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Design and Simulation of Curved Edge Patch Antenna for Ka Band Application

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Abstract: The aim is to study and design various rectangular microstrip patch antennas for wireless communication systems and to study the effect of various antenna parameters like Patch Length (L), Patch Width (W), substrate material, relative dielectric constant, substrate thickness etc. In the proposed research work antenna is designed and simulated to work in Ka band i.e. 26 GHz to 40 GHz. Various substrate material such as arlon, roger, and Al_2O_3 were considered for design process. Two resonant frequencies were observed in case of roger substrate and multi frequency bands are observed in case of Al_2O_3 substrate.

Keywords: Microstrip, Patch Length (L), Patch Width (W), Substrate Material, Relative Dielectric Constant

I. INTRODUCTION

Antennas are metallic structures designed for radiating and receiving electromagnetic energy. An antenna acts as a transitional structure between the guiding device (e.g. waveguide, transmission line) and the free space. Microstrip antennas are similar to parallel plate capacitors, in which one metal plate is extended than the others to form a ground plane. Size of the patch is mostly proportional to the operating frequency of the signal which is normally the resonance frequency of the patch. Due to this characteristic, microstrip antennas have relatively narrow bandwidths, usually a few percents. Several different shapes of patches, such as rectangular, circular, ring and etc. are employed in various applications. The advantages of microstrip antennas are light weight, low profile, ease of mass production, low fabrication cost, easy to integrate with other circuits, and various polarization [1-4].

Microstrip antennas can be fed directly by microstrip line or coaxial probe, and it can be excited using apertures on ground plane by coupling, which there is no physical contact with the radiating element. The efficiency of antenna depends on power to the radiating element that feeding technique is very important. Consequently, the feeding techniques have significant impact on the power to the radiating element that determines the efficiency of the antenna. Microstrip line feeding methods are generally used for its easier fabrication, since the feed line and radiating elements are in same surface of substrate. Impedance matching techniques are also simpler in comparison to other methods. However, for broadband applications, microstrip line feed antennas require thicker substrates, which increases surface waves and spurious feed radiation. The large profile of microstrip antenna limits the bandwidths to typically 2~5% [5].

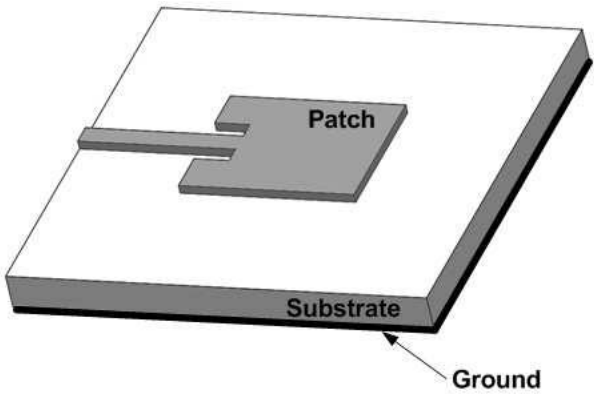

Fig. 1 Microstrip line feed.

Coaxial probe feed techniques are arranged by soldering coaxial connector to the patch where inner conductor is connected to patch and outer conductor to the ground plane. The main advantages of coaxial probe feeding are also easy to fabricate, match input impedance, and its low spurious radiation. However, it has the disadvantages of the

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narrow bandwidth and the requirement of drilling hole to the thick substrate which is difficult to model. Both microstrip line and coaxial probe feeding has inherent asymmetries which generates higher modes that produce cross-polarization radiation. To avoid these problems, aperture coupling feed technique is introduced [6-7].

Aperture coupling consists of two substrates separated by a ground plane. Microstrip line feed is located below the ground plane, whose electromagnetic fields are coupled to radiating patch through an aperture slot. The ground plane between substrates isolates feed line from radiating patch that minimizes interference of spurious radiation and polarization purity. Several factors in this design of an excitation method, such as substrate parameter, feed line width, slot size, shape, and position, decide the performance to improve bandwidth of the antenna [8-14].

