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Patch Antenna using Metamaterial Structure for improving parameters on 3.2 layers At 2.787 GHz

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Abstract— In this paper, a novel printed rectangular patch antenna with 3.2 layer, resonant at 2.787 GHz frequency, is proposed. The given antenna is composed of a rectangular patch antenna with retangular structure on 3.2 layers. The antenna is designed for resonating at 2.787 GHz frequency. The return loss of the proposed antenna is -40.762816 dB at 2.787 GHz frequency which is in good agreement. A rectangular vertical strip is also used for minimizing the return loss. The 50 ohm port is used to fed the proposed antenna.
Keywords—patch, return-loss, bandwidth, printed antenna.

I. INTRODUCTION

Antenna has been around for a long time, millions of years, as the organ of touch or feeling of animal, birds and insects. But in the last 100 years they have acquired a new significance as the connection link between a radio system and the outside World. The first radio Antenna was built by Heinrich Hertz, a professor at the Technical Institute in Karlsruhe, Germany. The IEEE standard defines an antenna as a part of a transmitting or receiving system that is designed to radiate or to receive electromagnetic waves [1]. A patch antenna is a low-profile antenna consisting of a metal layer over a dielectric substrate and ground plane. Typically, a patch antenna is fed by a microstrip transmission line, but other feed lines such as coaxial can be used. [2–3] The advantages of patch antennas are that they radiate with moderately high gain in a direction perpendicular to the substrate and can be fabricated in a low cost FR-4 substrate. Micro-strip antennas have unique features and attractive properties such as low profile, light weight, compactness and Conformability in structure [4]. With those advantages, the antennas can be easily fabricated and integrated in solid-state devices. Micro-strip antennas are widely applied in radio frequency devices with single-ended signal operation. This has recently been used in microwave design with a combination of meta-materials, either as a cover or a substrate [5]. In modern wireless communication systems, the micro-strip patch antennas are commonly used in the wireless devices. Therefore, the miniaturization of the antenna has become an important issue in reducing the volume of entire communication system [6]. V.G. Veselago in 1968 provided a theoretical report on the concept of meta-material (MTM) [7]. The "patch" is a low-profile, low gain, narrow bandwidth antenna [8-10]. Aerodynamic considerations require low profile antenna on aircraft and many kinds of vehicles. Typically a patch consists of thin conducting sheet about 1 by 1/2 $\lambda 0$ mounted on Substrate. Radiation from the patch is like radiation from two slots, at the left and right edges of the patch.

II. ANTENNA DESIGN THEORY

The designing parameters of rectangular microstrip patch antenna are L=24.8467mm, W=32.162 mm, cut width=5 mm, cut depth=9.12335 mm, length of transmission line feed=21.5467 mm, with width of the feed=mm. The rectangular micro-strip patch antenna is designed on FR-4 (Loss free) substrate with εr = 4.3 and height from the ground plane d=1.6 mm. A novel printed monopole antenna is composed of a rectangular patch printed antenna over the FR4 substrate. The design pedagogy is slightly different in this paper. For improvement in the return loss can be done by using another FR-4 substrate on 3.2 layer loaded with some simple structure which are symmetrical about X-axis but antenna will not resonant at 2.787GHz frequency. For adjusting the frequency, half size of second substrate is selected as compared to the previous one. Retangular structures are considered which makes the antenna to satisfactory operate at 2.787GHz frequency. A simple rectangular rod is also placed for further improving the performance in terms of impedance matching.

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The RMPA parameters are calculated from the following formulas

A. Calculation of Width (W)

$$W = \frac{1}{2f_r\sqrt{\mu_0\varepsilon_0}}\sqrt{\frac{2}{\varepsilon_r+1}} = \frac{C}{2f_r}\sqrt{\frac{2}{\varepsilon_r+1}}$$

Where C = free space velocity of light,

ε_r =Dielectric constant of substrate

The effective dielectric constant of the rectangular micro-strip patch antenna:

B. Actual length of the patch (L)

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left(\frac{1}{\sqrt{1+\frac{12h}{w}}}\right)$$

