EHB 335E HW 5 Solutions

① $K_{Vo} = \dfrac{2 \cancel{48\pi} \cancel{10^5}\, 10^3}{\cancel{300\pi} \cdot \cancel{.6\pi} \times 10^{\cancel{4}} \cdot \cancel{4\pi} \times 10^{\cancel{5}}} = 1000$

a) Mid-band gain: $\dfrac{V_o}{V_g} = \dfrac{R_i}{R_i + R_g} \cdot K_{Vo} \cdot \dfrac{R_y}{R_y + R_{out}} = \dfrac{50k}{50k+5} \cdot 1000 \cdot \dfrac{5k}{5k+1k}$

$$\frac{V_o}{V_g} = 757.6$$

b) $\tau_1 = C_1 (R_i + R_g)$ $\quad f_L = \left(\dfrac{1}{\tau_1} + \dfrac{1}{\tau_2}\right) \cdot \dfrac{1}{2\pi} = 24 + 44.2 = 68.2\,Hz$

$\tau_2 = C_2 (R_y + R_o)$

c) $\tau_1 = C_i (R_g \| R_i) \Rightarrow f_1 = \dfrac{1}{2\pi\tau_1} = 140\,kHz$

$f_2 = 3 \times 10^4\,Hz = 30\,kHz$ $\quad f_3 = 2 \times 10^6\,Hz = 2\,MHz$

$t_{R1} = \dfrac{0.35}{f_1}$ $\quad t_{R2} = \dfrac{0.35}{f_2}$ $\quad t_{R3} = \dfrac{0.35}{f_3}$

$t_R = 1.1\sqrt{t_{R1}^2 + t_{R2}^2 + t_{R3}^2} = 13.1\,\mu s$ or another way

$\tau_H = \tau_1 + \tau_2 + \tau_3 = 1.14 \times 10^{-6} + 5.31 \times 10^{-6} + 7.96 \times 10^{-8} = 6.53 \times 10^{-6}\,s$

$f_H = \dfrac{1}{\tau_H \cdot 2\pi}$

$t_R = \dfrac{0.35}{f_H} = 0.35 \cdot 2\pi \cdot \tau_H$

$= 14.4\,\mu s$

$\%\delta = \dfrac{T_D}{\tau_{L1}} + \dfrac{T_D}{\tau_{L2}} + \dfrac{T_D}{\tau_{L3}} = \dfrac{20 \times 10^{-6}}{6.63 \times 10^{-3}} + \dfrac{20 \times 10^{-6}}{3.6 \times 10^{-3}} + \dfrac{20 \times 10^{-6}}{1.54 \times 10^{-3}} = \%\,2.1$

(2) $K(s) = \dfrac{4000}{\left(\frac{s}{500\pi}+1\right)}$ $\quad f_H = 250\ Hz$

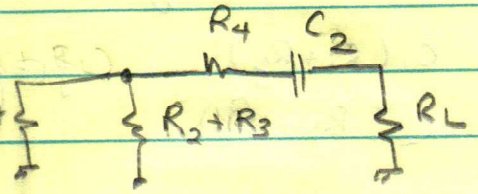
$$\frac{A_{Vo}}{1+KA_{Vo}} \approx \frac{1}{K}$$

Open loop gain : $\dfrac{V_o}{V_g} = \dfrac{R_1}{R_1+R_g} \cdot \dfrac{R_L}{R_L+R_4} \cdot K_{Vo} = 2685 = A_{vo}$

$K = \dfrac{R_2}{R_2+R_3} = \dfrac{1}{26}$ $\quad$ Closed loop gain $= \dfrac{R_1}{R_1+R_g} \times \dfrac{1}{K} \times \dfrac{R_L}{R_L+R_4}$

$= 17.5$

b) Lower cut-off : $\tau_{L1} = C_1(R_1+R_g)$



$\tau_{L2} = (R_L + (R_2+R_3) \,//\, R_{out} + R_4) \cdot C_2$

$\tau_{L2} \simeq (R_L + R_4)\, C_2$

$f_L = (\tau_{L1}^{-1} + \tau_{L2}^{-1}) \cdot \dfrac{1}{2\pi} = 21.3\ Hz$

Higher cut-off : $\tau_{H1} = \tau_1 \cdot (1+KA_{vo}) = 500\pi\left(1+\dfrac{2685}{26}\right) = 52134\pi = 1.64 \times 10^{-6}$

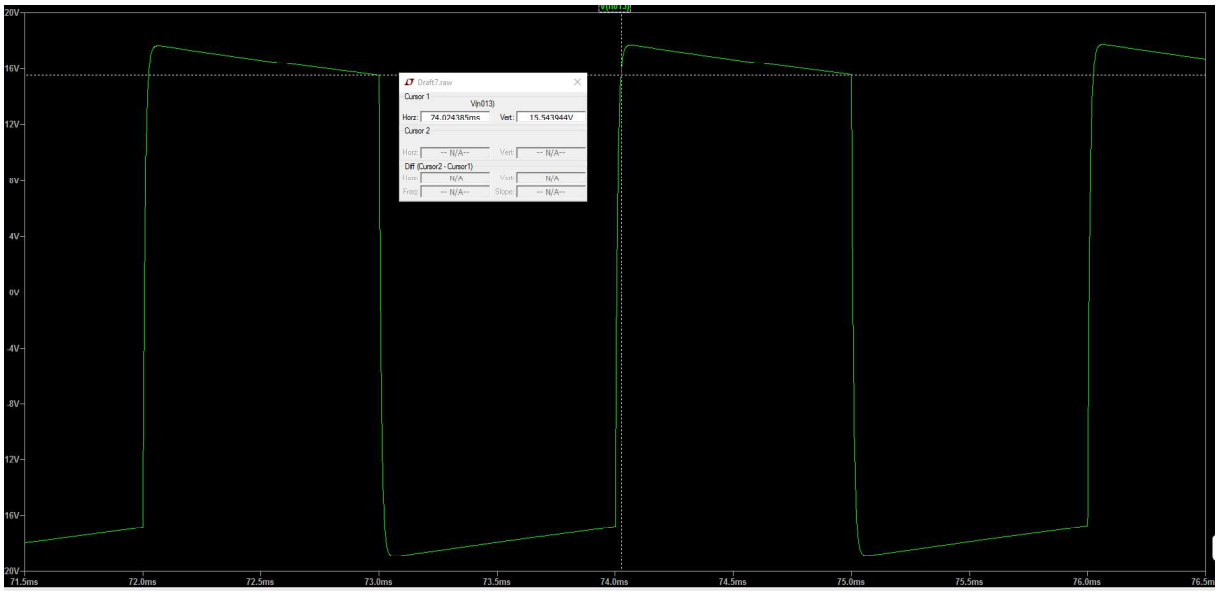
$\tau_{H2} = C_3\,(R_4 \,//\, R_L) = 4\times10^{-9} \cdot 2.17\times10^{3} = 8.72\times10^{-6}$

$f_H = \dfrac{1}{(\tau_{H1}+\tau_{H2})\,2\pi} = 15.4\ kHz$

d) Rise time $= t_R = \dfrac{0.35}{f_H} = 22.7\ \mu s$

$\sum \delta = \dfrac{T_D}{\tau_{L1}} + \dfrac{T_D}{\tau_{L2}} = \dfrac{1\times10^{-3}}{0.0234} + \dfrac{1\times10^{-3}}{0.011} = 13.3\ \%$

Question 4: Rise time is roughly 24.4 us. Compares well with 22.7 us.



Tilt is (17.7 – 15.6) / 15.6 = 13.5 %. Compares very well with %13.3.