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Abstract

Uncertainty Analysis for Low-Cost Transformer Type Inductive Conductivity Sensors

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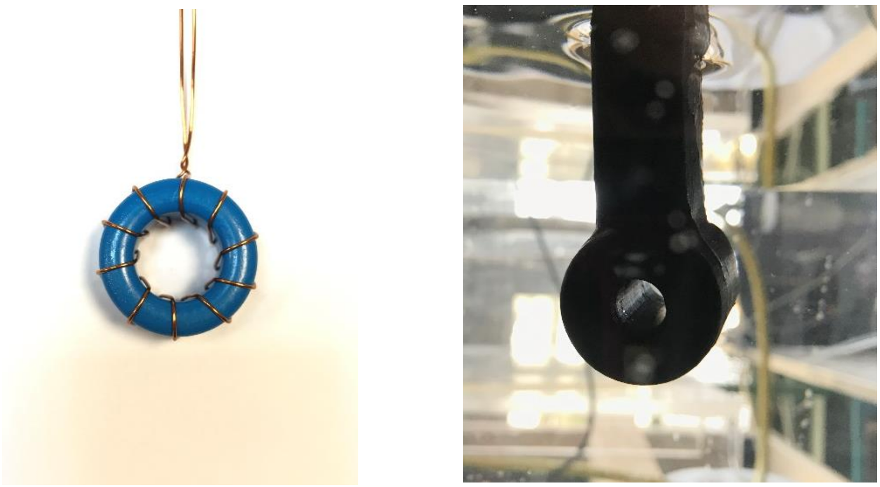
Transformer-type inductive conductivity sensors (TICS) are the industry standard for long-term conductivity measurement in fluids, since inductive sensors have the major advantage of being protected from corrosion and biofouling. However, TICS are more expensive than conductivity cells, due to the greater complexity of the sensor design. With an increasing demand for large-scale monitoring in oceanography and industry, there is a great need for low-cost inductive conductivity sensors [1]. This paper therefore analyzes the potential of TICS with reduced complexity for the use as a low-cost alternative. While the theory and design of TICS is well documented by numerous publications [2–5], there is little information published about the sensor uncertainty factors, as well as the implementation of low-cost TICS alternatives. In the scope of this work, a simple and cost-effective prototype was manufactured based on the results by Hui et. al [4]. Developed TICS was characterized and compared to a high precision industry standard inductive sensor. In various experiments, linearity and hysteresis error, the short- and long-term reproducibility and temperature error was quantified. The results were interpreted in regards to core material, geometric properties and noise shielding. After temperature compensation, the measurement uncertainty was determined to be around 0.3%, within the operational range between 10 to 60 mS/cm. Considering the outcome of the experiment, this paper provides a better understanding of performance and uncertainty characteristics in order to improve the design of low-cost transformer type inductive conductivity sensors.

Figures



(a) (b)

Figure 1: Magnetic core with copper coil windings (a). Sample sensor image under the conductive solution (b).