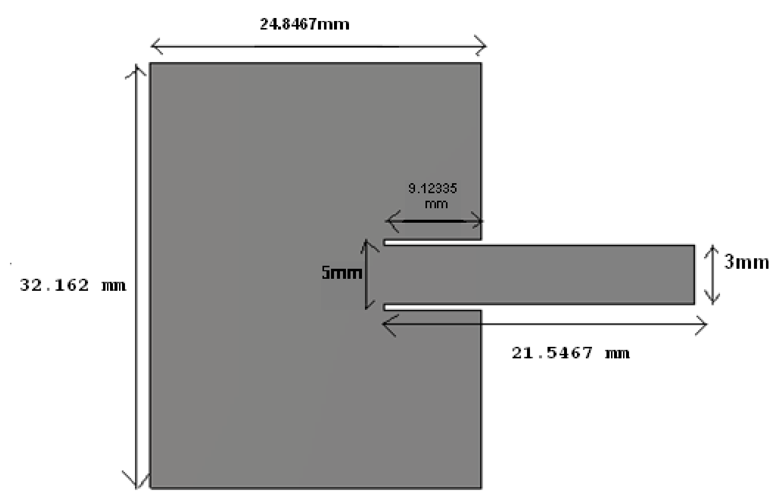
C. *The actual length of the Patch (L).*

$$L = L_{eff} - 2\Delta L$$

D. Calculation of Length Extension

$$\frac{\Delta L}{h} = 0.412\frac{(\varepsilon_{eff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{eff}-0.258)\left(\frac{W}{h}+0.8\right)}$$

Fig.1 shows the structure of the patch antenna and the Table. I, show the parameters of the patch antenna. The antenna is modeled and simulated using method of moment based electromagnetic simulation software CST, version 10, between 0 to 3GHz.



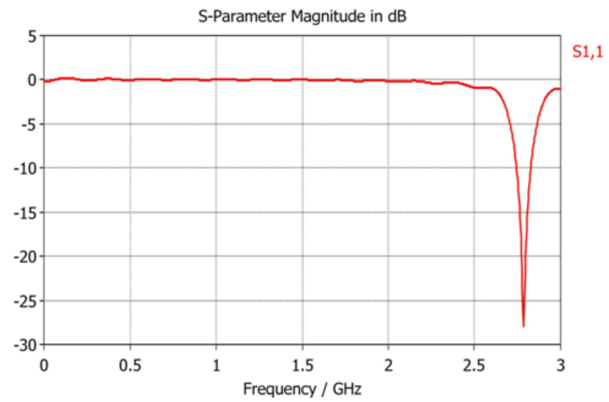


Figure 2: Simulation of return loss and bandwidth of RMPA alone.

TABLE.I: STRUCTURAL PARAMETERS OF SIMPAL PATCH ANTENNA

Sr. No.	**Parameters of patch antenna**		
	Parameters	***Dimension***	***Unit***
1.	Dielectric constant	4.3	-
2.	Loss tangent (tan)	.02	-
3.	Thickness (h)	1.6	mm
4.	Operating frequency	2.787	GHZ
5.	Length L	24.8467	mm
6.	Width W	32.162	mm
7.	Cut width	5	mm
8.	Cut depth	9.1235	mm
9.	Path length	21.5467	mm

