電工期末 E14082181 蘇品瑄

1、 $Z_{R1} = R_1 = 600\Omega$, $Z_{R2} = 300\Omega$, $Z_L = j\omega L = j \times 2000 \times (400\times10^{-3}) = 800j$

$$Z_c = \frac{1}{j\omega C} = -j \times \frac{1}{2000\times(90\times10^{-7})} = -5555.56j$$

$$Z_{eq} = Z_{R1} \parallel (Z_{R2} + Z_L) \parallel Z_c$$

$$= \frac{600\times(300+800j)}{600+(300+800j)} \parallel Z_c = (376.55+198.62j) \parallel Z_c$$

$$= \frac{(376.55+198.62j)\times(-5555.56j)}{(376.55+198.62j)+(-5555.56j)} = 403+177.66j = 440 \angle 23.79^\circ$$ #

2、
$$\frac{V_{out}}{V_{in}} = \frac{\frac{R_2R_3}{R_2+R_3} + Z_L + Z_{c_1+c_2}}{R_1 + \frac{R_2R_3}{R_2+R_3} + Z_L + Z_{c_1+c_2}} = \frac{\left(\frac{600^2}{1200} + 4j\omega + \frac{1}{2\times10^{-4}j\omega}\right)\times 1200\times10^{-4}j\omega}{\left(400+\frac{600^2}{1200}+4j\omega+\frac{1}{2\times10^{-4}j\omega}\right)\times1200\times10^{-4}j\omega}$$

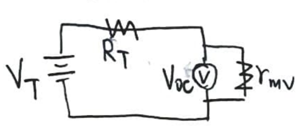
$[C_1 + C_2 = (40+160)\times10^{-6} = 2\times10^{-4}]$

$$= \frac{36j\omega - 0.48\omega^2 + 600}{48j\omega + 36j\omega - 0.48\omega^2 + 600} = \frac{(-0.48\omega^2+600)+j(36\omega)}{(-0.48\omega^2+600)+j(84\omega)}$$ #

3、
$$\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{0.5\times0.1}} = 4.472\ \text{rad/s}$$ #

$$B = \frac{\omega_0}{Q} = \omega_0^2 RC = \frac{R\cancel{C}}{L\cancel{C}} = \frac{4}{0.5} = 8\ \text{rad/s}$$ #

4、① Thevénin

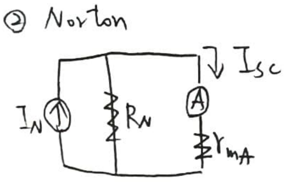


$$V_{oc} = V_T \times \frac{r_{mv}}{R_T + r_{mv}}$$

$$\Rightarrow V_T = V_{oc} \times \frac{R_T + r_{mv}}{r_{mv}} = V_{oc}\left(1 + \frac{R_T}{r_{mv}}\right)$$ #

when $r_{mv} \to 0$, $V_T = V_{oc}$

② Norton



$$I_{sc} = I_N \times \frac{R_N}{R_N + r_{mA}}$$

$$\Rightarrow I_N = I_{sc} \times \frac{R_N + r_{mA}}{R_N} = I_{sc}\left(1 + \frac{r_{mA}}{R_N}\right)$$ #

when $r_{mA} \to 0$, $I_N = I_{sc}$

5、(a) $k x_o + B\frac{dx_o}{dt} = M\frac{d^2x_m}{dt^2} = M\left(\frac{d^2x_i}{dt^2} - \frac{d^2x_o}{dt^2}\right)$

(b) $\begin{cases} X_i(j\omega) = |X_i|\, e^{j(\phi_i+\omega t)} \\ X_o(j\omega) = |X_o|\, e^{j(\phi_o+\omega t)} \end{cases}$

