Engineering College of Technology.

MYSTERIES: The Vanishing Fault – Why Did the Circuit Breaker Trip With No Recorded Fault?

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Emeritus Professor Akhtar Kalam | EIT EMERITUS PROFESSOR

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Introduction – Presenter

Emeritus Professor Akhtar Kalam

Emeritus Professor at Victoria University and EIT.
Academic Director and Chair of the Academic Board - Texila College Australia.
Director of Al-Kalam Educational Solutions.
Editor-in-Chief of AJEEE
Distinguished Professor/Adjunct Faculty in Australia, India, Malaysia and Oman.
He has published over 610 publications in his area of expertise and has written over 29 books.
Supervised 51 postgraduate research students to graduation, including 39 PhD's and 12 MEngs. Currently, 10 postgraduate research students (four PhD students at VU and six DEng students at EIT) are being supervised.
Public, University, and Motivational Lecturer.
Consultant for the electricity supply industries in Australia and overseas.
Assisted in change management plans for Universities and the higher education sector.

Education

The University of Bath, Bath, UK, D.Eng., Electrical Engineering
The University of Oklahoma, Norman, USA, MS, Electrical Engineering
Aligarh Muslim University, Aligarh, India, BSc. Eng., Electrical Engineering
St Xavier's College, Calcutta, India, Applied Science

Professional Society Activities

Australian Institute of Energy – Fellow
Engineers Australia – Fellow
The Institution of Engineers and Technology, UK – Fellow.
The Institution of Electrical and Electronic Engineers, USA –Life Senior Member.

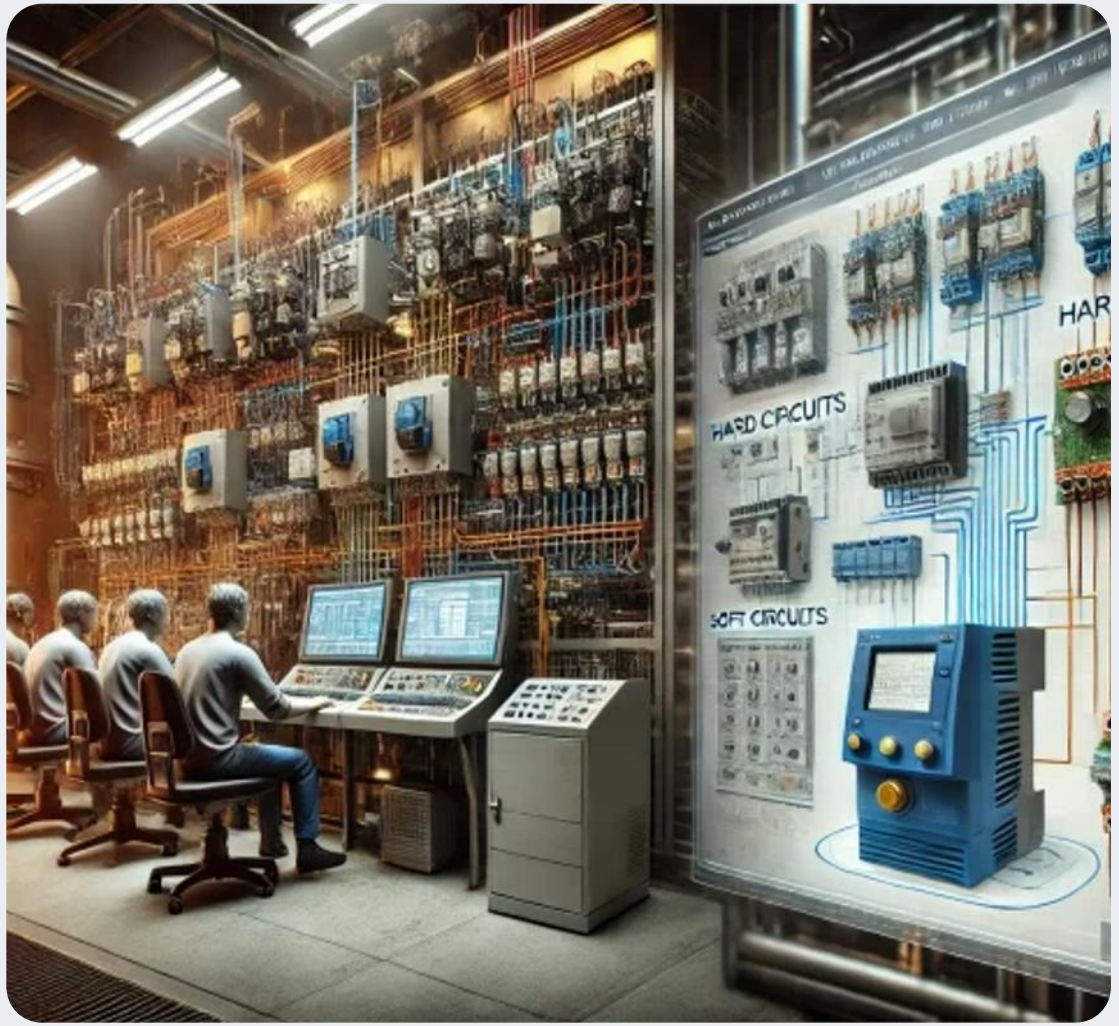
"My vision is to provide exciting higher education science and engineering courses, research, consultancy and collaborate in development work of the industry and communities within Australia and beyond."

Agenda

1	Electrical Engineering Mysteries
2	Learning Objectives
3	Overview
4	Assumptions and various characterisation
5	Engineering Investigations
6	Case Resolution
7	Lessons learnt and CONCLUSION

Why Study Electrical Engineering Mysteries?

- Real systems do not behave like textbooks
- Data is often incomplete or misleading
- Engineers must decide before all facts are known
- Safety, reliability, and cost are at stake

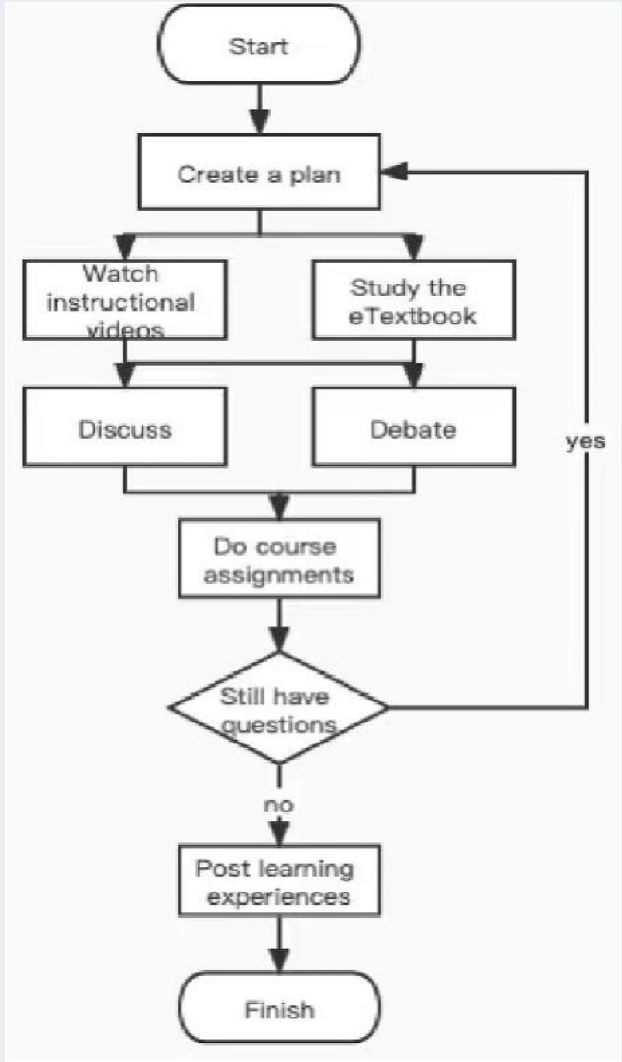


The Engineer as a Detective

- The gap between theoretical models and field reality.
- Importance of Event Records (SER) and Waveform Capture (COMTRADE).
- The "Mystery" framework:
  Observation → Hypothesis → Simulation → Verification.

