VOL. 16, NO. 1, 2017, 35-38
www.fke.utm.my/elektrika
ISSN 0128-4428

ELEKTRIKA
Journal of Electrical Engineering

Positions of Dual-band Textile Diamond Dipole Antenna with Dual-band Textile Artificial Magnetic Conductor Waveguide Sheet for Body Centric Communication

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Abstract: A dual-band textile Artificial Magnetic Conductor (AMC) sheet-like waveguide with dual-band textile diamond dipole antennas were designed for enhancing the transmission between the two antennas. The AMC surface is designed to have in-phase reflection at 2.45GHz and 5.8GHz with the objective to enhance the transmission between antennas. Both structures were made of fleece fabric with conductive patches made of SHIELDIT fabric. The performance of the two antennas with textile AMC sheet was investigated thoroughly in terms of transmission coefficient (S_{21}) parameters. The effect of different antennas' placement was also considered. Measurements were conducted rigorously to validate the simulated findings. Results showed that the S_{21} transmission between antennas improved significantly when incorporated with AMC waveguide sheet.

Keywords: Artificial Magnetic Conductor(AMC), dipole, transmission coefficient(S_{21}).

1. INTRODUCTION

Wireless Body Area Networks (WBANs) is one of the body centric communication. This short-range communication has been getting attention from researchers all over the world due to the needed of a reliable communication within human body [1]. In recent years, wearable antennas have been investigated thoroughly for many applications such as healthcare, personal entertainment, military and smart home [2-3]. However, the distinct properties of the human body cause the performance of the wearable antennas suffer degradation [4]. The presence of the human body causes high transmission loss between on-body antennas. The efficient wireless networking system within on-body transmission is depending on transmission between antennas. Therefore, by introducing the waveguide sheet beneath the wearable antennas, the performance of the antennas is enhanced [5]. The proposed AMC sheet are entirely made of textiles for both the substrate and the conducting parts, thus making it suitable for wearable communications. In this paper, several positions of dual-band textile diamond dipole antenna are investigated to measure the transmissions between antennas on the AMC sheet. Different antenna's placement is considered. Significant transmission enhancement is observed for all the positions compared to free space environment. Directive radiation patterns with high gain are obtained with the proposed AMC sheet, hence minimizing the radiation towards the human body.

2. DESIGN CONSIDERATION

2.1 Antenna Design

Dual-band textile diamond dipole antenna which is operated at 2.4 GHz and 5.8 GHz is used to be incorporated with a dual-band textile AMC sheet. The dimension of the proposed antenna is 60 mm x 60 mm as shown in Figure 1. It has wider bandwidth ranging from 2.3 GHz to 2.7 GHz and 5.2 GHz to 7.2 GHz with the omni radiation pattern. The parameters of the antennas are shown in Table 1. *W1, L1, W3* and *L3* parameters determine the resonant frequencies of the antenna. The bigger patch of the antenna resonates at 2.45GHz while the smaller patch of the antenna resonates at 5.8GHz. The size of the antenna is minimized by putting the small SMA port in the middle of the antenna.

2.2 Unit Cell of Artificial Magnetic Conductor(AMC)

A unit cell of the AMC is shown in figure 2. The outer patch of the AMC resonates at 2.45GHz while the inner patch resonates at 5.8GHz. The parameters of the unit cell are presented in Table 2. Both structures are purely made of textile. The fleece fabric is used as the substrate and ShieldIt fabric as the conducting patch. The fleece fabric has a dielectric constant of 1.3 with 1mm thickness.

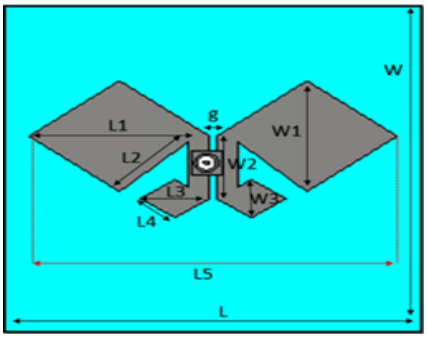

Figure 1. Dual-band Textile Diamond Dipole Antenna

Table 1. Parameters of the antenna

Parameters	Dimension(mm)
L	60.0
W	60.0
L1	23.0
L2	13.6
W1	20.4
W2	11.5
L3	10.0
L4	6.0
W3	7.0
L5	53.0
G	1.0

