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Design and Analysis of Single Patch Antenna for Radar Applications

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Abstract:- This project proposes the design and analysis of a single patch antenna for Radar applications. The proposed antenna contains 1 glittering material fed into the transmission line feed network. To better optimize the performance of the proposed antenna, an air gap containing the installed pads is used. Detailed analysis on the performance of the antenna with open air pockets. Stacked leaflets designed on a superstrate. The substrate and superstrate are separated by a 2mm air gap. The FR-4 material with a thickness of 0.8mm is used for both substrate and superstrate. The proposed design comprises between 7.76-9.46 GHz band frequencies with a maximum gain of 8.2 dB and directing radiation patterns. The antenna is designed and analyzed using the HFSS simulation tool. The proposed design has a total size of 70mmx70mmx3.6mm. This antenna has the advantage of low profile, easy operation, low cost and better performance.

I. INTRODUCTION

Definition of antenna or aerial just by means of "radio transmitter or receiver". Basically, an antenna can be considered as a link between the free space and the transmitter or receiver. Microstrip antennas (MSAs) are one of the most important classes because of their unique use in microwave communication. Novel design and development of microwave ovens are an important part of microwave communication systems that meet the desired radiation requirements.

Microstrip antenna technology is a developing topic in the antenna industry and creates interest among industry, academics, professional engineers and researchers worldwide.

Microstrip (MSA) antenna configuration is planar and has the advantages of printed circuit technology. The glossy MSA piece is engraved with a bronze or gold image on one side, with a dielectric board, on the other side of the board covering the lower metal plane.

G. A. Deschamps first proposed the MSA in 1953. Robert E. Munson and John Q. Howell developed active horns in the late 1970's. An MSA radiation strip of any geometry namely; square, triangle, rectangle, circle, elliptical, sectoral, annular ring etc. The MSA commonly used is the rectangular microstrip antenna because of its simplicity in design, manufacture and analysis.

There are many benefits to the use of MSAs other disadvantages than conventional microwave ovens. Low impedance bandwidth meaning 1-2% is a major result of MSAs, suffers from low profits, low imports and sometimes unwanted radiation patterns. An important function in MSAs is the growing impedance bandwidth, which is a very useful tool for microwave communication. In this case the advantage, cohesiveness, and patter of the desired radiation is another important factor in microwave communication.

MSAs have advantages over conventional microwave antennas (CMSAs) and have applications for a wide range of frequencies. The advantages of MSAs over CMSAs are as follows - planar configuration, low volume, low profile and light weight, Performance costs are low, It can be split in half-wavelength and form a large range, It has partially dispersed components, Antennas operate on two frequencies, three and many.

Disadvantages of MSAs are as follows - Low impedance bandwidth 1 to 5%, Slightly efficient compared to other antennas, Introduction to low microwave frequencies, MSA has limitations of high gain, Radiation is a negative fire.

Applications of MSAs are wireless local area network (WLAN) systems, satellite navigation receiver, satellite communication, satellite communication.

II. RADIATION MECHANISM OF MSAs

Radiation of the MSA comes from the periphery of the operator and ground plane. Radiation and current flow in the conductors are first tested to rule out microstrip by Lewin.

The MSA radiation study is best understood with a rectangular microstrip patch as shown in Fig. 1 (x). Figure 1 (y) shows the suspension of the electric field in the radiator.

Pool length varies locally and is part of the wavelength (2). MSA radiation defines fringing fields at the circular edges of a patch. The camps at the end in reference to the ground plane have solid and normal parts. The amendment line is / 2 long and normal sections are not in the section, so the direction of the distance generated by the remote field is canceled. Broadside direction and tangential components (those corresponding to the ground plane) are in the category. The patch may be represented by two / 2 spaces as shown in Fig. 1 (z).

