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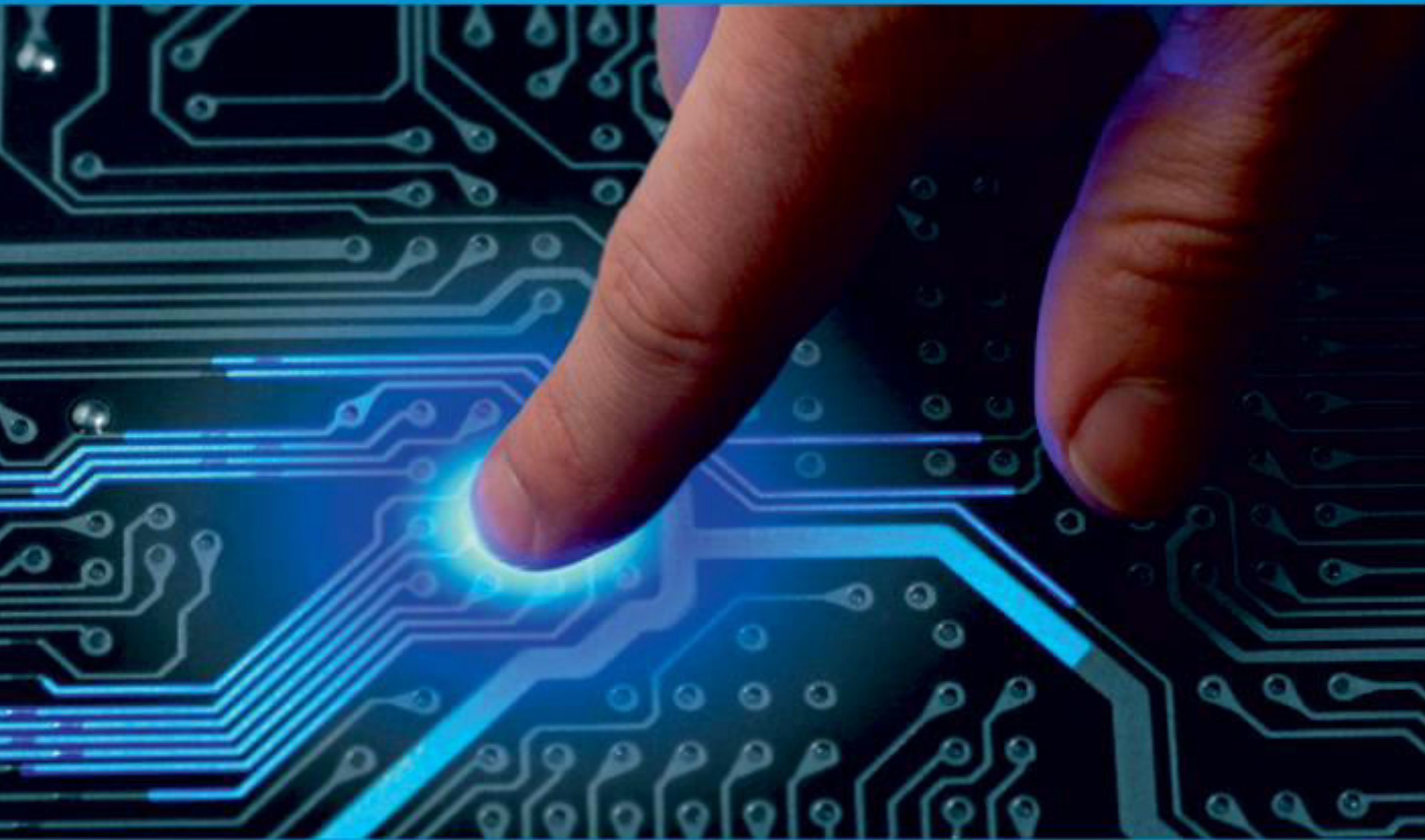

