Indian Journal of Science and Technology, *Vol 9(22), DOI: 10.17485/ijst/2016/v9i22/92812, June 2016*

ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645

Design of Frequency-Reconfigurable Microstrip Patch Antenna

Himanshu Anand* and Anil Kumar

Department of Electronics and Communication Engineering, Shepherd School of Engineering and Technology, Shiats-Du, Allahabad - 211007, Uttar Pradesh, India; sumant.himanshu4@gmail.com, anil.kumar@shiats.edu.in

Abstract

Background/Objectives: A frequency reconfigurable antenna is presented with operating frequency as 3.35 GHz. This antenna is capable of switching to six different frequencies. **Methods/Analysis:** A reconfigurable microstrip patch antenna has been designed with slots cut in the ground plane. Three p-i-n diode has been introduced between these slots on the ground plane. The antenna produced six different frequency bands between 4.1818 GHz to 7.2727 GHz at operating frequency 3.35 GHz. The projected antenna has been designed using Taconic35 substrate with a relative dielectric constant of 3.5 and thickness of 1.52 mm. **Findings:** The proposed antenna exhibits multi-frequency behavior. This antenna is capable of switching to six different frequencies viz. 4.1818 GHz, 4.2424 GHz, 7.3333 GHz, 4.3030 GHz, 7.2727 GHz and 7.2121 GHz. At these frequencies proposed antenna produces six Return loss viz.-19.6476 dBi, -20.8143 dBi, -23.8396 dBi, -22.8885 dBi, -21.5707 dBi and -25.6389 dBi and Gain of 2.5808 dBi, 2.0623 dBi, 2.5694 dBi, 2.2819 dBi, 3.2810 dBi and 3.1969 dBi. **Novelty/Improvements:** In this paper a compact frequency reconfigurable microstrip patch antenna has been presented with less Return loss and high gain in compare with the conventional one.

Keywords: Microstrip Patch Antenna, Reconfigurable Frequency, p-i-n Diode

1. Introduction

Patch antennas are assigned different names such as printed antennas, microstrip patch antennas or simply Micro Strip Antennas (MSA). Microstrip antennas are often used where thickness and conformability to the host surface are key requirements. Since the patch antennas can be directly printed onto a circuit board, these are becoming increasingly popular within the mobile phone market. These are low cost, have a low profile and are easily fabricated. In high performance aircraft, spacecraft, satellite, and missile applications, microstrip antennas are widely used. Presently there are many other government and commercial applications such as mobile, radio and wireless communications where microstrip patch antennas are being given preference[1-4].

Reconfigurable antenna is an antenna which is capable of reconfiguring its characteristics such as frequency, radiation pattern, bandwidth and polarization to adapt the environment. In recent days the reconfigurable antennas are attaining great attention especially in future wireless communication systems due to its ability to reduce front end system and allow pre-filtering at the receiver. The reconfigurable antennas also contain many other features besides its reconfigurable capability, the features like low cost, multipurpose functions, and size miniaturization. Microstrip antenna has been used as a platform to design reconfigurable antenna[5-11].

1.1 Proposed Antenna

A frequency reconfigurable design is proposed by using slot configuration in microstrip patch antenna with introducing p-i-n diode between slots, which works on the switching technique, i.e., ON-OFF state technique.

Reconfiguration of the antenna might be done in single part as well as multipart antenna. In single part antenna,

**Author for correspondence*

slots are cut in the antenna to distribute the current and reconfigurable components are installed in the slots to achieve reconfiguration while in multipart antenna, to achieve reconfiguration, current is distributed in some parts or all parts. Reconfigurable antenna is mainly used in laptop, circular phone, wireless system, Multiple Input Multiple Output System (MIMO), ultra wide band system and security based system, also it can be used in many other application by changing their functionality[12,13].

In this paper a reconfigurable microstrip patch antenna is proposed with slots cut in ground plane with substrate three p-i-n diode has been introduced between these slots on the ground plane. The antenna produced six different frequency bands between 4.1818 GHz to 7.2727 GHz at operating frequency 3.35 GHz.

2. Antenna Configuration

In this section the design prospect of the antenna is shown as Figure 1a and b. The material used in this structure is Taconic 35 as substrate with a relative permittivity of 3.5 and thickness of 1.52 mm. The dimension of the antenna is indicated by Length (L)=50 mm and width (W)=50 mm. The length of feed line is 61.3 mm where q=44 mm and p=17.3 mm. The feed line width is 3.4 mm. The other parameters which are indicated in Figure 1b i.e., back view of proposed design is as follows:-

J=3.39 mm, k=17.67 mm, l=31.95 mm, m=36 mm. Three switches have been used s1, s2 and s3.

