**Home Work Bode plot**

1. วงวาดกราฟโบเดตามสมการต่อไปนี้

(ก) $T(s) = \dfrac{10(s+1)}{(s+10)(s+100)}$

(ข) $T(s) = \dfrac{10s}{(s+10)^2(s+100)}$

(ค) $T(s) = \dfrac{100(1+s)}{(1+s/10)(1+s/100)}$

(ง) $T(s) = \dfrac{10^8(s+10)}{s^2+10,100s+10^6}$

(จ) $T(s) = \dfrac{s}{s+100}$

(ฉ) $T(s) = \dfrac{5}{s/2000+1}$

(ช) $T(s) = \dfrac{200(s+10)}{s+1000}$

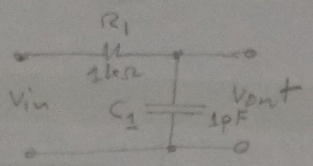
7.xx ให้วาดกราฟผลการตอบสนองความถี่ของสมการฟังก์ชันถ่ายโอน และหาค่าความถี่คัทออฟ

(ก) $T(s) = \dfrac{10(S+10)(s+100)}{(S+1)(s+10^3)}$

(ข) $T(s) = \dfrac{8s^2}{(0.2s+1)^2}$

Exam of frequency response

1




So, $C_1 \Rightarrow \frac{1}{sC_1}$, $R_1 = R_1$,

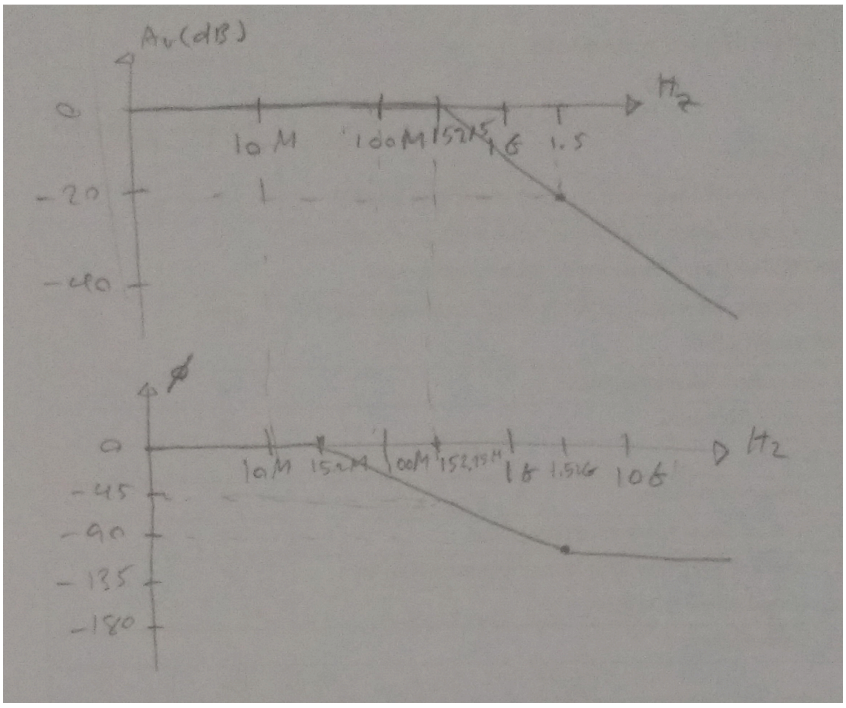
$$V_{out} = \frac{\frac{1}{sC_1}}{R_1 + \frac{1}{sC_1}} V_{in}$$

