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MYSTERIES: The Case of the Transformer That Hummed at Midnight

19 February 2026

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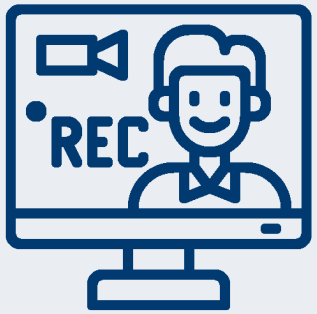
EIT EMERITUS PROFESSOR

Common Questions/FAQs



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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
	Introducing the Case
	The Critical Question
	Why Night-time matters?
	Why did Protection not operate?
	Key Technical Lessons
	Key Takeaways
	Q&A

Learning Objectives

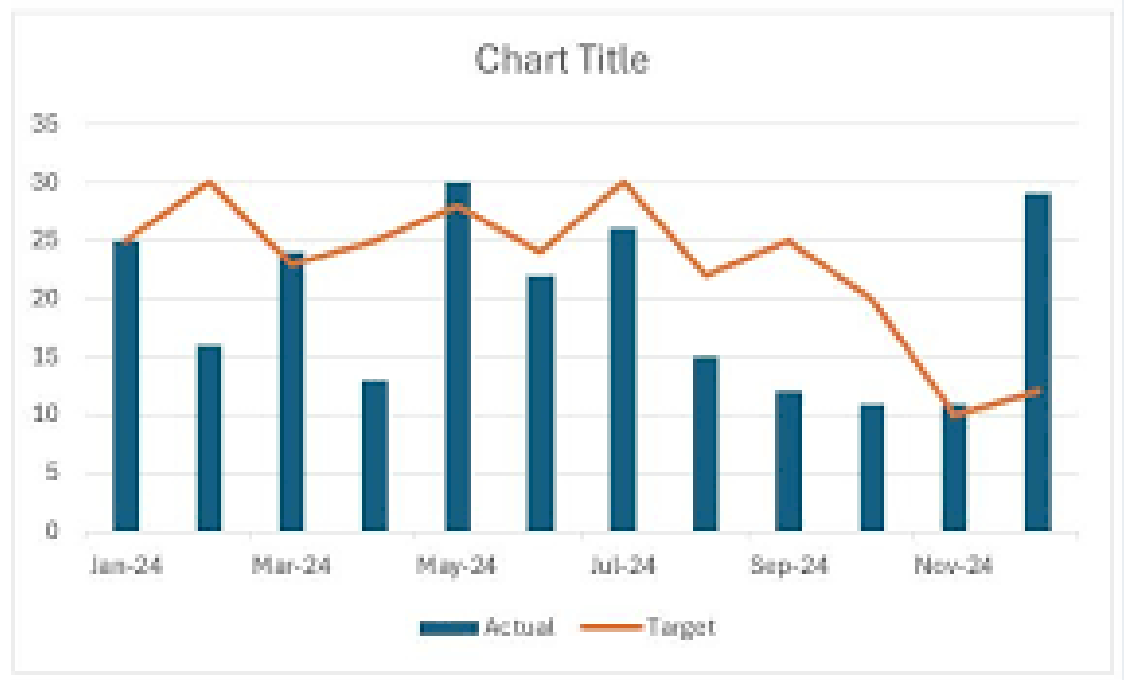
- Recognise non-obvious fault symptoms
- Apply systems thinking to power equipment
- Understand interactions between harmonics, magnetics, and mechanics
- Develop professional diagnostic reasoning

Why Study Engineering “Mysteries”?

- Many serious incidents begin as minor anomalies
- Real systems rarely fail cleanly
- Engineers are often called when the data is incomplete
- Experience = structured intuition

What Makes a “Mystery” in Engineering?

- Intermittent behaviour
- Time-dependent symptoms
- Non-electrical root causes
- Human assumptions masking reality



What Defines an Engineering Mystery?

