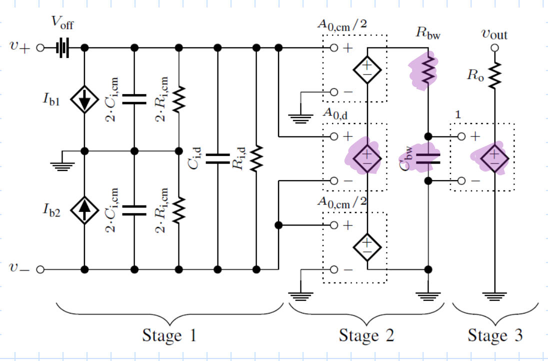
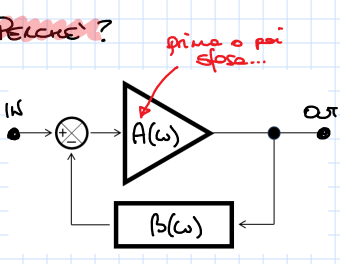
ESPERIENZA OPAMP REALI



$$A(\omega) = \frac{A_0}{1+j\omega\tau_0}$$

PERCHE'?



$$V_{OUT}(\omega) = \frac{A(\omega)}{\underbrace{1+\beta(\omega)A(\omega)}}V_{IN}(\omega)$$

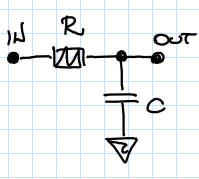
SE SI AZZERA PER UN DATO ω_0

⇓

POSSIBILE AVERE OUT SENZA IN

$V_{OUT} \propto e^{j\omega_0 t}$

ESEMPIO GENERICO (NON UN OPAMP...)



$$V_{OUT} = \frac{V_{IN}}{\underbrace{1+j\omega\tau}} \qquad \tau = RC$$

SI AZZERA PER $\omega_0 = j/\tau$ ← "POLO", vedere Metodi 2.

⇓

SOLUZIONE...

$$V_{OUT}(t) \propto e^{j\omega_0 t} = e^{-t/\tau}$$

IN GENERALE $\omega_0 = \alpha + j\beta$ ← se $\beta < 0$..

RISPOSTA $V_{OUT} \propto e^{j\alpha t} e^{-\beta t}$

OBIETTIVO SE USO RESISTENZE ($\beta \in \mathbb{R}$ e $\beta < 1$) VORREI CHE NON MI ANDASSE IN AUTO-OSCILLAZIONE

$$A(\omega) = |A(\omega)| e^{i\varphi(\omega)}$$

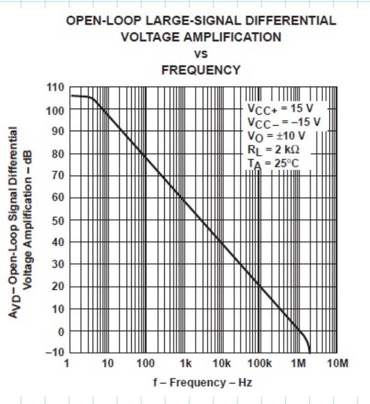
⇒ MARGINE DI FASE $\quad |A(\omega_1)| = 1$, $\quad \varphi(\omega_1) < \pi$

⇒ MARGINE DI GUADAGNO $\quad \varphi(\omega_\pi) = \pi$, $\quad |A(\omega_\pi)| < 1$

SE RISPETTATO.. ⇒ $\dfrac{A(\omega)}{1+\beta A(\omega)}$ NON HA ω_0 CON $Im(\omega_0) < 0$

PERCHE'? ⇒ Metodi 2

COMPENSAZIONE IN FREQUENZA

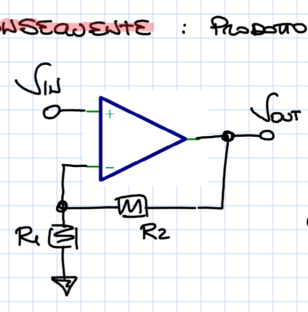


$$A(\omega) \simeq \frac{A_0}{1+j\omega\tau_0}$$

DC

approx di POLO DOMINANTE

CONSEGUENTE : PRODOTTO BANDA-GUADAGNO

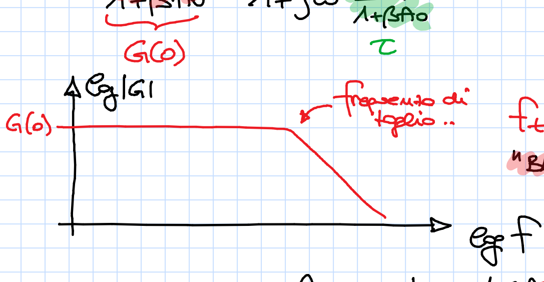


$$\beta = \frac{R_1}{R_1+R_2}$$

$$G(\omega) = \frac{A(\omega)}{1+\beta A(\omega)} = \frac{\frac{A_0}{1+j\omega\tau_0}}{1+\frac{\beta A_0}{1+j\omega\tau_0}}$$

