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Design of Frequency Reconfigurable Antenna with Circular Patch

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Abstract-*This paper showcases Frequency Reconfigurable Antenna with a circular patch design. The bandwidth of the proposed antenna is increased by circular patch array. The resonance frequency of the proposed antenna can be reconfigured into four different modes. The designed antenna is able to cover the frequency band 1.8-6 GHz with significant peak gain of 2.69 dB in operating band and perform the operation of removal frequency band in different modes. Changing the mode of antenna is done by two pin diode switches that are located between patch and strip-line.*

Index Terms-*CircularPatch, Frequency Reconfigurable Antenna, Microstrip Patch Antenna, Patch Antenna*

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I. Introduction

Antenna as a key and critical componentplays an important role in wireless telecommunication systems. Due to the activeadvancement of the multiband and multifunction wireless communication arrangements, there is a need of reconfigurable antennas [1] which are capable of modifying their operating frequency, bandwidth, far-field radiation pattern, or polarization properties to satisfy diverse communication requirements. Usually, reconfigurable antennas are classified according to the antenna parameters that are dynamically adjusted, typically the frequency of operation, radiation pattern, or polarization. Compared to traditional antennas, frequency reconfigurable antennas [2,3] offer many advantages such as compactsize, similar radiation pattern, and proper gain for all desired frequency bands. Besides, reconfigurable antenna as a multifunctional antenna can reduce the number of components, sizes, and hardware complexities of the wireless system[4]. The mechanism of the frequency reconfigurable antenna is to change the current distribution by mechanical or electrical ways. Electrically reconfigurable antennas can be realized by employing switches such as MEMS switches, PIN diodes, or varactors, which have been extensively studied for their promising potential applications in many fields. For example, frequency reconfigurable antennas are designed using RF MEMS switches [5,6]. In these works, the operating frequency band is changed by activating or deactivating the RF MEMS actuators.

In this paper a frequency reconfigurable antenna with the circular patch is proposed, designed and simulated. The bandwidth of the proposed antenna can be increased with the circular patch array used in the design.

II. Proposed Design And Configuration

A circular patch of radiusa is fed with microstrip line of width W_{ml} and length $L_{ml}$and is placed on the upper side of the substrate. A semiground plane of length L_g and width W_g is placed on the other side of the substrate. By integrating a circular patch the current distribution of the patch is disturbed and antenna starts to offer frequency band. The distance g between ground plane and edge of circular ring affects the impedance matchingand controls the return loss level. A small change in mldistance g creates adrastic change in return loss characteristics. The distance g is optimized using Ansoft HFSS v.15

