2

SMALL SLOTTED UWB ANTENNA BASED ON CURRENT DISTRIBUTION FOR BANDWIDTH ENHANCEMENT

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2.1 INTRODUCTION

This chapter presents numerical analysis of a small slotted UWB antenna by studying its current behavior. The active and neutral zones of antenna are determined before applying slots on its patch radiator. This is due to any modification applied on this active zone means disturbing its current distribution and affect to its impedance characteristics. It is shown from simulated and measured results that L and U slotted on the patch antenna result an UWB bandwidth. This simulation was performed by using the Zeland simulation software.

2.2 CURRENT DISTRIBUTION BEHAVIORS

As far as slots cut on the patch radiator of antennas are concerned, it is necessary to identify active and neutral zones in antennas where any modification in these areas will affect the impedance bandwidth. They can be identified with the study of their currents behavior.

The geometry of the antenna implies the current courses and makes it possible to identify active and neutral zones in the antenna, thus it will be possible to fix which elements will act on each characteristic.

The active zone is the matching and radiator zone. Acting on matching and radiating areas allows controlling the bandwidth. Zone closed to feeding point is the active zone. The neutral zones where geometry modifications are useless because neither the radiation pattern nor the matching bandwidth is much influenced

Through literature reviews and simulation observation, there are four types of current distribution modes in the antenna surface; vertical current mode, horizontal current mode, diagonal current mode and asymmetry current mode. In this section the current behavior of pentagonal antenna is studied. By observing the current distribution flow, the pentagonal has a diamond neutral zone. In this zone, the current levels are not too strong but they are not at zero level. Normally, this zone occurs at the middle of the antenna structure. The neutral zone for each frequency appears at different position. This is due to the difference current mode behavior at every frequency. Study on current distribution of planar monopole antenna by transmission line modeling (TLM) was performed in.

Figure 2.1 presents the current distribution on active and neutral zones for 5, 8, and 10.5 GHz of pentagonal antenna. From observation, each frequency has a different neutral zone size and position. The current behaviors on active zone are distributed along the bottom patch of pentagonal antenna.

The neutral zones of 5 GHz and 8 GHz have the same size. This neutral zone size is determined by observing the current distribution mode in the antenna surface. The slot size is precisely measured in order not to degrade the antenna performance. This size is analyzed and optimized by Zeland simulation software. The optimum size of diamond slot at 5 and 8 GHz is d_1 x d_2 of 4 x 4 mm, while d_3 x d_4 x d_5 of 6 x 4 x 2 mm at 10.5 GHz. The effect of this diamond slot to the return loss performance of pentagonal antenna is described in Figure 2.2.

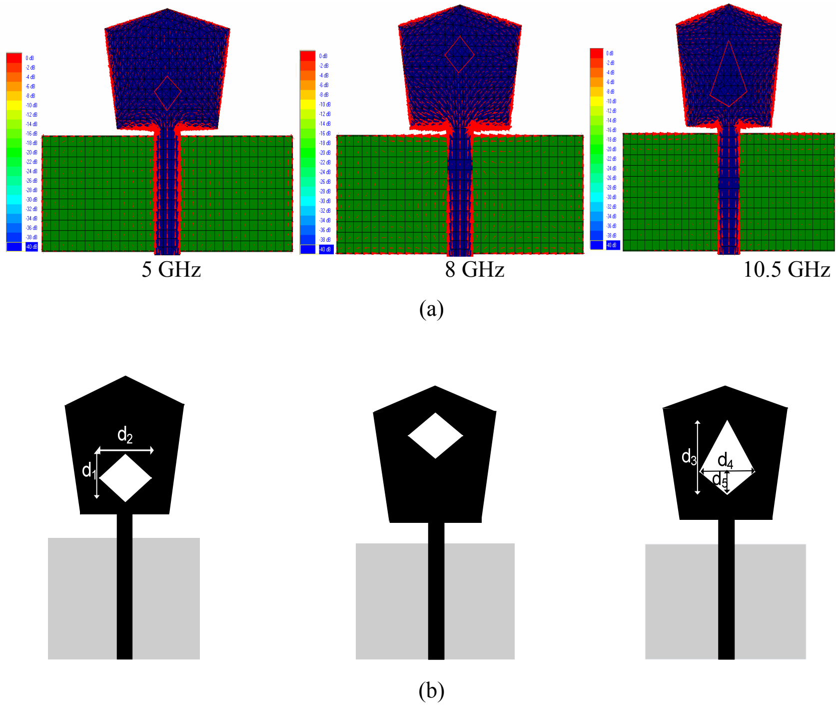

Figure 2.1 Neutral zones for 5 GHz, 8 GHz and 10.5 GHz of pentagonal antenna: (a) neutral zones of current distribution, (b) geometry of neutral zones

Figure 2.2 shows the simulated return loss for pentagonal antenna with and without diamond neutral slot. The antenna with their diamond neutral zone slots are simulated at 5.GHz. It is shown that the simulated return loss for all types of diamond slots does not influence the impedance bandwidth with respect to -10 dB. Thus, by identifying the neutral zone and active zones on an antenna, the size of antenna can be reduced and its characteristic can be controlled.

