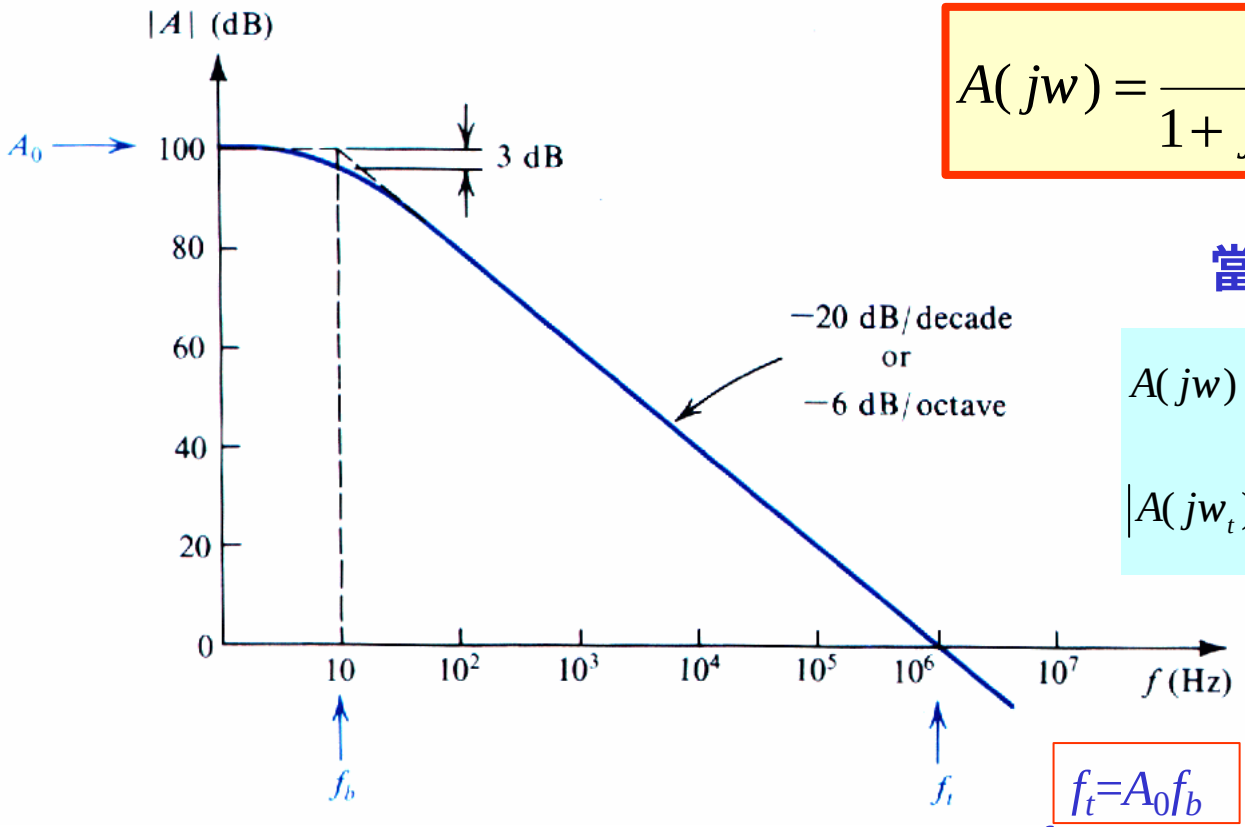
# 運算放大器的頻率響應

## 典型的運算放大器增益的頻率響應---很大的DC gain，很低的頻寬

### 簡易模型—STC circuit




$$A(jw)=\frac{A_0}{1+jw/w_b}$$

當$w>>w_b$

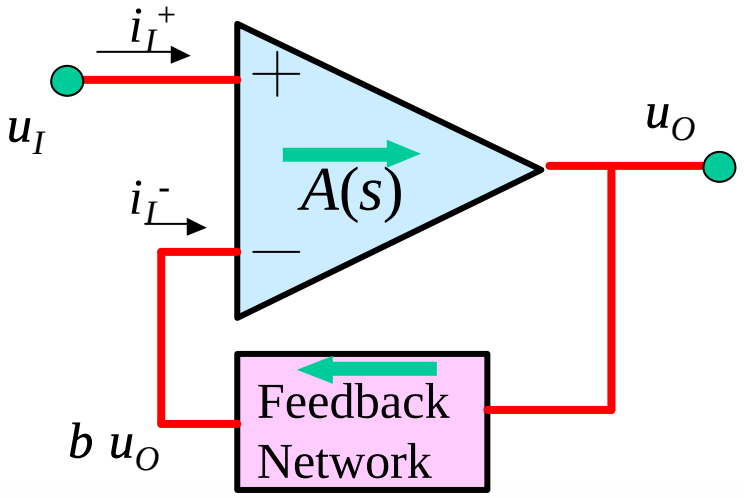
$$A(jw)\approx\frac{A_0}{jw/w_b}=j\frac{w_bA_0}{w}$$

$$\left|A(jw_t)\right|=\frac{w_bA_0}{w_t}=1\Rightarrow w_t=w_bA_0$$

