# Interference Cancellation Using Adaptive Beam Forming for 3 D Beam Steering

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***Abstract*** **— We have proposed design of ESPAR (Electronically Steerable Parasitic Array Radiator) antenna that is capable of electronic beam steering in order to avoid interference, null is placed in direction of interference source whereas maxima is placed in direction of desired signal source. Paper includes formulation of mathematical model, simulation and later designing of ESPAR antenna capable of dynamic tracking of active targets in 3D. Variable reactance set was loaded in array of elements surrounding center element. Reactance value for placement of maxima in specified direction in 3D axis is formulated using Quasi Newton Method. The radiation patterns can be controlled electronically by an external DC voltage with the use of a varactor diode loaded in each of the passive elements. The Electronically Steerable Passive Array Radiator (ESPAR) is an antenna that suits application in ad hoc computer networks. Wireless ad hoc networks are a solution comparable to wired systems in terms of quality and are relatively low cost. Gain of 8 dB is achieved in given direction of theta (θ) and phi (φ) firstly measured using simulations in HFSS, later simulated results were validated and antenna hardware was tested in anechoic chamber. Along with efficient beam forming designed antenna is a step forward towards green technology, operating at reduced powers without disrupting EIRP of antenna systems, thereby maintaining constant EIRP.**

***Keywords - ESPAR (Electronically Steerable Parasitic Array Radiator), HFSS (High frequency structure simulator), Parasitic, Directivity***

## I. INTRODUCTION

Signal to noise ratio (SNR) can be improved for Wireless local area network (WLAN) systems, Cellular networks, Radar systems by using electronically steerable directional antennas that are capable of 3D / 2D beam steering. Often phased array antennas are used for electronic beam steering they varies the directivity electronically but such antennas cannot be made compact because of limitation of minimum distance between elements. If the element spacing is decreased, element excitation cannot be controlled individually because the mutual coupling among elements becomes strong. In ESPAR systems phase shifters are not used instead mutual coupling is used it becomes feasible to have transmitter and receiver constructed in one system, its spread over conventional antenna is expected due to the compact size ,ultra light weight, low cost, and low power consumption. Moreover there is a single feed element instead of seven so losses for feed elements are also reduced. With the fast beam forming ability and its low-power consumption attribute, the ESPAR antenna makes the mass deployment of smart antenna technologies practical.

## II. DIAGRAMMATIC OVERVIEW

Conceptual diagrammatic overview of an ESPAR antenna is shown in fig.1 & fig. 2, here we have seven elements, elements number 1, 2, 3, 4, 5, 6 are parasitic elements whereas centre element is active and feed is applied on this element.

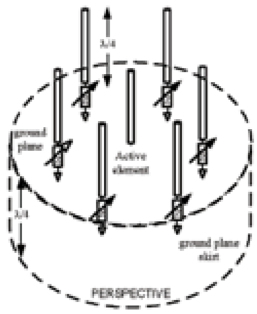


Figure1: Variable directionality achieved

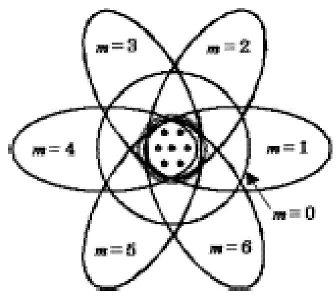


Figure 2: Omni directional pattern

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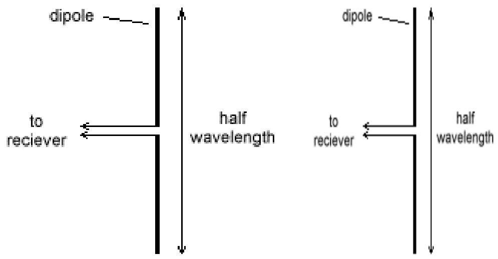
## III. MUTUAL COUPLING

Mutual coupling happen in high frequency structures when they are exposed to each other. The current on one structure is creating EM field and EM field induces current on another structure exposed to the field. There is transformation of EM energy from the first structure to the second structure. EM energy on the second is also coupled to the first one.

