
FUNDAMENTALS
Voltage Regulation for Smart Grid
Jon Hiscock
MD Fundamentals Ltd
“Improving the Health and Performance of the Electrical Grid”

Contents

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- Introduction
- History
- Voltage regulation
- The changing grid
- What’s the problem ?
- Solutions

The Electrical Grid

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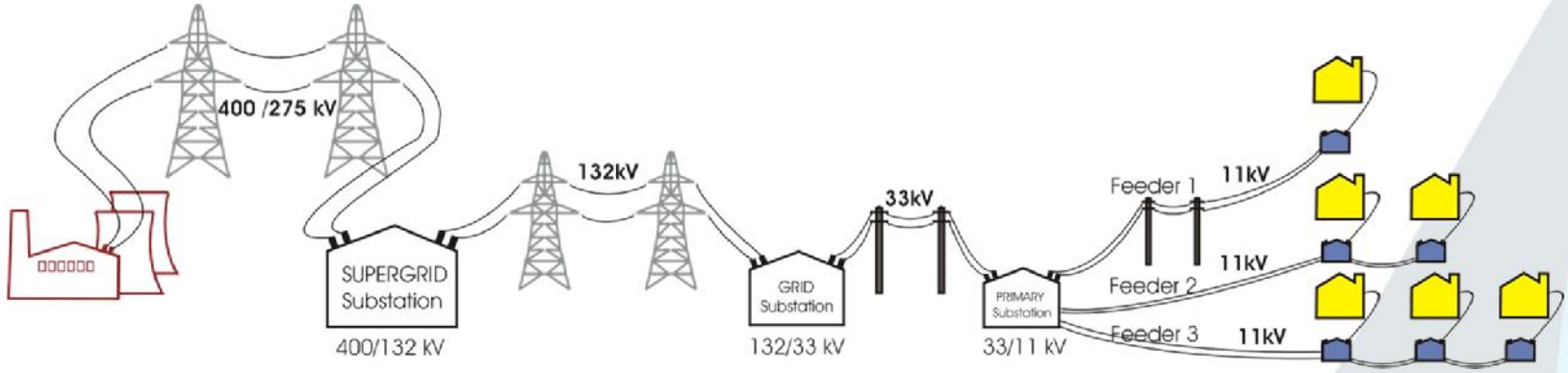

Transmission and Distribution Network

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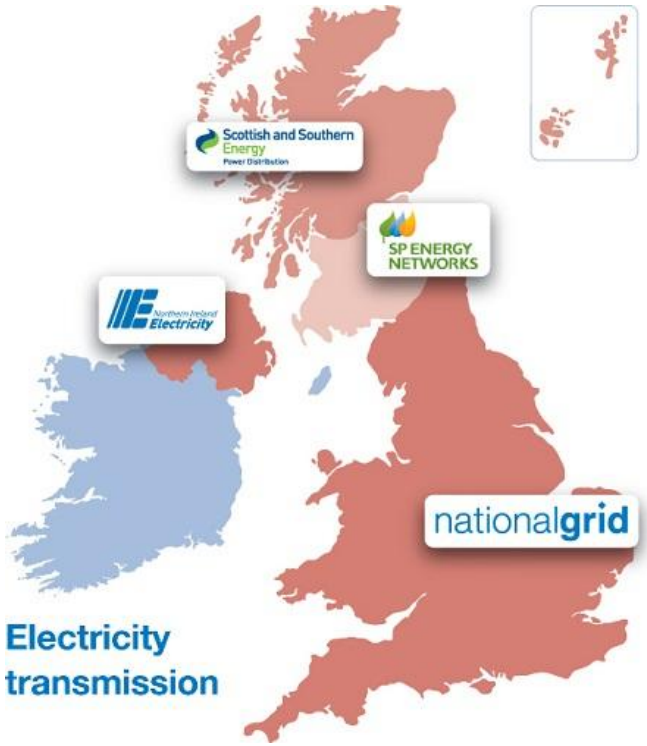

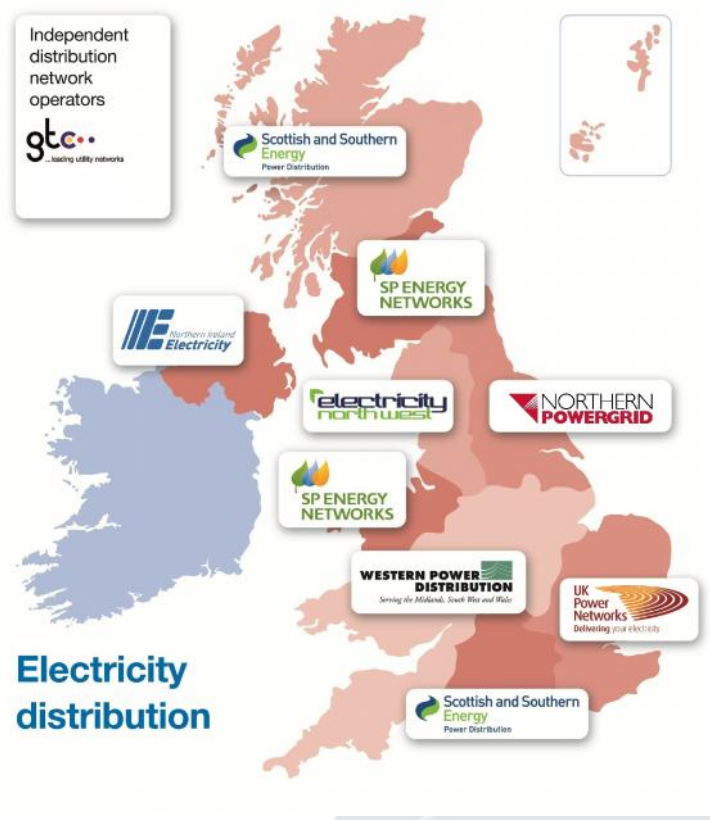

The industry is regulated by Ofgem

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ofgem

Office for gas and electricity markets

- Value for customers
- Quality of supply
  - Customer minutes lost
  - Customer complaints
- Voltage delivered = 230 V (+10%, -6%)

History

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Our History

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1950's — *AVE5*

1980's — *TAPP Module*

1994 — *Collaboration with Reyrolle on SuperTAPP*

1995 — *SuperTAPP sold overseas*

2000 — *MicroTAPP*

2006 — *SuperTAPP n+*

2008 — *Acquisition Of Whesco*

2009 — *Authorised MR Agent*

2012 — *Consolidated operations and moved to Swindon*

Further Growth and Expansion

Asset Services Launched

- Ex-Schneider & Powermann

Morgan Schaffer

- Exclusive Authorised UK Representative
- condition assessment of large high-voltage transformers using Dissolved Gas Analysis (DGA)

