Annular Shaped Patch for Lower Band Microwave Frequencies Application

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Abstract:

Shaping of the conductor or any of the other parts of the patch radiators plays important role in changing the working parameters of this type of antennas. In this work Annular, shape has been introduced on the conductor patch. Different dimensions have been introduced on the annular geometry and with a help of a simulation package obtained results are dependable on for application in microwave frequency ranging from 2.5 GHz to 5 GHz. Encouraging values of Bandwidth have been obtained with reasonable output of return loss.

1. Introduction:

Microstrip patch antenna increasingly becoming the most important part in wireless communication arena due to its role of providing efficient transmission and reception of most packages of information data. Research work continues to investigate enhancement on the structures of this type of radiators on any of its main parts; namely the conductive strip, dielectric substrate and the conductive ground plane. Now days enhancements are forwarded to produce patches with enough bandwidth (depending on the application), working at multiband mode and obtaining less insertion loss with acceptable gain level. Any improvement of these parameters are obtained by well-planned intervention on the original dimensions and area of any of the three main parts of the patch mentioned above.

Annular geometry is one of the famous geometrical interventions that can be introduced on any of the main forming parts, on some of them, or on all of them at once. Depending on the chosen material and its range of permittivity, the shape of the annular forming will be introduced; either on simple level of on a more complicated format like a concentric shape.

In this research work, a simple lunar shape on the conductive strip has been used with different status; namely: closed ring, open ring, changed inner diameter or changing of the outer diameter. For the intended application that is mainly forwarded for this antenna to work at lower side of microwave band covering: IMT, Bluetooth and WiMax, obtained bandwidth is sufficient with acceptable return loss. Direct application of the design is feasible and encouraged.

2. Design of the used structure:

This topic of patch structure in general and the annular shape of intervention on the conductive strip is supported by many well-known references as examples [1, 2, 3]. Operating wavelength and frequency are expressed by:

$$\lambda_{gs} = 2\pi R \tag{1}$$

R is the radius of the annular slot.
$\boldsymbol{\lambda_{gs}}$ is the guided wavelength.

$$\lambda_{gs} = \frac{\lambda_o}{\sqrt{\varepsilon_{reff}}} \tag{2}$$

Resonant frequency

$$f_n = \frac{ne_o}{l\sqrt{\varepsilon_{reff}}} \tag{3}$$

Where: n = 1,2,3 for mode number.

Geometry of proposed antenna is as shown in figure 1.

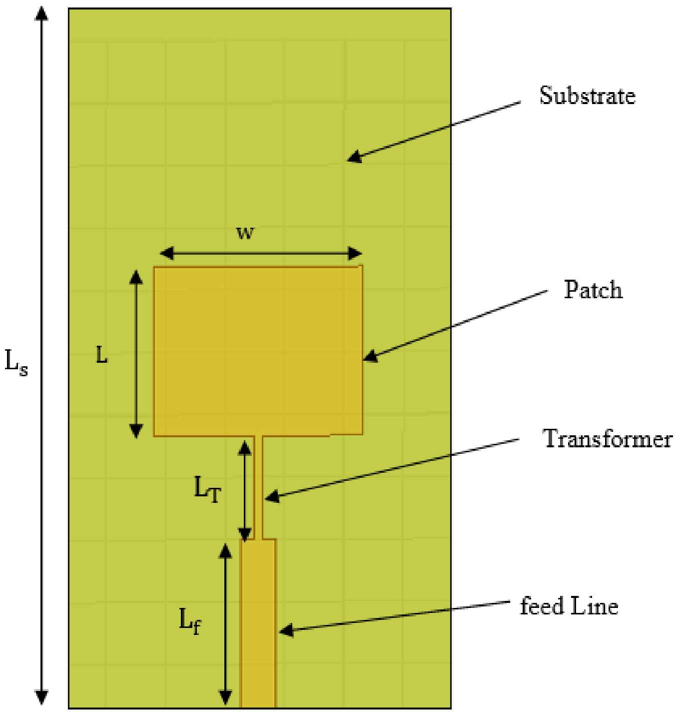


Fig. 1: Shows the geometrical configuration of the proposed patch antenna.

Material used in the structure was FR4 epoxy with relative permittivity $\varepsilon_r = 4.4$, and thickness = 1.6 mm. For the sake of investigations and obtaining results, the structure has been simulated using the HFSS software and different geometry and inclusions have been tried to arrive at suitable bandwidth range for the above-mentioned applications. Next section gives more details and investigations.

