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SIGNALS

Rockwell Collins

Monthly Newsletter of the

Amateur Radio Club

Volume 36 Issue 4 **Web Site** http://www.w5rok.us **January 2015**

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RCARC
Membership Meeting

Tuesday 27 January 2015
1700 Social 1730 Meeting
1800 Program

Methodist Richardson Medical Center
At Bush/Renner/Shiloh Intersection
Second Floor Conference Room 200

Subject:
Program TBD

Local Club News

Meeting Notice

The program for this month was not finalized when the newsletter was ready for publication, but the meetings are always great, so see you on the 28th.

RCARC Community Service Activities

Siren Testing Dennis Cobb WA8ZBT, Chris Havenridge KF5GUN, John McFadden K5TIP and Jim Skinner WB0UNI participated in the Richardson emergency siren testing on 7 January 2015. The testing was completed as scheduled this month since there was no threat of inclement weather. The siren testing is performed on the first Wednesday of each month. The sirens are monitored by amateur radio operators and reports made using the Richardson Wireless Klub (RWK) repeater at 147.120 MHz.

Crime Watch Patrol Jim Skinner WB0UNI participated in Richardson Duck Creek Crime Watch Patrol (CWP). CWP members, after successful completion of Richardson Police Department Training, patrol their neighborhoods and report all suspicious activities to the Police Department.

Straight Key Night (SKN)

Bob Kirby K3NT reported that he worked SKN with a World War II J-37 key and had a very enjoyable 1.5 hour CW QSO with Michael Ketchum K5MDK on 80 meters on the 31st (CST). Bob also said, "Michael's CW was very good. We ended just before midnight so we could welcome the New Year with family. What a great fun way to approach 2015." *(Contributed by Bob Kirby K3NT)*

Waves in the Attic

Bob Kirby K3NT reported that Sidney Ross Terry K5SRT is sporting two new stealth antennas in his attic at his new home in Edmond, OK. A VHF dual band J-Pole has been installed along with a HF 10 meter 1/4 wave vertical antenna. Way to go Ross. I was able to repair K5SRT's small LDG auto tuner so be on the lookout for Ross K5SRT on 10 meters soon. *(Contributed by Bob Kirby K3NT)*

Radio on + Listen = WOW!

While completing repairs on a small HF transceiver on the workbench last week, I was listening to a lady in Scotland speaking with a mobile ham in Nebraska. She stated that she was cooking dinner and had a few minutes to play radio while her family's meal was baking in the oven. I enjoyed listening to the Scottish and Nebraskan accents. Both stations were heard loud and clear on 29.620 MHz FM using only three clip test leads connected to the center pin of the radio's coax antenna connector.

This was a 10 meter FM repeater located in the state of New York. The time was early afternoon local. Amazing what 3 feet of wire will pull in at times. I continued to hear western European stations work the USA for over an hour. My software app reported 10 meters as being poor at the time. As DX Dave W0VX has taught us—turn that radio on, spin that dial and listen! *(Contributed by Bob Kirby K3NT)*

Membership Renewals

It is time for membership renewals for 2015. Please get your renewals into Joe Wolf N5UIC. Joe's email address and telephone number are on page 2 of this newsletter.

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VE SESSIONS

Dallas tests are held 4th Sat of each month at 1000 hrs. 13350 Floyd Rd. (Old Credit Union) Contact Bob West, WA8YCD 972.917.6362

Irving tests are held 3rd Sat of each month at 0900. Fifth and Main St. Contact Bill Revis, KF5BL 252-8015

McKinney VE test sessions are held at the Heard Museum the first Sunday of the month. The address is 1 Nature Place, McKinney TX. The time of the testing is 1430, ending no later than 1645. ***Note: no tests given on holiday weekends.***

Garland testing is held on the fourth Thursday of each month, excluding November, and begins at 1930 sharp. Location is Freeman Heights Baptist. Church, 1120 N Garland Ave, Garland (between W Walnut and Buckingham Rd). Enter via the north driveway. A HUGE parking lot is located behind the church. Both the parking lot and the Fellowship Hall are located on the east side of the church building, with big signs by the entrance door. Contact Janet Crenshaw, WB9ZPH at 972.302.9992.

