A Review on Circular Microstrip Patch Antenna with Slots for C Band Applications

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Abstract — Over the past one decade, there is a rapid growth in development of various applications involving wireless communication. The performance of all such wireless systems depends on the design and proper functioning of the antenna. Microstrip antenna are preferred for majority of their applications This is because of the inherent advantages such as size miniaturization, power consumption, simplicity, compatibility with printed-circuit technology, low profile, light weight, lower return loss, good radiation properties , small size, planar structure and ease of fabrication. C band are used in satellite communication, WiMAX, WLAN, Wi-Fi applications. This paper provides a comprehensive review of the research work done in the recent past by various authors on the design and optimization of the circular microstrip patch antenna with different slots operating in C band.

Keywords — Microstrip Patch Antenna, C Band, Slot.

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1. INTRODUCTION

The microstrip antennas have special characteristics such as low profile, small size, low weight, low cost, printed directly on circuit board and easy to analysis and fabricate . Due to these characteristics, it has been widely used for specific applications in satellite communications, mobile communication for GSM, mobile radio and remote sensing [1]. The microstrip antennas are also known as patch antennas or printed antennas. The microstrip antennas are mostly a broadside radiator. The patch is designed in such a way so that its pattern is maximum normal to it. End-fire radiator can also be chosen by proper mode selection. The microstrip patch antennas is one of the most useful antennas working at microwave frequencies (f > 1 GHz). It consists of a metallic "patch" on top of the dielectric substrate and below the dielectric material it has ground plane. The position of the feed has to be changed as before to control the input impedance. The patch, microstrip transmission line (or input, output pin of coaxial probe), and ground plane are made of high conductive material (typically copper). The patch may be in a variety of shapes, but rectangular and circular are the most common because ease of analysis and fabrication, attractive radiation characteristics, especially low cross polarization. These antennas, in general resonant efficiently at a single resonance frequency corresponding to their dominant mode and typically narrow bandwidth (1-2%) and low gain [2]. Therefore, in their conventional form, microstrip antennas fail to find many applications in modern satellite mounted antennas operating in C band of frequency spectrum must be conformal and compact in size, capable of operating at two or more frequency at a time and must present broadband performance. Considering these requirements conventional printed circuit antennas fail to serve their purpose in satellite communication systems. Extensive work in recent past has been reported through modification in conventional microstrip antennas geometrics by introducing slot in the patch.

2. LITERATURE SURVEY

Various papers on design of circular microstrip patch antenna with slots are analyzed. Summarized details of the research papers are furnished below including the description of necessary parameters.

A circular microstrip patch antenna having concentric diamond shape slot is analysed. The side lengths and angles of inserted diamond shape slot have been optimized to achieve a single layer multi frequency microstrip patch antenna applicable for C band space communication system. Bandwidth and gain are improved compared to conventional circular microstrip patch antenna, also fulfils all requirements for antennas used in satellite communication system. [4].

A circular microstrip patch antenna with L-slit is introduced at the right edge of the patch to reduce the resonant frequency. Introduction of L-slit reduces the size of antenna and increase the bandwidth compared to conventional circular microstrip patch antenna. Moreover, size reduction is used to enhance the return loss and bandwidth. Thus by introducing various slot shape in a patch antenna performance parameters can be enhanced and also reduces the size of antenna [3].

A circular patch antenna with a fractals is analysed .The designed antenna has been feed with L probe feeding technique. A circular patch antenna with a fractals produces a dual band application for C-Band application. Different performance parameters like return loss, bandwidth etc are enhanced and such kind of antennas are useful in Wi-Fi, Radar, military applications [5].

The design and development of a dual linearly polarized aperture coupled circular microstrip patch antenna at C-band is analysed. The antenna uses a novel configuration of symmetric and asymmetric coupling slots. Variations in isolation between orthogonal feed lines and antenna axial ratio with the position of coupling slots are studied and broadband isolation and axial ratio are achieved. The result shows that performance parameters of the antenna are enhanced [6].

A slotted circular patch antenna is analysed for dual band applications. Circular patches were reported to lose less energy by radiation and thus provide larger quality factors than other configurations e.g. rectangular patches. The directivity of circular or disk patch antenna is more when compared with rectangular patch antenna. To achieve higher gain and bandwidth structures are modified by introducing slots for different applications. By introducing cross slot at centre of circular patch a dual band is achieved. Also various performance parameters are enhanced [7].

