HUMAN BODY AS DATA TRANSMISSION MEDIUM

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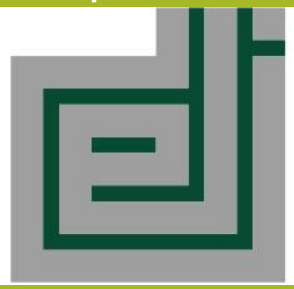


ELEKTRONIKAS UN DATORZINĀTŅU INSTITŪTS

INSTITUTE OF ELECTRONICS AND COMPUTER SCIENCE

Objectives

- Develop Human body signal transmission model
- Characterize Human body from the communication channel point of view
- Describe skin contamination influence on channel parameters

Introduction

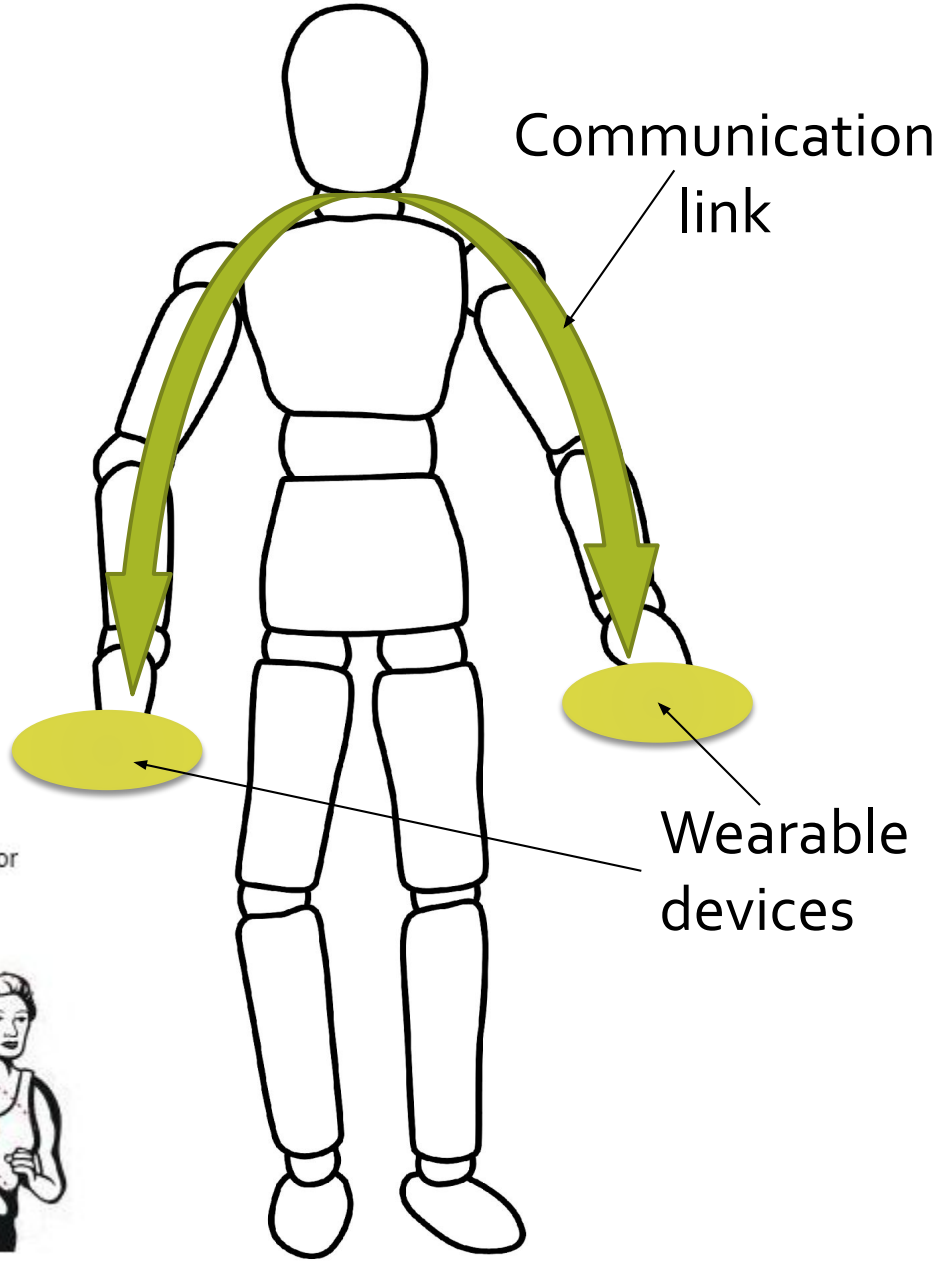
- Market growth by 210% in next 4 years [https://www.statista.com/]
- In 2021 number of wearable devices will reach 500 million units

Challenges in body sensor network area (BSN/BAN)

- Easy wearing/using
- Throughput limitation
- Privacy and security
- Energy efficiency

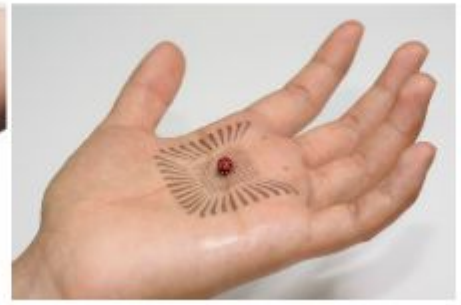
Body coupled communication

- Privacy and security as well as using wires
- Easy to wear as wireless devices
- Your body is your private transfer medium
- Energy efficient