3. Simulation, Results and Investigations:

3.1 Designed Single Rectangular Microstrip Patch Antenna

Figure 1 shows the geometrical configuration of the proposed patch antenna, printed on a 1.6 mm FR4-epoxy dielectric substrate of relative permittivity (ε_r) 4.4 and loss tangent (δ) 0.03.. The designed parameters of designed microstrip antenna are given in Table. 1.

Table 1: Parameters of Designed Rectangular Patch Antenna

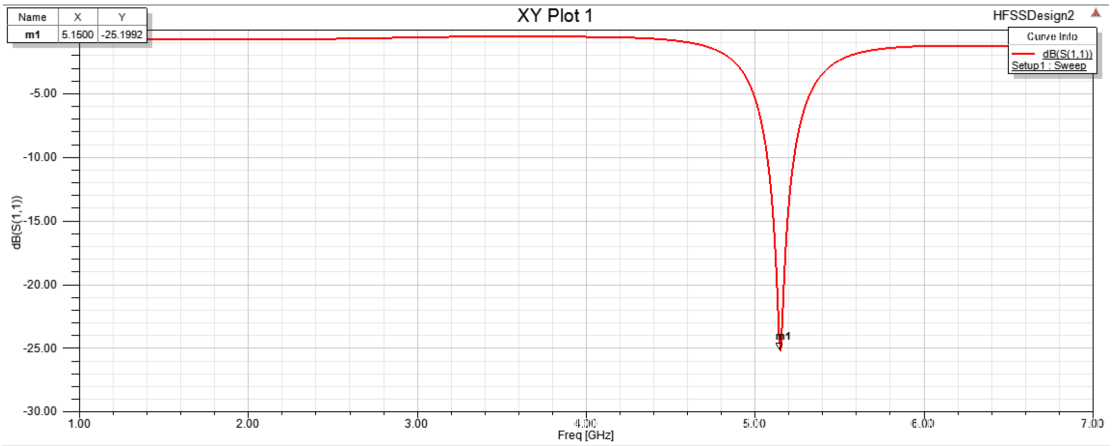
Parameter	Calculations	Optimizations
Material of the Patch	Copper	Copper
Patch Width (W)	17.56mm	16.86mm
Patch length (L)	13.56mm	12.86mm
Width of ground plane (W_g)	27.15mm	35.94mm
Length of ground plane (L_g)	22.79mm	58.94mm
Width of feed Line ($\boldsymbol{W_f}$)	3.059mm	3.059mm
Length of feed Line ($\boldsymbol{L_f}$)	14.896mm	14mm
Width of quarter wave transformer ($\boldsymbol{W_T}$)	0.723mm	0.723mm
Length of quarter wave transformer ($\boldsymbol{L_T}$)	8.294mm	8.294mm
Thickness of the Ground	0.35 μm	0.35 μm

3.1.1 Return Loss

The simulated results of return loss verses frequency curve of designed antenna is shown in Fig. 4.2 from which we can observe that, the antenna resonates at frequency 5.15 GHz which is almost equal to the design frequency of 5.2 GHz with minimum return loss (RL) of -25.199dB and Bandwidth 160MHz.

3.2 Closed ring on the patch

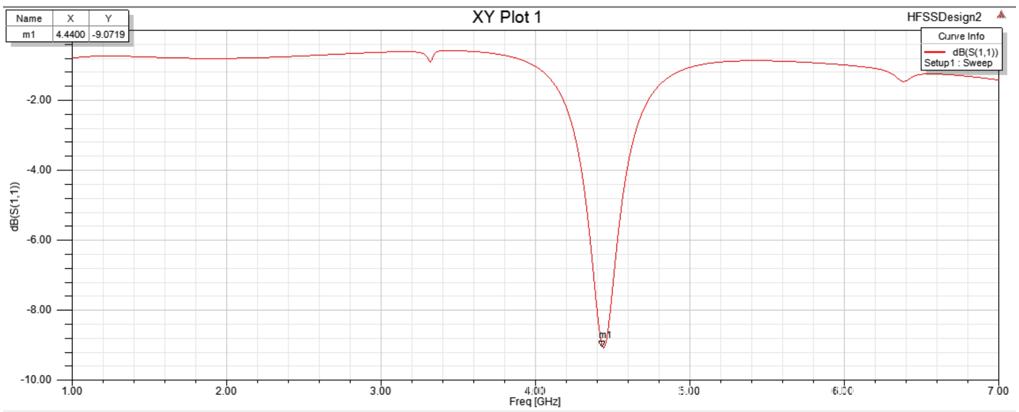
In this part of the design its focus on to adding complete ring slot in center of rectangular microstrip patch antenna (with inure radius $r_{in} = 4\ mm$ and outer radius $r_{out} = 5\ mm$) in the model that was designed in the previous part, since it was the width of this aperture 1mm, the slot using to change the disruption of current in the patch antenna. The geometrical configuration of the microstrip antenna with complete ring slot are shown in the Figure 1. The software used to simulate the proposed antenna is Ansett HFSS 15.0, it can be used to calculate and plot the parameters, Return Loss, Bandwidth of resonance frequency and Gain.



