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On-line diagnostics of reactor and transformer bushings by utilization of overvoltage transients

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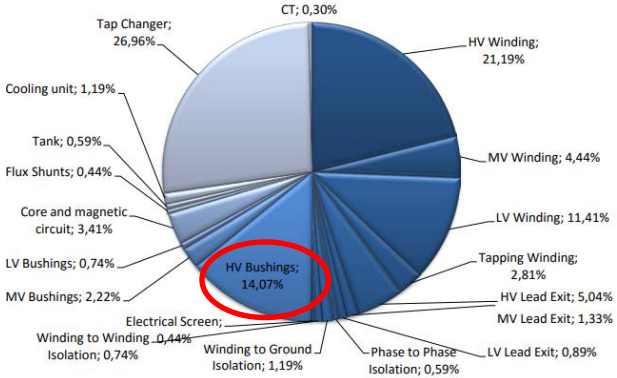
Introduction

- **The Electric Power System is constantly evolving in size and complexity**
- **The hazard rate for transformers and reactors is also going up in recent times**
- **A significant numbers of transformer and reactor failures is due to bushing failure (about 15-30 % of the cases)**
- **Transient overvoltages are further increasing the risk**
- **Bushings are exposed to various mechanical, thermal and dielectric stresses**
  - **Moisture and Ageing.**
  - **Partial discharges due to weakening of insulation.**
  - **Failure under transient overvoltages.**

Moisture ingress, short circuit of capacitance gradings, PD and X-wax, damaged OIP and broken connections

* https://www.hitachienergy.com/offering/product-and-system/transformers/power-transformers/system-intertie-transformers



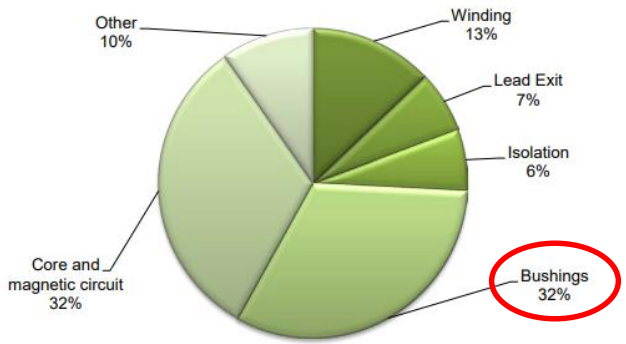


Figure 1. Causes of Transformer and Reactor failures. ("Transformer Reliability Survey 642 ", CIGRE Technical Brouchure 2015)

Objectives and approach

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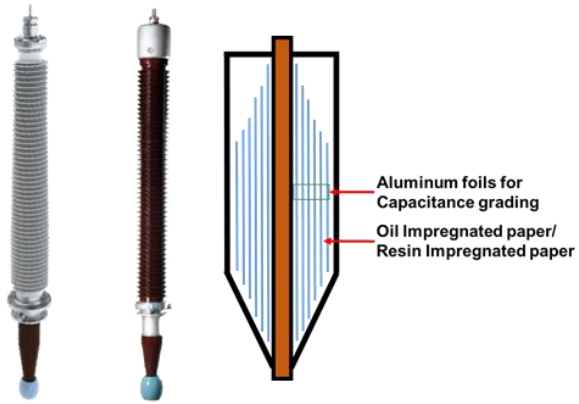

Figure 2. Condenser bushings

* https://www.hitachienergy.com/offering/product-and-system/transformer-insulation-and-components/bushings

Current diagnostic methods for bushings

- **Capacitance and Dielectric Dissipation factor measurements**
- **Dissolved Gas Analysis (DGA) for OIP bushings**
- **IEC 60270 based Partial discharge measurements**

All the methods are not online and are performed at intervals

- **Online monitoring of the reactors and transformers.**
- **Transient overvoltages are unavoidable and can be used for diagnosing the bushings for defects**
  - **Detection of transient overvoltages**
  - **Continuos partial discharge monitoring to better know the condition after every transient voltage event.**
- **Usage of non contact sensors and antennas to avoid putting the reactors and transformers out of service**

Transient Voltage Monitoring

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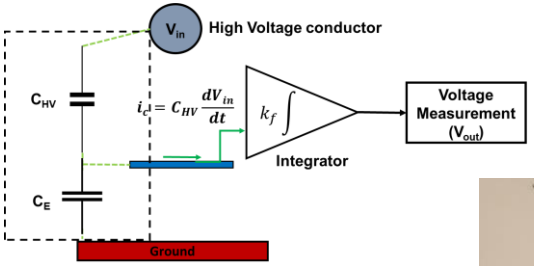

