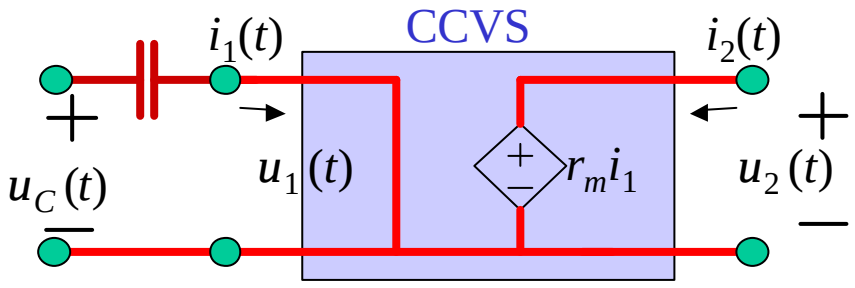
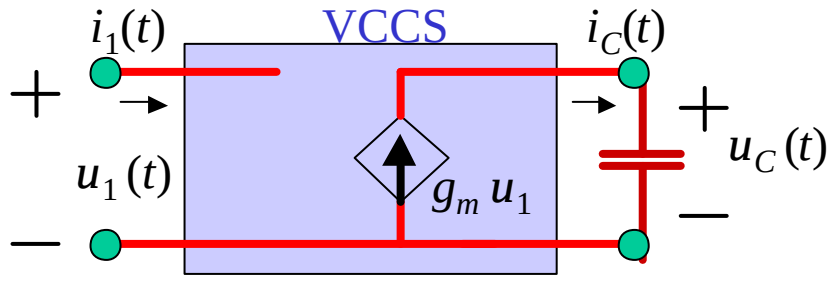
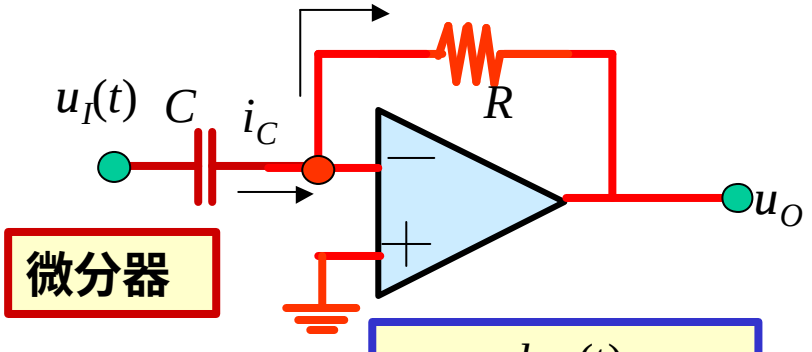
主動式積分器、微分器與濾波器

