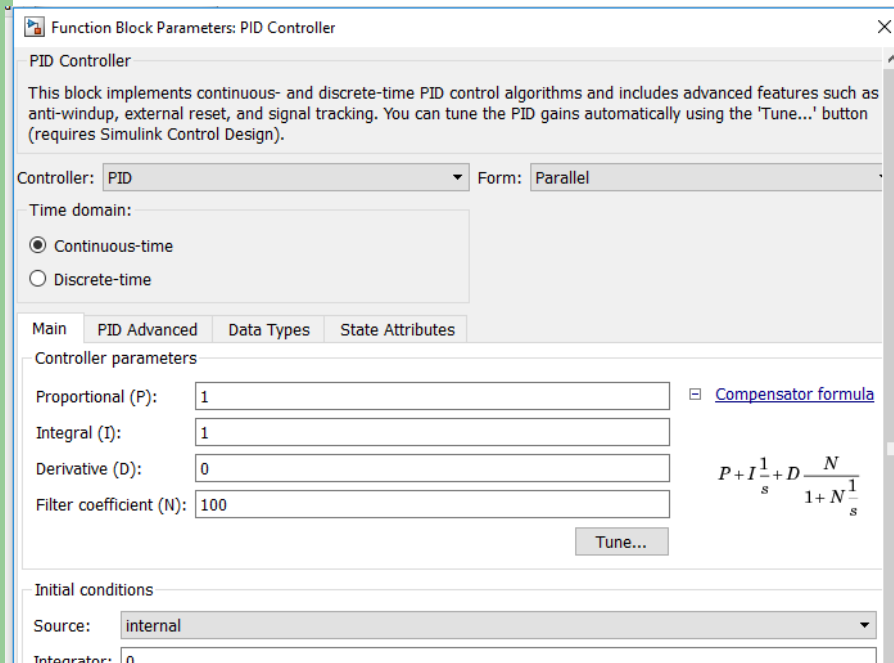


PID Controller

System & Control Engineering Lab.
School of Mechanical Engineering

PID Controller

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



The screenshot shows the 'Function Block Parameters: PID Controller' dialog box. It includes a description of the block, control mode options (Continuous-time selected), and a 'Controller parameters' section with input fields for Proportional (P), Integral (I), Derivative (D), and Filter coefficient (N). A 'Tune...' button is present. The 'Compensator formula' is displayed as $P + I \frac{1}{s} + D \frac{N}{1 + N \frac{1}{s}}$.

Function Block Parameters: PID Controller

PID Controller

This block implements continuous- and discrete-time PID control algorithms and includes advanced features such as anti-windup, external reset, and signal tracking. You can tune the PID gains automatically using the 'Tune...' button (requires Simulink Control Design).

Controller: PID Form: Parallel

Time domain:

Continuous-time

Discrete-time

Main PID Advanced Data Types State Attributes

Controller parameters

Proportional (P): 1 [Compensator formula](#)

Integral (I): 1

Derivative (D): 0

Filter coefficient (N): 100

$P + I \frac{1}{s} + D \frac{N}{1 + N \frac{1}{s}}$

Tune...

Initial conditions

Source: internal

Integrator: 0

PID Controller via ZN step response

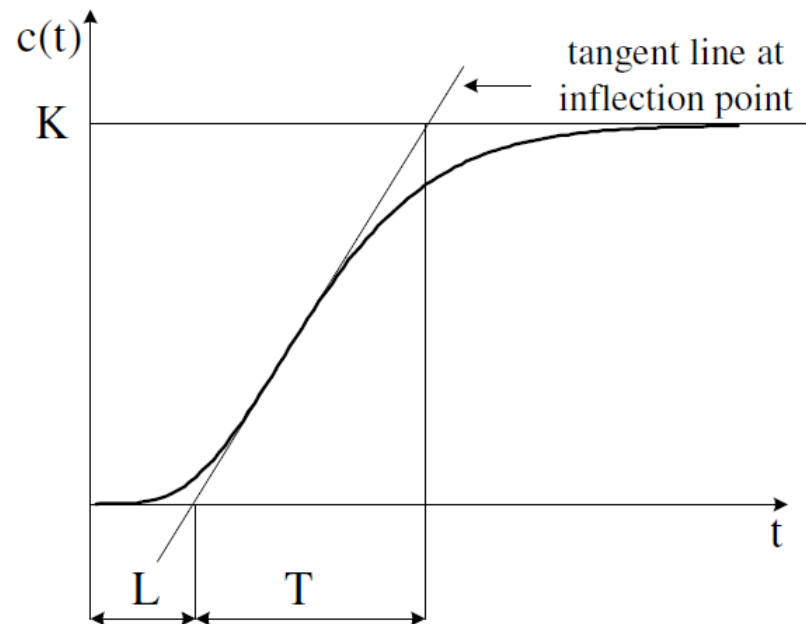


Figure 9: Open-loop step response (S-shaped response curve)

PID Controller via Ziegler-Nichol(ZN) step response

Type of controller	K_p	T_i	T_d
P	T/L	∞	0
PI	$0.9T/L$	$L/0.3$	0
PID	$1.2T/L$	$2L$	$0.5L$

