Radiation Properties of Modified Equilateral Triangle Microstrip Antenna with Folded Slots (MT-MSA)

Ridho CHAYONO, Yuichi KIMURA, and Misao HANEISHI
Dept. of Electrical & Electronic Systems, Saitama University
255 Shimo-Ohkubo, Sakura-ku, Saitama-shi, Saitama
338-8570, Japan
E-address: *haneishi@ees.saitama-u.ac.jp*

1. Introduction

A fractal model for a planar antenna has been studied as an effective antenna for achieving multi-band performance [1]-[5]. Unfortunately, it is difficult to achieve multi-band performance by using a simple configuration [2]. The Sierpinski gasket microstrip antenna (SG-MSA) can be used for a multi-band antenna with a simpler configuration [5]. Multi-band performances with excellent radiation properties have been achieved by using this type of antenna. However, it is difficult to achieve multi-band performance over three frequencies.

In this paper, a basic design technique for a multi-band modified equilateral triangle microstrip antenna with folded slots (MT-MSA) is presented. This antenna is also fed by an L-probe, as shown in Fig.1. The MT-MSA can achieve excellent multi-band performance over three frequencies without using a complex configuration. In order to verify the performance of this antenna, some test samples were constructed and tested in S- and X-bands. Results of experiments showed that satisfactory performance was achieved in both return-loss and radiation pattern characteristics for the MT-MSA tested here.

2. Basic Configuration of the MT-MSA

The basic configuration of the proposed MT-MSA is depicted in Fig.1. The configuration of the proposed antenna is an equilateral triangle geometry with folded slots. The antenna consists of a two-layer Teflon-fiber glass substrate of 1.2 mm in thickness having relative permittivity (ε_r) of 2.6 and loss tangent (tanδ) of 0.0018. The active patch, which is designed to operate at 5 GHz, is located at the upper layer, while the L-probe, which is a feeding probe, is located at the lower layer. The folded slots were set inside the active patch as shown in Fig.1.

The slot size of the test antenna was selected so as to achieve the desired multi-band performance. In order to achieve the multi-band performance in the region of 3-10 GHz, four folded slots were set inside of the MT-MSA as shown in Fig.1. The folded slot width (d1) is set at 0.4 mm for each element, and the interval between slot elements (d2 and d3) is also set at 0.4 mm. An L-probe of 3.6 mm in length and 1.75 mm in width is used as a feeding system. The antenna prototype was optimized by using an EM simulator (IE3D) based on MoM [6].

ISBN: 89-86522-78-0 94460©KEES

3. Results and Discussion

Both simulated and measured return-loss characteristics are shown in Fig.2. The results of measurements agree well with the results of simulation. Four resonant frequencies are observed at 3.45, 5.88, 6.69 and 8.44 GHz, which are associated with the resonant frequencies of the 1st mode, 2nd mode, 3rd mode and 4th mode, respectively. The resonant frequencies can be adjusted by changing the dimensions of folded slots.

Radiation patterns in H- and E-planes of the MT-MSA are shown in Fig.3. The measured and simulated radiation patterns in the co-polarization show good agreement as can be seen in Fig.3. A broadside pattern was achieved for all frequencies. Furthermore, directive gains of 6.03 dBi, 5.95 dBi, 1 dBi and 4.85 dBi were confirmed by measurements for the 1st mode, 2nd mode, 3rd mode and 4th mode, respectively.

The current distributions of the proposed antenna for each resonant frequency are shown in Fig.4. (a), (b), (c), and (d), respectively. These current distributions were obtained by using an EM simulator. The starting point of each current is at the bottom of the MT-MSA element as shown in Fig.4. For this reason, the L-probe is set at the bottom region of the test antenna for exciting the MT-MSA element. The current for the 1st mode is concentrated at the edge of the test antenna, while the currents for other modes are concentrated both at the edge and the folded slot, as shown in Fig.4.

4. Conclusion

An MT-MSA element fed by an L-probe is proposed here for achieving excellent multi-band performance. The radiation properties of the test antenna showed that the performance of the antenna is sufficient for it to function as a multi-band planar antenna. The results of measurements agree well with the results of simulation. The proposed antenna is therefore thought to be an attractive model for a multi-band planar antenna.

