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Comparative Study of Microstrip Patch Antenna for Wireless Communication Application

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***Abstract* — This paper describes variety of feeding technique applicable to microstrip patch antenna which is one of the important aspects. A good impedance matching condition between the line and patch without any additional matching elements depends heavily on feeding techniques used. After describing various feeding techniques, the paper gives a better understanding of the design parameters of an antenna and their effect on bandwidth and gain. Finally, simulation is done using design software IE3D. The Coaxial Probe Feed Microstrip antenna provides a bandwidth of around 20%. For aperture coupled antenna the simulated results of IE3D agrees well with the results generated by ANN (Artificial Neural Network model).**

***Index Terms* – Microstrip Patch Antennas, Gain, Bandwidth, IE3D, Feeding Techniques, Artificial Neural Network.**

I. Introduction

Microstrip patch antennas have various advantages such as low profile, light weight, easy fabrication and conformability to mounting hosts in addition size reduction and bandwidth enhancement are major design considerations for practical applications of microstrip antennas. Numbers of numerical methods have been developed by various researchers to ease computational efforts when designing microstrip patch antennas [1] which includes MoM based method. MoM involves the use of the Sommerfeld-type integrals to solve the dielectric slab Green's function. A comparison between various feeding techniques has been done. Finally, a microstrip patch antenna at specific frequency i.e. 1.25 GHz has been designed and, simulated on the design software IE3D for a better understanding of the design parameters of an antenna and their effect on the bandwidth and gain patterns. Input data have been generated from IE3D simulation software for the ANN model.

Input data consists of variation of the antenna reflection coefficient S(1, 1) and antenna impedance Z (1, 1) with various antenna parameters such as length and width of the patch, height of dielectric, patch offsets in X and Y direction, probe radius, slot length, stub length, probe centre, patch centre etc for S-band aperture coupled microstrip antenna and an L-band capacitively coupled microstrip antenna. The data set was used to train and validate the ANN model.

II. Types of Feed

A. Coaxial Probe Feed

In figure 1 a coaxial inner conductor extends through the ground plane and is connected to the patch conductor of size 19 mm X 19 mm at height 0.79 mm. The probe of radius 0.3 mm provides the impedance control in a similar manner to inserting the feed for an edge-fed patch. Probe feed mechanism is in direct contact with the antenna and most of the feed network is isolated from the patch which provides an efficient feeding and minimizes spurious radiation [3]. However it is more complicated to manufacture. Probe-fed patches have small bandwidth and are difficult to accurately analyze. The probe used to couple power to the patch can generate somewhat high cross-polarized fields if electrically thick substrates are used [1]. Measured two dimensional radiation patterns are shown in Fig 3 with ϵ_r=2.2 and loss tangent is 0.0009 while numerical results are listed in Table 1.

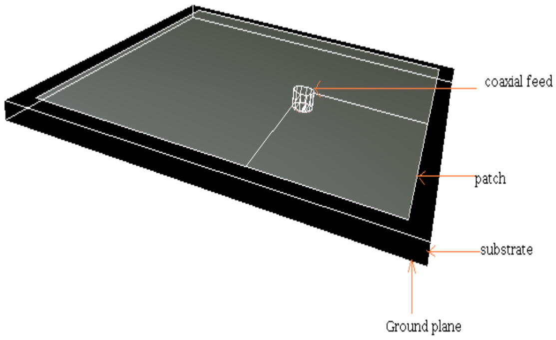


Fig. 1. Co-Axial feed patch antenna

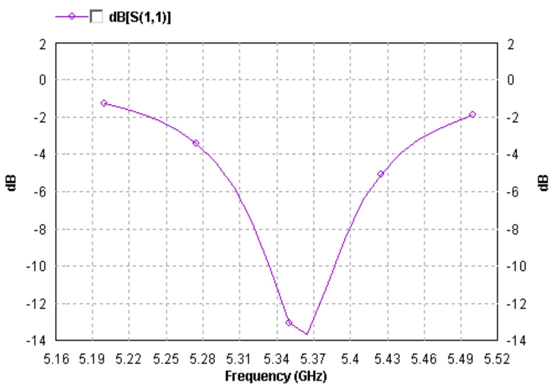


Fig. 2. Return loss S (1, 1) of curve.

