Hw # 9 – Solution – Electronics 1.

1) $$H(s) = 10^3 \frac{(s+1500)(s+2\times10^5)^2}{s(s+3000)(s+10^4)}$$

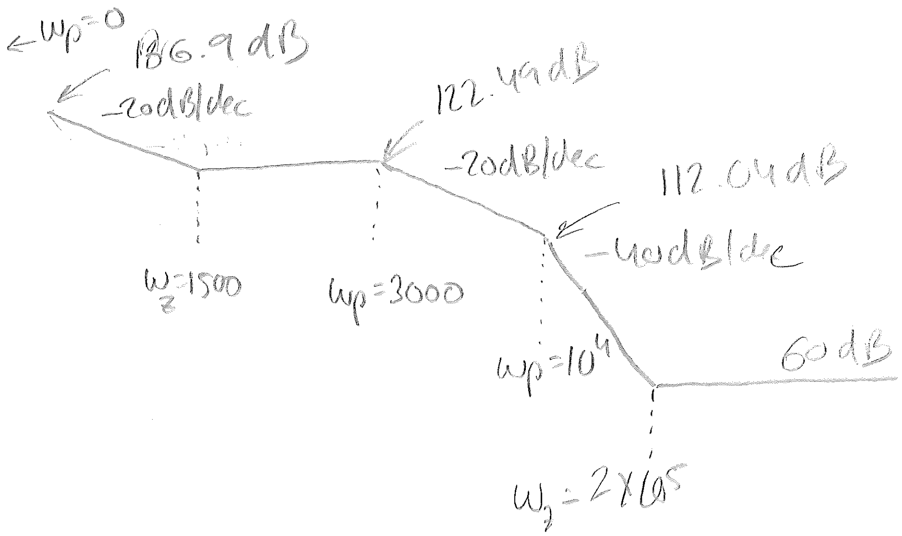
$w = 0 \rightarrow$ pole

$w = 1500 \rightarrow 0$

$w = 3000 \rightarrow$ pole

$w = 10^4 \rightarrow$ pole

$w = 2\times10^5 \rightarrow$ 0 – double.



Find dB at $w \to \infty$

$$H(s\to\infty) = 10^3 \frac{s^3}{s^3} = 10^3$$

$$|H(s\to\infty)| = 60\text{ dB}$$

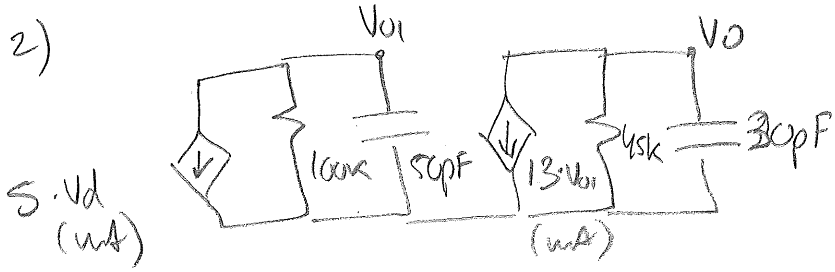
$$|H(s\to10^4)| = 40\text{ dB/dec} \log\left(\frac{2\times10^5}{10^4}\right) + 60\text{ dB} = 112.04\text{ dB}$$

$$|H(s\to3000)| = 20\text{ dB/dec} \log\left(\frac{10^4}{3000}\right) + 112.04\text{ dB} = 122.49\text{ dB}$$

$$|H(s\to0)| = 20\cdot\log\left(10^3 \frac{1500\,(2\times10^5)^2}{(3000)(10^4)}\right) = 186\text{ dB}$$

or $$\underbrace{20\text{ dB/dec}\cdot\log\left(\frac{1500}{1}\right)}_{63.52} + 122.49\text{ dB} = 63.52 + 122.49\text{ dB} = 186.9$$

2)



