

On-body Transmission Single-band Diamond Dipole Antenna with Waveguide Jacket

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Article Info

Article history:

Received Dec 12, 2017

Revised Feb 27, 2018

Accepted Mar 23, 2018

Keywords:

Dipole

Single-band

Transmission

Waveguide

ABSTRACT

This paper presents the investigation of on-body transmission single-band diamond dipole antenna with three different jackets. The jackets are named as normal jacket, grounding jacket and waveguide jacket. The on-body transmission is measured using two flexible single-band antennas attach to the jackets. A man with the height of 180 cm and 75 kg weight becomes as a model for the real measurement. The measurement is conducted in small space area by using portable network analyzer with flexible network cable. The measurement results show that the best performance for on-body transmission is with waveguide jacket. 10 dB transmission improvement is archived when the antenna is placed above the waveguide jacket compared to the normal jacket. It is found that the transmission of the antenna is also depends on the antenna orientation and further transmission loss occur when the antennas are placed above the grounding jacket.

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1. INTRODUCTION

Nowadays, human body has become a part of wearable wireless networking devices as the electronic devices become smaller and cheaper. Since human body becomes a part of communication network, the integration of wireless sensor network (WSN) and wireless personal area network (WPN) become body-centric wireless communication.

Due to complexity of the human body, many researchers around the world interested to investigate in this body-centric wireless communication area. Firstly, some fabric antennas have been investigated by [1]- [3] since 1999. They are using felt fabric as substrate and Zelt fabric as conducting element. However, the performance of the antenna deteriorated when the antenna is put above the human body [4]. The bulky size of coaxial port that has been used in [5-6] also is not suitable for wearable application.

Theoretically, the main characteristic of an artificial magnetic conductor (AMC) to influence the propagation electromagnetic waves is in-phase reflection coefficient [7]. Previous researchers have presented that the AMC may reduce the backward radiation and improve the gain of the antenna [8]-[9]. Then, sheet-like waveguide sheet is proposed by [10]-[13], [16] to reduce the distortion from the human body. The waveguide sheet is consisted of array of AMC. The function of the sheet-like waveguide is to reduce the transmission losses between the antennas.

In this paper, two single-band textile diamond dipole antenna which are operating at 2.4 GHz and 5.8 GHz are used to investigate the S₂₁ transmission above three different jackets; normal jacket, grounding

jacket and waveguide jacket. S21 transmission is measured in horizontal and vertical orientation for all jackets. The performance of the transmission for the jackets are compared and discussed.

2. MEASUREMENT SETUP

Two single-band diamond dipole antennas which are operated at 2.4 GHz and 5.8 GHz respectively have been used to be incorporated with three different jackets as shown in Figure 1. The jackets are made of fleece fabric named as normal jacket, grounding jacket and waveguide jacket. Normal jacket is a plain jacket while grounding jacket has attached with full ground plane fabric. The waveguide jacket is an array of AMC design from my previous work [4].



Figure 1. Overview of antennas and three different jackets

The orientation of the antenna is investigated above the jackets. The antennas are placed vertically and horizontally above each jacket as shown in Figure 2. One of the antennas is placed in the middle of the jacket which acts as a transmitter (Tx) while the other antenna (Rx) position is varied at eight different locations. The locations are labelled alphabetically from A to H as shown in Figure 3. The distance between the antennas is fixed at 14 cm.



(a) Horizontal polarization (b) Vertical polarization
Figure 2. Antenna polarization

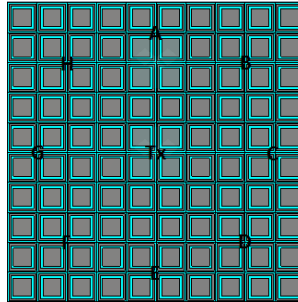


Figure 3. Positions of the antenna (Rx)

The experiment is conducted in small space area. A man becomes a model to wear the jackets. During the experiment, he stands up and the transmission between the antennas is measured as shown in Figure 4. The gap between both antennas and the jacket is set to 3 mm by using a foam ($\sigma_r = 1$). Portable network analyser is used to measure the transmission performance of the antennas.



