STANDARD OPERATING PROCEDURE

Electrical Impedance Tomography (EIT-kit) Hardware & Array Calibration

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Target Hardware:	EIT-kit Sensing Motherboard & 32/64 Mux Boards	**Methodology:**	Auto-Calibration Digital Rheostat Optimization

1. Purpose & System Overview

This Standard Operating Procedure establishes the protocol for assembling, calibrating, and operating the EIT-kit Electrical Impedance Tomography sensing system. EIT is a non-invasive imaging technique that maps internal conductivity and permittivity distributions by injecting high-frequency AC currents through surface electrode arrays and measuring resulting boundary voltages. The EIT-kit motherboard integrates an ESP32 microcontroller, AD5930 signal generator, AD8220 instrumentation amplifier, modified Howland voltage-controlled current source (VCCS), and a 20 MHz high-speed ADC converter.

The system supports up to 64 addressable channels across stacked multiplexer boards, operating in either 2-terminal mode (opposing electrode injection/measurement for high frame rates) or 4-terminal mode (adjacent electrode injection/measurement for maximum spatial resolution).

2. Electrode Selection & Contact Impedance Verification

Electrode contact impedance strongly dictates signal-to-noise ratio. The EIT-kit system utilizes either 1/2-inch 440C stainless steel sphere electrodes or standard 3M ECG monitoring pads. Sphere electrodes provide consistent, point-like skin contact without causing mechanical pinching or skin irritation.

1. Inspect 3D-printed array geometries for tight mechanical conformality around the subject.

2. Inject a 5V peak-to-peak differential sinusoidal AC signal across adjacent electrodes from 1 kHz to 100 kHz.

3. Measure signal amplitude ratio ($V_{measured} / V_{injected}$) to verify low contact impedance prior to imaging.

3. Automated Signal Calibration Protocol (Digital Rheostat Sweep)

To eliminate manual oscilloscope tuning, EIT-kit incorporates an automated digital rheostat calibration routine. Both current injection drive and voltage measurement gains are modulated by AD5270 rheostats across 2048 simulation states (1024 current gain states × 1024 voltage gain states).

1. Initialize Arduino library constructor: EIT_setup(array_num, electrode_num, sensing_method, auto_calibration = TRUE).

2. **Sample Period Calibration:** Calibrate sample collection rate over fixed input signal periods.

3. **Current Gain Optimization:** Evaluate all 32 electrode pairs (44,032 measurements) to identify the maximum current amplitude that preserves a clean sinusoidal waveform without clipping.

4. **Voltage Gain Optimization:** Perform a second 44,032 measurement sweep to select the highest voltage gain that maximizes ADC dynamic range utilization.

5. **Phase Reference Calculation:** Calculate current wave phase offset as a reference baseline for complex impedance extraction.

4. Data Acquisition & Image Reconstruction

1. Call take_measurement() to collect RMS voltage and phase data across array sequences.

2. Export raw boundary data via communication port to the mobile visualization API.

3. Set approximate subject boundary (circular, rectangular, or elliptical) and execute EIDORS or EIT-kit back-projection algorithms for 2D/3D conductivity map interpolation.

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