CRATOS HEARLIGHT nemobmi BRAINCODER CONFERENCE

WORKSHOP

NEURAL HORIZONS: FUTURE PANORAMA WITHIN BRAIN-MACHINE INTERFACES

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Dr. Ali Khaleghi

Department of electronic systems (IES)

Norwegian University of Science and Technology (NTNU)

Trondheim, Norway

ali.khaleghi@ntnu.no

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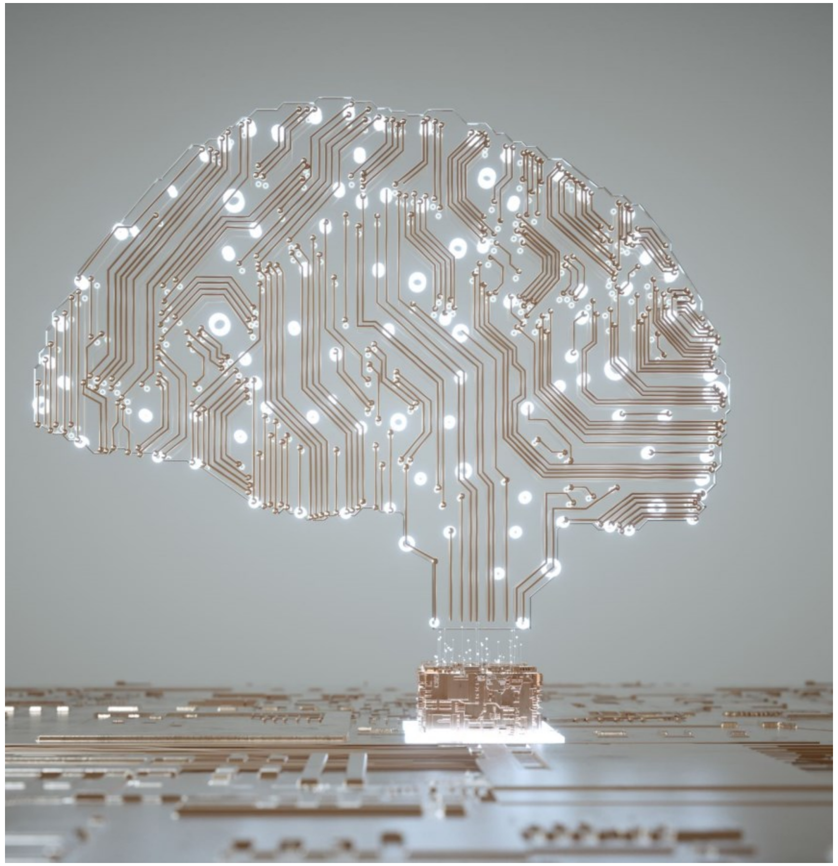
Outline

- Brain-Machine Interface (BMI) and latest advancements
- Wireless BMI development in B-Cratos
- High-Rate Battery free Communication System
- Wireless Powering and Telemetry & Telecommand signalling
- Implementation and measurement Results
- Conclusion



Brain-Machine Interface

Functionality

- **Establish direct communication** between the brain and external devices
- **Translate neural activity** into actionable commands

Significance of BMI

Medical Applications

- Restoring lost functionalities
- Assisting individuals with severe disabilities

Cognitive Enhancement

- Improving memory and learning capabilities
- Potential applications in education and training

Fields of Application

Healthcare

- Neurorehabilitation
- Assistive technologies for disabled individuals

Prosthetics and Robotics

- Controlling artificial limbs
- Enhancing mobility for amputees

Research and Experimental Psychology

- Advancing our understanding of the brain

Future Prospects

- Expanding applications in various **industries**
- Potential for mainstream adoption and **integration into everyday life**
- Ongoing research and development in BMI technology

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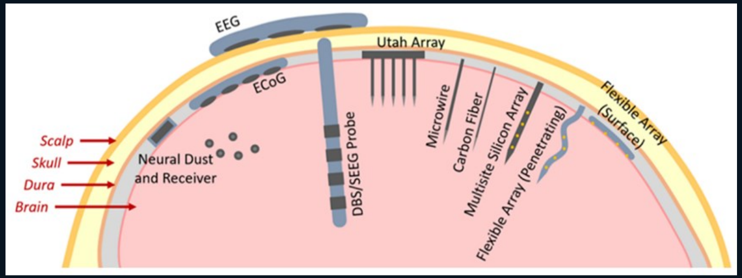
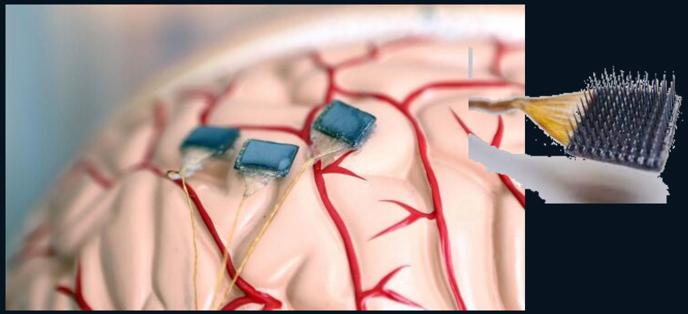


Different types of neural electrodes

Utah Electrode Array- Blackrock Neurotech



Brain-Machine Interface (BMI): Latest Advances

Signal Acquisition

- **Invasive:** Records brain activity via ultra-thin electrodes *for high precision*.
- **Partially Invasive:** ECoG sensors on the brain's surface balance accuracy and safety.
- **Non-Invasive:** EEG headsets detect brain signals without surgery.