Figure 4. Snapshot of the experiment setup

3. RESULTS AND DISCUSSIONS

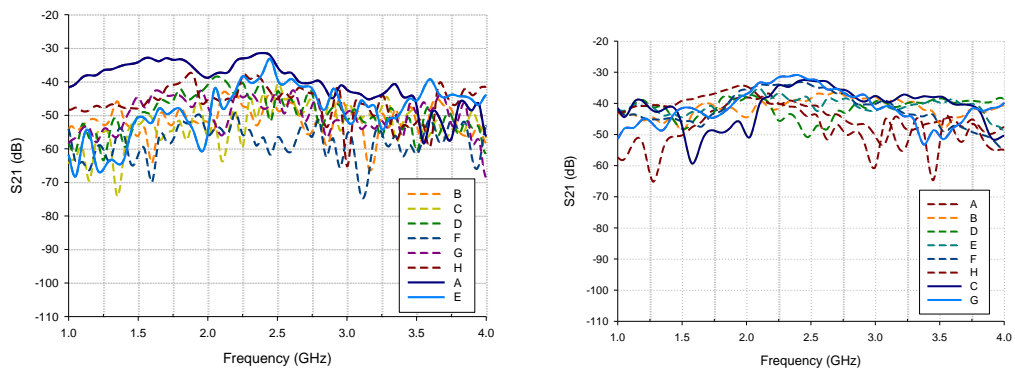
The results are divided and analyzed into two sub chapter. The first sub chapter explains about 2.4 GHz antenna transmission while the 2nd sub chapter elaborates about 5.8 GHz antenna transmission.

3.1. S_{21} Transmission of 2.4 GHz Textile Diamond Dipole Antenna

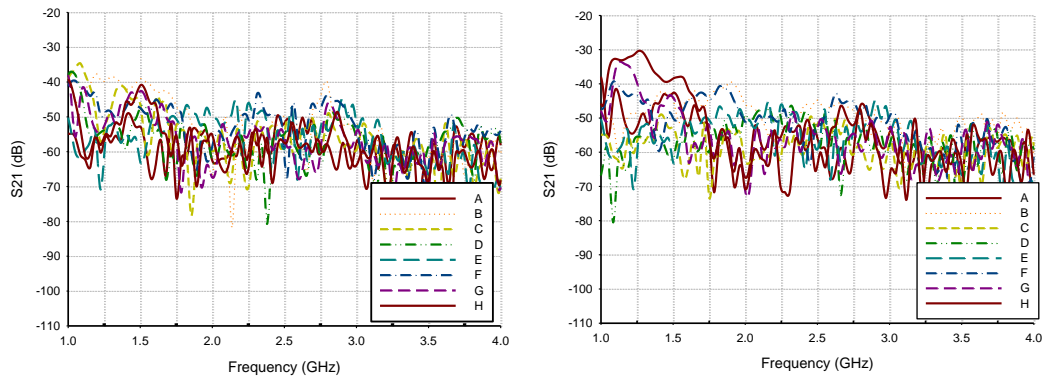
The S_{21} on-body transmissions of the antenna with three jackets were investigated. Graph in Figure 4 presents the S_{21} transmission of 2.4 GHz antenna with normal jacket in horizontal orientation. Figure 5(a) and Figure 5(b) denote the vertical arrangement respectively. Graphs in Figure 6 depict the measured S_{21} of antennas with grounding jacket while Graph in Figure 7 represents the measured S_{21} of antennas with waveguide jacket. Figures 6(a) and 7(a) represent for horizontal antenna orientation and figures 6(b) and 7(b) represent vertical antenna orientation.

When the antenna is placed horizontally, good transmission of the antenna observed at position A and E. For horizontal orientation, the S_{21} peaks are -32 dB and -33 dB for position A and E. Position C and G represent parallel arrangement in vertical orientation with S_{21} peaks at -30 dB and -32 dB at resonance. Graphs in Figure 5 show no transmission occurs between the antennas. The S_{21} peaks at -60 dB for both horizontal and vertical orientation which is at noise level. Finally positions A and E represent parallel arrangement in horizontal orientation with S_{21} peaks at -24 dB and -20 dB above the waveguide jacket while positions C and G in vertical orientation with S_{21} peaks at -24 dB and -24 dB.

