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Design of UWB Monopole Antenna and Comparative Study of Surface Current Reduction with Different Defected Ground Structures

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Abstract:
This paper presents an UWB monopole antenna with a circular slot and two rectangular steps for ultra wide band application. The proposed antenna has wide impedance bandwidth of 8.5GHz starting from 2GHz to 10.5GHz. Measured results such as return loss and radiation pattern shows the satisfactory bandwidth and radiation characteristics of the proposed antenna. Further the surface current of the monopole antenna is reduced by using defective ground structure. Comparative study of the various ground structure is presented.

1. Introduction

The research on UWB communication has achieved an unprecedented rapid development. Based on the non-carrier wave communication technique, UWB communication has attracted more and more people's attention for its inherent advantages, such as high data rate, low power consumption and low cost. The Federal communication commission (FCC) first approved rules of 3.1 to 10.6GHz for the commercial use of UWB communication in 2002. It defines UWB as any signal that occupies more than 500 MHz bandwidth in the 3.1 to 10.6 GHz band. It is even more relevant that the operating frequency is relatively low. A comparison with the other unlicensed bands that are currently available and used in the United States are ISM at 2.4 GHz operating over the frequency range of 2.4-2.4835 GHz has a bandwidth of 83.5 MHz and U-NII at 5 GHz has a bandwidth of 300 MHz and UWB over the frequency range 3.1 to 10.6 GHz has a bandwidth of 7500 MHz This comparison shows that UWB has the largest spectrum allocation for unlicensed use that the FCC has ever granted.

Currently, there are many different types of antennas that are being considered for UWB applications. Circular disk monopole is one of these antenna configurations which have simple structure, easy fabrication, wideband characteristics, and omnidirectional radiation pattern. Due to their wide frequency bandwidth, circular disk monopole antennas are considered as promising candidates for applications [9].

Defected ground structures (DGS) which are realized by etching defects in the backside metallic ground plane under a microstrip line. The defect in a ground is one of the unique techniques to reduce the antenna size. So design the antenna with DGS, the antenna size is reduced for a particular frequency as compared to the antenna size without the defect in the ground. DGS is realized by introducing a shape defected on a ground plane thus will disturb the shielded current distribution depending on the shape and dimension of the defect. The disturbance at the shielded current distribution will influence the input impedance and current flow of the antenna [10].

In this paper, a monopole UWB antenna with two steps and a slot is proposed. A comparative study of surface current distribution for different defective ground structures over the proposed antenna is presented.

2. Antenna Design

The antenna consists of a half circular disc of radius r=10mm and rectangular patch of area 10 x 20mm^2. The length and width of the two steps are (L1=3mm, W1=8mm) and (L2=3mm, W2=4mm) respectively. The circular slot of radius r_s=2mm is located at the centre of the half circular disk. The monopole antenna feeding structure is 50Ω micro strip feed line and they are printed on same side of the dielectric substrate. The substrate used in our antenna is FR4 with thickness 1.575 and relative permittivity εr=4.3. The length and width of the dielectric substrate are L=50mm and W= 42.8mm respectively. Patch and Ground plane are composed of Copper material. Antenna parameters are optimized using trial-and-error to satisfy the UWB requirements.

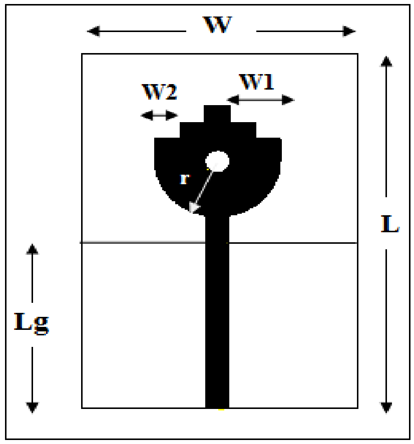

Figure 1: Geometry of the proposed antenna

The antenna shown above is constructed with a partial ground structure of width W=42.8mm and L=39.5mm. In order to provide the comparison of varying surface current distribution for different defected ground structures, we are using four DGSs namely,

