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A Survey on Compact Modified Dumbbell-Shaped DGS Having Square Loops

S. Yang

Assistant professor, Dept. of EE and CS, Alabama A & M University, Huntsville, AL 35810, USA

ABSTRACT: A compact modified dumbbell-shaped DGS (CM-DGS) on coplanar waveguide has two square loops. The small loop is inside the large loop. To further decrease the resonant frequency of this CM-DGS, a third square loop is embedded inside the small square loop and connected to the edge of this small square loop. The overall signal path is extended by the third loop. Simulation of the proposed DGS shows a lower resonant frequency and hence a size reduction effect.

KEYWORDS: DGS, resonance frequency, signal path.

I. INTRODUCTION

Microwave circuits work differently from general AC circuits [1]. At microwave frequencies, signal wavelength is comparable to or even smaller than the typical conductor size. In such cases, signals cannot be carried by a single wire and ground. Microwave signals have to be treated as traveling waves and must be transmitted with transmission lines. Microstrip is a popular transmission line at microwave and RF frequencies. A microstrip consists of a conducting strip line separated from the ground plane by a dielectric substrate. It is a conduction line on a printed circuit board (PCB) as usual, plus the ground plane at the bottom. Microstrip filters are one kind of microwave filters widely used in the front end of telecommunication systems. These filters are based on microstrip structures. Coplanar waveguide is one kind of derivatives of microstrip lines, and it was first proposed by Wen [2]. It consists of a metal line and two adjacent metal ground planes at the two sides of the metal line on a dielectric board. The back of the dielectric board can be the ground plane or empty. Coplanar waveguide can be used for microstrip filter implementation. Defected ground structure or DGS is a defect intentionally made in the ground plane of a planar transmission line (microstrip, stripline, coplanar waveguide and etc.). It will disturb the current distribution in the ground plane and increase the effective capacitance and inductance [3]. Micostrip filters can be built based on coplanar waveguide and DGS.

II. RELATED WORK

Bandstop DGS resonators can generate narrow stopbands at microwave frequencies with small circuit sizes. They are widely used in microwave subsystems, such as tunable resonators, lowpass and bandpass filters, amplifiers and antennas [4-10]. The dumbbell-shaped DGS on coplanar waveguide is one kind of such bandstop resonators [11]. Based on this kind of DGS, a modified dumbbell-shaped DGS (M-DGS) on coplanar waveguide was proposed by Safwat and others [12]. Based on M-DGS, a compact modified dumbbell-shaped DGS (CM-DGS) with two square loops was proposed for circuit size reduction [13]. In this paper, another CM-DGS with three square loops is proposed to further reduce the resonant frequency. This DGS is simulated on Sonnet Suit Software. Sonnet Suite is planar 3D EM simulation software based on Method of Moments. It is being widely used by many researchers [14]. Simulations on Sonnet Suite show the proposed DGS reduces the resonant frequency with the same circuit size.

III. MODIFIED DUMBBELL-SHAPED DEFECTED GROUND STRUCTURES

Figure 1 is the layout of a M-DGS on coplanar waveguide, with main dimensional parameters labeled. The substrate material is Rogers TMM10i with a relative dielectric constant of 9.8 and a loss tangent of 0.002. The thickness of the substrate is 1.27 mm. The back of the circuit board is empty (no metal). The coplanar waveguide parameters Gap/Width/Gap are 0.80/3.00/0.80 mm, and the characteristic impedance of this coplanar waveguide is 50 Ohm. The width of the slot line in the ground plane is 0.4 mm. The two square loops in the two ground areas are symmetrical along the center of the conduction line between the two ground areas.

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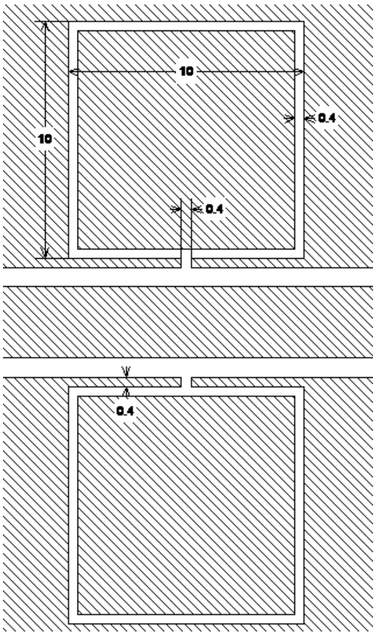

Fig. 1. Layout of a modified dumbbell-shaped DGS with mm as the unit.

The modified dumbbell-shaped DGS in Figure 1 is simulated on Sonnet Suite 14.52. Simulation results on reflection coefficient S11 and transmittance S21 are shown in Figure 2. The resonant frequency is at 2.40 GHz. In this DGS, the resonant frequency is mainly determined by the signal path, which is the square loop perimeter.

