INTERNATIONAL JOURNAL FOR ADVANCE RESEARCH IN ENGINEERING AND TECHNOLOGY

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DESIGN OF DOUBLE LAYERED CIRCULARLY POLARIZED SELF-DIPLEXING ANTENNA

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Abstract: *The paper proposes a double-layered circularly polarized self-diplexing antenna (SDA) using a square patch with a shorted hole, which is a new type antenna with improved diplexing characteristics. The equivalent relative permittivity can be adjusted by changing the size of hole. The E-plane radiation energy at 90 degree is largely reduced when the relative permittivity is unity. To utilize this characteristic, a double-layered SDA is proposed which consists of the lower layer of a square patch with a hole and the upper layer of a 0.5 λo air gap square patch and to achieve the very less VSWR and also it will act as a Multiple Resonant antenna.*

1. INTRODUCTION

Nowadays, due to their several key advantages over conventional wire and metallic antennas, Microstrip antennas have been used for many applications, such as Direct Broadcasting Satellite (DBS) Systems, mobile communications, Global Positioning System (GPS) and various radar systems. Their advantages include low profile, light weight, low cost, ease of fabrication and integration with RF devices, etc. They can also be made conformal to mounting structures. However, when they are applied in the frequency range below 2GHz, the sizes of conventional rectangular Microstrip patches seem to be too large, which makes it difficult for them to be installed on televisions, notebook computers or other hand-held terminals, etc. Several techniques have thus been proposed to reduce the sizes of conventional half-wavelength Microstrip patch antennas. In, using high dielectric constant material has been proposed. However, this will lead to high cost and high loss due to the use of high dielectric constant material. Also, poor efficiency due to surface wave excitation is another drawback of this method. Another technique for reducing the size of a Microstrip antenna is to terminate one of the radiating edges with a short circuit. The short circuit can be in the form of a metal clamper a series of shorting pins. In shorting pins were used in different arrangements to reduce the overall size of the printed antennas. It was shown that by changing the number of shorting pins and the relative positions of these pins, the resonant frequency of the short circuited Microstrip patch could be adjusted. Significant size reduction of Microstrip patch antenna have been achieved by using a single shorting pin located near the feed point. One problem with this method is the difficulty in fabrication, as shorting pins have to be accurately inserted into the substrate in specific positions. This difficulty becomes more obvious especially for antenna arrays. Recently, small folded patch antennas without a shorting wall/pin have been proposed. This kind of antenna also demonstrates the capability of size reduction. Other methods, which involve the modifications of patch shapes, have also been proposed. Small Microstrip patch antennas using square or rectangular slot loading have been proposed and studied. The ring antenna is a special case of slot-loaded Microstrip antennas and has been studied by several authors.

In a mobile satellite communications system, the finality of the isolation level between transmitting and receiving should be less than -170dB. To obtain a sufficient isolation level in a diplexer, a multistage filter is required. In this case, it is difficult to achieved both low insertion loss and miniaturizations. To cope with this problem, several types of self diplexing antennas **(SDAs)** have been proposed. In an isolation level of the order of -90dB was assigned. To obtain an isolation level of -90dB and restrict the insertion loss to -0.5dB, the filter must weigh almost 1.3 kg. The mass of the filter can be reduced to 600-700 gm by using an SDA that can obtain an isolation level of -50dB and requires a diplexer isolation level of -40dB. A simple and low-loss diplexer can be used when the isolation level of the SDA is low. However, the isolation levels were up only 48 dB in the antennas proposed .In this paper; we have proposed a single layered circularly polarized SDA using a square patch with a shorted hole. This can improve the diplexing characteristics. According to our knowledge, a square patch antenna with a hole for the lower layer of an SDA has not yet been studied. Therefore, the general characteristics of a square patch with an open and shorted hole are investigated in Section 2. Although a dielectric material is used in the square patch with a shorted hole considered in this paper, an antenna with 0.5 *lo* size can be made by controlling the equivalent relative permittivity. It has been noted that the isolation level could be improved by suppressing the radiation energy at ±90 degree.

Hence, we have proposed a new double-layered circularly polarized SDA that puts this theory into practice. The same circular polarizations for transmitting and receiving provides this SDA with a good polarization isolation level, in addition to isolation levels, by the frequency and by controlling the radiation pattern.

2. GENERAL CHARACTERISTICS OF SQUARE WITH HOLE

To investigate the characteristics of the square patch with a hole, we performed FDTD analysis, for both an open and shorted hole at 9 GHz. Fig. 1 illustrates a model of the square patch antenna with an open or a shorted square hole at the centre. The size of the square patch is 22.5mm, and the material of the substrate (with thickness = 2.55 mm) is used with relative permittivity εr = 2.6. The hole size *a* is varied from 0 to 12 mm. The feed point is placed at a position (a/2) +4mm from the centre. When a shorted hole is used, shorting pins are attached to the edge of hole at 0.1 λ_0, intervals.