Learning Objectives

- Understand unexplained breaker trips
- Analyse relay logic and blind spots
- Investigate DC and auxiliary systems
- Apply professional diagnostic methods

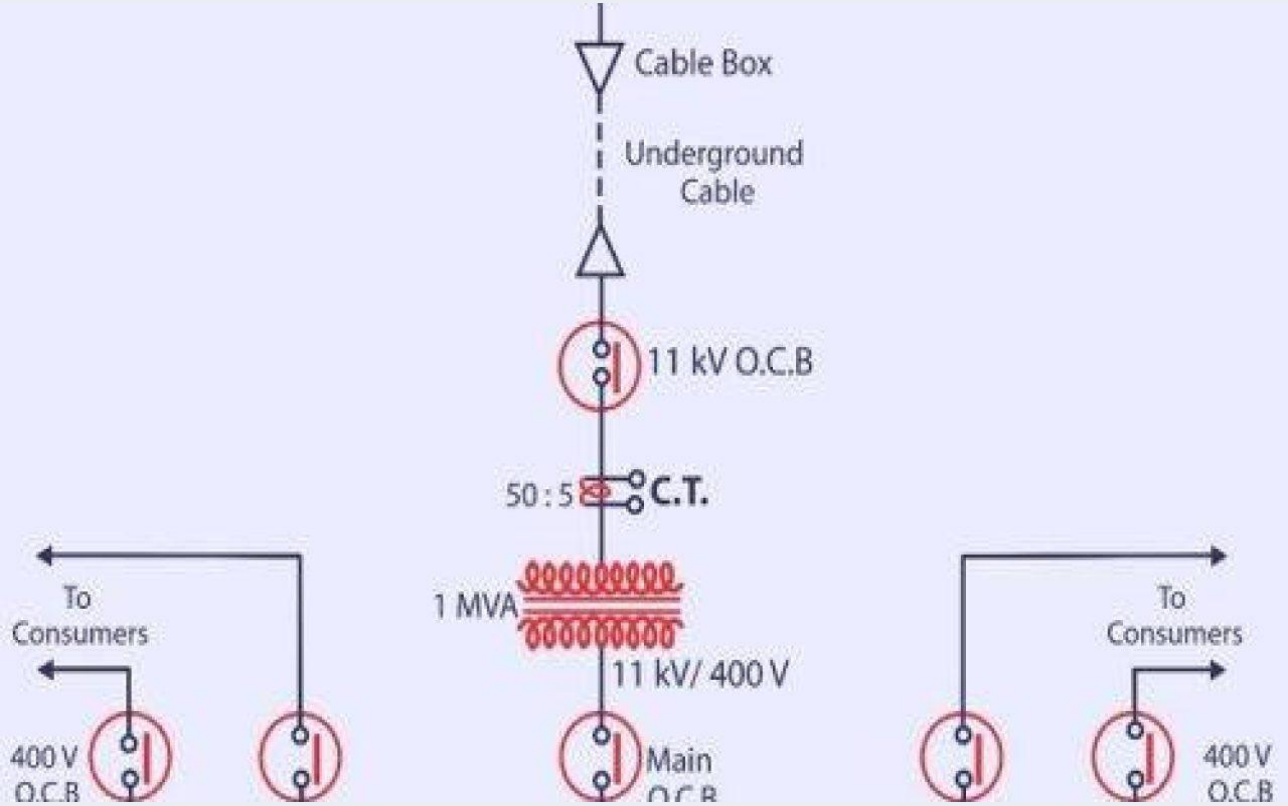


Overview

- Presentation objectives
- Structure of the mystery case
- Why transient faults matter

INCIDENT

- ❑ 11 kV industrial feeder tripped unexpectedly
- ❑ No protection relay fault record
- ❑ SCADA logs are normal before and after
- ❑ System restored without issue

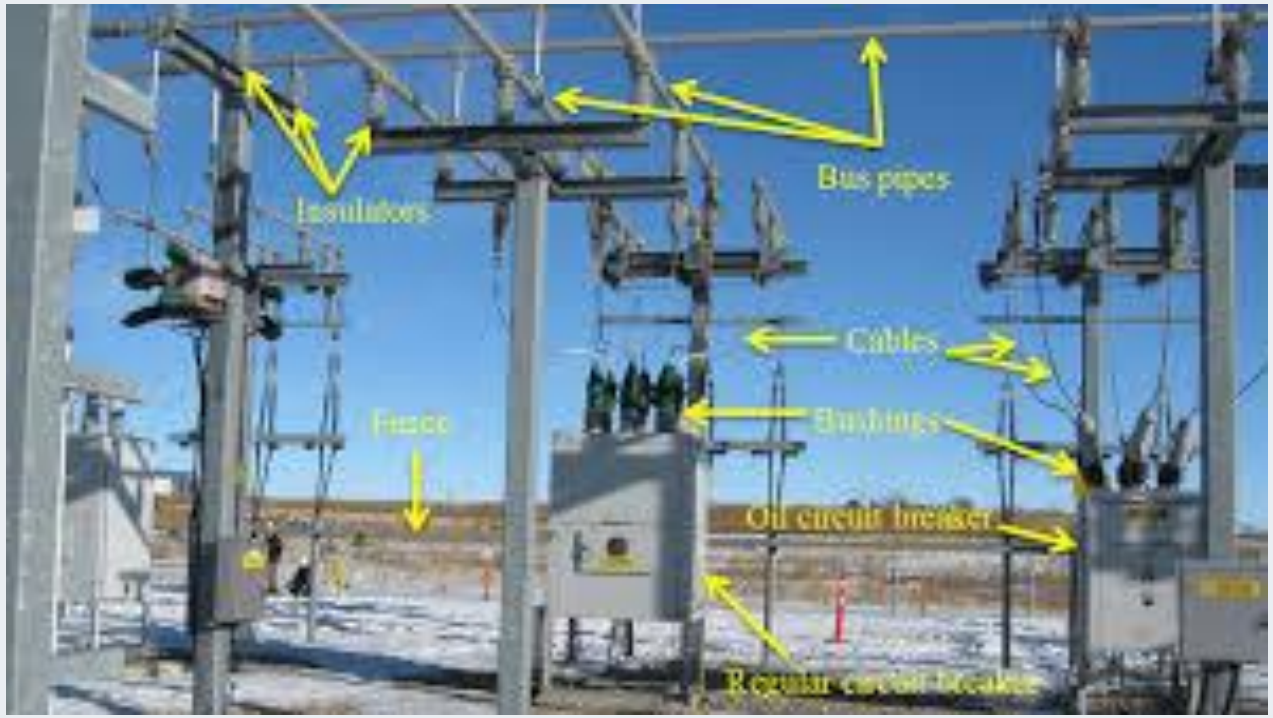


Scene Setting

- Rural feeder network overview
- Circuit breaker type and rating
- Environmental conditions

Why this is a Mystery?

- Random breaker trips
- No sustained short circuit detected
- Operators are unable to replicate the issue