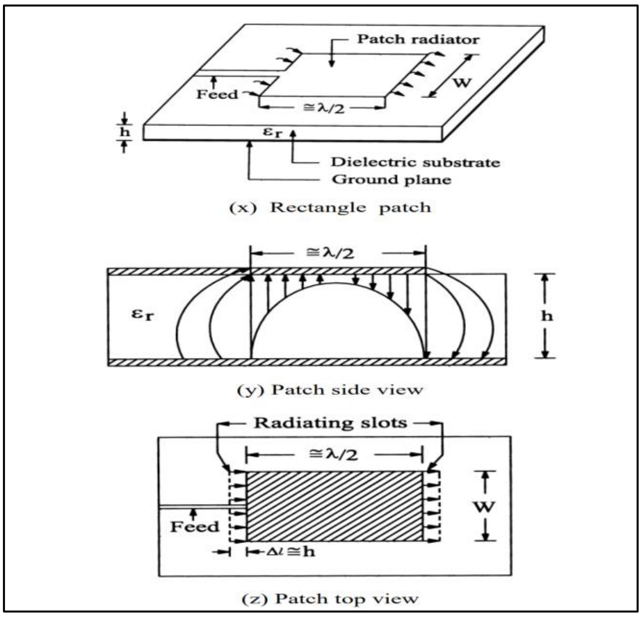

Fig 1: Radiation Mechanism of MSA

III. PROPOSED ANTENNA DESIGN

It is important to design and analyse the behaviour of a single antenna before designing the entire system. A single object antenna is designed on a FR-4 substrate with a thickness of 0.8mm and a relative clearance of εr = 4.4. The substrate is used based on its low cost and availability. Copper is used as a 35 µm radiant emission material. The length and width of the patch determine the resonant frequency according to the operating wavelength. In the case of a designed antenna, the active resonant length has been determined from the current distribution above the resonant frequency band.

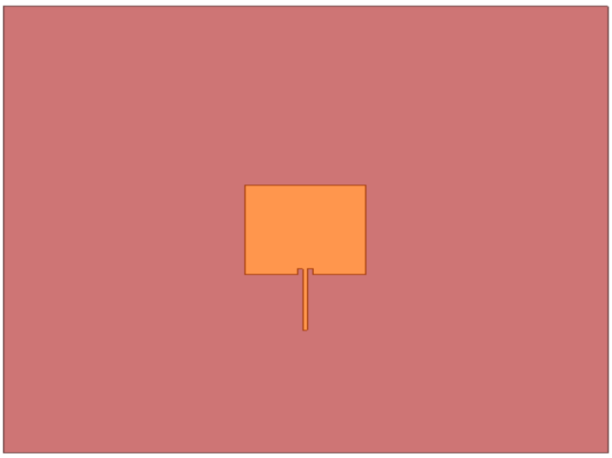

Fig 2: Single Patch Design

To enhance the performance, an airgap with stacked patch on the superstrate is used. A single element with an air gap stacked patch is shown in 3D format shown in Fig 3. The substrate clip is called a drin patch and the substrate clip is called a stacked patch. The diameter of the patch is 8.2mmx8.2mm, and the patch size is 9.3x9.3mm. The airgap between the substrate and the superstrate is 2mm.

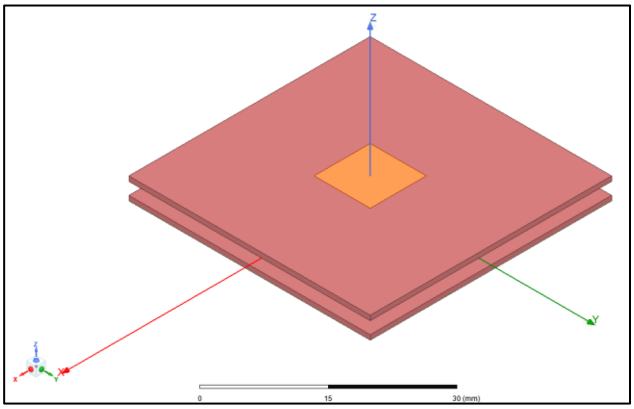

Fig 3: Layout of the Single element with air gap stacked patch.

IV. MEASUREMENT AND ANALYSIS

For the width calculation of the substrate following formula is used:

$$W = \frac{c}{2f}\sqrt{\frac{2}{\varepsilon_r+1}} \qquad \ldots(1)$$

Length is calculated by:

$$L = L_{eff} - 2\Delta L \qquad \ldots(2)$$

Where, w= width of the patch

C= velocity of light (3× 10^{11}mm)
f = Resonant frequency
L = Length of Patch
ε_r = Dielectric constant of substrate
$Leff$ = Effective length, and it is given by

$$L_{eff} = \frac{c}{2f\sqrt{\varepsilon_{reff}}} \qquad \ldots(3)$$

The normalized extension in length is given by,

$$\Delta L = 0.412h\frac{(\varepsilon_{reff}+0.3)\left(\frac{w}{h}+0.264\right)}{(\varepsilon_{reff}-0.258)\left(\frac{w}{h}+0.8\right)} \qquad \ldots(4)$$

Where, ε_{reff}= Effective dielectric constant, and the equation for it is given below

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{w}\right]^{\frac{-1}{2}} \qquad \ldots(5)$$

However, in the proposed design a square piece is used to reduce the analysis time. If a rectangular clip is used, two parameters (length and width) must be changed, and in a square strip only one different parameter (Length) is required. The microstrip line impedance and width can be calculated by the words given below. All of these formulas are used in many research articles by many authors. The antenna feed line is then upgraded to detect 50Ω distortion of the resonant frequency with slightly different magnitude than that calculated using formulas, in order to obtain the correct match.

