Partial discharge measurement at varied low frequency on thermally aged stator insulation

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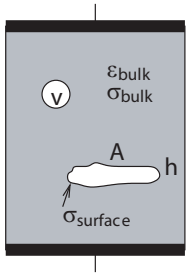
Introduction: PD(|V|,f)

- Partial Discharge (PD) activity depends on the frequency of the applied voltage.
- Several sources of frequency-dependence: relaxation of the solid dielectric and the charge across the cavity, and availability of electrons.
- PD in cavities within HV insulation tends to vary a lot between millihertz and tens of hertz; this range also has low requirement of current.

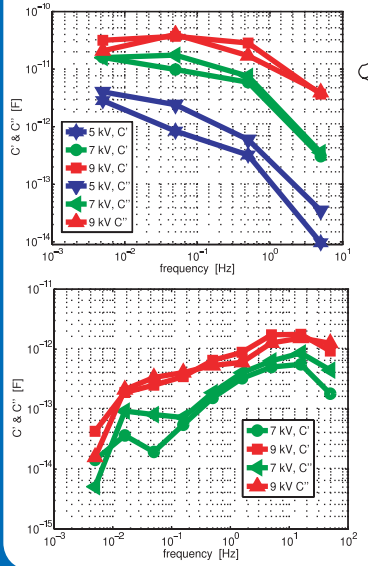


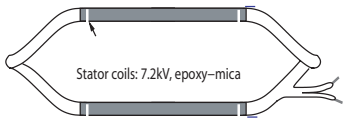
Our work is about the use of varied low-frequency PD measurement and dielectric spectroscopy, on stator insulation. Condition Assessment may be helped by distinguishing PD sources by their frequency dependence.

Varying the frequency as well as the amplitude, generates many results. For comparison in a plot. use an index, e.g. change in complex capacitance due to the current of the PD charge pulses:

$\Delta C' = \mathrm{sum}(\cos(\varphi)\, q(\varphi)\,) / |V|\,,\ C'' = \mathrm{sum}(\sin(\varphi)\, q(\varphi)\,) / |V|.$

Results





Figures to the left: PD measurements with varied V&f on two thermally aged stator coils, as indices ΔC′ and C″.

Note the different trend in the frequency dependence of these similar objects: different cavities?

Upper: coil A1, measured with increased amplitude and decreased frequency.

Lower: coil A2, with a random order of measurements.

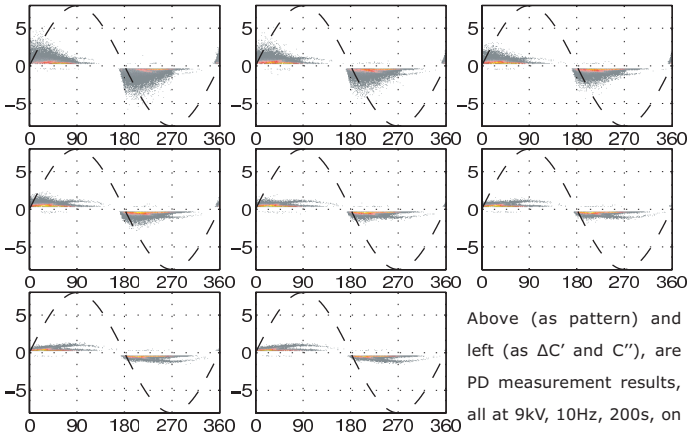
Recent Excitation

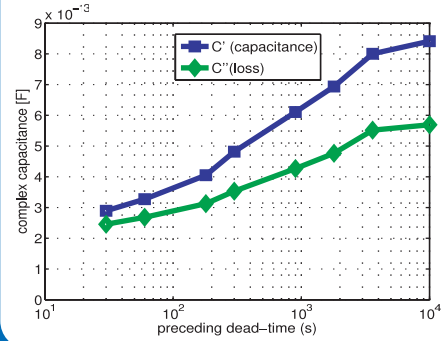
The mechanisms responsible for frequency-dependence of PD also result in dependence on recent excitation, e.g. from the previous measurement.

Quick industrial measurements are generally at one frequency, with increasing voltage: the effects of recent history are not so great.

When measuring PD at several different amplitudes and wide-ranging frequencies, results can depend strongly on the previous measurement: order and procedure matter.

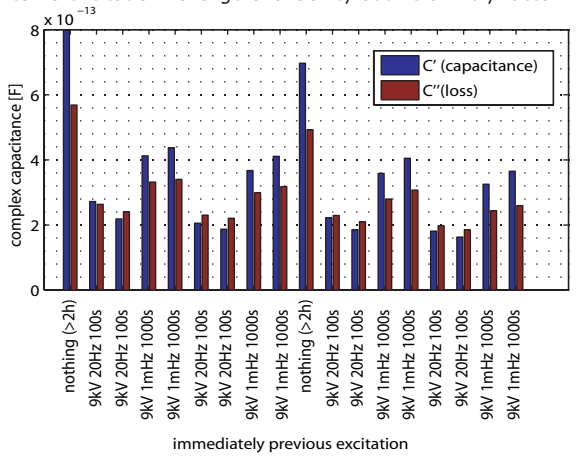
Lack of recent excitation in our test-objects tended the PD to larger discharges, more advanced in phase.





Above (as pattern) and left (as ΔC′ and C″), are PD measurement results, all at 9kV, 10Hz, 200s, on a thermally aged stator coil, with varied preceding deadtime since the last measurement. Deadtimes 10000, 3600, 1800, 900, 300, 180, 60, and 30 s are the patterns left to right, top to bottom. Calibrated PD charge on the y-axes is in nC.

When the same measurements were made with varied frequency of the previous excitation, a preceding low frequency is seen as `part way' to no excitation. Charge-availability seems a likely factor.



Above: PD measurements (all at 9kV, 10Hz, 200s) on a thermally aged stator coil, with varied frequency of the *preceding* applied voltage. Measurements and the stated prior excitations were interleaved; the order shown is chronological.

Summary

PD measurement with varied low frequency is of interest for stator insulation diagnostics, to distinguish different PD sources. "Complex Capacitance" representation is one reasonable index for comparison of many measurements.

Recent excitation makes a large difference to measurements of cavity PD: the factor can be >2.

This difference is particularly important when making several PD measurements with varied V and f in succession to get results for physical interpretation.

Effects of previous measurements' excitation are reduced by a sequence with an outer loop of increased amplitude and an inner loop of decreased frequency. A pause and a non-measured period of a cycle or more of excitation before each measurement also improve consistency of results.