

MYSTERIES: Paralleling Generators – When Two Perfect Machines Refused to Share

[Watch Webinar Recording Here](#)

Emeritus Professor Akhtar Kalam
EIT EMERITUS PROFESSOR



About ECT



We are dedicated to ensuring that you receive a world-class education and gain skills that you can immediately apply in the workforce.



Engineering Specialists

ECT - affiliated to the well-established Engineering Institute of Technology (EIT) - is an engineering education specialist. ECT delivers bachelor's and master's degrees.



Industry-Driven programmes

Our programmes are designed by industry experts, ensuring you graduate with cutting-edge skills that are valued by employers. Our programme content remains current with rapidly changing technology and industry developments.



UK Recognised Education

ECT is OfS registered, meeting the Office for Students' requirements for course quality, academic standards, student support and student protection.



Lecturers and Instructors

Our teachers are subject specialists with industry experience and the requisite academic qualifications. They bring extensive expertise from across the engineering sector, ensuring students learn from experienced professionals with both academic and real-world knowledge.



Unique Delivery Model

We deliver our programmes via a unique delivery methodology that makes use of live and interactive tutorials, an international pool of expert lecturers, dedicated learning support officers, hands-on workshops and state-of-the-art remote labs connected to real equipment, and simulation software.

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

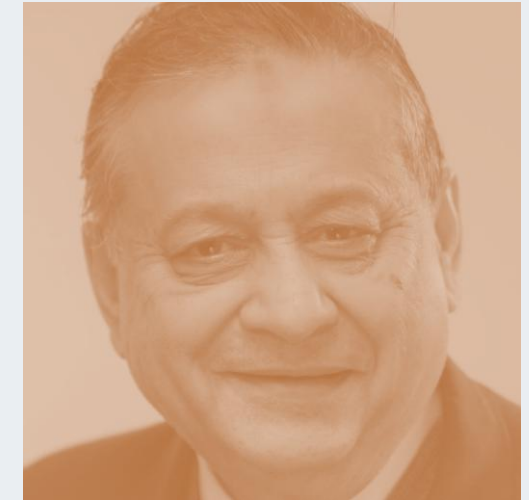
Professional Society Activities

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



Preliminaries



Learning Objectives

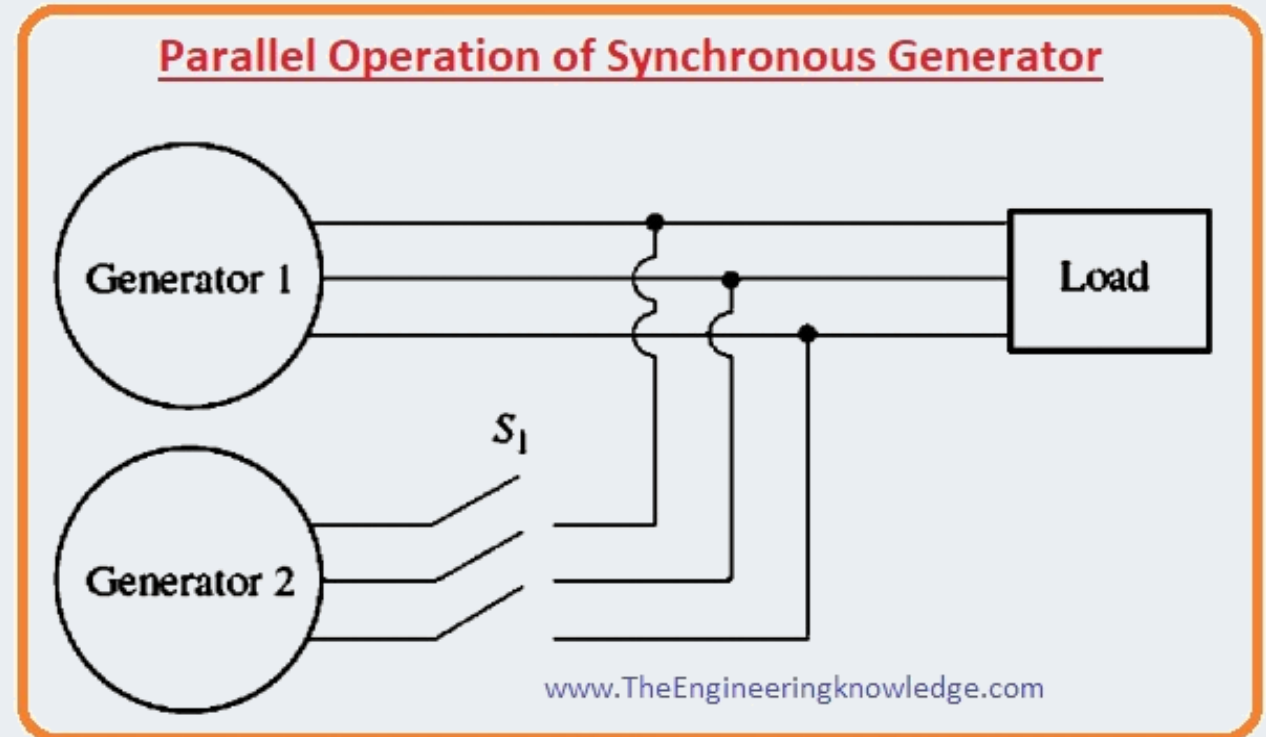
- Parallel Operation of DC Generators Definition: Parallel operation involves connecting multiple DC generators to provide a continuous, reliable power supply.
- Bus-Bar Connection: Generators are connected in parallel using bus bars, with the positive and negative terminals properly aligned.
- Load Sharing: By adjusting the induced emf, multiple generators can share the electrical load evenly.

