Design of an Ultra-Sensitive Electric-Field Sensor Using Digital Signal Processing

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***Abstract*—In the detection of underwater objects, knowledge of the magnetic field component (H-field) of extremely low-frequency (ELF) propagating electromagnetic (EM) waves is of scientific interest. Perturbations to the Earth's magnetic B-field can assist in the detection of ferromagnetic (e.g., steel) underwater objects in sea water. This method is known as "magnetic anomaly detection" (MAD). Propagating ELF waves can interfere with magnetometers used to measure B-field MAD. The ratio E/H of the interfering ELF wave, however, is a known constant (E/H = 377 V/A in free space). Thus measuring the E-field component of the ELF wave provides an indirect measurement of the B-field component that interferes with MAD.**

In the frequency range of interest (0.01 Hz to 1 Hz), the electric field component of the ELF wave is quasistatic and behaves essentially like a DC electric field over the time and distance scales of interest. Thus the E-field can be measured using known techniques for electrostatic measurement, such as field mills and the like. On the other hand, a field mill has the disadvantage that it is a mechanical device that is both heavy and power hungry, making it a less-than-desirable choice for lightweight, battery powered sensing platforms.

This paper describes an ultrasensitive E-field sensor under development that has no moving parts. Rather, it uses charge integration in combination with synchronous signal measurement and post-data acquisition Fourier-transform processing to detect the electric field incident on an induction electrode. The way in which these methods are combined to achieve field sensitivity will be discussed and compared with other existing charge-induction measurement techniques. Current results and data will be presented.