

Research Article

Frequency Reconfigurable T-Shaped Microstrip Patch Antenna

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Abstract

A frequency reconfigurable antenna is presented with operating frequency as 3.35GHz. This antenna is capable of switching to four different frequencies 2.3232 GHz, 7.9797 GHz, 6.8484 GHz and 6.9292 GHz. There are 2-p-i-n diodes used in between the different slots to achieve frequency reconfigurability. Proposed design has been found to have better performance over the conventional one by considering the characteristics like Return Loss, Directivity, Gain and VSWR.

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 microstrip 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 (Balanis *et al*, 1992; Park *et al*, 2009; Bernhard *et al*, 2001).

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 (Gardner *et al*, 2008; Mirkamali *et al*, 2010; Tawk *et al*, 2009; Yu *et al*, 2011; Zhangt *et al*, 2007).

As described in (Haupt *et al*, 2013), The idea of reconfigurable antenna appeared in early 1930s however, later on, In 1970, a pattern reconfigurable

antenna was designed for satellite communication (DiFonzo, *et al*, 1979) and in 1999, a reconfigurable leaky patch antenna with PIN diode was presented (Chang *et al*, 1999). From 1999 until the present day, microstrip antenna has been used as a platform to design reconfigurable antenna (Pourziad *et al*, 2013; Jusoh *et al*, 2013; Majid *et al*, 2012; Manafi *et al*, 2012; Madi *et al*, 2012; Razali *et al*, 2011; Xia *et al*, 2010).

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, 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 (Costantine *et al*, 2009; Safar *et al*, 2011).

In this paper a reconfigurable microstrip patch antenna is proposed with slots cut in ground plane with substrate two p-i-n diode has been introduced between these slots on the ground plane. The antenna produced four different frequency bands between 2.3232 GHz to 6.9292 GHz at operating frequency 3.35 GHz.

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This paper has been organised in the several sections. In section 2, antenna design is explained. In section 3, results obtained after simulation are discussed, and finally the paper is concluded in section 4.

2. Antenna Configuration

In this section the design prospect of the antenna is shown as Fig.1,(a) & (b).The material used in this structure is Taconic35 as substrate with a relative permittivity of 3.5 and thickness of 1.52mm.The dimension of the antenna is indicated by Length(L)=50mm and width(W)=50mm.The length of feed line is $r= 45.7$ mm the feed line width is 1.4mm.The patch length $p=24$ and width is $q=1.4$.The other parameters which are indicated in fig.1(b) i.e,back view of proposed design is as follows:- $J=13.62$ mm , $k=27.9$ mm , $l=42.18$ mm. Two switches has been used $s1$ and $s2$.

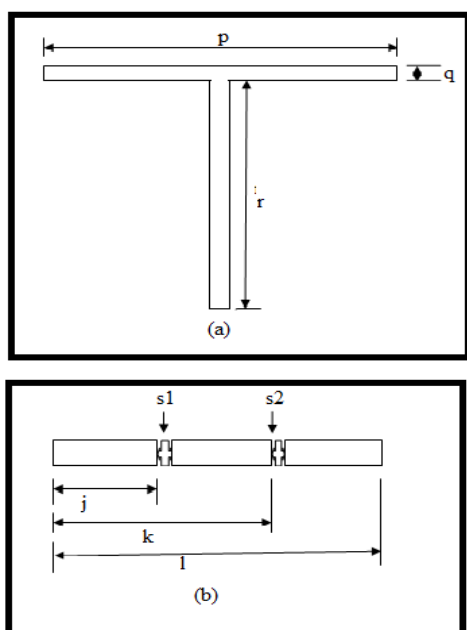


Fig.1: (a) Front View (b) Back View

Fig.1 (a) and (b) shows both the front and back view of the Antenna, $s1$ and $s2$ represents the switch1 and switch2 respectively. The working strategy of all these three switches has been explained in TABLE I. In Table 1 there are four frequencies corresponding to three different switching strategies of the switches

Table 1 Switch configuration details

Configuration	S1	S2	Resonant frequency (GHz)
F1	OFF	OFF	2.3232
F2	OFF	OFF	7.9797
F3	OFF	ON	6.8484
F4	ON	OFF	6.9292

Where, $s1$ =switch1 and $s2$ =switch2.