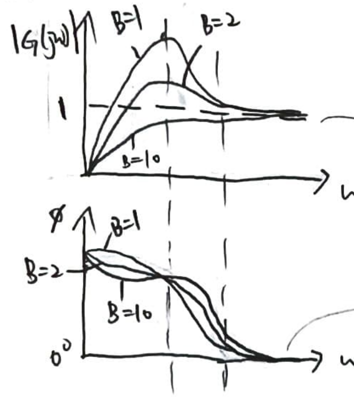
$$k|X_o|e^{j(\phi_o+\omega t)} + B|X_o|e^{j(\phi_o+\omega t)}(j\omega) = M\left[(j\omega)^2|X_i|e^{j(\phi_i+\omega t)} - (j\omega)^2|X_o|e^{j(\phi_o+\omega t)}\right]$$

$$\Rightarrow k X_o(j\omega) + B(j\omega)X_o(j\omega) = M(j\omega)^2[X_i(j\omega) - X_o(j\omega)]$$

$$\Rightarrow (-\omega^2M + j\omega B + k)X_o(j\omega) = -\omega^2 M X_i(j\omega)$$

$$\Rightarrow G(j\omega) = \frac{X_o(j\omega)}{X_i(j\omega)} = \frac{-\omega^2M}{-\omega^2M + j\omega B + k}$$

(c)

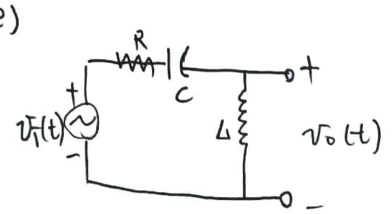


(d) if $G(j\omega)=\dfrac{X_o(j\omega)}{X_i(j\omega)}=1 \Rightarrow X_o(j\omega)=X_i(j\omega)$

$=\underbrace{|G|}_{1}\, e^{j\underset{0^\circ}{\phi}}=1$

高頻時, $|G|=1$, $\phi=0^\circ$, $G(j\omega)$才等於1

(e)



$$\frac{V_o(j\omega)}{V_i(j\omega)}=\frac{j\omega L}{j\omega L+R+\frac{1}{j\omega C}}=\frac{-\omega^2 L}{-\omega^2 L+j\omega R+\frac{1}{C}}$$

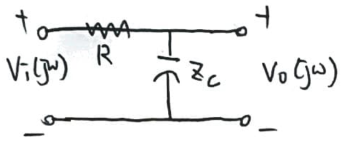
$$\frac{X_o(j\omega)}{X_i(j\omega)}=\frac{-\omega^2 M}{-\omega^2 M+j\omega B+k}$$

$M \leftrightarrow L$

$B \leftrightarrow R$

$k \leftrightarrow 1/C$

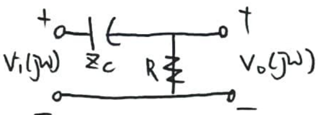
7、① low-pass filter



low ω ⇒ C斷路 ⇒ 過

high ω ⇒ C短路 ⇒ 擋

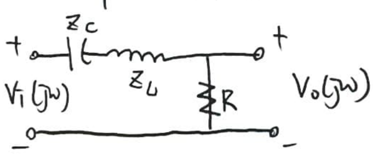
② high-pass filter



low ω ⇒ C斷路 ⇒ 擋

high ω ⇒ C短路 ⇒ 過

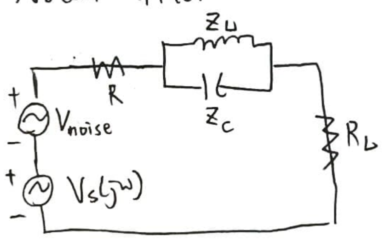
③ Band-pass filter



low ω ⇒ {C斷路, L短路} ⇒ 擋

high ω ⇒ {C短路, L斷路} ⇒ 擋

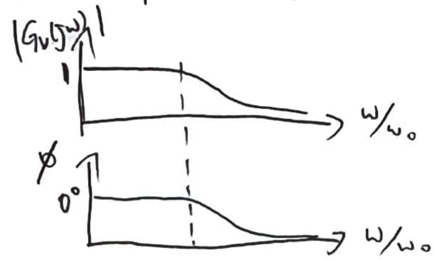
④ Notch filter



low ω ⇒ {C斷路, L短路} ⇒ 過

high ω ⇒ {C短路, L斷路} ⇒ 過

8. ① law- pass filter

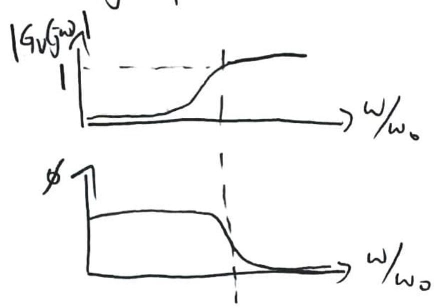


$|G_v|$ must be 1

low $w \Rightarrow \phi$ must be $0°$, so that there won't have noise in $|G_v(jw)|$.

