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Mysteries: When Lightning Didn't Strike, but the Surge Arresters Blew

16 April 2026

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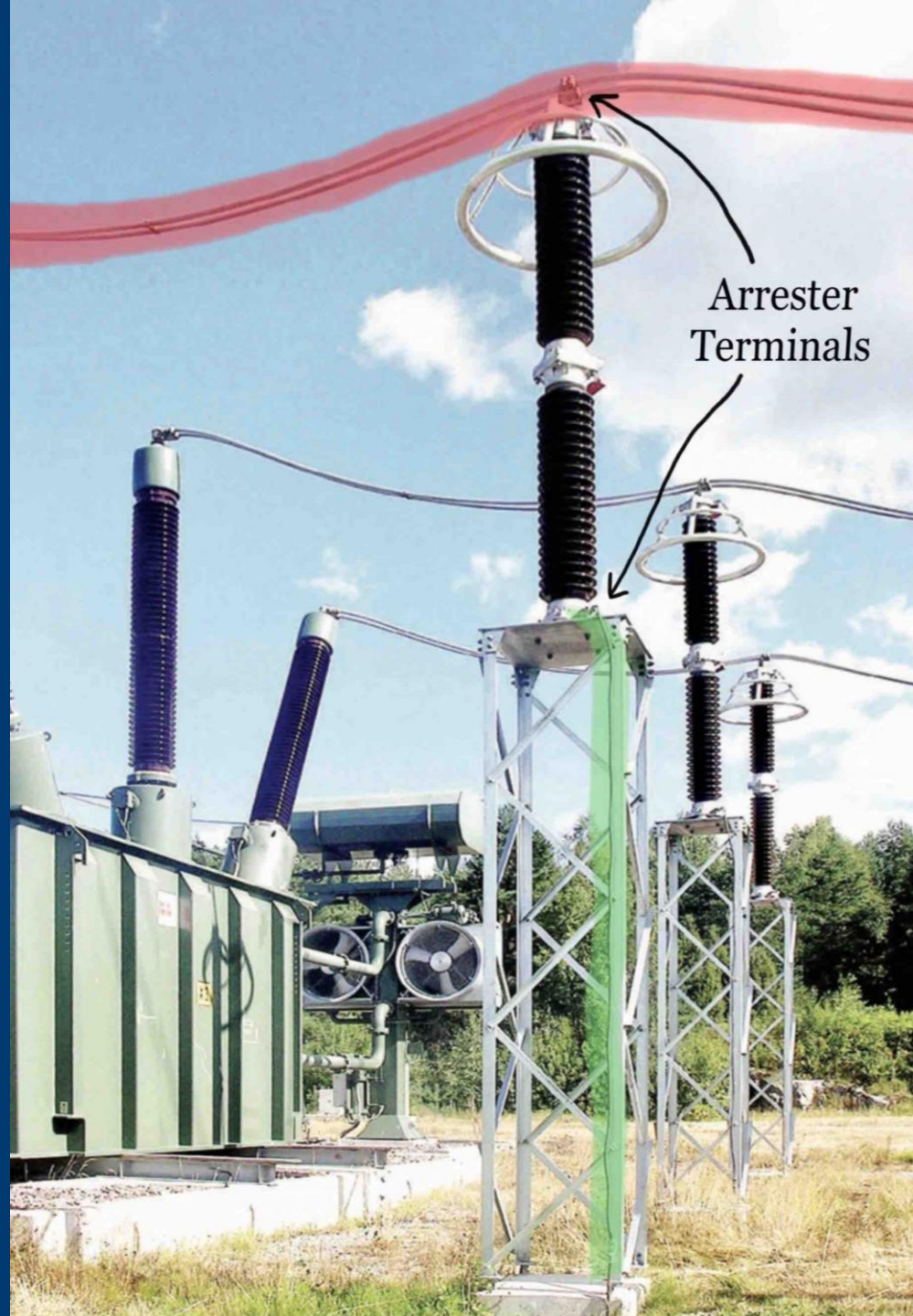
Emeritus Professor Akhtar Kalam

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.

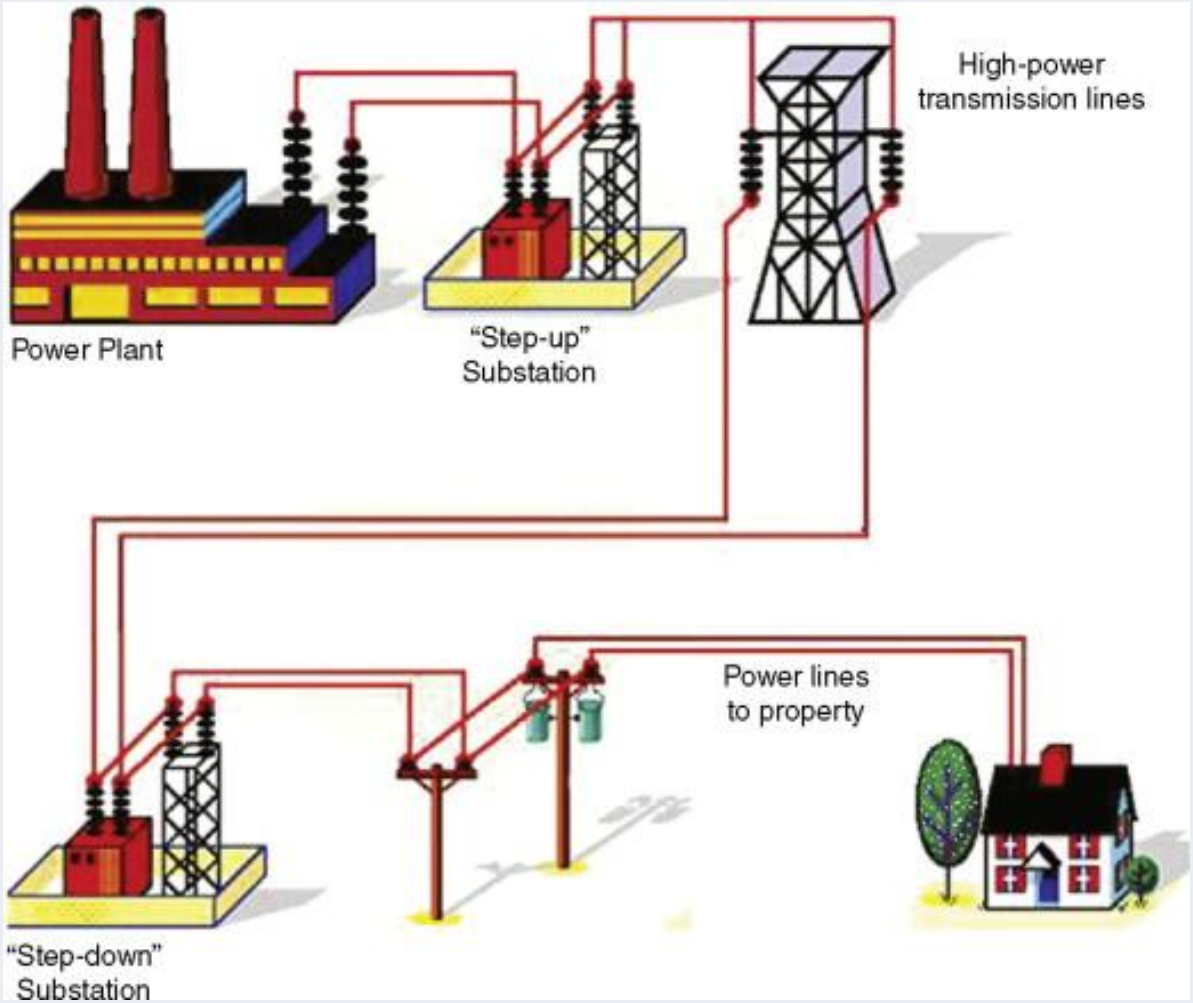
"My vision is to provide exciting higher education science and engineering courses, research, consultancy and collaborate in development work of the industry and communities within Australia and beyond."

Agenda

	Learning Objectives
	Overview
	Hypotheses
	Engineering Lessons
	Solution
	Takeaways
	Q&A

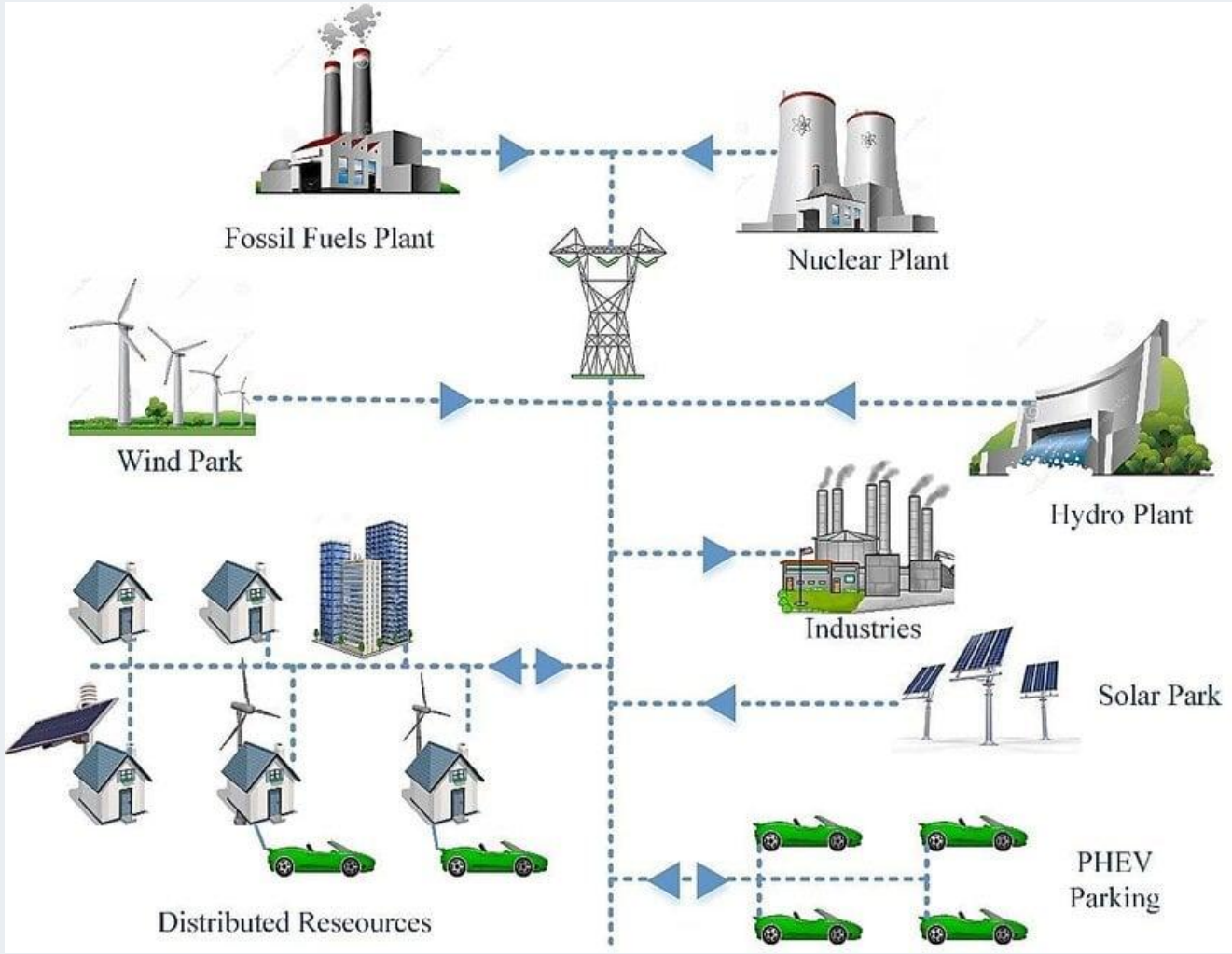
Learning Objectives

- Understand the surge arrester operation
- Analyse non-lightning transient events
- Diagnose protection failures
- Apply system-level reasoning



