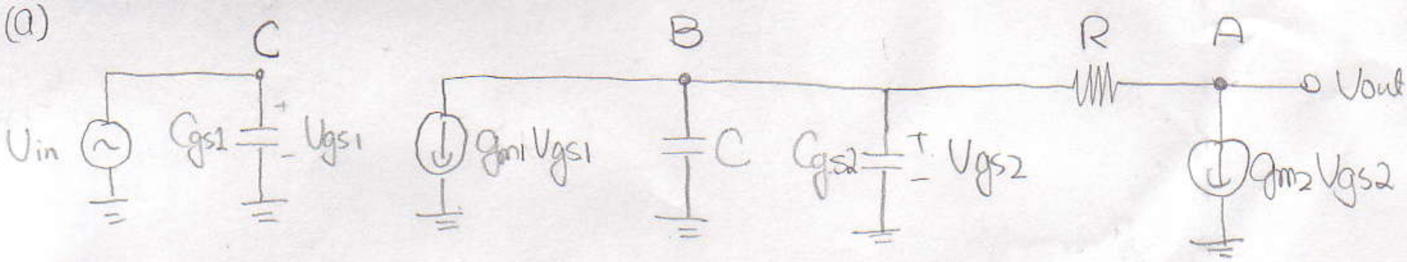
P.1

(a)



(b)

A: $\frac{V_{gs2} - V_{out}}{R} = g_{m2} V_{gs2}$, $\Rightarrow V_{gs2} = \frac{V_{out}}{1 - g_{m2} R}$

B: $V_{gs2} \cdot S(C + C_{gs2}) + g_{m1} V_{gs1} + \frac{(V_{gs2} - V_{out})}{R} = 0$

C: $V_{in} = V_{gs1}$

From A, B, C, we could derive the following expression

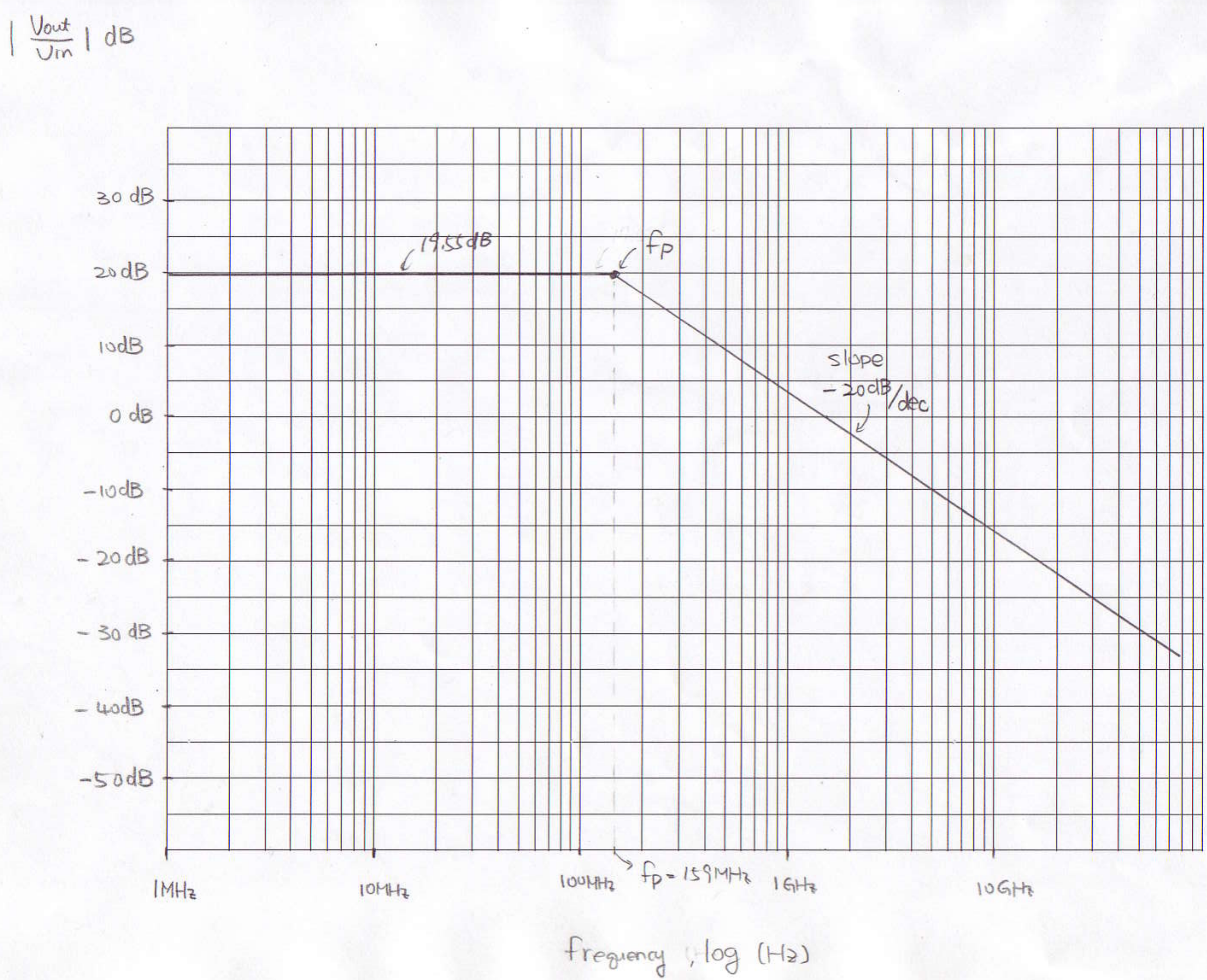
$$\Rightarrow \frac{V_{out}}{V_{in}}(S) = \frac{\frac{g_{m1}}{g_{m2}}(-1 + g_{m2} R)}{1 + S\left(\frac{C + C_{gs}}{g_{m2}}\right)} = \frac{9.5}{1 + S \cdot (1)(nsec)}$$

