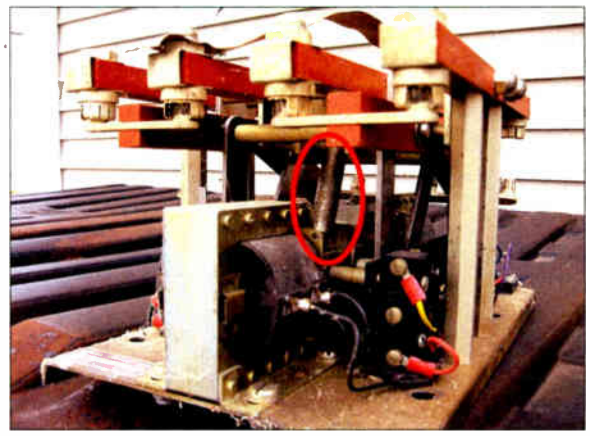
The yellow tally lights show switches set for daytime operation, the dark blue indicates nighttime position.

2. When pushed upward (a locking position), the micro-switch for that tower is bypassed. Thus, in case we develop a bad switch at the tower – and verify by visual inspection that it is indeed a switch and not a true contactor problem – we can bypass it and bring the transmitter back up. This arrangement has prevented down-time more than once.

MEANWHILE, OUT AT THE TOWERS

Now, about those pesky tower contactors: we are gradually replacing the old contactors with Kintronics units.

The old ones are, according to the name-plates, were made by the Cardwell Condenser Company and were extremely sturdy. The problem we encountered was the mechanical detent mechanism was breaking.



The Cardwell contactors would fail when this part broke apart.

The way it was designed – in the form of a spring-loaded telescoping rod about three inches long – one end went to a pivot and the other slid along a slot in the shuttle between the two solenoids, holding the contacts firmly in the selected position.

However, the rod would break loose from the pivot and then the contacts would sometimes bounce far enough back to re-open the micro-switch that had just closed. The end result was that the contactor had switched, but the system logic (the micro-switch) was lying to the control board. Unfortunately, parts to repair the contactors are now being found to be made of "unobtainium," so we have started replacing them with Kintronics units.

Since making these repairs and replacements, the phasor has become much more dependable, and I have been free of those post-sunrise and post-sunset phone calls for help.

Gary Glaenzer is the Chief Engineer for Hannibal Broadcasting in Missouri. You can contact Gary at gglaenzer@hqradio.com

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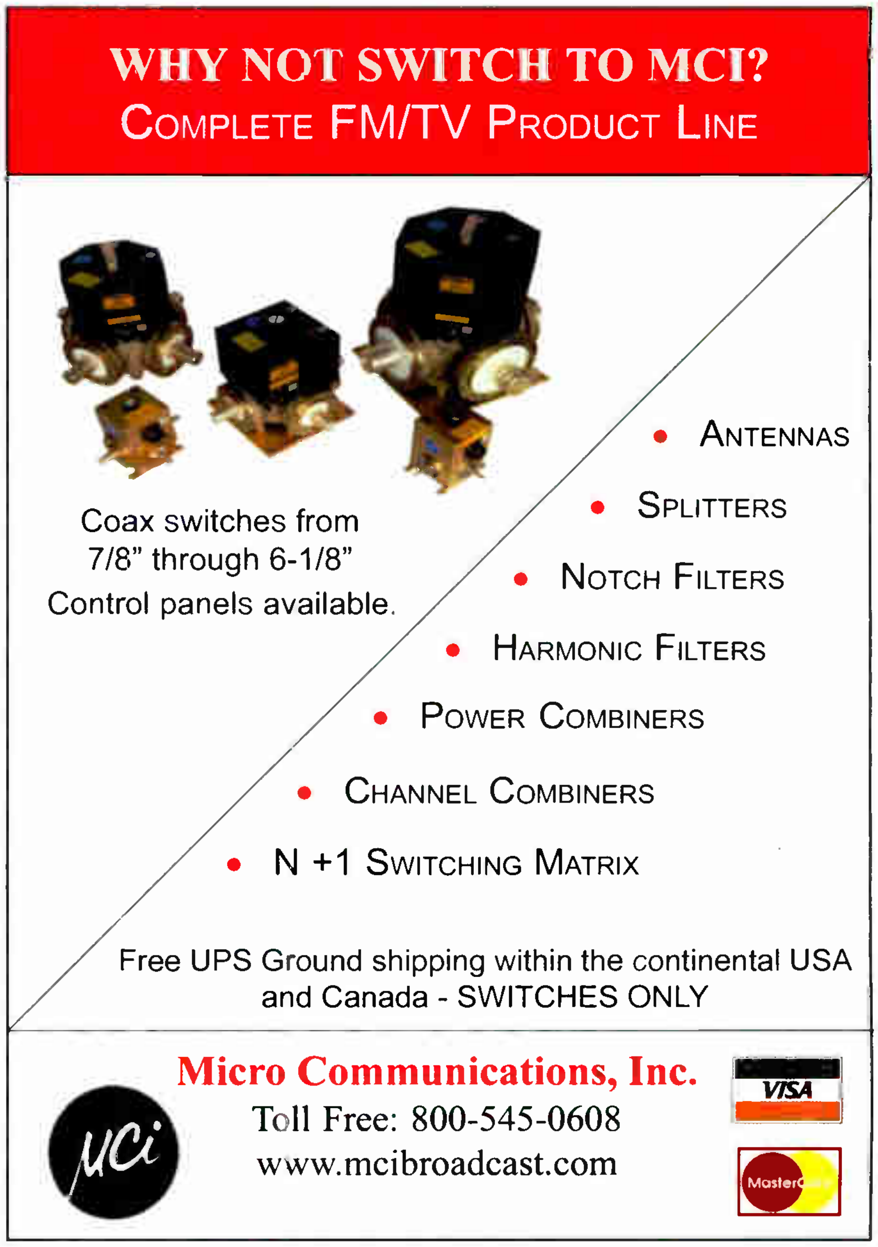

