DEMONSTRATION 4

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This is the fourth in a series of demonstrations to allow the reader to build a very simple and very inexpensive EH Antenna, and experience the excellent performance parameters of this new concept in antenna theory.

This document was prepared to present the detailed design of EH Antennas, as well as assistance in construction and tuning. Previous demonstrations used a 40 meter antenna as an example. For an example in this demonstration we will detail a 20 meter version.

DEMONSTRATION 4: The detailed information is presented in the following table, followed by appropriate comments. We have included information relative to the 40 meter antenna for reference.

HAM BAND		
	METERS	40
	MHz	7
FORM DIAMETER		
	INCHES	3.25
	CM	8.255
CYLINDER LENGTH		
	INCHES	4.5
	CM	11.43
CYLINDER SPACING		
	INCHES	3.25
	CM	8.255
CYLINDER TO COIL		
	INCHES	3.25
	CM	8.255
# TURNS ON PHASING COIL		3
# TURNS ON TUNING COIL		20
TAP AT# TURNS		1.25
# TURNS ON FEED COIL		12
APPROXIMATE TOTAL LENGTH		

INCHES	16
CM	40.64
BANDWIDTH - KHZ	
2:1 VSWR	160
.+/- 3 dB	360

PHYSICAL:

The antenna diameter is not critical, but it does have a direct effect on antenna bandwidth due to capacity between the cylinders. Unfortunately, we have not yet developed an equation to define the capacity as a function of diameter and length. From experience, for a 2.375 inch diameter antenna on 80 meters we get a 2:1 VSWR of 67 KHz. For one on the same frequency but 4 inches in diameter we get 160 KHz.

If the cylinders are spaced the same as the diameter, internal radiation is held to a minimum. Therefore, best results depend on this spacing. Note that the spacing between the lower cylinder and the tuning coil is also the same as the diameter. Also the feed coil should be spaced about 1 diameter below the tuning coil.

We have found that a very good antenna for the low bands (below 10 MHz), where it is desired to have both low angle and high angle radiation, should have a cylinder length to diameter ratio of 12. For 10 MHz and above there is no need for high angle radiation, therefore the ratio should be 6. These values are not the same as our example because the example was only to demonstrate bandwidth and efficiency of the EH antenna concept.

BANDWIDTH: The bandwidth can be further extended by using an antenna tuner, but only within the 3 dB bandwidth of the antenna. Typically, the +/- 3 dB bandwidth is approximately twice the 2:1 VSWR bandwidth. Therefore the 40 meter antenna detailed above can cover all of 40 meters by using an antenna tuner. It is only the lower bands where the bandwidth is an issue. This is because even very large diameter cylinders have low capacity. Larger is better, but even for a small diameter there will be adequate bandwidth to cover the part of the band you use most of the time. If you like to work over the entire band and the 3 dB bandwidth is less than the desired operating range; you need to construct a means to remotely tune the antenna. One method is to use an electric screw driver to move a copper or aluminum slug in and out of the coil. These non-ferrous slugs will increase the frequency because they effectively reduce the inductance, and have negligible effect on efficiency. The slug can be a short piece of pipe.

PHASING COIL: The purpose of the phasing coil located between the cylinders and connected between the top cylinder and the tuning coil is to provide a few degrees of phase shift. The EH Antenna concept is based on proper phasing between the E and H fields. If the voltage on the wire is not the same phase as the voltage on the cylinders, there will be no radiation from the wire. We found that a phase shift of about 3 degrees was equivalent to a 2:1 VSWR, so a shift of 6 degrees or more is typically used. We recommend you calculate a length of wire equal to 6 degrees (6/360 = 0.016 wavelengths), then wind the coil with that.

