Printed square UWB antenna

Razali Ngah, Yusnita Rahayu, Teguh Prakoso and Mohd Shukri Othman

Wireless Communication Centre
Faculty of Electrical Engineering
Universiti Teknologi Malaysia
razalin@fke.utm.my, vannebula2001@yahoo.com, fracosoe@gmail.com, cube_551@hotmail.com

Abstract - Ultra wideband (UWB) technology based on the use of very narrow pulses on the order of nanoseconds, covering a very wide bandwidth in the frequency domain, is one of the most promising solutions for future communication systems due to its high-speed data rate and excellent immunity to multipath interference. In this context, the antenna is one of the important components which determine the performance of UWB system. This paper presents a design of a printed square antenna with half ground plane and fed by a microstrip line for UWB applications. The designed antenna is simulated using Microwave Office. The parameters which affect the performance of the antenna are investigated. This paper also addresses the experimental measurements of return loss and radiation pattern. It has been demonstrated that the optimal design of this type of antenna can yield an ultra-wide bandwidth with satisfactory radiation properties over the entire bandwidth.

Keywords: Ultra wideband, printed square, antenna

1. Introduction

Several configuration of wideband monopole, such as circular, triangular, elliptical, pentagonal and hexagonal, have been proposed for UWB applications [1-4]. Compared with conventional UWB antennas such as spiral and log periodic antennas, wideband monopoles feature wide operating bandwidths, satisfactory radiation properties, simple structures and ease of fabrication. However, they are not planar structures because their ground planes are perpendicular to the radiators. As a result, they are not suitable for integration with printed circuit boards. This drawback limits practical applications of these wideband monopoles [5]. To overcome this problem, a printed square fed by a microstrip line is proposed. The parameters which affect the operation of the antenna are analyzed both numerically and experimentally. It has been demonstrated that the optimal design of this type of antenna can yield an ultra-wide bandwidth with satisfactory radiation properties over the entire bandwidth.

2. Antenna Design

The proposed wideband monopole antenna is illustrated in Figure 1. A square monopole with length of each side λ/4 of minimum frequency and a 50 Ω microstrip feed line are printed on the one side of the dielectric substrate. On the other side of the substrate, a ground plane with a dimension of (W × L1) is etched. The FR4 substrate of thickness 1.5 mm and relative permittivity of 4.7 was used in this design. L and W denote the length and the width of the dielectric substrate, respectively. L is constant at 50 mm in this study. The width of the microstrip feed line is fixed at W1 = 3.0 mm to achieve 50 Ω impedance. The conducting ground plane with a length of L1 = 100 mm only covers the section of the microstrip feed line. g is the height of the feed gap between the feed point and the ground plane.
3. Results and Discussion

The designed antenna is simulated using Microwave Office. It has been shown in the simulation that the operating bandwidth of the proposed monopole antenna is critically dependent on the feed gap g and the width of the ground plane W, and these two parameters should be optimized for maximum bandwidth.

Figure 2 shows the simulated return loss at different feed gaps, g of 1.5, 2, 2.5, and 3 mm, meanwhile the width of ground plane, W is fixed at 100 mm.

From the figure, it is observed that the -10 dB bandwidth changes significantly with varying feed gap g. This is due to the sensitivity of the impedance matching to the feed gap. The ground plane, serving as an impedance matching circuit, tunes the input impedance and the operating bandwidth while the feed gap is varied [5]. The optimized feed gap is found to be at \( g = 1.5 \) mm.

The simulated return loss curves with optimal feed gap g of 1.5 mm and different widths of the ground planes, W are plotted in Figure 3. It can be seen that the performance of the antenna is heavily dependent on the width W because the current is mainly distributed and transmitted on the upper edge of the ground plane along the y-direction. Simulation shows that the ground plane with a width of \( W = 100 \) mm can achieve the maximum bandwidth.

Figure 2 Simulated return loss at different feed gaps, g and at a fixed ground plane width, W

Figure 3 Simulated return loss at different width of ground plane, W and at a fixed feed gap, g

The prototype of the printed square monopole antenna with optimal design, i.e. \( g = 1.5 \) mm and \( W = 100 \) mm, as shown in Figure 1, was tested in the laboratory at WCC, Universiti Teknologi Malaysia. The return losses were measured using a Marconi test set and the radiation pattern measurements were carried out inside an anechoic chamber.

Figure 4 shows the simulated and measured return loss of the optimized antenna. The measured return loss agrees well with the simulation except at higher frequencies. The measured operating bandwidth of -10 dB is from 3 to 10.6 GHz, and in simulation from 3 to 8.5 GHz. From the figure, the measured return loss confirms the UWB characteristic of the proposed printed square monopole.

Figure 4 Simulated and measured return loss for the optimized ground plane width and feed gap
Figure 5 and 6 show the measured radiation patterns at 4 and 9 GHz, respectively. From the figures, it has demonstrated that the proposed antenna has omni directional properties over the entire operating bandwidth.

Fig. 5 Measured (a) E-plane and (b) H-plane radiation patterns with W = 100 mm and h = 1.5 mm at 4 GHz

Fig. 6 Measured (a) E-plane and (b) H-plane radiation patterns with W = 100 mm and h = 1.5 mm at 9 GHz

4. Summary

This paper presents simulation and implementation of a wideband printed square antenna for UWB application using Microwave Office simulation software. A printed square antenna fed by microstrip line is proposed and investigated. It has been shown that the operating bandwidth of the antenna is heavily dependent on the feed gap due to the impedance matching. The width of the ground plane also plays an important role in determining the performance of the antenna because the current is mainly distributed along the y-direction on the ground plane. It has been demonstrated experimentally that the proposed printed square antenna can yield an ultra-wide bandwidth, from 3 GHz to 10.6 GHz. It is also observed that the proposed antenna has omni-directional radiation pattern which shows that the antenna is a good candidate for future UWB applications.

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References