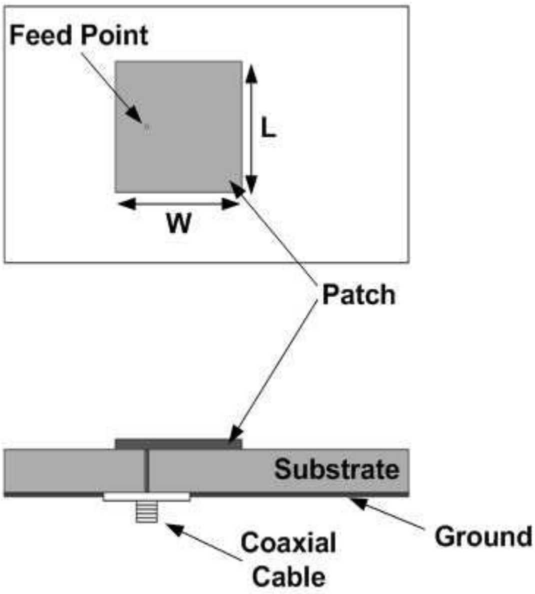

Fig. 2 Coaxial probe feed.

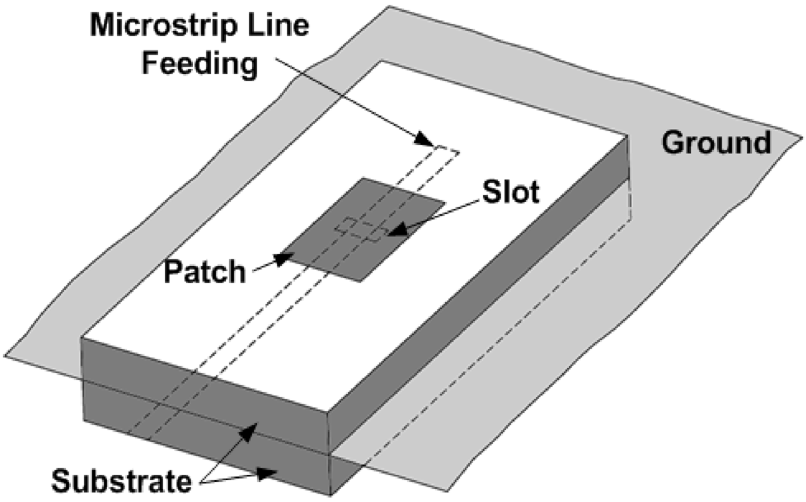

Fig. 3 Aperture coupling feed

II. DESIGN AND SIMULATION

The research work is carried out to investigate the Ka band microstrip patch antenna. Detailed literature review has been done in the field of Ka band antenna. Research work will be carried out in following steps: Design and simulation of Ka band microstrip patch antenna and its testing in frequency range of 26 GHz to 40 GHz.

The following flow chart lists the steps to be carried out in the proposed work so as to achieve desired objectives. The Ansys/Ansoft HFSS (High Frequency Structure Simulator) is used for designing and simulating the designed antenna.

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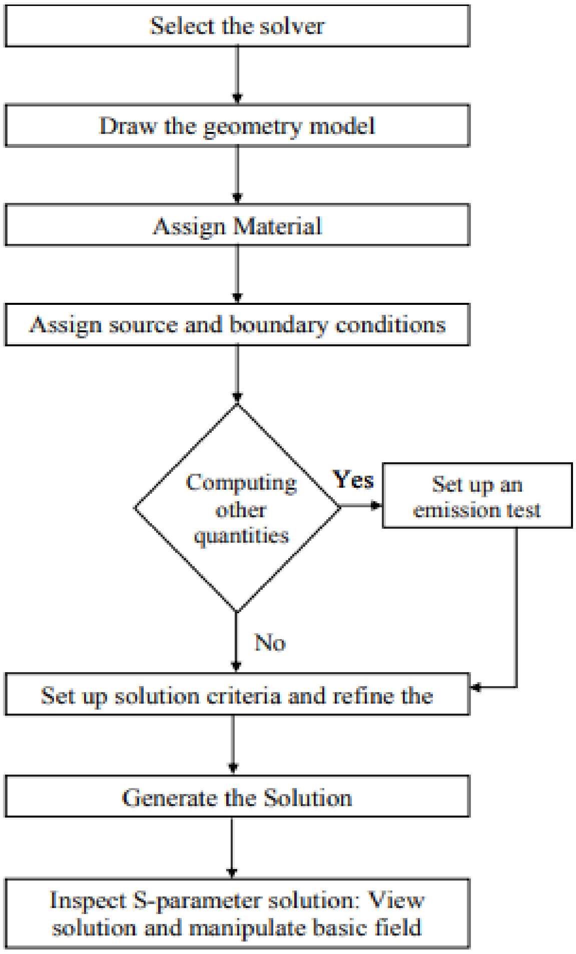