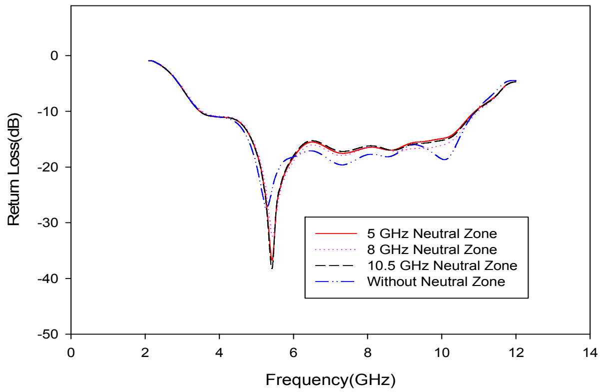

Figure 2.2 The simulated return loss for various diamond slots of pentagonal antenna at 5 GHz

The neutral zone can be used to simplify the antenna structure and integrate other function of the systems such as antenna circuits. This investigation has been proposed in, but not much explanation given. How to determine the neutral zone is not explained in detail. From simulation observation, as long as the size and the position of the neutral zone are precisely determined, this zone can be removed with no much influence on the radiation pattern and the matching bandwidth.

2.3 ANTENNA GEOMETRY

To validate the simulated result, an antenna prototype has been developed. Figure 2.3 shows the UWB antenna printed on the FR_4 substrate of $\varepsilon_r = 4.6$. The pentagonal antenna is vertically installed above a ground plane (l_{grd}) of 11 mm. The optimum feed gap (h) to the ground plane is found to be 1.5 mm. The dimension of substrate is chosen to be 30 x 30 mm^2 (W_{sub} x L_{sub}) in this study. Antenna has a pentagonal patch with a width (w) of 15 mm and a length (l) of 12 mm. The slot lengths of l_{s1}, l_{s2}, l_{s3}, and l_{s4} are 6, 9, 3, and 6.5 mm. The slot width is 0.5 mm in order to improve the bandwidth above 10 GHz.

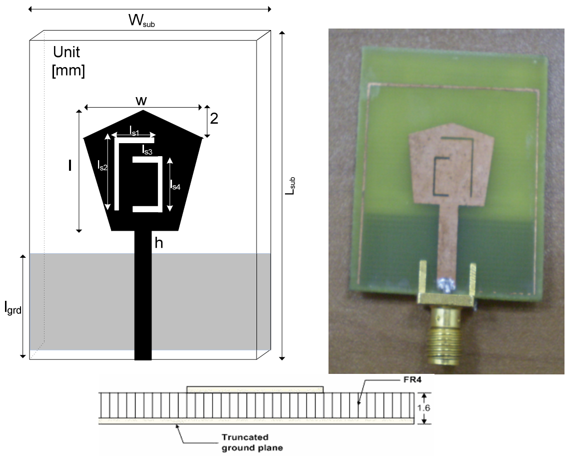

Figure 2.3 The Geometry and photograph of L and U Slotted UWB Antenna

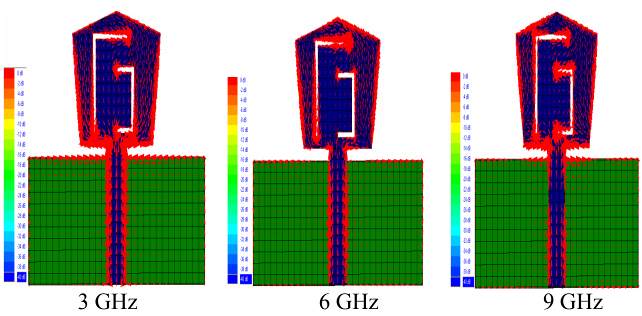

Figure 2.4 Current Distribution for L and U Slotted UWB Antenna

The L and U slotted antenna with current distribution at 3, 6, and 9 GHz is presented in Figure 2.4. It is shown that the vertical current is most concentrated near to the slots edges for all frequency range. It is also noticed that, the current distribution is less on the area between both slots without degrading its performance. This area is known as neutral zone.