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Radio Guide

by Scott Fybush

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Bill Stachowiak

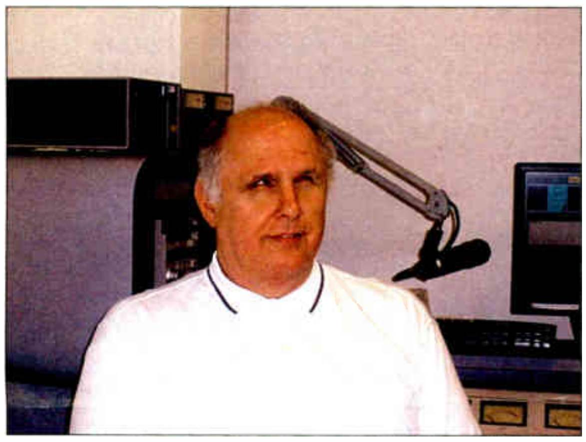
Keen Ears and a Sharp Memory Overcome a Missing Sense

One of the qualities that makes a great engineer is the ability to solve problems, overcome impediments, and get the job done, whether installing studio gear or bringing a dead transmitter back to life. As Scott Fybush relates, Bill Stachowiak has been doing just that for a long time – in a rather special way.

After almost thirty years as a commercial broadcast engineer, there is not much that Bill Stachowiak has not done.

Over those years, he has served as chief engineer for several radio groups in his native Buffalo, New York. He also ran a contract engineering firm that was responsible for more than 40 stations all over New York and Pennsylvania.

And while he does not think it is that big a deal – he has done it all without the sense of sight. Bill Stachowiak was born completely blind.



Bill Stachowiak

LISTEN AND LEARN

In an era before optical character recognition and screen readers, Stachowiak had friends and family read electronics books and magazines to him.

"When I was a kid, I lived and breathed this stuff," he says of his early years in Buffalo, when he would visit any local radio station that would let him in the door, then go home and take apart the household radios just to see if he could put them back together again. "If I didn't understand something, I literally couldn't sleep until I figured out how it worked."

Stachowiak continued his education at the State University of Cobleskill, where he became the chief engineer of the campus carrier-current station that was just going on the air when he arrived in the early seventies. But while he did just about everything at SUNY Cobleskill – even helping to build the new station's studios – he did not pursue a broadcast engineering career right away after graduation.

"I thought, that's it for my radio career," he said. He returned to Buffalo and started a company called "S&B Communications," fixing stereos and CB radios and installing two-way radio systems in taxicabs.

BACK TO RADIO

That changed in 1979, thanks to a chance encounter with Harv Moore, the morning man on Buffalo's WPHD-FM.

"I asked him if I could come in for a tour sometime," Stachowiak recalls, "and then I asked him, 'who's your chief engineer?'"

The job happened to be open at the time – but it did not stay that way for long. Stachowiak was soon back in the broadcast game, engineering WPHD and its sister station, WYSL(AM), and transitioning his S&B Communications out of stereos and taxi radios and into broadcast engineering.

At the peak in the nineties, Stachowiak oversaw a staff of ten engineers, covering a territory that stretched east to Albany, NY and southwest to Erie, PA – handling tasks that included studio design and construction, transmitter repair and maintenance.

At his current job, Stachowiak maintains studios in Buffalo's historic Rand Building that he designed and built with S&B. Upstairs in the building's penthouse, he is responsible for the three FM stations that transmit from the Rand rooftop (WBLK-FM, WJYE-FM and WYRK-FM).

Stachowiak checks out the PA cavity in WBLK's RCA FM auxilliary transmitter.

He also recently relocated a fourth FM station, WBUF-FM, from a hilltop site south of Buffalo to a new HD Radio-equipped facility in the city, and oversaw the transfer of Regent's lone Buffalo AM station, WECK, to new owners last year.

That would be enough of a challenge for a sighted engineer – so how does Stachowiak pull it off?

USING THE TOOLS AT HAND

"For a lot of things, I have help," he says. "There's obviously some things I can't do. I can't read schematics or do intricate soldering."

For those tasks – as well as more mundane things like driving to transmitter sites – Stachowiak depends on sighted assistants. But the combination of a prodigious memory, a keen sense of hearing, and the ability to negotiate a packed equipment rack or the innards of a transmitter by feel allow him to do most of the engineering work himself.

No, he has never been seriously bitten by high voltage. "All of us have gotten zapped, but never anything lethal," he says, noting that he is fastidious about making sure breakers are killed and interlocks are working before he goes to work on anything potentially dangerous.

Stachowiak says technology has made the world more accessible to him. He now uses a document scanner to read printed material, and a screen reader to check e-mail and access the Web.

