Re-configurable Sierpinski Gasket Antenna using RF-MEMS Switches

D. Anagnostou*[1], M. T. Chryssomallis[2], J. C. Lyke[3], and C. G. Christodoulou[1]

[1] The University of New Mexico, USA,
[2] Demokritos University of Thrace, Greece,
[3] Air Force Research Laboratory/VSSE Kirtland AFB.

Abstract—Fractal antennas have been well known for their multiband characteristics. A new approach to multi-frequency re-configurable antennas using RF MEMS switches is presented here. Fractal antenna elements can be connected together using RF MEMS switches in order to achieve a lager number of resonances. The RF MEMS switches permit a controlled connectivity of sections of the antenna's conductive parts. This conductive coupling between the triangular elements provides clear multiple frequency operation with a single fractal antenna. The analysis and design principles are discussed and presented here.

Index Terms *– Fractal antennas, Sierpinski, Re-configurable antennas, RF-MEMS*

I. INTRODUCTION

Multiband antennas, with the ability to radiate more than one pattern, at different frequencies, are necessary in radar and modern telecommunication systems [1-5]. The requirements for increased functionality, such as DOA estimation, 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.

In this work, RF MEMS are used in conjunction with a classic Sierpinski fractal antenna structure as the basis of a new re-configurable antenna approach [6-7]. In the past, re-configurable antennas have been restricted to the use of non-fractal elements, such as printed dipoles or conventional microstrip antennas. Here the use of fractal shapes permits a highly reconfigurable structure with different current path lengths that can be used in multiple frequency applications. The aim is to be able to adjust the currents on each element and therefore the radiation pattern for the required frequency of operation, polarization and mission in general. Several examples and their results are presented and discussed.

II. ANTENNAS WITH RF MEMS SWITCHES CONFIGURATIONS

In general, the coupling between the elements of a fractal antenna is very weak. Here we consider that the elements are connected with almost ideal RF MEMS switches. Therefore a switch conductively connects two adjacent antenna's elements when it is activated, changing the antenna's physical dimensions and shape. Small gaps are created in the etched fractal antenna, which are bridged small metallic patches with dimensions less than 2x1mm.

The presence of the switches themselves has a very little effect on the performance of the antenna. The magnitude of the reflection coefficient S_{11} with the switches present but not activated remains below –10dB all over the antenna's bandwidth. Several cases were analyzed with the switches turned ON and OFF at different locations of the fractal antenna.

In the following figures, the activated elements (those with currents) are shown in blue, while the inactive ones with gray. The active antenna region can be symmetric around the y-axis of the antenna as in Figures 1 and 2, or non-symmetric as in Figures 3 and 4. Also, the active elements can be symmetric with respect to the ground plane or can be a dipole like structure in free space as in Figure 5, where the antennas have the same S_{11} response, but different radiation pattern. By examining more configurations, a total of 14 resonant frequencies are obtained. Six of these frequencies are below 1.7 GHz, namely at: 450 MHz, 600 MHz, 1.2 GHz, 1.4 GHz, 1.5 GHz and 1.6 GHz, and most with a dipole like radiation pattern.

