Design of Circular Micro strip Patch Antenna with different Slots for WLAN & Bluetooth Application

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Abstract

In this paper, the design and analysis of circular microstrip patch antenna with different slot for the WLAN& Bluetooth Application is presented.The shape of proposed antenna is circular.The operating frequency of antenna is 1.5-2.5 GHz, The antenna design consists of a single layer of substrate with thickness 1.6 mm with dielectric constant of 2.4.The simulation results of proposed circular microstrip patch antenna for different slots are done by the help of IE3D Zealand Software. For the analysis of antenna we used the Cavity Model. This antenna is fed by a co-axial probe feeding. The effects of different parameters like return loss, radiation pattern are studied.

Keywords—*Circular Microstrip patch antenna* ***antenna***, *(CMPA)Return loss, Radiation Pattern, Antenna efficiency, Radiation efficiency*

1.Introduction

In recent years, the current trend in commercial and government communication systems has been to develop low cost, minimal weight, low profile antennas that are capable of maintaining high performance over a large spectrum of frequencies. This technological trend has focused much effort into the design of micro strip (patch) Antennas.The approach of the microstrip antenna enjoys all the advantages of printed circuit technology. The other drawbacks of basic microstrip structures include low power handling capability, loss, half plane radiation and limitation on the maximum gain. For many practical designs, the advantages of microstrip antennas far compensate their disadvantages [2]. However, research is still ongoing today to conquer some of these disadvantages. This paper, introduces designing and an analysis of Circular micro strip patch antenna with different slots for WLAN & Bluetooth applications. The circular micro strip patch antenna as shown in Figure 1.

2.Antenna Design and Structure

A.Circular Microstrip Patch Antenna

The proposed configuration of the antenna is shown in Figure 1. The antenna design consists substrate of a single layer of thickness 1.6 mm. The dielectric constant of the substrate is 2.4 and antenna is fabricated on RT Duroid material. as shown in Figure 1.

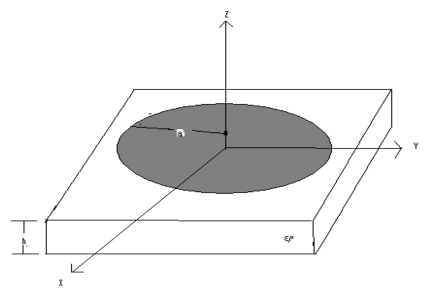

Figure 1. Microstrip Antenna with Circular Patch

There are different slots in designing the circular microstrip antenna,these slots are square rectangula r,cross ,U,H etc.The effect of changing The slot length and width are studied on parameters like gain,return loss, radiation efficiency,antenna efficiency etc.A coaxial probe feed is used at different points by changing the feed locations and their effect are seen on above parameters.

B. Design Equation

Because of fringing effect electrically the patch of antenna looks larger than its physical dimensions.The enlargement of L is given by eq 2.1shown below

$$\Delta L = 0.412h\frac{\left(\varepsilon_{reff}+0.3\right)\left(\frac{W}{h}+0.264\right)}{\left(\varepsilon_{reff}-0.258\right)\left(\frac{W}{h}+0.8\right)}$$

Where the effective (relative) permittivity is given by eq 2.2 shown below

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2}+\frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{W}\right]^{-\frac{1}{2}}$$

This is related to the ratio of h/W. The larger the h/W, smaller the effective permittivity the effective length of the patch is given by

The effective length of the patch L_{eff} now becomes:

$$L_{eff} = L + 2\Delta L$$

For a given resonance frequency f_o, the effective length is given by [9] as:

$$L_{eff} = \frac{c}{2f_o\sqrt{\varepsilon_{reff}}}$$

$$f_{nm} = \frac{cK_{nm}}{2\pi a_e\sqrt{\varepsilon_r}}$$

Where K_{nm} the derivative of the Bessel function of Order n & c is velocity of light

