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Full Length Research Paper

A metamaterial inspired miniaturized phi-shaped high gain antenna for skin cancer detection

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This paper introduces a new low cost, robust miniaturized micro strip high gain antenna inspired with metamaterial split ring resonator structure (SRR). Because of metamaterials property, there has been considerable reduction in size. The overall antenna structure is phi shaped which is equivalently two SRRs placed back to back. This miniaturized phi shaped antenna (MPSA) thus obtained, has been simulated on EM solver Ansoft HFSS and scattering matrix parameters are analyzed. Excellent performance in terms size, gain and radiation pattern is achieved. These types of antennas are very useful for applications where space of equipment is a constraint like microwave detection of skin cancer.

Key words: Metamaterial, split ring resonator, microwave, microstrip structures, miniaturized antennas.

INTRODUCTION

There has been extensive research regarding innovative structures and applications of metamaterials in microwave engineering since inception of its concept (Peng et al., 2009; Ali et al., 2008; Hao et al., 2009; Jun et al., 2010). These include split ring resonators (Sabah, 2010; Sharma et al., 2011), tunable microwave filters (Peng et al., 2009; Ali et al., 2008), phase shifters.

In this series of experimentation and research, some antennas inspired by metamaterials structures have been reported (Ziolkowski et al., 2009; Erentok et al., 2008; Sulaiman et al., 2010; Mahmood, 2004; Si et al., 2008). Most of these papers claim achievement either in terms of wider bandwidth or in terms of miniaturization (Palandoken et al., 2009; Ziolkowski et al., 2009). This paper reports an ever new small sized antenna structure inspired with metamaterial property. These types of small sized, high gain, directional antennas are very useful for applications where space is a constraint and a very small area is to be illuminated or in other words precise scanning is required like microwave detection of breast cancer or skin cancer (Fear et al., 2003). The antenna is physically phi shaped with two split rings (SRRs) back to back giving magnetic resonance and the metal strip interfacing the two leading to electrical resonance. Simulation of the antenna has been performed on Ansoft HFSS platform and the scattering parameters (s-parameters) obtained from this simulation are analyzed.

Furthermore, it is seen that the three dimensional radiation pattern of the antenna is highly directional, having large gain with more than fivefold reduction in size.

THE ANTENNA STRUCTURE

Structure of the miniaturized phi shaped antenna (MPSA) is shown in Figure 1. The RF signal ranging from 0.5 GHz to 7 GHz is fed at center of copper strip parallel to slots at other side of substrate through 50 ohm coaxial cables as shown in Figure 1. It should also be noted that instead of using conventional continuous ground plane, here it is composed of copper strips lying parallel in a plane. This helped in bringing resonant frequency of antenna to lower

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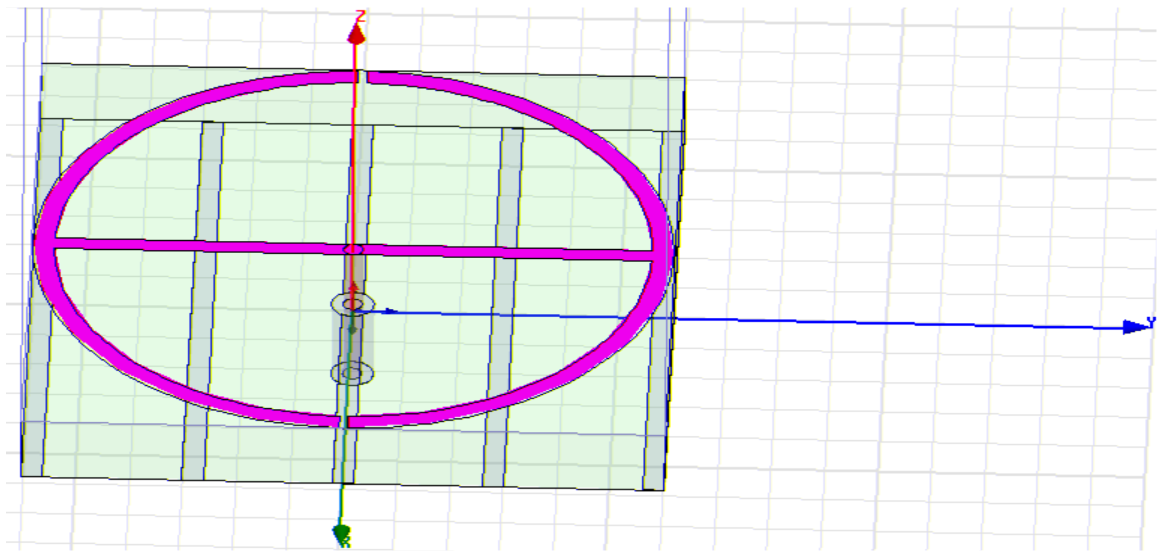