主動式積分器、微分器

$$i = C\frac{du}{dt} \qquad u = \frac{1}{C}\int_{t_0}^{t} i\,dt + u(t_0)$$





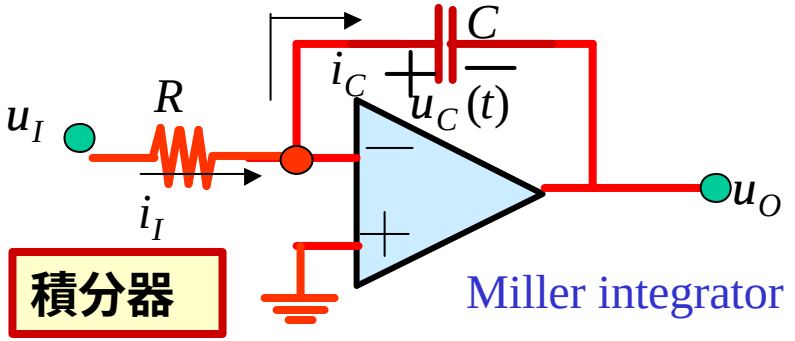


微分器

$$i_C = C\frac{du_I(t)}{dt}$$

$$u_O(t) = -CR\frac{du_I(t)}{dt}$$

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



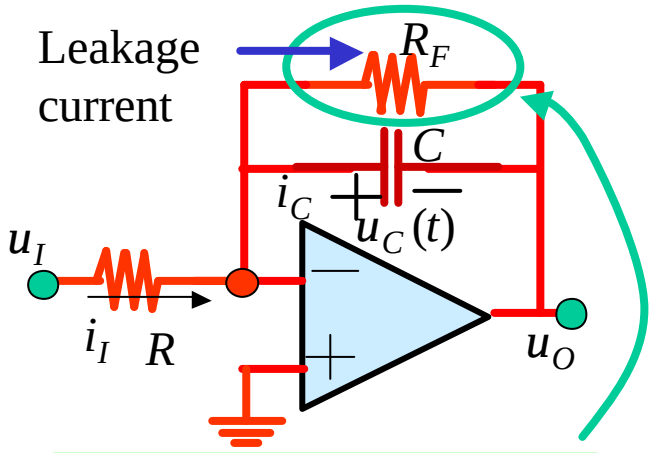
積分器

Miller integrator

$$u_O(t) = -\frac{1}{CR}\int_0^t u_I(t)dt + u_O(0)$$

$$\frac{V_o}{V_i} = -\frac{1}{sCR}$$

有關Miller integrator



通常會加一個大電阻提供DC的回授

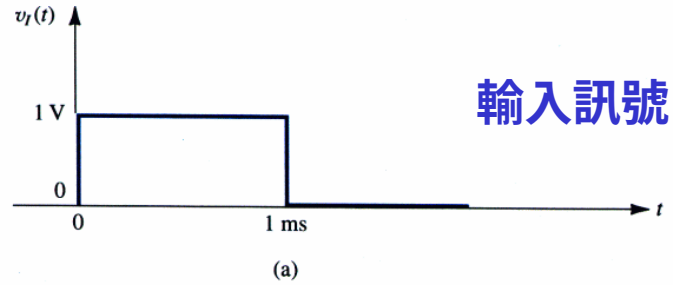
例題

R=10kΩ，C=10nF，R_F=1MΩ

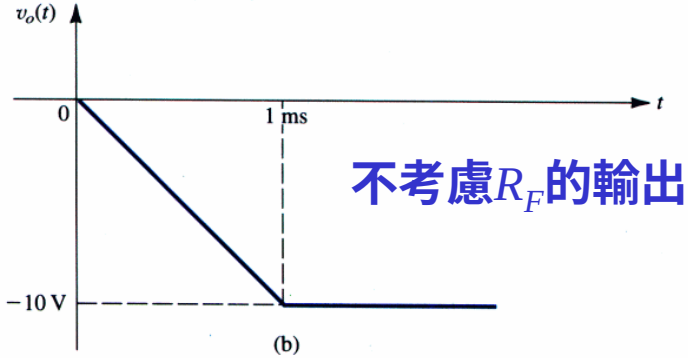
$R_F C$=10ms

Charging current i_I=1V/10kΩ=0.1mA

