Abstract

Sensor and edge-processing node for utility power-line monitoring detects incipient insulation faults by fusing multiple modalities. A Rogowski-based residual-current sensor, high-frequency partial-discharge (PD) pickup and fluxgate magnetometer feed a microcontroller/FPGA that generates a composite “Leak Index” (Lx). Auto-injected 1 kHz pilot tone self-calibrates sensor gain and offset, while Kalman filtering enables sub-mHz drift detection. Real-time phase-resolved PD mapping is locally compressed for LoRaWAN or similar low-bandwidth links. Adaptive thresholds compensate for humidity and temperature inputs. Dual harvesting—inductive line coupling plus photovoltaic panel—with $LiFePO_4$ UPS ensures 24/7 operation during outages. The compact clamp-on unit therefore supplies early, reliable warnings of ground leakage or PD activity across overhead or underground networks, reduces false alarms and allows cost-effective, condition-based maintenance.