(c) pole : $\omega_p = 10^9$ rad/sec , $f_p = 159.15$ MHz

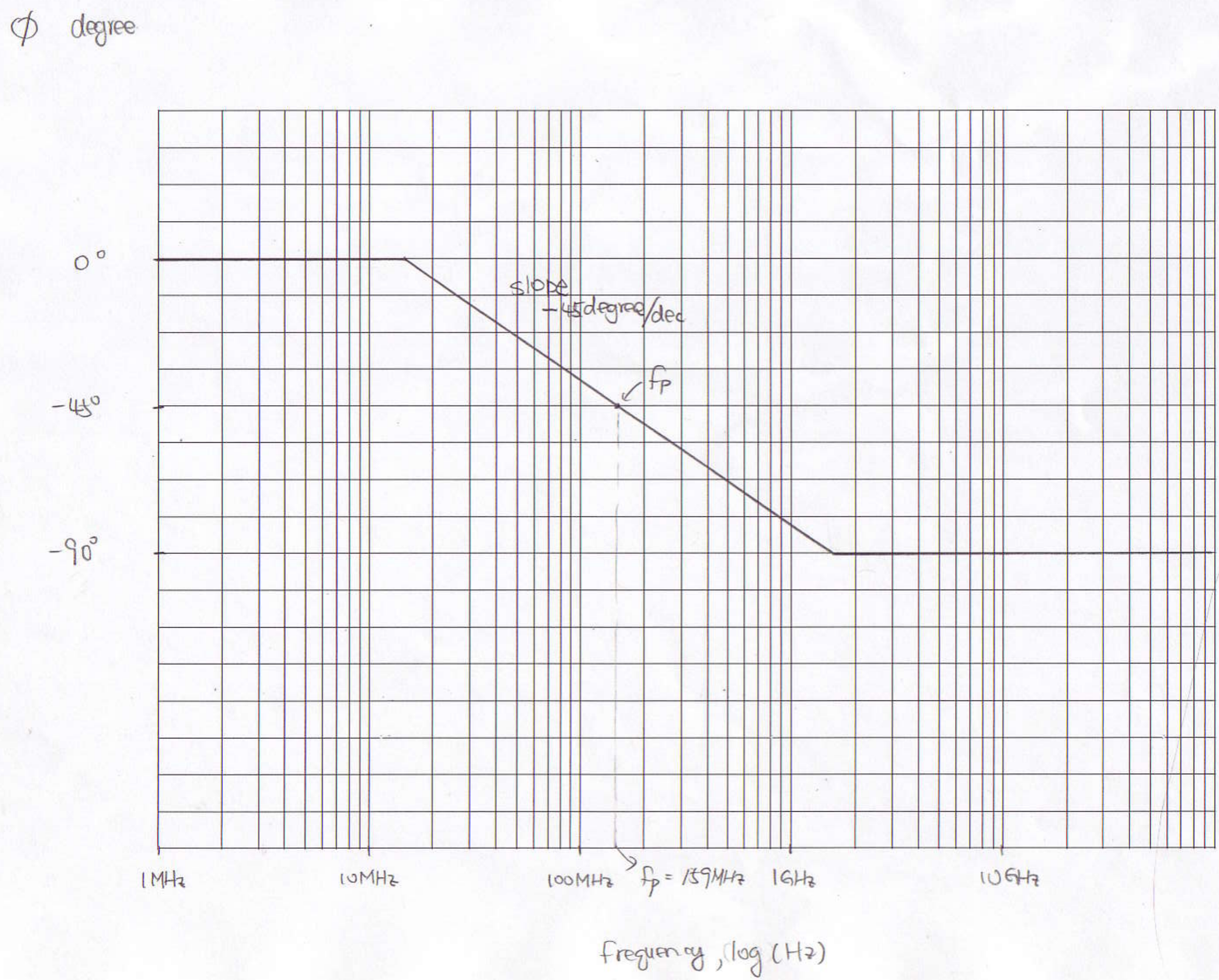
there is no zero.

(d) $$20\log\left|\frac{V_{out}}{V_{in}}(s)\right| = 20\log\frac{9.5}{\sqrt{1 + \left(\frac{\omega}{\omega_p}\right)^2}} = 20\log 9.5 - 20\log\sqrt{1 + \left(\frac{\omega}{\omega_p}\right)^2}$$

$$\phi(\omega) = 0^\circ - \tan^{-1}\frac{\omega}{\omega_p} \text{ (degree)}$$



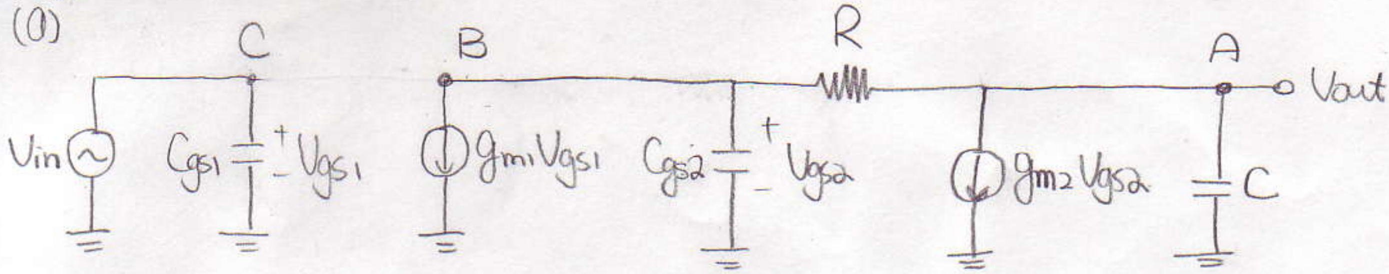
$\left|\frac{V_{out}}{V_{in}}\right|$ dB
30 dB
20 dB
10dB
0 dB
-10dB
- 20 dB
- 30 dB
- 40dB
-50dB
19.55dB
f_p
slope
- 20dB/dec
1MHz
10MHz
100MHz
f_p = 159MHz
1GHz
10GHz
frequency , log (Hz)



ϕ degree
0°
−45°
−90°
slope
−45degree/dec
fp
1MHz
10MHz
100MHz
fp = 159MHz
1GHz
10GHz
frequency, log (Hz)

P2

(a)



(b)

node A : $$\frac{V_{out} - V_{gs2}}{R} + g_{m2} V_{gs2} + V_{out} sC = 0$$

node B : $$g_{m1} V_{gs1} + V_{gs2} sC_{gs2} + \frac{(V_{gs2} - V_{out})}{R} = 0$$

