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Comparative Study of Feeding Mechanism Used in Micro-strip Patch Antenna System

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Abstract: In this paper, a comparative study of micro-strip patch antenna feeding method has been performed. Two different excitation methods, namely edge feed strip line and inset feed strip line has been used to excite the antenna. Antenna prototypes have been designed and simulated to perform the desired project. Different characteristics of antenna such as returnloss, VSWR, gain has been obtained, to get the response of radiating structure. Obtained characteristics of “Antenna 1”, which is an inset feed system shows return loss of -17.90 dB, -45.09 dB and -22.10 dB at matching frequency of 2.09 GHz, 3.54 GHz and 4.01GHz. “Antenna 2”, has return loss of -17.90 dB at centre frequency of 2.06 GHz. “Antenna 2” is edge strip line feed system. Gain of “Antenna1” and “Antenna2” is found to be 4.74 and 4.54 dBi respectively.

Index Terms: Microstrip patch antenna, edge feed strip line, inset feed strip line, Return loss, center frequency, gain

I. INTRODUCTION

Modern wireless communication should be capable of performing and handling different operations on its own. To fulfill the demands of users in terms of bandwidth, for transmission of video and voice information simultaneously, poses a big challenge for antenna designers. It leads to configure and design such a system that should be capable to handle every demand of users. For good and efficient communication system, antenna plays a major role. It is used for wirelessly transfer and reception of messages.

A low cost and easy to fabricate micro-strip patch antenna design configuration has been presented. Micro-strip patch antenna is a simple and low profile antenna. Manufacturing of such antennas can be done at a very low cost using modern printed circuit technology, hence making it inexpensive. Micro-strip antennas are very versatile in terms of resonant frequency, polarisation pattern and impedance. All this depends on the selection of patch shape and mode. In order to create variations in resonant frequency, impedance and polarisation pattern loads are added in between the patch and the ground plane[1-3]. The various feed types are Inset Feed, Coaxial Cable or Probe Feed, Coupled feeds, Quarter wave transmission and Aperture feeds [4]. Here we studied about the inset feed and coaxial probe fed excitation methods. The inset feed mechanism integrates both patch antenna as well as micro-strip feed on a single substrate whereas edge feed mechanism micro-strip antennas are fed via a probe and the feed line used is a coaxial cable. The major design problem related to using microstrip patch is the narrow band width limiting the use of conventional patch as broadband antennas. The conventional methods for broadening impedance bandwidth can be obtained by modifying the shapes of the radiation element [5] and also by focusing on feeding structure [6]

II. ANTENNA DESIGN

A rectangular micro-strip patch is embedded on a grounded substrate. The dimensions of patch and substrate are $L_p \times W_p$ and $L_s \times W_s \times H_s$ respectively. Figure 1(a) and 1(b) presents 3D view of “Antenna1” and “Antenna2”, which has been excited using edge strip line method and inset feed method respectively. In “Antenna 1”, feed line has dimension of $L_f \times W_f$ and spacing between the feed line and patch is S_f . Feed inset from edge of patch is of length, S_i . In “Antenna 2”, width of feed line in edge strip line method has been increased to 3 times that of feed line near the edge. Design specification used in HFSS has been presented in Table I.

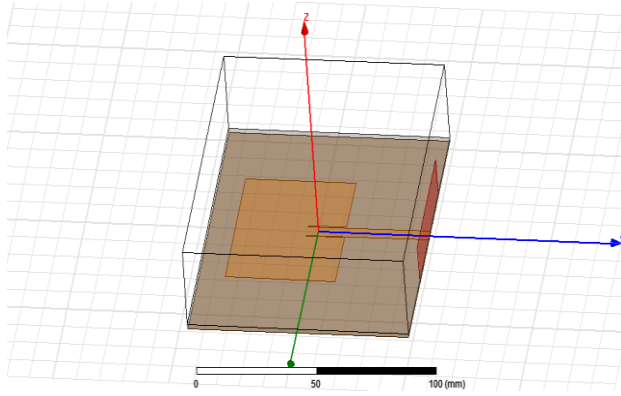


Fig1 (a) 3D view of Inset feed micro-strip patch antenna “Antenna1”

