Radiation and Frequency Reconfiguration Using Tilted Printed Monopoles

Y. Tawk[1, 2], C. G. Christodoulou[2]
[1] Notre Dame University, Louaize, Lebanon
[2] Configurable Space Microsystems Innovations & Applications Center (COSMIAC), University of New Mexico, Albuquerque, NM, USA,
yatawk@ieee.org

J. Costantine[3,4]
Electrical and Computer Engineering Department
[3] American University of Beirut, Lebanon
[4] California State University Fullerton, Fullerton, CA, USA

***Abstract*—This paper presents a reconfigurable printed two arms monopole antenna structure. The proposed antenna is able to change either its operating frequency or radiation pattern based on the activation of the integrated PIN diode switches. The purpose of the switches is to connect one of the two monopole arms or both to the antenna feeding line. A prototype antenna is simulated, built and tested. A good agreement is found between the simulated and measured data.**

I. Introduction

The huge advancement in wireless technology has pushed antenna and RF engineers to design communication systems that operate over several bands. More importantly, the idea of having a system that can change its operation based on user requirements or channel spectrum usage has led antenna researchers to investigate and study antenna structures that can change their operating frequency, radiation pattern or polarization [1], [2].

In this paper, we present an antenna structure that is capable of changing both its operating frequency and its radiation pattern. The corresponding reconfigurability is achieved by integrating four PIN diode switches within the antenna structure. In section II, the proposed antenna structure is discussed. Section III presents the biasing of the switches as well as the simulated and the measured data.

II. Antenna Structure

The corresponding antenna structure is shown in Fig. 1. It consists of two printed monopoles that are tilted by an angle of 25^0 from the vertical axis. The antenna is stripline fed and has a partial ground of dimensions 20 mm x 2 mm. The feeding line has a tapered form with an opening width of 4 mm and an ending width of 2 mm. The antenna is printed on Rogers Duroid 5880 substrate with a thickness of 1.6 mm and a dimension of 66 mm x 60 mm.

Each monopole arm has an initial length L_1=52.37 mm and a width of 1mm. Two PIN diode switches $\{S_{1,\,Left}, S_{1,\,Right}\}$ are used to connect the two printed monopole arms to the antenna tapered feeding line structure. Since both arms have an equal length, they will produce the same resonant frequency when either switch is activated. A second pair of switches $\{S_{2,\,Left}, S_{2,\,Right}\}$ is also incorporated into the antenna structure as shown in Fig. 1. The function of these two additional switches is to increase the length of each arm of the monopole antenna by an amount of 5.23 mm. Once activated, the antenna shifts its operating frequency to a lower band. The four switches are modeled using HFSS as lumped elements PIN diode from Infineon (BAR 64) [3].

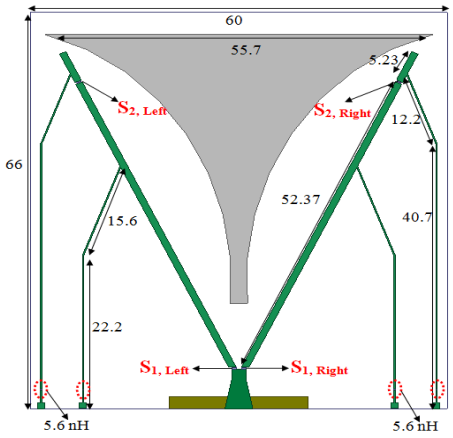

Figure 1. The proposed antenna structure

To achieve tunability in the antenna radiation pattern, the two printed monopoles are tilted by an angle of 25^0 and a curved shaped non radiating patch is placed between the two antenna arms. The job of this non radiating structure is to direct the radiated pattern to the left or to the right when either the left or right side switches are activated. Thus, based on the status of the four integrated PIN diode switches the proposed antenna tunes its operating frequency and radiation pattern.

III. Results

The proposed antenna structure is fabricated and tested. To activate the two PIN diodes $\{S_{1,\,Left}, S_{1,\,Right}\}$, an external bias tee is connected to the antenna feeding line. An appropriate current driver is designed to supply the PIN switches with the appropriate current levels. In order, to allow a DC ground connection for the two switches $\{S_{1,\,Left}, S_{1,\,Right}\}$, two biasing

lines {BL_1 and BL_2} of equal length and at the same position for the two monopole arms are printed into the antenna substrate. These two biasing lines have a length of {22.2+15.6=37.8 mm}.
As for the other two switches {$S_{2,\,Left}$, $S_{2,\,Right}$}, two additional biasing lines are included of length {40.7+12.2=52.9 mm}. Opposite to the first two switches, the job of these two additional biasing lines is to provide the switches {$S_{2,\,Left}$, $S_{2,\,Right}$} with the appropriate current level. The two biasing lines {BL_1 and BL_2} also provide a DC ground connection to the switches {$S_{2,\,Left}$, $S_{2,\,Right}$}. The position of the four biasing lines is optimized to ensure a minimal destructive effect on the antenna radiation characteristics. The width of the four biasing lines is 0.2 mm. A 5.6 nH SMD inductor is included at the end of each biasing line as shown in Fig. 1.

