Echo-Power Hardware Design Guide

# 1. Hardware Overview

The Echo-Power hardware is designed to integrate abnormal power detection capabilities into miniature constant-voltage transformers used in medical-grade devices. The system includes real-time sensing, MCU-based inference, and relay-based protection mechanisms. Below is the block-level description of the full hardware.

# 2. Block Diagram Description

- \*\*AC Input Stage\*\*: Equipped with surge protection and voltage scaling using ZMPT101B.  
- \*\*Current Monitoring\*\*: ACS712 provides real-time current sensing.  
- \*\*MCU Core\*\*: Raspberry Pi CM4 or STM32 performs 1D-CNN-based inference.  
- \*\*Isolation Interface\*\*: Optocouplers ensure safe isolation between high-voltage and control logic.  
- \*\*Output Control\*\*: A Solid State Relay (SSR) or MOSFET cuts power upon anomaly detection.  
- \*\*Indicators\*\*: LED and buzzer provide visual/audible anomaly alerts.

# 3. Components List (BOM)

- ZMPT101B – AC Voltage Sensor Module (Qty: 1)  
- ACS712 (5A/20A/30A) – Current Sensor Module (Qty: 1)  
- Raspberry Pi CM4 or STM32F411 – MCU platform (Qty: 1)  
- PC817 or TLP290-4 – Opto-Isolator (Qty: 2)  
- SSR-40DA or equivalent – Solid State Relay (Qty: 1)  
- DC-DC Buck Converter (12V to 5V) – Power supply (Qty: 1)  
- LED (red, green), Buzzer – Indicators (Qty: 2+1)  
- 12V 1A Adapter – Power Input (Qty: 1)

# 4. Wiring and Layout Notes

- Ensure proper insulation between high-voltage AC and low-voltage logic.  
- All sensors must connect to analog inputs or I2C/SPI interfaces where applicable.  
- SSR output line should be fused for safety.  
- Use opto-isolators on control signal paths to prevent backflow voltage spikes.