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Multi-Forked Microstrip Patch Antenna for Broadband Application

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Abstract: In this paper, a new design simulation of multi-forked microstrip patch antenna is presented. The proposed antenna design consists of rectangular patch structure loaded multi-slotted forked as a novel shaped of the patch, with Arlon AD320A (tm) dielectric. The coaxial probe feed technique and microstrip edge feed are used as a direct feed. The composite effect of integrating these multi-shapes forked patches techniques introducing the new multi- slotted patch. The best results of the proposed antennas were a wide impedance bandwidth which is 114% at 10.31 GHz resonance frequency for the microstrip line feed approach and maximum achievable gain is 6.3 dB for the coaxial probe feed approach. The simulated results of return loss, radiation patterns, and voltage standing wave ratio are obtained by using the finite element HFSS 13.0 software

Keywords: Multi-Forked, Multi-Slotted, Impedance Bandwidth, Directivity Gain, High Frequency Structure Simulator (HFSS).

1. Introduction

Simply microstrip patch antennas consist of a dielectric substrate on one side of a ground plane with metal patch on the other side [1-2]. In recent years the broadband microstrip antennas are attractive and wide spread proliferation for both military and commercial application because of low profile, light weight and low cost, etc. [3-5]. These antennas have a narrow bandwidth of less than 3% which confines their use in recent wireless communication systems. Therefore, the academics have developed numerous approaches like the hole coupling, use of shorting pins, stacking, modifications in the feed techniques and using the coupled parasites to enhance the bandwidth and directivity gain of MSA [6-11].

In various mobile communication systems the microstrip patch antennas are receiving benefits due to their advantages in terms of low electromagnetic coupling to the human head, low profile, light weight, increased mechanical reliability and high efficiency. The requirements of both bandwidth and size of the antennas are fully rigorous in many applications. Some of these applications it is coveted to have a dual band or multiband features [12]. These features can be gained by using tuning devices or coupling multiple radiating elements. Moreover, these techniques make antenna more complicated. A method of the proposed antenna is by establishing multi slots in the patch of microstrip antennas in which the radiating patch includes a multi-forked patch. By creating appropriate slot dimensions In order to make the proposed antenna useful for a multiband and wideband frequency applications. This is a simple method to achieve broadband and dual band features in microstrip patch antennas. Furthermore, this technique can minimization the dimensions of the antenna and resonating frequency [13-15].

This article presents a microstrip rectangular patch structure loaded multi-slotted forked antenna at X-, Ku- and K-band frequencies. The results are simulated and can be divided into two parts. In the first part, the proposed antenna is designed with a coaxial probe feed for dual bandwidth in X- and K-band applications. In the second part the proposed antenna is designed with a microstrip edge feed for X- and Ku-band applications. The simulation results are shown that the multiband antenna have achieved good results which are used for the radar, wireless communication, and satellite communication system [16-19]. The design and performance of the proposed antennas are carried out by using HFSS 13.0 software.

2. Antenna Design

The geometry of the proposed antenna is designed on an Arlon AD320A (tm) substrate of dielectric constant 3.2 with thickness 1.9 mm, the tangent loss of 0.0032 and the total size is about (29 × 24 × 1.9) mm3, is shown in figure 1. The dimensions of multi-forked microstrip patch antenna are illustrated in Table 1. The novel shape of the patch structure is shown in figure 1a. However, figures 1b and 1c are shown the two types of feed techniques which are coaxial probe feed and microstrip line feed, respectively.

The fed location of a coaxial probe is (xf=1 and yf=-2.4), which is optimized to match its input impedance 50 ohm and maximize the half power beamwidth of the radiation patterns at resonate frequencies 11.83 GHz and 18.09 GHz. The configuration of the proposed antenna with microstrip edge fed is placed at appropriate place (L3= 4.75mm and W4=2.5mm) to match its input impedance 50 ohm with resonant frequency 10.31 GHz.

