A Wing Stub Circular Microstrip Patch Antenna (WSCMPA) with Stable Return Loss and Radiation Pattern

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Abstract - A novel compact designed for Wing Stub Circular Microstrip Patch Antenna (WSCMPA) with stable return loss and radiation pattern is presented in this paper. There are 3 structures of UWB antenna which bandwidth ranging from 3.37 GHz to 10.44 GHz was presented. The conventional method in achieving a UWB compatible microstrip antenna is the utilization of circular monopole topology with a partial ground plane. However these structures produced unstable return loss and radiation pattern over the radiating frequency. Open stubs are added in the second design to further improve the antenna return loss characteristics. Furthermore, a wing stub is introduced to induce enhanced return loss characteristics and a stable radiation pattern in the last design. All the antennas were designed on Rogers 5880 printed circuit board (PCB) with overall size of 26 × 40 × 0.787 mm$^3$ and dielectric $\varepsilon_r = 2.2$. The performance of the designed antenna was analyzed in terms of bandwidth, gain, return loss, radiation pattern, group delay, and verified through actual measurement of the fabricated antenna.

Index Terms - Microstrip Antenna, Partial Ground Plane, Stable Return Loss, Stub Loaded, UWB

I. INTRODUCTION

In 2002, the Federal Communication Commission (FCC) of the United States [1] was authorized of its unlicensed operation of frequency band from 3.1GHz to 10.6GHz for indoor wireless communications. With the development of the Ultra Wideband (UWB) technology, UWB antennas have been studied intensively for communications and radar system. The uniqueness of UWB antenna that differs from the conventional antenna is the ability to transmit large amounts of digital data with very short pulses (in nanosecond or less) over a wide spectrum of frequency bands with very low power utilization. In order to run a stable antenna with a compact, portable system, radiation efficient, lower return loss at the desired frequency, a stable omni-directional printed antenna are desired. There are many different techniques were proposed to satisfy these requirements within UWB bandwidth. Large slot techniques are used in [2] to get a bandwidth enhancement and for the size reduction they used an L- or T-shaped bending. Wide aperture technique created multiple resonances that modified the microstrip feed [3]. A rotated slot was proposed in [4], where a microstrip feed line excited the two modes of a closed resonance. Another technique using a tapered slot feeding structure was proposed to transform the guided wave to free space wave without causing any reflection to the structure [5-6].

Recent studies of UWB antenna structures are specifically focused on the design rules and optimization technique [7-10]. The antenna was designed and fabricated on microstrip structure. The advantages of printed microstrip antenna are listed in [11-12], however, microstrip antennas also have several disadvantages [12-13].

The above mentioned techniques were developed to obtain wider effective bandwidth. However, a stable radiation pattern throughout the UWB frequency band is critical in some application. Some of the advantages are; in obtaining an...
“Wing” structure.

\[ V = \frac{5.98 (0.8)}{\left[ \exp \left( \frac{50 \sqrt{(\varepsilon_r + 1.41)}}{8} \right) \right]^{0.8}} \]

\[ = \frac{87.94}{(f \sqrt{\varepsilon_r})} \]
“wing” and it is
Parameter | Label | Design 1 (mm) | Design 2 (mm) | Design 3 (mm) \\
--- | --- | --- | --- | --- \\
Patch Radius | Rp | 8 | 7.76 | 7.76 \\
Feedline Width | Wf | 1.46 | 2.28 | 2.48 \\
Feedline Length | Lf | 16 | 13.2 | 13.2 \\
Step Width | Wstep | - | 1.5 | 1.7 \\
Step Length | Lstep | - | 5 | 5.3 \\
Ground Width | Wg | 32 | 31.16 | 26 \\
Ground Length | Lg | 16 | 18 | 18 \\
Block Length | Lb1 | - | 20 | 24 \\
Block Length | Lb2 | - | 20 | 22 \\
Block Length | Lb3 | - | - | 20 \\
Block Width | Wb | - | 2 | 2 \\
Block Spacing | Bs | - | 1 | 0.5 \\
Substrate Width | Ws | 32 | 31.16 | 26 \\
Substrate Length | Ls | 32 | 40 | 40 \\
Substrate Thickness | h | 0.8 | 0.787 | 0.787 \\
Dielectric constant | εr | 4.7 | 2.2 | 2.2 \\
SMA Impedance | Ω | 50 | 50 | 50 \\

A. Return loss, $S_{11}$
B. Radiation pattern
C. Group Delay

<table>
<thead>
<tr>
<th>Frequency (GHz)</th>
<th>Main Lobe Magnitude (dB)</th>
<th>Main Lobe Direction (angle)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Design 1</td>
<td>Design 2</td>
</tr>
<tr>
<td>3</td>
<td>1.7</td>
<td>2.4</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>2.5</td>
<td>3.7</td>
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<tr>
<td>6</td>
<td>2.8</td>
<td>3.4</td>
</tr>
<tr>
<td>7</td>
<td>2.7</td>
<td>2.3</td>
</tr>
<tr>
<td>8</td>
<td>1.3</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Realized Gain, \(\Phi=0^\circ\), Max. Value

Frequency / GHz

IJMOT-2013-3-414 © 2013 IAMOT
The author would like to bear appreciation towards Universiti Teknologi MARA (UiTM), Microwave Technology Centre (MTC) and Antenna Research Center (ARC) for providing measurement facility.

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VI. CONCLUSION

A novel printed Wing Stub Circular Microstrip Patch Antenna (WSCMPA) with stable return loss and radiation pattern has been designed and fabricated. This novel structural configuration could maintain the return loss and radiation pattern, with a decreasing antenna size. A wing stub pattern added to both side of the circular patch has been presented and discussed. Both simulated and measured results of return loss shows that the small compact size antenna offers an ultra wide impedance bandwidth from 3.37 to 10.44GHz for S11 < -10dB. This antenna yielded a doughnut shaped radiation pattern throughout the UWB frequency with the increment of antenna gain.

ACKNOWLEDGMENT
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