Table 2: PID Parameters

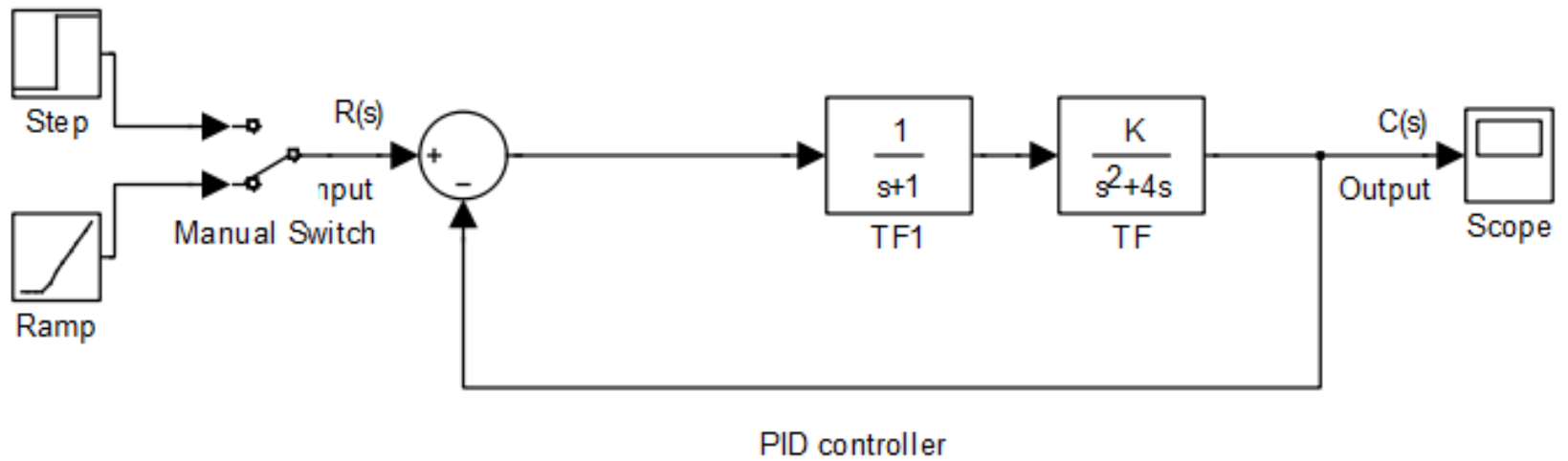
PID Controller via ZN frequency response

$$G_{PID}(s) = K_p \left(1 + \frac{1}{T_i s} + T_d s \right)$$

Type of controller	K_p	T_i	T_d
P	$0.5K_0$	∞	0
PI	$0.45K_0$	$1/1.2T_0$	0
PID	$0.6K_0$	$0.5T_0$	$0.125T_0$