Plano testing is on the third Saturday of each month, 1300 hrs at Williams High School, 1717 17th St. East Plano. Check Repeater 147.180+ for announcements.

Greenville testing is on the Saturday after 3rd Thursday, 1000 hrs at site TBA, contact N5KA, 903.364.5306. Sponsor is Sabine Valley ARA. Repeater 146.780(-) with 118.8 tone.

Richardson The Richardson Wireless Klub (RWK) VE team hold license testing on the third Thursday of each month at St. Barnabas Presbyterian Church, 1220 West Beltline Rd. Testing begins at 1900 hrs in room 12. Enter through the Northern most door on the east side of the church building. For further information contact Dave Russell W2DMR, at 972.690.9894 or E-mail warhog4@tx,rr.com.

S I G N A L S is the monthly newsletter of the Rockwell Collins Amateur Radio Club, published by and for its members.

President's Message

THIS SPACE RESERVED FOR PRESIDENT'S AND/OR VICE-PRESIDENT'S MESSAGE

Secretary's Report

There is no Secretary's Report this month because there was no regular membership meeting in December. In December several of the club members met at Dickey's Barbecue in Plano to celebrate the Christmas season with a time of food and fellowship.

Understanding Antennas For The Non-Technical Ham - Part 5

*Each month for the next year or so, we are including in **SIGNALS** excerpts of a book by Jim Abercrombie – N4JA (SK) on antenna design. This book is available online for free and can be located at http:// www.hamuniverse.com/basicantennas.pdf. Now, part 5...*

Understanding Antennas for the Non-Technical Ham

A Book By Jim Abercrombie, N4JA (SK)

Illustrations by Frank Wamsley, K4EFW

Edited by Judy Haynes, KC4NOR

Edited for the web , N4UJW

VI. STANDING WAVE RATIO

A standing wave ratio bridge is used to measure the standing wave ratio, or SWR. SWR is an indication of how well the radiating part of an antenna is matched to its feed-line or how well the tuner is matching the antenna system. Most amateurs pay far too much attention to SWR. An SWR reading below 2:1 is acceptable, because the mismatch is so small that the feed-line loss can be ignored. If you are using a modern transceiver, its power may fold back to a lower power output above this SWR level.

When you have mismatch between the feed-line and the antenna, part of the power feeding the antenna system reflects back toward the tuner and the transmitter. The part of the power going toward the radiating part of the antenna system is called forward power. The part reflected back down the feed-line is called reflected power. The larger the mismatch the larger the reflected power will be.

If the feed-line and antenna are not matched, waves traveling toward the radiating part of the antenna system meet the waves being reflected back down the feed-line. The waves interfere with each other, and at certain points along the feed-line, the amplitudes of both waves combine. This will result in a current maximum to be found at that point; and at that point, the current will appear to be standing still. The length of feed-line and the frequency will determine where this point occurs. At another point, the forward and reflected waves interfere, and they subtract from each other. At that point, there will be a current minimum. If you could visualize this phenomenon, you would see a series of current maximums and minimums standing still along the feed-line. This is why we refer to them as standing waves. At different points along the feed-line, where you have high current, you will have low voltage, and where you have low current, you will have high voltage. At any point along the feed-line, multiplying the voltage times the current will equal the power in Watts. When the feed-line is matched to the antenna, current and voltage remain the same all along the feed-line because there is no reflected current to interfere with the forward current.

As happens with the current, the voltage will also appear to be standing still. The voltage maximums and voltage minimums will not be at the same locations as the current maximums and minimums. SWR is the ratio of the maximum voltage to the minimum voltage on the line. It is called "Voltage Standing Wave Ratio" or VSWR, but we shorten it to just SWR. There is also a current SWR or ISWR, and it is the same value as the VSWR. For example, if the standing wave voltage maximum is 200 volts and the minimum voltage is 100 volts, the VSWR will be 2:1. If the voltage maximum and voltage minimum are equal, the SWR will be 1:1. If the voltage minimum is zero, the SWR is infinite.

