Condition monitoring algorithms

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TRANSPOWER

Summary of sections

1. Introduction – Condition monitoring
2. CVT voltage imbalance
3. Transformer tap changer hunting
4. Circuit breaker fault operations

Introduction

Condition Monitoring - Implement real time analysis trending and early warning indicators for three asset classes

- Condition Monitoring allows us to better understand the condition of our assets
- Improve Transpower's asset management capability
- Three asset classes chosen:

1. Transformer Tap Changer Hunting
2. Capacitive Voltage Transformer Imbalance
3. Oil Circuit Breaker Fault Operations

CVT voltage imbalance

Redcliffe 220 kV CVT

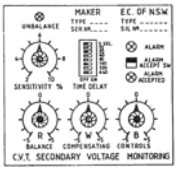
Penrose 220 kV CVT

CVT voltage imbalance

- Transpower uses CVTs on 220kV
- Stacks of capacitive elements
- Over time can fail, produce incorrect measurements
- Can lead to complete failure
- Monitor voltage of CVT for indication of capacitor failure

CVT voltage imbalance

- Existing CVT monitoring relays
  - Legacy equipment, gone unnoticed
  - Limited SCADA info
  - Phase voltage difference compared to a set sensitivity
  - Compensation, sensitivity and alarm time delay adjustments



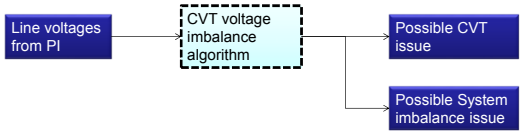
Typical layout of CVT monitoring relay

CVT voltage imbalance

- Replicate existing relay using software and PI info
- Phase voltage analogues not available
- Line voltages available through SCADA
- Different detection method needed

CVT voltage imbalance

- CVT voltage imbalance algorithm is born



- Major algorithm component:
  - Shewhart control chart method

Shewhart control chart method

- Control charts
  - Specialized time series plots
  - Assist in determining if a process is in statistical control.
- One control line for each line voltage difference
- Centre line, Upper and lower control limits
- Monitoring voltage imbalance
  - Comparison to fixed values lead to errors
  - Dynamic limits used (Centreline, Upper limit and Lower limit)
  - Count the number of limit violations over a time period

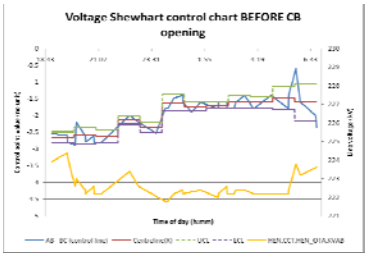
Shewhart control chart method

- Centre line (average)
- Upper control limit (UCL)
- Lower control limit (LCL)
- Standard deviation of averages:

$$\sigma_x = \frac{\sigma}{\sqrt{N}}$$

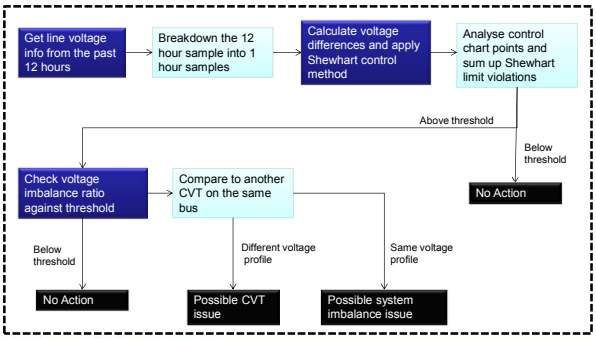
- Mean added to deviation to get limits:

$$\text{UCL / LCL} = \bar{X} \pm k\sigma_x$$



One control line of the Shewhart control method

CVT voltage imbalance - Algorithm



CVT voltage imbalance – Future improvements

- Additional data points received through SCADA
  - Phase voltage magnitudes, digitally replicate existing monitors
  - Voltage angles/phasors
- Voltage imbalance ratios using negative seq component
  - Can utilise existing SEL relays
  - Send info through into PI
- Re-calibrate existing CVT monitors
  - Compensation settings
  - PI data points

Transformer tap changer hunting

Wilton
220/110 kV

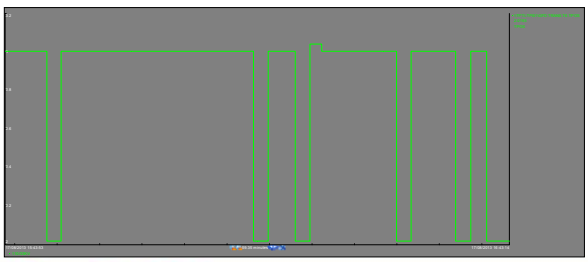
BPE
220/110 kV

Transformer tap changer hunting

- Transformer on load tap changers can have trouble deciding on a tap to meet the voltage set point
- Introduces unnecessary wear on the tap changer as this is related to the number of tap change operations
- Usually happens consistently at particular sites