Why This Story Matters

- Generator paralleling is a “solved theory”.
- Yet failures occur in modern plants.
- Real systems expose gaps between math and reality.
- Postgraduate engineers must think beyond equations.

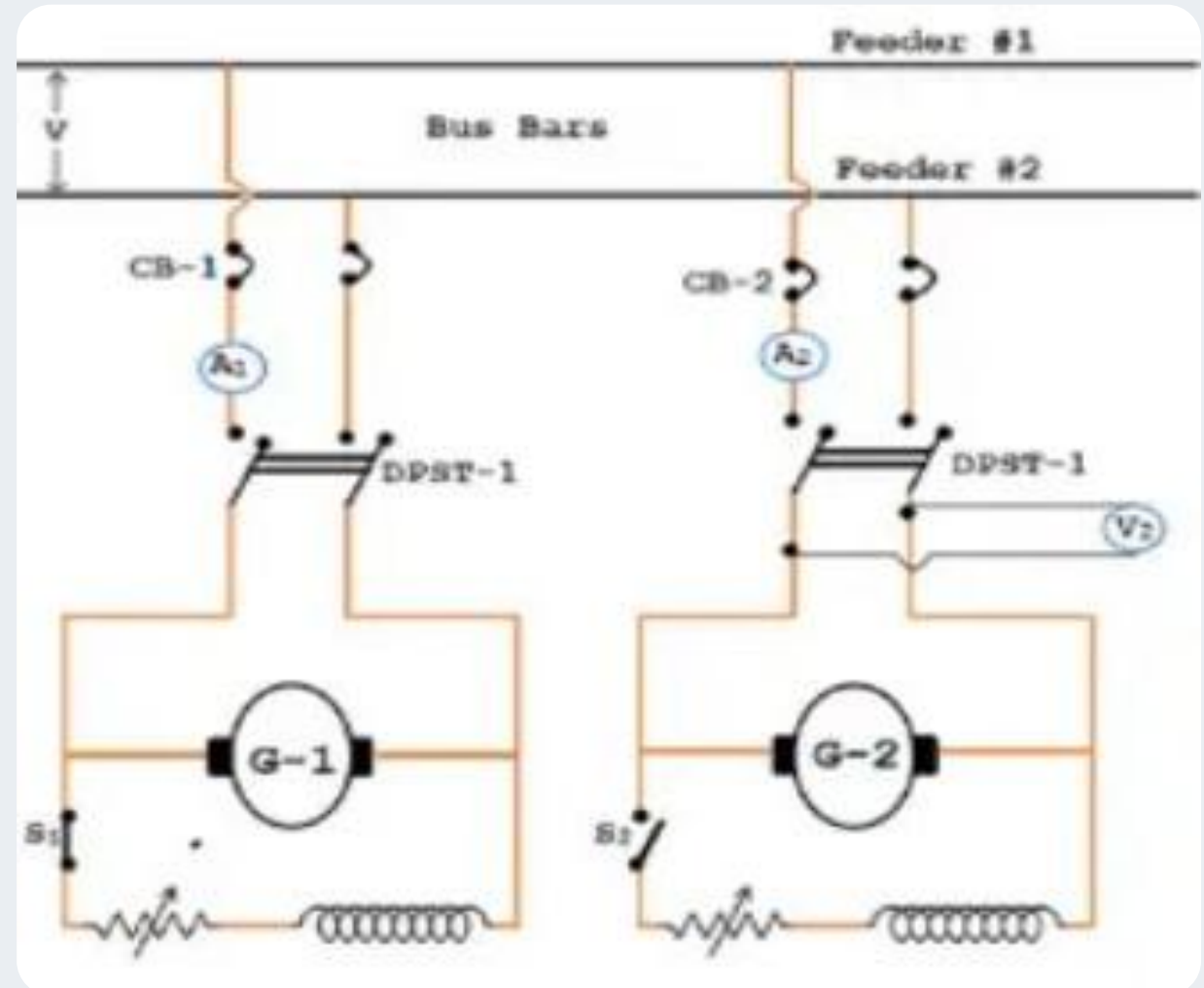
The Setup: Two “Perfect” Machines

- Two synchronous generators
- Same rating, same manufacturer
- Identical governors and exciters
- Recently commissioned system
- Intended for parallel operation.



