International Journal of Current Engineering and Technology
E-ISSN 2277 – 4106, P-ISSN 2347 – 5161

Available at http://inpressco.com/category/ijcet

Research Article

Frequency-Reconfigurable E-Shaped Microstrip Patch Antenna with P-i-N Diode

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Accepted 25 May 2016, Available online 03 June 2016, **Vol.6, No.3 (June 2016)**

Abstract

Frequency reconfigurable antenna is presented here with operating frequency of 5.25GHz. This antenna has feature to switch with three different frequencies 5.7374GHz, 5.7778 GHz, 5.8182GHz. The p-i-n diode is used in between the E-Shaped slots of the patch to configure the frequencies. Return loss, Directivity, Gain and VSWR are measured -20.892dBi, 8.1190dBi, 8.1522dBi and 1.3648 respectively. These value are best suited for designing the antenna.

Keywords: *E-Shaped Microstrip Patch Antenna, frequency Reconfigurable, RF, p-i-n Diode, VSWR.*

1. Introduction

Patch antenna is a type of radio antenna with a low profile, which can mounted on a flat surface. It consists of a flat rectangular sheet or "patch" of metal, mounted over a larger sheet of metal called a ground plane. Patch antennas are assigned different names such as shorted patch antenna, printed antennas, microstrip patch antennas (Lo *et al*, 1979). Microstrip antenna shapes are square, rectangular, circular and elliptical but any continuous shapes are possible. Some patch antennas do not use a dielectric substrate and instead are made of a metal patch mounted above ground plane using dielectric spacers; the resulting structure is less rugged but has a wider bandwidth. Because such antennas have a low cost, very low profile, are mechanically rugged and can be shaped to conform to the curving skin of a vehicle, they are often mounted on the exterior of satellite, missile applications aircraft and spacecraft, or are incorporated into mobile radio communication devices (Bancroft *et al*, 2004). 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 (Balanis *et al*, 1992).

Reconfigurable antenna is an antenna that capable to reconfigure its characteristics such as frequency, radiation pattern, bandwidth, and polarization to adapt the environment (Huff *et al*, 2008). Frequency reconfigurable antennas can adjust dynamically their frequency of operation (Gardner *et al*, 2008). Frequency reconfiguration is generally achieved by modifying physically or electrically the antenna dimensions using RF-switches, impedance loading or tunable materials (Mirkamali *et al*, 2010). In recent days the reconfigurable antenna are attaining great attention specially in future wireless communication systems due to its ability to reduce front end system and allow pre-filtering at the receiver[Tawk *et al*, 2009]. The reconfigure antennas also contains many other features due to which it is introduced in future wireless communication system such as its reconfigurable capability, low cost, multipurpose functions, and size miniaturization (Xiong *et al*, 2011).

1.1. Proposed antenna

A frequency reconfiguration design is proposed by using slot configuration in microstrip patch antenna with introducing diode between E-shaped patch. The introduced diode works on the switching technique, i.e., ON-OFF sate technique.A PIN diode is a diode with a wide, undoped intrinsic semiconductor region between a p-type semiconductor and an n-type semiconductor region. The p-type and n-type regions are typically heavily doped because they are used for ohmic contacts.

In this paper, a reconfigurable E-shaped microstrip patch antenna is proposed and two PIN diode is introduced between E-shaped slots of the patch. This antenna produced three different frequency band between 5.7374GHz to 5.8182GHz with resonant frequency 5.25 GHz.

2. Antenna configuration

The E-shaped microstrippatch antenna is shown in fig.1. A microstrip patch antenna is designed with

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length L=15mm and width W=18mm and thickness is 3.2mm which has 5.25GHZ resonant frequency. The substrate material is Taconic TLY(tm) which has relative permittivity 2.2. The slot length Ls=9mm,width Ws=1mm and Lt=3.5mm,Wt=5.9mm of E-shaped microstrip patch antenna. It is fed by coaxial at position (X0,Y0) . Coaxial feeding is done by inner conductor and outer conductor with radius of 0.65mm 2.35mm. The inner conductor is soldered on the top surface of the patch antenna and outer conductor is soldered is soldered on the ground plane. This design is done and results is covered by 5.7374-5.8182GHZ frequency range. The parameter are listed below:

L=15mm, W=18mm, h=3.2mm
Ls=9mm,Ws=1mm, Lt=3.5mm,Wt=5.9mm
(X_0,Y_0)=(3,6.4)
X_0

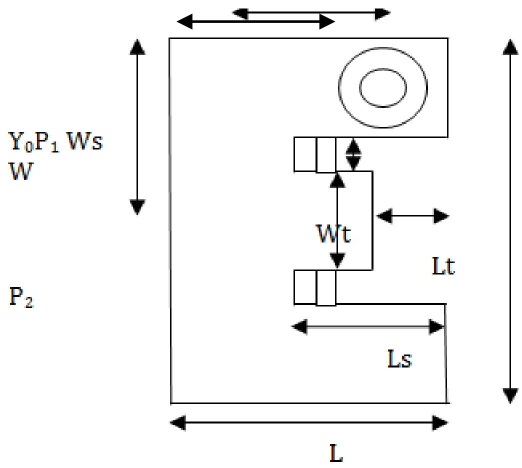

Fig.1 E-shaped antenna

There are two P-i-N diode as switches P_1 and P_2 used between E-shaped. The working strategy of all these two P-i-N have been explained in TABLE I. In TABLE I there are three frequencies corresponding to three different switching strategy of the switches.

Table 1 Switch Configuration Details

Configuration	P_1	P_2	Resonant frequency
F_1	OFF	ON	5.7374
F_2	ON	OFF	5.7778
F_3	ON	ON	5.8182

Where,P_1=switch1 and P_2=switch2.

3. Results and discussion

Fig.2 shown the variation of the Return loss with frequency for different switching phenomenon at different diode. The three different frequency bands have been obtained at three different frequencies. At frequency F_1=5.7374GHZ,the return loss is -16.3747dBi at switching condition P_1=OFF, P_2=ON. At frequency F_2=5.7778GHz, the return losses are -24.1305dBi at switching condition P_1=ON, P_2=OFF. At frequency F_3=5.8182GHz,the return losses are -22.1708dBi at switching condition P_1=ON, P_2=ON. The typical bandwidth is 0.5328GHZ or 9.14% fractional bandwidth at 5.25GHZ.

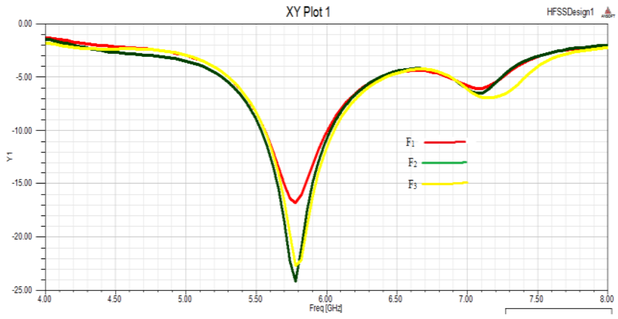

Fig.2 Return Loss

Fig.3 shows the graph obtained between the frequency and Gain. At frequency F_1=5.7374GHz the gain measured is 8.1841dBi at switching condition P_1=OFF, P_2=ON. At frequency F_2=5.7778GHz, the gain is 8.1452dBi and at switching condition P_1=ON, P_2=OFF. At frequency F_3=5.8182GHz, gain is 8.1273dBi at switching condition P_1=ON and P_2=OFF.

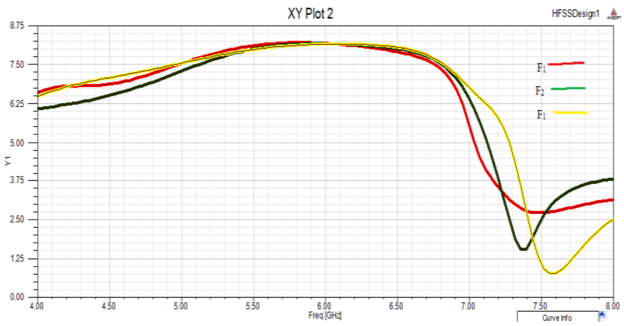

Fig.3 Gain spectrum

Fig.4 shows the graph obtained between the frequency and VSWR. At frequency F_1=5.7374GHz the VSWR measured is 2.6575 at switching condition P_1=OFF,P_2=ON at frequencyF_2=5.7778GHz, the VSWR is 1.0811 and at switching condition P_1=ON, P_2=OFF. At frequency F_3=5.8182GHz, VSWR is 1.3558 at switching condition P_1=1ON, P_2=1OFF.