The patch dimensions of the proposed antenna are (Lp=21.5mm and Wp=16.5mm) which are calculated initially by the following relationships [20-21]:

$$W_P = \frac{c}{2f} \times \sqrt{\frac{2}{\varepsilon_r + 1}} \qquad \ldots\ldots\ldots\ldots (1)$$

$$L_P = \frac{c}{2f\sqrt{\varepsilon_{eff}}} - 2\Delta L \qquad \ldots\ldots\ldots\ldots (2)$$

Where

$$\Delta L = 0.41h \frac{\varepsilon_{eff} + 0.3}{\varepsilon_{eff} - 0.258} * \frac{\left(\frac{W_P}{h} + 0.264\right)}{\left(\frac{W_P}{h} + 0.8\right)} \qquad \ldots\ldots\ldots\ldots (3)$$

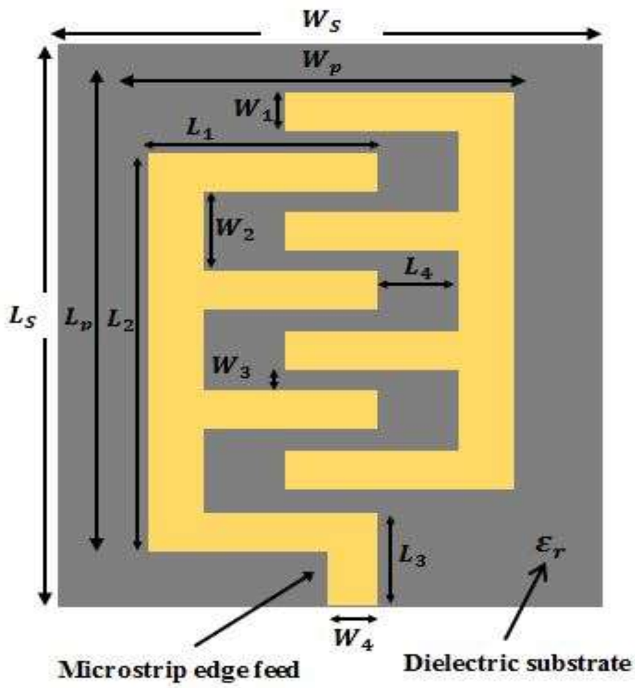
where ΔL is extension in length due to fringing effects and the effective dielectric constant is given by:

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2\sqrt{1 + 12\frac{h}{W_P}}} \qquad \ldots\ldots\ldots\ldots (4)$$

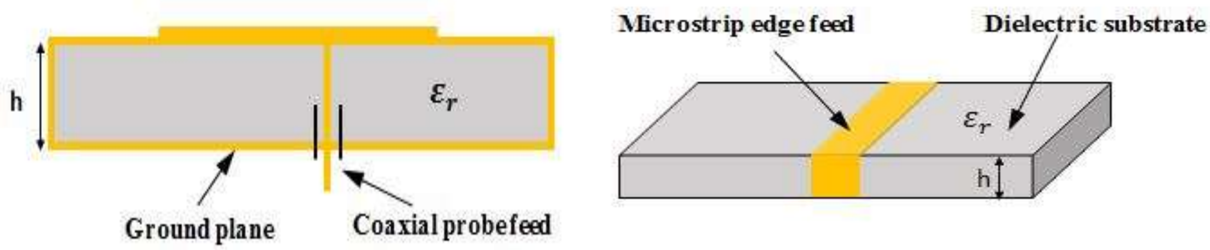
Where f and c are the resonant frequency (in GHz) and the light speed. Also, the ground plane dimensions would be given as [21]:

$$W_s = 6(h) + W_P \quad \text{........... (5)}$$

$$L_s = 6(h) + L_P \quad \text{........... (6)}$$



(a)



(b) **(c)**

Figure 1. Geometry of the proposed antenna (a) novel shape of the patch structure (b) coaxial probe feed and (c) microstrip line feed.

Table 1. Dimensions of the proposed antenna as shown in figure 1.

