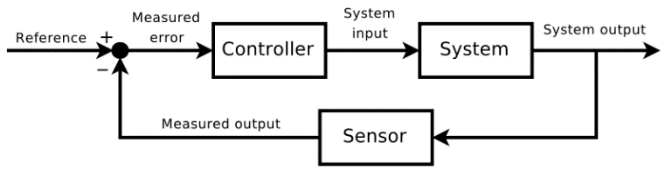
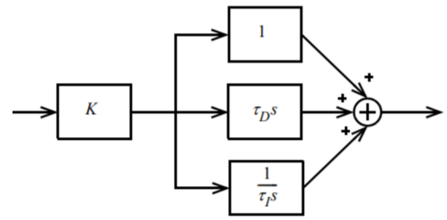


CLOSED LOOP CONTROL

To reduce disturbances, noises and increase the quality of control

PID CONTROLLERS

The figure left shows the parallel realization of the PID controller structure. Each term (P,I,D) can be turned off, properties given below. Parameterization of controller is summarized in next sections.

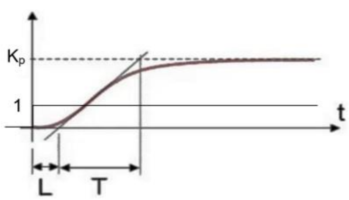


P – easy but there is error in following the reference signal (i.e. the set point)
PI – follows the reference signal but slow and can be unstable
PD – fast but does not follow the reference signal correctly
PID – all in one ☺

Ziegler-Nichols open loop method

Works for low order systems which can be approximated as $\frac{K_p}{(1+sT)} e^{-Ls}$

1) Turn off any integrator and differentiator in the controller. Set K (gain) to 1.
2) Measure the unit step response of the underlying open loop system (plant model identification, feedback term involved).
3) Estimate the gain K_p, time delay L and the dominant time constant T, see figure.
4) Apply the following controller parameters:

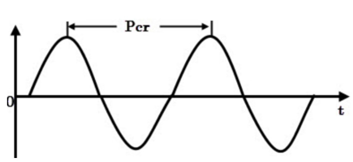


	K	τ_i	τ_D
P	$T/L/K_p$	Inf (off)	0 (off)
PI	$0.9T/L/K_p$	L/0.3	0 (off)
PID	$1.2T/L/K_p$	2L	0.5L

Ziegler-Nichols closed loop method

Works for closed loop systems which oscillates at certain gain level.

1) Turn off any integrator and differentiator in the controller. Set K (gain) to a low value.
2) Measure the unit step response of the closed loop system.
3) Gradually increase K until the system just starts to oscillate, this value is the Kcr – critical gain.
4) Estimate the period time of the oscillation, see figure.
5) Apply the following controller parameters:



	K	τ_i	τ_D
P	0.5Kcr	-	-
PI	0.45Kcr	Pcr/1.2	-
PID	0.6Kcr	Pcr/2	Pcr/8

Based on specification

1) Plot the Bode of the open loop system – feedback term (sensor) included.
2) Based on the desired phase margin or gain margin, decide how much the magnitude Bode plot should be shifted up/down to reach the desired margin (shift up: K=[shifted_value], if shift down K=1/[shifted_value]). Do not forget to convert from decibels to real numbers.
3) The integration time is the dominant time constant (time constants=-(1/real(poles))).
4) The differentiation time is the second dominant time constant.