TET4100 Kretsanalyse – Løsning

Institutt: Elkraftteknikk — Dato: 2012.08.15

Øving 1

1) Innforing Kretsanalyse 1.A

1.1)

$v_L \equiv 0$	$v_1(t=0^-)=0$
$i_C \equiv 0$	$i_{C2}(t=0^-)=0 \quad i_{C1}(t=0^-)=0$
bryter åpen	$i(t=0^-)=0$
$I_0=i_{C2}+i_2-i$	$i_2(t=0^-)=I_0 = 1\,A$
$v_2=R_2 \cdot i_2$	$v_2(t=0^-)=R_2 \cdot I_0 = 50\,V$
$i_0=\frac{V_0-v_1}{R_1}$	$i_0(t=0^-)=\frac{V_0}{R_1} = 2A$
$i_0=i_{C1}+i_L+i$	$i_L(t=0^-)=\frac{V_0}{R_1} = 2A$

1.2)

$i_L(t=0^-) \equiv i_L(t=0^+)$	$i_L(t=0^+)=\frac{V_0}{R_1} = 2A$
$v_C(t=0^-) \equiv v_C(t=0^+)$	$v_1(t=0^+)=0 \quad v_2(t=0^+)=R_2 \cdot I_0 = 50\,V$
$i_0=\frac{V_0-v_1}{R_1}$	$i_0(t=0^+)=\frac{V_0}{R_1} = 2A$
$v_2=R_2 \cdot i_2$	$i_2(t=0^+)=I_0 = 1\,A$
$i=\frac{v_1-v_2}{R_3}$	$i(t=0^+)=-I_0\frac{R_2}{R_3} = -1\,A$
$I_0=i_{C2}+i_2-i$	$i_{C2}(t=0^+)=-I_0\frac{R_2}{R_3} = -1\,A$
$i_0=i_{C1}+i_L+i$	$i_{C1}(t=0^+)=I_0\frac{R_2}{R_3} = 1\,A$

1.3)

$v_L \equiv 0$ $v_1(t=\infty)=0$

$i_C \equiv 0$ $i_{C2}(t=\infty)=0$ $i_{Cl}(t=\infty)=0$

$$i_0=\frac{V_0-v_1}{R_1} \qquad i_0(t=\infty)=\frac{V_0}{R_1}$$

$$I_0=i_{C2}+i_2-i$$

$$i_{C2}(t=\infty)=0$$

$$I_0=i_2-i$$

$$i=\frac{v_1-v_2}{R_3}$$

$$v_1(t=\infty)=0$$

$$i=-\frac{v_2}{R_3}$$

$$i_2=\frac{v_2}{R_2}$$

$$I_0=\frac{v_2}{R_2}+\frac{v_2}{R_3} \qquad v_2(t=\infty)=\frac{R_2\cdot R_3}{R_2+R_3}\cdot I_0 = 25\,V$$

$$i_2=\frac{v_2}{R_2} \qquad i_2(t=\infty)=\frac{R_3}{R_2+R_3}\cdot I_0 = 0{,}5\,A$$

$$i=\frac{v_1-v_2}{R_3} \qquad i(t=\infty)=-\frac{v_2}{R_3} = -0{,}5\,A$$

$$i_0=i_{Cl}+i_L+i \qquad i_L(t=\infty)=\frac{V_0}{R_1}+\frac{v_2}{R_3} = 2{,}5\,A$$

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2) Innforing Kretsanalyse 1.B

2.1) $$\overbrace{i_L(0^-)=\frac{V_{inn}}{R_1+R_2+R_3+R_4}}^{=1{,}8\,A} \qquad i_L(0^+)=i_L(0^-) \qquad i_L(\infty)=0$$

2.2) $$i_0(\infty)=\frac{V_{inn}}{R_1+R_3} = 3{,}6\,A$$

$$\tau_{LR}=\frac{L}{R_2+R_4} = 5\cdot 10^{-4}\,s \quad , \frac{1}{\tau_{LR}} = 2000$$

$$i_L(t)=i_L(0^+)\cdot e^{-\frac{t}{\tau_{LR}}}$$

$$i_0(t)=i_0(\infty)-i_L(t)=i_0(\infty)-i_L(0^+)\cdot e^{-\frac{t}{\tau_{LR}}} = 3{,}6-1{,}8\,e^{-2000t}$$

2.3) $$i_0(t_1)=i_0(\infty)-i_L(0^+)\cdot e^{-\frac{t_1}{\tau_{LR}}}$$

$$t_1=\ln\left(\frac{i_0(\infty)-i_0(t_1)}{i_L(0^+)}\right)\cdot(-\tau_{LR}) = 752\,\mu s$$

