Mini project 3

Modelling of a Three-Phase Induction Machine in the abc Reference Frame

Expected outcome: Report submission by 26-10-2026, Demonstration of simulated model by 30-10-2026.

Consider the following specifications for a three-phase induction motor.

Parameter	**Value**
Rating	3 hp, 220 V line, 60 Hz, 4-pole, star
Stator resistance r_s	0.435 Ω
Rotor resistance r'_r (referred)	0.816 Ω
Lls = L'lr	2.00 mH
L_M / Lms	69.31 mH / 46.21 mH
Inertia J	0.089 kg·m²
Rated load torque TL	11.9 N·m

Assume: Windings are sinusoidally distributed; space harmonics are neglected.The air gap is uniform (no slotting or eccentricity). Magnetic circuit is linear: no saturation, hysteresis or eddy-current loss. Winding resistances and leakage inductances are constant (no skin effect or temperature rise).

1. Derive the voltage, flux-linkage, torque and mechanical equations of the machine in abc phase variables.
2. Build the 6 × 6 inductance matrix relating the flux linkages to the currents.
3. Build the model and analyse its performance at steady state. i) on no load ii) Apply 50% of rated at t=1.0 s and iii) full load at t=2 s. Get the plots of: Speed Vs time, Torque Vs time, three phase stator currents Vs time, phase ‘a’ voltage and phase ‘a’ stator current vs time and torque vs speed.
4. Simulate a direct-on-line start and a load step, and interpret the transients. [t = 0: rotor at rest, all currents zero; full 220 V applied directly (direct-on-line start), no load. t = 1.0 s: rated load torque 11.9 N·m applied as a step. Run the Simulation t = 1.5 s.]. Plot speed Vs time, Torque Vs time and torque vs speed.
5. From the plots obtain the following. Peak starting current, Peak electromagnetic torque, speed at full load, Torque at that slip, stator current rated load.
6. Use auto transformer starter with suitable tapping and observe the effect on starting current.