E SHAPED FREQUENCY AND PATTERN RECONFIGURABLE ANTENNA FOR LTE AND WLAN APPLICATION

[1] Anuradha A. Palsokar, [2] Dr. S. L. Lahudkar
[1]Research Scholar, [2]Professor & H.O.D.
[1]Electronics & Telecommunication
[1] Rajarshi Shahu College of Engineering, Tathawade 411033 Pune, Maharashtra,

Abstract: ***This work presents the design of frequency and pattern reconfigurable antenna. The proposed antenna consists of E shaped radiator with four switches, so that the antenna achieves four state frequency and pattern reconfigurability. The antenna has a good impedance matching for the frequency of 3.3 GHz, 3.2GHz & 1.8GHz. The maximum percentage bandwidth obtained is 9.3% and maximum gain is 2.7dBi. More specifically, the antenna is able to steer its gain pattern to either the left, right directions or omnidirectional based on which combination of diodes are turned on. The antenna has a low profile of 32*42*1.6 mm and can be fabricated on a low cost FR4 substrate and with four p-i-n diodes. The antenna offers a low-cost, low-power solution for LTE and WLAN wireless systems that require frequency and beam reconfigurable antennas.***

Index Terms: Reconfigurable Antenna; LTE; Pattern Reconfigurable Antenna; WLAN

I. INTRODUCTION

The rapid and progressive technology continues requesting more brilliant and more versatile, minimal, and convenient antennas. Along these lines, antennas in present day applications must be multifunctional or versatile with the system/client necessities. Fixed performance antennas are constrained in their capacity to adapt to the evolving situation; in this way, reconfigurable antennas have turned into the practical answer for that circumstance. In addition, reconfigurable antennas are of small size and give adaptability by supplanting multiple fixed antennas. Frequency reconfigurable antenna is exceptionally alluring as it is valuable for wireless communication systems which have different requirements and multi-frequency applications. With control of the radiation pattern, the antenna can significantly upgrade performance of system, as it can enhance security and save direction by enhancing signal direction. There are a couple of techniques for accomplishing frequency reconfiguration. The length of the receiving antenna can be changed by including or expelling some portion of the length utilizing electronic switches. Another technique to change the length of the antenna is by utilizing capacitance, for example, varactor diodes. This permits smooth frequency tuning with changes of capacitance [4]. Pattern reconfigurable antennas are required for beam controlling and direction finding in multiuser environment. Being equipped for changing the radiation qualities, reconfigurable antennas are preferred in noisy environments to avoid the interference [8]. The blend of frequency and pattern reconfigurability into an antenna results in an improved and miniaturized version of antenna for size concerned and multifunctional system [1]. In recent days metamaterials and periodic structures are used to reconfigure antennas [2, 3, 6, 10].