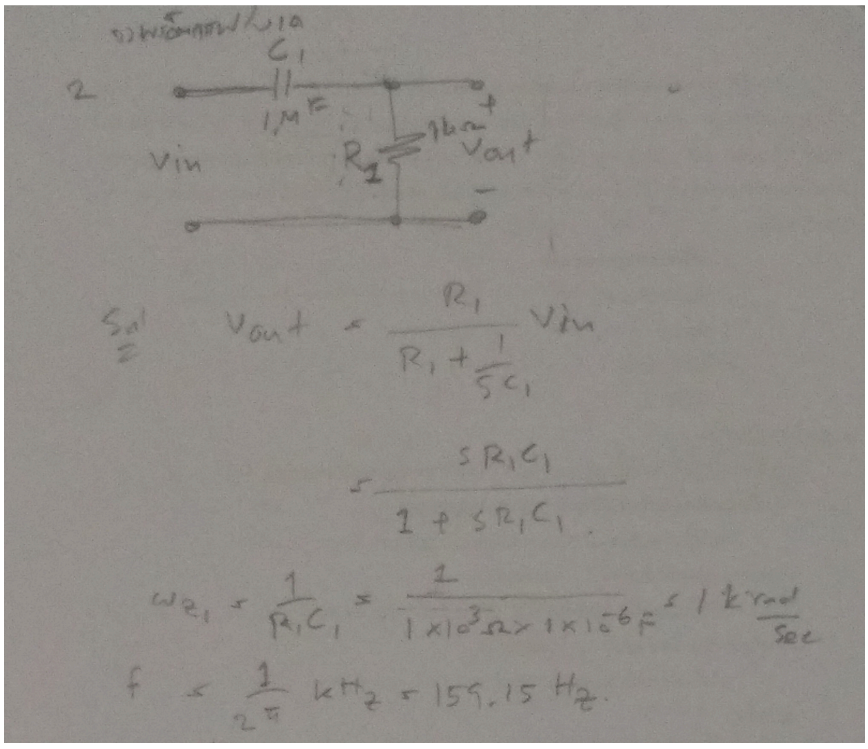
$$\frac{V_{out}}{V_{in}} = \frac{1}{1 + sR_1C_1} = \frac{1}{1 + \frac{s}{\omega_{p1}}}$$

$$\omega_{p1} = \frac{1}{R_1C_1} = \frac{1}{1 \times 10^3 \Omega \times 1 \times 10^{-12} F}$$