SOURCE COIL: With reference to the schematic diagram, note the coil in series with the coax center conductor. We call this the source coil. The *STAR* version of the EH Antenna will have minimum VSWR at a frequency other than where the reactance is zero and the radiation resistance is simultaneously maximum. Inserting this coil allows improved VSWR and, more importantly, allows minimum VSWR to coincide with maximum radiation. We prefer this coil to be located below the tuning coil a sufficient distance to eliminate most of the mutual coupling.

A BEER CAN VERTICAL: In the old days a beer can vertical was most Ham's dream, and a few were actually constructed. For a ¼ wavelength vertical, that is a lot of beer cans. This one only requires two cans. I prefer coke. These cans are 2 5/8 inches in diameter and 4 7/8 inches long, thus the length to diameter is a little less than two. We had some fiberglass rod in the junk box, so we used that for mounting. The plan was to hang the antenna from a tree, so no special mount was designed. The string is tied to the thing that opens the can. I might add that this antenna will withstand the weather if the spacer material will. If the spacer is made of wood strips, a good coat of varnish will allow it to be outside for a year or more. This version of the EH Antenna does not use any variable capacitors or other items subject to weather. Be sure to put a drain hole in the bottom of each can.

please put the picture here - - - -

The picture of the Coke Can Vertical shows the tuning coil and the tap. There was no good place to put the small phasing coil below the top cylinder, so we left it out. The source coil is air wound and located inside the main coil. It is mounted at right angle to minimize coupling. Sheet metal screws are used to make the electrical connections to the cans.

The picture of the 40 meter antenna includes a coke can beside it to illustrate size. The large flange at the base of the antenna is a mechanical arrangement to allow the use of a thin plastic pipe cover over the antenna.

this is a good place to put the picture of the 40 meter antenna.

It is true that the 20 meter antenna is longer than the 40 meter antenna. If the diameter of the 20 meter antenna was reduced to ½ inch, it would be much smaller. I point this out to exhibit the broad range of construction possible. Although I have not tried it, I believe you could build a very good 75 meter mobile antenna using a diameter as small as 1 inch and still outperform the best of the commercial mobile antennas. For the experimenter, please be aware that the smaller the antenna the larger the coil needed to resonate the antenna. That means that the efficiency will be reduced.

THE GOOD THE BAD AND THE BEAUTIFUL: I have tried to point out in these demonstrations the capability and the shortcomings of the *STAR* version of the EH Antenna. What are the advantages and short comings? The list below presents the pros and cons of the EH Antenna compared to a conventional Hertz antenna.

	.*STAR*	HERTZ
EFFICIENCY	VERY HIGH	VERY LOW FOR SMALL ANTENNAS
BANDWIDTH	VERY HIGH	VERY LOW ON LOW BANDS,
SIZE	VERY SMALL	VERY LARGE ON LOW FREQUENCIES,
EMI	VERY SMALL	VERY LARGE ON LOW FREQUENCIES,
RECEIVING	VERY QUIET	VERY NOISY

The following comments put these comparisons in perspective:

*) Efficiency – A 75 meter mobile antenna will have an efficiency of less than 3%. Efficiency of an EH antenna is limited only by the loss in the coil, typically only a few % is lost in heat.

*) Bandwidth – The instantaneous bandwidth of the EH Antenna is typically greater than a full size Hertz antenna. However, the antennas could be very small with narrow bandwidth. Both the standard 75 meter mobile antenna and the loop antenna are noted for their narrow bandwidth.

*) Size – A Hertz vertical antenna should be ¼ wavelength with ¼ wavelength radials – the EH Antenna is a dipole and needs no radials – its size is measured in inches.

*) EMI – For an EH Antenna it is virtually non existent, and is typically greater than 30 dB below the EMI created by a Hertz antenna.

*) Receiving – You have to experience this one to believe it – very quiet - - a superior signal to noise ratio with equal received signal level.

What else could you desire from an antenna? The beauty of the EH Antenna is un-equaled in the eyes of any one that appreciates antennas.

