



# DESIGN AND PERFORMANCE ANALYSIS OF A RMPA WITH VARIOUS SLOTS FOR SATELLITE COMMUNICATION

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**Abstract:** The compact design, low cost, and ease of production of microstrip patch antennas make them appealing for use in satellite communication applications. Using High Frequency Structure Simulator (HFSS), the fundamental theory and design of the antenna are examined, simulated, and optimized. Thus, the goal of this work is to improve a microstrip antenna's efficiency and bandwidth for RMPA antenna. By adding slot to different RMPA patch design antenna efficiency, Directivity and gain is compared and performance improvement is achieved. In this project, a rectangular microstrip patch antenna measuring 25 mm x 30 mm x 1.6 mm was designed and simulated. With a return loss of -12.7656 dB, the antenna's frequency bandwidth is 0.1608 GHz (4.2088 GHz – 4.3696 GHz), centered at 4.3 GHz. Glass epoxy substrate (FR4 epoxy) with a dielectric constant of  $\epsilon_r = 4.4$  has been used to design the suggested rectangular patch antenna. The suggested work by demonstrating that the slot improves the antenna performance and that the return loss is considerably compared to the antenna's gain, radiation efficiency, and directivity is done using the (HFSS) to obtain the desired outcomes.

**Keywords:** ANSYS HFSS (high-frequency structure simulator), FSS (Fixed Satellite Service), MSS (Mobile Satellite Service), VSWR (Voltage Standing Wave Ratio), RMPA (Rectangular Microstrip Patch Antenna), RF (Radio Frequency), rE (Radiation Efficiency), S-Parameters (Scattering Parameters).

## 1. INTRODUCTION

The antennas of a wireless communication system are vital parts. They have the power to convert any type of signal into waves that, when transmitted wirelessly, may go farther. Transmitted signals are received via a signal-receiving antenna. The data or information is sent using EMF waves. The reciprocal process feature of the reception antenna converts these electromagnetic waves into a signal or voltage that is delivered as input to the other end of a communication system. Radiation properties are the antenna's primary purpose. Transmission line is what makes this. A transmission line that maintains a constant speed while conducting current does not radiate power, nor does an infinitely long straight line. Microstrip patch antennas are becoming more and more common in wireless communications.

## 2. OBJECTIVES

The main objectives of this project are as follows.

- To develop a high-performance antenna for satellite communication resonated frequency at 4.3 GHz.
- To design various shape slots on Rectangular microstrip patch antennas, and optimize the Return Loss, VSWR and Band Width.
- To compare the performance of the antenna with parameters of Gain, Radiation efficiency and directivity.
- To enhance the overall communication and data transmission capabilities in satellite communication.

## 3. NECESSITY OF THE DESIGN

A patch antenna is the most often used kind of microstrip antenna. It is also possible to create antennas that use patches as constituent elements within an array. An insulating dielectric substrate, like a printed circuit board, is attached to the antenna element pattern of a patch antenna, which is a narrowband, wide-beam antenna, by etching it. A continuous metal layer is bonded to the opposite side of the substrate, forming a ground plane. While square, rectangular, circular, and elliptical are the most common forms for microstrip antennas, any continuous shape can be used. Some patch antennas are constructed from a metal patch placed atop a ground plane utilizing dielectric spacers rather than a dielectric substrate; this results in a less durable structure.

### Satellite Frequency Band Applications

Band spectrum	Frequency range	Type of satellite service
L Band	1.518-1.675 GHz	MSS (Mobile Satellite Service)
S Band	1.97 - 2.69 GHz	MSS
C Band	3.4GHz - 7.025 GHz	FSS (Fixed Satellite Service)
X Band	7.25 - 8.44 GHz	FSS

In the electromagnetic spectrum, the 4GHz–8GHz frequency region reserved for satellite communications is referred to as the "C-band." C-band satellite antennas are commonly used in regions of the world where heavy rain or other harsh weather conditions might impair communications. C-band satellite antennas are typically between 1.8 and 2.4 meters in size. Rain attenuation has less of an impact on C-band satellite communications, even though they are mostly used in Asia, Africa, and Latin America and require larger antennas.

## 4. SOFTWARE REQUIREMENT

The antenna design process is carried out using the ANSYS High Frequency Structure Simulator (HFSS) tool. It is a 3D simulation tool that may be used with antennas and antenna arrays, which are high frequency electronic components. This software program has global applications in wireless communication, Internet of things devices, radar applications, and satellite communication. It provides solutions for 3D EM design issues. comprehensive analysis and delivers accuracy that is assured. For a precise analysis, the parameters required to examine the antenna can be seen in 2D and 3D models.

## 5. DESIGN METHODOLOGY

The methodology section outlines the plan and method that how the study is conducted. This includes Universe of the study, sample of the study, Data and Sources of Data, study's variables and analytical framework. The details are as follows;

### 5.1 Feeding Techniques

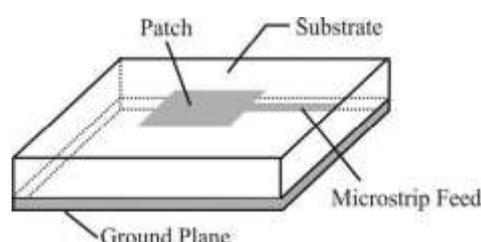


Fig.1 Microstrip Patch Antenna Feeding Techniques

The fundamental procedure (Fig. 1) for connecting the transmitter and receiving antennas so they may exchange information is called feeding. The feeding is produced within the same range since the antenna runs at a radio frequency. Radio frequency transmissions are used by the antennas to communicate with one another.

### 5.2 Edge Feed Technique

A feed line that joins the radiating patch with the substrate's external edge feed provides this feeding. The radiating patch and the feed element's width are less than one another thanks to the design. The edge of the microstrip patch is immediately attached to a conducting strip during this feeding operation. One advantage of this feeding approach is that it allows the conducting line to be carved on the patch antenna's substrate, giving it a planar shape. Comparing the conducting element to the patch antenna, the former has a narrower width.

### 5.3 Design Equation for Rectangular Patch Antenna

For use in a 4.3 GHz satellite communication application, a rectangular microstrip antenna was developed. The substrate used in the proposed rectangular patch antenna is FR4, with a height of 1.6 mm and a dielectric equal to  $\epsilon_r = 4.4$ . The frequency at which this microstrip antenna operates is 4.3 GHz. The following are the fundamental stages involved in creating a rectangular patch antenna (RPA):

A parameter Width of the radiating RPA is computed from this equation:

$$W = \frac{C}{2f_o} \sqrt{\frac{2}{\epsilon_r + 1}} \quad (1)$$

Where:

C: Velocity of light,  $3 \times 10^8$  m/s,

$\epsilon_r$ : dielectric constant of the substrate.

$f_o$ : resonant frequency of antenna

Effective Dielectric constant of the RPA is determined as:

$$\epsilon_{eff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[ \frac{1}{\sqrt{1 + \frac{2h}{W}}} \right] \quad (2)$$

The effective length is specified at the resonance frequency.

$$L_{eff} = \frac{C}{2fr\sqrt{\epsilon_{eff}}} \quad (3)$$

Extension length of the RPA compute with this equation

$$\Delta L = h \times 0.412 \times \frac{(\epsilon_{eff} + 0.3) \left( \frac{W}{h} + 0.264 \right)}{(\epsilon_{eff} - 0.258) \left( \frac{W}{h} + 0.8 \right)} \quad (4)$$

The length "L" of the RPA is calculated as:

$$L = L_{eff} - 2\Delta L \quad (5)$$

The proposed rectangular patch antenna is designed using electromagnetism simulation software HFSS.

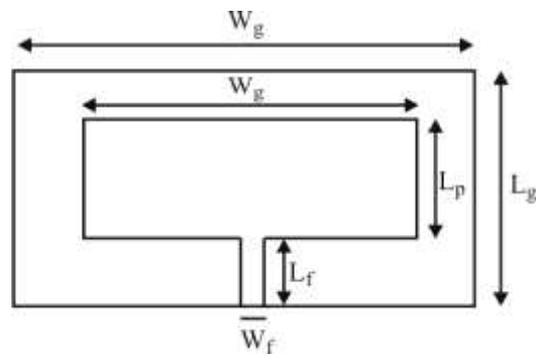


Fig.2 Schematic of Antenna Design

#### 5.4 Design Calculation for Microstrip Patch Antenna For 4.3 GHz.

$$C = 3 \times 10^8$$

$$\epsilon_r = 4.4 \text{ FR}_4$$

$$h = 1.6 \text{ mm}$$

$$f_o = 4.3 \text{ GHz.} = 4.3 \times 10^9 \text{ Hz}$$

Width of Patch

$$\begin{aligned} \omega &= \frac{C}{2f_o \sqrt{\frac{\epsilon_r + 1}{2}}} \\ &= \frac{3 \times 10^8}{2 \times 4.3 \times 10^9 \sqrt{\frac{4.4 + 1}{2}}} \\ &= 21.2304 \end{aligned}$$

$$\begin{aligned} \epsilon_{eff} &= \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[ 1 + 12 \left( \frac{h}{w} \right) \right]^{-\frac{1}{2}} \\ &= \frac{4.4 + 1}{2} + \frac{4.4 - 1}{2} \left[ 1 + 12 \left( \frac{1.6}{21.23} \right) \right]^{-\frac{1}{2}} \end{aligned}$$

$$\epsilon_{eff} = 3.93192$$

$$\begin{aligned} L_{eff} &= \frac{C}{2f_o \sqrt{\epsilon_{eff}}} = \frac{3 \times 10^8}{2 \times 4.3 \times 10^9 \sqrt{3.93192}} \\ &= 17.5922 \text{ mm} \end{aligned}$$

$$\begin{aligned} \Delta L &= \frac{0.412h(\epsilon_{eff} + 0.3) \left( \frac{W}{h} + 0.264 \right)}{(\epsilon_{eff} - 0.258) \left( \frac{W}{h} + 0.8 \right)} \\ &= \frac{0.412 \times 1.6 (3.93192 + 0.3) \left( \frac{21.23}{1.6} + 0.264 \right)}{(3.93192 - 0.258) \left( \frac{21.23}{1.6} + 0.8 \right)} \end{aligned}$$

$$\Delta L = 0.7303911$$

Length of Patch

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

$$= 17.59 - 2(0.7303911)$$

$$L = 16.12922$$

## Width of Substrate

$$\begin{aligned}\omega_s &= 6h + \omega \\ &= 6(1.6) + 21.2304 \\ \omega_s &= 30.8304\end{aligned}$$

## Length of Substrate

$$\begin{aligned}LS &= 6h + L \\ &= 6(1.6) + 16.12922 \\ LS &= 25.72922\end{aligned}$$

## Ground Dimensions

$$\begin{aligned}L_g &= L + 6h \\ &= 16.12922 + 6(1.6) \\ L_g &= 25.72922 \\ \omega_g &= \omega + 6h \\ &= 21.2304 + 6(1.6) \\ \omega_g &= 30.8304\end{aligned}$$

## Feed Length

$$\begin{aligned}L_f &= \frac{\lambda_g}{4} \\ \lambda_g &= \frac{\lambda}{\epsilon_{eff}} \\ \lambda &= \frac{C}{f} = \frac{3 \times 10^8}{4.3 \times 10^9} = 0.069767 \\ \lambda_g &= \frac{0.069767}{3.93192} = 0.017743 \\ L_f &= \frac{\lambda_g}{4} = \frac{0.017743}{4} = 0.004435 \\ L_f &= 4.435 \text{ mm}\end{aligned}$$

Table 1: Dimensions of Simulated Antenna

Name of the parameters	Length (mm)
Length of Substrate (Ls)	25.72mm
Width of Substrate (Ws)	30.83mm
Length of Patch (Lp)	16.129mm
Width of Patch (Wp)	21.23mm
Height of Substrate (Hs)	1.6mm
Length of Feedline (Lf)	4.43mm
Width of Feedline (Wf)	2mm
Width of Ground (Wg)	30.83mm
Length of Ground (Lg)	25.72mm

## 6. ANTENNA SIMULATION

A RMPA consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side. The patch is generally made of conducting copper and substrate made of FR4 material. Fig. 3 shows the Design of proposed Antenna.

