RECONFIGURABLE MULTIFUNCTIONAL ANTENNAS

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Abstract — In this work, several reconfigurable antennas are presented and discussed. The antennas to be presented cover a wide range of designs such as fractal antennas, triangular antennas, dipoles and monopoles with variable sleeves. All these antennas make use of MEMS switches, to make them reconfigurable. Some of the challenges that the designer has to face in biasing and integrating these switches with the antenna has are also presented and discussed.

. INTRODUCTION

The requirements for increased functionality, such as direction finding, radar, control and command, within a confined volume, place a greater burden in today's transmitting and receiving systems. A solution to this problem is the re-configurable antenna [1-3]. Antennas that can be used for multiple purposes, that function over several frequency bands and that can be integrated on a package for mass-production are the ultimate goals of commercial and defense investigators. Furthermore, applications of such systems in personal and satellite communications impose the requirement for elements miniaturized in size and weight.

Key-elements to obtain reconfigurability in many RF circuits are the Radio-Frequency MicroElectroMechanical Systems (RF-MEMS). Even though RF-MEMS have been used in the past to reconfigure filters, phase-shifters, capacitors and inductors, their integration in an antenna system has been limited as it faces a plethora of issues that need to be resolved. The absence of a reconfigurable RF-MEMS antenna system and the recent advances in fractal - and especially Sierpinski gasket- antennas combined with the availability of series cantilever RF-MEMS switches, sparked the pioneering idea to design a multiple-frequency antenna that will radiate on-demand the same radiation pattern at various frequencies. Such a system was designed and successfully implemented, as the first functional, fully integrated RF-MEMS reconfigurable self-similar antenna.

In this presentation we will illustrate how the use of RF MEMS switches can to enhance the frequency performance of several antennas.

II. EXAMPLES OF RECONFIGURABLE ANTENNA DESIGNS

1) <u>A Simple Dipole</u>: First, we work on a simple dipole antenna, shown in Figure 1. It can be used as an example to illustrate the application of RF-MEMS switches in a reconfigurable antenna design. Since other planar antennas, such as the bowtie, have a broader bandwidth than a planar dipole, this theoretical model may also be used to determine a 'maximum number of switches' to be used in order to achieve the desired reconfigurability.

The goal is set to design a reconfigurable dipole antenna that can operate on demand at any frequency in the X-band. In this application the bandwidth of the planar dipole is approximately 8.5%. The arms of the dipole are connected with RF-MEMS switches to additional patches. The basic function of the switches is to conductively couple the additional metallic patches thus extending on-demand each arm's length. When the switches are '*off*' the patches couple capacitively to the main arms, thus they slightly increase the antenna's bandwidth. When the switches are '*on*', the additional patches are connected to the antenna's arms via the continuous metallic path that each switch provides through its membrane.

To avoid unnecessary discontinuities in the structure, the dipole is set to have the same width as the switches (110 μm). In other words it can be considered as an extension of the switch's transmission line. Figure 2, depicts the S11 performance of this antenna.

