Rectangular Microstrip Patch Antenna Using Coaxial Probe Feeding Technique for 5.2 GHz WLAN Application

Abstract— In this paper, the design of a co-axial fed single layer microstrip patch antenna for 5.2 GHz WLAN application is presented. The radiation characteristics of this proposed structure are studied and analyzed using "CST Microwave studio V14", which is a commercially available electromagnetic simulator based on the method of finite difference time domain technique to achieve the desired specification. This antenna, based on a thickness of 2.4 mm Flame Retardant 4 (FR-4) substrate with a dielectric constant of approximately 4.3.The proposed antenna based on co-axial feed configuration has the maximum achievable bandwidth obtained about 350.2MHz (5.0408-5.391 GHz) at -10 dB reflection coefficient and the maximum achievable gain is 4.72 dB.

Index Terms— WLAN, Co-Axial Feed, Microstrip Patch Antenna (MSA), CST Microwave Studio

1. INTRODUCTION

As growth of wireless systems are increasing and demand for a variety of new wireless applications such as WLAN (Wireless Local Area Network), it is important to design broadband and high gain antennas to cover a wide frequency range. For recent wireless applications, the design of an efficient wide band small size antenna is a major challenge. In applications like high performance aircraft, satellite, missile, mobile radio and wireless communications, the major constraints are small size, low-cost fabrication, low profile, conformability and ease of installation and integration with feed networks.

Because of advancement of the technology, the requirement of an antenna to resonate at more than one frequency i.e. multi-banding is also increasing day by day. Microstrip patch antennas have more advantages and better prospects compared to conventional antennas, such as lighter in weight, low volume, low cost, low profile, smaller in dimension and ease of fabrication and conformity. Moreover, the microstrip patch antennas can provide frequency agility, broad band-width, feed line flexibility and beam scanning omni directional patterning. In its basic form, a microstrip Patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side as shown in Figure.1.1

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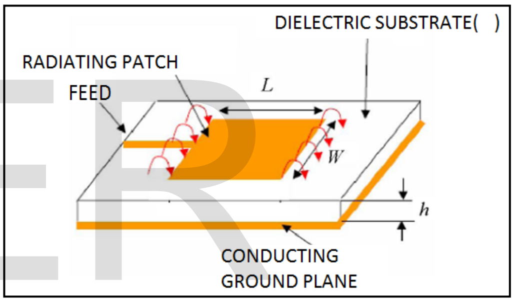


Figure 1: Microstrip patch antenna

The patch is normally 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. In order to simplify analysis and performance estimation, generally square, rectangular, circular, triangular, and elliptical or some other common shape patches are used for designing a microstrip antenna.

For a rectangular patch, the length L of the patch is usually $0.3333\lambda_o < L < 0.5\lambda_o$, where λ_o is the free-space wavelength. The patch is selected to be very thin such that $t \ll \lambda_o$ (where t is the patch thickness). The height h of the dielectric substrate is usually $0.003\lambda_o \leq h \leq 0.05\lambda_o$. The dielectric constant of the substrate (ε_r) is typically in the range $2.2 \leq \varepsilon_r \leq 12$. Microstrip patch antennas radiate primarily because of the fringing fields between the patch edge and the ground plane. For good performance of antenna, a thick dielectric substrate having a low dielectric constant is necessary since it provides larger bandwidth, better radiation and better efficiency. However, such a typical configuration leads to a larger antenna size. In order to reduce the size of the microstrip patch antenna, substrates with higher dielectric constants must be used which are less efficient and result in narrow bandwidth. Hence a trade-off must be realized between the antenna performance and antenna dimensions. But bandwidth of a microstrip patch antenna can be improved by various methods like cutting U-slot [1], increasing the substrate height, decreasing ε_r of substrate etc. Antenna array can also be used to improve the bandwidth [2]. Here, to start with, a simple microstrip patch antenna with coaxial feed is designed [3-4]

2. COAXIAL FEED TO MICROSTRIP ANTENNAS

The Coaxial feed or probe feed is one of the most common techniques used for feeding microstrip patch antennas. As seen from figure 1.2, the inner conductor of the coaxial connector extends through the dielectric and is soldered to the radiating patch, while the outer conductor is connected to the ground plane.

