TET4100 Kretsanalyse – Løsning

Institutt: Elkraftteknikk Dato: 2012.08.15

Øving 10

39) Aktive Filter 10.A

39.1) $V_{+}=0 \quad \rightarrow \quad V_{-}=0$

$$I_{inn}(s)=\frac{V_{inn}(s)}{R_{inn}} \qquad I_{ut}(s)=-\frac{V_{ut}(s)}{C_F||R_F} \qquad I_{inn}(s)=I_{ut}(s)$$

$$\frac{V_{ut}(s)}{V_{inn}(s)}=-\frac{C_F||R_F}{R_{inn}} \qquad H(s)=\frac{V_{ut}(s)}{V_{inn}(s)}=-\frac{R_F}{R_{inn}}\cdot\frac{1}{1+sR_FC_F}$$

Lavpassfilter: $K=\frac{R_F}{R_{inn}} \qquad \omega_c=\frac{1}{R_FC_F}$, $K=5$, $\omega_c = 100$ kHz

$$H(j\omega)=\frac{-K}{1+j\frac{\omega}{\omega_c}} \qquad |H(j\omega)|=\frac{K}{\sqrt{1+\left(\frac{\omega}{\omega_c}\right)^2}}$$

39.2)

$$\theta(j\omega)=\theta(H(j\omega))=\theta\left(\frac{-K}{1+j\frac{\omega}{\omega_c}}\right)=\theta(-K)-\theta\left(1+j\frac{\omega}{\omega_c}\right)$$

$$\theta(j\omega)=\theta(-K)-\theta(\omega_c+j\omega)$$

$$\theta(j\omega)=\pi-atan\left(\frac{\omega}{\omega_c}\right)$$

39.3)

$$V_{ut}=|H(j\omega_f)|\cdot V_{inn}$$

$$\theta_{ut}=\theta(j\omega_f)+\theta_{inn}$$

$$v_{ut}(t)=V_{ut}\cdot\sin(\omega_f t+\theta_{ut})$$

39.4) $\omega'_f \ll \omega_c \quad \rightarrow$

$$|H(j\omega'_{inn})|\approx K \qquad \theta(j\omega'_f)\approx\pi$$

$$v'_{ut}(t)\approx V_{inn}\cdot K\cdot\sin(\omega_f t+\pi) = 10\cdot\sin(2\cdot10^3 t+\pi)$$

39.5)

$$\omega_c^*=\frac{1}{R_F^*C_F} \quad \rightarrow \quad R_F^*=\frac{1}{\omega_c^*C_F}=\frac{1}{2\pi f_c^*C_F} = 79{,}6\ \text{k}\Omega$$

$$K=\frac{R_F^*}{R_{inn}^*} \quad \rightarrow \quad R_{inn}^*=\frac{R_F^*}{K} = 15{,}9\ \text{k}\Omega$$

40) Aktive Filter 10.B

40.1) $v_p = v_n$

$i_p = i_n = 0$

40.2) $v_p = 0 \quad \rightarrow \quad v_n = 0$

$$I(s) = \frac{V_s(s)}{Z_s}$$

$$V_0(s) = -I(s) \cdot Z_f = -\frac{Z_f}{Z_s} V_s(s)$$

40.3)

$$Z_s = R_s + \frac{1}{j\omega C_s} = R_s + \frac{1}{sC_s} = R_s \left(\frac{s + \frac{1}{R_s C_s}}{s} \right)$$

$$\omega_c = \frac{1}{R_s C_s}$$

$$Z_s = R_s \left(\frac{s + \omega_c}{s} \right)$$

$$Z_f = R_f$$

$$H(s) = \frac{V_0(s)}{V_s(s)} = -\frac{Z_f}{Z_s}$$

$$H(s) = -\frac{R_f}{R_s} \left(\frac{s}{s + \omega_c} \right)$$

40.4) $H(j\omega) = -\frac{R_f}{R_s} \frac{j\omega}{j\omega + \omega_c}$

Lave frekvenser: $H(j\omega \ll \omega_c) \approx -j \frac{R_f}{R_s} \frac{\omega}{\omega_c}$

Høye frekvenser: $H(j\omega \gg \omega_c) \approx -\frac{R_f}{R_s} \approx konstant$

Kretsen har en høypasskarakteristikk

Nærmere bestemt er dette et førsteordens høypassfilter

TET4100 Kretsanalyse – Løsning

Institutt: Elkraftteknikk Dato: 2012.08.15

41) Aktive Filter 11.C

41.1) strøm gjennom den første motstanden I_1

strøm gjennom den andre motstanden I_2

spenning mellom de to motstander V_1

$V_{ut}=V_n=V_p$

4 komponenter gir 4 ligninger:

$$I_1=\frac{V_{inn}-V_1}{R}$$

$$I_2=\frac{V_1-V_{ut}}{R}$$

$$V_{ut}=\frac{1}{sC}I_2$$

$$V_1=V_{ut}+\frac{1}{sC}(I_1-I_2)$$

setter inn I_1 og I_2 :

$$V_{ut}=\frac{1}{sRC}(V_1-V_{ut})=\frac{\frac{1}{RC}}{s+\frac{1}{RC}}V_1$$

$$V_1=V_{ut}+\frac{1}{sRC}(V_{inn}+V_{ut}-2V_1)=\frac{s+\frac{1}{RC}}{s+\frac{2}{RC}}V_{ut}+\frac{\frac{1}{RC}}{s+\frac{2}{RC}}V_{inn}$$

$$\frac{1}{RC}=\omega_c$$

$$V_{ut}=\frac{\omega_c}{s+\omega_c}V_1$$

$$V_1=\frac{s+\omega_c}{s+2\omega_c}V_{ut}+\frac{\omega_c}{s+2\omega_c}V_{inn}$$

$$V_{ut} = \frac{\omega_c}{s+\omega_c}\left(\frac{s+\omega_c}{s+2\omega_c}V_{ut} + \frac{\omega_c}{s+2\omega_c}V_{inn}\right)$$

$$V_{ut} = \frac{\omega_c}{s+2\omega_c}V_{ut} + \frac{\omega_c^2}{(s+\omega_c)(s+2\omega_c)}V_{inn}$$

$$\left(1-\frac{\omega_c}{s+2\omega_c}\right)V_{ut} = \frac{\omega_c^2}{(s+\omega_c)(s+2\omega_c)}V_{inn}$$

$$H(s) = \frac{\dfrac{\omega_c^2}{(s+\omega_c)(s+2\omega_c)}}{1-\dfrac{\omega_c}{s+2\omega_c}}$$

$$H(s) = \frac{\dfrac{\omega_c^2}{(s+\omega_c)(s+2\omega_c)}}{\dfrac{s+\omega_c}{s+2\omega_c}}$$

$$H(s) = \frac{\omega_c^2}{(s+\omega_c)^2}$$

41.2) Dette er et andre ordens LP-filter