Fig. 4 HFSS simulation process flow.

The designed flair type bowtie antenna is simulated for three different substrate arlon, roger, and Al2O3. Figure 5 show the designed geometry of the antenna.

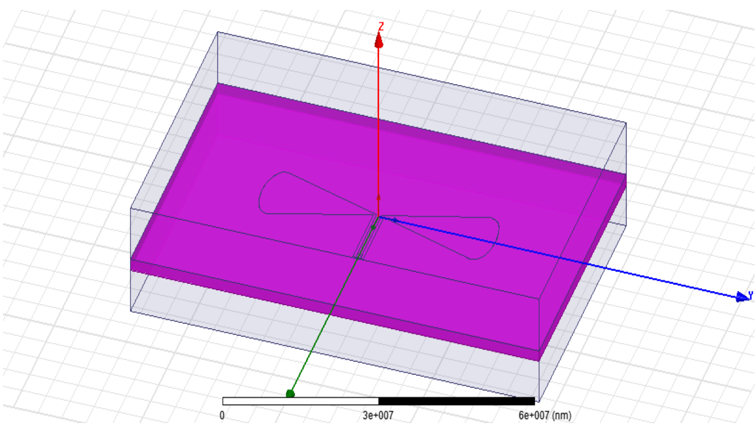

Fig.5 Designed antenna geometry.

III. RESULTS AND DISCUSSION

In this section of the research work curved edge bowtie antenna is designed and simulated for Ka band frequency range. The designed flair type bowtie antenna is simulated for three different substrate arlon, roger, and Al_2O_3. Figure 6 show the designed geometry of the antenna. Figure 7 shows the insertion loss for arlon substrate. Near Ka band resonant frequency is observed at 26 GHz with insertion loss of -10.6 dB. Insertion loss for frequency ranging from 26 GHz to 40 GHz having step size of 1 GHz with roger substrate is tabulated in Table 1.

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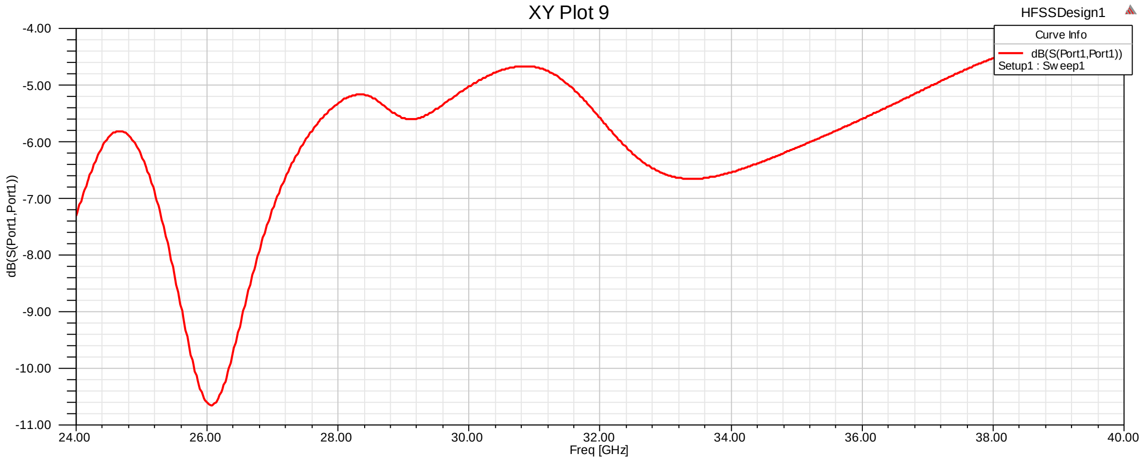

Fig.6 Insertion loss of designed flair antenna with arlon substrate.