III. SIMULATION RESULTS

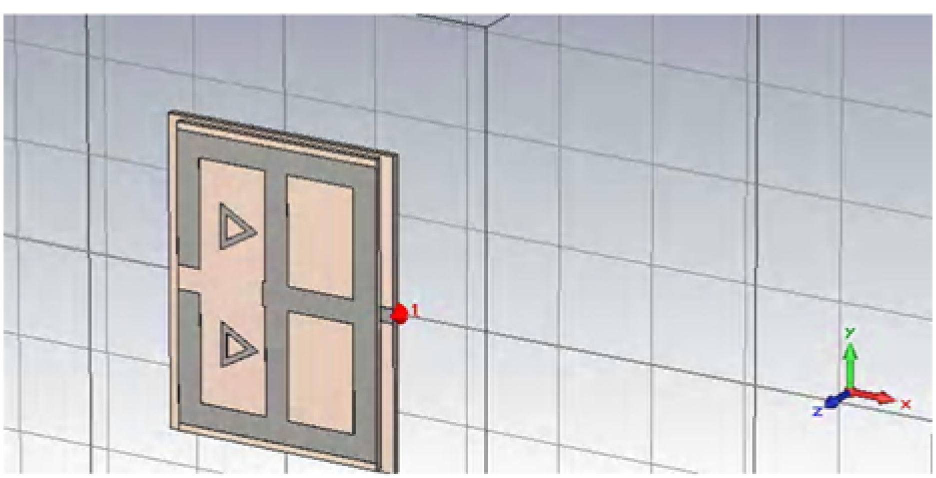


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Fig.3 shows the structure of the proposed antenna and the. The antenna is modeled and simulated using method of moment based electromagnetic simulation software CST, version 10, between 0 to 3GHz.

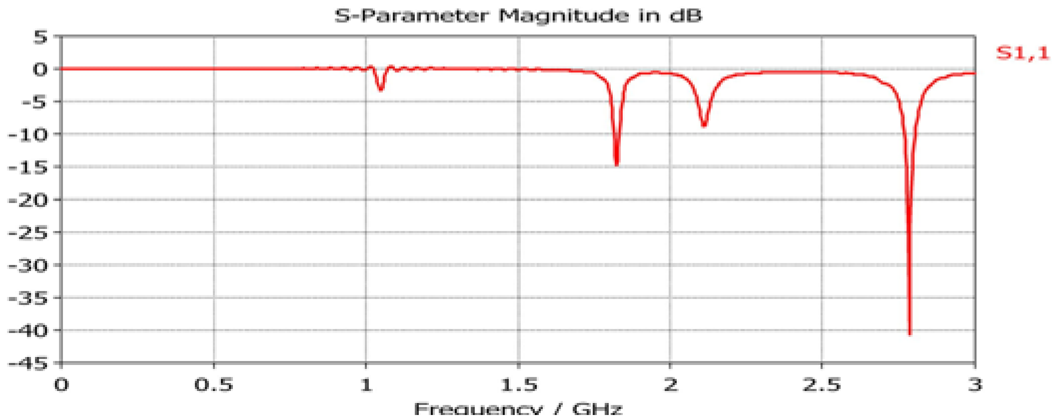

Fig. 2 and 4 shows the graph of return loss V/s frequency, VSWR Vs. frequency and impedance variations V/s. frequency respectively. The graph of return loss shows that antenna is resonating at 2.787GHz frequency with return loss of -40.762816dB and bandwidth of proposed antenna is increased up 33 MHz and directivity is also increased

