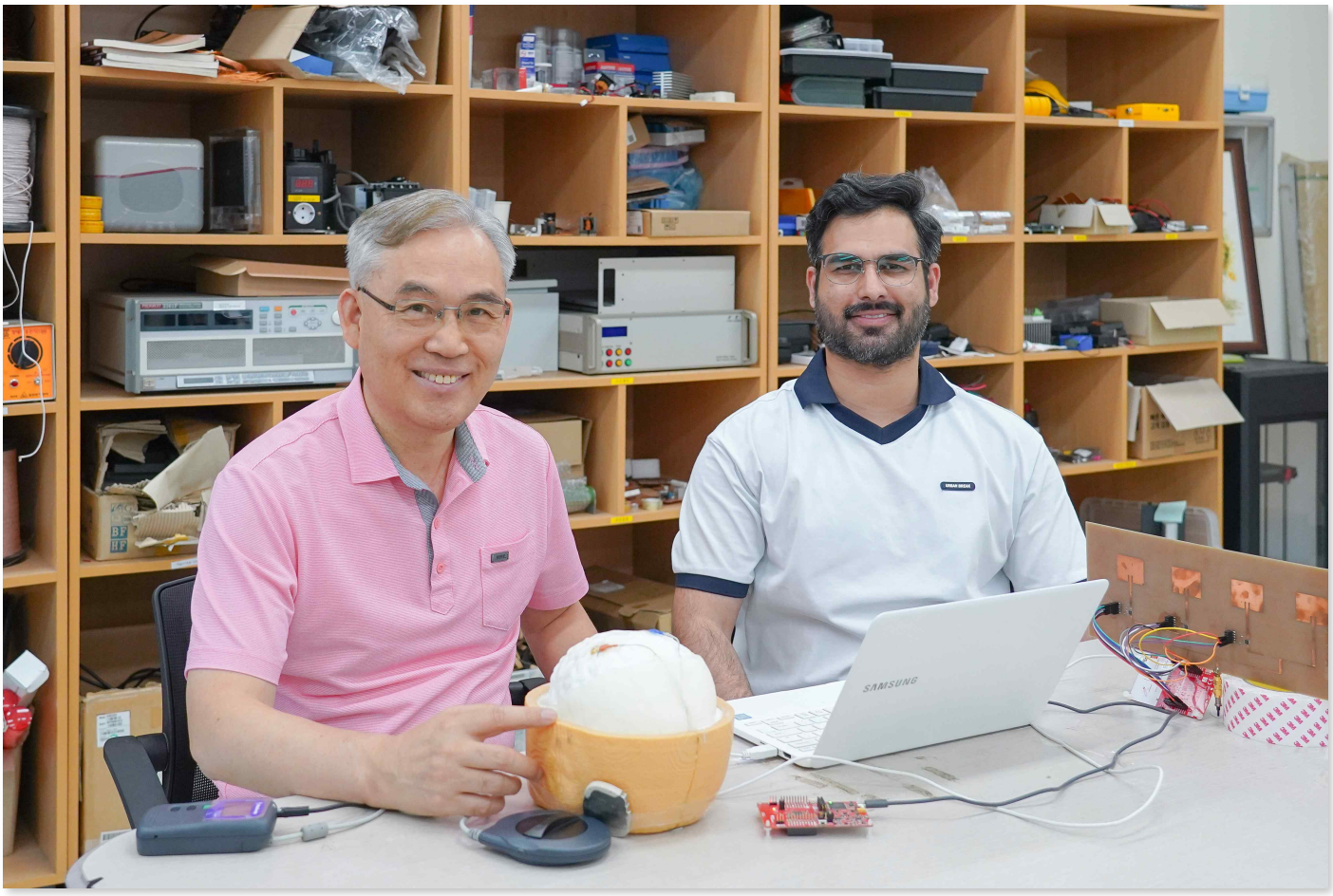
GIST develops Korea's first Bluetooth-based human implantable electronic drug communication technology: Core technology for implantable medical devices... No interruption even when the patient moves

- Professor Chun T. Rim's research team from the Department of Electrical Engineering and Computer Science, integrated development of a low-power Bluetooth (BLE) communication module for real-time wireless nerve stimulation and a digital phased array antenna... Stable and real-time nerve stimulation possible even with posture changes

