HV 2011 exam

a) See figure 2.25 and explanation.
type b has higher efficiency η

b) eq (2.38) yields $R_1 = 378{,}3\ \Omega$

c) (2.26) $$v(t) = \frac{V_0}{k}\,\frac{1}{(\alpha_2-\alpha_1)}\left[e^{-\alpha_1 t} - e^{\alpha_2 t}\right]$$

$$k = 378 \cdot 1{,}2 \cdot 10^{-9} = 454 \cdot 10^{-9}$$

$$\frac{1}{(\alpha_2-\alpha_1)} = 4{,}074 \cdot 10^{-7}$$

$$v(t) = \frac{250\cdot}{454 \cdot 10^{-9}} \cdot 4{,}074 \cdot 10^{-7} = 224{,}5\ \text{kV}$$

$$v(t) = 224{,}5\left(e^{-14663 \cdot t} - e^{-2469136 \cdot t}\right)$$

afløst $V_{max} = 216\ \text{kV}$ $\quad$ $30\% = 65\ \text{kV} \Rightarrow 1{,}38 \cdot 10^{-7}$

$90\%\ \ 195\ \text{kV} \Rightarrow 8{,}49 \cdot 10^{-7}$

So 50 $\quad T_1 = 1{,}67 \cdot (8{,}49 - 1{,}38) \cdot 10^{-7} = 1{,}18\ \mu s$

d) $T_2 = 49{,}3\ \mu s$ $\quad$ legge på graf afløst.

d) $$\eta = \frac{216}{250} = 0{,}864$$

②

d/ (2.29) $t_{max} = \frac{\ln(\alpha_2/\alpha_1)}{(\alpha_2 - \alpha_1)}$

$$t_{max} = \frac{\ln\left(\frac{1}{0.405\cdot 10^{-6}} \Big/ \frac{1}{68.2\cdot 10^{-6}}\right)}{\frac{1}{0.405\cdot 10^{-6}} - \frac{1}{68.2\cdot 10^{-6}}} = \underline{\underline{2.09\ \mu s}}$$

Passer med graf

$$V_{max} = 224.5\left(e^{-14663\cdot 2.09\cdot 10^{-6}} - e^{-2469136\cdot 2.09\cdot 10^{-6}}\right)$$

$V_{max} = \underline{\underline{216,4\ kV}}$ passer!

(2.37) $\eta = \frac{C_1}{C_1 + C_2} = \frac{10\cdot 10^{-9}}{10\cdot 10^{-9} + 1.2\cdot 10^{-9}} = \underline{\underline{0.89}}$

e/

table 3.3 s 83 ⇒ S=80 = 206 kV

(3.2) $\delta = \frac{P}{P_0}\frac{273 + t_0}{273 + t} = \frac{1022}{1013}\frac{273 + 20}{273 + 18} = 1,016$

δ = RAD tabel 3.5 s 89 ⇒ $k_d = 1,00$

(3.1) $V_d = k_d V_{d0} = 1.00 \cdot 206 = \underline{\underline{206\ kV}}$

p. 87 accuracy ± 3% ⇒

$$\underline{\underline{V_d = 206 \pm 6\ kV}}$$

f) (3.33) p. 126

$$C_e \approx \frac{2\pi\varepsilon l}{\ln\frac{1{,}15\,l}{d}} = \frac{2\pi\cdot 8{,}85\cdot 10^{-12}\cdot 1{,}00}{\ln\frac{1{,}15\cdot 1{,}00}{0{,}1}} = \underline{\underline{22{,}8\,pF}}$$

p. 152 first order truly exponential rise ⇒

$$\tau = T = \frac{R\cdot C_e}{6} = \frac{50000\cdot 22{,}8\cdot 10^{-12}}{6} = \underline{\underline{190\,ns}}$$

