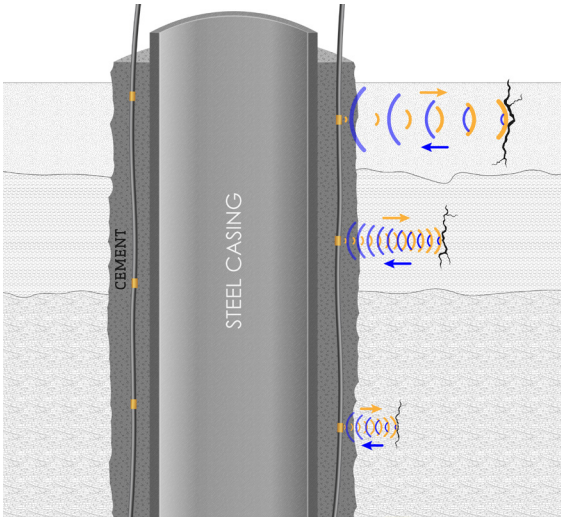
TECHBRIEF

ENERGY INFRASTRUCTURE MONITORING USING CONFORMAL COAXIAL HELICAL ANTENNAS AND DISTRIBUTED ELECTROMAGNETIC INTERROGATION SCHEMES

OPPORTUNITY:

The invention is a distributed radio frequency (RF)/electromagnetic (EM) interrogation scheme that leverages distributed antennas along a coaxial cable for subsurface, pipeline, and other energy infrastructure monitoring. This technology is available for licensing and/or further collaborative research from the U.S. Department of Energy's National Energy Technology Laboratory.



Coaxial cable

CHALLENGE:

In industrial and wireless sensing, the communication channel often determines the characteristics and performance of the overall sensing network. For wellbore monitoring applications, telemetry challenges are acute because of harsh environmental conditions (elevated temperature and pressure, chemical corrosives) which restrict the application of complex electronics and instrumentation. In addition, inherent absorption of electromagnetic radiation within the subsurface environment limits the potential for free space wireless power and signal delivery over distances. However, distributed wireless sensors throughout the subsurface environment could provide unprecedent visibility for monitoring and minimizing environmental impacts associated with the wellbore and ensure safe and productive operation of oil and gas recovery processes, enhanced geothermal systems and carbon storage sites. Similar needs exist for monitoring of natural gas pipelines and other energy infrastructure for which enhanced visibility can significantly impact reliability, resiliency, and security.

OVERVIEW:

NETL researchers have developed an in-situ distributed EM-based sensor for continuous real-time monitoring of wirelessly deployed sensors or EM properties of the surrounding environment. The approach represents a new way of deploying EM-based sensors in deep subsurface and other infrastructure monitoring applications using conformal coaxial antennas for distributed interrogation of sensors and surrounding environmental conditions. The technology is well-suited for deployment applications in a solid environment where it is important to minimize the impact of sensors and telemetry devices on potential leakage paths and failure mechanisms, such as in standard wellbore materials like cements. The technology provides an innovative approach for long-distance powering and communication of distributed antennas within highly attenuating media such as the subsurface. It is enabled by an innovative design of a coaxial cable with distributed antennas.

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ADVANTAGES:

Conventional free-space antennas are free standing and target radiation to the far field. Coupling to an external propagating mode of a coaxial cable has not been considered in previous technologies but provides significant advantages for energy infrastructure monitoring. Specific advantages of the new technology include:

- Can be used in areas with high EM attenuation for deeper penetration without compromising resolution and operating frequency.
- Provides efficient coupling to external sensors by confining EM radiation to the vicinity of the coaxial cable.
- Conformal helical antennas provide minimal added form factors, which makes their integration into existing systems easy.
- Can provide real-time information about the structure in the immediate vicinity at a high rate and with high resolution.

Coaxial helical antenna

APPLICATIONS:

- Monitoring rock stress state in geothermal wells
- Wellbore integrity monitoring
- Geochemical sensing in oil and gas industries
- CO_2 sequestration
- Natural gas pipeline monitoring
- Unconventional wellbore sensing
- Remote sensing and EM imaging
- Industrial sensing networks in chemical, nuclear, or fossil power plants
- Structural sensing in bridges and dams

PATENT STATUS:

U.S. Patent Pending (provisional patent application)

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