$$= 1 \text{ Grad/s}$$

$$f = \frac{1}{2\pi} GHz = 159.15 MHz.$$



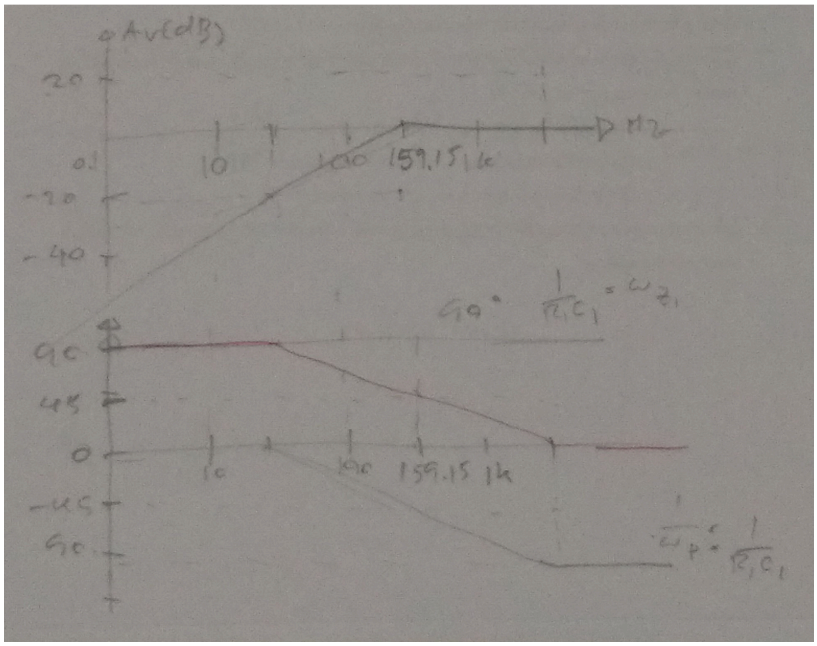

Sol

$$V_{out} = \frac{R_1}{R_1 + \frac{1}{sC_1}} V_{in}$$

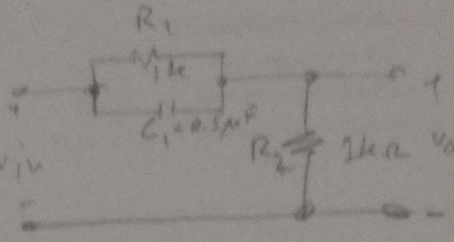
$$= \frac{sR_1C_1}{1 + sR_1C_1}$$

$$\omega_{z_1} = \frac{1}{R_1C_1} = \frac{1}{1\times10^{3}\Omega \times 1\times10^{-6}F} = 1\ k\frac{rad}{sec}$$

$$f = \frac{1}{2\pi}\ kH_z = 159.15\ H_z.$$


Av(dB)
20
0.1
-20
-40
10
100
159.15
Hz
90°
$\frac{1}{R_1C_1} = \omega_{z_1}$
90
45
0
-45
-90
10
100
159.15
1k
$\omega_p = \frac{1}{R_1C_1}$

3




Sol

$$Z_1 = R_1 \parallel \frac{1}{sC_1} = \frac{R_1}{1+sR_1C_1}, \quad Z_2 = R_2$$

$$V_{out} = \frac{\frac{R_2 V_{in}}{R_2 + \frac{R_1}{1+sR_1C_1}}}{} = \frac{R_2(1+sR_1C_1)V_{in}}{R_1 + R_2 + sR_1R_2C_1}$$

$$\frac{V_{out}}{V_{in}} = \frac{R_2}{R_1+R_2} \times \frac{(1+sR_1C_1)}{1+s\frac{R_1R_2}{R_1+R_2}C_1}$$

$$K = \frac{R_2}{R_1+R_2} = 0.5, \quad \omega_{P_1} = \frac{R_1+R_2}{R_1R_2C_1}$$

$$\omega_{P_1} = \frac{2K}{1K \times 0.5\mu F} = 4\times10^3 \text{ rad/s}$$

$$f_P = \frac{4\times10^3}{2\pi} Hz = \frac{7}{22}\times10^3 Hz =$$

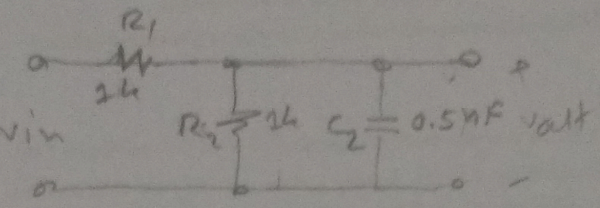
$$\omega_{Z_1} = \frac{1}{R_1C_1} = 2\times10^3 \text{ rad/s}$$

$$f_Z = \frac{7}{11}\times10^3 Hz =$$

$20\log K = 20\log 0.5$

$= -6 dB$

4




Sol $R_1 = R_1 \quad R_2 = R_2 // \frac{1}{sC_2} = \frac{R_2}{1+sR_2C_2}$

$$V_{out} = \frac{R_2 V_{in}}{1+sR_2C_2} \Big/ \left(R_1 + \frac{R_2}{1+sR_2C_2}\right)$$

$$= \frac{R_2 V_{in}}{R_1 + R_2 + sR_1R_2C_2}$$

$$\frac{V_{out}}{V_{in}} = \frac{R_2}{R_1+R_2} \times \frac{1}{1+s\frac{R_1R_2C_2}{R_1+R_2}}$$

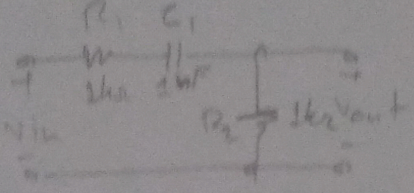
$K = 0.5 \qquad \omega_{p_1} = \frac{R_1+R_2}{R_1R_2C_2} = \frac{2k}{1k\times 0.5\,nF}$

