Coupling Characteristics between Two Dipole Antennas over Free Access Transmission Line using Paper Substrate

Yuka Shinozaki, Takuya Okura, Hiroyuki Arai
Graduate School of Engineering, Yokohama National University
79-5, Tokiwadai, Hodogaya-ku, Yokohama-shi, Kanagawa, 240-8501, Japan
E-mail: sinozaki-yuka-vs@ynu.jp

Abstract **–We presents characteristics of a free access transmission line consisting of a paper substrate and foam instead of dielectric substrate for easy installation in body area network applications. In this paper, we simulated the coupling characteristics between two dipole antennas above the proposed transmission line to show its basic performance. The average of coupling characteristics above the transmission line is increased by more than 10 dB compared with the performance of no assistance of proposed scheme.**

Index Terms **— WBAN, Free Access Transmission Line, Conductive Ink, Paper Substrate, Coupling Characteristics.**

1. Introduction

In Body Area Network (BAN), people wear a wide variety of sensors or wearable computers and collect information for the use of healthcare, entertainment and personal authentication. Wireless communication is desired because of simplicity wearing and easy moving [1], and free access mat [2] and transmission line [3] have been proposed to make another communication network between wireless devises. In this paper, we examine a flexible transmission line structure using the conductive ink for conductor [4], the paper substrate and the foam instead of dielectric substrate. This paper shows coupling characteristics between two dipole antennas above the proposed transmission line. We use simulation software of EMPro [5].

In section 2, we design both side coupled geometry of half-wavelength bandpass filter, as a basis component of the free access transmission line. We also simulate coupling characteristics between the transmission line and the dipole antenna, and that between two dipole antennas above the transmission line in section 3.

2. Free Access Transmission Line

In our previous work [6], we use ten sheets of paper instead of the dielectric substrate, and the width of transmission line w_1 is decided for characteristic impedance become 50 Ω. For the simplicity in fabrication process, we use the foam with its thickness of 2.0 mm under one sheet of paper instead of nine sheets of paper substrates. Bandpass filter in Fig. 2 is printed on the paper top with electric permittivity of 2.0, dielectric loss tangent of 0.025 and thickness of 0.18 mm. The coupling length l_1 is quarter wave-length at design frequency 2.45 GHz. It makes a microstrip line by putting copper tape on the bottom of foam. We calculate w_1 to have the characteristic impedance of 50 Ω by using formula in [7]. This bandpass filter is connected in series as a one-dimensional array structure as shown Fig.3. In this paper, we fix l_2 the length between resonators and l_3 the length between resonator and edge as $2l_1$.

3. Coupling Characteristics

In this section, we simulate coupling characteristics for two cases. First, between transmission line and dipole antenna to confirm the coupling characteristics. Second, between two dipole antennas to verify the performance of proposed transmission line geometry.

We simulate coupling characteristics between the transmission line and the dipole antenna (Fig.3). Dipole antenna is moved in 20 mm step along the y-axis direction (L_{D1}=0~460 mm). The height of dipoles from the transmission line is d = 1.0 mm. The coupling characteristics at 2.45 GHz are shown in Fig.4. The coupling drops at L_{D1}=120, 220 and 340 mm. For the adjustment of center frequency in coupling, then we lengthen its length l_1 from 28.0 mm to 31.0 mm, and l_2 is changed to $l_1/2$ from $2l_1$. After this parameter adjustment, the average of coupling characteristics improved by 4.5 dB and deep nulls in coupling are removed. We obtain almost same performance in the proposed structure with a paper substrate.

We use two 2.45 GHz dipole antennas to simulate the coupling characteristics as shown in Fig.5. Distance of dipole antennas and transmission line is d=1.0 mm. Dipole-1 is fixed above the resonator at L_{D1}=70.0 mm or stripline between resonators at L_{D1}=110.8 mm. Dipole-2 is moved in 20 mm step along the y-axis direction (L_{D2}=20~220 or 20~260 mm).

Fig. 6 shows coupling characteristics, where the black line is the case of L_{D1}=70.0 mm and the red one is the case of L_{D1}=110.8 mm. The green shows the coupling characteristics between two dipole antennas without transmission line and the blue one is free space propagation loss by Friis transmission equation.

As shown in Fig.6, when two dipole antennas are above the transmission line, coupling characteristics increased greatly compared with no transmission line case. The average of black line is -8.3 dB, and that of red one is -9.0 dB. The average of increasing coupling characteristics compared with no transmission line case, black line is 42.4 dB, red one is 36.4 dB.

4. Conclusion

We simulated the coupling characteristics between two dipole antennas above the proposed transmission line to show its basic performance. Distance of dipole antennas and transmission line was 1.0 mm. The average of coupling characteristics using the transmission line is increased by more than 10 dB compared with the performance of no assistance of proposed scheme. Therefore, we can design the one-dimensional transmission line using one sheet of paper substrate and foam.