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Design and Development of Micro-strip Patch Antenna for ISM band Applications

Porje Shubhangi Madhukar[1], Gosavi Shraddha Dattatray[2], Ugale Vaishnavi Bhausaheb[3], Prof. A. R. Chaudhari[4]

Department of Electronics & Telecommunication Engineering, MVPs Karmaveer Baburao Ganpatrao Thakare College of Engineering, Nashik, India

ABSTRACT: The high-frequency micro-antenna industry has grown exponentially with the amazing advances in communications during the last few years. Where the need to offer sure styles of those antennas, which are characterized by means of compact length, excessive performance, and transmission of excessive frequencies has emerge as a necessity. A microstrip patch antenna design is brought on this look at, which includes three conductive layers, a conductive patch on one aspect and an insulating substrate with a ground plane on the alternative side. Generally, a microstrip antenna is normally referred to as a "revealed antenna". Common shapes for microstrip patch antennae are square, square, circular, and oval, however some other scheme is permittable. The designed Antenna operates at a frequency of 2.4 GHz Using FR4 fabric as a substrate which has the dielectric regular of 4.4(εr). The designed Antenna can be used for ISM (business, medical and scientific) applications. The antenna is designed using ANSYS HFSS simulation software. The designed antenna has low profile, low value, clean fabrication. The designed antenna gives return loss much less than -10dB. The parameters together with go back loss, VSWR (voltage status wave ratio), advantage, radiation pattern has been simulated and analysed.

KEYWORDS: Patch Antenna, Multi-Slot, Return Loss, gain, HFSS.

I. INTRODUCTION

The Microstrip antenna is made up of a conducting patch on a ground plane separated by the dielectric substrate. This concept was undeveloped until the revolution in large-scale integration of electronic circuit in 1970.
The Microstrip Patch Antenna consist of a single-layer design which includes four parts (Patch, ground plane, substrate, and the feeding part). These antennas are integrated with printed strip- line feed networks and active devices. This is a relatively new area of antenna engineering. Patch antennas are classified as single – element resonant antennas. Once the frequency is obtained, everything (such as radiation pattern input impedance, etc.) remains constant. The patch is a very slim (t<<λo, where λo = the wavelength of free space), radiating metal strip (or array of strips) located on one side of a thin no conducting substrate, the ground plane is the same metal located on the other side of the substrate.

The patch is usually made of conducting material such as copper or gold and can take any possible shape. The radiating patch and the feed lines are usually photo etched on the dielectric substrate. The industrial, scientific and medical (ISM) bands are operated at the frequency range 2.4GHZ for industrial, scientific and medical purposes. The antenna is designed for 2.4 GHZ and it can be used for various ISM applications.

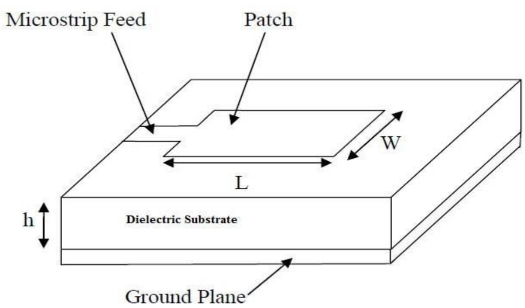

Figure 1:Microstrip Patch Antenna

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The most commonly employed microstrip patch antenna is rectangular patch antenna. Patch antenna is the ability to have polarization diversity. If the dielectric constant of the substrate increases, the antenna beam width decreases.
In section II, the single antenna is designed. In section III, effect of slot on different parameters. In section IV, simulation result and discussion. In section V, discuss about Antenna fabrication and results. In section VI, discuss about conclusion. At last detail about reference.