Figز 2: Return Loess of convention patch antenna at 5.15 GHz

3.2.1 Return Loss

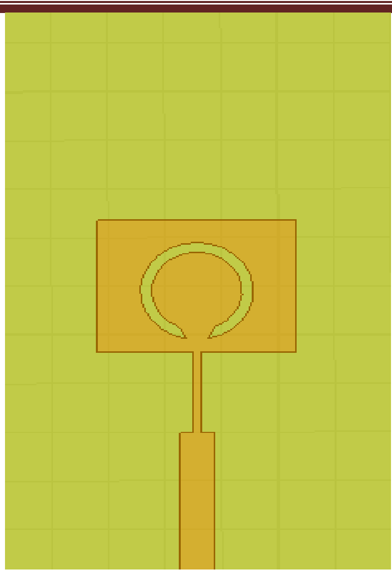
The simulated results of return loss verses frequency curve of designed antenna are shown in Fig.3 from which we can observe that, the antenna has one resonance frequency at 4.44 GHz with return loss RL = -9.07dB.



Figز 3: Return Loess of the antenna with complete ring slot.

3.3 Design Annular Shaped Microstrip Structure - Open Ring

In this part of the design focus on to adding an open ring slot in the center of the rectangular patch antenna with adjustments in the inner and outer ring radius (inner radius $r_{in} = 4.5\ mm$ and outer radius$r_{out} = 5.5\ mm$) instead of adding a complete ring slot, the geometrical configuration of the proposal microstrip antenna with open ring slot the same microstrip antenna complete ring slot, as shown in the Figure 7.



Figز 4: shows the geometrical configuration of the microstrip antenna with open ring slot.

3.3.1 Return Loss and Bandwidth

Figure5 below shows the result of return loss for microstrip antenna with open ring slot with double resonance frequencies, the designed antenna resonates at 2.64 GHz and 4.8 GHz, The return loss for 2.64 GHz is –13.39 dB and the return loss for 4.8 GHz is -25.68 dB, with Bandwidth 35MHz and 117MHz respectively.

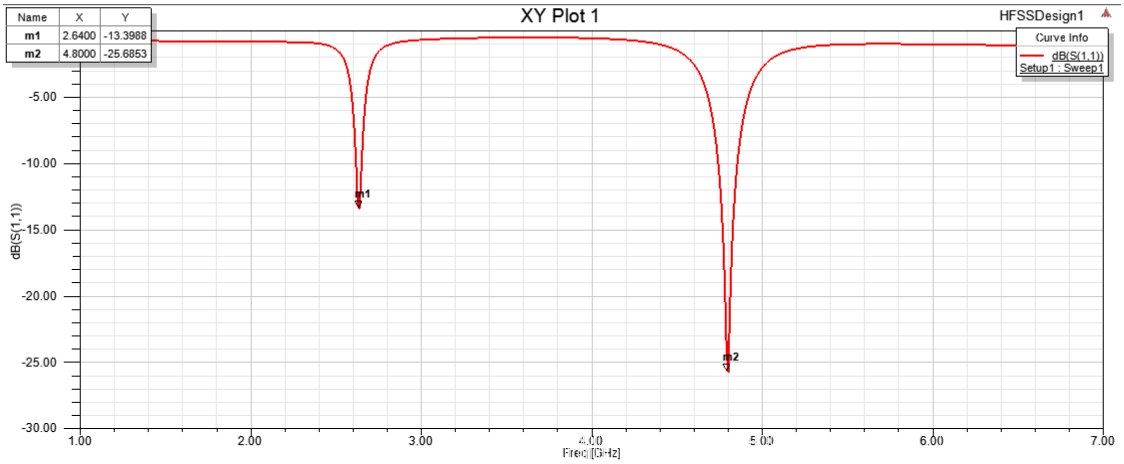


Fig 5: Simulated return Loess of the antenna with open ring slot.

