

PROJECT ABSTRACT

Smart Distribution Board with Per-Circuit Current Monitoring Dashboard

A smart distribution board with per-circuit CT monitoring, overload pre-alerts and a live circuit dashboard. Delivered built-to-order with instrumented board, firmware, dashboard, report, PPT and viva kit.

01. Title

Smart Distribution Board with Per-Circuit Current Monitoring Dashboard — turning a 10-way board into an instrumented one.

02. Introduction / Background

When a workshop MCB trips, the usual response is to reset it and hope — nobody knows which circuit was actually overloaded or whether the board is balanced across phases. This project turns a standard 10-way distribution board into an instrumented one: a clamp CT on every outgoing circuit feeds an ESP32 through a multi-channel conditioning stage. Firmware computes per-circuit RMS current, compares each against its MCB rating, watches phase balance and publishes over Wi-Fi via MQTT. The dashboard shows a live circuit table with current-vs-rating bars, board totals, phase-balance readout and 24-hour profiles, with alerts at 80% of breaker rating. The board is built to proper panel practice — MCBs, terminal blocks, earth bonding.

03. Problem Statement

The project addresses blind distribution boards: trips without forensics and imbalance without visibility. It demonstrates multi-channel CT instrumentation with honest approximately $\pm 3\%$ accuracy, overload pre-alerts and trip forensics — while stating explicitly that monitoring complements, never replaces, MCB protection.

04. Objectives

- Monitor current on each of 10 outgoing circuits with clamp CTs.
- Compute per-circuit RMS current, board totals and phase-balance in firmware.
- Publish all channels over Wi-Fi via MQTT on a 5-second design-target interval.
- Render a live circuit table with current-vs-rating bars and 24-hour profiles.
- Raise pre-alerts when any circuit crosses 80% of its MCB rating.
- Provide trip forensics: which circuit was climbing before a trip.

05. Proposed Methodology

Each outgoing circuit passes through its own clamp CT into the conditioning stage; the ESP32 samples all channels, computes RMS per circuit, totals the board load and evaluates phase-balance math. Readings publish as JSON over MQTT every 5 seconds. The dashboard renders the circuit table, rating bars, totals and balance readout; threshold crossings raise alerts with circuit ID, current and rating. 24-hour per-circuit profiles persist for load analysis. Each channel calibrates against a clamp reference meter.

06. System Architecture / Working

The ESP32 with multi-channel conditioning is the board monitor, publishing to an MQTT broker. The dashboard backend persists channel series and serves the circuit table, profiles and alerts. The 10-way board with MCBs, wired to a workshop load bank for demonstration, follows proper panel-building practice throughout.

07. Hardware / Software Requirements

- Hardware: ESP32 development board, 10-way distribution board with MCBs, 10x clamp CTs (SCT-013 class), multi-channel CT conditioning stage, workshop load bank, clamp reference meter for calibration.
- Software: Arduino IDE (C/C++ firmware), MQTT broker, web dashboard (HTML/CSS/JS).

08. Expected Outcomes

- A working instrumented 10-way distribution board.
- A live dashboard with circuit table, rating bars, balance readout and profiles.
- Working overload pre-alerts and trip forensics.
- A documented per-channel CT calibration procedure.
- Complete documentation: panel wiring diagram, report, PPT, viva Q&A, setup guide.

09. Applications

Workshop and laboratory boards, institutional distribution monitoring, and energy-audit instrumentation — anywhere circuit-level visibility prevents trips.

10. Future Scope

Energy sub-metering per circuit, harmonic analysis for power quality, automated load shedding by priority, and integration with facility management systems.