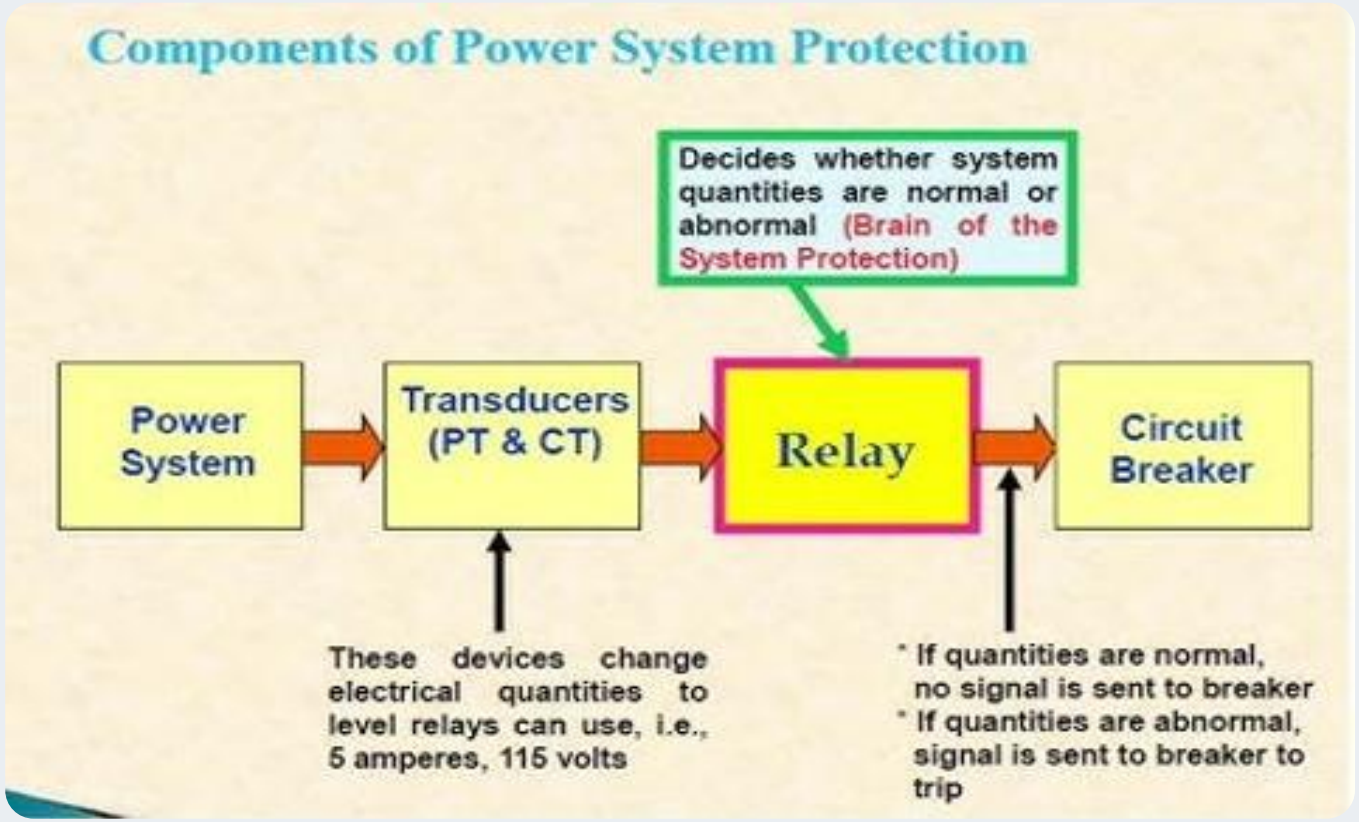
- ❑ Breakers do not trip randomly
- ❑ No recorded overcurrent or earth fault
- ❑ No visible equipment damage
- ❑ Yet the trip was real and disruptive

Initial (Often Wrong) Assumptions

- Relay malfunction
- SCADA failure
- Operator error

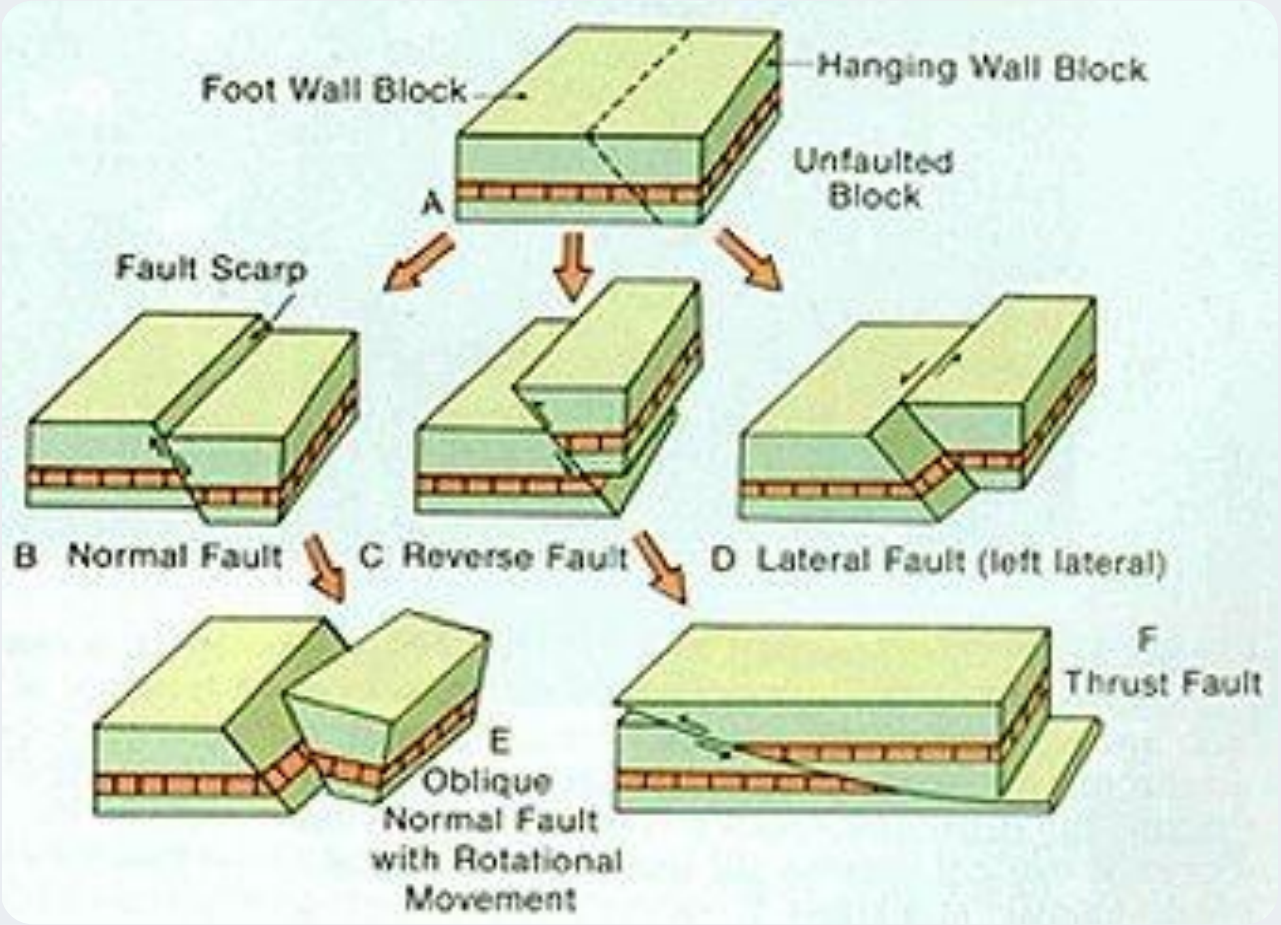
What Protection Relays Actually See

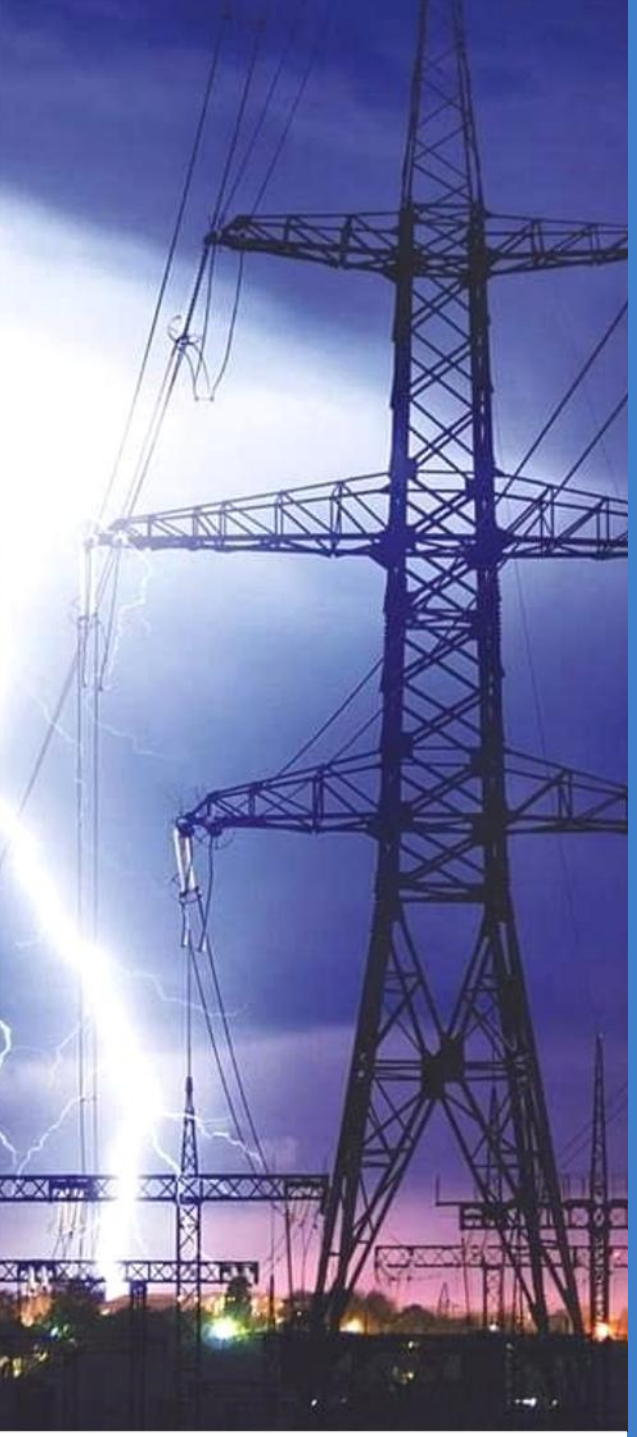
- CT secondary currents
- VT secondary voltages
- Discrete logic at sampling instants
- Threshold-based decisions



