A simple reconfigurable microstrip antenna for wideband applications

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Abstract The purpose of this paper is to introduce a new resonant frequency reconfigurable antenna for wideband wireless communications. The proposed antenna is composed of a rectangular microstrip antenna, a partial ground plane, and a microstrip line connected to the partial ground to enable frequency reconfigurability. We present a preliminary design that includes antenna simulations and their comparison with measured data.

Introduction

To meet the ever growing demand for wireless communications and increased bandwidth, reconfigurable and wideband antennas are a necessity. Various reconfigurable antennas have been studied and reported to satisfy such requirements [1-3]. This paper discusses the potential of a partially grounded rectangular microstrip antenna as a frequency reconfigurable antenna. Most frequency reconfigurable antennas depend on PIN diodes or MEMS switches to change the current paths on the antenna to achieve a multi-frequency function [4-5]. Although the direct change of current-paths on the antenna structure can easily change the operation frequencies, usually the radiation pattern changes from frequency to frequency. One of the merits of the proposed antenna is that its radiation pattern remains the same regardless of the frequency of operation. The experimental results are compared and investigated with the simulations. The simulation is performed by using CST microwave studio (MWS) [6]. The proposed antenna is successfully implemented and the simulated results show reasonable agreement with the measured results. In this design, a 7.1-to-10.9 GHz frequency range for -10 dB is obtained. The radiation patterns at various frequencies are also presented and discussed.

Antenna Configuration and Analysis

Figure 1 presents the configuration of the proposed antenna. The back of the microstrip antenna consists of a partial ground plane and an adjustable microstrip line connected to it. The total dimension of the antenna is 5.1 × 4.45 mm^2. The thin metal film is deposited on both sides of a semi-insulating (SI) Gallium arsenide (GaAs) substrate whose thickness is 450 um and its relative permittivity 12.9. The detail sizes of the antenna are presented in Table 1.

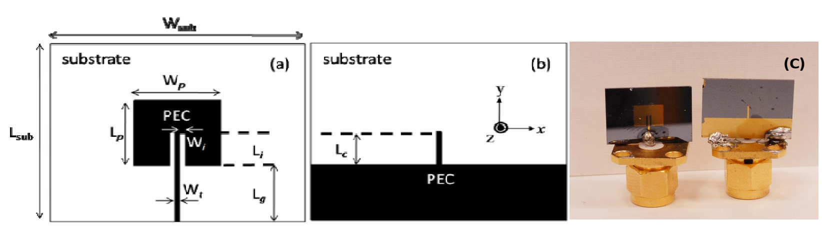

Fig.1. Geometry of the proposed antenna: (a) front view, (b) back view and (c) picture images of fabricated antennas

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W_{sub}	W_p	W_i	W_t	L_{sub}	L_p	L_i	L_c	L_g
5.0	*5.1*	*0.3*	*0.3*	*12.0*	*4.45*	*2.225*	*2.225*	*3.775*

Tab.1. Dimensions of the proposed reconfigurable antenna in mm

To obtain frequency reconfigurability, the length of an adjustable microstrip line, L_c, on the backside of the GaAs-substrate, is varied. According to the numerical results, the proposed reconfigurable antenna can tune its resonant frequency from 7.1 to 10.9 GHz, as shown in Figure 2.

