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MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

I SEMESTER M.TECH. (POWER ELECTRONICS & DRIVES)

END SEMESTER EXAMINATIONS, DECEMBER 2023

POWER SEMICONDUCTOR CONTROL DRIVES [ELE 5114]

Time: 3 Hours **Date: 05 December 2023** **Max. Marks: 50**

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitably assumed.
- Sine Graph sheet may be used.

1A. A variable frequency drive system needs to be operated more than 50% of rated speed till rated speed. Which control strategy out of V/f control or E/f control you prefer for this application? Justify your answer with necessary block schematics and characteristics. **(03)**

1B. Why vector control has become a popular approach for speed control in industrial AC drives? Explain the concept of indirect vector control using suitable block diagram representations. **(04)**

1C. Consider a three phase fully controlled rectifier fed 220V,10A, 1100 rpm seperately excited DC motor.The motor has armarure resistance of 1Ω. The converter is supplied with 415V three-phase AC supply. Calculate, the firing angle required to develop 12Nm braking torque at rated speed.

Assume that, enough filter inductance is added to ensure continuous conduction. **(03)**

2A A drive system has an equivalent load torque of 52Nm and equivalent moment of inertia of 1.1kgm^2, and running at a steady speed of 800rpm. The speed of the motor need to be changed from 800rpm to 500rpm in the reverse direction in 2 seconds. What should be the total torque to be developed by the motor? **(02)**

2B. A 200V 800rpm 8 A separately excited motor has the armature resistance and inductance of 2Ω and 18mH, respectively. The motor is controlled by a single phase fully controlled rectifier with an ac source voltage of 230V, 50Hz at firing angle α=30 degrees. Is a continuous armature current is ensured at this firing angle at rated speed? Derive the average output voltage of the converter & draw the waveforms of armature voltage and current in this case.

(Expression for armature current: Single-phase controlled rectifier fed separately excited DC motor

$$i_{(\omega t)} = \frac{V_m}{Z}\left[\sin(\omega t - \varphi) - \sin(\alpha - \varphi)e^{((\alpha-\omega t)/\omega\tau)}\right] - \frac{k\omega_m}{R_a}\left[1 - e^{((\alpha-\omega t)/\omega\tau)}\right])$$ **(06)**

2C. A DC chopper which is operating as class B is feeding back 1.1kW of power to DC source of 240V from a separately excited DC machine operating with 11Nm torque. Machine constant is 1.2 V/(rad/sec). Calculate the duty cycle at which chopper is operating. **(02)**

3A. Analyse the waveforms of armature voltage and current of a 3-Φ fully controlled rectifier fed DC drive with α = 75° . Clearly show the triggerring sequence. Derive the expression for average output voltage. Assume discontinuous conduction. **(04)**

3B An industrial AC drive require speed control in the range of 75% to full rated speed, without much power loss. Out of stator voltage control & rotor resistance control, which one you suggest? Justify your answer with the help of suitable schematic diagrams and characteristics **(04)**

3C. Compare the converter output voltages of a class A & class B chopper fed DC drives, fed with 220V DC supply. Assume the duty cycle of power semiconductor switch is 40% in both cases. Comment on the results obtained. **(02)**

4A. Will a 10kW motor be a suitable choice for the following drive system?

A drive system has two loads. One has rotational motion. It is coupled to the motor through a reduction gear with gear ratio 0.2 and efficiency 80%. The load has a torque of 8 Nm. Also note that the gearbox has a load torque of 1NM referred to motor shaft.

Other 10N load has translational motion at a uniform speed of 1.5 m/s. The coupling between motor and the translational load has an efficiency of 85%. The motor runs at a constant speed of 1420rpm. **(03)**

4B. A three-phase induction motor-based AC drive system is designed to apply slip power recovery scheme for its speed control in the sub-synchronous speed range. Draw the schematic diagram of such a system and explain the principle behind it. Can this be modified to work in super synchronous speed range? If 'Yes' explain the method. If 'No' explain the reason. **(04)**

4C. Is flux weakening mode of control suitable for constant power drives? Justify your answer with suitable characteristics & block schematics. **(03)**

5A. Analyze the steady state stability of operating points **A** & **B** in Fig. 5A.

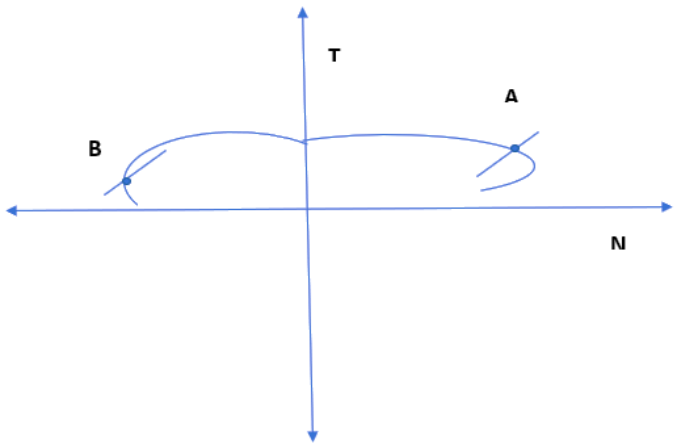

Fig. 5A **(02)**

5B. An industrial drive requires controlled motoring and re-generative braking mode of operation with bidirectional voltage input. Suggest a suitable chopper circuit for this application. Analyze its braking mode of operation with the help of output voltage, current and source current waveforms of the converter. **(04)**

5C. A reluctance motor needs to be selected to drive a robotic arm which require a smooth torque. Which type of reluctance motor will you select? Justify your choice. Also explain the fundamental difference in construction & working of different types of reluctance motors. **(04)**