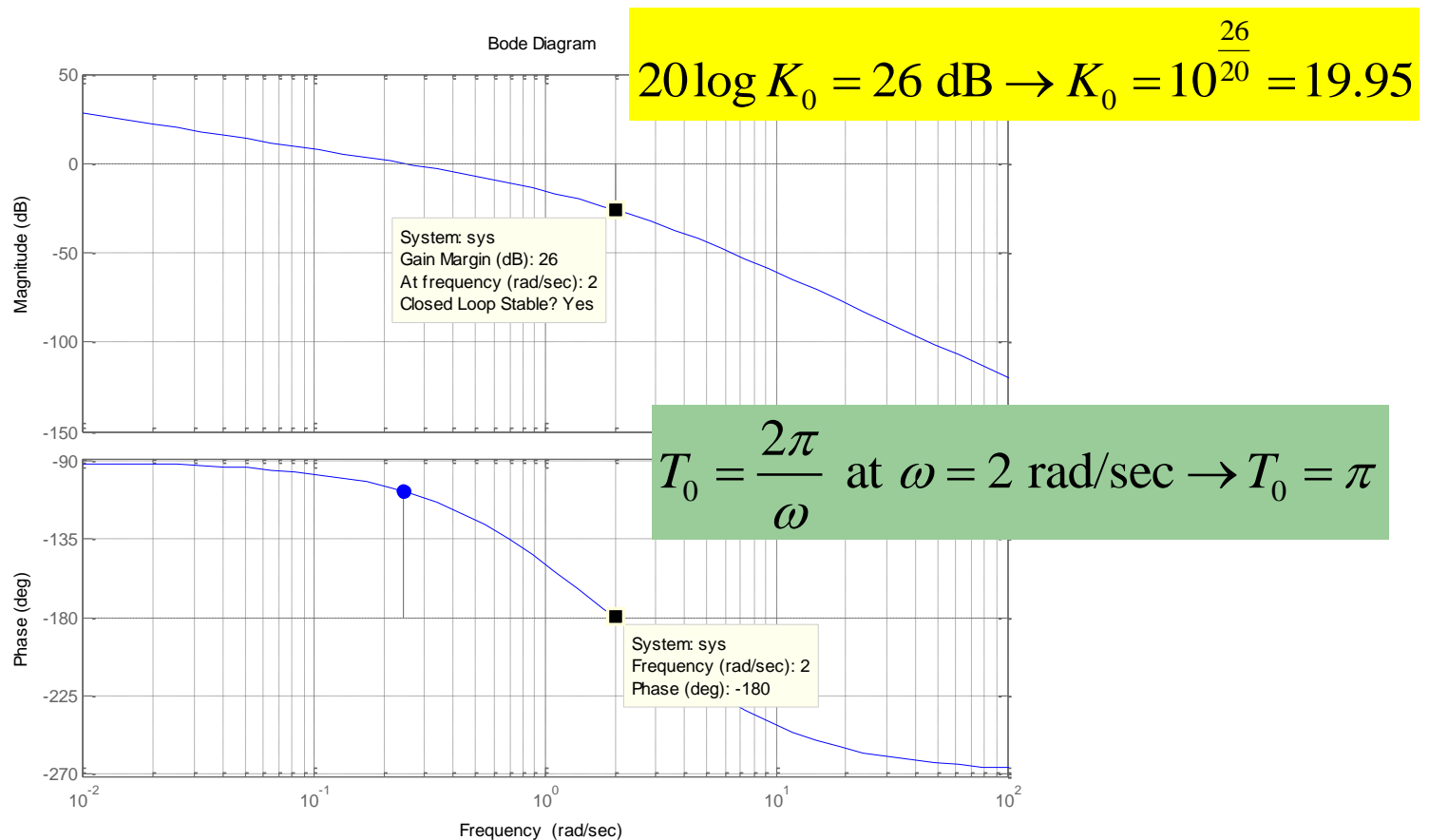
Table 1: PID Parameters

PID Controller design



PID Controller design

Open-loop TF-Bode diagram



PID Controller design

$$K_p = 0.6K_0 = 9.976$$

$$T_i = 0.5T_0 = 1.57$$

$$T_d = 0.125T_0 = 0.3927$$

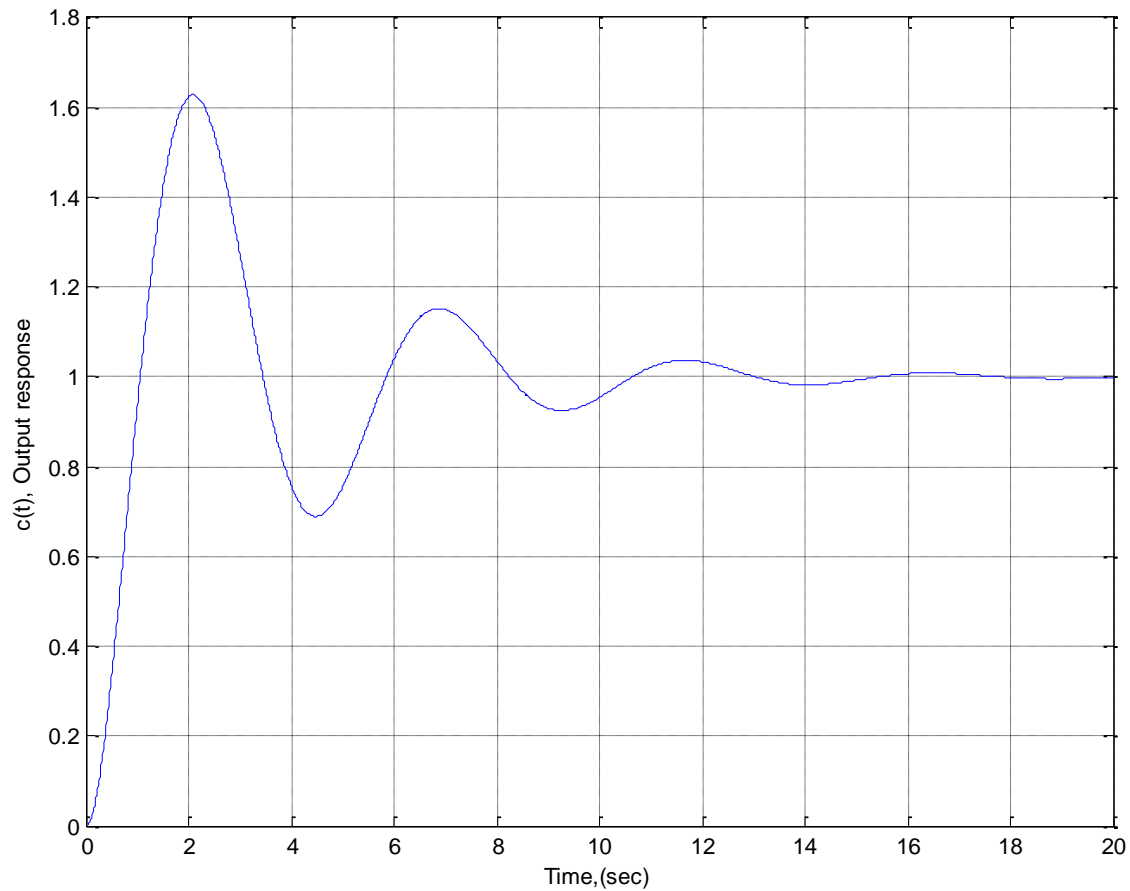
PID parameters for Simulink/MATLAB

$$P = K_p = 9.976$$

$$I = \frac{K_p}{T_i} = 6.354$$

$$D = K_p T_d = 9.976(0.3927) = 3.917$$

PID Controller design



P Controller

$$T_i = \infty \text{ and } T_d = 0.$$

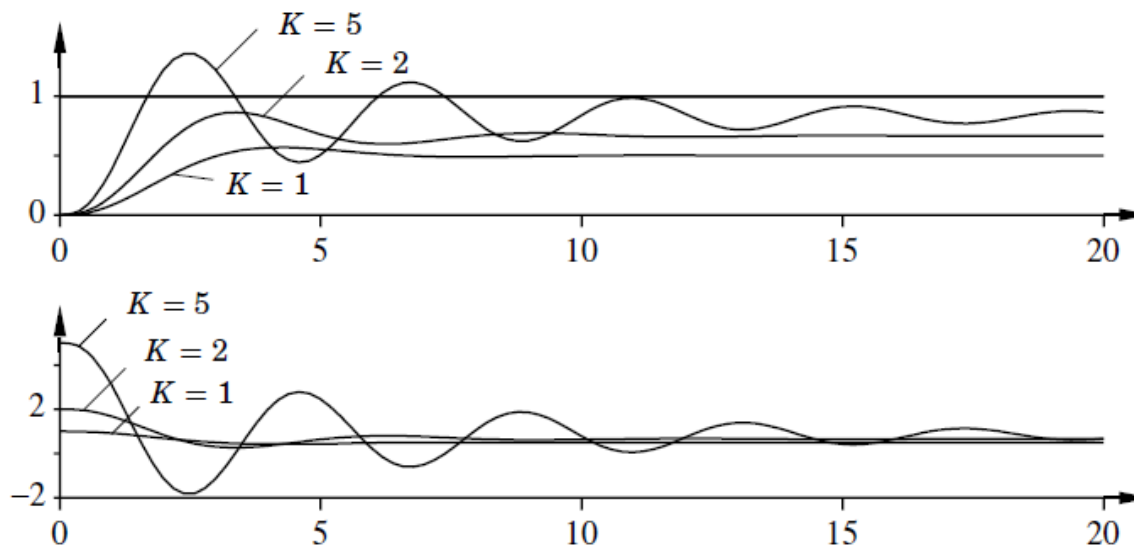


Figure 6.1 Simulation of a closed-loop system with proportional control. The process transfer function is $P(s) = 1/(s + 1)^3$.