Possible Categories of “Vanishing” Faults

- Transient faults
- Intermittent high-impedance faults
- Non-electrical triggers
- Protection system artefacts



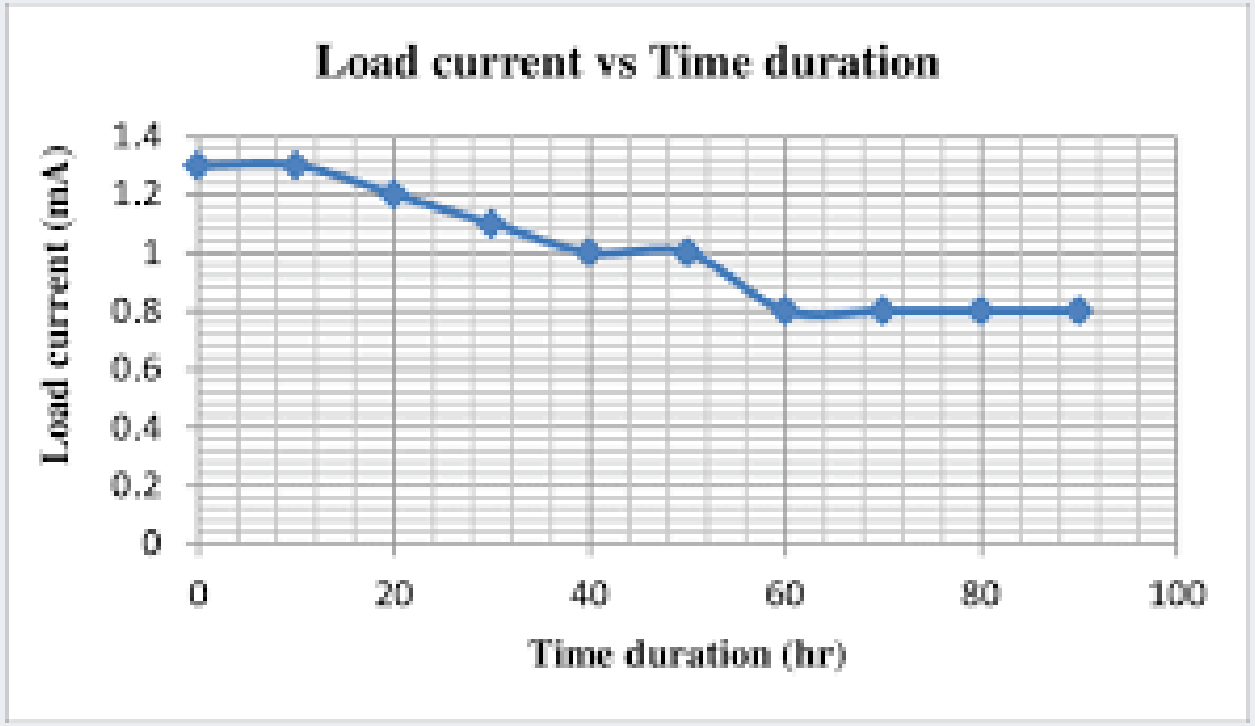


Transient Faults

- Lightning-induced over voltages
- Switching surges
- Momentary insulation breakdown

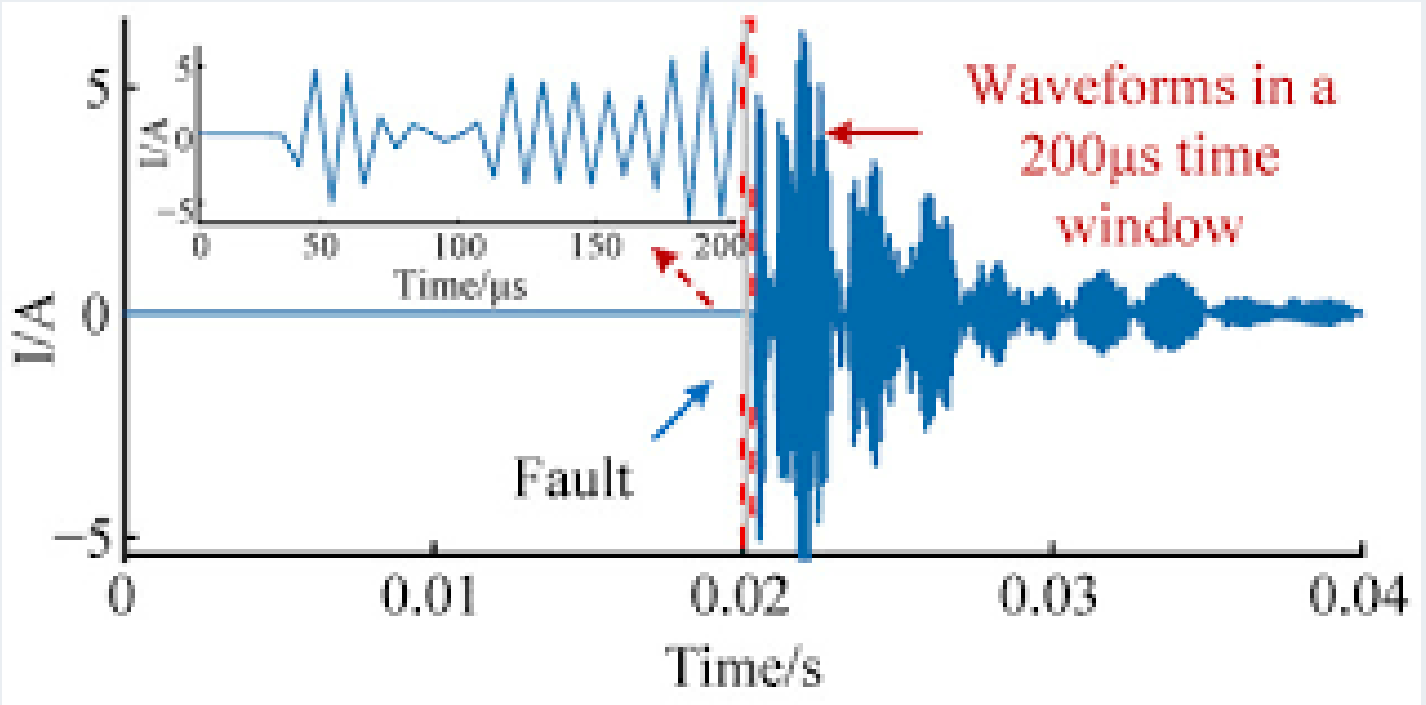
Why Transient Faults Leave No Trace

- Fault duration < relay event window
- Peak current clipped by CT saturation
- Event recorder not triggered



High Impedance Faults

- Definition and impact
- Challenges in detection
- Behaviour under varying load conditions