Total Tapchanger Solutions launched

- Partnering with Powerserve and Ferranti
- Multi-brand

SuperTAPP SG

Tightly integrated mechanical control buttons and indication

Communications IEC 61850, DNP3, IEC 60870-5-104

Ongoing development of voltage control functions

Moved to larger premises

Network Voltages

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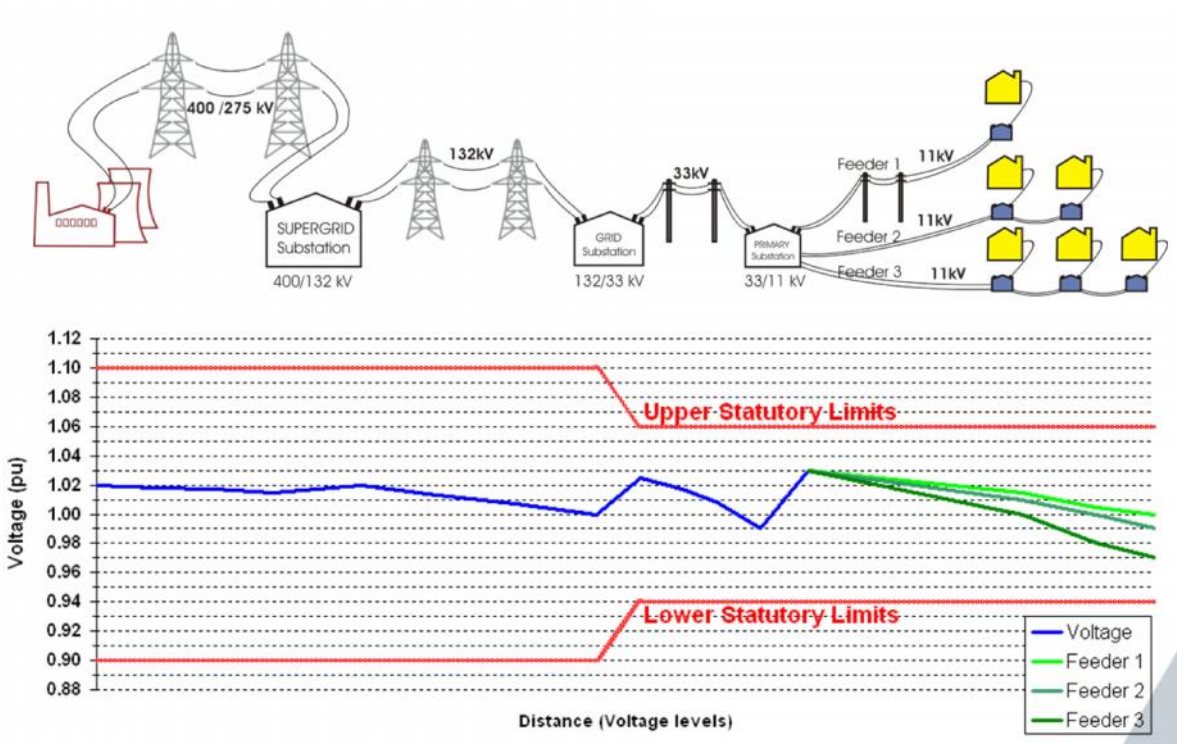

Voltage Regulation

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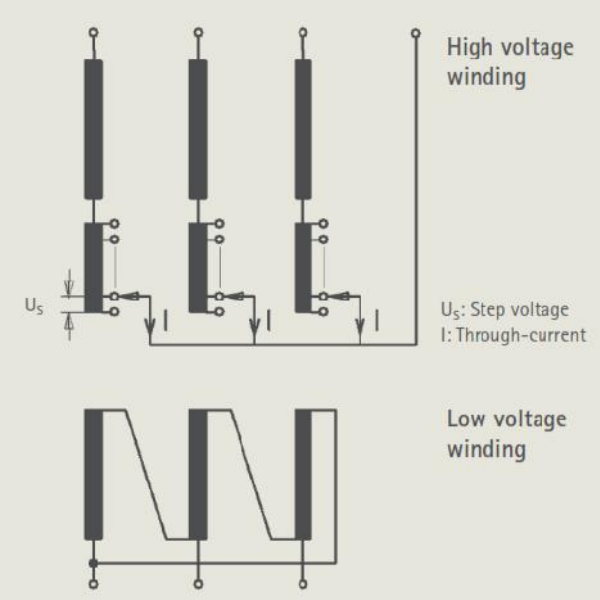
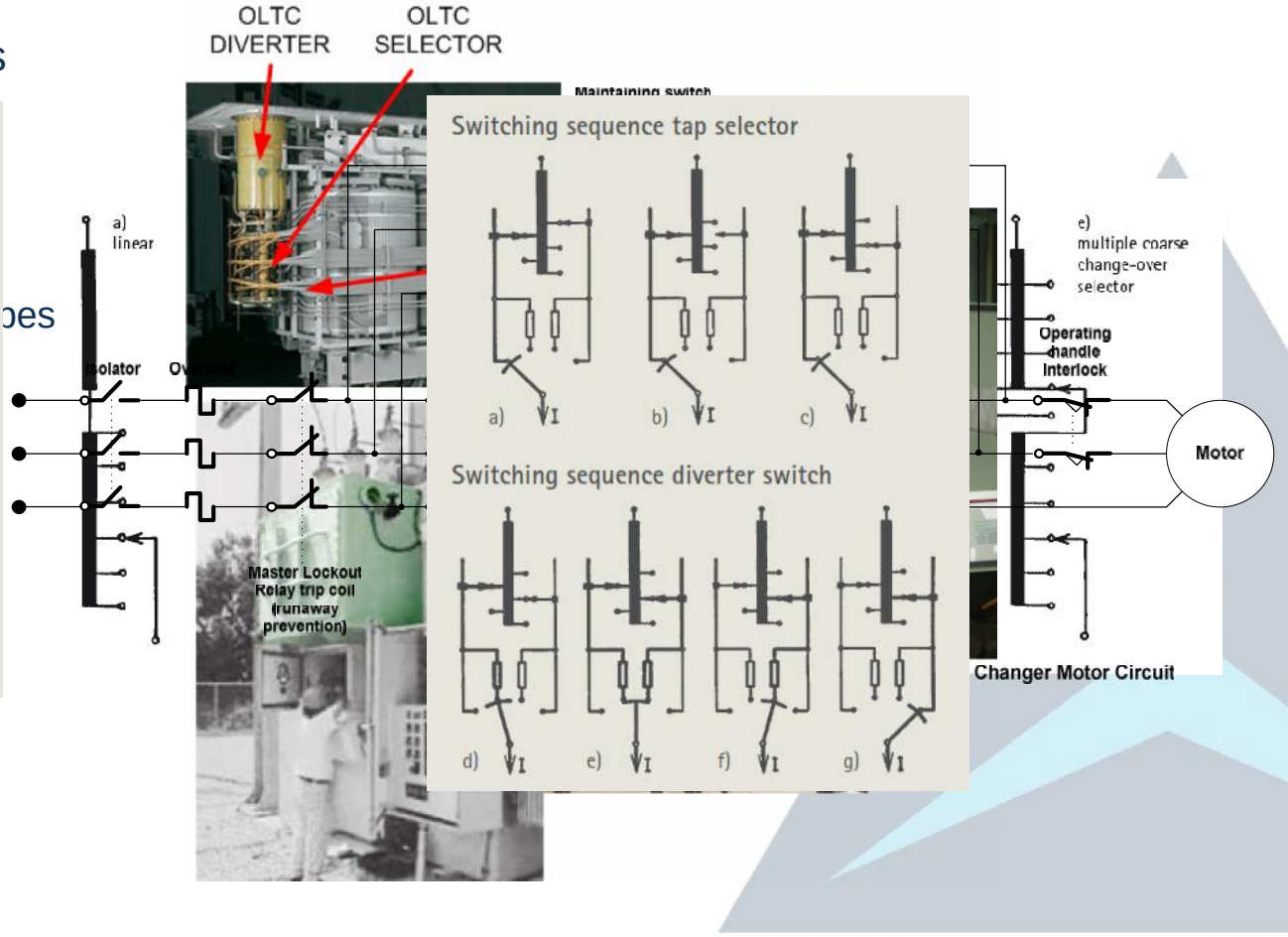
- Tap Changing Transformers