II. ANTENNA DESIGN

The designed antenna is printed on both sides, one side is patch and other side is ground plane. Microstrip patch antennas can be fed by a variety of methods. The antenna is designed by using a microstrip feed line because it is one of the easier methods to fabricate. The designed antenna is used as a substrate material is FR-4. The dielectric constant of the substrate material is 4.4. The geometry of the given antenna is illustrated in Fig.2.The antenna is fabricated on 50 x 50 mm FR-4 substrate with a dielectric constant of 4.4 (ε_r) and substrate thickness 1.6mm.

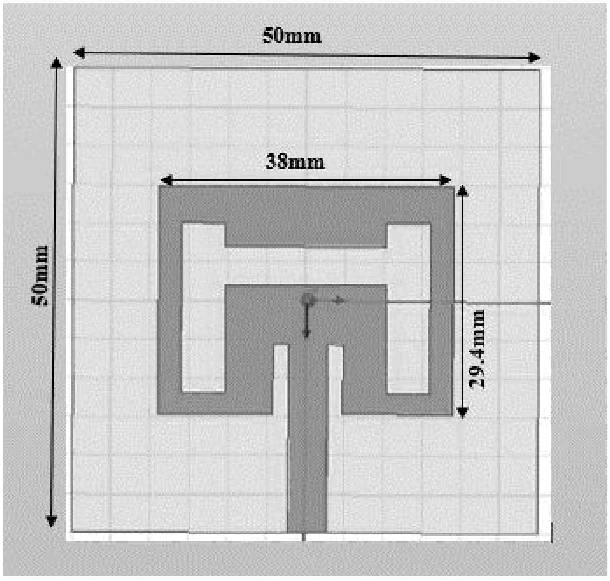

Figure 2:Geometry of antenna with dimensions in mm

The patch has dimension on 38 x 29.4 mm and it is fed by a microstrip line having width of 5mm.

Design Formulae & Calculations:

1. Width of Patch, $\mathbf{W} = \frac{c}{2f\sqrt{\frac{\varepsilon r+1}{2}}}$ **= 38.036 mm**

$$\boldsymbol{\varepsilon eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+12\left(\frac{h}{w}\right)^{-\frac{1}{2}}\right] = \mathbf{4.0858}$$

$$\mathbf{Leff} = \frac{c}{2f\sqrt{\varepsilon_{eff}}} = \frac{3\times10^8}{2\times2.4\times10^9\sqrt{4.0858}} = \mathbf{30.91}$$

$$\triangle\mathbf{L} = 0.412h\frac{(\varepsilon_{eff}+0.3)\left(\frac{W}{h}+0.265\right)}{(\varepsilon_{eff}-0.258)\left(\frac{W}{h}+0.8\right)} = \mathbf{0.738}$$

2. Length of Patch, $\mathbf{L} = L_{eff} - 2\triangle L$
$= 30.91 - 2\times 0.738 = \mathbf{29.43}$

3. Length of Substrate, $\mathbf{L_s} = L_{eff} - 2\triangle L$
$= 6\times1.6 + 29.43 = \mathbf{39.03}$

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4. Width of Substrate, $\mathbf{W_s} = 6h + W$

$$= 6 \times 1.6 + 38.036 = \mathbf{47.63}$$

5. Characteristic Impedance (Z_c):

$$\frac{W}{h} > 1 = \left(\frac{120\pi}{\sqrt{\varepsilon_{reff}\left[\frac{W_0}{h} + 1.393 + 0.667.\ell_n\left(\frac{W_0}{h} + 1.444\right)\right]}} \right)$$

$$= \frac{120\pi}{\sqrt{\varepsilon_{reff}\left[\frac{W}{h}+1.393+0.667\ell_n\left(\frac{W}{h}+1.444\right)\right]}} = \mathbf{2167.74}$$

