Research Results

Circular Shaped Wideband Microstrip Monopole Patch Antenna for Wideband Applications

Rashmi Kumari[1], Mr. Pramod Kumar[2], Dr. Jyoti Jain[3]

[1]M.Tech. Research Scholar, Department of Electronics & Communication, SIRT, Bhopal (M.P)
[2]Research Guide, Department of Electronics & Communication, SIRT, Bhopal (M.P)
[3]HOD, Department of Electronics & Communication, SIRT, Bhopal (M.P)

ABSTRACT

A compact circular monopole microstrip patch antenna has been presented for wideband applications. In this research work by combining a circular shaped patch and microstrip feed line with modified partial ground has been designed. Proposed Antenna provides a frequency band from 2.27 GHz to 13.811 GHz. Simulated results show that the proposed antenna achieves a good broadband characteristic. Proposed antenna is resonating at 2.732 GHz, 4.796 GHz, 8.252 GHz, 10.772 and 12.932 GHz. Resonating frequencies show that the proposed antenna is good for providing broadband applications. Proposed antenna has a lower cut-off frequency of 2.276 GHz and Upper Cut-off frequency is 13.796 GHz and so that the antenna offers 10-dB fractional impedance bandwidth is 286.71 % which is faraway improved than previous research work. In order to make broadband antenna the dimensions of circular-shaped patch and modified ground has been optimized. The presented antenna has been designed on FR-4 substrate, Loss Tangent (tan(δ)=0.02, dielectric constant (ε_r) = 4.3) with the thickness of substrate is 1.6 mm. The presented antenna has been examined on CST Microwave Studio.

KEYWORDS

Microstrip Patch Antenna, Broadband Applications, Circularly Shaped Patch Antenna.

1. INTRODUCTION

The shapes of Microstrip Parch Antenna can be anything ranging from triangular, circular, semi-circular and rectangular. The feed-lines and the radiating patch are usually photo-etched on the dielectric substrate. The dielectric substrate can be thick or thin, and must be chosen with permittivity between 2.2 to 12. The patch thickness should be much less than the operating wavelength of the antenna. The radiation in microstrip patch antennas is due to the fringing fields between the edge of the patch and the ground plane. A thick substrate with a very low dielectric constant is suitable for good antenna performance since it provides a larger bandwidth, better efficiency and better radiation. But in such a scenario, the antenna size increases. Thus to reduce the size, substrate with high dielectric constants must be used which have narrow bandwidth and are less efficient. Hence a proper trade-off must be done at the designing stage to realize an improved performance of an antenna at a particular operating frequency and constrained physical dimensions. The figure below shows a standard rectangular microstrip patch antenna.

The broadband monopoles highlight wide operating data transmissions, appropriate radiation properties, simple structures and ease of manufacture. Be that as it may they are not planar structures in light-weight of the actual fact that their ground planes are opposite to the radiators. Therefore, they are not appropriate for coordination with a imprint on a circuit board A printed circular disc monopole fed by microstrip line is put forward. The parameters that have an effect on the operation terms of the antenna in of its frequency domain characteristics are analyzed. the optimum style of this kind of Antenna are able to do an ultra wide bandwidth with satisfactory radiation properties the simulations have conjointly shown that the projected monopole antenna is non dispersive, that is extremely vital for UWB systems.

2. ANTENNA GEOMETRY

A microstrip patch antenna consists of a dielectric substrate sandwiched by a radiating patch on one side and the ground plane on the other side. The radiating patch is made of a good conductor material such as annealed copper or gold. It can take any shape in the two-dimensional plane and thus unlimited configurations are possible. Though as per as the structure of proposed antenna is concerned the circular shaped patch antenna with modified partial ground has been shown in figure 1 and figure 2. The presented antenna has been put in x-y plane and symmetrical in shape about longitudinal y axis. Circular-shaped patch along with the 50-ohm microstrip line has been printed on the top of Fiberglass Polymer Resin (FR-4)

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substrate with the thickness 1.6 mm. On the bottom side of the substrate partial ground has been designed. The presented antenna is energized by SMA port through a microstrip feed line. Optimized dimensions of the presented antenna shown in figure. The overall volume of antenna is (30 × 42.50 × 1.6) mm3. All Optimized dimensions of Circular -shaped patch structure has been shown in figure 1 modified Partial ground structure has been shown in figure 2 in which a square slot in both side have been cut and the combined optimized patch and ground antenna structure has been presented in figure 3.

