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PERFORMANCE EVALUATION OF SEMI CIRCULAR SHAPED PATCH ANTENNA USING PROBE FEED TECHNIQUE BY VARYING SUBSTRATE THICKNESS

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Abstract- *In this research article, a semi-circular patch antenna's performance has been evaluated with respect to S11 parameter and VSWR in which probe feeding technique has been incorporated and also its position is varied along with the substrate thickness. The substrate thicknesses taken are 1.6mm, 2.4mm, 3.2mm and 4.0mm. The antenna dimension is having patch radius of 30mm and the ground size of 50mm X 70mm. The proposed antenna is simulated on IE3D simulator and the S11, VSWR, gain and bandwidth of the antenna at different values of thickness of substrate are presented.*

Keywords: Semi-circular, VSWR, S11, gain, IE3D simulator.

1. INTRODUCTION:

In today's era of miniaturization, there is a growing need for antennas that are conformal and planar in structure. Microstrip antennas (MSAs) have gained significant popularity in practical applications due to their numerous advantages (references 1 to 4). In personal communication applications, the demand for compact MSAs is high since the available area for accommodating the antenna is limited.

In [5], a semi-circular patch antenna is presented in which three bands are achieved with waveport feeding technique to excite the antenna and thickness of substrate is 1.6 mm. some more circular and semicircular antenna have also been simulated for deep characterization. The systematic study highlights the behavior in terms of resonant modes of shorted patch [6]. In [7], a new and innovative design is presented for a compact suspended semicircular patch antenna with a half U-slot, allowing for dual-frequency operation. In order to thoroughly investigate this novel configuration, a parametric study is conducted, where the length and width of the slot, as well as the radius and position of the coaxial feed probe, are systematically varied. By incorporating a half U-shaped slot into a semicircular disk [8], a dual-frequency resonance antenna is achieved. The research reveals that the resonance frequency of the antenna is inversely proportional to the length and feed point of the slot, whereas it increases with the widening of the slot width and the radius of the coaxial probe feed. In [9], wideband T-probe proximity-fed regular circular and compact semicircular patch antennas are introduced. The research includes experimental measurements and computed results obtained using the finite-difference time-domain (FDTD) method.

In this research article, the investigation is performed on the performance of the semicircular patch mounted on the substrate having the dielectric constant 4.2 by varying the thickness of substrate from 1.6 mm to 4.0 mm with the step size of 0.8 mm. the VSWR and the S11 parameter has been compared at all the four values and the corresponding impedance bandwidth and gain are also compared.

2. ANTENNA DESIGN:

The antenna proposed here in this article is designed using the semicircular patch of the radius of 30 mm on the substrate having the ground dimensions of 50 mm X 70 mm. the probe feeding technique has been incorporated to excite the antenna. The simulation parameters are listed down in the Table 1 mentioned below.

Table-1: Simulation Software Parameters for Semi Circular Patch Antenna

Antenna Parameters	Value
Dielectric Constant	4.2
Frequency Range	0-3 GHz
Loss Tangent	0.0013
Ground Size	50mm×70mm
Radius of Semi Circle	30 mm
Substrate Thickness	1.6, 2.4, 3.2, 4 mm

The geometrical design of the semicircular patch antenna is demonstrated in Figure 1.

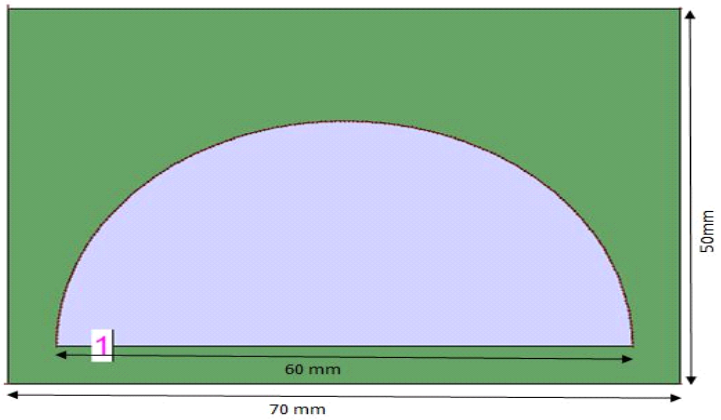

Fig-1: Design of Semi Circular patch antenna

3. RESULT AND DISCUSSION:

3.1 Simulation Results of Semi Circle Shape Patch Antenna with variation in Substrate Thickness

3.1.1 Return Loss vs. Frequency curve:

The return loss vs frequency graph with probe location x= 9.675 mm, y=5 mm, h= 1.6 mm is shown in Figure 2. The bandwidth of antenna is calculated on -10 dB. The antenna works in dual frequency mode while the bandwidth of higher mode of frequency is calculated because of high bandwidth in this region.