Figure 1a and b shows both the front and back view of the Antenna, s1, s2, s3 represents the switch1, switch2, switch3 respectively. The working strategy of all these three switches has been explained in Table 1. In Table 1 there are six frequencies corresponding to six different switching strategies of the switches:

Where, s1=switch1, s2=switch2 and s3=switch3.

The proposed antenna consists of four slots cut in the ground plane. These four slots are perpendicular to the feed line where the feed excites the slots. At the centre of feed line a low resistance radiation is achieved because of off-centre feeding. To achieve frequency reconfigurability, three switches are used in between the slots in order to change the effective length of the slots and thus controllable narrowband frequencies are produced. Here copper strip has been used to represent switching devices. When the copper strip is present, it means switch is ON whereas the absence of copper strip represents the OFF state of the switches.

3. Results and Discussion

Figure 2 shows the variation of the Return loss with frequency for different switching phenomenon at different diode. The six different frequency bands have been obtained at six different frequencies. At frequency f1=4.1818 GHz return loss is -19.6476 dBi at switching condition s1=1(ON), s2=0(OFF), s3=0(OFF). At frequency f2=4.2424 GHz and f3=7.3333 GHz the return losses are-20.8143 GHz and -23.8396 GHz respectively

Table 1. Switch configuration details.

Configuration	S1	S2	S3	Resonant frequency
F1	ON	OFF	OFF	4.1818
F2	ON	OFF	ON	4.2424.
F3	ON	OFF	ON	7.3333
F4	ON	ON	OFF	4.3030
F5	ON	ON	OFF	7.2727
F6	ON	ON	ON	7.2121

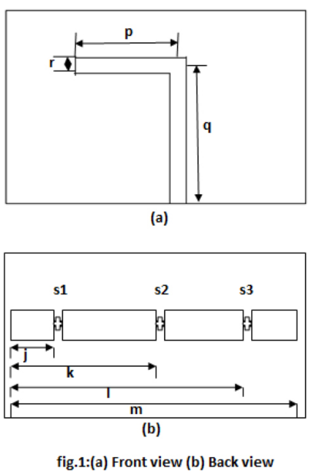

Figure 1. (a) Front view. (b) Back view.

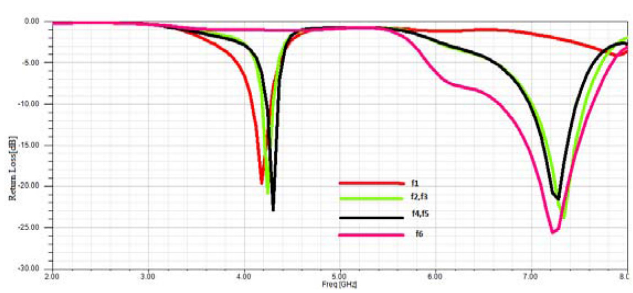

Figure 2. Return loss.

at switching condition s1=1(ON), s2=0(OFF), s3=1(ON). At frequency f4=4.3030 GHz and f5=7.2727 GHz, return losses are -22.8885 dBi and -21.5707 dBi respectively at switching condition s1=1(ON), s2=1(ON), s3=0(OFF). At frequency f6=7.2121 return loss is 25.6389 dBi at switching condition s1=s2=s3=1(ON). There are two frequencies f4=4.3030GHz and f6=7.2121GHz on which the return loss is better than conventional one at switching condition s1=ON, s2=ON, s3=OFF and s1=ON, s2=ON, s3=ON.

Figure 3 shows the Gain vs. frequency graph. At frequency f1= 4.1818 GHz the gain measured is 2.5808 dBi at switching condition s1=1(ON), s2=0(OFF), s3=0(OFF). At frequency f2=4.2424 GHz and f3=7.3333 GHz the gain is 2.0623 dBi and 2.5694 dBi respectively at switching condition s1=1 (ON), s2=0 (OFF), s3=1 (ON). At frequency f4=4.3030G Hz and f5=7.2727 GHz, gain is 2.2819 dBi and 3.2810 dBi respectively at switching condition s1=1(ON), s2=1(OFF), s3=0(OFF). At f6= 7.2121 GHz the gain is 3.1969 at switching condition s1=s2=s3=1, all are in ON condition. The maximum gain obtained is 3.2810 at f5=7.2727 GHz.

The Figure 4 shows the variation of VSWR with frequency. The value of VSWR has been obtained at six different frequencies. At f1=4.1818 GHz VSWR is 2.1671 with switching condition s1=1(ON). s2=0(OFF), s3=0(OFF). At f2= 4.2424GHz VSWR is 1.1820 and at f3=7.3333 GHz VSWR is 1.1480 with switching condition s1=1(ON), s2=0(OFF), s3=1(ON). At f4= 4.3030 GHz, VSWR is 1.6400 and at f5= 7.2727 GHz, VSWR is 1.1169 with switching condition s1=1(ON), s2=1(ON), s3=0 (OFF). At f6=7.2121 GHz, the VSWR obtained is 1.1028 with switching condition s1=s2=s3=1, all are in ON state.

