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# The Performance of Dual-band CPW-fed Printed Antennas for Wireless Body-Worn Applications

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***Abstract* - In this paper, we investigate the performance of two dual-band printed CPW-fed antennas, which have C-shaped and T-shaped geometrical shapes, for wireless body-worn applications. The simulated results in reflection coefficient, radiation characteristics and specific absorption rate (SAR) are presented.**

***Index Terms* - Wireless body are network (WBAN), coplanar waveguide (CPW), dual-band, printed antenna, SAR.**

## I. INTRODUCTION

With the advent of newer wireless standards and the increasing demand for new services, there is a need for universal handheld transceivers that operate with most of the wireless standards. Such a universal wireless device needs antennas that operate in multiple bands. Also, there is an increasing interest to use body-worn wireless devices for personal area network. Therefore, there will be an increased demand for small, lightweight and compact antennas that can accommodate multi-band communication applications. With this in view, we propose two compact dual-band C-shaped and T-shaped printed CPW-fed antennas for dual-band wireless body-worn applications [1-2] and investigate their performance under simulated body-worn scenarios.

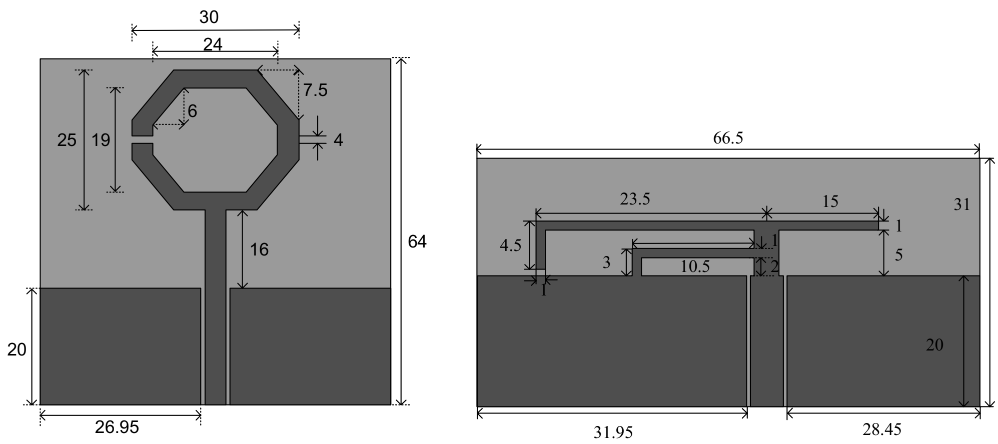
For WBAN applications, the antennas are placed closed to the human body and thus specific absorption rate (SAR) will become an important design criterion for wireless devices. It is well known that the portable wireless devices must meet various SAR regulatory standards [3]. Thus, the dual-band antenna performance of the proposed two printed antennas in the presence of human body is of practical importance for the design of WBAN/WPAN wireless networks.

In this paper, we first aim to investigate the design of C-shaped and T-shaped CPW-fed printed antennas and then study the interactions between the antennas and the human body as modeled by a lossy cylinder. Results on reflection coefficient, radiation characteristics and 1g and 10g SAR performance, are presented. The antenna characteristics for different cases were calculated using the commercially available High-Frequency Structure Simulator (HFSS®).

## II. ANTENNA CONFIGURATION AND SIMULATION MODELING

The configurations of dual-band C-shaped and T-shaped printed CPW-fed antennas are shown in Fig. 1. The printed antennas were constructed by printing them on Rogers® RO4003C substrate with dielectric constant of 3.38 and thickness of 1.524mm. A 50Ω CPW transmission line with a fixed single-strip width of 5.5mm and with a 0.3 mm gap between the strip and ground planes is used for feeding the antennas. Other dimensions of the antenna elements and ground planes are shown in Fig. 1 (units are in mm).The antennas were fabricated and their results in free space are measured and shown in Fig. 3.

