(30 Points) (1) In the circuits shown, R_s=5 KΩ, R_i=1KΩ , and G_m=10 mA/V, R_o=10 KΩ and R_L=10 KΩ .

a) In Fig.1 , Find the gain A=Vo/Vs .
b) In Fig.2 , Find the gain A=Vo/Vs.

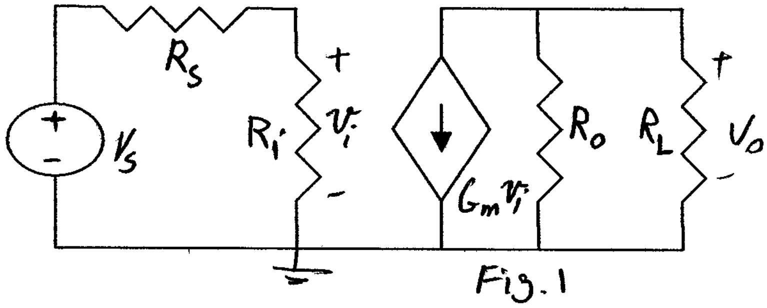


Fig.1

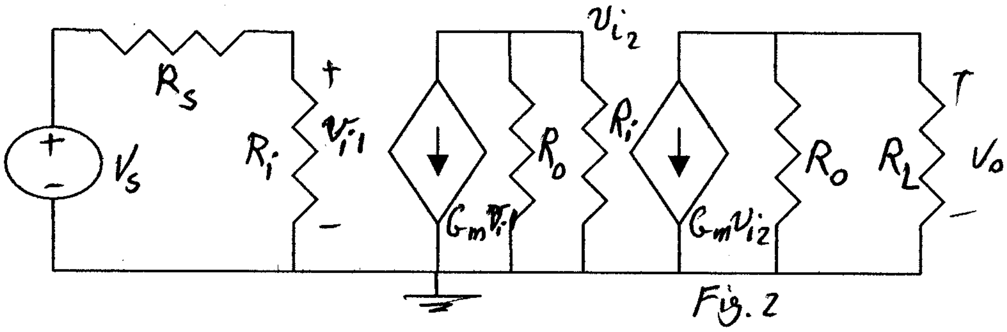


Fig. 2

Solution:

a) $$\frac{V_i}{V_s} = \frac{R_i}{R_i+R_s} = \frac{1}{1+5} = \frac{1}{6}$$

$$V_o = -G_m V_i \times (R_L \| R_o) = -10\,(10^k \| 10^k) V_i = -10 \times 5 V_i = -50 V_i$$

$$\frac{V_o}{V_i} = -50$$

$$\text{Gain} = A = \frac{V_o}{V_i} = \frac{V_i}{V_s} \cdot \frac{V_o}{V_i} = \frac{1}{6}(-50) = \boxed{-8.33}$$

(b) $$\frac{V_{i1}}{V_s} = \frac{R_i}{R_i+R_s} = \frac{1}{6}$$

$$V_{i2} = -G_m V_{i1} (R_o \| R_i) = -10\,(10 \| 1)\, V_{i1} = -9.1 V_{i1}$$

$$\frac{V_{i2}}{V_{i1}} = -9.1$$

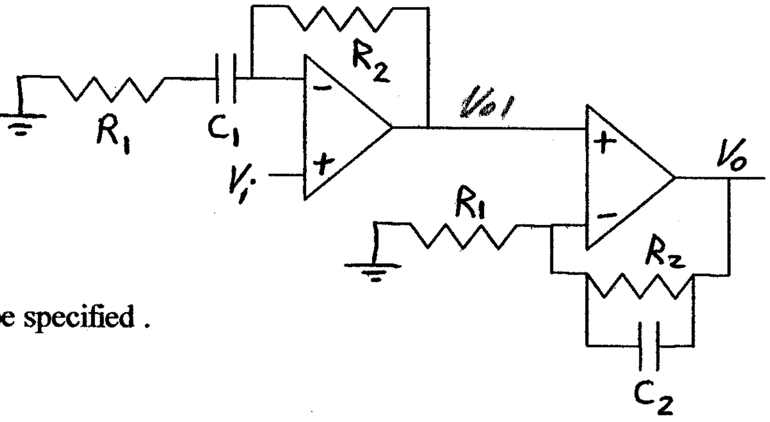
$$V_o = -G_m V_{i2} (R_o \| R_L) = -50\, V_{i2}$$

$$\frac{V_o}{V_{i2}} = -50.$$

$$V_o/V_s = \frac{V_{i1}}{V_s} \cdot \frac{V_{i2}}{V_{i1}} \cdot \frac{V_o}{V_{i2}} = \frac{1}{6} \times (-9.1)(-50) = \boxed{75.8}$$

(40 Points) (2) In the given circit, R1=10 K ,R2=50 K ,C1=1μF and C2= 1nF. Find the transfer function T= Vo/Vi . T should be in the form

T= K(1+τ1S).../(1+τ2S)...