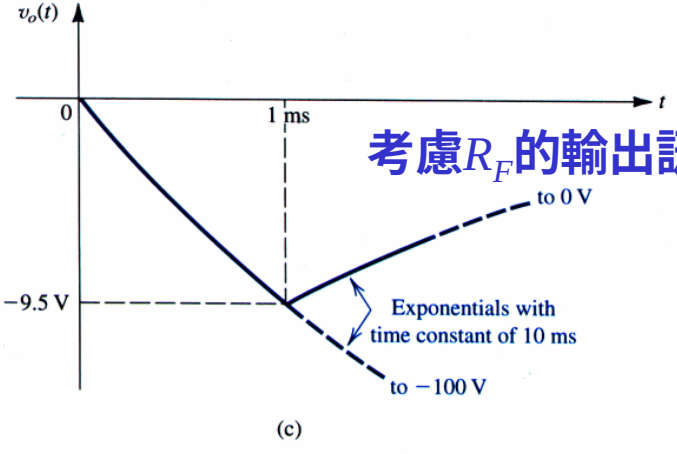
$i_I R_F$=0.1mA ·1MΩ=100V



輸入訊號



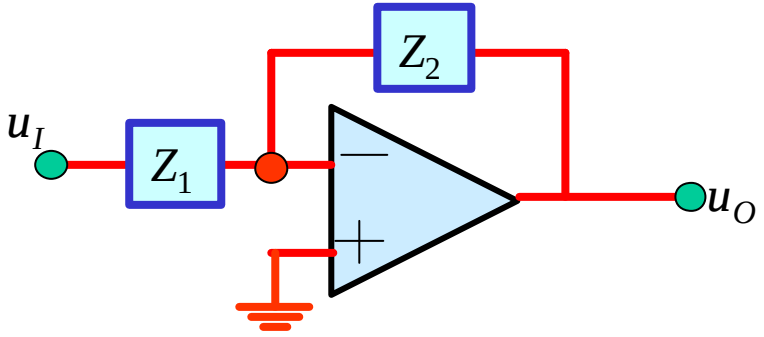
不考慮R_F的輸出訊號



考慮R_F的輸出訊號

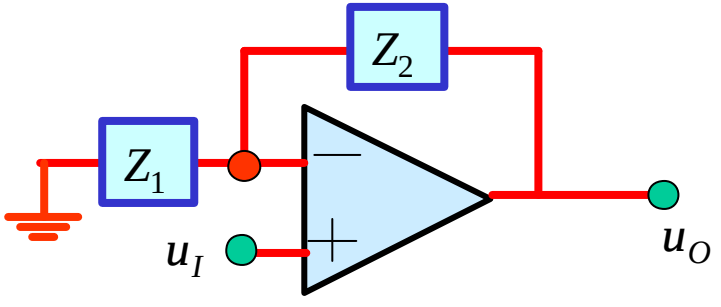
主動式濾波器

簡易主動式濾波器



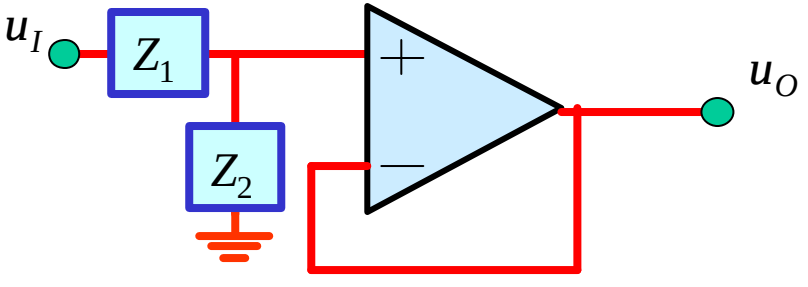
$$\frac{V_o(s)}{V_i(s)} = -\frac{Z_2(s)}{Z_1(s)}$$

Inverting configuration



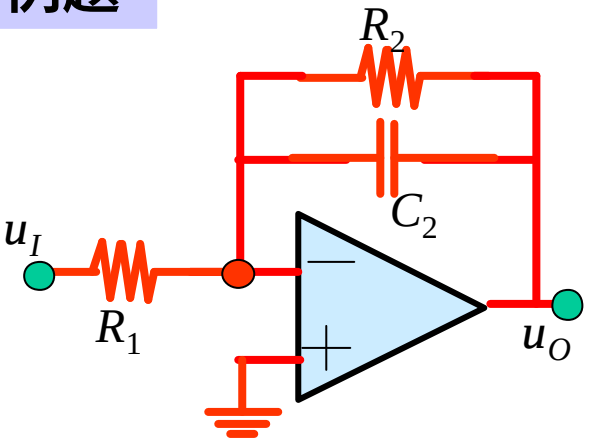
$$\frac{V_o(s)}{V_i(s)} = 1 + \frac{Z_2(s)}{Z_1(s)}$$

Noninverting configuration



$$\frac{V_o(s)}{V_i(s)} = \frac{Z_2(s)}{Z_1(s) + Z_2(s)}$$

例題



$$\frac{V_o(s)}{V_i(s)} = -\frac{Z_2(s)}{Z_1(s)} = -\frac{R_2 + \frac{1}{sC_2}}{R_1}$$

