

## On human body transmission wearable diamond dipole antennas above engineered jackets

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### Article Info

#### Article history:

Received Feb 18, 2020

Revised Jun 12, 2021

Accepted Jun 13, 2021

#### Keywords:

Dipole

Dual-band transmission

Dual-band waveguide

### ABSTRACT

This paper presents the propagation of dual-band diamond dipole antenna on three various jackets. The jackets are purely fleece fabric with Shieldit fabric patches on top of it. The network analyzers with the flexible lossless coaxial cable are used to measure the communication of the antennas. The experiment involves a man with ideal body mass index (BMI) wearing the jackets by placing the flexible antennas on top of it. It is observed that the best on-body communication is by wearing the engineered jacket. The 10 dB improvements are observed when the antenna is positioned on top of engineered jacket contrast to the regular jacket. In other words, the performance of the antenna is also be determined by antenna placement. High transmission losses cause the antenna mismatch when the antennas are positioned above the full conductive jacket.

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## 1. INTRODUCTION

Recently, on human body communication network is famous among the teenagers. Human body can be said as a portion of body-centric wireless communication, which consists of the integration of wireless personal area network (WPN) and wireless sensor network (WSN). Besides, the wearable wireless networking devices such as the electronic gadgets become simple and smaller when the transmission flows throughout the human body.

Previously, textile antennas have been investigated seriously since 1999 [1]-[9] to have the robustness and wearable antenna. The fabrics that have been used as substrate are felt fabric, jeans fabric and fleece fabric. However, the antenna is not able to perform well due to the behaviour of the human body [10]-[13]. The common coaxial port which is bulky size and rigid is not suitable for wearable use [14], [15].

The researchers have studied a different method to overcome the deterioration of the antenna's performance. Artificial magnetic conductor (AMC) has been integrated with the antenna to increase the antenna's performance. The main characteristic of the AMC [16] may increase the antenna's performance in terms of reflection coefficient, propagation and radiation pattern. Previous researchers have proved that the

used of the structure reduced the unwanted radiation and increased the antenna's performance [17], [18]. Sheet-like waveguide sheet is proposed [19]-[25] if the antenna is positioned near the human body. The structure can improve the antenna communication and decrease the transmission losses [26].

This paper investigated the propagation between two dual-band textile dipole antennas with three kinds of jackets; regular jacket, full conductive jacket and engineered jacket. The transmission of the antenna is measured in two orientations for jackets. The transmission of the antenna are compared and discussed. The performance of antenna ontegrated with waveguide jacket has improved significantly compared to the other jackets.

## 2. RESEARCH METHOD

Before the measurements are conducted, three types of jackets made by fleece fabric are fabricated. They are called regular jacket, full ground plate jacket and engineered jacket. Regular jacket is a normal jacket with no any conductive element as shown in Figure 1 (a). Full conductive jacket has attached with Shiledit fabric as shown in Figure 1 (b) while the engineered jacket is a structure from my previous work [14]. The conductive patches are made by Shieldit super fabric. Two similar dual-band diamond dipole antennas have been used to be integrated with the jackets as shown in Figure 1.



Figure 1. Photo of jackets: (a) reguler jacket, (b) full conductive jacket, (c) waveguide jacket

In this paper, the positioning of the antenna placement on top of the jackets is examined. The antennas are positioned up-down and left-right respectively above the jacket as presented in Figure 2. A transmitter (Tx) antennas is located at the centre of the jacket. Eight different positions with labelled alphabetically from A to H are placed around the Tx. The distance between them is fix at 14 cm as shown in Figure 3. In this experiment, a man wore the jackets with the antennas in a small space area. Figure 4 displays the setup of the measurement. 3 mm gap between both antennas and the jacket is fix by putting a piece of foam ( $\sigma_r = 1$ ). In this experiment, the  $S_{21}$  of the antennas is measured by using portable network analyser.

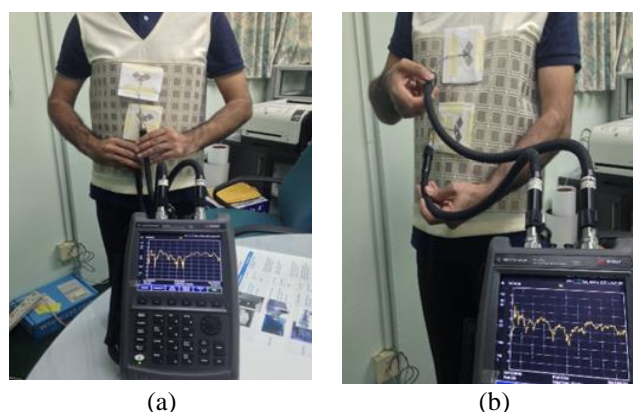


Figure 2. Antenna orientation: (a) horizontal orientation and (b) vertical orientation

