[Sharma* *et al.*, 5(8): August, 2016] ISSN: 2277-9655
IC™ Value: 3.00 Impact Factor: 4.116

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

DESIGN AND ANALYSIS OF U-SLOT LOADED CIRCULAR MICROSTRIP PATCH ANTENNA FOR DUAL FREQUENCY WIDE BAND OPERATION

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DOI: 10.5281/zenodo.60117

ABSTRACT

The paper proposes an effective design methodology for Circular Microstrip Patch Antenna loaded with U-slot. The performance parameters of the antenna designed on FR-4 (lossy) substrate are obtained and compared with that of a normal circular patch antenna designed under similar conditions. We have reported that on the insertion of a U-slot, the antenna resonates at two different frequencies and also presents marked improvement in the bandwidth. The radiation efficiency, return loss and directivity are measured for simple circular patch antenna and the modified antenna (antenna with U-slot). On insertion of a U-slot in the patch geometry, the radiation efficiency become marginally poor and directivity shows a good agreement and is more or less unaffected with the frequency.

KEYWORDS: Circular Microstrip Patch Antenna, U-slot, CST, Radiation Efficiency, Directivity, Return loss, Dual frequency.

INTRODUCTION

In present scenario, Microstrip antennas are drawing much attention in broad range of wireless communication systems due to their light weight, simplicity in structure, easy reproduction, conformability, low manufacturing cost, and very versatile in terms of resonant frequency, polarization, pattern and impedance at the particular patch shape and model[1-2]. The approach of microstrip antenna enjoys all the advantages of printed circuit technology. The two most advantages of antenna are light weight construction and the suitability for integration with component mounted on surface. The factors affecting antenna performance are patch geometries, substrate properties, and feed techniques [3]. However, these antennas in their general form, are found to be less suitable for modern communication systems as they can efficiently resonate at a single frequency and moreover, exhibits poor gain and narrow bandwidth. Therefore, an intensive research work has been carried out in recent times to modify these structures, so as to improve their performance and to find their extensive application in modern communication systems [4-6].

For last two decades, researchers have developed several methods to improve the bandwidth of a patch antenna. This can be accomplished by increasing the substrate thickness and use of a low dielectric constant substrate. This can extend efficiency (up to 90%) and bandwidth (up to 35%) [7]. In the past decade, lots of studies have been conducted by researchers to analyze the resonant frequency, bandwidth, and radiation efficiency of circular microstrip patch antenna. **Lu(2003)** analyzed a circular patch antenna and its arrays with a pair of L-shaped slots for broadband dual frequency operation. **Wong and Hsu(1997)** incorporated a U-shaped slot in a equilateral triangular microstrip antenna to make it a broadband structure. The concept used in calculating resonant frequency are effective radius and dynamic dielectric constants and were developed by **Wolff and Knoppik(1974)**. **Guo(1999)** reported the performance of U-shaped circular patch antenna with L-probe feeding to improve its bandwidth and gain. **Luk et al.(1997)** reported the performance of a circular U-slot patch with di-electric superstrate.

From the careful analysis of the art, it can be observed that a detailed study on circular microstrip patch antenna with U-slot for dual frequency operation is lacking. Therefore, this paper seeks to address the research gap identified. In this communication, we have reported the performance of a centre-feed U-slot loaded circular microstrip patch antenna and its performance parameters are compared with that of a simple circular patch antenna designed under identical conditions. By introducing a U-shaped slot of proper size in the patch, it was observed that the antenna resonates at two different frequencies. The design and analysis of the proposed antenna is done by tool named CST (Computer Simulation Technology). CST was founded in 1992 by Thomas Weiland. This tool works mainly in the areas of radio frequency , microwave circuits, EMC/EMI, particle acceleration, and various low-frequency applications. Accordingly, its customers are industries such as aerospace, automation, automotive, electronics, power engineering, and medical. The return loss as a function of frequency, directivity, and radiation efficiency of the modified structure are simulated to present in this paper.

ANTENNA CONFIGURATION

In this paper, we are going to design a U-slot loaded circular microstrip patch antenna. The patch lie in the XY plane over a large ground plane with substrate thickness (h<<λo). Embedding a suitable U-shaped slot in circular shape radiating patch is a very effective method for achieving a wide bandwidth. Several U-slot patch antennas has been reported recently to improve bandwidth[8-10]. To enhance the bandwidth we can increase the substrate thickness. However the size of an antenna is an important consideration in the design of patch antenna. The design of circular microstrip antenna includes the specified information of the dielectric constant of the substrate(Є), the resonant frequency(fr) and height of the substrate(h) for dominant mode.

