Monopole_Antenna_with_Tapered_Connection_and_Linier_Tapered.pdf

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Optimization of Compact UWB Monopole Antenna with Tapered Connection and Linier Tapered Transformer

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***Abstract*— A very compact UWB monopole antenna with stable radiation pattern is presented. The antenna is constructed on FR4 with dielectric constant of 4.4 and 1.6 thickness. The antenna has a bandwidth of 4.2 - 11.2 GHz. The antenna impedance adjustment process in the UWB frequency range can be adjusted by optimizing the tapered side and linear tapered transformers. The antenna structure have the same radiator and ground plane width. A partial ground plane produces an antenna with a stable omnidirectional radiation pattern for all UWB frequency bands. The antenna gain also shows very stable with a maximum gain of 3.5 dBi.**

Keywords*— *UWB, Omnidirectional, Matching Impedance

I. INTRODUCTION

Ultra-wideband (UWB) communication system is a solution in wireless communication systems on overcoming the scarcity of spectrum due to the high demand in telecommunications services [1]. The advantages are spectrum sharing capability, large channel capacity, capable of operating with low signal and noise ratio, resistance to jamming, good performance in multipath conditions and capability to penetrate various materials and having a simpler system design due to ultra-wideband systems does not require modulation. Many studies in this field were recorded after the issuance of ultra-wideband communication rules in the 3.1 - 10.6 GHz band by the Federal Communication Commission (FCC) [2]. One of the intense devices which developed by the researchers is the antenna. There are many variations of wireless communication systems that cause variations in antenna requirements. Meanwhile mobile communication systems required antenna with a small size and omnnidirectional radiation pattern. The UWB antennas that are printed on PCB substrate are currently very popular to develop. The design of a monopole antenna on substrate material with a stable omnidirectional radiation pattern can be found at [3]–[10]. The feeding technique used also varies, including coplanar waveguide (CPW) [3]–[5], [11] and micsrostrip line [6], [8]–[10], [12], [13]. Asymmetric antenna design is reported to be able to produce omnidirectional antennas and wide bandwidth according to UWB requirements [14].

There are many works have been done to have the UWB antenna with a smaller size and having a stable omnidirectional radiation pattern. For example the cactus shape monopole antenna on [3] using return loss controller with three different length of cactus arms. However, the radiation pattern is not shown for all UWB frequencies, thus can not be known whether the radiation patterns are stable on all UWB band or not. The rose shape monopole antenna design has been done on [4] but it is difficult to get a rose curve circumference. The design of polygon antenna on [5] and rectangular shape antenna on [6] also shows that the radiation patterns do not represent all of UWB bands.even though the antenna size is quite compact. On [7],[9], the algorithm for miniaturizing the structure of antenna has been developed while on [8] shows the antenna after fabrication. As the result, there is a small size monopole antenna but having less omnidirectional radiation pattern at higher frequencies. The quasi-circular antenna with additional curvature on the partial ground plane produce UWB antennas with very good working frequency of 3 – 11 GHz., but still have unstable radiation pattern on higher frequencies.

In this paper we propose the design and optimization of a new UWB antenna with omnidirectional polaradiation characteristics where the size is smaller and the design is much simpler than the antenna which reported on [3]–[11], [14]. The design process is carried out with EM software by analyzing several characteristics including return loss, current distribution, radation pattern and antenna gain.

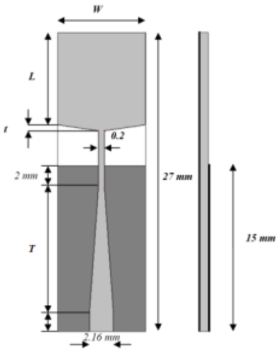

Fig. 1. Geometry of the proposed antenna.

II. ANTENNA DESIGN

The antenna structures consist of monopole antenna with a radiator that supplied by a microstrip line feed and using a partial ground plane. Antenna design is shown in Fig. 1. Monopole antenna is designed in square shape where the length is equal to the width of the substrate used. The antenna is designed and simulated on the FR4 substrate material with a thickness of 1.6 and a dielectric constant of 4.4. The overall size of the antenna is 8 × 27 × 1.6 mm.

