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Design of Multifunctional Microstrip Patch Antenna for Linear Polarization by using HFSS13

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Abstract– This paper proposes the design of multifunctional microstrippatch antenna for Wireless applications. The proposed antenna is suggested to be used in a mobile phone handset that covers dual frequency bands which include GSM 1900(1850-1990MHz) and Bluetooth(2400-2483.5MHz).The simulation of the antenna is performed using a High Frequency Structure Simulator(HFSS) software. Analysis for return loss, VSWR, gain and radiation pattern were carried out. The proposed antenna shows return loss of -34dB at 1.9GHz(Horizontal polarized) and -24dB at 2.4GHz(Vertical polarized) which implies good results. The impedance matching is good at the desired frequencies with VSWR < 2 respectively. The overall simulation results shows that the antenna worked well at the desired two frequencies and hence making the antenna suitable for use at same time for wireless applications. This antenna is implemented on FR4 Epoxy dielectric substrate with relative permittivity $\in rr$=4.4, thickness of the substrate h = 1.6mm.

Keywords– Microstrip Patch Antenna, Dual patch, Multifunctional, Linear Polarization, Coaxial Feed, HFSS

I. INTRODUCTION

With the ever-increasing need for mobile communication and the emergence of many systems, it is important to design broadband antennas to cover a wide frequency range. The design of an efficient wide band small size antenna, for recent wireless applications, is a major challenge. A microstrip patch antenna is a low profile antenna that has a number of advantages over other antennas that is lightweight, inexpensive, and easy to integrate with accompanying electronics [1] .Microstrip antennas are characterized by a larger number of physical parameters than conventional microwave antennas. Microstrip antennas are one of the most widely used types of antennas in the microwave frequency range. The huge application of wireless communication require an antenna to be operated with more than one operating frequency, that is why multifunctional feature is more desirable and that is achieved by introducing two patch at appropriate position. Microstrip patch antennas consist of a metallic patch that is on the top of a grounded dielectric substrate of thickness h, with relative permittivity and permeability ε_r and μ_r (usually $\mu_r = 1$).

In this paper, a rectangular shape patch antenna is chosen because it is easy to analyze using both the transmission line model and cavity models, which are most accurate for thin substrate. It required more radiating area than circular microstrip antenna and efficiency of rectangular microstrip patch antenna is superior as compare to circular microstrip antenna. In order to provide power supply to the antenna, coaxial feeding technique is used here. The main advantage of this type of feeding technique is that the feed can be placed at any desired position inside the patch in order to obtain impedance matching. This feeding method is easy to fabricate and has low spurious radiation effect. This antenna is designed on a Fiber Reinforced (FR-4) epoxy substrate. We used linear polarization i.e. for 1.9 GHz horizontal polarization and for 2.4 GHz vertical polarization and its performance characteristics which include Return Loss, VSWR and input impedance are obtained from the simulation in Ansoft's HFSS 13. The position of microstrip patches is adjusted to improve parameters

II. DESIGN METHODOLOGY

The rectangular microstrip patch antenna has dimensions 120mm x 80mm .The FR4-epoxy substrate [$\in_r$] used is 4.4 with dielectric loss tangent of 0.002, having thickness of 1.6mm. The value$\in_r$ is chosen such that it gives better efficiency. For this design dielectric loss tangent of 0.002 is used. Generally, substrate materials have many categories in accordance with their dielectric constant but for this design, 4.4 is used. Much higher value can significantly reduce the antenna's radiation efficiency and also its bandwidth [1].There are different methods that can be used in the design of multifunctional microstrip antenna. In this paper coaxial feeding technique is used simply because the feed can be placed at the desired position or location inside the patch to match its impedance. The architecture of the proposed antenna design using high frequency structure simulator software (HFSS) which starts with a conventional microstrip patch. This consists of an active radiating patches on one side of a dielectric substrate and the other side consists of ground plane. For multifunction purpose, one patch is kept horizontal for horizontal polarization and one is rotated to 90 degree in order to obtain vertical polarization. A & B are the feeding points as shown in fig 1.