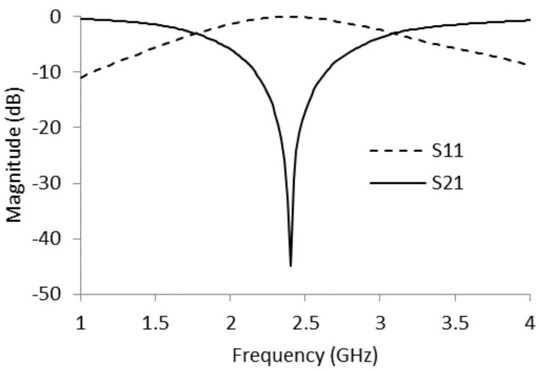

Fig.2. Simulation results of the modified dumbbell-shaped DGS

To decrease the resonance frequency of the modified dumbbell-shaped DGS mentioned above, a CM-DGS is used. Figure 3 shows the layout of this DGS with new dimensional parameters labeled. Other dimensional parameters are the same as in Figure 1. This DGS has two loop resonators. The smaller loop is inside the larger loop and connected to the larger one's edge through a slot. The structure is similar to the one proposed in [3].The resonant frequency of the CM-DGS is mainly determined by the total length of all the slotted lines. This DGS increases signal path length by the smaller square loop, and hence decreases the resonant frequency.

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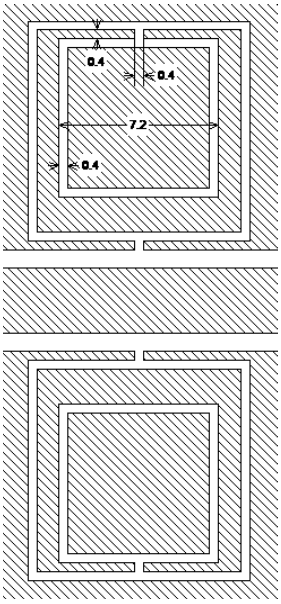

Fig. 3. Layout of a CM-DGS with mm as the unit.

This DGS is also simulated on Sonnet Suite 14.52. Simulation results on reflection coefficient S11 and transmittance S21 are shown in Figure 4. The resonant frequency is at 1.68 GHz, which is lower than 2.40 GHz, the resonant frequency of the M-DGS in Figure 1 with the same circuit size. Hence this CM-DGS has potential to reduce the circuit size.

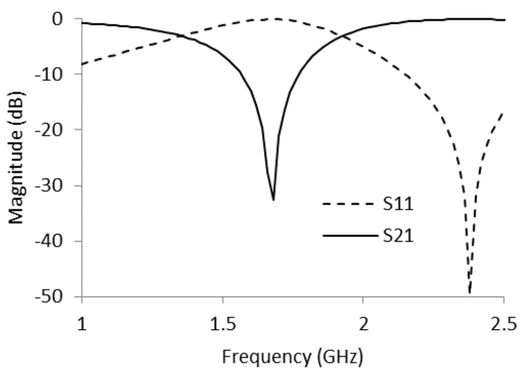

Fig. 4. Simulation results of the CM-DGS.

IV. PROPOSED COMPACT MODIFIED DUMBBELL-SHAPED DEFECTED GROUND STRUCTURE

To further decrease the resonant frequency of the CM-DGS mentioned above, a novel CM-DGS with three square loops is proposed. Figure 5 shows the layout of this new DGS with new dimensional parameters. Other dimensional parameters are the same as in Figure 3 and in Figure1. The smallest square loop is connected to the edge of the smaller square loop through a slot line. The overall signal path is further extended by the smallest square loop, and hence the resonant frequency should be further decreased.

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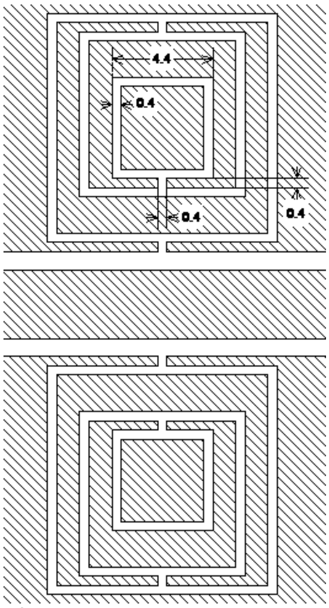

Fig. 5. Layout of the new CM-DGS with three square loops.

The proposed CM-DGS with three square loops is also simulated on Sonnet Suite 14.52. Simulation results are shown in Figure 6. This time the resonant frequency is further decreased to 1.54 GHz. This new resonant frequency is lower than 2.40 GHz and 1.68 GHz, the two resonant frequencies of the two DGSs with one square loop and two square loops.