Next, the simulation model for studying the influence of printed antennas close to lossy human body, on dual-band characteristics is shown in Fig. 2. The human body is modeled as a lossy circular cylinder with radius CR = 20mm and height CH = 64mm. In this configuration, the printed antenna is considered to be positioned parallel to the axis of the lossy cylinder, and is 6mm away from the bottom edge and with a spacing of D from the substrate of printed antenna. The electrical parameters of the lossy cylinder are set to be $\varepsilon_r$ =53, tanδ = 0.38 and σ = 1.2S/m, to simulate a human tissue.




(a) (b)

Fig. 1 Configurations of the proposed dual-band antennas: (a) C-shaped and (b) T-shaped, (unit: mm).

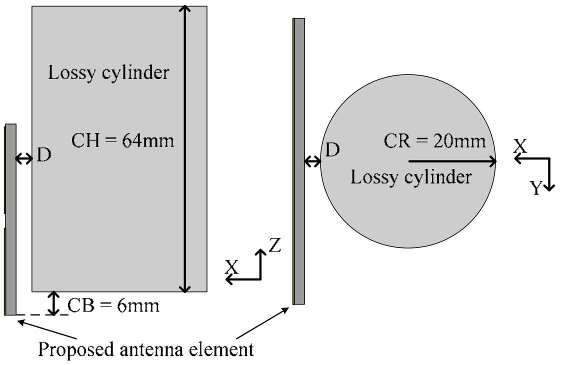



Fig. 2 Side view and top view of a lossy circular cylinder placed close to the antenna.

## III. SIMULATION RESULTS

The reflection coefficients of dual-band C-shaped and T-shaped printed CPW-fed antennas close to a lossy cylinder with spacing D = 2, 8, 15 and 25mm are shown in Figs. 3 (a) and (b) respectively. Also, the reflection coefficients of these printed antennas in free space environment are presented respectively as well for reference. It is observed that the impedance bandwidth performance of the printed C-shaped antenna is nearly unaffected by the close positioned lossy cylinder, but a small shift down of lower resonant frequency is observed when the lossy cylinder is placed D = 2mm to the printed C-shaped antenna. On the other hand, the printed T-shaped antenna shows better impedance bandwidth performance when it is placed closer to the lossy cylinder, e.g.: D = 2mm. This may be due to that the lossy cylinder attenuates a certain portion of the incident waves that leads to attenuated reflected waves therefore lower reflection coefficients at some frequencies. However, small shifts of two resonant frequencies are observed due to the presence of lossy cylinder.

In Figs. 4 and 5, the normalized radiation patterns in *xy*-plane (*H-plane*) of the printed C-shaped and T-shaped CPW-fed antennas when placed close to a lossy cylinder with spacing D = 2mm and 15mm at their respective resonant frequencies are presented respectively (solid lines). In the same manner, the radiation patterns of these antennas alone in free space environment at identical frequencies are also provided for the sake of completeness (dotted lines). In the case of the printed C-shaped antenna, it is observed that omni-directional radiation characteristics at lower resonant frequency are nearly unaffected due to the presence of lossy cylinder, but those at higher resonant frequency in some angular regions have been slightly deviated from being omni-directional. On the other hand, in the case of the printed T-shaped CPW-fed antenna, it is observed that radiation patterns in some angular regions have been deviated from being omni-directional at both resonant frequencies due to the presence of lossy cylinder, which can be seen in Figs. 5. Furthermore, an obvious notch at co-polarization component of radiation pattern at 2.5GHz is observed, when the printed T-shaped antenna is placed D = 15mm away from the lossy cylinder.

In Tables 1 and 2, the maximum average SARs of the printed C-shaped and T-shaped CPW-fed antennas for 1g and 10g lossy material for different spacing values D at their respective resonant frequencies are listed. As the maximum average SAR is linearly scalable to the input power, it is possible for these printed antennas to match the compliance limits [4].

