Proceedings of the 10th WSEAS International Conference on CIRCUITS, Vouliagmeni, Athens, Greece, July 10-12, 2006 (pp366-369)

Applications of Novel Defected Microstrip Structures (DMS) in Planar Passive Circuits

[1,2]J. A. Tirado-Mendez; [1,3]M.A. Peyrot-Solis; [1]H. Jardón Aguilar; [2]E. A. Andrade-Gonzalez; [2]M. Reyes-Ayala
[1]Electrical Engineering, CINVESTAV-IPN, Av. IPN 2508, Mexico City, D.F; Mexico, 07360.
[2]Electronics Department Metropolitan Autonomous University-Azcapotzalco, Mexico, D.F. México.
[3]Mexican Navy Research Institute, Mexico, D.F. Mexico.

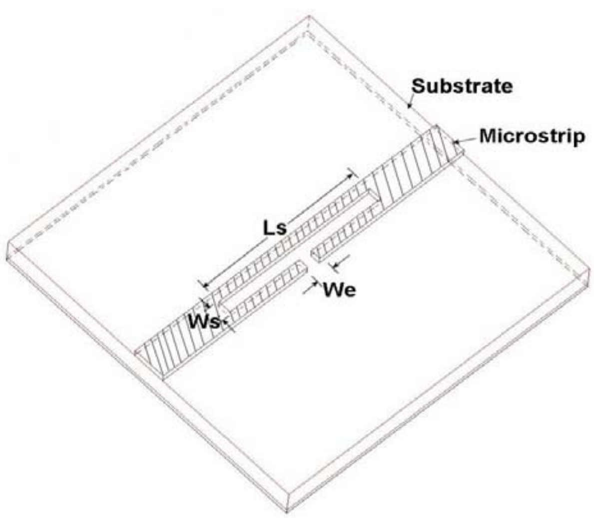
Abstract. A novel Defected Microstrip Structure (DMS) is used to enhance the behavior of different planar passive circuits like rectangular patch antennas. As examples, the structure is employed to reduce the patch antenna size and as a tuning technique. DMS is compared to a unit-cell Defected Ground Structure (DGS), observing some advantages concerning frequency response for narrow-band filtering applications.

Keywords: DGS, DMS; patch antenna, tuning, Microstrip filters, passive circuits.

1 Introduction

Lately, DGS structures have been employed successfully in several applications. The most common application is filtering, because of the inheritance behavior of such structures [1]. However, the latest applications have involved size reduction of active devices like amplifiers [2], and many other circuits [3]. New proposals of DGS establish the use of such structures to suppress harmonics in certain circuits than can be passive [4] or active [5].

In this work a new defected structure is proposed, and its applications can be extended to passive and active devices. The structure called Defected Microstrip Structure (DMS) is presented in figure 1. DMS shows two perpendicular slots with the largest along the microstrip structure. These slots, as well as in the DGS case, generates an increment in the associated inductance of the circuit, making the total structure to behaves as a band reject filter.



The associated inductance is function of the slot length. The structure has been employed successfully in reducing the size of rectangular patch antennas, achieving 22% of area reduction [6]. DMS also can be used as a tuning technique for patch antennas [7]. As in the case of DGS, DMS is useful to suppress harmonics in different circuits. In this case, the frequency response of a DGS and a DMS working at the same frequency band were compared, employing two different substrates, obtaining a better performance with the DMS considering insertion loss in the desired band.

2 DMS as a tuning technique

So far, there are several techniques to tune the resonant frequency of a square patch antenna. Some of these techniques include the use of stubs, shorting posts, and adjusting an air gap to modify the permittivity of the substrate [8]. Such techniques increase the resonant frequency of the patch antenna, so the tuning goes from a lower to a higher resonant frequency. Moreover, some of these techniques can be difficult to achieve. By using the DMS behavior, we can have an easy and complementary method to tune a rectangular patch antenna. In this case, the slots are placed along the non-radiating edges of the antenna, increasing the electrical length of the element as is depicted in figure 2, and as a result, the operating frequency is lowered. The method does not modify the performance of the antenna, regarding radiation pattern, or gain. This comparison can be observed in figure 3.

