Design of an Ultra Wideband Monopole Antenna for Handheld Devices

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***Abstract*— The basic motivation behind the choice of ultra wide band based antennas in wireless communication systems is there expedient feeding structure, wide bandwidth along with uncomplicated structure and low cost. Ultra Wideband wireless communication systems are not only serving in enabling applications like wireless monitors, wireless printers and efficient transfer of data from digital electronic devices but this standard is also finding its application in transfer of files among handheld devices such as personal digital assistants and especially for the mobile handsets. With every passing day handheld devices are miniaturizing which has given rise to the need of development of flexible antenna structures. This paper serves to present the design of a two layer monopole antenna with a physically flexible design in order to facilitate the small design and different shapes of the handheld device, under consideration. High frequency structural simulator of Ansoft Corporation has been adopted as the key simulation tool for this design.**

Keywords: HFSS (High frequency structural simulator), UWB (ultra wide band), VSWR (Voltage standing wave ratio), S11 (Input reflection coefficient).
ADS (Advance design system)

I. INTRODUCTION

An antenna can be regarded as a transducer that converts electrical energy into electromagnetic waves and conversely, electromagnetic waves into electrical energy. Basic difference between conventional narrowband antennas and UWB antennas is that of occupied bandwidth [1]. Due to this reason, UWB systems tend not to impede the narrowband communications in the identical frequency band. Conventional systems utilize the variation in either phase or frequency or even the power of the signal. Contrary to that UWB systems do so by performing time-modulation i.e. spawning radio energy at explicit time instants and engaging large bandwidth. Monopole antennas are gaining priority for handheld devices in the arena of UWB applications because of the fact that they provide better dipole optimization since half of the space required for the antenna is saved in the radiated portion [1]. A Monopole antenna generally comprises of a ground plane and an antenna element. In practice ground plane attains the tendency to influence the performance of an antenna [2]. In this paper we have focused our efforts towards the improvement of bandwidth and we have adopted the emerging design techniques to achieve the required task. The results presented in this paper are the evidences that by adopting our proposed design technique we can achieve enhanced impedance bandwidth in monopole antennas which are the demands of wireless handheld devices [3], [4].

II. ANTENNAS FUNDAMENTALS PARAMETERS

Antennas have many different parameters to judge the performance of antenna like bandwidth; the bandwidth is fundamentally the frequency or frequencies for which antenna has been design. In case of UWB based antenna we have frequencies from 3.1 to 10.6 GHz. In other parameters S11 (also called input reflection coefficient) which tells us how much power is transfer to antenna from load. Voltage standing wave ratio (VSWR), the ratio of output voltage to input voltage, of antenna is also important for design which tells how two transmission lines are matched. VSWR varies from one to infinity, if its value is one than this means that transmission lines are matched perfectly. VSWR with greater value can create reflection between load and antenna which will reduce the impact of antenna [5]. Next parameter is radiation pattern of antenna, which mainly relay on application of antenna. In antenna design radiation pattern mostly refers to the directional (angular) dependence of radiation from the antenna or other source [6]. Another parameter of design is efficiency of antenna, which tells how much power is lost in radiating a signal from antenna. The near and far field of an antenna is regions around antenna where different parts of fields are relatively more or less important.

III. MONOPOLE ANTENNA STUDY

The two basic shapes which are considered to be significant in providing relatively greater impedance bandwidth are circular and rectangular shapes respectively [7]. The variations of these basic two types also exist. In general monopole antennas require a ground plane this is due to the fact that there is always a need for reference [1].

C. Ground plane effect

Some research regarding the ground plane (Specially square and circular ground plane) for monopole antennas have been studied [8], [9]. Initially ground plane has been considered to be perpendicularly to antenna. Later due to requirement of antenna miniaturization parallel ground to antenna is given Importance.

D. Perpendicular ground plane vs parallel ground plane

Two ground planes of rectangular and square shapes as illustrated in figure 1 were investigated in terms of impedance bandwidth measured over S_{11}. By keeping either the width or the length constant two different rectangular ground planes were considered. It has been observed that the width change has greater effect than length when having a large ground plane (Copied Text) [8].

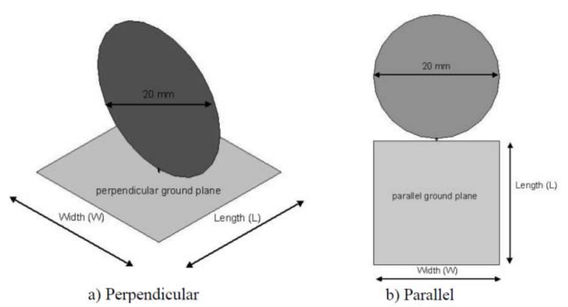


Figure 1: Printed Circuit Board monopole stack parameters

In terms of radiation pattern, either the perpendicular or parallel ground plane has no big difference on pattern shape. If miniaturization is required then reduction of group plane size can be done because it does not create large distortion over radiation performance.