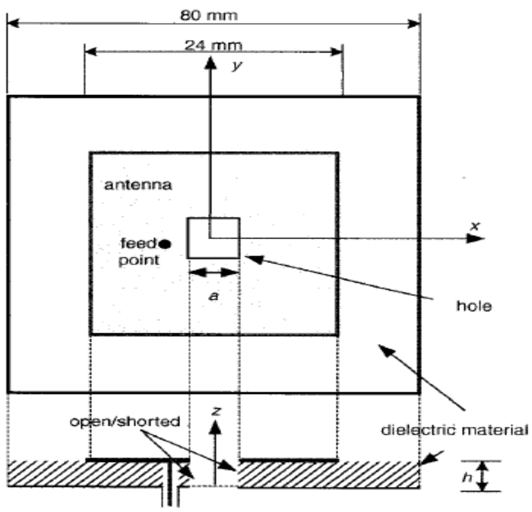

Fig. 1 *Structure of the square patch with a square hole*

3. RADIATION MECHANISM

Microstrip antennas are essentially suitably shaped discontinuities that are designed to radiate. The discontinuities represent abrupt changes in the microstrip line geometry. Discontinuities alter the electric and magnetic field distributions. These results in energy storage and sometimes radiation at the discontinuity. As long as the physical dimensions and relative dielectric constant of the line remains constant, virtually no radiation occurs. However the discontinuity introduced by the rapid change in line width at the junction between the feed line and patch radiates. The other end of the patch where the metallization abruptly ends also radiates. When the field on a microstrip line encounters an abrupt change in width at the input to the patch [4], electric fields spread out. It creates fringing fields at this edge, as indicated.

4. MICROSTRIP LINES

A micro strip line consists of a single ground plane and a thin strip conductor on a low loss dielectric substrate [9] above the ground plate. Due to the absence of the top ground plate and the dielectric substrate above the strip, the electric field lines remain partially in the air and partially in the lower dielectric substrate. This makes the mode of propagation not pure TEM but what is called quasi-TEM. Due to the open structure and any presence in discontinuity, the microstrip line radiates electromagnetic energy. The use of thin and high dielectric materials reduces the radiation loss of the open structure where the fields are mostly confined inside the dielectric.

5. QUASI TEM MODE OF PROPAGATION

The electromagnetic waves in free space propagate in the transverse electromagnetic mode (TEM). The electric and magnetic fields are mutually perpendicular and further in quadrate with the direction of i.e. along the transmission line Coaxial and parallel wire transmission line employ TEM mode of. In this mode the electromagnetic field lines are contained entirely within the dielectric between the lines. But the microstrip structure involves an abrupt dielectric interface between the substrate and the air above it. Any transmission line system which is filled with a uniform dielectric can support a single well defined mode of propagation at least over a specific range of frequencies (TEM for coaxial lines TE or TM for wave guides.) Transmission lines which do not have such a uniform dielectric filling cannot support a single mode of propagation. Microstrip falls [5], [6] in this category. Here the bulk of energy is transmitted along the microstrip with a field distribution which quite closely resembles TEM and is usually referred to as Quasi – TEM. The microstrip design consists of finding the values of width (w) and length (l) corresponding to the characteristic impendence (Z_o) defined at the design stage of the network. A substrate of permittivity(E_r) and thickness (h) is chosen. The effective microstrip permittivity (E_{eff}) is unique to a fixed dielectric transmission line system and provides a useful link between various wave lengths impedances and velocities. The microstrip in general, will have a finite strip thickness, 't' which influences the field distribution for moderate power applications. The thickness of the conducting strip is quite significant when considering conductor losses [8].For microstrip with $t/h \leq 0.005$, $2 \leq Er \leq 10$ and $w/h \geq 0.1$, the effects of the thickness are negligible. But at smaller values of w/h or greater values of t/h the significance increases.

6. SIMULATION RESULTS

After the calculation of above merits of the antenna is simulated using the SONNET software and the S11 parameter, Phase Angle, of the antenna is given below, plot within the frequency range of 8 GHz -12 GHz.

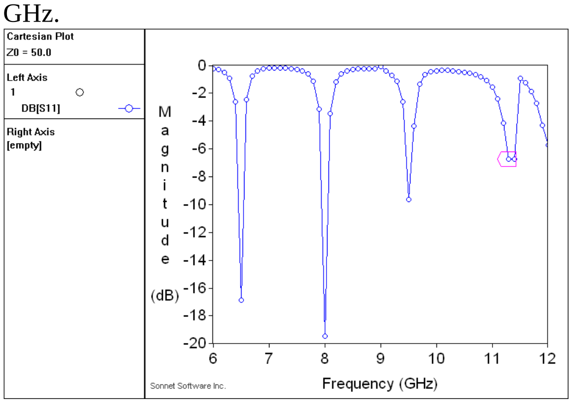

Fig: 2 Magnitude Response

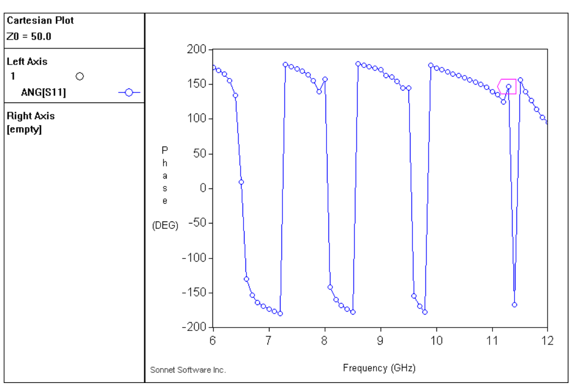

Fig: 3 Phase Angle

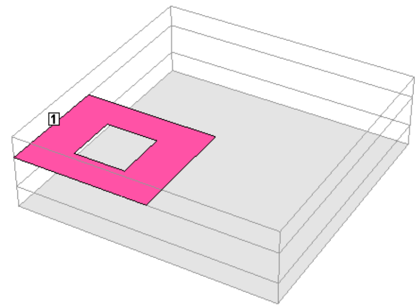

Fig: 5 3D View

7. CONCLUSION

We have proposed a new double-layered SDA using a rectangular patch with a shorted hole; have reported the characteristics of this square patch antenna and also it is designed to operate for multiple operating frequencies. By controlling the radiation pattern, isolation level - 54 dB can obtained and the VSWR is very less at the operating frequency .This antenna can be used to improve the isolation level and also it can be used many other application such as mobile, satellite communication.

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