Novel Design of a Low Cost Microstripline-fed Shorted Patch Antenna for Communication Applications

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Abstract
Features such as low profile, light weight, easily mounted and broad bandwidth are the key characteristics for antenna designed for communication applications. The microstrip antenna suits the features mentioned except for its narrow bandwidth and low gain. The bandwidth of the microstrip antenna usually ranges from less than 1% to several percent. This paper experimentally investigates an alternative approach in enhancing the bandwidth of the microstrip antenna for the various communication applications operating for S & C band frequency. The bandwidth enhancement technique which is studied is the Microstrip line-fed shorted patch antenna (MSFSPA). Results show a bandwidth enhancement of 23.29 % with better return loss of -18.38dB and -12.96 dB along with good radiation characteristics.

Keywords: Microstripline fed, Bandwidth, Light weight, Vector network analyzer, Communication, Dielectric constant.

Introduction
A design of low cost broadband antenna to cover wide frequency range has become a more challenge in today’s communication applications. This is because of the demand in mobile communication and its subsystems [1]. The antenna size should be small enough to fit into the modern communication systems equipment. In communication system applications, microstrip antenna plays a major role due to their several advantages such as low fabrication cost, conformability and ease of integration with feed network and so on [2]. From literature survey it is seen that improvement in the bandwidth of the microstrip patch antenna can be achieved and are found suitable for many broadband applications [3]. With increase in substrate thickness, use of low dielectric constant substrate, feeding techniques and use of
slots on the patch can result in wideband operation of an antenna [4, 5]. A shorted patch antenna with a shorting wall are generally a quarter-wavelength structure [6], and thus a compact antenna size at a fixed operating frequency can be obtained. Recently, this kind of shorted-patch antenna fed by an inset microstrip line has been reported [7], in which the shorted patch and the inset microstrip feed line both have a thin dielectric substrate, and narrow impedance bandwidth is expected.

In this paper, we present a novel design and construction of a low cost microstrip-line-fed shorted patch antenna (MSFSPA) with a wide impedance bandwidth (1:1.5 VSWR) of about 23% suitable for applications in communication system. Comparative studies of the antennas with and without slots of different size suspended through air substrate (dimensions) have been presented. The proposed antenna with slots shows a considerable increase in bandwidth and return loss when compared to conventional antenna.

**Design and Results**

The artwork of the microstrip-line-fed shorted patch antenna with V-slot (MSFSPA-V) is carried out using AutoCAD 2011 computer software and the schematic of the designed microstrip-line-fed shorted patch antenna with V-slot is shown in Fig.1. The dimensions of etched copper patch with length $L = 36.30$ mm and width $W = 47.32$ mm and is suspended above the substrate at a height of $h = 1.6$ mm. The antenna is fed by microstrip line feed technique which is also suspended above the air substrate at height $t = 3.2$ mm. The design parameters are calculated and are shown in Table.1.

<table>
<thead>
<tr>
<th>Table.1 Antenna design parameters</th>
<th>Dimensions (mm)</th>
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<tbody>
<tr>
<td>$W_f$</td>
<td>27.28</td>
</tr>
<tr>
<td>$L_f$</td>
<td>18.78</td>
</tr>
<tr>
<td>$d$</td>
<td>5.5</td>
</tr>
<tr>
<td>$h_1$</td>
<td>12.8</td>
</tr>
</tbody>
</table>

Using the design equations [8], the calculated length and width of the ground plane $L_g \times W_g$ are $= 110 \times 130$ mm. The dimensions calculated are the functions of $\lambda_o$, where $\lambda_o$ is free space wavelength. Since the patch is fed through microstrip line technique its main advantage is that, the feed is directly connected to the copper patch providing maximum flow of current through it.

![Fig.1 Designed microstrip line-fed shorted patch antenna V-slot (MSFSPA-V)](image)
The V-slots are etched on the copper plate suspended above substrate at a height $h_1 = 12.8$ mm. The slot dimensions are $l = 15$ mm and $w = 4$ mm. These slot dimensions are function of free space wavelength $\lambda_o$. The radiating patch is shorted to the ground by a pair of shorting plates of proper widths, and the shorted patch is directly fed by a 50 $\Omega$ microstrip feed line. Also, in this design, both the shorted patch and the microstrip feed line have an air substrate and thus the material cost of the proposed antenna is considerably reduced.

The proposed antenna is experimentally tested on Vector Network Analyzer (Rohde and Schwarz, Germany make ZVK model 1127.8651) for the frequency range 0.5 MHz to 6 GHz. The designed frequency for the microstripline-fed shorted patch antenna is 1.8 GHz. It is found that the proposed designed showed two resonant frequencies characterizing dual band nature suitable for communication applications. Fig. 2 shows the variation of return loss (RL) Vs frequency characteristic of the proposed antenna with corresponding resonant frequency $f_{r1} = 3.62$ GHz and $f_{r2} = 4.99$ GHz having -18.71 dB and -12.96 dB return loss at resonant frequency respectively. The calculated bandwidths are 14.25 % (800 MHz) at $f_{r1}$ = 3.62 GHz and 8.07% (320 MHz) at $f_{r2}$ = 4.99 GHz. The practical bandwidth of this antenna is calculated using equation (1). It is also seen that the radiation patterns are linearly polarized and broadsided in nature as shown in Fig. 3.

$$BW= \frac{f_2-f_1}{f_c} \times 100 \quad \text{----------------------------- (1)}$$

Where $f_2$ = higher frequency, $f_1$ = lower frequency, $f_c$ = centre frequency

From Fig. 3 it is also clear that the antenna shows better cross polarization level as low as -5 dB.

Fig. 2 Return loss Vs frequency characteristics of MSFSPA

Fig. 3 Measured radiation patterns at 3.62 GHz and 4.99 GHz
Conclusion

Finally, the measurements of Microstripline-fed shorted patch antenna on glass epoxy dielectric material for mobile, wireless and communication applications have been investigated and presented. The performance properties are analyzed for the optimized dimensions and the proposed antenna works well at the required frequency for both S & C-band.

Acknowledgements

Authors would like to thank, Department of Science and Technology (DST), Government of India, New Delhi, for sanctioning Vector Network Analyzer to this Department under FIST Project.

References


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