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Simulation of Two-Concentric Ring Microstrip Patch Antenna

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ABSTRACT:
In this paper, we are analyse a two-concentric microstrip patch antenna for GPS application. In the literature survey, most of the literatures are available on different types of antennas, but few publications are available on microstrip patch antenna for GPS application. Microstrip patch antennas are very compact and low in cost. The concentric array has high directivity when compared to the linear array and this concept is applied to the microstrip patch. We are able to obtain low return loss. In view of that, we are designed a concentric circular microstrip patch antenna.

I. INTRODUCTION

There are various ways to model a microstrip patch. This modelling is used to predict characteristics of a microstrip patch such as resonant frequency, bandwidth, radiation pattern, etc. Each GPS satellite transmits signals on two frequencies: L1 (1575.42 MHz) and L2 (1227.60 MHz). The L1 frequency contains the civilian Coarse Acquisition (C/A) Code as well as the military Precise (P) Code. The L2 frequency contains only the P code. The P code is encrypted by the military using a technique known as anti-spoofing and is only available to authorized personnel.

A novel coupling technique for circularly polarized square ring patch antenna is developed and discussed in [1]. The circular polarization (CP) radiation of the square-ring patch antenna is achieved by a simple microstrip feed line through the coupling of a square patch on the same plane of the antenna. Proper positioning of the coupling square patch excites two orthogonal resonant modes with 90 phase difference, and a pure circular polarization is obtained. The dielectric material is a square block of ceramic with a permittivity of 58 and that reduces the size of the antenna.

The prototype has been designed, fabricated and found to have an impedance bandwidth of 1.1% and a 3-dB axial-ratio bandwidth of about 0.03% at GPS frequency of 1573 MHz. The characteristics of the proposed antenna have been studied by simulation software HFSS and experiments. The measured and simulated results are in good agreement. In article [2], the authors have endeavoured to design a gap-coupled concentric ARMSA on the basis of equivalent circuit model. The inner ring is a feed, and the outer ring is a parasitic element. The effect of mutual coupling is also taken into account along with variation of feed point and gap between the rings. The gap-coupled ARMSA can be used for dual band operation and especially in mobile communication. The main focus is on the effect of the gap length and feed point on the radiation pattern of the gap-coupled ARMSA.

A new defected ground structure (DGS) presented [3, 4] consisting of concentric circular rings in different configurations is experimentally studied to examine the stop-band characteristics. Unlike previous DGS designs, a metallic shielding is introduced at the back of the DGS to suppress any leakage or radiation, and this would be advantageous for microwave circuit applications. A wide stop band is demonstrated with a set of prototypes designed for X-band is presented. Its application to suppressing mutual coupling in microstrip patch arrays is demonstrated.The author [5] describes a novel compact solution for integrating a Global Positioning System (GPS) and a Satellite Digital Audio Radio Service (SDARS) antenna in a very small volume to satisfy the requirements of the automotive market. The GPS antennais a classic small commercial ceramic patch, and the SDARS antenna is designed in order to fit in the reduced space without affecting radiation and band performance of the GPS antenna.The SDARS basic geometry is a square-ring microstrip antenna operating in the frequency range 2.320–2.345 GHz with left-hand circular polarization (LHCP), and it is wrapped around the GPS patch, which receives a right-hand circular polarization (RHCP) signal at 1.575 GHz. The overall volume of the presented integrated antenna solution is only 30X30X7.6mm^3, rendering it attractive for the automotive market.

Several authors [6-11] has presented different models to obtain the optimum design. The analysis and design of two-concentric ring antenna has proposed dual-band for GPS applications. Here, we considered different dielectric materials to obtain dual-bands.

II. ANALYSIS OF TWO-CONCENTRIC RING MICROSTRIP ANTENNA:

There are various ways to model a microstrip patch. This modelling is used to predict characteristics of a microstrip patch such as resonant frequency, bandwidth, radiation pattern, etc. In this section the transmission line model and is presented. This model is based on some assumptions, which simplify the calculations at the cost of less accuracy.

Figure 1 shows the proposed antenna consists of two-concentric rings arranged in a single plane above a single substrate. In the concentric circular ring microstrip patch antenna, the structure having physical gap is shown. The inner ring is fed coaxially, while the outer ring is a parasitic element. Now, this can also be shown as a parallel gap-coupled radiator using planar waveguide mode for inner ring and outer ring as shown in figure. The characteristic impedance of the two gap-coupled concentric circular ring microstrip patch antenna radiator can be analyzed by applying the theory of coupled microstrip antenna.