- Symptoms without alarms
- Intermittent or time-dependent behaviour
- Conflicting data
- Multiple plausible explanations

Introducing the Case

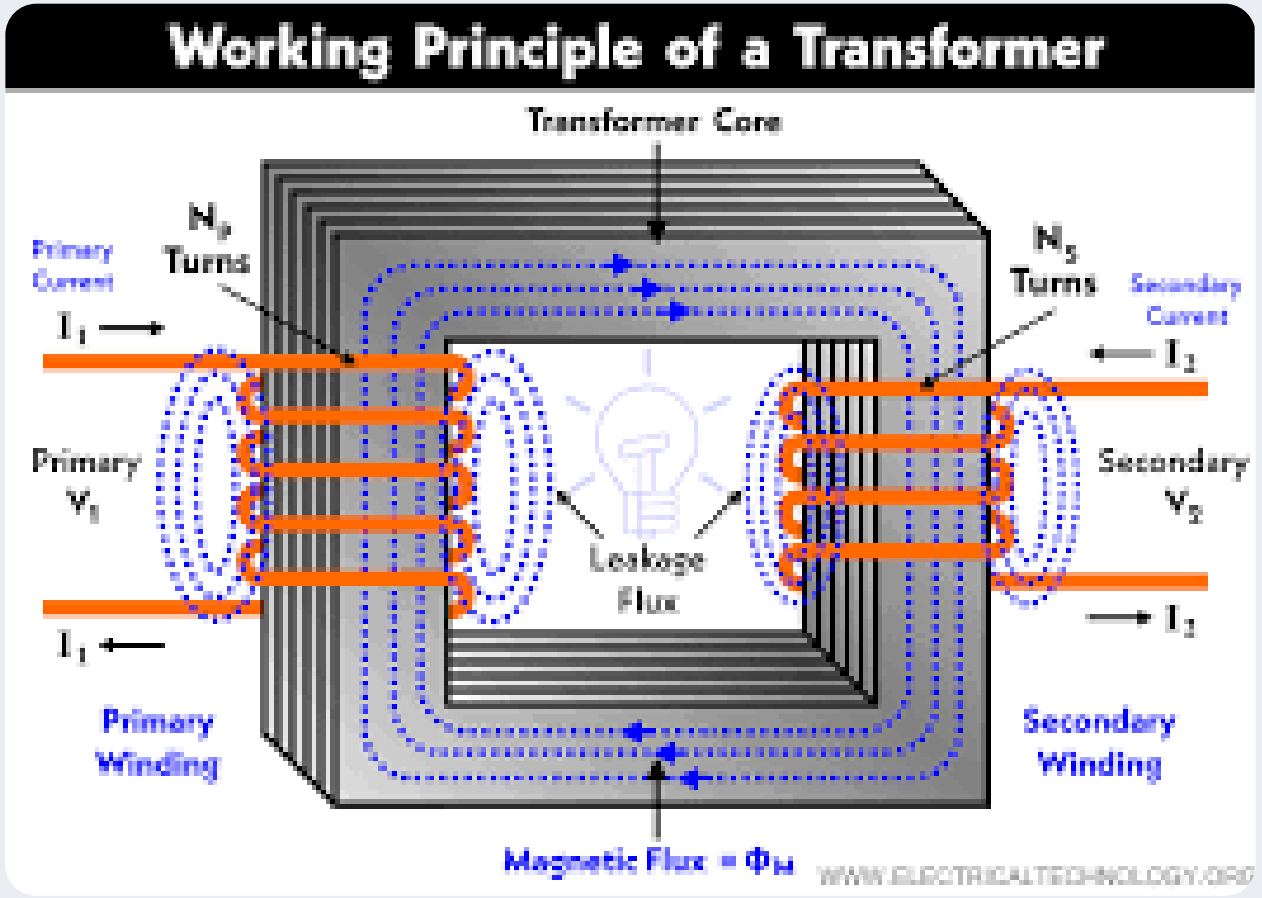
- Large oil-filled power transformer
- In continuous service
- No protection trips
- Complaint: loud humming at night

Initial Reported Symptoms

- Noise begins after midnight
- Persists for several hours
- Stops by early morning
- No daytime abnormalities

What Is “Normal” Transformer Hum?

- Magnetostriction in core steel
- Typically, at 100 Hz (50 Hz systems)
- Load-independent base hum
- Usually constant, not time-specific



Immediate Engineer Reactions

- “Transformer is ageing”
- “Core looseness”
- “Manufacturing issue”
- “Probably harmless”

What Is Normal Transformer Noise?

