Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 4, April : 2023

DISCRIMINATION OF RECTANGLE SEMICIRCLE AND SEMICIRCLE SLOTTED MICROSTRIP ANTENNA

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Abstract
The fifth-generation (5G) communication technology can provide many advantages such as a higher transmission rate over the current 4G system. Microstrip antenna with MIMO technology is used to achieve a high transmission rate for 5G operations below 6 GHz. A MIMO antenna is made up of several different antenna components. It has the ability to process signals in order to optimize the radiation reception pattern, which adapts automatically to the signal environment. Wideband communication requires a microstrip antenna that is lightweight, simple to manufacture, and tiny in size. The antenna is proposed for wireless applications. Designed on FR4 substrate. A compact MIMO antenna is designed and simulated using HFSS for wireless applications. HFSS is a predominant show full-wave electromagnetic (EM) field test framework. In this paper, we construct various MIMO antenna forms using software and discuss various antenna factors like return loss and VSWR.
Keywords: Rectangular, Semicircle, Semicircles Slotted.

I. Introduction

In recent days, wireless communication has developed at an enormous rate [1]. The wireless communication system is becoming very essential in everyday routines like Wi-Fi, WiMAX, WLAN, and mobile communication [2]. For enhancement of the performance of wireless communication systems, we require to design a multiband antenna [3-4]. For antenna design, microstrip patch antenna plays an important role in this modern network because of its characteristics like its simplicity in structure, conformability, low manufacturing cost, multifaceted in resonant frequency, polarization, enhancement of bandwidth, and suppression of undesirable cross-polarized radiations [5-7]. Microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate and a ground plane on the other side [8-13]. With the single configuration, a multiband antenna deliberates to work in distinct frequencies [14-17]. If possible, a stealth technology-enhanced object should have a very low radar cross-section (RCS). With the usage of antennas in military applications, RCS considerably rises since a radar signature is proportional to the reflections from the antenna surface [18]. The FSS-based isolation enhancement and RCS reduction techniques are proposed in communication for a two-port MIMO antenna. As this is a generalized technique, it can be extended to multiple-port antenna elements, if one can design a suitable FSS which can achieve high isolation and RCS reduction at the same time [19-21].

To reduce the radar cross-section & improve the isolation several methods that have been embraced by researchers. Such methods are AMC (Artificial Magnetic Conductor), EBG (Electromagnetic Band Gap) Material Absorber (MA), etc. Use FSS (Frequency Selective Surface) method is used to improve the isolation. The first step is to design different shapes of the antenna to improve isolation. Section I Rectangular Patch antenna with results Section II Semi-Circle Patch antenna with results. Section III Semi-Circle Slotted Patch antenna with results. Section IV Comparison of antennas & Conclusion.

II. SIMULATED RESULT FOR RECTANGULAR PATCH ANTENNA

The rectangular patch antenna has been designed on an FR4 substrate with 4.4 permittivities and 1.57mm thickness at 3.5GHz frequency. The overall Antenna size is 38 x 43 mm2. The simulation of the Single band Patch antenna designed in an HFSS simulator is shown in Fig.1. Also, it can be impractical to coat these surfaces with radar-absorbent materials.

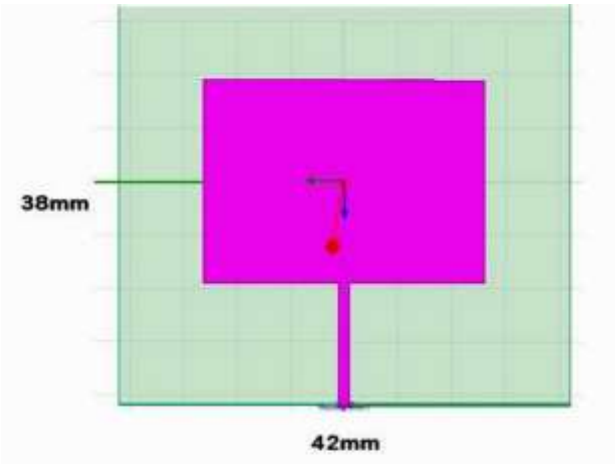


Fig.1 Single band Patch antenna

a) **RETURN LOSS GRAPH**

Their return loss or S11 parameter is the most fundamental parameter to examine the efficiency of an antenna. Return loss provides data on an antenna's reflected energy. It is easy to determine the operating frequency and antenna bandwidth from their return loss vs. Frequency graph. The reduced the S11 parameter value, the stronger the resonance of the antenna.