II. RELATED WORKS

A planar antenna having a rhombus-shaped radiator associated with three excitation lines at various slant points is utilized to achieve a compound reconfigurability. The antenna’s capability to work in various states (frequency, polarization, and pattern) makes the antenna strong to multipath situations, fading, and shadowing impacts [12]. Since the antenna switches in the vicinity of 5.2 and 5.8 GHz, the designed antenna can be used for WLAN gadgets with frequency, pattern and polarization reconfigurability. A frequency and pattern reconfigurable V– shaped printed antenna is displayed in [13]. The antenna works at two different frequencies. The variation in the frequency is accomplished by exclusively expanding the length of the two antenna arms. A triangular parasitic element is placed within the empty space between the two antenna arms which is used to change pattern of the antenna. A novel frequency and pattern reconfigurable slot antenna is also proposed by Majid et al. [4]. Usually slot antenna generates bidirectional radiation pattern, so reflector is situated behind the antenna to produce a directional radiation design. Two switches are set in the space to deliver three reconfigurable frequency groups: at 1.82 GHz, 1.93 GHz and 2.10 GHz. The presentation of four openings at the edge of the ground plane offers design reconfigurability. Beam angles are tuned using three switches placed on each opening. By manipulating the phase of upper and lower slits in the ground plane, the beam can be steered in to three different angles at 0, -15 ° and 15°. Frequency and pattern reconfigurable Planar monopole or a microstrip patch with three operation modes, i.e. an omnidirectional pattern mode at the lower frequency band of 2.21-2.79 GHz, a unidirectional pattern mode at the higher frequency band of 5.27-5.56 GHz, and both of them working simultaneously was proposed by Li et al [3]. It provides a low-profile, low-cost and reconfigurable solution for multi-standard wireless communication applications. The geometry of antenna consists of an upper patch, a bottom monopole and bottom ground. The bottom ground is defected and designed into a planar monopole and a wider ground with a slot between them. The monopole and the patch are designed to resonate at a lower frequency and a higher frequency, respectively. The substrate is truncated at the far end from the feed point to improve the omnidirectional radiation performance. Three p-i-n diodes are vertical assembled across the substrate to connect the upper patch with the bottom monopole. Two p-i-n diodes are placed on the bottom slot between the bottom monopole and ground. Measured gain and efficiency are low. Frequency and pattern reconfigurable antenna is proposed [7] for WiMAX and WLAN applications. It has a simple structure and compact size. By controlling five pin diodes, the antenna resonates at three modes of 3.5GHz, 5.8GHz and dual bands. For each mode, the antenna works as a monopole antenna and has pattern reconfigurable characteristics at 3.5GHz, which provides antenna diversity in wireless communications.

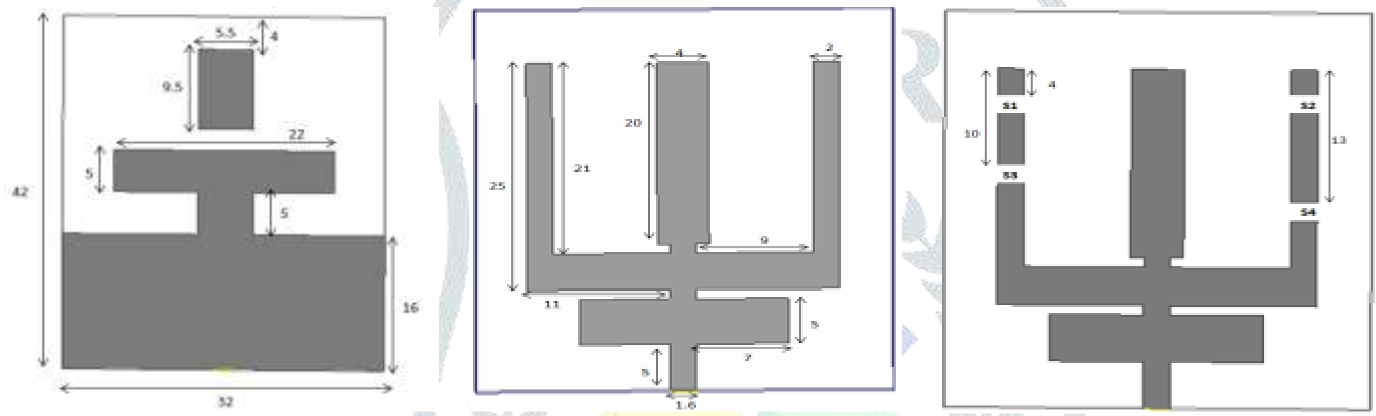
Shoaib et al. [5] designed frequency and pattern reconfigurable monopole which can alter the surface current distribution and radiating edges on antenna with two switches to achieve reconfigurability. The antenna could produce a dual frequency band of 2.45 GHz and 5.78 GHz with radiation pattern reconfigurability. The design of the antenna started with a CPW fed monopole, then a U-shaped and rectangular slot is made in the in the CPW-fed monopole antenna. Two switches were used to alter the size of rectangular slot. Aboufoul et al. [11] proposed a multimode antenna with the capability to switch between ultrawideband operation and narrow frequency band. To add more flexibility to the operation of the antenna the radiation patterns at the reconfigured frequency band can also be changed. On the back side of the substrate, a metal ground plane is printed and under the square patch element, the metal ground is wineglass shape truncated; this will improve the impedance matching and shape the radiation patterns e.g. radiation patterns are now more stable and consistent compared to conventional monopole antennas with partial grounds. Frequency reconfiguration is achieved by attaching a microstrip open circuit stub to the back ground plane to alter the impedance matching of the antenna. Radiation patterns reconfiguration is achieved by cutting 2 slots on the edges of the ground plane. If one slot is open and the other is shorted, the radiation patterns will no longer be omnidirectional and the open slots will perturb the current in the ground plane and will start to radiate.