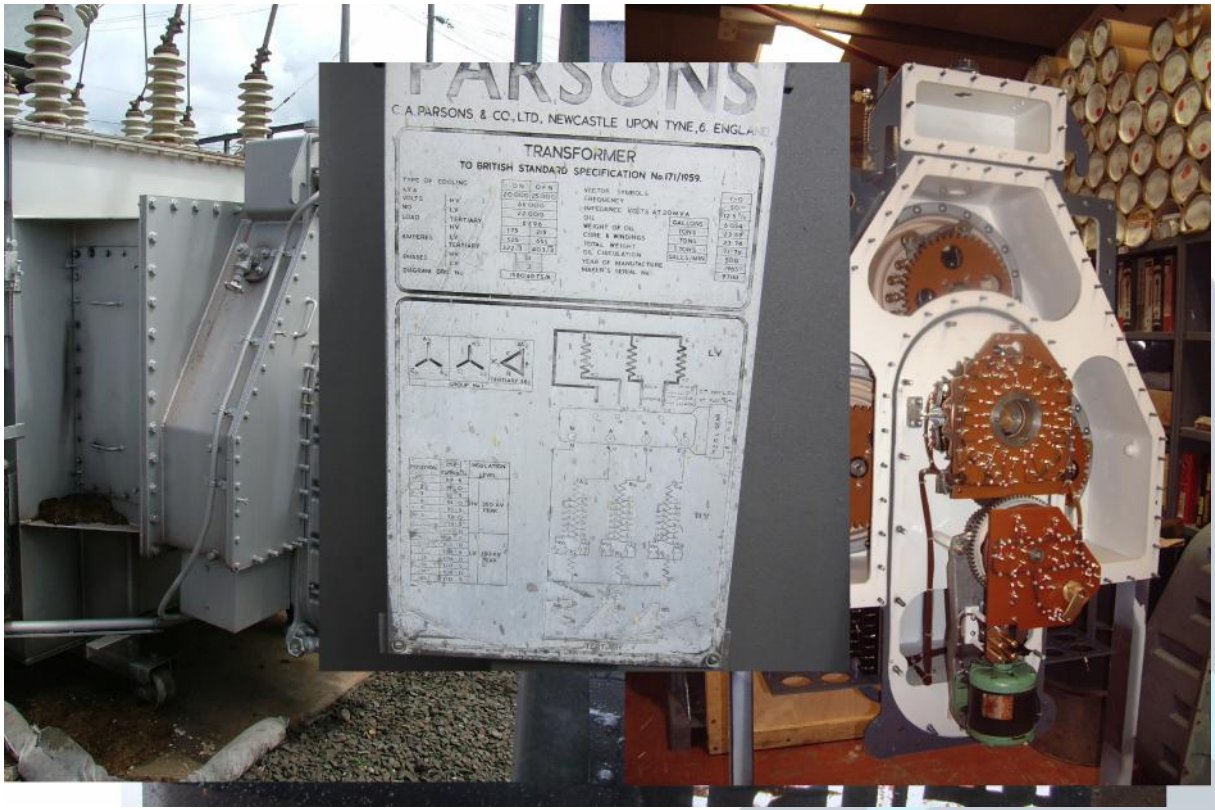


- Panel with AVC relay

Tapchanger Maintenance

Why ?

- Arcing
  - Oil degradation
  - Contact wear
- Mechanical system
  - Moving parts
- Old system
  - Design life 40 years ?
  - Records ?
  - Real maintenance ?
  - Genuine parts ?



Traditional AVC

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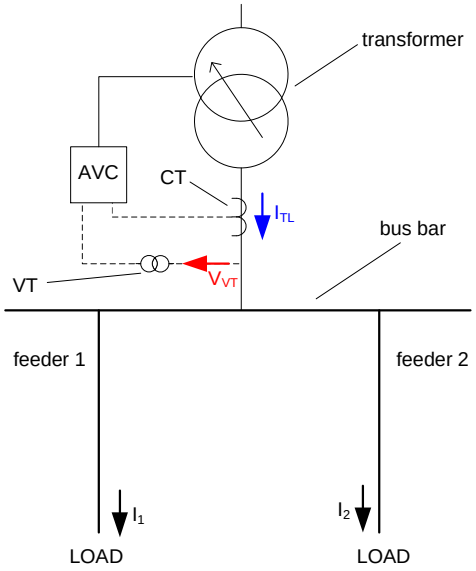
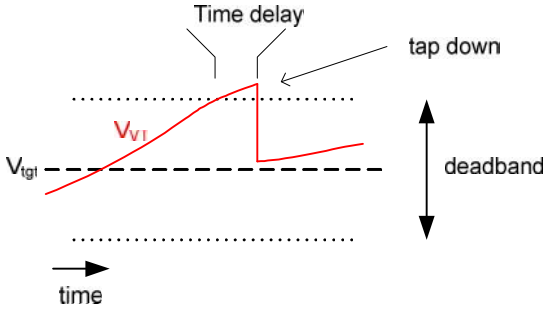
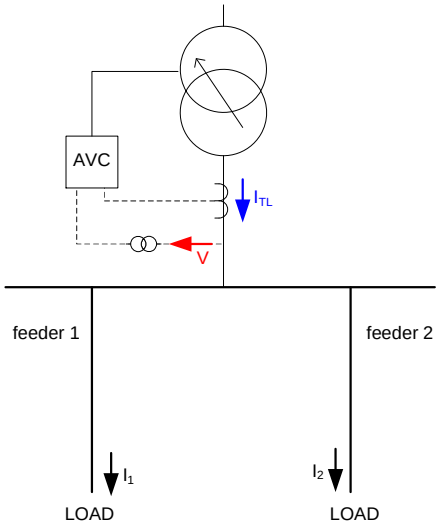


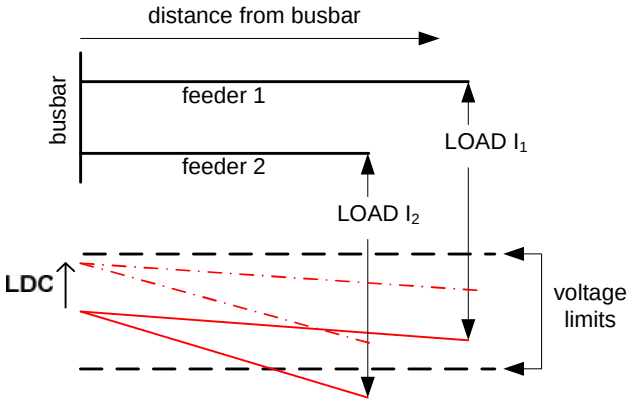


- V_{tgt} = desired busbar voltage
- Tap change initiated if V_{VT} 'out of band'
- Time delay included for short term voltage fluctuations

Load / Line Drop Compensation (LDC)



- Voltage drops on feeders
- LDC applied in proportion with I_{TL}



Circulating Current

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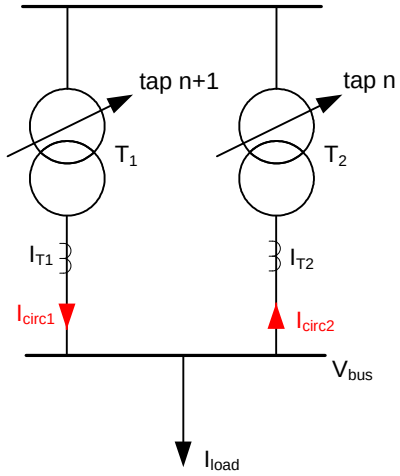
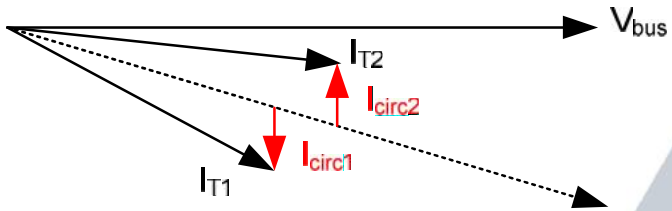
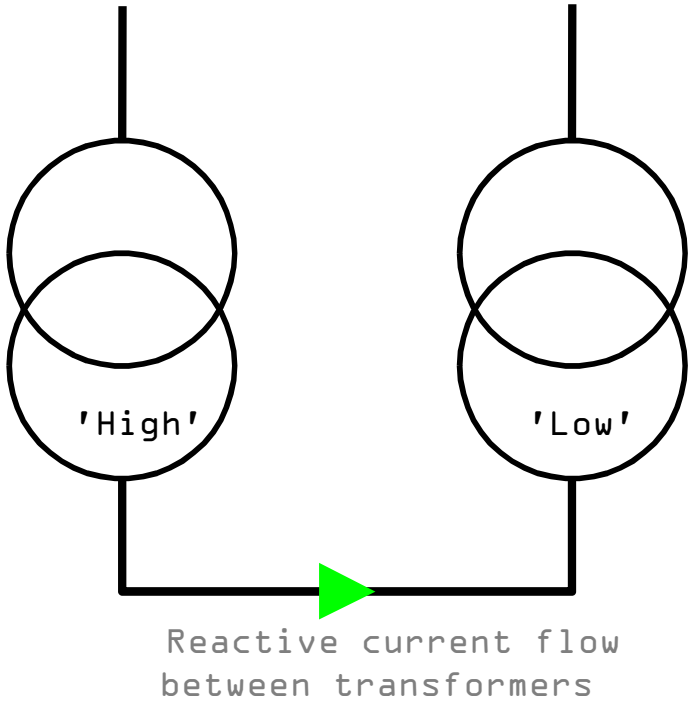
- Transformers operated in parallel for security of supply
- Circulating current flows when identical transformers on different tap positions
- Circulating current can cause increased losses