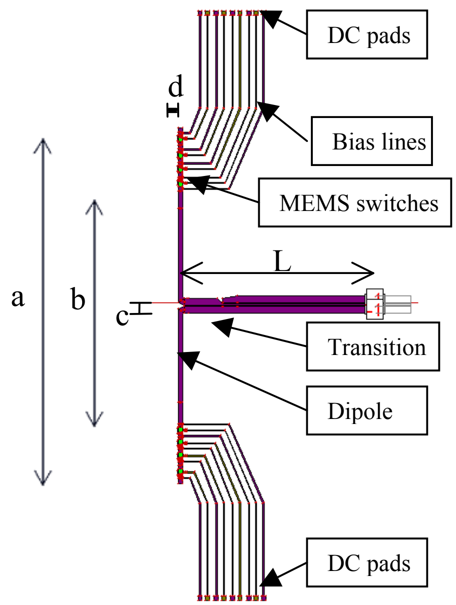


Figure 1. Topside view of the reconfigurable planar dipole antenna design

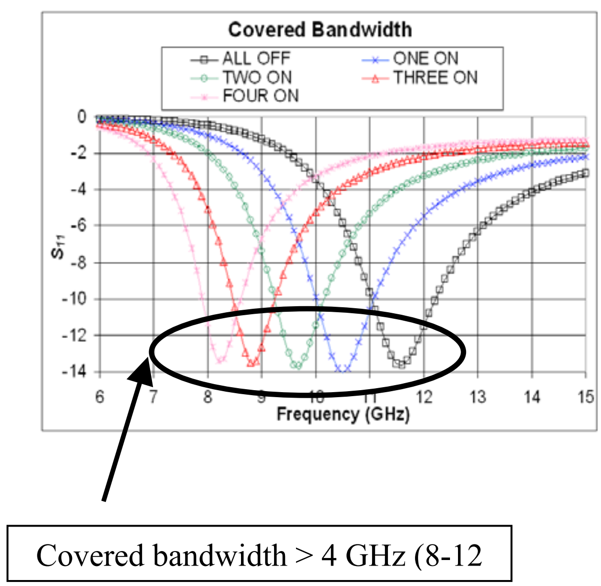


Figure 2. The antenna's performance at different configurations, illustrating the total covered bandwidth.

2) Cactus Antenna. In this case we use a monopole antenna with sleeves on its sides. Both the the main monopole part and the sleeves have extensions that can be connected through MEMS switches or PIN switches to create a frequency agile antenna as shown in Figure 4. In fact one can add several sleeves on the side to create even more resonances and increase the tunability of the antenna. .In Figure 3 we get a closer look on the surface current around the area of the monopole switch in the first and in the second resonant frequency, when the switch is ON, as well as in the area of the switches. We have taken as an example the case where only one of the sleeve switches is ON. As we can see from Figure 4, the length of the main monopole is the one that determines the first resonant frequency, while the second frequency is determined by the length of the sleeves and their order of activation

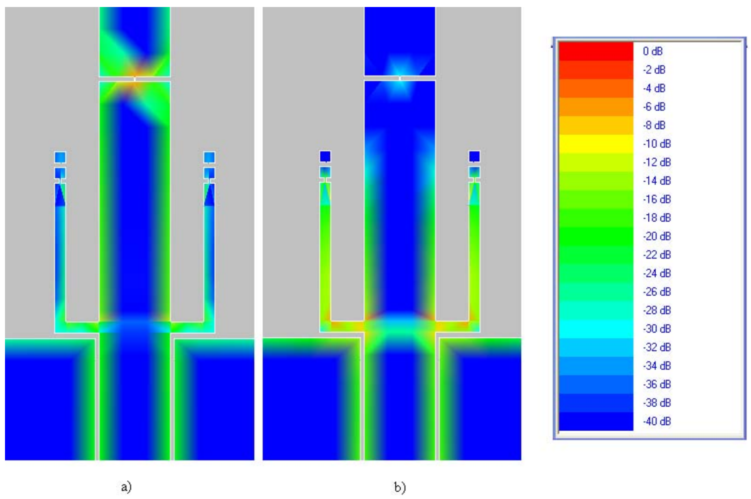


Figure 3. a) Surface currents at f_1=1.85 GHz and b) surface currents at f_2=3.4 GHz for the case of monopole switch ON and only one sleeve switch ON

