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Gain Enhancement of a Microstrip Patch Antenna Using I-Shaped Defective Ground Structure

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Abstract

The technology in an Antenna evolved with increase in designing of various antennas that could be used to work for various applications. Now-a-days huge frequency producing signals are preferred for any type of communication. Microstrip patch antennas which are also called as MPA could be one of the examples which would satisfy the need of this huge frequency producers. The attributes involved in the design of this antenna are in the enhanced format. In this paper, conventional microstrip antenna is given enhancement of gain by providing defected ground structure. The substrate used here is of relative permittivity or dielectric constant of 2.2. Ansys HFSS software is employed to design the antenna as it puts forth all the results that an antenna would radiate to give. A clear-cut view of antenna's radiating frequency is shown by this software. Co-axial feeding technique is incorporated to input or feed the antenna. Gain development has been the prime motto to design the antenna. This gain enhancement is achieved by introducing defective ground structure. It gives a gain of 10dB and radiates at a frequency of -20.92 at 7.88GHz. The above statement gives us an idea that the antenna would radiate in the X band which ranges from 4GHz to 8GHz.

Keywords: X-band, Coaxial feed, Microstrip Patch Antenna, Defective ground structure and Ansys HFSS.

1. Introduction

Evolution of antennas have started long back. But the real essence for antennas have been experienced only after discovering the incorporation of DGS. Various techniques have been proposed to obtain ideal antenna parameters but the simplest way is concluded to be using it (DGS).

A conventional microstrip patch antenna has been given with defective structure of the ground. This causes the application of Babinet's principle. It states that the even distribution of the current field across the ground is being disturbed by occurrence of the slot made in ground. This decreases the slot resistance, capacitance and inductance and gives up line characteristics of resistance, capacitance and inductance. This Defective Ground Structure is supplemented with co-axial feeding and a microstrip patch. In every antenna designed, the patch would reflect the responsibility of a resonating cavity where the short and open circuit of the system is maintained by top, bottom and side walls respectively. At the resonating frequency, the patch would develop substantial electric field in it. The act of analysing a microstrip patch can be proposed in two methods both analytical and numerical.

2. Literature survey

Ashwini K. Aarya has proposed in her paper that the efficiency of an antenna can be greatly enhanced by the usage of defective ground structure. It is observed that proliferation of the surface waves has been avoided by arranging the electric walls around the patch. The placement of electric walls in their paper is along the breadth of the patch [1]. Size reduction of the antenna is also a factor that has been considered while developing an antenna. U. Jamaluddin et all stated that the cross polarization is increased due to the adaptation to defective ground structure but this can be negotiated by maintaining or broadening of the impedance bandwidth and he also presented a difference in results of quenching of cross-polarization and increased impedance bandwidth both in presence and absence of V-shaped DGS [2].

The gain development is amicably explained by Reena Panwar and Deepak Bhatia [3] where they stated bandwidth and gain of the antennas are grown by using a switch made of pin diode in the defective ground structure. It presented the replacement of multiple antennas with reconfigurable antennas into the field of communication. Constatine A. Balanis explained the theory of antennas-its analysis and design in a detail description where a numerous edition has been published which would give the upgraded techniques to improve the antenna parameters edition to edition [4]. The disadvantage, narrow bandwidth, in a general microstrip patch antenna is overcome by DGS by Vrishali Mahesh Belekar et all. Antennas with different DGS shapes like “U”, “E” and “Psi” have been presented in their paper. It is to be noted that the bandwidth with three-DGS shapes is increased to double when compared with simple microstrip antenna. He proposed comparison between a normal slot and multiple polygon apertures [5]. The prominent play carried by standing of feed in the co-axial feed technique has been cleverly justified by Anuja Raj N. In this paper, performance of three types of antennas is described, which are 6 vertices patch antenna, DGS associated antenna and air-layer antenna. In the DGS associated antenna, the tri-angular slots are provided in the ground and is used to improvise the gain by decreasing the surface waves [8]. The surface waves yielded during the entry of co-axial feed of the antenna are prohibited by the entry of Defective ground structure. It also presented a way to overcome the presence of mutual coupling by making tri-rectangular slots in the ground. Mutual co-ordination of length, breadth, placement of slots has also been presented in achieving the reduction in mutual coupling [10].

