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# Improving Bandwidth in Patch Antenna Using Cavity Backing & Multilayer Structure

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***Abstract*— In this paper, multilayer microstrip patch antenna for C-Band radar applications has been introduced. It is fed by proximity coupled feed line and mutual coupling between multilayer substrates has been increased by etching circular cavity in the ground plane. A proposed antenna design consisting two rectangular patches with proximity feed line. Due to proper alignment of two patches on multiple substrates, two resonant modes are generated which improved the impedance bandwidth up to 40% (VSWR<2). The predicted efficiency from the results of simulation is 94%. This antenna maintains a constant gain of 4dB on operating frequency of 4.5GHz and designed by using structure simulator.**

***Index terms*—Multilayer structure, MSA Patch Antenna, cavity and Feed Line.**

## I. INTRODUCTION

Demand towards communication systems has increased continuously and challenged antenna engineers to come up with more compact antenna designs. In wireless communication, the demand of compact, high gain and wide band microwave antennas are mostly used because of high data transmission rate. For many applications discussed in [1], [2], [3], [4], various microstrip patch antennas have been designed by using different techniques. Moreover, microstrip patch antennas are radiated using a feeding mechanism including microstrip feed line and coaxial feed line [5], [6]. To enhance the bandwidth, proximity coupled [7]-[11] and aperture coupled feed line [12], [13] are used in microstrip antennas. A Microstrip feed line and coaxial feed line has been used for the narrowband systems having narrow bandwidth (5%) which neither increase the capacity nor the power efficiency of the operating band during transmission. So to overcome this problem, proximity and aperture coupled feed line has been used especially for the wideband systems [11]-[13]. This paper presents a design of microstrip patch antenna using proximity feed line and designed for (4-8) GHz C-Band applications. As reported in literature, proximity coupled feed line reported 13% maximum bandwidth as compare other feeding lines [14] used in microstrip antennas. Till date, proximity coupled microstrip patch antenna had reported a bandwidth of 21-22% [8], [11]. To enhance the bandwidth, special shapes of radiating patches, coplanar parasitic elements [15], stacked patch configuration [16] and impedance matching network [17] techniques are preferred. A stacking of patches technique is preferred in antenna designs because it's multiple layer structure sharing a common feed line and reduces the spurious back radiations. As mentioned in [6], multilayer structure antenna designed for L-Band applications and improved the bandwidth up to 25.7%. Now the same technique is applied in the proposed antenna design for enhancing the bandwidth. As concluded from comparison [6], bandwidth depends upon thickness, dielectric constant and volume of multilayer (stacked) structure. A proximity feed line is applied between the two different dielectric substrates, antenna was suffered with greater return losses up to -7dB [18]. To avoid these losses, a circular cavity has been etched on the grounded substrate with radius of 13.7557mm and achieved -10dB bandwidth up to 14% (4.2 to 4.8) GHz.

## II. ANTENNA DESIGN

As shown in fig. 1, the proposed antenna design with size 46.572mm X 34.8586mm is proposed. The following dimensions of the antenna are: W1 (Width of first patch) is 21.286mm, L1 (Length of first patch) is 17.4293mm, W2 (Width of second patch) is 21.286mm, L2 (Length of second patch) is 17.4293mm, Wf (Feed width) of the antenna is 4.8673mm, h1 (Height of first substrate) is 1.5mm, h2 (Height of Second substrate) is 1.6mm and h3 (Height of third substrate) is 1.5mm. The thickness of the ground plane is 0.9mm. The total height of the proposed wideband antenna is 6.7mm (0.6cm) which is mainly used for WLAN applications. The substrate materials are FR4 epoxy and Rogers's duroid 5870 mainly used in the proposed antenna design. In order to reduce the spurious radiations, a circular cavity is etched in the ground plane and its radius is selected according to the dimensions of the rectangular patch.