- Caused by magnetostriction
- Primarily load-independent
- Typically, constant over time
- Audible at 100 Hz (50 Hz systems)

Why the Symptom Didn’t Fit the Theory

- Noise was time-dependent
- No increase in load
- No temperature rise
- No oil or gas anomalies

Diagnostic Data Review

- Dissolved Gas Analysis: normal
- Oil quality: acceptable
- Winding temperature: stable
- Load current: unchanged

Gas Description		Key Gas Concentration (in ppm)		
		Normal Limits* (≤)	Action Limits** (>)	Potential Fault Type
Hydrogen	H_2	150	1,000	Corona, Arcing
Methane	CH_4	25	80	Sparking
Acetylene	C_2H_2	15	70	Arcing
Ethylene	C_2H_4	20	150	Severe overheating
Ethane	C_2H_6	10	35	Local Overheating
Carbon monoxide	CO	500	1,000	Severe overheating
Carbon dioxide	CO_2	10,000	15,000	Severe overheating
Total Combustibles	TDCG	720	4,630	

* As the value exceeds this limit, sample frequency should be increased with consideration given to planned outage in near term for further evaluation.

** As value exceeds this limit, removal of transformer from service should be considered.

This table is derived from information provided within ANSI/IEEE C57.104

The Critical Question

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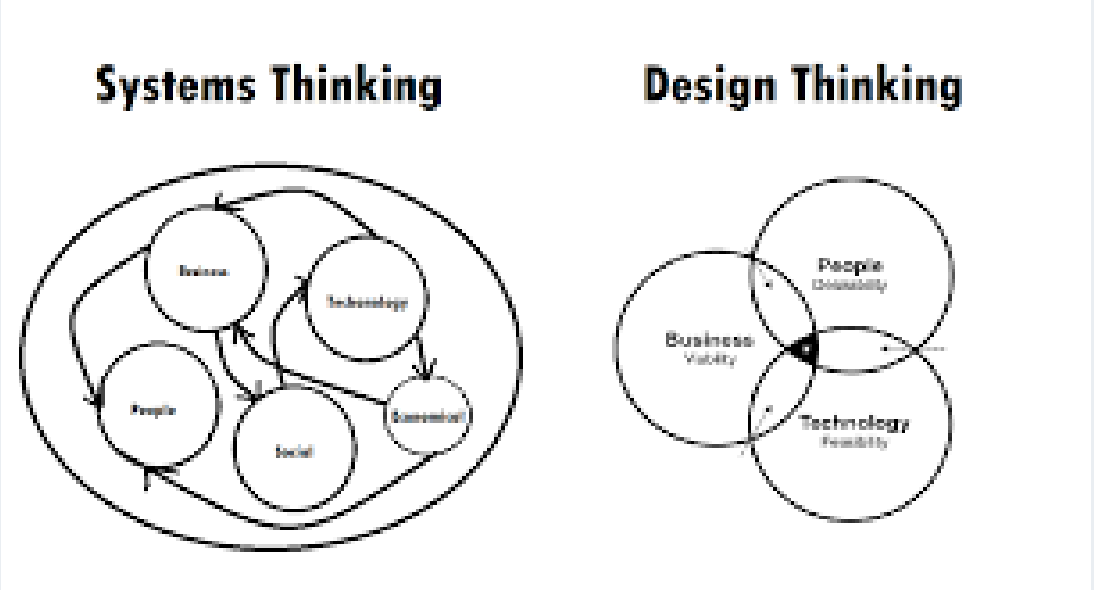
"If nothing is broken, what has changed?"

