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DESIGN AND ANALYSIS OF LOW RETURN LOSS WIDE BAND CIRCULAR MICRO-STRIP ANTENNA AT 5.8 GHZ

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Abstract -The growth of wireless and mobile communication has necessitated the development of efficient antennas with low return loss and wider bandwidth. Under this scenario, paper focuses on an efficient design of circular micro strip antenna at 5.8GHz and analyze the effects of slot in Circular microstrip antenna (CMSA). In the design circular patch is mounted on FR4. A circular slot and square slot is etched on the circular patch to glass epoxy substrate provide wide-band operation and individually effects of slots are analyzed. Antenna designs are simulated and analyzed by finite element method (FEM) based structural simulator (HFSS™ simulator software).The antenna is designed to operate in C band with low returnloss, high bandwidth and desirable voltage standing wave ratio (VSWR). Results of the proposed antenna structure shows that a square slot cut on circular patch will provide better bandwidth than a circular slotted CMSA.

Keywords – Microstrip patch antenna, VSWR, FEM, HFSSsimulator

I. Introduction

Antennas have come a long way since its inception. Antennas have become a major part of every electrical system. It can be used as the connecting bridge between the transmitter and free space and vice versa. Antennas are designed to be very simple with reduced size, lightweight, cheap and are used for low profile applications. Moreover, it should operate over the entire frequency band of a given system with higher bandwidth and minimum losses. There are different variants of antennas are available, but a single antenna may not possess all the desirable features. One type of antenna which possesses most of the desirable features for a mobile embedded application is a micro strip patch antenna. Microstrip patch antennas are light weight, low profile, low production cost, reliability, and ease of fabrication and integration with wireless technology equipment making them attractive for applications such as high performance aircraft, spacecraft, satellite, missile and embedded applications [1]. However, they possess low radiation efficiency, low power, high Q and very narrow frequency bandwidth [2].

Microstrip patch antennas are named based on the shape of the radiating patch. There are many available shapes of radiating patch such as square, rectangular, circular, elliptical, triangular, circular ring, and ring sector. Most common types of micro strip patch antennas are Square, rectangular and circular micro strip patch antennas. These features make them more common [2]. Circular microstrip patch antenna is more simple compared other patch antennas since it has only one degree of freedom to control (radius) as compared to rectangular microstrip which has two (length and width). Therefore, circular microstrip patch antenna is simpler to design and its radiation can be easily controlled [3].In addition, the physical size of the circular patch antenna is 16% less than that of the rectangular microstrip antenna at the same design frequency [4].

Micro strip patch antenna has got a radiating patch on one side of the dielectric substrate and it has a ground plane on the other side of the .The thickness of the metallic patch should be, $t<<\lambda_0$ (where $\lambda_0$is free space wavelength). Theheight of the substrate, $h<< \lambda_0$ (usually $0.003\ \lambda_0 \leq h \leq 0.05\ \lambda_0$) [2]. There are different substrates available which canbe used with dielectric constants which ranges from 2.2 to 12[2]. Thicker substrates with low dielectric constants willresult in better antenna performance in terms of efficiency, wider bandwidth and better antenna performance. But they result in larger antenna size. On the other hand, thin substrates with high dielectric constants are best suitable for microwave applications because their fields are tightly bound resulting in minimal undesired radiation and coupling [6]. It is rather very advantageous with its reduced size but the losses will be higher making them less efficient and also they result in narrow bandwidths [7].

There are several methods to feed a microstrip patch antennas. The frequently used ones are microstrip line, coaxial probe and aperture coupling [2]. The methods can be differentiated into contacting and non-contacting methods. In contacting method, RF power is directly fed to the radiating patch by use of a microstrip line. For the non-contacting case electromagnetic field coupling is used to transfer power between microstrip line and radiating patch. In the proposed circular patch antenna design, a microstrip line feed is used. Microstrip line feed is a contacting method and consists of a conducting strip of a very small width compared to that of the patch (width should be less than that of patch thickness). It is easy to fabricate, simple to match and simple to design. Since the impedance of antenna is designed at 50Ω. In-order to match the

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impedance, position of feed line in the patch should be adjusted. Inside the patch geometry different slots can be etched thereby increasing the performance of the antenna. Here a modified circular microstrip patch antenna with circular slot is designed and all its antenna parameters were analyzed using HFSS^{TM} simulator software.