DESIGN EQUATIONS

Fig. 1 shows the design of circular microstrip patch antenna loaded with U-slot.

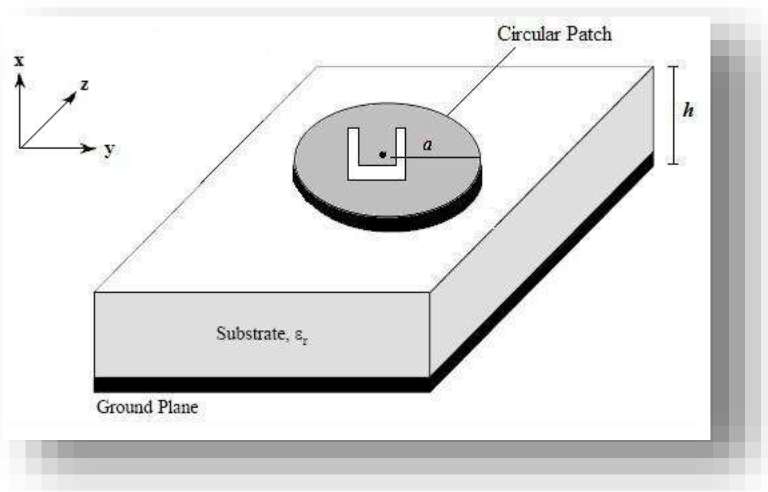

Figure1. Design of the circular microstrip patch Antenna

For designing a circular microstrip patch antenna, the calculations are done as below [11]:

$$a = \frac{F}{\sqrt{1 + \left(\frac{2h}{\pi \mathcal{E} F}\right)\left[\ln\left(\frac{\pi F}{2h}\right) + 1.7726\right]}}$$

$$F = \frac{8.791 \times 10^9}{f_r \sqrt{\in \mathcal{E}}}$$

ISSN: 2277-9655
Impact Factor: 4.116

Where,

- a=radius of the circular patch
- *h*=height of dielectric substrate
- ϵ_r=dielectric constant
- f_r=resonating frequency of antenna

Geometry and center feed arrangement of a circular patch antenna with the U-shaped slot using CST software are shown in fig.2. The circular patch antenna with a=20mm is designed on FR-4(lossy) substrate having thickness h=1.6mm, ϵ_r = 4.3 and loss tangent δ=0.025. A U-shaped slot with dimensions L1, W1, L2, W2 (L1=9mm, W1=8mm, L2, and W2 are varied) is introduced in a circular patch antenna.

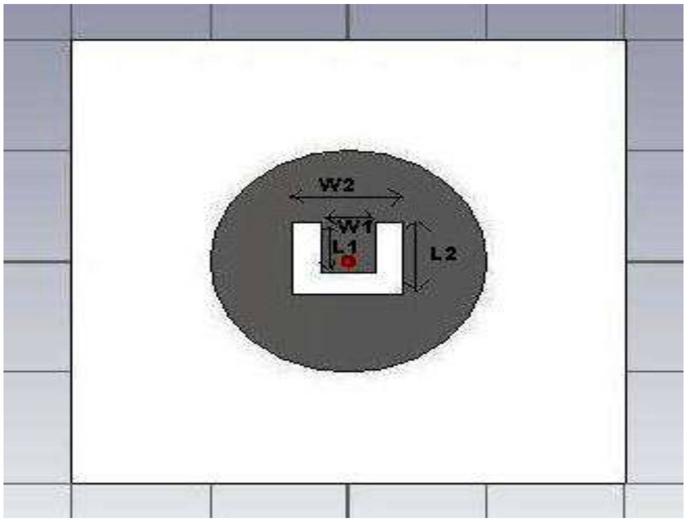

Figure 2. The Designed Antenna Geometry.

Here, In this paper, we have kept the values of the height of the substrate and dielectric constant as constant. On application of U-shaped slot in the circular patch geometry, the antenna now resonates at two different frequencies (3.35GHz and 3.94GHz). The variation of return loss as a function of resonant frequency for the circular antenna without U-slot and with U-slot are shown by figure 3 and figure 4 respectively.