KEEPING AN EAR ON THINGS

And, in some ways, he says the lack of sight may make him a better engineer.

"I think all of us who can't see have to rely on our hearing more," Stachowiak says. He believes that his attention to sound shows in the processing on his stations.

"I'm pretty proud of the way my stations sound, and I've heard some bad-sounding stations," he says.

A MENTOR AND FRIEND

During his S&B days, Stachowiak launched many younger engineers on the path to careers in the field.

"He really impressed me," says Al Marranca, now chief engineer of Citadel Broadcasting's Buffalo cluster.

Aural quality control does not require visual acuity.

"You know, when I first started working for him in 1986, he would walk around the (S&B) shop with no problems, and in the beginning I had a hard time believing he was visually handicapped. I would tease him about it," Marranca says.

After spending 14 years at S&B, Marranca left in 1999 for his current post. "[At] this group of stations I'm working at right now, the last three chief engineers came out of S&B," Marranca notes.

"Bill was my mentor," he says. "If it wasn't for him, there's no way I could be chief engineer at a cluster of stations."

Marranca says he thinks he has figured out how Stachowiak can do what he does. "Although he can't see, he has a very good way of visualizing things in his head. A lot of times, I'd read him a schematic and he'd immediately understand the circuit," Marranca says. "Once he worked on something, it was in his head, and there's still a few times when I'll call him just to jog my memory about something I'm working on."

GENERAL TURNABOUT

Ironically, the engineer who once worked for a Stachowiak now has a Stachowiak working for him – Bill's son Brian is an engineering assistant at Marranca's stations.

"Brian was working for his dad when S&B was still in business," Marranca recalls. "He and I went to lunch one day and he asked me if I'd consider him working for me. I told him, 'No way I'm going to take you from your dad. I want to hear it from him!'"

As it turned out, Bill was happy to have his son working for Marranca. And there was one more irony that Marranca notes. "Brian was 20 when he started working for me – that's the same age I was when I started working for Bill."

LOOKING TO RADIO'S FUTURE

As consolidation took hold, though, Stachowiak says the business became more challenging. "Where we used to have individual contracts with stations, once the big groups came in, everybody wanted a discount," he says. "With fuel costs going up and everything else, the stress level was getting too high."

In 2005, Stachowiak closed down S&B and joined one of his former contract clients, CBS Radio's Buffalo cluster, as chief engineer. (The cluster was sold to its current owner, Regent Communications, a year later.)

But he shares the concern of so many engineers about finding the next generation of talent. "No young kids have come up to me saying, 'I have an interest in engineering, can you show me the ropes,'" Stachowiak notes. "A lot has to do with broadcasters and the attitudes they've taken. I think engineers are severely underpaid for what we do and what we have to know."

ENGINEER TO THE CORE

By the way, Stachowiak is not the only blind broadcast engineer in the nation. A recent discussion on the Broadcast mailing list (www.radiolists.net) turned up several others. Stachowiak himself says he has occasionally heard mention of other blind engineers, but has never met any. "I'd like to get together with them, though," he says.

At 58, Stachowiak says he is hoping to stay on the job at Regent "as long as I can." "I'm always thinking about my job," he says. "I get home and I call the station to make sure everything's OK there."

That takes a special kind of person.

---

*A regular contributor to **Radio Guide**. Contact him at scott@fybush.com Bill can be reached at William.Stachwiak@RegentComm.com*

Wheatstone Evolution at Sandusky Radio, Phoenix

by Jim Hibbard

Earlier this year I was asked to design and integrate a renovation of the broadcast facility used by two of the five Sandusky Radio stations in the Phoenix, AZ market: KUPD "Arizona's Real Rock" and KDUS "The Fan AM 1060 Sports Radio." Phoenix is market rank 5.

Clayton Creekmore, the Chief Engineer, brought me in with very clear instructions: "You're the guy that's built 400 studios. You know what you're doing. Do it."

LOGISTIC CHALLENGE

The facility consists of a Technical Operations Center (TOC), a huge FM control room that can accommodate four sidekicks as well as musical guests for the morning show, an FM production room, an AM control room facing the AM talk studio, and an AM production room. Both production rooms were designed to double as backup air studios.

Together, Clayton and I developed the project and construction plan, reviewed the budget and preliminary equipment list, made some final changes, and placed orders for equipment and contractors. Clayton ran the schedule and oversaw the construction; I ran the studio installation and wiring.

This project was a rebuild-in-place, which is always more challenging than a completely new build-out. We had to work on one studio at a time to keep the entire operation running. So, one studio at a time, we moved walls, added windows, and converted a closet into a temporary production room. In the process, we created a completely new TOC, with new electrical and new IT.

The entire project took about three months from start of construction to finish, putting the last studio on the air this past September.

THE WHEATSTONE CHOICE

At the preliminary site visit in Phoenix, I met with staff, program directors, and operators, and sat in on the busy FM morning show, watching what they did and how they did it. I did the same for the local shows on the AM station.

Next, I did a complete survey of the existing installation, making an inventory of all equipment, and detailing its audio and control requirements. For budget reasons, we used as much existing equipment as possible.

Clayton had already decided upon Wheatstone. He had used Wheatstone at previous stations, and he already had a Wheatstone/Audioarts D-75 console and E-SAT router in his facility in Phoenix.