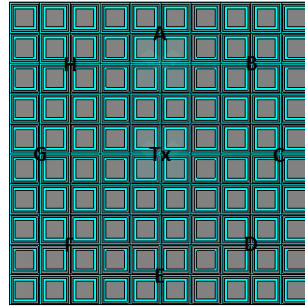


Figure 3. Positions of the Rx antenna



Figure 4. Snapshot of the experiment

### 3. RESULTS AND DISCUSSION

Further investigation is carried out to explore the best position of dual-band diamond dipole above engineered jacket, full conductive jacket and regular jacket. Figures 5, 6 and 7 show the  $S_{21}$  transmission between antennas above three types of jackets. When the antennas are placed vertically, good transmission between both antennas occur at position C and G as shown in Figure 5 and 7. If the antennas are placed horizontally, position A and E give the best transmission between the antennas. Good communication between the antennas depend on the position of the antenna In other words, to have a good transmission, both antennas must be at the same polarization. From the results, it shows that the arrangement of the antenna is important to have good transmission. The antenn’s pattern contributes to the good transmission. While the waveguide jacket allows the antennas wave propagates through it to have better transmission.

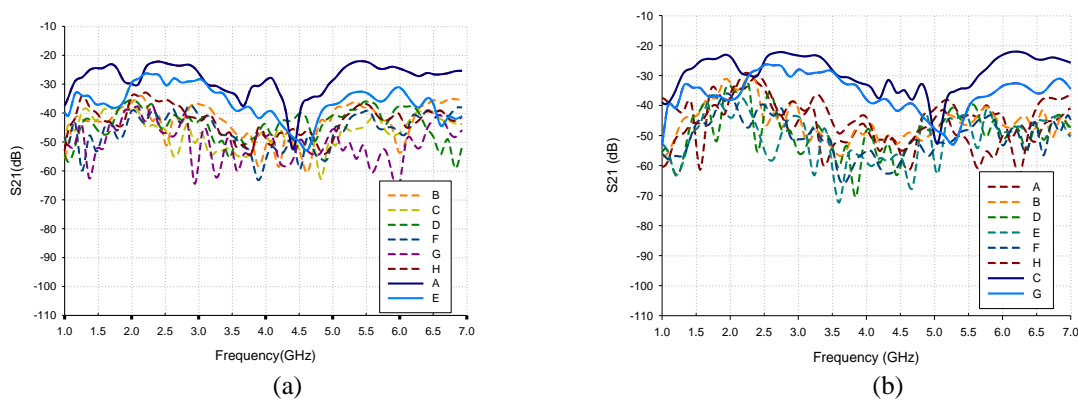


Figure 5.  $S_{21}$  transmission of dual-band diamond dipole above engineered jacket: (a) horizontal orientation and (b) vertical orientation

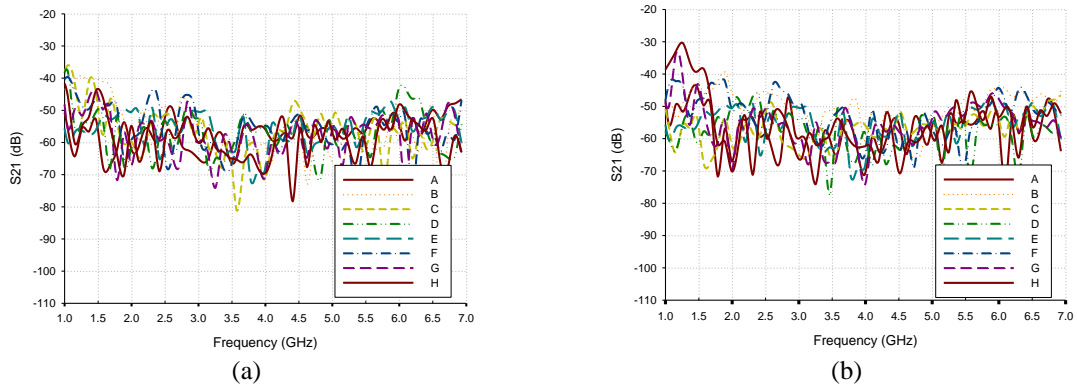


Figure 6.  $S_{21}$  transmission of dual-band diamond dipole above full conductive jacket: (a) horizontal orientation and (b) vertical orientation