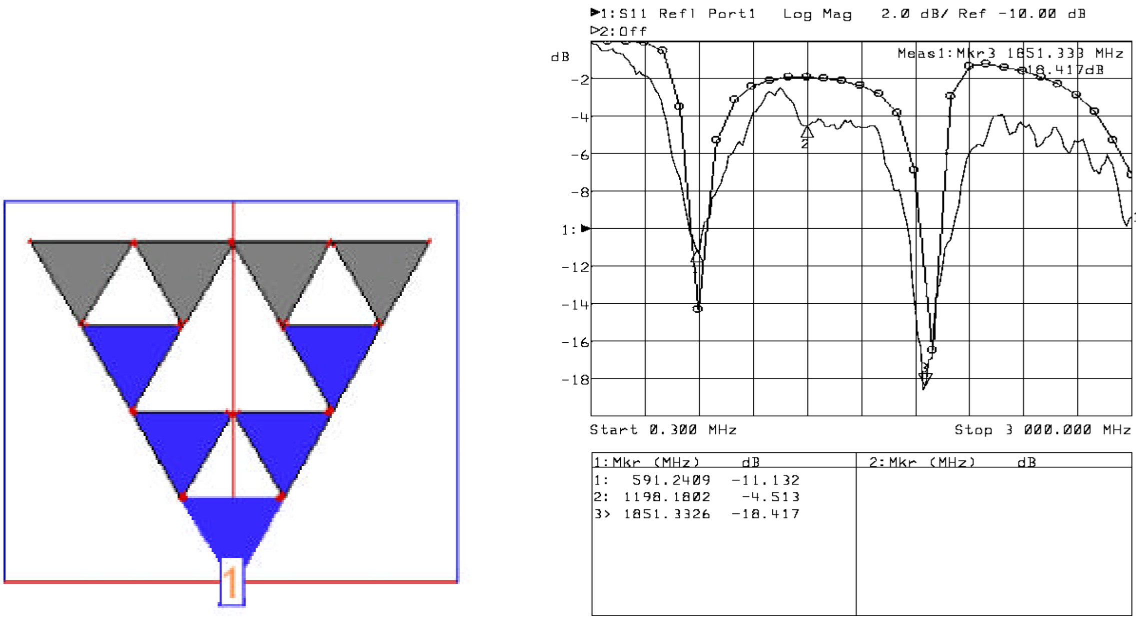


Figure 1. Symmetric re-configurable antenna structure with 5 activated elements and its S_{11} characteristic.

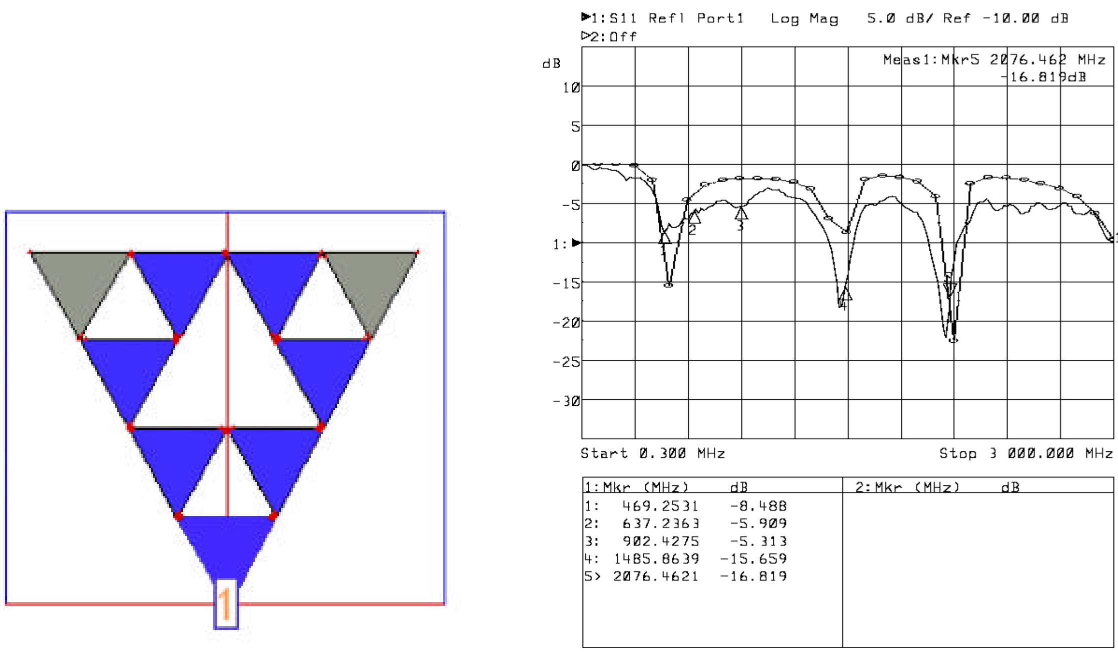


Figure 2. Symmetric re-configurable antenna structure with 7 activated elements and its S_{11} characteristic

