EPSH1/PED1/WPS1

CLB/SMN

Department of
ENERGY TECHNOLOGY
Aalborg University

Written examination in

High Voltage Engineering and Design of Switch Mode Converters

Tuesday 15th January 2013

09.00 – 13.00 (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 (High Voltage)

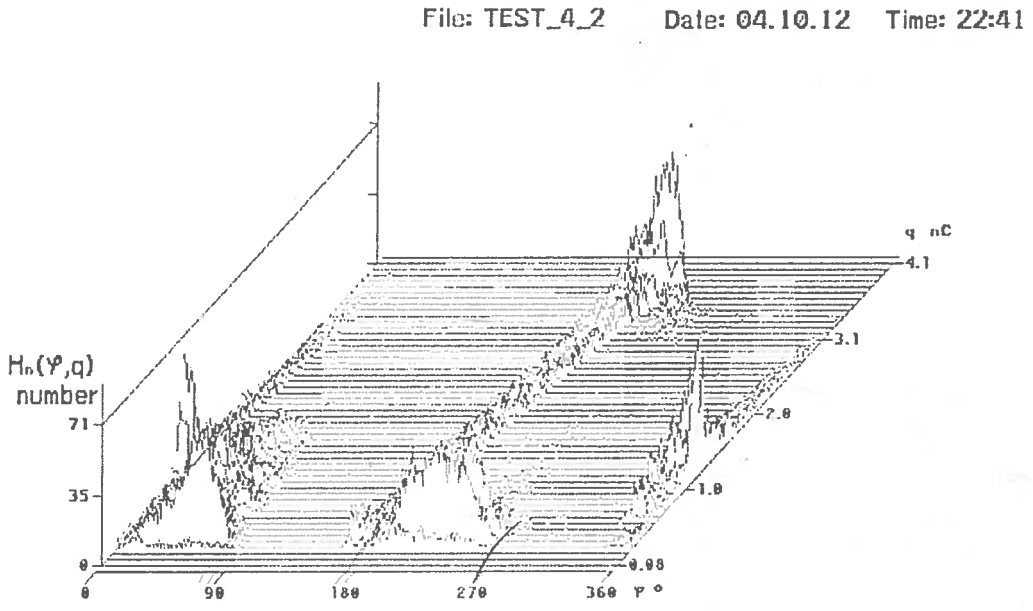
a) What is the AC voltage level to be exceeded for special safety rules for HV laboratory to apply? State briefly the most important safety rules for HV experiments.

b) A single stage lightning impulse generator, type b has been constructed in the HV lab. Already chosen components are: Discharge capacitance C_1 = 10 nF, load capacitance C_2 = 1,2 nF, front resistance R_1 and discharge resistance R_2 = 6500 Ω. Please *calculate* the *expected* impulse waveform. Is it 1,2/5 µs, 1,2/50 µs or 1,2/200 µs ?

c) Temperature in the HV laboratory is 5°C and air pressure p = 1022 hPa. A 25 cm sphere gap exhibited a breakdown for a peak voltage of 254 kVAC. What was the sphere gap spacing?

d) A Schering bridge have been used for measuring both capacitance C_x and loss angle tan δ_x for a dielectric device. The bridge was balanced for C_4 = 300 nF and R_3 = 44,1 Ω. Measured was C_x = 268 nF and loss angle tan δ_x = 0,03. Calculate the capacitance C_N of the normal capacitor used for this experiment. Which important qualities and characteristics should such normal capacitor possess?

