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A Linearly Polarized Coaxial Feeding Dual Band Circular Microstrip Patch Antenna for WLAN Applications

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Abstract

A dual band linearly polarized micro-strip antenna is designed and simulated to obtain electronic circuit miniaturization of an antenna in high speed wireless local area networks (IEEE 802.11a standard). The proposed antenna contains a substrate layer (FR-4 lossy) with a dielectric constant of 4.4 and there is a circular patch on the upper layer of the substrate. The coaxial probe feed is used to excite the desired antenna which reduces the spurious radiation and hence obtained good efficiency. It is shown that using cavity model 20% excess bandwidth can be achieved while maintaining the lower size of the antenna. An 'E' shaped slot is introduced in the radiating patch to obtain dual band resonance frequency with maximum current distribution on the surface. Finally the simulated results using Computer Simulation Technology (CST) microwave studio 2009 in this design is compared with manual computation results which are found to be suitable for WLAN applications.

Index Terms: Micro-strip antenna; Cavity model; Dual band antenna; Coaxial probe feed.

1. Introduction

The importance of electronic circuit miniaturization in wireless communication systems has increased rapidly due to their portability and easy of handling. In last decades the information and communication fields becomes popular because of availability of these tiny sized electronics devices and the capability of

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maintaining high performance. So the investigation on microstrip antenna is become a popular topic for new researchers because of light weight, low cost, planar or conformal layout, and ability of integration with electronic or signal processing circuitry[1]-[2]. Also there is versatility in terms of operating frequency, polarization pattern and impedance in application of microstrip antenna such as in aircraft, missiles (radar, proximity fuses and telemetry), satellite communications, remote sensing and biomedical applicators.

There are several types of microstrip antenna have been introduced and investigated and there observed some operational disadvantages which are narrow frequency bandwidth, larger value of Q, poor polarization purity and low efficiency [3]. But in some applications the microstrip patch antenna is the first choice where narrow frequency bandwidth with lower antenna size are desirable. Besides the use of thick dielectric substrate allow the good efficiency and large frequency band in a microstrip patch antenna [4]-[5]. Recently the coaxial probe feed method with staking and cavity model has become popular, because it reduces the value of surface wave while maintaining the lower size and larger bandwidth of the desired antenna. It has also observed that the use of E-shape slot on the patch reduces the size of the antenna by comparing it without slot [6]-[9]. .

In this research work it is desired to obtain a simple dual band, new single-fed antenna configuration for linear polarization without a polarizer while retaining their lower size, good efficiency and also cost effective. To obtain our desired dual band antenna firstly we have simulated single band microstrip antenna (MSA) also we have studied the effects of physical parameters on output and then it extend to dual band MSA. The simulated results of return loss, smith chart, radiation pattern, directivity, gain, and efficiency of the desired dual band antenna are demonstrated in section 4.

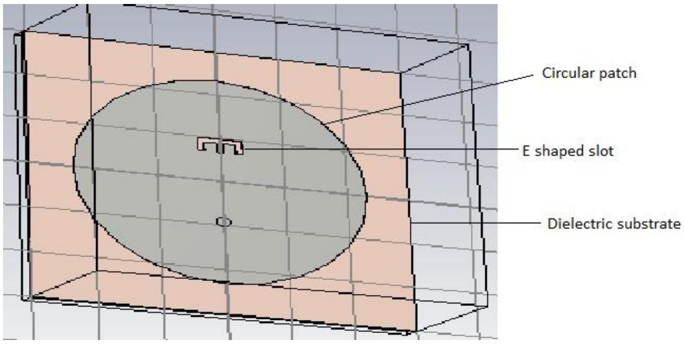


Fig.1. Geometry of dual band microstrip patch antenna

2. Antenna Configuration

The desired dual band linear polarized microstrip antenna which resonances at the frequency of 2.76GHz and 5.9GHz is shown in fig.1. One of the most popular circular patches is designed on the upper layer of substrate. It shows good output characteristics for single element. According to cavity model formulation by assigning some presumed specified information likes the resonant frequency (f_r), height of the substrate and the dielectric constant of the substrate (ε_r) the equations of our designed antenna are shown in this section [10]. The effective radius of the circular patch at a resonant frequency (f_r) for the dominant mode TM_{110} with counting fringing can be obtained using equation 1

$$\boldsymbol{a_{eff}} = \frac{X'_{11} \times C}{2\pi f_r \sqrt{\varepsilon_r}} \tag{1}$$

Here, the lowest order mode TM_{110}, uses X_{11}(1.84118)
Then the actual radius will be

$$a = \frac{a_{eff}}{\sqrt{\{1+\frac{2h}{\pi\varepsilon_r a_{eff}}[ln\left(\frac{\pi a_{eff}}{2h}\right)+1.7726]\}}} \quad (2)$$

3. Antenna Designed Specifications

The various parameters of the designed dual band circular microstrip antenna are shown table 1.