References:

[1] C. Puente, J. Romeu, R. Pous, and A. Cardama, "On the Behavior of the Sierpinski Multiband Fractal Antenna, "*IEEE Trans. Antennas Propagat.*, vol. 46, No. 4, pp. 517-524, April 1998.

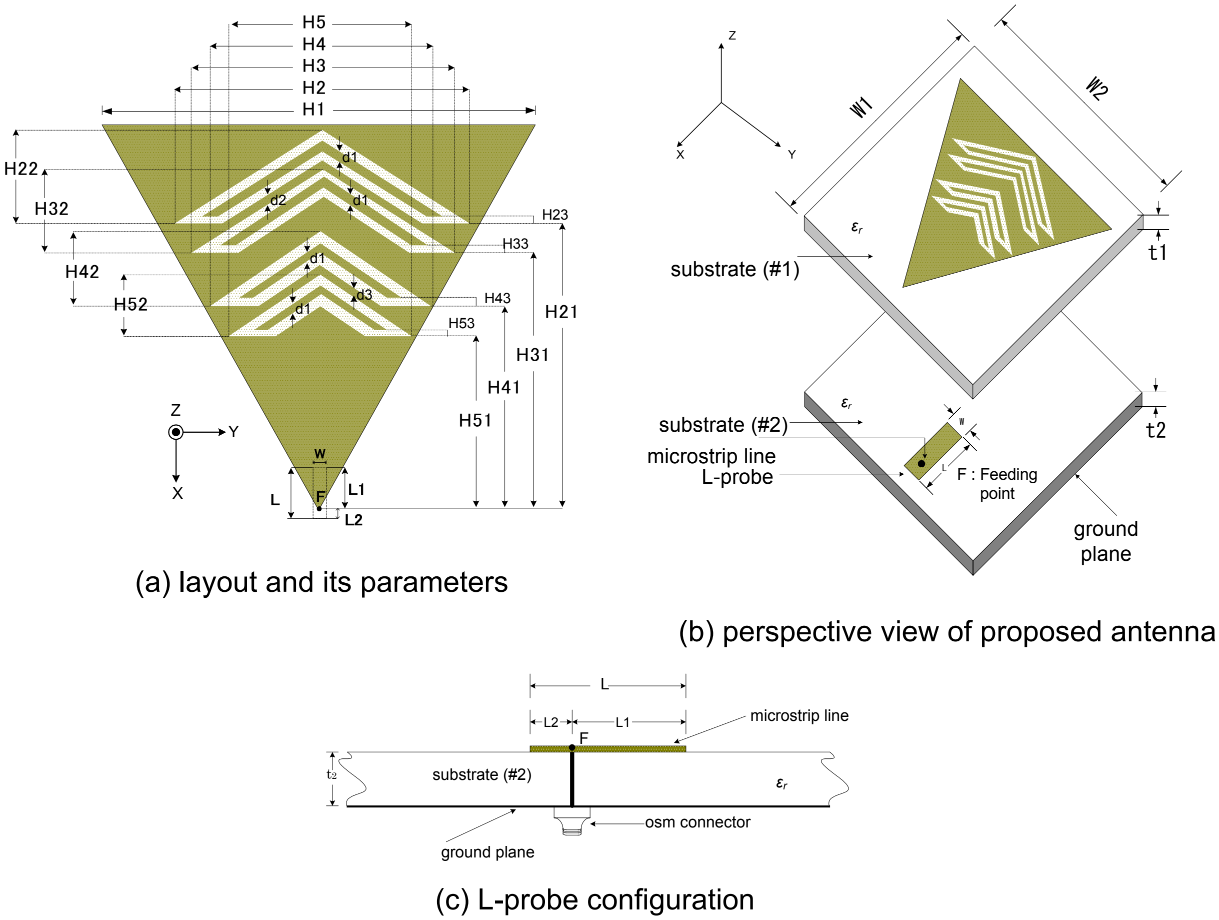
[2] C. Borja, and J. Romeu, " Multiband Sierpinski Fractal Patch Antenna," *IEEE Antennas and Propagation Int. Symp.*, vol. III, Salt Lake City, Utah, pp. 1708-1711, July 2000.