This work presents the design of E shaped frequency and pattern reconfigurable antenna for LTE & WLAN applications. The antenna's potential to operate in different states (frequency and pattern) makes the antenna robust to multipath scenarios, fading, and shadowing effects. The paper is organized as follows. In Section III, the compound reconfigurable antenna design is presented. Section IV provides results and discussion. Finally, conclusion is presented in Section V.

III. ANTENNA CONFIGURATION

The geometry of the proposed novel compound reconfigurable antenna is shown in Fig. 1. The antenna under examination can be manufactured on a 1.6-mm-thick FR4 substrate with dielectric consistent 4.3 and loss tangent of 0.023. The proposed antenna has a footprint of 32*42 mm. The antenna is made reconfigurable utilizing four switches associated on the patch; the position of switches is featured in figure. HFSS programming is utilized to design the antenna. Utilizing distinctive blends of these four switches it is observed that the antenna works in four different modes.

Fig. 1 (a& b) shows the design of the ground and patch structure of the proposed antenna, the position of switches is shown in fig. 1(c), all the dimensions are in mm.



(a) *(b)* *(c)*

Figure 1: Design of proposed antenna a) Ground Structure b) Design of Patch c) Switches position

A. Frequency Reconfigurability

The antenna consists of E shaped radiator which is designed to resonate at 3.3, 3.2 and 1.8 GHz. To obtain the frequency reconfiguration four p-i-n diodes are used. During first three modes, for various operating combinations of the diodes the antenna works in 3.3 or 3.2 GHz, during the fourth mode when S1, S2 are off and S3, S4 are off then the antenna works at 1.8 GHz and 3.2 GHz

B. Pattern Reconfigurability

To obtain the reconfigurability all the four diodes are utilized. When all the diodes are on or when S1, S2 are off and S3, S4 are on the current density is maximum along two corners of antenna. But when S1, S2 are on and S3 & S4 are turned alternately off then the current density is maximum along only one corner of antenna, hence pattern reconfigurability is obtained. Table 1.1 summarizes the frequency and pattern reconfigurability of proposed E shaped antenna.

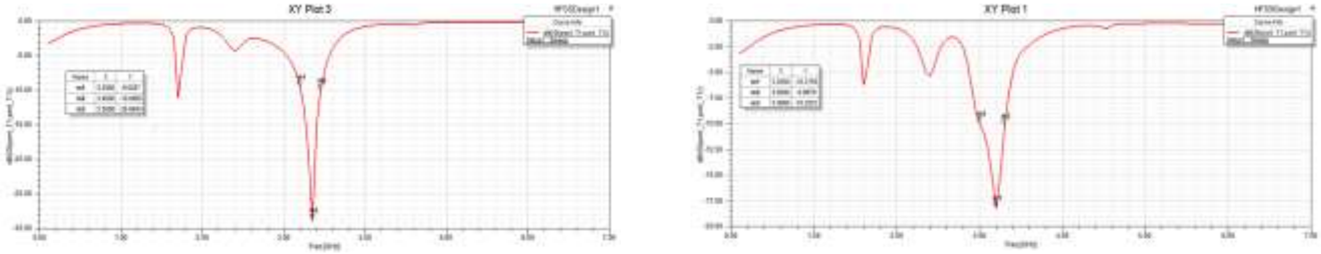
Table 1.1 Frequency and pattern reconfigurability of proposed E shaped antenna