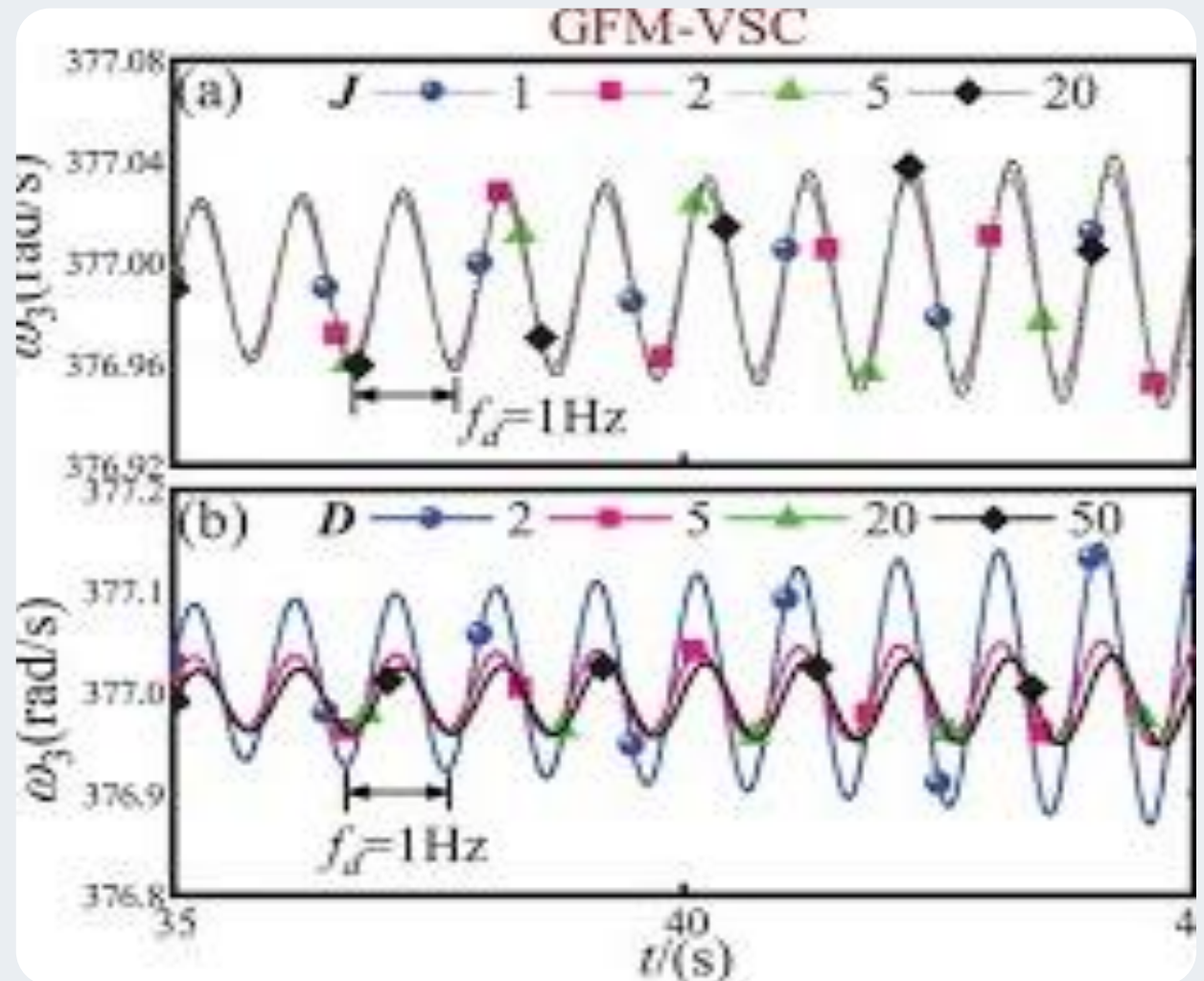
The Expected Behaviour

- Synchronise voltage, frequency, phase
- Close breaker
- Increase prime mover input
- The load should be divided proportionally
- Stable operation



Introducing the Case

- Synchronisation successful
- Breaker closed cleanly
- One generator took nearly all the real power
- The other “floated” near zero
- Adjustments made things worse.



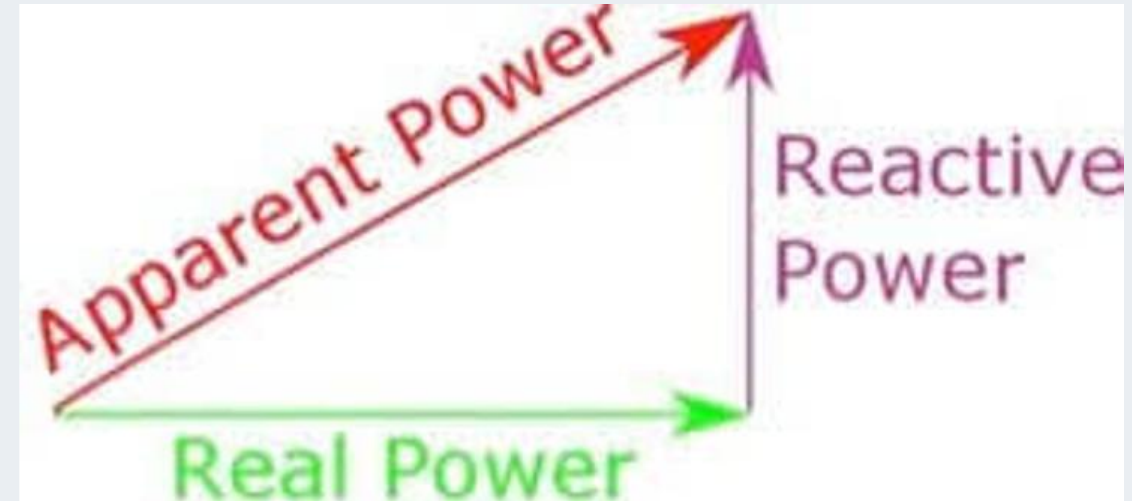
First Reactions

- “Faulty generator?”
- “Bad governor tuning?”
- “Incorrect wiring?”
- “Instrumentation error?”
- “Operator mistake?”