From this literature, it has been observed that the antenna performance can further be improved by adding co-axial feeding, varying the elements of I-shaped DGS like length, breadth and positioning of DGS. The standing position of the feeding and patch also plays major role in improving the gain. Dimensions of the patch can also be adjusted to achieve better results of antenna parameters. Variation in the performance of antenna can also be noted by using different shapes of the slots in the ground which is ultimately called as DGS.

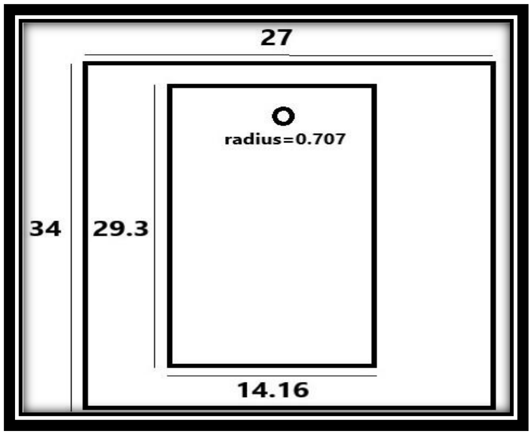
3. Present work

The proposed antenna is a combination of radiating patch, a substrate and a ground. The radiating patch is rectangular in shape. The substrate is made of Rogers/ RT duroid 5880. Initially, heterogeneous shapes were thought to be included in the ground which led to numerous harmonics along with resonant frequencies. Finally, ground is defected with a I-shape slot which makes it a defective ground structure. It is made by uniting all the arms of the slots made and subtracting them from the rectangular ground. Co-axial feed is provided to the antenna at the upper portion of the radiating patch. It is applied with a material which are perfect conductors. It is made by poking the smaller cylinder from the bottom of the ground into the substrate till the radiating patch. The two cylinders used in this process has be to connected co-axially. This type of feeding falls into the category of contacting feed technique. The substrate height in a design has to be as small as possible. The additional advantage of using this kind of feeding technique is it can be made anywhere around the patch but just it has to be made sure to touch both ground and the patch. Wave port is to be assigned to the design which can be the excitation to be given to the antenna. Width, length of the patch, length and width of the arms of the slots made in ground are varied to observe the changes in results and ultimately the gain enhancement is obtained.

Table. 1: Dimensions of the Design

S. No	Dimensions of the Design	Indicating Letter	Dimensioin (mm)
1	Length of the Substrate	S_L	34
2	Width of the Susbtrate	S_W	27
3	Length of the patch	P_L	29.3
4	Width of patch	P_W	14.16
5	Upper and Lower Arm Length of the slot-I	I_L	14.3
6	Upper and Lower Arm Width of the slot-I	I_W	3
7	Lenth of the Mid Arm of the Slot-I	I_{ML}	11.2
8	Width of the Mid Arm of the Slot-I	I_{MW}	3
9	Radius of cylinder below patch	R_1	0.707
10	Radius of the cylinder and circle below substrate	R_2	1.414

The table 1 represents every aspect of the designed antenna. It includes the names given to elements, their subscription and dimensions of every element included in the antenna. It shows the the dimensions used for designing of the antenna are in millimetre. It would help an individual to completely understand the construction of the designed antenna.



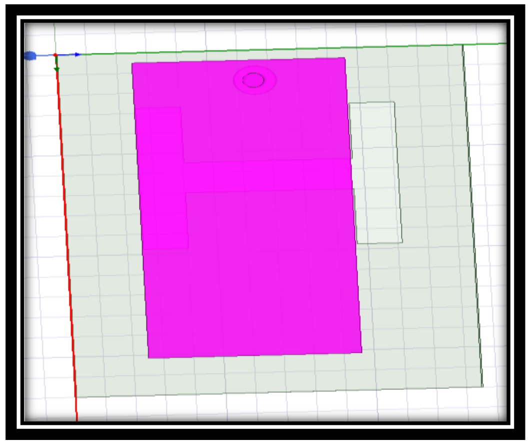
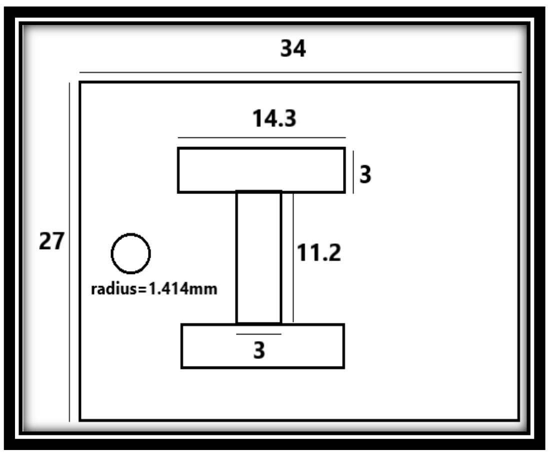