PI Controller

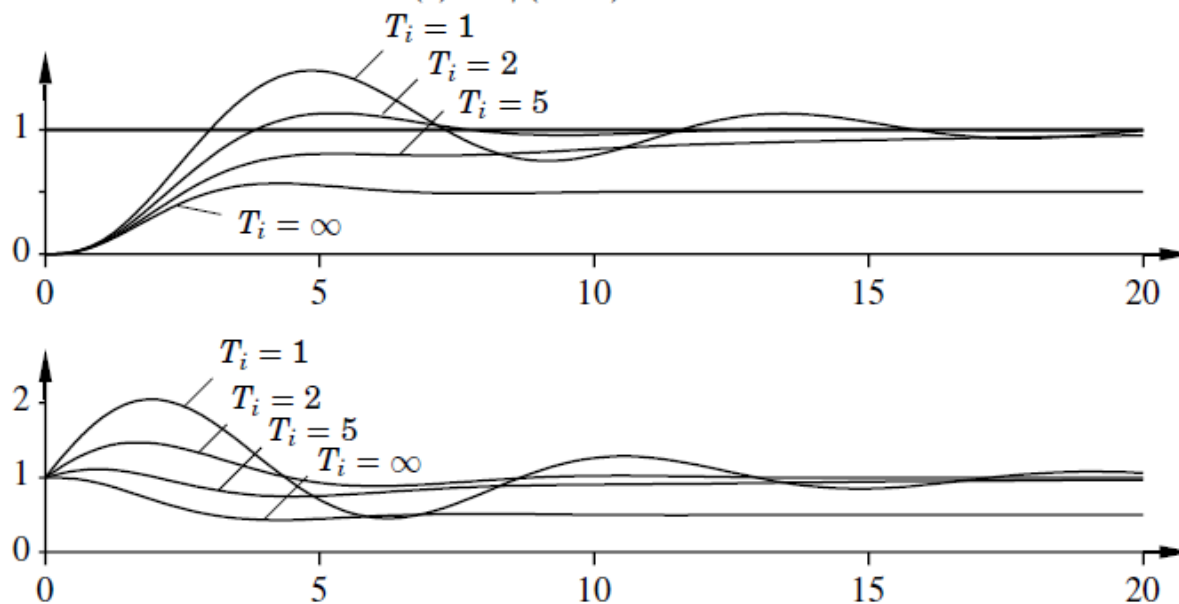


Figure 6.2 Simulation of a closed-loop system with proportional and integral control. The process transfer function is $P(s) = 1/(s + 1)^3$, and the controller gain is $K = 1$.

PD Controller

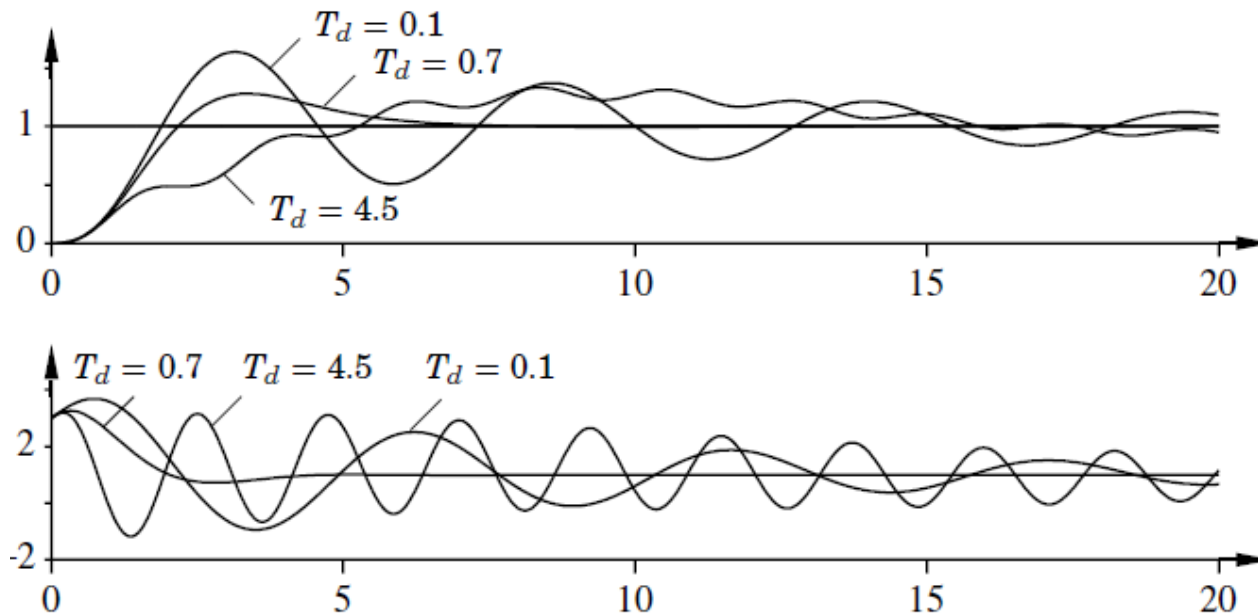
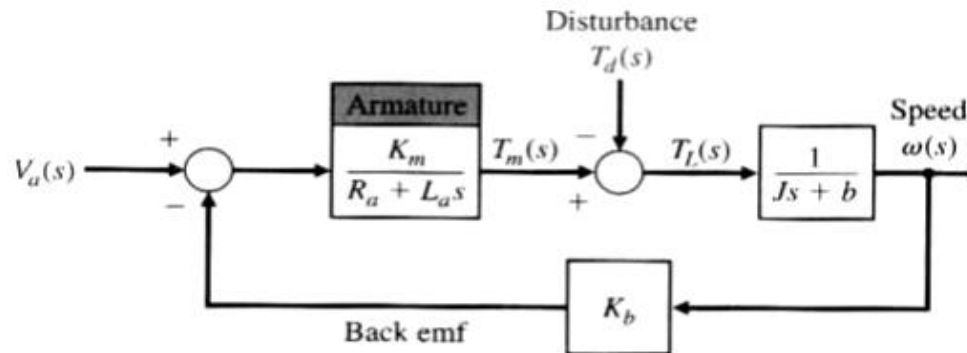


Figure 6.3 Simulation of a closed-loop system with proportional, integral and derivative control. The process transfer function is $P(s) = 1/(s + 1)^3$, the controller gain is $K = 3$, and the integral time is $T_i = 2$.

