ABSTRACT
In this paper, a rectangular microstrip patch antenna is proposed. The proposed antenna is exited through a 50 ohm microstrip feeding line. A prototype of the antenna is fabricated and tested. Return loss of -25.22 is achieved for 3.4GHz frequency.

Keywords
Single feed, rectangular patch, microstrip patch antenna and lowest frequency microwave bands.

1. INTRODUCTION
Microstrip patch antenna (MPA) is a new comer in the field of antenna engineering and it is seems to be reminded of characteristics generally to be desired when grouping an antenna specification [1]. There are requirement of low profile antennas, where the cost, size, performance and ease of installation are constraint [2]. These requirements are fulfilled by MPA. The Ofcom recently allot spectrum of 3.4GHz and 2.3GHz [3]. The lowest frequency microwave bands are 1.2GHz (1240-1325MHz, 23 cm), 2.3GHz (2300-2450MHz, 13 cm) and 3.4GHz (3400-3475MHz, 9 cm). Hence there is a need of an antenna for suitable transmission at this frequency. MPA is one of the best suggested antennas at this frequency.

In this paper, a simple single feed rectangular MPA is proposed for 3.4GHz frequency. The 50 ohm feeding line is used to excite an antenna. The further discussion is done in section 2, 3 and 4.

2. ANTENNA DESIGN
2.1 Design Specifications
Fig. 1 illustrates the antenna designed for 3.4GHz frequency. There are three essential parameters for the design of MPA.

2.2.1 Frequency of operation (fo)
The resonant frequency of the antenna must be selected appropriately. The satellite communication system uses s-band of frequency range from 2-4GHz. Hence the antenna designed must be able to operate in this frequency range. The resonant frequency selected for projected antenna design is 3.4GHz.

2.2.2 Dielectric constant of substrate (ε_r)
The dielectric substrate selected for projected antenna design is FR4_epoxy which has a dielectric constant of 4.4. A substrate with cheap cost has been selected since it reduces the overall cost of antenna.

2.2.3 Height of dielectric substrate (h)
For the MPA used in satellite communication it is essential that the antenna is not bulky. Hence the height of dielectric substrate is selected as 1.58mm.

Hence the essential parameters for design are:

- f_0 = 3.4GHz
- ε_r = 4.4
- h = 1.58mm

2.2 Design Procedure
Step 1 : Calculation of width (W)
The width of proposed MPA is given as,

\[ W = \frac{c}{2f_0\sqrt{(\varepsilon_r + 1)/2}} \]

Substituting c = 3 × 10^8 m/s, ε_r = 4.4 and f_0 = 3.4GHz it get,

\[ W = 26.84\text{mm} \]

Step 2 : Calculation of effective dielectric constant (ε_eff)
The effective dielectric constant of proposed MPA is given as,

\[ \varepsilon_{\text{eff}} = \varepsilon_r + \frac{1}{2} + \frac{\varepsilon_r - 1}{2} \left[ 1 + \frac{12h}{W} \right]^{1/2} \]

Substituting ε_r = 4.4, h = 1.58mm and W = 26.84mm it get,

\[ \varepsilon_{\text{eff}} = 4.92 \]

Fig. 1. (a) Top view (b) Side view of proposed antenna

Step 3 : Calculation of effective length (L_eff)
The effective length of proposed MPA is given as,

\[ L_{\text{eff}} = \frac{c}{2f_0\sqrt{\varepsilon_{\text{eff}}}} \]
Substituting \( c = 3 \times 10^8 \text{ m/s}, \epsilon_{\text{reff}} = 4.92 \) and \( f_0 = 3.4 \text{GHz} \) it get,

\[
L_{\text{eff}} = 19.88 \text{mm}
\]

Step 4 : Calculation of length extension (\( \Delta L \))
The length extension of proposed MPA is given as,

\[
\Delta L = 0.412h \left( \frac{\epsilon_{\text{reff}} + 0.3}{W} + 0.264 \right) - \left( \frac{\epsilon_{\text{reff}} - 0.258}{W} + 0.8 \right)
\]

Substituting all values it get,

\[ \Delta L = 0.73 \text{mm} \]

Step 5 : Calculation of actual length of patch (\( L \))
The actual length of patch of proposed MPA is given as,

\[ L = L_{\text{eff}} - 2\Delta L \]

Substituting values of \( L_{\text{eff}} \) and \( \Delta L \) it get,

\[ L = 18.42 \text{mm} \]

Step 6 : Calculation of ground plane dimension

\[
L_g = 6h + L = 27.9 \text{mm} \\
W_g = 6h + W = 36.32 \text{mm}
\]

3. PARAMETRIC STUDY
In this section, the effect of the physical parameters like patch length and patch Width are studied, by changing one variable at a time and maintaining all other variables Constant so that one can obtain an estimated antenna for the required applications.

3.1 Effect of Patch Width
The Figure below shows the effect of patch width on the S11 parameter. By changing the width dimensions the resonant frequency of antenna is decreased.

![Fig. 2. Variation of S11 parameter w.r.t patch width](image1)

3.2 Effect of Patch Length
The Figure below shows the effect of patch length on the S11 parameter, by varying the patch length there is a change in the desired frequency.

![Fig. 3. Variation of S11 parameter w.r.t patch length](image2)

4. RESULT AND DISCUSSION
The proposed antenna is simulated using High frequency structure Simulator (HFSS). The rectangular patch of dimensions \( L \times W \) is printed on the top of dielectric substrate FR_4 epoxy which has dielectric constant \( \epsilon_r = 4.4 \) and height \( h = 1.58 \text{mm} \). The ground plane is placed below the substrate has dimensions \( L_g \times W_g \). The single feed is used to excite the antenna has a dimension \( L_f \times W_f \).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating frequency</td>
<td>3.4GHz</td>
</tr>
<tr>
<td>Return loss</td>
<td>-25dB</td>
</tr>
<tr>
<td>Impedance</td>
<td>50 ohms</td>
</tr>
<tr>
<td>VSWR</td>
<td>1.06</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>92 MHz</td>
</tr>
</tbody>
</table>

Table 1. Simulated Result of Various Parameters

The simulated antenna design using HFSS is given in the Figure below:

![Fig. 4. Proposed antenna using HFSS](image3)

The simulation result of proposed antenna such as return loss and VSWR are given below,
5. CONCLUSION
A rectangular MPA for 3.4GHz is presented in this paper. The return loss less than -10 dB is achieved by proposed antenna. Return loss of -25.22 dB is achieved. Bandwidth and VSWR yield in 3.4GHz are 92MHz and 1.06 respectively. Future work can be done on antenna parameter, which is return loss by changing substrate material and by using different patch shapes.

6. REFERENCES