Johnson County Radio Amateurs Club, Inc.
P.O. Box 93
Shawnee Mission, KS 66201

FEEDBACK

November 2015

Auction ring man **Bill Gehry, WA2FNK** points out the current high bidder to auctioneer **Dave Schulman, WDØERU**. (photo NØCVW)

Ensor Auction Raises Nearly $4000

The JCRAC holds an auction of radio gear out at the Ensor Park and Museum each October. This year's event, a Friday night campfire followed by a Saturday morning auction, saw forty-eight successful bidders engage in one hundred eighty-five transactions, bringing $3732.60 to the JCRAC, which donated half that amount to the City of Olathe, which owns and operates the Ensor Park and Museum. Another $234 went to individuals who consigned goods for sale at the auction.

OCTOBER MEETINGS

***November 13** – MO-KAN Council of Clubs*

***November 27** – No Meeting*

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

Much of the membership travels to the Pizza Shoppe at 8915 Santa Fe Drive for pizza buffet and an informal continuation/criticism/clarification of the topics raised at the meeting ... or anything else.

Leave the church, turn right (west) on 75th. Turn left (south) on Antioch. Turn right (west) on Santa Fe. Pizza Shoppe is just past the Sonic on your left.

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-> FEEDBACK <-

A publication of the
Johnson County Radio Amateur Club, Inc.

Bill Gery, KA2FNK, President

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Cal Lewandowski, KCØCL,Treasurer / FEEDBACK distribution

* * *

Chip ACØYF and Deb KDØRYE Buckner, Editors

Charlie Van Way, NØCVW, Photography

All email addresses are available at w0erh.org

Another Upgrade to the FEEDBACK

In a forthcoming installment of the Hambone stories, one of the characters wields (what we are assured is) some high-end photographic equipment. At a post-club-meeting get together at the Pizza Shoppe, your editor--who makes SOME effort to make the newsletter intelligible to the readers--challenged Hambone author **Jaimie Charlton, ADØAB**'s, need to refer to a six-syllable piece of photographic kit.

Unfortunately for your editor's ego, **Charlie Van Way, NØCVW** was seated at the table. Charlie identified the equipment, and expressed his opinion that because many hams--he pointed to several club members at adjoining tables--had an interest in photography, much of the membership would find the detail to be interesting.

Your editor, whose experience with a good quality 35mm cameras consists of an inadvertant demonstration that its

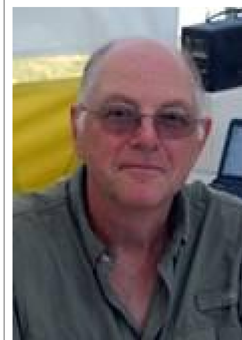
specific gravity exceeded that of water, asked why, if there was so much photographic talent in the club, he was using a cellphone to document club events.

Fortunately, for the club membership, Charlie instantly volunteered to serve as staff photographer for the FEEDBACK. You will see his work throughout this issue.

-- Chip ACØYF and Deb KDØRYE Buckner

PRESIDENT'S CORNER

Uncertain weather threatened the Ensor weekend. When would the rain start? When would it end? As it turned out, the rain held off



long enough to permit the Friday night campfire. Saturday, the rain ended around sunrise. The Park dried slowly, but sufficiently thoroughly to allow the auction to start right on time.

There are many to thank for the success of the auction. The first thank you, of course, goes to **Dave Schulman, WDØERU**, our auctioneer. **Diana Fiddick, KDØOBP**, **Ted Knapp, NØTEK**, **Cal Lewandowski, KCØCL**, and **John Hochscheid, WØBBQ** all stepped up to assist with clerking and handling the check ins. **Herb Fiddick, NZØF, Bill Brinker, WAØCBW** and **Jay Greenough, WJØX,** helped with tables and chairs. Thanks to everyone who donated items for the auction.

Skywarn Recognition day will be December 4 (0000 to 2400 UTC) this year. The National Weather Service and the American Radio Relay League sponsor the event. If you have questions, or want to sign up to help, please contact me. You can get additional information at http://hamradio.noaa.gov.

The Thanksgiving holiday means we have but one meeting this month. Have a safe and happy Thanksgiving.

– Bill Gery – WA2FNK

Second Annual HF Shoot Out - October 23, 2015

Lon Martin, KØWJ conducted the JCRAC's second annual HF shoot out ahead of the club's October 23 meeting. Participants tuned to 7.267 MHz and attenuated their signal to 20 watts and transmitted to a receiving unit next door in the parking lot of the First Assembly of God Church of Overland Park.

After several trials, the top three finishers were:

1. Donell Reed, KØIFO - 10 dBm
2. Cal Lewandowski, KCØCL - 7.7 dBm
3. Van Van Daveer, KØHCV - 6 dBm

Lon said that he was working on a hand-held UHF competition for January.

-- FEEDBACK --

***Lon Martin, KØWJ** explains the HF shootout rules to **Ted Knapp, NØTEK** and **Van Van Daveer, WØHCV**, in the Overland Park Christian Church parking lot. (photo by NØCVW)*

***Tom Wheeler, NØGSG**, armed with a GW Instek GSP-730 spectrum analyzer, measured the signal received next door in the parking lot of the First Assembly of God Church of Overland Park, about 400 feet to the west. (photo by NØCVW)*

Johnson County Radio Amateurs Club - October 9, 2015

Meeting Date: Friday October 9, 2015. The meeting Started at 7:30PM.

Attendance: Self introduction with name and call sign. 31 signed the check in sheet. This was followed by the Pledge of Allegiance.

The Minutes from the September 25, 2015 were accepted with 1 opposed vote.