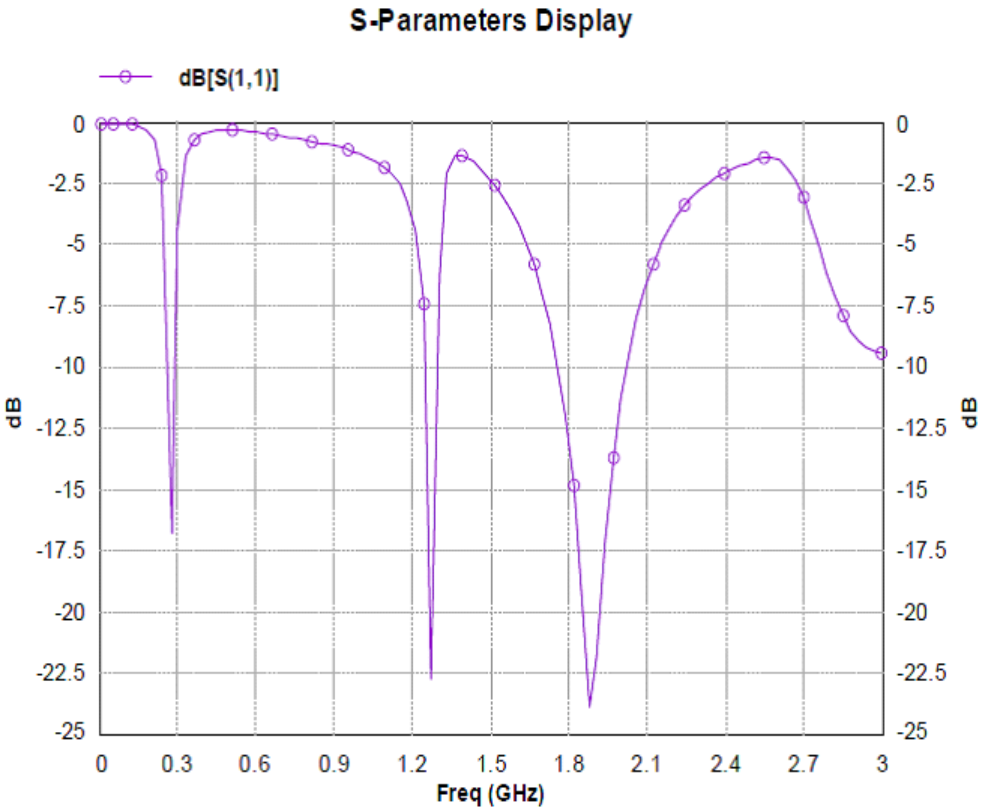

Fig-2: Return loss Vs Frequency Curve of Semi Circular antenna of Substrate thickness 1.6 mm

Bandwidth Calculation*:*

f_H = 2.02203 GHz

f_L = 1.75771 GHz

$f_C = f_H + f_L /2$= 1.88987 GHz

Fractional Bandwidth= 13.98%

The fractional bandwidth of antenna is found to be 13.98% at central frequency 1.88987 GHz and at resonant frequency of 1.88326 GHz.

3.1.2 VSWR vs Frequency Curve:

The VSWR vs Frequency Curve is shown in Figure 3. It can be observed from the figure that the VSWR is below two in the operating frequency range. The value of VSWR at resonating frequency is 1.01.