high $w \Rightarrow \phi$ can be any number, because $|G_v(jw)|$ would be zero.

② high- pass filter

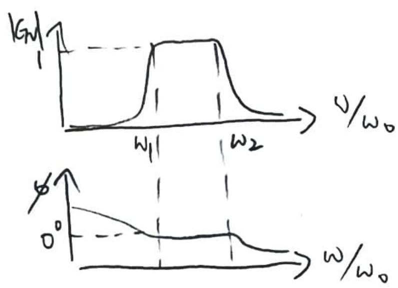


low $w \Rightarrow \phi$ can be any number, because $|G_v(jw)|$ would be zero.

high $w \Rightarrow \phi$ must be $0°$, so that there won't have noise in $|G_v(jw)|$.

$|G_v|$ must be 1

③ Band - pass filter

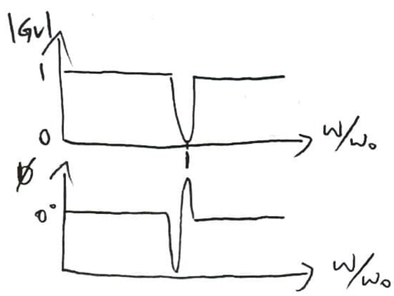


$|G_v|$ must be 1

$w_1 < w < w_2 \Rightarrow \phi$ must be $0°$, so that there won't have noise in $|G_v|$.

$w < w_1$
$w > w_2$ $\Rightarrow \phi$ can be any number, because $|G_v(jw)|$ would be zero.

④ Notch filter

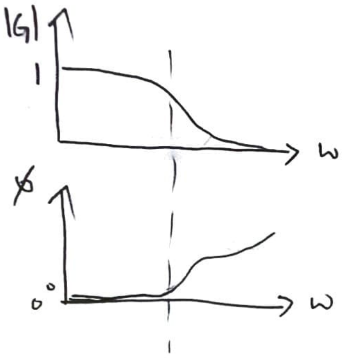


$w = w_0 \Rightarrow \phi$ can be any number, because $|G_v|$ would be zero.

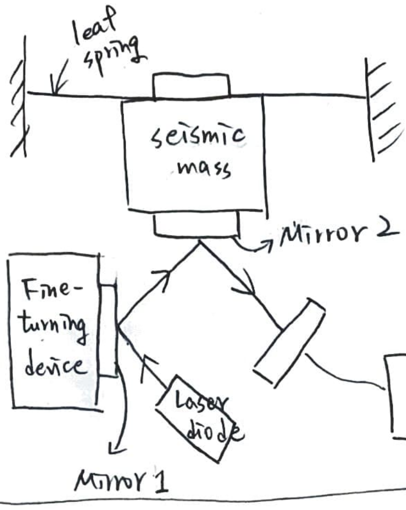
$w \neq w_0 \Rightarrow \phi$ must be $0°$, so that there won't have noise in $|G_v|$.

$|G_v|$ must be 1

6、



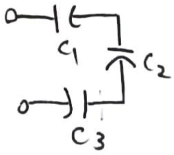
低頻時，$|G|=1$，$\phi=0^\circ$，$G(j\omega)$ 才等於 1



The schematic of an optical accelerometer

When vibration occurs, the leaf spring undergoes elastic deformation, and the seismic mass moves up and down. The position of the projected light spot on the four-quadrant photodetector then shifts.