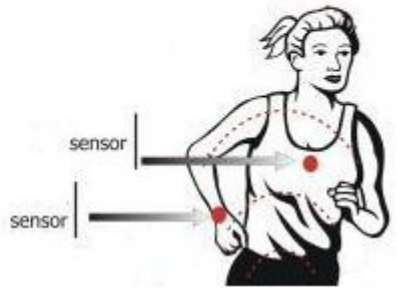


I. Secure personal data exchange

II. Energy efficient solution for flexible wearable device communication



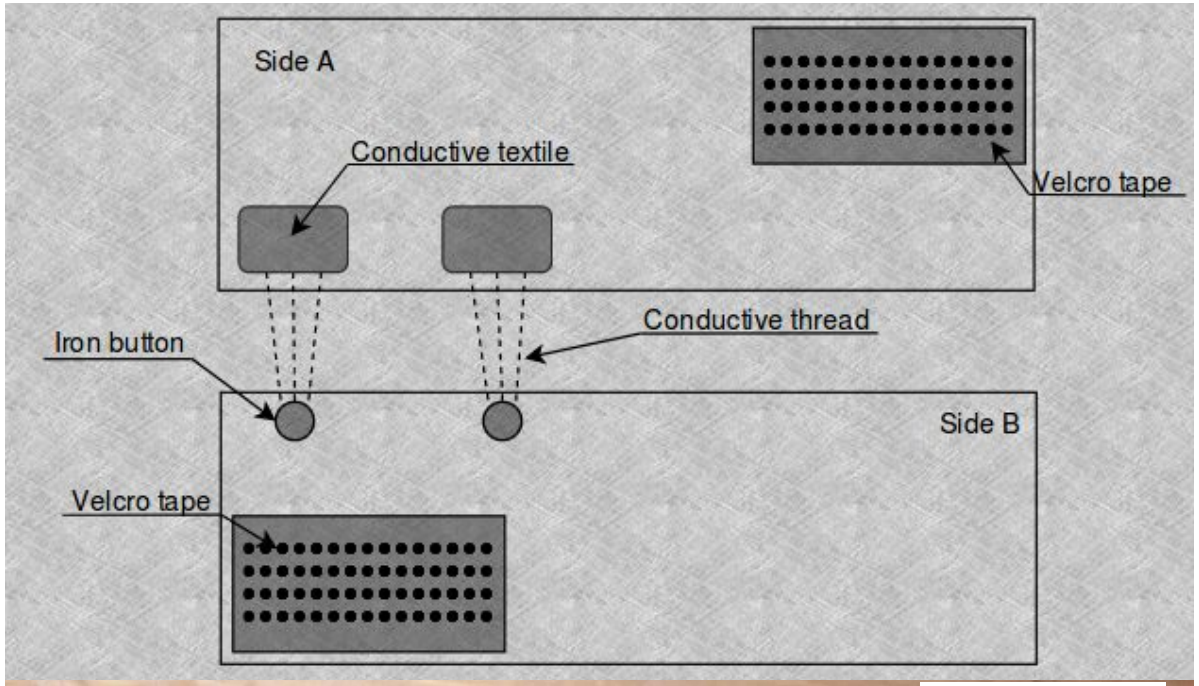
III. Body network sensor data collecting