In measuring SWR at the transmitter, you need to realize that feed-line losses affect the SWR readings. If the feed-line losses are high, much of the power reflecting back from the antenna will be lost, and the SWR reading on the meter will indicate it is lower than it actually is. If a feed-line is so lossy that it consumes all forward and reflected power, it will measure an SWR of 1:1.

When measuring SWR on an antenna having a small amount of reflected power, the length of the feedline between the bridge and the antenna may affect your SWR reading. An example of this is a 70-ohm antenna being fed with 50-ohm coax. Different lengths of feed-line will give you small differences in SWR readings because at certain lengths, the mismatched feed-line starts to act like a series matching section. In the case of a 70-ohm antenna fed with 50-ohm coax, if the feed-line is a half wave long, the SWR will measure 1.4:1. At some particular length of feed-line and on one frequency, the SWR will measure 1:1 because that length of that feed-line transforms the impedance to make a match. Some hams have adjusted their feed line length to get a perfect match. This is called "tuning your antenna by tuning your feed-line." With other feed-line lengths, you will measure something different. Suppose the impedance of the feed-line and the antenna are perfectly matched. Then there is no reflected power. You will get a 1:1 reading on the SWR-bridge with any length of feed-line.

There is a myth that reflected power is burned up as heat in the transmitter. The reflected power coming back down the feed-line sees an impedance mismatch at the transmitter or tuner and it reflects back up again. The reflected power does not get back into the transmitter. Because the reflected power reflects back and forth, the radiating part of the antenna system absorbs most of the power being reflected back up each time. All of it eventually is radiated except for the power lost in the feed-line. The losses in a real feed-line will burn up some of the power on each pass. This is why the feed-line loss increases with SWR.

Built-in tuners are found in most modern transceivers. If yours doesnt have one, then you can use an outboard tuner to give the transceiver a proper load. The place you want a 1:1 SWR is between the output of a transceiver and antenna or between the transceiver and the input of a tuner in order for the transmitter to deliver its maximum power. Because built-in tuners are in most modern transceivers,

many hams use them to match antenna systems having high loss.

VIII. HALF-WAVE RESONANT DIPOLE ANTENNAS

1. The Half-Wave Flat-Top Dipole

Most dipoles consist of two pieces of wire of equal lengths with one of the two ends connected together through an insulator. The far ends of the wires are also connected to insulators. The two conductors of a feed-line are separated and connected across the gap at the center insulator. The antenna is held up by rope that connects the insulated ends of the antenna to two supports. It is a "balanced" antenna, because equal currents flow on both halves of the antenna. Coax is an unbalanced feed-line. (The possible effect of using an unbalanced feed-line on a balanced antenna like a dipole will be discussed later.) The dipole that is stretched between two high supports is called a flattop dipole, distinguishing it from other configurations.

The simplest antenna system of all is the half-wave resonant dipole fed with coax and no tuner. The only reason for using a half-wave resonant dipole antenna is to eliminate the need for a matching device such as a tuner. The feedpoint impedance will be near 50 ohms at ordinary heights and they can be fed directly with 50-ohm coax from the output of todays modern radios. The two halves of a dipole are fed 180 degrees out of phase, meaning when one side is fed positively, the other side is fed negatively. That is why a feed-line has two conductors. Of course, the sides swap polarity on each half cycle.

If you could visualize the current flowing on the half-wave dipole, the current will appear to be standing still. The maximum current will be seen at the center of the wire and no current will be at the ends. This occurs because the electrons flowing out to the ends reflect back toward the center where they meet the next wave and the current is reinforced there. The minimum voltage occurs at the center and the maximum voltage occurs at the ends of the half-wave resonant dipole. If you were to measure the voltage and the current at any point on the dipole wire, the voltage times the current will equal the power in Watts.

