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Analysis and Designing of E-Shape Micro strip Patch Antenna for MIMO Application

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Abstract— In this paper design and analysis of E-shaped microstrip patch antenna is given that can be used for various MIMO applications. The frequency band selected for design is 2.4GHz ISM Band. E-Shape patch was selected for the application as it is less vulnerable to interference when several antenna elements are placed adjacent to each other to form an array in multiple antenna system. The proposed E-shaped patch antenna is intended to be applied for WLAN operating in 2.4 GHz band in MIMO environment.

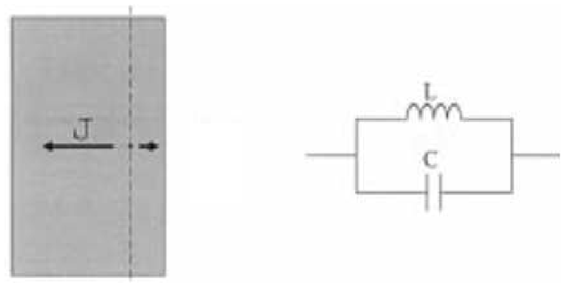
***Index Terms*—E-shaped patch, MIMO, Mutual coupling, Return loss.**

I. INTRODUCTION

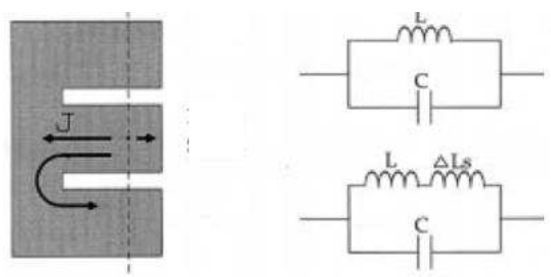
The antenna is usually the last element considered when designing RF equipment. However, in a wireless link environment, the transmitting and receiving antenna are directly involved to achieve the desired overall performance. An important feature is the property of reversibility; the same antenna can be used with the same characteristics as a transmitter or as a receiver antenna. An antenna is characterized by its centre frequency, bandwidth (BW), polarization, gain, radiation pattern and impedance. In recent years, the current trend in commercial and government communication system has been to developed low cost, minimal weight, low profile antennas that are capable of maintaining high performance over a large spectrum of frequencies. This technological trend has focused much effort into the design of Microstrip (patch) antennas. With simple geometry patch antennas offer many advantages not commonly exhibited in other antenna configurations. For example, they are extremely low profile, lightweight, simple and inexpensive to fabricate using modern day printed circuit board technology, compatible with microwave and millimeter-wave integrated circuits (MMIC), and have the ability to confirm to planar and non planar surfaces Multiple-input-multiple-output technology is a generic term used to describe techniques proposed to improve capacity, bandwidth efficiency or data rates for the next generation wireless communication systems [2]. Recent studies have shown that the multiple input multiple output (MIMO) system is a promising solution to cater to the growing demands for a higher data rate, higher capacity and a more spectrum efficient wireless communications system This has led to extensive work to design antennas that can optimize the MIMO system performance. The E-shaped Patch antenna is less vulnerable to Interference when several antenna elements are placed adjacent to each other to form an array in multiple antenna system.

II. PERFORMANCE FEATURES OF E-SHAPED PATCH ANTENNAS

The topological shape of the patch resembles the letter "E" hence the name E-shaped patch antenna. Significant reduction of antenna size can be realized when the E-shaped patch is used instead of the conventional rectangular microstrip patch antenna. The slot length and width are important parameters in controlling performance of the E-shaped patch antenna. The slot length and width of the antenna should be carefully selected to get the optimized performance of the E-shaped patch antenna.



"(a)"



"(b)"

Fig. 1: (a) Equivalent circuit for normal patches (b) Equivalent circuit for E-shaped patch

The ordinary microstrip patch antenna can be modeled as a simple resonant LC circuit as in figure 1(a). Currents flow from the feeding point to the top and bottom edges and C values are determined by these currents path length. When two slots are incorporated into the patch, the resonant feature changes, as shown in figure1 (b). In the middle part of the patch, the current flows like normal patch. It represents the initial LC circuit and resonates at the initial frequency. However, at the edge part of the patch, the current has to flow

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around the slots and the length of the current path is increased. This effect can be modeled as an additional series inductance Δ Ls. So the equivalent circuit of the edge part resonates at a lower frequency. Therefore, the antenna changes from a single LC resonant circuit to a dual resonant circuit.

III. ANTENNA DESIGN

The E-shape microstrip patch antenna has been designed with over all dimensions W (mm) x L (mm) [1].The designing of E-shaped microstrip patch antenna, the resonant frequency = 2.4 GHz and the dielectric substrate Epoxy resin i.e. FR-4 material is used for fabrication. The dielectric constant of the substrate is = 4.4 and thickness of the substrate h = 1.6mm to design the E-shaped microstrip patch antenna. The width and length of the microstrip antenna are determine as follows.

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

Where C is the free-space velocity of light.