node C : $$V_{in} = V_{gs1}$$

From A, B, C, we could get the following expression

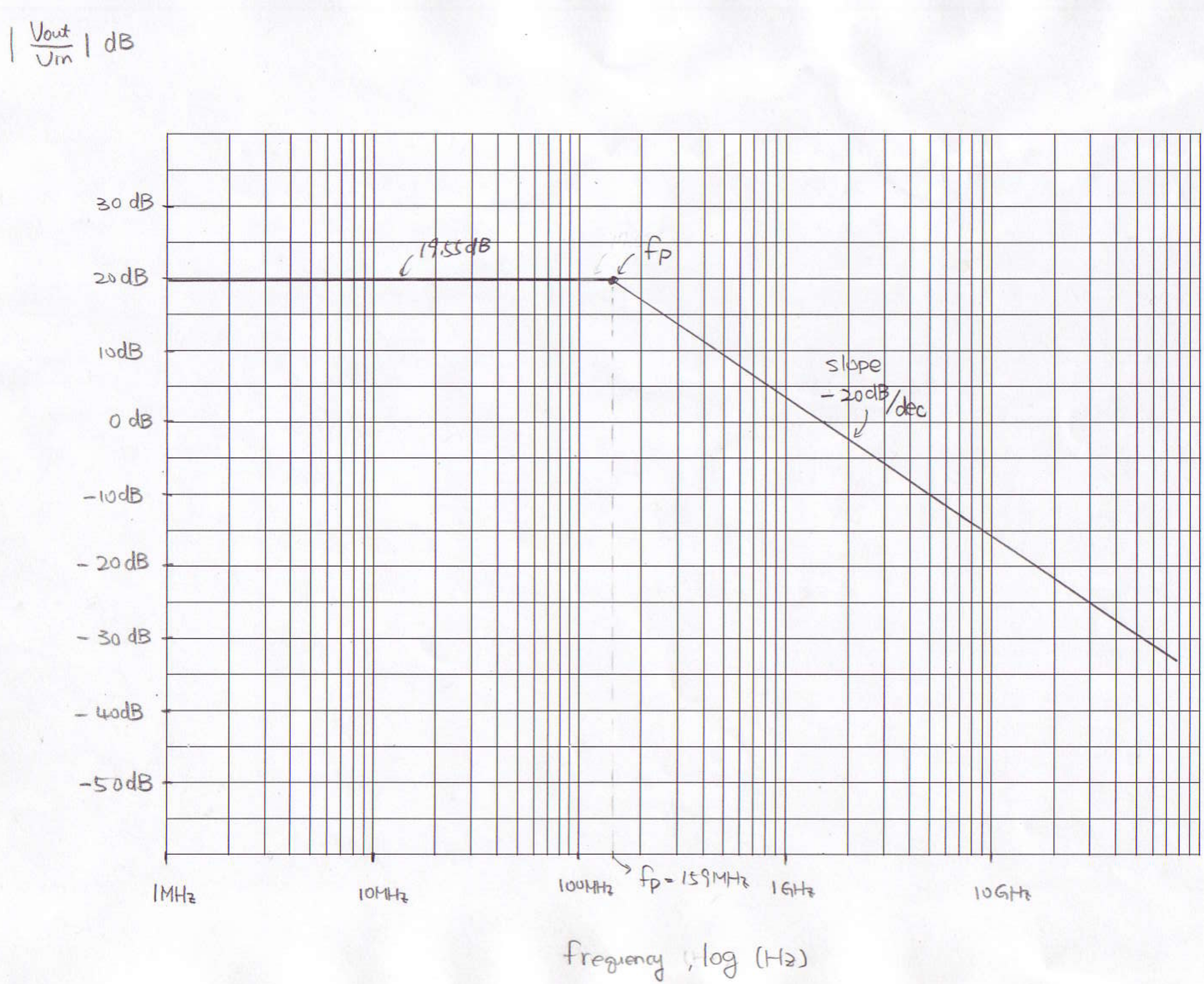
$$\frac{V_{out}}{V_{in}}(s) = \frac{g_{m1} R (g_{m2} R - 1)}{(g_{m2} \cdot R - 1) + (1 + sRC)(1 + sRC_{gs2})} \overset{(C_{gs2}=0)}{=} \frac{\frac{g_{m1}}{g_{m2}}(g_{m2} R - 1)}{1 + s\frac{C}{g_{m2}}} = \frac{9.5}{1 + s(1)(n\sec)}$$

(c) pole : $\omega_p = 10^{+9}$ rad/sec , $f_p = 159.15$ MHz

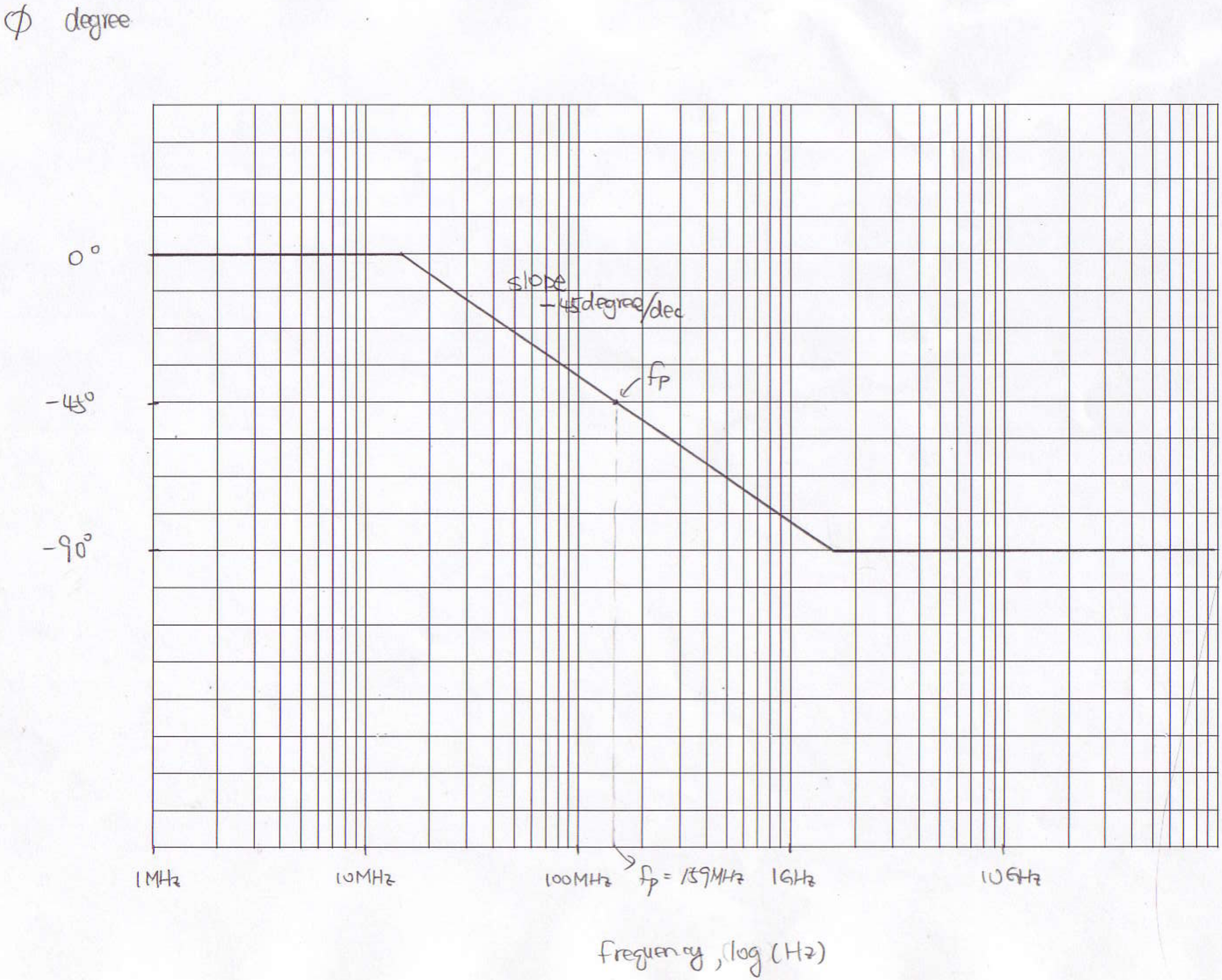
there is no zero.