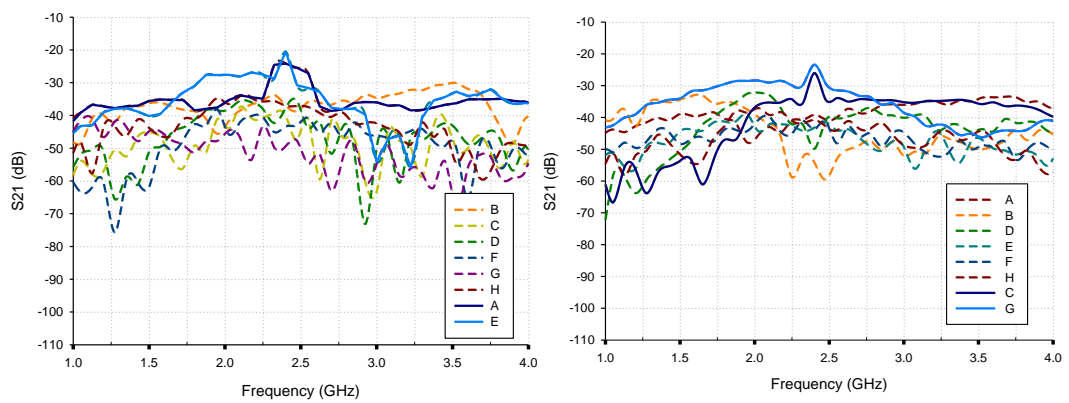
Graphs in Figure 8 show the comparison of measured S_{21} results from Figure 5 to 7. The best performance of S_{21} transmission from graphs in Figure 5 to Figure 7 is compared. It shows that the S_{21} peaks are improved by 8 dB and 13 dB at resonance for horizontal orientation. For vertical horizontal, 6 dB and 8 dB improvement is achieved when the antenna is placed above the waveguide jacket. When the antennas are placed above the normal jacket, the transmission is disturbed by the presence of human body. The waveguide jacket acts as a path for the wave to propagate between the antennas and improve the transmission.



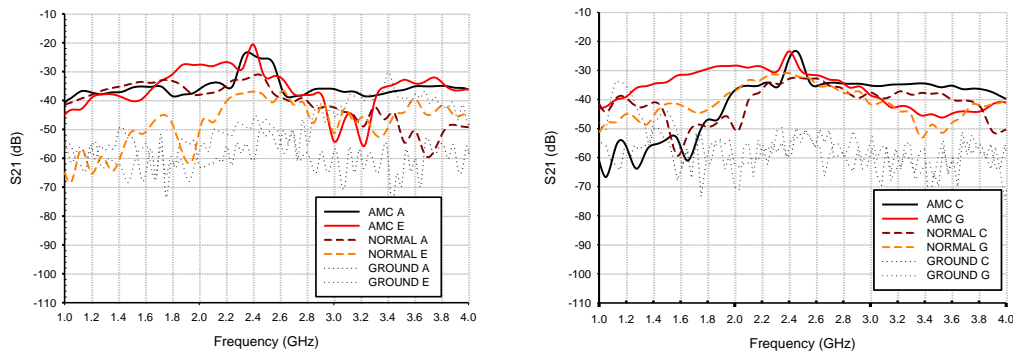
(a) Horizontal orientation (b) Vertical orientation
 Figure 5. Measured S_{21} of 2.4 GHz textile diamond dipole above normal jacket



(a) Horizontal orientation (b) Vertical orientation
 Figure 6. Measured S_{21} of 2.4 GHz textile diamond dipole above grounding jacket



(a) Horizontal orientation (b) Vertical orientation
 Figure 7. Measured S_{21} of 2.4 GHz textile diamond dipole above waveguide jacket



