CREATING THREE DUAL ISOSCELES TRIANGULAR SLOTS ON THE PATCH AND BANDWIDTH ENHANCEMENT FOR SLOTTED METAMATERIAL MICROSTRIP PATCH ANTENNA

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ABSTRACT: FR4 is an inexpensive and easily available substrate material, which can be used to design efficient and cost effective microstrip patch antenna. This paper focuses on increasing the bandwidth of the microstrip patch antenna. Paper discusses about design of a rectangular patch antenna, having coaxial probe as a feed. To get the improved bandwidth, a rectangular slot has been dug along with a pin short, which changes the interaction of radiation. A huge increase in bandwidth is observed using the proposed design; almost 3 fold. All the simulation work is done using IE3D simulating software from Zeland has been used.

Key words: FR4, rectangular antenna, slot, pin short

I. INTRODUCTION

In increasing growth of wireless communication system compact antennas plays an important role to fulfill the requirements. Antenna is basically the transition between a guiding device and free space. Antenna is one type of transducer that converts electrical energy to electro-magnetic energy in the form of electromagnetic waves. Antenna are required by any radio transmitter or receiver to couple its electrical connection to electromagnetic field. Nowadays there is a demand for small antennas, broadband antennas, multi-frequency antennas for mobile and satellite communication systems. A Dual band antenna is a kind of antenna designed for use on two different bands which provides various applications such as Satellite Communications, Wireless Communications, Area monitoring, Forest fire detection, Disaster prevention etc.

A Patch antenna is a kind of radio antenna with a low profile, which can be mounted on a flat surface. It consists of a flat rectangular sheet of metal, mounted over a larger sheet of metal called a ground plane. A patch antenna is a cantle of metal mounted on a substrate of thickness with dielectric constant $\varepsilon$. It is an easy to fabricate, low cost, dielectric constant, small-sized and low weight antenna. Different types of patch antennas are circular, square, rectangular, triangle, circular disk, ellipse, disk with slot, quintuple. Small size antennas are planar antennas or microstrip patch antennas that have various applications in the field of wireless communication systems. To improve the capacity of communication channel multiple input multiple output is considered as an antenna technology [2].Antenna array is a systematic arrangement of radio waves working together. Various kinds of antenna array are used like array factor, directional array, phased array and interferometric array. Different concepts used in antenna array are Broad side array and End fire array. In broadside array antennas are placed in straight line and they produced the beam which is perpendicular to the line. In broadside array radiation is maximum when it is perpendicular to the axis of the array but when radiation is maximum towards the array axis it is termed as end-fire array. To enhance the gain of antenna magneto-dielectric materials are used with high permittivity. Magneto-dielectrics are materials that can be polarized both electrically and magnetically to an applied electromagnetic field.

II. LITERATURE REVIEW

The Gordon et.al described that the band width of microstrip antennas can be increased by using thick substrate but with thick substrate coaxial probe feed introduces inductive component due to which unavoidable impedance mismatch occurs. So the solution to impedance mismatch was found in the form of capacitive feeding mechanism which can be
used for annular ring MPA elements, consisted a small capacitor patch in the same layer as in the radiating element. [1]

A. Gordon et.al experimented on following three designs

1) Rectangular radiating elements,
2) Circular radiating elements and
3) Annular ring radiating elements

Feeding mechanism was common in all three designs. The position of the probe feed was decided to be in the center of the small patch. Design tool used was IE3D 12th version Zeland, substrate was FR4 with thickness 1.6 mm having dielectric constant 4.4. Height of patch from ground was taken as 15 mm, ground plane was taken as square of 150x150 mm and probe diameter 0.9 mm. Experimental Results are shown below:

Resonant frequency- 1800MHz
10 dB return loss Band Width

<table>
<thead>
<tr>
<th></th>
<th>Rectangular</th>
<th>Circular</th>
<th>Annular Ring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simulated</td>
<td>25.9%</td>
<td>26.8%</td>
<td>25.9%</td>
</tr>
<tr>
<td>Measured</td>
<td>26.4%</td>
<td>27.0%</td>
<td>26.1%</td>
</tr>
</tbody>
</table>

B. Gain

<table>
<thead>
<tr>
<th></th>
<th>Rectangular</th>
<th>Circular</th>
<th>Annular Ring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simulated</td>
<td>8.5 dBi</td>
<td>8.8 dBi</td>
<td>8.0 dBi</td>
</tr>
<tr>
<td>Measured</td>
<td>8.2 dBi</td>
<td>8.6 dBi</td>
<td>8.5 dBi</td>
</tr>
</tbody>
</table>

Garima et. al. proposed concentric diamond shape slotted circular patch microstrip antenna which is...
useful for C band and space communication systems. Main disadvantage of microstrip antennas is efficiently at a single resonance frequency corresponding to their dominant mode, narrow bandwidth (1-2%) and low gain. They proposed antenna useful for satellite communication systems as it presents the desired performances, viz. improved bandwidth, gain and multiple operating frequencies needed for satellite communication systems. FR4 with having thickness of 1.59 mm, dielectric constant of 4.4 and loss tangent of 0.025 was used as substrate. Circular patch radius is 16.2 mm was fabricated. To improve bandwidth path of the patch current has been increased by digging a diamond shape slot having dimensions a= 6 mm and b= 10 mm as shown in figure.