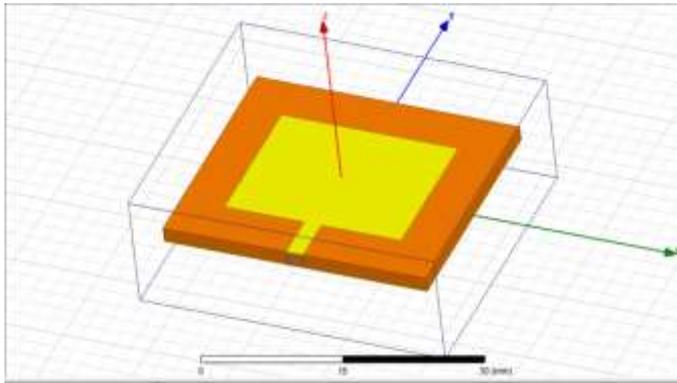


Fig. 3 Design of the Antenna

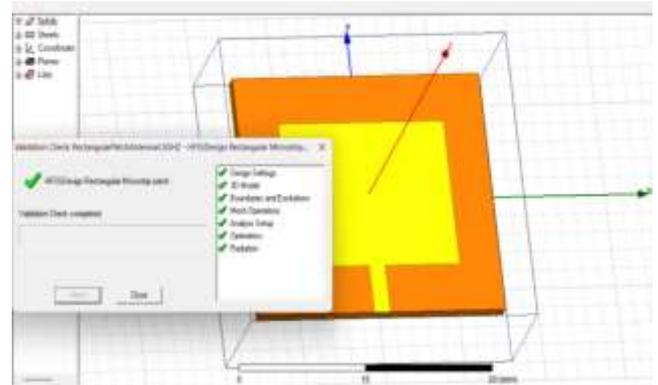


Fig. 4 Validation Check of the Antenna

Fig. 4 shows the Validation Check to verify that all Design Settings, 3D Model, Boundaries and Excitations, Mesh Operations, Analysis Setup, Optometric and Radiation have been completed.

### 6.1 Simulation Results

#### 6.1.1 S-Parameters (Scattering Parameters):

S-parameters are used to describe how an electrical network (such as an antenna or a network of components) responds to signals at different frequencies. There are various S-parameters, such as  $S_{11}$ ,  $S_{12}$ ,  $S_{21}$ ,  $S_{22}$ , which describe the input/output relationships and signal reflections.

$S_{11}$  Plot S-Parameter is very important in determining the performance of the antenna.  $S_{11}$  determines the return loss of the antenna i.e The amount of input power reflected back is measured by  $S_{11}$ . Ideally  $S_{11}$  is expected to be infinitely negative. But practically it never reaches negative infinity and a design with high  $S_{11}$  in negative direction is the best one.

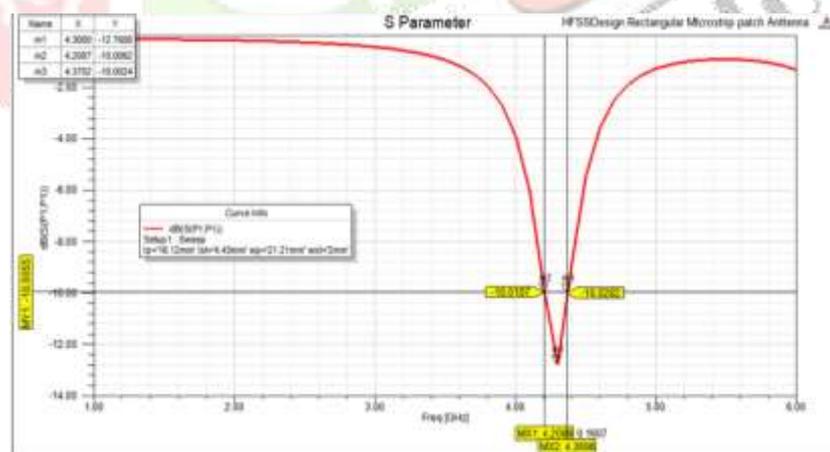


Fig 5 Output of the Antenna S Parameter

### 6.1.2 Voltage standing wave ratio (vswr):

The value of VSWR should not be less than 1 and not more than 2. In the ideal case, it is 1. Figure 6, which plots the value of VSWR against frequency, shows that the value of 1.5974 is achieved at 4.3 GHz. The following antenna has a frequency coverage range of 4.2087 GHz to 4.3702 GHz.

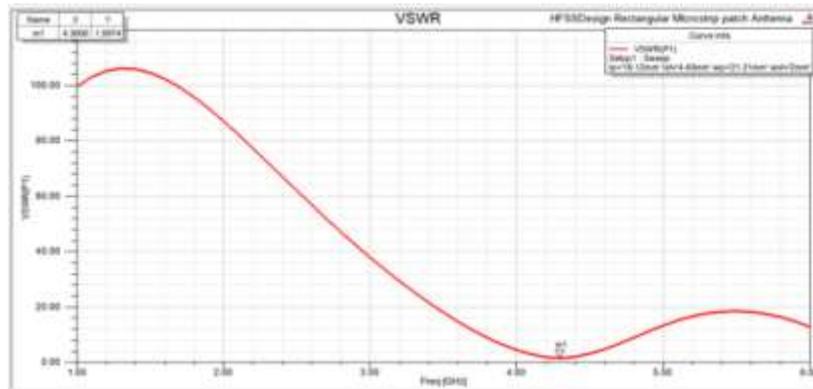


Fig. 6 Output of the Antenna VSWR

### 6.1.3 Gain Plot:

A gain plot shows the gain of an antenna or a system over a range of frequencies. It provides information about the amplification or attenuation of signals at different frequencies. Figure 7, which shows the antenna's three-dimensional Gain patterns, shows that the antenna's Gain total is 1.8967dB.

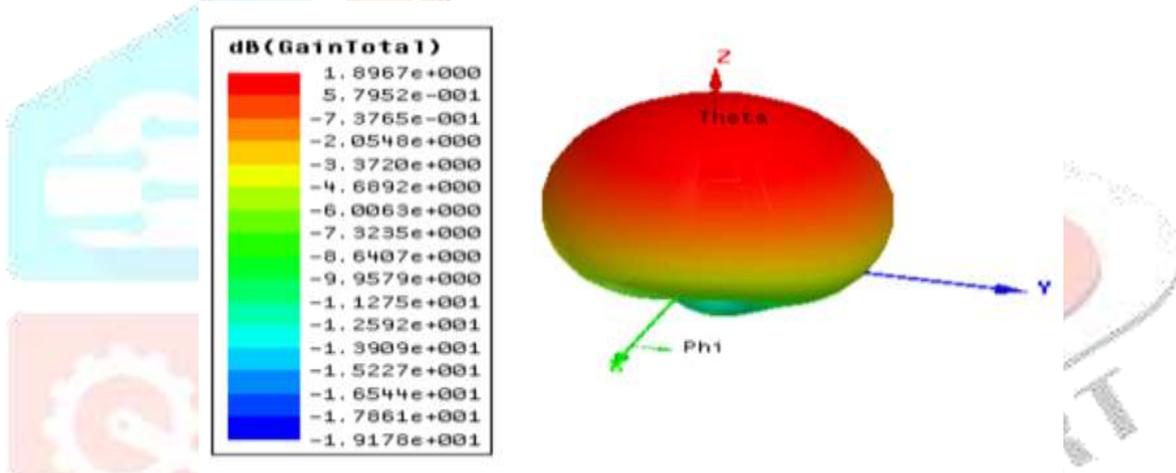


Fig. 7 Output of the Antenna Gain plot.

### 6.1.4 Radiation Efficiency (rE):

Radiation efficiency is a measure of how well an antenna converts input power into radiated electromagnetic energy. It considers losses in the antenna structure and is expressed as a percentage. Figure 8, which shows the antenna's three-dimensional radiation Efficiency patterns, shows that the antenna's radiation Efficiency is 19.442 dB.

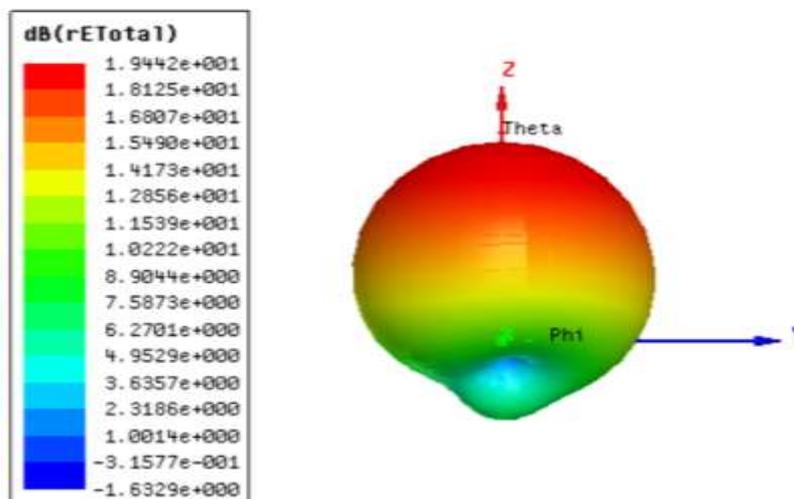


Fig. 8 Output of the Antenna rEplot

### 6.1.5 Directivity Plot:

A directivity plot shows how the directivity of an antenna (the ability to focus energy in a particular direction) varies with frequency.

Directivity is a fundamental antenna parameter. It is a measure of how 'directional' an antenna's radiation pattern is. An antenna that radiates equally in all directions would have effectively zero directionality, and the directivity of this type of antenna would be 1 (or 0 dB). Figure 9, which shows the antenna's three-dimensional Directivity patterns, shows that the antenna's Directivity Total is 3.57dB.

