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Design Compact Dual Band MIMO Antenna with High Isolation

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Abstract: In this paper, a rectangular microstrip patch antenna is designed using HFSS software. The designed antenna has a resonating frequency of 2.4 GHz which is applicable to Wireless Local Area Network (WLAN). This paper shows the design considerations of the proposed antenna as well as the simulated results of the same. The design is made on FR-4 Epoxy material used as a dielectric material with its dielectric constant= 4.4 and thickness of 1.5mm. The proposed antenna is then fabricated on the basis of the simulated design in HFSS simulation software. After fabricating the MSA, the fabricated results were taken and are shown in the paper. The simple structured configuration and low profile of the proposed antenna makes the fabrication process easy and also suitable for the application in the WLAN.

I. INTRODUCTION

Micro strip antenna was first introduced in the 1950s. However, the technology of Printed Circuit Board (PCB) was later introduced in 1970s.Therefore, from that time MSA had become a very common antenna having wide range of applications due to their advantages light weight, low profile, low cost, planar configuration and many more. MSAs are widely used in Radio-Frequency Identification (RFID), Broadcast radio, mobile systems, Global Positioning System (GPS), satellite communication, television systems, multiple-input multiple output (MIMO) systems, vehicle collision avoidance system, surveillance system, direction founding, radar systems, remote sensing, missile guidance, and so on . Because of micro strip patch antenna's many unique and attractive properties, there seems to be little doubt that it will continue to find many applications in the future. Its properties includes, light weight, low profile, easy fabrication, compact and conformability to mounting structure. In this design, we are concentrating on rectangular microstrip patch antenna which consists of rectangular patch of length [L1] and width [W2] of the patch. The proposed antenna works on the wireless local area network (WLAN) frequency of 2.4GHz (2400-2484MHz) which is based on IEEE 802.11b for WLAN applications . The Substrate material used is FR-4 Epoxy which has permittivity i.e. its dielectric constant.

II. SYSTEM OVERVIEW

The challenge for radiofrequency engineers is mainly to understand the complex systems starting with the transmitter and ending with the receiver. It is not enough to investigate only single components of the communications link. The antennas are an integral part of the MIMO system. MIMO systems exploit the multipath structure of the propagation channel. The antennas are adapted to the propagation channel. Correlations among channel coefficients are influenced by the antenna properties. As the antennas are collocated in a MIMO array, mutual coupling effects may occur. All these effects should be considered when designing an antenna array for MIMO systems. Therefore, a major concern in MIMO systems is the integration of several antennas into small handheld devices. Finding feasible antenna configurations is an integral part of enabling the MIMO technology. Microstrip geometries which radiate electromagnetic waves were originally contemplated in the 1950's where size, cost, performance, ease of installation, and aerodynamic profile were constraints, such as in the case of high-performance aircrafts, spacecrafts, satellites and missile applications. Presently, there are other government and commercial applications, such as mobile radio and wireless communications, which have similar specifications.

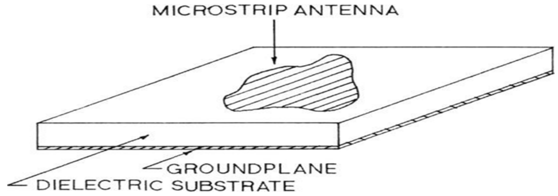

Fig 2.1. Patch Antenna

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A. Features of Microstrip Antenna

1) A very thin flat metallic region often called the patch
2) A dielectric substrate
3) A ground plane, which is usually larger than the patch
4) A feed, which supplies the element power.
5)

III. RECTANGULAR MICROSTRIP PATCH ANTENNAS

The rectangular microstrip patch antenna (RMSPA) is by far the most widely used configuration. Figure 4.1 shows the geometry of this antenna type. A rectangular metal patch of width $W=a$ and length $L=b$ is separated by a dielectric material from a ground plane by a distance h. The two ends of the antenna (located at 0 and b) can be viewed as radiating edges due to fringing fields along each edge of width $W=a$. The two radiating edges are separated by a distance $L=b$. The two edges along the sides of length L are often referred to as non-radiating edges.

