



Real time monitoring of ground displacement
status for applicable industries

**Wireless sensor network
based ground displacement
data transmission
technology in tunnel**

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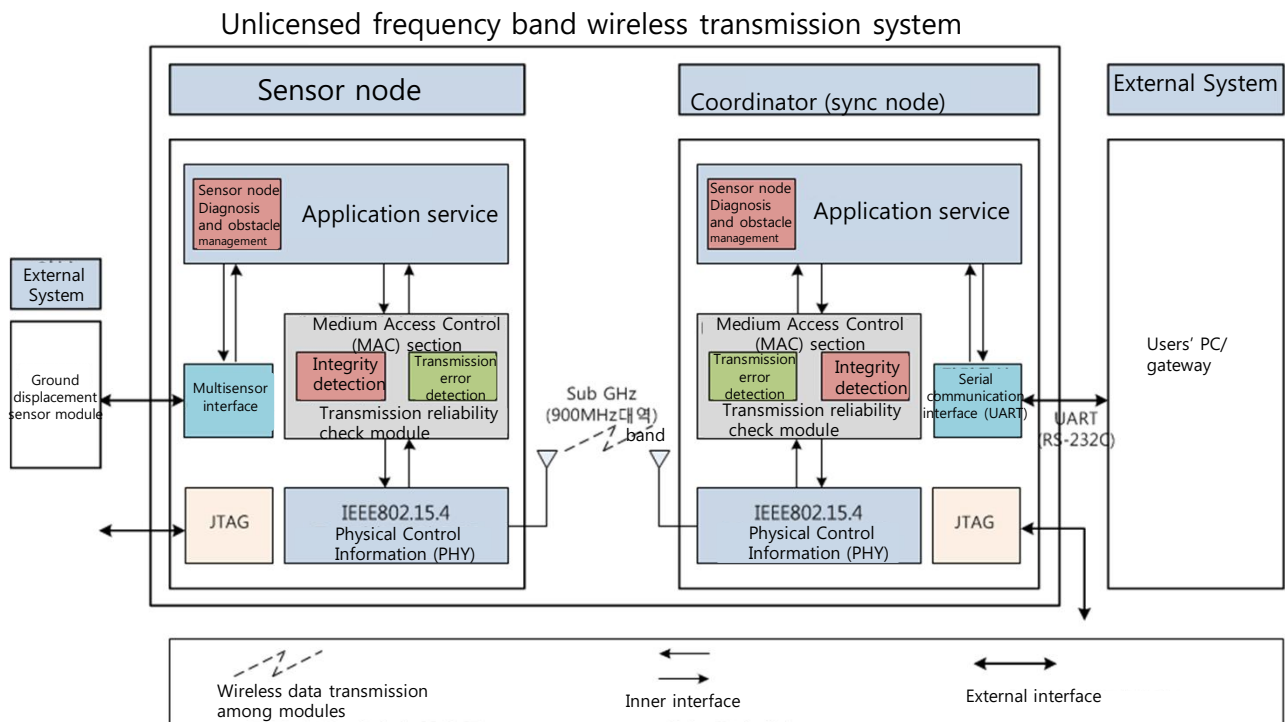
TECHNOLOGY BRIEF

Wireless sensor network based ground displacement data transmission technology for tunnel

Technology Overview

Ground displacement data analysis system provides measurements of accurate changes such as ground pressure, load, stress, and aging based on displacement sensor. Real time gathering of sensing information using ubiquitous sensor network technology to analyze and manage ground displacement.

- Transmit ground displacement data to long-distance area (more than 1km) using 900MHz band wireless sensor network in tunnel.
- Use unlicensed frequency 900MHz band (902MHz ~ 928MHz) for outdoor long-distance transmission.