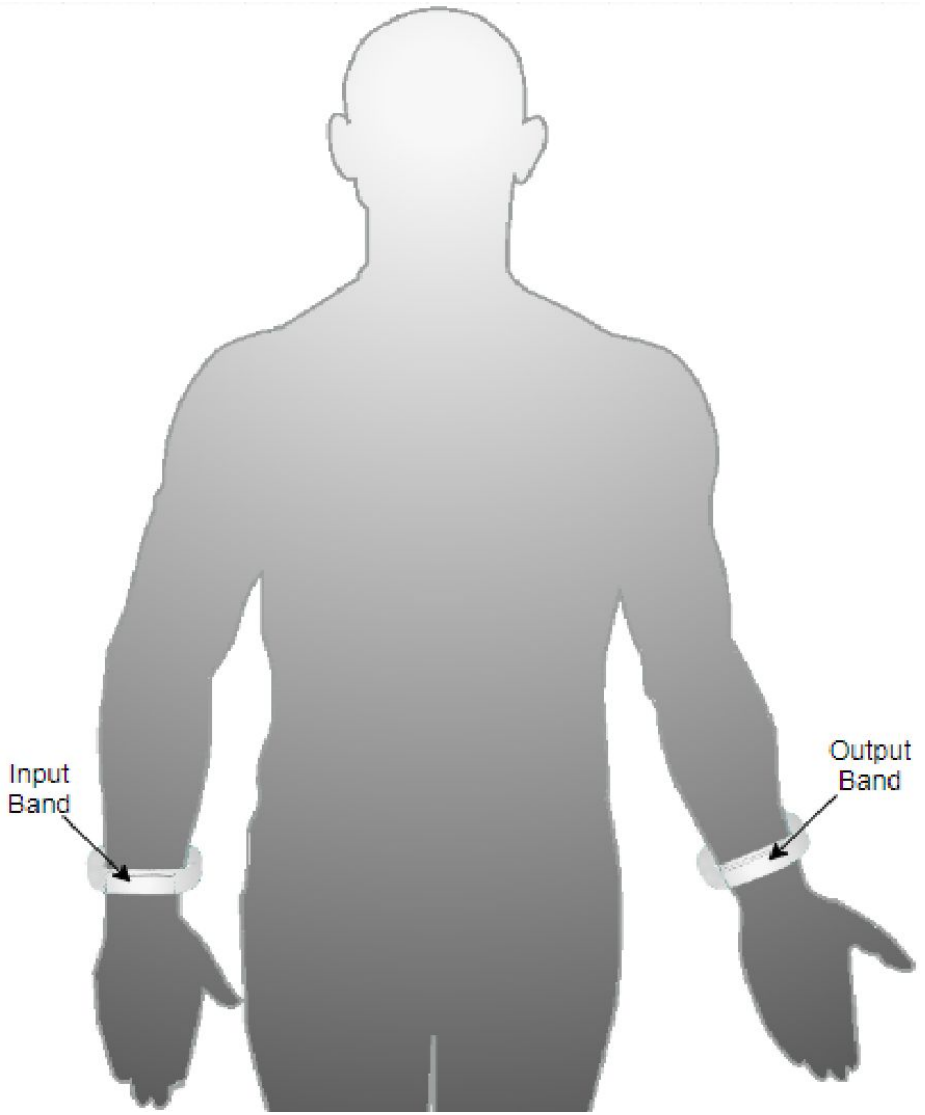
Safety

IEEE recommended limits		Limits during tests
Frequency range	Current	
0kHz-3kHz	0.5 (mA)	~300μA
3kHz-100kHz	$2 \times f_{kHz}(mA)$	
100kHz-110MHz	50 (mA)	

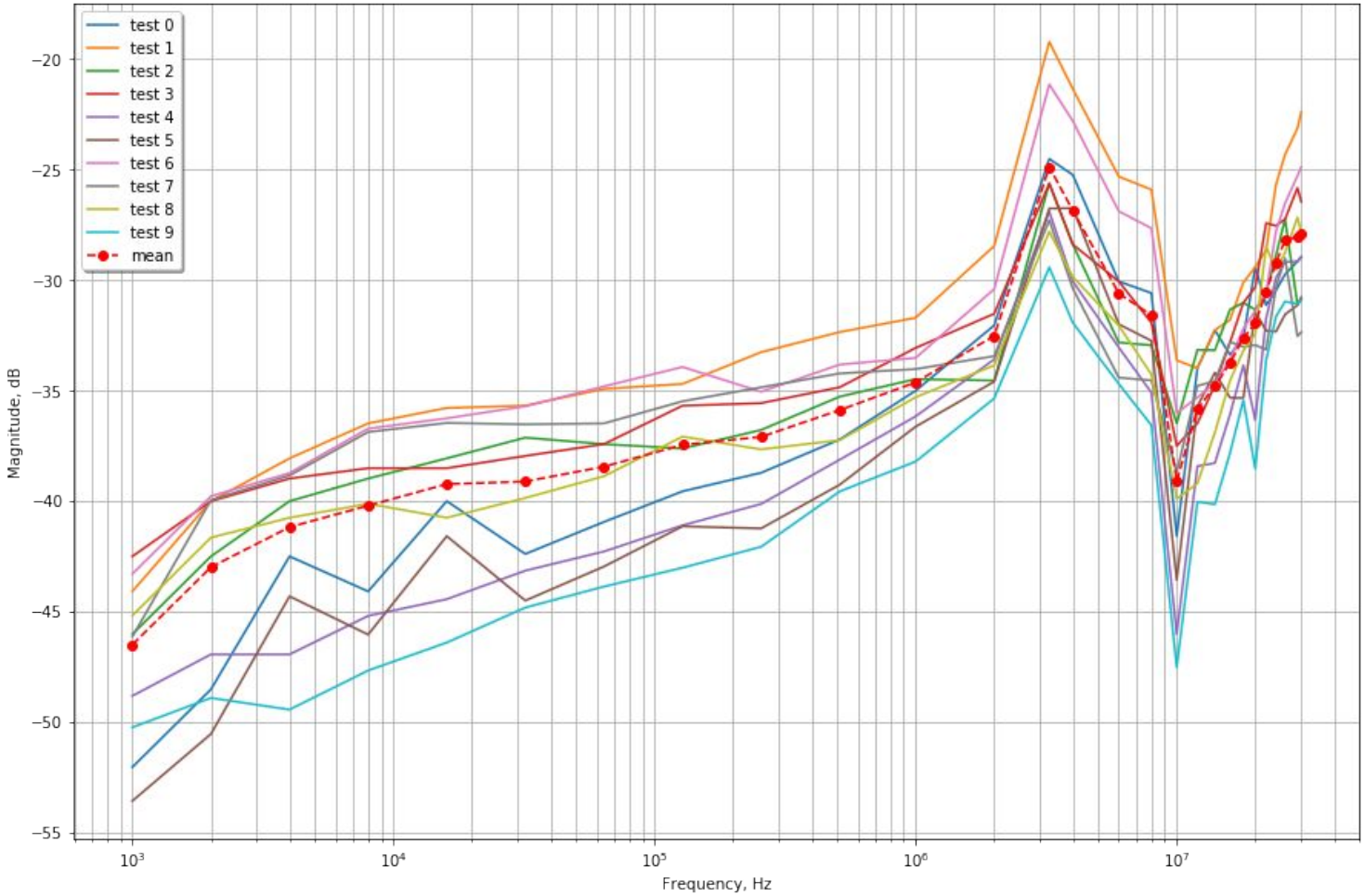
Setup


Side A
Conductive textile
Velcro tape
Conductive thread
Iron button
Side B
Velcro tape