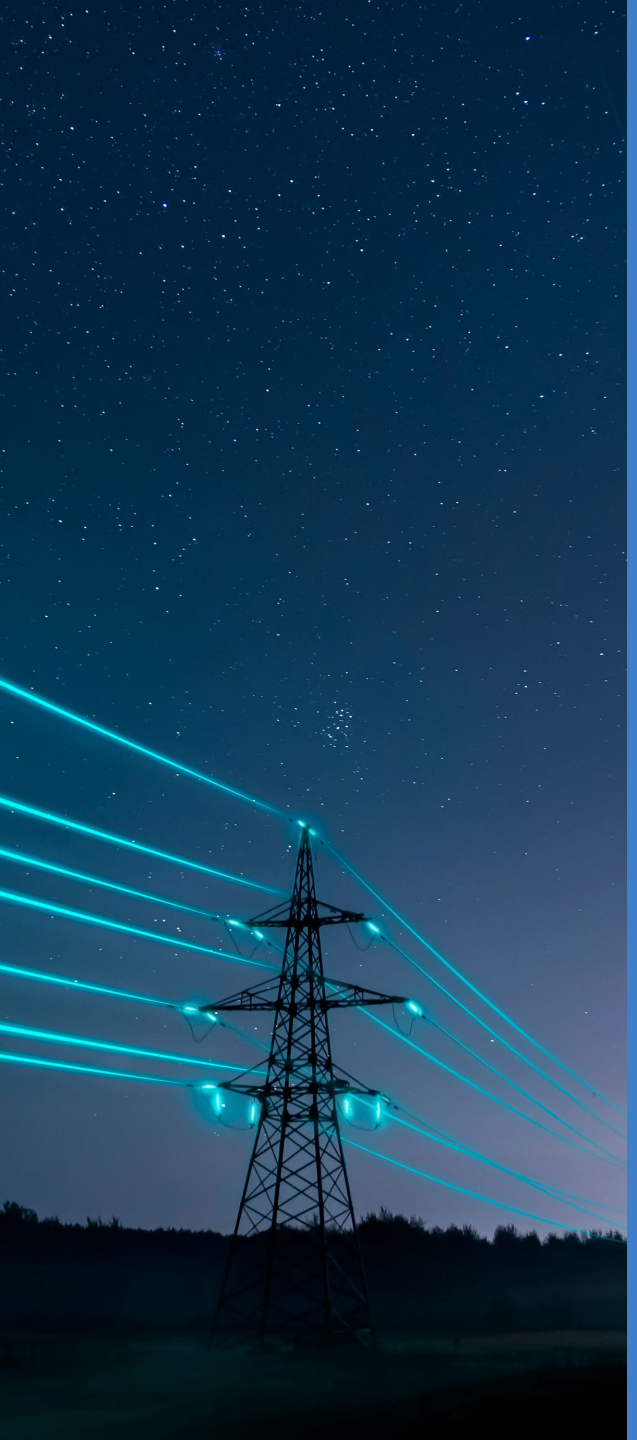
Expanding the Investigation Scope

- Electrical behaviour
- Mechanical response
- Magnetic forces
- Network configuration
- Environmental conditions



Hidden Clue: Network Reconfiguration

- Off-peak switching operations
- Capacitor banks switched in
- Feeder reconfiguration
- Voltage regulation changes

