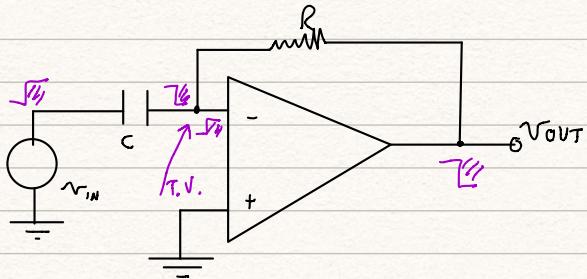


STABILITÀ E COMPENSAZIONE, STADIO DERIVATORE E RETROAZIONE POSITIVA

CIRCUITO DERIVATORE: STABILITÀ E COMPENSAZIONE

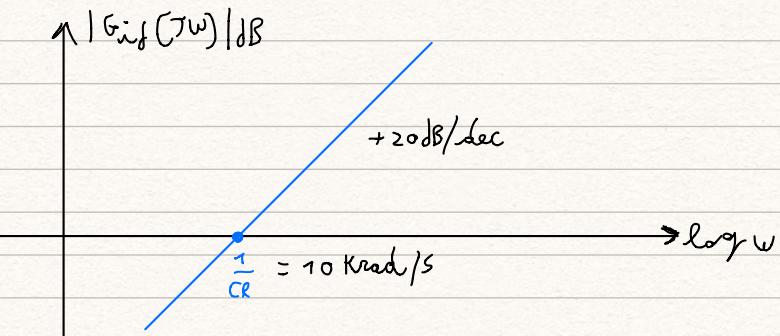


$$Z_2(s) = R$$

$$Z_1(s) = \frac{1}{sC}$$

$$G_{inf}(s) = -\frac{Z_2(s)}{Z_1(s)} = -RSC = -sCR$$

$$CR = 10^8 \cdot 10^4 = 10^{-3} s = 100 \mu s$$



ASSUNZIONI

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

$$A_0 = 80 \text{ dB}$$

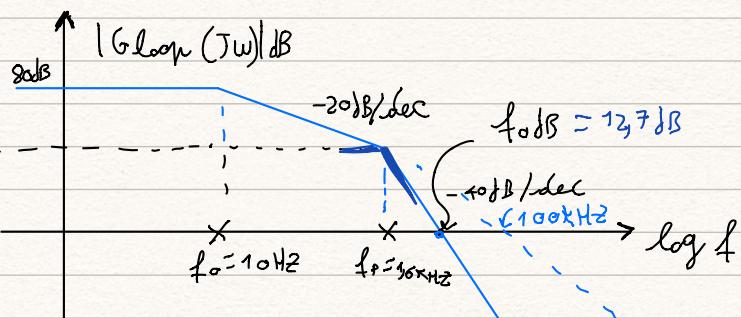
$$\tau_0 = 15,9 \text{ ms}$$

$$f_0 = \frac{1}{2\pi\tau_0} = 70 \text{ Hz}$$

STABILITÀ?

calcolo G_{loop} $\longrightarrow G_{loop}(s) = \frac{1/sC}{R + 1/sC}$

$$A(s) = \underbrace{\frac{-A_0}{1 + RSC}}_{2 \text{ POLI}} \cdot \underbrace{\frac{1}{1 + s\tau_0}}_{2 \text{ POLI}}$$



$$|G_{loop}(0)| \cdot f_0 = |G_{loop}(f_p)| \cdot f_p$$

$$|G_{loop}(f_p)| = \frac{|G_{loop}(0)| f_0}{f_p} = +36 \text{ dB}$$

$$36 \text{ dB} - 0 \text{ dB} = 40 \log \frac{f_0 \text{ dB}}{f_p}$$

$$f_0 \text{ dB} = 12,7 \text{ kHz}$$

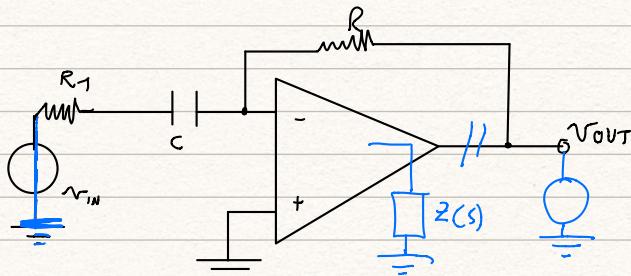
MARGINE DI FASE:

$$\varphi_n = [180^\circ - \arctg \frac{f_0 \text{ dB}}{f_0} - \arctg \frac{f_0 \text{ dB}}{f_p}] - (-360^\circ) = -180^\circ - 90^\circ - 83^\circ + 360^\circ = +7^\circ$$

MATEMATICAMENTE SAREBBE STABILE ($\varphi_n > 0$)

IN PRATICA $\varphi_n < 45^\circ \rightarrow$ NON VA BENE!

