$$G(s) = \frac{1}{(s+1)^3} =$$

$$= \frac{1}{s^3 + 3s^2 + 3s + 1}$$

$$(s+1)(s+1) \equiv \text{conv}([1\ 1],[1\ 1])$$

PID

1) Standard (reale)

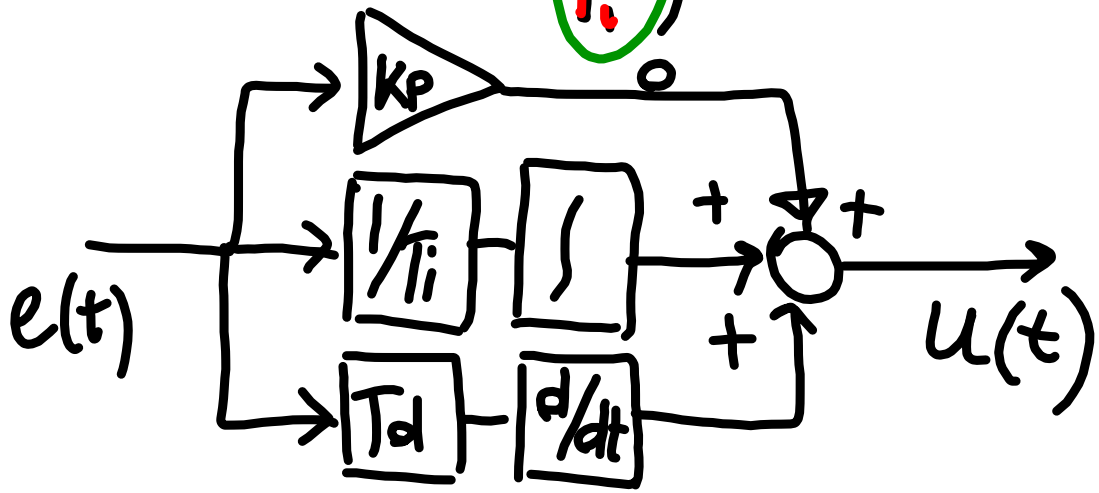
$$u(t) = K_p \left(e(t) + \frac{1}{T_i} \int_0^t e(\tau)\,d\tau + T_d \frac{de(t)}{dt} \right)$$

- K_p → migliora l'errore a regime
- $1/T_i$ → annulla l'errore a regime (pericolo instabilità!)
- T_d → riduce la sovraelongazione (stabilizzante)

2) PID ideale

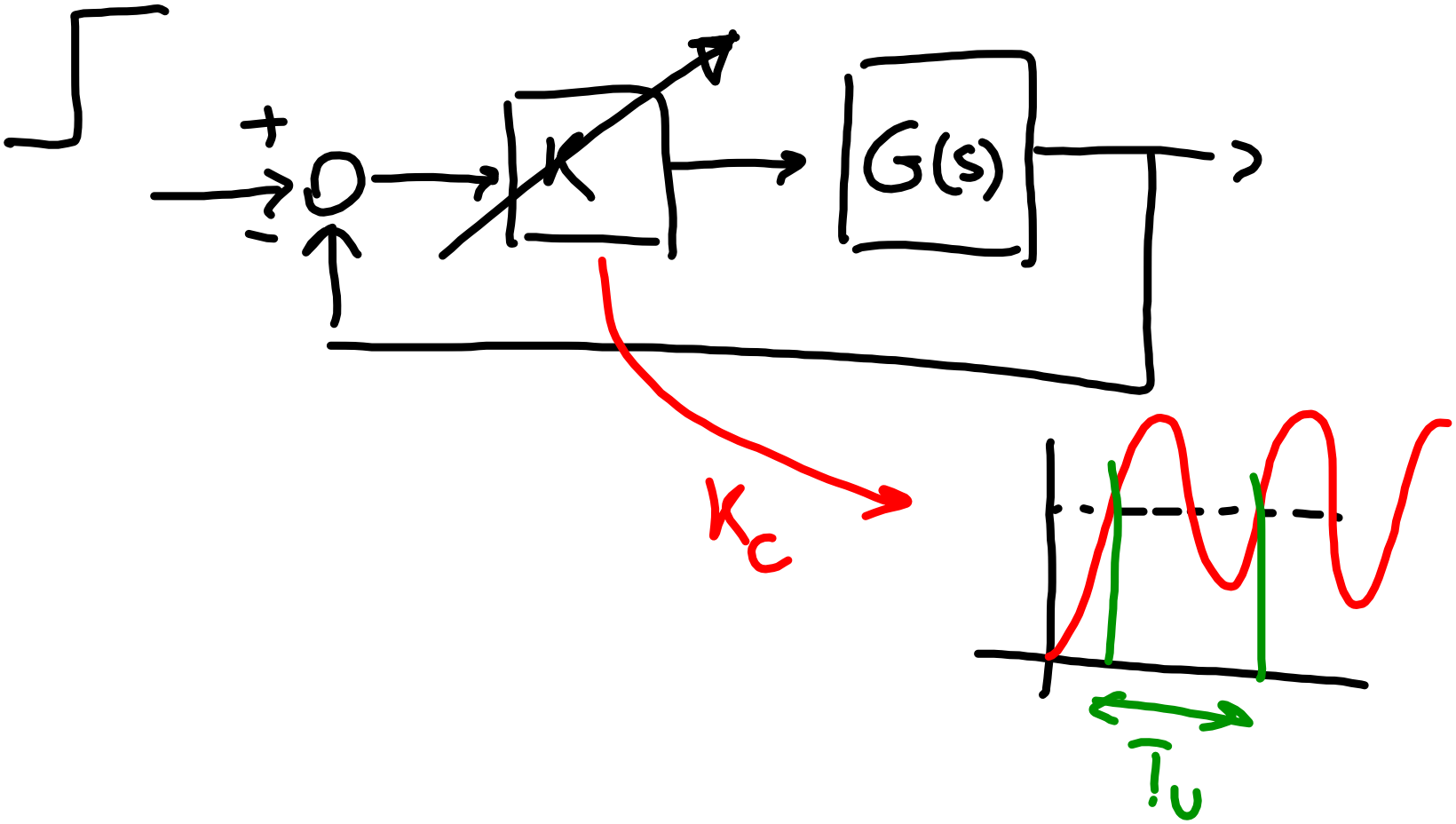
$$u(t) = K_p\, e(t) + \frac{1}{T_i}\int_0^t e(\tau)\,d\tau + T_d \frac{d\,e(t)}{dt}$$

