THE SPEECH - by Ted Hart - CEO - EH Antenna Systems 1-706-484-1984

The following are words to describe the viewgraphs used at a speech given before the Pennsylvania Association of Broadcasters in October 2000 at Hershey, Pennsylvania. These words do not duplicate the speech verbatim, but rather give a brief introduction to each slide for the purpose of allowing those not in attendance to gain an insight to the concepts of the EH Antenna.

INTRODUCTION - This slide is self-explanatory

THE POYNTING VECTOR - About 120 years ago John Henry Poynting, a British Physicist and college professor discovered that all radiation, including light waves, had several features as described in the Poynting Theorem and depicted by the Poynting Vector: 1) Radiation is created by, and contains, an electric (E) field and a magnetic (H) field. 2) The fields are at right angles to each other and oriented as shown by the Poynting Vector. 3) The fields must occur simultaneously, i.e., they must be in time phase. 4) The magnitude of the fields must be in a ratio to give an impedance of 377 ohms. If these requirements are satisfied, then radiation occurs as indicated by radiation vector S.

At about the same time (1880's) a physicist and college professor in Germany, Heinrich Hertz, discovered that radio waves were periodic, leading to the concept of resonant antennas. All antennas, until the development of the Crossed Field Antenna and the EH Antenna, were variations of the Hertz antenna, more commonly referred to as various types of wire antennas. Typical explanation of the wire antenna is based on causing a current to flow in the antenna. An alternating current causes the development of an H field, which in turn causes the development of an E field. As the fields expand away from the antenna, at a distance of nominally Lambda/pi the fields become in time phase and satisfy other criteria of the Poynting Vector, thus radiation occurs. Unfortunately, the E and H fields must be very large in the vicinity of the Hertz antenna, thus the cause of electromagnetic interference (EMI).

GLOSSARY - This is provided to ensure that the meaning of words used in this presentation are consistently defined. In particular, when current travels on a wire it is called conduction current. That same current, when passing thru a capacitor, is called displacement current. Maxwell's equations are primarily a summation of the work done by Ampere, Faraday, and others. However, he did see the need to name the current that flows thru a capacitor. It must be noted that it is the current - not the wire - that causes a magnetic field. Therefore, a magnetic field will be developed in and around a capacitor carrying current.

E AND H FIELDS ASSOCIATED WITH THE EH ANTENNA - When a RF signal is applied to an EH Antenna (in this case the connections are made to the apex of each cone) two things happen: 1) The applied voltage causes an E field to exist between the cones. 2) The natural capacity between the cones allows a current to flow, first as conduction current up one cone, then as displacement current thru the capacitor, then as conduction current down the other cone returning to it's apex, thus completing the circuit.

The displacement current causes an H field to be developed that encircles the area between the cones. *Note - a magnetic field must be circular and closed.*

It would appear that the Poynting theorem is satisfied, except for the fact that due to the phase of the current leading the phase of the applied voltage thru the capacitor, the H field leads the E field in time phase.

THE EH ANTENNA CONCEPT - If an inductor is placed in series with the antenna feed, it will cause the current to be phase shifted (time delayed) relative to the phase of the voltage. If the amount of inductance is correctly chosen, the amount of delay thru the inductor can be made equal to the amount of lead thru the capacitor at the desired operating frequency, thus the E and H fields can be caused to be in time phase. For this case, all criteria of the Poynting Theorem are satisfied and radiation occurs. The actual radiation pattern of an EH Antenna is non-directional in the azimuth plane.

THE EQUIVALENT CIRCUIT - What is truly amazing is that the EH Antenna acts exactly as you would expect a Hertz antenna to act, i.e., there is a radiation resistance of much less than an ohm. However, when the E and H fields are brought into time alignment, the radiation resistance becomes a very respectable value, and can be made to be 50 ohms or almost any desired value, depending on the included angle between the two elements of the antenna.

The name EH Antenna was given to this concept to denote that the E and H fields are developed simultaneously and have the proper characteristics to satisfy the Poynting Theorem.

TYPES OF EH ANTENNAS - Three of the most significant physical configurations of the EH Antenna are depicted - the bi-cone, the dipole, and the disc-cone. Each has its preferred application.