And numerical values of K ,τ1 and τ2 should be specified .

Solution:

$$\frac{V_{o1}}{V_i} = 1 + \frac{R_2}{Z_1} = 1 + \frac{R_2}{R_1 + \frac{1}{SC_1}} = 1 + \frac{SR_2C_1}{1 + SR_1C_1} =$$

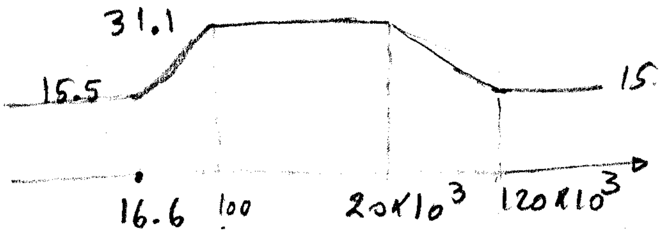
$$\frac{V_{o1}}{V_i} = \frac{1 + SC_1(R_1 + R_2)}{1 + SR_1C_1}$$

$$\frac{V_o}{V_{o1}} = 1 + \frac{Z_2}{R_1} = 1 + \frac{\frac{1/SC_2 \cdot R_2}{R_2 + 1/SC_2}}{R_1} = 1 + \frac{R_2/R_1}{1 + SR_2C_2}$$

$$\frac{V_o}{V_{o1}} = \frac{1 + R_2/R_1 + SR_2C_2}{1 + SR_2C_2} = \left(1 + \frac{R_2}{R_1}\right) \frac{1 + SC_2 \frac{R_2}{1 + R_2/R_1}}{1 + SR_2C_2}$$

$$\frac{V_o}{V_i} = \frac{V_{o1}}{V_i} \cdot \frac{V_o}{V_{o1}} = \left(1 + \frac{R_2}{R_1}\right) \frac{(1 + SC_1(R_1 + R_2))\left(1 + SC_2 \frac{R_2}{1 + R_2/R_1}\right)}{(1 + SR_1C_1)(1 + SR_2C_2)}$$

$$\frac{V_o}{V_i} = 6 \frac{(1 + 0.06S)(1 + 8.3 \times 10^{-6} S)}{(1 + 10^{-2} S)(1 + 5 \times 10^{-5} S)}$$