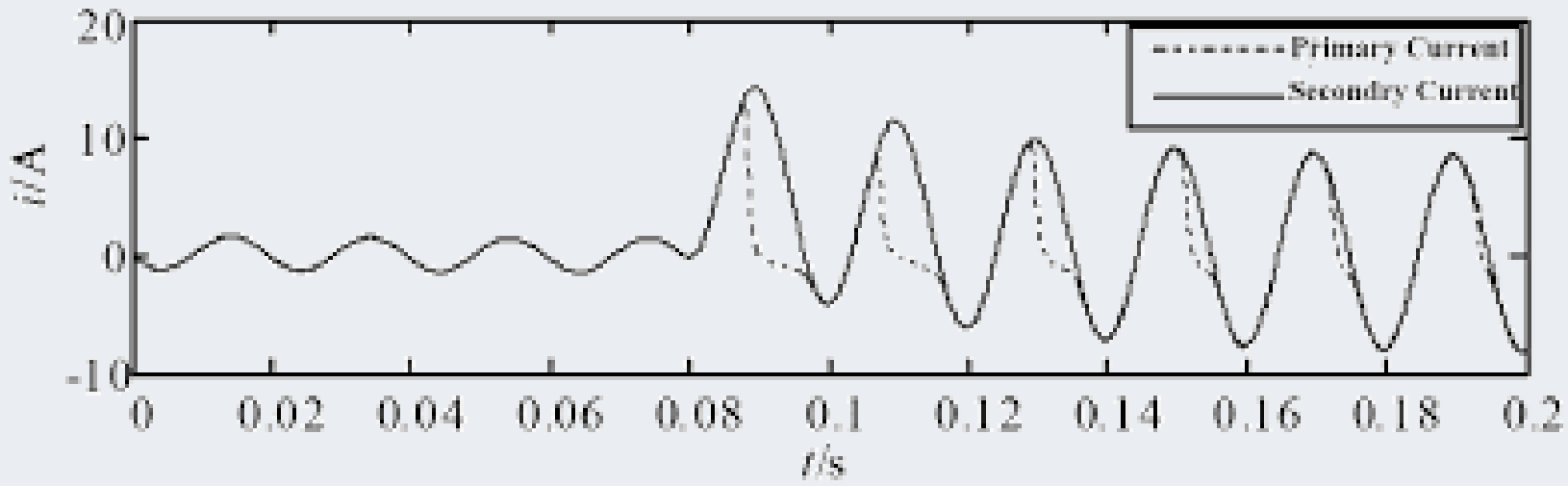


High-Impedance Fault Characteristics

- Low fault current
- Intermittent arcing
- Unstable arcing behaviour
- Often invisible to protection
- Loose connections
- Contaminated insulators
- Carbonised cable terminations

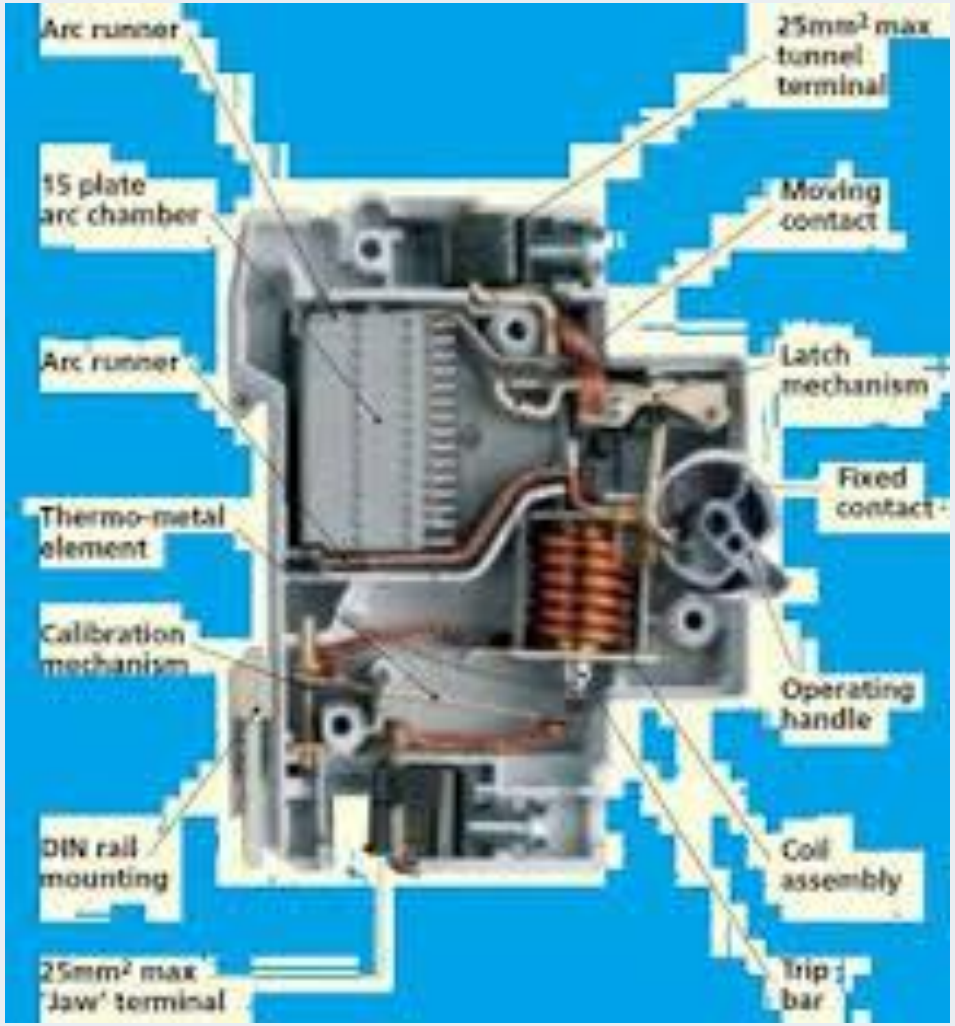
CT Saturation Effects

- High DC offset during faults
- Core saturation limits secondary current
- Relay sees reduced or distorted signal



Breaker Self-Protection Functions

- SF6 / vacuum pressure monitoring
- Spring charging supervision
- Internal pressure monitoring
- Anti-pumping logic



Mechanical and Auxiliary Causes

- Loose control wiring
- Vibration-induced contact bounce
- Auxiliary relay chatter

First Clues

- Logs indicate momentary disturbances
- Protection did not latch as permanent fault
- Vegetation proximity to line

