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Proceeding Paper

Effect of Bandage Materials on Epidermal Antenna †

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Abstract: This study explores the effect of different types of bandages on the performance of an epidermal antenna. Three identical dipole antennas are designed on three different types of bandages, and the measured reflection coefficients, S_{11}, show that the antennas resonate at the same frequency despite the different types of fabric bandages. However, the antennas resonance frequency shifts to a lower frequency when the antennas are mounted on the body. The transmission coefficient, S_{21}, over a 60 cm link with a standard RFID antenna is at least −30 dB, and −34 dB in free space and on the body, respectively, demonstrating that the antenna is suitable for communication and wireless RF power transfer in wearable applications.

Keywords: epidermal antenna; dipole; smart bandage; e-textiles; wearable application

1. Introduction

Smart bandages incorporate various types of sensors to continuously monitor of wound−related parameters, such as temperature, moisture level, pH level, and wound oxygenation, in chronic wound care and management [1,2]. They provide wound data to health practitioners, which allows them to remotely assess the healing of chronic wounds without removing the bandage. The smart bandage requires a power source for embedded electronics, and an antenna for wireless data transmission to an external device. An antenna design is critical in the development of a wireless smart bandage since it can be used to transmit data and harvest RF energy.

Several antenna designs for smart bandages have been presented in the literature. In [3], a via free planar antenna, similar to an adhesive bandage, for medical telemetry service is proposed. However, the antenna includes a ground plane, which increases the thickness of the antenna and, therefore, is less suitable for wearable applications. Similarly, in [4], a planar rectangular loop antenna is implemented in a battery−powered smart bandage for wireless monitoring of wounds. The antenna is small in size but operates at a higher frequency of about 2.4 GHz. Furthermore, near−field communications (NFC) antennas are also being investigated for wireless smart bandages [5]. Such bandages have a very low reading range, and need the bandage to be in close proximity to the reader, which is especially undesirable for applications requiring continuous monitoring.

In this study, we proposed an all−fabric epidermal antenna operating at 915 MHz for smart bandages in healthcare applications. The study also explored the effect of different types of bandages on the epidermal antenna resonance frequency. Three identical dipoles were designed on three different types of bandage materials. The performance of the antennas in terms of the reflection coefficient in free space and in the presence of body were investigated. Measurements demonstrate that the different types of bandage material have no discernible effect on the antenna performance.

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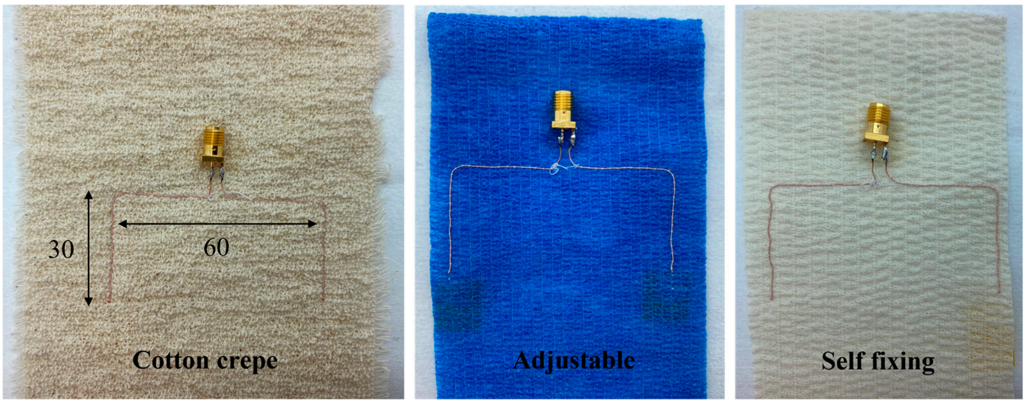
2. Antenna Design

The epidermal antenna design is based on an electrical dipole with bending radiating arms to reduce the antenna size. The radiating arms of the antenna were tuned to resonate at 915 MHz in the presence of human tissue. The antennas were made of silk coated Litz wires with a diameter of 0.36 mm. A PFAFF creative 3.0 sewing machine was used to embroider Litz wires into three types of bandages: (i) cotton crepe bandage made of cotton, (ii) self−fixing cohesive support bandage made of cotton/elastane with latex, and (iii) adjustable cohesive bandage made of polypropylene and elastane, as shown in Figure 1.



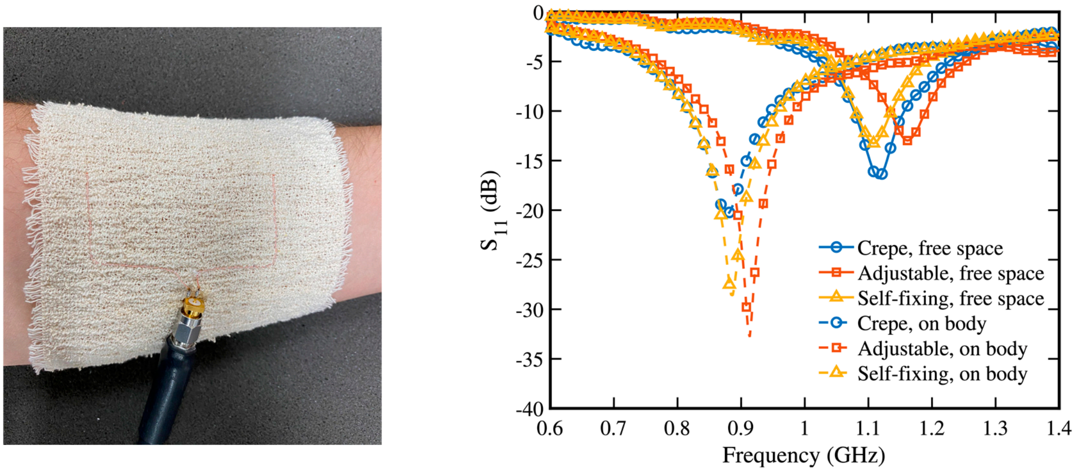
(**a**) (**b**) (**c**)