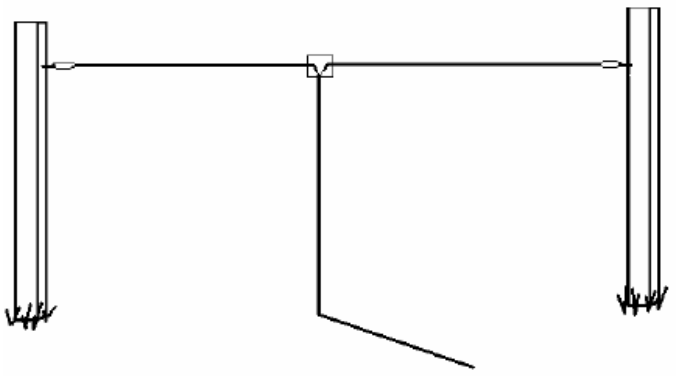

Figure 1. Flat Top Dipole

2. Inverted-V Dipole

Another configuration for the half wave resonant dipole is one having one support in the center and the ends stretched down toward the ground. The single support can be a tree, mast, or tower. The ends of a dipole have high RF voltages on them, and need to be at least 10 feet above ground for safety. This antenna is called an "inverted-V," because the shape of the dipole looks like a "V" turned upside down. Most dipoles illustrated in this book can be put up in the inverted-V configuration. This configuration works well because the current is concentrated on the middle two-thirds of the antenna at the apex. The current in an antenna is what is responsible for the radiation. The ends of the antenna have very little current in them and it doesnt matter if the ends are close to the ground. The middle of the antenna is up high where the radiation is taking place and that is the place you want the radiation to be. An inverted-V has an advantage that the horizontal space required for it is less than what is needed for a flat-top dipole. The angle between the wires on an inverted-V needs to be greater than 90 degrees. The gain of an inverted -V is 0.2 dBd and it has a radiation pattern nearly omni-directional. Since it is easy to construct and works so well, the inverted-V is the most commonly used dipole. An explanation of the decibel will come later.

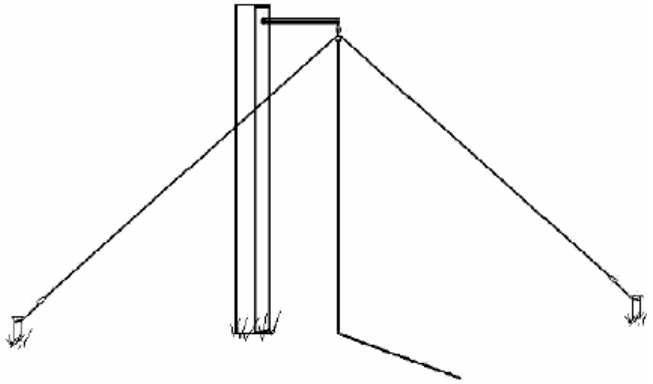

Figure 2. The Inverted-V Dipole

In figure 3, the top graph shows how the radiation would appear to you, if you were situated above the dipole and you were looking down on it. The plane of the antenna runs from side to side on the top graph, and that graph demonstrates only a 5-dB null off the ends of the antenna. Therefore, it is essentially omnidirectional. The bottom graph shows how the radiation would appear if you were looking at the antenna from the end of the wire. As you can see, the pattern shows no radiation at the horizon and its maximum radiation is at about 40 degrees above the horizon, and the radiation straight up is only down 3 dB from its maximum. This antenna was modeled on 80 meters with the apex at 65 feet above ground and the ends at 35 feet.