3.3.2 Gain

Figure6 shows the gain = 4.17 dB.

Obtained two resonance frequencies at 2.64 GHz, 4.8 GHz, with improved Return Losses are -13.4 dB, -25.7 dB respectively, acceptable Bandwidth 24MHz, 116MHz and acceptable value of gain 4.18 dB. This design can be used in a WiMAX application and IMT application.

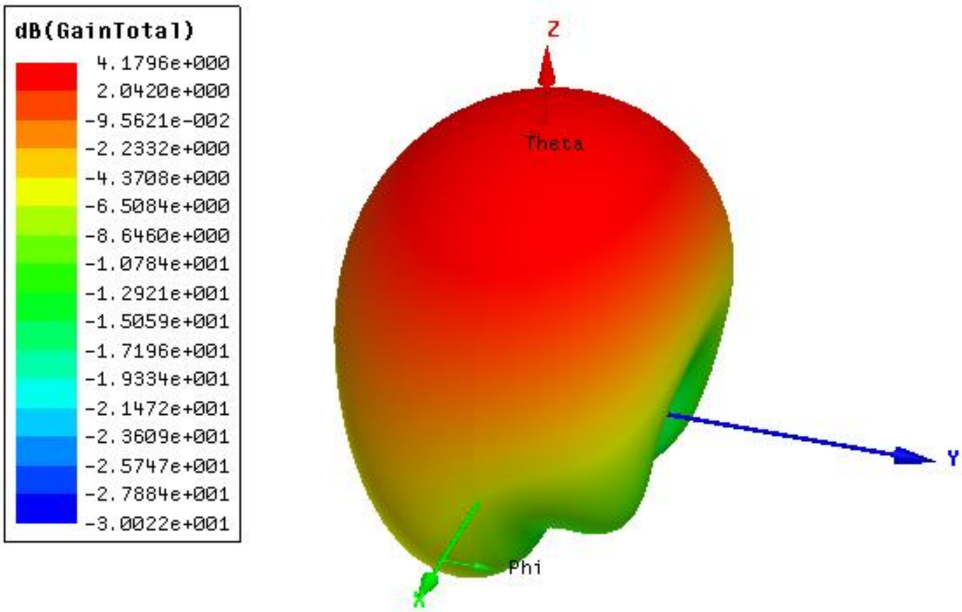


Fig. 6: Gain of the designed proposal antenna.

