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Wireless System for Long-term and Real-time Subsurface CO2 Monitoring

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Location: N328 Eng Bld 1

Zoom: https://uh-edu-cougarnet.zoom.us/j/89084944019

Committee Chair:

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Abstract

The data and power transfer systems for long-term underground CO_2 sequestration monitoring are normally based on wire-line cable, which will lead to a high potential leakage path through casing and cement annulus in high-temperature, high-pressure, and hash underground environments. In this dissertation, a novel wireless communication and power transfer system has been developed for real-time underground CO_2 monitoring. The system includes an array of toroidal transceivers winding around the highly conductive casing string for wireless power transfer to the deep subsurface, which helps to maintain well integrity and reduce potential leakage by eliminating the need to perforate the casing or an umbilical in the cement annulus. The metal casing's amplification effect significantly enhances the wireless power transfer

efficiency and communication performance, which provides a highly conductive power/electric current pathway instead of omnidirectional wireless radiation loss in the subsurface. The toroidal transceiver’s design has been optimized to improve the received signal, and our results show significant improvements in wireless power transfer efficiency. Using the optimized design, we can receive 1 to 10 %power transfer efficiency at 800 meters deep using only one toroidal transceiver with 1Acurrent as input. Compared with other wireless antenna designs, such as the helix coil antenna, our system has shown 26,000 times power transfer efficiency improvement. Using the optimized design, for this 800 m long subsurface wireless system, the channel capacity could improve about 14,000 times from 0.35 bps to 5 kbps, and the energy efficiency improved 109times from 10-3 bit/J to 106 bit/J. For experiments, a lab-scale system is built, and our experimental receiving voltage measurements support the simulation results. This scaled-down wireless communication system with USRP as transceivers was tested at different symbol rates and the bandwidth from the voltage signal spectrum and constellation figures were compared and matched. Furthermore, we used this system not only for leakage monitoring communication but also for CO_2 migration monitoring. We tested the model with and without the CO_2 plume, we could see the difference response from the voltage signal. At the same time, we build a new model in COMSOL to do the time-domain reflectometry (TDR), the difference of properties can also be detected.