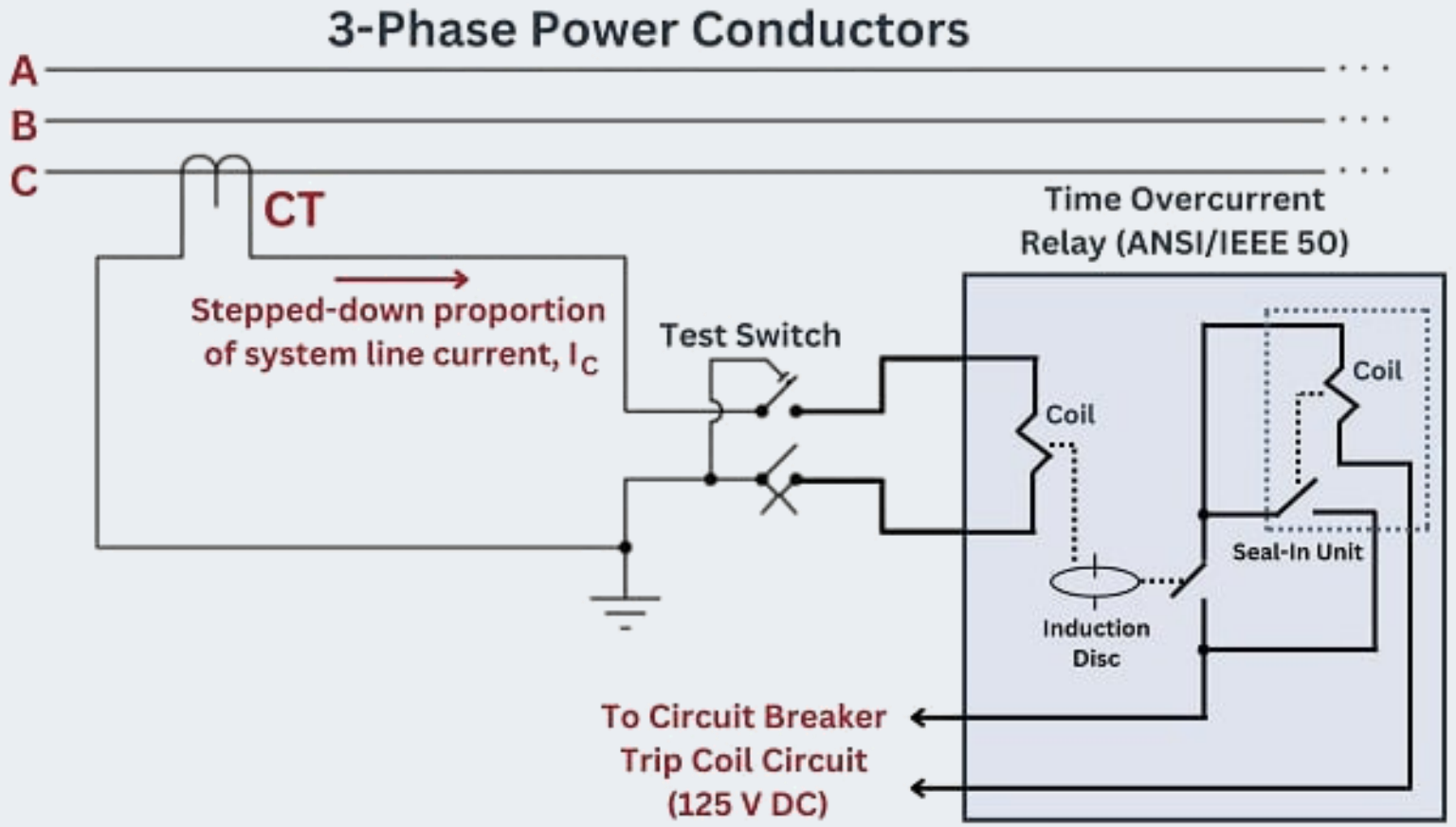
Engineering Investigations

- Transient fault considerations
- Arc-over potential
- Wind-induced conductor movement

Protection Coordination Issues

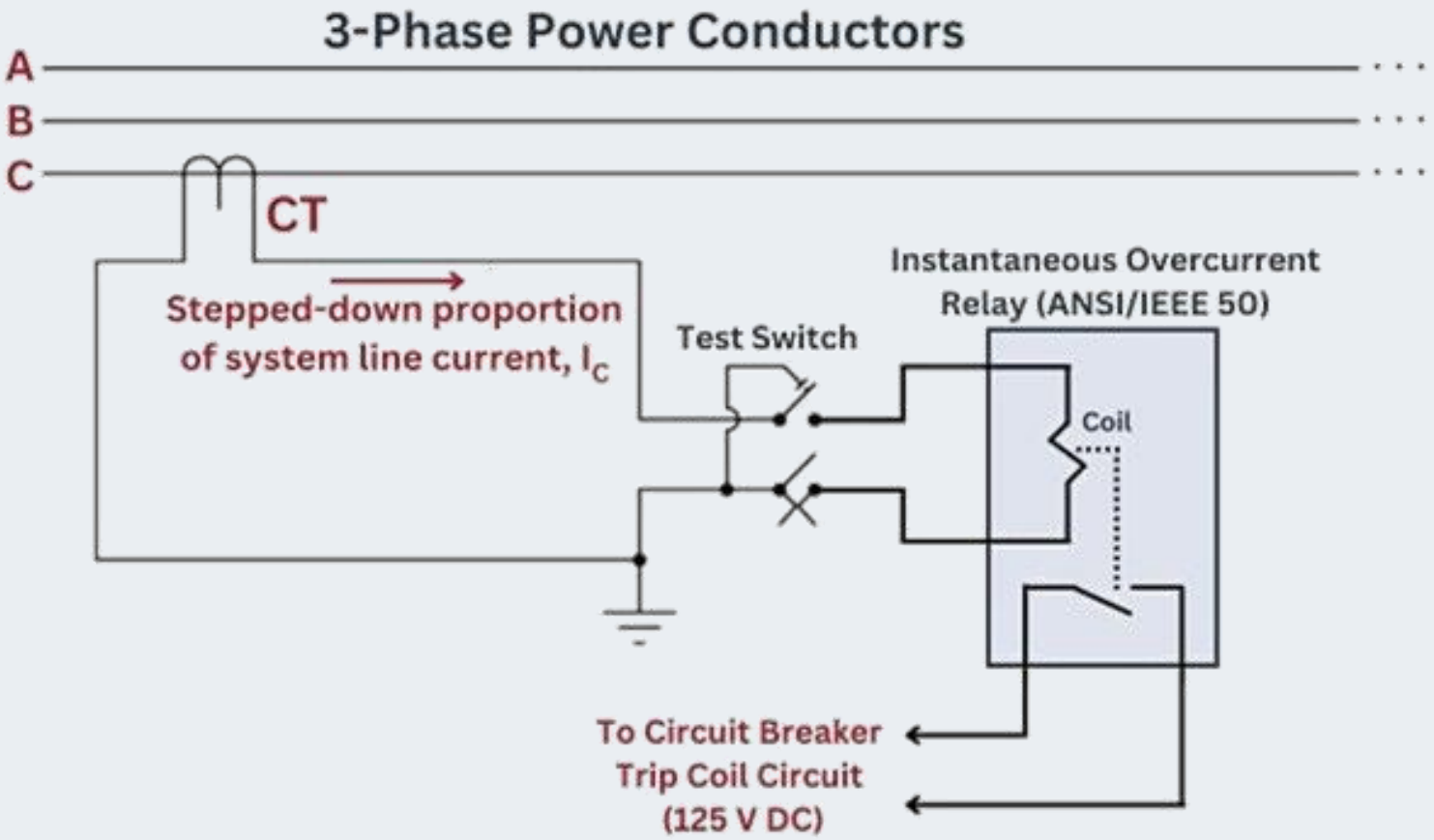
- Mis-coordination risks
- Short tripping times during transients
- Over-sensitivity of relay settings

Overcurrent Protection – 50 / 51



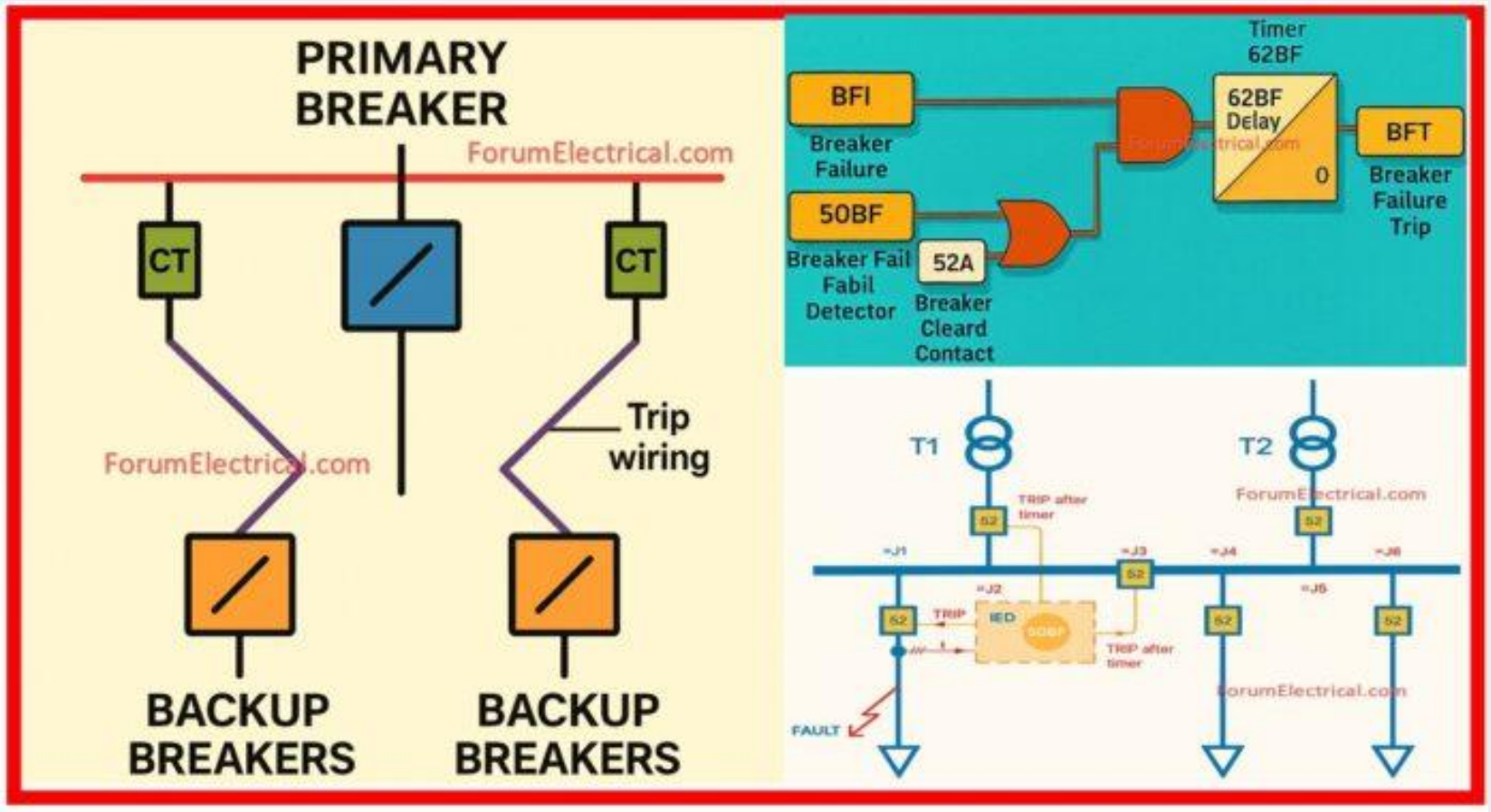
Instantaneous and inverse-time overcurrent elements may not operate for short-duration or distorted currents.