$$= \frac{A_0}{1+j\omega\tau_0+\beta A_0} = \frac{A_0}{1+\beta A_0 + j\omega\tau_0}$$

$$= \underbrace{\frac{A_0}{1+\beta A_0}}_{G(0)} \cdot \frac{1}{1+j\omega \underbrace{\frac{\tau_0}{1+\beta A_0}}_{\tau}} =$$



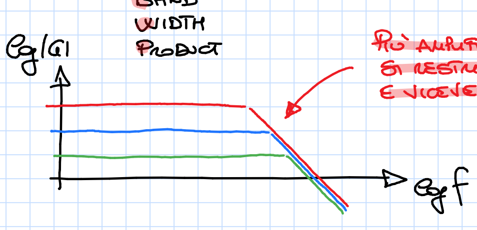
$f_t = 1/2\pi\tau$

"BAND WIDTH"

$$G(0)f_c = \frac{A_0}{\cancel{1+\beta A_0}} \cdot \frac{1}{2\pi} \cdot \frac{\cancel{1+\beta A_0}}{\tau_0} = \frac{A_0}{2\pi\tau_0}$$

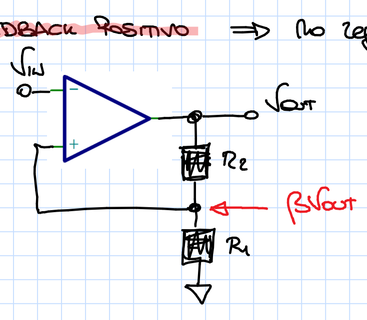
← COSTANTE! (CIRCA..)

GAIN BAND WIDTH PRODUCT



PIU' AMPLIFICO.. PIU' SI RESTRINGE LA BW... E VICEVERSA...

FEEDBACK POSITIVO ⇒ no regole d'oro..



$V_{IN} = \beta V_{OUT}$

SOLUZIONE INSTABILE

⇓

~~DIVERGENZA~~ SATURAZIONE

COME ANALIZZARE QUESTI CIRCUITI

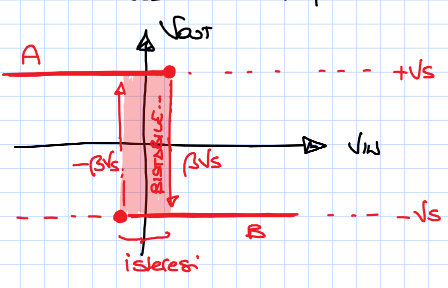
1. IPOTIZZARE SATURAZIONE
2. VERIFICARE A QUALI CONDIZIONI SI AUTOSOSTIENE

OPZIONE A $V_{OUT} = +V_S$

RICHIEDE.. $V_{IN} < \beta V_{OUT} = +\beta V_S$

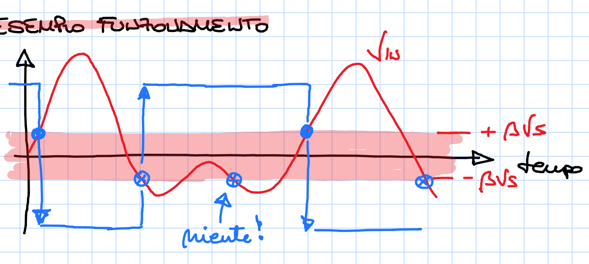
OPZIONE B $V_{OUT} = -V_S$

RICHIEDE $V_{IN} > \beta V_{OUT} = -\beta V_S$

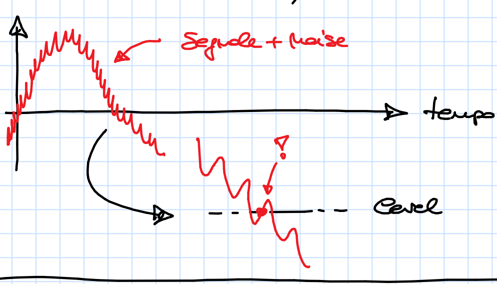


"TRIGGER DI SCHMITT INVERTENTE"

