**EPSH1/PED1/WPS1**

**2017**

**November 2017/CLB/SMN**

**Written examination in**

**High Voltage Engineering and Design of Switch Mode Converters**

**Friday 27th January 2017**

**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.

Both exercises in HV and SMC individually have to be passed in order to pass the course. This means that at least 50 % of both the HV exercise and the SMC exercise have to be correctly answered.

The HV exercise and the SMC exercise have the same weight.

A student taking High Voltage Engineering Master course at Department of Energy Technology at AAU wants to do some measurement in the HV lab.

**Exercise 1 (High Voltage)**

The student wants to design a single stage impulse generator in the HV lab. He chooses the type b circuit.

(1) Explain why the discharge capacitance C1 is chosen be larger than the load capacitance C2.

(2) Now the values of C1, C2 are given as 20nF and 2nF respectively. The student plans to generate a standard switching impulse waveform. Please decide the values of R1 and R2 in the circuit.

(3) The charging voltage on C1 is 50 kV. Based on parameters defined in (2), write down the voltage V(t) on the load capacitor and draw the impulse curves by Matlab or other software. Calculate the front time T1 and the time to half-value T2 based on the curve of V(t). State whether T1 and T2 fulfill the requirement of the standard switching impulse waveform.

**Exercise 2 (High Voltage)**

(1)The volume resistivity of a dielectric plane is to be measured. Shall the student choose AC voltage source or DC voltage source in the test? And explain why.

(2) Now the voltage U= 500V is applied on the dielectric. After 1 minute, the current flow through the dielectric bulk is recorded as I = 20nA. The dimensions of the dielectric are shown in the following figure. Calculate the volume resistivity of the dielectric.



(3)Now the dielectric is inserted into a tank of transformer oil. A sinusoidal voltage U= 18 kV is applied on the tank. The arrangement is shown in the following figure. The relative permittivity of the oil and the dielectric are  respectively. The thickness of the tank and the dielectric plane are  respectively. Calculate the electric field magnitude in the oil before and after inserting the dielectric and explain why the value changes. Assume an ideal uniform electric field exists in the oil and the dielectric.



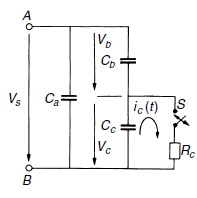
(4)Now the student installs the dielectric between two capacitor plates. The plates contact with each surface of the dielectric ideally, i.e. there is no air between the dielectric and plates. Then the student installs the capacitor plates with the dielectric into the Schering bridge and measures the properties of the dielectric. The schematic of the test circuit is shown in the following figure. The standard capacitor CN has a value of 37.2 pF. When the voltage drop at the dielectric equals 200kV, the zero-indicator indicates zero. The values of R3 and R4 are 242Ω and 652Ω respectively, and the dissipation factor tanδ = 0.006. Please calculate the active power dissipated by the dielectric and explain what causes this power loss.



**Exercise 3 (High Voltage)**

The student wants to measure the PD activity in a home-made capacitor with the electrical current pulse method.

(1) The equivalent circuit of the capacitor under test is shown in the following figure. Cc stands for a void filled with air in the capacitor. When the applied voltage between the capacitor exceeds a certain level, the student measured a PD signal with a certain quantity of q0. Explain whether the charge quantity measured equals the quantity involved in the void during PD happens.



(2) The following figure shows phase resolved partial discharge (PRPD) in the capacitor with U = 30 kV. Explain the content of x and y axis.

(3)Based on the following figure, explain which type of PD happens with the capacitor.

(4) Explain the importance for the dielectric of the type of PD from (3).