Table 1. The value of different parameters of dual-band rectangular microstrip antenna

Variable	**Value**
Radius of the patch(a)	26 mm
Height of the patch(h)	.07mm
Effective dielectric constant of the patch(ε_{eff})	4.9
Width of small slots(w)	1 mm
Length of small slots(l)	2 mm
Width of large slot(W)	1 mm
Length of large slot(L)	7 mm

4. Simulation Results

Antennas were designed and tested to verify the circularly polarizing operation of the proposed configuration. The different simulated results (using the CST microwave stdio2009) like return loss, Smith chart, voltage standing wave ratio (VSWR), directivity and gain are discussed below.

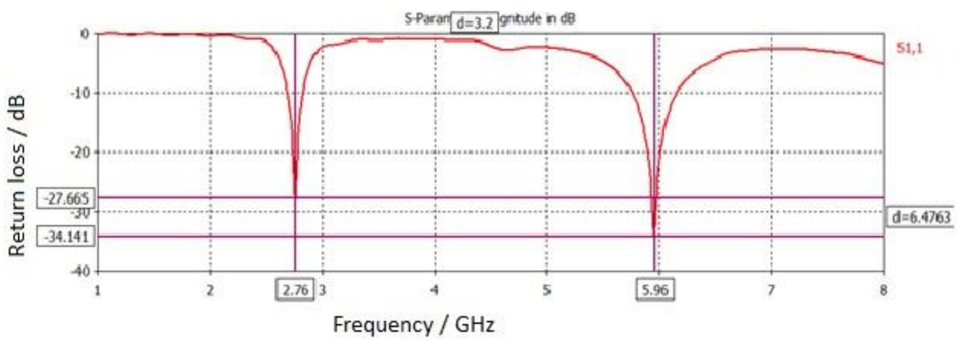


Fig.2. Simulated return losses of dual band MSA at 2.76 GHz and 5.96 GHz

4.1 Return Loss, Smith chart, VSWR

In antenna the return loss (RL) is a parameter which indicates how the impedance matching has occurred in between transmitter an antenna. For the case of good impedance matching the power losses become minimum and the antenna becomes more efficient. The proper impedance matching is obtained through the proper selection of the input feed point. The return loss of the designed dual band microstrip patch antenna is shown in fig.2. It is seen that the return loss, -27.665 dB is found at a resonant frequency of 2.76 GHz and that of -34.141dB is found at a resonant frequency of 5.96 GHz, where -10dB is acceptable for practical applications. The bandwidths are found 120 MHz at the resonant frequency of 2.76 GHz and 200 MHz at the resonant frequency of 5.96 GHz, in which 84 MHz is acceptable bandwidth [11].

Fig.3. shows the smith chart which is helpful to calculates the impedance of our designed antenna. The impedance of the designed antenna is founded 45 ohms which is close to acceptable value, 50 ohms. The smith chart shows two circles for two resonating frequencies. The circles pass through resistance 1 circle which proves that the antenna is perfectly matched and thus losses are minimum.

The another important parameter for a microstrip antenna to obtain proper impedance matching is VSWR. Fig.4. shows the VSWR curve. It shows that the value of VSWR of our designed antenna is below 2 for the whole bandwidth where for a practical antenna the value of VSWR should be less than or equal to 2 is acceptable. So this parameters indicates that the designed antenna is operable in required frequency band.

