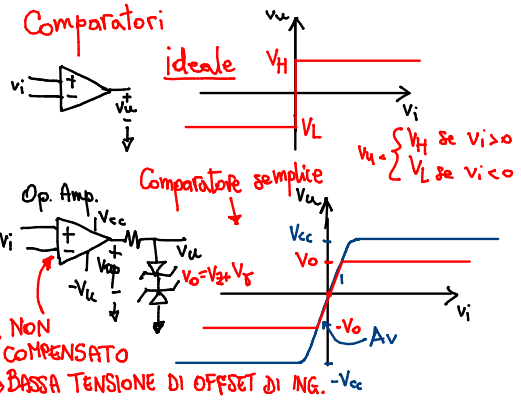
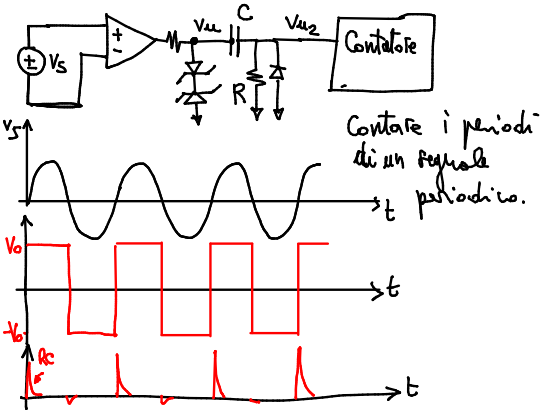
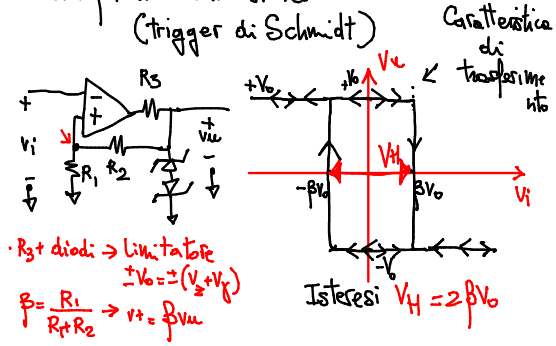
CIRCUITI A SCATTO

Comparatori





Comparatore con Isteresi (Trigger di Schmidt)

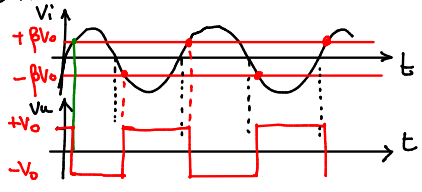


- R_3 + diodi → limitatore $\pm V_o = \pm(V_z + V_\gamma)$
- $\beta = \frac{R_1}{R_1 + R_2}$ → $v_+ = \beta v_u$

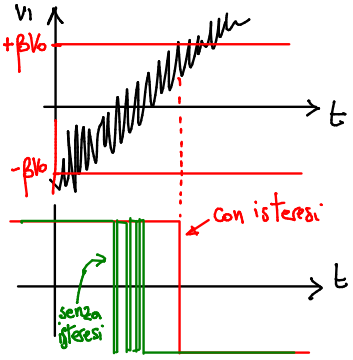
EFFETTI dell'isteresi

1) COMMUTAZIONE + VELOCE
   perché durante la commutazione la V^+ varia in direzione opposta a v_{in}