e) A partial discharge measurement have shown the H(φq) diagram shown below

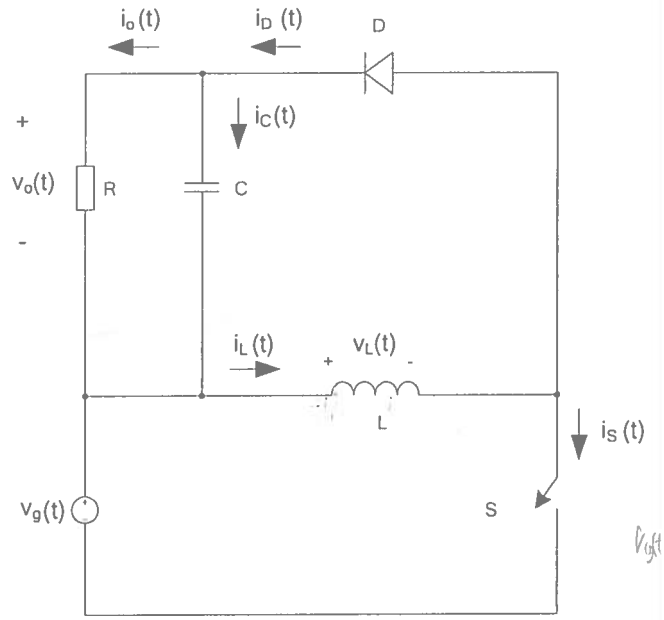


Which type of PD activity is clearly detected? What causes such PD activity? Explain the axes of the graph!

f) Finally, explain briefly the purpose and use of dielectric spectroscopy. You can refer to the textbook.

Problem 2 (Design of Switch Mode Converters)

The shown converter operates in continuous conduction mode. And the components are assumed ideal.



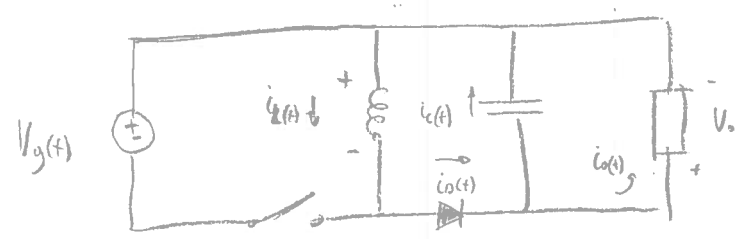
$T_s = 10\ \mu s$ R= 10 Ω $V_g = 20$ V $V_o = 50$ V L= 200μH

a) Calculate the input power of the converter (Power from V_g)

b) Make a sketch of $i_D(t)$ and $i_C(t)$ for one switching period T_s

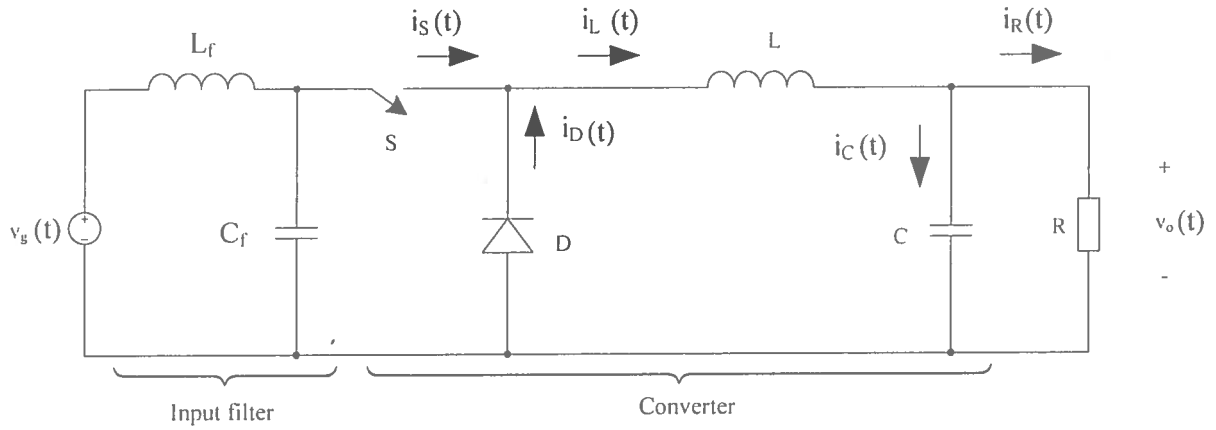
c) Calculate the average current of transistor S

d) Calculate the slopes m1 and m2



Problem 3 (Design of Switch Mode Converters)

The converter components are ideal and the converter operates in continuous conduction mode.



The converter need an input filter and the filter parameters are: L_f = 470 μH C_f= 470 μF

a) Do a sketch of the small signal model of the converter

b) Derive the filter output impedance $Z_o(s)$

c) What is the filter resonant frequency

d) Do a sketch of the filter with damping included. There are several approaches to including damping, please write a motivation text of why you choose this filter damping.