[3] J. Anguera, E. Martinez, C. Puente, C. Borja, and J. Soler, "Broad-Band Dual-Frequency Microstrip Patch Antenna With Modified Sierpinski Fractal Geometry," *IEEE Trans. Antennas Propagat.,* vol. 52, No.1, pp. 66-73, Jan. 2004.

[4] S.R. Best, "Operating band comparison of the perturbed Sierpinski and modified Parany Gasket antennas", *IEEE Antennas and Wireless Propagation Letters*, vol.1, pp. 35 -38, 2002.

[5] S. Tada, R. Chayono, Y. Kimura, and M. Haneishi, "A Consideration on Radiation Properties of Multiband Sierpinski Gasket Microstrip Antenna (SG-MSA)", *Proceeding of ISAP 2004*, pp. 697-700, Aug. 2004.

[6] IE3D User's Manual, Release 10, Zeland Software, Inc., June 2003.

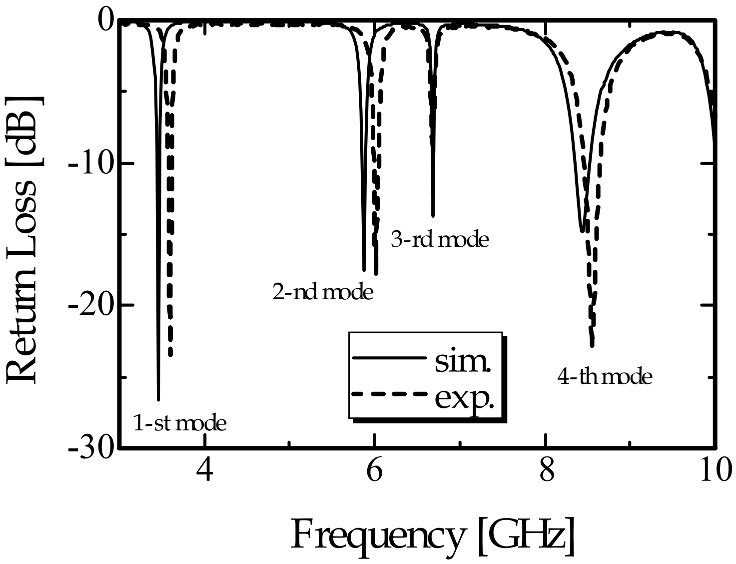


(a) layout and its parameters

(b) perspective view of proposed antenna

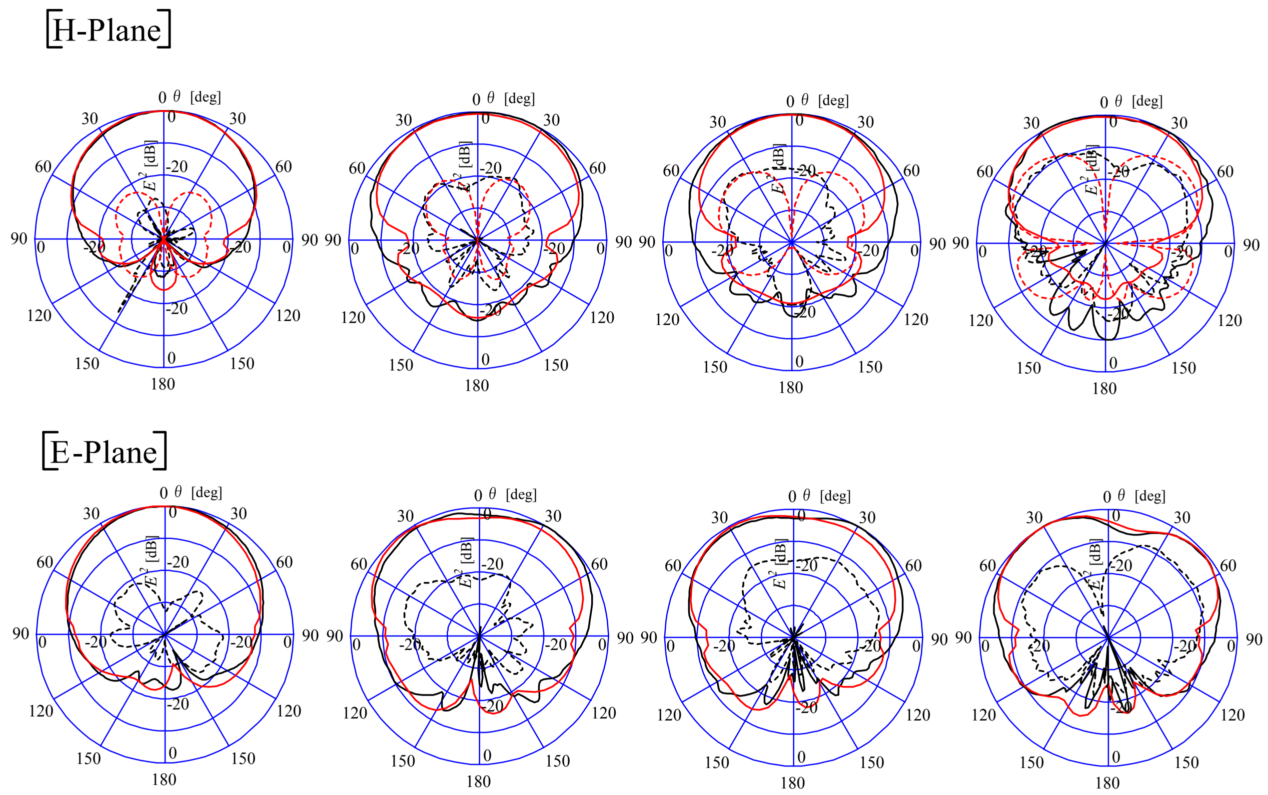
(c) L-probe configuration

Fig.1. Basic geometry of the test antenna.



