Electric-Magnetic Electrically Small Antennas (E-M ESAs)

John S. (Jack) Belrose, VE2CV, VE3CVV, VY9CRC

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- **<u>Preface</u>**
- **I have spoken about and written about electrically small (compact) transmitting loop antennas, and electrically small monopole/dipole antennas (dating to 1953).**
- **There has been a continuing controversy concerning the performance of electrically small transmitting loop antennas. Professor Mike Underhill, G3LHZ, has written and re-written about small loops, claiming unrealistically high radiation efficiencies, beginning in 1997, by an IEE paper entitled *"Magnetic Loop or small Folded Dipole".* This paper and 2-follow-on papers are egregious examples of claiming antennas that violate the fundamental limitations of ESAs.**
- **G3LHZ has not given up. RadCom will not publish additional papers he wanted to publish --- so he is now publishing on the WEB --- one can publish whatever on the WEB.**
- **Some of you might remember that at our 2004 QCWA International Convention I presented a paper on *"Truths and Untruths about Electrically Small Antennas"* (title of paper paraphrased from G3LHZ's published papers).**
- **This paper is concerned with combining electric and magnetic antennas.**

Electric-Magnetic Electrically Small Antennas

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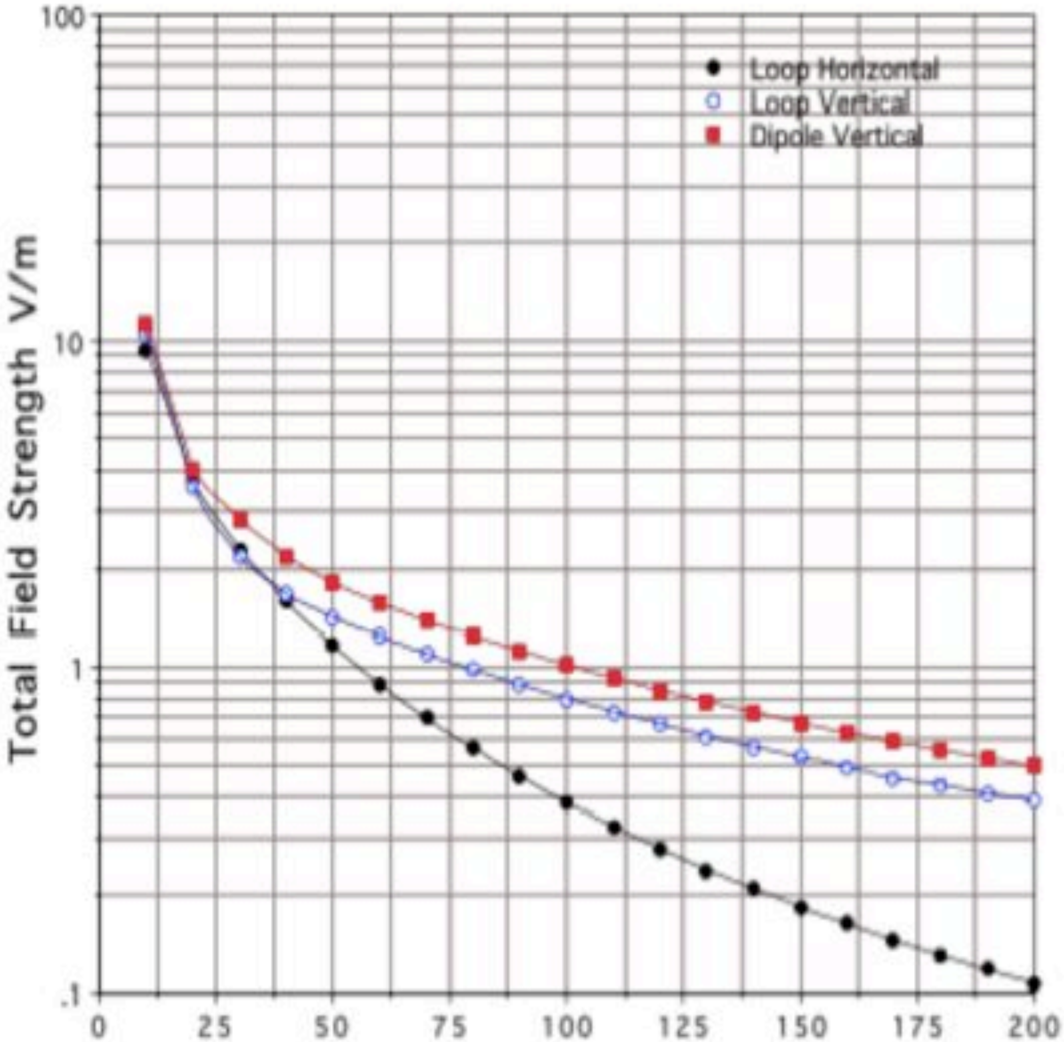
Abstract: The use of a loop antenna combined with a vertical monopole, described here as an electric-magnetic electrically small antenna (E-M ESA) system has been proposed as a technique to miniaturize antennas, providing, according to some authors: 1) a reduction in near field reactive energy; 2) improved radiation efficiencies relative to a single element antenna alone; and 3) the maximum antenna system bandwidth. But practical antenna systems have not been modeled, including tuning and matching losses; and for our understanding of the radiation characteristics of such an antenna system, a detailed study of the fields in the near and far field regions has not been made. The purpose of this paper is to present such a study by numerical modeling, and to critically comment on performance.