(a) Horizontal orientation

(b) Vertical orientation

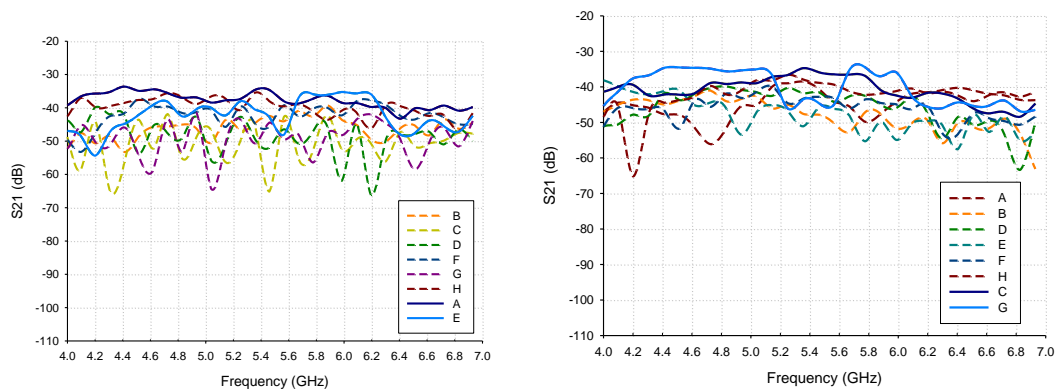
Figure 8. Comparison of Measured S_{21} of 2.4 GHz textile diamond dipole above different jackets

3.2. S_{21} Transmission of 5.8 GHz Textile Diamond Dipole Antenna

The measured S_{21} transmissions are plotted in Figure 9 to Figure 11 for antenna above normal jacket, grounding jacket and waveguide jacket. Figure 9(a), 10(a) and 11(a) show the 5.8 GHz diamond dipole 's transmission results in horizontal orientation while Figure 9(b), 10(b) and 11(b) depict the vertical horizontal.

Among the 8 positions varied, the best transmission is obtained when the antenna placed in parallel arrangement. For horizontal orientation, positions A and E represent the parallel arrangement and position C and G for vertical orientation. When the antennas are placed above the grounding jacket, the transmission occurs at the noise floor level. Transmission improvements at resonance 5.8 GHz are observed at both horizontal and vertical orientations. From the horizontal orientation results, the S_{21} peaks are -28 dB and -30 dB with improvement of 10 dB and 8 dB from the transmission above the normal jacket. The comparison S_{21} results in vertical orientation are shown in Figure 12(b). The S_{21} peaks are -37 dB and -34 dB for position C and G above the normal jacket while -28 dB for both position C and G above the waveguide jacket.

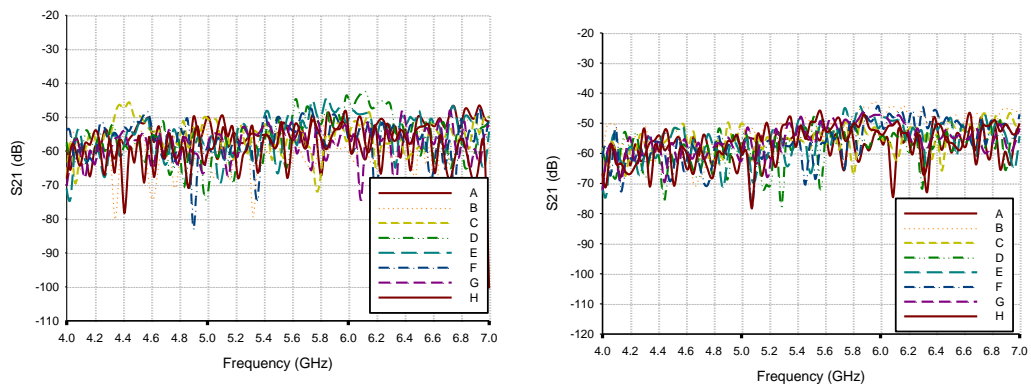
From the presented results, the presence of waveguide jacket improves the antennas' transmission compared to normal jacket. The structures of the waveguide jacket itself which is artificial magnetic conductor (AMC) help the wave to propagate through it.