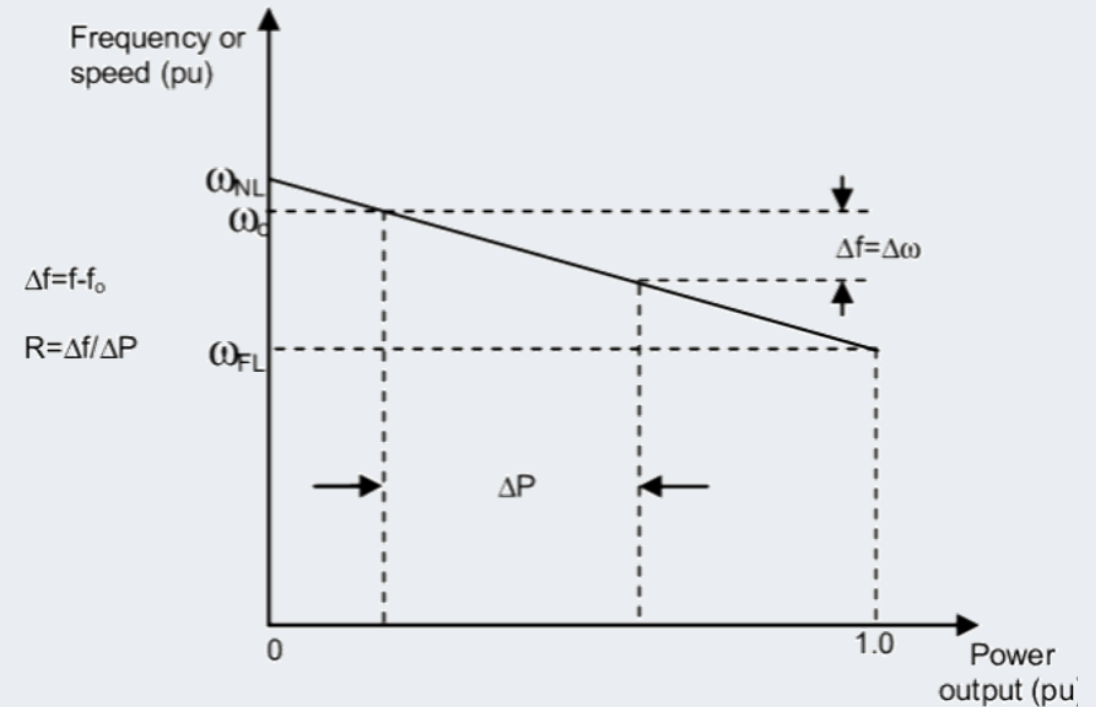
Theory Refresher: Real vs Reactive Power

- Real power (kW): controlled by prime mover/governor
- Reactive power (kVAr): controlled by excitation
- Sharing depends on control characteristics
- Identical ratings $\neq$ identical behaviour