C. Design Procedure

If the substrate parameter(ε_r and h) and the operating frequency(f_r) are known than we can easily calculate the dimensions of patch antenna using above simp lified equation following design equation to design the antenna

Step 1: Using equation (2.4) to find out the resonant frequency of circular patch

Step2:Calculate the effective permittivity using the equation (2.2)

Step 3:Compute the extension of the length using the equation (2.1)

Step 4: Determine the length L by solving the equation for L giving the solution

Table 1. Dimensions of the Prescribed Antenna

Resonant Frequency(Fr)	1.5-3 GHz
Dielectric Constant (ε_r)	2.4
Radius of circular patch (r)	25 mm
Substrate Thickness(h)	1.6 mm
Loss Tangent	0.02

3.Method of Analysis

There are many methods of analysis for microstrip antennas. The microstrip antenna generally has a two- dimensional radiating patch on a thin dielectric substrate and therefore may be categorized as a two-dimensional planar component for analysis purposes. The analysis methods for microstrip antennas can be broadly divided into two groups. In the first group the methods are based on equivalent magnetic current distribution around the patch edges (similar to slot antennas).

There are three popular analytical techniques [3],

- The Transmission Line Model
- The Cavity Model
- The Multiport Network Model

In the second group, the methods are based on the electric current distribution on the patch conductor and the ground plane (similar to dipole antennas used in conjunction with Full-wave Simulation/Numerical analysis methods). Some of the numerical methods for analyzing microstrip antennas are listed as follows:

- The Method of Moments
- The Finite-Element METHOD
- The Spectral Domain Technique
- The Finite-Difference Time Domain Method

In this work we used the Cavity Model Method.

4. Results & Discussions

For the proposed circular microstrip antenna design ,IE3D software is used.The proposed antenna is designed with the circular patch radius of 25 mm with different slots e.g. square,rectangle,h,u,cross etc..The slot length and width is varied for obtaining the better return loss,gain and radiation and antenna efficiency and obtaining the resonant frequency for the desired wireless applications of WLAN and Bluetooth applications .The feed locations are also varied at different locations points to obtain the better results.Some of better results obtained for the proposed circular microstrip patch antenna are discussed with their s parameters return loss vs frequency graph and 3D radiation pattern.

4.1. Circular Microstrip Antenna Designed without Slot

Figure 2 shows Circular Patch with Radius=25mm &Feed Location at position =(-7,0)

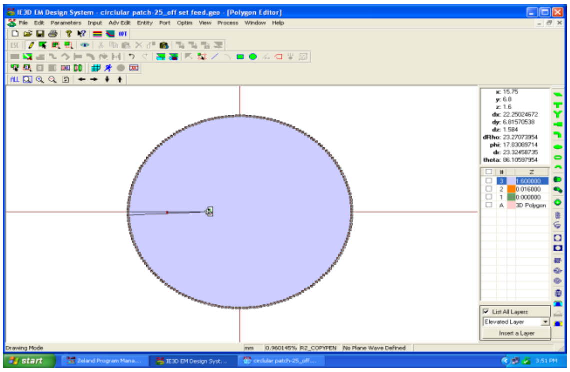

Figure 2. Cmpa Designed without Slot

Figure 3 shows Return Loss (S11) for above antenna designed & Return loss of -20 dB is obtained at a frequency range of 2.24 GHz. as shown below

