JOHNSON COUNTY RADIO AMATEURS CLUB, INC.
P.O. Box 93
Shawnee Mission, KS 66201

FEEDBACK

FEBRUARY 2017

January VHF Antenna Shootout Results

Charlie Van Way, NØCVW's, home brew 3-element tape-measure Yagi antenna bested the field of ten JCRAC members who tested a variety of antennas in the club's 2017 VHF Antenna Shootout.

Tom Wheeler, NØGSG, (top left) tested the output (watts out) of participant's transmitter. He normalized the output to 1.0 watt and recorded the ratio (dbW). Participants affixed their antennas and sent an FM signal across the room to Lon Baker, KØWJ, (below right) who measured the received signal, relative to a milliwatt (received dBm).

The two subtraced the dBW handicap from the received dBm to get an adjusted dBm. Having controlled for variety in transmitter output, assuming a constant signal path, and using the same receiver for all tests, the difference in received signal should be attributable to the antenna.

Call	Name	Radio	Antenna	Watts out	dBW	Rec'd dBm	Corrected dBm
NØCVW	Charlie	VX7R	H-brew yagi	1.03	+0.13	+3.2	+3.07
NZØF	Herb	KW TH-215A	stock duck	0.52	-2.84	-1.2	+1.64
ADØUN	Harald	FT-827	H-brew yagi	1.00	+0.00	+1.1	+1.10
NZØF	Herb	KW TH-215A	stock duck	0.52	-2.84	-1.9	+0.94
NØCVW	Charlie	VX7R	stock duck	1.03	+0.13	+0.3	+0.17
NØGSG	Tom	UV5R	1/2-wave end fed	1.85	+2.67	+1.8	-0.87
ADØAB	Jaimie	FT60	NULL	2.00	+3.01	+1.1	-1.91
KCØULE	Stacia	HTX202	stock duck	1.38	+1.40	-1.3	-2.70
K6TBJ	Rod	UV5R	SRJ77CA Diamond	1.09	+0.37	-2.9	-3.27
KEØIDD	Patrick	FT60	stock duck	4.61	+6.64	+0.7	-5.94
KEØHZL	Chris	UV5R	SRJ77CA Diamond	5.16	+7.13	+0.8	-6.33
NØTEK	Ted	VX7R	stock duck	4.92	+6.92	+0.2	-6.72

FEBRUARY MEETINGS

February 10 *-- Waterproofing Connectors - Bill Brinker, WAØCBW*
February 24 *– Solar Power - It's not just about the Sun - Lee Ward, KØLW*

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

Bill Gery, KA2FNK, President

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All email addresses are available at w0erh.org

The One-Room School

According to the Kansas One Room Schools website, Kansas once had 9000 one-room schools. The poor teacher--with students who were learning the alphabet and students who were learning more advanced topics--had to come up with topics to hold the attention of each group. In this era, we still have beginning students and advanced students, but the numbers are such that we put the beginners in elementary school and the more advanced scholars in middle schools and high schools. Whatever the era, the local schools had to address the needs of all kinds of students each day.

If the JCRAC, which touts its "classes" in its club logo, were a school, what kind of school would it be?

Does Johnson County have enough amateur radio enthusiasts that its clubs can be a "district" that has elementary, middle and high schools? If so, which does the JCRAC aspire to be? Or are our numbers such that the JCRAC has to be a one-room school house?

The question is pertinent because , at the suggestion of several club members, the FEEDBACK began publishing the names and photographs of people attending their first JCRAC meeting. The FEEDBACK published 31 such photographs in 2016.

Let us make the very generous assumption that half of those people were seasoned hams who had come from out of town or were visiting from some other part of the city. That leaves us with 15 or 16 new hams or ham wannabees who came to a JCRAC meeting. Have we picked up fifteen regular attendees? Have we picked up two? If not, it would appear that our "new students" did not find our curriculum to be something that addressed their needs.

Are we the "high school" club, which requires newcomers to start elsewhere? Or should/must we be the one-room school? Do we set aside the first ten minutes of a ***(continued in the next column)***

meeting, or perhaps the first meeting of each month, or a new third-Friday meeting--for fundamentals? Should we aspire to be a two-room school house with a pair of teachers covering different topics for different students in different rooms?

Perhaps the school/club analogy is inappropriate. No club can be all things to all people. It may be that the best role for the JCRAC is as an "after school hangout" where educated people can confer with people who have similar interests.

Let's be the club we choose to be, rather than the club that it is easy to be.

-- Chip Buckner -- ACØYF

PRESIDENT'S CORNER

The ice storm that wasn't, at least in the Kansas City area was the only real weather event in the first month of the new year. Parts of western Kansas, Nebraska and southwest Missouri were not so fortunate.

We have started working on scheduling the programs that were suggested during the January 13 meeting. There were plenty of good ideas. With the few we did not get to from last year we have enough to fill the year.

The beginning of public service season is rapidly approaching. Watch Larry' list and select a couple to support. Volunteering for one of these events is a proven way to increase your skill as an Amateur radio operator, serve the community. This while having fun.

– Bill Gery – WA2FNK

Johnson County Radio Amateurs Club - January 13, 2017

Meeting Date: Friday January 13, 2017. The meeting Started at 7:30PM.

Attendance: Self introduction with name and call sign. 24 signed the check in sheet. This was followed by the Pledge of Allegiance.

There were no Minutes to read due to the last meeting being the Christmas Party.

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

Cash on Hand	$ 81.00	Repeater Operating Reserve	$ 893.65
Checking Account	$ 964.59	Memorial Fund	$ 310.00
Savings Account	$ 10,348.83	Active Members	153
Total	$ 11,394.42		

Old Business:

- We welcomed all 1st time visitors to tonight's Club meeting.
- Repeater Update – All are working well! Recently we were able to remove the original UHF antenna off the roof of the Black & Veatch building. Thanks goes to Patrick Davidson KE0IDD.
- Chuck Kraly K0XM from the Back Yard Repeater Group has expressed an interest in purchasing the UHF Antenna. The Club's leadership will discuss this and get back to him.
- WW1USA will be operating indoors on January 28 and 29. Included in the remote operation will be John Raydo's K0IZ Colorado station!

