Design, Implementation, and Validation of an EIT Measurement Setup

Graduate

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Introduction: Electrical Impedance Tomography (EIT) reconstructs conductivity distributions from currents injected at the boundary and voltages measured on electrodes. It is low-cost, portable, and potentially real-time, but it requires a precise measurement chain and consistent noise handling. This work considers a 16-electrode demonstrator operated with direct current.

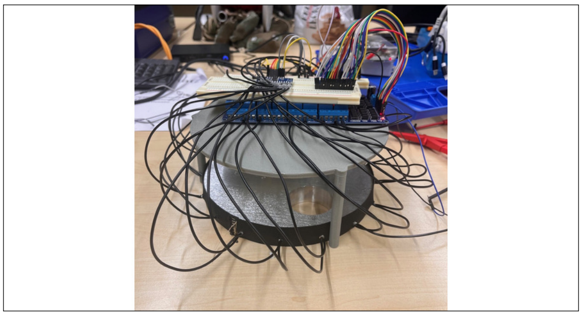
Objective: To design, build, and commission an EIT demonstrator with automated data acquisition and a consistent interface to a reconstruction pipeline. In addition, to derive a contrast-to-noise-based conductivity window to guide the choice of future phantoms and operating parameters. The inverse solver is used but not redeveloped; the focus is on the measurement chain, data quality, and practical operating regimes.

Approach: Hardware. Build a 16-electrode demonstrator with a flexible electrode belt, a relay rack for ground rotation, two 16-channel multiplexers (74HC4067), and Raspberry Pi control. Voltage and current are measured with two GDM-8351 bench multimeters via SCPI/USBTMC; the current source is set manually.

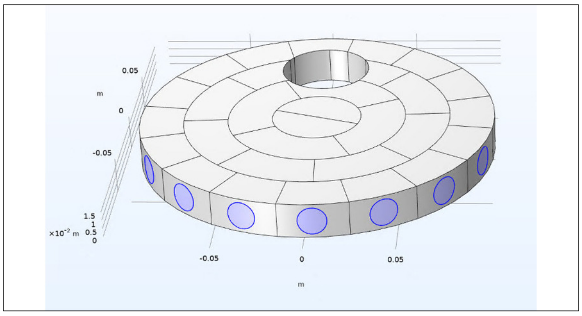
Software. Python automation for measurement sequences, CSV storage, and a lightweight web UI. The protocol uses a fixed source electrode, rotating ground, and a full sweep of all measurement electrodes; per state exactly one paired voltage-and-current reading, repeated over multiple cycles in the instrument's slow mode.

Modeling and analysis. Two COMSOL models are used; one to provide system matrices for reconstruction (with a contact model) and one forward model to estimate the expected change in electrode potentials between a homogeneous case and a case with the bore. This predicted potential change is scaled linearly to the real operating point (by injected current and background conductivity). Detectability is assessed as the ratio of the overall potential-change magnitude across all measurement electrodes to the global noise level. The noise level is obtained from repeated measurements per state (standard deviation per state) and averaged over all valid states. From this, a practical conductivity range for future phantoms is derived.

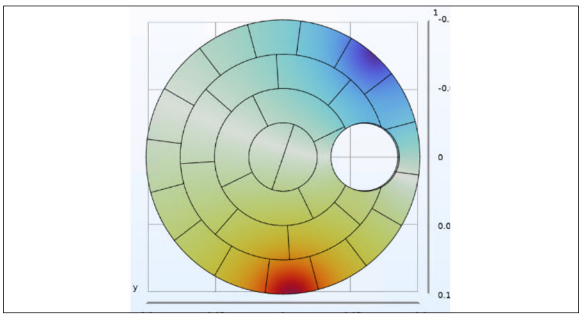
Completed EIT demonstrator: electrode belt on the cylinder, 3D-printed holder, multiplexer, relay and wiring.
Own presentment



Model of the cylindrical EIT phantom with 16 peripheral electrodes (blue) and a central inhomogeneity (bore).
Own presentment



Electric potential distribution in the phantom under current injection, computed with the finite-element model.
Own presentment



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Subject Area
Computational Engineering, Electronics and Control Engineering