ABSTRACT

In this paper a microstrip patch antenna has been used for microwave frequency. The patch antenna is printed on RT/DUROID 5880. In addition a rectangular conducting plate of comparable dimensions was placed above the patch in order to enhance the bandwidth. The package was used to analyze the effect of the top patch, in particular the variation of VSWR with two parameters, namely the distance between the two patches and the size of the upper patch. Simulation and experiment result of a constructed array of two multipatch microstrip antenna with resonance frequency at 5.2 GHz shows the return loss S11 of about -29 dB, gain level of about 10.683 dB with 23.07% bandwidth improvement and after that we have designed an array of three multipatch microstrip antenna and achieved a bandwidth about 29.61% with directivity about 11.47 dB and return loss -29 dB at the frequency 5.74GHz. 

Keywords: Multipatch Microstrip Antenna, Microstrip antennas (MSA), Resonant frequency, Advanced Design System(ADS).

1. INTRODUCTION

Microstrip antennas are used in a wide range of applications, but due to its narrow impedance bandwidth restriction occurs. Microstrip patch antenna is very well known form of printed antenna. Microstrip patch antennas are getting popular in wireless application due to their low profile structure, simple geometry and low fabrication cost. It is a very important element in communications and radar applications since it provides a wide variety of designs, either planar or conformal. Microstrip antennas can be fed by various techniques, besides its advantage of being compact and suitable for antenna array designs. The microstrip antenna generally consists of a radiating element (patch), an intermediate dielectric layer, and a ground plane. The radiating element or patch is generally made of conducting material such as copper or gold and can take any possible shape like rectangular, square, circular, elliptical, triangular etc.

Microstrip antenna performance is affected by the patch geometry, substrate properties and feed techniques. One of the advantages of microstrip antennas is the freedom to choose from a variety of patch geometries. A dielectric substrate with properties such as low loss, low dielectric, and sufficiently thick substrate can provide maximum radiation efficiency and bandwidth. However, the antenna dimensions are large when low dielectric substrates are used. Low loss substrates provide good radiation efficiency, but also make the microstrip antenna a high-Q device, resulting in narrow bandwidth. The use of high dielectric substrates with higher loss gives reduced performance, but greater bandwidth and smaller dimensions.

2. Multipatch Microstrip Antenna

When an antenna has more than one patch over the dielectric substrate it is called as a Multipatch Microstrip antenna. Multipatch Microstrip antenna provides basic information on patch antenna design and operation, directed to engineers who are mainly designers of RF/microwave circuits. In high performance aircraft, spacecraft, satellite and missile applications, where size, weight, cost, performance, ease of installation and aerodynamic profiles are important, low profile antennas may be required. To meet these requirements, Multipatch Microstrip antennas are used. Multipatch antennas are narrowband, wide beam antennas fabricated by etching the antenna element pattern in metal trace bonded to an insulating dielectric substrate with a continuous multi metal layer bonded to the opposite side of the substrate which forms a ground plane.

Figure 1. Multipatch Microstrip Antenna
The relation for the resonant frequency of the multidielectric layer Microstrip Antenna can be expressed as

\[ f_r = \frac{c}{2(L + 2\Delta L)\sqrt{\varepsilon_e}} \]

The relation for the quasi static permittivity of the multidielectric layer can be expressed as

\[ \varepsilon_e = \frac{\varepsilon_{r1} \varepsilon_{r2} (q_1 + q_2)^2}{\varepsilon_{r1} q_1 + \varepsilon_{r2} q_2} + \frac{\varepsilon_{r3} (1 - q_1 - q_2)^2}{\varepsilon_{r3} (1 - q_1 - q_2 - q_3) + q_3} \]

Where \( q_1, q_2 \) and \( q_3 \) are filling factors respectively. The length of the patch can be obtained by determining the effect of frequency on the substrate permittivity. The dispersive behavior of the permittivity can be determined as

\[ \varepsilon_{\text{eff}} = \varepsilon_r' - \frac{\varepsilon_r' - \varepsilon_e}{1 + P(f)} \]

Where \( \varepsilon_e \) is the permittivity which takes into account \( \varepsilon_r' \) and \( \varepsilon_{\text{eff}} \) multilayer effect on a microstrip line as all the formulae calculated were for single layer.

\[ \varepsilon_r' = \frac{(\varepsilon_e \times 2)^{1} - 1 + A}{1 + A} \]

Where the parameter A can be expressed by eq. given below in terms of \( h_{12} \), the height between layers 1 and 2 and W.

\[ A = \left( 1 + \frac{12 \times h_{12}}{W} \right)^{-\frac{1}{3}} \]

3. Design of Multipatch Microstrip Antenna

Antennas with dual patch consist of a very thin metallic strip (lower patch) placed a small fraction of a wavelength above a ground plane. Another thin rectangular parasitic conducting plate (21.6 x 16.4 mm) is placed above lower patch is separated by an air gap \( (\varepsilon_r = 1.07) \) of width 2.2mm. A microstrip feed is also connected to the patch. The Multipatch is designed so its pattern is maximum normal to the patch.