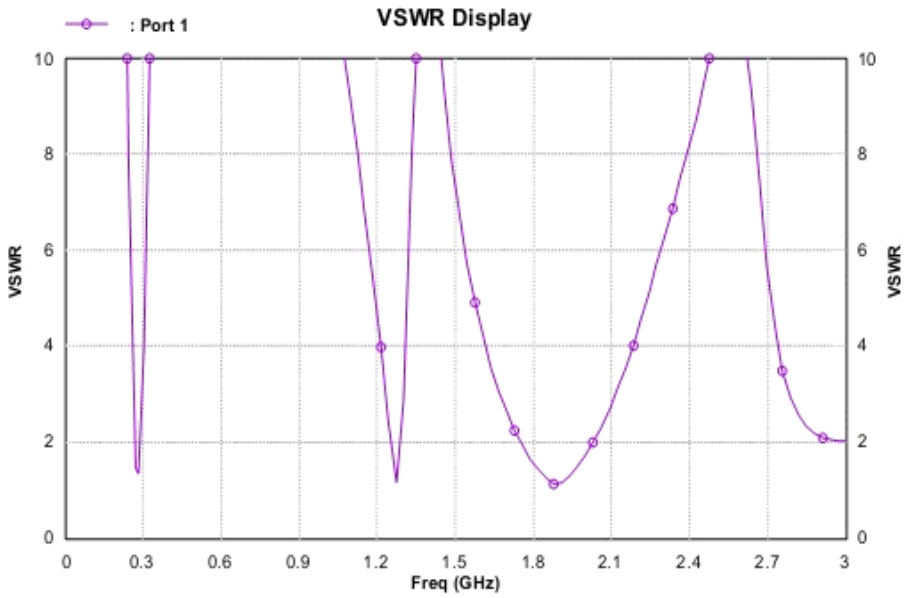

Fig-3: VSWR Vs Frequency Curve of Semi Circular antenna of Substrate thickness 1.6 mm

3.2 Simulation Results of Semi Circle Shape Patch Antenna with Substrate Thickness of 2.4mm:

3.2.1 Return Loss Vs Frequency curve:

The return loss vs frequency graph with probe location x= 20.65 mm, y=5 mm, h= 2.4 mm is shown in Figure 4. The bandwidth of antenna is calculated on -10 dB.

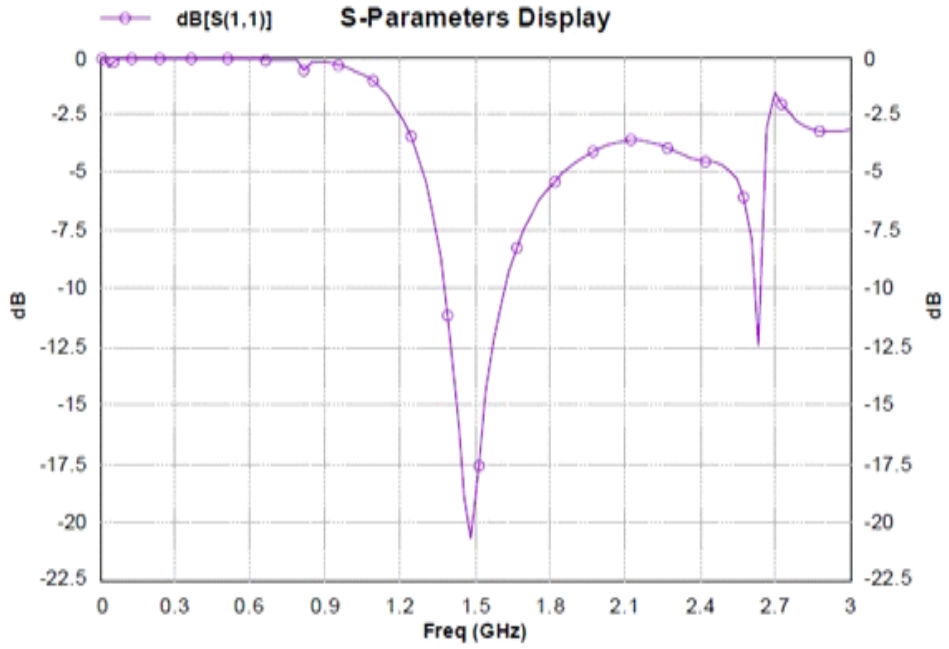

Fig-4: Return loss Vs Frequency Curve of Semi Circular antenna of Substrate thickness 2.4 mm

Bandwidth Calculation:

f_H = 1.61894 GHz

f_L = 1.38106 GHz

$f_C = f_H + f_L /2$= 1.5 GHz

Fractional Bandwidth= 15.859%

The fractional bandwidth of antenna is found to be 15.859% at central frequency 1.5 GHz and at resonant frequency of 1.48678 GHz.