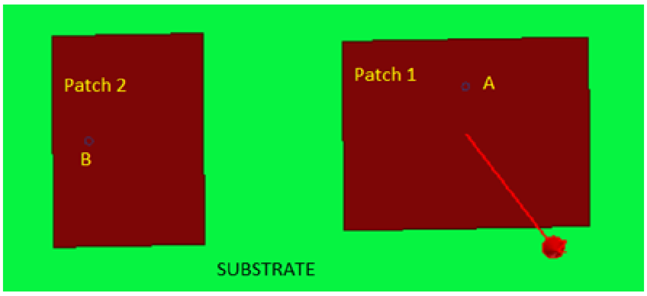

Fig 1: Simulation of Microstrip patch antenna[3].

III. PHYSICAL PARAMETERS OF ANTENNA

The different parameters of this antenna can be calculated by the transmission line method[2].

Step 1: *Width of the Patch*

The width of the patch can be determined by

$$W = \frac{C}{2f_0\sqrt{\frac{\epsilon_r+1}{2}}}$$

Where, C is velocity of light, f_o is Resonant Frequency & $\varepsilon_r$is Relative Dielectric Constant

W_A =38mm; W_B =48mm

Step 2*: Length of patch*

Effective length of the patch can be calculated as -

$$L_{eff} = \frac{C}{2f_0\sqrt{\epsilon_r}}$$

The effective constant can be obtained by -

$$\varepsilon_{eff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]$$

Where,

ε_{eff} = Effective dielectric constant

ϵ_r = Dielectric constant of substrate

h = Height of dielectric substrate

W = Width of the patch

The dimensions of the patch along its length extended on each end by a distance ΔL, which is given by

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

The actual length L of the patch is given as$L = L_{eff} - 2\Delta L$

L_A = *28.34mm;* L_B =*34mm*

Table I: Design Parameters of Antenna

S.N	**Design Material**	**Values (mm)**
1	Substrate	120 x 80
2	Ground	120 x 80
3	Patch 1 (Horizontal)	44 x 34
4	Patch 2 (Vertical)	27 x 38
5	A and B	CoaxialConnectors

IV. POLARIZATION

The polarization of an antenna refers to the orientation of the electric field in radio wave with respect to the Earth's surface and is determined by the physical structure of the antenna. There are two polarization techniques are discuss here.

A. Circular polarization

Circularly polarized light consists of two perpendicular electromagnetic plane waves of equal amplitude and 90° phase difference. The light illustrated is right- circularly polarized. If light is composed of two plane waves of equal amplitude but differing in phase by 90°, then the light is said to be circularly polarized. If the electric vector of light coming towards you appear as rotating in counterclockwise direction then the light is said to be right-circularly polarized else the light is said to be left-circularly polarized light [7]

B. Linear polarization

The orientation of a linearly polarized electromagnetic wave is defined by the direction of the electric field vector. For example, if the electric field vector is vertical (alternately up and down as the wave travels) the radiation is said to be vertically polarized[4].

- *Horizontal Polarization* - Horizontally polarized antennas have their electric field parallel to the Earth's surface. Horizontally polarized signals oscillate from left to right. At low frequencies horizontally polarized waves not only parallel to the earth surface but also touches to it. Since the earth acts as a good conductor at low frequencies, it shorts some of the frequencies and prevents the signals from traveling very far.
- *Vertical Polarization* - An antenna is vertically polarized when its electric field is perpendicular to the Earth's surface. Vertically polarized signals oscillate from top to bottom. Signals are transmitted in all directions. Therefore vertical polarization is used for ground-wave transmission, allowing the radio wave to travel a considerable distance along the ground surface with minimum attenuation.