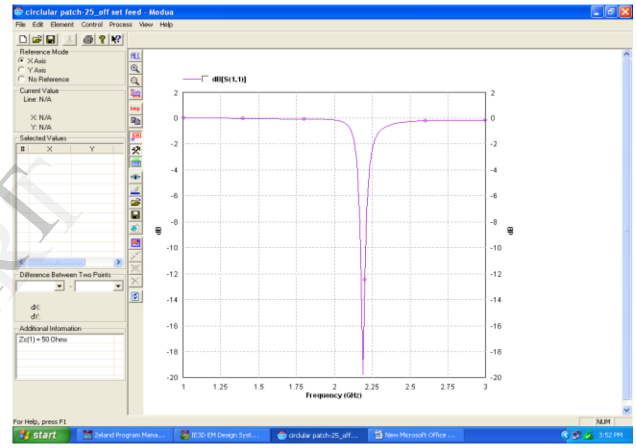

Figure 3. Return Loss vs Frequency

We obtained the following antenna parameters

1)Radiation Efficiency=87.67%

2) Antenna Efficiency=82.70 %

3) Gain of +6.51 dBi

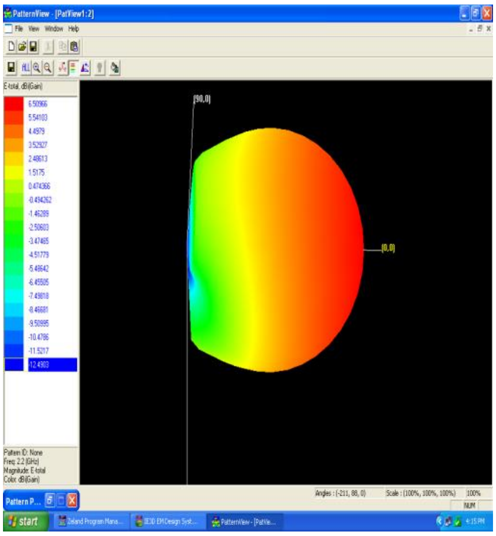

Figure 4. 3D Radiation Pattern

4.2. Cmpa Designed with Square Slot

Figure 5 shows Circular Patch with square slot with slot length and width l,w =(7,7) at Feed Location (-7,0) & at Slot position (7,7)

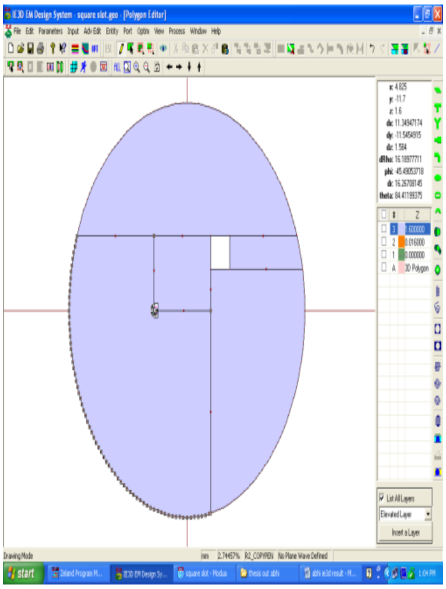

Figure 5.Cmpa Designed with Square Slot

Figure 6 shows Return Loss (S11) for square slotted antenna & the Return loss of -14.2 dB is obtained at a frequency range of 2.17 GHz as shown below:

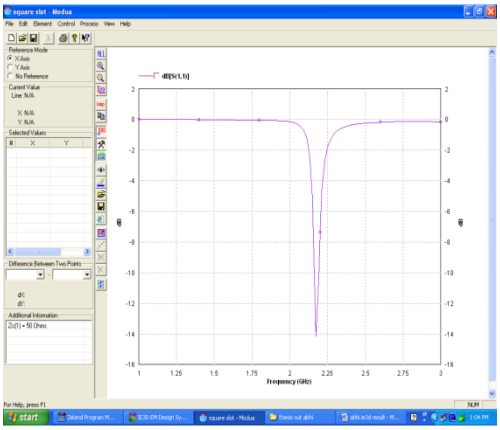

Figure 6.Return Loss vs Frequency

We obtained the following antenna parameters in square slotted antenna

1) Radiation Efficiency=88.47%
2) Antenna Efficiency=84.98 %
3) Gain of 6.59 dBi

Figure 7 shows 3D radiation pattern

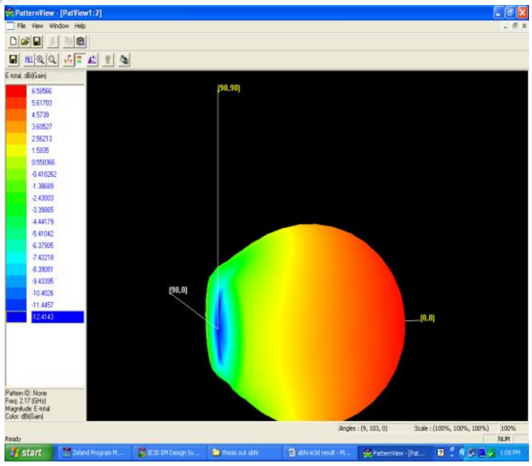

Figure 7. 3D Radiation Pattern

4.3.Cmpa Designed with Rectangular Slot

Figure 8 shows Circular Patch with rectangular slot with Feed Location (-7,0) & Slot position at (10,10) with slot length and width l,w (7,5)

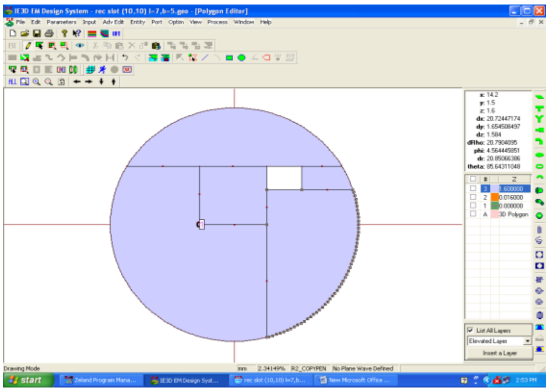

Figure 8.Cmpa Designed with Rectangular Slot

Figure 9 shows Return Loss (S11) for rectangular slotted antenna & theReturn loss of -14 dB is obtained at a frequency range of 2.17 GHz as shown below:

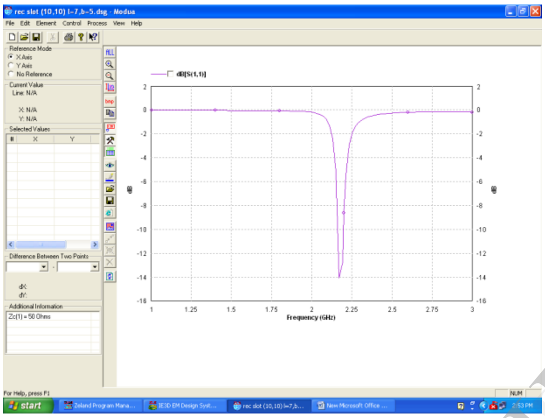

Figure 9. Return Loss vs Frequency

We obtained the following antenna parameters in rectangular slotted antenna
1) Radiation Efficiency=88.32%
2) Antenna Efficiency=83.88 %
3) Gain of+ 6.53 dBi

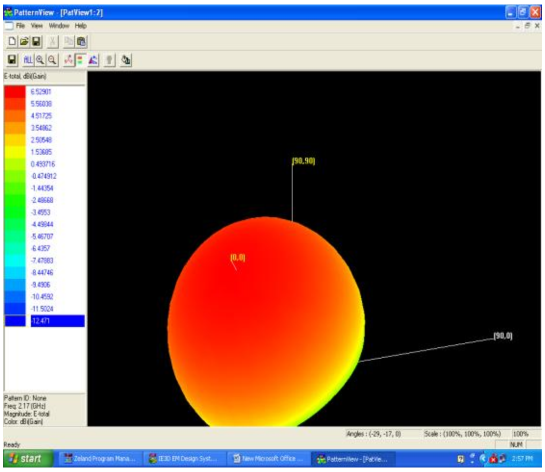

Figure 10.3D Radiation Pattern

4.4. Cmpa Designed with H Slot

Figure 11 shows Circular Patch with H slot with slot length and width l,w (7,2) at Feed Location (-22,0)