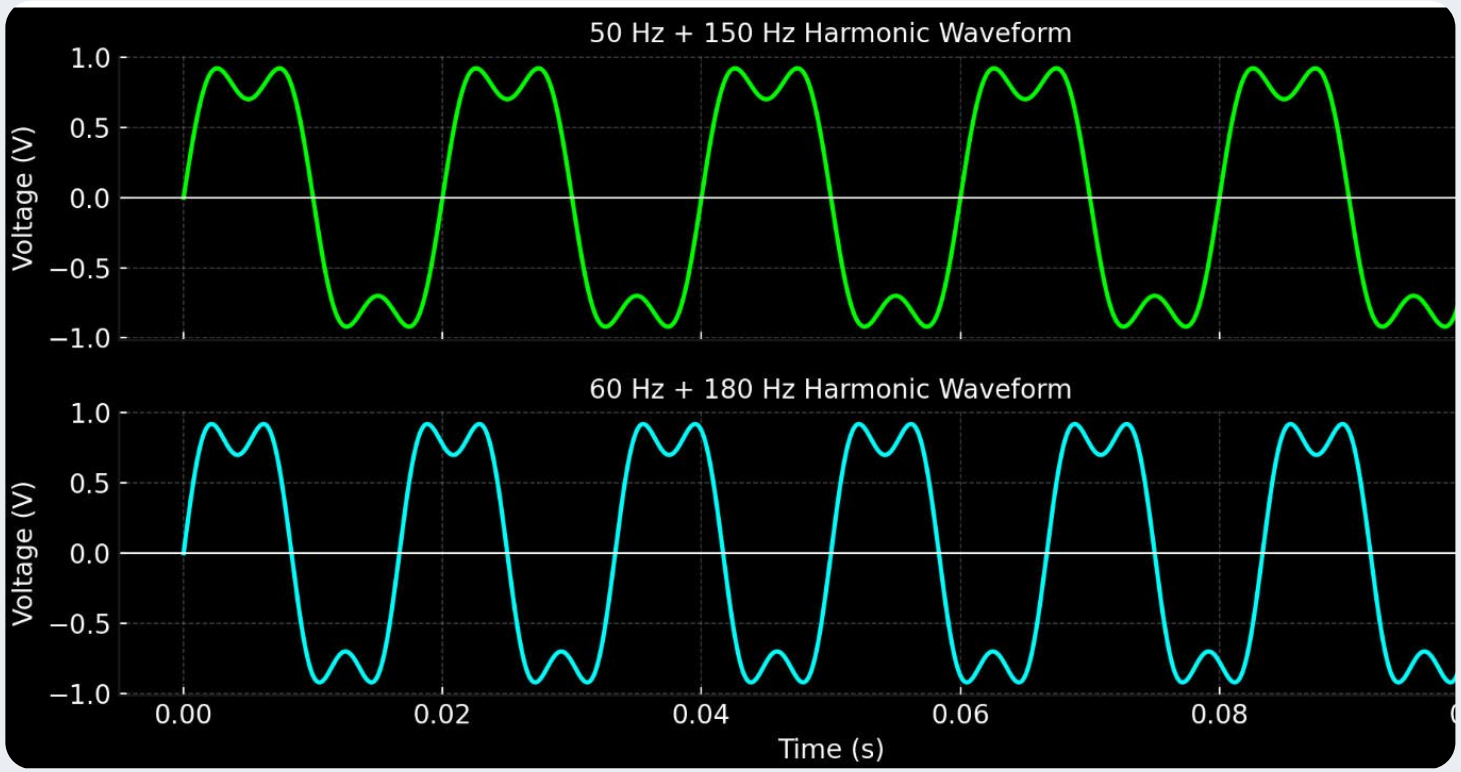


Why Night-Time Matters?

- Network switching occurs off-peak
- Capacitor banks may be energised
- Industrial and EV loads change
- Harmonic profile shifts

