A Wideband Antenna with Defected Patch Structure Applicable for Wireless Communication

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Abstract

With defected patch structure a wideband monopole antenna presented in this paper. In this article a slot geometry is applied in design of the patch structure. Iterative patch structures are considered to obtain optimized results. The antenna is simulated and designed by CST Microwave Studio SuiteTM. The proposed one applicable for WLAN (5.2/5.8GHz) and WiMax bands (3.5/5.5 GHz). The antenna exhibits gain of 2.7dB, 3.7dB and 4.0dB at frequencies 3.5GHz, 5.2GHz and 5.8Ghz respectively. The operating bandwidth of antenna exhibits a wide bandwidth of 3.5GHz to 7.5GHz.

Keywords: Antenna, Iterative, Monopole, Slot Geometry, Wideband.

1. Introduction

Iterative structures are being applied in modern world in patch antennas to gain large bandwidth and several other advantageous features. There is a huge demand for wideband patch antennas in wireless communication11,12. In this paper a wideband monopole antenna with iterative patch structure applicable for various WLAN and WiMAX applications is presented. Several slot geometries like square, rectangular, triangular, trapezoidal, circular, elliptical etc. in combination with either a rectangular, fork like or circular tuning stub, optimized for wide-band operation, is found in literature4-8. In this paper a novel geometry of iterative square structures has been chosen for achieving UWB operation. The different iterative patches are designed in CST Microwave Studio SuiteTM environment. The finalized monopole is proposed to be applicable in the WLAN bands (5.2/5.8 GHz) and WiMAX bands (3.5/5.5 GHz). The antenna exhibits a gain of 2.7 dB, 3.7 dB, 3.9 dB and 4.0 dB at frequencies 3.5 GHz, 5.2 GHz, 5.5 GHz and 5.8 GHz respectively. The antenna exhibits a wide bandwidth of 3.5 GHz to 7.5 GHz respectively.

2. Antenna Design

Iterative patch structure is employed in the design of the proposed monopole. Figure 1 shows the iterative patch structures. The first iteration (Figure 1a) is a square patch whose length of each side is equal to ‘a’. The second iteration (Figure 1b) is a patch where four square shaped structures are added at the four corners of the previous one. The length of each side of a small square structure is one half of ‘a’.

\[ a' = \frac{1}{2} a \]

The third and final iteration is shown in Figure 1c.

Figure 1. (a) 1st iteration (b) 2nd iteration (c) 3rd iteration.

The Proposed Monopole antenna is shown in Figure 2. The finalized patch consists of a square slot in the middle.
and four small square slots at the four corners. The length of each side of the centre slot $s'$ is $\frac{5}{2}$ times of a small one whose length of each side is equal to $s$.

$$s' = \frac{5}{2} s$$  \hspace{1cm} (2)

The ground plane and the patch are composed of copper (annealed) material and the substrate material utilized is Teflon (PTFE) having a dielectric constant of 2.1. The various dimensions of the patch are given in Table 1.

Table 1. Parameter dimensions

| Parameter | Dimension (mm) |
|-----------|----------------|
| S1        | 3.75           |
| S2        | 1.50           |
| S3        | 4.25           |
| S4        | 6.25           |
| S5        | 2.75           |
| S6        | 1.25           |
| Fl        | 14.5           |
| Fw        | 2.60           |
| Gl        | 9.50           |
| Gw        | 18.0           |

3. Results and Discussion

The iterative behavior of the patch is studied with the help of comparison plots. Figure 3 shows a comparison plot of the three different iterations. A maximum bandwidth has been obtained in the 3rd iteration shown in red.

Figure 3. Iterative plots of return loss.

Figure 4 shows the $S_{11}$ vs. Frequency plot of the antenna for some common substrates available in the market. The properties of the substrate are given in Table 2. It is observed that the return loss increased when a substrate of a higher dielectric constant is used e.g. Roger RT6006 having a dielectric constant of 6.15 with a reduction in -10db bandwidth. A maximum bandwidth of 4 GHz (3.5 – 7.5 GHz) is obtained when Teflon having a dielectric constant of 2.1 is used as the substrate.

Table 2. Substrate properties

| Substrate       | Dielectric constant |
|-----------------|---------------------|
| FR-4            | 4.3                 |
| G-10            | 4.8                 |
| Teflon          | 2.1                 |
| Roger RT6006    | 6.15                |
Figure 5 shows the comparison plot of the patch structure with slot and without slot. It has been observed that the desired bandwidth has been obtained by the addition of square slots in the patch. A slight decrease in return loss is observed at a frequency of around 7 GHz.

The half feed length \( f' \) is varied from 1.1 mm to 1.5 mm. A feed length of \( f' = 2f = 2 \times 1.3 = 2.6 \) mm has been chosen to obtain maximum bandwidth.

![Figure 5. Effect of square slots in patch.](image1)

Figure 6 shows the \( S_{11} \) vs Frequency plot of the patch for different feed lengths. Here \( f \) is half feed length and \( f' \) is the total feed length.

\[
f' = 2f
\]

(3)

![Figure 6. Variation of Feed length (for Teflon substrate).](image2)

Figure 7 shows the variation of \( S_{11} \) parameter (Return Loss) vs. Frequency of the proposed patch. An extended bandwidth of 4 GHz (3.5 GHz to 7.5 GHz) has been observed from the Figure.

Figure 8 shows the VSWR vs. Frequency plot of the proposed structure. It has been observed that the VSWR is less than 2 throughout the entire bandwidth.

![Figure 7. Return Loss vs. Frequency.](image3)

![Figure 8. VSWR vs. Frequency.](image4)
Figure 9. Gain vs. Frequency.

Figure 9 shows the Gain vs. Frequency plot of the monopole antenna. It has been increasing from 2.7 dB to 4.0 dB throughout the frequency band from 3.5 GHz to 7.5 GHz.

4. Conclusion

The proposed monopole satisfies all the requirements of an UWB antenna in perspective of Return Loss, VSWR and Gain which is verified from respective simulation results. It is well applicable for all microwave frequency applications from 3.5 GHz to 7.5 GHz particularly the WLAN and WiMAX communication purposes.

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