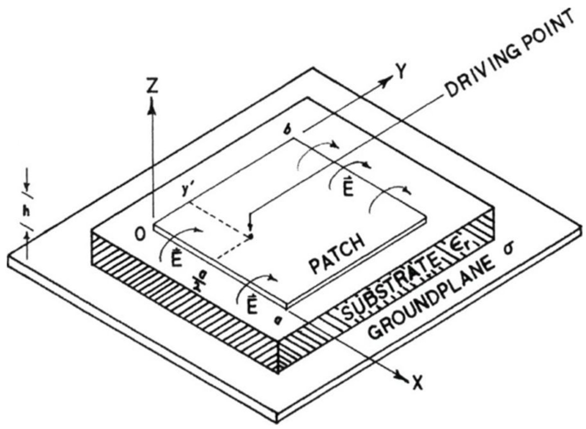

Fig 3.1. Geometry of RMSPA

We can identify three types of losses in MSPA. In the first place, the existence of a dielectric substrate over a conducting ground plane can cause the excitation of surface waves along the air-dielectric interface and within the substrate. These surface waves propagate parallel to the interface without attenuation and radiate some of their energy as the reach the microstrip discontinuity. A grounded dielectric layer always supports a finite number of surface wave modes, but since the lowest order TM-type mode has a zero cutoff frequency, a MSPA will, in general, always excite some surface-wave power. Except for very thin substrates, conductor and dielectric losses are quite small. The dielectric loss displays strong dependence on frequency and is independent of surface roughness, and can be minimized by choosing a low-loss substrate. The conductor losses, however, depend on frequency and substrate surface roughness, and are more difficult to control.

IV. ANTENNA SIMULATION

A. Software Used

All designs are simulated with *HFSS*^{TM} *v10* as in previous cases in this work. We have analyzed arrays of 2, 4 and 6 element.

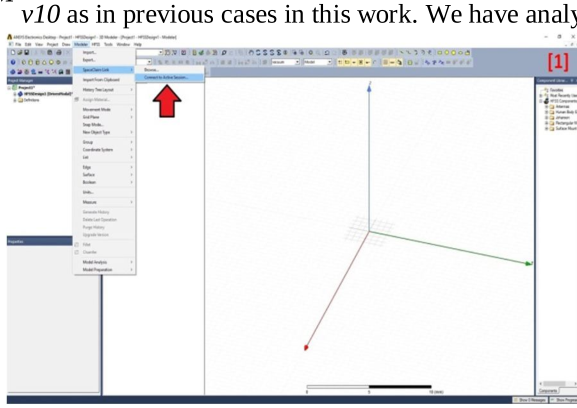

Fig 4.1. HFSS Step1

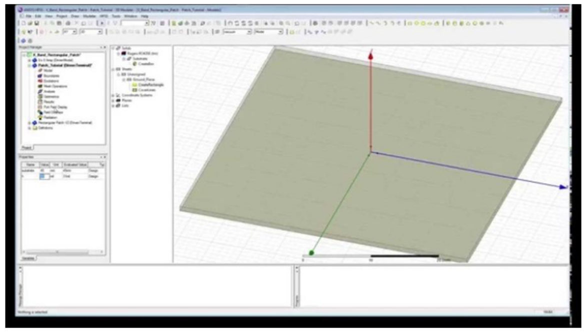

Fig 4.2. HFSS Step2

When we completed the design part of the proposed antenna we got the simulated results of the antenna which includes return loss (S11 parameter), VSWR, 2D radiation pattern as well as 3D radiation pattern. In fig. 5.4(a) we could observe that the designed antenna is providing -12.0505dB return loss at the resonant frequency of 2.4GHz. And in fig.5.4(b) we got voltage standing wave ratio with minimum value of 0.5550 at 2.3680GHz.

