2.3

(1) $-5V \le V_o \le 15V$

$$\begin{cases} \dfrac{V_b - V}{5\times10^3} = \dfrac{V-0}{25\times10^3} \\ \dfrac{V_a - V}{12\times10^3} = \dfrac{V-V_o}{60\times10^3} \end{cases}$$

$\therefore V_o = 20 - 5V_a$

$\therefore -15 \le 20 - 5V_a \le 15$

$\therefore 1V \le V_a \le 7V$

2.7

$I_1 = I_2$

$\dfrac{R_s(I_s - I_1) - V_1}{R_2} = I_1$

$\dfrac{V_1 - V_o}{R_f} = I_2$

$\therefore I_s = I_1 = I_2$

$\therefore V_o = -R_f I_s$

2.8

$\dfrac{V_s - V_n}{R_1} = I_1$, $I_1 = I_2$, $V_n = V_p$, $I_2 = I_3$

$\dfrac{V_n - V_o}{R_f} = I_2$, $\dfrac{V_o - V_p}{R_3} = I_3$, $\dfrac{V_p}{R_2} = I_{RL}$, $\dfrac{V_p}{R_2} = I_4$

$I_3 = I_4 + I_{RL}$

$\because \dfrac{R_f}{R_1 R_3} = \dfrac{1}{R_2}$

$\therefore \dfrac{V_s - V_p}{R_1} = \dfrac{V_p - V_o}{R_f} = \dfrac{V_o - V_p}{R_3}$

$\therefore V_p = V_o = V_s$

$\dfrac{V_s - V_p}{R_1} = \dfrac{V_p}{R_2} + I_{RL}$

$\therefore \dfrac{V_p}{R_2} + I_{RL} = 0$

$\therefore I_{RL} = -\dfrac{V_s}{R_2}$

2.9

$\frac{R_f}{R_1 R_3} = 10^{-3}\,\Omega^{-1}$

$\frac{1}{R_2} = 10^{-3}\,\Omega^{-1}$

$\therefore \frac{R_f}{R_1 R_3} = \frac{1}{R_2}$

$\therefore I_{RL} = -\frac{V_S}{R_2} = \frac{-10}{1\times10^3} = -10^{-2}\,A$

$\therefore I_3 = \frac{I_{RL}\cdot R_L}{R_2} + I_{RL} = -1 + (-10^{-2}) = -1.01\,A$

$\therefore V_0 = I_3 R_3 + V_p = I_3 R_3 + I_{RL} R_L = -2010\,V$

2.12

$$\begin{cases} \frac{V_1 - V_p}{R_a} = \frac{V_p}{R_b} \\ \frac{V_2 - V_n}{R_a} = \frac{V_n - V_0}{R_b} \end{cases}$$

$\therefore V_0 = \frac{R_b}{R_a}(V_1 - V_2) = \frac{R_b}{R_a} V_d$

$\therefore \frac{R_b}{R_a} = 100$

$R_a = R_a,\ R_b = R_b \quad \therefore A_{cm} = 0$

$R_i = R_a + R_a \quad \therefore R_a = 2.5\,k\Omega$

$\therefore R_b = 250\,k\Omega$.

2.16

$$\frac{V_i-V_1}{R_1}=\frac{V_1-V_2}{\frac{1}{sC_1}}+I_2$$

$$\frac{V_1}{(1-\alpha)R_2}=\frac{-V_2}{\alpha R_2}=I_2 \longrightarrow V_1=\frac{\alpha-1}{\alpha}V_2 \rightarrow V_1+V_2=\frac{2\alpha-1}{\alpha}V_2$$

$$\frac{V_i-V_1}{R_1}=\frac{V_2-V_0}{R_1} \longrightarrow V_0=V_1+V_2-V_i$$

$$V_i-V_1=sC_1R_1(V_1-V_2)+\frac{V_1-V_2}{R_2}\cdot R_1$$

$$V_i-\frac{2\alpha-1}{\alpha}V_2=(sC_1R_1+\frac{R_1}{R_2})(V_1-V_2)=(sC_1R_1+\frac{R_1}{R_2})\cdot\frac{-1}{\alpha}V_2$$

$$\therefore V_i=(\frac{\alpha-1}{\alpha}-\frac{sC_1R_1+\frac{R_1}{R_2}}{\alpha})V_2$$

$$\therefore V_i=\frac{2\alpha-1}{\alpha}\cdot\frac{1}{(\frac{\alpha-1}{\alpha}-\frac{sC_1R_1+\frac{R_1}{R_2}}{\alpha})}V_2-V_0$$

$$\therefore V_0=\frac{2\alpha-1}{\alpha-1-sC_1R_1-\frac{R_1}{R_2}}V_2-V_2$$

$$=\frac{\alpha R_2+sC_1R_1R_2+R_1}{(\alpha-1)R_2-sC_1R_1R_2-R_1}V_2$$

$$\therefore \frac{V_0}{V_i}=-\frac{R_1+\alpha R_2+sC_1R_1R_2}{R_1+(1-\alpha)R_2+sC_1R_1R_2}$$

令 $s=j\omega$,

则 $\frac{V_0}{V_i}=-\frac{R_1+\alpha R_2+j\omega C_1R_1R_2}{R_1+(1-\alpha)R_2+j\omega C_1R_1R_2}$.

2.17.

$$\frac{V_i}{R_1} = I_1 + I_2.$$

$$I_1 = \frac{-V_o}{\frac{1}{sC_1}}, \quad I_2 = \frac{-V_o}{R_2 + \frac{1}{sC_2}}$$

$$\therefore \frac{V_i}{R_1} = \frac{-V_o}{\frac{1}{sC_1}} + \frac{-V_o}{R_2 + \frac{1}{sC_2}}$$

$$\therefore H(s) = \frac{V_o}{V_i} = -\frac{sC_2R_2 + 1}{s^2C_1C_2R_1R_2 + s(C_1R_1 + C_2R_1)}.$$