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Broadband microstrip patch antenna of reduced sized for multiband applications

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A small size wideband microstrip patch antenna is designed for S,C and X-band applications. The proposed antenna has been designed by a simple metallic patch and modified ground plane on dielectric substrate. In the ground plane, three rectangular slits are incorporated to obtain a large bandwidth of 140% (1.88 to 10.58 GHz). The proposed antenna may also be used as a multiband antenna by shifting the feeding position. The multiple numbers of frequency bands are achieved with percentage bandwidth of 80, 38, 32, 15 and 13%, respectively. The proposed antenna is simulated using Ansoft designer software. The simulated results are verified with the experimental data by standard microwave bench and network analyzer.

Keywords: Radar communication, X-band, Microstrip patch, Broadband, Ansoft designer

1 Introduction

In microwave communication system small size, simple structure, broadband, high gain and high efficiency antennas are required. Generally, microstrip antenna has narrowband, low gain and low efficiency. However, researchers are trying their best to enhance bandwidth, gain and efficiency. Due to this improvement of parameters, microstrip patch antennas are accepted in many *RF* and microwave communications such as mobile communication, radar communication and today it is very popular for applications of image processing in medical applications. The limitations of microstrip antennas are narrow frequency band and disability to operate at high power levels of waveguide, coaxial line or even strip line. However, the challenge in microstrip antenna design is to increase the bandwidth and gain[1]. Different shapes of small size microstrip antennas have been developed to provide wideband, high gain, and minimum reflection coefficient to improve the efficiency. The good impedance matching over the single feed arrangements provides high efficiency and less back wave of the microstrip patch antennas. The power radiation of the antenna elements can be modified by shifting feeding position. The corporate feed network can guide beam by introducing phase change[2-4]. The selection of design parameters like dielectric constant of material, height of substrate and frequency are drawing very important role because antenna performance depends on these parameters. Radiation pattern can be made superior by using proper design structures[5-6]. In radar communication systems, different types of radars like imaging radar, sensing radar and synthetic aperture radar (SAR) are working in S, C and X bands. The microstrip patch antennas are the foremost choice for this high frequency band such as C and X-band due to its low cost, light weight, and robustness[7-9]. Chatterjee[10] reported that maximum 201 MHz bandwidth is achieved with 47.4% size reduction by introducing three unequal rectangular slots at the edge of the radiating patch. Mandal[11] reported that maximum 86.79% bandwidth is achieved by introducing inverted U-shaped slot on the ground plane. Maximum[12] 255 MHz bandwidth is achieved by introducing inverted L and T shape parasitic elements at both the radiating aperture of a microstrip patch antenna. In the present paper, a small size and very large bandwidth of 8.7 GHz (140%) microstrip patch antenna has been designed for S, C and X-band applications. The results at different feeding positions are compared. The proposed antenna is simulated using Ansoft designer software to analyze its performance. Simulated result has been confirmed by measured results.

2 Antenna Design

The geometry of the proposed microstrip patch antenna is shown in Fig. 1(a). The antenna is designed using permittivity 2.4 with 1.6 mm thick PTFE

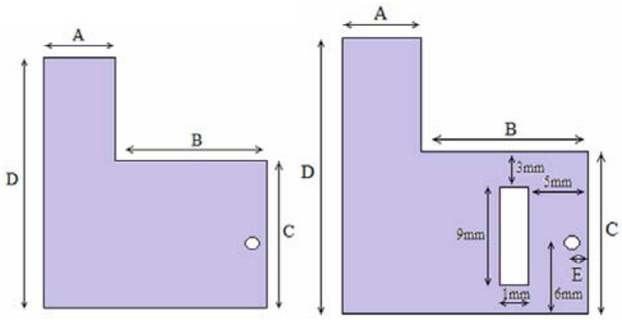


Fig.1 — (a) Proposed patch of microstrip antenna. (b) Modified patch

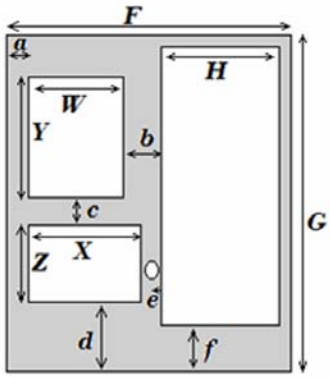


Fig. 2 — Modified ground plane top view of proposed antenna

Table 1 — Geometrical parameters and dimensions of Figs 1(a), 1(b) and Fig. 2 (all dimensions in mm)

Parameters	Dimensions	Parameters	Dimensions
A	4	X	15.25
B	10	Y	19
C	14	Z	14
D	23	*a*	3
E	1	*b*	2.75
F	43	*c*	2
G	46	*d*	5
H	18.25	*e*	0.75
W	14	*f*	4

substrate. Fig. 1 shows the radiating surface of the antenna whereas Figs 1(b) and 2 are show the modified radiating patch and ground plane of the same antenna, respectively. All the dimensions are given in Table 1.