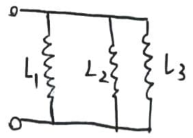
9. ①



$$v_{eq} = v_1 + v_2 + v_3 = \frac{q}{c_1} + \frac{q}{c_2} + \frac{q}{c_3} = \frac{q}{C_{eq}}$$

$$\Rightarrow C_{eq} = \frac{1}{1/c_1 + 1/c_2 + 1/c_3} \#$$

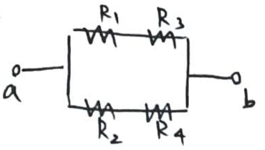
②



$$q_{eq} = q_1 + q_2 + q_3 = \frac{v}{L_1} + \frac{v}{L_2} + \frac{v}{L_3} = \frac{v}{L_{eq}}$$

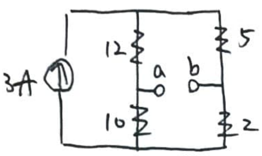
$$\Rightarrow L_{eq} = \frac{1}{1/L_1 + 1/L_2 + 1/L_3} \#$$

11.



$$R_T = R_N = (\underset{12}{R_1} + \underset{5}{R_3})^{17} \parallel (\underset{10}{R_2} + \underset{2}{R_4})^{12} = \frac{17 \times 12}{17 + 12} = 7.03\ \Omega \#$$

① Thevénin

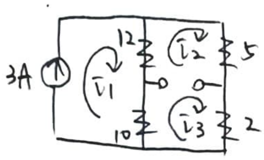


$$V_T = V_a - V_b = I_a R_a - I_b R_b$$

$$= 3 \times \frac{5+2}{(12+10)+(5+2)} \times 10 - 3 \times \frac{(12+10)}{(12+10)+(5+2)} \times 2$$

$$= 2.69\,V \#$$

② Norton



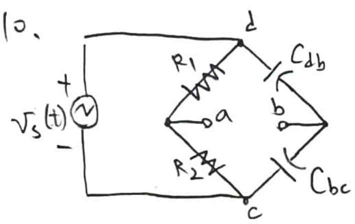
$$i_1 = 3$$

$$5 i_2 + 12(i_2 - i_1) = 0 \Rightarrow 17 i_2 = 36 \Rightarrow i_2 = \frac{36}{17}$$

$$2 i_3 + 10(i_3 - i_1) = 0 \Rightarrow 12 i_3 = 30 \Rightarrow i_3 = \frac{30}{12} = 2.5$$

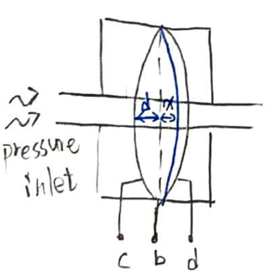
$$I_N = i_3 - i_2 = 2.5 - \frac{36}{17} = 0.38\,A \#$$

10.

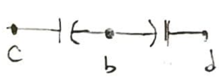


$$V_{ab}(jw) = V_s(jw)\left(\frac{Z_{C_{bc}}}{Z_{C_{db}} + Z_{C_{bc}}} - \frac{R_2}{R_1 + R_2}\right)$$

$$C = \frac{\varepsilon A}{d} \Rightarrow \begin{cases} C_{db} = \dfrac{\varepsilon A}{d - x} \\ C_{bc} = \dfrac{\varepsilon A}{d + x} \end{cases} \quad (\varepsilon = 8.854)$$



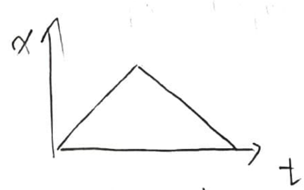
$$\Rightarrow \begin{cases} Z_{C_{db}} = \dfrac{1}{jwc} = \dfrac{d - x}{jw\, 8.854 A} \\ Z_{C_{bc}} = \dfrac{1}{jwc} = \dfrac{d + x}{jw\, 8.854 A} \end{cases}$$



$$V_{ab}(jw) = V_s(jw)\left(\frac{d + x}{2d} - \frac{R_2}{R_1 + R_2}\right)$$

If $R_1 = R_2$, $V_{ab}(jw) = V_s(jw)\left(\frac{x}{2d}\right)$

$$V_{ab}(t) = V_s(t)\left(\frac{x}{2d}\right)$$



displacement input