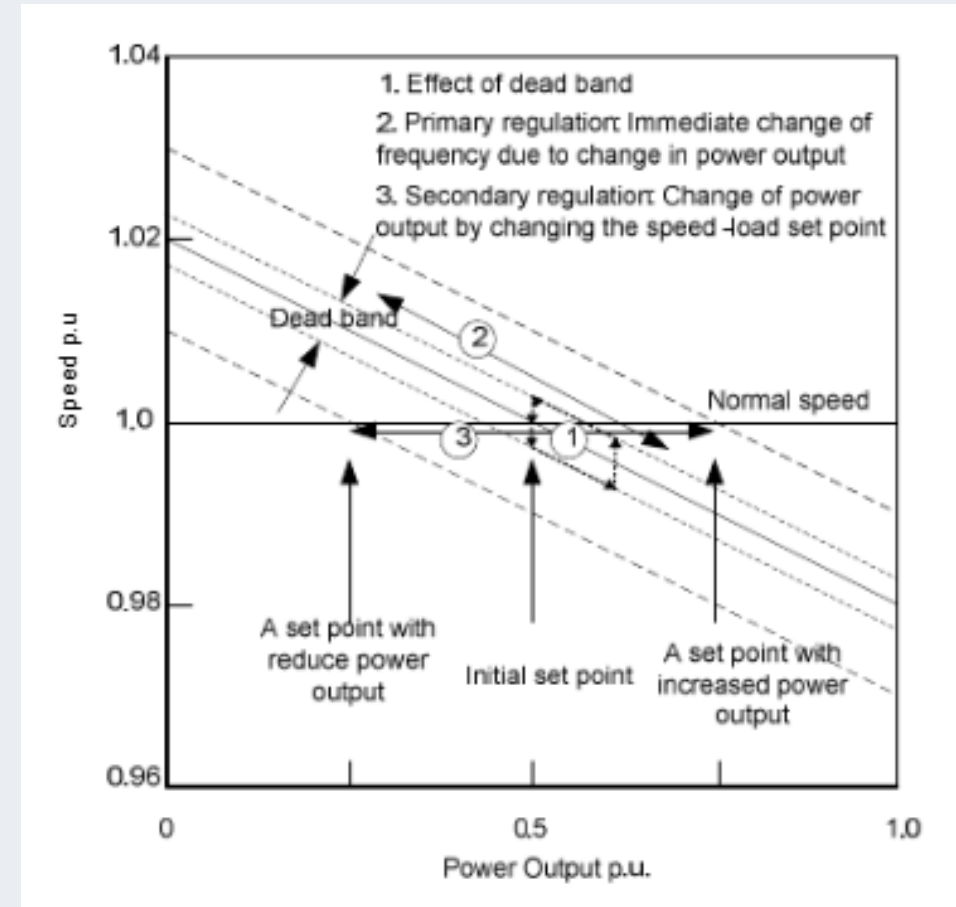
Governor Control Basics

- Governors regulate speed (frequency)
- Droop characteristic enables load sharing
- Without droop → instability
- Matching droop slopes is essential



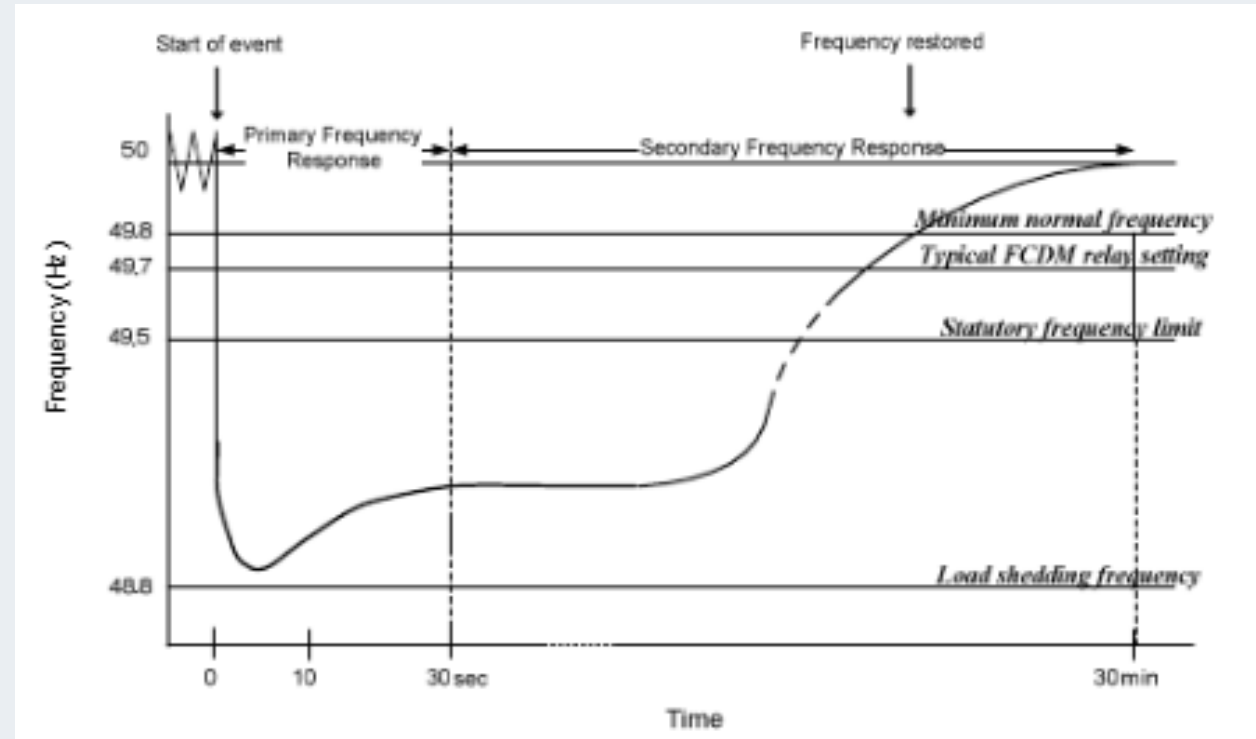
The Hidden Assumption

- Assumed both governors had identical droop
- Assumed factory settings were equal
- Assumed “same model” = “same response”
- No direct droop verification performed



Field Measurements Begin

- Frequency vs power measured
- Load ramp tests performed
- Individual generator response recorded
- Small discrepancies observed