V. FEEDING TECHNIQUES

Microstrip patch antennas can be fed by a variety of methods. These methods can be classified into two categories- contacting and non-contacting. In the contacting method, the RF power is fed directly to the radiating patch using a connecting element such as a microstrip line. In the non-contacting scheme, electromagnetic field coupling is done to transfer power between the microstrip line and the radiating patch. The four most popular feed techniques used are the microstrip line, coaxial probe (both contacting schemes), aperture coupling and proximity coupling (both non-contacting schemes).

A. Microstrip Feed Line

In this type of feed technique, a conducting strip is connected directly to the edge of the microstrip patch as shown in figure. The conducting strip is smaller in width as compared to the patch. This kind of feed arrangement has the advantage that the feed can be etched on the same substrate to provide a planar structure

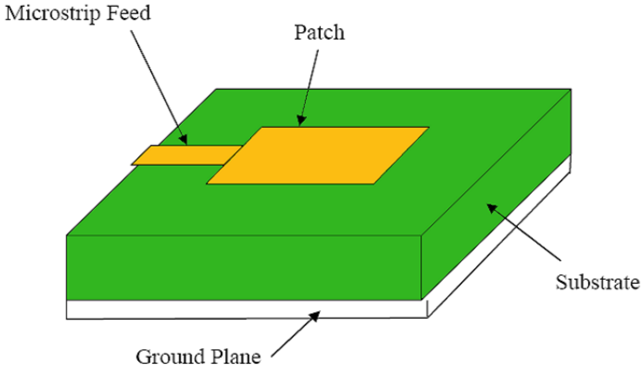

Fig. 2: Microstrip feed line

B. Aperture Coupled Feed

In aperture coupling as shown in figure 2.4 the radiating microstrip patch element is etched on the top of the antenna substrate, and the microstrip feed line is etched on the bottom of the feed substrate in order to obtain aperture coupling. The thickness and dielectric constants of these two substrates may thus be chosen independently to optimize the distinct electrical functions of radiation and circuitry. The coupling aperture is usually centered under the patch, leading to lower cross-polarization due to symmetry of the configuration. The amount of coupling from the feed line to the patch is determined by the shape, size and location of the aperture. Since the ground plane separates the patch and the feed line, spurious radiation is minimized

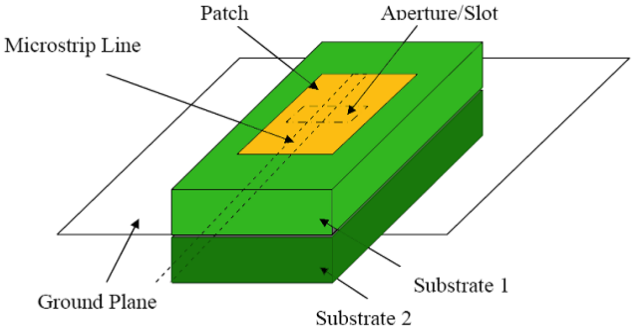

Fig. 3: Aperture feeding

The major disadvantage of this feed scheme is that it is difficult to fabricate because of the two dielectric layers that need proper alignment. Also, there is an increase in the overall thickness of the antenna.

C. Coaxial Feeding technique

The Coaxial feed or probe feed is one of the most common techniques used for feeding microstrip patch antennas. As shown in figure 2, the inner conductor of coaxial connector extends through the dielectric and is soldered to the radiating patch, while outer conductor is connected to the ground plane.

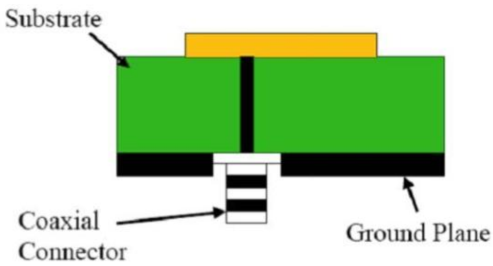

Fig. 4: Coaxial feed Technique

The main advantage of this type of feeding scheme is that feed can be placed at any desired position inside the patch in order to obtain impedance matching. This feed method is easy to fabricate and has low spurious radiation effects. However, its major disadvantage is that it provides narrow bandwidth and is difficult to model since a hole has to be drilled into the substrate. Also, for thicker substrates, the increased probe length makes the input impedance more inductive, leading to matching problems. We used thick dielectric substrate in improvement of bandwidth. Coaxial feed has different challenges such as spurious feed radiation [7].
The inner and outer radius of co-axial probe is 0.65 mm and 1.5 mm respectively. Proper impedance matching always yields the best desired result.

