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Microstrip patch Antenna for Low Power Transceiver application

M. Nikitha[1], E. Priya dharshini[2], S. Rajaalakshmi[3], C. Balamurugan[4]

[1,2,3]UG Student Department of Electronics and Communication Engineering, National Engineering College, Kovilpatti – 628 503,Tamil Nadu.
[4]Professor, Dept. of Electronics and Communication Engineering, National Engineering college, Kovilpatti-628 503, Tamil Nadu.

Abstract - *In this paper the design and development of a compact microstrip patch antenna for bandwidth improvement and antenna size reduction in a single design is proposed. The well-known technique of effective substrate thickness increment is performed to improve the impedance bandwidth, whereas for size reduction the electrical length of the conducting patch has been increased. In this design, FR4 substrate is used as a dielectric medium for the patch antenna which is low cost and highly efficient. The microstrip patch antenna for 5G mobile communication is reviewed from intensive literature survey and design specifications for proposed frequency band were discussed and Patch antenna to work 9 GHz is designed and simulated using HFSS tool and results were discussed.*

***Key Words*: Microstrp patch antenna, FR4 substrate, Antenna performance, Return loss, VSWR, Radiation characteristics.**

1. INTRODUCTION

In this fifth generation of wireless communication, primary objective is to provide high data rare, reduced latency, increased spectrum efficiency…etc. in such wireless communication antenna plays an important role. For 5G applications antenna and signal processing units are combined to in order to provide the better quality of service with reduction in battery usage and compact structure. To satisfy the above said requirement, microstrip patch antenna is preferred to operate in high frequency range. Broadband microstrip patch antenna is also preferred in broadband application such as transceiver to receive signal from different frequency band of S, C and UWB. Microstrip antenna basically narrow band antenna when shape of the radiating element is simple rectangle and can be converted into wideband by changing the antenna structure. Design parameter of the microstrip patch antenna such as dielectric constant and proposed resonance frequency plays significant role in antenna miniaturization without reduction in performance. The desired range of dielectric constant is from 2.2 to 12 for designing narrowband microstrip patch antenna.

2. LITERATURE SURVEY

Many researchers have proved that patch antenna can also be designed with magneto-dielectric materials without reduction in performance.

Zhenya LI et. Al done a research on CPW fed ultra-wideband slot antenna with broadband dual circular polarization and proved that broadband characteristics of the patch antenna can be obtained using CPW feeding and slot based patch antenna structure. Nadeem Asraf et. Al researched on optimized broadband and dual band printed slot antenna for future millimeter wave mobile communication and achieved broadband impedance bandwidth of more than 20 GHz . Microstrip antenna using silver nano particle printed on polyethylene terephthalate (PET) was proposed by J.Matyas et al . antenna is operated in two different frequency band. Substate is printed by inkjet printer FUJIFILM Dimatrix DMP 2800. Ink is prepared by conditioning silver layer into nano paticle in nytrozen (N2) atmosphere condition. Nano particle is further conditioned to achieve good dispersion. After that antenna was successfully printed on the PET substrate. Author proved that better impedance matching is provided at 2.02 GHz and 2.3 GHz with acceptable return loss.

3. PROPOSED WORK

In this proposed work FR4 substrate is chosen for the fabrication since it has the advantages of low cost and high efficiency with miniature in size. As a part of the proposed work, Microstrip patch antenna to work in 9GHz was designed and simulated for the following specifications shown in table 1.

Particulars	Dimension in mm
width of the patch	10.14
Length of patch	7
Thickness of substrate	1.6
Quarter wave feed length	8.33
Quarter wave feed width	0.5
Edge feed length	2.1
Edge feed width	2.8
Ground length	29.34
Ground width	26.2
Dielectric constant	4.4
Loss tangent	0.008

Transmission line model is used to design the microstrip patch antenna to work at 9 GHz as mentioned below,

$$w = \frac{c}{2f_{0}\sqrt{\frac{\varepsilon_r+1}{2}}} \qquad (1)$$

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

$$L = \frac{c}{2f_{0}\sqrt{\varepsilon_{reff}}} - 0.824h\frac{\left((\varepsilon_{reff}+0.3)\left(\frac{w}{h}+0.264\right)\right)}{(\varepsilon_{reff}-0.258)\left(\frac{w}{h}+0.8\right)}$$

Where L and W are the length and width of the patch, f_o – resonant frequency, c is the velocity of light, ε_r is dielectric constant. The width of the patch was calculated by substituting ε_r = 5.9 f_o =9 GHz, m/s in equation (1).

The effective dielectric constant was determined using equation 2. Then, length of the microstrip patch antenna was calculated by applying the values of ε_{reff} , f_o = 9 GHz, and m/s in equation 3. Quarter wave feedline is preferred to achieving better impedance matching between patch and source and feedline is suitably designed and dimension the matching line is mentioned in table 1.The simulation model of the proposed antenna shown in

figure1.