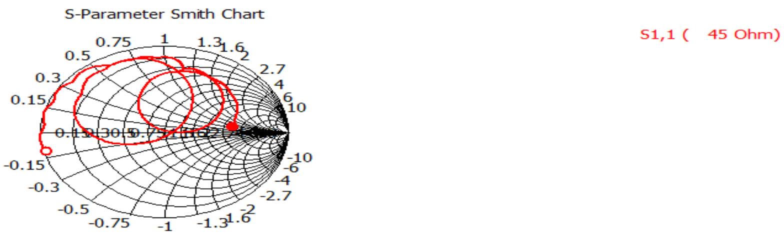
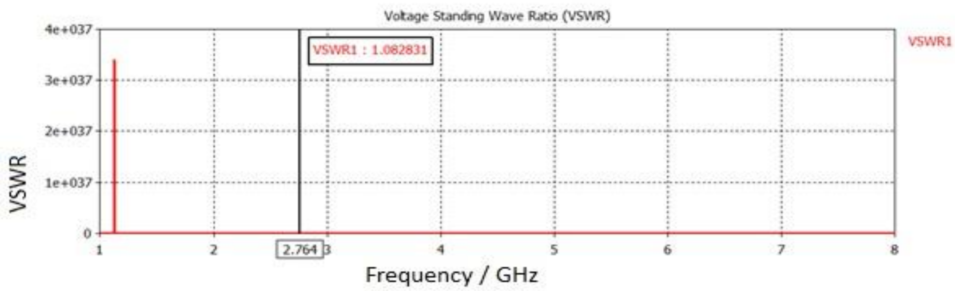
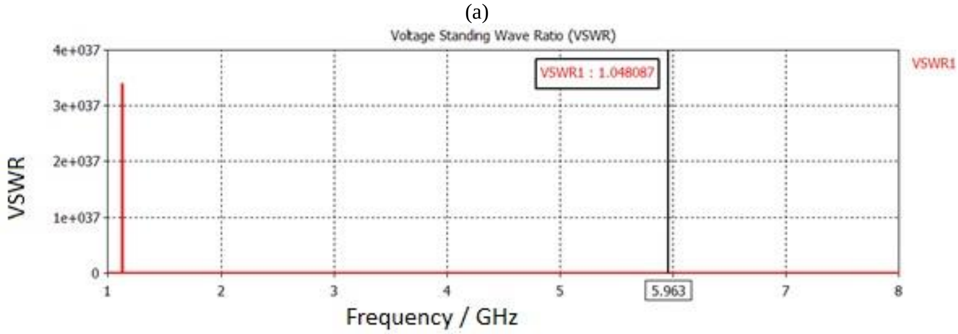


Fig.3. Smith chart of dual band MSA at 2.76 GHz and 5.96 GHz.



(a)



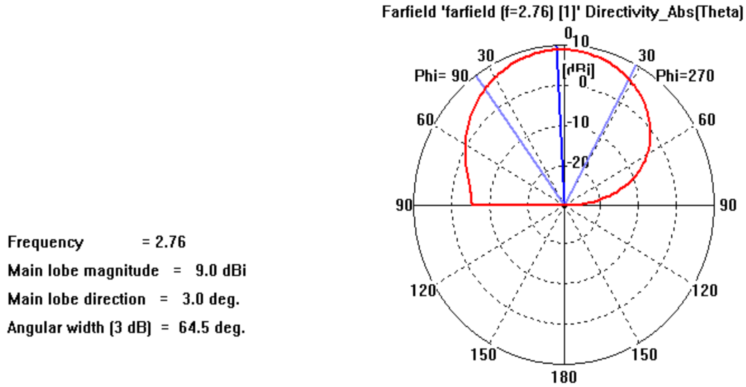
(b)

