UNIVERSITY OF Southampton
School of Electronics and Computer Science

Measurement of Leakage Current at the Oil-pressboard Interface during Surface Discharge

H. Zainuddin*, P. L. Lewin and P. M. Mitchinson
The Tony Davies High Voltage Laboratory
University of Southampton, Southampton, UK

Introduction

Surface discharge at the oil-pressboard interface is classified as one of the most dangerous fault conditions of large transformers. Surface discharges can be sustained for long periods without surface flashover or breakdown as long as the surface breakdown voltage is not exceeded. If an applied voltage, above the surface partial discharge inception voltage (PDIV) but less than surface flashover voltage persists, the resulting discharges can develop a creeping path in the form of white marks on the pressboard surface due to the drying out of the pressboard by localized heating (forcing oil and water out of the pressboard pores).

From surface discharge experiments using a needle-bar electrode configuration, temporary full-length discharges may occur across the pressboard surface bridging the needle tip and the earth without resulting in complete electrical breakdown when the white marks have reached the earth bar. The full-length discharge is observed travelling along the same path as the white marks. The occurrence of this full-length discharge leads to a small leakage current (mA range) flowing to earth that is unlikely to trip the earth fault protection relays. The leakage current is measured using a shunt resistor, a method that has been extensively used to measure leakage current for outdoor insulation systems. The leakage current is also measured using a commercial partial discharge detection system to allow comparison of the leakage current waveform from the oscilloscope against the corresponding phase resolved partial discharge (PRPD) pattern obtained.

Surface Discharge Experiment

- A needle-bar electrode configuration is used to promote surface discharges at the oil-pressboard interface.
- A shunt resistor of 50 Ω is connected in series with the needle-bar electrode between the earth bar towards the earth. (Standard method regardless of the frequency content of the current). A digital oscilloscope is used to capture the current waveform during the occurrence of a full discharge (Figure 1).
- The OMICRON Mtronix PD measurement system is used in parallel with the needle-bar electrode configuration and current measurement. It is used to:
  - determine the PDIV of the pressboard surface, which allows the useful range of applied voltage to be determined, and to
  - monitor and record the PD patterns during the experiment.

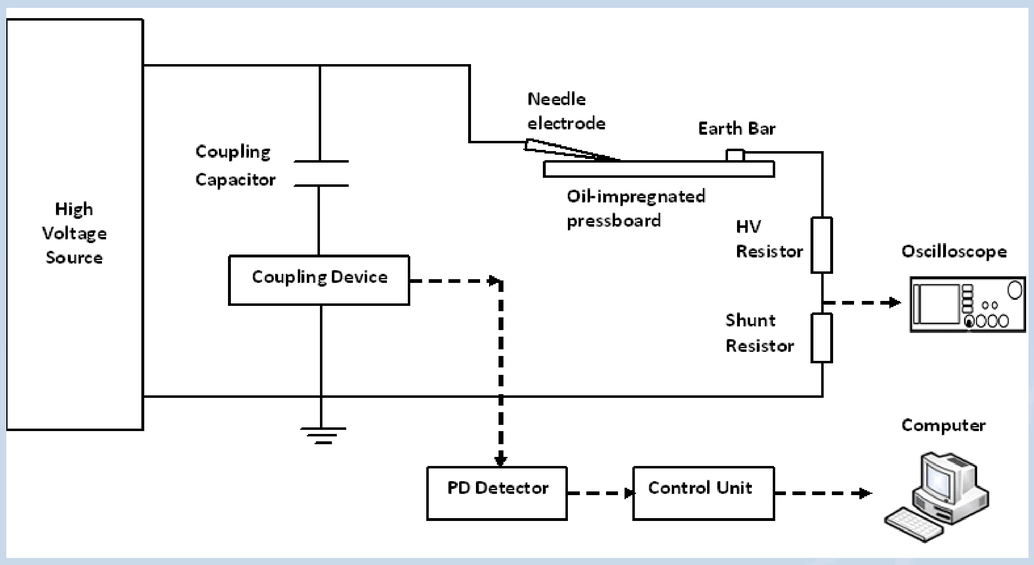

Figure 1: Experiment to measure leakage current

- Pressboard sample: 1.5 mm thick, 3% moisture level (vacuum impregnated with mineral oil)
- Distance between needle electrode and earth bar = 30 mm. (To limit the effects of flashover or breakdown on the measurement equipment)
- Voltage applied = 25 kV (for over 3 days, 8 to 9 hours per day).

  Note: PDIV = 21kV (approx.). Surface flashover voltage = 40kV (approx.)

