ABSTRACT: The aim of this paper is to design a modified rectangular microstrip patch antenna for high band applications especially for Ku-band and Ka-band applications. High band is achieved using inserting vertical slits in the rectangular patch. The result shows that the return loss as -5 dB is achieved at the first resonant frequency of 12 GHz in Ku-band. Return loss as -12 dB is achieved at the second resonant frequency of 31 GHz and return loss as -14 dB is achieved at the third resonant frequency of 39 GHz used in Ka-band application. Another aim to make operate the proposed antenna to give better performance in high band application.

KEYWORDS: Antenna Design, BW Enhancement, Microstrip Patch Antenna, Rectangular Microstrip Patch Antenna, Return loss.

I. INTRODUCTION

Microstrip antennas are attractive due to their light weight, conformability and low cost. These antennas can be integrated with printed strip-line feed networks and active devices. This is a relatively new area of antenna engineering. The radiation properties of microstrip structures have been known since the mid-1950. The application of this type of antennas started in early 1970 when conformal antennas were required for missiles. A major contributing factor for recent advances of microstrip antennas is the current revolution in electronic circuit miniaturization brought about by developments in large scale integration. As conventional antennas are often bulky and costly part of an electronic system, microstrip antennas based on photolithographic technology are seen as an engineering breakthrough [1-2].

In this paper, compact design of microstrip patch element with microstrip feed line is proposed for Tri band (X-band, Ku-band and K-band) applications. The principal applications of X-band, Ku-band and K-band are radar, aircraft, spacecraft and mobile or satellite based communication system.

II. ANTENNA DESIGN AND GEOMETRY

A. DESIGN OF MICROSTRIP PATCH ANTENNA

The geometry of the existing antenna has been shown in Fig. 1. The antenna comprises of circular and rectangular slots both on the radiating patch and ground plane. The design process begins with the radiating patch with substrate, ground plane and a feed line. It is printed on a 1.6 mm height FR4 substrate that contains dielectric loss tangent 0.02, permittivity 2.2.

The length and width of the microstrip patch antenna is calculated with the help of the following equations which is stated by the specified approximation [3-4].
i) To calculate width
\[
W = \frac{1}{2\pi \sqrt{\mu_0 \varepsilon_0}} \sqrt{\frac{2}{\varepsilon_r + 1}}
\]

ii) To calculate Length
\[
L = \frac{c}{2 f_0 \sqrt{\varepsilon_r}} - 2 \frac{L}{L}
\]

\[
\varepsilon_r = \frac{1}{2} \left( \varepsilon_r + 1 \right) + \frac{1}{2} \left( \varepsilon_r - 1 \right) \left( 1 + \frac{10h}{W} \right)
\]

\[\varepsilon_r=\text{dielectric constant of the substrate}\]
\[h=\text{height of the substrate}\]

Fig. 1. Existing Square shaped Microstrip Patch Antenna

In fig 1, shows existing antenna is determined as 40 x 40 mm. The radius is 7.5 mm. The path dimension is 17 x 10 mm.

B. Design of Proposed Rectangular Microstrip Patch antenna

The geometry of the proposed antenna has been shown in Fig. 2. Basically, microstrip patch antenna consists of three layers: a metallic layer with antenna element pattern, dielectric substrate and another metallic layer as the ground plane[5-6]. The antenna is designed by using FR-4 with permittivity \(\varepsilon_r = 2.2\) and height, \(h = 1.588\) mm. The antenna has a simple structure fed by 50 \(\Omega\) microstrip line.

i) To calculate Width
\[
W = \frac{1}{2f_0 \sqrt{\mu_0 \varepsilon_0}} \sqrt{\frac{2}{\varepsilon_r + 1}}
\]

ii) To calculate Length
\[
L = \frac{1}{2f_0 \sqrt{\varepsilon_{eff}} \sqrt{\varepsilon_0 \mu_0}} - 2 \frac{L}{L}
\]
Where,

\[
L = 0.41h \frac{\varepsilon_r + 0.3}{\varepsilon_r - 0.258} \frac{w}{h} + 0.264
\]

And

\[
\varepsilon_{\text{eff}} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2\sqrt{1 + \frac{h}{w} \frac{12h}{w}}}
\]

Where, \( \lambda \) is the wave length, \( f_r \) (in GHz) is the resonant frequency, \( L \) indicates the length and \( W \) indicates the width of the patch element and \( \varepsilon_r \) is the relative dielectric constant.

![Proposed Antenna](image)

**Fig. 2. Proposed Antenna**

In fig2, shows Proposed antenna is determined as 4 x 2.2 mm as first stub and 2 x 4.9mm as second stub with 3 array. The transmission line is 1.7 mm.

Step by step procedure to design the proposed antenna:

Step 1:
Step 2:

![Proposed antenna design steps](image)

In fig 3 (a) (b) shows Proposed antenna design steps follows as step 1 and step 2.

III. RESULT AND DISCUSSION

It’s easy to simulate the design through computer before real time implementation. The ADS software helps us to determine bandwidth, return loss, gain and directivity. This tool also helps to reduce the fabrication cost because only the antenna with the best performance can be fabricated. The simulation results of existing antenna and the proposed antenna design shown in figure 4 and figure 5.

A. RETURN LOSS AND BANDWIDTH:

In fig 4, shows the return loss of existing antenna as -20.9 dB is achieved at the first resonant frequency of 10.4 GHz. The return loss of -16 dB at the second resonant frequency of 13.9 GHz.

![Return loss result for Microstrip Patch Antenna](image)

For step 1:

In fig 5(a), shows the return loss for proposed antenna as -30 dB is achieved at the first resonant frequency of 30 GHz used in Ka-band application.
For step 2:
In fig 5(b), shows the return loss as -5 dB is achieved at the first resonant frequency of 12 GHz in Ku-band. Return loss as -12 dB is achieved at the second resonant frequency of 31 GHz and return loss as -14 dB is achieved at the third resonant frequency of 39 GHz used in Ka-band application.

B. DIRECTIVITY AND GAIN
In Fig 6 (a) and (b), shows the result of gain and directivity where the existing antenna has gain as 4.96276 dB and directivity as 8.4735 dB.
Fig. 7(a) and (b) shows the proposed antenna has gain value as 7.09879 dB and directivity as 10.7106 dB.

C. Radiation Pattern

An antenna radiation pattern or antenna pattern is defined as a mathematical function or a graphical representation of the radiation properties of the antenna. Figure 8 and 9 shows the radiation pattern for existing antenna and proposed antenna.

In Fig 8, shows the radiation pattern for existing antenna and it has side lobe with improper radiation effect.
In Fig 9, shows the radiation pattern for proposed antenna and it has no side lobe with proper radiation effect.

IV. CONCLUSION

Antenna plays a vital role in communication whether it an ISM band, C band, X-band, Ku-band or Ka-band. The proposed antenna delivers high return loss and bandwidth where a single antenna can used for Tri-band application. The proposed design has the capability to work in two different high band frequency such as, Ku-band, Ka-band whereas the existing method can be used only for two low band applications. The proposed method has reduced side lobes. Thus, Rectangular Microstrip Patch Antenna has much better result for satellite communication.

V. FUTURE WORK

The shape of the antenna can be changed in order to get more return loss and efficiency. Even the same antenna design can be used for Many band application.

REFERENCES