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Slotted Rectangular Microstrip Antenna for Satellite Communication in C Band

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Abstract- The idea behind this study is to simulate a low-profile microstrip radiator for satellite communication for the 6 GHz–8 GHz frequency range in the C Band. The planar dimensions of the antenna are 15 x 20 mm2. It has a height of 0.8 mm, and the permittivity of the substrate is 2.2. It is printed on the RT5880 substrate. The two main antenna characteristics, return loss and VSWR, have been analyzed using the High Frequency Structural Simulator electromagnetic suite 16.2 (HFSS). An H-shaped slotted design is optimized for C-band operation. Here, we are able to successfully achieve a return loss of about -42.0505 dB at the 7.9300 GHz frequency. The VSWR of this antenna is 1.01592 for a 7.9300 GHz frequency. The value of the -10 dB bandwidth is coming out to be about 100 MHz. Satellite communication serves as one of its applications.

Keywords– Satellite Communication, X band, Return Loss, VSWR, HFSS

1. INTRODUCTION

Microstrip antennas are designed to be compact, low-weight, and low-profile [1]. The desired radiating frequency can be achieved through the cuts in the patch [2]. It has wide applications such as mobile communication [3], Radar Altimeter [4], and detecting the Breast cancer [5]. They are Compact size, Planner size, ease of integration with various circuits, and cost-effectiveness make them suitable for the Satellite communication. The Microstrip radiator has disadvantages such as narrow bandwidth and small gain, which scientists are trying to overcome [6]. A microstrip antenna can be designed into various shapes, such as triangular, circular, rectangular, and square. The properties of the Microstrip radiator improves by introducing various cuts on the font make them suitable for various application of interests Researchers are making various changes to make the Microstrip antenna suitable for the various application such as adding electronics switches to make them work as the Reconfigurable antenna that works on dual frequency at same time, Making defects in ground adding the cuts in patch to increase the bandwidth and Gain. The following research paper focuses on the simulation of the Microstrip radiator that works in C band for satellite communication, which radiated at about 7.93 GHz frequency to obtain improved antenna characteristics such as S11 and VSWR. The 7.93 GHz frequency is specifically used in short-range radar sensors, industrial level-measurement systems, UAV communication links, and point-to-point microwave backhaul, making this antenna suitable for these practical applications.

2. DESIGN OF ANTENNA

The Microstrip radiator is very simple in terms of design. It has a substrate, a ground plane, and a patch, which can have different shapes as per the requirement. We have proposed a rectangular patch low-profile Microstrip antenna that radiates in the C band range of frequencies, useful in satellite communication and wireless communication.

We have tried to design the antenna in three steps with different approaches, which can be understood as follows.

Step1: Design of radiator 1

The following antenna Shown in Figures 1 and 2 designed based on the properties mentioned in Table 1. The patch of the following antenna is initially rectangular in shape. The back plane and the front of the antenna are conducting.

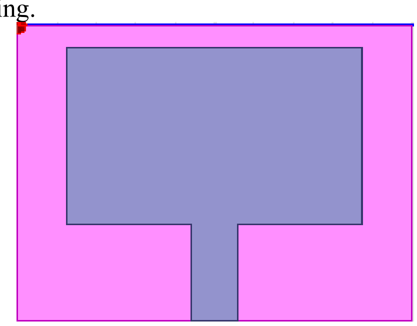

Figure 1: Design of the front Plane of radiator 1

Figure 2: Full Ground Plane of radiator 1

The reflection coefficient gives an idea of the reflected energy. Here in the Plot the value of S_{11} is -7.0699 dB at 10.160 GHz, which is poor, and we will try to optimize it in the design of antenna 2 as discussed in step 2.

Table 1: Design Requirement Antenna 1

S.NO	Components	Value
1	Substrate	15 mm × 20mm × 0.8mm
2	Dielectric Substrate	RT5880
3	Dielectric Constant	2.2
4	Ground (conducting)	15 mm × 20mm
5	Rectangular Patch	9 mm × 15mm
6	Rectangular Feed	4.9 mm × 2.4
7	Cuts in Patch	No
8	Simulator	HFSS electromagnetic suit 16.2

The Rectangular plot for Antenna 1 can be analyzed from Figure 3

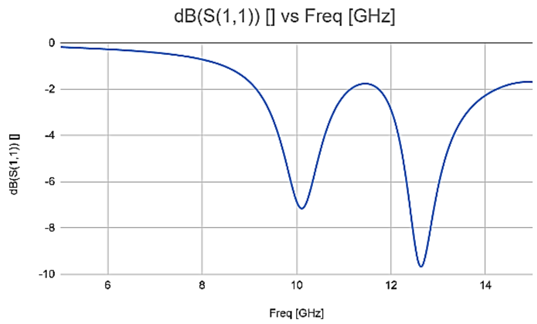

Figure 3: Rectangular plot of the reflection coefficient (S11) for Antenna 1

Step 2: Design of Antenna 2

The design steps for Antenna 2 are almost similar to those of Antenna 1. We have introduced two parallel cuts, one horizontal cut and two vertical cuts, shown in Figure 4 as referred in Table 2. The cuts are rectangular in shape.