The input impedance characteristics of the gap-coupled circular ring microstrip patch antenna can be analyzed. Figure which shows two-gap coupled annular ring antennas in which inner one is fed at point (x, 0) by a coaxial cable ($a1 < x < b1$), where $a1$and $b1$ are inner and outer radii of the inner ring and outer ring, respectively. The thickness of the substrate h is small as compared to the difference between the inner and outer radii of the inner ring

The reflection coefficient can be calculated as

$$\rho = \frac{Z_{in} - Z_0}{Z_{in} + Z_0} \tag{1}$$

Z_0 is impedance of the coaxial feed = 50 ohms
Z_{in} is input impedance of microstrip antenna

$$\text{VSWR} = \frac{1 + |\rho|}{1 - |\rho|} \tag{2}$$

The return loss of the antenna is

$$\text{RL} = -10 \log \left(\frac{1}{\rho^2} \right) \tag{3}$$

Radiation pattern of antenna can be calculated by

$$E_\theta = \left[\sum_{t=1}^{N} a_t E_{at} J_1^{'}(ka_t \sin\theta) - \sum_{t=1}^{N} b_t E_{bt} J_1^{'}(kb_t \sin\theta) \right] \cos\phi \tag{4}$$

Where, E_{at} and E_{bt} are the inner and outer peripheries of the t^{th} ring respectively, a_t, b_t, has two ring radius, k is wave number, $J_1^{'}$ is Bessel function.

From the above results it is evident that the above mentioned prototype isn't best suitable for our GPS system. As it is said in abstract, Antennas performance should be precise so that it is compatible with our required system. The main disadvantages of above proposed model is that it gives very high return loss. From the plot of return loss it is seen that there isn't sudden transition in plot which is required at resonant frequency of L1 and L2 band. Even Gain, Directivity, Radiation pattern are less for this model to be compatible.

In order overcome above mentioned problem, we came up with another model which the same concept of two-concentric circular microstrip patch antenna. Some of reasons for selecting this model is that it has less return loss (i.e. more number with negative sign), more gain with polar plot of directivity and gain being same, we now concentrate on the return loss. With different dielectric constants return losses are observed and these materials results are presented here: Ethylene Glycol, Methanol.

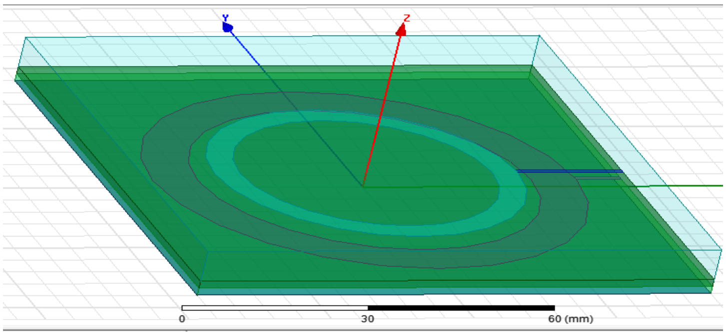

Figure 1. Proposed model of two-concentric ring microstrip antenna

Above figure shows the model of the second proposed antenna. Antenna consists of two-concentric rings arranged in a different plane (patch is sandwiched between two substrates).

III. RESULTS AND DISCUSSIONS

Figure 1 shows the proposed antenna. Using (3-4) return loss and gain has evaluated. It has the specifications of proposed two-concentric ring microstrip antenna are as follows:

Effective relative permittivity ε_{eff} is12.76, thickness of dielectric substrate-1 h_1=1.6mm, thickness of dielectric substrate-2 h_2=1.6mm, inner radius of inner ring a_1=22.1 mm, outer radius of inner ring b_1=26.1 mm, inner radius of outer ring a_2=29.1mm, outer radius of outer ring b_2=37.1mm.

Feed line for this type of antenna is transmission line which is applied for the outer ring. The most important point in this two-concentric circular ring is that inner ring radiates at L1 band (1.22GHz) and outer ring radiates at L2 band (1.57GHz). Using HFSS the simulations are carried out and the results are presented in figs. (2-4). The gain plot has shown in fig. 2. The return loss of Ethylene Glycol (ε_r=37), Methanol (ε_r=33) dielectric materials are found for Ethylene Glycol is - 12.48, Methanol is - 23.23, these arw shown in fig. (3-4). Methanol has dual-band frequency suitable for GPS application.