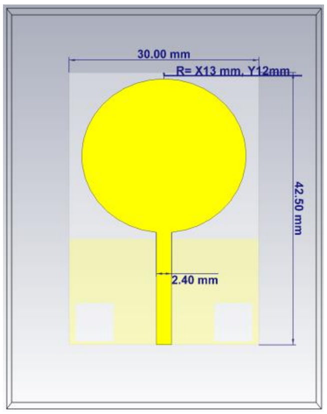

Fig. 1 Geometry of the Cicular-shaped Patch (Front).

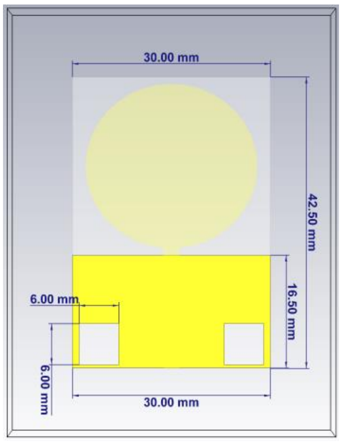

Fig. 2 Geometry of the Modified Partial Ground Structure (Back).

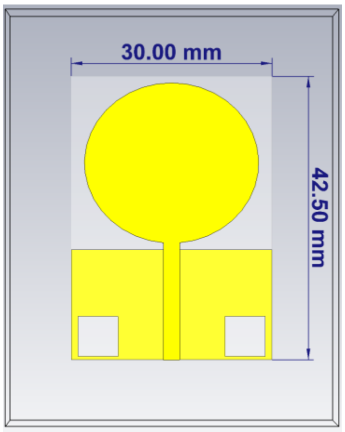

Fig. 3 Geometry of the Combined Patch and Square slots Ground Structure.

3. ANTENNA EVOLUTION

In the first step a circular patch antenna with microstrip feed line has been designed with full ground structure in which the x radius is 13 mm and the y radius is 12 of a circular shaped patch. The return loss characteristics (S11) of Antenna 1 shown in figure 4 it can be observed that no good return loss is from 2 GHz to 6.2 GHz it is due to the lower impedance matching between the patch and ground which does not suitable for wideband applications.