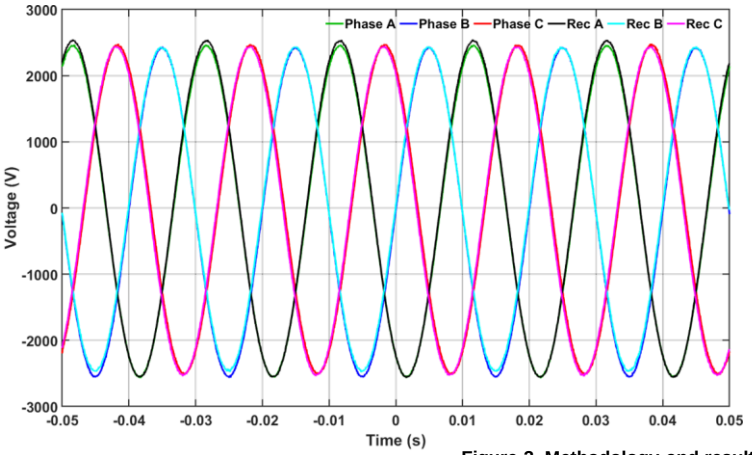

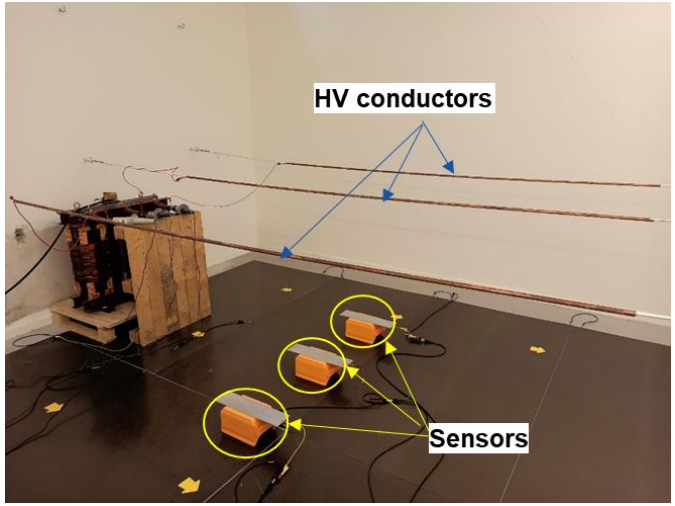

Figure 3. Methodology and results from the laboratory model

- A highly sensitive, linear and wide band, non contact capacitive based sensor system
- Three phase measurements are complex due to cross capacitance coupling, so a decoupling methodology is also proposed to reconstruct the on 3 phase voltages on conductors

On-field test Results

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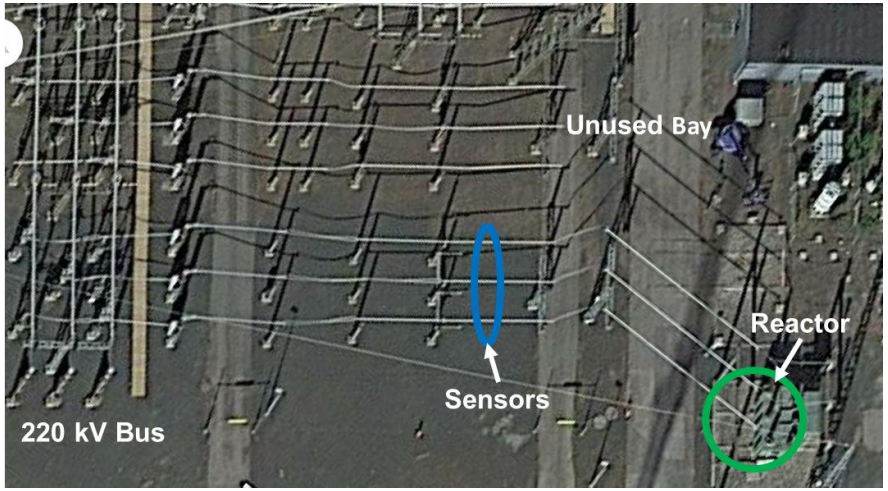
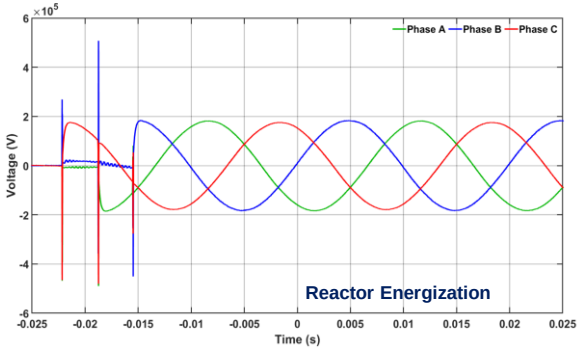


Figure 4. Google maps image of the test site



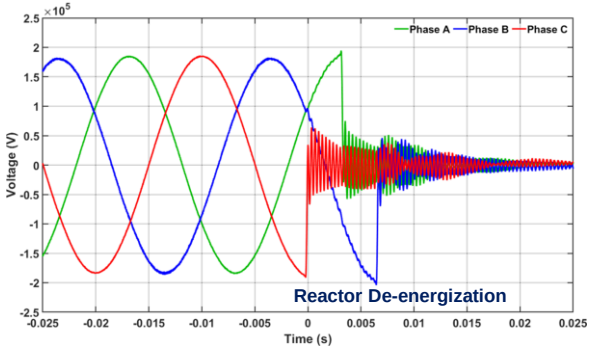


Figure 5. Typical transient events recorded

- An online monitoring system was devised for measurement of three phase voltages.
- A 3 phase, 220 kV, 150 MVAr reactor at the SVK's Hagby substation, Stockholm was monitored continuously to record the transient events that occurred during the operation of reactor.

Conclusions and Further works

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- Using the non-contact capacitive sensors, the voltages and the transient events can be monitored online with very good accuracy.
- Design and develop Ultra-High Frequency (UHF) antennas for detecting the PD activity in the bushings due to the transient voltages.
- Further onsite measurements involving both the transient voltage and PD monitoring needs to be carried out.
- To model and understand the electric field distribution in the condenser bushings under practically occurring transient voltages.