In Fig.2 below the S11 parameter vs frequency graph.

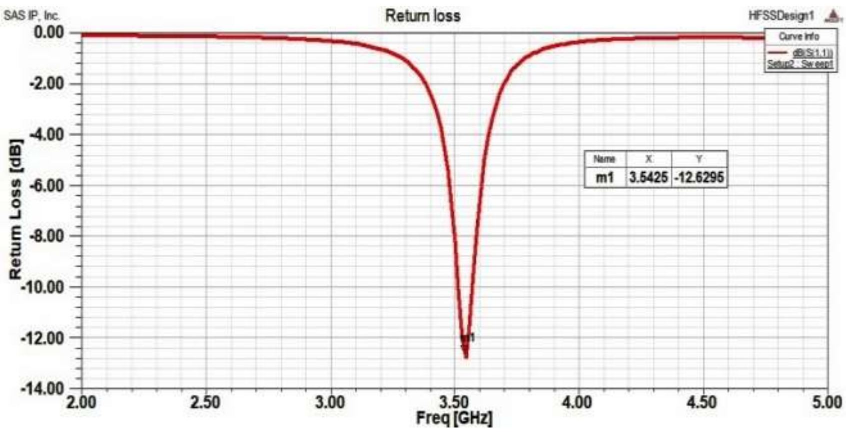


Fig.2.Return Loss of Single band Patch antenna

This shows there return loss value of rectangular Patch antennas-12.62dB at the frequency of 3.54GHz. The ideal value of return loss is around -10dB. Which means 90% power will be transfer to source and 10% will be reflected towards load.

b) VOLTAGE STANDING WAVE RATIO (VSWR)

The VSWR is another parameter to determine impedance matching of the antenna. Actually, it is a measure of impedance matching of loads to the characteristic impedance of a transmission line. Impedance mismatches results in standing wave along the transmission line, and VSWR is defined as the ratio of the partial standing wave’s amplitude at node to the amplitude at a node along the line. The standard value of VSWR is 1 to 2. From the graph of the patch antenna below it is seen that the value of VSWR is within the standard limit around the operating frequency range.

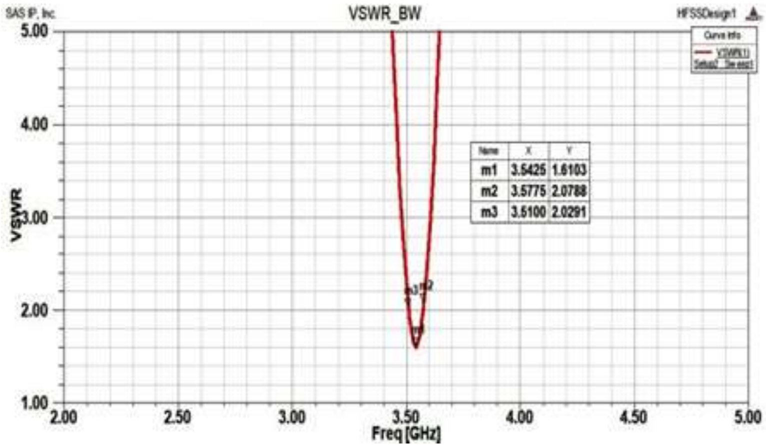
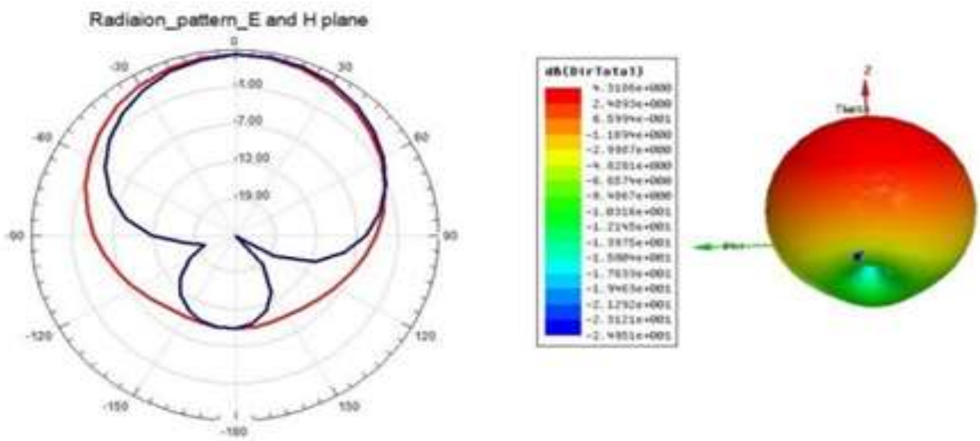


