The human body as an electrical conductor, a new method of wireless power transfer

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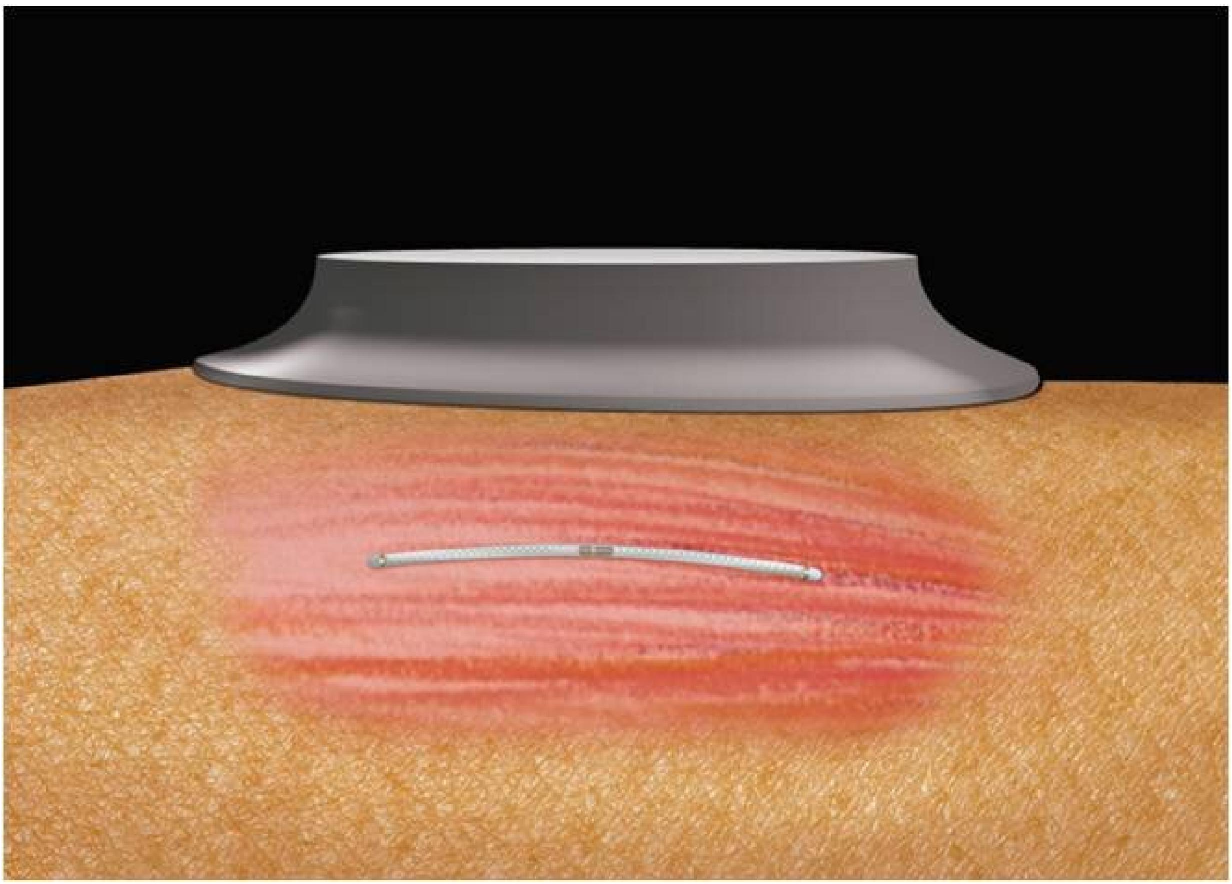


Credit: BERG-UPF

The project, Electronic AXONs: wireless microstimulators based on electronic rectification of epidermically applied currents (eAXON, 2017-2022), funded by a European Research Council (ERC) Consolidator Grant awarded to Antoni Ivorra, head of the Biomedical Electronics Research Group (BERG) of the Department of Information and Communication Technologies (DTIC) at UPF principally aims to "develop very thin, flexible, injectable microstimulators to restore movement in paralysis," says Ivorra, principal investigator of the project.