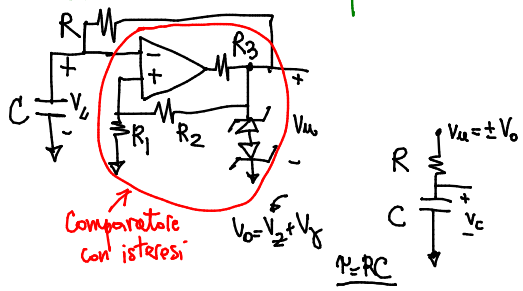
2) RITARDO nella commutazione

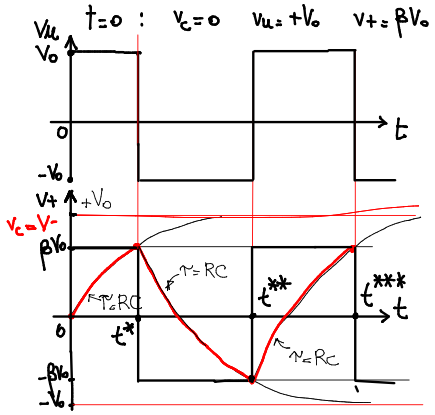


3) MINORE SENSIBILITÀ AL RUMORE



Generatore di onda quadra





$t^{**} > t \geq t^*$

$v_C(t) = A e^{-t/\tau} + B$

$v_C(t^*) = +\beta V_o = A e^{-t^*/\tau} + B$

$\lim_{t\to\infty} v_C(t) = -V_o = B$

$A = V_o(1+\beta) e^{t^*/\tau}$

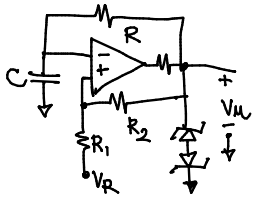
$v_C(t) = V_o(1+\beta) e^{-\frac{t-t^*}{\tau}} - V_o$

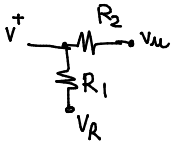
$v_C(t^{**}) = -\beta V_o = V_o(1+\beta) e^{-\frac{t^{**}-t^*}{\tau}} - V_o$

$t^{**} - t^* = \tau \ln\left[\frac{1+\beta}{1-\beta}\right] = T/2 \rightarrow T = 2\tau \ln\left[\frac{1+\beta}{1-\beta}\right]$

$$T = 2RC \ln\left[1 + \frac{2R_1}{R_2}\right]$$

- Per ottenere un'onda rettangolare (semionde di durata diversa) si deve rendere il circuito asimmetrico. Per esempio:
  1) Soglie diverse per il comparatore
  2) costanti di tempo diverse in carica e scarica
  3) asintoti diversi in carica e scarica



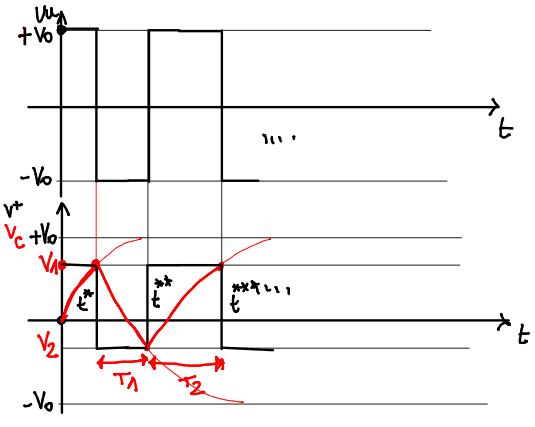


$$v^+ = \frac{R_2}{R_1+R_2} V_R + \frac{R_1}{R_1+R_2} V_u$$

$$v^+ = (1-\beta) V_R + \beta V_u$$

se $V_u = +V_o$ $v^+ = (1-\beta)V_R + \beta V_o = V_1$

se $V_u = -V_o$ $v^+ = (1-\beta)V_R - \beta V_o = V_2$



$t^* < t < t^{**}$ $\quad v_c(t) = Ae^{-t/\tau} + B$

$v_c(t^*) = V_1 = Ae^{-t^*/\tau} + B$

$\lim_{t\to\infty} v_c(t) = -V_0 = B$

$A = (V_1 + V_0)e^{t^*/\tau}$ $\quad T_1 = t^{**} - t^*$

$v_c(t^{**}) = V_2 = (V_1 + V_0)e^{-T_1/\tau} - V_0$

$T_1 = \tau \ln\left(\frac{V_1 + V_0}{V_2 + V_0}\right)$

$t^{**} < t < t^{***}$

$v_c(t^{**}) = V_2 = Ae^{-t^{**}/\tau} + B \rightarrow A = V_2 - V_0 e^{t^{**}/\tau}$