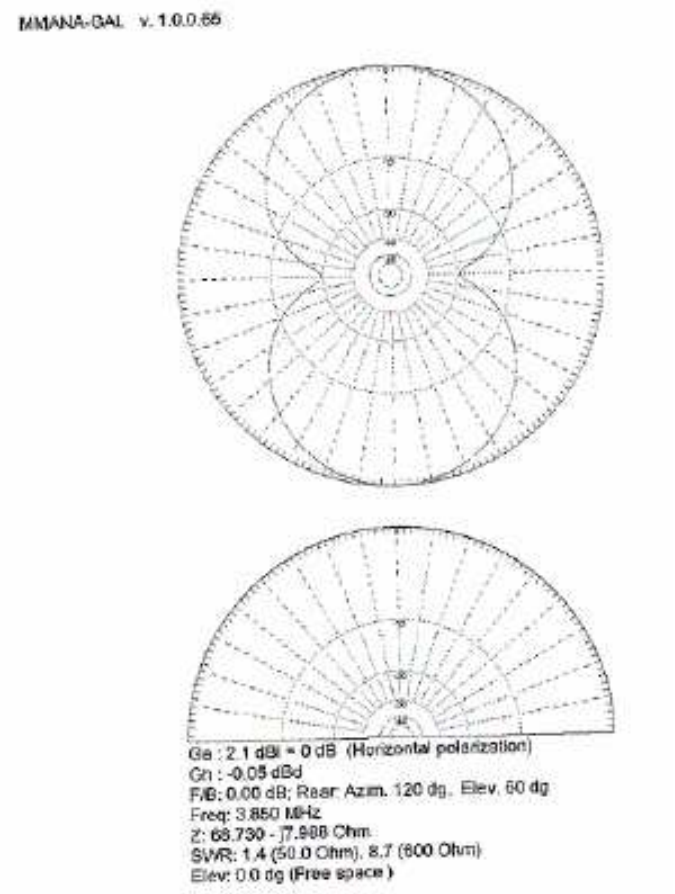

Figure 3. Radiation Pattern of Inverted-V for 80-Meters at 65 Feet

It is a myth that a horizontal antenna orientation makes a difference on 80 meters at heights used by most amateurs. I have heard many amateurs say on 80 meters, "The reason my signal is weak to you is because you are off the end of my dipole." The radiation pattern from a dipole is essentially nondirectional until the dipole is elevated more than a half wave, that is about 125 feet on 80 meters, and it is 65 feet on 40 meters. The main reason it makes no difference regarding orientation is because propagation for signals closer than 500 miles (the distance of most 80 meter contacts) is essentially by high angle radiation nearly straight up and down. Only signals radiated and received at low angles make a difference in antenna orientation even at low heights above ground. At low heights, there are nulls about 3 to 4 dB off the dipole ends.

3. Dipole Shape Variations

The wire of a dipole doesnt have to be run in a straight line. A dipole does not have to be perfectly horizontal. Thats the way it is usually depicted in books and magazines, but you can bend the legs of the antenna up, down or sideways.

