Wireless Power to Sensors Embedded in Concrete Structures

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Structural health monitoring sensors installed to monitor the integrity of bridges, buildings, and nuclear containment structures need to send significant amount of data periodically to a central server for further analysis and decision making. Although data can be transferred through wired connections wireless transmission of data with proper encryption is greatly preferred. Similarly, sensors need DC power for their basic operation, e.g., measurement and processing of data and rf transmission of data. Traditionally power is provided through extensive wiring mechanism which is highly undesirable because of the labor and cost involved in installing and maintaining/replacing those wires. Similar to wireless data transmission power can also be transferred to the sensors wirelessly from an external transmitter to recharge the sensor (e.g piezoelectric sensor) batteries. A single transmitter can be used to send wireless power to a multitude of arrayed sensors. Historically wireless power transfer has adopted one of two principles, near-field and far-field power transfers [Shams and Ali *IEEE Sensors Journal*, vol. 7, no. 12, pp. 1573-1577, December 2007].

The former applies to very short distance power transfer where power is transferred through magnetic fields [Jin et al. *Applied Computational Electromagnetic Society (ACES) Journal*, 30(3):261-9, March 2015] that are coupled between the transmit and receive sides. Examples include RFID systems, wireless cell phone battery charging, vehicle battery charging using below the pavement magnetic coils. In most cases these are achieved at frequencies below 100 MHz and at distances of at most several feet. This approach is not feasible at large distances because the magnetic field decreases very rapidly with distance.

In this work we will present the efficacy of wireless power transfer by both near and far field techniques to sensors that are embedded below concrete. The near field experimental studies will show power transfer at frequencies near 10 MHz. Experimental results of battery charging for sensors embedded in dry and freshly made concrete will be presented. For the far field case we will demonstrate power transfer for sensors embedded under concrete at frequencies near 5.7 GHz using a microstrip rectenna.