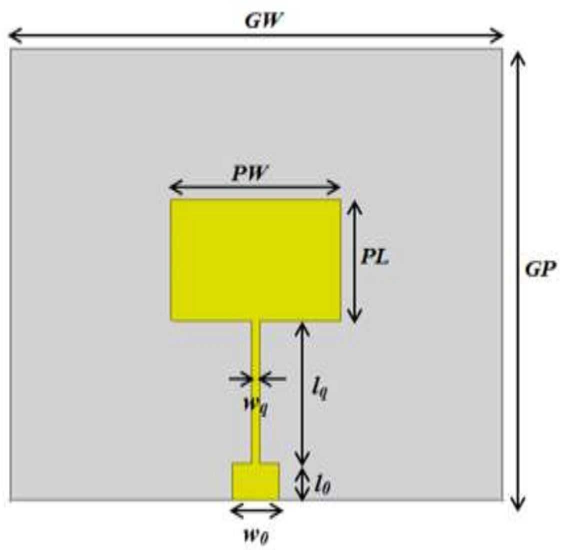

Fig.1 Simulation model of proposed antenna

4. Results and Discussion

Proposed microstrip antenna using FR4 substrate was simulated using High Frequency Structure Simulator (HFSS) and performance of microstrip patch antenna using FR4 substrate was analyzed in terms of Return loss, Voltage standing wave ratio and its radiation characteristics. FIG 2 shows that return loss measurement of our proposed microstrip antenna using FR4 substrate for 5G mobile applications. From the figure, it is inferred that our antenna achieves return loss of -21.1068 dB at a resonant frequency of 9GHz. The designed Microstrip patch antenna achieves bandwidth of 1.1 GHz. It is also inferred that proposed antenna can be able to receive the wideband signal at the centre frequency of 9GHz and bandwidth of more than 1 GHz. Microstrip antenna for different centre frequency can also be designed using FR4 substrate with wider bandwidth.

Proposed antenna suitably employed for the mobile communication application with radio channel centre frequency of around 2 GHz. For carrying the voice traffic channel bandwidth of 4 KHz is sufficient [8] proposed antenna performs well in the frequency range around 9GHz provided that channel allocation policy of the cellular system is proper in such a way that adjacent channel interference and co-channel interference are properly minimized.

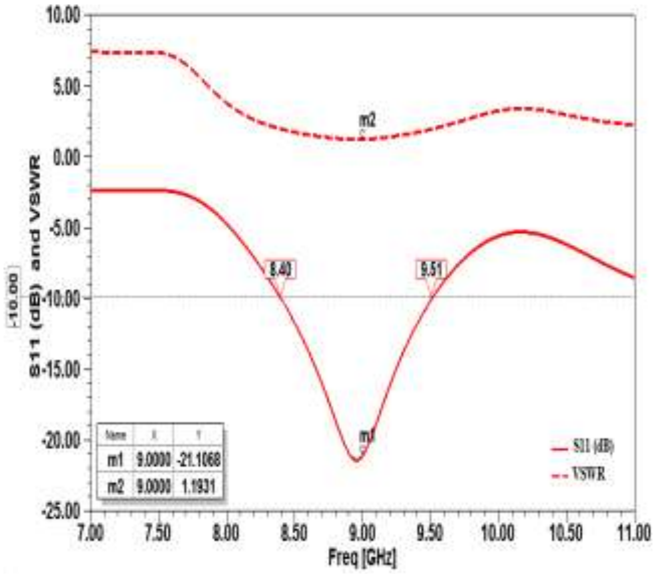

Fig.2 Return loss and VSWR measurement of the proposed antenna

Figure 2 also shows the Voltage Standing Wave Ratio (VSWR) measurement of the proposed antenna using FR4 substrate. VSWR is an important parameter of the antenna which tells about amount of input power reflected back from the antenna. From the figure it is inferred that proposed antenna achieves better impedance matching between the source and antenna radiating element. Proposed antenna achieves VSWR of 1.19 at the resonant frequency of 9 GHz. For practical application antenna should have VSWR of less than 2 but proposed antenna achieves VSWR of 1.19. Hence it concluded that proposed antenna can suitably employed at the resonance frequency of 9 GHz. Figure 3 shows the impedance characteristics of proposed antenna.

Proposed antenna achieves the antenna impedance of 50.83 Ω at the resonant frequency of 9 GHz. From the figure it is concluded that proposed antenna using quarter wave matching line achieves better impedance matching between port and antenna radiating element. Figure 4 shows the radiation pattern of the proposed antenna designed using FR4 substrate. Proposed antenna achieves reasonable radiation characteristic at the resonant frequency of 9 GHz. It is also inferred that proposed antenna has sufficient main lobe in both E and H-plane radiation pattern and has smaller back lobe characteristics in E-plane radiation pattern.

