TECHNICAL SPECIFICATION:

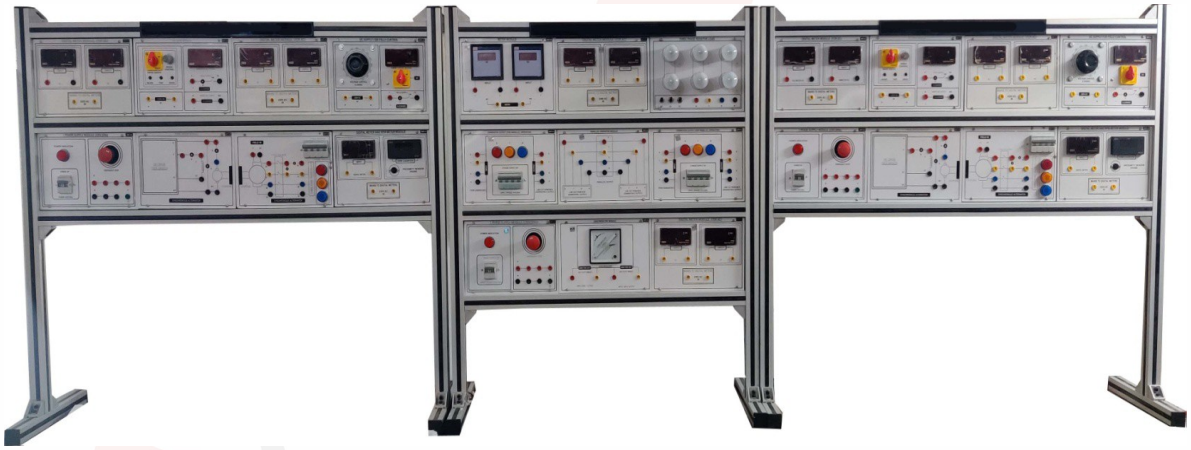
Power System Protection Laboratory Workbenches

1. PURPOSE:

To procure a modular protection laboratory workbench capable of delivering practical, hands-on training in power system protection for:

- Synchronous generators
- Power transformers
- Transmission lines
- Protection coordination and grading
- Relay parameterization and performance evaluation

The system shall allow controlled simulation of normal operating conditions, abnormal system conditions, and power system faults.



2. GENERAL REQUIREMENTS:

The offered system shall be:

- A fully integrated laboratory workbench or modular training platform
- Designed for three-phase operation at 400 V (50/60 Hz)
- Digital relays
- Suitable for safe indoor laboratory use
- Electrically protected against overload and short-circuit

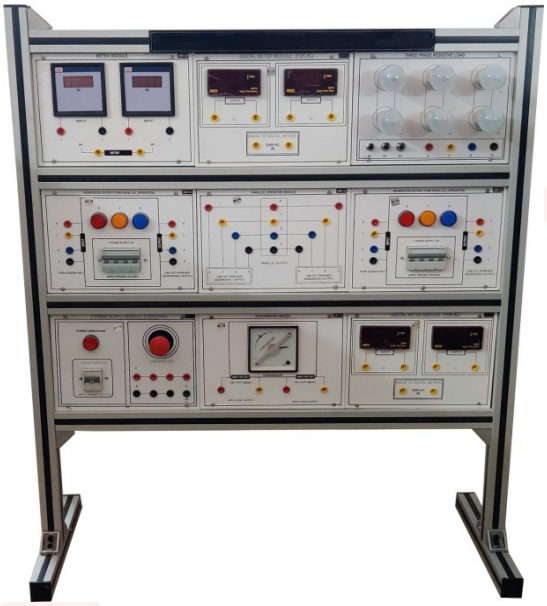
Note: Specifications are subject to change, Photos shown above are Indicative, Actual Product can Vary.

- Designed with safety laboratory connectors (minimum CAT II rating)
- Compliant with applicable IEC/EN safety standards
- Expandable for future additions

The system shall support repeated fault simulation without equipment damage.

3. FUNCTIONAL CAPABILITIES:

The target is to procure TWO complete workbenches. Each workbench shall enable controlled experimentation in the following domains.