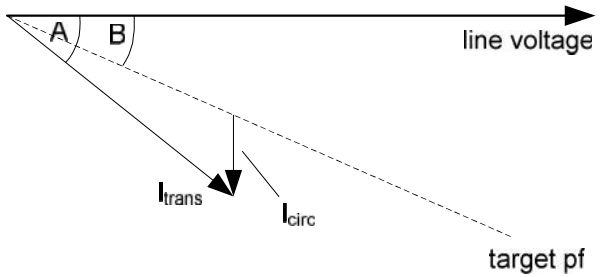
Voltage Control Principle

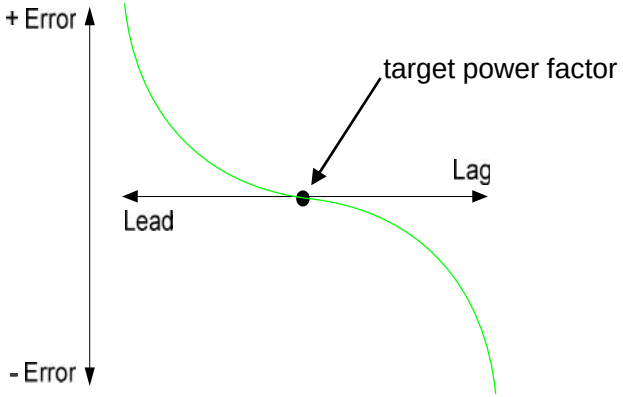


'Transformers are on the correct tap position when minimum circulating current flows between them and the system voltage is correct'

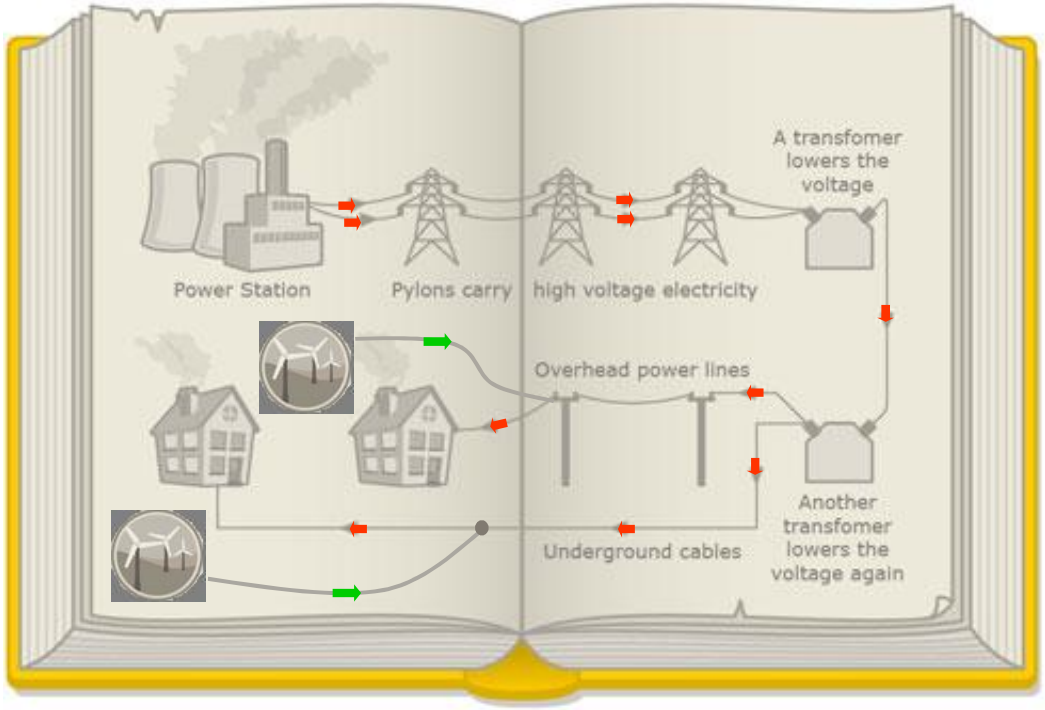
Voltage Control - TAPP

- Compares transformer load pf with target pf
- Voltage error when load pf deviates significantly from target pf
- Target pf for TAPP = actual pf of load (0.96 lag)





Changing Grid



Network Voltages

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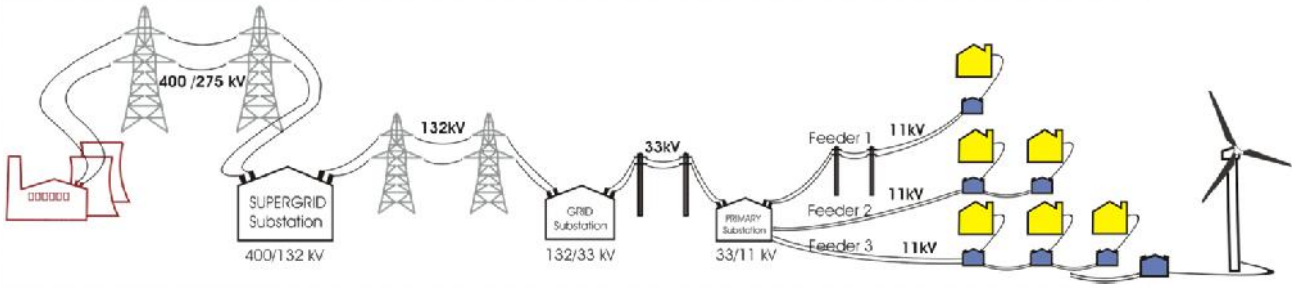
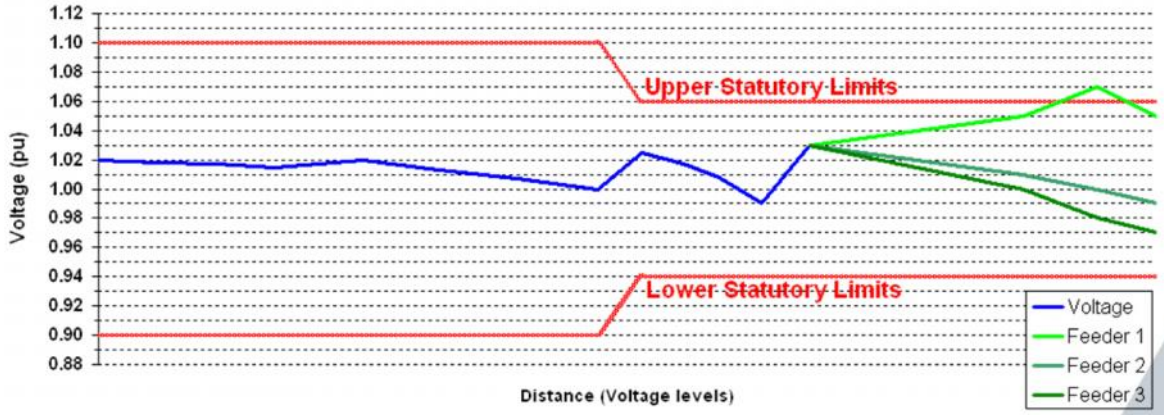
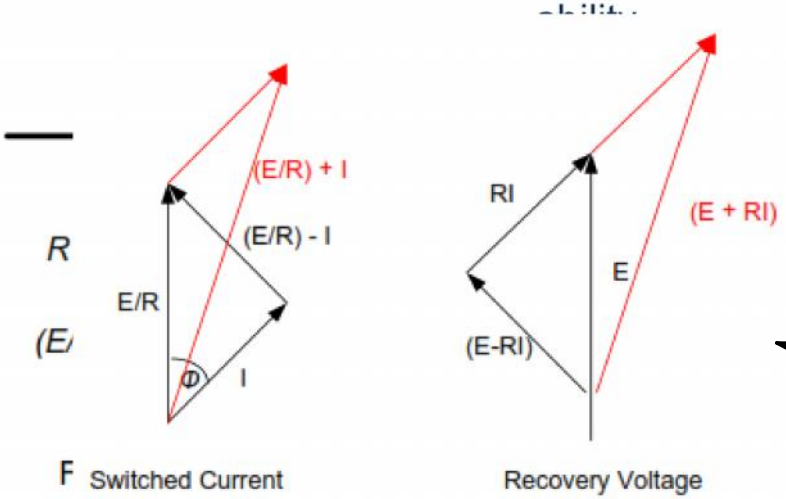
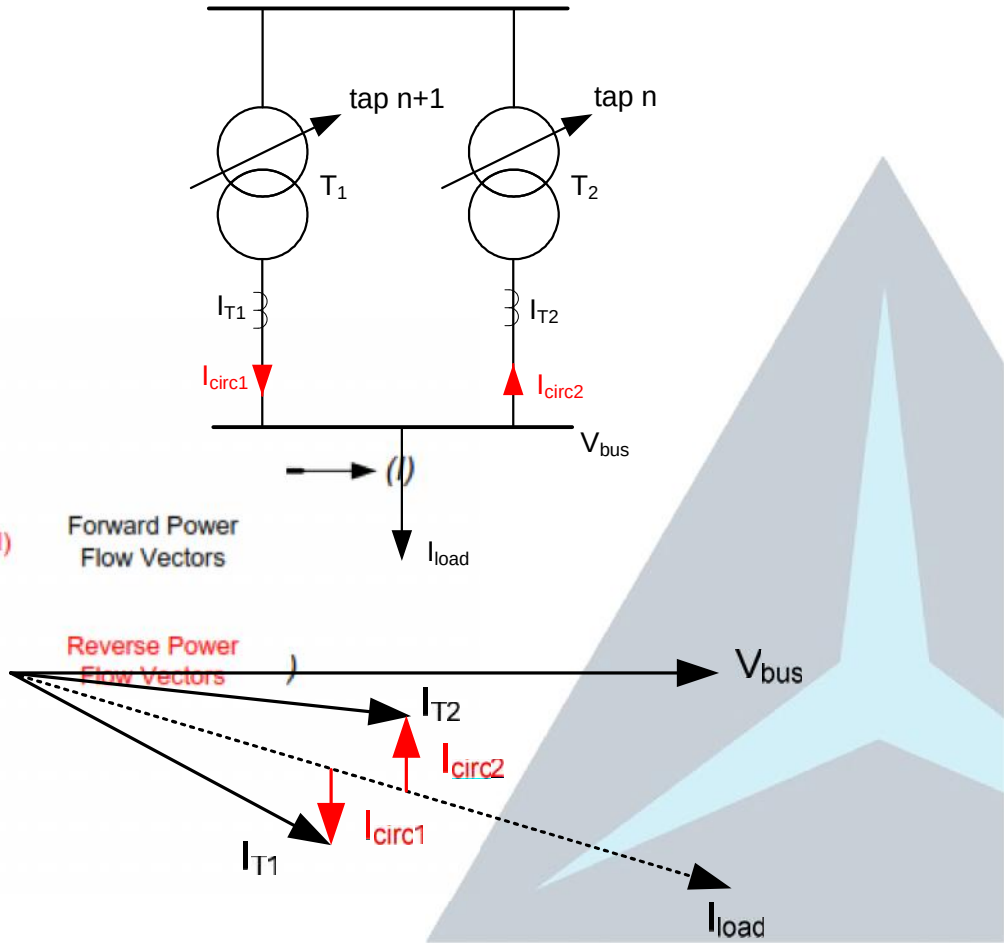




