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BANDWIDTH ENHANCEMENT USING COPLANAR COUPLED FEEDING METHOD WITH THE COMBINATION OF A PARTICULAR SHAPE OF GROUND-PLANE SLOT

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Abstract--- A MEMS (micro electro-mechanical- system) unidirectional radiation fractal microstrip antenna using coplanar coupled feeding method combining the ground with a particular shape of slot is proposed. The particular shape of ground-plane slot with the combination of coplanar coupled feeding method enhanced the bandwidth of antenna. The construction method of the shape of ground-plane slot is to copy the fractal shape of the upper antenna slot accordingly to the ground plane, and to simplify, transshape the shape of ground-plane slot. -10dB bandwidth of the proposed antenna element（70MHz） is a double of that of the conventional contact fed antenna without ground slots（30MHz）, at operating frequencies around 1.96GHz，and the gain reduction is only 0.18dB compared with the contact fed antenna without ground slot.(changed into 3.79dB from 3.97dB). -10dB bandwidth of 2 elements antenna array is about 100 MHz, at operating frequencies around 1.93 GHz, and the gain of the antenna array is about 6.3dB. So far as I know this is a novel bandwidth enhancement method.

Keywords - bandwidth enhancement, combination, coplanar coupled feeding method, MEMS fractal microstrip antenna, particular shape of ground-plane slot, unidirectional radiation antenna.

I. INTRODUCTION

The bandwidth of L-band microstrip antenna is relatively narrow, especially for conventional fractal microstrip antenna. It is hard to widen the bandwidth of conventional contact fed microstrip antenna. But it is relatively easy to widen the bandwidth of coupled fed microstrip slot antenna. There are some reports of the bandwidth enhancement of coupled fed microstrip slot antenna. A coupled fed wide-slot antenna with a rotated slot can reach an -10dB operating bandwidth of 2.2 GHz at operating frequencies around 4.5 GHz [1]. Another coupled fed printed wide-slot antenna with a fractal-shaped slot can reach a -10dB operating bandwidth of 2.4 GHz at operating frequencies around 4 GHz [2]. An aperture coupled microstrip Patch Antenna can achieve measured bandwidth of 15.44% (11.11 GHz - 12.97 GHz) [3]. But these reported antennas are not unidirectional radiation antennas and are somewhat complicated. The feeding line is not coplanar with the antenna patch. The manufacture of unidirectional radiation antenna is difficult, especially for MEMS technology. The proposed novel bandwidth enhancement method using a particular shape of ground-plane slot with the combination of coplanar coupled feeding method is relatively simple. The coupled feeding line is coplanar with the antenna patch. The manufacture of unidirectional radiation antenna is easy. The construction method of the shape of ground-plane slot is to copy the fractal shape of the upper antenna slot accordingly to the ground plane, and to simplify, transshape the shape of ground-plane slot. The bandwidth of the proposed coplanar coupled fed unidirectional radiation antenna with slotted ground is about a double (70MHz) of that of the conventional contact fed antenna without ground slots (30MHz). The gain of the proposed antenna is 3.79dB, which is generally the same compared with the contact fed antenna without ground slot (changed into 3.79dB from 3.97dB). The particular shape of ground-plane slot is novel, and the main novel contribution of this paper is that the combination of coplanar coupled feeding method and the particular shape of ground-plane slot achieved bandwidth enhancement of unidirectional radiation microstrip antenna with the cost of 0.18dB gain reduction. The forming of array furthermore enhanced the antenna bandwidth, which reached about 100MHz.

II. ANTENNA CONFIGURATION

The central resonant frequency of the proposed fractal antenna is around 1.95GHz. Double substrate (0.45mm high resistivity silicon+4mm quartz glass) is utilized. The patch antenna and microstrip line are spattered on the high resistivity silicon; the quartz glass is bonded with high resistivity silicon and is underneath the high resistivity silicon, the nethermost is the ground, which is spattered on the quartz glass. The patch antenna, microstrip line and ground are gold. The design is simulated with Ansoft HFSS.