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}}$$

Where the dimensions of the patch along its length have been extended on each end by a distance *ΔL*, which is a function of the effective dielectric constant ε_{reff} and the width to- height ratio (*W/h*), and the normalized extension of the length, is

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

The actual length of the patch (L) can be determine as

$$L_{eff} = \frac{C}{2 f_r \sqrt{\varepsilon_{reff}}}$$

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

By cutting two symmetrical parallel slots into the rectangular microstrip antenna, it became an E-shaped patch. The slot width Ws and slot length Ls was varied to get the optimized results at the desire frequency. The center arm of E shaped patch was further trimmed to shift the frequency to the desired frequency range. Two separate square slots were employed at the corner of E shaped patch for further optimization of the antenna. By varying the feed location, the value of resistance was controlled such that it matched the characteristic impedance of the coaxial feed.

IV. GEOMETRY OF THE E-SHAPED PATCH ANTENNA

The geometry of E-shape microstrip antenna as shown in figure 2.All the dimensions such as patch length, width, slot length, slot width are shown for the optimized E-shaped patch antenna.

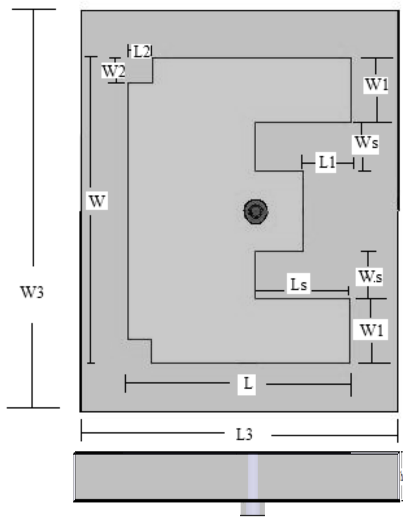

Fig. 2. Top view and side view of proposed E shaped patch antenna

The dimensions of the E-shape microstrip patch antenna at operating frequency 2.4GHz as shown in Table 1. The slot length Ls and slot width Ws are selected such that to get the optimized performance of the E-shaped patch antenna.

Table 1. Dimensions of the Optimized Antenna

Frequency (f_r)	2.4GHz
W	38mm
L	28mm
W3	50mm
L3	40mm
Ws	6mm
Ls	12mm
W1	8mm
W2	3mm
L2	3mm
Dielectric(ε_r)	4.4
Thickness(h)	1.6mm

V. RESULTS

The antenna is simulated & designed using Ansoft's HFSS 11.1v. HFSS stands for High Frequency Structure Simulator. The software is based on FEM method, in this method large structures are converted into number of triangular, pyramidal or trapezoidal shape structure for ease of analysis. The results for fabricated antenna are found by Agilent's network analyzer E5062A the simulated & measured results are compared below.

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A. The return Loss for 2.4 GHz centre frequency using simulation of antenna design was found to be -32.76 dB.

Whereas experimentally it was -24.06dB

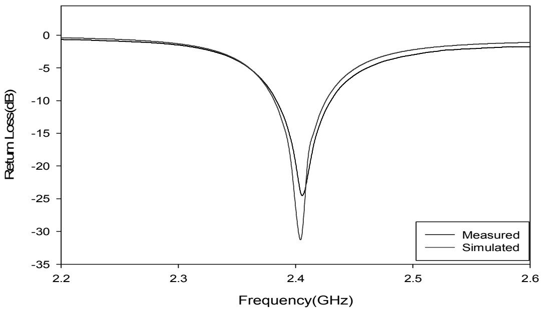

Fig. 3.Simulated and measured Return Loss for the proposed Antenna

Results are quite satisfactory with agreement between measured and simulated data.

Voltage Standing Wave Ratio (VSWR): Source generates the signal towards antenna; some waves are reflected back to source along with traveling waves. These constructive and destructive waves create standing waves. A pattern is shown below Fig 4.

B. The VSWR bandwidth is measured for 2dB below frequency response of an antenna. It is found to be 1.05 at 2.405 GHz from simulation and 1.09 at 2.405 GHz from experiment. Using simulation result we have 50 MHz VSWR bandwidth for center frequency 2.4 GHz & Where a from experimental set up we have 60 MHz VSWR bandwidth for center frequencies 2.4 GHz Figure 6.3 shows comparison of simulated & experimental results for MSA.As the single element is going to be use in array the overall bandwidth can be improved

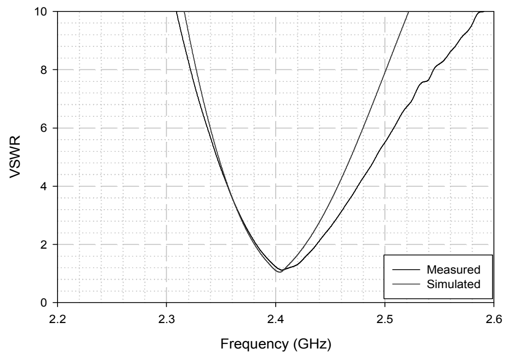

Fig 4: Simulated and measured VSWR for the proposed Antenna

VI. CONCLUSION

This paper presents the analysis and designing of E-shaped patch antenna intended to be used for MIMO application at 2.4 GHz operating frequency. The simulation of the proposed design was done through Ansoft's HFSS simulation software. The fabricated antenna was tested with Agilent's network analyzer E5062A.The simulated and measured results were compared and were found to be good agreement with each other.

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