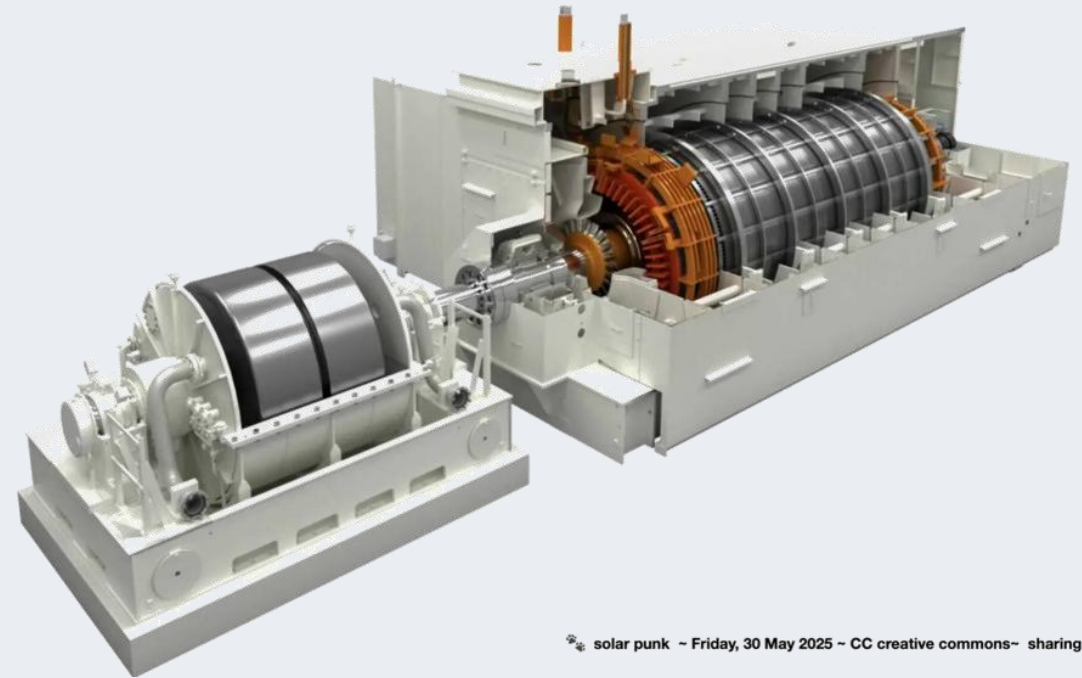
The Critical Discovery

- Generator A droop: $\sim 4\%$
- Generator B droop: $\sim 1\%$
- Both “within acceptable range”
- But not compatible for sharing



Why One Generator Dominated

- Lower droop = stiffer speed control
- A stiffer machine resists frequency change
- It absorbs most real power changes
- The other machine backs off



solar punk ~ Friday, 30 May 2025 ~ CC creative commons~ sharing

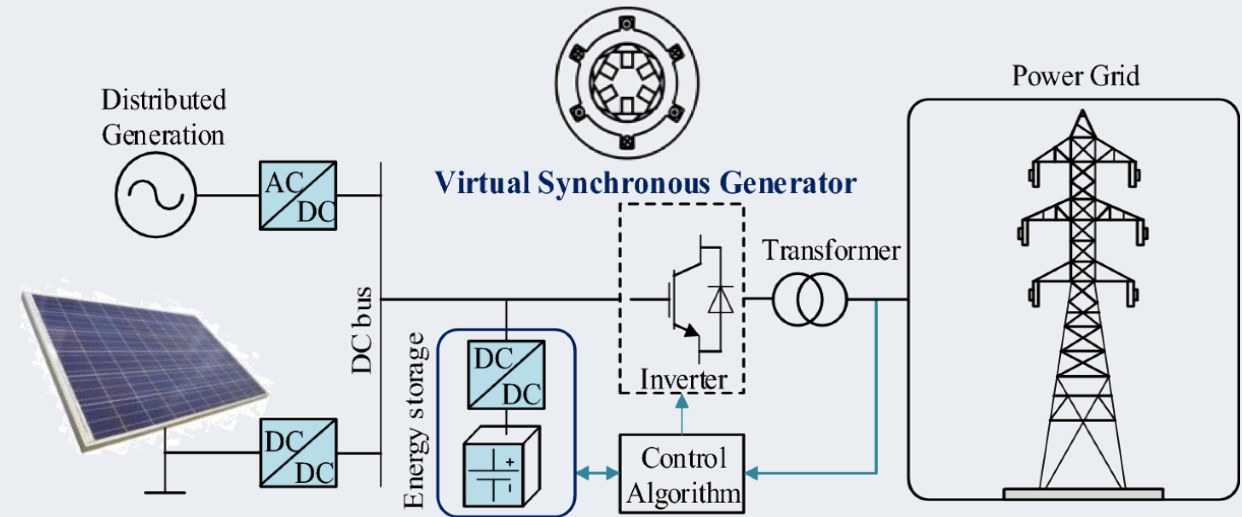
Why Adjusting Speed Didn't Help

- Speed bias shifts operating point
- Does not change droop slope
- Temporary improvement only
- Instability increased under load



What About Reactive Power?

- Reactive power sharing also problematic
- Exciters set to voltage control mode
- No VAr droop enabled
- Circulating reactive currents observed