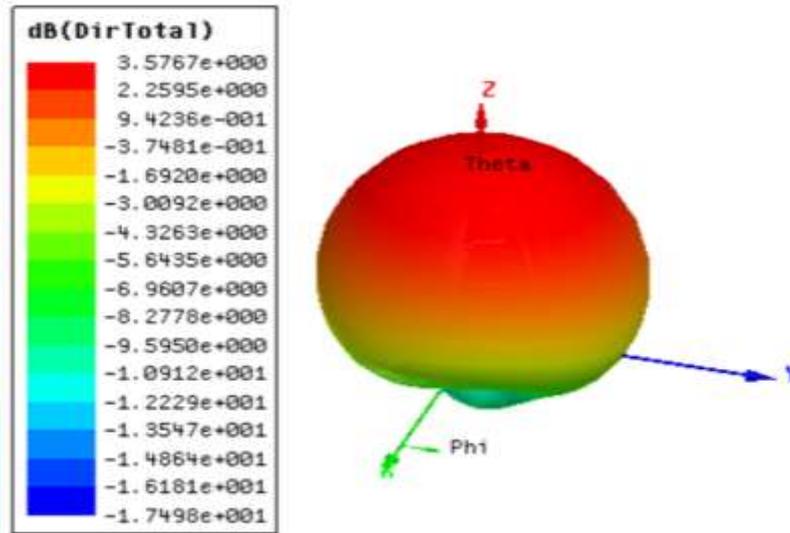


Fig. 9 Output of the Antenna Directivity plot

## 7. RMPA WITH VARIOUS SLOT

### 7.1 RMPA with Circle Slot

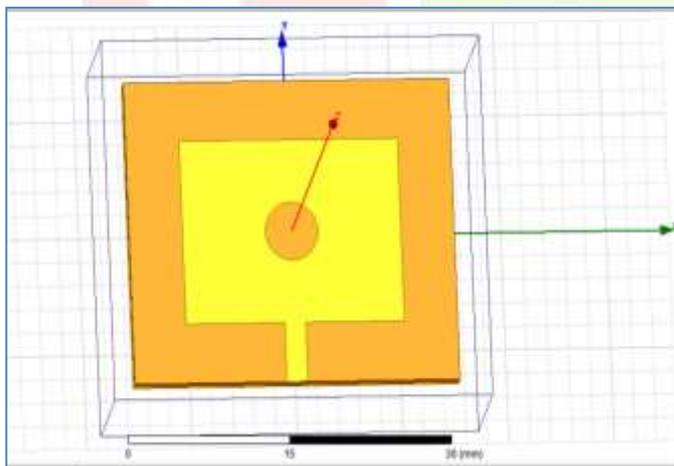


Fig. 10 Design of Rectangular patch with circle slot

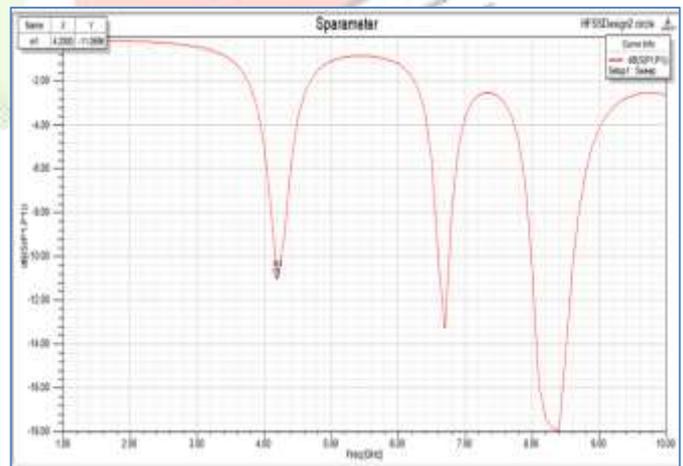


Fig. 11 Output of the Antenna S Parameter with circle slot

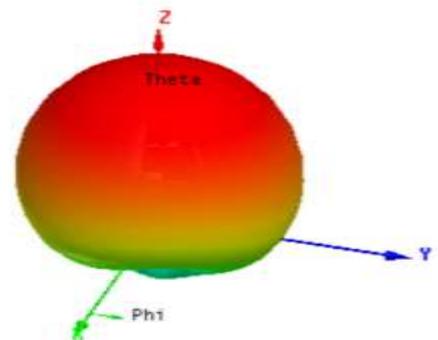
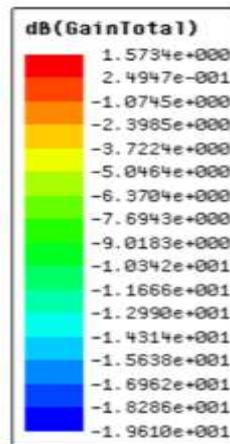
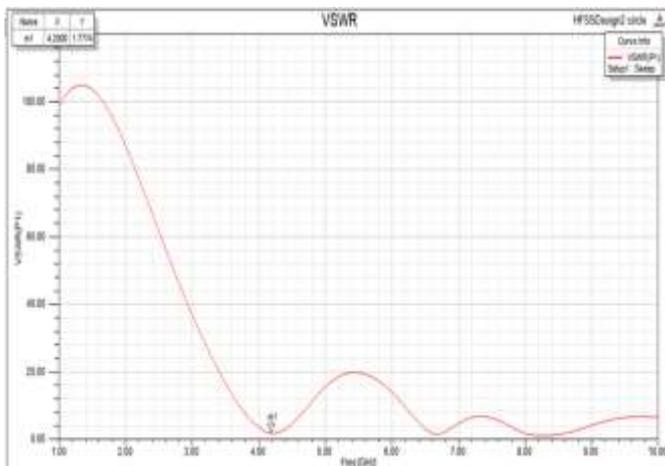


Fig. 12 Output of the Antenna VSWR with circle slot

Fig. 13 Output of the Antenna Gain plot

with circle slot

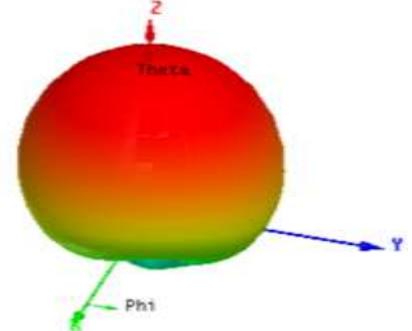
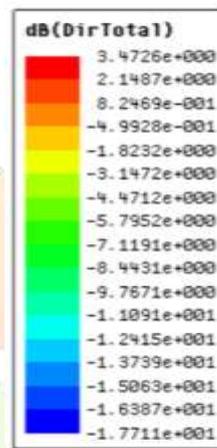
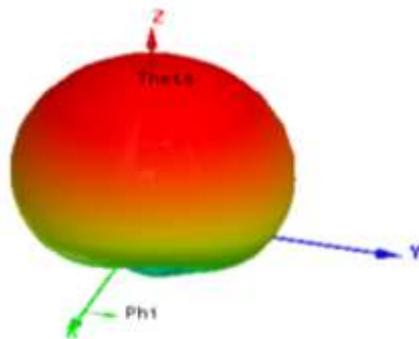
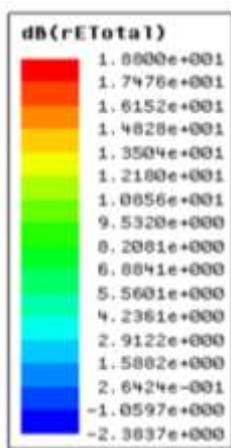


Fig. 14 Output of the Antenna rEplot with circle slot  
Directivity plot with circle slot

Fig. 15 Output of the Antenna

### 7.2 RMPA with Circle Ring Slot

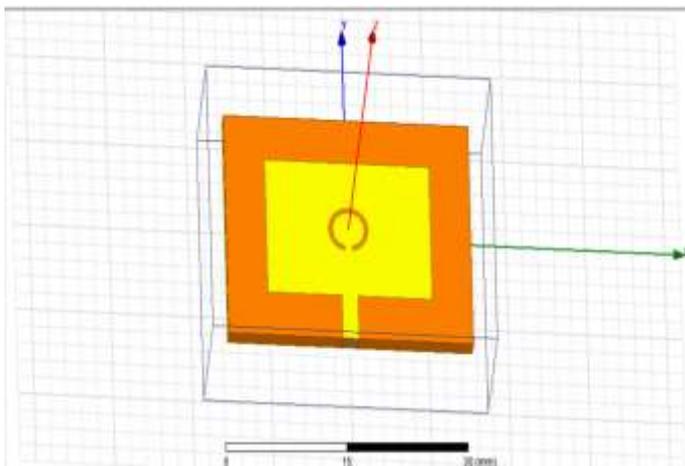


Fig. 16 Design of Rectangular patch with circle ring slot with circle ring slot

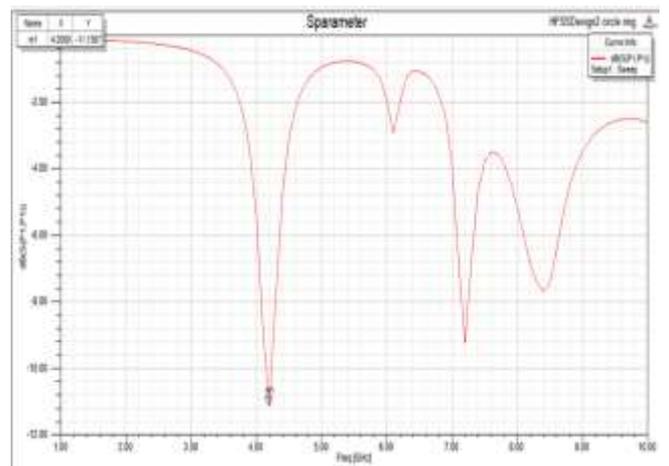


Fig. 17 Output of the Antenna S Parameter

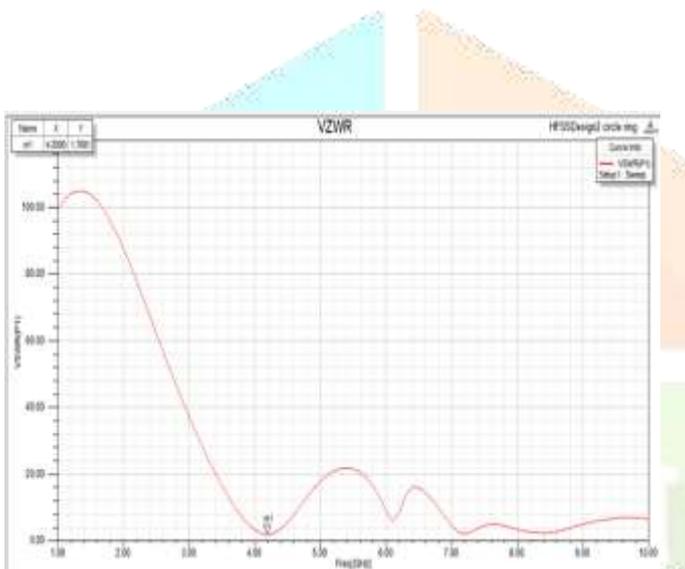


Fig. 18 Output of the Antenna VSWR with circle ring slot plot with circle ring slot

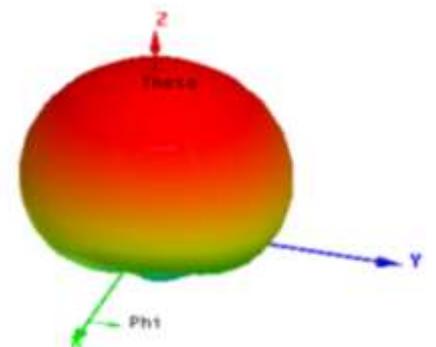
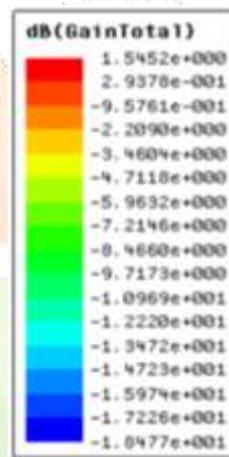


Fig. 19 Output of the Antenna Gain

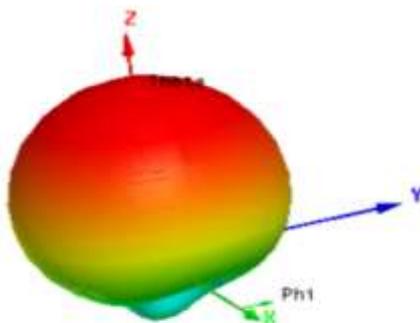
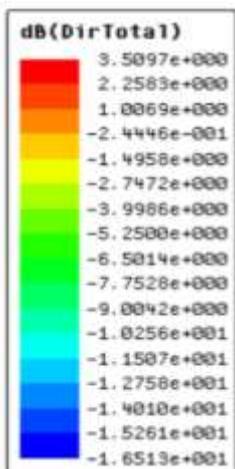


Fig. 20 Output of the Antenna Directivity plot with circle ring slot rEplot with circle ring slot

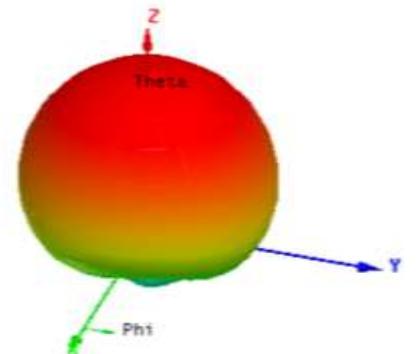
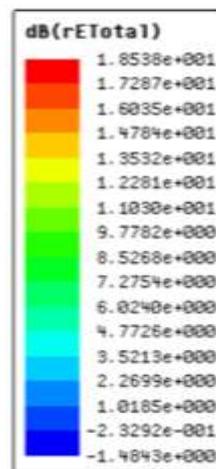


