PROJECT ABSTRACT

# Load Flow Demonstration Panel using Analog Network

*An analog load-flow demonstration panel: a scaled AC network with plug-in R/X impedance branch modules, metered busbar nodes, a variac-fed source and plug-in load modules, reconfigurable between radial and ring topologies with patch cords — so power flow, voltage drop and reactive compensation become visible and touchable. Delivered as a built-to-order student project with hardware, report, PPT and viva preparation.*

## 01. Introduction / Background

Load-flow analysis is usually pure software — buses and branches solved by Newton-Raphson on a screen, with the physical meaning buried under matrices. Before digital computers, power engineers studied the same problems on AC network analyzers: scaled physical models of power systems where you could plug in a line, switch a load and watch the power flow change. This project revives that approach as a bench-top teaching panel: a low-voltage scaled AC network with plug-in R/X impedance modules, busbar nodes carrying digital panel meters, a variac-fed source representing the grid, and lamp-bank load modules in resistive and inductive variants. Reconfiguring the topology with patch cords, adding loads, or switching in capacitor banks produces immediate, visible changes in bus voltages and branch currents — voltage drop, reactive power flow and compensation become things students can touch.

## 02. Problem Statement

Power-systems courses teach load flow as mathematics, and students can solve a 4-bus system on paper while having no intuition for what happens when a feeder is loaded, looped into a ring, or compensated with capacitors. Software tools answer the numbers but hide the causality. An analog network panel restores the physical intuition: every cause (new load, new branch, capacitor switched in) has an immediately visible effect on the meters, and the per-unit scaling concept connects the safe low-voltage model to the high-voltage system it represents.

## 03. Objectives

- Build a 4–6 bus scaled AC network panel with plug-in R/X impedance branch modules.
- Meter every bus node (voltage, current) with digital panel meters.
- Allow rapid topology reconfiguration (radial, ring, multi-feeder) via patch cords.

- Provide plug-in resistive and inductive load modules plus a switchable capacitor bank.
- Document the per-unit scaling concept and a full experiment procedure in the manual and report.

## 04. Proposed Methodology

- Fabricate the busbar panel with plug-in holders for impedance modules and fused branch positions.
- Build the R/X impedance modules, lamp-bank load modules and the capacitor bank to matched per-unit values.
- Wire digital panel meters per bus and a variac-fed source with a documented per-unit base.
- Verify the network: radial baseline, loading steps, ring reconfiguration, then compensation — recording meter readings at each stage.
- Write the experiment procedure (topology comparison, voltage-drop study, compensation study) for the report.

## 05. System Architecture / Working

The variac-fed source energises the scaled network at a safe low AC voltage representing the grid infeed. Students plug impedance modules into the panel to build a feeder — radial first, then ring or multi-feeder with patch cords. Load modules plugged in at chosen buses make the bus meters show the voltage profile sagging along the feeder; branch current meters reveal how power flow redistributes when the topology changes from radial to ring. Switching in the capacitor bank demonstrates reactive compensation: power factor improves and bus voltages recover. The manual's per-unit scaling section maps every measured value back to the high-voltage system being modelled.

## 06. Hardware / Software Requirements

- Busbar panel with patch-cord topology and fused branch holders
- Plug-in R/X impedance branch modules
- Digital panel meters per bus (voltage, current)
- Lamp-bank load modules (resistive + inductive); switchable capacitor bank
- Variac-fed scaled AC source with documented per-unit base
- No software required; experiment manual and per-unit scaling guide included

## 07. Expected Outcomes

- A working analog network demonstrating radial vs ring power flow, voltage drop and compensation.
- Student-recorded experiment datasets from the documented procedure.

- A clear per-unit mapping between the model and the represented HV system.
- Complete documentation: report, PPT, viva Q&A and experiment manual.

## 08. Applications

- Teaching power-flow concepts, voltage drop and reactive compensation in power-systems laboratories.
- Building intuition for per-unit modelling before students use digital load-flow software.
- Demonstration rig for open days and department showcases.

## 09. Future Scope

- Automated (relay-switched) topology reconfiguration with SCADA-style control.
- Data-acquisition interface logging all bus meters to a PC for plotting.
- Fault-study extensions: short-circuit demonstration with measured fault currents.