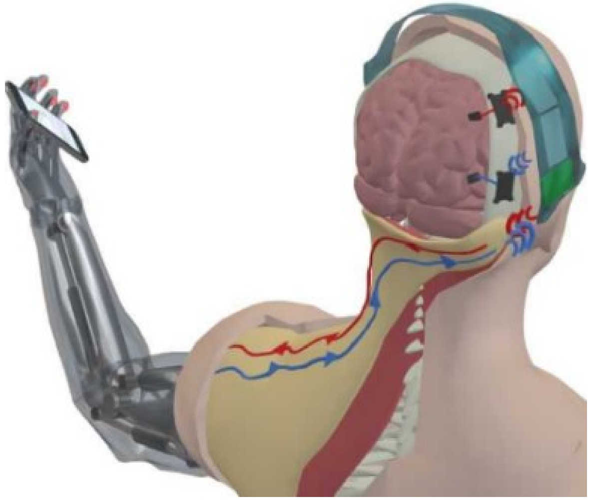
Signal Processing

- **Preprocessing:** AI filters noise to enhance signal clarity.
- **Feature Extraction:** Machine learning deciphers thought patterns.
- **Classification:** AI translates signals into commands for external devices.

Output Application

- **Device Control:** Patients use Synchron's BMI to control *smart devices* via thought.
- **Sensory Feedback:** Research is advancing *bidirectional* BMI communication.

Wireless BMI System in B-CRATOS



High data rate brain readout

- Near-zero power high data rate backscatter communication 32-64 Mbps

Wireless powering of the Brain implant

- Supply power to the BMI ASIC, 25-50mw
- Supply power for the communication unit
- Supply power for Telemetry and telecommand

Wireless telemetry and tele-command

- Communicate brain stimulation data to the implant
- Read implant health status (voltage, temperature, charge status, etc)

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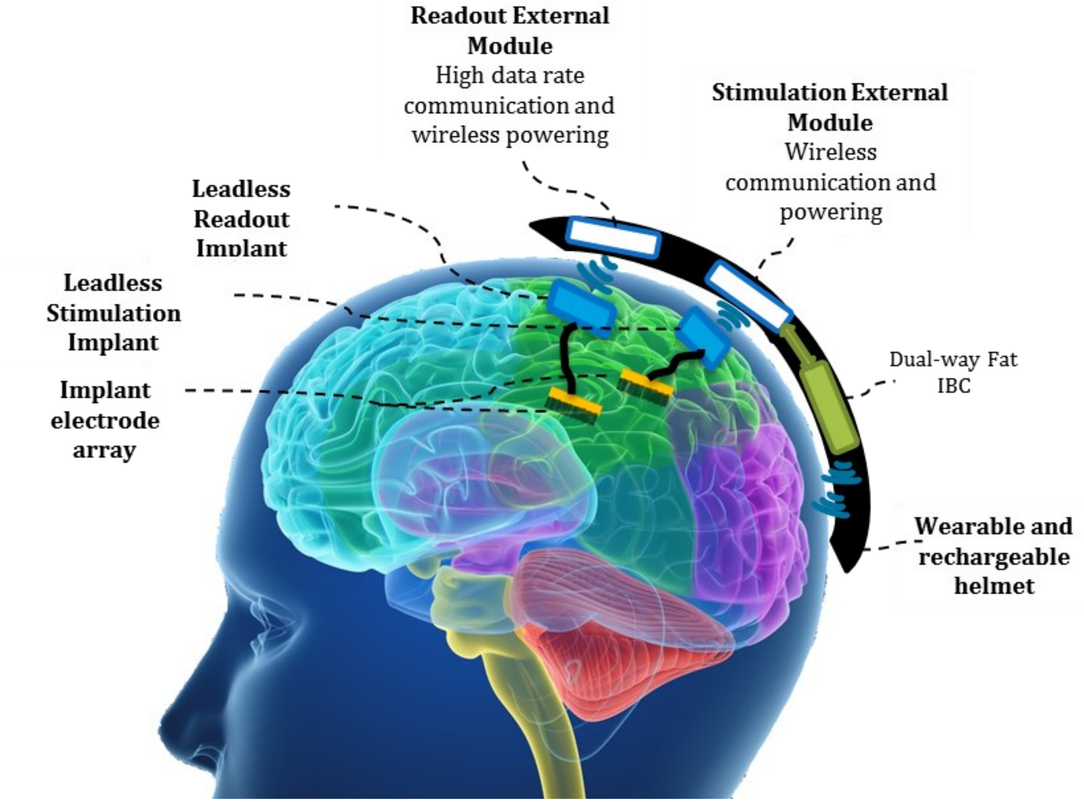
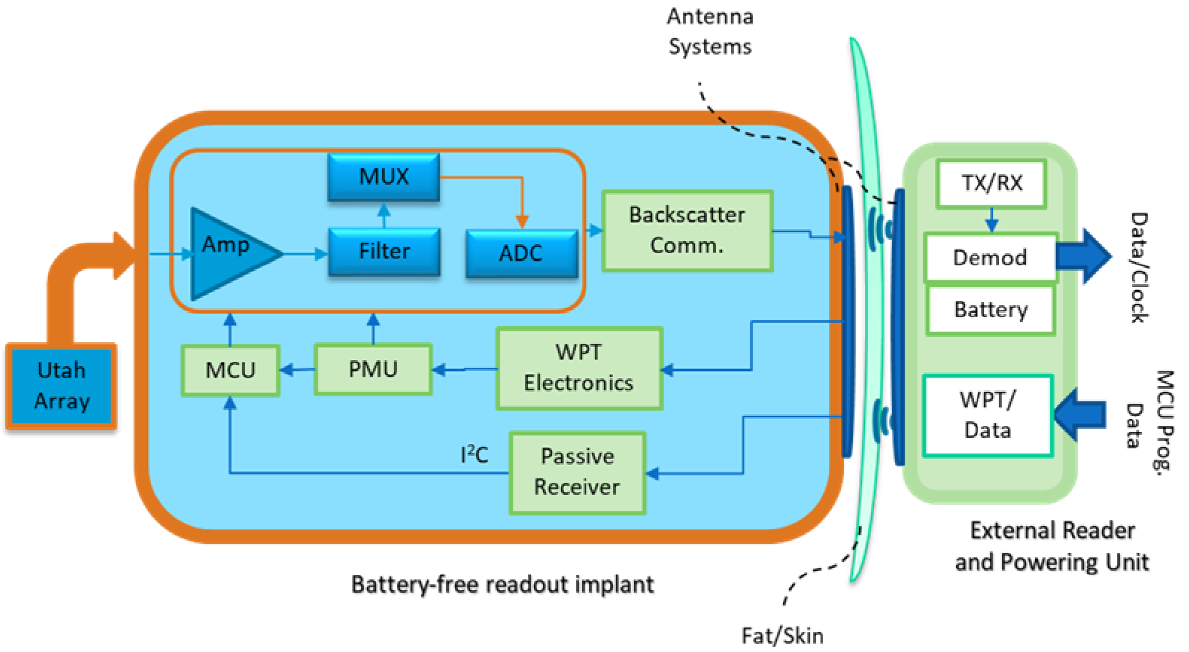
Wireless System Design Overview

