Steady State Behaviour of a Synchronous Machine
Steady state, Open Circuit Conditions

\[ v_{do} = 0 \]

\[ v_{qo} = \omega_0 \psi_{do} = \frac{\omega_0 M_{df}}{R_f} v_f o \]

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

where \( \omega = \omega_o \) is the steady state electrical speed.
Steady state, Open Circuit Conditions

If stator winding is star connected

\[ V_{L-L}(rms) = \frac{\omega_0 M df}{R_f} v_f o \]

\[ T_e = 0 \]

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

\[ T'_{eo} = \frac{VE_f d \omega o x_d \sin \delta}{\omega o x_d} + \frac{V^2 \sin 2\delta(x_d - x_q)}{2\omega o x_d x_q} \]

\[ E_f d \omega o = \frac{x_d f}{R_f} v f o, \quad x_d f = \omega o M d f \]

\[ x_d = \omega o L_d, \quad x_q = \omega o L_q \]