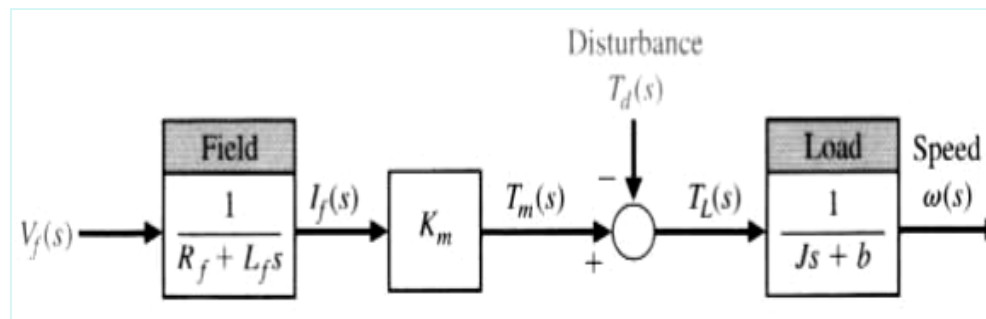
DC motor

Speed control

Armature Controlled DC motor



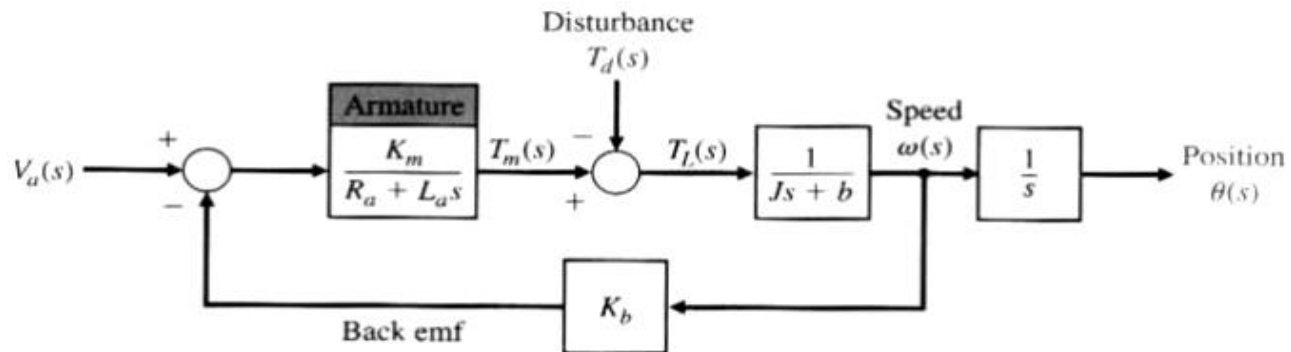
Field Controlled DC motor



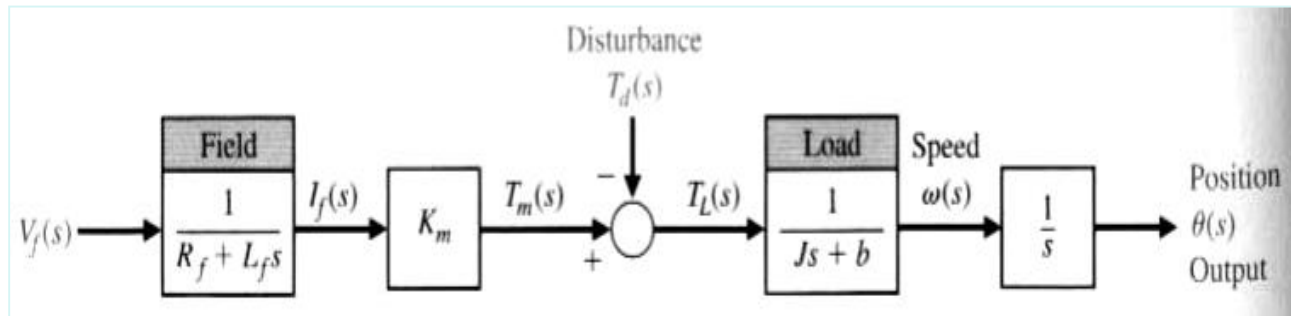
DC motor

Position control

Armature Controlled DC motor



Field Controlled DC motor

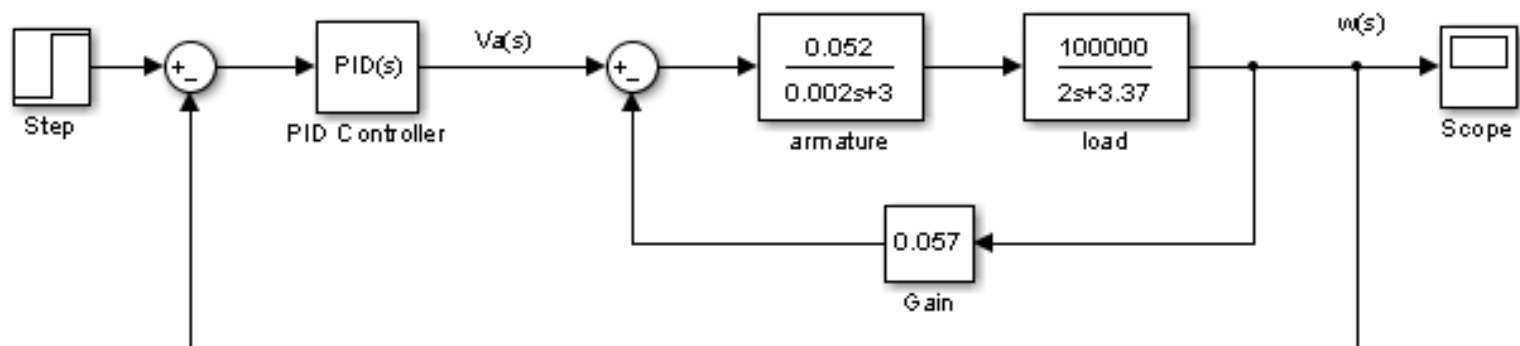


Speed control for Armature controlled DC motor

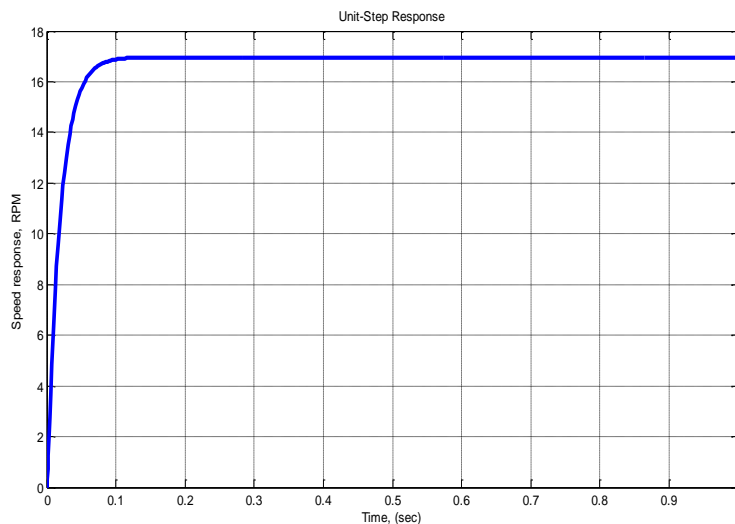
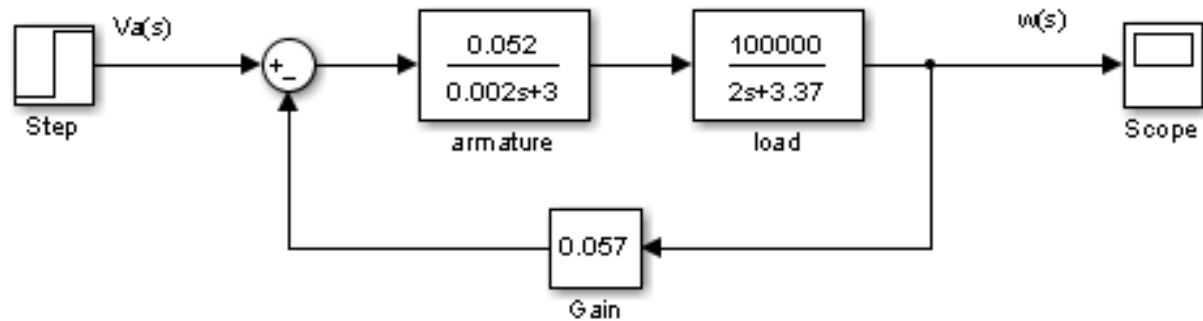
$$J = 2.0069 \times 10^{-4} \text{ kg} \cdot \text{m}^2 / \text{rad}, K_t = 0.052 \text{ N} \cdot \text{m} / \text{A}$$

