NARROWBAND MICROSTRIP PATCH ANTENNA FOR RADAR APPLICATION

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Abstract—This paper presents a novel narrowband microstrip patch antenna for radar application. The proposed antenna consists of rectangular radiating patch which provides a narrowband behavior and relatively good impedance matching working in the band of 3-12 GHz. A parametric study is performed on three different antenna structures. The measured results give three narrow band stable signal transmission within the band of interest. Proposed Antenna is designed using ANSYS HFSS antenna design tool.

Keywords: Microstrip-feed, slot antenna, ultra wideband (UWB) antenna.

1. INTRODUCTION

Ultra-wideband (UWB) radio is an emerging and promising technology with uniquely attractive features inviting major advances in wireless communications, networking, radar, imaging and positioning systems [1]. In the U.S., the Federal Communications Commission (FCC) allocated the frequency band 3.1-10.6 GHz for UWB applications in 2002. In either conventional communication systems or UWB communication systems, an antenna plays a very crucial role. Owing to its wide bandwidth, high data rate, and short-range characteristics, ultra wideband (UWB) communication has been widely used in radar and miniature laptop applications [2].

Ultra Wideband Radio (UWB) is a potentially revolutionary approach to wireless communication in that it transmits and receives pulse based waveforms compressed in time rather than sinusoidal waveforms compressed in frequency [3].

In addition, for miniaturizing the wireless communication system, the antenna must also be small enough to be placed inside the system. To achieve this, planar monopole antennas are good candidates for narrow-band applications, as they exhibit narrow bandwidth, compact and simple structure, and ease of construction. Moreover, the omnidirectional radiation properties of monopole antenna make them very suitable for base-station and for indoor applications [4].

Recently, there are various types of UWB antennas which have been designed to achieve the requirement for different applications. The compact size microstrip antenna is presented that have its applications in UWB frequency range is proposed [5]. Its bandwidth is impressive in view of its mechanical simplicity. However, it is not the most suitable for portable communication systems due to the size of the antenna. A new modified low profile small size UWB antenna is investigated.

In this paper, a Microstrip-fed Planar UWB antenna with Defected ground plane is used to improve the bandwidth, radiation characteristics and overall performance of antenna [5].

2. ANTENNA GEOMETRY

2.1 Antenna 1

A design of compact size microstrip antenna is designed that have its applications in UWB frequency range is shown in figure 1. The ground element of the proposed antenna is taken in the form of defected ground structure. The antenna is fed by a microstrip feeding technique and printed on a dielectric Fr4 substrate of dimension (30mm X 30 mm X 1.59mm) permittivity \( \varepsilon_r = 4.4 \) and height \( h = 1.59 \) mm. The optimization on the microstrip has been done to accomplish an -10 dB return loss criterion.
Table 1 Antenna Description

<table>
<thead>
<tr>
<th>S.NO</th>
<th>Description</th>
<th>Value/mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Antenna Length</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>Antenna width</td>
<td>30</td>
</tr>
<tr>
<td>3</td>
<td>Substrate thickness h</td>
<td>1.59</td>
</tr>
<tr>
<td>4</td>
<td>Feed Size</td>
<td>1.45</td>
</tr>
</tbody>
</table>

(a) Calculation of width of patch:
The width of the antenna is calculated by equation

$$W = \frac{1}{2} f_r \sqrt{\mu_0 \varepsilon_0} \times \sqrt{\frac{2}{\varepsilon_r+1}}$$

(b) Calculation of effective dielectric constant:
The effective dielectric is calculated by equation

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2} \sqrt{\frac{\varepsilon_r}{\varepsilon_0}} + \frac{\varepsilon_r-1}{2}$$

(c) Calculation of the effective length:
The effective length is calculated using equation

$$f_r = \frac{1}{2L \sqrt{\varepsilon_r \varepsilon_0 \mu_0}} = \frac{v_e}{2L \sqrt{\varepsilon_r}}$$

2.1.1 Results and Discussion

(a) S-Parameter

Figure 2 shows the simulated return losses (S parameter) of the proposed antenna. Basic description of antenna is shown in Table 1. The antenna bandwidth that is lower than -10dB occupies 7.3 GHz. It can operate well in UWB applications. The ground plane size selection is also based on the study on the microstrip slot antennas.
(b) Smith Chart

The Smith Chart is a fantastic tool for visualizing the impedance of a transmission line and antenna system as a function of frequency is shown in figure 3.

