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Comparative Analysis of Microstrip Phased Array Antenna Design

Prabhakaran. M
PG Scholar
K.S.R College of Engineering, Tiruchengode, India

Veeramani. R
Assistant Professor/Department of ECE
K.S.R College of Engineering, Tiruchengode, India

***Abstract*— This paper compares a micostrip phased array antenna using mutual coupling, reactive loading and Microstrip phased array antenna by changing length of the feed line. In reactance loading method the tunable progressive phase shift is achieved by varying the reactance loading. Parallel combination of capacitor and inductor is used as the reactive loading. The antenna is designed to operate at centre frequency 2.4GHz. In transmission line method the phase shift is achieved by changing length of the transmission line. The array antenna is designed using standard equation and simulated by software called, Ansoft High Frequency Structure Simulator (HFSS). Finally both the method will be compared in terms of reflection coefficient, radiation characteristics and phase angle.**

Index terms -MANETs, Malicious, Mobility,false positive, Detection efficiency, Delay Constraint.

I. INTRODUCTION

Antennas play a crucial role in wireless communication systems. Microstrip patch antennas are widely used because of it has the advantages such as low profile, light weight, simple and inexpensive to manufacture using modern printed circuit technology, compatible with MMIC designs. However single microstrip element produces a low gain, less efficiency and lesser directivity. This can be overcome by array antenna. The array antenna contains more than one microstrip patch elements; it improves gain, efficiency and directivity.

Some wireless applications require change in the direction of the radiation pattern. This can be achieved by phased array antenna. Phased array is an array of antennas in which the relative phases of the respective signals feeding the antennas are varied in such a way that the effective radiation pattern of the array is reinforced in a desired direction and suppressed in undesired directions.

Phased array concept is achieved by different methods [9]. The methods are

- Beam steering using phase shifters
- Phase shifting by changing frequency
- Phase shifting by changing length of feed line
- Phase shifting by changing permittivity (dielectric constant)
- Phase shifting by changing permeability
- Beam steering using mutual coupling and reactance loading

In this paper phase shift is achieved by changing length of feed line [8] and beam steering using mutual coupling and reactance loading methods [1] are compared in terms of radiation pattern, phase angle.

The phased array antennas beam steering capability is provided by phase shifter [6]. Phase shifter is classified into analog and digital. However, one main disadvantage associated with the phase shifter is cost. The cost of phase shifter is half of the entire array system. So researchers developed phase shifters using solid state devices, Micro Electro Mechanical Systems (MEMS) and ferrite materials. But the cost of the phase shifter is still too high using these techniques.

Electronically Steerable Passive Array Radiator (ESPAR) is able to achieve beam steering without need of phase shifters. It is based on the mutual coupling and reactance loading [1-5]. This paper proposes a parallel combination of capacitor and inductor for the reactance loading.

II. THEORY AND DESIGN

A. Microstrip Phased Array Antenna using Mutual Coupling and Reactance Loading:

In this paper Microstrip phased array antenna is designed using mutual coupling and reactance loading. The geometry of the phased array antenna is shown in figure.1. The antennas are designed on a Rogers RT/Duroid 5880 (tm) substrate ($\epsilon_r = 2.2$). The antenna is designed to operate at 2.4GHz. The dimensions of the patch antennas are calculated from [11]. The RF power is given via coaxial probe feeding for centre element. The main advantage of this type of feeding is low spurious radiation.

The center element (driven antenna) is fed by an RF source and nearby patch antennas (passive antenna) are excited by center element through the mutual coupling. The dimensions and dielectric constant of the passive antenna are same as the driven antenna. The phase shift is achieved by changing reactance loading of passive antennas. Here parallel combination of capacitor and inductor is used for the reactance loading. The array antenna is simulated using Ansoft HFSS.

The scan coverage angle of the phased array antenna is ±50° is achieved in simulation. In this way the beam steering is achieved in a desired direction. This type of reactance loading greatly reduced side lobes. The dimensions of the patch antennas are given in Table1.