Fig.4. The VSWR of dual band MSA at (a) 2.76 GHz; (b) 5.96 GH

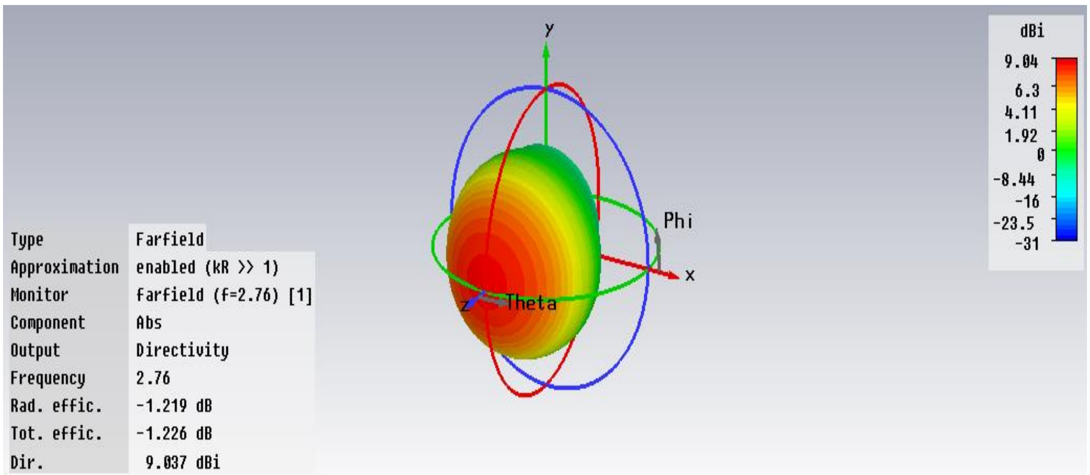
4.2 Directivity and Gain

The directivity of the designed dual band circular microstrip antenna in both 2D and 3D pattern are shown in fig.5. and fig.6. and the gain in fig.7. and fig.8. respectively. From the fig.5. it is clear that the directivity is 9.037dB at the resonant frequency of 2.76 GHz and that of 5.96 GHz frequency is 7.992dB which agree well with the previous results. From 2D pattern it also clear that the main lobe magnitudes are found at the angle of 3.0 deg and 25.0 deg with positive Z direction at the resonant frequency of 2.76 GHz and 5.96 GHz respectively. So it proves that the designed dual band antenna is a high directional antenna [11]-[13].

From fig.7. and fig.8. the gains of the dual band antenna are 7.819 dB and 7.878 dB found at these two resonance frequencies respectively. Since the designed antenna is a high directional antenna so the gain of the antenna is high at a specific direction. From 2D pattern it is also clear that the main lobe magnitudes of gain are 7.8 dB and 5.6 dB are found at the angle of 3.0 deg and 25.0 deg with positive Z direction at 2.45 GHz and 4.1 GHz frequencies respectively and these are suitable values for practical applications.

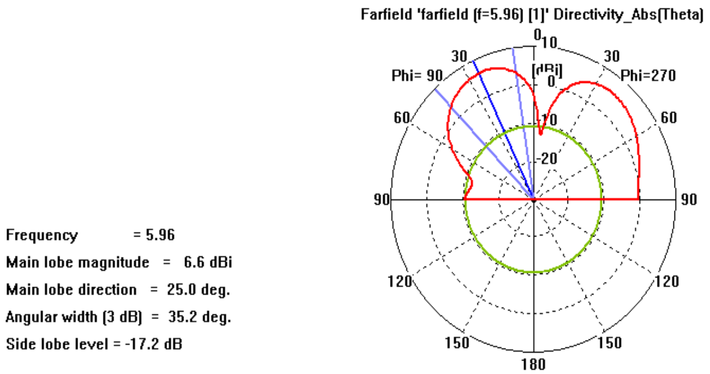


(a)

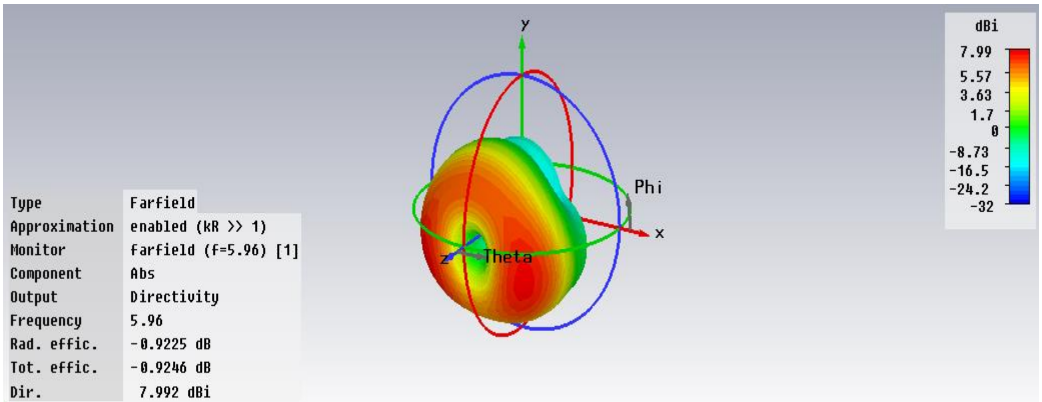


(b)