3 Antenna Results

The results of Figs 3 and 4 show that the slot line in the patch of the microstrip antenna has almost no effect on the nature of the signal. Figures 5 and 6

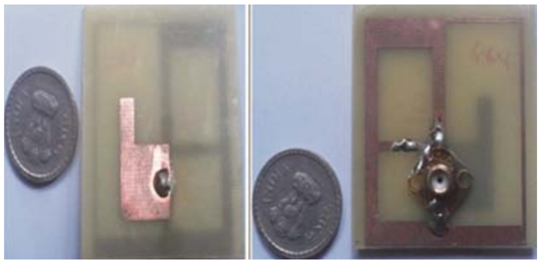


Fig. 3 — Photograph of radiating patch and ground plane of the proposed antenna at feeding position (19, 7)

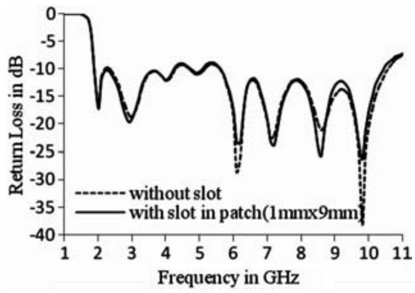


Fig. 4 — Return losses with slot and without slot in patch

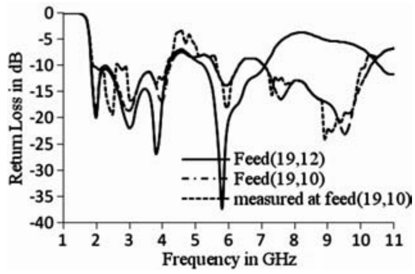


Fig. 5 — Return loss versus frequency at different feeding position

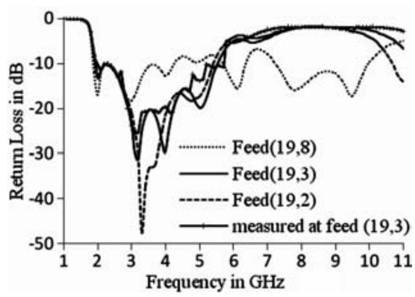


Fig. 6 — Return loss versus frequency at different Feeding position

show the simulated results of proposed microstrip patch antenna at different feeding positions. With the shifting of feed position through the upward direction of ground plane, broadband microstrip patch antenna is converted into multiband patch antenna. Similarly, with the change of feed position towards the downward direction, the percentage bandwidth is reduced from 140 to 95%. The simulated results have been confirmed by some measured data also. Figs 7 and 8 show that the behaviour of the transmitted signal and the parameters are not changed significantly with the change of dimension of the slits. The nature of the transmitted signal changes proportionally with the dimensions of the slits. Figure 9 shows that the simulated and measured results of microstrip patch antenna are in good parity. The simulated bandwidth is 140% with feeding position located at (19, 7) where as the measured bandwidth of 148% with approximately same return loss. All the results from Figs 5 to 9 of the proposed antenna are discussed briefly in Table 2. The simulated and measured gain of the proposed antenna are positive (+3dB) through the frequency band which show the VSWR, simulated and measured radiation pattern of proposed microstrip patch antenna at different resonant frequencies as shown in Figs 10-12, respectively.

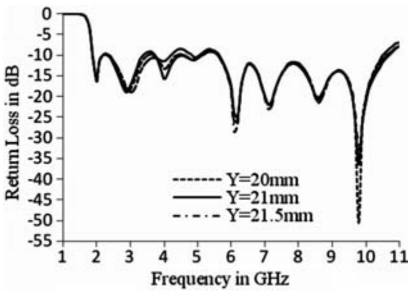


Fig. 7 — Return loss versus frequency at different value of Y

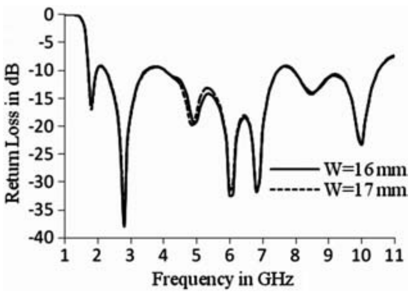


Fig. 8 — Return loss versus frequency at different value of *W*

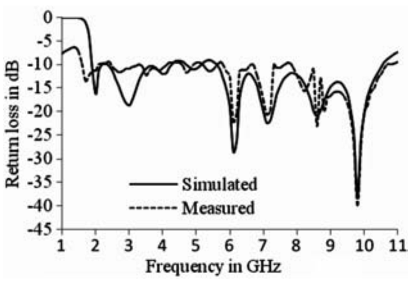


Fig. 9 — Simulated and measured results of return loss with optimum feeding position