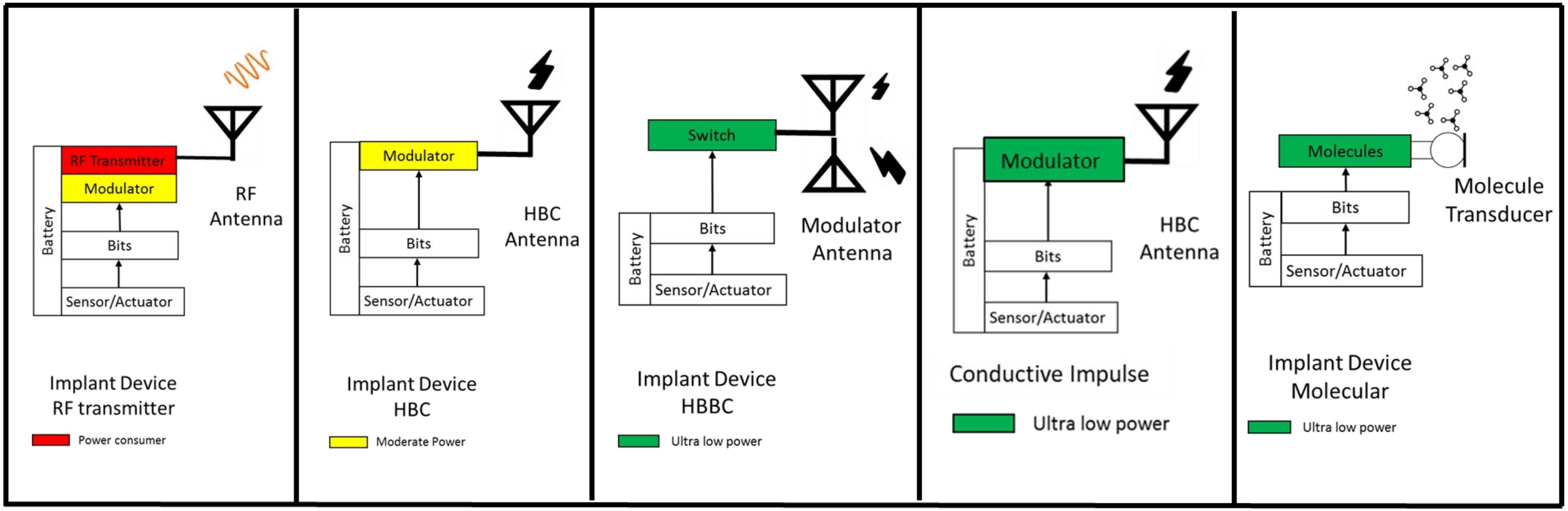




Implant Unit

External support

Wireless Comm. Technologies for Implants



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High-rate Data Wireless Backscatter for BMI

Method:

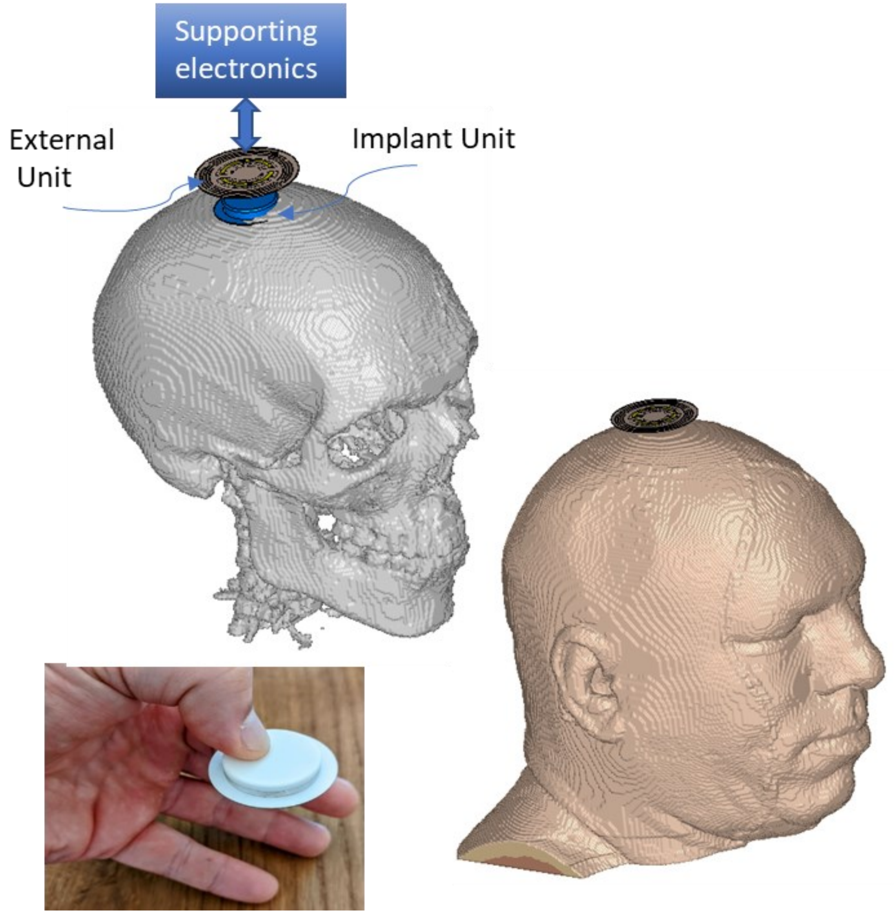
Radar technique for remote data sensing (RF backscatter)