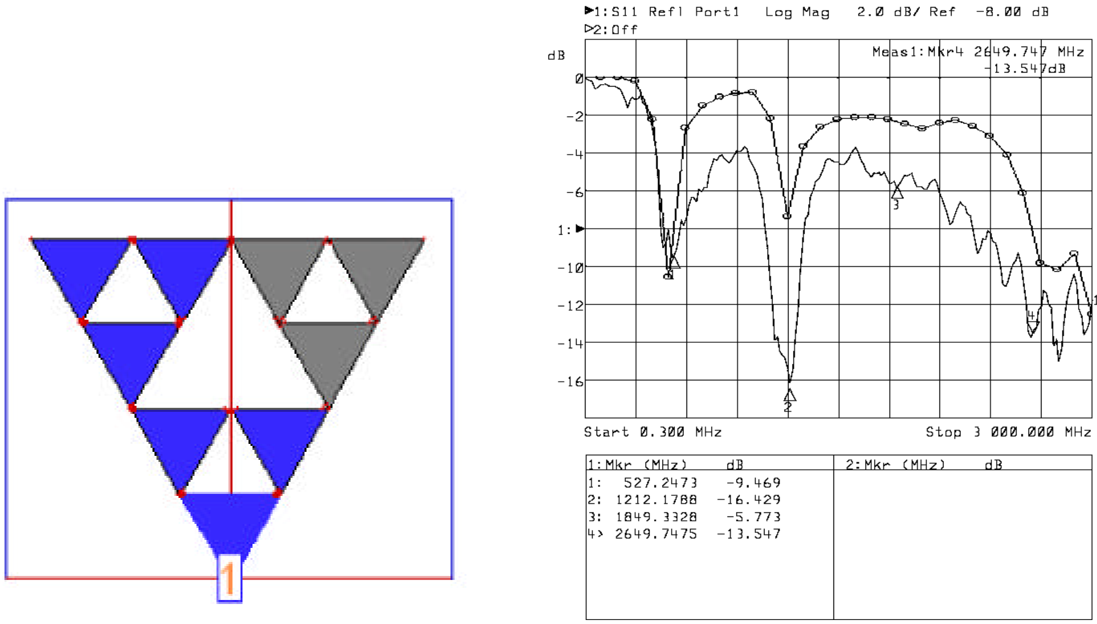


Figure 3. Non-symmetric re-configurable antenna structure with 6 activated elements and its S_{11} characteristics

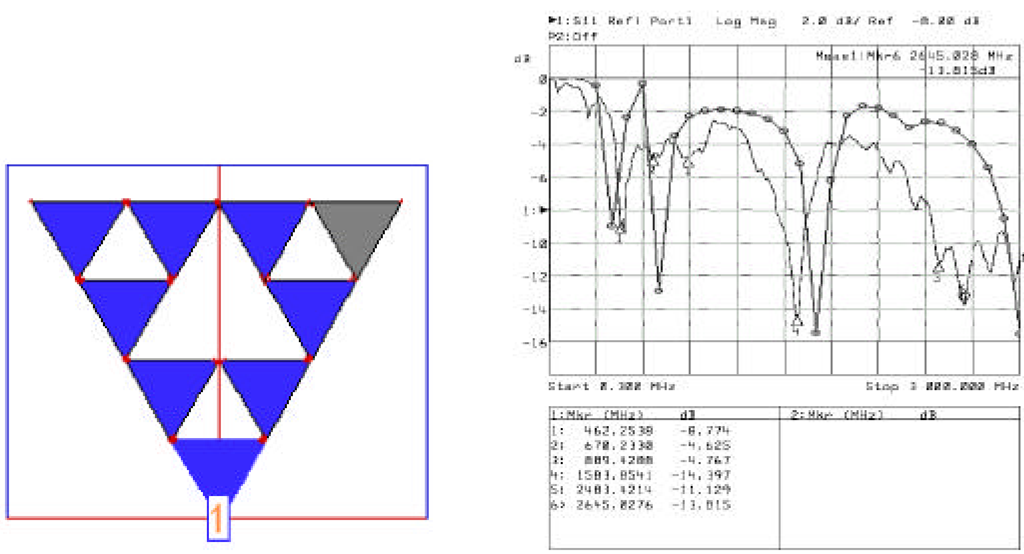
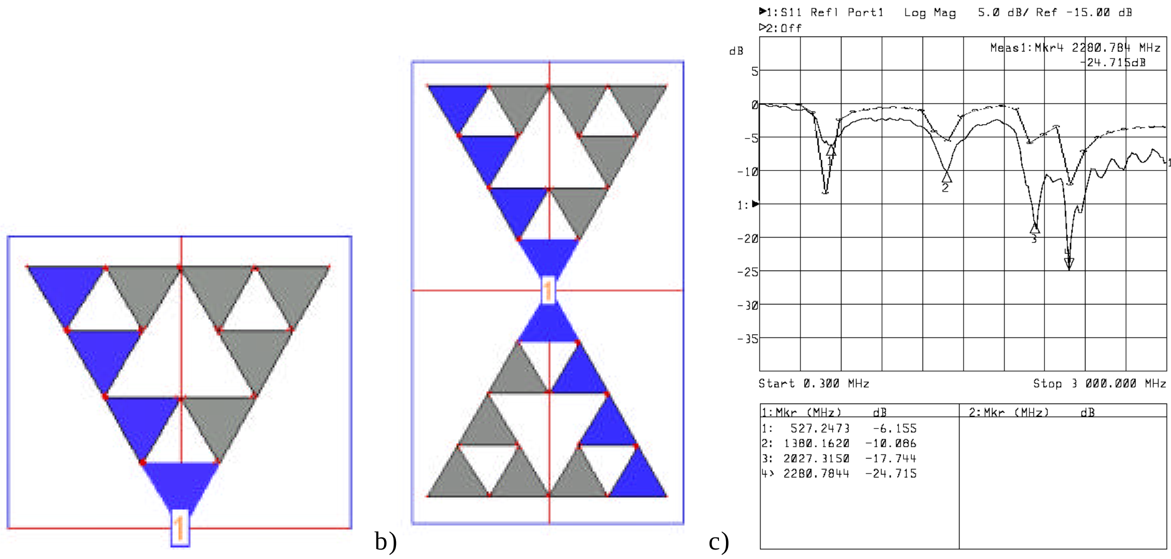