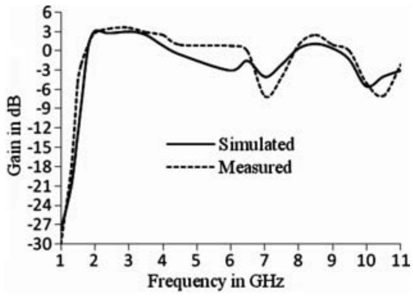
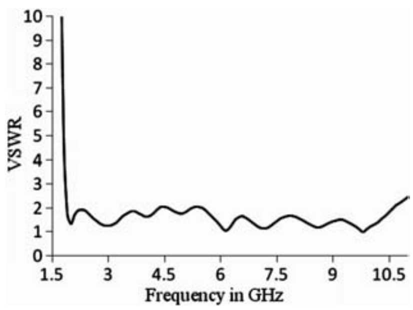


Fig.10 — Gain versus frequency of proposed antenna



. Fig. 11 — VSWR of proposed microstrip patch antenna

Table 2 — Simulated results at different frequency with respect to feeding position

Feeding position	Resonance frequency (in GHz)	Frequency band (in GHz)	% of Bandwidth	Applications
(19,2)	3.3	1.95 to 5.4	93%	S and C-band
(19,3)	3.2	1.95 to 5.5	95%	S and C-band
(19,7)	6.10 and 9.8	1.88 to 10.58	140%	L,S,C and X-band
(19,8)	2, 3 and 9.5	1.85 to 4.3, 5.6 to 6.4 and 7.2 to 10	80%, 13% and 32%	S,C-band and X-band
(19,10)	2, 3 and 9.5	1.85 to 4.3, 5.5 to 6.4 and 7 to 10.3	80%, 15% and 38%	S,C-band and X-band
(19,12)	2, 3,3.8 and 5.8	1.85 to 4.2, 5.2 to 7.1 and 10.5 to 12	77%, 31% and 13%	S,C-band and X-band

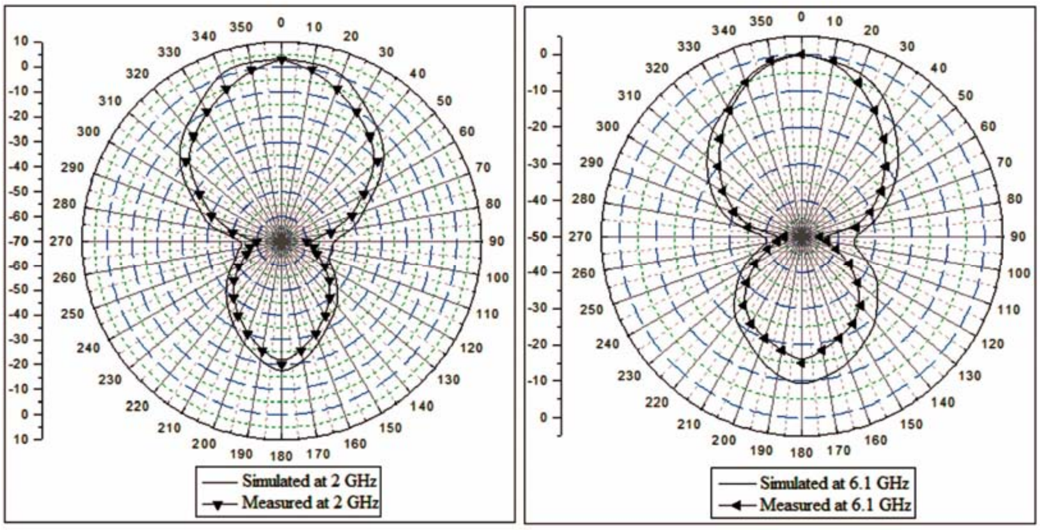


Fig. 12 — Radiation pattern of proposed microstrip patch antenna

4 Conclusions

The proposed microstrip patch antenna may be used as a wideband or multiband antenna at very high frequency band. With the change of feed position, the results change significantly.Due to this, it can be used as a multipurpose broadband antenna at different frequency bands like S, C and X-band. That is why it may be very popular in wireless communication applications.

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