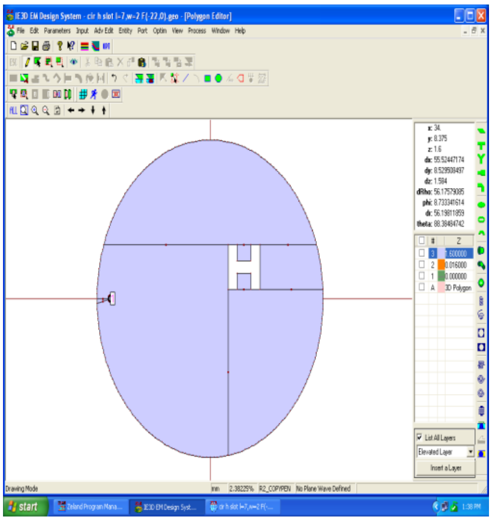

Figure 11. Cmpa Designed with H Slot

Figure 12 shows Return Loss (S11) for above antenna designed &
Return loss of -31 dB is obtained at a frequency range of 1.7 GHz as shown below:

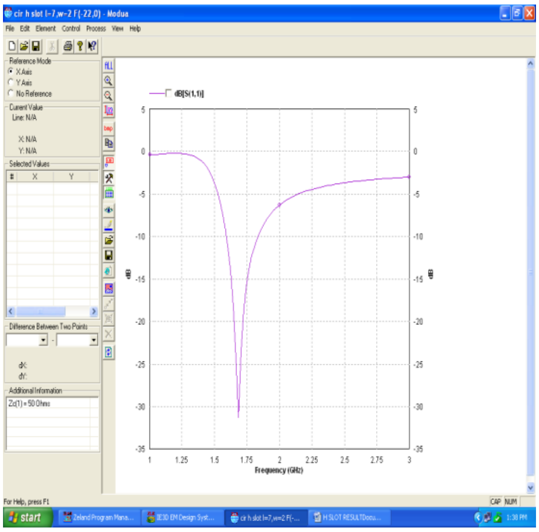

Figure 12. Return Loss vs Frequency

We obtained the following antenna parameters in H slotted antenna
1) Gain of -10.84 dBi
2) Radiation Efficiency=6.23%
3) Antenna Efficiency= 5.4%

Figure 13 shows 3D radiation pattern for H slotted antenna

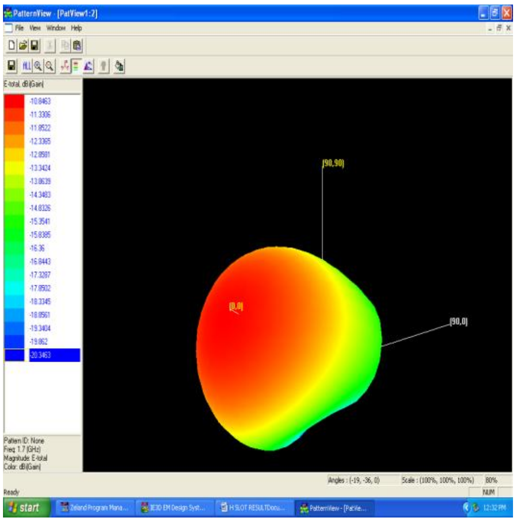

Figure 13. 3D Radiation Pattern

4.5.Cmpa Designed with Cross Slot

Figure 14 shows Circular Patch with cross slot with slot length and width l, w (10,3) at Feed Location (-7,0) & Slot Position(7,7)

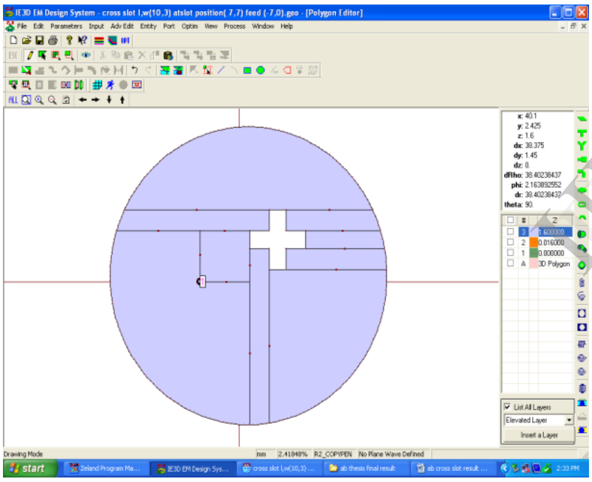

Figure 14. Cmpa Designed with Cross Slot

Figure 15 shows Return Loss (S11) for cross slotted antenna

Return loss of -9 dB is obtained at a frequency range of 2.13 GHz as shown below:

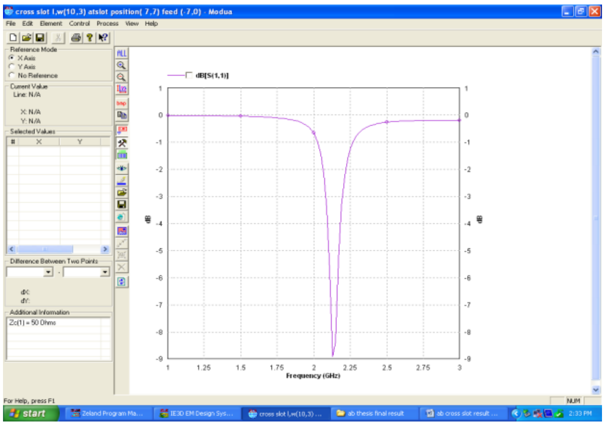

Figure 15. Return Loss vs Frequency

We obtained the following antenna parameters in cross slotted antenna

1) Gain of +5.93 dBi
2) Radiation efficiency=78.31%
3) Antenna efficiency=72.98 %

Figure 16 shows 3D radiation pattern for cross slotted antenna

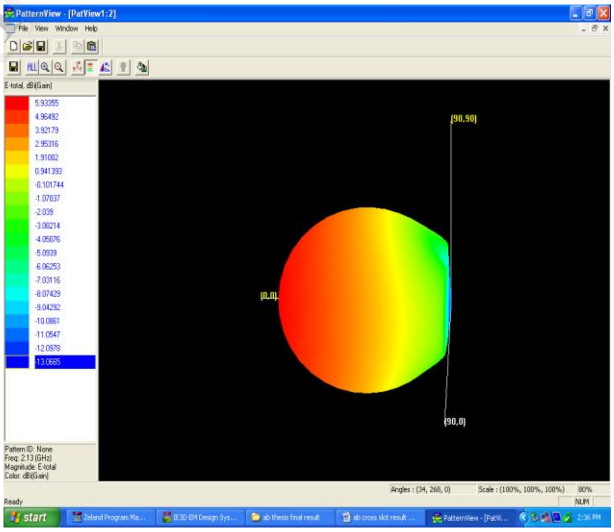

Figure 16. 3D Radiation Pattern

4.6 Cmpa Designed with U Slot

Figure 17 shows Circular Patch with U slot with slot length and Width l,w (7,2) at Feed Location (0,-22)

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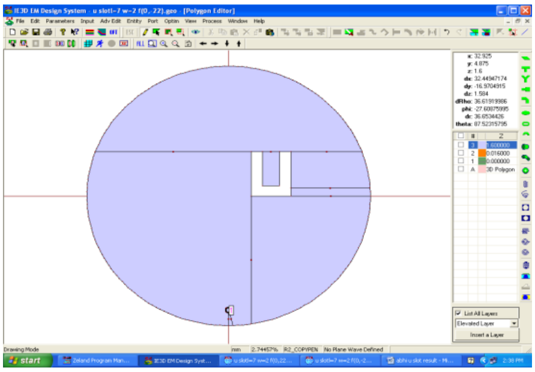

Figure 17. Cmpa Designed with U Slot

Figure 18 shows Return Loss (S11) for above antenna designed & Return loss of -24 dB is obtained at a frequency range of 1.7 GHz as shown below:

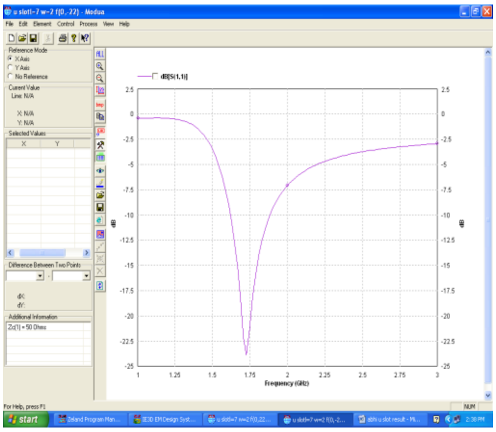

Figure 18. Return Loss vs Frequency

We obtained the following antenna parameters in U slotted antenna
Gain= -10.69 dBi , Antenna Efficiency=52.57%
Radiation Efficiency=35.68 %

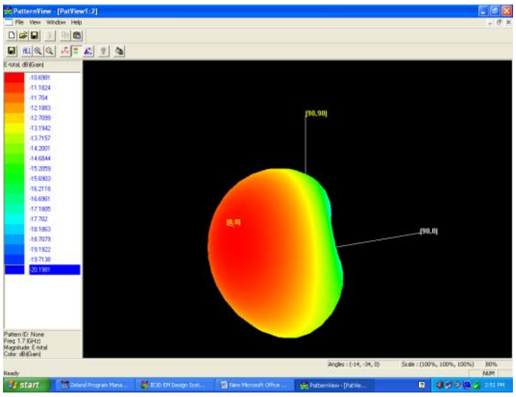

Figure 19.3D Radiation Pattern

Table 2. Result Comparison

Shape of Slots	Resonant frequency (fo) GHz	Return Loss (dB)	Gain(dBi)	Antenna Efficiency (η)%	Radiation Efficiency (η)%	Feed Position(x,y)
Without Slot	2.24	-20	+6.51	82.70	87.67	(-7,0)
Square	2.17	-14.2	+6.59	84.98	88.47	(-7,0)
Rectangle	2.17	-14	+6.53	83.88	88.32	(-7,0)
H	1.7	-31	-10.84	5.4	6.23	(-22,0)
Cross	2.13	-9	+5.93	72.98	78.31	(-7,0)
U	1.7	-24	-10.69	52.57	35.68	(0,-22)

5. Conclusion and Future Prospectus

This paper presents the designing and analysis of the Circular Microstrip patch antenna is done using IE3D software and analysis is done by using Cavity Model method. In this paper, the prescribed antenna design is simulated over the value of the return loss and gain,antenna and radiaton efficiency From the simulation results, we can say that the square slot circular microstrip antenna gives the better results at operating frequency 2.17GHz. Without changing the permittivity and height of the substrate, the effect of various parameters of Cmpa are studied. In simulation and measurement the return loss has a negative which states that the losses are minimum during the transmission. Circular Micro strip patch antenna were successfully incorporated with H, U, +, Rectangle & square slots The effect of varying the slot width and slot length were studied under great details with the help of experimental results. The proposed patch yield desirable results throughout the operating frequency range. Above all, the Cmpa designed with square slot gave the better results with gain of + 6.59 dBi &antenna efficiency 84.98 % and radiation efficiency 88.47 % at resonance frequency of 2.17 GHz and we obtained the minimum return loss of -31 dB of CMPA designed for H slot.Thus the proposed antenna can be used for WLAN & Bluetooth application with the resonant frequency between 1.5-3 GHz. In future others different type of feed techniques and different methods of analysis models can be used to calculate the overall performance of the antenna without missing the optimized parameters in the action. The gain,antenna efficiency, radiation efficiency can further enhanced by incorporated the different type of slots cutting in conventional circular microstrip patch antenna and using different substrate we can further achieved the better antenna parameters. and designed Cmpa can be used in high frequency range of wireless communication e.g. WIMAX ,X Band ,KU Band etc.

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