Background: All this sounds too good to be true (wishful thinking??). A reduction in near field reactive energy and a maximum in far-field field-strengths is reminiscent of similar claims that have been made by the inventors of the crossed-field antenna, claims that, according to the author, ask the reader to ignore the basic principles governing the laws of electrodynamics.

Case Study

I have numerically modeled a loop and a dipole, dipole length equal to the perimeter of the loop: 0.067 wavelengths (5.34 m) for a 1.7 m diameter loop, frequency 3.75 MHz.

First let us consider that the loop and dipole are separately tuned and fed, the center of the loop and the center of the dipole are at a height of 20 m over average ground.

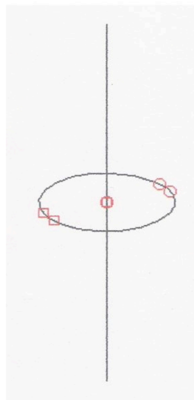


Single element antenna system:

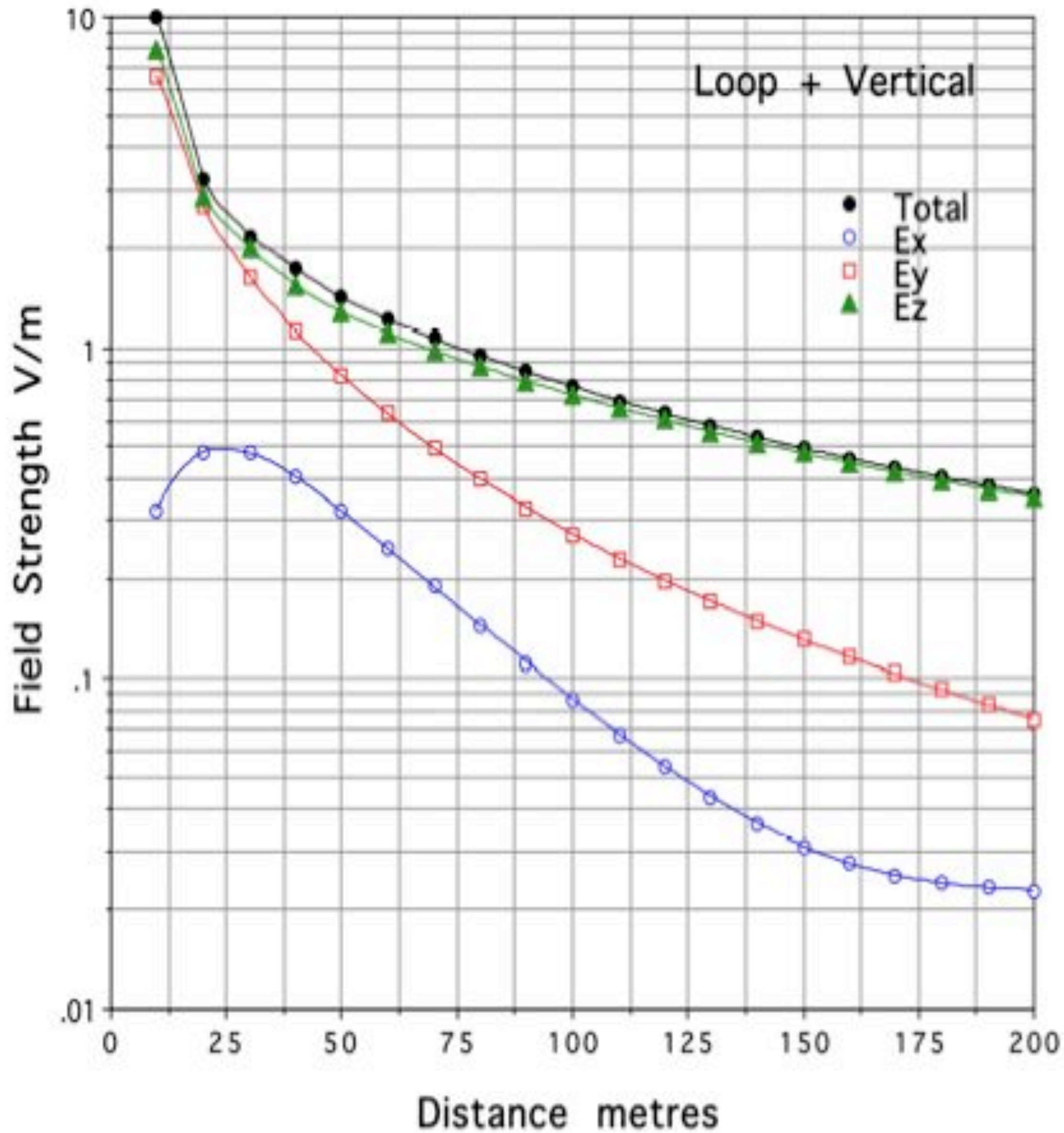
Total field strengths versus distance for a horizontal loop, a vertical loop, and a vertical dipole. Loop perimeter and dipole length are ~0.0 7 wavelengths. Transmitter power 1 kW.

Note: 0.45 V/m at 200m corresponds to a radiation efficiency of -10.5 dB with reference to a lossless electrically short monopole antenna.

Two element antenna system, Configuration 1:
Dipole along the axis of the loop, with the dipole centered in the loop plane.



Expectation: clearly the dipole has zero mutual impedance to the loop, and therefore the radiated fields are generated independently. The radiation patterns are dependant on the relative amplitudes of the feeder currents, but not on their phase difference.