Fig.5. Directivity of dual band MSA at 2.76 GHz (a) 2D pattern; (b) 3D pattern

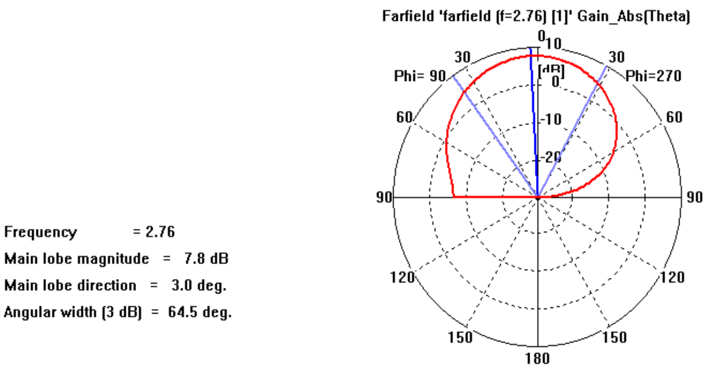


(a)

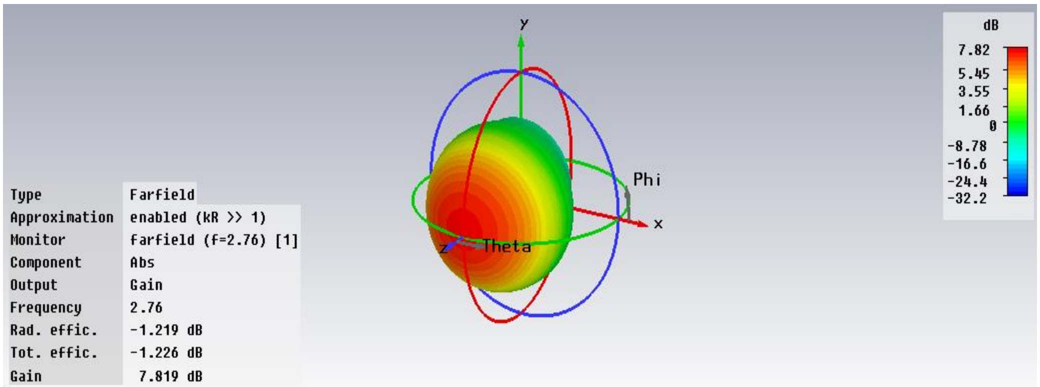


(b)

Fig.6. Directivity of dual band MSA at 5.96 GHz (a) 2D pattern; (b) 3D pattern

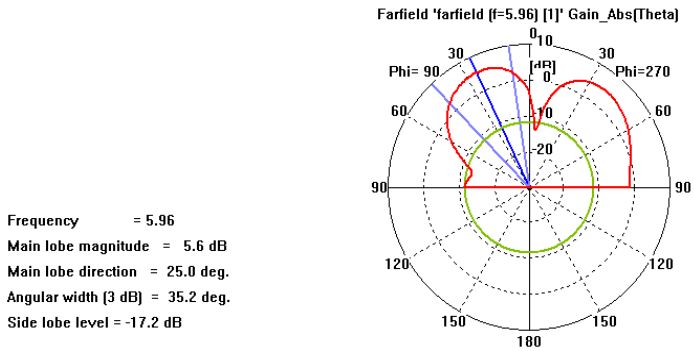


(a)

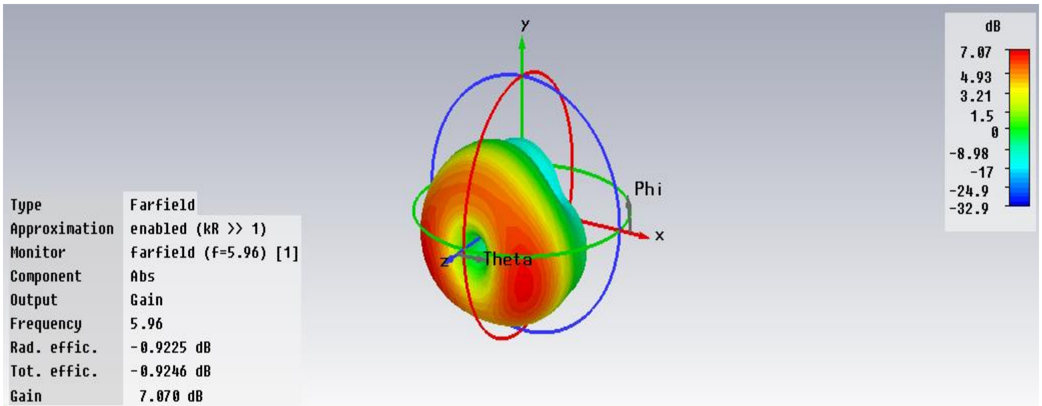


(b)

Fig.7. Gain of dual band MSA at 2.76 GHz (a) 2D pattern; (b) 3D pattern



(a)



(b)

Fig.8. Gain of dual band MSA at 5.96 GHz (a) 2D pattern; (b) 3D pattern

5. Summary of the results

The results of the dual band antenna operating at 2.76 GHz and 5.96GHz are summarized in table 2.