DGRIVATORE APPROSSIMATO



$$Z_2(s) = R$$

$$Z_1(s) = \frac{1}{sC} + R_1 \approx \frac{1 + sCR_1}{sC}$$

$$G_{id}(s) = \frac{-Z_2(s)}{Z_1(s)} = -\frac{sRC}{1 + sCR_1}$$

ZERO NELL' ORIGINE

POLI CON $T_P = CR_1$

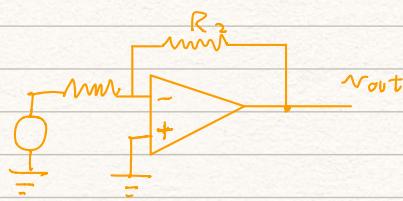
$$f_p = \frac{1}{2\pi T_p}$$

$$|G_{id}(j\omega)| \text{ dB}$$

$$(-R_2/R_1)$$

$$f_0$$

$$\log f$$



GUADAGNO D'ANELLIO

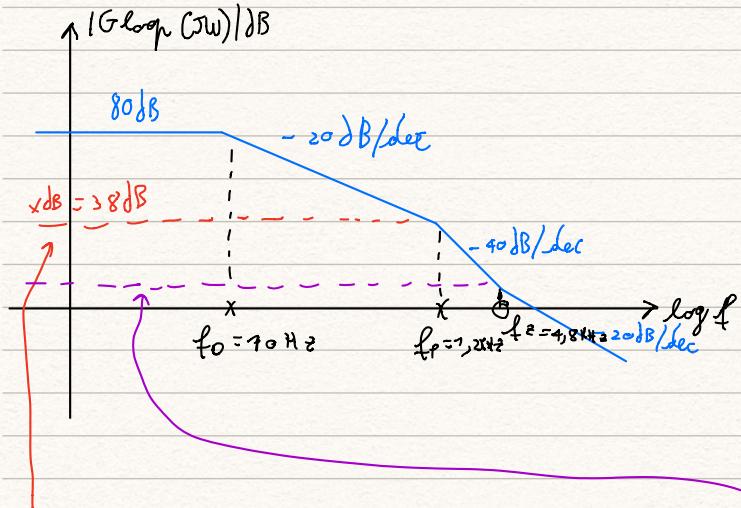
$$G_{\text{loop}}(s) = - \frac{R_1 + 1/sC}{R + R_1 + 1/sC} \cdot A(s) \approx - \frac{1 + sCR_1}{1 + sC(R + R_1)} \cdot \frac{A_0}{1 + sC}$$

segliendo:

$$R_1 = 1/B_R = 3,3 \text{ k}\Omega$$

$$\tau_p = C(R + R_1)$$

$$\tau_z = CR_1$$



$$10^x \cdot f_0 = x \cdot f_p \rightarrow x = \frac{10^x f_0}{f_p} \rightarrow 38 \text{ dB}$$

z POLE

$$f_0 = 10 \text{ Hz}$$

$$f_p = \frac{1}{2\pi\tau_p}$$

1 ZERO

$$f_p = \frac{1}{2\pi\tau_z}$$

$$38 \text{ dB} - y = 40 \log \frac{f_z}{f_p} \rightarrow y = 14 \text{ dB}$$

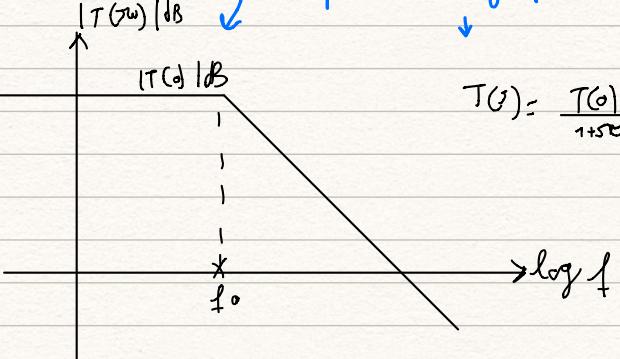
$$14 \text{ dB} - 0 \text{ dB} = 20 \log \frac{f_0 \text{ dB}}{f_z}$$

$$f_0 \text{ dB} = 24 \text{ kHz}$$

MARGINE DI FASE

$$\varphi_n = [-180^\circ - \arctg \frac{f_0 \text{ dB}}{f_0} - \arctg \frac{f_0 \text{ dB}}{f_p} + \arctg \frac{f_0 \text{ dB}}{f_z}] - (-360^\circ) \approx +79^\circ !!!$$

come questo è grafico?