Antenna 1

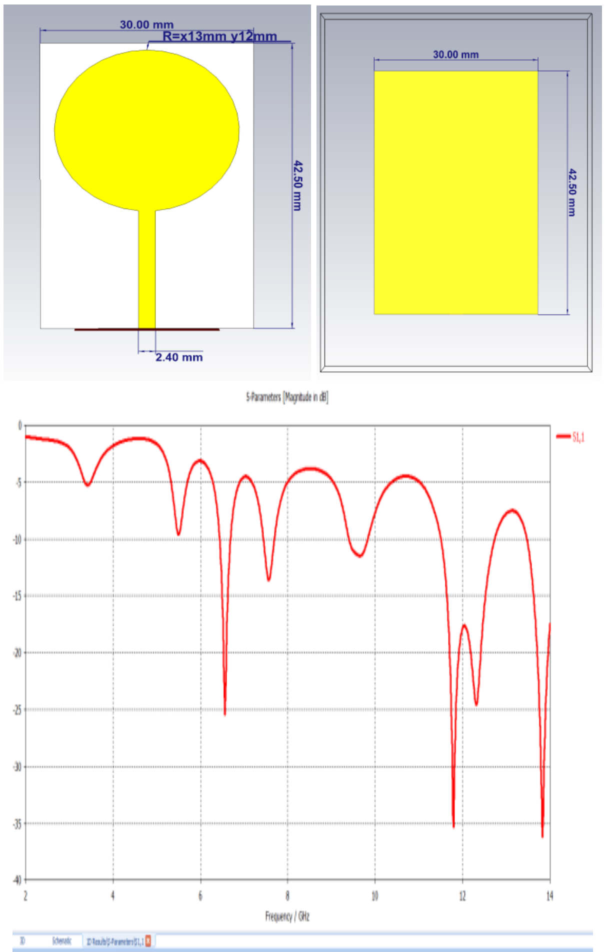

Fig.4 Antenna 1 and S_{11} Return Loss Characteristics of Antenna 1

Antenna 2

In Antenna 2 the Circular-shaped structure with full ground structure has been cut down below the patch shape or it can be said that no overlapping between patch and ground shown in figure 5, in order to make impedance matching between Patch and ground but still the return loss or S11 has lowered down from -10dB from 2.23GHz to 6.5GHz and from 7.3GHz to 13.79GHz so from here it is clear that some point of impedance matching between patch and ground required to its optimized value so that the whole S11 graph may reached to below -10dB and antenna shell be suitable for broad band applications.

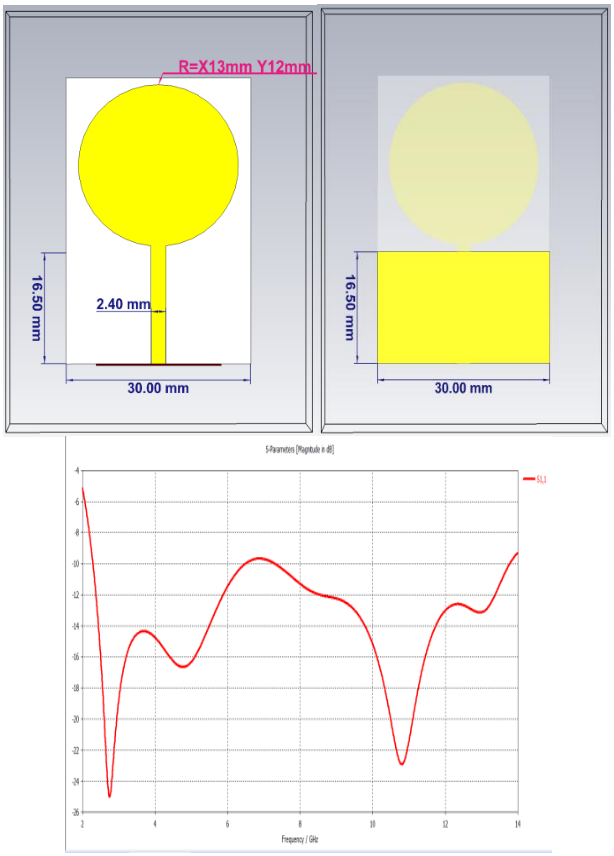

Fig.5 Antenna 2 and S_{11} Return Loss Characteristics of Antenna 2

Antenna 3

In Antenna 3 the ground structure has been cut down to below the patch but not to down below microstrip feed line shown in figure 6. After simulated this antenna the return loss (S11) curve shows that the Impedance matching between Patch and ground has been achieved satisfactorily. As the return loss reached below -10dB from the 2.276GHz frequency range to 13.796GHz which made this antenna feasible for good broadband applications.

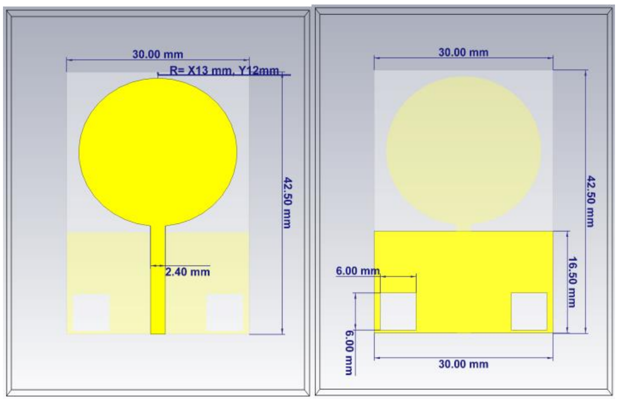

Fig. 6 Geometry of the Patch and Square slots Cut Partial Ground Structure Antenna 3 (Front & Back).