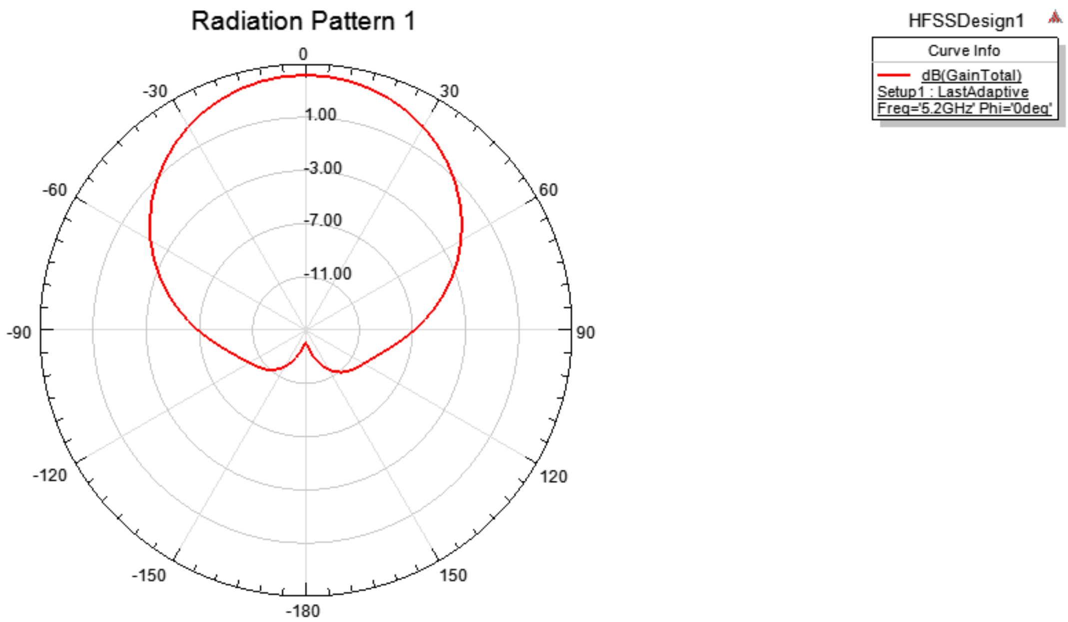


Fig. 7: The Radiation pattern of the antenna.

3.4 Open Ring Structure with changed dimensions

3.4.1 Open ring structure with increased inner dimensions

In this design, the inner radius of the ring was increased to be 4.8mm, while its outer radius is fixed. By using these modifications, two resonance frequencies at 2.57GHz, 4.79GHz have been obtained with Return Losses valued at -13.75dB, -38.87dB respectively with acceptable Bandwidth form 38MHz to 123MHz with gain of 2.67dB.

This design can be used in WiMAX and IMT applications. Figure 13 and 14 shows the obtained results after these modifications.

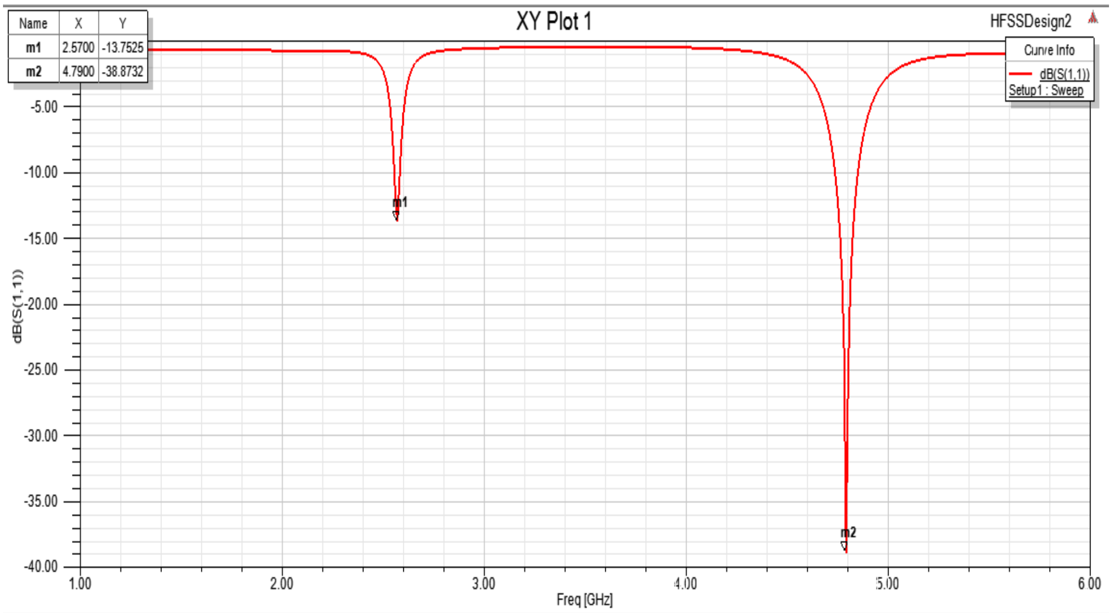


Fig. 8: Simulated return Loess of open ring structure with increased inner dimensions.

