

**JOHNSON COUNTY  
RADIO AMATEURS CLUB,  
INC.**

P.O. Box 93  
Shawnee Mission, KS 66201

# FEEDBACK

**NOVEMBER 2014**



## PRESIDENT'S CORNER

Great weather for the Ensor events this year. Temperatures Friday evening could not have been better to gather at the farm. The fire was carefully tended by Don as always. As with years past, people popped by all evening. It was great to see so many. The auction featured many great items. This was due to the tremendous efforts and time that auctioneer Dave Schulman (WDØERU) put forth.

The number of items on consignment filled ten tables. There were some great deals. Thanks to Diana (KDØOBP), Ted (NØTEK), Cal (KCØCL) and John (WØBBQ) for stepping up to assist with clerking and handling the check ins. At this time we do not have how much funds were raised. Hope to have this information for the November meeting.

Thanks everyone who donated items for the auction. It is not too early to start collecting items for next year.

Skywarn Recognition day will be December 6 (0000 to 2400 UTC) this year. This event is sponsored by the National Weather Service and American Radio Relay League. If you would like to help with this event, please sign up. Contact me if you have any questions. For more information see <http://hamradio.noaa.gov>.

Only one meeting this month November 14 due to Thanksgiving. Happy Thanksgiving everyone. Hope everyone has a safe holiday.

Bill Gery – WA2FNK

## NOVEMBER MEETING

**November 14** – “WWI Thing You Did Not Know, But Should” – Charlie Van Way - NØCVW

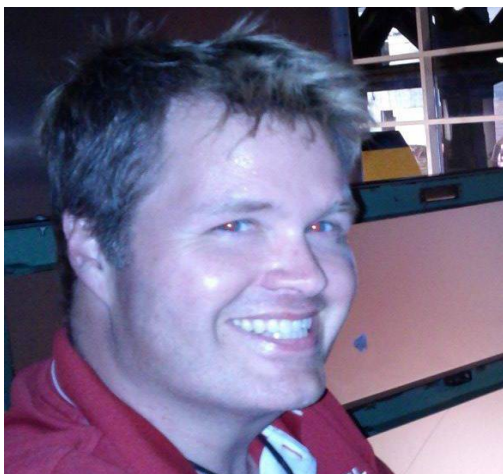
**November 28** - No Meeting

The Johnson County Radio Amateurs Club normally meets on the 2<sup>nd</sup> and 4<sup>th</sup> Fridays of each month at 7:30 PM at the Overland Park Christian Church (north entrance), 7600 West 75<sup>th</sup> Street (75<sup>th</sup> and Conser), west of the Fire Station.

The "Annex" meeting (socializing over pizza) occurs at the Pizza Shoppe at 8915 Santa Fe Drive (west of Antioch) immediately after the regular meeting.

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Brian Short, KCØBS

## Johnson County Dominates ARRL November News

The ARRL conferred the 2014 Philip J. McGan Silver Antenna Award to **Brian Short**, KCØBS. The award recognizes "outstanding public relations efforts in promoting Amateur Radio to the non-ham community". The full announcement, which details many of Brian's services to the amateur radio community, appears on the ARRL website at [www.arrl.org/news/kansas-radio-amateur-is-arrrl-mcgan-silver-antenna-award-winner](http://www.arrl.org/news/kansas-radio-amateur-is-arrrl-mcgan-silver-antenna-award-winner).

\* \* \*

The ARRL announced that W1AW centennial celebration portable operations will originate from Johnson County's Ensor Farm beginning on the evening of November 4.

## Johnson County Radio Amateurs Club

Meeting Date: Friday October 10, 2014. The meeting started at 7:30PM.

Attendance: Self introduction with name and call sign. 21 signed the check in sheet. This was followed by the Pledge of Allegiance.

The Minutes from the September 26, 2014 meeting were read and accepted with 1 opposed vote.

The Treasurer's report, as follows, was read and accepted unanimously.

Cash on Hand	\$ 81.99
Checking Account	\$ 390.32
Savings Account	<u>\$ 8,699.12</u>
Total	\$ 9,171.43

Repeater Operating Reserve	\$ 25.87
Memorial Fund	\$150.00
Active Members	139

### Old Business:

- Both the 440 Repeater and 2m Repeater are working fine. The new Black & Veatch sign and we need to re-move our original 440 m repeater antenna. This may be the beginning of losing our location here. We need to start the process of looking for a new location.
- Projector Donation to the Church – The Church was notified of, and accepted, our offer of donating a new projector to replace the malfunctioning one in the Fellowship hall. The Church was very appreciative of the gift of a projector to replace the malfunctioning one. Thank you so much! Your group is a blessing and we are so very glad to have you as a part of our community.
- Ensor Auction – October 24 and 25. We plan to move the equipment from Dave's location up north to Ensor on Wednesday October 22 starting at 9 AM. Once the equipment is loaded it will be unloaded at Ensor around 11 AM. Set-up for the preview will be on Friday October 24 at 9 AM. The preview will be from 12 – 4 PM. Be sure when checking into Nets to mention the Auction.
- Club Shirt Update - Bill Gery, KA2FNK is still working on collection information.