$$K_b = 0.057 \text{ V} \cdot \text{s} / \text{rad}, b = 3.3677 \times 10^{-4} \text{ N} \cdot \text{m} \cdot \text{s} / \text{rad}$$

$$R_a = 2.9981 \Omega, L_a = 2.0864 \times 10^{-3} \text{ H}$$



Speed control for Armature controlled DC motor



System type = 0

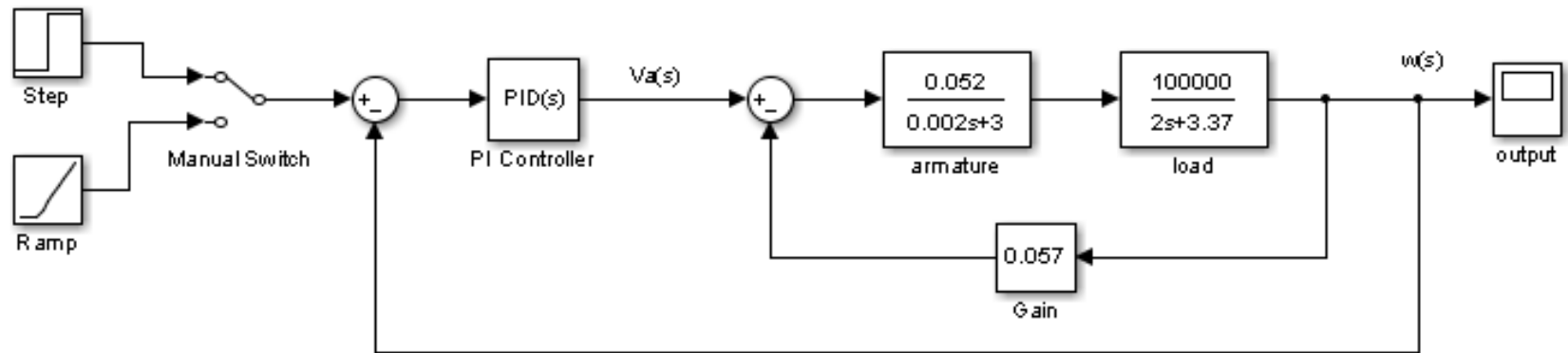
$$I = 2.0069 \times 10^{-5} \text{ kg} \cdot \text{m}^2 / \text{rad}, K_t = 0.052 \text{ N} \cdot \text{m} / \text{A}$$
$$K_b = 0.057 \text{ V} \cdot \text{s} / \text{rad}, b = 3.3677 \times 10^{-5} \text{ N} \cdot \text{m} \cdot \text{s} / \text{rad}$$
$$R_a = 2.9981 \Omega, L_a = 2.0864 \times 10^{-3} \text{ H}$$