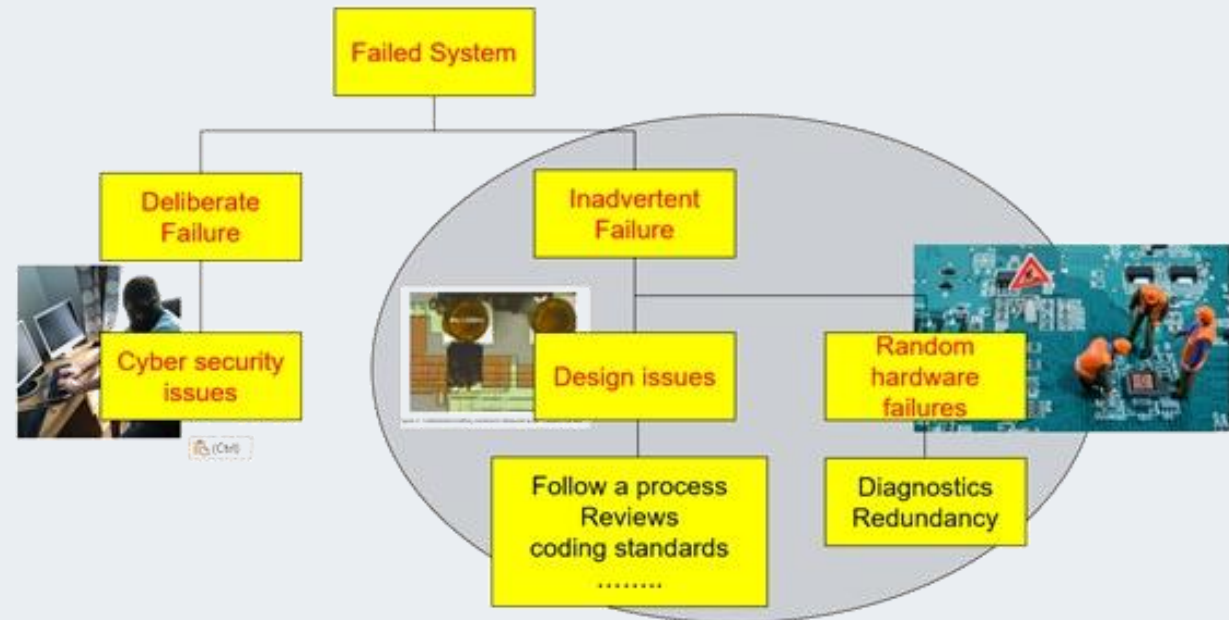
Circulating Currents Explained

- Small voltage differences → large reactive currents
- No useful load delivered
- Increased heating
- Reduced system stability



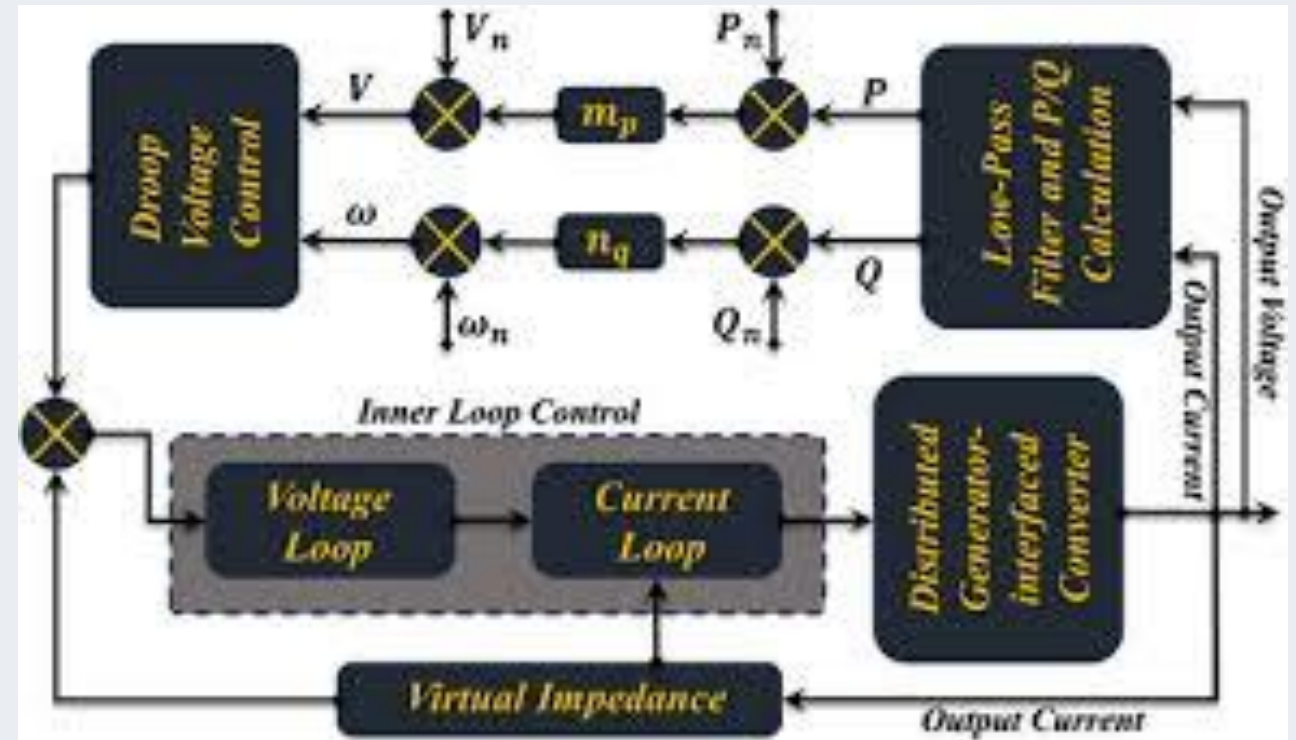
The Root Cause (Summarised)

- Mismatched governor droop
- No coordinated control philosophy
- Overreliance on factory defaults
- Lack of system-level testing