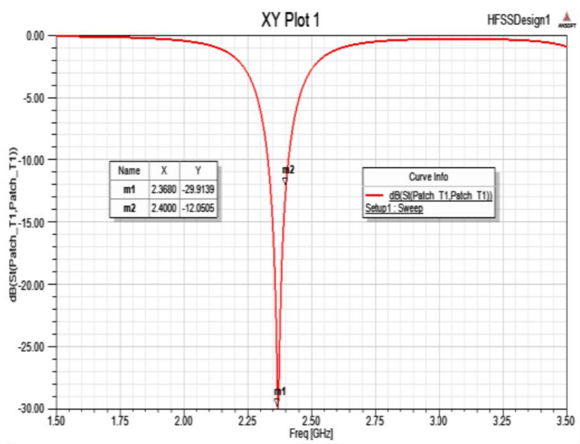

Fig 4.3 S11 Parameter

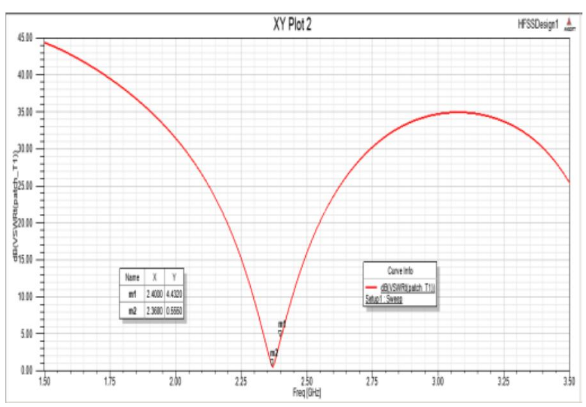

Fig 4.4. VSWR

Radiation pattern refers to the direction of the electromagnetic waves radiates away from the antenna. For these results we set the solution frequency to 2.4GHz for the maximum number of 15 adaptive solutions with maximum delta S of 0.02. The radiation pattern for the proposed antenna is omnidirectional and also this antenna can be used at WLAN application.

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V. FABRICATION PROCESS

A. Paint the design to black completely using any design software
B. Now, print the back footprint on a transparent film
C. Now, Laboratory part, 2 chemicals have been used. One for developing(developer) and the other for etching the copper (etcher).
D. Heat the etcher solution to max to max 20 minutes. Not more than that.
E. Now, cut the transparent printed image and draw marks of it's edges on the double sided copper clad material (i.e. double sided FR-4 substrate). Cut the FR-4 substrate with marked dimension.
F. Once the FR-4 is cut, remover the sticker from one layer
G. Now, attach the film on the top side of FR-4 substrate
H. The black part of the film acts as a shielding mask during the photo exposure process
I. The area that is masked will maintain it's photoresist properties and eventually will protect copper from etching. So mask it at boundaries
J. The masked FR-4 is inserted in UV light Exposure (The proper surface should face the light). UV exposure should last for only 2 minutes not more than that.

It should be kept at value of 125.

Now, you will get impression of what was printed on transparent paper onto the substrate. Remove the sticker from ground plane of FR-4 substrate. Now, the chemical process starts :

Insert board in the developer. Keep the board in developer tank for 1 minute i.e. 60 seconds.

VI. CONCLUSION

The proposed antenna is having the return loss of -12.0505 dB at 2.4GHz. The designed MSA has been simulated on HFSS simulation software. Also for this antenna a sufficient bandwidth is introduced via the microstrip feed line at the desired resonant frequency of 2.4GHz is achieved. As mentioned above the designed MSA is optimized such that it covers WLAN. The proposed antenna is a low profile antenna thus it is very compact, easy to fabricate and is fed by a microstrip feed line which makes it an attractive structure for current as well as future WLAN applications. The fabrication process is easy and cost effective. As observed the fabricated results are much finer as compared to the simulated one.