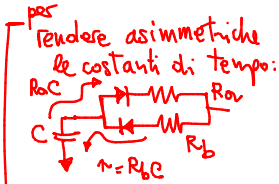
$\lim_{v_c\to\infty} v_c(t) = +V_0 = B$

$v_c(t^{***}) = V_1 = (V_2 - V_0)e^{-T_2/\tau} + V_0 \rightarrow T_2 = \tau \ln\left(\frac{V_2 - V_0}{V_1 - V_0}\right)$

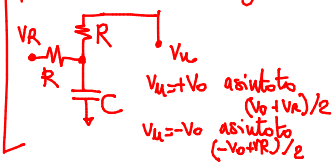
$T = T_1 + T_2$

$\delta = \frac{T_2}{T_1 + T_2}$ ↑ duty cycle

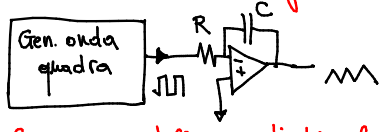
per rendere asimmetriche le costanti di tempo:



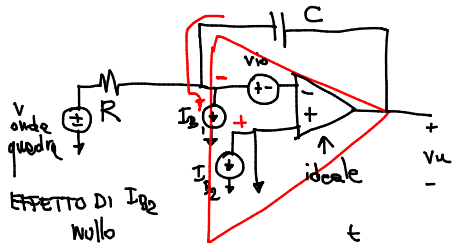
per rendere asimmetrici gli asintoti



Generatore d'onda Triangolare



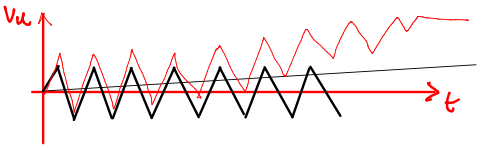
Compromessa dalle correnti di polarizzazione d'ingresso e dalla Tensione di offset di ingresso dell'operazionale

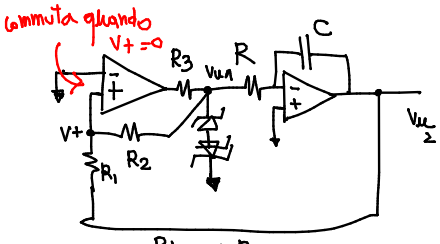


EFFETTO DI I_{B2} nullo

EFFETTO DI I_{B1}: $v_u(t) = v_u(0) + \int_0^t \frac{I_{B1}}{C} dt' = v_u(0) + \frac{I_{B1}}{C} t$

EFFETTO DI V_{io}: $v_u(t) = v_u(0) - \frac{V_{io}}{RC} t$ ← due rampe





β

$V^+ = \frac{R_1}{R_1 + R_2} v_{u1} + \frac{R_2}{R_1 + R_2} v_{u2} = \beta v_{u1} + (1 - \beta) v_{u2}$