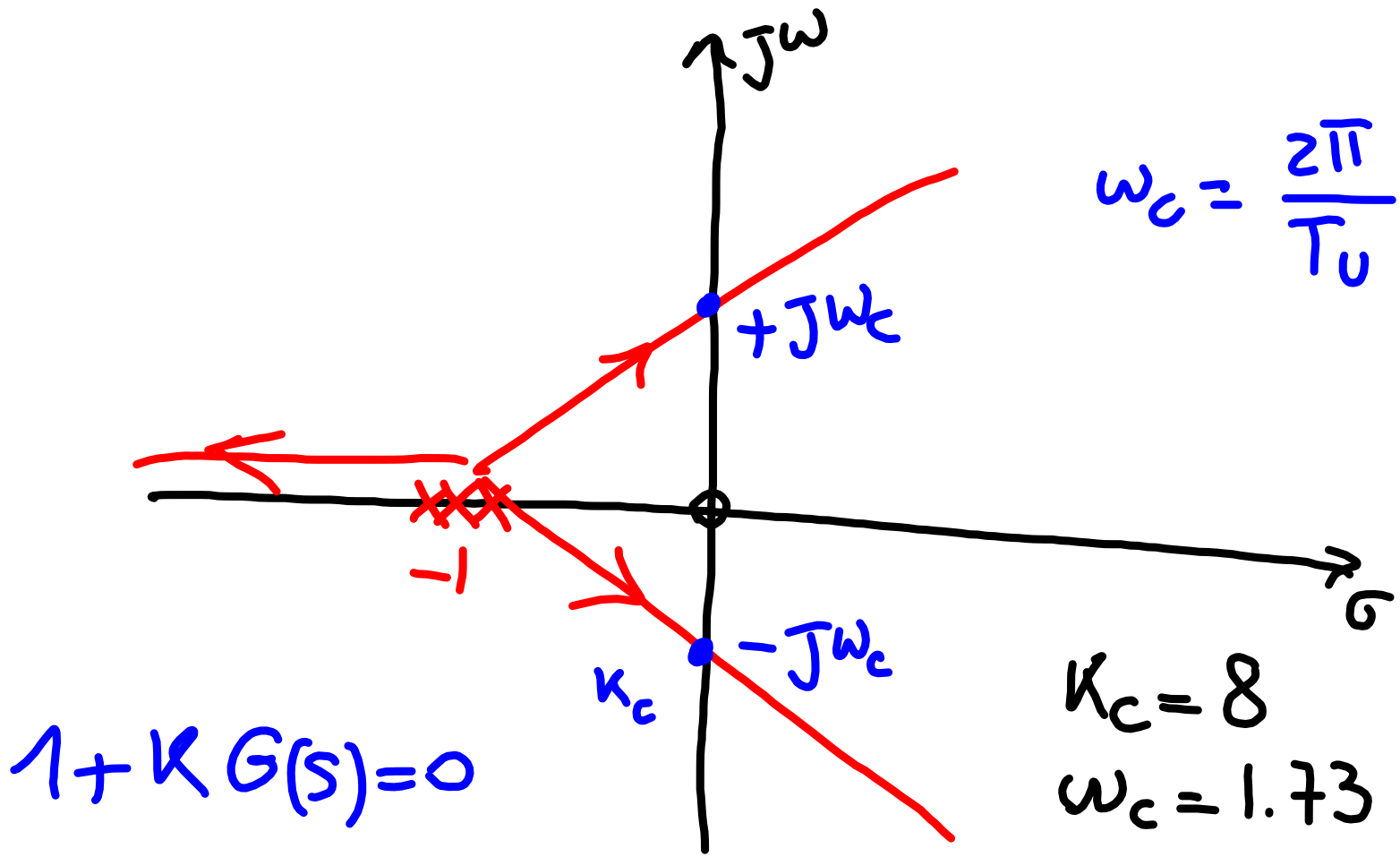
K_i K_d



Formule di Ziegler Nichols

- $K_p = 0.6 \; K_c$
- $T_i = 0.5 \cdot T_u$
- $T_d = 0.125 \cdot T_u$


+
−
K
G(s)
K_c
T_u



$\omega_c = \frac{2\pi}{T_U}$

$1 + K G(s) = 0$

$K_c = 8$

$\omega_c = 1.73$

PID in Simulink (2017)

1) $P + I\frac{1}{s} + \boxed{D \cdot s} = \frac{P \cdot s + I + D s^2}{s}$

non fisicamente realizzabile

2) Termine derivativo filtro

$$D\,\frac{N}{1 + N \cdot \frac{1}{s}} = D\,\frac{sN}{s+N}$$

$N \to \infty$