New Business:

- Because of our efforts last year providing volunteers at the Ensor Park and Museum, the City of Olathe (who is the Caretaker of the Museum) gave the Club $720.00.
- Field Day 2017 will again be at the same location as last year (Observation Tower at Shawnee Mission Park).
- Ted Knapp N0TEK recently changed the format of the Club's website. Take a look and let me know what you think.
- The JCRAC 2nd Annual VHF Shootout will take place at 6:00 pm on January 27 (which is before the Club Meeting).
- We will not be able to have the March 24th Club Meeting at the Church due to room unavailability. Be thinking of an alternate location or activity for that night.
- For his effort in accepting official "NTS" Traffic, Keith McKinney KE0AEP was presented with a Certificate from John Morse N0EI.

Reports:

- 6 m – None.
- 10 m SSB Roundtable – 8 participated on January 12.
- 440 Wheat Shocker net – 11 Check-ins on January 11 and 13 Check-ins on January 4.
- 2m Wheat Shocker net – 21 Check-ins on January 12 and 17 Check-ins on January 5.
- HF Activity – Venezuela, St. Croix, Costa Rica, South Africa, Scotland, Brazil, Cuba, Chile, and Antarctica. All on 40 Meters with 10 watts on JT65 with an Inverted "V" (apex at 30').

Announcements:

- Emergency Communications 101 seminar on Saturday February 4, 2017 from 1 pm to 3 pm at the Salvation Army Harbor Light Village, 6723 State Avenue in KC, KS.
- DMR Program Class January 21 and 22 at the Johnson County Library at 87th Street. Contact Chuck Kraly K0XM.
- Watch Larry's List for upcoming events.

Business meeting adjourned at 7:58 PM

Program:

- The Program for this evening was a discussion of potential Programs for 2017.

Johnson County Radio Amateurs Club - January 27, 2017

Meeting Date: Friday January 27, 2017. The meeting Started at 7:30PM.

Attendance: Self introduction with name and call sign. 28 signed the check in sheet. This was followed by the Pledge of Allegiance.

The Minutes from the January 13, 2017 meeting were read and accepted with one opposed vote.

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

Cash on Hand	$ 81.00	Repeater Operating Reserve	$ 909.65
Checking Account	$ 1,276.40	Memorial Fund	$ 310.00
Savings Account	$ 10,348.83		
Total	$ 11,706.23	Active Members	154

Old Business:

- We welcomed all 1st time visitors to tonight's Club meeting.
- Repeater Update – All are working well!
- It was decided to sell one of the 2 small excess Repeater Antenna the Club owns. We will keep the large UHF antenna.
- Field Day 2017 will be at the Observation Tower in Shawnee Mission Park.
- WW1USA will be operating indoors on January 28 and 29. Included in the remote operation will be John Raydo's K0IZ Colorado station!
- We will not be able to have the March 24th Club Meeting at the Church due to room unavailability. We are currently working on an alternative location.

New Business:

- None.

Reports:

- 6 m – None.
- 10 m SSB Roundtable – 5 participated on January 26.
- 440 Wheat Shocker net – 10 Check-ins on January 25 and 16 Check-ins on January 18.
- 2m Wheat Shocker net – 17 Check-ins on January 26 and 18 Check-ins on January 19.
- HF Activity – None.

Announcements:

- Emergency Communications 101 seminar on Saturday February 4, 2017 from 1 pm to 3 pm at the Salvation Army Harbor Light Village, 6723 State Avenue in KC, KS.
- LaCygne Hamfest February 4
- Watch Larry's List for upcoming events.

Business meeting adjourned at 7:58 PM

Program:

- Instead of a Program we held the 2nd Annual VHF Handheld Shootout before the meeting.

Hambone's Bad Antenna--Jaimie Charlton, ADØAB

"That was a really fun hamfest, wasn't it?", shouted Elmer to his nephew, Hambone, who was hanging precariously in a tree. "I got a really good deal on a big scale SWR meter and tuner. Both are in pristine shape," continued Elmer, decked out in a new yellow ski jacket that Santa brought him as his warm words turned to puffs of vapor in the crisp Kansas wintertime air. "You can have them if you want. I just bought them because they looked good and were cheap."

Hambone, on the other hand, was in no mood for pleasant conversation. His hatless head and nose were already red from the cold and his naked ears were taking on a nice shade of blue. With one hand clinging to an overly flexible limb on a willow tree and the nearly numb fingers on the other working to free his new wire antenna from the tangles of a grabby branch, Hambone was one step away from a trip to the emergency room.

"Look out, Unck, this antenna's coming down!" he shouted as wire and feedline fell to earth at Elmer's feet with Hambone descending not far behind.

"I can't figure it out. I bought this Majic Match antenna from a guy at the 'fest a couple of months ago. He said it was a hybrid design 40 meter dipole that's only about half as long as a regular dipole. He said it easily works the whole band with an SWR of less than 1.2:1, without a tuner. He said it was the *majic matcher* at the feedpoint and these *length-enhancing modules* on the wires that gave it such great performance. He even threw in some coax because he said that to get the best performance the antenna should be connected with the best coax and he didn't want me to have any problems." Pausing to catch his breath, Hambone continued, "I thought that made it a really good deal."

"So, what's the problem?" asked Elmer.

"It doesn't seem to work all that well."

"Let's go inside and have a look at it. You need to get out of this cold," said Elmer as he gathered up Hambone's antenna and headed for the ever-brewing coffee pot in his shack.

****

"Okay, Hammy, what're the details? 'It doesn't seem to work" is not a technical description of a problem. It could be nothing more than operator's imagination," said Elmer as he caressed a cup of hot java.