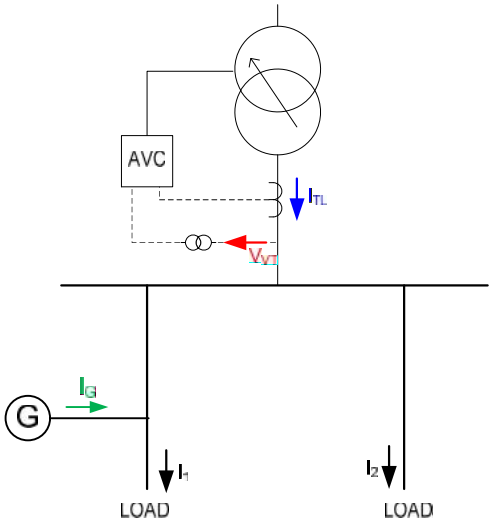
What's the Problem ?

- Some OLTCs have limits
  - Asymmetrical diverters
  - Single resistor
  - Circulating current + load
- Reverse Power Assessments
-

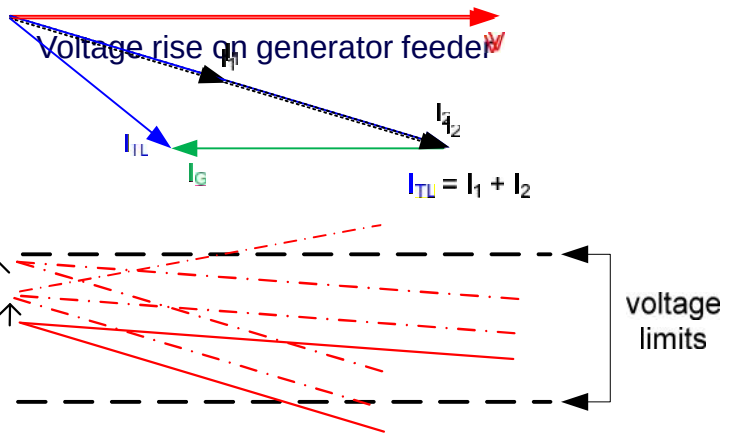




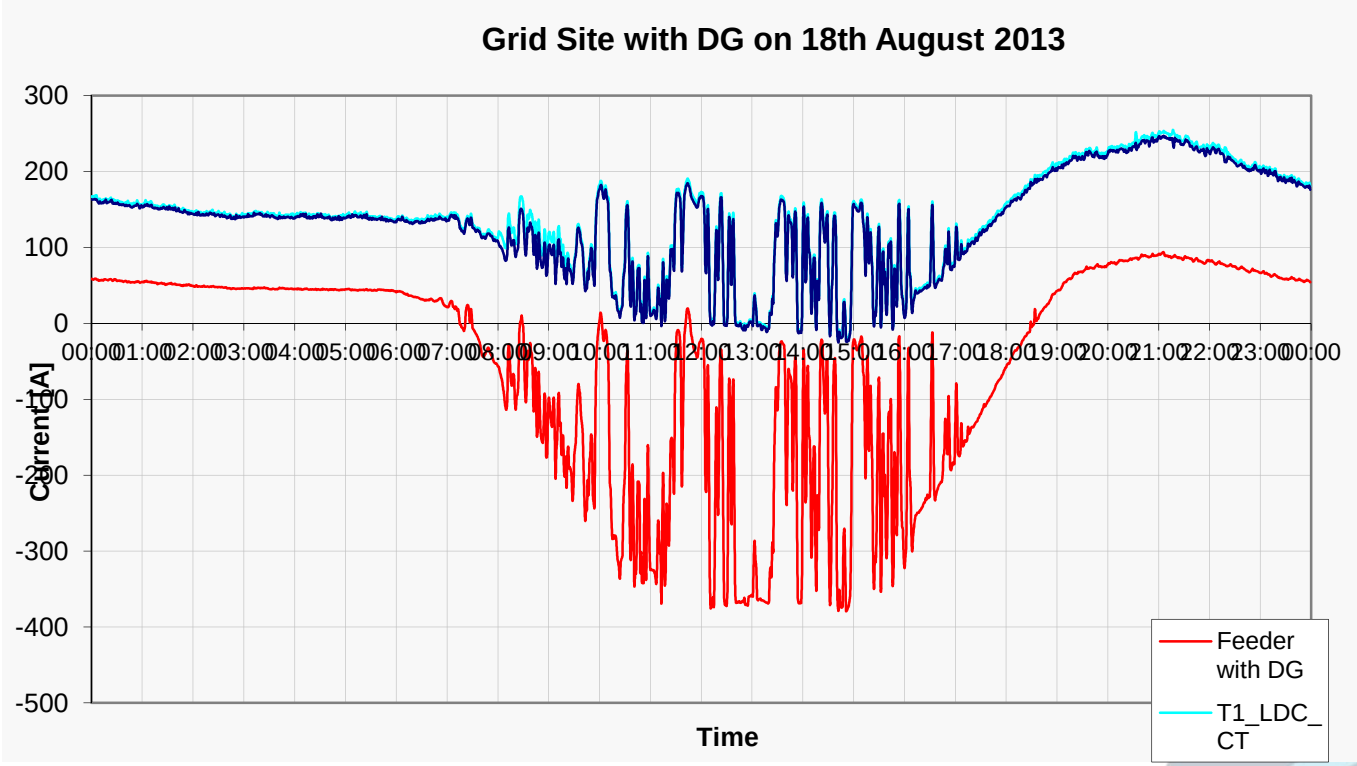
Voltage Control Issues



- Voltage drops on feeders
- Load Drop Compensation (LDC) applied in proportion with I_{TL}
- I_{TL} no longer represents 'true' load - LDC reduced
- Voltage errors due to power factor variation
- Voltage rise on generator feeder