Earth Fault Protection – 50N / 51N



Residual current-based earth fault elements can miss high-impedance or transient faults.

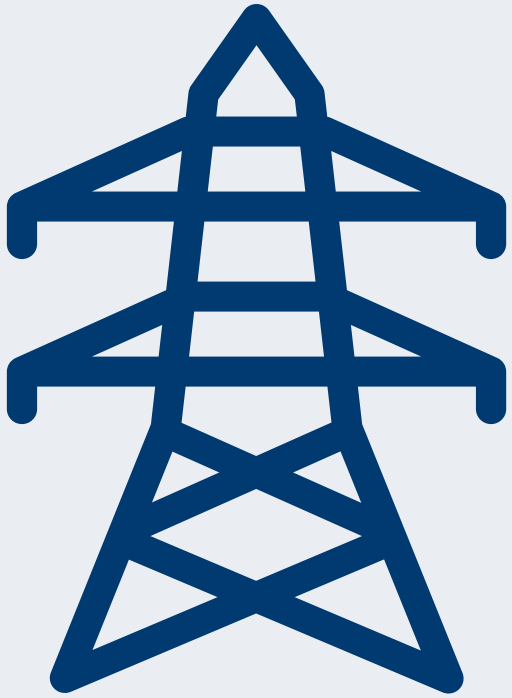
Breaker Failure Protection Logic



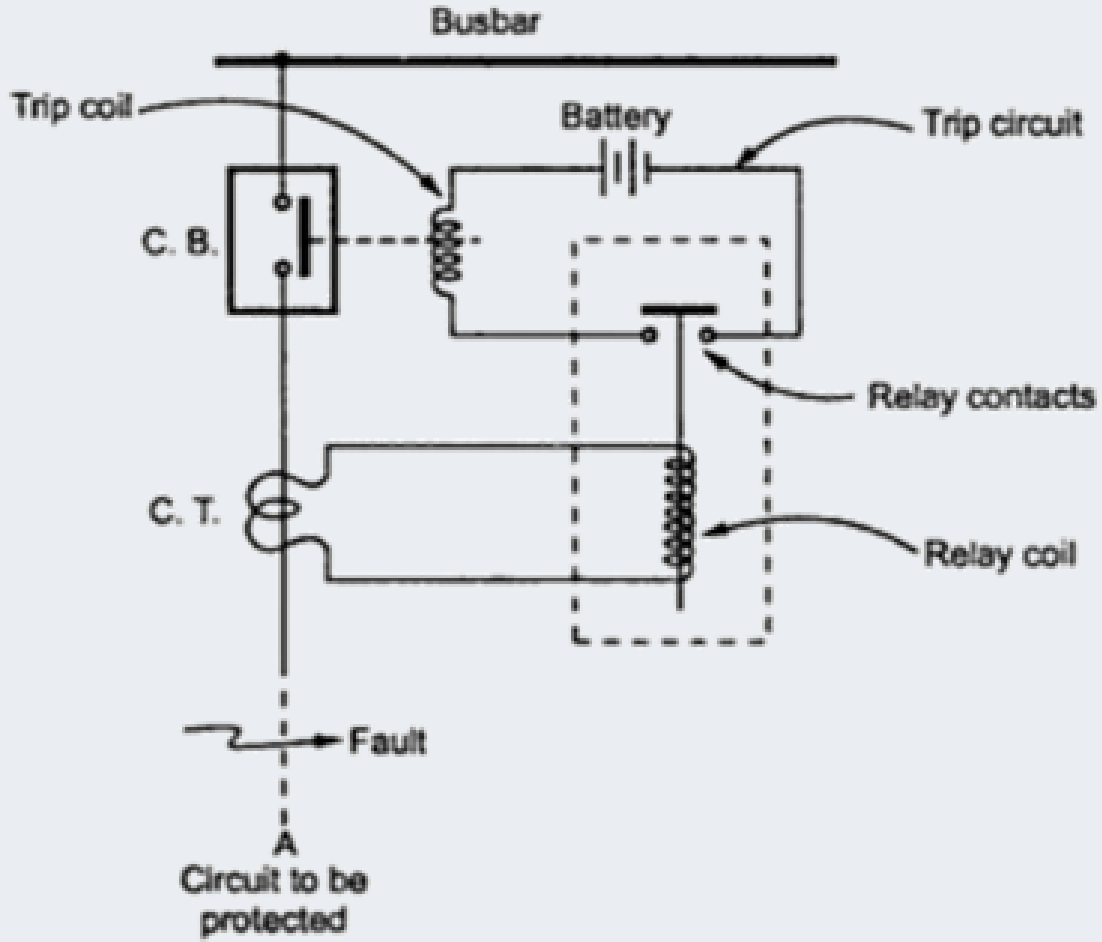
If the current does not decay after a trip command, breaker failure logic initiates backup tripping.

Role of DC Control Systems

- Protection depends on DC integrity
- DC faults cause false trips
- Often overlooked in investigations



DC Trip Circuit – Simplified Schematic



Unintended leakage or wiring faults can energise the trip coil without any primary fault.

Environmental Influences

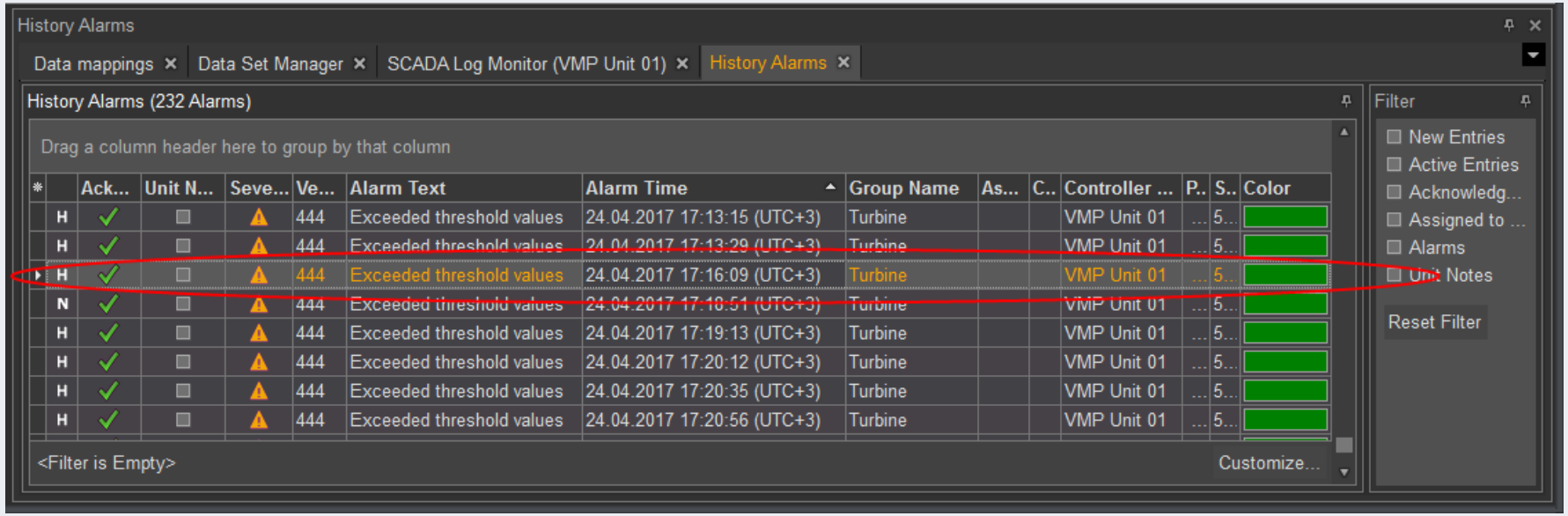
- Moisture ingress
- Temperature extremes
- Dust and contamination