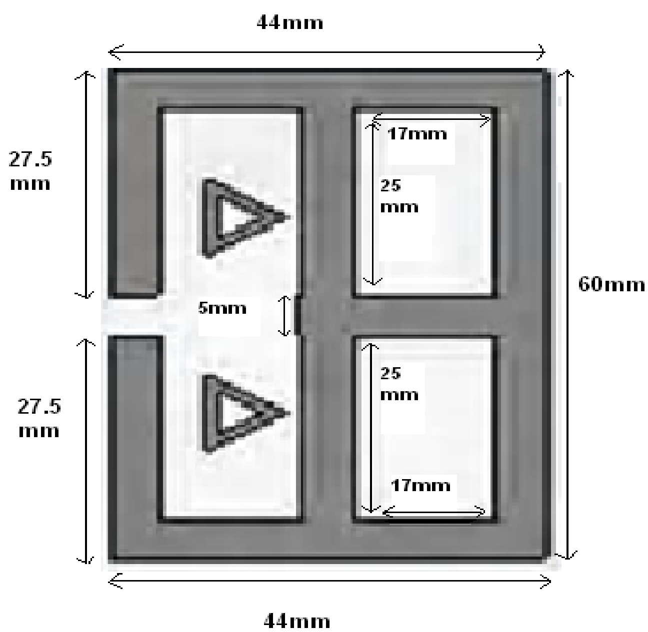

Fig.5 shows the structure of the proposed antenna

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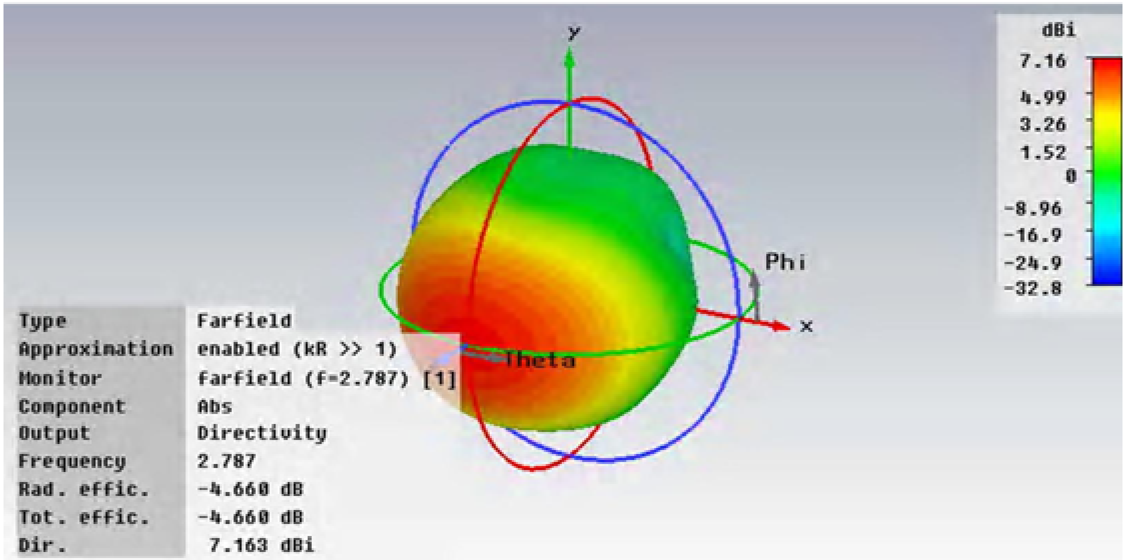

Figure 6: directivity graph

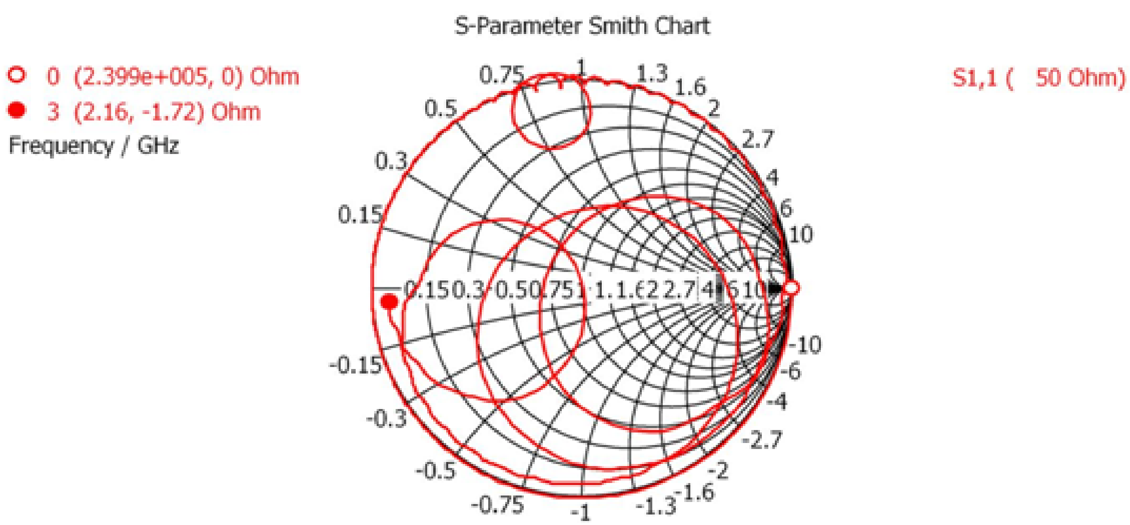

Figure 7: Smith chart of RMPA loaded with metamaterial

The smith chart is very useful when solving transmission problems. and The real utility of the Smith chart, it can be used to convert from reflection coefficients to normalized impedances (or admittances), and vice versa.