Keywords

Ground displacement, low-powered long-distance transmission, sensor network, sensor node

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| Technology Classification Code | | |
|--------------------------------|---------------------------------|------------------------|
| Sector | Sub Sector | Industry |
| Smart Service | Internet / communication object | IoT network technology |

TECHNOLOGY BRIEF

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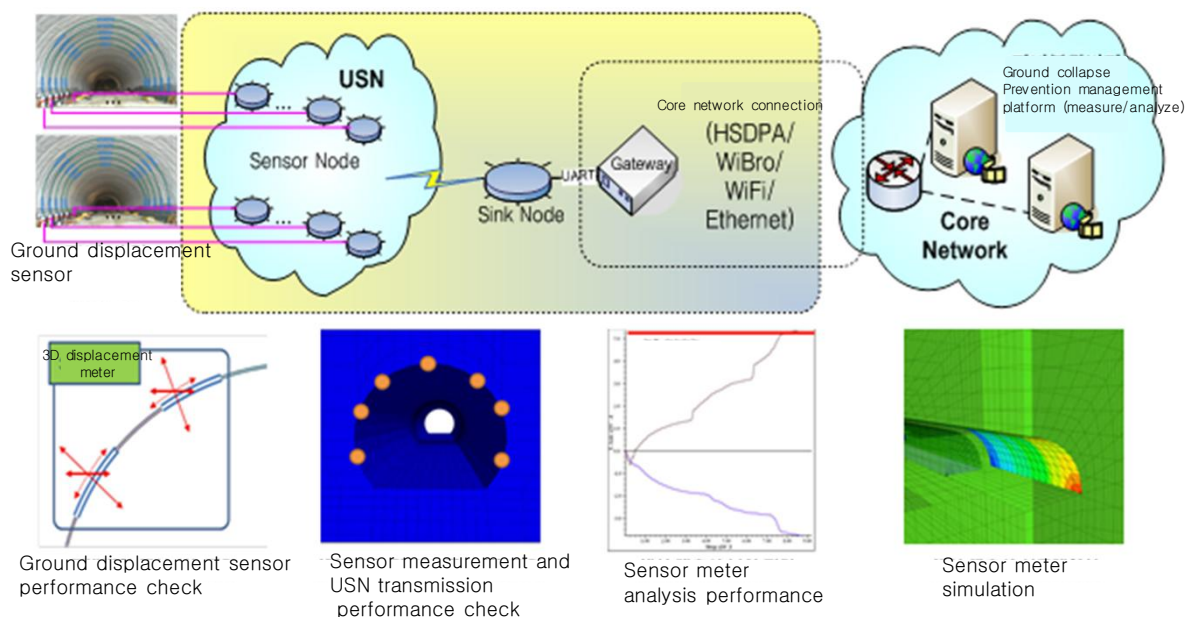
■ Technology Description

► Measure ground displacement status around the tunnel and use the platform for real time wireless sensor network transmission technology

- Sensor nodes gather information from ground displacement sensor inside the tunnel, and real time data transmission for reliability to ground collapse disasters data analysis system.

- Ground displacement sensor module (sensor data logger) interface technology in tunnel
- Unlicensed 900MHz band wireless transmission technology
- Auto recover and restart sensor node and coordinator node

- Sensor module power control technology for low-power
- Wireless remote transmission error check and error correction technology
- Wireless remote transmission Range Extender technology
- Sensor node low-powered MAC control technology



[Wireless sensor network based ground displacement remote transmission and data analysis system diagram]

■ Application Fields

- #### ► Long-distance wireless communication technology using unlicensed frequency band for various applicable basic technology such as real-time monitoring system, remote reading system, and wireless facility status monitoring of factories. (Outdoors)

■ Outstanding Features

Small output long-distance wireless communication technology base on international standardized technology for unlicensed frequency band

- Previously, needed to rely on human work to manage rock excavation or ground status of the tunnel.