(d) $$20\log\left|\frac{V_{out}}{V_{in}}(s)\right| = 20\log\frac{9.5}{\sqrt{1 + (\frac{\omega}{\omega_p})^2}} = 20\log 9.5 - 20\log\sqrt{1 + (\frac{\omega}{\omega_p})^2}$$

$$\phi(\omega) = 0° - \tan^{-1}\frac{\omega}{\omega_p} \text{ (degree)}$$



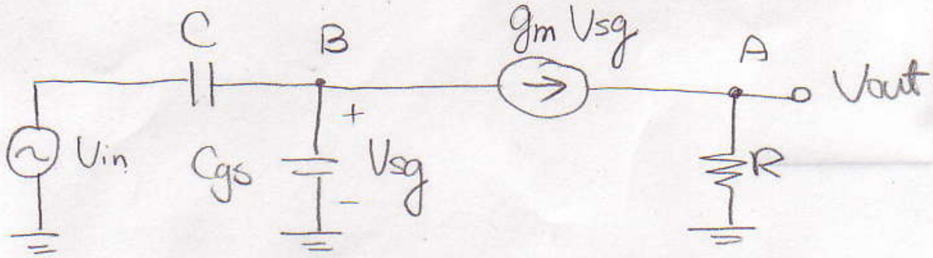
$\left|\frac{V_{out}}{V_{in}}\right|$ dB
30 dB
20 dB
10dB
0 dB
-10dB
-20 dB
-30 dB
-40dB
-50dB
19.55dB
f_P
slope
-20dB/dec
1MHz
10MHz
100MHz
f_P = 159MHz
1GHz
10GHz
frequency, log (Hz)



φ degree
0°
-45°
-90°
slope
-45degree/dec
fp
1MHz
10MHz
100MHz
fp = 159MHz
1GHz
10GHz
frequency, log (Hz)

P3

(a)



(b)

node A : $g_m V_{sg} = \frac{V_{out}}{R}$

node B : $V_{sg} \cdot SC_{gs} + (V_{sg} - V_{in}) \cdot SC + g_m V_{sg} = 0$

From A. B, we could get the following expression.

$$\frac{V_{out}}{V_{in}}(s) = \frac{SRC}{1 + S\left(\frac{C + C_{gs}}{g_m}\right)} \overset{(C_{gs}=0)}{=} \frac{S(10)(nsec)}{1 + S(10)(nsec)}$$

(c)

pole : $\omega_p = 10^8$ rad/sec, $f_p = 15.92$ MHz

zero : $\omega_z = 0$ rad/sec, $f_z = 0$ Hz

$$20\log\left|\frac{V_{out}}{V_{in}}(s)\right| = 20\log 10^{-8} + 20\log \omega - 20\log\sqrt{1 + \left(\frac{\omega}{\omega_p}\right)^2}$$

$$\phi(\omega) = 0^\circ + 90^\circ - \tan^{-1}\frac{\omega}{\omega_p} \text{ (degree)}$$

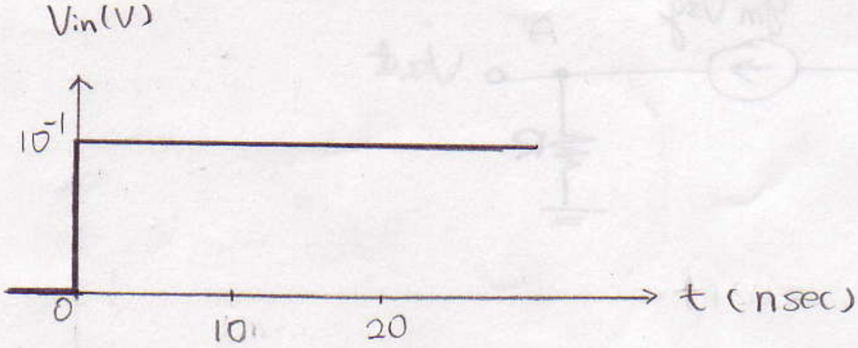
(d) $V_{in}(t) = 10^{-1} \cdot U(t)$ (Volt) , $U(t)$ is the unit step function at $t=0$

$\therefore V_{in}(S) = 10^{-1} \cdot \frac{1}{S}$ (Volt)

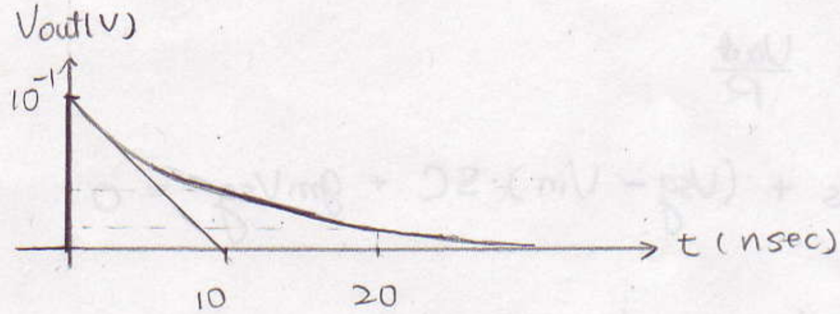
$\therefore V_{out}(s) = 10^{-9}(\text{Volt}) \cdot \frac{1}{1 + S(10)(nsec)}$

$\therefore V_{out}(t) = \mathcal{L}^{-1}[V_{out}(S)] = 10^{-1} e^{-10(nsec)^{-1} \cdot t}$ (Volt) when $t \geq 0$

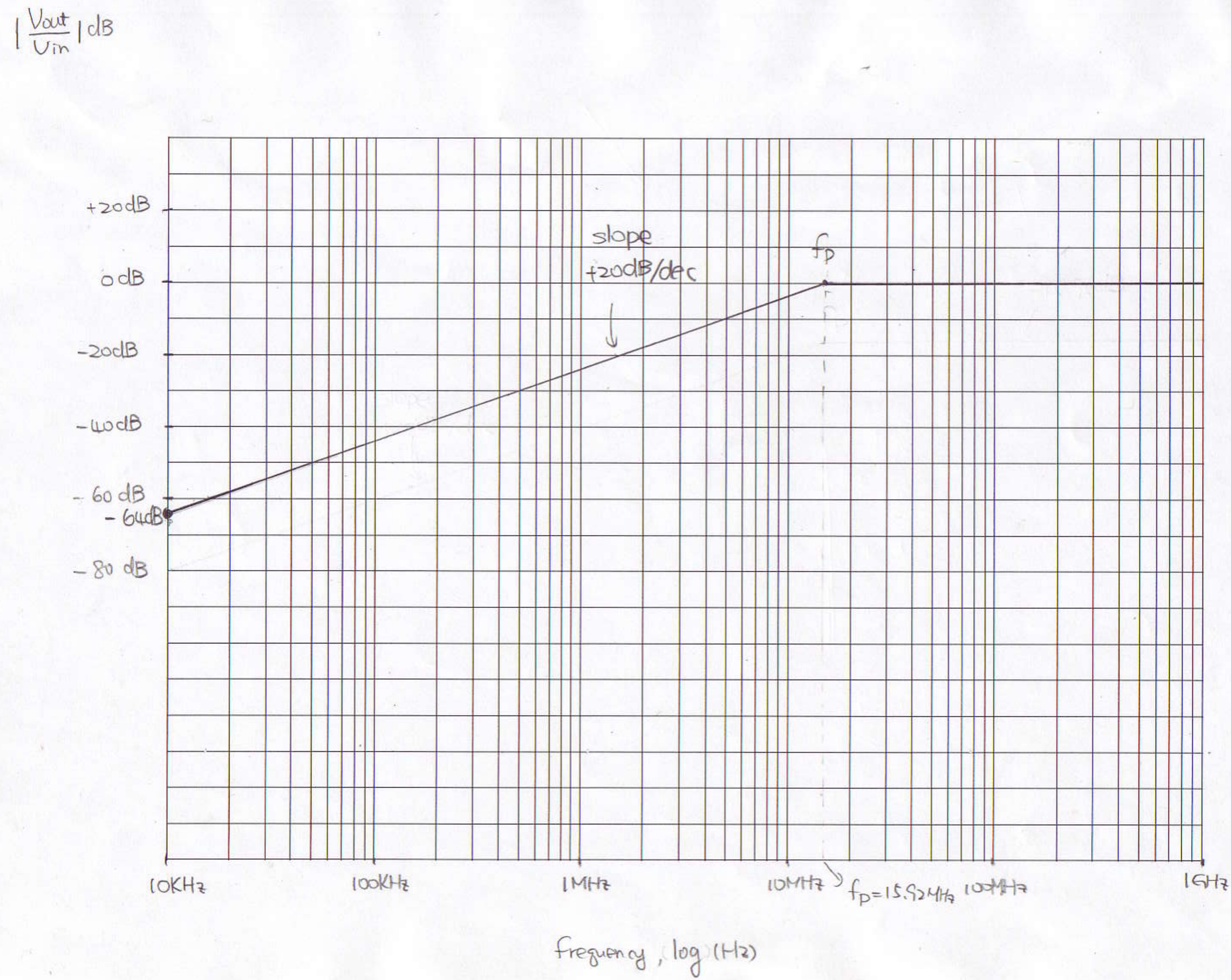
$V_{out}(t=0) = 10^{-1}$ (Volt), $V_{out}(t=\infty) = 0$ (Volt), τ(time constant) = 10(nsec)