"Well, Unck, when I first put this antenna up between the lower branches of the trees and connected it with my own coax, my transceiver would only drive it at very low power, even with the built-in tuner. I hooked up my separate SWR meter and…"

"You mean *MY* SWR meter, don't you?" Interjected Elmer.

"Yes, Unck, your meter. Anyway, your meter showed an SWR of almost 4:1. I figured that can't be right."

Elmer just smiled and nodded as Hambone continued. "I remembered what the guy said about using the best coax so I reconnected the antenna with the coax he gave me. That brought the SWR down to a little over 1.6:1. Not as low as the guy promised, but much better. So. I guess the guy was right about the coax being important. At least the transceiver would now drive the antenna."

"So, did it work any better?"

"A little. I made a few contacts and got only so-so signal reports. I figured that the antenna was too low. I moved it up to the higher tree branches. That seemed to help, but signal reports still weren't all that good. Maybe the trees were the problem. I was just taking it down to move it to a different location when you came along," said Hambone.

"It looks to me, Hammy, like you were taken. The very fact that you showed any SWR, let alone 4:1, means the antenna does not have a 50 ohm input impedance and does not match 50 ohm coax.. I think the meter was quite correct."

"But Unck, I bought it from a ham at at hamfest! I paid $65 for it. The guy wanted $75, it has to be good!"

While Hambone was bemoaning his plight, Elmer was busy with his tape measure and yellow pad.

"Not necessarily, I've bought a lot of junk as well as good stuff at hamfests. It is definitely a buyer beware situation. But, let's see what you've got.

"While you were talking, I was measuring your antenna. The length of a forty-meter dipole should be somewhere around sixty-four to sixty-seven feet overall. This one is way less than that."

"That's fine, Unck. But my biggest concern is the high SWR. It's lucky the guy threw in this extra-good coax. I'm sure if I install the antenna in a better location the SWR will go down and I'll get great signal reports."

see HAMBONE on page 6

from HAMBONE on page 5

"Not so fast, Hammy. The purpose of a transmitting antenna is to get as much of the RF power your transmitter sends it to appear at the distant receiver. How well it does that depends on a lot of things including its location and installation. Relatively low SWRs like 2:1 or even 3:1 have very little to do with it."

"But Unck, all the catalogs brag how low their antennas' SWRs are. They never say anything about location and installation."

"The subject of transmitting antenna effectiveness is a big one, but it can be broken down to a few simple ideas. For example, you can think of the antenna as a transducer or power converter that converts the RF from your transmitter to radio waves that zip away to a distant receiver. That zipping away part is very important.

"An antenna that has a 50 ohm input impedance 'transforms' the low 50 ohm impedance of your coax to the higher 377 ohm impedance of free space that the radio waves move in. When that happens, your RF power can flow smoothly from your transmitter through your 50 ohm coax, through your antenna and into the aether (I love that weird word) as radio waves."

"I see," added Hambone. "It's like the transmission and wheels of a car. They take the rotary motion of the engine and convert it to the car's motion so it can zip along the road."

"That analogy is not exact, but we can go with it, especially if you think of the car's transmission as a speed step-down transformer which transforms the relatively high RPM/low torque of the engine to high torque/low RPMs of the wheels."

"Okay, Unck, but where does SWR come in?"

"I'm getting to that. The SWR or standing wave ratio indicates how well the antenna is accepting the RF power delivered to it by the coax. If the impedance of the antenna matches the impedance of the coax, the antenna will accept all the power delivered to it and your SWR will be 1:1. But if those impedances don't match, the antenna rejects some of the RF power by 'reflecting' it back to the transmitter. That's when your meter indicates and SWR of 1.5:1 or 2: or even higher.

"Using your car analogy, a mismatch is like trying to drive your car in the wrong gear."

"I think I get it. So, that means an antenna with an SWR of 1.5:1 is bad and 2:1 is really bad! I bet you couldn't make any contacts with it at all."

"Oh, not at all! An SWR of 1:1 is ideal, but even with an SWR of 1.5:1, only about 4% of the power is reflected. With an SWR of 3:1 only about 25% of the power is reflected back towards the transmitter."

"That seems like a lot."

"It's not as bad as it sounds because on the lower bands where coax losses are very small, most of the reflected power gets re-reflected when it hits the transmitter and goes back to the antenna. But even if that 25% of the power were totally lost, it would only reduce the signal at the receiver by about 1.25 dB – hardly noticeable.

"So, you see, SWR only indicates how well your antenna matches your coax, not how well it radiates."

"So Unck, why all the interest in having a very low SWR?"

"One reason is it's easy to measure. Having your SWR meter read 1.5:1 or less gives you a warm and fuzzy feeling that all is well with your antenna. But it tells you nothing about how well your antenna is actually sending a signal to a distant receiver.

"A more important reason is that the reflected power raises the voltage inside the transmitter's final stage. If that voltage gets high enough, it can damage the output transistors. That's why the transceiver manufacturers specify a maximum SWR for their devices."

"Okay Unck, if all that is true about the SWR indicating how well the antenna matches the coax, what is special about the coax the guy gave me that makes it reduce the SWR? It has the exact same 50 ohm impedance as my old coax. See, it's stamped right on it."

"The short answer is: nothing. You've been had. It is actually worse than your existing coax."

"You're WRONG, Unck! I can show you that the new coax gives a lower SWR," shouted Hambone as he became increasingly frustrated with his new antenna and that what he thought he knew about antennas just wasn't so.

"Calm down, Hammy. It's very simple. Look at how the SWR meter actually measures SWR."

"Doesn't it just measure the power going out of the transmitter and compare it to the reflected power coming back?"

"That's more or less true, but let's look at how it does it," continued Elmer.

Your meter is located right here at the transmitter end of your coax, right?"

"Well, yeah," agreed Hambone.

"So, it sees the power going out of the transmitter towards the antenna, doesn't it?"

"Yeah, and it sees the power reflected back by the antenna, doesn't it?"

see HAMBONE on page 7

from HAMBONE on page 6

"Not exactly. The meter 'knows' the true outgoing power accurately because it is located right here at the transmitter. But it doesn't know how much of that power actually reaches the antenna."