Fig. 21 Output of the Antenna

### 7.3 RMPA with Triangle Slot

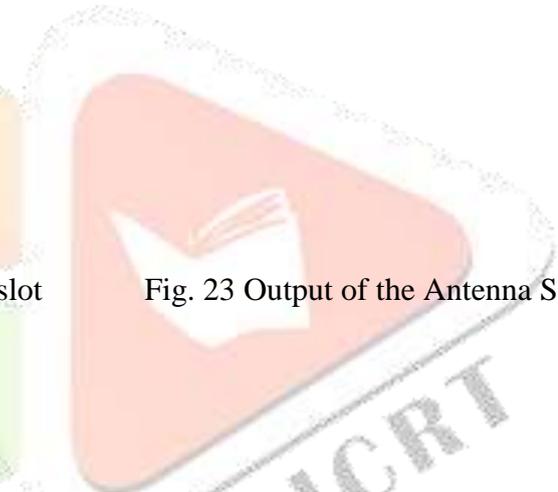
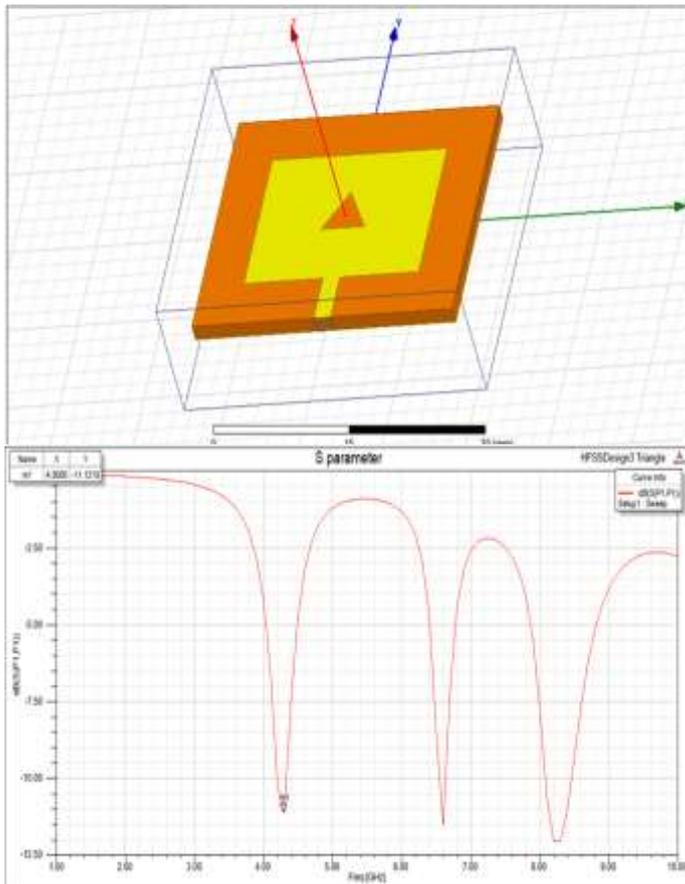


Fig. 22 Design of Rectangular patch with Triangle slot with Triangle slot

Fig. 23 Output of the Antenna S Parameter

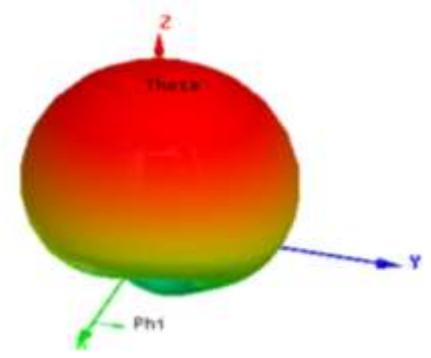
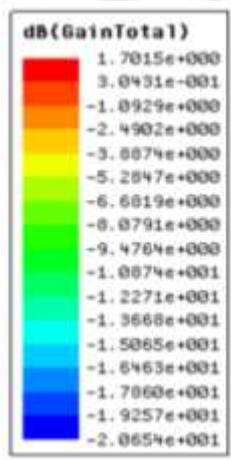
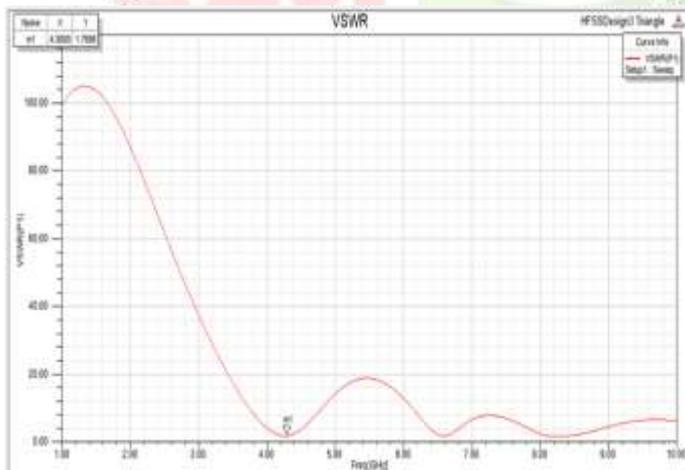


Fig. 24 Output of the Antenna VSWR with Triangle slot with Triangle slot

Fig. 25 Output of the Antenna Gain plot

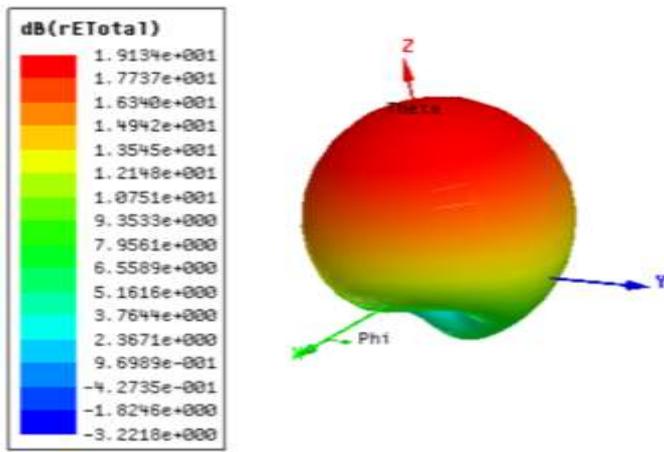


Fig. 26 Output of the Antenna rEplot with Triangle slot

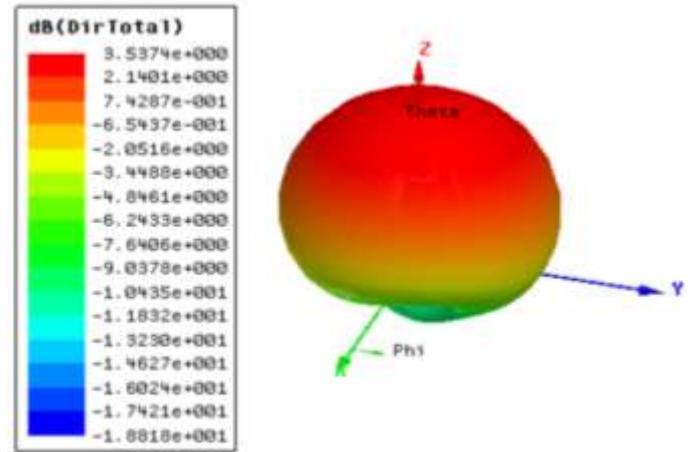


Fig. 27 Output of the Antenna Directivity plot with Triangle slot

### 7.4 RMPA with Triangle Ring Slot

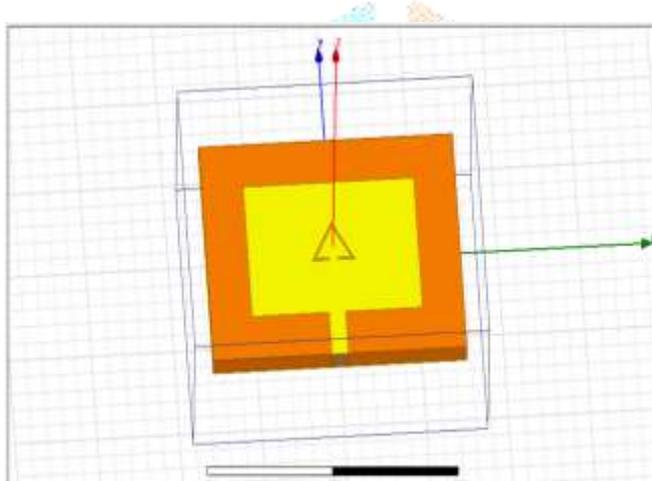


Fig. 28 Design of Rectangular patch with Triangle ring slot

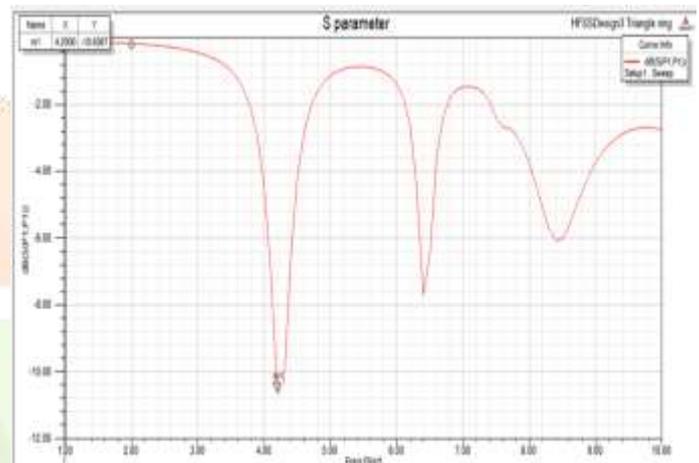


Fig. 29 Output of the Antenna S Parameter with Triangle ring slot

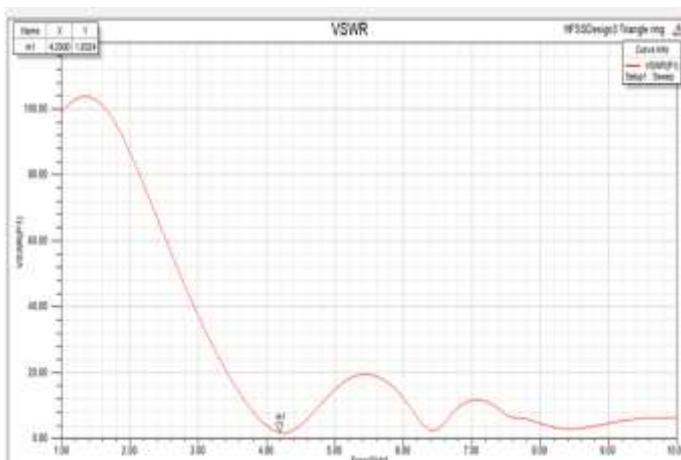


Fig. 30 Output of the Antenna VSWR with Triangle ring slot

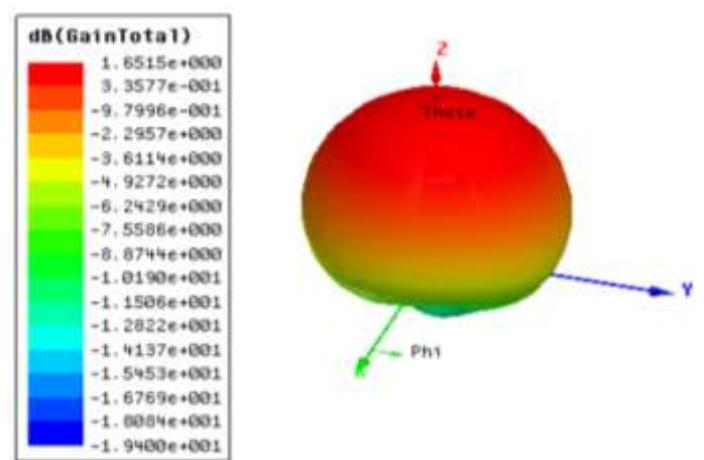


Fig. 31 Output of the Antenna Gain plot with Triangle ring slot

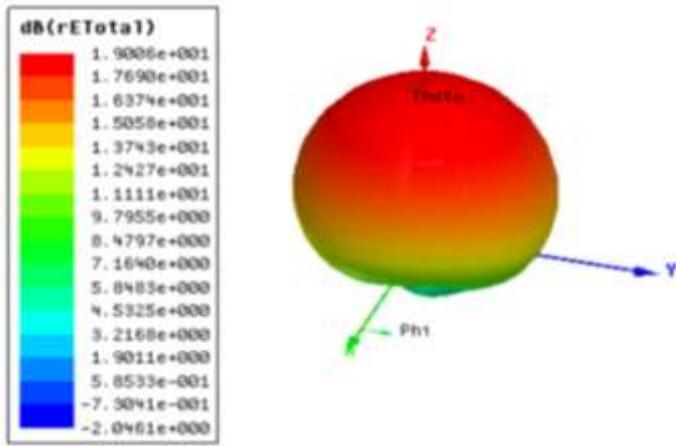


Fig. 32 Output of the Antenna rEplot with Triangle ring slot Directivity plot with

