- Op till Now we did speed control.
- Now position control.

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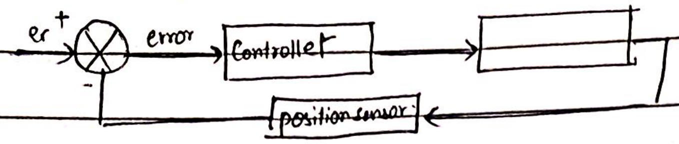

$\frac{d\theta}{dt} = \omega(t)$

Now $x_1(t) = \theta(t)$

$x_2(t) = \omega(t)$

$x_3(t) = i_a(t)$

$y(t) = \theta(t)$

use equations from speed control :

$$\begin{bmatrix} \dot{x}_1(t) \\ \dot{x}_2(t) \\ \dot{x}_3(t) \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & -B/J & \frac{K_T}{J} \\ 0 & -K_b/L_a & -R_a/L_a \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \\ x_3(t) \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1/L_a \end{bmatrix} u(t)$$

$y(t) = x_1(t)$

$\dot{x}(t) = Ax(t) + bu(t)$

$y(t) = c\,x_1(t)$.

$$\underbrace{A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & -1 & 1 \\ 0 & -1 & -10 \end{bmatrix} \quad b = \begin{bmatrix} 0 \\ 0 \\ 10 \end{bmatrix} \quad c = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix}}_{\text{after putting values}}$$

↳ only function of x_1

Transformation of state variables :

- transforms original state variables to a covinient one.

$x = P\bar{x}$ $\quad\quad$ $\bar{x} = P^{-1}x$

↳ transformation matrix.

System will not change, but A B C D matrices will change

$$P\dot{\bar{x}}(t) = AP\bar{x}(t) + b\,u(t) \quad (\times P^{-1})$$
$$y(t) = cP\bar{x}(t) + d\,u(t)$$

$$\dot{\bar{x}}(t) = P^{-1}AP\bar{x}(t) + P^{-1}b\,u(t)$$
$$y(t) = cP\bar{x}(t) + d\,u(t).$$

$$\left.\begin{aligned} \bar{A} &= P^{-1}AP & \bar{B} &= P^{-1}B \\ \bar{C} &= CP & \bar{D} &= D \end{aligned}\right\} \text{new matrices}$$

FOR SPEED CONTROL:

$$x = \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} \omega \\ i_a \end{bmatrix}$$

$$\bar{x}_1 = \omega \qquad \bar{x}_2 = -\omega + i_a$$ new defination

$$\bar{X} = \begin{bmatrix} \bar{x}_1 \\ \bar{x}_2 \end{bmatrix} = \begin{bmatrix} x_1 \\ -x_1 + x_2 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ -1 & 1 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

$\hookrightarrow P^{-1}$ matrix

$$\text{So } P = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix}$$

CALCULATING A, B, C, D FOR SPEED CONTROL:

$$\bar{A} = P^{-1}AP$$
$$\bar{b} = P^{-1}b$$
$$\bar{c} = cP$$

→ Do the calculation's later on!

~~Conver~~ CONVERSION OF STATE VARIABLE TO TRASFER FUNCTION :

- Simply take Laplace transform.

$L(\dot{x}(t)) = sX(s) - x^0 = AX(s) + bU(s)$.

$Y(s) = cX(s) + dU(s)$

Transforming and manipulation

$(sI - A)X(s) = x^0 + b(U(s))$

$\Downarrow$ Finally

$X(s) = (sI - A)^{-1}x^0 + (sI - A)^{-1}bU(s)$

$Y(s) = c(sI - A)^{-1}x^0 + [c(sI - A)^{-1}b + d]U(s)$

so, if x^0 and $U(s)$ are know $X(s)$ and $Y(s)$ can be computed.

$$TF = \frac{Y(s)}{U(s)} = G(s) = c(sI - A)^{-1}b + d$$

determinant of $(sI - A)$

STRICTLY PROPER

$n_P > n_Z$

$$\cancel{G(s) =} \quad G(s) = \frac{c(sI - A)^{+}}{(sI - A)}$$

$$(s - a_{11})(s - a_{22})(s - a_{nn}) = s^n + \alpha_1' s^{n-1} + \alpha_2' s^{n-2} \dots + \alpha_n$$

$$G(s) = \frac{c[Q_1 s^{n-1} + Q_2 s^{n-2} - - Q_n]}{s^n + \alpha_1' s^{n+1} \dots \alpha_n}$$