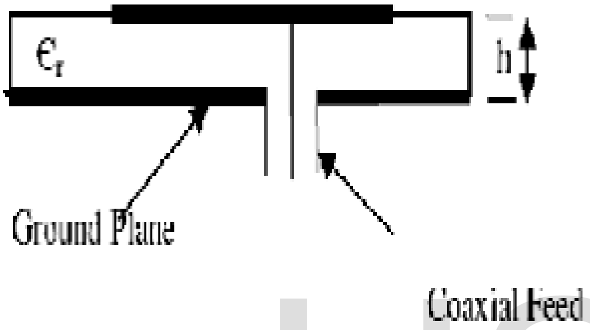


Figure 2: Coaxial feed Technique

The main advantage of this type of feeding scheme is that the 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. By using a thick dielectric substrate to improve the bandwidth the coaxial feed suffer from numerous disadvantages such as spurious feed radiation and matching problem. But the bandwidth can be improved by various methods written above. Recently many microstrip patch antenna for different applications with coaxial-feed have been presented [5-8].

3. ANTENNA DESIGN

Figure 3 shows the front view geometry and the designed structure of the designed microstrip patch antenna with single band operation for the WLAN band on the CST Microwave Studio software. The feed point location and the dimensions for the designed antenna has been optimized so as to get the better possible impedance match to the antenna. The antenna is excited by coaxial feed line designed for a 50 ohm characteristic impedance and is printed on substrate with a thickness of 2.3 mm, dielectric constant of 4.3 and loss tangent of 0.02. The dimensions of the proposed antenna are written below:

Dimensions of Rectangular patch antenna

Ground size =17.7 mm×12.9 mm

Substrate size =17.7mm×12.9mm

Patch size =8.85mm×6.45mm

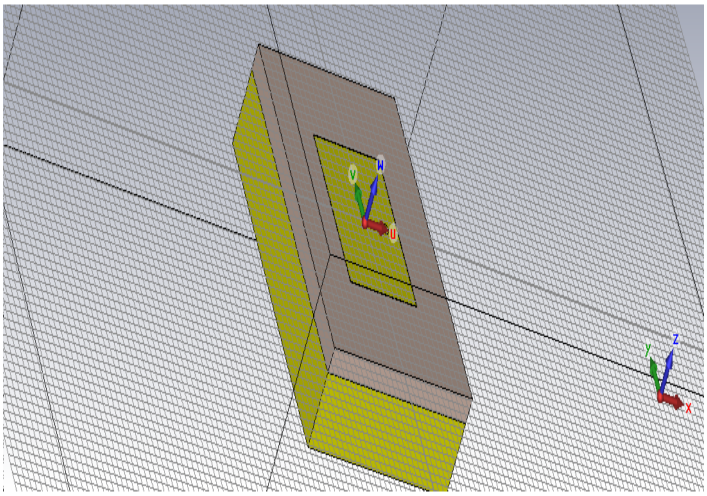


Figure 3: Front view of proposed microstrip patch antenna

The height of the ground which is beneath the substrate and made of FR-4 material is taken to be three times the thickness of substrate for simulation purposes i.e. 3×1.5748 mm and of the patch which is also made of material copper is 0.02mm. The outer conductor (from bottom of ground to top of ground) is made of substrate material and inner conductor (from bottom of ground to top of patch) is made of copper . The inner and outer radius of co-axial probe is 1.2 mm and2 mm respectively. Proper impedance matching always yields the best desired result.