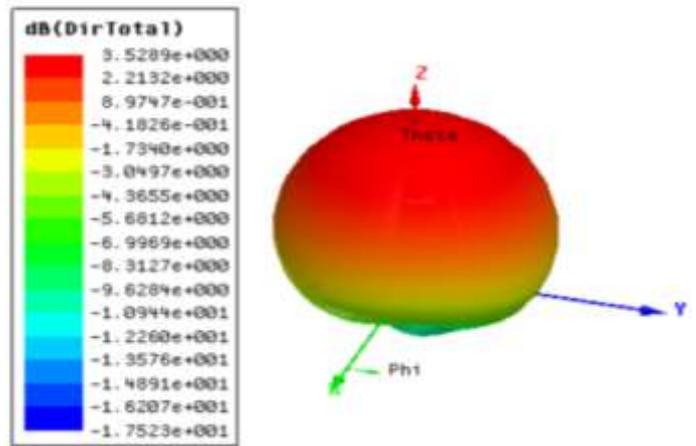


Fig. 33 Output of the Antenna Directivity plot with Triangle ring slot

### 7.5 RMPA with Square Slot

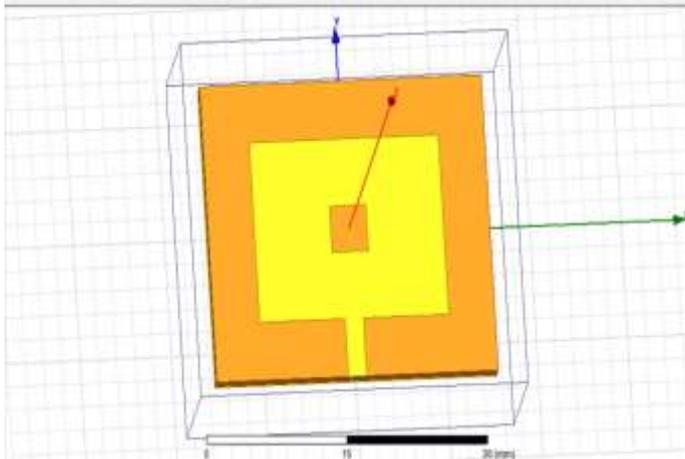


Fig. 34 Design of Rectangular patch with Square slot Parameter with square slot

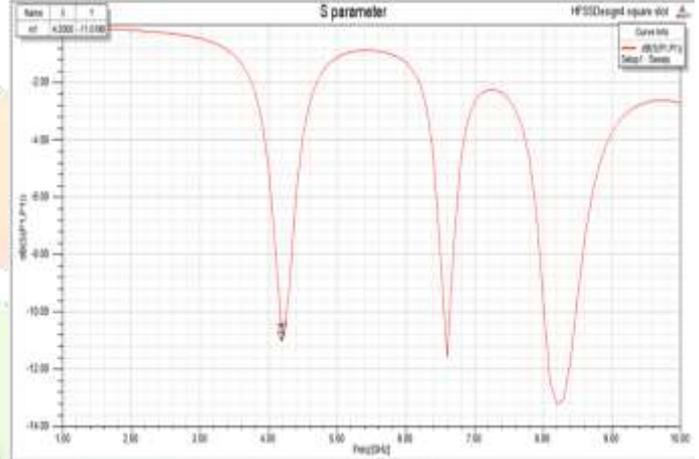


Fig. 35 Output of the Antenna S Parameter with square slot

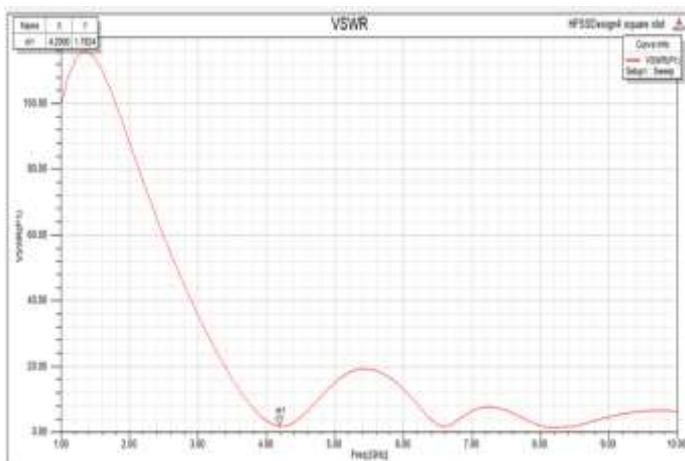


Fig. 36 Output of the Antenna VSWR with Square slot plot with square slot

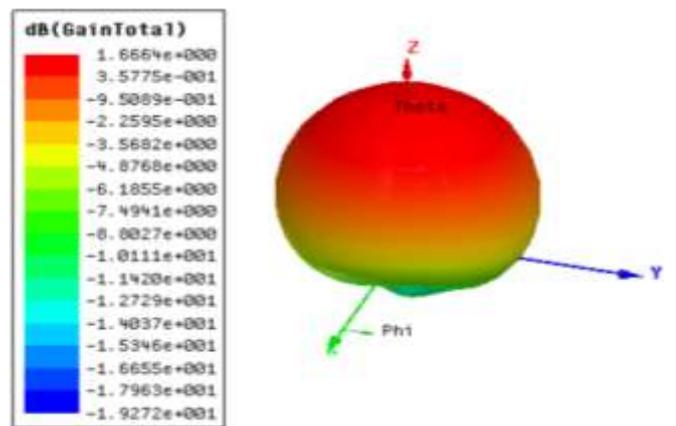


Fig. 37 Output of the Antenna Gain plot with square slot

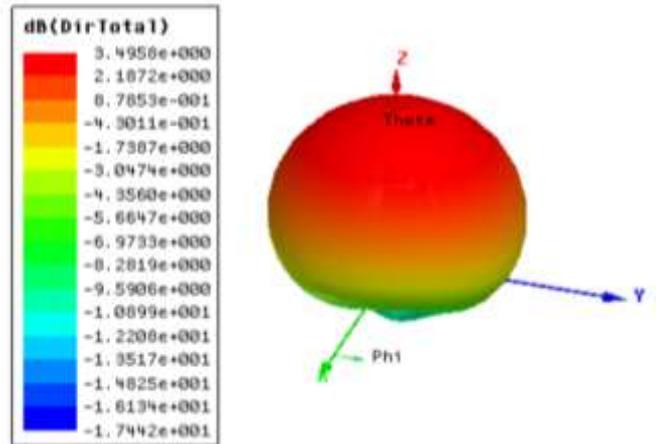
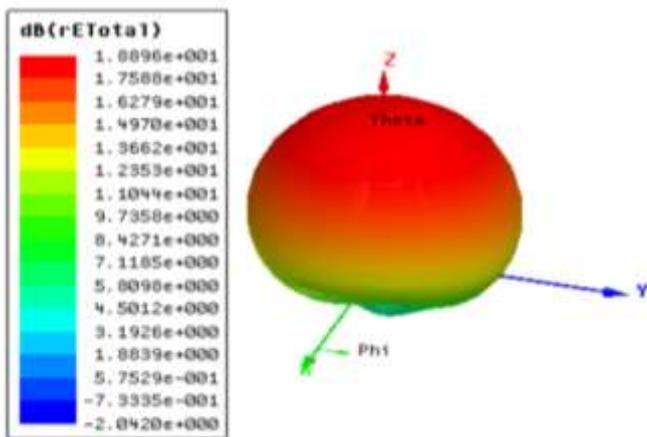


Fig. 38 Output of the Antenna rEplot with Square slot Directivity plot with Square slot