A. Change in the Antenna Operating Frequency:

The comparison between the simulated and measured antenna reflection coefficient is shown in Fig. 2. This plot corresponds to the two cases:
Case 1: {$S_{1,\,Left}$} OR {$S_{1,\,Right}$} are ON (red dotted curve)
Case 2: {$S_{1,\,Left}$, $S_{2,\,Left}$} OR {$S_{1,\,Right}$, $S_{2,\,Right}$} are ON (blue solid curve)
For case 1 the antenna covers the band 3.19-3.29 GHz while for case 2 the band 2.95-3 GHz is covered. The change in the operating frequency of the antenna is due to the increase in the length of the arms of the monopole when activating the switches $S_{2,\,Left}$ or $S_{2,\,Right}$.

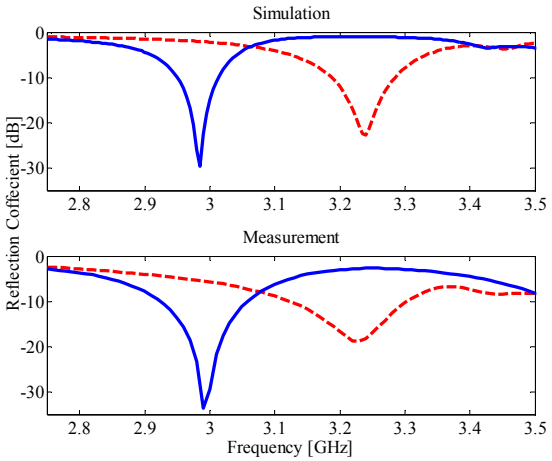

Figure 2. The comparison between the simulated and the measured antenna reflection coefficient when "{$S_{1,\,Left}$} OR {$S_{2,\,Left}$} are ON (red dotted curve)" and when "{$S_{1,\,Left}$, $S_{2,\,Left}$} OR {$S_{1,\,Right}$, $S_{2,\,Right}$} are ON (blue solid curve)"

B. Change in the Antenna Radiation Pattern:

The proposed antenna structure is also able to change its radiation pattern based on the status of the integrated four PIN diode switches. Therefore, we can consider the following three cases:

Case 1: When $S_{1,\,Left}$ is ON, the antenna radiated beam will be directed to the left side. The simulated 3D antenna radiation pattern at f=3.25 GHz is shown in Fig. 3(a). From this plot, we can inspect that the maximum radiation occurs to the left side and at a tilted angle by following the tilt angle of the arm of the left monopole antenna.

Case 2: When $S_{1,\,Right}$ is ON, the 3D antenna pattern at f=3.25 GHz is shown in Fig. 3(b). The same pattern is obtained as for Case 1, but now the maximum beam is directed to the right side of the antenna.

Case 3: When both switches {$S_{1,\,Left}$, $S_{1,\,Right}$} are ON, the radiation pattern is the summation of the pattern radiated by the left and the right monopole arms. Therefore, the corresponding radiation pattern shown in Fig. 3(c) corresponds to this case for f=3.25 GHz.

It is important to note that an identical pattern is obtained when the length of each arm of the monopole is increased by activating the second pair of switches.

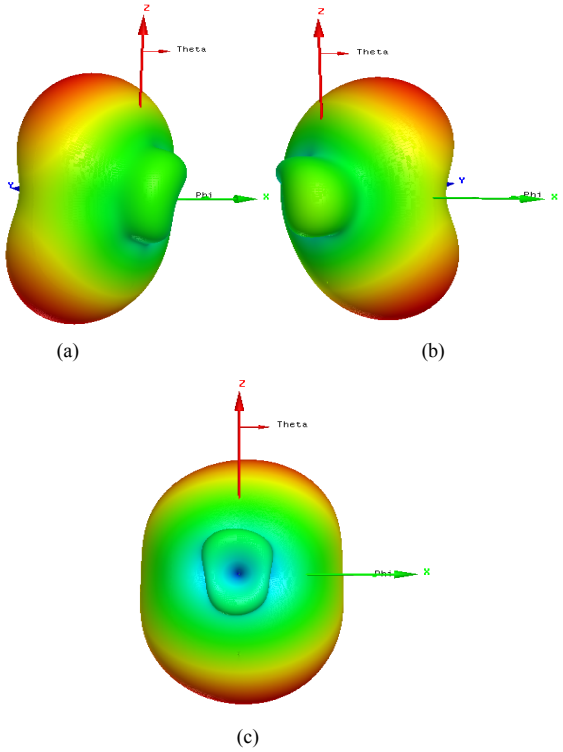

Figure 3. The 3D antenna radiation pattern at f=3.25 GHz when (a) $S_{1,\,Left}$ is ON (b) $S_{1,\,Right}$ is ON (c) both are ON

REFERENCES

[1] S. Yang, C. Zhang, H. Pan, A. Fathy, and V. Nair, "Frequency reconfigurable antennas for multiradio wireless platforms," *IEEE Microwave Magazine*, vol. 10, no. 1, pp. 66–83, Feb. 2009

[2] C. G. Christodoulou, Y. Tawk, S. A. Lane, and S. R. Erwin, "Reconfigurable antennas for wireless and space applications," *Proceedings of the IEEE*, vol. 100, no. 7, pp. 2250 –2261, Jul. 2012

[3] Infineon Technologies, http://www.infineon.com