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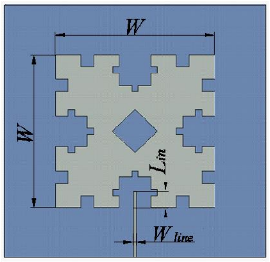


Fig. 1. structure of coupled fed fractal microstrip antenna without ground slots, W=27mm, Wline=0.54mm, Lin=3.25mm.

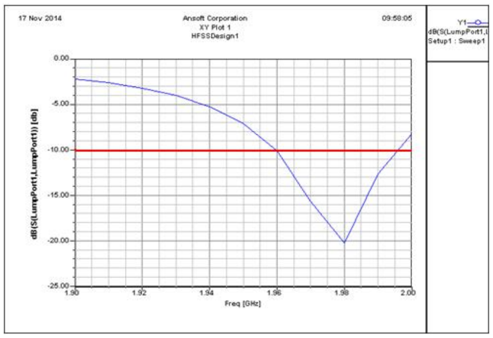


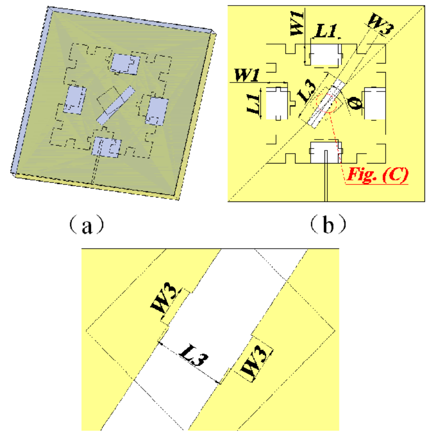
Fig. 2. S11 of coupled fed fractal microstrip antenna without ground slots, -10dB bandwidth is about 35MHz, at operating frequencies around 1.98 GHz.

In order to make L-band microstrip antenna smaller and more suitable for MEMS manufacture, fractal technique is applied to the design of microstrip antenna [4], but the gain of fractal antenna is low. To remedy this neglect, relatively thicker substrate is adopted in this paper. In order to achieve size reduction and obtain better gain, the fractal iteration order and iteration factor can be neither too big nor too small. The fractal method is Minkowski combining rotate-Sierpinski. The fractal iteration order and iteration factor of Minkowski is 2 and 1/5 respectively. The fractal iteration order and iteration factor of Sierpinski is 1 and 1/5 respectively. The Sierpinski fractal shape rotates 45º. The feeding method is coplanar coupled microstrip line feeding. The structure of the antenna element is shown in Fig. 1. Simulation results are shown in Fig. 2, from which we can see, central frequency is 1.98GHz, the bandwidth is about 35MHz(<2%). The gain is 3.75dB.

III. BANDWIDTH ENHANCEMENT

A. *The Proposed Bandwidth Enhancement Method*

To achieve wider bandwidth, based on the coplanar coupled method, the ground is slotted. The ground slot shape is particular, and is a simplified transfiguration of the upper fractal shape of antenna slot. There are 5 slots. 4 rectangular slots are under the central part of 4 borderlines of antenna. The central slot is cater-cornered and its shape is close to the rectangle, just the central part of the long side of rectangle protrudes slightly. The inclination angle of the central slot, the length and the width of all the slots are set as parameters. The structure and parameter simulation results are shown in Fig.3 and Fig. 4. In Fig.4 we can see the central frequency is 1.96GHz, band bandwidth is enhanced because another resonant mode in the vicinity of the fundamental mode is excited. -10dB bandwidth is about 70MHz. (3.6%), which is about a double of that of the coplanar coupled fed antenna without ground slots (35MHz). The gain is 3.79dB, which is generally the same compared with that of the coplanar coupled fed antenna without ground slot.



（a） （b）

（c）

Fig. 3. structure of the proposed coupled fed fractal microstrip antenna with slotted ground, L_1=7.1mm, W_1=4.9mm, L_2=11.5mm, W_2=2.2mm, ϕ=11º (angle between the edge of the central slot and the diagonal of the antenna), L_3=2.329mm, W_3 =1.212mm.

