# Armature Control Method of Separately Excited DC Motor

$$E_b = \frac{\Phi ZNP}{60A}$$

$$E_b = \left(\frac{ZP}{A}\right)\Phi\left(\frac{N}{60}\right)$$

$$T_e = \left(\frac{\Phi ZP}{2\pi A}\right)I_a \qquad T_e = \left(\frac{ZP}{2\pi A}\right)\Phi I_a$$

$$E_b = \left(\frac{ZP}{2\pi A}\right)\Phi\left(\frac{2\pi N}{60}\right)$$

$$T_e = (K_a\Phi)I_a = K_t I_a = K_V I_a = K_m I_a$$

$$E_b = (K_a\Phi)\omega_m = K_m\omega_m = K_V\omega_m = V_a - I_a R_a \qquad K_a = \frac{ZP}{2\pi A}$$

$$\omega_m = \left(\frac{V_a - I_a R_a}{K_a\Phi}\right)$$

$$\omega_m = \left(\frac{V_a}{K_a\Phi}\right) - \left(\frac{R_a}{K_a\Phi}\right)I_a$$

$$\omega_m = \left(\frac{V_a}{K_a\Phi}\right) - \left(\frac{R_a}{(K_a\Phi)^2}\right)T_e$$

# Field Control Method of Separately Excited DC Motor

$$\Phi \propto I_f$$

$$\Phi = K_f I_f$$

$$E_b = (K_a \Phi)\omega_m = (K_a K_f) I_f \omega_m = K_{af} I_f \omega_m = V_a - I_a R_a$$

$$T_e = (K_a K_f) I_f I_a = K_{af} I_f I_a = K_t I_f I_a$$

# DC Series Motor Drive

$$\Phi = \Phi_a + \Phi_{res}$$

$$\Phi_a \propto I_f \propto I_a$$

$$\Phi_a = K_f I_a$$

$$T_e = K_{af} I_a^2 = K_{af} \left( \frac{(V - K_{res}\omega_m)}{(R + K_{af}\omega_m)} \right)^2$$

$$E_b = (K_a \Phi)\omega_m = K_a(\Phi_a + \Phi_{res})\omega_m = K_a(K_f I_a + \Phi_{res})\omega_m$$

$$E_b = (K_{af} I_a + K_{res})\omega_m = K_{af} I_a \omega_m + K_{res}\omega_m = V - I_a R$$

$$I_a(R + K_{af}\omega_m) = V - K_{res}\omega_m$$

$$I_a = \frac{(V - K_{res}\omega_m)}{(R + K_{af}\omega_m)}$$

$$where R = R_a + R_f$$

$$K_{af} = K_a K_f$$

$$K_{res} = K_a \Phi_{res}$$

$$T_e = (K_a \Phi) I_a = (K_a \Phi_a) I_a = (K_a K_f I_a) I_a = K_{af} I_a^2$$