### New Business:

- Annual Christmas Party will be on December 12. Bring your favorite food item to share.

### Reports:

- 6 m – NR.
- 10 m SSB Roundtable – NR.
- 440 Wheat Shocker net – 20 check-ins on October 8 and 13 check-ins on October 1.
- 2m Wheat Shocker net – 27 check-ins on October 9 and 28 check-ins on October 2.
- HF Activity – 10m is open. Bolivia, New Caledonia, Australia 10m CW. Brazil, Southern Europe, Greece, Belgium, Falkland Islands on 10m.

### Announcements:

- Skywarn Recognition Day December 5-6, 2014
- Southside Hamfest October 18.

Business meeting adjourned at 8:09 PM

### Program:

- The Program for this evening was "Three Useful Knots" by Bill Gery, KA2FNK.



## Johnson County Radio Amateurs Club

Meeting Date: Friday October 10, 2014. The meeting consisted of a cook-out at the Ensor Farm and a preview of items for the following day's auction.



## A "Sleeper" Electronics Project -- Tom Wheeler, NØGSG

### Introduction

It's a nice warm summer evening and your family is feeling a little restless. Perhaps a trip to the Dairy Queen on Cruiser Avenue is in order, you suggest. So everyone piles into the family car, and together you trundle down the Avenue towards the DQ. At night it transforms into an automotive Mecca, a mile-long stretch of brightly-lit car dealerships, fast food joints (replete with neon signage), and plenty of parking lot acreage for folks who just want to hang out.

The "Avenue", of course, is a special place for all teenage drivers, who are proud to show off their wheels; anything goes, from exotic foreign cars, American Mustangs and Camaros, and even cars of dubious breeding, often slapped together by the owners out of odd parts and sometimes held together with copious amounts of duct tape.

A red light beckons ahead, and the traffic slows. Side by side at the front of the pack sits a bright yellow Corvette and what looks like a non-descript dark gray family sedan (perhaps an 80s Taurus). The Corvette's driver impatiently revs his engine--the the universal signal of dislike for traffic lights--and the an unspoken invitation: *I'm faster than you, and I'm ready to prove it.* The Taurus revs its engine, too. It makes sort of a wheezing noise. But the acceptance of the proposition is clear. *Okay, I'm game. Let's go.*

It's over within seconds. The squabbling din of two sets of tires arrives in time with the green light. The Corvette takes off, its engine shrieking, leaving a an immense cloud of tire smoke in its wake. The Taurus is nowhere to be seen, but the wheezy sound it was making a few seconds ago has been replaced with a powerful whine, reminiscent of a departing jet. It's breathing deeply. The little Taurus has smoked the Vette. Trolling Corvettes and other such "performance" cars is such great fun for the builders of sleeper cars.

Electronics is a fertile ground for sleeper projects too. As a teenager (yes, they had electronics then - - no wisecracks from the peanut gallery!) I tried to build quite a few sleepers. A pocket radio that put out more power than a large car stereo? Sure, great fun to show off in the Radio Shack sound room just to watch customers' jaws drop. A normal-looking CB radio with ten times the normal (and legal) power? Well, definitely less than legal, but with utilitarian value - - who doesn't want to talk louder and farther? (Of course, this was in the 70s - - where bigger was better!)

Much vintage electronics from the 60s and 70s has a lot of potential performance built in, which brings us totoday's topic: The Newcomb 20 and 30 series phonographs of the 1970s.

### *Newcomb Phonographs - Audio, but Not Ham Radio!*

Anyone who grew up in the 50s, 60s, or 70s probably carries fond memories of Newcomb classroom phonographs. Figure 1 shows two rare EDT-series units (yes, they're really mustard yellow!) from the late 70s.

The EDT-30MV, pictured at left, was a high end model. It featured variable speed control (by a super-simple magnetic negative-feedback regulator using a permanent magnet suspended above a spinning aluminum disk on the motor shaft), separate bass and treble controls (what we call the "losser" type--often used in older tube amplifiers), loudness compensation circuitry (sounds decent even at low volume), a huge 6x9 inch internal loudspeaker (mounted on a sub-frame spring-mounted to the cabinet to reduce acoustic feedback), and a very stout amplifier capable of 10 watts RMS (18 watts IHF) over the entire audio passband of 50 to 20,000 Hz.

