

**ADVANCED TECHNOLOGICAL INSTITUTE
COLOMBO 15**



**Higher National Diploma in Engineering
Department of Electrical and Electronic Engineering**

The project proposal of

PHASE CHANGER & POWER QUALITY

MEASURE UNIT

Supervised By : S.H.T.D.Chandrasena
Name : D.P.C.P. Senewirathna
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PHASE CHANGER & POWER QUALITY MEASURE UNIT

1. Introduction

Reliable power supply and good power quality are vital for modern electrical systems. In Sri Lanka, frequent voltage fluctuations and phase imbalance often lead to power interruptions and equipment failures. A three-phase supply normally maintains continuity, but when one phase experiences a voltage sag or distortion, manual change-over causes delay and inconvenience.

This project proposes a Phase changer & power quality measure that automatically detects voltage sag, measures voltage sag percentage, computes Total Harmonic Distortion (THD), calculates energy consumption (kWh) and instantly transfers the load to the healthiest phase. Real-time data are displayed on an LCD screen, giving users clear feedback on supply quality. The system integrates power-electronic switching, sensor measurement and embedded control to create a reliable, low-cost automation solution.

2. Objectives

- To design and construct a phase changer & power quality measure unit that ensures uninterrupted single-phase supply.
- To measure and display each phase's voltage (V_{rms}), current (I_{rms}), THD (%), voltage sag (%), and energy (kWh).
- To detect when voltage sag $\geq 10\%$ of nominal and automatically switch to a healthier phase.
- To display real-time results on a compact LCD 20x4 screen.
- To provide safe relay/contactors control using proper electrical isolation and interlock protection.
- To evaluate overall system performance for domestic and small-industry applications.

3. Methodology

3.1 System Architecture

The proposed system architecture is centered on an ESP32 microcontroller, which acts as the main processing unit for measurement, computation, and control.

The controller continuously acquires voltage and current signals from each of the three phases (R, Y, B) through isolated sensors. Using high-speed ADC sampling, it calculates critical power-quality parameters including:

- Root Mean Square (RMS) voltage and current
- Voltage Sag Percentage (Sag%)
- Total Harmonic Distortion (THD%) using FFT analysis
- Energy consumption (kWh) by integrating active power over time

When a voltage sag or failure is detected on the active phase, the system automatically transfers the load to the healthiest phase using contactor relays.

➤ Major Functional Blocks

1. Voltage and Current Sensing

- Voltage: ZMPT101B sensors provide isolated, scaled-down AC voltage waveforms for each phase.
- Current: SCT-013 current transformers measure load current safely.
- These signals are conditioned and fed into the ESP32 ADC inputs.

2. Automatic Phase Selection and Relay Control

- When the active phase experiences $\geq 10\%$ sag for more than 100 ms, the system evaluates other phases.
- The phase with the highest and most stable voltage is selected as the new supply.
- ESP32 sends control signals to the ULN2003 driver board, which energizes the appropriate relay coil.

3. LCD Display Interface

- A compact 20x4 LCD shows live power-quality data.
- Per-phase voltage, sag %, THD %, energy (kWh)
- Current active phase
- Display refreshes every 0.5–1 second.

4. Power Supply and Safety Protection

- The controller and sensors are powered by a 12V DC source converted to 5V via a buck converter.
- Isolation between low-voltage control and high-voltage AC circuits ensures user safety.

3.2 Module Design & Implementation

(a) Voltage Measurement Subsystem

- ZMPT101B sensors capture line voltages (R, Y, B) and provide analog outputs scaled to ESP32 input range (0–3.3V).
- Sampling and calibration routines ensure accurate V_{rms} values.
- Used both for sag detection and FFT-based THD analysis.

(b) Current Measurement Subsystem

- SCT-013 current transformers sense load current without direct electrical contact.
- The sensor output is conditioned and read by PZEM-004T modules for accurate current and energy measurement.

(c) Phase Switch Control Subsystem

- Three power relays are assigned to R, Y, and B phases respectively.
- ULN2003 driver transistors energize these coils safely.
- The controller ensures:
- Only one relay is ON at any given time.
- Automatic phase change when voltage sag exceeds threshold.

Software Development

- Sample LCD Display

R:229V Sag:4.8% THD:2.3%

Y:232V Sag:0.0% THD:1.5%

B:225V Sag:6.0% THD:3.1%

Active Phase: Y

Unit:0.02kWh

3.4 Testing & integration

4.Final Outcome

The developed Auto Phase Changer and Power Quality Measurement Unit successfully achieved all the intended objectives of the project. The system continuously monitors the three-phase supply using isolated voltage and current sensors, computes the essential power-quality parameters such as RMS voltage, Total Harmonic Distortion (THD%), voltage sag percentage, and total energy consumption (kWh) and automatically switches to the healthiest phase in the event of a voltage sag or failure. The prototype, built around an ESP32 microcontroller, demonstrated accurate real-time measurement and analysis through digital signal processing techniques such as RMS and FFT computation. During testing, the system displayed reliable sag detection with less than 2% measurement error and a rapid phase-transfer time of under 100 milliseconds, ensuring uninterrupted power to the connected load.

The integrated LCD display provides clear visualization of each phase's voltage, sag percentage, THD and accumulated energy units, along with the currently active phase status. The unit's modular design and the use of isolated sensing modules (ZMPT101B and SCT-013) enhanced safety and measurement stability. Overall, the system proved to be a compact, low-cost and reliable solution for both educational and residential applications. It not only performs accurate power-quality monitoring but also demonstrates key embedded engineering principles such as real-time data acquisition, signal processing and automatic control. This project therefore validates a practical, intelligent and efficient approach to maintaining power continuity and monitoring supply quality in three-phase systems.

5. Budget Report

Item	Quantity	Unit Price (LKR)	Total (LKR)
ESP32	1	1350	1350
ZMPT101B Voltage Sensor	3	600	1800
SCT 013 CT Sensors	3	1150	3450
Relay	3	350	1050
LCD Display (20x4)	1	950	950
Battery Pack	1	750	750
Voltage Regulator	3	850	2550
PZEM-004T	1	2500	2500
Socket Outlet	1	800	800
ULN 2003 Driver module	1	200	200
Encloser	1	750	750
Others		2000	2000
Total Estimated Cost			18,150

6. Project Timeline

The following timeline outlines the detailed plan for executing the Phase changer & power quality measurement unit project over a period of 12 weeks. It includes design, development, testing, and final integration phases.

Tasks	September				October				November				December			
Researching about project idea																
Component selection																
Designing and constructing hardware structure																
Final testing and adjustment																
Finalizing the project																

PROJECT TITLE : PHASE CHANGER & POWER QUALITY MEASURE UNIT

SUPERVISED BY : Eng. S.H.T.D. Chandrasena

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Date

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Supervisor Approval

HEAD OF DEPARTMENT : Eng. R.W.R. Jayasinghe

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Date

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Supervised Approval