TODAY'S CLASS : IMPROVING CONTROLLER'S PERFORMANCE

↳ PID : Detrimental effects of SATURATION

HOW TO COUNTERACT ?

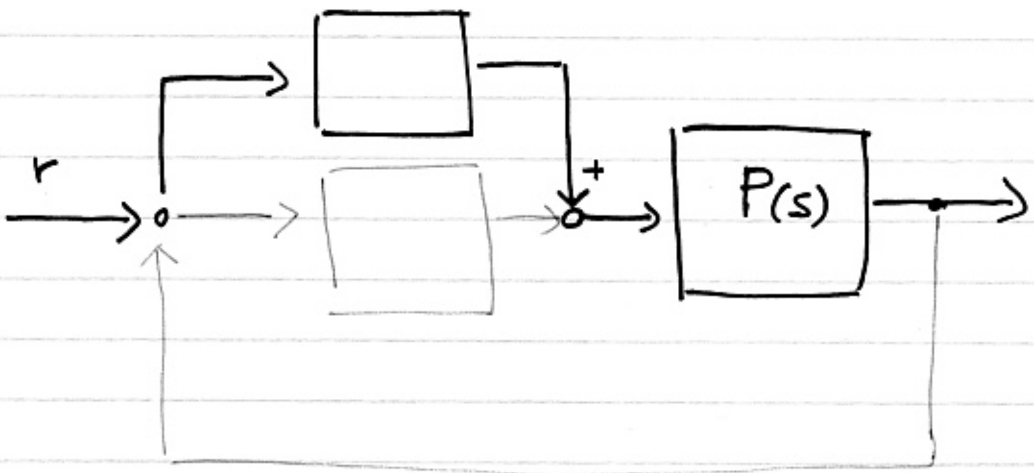
↳ GENERAL CASE : HOW TO "REDUCE" THE EFFORT REQUIRED FROM $C(s)$

- FEED FORWARD : USE OUR KNOWLEDGE OF $P(s)$ TO ~~DESIGN~~ DESIGN "NOMINAL" CONTROL (OPEN LOOP)

- then FEEDBACK IS USED "ONLY" TO COMPENSATE FOR ERRORS, ROBUSTNESS

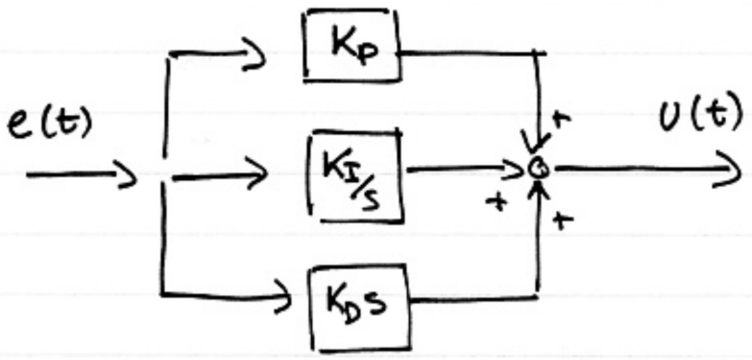
(VIDEO & NOTES)

- AT THE END : EXPLICIT APPLICATION TO OUR CASE (Feedforward for MOTOR)



HOW TO IMPROVE THE PID RESPONSE?

- we considered :



- Assume $y(t) = 0$ up to $t = 0$

$$r(t) = \mathbb{1}(t)$$

$$\Rightarrow \quad e(t) \cong \mathbb{1}(t)$$ for very small t, with $P(s)$ proper

- $$K_D s\, E(s) \simeq K_D + \dots$$

$$\downarrow \mathcal{L}^{-1}$$

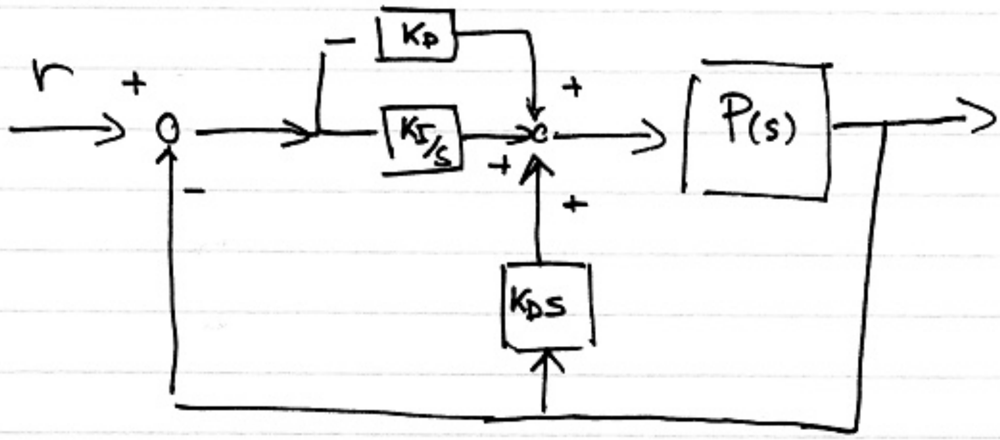
$$K_D \frac{d}{dt} e(t) \simeq K_D\, \delta(t)$$ ← PART OF $u(t)$

▷ NON PHYSICAL : we add pole in $-\frac{1}{T_L}$

▷ IT CAN STILL BE VERY HIGH, SATURATE ...