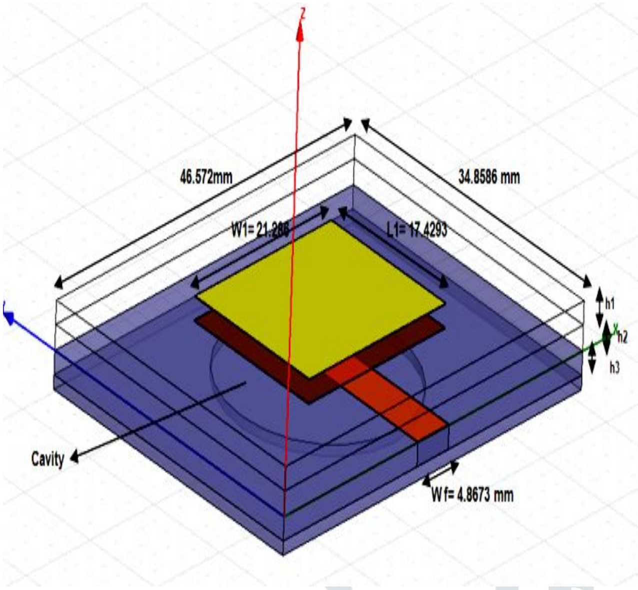



Fig.1 Proposed Antenna Design with Multilayer Structure

The substrates are selected with a medium size of thickness neither too thick nor too thin. All simulations of the proposed antenna design have been done using HFSS ver.11. The excitation source is 50Ω internal resistance used in between the end of the feeding strip and beneath the ground plane in the antenna. The description of design parameters are shown in table 1.

TABLE 1

PARAMETER DESCRIPTION OF MULTILAYER STRUCTURE ANTENNA DESIGN

| S.No. | Parameter Description | Value (mm) |
|---|---|---|
| 1. | Substrate-1 thickness | 1.5 |
| 2. | Substrate-2 thickness | 1.6 |
| 3. | Ground Substrate thickness | 1.5 |
| 4. | Feed width | 4.8673 |
| 5. | Feed length | 15.13175 |
| 6. | Cavity radius | 13.7557 |
| 7. | Cavity depth | 0.9 |

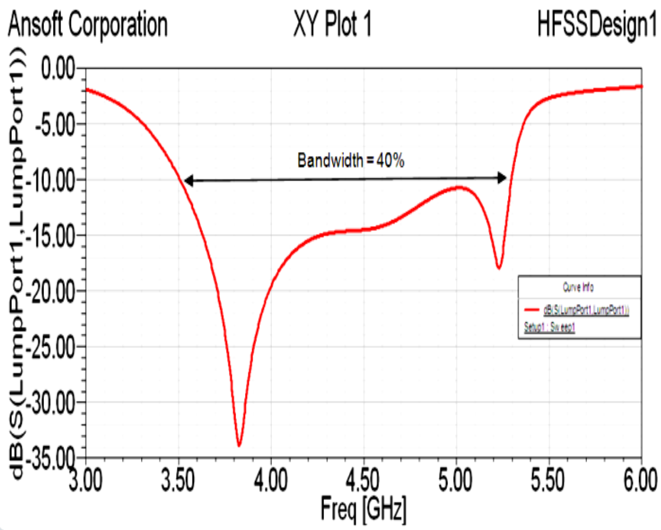



Fig. 2 Simulated Results of Proposed Antenna Design

## III. SIMULATED RESULTS

The simulated result of the proposed antenna is shown in fig.2 in which two resonant modes are generated which makes band more wider and reported -10dB bandwidth of 40%. The first resonant mode exists with -34dB return loss at 3.8GHz frequency and second resonant mode exists -19dB return loss at 5.2GHz frequency. The impedance bandwidth achieved when its voltage standing wave ratio is less than 2 (VSWR<2) as shown in fig.3. VSWR is calculated by using equation (1):

$$VSWR = \frac{V_{max}}{V_{min}} = \frac{1+|\Gamma|}{1-|\Gamma|} \quad (1)$$

Where |Γ| is the reflection coefficient, Return loss defined in dB in equation (2):

