A Frequency Reconfigurable Rotatable Microstrip Antenna Design

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Abstract

This paper presents a new frequency reconfigurable antenna design. The reconfigurability is achieved via a rotational motion of a part of the antenna patch. The rotating part has the form of a circle and contains four different shapes. Each shape corresponds to a different antenna structure. With every rotation, a different antenna structure is fed in order to produce a different set of resonant frequencies. A prototype antenna was fabricated and tested to prove the suggested method. A complete agreement was found between the simulated and the measured data.

Introduction

The RF reconfigurability of a radiating structure (antenna) is of great interest in the field of wireless communications particularly for MIMO systems and cognitive radio applications. The basic concept of RF reconfigurability is to dynamically alter the physical structure of the antenna by connecting and/or disconnecting different parts of the antenna structure which interact with its radiation properties and thereby alters its RF response.

The design of reconfigurable antennas has received significant attention in recent years. In [1], a frequency reconfigurable antenna to cover either the 3-5 GHz or 5-8 GHz bands is designed. In the proposed structure, an UWB antenna is also incorporated making it suitable for cognitive radio communication. A pattern/frequency reconfigurable antenna is investigated in [2]. The authors used an L-shaped slot, PIN diodes, lumped capacitors and bias networks to obtain the required pattern/frequency tuning. The theory of cellular automata was implemented in [3] in order to generate different shapes accordingly. This has the effect of producing frequency reconfigurable antennas. In [4], a reconfigurable antenna for MIMO systems is proposed. The antenna can give polarization and pattern diversity depending on which arms are switched into the current path.

In this work, a new reconfigurable antenna design is investigated. The antenna patch has a circular form that rotates to feed different shapes. Frequency reconfigurability is achieved while maintaining the same omni-directional radiation pattern in both the E and H planes. Four different rotations can be done making the antenna cover five different bands (from 2 GHz up to 7 GHz) correspondingly.

Antenna Structure

The design of reconfigurable antennas requires the inclusion of necessary switching elements. These elements perform the job of connecting different parts of the antenna. This allows the antenna to modify its shape and hence its RF response (return loss/ radiation pattern) will change accordingly.
Previous work on reconfigurable antennas has shown that lumped elements (capacitors/inductors), RF MEMs, PIN diodes or photoconductive switches can perform the switching job. The use of these switching elements (except the photoconductive switches) requires the design of appropriate biasing network for the

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activation/deactivation purpose [5]. Photoconductive switches usually require a high laser pumped power level to excite enough electrons from the valence band to the conduction in order to make the switch conductive [6].

In this work, a new technique is proposed to produce a frequency reconfigurable antenna design. The frequency tuning is achieved via a rotational motion of an antenna part. The importance of this technique is that no biasing networks are required which lie on the antenna plane and might degrade the antenna performance. Also, there is no need for laser inclusion which might increase the system cost and complexity as is the case of photoconductive switches.

The corresponding antenna structure is shown in Fig. 1. It consists of two layers. The bottom layer is a partial ground to allow radiation above and below the substrate. The top layer is a rotating circular shape. The chosen susbtrate is Taconic TLY with a dielectric constant of 2.2 and a thickness of 1.6 mm.

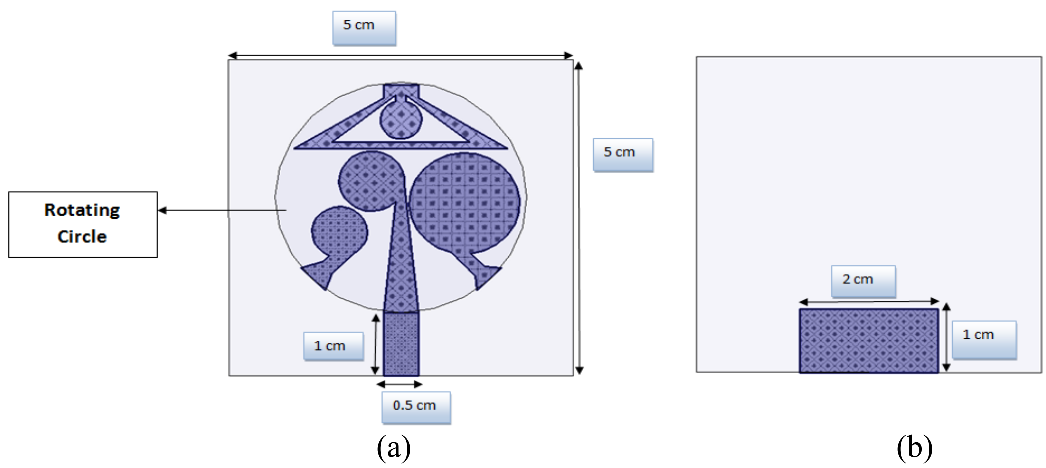

Fig. 1. Antenna structure (a) top layer (b) bottom layer

The rotating circular part includes four different RF shapes as shown in Fig. 1(a). It has a radius of 1.8 cm. It consists of three circular patches and one slotted triangle. With every rotation, a different antenna shape is fed. If the antenna position shown in Fig. 1(a) is taken as a reference, then we can rotate either clockwise or counterclockwise by 45^{o} to feed one of the two remaining circles. A rotation of 180^{o} is needed to feed the slotted triangle. The process of rotation and the corresponding dimension for each shape is summarized in Fig. 2(a).

