Waveguide Surface on Textile for Body Area Network

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***Abstract*—Communication in Body Area Network (BAN) is very challenging because of the high electromagnetic absorption of human tissues. In this study, a waveguide surface printed on textile is used to guide electromagnetic waves between two on-body devices. A half-wavelength dipole is used to excite the waveguide surface. Simulation are presented at 2.4GHz for planar and curved surface on a textile substrate.**

I. Introduction

Wireless body area communication is an emerging technology for health service. In several eHealth application, communication between on-body devices is needed. Some specific antenna have been proposed to enhance the propagation for on-body communication using suitable radiation pattern [1]. An improvement of the propagation would be also possible using a dedicated meta-surface between the two terminals. Metasurface on textile have been proposed to enhance gain or antenna efficiency in wearable application, mainly for off-body application [2]. Recently, Quarfoth et al. has demonstrated the use of impedance surface to guide surface waves in a substrate [3] using surface waves.

In this paper, a waveguide surface at 2.4GHz integrated in textile substrate is investigated to enhance the transmission power between two on-body terminals. This meta-surface will also reduce electro-magnetic (EM) interaction with human body. In litterature, most of the reported textile material for EM application have a relatively low permittivity ranging from 1.2 to 2, a tanD ranging from 0.004 to 0.05 and a thickness between 1 and 5mm [4], [5]. The low thickness and permittivity limits the confining capabilities of the substrate. In the following sections, the guiding effect of such impedance surface printed on a textile substrate is studied.

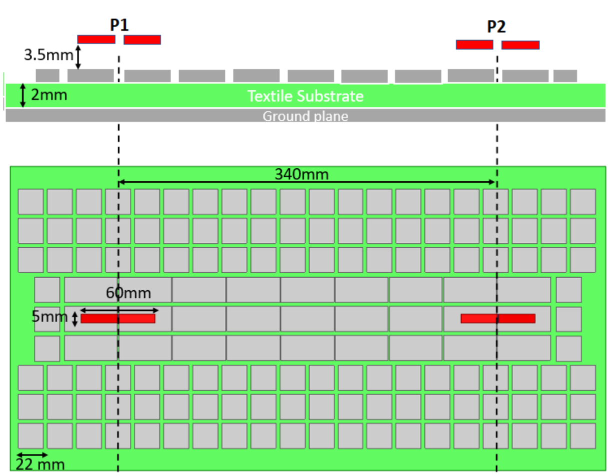

Fig. 1. Geometry of the Waveguide Surface (gray) and excitation dipole (red)

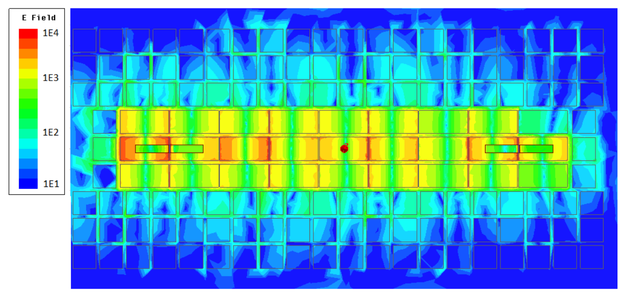

Fig. 2. E field on the planar surface in the loss-less case @2.44GHz

II. Waveguide Surface design

The proposed surface is inspired by Quarfoth studies [3] and is based on half-wavelength and quarter wave-length metal strips. The waveguide surface is designed on a 2-mm thick substrate with a 1.5 relative permittivity. The surface design is presented in Fig. 1, with half-wavelength (44mm x 22mm) patch to guide the signal and quarter-wavelength (22mm x 22mm) patch to block the signal. The impedance surface is excited using a halfwave-length dipole. Two dipoles separated by a 340mm distance are placed 3.5mm above the impedance surface and are connected respectively with Port 1 and 2.

