

Load Characteristic INDMOT3P_A

Load Characteristic INDMOT3P_A Induction Motor Load Model without Saturation

Parameter List

Flag : Include Bus
Frequency in
Vsource

Lfm : Loading Factor

Electrical Circuit

Rs: Stator Resistance

Xs: Stator Reactance

Xm: Magnetizing

R1: Rotor winding 1

X1: Rotor winding 1

R2: Rotor winding 2

X2: Rotor winding 2

Mechanical Power

H: Inertia

Etrq: Torque Exponent

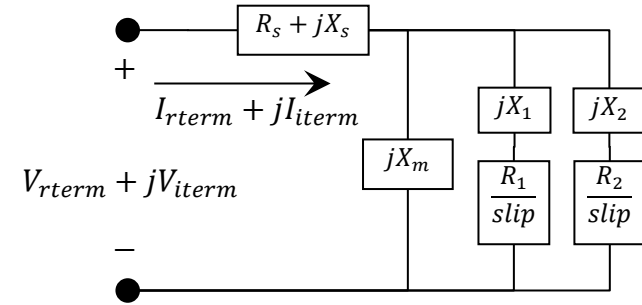
Tnom: Nominal Torque

Tripping Terms

Vtr1,Ttr1,Ftr1,Vrc1,Trc1

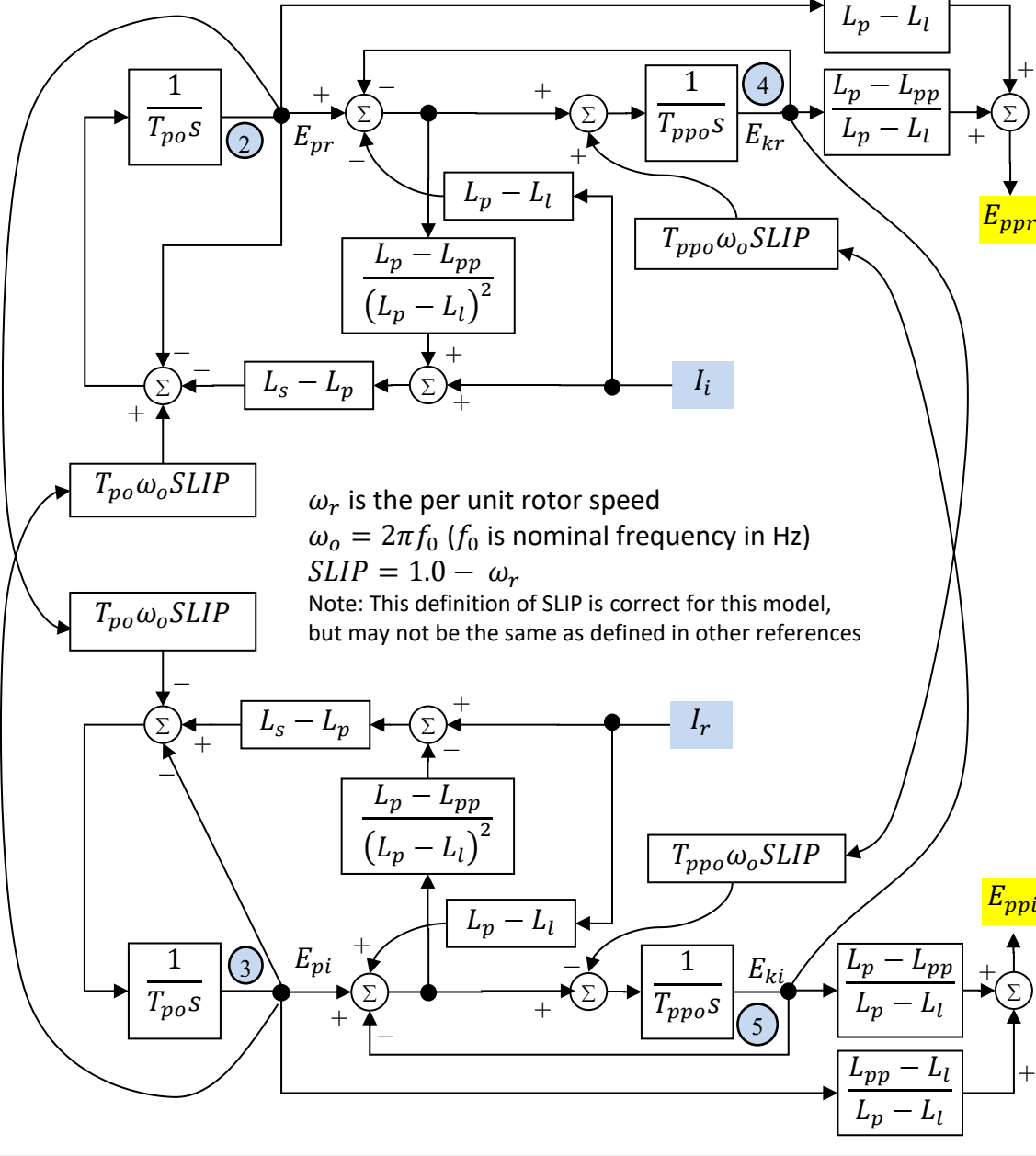
Vtr2,Ttr2,Ftr2,Vrc2,Trc2

- Equivalent steady state circuit model at nominal frequency is shown to the right with 7 input impedance terms
- Input impedances are given on an MVABase which is equal to the power flow MW value divided by the input parameter L_{fm} (loading factor for motor).
 - $MVABase = LoadMW/L_{fm}$
- For the dynamic model, these terms are converted to reactances and time constants as shown in the table on the right, with the dynamic block diagram shown on the next page
- To model a single cage motor set $R_2 = X_2 = 0$. This will be treated by setting $L_{pp} = L_p$ and $T_{ppo} = 0$. (Note: For double cage, R_2 and X_2 are infinite, but setting them to zero causes the software to treat them as infinite).
- Mechanical Torque is given by
 - $T_{mech} = T_{nom} \omega_r^{Etrq}$
 - Where ω_r is the rotor speed in per unit
 - For motor starting use input parameter T_{nom}
 - For online motors, T_{nom} is calculated at initialization
- Set $Flag > 0$ so that the equations used for internal voltage include bus frequency dependence.
- 2 stages of under-voltage load tripping and reconnecting defined by the 10 inputs parameters. See description on a following page for more information
 - Stage 1: $Vtr1, Ttr1, Ftr1, Vrc1, Trc1$
 - Stage 2: $Vtr2, Ttr2, Ftr2, Vrc2, Trc2$



	Double Cage	Single Cage
R_s	R_s	R_s
L_s	$Xs + Xm$	$Xs + Xm$
L_l	Xs	Xs
L_p	$Xs + \frac{1}{\frac{1}{Xm} + \frac{1}{X1}}$	$Xs + \frac{1}{\frac{1}{Xm} + \frac{1}{X1}}$