"Why not?"

"Because it's not at the antenna. We've always assumed that coax is almost lossless at frequencies below about 30 megahertz. But that's not true if the coax is defective, poorly made or has water in it. In those cases, the coax itself absorbs some of the power so not all of it reaches the antenna."

"Unck, you mean bad coax acts like a resistor between my transmitter and antenna and cuts down my signal?"

"Yes, but it's worse than that. Assuming the antenna is not a perfect match to the coax, the loss in the coax also cuts down the power reflected back from your antenna making the SWR look better – that is lower – than it really is."

"Sorry Unck, I still don't see how bad coax makes for good SWR."

"It doesn't. It just makes your SWR *look* better than it is."

"Well, my coax is about 100 feet long and it is old. The guy at the 'fest said the antenna matches 50 ohms and its SWR is very low. But because my locaiton has trees and stuff, the SWR might be slightly higher. That's why he gave me this new extra good coax that will reduce my SWR."

"Hammy, your coax is high quality RG-8 and it is well installed. Dill, our club's resident super tech, blessed it himself. The *ARRL Antenna Book* shows RG-8 has a matched loss of about 0.4 dB/100' at 10 MHz. I don't think there's any problem with it.

"But, let's take a look at this so-called special coax," continued Elmer as he connected one end to his analyzer and left the other end open.

"Before I turn on the analyzer, what do you think the SWR of just this open-ended coax should be? Remember, this is 'really high quality' coax."

"That's easy, Unck, infinite. There's nothing connected so all the power going through will be reflected back when it gets to the open far end."

"Right you are, Hammy. Now let's see what the analyzer says."

"Oh my gosh, Unck, it says the SWR is about 2.3:1! How can that be, there's nothing there?"

"Like I said, Hammy, you've been had," crowed Elmer as he pulled out his pen and scratched some calculations on his ubiquitous yellow pad. "It looks like your super cable really has about 4 dB of loss.

"That's why you don't seem to be 'getting out' and even your received signals aren't all that strong. 4 dB is a lot of loss."

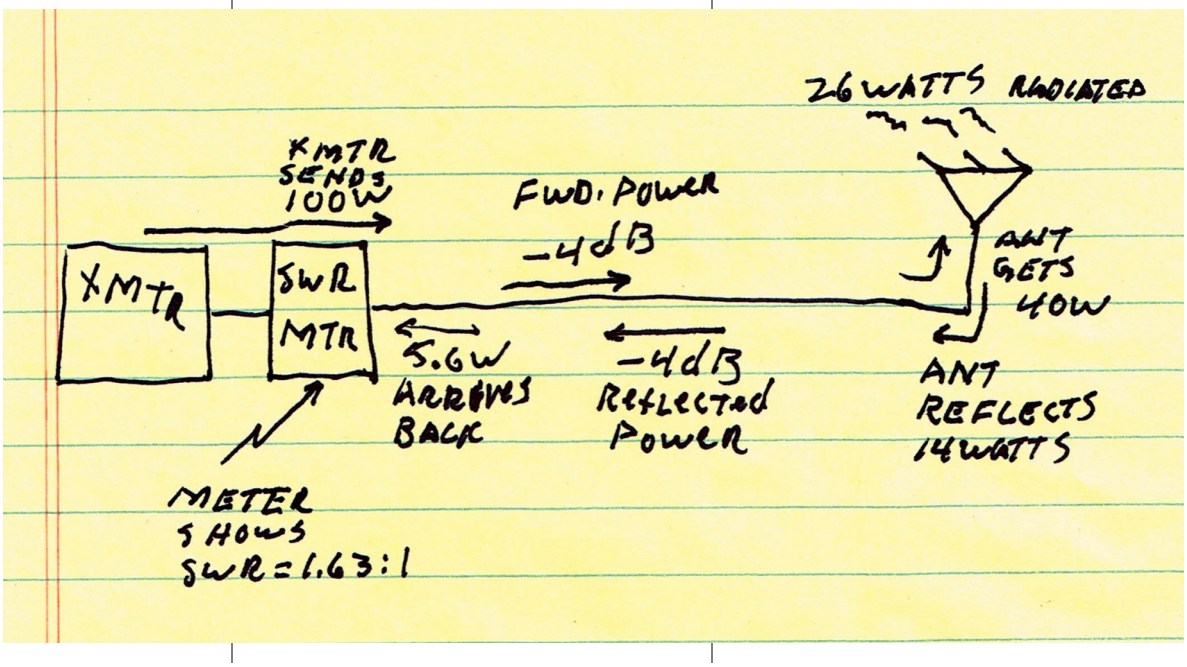
For the next few minutes the only sound heard was that of Elmer's pen scratching on his yellow pad and an occasional low whimper from Hambone as he regretted losing $65 to that antenna grifter.

Finally, Elmer spoke and revealed his sketch. "Hammy, here's what's happening. Your transceiver starts out by sending 100 watts into your not-so-super coax. Since the coax has 4 dB of loss, only about 40 watts make it to the antenna."

"I guess that's why my signal sounds weak," sighed Hambone.

"Oh, it gets worse," continued Elmer. "Let's say that 4:1 SWR you measured with you good coax is about right. Crunching the numbers means that about 36% of that 40 watts was being rejected by the antenna and reflected back. Just so you know, that 4:1 SWR means the antenna has an input impedance of about 200 ohms, not the 50 ohms the guy told you."

see HAMBONE on page 8



from HAMBONE on page 7

"Unck, I'm confused with all these numbers."

"It's simple, You only need a couple of basic formulas.

[Note to reader: If you want still more numbers and mathy stuff, Elmer's yellow pad formulas appear at the end the story.]

Let's start out with 100 watts of power. Because of your lossy cable, only about 40 watts make it to the antenna. Because the antenna does not match the cable, 36% of the 40 watts, or about 14 watts, are reflected back by the antenna leaving only 26 watts for the antenna to radiate."