3.2.2 VSWR vs Frequency Curve:

The VSWR vs Frequency Curve is shown in Figure 5. It can be observed from the figure that the VSWR is below 2.0 in the operating frequency range. The value of VSWR at resonating frequency is 1.30

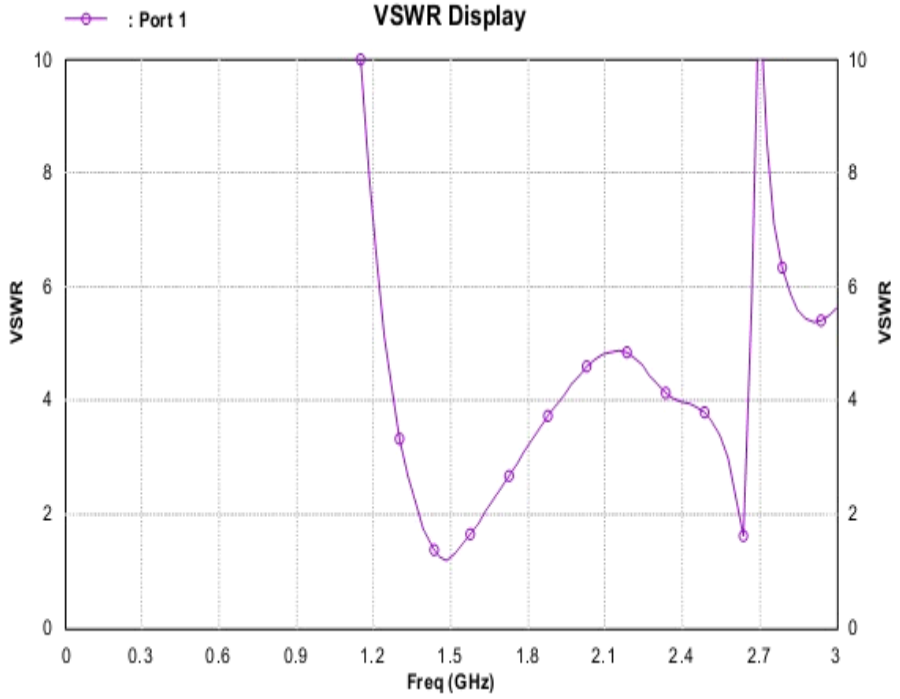

Fig-5: VSWR Vs Frequency Curve of Semi Circular antenna of Substrate thickness 2.4 mm

3.3Simulation Results of Semi Circle Shape Patch Antenna with Substrate Thickness of 3.2mm:

3.3.1 Return Loss Vs Frequency curve:

The return loss vs frequency graph with probe location x= 11.25 mm, y=5 mm, h= 3.2 mm is shown in Figure 6. The bandwidth of antenna is calculated on -10 dB.

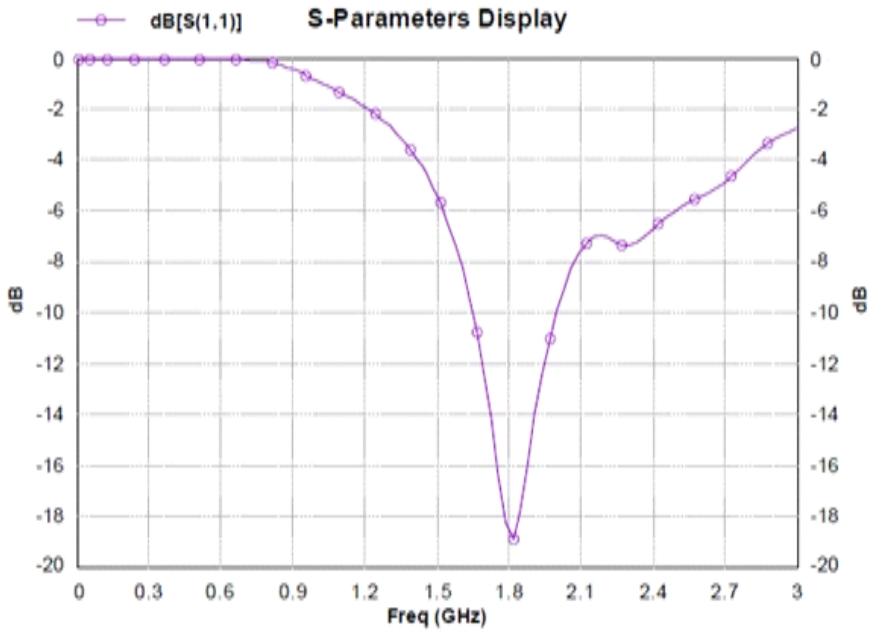

Fig-6: Return loss Vs Frequency Curve of Semi Circular antenna of Substrate thickness 3.2 mm

Bandwidth Calculation:

f_H = 1.9982 GHz

f_L = 1.6535 GHz

$f_C = f_H + f_L /2$= 1.82585 GHz

Fractional Bandwidth =18.87%

The fractional bandwidth of antenna is found to be 18.87% at central frequency 1.82585 GHz and at resonant frequency of 1.81508 GHz.

