Steady State Behaviour of a Synchronous Machine

Steady state, Open Circuit Conditions

$$v_{do} = 0$$

$$v_{qo} = \omega_o \psi_{do} = \frac{\omega_o M_{df}}{R_f} v_{fo}$$

$$v_a = \sqrt{\frac{2}{3}}[v_{do}\cos(\theta) + v_{qo}\sin(\theta)]$$

where $\omega = \omega_o$ is the steady state electrical speed.

Steady state, Open Circuit Conditions

If stator winding is star connected

$$V_{L-L}(rms) = \frac{\omega_o M_{df}}{R_f} v_{fo}$$

$$T_e = 0$$

since current through the machine is zero

Synchronous Machine Connected to a Source: Steady State Torque

If,

$$v_a = \sqrt{\frac{2}{3}} V \sin \omega_o t$$

$$v_b = \sqrt{\frac{2}{3}} V \sin(\omega_o t - \frac{2\pi}{3})$$

$$v_c = \sqrt{\frac{2}{3}} V \sin(\omega_o t + \frac{2\pi}{3})$$

$$\theta = \omega_o t + \delta$$

Synchronous Machine Connected to a Source: Steady State Torque

$$T'_{eo} = \frac{VE_{fdo}\sin\delta}{\omega_o x_d} + \frac{V^2 \sin 2\delta (x_d - x_q)}{2\omega_o x_d x_q}$$

$$E_{fdo} = \frac{x_{df}}{R_f} v_{fo}, \quad x_{df} = \omega_o M_{df}$$

$$x_d = \omega_o L_d, \quad x_q = \omega_o L_q$$