EPSH1/PED1/WPS1

CLB/SMN

DEPARTMENT OF ENERGY TECHNOLOGY
AALBORG UNIVERSITY

Written re-examination in

High Voltage Engineering and Design of Switch Mode Converters

Wednesday 25th February 2015

09.30 – 13.30 (4 hours)

Please provide sufficient text description and reference to textbook and equations so your method of solution is clear and easy to follow. Statements and results will only give credit if explained thoroughly.

Problem 1 (25%)

Students' pursuing the Masters at Department of Energy Technology at AAU wants to perform testing of power system equipment regarding lightning overvoltage.

For this purpose a group of students wants to design and construct a setup in the HV laboratory in order to test specific equipment. During this the following questions arises, which are to be answered at this examination.

A 1,2/50 μs single stage impulse generator, type b with a maximum output peak impulse voltage V_{max} = 200 kV should be designed. Already chosen components: Discharge capacitance C_1 = 10 nF, load capacitance C_2 = 1,2 nF, discharge resistance R_2 = 9500 Ω

Temperature in the HV laboratory is 23°C and air pressure p = 970 hPa

a) The HV students want to make a setup for 140 kV lightning impulse testing in the HV laboratory by constructing a single stage impulse generator fed by a HV transformer. What is the safety distance for such a setup? How is it to be measured in practice? Make a sketch to show this.

b) Draw a graph of the impulse voltage waveform generated by the impulse generator for a charging voltage of V_0 = -115 kV using a sufficient number of calculated points of the curve V(t). Determine graphically on the basis of this graph front time T_1, time to half T_2 and the efficiency η. Please show clearly on the graph how you do this! Comment on the obtained accuracy of T_1 andT_2 according to IEC 60.

c) The students want to measure the impulse voltage from b) by means of a sphere gap. What should be the *precise* distance S between a pair of 12,5 cm spheres for the sphere gap to ignite (i.e. make a spark) for this voltage? State clearly how you do this!

Problem 2 (25%)

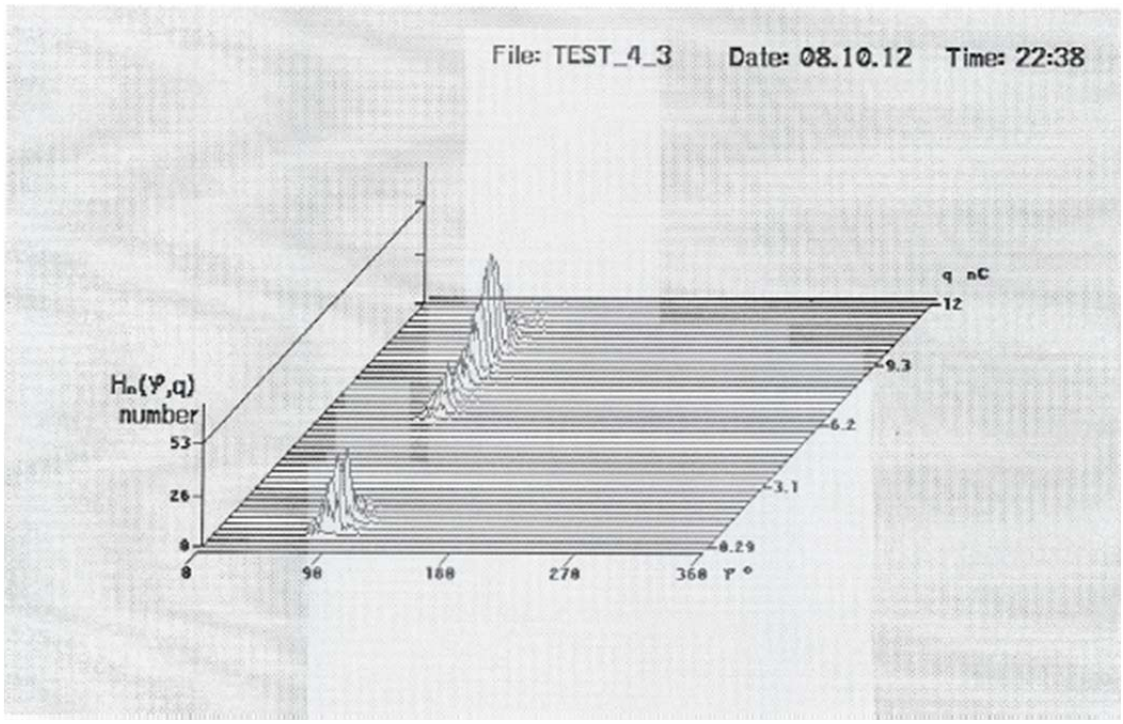
The students now want to test a HV capacitor with C = 450 pF using non-destructive test methods.

a) Explain briefly the most important methods for non-destructive HV testing.

b) A Schering bridge has been used for measuring the loss angle tan δ for the capacitor at 243 kV and the result was tan δ = 0, 008. Calculate the current through the capacitor (result as a phasor, i.e. in complex polar coordinates) during the measurement and the loss P in the capacitor. What causes these losses?

c) Explain the basics of the so-called "straight detection" measurement setup for measuring Partial discharges (PD).

d) A partial discharge measurement of the capacitor at 260 kV has resulted in the H(φq) diagram shown below



Take a close look at the PD pattern. What causes such a measuring result? Explain your conclusions.

e) Compare the results of question b) and d). What can you conclude regarding the condition of the capacitor?