IV. CONCLUSION

A printed RMPA antenna at 2.787 GHz frequency is analyzed. The antenna is modeled on low cost and easily available FR4 substrate. The antenna is resonating at 2.787GHZ with return loss -40.762816dB and bandwidth of proposed antenna is increased up 33 MHz and directivity is also increased Using CST-MWS software

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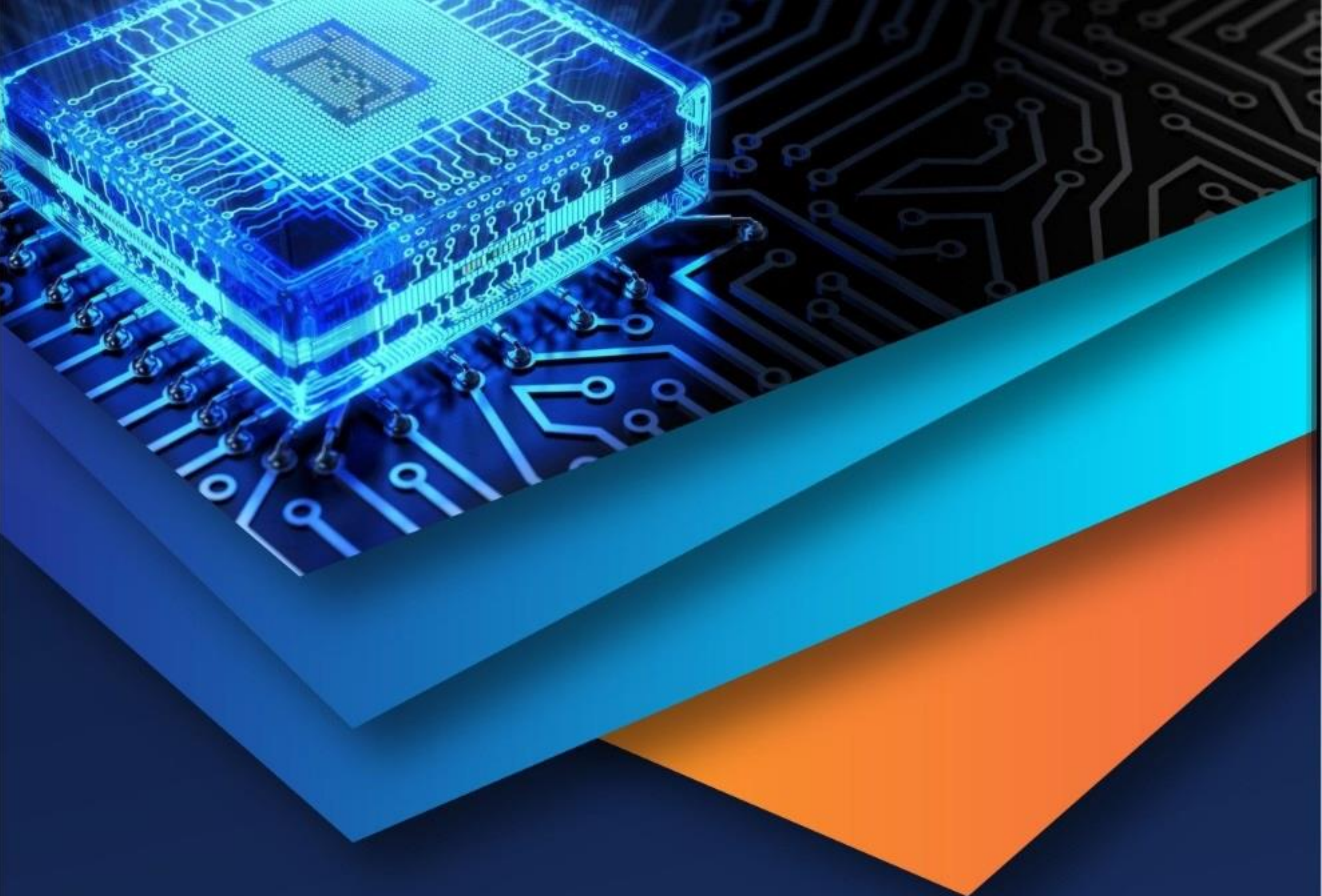

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