VI. SIMULATION RESULTS

The proposed multifunctional patch antenna as shown in figure1 simulated using HFSS Software. The details of the resonant frequencies are as shown in the table II.

Table II: Results from simulation

Frequency (GHz)	Return Loss (dB)	VSWR (dB)
1.9	-34.81	1.03
2.4	-24.88	1.12

Return loss is a convenient way to characterize the input and output of the signal sources .when the load is mismatched all the available power from generator should not be delivered to the load. Figure 3 shows the different simulated performance parameter. Fig. 3 shows the simulated results of scattering parameters [S11 and S22 in dB] i.e. reflection coefficient of proposed antenna. S11 gives the reflection coefficient at port 1 where we apply the input to the microstrip patch antenna and S22 gives the reflection coefficient at port 2 where we apply the input to the microstrip patch antenna. It should be less than -10 dB for the acceptable operation. This reflection coefficient value suggests that there is good matching at the frequency point below -10 dB region. A negative value of return loss shows that, this antenna may not have many losses while transmitting the signals. The designed antenna resonates at 1.9GHz and 2.4GHz. The values of return loss at center frequencies of 1.9GHz and 2.4GHz are -34.81dB and -24.88dB respectively as shown in the figure5. The VSWR is a measured of how well matched antenna is to the cable impedance. A perfectly matched antenna would have a VSWR of 1:1 which indicates how much power is reflected back or transferred into the cable. The voltage standing wave ratio obtained from the simulations are 1.03dB at 1.9GHz and 1.12dB at 2.4GHz. Under normal condition the voltage standing wave ratio should be < 2. The obtained result is considered to be desired one if level of mismatched is not very high. A high value of VSWR implies that the port is not properly matched.
The radiation pattern for E and H-plane of the antenna at center frequencies of 1.9GHz and 2.4GHz are shown in figure 6. It is observed that from the radiation pattern the designed antenna has good radiation pattern throughout the operating frequency bands. Additionally, for this design smith chart showing s11 parameter at the Centre frequencies.