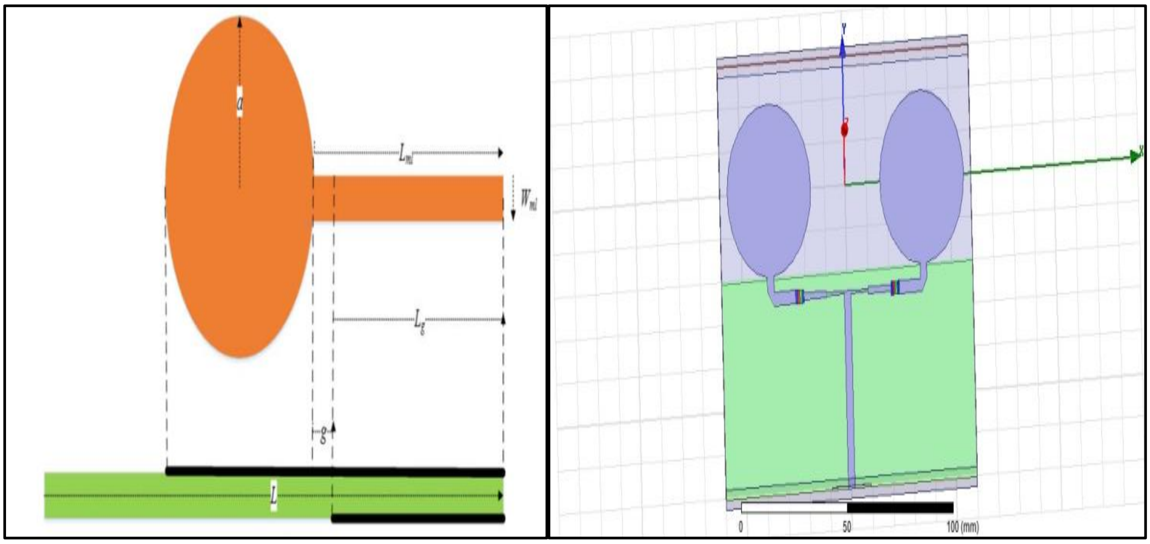


Fig. 1(a) Proposed Antenna StructureFig. 1(b) Proposed Antenna Design

Ansoft HFSS Software is used for simulating and analyzing the proposed antenna and obtaining S parameters, Fig1 shows the proposed antenna structure and Fig 2 shows the return loss when both the switches are ON and the result is between 1.8-6 GHz. The material used is FR4 with relative permittivity of 4.4.

Table 1 Proposed Designs Specifications

Parameter	(mm)	Parameter	(mm)	Parameter	(mm)	Parameter	(mm)
a	20	L_{ml}	50.46	L_g	52	L_4	14.10
L	100	h	1.6	W_g	120	L_5	4.39
W_{ml}	3.07	W_{g2}	160	d	8.6	L_6	3.56
L_{ml2}	44.98	L_1	8.46	L_2	10.84	L_2	10.84

III. Equations

The geometry of circular patch antenna is shown in Fig. 1. The resonant frequency f_r of a circular patch antenna is approximately given without considering the effect of probe radius by

$$f_r = \frac{Knm * C}{2\pi a_e \sqrt{\varepsilon_r}} \qquad (1)$$

Where, a_e= Effective radius of the circular patch
C= Velocity of light in free space
$\varepsilon_{r=}$ Relative permittivity of the medium
$K_{nm=}$ m^{th} zero of the derivative of the Bessel function of order n.

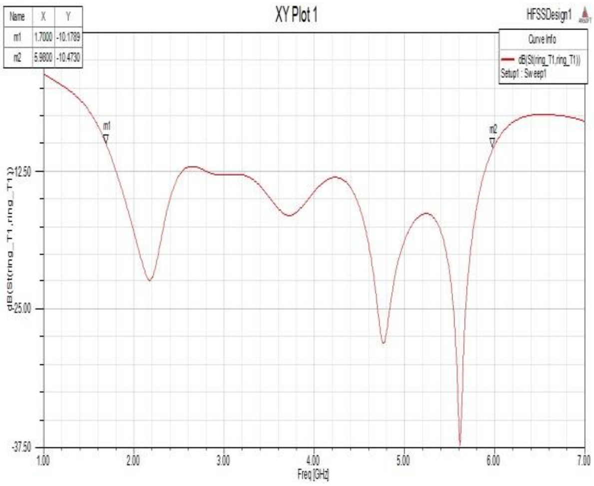
Microstrip Feed Line Width Calculator:

$$W = \frac{7.48 \times h}{e^{\left(Z0 \frac{\sqrt{\varepsilon r + 1.41}}{87}\right)} \left(Z0 \frac{\sqrt{\varepsilon r + 1.41}}{87}\right)} - 1.25 \times t(2)$$

Z_0 = Single Ended Impedance
w = Width
t = Trace Thickness
h = Dielectric Thickness
ε_r = Relative Dielectric Constant

IV. Results And Discussion

Fr-4 substrate of thickness 1.6 mm is used to design the proposed antenna. The dielectric constant and loss tangent of the substrate is 4.4 and 0.001, respectively. Table 1 summarized the design specifications. Proposed antennas are fabricated with standard photolithography process. Antenna structures Figure 2, 3, 4 and 5 shows the return loss characteristics of antenna ranging from 1.8 to 6 GHz. Ant1 is designed as a reference antenna. Figure 3 shows the return loss when the left switch is on and Figure 4 gives the return loss when right switch is on and all four operation mode antenna gives a significant return loss less than -10 dB. Figure 6,7,8,9 shows the corresponding VSWR that is close to 1.