This antenna is a monopole antenna in the form of patch square with a side length of 8 mm. The design of line width and substrate width are similar as [15], but the patch and substrate length are modified to different size. The antenna is supplied by two 50Ω and 105Ω lines and use linear tapered transformers to adjust the impedance of the two lines as in [15]. Feed lines and monopole patches are connected to one tapered side. The matching impedance adjustment of UWB can be optimized by combining and controlling the tapered connection section and linear tapered transformers. The partial ground plane structure of the antenna design is the main part on obtaining ultrawideband frequency response and omnidirectional radiation patterns. Moreover, the similarity between the width of substrate, patch and ground plane allows the antenna response to have a stable polaradiation for the entire UWB frequency range.

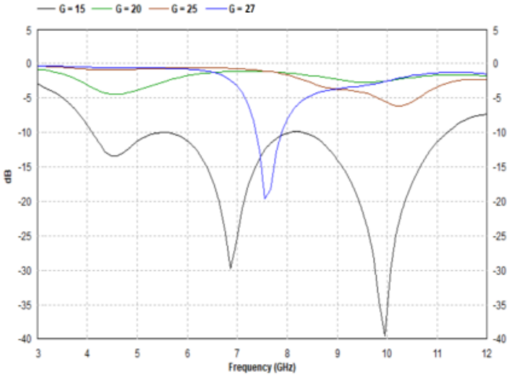

Fig. 2. S11 versus variation of ground length G (mm)

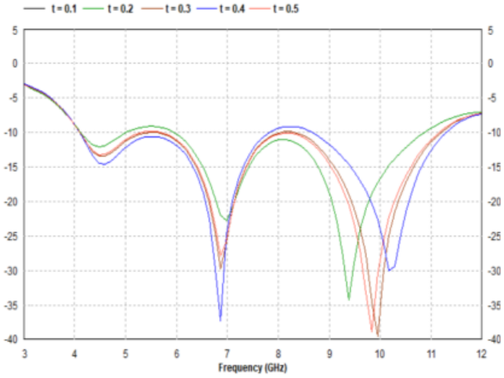

Fig. 3. S11 versus variation of tapered side high t (mm).

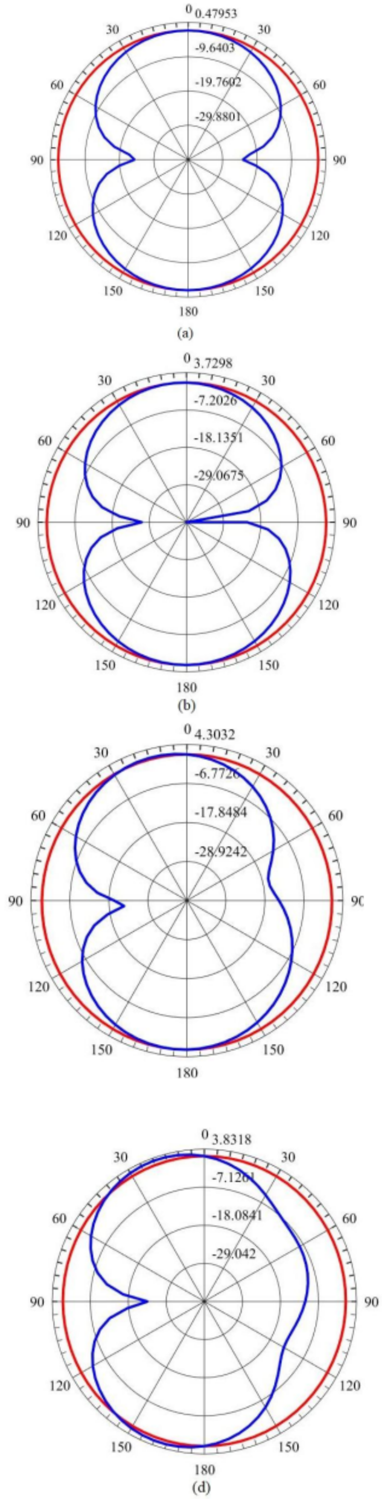

Fig. 4. Simulation of Antenna pattern, (a) 4 GHz, (b) 6 GHz, (c) 8 GHz, (d) 10 GHz. Red = H - plane , blue = E –plane

III. PARAMETRIC STUDY

Parametric studies are carried out on several parts of the antenna structure to optimize the antenna characteristics in order to have an omnidirectional radiation patterns and having the frequency responses that meet the needs of ultra-wideband communication systems.