II.Circular Microstrip Antenna

In this proposed design, a circular micro strip antenna (CMSA) resonating at 5.8GHz was designed. Narrow bandwidth is the major disadvantage of a CMSA. So the design focused on improving the bandwidth and achieving low return loss with maximum efficiency by having a tradeoff between bandwidth and return loss. A circular micro strip antenna with circular patch of radius 'a' was designed and is shown in Fig.1. Circular patch is mounted on glass epoxy FR-4 squaresubstrate (ε_r=4.4) with dimension 30*30mm and thickness h=1.575mm. The thickness of the substrate is taken such that it should be within in the limit of $0.003\lambda_0 \leq h \leq 0.05\ \lambda_0$.The designed circular microstrip antenna is fed by microstrip line feed [8]. The width of the line feed should be less than the thickness of the patch.

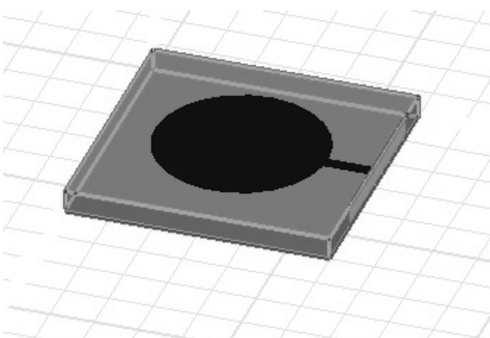

Figure. 1: Circular Microstrip Antenna without Slot

A. Antenna Design

Circular microstrip patch antenna is more simple compared to rectangular microstrip patch antenna since it has only one parameter to control i.e. radius as compared to rectangular microstrip which has two i.e. length and width. When compared to rectangular micro strip antenna, size is very less for CMSA for the same frequency which is a very much desirable frequency of mobile embedded applications. The modified circular microstrip patch antenna was designed using FR-4 glass epoxy substrate with a dielectric constant of 4.4. Choosing this substrate provides better antenna performance and also it has less loss tangent. In this design, the height of the substrate was taken to be 1.575mm. Based on the design equations of circular microstrip patch antennas, radius obtained was 8.6mm.

Circular Patch Radius $$a = \frac{F}{\{1+\frac{2h}{\pi F\varepsilon_r}\left[\ln\left(\frac{\pi F}{2h}\right)+1.7726\right]\}^{\frac{1}{2}}}$$

Where,

$$F = \frac{8.791\times 10^9}{f_r\sqrt{\varepsilon_r}}$$

ε_r-Dielectric constant of substrate

h- Height of substrate

a- Radius of the patch

f_r- Resonant frequency

Table I: Antenna Design Parameters

Parameter	Values
Frequency band	ISM band
Operating Frequency	5.8GHz
Radius of Circular Patch	9.7 mm
Substrate dielectric material	FR-4 glass epoxy
Substrate dielectric constant	ε_r = 4.4
Substrate thickness	1.575mm
Feeding technique	Line feed
Ground Plane	30mm*30mm

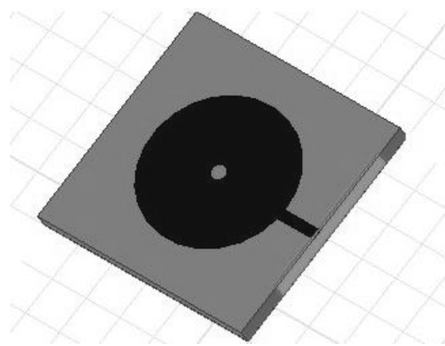

Figure. 2: Circular microstrip antenna with circular slot

Circular Microstrip Antenna With Circular Slot And Square Slot

The circular patch geometry has been modified by inserting a circular slot as shown in fig 2. By inserting the slot, the current path on the patch increases resulting in better antenna efficiency. By varying the size of the slot the effective radius of the patch decreases thereby increasing the resonant frequency of antenna. In the proposed antenna design after inserting the circular slot higher bandwidth of about 400 MHz and low return loss of

-33.8 dB was obtained thereby reducing the narrow bandwidth problem.Higher bandwidth makes them suitable for embedded application. Radiation pattern was found to be omnidirectional. For these application, we require an omnidirectional radiation pattern [9].