→ Midband gain → $(5\,mS)(100k) \cdot (1.3\,mS)(45k) = 29.25 \times 10^3$ V/V

$$A_M = 89.32\,dB$$

→ Poles $\omega_{p1} = \dfrac{1}{(100k)(50pF)} = 2 \times 10^5\, r/s$

$$\omega_{p2} = \frac{1}{(45k)(30pF)} = 7.4 \times 10^5\, r/s$$

→ $$A(s) = \frac{K}{(s + 2\times10^5)(s + 7.4\times10^5)} = 29.25\times10^3$$

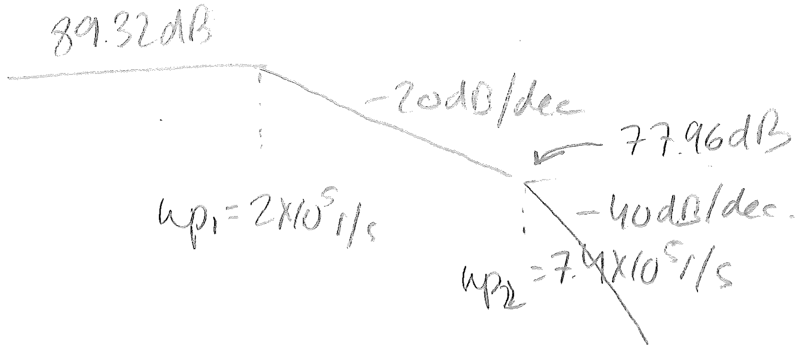
$s \to 0$ $$K = (29.25\times10^3)(2\times10^5)(7.4\times10^5) = 4.3\times10^{15}$$

$$A(s) = \frac{4.3\times10^{15}}{(s + 2\times10^5)(s + 7.4\times10^5)}$$

also

$$A(s) = \frac{29.25\times10^3}{\left(1 + \frac{s}{2\times10^5}\right)\left(1 + \frac{s}{7.4\times10^5}\right)}$$ (Alternate form with DC gain in numerator)

2(cont'd): Gain plot:



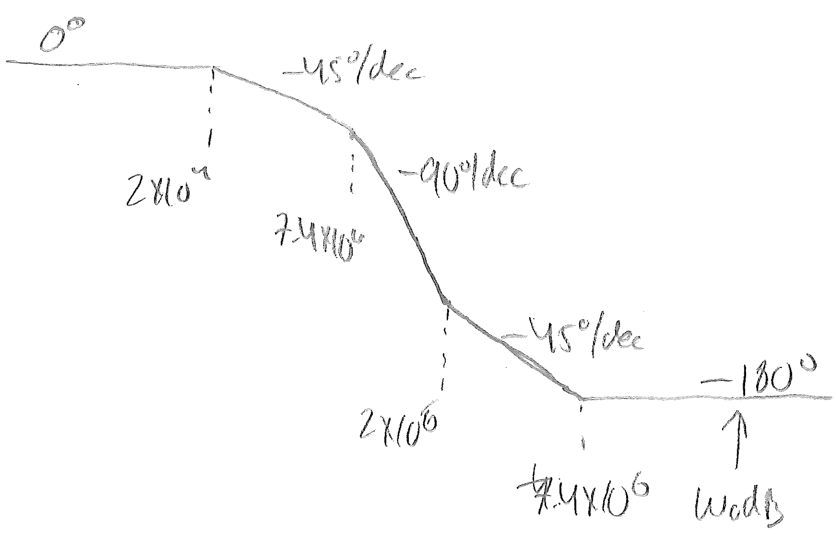
$$89.32\,\text{dB} - \underbrace{20\,\text{dB/dec}\cdot\log\left(\frac{7.4\times10^5\,1/s}{2\times10^5\,1/s}\right)}_{11.36} = 77.96\,\text{dB}$$

$$\omega_{0dB} \rightarrow \quad 40\,\text{dB/dec}\,\log\left(\frac{\omega_{0dB}}{7.4\times10^5\,1/s}\right) = 77.96\,\text{dB}$$

$$10^{\left(\log \frac{\omega_{0dB}}{7.4\times10^5\,1/s}\right)} = 10^{\left(\frac{77.96}{40}\right)}$$

$$\omega_{0dB} = \left(10^{77.96/40}\right)\cdot 7.4\times10^5\,1/s$$

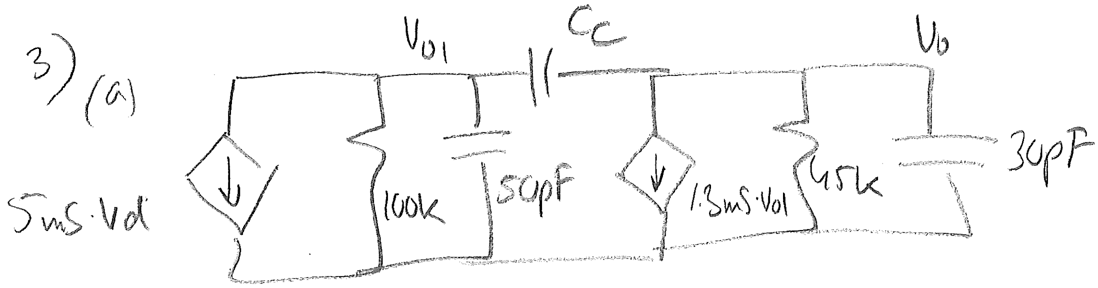
$$\omega_{0dB} = 6.57\times10^7\,1/s$$



Pole at 2×10^5 1/s
$(0, 2\times10^4)$ 0°
$(2\times10^4 - 2\times10^6)$ -45°/dec
$(2\times10^6, \infty)$ -90°

