Comparison of Different Planar Monopole UWB Antenna Using HFSS

Ria Kalra , Sukhdeep Kaur

Abstract - Since the release by the Federal Communications Commission (FCC) of a bandwidth of 7.5GHz (from 3.1GHz to 10.6GHz) for ultra wideband (UWB) wireless communications, UWB is rapidly advancing as a high data rate wireless communication technology. As is the case in conventional wireless communication systems, an antenna also plays a very crucial role in UWB systems. However, there are more challenges in designing a UWB antenna than a narrow band one. A suitable UWB antenna should be capable of operating over an ultra wide bandwidth as allocated by the FCC. At the same time, satisfactory radiation properties over the entire frequency range are also necessary. This paper focuses on UWB antenna design and analysis. Extensive investigations were also carried out on different types of Planar Monopole UWB antennas .The first type of antenna studied in this paper is circular disc monopole antenna. The disc monopole originates from conventional straight wire monopole by replacing the wire element with a disc plate to enhance the operating bandwidth substantially .Based on the understanding of circular disc monopole, different compact versions featuring low-profile and compatibility to printed circuit board are proposed and studied. All of them are printed disc monopoles, fed by a micro-strip line .Investigations have also been carried out in this thesis to analyze the design parameters of different monopole antenna such as planar circular monopole antenna, planar ring monopole antenna, modified planar rectangular antenna with and without notch. It has been demonstrated that these antennas are suitable for UWB applications.

Index Terms— High frequency structure simulator (HFSS), modified rectangular antenna, planar circular monopole antenna (PCMA), planar ring monopole antenna(PRMA), power density spectrum (PDS), ultra wide-band(UWB).

1.INTRODUCTION

Present time is witnessing a very rapid growth of wireless communications, for which antennas with very large bandwidth are in strong demand, so that various applications are covered with fewer or preferably with a single antenna.

It will be preferred that an antenna has bandwidth in excess of frequency range from 800MHz to 11GHz or even more, to include all the existing wireless communication systems such as AMPC800, GSM900, GSM1800,PCS1900,WCDMA/UMTS (3G), 2.45/5.2/5.8-GHz-ISM, UNII,DECT, WLANs, European Hiper LAN I, II, and UWB (3.1–10.6GHz). Out of all the above-mentioned wireless systems, ultra-wide bandwidth (UWB) wireless technology is most sought for very high-data-rate and short-range wireless communication systems, coding for security and low probability of interception, rejection of multipath effect, modern radar systems, and so forth. As mentioned above, this technology uses ultra-wide bandwidth of 7.5 GHz, ranging from 3.1GHz to 10.6GHz.

One of the challenges for the implementation of UWB systems is the development of a suitable or optimal antenna.The first important requirement for designing an UWB antenna is the extremely wide impedance bandwidth. In 2002, the US FCC allocated an unlicensed band from 3.1GHz to 10.6GHz on the frequency spectrum for UWB applications. Hence, up to 7.5GHz of bandwidth is required for a workable UWB antenna. And commonly, the return loss for the entire ultra-wide band should be in the criterion of less than -10dB.

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Next, for indoor wireless communication, omnidirectional property in radiation pattern is demanded for UWB antenna to enable convenience in communication between transmitters and receivers. Therefore, low directivity is desired and the gain should be as uniform as possible for different directions. Another important requirement is the radiation efficiency.Since the power transmitted into space is very low, the radiation efficiency is required to be quite high.Moreover, linear phase in time domain characteristics is desired for UWB application. Since linear phase will produce constant group delay, the transmitted signals, in the form of extremely short pulses, will not be distorted and hence the system works effectively. Last but not least, since UWB technology is mainly employed for indoor and portable devices, the size of the UWB antennas is required to be sufficiently small so that they can be easily integrated into various equipments.

Planar and printed monopole antennas are the good candidates for use in UWB wireless technology because of their wide impedance bandwidth and nearly omnidirectional azumuthal radiation pattern. Many shapes of planar, also known as planar disc, monopole antennas are reported, which yield very large bandwidth. Some of these reported configurations have bandwidth in excess of that required for UWB application.Printed monopole antennas (PMAs) are truly planar and have radiation patterns similar to that of a dipole antenna.These monopoles can be integrated with other components on printed circuit board, have reduced size on dielectric substrate,and are easy to fabricate. Printed antennas, commonly fabricated on FR4 substrate, are very cost effective, which is ideally suited for UWB technology-based

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low-cost systems.