$\Rightarrow$ We can consider a PI - D configuration

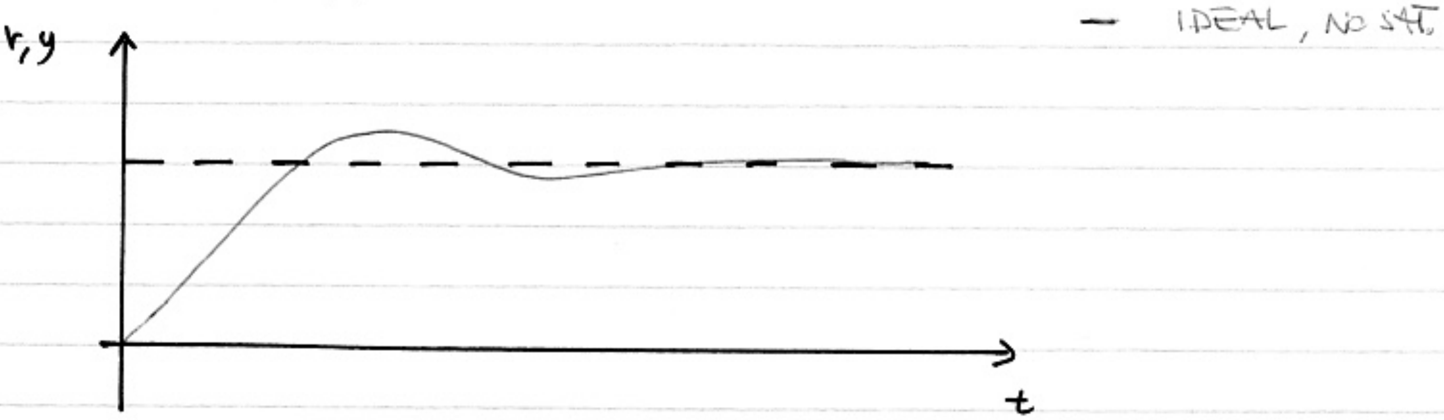
PI-D



$P(s)$ PROPER, TYPICALLY HIGH. REL. DEG. $\Rightarrow$ SMOOTHS THE SIGNAL

- EVEN WITHOUT IMPULSES, HIGH GAINS $\Rightarrow$ SATURATION

what happens?



▷ WITH RESPECT TO THE DESIGNED BEHAVIOUR

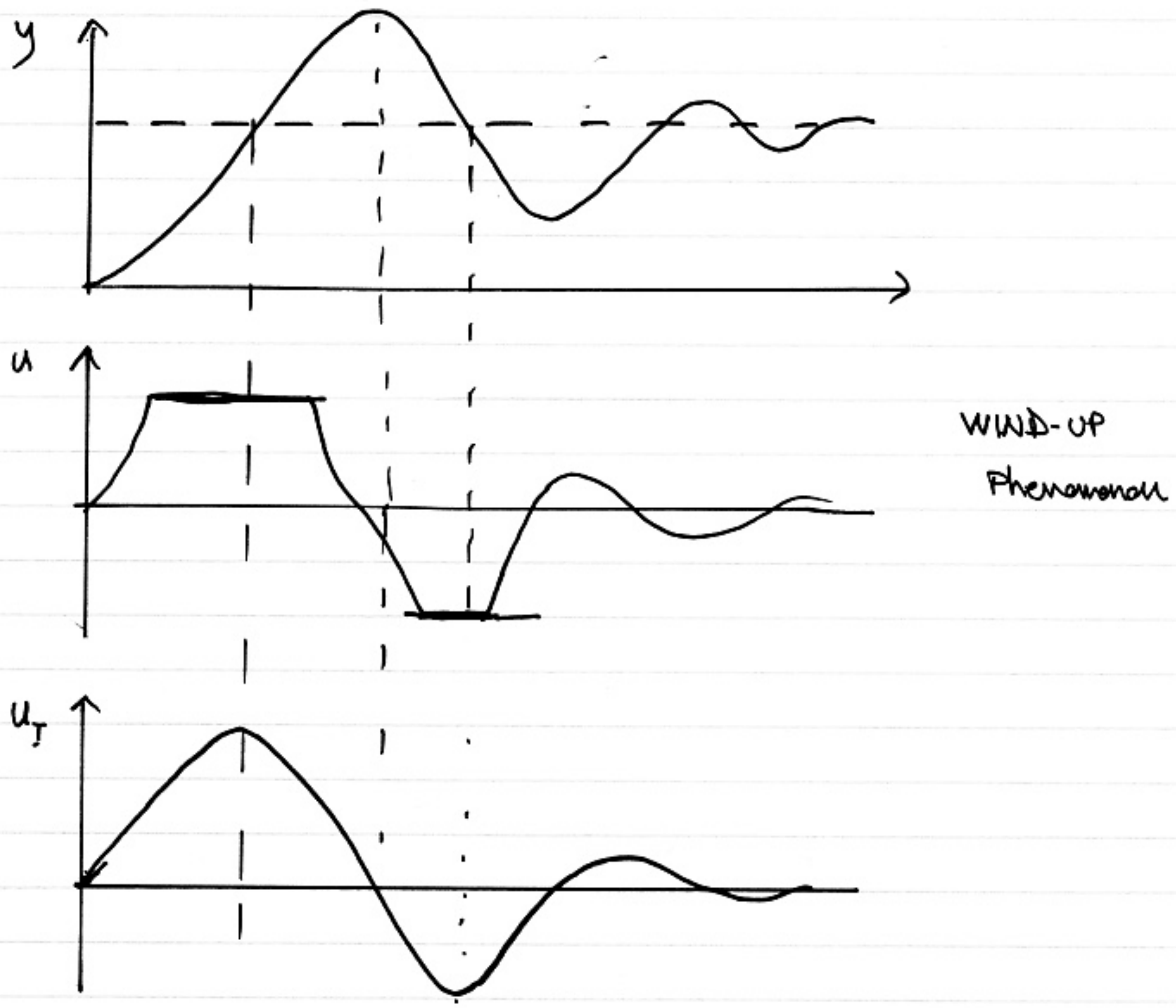
- $e(t)$ is Larger, takes longer to $e(t_c)=0$
- $e(t)$ is INTEGRATED in K_I/s : INERTIA EFFECT