$$T(j) = \frac{T(j)}{1+sC}$$

$$T(s) \approx \frac{T(j)}{s\tau_o}$$

$$f_0 = \frac{1}{2\pi\tau_o}$$

$$|T(jw)| = \frac{|T(j)|}{\sqrt{1 + \omega^2\tau_o^2}}$$

$$f \gg f_0 \quad |T(j\omega)| \approx \frac{|T(\omega)|}{\omega^{\alpha}}$$

$$\omega = \bar{\omega} \quad |T(j\bar{\omega})| \bar{\omega} = |T(\omega)| \frac{1}{\tau_0}$$

$$\forall \omega (\omega > \omega_0) \quad |T(j\omega)| \omega = |T(\omega)| \frac{1}{\tau_0}$$

$$20 \log_{10} |T(j\omega)| + 20 \log_{10} \omega = 20 \log |T(\omega)| + 20 \log |1/\tau_0|$$

$$|T(j\omega)|_{dB} - |T(\omega)|_{dB} = 20 \log \frac{|1/\tau_0|}{\omega}$$

\approx poli

$$T(s) = \frac{T(\omega)}{(1+s\tau_1)(1+s\tau_2)}$$

$$f_1 = \frac{1}{2\pi\tau_1}, \quad f_2 = \frac{1}{2\pi\tau_2}$$



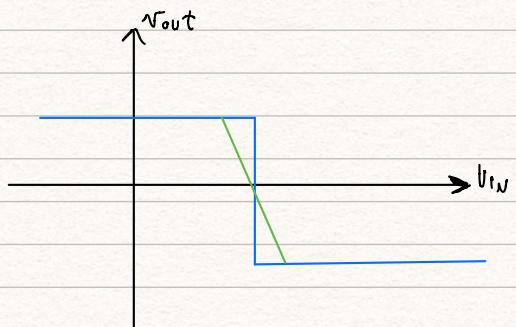
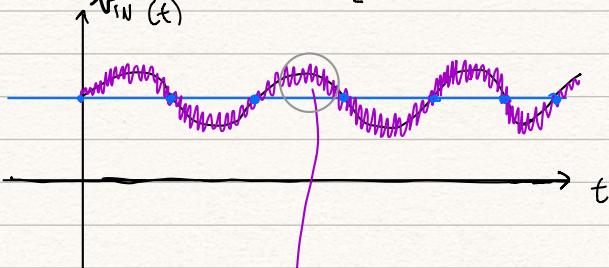
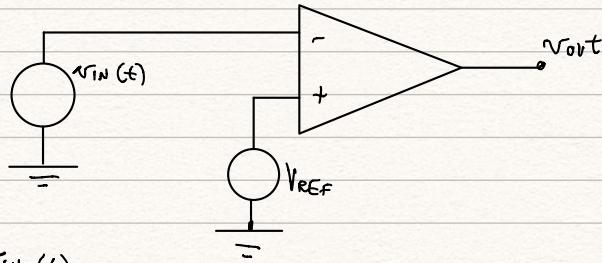
$f_1 \ll f_2$

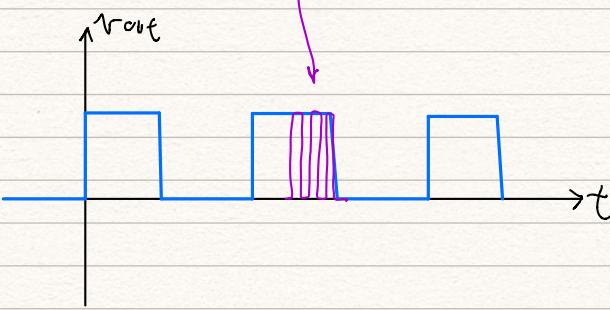
$$T(s) \approx \frac{T(\omega)}{s\tau_1}$$

$f_1 \gg f_2$

$$T(s) \approx \frac{T(\omega)}{s^2\tau_1\tau_2}$$

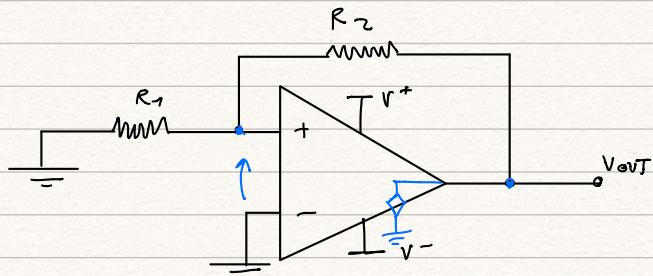
RETROAZIONE POSITIVA:





per evitare le commutazioni spurie per effetto del rumore \rightarrow comparatore con interesi

TRIGGER DI SCHMITT



L^+ livello di saturazione positiva di V_{out}
 L^- livello di saturazione negativa di V_{out}
 $L^- = V_{out} \leq L^+$

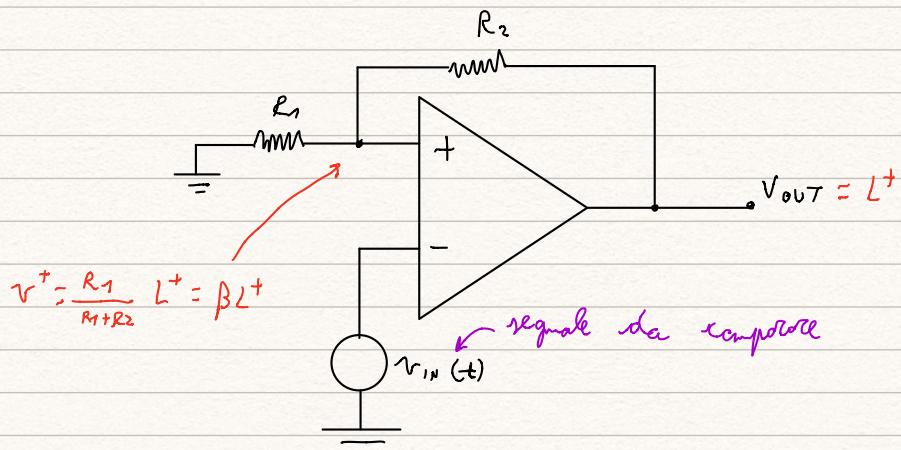
SOLO DUE STATI STABILI:

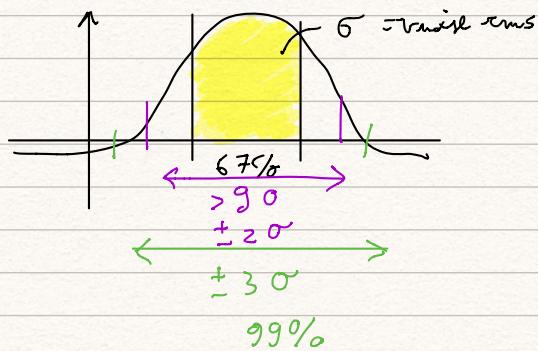
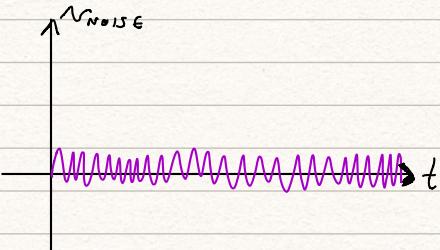
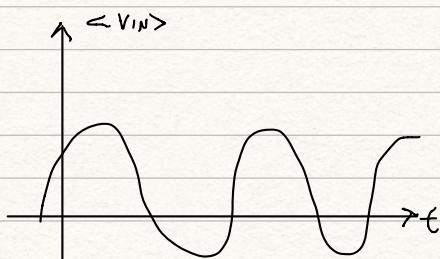
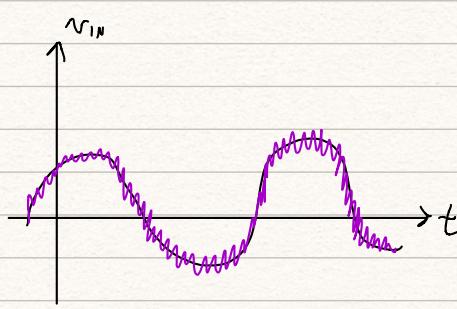
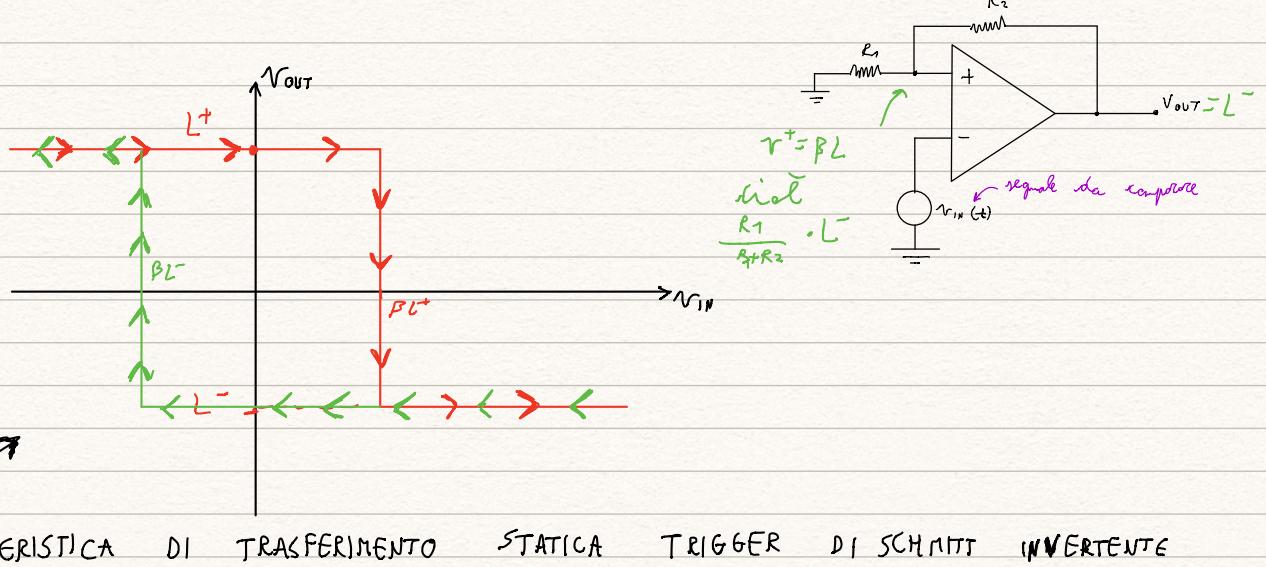
$$\cdot V_{out} = L^+ \rightarrow V^+ = \frac{R_1}{R_1 + R_2} L^+$$

$$\cdot V_{out} = L^- \rightarrow V^+ = \underbrace{\frac{R_1}{R_1 + R_2}}_{\beta} L^- \quad L^- = \beta L^+$$