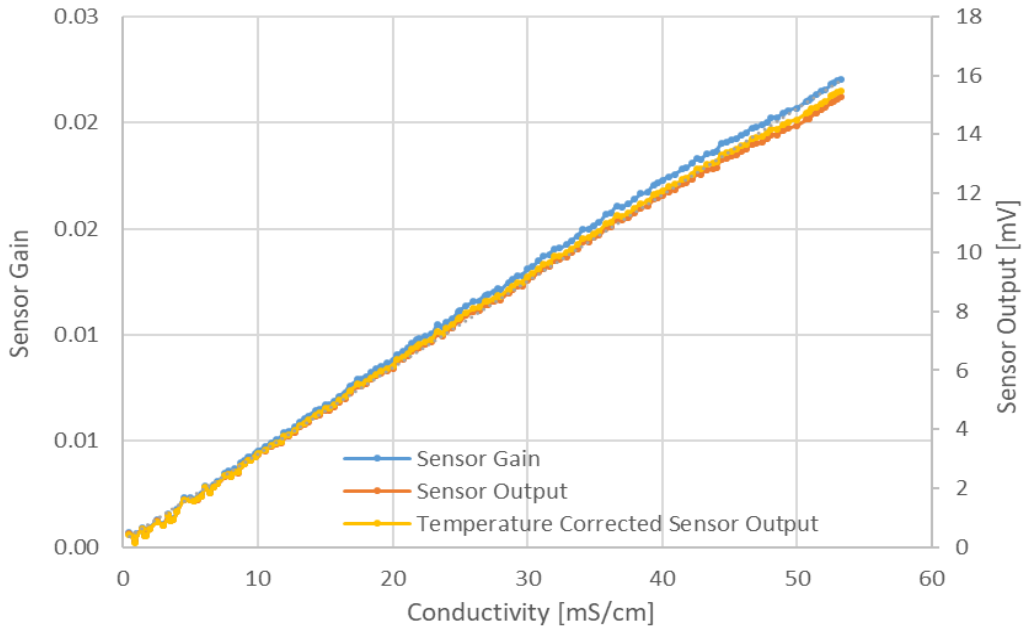


Figure 2: Plot displays sensor output amplitude [mV] and sensor gain readings vs. changing solution conductivity.

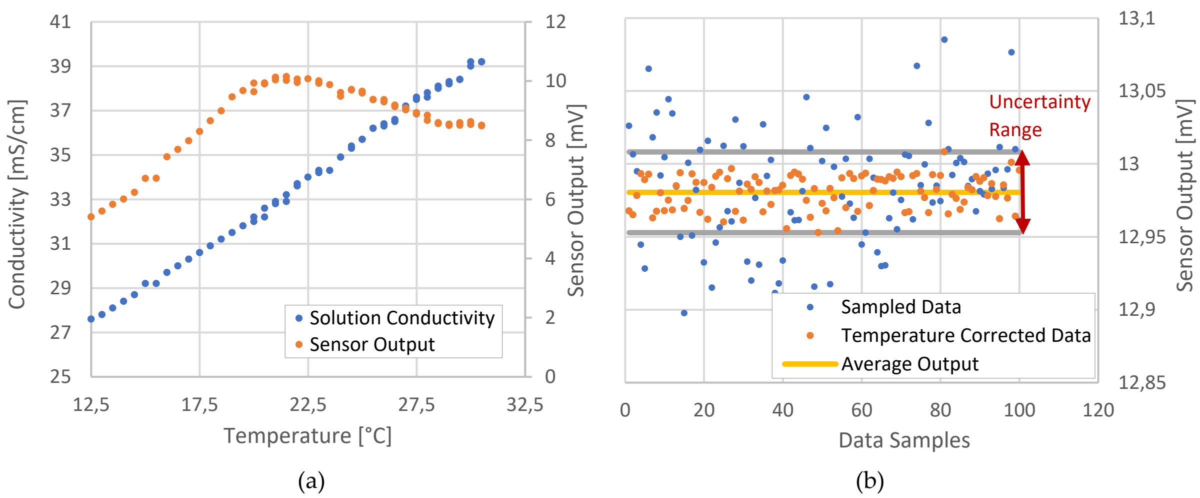


Figure 3: Figure shows experiment data points of sensor output amplitude and solution conductivity with respect to changing solution temperature (a). Uncertainty of sensor measurement is determined by the repeatability experiment. Uncertainty range is shown with red two sided arrow (b).

References

1. Tyler R.H.; Boyer T.P.; Minami T.; Zweng M.M.; Reagan J.R. Electrical conductivity of the global ocean. In *Earth, Planets and Space*, Vol. 69, 1st ed, **2017**, doi: 10.1186/s40623-017-0739-7.
2. Striggow K.; Dankert R. The exact theory of inductive conductivity sensors for oceanographic application. in *IEEE Journal of Oceanic Engineering*, Vol. 10, no. 2, April **1985**, pp. 175-179, doi: 10.1109/JOE.1985.1145085.
3. WU S.; LAN H.; Liang J-J.; Tian Y.; Deng Y.; Li H-Z. Investigation of the Performance of an Inductive Seawater Conductivity Sensor. in *Sensors & Transducers*, Vol. 186, March **2015**, pp. 43-48.
4. Kang Hui S.; Jang H.; Kim Gum C.; Yu Song C.; Kim Yong H. A new design of inductive conductivity sensor for measuring electrolyte concentration in industrial field. *Sensors and Actuators A: Physical,* Vol. 301, **2020**, doi: 10.1016/j.sna.2019.111761.
5. Ribeiro A.L.; Ramos H.M.G.; Ramos P.M.; Pereira J.D. Inductive conductivity cell for water salinity monitoring. in *Metrology for a Sustainable Development*, Rio de Janeiro, Brazil, **2006**, pp. 17-22.