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. In the simulation process, 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

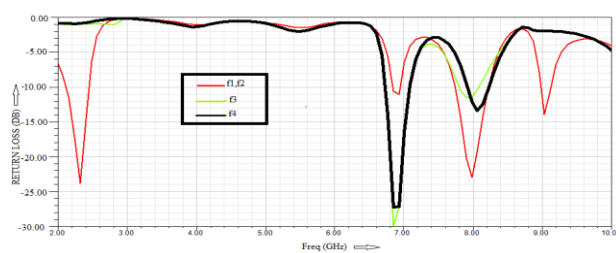


Fig.2: Return Loss

Fig 2. Shows the variation of the Return loss with frequency for different switching phenomenon at different diode. The four different frequency bands have been obtained at four different frequencies. At frequency $f1=2.232$ GHz and $f2=7.9797$ return loss is -23.9999 dBi and -23.000 dBi respectively at switching condition $s1=0$ (OFF), $s2=0$ (OFF). At frequency $f3=6.8484$ GHz the return loss is -29.9989 dBi at switching condition $s1=0$ (OFF), $s2=1$ (ON).At frequency $f4=6.9292$ the Return loss is -27.3252 dBi at switching condition $s1=1$ (ON), $s2=0$ (OFF).

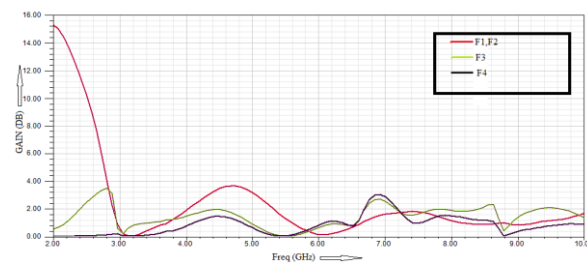


Fig.3: Gain spectrum

Fig.3 shows the graph obtained between the frequency and Gain At frequency $f1= 2.3232$ GHz the gain measured is 12.6486 dBi at switching condition $s1=0$ (OFF) and $s2=0$ (OFF).At frequency $f2=7.9797$ GHz and the gain is 1.1985 dBi at switching condition $s1=0$ (OFF) and $s2=0$ (OFF).At frequency $f3=6.8484$ GHz gain is 2.6721 dBi at switching condition $s1=0$ (OFF) and $s2=1$ (ON).At $f4=6.9292$ GHz the gain is 2.8560 at switching condition $s1=1$ (ON) and $s2=0$ (OFF).The maximum gain obtained is 12.6486 at $f1=2.3232$ GHz

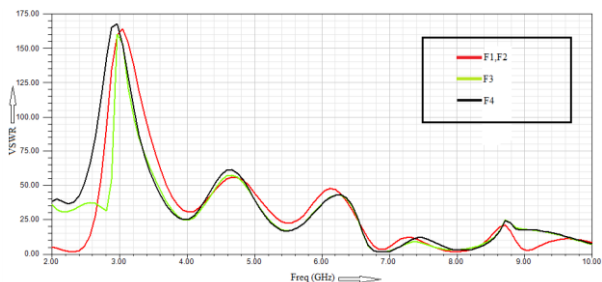


Fig.4: VSWR vs. Frequency

The fig.4 shows the variation of VSWR with frequency. The value of VSWR has been obtained at four different frequencies. At $f_1= 2.3232$ GHz VSWR is 1.6777 with switching condition $s_1=0$ (OFF) and $s_2=0$ (OFF). At $f_2= 7.9797$ GHz VSWR is 1.7260 at switching condition $s_1=0$ (OFF) and $s_2=0$ (OFF). At frequency $f_3= 6.8484$ GHz VSWR is 1.4331 at switching condition $s_1=0$ (OFF) and $s_2=1$ (ON). At frequency $f_4=6.9292$ GHz the VSWR obtained is 2.4135 with switching condition $s_1=1$ (ON) and $s_2=0$ (OFF).