Results and Discussions

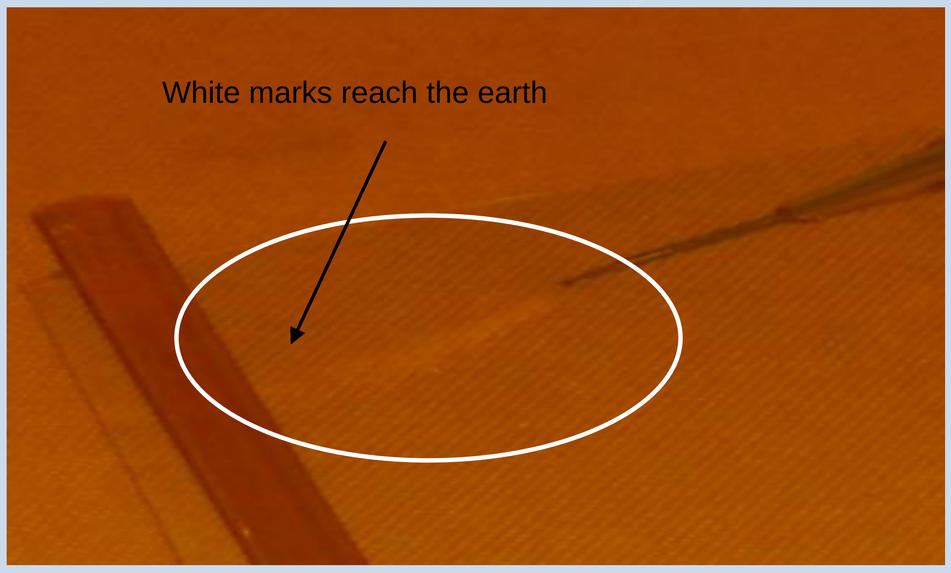

Figure 2: White marks bridging the gap after about 4 hours of experiment.

- Full white marks are always followed by thin arcs at the earth bar and full discharges without tripping the protection system resulting in a leakage current flowing from the needle tip towards the earth electrode.

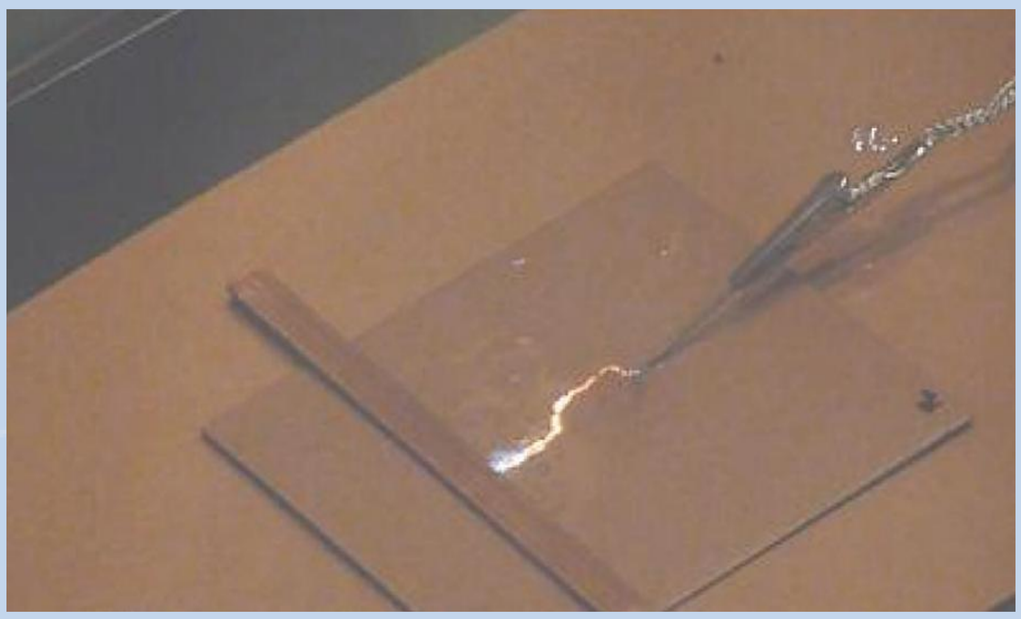

Figure 3: Example of a full-length discharge without tripping the protection system (overcurrent protection is set to 20mA – HV side current)