Label	Dimension (mm)
L_1	11.00
L_2	21.50
L_3	4.75
L_4	2.50
L_s	29.00
L_p	21.50
W_1	2.00
W_2	4.50
W_3	1.25
W_4	2.50
W_s	24.00
W_p	16.50
h	1.90
x_f	1.00
y_f	-2.40

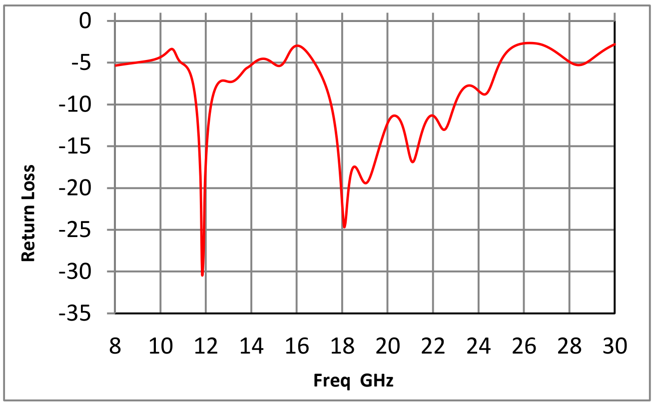
3. Results and Discussion

In this project, the broadband impedance matching is proposed for bandwidth enhancement. This study has used two types of feed techniques which are coaxial probe feed and microstrip line feed with a novel shape of patch structure. The simulation results of the proposed antennas are done by using the commercial software Ansoft HFSS (13.0). These results are the return loss (reflected power S11), voltage standing wave ratio (VSWR), radiation patterns and the electric field distribution.

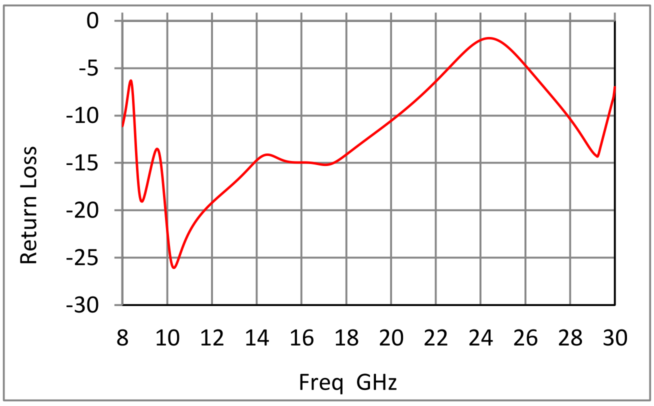
The simulation results of S11 and VSWR for both proposed antennas are shown in the figures 2 and 3, respectively. The performance of the proposed antennas depends on the value of return loss and its value should be less than -10 dB.

Figure 2a shows the simulation values (S11) obtained for the proposed antenna fed by a coaxial probe are -30.26 dB and -24.03 dB at resonating frequency 11.83 GHz and 18.09 GHz, respectively. Also, figure 2b shows the simulation values (S11) obtained for the proposed antenna fed by a microstrip edge are -25.28 dB and -13.50 dB at resonating frequency 10.48 GHz and 29.33 GHz, respectively.

The simulation results of the bandwidth and gain from the return loss characteristics for the proposed antenna fed by a coaxial probe are (7.35% and 30.95%) and (3.16 dB and 6.3 dB) at resonating frequency 11.83 GHz and 18.09 GHz, respectively. However, the simulation results of the bandwidth and gain for the proposed antenna fed by a microstrip edge are (114.27% and 6.81%) and (5.08 dB and 3.5 dB) at resonating frequency 10.48 GHz and 29.33 GHz, respectively.