Fig. 39 Output of the Antenna



### 7.6 RMPA with Square Ring Slot

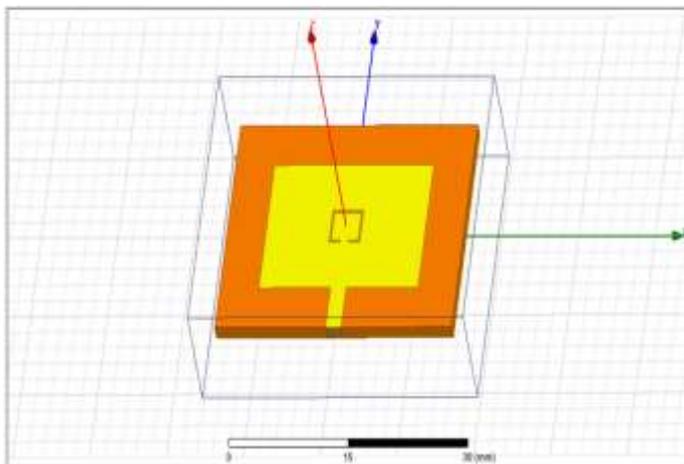


Fig. 40 Design of Rectangular patch with Square ring slot with square ring slot

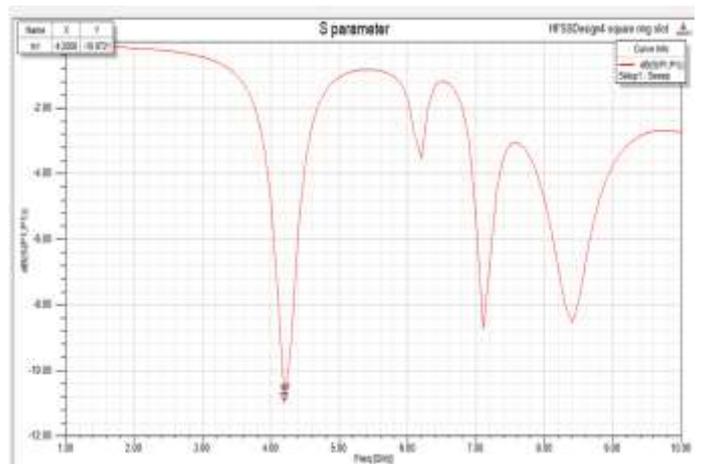


Fig. 41 Output of the Antenna S Parameter

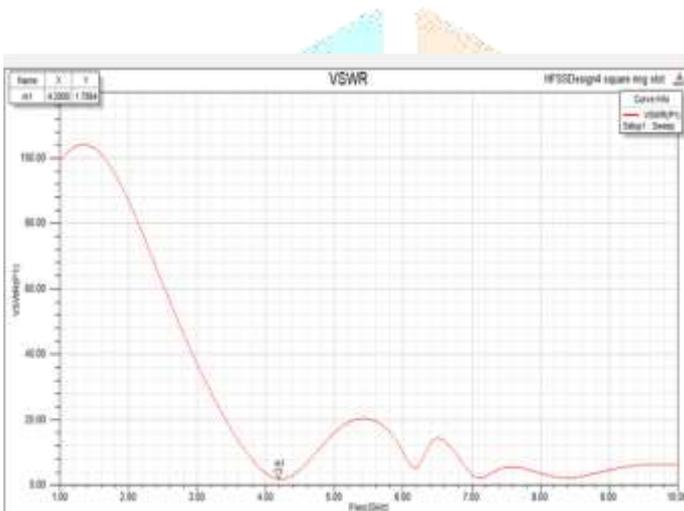


Fig. 42 Output of the Antenna VSWR with square ring slot with square ring slot

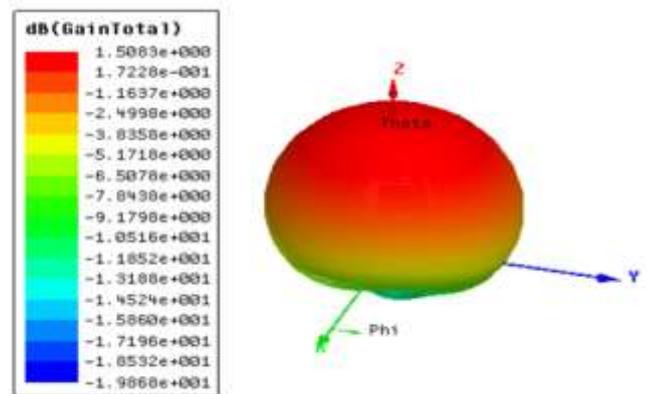


Fig. 43 Output of the Antenna Gain plot

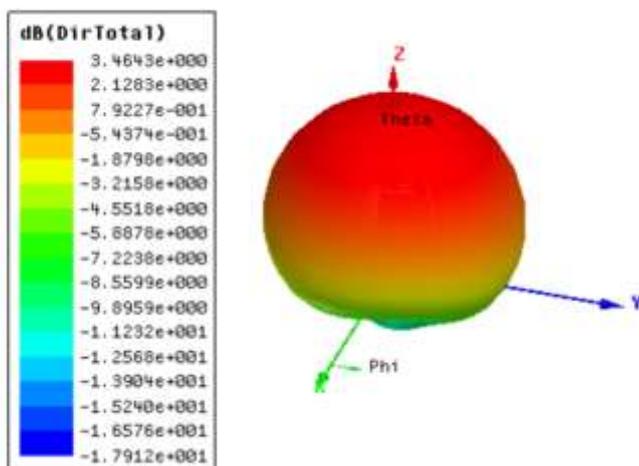


Fig. 44 Output of the Antenna Directivity plot with Square ring slot

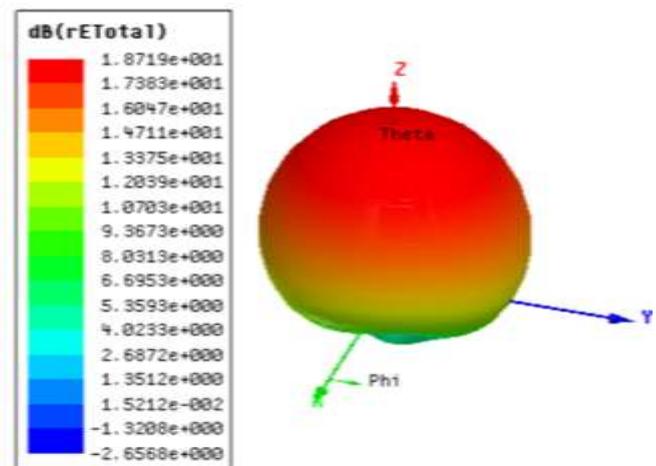


Fig. 45 Output of the Antenna rEplot with square ring slot

### 7.7 RMPA with Rectangle Slot

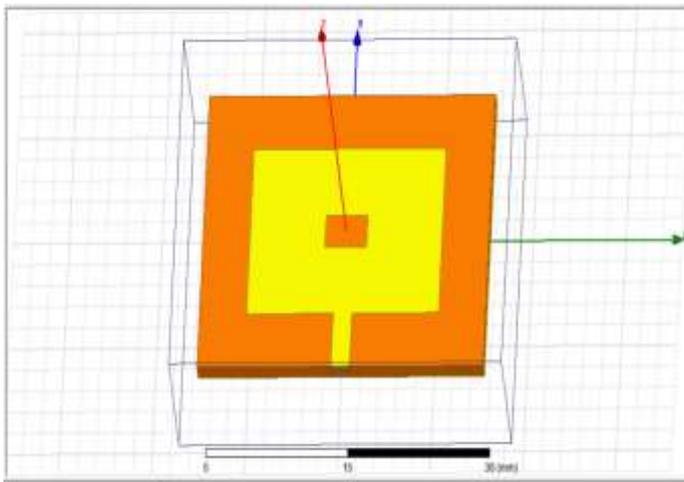


Fig. 46 Design of Rectangular patch with Rectangle slot with Rectangle slot

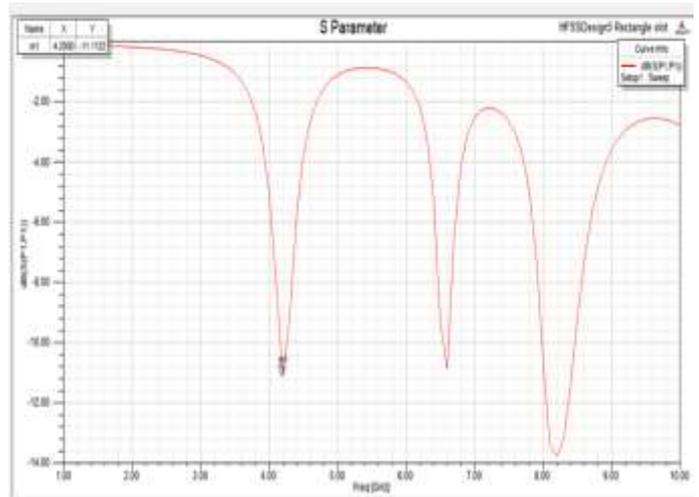


Fig. 47 Output of the Antenna S Parameter

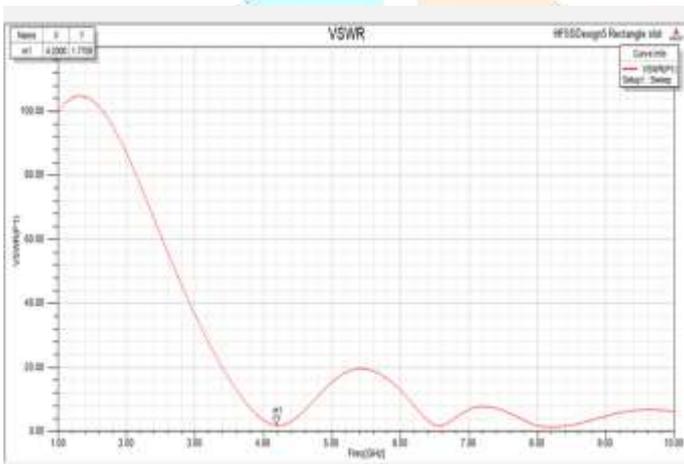


Fig. 48 Output of the Antenna VSWR with Rectangle slot with Rectangle slot

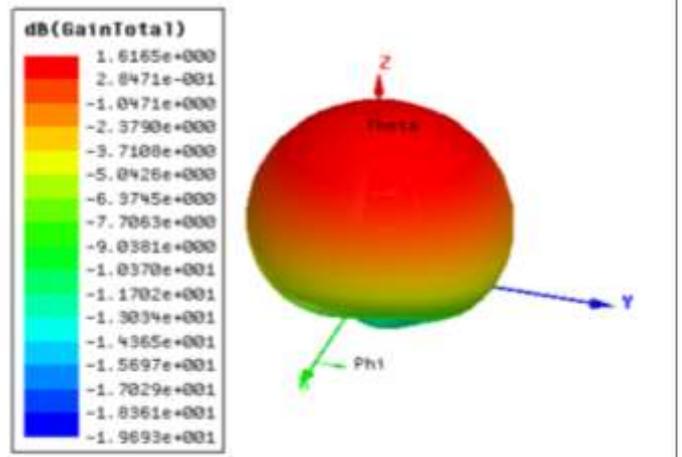


Fig. 49 Output of the Antenna Gain plot

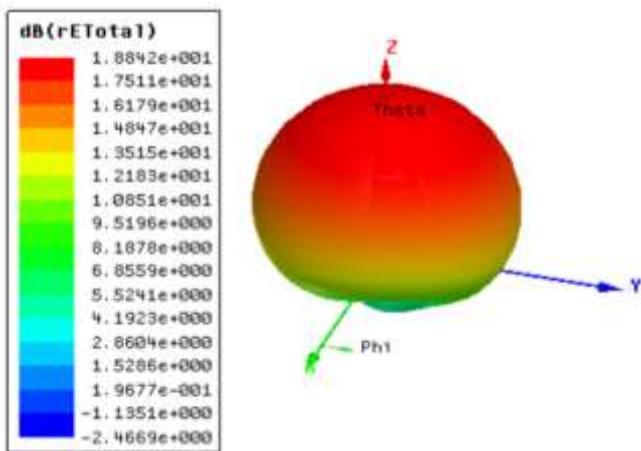


Fig. 50 Output of the Antenna rEplot with Rectangle slot

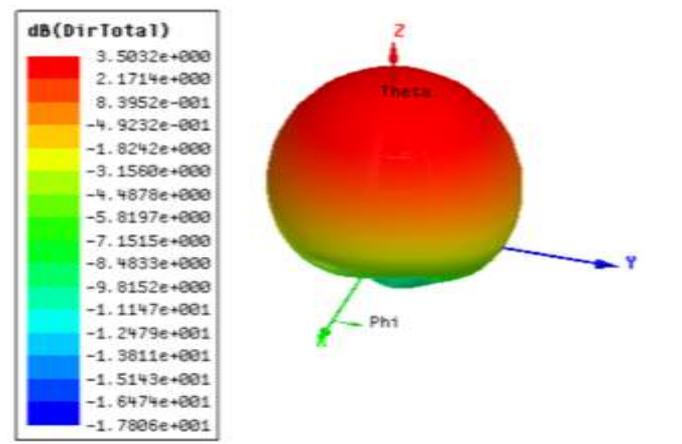


Fig. 51 Output of the Antenna Directivity plot with Rectangle slot

### 7.8 RMPA with Rectangle Ring Slot

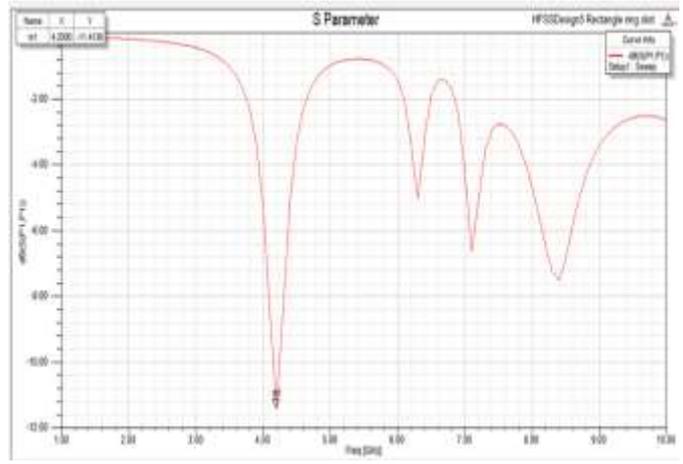
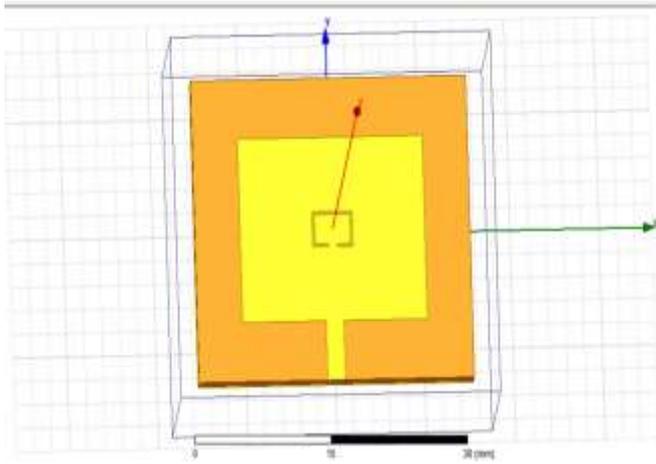


