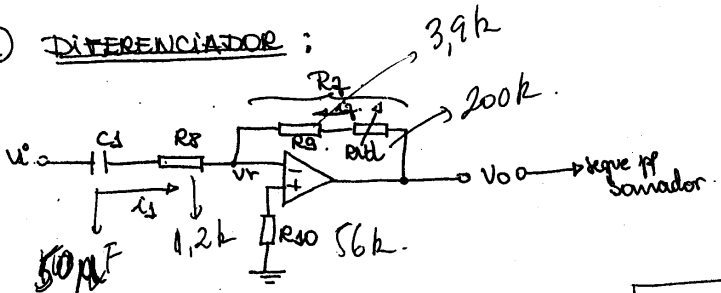
PID Analógico
TORNEIRA ELÉTRICA

① DIFERENCIADOR :

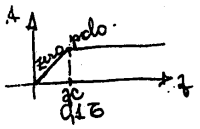


$$X_C = \frac{1}{sC} = \frac{1}{j\omega C}$$

$$\frac{V_o}{V_i} = \frac{R_f}{R_1 + \frac{1}{sC_1}} = \frac{R_f}{\frac{R_8 C_1 s + 1}{sC_1}} \Rightarrow \boxed{\frac{V_o}{V_i} = \frac{R_f C_1 . s}{R_8 . C_1 . s + 1}}$$

T_d

polo (introduzido pelo resistor R_8 – filtra ruídos de alta frequência).



$$\boxed{\frac{V_o}{V_i} = \frac{T_d . s}{0,1 . T_d . s + 1}}$$
Diferenciador

onde: $T_d = R_f . C_1 \Rightarrow \boxed{T_d = (R_9 + R_{vd}) . C_1}$

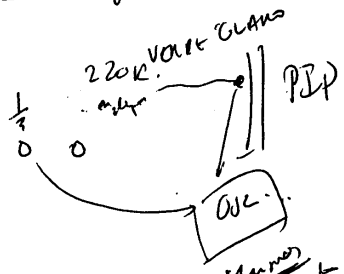
$K_d = \frac{1}{T_d}$

- pf $R_{vd\,max} \Rightarrow \boxed{T_d = 20,4\,s}$ /2
- pf $R_{vd\,min} \Rightarrow \boxed{T_d = 0,39\,s}$ /2
- pf eliminar T_d, abrir "jump" na saída do circuito.

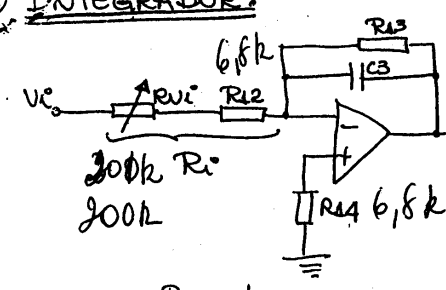
Obs: sem o resistor R_8:

$$\frac{V_o}{V_i} = \frac{R_f}{\frac{1}{sC_1}} \Rightarrow \boxed{\frac{V_o}{V_i} = \frac{R_f C_1 . s}{T_d}}$$

→ Introduz apenas um zero. Não é factível!!



② INTEGRADOR:



$C_3 = 50\,\mu F$

$R_{13} = 10\,M$

$u(t) = K_p\left[e(t) + \frac{1}{T_i}\int e(t)dt + T_d\frac{de(t)}{dt}\right]$?

$$\frac{\frac{R_{13}\cdot\frac{1}{sC_3}}{R_{13}+\frac{1}{sC_3}}}{Ri} = \frac{\frac{R_{13}}{sC_3}}{Ri} \Rightarrow \frac{Vo}{Vi} = \frac{R_{13}}{(R_{13}C_3 s+1)\cdot Ri} \Rightarrow \%\,Ri$$

$$\frac{Vo}{Vi} = \frac{1}{C_3 Ri\, s + \frac{Ri}{R_{13}}} \quad 0,\ \text{pois } R_{13}=10M\Omega. \Rightarrow \boxed{\frac{Vo}{Vi} = \frac{1}{Ri C_3 s + 1}}$$

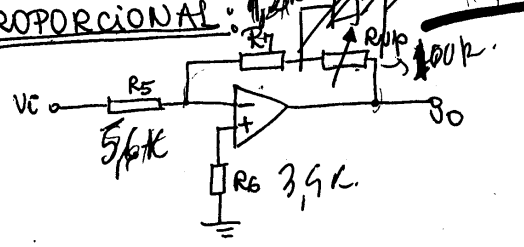
τ_i

onde: $\tau_i = Ri\cdot C_3 \Rightarrow \boxed{\tau_i = (RVi + R12)\cdot C_3}$

$K_i = \frac{1}{\tau_i}$

- p/ $RVi_{máx} \Rightarrow \tau_i = 20{,}68\,s$; /2
- p/ $RVi_{mín} \Rightarrow \tau_i = 0{,}68\,s$; /2
- p/ eliminar a ação integral, abrir "jump" na saída do circuito.

② PROPORCIONAL:



$RVp = 580\,k\Omega$

$$\frac{Vo}{Vi} = \frac{R7 + RVp}{R5}$$

K_p 103,78 kΩ

- $K_{p\,máx} = 78{,}6$
- $K_{p\,mín} = 40$

0,214 kΩ

$R7 = 220\,K\Omega$
$RVp = 220\,K\Omega$
$R5 = 5{,}6\,K$