PI-Speed control for Armature controlled DC motor

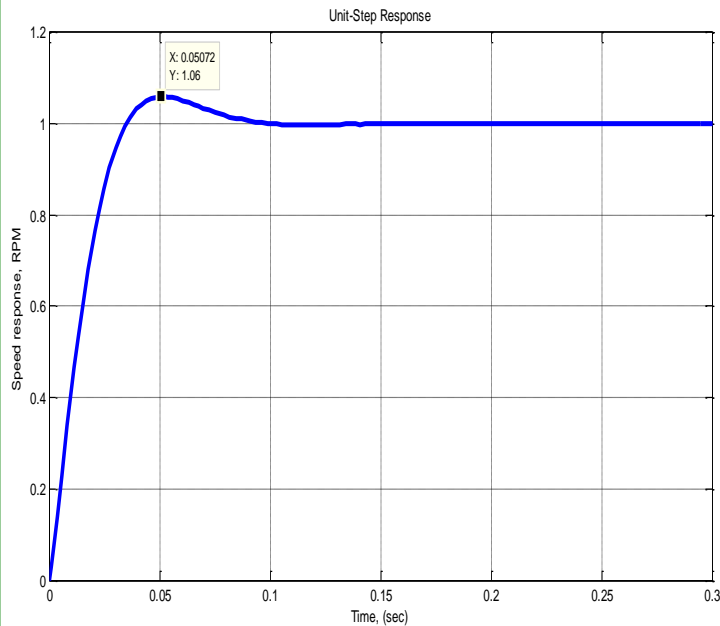
PI parameters for Simulink/MATLAB

$$P = K_P = 0.05$$

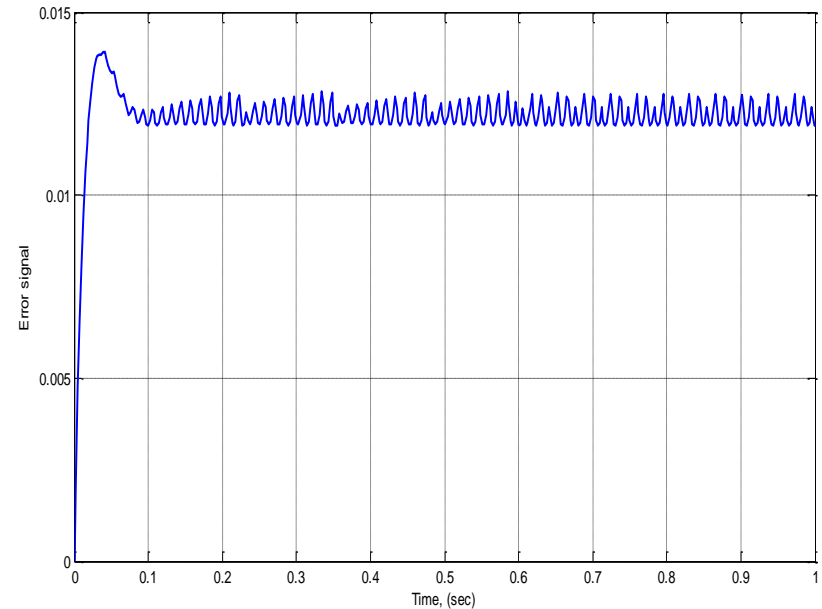
$$I = \frac{K_P}{T_i} = \frac{0.05}{0.01} = 5$$



Speed control for Armature controlled DC motor

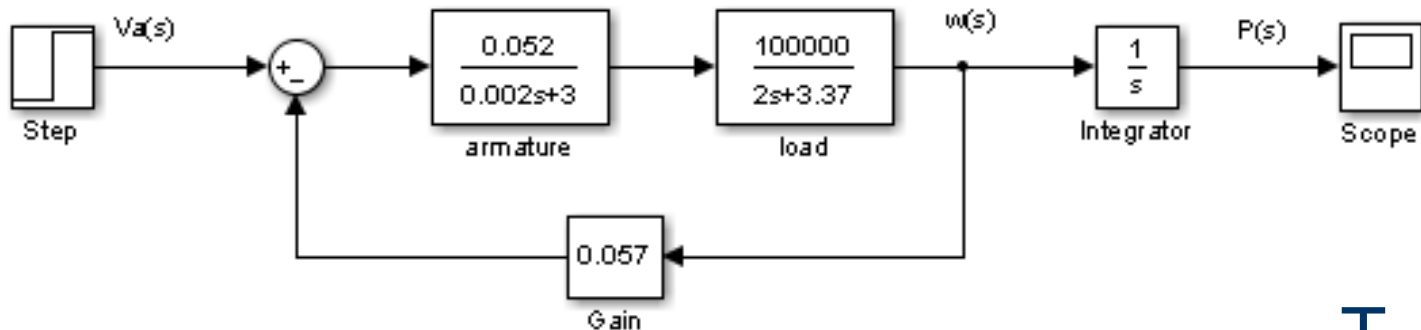
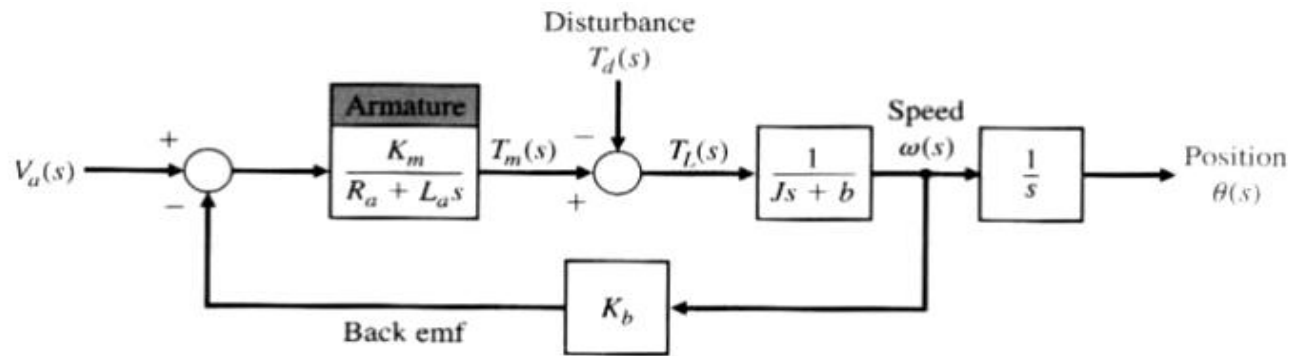