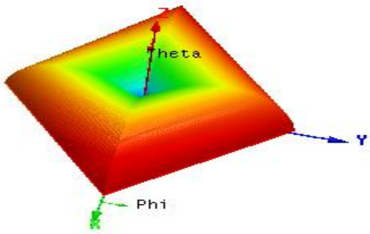

Figure 2. Polar plot-Gain of

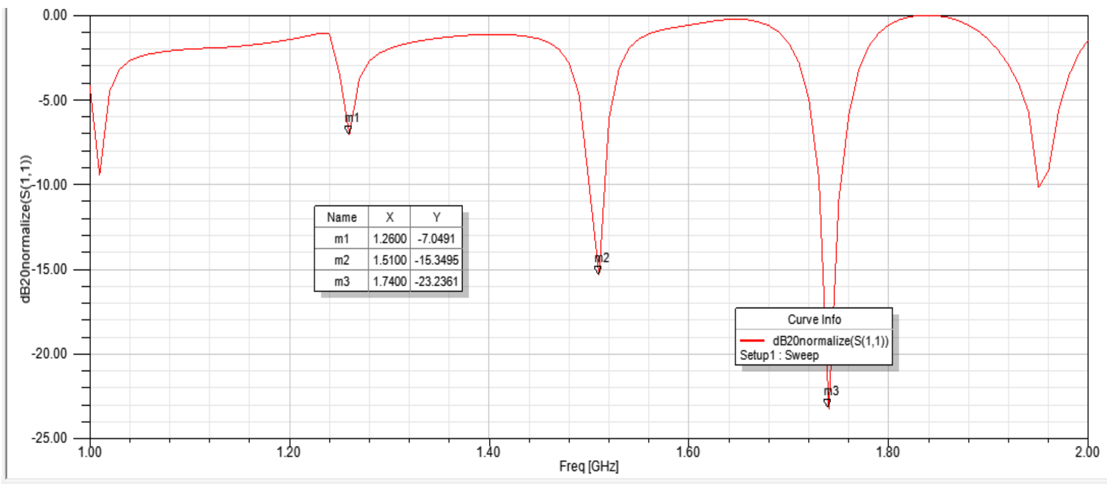

Figure 3. Methanol ε_r=33

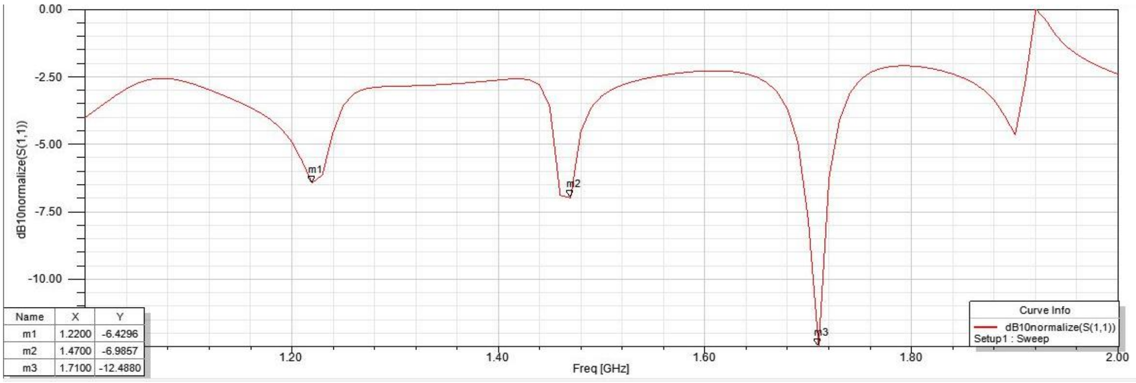

Figure 4. Ethylene Glycol ε_r=37

IV. CONCLUSIONS

Here, the materials used as substrates were changed and results were obtained. Upon thorough perusal with different materials, we came to a conclusion that Methanol and Ethylene glycol suited the best characteristic parameters. The overall working of antennas was studied. The major parameters that affect the design are studied and their implications were observed for return loss -23.23dB. The designed two-concentric circular ring microstrip antenna is operated at the desired frequency and power levels. Several patch antennas were simulated and the desired level of optimization was obtained. It was concluded that the software results we obtained matched the theoretically predicted results for Ethylene Glycol, Methanol materials.

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