4. RESULT ANALYSIS

Return loss characteristics shows that the optimized Antenna 3 is providing good return loss curve the lower cut-off frequency is 2.276 GHz and the higher cut-off frequency is 13.796 GHz. So this antenna became a Broadband Antenna. It can be observed that the presented antenna is resonating at 2.732 GHz, 4.796 GHz, 8.252 GHz, 10.772 and 12.932 GHz in figure 11. Proposed antenna provided the fractional impedance bandwidth of 286.71% from 2.276 to 13.796 frequency bands.

$$Fractional\ Bandwidth\ = 2\left(\frac{f_H - F_L}{f_c}\right) \times\ 100)\ \%$$

$$f_c = \frac{(f_H + F_L)}{2}$$

$$f_c = \frac{(13.796 + 2.276)}{2}$$

$$f_c = \frac{(13.796 + 2.276)}{2}$$

$$f_c = \frac{(16.072)}{2}$$

$$f_c = 8.036$$

$$= 2\ \times \left(\frac{13.796 - 2.276}{8.036}\right) \times\ 100\ \%$$

$$= 2 \times \left(\frac{11.52}{8.036}\right)\ \times\ 100\ \%$$

$$Fractional\ Bandwidth\ =\ 286.71\%$$

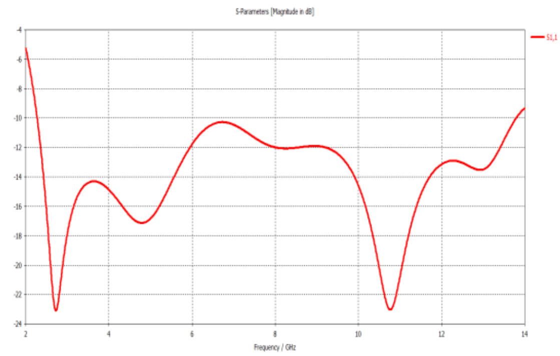

Fig.7 S_{11} Return Loss Characteristics of Proposed Antenna 3

2D Radiation Pattern of presented antenna has been shown in figure. At 2.72 GHz omni-directional radiation pattern has been analyzed.

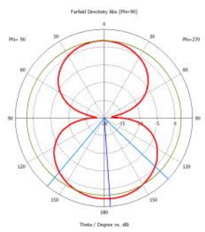

Fig. 8 2D Farfield at 2.72 GHz

2D Radiation Pattern of presented antenna has been shown in figure. At 4.78 GHz omni-directional radiation pattern has been analyzed.

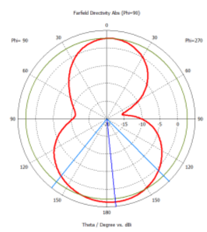

Fig. 9 2D Farfield at 4.78 GHz

2D Radiation Pattern of presented antenna has been shown in figure. At 8.25 GHz omni-directional radiation pattern has been analyzed.

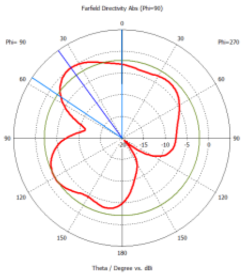

Fig. 10 2D Farfield at 8.25 GHz

2D Radiation Pattern of presented antenna has been shown in figure. At 10.77 GHz omni-directional radiation pattern has been analyzed.