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

Cash on Hand	$ 375.96	Repeater Operating Reserve	$ 935.87
Checking Account	$ 407.48	Memorial Fund	$ 310.00
Savings Account	$ 7,473.26	Active Members	134
Total	$ 8,256.70		

Old Business:

- Repeater Update – After further analysis, the noise being heard on the 145.29 Repeater is coming from noise in and around the area of the Repeater site.
- Official Club Name Badges – Orders will be placed through Cal, KCØCL. Cost is $9 each.
- Ensor Auction – The dates for the Ensor Auction and activities is Friday and Saturday October 30 and 31. Jack Holzer from the Johnson County Sherriff Dept. has again donated a bunch of items for this year's auction!
- WW1USA – Upcoming Event which will be organized by the Club is December 12-13.
- The Kick-Off Meeting for the Charter Members of the Mo-Kan Regional Council of Amateur Radio Organizations was held on Saturday September 26, 2015. The purpose of this meeting to get together the Leaders of all the area Clubs in order to exchange ideas and coordinate events.

New Business:

- "Van" Van Daveer KØ0HCV reported that the new Fusion Repeater has shipped. This new Fusion Repeater will replace the current but older 146.91 Fusion Repeater. The older Fusion Repeater can be repaired for $300 and would become a very nice back-up Repeater. The current owner of the older Fusion Repeater is Brian Short KCØBS and he is OK with letting the Club have it if we wanted to make those repairs. A motion was made to spend up to $300 to revamp and repair the older Fusion Repeater. The motion was seconded, a short discussion followed, and the motion passed with a unanimous vote.
- John Raydo KØIZ made the Club aware of a program through Amazon in which they will donate 1/2% of the purchase price to charitable organizations. The program is called AmazonSmile. A motion was made to have Cal Lewandowski KCØCL look into and register the Club for this program. The motion was seconded, a short discussion followed, and the motion passed with a unanimous vote.

Reports:

- 6 m – NR.
- 10 m SSB Roundtable – 11 participated on October 8.
- 440 Wheat Shocker net – 16 check-ins on October 7 and 15 check-ins on September 30.
- 2m Wheat Shocker net – 30 check-ins on October 8 and 18 check-ins on October 1.
- HF Activity – Chesterfield Island DXpedition TX3X October 1 – 12, 2015.

Announcements:

- Welcome to all the 1st time visitors.
- HF Mobile Shootout October 23. Lon Martin, K0WJ will be organizing this event. More details to come.
- Skywarn Recognition Day is December 4 -5. The event starts at 7:00 pm on the 4th and ends at 7:00 pm on the 5th. See Bill Gery, KA2FNK for information.
- Watch Larry's List for upcoming events.

Business meeting adjourned at 8:02 PM

Program: The Program for this meeting was a Vintage Radio Show and Tell.

Johnson County Radio Amateurs Club - October 23, 2015

Meeting Date: Friday October 23, 2015. The meeting Started at 7:30PM.

Attendance: Self introduction with name and call sign. 22 signed the check in sheet. This was followed by the Pledge of Allegiance.

The Minutes from the September 25, 2015 were accepted with 1 opposed vote.

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

Cash on Hand	$ 408.96	Repeater Operating Reserve	$ 935.87
Checking Account	$ 320.84	Memorial Fund	$ 310.00
Savings Account	$ 6,473.26	Active Members	136
Total	$ 7,203.06		

Old Business:

- Repeater Update – Bill Brinker, WA0CBW reminded the Club when using the Digital Fusion Repeater please give a short delay after keying the mic before speaking to give the Repeater a chance to figure out which mode you are using. If you don't it won't transmit the first part of you conversation.
- The question was asked once the older 146.91 Fusion Repeater is repaired should it become a Back-up or is it better to have it as another primary repeater. Bill Brinker, WA0CBW said it's best that it become a Back-up.
- "Van" Van Daveer K0HCV reported that the new Fusion Repeater has arrived. He will work with Water One, the owner of the tower site, to gain access for installation.
- Official Club Name Badges – Orders will be placed through Cal, KC0CL. Cost is $9 each.
- Ensor Auction – The dates for the Ensor Auction and activities is Friday and Saturday October 30 and 31. Jack Holzer from the Johnson County Sherriff Dept. has again donated a bunch of items for this year's auction!
- WW1USA – Upcoming Event which will be organized by the Club is December 12-13.

New Business:

- WW1USA – The 2016 Event dates have been set. They are February 13-14, May 7-8, July 23-24, and October 8-9. A recommendation was made to the have the Club sponsor the May 7-8 Event (which will be outside). A motion was made to sponsor the May 7-8 Event. The motion was seconded and the motion passed with a unanimous vote.

Reports:

- 6 m – NR.
- 10 m SSB Roundtable – 9 participated on October 22.
- 440 Wheat Shocker net – 18 check-ins on October 14.
- 2m Wheat Shocker net – 21 check-ins on October 22 and 18 check-ins on October 15.
- HF Activity – Chesterfield Island DXpedition until the 28th of October. 10m has been open lately. Canary Island on 40m.

Announcements:

- Welcome to all the 1st time visitors.
- Skywarn Recognition Day is December 4 -5. The event starts at 7:00 pm on the 4th and ends at 7:00 pm on the 5th. See Bill Gery, KA2FNK for information.
- Watch Larry's List for upcoming events.

Business meeting adjourned at 7:54 PM

Program: There was no Program for this meeting due to the HF Shootout.

Improving the RIT in the Uniden HR-2510 Transceiver

by Tom Wheeler, NØGSG

The Uniden HR-2510 is a mobile 10 meter transceiver that was manufactured in the late 1980s. The radio covers the entire 10 meter ham band (28.000 ~ 29.999 MHz) in CW, AM, FM, and SSB modes with 25 watts of transmitter power output. It's a compact package (about the size of a typical CB radio) and is great for operating 10 meters either as a base or mobile. This radio is a good-looking unit, as shown in Figure 1.

