DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

ENEE5303: Electrical Machine Drive and Special Machines

***Midterm Exam*, Date: 23/11/2020, Time: 11.25 – 12.40 (75 minutes)**

1) A motor has an inertia of 1.32 kg-m^2 is driving a Nissan Leaf electric vehicle and it is connected to the wheels through a set of gears. The weight of the vehicle is 1520 kg and the radius of the wheel is 0.62 m. The gears have teeth ratio of 7.94:1. **[25%]**
   (a) Calculate the inertia referred to the motor's shaft.
   (b) Draw the torque profile of the motor and then calculate the effective value of the electromagnetic torque developed by the motor for the speed profile shown in Fig. 1.
   Note: Ignore the windage and friction torque losses

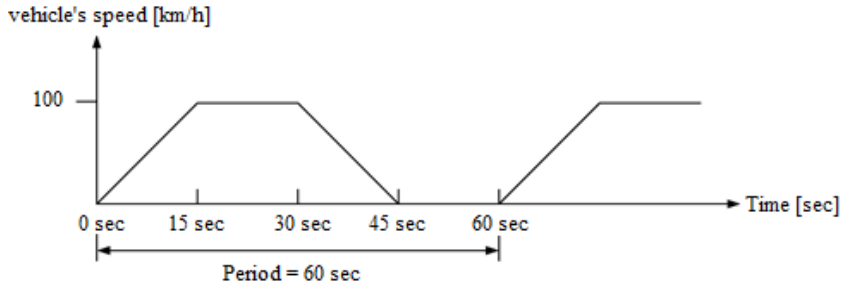

Fig. 1

2) Figure 2 shows the four quadrant-torque speed characteristics of DC machine. The machine is driven over the speed range -2η_r to 2η_r [rpm] where η_r is the rated speed of the machine in rpm. **[15%]**
   (a) Plot the motor's voltage, and flux versus the motor's speed for the speed range 0 to 2η_r, assuming the motor is running in the first quadrant at rated current.
   (b) Draw the trajectory that illustrates the torque speed variations of the DC machine from point P_1 to point P_2.

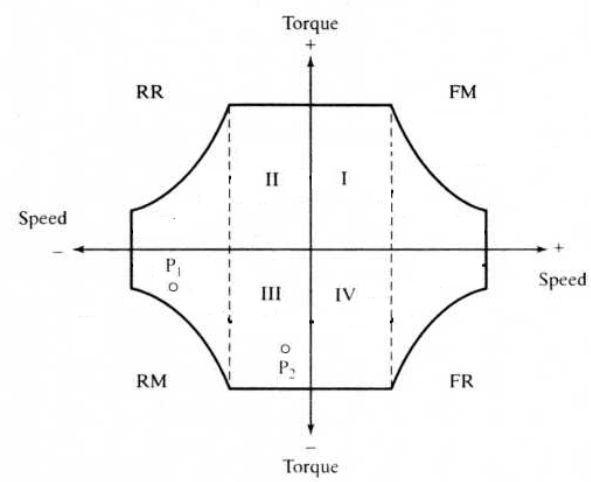

Fig. 2

3) A single-phase full wave controlled rectifier is used to control the speed of a separately excited DC motor rated at 200 V and 2000 rpm. The converter is connected to a single-phase 230 V, 50 Hz supply. The armature resistance is 50 mΩ, the motor voltage constant is 0.0975 V/rpm, and the no-load current is 10 A. Assume that the motor current is continuous and ripple free, **[30%]**
   (a) Draw the drive circuit.
   (b) Calculate the motor rated current.
   (c) Calculate the motor rated torque and power.
   (d) Calculate the no load speed when the firing angle is 60^{o}.
   (e) Calculate the firing angle to obtain the rated speed of 2000 rpm at rated motor current.

4) A DC separately excited motor controlled by a two-quadrant (I and IV) chopper circuit consisting of two IGBTs and two diodes. The motor current is controlled by a PWM current controller: **[30%]**
   (a) Draw the drive circuit.
   (b) Draw the control system in time-domain.
   (c) Draw the closed loop control systems for the speed controller in s-domain.
   (d) Derive the transfer function of the speed controller.
   (e) Show, perhaps with the aid of a sketch, the operation and implementation of current controller to generate the gate drive signals for forward motoring.

END OF PAPER
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