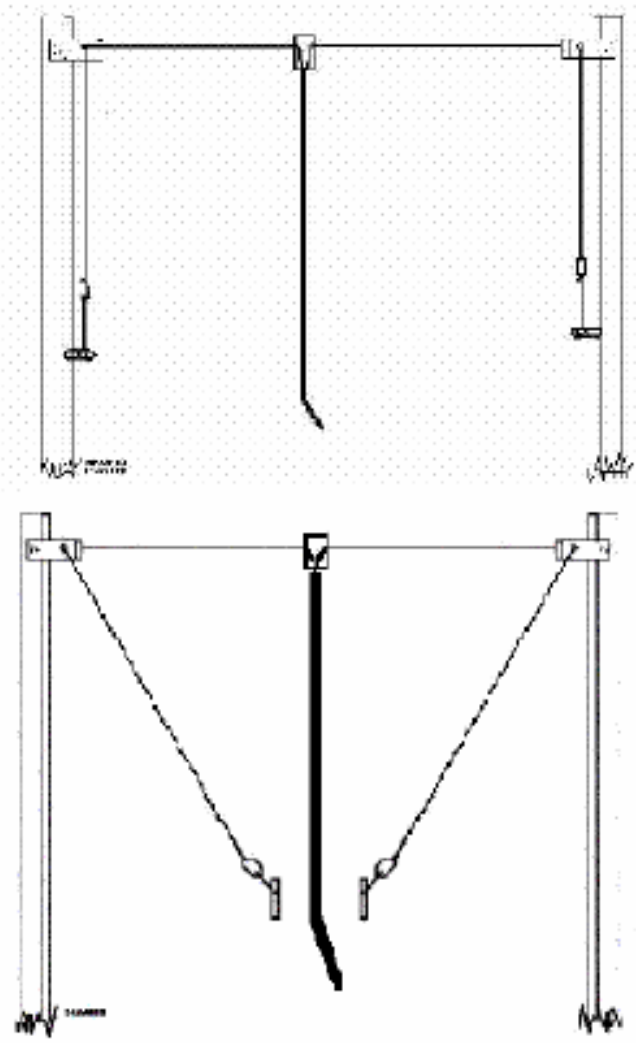

Figure 4. Two Dipole Shape Variations

If you make either wire one-half wavelength long and carefully prune it to resonance, you can use it without a tuner on and near its resonant frequency. Both antennas have the current part at the top where most of the radiation takes place. The vertical parts of these antennas radiate a weak vertically polarized wave. The only reason these dipoles are contorted this way is to make them full-sized and to fit in the available space. Other shapes are possible, and you can be creative at your location. There are many more dipoles than the ones just described. We will explore the other kinds of dipoles in section "X" of this book.

4. Calculating the Length of a Half-Wave Resonant Dipole

The approximate length in feet of a half-wave resonant dipole is found by dividing 468 by the frequency in MHz. The actual length of it will be determined by several factors. Using larger diameter wire will make the dipole resonate lower in frequency. Therefore, to make it resonant at the higher desired frequency,

It must be shortened. Raising a dipole higher above ground will make it resonate higher in frequency. An insulated wire will make the dipole resonate lower in frequency than a bare wire.

Using the above formula, cut the antenna a little longer than the calculations say. If the SWR is best at a lower frequency than you desire, the antenna will have to be made shorter by pulling the excess wire through the end insulators, folding the ends of the extra wire back on itself. Then wrap the ends of the overlapped wire on itself so it wont come loose. This causes the excess wire to "short" itself to the rest of the antenna. If you are using insulated wire, you will need to cut off the excess wire. The reverse is true if the antenna resonates too high in frequency. The extra wire can be let out to make it resonate on a lower frequency. This is why you originally cut the wire a little longer.

5. The Decibel

The decibel (dB) is a unit of measurement for comparisons of the ratio of power, current, and voltage and is the term we will use in comparing antennas in this book. At one time, antenna comparisons were made using a dipole as a standard, but today most comparisons use the isotropic radiator as a reference. An isotropic radiator is an imaginary antenna that radiates equally well in all directions. It has no gain. The terms "dBi" and "dBd" are used to label which reference is being used. In this book, we will use the dipole as a standard for the most part.

How do you derive decibels from power ratios? The formula for power ratios is dB = 10 log P1/P2. For voltage and current, the values are doubled. Formulas of this type are beyond the scope of this book. Doubling the power will produce a 3 dB stronger signal. Double the power and double it again will equal a 4 times power increase and that gives 3 dB plus 3 dB or 6 dB. Double 4 and that is a power increase of 8 and that adds 3 more dB for a total of 9 dB. Increasing the power from 1 Watt to 10 watts or increasing it 10 times will give a 10-dB increase. Multiply 10-Watts times 10 give us 100 watts, which adds another 10 dB above 1 Watt for 20 dB. Therefore, increasing the power another 10 times to 1000 Watts will produce a signal 30 dB stronger than 1 Watt.

Your receiver, if modern, will have a signal strength meter or "S Meter." That meter is calibrated in "S Units" from one to nine and decibels over S-9. S-9 is usually calibrated using 50 microvolts (uV) from a signal generator. Each S-unit is approximately a difference of 5 or 6 dB. Therefore, a reading of S-9 is about 6 dB stronger than S-8. Therefore, from S-0 to S-9 is 54 dB. On some low cost transceivers, the S units and dB above S-9 are only relative signal readings and actually have nothing to do with decibels.

