A Novel Method For Enhancing Gain Of Microstrip Antenna

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Abstract: Microstrip antennas are very popular in recent decades due to its small size, low cost, light weight, and easy fabrication. This antenna has many useful characteristics like thin profile, both linear and circular polarization, dual frequency operation possible, and with any shape. It has several applications in wireless communication, in telemmedicine, in mobile communication. However, the types of applications of microstrip antennas are restricted by the antenna inherently low gain and narrow bandwidth. Accordingly, increasing the gain and bandwidth of the microstrip antenna has been a main goal of research in the field. Aim of this paper is to increase gain of microstrip antenna. So, made some changes in different parameters of microstrip antenna like patch length, width or substrate size and gain and efficiency are observed.

Keywords: Microstrip, Antenna, Gain, Efficiency, patch

1 INTRODUCTION

Now a day’s wireless communication has many applications in different areas such as satellite communication, mobile communication, WLAN and Remote sensing, etc. Such systems require better performance, low cost, speed and reduced size, etc. For fulfillment of such criteria, antennas are designed of different shapes and sizes suited for different applications. Microstrip Antennas, earlier used only for defense and commercial applications, are replacing many conventional antennas [1]. However, the types of applications of microstrip antennas are restricted by the antennas inherently low gain and narrow bandwidth (BW). Accordingly, increasing the gain and bandwidth of the microstrip antenna has been a primary goal of research in the field. Thus, several advantages of microstrip antennas led to the design of different configurations for various applications. Large gain and small size antenna provide high efficiency and good reliability [2]. Microstrip antenna is fabricated on PCB. It is used at microwave frequency. Its fabrication is easy due to PCB techniques. They are very popular in recent decades due to small size and easy fabrication. By selecting different patch length and patch width output parameters are observed for microstrip patch antenna [3]. Microstrip antenna consists of dielectric slab, one side consists of radiating patch and other side act as ground plane. Both linear and circular polarizations are used for microstrip antenna. Conducting patch made by copper or gold and has any shape like circular, rectangular, elliptical, etc., but the rectangular and circular patches are most popular due to easy fabrication, and their useful characteristics [4]. Microstrip antennas have different types, such as microstrip dipole, microstrip patch, microstrip traveling wave and microstripi slot [5]. Characteristics of microstrip antenna are thin profile, it has several applications like in wireless communications, in telemedicine’s, in mobile communications, etc. The performance of any antenna can be determined by certain parameters, such as, gain, bandwidth, half power beam width (HPBW), antenna efficiency, side lobe level (SLL), cross polar level (CPL), standing wave ratio (SWR), and return loss (RL). Also, to understand the performance of a given antenna in RF range, one should have thorough knowledge of Smith Chart and Scattering parameters [7]. Antenna gain is defined as ratio of radiated power in specific direction to its power in isotropic direction. Antenna efficiency considers all losses such as dielectric losses, conduction losses, and reflection losses [8]. In this paper, gain enhancement obtained using slotting techniques. This technique is simple than other techniques because there is freedom to add desired slot. In this, EBG structure is used which reduces surface wave effect and obtain improvement in gain [9]. Antenna bandwidth is described based on gain, Impedance or VSWR. Height of the substrate and the width of the patch play an important role for the maximizing of the radiation efficiency and the bandwidth of the microstrip antenna. If higher is the height (1.5 mm) of substrate then more volume of fringing effect occurred, and its output is better return loss and bandwidth. If Height is above 1.5 mm then reduction in antenna parameters are obtained [10]. Using photonic crystals as substrate its one of the types to increase gain. For good antenna performance, select thick substrate whose dielectric constant is in the lower end of range, it produces better efficiency and high gain [11].

2 PARAMETRIC STUDY

The gain of the antenna is closely related to the directivity, it is a measure that considers the efficiency of the antenna as well as its direction capabilities. Antenna gain is defined as ratio of radiated power in specific direction to its power in isotropic direction. Antenna efficiency is a ratio of total radiated power to input power at feed point.

\[ \text{Gain} = \frac{E.D}{\text{Directivity}} \]  

\[ D = \text{Directivity} \]

In this paper, gain variation is obtained due to change in different parameters like patch size, patch length, patch width, feed position, ground plane size and substrate air gap. "Fig. 1" shows single microstrip antenna with top side and bottom side of substrate. The structure is optimized to operate overi
5.725- 6.4 GHz. The structures is simulated using IE3D software.

Now we consider different parameters of microstrip antenna for gain enhancement.

A Effect of change in RISi Square patchi sizei
The isuspended MSAi with RISi is optimized and its dimensions are MSAi patchi of 12.8 mm x 14.5 mm, ifeed positioni at 4.7 mm alongi width edgesi on x axisi, iground planei of 38 mm x 38 mm and a Reactive Impedance Surfacei of 5x5 squarei patchesi of sizei and spacingi 4 mm. The optimized antennai structurei providesi an impedance bandwidthi of 679 MHzi, maximumi efficiencyi upi to 73.5%. Three different RIS square patch size are used 3 mm (pink color), 4 mm (green color) and 5 mm (blue color). "Fig. 2 and 3" shows the magnitude of the igaini, ichefficiencyi and its ivasiation overi the operating frequencyi increases slightlyi with decreasei in RIS squarei patchi sizei.