III. EFFECT OF SLOT ON DIFFERENT PARAMETERS OF MICROSTRIP PATCH ANTENNA

(1) EFFECT OF SLOTS ON BANDWIDTH
(2) One of the most common reasons is to increase the bandwidth of the antenna. By introducing a slot, you can create additional current paths which can introduce new resonant frequencies. If these new resonances are close to the original resonant frequency of the patch, they can combine to create a wider overall bandwidth
(3) EFFECT ON SLOTS ON THE GAIN
(4) Gain relates the intensity of antenna in a given direction to the intensity that would be produced by a hypothetical ideal antenna that radiates equally in all direction or isotropically and has no losses. By using high permittivity substrate and by different shape of slot we can enhance the gain of antenna.
(5) EFFECT OF SLOT ON RADIATION PATTERN
(6) The presence of a slot in a patch antenna definitely impacts the radiation pattern in
(7) **Directivity:** Slots can alter the way the antenna radiates energy, affecting its directivity. The specific change depends on the slot's characteristics like size, shape, and location.
(8) EFFECT OF SLOT ON SIZE OF ANTENNA
(9) With the help of slot size of microstrip patch antenna is reduced. This effect can be done by changing the path of current. When slots are cut into patch current is changed. Current travels extra patch as compare to the without slot microstrip patch antenna.

IV. SIMULATION RESULTS AND DISCUSSION

In this section, the antenna parameters such as return loss, gain, voltage standing wave ratio (VSWR), radiation pattern.

I. Return Loss

Return loss is the loss of power in the signal reflected or returned by the discontinuity of transmission line. It is related to the reflection coefficient and SWR. Return loss can be expressed as, RL= -20 log [Γ]

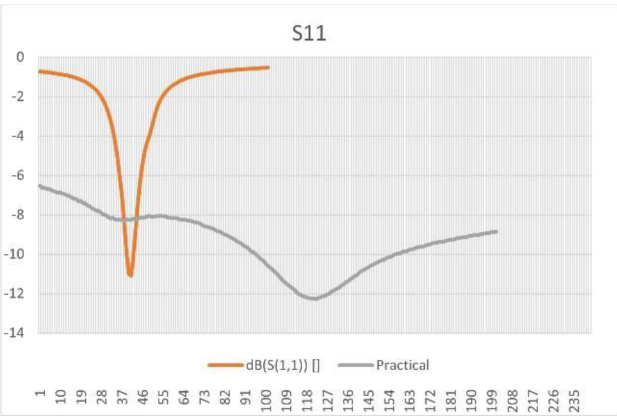

Figure 3:Return Loss(S11)

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II. voltage standing wave ratio (VSWR)

It is defined as a measurement of the mismatch between the load and the transmission line. For ideal case the value of VSWR is 1.

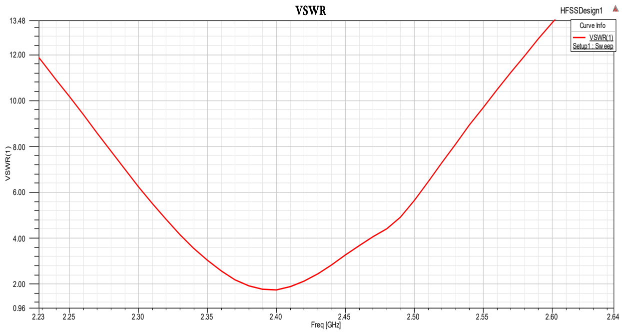

Figure 4: VSWR

III. Radiation Pattern

Radiation patterns are the graphical representation of the electromagnetic power distribution in free space.

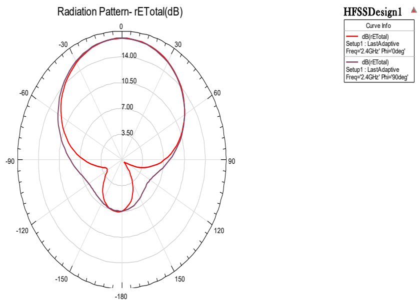

Figure 5:Radiation Pattern(rETotal)

IV. Gain

Gain is the ratio of radiation field intensity of test antenna to that of the reference antenna. The gain of the designed antenna is 3.97 dB.