Table 2. Output parameters of the dual band antenna resonating at 2.76 GHz and 5.96 GHz frequencies

Resonating frequency, fr (GHz)	Return Loss(dB)	Bandwidth (MHz)	VSWR	Directivity (dBi)	Gain (dB)
2.76	-27.665	120	1.08	9.037	7.819
5.96	-34.141	200	1.05	7.992	7.878

From the above table it is clear that the desired microstrip antenna provides good impedance matching at two resonance frequencies of 2.76 GHz and 5.96 GHz with return losses of -27.665 dB and -34.141 dB respectively. So it is a dual band antenna with high directivities of 9.037 dB and 7.992 dB at these two resonance frequencies respectively. Also the higher value of gains of our designed antenna has achieved because of high directivity of the antenna.

6. Physical Parametric Study of Dual Band Antenna

The effect of radius of the circular patch on the performance of the designed microstrip antenna is shown in fig.9. From figure it is seen that with the decreasing value of radius of the radiating patch the resonating frequency increases. At the same time there is changing the return loss with the changing value of radius of the patch. Thus it is a very important tools for determining the actual dimensions of designed circular microstrip patch antenna. Also this study is very helpful to obtain good impedance matching.

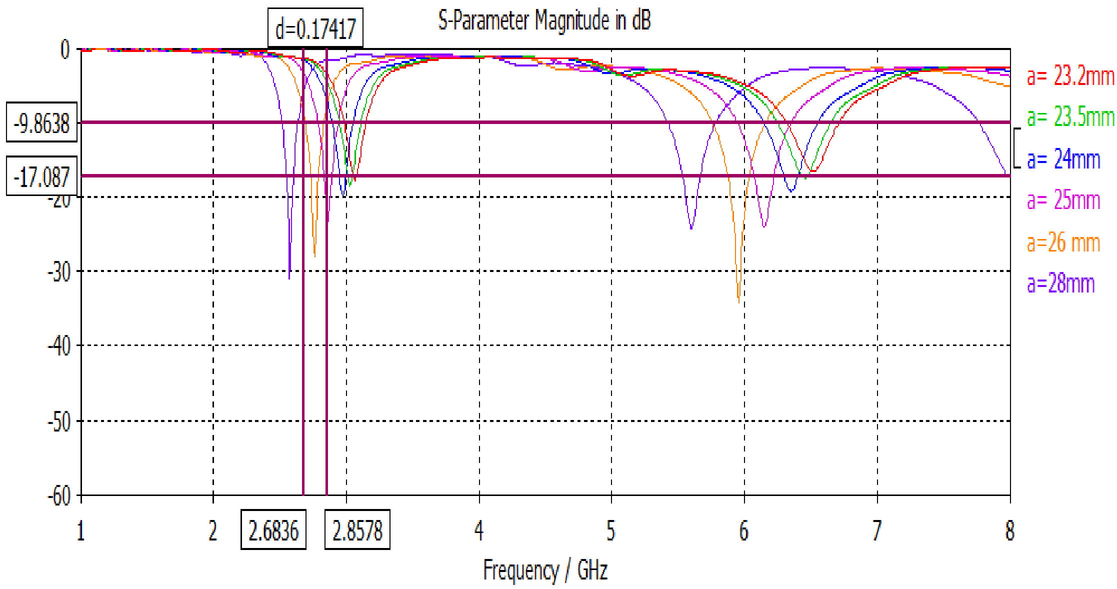


Fig.9. Variations of S parameter with respect to the radius of the patch

7. Conclusions

The work in this research was primarily focused on the design and simulation of simple, small and high efficiency dual band circular microstrip patch antennas using coaxial feeding technique. Then from the simulation results the multiband microstrip antenna has designed. The designed rectangular antenna covers two frequencies of 2.76 GHz and 5.96 GHz which produces the bandwidth of approximately 3% while maintaining their lower size and good efficiency. And also it has shown that the designed antenna provides good impedance matching of approximately 50 ohm's at resonant frequencies. Due to easy of fabrication with coaxial feeding line it can be used for various applications such as in military purposes, radio altimeters and various wireless devices.

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