The Wheatstone equipment list was developed by Clayton along with Darrin Paley, the Wheatstone Sales Engineer for this project, and Doug Tharp from SCMS. The system consists of three Evolution 6 Series Control Surfaces, one Audioarts D-75N Console, seven Wheatstone E-SAT I/O Frames, and one E-NET 8 switch. I reviewed it and made a few changes, mostly adding more analog I/O, as the facility had very little existing digital equipment.

The new equipment included the custom furniture, microphones, microphone arms, microphone preamps, some peripheral equipment and, of course, the signature speaker hangers from my company, Pacific Mobile Recorders. Once the equipment list for each control room, studio, and TOC was finalized, I started laying out the spreadsheets for the router and wiring.

EVOLUTION

The E-6 is Wheatstone's newest console. We chose it because it had all of the features that we needed: multiple mix-minus capability, pre and post aux sends, and extensive programmability. A 20-fader console was selected for the FM control room; 12-fader consoles for the AM air control room and AM production room.

E-SAT is a self-contained frame that accommodates up to 16 stereo analog or AES digital sources (inputs), 16 stereo analog or AES digital destinations (outputs), and GPIO (opto/relay). It performs all of the mixing for the console. It is smaller and less expensive compared to the Wheatstone Bridge. For KUPD/KDUS, it was ideal.

KUPD's Wheatstone Evolution E-6 (console control monitor is on the left)

Audio routing is via tried-and-true TDM (Time Division Multiplex). Since all mixing for the console is done in the E-SAT, in the event of a TOC problem, each studio can operate independently. The Wheatstone E-NET 8 ties all of the E-SAT frames together so that all sources can be available anywhere.

PREPPING THE INSTALL

Prior to the facility upgrade, the stations' RCS automation computers were situated in the control rooms. We moved them all to the new TOC along with the shared ISDNs and Starguide satellite receivers. (We left the Internet and VoxPro PCs in the control rooms.)

Before we even moved the equipment into the new studios, I set up the racks in the engineering room, put the Wheatstone surfaces on card tables, connected them to their local frames, did basic programming (source/destination naming), and ensured that they were all talking to each other. We supplied all of the pre-wiring in advance.

In the studios, as much as possible, I kept the layout consistent, i.e. all microphones to the same channels in a frame, all outputs from the same channels, etc. Everything terminated at Krone punch blocks. To make installation and programming easy, I kept the Krone block channel number the same as the router frame ID number.

One of my standard practices is to run tie lines between each control room and TOC. For Sandusky Phoenix, we ran 40 pairs of stranded, shielded CAT5E, punched down to Krone blocks at each end. These are used for various control functions analog, for miscellaneous audio, analog and digital, and for a backup audio PGM A and PGM B feed from each studio to TOC as standby.

THE BUILD-OUT

Everything mostly went together as planned but, as with most projects, there were instances of design-on-the-fly to accommodate last minute revisions, making and documenting changes along the way.

The E-6 in operation in the KUPD Control Room.

The Audioarts D-75N digital console that the station already owned was moved to the FM production room. The "N" means that although it is a stand-alone console and not a control surface, it can access sources on the station's Wheatstone network, and send sources and mix buses to the network for use in other control rooms or TOC.

Of all of the Wheatstone products I have installed over the years – G-series consoles, Audioarts D-series consoles, and Bridge Routers – by far, the E-series is now my favorite.

A GREAT GUI

The E-Series GUI is user-friendly, extremely easy to learn and program, and allows the user to custom configure each console. In addition, 90% of what I needed to configure was done without having to be in front of the console. After spending the day at the studio wiring and installing, I could relax in my hotel room, access the system remotely, and program without distraction. This I really liked.

The GUI is also used to set up events and presets. After getting really comfortable with the system, I was able to build salvos and test them remotely, because you can actually see the crosspoints move!

For the FM's regular programming, I set up one preset for the morning show and another for everyone else. The AM was a bit more involved. Most of The Fan's programs are remotes, so it required different presets for the local in-studio show, different remote operating styles, and satellite shows.

The AM Control Room looking into the studio.

I also set up events to route mix-minus, aux sends, and talkback for the shared ISDNs. Each of the events and presets were assigned to programmable buttons on the consoles.

THE EVOLUTION EVOLVES

Wheatstone has really done a good job with the GUI – and it is constantly evolving and getting better.

I did find a few bugs in the system that Kelly Parker, Wheatstone's west coast support engineer, was able to duplicate. Wheatstone was right on the ball in getting them corrected – they were fixed overnight! After loading in the updated software the next morning, it was smooth sailing.

It is a pleasure working with Kelly and the guys at Wheatstone in North Carolina; their technical support is outstanding. And, if I came up with a good idea and Wheatstone agreed, they would make it so.

My only complaint – and it is a minor one – is that when the console reboots, it comes back with all channels off; I would like the channels that were on to come back on. I am told other stations prefer them to come back with the channels off, so hopefully Wheatstone will make it a user setup option.

STATION STAFF

At first it was a shock to the station's operators, announcers, and DJs to find out that the E-6 is not a console, it is a surface. But once they got the concept that it has a router on every channel, what I heard was "we can really start doing some great radio!"

Many on the staff became more savvy, especially the full-timers. For the others, we boiled it down to "push this button and you will be all set."