III.Circular Microstrip Antenna With Square Slot

Figure 2 shows a CMSA with circular slot. Now we are replacing this circular slot with a square slot. After cutting the square slot there was 20% improvement in bandwidth and return loss remained nearly same. CMSA with square slot is shown in figure 3.

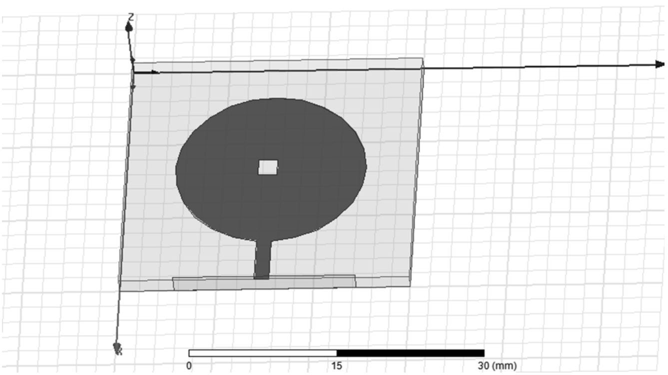

Figure 3: CMSA with square slot

IV. Simulation Results And Discussion

The proposed circular microstrip patch antenna with circular slot and square slot is designed according to the dimensions detailed in Table1.The simulation is done in finite element method (FEM) based structural simulator (HFSS simulator software). The S parameters of the proposed antenna with circular and square slots are given in Fig.4 and Fig.5 respectively. The return loss is in the order of -33.8dB with a bandwidth of about 400 MHz in the case of CMSA with circular slot and return loss of -25.8dB with a bandwidth of about 440MHz in case of CMSA with square slot. The bandwidth is obtained with the above dimensions of patch and the substrate. The obtained bandwidth shows that the designed CMSA has high data rate applicability for embedded applications [10]. Fig.6 and fig 7 shows the VSWR plot of the designed antenna with circular and square respectively. Ideal VSWR is said to be at one and the VSWR of the proposed model is found to be almost 1.102 at 5.8 GHz for square and 1.12 for circular and adirectivity of 9.41 dB for square slot and 9.025 for circular slot along the elevation plane. The gain of the proposed circular patch antenna is also simulated using HFSS and it is found to be around 9.56 dB for the far field pattern for square slot and 9.51 dB for circular slot is shown in figure 8 and 9 . Fig.10 shows the directivity plot of circular slot and Fig.11 shows directivity plot of the square slot. Radiation Patterns are shown in figure 12 and 13 for circular and square slot respectively. Radiation pattern is found to be in omnidirectional which are very much desired for mobile embedded applications.