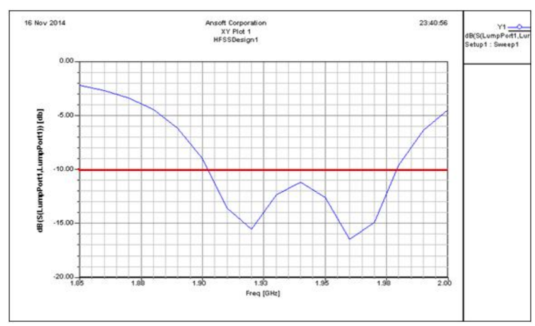


Fig. 4. S_{11} of the proposed coupled fed fractal microstrip antenna with slotted ground, -10dB bandwidth is about 70MHz.

B. *The Reference Antennas*

As a contrast, conventional contact fed microstrip antennas with and without ground slots are simulated at the same conditions.

Contact fed antenna without ground slots

The structure of contact fed fractal microstrip antenna without ground slots and the simulation results are shown in Fig. 5 and Fig. 6. Central frequency of conventional contact fed antenna without ground slots moves to 2.04GHz, the gain is 3.97dB, -10dB bandwidth for 2.04 GHz is about 30MHz, which is very narrow compared with the proposed coplanar coupled fed antenna with ground slots. So the microstrip antenna bandwidth cannot be enhanced by using contact feeding method with the combination of ground without slots.

Contact fed antenna with ground slots

The structure of contact fed fractal microstrip antenna with ground slots and the simulation results are shown in Fig. 7 and Fig.8. Central frequency of conventional contact fed antenna with ground slots moves to 2.02 GHz, the gain is 4.22dB, -10dB bandwidth for 2.02 GHz is about 35MHz. That is to say, the bandwidth cannot be enhanced by just using ground slot but using contact feeding method.

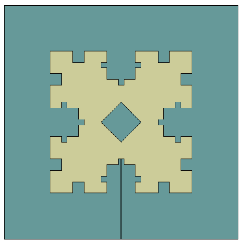


Fig. 5. structure of contact fed fractal microstrip antenna without ground slots

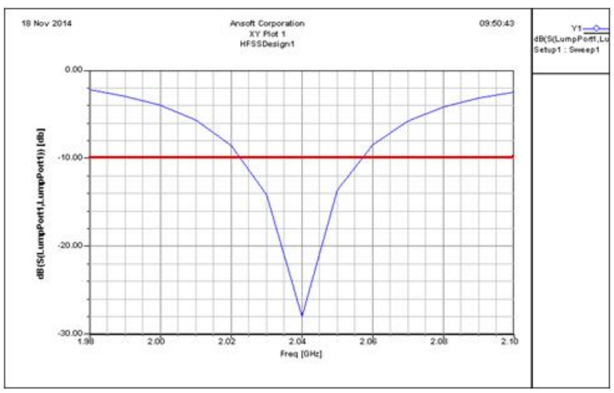


Fig. 6. S_{11} of contact fed fractal microstrip antenna without ground slots, -10dB bandwidth for 2.04 GHz is about 30MHz.

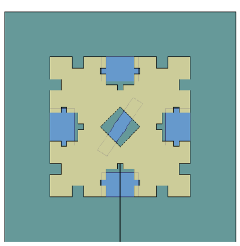


Fig. 7. structure of contact fed fractal microstrip antenna with slotted ground.

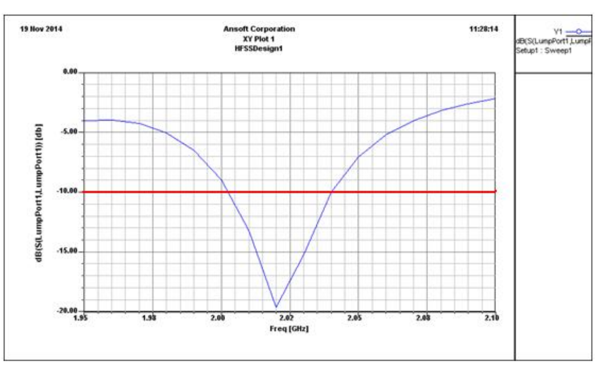


Fig.8. S_{11} of contact fed fractal microstrip antenna with slotted ground, -10dB bandwidth for 2.02 GHz is about 35 MHz.