3. ANTENNA CONFIGUARATION

3.1 Circular patch antenna with L slit

The configuration of the antenna is shown in Figure 1. The Circular patch antenna has a radius of 5mm. The dielectric material selected for this design with ε_r=2.4 and substrate height =1.6 mm. L-slit is created whose dimensions and the location of coaxial probe-feed (radius=0.2 mm) are shown in the fig 1. For the proposed antenna two resonant frequencies are obtained at 5.769GHz and 9.74Ghz.Different dimension of the slit are analysed. But the optimal parameters of the slit are listed below [3].

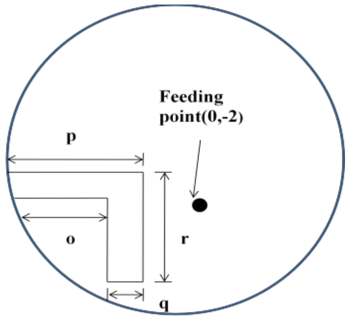


Fig. 1 Antenna with L-slit [3]

The dimension of the L-slit is listed in Table 1.

Parameters	O	P	q	r
Values	2.74	5.64	1.4	4.1

Table 1 L-Slit Dimension [3]

Simulated results concludes that the proposed antenna resonant frequency are 5.769GHz and 9.74GHz and their corresponding return losses are -15.35dB and -25.47dB respectively. Also the bandwidth improves [3].

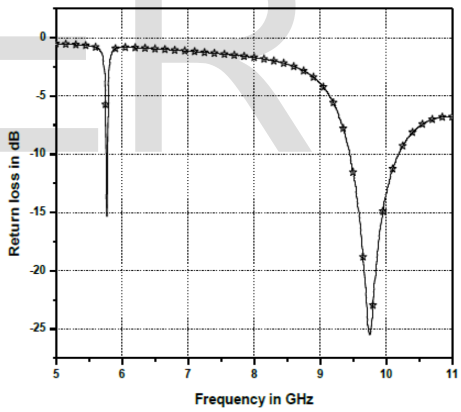


Fig 2 Return Loss v/s Frequency [3]

3.1.1 Simulated Results and Discussion

Below is the comparison of antenna without slot and antenna with L-slit.

Antenna without slot	Antenna with L-slit
Works with a single frequency	Works with a dual frequency
At 10.36GHz frequency, Return Loss is -14.51dB	At 5.769GHz frequency, Return loss is -15.35dB and At 9.74GHz frequency, Return loss is -25.47dB

Table 2 Comparison [3]

3.2 Circular patch antenna with diamond slot

The configuration of antenna is shown in figure 2.The circular patch antenna has a radius of 16.2mm.The dielectric selected for the design is epoxy FR-4 (ε_r=2.4) and substrate height is 0.159cm.Diamond slot is created with different dimensions. Performance of the proposed antenna gets affected by the side lengths and angles of the inserted diamond slot. Below is the table of different dimension of the diamond slot [4].

a(mm)	b(mm)
4	8
5	9
6	10
7	11

Table 3 Diamond Slot Dimension [4]

Increasing the size of inserted slot, effective radius of circular patch decreases which in turn increases the resonance frequency of antenna. With a=4mm and b=8mm input bandwidth approaches to 17.28%.With a=7mm and b=11mm input bandwidth approaches to 20.78%.Thus insertion of slot improves the input bandwidth. Bandwidth keeps on increasing with increase in slot size. But finally a limit arrives where bandwidth starts decreasing. But after analysis it is found that overall best performance is achieved with a=6 mm and b=10mm [4].