The HR-2510 is one of several 10-meter monoband radios marketed in the 80s and 90s by Uniden, Radio Shack, Ranger Communications, and a host of others. It has a loyal following, despite having a few drawbacks. These include a primitive (and somewhat unstable!) PLL frequency synthesizer with coarse 100 Hz frequency steps (most modern radios provide 1 Hz steps with no gimmicks), lack of a standard external speaker jack (you have to wire the speaker onto an option plug), and a funky, ultra-touchy receive incremental tuning (RIT) control with a control range of ± 3 kHz nominal.

6 kHz is an immense range for RIT, especially for a radio with frequency steps of 100 Hz (0.1 kHz for comparison), and when operating mobile, that makes it very hard to drive and tune properly onto signals--especially since there's no "zero" detent on the RIT control.

This limitation is easily corrected by adding two additional resistors to the RIT circuit, as shown in Figure 2.

The HR-2510 RIT circuit is pretty straightforward. Like most modern radios, the HR-2510 uses a voltage-controlled-oscillator (VCO) to provide both the receiver and transmitter frequencies. A VCO essentially converts a DC voltage to an output frequency; changing the DC input voltage to the VCO shifts its output frequency.

The RIT DC control voltage from this circuit feeds a VCO that mixes with the PLL's steady oscillator to produce the final output frequency of the radio.

The RIT circuit of Figure 2(a) is a variable voltage divider, with the RIT control RV675 providing a control voltage for the VCO in the range of about 0.65 V (wiper at the bottom - full counter-clockwise control rotation) to 7.2 V (wiper at the top--full clockwise control position).

This very wide "delta voltage" (ΔV) of 6.5V is enough to shift the receiver a full 6 kHz (± 3 kHz).

see RIT on page 7

Figure 1: The Uniden HR-2510

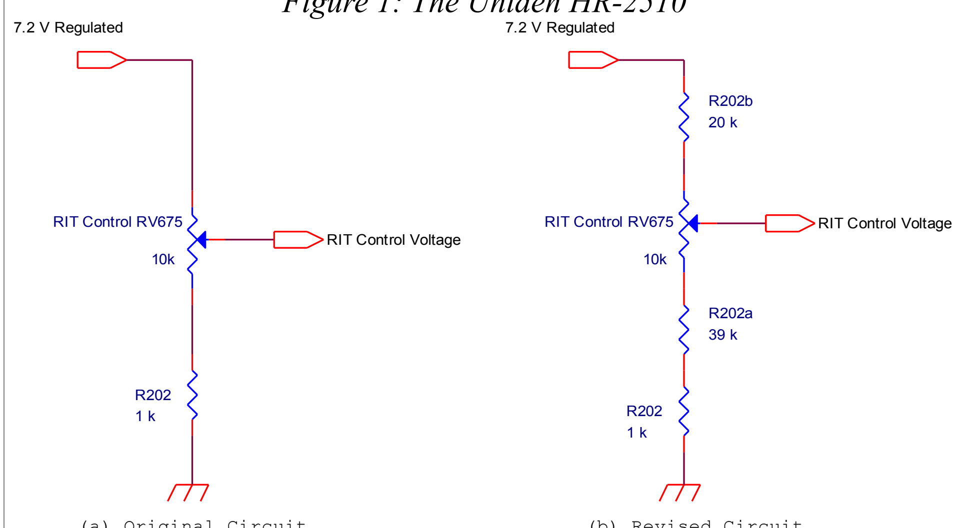


Figure 2: Elecrical Changes to the HR-2510 RIT Circuit

from RIT on page 6

Reducing the ΔV value to say, ±1 V, is a much more reasonable approach and will reduce the RIT adjustment range to about ±250 Hz.

The new resistors, R202b and R202a in the revised circuit of Figure 2(b) do just that. They make the potentiometer RV675 a smaller fraction of the total circuit resistance, which effectively limits the voltage "swing" of the RIT control voltage, and hence, the RIT control range.

DANGER - MATH AHEAD!

We can easily verify what's going on with a little arithmetic. Remember the voltage divider rule? It can be used to check this out. The maximum output voltage is produced when the wiper of RV675 is at the top:

1) $$V_{MAX} = V_{IN}\left(\frac{RV_{675} + R_{202a} + R_{202}}{R_T}\right) = V_{IN}\left(\frac{RV_{675} + R_{202a} + R_{202}}{RV_{675} + R_{202a} + R_{202} + R_{202b}}\right)$$

(1a) $$V_{MAX} = 7.2V\left(\frac{10k + 39k + 1k}{10k + 39k + 1k + 20k}\right) = \underline{5.14V}$$

By visualizing the wiper of RV675 at the bottom, we can get the minimum output voltage as well:

(2) $$V_{MIN} = V_{IN}\left(\frac{R_{202a} + R_{202}}{R_T}\right) = V_{IN}\left(\frac{R_{202a} + R_{202}}{RV_{675} + R_{202a} + R_{202} + R_{202b}}\right)$$

(2a) $$V_{MIN} = 7.2V\left(\frac{39k + 1k}{10k + 39k + 1k + 20k}\right) = \underline{4.11V}$$

(3) $$\Delta V = V_{MAX} - V_{MIN} = 5.14V - 4.11V = \underline{\underline{1.03V}}$$

This ΔV range value is the exact 1V control range we want. Incidentally, the choice of R202a and R202b, the added resistors, must also satisfy the condition of the RIT control voltage being equal to about 4.6 volts with the RIT control at its center position. This requires a bit more math to demonstrate, but essentially the resistors can be calculated by first finding the current that results in a 1V drop across RV675:

(4) $$I = \frac{V_{RV675}}{R_{RV675}} = \frac{1V}{10k} = 100\ \mu A$$

This same current will flow through R202, R202a, and R202b (ignoring any loading effects). If we desire 4.6 volts at the middle of RV675, the total resistance from the center of RV675 to ground must be:

(5) $$R_{LOWER} = \frac{V_{RV675-MID}}{I_{RV675}} = \frac{4.6V}{100\ \mu A} = 46k$$

Since the lower half of RV675 is just 5k (half of the pot's value), and R202 is already known to be 1k, then R202a simply makes up the difference of resistance to account for the desired voltage drop:

(6) $$R_{202a} = R_{LOWER} - {R_{RV675}}/{2} - R_{202} = 46k - 5k - 1k = \underline{40k}$$

How to Perform the Modification

Performing this modification requires some disassembly of your HR-2510. If you're not comfortable doing this, seek help! There are many people in the club that can assist you.