$20\log 0.5 = \_\_\_ dB$

$\omega_{p_1} = 4\times10^6$ rads/s

$f_{p_1} = \frac{7}{11}\times10^6$ Hz

5




$C_{in}$

$Z_1 \quad Z_1 = R_1 + \frac{1}{SC_1} = \frac{1+SR_1C_1}{SC_1} \quad ; \quad R_2 = R_2$

$$V_{out} = \frac{R_2 V_{in}}{R_2 + \frac{1+SR_1C_1}{SC_1}} = \frac{SR_2C_1 \times V_{in}}{1+SR_2C_1+SR_1C_2}$$

$$\frac{V_{out}}{V_{in}} = \frac{SR_1C_1}{1+S(R_1+R_2)C_1}$$

$$\omega_{z1} = \frac{1}{R_1C_1} = \frac{1}{2k\Omega \times 1nF} = \frac{1\,M\,rad/sec}{1}$$

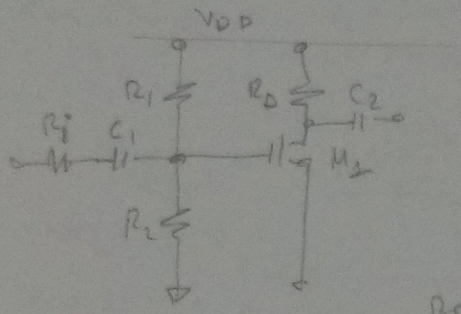
$$f_{z1} = \frac{1}{2\pi} \times 10^6\ Hz$$

$$\omega_{p1} = \frac{1}{(R_1+R_2)C_1} = \frac{1}{2k\Omega \times 1nF} = 0.5\,M\,\frac{rad}{sec}$$