As an example for the use of this technique, a rectangular patch antenna was designed to resonate at 1.45 GHz, with width *W* and length *L*. The antenna

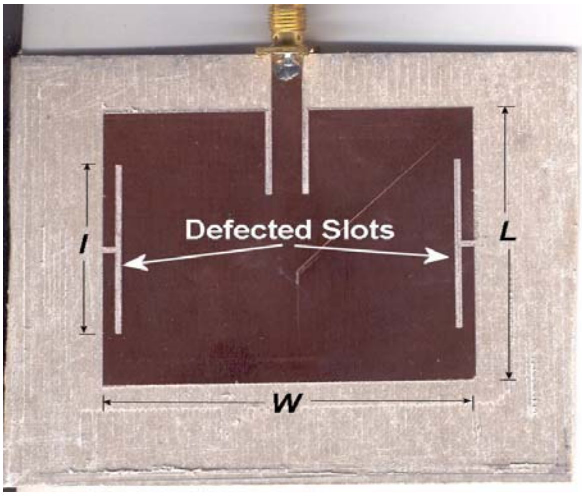
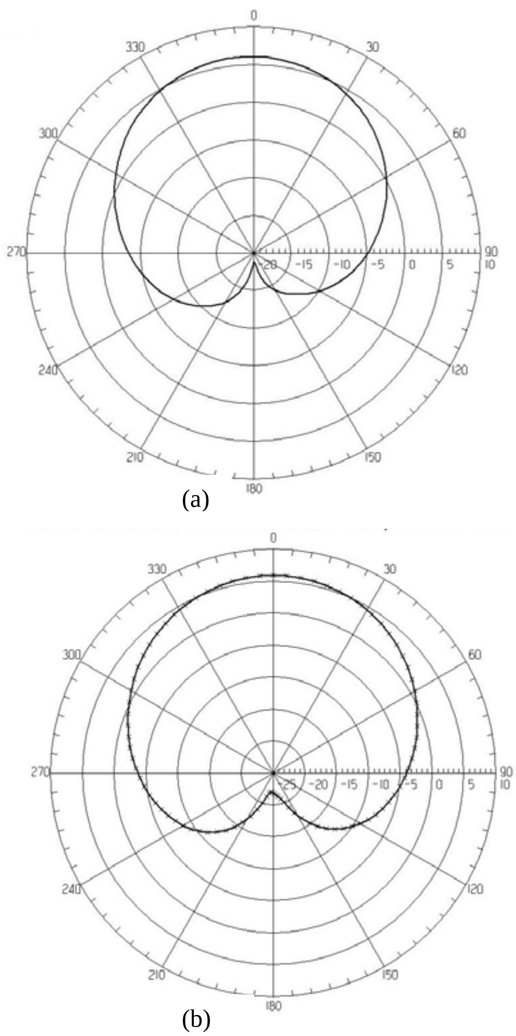


Fig. 2. Rectangular patch antenna with defected slots along the non-radiating edges



(a)

(b)

Figure 3. Radiation pattern of: a) Patch antenna without DMS, b) Patch antenna with DMS

was simulated with HFSS and measured, and it was observed that the antenna was out of band. Therefore, the DMS technique was employed to tune the element to the desired frequency. In figure 4, we observe the behavior of the resonant frequency as a function of the normalized slot length (*l/L*), where *l* is the slot length. Figure 5 depicts the comparison of the tuned and non tuned antenna.

In this case, we can observe that the resonant frequency is lowered as the slot length is increased, achieving a tuning rage of more than 100 MHz. According to the figure, the required normalized slot length is close to 0.35 to tune the antenna to the desired frequency.

This technique is easy to achieve, since it is only needed to etch the slots along the non-radiating edges without the use of a complicated technology as can be the case of the technique which modify the air gap mentioned in [8], avoiding any interference with the performance of the antenna.

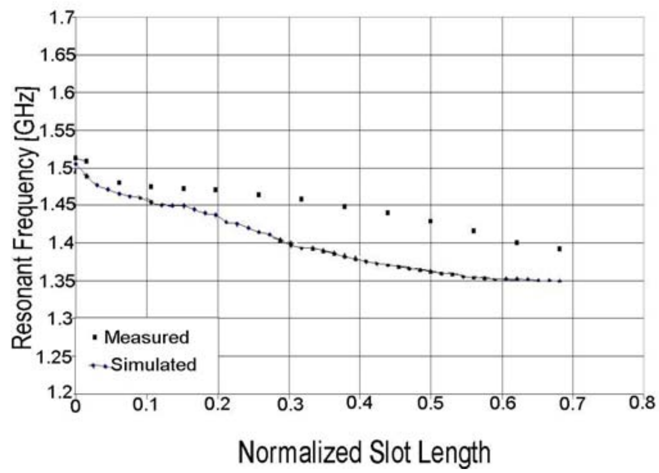


Fig. 4. Resonant frequency behavior against normalized slot length

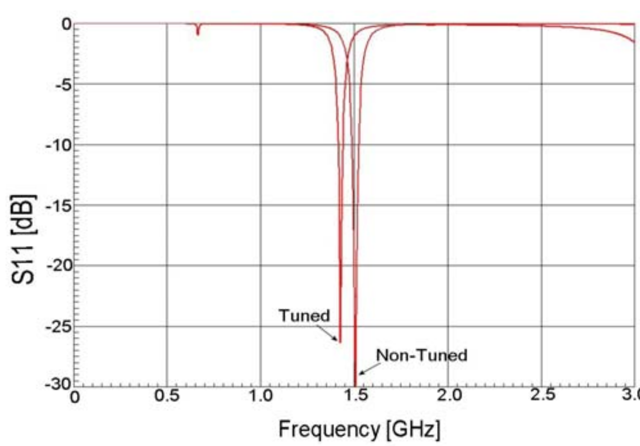


Figure 5. Comparison between tuned and non-tuned patch antenna

Proceedings of the 10th WSEAS International Conference on CIRCUITS, Vouliagmeni, Athens, Greece, July 10-12, 2006 (pp366-369)