The steps are as follows:

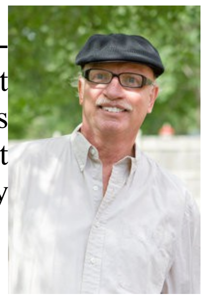
1. Disconnect the radio from all power and antenna connections.
2. Remove the top and bottom covers.
3. Pull off the RIT and RF Gain knobs. Using a thin-wall 3/8" socket, remove the hex nuts from both the RIT and RF Gain control shafts.
4. Remove the four screws holding the plastic front panel onto the chassis, and carefully tilt the chassis out to expose the RIT / RF Gain sub-board.
5. De-solder the shield tab from the RIT/RF Gain sub-board and remove the single screw holding it on.
6. Carefully maneuver the sub-board from the front of the radio, being careful not to break any of the attaching wires.
7. De-solder the orange wire from its two connection points.
8. Make the two trace cuts on the sub-board as shown in Figure 3. Lightly scrape off the solder resist in the two areas shown; you'll be adding two resistors.
9. Install R202a and R202b as shown in Figure 4.
10. Add the red jumper wire as shown, and re-solder the orange wire as shown.
11. Re-install the RIT/RF Gain sub-board into the unit being careful to not pinch any wires. Don't forget to re-solder the shield to the board!

see RIT on page 13

Hambone and His SDR - Jaimie Charlton, ADØAB

As our story opens, we find Hambone in his shack puzzling over a dazzling array of colors on his laptop screen as his transceiver plays an AM broadcast station.

“What’s happenin',” inquired Uncle Elmer, startling his young nephew. “Is something wrong, I haven’t seen you for a few days?”



“Oh, hi Unck. Nothing’s wrong, I just can’t figure this thing out. It doesn’t seem to make any sense.”

“What is that?”

“This was advertised as a really cheap spectrum analyzer. Basically, it’s a dongle, a short piece of micro-coax plus some free software downloads. I bought the version for my FT950 transceiver, but the only differences between transceiver types are the instructions and the coax jumper. The whole thing cost me about $60, but now I’m beginning to think I’ve been screwed.”

“Well, $60 is pretty cheap for a spectrum analyzer, even a cheap one,” mused Uncle Elmer. It looks nice on your screen–all those colors and graphs–what’s the problem?”

“I followed the instructions exactly. It turns out that the FT950 is particularly easy to connect up. There is a plug inside that lets you connect the little coax jumper to the IF section of the receiver. I just ran the coax out through an air vent and plugged the other end into the dongle. Then, I plugged the dongle into the USB port on my laptop. I thought that connecting to the radio would be the hard part, but it was easy.

Then I had to install the software. That was tougher, mostly due to ‘operator error’...”

“Make that ‘operator dumbness’,” interrupted Hambone’s little brother, Dude, as he barged into the shack.

Ignoring his bro, Hambone continued, “But I got the thing set up and running thanks to Bry, a really smart ham who also plays the drums. It turns out that this is really an entire SDR receiver that will play its audio through the laptop speakers as well as creating waterfall and pan adapter displays of the transceiver’s IF pass band.”

“So, what’s the problem?” asked Elmer.

“Look at this top graph, it’s a spectrum displaying the IF of the transceiver with that AM broadcast station in the center. You can see the carrier right here and the upper and lower sidebands next to it. You can see the sidebands get bigger and smaller and move out farther or get in closer to the carrier - take up more or less bandwidth - depending on the sound being transmitted.”

“Sooo, what’s the problem?”

“Don’t you see, Uncle, this is an *amplitude* modulated signal, yet the amplitude of the carrier never changes! How can that be?”

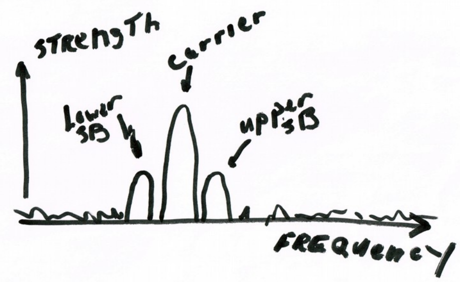
“You’re right,” said Dude. “Maybe there’s a problem with that software, it was free, you know.”

“No, there’s nothing wrong with the software,” said Elmer. What’s wrong is your understanding of amplitude modulation.”

Having now gained the boys’ attention, Elmer continued. “Although AM, or amplitude modulation, is not very popular with hams now, it is the first way voice was sent wirelessly. Basically, designers simply used an audio signal to vary the strength of a transmitter’s RF.

“I’m not sure, but I believe the thinking was that they were using the transmitter’s RF to somehow ‘carry’ the voice.”

“That sounds logical to me and that’s how I thought it works,” said Hambone.



“Logical, but wrong or, at least, incomplete. To understand what’s happening we must take a broader look at what modulation means.

What *really* happens when we generate an AM signal is that the RF and the voice signals are *multiplied* together. The multiplication occurs because the system is actually nonlinear.”

“What do you mean, non-linear? My new Ameritron amplifier is called a linear amplifier, not a non-linear amplifier,” argued Hambone.