$$V_1 = Z_{11} * I_1 + Z_{12} * I_2 \qquad (1)$$

$$V_2 = Z_{21} * I_1 - Z_{22} * I_2$$




Antenna 1 Antenna 2

Figure 3: Antenna 1 & Antenna 2 placed side by side

Here if antenna 2 is short and current *Io* is flowing in antenna 1 we can find current *I2* in antenna 2

$$I_2 = Z_{21} / Z_{22} * I_o \qquad (2)$$

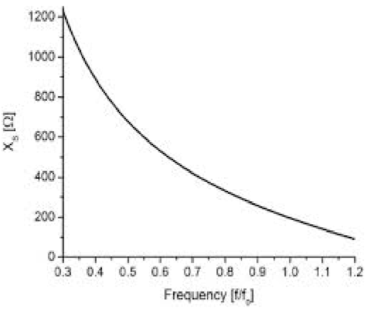



Figure 4: Distance vs. Reactance graph

Where $Z_{22}$ is constant values and $Z_{21}$ is calculated using distance Vs reactance graph in Figure 4.By controlling phase of $I_2$ beam can be steered in any desired direction [5].

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## IV. ANTENNA STRUCTURE

Seven monopole elements are place over aluminum ground plane, length of each monopole is lambda/4 and diameter of ground plane is lambda/2. Passive elements are loaded with varactor diodes through SMA connectors. Centre element is also excited through SMA connector and feed is applied only to the centre element. Fig. 5 shows the designed ESPAR antenna model.

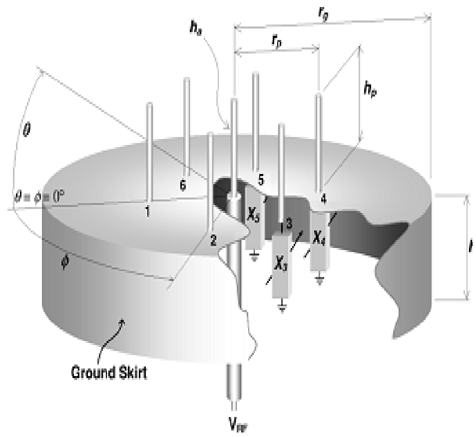


Figure 5 Seven Element Antenna

Loading of the parasitic elements is show in fig.6 each element is loaded with varactor diode and right angle male SMA adapter is used for loading.

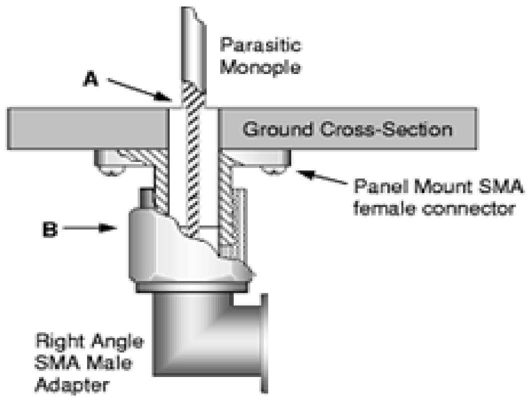


Figure 6: Loading of parasitic elements

## V. HFSS MODEL

Model simulated in HFSS Figure 7, Model was simulated in HFSS version 12.Antenna design parameters are given in table 1.

TABLE I: ANTENNA DESIGN PARAMETERS

| Parameter | Length |
|---|---|
| Freq | 2.45 GHz |
| Lambda | 122.449 mm |
| Monopole length | 30.6 mm |
| Ground plane radius | 61.224 mm |
| Ground plane length | 30.6 mm |
| Ground plane thickness | 5 mm |
| Monopole thickness | 4 mm |

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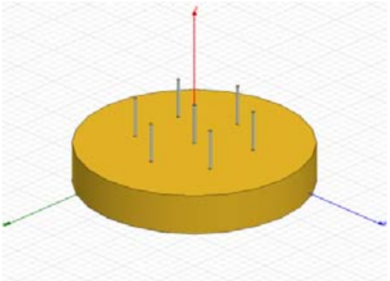