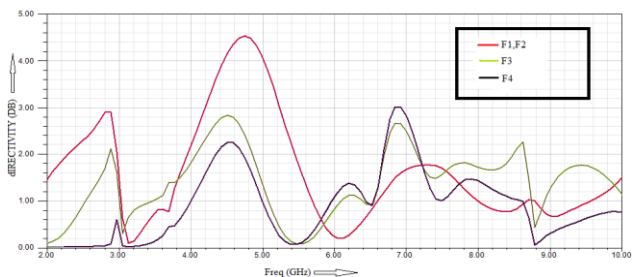


Fig.5: Directivity Vs frequency

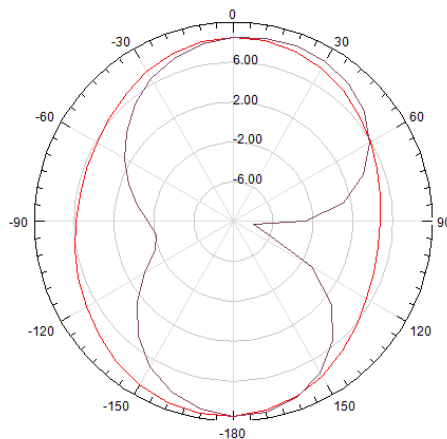
Fig.5 shows the Directivity graph of the proposed Antenna design. The Directivity has been obtained at six different frequencies ,at 2.3232 GHz,7.9797 GHz,6.8484 GHz and 6.9292 GHz the obtained Directivity are 2.0373 dBi,1.0120 dBi,2.6636 dBi and 3.0096 dBi respectively.

Table 2 shows the summarised values of Return Loss, Gain, VSWR and Directivity obtained at four different frequencies at three different switching conditions

Table 3 Simulated resonant frequency, return loss, gain, VSWR and directivity

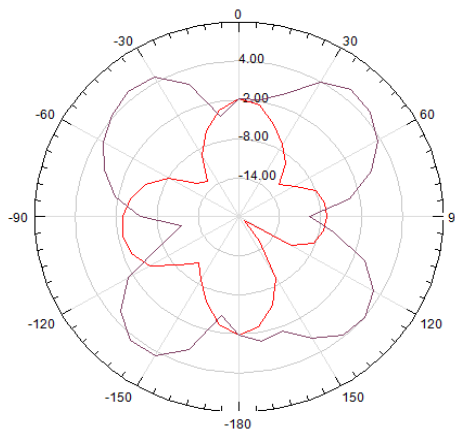
Frequency (GHz)	Return loss(dBi)	Gain (dBi)	VSWR	Directivity (dBi)
2.3232	-23.9999	12.6486	1.6777	2.0373
7.9797	-23.000	1.1985	1.7260	1.0120
6.8484	-29.9989	2.6721	1.4331	2.6636
6.9292	-27.3252	2.8560	2.4135	3.0096

Fig 6-fig 9 shows the radiation pattern obtained on different frequencies, viz.2.3232 GHz, 7.9797 GHz, 6.8484 GHz and 6.9292 GHz respectively.



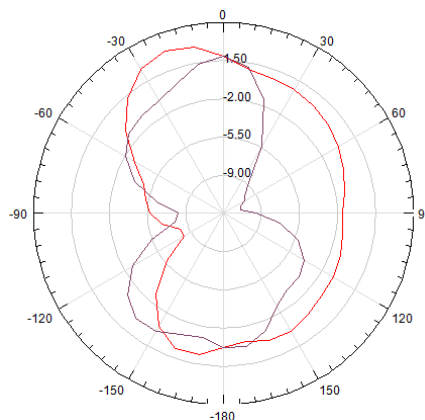
— E-Plane,2.3232 GHz
phi='0 deg'
— H-Plane,2.3232 GHz
phi='90 deg'

Fig.6



— E-Plane,7.9797 GHz
phi='0 deg'
— H-Plane,7.9797 GHz
phi='90 deg'

Fig.7



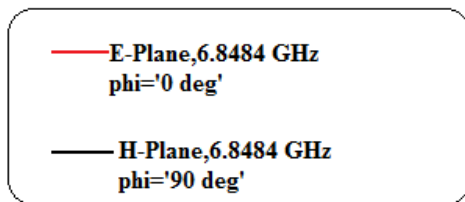


Fig.8

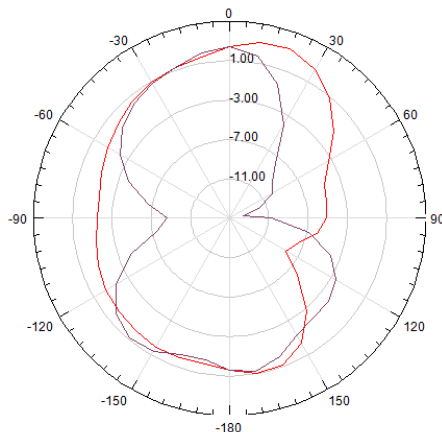


Fig.9

Conclusions

The antenna has been designed which has the characteristics of frequency reconfigurability. To achieve frequency reconfigurability three p-i-n diode has been used between the slots which can produce four frequency bands ranges from 2.3232 GHz to 6.9292 GHz. This antenna has relatively good Return loss, Gain, Directivity, VSWR and is compact in size.