$$U_I(t) = K_I \int_0^t e(\tau)\, d\tau$$

- the negative $e(t)$ after t_c must erode this accumulated error
- It takes LONGER for $u(t) = u_p(t) + u_D(t) + u_I(t)$ to SWITCH SIGN

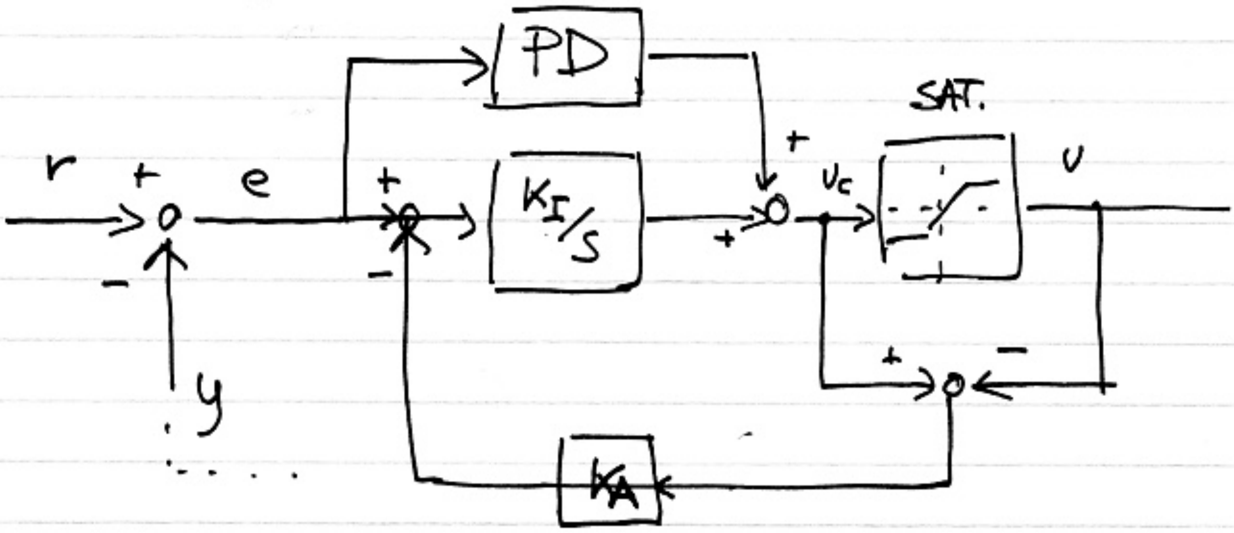
$\Rightarrow$ EXTRA OVERSHOOT,

POSSIBLY also saturation for negative u



$\Rightarrow$ ANTI-WINDUP ARCHITECTURE

- detects saturation
- mitigates effects



- IF $U_c = U$, NO SATURATION, "NORMAL" PID
- IF $U_c \neq U$ THE INTEGRATOR INPUT IS

$$e(t) - K_A\left(U_c(t) - U(t)\right)$$

$$\Delta \quad T_a \simeq (K_A K_I)^{-1} \simeq \frac{t_s^*}{3}$$

APPROXIMATE RELATION FOR DESIGN

PERFORMANCE SPEC.

$$\Rightarrow K_A = \frac{3}{t_s^* K_I}$$

AS A FIRST, TENTATIVE CHOICE

ADAPT BY TRIAL & ERROR.