EEE6001 Tutorial sheet 3 – Transformers and Motors

1. A 50kVA transformer which steps down from 6600V to 220V has a primary resistance of 10Ω and a secondary resistance of 0.01Ω. Find:
   (a) the total resistance referred to the primary side
   (b) the total resistance referred to the secondary side
   (c) the copper loss when operating on full load.

2. When the secondary winding of a transformer is short-circuited and a voltage of $30V_{rms}$ is applied to the primary, the current in the primary winding is $20A_{rms}$ and the input power is 200W. Find the winding resistance and leakage reactance referred to the primary side.

3. The no-load current drawn by a transformer is $5A_{rms}$ at 0.3 lagging power factor when supplied from a $230V_{rms}$, 50 Hz supply. The number of turns on the primary is 200. Calculate:
   (a) the maximum flux in the core
   (b) the core loss
   (c) the magnetising current

4. A single phase transformer has 1200 turns on the primary and 200 turns on the secondary. The no-load current is $4A_{rms}$ at a 0.25 lagging power factor. Calculate the primary current and power factor when the secondary current is $320A_{rms}$ at a 0.8 lagging power factor.

5. A 120V, 4 pole DC shunt motor runs at 500rpm and draws an armature current of 15A when driving a certain load. The field winding is connected is connected across the armature supply and draws a field current of 4A. If the armature resistance is 0.5Ω, calculate the load torque and the motor efficiency.

6. A 600V wound field shunt DC motor has its field winding connected across the armature supply. When driving a particular load, the motor runs at 500rpm, drawing an armature current of 5A and a field current of 300mA. The armature resistance is 3Ω. Calculate the load torque and motor efficiency. If the field current is reduced to 200mA driving the same load torque, what is the new armature current and motor speed?

7. With reference to figure 1, show how the inertia of the load (*Jo*) will be reflected back to the motor.

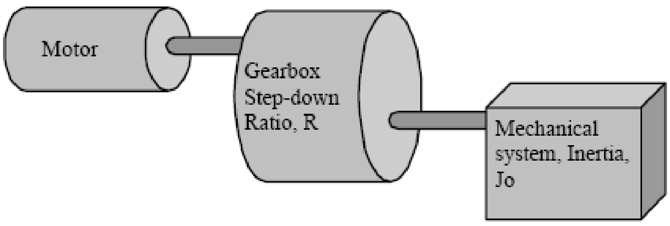

Figure 1.

A permanent magnet servo motor is used to drive a portable centrifuge, through a 1:2 gearbox which steps the motor speed up to the required centrifuge load speed of 4000 rpm. Given the motor data below, and that the centrifuge load is dominated by its inertia of 0.1kgm2, calculate the motor current required to accelerate the centrifuge from standstill to full speed in 4 seconds under constant acceleration.

In order to maintain the separation of the samples in the centrifuge, the load has to be decelerated back to standstill in 1 second under constant deceleration. Given that the entire cycle lasts for 10 seconds, draw the profile of the current drawn by the motor. (continued overleaf)

Calculate the voltage requirement of the supply, and sketch the voltage profile applied to the motor. Calculate the power dissipated in the motor windings.
Winding resistance = 0.1Ω
Motor inertia= 0.2kgm^2
Motor back emf constant = 1.6 Vs rad-1.

8. Draw the equivalent circuit and derive the operational characteristics of a series connected, wound field DC motor. Given the motor and load parameters below, calculate the operating speed and current of a series wound field motor when supplied from a 12V DC supply, driving a fan load where $T_{load} = B_f.\omega^2$.
Motor parameters: R_f= 1Ω, R_a=0.2Ω, M=1Vrad^{-1}s^{-1}
Fan constant: B_f=0.01Nmrad^{-2}s^{-2}

9. Draw the approximate equivalent circuit for a 3-phase star connected induction motor, explaining what each component represents. Derive an expression for the output torque of the motor, and show this is a function of slip for a motor fed from a fixed frequency and voltage supply. Given the motor parameters below, calculate the operating speed of the motor if loaded with a constant torque load of 20Nm, given that the motor is fed from a 415V_{line}, 3-phase, 50Hz supply and that the motor is a 4-pole machine.
If there is a step change in load to 40Nm, calculate the change in operating speed. What would happen if the load of 40Nm was initially applied to the motor at standstill?
R_2' = 1Ω; R_1 = 2Ω; (L_1+L_2') = 20mH;

10. Using the equivalent circuit derived in question 9 calculate the rated full-load current, torque, output power, power factor and efficiency of a basic induction motor with the following equivalent parameters:
V_{line} = 415V
Number of poles = 4
Frequency = 50Hz
Rated Full Load speed = 1400rpm
R_1 = 0.3Ω; X_1 = 1.1Ω; R_2' = 0.15Ω; X_2' = 0.75Ω;
The motor is now used on a 3-phase inverter supply and controlled to operate with constant flux. Find the new frequency required to provide full-load torque at half synchronous speed (750rpm). Calculate the new current, voltage and efficiency.

Other practice questions can be found on the Tutorial sheet and past exam questions for EEE202 which are posted on the web.