- Real time monitoring of ground displacement using wireless sensor network

- Real time monitoring of ground displacement using wireless sensor network

Small output long-distance transmission using wireless sensor network

- Transmission output of 10mW or less, and transmission distance over 1km

- In tunnel, gather data from ground displacement sensor (slope, strain gauge, acceleration) in arc type sensor.

▶ Collect ground displacement sensing data fro sensor module in tunnel.

▶ Small output long-distance wireless transmission based on 900MHz unlicensed frequency band

▶ Star Topology or 2D linear multi-hop based on long-distance transmission in tunnel

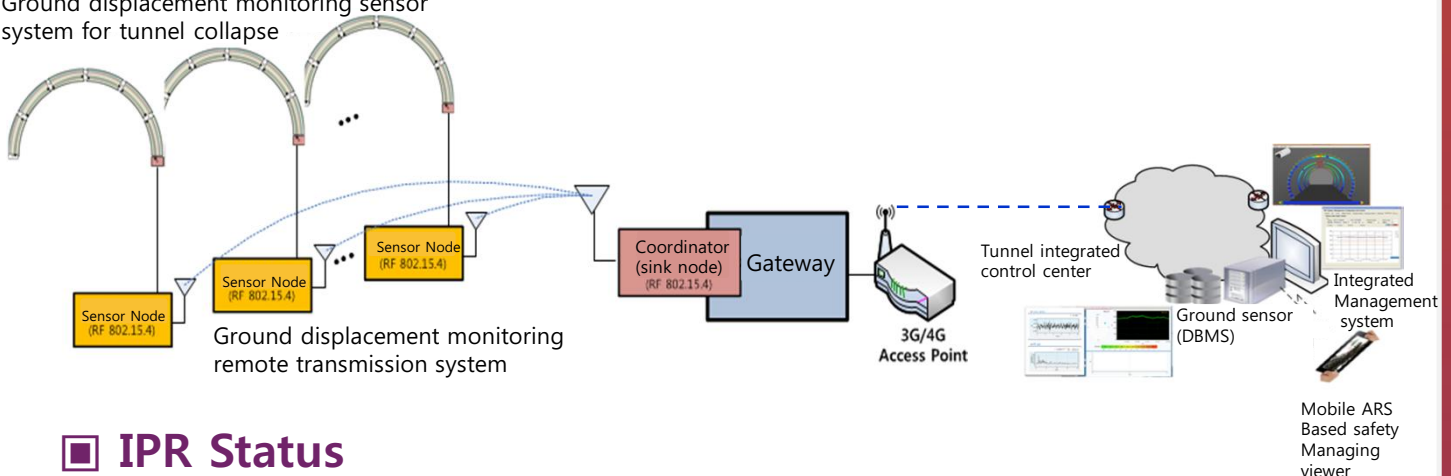
▶ Power control of sensor node for effective power use of sensor module

▶ Automatic recovery and restart for system error or abnormal sensor node

▶ Long-distance transmission error detection and error recovery

▶ Small, low-powered, and low-priced sensor node

Ground displacement monitoring sensor system for tunnel collapse



■ IPR Status

Korean Patent:
1 article applied

■ Technology Trend

Can be used extensively from various applications (safety service for outdoors disaster, gas and electricity meter, healthcare, automation, monitoring data transmission, and etc.) of unlicensed frequency band to IoT market.

□ Korea

- ETRI used "development of strong power saving sensor network technology" to develop MAC technology based on TDMA.
- Samsung Electronics and KETI developed MAC function that meets the requirements of ISA-100-10a.
- SKT internet object low-powered and highly reliable technology to develop telemeter service.
- SKT finished building low-power wide-area (LPWA) IoT network based on LoRa for national network service for internet objects.
- Korea Institute of Geoscience and Mineral Resources (KIGAM) and ETRI are developing real-time monitoring system for landslides.

