A COMPACT MULTIBAND PARTIALLY REFLECTIVE SURFACE ANTENNA FOR XBAND AND WLAN APPLICATIONS

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Abstract - A multiband partially reflective surface (PRS) antenna specifically employed for X-band(radar communication) and WLAN applications is presented in this paper. RT-Duroid 4003 is used as a substrate with thickness of 20 mils and relative permitivity of 2.2 .The prototype consists of a microstrip patch as the source antenna, PEC ground plane and PRS surface which operated at 5.498GHz and 7.535GHz. Antenna exhibits omni-directional radiation patterns with reasonable gain on all operating frequency bands. Analysis and simulation of prototype was performed using Agilent Advanced Design System (ADS) .

Index terms: **GSM, Partially reflective surface, WLAN, radiation pattern, microstrip patch array, X-band**

I.INTRODUCTION

Wireless technologies require compact and low profile components for communication systems. The characteristic parameters of antenna mainly depend upon the size of radiating element which is approximately one-half of a free-space wavelength. This implies a trade-off between the size of antenna and operating frequency. Recently, Partially Reflective Surface (PRS) antennas have received significant attention due to their compact structure and ease of achieving high directivity. PRS antennas usually employ a microstrip antenna acting as the radiating source and a metallic or metallo-dielectric periodic array, located approximately half a wavelength above the radiator to enhance the directivity. Generally, the centre–fed PRS antenna provides a broadside beam.

This paper proposes initially a PRS antenna with 2x2 microstrip periodic array as the radiator which operates at 1.8GHz and 5.375GHz(5.042GHz-5.689GHz) suitable for GSM and WLAN(IEEE 802.11 a) applications. Then, the research is extended by increasing the number of radiating elements to enhance the operating frequency suitable for X-band applications.

The rest of the paper is organised as follows. The concept of PRS antenna is described in section II. Section III presents the overall design methodology of the proposed PRS antenna with varying number of reflectors. Discussions on various simulated results are provided in section IV. Finally some conclusions are drawn in section V.

II.CONCEPT OF PRS ANTENNA

The schematic model of a conventional PRS antenna is shown in Fig.1.It is composed of a source antenna (exciter) embedded between a ground plane and a dielectric superstrate employed as the PRS. The PRS is placed at a distance Lr above the ground plane with a reflection coefficient Γ=R.exp(jφ).The electromagnetic waves radiating from the source experience multiple reflections and transmissions within the cavity. According to the ray theory, a maximum directivity at the broadside is obtained when the condition below is satisfied

$$\varphi - \pi - \frac{4\pi Lr}{\lambda} = 2N\pi, \qquad N=0, \pm 1, \pm 2... \qquad (1)$$

where λ is the free space wavelength at the resonant frequency.

Hence, the antenna profile is determined by

$$Lr = \left(\frac{\varphi}{\pi} - 1\right)\frac{\lambda}{4} + N\frac{\lambda}{2}, \quad N=0, \pm 1, \pm 2... \quad (2)$$

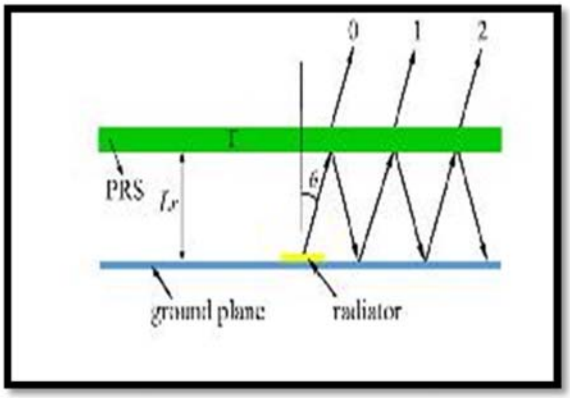

Fig.1. Schematic model of a conventional PRS antenna

Partially reflective surface (PRS) antennas have attracted a significant attention due to their compact structure and high diretivity.The directivity of the PRS antenna depends on the PRS reflectivity

$$D= \frac{1+R}{1-R} \text{Dsource}. \quad (3)$$

where Dsource is the directivity of the source antenna, and R is the PRS reflection coefficient magnitude. It is also known that a center-fed PRS antenna can radiate a broadside pattern.

III.PROPOSED DESIGN METHODOLOGY

The proposed PRS antenna is designed by initially beginning with a microstrip square patch acting as the source (exciter) with a length of 36.7mm using the below equation:

$$L = \frac{c}{2fr\sqrt{\varepsilon r}} \quad (4)$$

Where c is the speed of light(3x10^8 m/s), fr is the operating frequency and εr is the dielectic permitivity of the substrate (2.2). The patch antenna is etched on a 20mil-thick Rogers4003 substrate (εr=2.2) and simulated in Advanced Design System.The cavity length Lr =29mm which is approxmiately half a wavelength is created. Finally, the PRS surface employing radiators are designed using microstrip array elements etched on the same Rogers 4003 substrate.The number of the radiating elements is increased to enhance the operating frequency.