Reverse Power



Industry Challenges

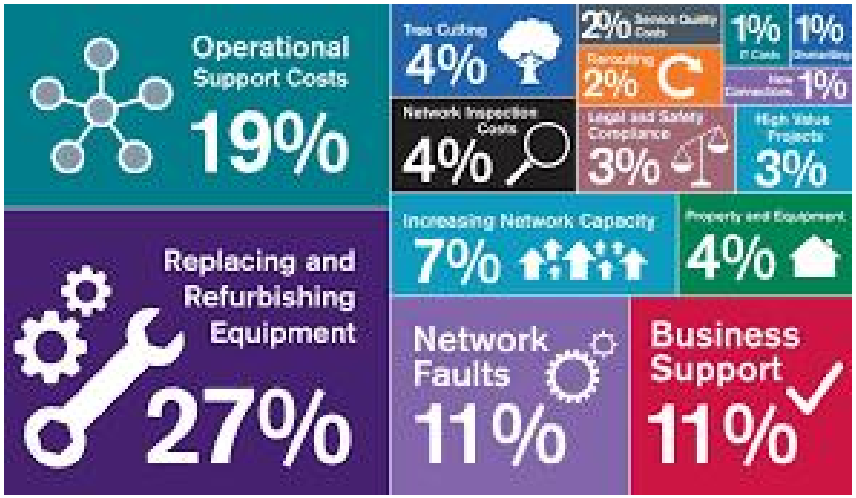
Ageing assets

- Missing records
- Obsolete parts
- OEM ceased trading
- Non-operational AVC schemes
- Health and safety risks

Reverse Power

- Capability of OLTCs unknown
- Voltage control issues
- Planners under pressure to make decisions on connecting DG

Industry Challenges



Challenges facing the Network Operators :

RIIO Deliverables -

- Accommodate more DG
- Reduce losses
- Improve health indices
- Reduce interruptions and complaints
- Continuous Innovation

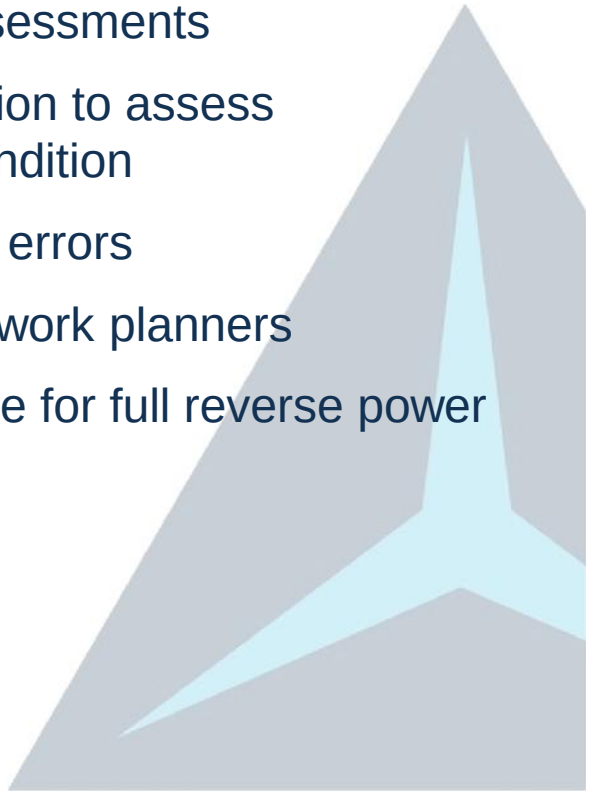
Total Tapchanger Solutions

Our Offering:

- Formal partnerships with Powerserve, Ferranti and MR
- Access to original designs
- OEM spare parts from original drawings and material specs
- Multi-brand - Full maintenance and upgrade of all types of Tapchanger
- Expanding expertise to provide a Total Solution

Reverse Power -

- Theoretical Assessments
- On site inspection to assess Tapchanger condition
- Voltage control errors
- Support for network planners
- Upgrade service for full reverse power capability



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Control Scheme Solutions

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Tapchanger Retrofits

- Reasons for replacement
  - Life extension of transformer
  - Broken tapchanger
  - Reverse power limitations
  - Uprating
- Information required
  - Transformer winding configuration
  - Barrier board location
  - Interfacing requirements
  - Dimensions
  - Access

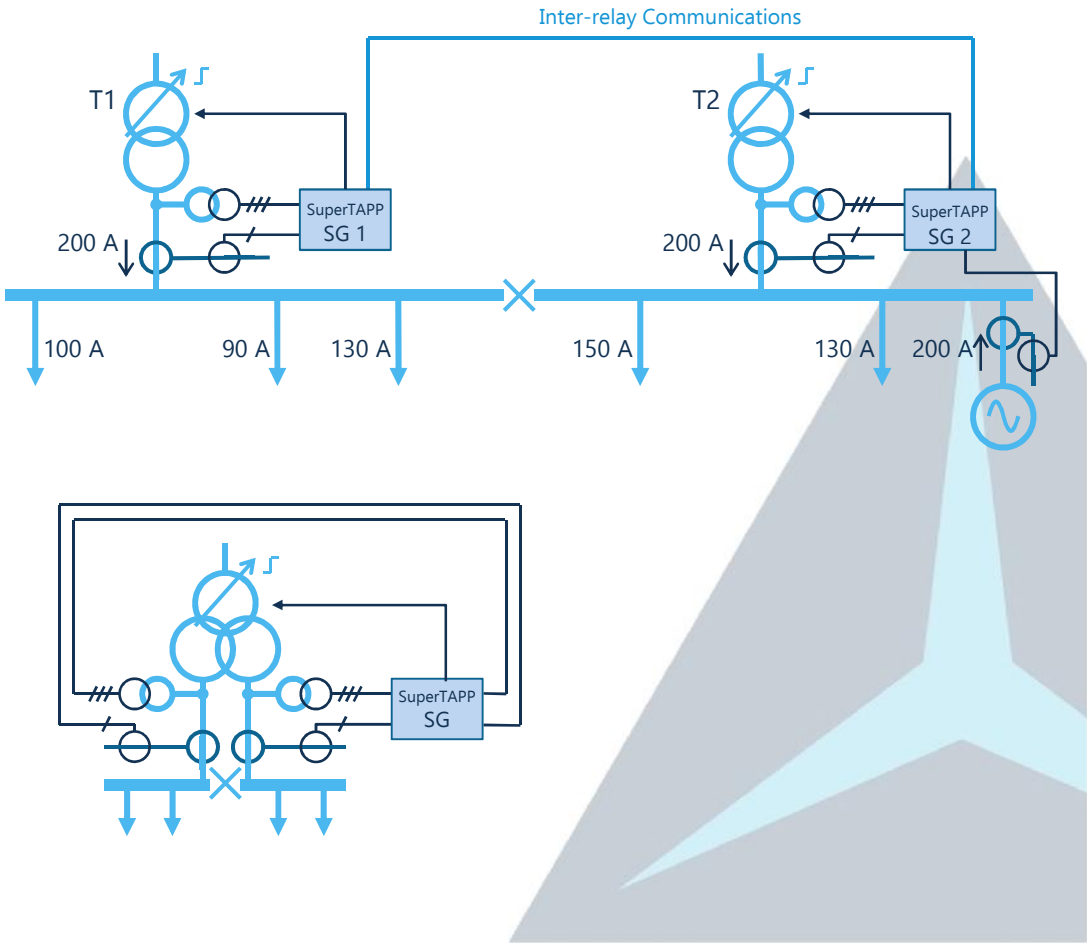
Solution for AVC

Problems

- Inaccurate LDC
- Voltage rise
- Voltage errors with parallel control
- Reverse power OLTC operation