3) Innforing Kretsanalyse 1.C

3.1) Induktor med tap:

$$v_L = L\frac{d\,i_L}{dt} \qquad v_R = R\cdot i_R$$

$$i_L = i_R$$

$$v_{L+R} = R\cdot i_L + L\frac{d\,i_L}{dt}$$

$$v_{L+R} = v_C$$

Kondensator med tap:

$$i_C = C\frac{d\,v_C}{dt} \qquad i_G = G\cdot v_G$$

$$v_G = v_C$$

$$i_{C+G} = G\cdot v_C + C\frac{d\,v_C}{dt}$$

$$i_{C+G} = -i_L$$

Setter opp differensialligningen for spenningen over kondensatoren:

(kan også sette opp differensialligning for strømmen i spolen)

$$v_C = -R\left(G\cdot v_C + C\frac{d\,v_C}{dt}\right) - L\frac{d}{dt}\left(G\cdot v_C + C\frac{d\,v_C}{dt}\right)$$

$$-v_C = R\left(G\cdot v_C + C\frac{d\,v_C}{dt}\right) + L\left(G\frac{d\,v_C}{dt} + C\frac{d^2 v_C}{dt^2}\right)$$

$$0 = (RG+1)\cdot v_C + (RC+LG)\frac{d\,v_C}{dt} + LC\frac{d^2 v_C}{dt^2}$$

$$0 = \frac{RG+1}{LC}\cdot v_C + \left(\frac{R}{L}+\frac{G}{C}\right)\frac{d\,v_C}{dt} + \frac{d^2 v_C}{dt^2}$$

Annengrads differensialligning med karakteristisk ligning:

$$0 = s^2 + s\left(\frac{G}{C}+\frac{R}{L}\right) + \frac{1+RG}{LC}$$

3.2) $$\left(\frac{G}{2C}+\frac{R}{2L}\right)^2-\frac{1+RG}{LC}=s^2+s\left(\frac{G}{C}+\frac{R}{L}\right)+\left(\frac{G}{2C}+\frac{R}{2L}\right)^2$$

$$s^2+s\left(\frac{G}{C}+\frac{R}{L}\right)+\left(\frac{G}{2C}+\frac{R}{2L}\right)^2=\left(s+\left(\frac{G}{2C}+\frac{R}{2L}\right)\right)^2$$

$$\left(\frac{G}{2C}+\frac{R}{2L}\right)^2-\frac{1+RG}{LC}=\left(s+\left(\frac{G}{2C}+\frac{R}{2L}\right)\right)^2$$

$$\pm\sqrt{\left(\frac{G}{2C}+\frac{R}{2L}\right)^2-\frac{1+RG}{LC}}=s+\left(\frac{G}{2C}+\frac{R}{2L}\right)$$

$$s_{1,2}=-\left(\frac{G}{2\mathrm{C}}+\frac{R}{2\mathrm{L}}\right)\pm\sqrt{\left(\frac{G}{2\mathrm{C}}+\frac{R}{2\mathrm{L}}\right)^2-\frac{1+RG}{LC}}$$

3.3) $0=s^2+s\dfrac{G}{C}+\dfrac{1}{LC}$ $\quad s_{1,2}=-\dfrac{G}{2\mathrm{C}}\pm\sqrt{\left(\dfrac{G}{2\mathrm{C}}\right)^2-\dfrac{1}{LC}}$

parallell RLC-krets (egentlig GLC)

$G_{Krit}=2\sqrt{\dfrac{C}{L}}$ $\qquad G_{Ov}>2\sqrt{\dfrac{C}{L}}$ $\qquad G_{Und}<2\sqrt{\dfrac{C}{L}}$

3.4) $0=s^2+s\dfrac{R}{L}+\dfrac{1}{LC}$ $\quad s_{1,2}=-\dfrac{R}{2\mathrm{L}}\pm\sqrt{\left(\dfrac{R}{2\mathrm{L}}\right)^2-\dfrac{1}{LC}}$

seriell RLC-krets

$R_{Krit}=2\sqrt{\dfrac{L}{C}}$ $\qquad R_{Ov}>2\sqrt{\dfrac{L}{C}}$ $\qquad R_{Und}<2\sqrt{\dfrac{L}{C}}$

NB: $\dfrac{1}{2}\sqrt{\dfrac{L}{C}}<R<2\sqrt{\dfrac{L}{C}}$ eller $\dfrac{1}{2}\sqrt{\dfrac{C}{L}}<G<2\sqrt{\dfrac{C}{L}}$ er alltid underdempet

dette er ikke avhengig av parallel eller seriell kobling