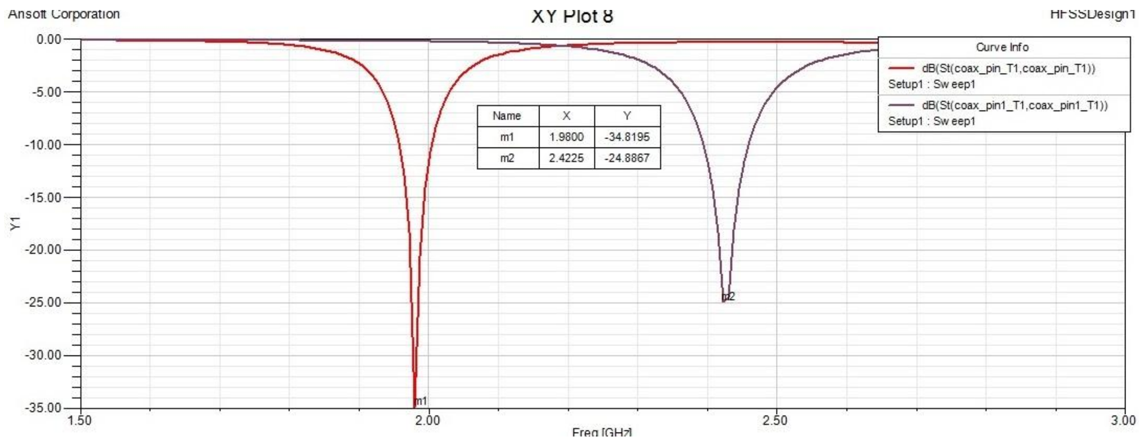

Fig.5: S11 and S22 indicating return losses

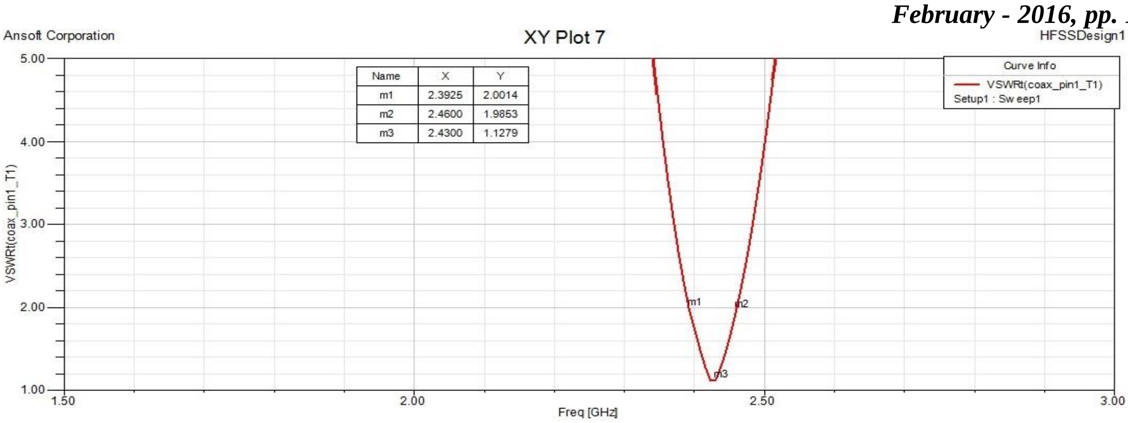

Figure 4: VSWR for 2.4 GHz

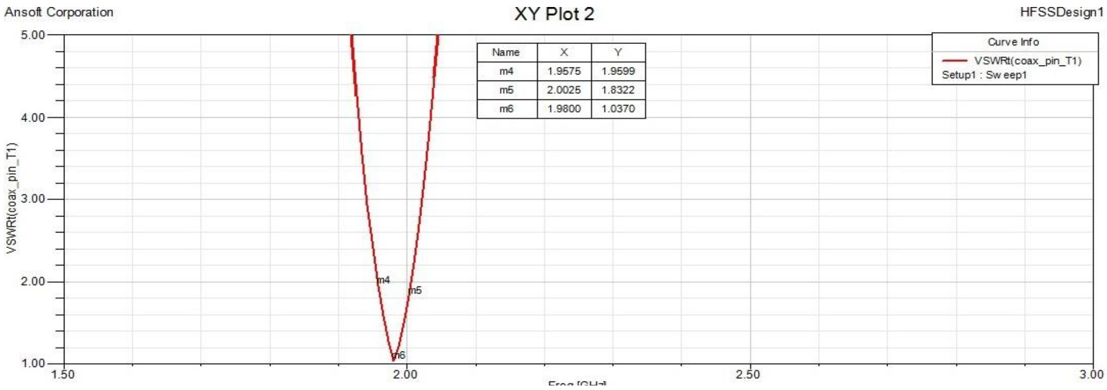

Figure 5: VSWR for 1.9 GHz

VII. CONCLUSION

The Design of multifunctional microstrip patch antenna for wireless applications has been proposed. It is observed that the proposed antenna can effectively operates in two frequency bands for the range of GSM (1900MHz) and Bluetooth (2400-2500MHz) .The location of the patch is optimized in such a way that the antenna can operate in two frequency at same time. All the parameters are said to be as the return loss, radiation Pattern, VSWR, results obtained are considered to be good and acceptable values. VSWR level of mismatched is low since the position of both the patches are properly matched so thenit is properly matched. From the result it is conclude that the different parameters such as return loss, radiation Pattern, VSWR associated with the antenna has desired values.

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