Fig. 1 (a) Single microstrip antenna (b) Top side of substrate (c) Bottom side of substrate (d) Bottom view (e) Front view

Fig. 2 Gain Vs Frequency

Fig. 3 Efficiency Vs Frequency
**Effect of Microstrip Patch Length**

Consider three patch lengths 11.8 mm (pink color), 12.8 mm (green color), 13.8 mm (blue color). The gain and efficiency increase slightly with decrease in patch length and vice versa, as shown in “Fig. 4 and 5”.

![Fig. 4 Gain Vs Frequency](image1.png)

![Fig. 5 Efficiency Vs Frequency](image2.png)

As shown in above fig. 4 and fig. 5, when patch length is 11.8 mm gain is 6.5 dB and efficiency is 63%, if patch length is 13.8 mm then gain is 6.3 dB and efficiency is 65%. So, patch length should be minimum for betterment of gain and efficiency.

**Effect of microstrip patch width**

Consider three patch widths 13.8 mm (pink color), 14.8 mm (green color) and 15.8 mm (blue color). “Fig. 6 and Fig. 7” shows the gain and efficiency values observed almost same for increase or decrease in patch width.

![Fig. 6 Gain Vs Frequency](image3.png)

![Fig. 7 Efficiency Vs Frequency](image4.png)

**Effect of Ground Plane Size**

Consider, 3 ground planei of sizei 34 mm, 38 mm and 42 mm. The ichange in iground planei idimsions of MSAi does not ichange the iresonant ifrequency of the iantenna. Significant improvement in i0gain and i0efficiency is observedi with increase in iground iplane isize. “Fig. 9 and Fig. 10” shows when size is 34 mm then gain is 6.5 dB and efficiency is 66%, if size is 42 mm then gain is 7.35 and efficiency is 75%. So, keep ground plane size maximum then highest value of gain and efficiency is obtained.
Effect of Substrate air gap
The optimized suspended MSA with iRIS has a substrate air gap of height 0.5 mm, 1.0 mm and 1.5 mm. The change in height of substrate air gap of suspended MSA changes the resonant frequency of the antenna. The gain, bandwidth and efficiency decrease significantly by decreasing substrate air gap height, as shown in “Fig. 11 and Fig. 12”.

As shown in Fig. 11 and Fig. 12, when air gap is 0.5 mm, then gain and efficiency are 6.5 dB and 65%, if air gap size is 1.5 mm, then gain and efficiency are 7 dB and 75%. Keep substrate air gap maximum for maximum gain and efficiency. Gain and efficiency can vary by changing different parameters of microstrip antenna.

3 RESULT
Following table shows gain and efficiency of a Microstrip Antenna by considering all the above parameters.

<table>
<thead>
<tr>
<th>Sr No</th>
<th>Parameter</th>
<th>Size</th>
<th>Gain (dB)</th>
<th>Efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RIS Square patch size</td>
<td>3 mm</td>
<td>7</td>
<td>72</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 mm</td>
<td>6.7</td>
<td>70</td>
</tr>
<tr>
<td>2</td>
<td>Patch Length</td>
<td>11.8 mm</td>
<td>6.5</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13.8 mm</td>
<td>6.3</td>
<td>65</td>
</tr>
<tr>
<td>3</td>
<td>Patch width</td>
<td>13.8 mm</td>
<td>7</td>
<td>71</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15.8 mm</td>
<td>7</td>
<td>72</td>
</tr>
<tr>
<td>4</td>
<td>Ground Plane Size</td>
<td>34 mm</td>
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<tr>
<td></td>
<td></td>
<td>42 mm</td>
<td>7.35</td>
<td>75</td>
</tr>
<tr>
<td>5</td>
<td>Substrate air gap</td>
<td>0.5 mm</td>
<td>6.5</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.5 mm</td>
<td>7</td>
<td>75</td>
</tr>
</tbody>
</table>

4 CONCLUSION
Microstrip antenna is widely used because of its different advantages but it has some disadvantages like low gain. Gain is an important parameter of microstrip antenna, so the gain of antenna must be increased for different applications. In this paper, gain enhancement is obtained by changing some parameters of microstrip antenna considering patch size, patch length, patch width, feed position, ground plane size and substrate air gap, etc. Gain and efficiency can vary by changing these parameters of microstrip antenna. So, by considering maximum ground plane size and maximum substrate air gap and minimum patch size, maximum gain and efficiency for Microstrip Antenna are obtained. Gain and efficiency can vary by changing different parameters of microstrip antenna.

5 REFERENCES