4. GENERATOR PROTECTION TRAINING CAPABILITIES:

4.1 Generator Operation:

- Perform manual and automatic synchronization
- Control and observe active and reactive power
- Observe power factor variation
- Study generator behavior under balanced and unbalanced loading
- Operate the generator in motoring and generating modes

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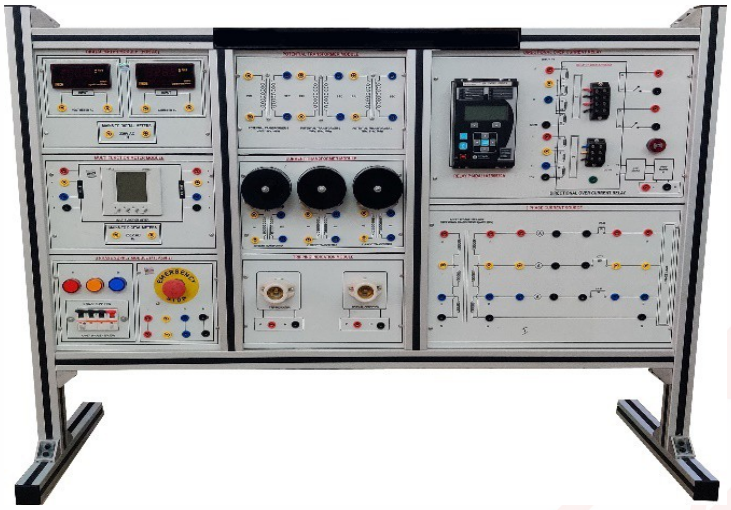

4.2 Fault Simulation:

The system shall allow simulation of:

- Single-phase faults
- Phase-to-phase faults
- Three-phase faults
- Earth faults
- Internal and external faults relative to protection zone

Faults shall be safely generated and cleared.

4.3 Protection Behaviour Analysis:

The system shall enable determination of:

- Pick-up (operating) current/voltage
- Tripping time
- Reset ratio
- Release time
- Characteristic curves
- Operation under unbalanced conditions
- Reverse power conditions

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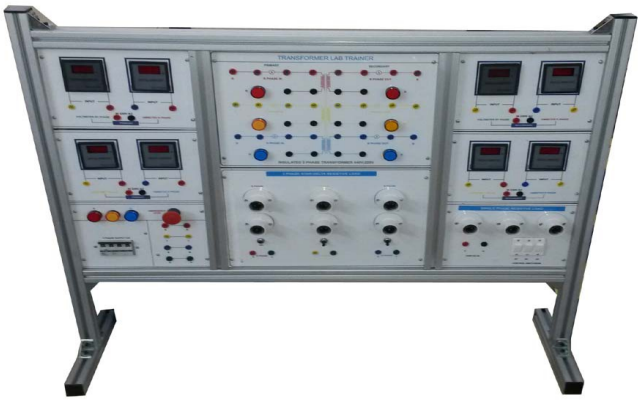
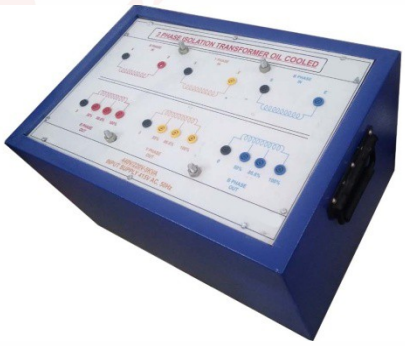
- Over/under voltage conditions
- Over/under frequency conditions
- Thermal effects (simulated acceptable)
- Students shall be able to:
- Compare measured values with set values
- Analyze misoperation due to incorrect settings
- Study zone selectivity

5. TRANSFORMER PROTECTION TRAINING CAPABILITIES:





5.1 Transformer Operation Studies:

- Study of transformer energization
- Observation of inrush phenomena
- Study of vector group effects
- Study of CT ratio and polarity influence

5.2 Fault Conditions:

The system shall allow simulation of:

- Internal faults
- External faults

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- Earth faults
- Inrush conditions
- Incorrect current transformer configuration

5.3 Protection Evaluation:

Students shall be able to:

- Observe discrimination between inrush and internal faults
- Measure differential quantities
- Design of % differential relays
- Determine tripping time
- Study grading with upstream and downstream protection
- Configure protection parameters and verify performance

6. TRANSMISSION LINE PROTECTION CAPABILITIES:

The workbench shall include an adjustable transmission line simulation environment capable of:

- Representing different line lengths
- Representing different fault locations
- Adjustable impedance conditions

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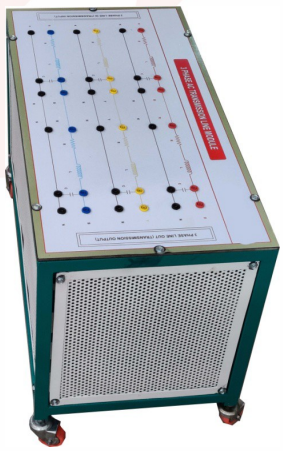
- Simulating forward and reverse faults
- The system shall allow:
- Study of zone-based protection
- Determination of reach settings
- Study of fault resistance influence
- Testing faults inside and outside protection zone
- Evaluation of backup protection



