National University of Singapore

Department of Electrical & Computer Engineering

EE4502: Electric Drives and Control

TUTORIAL - 4 Induction Motor Drives

Year 2021-22

1. A 480 V, 50 Hz, 4-pole, three-phase induction motor is drawing 60 A at 0.85 power factor lagging. The stator copper losses are 2 kW, and the rotor copper losses are 700 W. The friction and windage losses are 600 W, the core losses are 1800 W, and the stray losses are negligible. Find the following quantities:

   (a) The synchronous speed of the motor.

   (b) The air-gap power.

   (c) The rotor speed at rated load.

   (d) The rotor frequency of this motor at rated load.

   (e) The shaft torque at rated load.

   (f) The output power, P_{out}

   (g) The efficiency of the motor

   (Ans. 1500 rpm, 38.6 kW, 1473 rpm, 0.9 Hz, 241.8 N.m, 37.3 kW and 88%)

2. A 400 V, 3-phase, 50 Hz, 4-pole, 1370 rpm, delta connected induction motor has the following parameters referred to the stator:

$$R_s = 2\ \Omega, R_{r'} = 5\ \Omega, X_s = 5\ \Omega, X_{r'} = 5\ \Omega\ \Omega, X_m = 80\ \Omega$$

   The motor speed is controlled by stator voltage control. When driving a fan load it runs at rated speed with rated voltage being applied.

   Determine the motor terminal voltage, current and torque at 1200 rpm.

   (Ans. 253 V, 17.9 A, 36.9 N.m)

3. A three-phase, 60 Hz, 4-pole, 440 V(line-to-line, rms), induction motor drive has a full-load(rated) speed of 1746 rpm. The rated motor torque is 40 N.m. The air-gap flux-density is kept constant at its rated value.

   (a) Plot the torque-speed characteristics (the linear-portion) for the following values of the frequency f: 60 Hz, 45 Hz, 30 Hz, and 15 Hz

   (b) The motor is supplying a load whose torque demand increases linearly with speed, such that it equals the rated torque of the motor at rated speed. Determine the speed of operation at the four values of the frequency in part(a).

   (Ans. (b) 1746, 1309.5, 873 and 436.5 rpm)

4. A 3-phase, delta connected, 6-pole, 50 Hz, 400 V, 925 rpm, squirrel-cage induction motor has the following parameters:

$$R_s = 0.2\ \Omega, R_{r'} = 0.3\ \Omega, X_s = 0.5\ \Omega, X_{r'} = 1\ \Omega$$

The motor is fed from a voltage source inverter with a constant v/f ratio from 0 to 50 Hz and constant voltage of 400 V above 50 Hz frequency.

(a) Determine the breakdown torque for a frequency of 100 Hz as a ratio of its value at 50 Hz.

(b) Also obtain the torque at rated motor current and 75 Hz as the ratio of rated full-load torque of the motor.

(c) Calculate the motor torque at 30 Hz and a slip-speed of 60 rpm.

(Ans. (a) 0.267, (b) 0.608 and (c) 746.66 N.m)

5. A 440 V, 50 Hz, 6 pole, 925 rpm, delta-connected squirrel cage induction motor has the following parameters per phase referred to the stator:

$$R_s = 0.2\ \Omega, R_{r'} = 0.3\ \Omega, X_s = 0.5\ \Omega, X_{r'} = 1.0\ \Omega, X_m = \infty\ \Omega$$

The induction motor is fed from a voltage source inverter and operated at a constant (v/f) control up to 50 Hz and at rated voltage of 400 V above 50 Hz. Assume the torque-speed curves to be parallel in the region of interest.

(a) Determine the speed of the motor for a frequency of 30 Hz and one-fourth of the full-load torque.

(b) Determine the frequency and motor current for a speed of 500 rpm and 60% of full-load torque.

(c) Determine the motor torque for a frequency of 40 Hz and speed of 750 rpm.

(Ans. (a) 581.25 rpm, (b) 27.25 Hz and 55.58 A and (c) 617.6 N.m)

6. A 400 V, 50 Hz, 4 pole, 1370 rpm, star-connected squirrel cage induction motor has the following parameters per phase referred to the stator:

$$R_s = 1.9\ \Omega, R_{r'} = 2.0\ \Omega, X_s = 3\ \Omega, X_{r'} = 3\ \Omega, X_m = \infty\ \Omega$$

The motor is fed by a nonsinusoidal supply. Calculate the motor torque, current and efficiency at the rated speed if the fundamental, fifth and seventh harmonic phase voltages are 254 V, 100 V and 40 V respectively. Neglect higher harmonics, friction, windage, core losses and skin effect.

(Ans. 43 N.m, 10.5 A, 82.8%)

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