Fig. 52 Design of Rectangular patch with Rectangle ring slot Parameter with

Fig. 53 Output of the Antenna S Rectangle ring slot

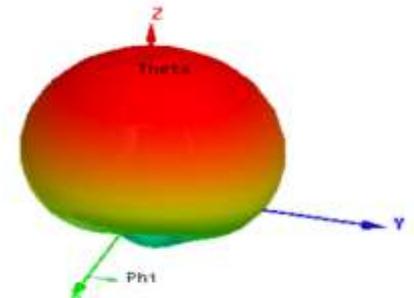
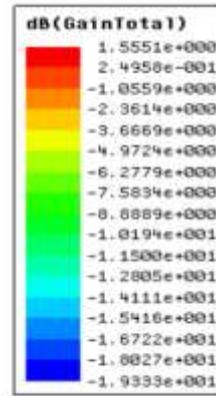
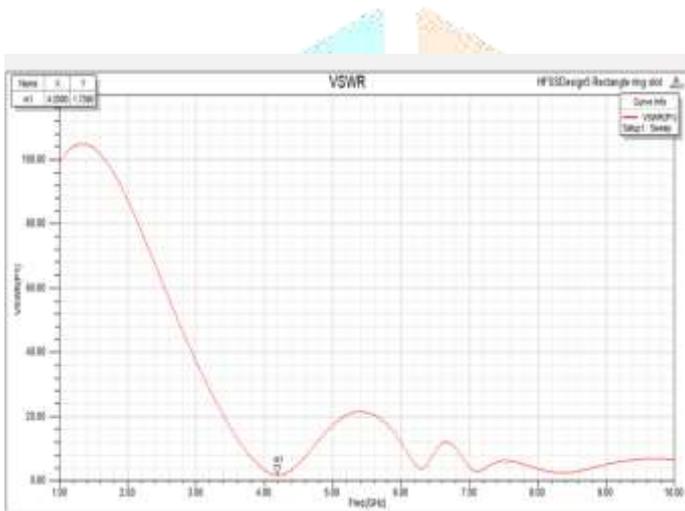


Fig. 54 Output of the Antenna VSWR with Rectangle ring slot with Rectangle ring slot

Fig. 55 Output of the Antenna Gain plot with Rectangle ring slot

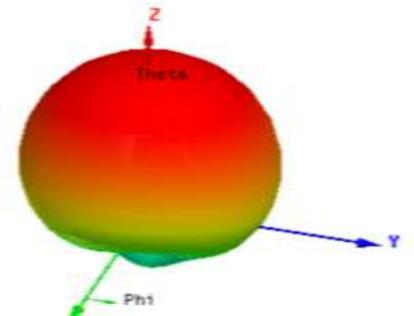
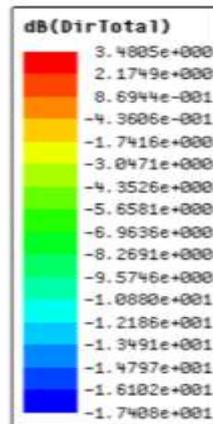
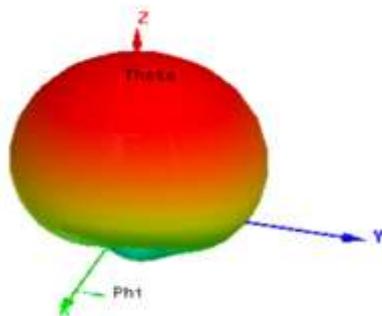
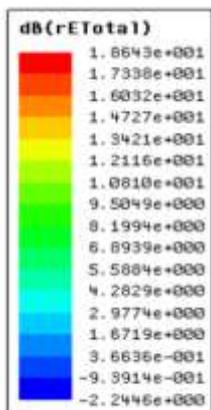


Fig. 56 Output of the Antenna rEplot with Rectangle ring slot Antenna Directivity

Fig. 57 Output of the plot with Rectangle ring slot

### 7.9 RMPA with Ellipse Slot

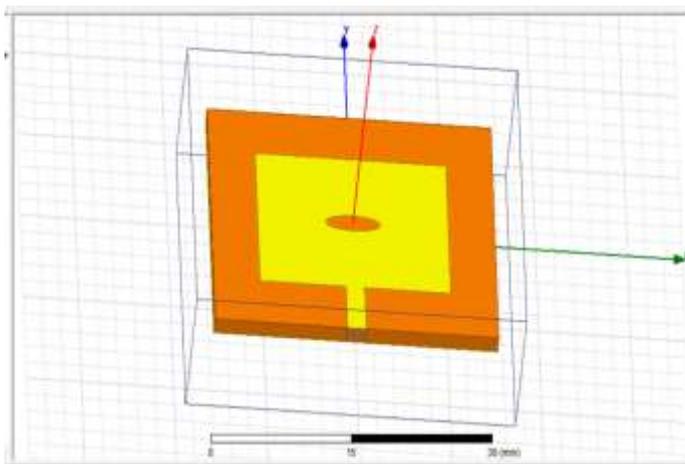


Fig. 58 Design of Rectangular patch with Ellipse slot

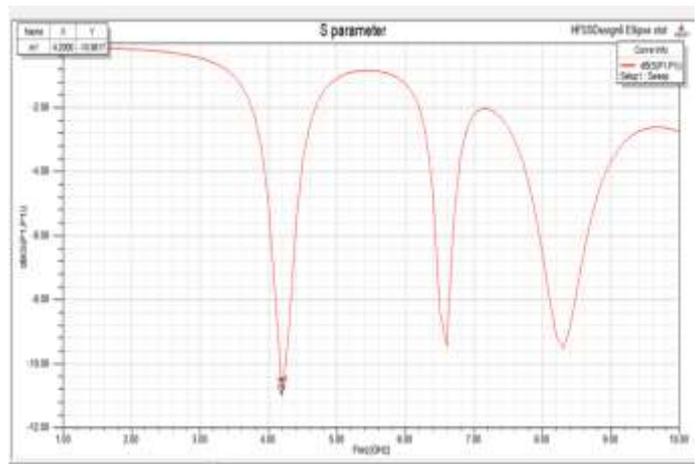


Fig. 59 Output of the Antenna S

Parameter with Ellipse slot

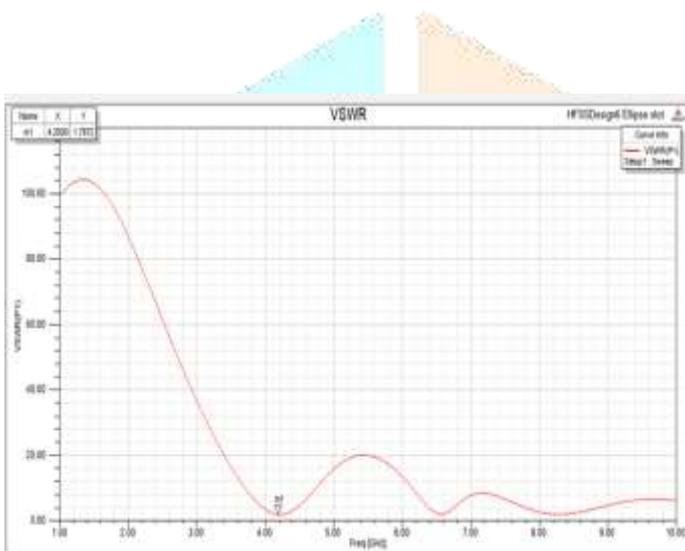


Fig. 60 Output of the Antenna VSWR with Ellipse slot with Ellipse slot

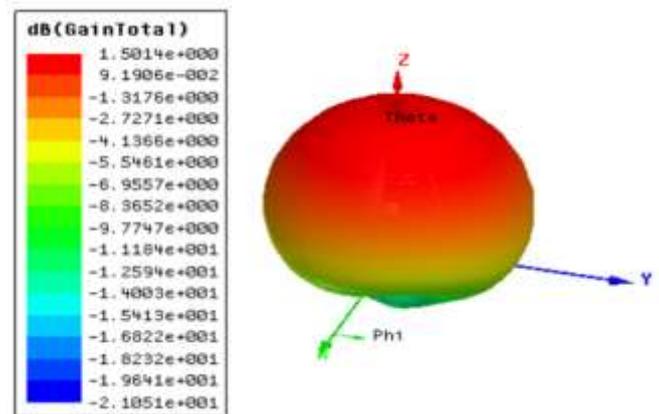


Fig. 61 Output of the Antenna Gain plot

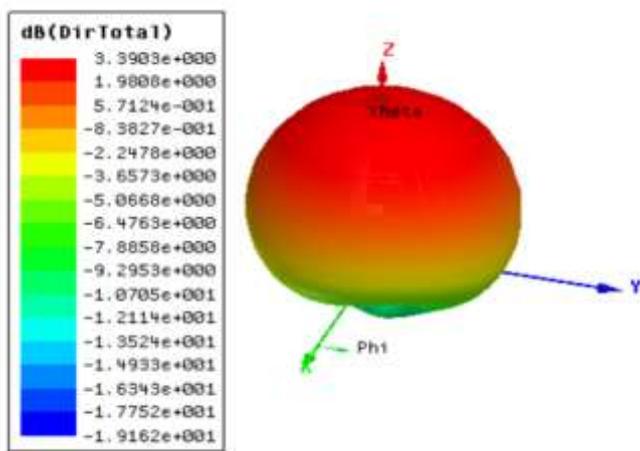


Fig. 62 Output of the Antenna Directivity plot with Ellipse slot rEplot with Ellipse slot