Human Factors

- Maintenance-induced latent faults
- Incorrect settings updates
- Temporary test links left installed

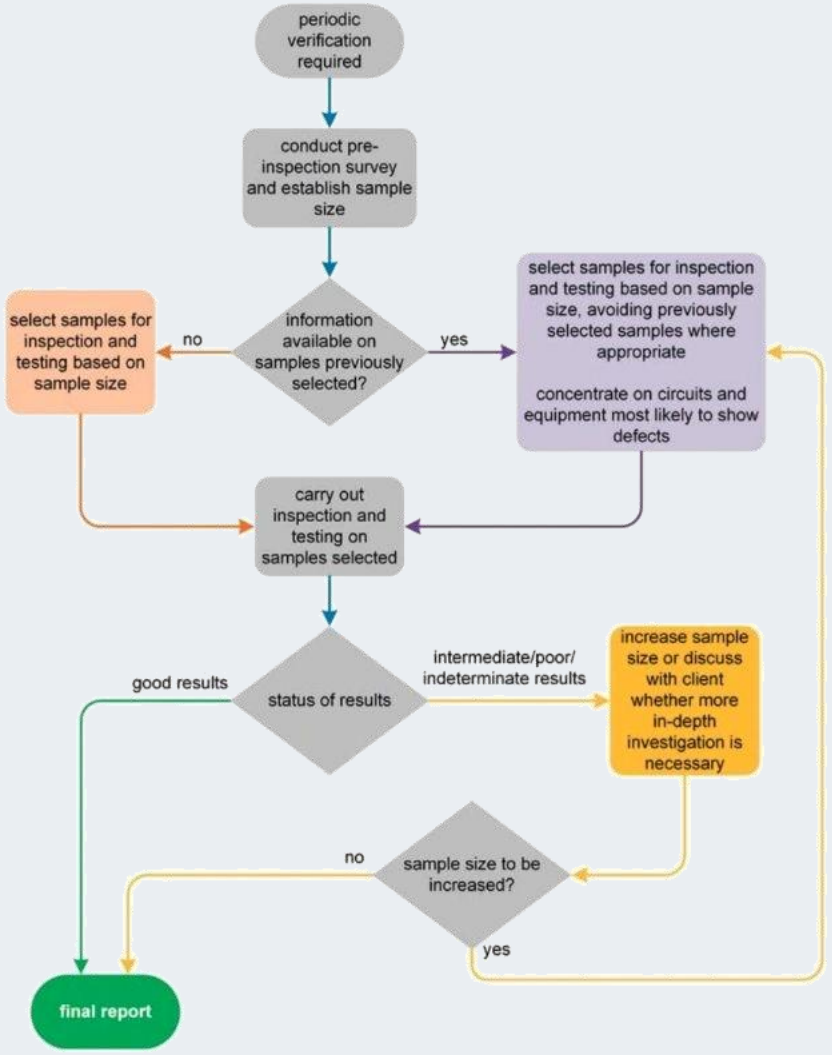
Event Records vs Reality

- No record ≠ no event
- Resolution and triggering matter
- Logs require interpretation



Structured Investigation Approach

- Preserve evidence
- Review settings and logic
- Inspect primary equipment
- Test DC and auxiliary circuits



Asking the Right Questions

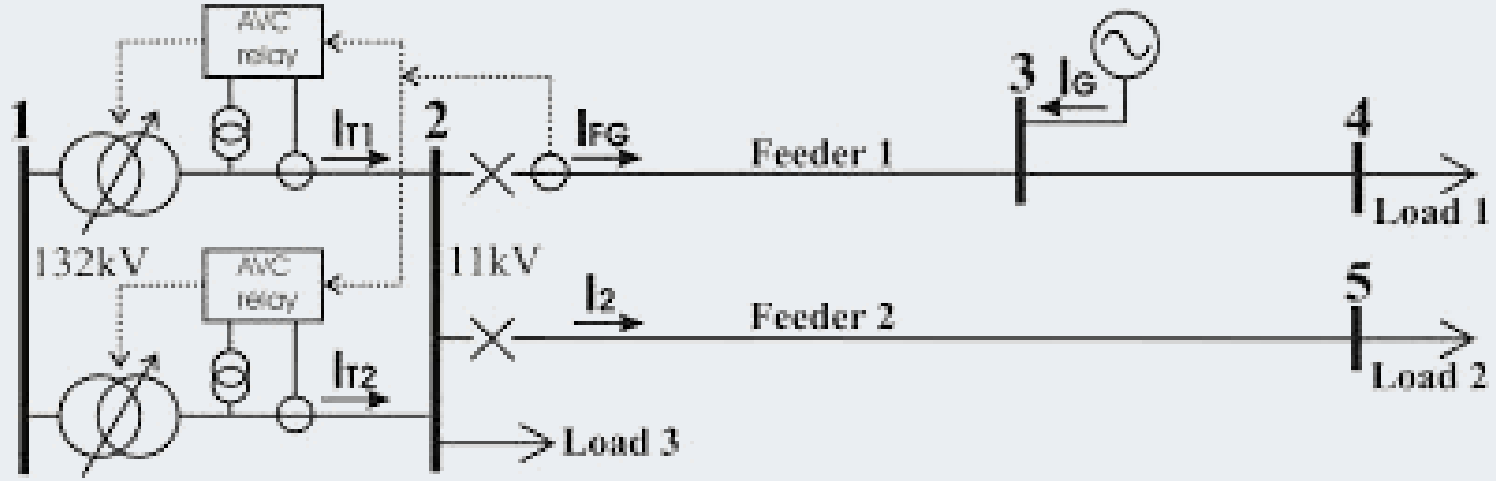
- What changed recently?
- Was weather involved?
- Did anything almost fail?

Case Resolution

- Moisture in marshalling kiosk
- DC trip circuit leakage
- Momentary unintended trip

Why No Fault Was Recorded

- No primary fault current
- Relay never asserted
- Trip initiated in control circuit



What Students Usually Miss

- DC systems importance
- Environmental effects
- Human–machine interfaces

How This Appears in Practice

- Nuisance trips
- Loss of customer confidence
- Regulatory scrutiny

Engineering Judgment Under Uncertainty

- Decisions without complete data
- Balancing risk and cost
- Knowing when to escalate

Discussion Questions

- Would you reclose immediately?
- What evidence would you demand?
- When is replacement justified?

Key Takeaways

- Not all trips are electrical faults
- Protection has blind spots
- Good engineers are good detectives

Deepening the Investigation

- Load variations influencing sensitivity
- Local weather impact
- Soil and environmental conditions

Root Cause Revealed

- Arc-over due to vegetation during wind
- Transient and self-clearing nature
- Protection activated before clearing

Missed Factors

- No transient monitoring devices in place
- Assumptions about permanent faults
- Inadequate vegetation clearance planning

Professional Insight

- Importance of SCADA data review
- Use of high-speed fault recorders
- Routine environmental risk assessments

Design and Protection Checklist

- Review relay coordination
- Include transient scenarios
- Vegetation and environmental inspections

Regulatory Implications

- AS/NZS 3000 requirements
- IEC transient protection standards

Lessons for Professional Engineers

- Transient faults can cause breaker trips without permanent faults
- Data analysis is crucial
- Coordination saves operational costs
- Think beyond fault currents
- Respect auxiliary systems
- Investigate systematically

Conclusion

- Understanding transient phenomena prevents misdiagnosis
- Proactive engineering reduces downtime
- “Absence of evidence is not evidence of absence.”

Q&A

- Questions and discussions
- Real-world insights welcome

Thank You!

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Bachelor of Engineering (Honours) in Electrical Engineering	September 2026, February 2027
Master of Science (Power System Analysis and Renewable Integration)	October 2026, February 2027
Master of Science (Industrial Automation and Instrumentation Control)	October 2026, February 2027

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