3.3.2 VSWR vs Frequency Curve:

The VSWR vs Frequency Curve is shown in Figure 7. It can be observed from the figure that the VSWR is below two in the operating frequency range. The value of VSWR at resonating frequency is 1.25.

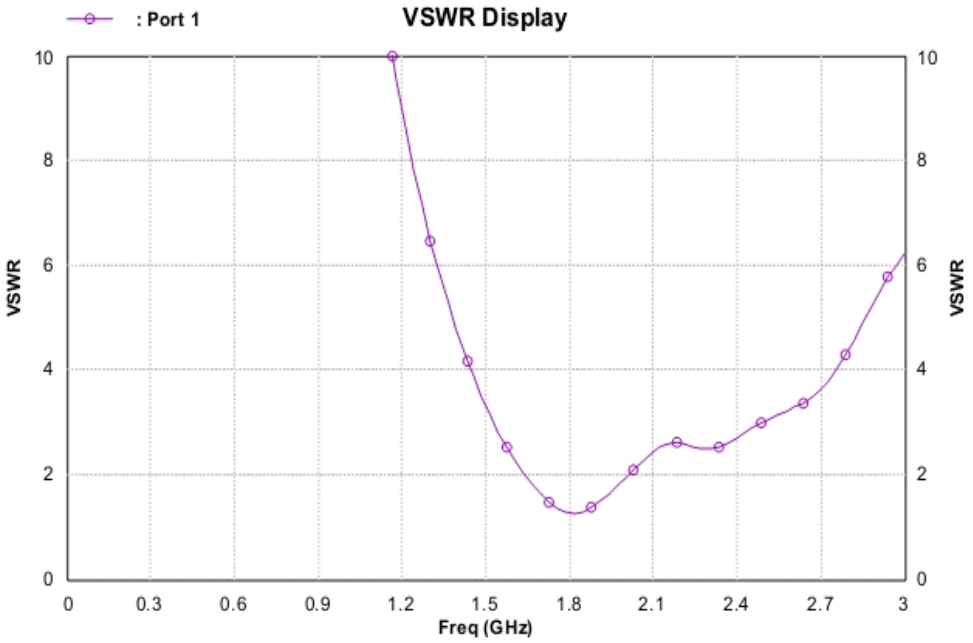

Fig-: VSWR Vs Frequency Curve of Semi Circular antenna of Substrate thickness 3.2 mm

3.4 Simulation Results of Semi Circle Shape Patch Antenna with Substrate Thickness of 4.0 mm:

3.4.1 Return Loss Vs Frequency curve:

The return loss vs frequency graph with probe location x= 11.25 mm, y=5 mm, z= 3.2 mm is shown in Figure 8. The bandwidth of antenna is calculated on -10 dB.

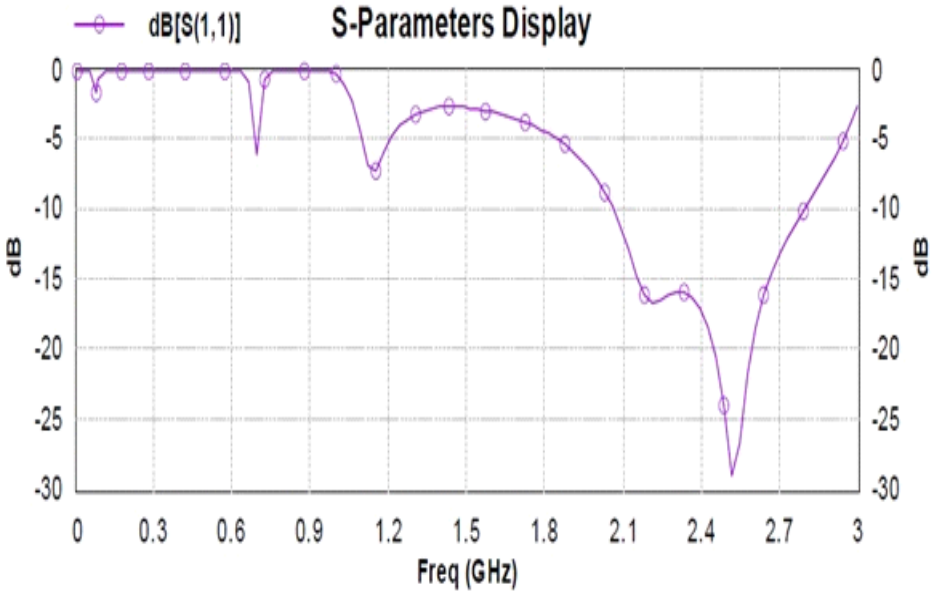

Fig-8: Return loss Vs Frequency Curve of Semi Circular antenna of Substrate thickness 4 mm