![Figure 2. Layout of Single Patch on ADS momentum with feed line](image)

The figure shows 21.6 x 16.4 mm rectangular patch connects with a feed line. A multilayer antenna substrate of low electrical loss, and the upper honeycomb, prevent surface wave propagation and increase the bandwidth. The antenna patch is deposited on the underside of the substrate which acts as a protective cover.

4. Multipatch Microstrip antenna Array

Microstrip antennas are very versatile and are used, among other things, to synthesize a required pattern that cannot always be achieved with a single element. A standard configuration for microstrip antenna is a single rectangular patch. It consists of sandwich of two parallel conducting layer separated by single thin dielectric substrate. The lower conductor function as ground plane and upper conductor represents the antenna radiating part. This is simple configuration that is rugged and relatively easy to fabricate, but it is limited in its bandwidth. The bandwidth is limited to 0.5%-2%. Nowadays several methods have been attempted to enhance the bandwidth. One effective method is to add a second patch in front of the basic one, resulting in the so called dual patch microstrip
Antenna. The concept of stacking patches is realized through electromagnetic coupling which gives the bandwidth enhancement. Microstrip antenna arrays became very popular for their low profile and lightweight as well as their flexibility. The major advantage of Microstrip array antenna is the increased gain and directivity. The elements can be fed by a single line or by multiple lines in a feed network arrangement. In addition, they are used to scan beam of an antenna system, increase the directivity and gain, and perform various other functions which would be difficult with a single element.

Microstrip Arrays are limited in that they tend to radiate efficiently only over a narrow band of frequencies and they cannot operate at the high power levels of waveguide, coaxial line or strip line. With the need for light weight missile antennas and strip line transmission surface they have assumed an increasingly large share of the conformal missile antenna developments. The introduction of microstrip elements conformal to space vehicles and the obvious potential of such light weight array antennas lead to substantial interest in extending this technology towards full scanning capability.

5. Simulation and analysis of an array of two multipatch microstrip antenna

![Figure 3](image3.png)

**Figure 3.** Layout scheme of transformed rectangular patch on ADS momentum with Multipath Array and feeding line

![Figure 4](image4.png)

**Figure 4.** 3D view of Multipatch array

![Figure 5](image5.png)

**Figure 5.** Return losses at the resonant frequency 5.2 GHz

![Figure 6](image6.png)

**Figure 6.** Antenna parameters from Momentum (ADS)
A Multipatch microstrip antenna array has been successfully designed by calculating all the parameters required for it on a particular frequency requirement. Its simulation is done on ADS, with optimized parameters.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Frequency</td>
<td>5.2GHz</td>
</tr>
<tr>
<td>Return loss</td>
<td>-29 dB</td>
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<tr>
<td>Gain</td>
<td>10.0683 dB</td>
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<tr>
<td>Directivity</td>
<td>10.7524 dB</td>
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<tr>
<td>Efficiency</td>
<td>99.35 %</td>
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<tr>
<td>Bandwidth</td>
<td>23.07%</td>
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Table 1. The results obtained

6. Simulation and analysis of an array of three multipatch microstrip antenna

Here an Array of three Multipatch Microstrip Antenna has been designed. Here we are more concerned to enhance the directivity of an antenna so we have attached one more antenna to the array of two multipatch microstrip antennas to improve the bandwidth and directivity. Its simulation is done on ADS, with optimized parameters.

![Figure 7](image1.png)

Figure 7. Layout of triple Patch on ADS momentum with feed line

![Figure 8](image2.png)

Figure 8. 3D view of Multipatch array

![Figure 9](image3.png)

Figure 9. Return losses at the resonant frequency 5.74 GHz
Figure 10. Antenna parameters from Momentum (ADS)

<table>
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<tr>
<th>Parameter</th>
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<td>5.74 GHz</td>
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<td>-29 dB</td>
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<tr>
<td>Gain</td>
<td>8.72897 dB</td>
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<tr>
<td>Directivity</td>
<td>11.4703 dB</td>
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<td>Efficiency</td>
<td>76.10 %</td>
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<td>Bandwidth</td>
<td>29.61%</td>
</tr>
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</table>

Table 2. The results obtained

7. CONCLUSION

This paper has been presented for the purpose that to increase the bandwidth and directivity we should use the multilayer multipatch microstrip antenna. Using this technique we have also improved the directivity of antenna which is highly desirable for high performance fighter aircraft. For achieving the highly directional antenna we have designed an array of multipatch microstrip antenna and achieved a bandwidth of 29.61% and directivity of 11.4703 dB.

REFERENCES


AUTHOR'S BIOGRAPHY

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