$$RL = -20\log|\Gamma| \text{ (dB)} \quad (2)$$

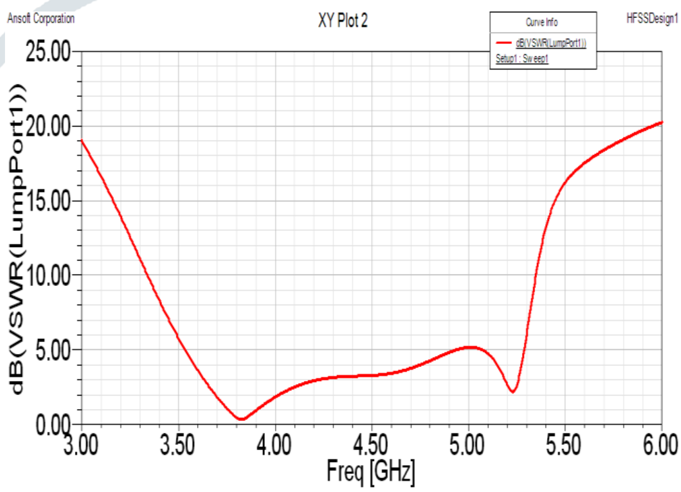



Fig. 3 VSWR Vs Frequency

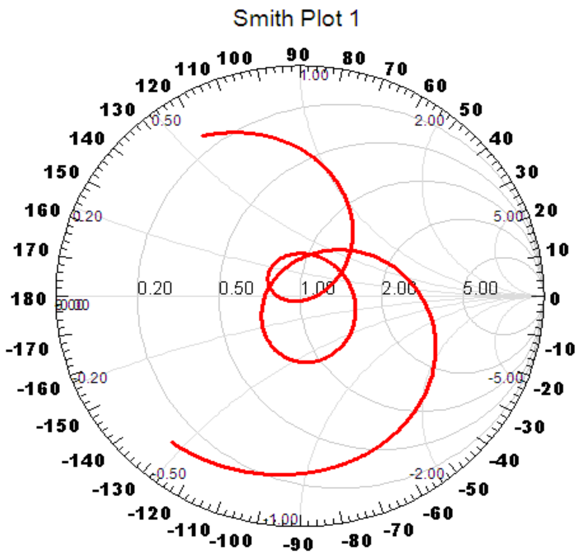



Fig. 4 Smith chart

As the smith chart curve passing with closer value to 1, then impedance matching is good between patch and feed line as shown in fig 4. The proposed antenna design gain is 4dB for different values of theta as shown in fig.5.

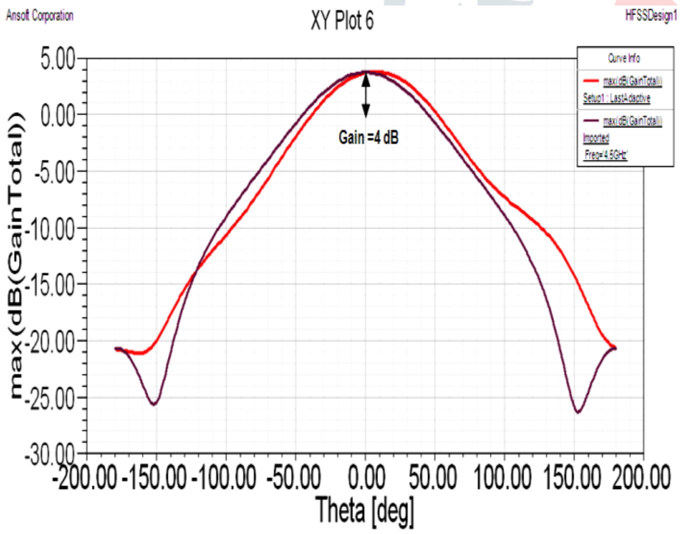
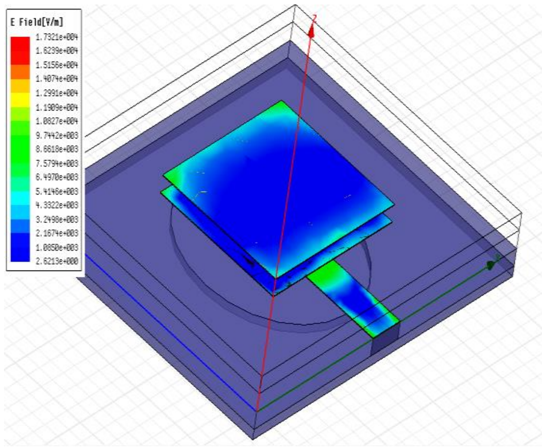
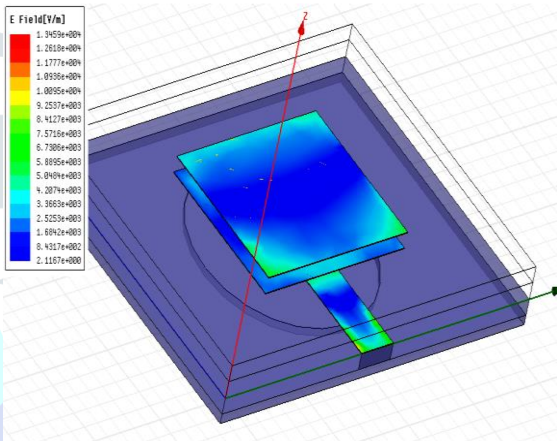



