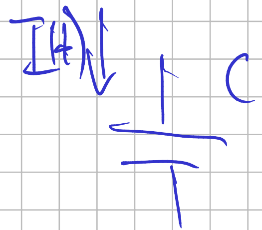
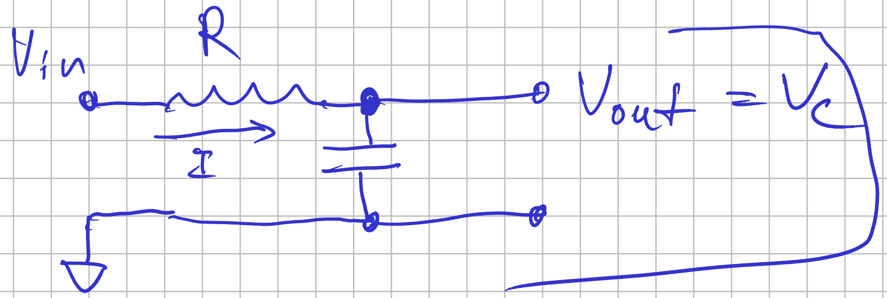
Integrator and differentiator



$$Q(t) = \int_{-\infty}^{t} I(t')\,dt'$$



$$I_{in} = \frac{V_{in} - \overset{\approx 0}{V_c}}{R} \simeq \frac{V_{in}}{R}, \text{ if } \underline{V_c \approx 0}$$

$$V_{out} = V_c = \int \frac{I\,dt}{C} \approx \int \frac{V_{in}(t)}{R \cdot C}\,dt$$

$$V_{out}(t) \sim \int_{-\infty}^{t} V_{in}(t')\,dt'$$

$$f(t) = \int_{-\infty}^{\infty} \boxed{f_\omega} \cdot e^{i\omega t} \, d\omega$$

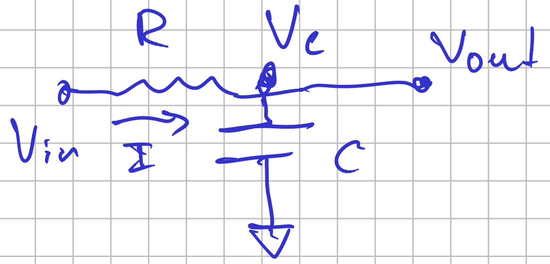
$$F(t) = \int_{-\infty}^{t} f(t')\, dt' = \int_{-\infty}^{t} \left[\int_{-\infty}^{\infty} f_\omega \, e^{i\omega t'} \, d\omega \right] dt' = \int_{-\infty}^{\infty} d\omega \, f_\omega \int_{-\infty}^{t} e^{i\omega t'} \, dt'$$

$$= \int_{-\infty}^{\infty} d\omega \, f_\omega \frac{e^{i\omega t'}}{i\omega} \Bigg|_{\cancel{-\infty}}^{t} = \int_{-\infty}^{\infty} \boxed{\frac{f_\omega}{i\omega}} \, e^{i\omega t} \, d\omega$$

$$\Updownarrow$$

$$F(t) = \int_{-\infty}^{\infty} F_\omega \, e^{i\omega t} \, d\omega$$

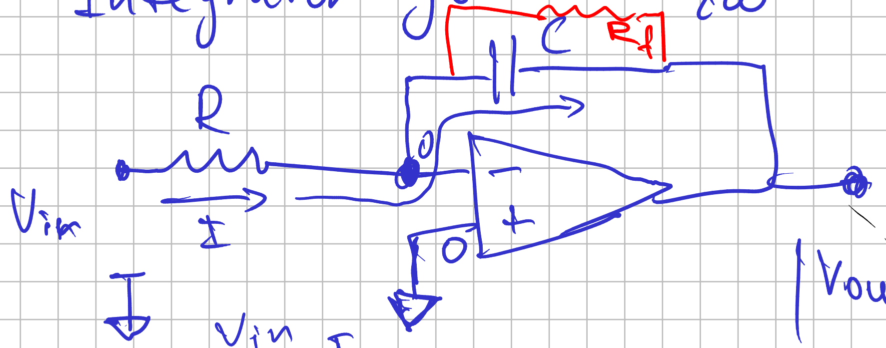
$$\boxed{F_\omega = \frac{f_\omega}{i\omega}}$$



$$V_{out\,\omega} = \frac{1}{R + 1/i\omega C} \cdot \frac{1}{i\omega C} \cdot V_{in\,\omega}$$