$f_t=A_0f_b$

Unity-gain freq.

# 對close-loop gain的影響




$$G(s) = \frac{V_o(s)}{V_i(s)} = \frac{A(s)}{1 + bA(s)}$$

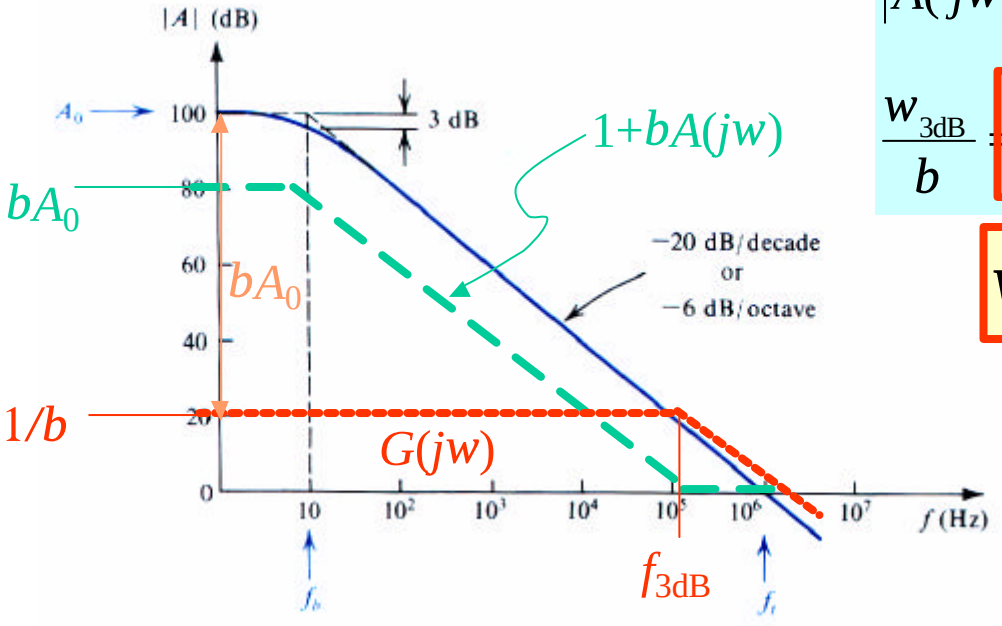
$$A(jw) \approx \frac{A_0}{jw/w_b} = j\frac{w_b A_0}{w}$$

$$\left|A(jw_{3dB})\right| = \frac{w_b A_0}{w_{3dB}} = \frac{1}{b} \Rightarrow w_{3dB} = bw_b A_0$$