E. Specification Ultra Wideband Monopole Antenna

By using Line calculator in ADS (Advance Design System) we find feed line width of 0.54mm which is good for line which has line impedance of 50 ohms.

$$\lambda = \frac{c}{f} = \frac{3x10^8}{3.1x10^9} = 0.0967m = 9.67cm$$

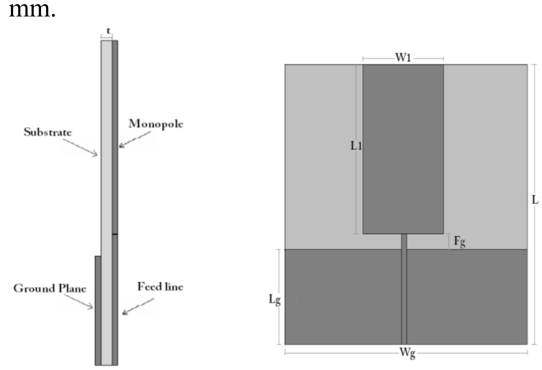
$$L = \frac{\lambda}{4} = \frac{9.67}{4} = 2.41cm$$

For PRMA, if length = L and width = W, then

L = L, r = W/2π for PRMA1 [11]

F. *Rectangular shaped UWB planar monopole antenna*

We have performed several simulations for the optimization of the proposed design of UWB antenna by using HFSS software. Our optimized HFSS simulation result for the frequency range from 3.34 to 12.1 GHz as shown in figure 3. The antenna size is 28.6 x 30 mm^2. The antenna length L_1 and width W_1 are respectively 18 mm and 11.5 mm. Ground plane dimension L_g is 10 mm and feed gap Fg is 0.6 mm. The substrate has material Rogers having permittivity 3.45 and dielectric loss of 0.004. The thickness of substrate is 0.25 mm. Antenna and ground are made up of copper and having thickness 0.035 mm and calculated feed line width is 0.54 mm.



(a) **(b)**

Figure 2: Showing the layout of a monopole antenna (a) Side view (b) Front view of antenna for frequency range from 3.34 to 12.1 GHz (bandwidth of 8.76GHz).

1) Simulated result for the printed monopole antenna

In this proposed design, a 50 ohms microstrip line serves to feed the rectangle shaped antenna as shown in figure 2. As clearly seen from the graph that the frequency range of 8.76 GHz antenna is showing return loss under -10 dB which means that -3 dB of power can be transmitted properly.

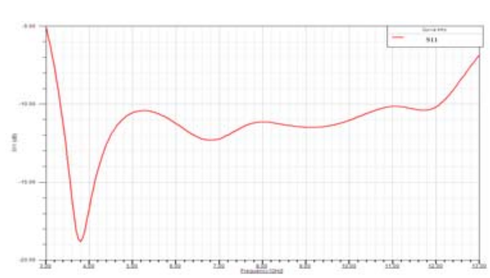


Figure 3: Showing the result of simulated return loss for rectangular antenna

Return loss S11 is a parameter that tells us how much power is radiated from load to the antenna; if it is 0 dB this means that no power is transmitted to the antenna. If it is -10 dB means 3dB of power is transferred to the antenna. Here for our purposed antenna we set level of -10 dB from figure we can observe that lower frequency for our antenna is 3.34 GHz and higher frequency is 12.1 GHz. Within this range our antenna has a return loss less than 10 dB.

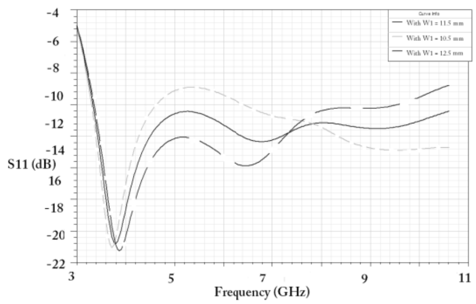


Figure 4: Showing the results of simulated return loss of rectangular antenna for different values of W1

2) Effect of monopole plate size

In figure 4 and 5 simulated results for optimized W1 and L1 along with some different values are presented to show the effect in return loss by changing antenna dimension. In these figures L1 varies from 17 to 19 mm and W1 varies from 10.5 to 11.5 mm