At the end of the day, Sandusky Radio got just what they wanted.

Jim Hibbard is President of Pacific Mobile Recorders, a full service studio design and system integrator. Contact him at jim@pacificmobilerecorders.com


Tower Site Calendar
2009
KPRK

The Advanced Radio Consoles from Arrakis

by Ken Kuenzie

Back in 1997 I formed Viper Communications Inc. (VCI). We then bought two stations which I had previously worked at during the past three decades: KMYK (formerly KYLC FM) and KRMS AM, located in Osage Beach, Missouri, playground of the Midwest coast and host to over 200,000 summer visitors.

The FM station KMYK "Mike FM" is 50 kW at 93.5, the second oldest FM in Missouri; it has been on the air since 1964. Our 1 kW AM is "NewsTalk 1150" KRMS, the only AM station in the Tri-County area.

TIME FOR A CHANGE

As both stations had started to show their ages, we decided this last spring to update our studios. We were looking at replacing the 23-year-old Autograms and the Harris Medalist that came with KRMS.

What we really wanted to accomplish was to have a console setup that we could add onto or expand to the other studios as we worked our way through the nightmare of 50+ years of undocumented engineering in our three studios. We knew this was going to be expensive, but planned to convert all of the studios over time.

In 2002, we had inherited a 12000 series Arrakis console when VCI purchased WENG in Florida. We found it to be well installed and easy to work on. Since we had such a good experience with the 12000, we went to the Arrakis booth at the next NAB Show in Las Vegas. There we learned about their new console line, the ARC series (Advanced Radio Console), which had just been released by Arrakis.

DESIGNED FOR BROADCAST NEEDS

The ARC consoles come in ten and fifteen channel models. All have dual buses (Program and Audition) so that a console can be on-air while, at the same time, performing background work.

The ten channel model has two microphone channels while the fifteen channel version has five channels that are each internally selectable for either a microphone or stereo line input. (Having the capability to run five microphones definitely can be useful for large talk formats.) For stations using condenser microphones, 48-Volt phantom power is provided by an inexpensive option.

The consoles feature a cue speaker in the meter bridge for cue and talkback, as well as a headphone amplifier which can drive both high impedance and 8-Ohm headphones. All models have a single, convenient phone channel that interfaces with an external telephone hybrid. The channel has relay isolated logic to control the hybrid and a "Talk to Caller" button for easy off-line work.

The ten channel model is available in both unbalanced and balanced versions (the unbalanced version has RCA connectors to plug straight into consumer type source equipment). We found the balanced version best met our needs.

ADVANCED RADIO CONSOLES

The ARC-10BP and ARC-15BP models have balanced inputs and outputs, and each have a PC channel that connects to a PC via a USB cable, for playing and recording in digital format to/from the PC. The codec is Windows sound card compatible and can be used with third-party audio software.

One of the options that we found useful for the ARC is the ARC-16SW audio routing switcher. It has 16 stereo inputs and three stereo outputs. The switcher is Windows PC controlled, with easy to use software that can be software labeled. The switcher is used as an input and output router with the console.

We decided that the ARC consoles with the switchers were a perfect way to do the studios and have the redundancy we needed, as well as the flexibility to share lots of equipment to all the studios.

THE FM STUDIO UPGRADE

We bought the first ARC-10 after the show, to go into the FM studio as the old Autogram there was just about to give up the ghost.

KMYK's on-air studio with the new Arrakis ARC-10.

To be honest, we were worried at first, as we would be trying to keep the stations on the air while ripping out the old consoles and installing the new ones. However, installation proved to be pretty simple. In fact, once we had all the old wire out of the studio, the new equipment installed, and wires labeled, it was pretty much plug and play.

The microphone channels are easy to wire because they have XLR connectors. The stereo line input connectors use RJ45 connectors. A great help was having the RJ45 interface cables made up ahead of time. Arrakis supplies ten foot long cables with the console; they are terminated with RJ45s at one end and left unterminated at the other end.

The instruction manual proved to be easy to understand, and Arrakis customer support answered our questions promptly. From start to finish we did each studio install in about a day, from rip out, rewire, to ready to air.

STAFF PLEASER

When we purchased and installed the ARC-10 for the FM, the reaction was very positive. Everybody liked the layout and the easy operation with the Arrakis audio switcher, the telephone interface, and the computer interface.

Arrakis provides a version of their "Digilink Xtreme" Windows Automation software that features a 500-event play list, a 300-cart jingle wall, and a recorder-editor with the ARC console. The Arrakis software has logic that starts and stops the on-screen playlist just like a multi-deck cart machine.

I like the contemporary clean design and ease of use. It was nice to be able to get rid of all the add-ons that we had fabricated over the years. For example, with the old consoles we had to have an outboard mixer to create mix-minus for the phones. We also had to deal with limited inputs to handle all the different satellite feeds.

Now everything is fully incorporated into the console and the audio switcher.

AM AND PRODUCTION

Once we found how easily the ARC-10 went in and how clean it sounded we just decided to bite the bullet and get two more – another ARC-10 for the production room and the larger ARC-15 with the extra microphone channels for the KRMS AM NewsTalk station.

An Arrakis ARC-15 is the heart of KRMS' NewsTalk studio.

The ARC-15 has been perfect for our NewsTalk station, which produces over eight hours a day of local programs. Now with five microphone channels available on the console, we have enough for the many guests we have in the station on a daily basis.