3 DMS as a suppressing filter

Many recent applications of DGS involved the suppression of non-desired harmonics, to prevent interferences with other equipments, achieving electromagnetic compatibility. These applications are focused, mainly in patch antennas and filters. Moreover, some of these are used in enhancing the performance of several active circuits. As an example, DGS are being employed to filter some harmonics to improve the power added efficiency of power amplifiers such as class F, where harmonic suppression at the output port is of great importance.

In this section, a comparison of frequency response of DGS and DMS structure is made. In this case, we try to suppress the second harmonic of a system which operates at 1.8 GHz, so the rejected frequency band must be centered at 3.6 GHz. In this case, we are assuming a circuit which can be used in a multistandard system, so the rejected band should be very narrow and provide the lowest attenuation in the desired band, in this case, at 1.8 GHz.

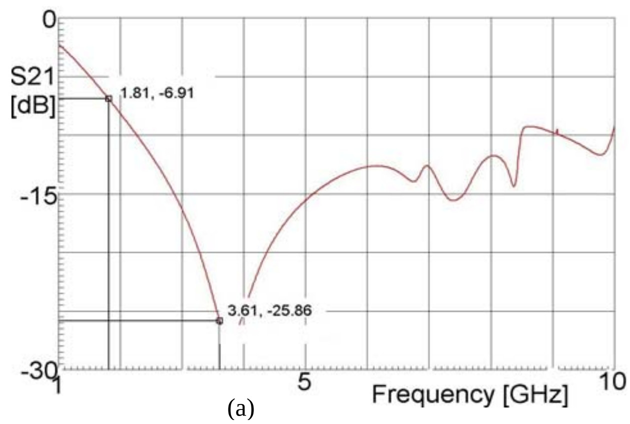
Figure 6 shows the behavior for different permittivity and thickness substrates, where the DMS as well as the DGS where designed to suppress the second harmonic.

The simulations were made with HFSS, and as can see in the figure, the attenuation factor is bigger when we use a unit cell DGS, compared to the DMS. By using a substrate Duroid 6010 with permittivity of 6.15 and thickness of 0.635 mm, it is observed that the attenuation obtained at 1.8 GHz is close to 7 dB, meanwhile in the DMS case, the attenuation is less than 1 dB. On the other hand, when Duroid 5880 with permittivity of 2.15 and thickness of 1.27 mm is used, the attenuation is 1.8 dB and 0.46 dB for the DGS and DMS, respectively.

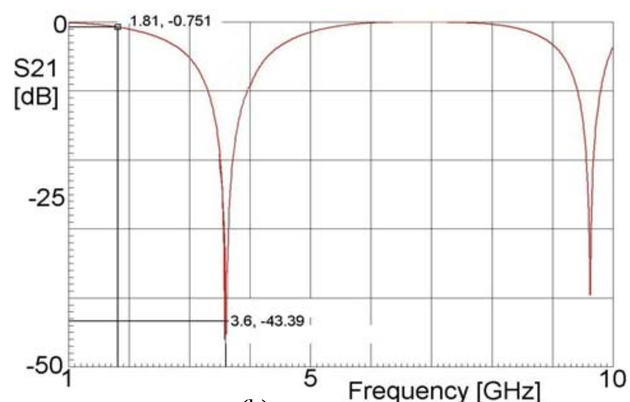
For both cases, it is observed that the attenuation introduced by the DMS is lower than insertion loss obtained by the DGS. For multistandard and narrow band suppression harmonics applications, DMS is a very good option. On the other hand, when we need to suppress other harmonics than the second one, we can employ the DGS structure, but considering the attenuation introduced by this unit cell.