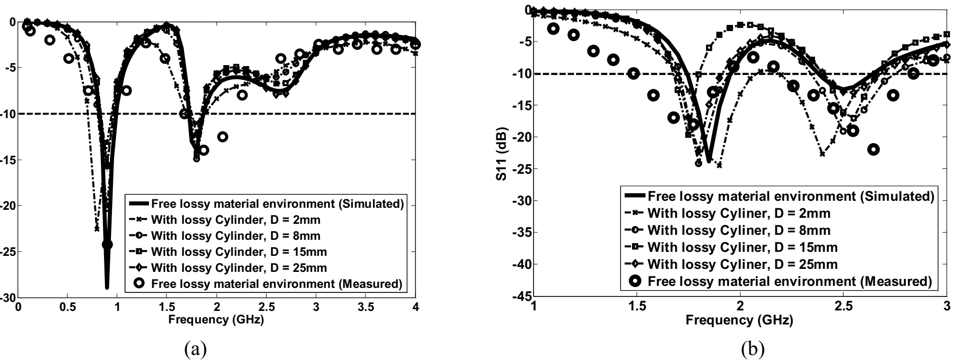



Fig. 3 Comparison of reflection coefficients of printed CPW-fed antennas lose to a lossy cylinder with spacing D = 2, 8, 15 and 25mm (a) printed C-shaped antennas and (b) T-shaped antennas

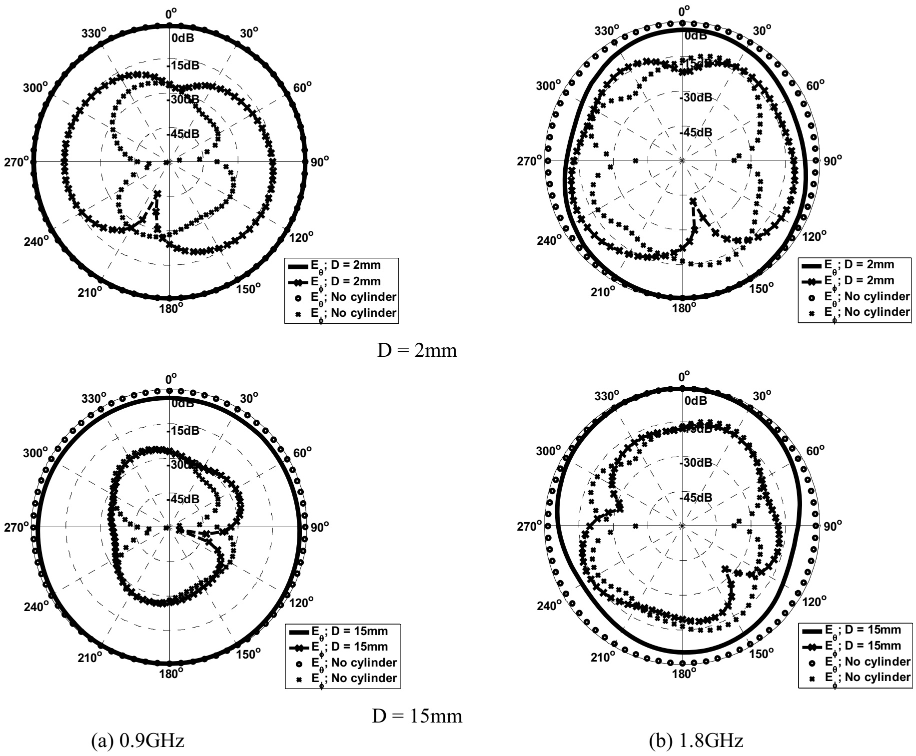



Fig. 4 Radiation patterns of printed C-shaped CPW-fed antenna with spacing D = 2mm and 15mm to the lossy cylinder at resonant frequencies: (a) 0.9GHz and (b) 1.8GHz.