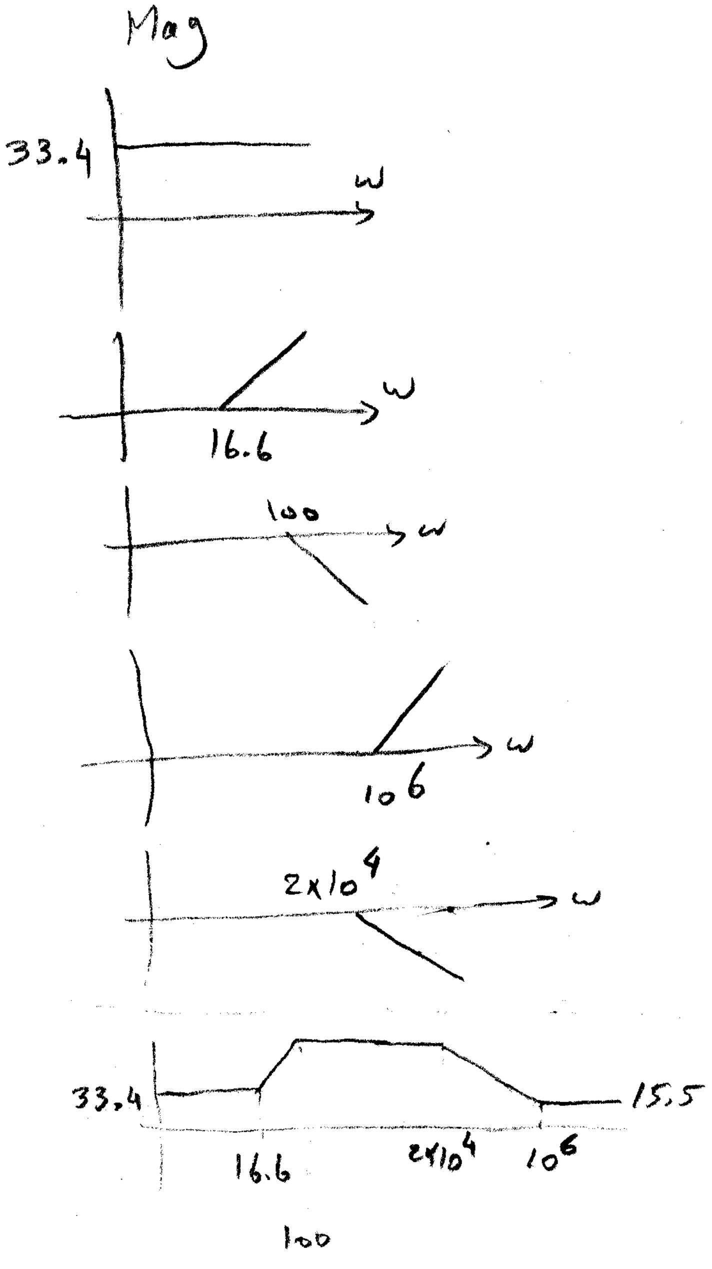
(30 Points) (3) For the given transfer function, sketch the magnitude and phase of its bode plot.

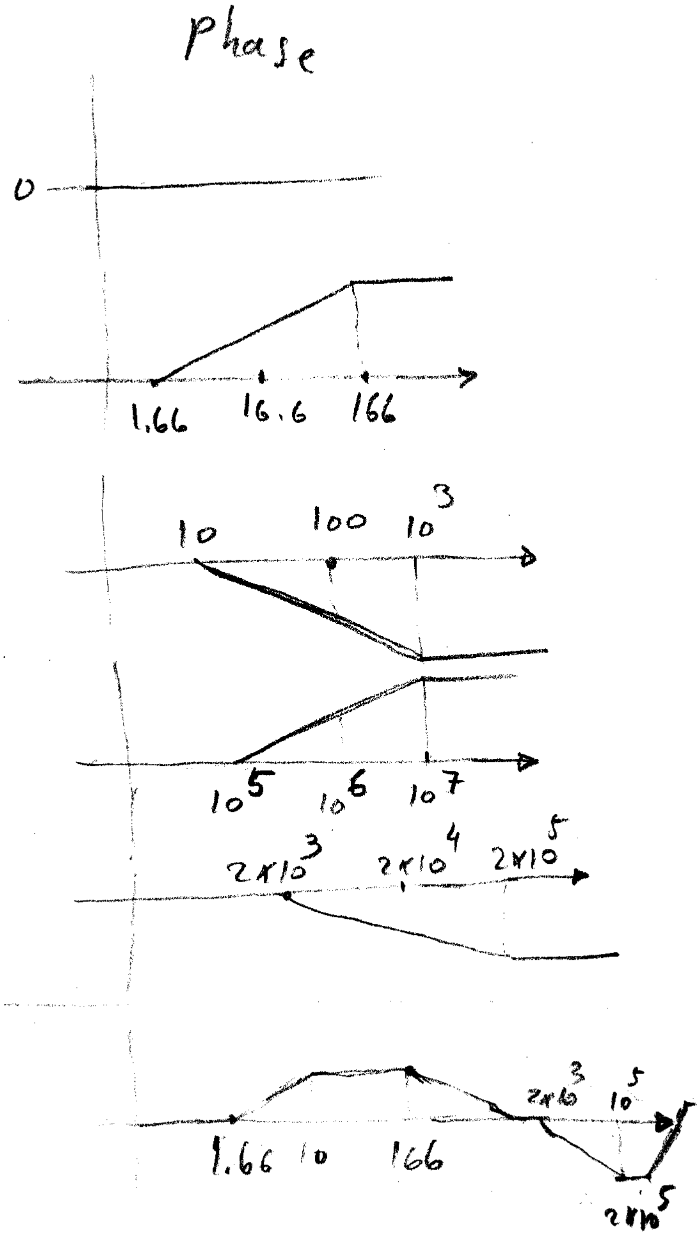
$$T = (1 + 0.06\,S)(50 + 5*10^{-5}\,S)/(1+0.01\,S)(1 + 5*10^{-5}\,S)$$

