Questions
DC Motor Drive

Module EE5303 – Electrical Machine Drive and Special Machines
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Problem 1

A 220 V, 1500 rpm, 11.6 A separately excited motor is controlled by a single-phase fully controlled rectifier with an ac source voltage of 230 V, 50 Hz. Enough filter inductance is added to ensure continuous conduction for any torque greater than 25 % of rated torque, $R_a = 2\ \Omega$.

1. What should be the value of the firing angle to get the rated torque at 1000 rpm?
2. Ca1culate the firing angle for the rated braking torque and -1500 rpm.
3. Ca1culate the motor speed at the rated torque and $\alpha = 145^0$ for the regenerative braking in the second quadrant.

Problem 2

A separately excited DC motor is rated at 10 kW, 240 V, 1000 rpm and is supplied with power from a fully controlled, single-phase bridge rectifier. The power supply is sinusoidal and rated at 240 V, 50 Hz. The motor armature resistance is 0.4217 and the motor constant is 2 V.s/r. Some additional inductance is included in the armature circuit to ensure continuous conduction but its value is not known. Calculate the speed, and efficiency of operation for SCR firing-angles $\alpha = 0°$ and $\alpha = 20°$ if the load torque is constant.

Problem 3

A 100-hp separately excited DC motor rated at 500 V and 1750 rpm has the following parameters at rated field current:

$I_a = 153.71$ A, $R_a = 0.088\ \Omega$, $L_a = 1.83$ mH, and $K' = 2.646$ V/rad/sec

1. Draw its torque, induced emf, power, and field flux vs. speed in normalized units for rated armature current and for an intermittent operation at 1.2 p.u. armature current for the speed range of 0 to 2 p.u.
2. If the same DC motor is operated from a fully-controlled three-phase converter fed from a 460 V, 60 Hz, 3-phase AC supply. Calculate the triggering angle when the machine is delivering rated torque at rated speed. The armature current is assumed to be continuous.
3. Assuming the current is continuous, draw α vs. speed, maintaining the load torque at rated value, for part (2.), for a speed range of 0 to 1 p.u.

Problem 4

A separately excited DC motor is controlled from three-phase full-wave converter fed from a 460 V, 3-phase, 60 Hz AC supply. The DC motor details are as follows:

250 hp, 500 V, 1250 rpm, $R_a = 0.052\ \Omega$, $L_a = 2$ mH.

1. Find the rated current and the constant K' when the field is maintained at rated value.
2. Draw the torque-speed characteristics as a function of α.

Problem 5

Design a speed, current and flux PI controllers for the control system of 4 quadrant, three-phase converter controlled DC motor drive. The motor parameters and ratings are as follows: 220 V, 8.3 A, $R_a = 4\ \Omega$, $L_a = 72$ mH, $J_{tot} = 0.0607$ kg.m^2, B=0.0869 N.m/rad/sec, L_f =78 mH K' =1.26 V/rad/sec. All controllers have natural frequencies of 0.5 kHz, 1 kHz, and 2kHz, respectively.

Problem 6

A separately excited DC motor with $R_a = 0.3\ \Omega$ and $L_a = 15$ mH is to be DC chopper speed controlled over a range 0-2000 rpm. The DC supply is 220 V. The load torque is constant and requires an average armature current of 25 A. Calculate the range of duty cycle required if the motor design constant has a value of 0.00167 V. s per revolution.

Problem 7

A DC motor is driven from a chopper with a source voltage of 24 V DC and at a frequency of 1 kHz. Determine the variation in duty cycle required to have a speed variation of 0 to 0.4 p.u delivering a constant 1.5 p.u load. The more details are as follows:

1 hp, 10 V, 2500 rpm, 78.5 % efficiency, $R_a = 0.053\ \Omega$, $L_a = 2$ mH, K' =0.0191 V/(rad/sec)

The chopper is one-quadrant, and the on-state drop voltage across the device is assumed to be 1 V regardless of the current variation.