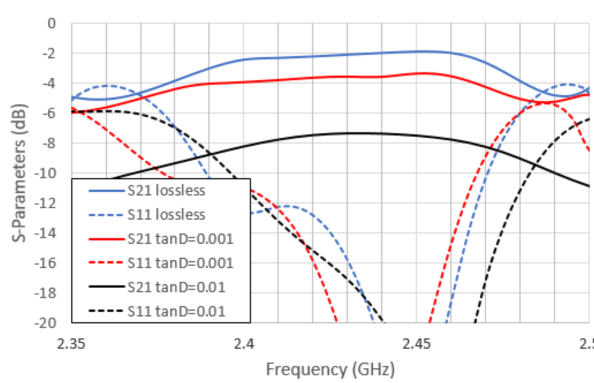

Fig. 3. S-Parameters of the planar Waveguide surface

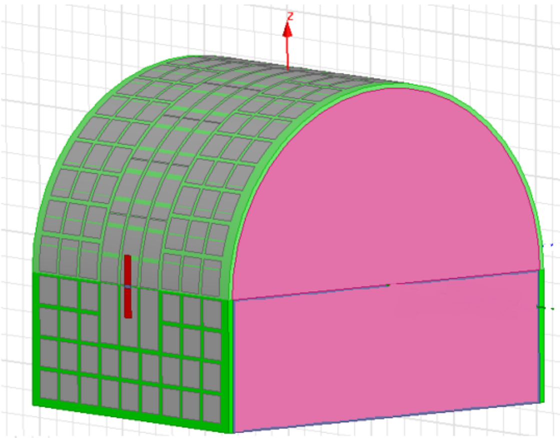

Fig. 4. Curved surface model and E field @2.44GHz

The magnitude of the E field in the substrate is presented in Fig. 2 and show that most of the field is concentrated in the half-wavelength patches. S-parameters of the structure are presented in Fig. 3 with 3 different configurations : loss-less case, lossy case with TanD=0.001 and TanD=0.01 in the textile substrate and copper conductivity(58E8 S/m). First, the loss-less case with perfect conductor and dielectric show that more than 60% of the power is transmitted to the second port. A non-negligible part of the transmitted field is radiated by the structure. Then, the effect of dielectric and conductive loss is reducing the transmission level but do not affect the input impedance and frequency bandwidth. For on-body communication, very high losses are observed when the communicating device are placed on opposite position around the human body, as an example between the chest and the back. In the following section, the effect of curvature on the impedance surface is studied to assess the guiding capabilities in this configuration.

III. EM GUIDED AROUND A CURVED SURFACE

In order to model the transmission of a EM wave around a human body, a simulation with a 300-mm diameter half-cylinder is performed. The cylinder is modeled with a homogeneous human body phantom with er=44.82 and s=0.85S/m. The textile substrate has a thickness of 2mm, a permittivity of Er=1.5 and a tanD=0.01. The two dipoles are placed on opposite position at 3.5mm above the impedance surface as shown in Fig.4. The magnitude of the E field show that a large part of the field is guided around the surface Fig.5. S-parameters with and without the waveguide surface are presented in Fig.6. A maximum transmission between the 2 ports of -10dB is obtained at 2.45GHz over a limited bandwidth. Without the impedance surface, a transmission level of -80dB is observed, which is clearly a worst case as multi-path effect is not considered in this model.

IV. CONCLUSION

In this work, a waveguide surface designed on textile substrate has been proposed to enhance transmission level between two on-body devices. A simulated model on a curve structure show that the transmission in this scenario can be improved by several decades.

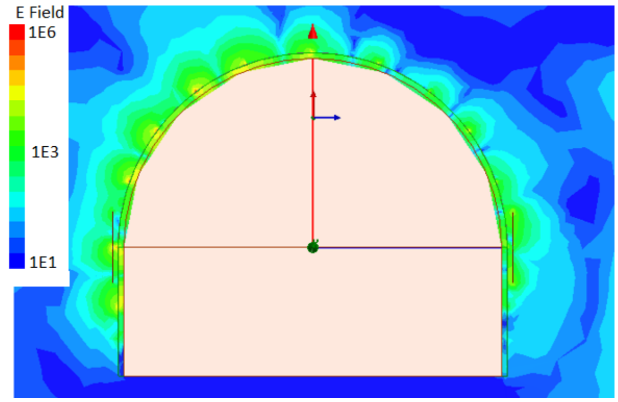

Fig. 5. Curved surface model and E field @2.44GHz

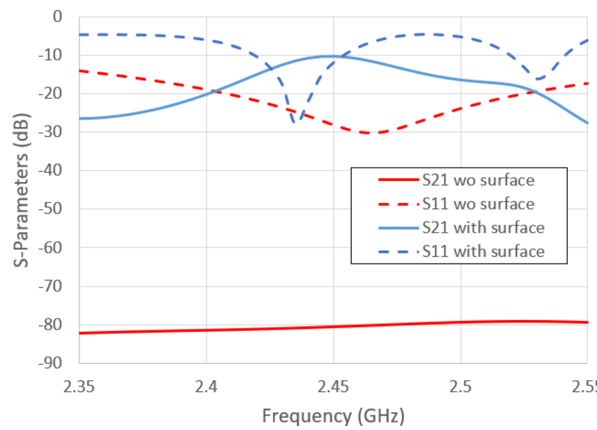

Fig. 6. S-Parameters of the curved structure with and wo the waveguide surface

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