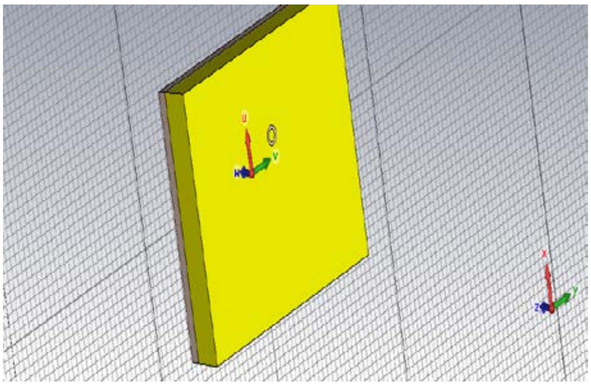


Figure 4: Bottom view of the proposed microstrip patch antenna

As the proposed antenna is coaxial fed so, we can view outer and inner conductor of the coaxial feed line very clearly in Figure 4..

4. SIMULATION RESULTS

Return loss is a convenient way to characterize the input and output of the signal sources or when the load is mismatched, not all the available power from generator is delivered to the load. Figure 5 shows the simulated reflection coefficient [S_{11}] of the proposed antenna in dB. S_{11} gives the reflection coefficient at port 1 where we apply the input to the microstrip patch antenna. It should be less than -10 dB for the acceptable operation. It shows that the proposed antenna resonates at frequency equal to 5.212 GHz .The simulated impedance bandwidth of about 350.2 MHz (5.0408-5.391 GHz) is achieved at -10 dB reflection coefficient (VSWR≤2). The reflection coefficient value that is achieved at this resonant frequency is equal to -23.154 dB. This reflection coefficient value suggests that there is good matching at the frequency point below the -10 dB region. A negative value of return loss shows that this antenna had not many losses while transmitting the signals.[9]

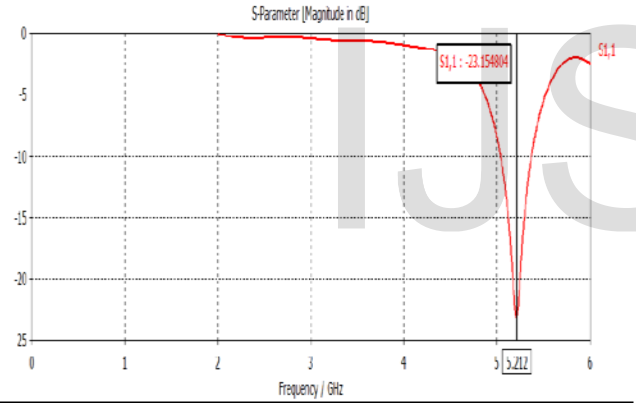
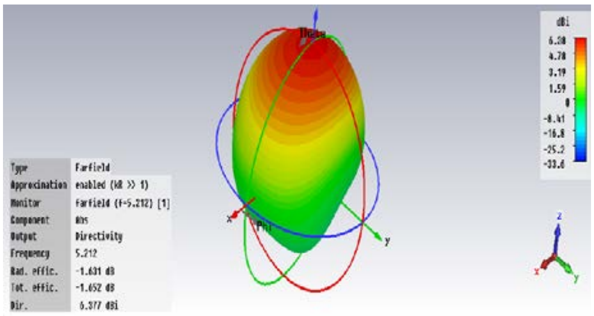


Figure 5: Simulated reflection coefficient [S11] of the proposed microstrip patch antenna

The directivity is dependent only on the shape of the radiation pattern [9] .Figure 6 shows the simulated 3-D radiation pattern with directivity of 6.38 dBi for proposed antenna configuration at the resonating frequency of 5.212 GHz.



Type	Farfield
Approximation	enabled (kR >> 1)
Monitor	farfield (f=5.212) [1]
Component	Abs
Output	Directivity
Frequency	5.212
Rad. effic.	-1.631 dB
Tot. effic.	-1.652 dB
Dir.	6.377 dBi

Figure 6: 3D Radiation pattern for fr=5.212 GHz

Figure 7 shows the VSWR (voltage standing wave ratio) plot for the designed antenna. The value of VSWR should lie between 1 and 2. SWR is used as an efficiency measure for transmission lines, electrical cables that conduct radio frequency signals, used for purposes such as connecting radio transmitters and receivers with their antennas, and distributing cable television signals. Here the value of the VSWR for the proposed microstrip patch antenna is 1.149at the specified resonating frequency. The achieved values of reflection coefficient and VSWR are small.