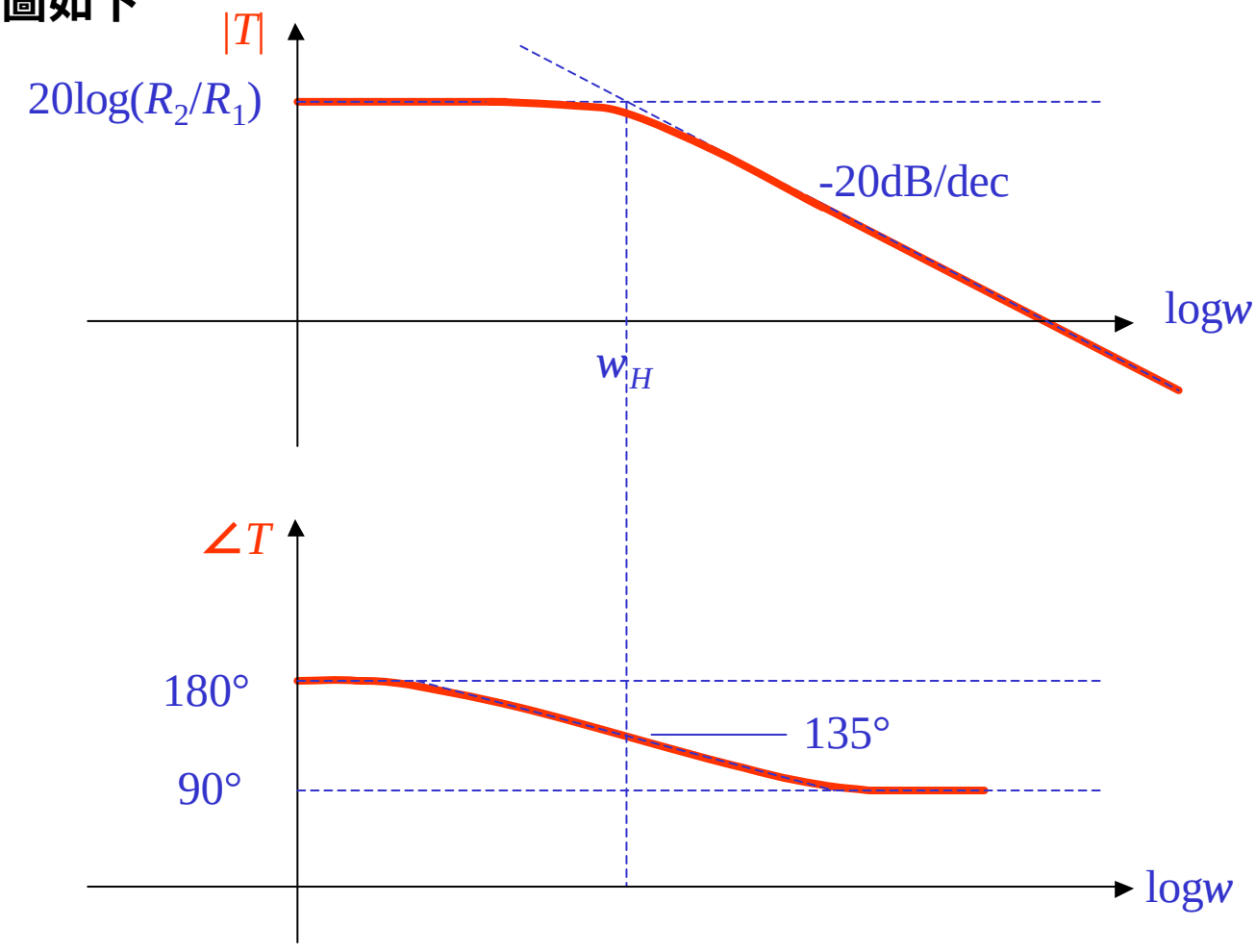
$$= -\frac{1}{R_1}\frac{R_2\frac{1}{sC_2}}{R_2 + \frac{1}{sC_2}} = \underbrace{-\frac{R_2}{R_1}}_{A_0}\left(\frac{1}{1+sR_2C_2}\right)$$

$$T(jw) = \frac{V_o(jw)}{V_i(jw)} = A_0\left(\frac{1}{1+jwR_2C_2}\right) = A_0\left(\frac{1}{1+jw/w_H}\right)$$

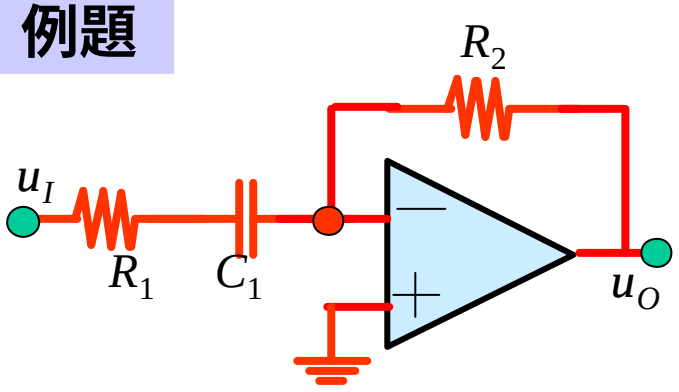
$w_H = 1/R_2C_2$

為一個有增益的低通濾波器

波德圖如下



例題



$$\frac{V_o(s)}{V_i(s)} = -\frac{Z_2(s)}{Z_1(s)} = -\frac{R_2}{R_1 // \frac{1}{sC_1}}$$

$$= -\frac{R_2 sC_1}{1+sR_1C_1} = \underbrace{-\frac{R_2}{R_1}}_{A_\infty}\left(\frac{sR_1C_1}{1+sR_1C_1}\right)$$

$$T(jw) = \frac{V_o(jw)}{V_i(jw)} = A_\infty\left(\frac{jwR_1C_1}{1+jwR_1C_1}\right) = A_\infty\left(\frac{jw/w_L}{1+jw/w_L}\right)$$

$w_L = 1/R_1C_1$

為一個有增益的高通濾波器

波德圖自行練習畫

討論

主動式與被動式濾波器各有何優缺點？