Solution = Smart AVC

- Extra current measurements - feeders
- Accurate load calculation
- Generator measurement / estimation
- Enhanced TAPP – accurate parallel control
- Built-in load averaging
- Reverse power blocking



SuperTAPP SG Features

One serial and two Ethernet rear ports for IEC 61850, DNP3 and IEC 60870

Withdrawable case, easily upgradeable without disturbing existing wiring

Digital and mA I/O modules for plant, SCADA and tap position indication

Front panel USB port for settings and data download

Easy to use control panel making engineering simple

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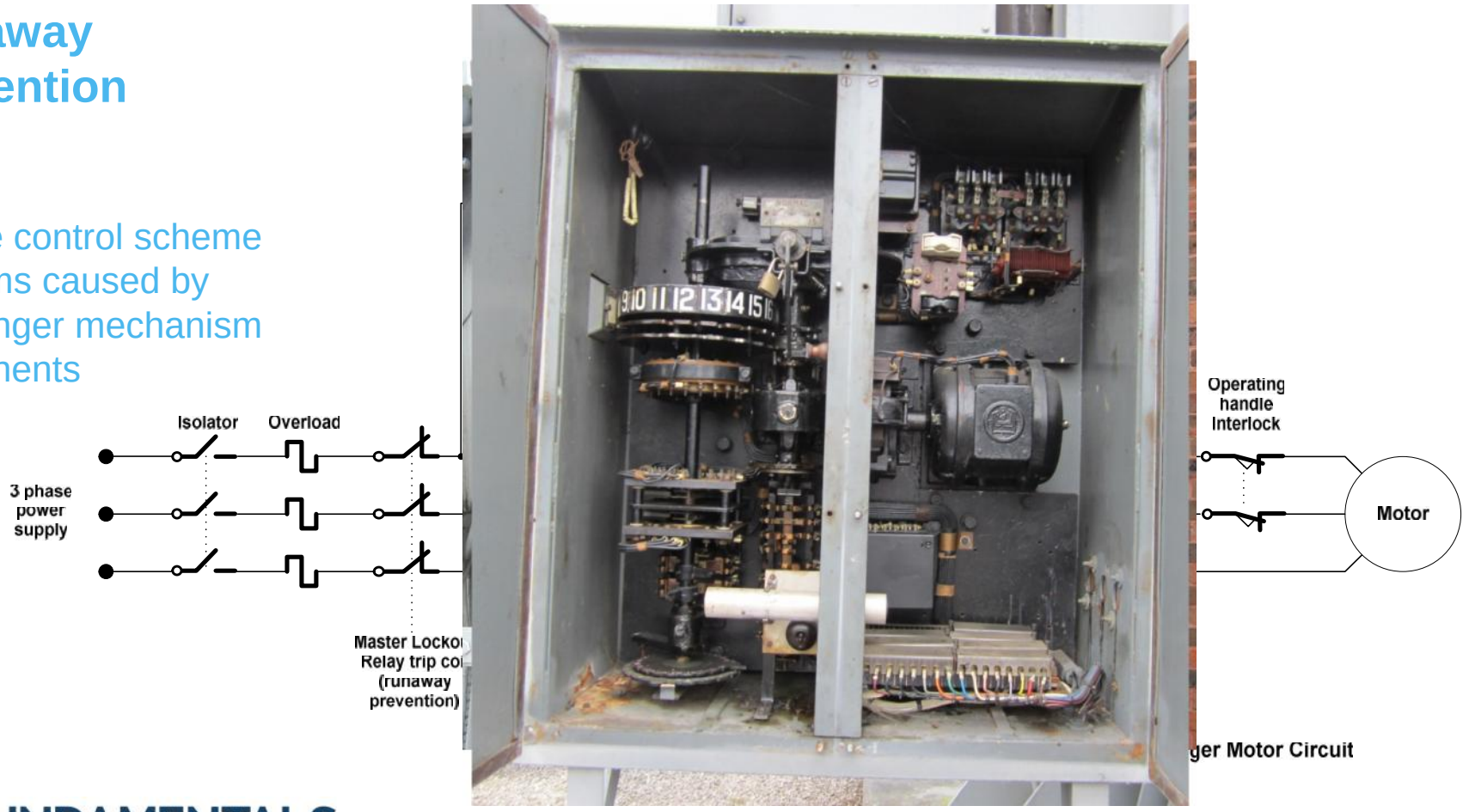
Runaway Prevention

Voltage control scheme problems caused by tapchanger mechanism components



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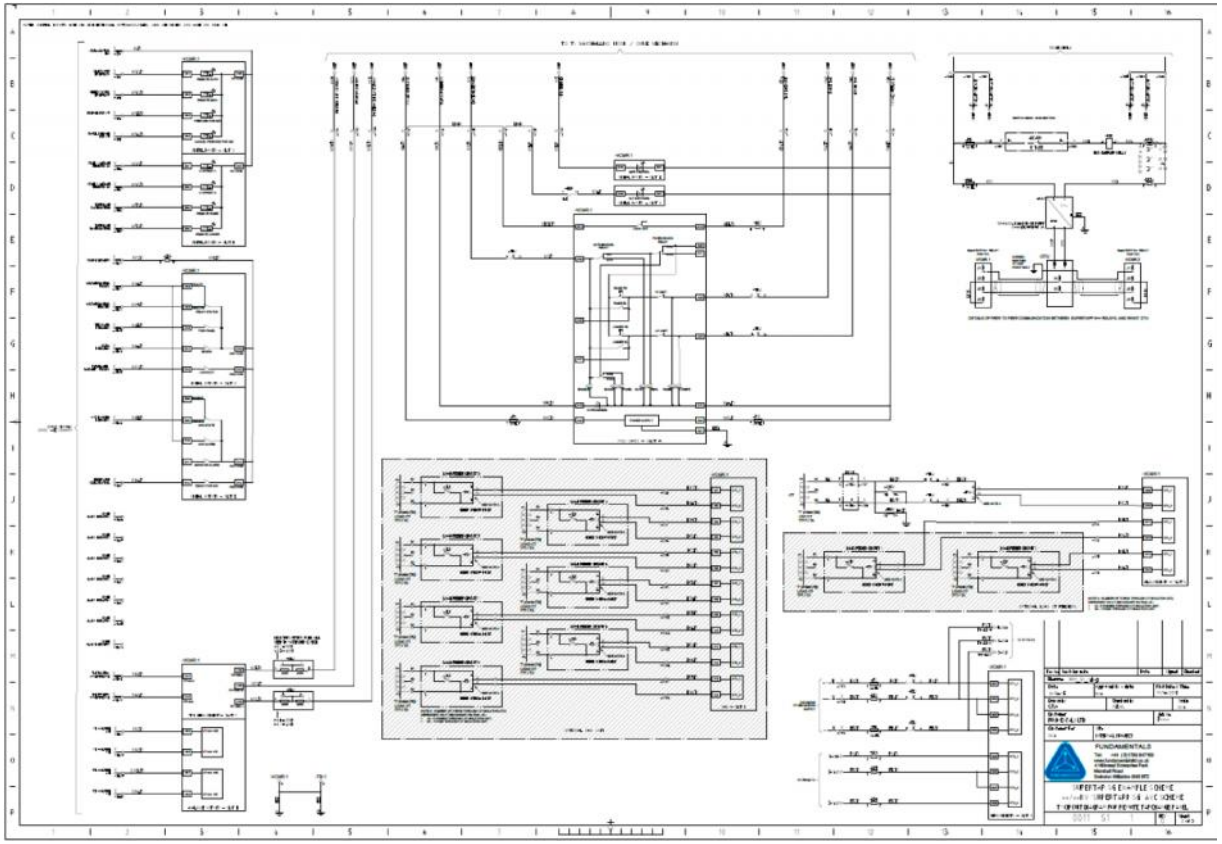
Scheme Design Support

