EUROPEAN SCHOOL OF ANTENNAS

Antennas and Propagation for Body-Centric Wireless Communications

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Introduction to Body-Centric Wireless Communications (P. S. Hall/K. Ito)

Basics of Antennas for Body-Centric Wireless Communications and Human-Body Phantoms (K. Ito)

Applications of Wearable Sensors in Biomedicine and Sport and Performance Monitoring (GZ Yang)

Antennas and Propagation for Body-Centric Channels (P. S. Hall)

Wireless Devices and Radio Channel Characterisation for On/Off/Body-Body Applications (W. Scanlon)

Cooperative Wireless Body Area networks and Ultra Wideband for BAN (A. Alomainy)

Measurement Techniques and Methodology for PAN/BAN Antennas and Radio Characterisation (C. G. Parini)

Numerical Modelling Techniques for Body-Centric Wireless Communications (Y. Hao)

Antenna Specifications and Advanced Technologies for Future Body-Centric Wireless Communications (Y. Hao)
IEEE 802.15 WPAN™ Task Group 6
Body Area Networks (BAN)

The IEEE 802.15 Task Group 6 (BAN)

• formed in November 2007

• is developing a communication standard optimized for low power devices and operation on, in or around the human body (but not limited to humans) to serve a variety of applications including medical, consumer electronics, personal entertainment and other
**Domains of body centric communication**

- **off-body**
  - off-body to an on-body device or system

- **on-body**
  - within on-body networks and wearable systems

- **in-body**
  - communications to medical implants and sensor networks
Body - Centric Wireless Communications

• **Frequencies:**
  MHz -> On-Body, In-Body
  GHz -> Off-Body

• **Mechanism:**
  - Electric current
  - Electrostatic/magnetic coupling
  - Space/Creeping/Surface wave propagation

• **Key points:**
  - Electrodes/Antennas
  - Propagation channels
  - Modulation scheme
  - System optimization
Channel Characterization

**Need to understand and model propagation channels**
- to enable transceiver design
- to minimise power use
- to maximise capacity
- to optimise antennas

**Parameters measured**
- $S_{21}$ between 2 antennas on body over time with body movement

**Parameters extracted after processing**
- mean path loss – used to fix transmit power, or determine required receiver sensitivity. Determines battery power drain
- variation of path loss – used to estimate outage rates, block encoding size, equaliser settings
  - fast fading statistic
  - slow fading statistic
  - average fade duration
  - level crossing rate
- Doppler shift – used in modulation or receiver design
Wearable Antennas

Environment for on-body channels
- next to skin or in loose clothing
- tissue parameters different for different locations
- coverage to other parts of body + off body

Requirements
- no detuning
- low fringing field in tissue (high efficiency, low SAR)
- good coupling to surface, creeping, free space waves
- compact
Numerical phantoms

Whole Body Adult Male Phantom
- based on the data set generated by the visible human project
- **Tissues: more than 100 different tissue/organ types**

Electric field distribution in and around the arm

\[ \varepsilon_r = 170.73 \]
\[ \sigma = 0.62 \text{ S/m} \quad @ 10 \text{ MHz} \]
**Experimental phantoms**

**Liquid phantoms**
- Saline solution
- Sugar and saline solution
- Alcohol, etc.

**Gel phantoms**
- Polyethylene powder, TX151
- Glycerol, etc.

**Semi-hard phantoms**
- Agar
- Silicone rubber, etc.

**Solid phantoms**
- Ceramics
- Resin, etc.
Applications Examples

Goal
• Develop low-profile unobtrusive body worn antenna for UHF band for Squad level communications
• Replace large monopole whip antennas

Challenges
• Human body Characteristics
  – High losses (\(\tan\delta = 0.5-0.9\))
  – High Dielectric Constant (\(\varepsilon_r = 42\) (ave) – 62 (muscle))
• Antenna Design
  – Metallic shielding doesn’t increase efficiency (body-worn antenna gains <\(-10\)dBi)
  – No utilization of body miniaturization effect
  – Use body as high permittivity dielectric for miniaturization
  – Design and optimize on-body
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