Figure 7: HFSS Simulation

3 D polar plots for three different set of reactances are shown in following figures showing steering of beam Figure (8, 9 and 10)

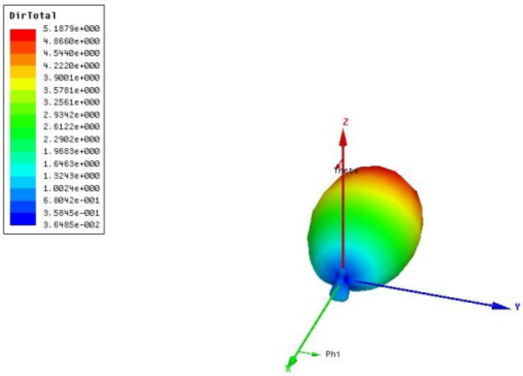


Figure 8: Polar Diagram

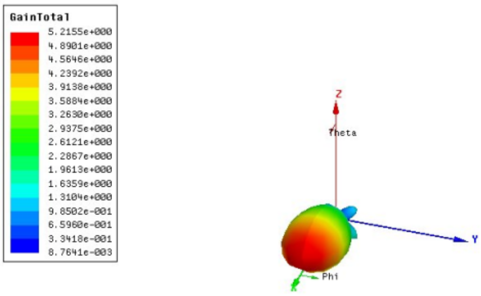


Figure 9: Polar Diagram

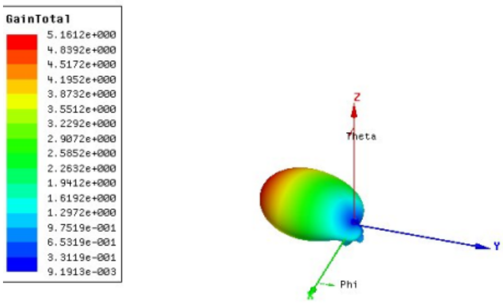


Figure 10: Polar Diagram

## VI. PROTOTYPE MODEL

Figure 12: Designed Antenna

## VII. ANECHOIC CHAMBER RESULTS

Designed antenna system performance was measured is Anechoic Chamber and actual results were hundred percent compliant with simulation. 8 dB gain was achieved for θ=90 and φ=30

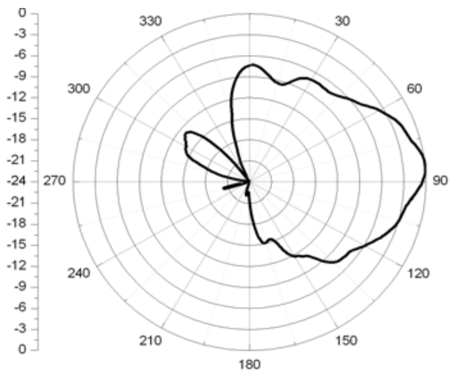


Figure 13: Elevation Plot θ=90

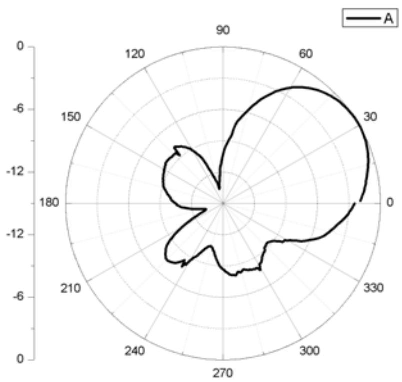


Figure 14: Azimuth Plot φ=30

## VIII. CONCLUSIONS

We proposed, simulated and designed a prototype for an electronically steerable parasitic array radiator (ESPAR)

Antenna Radius of this configuration is lambda/2 working at the frequency of 2.45 GHZ. Beam steering was achieved by varying the reactance values computed using a mathematical model. Antenna simulation results obtained are compliant with the mathematical model showing beam steering for different values of reactances.

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