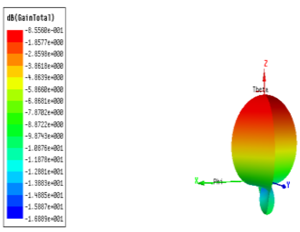

Figure 6: GainTotal (dB)

V. Efficiency

The term efficiency can be defined as the ability to achieve an end goal with little to no waste, effort, or energy.

η = Energy output/Energy input × 100%

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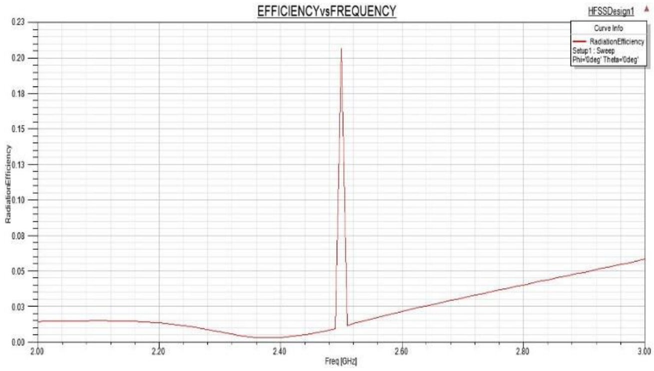

Figure 7:Frequency vs Efficiency

V. FABRICATION

As the design of the proposed antenna is analysed and simulated on the HFSS simulation software. That design is to be converted into another format like, AutoCAD DXF, BMP files. We have used DXF file format and fabricated the MSA as shown in fig.8 below.

A. Fabrication of Microstrip Patch Antenna

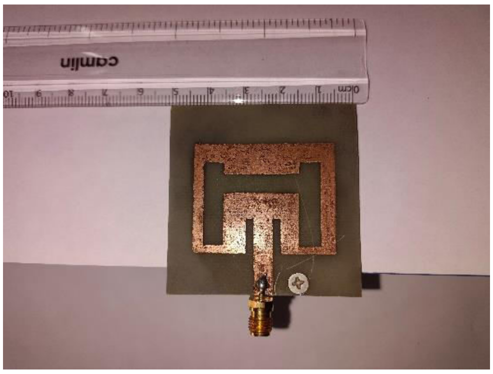

Figure 8: Fabricated Antenna

B. Fabricated Results

Hence, we got the results of the fabricated antenna using the Vector Network Analyzer (VNA) as shown in fig.9,10. Fig.9 shows the return loss (S11 parameter). Fig.10 shows the VSWR plot of the fabricated antenna.

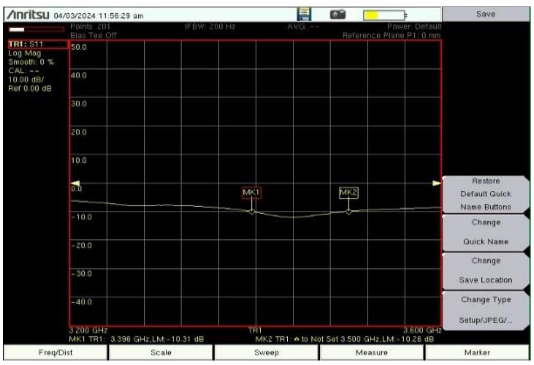

Figure 9: S11

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Figure 10: VSWR

VI. CONCLUSION

Finally, Microstrip patch antenna is designed using HFSS simulation software. The antenna is designed using a FR4 epoxy substrate. The designed antenna structure operated at 2.4GHz. Based on the experimental results, the antenna parameters such as VSWR, S Parameter, Efficiency, Radiation Pattern, gain, and bandwidth helps us to identify the effective antenna. The antenna resonates at 2.4 GHz with a VSWR of 1.6. The fabrication of this patch array antenna will be our targeted work.

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