In terms of today's audio ratings, this honest 10 watts RMS would probably be rated as 500 or 1,000 watts. For sure, the people writing specs nowadays have a lineage directly traceable to Pinocchio and are aided and abetted by the Federal Trade Commission's total abandonment of its earlier regulations (dating to the 1970s) regarding power output claims of home audio devices.

Ten RMS watts into an efficient speaker system can be house-shaking loud, and at the same time, clean. By comparison, most consumer phonos, such as the current plastic Crosley models (which have some very eye catching styling), have a power output of about 1 watt and drive tinny 3" speakers. Not a recipe for high-fidelity.

Did I mention that the Newcomb phonographs are built like tanks? These units were made to be classroom-tough and teacher-proof. The cases are heavy wood laminate, and the chassis are heavy gauge stamped steel. All the cabinet corners are protected by steel covers. Not very pretty, but functional.

### *Extracting More Performance*

In stock form, Newcomb phonographs were at best "mid-fi" devices. Ruggedness and classroom-loud sound were the primary design goals, though the engineers obviously knew a lot of about high-fidelity design. The

***See SLEEPER on page 5***



#### *From SLEEPER on page 4*

solid-state amplifier circuitry is almost entirely direct-coupled, with no transformers in the signal path. The gain circuitry is appropriately divided between a two-stage preamp-equalizer and traditional power amplifier, with good power supply filtering and extensive use of negative feedback. So the amplifier itself is capable of clean, low-distortion audio.

The primary limiting factor is the needle and pickup cartridge. Newcomb (and many others) used the ubiquitous Astatic 89T ceramic cartridge, which was

the 1 to 3 gram range - - and that means that residual friction in the tonearm assembly--which might not have been a problem for a cartridge pushing down with 10 g of force--suddenly becomes a huge enemy. Friction must be reduced as much as possible. (A good rule of thumb is that any residual friction should be less than 1/100 of the tracking force; that means 10 millionths of a gram of horizontal force is the ideal maximum permissible for a 1 g downward tracking force. That's very low friction!)

Finally, high gain amplifiers and magnetic cartridges are very sensitive to hum. The electric motor in most vin-

tage phonos is magnetically unshielded and radiates quite a strong 60 Hz magnetic field. Everything must be strategically shielded to prevent hum pickup.

Fortunately, the steel chassis of the EDT-series phonos provides a good measure of magnetic shielding.



*Figure 1: Good Things Do Come in Pairs. A Twin Set of Newcomb EDT-Series Phonos from the Late 1970s.*

meant to track at 8-10 grams of force. Ceramic cartridges are great for inexpensive systems (Crosley and most of the current brands of portable/USB phonos use them) because they are cheap, lightweight, and fairly rugged. In a Newcomb player, the 89T actually sounds pretty good. But tracking at 8-10 grams isn't good for your vinyl (that's a lot of force), and the 89T struggles to reproduce any recordings with high modulation levels (typical of most 45s and many hard-rock LPs). Moving to a quality magnetic cartridge can greatly improve the audio, but additional problems must be overcome. First, magnetic cartridges, though they sound great, put out only about 6 mV of audio, compared to the 1,500 mV (1.5 V) typical of a ceramic unit. An additional preamp is needed.

Second, along with the greater precision of a magnetic cartridge, much lower tracking forces must be accommodated. Most good magnetic cartridges track in

#### *The New Cartridge*

The Shure M44-7 was the cartridge of choice for this project. It's rated to track at 1.5 - 3.0 g of force, and is popular with DJs because of its high skip resistance. It also provides 9.5 mV output, rather than the standard 6.0 mV; with both channels wired in series (for mono), the total output is more than 18 mV - - which pushes any residual hum almost 10 dB down, as the preamplifier gain can be reduced by 9.5 dB.

#### *Tone Arm Modifications*

The Newcomb tone arm is of die-cast zinc and is fairly light. A simple spring mechanism adjusts the tracking force, and this was modified (approximately 3 mm of the spring coils were removed) to bring the tracking force down to 2.5 g.