Fig.3 Simulated VSWR of Rectangular Patch antenna

Fig. 3 shows the VSWR of this Rectangular Patch antenna. The VSWR value is 1.61 at 3.54GHz frequency. The bandwidth of the antenna is calculated (as shown above in Fig.) to be 35 MHz and a center frequency of 3.54GHz is obtained which is very close to the desired design frequency of 3.5GHz.

c)RADIATIONPATTERN(2D&3D) GRAPH

2D radiation pattern of the patch antenna a optimization provides a good radiation pattern. The 2D radiation pattern of patch antenna is shown as follows. In simple words it is the power radiated in a certain direction with reference to an isotropic antenna. Just like the 2D radiation pattern a good antenna should also maintain its 3D radiation pattern throughout the frequency range of operation. From 3D radiation pattern it very easy to observe the power delivered to a specific direction. 3D radiation pattern of the single element antenna is shown.



Fig(a) Fig(b)

Fig.4. Radiation pattern and Gain of Rectangular Patch antenna

Fig. 4 shows the radiation pattern of the Rectangular Patch antenna at 3.5 GHz. The Fig (a) show radiation pattern of patch antenna is direction align both E plane (blue) and H plane (red). In Fig. (b) graph the red color shows a Gain of Rectangular Patch antenna is around 4.3dBi at 3.5GHz.

II SIMULATED RESULTS OF SEMI-CIRCLE PATCH ANTENNA

The Semi-Circle Patch antenna design at 3.5 GHz using Ansoft HFSS is shown in Fig. 5. The Semi-Circle Patch antenna has been designed on a FR4substrate with 4.4 permittivity and 1.57 mm thickness at 3.5 GHz frequency. The overall Antenna size is 38x43mm2.

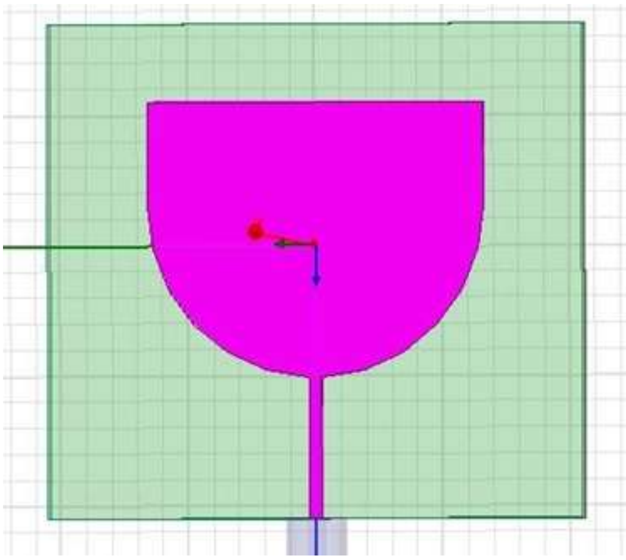


Fig.5 Semi-Circle Patch antenna

b)Return loss graph

Their return loss or S11 parameter is the most fundamental parameter to examine the efficiency of an antenna. Return loss provides data on an antenna's reflected energy. It is easy to determine the operating frequency and antenna bandwidth from their return loss vs. Frequency graph. The reduced the S11 parameter value, the stronger the resonance of the antenna. In Fig.6 below the S11 parameter vs. Frequency graph is shown.