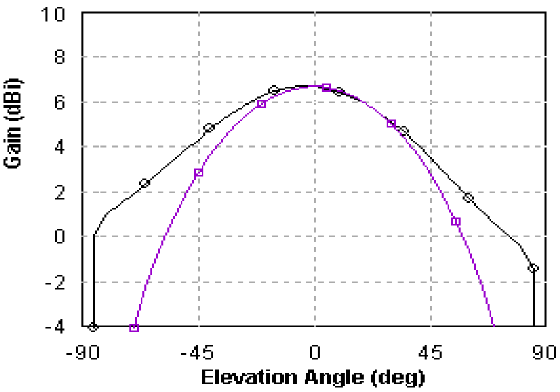


Fig. 3. Two dimensional Radiation Pattern.

TABLE.1

Frequency (GHz)	Gain (dB)	Return Loss (dB)	Bandwidth (MHz)
5.35	6.8	-14	51

B. *Aperture Coupled Feed*

In basic aperture coupled patch antenna the radiating microstrip patch element is etched on the top of the antenna substrate, and the microstrip feed line is etched on the bottom of the feed substrate. The thickness and dielectric constants of these two substrates may thus be chosen independently to optimize the distinct electrical functions of radiation and circuitry. Although the original prototype antenna used a circular coupling aperture, it was quickly realized that the use of a rectangular slot would improve the coupling, for a given aperture area, due to its increased magnetic polarizability [6]. The aperture coupled microstrip antenna involves over a dozen material and dimensional parameters, and we summarize the basic trends with variation of these parameters below: antenna substrate dielectric constant, antenna substrate thickness, microstrip patch length, microstrip patch width, feed substrate dielectric constant, feed substrate thickness, slot length, slot width, feed line width, feed line position relative to slot, position of the patch relative to the slot [7].

In such technique, the ground plane separates the radiating patch and the microstrip feed line. Coupling between the patch and the feed line is made through a slot or an aperture (usually centered under the patch) in the ground plane hence spurious radiation is minimized [4]. The geometry of aperture coupled antenna is shown in Fig. 4 with S11 in Fig 5 and radiation pattern in Fig 6. Here in this slot dimensions are 0.11mm X 0.9 mm and stub length is 1.7 mm.

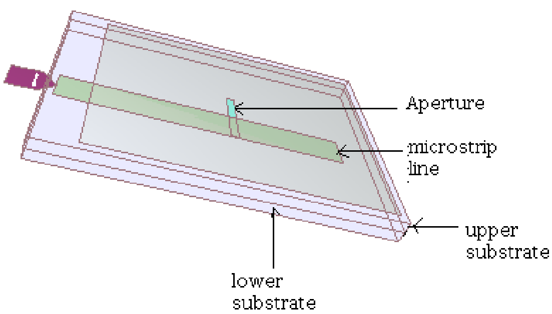


Fig. 4. Aperture coupled feed Microstrip antenna

Frequency (GHz)	Gain (dB)	Return Loss (dB)	Band Width (%)
2.25	6	-14	5

TABLE.2

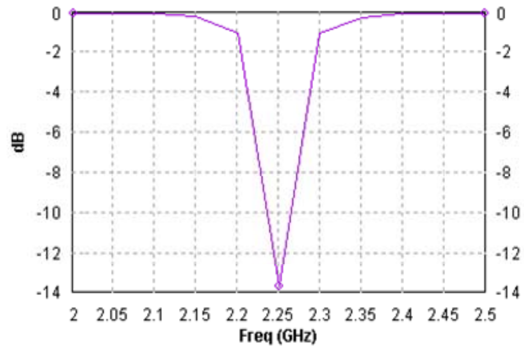


Fig. 5. Return loss S (1,1) versus Frequency Curve.