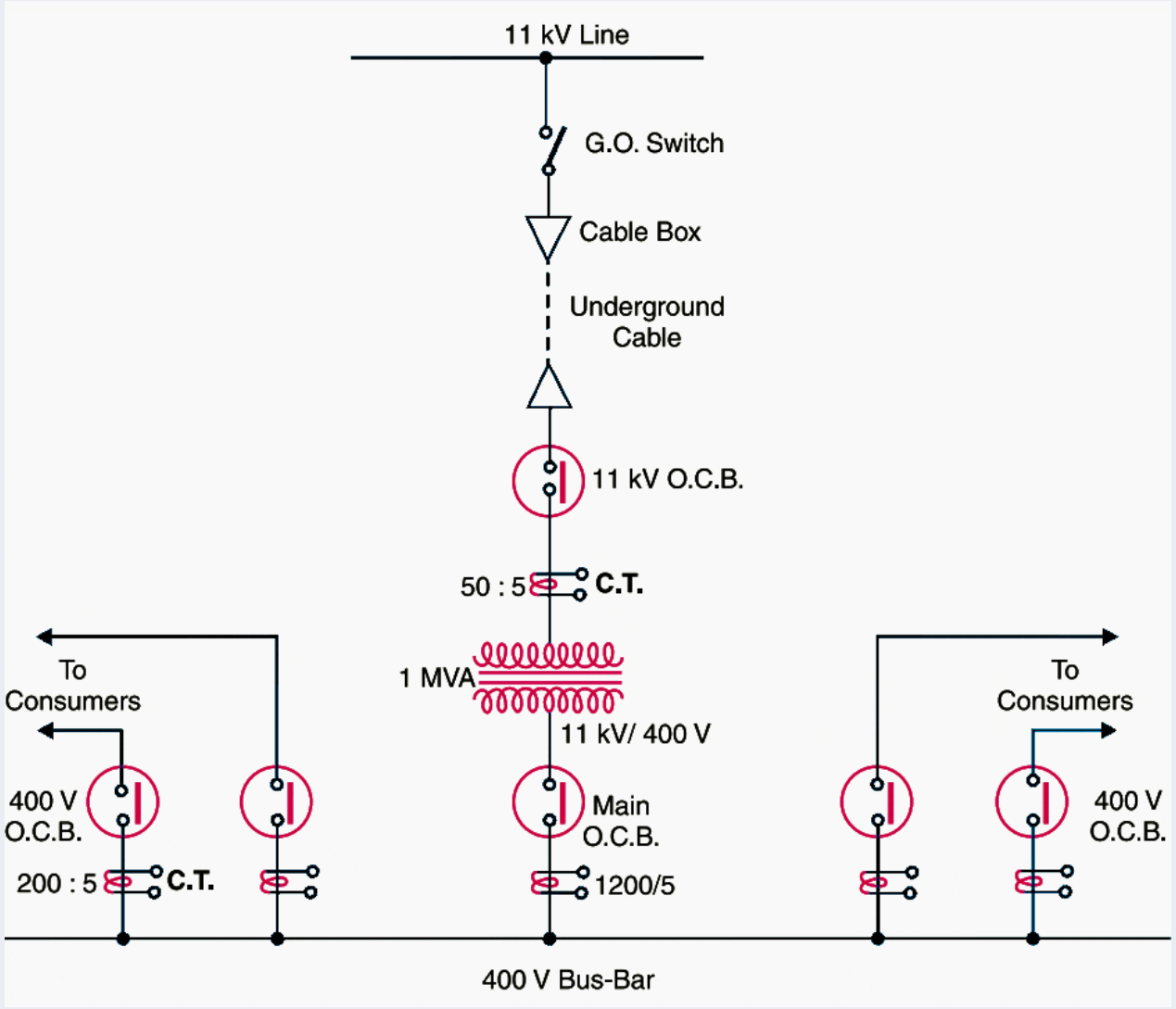
Why This Case Matters

- Increasing unexplained equipment failures
- The growing complexity of modern grids
- Misinterpretation of protection events



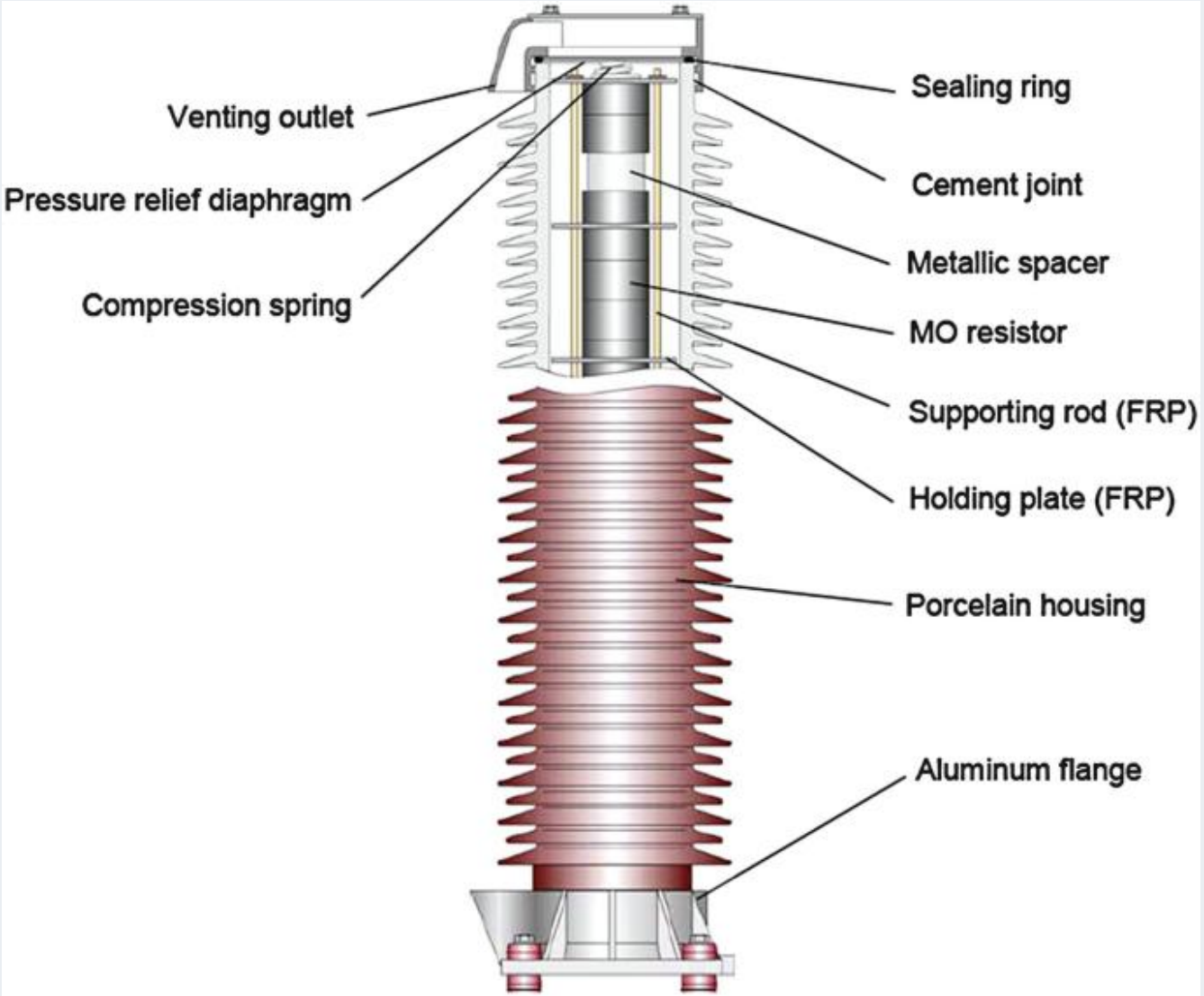
Case Scenario

- 11 kV distribution feeder
- Multiple surge arresters failed
- No lightning recorded
- Failures occurred within minutes



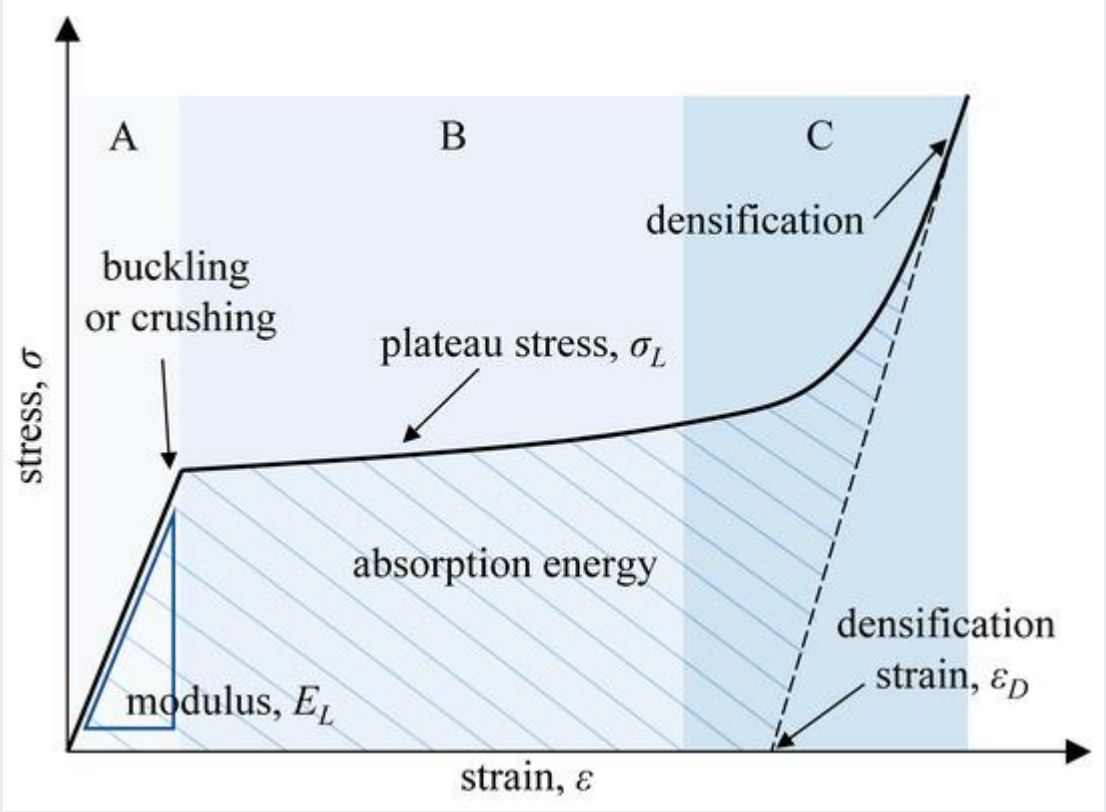
What is a Surge Arrester?