"If that's true, Unck why doesn't the SWR meter show a high SWR?"

"Wait, there's more. That 14 watts of reflected power must pass back through the lossy cable to get to the SWR meter. Reducing 14 watts by 4 dB means only about 5.6 watts of reflected power gets to your meter. That gives an SWR of about 1.63:1 which is not too far from what you measured."

"Jeez Unck, I've really been had. I blew $65 for nothin'. My 100 watt transceiver is really only radiating 26 watts!"

"Not so fast. The $65 was not a total loss. For one thing, you learned there is no magic in antenna design and hamfests are buyer beware markets. You also learned that it's the impedance of the feedline and the impedance of the antenna that determine your SWR. Changing the length or quality of your feedline just changes what the SWR meter reads, not the actual SWR. That alone is worth the money."

"Still, Unck, I hate being had."

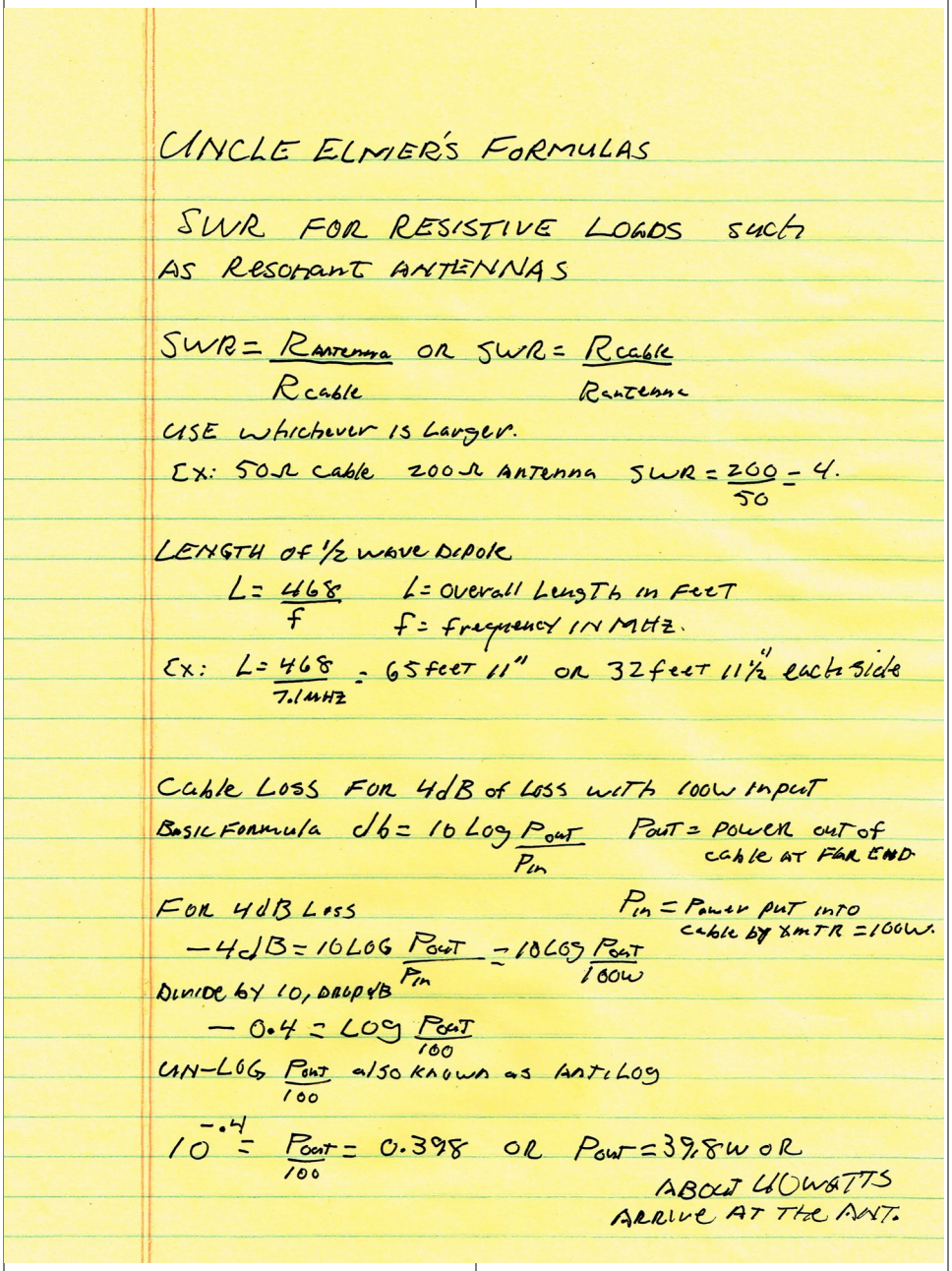
"Don't we all. But cheer up, you're not completely out the money. Because that antenna has about a 200 ohm impedance, you can match it to your good 50 ohm coax with a 4:1 current balun.

"Just go down to the Candy Store and buy one and install it in place of that *majic matcher* which is nothing but a piece of plastic. That will probably make a useable antenna."

"Thanks for the help,Unck! I'm going right now. I can't wait to get the antenna back up!"

"You're welcome Hammy. Let me know if you need more help. But don't ask me to climb that tree. Oh, and put a hat on before your mother sees you."

>> *FEEDBACK* <<



UNCLE ELMER'S FORMULAS

SWR FOR RESISTIVE LOADS SUCH AS RESONANT ANTENNAS

$SWR = \frac{R_{antenna}}{R_{cable}}$ OR $SWR = \frac{R_{cable}}{R_{antenna}}$

USE WHICHEVER IS LARGER.

EX: 50Ω CABLE 200Ω ANTENNA $SWR = \frac{200}{50} = 4.$

LENGTH OF ½ WAVE DIPOLE

$L = \frac{468}{f}$ L = OVERALL LENGTH IN FEET

f = FREQUENCY IN MHz.