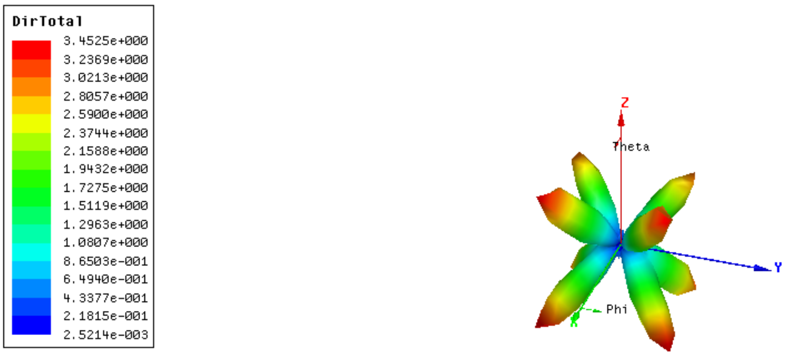

Fig. 7 3D directivity polar plot for flair antenna with arlon substrate.

Table 1 Insertion loss for arlon substrate with flair antenna design.

Frequency (GHz)	Insertion Losses (dB)
24	-7.31296765
25	-6.240330956
26	-10.59389024
27	-7.207458593
28	-5.326018575
29	-5.588332772
30	-5.032327484
31	-4.68823309
32	-5.589167982
33	-6.57823064
34	-6.542198312
35	-6.10804187
36	-5.601930013
37	-5.046921513
38	-4.530243428

Figure 8 shows S-parameter for frequency ranging from 26 GHz to 40 GHz. With roger substrate the designed flair antenna shows three resonant frequencies 34 GHz and 38.60 GHz with insertion losses -18 dB and -12.50 dB respectively. Figure 9 shows the 3D directivity polar plot of the designed flair antenna. Insertion loss for frequency ranging from 26 GHz to 40 GHz having step size of 1 GHz with roger substrate is tabulated in Table 2.

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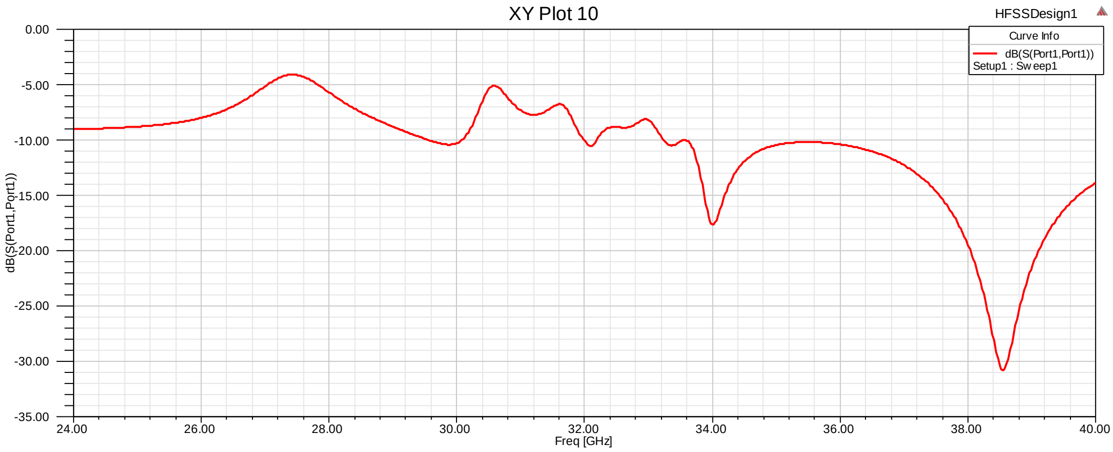

Fig. 8 Insertion loss of designed flair antenna with roger substrate.