Switch Position	Mode	Frequency	Radiation Pattern
All four switches on	1	3.3GHz	Omni directional
S1,S2,S3 on and S4 off	2	3.2GHz	Covering Left half plane
S1, S2 and S4 on and S3 off	3	3.3GHz	Covering right half plane
S1, S2 off and S3 & S4 on	4	1.8 GHz & 3.2GHz	Omni directional

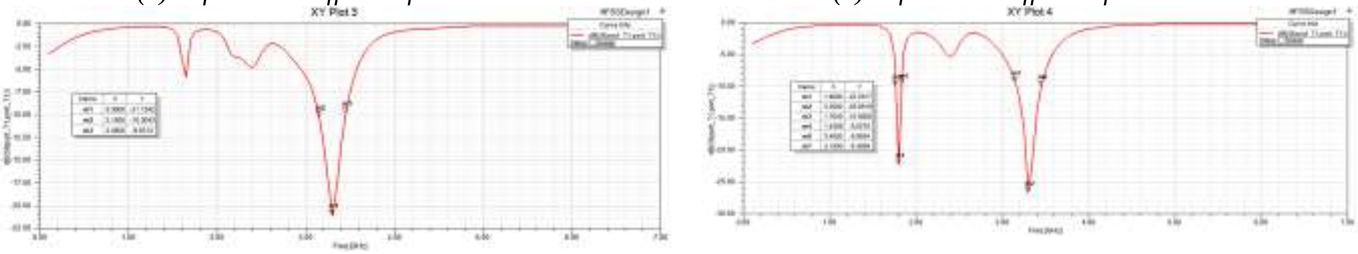
IV. EXPERIMENTAL RESULTS

A. Impedance Characteristics

The proposed antenna is designed using HFSS, the reflection coefficient characteristics of this frequency reconfigurable antenna are plotted in Fig. 2, among the four modes of working the minimum measured percentage bandwidth of 3% is obtained when S1, S2 off and S3 & S4 on, for resonant frequency of 1.8GHz. The maximum measured percentage bandwidth is 9.3% for resonant frequency 3.2GHz when S1, S2, S3 on and S4 off.