- Protective device against overvoltage
- Diverts surge energy to ground
- Typically, metal oxide varistor (MOV)



Normal Operation

- High resistance under normal voltage
- Conducts during overvoltage
- Returns to normal after surge



Failure Observations

- Arrester rupture
- Burn marks
- No external lightning evidence

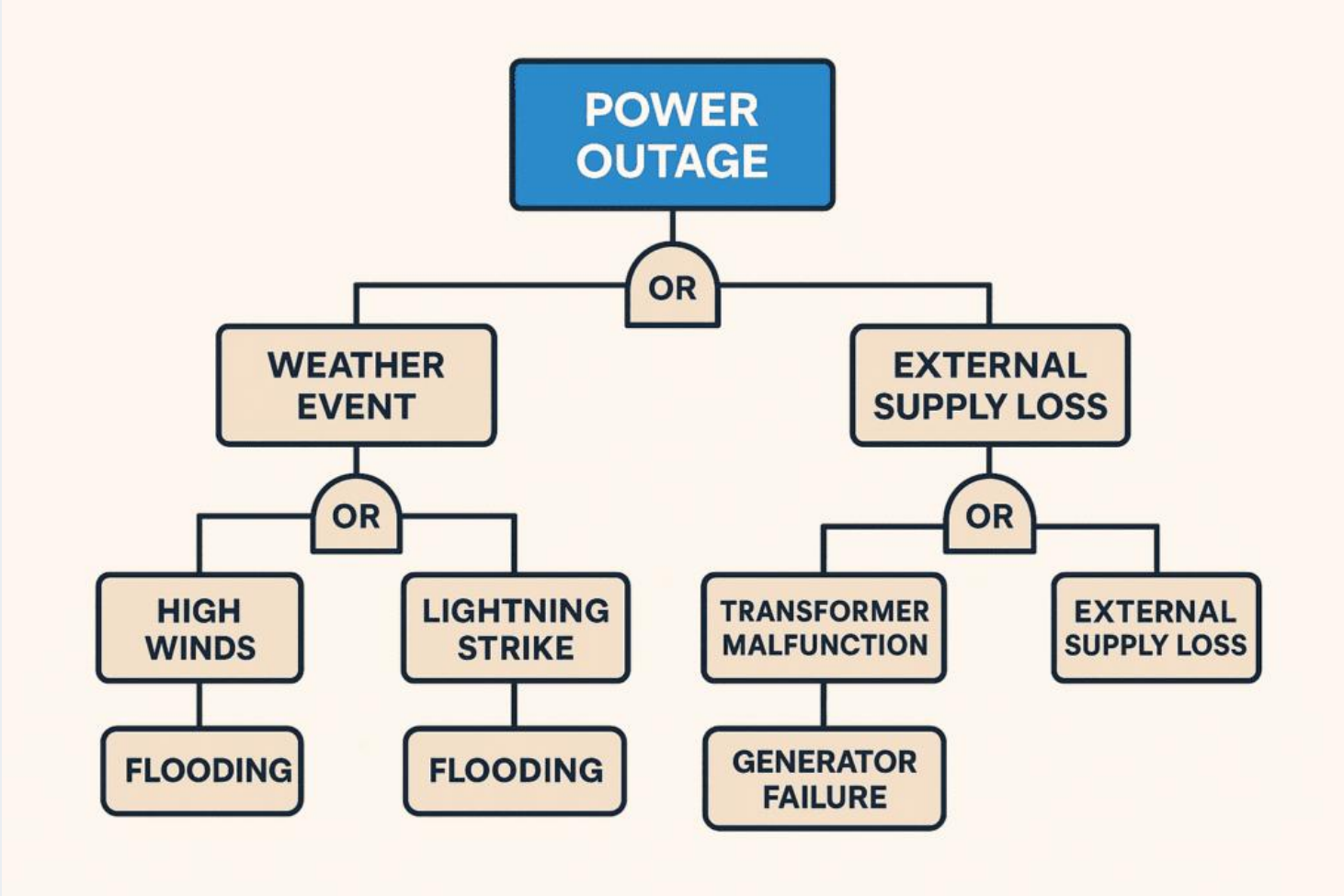
a) Slip-on housing blown off.

b) Mold-in-place housing split.

c) Small holes.

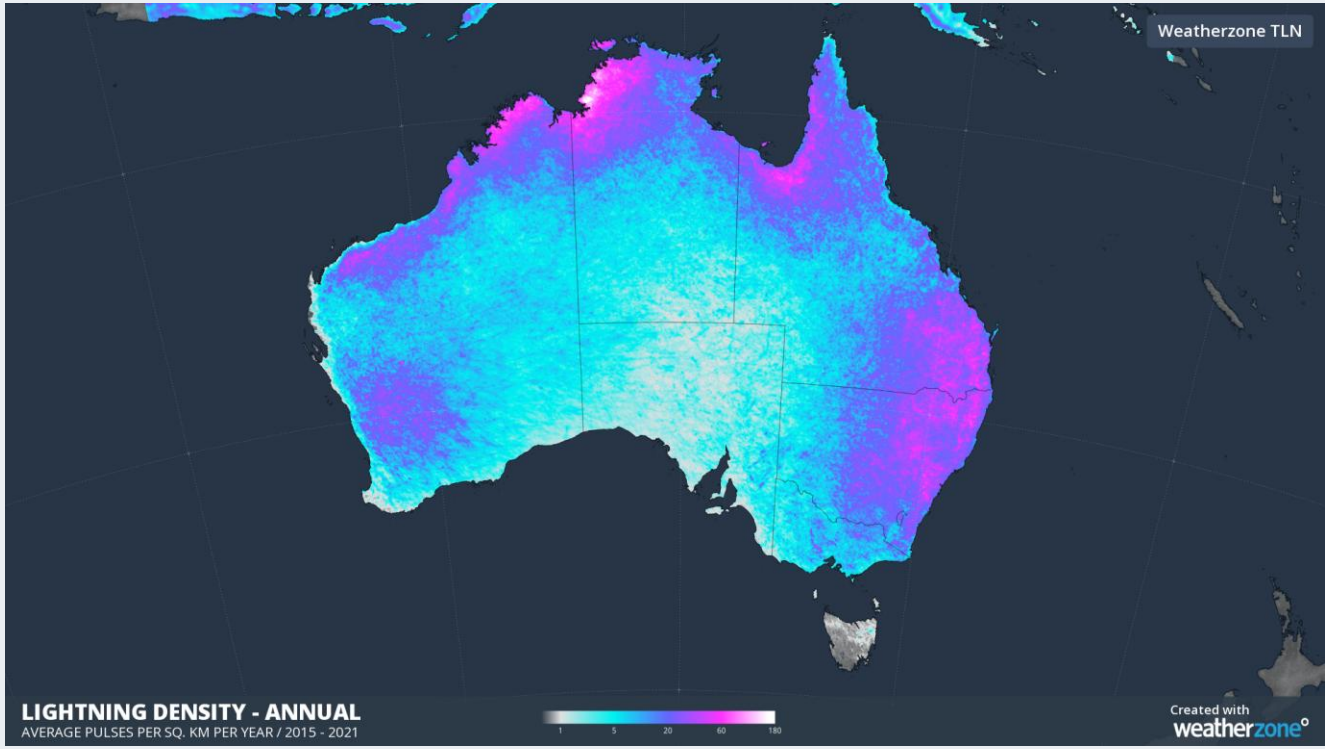
Initial Hypotheses

- Undetected lightning
- Manufacturing defect
- Ageing
- System transient



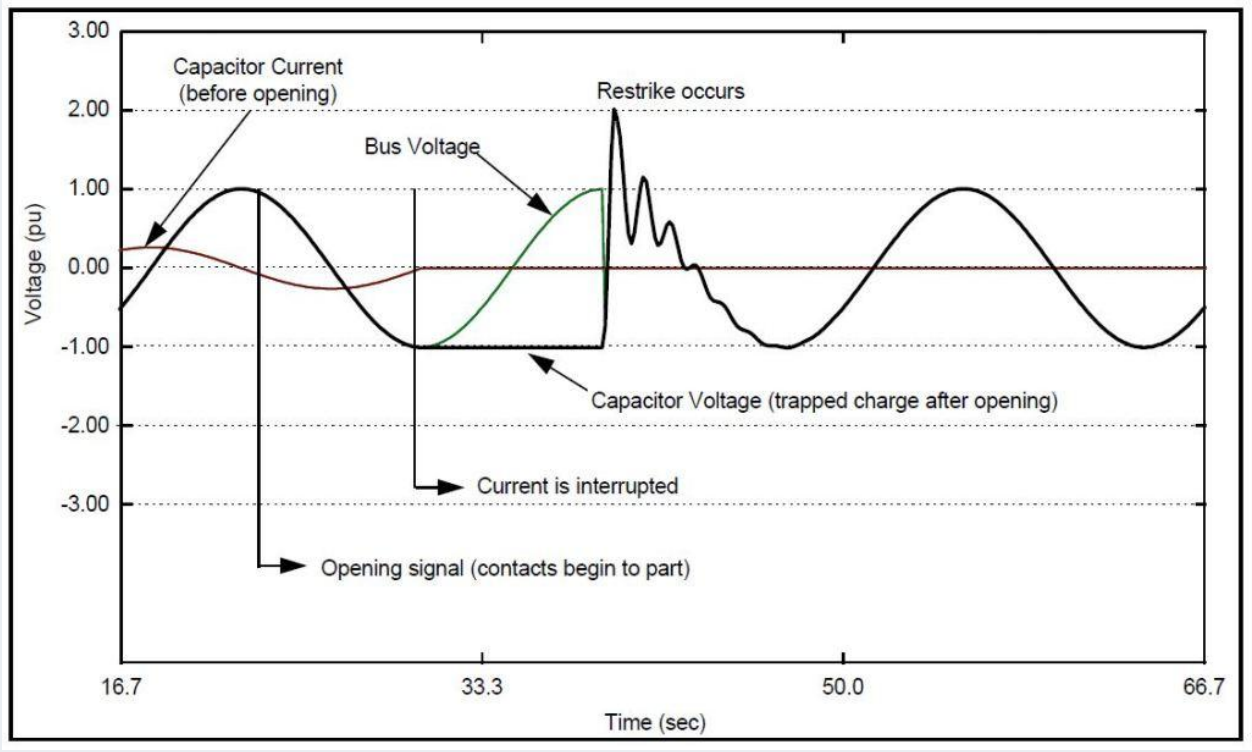
Lightning Data Analysis

- No strikes recorded in the area
- Weather conditions stable
- Hypothesis rejected