## IV. CONCLUSION

In this paper, we investigate the performance of printed C-shaped and T-shaped CPW-fed dual-band antennas placed close to a lossy human body for body-worn applications. The antenna performance, such as reflection coefficient, radiation characteristics as well as 1g and 10g SARs, are presented with different spacing between antenna and lossy cylinder. It is hoped that these results will be helpful to decide the suitability of the antenna for WBAN applications.

## ACKNOWLEDGEMENT

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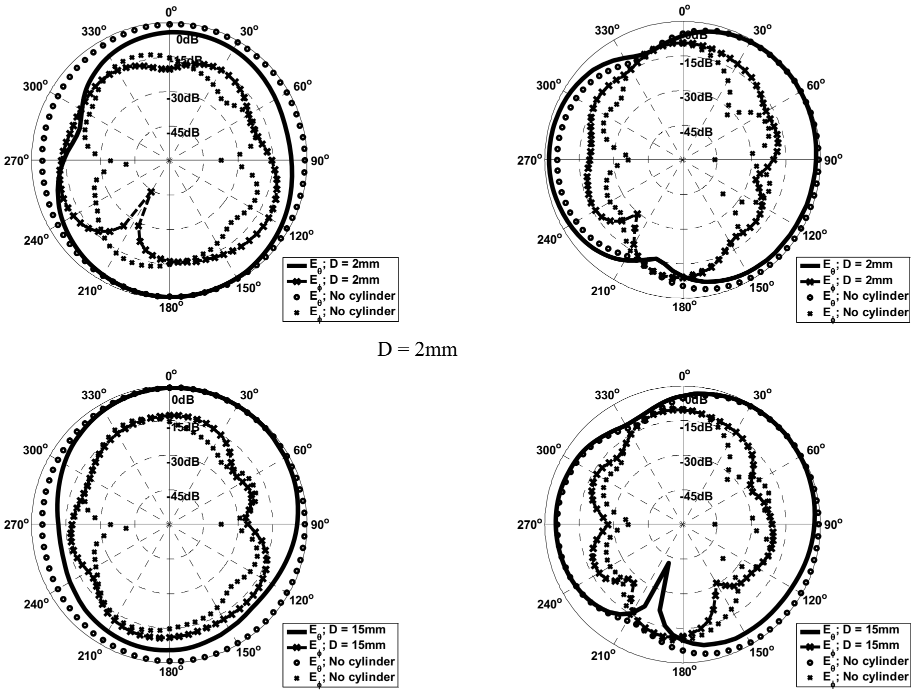


D = 2mm

D = 15mm

(a) 1.85GHz (b) 2.5GHz

Fig. 5 Radiation patterns of printed T-shaped CPW-fed antenna with spacing D = 2mm and 15mm to the lossy cylinder at resonant frequencies: (a) 1.85GHz and (b) 2.5GHz

Table 1 Maximum average 1g and 10g SAR of the printed dual-band C-shaped CPW-fed antenna (W/Kg, Input Power: 1W)

| Category | 1g | | 10g | |
|---|---|---|---|---|
| D (mm) | 0.9GHz | 1.8GHz | 0.9GHz | 1.8GHz |
| 2 | 55.59 | 69.86 | 26.15 | 32.7 |
| 8 | 38.19 | 50.16 | 20.21 | 26.28 |
| 15 | 25.42 | 31.38 | 14.66 | 17.44 |
| 25 | 14.76 | 15.01 | 9.13 | 8.5 |

Table 2 Maximum average 1g and 10g SAR of printed dual-band T-shaped CPW-fed antenna (W/Kg, Input Power: 1W)

| Category | 1g | | 10g | |
|---|---|---|---|---|
| D (mm) | 1.85GHz | 2.5GHz | 1.85GHz | 2.5GHz |
| 2 | 104.58 | 101.69 | 42.63 | 39.44 |
| 8 | 61.81 | 51.08 | 30.19 | 20.56 |
| 15 | 25.3 | 27.63 | 12.4 | 11.31 |
| 25 | 15.08 | 11.92 | 8.3 | 4.91 |