sciforum-186370: A Study on Magnetic Sensor and AI API Applications for Wireless Communications in Harsh Environments

Jang-Yeol Kim, Hyun Joon Lee, Kye-Seok Yoon, Jung Hoon Oh, In-Kui Cho

Radio Research Division, Electronics and Telecommunications Research Institute (ETRI), Daejeon, 34129, Republic of Korea

Conventional electric-field-based wireless communication is difficult to operate in underwater and underground environments. Therefore, this study investigates magnetic-field-based wireless communication as an alternative approach. Magnetic sensors can detect extremely weak magnetic signals due to their ultra-high sensitivity, enabling medium- to long-range communication over distances from tens to hundreds of meters while overcoming the limited transmission range of conventional magnetic-field communication systems. Thus, these sensors can serve as effective receiving elements in harsh-environment wireless communication systems. For experimental verification, giant magneto-impedance (GMI) and magnetic induction (MI) sensors were developed and applied as receiving elements. Wireless communication experiments were conducted in freshwater environments using QPSK modulation and demodulation at 20 kHz in the very low frequency (VLF) band. The developed systems successfully achieved a data rate of 2 kbps, with communication distances of 10 m for the GMI sensor and 40 m for the MI sensor. These results confirmed the feasibility of applying magnetic sensors to underwater wireless communication. In addition, surface-to-underground communication experiments were performed in a limestone mine. To verify long-range communication exceeding 100 m, the MI sensor, which exhibits higher sensitivity than the GMI sensor, was employed at 15 kHz. Furthermore, an on-device AI API based on an end-to-end Speech-to-Text-to-Speech (STS) framework was integrated to support voice communication in the narrow-band magnetic-field communication system. Experimental results demonstrated stable bidirectional data and voice communication over a distance of 100 m. The results verify that magnetic sensors are effective receiving elements for wireless communication in harsh environments and demonstrate the practical applicability of on-device AI API technology in magnetic-field-based wireless communication systems.

Acknowledgment

This work was supported by the Institute of Information & Communications Technology Planning & Evaluation (IITP) grant funded by the Korea government (MSIT) (No. 2019-0-00007, Magnetic Field Communication Technology Based on 10 pT-Class Magnetic Field for Middle- and Long-Range Applications).