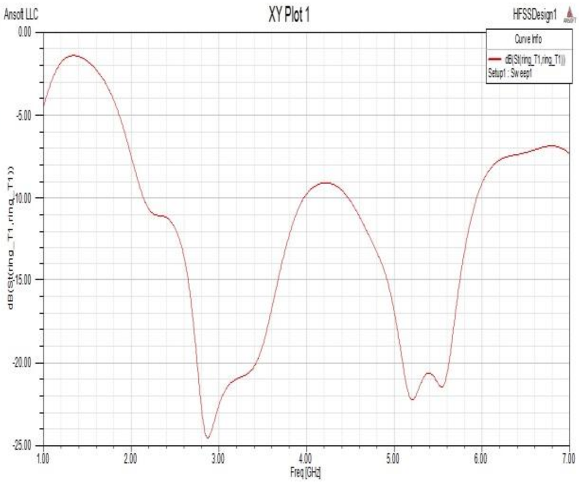


Fig.2 S_{11} Vs Frequency curve when Both switches are ONFig. 3 S_{11}Vs Frequency curve when Left switch is ON

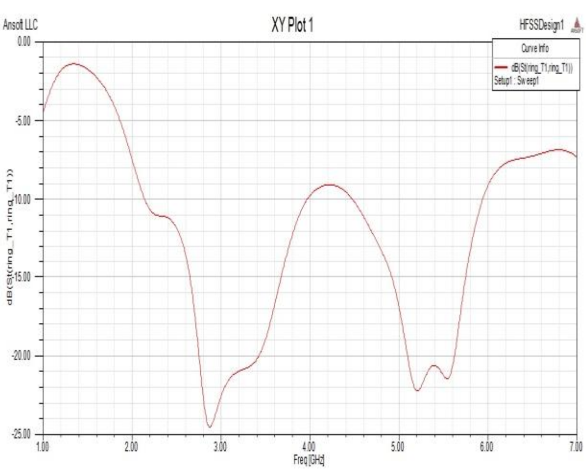


Fig. 4 S_{11}Vs Frequency when Right switch is ON

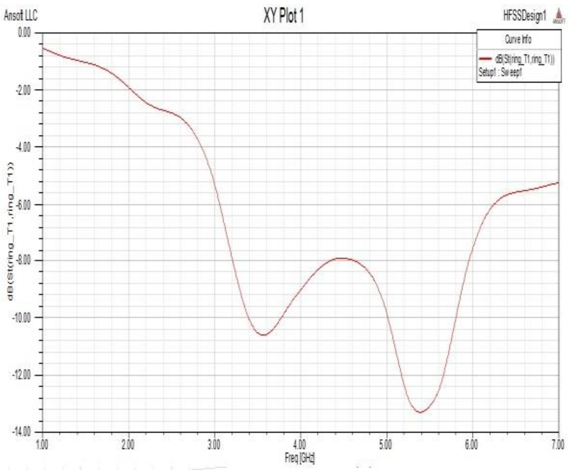


Fig. 5 S_{11}Vs Frequency when Both switches are OFF

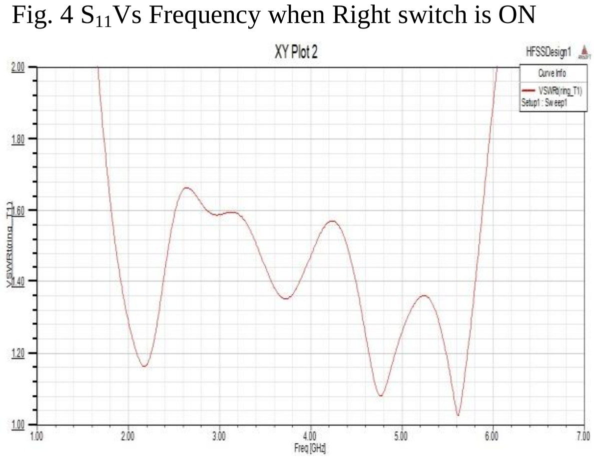


Fig. 6 VSWR when Both switches are ON

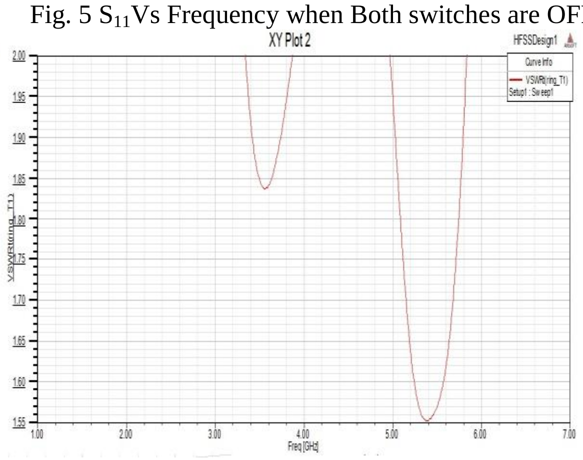


Fig. 7 VSWR When Both switches are OFF

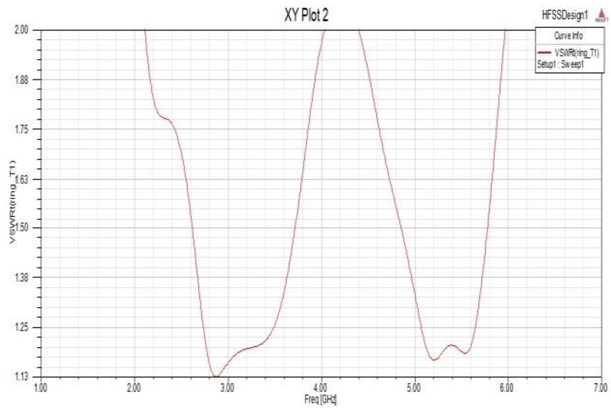


Fig. 8 VSWR when Left switch is ON

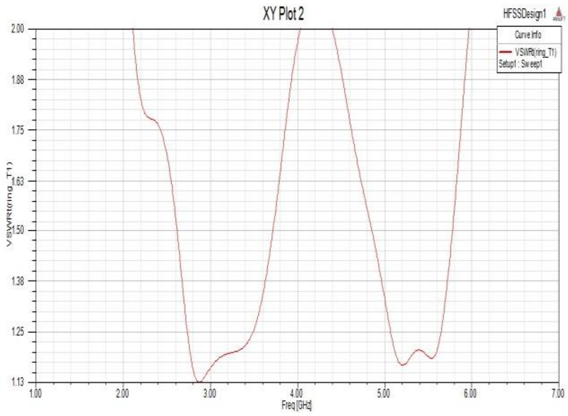


Fig. 9 VSWR when Right switch is ON

When left switch is off and the left patch is disconnected from the main circuit then it shows some variation in return loss and we obtain two band 2.1-4 GHz and 4.6-6 GHz.

When both the switches are in off condition we obtain a totally distorted result.

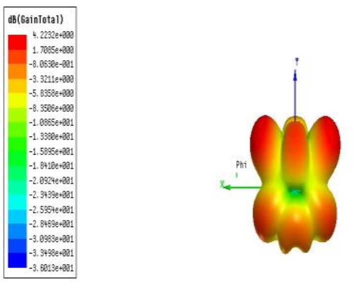


Fig. 10 Radiation Pattern when Both switches are OFF

