Key B-CRATOS milestones reached:

Implant and Wireless Power Transmission prototype for stimulation and readout of brain signals

Two years after the start of the B-CRATOS "Wireless **B**rain-**C**onnect inte**R**f**A**ce **TO** machine**S**" FET-Open project, the teams working on Brain Interface – *Wireless Powering and Communication* (led by the Norwegian University of Science and Technology-NTNU) and *System Integration* (led by BlackRock Microsystems Europe-BRME) met the set goal and achieved two critical milestones for the continuation of the project:

- Develop a Functional stim/read implant, which was tested in the lab as a wireless cortex readout and stimulation
- Develop a ready prototype of Wireless Power Transmission (WPT) for stim/read, which proved efficient in the lab

The achievement of these milestones was a challenge necessitating a combined work between the technology developed by NTNU for WPT and the neural interface platform BRME works on.
The implant lies at the heart of the project. It enables wireless reading of signals from the brain and in return, stimulates the brain based on the sensory data integrated with the artificial limb. The project demands high channel bandwidth readout for precise control and minimized noise artifacts during motor intention readout. The specification requires 30 kHz sampling rate per channel with a 16-bit resolution, allowing for sequential reading and stimulation. With a 32-electrode array, the rate rises to 32 Mbps including the supporting channels for stimulation. State-of-the-art wireless technologies capable of supporting this rate include WiFi and UWB. However, integrating them with the implant demands significant power and generates thermal effects that are intolerable due to side effects and the need for battery and wireless charging.

Our solution tackles this issue using the wireless backscatter communication technique (a radar remote sensing approach), in collaboration with our project partner at NTNU. The external transceiver system supplies to the system's power needs, reducing the implant's power consumption for communication to nearly zero. By eliminating the active transceiver, we minimize thermal effects, battery needs for communication, thus the power requirements are limit to the neural implant chip and its supporting electronics. This approach successfully manages wireless power of up to 30 mW with minimal electronics. The system offers dual-way wireless connectivity for telemetry and telecommand, allowing us to monitor the implant's health status and reprogram it using in-application programming (IAP) wirelessly. This proves beneficial for precise control and sensing of external devices, like a prosthetic hand.

The feedback loop is a crucial system component; it ensures the time between system communication, data processing, actuation, and command for stimulation, in which the connectivity delay is under 15 msec, establishing real-time two-way interaction between the brain and external aids.

Our next steps are to integrate the system with chip technology from our BRME partner.

Ethics remarks

As the project advances, it shall be reminded that the ethical questions it raises are taken into account, with the support of an external ethics advisory board. As for, regarding the implant, it was designed to be located on top of the skull under the skin, out of the brain. The Specific Absorption Rata (SAR) and Thermal effects were also limited in design and tested to respect European standards and ensure they have no side effects in these radio-frequency and thermal aspects.

About B-CRATOS

B-CRATOS is an ambitious project funded by the European Union's Horizon 2020 research and innovation program that aims to create a revolutionary untethered brain-machine interface by merging wireless communication, neuroscience, bionics, artificial intelligence, and sensing technologies. The project brings together 25 specialists in neuroscience, electronics, biomedical engineering, and AI from one SME, three research institutes, and three universities. The goal is to create a proof-of-concept battery-free high-speed wireless in-body communication platform for Brain-Machine-Body connectivity.

The project will overcome technological barriers of wireless brain-machine-body communication, and represents the beginning of a paradigm shift in how signals can be sent to restore function and empower individuals. The technology developed by B-CRATOS will have profound effects in several fields such as neuroprosthetics, electroceuticals, brain-computer interfaces, and virtual reality transmission. The wireless brain-machine interfaces developed in this project will enable real-time monitoring and control of a robotic arm and somatosensory stimulation for real time sensation.

The following partners are working within the project: Uppsala University, SiNANO Institute, Scuola Superiore Sant'Anna, Blackrock Microsystems Europe GmbH, Links Foundation, Deutsches Primatenzentrum GmbH, Norwegian University of Science and Technology

To discover more about the project and its involved partners, visit www.b-cratos.eu

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