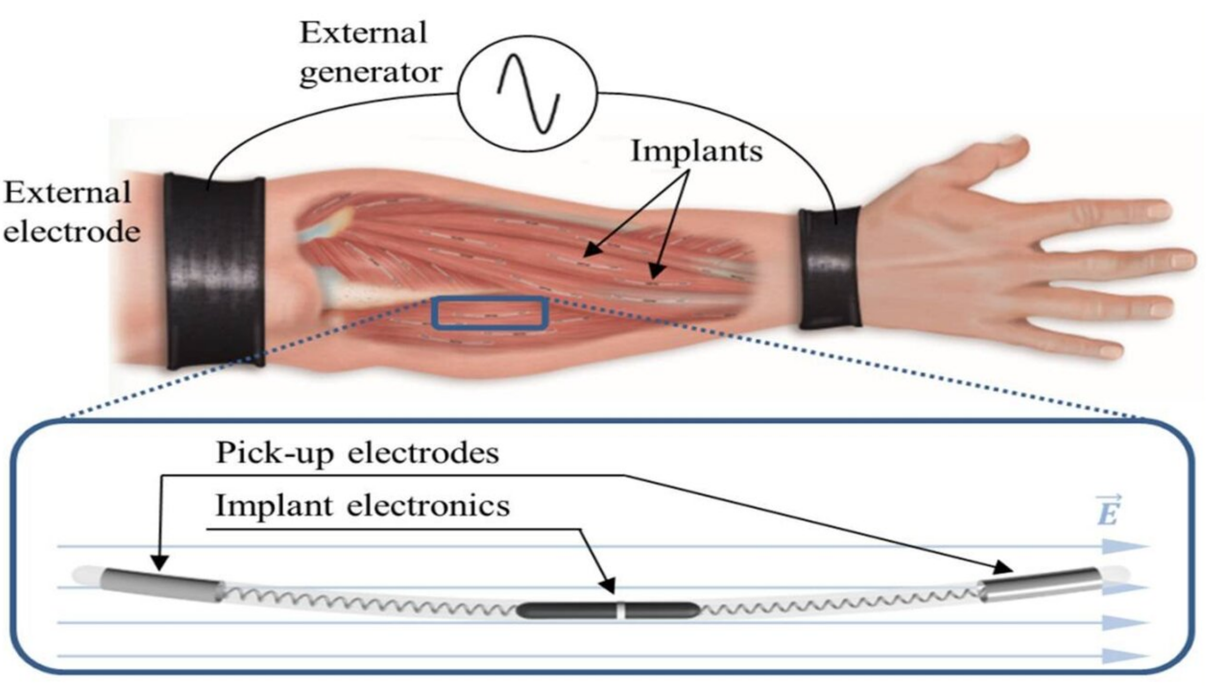
A secondary goal of this project is to illustrate how volume conduction (also known as galvanic coupling) can be used to transfer power wirelessly to electronic implants. Volume conduction is considered an alternative to batteries or wireless power transfer based on inductive coupling since these two supply methods imply that implants must be relatively large to accommodate the components needed to obtain the energy required for operation.

One of the main parameters of interest to know if a technology has the potential to supply implants is to determine the maximum power implants can receive by using the proposed method. Thus, the main goal of the study published in the journal *IEEE Access* is to use equations to determine the maximum power an implant can receive by means of volume conduction when the currents applied are safe according to electrical safety standards. Its authors are Marc Tudela, Laura Becerra-Fajardo, Aracelys García-Moreno, Jesus Minguillon and Antoni Ivorra.

"Today, the main element that hinders the development of minimally invasive implants is the way they get power. In this regard, we believe that volume conduction has the potential to solve this problem. Volume conduction allows us to develop thread-like devices that can be implanted by injection," Tudela explains.

Wireless Power Transfer (WPT)

The method of wireless energy transfer via volume conduction consists of using the body's own tissues as a channel for transferring electrical power. Using an external system, electrical currents are delivered through the human body and these currents flow through tissues and a small amount is drawn by the implants.



The method of wireless energy transfer via volume conduction consists of using the body's own tissues as a channel for transferring electrical power. The authors propose delivering currents with magnitudes above one ampere that are harmless due to their high frequency. Credit: BERG-UPF

This is how the implants get the energy necessary for operating. The innovative aspect of the authors' approach is the thread-like form of the implants, which allows them to be injected without surgery, and the use of high frequency currents (> 5 MHz) applied in bursts, rendering them completely harmless and imperceptible.

To produce power to implants in the region of milliwatts, the authors propose applying currents with magnitudes of the order of a few amperes for which the external system must generate tensions of around a few hundred volts. These magnitudes would be most harmful if they corresponded to alternating currents of a frequency like that of the grid (50 Hz). However, this method completely avoids using higher frequencies. Specifically, the authors propose the use of alternating currents with a frequency of greater than 5 MHz.

The authors of the study published in *IEEE Access* obtained mathematical models that allowed them to determine the maximum local power that can be obtained by an implant using volume conduction according to the size of the implant, its electronic charge and the properties of the tissue where it will be placed. Finally, they validated these models in vitro using a saline solution that simulates the electrical properties of human tissue and obtained a good correlation between experimental and analytical results.

Devices that can be easily implanted by injection

Thus, the study results show that by applying high frequency electrical currents in a burst -harmless for the human body and that meet the main international safety standards- can yield powers of greater than 1 mW in very thin (section less than 1 mm), short (

"Another interesting result we have obtained is that the application of high frequency electrical currents in the form of bursts, rather than continuously, enables maximizing the power obtained in the implants," Tudela comments. And the researcher adds, "our results indicate that an implant with a section of only one millimetre and a length of about one centimetre could get 100 times the power currently required by a pacemaker."

More information: Marc Tudela-Pi et al, Power Transfer by Volume Conduction: In Vitro Validated Analytical Models Predict DC Powers Above 1 mW in Injectable Implants, *IEEE Access* (2020). DOI: 10.1109/ACCESS.2020.2975597

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