*See SLEEPER on page 6*

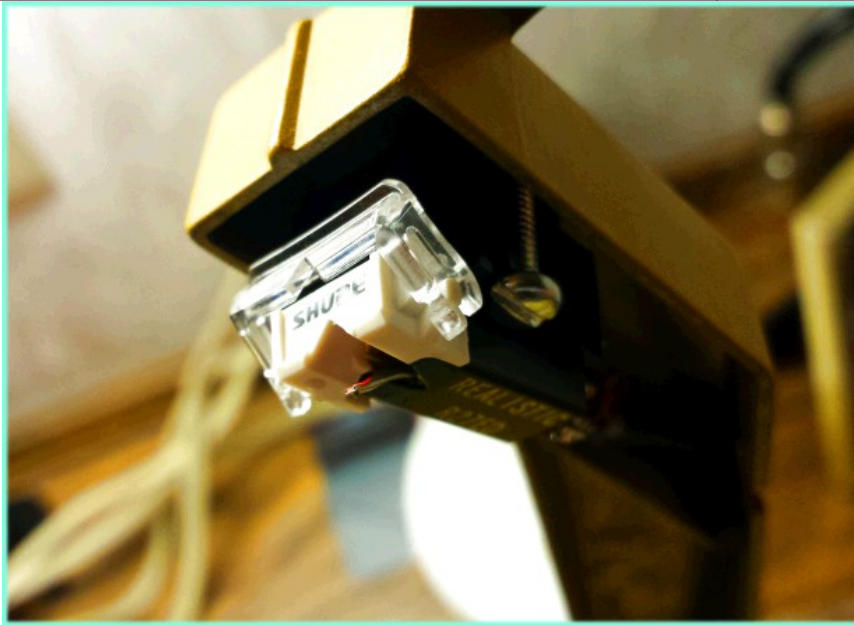


Figure 2: M44-7 Mounted in the Tone Arm

were removed with solvent, and a small amount of graphite lubricant was distributed onto the mating surfaces upon reassembly.

The arm now successfully passes the "tracking from hell" test, which consists of playing a 45 RPM record deliberately placed off-center on the turntable platter (more than 12.5 mm of peak eccentricity at the record's edge) with very minimal needle wander and zero skips.

### The Preamplifier

An RIAA-equalized preamplifier using the Burr-Brown OPA-627 precision low-noise operational amplifier was built "dead bug" style on a small piece of copper plate. This copper plate was sized to fit under the existing magnetic shield of the unit's main

amplifier in order to keep hum pickup to an absolute minimum. The amplifier is equipped with its own voltage regulator and extensive filtering to prevent unwanted feedback. Additionally, an equalization network is provided at the amplifier's output to emulate the impedance characteristics of the original ceramic cartridge so that the stock amplifier in the unit has a correct frequency response. Figure 3 is the schematic diagram of the new amplifier, and Figure 4 shows it as installed in the unit.