(a)



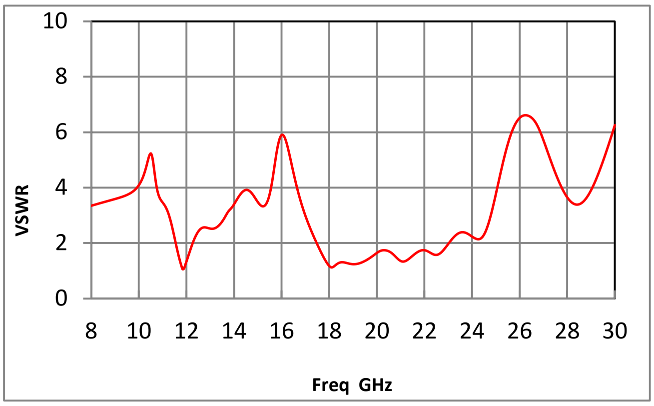
(b)

Figure 2. Return loss of the proposed antennas with (a) coaxial probe feed (b) microstrip edge feed.

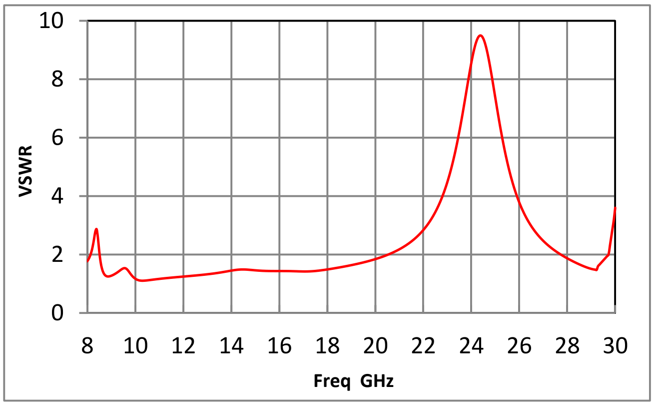
Figure 3a shows the simulation values (VSWR) obtained for the proposed antenna fed by a coaxial probe are 1.06 and 1.12 at resonating frequency 11.83 GHz and 18.09 GHz, respectively. Also, figure 2b shows the simulation values (VSWR) obtained for the proposed antenna fed by a microstrip edge are 1.10 and 1.60 at resonating frequency 10.48 GHz and 29.33 GHz, respectively.

Figure 4 shows the radiation patterns of the proposed antennas in two dimensions which are simulated in the far field region. This figure represents the optimum radiation pattern of the proposed antennas. While the radiation pattern of the proposed antenna fed by a coaxial probe at resonating frequency 18.09 GHz in three dimensions is simulated in the far field region, as shown in figure 5.

The electric field distributions on the patch of proposed antennas with coaxial probe feed and microstrip edge feed are shown in figure 6.

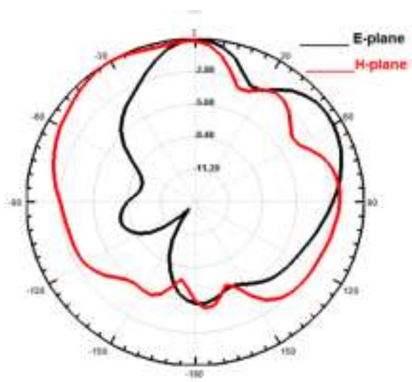


(a)

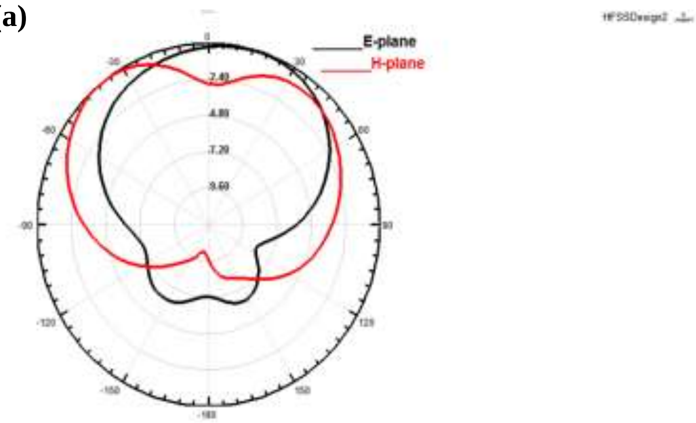


(b)

Figure 3. VSWR of the proposed antennas with (a) coaxial probe feed (b) microstrip edge feed.