Side A


Input Band
Output Band

Results – Human body frequency response



Results – Channel parameters

ΔF	1MHz
Fc	3.25MHz
Attenuation	−22dB÷−25dB
SNR	16.9dB
Impedance at Fc	120Ω

Next steps

- More measurements
- Identify the relationship between the location of the electrodes and the output power
- Find optimal signal power to ensure high SNR but minimize the signal interference on/from other users

USB to Human interface

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Objectives

Main objective is to design and test system that would allow to transmit data through human body over USB, to show usability of the BCC technology. (USB was chosen as the most common user interface to interact with PC) To accomplish that objective following tasks should be performed:

- Chose carrier frequency
- Chose modulation
- Design modulator and de-modulator
- Create prototype of the system (USB->TTL->BCC => BCC->TTL-USB)
- Measure current consumption and maximum throughput of the system

Introduction

Body Coupled Communication is type of communication where users body is used as data transmission medium (On the figure 1 could be seen BCC visualisation).

BCC should be:

- Energy efficient
- Secure
- Easy-to-Wear

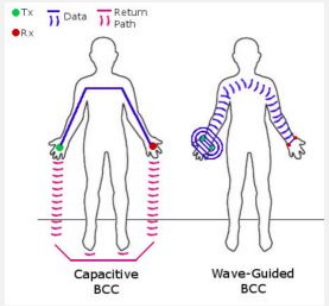


Figure: BCC visualisation

Carrier Frequency

To find correct carrier frequency the amplitude frequency response of the human body were measured. The results could be seen on the figure 2

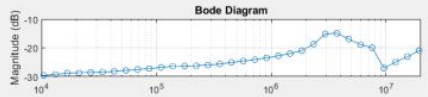


Figure: Human Body Amplitude-Frequency Response [1]

Could be seen that the most suitable band is 2-5 MHz, with peak at 3.25MHz

Modulation

Two pairs of modulator/demodulator were designed - ASK (figure 3a) and FSK (figure 3b).

(a) ASK schematic

(b) FSK schematic

Safety

The current through human body during experiment didn't exceded 0.1μA

Setup

On the Figure 4 experiment setup could be seen

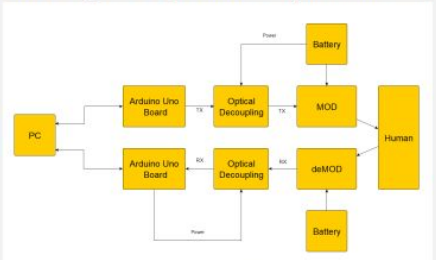


Figure: Setup Diagram

Results

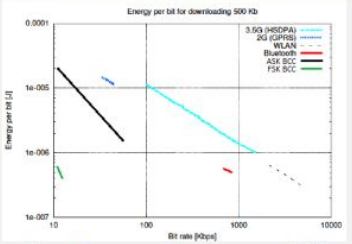


Figure: Energy per Bit measurements [2]

- ASK Power Consumption - 0.2W
- ASK Max Throughput - 57600 bps
- ASK J/bit - 3.52e-6
- FSK Power Consumption - 6.5mW
- FSK Max Throughput - 14400 bps
- FSK J/bit - 4.51e-7

Conclusion

During this research two modulation suitability for BCC were analysed and results shows, that FSK has bigger potential in BAN-WSN systems. During experiments was shown that energy efficiency of BCC system is comparable to WLAN and Bluetooth [2]

Discussion

During experiments multiple subjects were tested, and interesting phenomenon were discovered - persons with colder hands had drastically lower max throughput value. For measurements thermal camera were used. There were two hypothesis about this effect:

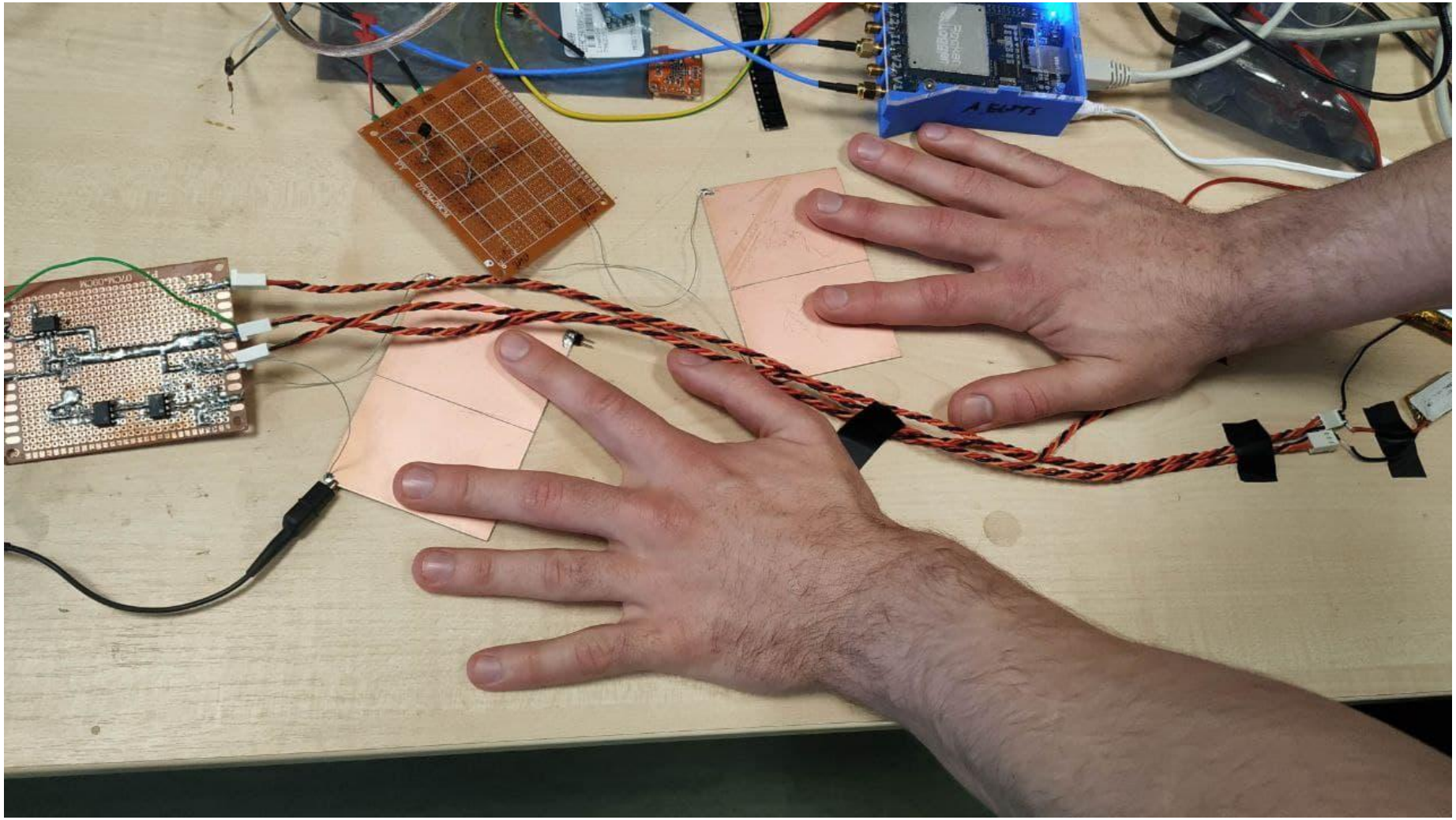
- The capillary structure causes both, cold fingers and bad conductivity
- The temperature of the skin/body causes change of conductivity

To check them the capillary photos were taken, but significant difference in structure have not been noticed (Cold/Warm hand subjects). But at the same time, in warmer weather, the person with "cold fingers" had much better conductivity, than in previous experiment, when ambient temperature were lower.

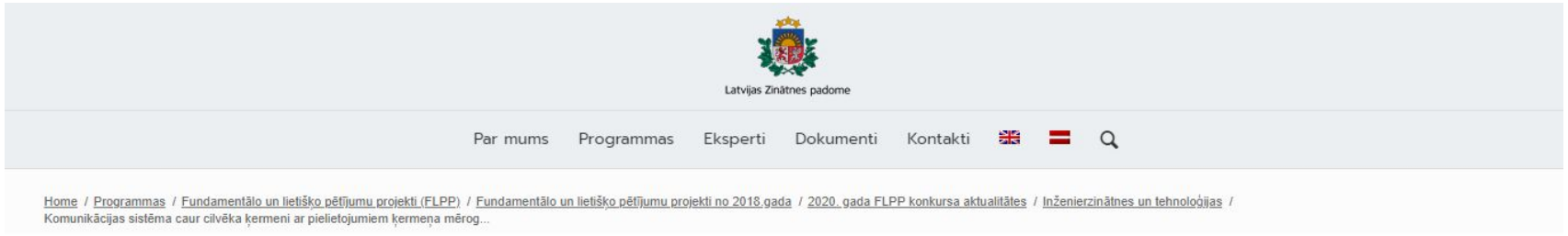
References

[1] Juris Ormanis and Krisjanis Nesenbergs.
Human skin as data transmission medium for improved privacy and usability in wearable electronics.
In *2018 IEEE International Symposium on Medical Measurements and Applications (MeMeA)*, pages 1–6, 2018.

[2] G Perrucci, Frank Fitzek, Joerg Widmer, Qing Wei, and Wolfgang Kellerer.
Survey on energy consumption entities on mobile phone platform.
01 2011.



Body-Coupled Communication for Body Area Networks (BCC)



Komunikācijas sistēma caur cilvēka ķermeni ar pielietojumiem ķermeņa mēroga bezvadu tīklos