See SLEEPER on page X

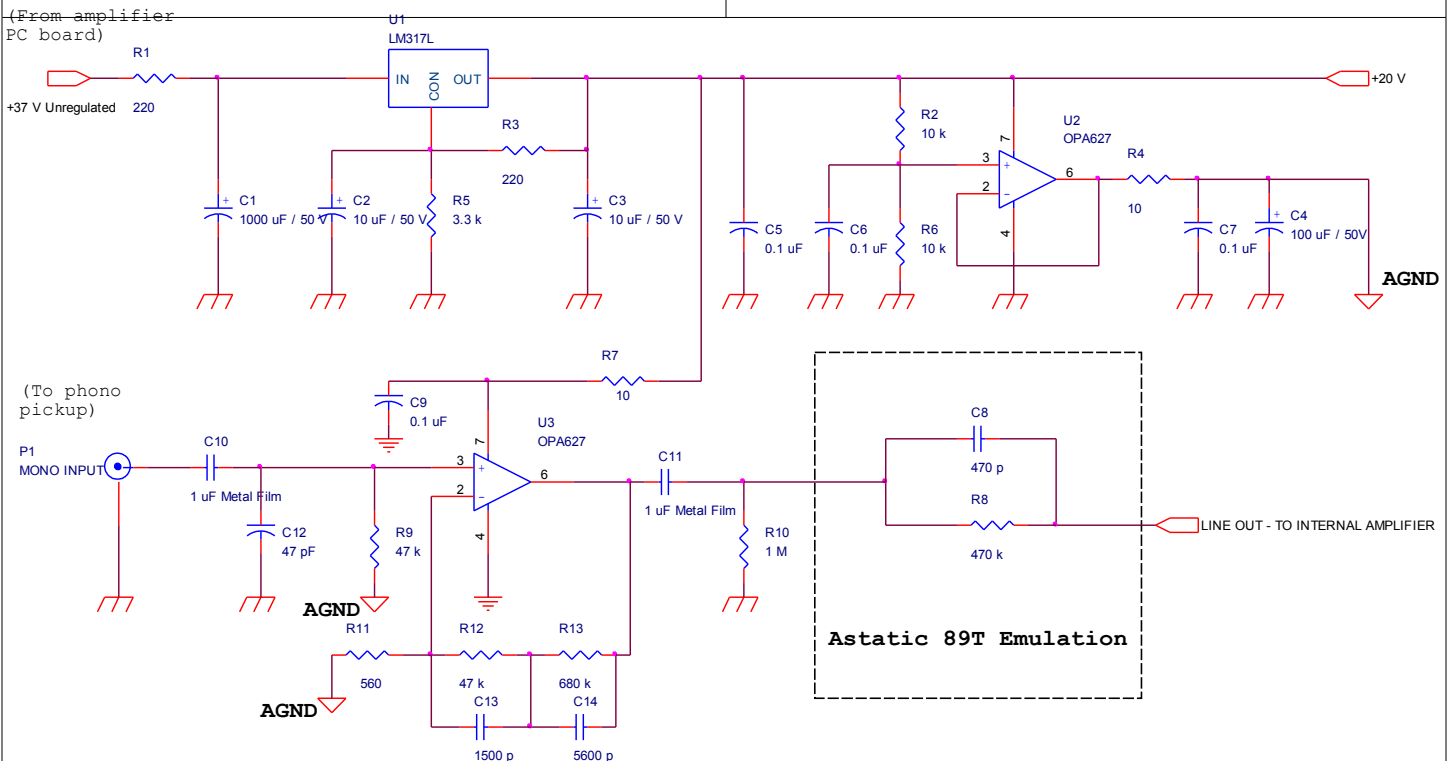


Figure 3: Preamplifier Schematic



## From SLEEPER on page X

### *So How Does it Play?*

The sound quality of the modified unit is very good. With good quality headphones (or external speaker) connected, there are only subtle differences between the audio coming from this phonograph (in mono) and the audiophile-grade system in the laboratory. These differences are in two forms, high-modulation tracking and signal-to-noise.

The M44-7 cartridge uses a spherical 0.7 mil diamond needle, instead of the elliptical needle in the reference system (M91ED Shure). This causes a slight increase in groove noise compared to the higher-grade system, and a very slight increase in distortion in very high modulation sections of recordings. Most listeners simply will not hear the difference.

Because I have a pair of the Newcomb record players, side-by-side comparison between the new magnetic cartridge setup and stock Astatic 89T ceramic cartridge is easy; the old 89T, while great sounding, simply has no hope of tracking loud passages without smearing and distorting the sound.

Induced hum is inaudible except at mid to high volume settings, where it's barely audible. It's probably more than 60 to 70 dB below maximum output.

The mechanical vibration of the old shaded-pole motor still propagates up through the metal chassis and can be heard with the volume up during quiet passages--but it's certainly not objectionable for most listening, and might be improved with additional mechanical isolation measures.

With a good quality 12" or 15" speaker system plugged in, this thing can rock the house.