L_{pp}	$Xs + \frac{1}{\frac{1}{Xm} + \frac{1}{X1} + \frac{1}{X2}}$	Same as L_p
T_{po}	$\frac{X1 + Xm}{\omega_o R1}$	$\frac{X1 + Xm}{\omega_o R1}$
T_{ppo}	$\frac{X2 + \frac{X1 * Xm}{X1 + Xm}}{\omega_o R2}$	0

Double-Cage Motor Block Diagram



Mechanical Equation

$$T_{elec} = E_{ppr}I_r + E_{ppi}I_i$$

$$(1) \frac{d\omega_r}{dt} = \frac{1}{2H} (T_{elec} - T_{nom}\omega_r^{Etrq})$$

Network Interface Equations

$$StatorCurrent = I_r + jI_i$$

$$Z_{source} = R_s + jL_{pp}$$

$$Y_{source} = \frac{1}{R_s + jL_{pp}} = G + jB$$

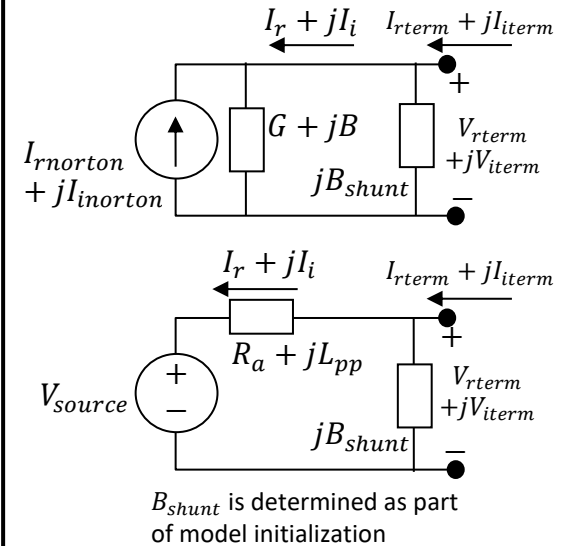
ω_{bus} = terminal bus frequency in per unit

If $flag \leq 0$

$$Then \quad V_{source} = (E_{ppr} + jE_{ppi})$$

$$Else \quad V_{source} = \omega_{bus}(E_{ppr} + jE_{ppi})$$

$$I_{rnorton} + jI_{inorton} = V_{source}(G + jB)$$



Under-Voltage Tripping and Reconnecting

This model contains 2 stages of under-voltage load tripping and reconnecting defined by the 10 inputs parameters

Stage 1: V_{tr1} , T_{tr1} , F_{tr1} , V_{rc1} , T_{rc1}

Stage 2: V_{tr2} , T_{tr2} , F_{tr2} , V_{rc2} , T_{rc2}

The motor will be reduced by a fraction of F_{tr1} if the terminal voltage falls below V_{tr1} for T_{tr1} seconds. This portion of the load will reconnect if the voltage subsequently got above V_{rc1} for T_{rc1} seconds. The same logic is applied for V_{tr2} , T_{tr2} , F_{tr2} , V_{rc2} , and T_{rc2} .

This tripping and reconnecting is not modeling the dynamics of different portions of the loads slowing down and restarting. There is only one rotor speed state for this entire load model. When using fractional tripping, this model approximates 1000s of individual motors. The fractions of load that trip and then reconnect will not exhibit the restarting torques seen with 1000s of individual motor models.

If this model is being used to represent a single large motor, then the two stages should only be used to trip the entire motor and motor reconnecting should not be done. The parameters should be set as follows to model this.

$F_{tr1}=F_{tr2}=1.0$

$V_{rc1}=V_{rc2}=0.0$

Single-Cage Motor Block Diagram