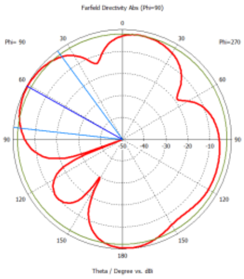

Fig. 11 2D Farfield at 10.77 GHz

3D Radiation Pattern of presented antenna with antenna structure has been shown in figure. At 2.72 GHz Omni-directional radiation pattern has been analyzed.

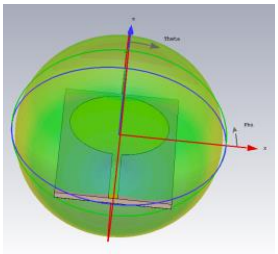

Fig. 12 Farfield 3D View with Antenna Structure at 2.72 GHz

3D Radiation Pattern of presented antenna with antenna structure has been shown in figure. At 4.78 GHz Omni-directional radiation pattern has been analyzed.

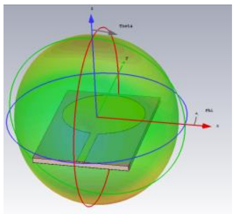

Fig. 13 Farfield 3D View with Antenna Structure at 4.78 GHz

3D Radiation Pattern of presented antenna with antenna structure has been shown in figure. At 8.25 GHz Omni-directional radiation pattern has been analyzed.

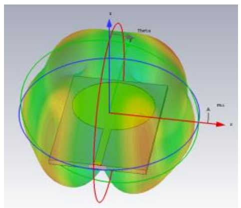

Fig. 14 Farfield 3D View with Antenna Structure at 8.25 GHz

3D Radiation Pattern of presented antenna with antenna structure has been shown in figure. At 10.77 GHz Omni-directional radiation pattern has been analyzed.

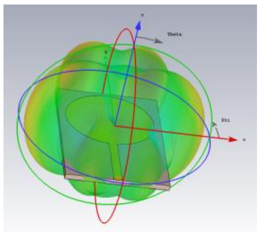

Fig. 15 Farfield 3D View with Antenna Structure at 10.77 GHz

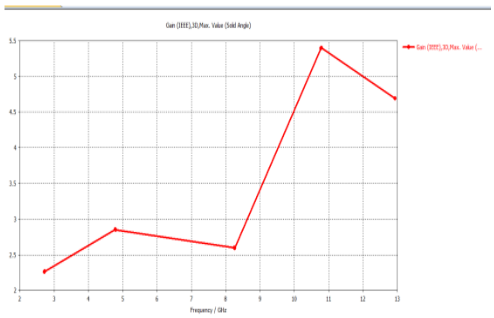

Fig.16 Gain of Proposed Antenna

Table 1 Comparison Table between Previous Research Work and Proposed Work

Parameters	Previous Research Work	Proposed Research Work
Antenna Size	40mm * 34 mm	42.5 mm * 30 mm
Lower Operating Frequency	4.1 GHz	2.276 GHz
Higher Operating Frequency	5.8 GHz	13.796 GHz
Resonating Frequencies	4.1, 5.6 GHz	2.732 GHz, 4.796 GHz, 8.252 GHz, 10.772 and 12.932 GHz
Bandwidth	34%	286.71%

Return Loss	-	-23 dB at 2.47 GHz
Applications	Broadband Applications	Broadband Applications

5. CONCLUSION

A very effective structure of microstrip patch antenna has been designed in research work. Proposed Antenna shows that it is having improvement in all aspects weather it depends on size, lower cut-off frequency, higher cut-off frequency, return loss characteristics (S11) and overall bandwidth. Simulated results show that the proposed antenna achieves a good broadband characteristic. Proposed antenna is resonating at 2.732 GHz, 4.796 GHz, 8.252 GHz, 10.772 and 12.932 GHz. Resonating frequencies show that the proposed antenna is good for providing broadband applications. Proposed antenna has a lower cut-off frequency of 2.276 GHz and Upper Cut-off frequency is 13.796 GHz and so that the antenna offers 10-dB fractional impedance bandwidth is 286.71 % which is faraway improved than previous research work.

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