Figure. 1. Top view of the Model Design **Figure. 2. Designed Antenna Top view**

The figure 1 shows the Substrate and patch in the model design. The circle in the patch is the face of the inner conducter (cylinder) used for co-axial feeding. This shows the top view of the Model Design of the proposed antenna. Picture shown in figure 2 is the the microstrip patch inscribed above the substrate. The circle at the top portion of the patch shows upper portion of the inner conducter with which feeding is adapted. The top view of the original designed antenna is shown the figure 2.



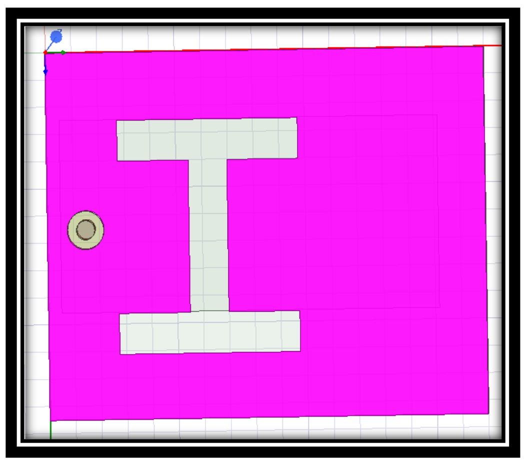


Figure. 3. Bottom view of Model Design **Figure. 4. Bottom view of Designed Antenna**

Figure 3 shows the DGS structure where the defect is formed by the slot in the ground in the shape of I. The radius represented here is the virtual circle made out of the ground. The bottom view in the model design is visualized in the figure 3. The figure 4 shows the bottom siew of the designed antenna where the defect and a circle is clearly visualized. The circles shown towards the right of the figure shows the face of the outer conducter used for providing the co-axial feeding.

4. Results and discussion

This section presents the results acquired in association of defective ground structure with microstrip patch antenna. Usually, a regular antenna would possess many disadvantages such as surface wave excitation, low impedance, gain, huge size, complexity in construction etc which can be overcome by this proposed design. Here, the contribution of Defective ground structure made this antenna more usable allowing it to make an introduction into any field of operation. Before obtaining the results presented here with co-axial feed, line feeding is being applied to the designed antenna as an input which yielded a gain of about 6dB. Later the gain is increased to 10dB by changing the feeding technique to co-axial feed.Position of the feed is changed throughout the patch to obtain greater improvement in gain. It also decreased the surface wave excitations and harmonic frequencies. The following figures 5 and 6 represents the gain of the antenna with co-axial feed and line feed respectively. Other figures from 7 to 10 would represent the results of antenna with co-axial feeding technique.