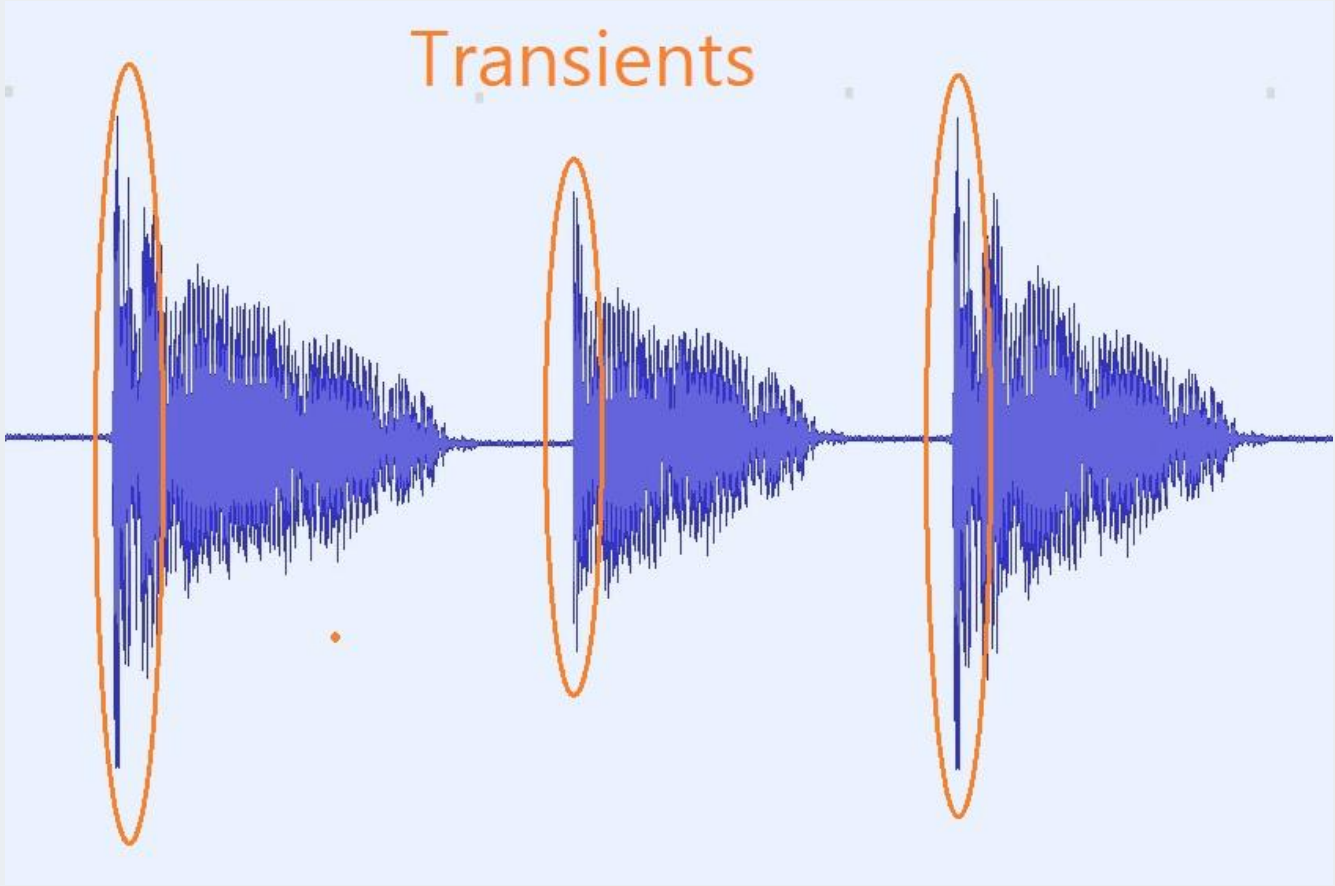
Load & Switching Logs

- Switching operations occurred
- Capacitor bank energisation
- Timing aligns with failure



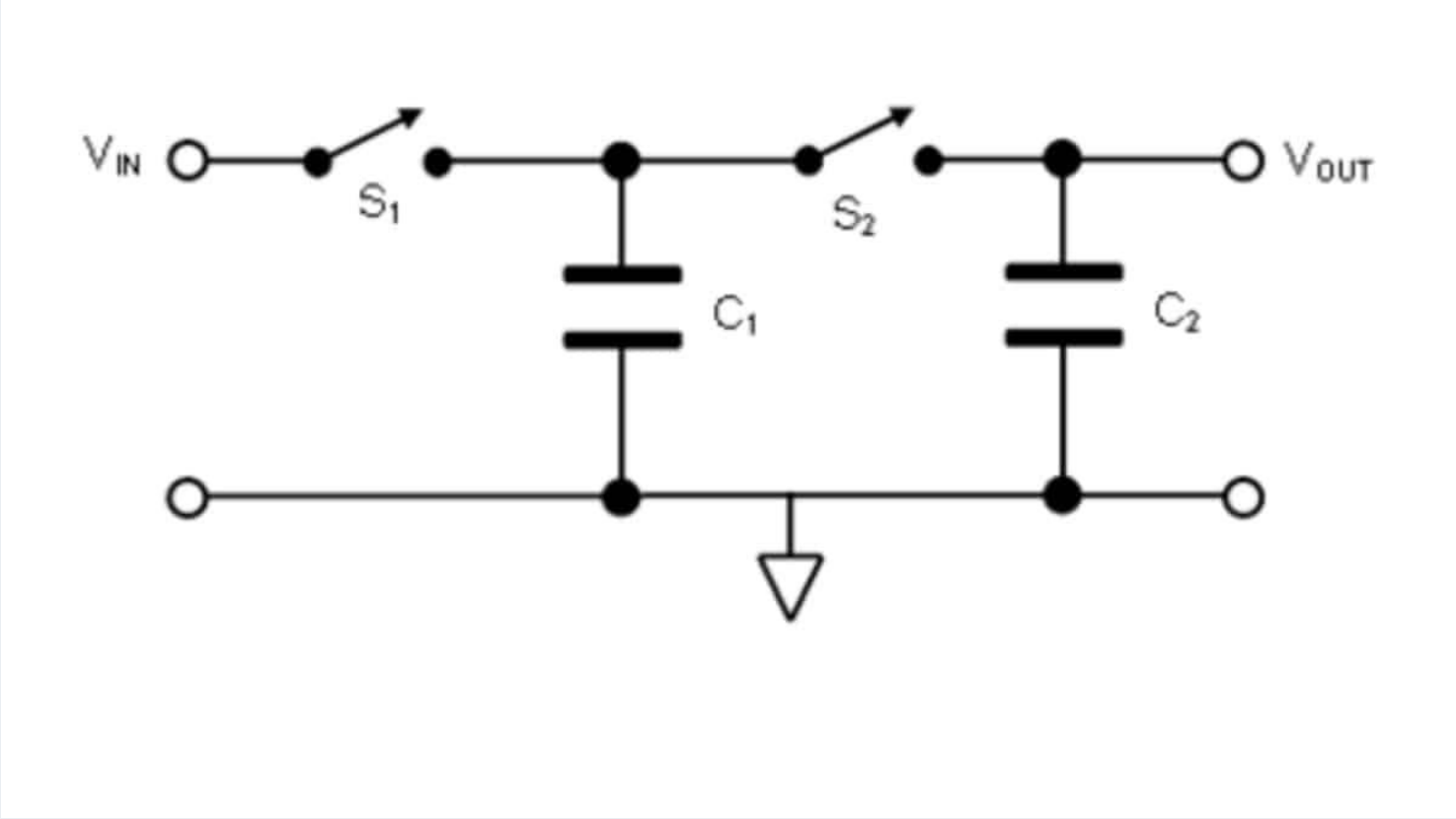
Switching Transients

- Fast voltage spikes
- High frequency oscillations
- Can exceed insulation limits



