PROJECT ABSTRACT

Single-Phase Digital Energy Meter with LCD Cost Display

An Arduino-based digital energy meter that samples voltage and current, integrates real power into kWh with EEPROM backup, and shows tariff-based cost on an LCD — delivered built-to-order with working prototype, calibration procedure, firmware, report, PPT and viva kit.

01. Title

Single-Phase Digital Energy Meter with LCD Cost Display

02. Introduction / Background

Every electricity bill rests on one measurement: energy, the time-integral of power. Utility meters do this with dedicated metrology chips, but the principle — sample v(t) and i(t), multiply, accumulate — is fully implementable on a microcontroller and makes an excellent teaching build. It forces engagement with the real subtleties: sampling both waveforms together, why real power differs from apparent power on reactive loads, how calibration constants map ADC counts to volts and amps, and why a meter must remember its reading through power cuts. This project builds that meter for a single-phase demo circuit: isolated V/I sensing, an Arduino integrating real power into kWh with EEPROM backup, a tariff-based cost display, and a buyer-run calibration procedure against a known load.

03. Problem Statement

Students see energy meters as sealed boxes; the measurement principle, calibration discipline and register-protection ideas inside them stay abstract. The project addresses this by building the meter from first principles — sampling, multiplication, integration, non-volatile storage — where every stage is inspectable in firmware and every accuracy claim is earned through the student's own calibration procedure.

04. Objectives

- Sample voltage and current waveforms simultaneously with isolated sensing.
- Compute real power by sample-wise V×I multiplication and integrate into kWh.
- Back up the energy register to EEPROM across power cuts.
- Display live V, I, W, PF estimate, kWh and tariff-based cost on an LCD.
- Provide a buyer-run calibration procedure against a known resistive load.

- Stream readings over serial for PC logging and plotting.

05. Proposed Methodology

The methodology has four stages. (1) Sensing: isolated voltage and CT/Hall current signals are scaled to the Arduino ADC. (2) Measurement: firmware samples both channels many times per mains cycle, multiplies sample pairs for instantaneous power, averages over whole cycles for real power, and integrates into the kWh register checkpointed to EEPROM. (3) Calibration: the buyer connects a known resistive load and adjusts voltage/current constants per the documented procedure until readings match. (4) Demonstration: resistive and reactive demo loads show correct real-power behavior (W < V×I on reactive loads) on the LCD and serial plots.

06. System Architecture / Working

The chain flows as: 230 V demo circuit -> isolated voltage sensing + CT/Hall current sensing -> Arduino (sampling, V×I integration, EEPROM checkpointing, tariff math) -> 16x2 LCD (V, I, W, PF, kWh, cost) and serial output. Calibration constants live in EEPROM, set by the buyer-run procedure. A tamper-evident long-press sequence guards the reset function, and the demo load bank provides resistive and reactive loads for the PF demonstration.

07. Hardware / Software Requirements

- Hardware: Arduino Uno/Nano, isolated voltage sensing stage, CT or Hall-effect current sensor, 16x2 LCD, demo load bank (resistive + reactive).
- Software: Arduino IDE, C/C++ firmware (sampling, integration, EEPROM, tariff, LCD/serial).
- Test: multimeter and a known rated load (e.g. lamp) for calibration.

08. Expected Outcomes

A working digital energy meter that correctly integrates real power into kWh, survives power cuts via EEPROM backup, displays tariff-based cost, and — after the buyer's calibration — reads within a low single-digit percent design target on the demo loads; plus firmware, wiring docs, report, PPT and viva Q&A.

09. Applications

The same measurement principle sits inside smart meters, energy audits, submetering for tenants, and solar net-metering. The bench meter teaches the metrology fundamentals behind all of them.

10. Future Scope

Three-phase metering with three sensing channels; slab/tiered tariff firmware; SD-card load-profile logging; and wireless (ESP32) remote reading of the meter.