"Whoa there, big guy!" said Elmer, stepping back. "Don't get a twist in

see HAMBONE on page 9

from HAMBONE on page 8

your knickers! I'm not criticizing your new toy.

Modern transceivers digitally generate their AM, SSB and FM signals at low levels and then amplify them with linear amplifiers. These circuits are easy to manufacture and don't need a lot of adjustment. The good news is that hams can spend more time operating and less time adjusting their equipment. The bad news is they lose track of what is going on inside their black boxes. As you guys have done."

"Okay, okay, stop arguing," chimed in Dude. "Exactly what do you mean by nonlinear and signal multiplying?"

We don't need to go into exactly what that means now, but suffice it to say that when one signal, like a voice signal, is used to vary the amplitude of another, such as the RF, the two signals are actually being multiplied together and all kinds of interesting things happen. That is, the original signals don't disappear, but a lot of new signals are created, especially sum and difference signals."

"But Uncle," asked Hambone, "Why don't audio signals get multiplied together in a stereo or hi-fi amplifier?"

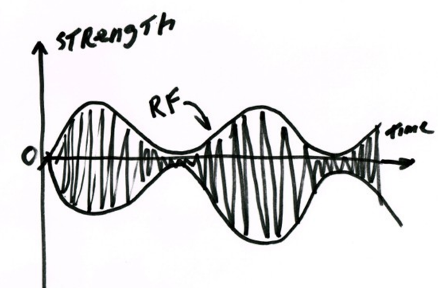
"That's easy. In those amplifiers the audio frequencies all pass through without one frequency affecting another. The only thing the amp does is make the signals stronger. That's what being linear means, one signal does not affect others passing through the amplifier at the same time. The fact that the various frequencies don't affect each other means that no multiplication takes place. Of course, no amplifier is perfectly linear, so even the best audio amps introduce a little IM, or intermodulation, distortion."

"I don't understand how using an audio signal to make an RF signal stronger and weaker does that," said Dude.

"Here's what's going on. In the old days before digital signal generation, it was a lot easier to understand how an AM transmitter worked. So, I'll explain it from that point of view.

Back then an AM transmitter consisted of a powerful CW transmitter and an audio amplifier. The audio amplifier – also called the modulator - was designed to provide one-half the power of the transmitter. In other words, a 1,000 watt transmitter had a 500 watt modulator. The output from the modulator was connected in series with the B+ supply of the final power amplifier so that the audio signal raised and lowered the voltage and hence the total power fed to the final amplifier. That is, if the transmitter were just sitting there with no audio, its average RF power output would be 1,000 watts. But, if voice is passing through the audio amplifier, the positive peaks of the voice increase the instantaneous RF power and the negative going dips decrease the instantaneous RF power. The overall effect is that the peak power is increased by 500 watts to a total of 1,500 watts."

"I think you're wrong, Unck," said Hambone. "I've used my oscilloscope to look at the waveform of the output of my transceiver when it's set to AM and the RF voltage goes way up and down with the voice peaks and valleys. Sort of like this sketch. So, why does the spectrum analyzer show a steady carrier?"



"I know you don't like it, but let's do some simple math to see exactly what's happening. As an added bonus, I'll show you where SSB signals come from, too," added Elmer as he enthusiastically grabbed his ever-present yellow pad and pencil.

DANGER! Math Ahead!

"Let's start out with a plain old RF sine wave, we'll call a carrier to stick with the common name. Mathematically, we can write it like this:

$$K_{carrier}(t) = K_c \sin(2\pi f_c t)$$

Where:

- t=time
- $K_{carrier}(t)$ is the instantaneous value of the RF carrier at any particular time
- K_c is the peak value of the RF carrier
- f_c=RF carrier frequency in Hertz

Of course you already know that pi, π, is about 3.1416"

"Oh God, save us from Uncle Elmer's yellow pad Greek-letter math," moaned Hambone, looking for any way to escape this discussion.

"Please Hambone, suppress your inner merriment," continued Elmer.

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from HAMBONE on page 9

"That $K_{carrier}(t)$ you see on the left side of the equal sign is what you're seeing on your oscilloscope. It simply means that the value K, what you're looking at on your scope, varies with time. That is, it goes up and down. The stuff on the right side of the equal sign says how far up and down it goes. The K_c says how high and low it goes and the f_c says how fast it goes."

"That seems simple enough for a carrier wave," said Dude. "But what about audio, it's more complicated with lots of different frequencies?"

"Right, you are. So, let's simplify things by sending only one audio tone. After all, if you can send one tone, you can send them all, right?"

"I guess so," agreed Hambone, suspicious that somehow all this was going to lead to work.

"Well, since a single audio tone is the same as an RF signal, only at a lower frequency, we can use the same formula we used above except we insert a lower – that is, audio – frequency like this:

$$K_{audio}(t) = K_a \sin(2\pi f_a t)$$

Where:

- t=time, just like above
- $K_{audio}(t)$ is the instantaneous value of the audio tone at any particular time
- K_a is the peak value of the audio tone
- f_a= frequency of the audio tone in Hertz

Now, let's write the two expressions together. But to remove some clutter, let's say that the peak values of both expressions, K_c and K_a, are both equal to 1 so we don't have to write them anymore.

$$K_{carrier}(t) = \sin(2\pi f_c t)$$

$$K_{audio}(t) = \sin(2\pi f_a t)$$

"Wow!" exclaimed Dude. "Those two equations look almost alike. Only the frequencies are different."

"Yes," said Elmer. "The only difference between an audio signal and an RF signal is the frequency."

"If that's true," asked Hambone, "why don't we just put an antenna on an audio amplifier and radiate the audio signals and forget about using RF at all?"