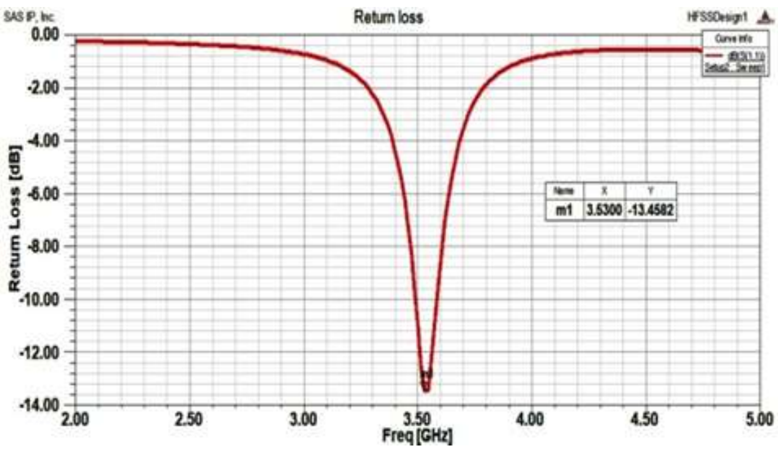


Fig.6 Simulated Return Loss of Semi-Circle Patch antenna

From Figure we see that the return loss value of Semi-Circle Patch antenna is -13.45 dB at 3.53GHz. The ideal value of return loss is around -10dB. Which means90% power will be transfer to source and 10% will be reflected towards load.

c)Voltage Standing Wave Ratio (VSWR)

The VSWR is another parameter to determine impedance matching of the antenna. Actually, it is a measure of impedance matching of loads to the characteristic impedance of a transmission line. Impedance mismatches results in standing wave along the transmission line, and VSWR is defined as the ratio of the partial standing wave's amplitude at an antinode to the amplitude at anode along the line. The standard value of VSWR is 1 to 2. From the graph of the patch antenna below it is seen that the value of VSWR is within the standard limit around the operating frequency range.

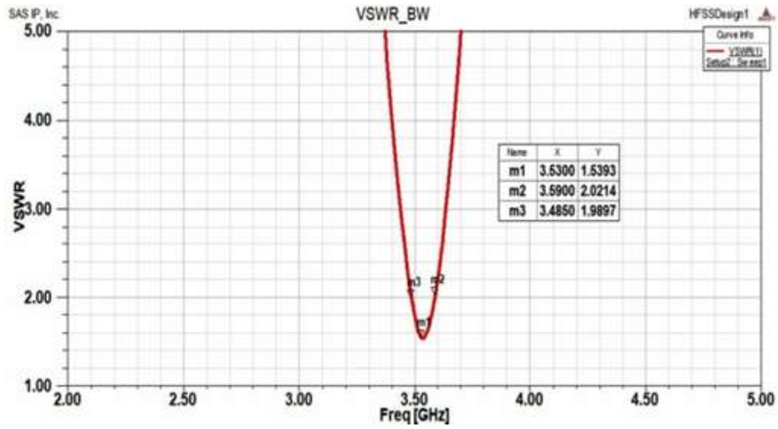


Fig.7Simulated VSWR of Semi-Circle Patch antenna

Fig. 7 shows the VSWR of this Semi-Circle Patch antenna. The VSWR value is 1.53 at 3.53GHz frequency. This antenna offers good bandwidth of 90MHz (3.49-3.58GHz).

d)RADIATIONPATTERN (2D&3D) GRAPH

2D radiation pattern of the patch antenna a optimization provides a good radiation pattern. The 2D radiation pattern of patch antenna is shown as follows. In simple words it is the power radiated in a certain direction with reference to an isotropic antenna. Just like the 2D radiation pattern a good antenna should also maintain its 3D radiation pattern throughout the frequency range of operation. From3D radiation patterns it very easy to observe the power delivered to a specific direction. 3D radiation pattern of the semi-circle patch antenna is shown.

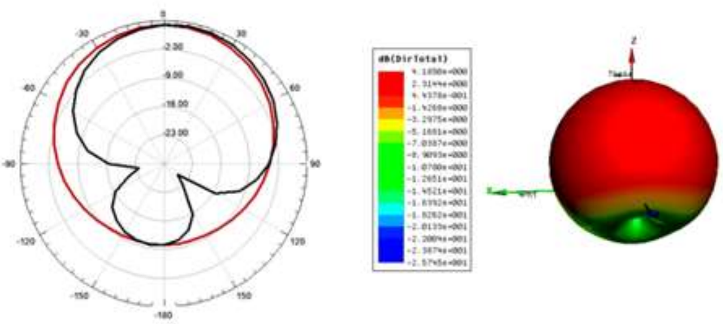


Fig.(a) Fig.(b)

Fig.8 Simulated Radiation pattern and Gain of Semi-Circle Patch antenna

Fig. 8 shows the radiation pattern of the Semi-Circle Patch antenna at 3.5 GHz. The Fig (a) show radiation pattern of Semi-Circle Patch antenna is directional in both E plane (blue) and H plane(red). In fig.(b) graph the red color shows a Gain of Semi-Circle Patch antenna is around 4.2dBi at 3.5GHz.