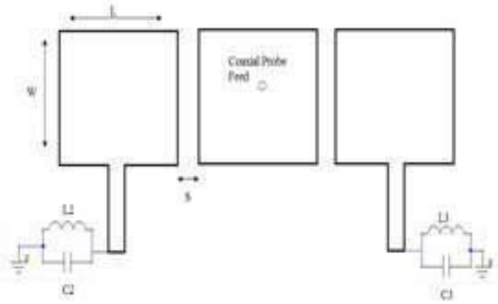

Figure1. Geometry of a Phased Array Antenna

Table 1- Dimensions of the Patch antenna

Length of the patch (L)	3 cm
Width of the patch (W)	4 cm
Operating Frequency (f_r)	2.4 GHz
Dielectric constant (ϵ_r)	2.2
Gap between two elements (S)	0.5cm

B. Microstrip Phased Array Antenna by Changing Length of the Feed Line:

In this method the analog beam steering capability is achieved by changing physical length of the feed line. The radiating element in the Microstrip antenna is designed to operate at center frequency 2.7GHz. Length and width of the patch antennas are calculated using [11]. Figure 2 shows the two element Microstrip phased array antenna.

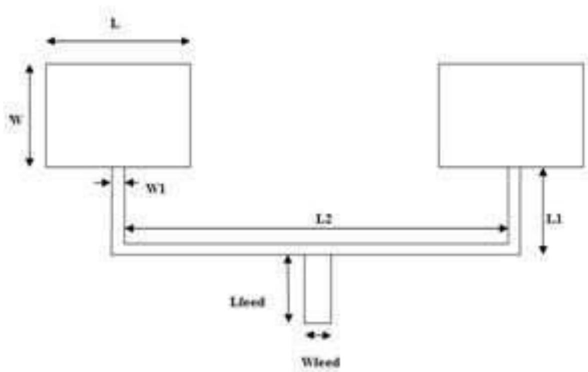

Figure2. Two Element Microstrip Phased Array Antenna

Here analog beam steering is achieved by shifting the feed line towards right or left. The dimensions of the antennas are shown in table 2.

The two element Microstrip phased array antenna is extended to four elements. Figure 3 shows the four element Microstrip phased array antenna design. Phase shift is achieved by shifting the feed line towards right or left.

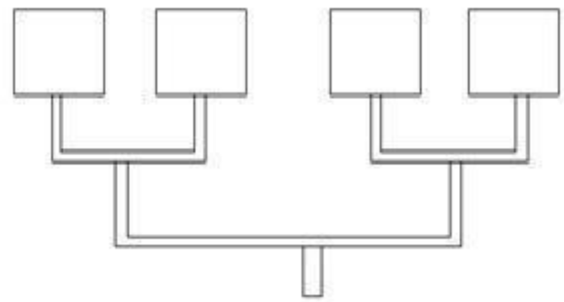

Figure 3. Four Element Microstrip Phased Array Antenna

Table2. Dimensions of the Phased Array Antenna

S.No	Antenna Parameters	Dimensions in mm
1	W	33.81
2	L	26.105
3	W1	3.06
6	Lfeed	14.77
7	Wfeed	3.06

III. Simulation Results and Discussion

The phased array antennas are simulated using electromagnetic solver Ansoft High Frequncy Structure Simulator (HFSS) and the results are discussed in this section. Figure 4 shows the Microstrip phased array antenna using mutual coupling and reactance loading method HFSS model. Return loss and radiation patterns are shown in figure 5 and 6 respectively.