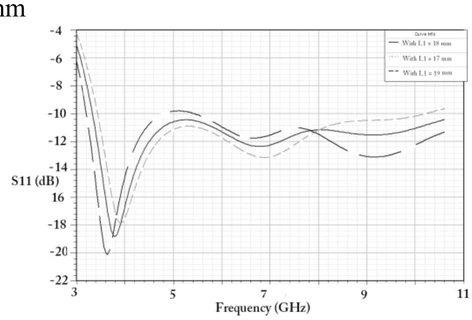


Figure 5. Showing the result of simulated return loss of rectangular antenna for different values of L_1

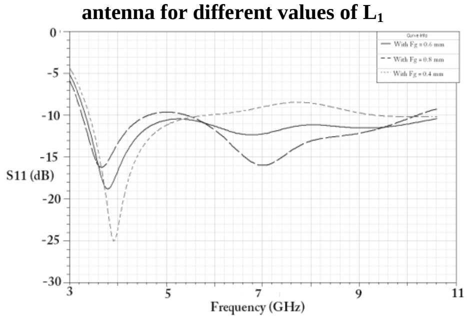


Figure 6. Showing the result of simulated return loss of rectangular antenna for different values of Fg

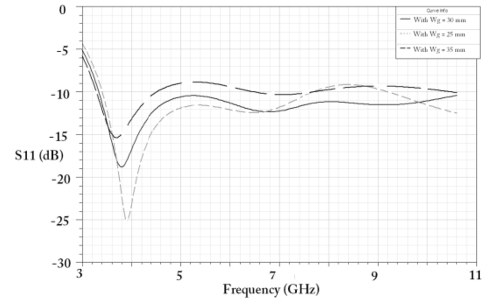


Figure 7. Showing the results of simulated return loss of rectangular antenna for different values of Wg

3) Effect of the Feed gap (Fg)

Feed gap is the distance between the rectangular antenna and the ground plane that always has affects on the performance of antenna. We have also optimized the affects of feed gap on antenna performance and our optimized simulation result has shown in figure 6. When we used Fg = 0.6 mm to 0.8 mm we observed that the frequency range is shrinking but if this value has changed to downward like up to 0.4 mm it showed the results in shifting a bandwidth to the lower frequency range.

4) The Effect of the ground plane size (Wg)

In general the bandwidth of monopole antennas depend on the size of ground plane [10]. The width Wg of the ground plane in this case is selected to be 30 mm. As far as the length of the ground plane Lg is concerned it has been observed through simulation results that parameter S11 is not affected by varying the length Lg. These observations are illustrated in figure 7.

5) VSWR and Radiation pattern

VSWR tells us how two lines are perfectly match. Its value varies from one to infinity, if it has value one that means it's perfectly match, but for higher values it has many losses. In our purposed rectangular antenna we achieve it less than two for the bandwidth of 8.75 GHz from 3.34 to 12.1 GHz.

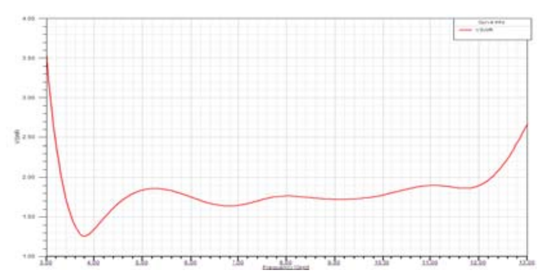
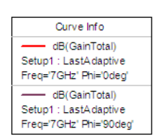


Figure 8. Voltage standing wave ratio of simulated antenna



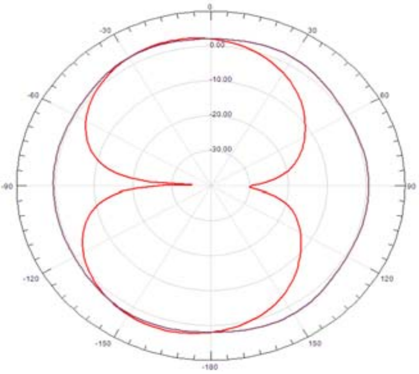


Figure 9. Radiation pattern of proposed antenna

VI. CONCLUSION

In this study, we have successfully demonstrated a design of ultra wideband monopole antenna for the wireless handheld devices. The measured results showed that the proposed UWB antenna can achieve ultra-broad bandwidth with enhanced performance with a high return loss greater than -10 dB from 3.34 to 12.1 GHz (bandwidth of 8.76 GHz) which was the promising achievement of our work .

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