EX: $L = \frac{468}{7.1\,MHz} = 65$ FEET 11" OR 32 FEET 11½" EACH SIDE

CABLE LOSS FOR 4dB OF LOSS WITH 100W INPUT

BASIC FORMULA $dB = 10 \log \frac{P_{out}}{P_{in}}$ P_{out} = POWER OUT OF CABLE AT FAR END

FOR 4dB LOSS P_{in} = POWER PUT INTO CABLE BY XMTR = 100W.

$-4dB = 10LOG \frac{P_{out}}{P_{in}} = 10LOG \frac{P_{out}}{100W}$

DIVIDE BY 10, DROP dB

$-0.4 = LOG \frac{P_{out}}{100}$

UN-LOG $\frac{P_{out}}{100}$ ALSO KNOWN AS ANTILOG

$10^{-.4} = \frac{P_{out}}{100} = 0.398$ OR $P_{out} = 39.8W$ OR ABOUT 40 WATTS ARRIVE AT THE ANT.

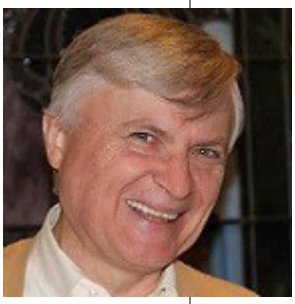
The "Amateur" in "Amateur Radio" - Chip Buckner, ACØYF

The Second JCRAC VHF Shootout

I have decided to win the next VHF shootout.

For those of you who missed the January 27 meeting--or are otherwise unfamiliar with the mechanics of the VHF shootout--contestants bring in VHF transmitters and one or more antennas. The club (Tom Wheeler, NØGSG) measures the RF output of each transmitter, the contestants attach their antennas and send a 146.00 MHz signal across the room to where the club (Lon Martin, KØWJ) measures the received signal. The idea is that if transmitter #1 puts out twice as much power as transmitter #2, we should expect the signal received from transmitter #1 to be double the signal received from transmitter #2. If transmitter #1 does not get exactly twice as much of its signal to the receiver, we attribute the difference to the antennas.

In short, the contest is designed to measure the effectiveness of VHF antennas. Many people who hope to win a contest that tests antenna effectiveness would seek to design or acquire an effective antenna for their transmitter. The engineers in the club would likely worry about matching impedance, reducing ohmic resistance and focussing the signal toward the receiving antenna. Because I am a lawyer, rather than an engineer, the first thing that came into my mind was "can I game this system?" I am confident that the the system can be gamed ... and had an idea of how to do it. Would it work? For that, I needed an engineer.



Fortunately, I know some engineers. So I asked Tom Wheeler, NØGSG, Jaimie Charlton, ADØAB and Bill Brinker, WAØCBW:

During the recent VHF shoot-out, when Tom/Lon were measuring RF at the receiver, what was being measured?

Logic--which rarely helps me in matters involving RF communication--suggests that you/they were measuring energy at a particular point (the receiving antenna) within a particular band of frequencies (146.00 MHz +/-) over a specific time period. Am I close?

As an intellectual matter, I am wondering whether one could game the system using an HT in DMR mode for calibration and then slipping into FM mode for the broadcast.

One possible answer would be "no, because the on/off period of a DMR transmission is slow enough that the measuring device can tell what the peak is". If that is the case, is there an on/off speed that would be fast enough that your test equipment could not reliably pick up the peak power?

If so, the DMR on/off cycle would have to be pretty quick, wouldn't it? I'm guessing it would have to be considerably shorter than the period of a wave, which it would seem to me, would be likely to defeat the utility of the wave to communicate data.

The risk of asking the engineers is that you might get an answer that makes you wish you hadn't asked the question. Fortunately for me, Jaimie came right back with the best of all possible openings.

That's a good question, Chip!

I can't wait to see what the answer is. I have often wondered if DMR isn't operating with a handicap (relative to continuous modes like Fusion or FM) because it only is transmitting half the time. I haven't been curious enough to investigate it, though.

On the other hand, the switching freq of DMR is only about 30 cycles per second. So, my question which is a reformulation of your question is, are the sending and/or receiving measuring instruments reading peak or average power (averaged over a time period greater than the switching time of DMR)?

We'll see what the Gurus have to say,

Jaimie

Bill, aka "Guru #1" was the first with an answer.

You are pretty close. They were measuring the amplitude of an RF signal at a specific frequency at the end of a sampling antenna. Changes in amplitude over time were not measured. There should not have been any noticable changes assuming the equipment was working correctly. The output

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power of each radio was compared to an arbitrary level and a plus or minus correction factor added to the measured signal to create an equal power out measurement for each radio.

That last sentence, by the way, is how I *should* have described how the VHF shootout works. Bill continued:

The test equipment always measures the peak. The RMS, average, and Peak to Peak (PEP) power are computed from the peak measured voltage. The RF carrier power is the same for FM or AM or SSB or TDMA (DMR). For the test they were only measuring power out and not the modulation. Also a DMR radio power out is constant during a simplex transmission. It only pulses during a duplex or repeater transmission. Bill - WA0CBW

OK. Tom measures peak at the transmitting side, so switching to duplex/repeater mode isn't going to help me. Tom's meter is too smart for that. Can I do something at the receiving end? Chip to the engineers:

OK, Jaimie, Bill says "peak".

Does that mean you do a "reset" between competitors?

Does that mean that if I sit over by the receiving antenna, I could key my HT for a moment and it would "look" at though the competing antenna/transmitter was super effective ... because you couldn't tell that the average/typical received signal was much lower than the aberrational peak?

I am not clever enough to understand why the lower average power of DMR could be a handicap. To me, that would seem to be like saying CW operates at a handicap (to what?) because of all that dead space between the dots and dashes. So long as there is sufficient difference between signal-on and signal-off, I don't much care what the average-signal or signal-off levels are ... do I?

CHIP

This time, Bill Brinker was the first to respond:

Chip,

Again you nailed it. DMR does NOT have lower average power. It is the same as any other power. It has a lower power requirement BECAUSE it doesn't transmit all the time. Meaning your battery last longer!