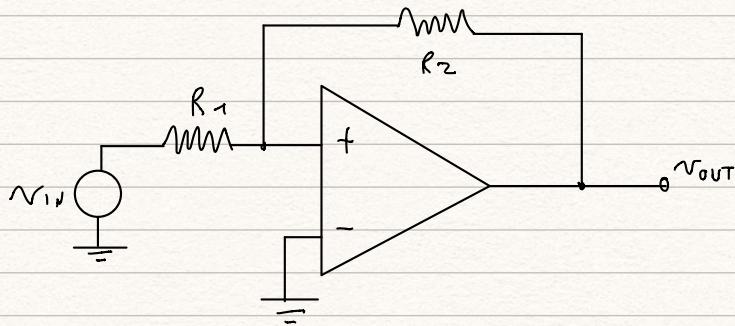
CIRCUITO BISTABILE

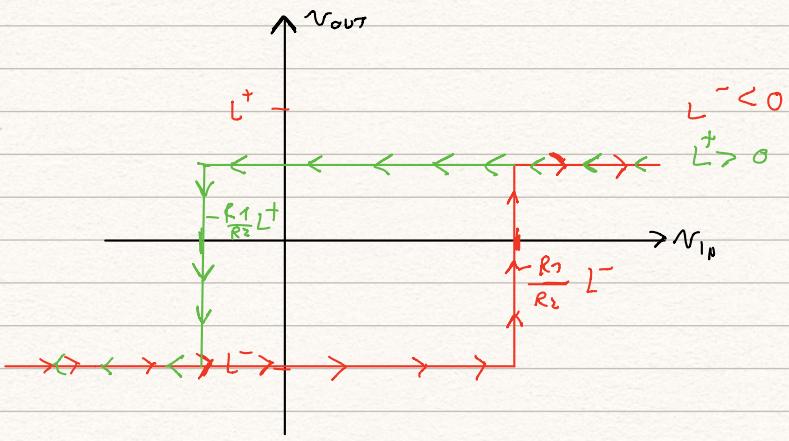
TRIGGER DI SCHMITT IN CONFIGURAZIONE INVERTENTE:





CONFIGURAZIONE NON INVERTENTE:





$$V^+ = \frac{R_1}{R_1 + R_2} V_{out} + \frac{R_2}{R_1 + R_2} V_{in}$$

$$V_{out} = L^-$$

$$V^+ = \frac{R_1}{R_1 + R_2} L^- + \frac{R_2}{R_1 + R_2} V_{in}$$

per quale V_{in} $V^+ = 0$

$$0 = \frac{R_1}{R_1 + R_2} L^- + \frac{R_2}{R_1 + R_2} V_{in}$$

$$V_{in} = -\frac{R_1 L^-}{R_2} \approx -\frac{R_1}{R_2} L^- > 0$$

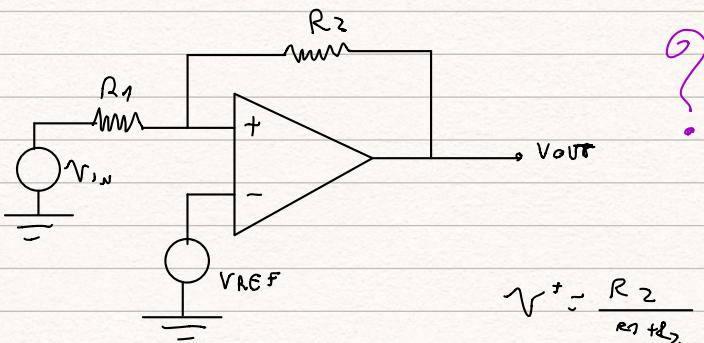
$$V_{out} = L^+$$

per quale V_{in} $V^+ = 0$?

$$0 = \frac{R_1}{R_1 + R_2} L^+ + \frac{R_2}{R_1 + R_2} V_{in}$$

$$V_{in} = -\frac{R_1}{R_2} L^+ < 0$$

Come effettua la sommazione non rispetta a 0V?