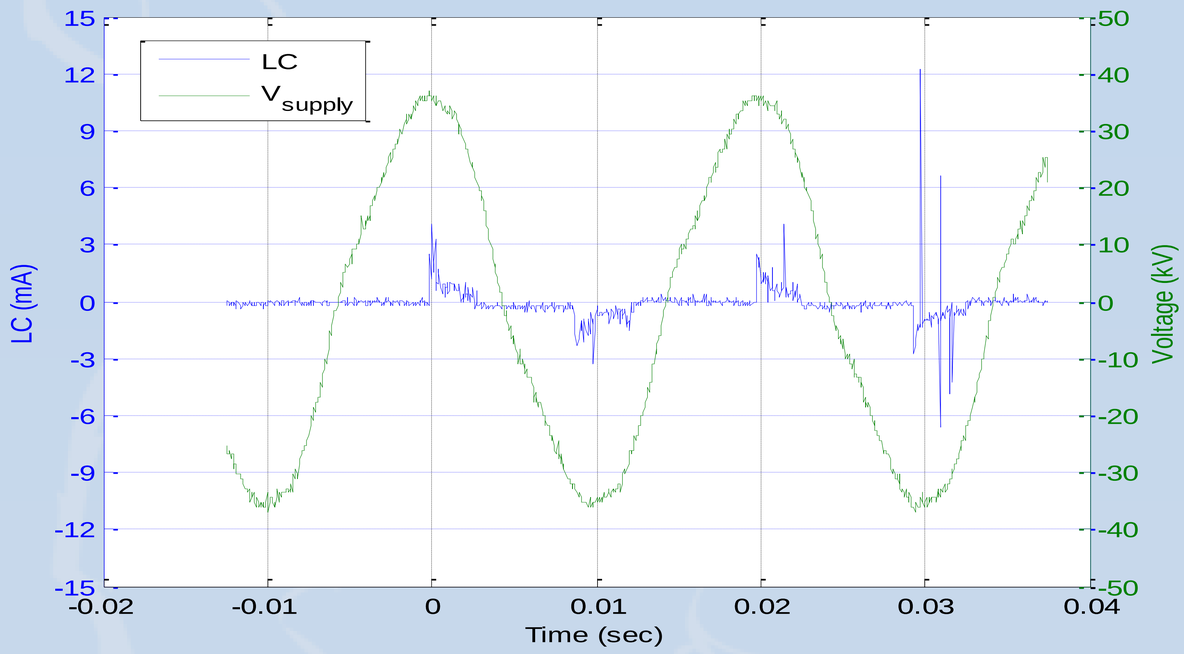

Figure 4: Example of a leakage current waveform during a full-length discharge with respect to supply voltage

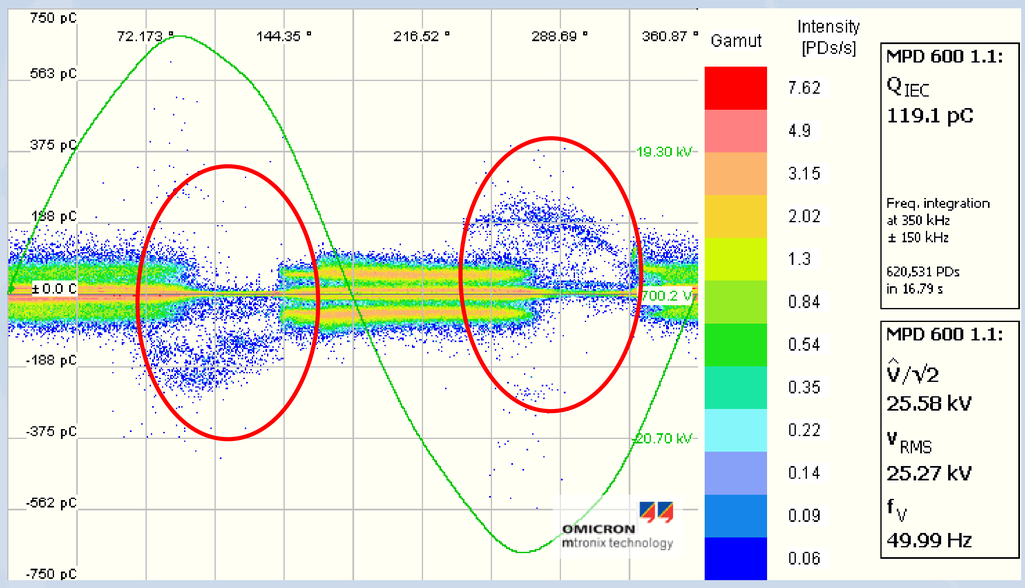

Figure 5: PRPD patterns during which a full-length discharge occurred once (PD histogram for 17 s) – The full discharge gives a corona-like PRPD pattern as indicated by red circles

Conclusions

- The shunt resistor approach, which is normally used to measure leakage current for outdoor insulation, is suitable for measuring the leakage current during surface discharge at the oil-pressboard interface
- It would appear that for each cycle of supply voltage, the onset of leakage current requires a certain positive and negative voltage threshold to be exceeded
- The peak of leakage current is approximately 3 mA (if individual pulses are neglected), which is small compared to the overcurrent protection limit, i.e. HV side current of 20mA
- The corona-like of PRPD pattern shows an interesting result using PD measurement which is might be useful for condition monitoring of surface discharges in power transformers.
- Further work will investigate the effect of moisture content of the board on the leakage current measurement.

Contact details : hz3g09@ecs.soton.ac.uk
University of Southampton, Highfield, Southampton, SO17 1BJ, UK