Results and Discussion

The fabricated antenna structure is shown in Fig. 2(b). The dimensions for the different parts were chosen to give the best match at the corresponding resonant frequency. The different shapes were simulated using HFSS v11.

The comparison between the simulated and the measured return loss for each rotation is shown in Fig. 3. By comparing the different plots, one can easily notice the frequency tuning:

For shape 1: the band 2.3 GHz-2.6 GHz is covered.
For shape 2: the band 2.6 GHz-3.4 GHz is covered.
For shape 3: the band 4 GHz-5 GHz is covered.
For shape 4: the bands 3 GHz-4 GHz / 5.26 GHz- 7 GHz are covered.

The antenna radiation pattern at phi=0° (xz plane) for the different shapes is shown in Fig. 4. The antenna preserves its omnidirectional pattern while changing its resonant frequency. A property that is essential for current wireless applications especially for cognitive radio systems. The antenna peak gain values are summarized in Table 1 for the different shapes at specific frequencies.

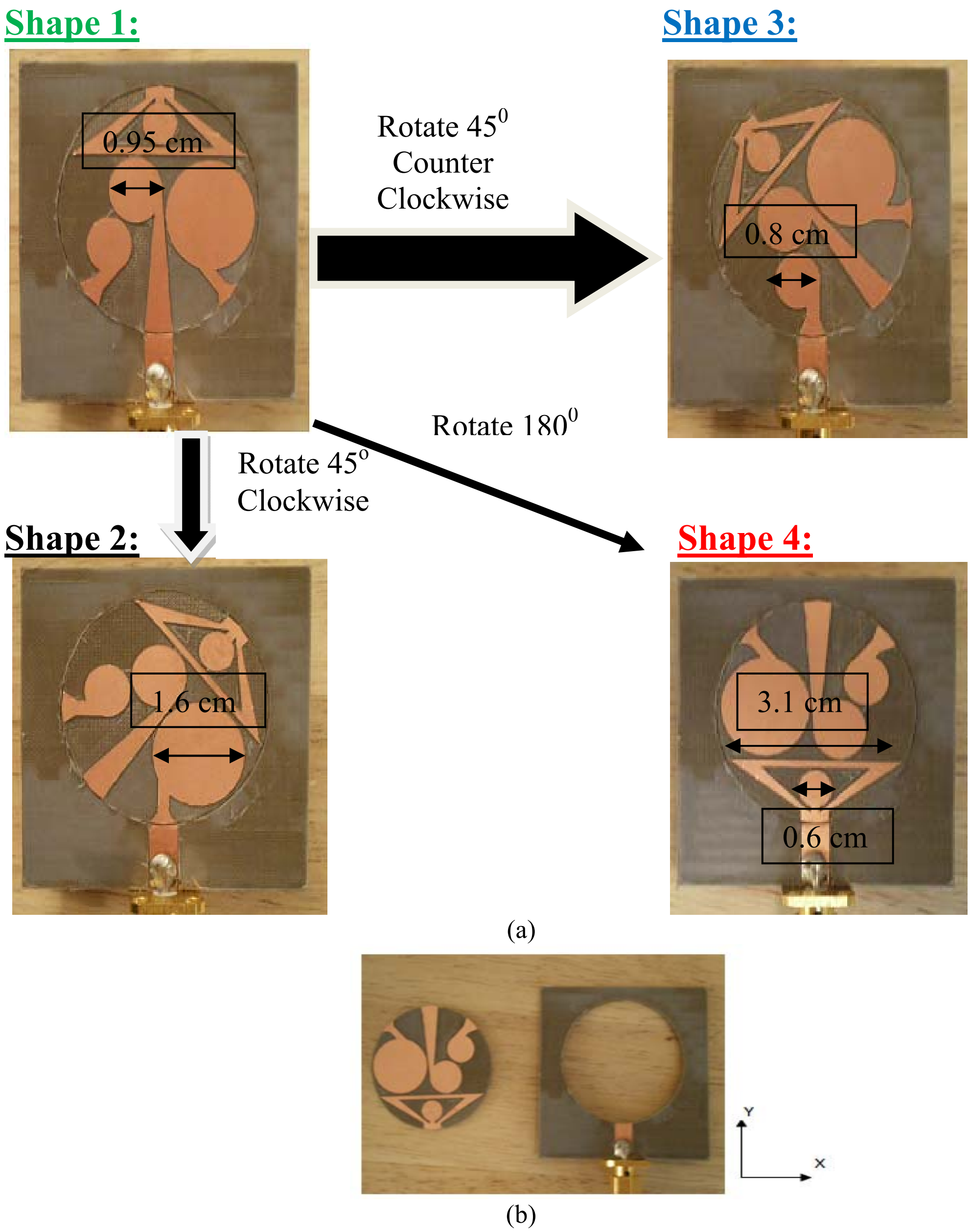

