

# EH ANTENNA – DEFINITION

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## INTRODUCTION:

Although the EH Antenna has been around for a few years, many persons still hesitate to accept a new concept for antennas because the Hertz antenna has been around for more than 120 years. Most probably the reason is a deficient explanation of the new concept. Also, there is a question, after so long a period of time, why change now? This document defines the EH Antenna concept and the benefits. In reality, the EH Antenna is nothing more than a Hertz antenna driven with a phase shift network that allows radiation to occur at the antenna, with associated benefits. To put this in proper perspective, the equivalent circuit of Figure 1 is the basis of our discussion. Note a RF source driving a EH Phasing Network followed by a matching network. The purpose of the matching network is to provide a conjugate impedance match to the antenna. For now, disregard the EH phase shift network ( $+j\phi$ ) while the Hertz antenna is defined. The EH antenna is a modified Hertz antenna; therefore details of that antenna must be understood first.

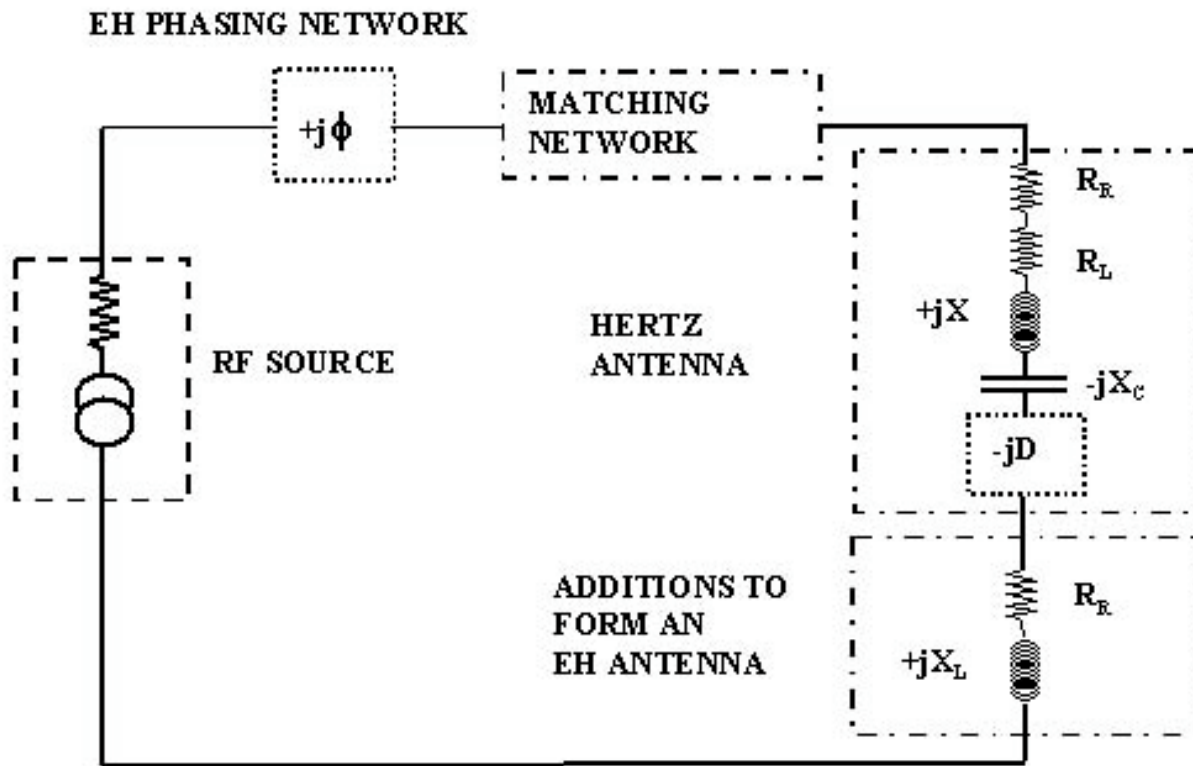


FIGURE 1 – AN EQUIVALENT CIRCUIT

## THE HERTZ ANTENNA:

The equivalent circuit of a Hertz antenna is comprised of both radiation resistance ( $R_R$ ) and loss resistance ( $R_L$ ) in addition to both inductance and capacitance denoted respectively as  $+jX_L$  and  $-jX_C$ . Each of these has a value that is a direct function of the physical characteristics of the antenna. Small Hertz antennas are capacitors with low inductance. In this case an external inductance is added to cancel the capacitive reactance, thus to resonate the antenna. The word resonance is used to indicate that the current applied to the antenna is in phase with the applied

voltage, thus allowing maximum current flow, thus maximum power transfer from the source to the antenna. As the size of the antenna increases, both the capacity and the inductance increase until their reactance is equal when the antenna element is near  $\frac{1}{4}$  wavelength, allowing the antenna to be self resonant. These larger antennas also have a higher radiation resistance and a higher loss resistance. If the antenna is short in length but large in diameter, it will have a high capacity and low inductance. The effect is to reduce the amount of external inductance necessary for resonance, thus effectively increasing the bandwidth and, since the loss in the external inductance is proportional to inductance, to increase the efficiency of the system (the antenna + the network).

The function denoted as  $-jD$  denotes the phase shift between the applied voltage and the displacement current through the natural capacity of the antenna. This signifies that the H field of a Hertz antenna leads the phase of the E field. This should be an integral part of every Hertz antenna, but has been accepted as fact and, since nothing could be done about it (until now) it was just ignored.