Generic AVC system design exists

We can integrate SuperTAPP SG into existing schemes



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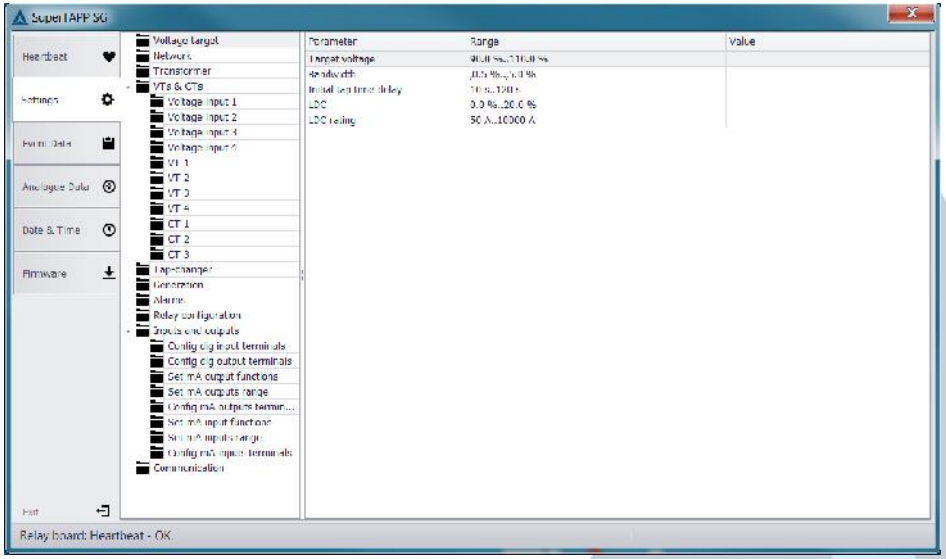
PC Software

Settings management

Relays management

Events logging

Monitoring and maintenance data



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Complete Support for AVC

Technical support

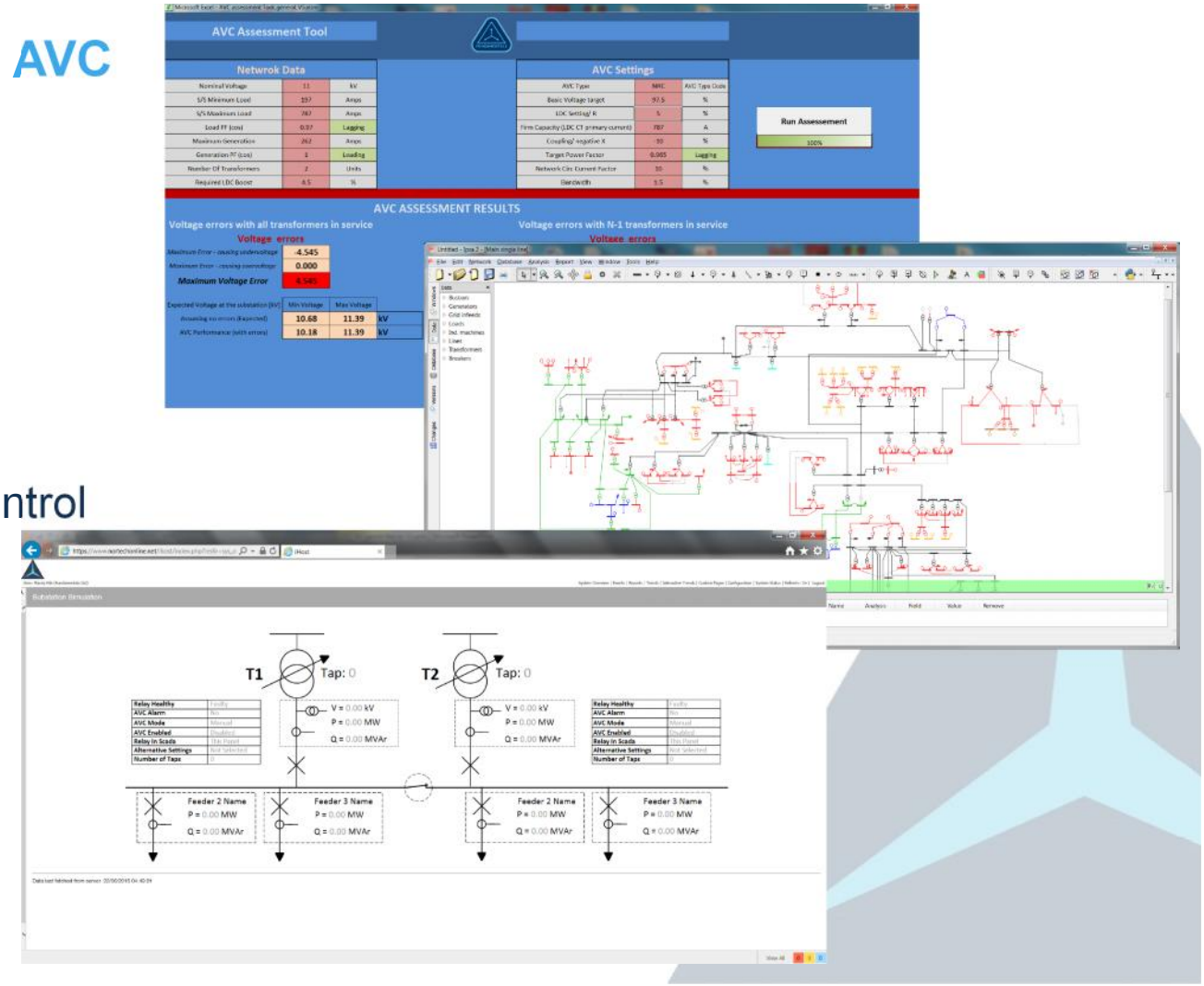
AVC assessment tool

Network analysis

DG connection support

Monitoring and voltage control management

SuperTAPP Mimics



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Summary

- Voltage regulation important for network operation
- Transformer, OLTC, drive mechanism, panels, kiosks, relays
- Modern issues
  - Distributed generation
  - Aged assets
- Solutions
  - Smart AVC relay
  - AVC scheme upgrades
  - Total Tapchanger Solutions

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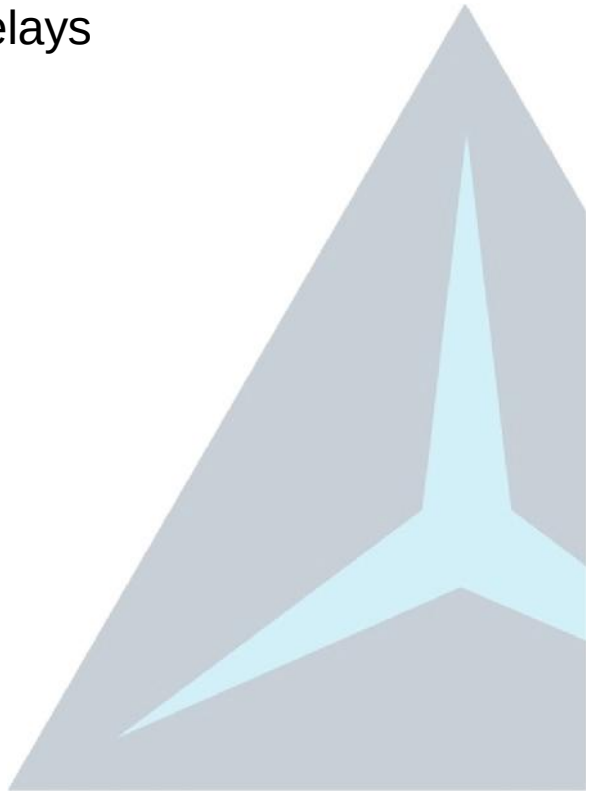

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End of Presentation

Any questions?