Sākums 01/2021 | **Noslēgums** 12/2023

Projekta numurs

lzp-2020/1-0358

Finansējums

300000 EUR

Projekta vadītājs

Atis Elsts

https://www.edi.lv/projects

atis.elsts@edi.lv

Projektu īsteno

Elektronikas un datorzinātņu institūts

Zinātnes nozare

Inženierzinātnes un tehnoloģijas

5G and Chip implants

Seminar - This is science, not a witchcraft

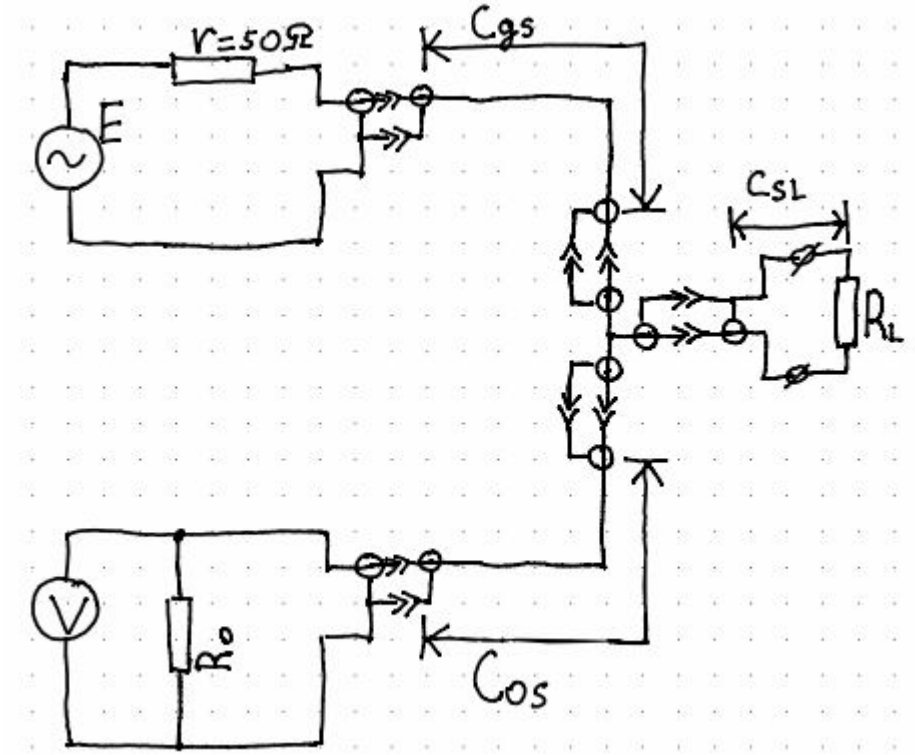
Semināra programma:

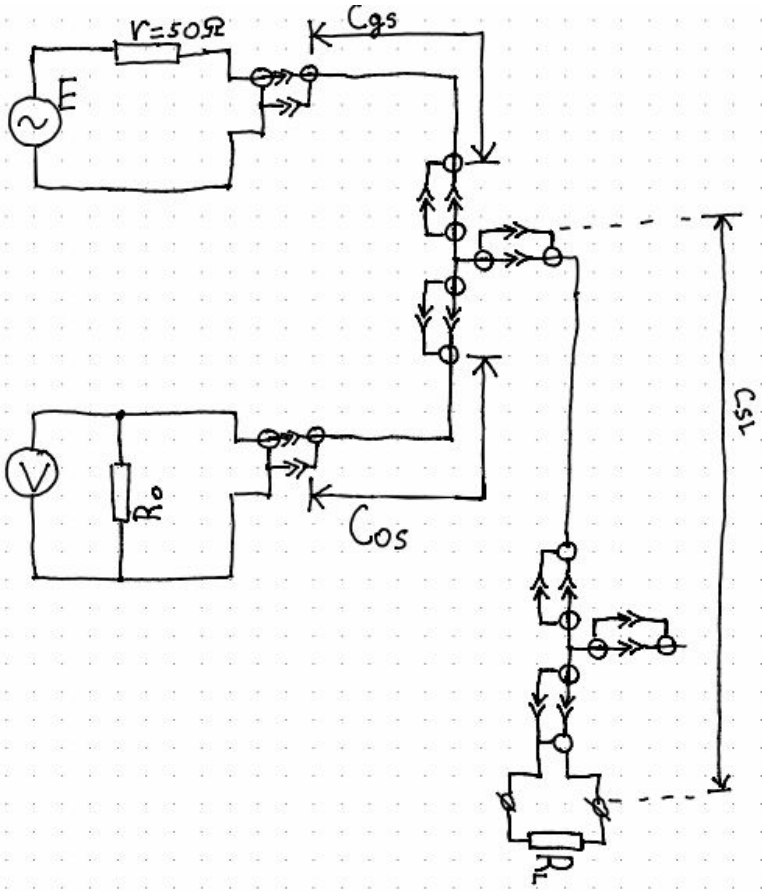
14:00-14:05: Ievads, M. Greitāns.
14:05-14:25: Projekta plāni un mērķi, A. Elsts.
14:25-14:40: Komunikācija caur cilvēka ķermeni: iestrādnes un izaicinājumi, J. Ormanis.
14:40-15:00: Diskusija.