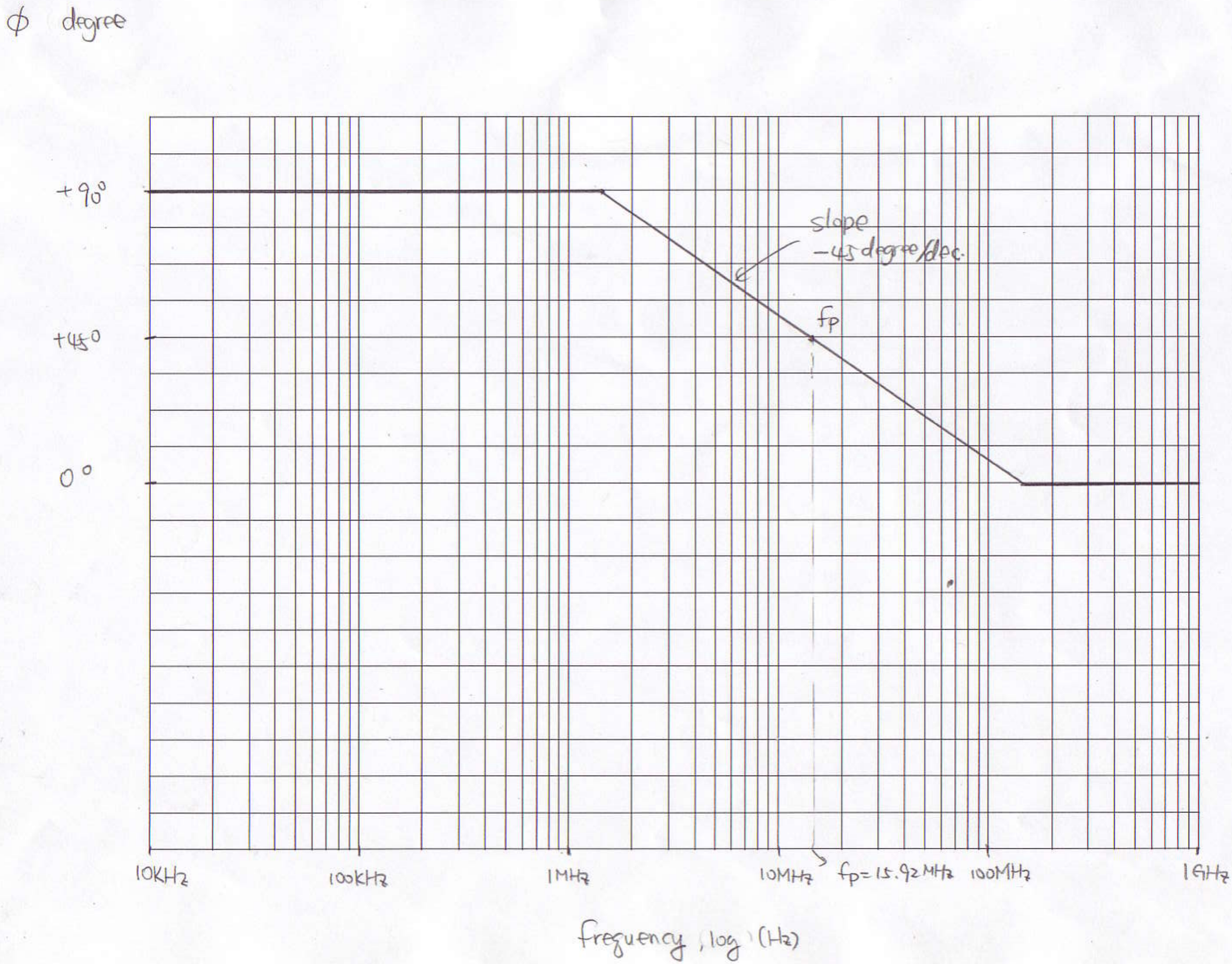


Vin(V)
10^-1
0
10
20
t (nsec)



Vout(V)
10^-1
10
20
t (nsec)

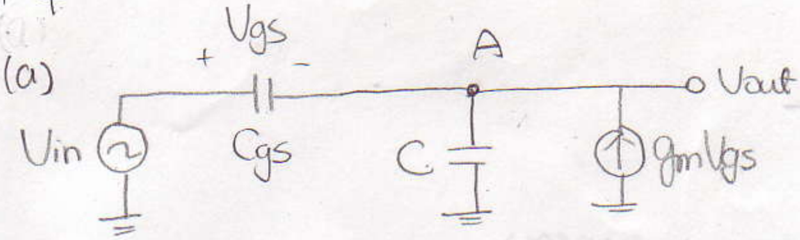

$|\frac{V_{out}}{V_{in}}|$ dB
+20dB
0 dB
-20dB
-40dB
-60 dB
-64dB
-80 dB
slope
+20dB/dec
f_p
10KHz
100KHz
1MHz
10MHz
f_p=15.92MHz
100MHz
1GHz
frequency, log (Hz)



φ degree
+90°
+45°
0°
slope
−45 degree/dec.
fp
10KHz
100KHz
1MHz
10MHz
fp = 15.92 MHz
100MHz
1GHz
frequency, log (Hz)

P4

(a)