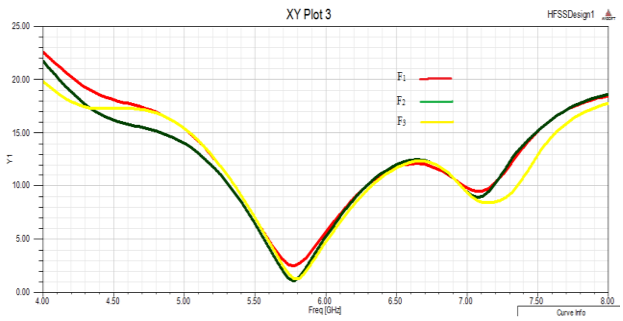

Fig.4 VSWR vs. Frequency

Fig.5 shows the graph obtained between the frequency and VSWR. At frequency F_1=5.7374GHz the Directivity measured is 8.1147dBi at switching condition P_1=OFF, P_2=ON .At frequency F_2=5.7778GHz, the Directivity is 8.1197dBi and at switching condition P_1=ON, P_2=OFF. At frequency F_3=5.8182GHz, Directivity is 8.1227 at switching condition P_1=1ON, P_2=1OFF.

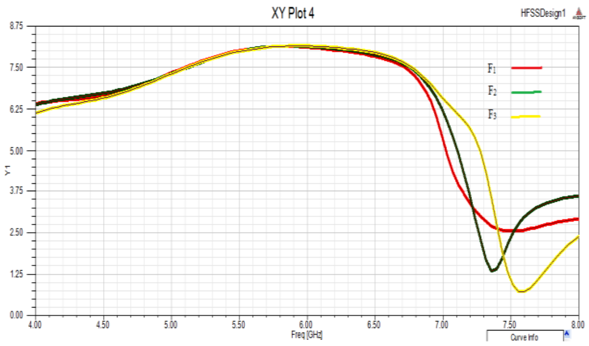

Fig.5 Directivity Vs frequency

Fig.6-fig.8 show the radiation pattern obtained on different frequencies 5.7374GHZ, 5.7778GHZ and 5.8182GHZ.

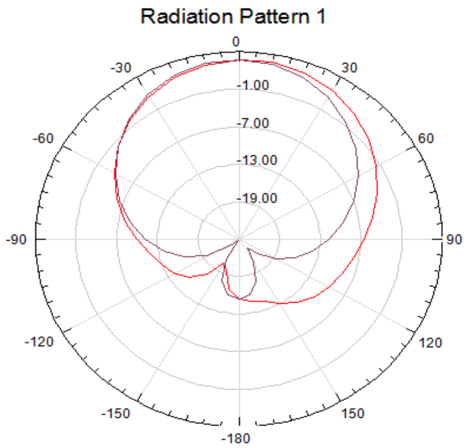

Fig.6 Radiation Pattern at F_1=5.7374GHZ

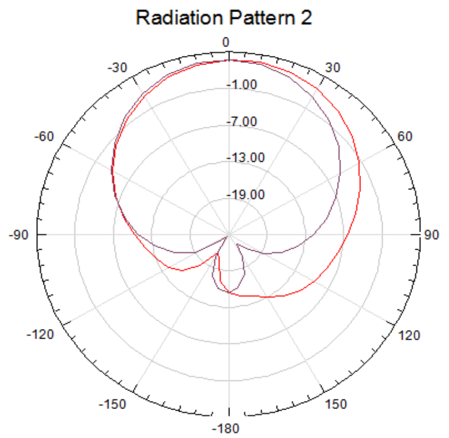

Fig.7 Radiation Pattern at F_2=5.7778GHZ

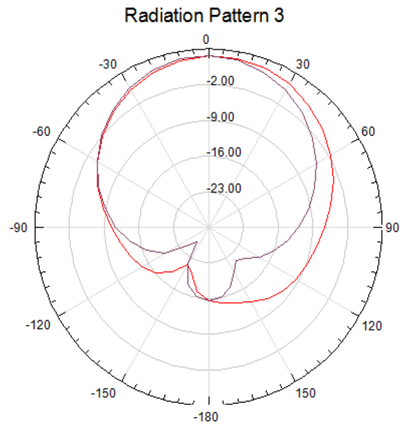

Fig.8 Radiation Pattern at F_3=5.8182GHZ

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

Frequency (GHz)	Return loss(dBi)	Gain (dBi)	VSWR	Bandwidth (%)
5.7374	-16.3747	8.1841	1.6575	7.67
5.7778	-24.1305	8.1452	1.0811	11.16
5.8182	-22.1708	8.1273	1.3558	8.59

Conclusions

The E-shaped microstrip patch antenna has been designed which has the characteristics of frequency reconfigurability. To achieve frequency reconfigurability two p-i-n diode has been used between E-shaped which can produce three frequency bands ranges from 5.7374GHz to 5.8182GHz. This antenna has relatively good Return loss, Gain, Directivity, VSWR and is compact in size.

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