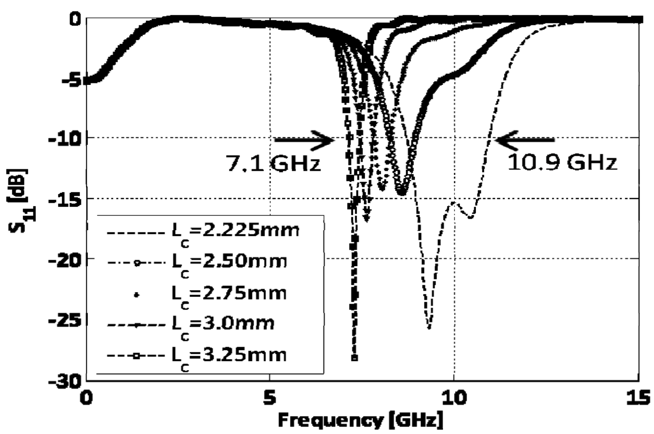


Fig.2. Full-wave simulated return losses in dB for different L_c-values

The frequency sweep is possible due to the variation of the ***L-C*** values in the adjustable microstrip stub line. As the length of the frequency control-stub line is changed, both, the Inductance (***L***) and Capacitance (***C***) of the stub line will change as well. To evaluate this effect an equivalent circuit in Figure 3 is used. The proposed circuit model is composed of a parallel connection of R_a, L_a and C_a, representing the antenna, and another circuit for the stub line which is a connection of parallel C_f and a series L_f. The inductance (***L***) can be determined based on $L = (Z_c \tan\theta)/\omega$ where Z_c is the characteristic impedance of the microstrip stub line on the back and θ is the electrical length at the angular frequency ω. The capacitance (***C***) of a line can also be computed by the ***L-C*** relation of $C = (2\pi)^2/(\omega^2 L)$ at the resonant frequency. The results from an equivalent model are presented in Figure 4.

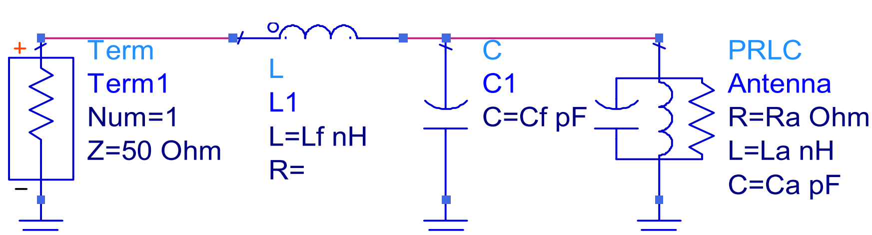
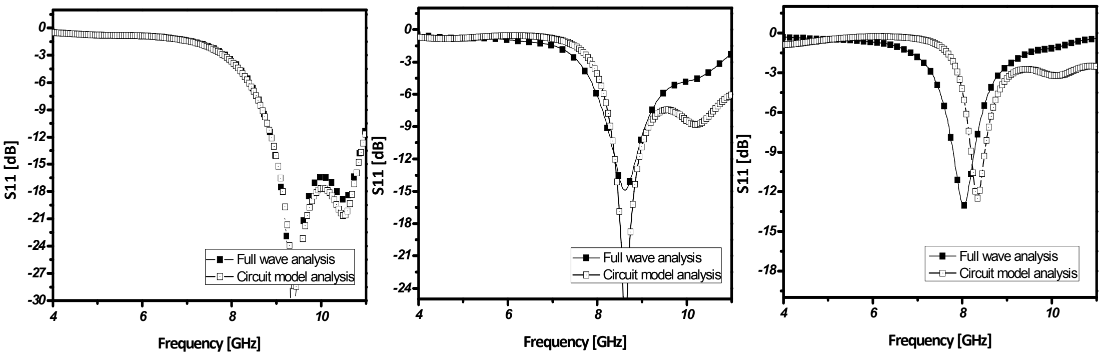


Fig.3. Equivalent circuit model of the frequency controlling stub line



(a) (b) (c)

Fig.4. Return loss comparison between full wave analysis and equivalent circuit analysis for various L_c ; (a) L_c = 2.225 mm, (b) L_c = 2.250 mm, (c) L_c = 2.2275 mm

Fabrication Process

The proposed reconfigurable antenna structure is fabricated on a 450 µm-thick semi-insulating GaAs substrate. First, a layer of negative, AZ 5214E-IR, photoresist (PR) is applied to the cleaned substrate that evenly covers the surface of a GaAs. Next a structure is patterned onto the PR layer by using a photolithographic technique. A 500/3000 Å-thick Ti/Au is evaporated with an electron-beam metal evaporation and finally, the sacrificial layer is removed and the device is released using a lift-off process. With the same procedure the partial ground and frequency controlling stub line are also fabricated.