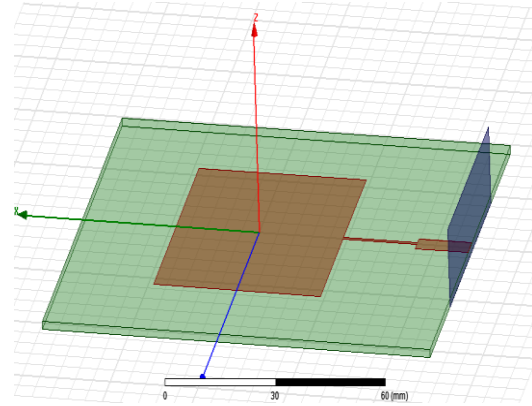


Fig1 (b) 3D view of Edge feed micro-strip patch antenna “Antenna2”

Table I. Design Specification used in HFSS

S. No.	Antenna Specifications	Value (in mm)
1.	Patch Length, L_1	47.37
2.	Patch Width, W_1	56.43
3.	Feed Line Width, W_f	4.853
4.	Feed Line Length, L_f	52.18
5.	Feed Inset from edge, S_i	16.44
6.	Spacing Between Feed, S_g	0.5117
7.	Width of Substrate, W_s	112.9
8.	Length of Substrate, L_s	94.74
9.	Height of Substrate, H_s	1.575

Different equations have been used to calculate the frequency of operations. These equations are implemented and simulated to obtain the required specifications. F1 has been found by using conventional equations of the microstrip patch antenna systems. These equations are as follows:

$$W = \frac{c}{2f_0} \sqrt{\frac{2}{\epsilon_r + 1}} \quad (1)$$

$$L = \frac{c}{2f_0 \sqrt{\epsilon_{eff}}} - 2\Delta L \quad (2)$$

$$L_{eff} = L + 2\Delta L \quad (3)$$

$$\Delta L = 0.412 h \left[\frac{(\epsilon_{eff} + 0.3) \left(\frac{W}{h} + 0.264 \right)}{(\epsilon_{eff} - 0.258) \left(\frac{W}{h} + 0.813 \right)} \right] \quad (4)$$

$$\epsilon_{eff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left(1 + 12 \frac{h}{W} \right)^{-\frac{1}{2}} \quad (5)$$

In these equations, f_0 , is central resonant frequency, c is speed of light and h is substrate thickness.

III. SIMULATIONS

This section presents the simulation results of proposed microstrip patch antenna. System has been designed and simulated on the High Frequency Structure Simulation (HFSSv13) software.