$$= \boxed{\frac{1}{1 + Ri\omega C}} \, V_{in\,\omega}$$

Integrator gain $= \sim \frac{1}{i\omega}$



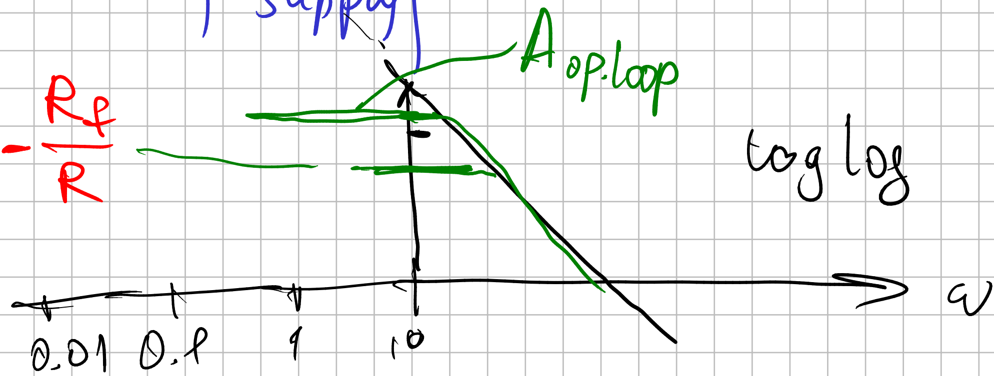
$\frac{V_{in}}{R} = I$

$$G(\omega) = -\frac{Z_f}{Z_{in}} = -\frac{\frac{1}{i\omega C}}{R}$$

$$= -\frac{1}{i\omega(RC)}$$

$|V_{out}| > |V_{power\ supply}|$

$$G(0) = -\frac{R_f}{R}$$



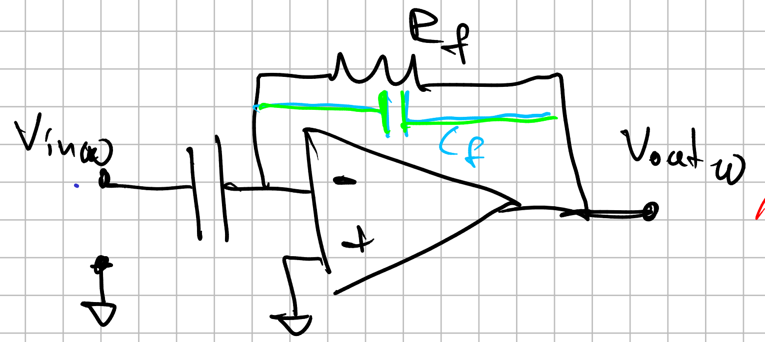
differentrator

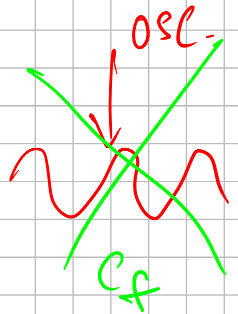
$$V_{out} \sim \frac{d\,V_{in}(t)}{dt}$$

$$F(t) = \frac{d}{dt} f(t) = \frac{d}{dt}\int_{-\infty}^{\infty} f\omega\, e^{i\omega t}\, d\omega = \int_{-\infty}^{\infty} f\omega \left(\frac{d}{dt} e^{i\omega t}\right) d\omega$$

$$= \int_{-\infty}^{\infty} \boxed{f\omega\, i\omega}\, e^{i\omega t}\, d\omega$$

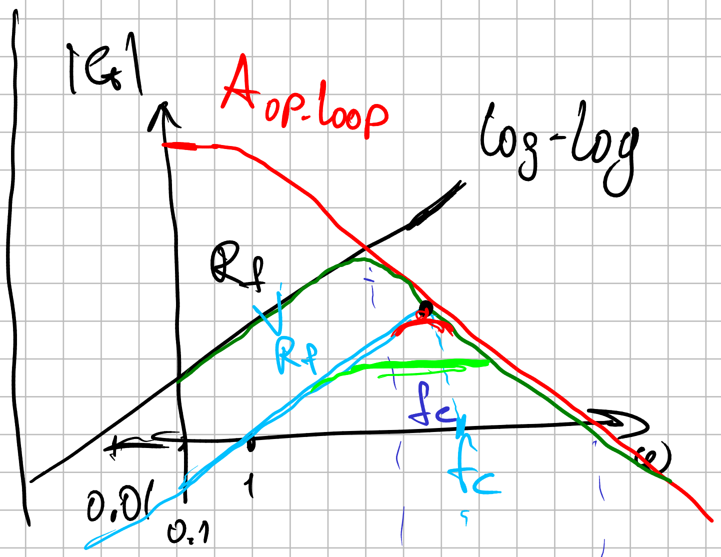
$$\boxed{F\omega = i\omega f\omega}$$





$$G = -\frac{Z_f}{Z_{in}} = -\frac{R_f}{1/i\omega C} =$$

$$= \boxed{-\underbrace{R_f C}\cdot i\omega}$$



f_c - ?

$$\underbrace{G}\underbrace{BW} = const$$

$$R_f C \cdot f_c = const$$

$$\boxed{f_c = \frac{GBW}{R_f C}}$$