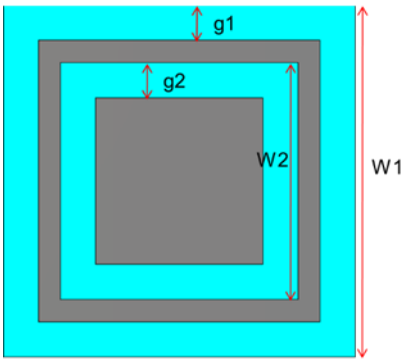

Figure 2. Unit cell of AMC

Table 2. Parameters of unit cell of the AMC

Parameters	Dimensions(mm)
W1	31
W2	21
g1	4
g2	3

2.3 Arrays of AMC sheet

The array of AMC sheet is simulated and investigated as shown in figure 3. The transmission between antennas are investigated at different position with dual band antenna above the AMC sheet. The positions are labeled as A, B, C, and D. In this study the positions and the orientations of the antennas are considered. Position B presents the longest distance with different orientation while position C presents the closest distance with the same orientation.

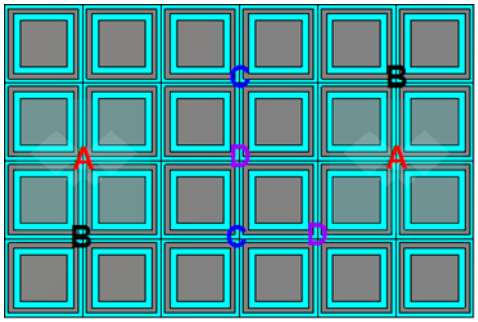

Figure 3. Positions of dual-band antenna above the AMC sheet

3. RESULT AND DISCUSSION

The dual-band textile diamond dipole antenna resonates at 2.45GHz and 5.8GHz. The reflection coefficient graph of the antenna is shown in Figure 4. The return loss of depth at 2.45GHz is -35dB while at 5.8GHz is-24dB. The computed current distributions of the antenna are displayed in Figure 5. At 2.45GHz strong current can be seen being induced at bigger patch while at 5.8GHz, strong current being induced at smaller patch.

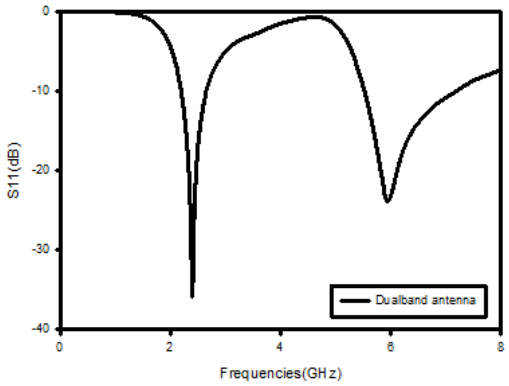

Figure 4. Reflection Coefficient of the antenna

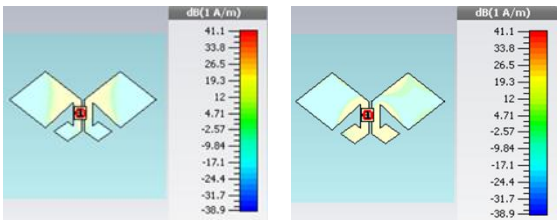

Figure 5.a) Current Distribution at 2.45GHz b) Current Distribution at 5.8GHz

From the S- parameters results (Figure 6), the S_{21} transmission which is indicated by dotted lines decreases as the distance increase, as predicted. The reflection coefficient (S_{11}) of the antenna which are indicated by solid lines are following the AMC behavior. The transmission of the two dual-band antenna is improved with the presence of textile AMC waveguide. Highest S_{21} peak is observed at position D which is -19.3dB at 2.4 GHz while at -20dB at 5.8 GHz. Electromagnetic waves are being concentrated into the AMC surface, hence the low transmission loss between two antennas is observed.

To observe the current flows between antennas above the AMC surface, simulated current distributions are retrieved for visualization. Figure 7 illustrates the current distributions of two dual-band diamond dipole antenna placed on top of textile AMC sheet. The 2.45GHz antennas' configuration are shown in Figure 7a, c, e, g while Figure 7b, d, f, h presents the configurations of 5.8GHz. For both configurations, strong current distributions are noticed between the two antennas along the adjacent patches. At 2.45GHz, high strength of current is observed flowing between the outer patch of the AMC while at 5.8GHz, the strong current is observed flowing at the inner patch of the AMC. From the such current distributions, enhanced transmission between antennas is achieved when having AMC surface beneath them.