Results

A proposed antenna was fabricated for two different L_c-values. In Figures 5 and 6, the measured vs. simulated return loss and radiation patterns in xy-plane were presented for lengths (a) L_c = 2.225 mm and (b) L_c = 2.250 mm, respectively.

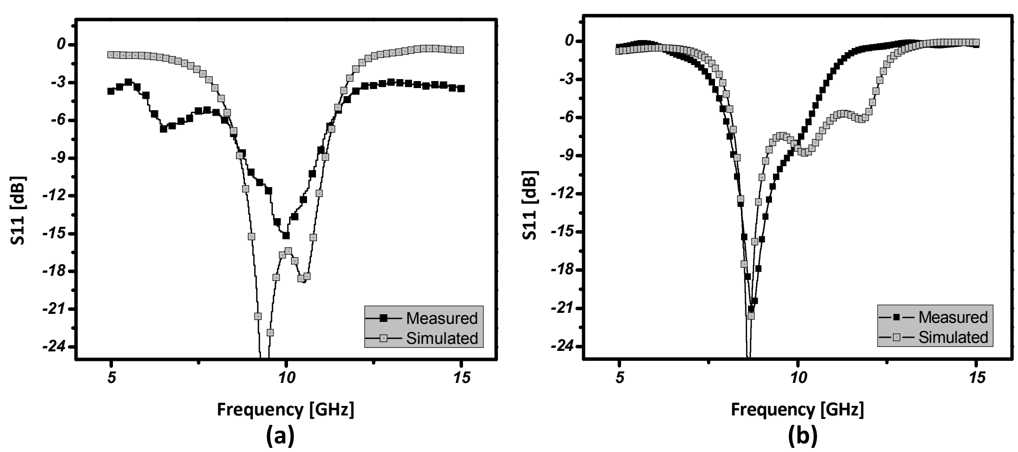


Fig.5. Simulated and measured return loss in dB; (a) L_c=2.225 mm, (b) L_c=2.250 mm

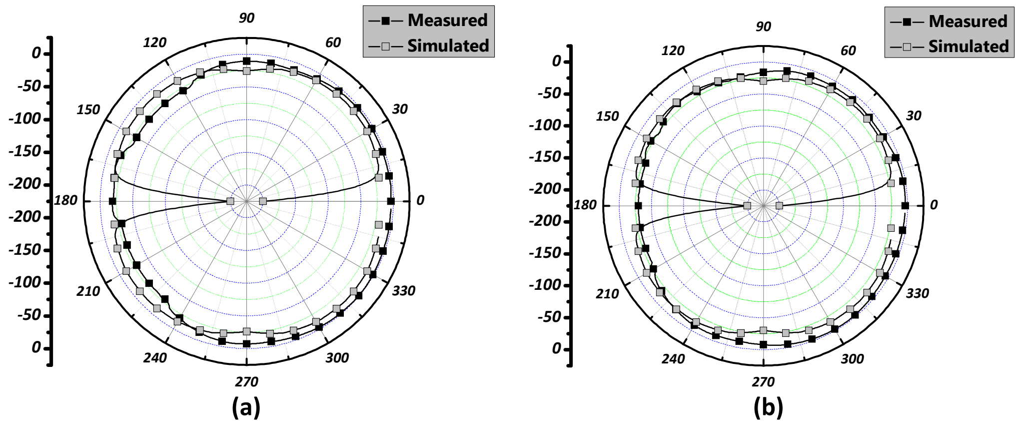


Fig.6. Simulated and measured radiation pattern in xy-plane; (a) L_c=2.225 mm at f = 10GHz, (b) L_c=2.250 mm at f = 8.65GHz

Conclusion

The performance of a frequency reconfigurable microstrip antenna with a partial ground has been investigated by varying the physical length of a microstrip stub line extended from the ground on the back of the antenna deposited on a SI-GaAs substrate. The analysis of the resonant frequency shift is examined by using a proposed equivalent circuit model. The model is also verified against measured data. One of the main advantages of using the proposed antenna is that the radiation pattern is kept the same, regardless of the resonant frequency variation.

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