HV 2011 exam

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

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

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

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

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

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

$v(t) = 224{,}5 \left(e^{-14663 \cdot t} - e^{-246136 \cdot t} \right)$

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

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

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

$T_2 = 49{,}3\ \mu s$ Lægge på graf aflæst.

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

②

d/ (2.25) $t_{max} = \dfrac{\ln(\alpha_2/\alpha_1)}{(\alpha_2 - \alpha_1)}$

$t_{max} = \dfrac{\ln\left(\frac{1}{0.405\cdot10^{-6}} \Big/ \frac{1}{68.2\cdot10^{-6}}\right)}{\frac{1}{0.405\cdot10^{-6}} - \frac{1}{68.2\cdot10^{-6}}} = \underline{\underline{2,09\ \mu s}}$

Passer med graf

$V_{max} = 224.5\left(e^{-14663\cdot2.09\cdot10^{-6}} - e^{-2469136\cdot2.09\cdot10^{-6}}\right)$

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

(2.37) $\eta = \dfrac{C_1}{C_1 + C_2} = \dfrac{10\cdot10^{-9}}{10\cdot10^{-9} + 1.2\cdot10^{-9}} = \underline{\underline{0.89}}$

e/

table 9.3 : 83 ⇒ S=80 ⇒ 206 kV

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

δ=RAD tabel 3.5 : 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) (3.32) p. 126

$$C_e \approx \frac{2\pi\varepsilon\ell}{\ln\frac{1.15\ell}{d}} = \frac{2\pi \cdot 8.85\cdot10^{-12}\cdot 1.00}{\ln\frac{1.15\cdot 1.00}{0.1}} = 22.8\,pF$$

p. 152 first order only expanded Ric ⇒

$$\tau = \frac{R\cdot C_e}{6} = \frac{50000\cdot 22.8\cdot10^{-12}}{6} = 190\,ns$$

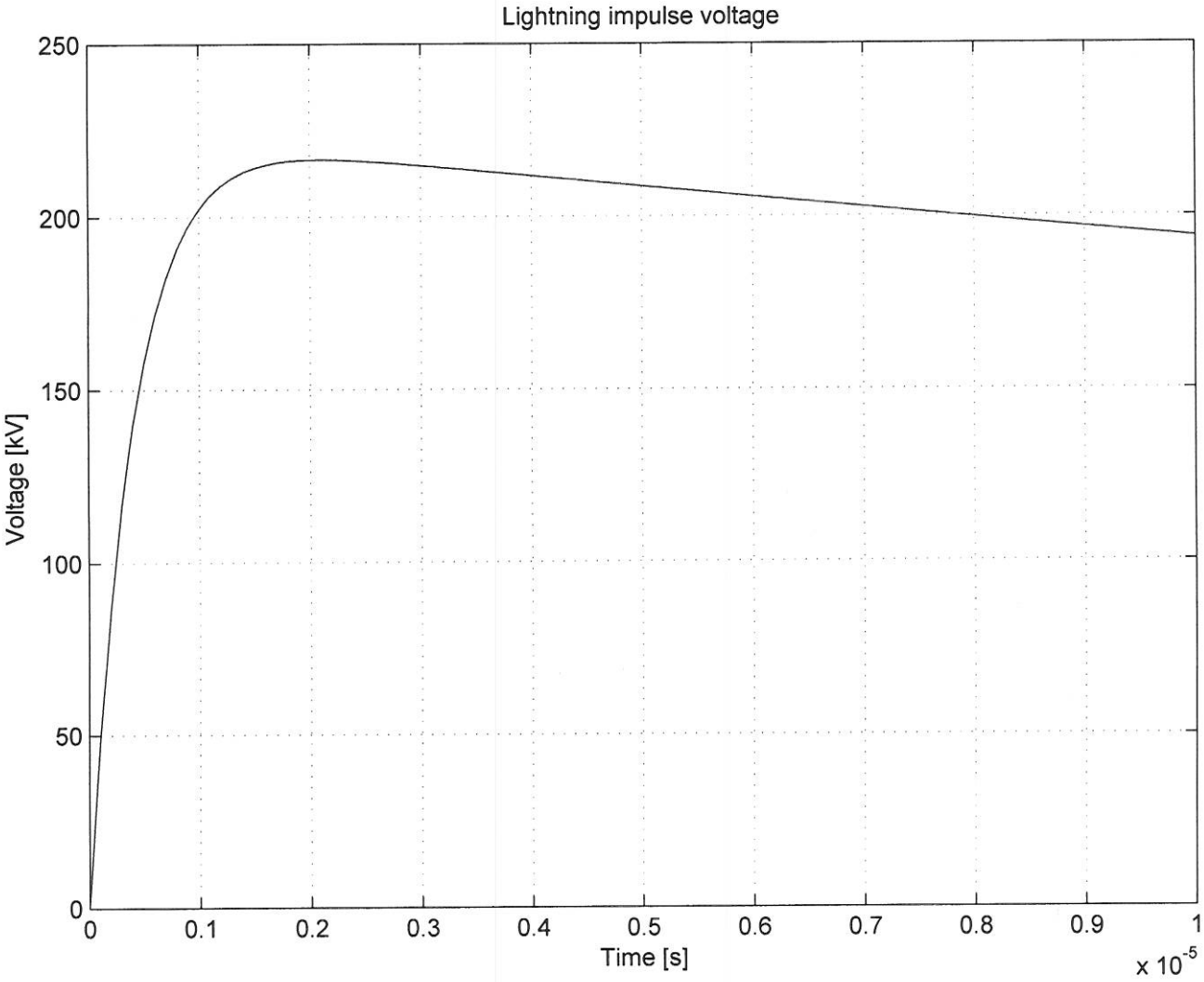
g) (3.53) p. 139 $\quad \delta = \frac{\Delta V}{S\cdot T_c} = \frac{T}{T_c}$

$$\delta = \frac{150\cdot10^{-9}}{300\cdot10^{-9}} = 0.632, \quad S = 218/0.3 = 727\ kV/\mu s$$

$$\Delta V = \delta \cdot S \cdot T_c = 0.632\cdot 727\cdot 0.3 = 138\,kV$$

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

$$= 356\,kV$$


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