This paper focuses on UWB planar printed circuit board (PCB) antenna design and analysis. Extensive investigations are carried out on the development of different planar UWB antennas . Firstly, the planar circular antenna designs for UWB system is introduced and described. Secondly, printed UWB circular ring monopoles were realized by replacing the disc elements of planar circular disc monopole antennas with circular ring elements.Next is the design of modified rectangular antenna with and without notch.All the antenna designs mentioned above cover the UWB range of 3.1-10.6 GHz.

2. Antenna Design and Simulated Return Loss

Fig. 1 shows the structure of the proposed antenna with optimum dimensions. As it can be seen the proposed antenna consists of a circular radiation element and a microstrip line feed. The circular disc monopole with a radius of *r* and a 50- microstrip feed line are printed on the same side of the FR4 (Flame Resistant 4) substrate (the substrate has a thickness of *H*=1.6mm and a relative permittivity of 4.4). *L* and *W* denote the length and the width of the substrate, respectively. The width of the microstrip feed line is fixed at *W*1=2.0mm to achieve 50- impedance. On the other side of the substrate, the conducting ground plane with a length of *L*1=17.5 mm only covers the section of the microstrip feed line. *h* is the feed gap between the feed point and the ground plane. Figure 2, shows the structure of printed UWB circular ring monopoles which is realized by replacing the disc elements of planar circular disc monopole antennas with circular ring elements. The proposed circular ring monopole antennas can exhibit nearly same characteristics as their disc counterparts.In order to reduce the return loss, the ground is truncated from the middle.Figure 3 shows the comparison of the simulated return loss curve of planar circular antenna and planar ring antenna.

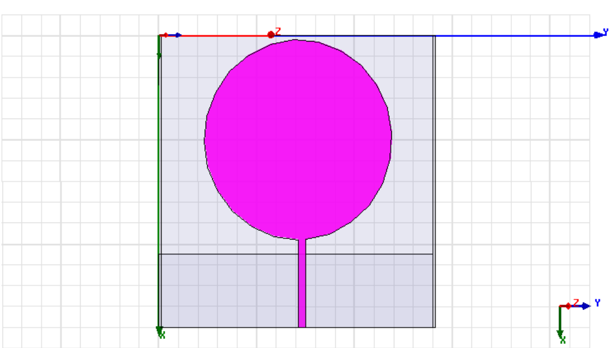

Figure 1:Geometry of circular monopole antenna

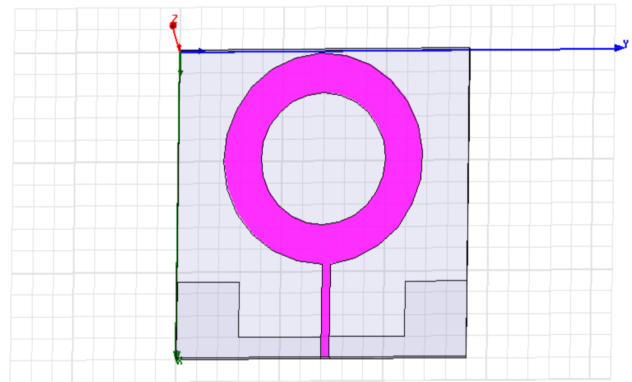

Figure 2:Geometry of ring monopole antenna

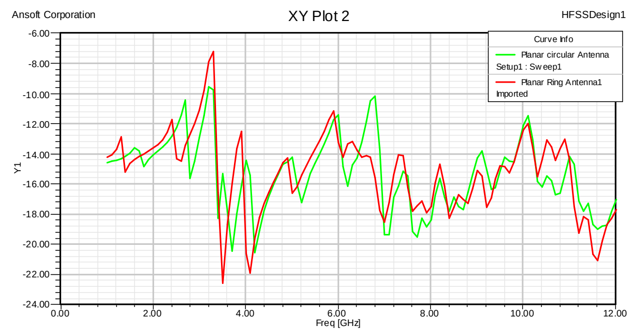

Figure 3.Simulated Return Loss Curve

It is observed in Figure 3 that the simulated -10dB bandwidth ranges from 1.0 GHz to 12 GHz. And the entire UWB range of 3.1-10.6Ghz is covered.The performance of Circular Ring Antenna is better than Circular Disc Antenna.