7. OVERCURRENT AND DIRECTIONAL PROTECTION STUDIES:

The system shall allow students to:

- Implement time overcurrent protection
- Select inverse characteristics
- Set time multipliers
- Determine coordination margins
- Prepare grading schedules
- Study directional elements
- Study forward and reverse power flow
- Study interaction between primary and backup protection

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- The system shall allow verification of:
- Selectivity
- Sensitivity
- Speed
- Stability

8. MEASUREMENT AND PERFORMANCE ANALYSIS CAPABILITIES:

The laboratory workbench shall provide facilities to:

- Measure three-phase voltage and current
- Measure active, reactive and apparent power
- Measure power factor
- Measure fault current magnitude
- Record tripping times with millisecond resolution
- Capture event sequences
- Export measured data for analysis
- Phasor measurement units
- The system shall allow:
- Comparison between theoretical and measured values
- Plotting of protection characteristics
- Analysis of operating vs restraint quantities
- Disturbance recording

9. PARAMETERIZATION AND CONTROL:

The system shall support:

- Digital configuration of protection parameters
- Adjustment of operating thresholds
- Adjustment of time delays
- Storage and recall of multiple settings

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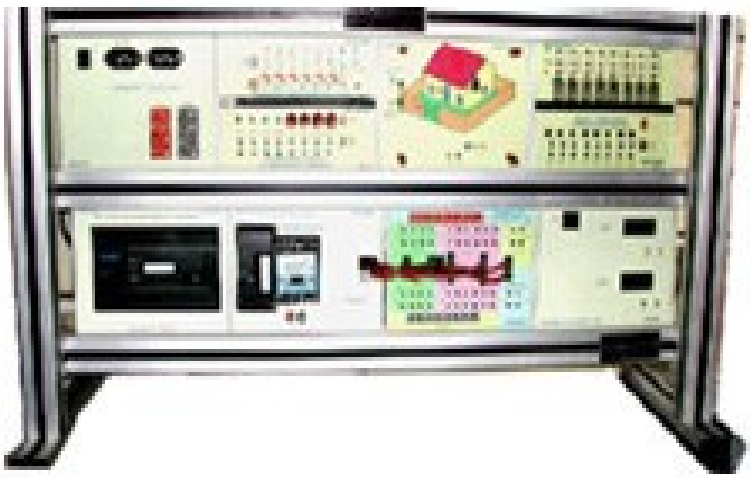
- User access control
- Reset and recovery after trip

10. SCADA AND VISUALIZATION REQUIREMENTS:

The system shall include supervisory software capable of:

- Real-time single-line diagram visualization
- Display of measured electrical parameters
- Indication of protection status
- Event logging
- Fault recording
- Data export for reporting
- Printing of experiment results
- The interface shall allow:
- Configuration of protection parameters
- Resetting and acknowledgment of alarms
- Monitoring of system state



11. EDUCATIONAL SOFTWARE REQUIREMENTS:

The laboratory shall include structured educational content with:

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- Guided experiment procedures
- Step-by-step setup instructions
- Embedded diagrams
- Data entry capability
- Automatic evaluation and feedback
- Knowledge assessment modules
- Printable documentation
- The system shall support instructor-led and self-learning modes.

12. SAFETY REQUIREMENTS:

The workbench shall include:

- Overcurrent protection
- Short-circuit protection
- Emergency stop
- Safe fault injection method
- Insulated terminals
- Clearly identified earthing
- Protection against accidental contact with rotating parts
- Visual fault indication

The system must prevent hazardous energy exposure during experiments.

13. PERFORMANCE REQUIREMENTS:

The system shall:

- Support continuous laboratory use
- Allow repeated fault testing without degradation
- Maintain measurement accuracy within ±2% or better
- Provide tripping time measurement accuracy within ±5 ms or better

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14. DELIVERY AND COMMISSIONING:

The supplier shall provide:

- Installation and commissioning
- Functional demonstration of all experiment capabilities
- Instructor training
- Complete documentation
- Wiring diagrams
- Example protection settings

Installation and commissioning:

The vendor needs to include installation, testing and commissioning of the whole set up on the site (EE Lab)

TRAINING:

The vendor shall provide comprehensive on-site training for technicians for a duration of 3–5 days.

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