The production room utilizes another ARC-10.

We have an area for equipment with three racks that house the automation, Tieline, satellite receivers, Marti receiver, audio router, etc. By mounting the ARC-16 switchers right on the wall next to each other it made it easy to wire the three studio-shared audio inputs from the satellite receivers, so that they feed each of the studios and the Tieline simply and cleanly.

With the Arrakis ARC consoles and switchers, we now have a lot of versatility. We can put any one of the studios on the air – AM, FM or Internet – at anytime. Plus, with the Arrakis audio switcher software, we can go direct from automation to on-air, in effect turning all three studios into production rooms.

A VERY POSITIVE EXPERIENCE

My experience with the Arrakis ARC consoles and switchers has been very positive. As I pen this article, I am currently in Englewood, Florida working on my new station – and installing an Arrakis 12000 series modular console.

As mentioned, everybody on staff likes the console layout and the easy operation with the Arrakis audio switcher. The installation of the consoles went easily and they have a very clean sound. I even recommended the ARC to the folks at WSRQ in Sarasota and they have since purchased an ARC-15 of their own.

Recently, Arrakis told me that they are about to introduce a modular ARC console which supports two phone channels. I am looking forward to this as I would like to have two channels dedicated to phones for the AM station in the future.

President of Viper Communications, Inc. in Osage Beach, MO, Ken Kuenzie has 37 years of broadcast experience from announcing to engineering to ownership. You can contact him at kenkuenzie@verizon.net

Logitek Brings Digital Studios to Texas Public Radio

by Wayne Coble

Texas Public Radio (TPR) has been updating broadcast studios in our San Antonio facility for the past few years. Our focusing has been on bringing the whole audio plant up to speed on digital operations.

As of early 2007 we had already replaced the studio-transmitter links and some other items in the audio chain. The consoles were some of the last big components that needed to be upgraded.

IT WAS TIME

We were looking to replace equipment that was about 20 years old – consoles that had reached their end of life (maybe beyond!). They were still usable but we were concerned about the availability of replacement parts and the viability of the equipment in the long term. We were getting to the point that we needed to look at something more reliable and with new features that could accommodate our changing needs at TPR.

A large federal grant combined with local matching funds opened the way to re-doing our studios. Four studios were renovated in the summer of 2007 and a fifth was done this year.

When we started the project, the existing studios were in various states of design ranging from "reasonable" to "awful." The room most in need of renovation was Production Studio 2, where the studio furniture consisted of three folding tables with equipment stacked on, under, and around the tables.

Production Studio 2 – Before

As you can see, the room was also a catch-all for unused furniture, decommissioned computers and obsolete broadcast equipment.

MAKING THE CHOICE

One goal we had in our renovation was to create a common look and feel among all of the new studios. We wanted the new consoles to be user-friendly while offering some of the functionality that had recently appeared in console systems.

Along with some obvious furniture issues here and there, the old studios had a bunch of different console models from different manufacturers, and this made things somewhat difficult for our operators, who had to learn how to operate all of the different consoles – and remember the quirks of each board when they went into a new room.

We were especially interested in a router-based console because this type of system eliminates the necessity for dedicated-purpose studios. Any input in the facility can appear on any surface in any studio and can be easily routed to any transmitter or additional program stream. This new capability would make for a much more versatile and efficient operation than conventional console systems.

After evaluating several different options and giving it a lot of thought, we decided to go with Logitek for our new consoles.

FEATURE RICH AND RELIABLE

The fact that the costs of the other console systems we had considered were somewhat higher made us skeptical that Logitek could deliver the same set of features and reliability.

However, after further research we found the company was the first in the U.S. to produce router-based studio solutions and can show a proven, ten-year track record. Other factors that influenced our decision included the impressive list of broadcast users; the highly regarded reputation of the company for quality, dependability and customer support; better ergonomic design of the system for reduced operator error; more capabilities for signal processing and control; and a better interface with peripheral equipment.

In the end, we chose the Logitek Audio Engine and the Mosaic control surface for all five studios. The Logitek system is completely router-based, with the console acting as a controller for all of the audio residing on the router.

MORE THAN A ROUTER

The Audio Engine is much more than a standard router.

In addition to X-Y audio routing selection, the Engine provides mixing, control, dynamics, EQ, delays and other functions. Multiple mix-minuses are available, which track their assigned audio source (such as a codec) no matter where that source appears on a control surface. Advanced scripting functions allow for one-button event triggers, which allow operators to perform complex operations easily.

The Mosaic surface comes in several different frame sizes and offers traditional console styling along with a low profile that helps us maintain sight lines between operators and rooms. The Mosaic's design comprises several different modules that contain faders, soft keys, and monitor controls, so Logitek was able to configure the control surfaces to our specifications with just the right number of faders and other controls.

Our design called for one Audio Engine and one Mosaic surface per studio. The Mosaic surfaces are all identical 12-channel units; the Engines are networked to allow sharing of audio sources between the different studios.

PUTTING IT TOGETHER

Installation of the Logitek system was a breeze. Along with the new consoles, our renovations included new furniture from Designcraft in Michigan.

Logitek worked closely with the furniture manufacturer to make sure they had the specs they needed for copy boards, the exact dimensions of the consoles and the meter bridges, etc. Logitek even supplied a wood sample of the console end-pieces to Designcraft so they could match the cabinets to the consoles.