(a)



(b)

Figure 4. Radiation patterns for the proposed antennas with
(a) coaxial probe feed (b) microstrip edge feed.

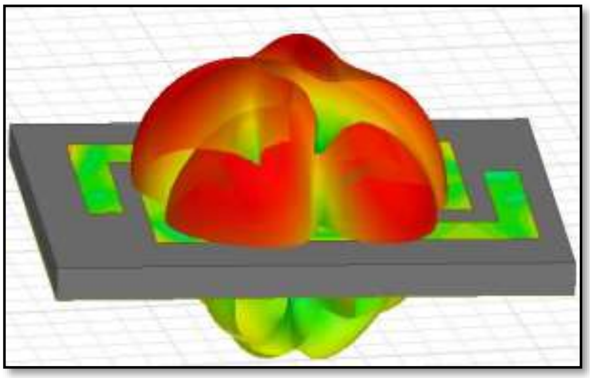
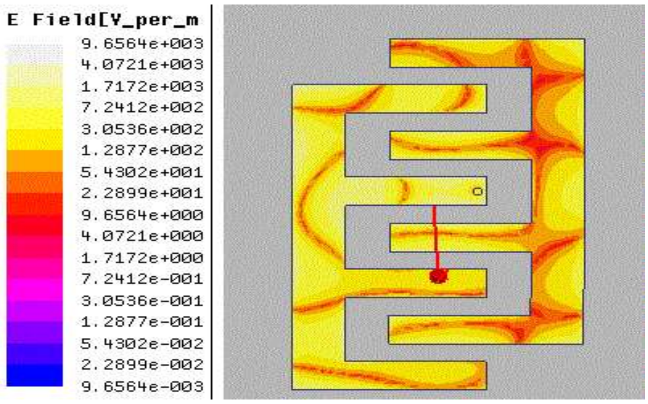
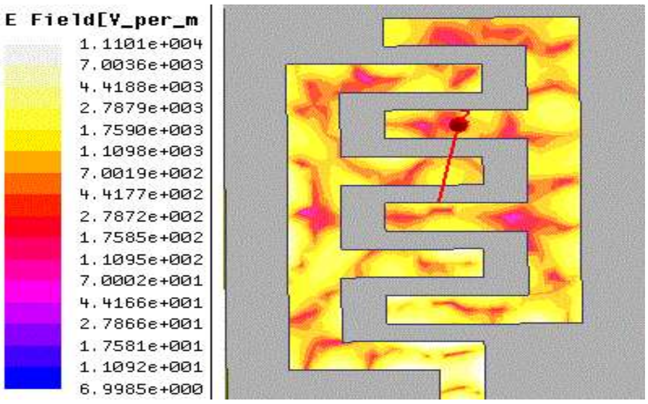


Figure 5. Radiation pattern in three dimensions for the proposed antennas with coaxial probe feed at resonant frequency 18.09 GHz.



(a)



(b)

Figure.6 Electric field distributions on the patch of proposed antennas with (a) coaxial probe feed (b) microstrip edge feed.

4. Conclusion

In this paper, multi-forked microstrip patch antenna is designed and simulated and their operating frequencies are in the X-, Ku, and K-bands. The proposed antennas design consist of rectangular patch structure loaded multi-slotted forked as a novel shaped of the patch. The proposed antennas provide dual band, useful frequencies and good radiation characteristics. The improvement in the bandwidth is the major achievement. However, the simulation results of the bandwidth and gain for the proposed antenna fed by a microstrip edge are (114.27% and 6.81%) and (5.08 dB and 3.5 dB) at resonating frequency 10.48 GHz and 29.33 GHz, respectively. The value of the VSWR is close to unity at resonating frequency 10.48 GHz. It conclude that the Simulation results in this study make the proposed antennas to be utilized for radar, satellite and wireless communication application and can be fabricated easily.

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