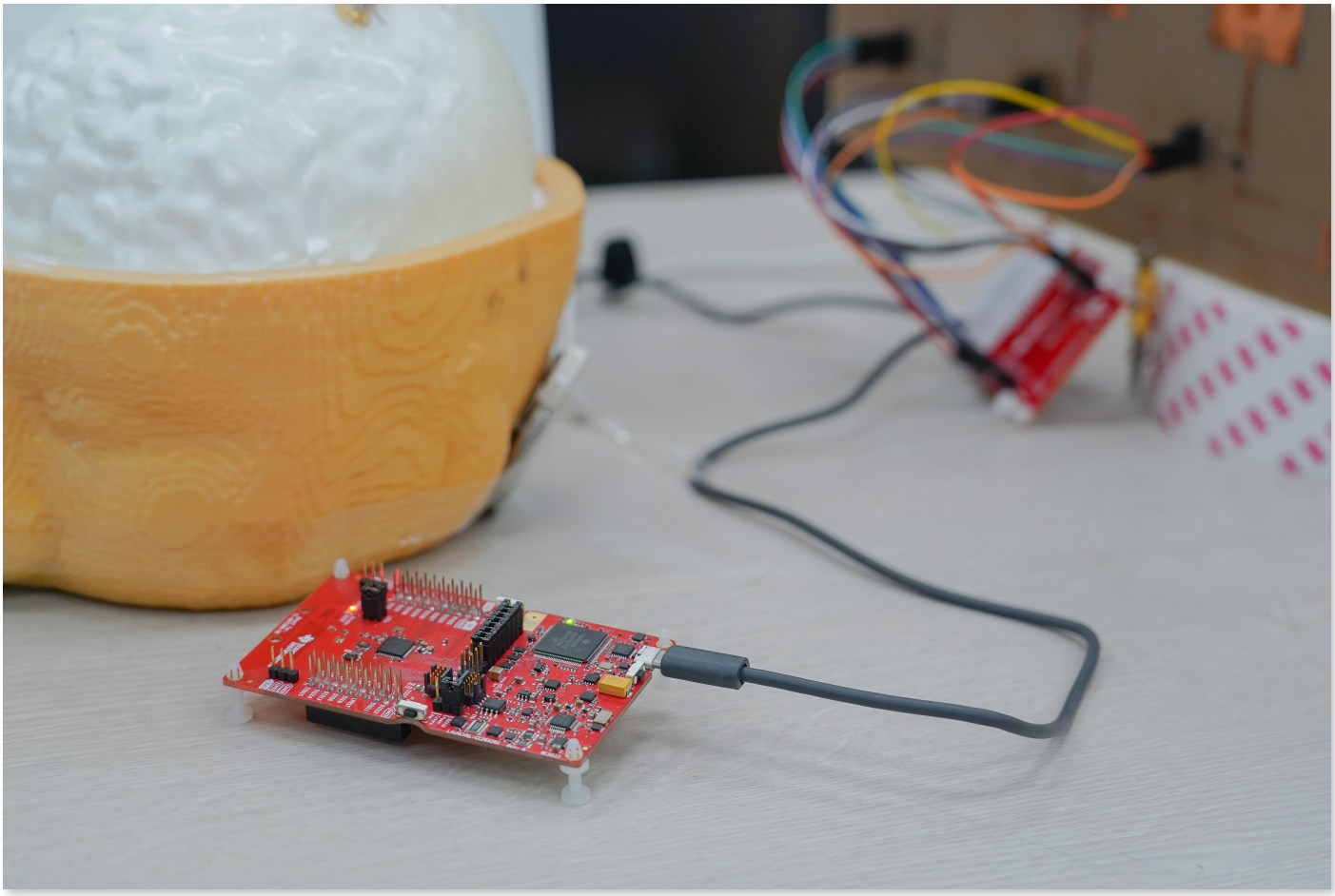
- Expected to commercialize next-generation implantable medical devices and lead the 35 trillion won implantable electronic drug market... Published in the June 2025 issue of the international academic journal 《IEEE Transactions on Industrial Informatics》



▲ (From left) GIST Professor Chun T. Rim and Dr. S. Ahson A. Shah

The Gwangju Institute of Science and Technology (GIST, President Kichul Lim) announced that the research team led by Professor Chun T. Rim of the Department of Electrical Engineering and Computer Science, in collaboration with OceansBio, Inc., has developed a dynamic beamforming antenna system based on low-power Bluetooth (BLE) that can be applied to implantable medical devices.