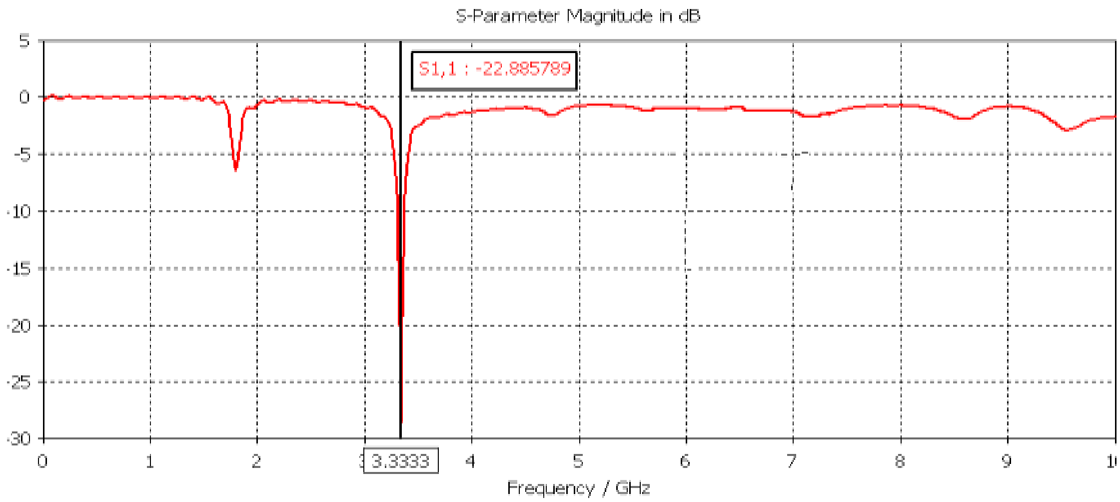

Figure 3. Return loss in db vs Resonating frequency for circular patch antenna without U-slot

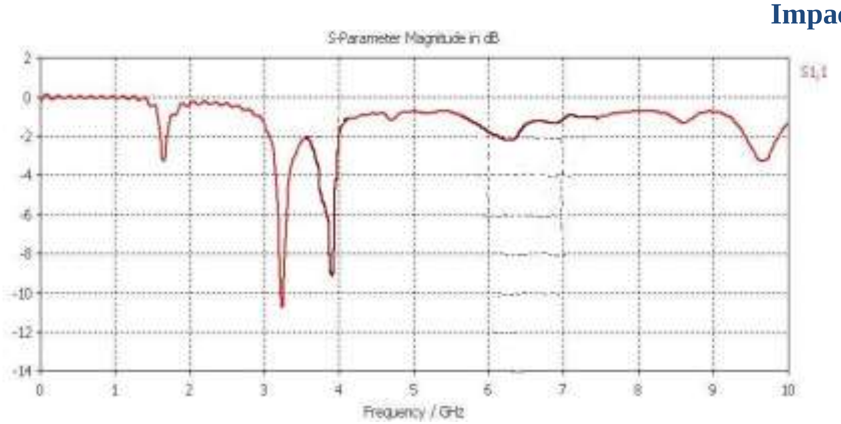

Figure 4. Return loss in db vs Resonating frequency for circular patch antenna with U-slot

RESULTS AND DISCUSSION

The simulation results shows the return loss that can be measured from frequency plot which was plotted against frequency versus S_{11} parameter. Then we can measure the return loss and bandwidth for particular frequency. Table 1 shows the comparison of the performance parameters of the antenna without U-slot and with U-slot.

Parameter of the circular microstrip patch antenna	**Without U-slot**	**With U-slot**
Directivity(dbi)	8.748	9.972
Radiation Efficiency(dB)	-3.708	-3.341

From the table, it is observed that the radiation efficiency become significantly low on introduction of U-slot which were expected due to application of dielectric substrate with higher loss tangent. The directivity of the antenna become significantly large and it is more or less unaffected with the frequency.

CONCLUSION

In this article, U-slot loaded circular microstrip patch antenna is successfully designed and simulated for dual frequency wideband operation. The performance parameters of the modified structure are compared with that of a simple circular microstrip patch antenna excited under similar conditions. The modified antenna resonates at two different frequencies with improve bandwidth. On insertion of a U-slot in the patch geometry,the radiation efficiency become marginally poor and directivity shows a good agreement.

ACKNOWLEDGEMENT

Authors are thankful to MITS, Gwalior for permitting them to use experimental facilities available there.

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