se $v_{u1} = +V_0 \rightarrow v_{u2} = \beta V_0 + (1 - \beta) v_{u2}$

se $v_{u1} = -V_0 \rightarrow v_{u2} = -\beta V_0 + (1 - \beta) v_{u2}$

se $V_{u_1} = +V_0$ → commutazione quando

$v_+ = 0 \rightarrow v_{u_2} = -\frac{\beta}{1-\beta} V_0 = V_L$

se $V_{u_1} = -V_0$ → commutazione si ha quando

$v_+ = 0 \rightarrow v_{u_2} = \frac{+\beta}{1-\beta} V_0 = V_H$

2 soglie di commutazione

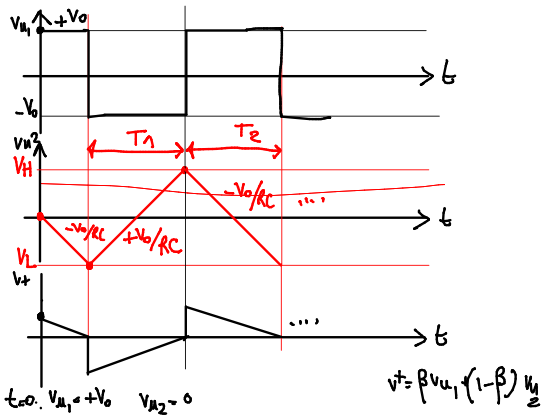
Integratore

$$v_{u_2}(t) = v_{u_2}(0) - \frac{1}{RC}\int_0^t v_{u_1}(t')dt'$$

$$\frac{dv_{u_2}}{dt} = -\frac{v_{u_1}}{RC}$$

se $v_{u_1} = +V_0 \rightarrow \frac{dv_{u_2}}{dt} = -V_0/RC$

se $v_{u_1} = -V_0 \rightarrow \frac{dv_{u_2}}{dt} = +V_0/RC$



$$T_1 = \frac{V_H - V_L}{V_0/RC} \qquad T_2 = \frac{V_H - V_L}{V_0/RC}$$

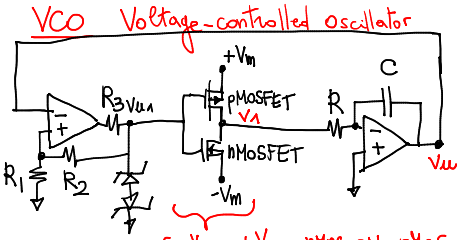
$$T = T_1 + T_2 = \frac{2(V_H - V_L)}{V_0/RC} = \frac{4\beta V_0 RC}{(1-\beta)V_0} = \frac{4\beta RC}{1-\beta}$$

$$= \frac{4R_1RC}{R_2}$$

ampiezza picco-picco $= V_H - V_L =$

$$\frac{2\beta V_0}{1-\beta} = \frac{2R_1}{R_2} V_0$$

VCO Voltage-controlled oscillator



se $V_{u_1} = +V_0$ nMOS ON, pMOS OFF → $v_1 = -V_m$

se $V_{u_1} = -V_0$ nMOS OFF, pMOS ON → $v_1 = +V_m$

1) $v_{u_1} = +V_0 \rightarrow v_+ = \beta V_0 = V_H$ soglia positiva

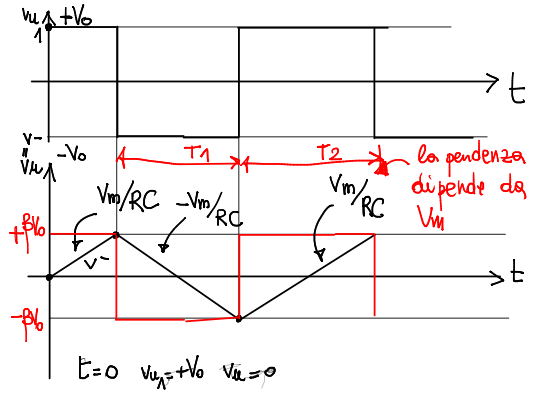
$v_1 = -V_m$

$$\frac{dv_u}{dt} = \frac{+V_m}{RC} = \frac{dv^-}{dt}$$

2) $v_{u_1} = -V_0 \rightarrow v^+ = -\beta V_0 = V_L$ soglia negativa

$v_1 = +V_m$

$$\frac{dv_u}{dt} = \frac{-V_1}{RC} = \frac{-V_m}{RC} = \frac{dv^-}{dt}$$

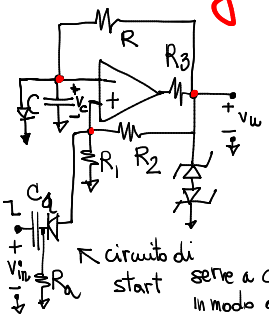


$$T_1 = \frac{2\beta V_0}{V_m/RC} = \frac{2\beta V_0 RC}{V_m} = T_2$$

$$T = T_1 + T_2 = \frac{4\beta V_0 RC}{V_m} \rightarrow f = \frac{1}{T} = \frac{V_m}{4\beta V_0 RC}$$