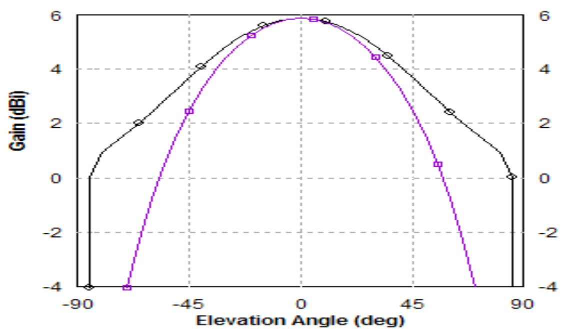


Fig. 6. Two dimensional Radiation Pattern

B. *L- band Capacitively Coupled Feed*

Geometry of L-Band Capacitively coupled microstrip antenna is shown in figure 8. In contrast to the direct contact methods, which are predominantly inductive, the capacitively-coupled patch antenna coupling mechanism is capacitive in nature. The difference in coupling significantly affects the obtainable impedance bandwidth, thus bandwidth of a capacitively-coupled feeding is inherently greater than the direct contact feed patches. In capacitively coupled upper patch and lower patch dimension is 99mm X 99mm and 22mm X 22mm, Upper patch height 2.6 mm, lower patch height is 2.2 mm and the centre at lower patch where the probe feed of radius 0.2 mm is located is 2.5mm and feed centre 2.1 mm. Also return loss and Radiation patterns are shown in fig 7 and 9 with numerical results listed in table 3.

Frequency (GHz)	Gain(dB)	Return Loss (dB)	Bandwidth (MHz)
1.25	8	-42	246

TABLE 3.

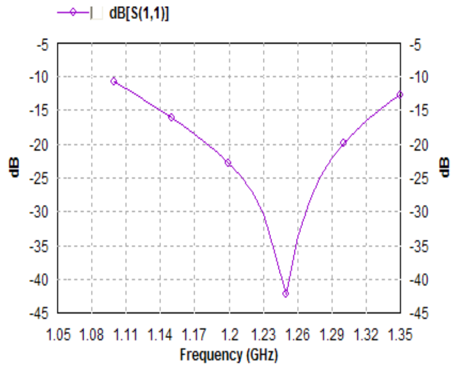


Fig. 7 Return Loss S(1,1) versus Frequency curve.

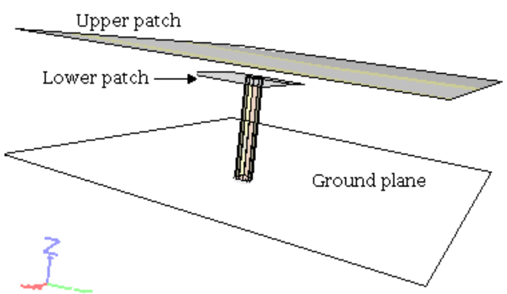


Fig 8. L-Band Capacitively Coupled Microstrip Antenna

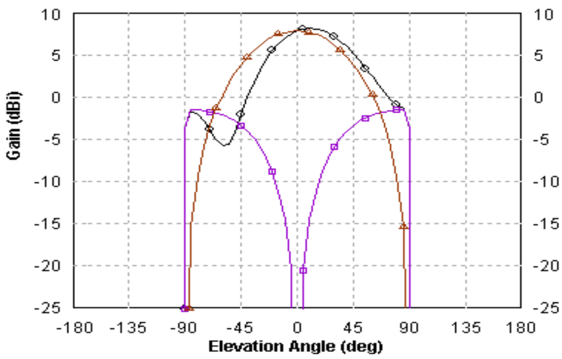


Fig. 9. Two dimensional Radiation Pattern at 1.25 Ghz

III. Comparative Study

We have studied that capacitively coupled antenna have more bandwidth as compared to aperture coupled antenna at a specific frequency of 1.25 GHz and have more gain as shown in table 4.

TABLE 4

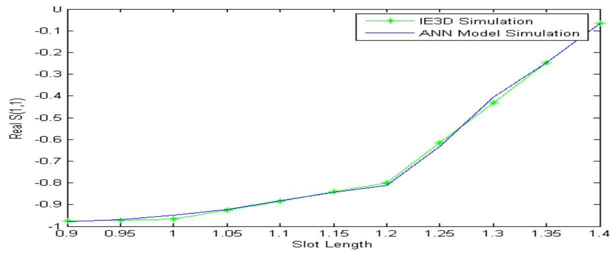
Configuration	Frequency (GHz)	Gain (dB)	Bandwidth (%)
Aperture coupled Antenna	1.25	9	12
Capacitively coupled Antenna	1.25	9.5	20

IV. Parametric Study of Aperture Coupled Antenna

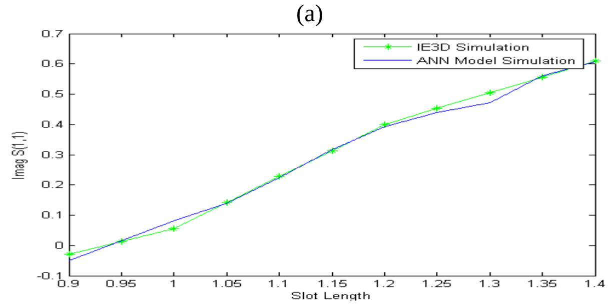
In this section we will discuss the various parameters on the response of Aperture coupled microstrip antenna. The antenna structure is analyzed using MOM based electromagnetic simulator IE3D and ANN based model with various input parameters shown in table 5.