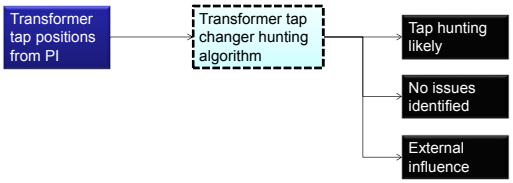
Transformer tap changer hunting

- Information exists, just a matter of monitoring and using it effectively



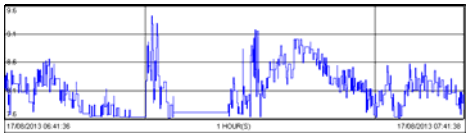
Transformer tap changer hunting

- Algorithm developed using inputs from PI to pick out suspected incidents of tap hunting

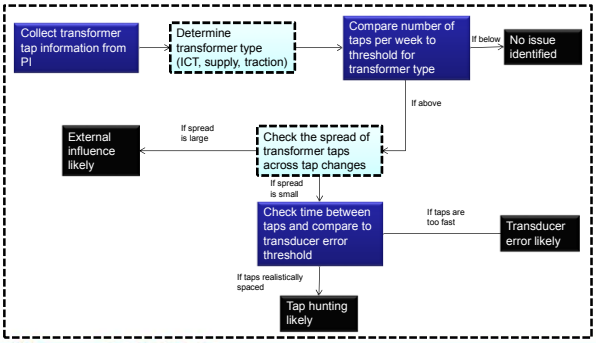


Transformer tap changer hunting

- Challenge is isolating tap hunting events from legitimate external influences or transducer errors



Transformer tap changer hunting



Circuit breaker fault operations

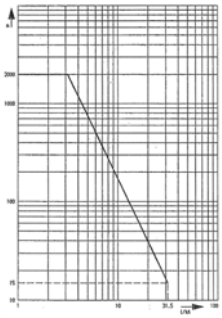
Takapu rd
33 kV
Bulk Oil

Edgecumbe
220 kV
Minimum Oil

Albury
110 kV
SF6

Circuit breaker fault operations

- Circuit breaker wear dependent on number of fault operations and breaking current
- Want a way of tracking circuit breaker operations to anticipate maintenance requirements
- Both dielectric breakdown and wear of contacts

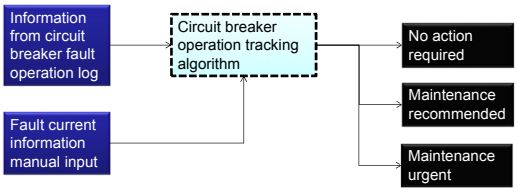


Circuit breaker fault operations

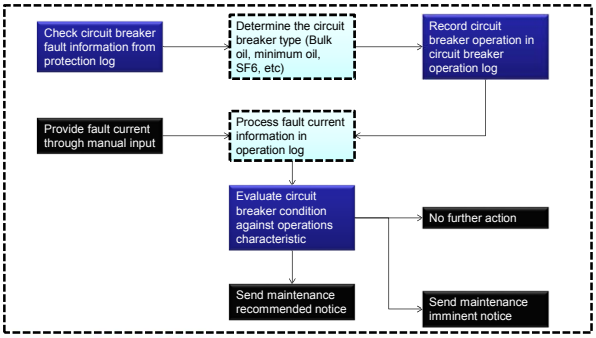
- PI provides information on opening and closing of breakers
- Does not sample fast enough to catch fault currents
- Fault current information is stored temporarily in relays but can only be extracted manually at present
- Potential for obtaining the information easier in the future

Circuit breaker fault operations

- Algorithm developed using information databases, PI and manual inputs



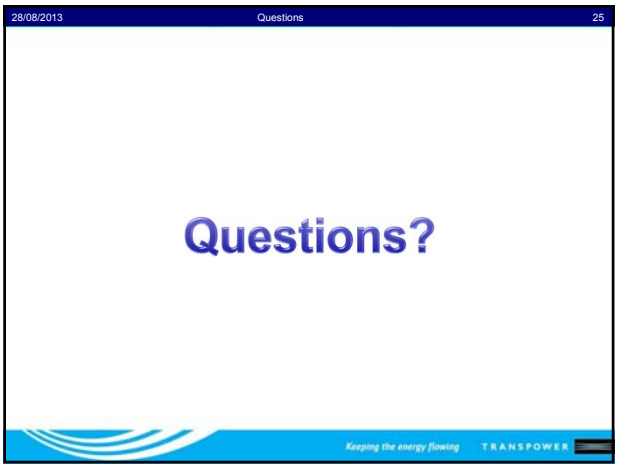
Circuit breaker fault operations



Circuit breaker fault operations

- Future improvements can be made to this process with remote fault current monitoring
- Transpower's new standard OC/EF relays have advanced CB monitoring capability
- Previous model SEL relays still have some limited capability
- Alstom modular CB monitoring system

SEL-451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Questions
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Questions?
Keeping the energy flowing
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