Initially, the PRS antenna was designed using (2x2) array i.e, 4 radiating elements. The length of each square patch is L=10mm and the periodicity between the two adjacent patches is 24mm as shown in Fig.2. The simulated results of this antenna provided high directivity and a broadside radiation pattern. The antenna is operated in multi-band such as 1.8GHz and 5.375GHz(5.042GHz-5.688GHz) suitable for GSM and WLAN applications as shown in Fig4. Having achieved this, the research was further extended by increasing the number of radiating elements to enhance the operating frequency.

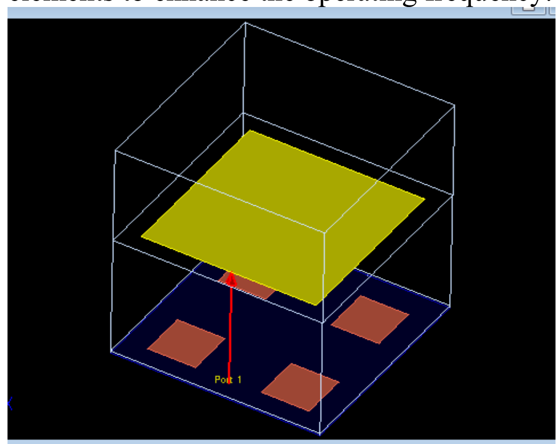

Fig.2. PRS antenna with 2x2 radiators

Further the PRS antenna theory was tried with 4x1 radiators but it was not efficient and did not provide good results.So, the design was tried with 6x6 array elements as shown in Fig.3. The above mentioned PRS antenna was designed with the same microstrip patch of length L=36.7mm as the exciter but the radiators with increased number of elements i.e., 18 elements.

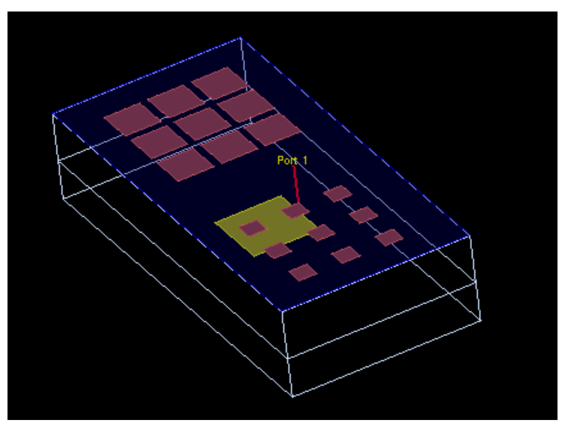

Fig.3. PRS antenna with 3x3 radiators

The PRS surface in the above Fig is divided into two parts. Part I consisting of 3x3 array, where each element consisting of microstrip patch of length L= 20mm and Part II consisting of 3x3 array,microstrip patch of length L=10mm. The cavity length and the periodicity between the patches are considered as same as the previous case. Simulated results of this antenna as shown in Fig.5 was efficient than the previous case. The modifications introduced two new bands at higher frequencies i.e, 5.498GHz and 7.535GHz, respectively.The directivity and radiation pattern was also improved

IV.SIMULATION RESULTS

The following simulation results were obtained in ADS with an array of four microstrip patch antennas as radiators for a source placed at a cavity length of Lr =29mm.

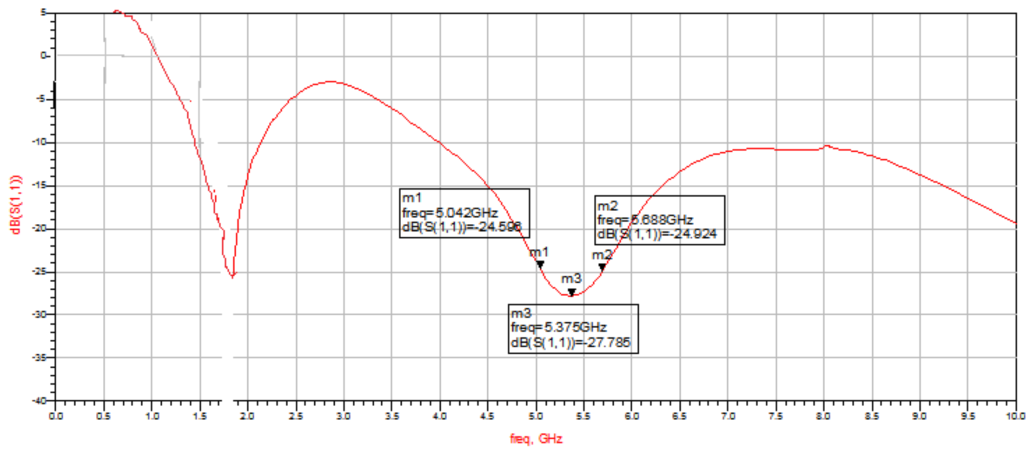

Fig.4. Simulated results of 2x2 PRS antenna

The above designed antenna operated at 1.8GHz and 5.375GHz (5.042GHz-5.688GHz) with a return loss of -25dB and -27dB, respectively. The operating frequency is improved by increasing the number of elements. The research was further extended to 4x1 array which did not provide good results.