THE EH ANTENNA FARM - The majority of experimentation and development of the EH Antenna was done in the comfort of my office with antennas that were a very good size compatible with performing at 7 MHz, allowing comparison tests to be made on the 40 meter Ham band. As a rule, the total height of the antenna is typically less than 1.5% of a wavelength. That translates to less than 2 feet tall at 7 MHz. The picture displays AM Broadcast versions of the EH Antenna.

On the left of the picture is the dipole. The first antenna was a cylinder over a ground plane. It tuned up nicely, but we are not sure where the radiation went. Then the second cylinder was added with the ground plane disconnected, which resulted in a very good antenna for AM broadcast. About that time experiments in the office led to the bi-cone version in the right of the photo. Unfortunately, that one did not work. It would not properly tune up. Later we found that it was just too large for the high end of the AM broadcast band.

About that time, Bob Zimmerman joined me in the development of the EH Antenna concept and concluded that a disc-cone would make a very good antenna. We all knew that a ground plane version would be best. Unfortunately, the EH Antenna does not follow the rules laid out for conventional Hertz antennas. To give 50 ohms, the angle between the cone and disc was set at 46.3 degrees. By experiment, using various radio stations as signal sources and a receiver at the antenna, it was found that the antenna had very poor performance as a low angle radiator, necessary for AM Broadcast. However, it exhibited a narrow antenna pattern at an angle about half way between the cone and disc. A narrow pattern can be directly translated as antenna pattern gain, remarkable for a small antenna. Again, this is not a conventional antenna. The author standing on the disc and leaning against the cone depicts the size of the antenna. Although that antenna has no further use, by verifying the concept of a high gain antenna and displaying the direction of it's pattern justified it's short life. It was necessary to create and test various configurations of this new antenna concept to gain a better understanding.

After this picture was taken, two more antennas were added. One is a bi-cone having a diameter of 7 feet and a height just less than 4 feet. This one will be used on the high end of the AM Broadcast band. The other antenna is a 65-foot vertical tower to be used for comparison testing.

E & H FIELDS AS A FUNCTION OF RADIUS - For the H Field, the graph displays the circumference of the cone as a function of the radius of the cone, in other words, current density. For the E field, the graph displays the spacing between cones as a function of radius, in other words, E field intensity. The graph illustrates that the magnitude of the E and H fields is very large very near the apex of the antenna and diminishes away from the apex. Also, the magnitude of both the E and H fields have similar shapes which demonstrates that there is excellent efficiency in the integration of the E and H fields to cause radiation. Within the antenna, the magnitude of the E and H fields are significantly reduced to low values at the aperture. Conversely, they are a maximum near a conventional Hertz antenna, the major source of EMI.

In a sense, the intense radiation near the apex of the cones could be compared to a microwave horn wherein a stub antenna develops radiation in a short section of waveguide, then the radiated signal exits into free space thru the aperture of the horn. In effect, the horn causes shaping of the antenna pattern, thus antenna pattern gain. In a similar manner, the radiation is developed very near the apex of the cones, then is guided to free space between the cones.

All antennas can be thought of as transducers, transforming the free space impedance of 377 ohms to the feed point impedance. In this case, 50 ohms is the desired impedance.

PERFORMANCE OF THE EH ANTENNA -

SIZE - the preferred size of the EH Antenna is specified as the sloping radius of a cone (or length of a cylinder) and is nominally between 0.5% and 0.8% of a wavelength.

For example, an excellent FM Broadcast antenna could be constructed at 100 MHz having a total height of less than one inch. It might cause a problem in high power applications due to arc over, but - - - - .

EFFICIENCY - The total loss in the antenna would be due to skin conduction loss. For a 7 MHz bi-cone, calculations showed that for 100 watts applied to the antenna, 2 milliwatts would be lost due to heat. Obviously, a large version for AM Broadcast would have even less loss due to the greater area. Care must be taken with the phasing network to minimize the loss.

BANDWIDTH - The Q of a typical EH Antenna is less than 10. For example, the 3 dB instantaneous bandwidth at 1 MHz would be greater than 100 KHz, far greater than any other antenna, regardless of size.