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$$Z_0 = \frac{120\pi}{\sqrt{\varepsilon_{reff}}\left(1.393 + \frac{w}{h} + \frac{2}{3}\ln\left(\frac{w}{h} + 1.4444\right)\right)} \quad \ldots(6)$$

Also the width of the microstrip line is given by expression

$$W = \frac{1}{2fr\sqrt{\mu 0 \epsilon 0}}\sqrt{2\,\epsilon r+1} \quad \ldots(7)$$

When W is the width of the microstrip line, fr resonant frequency ϵr is the approximate allowance, and $\mu 0$ $\epsilon 0$ is the free space openness and free space respectively. The single-item antenna is shown in Figure 2 and is designed to sound at 8.5 GHz. Pocket size is 8x8mm. The radiation strip is located at a depth of 0.8mm thick FR-4.

V. ANALYSIS

➢ *Return loss*

The return loss plot of the single element antenna is shown in Figure 4, where the return loss at 8.5 GHz is -23 db. The bandwidth of this antenna is 0.23 GHz (8.34-8.57) GHz.

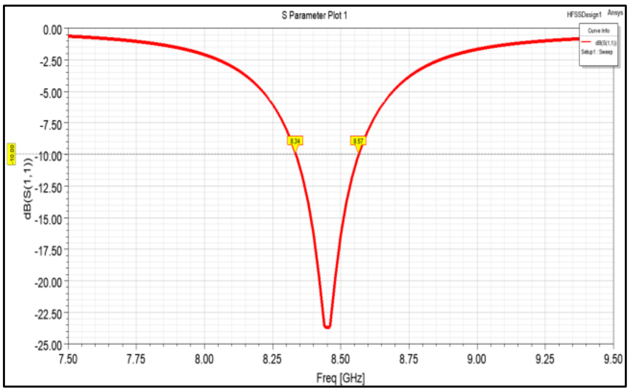

Fig 4: Return Loss plot of single element antenna.

➢ *Gain:*

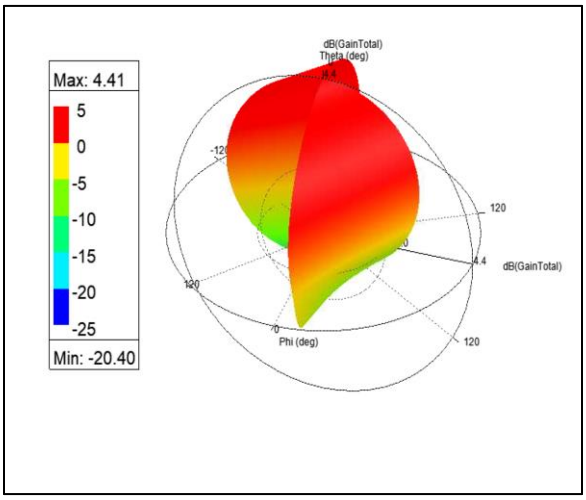

Fig 5: Gain Plot of single element antenna at 8.5 GHz

➢ *Radiation Pattern* –

Fig 6 shows the radiation for the single patch antenna which have maximum radiation in the vertical direction and have some minor radiation below the vertical axis.

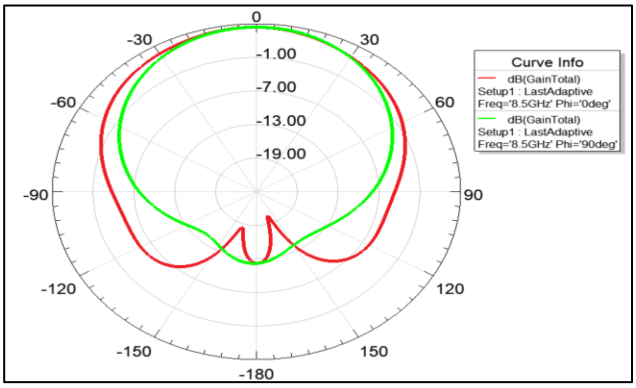

Fig 6: Radiation Pattern of single element antenna at 8.5 GHz.

➢ *Bandwidth*

Bandwidth can be defined as a large Spectrum. More the range more it can will be prone to Noise but the noise factors can be eliminated. But on the Other side with more the bandwidth it is more capable to Convey the frequency signal.

Single patch antenna without air gap has a Bandwidth of **0.23 GHz.** But by introducing stacked air gap the Bandwidth is enhanced to **1.71 GHz.**

VI. CONCLUSION

This Project the design and analysis of a single patch Antenna for the Radar application is designed and Analyzed. The proposed antenna is a single patch Antenna with an overall dimension on 70mm x 70mm x 3.6mm. a detailed performance analysis is carried in Antenna with air gap stacked patch. By introducing the air gap the design results in an Enhanced bandwidth from **0.23 GHz** to **1.71 GHz**FR-4 material with a thickness of 0.8mm is used for the both Substrate and Superstrate.

The Proposed antenna design resonates between the band Frequencies 7.76-9.46 GHz with a peak gain of 8.2 dB And with directional radiation pattern. The promising performance of the proposed antenna Makes it suitable for Radar application.

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