References

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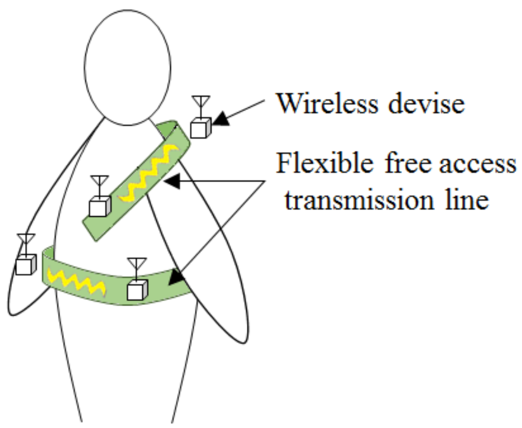

Fig. 1. Application example.

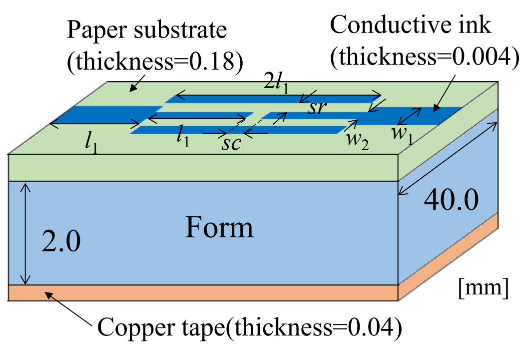

Fig. 2. Both side coupled geometry of half-wavelength bandpass filter.
(w_1=10.4, w_2=3.5, sc=1.7, sr=2.1, l_1=28.0 [mm])

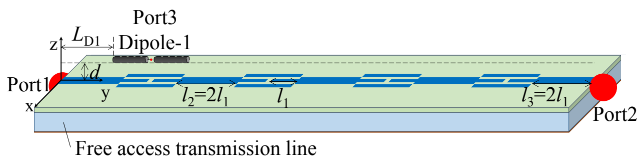

Fig. 3. Dipole antenna over transmission line.
(l_1=28.0, l_2=l_3=2l_1=56.0 [mm])

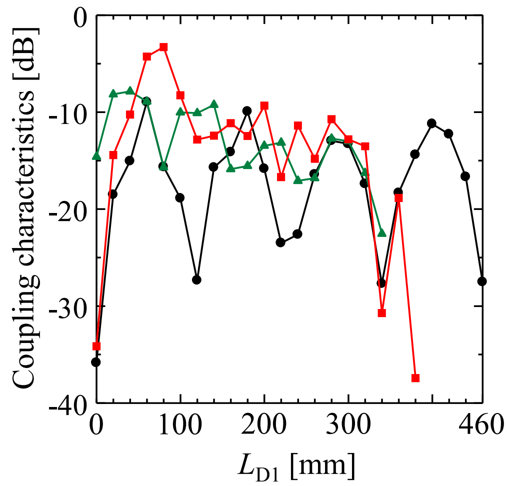

Fig. 4. Coupling characteristics between transmission line and dipole antenna.
(Black: l_1=28.0, l_2=l_3=2l_1=56.0, Red: l_1=32.0, l_2=l_1/2=16.0, l_3=2l_1=64.0[mm], Green: use ten sheets of paper substrate)

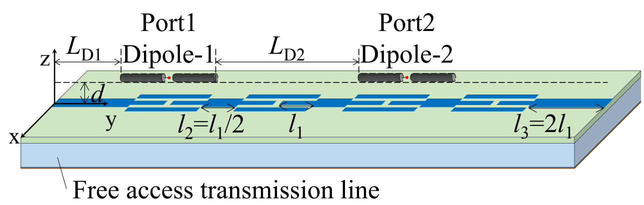

Fig. 5. Two dipole antennas over transmission line.
(l_1=32.0, l_2=l_1/2=16.0, l_3=2l_1=64.0 [mm])

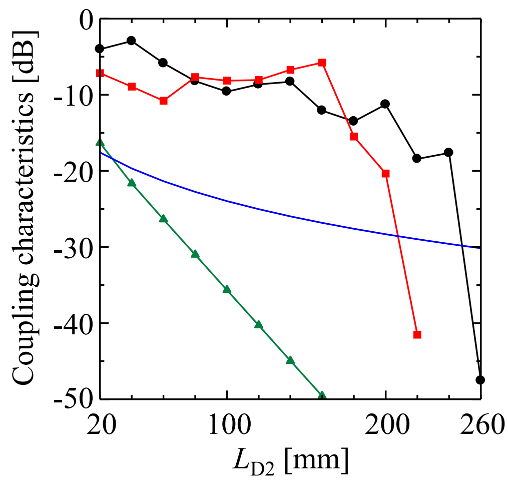

Fig. 6. Coupling characteristics between two dipole antennas.
(Black: L_{D1}=70.0 mm, Red: L_{D1}=110.8 mm, Green: w/o transmission line, Blue: free space propagation loss)