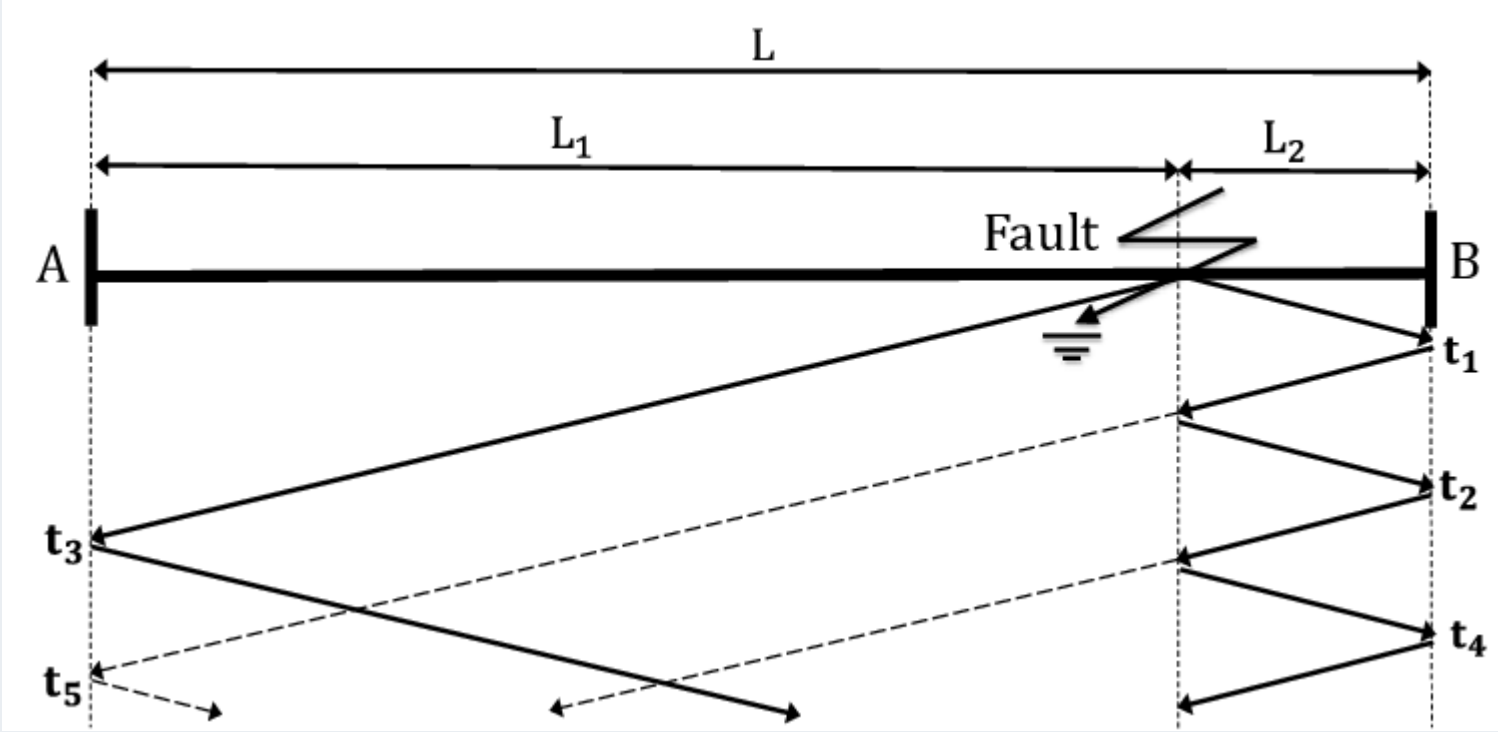
Capacitor Bank Energisation

- Inrush current
- Voltage overshoot
- Resonance possibility



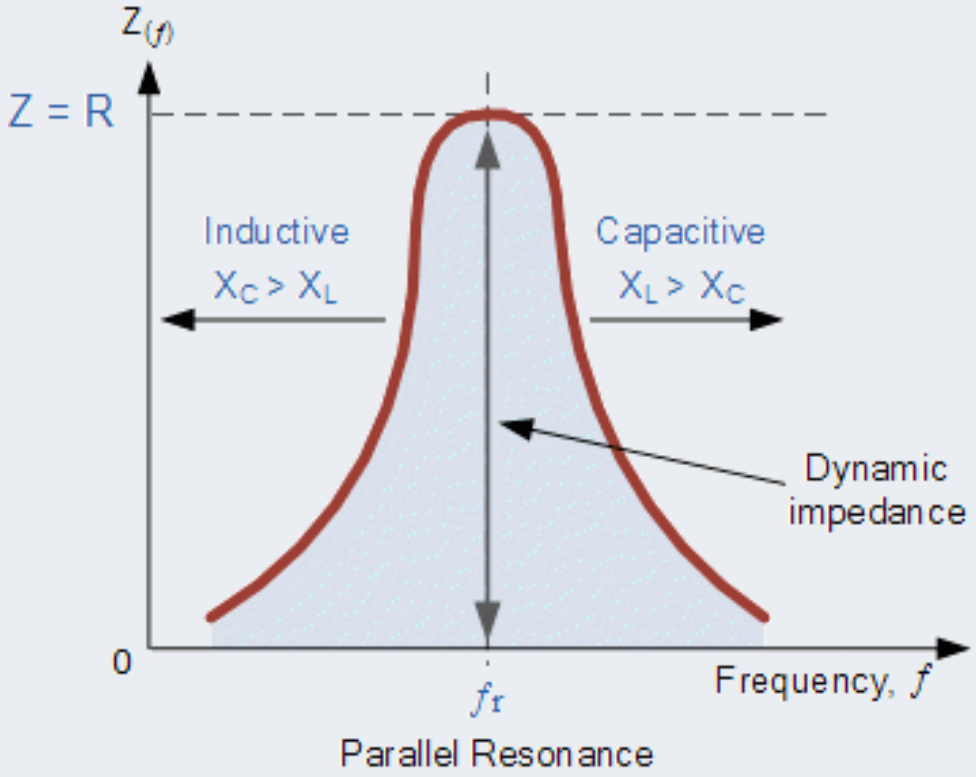
Travelling Waves

- Reflections along feeder
- Voltage amplification
- Localised overvoltage



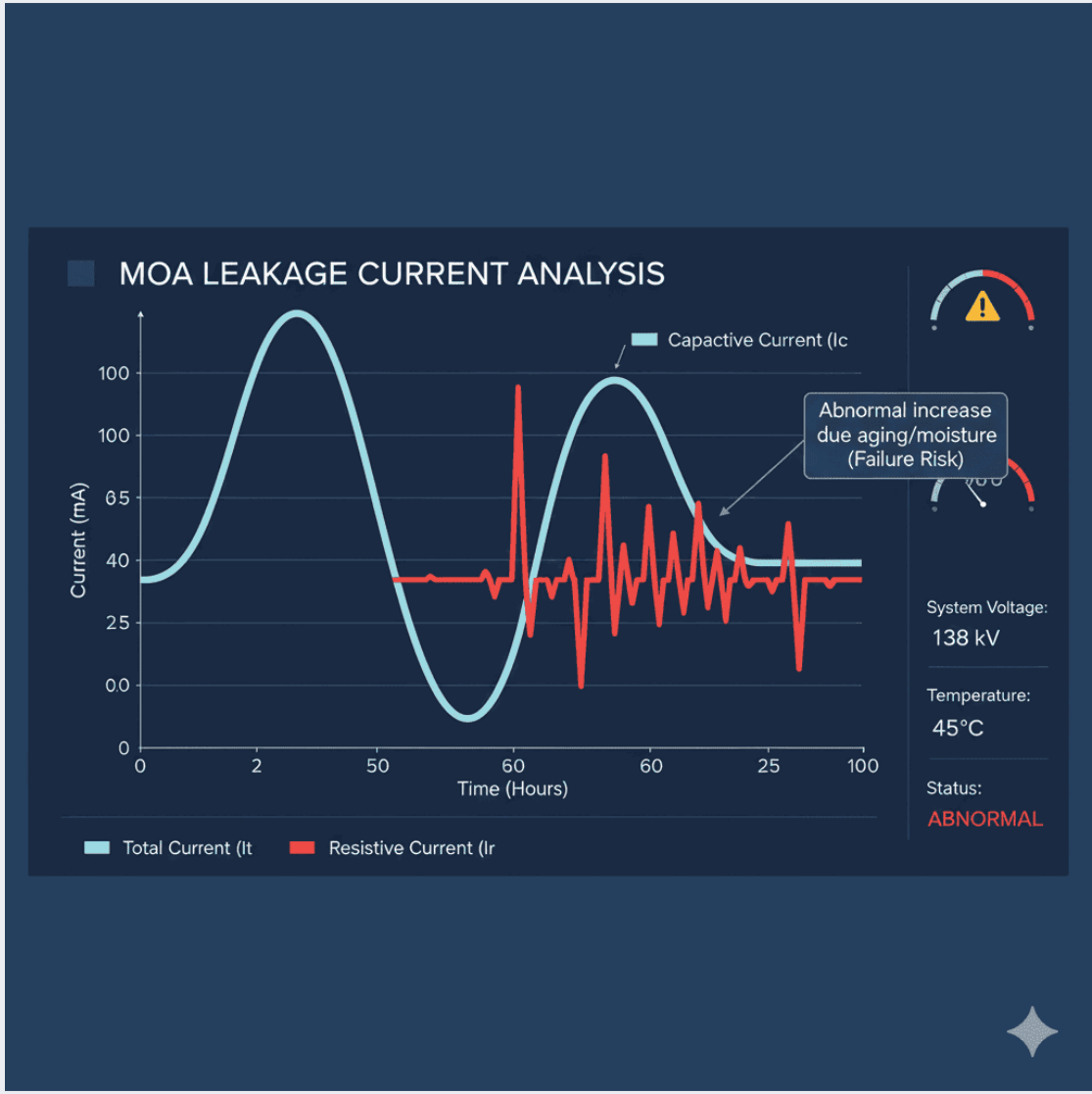
Resonance Condition

- Inductance + capacitance interaction
- Amplified oscillations
- Sustained overvoltage