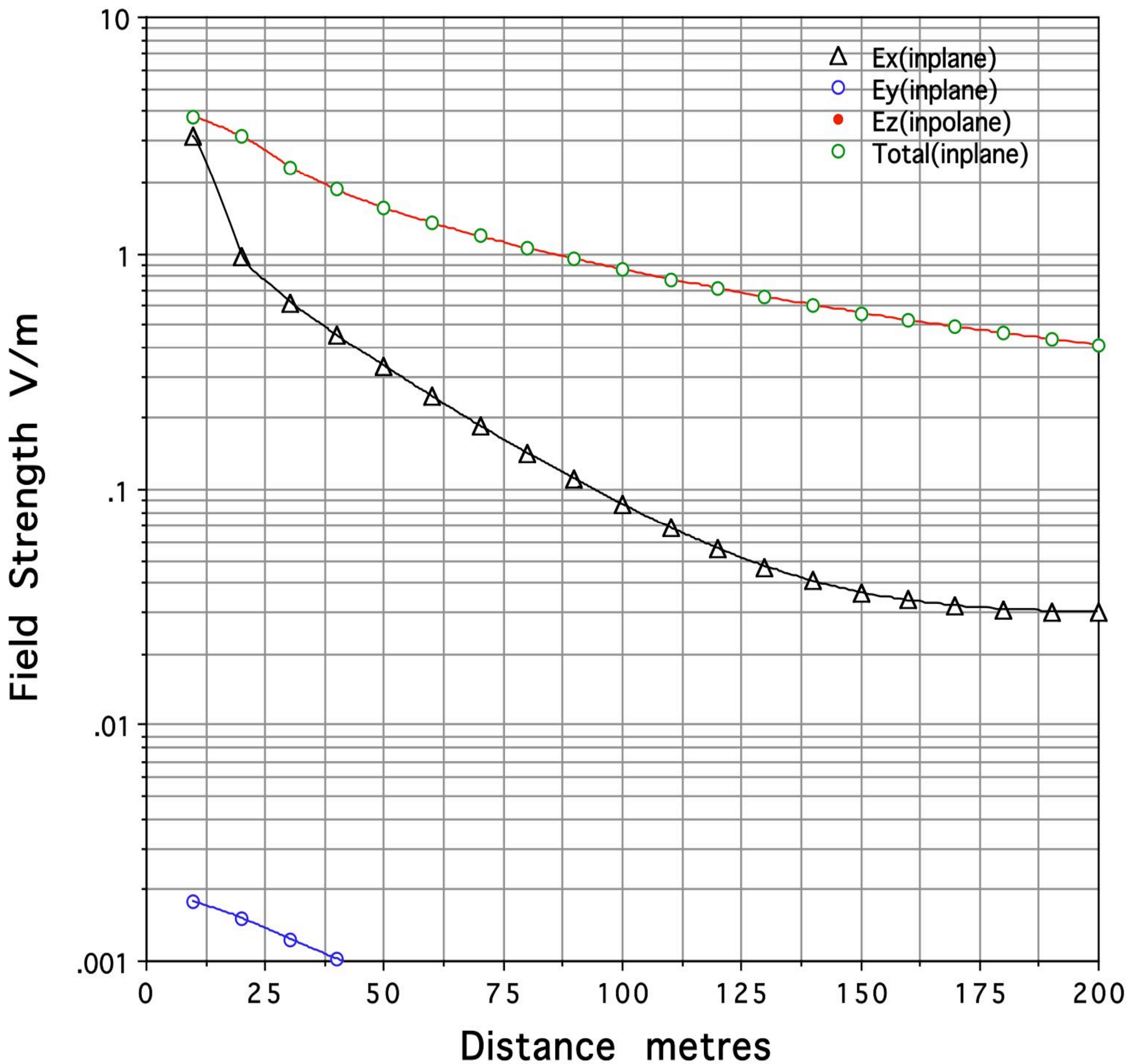


Two element antenna system, Configuration 1:

Field strength versus distance, currents are adjusted so that equal powers are fed to each