Fig. 2. (a) The different shapes for the same antenna structure (b) The fabricated prototype

Conclusion

This paper presents a new reconfigurable antenna design via a rotational motion of the antenna patch. A good agreement was found between the simulated and the measured data. The antenna preserves the same radiation pattern for the four different stages while performing a frequency tuning. We are now in the process of controlling the rotating part via a Field Programmable Gate Array (FPGA) connected to a computer. For future work, we are looking to increase the radius of the rotating circle to include more shapes in order to achieve frequency tuning from 1 GHz till 10 GHz.

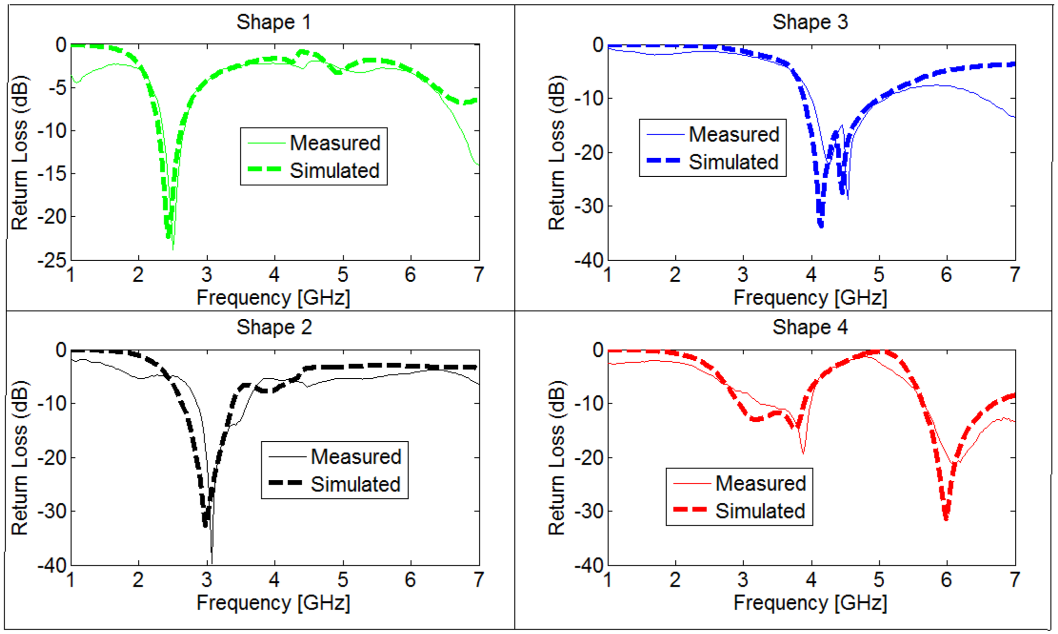

Fig. 3. The simulated and measured return loss for the different stages

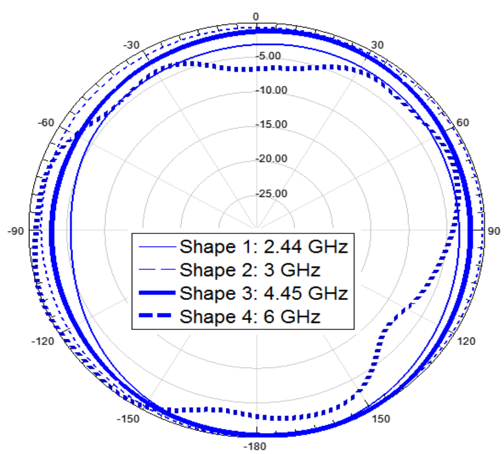

Fig. 4. Antenna radiation pattern in the xz plane

Table 1: Antenna Peak Gain for different Shapes

	Shape 1	**Shape 2**	**Shape 3**	**Shape 4**
f (GHz)	**2.44**	**3**	**4.45**	**6**
Gain (dB)	**4.57**	**3.12**	**2.72**	**5.9**

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