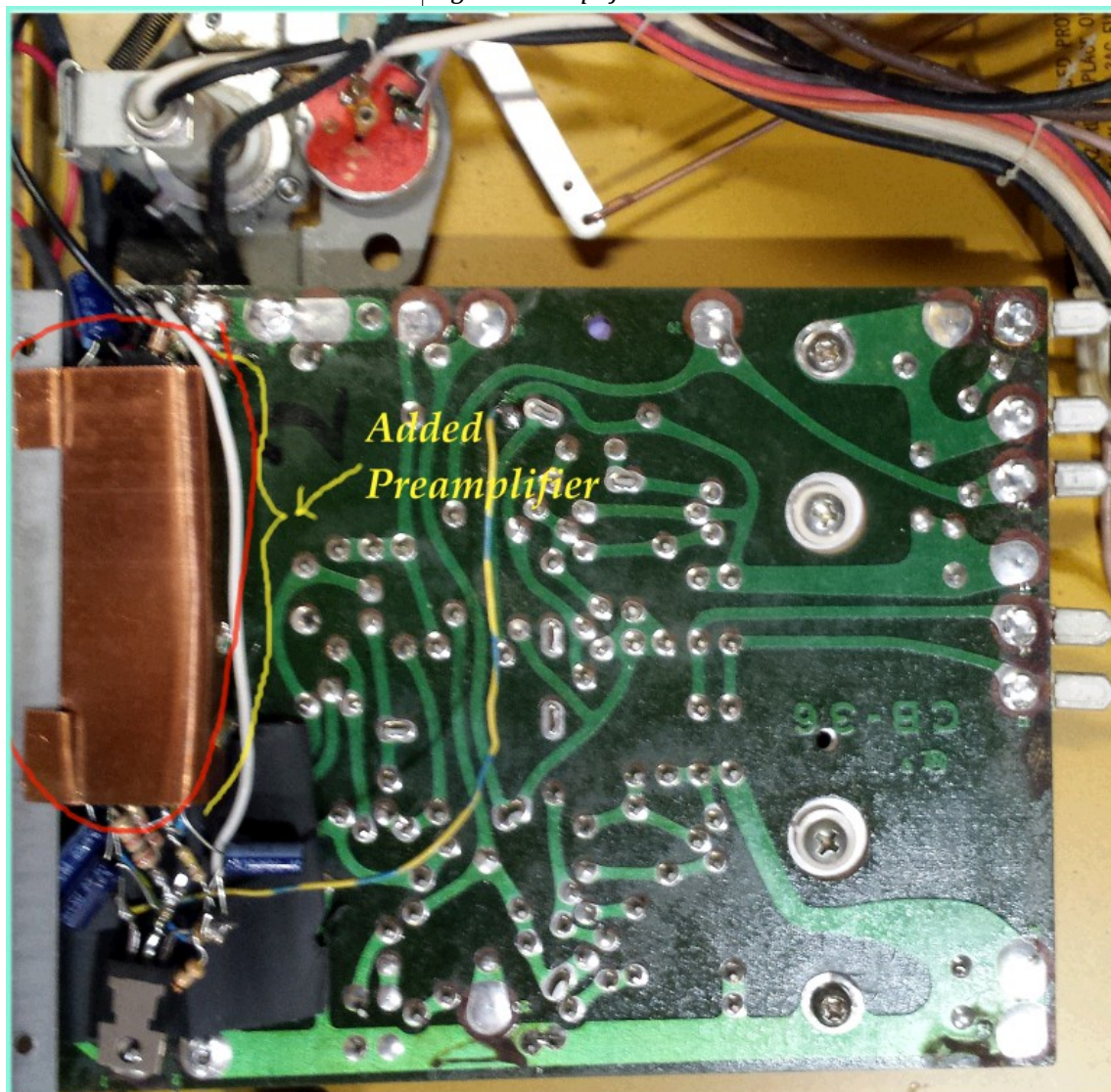
### *Conclusion*

In the world of sleeper electronics, there isn't a real equivalent to the streetlight warfare of the Avenue. But both avocations share a common theme, and that is the theme of engineering optimization. It's not really about high tech; there's nothing high tech about this project, after all. Sometimes it's simply to answer the question, "What if?"

That's the real fun of sleeper projects - - because in the end, no matter if your goal is to build a faster street rod, a hotter transmitter, or a better sound system, you are your own competitor. You can always do it better, perhaps cheaper, by applying your imagination. That's a dimension of ham radio that attracts many of us.

Good luck in your next project!

*Fig 4: Preamplifier Installed in Unit*



## Hambone and SWR -- Jaimie Charlton, ADØAB

"Hi Hambone, I haven't seen you for a while, how's that new antenna doing?"

"I've been pretty busy with a new part time gig, but I've had some good luck Dxing. I worked Western Kiribati and Fiji both with that new antenna. But, Elmer, I'm a little concerned that it is not the high quality antenna I thought it was."

"Why is that?"

"Well, my SWR meter shows it has an SWR on 40 meters of 1.6 to 1 and a whopping 1.9 to 1 on 20 meters. That tells me it may really be a pretty poor quality antenna. What is SWR, anyway?"

"Remember, Hambone, SWR stands for Standing Wave Ratio which is short for VSWR or Voltage SWR. One thing it isn't is a measure of the quality of an antenna. In fact, it's not a measurement of an antenna at all!

"How can you say that? All antenna ads always boast how low their antennas' SWRs are. It's like golf, the lower the 'score' the better."

"Yeah, I know, they're just trying to pander to hoi polloi of ham radio. VSWR, or SWR is actually a transmission line effect that occurs when the characteristic resistance of the line doesn't match the impedance of the antenna at the operating frequency. It does not indicate how good a radiator an antenna is.

To really understand what SWR is you must first understand how reflections occur. This is one of the closest things to smoke and mirrors you are going to run into in radio - especially the mirror part. So, stick with me."

"I'll try but, what's that about mirrors?"

"There's no looking glass here, Hambone, but like Alice, we're going to see some very strange things. Let's start with the transmission line that goes from the output of your transmitter to your antenna."

"First off, all transmission cables have a characteristic resistance that is measured between the two conductors, not end to end. Sometimes, you will hear the term characteristic impedance or just impedance when describing transmission line. These are all the same thing.

For example, there's 50 and 75 ohm coax, 300 ohm twinlead, 450 window line and 600 ohm ladder line to name a few of the most popular ones. But, if you try to measure the characteristic resistance with your multimeter, you will not get those numbers, unless you've connected it to an infinite length of line --and that's not very practical.

That's because the characteristic resistance exists only when energy is moving down the line. When you connect your multimeter to a section of line, the multimeter sees the characteristic resistance for only for the instant of time that it takes to charge that line; then it reads open circuit. Not only that, this resistance does not result in any power loss. I said this would get strange."

"I see, Elmer, that's why there's different types of cables like RG-8 or RG-59. But, how does this relate to SWR?"

"I'm getting there. Let's start with a very long piece of cable, say 50 ohm coax connected to a 100 ohm resistor load at the far end. At our end, we have a transmitter that puts out a single very short 50 volt pulse. Since the cable's characteristic resistance is 50 ohms, the current associated with that pulse is 1 amp."