Features:

- Passive communication unit
- RF emission (tone signal)
- High-rate support (up to 64 Mbps)
- Simple implant electronics (an RF switch)
- Energy saving (50-100 mW)
- Reduced thermal effects (Safety)
- Space saving (Minimal electronics)
- Battery-free communication
- Data security

Drawbacks:

- Complex reader system
- Susceptible to in-band RF interference
- Strong EMC/ EMI considerations
- Requires RF authorization for Medtech
- System Relibility



System integration

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Antenna System Design Considerations

Implant Antenna	Reader Antenna	WPT/ NFC System
EMC/EMI	SAR	Integration

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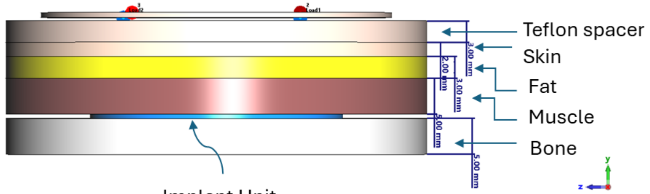
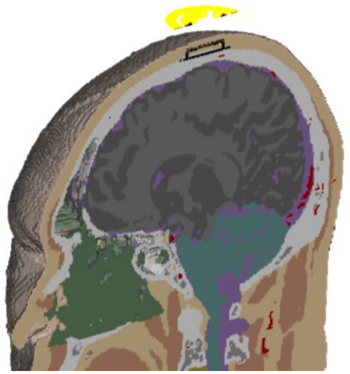
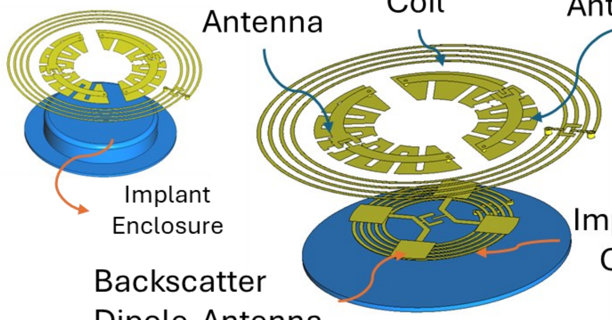
Small Antennas for BMI Wireless Backscatter

- Small Antenna matching
- High-Q for eff. But bandwidth limit
- Antenna RCS adjustment
- **Antenna virtual size development**







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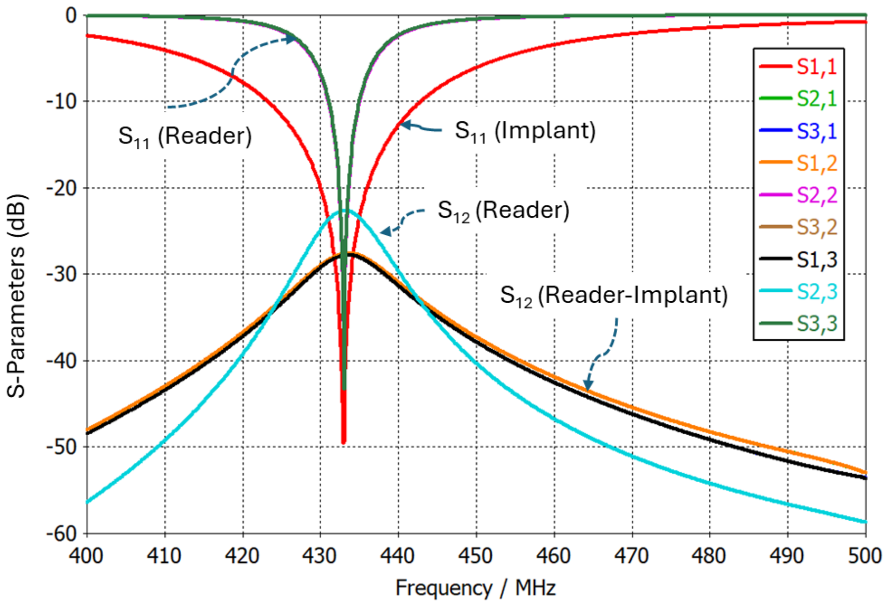
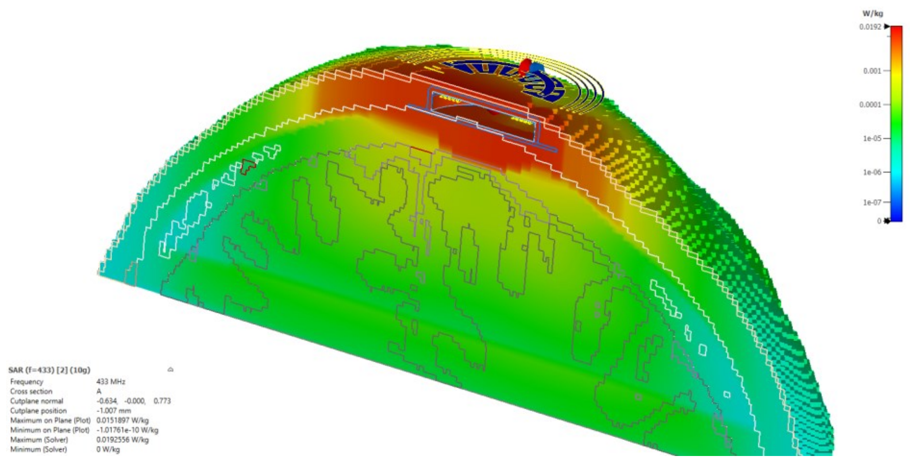
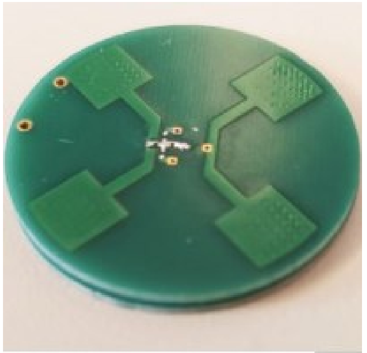
Backscatter: Implant and Reader Antennas