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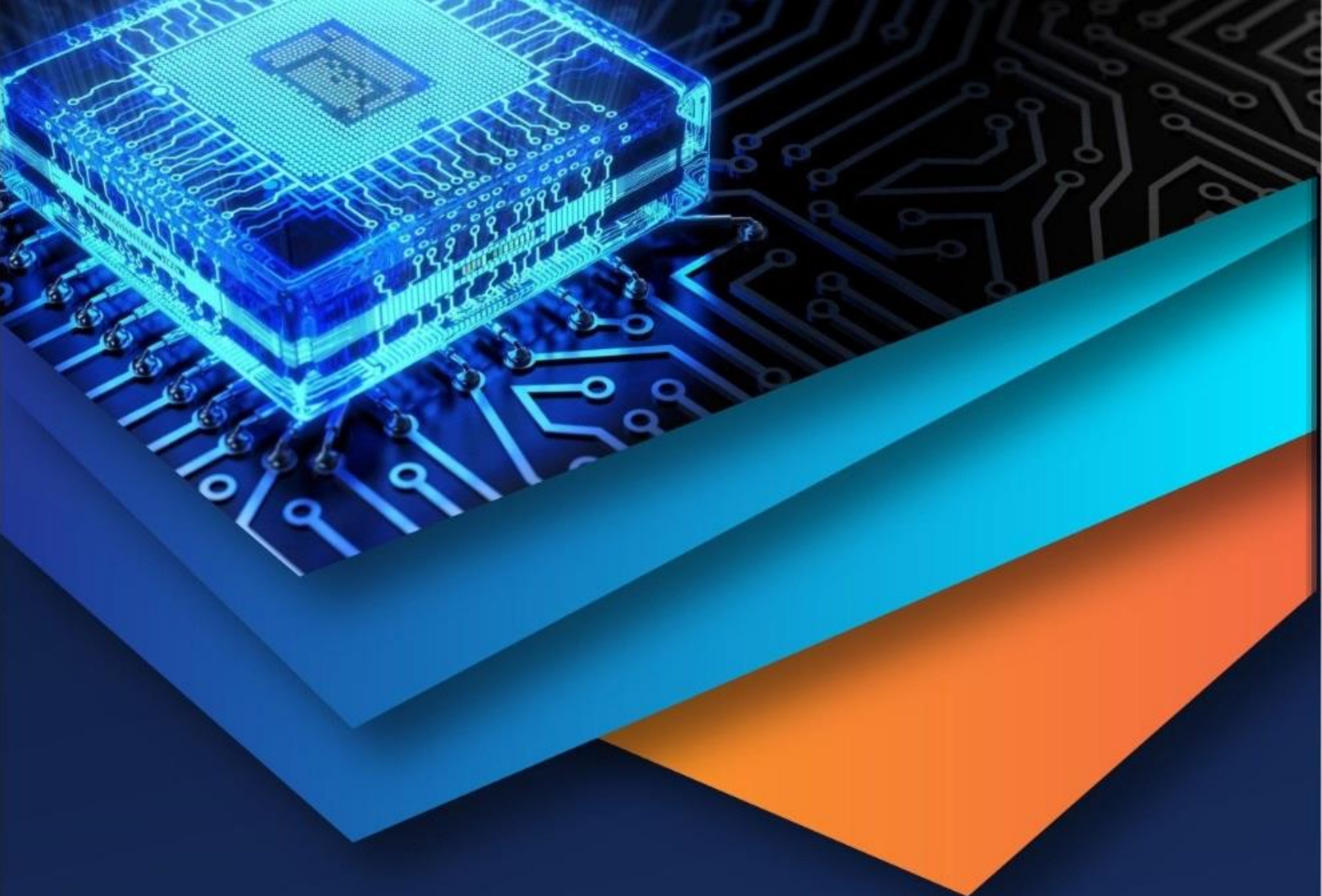

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