"Why is that?"

"Simple Ohm's Law,  $I=E/R$ , Hambone. 50 volts applied across 50 ohms of characteristic resistance results in a current of 1 amp. You see, resistance can also be thought of as the ratio of voltage to current in a circuit. Since the pulse is very short and the cable is very long, the pulse doesn't 'see' the 100 ohm resistor at the far end, yet.

But the pulse eventually does get to the far end and encounters the 100 ohm resistor. Now we have a problem. How can we have a pulse whose voltage to current ratio is 50 (ohms) suddenly have a voltage to current ratio of 100 when it hits the 100 ohm load resistor?

We explain this by saying that some of the 50 volt pulse and its associated current is absorbed by the resistor and some is reflected back towards the source. That is, we sort of create a new pulse at the load that travels back towards the transmitter. We call this reflected pulse a reflected wave."

"So, Elmer, you're telling me that we have two different pulses going opposite directions at the same time on the same cable?" A tone of incredulity was clearly evident in young Hambone's voice.

"I said it was going to get strange. But, yes. You can see the same effect in a very still swimming pool. If you slap the water at one end, you create a wave that travels towards the far end. The wave doesn't change much until it hits the far end of the pool. There it splashes up on the wall. Some of the wave's energy goes into the wall, but some of the water falls back and starts a similar, but smaller wave coming back towards you.

*See HAMBONE on page 9*



**From HAMBONE on page 8**

A reflected wave has just been created in the water. Now, if you keep slapping the water at a regular rate, you will send a continuous stream of waves that also gets reflected."

"That's nice, Elmer, but where does the SWR come in?"

"If you close your mouth and open your eyes, you will see that your out-going waves and reflected waves interact causing some waves to be larger and smaller along the way. Further – and this is the amazing part – those peaks and valleys of wave heights stay in one place even though the waves causing them are moving and moving in opposite directions!

You might say that those waves are *standing* still. You might even call them *standing waves*. In fact, you might even measure the height of the big ones and divide it by the height of the small ones and call it the *standing wave ratio*." Said Elmer, smiling slyly.

"Whoa, very tricky, Elmer, how you snuck that in. But how does it relate to my antenna?"

"Here's how. The fact that the wall reflected some of the power in your wave does not indicate that it is a poor quality wall. The wall absorbed as much power as it could and sent the rest back. If the wall sloped gently up from the water, like a beach, it would have absorbed more power and the reflected wave would have been smaller."

"I get it!" exclaimed Hambone. The amount of reflected waves, or standing wave ratio, doesn't say anything about the 'quality' of the wall or beach, it simply says that something is there that is different from water."

"Yes, Hambone! And your SWR meter is simply saying, *at that frequency*, your antenna's input – or driving point - impedance is different from your feed-line's characteristic resistance. It doesn't say anything about how much signal your antenna is putting out."

"But why does my SWR change when I change frequencies? My transmitter, coax and antenna don't change."

"It's true that your transmitter and coax don't change, but the length of your antenna and all of its characteristics do. That's because antennas are not measured in inches and feet, but in wavelengths of the operating frequency. It is a little like we're measuring with a rubber yardstick. A 17 foot vertical antenna is about half a wavelength tall at 28.5 MHz (10 meter band), but only a quarter wavelength tall at 14.25 MHz (20 meter band).

Physically, this is the same antenna. But electrically, because we are operating it at two different wavelengths (i.e. frequencies), it appears to be two entirely

different antennas. From the point of view of your 50 ohm coax, the antenna is a sloping beach at 20 meters and a solid wall at 10 meters."

"So Elmer, you're telling me that SWR merely indicates how well my cable matches my antenna and not how well I'm getting out?"

"Yes. Let's try an example. Say that you have a length of 50 ohm coax connecting your transmitter to a 50 ohm resistor. Without going into the math, your SWR is 1:1 indicating a perfect match. Yet, the resistor is not an antenna and is not radiating anything."

"Yeah, but nobody expects a resistor to radiate."

"Quite the opposite, my naive friend. Many hams have water in their coax and broken antennas with loose connections, shorts etc and still expect them to radiate. Any of these problems could present a 50 ohm load and a 1:1 SWR but still not radiate."

On the other hand you might have a very good antenna whose impedance is only 30 ohms. It's SWR would be about 1.7:1. Yet, it could be very efficient and have a low angle of radiation and perform really well.

On our third hand, you might have an antenna with 50 ohm impedance that actually displays an SWR of 3:1. It could be a great antenna, but you are operating it at a frequency where it has some capacitive, or even inductive, reactance (Aside for geeks:  $Z = 30 - j40$ , or  $Z = 50 \angle -57.3^\circ$ ).