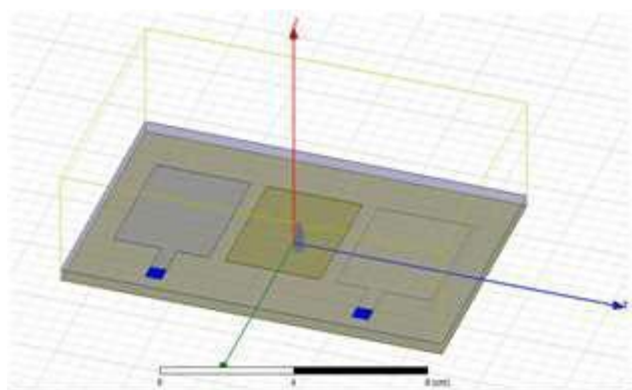

Figure 4. Microstrip Phased Array Antenna using Mutual Coupling and Reactance Loading-HFSS Model

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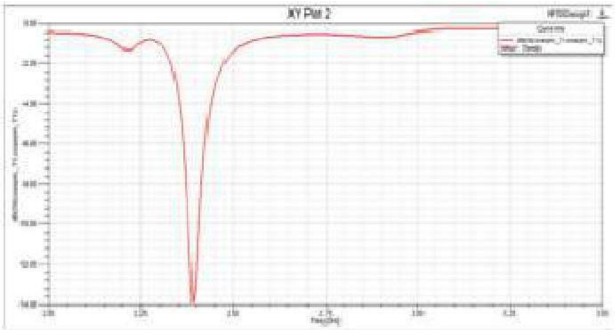


Figure 5. Return loss

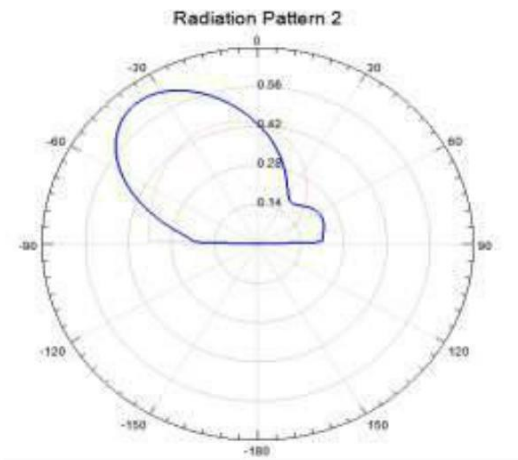


Figure 6a. Radiation Pattern (L2=100nH, C2=0.01pF, L3=100nH, C3=1pF)

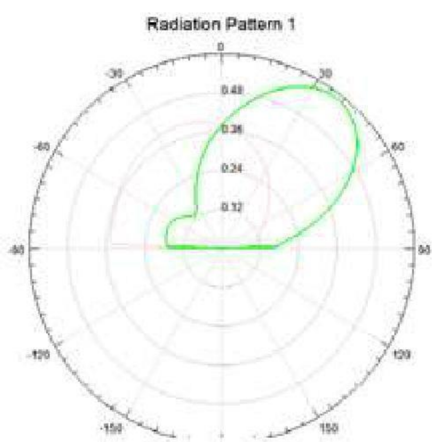


Fig 6b. Radiation Pattern (L2=100nH, C2=1pF, L3=100nH, C3=0.01pF)

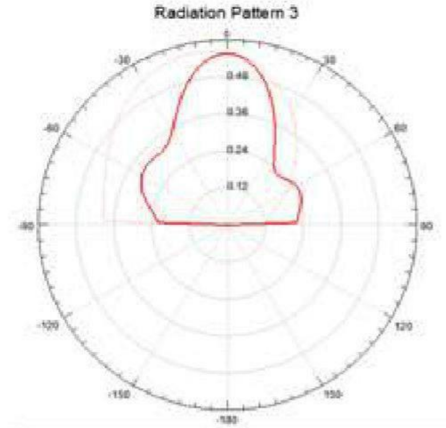


Figure 6c. Radiation Pattern (L2=100nH, C2=0.01pF, L3=100nH, C3=0.01pF)

Table 3 gives the simulated scan angle for the different capacitor and inductor values.

Table.3 Simulated Results for Different Loading

S.NO	C2(pF)	C3(pF)	L2(nH)	L3(nH)	Scan Angle (deg)
1	0.01	1	100	100	-50 to -20
2	0.01	0.01	100	100	-20 to +20
3	1	0.01	100	100	+20 to +50

Figure 7 shows the two element Microstrip phased array antenna by changing length of the feedline HFSS model. The corresponding return loss and radiation patterns are shown in Figure 8 and 9.