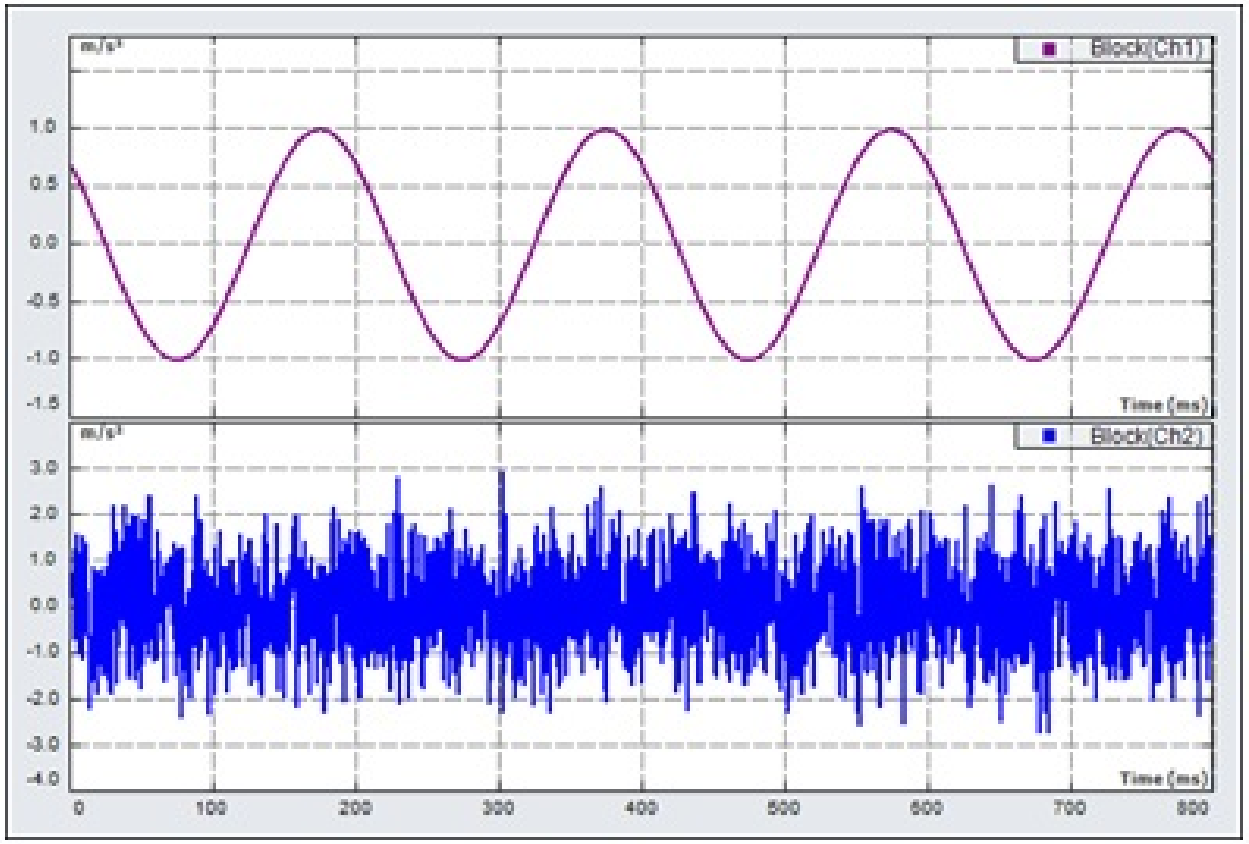
Introduction to Harmonics

- Generated by non-linear loads
- Increase magnetic distortion
- Not always visible in RMS values
- Can excite mechanical structures



Harmonics and Transformer Cores

- Distorted flux waveform
- Increased magnetostriction
- Core vibration amplification
- Audible noise increase



Network Resonance Explained

- Capacitor banks add capacitance
- Transformers add inductance
- Certain frequencies amplify
- Harmonics can be magnified

The Midnight Trigger Identified

- Capacitor bank switched in at midnight
- Harmonic resonance occurred
- Core vibration increased
- Audible hum intensified

Why Did Protection Not Operate?

- No overcurrent
- No thermal overload
- No differential imbalance
- No insulation stress detected

Why did people notice the Noise?

- Reduced ambient noise at night
- Human hearing more sensitive
- Residential proximity
- Psychological amplification

Verification Strategy

- Harmonic measurements
- Switching sequence correlation
- Temporary capacitor isolation
- Acoustic monitoring

Confirmation of Root Cause

- Noise coincided with capacitor switching
- Harmonic levels increased
- Noise ceased when the configuration changed
- Root cause confirmed

Engineering Solution Implemented

- Switching time adjusted
- Harmonic filtering added
- Monitoring installed
- No transformer replacement

Cost and Risk Avoided

- No unnecessary asset replacement
- No outage required
- No service disruption
- Improved system understanding