Figure 1. Structure of the phi shaped antenna.

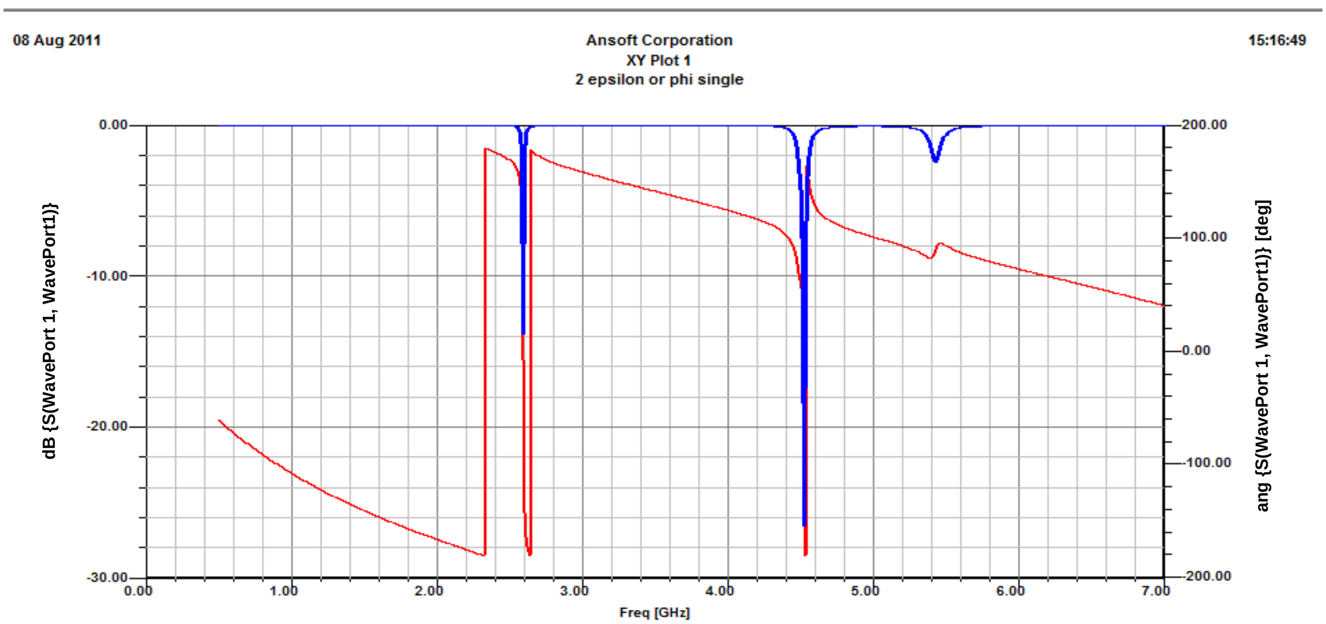

Figure 2a. Reflection coefficient S_{11} (Blue-magnitude and red-phase).

side. Physical parameters of the MPSA antenna are as follows:

Substrate Dielectric constant = 5.7(Mica); Substrate Thickness = 0.785 mm; Radius of Inner Circle = 2.8mm; Radius of Outer Circle= 3.0 mm; Width of Central Rectangular Strip is taken to be 0.18mm respectively. The structure is fed by coaxial cable (PEC). The MPSA was simulated in far field environment to analyze its behavior as a radiator.