Fig. 9 3D directivity polar plot for flair antenna with roger substrate.

Table 2 Insertion loss for roger substrate with flair antenna design.

Frequency (GHz)	Insertion Losses (dB)
24	-9.05955
25	-8.82074
26	-8.03317
27	-5.19387
28	-5.71643
29	-8.80692
30	-10.3092
31	-7.34392
32	-10.0723
33	-8.23265
34	-17.6201
35	-10.4723
36	-10.42
37	-12.3033
38	-19.5393

Figure 10 shows S-parameter for frequency ranging from 26 GHz to 40 GHz. With Al2O3 substrate the designed flair antenna shows three resonant frequencies 34 GHz and 38.60 GHz with insertion losses -18 dB and -12.50 dB respectively. Figure 11 shows the 3D directivity polar plot of the designed flair antenna. Insertion loss for frequency ranging from 26 GHz to 40 GHz having step size of 1 GHz with roger substrate is tabulated in Table 7.

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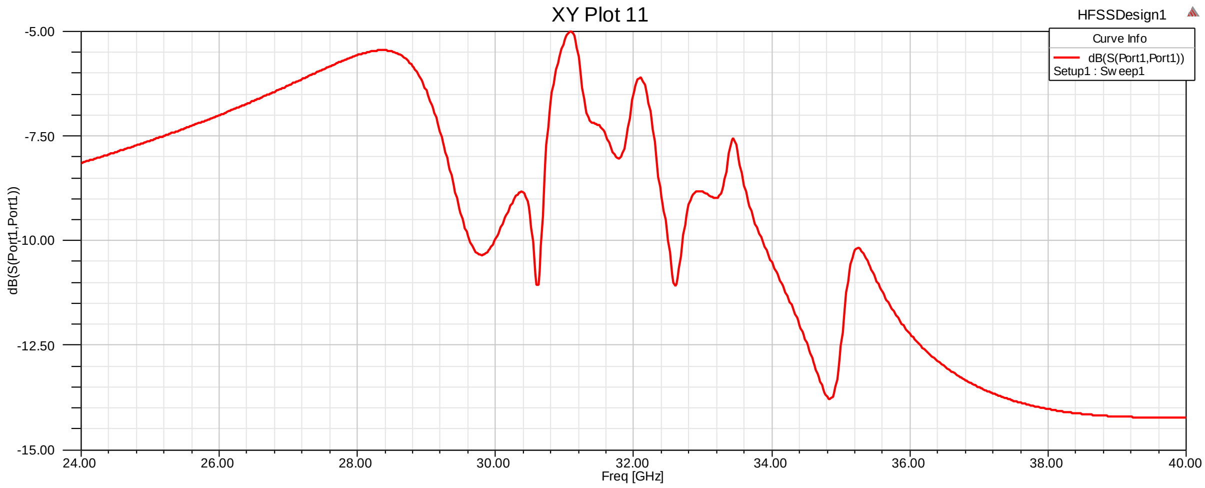

Fig. 10 Insertion loss of designed flair antenna with Al2O3 substrate.

Fig. 11 3D directivity polar plot for flair antenna with Al2O3 substrate.

Table 3 Insertion loss for Al2O3 substrate with flair antenna design.

Frequency (GHz)	Insertion Losses (dB)
24	-9.05955
25	-8.82074
26	-8.03317
27	-5.19387
28	-5.71643
29	-8.80692
30	-10.3092
31	-7.34392
32	-10.0723
33	-8.23265
34	-17.6201
35	-10.4723
36	-10.42
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IV. CONCLUSION

The aim of this research work was to design a compact microstrip patch antenna for use in wireless. Different antennas were designed in this thesis work according to the requirements of Ka band application. In second section of the research work curved edge i.e. flair end antenna is deigned and simulated with three different substrates. In case of arlon near Ka band resonant frequency is observed at 26 GHz. In case of roger substrate two resonant frequency were observed at 34 GHz and 36.60 GHz. In case of Al2O3 substrate four resonant frequencies were observed at 29.80 GHz, 30.60 GHz, 32.60 GHz, and 34.80 GHz.

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