4 Conclusions

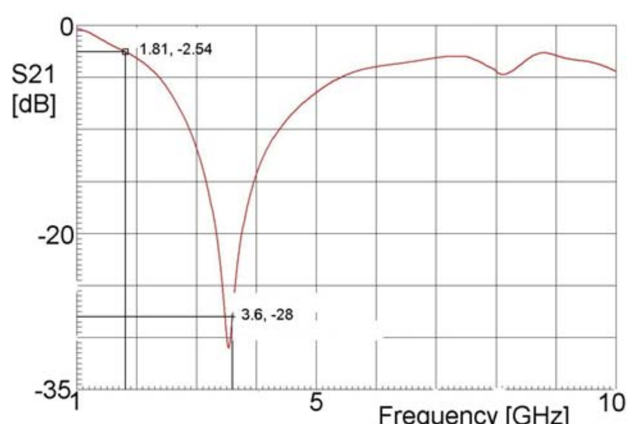
DGS structures have been widely employed in enhancing the performance of passive and active devices. This work presents a novel structure called Defected Microstrip Structure (DMS), which has been employed successfully in several applications such as reducing the size of rectangular patch antennas without degrading the performance of the antenna; as a tuning technique for patch antennas as a complement of other techniques, since this one lower the resonant frequency of the device, as well as it is very simple to achieve with no need of complicated technology to be designed. Like DGS, other application of DMS is the suppression of harmonics without introducing a big attenuation in the fundamental frequency as it is observed in section III. This technique can be employed to suppress harmonics in amplifiers of high efficiency as can be a class F.



(a)

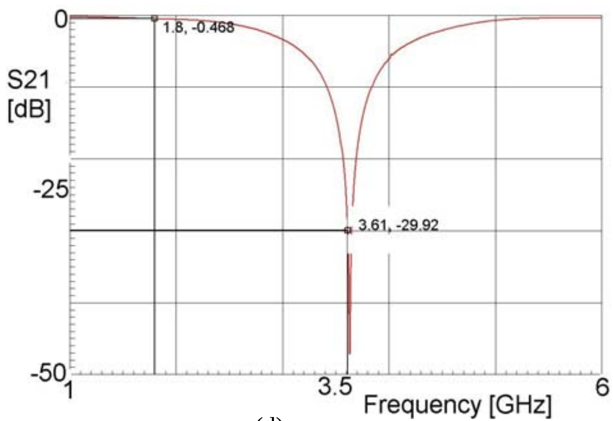


(b)



(c)

Fig. 6. Suppression of second harmonic with DMS and DGS structures. a) DGS, Duroid 6010, b) DMS, Duroid 6010, c) DGS, Duroid 5880, d) DMS, Duroid 5880



(d)

Fig. 6. Cont'n

Acknowledgement:
This work was supported by Project CONACyT-Marina 2003-02-11873

References:

[1] C-S Kim, J-S Park, D. Ahn, J-B Lim; "A Novel 1-D Periodic Defected Ground Structure for Planar Circuits"; *IEEE Microwave and Guided Wave Letters*, Vol. 10, No. 4, pp. 131-133, April 2000.

[2] J-S Lim, J-S Park, Y-T Lee, D. Ahn, S. Nam; "Application of Defected Ground Structure in Reducing the Size of Amplifiers"; *IEEE Microwave and Wireless Components Letters*; Vol. 12, No. 7, pp. 261-263; July 2002.

[3] N. C. Karmakar, M. N. Mollah; "Potential Applications of PBG Engineered Structures in Microwave Engineering: Part I"; *Microwave Journal*; pp. 22-42; July 2004.

[4] A. S. Andrenko, Y. Ikeda, O. Ishida; "Application of PBG Microstrip Circuits for Enhancing the Performance of High-Density Substrate Patch Antennas"; *Microwave and Optical Technology Letters*; Vol. 32, No. 5, pp. 340-344, March 5, 2002.

[5] Y. Chung, S-S Jeon, S. Kim, D. Ahn, J-I. Choi, T. Itoh; "Multifunctional Microstrip Transmission Lines Integrated with Defected Ground Structure for RF Front-End Application"; *IEEE Transactions on Microwave Theory and Techniques*; Vol. 52, No. 5, pp. 1425-1432, May 2004.

[6] J. A. Tirado-Mendez, H. Jardon-Aguilar, F. Iturbide-Sanchez, I. Garcia-Ruiz, V. Molina-Lopez, R. Acevo-Herrera; "A Proponed Defected Microstrip Structure (DMS) Behavior for Reducing Rectangular Patch Antenna Size"; *Microwave and Optical Technology Letters*; Vol. 43, No. 6, pp. 481-484, December 20, 2004.

[7] J. A. Tirado-Mendez, H. Jardón-Aguilar, F. Iturbide-Sanchez; "Application of Defected Microstrip Structure as a Tuning Technique for Rectangular Printed Antennas"; *Microwave and Optical Technology Letters*, Vol. 48, No. 2, February 2006, pp. 370-373.

[8] Ramesh Garg, Prakash Bhartia, Inder Bahl, Apisak Ittipiboon; *Microstrip Antenna Design Handbook*; Norwood MA, Artech House 2001.