Figure 5 depicts the gain and directivity measurement of the proposed antenna at the resonant frequency of 9 GHz. Proposed antenna achieves the gain of 4 dB at the resonant frequency of 9 GHz and has the peak gain of 5.8 dB at the frequency of 10 GHz. gain of the proposed antenna is reasonably good since the proposed antenna can suitably employed at the low power receiver devices application such as mobile phone devices. Proposed antenna achieves the directivity of 4.6 dB at the resonant frequency of 9 GHz and peak value of 7.8 dB at 10 GHz. Hence it is concluded that proposed antenna can suitably employed for the wideband signal transmission and reception at the centre frequency around 9 GHz.

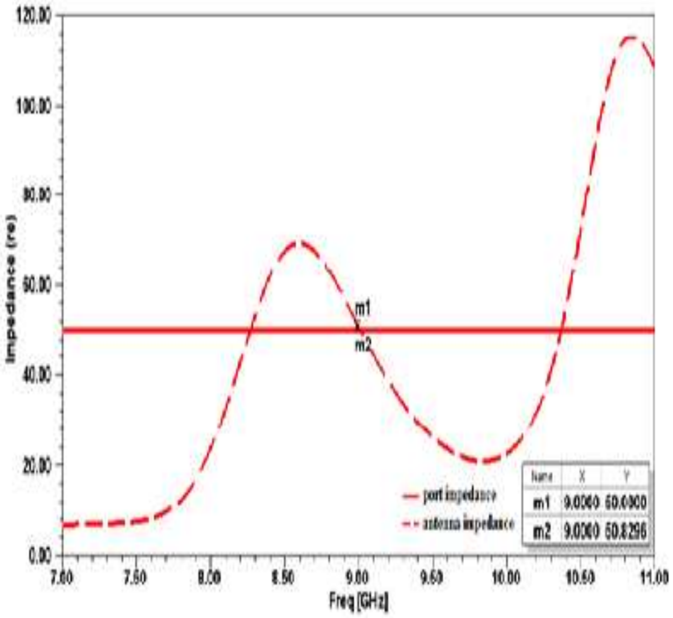

Fig.3 impedance measurement of the proposed antenna

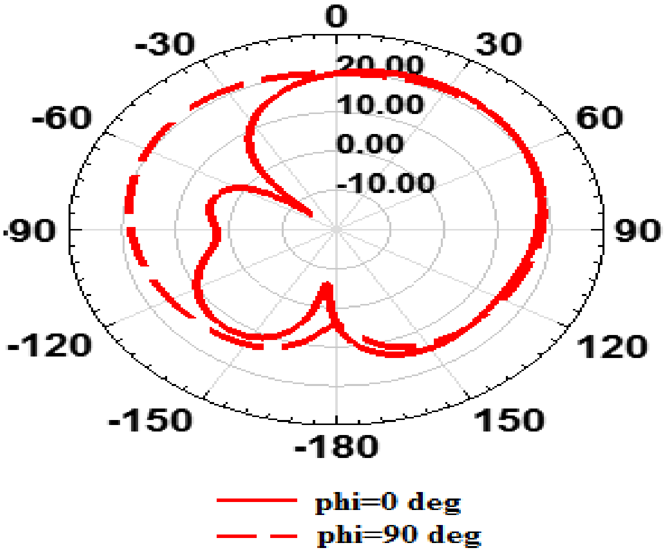

Fig.4 radiation characteristic of the proposed antenna

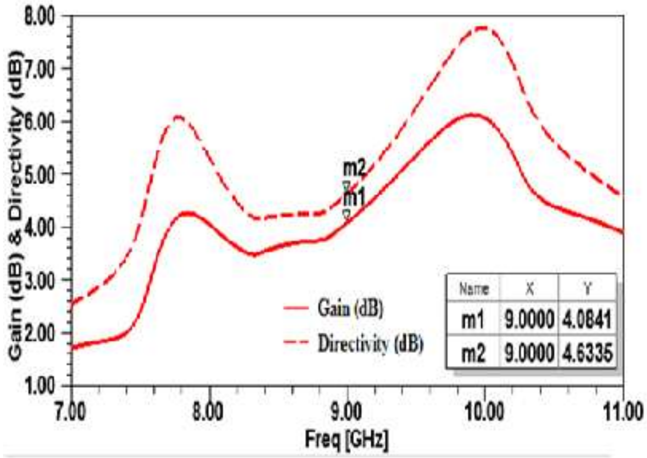

Fig.5 Gain and Directivity measurement of the proposed antenna

5. CONCLUSION

The Microstrip patch antenna using FR4 substrate is designed and simulated to work at 9 GHz. The measured results show that the microstrip patch antenna is suitably employed for low power wireless transceiver such as mobile to achieve desirable characteristics.

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