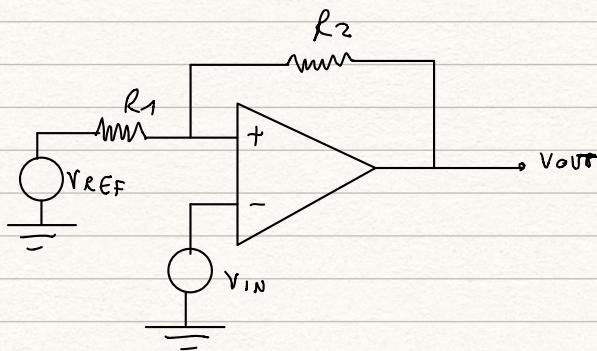


$$V^+ = \frac{R_2}{R_1 + R_2} V_{in} + V_{out} \frac{R_1}{R_1 + R_2}$$

la sommatoria si ha per $V_E = 0$

$$V^+ = V^- = V_{REF}$$

$$\frac{R_2}{R_1 + R_2} V_{IN} + \frac{R_1}{R_1 + R_2} V_{OUT} = V_{REF}$$



Condizione di sommatoria $V_E = 0$, cioè $V^+ = V^- = V_{IN}$

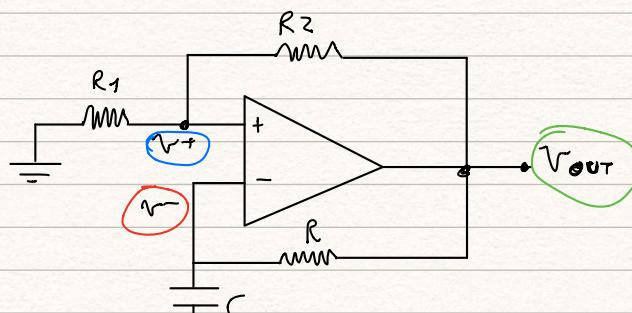
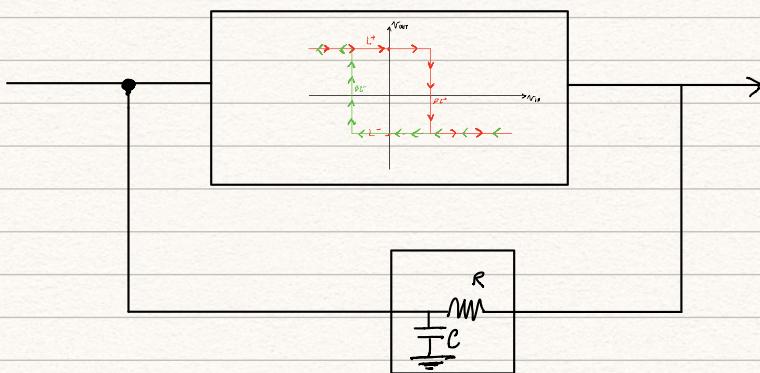
$$V^+ = \frac{R_1}{R_1 + R_2} V_{OUT} + \frac{R_2}{R_1 + R_2} V_{REF}$$