Fig 4 shows the structure of Modified Rectangular Antenna with increase in step size.In order to maximize the impedance bandwidth a pair of notches is placed at the two lower corners of the rectangular radiator and notch structure is also embedded in the truncated ground plane. The dimensions of the first rectangle attached to the feed line is specified as L1*W1 and the dimension of second rectangle as L2*W2 is placed on one side of an FR4 substrate of thickness 1.524 mm and relative permittivity 4.4. (L1*W1=4mm*6mm and L2*W2=4mm*10mm)The partial ground plane is located on the other side of the monopole. The dimension of the substrate is L*W=26mm*17mm.The antenna is fed by a microstrip of 50Ω feedline of width = 2mm and length = 10mm.The length of the partial ground is 5 mm and it is truncated.In order to improve the performance a notch is cut from the radiator of length 6mm and width 2mm as shown in Fig 5

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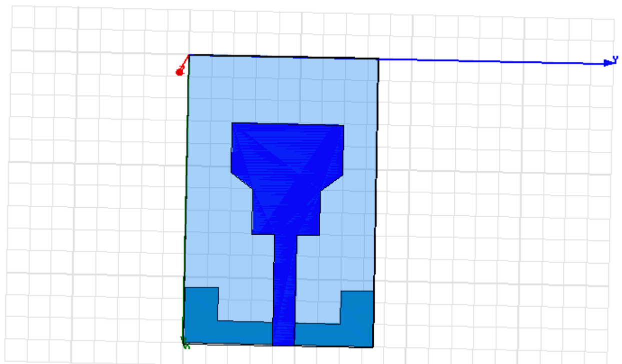

Figure4: Geometry of Modified Rectangular Antenna

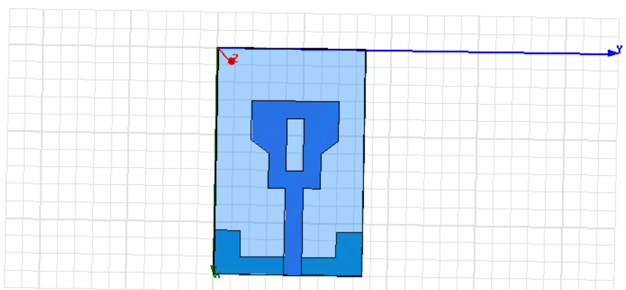

Figure5: Geometry of Modified Rectangular Antenna With Notch

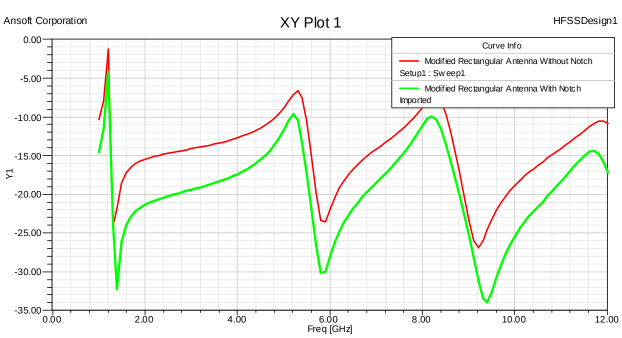

Figure 6:Comparison of Simulated Return Loss Curve

This design provides a matching impedance bandwidth from 1.3 GHz to 12 GHz, and an almost stable omni-directional radiation pattern simultaneously. One of the main features of this antenna is its size reduction compared to other UWB planar antenna designs such as PDMA,PRMA,PTMA,PSMA etc. It is observed that Modified Rectangular Antenna with Notch has lower return loss as compared to Modified Rectangular Antenna without Notch.

3.CONCLUSION

Multiresonance printed monopole antennas are being used increasingly for applications of UWB technology because of thei attractive features. Some of the design aspects of these antennas have been discussed in this paper. A systematic study has been presented to explain ultra-wide impedance bandwidth obtained from different monopole antenna.

Circular disc monopole antenna originates from a conventional monopole by replacing the wire element of with a circular disc element. The antenna configuration has also evolved from a vertical disc to a planar version by using microstrip line for the ease of integration with printed circuit board.Investigations have also been carried out in this paper to analyse the design parameters of different monopole antenna. In a broad sense, the ground plane serves as an impedance matching circuit, and it tunes the input impedance and hence changes the operating bandwidth when the feed gap is varied. The dimension of the radiator also has an impact on the antenna performance.

In order to maximize the impedance bandwidth a pair of notches is placed at the two lower corners of the radiator and notch structure is also embedded in the truncated ground plane in case of modified rectangular antenna(Modified PRMA). This phenomenon occurs because the two notches affect the electromagnetic coupling between the radiator and the ground plane. Moreover, the modified truncated ground plane acts as an impedance matching element to control the impedance bandwidth of a rectangular monopole.

A systematic study has been presented to explain ultra-wide impedance bandwidth obtained from different monopole antenna.

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