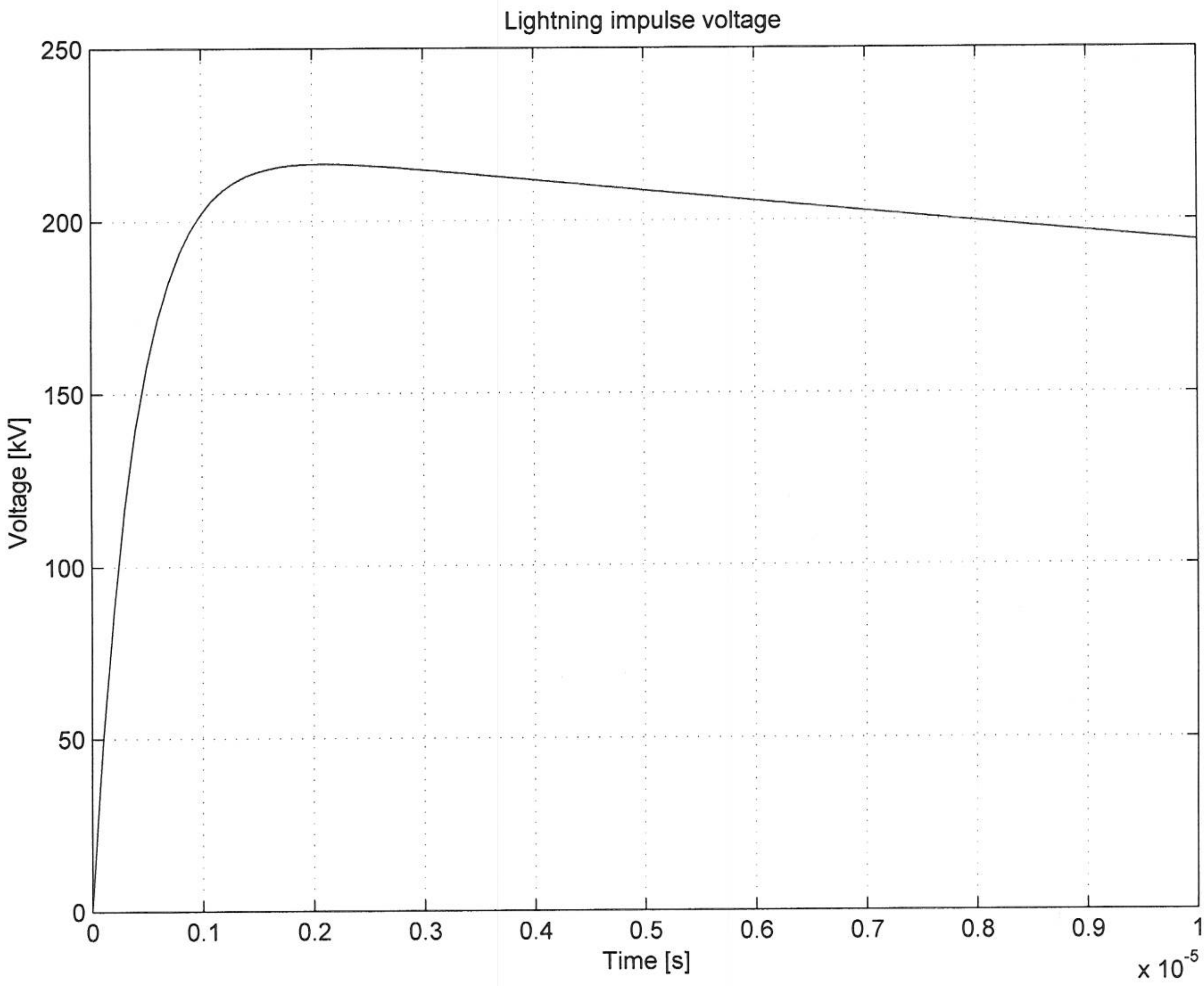
g) (3.53) p. 139 $\quad \delta = \frac{\Delta V}{S\cdot T_c} = \frac{T}{T_c}$

$$\delta = \frac{190\cdot 10^{-9}}{300\cdot 10^{-9}} = 0{,}632\ ,\ S = {}^{218}/_{0{,}3} = 727\ {}^{kV}/_{\mu s}$$

$$\Delta V = \delta\cdot S\cdot T_c = 0{,}632\cdot 727\cdot 0{,}3 = \underline{\underline{138\,kV}}$$

So actual voltage is $V_{meas} + \Delta V = 218 + 138$

$$= \underline{\underline{356\,kV}}$$



Lightning impulse voltage
250
200
150
100
50
0
Voltage [kV]
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Time [s]
x 10^-5