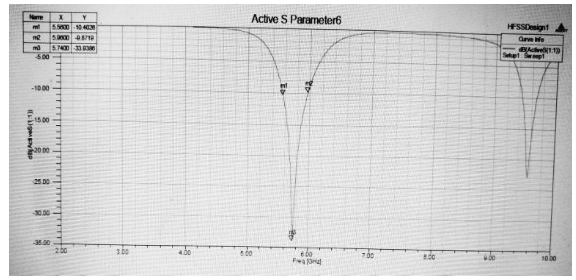

Figure 4: Return loss of CMSA with circular slot

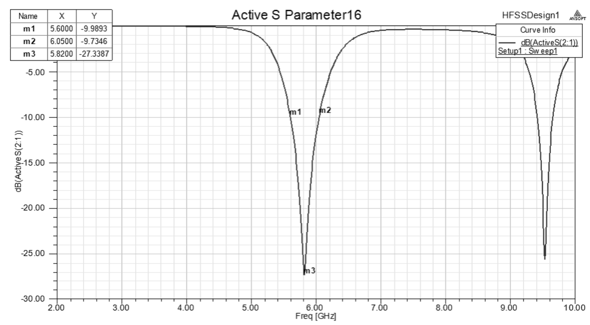

Figure 5: Return loss of CMSA with square slot

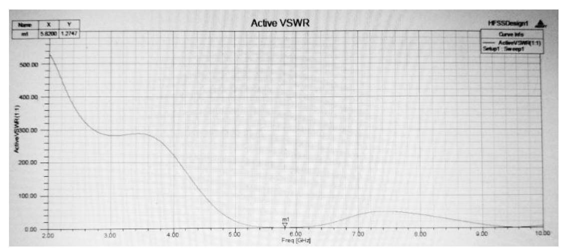

Figure 6: VSWR plot of Circular slot

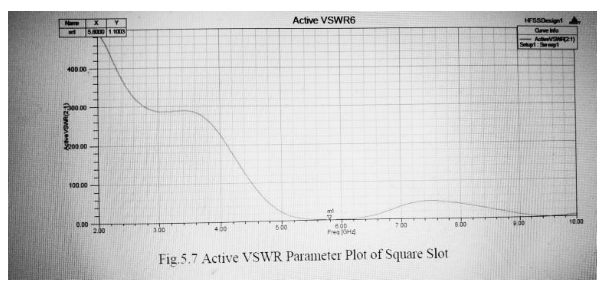

Figure 7: VSWR plot of square slot

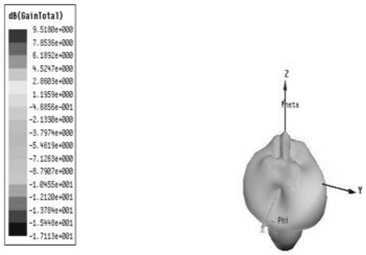

Figure 8: Gain Plot of Circular slot

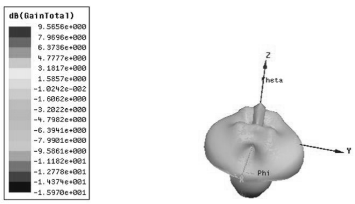

Figure 9:Gain Plot of Square slot

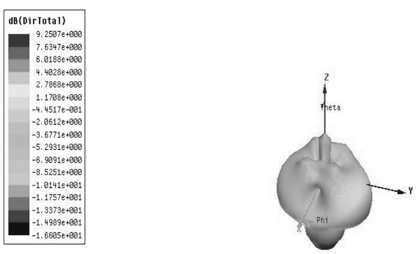

Figure 10: Directivity plot of Circular Slot

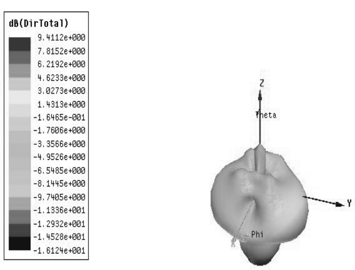

Figure 11: Directivity plot of Square Slot

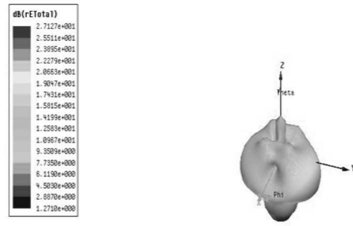

Figure12: Radiation Pattern of Circular slot

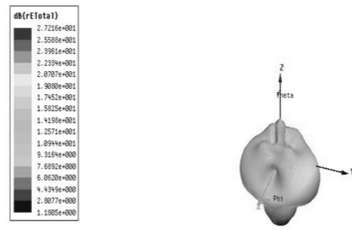

Figure13: Radiation Pattern of Square slot

Comparison Results Of Square And Circular Slot

Perormance comparison of effects of slots in CMSA is depicted in the table 2 shown below . Square slotted CMSA is having 20% more bandwidth than a Circular slotted CMSA , But in case of Return loss Circular slotted CMSA is more versatile.

Parameters	Circular slotted CMSA	Square slotted CMSA
Bandwidth	400MHz	440MHz
Gain	9.5100dB	9.5656dB
Directivity	9.2507dB	9.411dB
Return loss	-33.3081dB	-25.3387dB
VSWR	1.2747	1.1003

Table 2: Performance Comparison

V. Conclusion

In this paper we have proposed a Circular microstrip antenna with circular slot and square in order to resolve the existing problem of narrow bandwidth. Both circular and square slotted CMSA was designed and analyzed. Square slotted CMSA is having wider bandwidth with more return loss and Circular slotted CMSA is having less return loss with less bandwidth when compared with the former one. The parametric study showed that widebandcharacteristics can be achieved for a smaller antenna only with the appropriate choice of parameters. The proposed antenna was designed at 5.8GHz with wider bandwidth and lower return loss. Hence this antenna can be used widely for high data rate embedded applications. The physical implementation of this antenna can be integrated with embedded devices permit it to operate in wider range of applications.

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