Ham Radio Outlet Store Update

(The following was posted at rwk-ntx@yahoogroups.com)

As you may know Ham Radio Outlet (HRO) is opening a new store at 701 E. Plano Parkway, Suite 406, Plano, Texas 75074 (across Plano Parkway from Fry's and .5 miles from Texas Towers).

Heard from Steve Gilmore, HRO's National Sales Manager this morning, he said they are having some difficulty with some of the construction due to the weather in Dallas, it has slowed things down just a bit.

They are shooting for a February opening and are working diligently to get the store open as soon as possible.

"When we see the light at the end of the tunnel concerning the build out, and we are sure it's not a train, we will make this information available via direct mailings and the website."

I had hoped that he would say something about having a large Grand Opening Sale, but nothing on that point.

This new store will include a multi-thousand foot retail floor plan, which will stock and have on display a vast selection of amateur radio products and accessories. *(Posted by Steven E. Johnson KE5SVR)*

Ham Apps for Smart Phones

(The following was posted at rwk-ntx@yahoogroups.com)

From the ARRL Contest Update for Dec. 3, 2014:

The recent West Mountain Radio newsletter, at http://www.westmountainradio.com/pdf/winter-2014-newsletter.pdf, contained a great list of ham radio apps for your smart phone. Some are free and some are a couple of dollars -- all are useful. Of course, there are many more ham radio apps out there. Just search for "ham radio" at your favorite app store. *(Posted by Douglas Kilgore KD5OUG)*

Finally an Antenna That Works

Some of you may remember a previous article I wrote about my struggles with living in a mobile home park and wanting to do HF. (http://www.eham.net/articles/22237)

Recently - I decided to set up my radio and an antenna at my son's house about 6 miles away and try to get on the air with a remote station.

My radio is a Kenwood TS-480SAT so I figured that I could either use the Kenwood KNS program or even Remote-Hams.com to get my radio connected to the internet so that I could access it from the "Antenna Free Zone". First attempt was with a shortened G5RV Lite (not the Jr.)- it is a 102' antenna that has some "coils" in it that shorten it to 66'. This worked but was very noisy. I didn't find out till a couple of days ago that the entire neighborhood where my remote was being set up has terrible line noise from the old transformers there.

I knew that a loop antenna is inherently quieter that a dipole so I began to research that angle. That is when I

stumbled upon the work of AG6IF - Jim. He has done extensive modeling on the loop design and has developed what he calls "The Talented Balun". He determined that most Loop antennas have an impedance of around 115 Ohms. (Don't get picky - I said "around".) Anyway - most people then use a 4:1 balun if they want to coax feed their loop. As you can see - the 4:1 balun will take the impedance well below the desired 50 Ohm target. This prompted Jim to develop and build his 2.5:1 balun which he calls "The Talented Balun".

Well - to say that I am absolutely blown away with this antenna would probably be an understatement. But I can't think of any other suitable accolades. All of the local (Great Lakes Area) HF Nets are being heard like never before and the other Net members have been asking me if I moved to a new QTH. The neighborhood where my remote is has some very noisy electric transformers - but I have been able to deal with it since it is mostly on 75 meters - 40 on down are very enjoyable. In fact - I was even more amazed when I put my call out to the Route 66 special event station in Albuquerque, NM and the guy came back on the first try - and that was on 17 meters. A few days later on 20 meters - I worked a guy in Mississippi who had just received his General ticket and was using the /AG identifier. I was his first HF contact and both of us were excited.

This loop - even at only 22' AGL - is definitely not a "cloud warmer" - in fact - about an hour ago, I worked EA8YB in the Canary Islands on 17 meters with a 59+ signal. Wow - I was beginning to think that living in a mobile home park with no antennas allowed would spell the end of my HF activity. But thanks to a lot of research - and the fantastic product created by Jim AG6IF - I am back on the air!!! This is one antenna product that actually delivers and I will definitely be telling everyone I can about how well it works. Below is a picture describing the antenna layout and my station.