"That's a great question, Hambone, and a discussion for another time. Right now let's stick to figuring out why your spectrum analyzer shows your AM signal has a constant amplitude carrier even though your scope shows it going up and down," said Elmer getting the discussion back on track.

"If we just add these two signals together and amplify them, nothing much happens. We simply get stronger versions of both signals. But, if we multiply them together, say, by having the audio signal control the strength of the carrier signal, things get interesting."

"Ugh!", added Hambone. "Interesting to you means mind-numbingly complicated to me. But, go on, I know there's no stopping you now."

"Here we go," smiled Elmer getting out a newly sharpened pencil.

"Wait a second," interrupted Dude. "If we really are going to multiply the carrier by the audio by having the audio vary the output of the final RF amplifier, what happens when the audio signal goes negative, does it just cut off the final RF amp and maybe blow the transistor?"

"Great catch!" Dude. "The value of $K_{audio}(t)$ varies between +1 and –1 because those are the maximum and minimum values of any sine wave. We don't want that –1 to hit our amplifier so we add enough DC to the audio waveform to keep it from going negative. This makes our new audio waveform look like:

$$K_{audio}(t) = 1 + \sin(2\pi f_a t)$$

The '1' represents the DC voltage necessary to make the amplitude of the sine wave go from 0 to +2 instead of –1 to +1. You can think of the '1' term as the DC voltage fed to the final power amplifier when there is no audio present. Now the amplifier never sees a negative input voltage from the modulator.

"Getting back to the multiplication," continued Elmer, "for lack of a better name I'm going to call the result of the multiplication $K_{signal}(t)$ and abbreviate it $K_s(t)$. This gives us:

$$K_s(t) = K_{carrier}(t) K_{audio}(t)$$

$$K_s(t) = \sin(2\pi f_c t)[1 + \sin(2\pi f_a t)]$$

Notice I've put Dude's '1' in there and added brackets. It looks different, but it really is the same as before. The brackets just make it clear where the '1' belongs."

"But Unck," asked Hambone, "I don't see how you multiply all that stuff together."

"It's simple," said Elmer, as he took a well-worn book from a back shelf. "You look it up in a book of standard math tables, like this one. We are engineers, not mathematicians, so we are more interested in the answer than in deriving the details. See, right here under trigonometry functions, it gives the formula:

see HAMBONE on page 11

from HAMBONE on page 10

$$\sin x \sin y = \frac{1}{2}[\cos(x-y) - \cos(x+y)]$$

"Nice, Unck, but what does that have to do with our stuff?"

"Simple, Dude, if we just make the following substitutions for x and y

$2\pi f_c t = x$
$2\pi f_a t = y$

and plug all of this into our formula for $K_s(t)$ above, we get:

$$K_s(t) = \sin(2\pi f_c t)[1 + \sin(2\pi f_a t)]$$

$$K_s(t) = \sin(2\pi f_c t) + \sin(2\pi f_c t)\sin(2\pi f_a t)]$$

$$K_s(t) = \sin(2\pi f_c t) + \frac{1}{2}[\cos(2\pi f_c t - 2\pi f_a t) - \cos(2\pi f_c t + 2\pi f_a t)]$$

Finally, simplifying the cosine parts and rewriting we get a thing of beauty, this equation which says it all:

$$K_s(t) = \sin(2\pi f_c t) + \frac{1}{2}[\cos(f_c - f_a)t - \cos(f_c + f_a)t]$$

"Unck, this is all giving me a headache. Let's take a break, that way you can have a cup of coffee and Dude and I can go away and forget to come back," pleaded Hambone.

MOST MATH DANGER IS PAST – There is still some but, you may carry on as before

"Oh no, Hambone, this is where the fun really gets started. Just look at that beautiful expression, it explains why you see what you see on your spectrum analyzer and oscilloscope. It tells all about AM and SSB, too. You just have to recognize what you are looking at.

For example, take that first term, $\sin(2\pi f_c t)$. That's your carrier. It's a sine wave that just sits there at its frequency, f_c, and at full strength, never varying. That's why your spectrum analyzer-which shows frequency horizontally and signal strength vertically-shows the carrier as constant in both amplitude and frequency."

"Oh yeah," said Dude. "I never thought about it like that."

"Now, look inside the brackets, those are your upper and lower sidebands. The first one, $f_c - f_a$, is your lower sideband. It is the carrier frequency minus the audio frequency.

"Oh yeah," said Dude. "I never thought about it like that."

"Now, look inside the brackets, those are your upper and lower sidebands. The first one, $f_c - f_a$, is your lower sideband. It is the carrier frequency minus the audio frequency."

"Oh, and the other term with $f_c + f_a$ is the upper sideband. It's the carrier frequency plus the audio frequency," added Hambone excitedly. "And since both sidebands contain f_a, which is really the audio signal, they both carry the same information. It's just like the book says."

"But wait, there's more," continued Elmer. "Notice that minus sign in front of the upper sideband, it means that it has the opposite polarity of the lower sideband. It's not quite the same thing as being out of phase with the lower sideband as they are of different frequencies. This will come in handy later."

"Wait a minute, Unck, if both sidebands contain all the same information, doesn't that mean that the upper sideband just subtracts away, or cancels out, the lower sideband?" asked Hambone.

"No, because although they carry the same information in the form of the audio frequency or frequencies, those sidebands themselves are both at slightly different frequencies. Look on your spectrum analyzer. All the lower sideband frequencies are slightly below the carrier and all the upper sideband frequencies are above it. Since they don't overlap, they don't cancel each other. If you look closely, you'll see the two sidebands are actually mirror images of each other. It's like one is left-handed and the other right-handed."

"I got it," added Dude. "They carry identical information, but they are not identical signals."