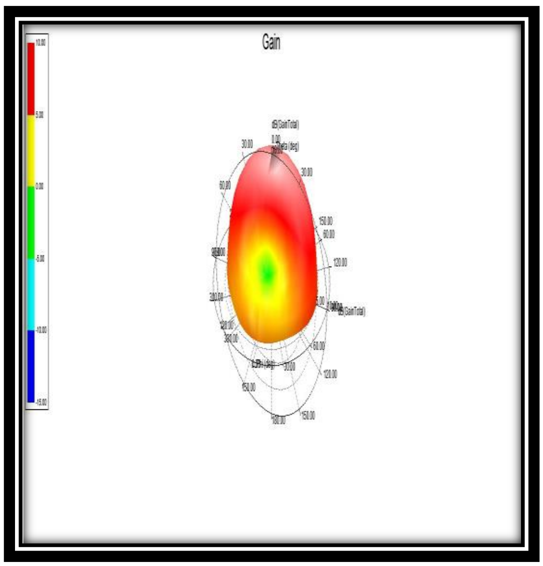


Figure. 5. Gain of the antenna with co-axial feed

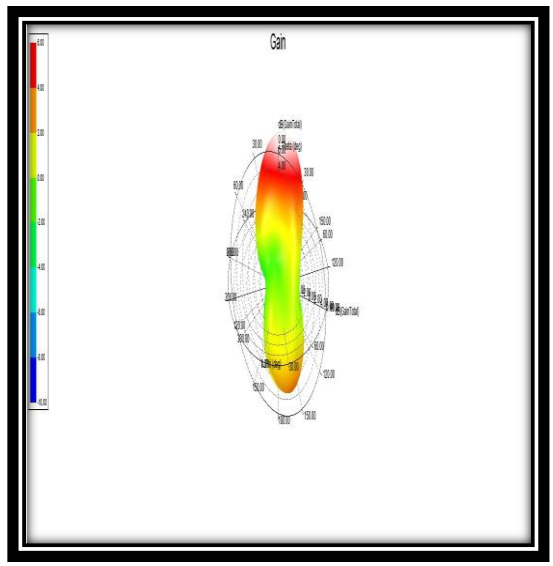


Figure. 6. Gain of the antenna with line feed

The figure 5 shows the gain of the antenna with co-axial feeding technique. The portion shown in red is the maximum gain obtained by the proposed antenna. The colors changing from red to blue represents the reduction in gain. The gain obtained by this antennas is 10dB. This is a three-dimensional plot of tha gain of the antenna. Figure 6 depicts the gain of the antenna with line feeding technique. It is shown that the gain obtained by this feeding is about 6dB. The variation in the figures 5 and 6 shows the increament of gain by changing the feeding technique from microstrip line to co-axial feeding. The position of the co-axial feeding has also been changed to obtain the increased gain. Figure 7 exhibits the relation plot of the frequency Vs return loss where the return loss of an antenna can be observed. Here the return loss obtained is -20.92dB at 7.88GHz and -17.46dB at 8.81GHz. The lesser the return value, the better is the antenna. The figure 8 shows the bandwidth of the antenna which is plotted between two points at -10dB. The proposed antenna provides a bandwidth of 0.45GHz across 7.88GHz and 0.15GHz across 8.81GHz.