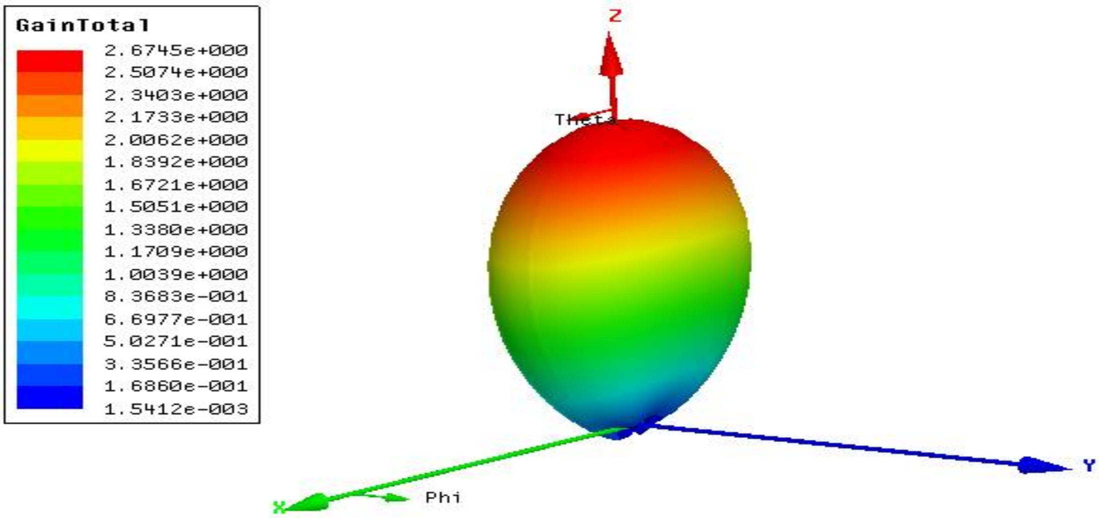


Fig .9: Radiation pattern gain of open ring structure with increased inner dimensions.

3.4.2 Open ring structure with decreased outer dimensions

In this design, the outer radius of the ring was decreased to be 5.2mm, while its inner radius is fixed. By using these modifications, two resonance frequencies at 2.78GHz, 4.88GHz have been obtained with Return Losses valued at -17.05dB, -29.7dB respectively with acceptable Bandwidth form 34MHz to 104MHz with gain of 4.64dB.

This design can be used only in IMT application. Figure 15 and 16 shows the obtained results after these modifications.

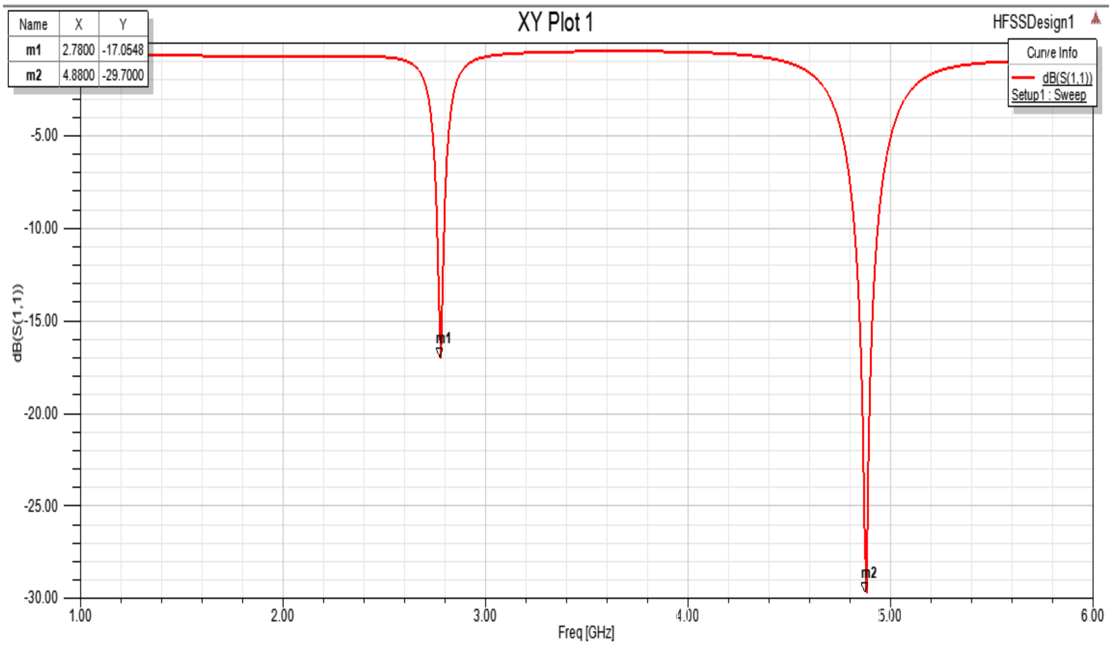


Fig. 10: Radiation pattern gain of open ring structure with decreased outer dimensions.

4. Conclusions

An annular structured patch antenna has been designed and simulated. Different annular ring dimensions have been investigated and tested. Sufficient bandwidth values are obtained and return loss at practical level.

5. References

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