3.1 Simulation Results of “Antenna 1”

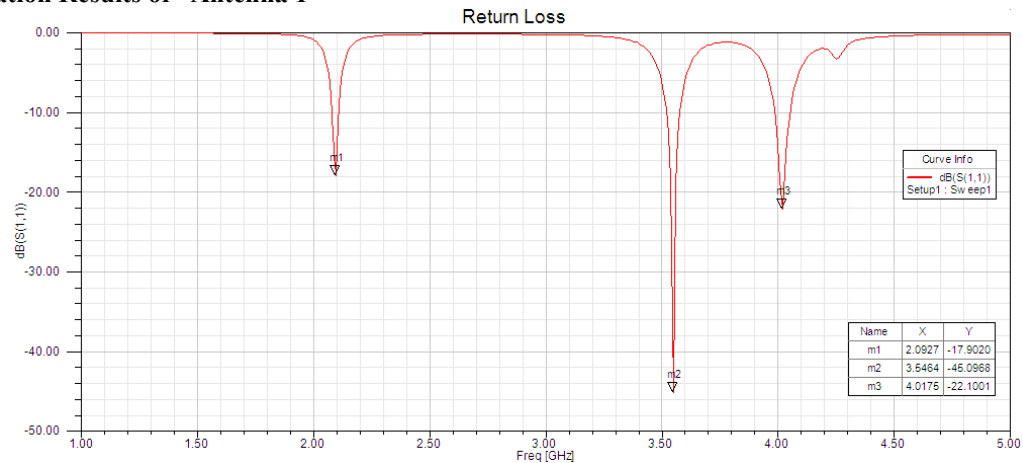


Fig 3(a) S parameter Vs frequency plot of Antenna 1

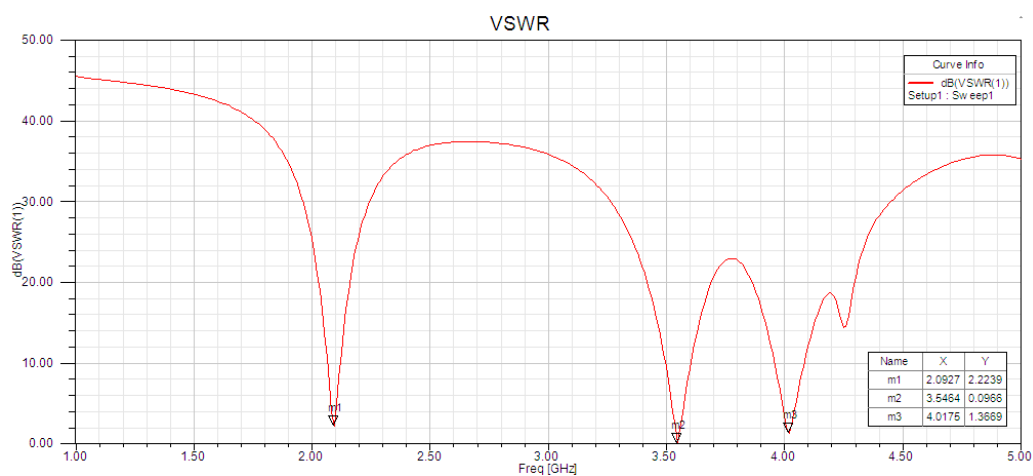


Fig 3(b) VSWR curve of Antenna 1

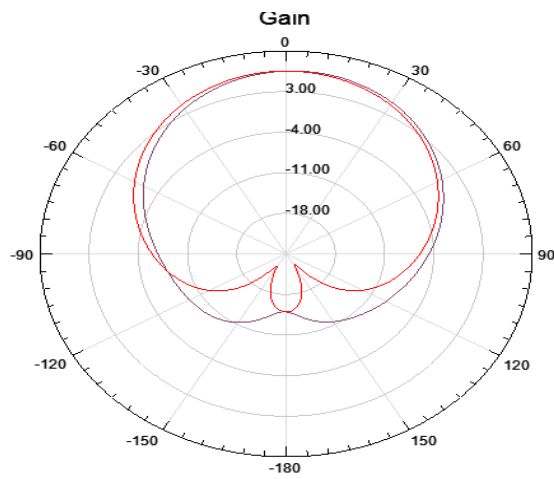


Fig 3(c) Gain of Antenna 1 in terms of Radiation Pattern

3.2 Simulation Results of “Antenna 2”

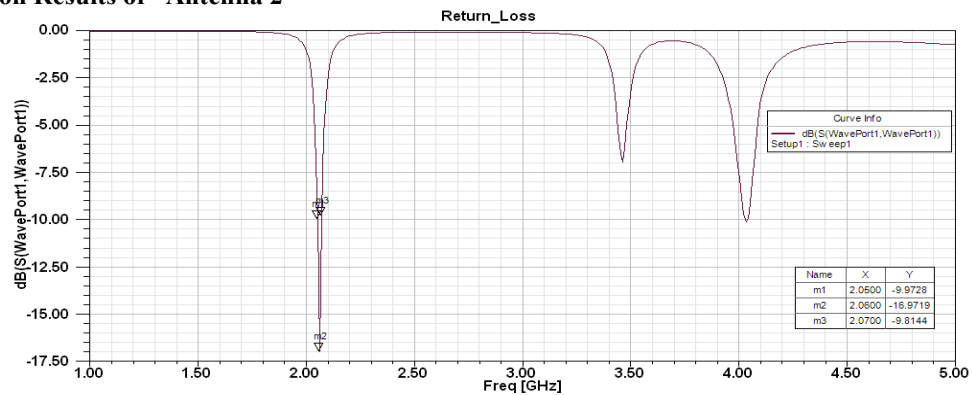


Fig 4(a) S parameter Vs frequency plot of Antenna 2

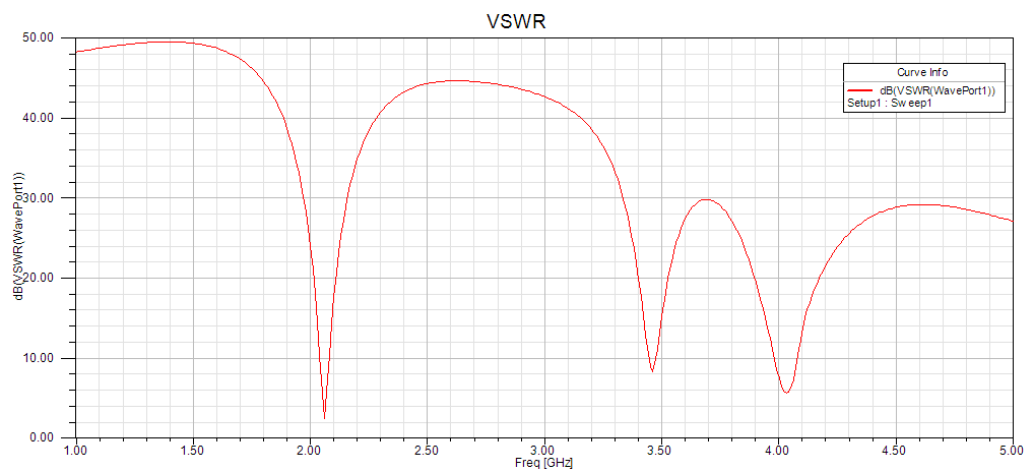


Fig 4(b) VSWR curve of Antenna 2

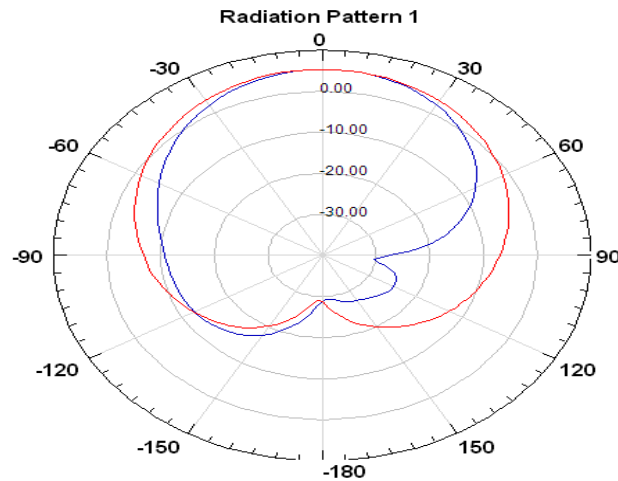


Figure 4(c). Gain of Antenna 1 in terms of Radiation Pattern

IV. RESULT AND DISCUSSION

Figure 3 shows antenna characteristics of “Antenna1”. S_{11} Vs Frequency plot of antenna is shown in Fig. 4(a). It is found that antenna is well matched at different frequency interval within frequency range 2.09-4.01 GHz. Fractional bandwidth of 40 MHz (2.07 GHz- 2.11 GHz), 60 MHz (3.57 GHz- 3.51 GHz) and 180 MHz (3.97 GHz-4.05 GHz) having return loss of -17.90dB, -45.09 dB and -22.10 dB has been obtained. Antenna has good matching at 2.09 GHz, 3.54 GHz and 4.01GHz. From Fig. 3(b), VSWR value of the antenna is found to be in between 1.3 – 2.2 for the matching frequency of the antenna, which is advantageous. Gain of the antenna in terms of radiation pattern has been presented in Fig. 3(c), which is found to be 4.74dBi. Different antenna parameter of “Antenna1” is presented in Table II.