Figure 4. Non-symmetric re-configurable antenna structure with 8 activated elements and its S_{11} characteristic

III. CONCLUSIONS

A new approach to multiple frequency fractal antennas using RF MEMS switches was presented. Instead of utilizing only the resonant frequencies offered to the designer by the nature of the fractal antennas, additional resonances can be enforced to the structure by making use of RF MEMS switches. The placement of each switch can control the current on each conductive part of a fractal antenna. That affects the resonance behavior of the entire antenna and its radiation pattern. This way, multi-fractal antenna structures such as a fractal within a fractal as described in this paper, can be designed. Several other types of fractal antennas can be used in conjunction with RF MEMS switches to create a re-configurable and more versatile antenna. Good matching though still remains a serious challenge with this type of antennas. Finally, such an approach to re-configurable antennas permits deliberate alterations in antenna performance to accommodate changes in mission, environment, tolerance to defects and faults in modern communication systems.



a) b) c)

Figure 5(a-c). Non-symmetric re-configurable a) monopole and b) dipole antenna structures with 4 activated elements and c) their S_{11} characteristic.

IV. REFERENCES

[1] J. Gianvittorio, Y. Rahmat-Samii, *Fractal Element Antennas: A Compilation of Configurations with Novel Characteristics,* Antennas and Propagation for Wireless Comms. 2000, IEEE-APS Conference, pp. 129 –132

[2] C. Puente, J. Romeu, R. Pous, X. Garcia, F. Benitez, *Fractal multiband antenna based on the Sierpinski gasket*, Electronics Letters, Volume: 32 Issue: 1, 4 Jan. 1996, Page(s): 1 –2

[3] J. Romeu, J. Soler, *Generalized Sierpinski fractal multiband antenna,* Antennas and Propagation, IEEE Transactions on, Volume: 49 Issue: 8, Aug. 2001, Page(s): 1237 –123

[4] C. Puente-Baliarda, J. Romeu, R. Pous, A. Cardama, *On the behavior of the Sierpinski multiband fractal antenna* Antennas and Propagation, IEEE Trans., Vol.46 Issue: 4, April 1998 pp. 517 –524

[5] D. Anagnostou, C.G. Christodoulou, and J.C. Lyke, *Re-configurable Array Antennas for Wideband Applications*, IEEE Aerospace Conference, March. 2002

[6] D. Anagnostou, M. Khodier, J. Lyke, C. Christodoulou, Fractal antenna with RF-MEMS switches for multiple frequency applications, Antennas and Propagation Society International Symposium, 2002, IEEE, Volume: 2, 2002, pp. 22 –25.

[7] D. Anagnostou, *Fractal Antennas with RF-MEMS Switches*, Masters Thesis, University of New Mexico, Electrical and Computer Engineering Dept, December 2002.