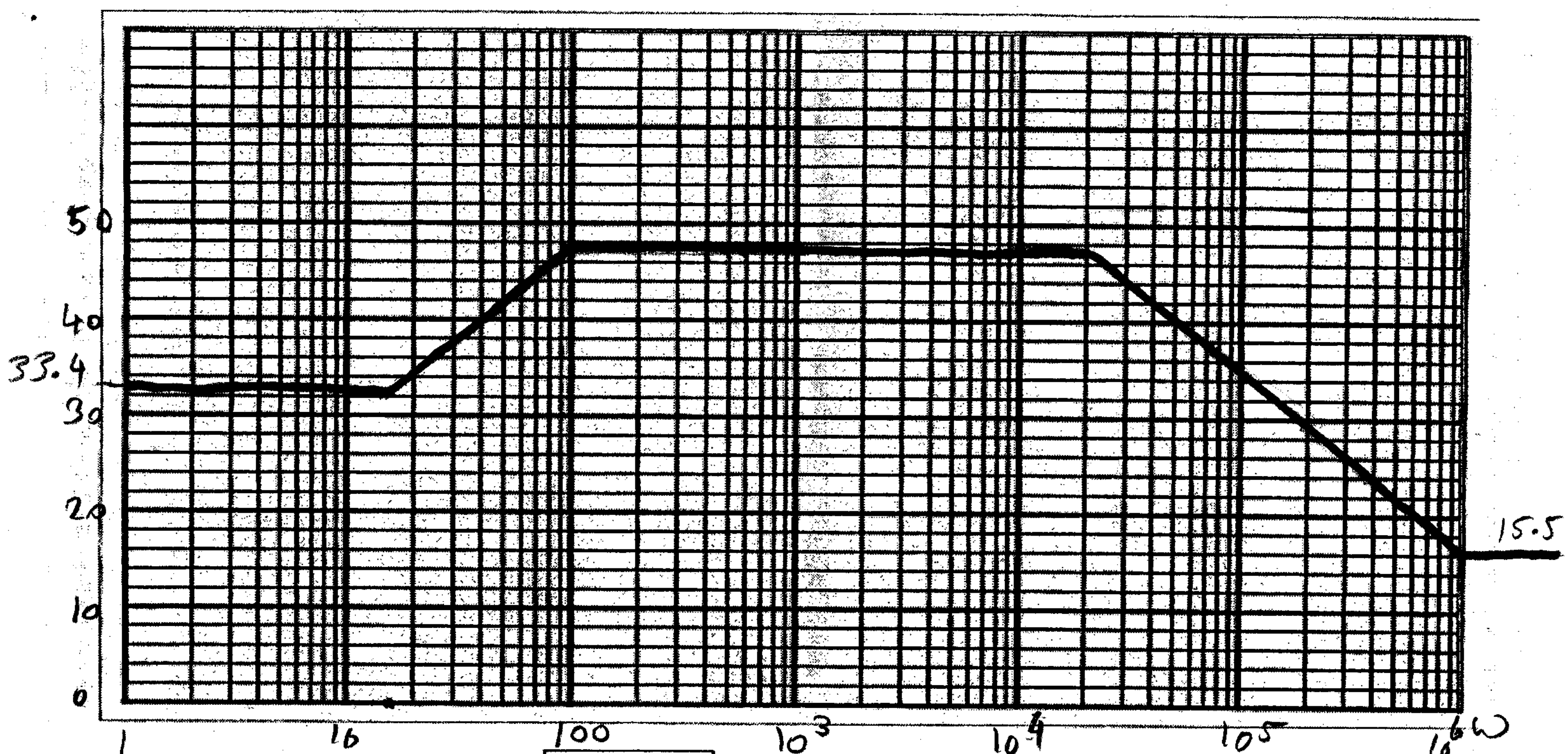
$$T = 50\,\frac{(1+0.06S)(1+10^{-6}S)}{(1+0.01S)(1+5\times10^{-5}S)}$$

$$|T|_{dB} = |1+0.06S|_{dB} + |(1+10^{-4}S)|_{dB} + \left|\frac{1}{1+0.01S}\right|_{dB} + \left|\frac{1}{1+5\times10^{-5}S}\right|_{dB}$$