Meander loaded loop
Dual Port Reader Antenna



Induced SAR reader antenna



Patch loaded cross dipole
Implant Antenna

Reader-head gap: 3 mm
Reader implant range: 15 mm

	SAR (10g) [W/Kg], Pin: 1W
Multi layer Tissue	2.7
Heterogeneous model	1.66

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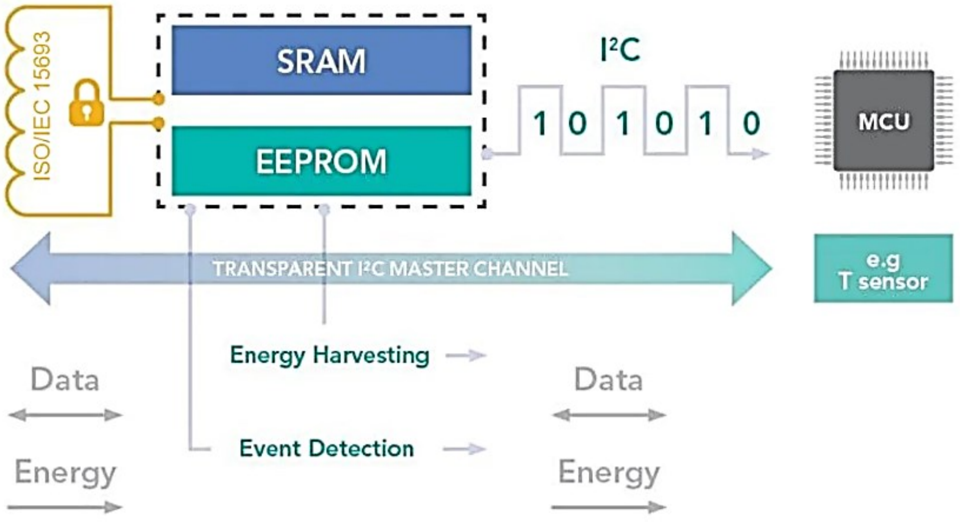
Wireless Power Transfer

- **Extend the power transfer distance**
  - Frequency selection
  - Coil size and structure
  - Resonance coupling
- **Improve the power capacity and transfer**
  - Q-factor adjustment
  - Electronic circuits and adaptive matching
  - Feedback control
- **Improve the misalignment tolerances**
  - Array coil structure
  - Metasurface coil structure
- **Safety Considerations**
  - Thermal effects
  - Electromagnetic compatibility



NFC Wireless Power and T&TC

- **Standard NFC two way data connectivity**
  - Data rate: max 420 kbps
  - ISO15693
  - Latency: below: 15 msec
  - Frequency: 13.56 MHz
- **Magnetic induction technique for WPT**
  - Resonance coupling
  - Dual coil energy transfer

NFC Wireless Power and T&TC

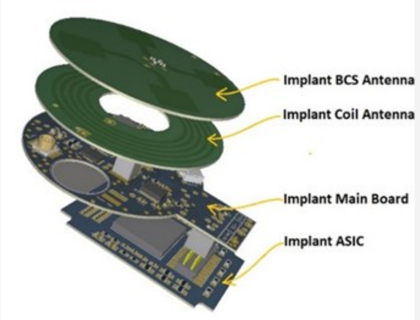
Communication Protocol:
- Standard NFC interface: ISO15693
- Reader at 13.56 MHz

Magnetic coils:
- Resonance coupling

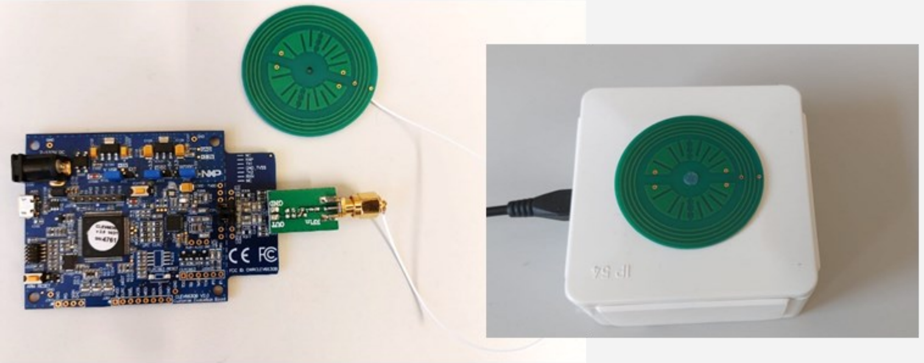
Powering protocol:
- Continuous

Technical Specifications:
- **Applied power**: Max 1 W, Typ. 250 mW
- **Interface** for power: USB control
- **Data interface:** UART
- **Communication:** Two-way (420kbps)
- **SAR:** SAR (10g)< 0.2 W/ Kg at 500 mW power
- **Range:** 3-5 cm
- **Latency:** 15 msec
- **Received power:**
  - Single coil: 25 mW
  - Dual channel dual coil: 40 mW