□ Global

- Neul(UK), TI(US), and OnRamp(US) used internet object device and development environment board to make these products: weightless wireless transmission chip, IEEE 802.15.4g FSK and IEEE 802.15.4k broad communication chip, and platform solution.
- Microchip Technology released a LoRa technology low-speed wireless network standard module RN2483 series for national network of LPWAN(Low Power Wide Area Network). Star topology of LoRaWAN protocol does not have similar sync overhead phenomenon like net based network, so it is low-powered and multiple applications can be opened simultaneously in network.
- LinearTech(US) acquired Dust Network and developed a highly reliable and energy efficient TSMP (Time Synchronized Mesh Protocol) technology. Applied this to ISA and WirelessHART technology to be one of the most superior wireless communication technology.

■ Market Trend

- INFOSO DG of EU is in progress of WINSOC project for small landslide detection, gas leak detection, and global warming monitoring (WINSOC: Wireless Sensor Networks with Self-Organization Capabilities for Critical and Emergency Applications).
- Europe is expected to expand the range of IoT/USN from object and human scope to a national scope. Research and development for applications in improving safety and reliability of environment and food, making healthcare very important, monitoring environment and industries, marketing, building automation, home automation, security, and healthcare.
- United States Department of Defense under the funds and technological supports of DRPA, ITAO, and major corporates has been developing ubiquitous computing related hardware, software, and network technology and is researching to apply such technology to fields of environment monitoring, agriculture, industrial monitoring, logistics, healthcare, vehicle. Major universities such as UCLA, MIT, CMU and private companies such as Intel, HP, IBM are also helping this project.
- SigFox has built IoT wireless communication network in France, Netherland, Spain, Britain, Russia, and etc. The market goal is to promote services for lower data transmission and less frequently used network objects.
- Sierra Wireless White paper predicts a LPWA connection of lower than 100 million lines in 2016, 1.5 billion lines in 2020, and 2.7 billion lines in 2022.

□ Market Leaders

► Neul(UK), OnRamp(US)

- Weightless wireless transmission chip, IEEE 802.15.4g FSK and IEEE 802.15.4k broad communication chip, and platform solution.

► LinearTech(US)

- TSMP (Time Synchronized Mesh Protocol) Technology

► LoRa Alliance

- LPWA (Low-power Wide-area) wireless communication technology

□ Technology Demand

| | |
|-------------|--|
| Application | Tunnel monitoring, remote reader, tracking of mobile facilities, bridge monitoring |
| Industry | Ground measuring device company, construct/civil industry |

■ Scope of Technology Transfer

■ Technology Transfer Details

- Wireless sensor network link of coordinator node and sensor node
- LPL(Low-Power-Listening) MAC control function for sensor node
- Power ON/OFF function for electricity use on ground displacement sensor
- 900MHz unlicensed frequency band long-distance wireless transmission function
- Abnormal behavior detection and recovery restart function for sensor node
- Ground displacement sensor module interface function
- Long-distance transmission coordinator and sensor node module design technology

■ Technology Transfer Range

- Ground displacement data collection and remote wireless transmission sensor node software in tunnel
- Linking sensor node to long-distance communication supporting coordinator software in tunnel
- Define user and system requirements
- Test procedure / test results
- Ground displacement data transmission sensor node detailed specifications for tunnel
- Ground displacement sensor node module circuit
- Ground displacement coordinator module circuit

■ Applications and Effects

▶ Various service based on small output long-distance communication

- Collect and analyze disaster/accident data using soil moisture, water content, and slope sensor of ground changes and landslide ground changes in tunnel. Real-time status monitoring system for prevention of disasters.
- Highly reliable long-distance communication technology for gas remote meter and electricity remote meter.
- Tracking for mobile objects and moving facilities.

▶ Long-distance communication object technology for IoT

- Expected to apply in large object connections based on unlicensed band long-distance communication. Not only is this technology applicable for real-time monitoring and tracking facilities, but also applicable for broad range of things such as environment monitoring, smart city, and healthcare.