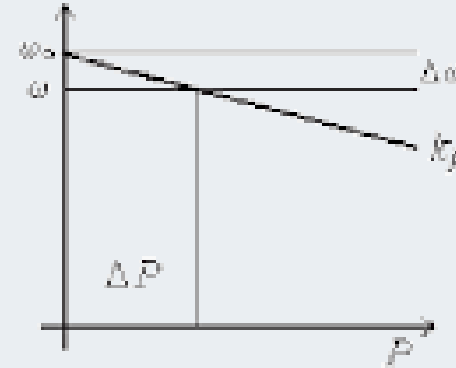
The Fix: Real Power Sharing

- Standardised droop settings
- Verified frequency–power slopes
- Re-tested under dynamic load
- Stable proportional sharing achieved

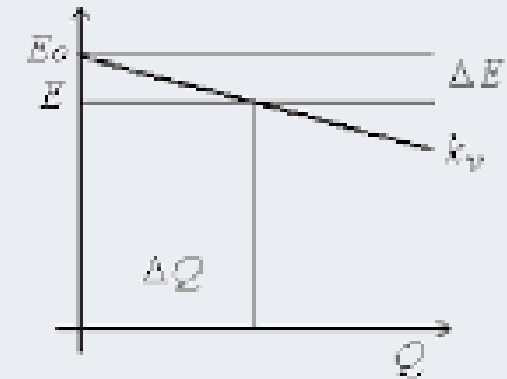


The Fix: Reactive Power Sharing

- Enabled voltage droop (or VAr control)
- Coordinated excitation settings
- Reduced circulating currents
- Thermal margins restored



Frequency x Active Power



Voltage x Reactive Power

Why This Happens So Often

- Commissioning under no-load conditions
- Control systems tested in isolation
- “Within tolerance” thinking
- Missing interdisciplinary oversight



Textbook vs Field Reality

- Textbooks assume idealized controls
- Real systems include tolerances
- Control interactions dominate behaviour
- Measurements matter more than labels



Broader Lesson: Perfection Can Be the Enemy

- Overly tight control causes conflict
- Intentional flexibility improves stability
- Droop is a feature, not a defect
- Cooperation beats precision



Similar Mysteries in Power Engineering

- UPS systems that won't share
- Parallel inverters oscillating
- Microgrids with unstable islands
- Wind turbines fighting frequency



What Postgraduate Engineers Must Remember

- Controls define behaviour
- Matching ratings is not enough
- Measure dynamic response
- Always ask: “What assumption am I making?”



Discussion

- How would this change with three generators?
- What if one were inverter-based?
- Would isochronous control help?
- Where would you instrument first?



Key Takeaways

- Generator paralleling is a control problem
- Droop enables cooperation
- “Identical” machines are never identical
- System thinking beats component thinking



**You are an
incredible person
and have so much
to offer this world.**

YourTherapySource.com

Why This Is a Mystery Worth Remembering

- Simple problem, complex cause
- No alarms, no obvious faults
- Required engineering judgment
- A lesson learned once—never forgotten



Closing Thought

*“Engineering Is Not About Perfect Parts;
It’s About Cooperative Systems.”*

Upcoming Mysteries Webinars

Register now!

- 9 April – The Solar Inverter That Wouldn't Sync at Noon
- 16 April - When Lightning Didn't Strike, but the Surge Arresters Blew
- 14 May – The Disappearing Neutrals in a TN-C-S Network
- 21 May - Why the UPS Failed During a Blackout But Passed All Tests?
- 11 June – Cable That Melted at 60% Load
- 18 June - The Phantom Neutral - Why the Feeder Voltage Floated Overnight?
- 9 July – The Relay That Refused to See a Short
- 16 July - The Capacitor Bank That Blew Itself Up Quietly
- 13 August – The Motor That Wouldn't Start - Unless It Was Empty
- 20 August - The Neon Sign That Pulsed with Passing Trucks
- 10 September – The Battery Bank That Lost Capacity Overnight
- 17 September - The Streetlight That Kept Turning on at Noon
- 12 November – The Transformer That Changed Tap Position by Itself
- 19 November – The Circuit That Lost Half Its Phase Over the Years
- 10 December – The PLC That Spoke Back - A Control Loop with a Mind of Its Own
- 17 December - The Resonant Substation - Lights Flicker Without Load Change
- 27 January - The Induced Voltage That Woke the Cattle

Thank You!

Upcoming Programmes

Engineering College of Technology (ECT) <i>UK-Recognised Qualifications</i>	Start Date
Bachelor of Engineering (Honours) in Industrial Automation	September 2026, February 2027
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

Professional Certificates

Looking to upskill further? Check out the Professional Certificates!

These **3-month, non-accredited Professional Certificates of Competency**, delivered by ECT's affiliated institute, EIT, are designed by industry leaders and academics for technicians, technologists, engineers, and engineering professionals seeking to advance their expertise in a specific area. Featuring live, interactive webinars led by expert instructors with technical know-how, along with dedicated learning support, these courses are the perfect complement to an existing degree, qualification, or relevant work experience.

[Find out more!](#)

Contact Us:



Website
www.ect.ac.uk



Programmes
<https://www.ect.ac.uk/programmes/>



Head Office
Whittle Way, Stevenage SG1 2FS,
United Kingdom



Phone
Inside UK: 0203 582 1389
Outside UK: +44 203 582 1389