$$F = \frac{1}{4\pi} \times 10^6\ Hz$$

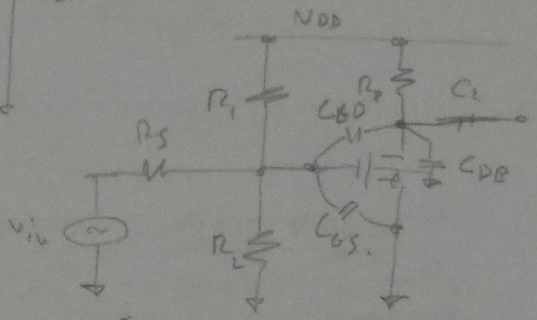
Frequency response

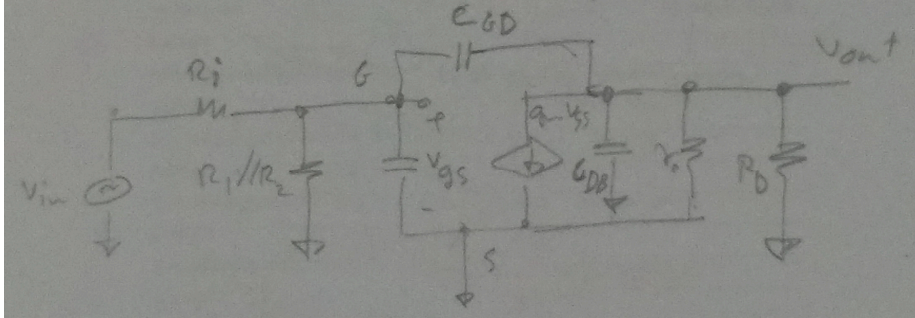
Common source : CS

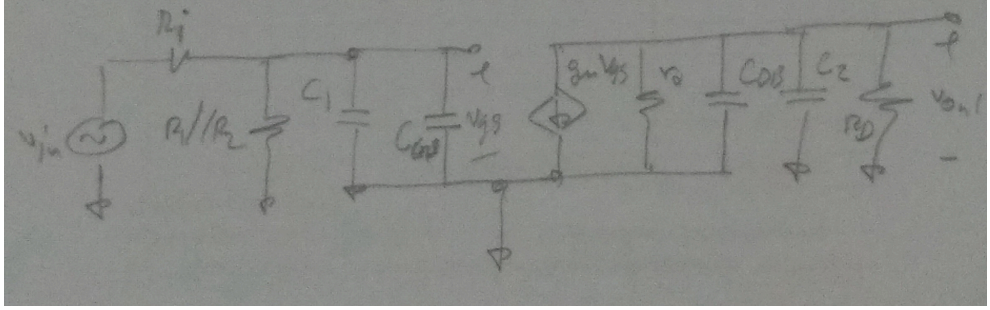



$A_v = g_{m1}(r_o // R_D)$

$C_1 = C_2 \geq 1\mu F$



$C_{T1} = C_1 + C_{GS}$ , $C_{T2} = C_{DB} + C_2$.

$R_{T1} = R_1 // R_2$ , $R_{T2} = r_o // R_D$.

$$R_{T1} // \frac{1}{sC_{T1}} = \frac{R_{T1}}{1 + sC_{T1}R_{T1}}$$

$$R_{T2} // \frac{1}{sC_{T2}} = \frac{R_{T2}}{1 + sC_{T2}R_{T2}}$$

$$V_{out}(s) = \frac{-g_{m1} R_{T2} V_{gs}(s)}{1 + sC_{T2}R_{T2}}$$

$$V_{gs}(s) = \frac{\frac{R_{T1} \times V_{in}(s)}{1 + sC_{T1}R_{T1}}}{\frac{R_{T1} \times V_{in}(s)}{1 + sC_{T1}R_{T1}} + R_i}$$

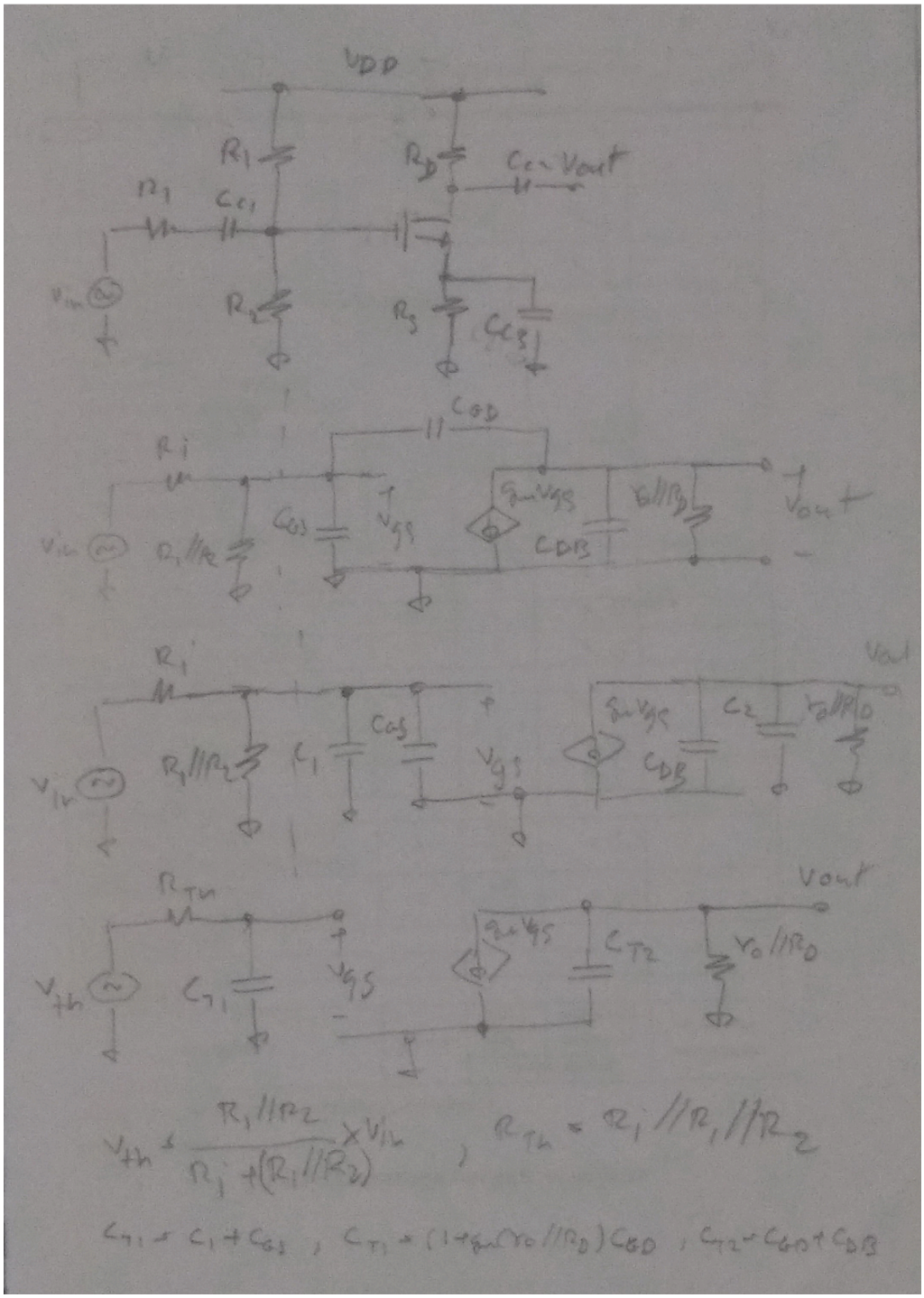
$$= \frac{R_{T1} V_{in}(s)}{(1 + sC_{T1}R_{T1})R_i + R_{T1}}$$