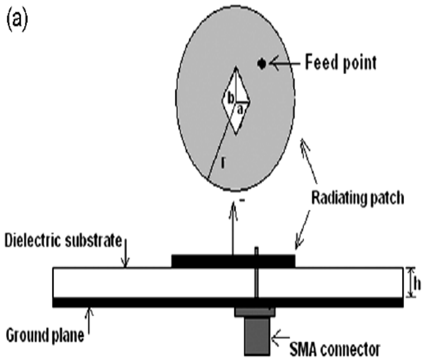


Fig. 3 Antenna with Diamond slot [4]

Simulated results concludes that the proposed antenna resonant frequency are 5.90GHz and 7.49GHz and their corresponding gain are 5.84dB and 5.71dB respectively. Also bandwidth value is approximately six times higher than a conventional circular microstrip patch antenna. Return Loss characteristics for different dimension of slots are furnished below [4].

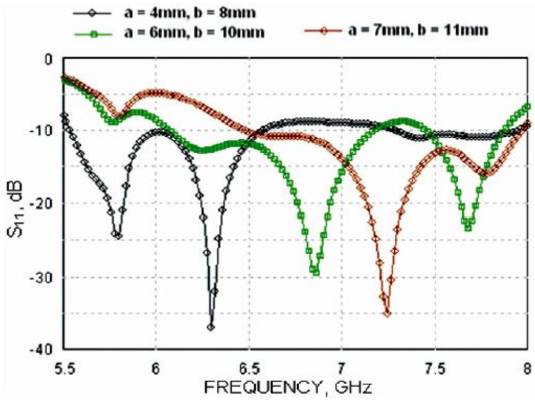


Fig 4 Return Loss v/s Frequency [4]

3.2.1 Simulated Results and Discussion

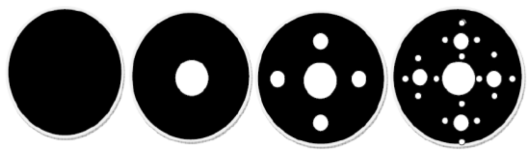
Below is the comparison of antenna without slot and antenna with a diamond slot.

Antenna without slot	Antenna with Diamond slot
At 5.90GHz frequency, bandwidth is 2.42% and at 7.49GHz frequency, bandwidth is 2.53%	At 5.90GHz frequency, bandwidth is 17.28% and at 7.49GHz frequency, bandwidth is 20.78%
At 5.90GHz frequency, gain is 1.2dB and at 7.49GHz frequency, gain is 1.5dB	At 5.90GHz frequency, gain is 5.84dB and at 7.49GHz frequency, gain is 5.71dB

Table 4 Comparison [4]

3.3 Fractals circular patch antenna

The configuration of antenna is shown in figure 5(a).The circular patch antenna has a radius of 16mm.The dielectric selected for the design is ε_r=2.4 and thickness is 4mm has been taken to construct a fractals. In the 1st iteration shown in Fig. 5(b) we divide circle into five smaller circle with radius = 5:1mm and then removed the circle at the centre as the remaining circle is four. In the 2nd iteration shown in Fig. 5(c) we divide each remaining four circle into five circle with radius = 1:35 mm. Then drop the entire centre circle for each remaining circle. The reaming small circle for this stage is sixteen. In the 3rd iteration shown in Fig. 5(d) we divide each remaining sixteen circle into five with radius = 0:2 mm. The entire centre circle for each remaining circle is being omitted [5].



(a) (b) (c) (d)

Fig. 5 Geometry of fractals antenna (a) 0th iteration, (b) 1st iteration, (c) 2nd iteration, (d) 3rd iteration [5].

3.3.1 Simulated Results and Discussion

Simulated results concludes that the bandwidth of antenna for 0 iteration is 0.6198 GHz (6.8243-7.4505),while for 1st iteration is 0.3003 GHz (6.524-6.8243), 2nd iteration are 0.2812 GHz (6.4989-6.7796) at lower band and 0.293 GHz (7.738-7.441) at upper band respectively as well as for 3rd iteration are 0.294 GHz (6.4856-6.7796) at lower band and 0.3706 GHz (7.3866-7.7572) at upper band. As the iteration increases the bandwidth is increases as well as it generates another resonant frequency at 7.5GHz.Gain and efficiency of such type of antenna is very high [5].