(c) VSWR

Figure 2: S-Parameter

Figure 3: Port Impedance In terms of Smith Chart

Figure 4: Frequency (GHz) versus VSWR plot
VSWR graph is shown in figure 4 and it is defined in terms of the input reflection coefficient $\Gamma$ as:

$$\text{VSWR} = \frac{1 + |\Gamma|}{1 - |\Gamma|}$$

$\Gamma$ is defined in terms of input impedance $Z_{\text{in}}$ of the antenna and the characteristic impedance $Z_0$ of the feed line as given below

$$\frac{Z_{\text{in}} - Z_0}{Z_{\text{in}} + Z_0}$$

### 2.2 Antenna 2

A compact size microstrip antenna is presented that have its applications in UWB frequency range. The antenna is fed by a microstrip feeding technique and printed on a dielectric Fr4 substrate of permittivity $\varepsilon_r = 4.4$ and height $h = 0.8$ mm. The optimization on the microstrip has been done to accomplish an -10 dB return loss criterion. Moreover, in comparison with a simple ground, the proposed design is modified which enhances the bandwidth and improves input return loss.

UWB antenna consists of modified rectangular patch with two square slots which is embedded on to the lower portion of patch (both right and left side).

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**Figure 5:** Antenna Geometry (Top View)

**Figure 6:** Antenna Geometry (Bottom View)

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### 2.2.1 Results and Discussion

(a) S-paramter

S-parameters describe the input-output relationship between ports (or terminals) in an electrical system. For instance, if we have 2 ports (intelligently called Port 1 and Port 2), then $S_{12}$ represents the power transferred from Port 1 to Port 2. $S_{21}$ represents the power transferred from Port 2 to Port 1. The S-parameter of above designed is shown in figure 7.

The antenna is resonating at 8.3 GHz which covers only few bands of UWB. As return losses of antenna is -25dB.
(b) **VSWR**

The most common case for measuring and examining VSWR is when installing and tuning transmitting antennas. Ideally, VSWR must lie in the range of 1-2. Below figure 8 is shows the VSWR plot.

(c) **Smith Chart**

Normalized scaling allows the Smith Chart to be used for problems involving any characteristic impedance or system impedance, although by far the most commonly used is 50 ohms. Smith Charts can be used to increase understanding of transmission lines and how they behave from an impedance viewpoint. Smith Charts are also extremely helpful for impedance matching.

The Smith Chart is used to display a real antenna's impedance when measured on a Vector Network Analyzer (VNA). Smith Charts is a useful tool for making the equations involved in transmission lines easier to manipulate and is shown in Figure 9.
2.3 Antenna 3

Further, to increase the overall performance of the former antenna, DGS technique is used. A compact size microstrip antenna is presented that has its applications in UWB frequency range is shown in Figure 10-11. The antenna is fed by a microstrip feeding technique and printed on a dielectric Fr4 substrate of permittivity εr = 4.4 and height h = 0.8 mm. The optimization on the microstrip has been done to accomplish an -10 dB return loss criterion. Moreover, in comparison with a simple ground, the proposed design is modified which increases the bandwidth and improves input return loss.

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S-parameters describe the input-output relationship between ports (or terminals) in an electrical system. For instance, if we have 2 ports (intelligently called Port 1 and Port 2), then S12 represents the power transferred from Port 1 to Port 2. S21 represents the power transferred from Port 2 to Port 1. In Figure 12, it is clearly shown that the antenna exhibits higher frequency narrow band. By using DGS application, the antenna gives an optimized result which fulfills all the requirements of UWB antenna.
Matching the impedance of the antenna to the impedance of the feed line is typically done using an antenna tuner. The tuner can be installed between the transmitter and the feed line, or between the feed line and the antenna. Both installation methods will allow the transmitter to operate at a low VSWR. Ideally, VSWR must lie in the range of 1-2. Below figure 13 is shows the VSWR plot.

(c) Smith Chart

The Smith Chart is shown in figure 1.4 and plotted on the complex reflection coefficient plane in two dimensions and is scaled in normalized impedance (the most common), normalized admittance or both, using different colours to distinguish between them. These are often known as the Z, Y and YZ Smith Charts respectively.
3. CONCLUSION

In this paper, a microstrip-fed ultra-wideband planar monopole antenna is designed and studied. This antenna is low profile small size antenna. Antenna 3 operates in the specified resonate at 3.4 GHz, 4.9 GHz and 8.3 GHz. The simulation results and other measurement results of the designed antenna show a good agreement in terms of the VSWR, antenna gain, and Smith chart.

4. REFERENCES