(a) Reflection coefficient for mode 1 *(b) Reflection coefficient for mode 2*

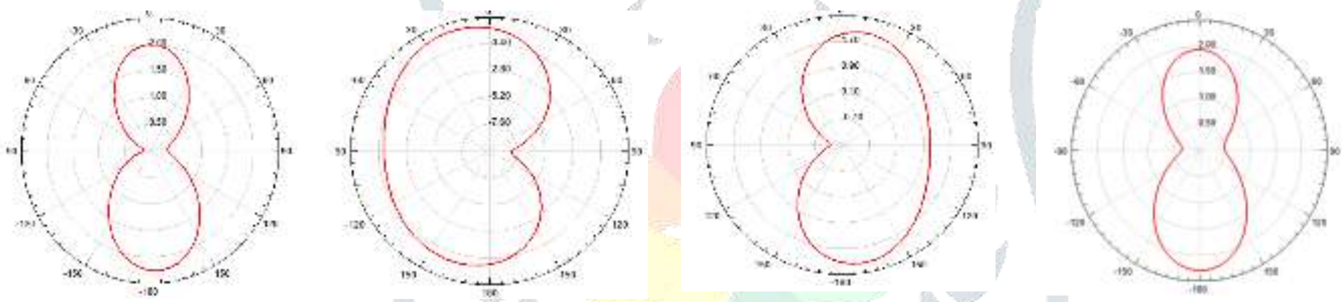


(c) Reflection coefficient for mode 3 *(d) Reflection coefficient for mode 4*

Figure 2: Reflection Coefficient of the antenna for different modes of operation

B. Radiation Characteristics

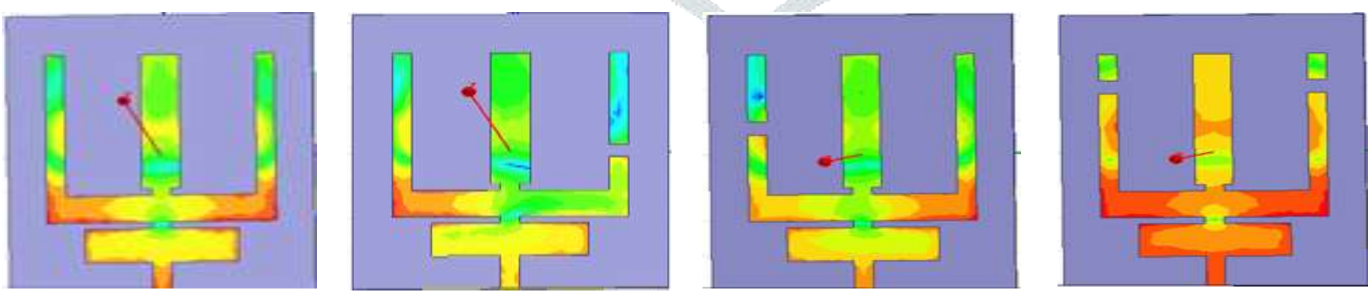
During the first mode when all four switches are on the resonant frequency obtained is 3.3GHz, the radiation pattern is observed omnidirectional. A gain of 2.33dBi gain is obtained in this mode of working. When S1, S2, S3 are on and S4 off, the radiation pattern covered left half with a resonant frequency of 3.2GHz and peak gain 2.7dBi. During the third mode S1, S2 and S4 are on and S3 is off, the obtained resonant frequency is 3.3GHz, at a gain of 2.25dBi. The radiation pattern obtained is covering the right half with a bandwidth of 9%. When S1, S2 are off and S3 & S4 are on, the antenna works in dual band with resonant frequency of 1.8 GHz & 3.2GHz. The antenna works with omnidirectional pattern and a gain of 2.34 dBi.



(a) Mode 1 *(b) Mode 2* *(c) Mode 3* *(d) Mode 4*

Figure 3: Radiation pattern of the antenna in four different modes of operation

The current distributions for various modes of antenna are as shown below. The current distribution for first and fourth mode shows that the maximum current is along the corners of E shape of antenna, whereas minimum current is along the edges of antenna. Inn both of these modes the radiation pattern obtained is omnidirectional. In the second mode the maximum current is along the left corner so the radiation pattern is along the left half of radiation plane. In the third mode the current is observed maximum along the right corner of the E shaped antenna hence the obtained radiation pattern is along the right half of the radiation plane.



(a) Mode 1 *(b) Mode 2* *(c) Mode 3* *(d) Mode 4*

Figure 4: Current distribution in different operating modes of antenna

The gain and bandwidth performance of the antenna is summarized in the following table 2.

Table 2: Gain and bandwidth of antenna in four modes of operation

Mode	**Resonating Frequency**	**Gain**	**% BW**
1	3.35GHz	2.33dBi	7.5%
2	3.2GHz	2.7dBi	9.3%
3	3.3GHz	2.25dBi	9%
4	1.8 GHz & 3.2GHz	2.34dBi	3% & 9%

The above table shows that the maximum gain of 2.7 dBi is obtained in mode 2 and the maximum percentage bandwidth is also obtained in mode 2 which is 9.3%.

V. CONCLUSION

E shaped frequency and pattern reconfigurable antenna is presented. A simple structure is discussed which can be fabricated using FR4 substrate and four PIN diodes. As the antenna switches between 3.3GHz and 1.8 GHz it can be used for WLAN & LTE applications with three different radiation patterns. The gain of antenna is also good in the range of 2.7dBi and maximum percentage bandwidth of 9.3% at 3.3GHz.

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