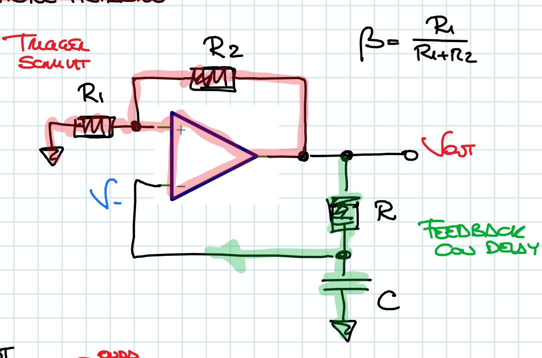
ESEMPIO FUNZIONAMENTO



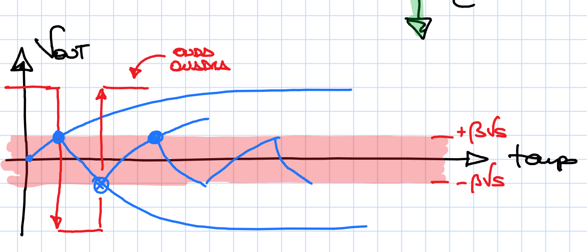
A CHE SERVE? ESEMPIO, TRIGGER SU ADZ A SALIRE



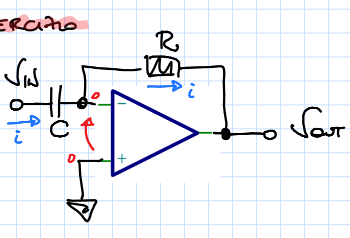
MULTIVIBRATORE ASTABILE



$$\beta = \frac{R_1}{R_1+R_2}$$



ESERCIZIO



ANALISI SEMPLICE 1

$$G = -\frac{Z_R}{Z_C} = -j\omega RC = -j\omega\tau$$

$$V_{out}(\omega) = \underbrace{-j\omega\tau\, V_{IN}(\omega)}$$

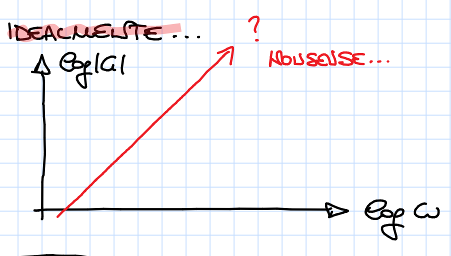
$-\tau$ derivata?

ANALISI SEMPLICE 2

$$i = \dot{q} = C\frac{dV_{IN}}{dt}$$

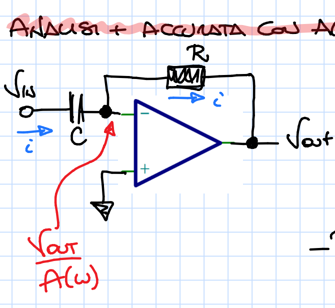
$$V_{out} = -Ri = -\underbrace{RC}_{\tau}\frac{dV_{IN}}{dt}$$

IDEALMENTE...



? NONSENSE...

ANALISI + ACCURATA CON $A(\omega)$



$$\begin{cases} V_{OUT} = -\dfrac{V_{OUT}}{A(\omega)} - Ri \\ V_{IN} = \dfrac{i}{j\omega C} - \dfrac{V_{OUT}}{A(\omega)} \end{cases}$$

$$-Ri = \frac{1+A(\omega)}{A(\omega)}V_{OUT}$$

$$V_{IN} = -\frac{1}{j\omega\tau}\cdot\frac{1+A(\omega)}{A(\omega)}V_{out} - \frac{V_{out}}{A(\omega)}$$

$$j\omega\tau A(\omega)V_{IN} = -[1+A(\omega)]V_{out} - j\omega\tau V_{OUT} = -[(1+j\omega\tau)+A(\omega)]V_{out}$$

$$V_{OUT} = -j\omega\tau\frac{A(\omega)}{(1+j\omega\tau)+A(\omega)}V_{IN} = -j\omega\tau\frac{A_0 V_{IN}}{(1+j\omega\tau)(1+j\omega\tau_0)+A_0}$$

II grado... ok.

$$\underbrace{1+A_0}+j\omega(\tau+\tau_0)-\omega^2\tau\tau_0$$

Nel limite → ∞..

RISONANZA

$$\omega^2 = \frac{A_0}{\tau\tau_0} =$$

$$f_r^2 = \frac{\omega^2}{(2\pi)^2} = \frac{1}{2\pi\tau}\cdot GBWP$$