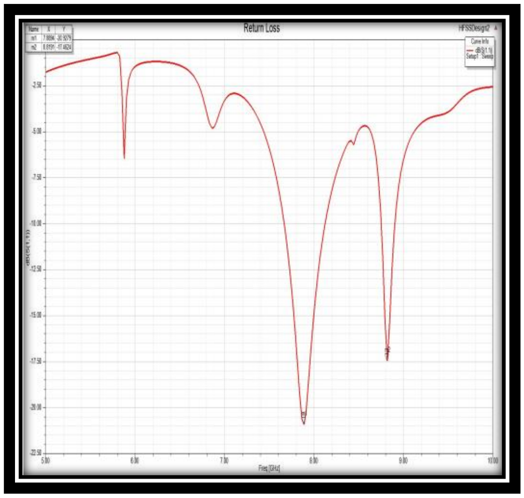


Figure. 7. Frequency Vs Return loss

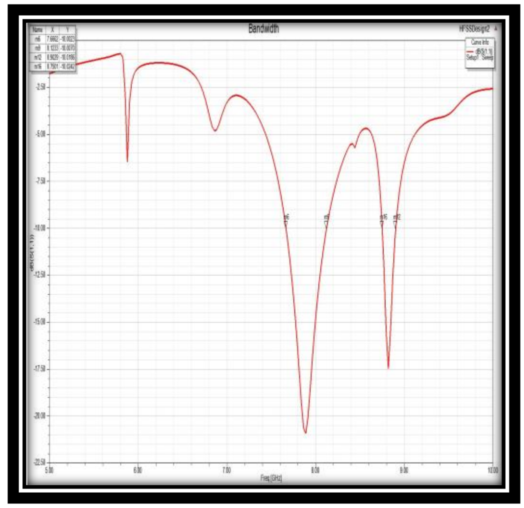


Figure.8. Bandwidth of the antenna

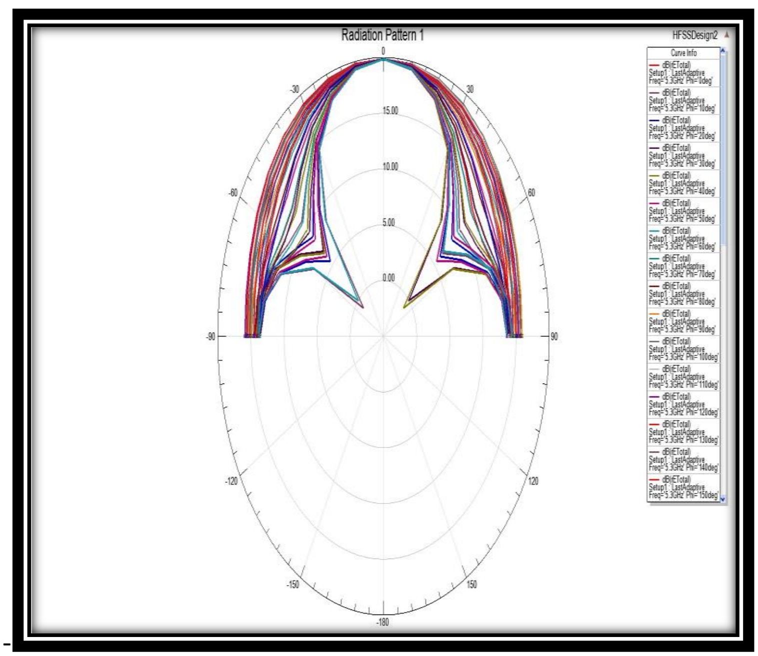


Figure. 9. Radiation pattern of antenna

The figure 9 shows the radiation pattern of the antenna. It is a two-dimensional plot of the radiating area of antenna. The figure 10 shows the Voltage standing wave ratio of antenna. Here the VSWR is found to be 1.2. VSWR has no units. It represents amount of power radiating back. It is a two- dimensional plot.

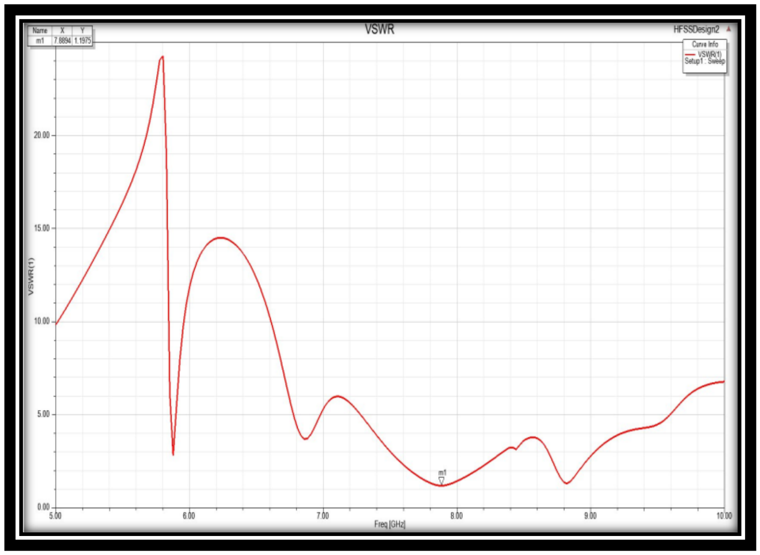


Figure. 10. VSWR

5. Conclusion

The proposed antenna aimed at obtaining the gain enhancement. This prime motto was achieved by incorporating defective ground structure into the conventional microstrip patch antenna. Introducing DGS would make the antenna more desirable in Radar. The gain obtained was upto 10dB. It also decreased the return loss and increased bandwidth when compared with the results obtained with conventional MPA. This antenna can also be broadened to apply its applications in many fields. The proposed antenna finds its applications in X-band which ranges from 4GHz to 8GHz. This X-band majorly constitute microwave frequencies. Thus detecting the vehicle speed, controlling of the air traffic, predicting the weather and other promicing roles which could be acted upon by the designed antenna. When compared with the existing antenna with line feeding which yields gain of 6dB, the designed antenna is presented with co-axial feeding where gain yields 10dB. This is obtained not only by transforming to co-axial feed but also maintaing the proper standing position of the co-axial feeding.

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