Some significant parameters that need to be optimized are the length of the ground plane *G*, the patch length *L*, tapered connection *t*, and linear transformers.

IV. RESULT AND DISCUSSION

Patch antenna design usually uses a ground plane that covers all parts of the substrate to produce an antenna with omnidirectional polaradiation and narrow band frequency response. Fig. 2 shows S11 of the antenna when the ground surface cover the substrate surface for the ground length $G =$ 27 mm, then narrow band response is obtained. By changing the ground length *G* and keeping the ground width constant, the antenna response changes from narowband to ultrawideband. Furthermore, maintaining the ground size of 15 mm, then observing the variation in length *L*, will obtaind a constant frequency response, except the minimum value of s11 changes at a higher frequency. This shows that part *L* affects mainly on the antenna resonance frequency.

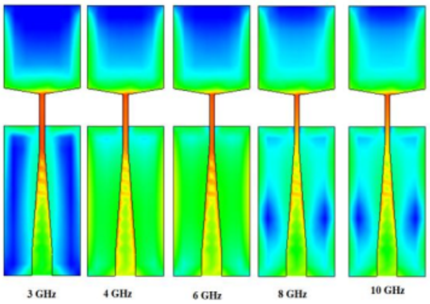

Fig. 5. Current distribution of the antenna.

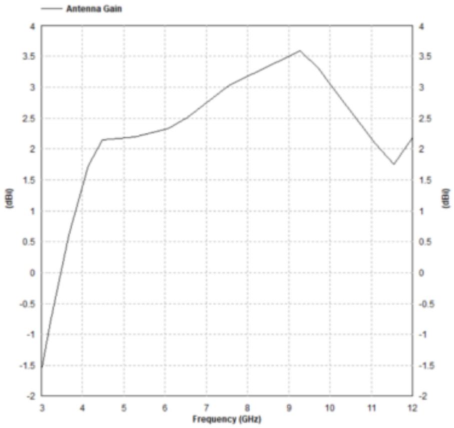

Fig. 6. Gain of the antenna.

Broadband matching impedance adjustments involve several parameters, namely tapered connection, linear tapered transformers. Patch square must be adjusted to the 50Ω transmission line. Before reaching the match condition there are two peaks between 3 and 10 GHz which are above -10 dB. This can be softly tuned by adjusting the *t* value and linear tapered transformers. The value of S11 for changes in *t* and linear transformer values is shown in Fig. 3. The optimization process is done by firstly optimizing the tapered transformer, then proceed by optimizing the tapered side *t* on the square radiator.

The radiation pattern of the designed antenna is omnidirectional. The simulation results show a very stable radiation pattern in the UWB frequency band. Radiation patterns for discrete frequencies of 4, 6, 8 and 10 GHz are shown in Fig. 4. The resulting radiation pattern associated with the current distribution of the antenna can be seen in Fig. 5. Meanwhile, the current is distributed at the center of antenna feed for the same frequency i.e. 4, 6, 8 and 10 GHz.

The simulation result of gain for this antenna is shown in Fig. 6. It can be seen that the gain of the antenna is stable enough for the UWB working frequency where the maximum gain is achieved at a frequency of 9.2 GHz which is 3.57 dBi..

After antenna optimization, the antenna size is 8 × 27 × 1.6 mm which is smaller than the antenna that has been reported on [3]–[11], [14] making it suitable for mobile devices with UWB systems

V. CONCLUSION

A very compact UWB monopole antenna is presented. Antennas are designed on cheap and strong materials, FR4. The antenna has a good band for the UWB system, with omnidirectional radiation patterns that are very stable at all UWB frequencies. The impedance matching process can be obtained by optimizing the tapered sides and linear tapered transformers in all UWB frequency ranges. Obtaining a very small antenna size thus the antenna can be used easily in various UWB devices.

VI. CONCLUSION

After these simulated results, antenna fabrication will be conducted to know the actual performance of the antenna by comparing the antenna parameter from the simulation and the result of antenna measurements to validate the design.

VII. ACKNOWLEDGMENT

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