**EPSH1/PED1/WPS1**

**CLB/SMN**

DEPARTMENT OF ENERGY TECHNOLOGY
AALBORG UNIVERSITY

# Written examination in

# High Voltage Engineering and Design of Switch Mode Converters

## Monday 25th January 2016

## 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 (33%)

A 1,2/50 μs single stage impulse generator, type b with a maximum output peak impulse voltage $V_{max}$ = 100 kV should be designed. Already chosen components: Discharge capacitance $C_1$ = 10 nF, load capacitance $C_2$ = 1,5 nF, discharge resistance $R_2$ = 9500 Ω

Temperature in the HV laboratory is 15°C and air pressure p = 1027 hPa

a) Draw a graph of the impulse voltage waveform generated by the impulse generator for a charging voltage of $V_0$ = 95 kV using a sufficient number of calculated points (or MATLAB) 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!

b) 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 (33%)

Test of a HV capacitor with C = 400 nF 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 42 kV and the result was tan δ = 0, 152. Calculate the current through the capacitor (result as a phasor, i.e. in complex polar coordinates, explain your method) during the measurement and the loss P in the capacitor. What causes such losses?

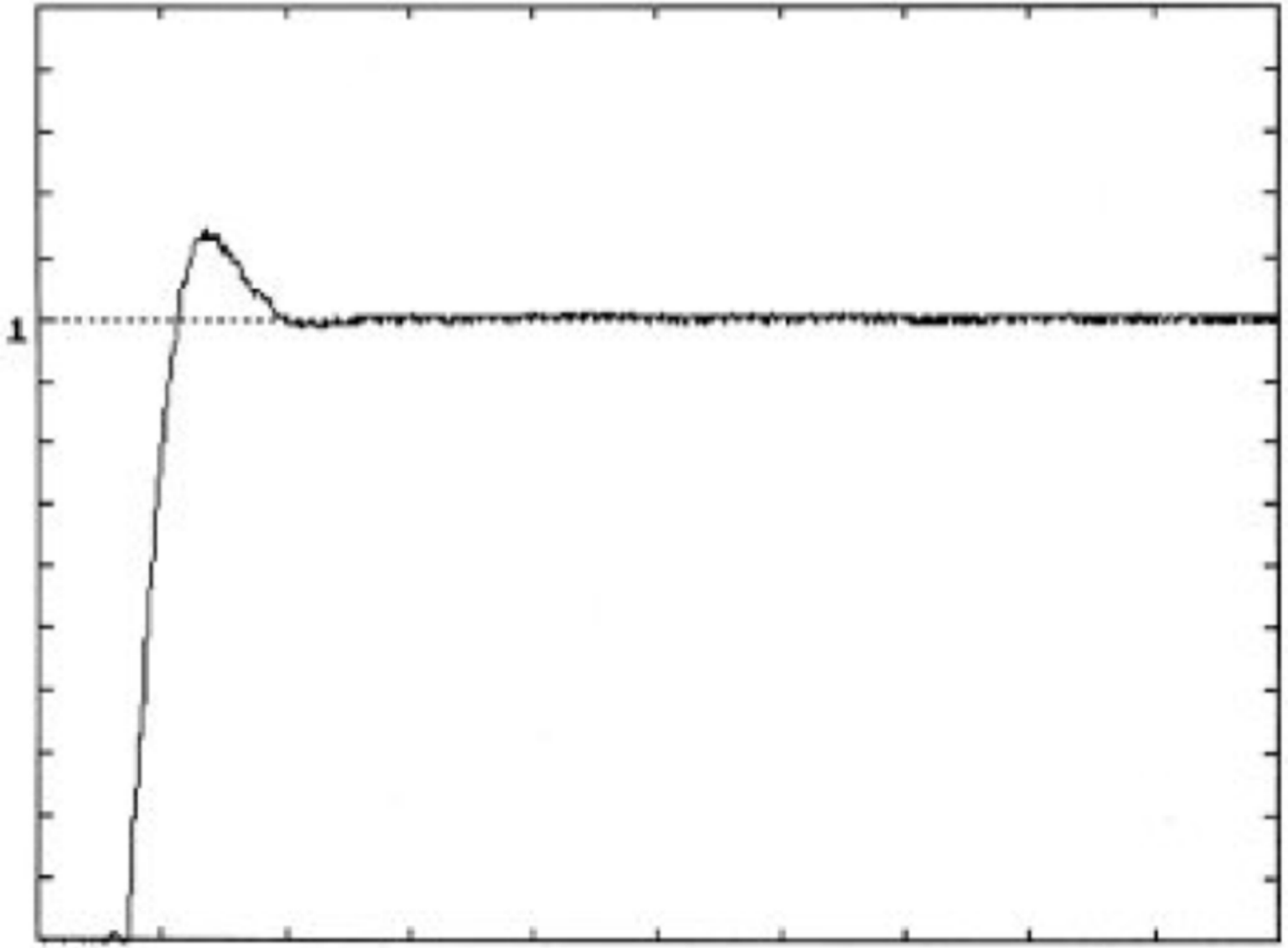
c) The losses calculated in b) are not acceptable. What should be the loss angle tan δ in order to lower the losses to 10 kW?

## Problem 3 (33%)

A high voltage impulse voltage divider has a unit step response as shown in the figure attached to this set of exercises.

a) Calculate the response time of this voltage divider as explained in Kuffel chapter 3.6.2. Explain carefully your procedure (you can write on the sheet with the figure and hand in). General approximations are of course acceptable.

b) A front chopped 1,2/50 μs is chopped at $T_c$ = 0,4 μs and its peak voltage was recorded to 418 kV using the above question a) voltage divider. What was the actual peak voltage?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Unit Step Response
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