Your analogy to CW is right on. When it is keyed, the power is the same. In CW it doesn't matter if you send fast or slow when you key down you have a fixed amount of power. A CW carrier and a DMR carrier are the same when the transmitter is keyed.

Adding modulation to the carrier is a different story for Hambone.

A DMR carrier in duplex has a 30ms frame consisting of 2 payloads of data and 2.5ms of sync or embedded signalling. There is also 2.5ms between each frame. So for every 30ms the carrier drops for 2.5ms to listen for the sync information from the repeater. By the way the repeater transmits continuously. When DMR radios are in the simplex mode the 2.5ms sync time contains transmit information and the carrier does NOT drop. It is on for the entire 30ms frame.

For those that want to know: Each payload consists of 108 bits and the sync 48 bits making one frame equal to 264 bits. This is enough to carry 60ms of compressed speech for each 30ms of time

As to "peak: it is like saying the largest. The spectrum analyzer displays the signal from "0" to its "peak" or maximum. It is measuring the amplitude of the signal. Just like a voltmeter measures the maximum value of a voltage you are measuring. Or a peak "S" meter reading on your receiver (which is what a spectrum analyzer really is).

As I said in my other email the peak value is constant but decreases as the battery voltage lowers. If you want to cheat be sure your battery is fully charged. The RF output depends on the battery voltage.

Bill - WA0CBW

Tom's turn:

Chip, Jaimie, Bill:

In regard to Chip's very good question, the answer is "it depends." But first, let's take a brief look at the air interface (AI) layer of ETSI TS 102 361-1, the technical standard behind DMR. For practical purposes, the duty cycle of a DMR base station (BS) is close to 100%, and for a DMR mobile station (MS) in duplex mode (using a repeater) is about 50%. Contemporary mobile DMR radios (MD380, etc) also tend to be 50% duty cycle (one time slot) in simplex TX as well.

Chip, you are absolutely correct that the average power SHOULD equal the maximum power times the

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duty cycle. Please note that we're talking about POWER, and not RF VOLTAGE. Two entirely different animals. With a 50% duty cycle, the average RF voltage will be ~70.7% of the maximum steady-state value. This is important to know and I'll demonstrate why shortly.

In DMR a "frame" is a 60 ms interval containing two time slots (1 and 2). The MS may use slot 1 or 2 (50% duty cycle), but the BS transmits the entire duration (100% of the 60 ms) until there is no more data to pass.

The BS then ceases transmitting.

*Knowing this, we can better address Chip's question. Over a period of time consisting of at least 10 frames, the duty cycle and *average* RF output power of a DMR mobile station (HT) is about 50% of the continuous wave (CW) output exhibited in FM operation. That translates to a 3 dB reduction in average RF output when compared to FM mode.*

The method of measurement within the power meter determines the RF power level that will be reported. A power meter that computes a true average will show close to 50% (actually, slightly less) of the FM/CW reading when in DMR transmit.

*However, many inexpensive meters, such as those used in amateur service, are incapable of reporting the true average--as they don't directly measure forward power to begin with, but rather, voltage, and use a simple rectifier circuit to peak-rectify the RF signal back to DC, followed by a R-C low pass filter to smooth things out so that a mechanical meter movement can then show a quasi-average. HOWEVER...averaging the VOLTAGE does not give the same answer as averaging the TRUE POWER, because P = V^2 / R. . . to get an correct answer when reading the voltage, you must average VOLTAGE SQUARED or have some kind of correction factor built in for varying duty cycle. *The conclusion here is that a simple average-reading meter (like most hams have) that's computing average power based on the average of the VOLTAGE it sees will be increasingly inaccurate as duty cycle falls below 100%, as it is only calibrated to correctly read when the waveform is a continuous sine wave*.*

Some power meters are advertised as "peak reading" and these instruments will probably show the full RF power (or a value close to it) that's transmitted during each half of the TDMA frame. Many of these meters (such as the MFJ variety) use an active circuit powered by a battery to compute and hold the peak reading.

I hope that you are seeing that the test instrument used to measure power has a great impact on how it reads out. The instrument that Lon is using is a general-purpose spectrum analyzer. We could learn more about its characteristics by looking up its data sheet, however my guess is that this instrument is not of the class that can accurately measure pulsed RF power, as it's just not fast enough to do that.

The second power measurement was Lon's spectrum analyzer, coupled to an unknown antenna. The relevant variables that are totally unknown are the gain and directivity of the receive antenna, the quality of decoupling of that antenna from the feedline and surroundings, as well as the nature of the path between the transmitter and receiver. The room was full of persons (RF absorbers) who tended to walk around randomly and freely, and the structure of the church is concrete and steel. Neither of these two conditions lead to quality, repeatable measurements.

However, I think the results are still fairly valid. The two beam antennas stood out as being the top emitters of RF. There were times when strange things happened...such as the same antenna being used on two different HTs with similar power levels (1 watt), but resulting in a vastly different received RF power. This is most likely due to the highly reflective environment, where movements of only a cm in any direction will greatly influence the standing wave pattern of the reflections, and hence, the received RF power.

I think next time we'll bring dice...key your radio, roll the dice, and double sixes wins!

This is still a great event...a good ice breaker and a great stimulator for creative thought about how to build better antennas.

73,

Tom

Jaimie is unconvinced.

Hi All,

You gotta love these tricky techie discussions and leave it to Chip to find some thread to pull.

Oh, oh. Jaimie may have figured out that I turned a simple question

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into an exercise in which I get other people to write my column. He continues.

While everything [Tom has written] sounds fine, I don't think the fat lady has sung, yet.

Yes, the DMR HT transmits only half the average power as a 'regular' HT as evidenced by its longer battery life. Note that I said 'regular' instead of FM because DMR, like Fusion is FM.

But, the real question is does that reduced average transmitter power (talking about the HT only, not the base station) result in a reduced signal to noise ratio? Or, bowing to the digital nature, Bit Error Ratio, BER. This is important because the purpose of the whole thing is to transmit information (voice, in this case) accurately.