III SIMULATED RESULTS OF SEMI-CIRCLE SLOTTED PATCH ANTENNA

a) Return loss graph

Their return loss or S11 parameter is the most fundamental parameter to examine the efficiency of an antenna. Return loss provides data on an antenna's reflected energy. It is easy to determine the operating frequency and antenna bandwidth from the return loss vs. frequency graph. The reduced the S11 parameter value, the stronger the resonance of the antenna. In Fig. 9 the S11 parameter vs. Frequency graph is shown.

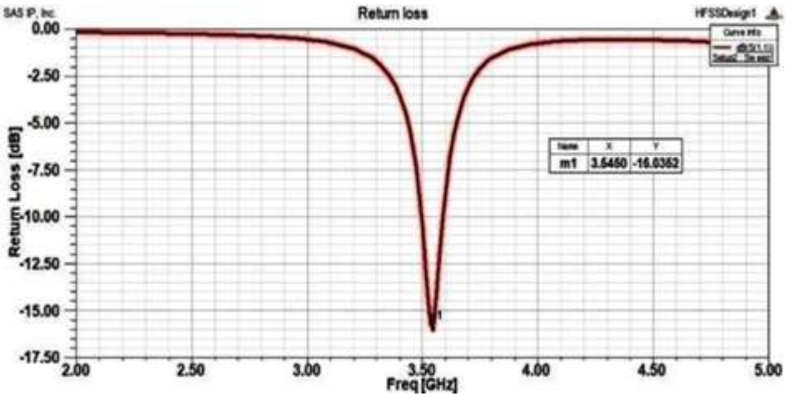


Fig. 9 Simulated Return Loss of Semi-Circle Slotted Patch antenna

Fig.9 shows the return loss value of Semi-Circle Slotted Patch antenna is -16.03 dB at 3.54 GHz. The ideal value of return loss is around -10 dB. Which means 90% power will be transfer to source and 10% will be reflected towards load.

The Semi-Circle Slotted Patch antenna design at 3.5GHz using HFSS is shown in Fig.9. The Semi-Circle Slotted Patch antenna has been designed on a FR4 substrate with 4.4 permittivity and 1.57 mm thickness at 3.5 GHz frequency. The overall Antenna size is 38x43mm^2.

The simulation of the Semi-Circle Slotted Patch antenna designed in a HFSS simulator is shown in the Fig. 10.

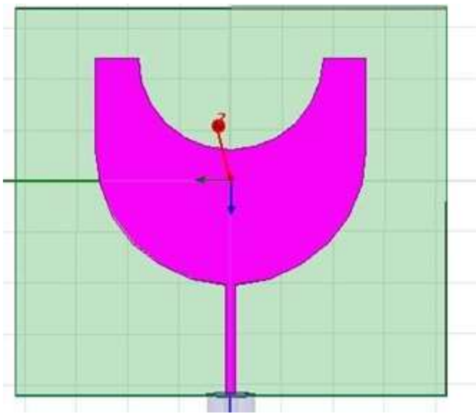


Fig. 10 Semi-Circle Slotted Patch antenna

b) VOLTAGESTANDINGWAVERATIO(VSWR)

The VSWR is another parameter to determine impedance matching of the antenna. Actually, it is a measure of impedance matching of loads to the characteristic impedance of a transmission line.

Impedance mismatches results in standing wave along the transmission line, and SWR is defined as the ratio of the partial standing wave's amplitude at an antinode to the amplitude at anode along the line. The standard value of VSWR is 1 to 2. From the graph of the patch antenna below it is seen that the value of VSWR is within the standard limit around the operating frequency range.

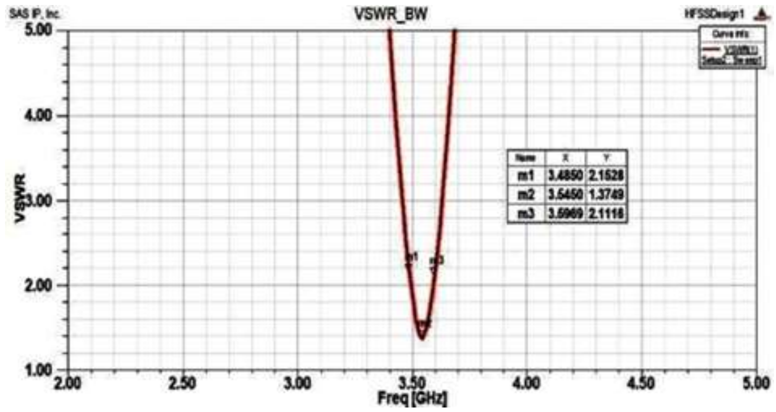


Fig. 11 Simulated VSWR Semi-Circle Slotted Patch antenna

Fig. 11 shows the VSWR of this Semi-Circle Slotted Patch antenna. The VSWR value is 1.37 at 3.54 GHz frequency. This antenna offers good bandwidth of 100MHz (3.49-3.59GHz).