It is our hope and expectation that you will experiment with the *STAR* version of the EH Antenna. We have shown that the antenna physical characteristics are not critical, so do not hesitate to play. You do need to build a simple diode field strength meter, and a signal generator is a big help getting the antenna tuned close to frequency. A grid dip meter will also serve that purpose. There are several types of antenna test equipment on the market.

COAX FEED: The EH Antenna is an excellent antenna, but it is only useful if the radio can communicate with the antenna. Unfortunately, this requires some form of transmission line, typically coax. It is my opinion that the E field of the antenna couples to the coax, even though the E field is primarily contained very close to the antenna. This causes current on the coax, which in turn develops an E field that interacts with the E field of the antenna. If the coax is changed (moved, rolled up) then the interaction is changed and the result can be measured as a change in VSWR of the antenna. This can be demonstrated as follows: connect your radio to the antenna through a short section of coax, no more than 3 feet. Set the antenna matching to give a good match. Note the frequency and the impedance or VSWR. Now, connect a long piece of coax or wire – only the shield of the coax – by using a jumper wire to the ground terminal on the antenna or the analyzer. Note that there is a change in the match, both in frequency and impedance. Next, connect the coax normally to the antenna and measure the frequency and impedance at the other end of the coax. Be careful to not change the location of the coax. You will see approximately the same effect. For this reason a wire should always be connected to the antenna test equipment to ground it. Normally, the wire can be connected to the ground wire of house wiring.

10 STEPS TO SUCCESS: We want to walk you through the construction and tuning of an EH Antenna. We are not trying to tell you how to drill holes or other simple mechanical activities. What we do want to tell you are those things unique to the EH Antenna that can be gained only from experience or from this demonstration. If you do not have the necessary test equipment to perform one of the following steps, beg borrow or steal from your Ham friend, or have him help you.

Step 1) Select the form and construct the cylinders.

Step 2) Measure the capacity between the cylinders.

Step 3) Calculate the length of wire for the phasing coil, then install it.

Step 4) Calculate the inductance of the tuning coil (to make it series resonant with the capacity of the cylinders), then install it with a couple of extra turns.

Step 5) Connect the top of the coil to the top cylinder. Space the wire away from the lower cylinder to minimize capacity coupling. We prefer running this wire down the center of the lower cylinder. Use some form of plastic spacers to keep the wire in place.

Step 6) Connect a wire to the top of the lower cylinder. This will be “ground” for the antenna.

Step 7) Connect a short piece of coax to the lower end of the coil and the lower cylinder wire. Measure the resonant frequency and remove turns to set the frequency just below the desired frequency.

Step 8) Connect the lower cylinder wire to the bottom of the coil. Connect a short piece of coax to the "ground" of the antenna (you just created) and to a tap on the coil 2 turns above the bottom.

Step 9) Measure the value of X when R = 50 ohms. Calculate a coil with that reactance and install it in series with the center lead of the coax. Alternately, experimentally determine the value of inductance that allows minimum VSWR to occur at the same frequency as the maximum radiation.

Step 10) Adjust the tap on the coil to get perfect VSWR, then again adjust the top turns on the coil to place the antenna resonant frequency where desired. The impedance of the antenna can be adjusted by spreading turns on the low end of the coil. The operating frequency can be adjusted by spreading turns on the top of the coil. Be aware that changing the tap will also change the frequency, so start low with too many turns, correct the VSWR then set it on frequency. Hot glue will keep it there.

If you use a MFJ or other battery powered analyzer, connect a ground to it. Without the ground, the readings will be unstable and affected by touching the analyzer because any object in the vicinity of the antenna will cause a change in the antenna characteristics. The third wire power ground from the wall socket works great.

Step 11) Wind a coil of coax about 3 feet below the antenna. By using the proper size coil and using a capacitor or ferrite slug, the coil can be made resonant at the operating frequency. This effectively places high impedance in series with the coax shield and prevents current on the outside of the coax shield. By doing this the length of the coax and it's location will no longer affect the antenna performance.