Skysong Innovations
Advancing the Arizona State University Knowledge Enterprise

1475 N. Scottsdale Road, Suite 200
Scottsdale, AZ 85287-3538
Phone: 480 884 1996 Fax: 480 884 1984

Case ID:M23-088P^
Published: 11/3/2023

Inventors

Junliang (Julian) Tao

Yi Zhong

Contact

Physical Sciences Team

Vibrational Wireless Underground Communication System

Wireless underground sensing networks (WUSNs) aim to provide real-time remote sensing of soil properties and monitoring of underground activities. Most subterranean animals have already mastered the use of vibrations for underground communication, localization of prey, and detection of predators. Humans, on the other hand, have yet to develop communication systems that can overcome the complexity of underground environments and soil composition that limit the range and reliability of data transmission without the use of electromagnetic (EM) waves. The performance of wireless underground communication (WUC) modules is crucial to the success of WUSNs; however, the complex underground environments that consist of various soil compositions and textures pose challenges to the success of WUC.

One emerging technology is magnetic induction (MI) based communication. MI technology overcomes the dynamic channel condition problem. Since the magnetic permeabilities of air, water, and soils are similar. However, high total path loss of MI limits the transmission range. Also, the high energy consumption of MI limits its applicability. Another potential solution for WUC is seismic/acoustic communication. What is still needed is further research into seismic/acoustic communication that solves its current drawbacks including unidirectional communication, low data rates, and large equipment.

Researchers at Arizona State University have developed a wireless, vibration-based underground communication system. Experimentation resulted in a system capable of transmitting up to 80cm at a bit rate of 16-17 bits per second. This system includes a bio-inspired vibrating source, a micro-electromechanical system (MEMS) accelerometer, a microcontroller, and a set of algorithms for encoding and decoding information. The source is simultaneously small in size, low in cost, and energy-efficient, while the on-off-keying decoding algorithm enhanced and error-correction algorithm is robust in transmitting textual and imaginary information. This developed system demonstrates potential for implementation in the Internet of Underground Things (IoUT), by leveraging seismic waves produced by vibrations to carry information through soil.

Related publications:

Bio-inspired vibrational wireless underground communication system

Bio-Inspired Vibrational Transmitters for Wireless Underground Communication

Potential Applications:

- Underground sensing and monitoring (e.g., for mine/reservoir monitoring,

underground infrastructure monitoring, etc.)
- Geotechnical engineering (e.g., for geotechnical site investigation)
- Precision agriculture
- Search & rescue operations
- Landslide monitoring

Benefits and Advantages:

- Impact-based and rotation-based vibrational source
- Small-sized vibration based WUC system
- Cost-effective & energy-efficient
- Low-cost installation