Excitation
$$u(t) = u_1(t) + u_2(t) + u_3(t)$$

D. C. Motor

$$G(s) \quad = \quad \frac{b}{s(s+a)}$$

Output
$y(t)$

Least Squares identification method

$$\widehat{\boldsymbol{\theta}}(k) = \widehat{\boldsymbol{\theta}}(k-1) + L(k)\epsilon(k)$$

$$L(k) = \frac{\boldsymbol{P}(k-1)\phi(k)}{\gamma + \phi^T(k)\boldsymbol{P}(k-1)\phi(k)}$$

$$\boldsymbol{P}(k) = \frac{1}{\gamma}\left[\boldsymbol{P}(k-1) - \frac{\boldsymbol{P}(k-1)\phi(k)\phi(k)^T\boldsymbol{P}(k-1)}{\gamma + \phi^T(k)\boldsymbol{P}(k-1)\phi(k)}\right]$$

$$\epsilon(k) = y(k) - \widehat{y}(k)$$

$$\widehat{y}(k) = \phi^T(k)\widehat{\boldsymbol{\theta}}(k-1)$$

Estimate
$\widehat{\boldsymbol{\theta}}(k)$

Geometric series method

Estimates
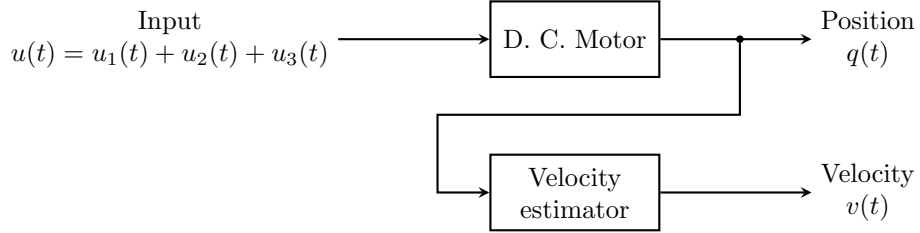$\hat{a}, \hat{b}$

Figure 1: Identification of the DC motor parameters

Input
$$u(t) = u_1(t) + u_2(t) + u_3(t)$$

D. C. Motor

Position
$q(t)$

Velocity
estimator

Velocity
$v(t)$

Figure 2: Open loop system

Perturbations
$$d(t) = d_1 + d_2\xi(t)$$

Reference
$$q_d(t) = r_1(t) + r_2(t) + r_3(t)$$

$+$

$-$

$e_q(t)$

PID
Controller

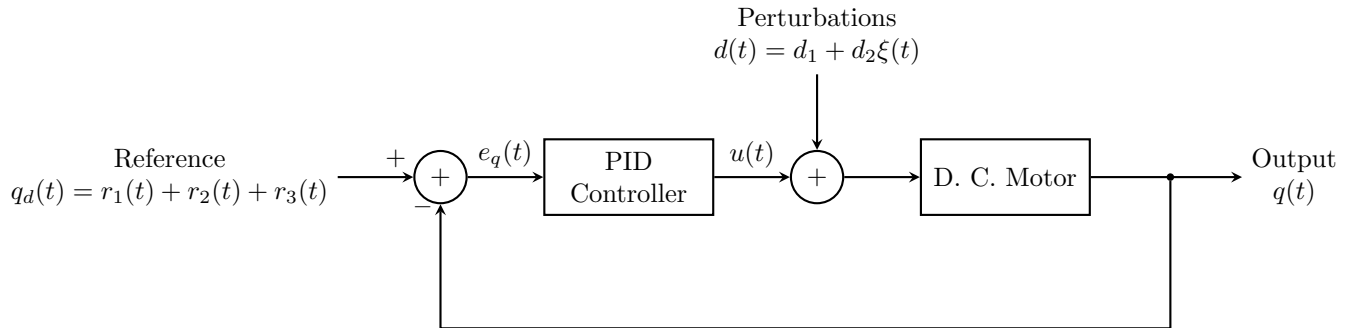$u(t)$

$+$

D. C. Motor

Output
$q(t)$

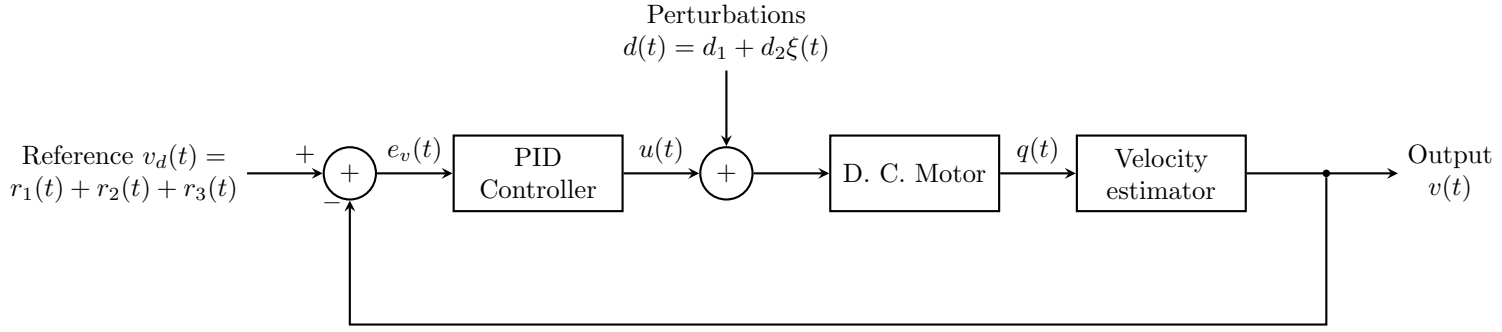Figure 3: Closed loop system with a PID Controller

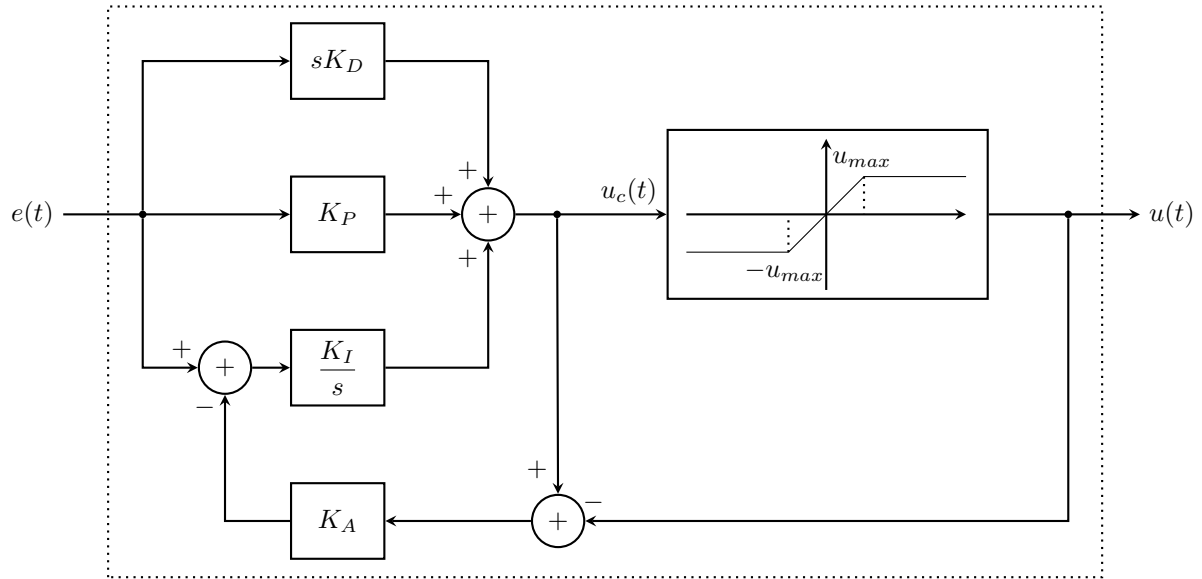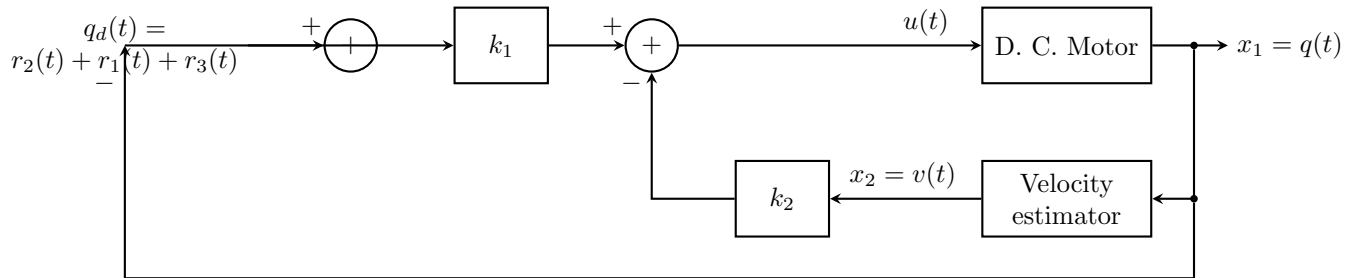1

Figure 4: Closed loop system with a PID Controller

Figure 5: PID Controller with anti-windup

Figure 6: State feedback control