Finally a PRS antenna was designed with an array of 18 (6x6) microstrip patches with two different dimensions L1=10mm and L2=20mm.The cavity length and the source antenna was considered from the previous case. This configuration achieved a significant rise in the operating frequency and operated at 5.498GHz (WLAN applications) and 7.535GHz (X-Band Radar communications), respectively. The center-fed PRS antenna also achieved a broadside radiation pattern as shown in Fig. 6. The return loss was found at -17dB and -45dB.The directivity achieved was 5.435dB with realized gains over 12dBi.

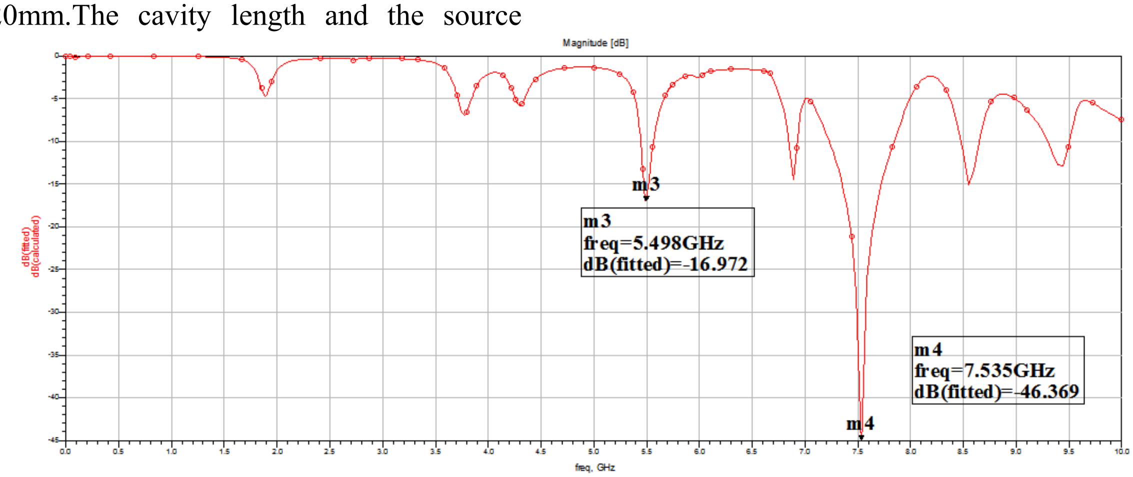

Fig.5 Simulated results of 6x6 PRS antenna

The radiation pattern of the proposed antenna is shown as follows

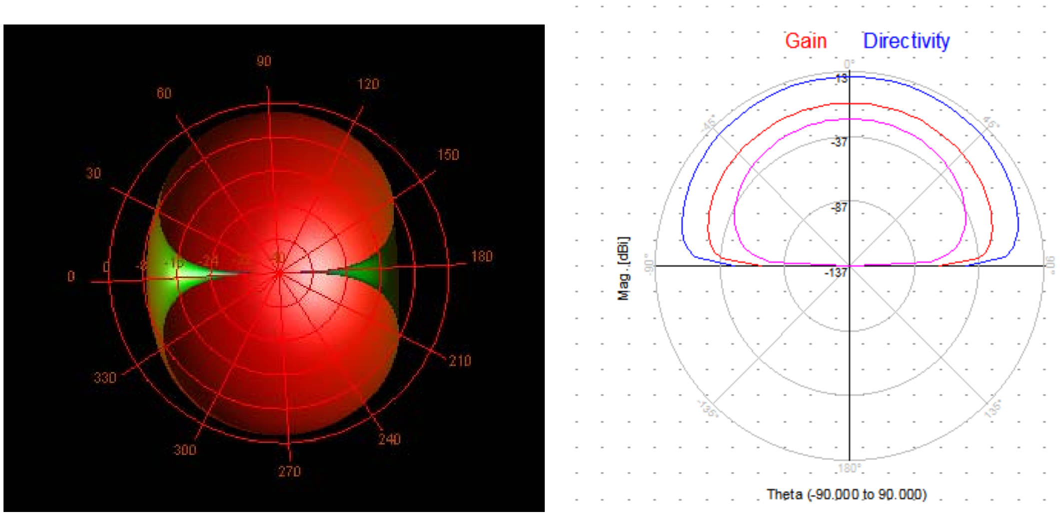

Fig.6. Radiation pattern of 6x6 PRS antenna

V.CONCLUSION

A compact multiband PRS antenna has been proposed in this paper. Compared to some of the PRS antennas that have been reported in the literature, the proposed antenna is simple in its structure with enhanced directivity in relatively wide frequency range.

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