Figure 1. Manufactured prototype of the embroidered all−fabric epidermal antennas: (**a**) cotton crepe bandage; (**b**) adjustable bandage; and (**c**) self−fixing bandage.

3. Measurements and Results

3.1. Reflection Coefficient

The reflection coefficient, S_{11}, of the antennas were measured with a vector network analyser (VNA) in free space and in the presence of the body, Figure 2a. Figure 2b shows that the antennas resonate at around 1.10 GHz in free space, and 915 MHz when the antennas are mounted on the body. It is observed that the different types of bandages have no significant effect on the antenna resonance frequency, as shown in Figure 2b. However, the resonance frequency shifts to a lower frequency of 915 MHz in the presence of the body. This is due to the high dielectric constant and conductivity of human tissue.

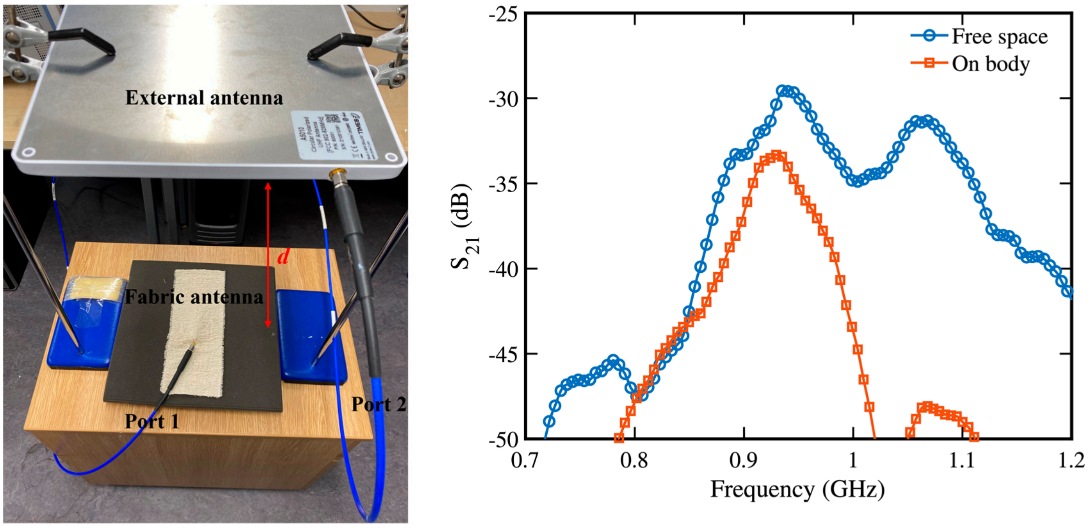


(**a**) (**b**)

Figure 2. (**a**) All−fabric epidermal antenna mounted on the human arm; (**b**) measured reflection coefficient, S_{11}, of the three identical antennas in free space and on the body.

3.2. Transmission Coefficient

The experimental setup, Figure 3a, was used to measure the transmission coefficient, S_{21}, between the fabric antenna and an external antenna. A circularly polarized antenna, with 8.2 dBi gain and operating at 915 MHz, was placed about 60 cm away from the bandage antenna. Both antennas were connected to a vector network analyser (VNA) and the transmission losses were measured. The measured S_{21} frequency responses are depicted in Figure 3b for both cases with and without human tissue. The results show that S_{21} is about −30 dB in free space, and −34 dB when mounted on the body. This shows that for a 30 dBm RF input power, at least −4 dBm will be received by the receiver antenna, indicating that the bandage antenna is suitable for RF power harvesting over a short distance at the UHF band.



(**a**) (**b**)

Figure 3. (**a**) Experimental setup for measuring transmission performance; (**b**) measured transmission coefficient, S_{21}, between the all−fabric antenna and an external antenna, showing that the transmission losses for the antenna in free space and on the body are −30 dB and −34 dB, respectively.

4. Conclusions

All-fabric epidermal antenna fabricated on fabric bandages is demonstrated in this paper. The resonance frequency of the antenna shifts to a lower frequency when it is mounted on the body due to the high relative permittivity and conductivity of human tissue. The measured results show that the different types of bandages have no significant effect on the antenna resonance frequency. Transmission losses, S_{21}, of the antenna is −34 dB in the presence of human tissue when the external antenna is 60 cm away from the arm on which the antenna is mounted. This means that the receiver antenna will receive at least −4 dBm for an input power of 30 dBm. The antenna is flexible, lightweight, easy to fabricate, and comfortable to the body, and, therefore, can be used to develop wireless and battery−free smart bandages. The objective of our future work is to closely investigate all fabric dipole array for RF information and RF power transfer for wearable applications.

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