RESULTS

Simulation of the antenna was performed on EM solver Ansoft HFSS. The simulation results are shown in Figure 2. In Figure 2a, it can be observed that reflection coefficient S_{11} is showing phase reversal (zero crossing) at two different frequencies hence indicating existence of metamaterial property. Out of these two resonant frequencies, at 4.52 GHz, the value of reflection coefficient is quite supportive, that is, -27 dB for antenna

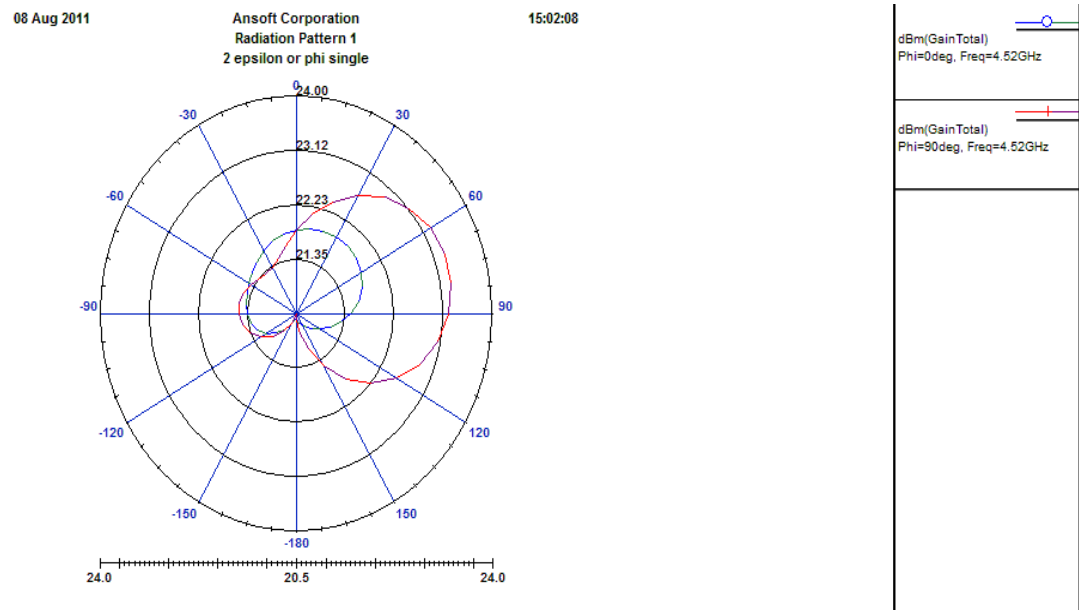

Figure 2b. Polar Gain curve of PSA.

Figure 2c. Three dimensional radiation pattern of PSA.

application.

The polar gain curve and 3-D radiation pattern have been plotted in Figure 2b and c respectively. It can be seen that the radiation pattern is highly directional because of metamaterial property and thus shows very high gain with peak value of 23.6 dBm. At the same time, more than fivefold reduction in size has been obtained as compared to half wavelength radiator.

CONCLUSION

This paper successfully demonstrates behavior of a miniaturized micro strip high gain antenna inspired with metamaterial split ring structures. Instead of conventional ground plane, parallel arranged copper strips were used which helped in reducing the size of antenna. More than fivefold reduction in size has been obtained as compared to standard requirement of half size of wavelength. Radiation pattern of the antenna is highly directional because of metamaterial property. This type of small sized, high gain and directional antenna is useful in microwave detection of breast cancer and skin cancer since it resonates in between 4 GHz - 6GHz, range used for this application. Small sized sharp beam antennas are very good candidates where precise scanning of a region is required like microwave cancer detection. Other applications can be sensors for ground penetration radar, satellite communication and other handheld portable wireless equipments.

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