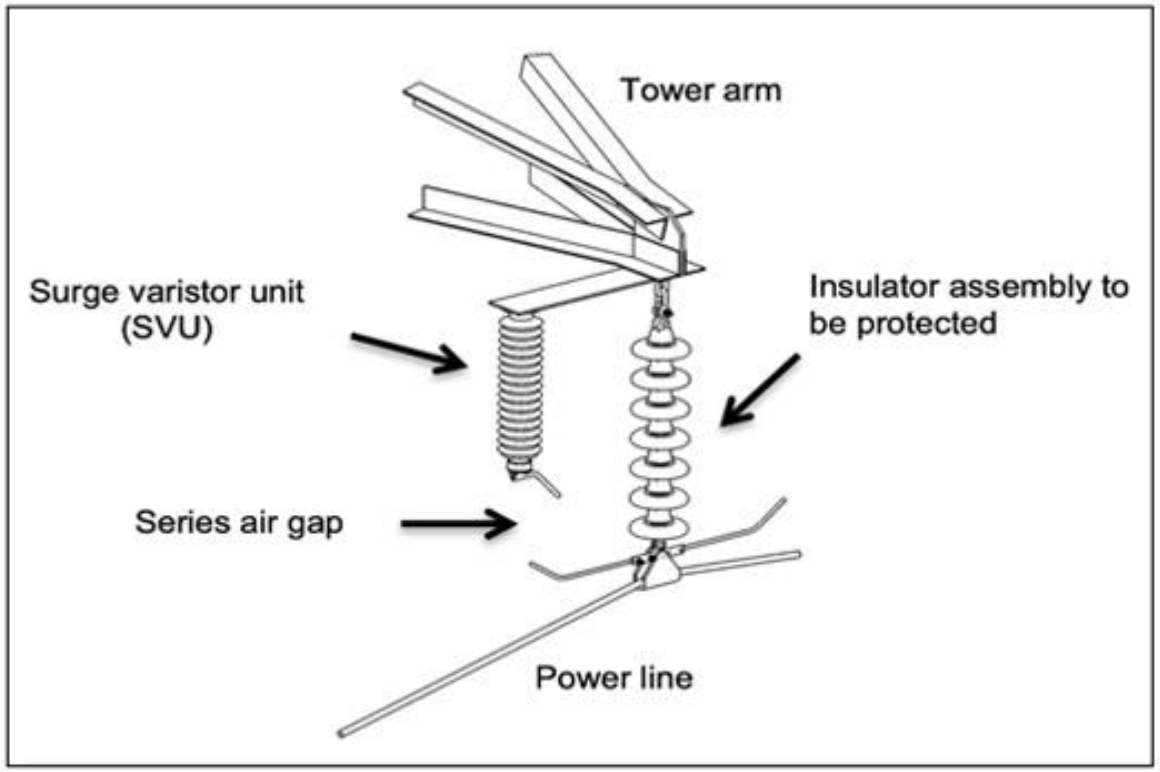
Arrester Stress Mechanism

- Repeated energy absorption
- Thermal buildup
- Failure without lightning



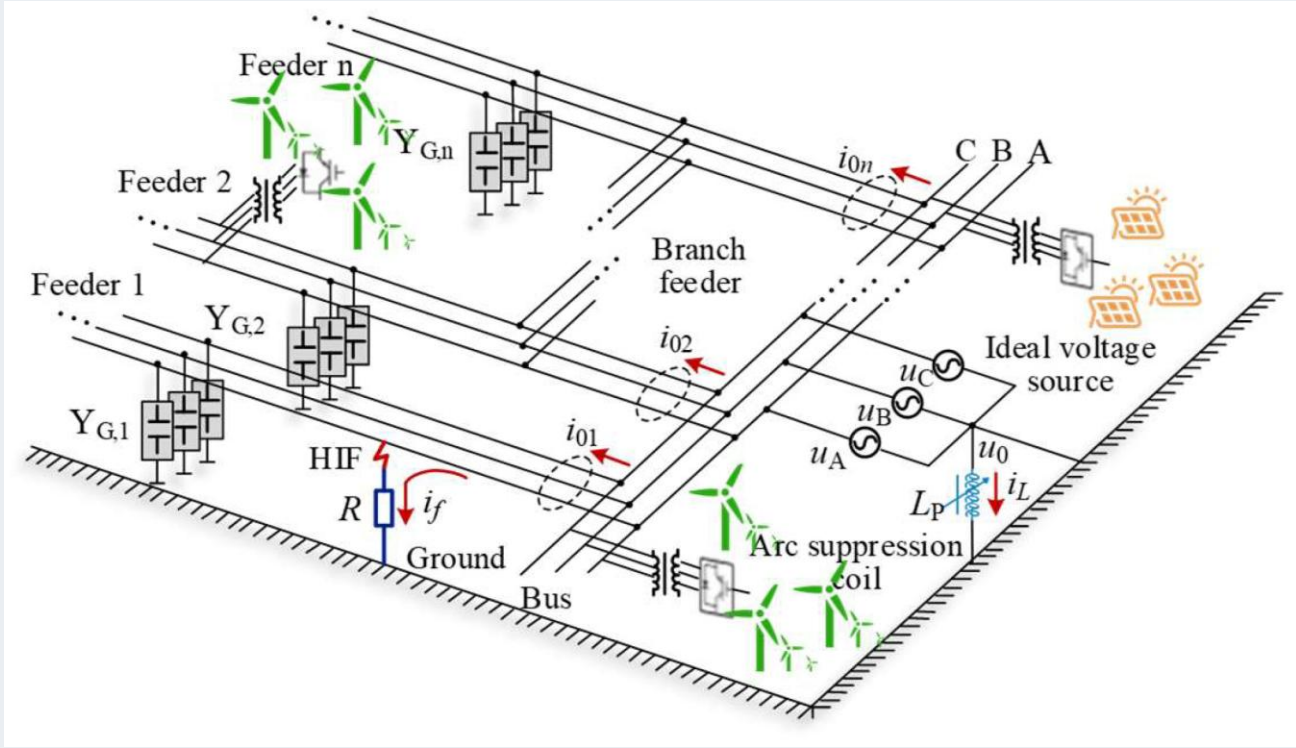
Hidden Cause Identified

- Capacitor switching transient
- Resonance in feeder
- Repetitive stress on arresters



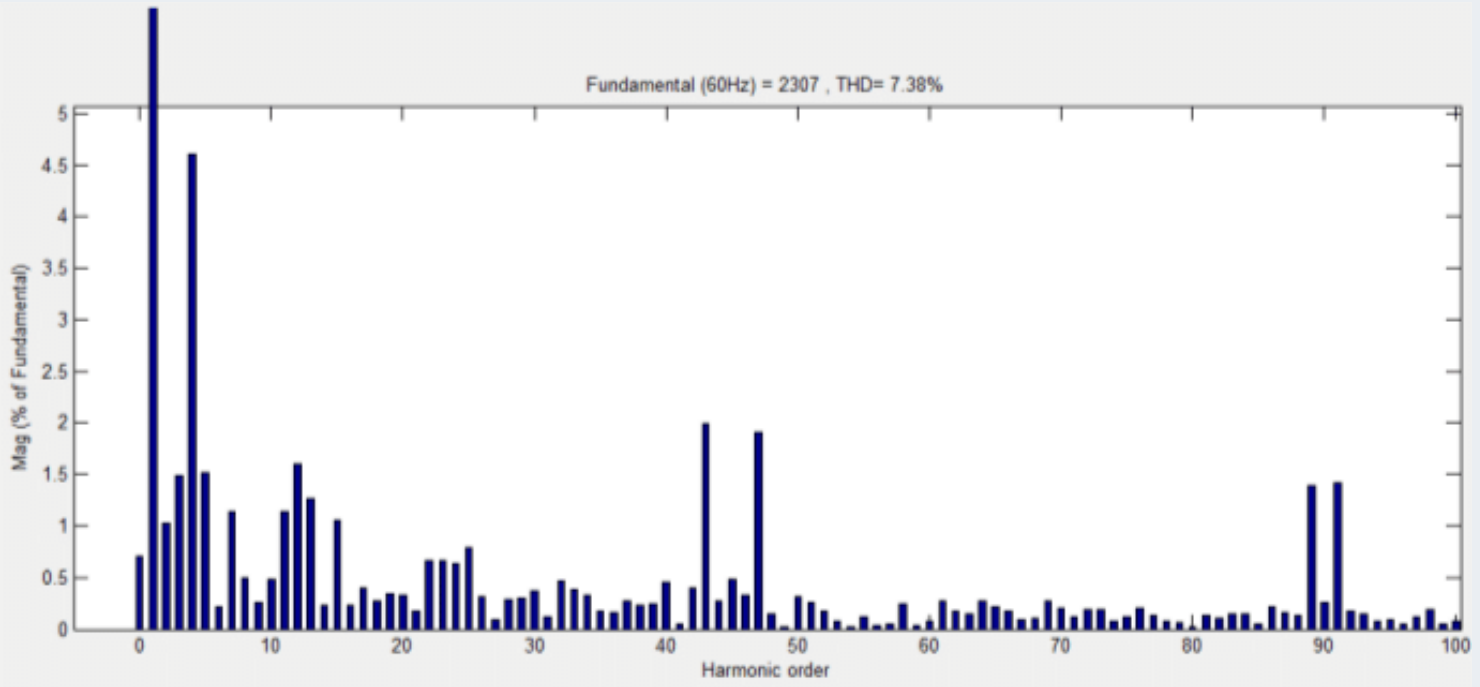
Why Multiple Failures?

- Distributed resonance points
- Similar arrester ratings
- Simultaneous exposure