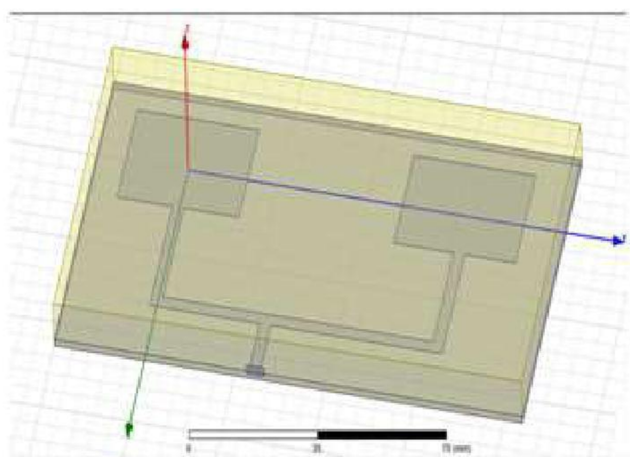


Figure7 . Two Element Microstrip Phased Array Antenna-HFSS model

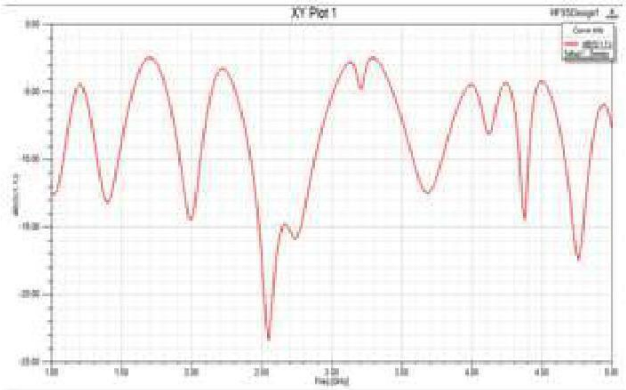


Figure8. Return Loss

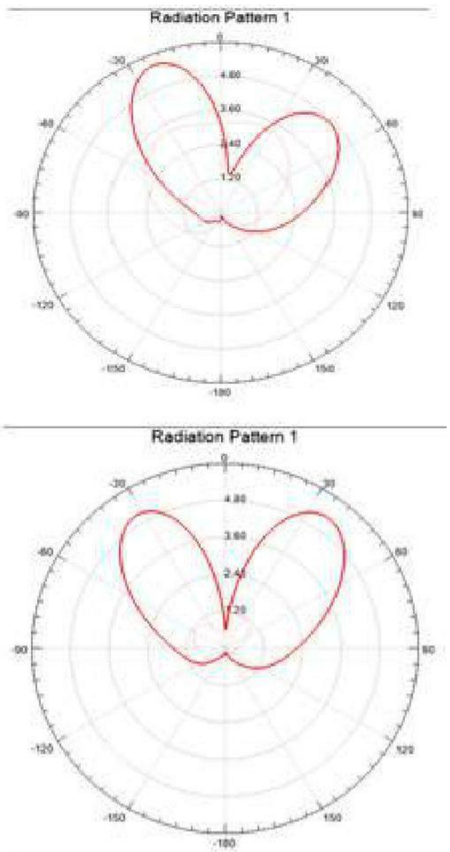


Figure 9. Radiation Pattern- Two Element

Figure 10 shows the four element Microstrip phased array antenna by changing length of the feedline HFSS model. The corresponding return loss and radiation patterns are shown in Figure 11 and 12.