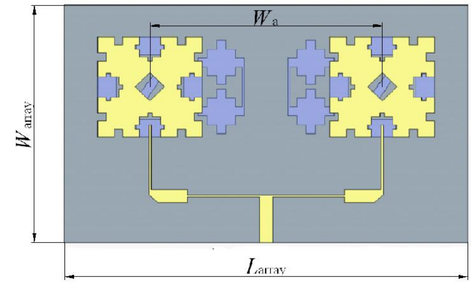


Fig. 9. Structure of the proposed coupled fed fractal microstrip antenna array with fractal DGS, W_a=60mm=0.388 λ 0, L_{array}=10.444cm, W_{array}=64.44cm

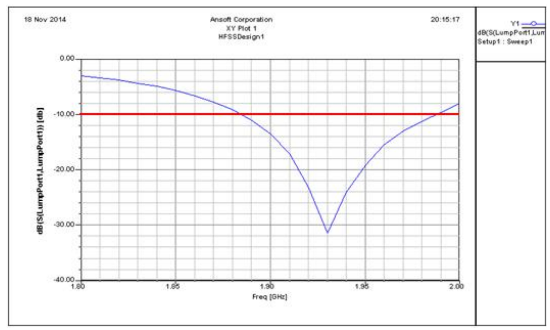


Fig.10. S_{11} of the proposed coupled fed fractal microstrip antenna array with fractal DGS, -10dB bandwidth is over 100 MHz.

TABLE I

-10 DB BANDWIDTH COMPARISON AMONG COUPLED/CONTACT FED ANTENNA WITH/WITHOUT GROUND SLOTS

Antenna	Central Frequency(GHz)	Bandwidth (MHz)
Coupled fed /with Ground Slots	1.96	70
Coupled fed /without Ground Slots	1.98	35
Contact fed /with Ground Slots	2.02	35
Contact fed / Without ground slots	2.04	30

C. Analysis and Discussion

The -10 dB bandwidth comparison among coupled/contact fed antennas with/without ground slots is shown in TABLE I, from which, we can see the bandwidth of the proposed coupled fed antenna with a particular shape of ground-plane slot is significantly wider than that of the rest. The bandwidth can be significantly enhanced neither by just using coplanar coupled feeding method but with the combination of ground without slots, nor by just using ground slot but with the combination of using contact feeding method. Only with the combination of coplanar coupled feeding method and the particular shape of ground-plane slot, can be achieved significant bandwidth enhancement. Maybe there are some other particular shapes of ground slot, which with the combination of contact feeding method can achieve bandwidth enhancement, but I did not find these particular shapes of ground slot.

Array

A 2 elements antenna array with fractal DGS [5] is formed, illustrated in Fig. 9. The 2-elements antenna array resonates at 1.93 GHz, the bandwidth (S_{11}<-10dB) is about 100MHz (5.2%), as shown in Fig. 10. The bandwidth is further enhanced. The gain is about 6.3dB.

IV. CONCLUSION

Through the novel bandwidth enhancement method the bandwidth of the unidirectional radiation fractal microstrip antenna is significantly enhanced with a slight gain reduction, compared with the conventional contact fed antenna without ground slot (changed into 3.79dB from 3.97dB). The forming of array enhanced the bandwidth of antenna furthermore. Possible reason for the improvement of performance is that the combination of coplanar coupled feeding method and the particular shape of ground-plane slot depressed the quality factor and excited more resonant modes in the vicinity of the fundamental mode. The MEMS manufacture of the proposed antenna is relatively easy. The proposed novel bandwidth enhancement method can be applied in other (fractal shape) microstrip antenna. The proposed particular slot construction method on ground-plane may be applied in other fractal microstrip antenna to improve antenna performance.

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