$$V_{IN} = \frac{R_1}{R_1 + R_2} V_{OUT} + \frac{R_2}{R_1 + R_2} V_{REF}$$

↑

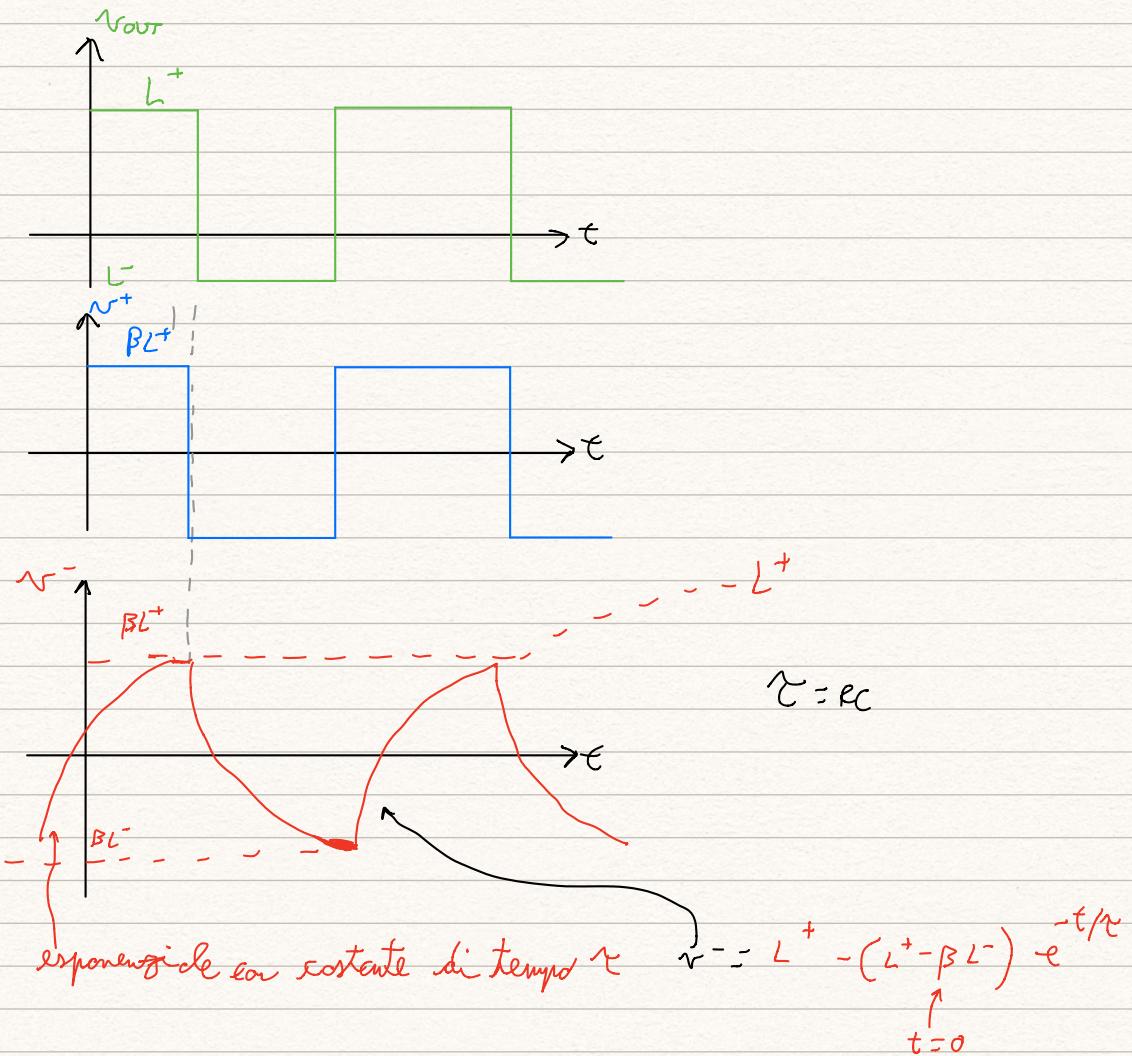
GENERATORE DI FORMA D'ONDA QUADRA

(MULTIVIBRAZIONE ASTABILE)



L^+

$$V^+ = \frac{R_1}{R_1 + R_2} V_{OUT} = \beta V_{OUT}$$



$$\Theta^+ = T^+ \quad v^+ = \beta L^+$$

$$\beta L^+ = L^+ - (L^+ - \beta L^-) e^{-T^+/\tau}$$

$$T^+ = \tau \ln \frac{1 - \beta(L^-/L^+)}{1 - \beta}$$

$$\Theta^- = T^- \quad v^- = \beta L^-$$

$$\beta L^- = L^- - (L^- - \beta L^+) e^{-T^-/\tau}$$

$$T^- = \tau \ln \frac{1 - \beta(L^+/L^-)}{1 - \beta}$$

$$\text{normal} \quad L^+ = -L^- = L > 0$$

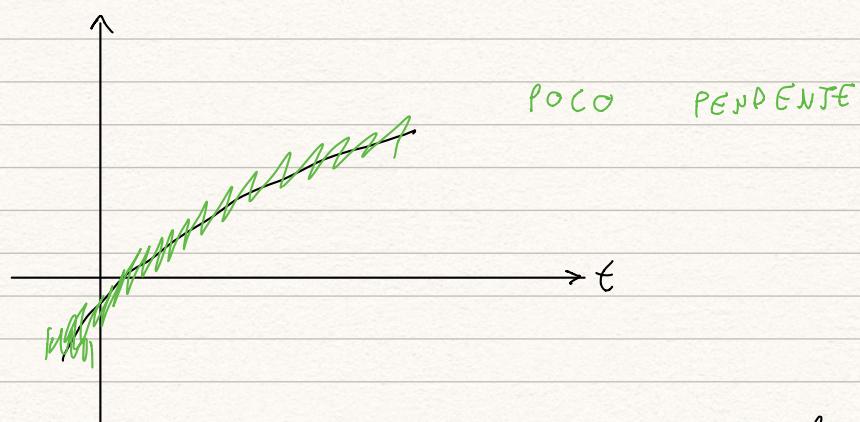
$$T^+ = \tau \ln \frac{1 + \beta}{1 - \beta}$$

$$T^- = \tau \ln \frac{1 + \beta}{1 - \beta}$$

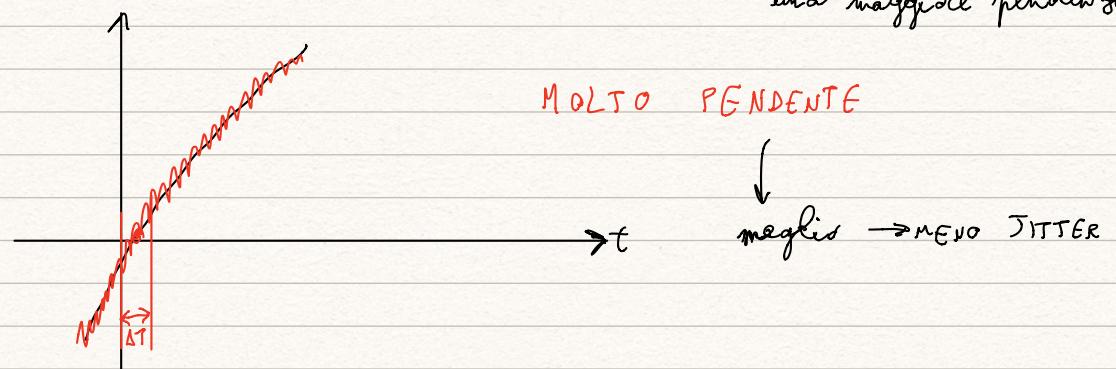
$$T = T^+ + T^- = 2\pi \ln \frac{1+\beta}{1-\beta}$$