Fig. 5 Gain Vs Theta

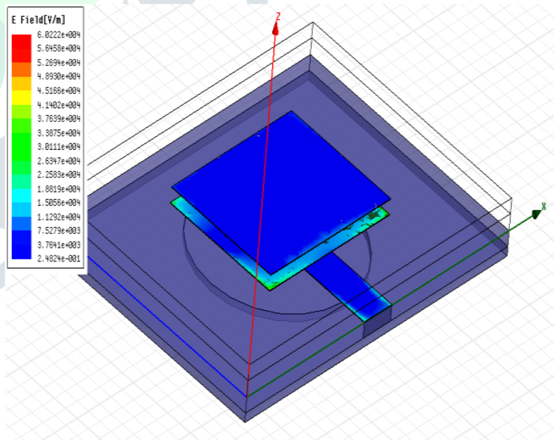
As illustrated in Fig. 6, simulated electric field distributions on the multilayer structure antenna at 3.5GHz, 4.5GHz and 5.5 GHz. At 3.5 GHz, it can be observed that the strong electric field current is presented at the corner portion of the both rectangular radiators and in the end side of the feed line. At 4.5 GHz, it can be observed that the majority of the electric field strength improved as compare with 3.5GHz frequency. The electric field is highly concentrated at the corner portion of the radiators and also spreading over the feed line.



(a) At 3.5GHz



(b) At 4.5GHz



(c) At 5.5GHz

Fig. 6 Electric Field Distribution in Multilayer Microstrip Antenna (a) 3.5GHz, (b) 4.5GHz, (c) 5.5GHz

At 5.5 GHz frequency, electric field strength decreased. So, weak electric field associated on the top of the radiator and feed line. As shown in fig.7, the 3-D polar plots of the proposed antenna design having different planes and strong electric field originated in last three cases.

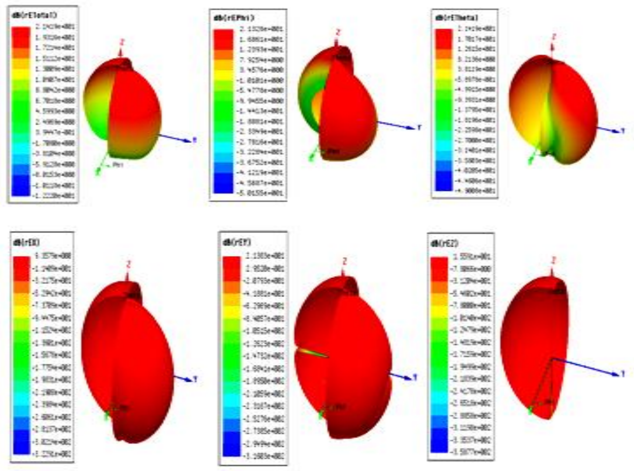


Fig.7 3-D polar plot in Radiation Electric Field of proposed antenna design

## IV. CONCLUSION

In this paper, wideband multilayer microstrip patch antenna has been proposed for Radar C-Band applications. The antenna has been designed using multilayer substrates with proximity feed line but return losses and spurious wave radiations are reduced by cutting a cavity in the ground plane. The antenna design with dimensions of 47 X 35 $mm^2$ radiated at resonant frequency of 4.5 GHz with acceptable radiation efficiency 94%. Bandwidth enhancement has been done by applying proximity coupled feed line and applying cavity in the proposed antenna design. A cavity maintained a strong mutual coupling between the multilayer substrates in the antenna design. A multilayer antenna has been designed and simulated, and achieved -10dB bandwidth of 40% having two resonant modes.

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