If you want more information about AG6IF's great antenna - please follow this link - http://www.ebay.com/gds/Ham-Talented-Balun-skyloop-antenna-160-80-40-20-15-10m-/10000000175955422/g.html

I have also posted a "Product Review" with some of the same above text in it. In case you hadn't noticed - - I am very excited about the opportunity to finally be on the air with a good signal and the ability to receive also.

73 to everyone - Keep Smiling - Keep Experimenting - And above all else - HAVE SOME FUN!!

(By Tom Garrisi W8BNL, courtesy of eHam.net)

Upcoming Events

JANUARY

24-26 **January VHF—**Objective: Amateurs in US and Canada (and possessions) work as many amateur stations in as many different 2 degrees x 1 degree Maidenhead grid squares as possible using authorized frequencies above 50 MHz. Stations outside US & Canada (and possessions) may only work stations in US (and possessions) and Canada. Begins 1900 UTC Saturday, ends 0359 UTC. More info at http://www.arrl.org/january-vhf.

FEBRUARY

9-13 **School Club Roundup—Objective:** To exchange QSO information with club stations that are part of an elementary, middle, high school or college. Non-school clubs and individuals are encouraged to participate. Sponsored by the ARRL, it's Hudson Division Education Task Force and the Long Island Mobile Amateur Radio Club (LIMARC) to foster contacts with and among school radio clubs. All amateur bands except 60, 30, 17 and 12 meters are permitted. Repeaters are not to be used. The event runs Monday through Friday from 1300 UTC Monday through 2359 UTC Friday. A station may operate no more than 6 hours in a 24-hour period, and a maximum of 24 hours of the 107 hour event. More Info at http://www.arrl.org/school-club-roundup.

21-22 **International DX – CW—Objective:** To encourage W/VE stations to expand knowledge of DX propagation on the HF and MF bands, improve operating skills, and improve station capability by creating a competition in which DX stations may only contact W/VE stations. W/VE amateurs work as many DX stations in as many DXCC entities as possible on the 160, 80, 40, 20, 15, and 10 meter bands. DX stations work as many W/VE stations in as many of the 48 contiguous states and provinces as possible. **Contest Period:** Starts 0000 UTC Saturday; ends 2359 UTC Sunday. No contest QSOS may be made on 12, 17, 30 or 60 Meters. More info at http://www.arrl.org/arrl-dx.

REGULAR ACTIVITIES

Daily	DFW Early Traffic Net (NTS) at 6:30pm 146.88 – PL 110.9Hz
Daily	DFW Late Traffic Net (NTS) at 10:30pm 146.72 – PL 110.9Hz
Daily	Texas CW Traffic Net (NTS) at 7:00pm and at 10pm on 3541 KHz www.k6jt.com
1st Wednesday	Richardson Emergency Siren Test. At noon using the Richardson Wireless Klub (RWK) repeater at 147.120 MHz.
2nd Wednesday	ARES North Texas HF Net Every month—3860 KHz at 830 pm—930pm

Rockwell-Collins

Amateur Radio Club

Mail Station 461-290

P.O. Box 833807

Richardson, TX 75083-3807

TO:

CLUB STATIONS
(972) 705-1349

W5ROK REPEATER
441.875 MHz +5 MHz Input
131.8 Hz PL - RX and TX

W5ROK-1 PACKET BBS ROK Node
145.05 MHz

W5ROK-N1, W5ROK-N2 & W5ROK-N3 HSMM-MESHNET Nodes 2.4 GHz

Tuesday 27 January 2015

1700 Social 1730 Meeting

Methodist Richardson Medical Ctr
At Bush/Renner/Shiloh Intersection

Second Floor Conference Room 200

NEXT SIGNALS INPUTS DEADLINE:
➔➔➔ 13 February 2015 ➔➔➔