Planar implant coil



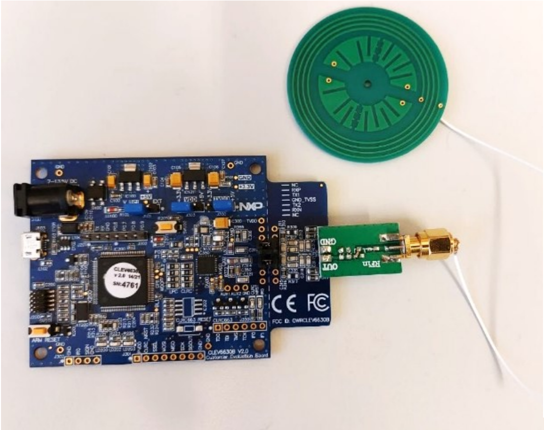
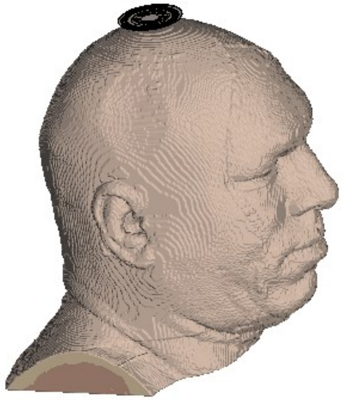
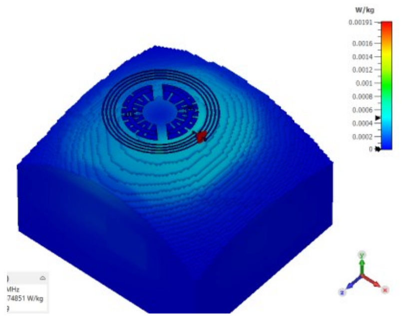
Implant integrated model



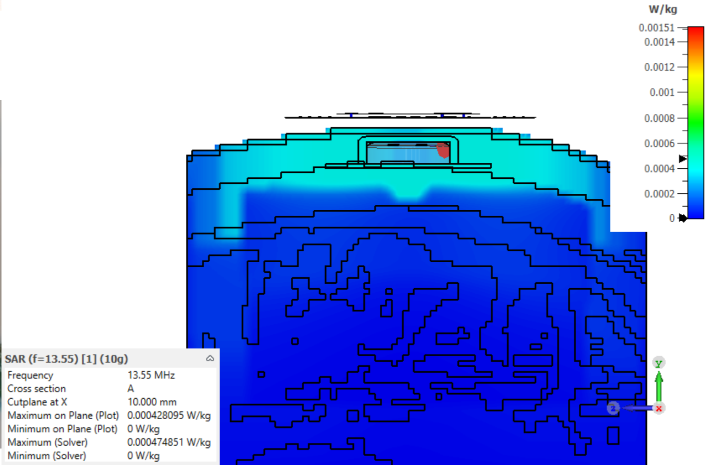
External NFC interegator

External Unit

- NFC reader: Modified Evaluation board
- Powering: Magnetic antennas (coils)
- Powering protocol: Continuous
- USB control interface for power
- UART for data interface
- Embedded software for Two-way connection
- Applied power: Max 1 W, Typ. 250 mW
- Battery powered
- SAR (10g)< 0.2 W/ Kg at 500 mW power

Simultanous WPT and low rate connectivity

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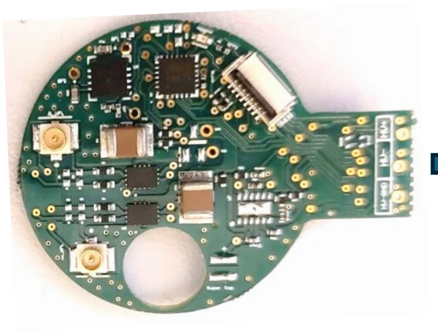
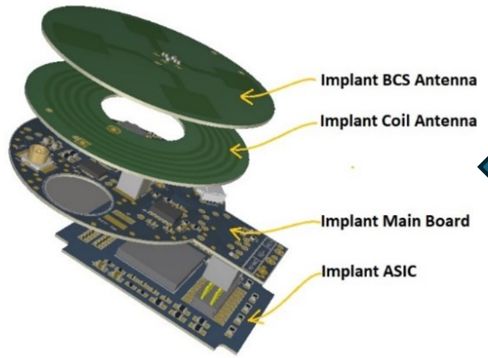
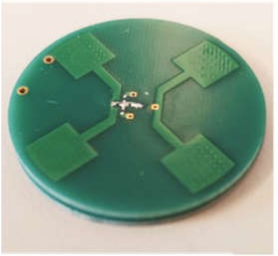
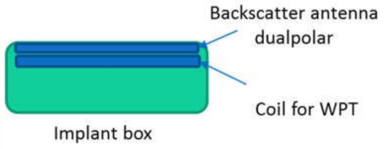
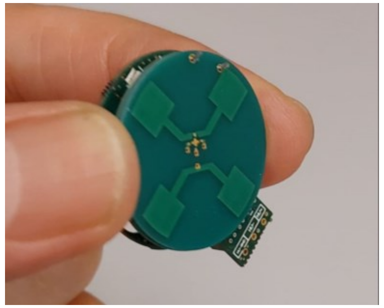
System Integration

