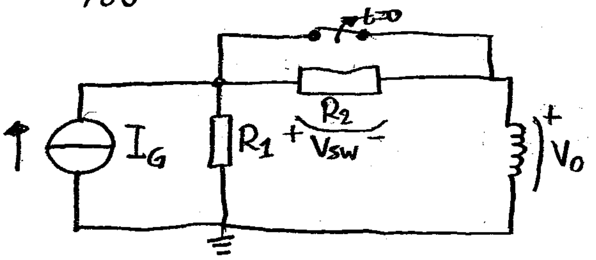
Inbyggd elektronik 2018-05-02 #12

7.41



a) Determine $V_0(t)$

$$V_0 = L\frac{di_L}{dt}$$ if I know i_L I can calculate $V_0(t)$

$t<0s$ $\quad i_L(t)=I_G \quad i_L$ is continous $\Rightarrow i_L(0)=I_G$

$$i_L(t) = i_L(\infty) + (i_L(0) - i_L(\infty))e^{-\frac{(t-t_0)}{\tau}}$$

$$i_L(\infty) = I_G \cdot \frac{R_1}{R_1+R_2}$$

Thevenin resistance seen by L is $R_{TH} = R_1 + R_2 \Rightarrow \tau = \frac{L}{R_{TH}} = \frac{L}{R_1+R_2}$

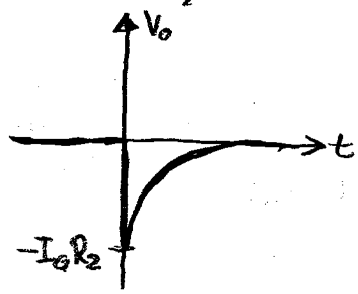
$$i_L(t) = I_G\frac{R_1}{R_1+R_2} + \left(I_G - I_G\frac{R_1}{R_1+R_2}\right)e^{-\frac{t}{L/(R_1+R_2)}} = I_G\frac{R_1}{R_1+R_2} + \left(\frac{I_GR_1 + I_GR_2 - I_GR_1}{R_1+R_2}\right)e^{-\frac{t}{L/(R_1+R_2)}} =$$

$$= I_G\frac{R_1}{R_1+R_2} + I_G\frac{R_2}{R_1+R_2}e^{-\frac{t}{L/(R_1+R_2)}}$$

$$V_0(t) = L\frac{di_L}{dt} = L\left(0 + I_G\frac{R_2}{R_1+R_2}e^{-\frac{t}{L/(R_1+R_2)}} \cdot \left(-\frac{1}{L/(R_1+R_2)}\right)\right) = -\frac{\cancel{L}I_GR_2}{\cancel{R_1+R_2}}\frac{\cancel{R_1+R_2}}{\cancel{L}}e^{-\frac{t}{L/(R_1+R_2)}} =$$

$$= -I_GR_2e^{-\frac{t}{L/(R_1+R_2)}}$$

($i_L(t)>0$, $V_0(t)<0$ stored energy is delivered to the circuit)



b) As R_2 increases the voltage over the inductor increases (as $R_2 \to \infty$ $V_0 \to -\infty$) in a shorter time $\tau \to 0$ $\tau = \frac{L}{R_1+R_2}$

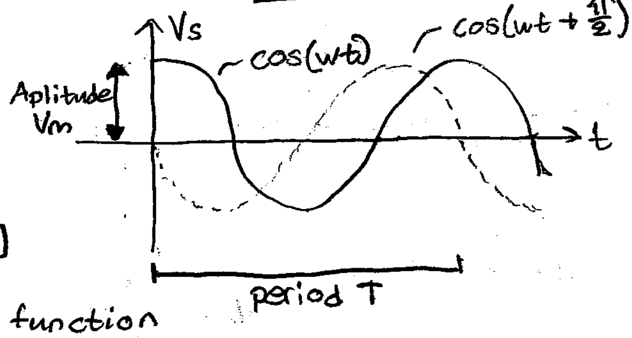
c) Find $V_{SW}(t) = R_2 \cdot i_L(t) = I_G\frac{R_1}{1+\frac{R_1}{R_2}} + \frac{I_GR_2}{1+\frac{R_1}{R_2}}e^{-\frac{t}{L/(R_1+R_2)}}$

d) As $R_2 \to \infty \Rightarrow V_{SW} \to \infty$ for a short while. A large voltage V_{SW} exist for a time $\tau = \frac{L}{R_1+R_2}$

Opening an inductive circuit causes a large voltage to be induced over the inductor L. (This large voltage might damage other components)
In the problem 7.41 the large voltage fell over the switch causing it to arc over the switch.

Sinusoidal sources Chapter 9.1–9.3

$V_S = V_m \cos(wt+\phi)$



Period T, frequency $f = \frac{1}{T}\ [s^{-1}]$
$[s]$

angular frequency $w = 2\pi f$ [rad/s]

Amplitude $\pm V_m$ bounds the cos function

ϕ is the phase angle; determines the value at $t=0$

ϕ does not change w or Amplitude. $\phi > 0$ curve shifts to left
$\phi < 0$ curve shifts to right

Note wt and ϕ needs to be the same unit
w is normally rad
ϕ can be rad but also commonly deg. ($2\pi = 360°$)

- Root Mean Square (RMS) value

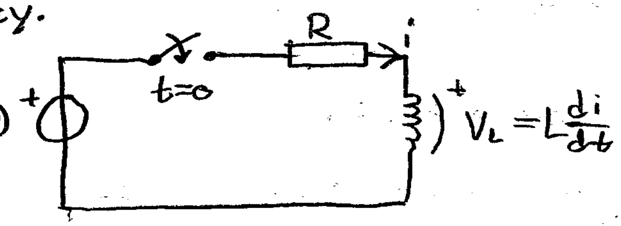
$$V_{RMS} = \sqrt{\frac{1}{T}\int_{t_0}^{t_0+T} V_m^2 \cos^2(wt+\phi)\,dt} = \begin{Bmatrix}\text{for} \\ \text{any} \\ \text{sinusoidal}\end{Bmatrix} = \frac{V_m}{\sqrt{2}}$$

also called efective value. The power in a load R having a sinusoidal voltage over it is $P = \frac{V_{RMS}^2}{R}$. $(P = I_{RMS}^2 \cdot R)$

- All waveforms can be built up from sumation of sinusoidals of differend frequency.

Ch. 9.2

$V_s = V_m \cos(wt+\phi)$



$$L\frac{di}{dt} + Ri = V_m \cos(wt+\phi)$$

Solving for i: $$i(t) = \underbrace{\frac{-V_m}{\sqrt{R^2+w^2L^2}}\cos(\phi-\theta)e^{-\frac{R}{L}t}}_{\text{Transient}} + \underbrace{\frac{V_m}{\sqrt{R^2+w^2L^2}}\cos(wt+\phi-\theta)}_{\text{Steady-state}}$$

$\theta = \arctan\left(\frac{wL}{R}\right)$

If we are only interested in the steady-state solution we need to determine the amplitude and phase angle in branches/nodes of the circuit. (jw-method).

Note on steady-state solution
① A sinusoidal with same frequency as the source (true for linear circuits R, L, C)
② The amplitude generally differs from the source
③ The phase angle generally differs from the source.