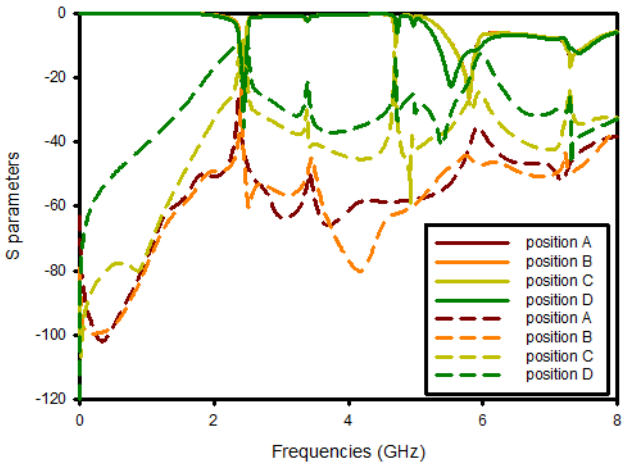

Figure 6. S- parameters of dual-band antenna with AMC sheet

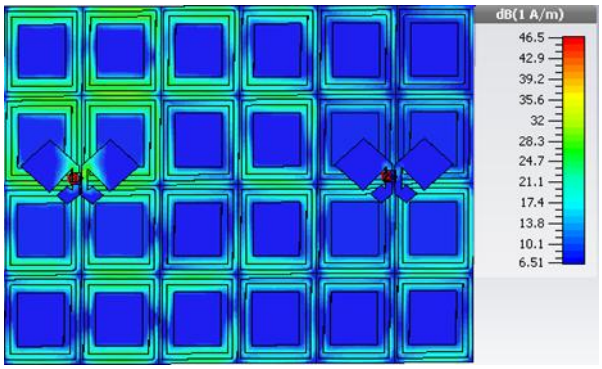

Figure 7a) Current Distribution at position A at 2.45GHz

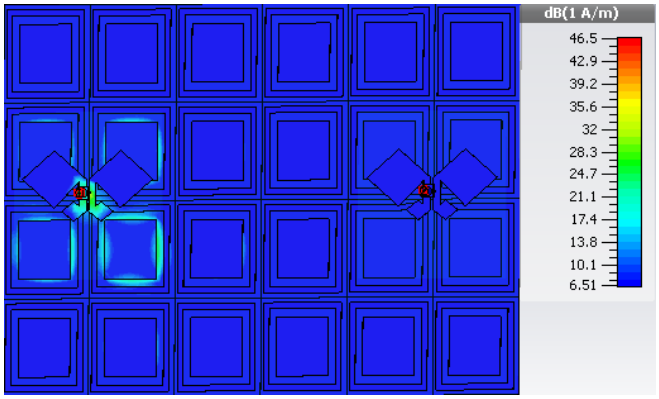

Figure 7b) Current Distribution at position A at 5.8GHz

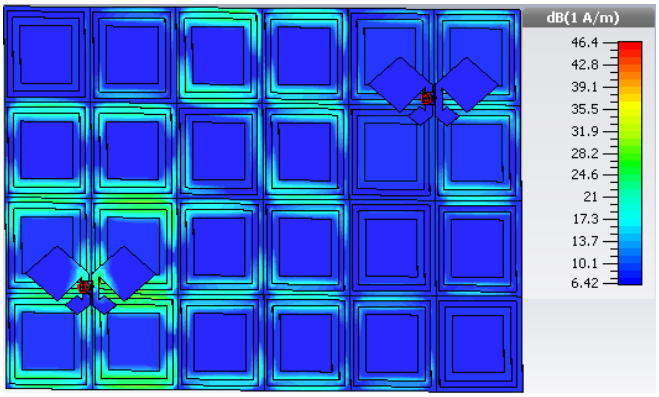

Figure 7c) Current Distribution at position B at 2.45GHz

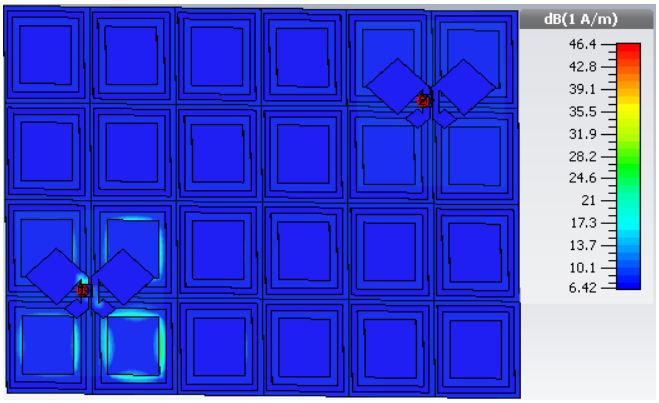

Figure 7d) Current Distribution at position B at 5.8GHz

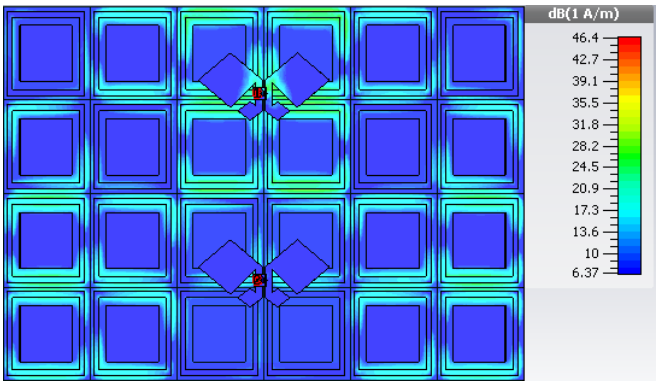

Figure 7e) Current Distribution at position C at 2.45GHz

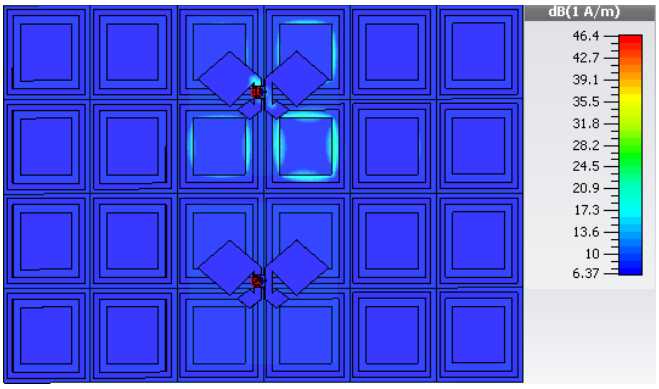

Figure 7f) Current Distribution at position C at 5.8GHz

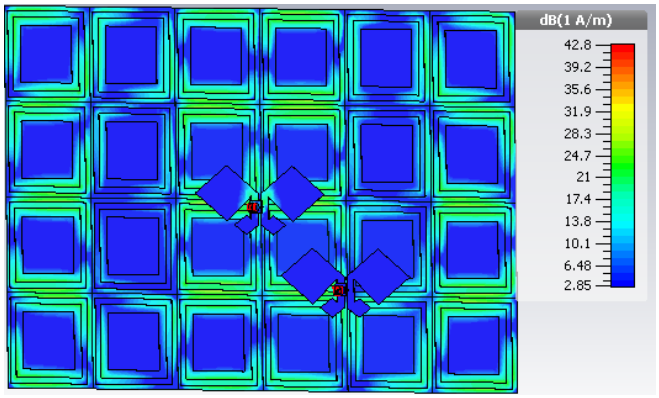

Figure 7g) Current Distribution at position D at 2.45GHz

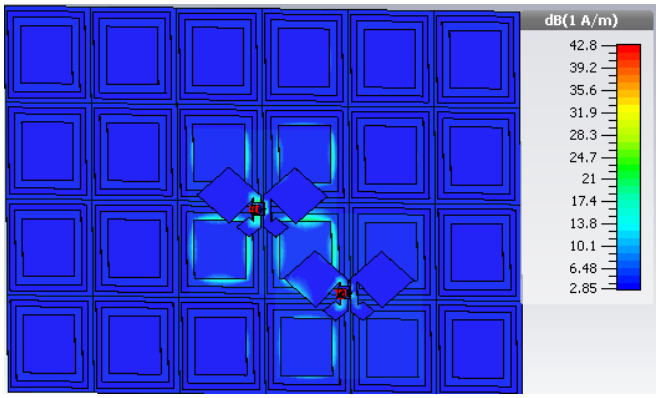

Figure 7h) Current Distribution at position A at 5.8GHz

4. CONCLUSION

The dual-band textile diamond dipole antenna resonates at 2.45Ghz and 5.8GHz. When the antenna is placed on top of the AMC sheet, the transmission between the antenna is enhanced. For all positions, significant improvement transmission S21 are achieved when having AMC sheet compared to free space transmission. However, the S_{21} performance decreases as distance increases. The S_{11} results show that the bandwidth of the antenna above the AMC surface become narrower compare to the free space environment.

ACKNOWLEDGMENT

This work were supported by Ministry of Higher education (MOHE), Research Management Centre (RMC), Universiti Teknologi Malaysia (UTMJB) Johor Bahru, under research grant no Q.J130000.2523.05H35, 12H09 and 4F360.

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