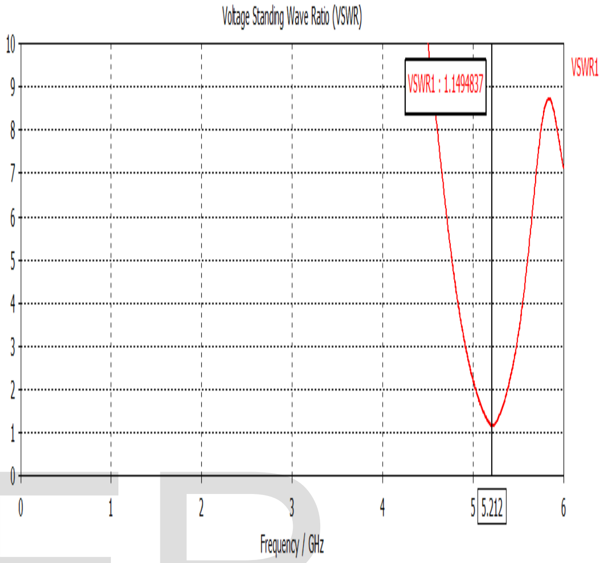
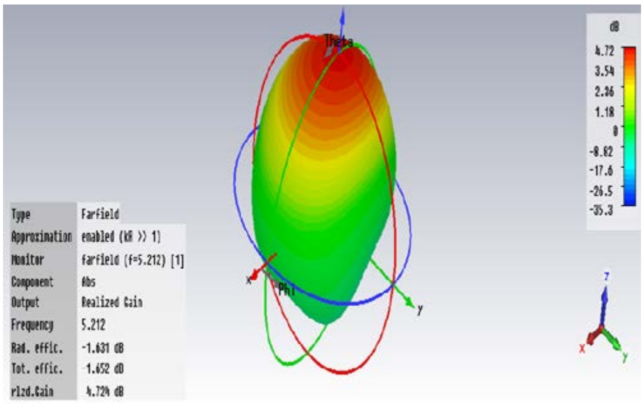


Figure 7: VSWR plot for the proposed microstrip patch antenna

Basically, the gain is the ratio of the radiated field intensity by test antenna to the radiated field intensity by the reference antenna. Antenna gain, usually expressed in dB, simply refers to the direction of maximum radiation [9] The maximum achievable gain is 4.72 dB at the resonating frequency of 5.212 GHz which is shown in figure 8.



Type	Farfield
Approximation	enabled (kR >> 1)
Monitor	farfield (f=5.212) [1]
Component	Abs
Output	Realized Gain
Frequency	5.212
Rad. effic.	-1.631 dB
Tot. effic.	-1.652 dB
rlzd.Gain	4.724 dB

Figure 8: Gain for the proposed microstrip patch antenna

5. DISCUSSION

The proposed antenna is designed to operate at 5.212 GHz WLAN frequency band which corresponds to IEEE 802.11a (5.0408-5.391 GHz) WLAN application. The reflection coefficient achieved at the resonant frequency is equal to -23.154. It can be noticed that acceptable broadside radiation pattern is obtained at the resonating frequency of 5.212 GHz. In this proposed design a gain of 4.72 dB has been investigated for the frequency of 5.212 GHz. The value of gain is not good enough for an acceptable operation. We can further analyze this designed structure by cutting different slots on the patch.

6. CONCLUSION

The designed single band microstrip patch antenna is operating in the frequency band of 5.0408 GHz - 5.391 GHz covering 5.2 GHz WLAN communication standard. The proposed antenna exhibits a bandwidth of about 350.2 MHz (5.0408-5.391 GHz) at -10 dB reflection coefficient which corresponds to 5.2 GHz WLAN standard The resultant gain of desired antenna is 4.72 dB which is not so good but it can be increased by using gain enhancement techniques and the directivity of the proposed antenna is 6.38 dBi which shows that the antenna radiates in omni-directional nature.

7. REFERENCES

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