Figure 5 shows the Directivity graph of the proposed Antenna design. The Directivity has been obtained at six different frequencies , at 4.1818 GHz, 4.2424 GHz, 7.3333 GHz, 4.3030 GHz,7.2727 GHz, 7.2121 GHz, the obtained Directivity are 2.6800 dBi, 2.1628 dBi, 2.4036 dBi, 2.4319 dBi, 2.9922 dBi and 2.7520 dbi respectively.

Table 2 shows the summarized values of Return Loss, Gain, VSWR and Directivity obtained at six different frequencies at six different switching conditions.

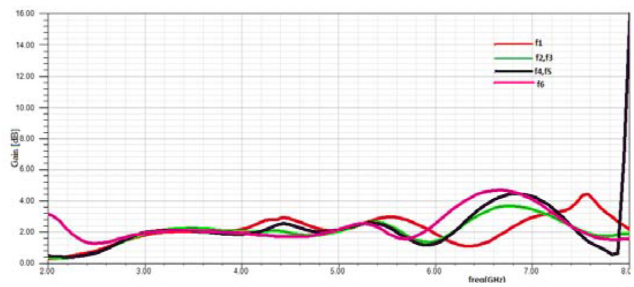

Figure 3. Gain spectrum.

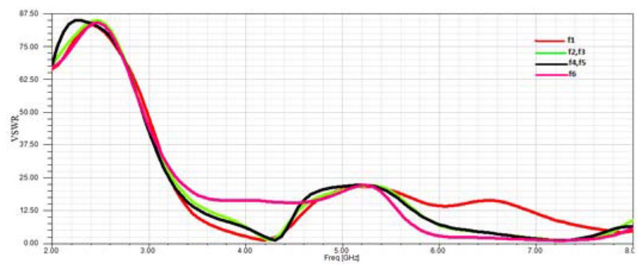

Figure 4. VSWR vs. frequency.

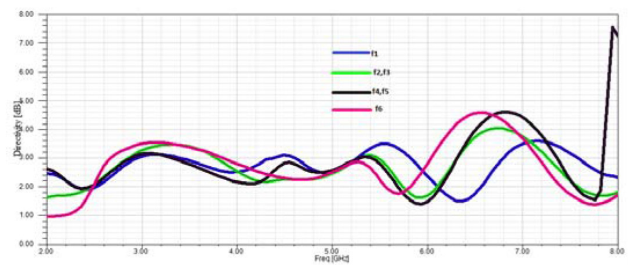

Figure 5. Directivity vs. frequency.

Table 2. Analyzed resonant frequency, return loss, gain, VSWR, directivity and bandwidth.

Frequency (in GHz)	Return loss (in dBi)	Gain (in dBi)	VSWR	Directivity (in dBi)	Bandwidth (%)
4.1818(F1)	-19.6476	2.5808	2.1671	2.6800	4.88
4.2424(F2)	-20.8143	2.0623	1.1820	2.1628	2.65
7.3333(F3)	-23.8396	2.5694	1.1480	2.4036	7.59
4.3030(F4)	-22.8885	2.2819	1.6400	2.4319	2.80
7.2727(F5)	-21.5707	3.2810	1.1169	2.9922	6.73
7.2121(F6)	-25.6389	3.1969	1.1028	2.7520	13.53