3.4 Circular Patch Antenna Using a C-Shaped Coupling Slot

The configuration of the dual-feed aperture-coupled circular microstrip patch antenna is shown in Fig. 6. The antenna consists of three substrate layers. The circular patch is etched on the top substrate and the dual orthogonal apertures and feed lines are etched on the bottom substrate. Rohacell foam is sandwiched between the top (patch) and bottom (feed) layers for bandwidth enhancement. For the same objective, the height of the foam and the lengths and positions of the coupling apertures are optimized such that both the radiating circular patch and the coupling slots resonate at close frequencies. To increase the isolation between the two ports, the separation along the x direction between the apertures is optimized. Configuration of the proposed dual polarized aperture coupled circular patch antenna: Dimensions: layer I: r =10 mm, h = 0:79 mm , ε_r = 2:45 mm,; layer II: Rohacell: h = 4mm, ε_r = 1:06; layer III: linear- slot l_1 =14:5mm, w = 2mm, C -slot l_2 = 5:5 mm, l_3 = 3mm, w = 2mm, d = 3:25 mm; layer IV: h = 0:79 mm, ε_r = 2:45 mm, feed lines: w = 2:27 mm, s = 1:5 mm, s = 2:75 mm [6].

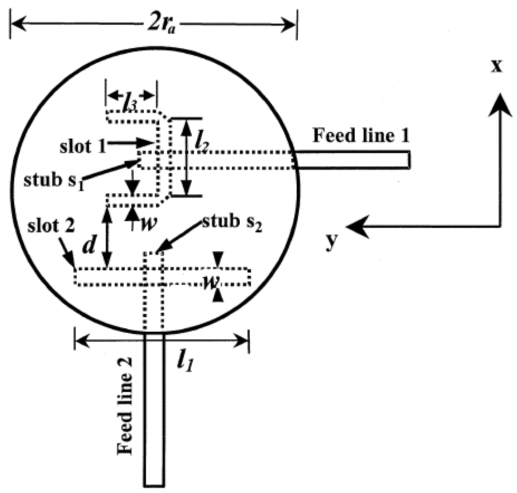


Fig. 6 Circular Patch Antenna Using a C-Shaped Coupling Slot [6]

3.4.1 Simulated Results and Discussion

A simulated result concludes that the performance parameters like return loss, bandwidth, gain, radiation pattern etc are enhanced. Also exhibits low cross polarization. These antennas are suitable for RF and C band applications [6].

3.5 Circular Shaped Slotted Microstrip Patch Antenna

The configuration of antenna is shown in Figure 7. The antenna is mounted on an Roger RT/Duriod 5880(tm) substrate having relative permittivity of 2.2 ,height is 2mm and dielectric loss tangent tan δ=0.009 The antenna is fed by a coaxial transmission line the method called probe feeding. The radius of the patch is 22 mm and thickness of 0.5 mm , ground plane with thickness of 1 mm both made from copper plate with relative permittivity of 1.Feed with inner conductor radius of 0.12 mm is located at 12 mm. Excitation to patch conductor is given using waveport. Dimension of the slots are l=21 mm and w=0.5 mm [7].

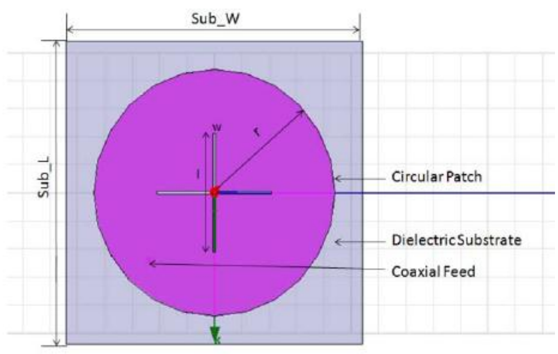


Fig. 7 Circular Patch Antenna with a cross slot [7]

3.5.1 Simulated Results and Discussion

Simulated results shows that by changing the substrate height and feed locations parameters like return loss, VSWR and operating frequency also changes. Introducing cross slots enhance the parameters like bandwidth, return loss, gain etc. [7]

4. CONCLUSION

The microstrip patch antennas are most preferable antennas due to its inherent advantages like small size and weight, low cost, printed directly on the circuit board, low profile and easy to fabrication.

The slotted antennas are used in C Band applications like satellite communication, WLAN, WiMAX, Wi-Fi etc. This paper describes about the introduction of different slots on the antenna have resulted in improvement of various performance parameters of the antenna like gain, bandwidth, return loss etc.

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