Figure 4 shows antenna characteristics for “Antenna 2”. S_{11} Vs Frequency plot of antenna is shown in Fig. 4(a). It is seen that antenna is well matched at frequency interval within frequency range 2.05-2.07 GHz. Bandwidth of 20 MHz, having return loss of -17.90dB has been obtained. Antenna has good matching at 2.06 GHz. From Fig. 4(b), VSWR value of the antenna is found to be in between 1.5 for the matching frequency of the antenna. Gain of the antenna in terms of radiation pattern has been presented in Fig. 4(c), which is found to be 4.54dBi. Different antenna parameter of “Antenna2” is shown in Table III.

Table II Antenna Parameters for “Antenna 1”

S.No	Quantity	Value
1.	Incident Power	1(W)
2.	Radiated Power	0.356683(W)
3.	Accepted Power	0.407451(W)
4.	Max U	0.153738(W/sr)
5.	Peak Directivity	5.4165
6.	Peak Gain	4.74161
7.	Peak Realized Gain	1.93197
8.	Radiation Efficiency	0.875402

Table III Antenna Parameters for “Antenna 2”

S.No	Quantity	Value
1.	Incident Power	1(W)
2.	Radiated Power	0.854948(W)
3.	Accepted Power	0.94595(W)
4.	Max U	0.341876(W/sr)
5.	Peak Directivity	5.02515
6.	Peak Gain	4.54172
7.	Peak Realized Gain	4.29624

8.	Radiation Efficiency	0.903798
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V. CONCLUSION

Presented study of microstrip patch antenna concludes that inset feed is suitable, as antenna 1 can act in place of three antennas, which can be used to perform different activity one by one. Antenna is well matched at three different frequencies which fits in range defined for IEEE 802.11 standards. Antenna gives overall bandwidth of 280 MHz in comparison to edge feed which has only 20 MHz bandwidth. This structure is particularly simple to fabricate, uses a low cost substrate and occupies a small space. Moreover, good radiation pattern is obtained.

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