- Horizontal
- Vertical
- Horizontal + Vertical
- H-shaped

To study the performance of these DGSs, the ground plane thickness is increased to 1mm. Now, the defected structures are constructed for a thickness of 0.9mm by specifying the thickness co-ordinates of (-0.1,-1) on the ground plane. Horizontal DGS is constructed by cutting out 4mmx42.8mm of ground for every 10mmx42.8mm along the length of the antenna. In a similar way, vertical DGS is constructed by cutting out 4mmx50mm of ground for every 10mmx50mm along the width of the antenna for a thickness of 0.9mm. The third type of DGS is constructed with a combination of first two types. In this, for every 10mmx10mm area of ground, 4mm of length and 4mm of width in ground is taken away leaving behind a ground surface of 6mmx6mm. The last DGS constructed is H-shaped structure which is designed in such a way that it is placed exactly behind the patch structure. The design has two vertical sections and a horizontal section bridging them.
The vertical section has a length of 10mm and width 3mm and the horizontal section has a length 2mm and width 8mm.

3. Results and Discussion

All the simulation has been carried out in CST Micro Wave Studio (MWS). The simulated return loss for the proposed antenna is plotted in fig. The measured and the simulated are in good agreement with the measured 10dB bandwidth ranges from 2 to 10.5GHz. In general, the result still shows satisfactory agreement for the proposed antenna for UWB operation. By examining the current distribution of the circular disk monopole antenna, we can cut two steps and a circular slot without disturbing the current distribution of the antenna. The cutting circular slot is used to reduce the overall antenna area. The cutting steps are used to increase the antenna perimeter which affects the lower resonant frequency and then increase the maximum achieved bandwidth. It is well known that the current distribution mainly concentrate on the edges rather than in the centre of the circular disk monopole antenna. So, by increasing the antenna perimeter, the surface current will take longer length and in turn will decrease the lower resonant frequency fl [9].

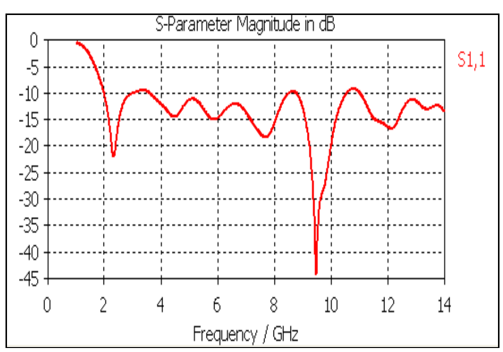

Figure 2: Return loss of proposed antenna

The simulated antenna return loss is shown in the figure 2. The observed results show that 10dB bandwidth is 8.5GHz, which ranges from 2 to 10.5GHz. By examining the surface current of the proposed antenna the maximum value obtained is 63.8 A/m. surface current distributions for various DGS are analysed.

For vertical DGS design the max simulated surface current value is 17.9A/m and the directivity is 8.252dBi. In the case of horizontal DGS design surface current value is 23.5A/m and the directivity is 8.761dBi. Similarly maximum surface current and directivity value for horizontal + vertical DGs and H-shaped DGS are 17.6A/m, 25.8 A/m and 8.25dBi, 7.621dBi respectively.
The simulated results show that there is acceptable reduction in surface current. Table 1 shows the variation of surface current distribution, directivity and return loss for different defective ground structures.

Type of ground structure	Surface current (A/m)	Directivity (dBi)	Return loss (dB)
Horizontal DGS	23.5	8.761	-45
Vertical DGS	14.7	9.395	-35
Horizontal + vertical DGS	17.6	8.25	-22
H-shaped DGS	25.8	7.621	-24

Table 1: The measured surface current, directivity and return loss

4. Conclusion

In this paper, a monopole antenna for UWB has been presented. The antenna operates for a bandwidth of 8.5GHz from2 to 10.5GHz. The comparative study of various defected ground structure shows that the vertical DGS gives a lower value of surface current (14.7A/m). Further the study also shows that the directivity of the antenna is also improved with the introduction of DGS.

5. References

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