[H1=23.56;H2=17.2;H3=16;H4=12.8;H5=10.8;H21=15.7;H31=14.4;H41=11.6;H51=10.5;H22=4.3;H32=4;H42=3.2;H52=2.7;H23=H33=H43=H53=0.4;d1=d2=d3=0.4;L=3.6;L1=2.8;L2=0.8;t1=t2=1.2;W=1.75;W1=W2=60, all in mm]

Fig.2. Simulated and measured return-loss characteristics of the proposed antenna.



@3.45 GHz (a) 1st mode

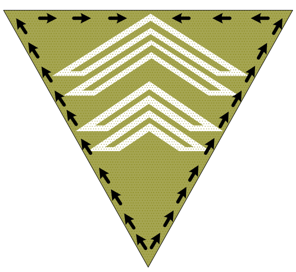
@5.88 GHz (b) 2nd mode

@6.69 GHz (c) 3rd mode

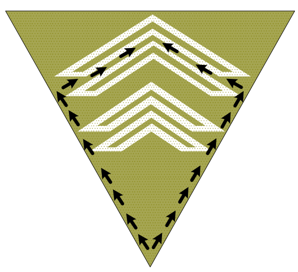
@8.44 GHz (d) 4th mode

[co-pol: —— exp. —— sim. x-pol: - - - - exp. - - - - sim.]

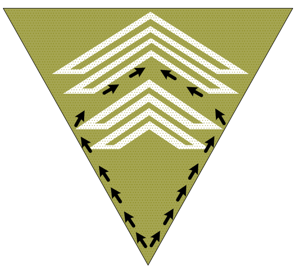
Fig.3. Simulated and measured radiation pattern characteristics of the test antenna.



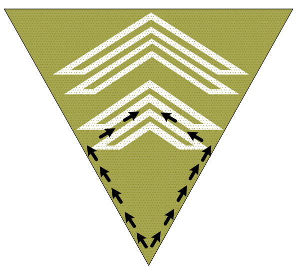
(a). 1st mode (@3.45 GHz)



(b). 2nd mode (@5.88 GHz)



(c). 3rd mode (@6.69 GHz)



(d). 4th mode (@8.44 GHz)

Fig.4. Generalized current distributions obtained by using a simulator (IE3D) for each frequency.