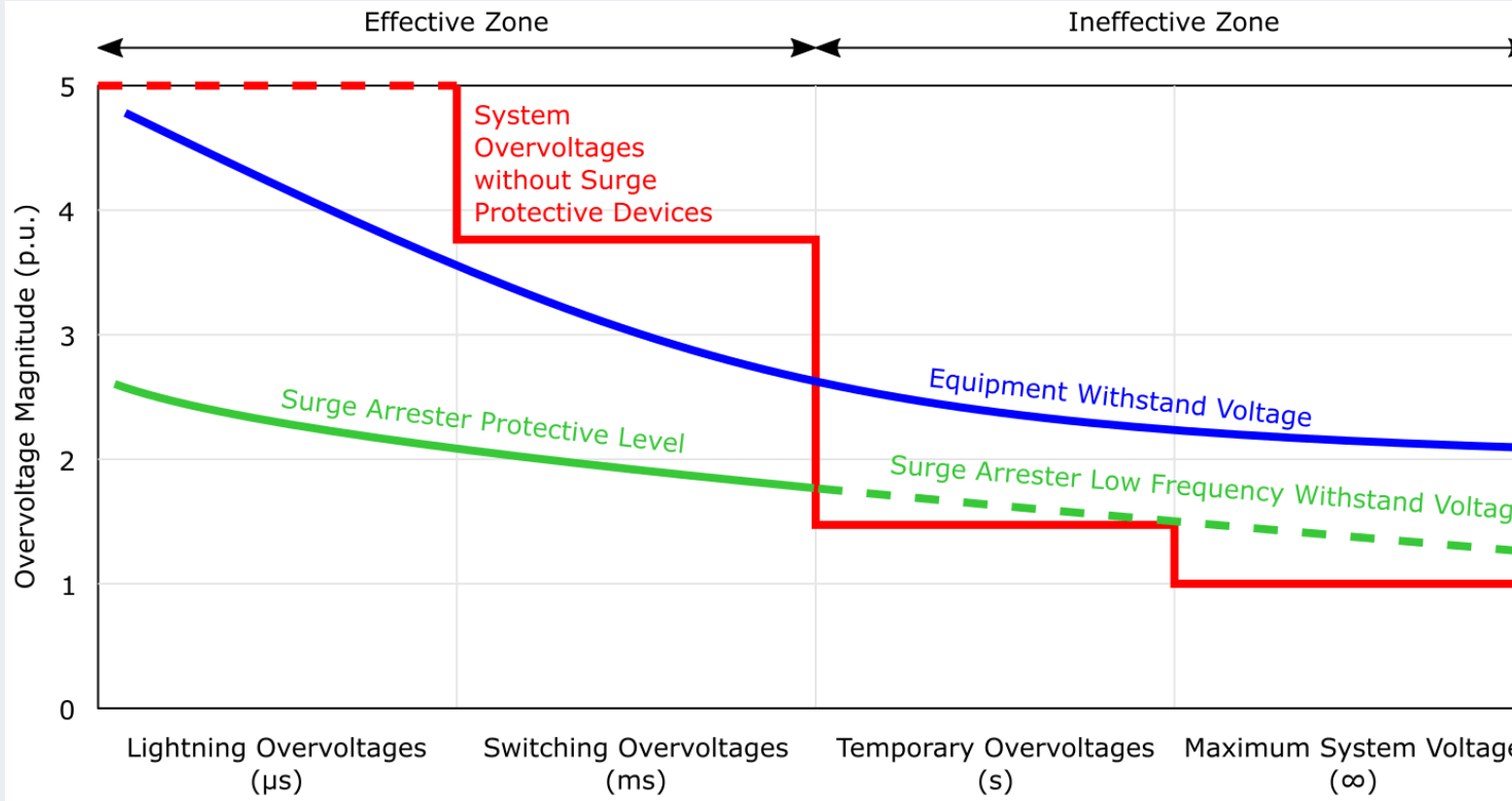
Role of Harmonics

- Background distortion
- Amplifies resonance
- Increases stress



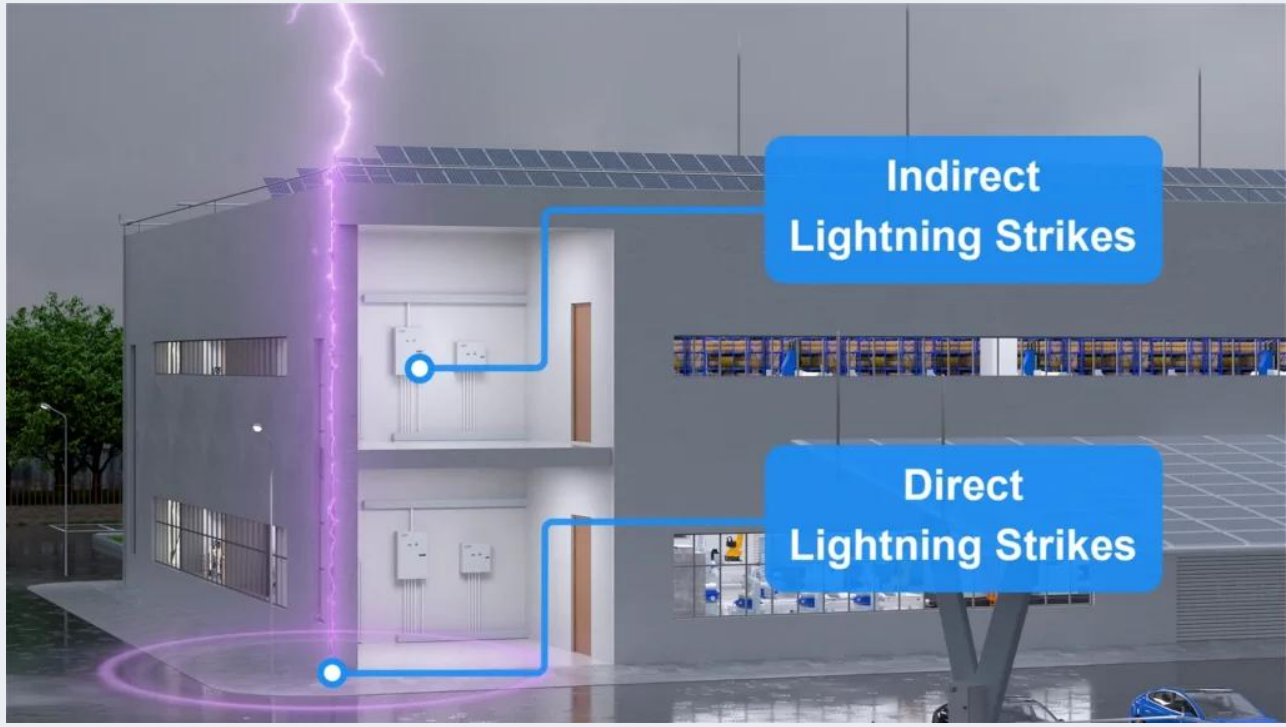
Protection Coordination Issue

- Arresters not designed for repetitive events
- Coordination mismatch
- No upstream protection triggered



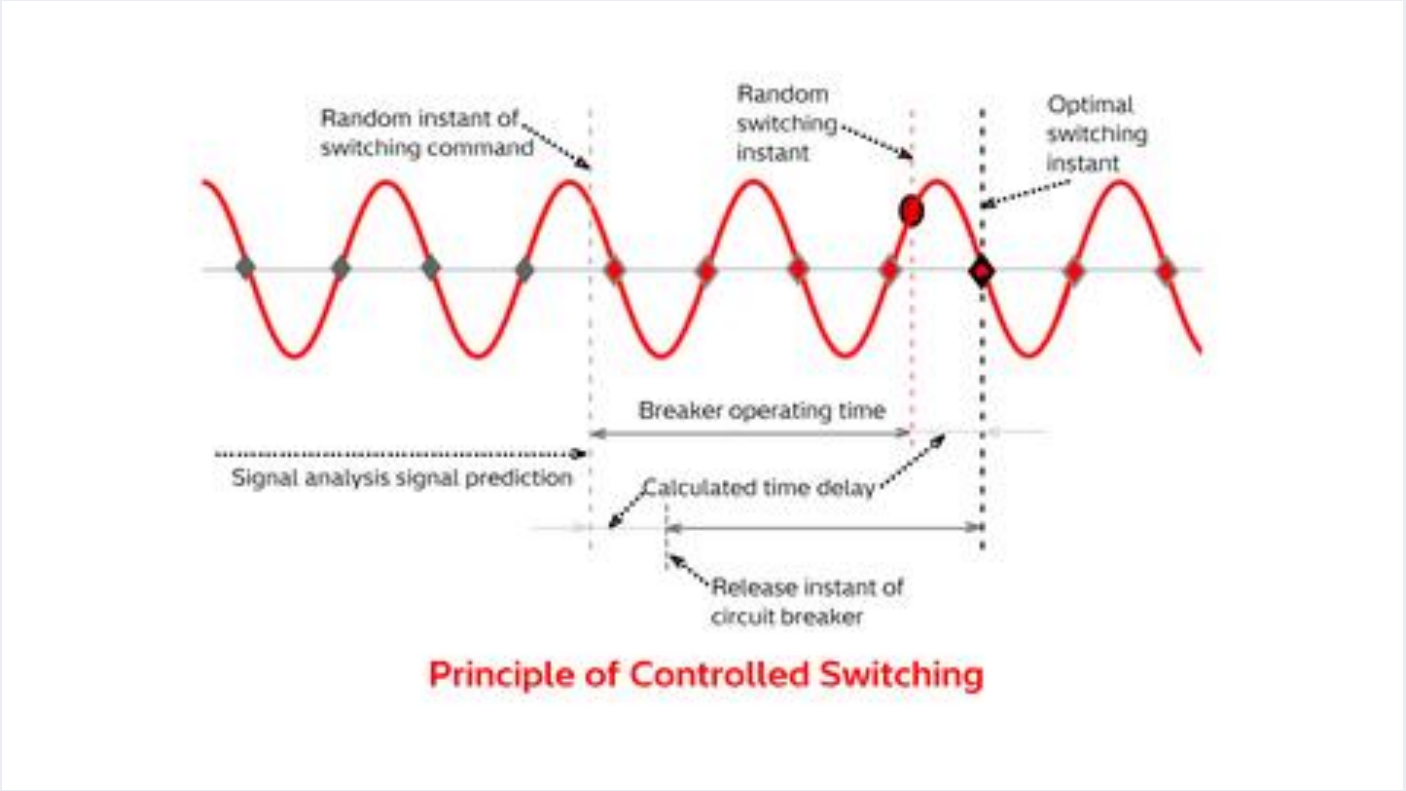
Engineering Lessons

- Not all surges are lightning
- Switching events are critical
- System modelling is essential



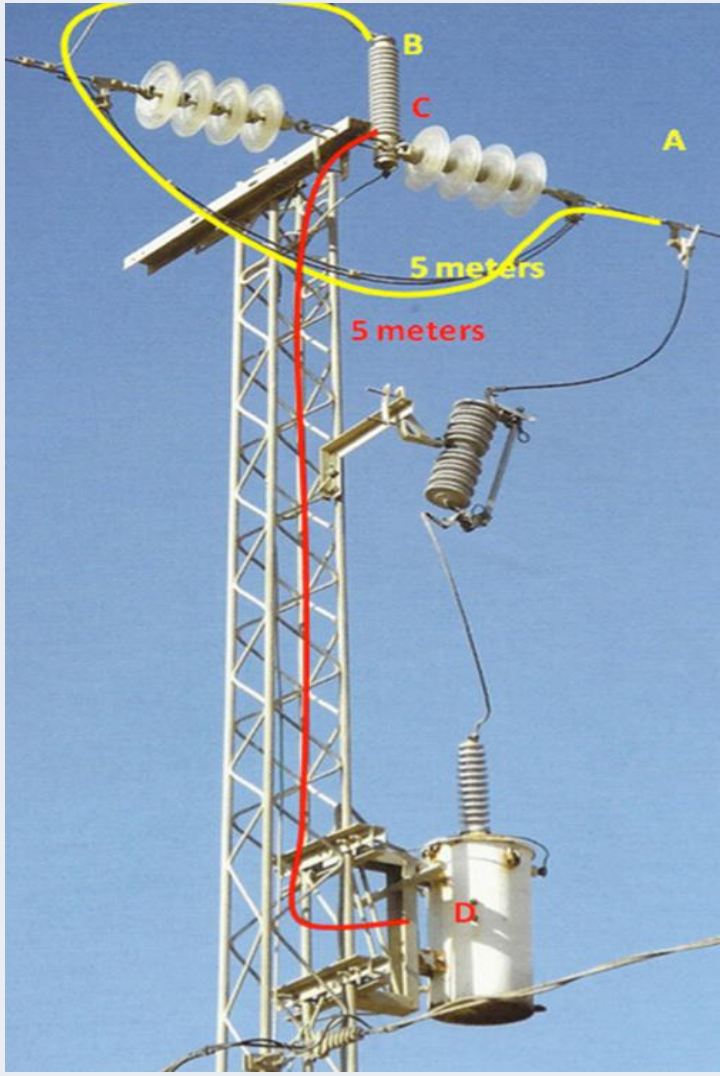
Solution 1: Controlled Switching

- Point-on-wave switching
- Reduces transients
- Improves system stability



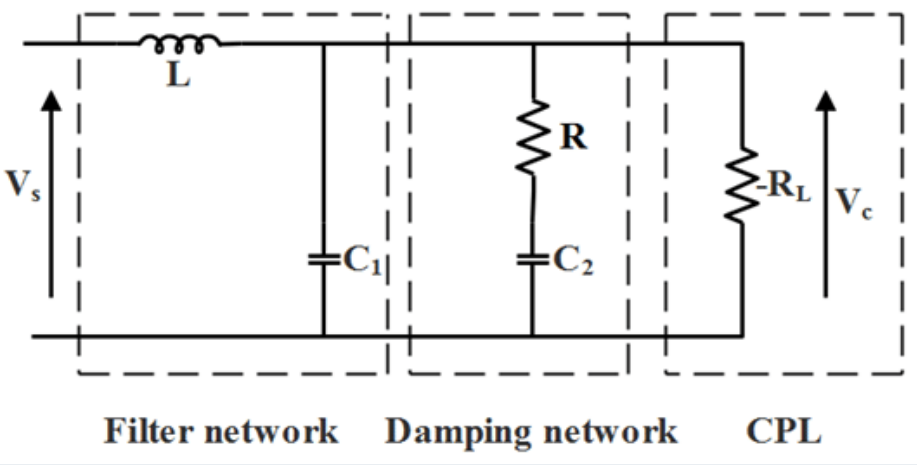
Solution 2: Surge Protection Redesign

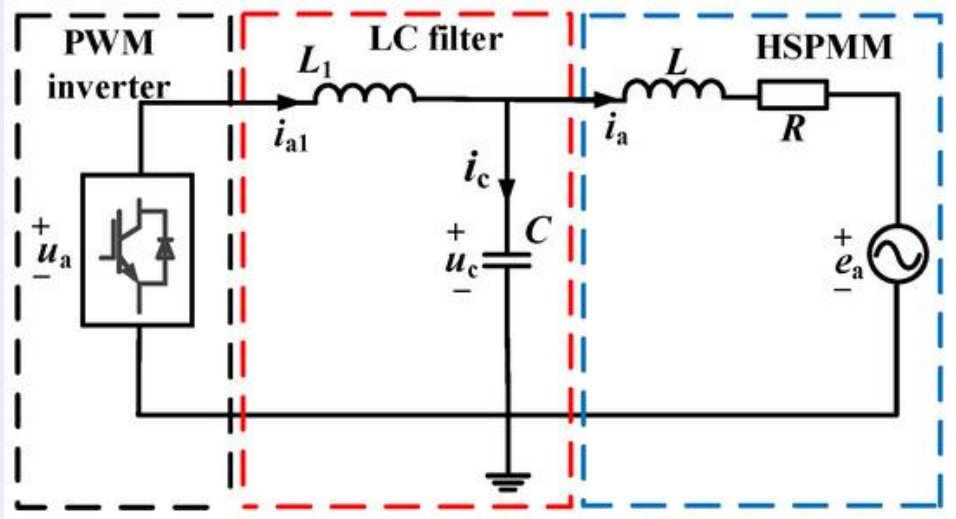
- Higher energy-rated arresters
- Proper placement
- Improved coordination