(b)

node A : $-V_{out} \cdot SC + g_m V_{gs} + (V_{in} - V_{out}) \cdot SC_{gs} = 0$

and $V_{in} - V_{out} = V_{gs}$

we could get the following expression

$$\frac{V_{out}}{V_{in}}(S) = \frac{\frac{1}{g_m}(g_m + SC_{gs})}{1 + S\left(\frac{C_{gs}+C}{g_m}\right)} \overset{(C_{gs}=0)}{=\!=} \frac{1}{1+S\frac{C}{g_m}} = \frac{1}{1+S(10)(nsec)}$$

(c) pole : $\omega_p = 10^8$ rad/sec , $f_p = 15.92$ MHz

there is no zero.

$$20\log\left|\frac{V_{out}(s)}{V_{in}(s)}\right| = -20\log\sqrt{1+\left(\frac{\omega}{\omega_p}\right)^2}$$

$$\phi(\omega) = -\tan^{-1}\frac{\omega}{\omega_p} \text{ (degree)}$$

(d) $V_{in}(t) = 10^{-1} U(t)$ (Volt) $V_{in}(s) = 10^{-1}\frac{1}{S}$ (Volt), $U(t)$ is the unit step function at $t=0$

$$\therefore V_{out}(S) = 10^{-1}(\text{Volt}) \cdot \frac{1}{S(\text{sec})(1+S(10)(nsec))}$$

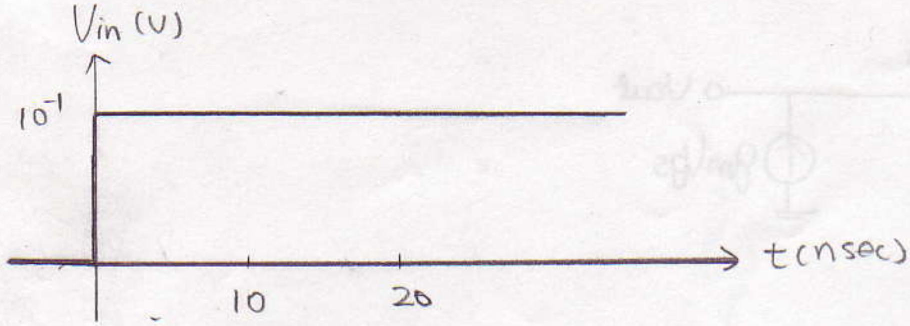
$$\Rightarrow V_{out}(t) = \mathcal{L}^{-1}[V_{out}(s)]$$

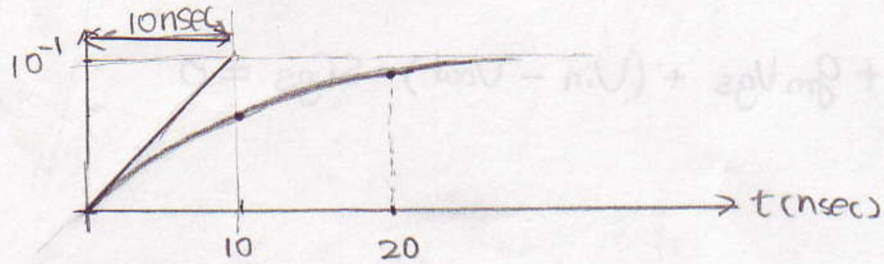
$$= \mathcal{L}^{-1}\left[10^{-1} \cdot \left(\frac{1}{S} - \frac{10^{-8}}{1+S(10^{-8})}\right)\right] \quad \left[\because \mathcal{L}^{-1}\left[\frac{1}{S+a}\right] = e^{-at}\right]$$

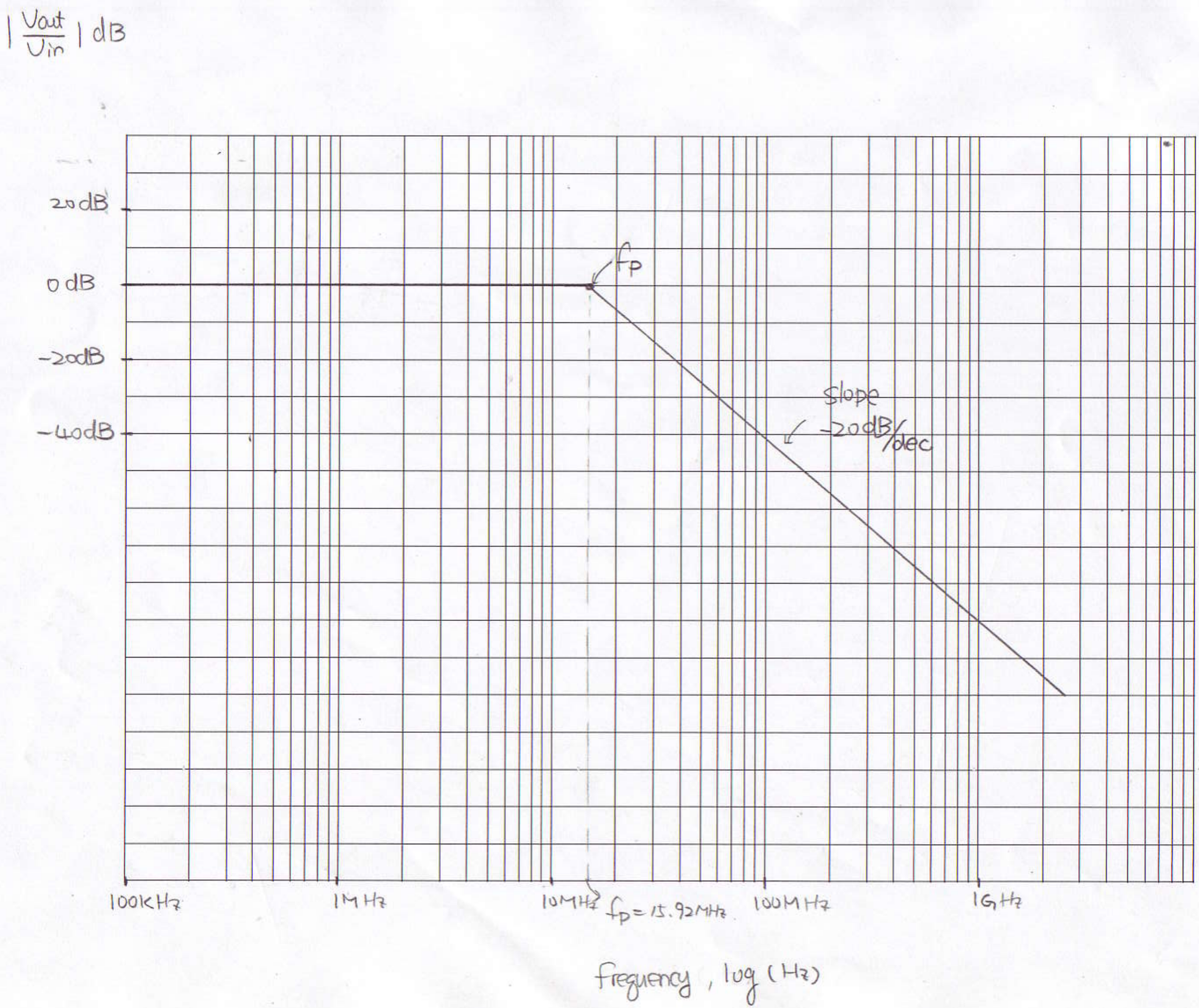
$$= 10^{-1}(\text{Volt}) \cdot \left(1 - e^{-10(nsec)^{-1}t}\right) \quad \text{when } t \geq 0$$