PERIODO

RC

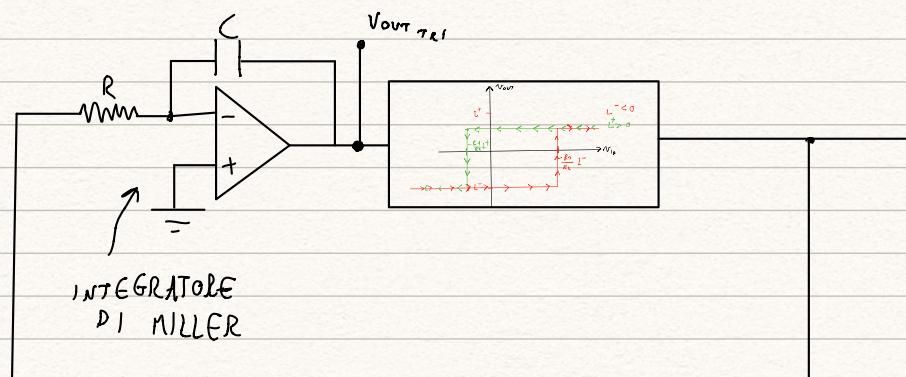


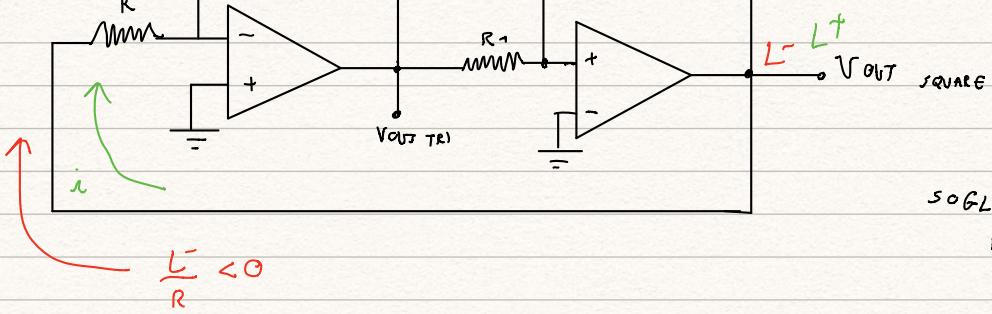
se sceglie β piccolo ho
una maggiore pendente



"JITTER" = VARIAZIONE SUL PERIODO

GENERATORE DI Onda QUADRA E TRIANGOLARE

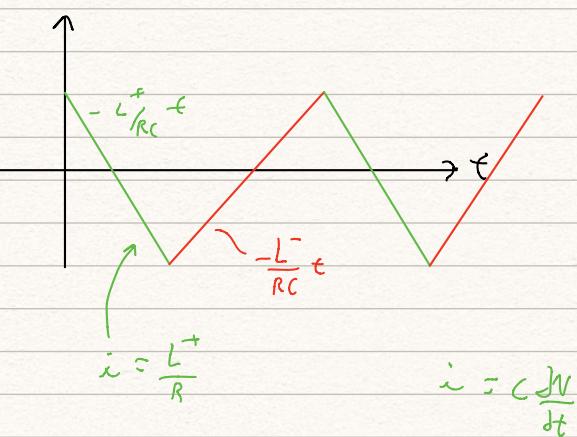
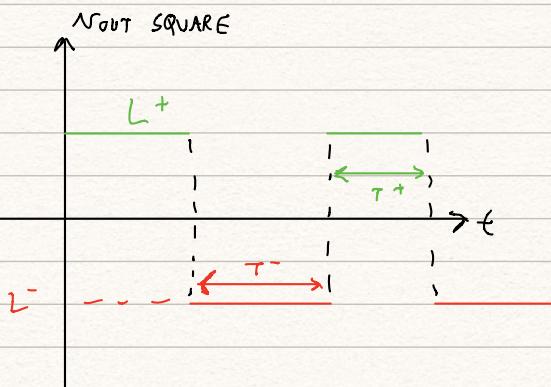




SOGIG TRIGGER DI SCHNITT NON
INVERTERTE

$$V_{TH^+} = L^- \frac{R_1}{R_2}$$

$$V_{TH^-} = -L^+ \frac{R_1}{R_2}$$



T^- :

$$-\frac{L^-}{RC} T^- = (V_{TH^+} - V_{TH^-})$$

$$T^- = -\frac{RC}{L^-} \left(L^- \frac{R_1}{R_2} + L^+ \frac{R_1}{R_2} \right) \approx$$

$$\boxed{L^+ \approx L^-}$$

$$\approx RC \frac{L^+ / R_2 \cdot 2}{L^-}$$

?

T^+

$$-L^+ \frac{T^+}{RC} = (V_{TH^-} - V_{TH^+})$$

$$T^+ = \frac{RC (-L^+ R_1 / R_2 + L^- R_1 / R_2)}{-L^+} =$$

$$\approx RC \frac{L^- R_1 / R_2 \cdot 2}{-L^+}$$

$$T = T_1 + T_2 = \frac{R_1}{R_2}$$