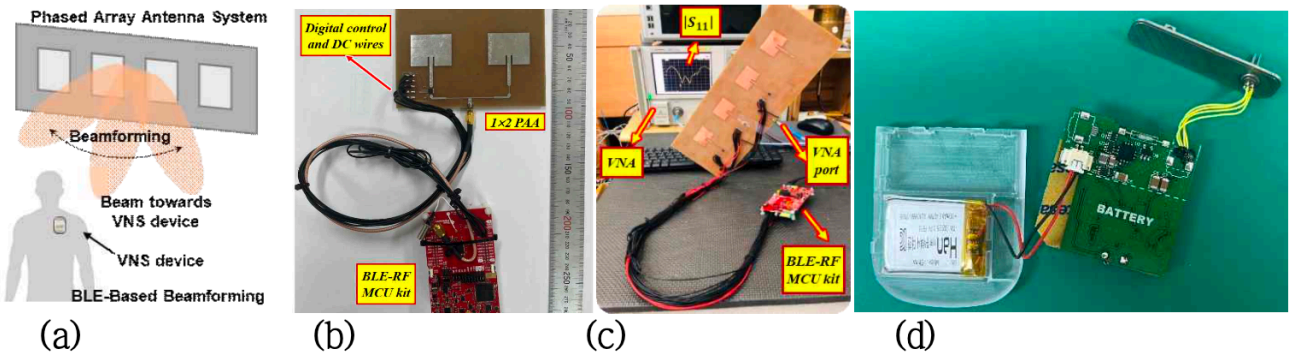
It is significant in that it is the first time in Korea that BLE has been applied to implantable electronic drugs, and that BLE technology, which is widely used in the industrial and home appliance fields and has proven its stability, has been expanded to the medical device field.



▲ BLE-PAA: Dynamic Beamforming Antenna System Based on Bluetooth Low Energy (BLE) Applicable to Implantable Medical Devices

This technology is based on a small phased array antenna applicable to implantable vagus nerve stimulation (VNS), and is designed to enable real-time wireless stimulation by combining a BLE communication module and digital phase control technology.

(a) (b) (c) (d)



▲ (a) Technology Summary (b) 1x2 BLE-PAA (c) 1x4 BLE-PAA (d) VNS Electromagnetic. VNS Electromagnetic (d) is implanted inside the human body. BLE-based remote stimulation is performed using beamforming PAA (b).

VNS is a representative implantable electromagnet that is used as a promising treatment for intractable neurological diseases such as epilepsy and depression, but existing products have the problem of frequent wireless communication disconnection due to changes in the patient's posture or position.

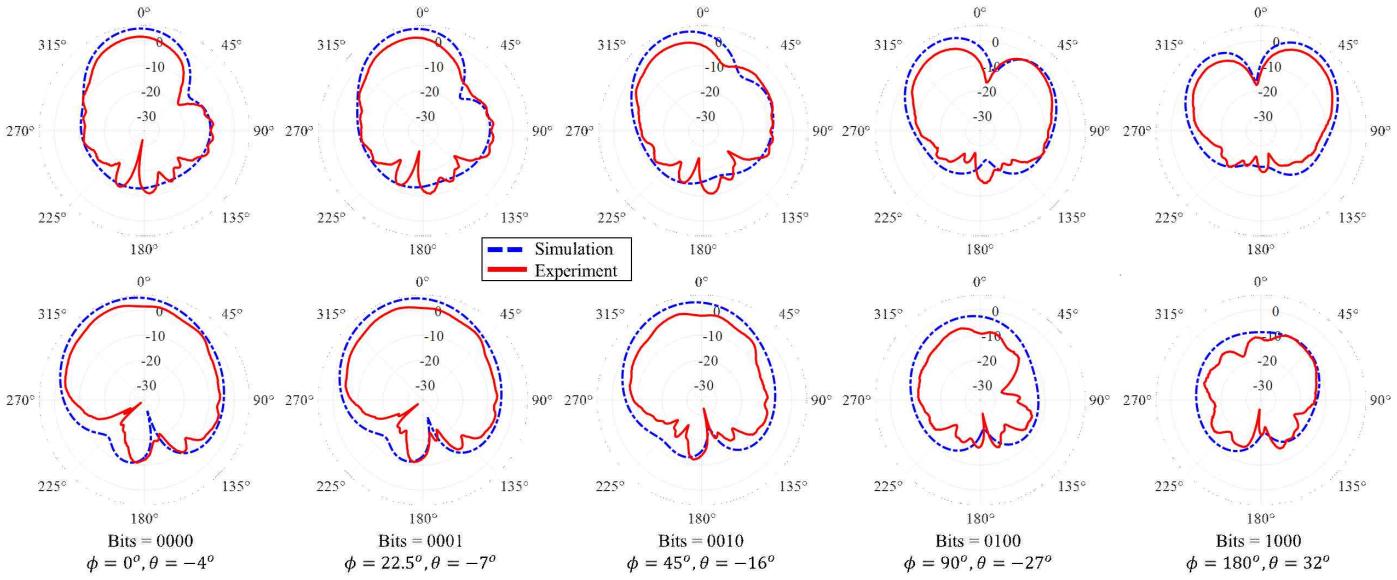
The research team noted that the cause of this problem is that the alignment between the internal antenna and the transmitter in the hospital room is misaligned depending on the patient's movement. When the patient moves, the direction between the two devices changes, which causes the internal reception power to decrease rapidly, which makes wireless communication unstable and makes real-time nerve stimulation control difficult.