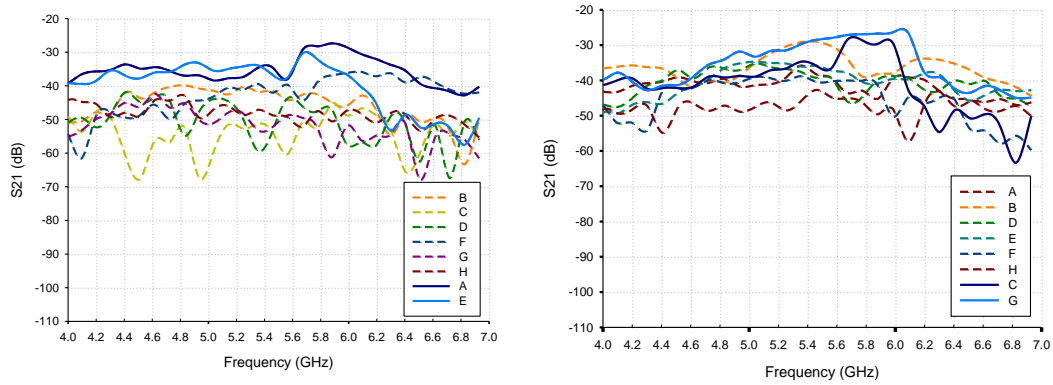
(a) Horizontal orientation

(b) Vertical orientation

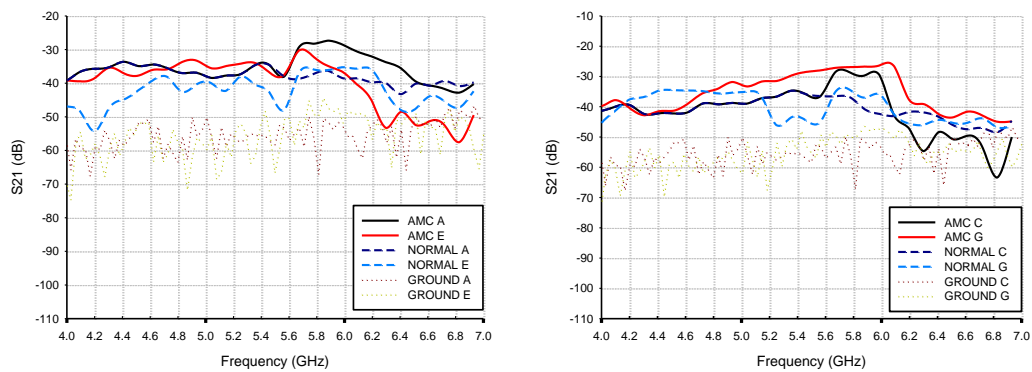
Figure 9. Measured S_{21} of 5.8 GHz textile diamond dipole above normal jacket



(a) Horizontal orientation (b) Vertical orientation
 Figure 10. Measured S_{21} of 5.8 GHz textile diamond dipole above grounding jacket



(a) Horizontal orientation (b) Vertical orientation
 Figure 11. Measured S_{21} of 5.8 GHz textile diamond dipole above waveguide jacket



(a) Horizontal orientation (b) Vertical orientation
 Figure 12. Comparison of measured S_{21} of 5.8 GHz textile diamond dipole above different jackets

4. CONCLUSION

In conclusion, two single-band textile diamond dipole antenna with normal jacket, grounding jacket and waveguide jacket have been measured and investigated. The position of the antenna determined the transmission of the antenna. 10 dB improvement when both antennas in the same. The waveguide jacket provides clear transmission path and reduces transmission loss. The in-phase reflection characteristic in waveguide jacket is predicted to enhance the transmission between the antennas. Meanwhile, the ground jacket is not suitable for antenna propagation as presented in the results.

ACKNOWLEDGEMENTS

The authors wish to thank the Research Management Centre, Faculty of Electrical Engineering, Universiti Teknologi Malaysia (UTM) and the Malaysian Ministry of Education (MOE) for providing the Grant (Vote No: 4F883 and 12H08).

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