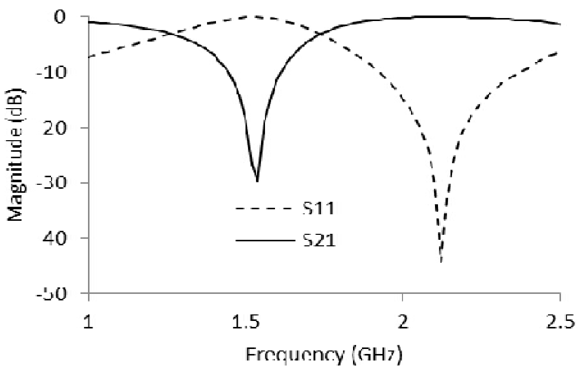

Fig. 6. Simulation results of the proposed CM-DGS having three square loops.

V. SUMMARY

To decrease the resonant frequency of a CM-DGS with two square loops, a third square loop is embedded inside the second square loop, and connected to the edge of the second square loop. The total signal path is extended by the additional third square loop. The proposed DGS with three square loops and the original CM-DGS are simulated on Sonnet Suite. Simulations show the resonance frequency is decreased from 1.68 GHz to 1.54 GHz. Hence, the proposed DGS has the potential on circuit size reduction.

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REFERENCES

[1] D. M. Pozar, Microwave Engineering, 2nd edition, John Wiley and Sons, 1998.
[2] C. P. Wen, "Coplanar waveguide: a surface strip transmission line suitable for nonreciprocal gyromagnetic device applications", IEEE Transactions on Microwave Theory and Techniques, vol. 7, pp. 1087-1090, 1969.
[3] L. H. Weng, Y. C. Guo, X. W. Shi, and X. Q. Chen, "An overview on defected ground structure," Progress In Electromagnetics Research B, vol. 7, pp. 173-189, 2008.
[4] S. Y. Huang, and Y. H. Lee, "A compact E-shaped patterned ground structure and its applications to tunable bandstop resonator", IEEE Transactions on Microwave Theory and Techniques, vol. 57, no. 3, pp. 657-666, 2009.
[5] L. H. Zhou, Y. L. Ma, J. Shi, J. X. Chen, and W. Che, "Differential dual-band bandpass filter with tunable lower band using embedded DGS unit for common-mode suppression", IEEE Transactions on Microwave Theory and Techniques, vol. 64, no. 12, pp. 4183 – 4191, 2016.
[6] J. Lu, J. Wang, and H. Gu, "Design of compact balanced ultra-wideband bandpass filter with half mode dumbbell DGS", Electronics Letters, vol. 52, issue 9, pp. 731 – 732, 2016.
[7] S. Liu, J. Xu, and Z. Xu, "Sharp roll-off lowpass filter using interdigital DGS slot", Electronics Letters, vol. 51, issue 17, pp. 1343 - 1345, 2015.
[8] F. Yang, J. Lees, H. Choi, H. Yu, and P. J. Tasker, "Continuous class BJ power amplifier with DGS output matching", IEEE MTT-S International Microwave Symposium (IMS), pp. 1-4, 2014.
[9] A. Ghalib, and M. S. Sharawi, "Analyzing DGS behavior for a MIMO antenna system using theory of characteristic modes", IEEE Middle East Conference on Antennas and Propagation (MECAP), pp. 1-4, 2016.
[10] A. Zaidi, A. Baghdad, A. Ballouk and A. Badri, "Design and optimization of an inset fed circular microstrip patch antenna using DGS structure for applications in the millimeter wave band", 2016 International Conference on Wireless Networks and Mobile Communications (WINCOM), pp. 99-103, 2016.
[11] D. Ahn, J. S Park, C. S. Kim, J. Kim, Y. Qian, and T. Itoh, " A design of the lowpass filter using the novel microstrip defected ground structure", IEEE Transactions on Microwave Theory and Techniques, vol. 49, no. 1, pp. 86-93, 2001.
[12] A. M. E Safwat, P. Podevin, P. Ferrari, and A. Vilcot , "Tunable bandstop defected ground structure resonator using reconfigurable dumbbell-shaped coplanar waveguide", IEEE Transactions on Microwave Theory and Techniques, vol. 54, no. 9, pp. 3559-3564, 2006.
[13] J. Wang, H. Ning, and L. Mao, "A compact reconfigurable bandstop resonator using defected ground structure on coplanar waveguide", IEEE Antennas and Wireless Propagation Letters, vol.11, pp. 457-459, 2012.
[14] www.sonnetsoftware.com/resources/technical-references-ustomers.html