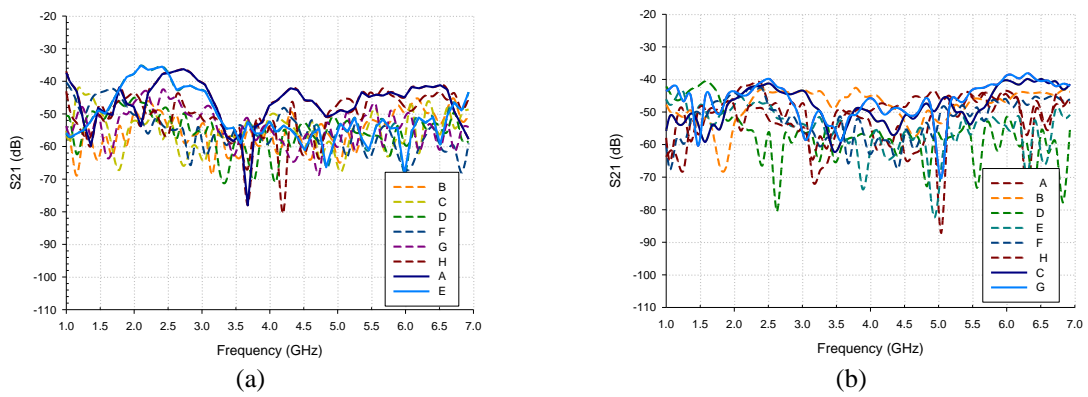


Figure 7.  $S_{21}$  transmission of dual-band diamond dipole above regular jacket (a) horizontal orientation and (b) vertical orientation

The measurement results are compared in Figure 8. As can be observed, the high  $S_{21}$  peak with -22 dB at 2.45 GHz and -24 dB at 5.8 GHz at position A in horizontal polarization. The high  $S_{21}$  peak with -20 dB at 2.45 GHz and -25 dB at 5.8 GHz at position C in vertical polarization. The high  $S_{21}$  peak is contributed by having AMC surface beneath it. The high  $S_{21}$  peak for transmission between antennas above the normal jacket with -38 dB at 3.45 GHz and -40 dB at 5.8 GHz. Lower  $S_{21}$  peak is observed compared to the waveguide jacket because of human body effect. High transmission losses occurred when placed near to the lossy human body. From the Figure 6, the  $S_{21}$  transmission between antennas above the grounding jacket are in noise level with -60 dB. This is because the antenna suffer a very high mismatch and transmission loss above the full conductive jacket.

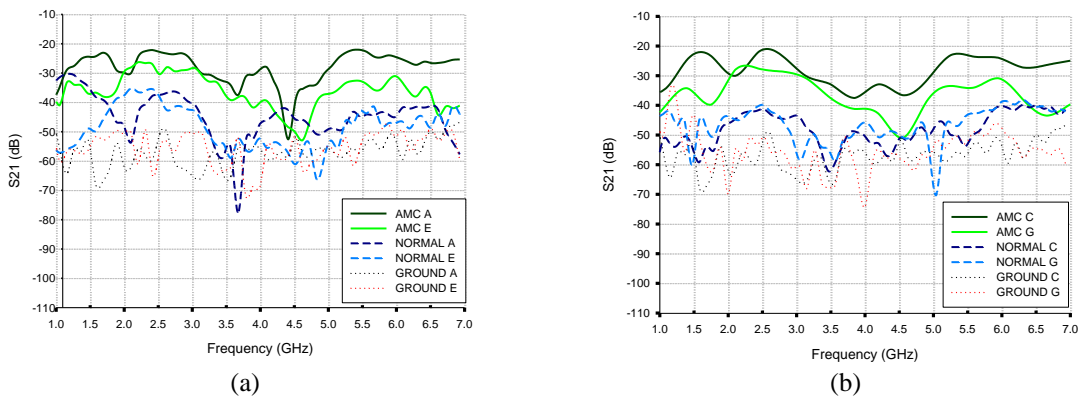


Figure 8. Comparison  $S_{21}$  transmission of dual-band diamond dipole above three jackets: (a) horizontal polarization and (b) vertical polarization

#### 4. CONCLUSION

As conclusion, two wearable antenna with regular jacket, full conductive jacket and engineered jacket have been fabricated and measured. The position of the antenna above jacket need to be considered in achieving better antenna's transmission. The engineered jacket offers clear transmission route and lower the transmission loss because of AMC characteristic. The in-phase reflection characteristic can increase the antennas' communication. Meanwhile, the full conductive jacket cause the antenna mismatch and not appropriate for antenna transmission.

#### ACKNOWLEDGEMENTS

The authors express gratitude the Ministry of education (MOE) for supporting the research work; Advanced RF and Microwave Research Group (ARFMRG), School of Postgraduate Studies (SPS), Research Management Centre (RMC), School of Electrical Engineering, Faculty of Engineering, and Universiti Teknologi Malaysia (UTM) Johor Bahru for the support of the research under grant no 04G67.

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