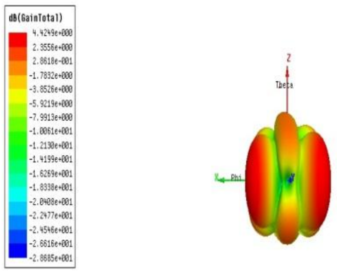


Fig. 11 Radiation Pattern when Left Switch ON

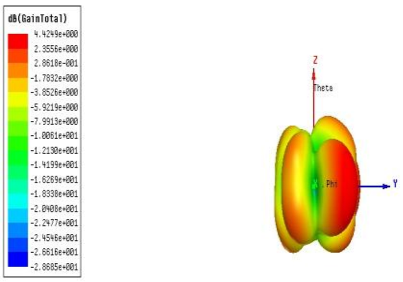


Fig. 12 Radiation Pattern When Right switch ON

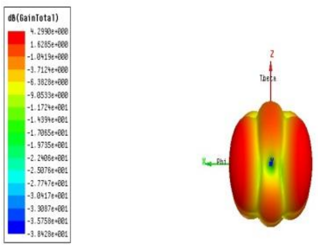


Fig.13 Radiation Pattern when Both switches are ON

Figure 10,11,12,13 shows Radiation patterns of two element circular ring antenna array E-plane, H-plane, at (a) 3.3 GHz, (b) 5.1 GHz, (c)8.1 GHz, and (d) 10.3 GHz.

V. Conclusion

In this paper a frequency reconfigurable antenna using two circular patches is presented. The bandwidth and gain of the proposed antenna is improved. In this way antenna bandwidth has enhanced without increase in size or additional cost. The designed antenna is able to cover the frequency band 1.8-6 GHz. As to excellent performance, convenient adjusting, and simple structure, the proposed reconfigurable antenna may have many potential applications in modern multiband and multifunctional mobile communication systems.

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