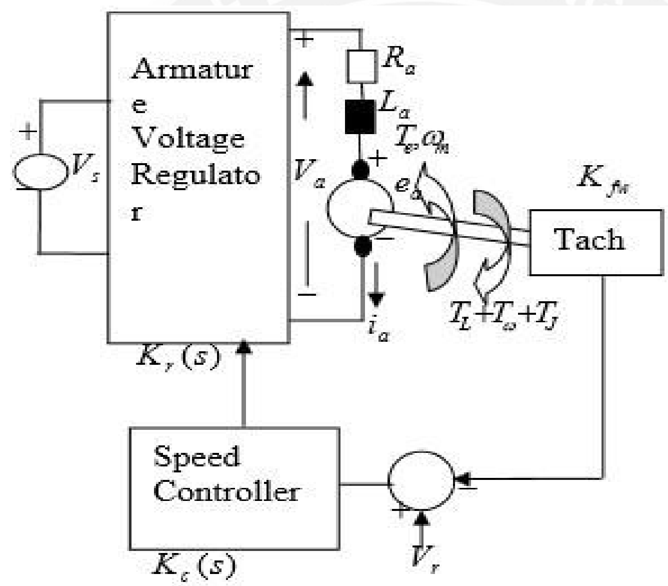
5.2 Closed Loop Control with Current and Speed Feedback

Closed loop control improves on the drives performance by increasing speed of response andimproving on speed regulation. So the functions of closed loop control is that ωn is increased, ε is reduced, ts is reduced, and Speed Regulation(SR)is reduced. A closed loop speed control scheme is shown below



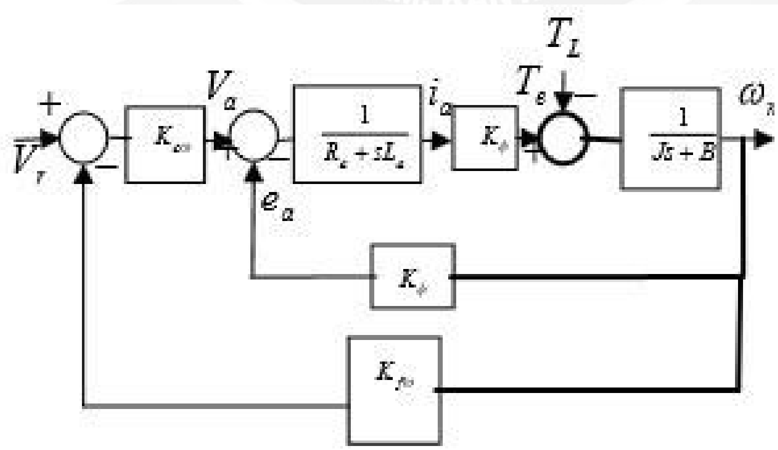


Figure 5.2.1 Closed Loop Speed Control

(Source:"Fundamentals of Electrical Drives" by G.K.Dubey,page-192)

Where,

$K_{f\omega}$ is the tachometer feed back gain

$K_c(s)$ is the speed controller gain

$K_r(s)$ is the armature voltage regulator gain

The dynamic equation by mason's rule is,

$$\begin{pmatrix} \omega_m \\ i_a \end{pmatrix} = \frac{\begin{pmatrix} K_\phi K_{c\omega}(s) & -(R_a + sL_a) \\ (Js+B)K_{c\omega}(s) & K_\phi K_{f\omega}(s) K_{c\omega}(s) \end{pmatrix} \begin{pmatrix} V_r \\ T_L \end{pmatrix}}{D_o(s)} \quad (23)$$

Where,

$$D_o(s) = s^2 J L_a + (R_a J + B L_a)s + R_a B + K_\phi^2 + K_\phi K_{f\omega}(s) K_{c\omega}(s) \quad (24)$$

$$D_o(s) = J L_a [s^2 + (\frac{R_a J + B L_a}{J L_a})s + \frac{R_a B + K_\phi^2 + K_\phi K_{f\omega}(s) K_{c\omega}(s)}{J L_a} \quad (25)$$

$$\begin{pmatrix} \omega_m \\ i_a \end{pmatrix} = \frac{\begin{pmatrix} K_\phi K_{cap} & -(R_a + sL_a) \\ (Js+B)K_{cap} & K_\phi K_{f\omega} K_{cap} \end{pmatrix} \begin{pmatrix} V_r \\ T_L \end{pmatrix}}{D_o(s)}$$

Where,

$$D_o(s) = s^2 J L_a + (R_a J + B L_a)s + R_a B + K_\phi^2 + K_\phi K_{f\omega} K_{cap}$$

$$D_o(s) = J L_a [s^2 + (\frac{R_a J + B L_a}{J L_a})s + \frac{R_a B + K_\phi^2 + K_\phi K_{f\omega} K_{cap}}{J L_a}$$

Last Equation is a second order system

The Natural Frequency of Oscillation, ω_n is,

$$\omega_n = \sqrt{\frac{R_a B + K_\phi^2 + K_\phi K_{f\omega} K_{c\omega p}}{J L_a}}$$

$$\varepsilon = \frac{R_a J + B L_a}{2\omega_n J L_a}$$

This is always higher than the open loop case due to the factor K_ϕ, $K_{f\omega}$, $K_{c\omega p}$

The Damping Ratio, ε, is

$$SR = \frac{-R_a}{R_a B + K_\phi^2 + K_\phi K_{f\omega} K_{c\omega p}}$$

This is lower than in the open loop case due to the increase in ω_n Speed Regulation (SR) is also derived as

$$\begin{pmatrix} \omega_m \\ i_a \end{pmatrix} = \frac{\begin{pmatrix} K_\phi K_{ci} K_{c\omega} & -(R_a + sL_a + K_{ci} K_{fi}) \\ (Js+B) K_{c\omega} K_{ci} & K_\phi + K_{f\omega} K_{c\omega} K_{ci} \end{pmatrix} \begin{pmatrix} V_r \\ T_L \end{pmatrix}}{D_o}$$

SR is also lower than in the open loop case due to the factor K_ϕ, $K_{f\omega}$, $K_{c\omega p}$. This is an indication of a better drive performance.