2.3.1 Impedance and Pattern Bandwidth

The simulated and measured return loss is shown in Figure 2.5. The measured return loss is slightly shifted to the simulated one, but they still cover 2.5 GHz to 10.1 GHz as what the UWB required. From the simulation, the U slot improves the upper dip resonance of 10.3 GHz and the L slot improves the lower dip resonance of 5.3 GHz. The coupling of both slots has shown a very good return loss below -10 dB. The length of L slot is 14.5 mm approximately equal to 0.25λ at 5.3 GHz, and the length of U slot is 11.5 mm approximately equal to 0.4λ at 10.3 GHz. In addition, since the antenna is fed by a micro-strip line, misalignment can result because etching is required on both sides of the dielectric substrate. The alignment error results degradation to the antenna performance.

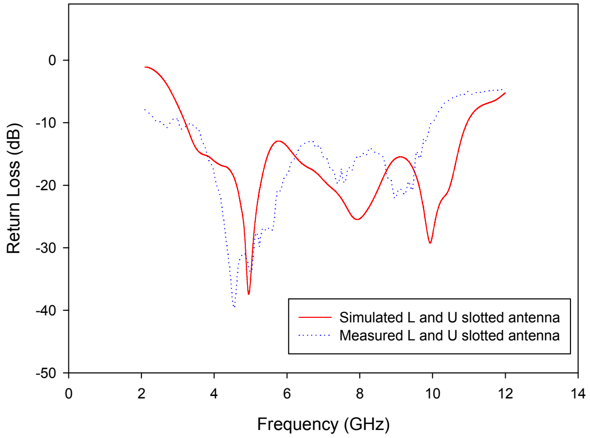

Figure 2.5 The Measured and Simulated Return Loss for L and U Slotted UWB Antenna

Figure 2.6 shows the simulated and measured E and H planes for 4 GHz, and 5.8 GHz. The results show that the radiation patterns are changing as the frequency increases. The H planes show a good omni directional for both frequency ranges. The E-planes are relatively broad and slightly distorted at 5.8 GHz.

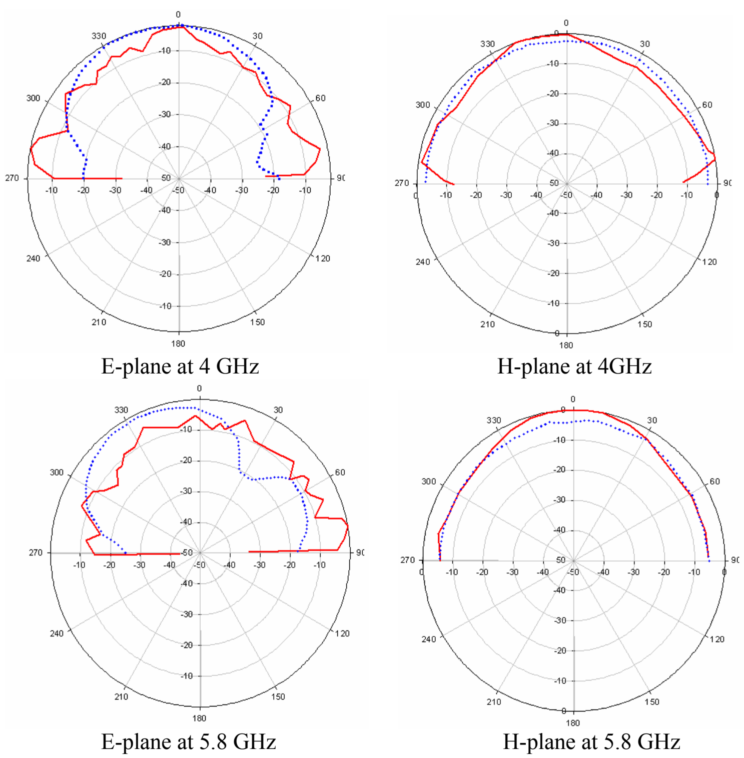

Figure 2.6 The Measured (solid) and Simulated (dotted) Radiation Pattern for L and U Slotted UWB Antenna

2.4 CONCLUSION

This chapter presents current distribution for small UWB antenna. It is shown that the current behavior on active zone is very critical part in defining the bandwidth performance. Neutral zone can be used to reduce the size of antenna if properly designed. The L and U slotted antenna has shown the UWB bandwidth with omni directional radiation pattern.

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