$$= \frac{R_{T1} V_{in}(s)}{R_{T1} + R_i + sC_{T1}R_{T1}R_i}$$

$$= \frac{R_{T1}}{R_{T1} + R_i} \times \frac{V_{in}(s)}{1 + sC_{T1}\frac{R_{T1}R_i}{R_{T1} + R_i}}$$

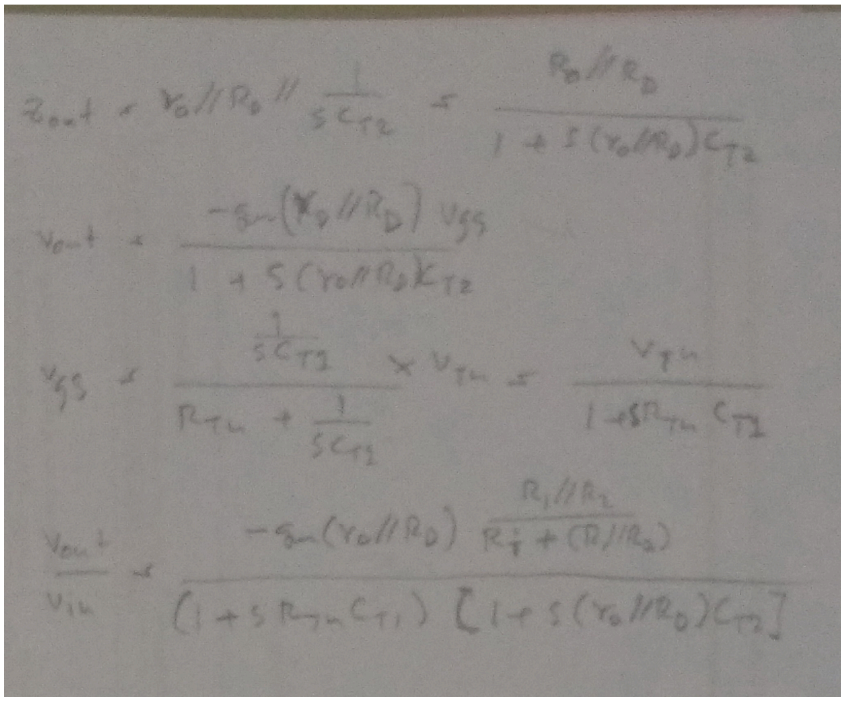
$$= \frac{R_{T1} V_{in}(s)}{(R_{T1} + R_i)[1 + sC_{T1}(R_{T1} // R_i)]}$$

$$\frac{V_{out}}{V_{in}}(s) = \frac{-g_{m1} R_{T1} R_{T2} // (R_{T1} + R_i)}{[1 + sC_{T1}(R_{T1} // R_i)](1 + sC_{T2}R_{T2})}$$