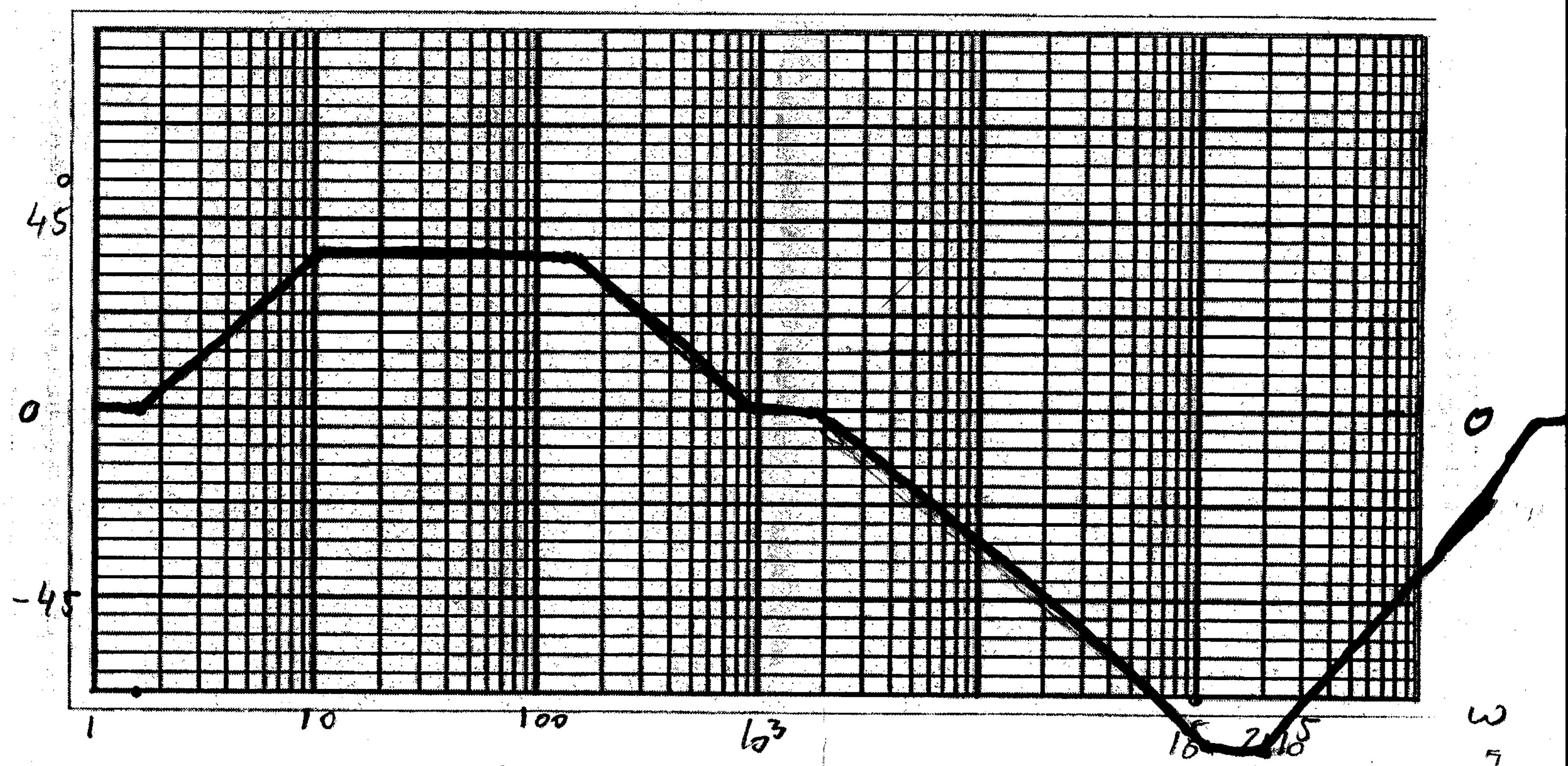
$$\angle T = \angle(1+0.06S) + \angle(1+10^{-4}S) + \angle\frac{1}{1+0.01S} + \angle\frac{1}{1+5\times10^{-5}S}$$







Magnitude



Phase