Key Technical Lessons

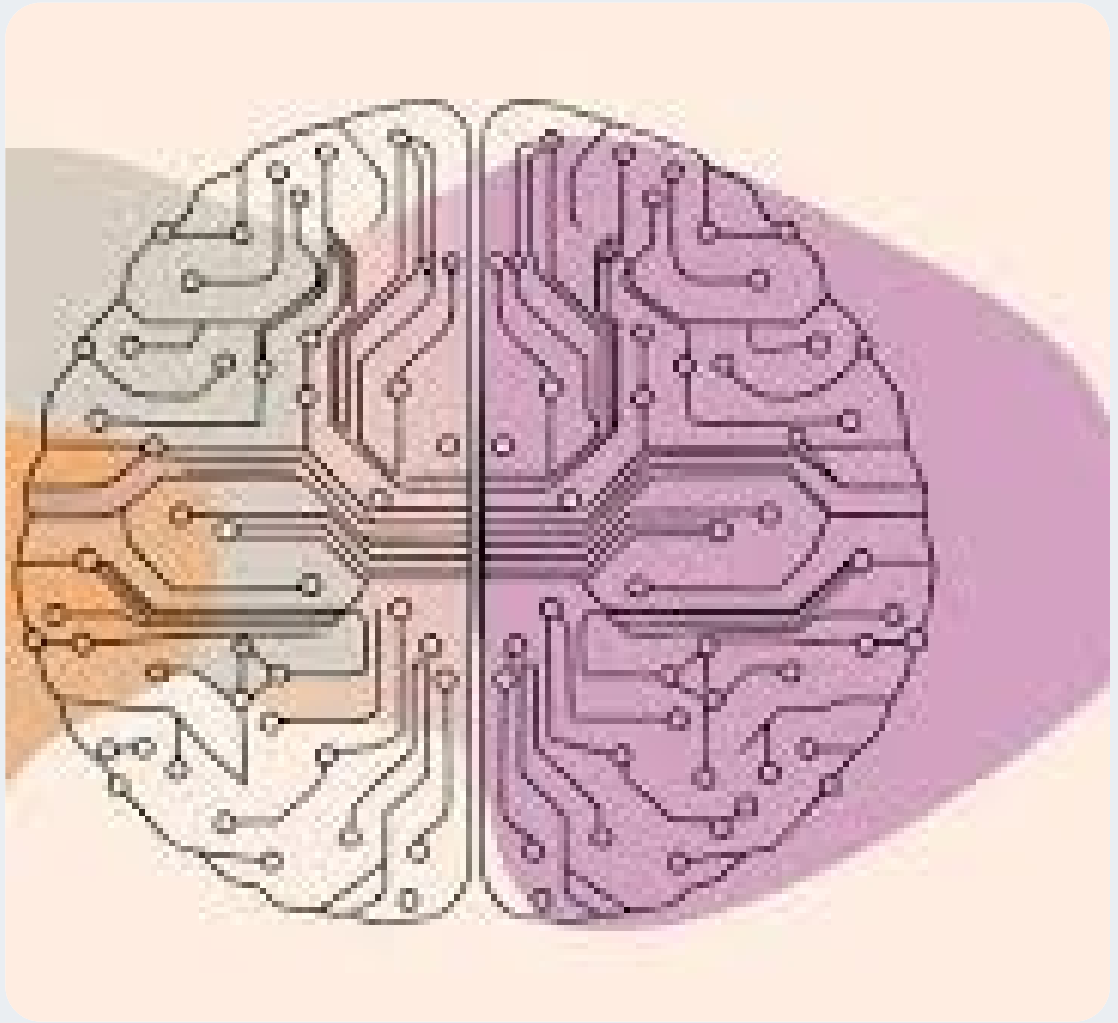
- Symptoms can be misleading
- Equipment may be innocent
- System interactions dominate
- Time patterns matter

Common Engineering Pitfalls

- Component-level tunnel vision
- Over-reliance on alarms
- Ignoring “soft” evidence
- Rushing to replacement

Professional Skills Demonstrated

- Systems thinking
- Interdisciplinary knowledge
- Evidence-based reasoning
- Communication with stakeholders



Discussion

(1) What would YOU investigate first if protection data is normal, but complaints persist?

(2) How would you justify NOT replacing the transformer to management?

Reflection

- Would a junior engineer solve this?
- What experience was critical?
- How could procedures improve detection?

Broader Industry Parallels

- Ferro resonance incidents and false trips
- Harmonic-induced relay maloperations
- Cable sheath heating - Cable failures due to induced currents
- HVDC harmonics - vibration issues
- Relay mis operations from CT saturation

Closing Thought

“Not all problems announce themselves electrically.
Some speak through sound, time, and behaviour.”

Key Takeaways

- Not all faults are failures
- Time patterns matter
- Network behaviour matters
- Investigation beats assumption

From Student to Professional Engineer

- Textbook problems have answers
- Real systems have stories
- Engineers must listen carefully
- Curiosity is a technical skill

Final Thought

"The system was speaking. The question was whether anyone was listening."

Q&A

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Thank You!

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52872WA Advanced Diploma of Robotics and Mechatronics Engineering	08/04/2026
52910WA Graduate Certificate in Hydrogen Engineering and Management	05/05/ 2026
Graduate Certificate in Civil Engineering: (Structural Analysis and Design)	29/06/2026
Graduate Diploma of Engineering (Mechanical)	29/06/2026
Online - Master of Engineering (Industrial Automation)	29/06/2026
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On-Campus - Bachelor of Science (Mechanical Engineering)	20/07/2026
Doctor of Engineering	20/07/2026

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Master of Science (Power System Analysis and Renewable Integration)	1 June 2026
Master of Science (Industrial Automation and Instrumentation Control)	1 June 2026

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