**Figure 3:** Design of proposed antenna

As a result resonating frequencies of 6.23GHz and 6.859GHz (simulated) and 6.66GHz and 7.42GHz (measured) were observed and bandwidth of 15.99% (simulated) and 13.58% (measured) along with Gain of 5.84 at 6.66GHz and 5.71 at 7.42GHz were observed, which is huge improvement over non-slated design. [3]

To obtain improved bandwidth and circularly polarized radiation over conventional elliptical antenna, in this paper the elliptical shape patch antenna with truncated edges has been introduced. In [4] tow antennas were studied (1) a conventional elliptical antenna and (2) edges truncated elliptical antenna. FR4 with having thickness of 1.59 mm, dielectric constant of 4.4 and loss tangent of 0.025 was used as substrate. Ellipse patch with semi major axis a = 15 mm and semi minor axis b = 14.43 mm after truncation L1= L2=7.75 mm as shown in figure.

**Figure 4.** Edge truncated elliptical patch antenna

Results showed resonating frequency =2.71 GHz and 2.80 GHz (simulated) and 2.692 GHz and 2.802 GHz (measured) were measured. Input impedances = (62.30+ j11.71) ohm corresponding 2.692 GHz and (48.49+ j5.34) ohm corresponding 2.802 GHz resonant frequency, Minimum Axial ratio = 0.68 dB at 2.751 GHz, Gain = 1.71 dB at 2.751 GHz

### III. PROPOSED DESIGN AND RESULTS

#### A. Design specification

To design this antenna, IE3D simulating software from Zeland has been used. The FR4 substrate having thickness of 1.59mm, dielectric constant of 4.4 and loss tangent of 0.025 is used. We have chosen FR4 because it is inexpensive and easily available substrate material.

#### B. Design dimensions

The rectangular patch of dimension of LxW = (20 mm x 30 mm) has been designed. We used coaxial probe for connecting microstrip patch antenna at coordinates (-5 mm, 8.325 mm) and same arrangement is used the conventional as well as the Slotted Rectangular microstrip patch antenna. To get the improved bandwidth, a rectangular slot of dimensions 7 mmx0.5 mm at point (-6.5, 6) has been dugged and a pin short at (-5, -10) is used (as shown in figure).
C. Return loss and bandwidth

After simulation on different slot area with different coordinates of the patch. Conventional rectangular patch has return loss of -26.46 dB with 3.346 GHz resonant frequency, whereas return loss of single slotted and pin shorted patch is -40.15 dB on 3.628 GHz resonant frequency. Bandwidth is taken 10 dB down of return loss curve. Conventional patch had bandwidth 3.227% and after modification enhanced bandwidth of 11.24% is obtained.

D. Smith Chart

The smith chart is a transform of a complex rectangular plane with real number on the x-axis and imaginary on the Y-axis. The input impedance of antenna can be calculated using smith chart. The input impedance of modified patch is calculated to $49.31\Omega + j0.76$ at resonant frequency 3.628 GHz.

E. Radiation Pattern

It’s graphical representation of radiated/ received power in certain direction. Since a microstrip patch antenna’s radiation is normal to patch surface, the
elevation pattern for $\phi = 0^\circ$ and $\phi = 90^\circ$ becomes important.

Figure 8 (a) and (b) Simulated radiation pattern of conventional patch and single slotted, pin shorted rectangular patch

The simulated E-plane and H-plane pattern of conventional patch and single slotted, pin shorted rectangular patch is illustrated in Figure 8 (a) and (b). Radiation pattern is uniform and smooth over a large band of frequencies and infinite ground plane would prevent any radiation towards back of the antenna.

Table 1: Comparison of without slot and with single slot circular MPA

<table>
<thead>
<tr>
<th>Sr. no.</th>
<th>Characteristics</th>
<th>Conventional Rectangular Patch</th>
<th>Single slotted and pin shorted rectangular Patch</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Resonant Frequency (GHz)</td>
<td>3.346</td>
<td>3.630</td>
</tr>
<tr>
<td>2.</td>
<td>Return loss (dB)</td>
<td>-26.46</td>
<td>-40.15</td>
</tr>
<tr>
<td>3.</td>
<td>Gain (dBi)</td>
<td>3.68</td>
<td>1.60</td>
</tr>
<tr>
<td>4.</td>
<td>Bandwidth (%)</td>
<td>3.227</td>
<td>11.24</td>
</tr>
<tr>
<td>5.</td>
<td>Antenna Efficiency (%)</td>
<td>40</td>
<td>30</td>
</tr>
<tr>
<td>6.</td>
<td>Radiation Efficiency (%)</td>
<td>42</td>
<td>30</td>
</tr>
</tbody>
</table>

IV. CONCLUSION

The FR4 substrate with aforesaid properties and dimension has been used. To optimized the output different location of the slot have been tried, maximum bandwidth was observed for slot dimension 7mmx0.5mm at point (-6.5, 6) has been dugged and a pin short at (-5, -10) is used. For the same dimensions conventional patch had bandwidth 3.227% and proposed design had bandwidth of 11.24%.

REFERENCES


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