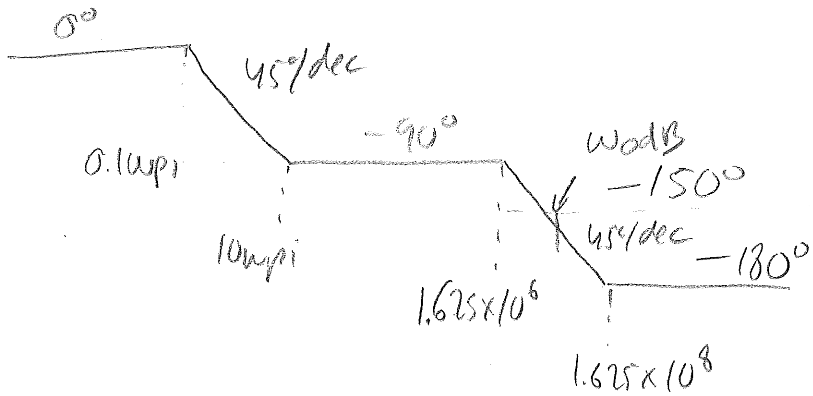
Pole at 7.4×10^5 1/s
$(0, 7.4\times10^4)$ 0°
$(7.4\times10^4, 7.4\times10^6)$ -45°/dec
$(7.4\times10^6, \infty)$ -90°

3) (a)



(b) $\omega_{p2} = \dfrac{g_{m5}}{C_1 + C_2} = \dfrac{1.3\,mS}{(50pF + 30pF)} = 16.25 \times 10^6\ r/s = 1.625 \times 10^7\ r/s$

(c)



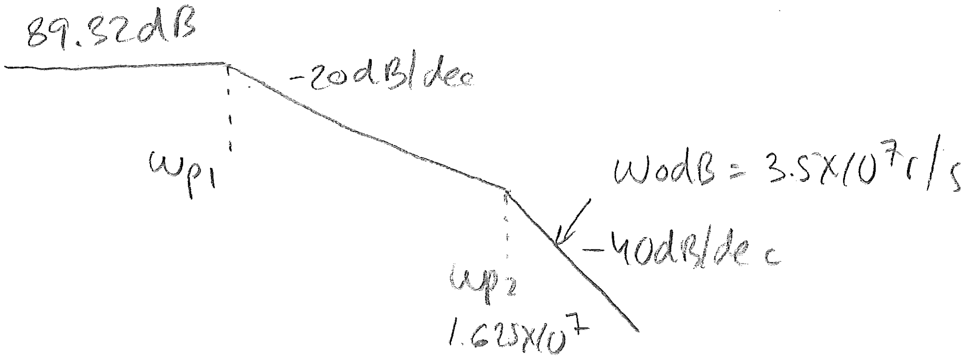
Drop of 60° from $\omega = 1.625 \times 10^6\ r/s$ to ω_{odB}:

$$60\,dB = 45°/dec \cdot \log\left(\frac{\omega_{odB}}{1.625 \times 10^6}\right)$$

$$\omega_{odB} = \left(10^{60/45}\right)(1.625 \times 10^6) = 3.5 \times 10^7\ r/s$$

(d)

(e)



3-cont'd)

→ Gain at 2nd pole:

$$0dB + 40\log\left(\frac{3.5\times10^{7}}{1.625\times10^{7}}\right) = 13.33\,dB$$

(f) → Must gain $(89.32 - 13.33) = 75.99\,dB$ up to ω_{p1} at a 20 dB/decade gain.

$$75.99\,dB = 20^{dB/dec}\cdot\log\left(\frac{1.625\times10^{7}}{\omega_{p1}}\right)$$

$$10^{\left(\frac{75.99}{20}\right)} = \frac{1.625\times10^{7}\,1/s}{\omega_{p1}}$$

$$\omega_{p1} = \frac{1.625\times10^{7}\,1/s}{6.3023\times10^{3}} = 2.578\times10^{3}\,r/s$$

(g) $$C_c = \frac{1}{g_{m5}\cdot R_{o1}\cdot R_{o2}\cdot \omega_{p1}} = \frac{1}{(1.3\times10^{-3})(100\times10^{3})(45\times10^{3})(2.578\times10^{2})}$$

$C_c = 66.3\,pF$

(h)