Logitek's Customer Support manager John Davis also provided tremendous help in our installation. We had given him a lot of information about our configuration up front, so when our Logitek consoles arrived they were ready to use out of the box with only a few tweaks.

QUICK INSTALLATION

The prewired breakout "66" style punch blocks we got from Logitek for connecting our audio sources to the Audio Engines certainly simplified our installation; we did not have to spend huge amounts of time making tedious punch-down connections.

Even easier was the networking connection between the engines – being able to run a single fiber-optic cable between studios instead of a massive bundle of individual pairs saved us a lot of time and headaches. The whole installation went very smoothly, requiring only a couple weeks per studio to remove old equipment, re-do the wiring, and install the new furniture and consoles.

Production Studio 2 – After

We started the 2007 phase in mid-July and completed it in September. Oddly enough, most of our hassles had nothing to do with equipment – they revolved around the carpet we had ordered for the facility. It was harder to work the carpet delivery and installation into our schedule than the furniture or consoles. The final result was great, though.

STUDIO EASILY ADDED

The installation of the fifth Logitek console, in the summer of 2008, went equally well for us. Unlike the other rooms, which were renovations of existing studios, our Production Studio 3 was an addition to our studio complement.

This room had previously been used as an office and then as an engineering workshop/storage area. After finding new homes for the equipment that was cluttering the room (or recycling old items), we wired the room for operation, set up the new furniture, and installed the Logitek equipment.

Once again, the installation went smoothly using the pre-wired punch blocks and pre-configured router. Logitek's Davis was again a big help to us. Logitek's support gets five gold stars from us – they are top notch.

Our operators have easily transitioned to the new Logitek boards. Having so many features at their fingertips blew their minds, especially their access to virtually unlimited numbers of inputs at every channel. In spite of the extra features, though, the boards were not intimidating to our operators. They are laid out nicely – the Mosaic boards do not look like something out of a spaceship, they look like a console that everyone is familiar with.

The new facilities look great, operate beautifully, and should serve us well for many years to come.

Wayne Coble is the Director of Engineering & Technology for Texas Public Radio in San Antonio, TX. Contact him at wayne@tpr.org

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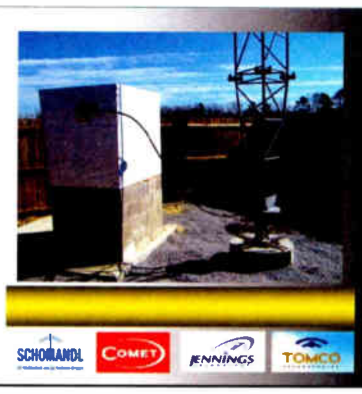

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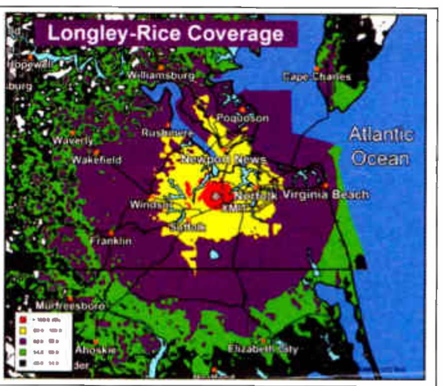

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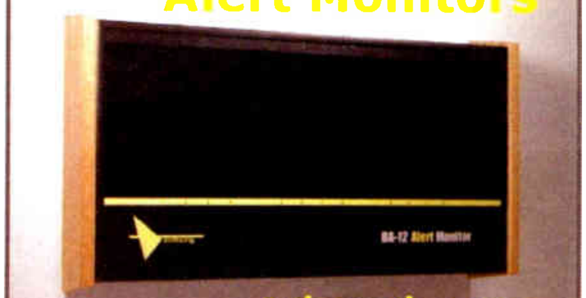

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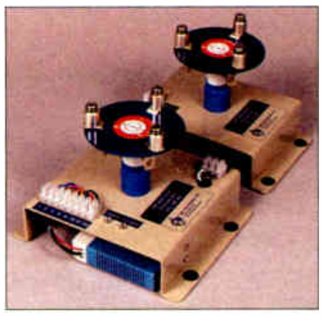
LBA Introduces Innovative RF Vacuum Contactor

LBA Technology, Inc. announces the availability of the first new generation of RF power contactors in years.

These innovative RF contactors respond to the needs of broadcast, communications, and industrial radio frequency users of heavy duty RF relays.



The VC-1 high reliability vacuum contactor system is designed for versatility. One series permits a wide range of operating voltages, and can be configured at any time for 1PDT through 4PDT operation. It goes well beyond the capabilities of most currently available mechanical RF contactors, but is a direct replacement in many broadcast applications up to 50,000 watts.

A few key features of the VC-1 relay system are:

- 25 million cycle life, no open contacts.
- RF rated at 40A and 10 kV peak at 1 MHz.
- Switches 50,000 Watts in a 50 Ohm AM MW system.
- Rated DC to 30 MHz.
- Silent, vibration free switching.
- Direct substitution for popular mechanical latching RF contactors.
- Universal for 24, 110, 220 VAC 50/60 Hz supply.
- Modular SPDT units, permits up to 4PDT, remote locating of modules.
- Includes interlocks and status lights.