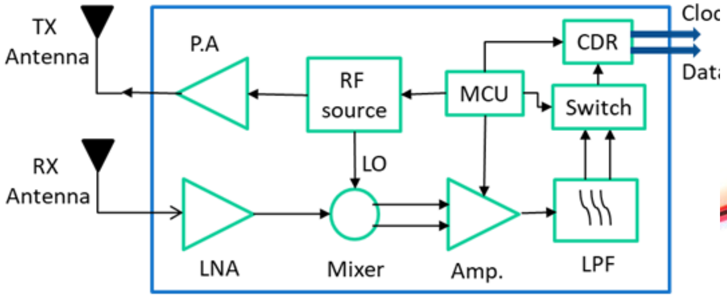




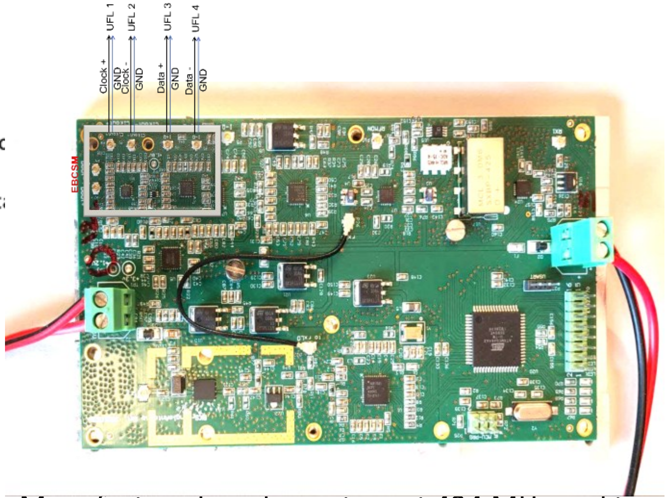








Reader system with Zero-IF



Manufactured reader system at 434 MHz and tunable bandwidth to support up to 32 Mbps.

RF Backscatter Reader System

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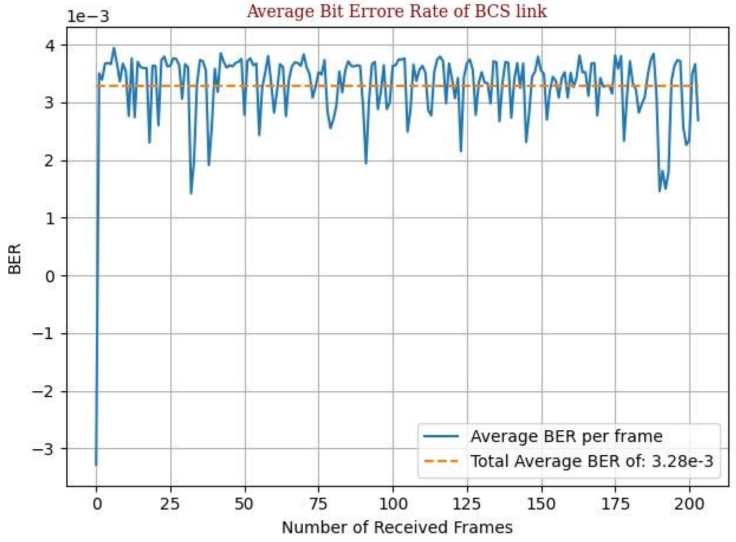
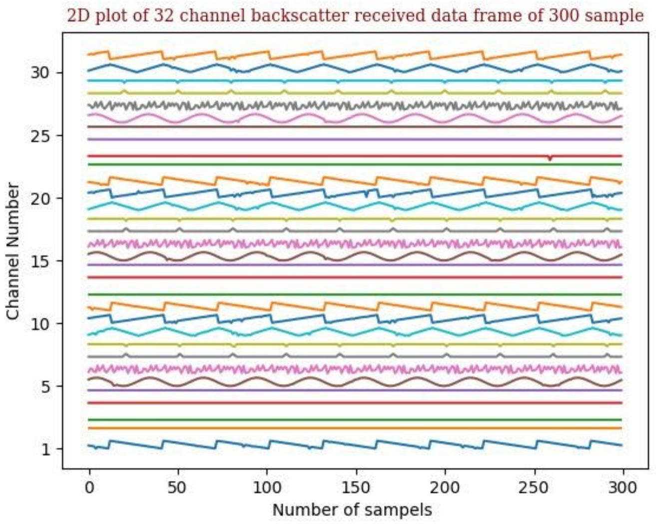
Integrated system: OTA test

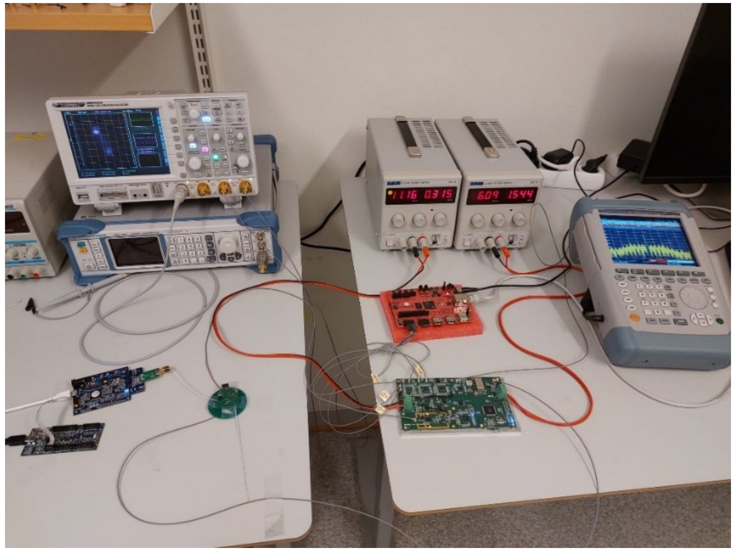
- Backscatter link test and results(on air)
  - Data rate of 16-32 Mbps