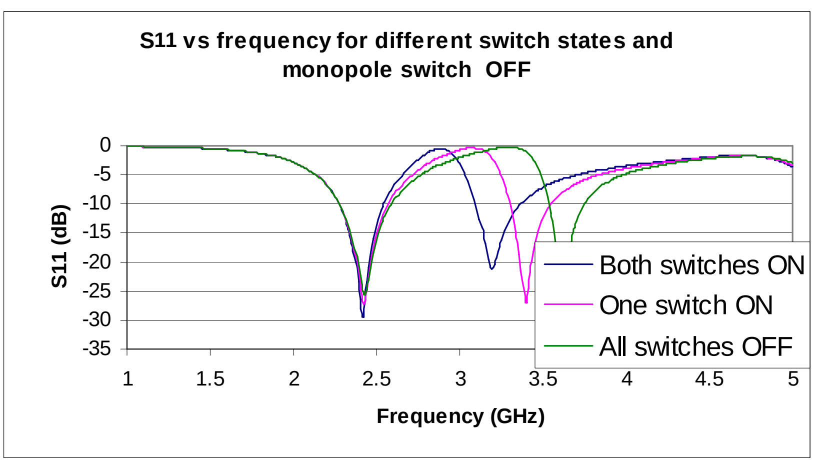
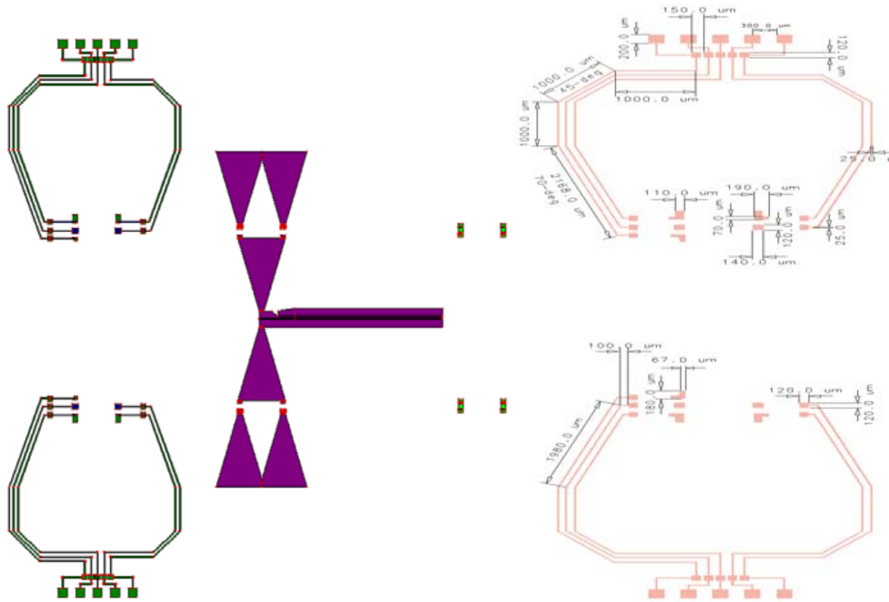


Figure 4. S_{11} versus frequency when monopole switch OFF for L_4=0.5 mm and L=12 mm

3) Fractal Antenna. Several fractal antenna configurations can be connected together using RF MEMS switches to achieve resonance at a number of desired frequencies. The RF MEMS switches permit a controlled connectivity of sections of the antenna's conductive parts, and therefore enhance the coupling between the triangular elements allowing clear multiple frequency operation with a single fractal antenna as shown in Figure 5. The antenna is fabricated on a quarter of a silicon wafer with a diameter of 4-inches. Due to its small size, many antennas can be developed on a single silicon wafer with the same MEMS process, making it suitable for mass-production military or commercial applications.



(a) (b) (c) (d)

Figure 5. a-c) Different layers of the layout of the antenna. Wire bonding and the small metal connections of the switches to the biasing electrodes are not included. d) Basic dimensions of

IV. Conclusion

A reconfigurable planar dipole antenna, a cactus antenna, and a fractal antenna were presented to demonstrate how they can be made to act as reconfigurable antennas. MEMS or PIN switches can be used to provide the antenna with greater flexibility and frequency agility. The increased demand for multifrequency, and multifunctional antennas that can be used in applications such as direction finding, radar, control and command, make these reconfigurable antennas the prime candidates for the job.

References

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