element of the antenna system (total power 1 kW).

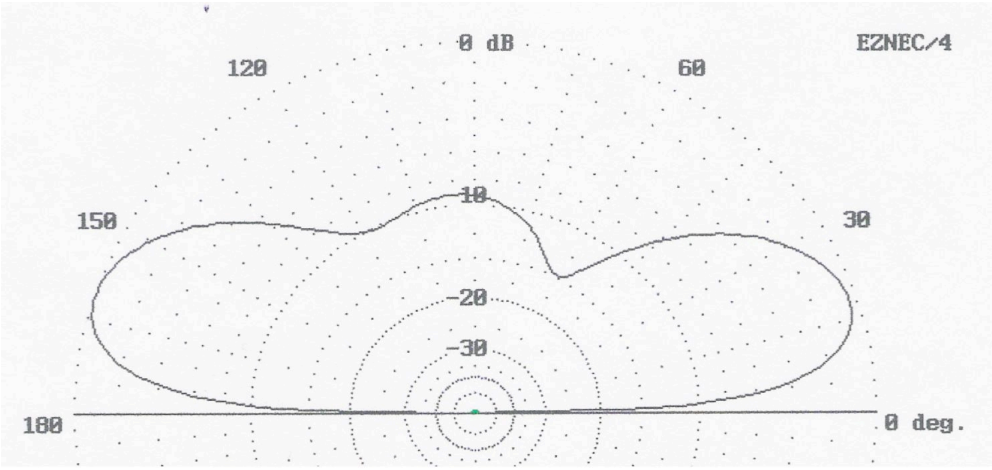
Two element antenna system, Configuration 2:
Co-planar dipole and loop, dipole centered.