"Okay, all right already, enough with the fancy math. I get it. SWR is not a measure of quality, it's not good or bad. It depends on the antenna and cable and doesn't say anything about how strong a signal the antenna radiates. But what happens to the reflected power?"

"At last, Hambone, you got it. Which is good because it's getting late and I'm getting tired. That reflected power eventually get radiated. We'll leave how that happens for a future discussion.

But one last question, do you know an easy way to lower your SWR regardless of operating frequency?"

"I give up, Elmer, how?"

"Use old, damaged, water-logged, lossy coax. Crummy coax reduces SWR because it loses the reflected waves before they get back to your SWR meter. Of course, it also loses your transmitter power before it gets to your antenna, too. Not good, but your SWR will look real low. So, if everything looks good and your SWR is low and doesn't change with frequency, but you still can't get out. You might have lossy coax."

"Good night, Elmer."

"Good night, Hambone."

***A mathematical "sidebar" follows***

## SWR - Elmer's Sidebar

So, where did those numbers that Elmer was tossing about come from? Here's where.

First, we need to figure out how much voltage is reflected from that 100 ohm load resistor at the far end of the 50 ohm coax. We do that by introducing the *Reflection coefficient*,  $k$ , a number that relates the cable and load impedances to the size of the reflected voltage pulse.

$$k = (Z_L - Z_0) / (Z_L + Z_0)$$

Where:

$Z_0$  = cable characteristic impedance

$Z_L$  = load impedance

Notice that both the cable characteristic impedance and the load impedance can both be complex quantities. That means that  $k$  can also be complex.

Complex  $k$  is of the form  $k = r \pm jx$

Where:

$r$  = the real or resistive part of  $k$

$x$  = the reactive part of  $k$ ;  $-j$  indicates that  $x$  is capacitive and  $+j$  indicates that  $x$  is inductive

In our example both quantities are resistive to simplify the principle:

$$k = (100 - 50) / (100 + 50) = 50 / 150 = 1/3 \text{ or } 0.333$$

That means that the reflected voltage pulse going back towards the transmitter is 1/3 as strong as the 50 volt forward pulse or about 16.67 volts.

Notice that if the load impedance equals the cable impedance,  $k=0$  which means no reflected voltage pulse is created. Likewise, if the load impedance equals  $\infty$  or 0 ohms corresponding to an open or short circuit at the far end respectively,  $k$  equals 1 or  $-1$ . This indicates that the reflected voltage equals the incident voltage or, all the voltage is reflected. The  $-$  sign indicates that the reflected voltage is of the opposite polarity.

Since  $k$  refers to the actual size of the reflected voltage and VSWR is the ratio of the reflected to the incident voltage:

$$SWR = (1 + |k|) / (1 - |k|)$$

$|k|$  is the magnitude of the complex value of  $k$  or  $\sqrt{(r^2 + x^2)}$ . The magnitude is used because VSWR is not a complex quantity.

Because our load is purely resistive and our cable is lossless,  $x=0$  in our example, therefore,

$$|k| = 0.333$$

$$SWR = (1 + 0.333) / (1 - 0.333) = 1.333 / 0.667 = 2 \text{ or } 2:1$$

Further since reflected power is proportional to the square of reflected voltage, the percentage of reflected power is:

$$\%P_{\text{reflected}} = |k|^2 = 0.333^2 = .11 \text{ or } 11\%$$

This means that a mismatch that results in a 2:1 SWR only reflects 11% of your transmitted power. In the case of the 50 ohm antenna that gives a 3:1 SWR, the calculation is as follows:

$$Z_0 = 50 \text{ ohms or } 50 + j0$$

$$Z_L = 30 - j40 \text{ ohms note that the } |Z_L| = \sqrt{(30^2 + (-j40)^2)} = \sqrt{(900 + 1600)} = 50 \text{ ohms}$$

$$k = (Z_L - Z_0) / (Z_L + Z_0)$$

$$k = (30 - j40 - 50) / (30 - j40 + 50) = (-20 - j40) / (80 - j40) = 0 - j0.5 \text{ ohms}$$

$$|k| = \sqrt{(0^2 + (-j0.5)^2)} = \sqrt{0.25} = 0.5$$

$$SWR = (1 + |k|) / (1 - |k|) = (1 + 0.5) / (1 - 0.5) = 1.5 / 0.5 = 3 \text{ or } 3:1$$

So, even though the impedance of the antenna is 50 ohms, it does not match a 50 ohm coaxial cable because that impedance includes 40 ohms of capacitive reactance. The result would be the same if the reactance were inductive.

Even if the antenna were operating at its resonant frequency where  $x=0$ , it would still not match the 50 ohm line because it would present only a 30 ohm load. In that case:

$$SWR = 1.67:1$$

So, you won't get a match if the load is even partially reactive and resonance does not guarantee a match either. Hence the market for tuners.