Usually, the decrease in reception power can be compensated for by increasing the transmission power, but the internal communication of the human body is subject to strict safety regulations on electromagnetic waves, so the transmission power cannot be increased arbitrarily.

To solve this, the research team developed a phased array antenna capable of digital beam steering in the 2.45 GHz BLE frequency band. This made it possible to automatically adjust the beam steering and intensity according to the patient's movement as well as to enable real-time two-way communication.

The 'dynamic beamforming' technology, in which a microprocessor linked to the BLE module automatically adjusts the direction and intensity of the beam according to the patient's movement, was implemented, enabling constant reception sensitivity to be maintained anytime, anywhere.

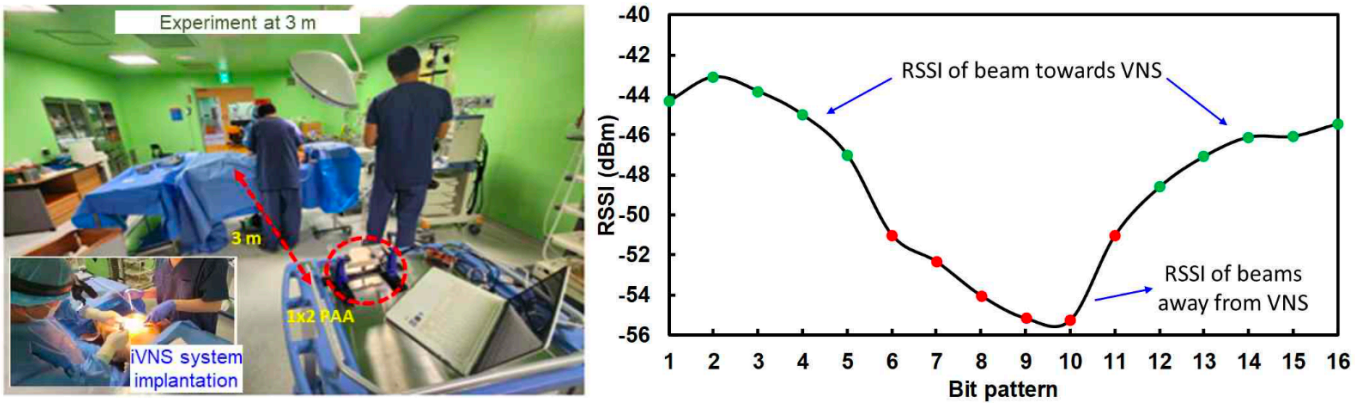
In particular, while two or more digital phase shifters were previously required for beam steering, this study proposed a simple structure that can be implemented with only one phase shifter, thereby contributing to the miniaturization of the device and improved efficiency.



▲ Beam direction E-graph (top), H-graph (bottom) for various phase changes of the digital phase converter. Gain pattern of the PAA system integrated with a medical commercial BLE-MCU. This shows that beam steering toward the VNS electromedicine is successful.

In particular, while two or more digital phase converters were previously required for beam steering, this study proposed a simple structure that can be implemented with only one phase converter, contributing to miniaturization and efficiency improvement of the device.

The research team proved that stable communication and nerve stimulation transmission are possible even inside the human body through experiments under various conditions, such as gels simulating human tissue and animal models using actual pigs.



▲ BLE-based beamforming and communication function experiment in an actual clinical environment of a hospital (left) and experimental results graph in an indoor saline solution situation for various phase changes provided through digital bit patterns (right). The graph above (right) shows that the signal intensity received from the VNS electromedicine varies depending on beam steering.

This study is evaluated as a result that shows that BLE-based phased array antenna technology can be a key technology for commercializing next-generation implantable electronic drugs.

Professor Lim Chun-taek said, “The global market for implantable electronic drugs will reach approximately 35 trillion won as of 2025, and the vagus nerve stimulator (VNS) market alone will be approximately 1.4 trillion won, growing 11.4% annually,” and explained the significance of this research result, saying, “The technology developed this time will also contribute to enhancing the export competitiveness of our company’s medical device industry in the future.”

This study, supervised by Professor Chun T. Rim of GIST and participated by Dr. S. Ahson A. Shah (first author), CEO Hyunung Lee of OceansBio (second author), and Researcher You Lim Jang (third author), was supported by the National Research Foundation of Korea. It was published in the June 2025 issue of 《IEEE Transactions on Industrial Informatics》, an international academic journal published by the Institute of Electrical and Electronics Engineers (IEEE).

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