$V_{out}(t=0) = 0$ (volt), $V_{out}(t=\infty) = 10^{-1}$ (Volt)

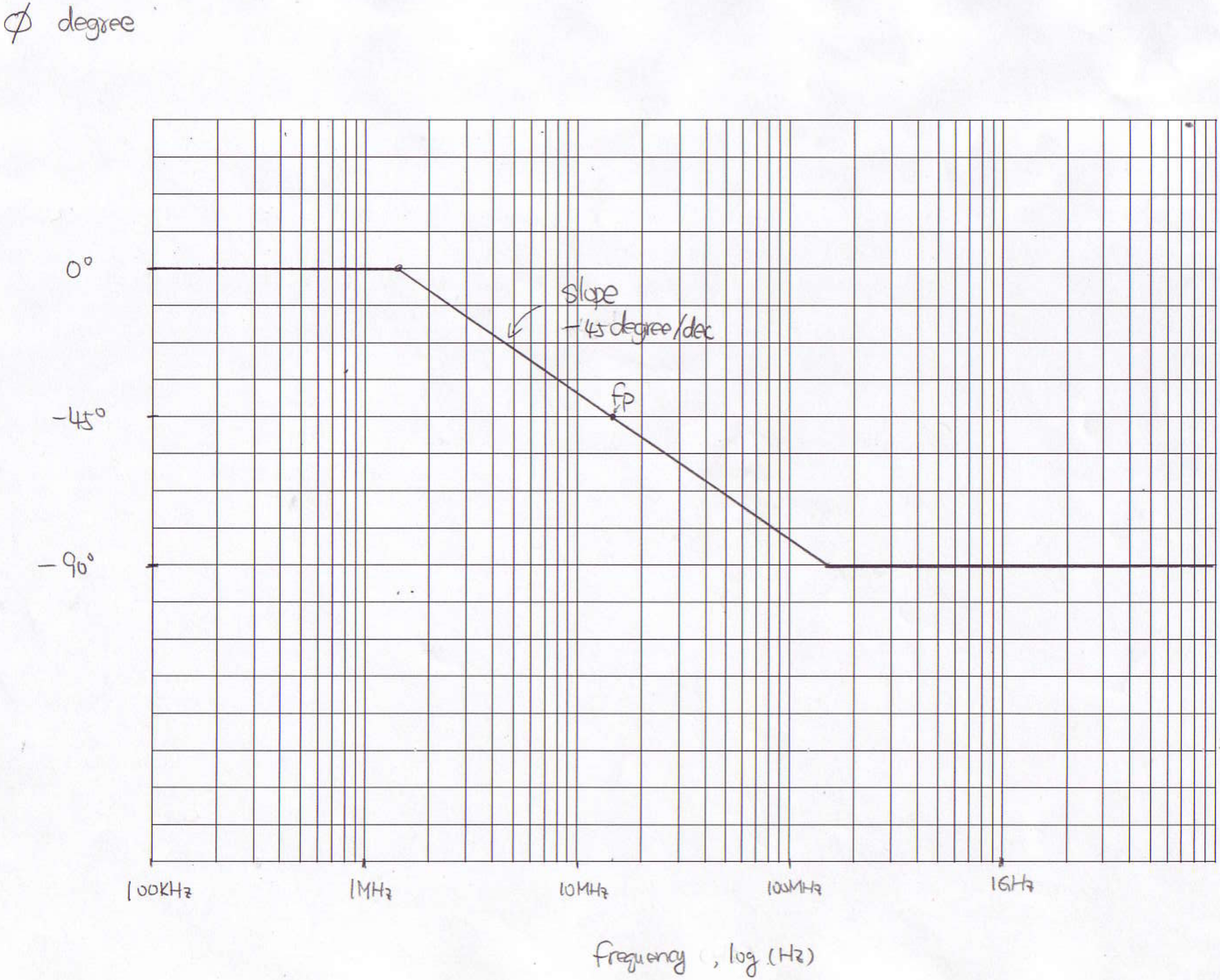
τ (Time constant) = 10 (nsec)


Vin (V)
10⁻¹
t(nsec)
10
20


10nsec
10⁻¹
t(nsec)
10
20



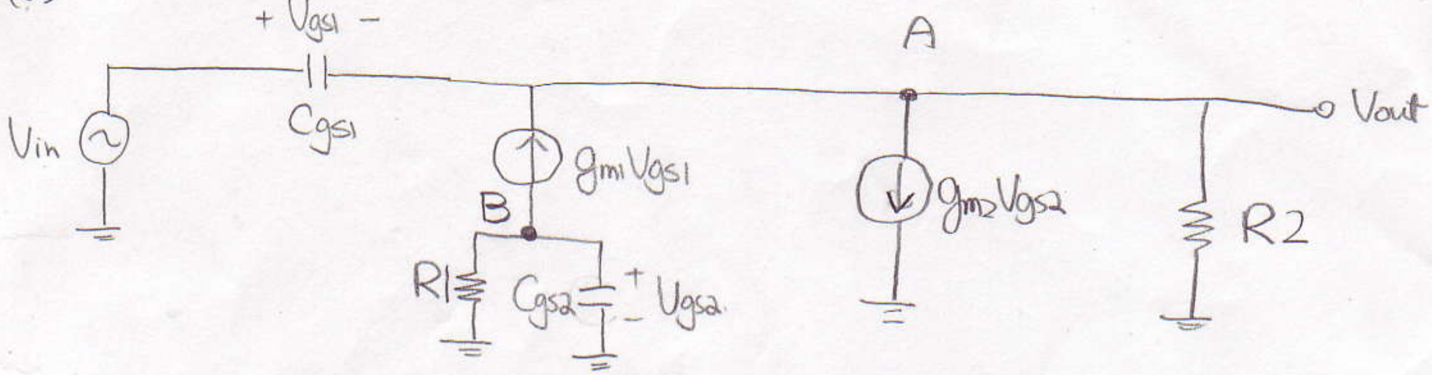
$\left|\frac{V_{out}}{V_{in}}\right|$ dB
20dB
0dB
-20dB
-40dB
f_p
slope
-20dB/dec
100KHz
1MHz
10MHz
$f_p = 15.92$MHz
100MHz
1GHz
frequency, log (Hz)



ϕ degree
0°
-45°
-90°
slope
-45 degree/dec
fp
100KHz
1MHz
10MHz
100MHz
1GHz
frequency, log (Hz)

P5

(a)



(b)

node A : $-g_{m2}V_{gs2} - \frac{V_{out}}{R_2} + g_{m1}V_{gs1} + (V_{in}-V_{out})\cdot SC_{gs1} = 0$

node B : $+g_{m1}V_{gs1} + V_{gs2}SC_{gs2} + \frac{V_{gs2}}{R_1} = 0$

From A.B

$$V_{out} = \left(\frac{g_{m1}g_{m2}R_1R_2}{R_1C_{gs2}S+1} + g_{m1}R_2 + SC_{gs1}R_2 \right) V_{gs1}$$