Bandwidth Calculation:

f_H = 2.7981 GHz

f_L = 2.06167 GHz

$f_C = f_H + f_L /2$= 2.42511 GHz

Fractional Bandwidth= 30.249%

The fractional bandwidth of antenna is found to be 30.249% at central frequency 2.42511 GHz and at resonant frequency of 2.51927 GHz.

3.4.2 VSWR Vs Frequency Curve:

The VSWR Vs Frequency Curve is shown in Figure 9. It can be observed from the figure that the VSWR is below two in the operating frequency range. The value of VSWR at resonating frequency is 1.06.

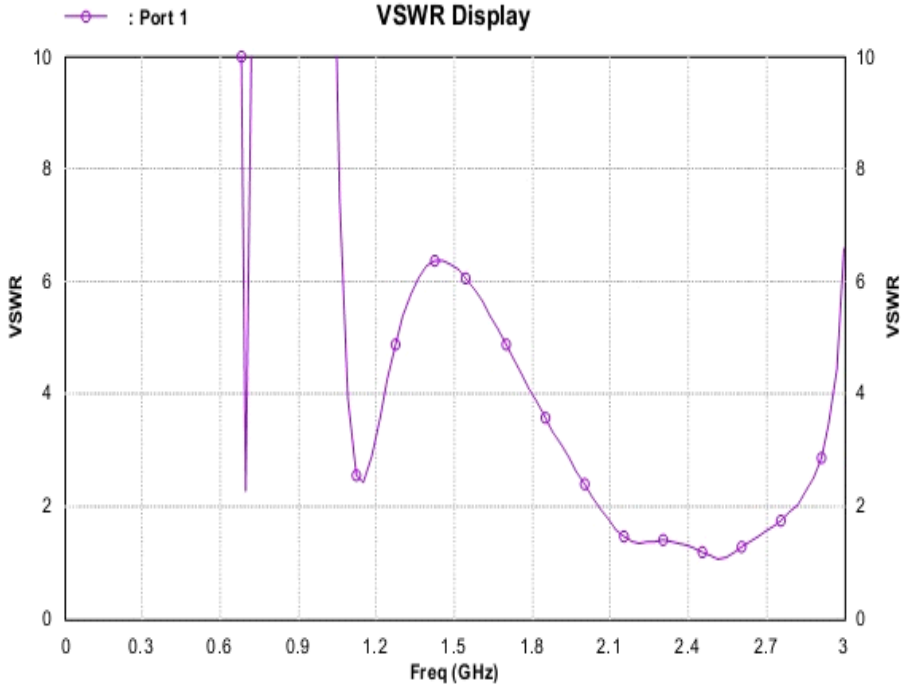

Fig-9: VSWR Vs Frequency Curve of Semi Circular antenna of Substrate thickness 4.0 mm

Table-2: Simulation results of Semi Circular Patch Antenna

FIGURES/ SHAPES OF MICROSTRIP ANTENNA	SUBSTRATE THICKNESS (in mm)	f_L, f_H, f_C (GHz)	FRACTIONAL BANDWIDTH (in %age)	GAIN (in dBi)
 SEMI-CIRCULAR SHAPE	1.6mm	f_H = 2.02203 f_L = 1.75771 f_C = 1.88987	13.98%	3.97
	2.4mm	f_H = 1.61894 f_L = 1.38106 f_C = 1.5	15.85%	3.55
	3.2mm	f_H = 1.9982 f_L = 1.6535 f_C =1.82585	18.84%	3.06
	4.0mm	f_H = 2.7981 f_L = 2.06167 f_C =2.42511	30.24%	4.76

Table 2 demonstrates the consolidated report of the investigations performed on the semicircular patch antenna by varying the substrate thickness along with the impedance bandwidth and the gain.

4. CONCLUSION:

The semicircular patch antenna has been presented in this research article with probe feeding technique. The investigation has been performed by varying both the probe feeding position and the substrate thickness. It is evident from the results that the bandwidth and the gain are increasing as the increase in the substrate thickness is happening. The overall simulation and investigations are performed on IE3D simulation software.

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