Expectation: here the dipole and loop are closely EM coupled, and so the radiation patterns are dependant on the relative amplitudes and the phase of the feeder currents.

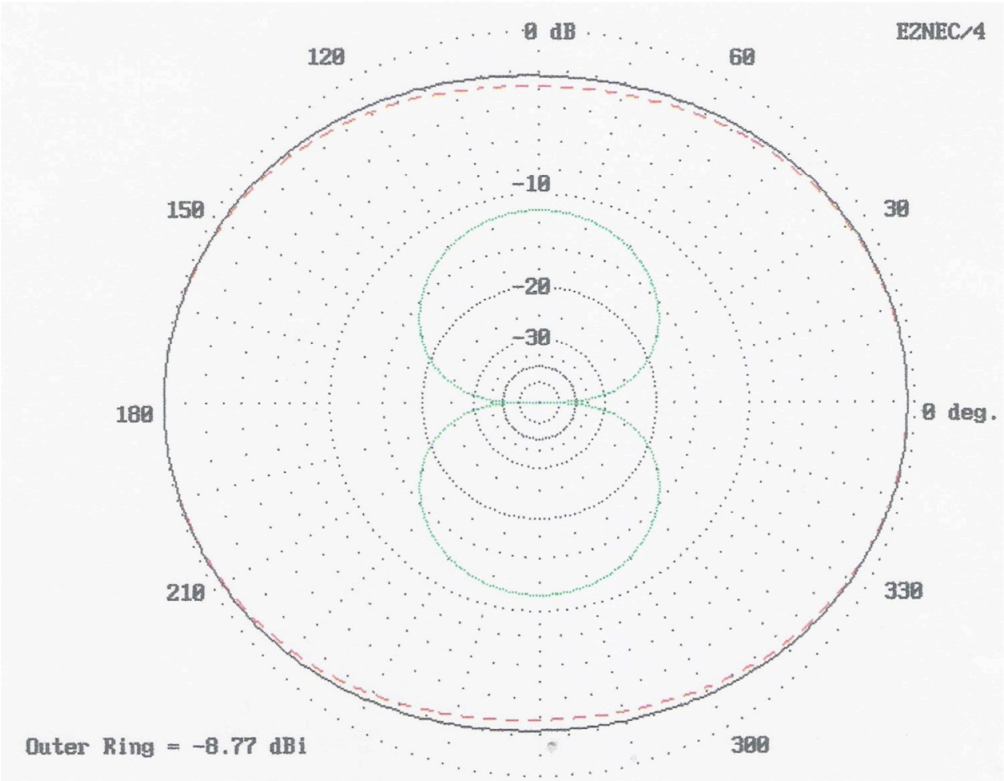


Two element antenna system, Configuration 2:

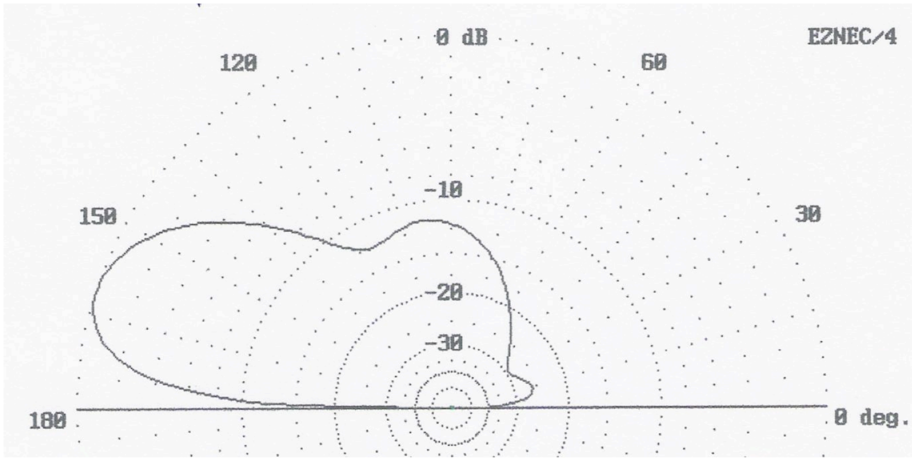
Field strength versus distance, in phase feeder currents are adjusted so that equal powers are fed to each element of the antenna system (total power 1 kW).