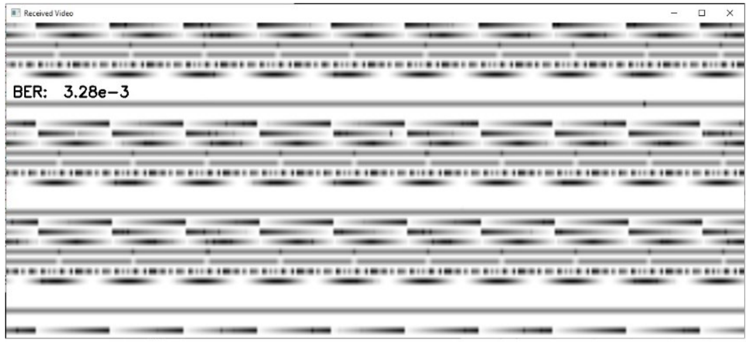
BER performance



Received data pattern



Test setup



Visual data inspection

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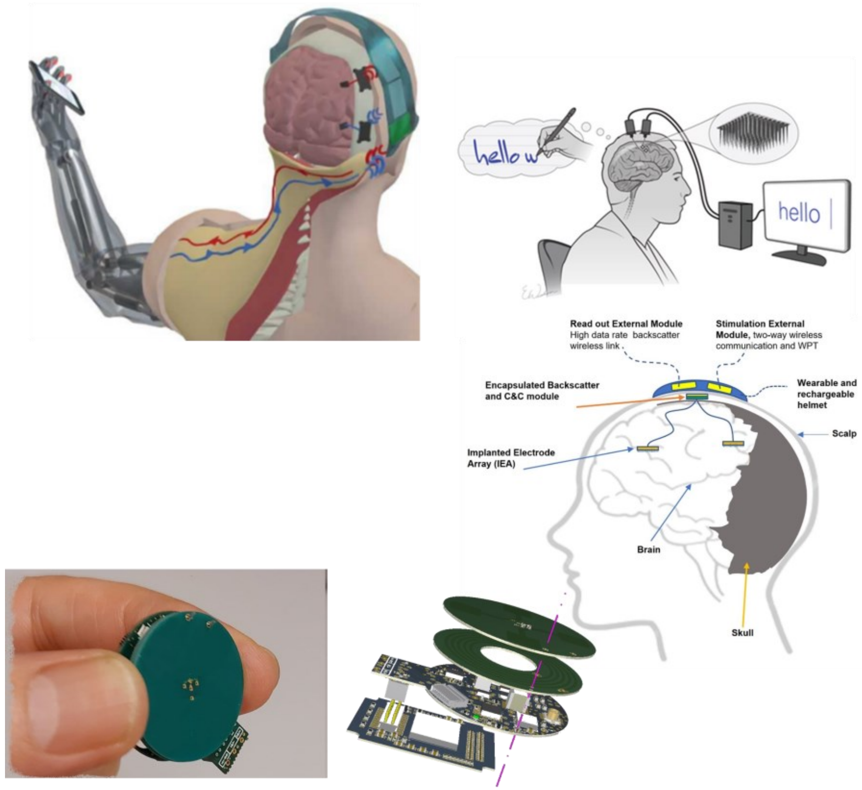
B-CRATOS Wireless Lab Model Experiment



- Up to 420 Kbps Two-Way wireless communication link
- Near to zero Power consumption
- More than 35 mw power generation
- High data rate real-time neural readout (30-60 Mbps)

System verification for prosthetic arm control

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Animal Implant Testing

Implant & Antenna Placement

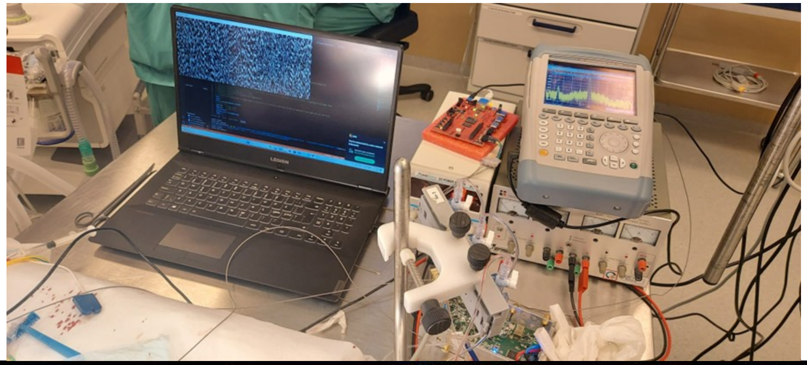
- **Location:** Implant integrated under skin in the head
- **Backscatter Antenna:** 1 cm distance to implant (tested on pig with thick skin)
- **WPT External Antenna:** Placed 3 cm away

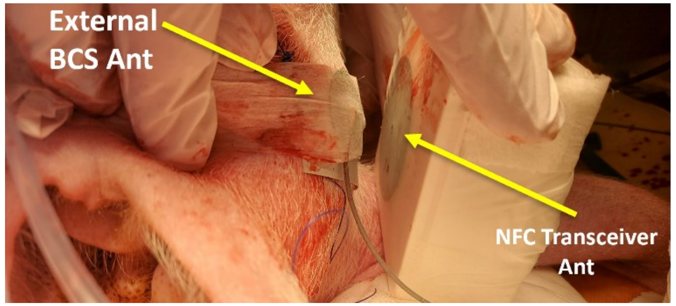
Test Environment & Conditions

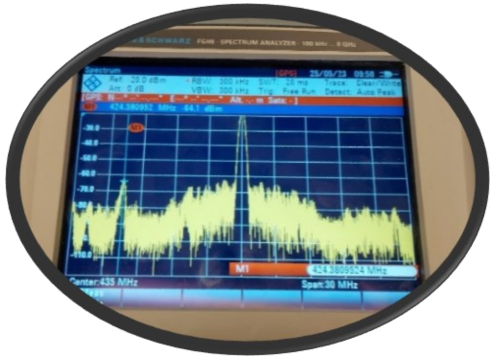
- **Test at:** OUS OR Room in a hospital
- **Backscatter Speed:** 10 Mbps (limited due to interference)

Data Handling

- **Dummy Data:** Successfully transmitted and received signal







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Thanks for Your Attention