TABLE 5

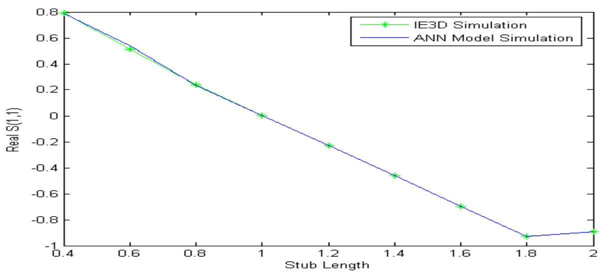
Frequency (GHz)	Slot length (cm)	Stub length (cm)	Real S(1,1)	Imaginary S(1,1)	Z (dB)
2.25	0.9	2	-0.5813	5.73e04	-4.71
2.25	1	2	-0.3677	0.1689	-7.86
2.25	1.2	2	-0.4057	-0.4379	-4.48
2.25	1.12	0.4	0.7977	0.4863	-7.95
2.25	1.12	0.8	0.4765	0.6675	-1.93
2.25	1.12	1.8	-0.1791	-0.4836	5.10



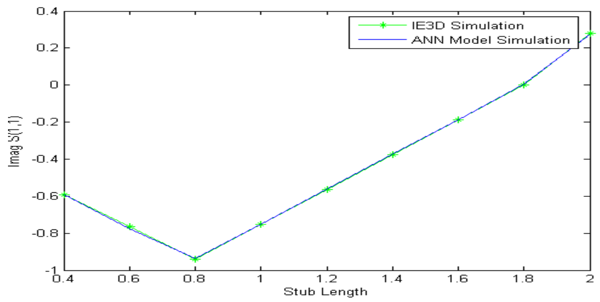
(a)



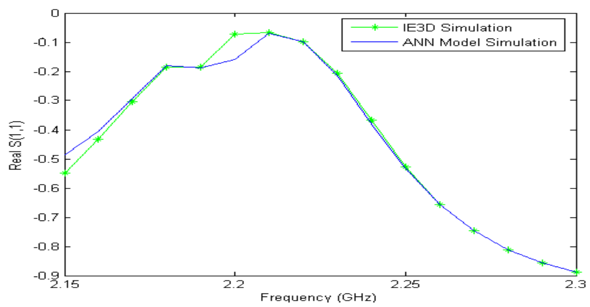
(b)



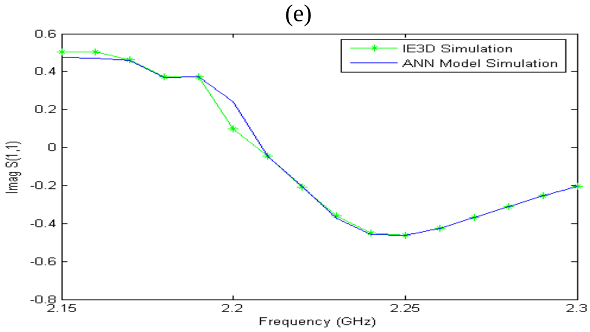
(c)



(d)



(e)



(f)

Fig. 12. (a) Real S(1,1) Versus Slot length (b) Imaginary S(1,1) Versus Slot length (c) Real S(1,1) Versus Stub length (d) Imaginary S(1,1) Versus Stub length (e) Real S(1,1) Versus Frequency (f) Imaginary S(1,1) Versus Frequency.

V. Conclusion

A method of comparative simulation between IE3D analysis and ANN is proposed. From the comparative study of different configurations of feeding techniques it is concluded that capacitively coupled microstrip antenna provides a bandwidth of around 20%. Comparison and simulated results are also compared with fabricated hardware's measurement. All three designs of feeding technique achieved the best return losses at the desired frequency region, which is 1.25 GHz. In parametric study of Aperture Coupled Antenna and L-Band Capacitively coupled Microstrip Antenna it is concluded that results generated using Artificial Neural Network(ANN) were in good approximation with that of IE3D simulation results.

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