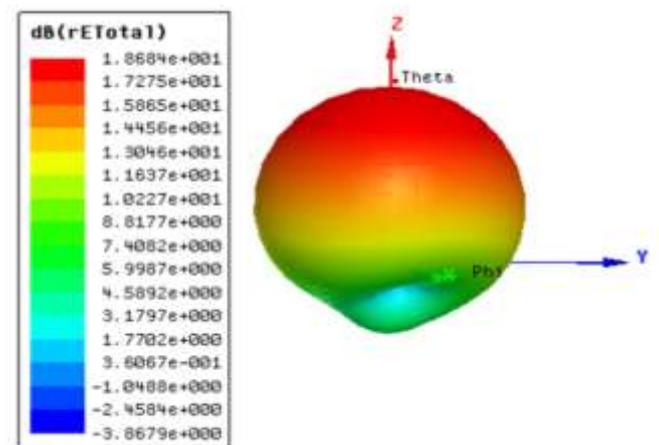


Fig. 63 Output of the Antenna

### 7.10 RMPA with Ellipse Ring Slot

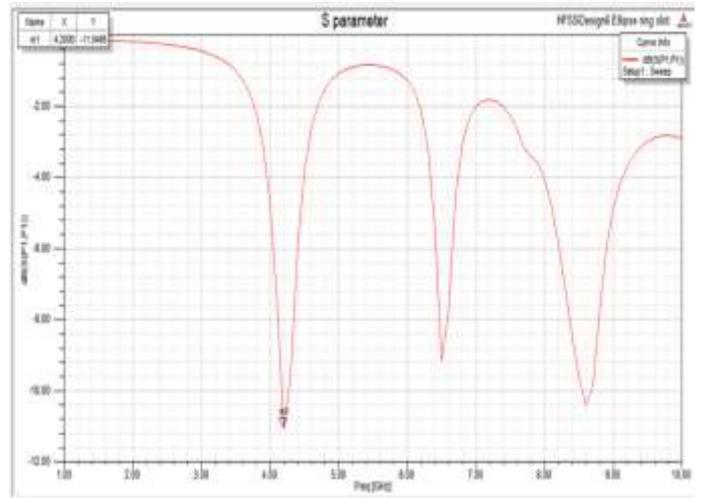
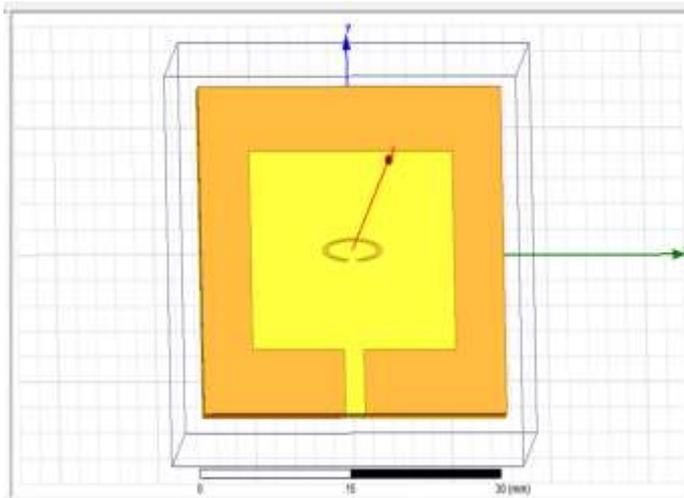


Fig. 64 Design of Rectangular patch with Ellipse ring slot with Ellipse ring slot

Fig. 65 Output of the Antenna S Parameter

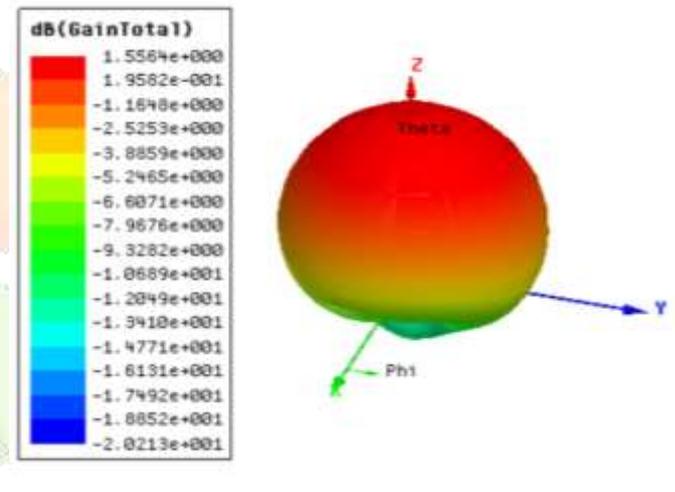
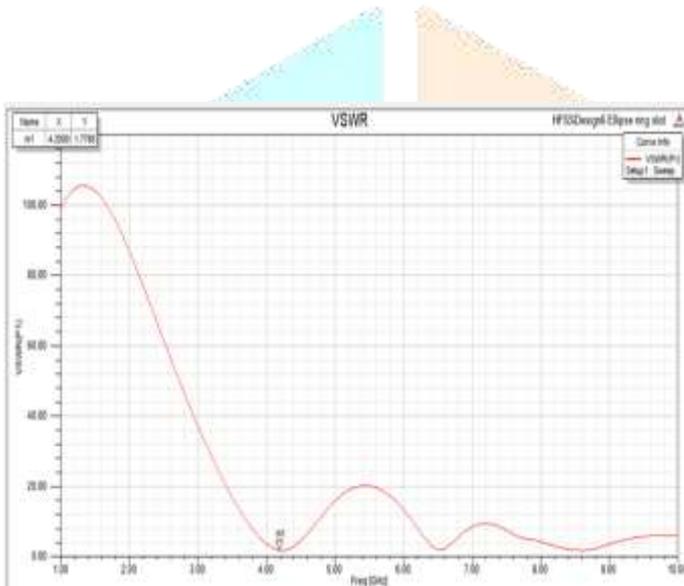


Fig. 66 Output of the Antenna VSWR with Ellipse Ring slot plot with Ellipse Ring slot

Fig. 67 Output of the Antenna Gain

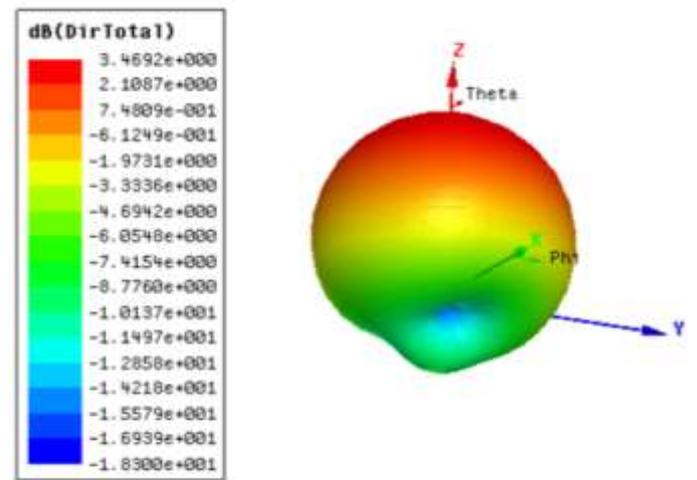
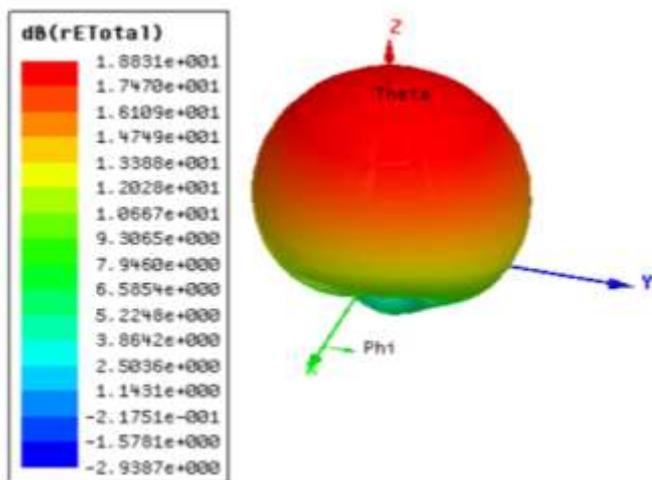


Fig. 68 Output of the Antenna rEplot with Ellipse ring slot Directivity plot

Fig. 69 Output of the Antenna with Ellipse ring slot

Table 2 Proposed Antenna Parameter

S.NO.	PARAMETERS	SIMULATIONOUTPUT
1	Resonated Frequency	4.300
2	S-Parameters (Scattering Parameters)	-12.7656dB
3	Voltage Standing Wave Ratio (VSWR)	1.5974
4	Gain Plot	1.8967
5	Radiation Efficiency (rE)	19.442
6	Directivity Plot	3.5767

### Comparison of different slot of patch Antenna

Table 3 shows the different slots on the patch of RMPA for the values of Gain, Radiation Efficiency and Directivity.

Table 3 Comparison of Gain, Radiation Efficiency and Directivity for different slot of RMPA Antenna

S.No.	Shapes of patch with	Gain Plot (dB)	Radiation Efficiency (rE) (dB)	Directivity Plot (dB)
1. Circle	Slot	1.5734	18.800	3.4726
	Ring Slot	1.5452	18.538	3.5097
2. Triangle	Slot	1.7015	19.134	3.5374
	Ring Slot	1.6515	19.006	3.5289
3. Square	Slot	1.6664	18.896	3.4958
	Ring Slot	1.5083	18.719	3.4643
4. Rectangle	Slot	1.6165	18.842	3.5032
	Ring Slot	1.5551	18.643	3.4805
5. Ellipse	Slot	1.5014	18.684	3.3903
	Ring Slot	1.5564	18.831	3.4692

### Comparison of different slot of patch Antenna

Table 4 shows the different slots on the patch of RMPA for the values of Resonated Frequency, Return Loss and VSWR.

Table 4 Comparison of Resonated Frequency, Return Loss and VSWR for different slot of RMPA Antenna

S.No	Shapes of patch with	Resonated Frequency at GHz	Return Loss	VSWR
1. Circle	Slot	4.2	-11.0596	1.7774
	Ring Slot	4.2	-11.1357	1.7681
2. Triangle	Slot	4.3	-11.1210	1.7698
	Ring Slot	4.2	-10.6367	1.8324
3. Square	Slot	4.2	-11.0198	1.7824

	Ring Slot	4.2	-10.9721	1.7884
4. Rectangle	Slot	4.2	-11.1122	1.7709
	Ring Slot	4.2	-11.4138	1.7350
5. Ellipse	Slot	4.2	-10.9817	1.7872
	Ring Slot	4.2	-11.0486	1.7788

## 8. DISCUSSION AND CONCLUSION

### 8.1 Discussion

The Simulated Results of Rectangular Microstrip Patch Antenna shown in Fig.4.1. At 4.30 GHz. Frequency Simulated Rectangular Microstrip Patch Antenna alone exhibits the Return Loss of -12.7656dB and Bandwidth improvement 160.8 MHz. This RMPA radiating patch resonates at frequencies 4.30 GHz. This shows that the radiating patch of the single band antenna then the resulting antenna is found for resonant frequency tends to lower side, which shows that the Antenna is compact in size as well as better performance in gain and bandwidth. Enhancing Bandwidth near about 0.160 GHz was achieved and Antenna was used for satellite communication. This work used slots such as circle, Triangle, Square, Rectangle, Ellipse slot to enhance and compare the value of Gain, Radiation Efficiency and Directivity of RMPA.

Table 3 Shows that Circle, Triangle, Square, Rectangle, Ellipse ring slots have high values of Gain, Radiation Efficiency and Directivity to compare the Circle ring, Triangle ring, Square ring, Rectangle ring, Ellipse slot.

Table 4 shows the Triangle slot exactly resonated at 4.3 GHz other than slot and circle ring slot, triangle ring slot, square ring slot resonated at 4.2GHz. Circle ring slot is high value for Return loss and VSWR compared to Circle slot.

Triangle slot, square slot, Rectangle ring slot, Ellipse ring slot have more value for Return loss and less value for VSWR.

### 8.2 Conclusion

HFSS is used for designing patch antennas and edge feeding technique is applied to the antenna substrate made of Glass Epoxy (FR4), Ground and Patch is designed.

A proposed rectangular microstrip patch antenna for a satellite communication system designated at C Band resonated at 4.3 GHz. The optimized return loss and radiation pattern for far fields have been attained. The simulation results show that the C Band antenna achieves a high return loss -12.7656 dB. This antenna met the better requirements for satellite communications. The antenna is very compact and lightweight, which makes it suitable for satellite communication. This work involved rectangular patch antennas; different patch designs were simulated in the order circle, Triangle, Square, Rectangle, Ellipse slot and ring slot on the rectangular patch respectively.

Triangle slot is better than other shape slots for Gain, Radiation Efficiency and Directivity. Rectangle ring slot is better Return Loss and minimum value for VSWR compared to other shape slots. Comparison shows that the proposed results are better to use the C band Applications.

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