LBA Technology President Jerry Brown commented, "The VC-1 system brings a new era of reliability to radio broadcasters and other power RF users. The remote sealed contact modules will permit the design of more functional and cost effective directional antenna phasors and other equipment with reduced ongoing maintenance costs."

LBA Group
jgeorge@lbagroup.com
www.lbagroup.com/technology

Inovonics Model 730 RDS Encoder

Inovonics is now shipping its new flagship RDS Encoder, the Model 730.

Building on the success of the Model 713, the 730 represents a giant leap for Inovonics in RDS technology.

New features:

1. RDS Tagging is the fast becoming the new hot profit center for radio broadcasters. The Model 730 has been fully tested with the new Microsoft Zune Portable FM Receiver/Audio Player.
2. The Model 730 can connect to everything via USB, COM, TCP/IP and UDP ports.
3. With a bright display and digital jogging wheel switch you can edit nearly any setting from the front panel.
4. Never be out of date with new field firmware updateable capabilities.
5. We now include a new Windows remote program with a great modern look and designed for easy operation.

Inovonics
831-458-0552 – steve@inovon.com
www.inovon.com

Logitek Unveils JetStream Mini IP Audio Router

New product offers easy setup, cost-effective IP audio streaming for on-air and production applications.

Logitek Electronic Systems has unveiled the JetStream series, IP-based audio routers that provide audio I/O, mixing, processing and audio distribution needs for Radio applications. The first in the series, the JetStream Mini, provides enough capacity for one 24 channel radio console. Logitek's existing control surfaces – Mosaic, Artisan, and Remora – provide the user interface to the JetStream.

"The JetStream represents the next generation of IP-based audio routing systems," said Tag Borland, Logitek president. "These products take advantage of the latest network protocols and are therefore extremely easy to set up, administer and use." Borland stated that users do not need to have in-depth knowledge of computer networking. "Just enter the names of the channels and the JetStream will do everything else. It acquires addresses, advertises its shared channels and makes a list of sources offered by other JetStream units on the network," said Borland.

One JetStream Mini unit provides eight I/O card slots that accommodate five types of I/O cards: four mic preamps (with phantom power); four stereo analog line inputs; four stereo analog line outputs; four stereo AES or S/PDIF digital inputs and four stereo AES or S/PDIF digital outputs. All I/O connections use StudioHub+® compatible RJ-45 connectors.

Also included are 12 GPI and 16 GPO contacts; four RS-485 ports with AES cue audio; 2 GbE ethernet ports and redundant power supplies in a single two rack unit enclosure. The unit's 24 stereo channels of mixing can be shared by one to four control surfaces. A DVI connector provides connection of a video monitor for operating Logitek's vScreen application (meters, router controls, and system information; user-configurable).

The JetStream's auto configuring mix includes VLAN tagging, DHCP, DNS, MADCAP, AutoIP, MDNS, DIFFSERV, SIP and SDP. Optional codecs offer choice of VoIP telephony, MPEG2, AAC, or APT-X access. External network sync may be connected to one JetStream unit; other units in the network will automatically lock to the sync signal.

The JetStream Mini was designed not only to be easy to set up and use, it is easy on the user's budget as well. A fully configured JetStream Mini router is priced at around US $6,000. "A single studio operation with a Remora control surface costs less than $8,000, providing a very comfortable entry point for stations wanting the convenience of IP audio operation. A networked studio is about $10,000," said Borland.

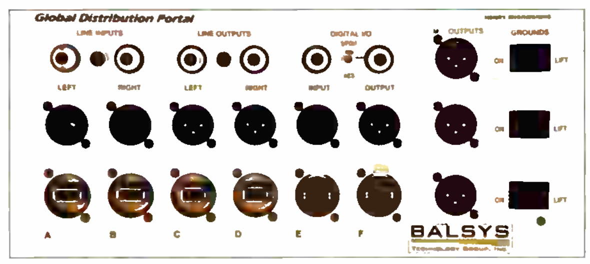
The company is now accepting orders for JetStream Mini units and plans initial deliveries by the end of the year.

Logitek
800-231-5870 – frank@logitekaudio.com
www.logitekaudio.com

Balsys Announces Global Distribution Portal

Balsys Technology Group, Inc. is pleased to announce immediate availability of their Global Distribution Portal panel.

The GDP provides convenient two-way interface between any studio/central audio system and external equipment. Active circuitry supports both analog and digital stereo I/O in both professional and consumer formats, utilizing the most commonly encountered audio connectors. Three mono summed output feeds at mic level are provided, each with ground lift switches, and are spaced to permit use of wireless "Butt Plug" transmitters. Also included are six utility feedthrough connectors.



Standard configuration is two each USB, Fire Wire, and RJ-45, but all are interchangeable and can easily be field configured as desired. The unit is 3RU in height, and intended for mounting in walls or broadcast furniture. Rackmount adaptors are optionally available.

According to Larry Lamoray, CEO of The Balsys Companies: "The Global Distribution Panel is ideal for providing a universal broadcast studio audio interface to the outside world without requiring intrusion into the studio, as well as for many remote and mobile applications. The fact that it supports all the audio connectors commonly used simplifies third party interface without having to search for special cables."

The GDP has been developed jointly by Balsys and Henry Engineering.

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www.natehome.com

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www.frontiernet.net/~ibs/2Kconvo.html

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