VCO → f ∝ V_m

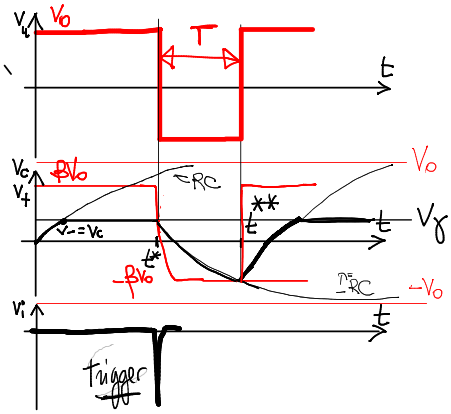
Generatore di impulso rettangolare



istante $t=0$

poniamo $V_+ = 0$ $V_u = +V_0$

↖ circuito di start serve a causare $V_+ < V^-$ in modo da avere una transizione del Comp



v^- per $t^* < t < t^{**}$

$$v^- = Ae^{-t/\tau} + B$$

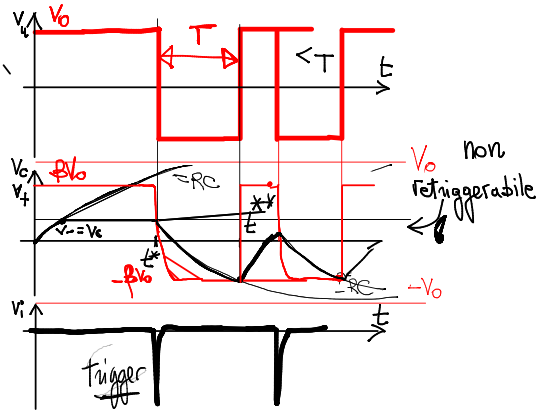
$$v^-(t^*) = V_\gamma = Ae^{-t^*/\tau} + B$$

$$\lim_{t\to\infty} v^- = -V_0 = B \qquad A = (V_\gamma + V_0)e^{t^*/\tau}$$

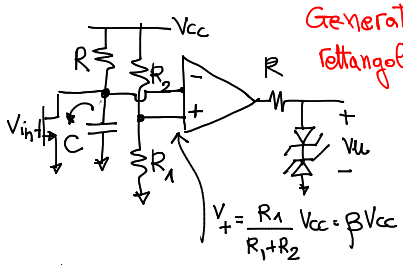
$$v^- = (V_\gamma + V_0)e^{\frac{-t+t^*}{\tau}} - V_0$$

$$v^-(t^{**}) = -\beta V_0 = (V_\gamma + V_0)e^{-\frac{T}{\tau}} - V_0$$

$$T = \tau \ln\left[\frac{V_\gamma + V_0}{V_0(1-\beta)}\right]$$



Generatore di impulsi rettangolari RETRIGGERABILE

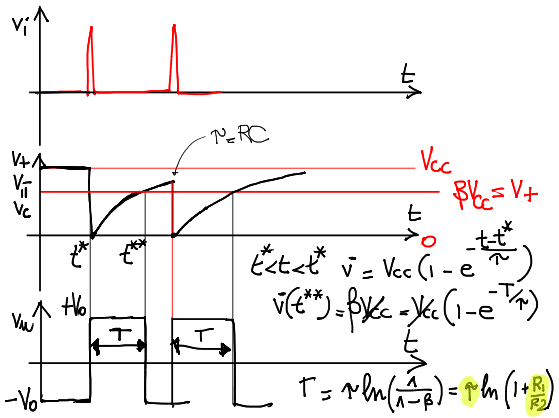


Con costante RC

Se $V_{in}=0$ MOS OFF → Vc si carica a tensione V_{cc}

→ $V_u = -V_0$

Se impulso positivo su V_{in} MOS ON → Vc si scarica a 0



Es 3. SPICE

Progettare un gen d'onda rettangolare che abbia il periodo rappresentato in figura