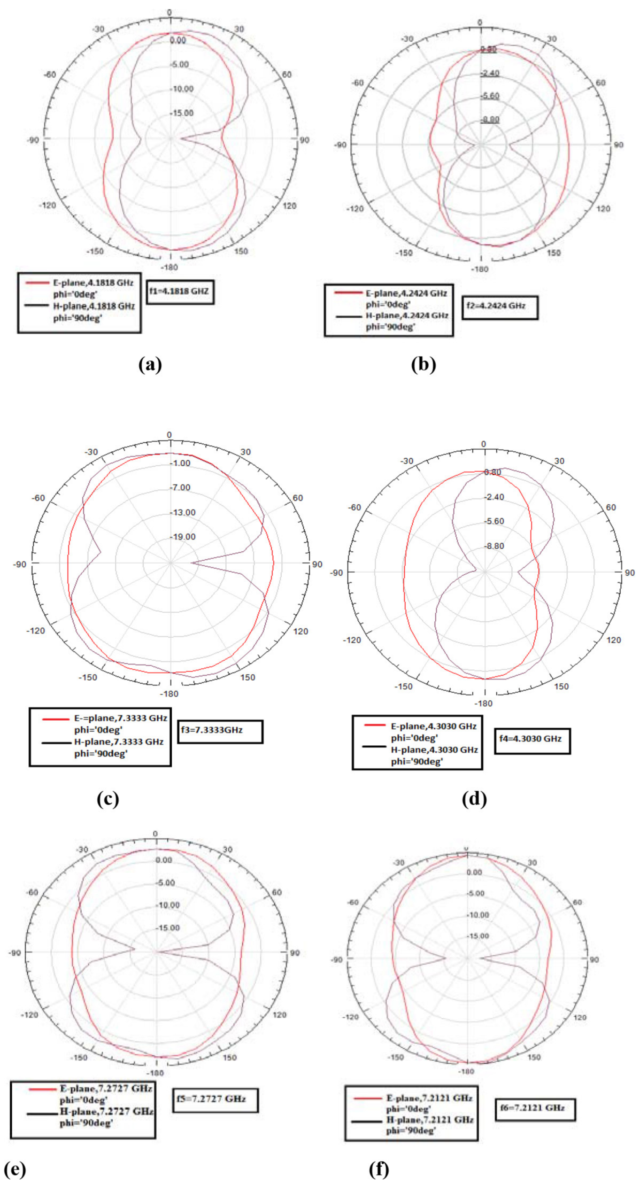

Figure 6. Radiation pattern..

Figure 6 (a), (b), (c), (d), (e), (f) shows the radiation pattern on E-Plane and H-Plane obtained on different frequencies, viz.4.1818 GHz, 4.2424 GHz, 7.3333 GHz, 4.3030 GHz, 7.2727 GHz, and 7.2121 GHz respectively.

4. Conclusion

To achieve frequency reconfigurability three p-i-n diode has been used between the slots which can produce six frequency bands ranges from 4.1818 GHz to 7.2727 GHz. This antenna has relatively good Return loss, Gain, Directivity, VSWR and is compact in size.

5. References

1. Mezall SY. New compact microstrip patch antenna: Design and simulation results. Indian Journal of Science and Technology. 2016 Mar; 9(12).DOI: 10.17485/ijst/2016/v9i12/85950.
2. Balanis CA. Antenna theory: A review. Proceedings of the IEEE; 1992. p. 7-23.
3. Park SY, Oh SJ, Park JK, Kim JS. Dual-band antenna for WLAN/UWB. Applications, Microwave Conference (APMC); 2009. p. 2707-10.
4. Bernhard JT, Wang R, Clark R, Mayes P. Stacked reconfigurable antenna elements for space-based radar applications. IEEE Antennas and Propagation Society International Symposium; 2001. p. 158-61.
5. Gardner P, Hall PS, Kelly J. Reconfigurable antennas for cognitive radio: Requirements and potential design approaches. Institution of Engineering and Technology Seminar on Wideband Multiband Antennas and Arrays for Defense or Civil Applications; 2008. p. 94.
6. Mirkamali A, Hall PS. Wideband frequency reconfiguration of a printed log periodic dipole array microw. Opt Lett. 2010 Apr; 52(4):861-4.
7. Tawk Y, Christodoulou CG. A new reconfigurable antenna design for cognitive radio. IEEE Antennas Wireless Propag Lettt. 2009; 8:13-81.
8. Yu Y, Xiong J, Li H, He S. An electrically small frequency reconfigurable antenna with a wide tuning range. IEEE Antennas Wireless Propag Lett. 2011; 10:103-6.
9. Zhangt Y, Wang BZ, Yang XS. Fractal Hilbert microstrip antennas with reconfigurable radiation patterns. Microw Opt Technol Lett. 2007 Feb; 49(2):352-4.
10. Rameswarudu ES, Sridevi PV. A Novel triple band planar microstrip patch antenna with defected ground structure. Indian Journal of Science and Technology. 2016 Jan; 9(3). DOI: 10.17485/ijst/2016/v9i3/84674.
11. Dheeraj K, Pourush PKS. Ni ferrite based microstrip phased array antenna in L-band. Indian Journal of Science and Technology. 2010 Dec; 3(12).
12. Costantine J, Tawk Y, Christodoulou CG, Barbin SB. A star shaped reconfigurable patch antenna. Proceedings IEEE IMWS; Guadalajara, Mexico. 2009 Feb. p. 19-20.
13. Constantine J, Al Safar S, Christoudoulou CG, Abdallah CT. Reducing redundancies in reconfigurable antenna structure using graph models. IEEE Transaction on Antennas and Propagation. 2011 Mar; 59(3).