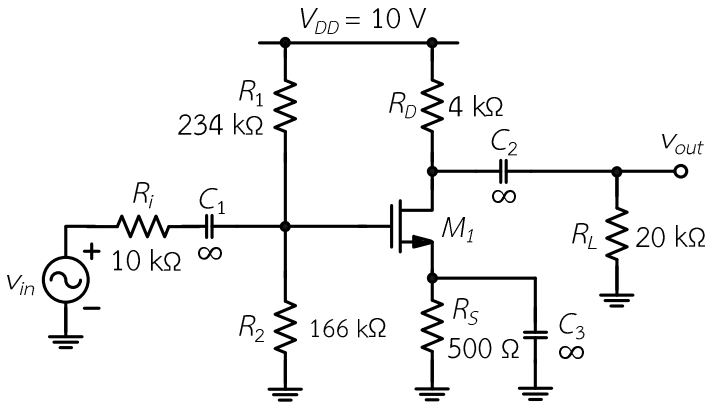



$$V_{th} = \frac{R_1 // R_2}{R_i + (R_1 // R_2)} \times V_{in} \quad , \quad R_{TH} = R_i // R_1 // R_2$$

$C_{T1} = C_1 + C_{GS}$ , $C_{T1} = (1 + g_m (r_o // R_D)) C_{GD}$ , $C_{T2} = C_{GD} + C_{DB}$



**แบบฝึกหัดที่ 7.12** รูปที่ 7.55 แสดงวงจรขยาย กำหนดให้มอสเฟต n-channel มีค่า $K_n$ = 0.8 mA/V$^2$, $V_{TN}$ = 2 V, $\lambda$ = 0, $C_{gd}$ = 20 fF และ $C_{gs}$ = 100 fF (ก) จงหาอัตราขยายที่ย่านความถี่กลาง (ข) จงหาค่าความความจุมิลเลอร์ (ค) ความถี่คัทออฟ (**ตอบ** (ก) $A_v$ = -6.69 (ข) $C_M$ = 167.6 fF และ (ค) $f_{-3dB}$ = 1.32 GHz)




**รูปที่ 7.55** วงจรในแบบฝึกหัดที่ 7.12

**แบบฝึกหัดที่ 7.10** กำหนดให้มอสเฟต n-channel มีค่าแบนวิดธ์ที่อัตราขยายเท่ากับหนึ่งของมอสเฟต $f_T$ = 1.2 GHz ค่า $C_{gsp}$ = $C_{gdp}$ = 3 fF และสมมุติให้ $K_n$ = 1.5 mA/V$^2$ และ $V_{TN}$ = 0.4 V ถ้ากระแส $I_{DQ}$ = 100 μA จงหาค่าความจุของตัวเก็บประจุ $C_{gs}$ สมมุติให้ $C_{gd}$ = 0 จงที่น้อยสุดที่ทำให้ (**ตอบ** $C_{gs}$ = 66.6 fF)

**แบบฝึกหัดที่ 7.11** กำหนดให้มอสเฟต n-channel มีค่า $g_m$ = 1.2 mA/V ค่าความจุตัวเก็บประจุ $C_{gs}$ = 60 fF, $C_{gd}$ = 0 และ $C_{gsp} = C_{gdp}$ จงหาค่าความจุของตัวเก็บประจุ $C_{gsp} = C_{gdp}$ ที่น้อยสุดที่ทำให้ค่าแบนวิดธ์ที่อัตราขยายเท่ากับหนึ่งของมอสเฟต $f_T$ = 2.5 GHz (**ตอบ** $C_{gsp} = C_{gdp}$ = 8.2 fF)