EH Antenna Phase Shift Experiment

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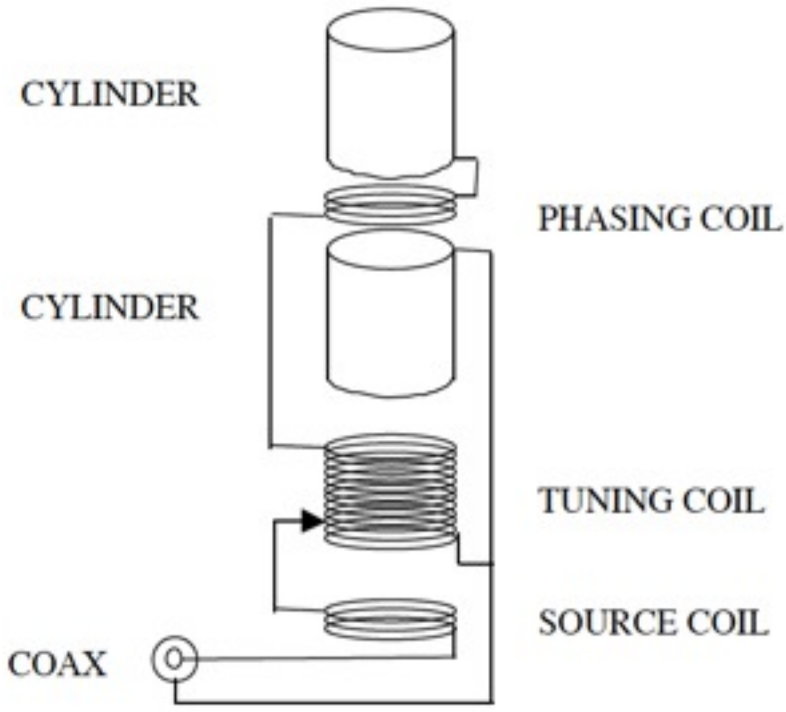
Background:

Phase shift of the Electric (E) and magnetic (H) fields is proposed as the principle by which the EH antenna creates a combined far (EM) field within itself. The antenna can be much smaller because it has little or no near field space. This experiment sets out to test the phase shift theory by measuring with E and H probes.

An H field probe is a magnetic loop. An E field probe is just a short antenna. They can be made by amateurs from scratch, though I used a ready made set.

For those unfamiliar with the EH antenna, here is a functional circuit diagram.



There are numerous links on the web providing information on the design, which I don't intend to repeat here. It suffices to say I am keenly interested in small antennas. I have made what I believe to be a through investigation of the EH antenna, of which this forms a part. This study is intended to prove, or disprove the existence of the phase shift between the fields.

Equipment used:

Tektronix TDS220 100MHz digital storage oscilloscope
Field probe set with 2x 2.0m BNC cables
EH antenna made for 20m band
Transmitter consisting of Softrock SDR, MoBo 4.3 expander, 20W RF amplifier based on RD16HHF1 MOSFETs
3m of RG58 coax cable
Fibreglass poles to support antenna and probes
2x Ferrite clip-on beads, type 43 material
Type 61 ferrite rods

The test environment was a loft room approximately 8m x 5m, with a roof window. Photo:

Method of test:

The two probes were hung down by their coax from a roof window, and with the ends of the probes 30cm from the centre of the EH antenna. The EH antenna was fixed on a fibreglass pole using nylon cable ties. The top of the EH antenna approx 50cm from the glass window above.

EH antenna was excited by approximately 4W of RF power at 14.1MHz. It had been previously shown to be resonant with the 20m band, by measuring the VSWR with a network analyser.

The antenna was driven without a source coil. Importantly, the RF amplifier used is tolerant of high VSWR. A bad mismatch makes the amplifier get hot, but does not cause a failure of the transistors.

With RF power applied, adjusted the ‘scope timebase and input gain to get several divisions of waveform for the E and H traces. The main coil tap point for the EH antenna was made from a flying lead. The relative phase from the E and H probes was observed on the scope, both in YT (normal) and XY (Lissajous figure) mode.

The input frequency was changed to 11MHz and 17MHz during the tests, as noted. The coil tap was made using a flying lead as shown in the next photo. Initially the source coil was not inserted, which is shown in the next photo:

Results:

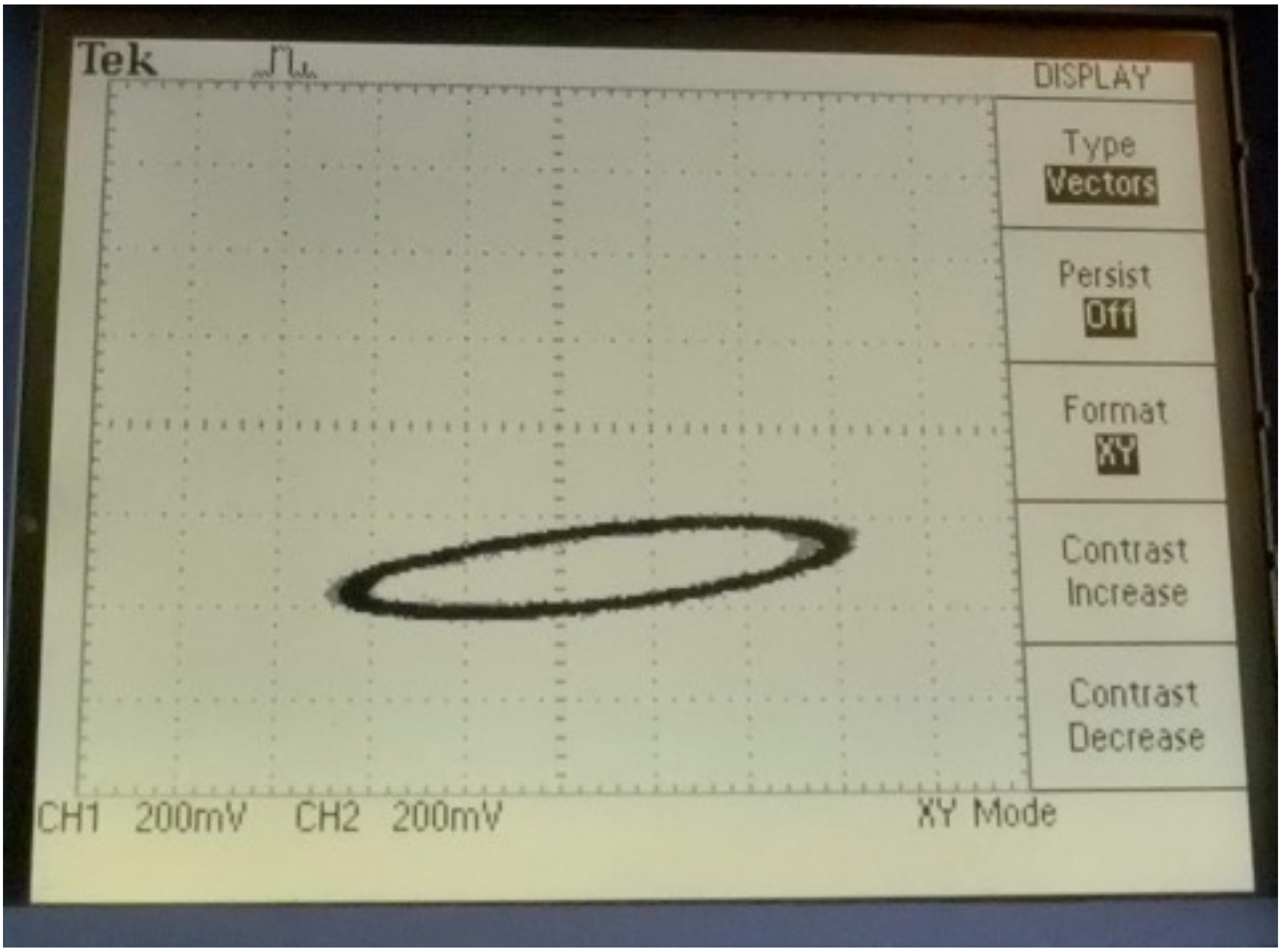
Moving the tap point on the coil made no measurable difference to the phase relationship between the traces. That is, it did not make a difference to the shape of the Lissajous figure. The amplitude of the fields did vary with the tap position but not the overall shape.

Clipping ferrite beads on the feeder cable and moving them about made no difference to the E and H phase. Placing ferrite rods inside the main coil made no difference to the field phase. Shorting the 2 turn "phasing coil" made no difference to the phase. Placing a source coil in line made no difference to the phase.

Changing the frequency did change the phase. It was found a frequency near 11MHz caused a circular lissajous figure, with 90 degree shift. However moving the coil tap at this excitation frequency did not change the shape of the figure.

The frequency was changed to 17MHz, which was observed to change the phase relative to 14MHz. Again moving the tap did not make a measurable difference to the phase.

The next photo was taken just as an example of a lissajous figure encountered during the tests. I found the biggest problem was keeping signal levels high enough, as the test antenna had severe mismatch sometimes. The Tek scope could not be used on its higher input gain settings, because<200mV introduces a phase shift of its own (bandwidth limit). For these reasons, I found it difficult to keep X & Y deflection equal. However, the overall shape still indicates the phase so long as the input amplitudes are fairly close.



Uncertainties:

The probes used will have some pickup of the opposite fields, Their field duality is not specified, but assumed to be better than 10dB.

The area used for test had a limited height. Some metal objects were present, but excepting the probes and cables, always at least 50cm from the antenna elements.

The transmitter had an unleveled power output. However the phase was measured primarily the by lissajous method, where magnitude of the X and Y deflection makes the figure change size not shape.

The lissajous figure method of phase measurement relies on the observer. Using an instrument with phase measuring capability would be better, but none was available.

Near field measurements on antennas are subject to a number of other uncertainties, which are too complex to go into here. None are believed to significantly affect this type of phase measurement.

Conclusion:

Feeding the two parts of a short dipole from a tapped coil, and moving the tap makes no difference to the phase of the E and H fields. Changing the frequency is expected to change the phase, as the elements change relative to the signal wavelength.

Additionally it was noted the magnitude of the E or H fields did not increase above the level noted at 14MHz.

The formation of the field is described by Maxwell's equations, which are beyond my mathematical ability. It's interesting to note few people calculate the equations directly, and software programs evaluate their results numerically.

Electrical phase shift from a tapped coil is used in many electronic circuits, notably the Hartley oscillator. However, from these results, the generation of E and H near fields from a dipole is not changed by the phase relationship of the voltage feeding the dipole elements.

Observations:

For a linear 2-port electrical network, no form of input signal can affect its basic characteristics. From these results, it could be inferred that this holds true for antenna systems. The "network" of the near/far field radiation is not changed by the input signal. The only way to change the characteristics of the antenna network is to change the environment of the near field.

The overall effectiveness of the EH antenna design is beyond the scope of this experiment. However the major reason given for its effectiveness has been disproved.

Reference: http://en.wikipedia.org/wiki/Near_and_far_field