HARMONIC RADIATION - The performance bandwidth of an EH Antenna is totally dictated by the phasing network, not the antenna itself. The typical network does not allow instantaneous bandwidths that would encompass harmonic frequencies, thus the antenna will not radiate harmonic frequencies.

EMI - The E and H fields are contained. In comparison to a Hertz antenna, EMI is essentially eliminated, allowing the antenna to be placed in areas such as on a building in the center of a city. This is the ideal location for AM Broadcasting.

EH ANTENNA FOR COMMUNICATIONS - In addition to its exceptional performance as a transmitting antenna, that same performance carries over as a receiving antenna. One significant feature is that since the antenna will respond only to radiation and not to individual E or H fields, which are the source of man made noise, it is a very good communications antenna at all frequencies and in particular in the HF portion of the spectrum.

PHASED ARRAYS - When used in a phased array, each EH Antenna would not be subjected to the large E and H fields, as would conventional Hertz antennas. Therefore, with coupling between antennas virtually eliminated, design and tuning of the array is classical textbook.

WHAT ELSE COULD YOU ASK FOR ?

THE NEXT STEP - We have been waiting patiently for the FCC to grant an experimental license at 1590 KHz. This will allow quantified FCC type field measurements to prove the concept for AM Broadcast. The 65-foot tower previously mentioned has 120 radials and was specifically constructed for the test. Comparison measurements will effectively allow removal of ground characteristics from the EH Antenna performance parameters. When that test is completed (we hoped to receive the FCC permit a couple of months ago), we will disseminate the results thru the NAB to ensure that all members will be notified.

HAMS - and others who might be interested in experimenting with the antenna concept, will find the following web site interesting - - "http://www.qsl.net/w0kph" --. Jack, a retired IBM programmer, developed that site. He has been fascinated with the Crossed Field Antenna and is now experimenting with the EH Antenna. His pictures and text will prove interesting.

AN INTRODUCTION TO THE

EH ANTENNA

By
Ted Hart - CEO

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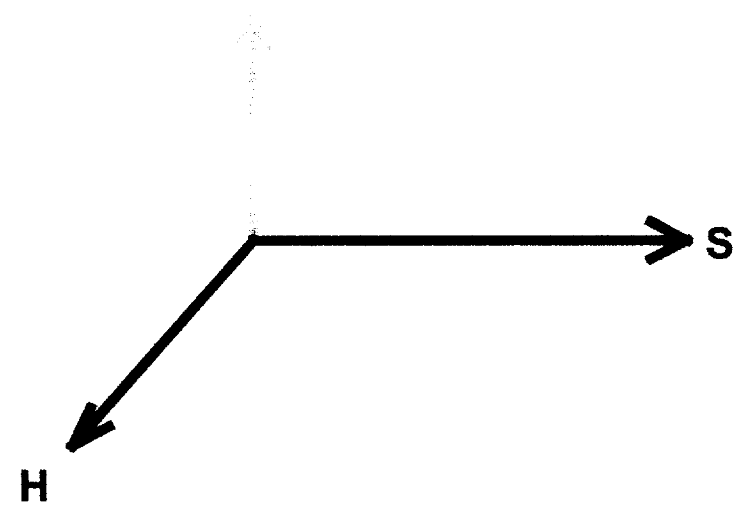
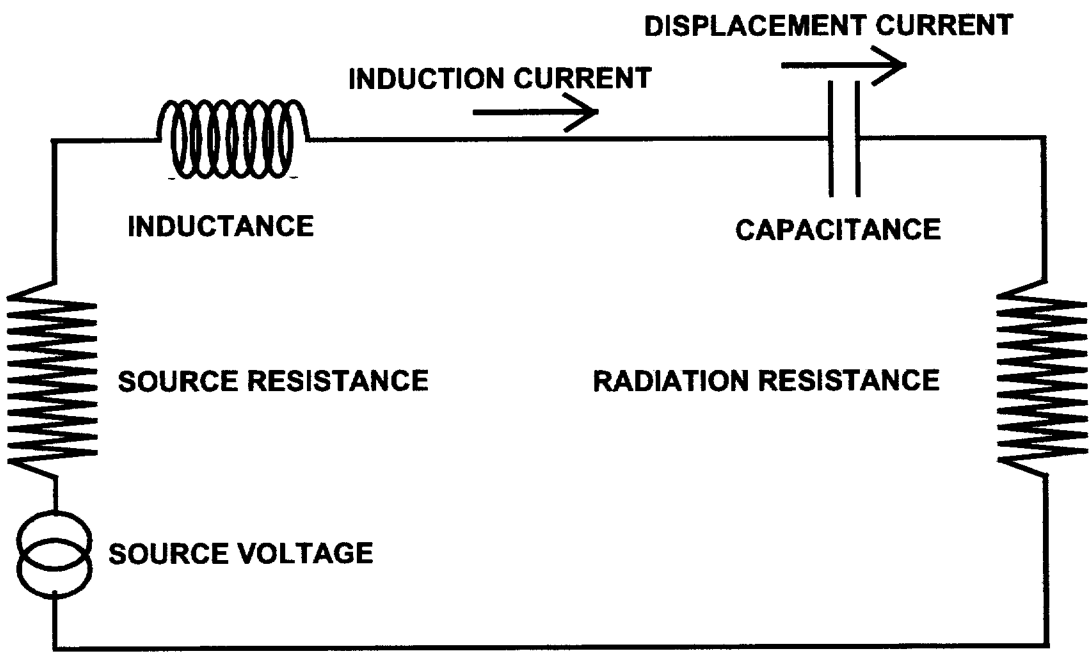
THE POYNTING VECTOR