I don't know the answer, but it seems to me that there are at least two considerations.

The first is that since average DMR HT transmitted power is one-half (50% duty cycle) that of a continuously running transmitter of the same peak power (100% duty cycle), the average received signal power from the DMR transmitter will be 3dB lower relative to the received noise power compared to that of a continuous transmitter. That is, S/N for DMR will be 3dB worse than for continuous transmission. Of course, the bandwidth over which the power is being measured is the same for both cases. But is that really true? Read on for the second consideration.

The second consideration is concerned with the nature of the receiver. It seems to me, if the DMR signal is being received by an ordinary continuously running receiver, the average S/N for a DMR signal will less than that of a continuous signal. That's because the average transmitted power is only one-half and the signal is present only half of the time - okay, that's just two ways of saying the same thing, but you get my point.

When the receiver is receiving the DMR signal, it is also receiving noise. During this half of the time, the S/N is the same as for a continuous signal. But, even though the DMR transmitter stops (the second half of its cycle) the receiver keeps on receiving noise. So, over the whole 30ms cycle, the signal is present one-half the time, but the noise is present all of the time resulting in twice as much noise power received.

But, what if the receiver's input is gated so it does not receive noise during the transmitter's "off" time. How does this affect the received S/N and resultant BER? The average received power is still only half of that from a continuously running transmitter and the thermal noise from the receiver itself is probably still present. Does gating the receiver improve the S/N for DMR signal? Obviously, it would make no difference for a continuously running signal although it would sound very chopped up.

An ancillary question is if the receiver is gated off during the "off" part of the the HT's transmit cycle, how does it know when to turn back on?

There is actually a lot more to this, but I'm getting tired of writing and I think I've muddied the waters enough.

Jaimie

Tom, on the other hand, IS convinced.

Hello Jaimie,

The fat lady sung in 1950. That's about the time that gated AGC was introduced in analog TV receivers!

The DMR mobile receiver, once it obtains frame sync from the base station (and holds it), reads the control data from the frame during receive. From the control data (and its internal crystal timing oscillator) it determines when it can transmit. The receiver is not gated by a discrete circuit, but instead by the modem and codec circuitry (one chip--collectively labeled the 'vocoder' in these radios), under firmware control. When the unit is in receive mode, the modem listens on the channel; when a preamble and sync pattern is detected (it's modified HLDC, similar to Ethernet), the CPU is interrupted, and the vocoder chip streams the control portion of the in-band data to the CPU; the CPU in turn analyzes this data (right talkgroup, color code, etc), and if it's voice data, commands the vocoder to play the streamed audio data. The receiver is effectively listening only during the half of the frame that the base station is sending.

The "preamble" is a repeating pattern that's used to mark the beginning of a data frame. It may be a stream of 1s, 0s, or alternating 1s and 0s (not very bandwidth

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efficient). The preamble sounds like a steady tone or buzz in a receiver, if the data rate is low enough. The preamble gets the hardware (analog modems) in sync.

The "sync pattern" is a unique digital pattern placed after the preamble. It's used to mark the beginning of the actual data. From this, the receiver learns where the first data byte in the frame is. The sync pattern alerts the digital portion of the system (shift registers, buffer memory, etc) that data is on the way, and it must be stored.

The first approximation of this system has no decibel loss. Higher approximations take into account the losses due to switching, receiver turn-around, digital receive hysteresis, and other factors.

A digital receiver, while out of sync with the transmitter, is less sensitive that one that is in sync, as it must now listen 100% of the time to find the beginning of the precious data frames. GPS and DTV both exhibit the same effect, though GPS does something that DTV and DMR do not: GPS digitally obtains "receiver gain" by virtue of the repeating nature of the satellite transmissions.

Chip - are you still there? Does this make sense? It's very cool stuff, definitely not in the ARRL handbook--but also pretty intuitive if you think about it.

Jaimie - your turn!

73,

Tom

Now, even Jaimie is convinced.

I thought it must be something like that simply because the designers would not give up a 3dB S/N reduction. The gated receiver technology is used in both MW and optical receivers to reduce the error probability.

This is a case where the analysis of a digital system parts ways with the analysis of an analog system.

Chip,

This is actually a pretty simple sync system and its details can be found by googling DMR.. If you would like some soporific reading material, check the system used on optical carriers like OC768 which is used by communications companies on their fiber optic cables. This system allows for lots of sync loss (thousands per second) and still doesnt lose the data.

You gotta love digital systems, they do a lot with ones and zeros.

Jaimie

I am, as I observed in a subsequent email, rather surprised--and pleased--with how well I think I followed all of that.

Of course, the advantage of having a limited understanding is that I HAVE to approach these things at the intuitive level. This means that I don't even consider the Charlton-objections, which means that I can skim past the parts of the Wheeler-explanations that address the concerns that I don't understand.

For my--and my fellow amateur's purposes--there are several conclusion that we should draw from this exchange. From least to most important:

1. Contestants cannot use a DMR HT to game the VHF shootout.

2. Our club has a ridiculous number of talented people who understand this stuff.

3. If you have a question, our club's talented people will take the time to help.

4. If you have a question, these talented people will make you feel good that you wanted to learn, rather than make you ashamed of your ignorance.

5. Speaking as someone who witnessed both the JCRAC shootout and the subsequent shootout in the pages of the FEEDBACK, the one recounted here was *way* more informative and entertaining!

The last word, however, has to go to Tom, who may have a bit of lawyer in him somewhere ...

Chip,

You gotta admit, Jaimie and I do tend to dig into the weeds! :)

Instead of gaming the equipment, just bribe the judges!

73,

Tom

* * *

Shortly before publication, I offered Tom, Jaimie and Bill the opportunity to review their remarks. Jaimie observed that the group hadn't really answered my question ... and proceeded to elaborate. But that elaboration will have to wait for another issue.

>> FEEDBACK <<