Solution 3: Damping & Filters

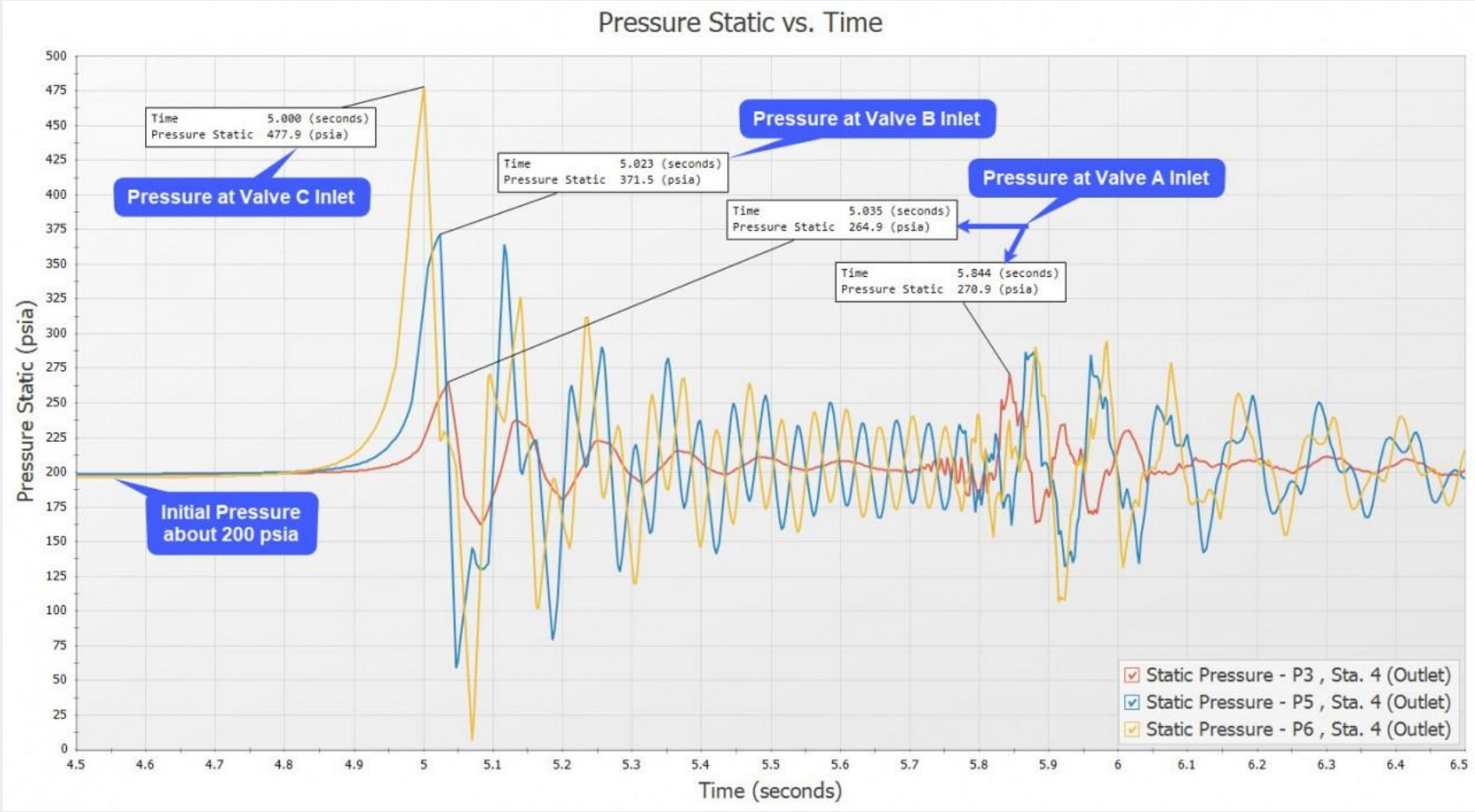
- Harmonic filters
- Damping resistors
- Reduce resonance





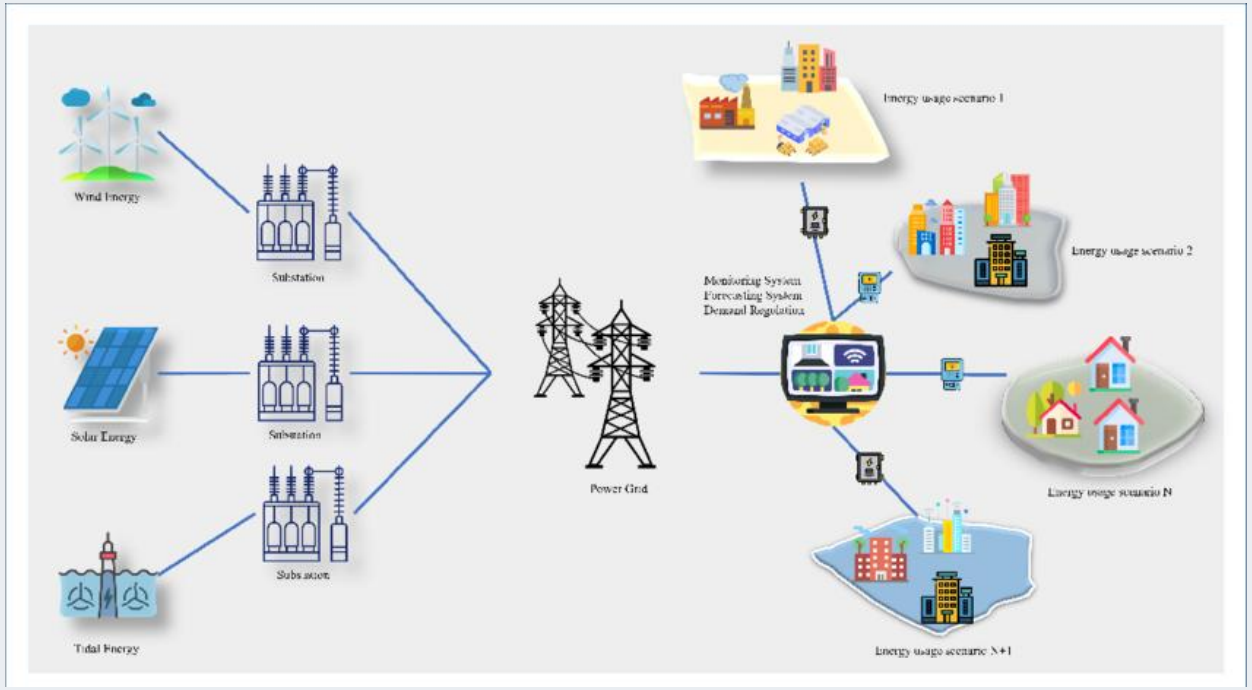
Solution 4: System Studies

- EMT simulations
- Transient studies
- Scenario testing



Broader Implications

- Renewable integration increases switching
- More power electronics
- Higher transient risks

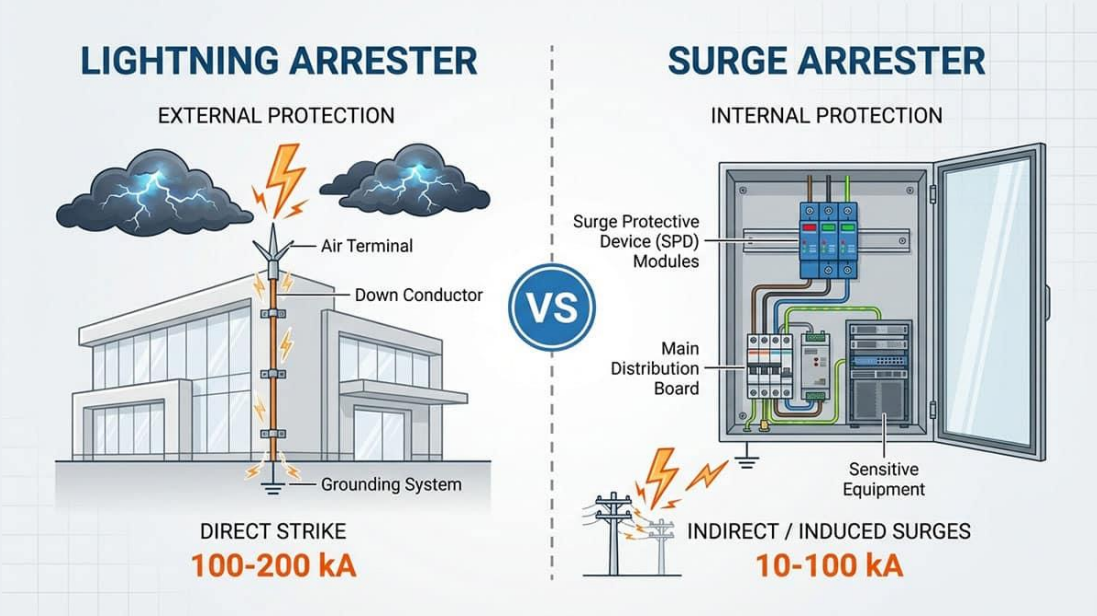


Discussion Questions

- Could this be predicted in design?
- What data is most critical?
- How would you protect the system?

Key Takeaways

- Surge arresters can fail without lightning
- Switching transients are major threats
- System-level thinking is essential



Closing

- Questions & Discussion
- Thank You

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Bachelor of Engineering (Honours) in Electrical Engineering	21 September 2026
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Master of Science (Industrial Automation and Instrumentation Control)	1 June 2026

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Q&A

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