Defected Ground Plane of Wearable Circular Patch Antenna

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Abstract. In this paper, Circular patch antenna design with defected ground plane is designed. The antenna is designed with circular patch and defected ground plane to allow it to operate in lower frequency as well as improved the antenna gain. The antenna has a feeding port and two defected ground slots to affect the frequency of the antenna. The proposed antenna is designed and simulated using Computer Simulation Technology (CST) Studio Suite 2016. The designed antenna has an operating frequency of 2.42GHz. A prototype has been fabricated and tested using network analyser and the measured results are in a good agreement with simulations.

1. Introduction

In recent years, there has been growing interest in wearable wireless technologies that enable solution for developing so-called smart clothes. In the future, the clothing will facilitate communication among object and people [1]. However, the major challenge of designing wearable antenna is to make the technology invisible to the users. Another key aspect is the robustness of the antenna performance to the mechanical solicitation, operating scenario, and operation such as ironing and washing. Furthermore, the wearable antenna operates in proximity or direct contact with the human body hence strongly effect the antenna performance [2].

An important feature of wearable devices is that they must allow wireless communications from or to the body via conformal and wearable antennas. Since these antennas must be located on body, their design strategy may be quite different compared to conventional antennas. Hence, the characteristics of the antenna is fabrics, which are wearable, durable and flexible, made it suitable to be integrated into clothing. Wearable antennas are generally used for body-centric communications within the sphere of personal area network (PAN) and body area network (BAN). There are number of specialized occupation segments that apply body centric communication systems, such as fire fighters, military and paramedics [3].

Since a flat conformal structure with a larger ground plane is required, patch antennas are usually chosen as the basis of wearable antenna designs [4-6]. Here, we proposed defected ground plane wearable antenna that are compact, flexible, light weight, low-cost with the polarization perpendicular to the body. The antenna consists of two slots in the ground plane that improve the antenna gain as well
and antenna efficiency. It is also reduced the total size of the antenna compared with the non-slotted ground plane.

2. **Antenna design development and specification**

Several simulations were run in order to optimize each of the antenna parameters. The final dimensions of the antenna were obtained after a complete parametric study of all the conductive parts. The antenna includes a single layer of patch, one feeding line port and the ground plane which has been defected in two cutting slots by using the subtract method in CST. Firstly, for perfect match of load impedance of microstrip feedline to the radiation patch, a circular microstrip patch antenna was designed with inset line feed. Then the ground plane is defected by inserting two slots. The result of frequency before cutting the ground plane was 2.9 GHz. However, by introducing the defected ground plane, the frequency is shifted to the lower frequency which is at 2.45 GHz that has been targeted. In order to improves the antenna impedance matching, the width of the feed line is line is reduced and longer. While making the slot along the side of the feeding line shorter and narrower. These changes lead to the desirable value of $S_{11}$ of our proposed antenna design. Shown in figure 1 is the schematic circular patch antenna with a radius of 24mm. Whilst shown in figure 2 is the fabricated antenna using Conductor (shieldit) with a thickness of 0.17mm, conductivity of $1.18 \times 10^5$ and substrate(felt) with a thickness of 3mm, permittivity 1.44 and loss tangent of 0.044.

![Figure 1](image1.png)

**Figure 1.** Simulated design of wearable circular patch antenna. (a) Front View, (b) ground plane view
3. Result and Discussion

A circular shaped Microstrip patch antenna with single band characteristics is investigated in this paper by using relevant standards of various principles. A software tool named CST simulator is used to construct this proposed design. Defected ground plane with two slots are used to improve the impedance matching of the scheduled antenna. This report provided an insight of circular patch antenna with and without the defected ground. The antenna developed using the CST 2016 software to simulate the results. A prototype has been fabricated using the conductor shieldit material with felt substrate. The input return loss is represented by $S_{11}$ parameters results describing the electrical behavior between the ports, by measuring the input signal and the output signal of the source we can have an accurate way for getting the return loss value. Shown in figure 3 is the effect of introducing the defected ground plane on the antenna. The effect is clearly noticeable on the antenna performance where the frequency shifted from 2.9GHz to 2.45GHz.

![Figure 2](image1.png)

**Figure 2.** Fabrication of circular patch antenna using conductor shieldit material with felt substrate. (a) Front view, (b) Antenna rear view.

![Figure 3](image2.png)

**Figure 3:** $S_{11}$ result of without defected ground plane and with defected ground plane.
Figure 4: Farfield result of (a) Circular antenna without defected ground plane, (b) circular antenna with defected ground plane.

Shown in figure 4 is the 3D view of the farfield and the impact on the gain that the effected ground did to the antenna. The antenna gain increased form 0.71dB to 1.43dB which is almost double from the original gain. It is considered significant improvement. It is believed by introducing slot at the back of the ground plane has affected the main lobe radiation of the antenna hence become more directive consequently increase the antenna gain. Figure 5 and 6 is the result of the antenna simulation versus measurement and VSWR respectively. It is clearly showing that the measurement results are identically the same as simulation.

Figure 5: S11 Measurement versus simulation result
4. Conclusion

In this paper, a circular patch wearable antenna has been designed and simulated using CST software for W. A defected ground plane has been introduced to the original design to acquire the targeted frequency which is at 2.45 GHz. This antenna can be used in the WLAN application and it has bandwidth of 67 MHz. Two slots have been cut from the ground plane of the antenna to affect the resonant frequency and some changes have been done to the feeding line to improve the $S_{11}$ parameters. The integration of two slots on the ground plane resulted in stable radiation patterns and a low backward radiation. A prototype has been fabricated and tested using a network analyzer and the simulated and measured reflection coefficients are shown in figure 5 and 6, with a satisfactory agreement. The antenna has a low profile and suitable as wearable antenna for wearable application.

5. References

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