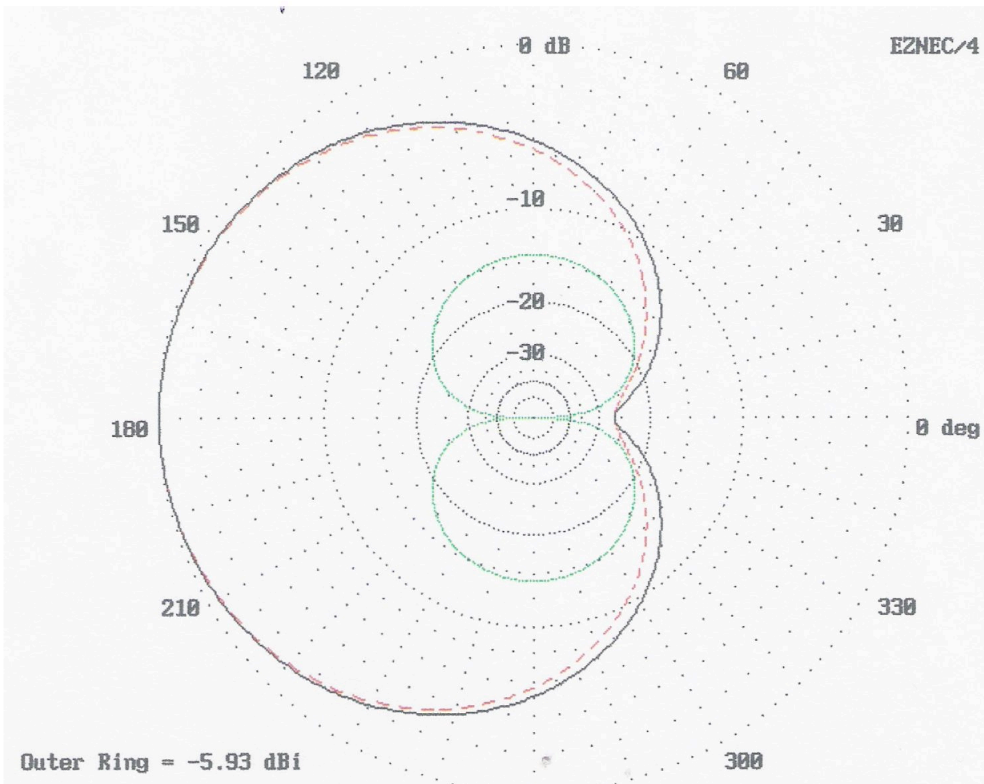


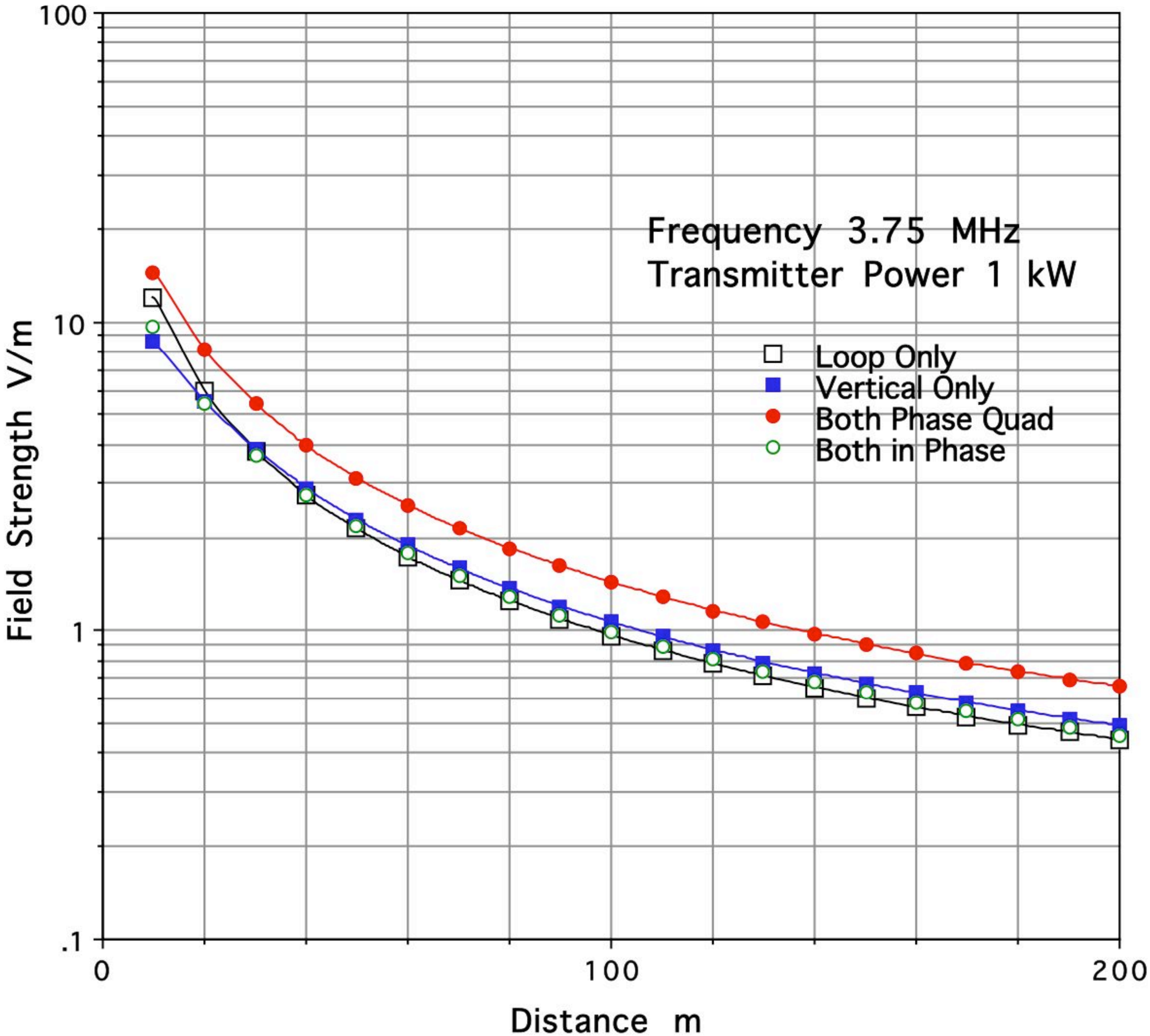
0 dB
EZNEC/4
120
60
-10
150
30
-20
-30
180
0 deg.



0 dB
EZNEC/4
120
60
-10
150
30
-20
-30
180
0 deg.
210
330
Outer Ring = -8.77 dBi
300


0 dB
EZNEC/4
120
60
-10
150
30
-20
-30
180
0 deg.


0 dB
EZNEC/4
120
60
-10
150
30
-20
-30
180
0 deg.
210
330
Outer Ring = -5.93 dBi
300



Frequency 3.75 MHz
Transmitter Power 1 kW
Loop Only
Vertical Only
Both Phase Quad
Both in Phase
Field Strength V/m
100
10
1
.1
0
100
200
Distance m

<u>Conclusions:</u> The E-M ESA antenna system numerically modeled is certainly model dependant, but we can clearly deduce some characteristic features of this two element antenna system.

1) When the dipole is along the loop axis, with the dipole center in the loop plane, the dipole has zero mutual impedance to the loop. The radiation fields are generated independently, and depend on the magnitude of the feeder currents independent of their phase difference. There is as expected no reduction in near field energy. And, in the far field region, there is no advantage in using this antenna system configuration for propagation paths over real ground, since the total field is dominantly vertically polarized, and the loop radiates a horizontally polarized signal.

2) When the loop and dipole are co-planar, dipole centered on the loop, the dipole and loop are closely coupled, and the radiation patterns depend on the magnitude and phase of the feeder currents. An interesting feature of this configuration is that a directional pattern can be realized if the feeder currents are in phase quadrature (a 3 dB increase in gain, 23 dB front/back ratio). A cardiodal shaped directional pattern for spaced vertically polarized antenna systems is well known, but the interesting feature here is that the antenna elements are not spaced, they are essentially co-located.

- **The End**