

Answer the following questions:

First Question(9+9Marks)

1-a) Write short notes on the following:

- 1)- PM dc motors
- 2)- Moving coils dc motors
- 3)- Dynamic braking of shunt and series dc motors
- 4)- Ward-Leonard Ilgener system.

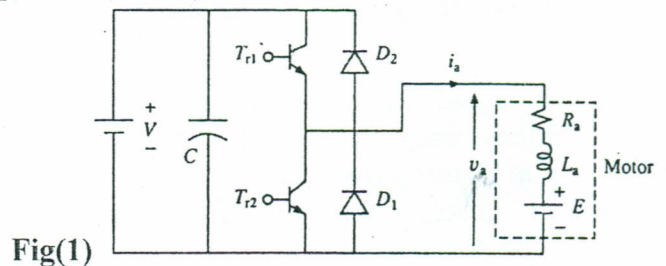
1-b) A 220 V dc series motor runs at 1000 rpm (clockwise) and takes an armature current of 100A when driving a load with a constant torque. Resistances of the armature and field windings are  $0.05 \Omega$  each.

- i) Find the magnitude and direction of motor speed and armature current if the motor terminal voltage is reversed and the number of turns in field winding is reduced to 80%. Assume linear magnetic circuit.
- ii) If the motor is operated now under dynamic braking at twice the rated torque and 800 rpm. Calculate the value of braking current and resistor. Assume linear magnetic circuit

Second Question(6+4+8Marks)

2-a) Explain how can we use Fig1 to get motoring and regenerative braking modes of separately excited motor

2-b) Explain dynamic braking method of separately excited motor by chopper control



Fig(1)

2-c) A 230 V, 960 rpm and 200A separately excited dc motor has an armature resistance of  $0.02 \Omega$ . The motor is fed from a chopper which provides both motoring and barking operations. The source has voltage of 230 V. assuming continuous conduction.

- i) Calculate duty ratio of chopper for motoring and braking operation at rated torque and 350 rpm.
- ii) If the maximum duty ratio of chopper is limited to 0.95 and maximum permissible motor current is twice the rated, calculate maximum permissible motor speed obtained without field weakening and power fed to the source.
- iii) If the motor field is also controlled in (ii), calculate field current as function of its rated value for a speed of 1200 rpm

Third Question(9+10 Marks)

3-a) A 6 MW, 3-phase, 11kV, Y-connected, 6-pole, 50Hz, 0.9(leading) power factor synchronous motor has  $X_s=9 \Omega$  and  $R_s=0$ . Rated field current is 50A. Machine is connected by variable frequency control at constant (v/f) ratio up to the base speed and at constant V above base speed.

Determine

- i) Torque and filed current for the rated armature current, 750 rpm and 0.8 leading power factor.
- ii) Armature current and power factor for half the rated motor torque, 1500 rpm and rated field current.
- iii) Armature current and power factor for regenerative braking power output of 4.2MW at 750 rpm and rated filed current
- iv) Torque and field current for regenerative braking operation at rated armature current, 1500 rpm and unity power factor.

3-b) Describe the operation of brushless dc motor, why it is known as a brushless dc motor? What are its advantages over a conventional dc motor? What is the low cost brushless dc motor drive?

**Fourth Question(6+6+6 Marks)**

**4-1) Explain** the factors affect electrical drive system selection.

**4-2) Illustrate** the performance characteristics of a three-phase induction motor under the following operating condition:

- i) Unbalance supply voltages and;
- ii) Unbalance rotor impedances.

**4-3) Prove that**, during starting of induction motor, rotor winding energy loss can be reduced if started by using method based on the variation of synchronous speed.

**Fifth Question(6+12 Marks)**

**5-1)** A PWM-VSI is used to feed a three phase induction motor with  $V/f$  control. A three-phase constant voltage-constant frequency source is available.

- a) **Select** a suitable configuration allowing motoring/regenerative braking,
- b) **Draw** a complete closed loop speed control of the selected configuration and briefly explain its operating principle.

**5-2)** A three-phase, 440 V, 50 Hz, 6-pole, Y-connected induction motor has the following parameters referred to the stator:

$$R_s = R_r' = 1.2 \Omega, X_s = X_r' = 1.4 \Omega.$$

Full-load slip is 4 %. The motor is fed from a voltage source inverter with  $V/f$  control and allows frequency variation from 10 to 100 Hz. **Calculate:**

- a) Starting torque/ampere ratio at minimum frequency and **compare** with its value if the motor is started at rated voltage and frequency.
- b) Speed for frequency of 30 Hz and half load torque.
- c) Maximum torques for an operating frequency of 100 Hz for both motoring and braking operations.
- d) Motor torque at rated current and 100 Hz.

**Sixth Question(7+12 Marks)**

**6-1)** Static Kramer drive scheme is a speed control method of induction motor based on slip-power recovery principle, **Explain** how it can be designed for low speed range control and high speed range control.

**6-2)** A three-phase, 400 V, 50 Hz, 960 r.p.m, 6-pole, Y-connected wound rotor induction motor has the following parameters referred to the stator:

$$R_s = 0.1 \Omega, R_r' = 0.6 \Omega, X_s = X_r' = 1.4 \Omega.$$

The motor drive a load whose power varies as cubic of speed; the stator to rotor effective turns ratio is 2. The motor speed is controlled by static rotor resistance control.

- a) **Draw** a complete static rotor resistance control scheme with its closed loop control.
- b) If the value of the external resistance is chosen such that the breakdown torque is obtained at standstill for a duty cycle ( $\delta$ ) of zero, **determine** the value of the external resistance.
- c) **Calculate** the value of the external resistance so that the motor runs at 800 r.p.m. for the duty cycle of 50 %.