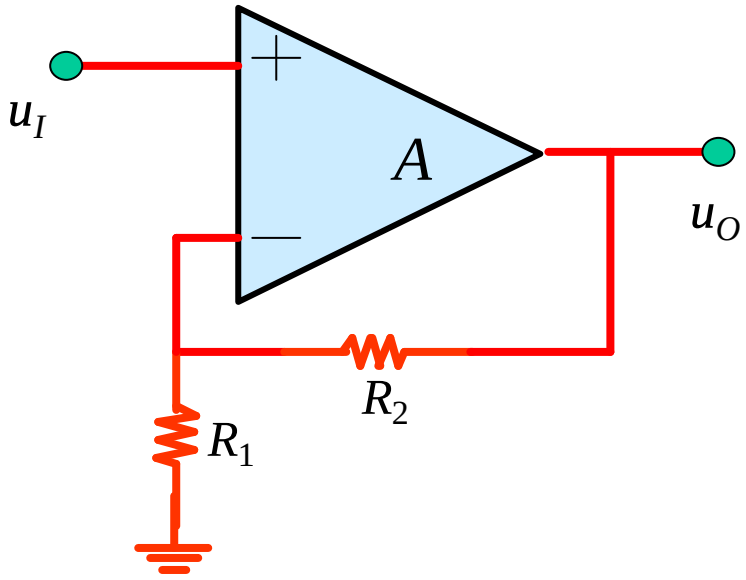
$$\frac{w_{3dB}}{b} = w_b A_0 = w_{3dB} G_0$$

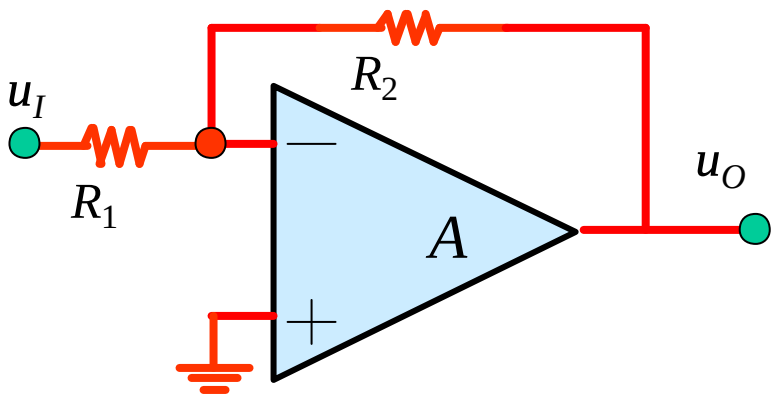
$$w_b A_0 = w_{3dB} G_0 = w_t \cdot 1$$

Gain-bandwidth product



# 例題




$$G=\frac{V_0(s)}{V_i(s)}=\frac{1}{R_1/(R_1+R_2)+1/A(s)}$$

$$=\frac{1}{\frac{R_1}{R_1+R_2}+\frac{1}{A_0}+\frac{s}{A_0 w_b}}$$

$$=\frac{1+R_2/R_1}{1+\frac{1}{A_0}\left(1+\frac{R_2}{R_1}\right)+\frac{s}{w_t/(1+R_2/R_1)}}$$

$$G=\frac{V_0(s)}{V_i(s)}=-\frac{R_2/R_1}{1+(1+R_2/R_1)/A(s)}$$

$$=-\frac{R_2/R_1}{1+\frac{1}{A_0}\left(1+\frac{R_2}{R_1}\right)+\frac{s}{w_t/(1+R_2/R_1)}}$$

## 例題

Consider an op amp with $f_t$=1MHz. Find the 3-dB frequency of closed-loop amplifiers with nominal gains of +1000, +100, +10, +1, -1, -10, -100, -1000. Sketch the magnitude frequency response for the amplifiers with closed-loop gains of +10 and –10.

| Closed-Loop Gain | $\frac{R_2}{R_1}$ | $f_{3dB} = f_t/(1 + R_2/R_1)$ |
|---|---|---|
| +1000 | 999 | 1 kHz |
| +100 | 99 | 10 kHz |
| +10 | 9 | 100 kHz |
| +1 | 0 | 1 MHz |
| −1 | 1 | 0.5 MHz |
| −10 | 10 | 90.9 kHz |
| −100 | 100 | 9.9 kHz |
| −1000 | 1000 | ≃1 kHz |