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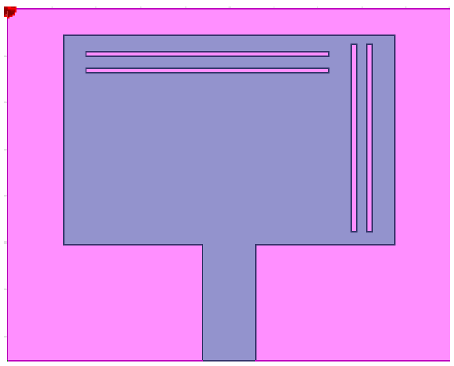

Figure 4: The Design of the front plane Antenna 2

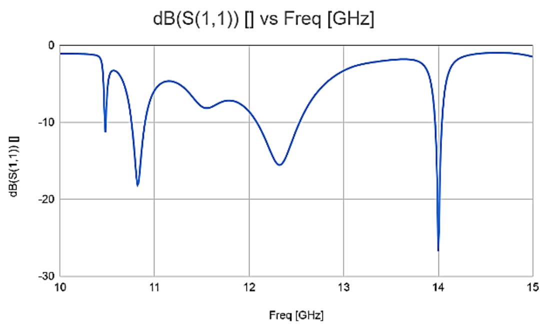

Figure 5: Rectangular plot of the reflection coefficient (S11) for Antenna 2

Table 2: Design Requirement of Antenna 2

S.NO	Components	Value
1	Substrate	15 mm × 20mm × 0.8mm
2	Dielectric Substrate	RT5880
3	Dielectric Constant	2.2
4	Ground (conducting)	15 mm × 20mm
5	Rectangular Patch	9 mm × 15mm
6	Rectangular Feed	4.9 mm × 2.4
7	Horizontal Cuts	0.2 mm × 11 mm
8	Verticals Cuts	8 mm × 0.3 mm
9	Simulator	HFSS electromagnetic suit 16.2

The Rectangular Plot of Antenna 2 is visible in the Fig 5 .Antenna 2 has an improved value of the S11. The Reflection coefficient has come out to be -28.2076 dB at 14.00 GHz.

Step 3: Design of Antenna 3

The design of Antenna 3 has an enhanced version of Antenna 2, shown in Figure 6 with an extra rectangular cut in the vertical cuts, of the dimension mentioned in Table 3.

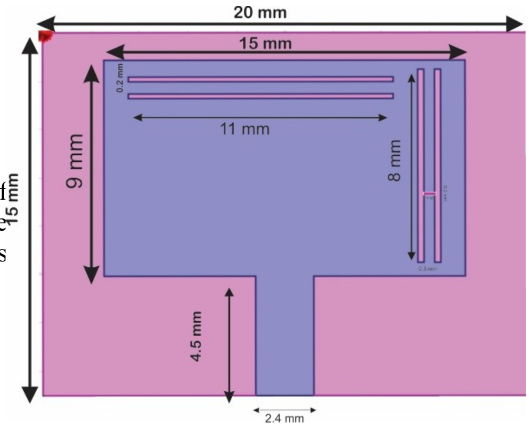

Figure 6: The Design of the front plane Antenna 3

Table 3: Design Requirement of Antenna 3

S.NO	Components	Value
1	Substrate	15 mm × 20mm × 0.8mm
2	Dielectric Substrate	RT5880
3	Dielectric Constant	2.2
4	Ground (conducting)	15 mm × 20mm
5	Rectangular Patch	9 mm × 15mm
6	Rectangular Feed	4.9 mm × 2.4
7	Horizontal Cuts	0.2 mm × 11 mm
8	Verticals Cuts	8 mm × 0.3 mm
9	Rectangular H cut	0.2 mm × 0.4 mm
10	Simulator	HFSS electromagnetic suit 16.2

Rectangular graph of the reflection coefficient of the radiator 3 is visible in Fig 7.

The value of the S_{11} is -42.0505 dB at 7.9300 GHz frequency. Antenna 3 is radiating at a low frequency compared to antennas 1 and 2.

Common Design of Ground plane for antenna 2 and antenna 3 with Rectangular cuts

As per Fig 8, One Vertical rectangular cut of (L)13mm × (W)0.5 mm and one Horizontal rectangular cut of (L)0.5

mm × (W)14.5 mm have been introduced in the ground plane, which is conducting.