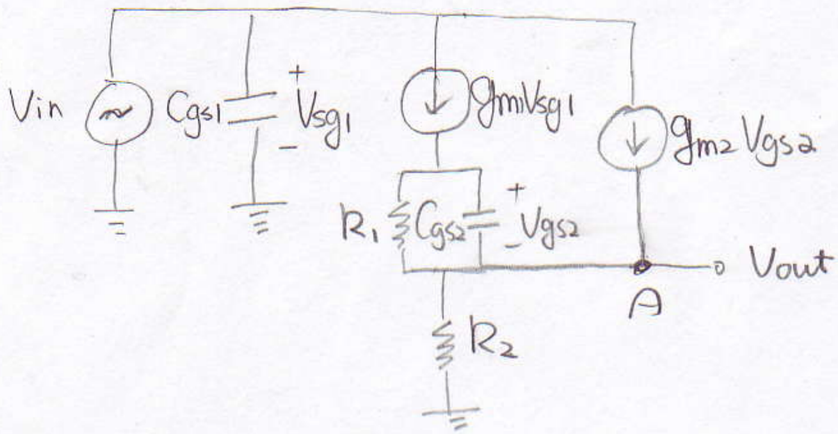
$\because V_{in} - V_{out} = V_{gs1}$

$$\therefore \frac{V_{out}}{V_{in}} = \frac{(g_{m1}g_{m2}R_1R_2+g_{m1}R_2) + S(g_{m1}R_1R_2C_{gs2} + R_2C_{gs1}) + S^2(R_1R_2C_{gs1}C_{gs2})}{(g_{m1}g_{m2}R_1R_2+g_{m1}R_2+1) + S(g_{m1}R_1R_2C_{gs2}+R_2C_{gs1}+R_1C_{gs2}) + S^2(R_1R_2C_{gs1}C_{gs2})}$$

$$= \left(\frac{g_{m1}g_{m2}R_1R_2+g_{m1}R_2}{g_{m1}g_{m2}R_1R_2+g_{m1}R_2+1}\right) \cdot \frac{1 + S\left(\frac{g_{m1}R_1R_2C_{gs2}+R_2C_{gs1}}{g_{m1}g_{m2}R_1R_2+g_{m1}R_2}\right) + S^2\left(\frac{R_1R_2C_{gs1}C_{gs2}}{g_{m1}g_{m2}R_1R_2+g_{m1}R_2}\right)}{1 + S\left(\frac{g_{m1}R_1R_2C_{gs2}+R_2C_{gs1}+R_1C_{gs2}}{g_{m1}g_{m2}R_1R_2+g_{m1}R_2+1}\right) + S^2\left(\frac{R_1R_2C_{gs1}C_{gs2}}{g_{m1}g_{m2}R_1R_2+g_{m1}R_2+1}\right)}$$

P6

(a)



(b)

node A: $-\dfrac{V_{out}}{R_2} + g_{m2}V_{gs2} + g_{m1}V_{sg1} = 0$

and $V_{in} = V_{sg1}$, $V_{gs2} = g_{m1}V_{sg1} \cdot \left(R_1 // \dfrac{1}{SC_{gs2}}\right)$

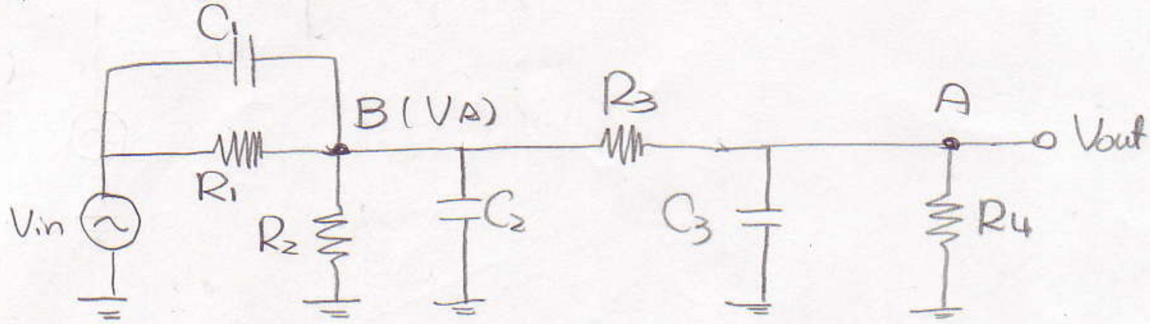
We can get the following expression.

$$\frac{V_{out}}{V_{in}} = \left(g_{m2}g_{m1}\left(R_1 // \frac{1}{SC_{gs2}}\right) + g_{m1}\right) \cdot R_2$$

$$= \frac{(g_{m1}g_{m2}R_1R_2 + g_{m1}) + S(g_{m1}C_{gs2}R_1)}{1 + SC_{gs2}R_1}$$

$$= (g_{m1}g_{m2}R_1R_2 + g_{m1}) \cdot \frac{1 + S\left(\dfrac{g_{m1}C_{gs2}R_1}{g_{m1}g_{m2}R_1R_2 + g_{m1}}\right)}{1 + S(C_{gs2}R_1)}$$

P17



node A : $\dfrac{V_{out} - V_A}{R_3} + \dfrac{V_{out}}{R_4 // \frac{1}{sC_3}} = 0$

node B : $\dfrac{V_A - V_{in}}{R_1 // \frac{1}{sC_1}} + \dfrac{V_A}{R_2 // \frac{1}{sC_2}} + \dfrac{V_A - V_{out}}{R_3} = 0$

From A, $V_A = \left(1 + \dfrac{R_3}{R_4 // \frac{1}{sC_3}}\right) V_{out} = \dfrac{s(36\times10^{-6})(sec) + 7}{6} V_{out}$

From B, $\dfrac{V_{in}}{R_1 // \frac{1}{sC_1}} = V_A \left(\dfrac{1}{R_3} + \dfrac{1}{R_2 // \frac{1}{sC_2}} + \dfrac{1}{R_1 // \frac{1}{sC_1}} \right) - \dfrac{V_{out}}{R_3}$

$$= V_A \cdot \left(\frac{(R_1R_2 + R_1R_3 + R_2R_3) + s(R_1R_2R_3C_2 + R_1R_2R_3C_1)}{R_1R_2R_3} \right)$$

$$- \frac{1}{R_3} V_{out}$$

$$= \left\{ \frac{s(36\times10^{-6})(sec) + 7}{6} \cdot (2\times10^{-3} + s(6)(nsec)) - 10^{-3} \right\} V_{out}$$

$$\therefore \frac{V_{out}}{V_{in}} = R_1 // \frac{1}{sC_1} \cdot \left\{ \frac{36\times10^{-6}s + 7}{6} \cdot (2\times10^{-3} + 6\times10^{-9}s) - 10^{-3} \right\}$$

$$= \frac{8}{3} \cdot \frac{1 + s(7.125)(\mu sec) + s^2(13.5)(\mu sec^2)}{1 + s(4)(\mu sec)}$$