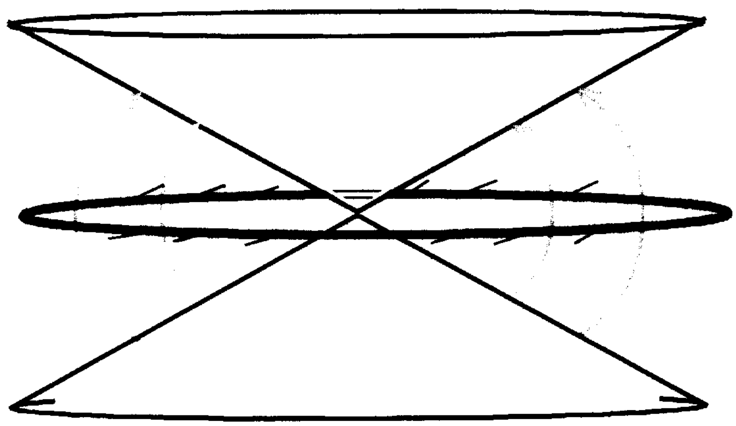


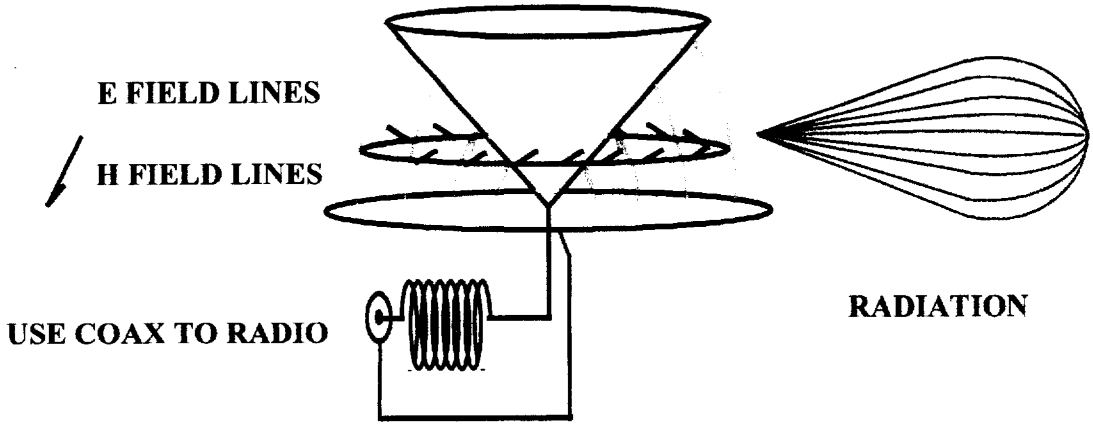
GLOSSARY



DISPLACEMENT CURRENT
INDUCTION CURRENT
INDUCTANCE
CAPACITANCE
SOURCE RESISTANCE
RADIATION RESISTANCE
SOURCE VOLTAGE

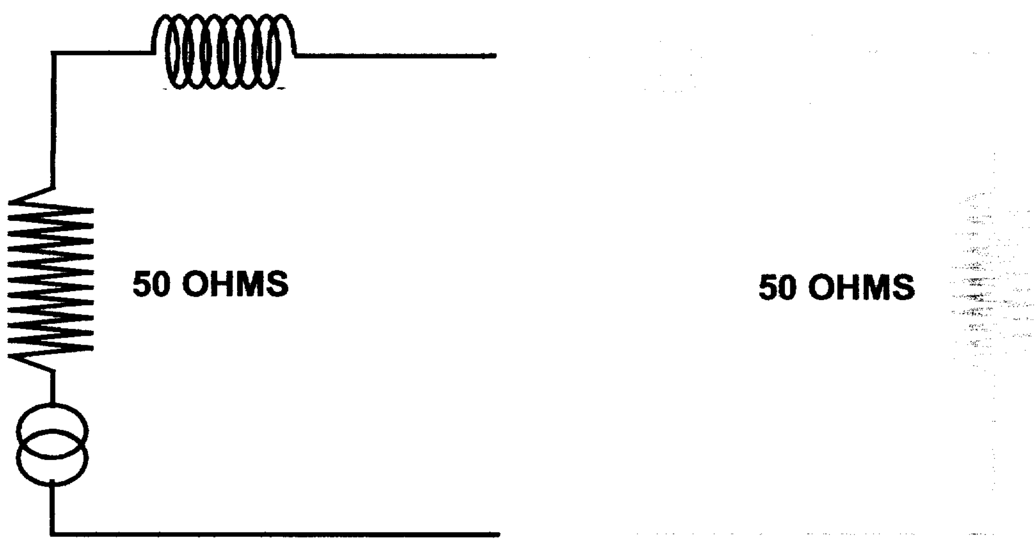
AND H FIELDS
ASSOCIATED WITH THE

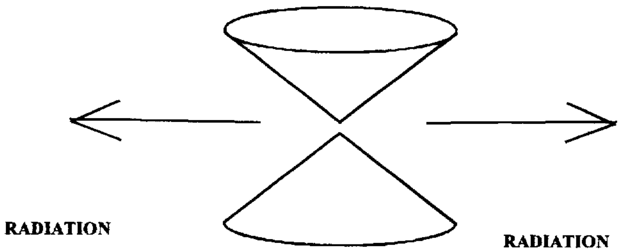




AN INDUCTOR IN SERIES WILL CAUSE THE PHASE OF THE CURRENT TO BE DELAYED, THUS ALLOWING THE H FIELD TO BE IN TIME PHASE WITH THE E FIELD.

