Voltage Regulation for Smart Grid

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“Improving the Health and Performance of the Electrical Grid”
Contents

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• History
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The Electrical Grid
The industry is regulated by Ofgem

Office for gas and electricity markets

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

- 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

- \( V_{\text{tgt}} \) = 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

- 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.

Reactive current flow between transformers
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

- Power Station
- Pylons carry high voltage electricity
- Overhead power lines
- Underground cables
- Transformer lowers the voltage
- Another transformer lowers the voltage again
What's the Problem?

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

- Reverse Power Assessments

\[
\begin{align*}
R & \quad (E/R) + 1 \\
(T_1) & \quad (E/R) - 1 \\
(T_2) & \quad (E + R) \\
I_{load} & \quad I_{T1} \\
I_{circ1} & \quad I_{circ2} \\
V_{bus} & \quad I_{T2} \\
\end{align*}
\]
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

\[ I_{TL} = I_1 + I_2 \]
Reverse Power

Grid Site with DG on 18th August 2013

Feeder with DG
T1_LDC_CT
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
Control Scheme Solutions
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

FUNDAMENTALS
Runaway Prevention

Voltage control scheme problems caused by tapchanger mechanism components
Scheme Design
Support

Generic AVC system design exists
We can integrate SuperTAPP SG into existing schemes
PC Software

Settings management
Relays management
Events logging
Monitoring and maintenance data
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
End of Presentation

Any questions?