"Now, you're getting it. The last thing to look at is that big '1/2' multiplying the sidebands," continued Elmer. "That means the voltage of each sideband is equal to one-half of the carrier's voltage. And, because each sideband has only one-half of the carrier's voltage, it carries one-fourth of the carrier's power. Since there are two sidebands, their total power adds up to one-half of the carrier's power. Since there are two sidebands, their total power adds up to one-half of the carrier's power. This is as good as it gets because we've assumed 100% modulation

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from HAMBONE on page 11

with a single tone to simplify the math. As you can see from your analyzer, the sidebands are usually much weaker because real voice only hits 100% modulation on its peaks.

"That's why the sidebands look so much smaller on the spectrum analyzer. Each is only one-fourth the strength of the carrier," observed Hambone. "But why does it look like the carrier is going up and down with the voice when I look at my signal on my oscilloscope?"

"That's easy," said Elmer. "Your o'scope is showing the total of the carrier and both sidebands or, Ks(t), from the equations we talked about earlier. When you add everything together, it does vary with the voice. The carrier may be constant, but the sidebands definitely are not.

"So, as a practical example, let's take a 1,000 watt AM transmitter. It will have 500 watts of power carrying voice in the two sidebands and 1,000 watts of carrier just going along for the ride.""That seems like a lot of wasted power," said Hambone.So, as a practical example, let's take a 1,000 watt AM transmitter. It will have 500 watts of power carrying voice in the two sidebands and 1,000 watts of carrier just going along for the ride."

"That seems like a lot of wasted power," said Hambone.
"It is," said Elmer, but it gets worse. "Remember, both sidebands carry the same information so, it's like transmitting everything twice. If you think about it, our AM transmitter is expending 1,000 watts to send only 250 watts of unique audio. If we get rid of the carrier and one sideband, we are left with a bare-bones 250 watt signal. That is a single sideband signal and the fact that it is as effective as a 1,000 watt AM signal is what has made it so popular with hams."

"Now I see why my 100 watt transceiver is only rated at 25 watts in its AM mode," said Hambone. "It's doing a lot of work for nothing."

"That's right," continued Elmer. It also looks like your SDR spectrum analyzer is working just fine."

"Thanks, Unck, but how about those SSB signals?" asked, Dude.

"Hey Dude, please don't be mad, but the secrets of sideband, are already in there. But it's time now, for a snack and a nap."

With that, Uncle Elmer switched his shop radio to the oldies station and headed for the refrigerator.

-- FEEDBACK --

WØDEW uses 0 watts to reach a Japanese Ham

Jay Burgherr, NØFB, shared an email from **Don Warkentien, WØDEW**:

Having a great time here in Japan. My son Dale and his girl friend Tomoco have been running us all over the place. We have eaten so much good food I can't believe it and I never thought I would like any kind of Japanese food.

Lots of beautiful things to see and the people here are just fantastic. Even just going into a store and buying a small item the people that you deal with are very genuinely friendly and willing to do whatever is necessary to communicate, even with the incredible language barrier.

I even made a very short contact with a Japanese ham while we were in Tokyo not via radio. We had gone to the top of the World Trade Center there to look out the windows and the unobstructed view of Tokyo, it was great. As we walked around the perimeter of the building we came to a corner by the windows and there was I guy sitting there with a pad of paper and I think a dual band talkie. He was talking on the radio so I did not want to disturb him. I stepped back, got a piece of paper and a pen. I wrote on the paper "73 de WØDEW", laid it on the table in front of him. He looked at it and immediately dropped his microphone, shook hands with me with a big smile. He was so pleased and excited he knocked his radio off the table and I walked away. It was probably his best contact of the day. You see, there are no repeaters in Japan. Only the higher class license operators are able operate hf and he was doing the best he could with what he had available. Out of the blue, he suddenly makes contact with another ham from Kansas in the USA.

from RIT on page 8

Checkout and Alignment

After you've made this modification, you'll need to check the receive and transmit frequency alignment of the radio. This is critical; you want the radio to be listening on exactly the same frequency as it's transmitting on when the RIT control is in the center position. This procedure requires a second, accurately calibrated receiver and transmitter.

Checkout Procedure

1. To check that you've made the modification successfully, connect a dummy load and power to the radio, and a DC voltmeter to the test point on the main board as shown in Figure 5.
2. With the RIT control at the midpoint (12 o'clock position), the voltage on the test point should be 3.3 V ± 0.2 V. If this is not the case, double-check your wiring.
3. The test point voltage should vary from approximately 3 V (full CCW) to 4 V (full CW).

If you get these results, congratulations--you've successfully applied the RIT modification!

Receive and transmit frequency alignment

1. Using a transmitter of known frequency (for example, 28.400 MHz), USB mode, *OPERATING INTO A DUMMY LOAD*, transmit a fixed audio tone of 1 KHz. Use the minimum power necessary. (You need to be able to monitor the audio tone as it is being sent.) You can also use a signal generator set to 28.401000 MHz for the signal source.