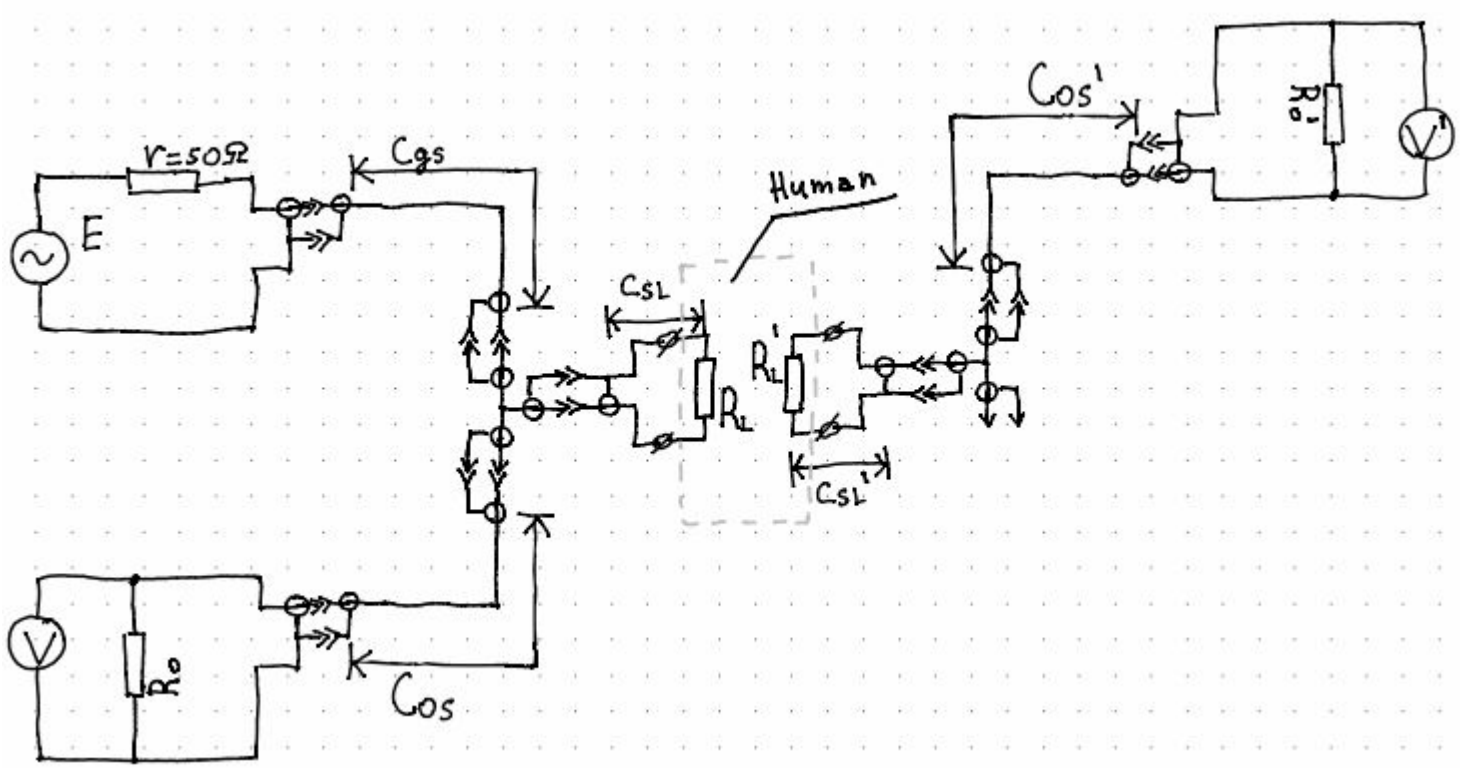
Aicinām rezervēt laiku un reģistrēties https://shorturl.at/ouxH4 līdz 17. jūnijam.

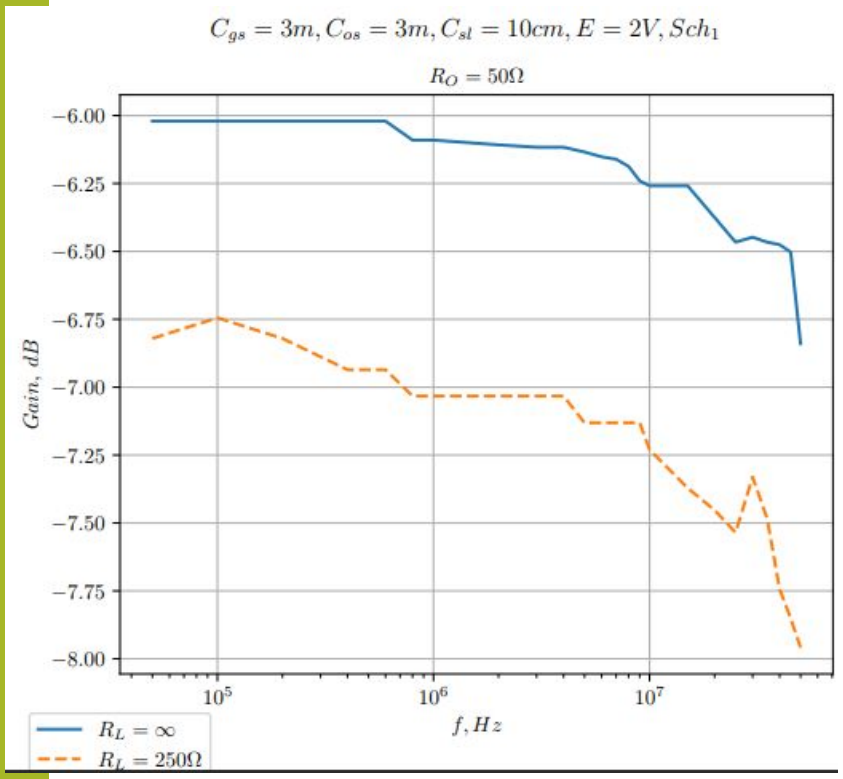
Atjaunots 19.06.2021.: Semināra ieraksts pieejams YouTube:

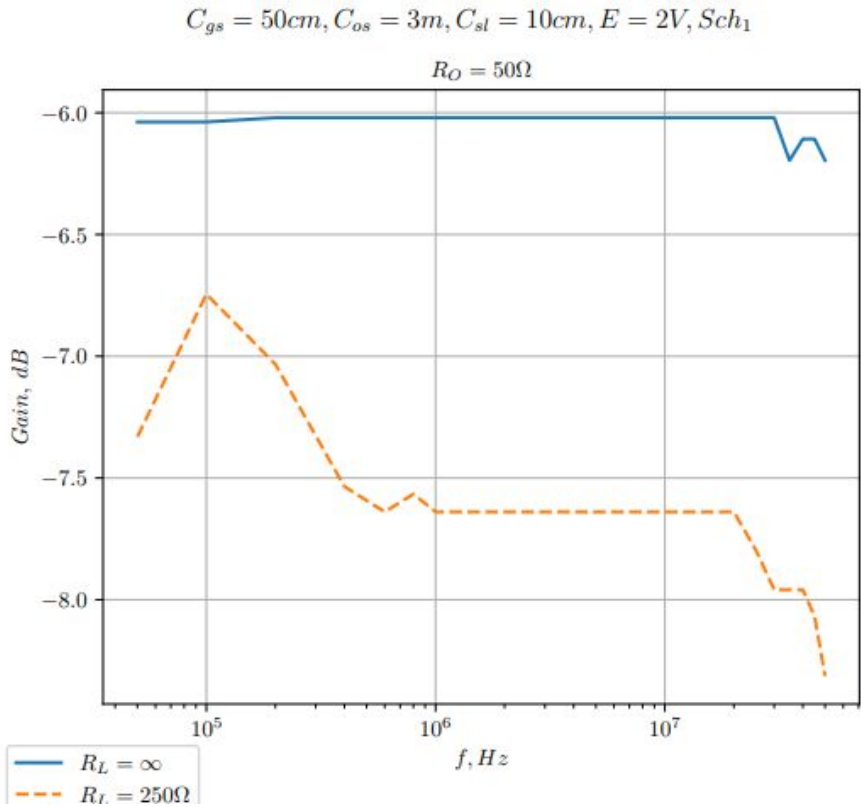
Signal Loss in Body Coupled Communication: Guide for Accurate Measurements

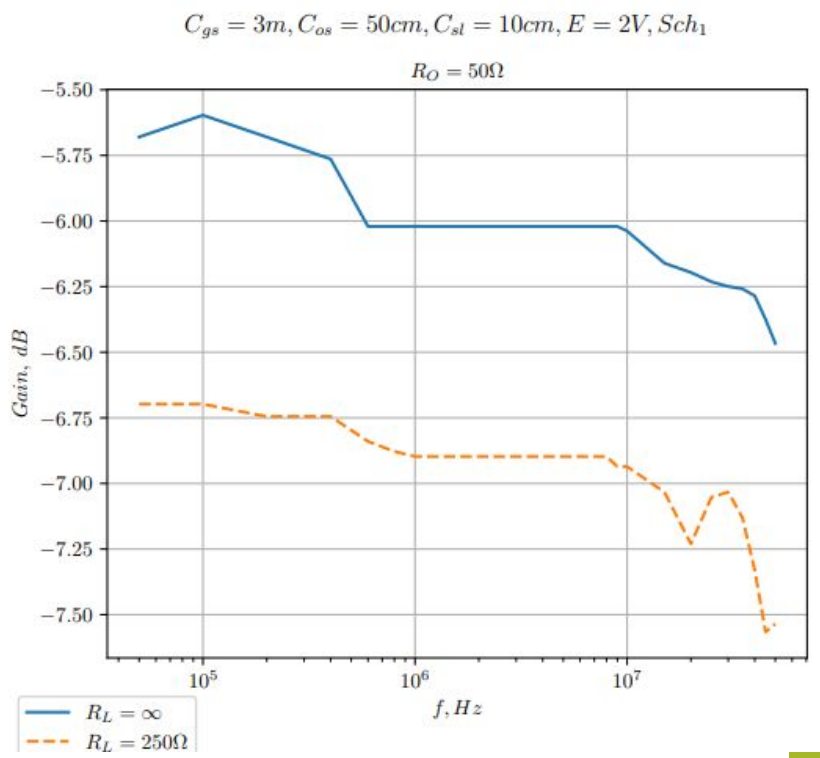





r=50Ω
Cgs
E
Human
Cos'
Csl
Rl'
Rl
Csl'
Ro
Cos


$C_{gs} = 3m, C_{os} = 3m, C_{sl} = 10cm, E = 2V, Sch_1$
$R_O = 50\Omega$
$Gain, dB$
f, Hz
$R_L = \infty$
$R_L = 250\Omega$


$C_{gs} = 50cm, C_{os} = 3m, C_{sl} = 10cm, E = 2V, Sch_1$
$R_O = 50\Omega$
$Gain, dB$
f, Hz
$R_L = \infty$
$R_L = 250\Omega$


$C_{gs} = 3m, C_{os} = 50cm, C_{sl} = 10cm, E = 2V, Sch_1$
$R_O = 50\Omega$
$Gain, dB$
f, Hz
$R_L = \infty$
$R_L = 250\Omega$

Next steps

- Publish Guide for measurements
- Finish Measurement Automation Stand
- Complete Data Collection
- Publish DataSet Article
- Identify the relationship between the location of the electrodes and the output power
- Find optimal signal power to ensure high SNR but minimize the signal interference on/from other users
- Create Parametric model
- Publish Parametric Model
- Get PHD

Thank you for attention