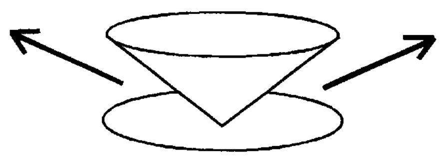
EXACT EQUIVALENT CIRCUIT
AT THE CENTER FREQUENCY



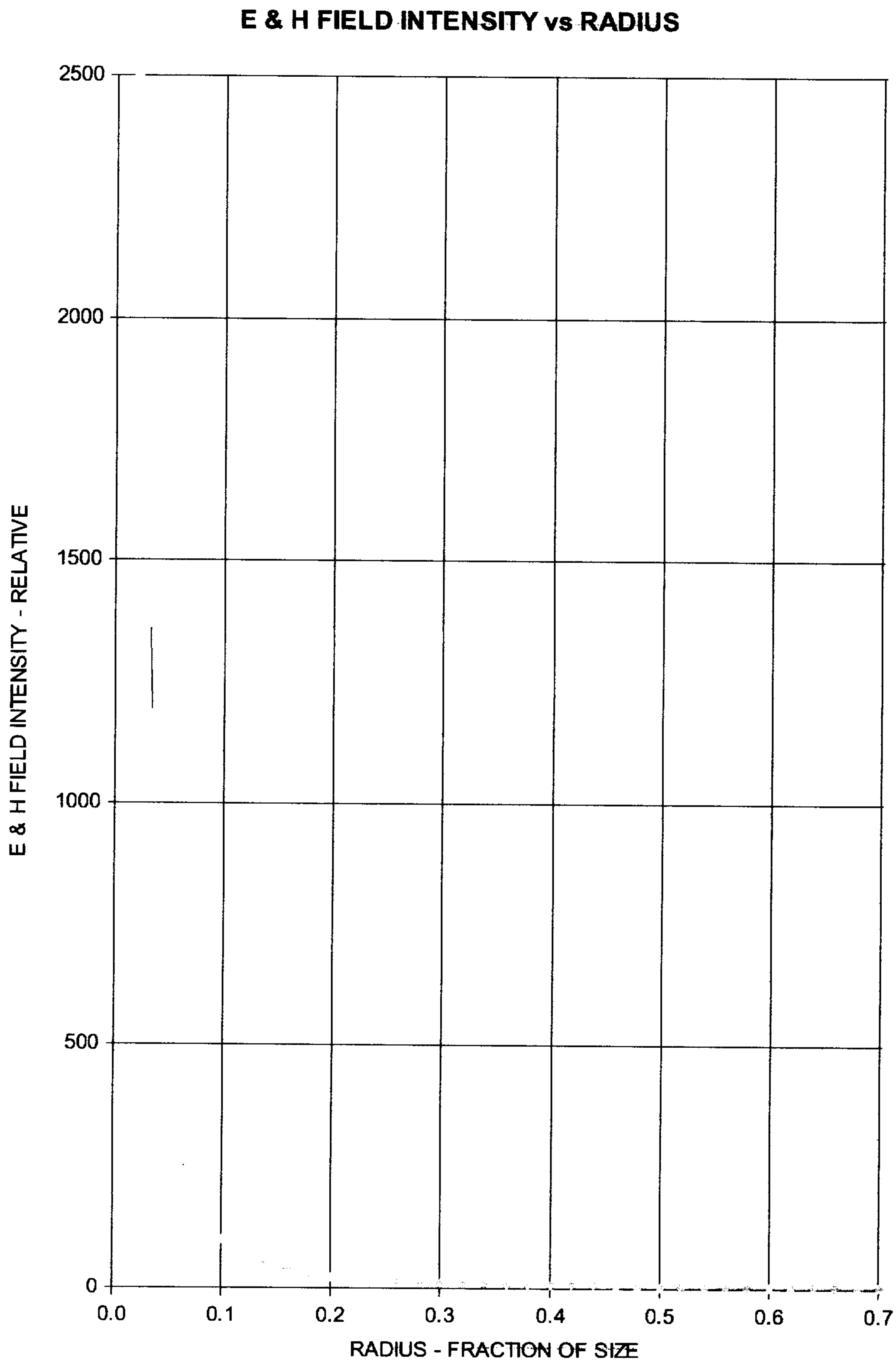


BICONNICAL ANTENNA

- DIPOLE VERSION



DISC-CONE ANTENNA


E & H FIELD INTENSITY vs RADIUS
2500
2000
1500
1000
500
0
E & H FIELD INTENSITY - RELATIVE
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
RADIUS - FRACTION OF SIZE

PERFORMANCE PARAMETERS
of the
EH ANTENNA

SIZE - 0.0073 λ NOMINAL AT DESIGN CENTER

EFFICIENCY - 100% LESS LOSS IN TUNING INDUCTOR

ANTENNA PATTERN GAIN - tbd

BANDWIDTH - TYPICAL OF A VERY LOW Q CIRCUIT

EMI - NEGLIGIBLE

HARMONIC RADIATION - NONE

RECEPTION - - DOES NOT RESPOND TO INDEPENDENT E OR H FIELDS, THUS VERY QUIET

EH ANTENNA SYSTEMS