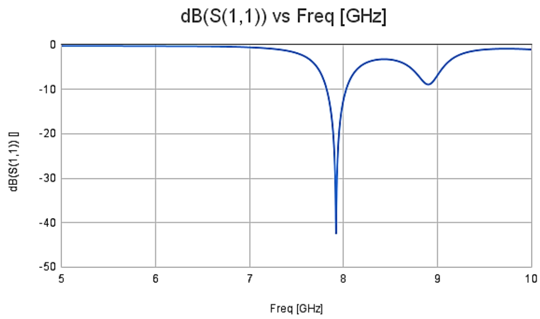

Figure 7: Rectangular graph of the reflection coefficient (S11) for Antenna 3

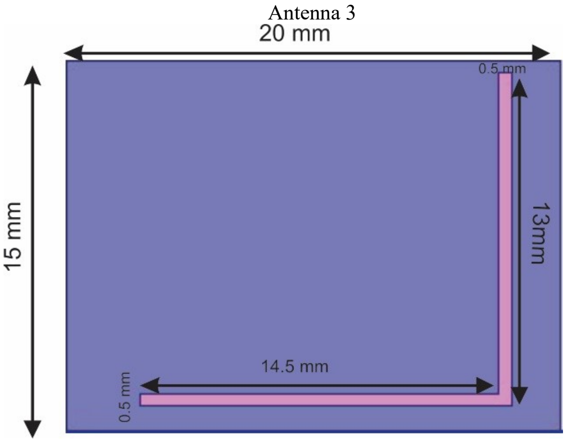

Figure 8: Design of the back plane of radiator 2 and antenna 3

3. RESULTS AND DISCUSSIONS

The presented antenna has been made and simulated with the High Frequency Structural Simulator. Rectangular plot for the various Antenna characteristics like S11, VSWR, Bandwidth, and Radiation pattern has been obtained, which can be analyzed from Figure 9, Figure 10, and Figure 11.

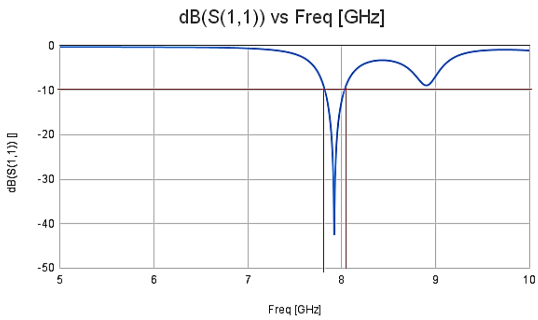

Figure 9: Rectangular plot of the reflection coefficient (S11) for radiator 3

The value of the S_{11} Parameter is -42.0505 at 7.9300 GHz frequency range, which is good as the value is less than 10 dB, which is desirable for the reflection coefficient. The Bandwidth of Antenna 3 can be calculated from the Fig 9, which is 100 MHz.The value of VSWR ranges from 1 to infinite and the desired value of the VSWR is below 2. The value of VSWR for Antenna 3 is 1.01592.

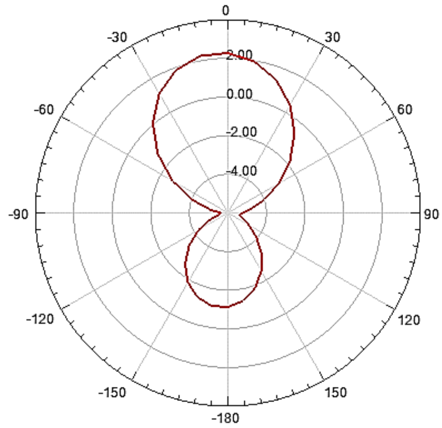

Figure 10: Polar plot for radiator 3

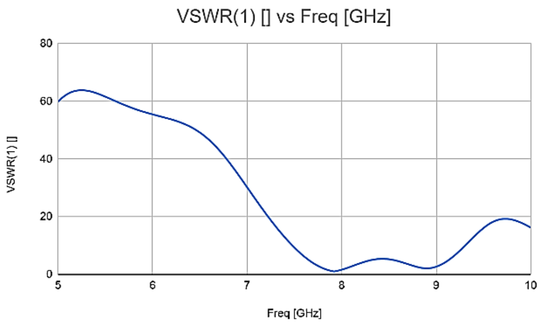

Figure 11: VSWR plot of Antenna 3

4. CONCLUSION

The proposed paper presents a low-profile microstrip antenna operating in the C band at a frequency of 7.9300 GHz. The proposed design has achieved the VSWR < 2 and S_{11}, having very little return loss, which is desirable for the optimized performance of the antenna. The application for the proposed antenna includes short-range radar sensors, industrial level-measurement systems, UAV communication links, and point-to-point microwave backhaul. Future research could focus on improving the antenna's gain and bandwidth by using strategies like interconnected patches. Additionally, the design can be expanded to serve C-band antennas through reconfigurable operation in the 7–8 GHz range, utilizing PIN or MEMS switches. The suggested antenna's practical usability will be enhanced by additional downsizing employing cutting-edge substrates and experimental validation through prototype construction and VNA testing.

Table 4: Comparing the antenna characteristics

Ref.	S_{11} (dB)	Dimension(mm)	Bandwidth
[3]	-30.25	16 ×16×0.8	840 Mhz
[6]	-25	18×28×0.8	2.5GHz
Proposed work	-42.0505	15×20×0.8	100 Mhz

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5. REFERENCES

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