Challenges Toward Design and Fabrication of Smart Clothing

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1. Introduction

1.1 Typical Solutions up to Date: Military and law enforcement uniforms • the camera - on the helmet • the transmitter and antenna - in the backpack...

1.2 Objectives

We want to

>>> integrate a textile-based antenna into a regular garment

>>> enable full-duplex voice communication without dependence on mobile phone >>> measure and transfer vital body parameters to a remote site

https://imgur.com/gallery/K2Vpu

>>> temperature, pulse, ECG, oxygen level, location: geo-coordinates, altitude



american-soldiers-to-fight-for-afghanista

Radiation Patterns when antenna is placed on arm

simulated radiation patterns:

 $G_{sim} = 5.04 \text{ dB}, e_{rad} = 55.3\%, e_{tot} = 51.1\%, cross-pol < -20 \text{ dB}$





received power

measured from

the sleeve-

mounted

textenna

in dBm

2. Textile Antennas

Prototype of a 2.45 GHz Jeans-based Wideband Antenna

- we started with jeans-based antenna
- circularly polarized, wideband

Design and Fabrication



Results



SAR Computation

human voxel model

SAR evaluation



W/kg 0.341 + 0.31 -0.279 -0.248 -0.217 -0.186 -0.155 -0.124 -0.0931 -0.062 -

by IEEE/IEC 62704-1 norm: max simulated SAR = 0.34 W/kg, which is much lower than 2 W/kg that is allowed by IEEE C95.3 norm - similar result



testing of the textenna mounted on a jacket sleeve

- meet Gustav: a 38-year-old male, 176 cm tall, weighs 69 kg.
- The SAR analysis was performed using voxel size 2.08 mm × 2.08 mm × 2 mm
- power density (W/kg) averaged over 10 g of the tissue and with an antenna input power of 0.5 W

3. Exploring Communication Scheme Variants

- goal: full duplex voice communication up to a few tens of meters
- initial approach:
 - discrete 2.45 GHz transceivers
- Arduino-based circuits

Principle schematic of one transceiver set (one person)



transceiver



Source of firefighter image: 123RF https://www.123rf.com/photo_22349918_serious-firefighter-inuniform-on-a-white-background.html

M. Joler, A. Kolonić, and M. Boljkovac, "A Wideband Circularly Polarized Jeans-Based Antenna at 2.45 GHz," Open Journal of Antennas and Propagation, 2020, 8, 1-18.

Prototype of a Sleeve-Badge Textile Antenna

• initial goal: embed a textile antenna into a jacket sleeve make it circularly polarized



Transceiver circuits: first test



Electronics Challenge," 18th International Conference on Sensor Networks and Signal Processing, SNSP 2018, Xi'an, China, October 28-31, 2018, Conference Proceedings, Invited Talk.

Comments:

Rx

- wires will ultimately be adjusted to optimum lengths
- power supply will be substituted with more practical solutions

Early tests:

- communication worked on a 5m range
- 20-30 m range had too much noise for useful communication
- likely reason:
- a variety of cheap electronic components from different vendors

Improved transceiver circuits \rightarrow longer range







• with higher quality modules \rightarrow already a longer range, 30 m minimum

M. Joler, A. Berkarić, and V. Klen, "Testing an Arduino-based Approach for Full-Duplex Voice Communication and Body-Parameter Sensing Electronics for Use with Smart Clothing," International Journal of Antennas and Propagation, vol. 2019, Article ID 8598912, 8 pages, May 2019, DOI: 10.1155/2019/8598912.

a prototype of a right-hand circularly polarized sleeve-badge antenna



M. Joler and M. Boljkovac, "A Sleeve-Badge Circularly Polarized Textile Antenna," IEEE Trans. Antennas and Propagation, vol. 66, no. 3, March 2018, pp. 1576-1579.

antenna matching and bandwidth



measured antenna: bandwidth = 140 MHz, fractional bandwidth = 5.6%

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4. On the Integration of Body Sensors

• nowadays, typical approaches take advantage of a mobile phone as •... either a control and processing unit and the storage device

•... or an interface for communication with a remote center

• we explored an approach to submit a sensor data to a designated web page by connecting the transceiver module directly to a nearby access point (e.g. a router or mobile phone hotspot) • the designated web page was displaying the sensor reading (e.g. temperature) in real time

H

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ESP8266 - Temperature

Temperature in Celsius degrees: 24.0625*C



Testing ambience sensors and algorithms to measure barometric pressure, air temperature, and compute altitude



192. XXX.XX.XX some IP address

:D

On the way to design our customized PCB circuits in order to minimize the volume factor



PoC sensor circuit packaged within a carry-on box

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