%Overshoot = 6%,
Settling time = 0.08 sec



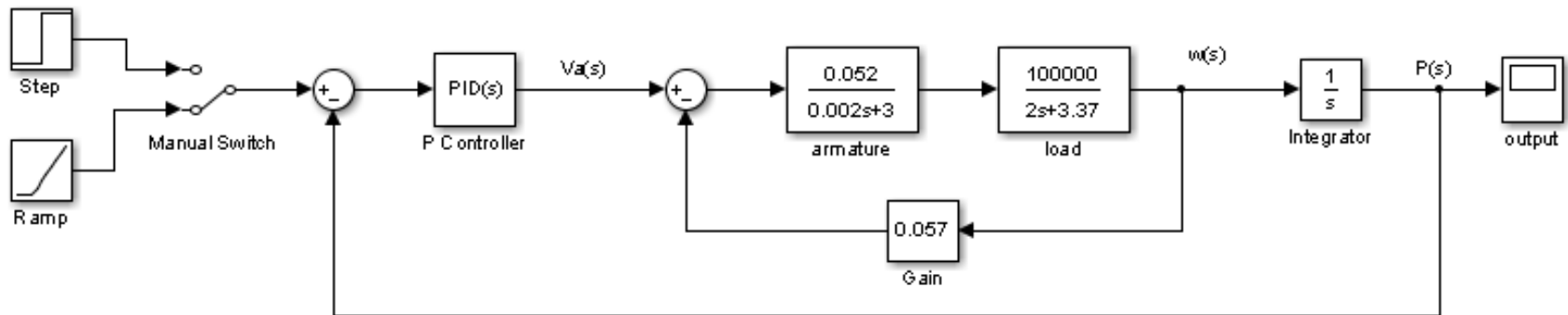
Steady state error for unit-ramp input = 0.012

Position control for Armature controlled DC motor

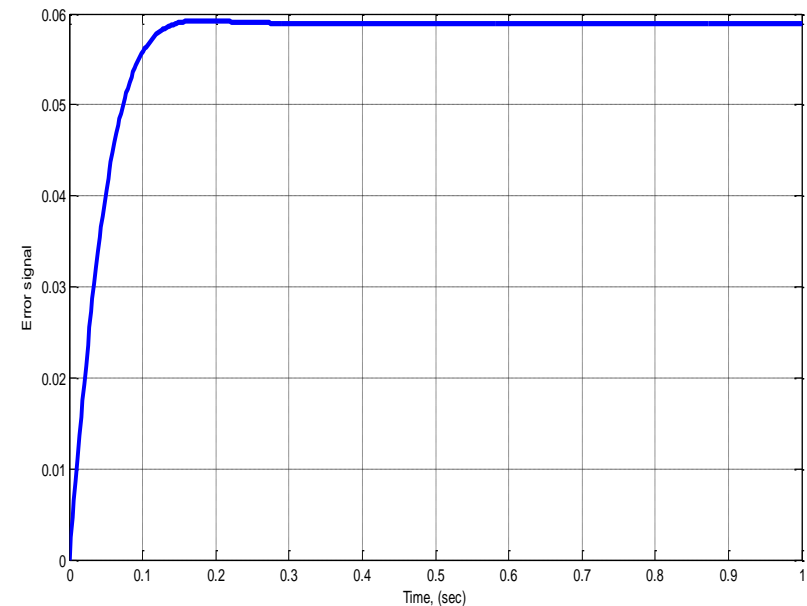
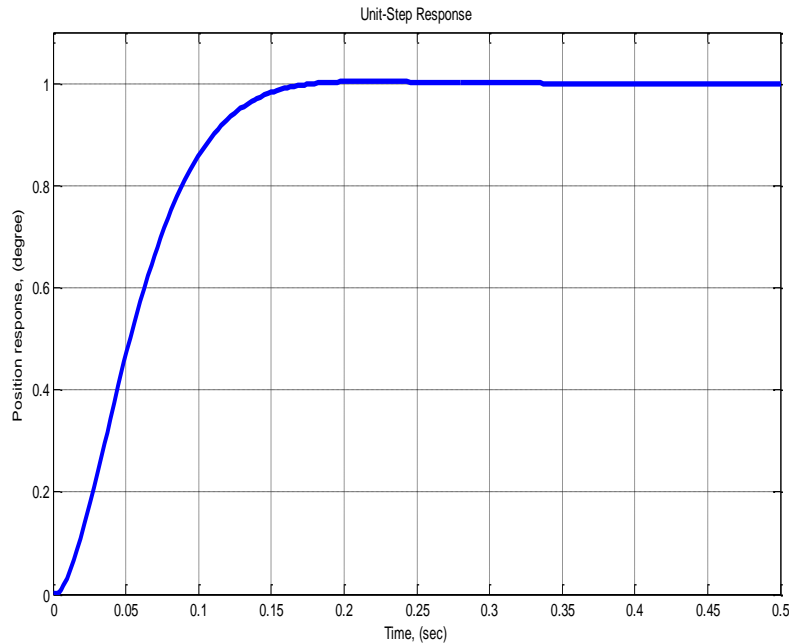


$$T_d = 0$$

Position control for Armature controlled DC motor



Position control for Armature controlled DC motor



Steady state error for unit-ramp input = 0.06

$$P = K_P = 1; \quad I = \frac{K_P}{T_i} = 0; \quad D = K_P T_d = 0$$