see RIT on page 14

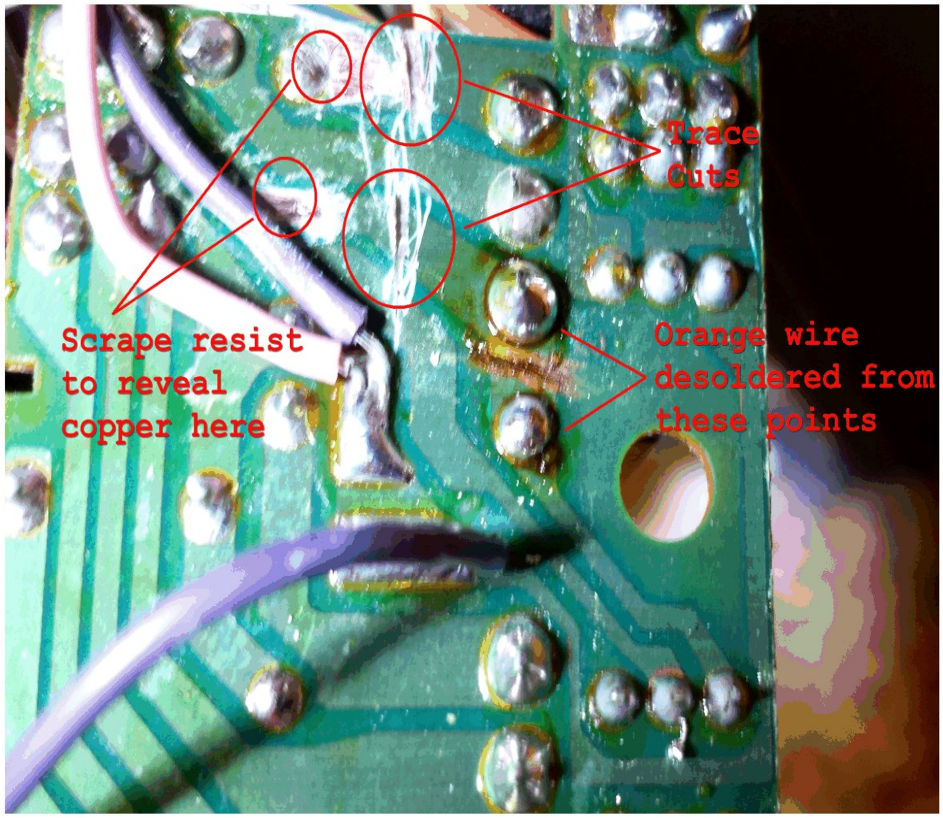

Figure 3: Cuts on the RIT / RF Gain Sub-board

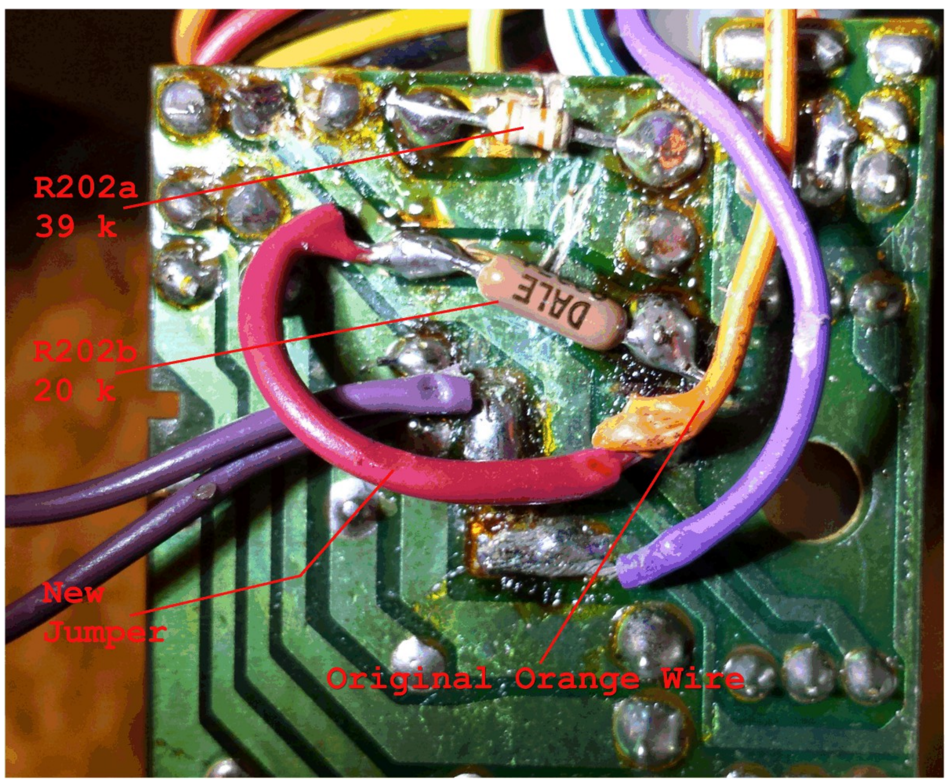

Figure 4: Final Changes to the RIT / RF Gain Sub-board

from RIT on page 13

2. Set the HR-2510 to the same frequency (28.400.0 MHz), and USB mode. No antenna is necessary. The RIT function should be at 12 o'clock (disengaged).
3. Using a non-metallic adjustment tool, carefully adjust the core of coil L315 (near the front of the DIGITAL/PLL unit) until the received audio frequency is exactly the same pitch ("zero beat") as the transmitted tone. This calibrates the receive frequency of the radio. Be careful not to break the core of L315!
4. Turn off the transmitter, and connect the dummy load to the HR-2510. With the second transceiver in RECEIVE mode, transmit the 1 kHz audio tone from the HR-2510, again using minimum power.
5. Now adjust VR111 (near the right-front of the analog circuit board--marked as "TX Frequency Adjustment" in Figure 5) until the tones are again at zero-beat. This calibrates the transmit frequency to be exactly the same as the receive frequency.
6. Repeat Steps 1 through 5 (there is a small interaction between VR111 and L315) until everything lines up perfectly.

Figure 5: Main Board Test Point for RIT Voltage Check

Note that LSB transmit/receive frequencies should "track" also; if they don't, adjustment of L9 on the analog circuit board should correct the frequency error between USB and LSB modes. If a 1 kHz signal source isn't available, the adjustments can be carefully made using speech (have a friend do the talking while you make adjustments.)

Conclusion

The HR-2510 is a great mobile radio, and it's much easier to operate when the RIT control operates properly. Not only will you find it easier to work stations (they can only hear you when you're calling on the right frequency), but your contacts will find it much more pleasant to work you as they won't have to chase your signal up or down the band.

Happy operating!