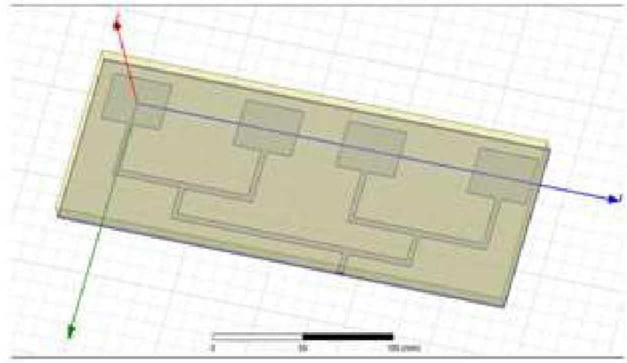


Figure 9. Four Element Microstrip Phased Array Antenna-HFSS model

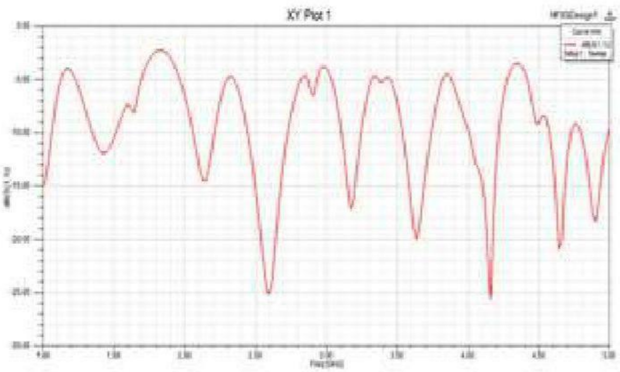
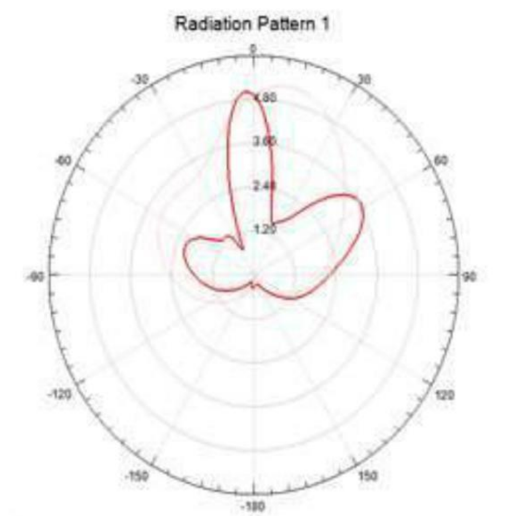


Figure 10. Return Loss



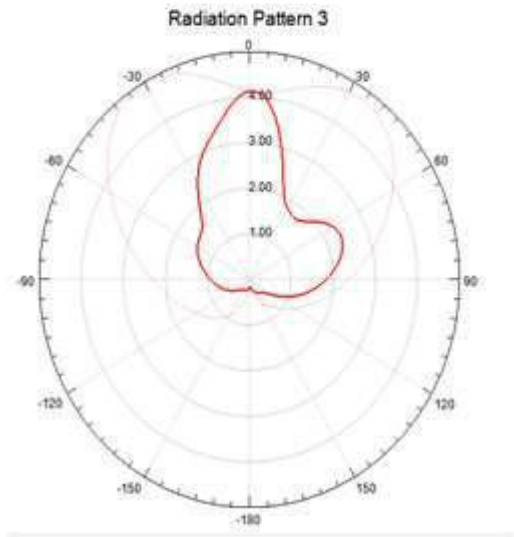


Figure 11. Radiation Pattern- Four Element

The results comparison for the phased array antenna by changing length of feed line is given in Table4.

From the above results phased array antenna using mutual coupling and reactance loading method covers the more angles (+50° to -50°) compared to phase shift by changing length of the feed line method.

Table 4. Phased Array Antenna by Changing Length of the feed line- Results

S.NO	METHOD	FREQUENCY(GHZ)	PHASE ANGLE (DEG)
1	TWO ELEMENT	2.7	+25 & -25
2	FOUR ELEMENT	2.7	+ 5 & -5

IV CONCLUSION

In this paper two methods for achieving Microstrip phased array antennas are compared. Reactance loading method is designed to operate at 2.4GHz. The phase angle achieved in this method is +50° to -50°. Beam steering by changing length of the feed line method is designed at 2.7GHz. The coverage angle of this antenna is less compared to reactance loading method. The array antennas will be fabricated using Eleven lab and the results will be obtain using Network Analyzer.

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