References

- C. Balanis, (1992), Antenna theory: A review, *Proceedings of the IEEE*, 80,pp.7-23.
- S. Park, S. J. Oh, J. K. Park, and J. S. Kim (2009), Dual-band antenna for WLAN/UWB applications, *Microwave Conference, APMC 2009*, 2707-2710, Asia Pacific,2009.
- J.T. Bernhard, R. Wang, R. Clark, and P. Mayes (2001), Stacked reconfigurable antenna elements for space-based radar applications, *IEEE Antennas and Propagation Society International Symposium*,1,pp. 158-161.
- P. Gardner, P. S. Hall, and J. Kelly (2008), Reconfigurable antennas for cognitive radio: Requirements and potential design approaches, *Institution of Engineering and Technology Seminar on Wideband, Multiband Antennas and Arrays for Defence or Civil Applications*, 89,pp.94.
- A. Mirkamali and P. S.hall (2010),wideband frequency reconfiguration of a printed log periodic dipole array,microw.opt.Lett.52(4),pp.861-864.
- Y. Tawk and C.G. Christodoulou (2009), A new reconfigurable antenna design for cognitive radio ,*IEEE Antennas wireless propag.Lett.*,8,pp.13-81.
- Y.Yu,J.Xiong,H.LI AND S.HE ,An electrically small frequency reconfigurable antenna with a wide tuning range(2011),*IEEE antennas wireless propag.lett.*,10,pp.103-106.
- Y.Zhangt,B.Z.Wang,and X.S. Yang (2007),Fractal Hilbert microstrip antennas with reconfigurable radiation patterns,*Microw.opt.Technol.Lett.*,49(2),pp.352-354.
- Haupt, R. L. and M. Lanagan (2013),Reconfigurable antennas, *IEEE Antennas and Propagation Magazine*,55(1),2013,pp. 49-61.
- A.DiFonzo,D. Karmel, and P. Atia, Multiple shaped beam reconfigurable satellite antenna (1979),*IEEE Antennas and Propagation Society International Symposium*,17,pp. 457-460.
- Chang, B. C. C., Y. Qian, and T. Itoh (1999), "A reconfigurable leaky mode/patch antenna controlled by PIN diode switches,"*IEEE Antennas and Propagation Society International Symposium*, Vol. 4,pp. 2694-2697.
- A.Pourziad, S. Nikmehr, and H. Veladi (2013),A novel multi-state integrated RF MEMS switch for reconfigurable antennas applications, *Progress In Electromagnetics Research*,139,pp. 389-406.
- M.Jusoh, M. F. B. Jamlos, M. R. Kamarudin, T. Sabapathy, M. I. Jais, and M. A. Jamlos (2013), A fabrication of intelligent spiral reconfigurable beam forming antenna for 2.35-2.39 GHz applications and path loss measurements, *Progress In Electromagnetics Research*,138,pp.115-131.
- H.A. Majid,, M. K. A. Rahim, M. R. Hamid, and M. F. Ismail (2012),Frequency and pattern reconfigurable Yagi antenna,*Journal of Electromagnetic Waves and Applications*,26,(2-3),pp. 379-389.
- S. Manafi, S. Nikmehr, and M. Bemani (2012), Planar reconfigurable multifunctional antenna for WLAN/WiMAX/UWB/PCSDCS/UMTS applications, *Progress In Electromagnetics Research C*, 26,pp. 123-137.
- M.A .Madi, M. Al-Husseini, A. Ramadan, K. Y. Kabalan, and A. El-Hajj (2012), A reconfigurable cedar-shaped microstrip antenna for wireless applications ,*Progress In Electromagnetics Research*, 25,pp. 209-221.
- A.R. Razali. and M. E. Bialkowski (2011), Reconfigurable coplanar inverted-F antenna with electronically controlled ground slot, *Progress In Electromagnetics Research B*,34,pp. 63-76.
- Xia, Y. Q., J. Luo, and D. J. Edwards (2010), Novel miniature printed monopole antenna with dual tunable band-notched characteristics for UWB applications, *Journal of Electromagnetic Waves and Applications*,24(13),pp. 1783-1793.
- J. Costantine, Y. Tawk, CG. Christodoulou, S. B. Barbin (2009) A Star Shaped Reconfigurable Patch Antenna,in Proc. IEEE IMWS, Guadalajara, Mexico, pp. 19-20.
- Sinan Al Safar, Christos G. Christoudoulou, Chaouki T. Abdallah (2011), Reducing Redundancies In reconfigurable Antenna Structure Using Graph Models,*IEEE Transaction on Antennas & Propagation*, 59(3).