d)Radiation Pattern (2D&3D) graph. 2D radiation pattern of the patch antenna after optimization provides a good radiation pattern. The 2D radiation pattern of patch antenna is shown as follows. In simple words it is the power radiated in a certain direction with reference to an isotropic antenna. Just like the 2D radiation pattern a good antenna should also maintain its 3D radiation pattern throughout the frequency range of operation. From 3D radiation patterns it very easy to observe the power delivered to a specific direction. 3D radiation pattern of the Semi-Circle Slotted Patch antenna is shown.

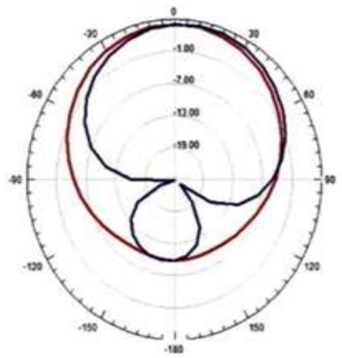


Fig.(a)

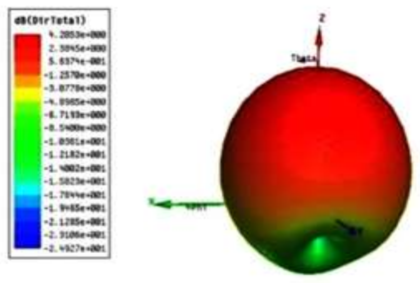


Fig.(b)

Fig.12.simulated Radiation pattern and Gain of Semi-Circle Slotted Patch antenna

Fig.12 shows the radiation pattern of the Semi-Circle Slotted Patch antenna at 3.5 GHz. The Fig (a) shows a diagram pattern of Semi – circle Slotted Patch

Antenna is directional in both E plane (blue) and H plane (red). In fig. (b) graph the red color shows a Gain of this antenna is around 4.2dB at 3.5GHz.

COMPARISION OF ANTENNA

Table No.1 Comparison of Antenna

Shape of MSA	Frequency (GHz)	Return loss (dB)	VSWR	Bandwidth (MHz)	Gain (dB)
Rectangular MSA	3.54	-12.62	1.61	30	4.3
Semi-Circle MSA	3.53	-13.43	1.53	90	4.2
Semi-Circle slotted MSA	3.54	-14.20	1.42	100	4.2

Table shows the comparison of antenna.

Table 2 Performance comparison of the proposed MIMO with reference antennas

Ref.	Size (mm^2)	Freq. (GHz)	Bandwidth [MHz]	ECC	CCL
[8]	80 x 100	2.8	100	0.3	No
[9]	32 x 57	5.8	210	0.05	No
[10]	30 x 65	2.4	90	NA	No
[11]	30 x 54	5.8	200	0.05	No
[12]	10 x 41	2.4	80	0.1	No
[13]	38 x 43	5.3	130	0.001	No
[14]	65 x 100	2.4	500	0.01	No
[15]	60 x 95	2.0	300	NA	No
[16]	30 x 38	5.0	NA	0.01	No
[17]	70 x 140	3.5	340	NA	No
Proposed Work	20 x 60	3.3	3200	0.001	**Yes**

IV. CONCLUSION:

A compact MIMO antenna is designed and simulated using HFSS for wireless applications. The simulation results of the antenna are presented here. From table 1 we conclude that semi-circle slotted antenna we achieved good bandwidth and return loss characteristics. The wideband characteristics have been obtained using step partial gnd DGS techniques. The proposed antenna has very small dimension of 20x60mm^2. Table 2 describe the comparison of reference our proposed antenna with previous antennas. This shows frequency is up to 3.2 GHZ. The proposed MIMO antenna has excellent bandwidth of 3400 MHz (2.33-5.90 GHz) and peak gain is around 2.2 dBi. This proposed MIMO antenna is suitable for wireless communications.

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