## THE EH ANTENNA:

The Hertz antenna is converted to an EH Antenna by inserting a phase shift network .....simply by adding a phase shift network ( $+j\phi$ ). This cancels the effect of  $-jD$ . When the phase of the current from the source is delayed 90 degrees ( $+j\phi$ ) relative to the voltage, this causes the E and H fields of the antenna to be in phase. This is the criteria for development of radiation as defined by the Poynting Theorem. This in turn causes the following components to appear in the antenna: An additional radiation resistance ( $R_R$ ) is added which improves the efficiency of the antenna and enhances the bandwidth, and an inductance ( $+jX_L$ ) is added due to displacement current through the natural capacity of the antenna. This effectively increases the capacity of the antenna by subtracting from  $-jX_C$ , thus reducing the amount of tuning inductance necessary in the network to resonate the system, thus reducing loss in the tuning inductor and lowering the Q. This component effectively increases the capacity by a factor of the square root of two for very small EH Antennas that do not have wire inductance.

It should be noted that the value of the individual added components is a function of the physical configuration of the original Hertz antenna. For example, a small EH dipole has almost no inductance due to current on very short conductors. Because a small EH Antenna does not have an H field developed from inductance on a wire, it can be very small and exhibit overall high efficiency and large bandwidth. Further, since the concept brings the beginning of radiation from the far field to the antenna, large E and H fields are no longer required and thus EMI is virtually eliminated. When used as a receiving antenna, it does not respond to local independent E or H fields, thus it provides superior signal to noise ratio.

## SUMMARY:

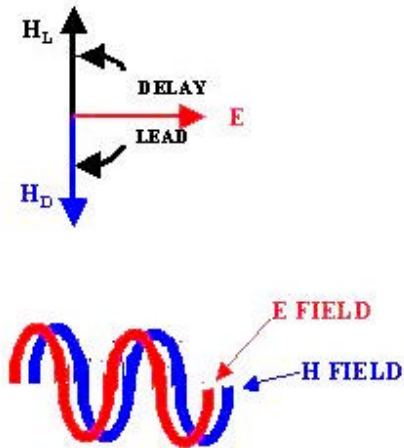
### DIFFERENCE BETWEEN AN EH ANTENNA AND A HERTZ ANTENNA:

The voltage and current applied to a Hertz antenna are in phase, therefore the E and H fields are not in phase, thus radiation does not occur until a great distance from the antenna. A proper phase shift network allows the Hertz antenna to become an EH Antenna where a 90 degree phase delay between the current and voltage applied to the antenna cause the E and H fields to be in phase, therefore the EH antenna is able to transfer power from the transmitter directly to radiation. This is the basis of the EH Antenna patent.

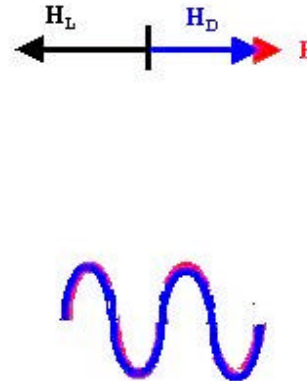
## A PHYSICAL DESCRIPTION OF THE EH ANTENNA FIELDS

To gain a better understanding of the EH Antenna concept, it is necessary to look at the E and H fields. In the drawing below of a Hertz antenna, note that the E field is developed by the applied voltage. The  $H_L$  field is developed by the current through the inductance of the antenna conductor, thus it is delayed in time phase. Here we use the clock convention for delay and lead. The  $H_D$  field is developed by the displacement current through the natural capacity, thus it leads the applied voltage in time phase.

## HERTZ ANTENNA



## EH ANTENNA



From this drawing we can see that radiation can not be created at the Hertz antenna because the E and H fields are not in phase.

For this paper we are only interested in the relative phase of the fields, not the amplitude.

Next we see the EH antenna is created by shifting the phase of the applied current relative to the applied voltage. This causes  $H_L$  to be delayed an additional 90 degrees, and is now 180 degrees relative to the applied voltage.  $H_D$  has also been delayed 90 degrees and is now in phase with the applied voltage. In other words, the  $H_L/H_D$  vector is rotated counter clock wise.

It would appear that  $H_L$  subtracts from  $H_D$  since they are 180 degrees relative to each other. However, it is believed that the entire useful H field of any antenna is caused by displacement current through the natural capacity. As evidence of this, a very small dipole EH antenna has almost no conductor inductance, thus  $H_L$  is almost 0. Since E and  $H_D$  are in phase, radiation is created at the antenna. This also implies that we can have a very efficient antenna since there is no loss resistance associated with  $H_D$ . Further, since E and  $H_D$  are in phase allowing power to be radiated, a large radiation resistance is created indicating an efficient power transfer from the EH Antenna to radiation.

Since there is a necessary physical relationship between the E and H fields to cause radiation in accordance with the Poynting Theorem, the above can not be accomplished by using a phase lead in the EH network rather than a phase delay. This is further evidence that the H field of all antennas is developed by displacement current.

What is the minimum size EH Antenna? It is determined by the allowable inefficiency for the intended use, which is dictated by the amount of antenna capacity resulting in the necessary external tuning inductance with its associated loss. As seen above, a very small EH antenna has no measurable loss in the conductors, thus the total loss is in the phasing matching network. This is typically a small fraction of a dB. As an example, an EH Antenna dipole with 0.005 wavelength elements and a diameter of 1/3 the element length produces radiation levels greater than a 1/2 wavelength Hertz dipole.

**The above uniquely defines the EH Antenna concept.**

## APPENDIX:

### POYNTING VECTOR SYNTHESIS

The following criteria are necessary for the successful creation of Poynting Vector Synthesis:

- 1) Both E and H fields must exist across the same volume of space.
- 2) The H field must be at right angle to (encircle) the E field.
- 3) E and H fields must be in the ratio of 377 ohms.
- 4) E and H fields must have the same curvature.
- 5) E and H fields must be in time phase.