## 2nd Semester Final Examination, April/May 2012

Subject : Power Electronics II

Code No. **EE 1013**
Branch: EE
Full Marks : 70

Time : 3 hours

(i) The questions are of equal value
(ii) Answer any ***three*** questions taking ***one*** from each group.
(iii) Graph papers will be supplied.
(iv) One mark reserved for brief and precise answers.

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### Group A

1. (a) State the switching constrains of a Matrix converter and briefly discuss the reason behind this.

(b) A matrix converter schematic is shown in Fig. 1. A particular switching state is shown in the Table-1. Assuming sinusoidal input voltages and sinusoidal output currents, find the output line voltage space vector and input line current space vector for the switching combination. Comment whether these space vectors can be utilized in SVPWM generation of switching pulses.

Table-1

| $S_{Aa}$ | $S_{Ab}$ | $S_{Ac}$ | $S_{Ba}$ | $S_{Bb}$ | $S_{Bc}$ | $S_{Ca}$ | $S_{Cb}$ | $S_{Cc}$ |
|---|---|---|---|---|---|---|---|---|
| *1* | *0* | *0* | *0* | *1* | *0* | *0* | *0* | *1* |

(c) Considering a particular active switching state vector in input current hexagon and a particular active switching state vector in output voltage hexagon, state which switches in the Matrix Converter will be conducting in that duration.

(d) Describe briefly four step output current direction based commutation strategy.

[4+(4+4)+4+7]

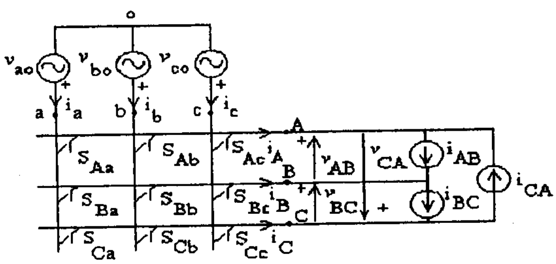


Fig. 1

2. (a) Show that for a rotor flux oriented vector control drive for an induction motor the electromagnetic torque can be expressed as $T_e = k_t' \times i_{ds}^e \times i_{qs}^e$.
   (b) Draw a schematic diagram to illustrate the direct vector control drive of induction motor with flux sensors.
   (c) How the slip is determined in indirect vector control of a squirrel cage induction motor?
   (d) What are the advantages and disadvantages of the vector control of salient pole wound rotor synchronous motor?

[6+6+6+5]

### Group B

3. a) A 3-phase Y-connected <u>220 V, 7.5 kW, 60 Hz, 6-pole</u> squirrel cage induction motor has the following parameter values per phase (referred to stator):

$r_1 = 0.294\ \Omega,\ r_2' = 0.144\ \Omega,\ r_1 = 0.503\ \Omega,\ r_2' = 0.209\ \Omega,\ x_m = 13.25\ \Omega.$

The rated slip for constant voltage operation is around 2%. The total friction, windage and core losses may be assumed to be constant at 410 W and is independent of load. You may assume a suitable value of efficiency. The rated load power factor is 0.87 lag. The stator to rotor effective turns ratio is 0.6.

If a speed range of 500-1000 rpm is to be obtained with a static Kramer system decide on the ratings of the converters and the transformer. Also, find the firing-angle range for the feedback path converter. Draw the circuit diagram. Assume a meaningful turns ratio for the rotor side transformer. Draw the phasor diagram at rated speed. Derive in brief the expressions used.

b) The above machine is to be run from a low cost V/f drive without steady-state speed error. Draw the block diagram of the drive system and explain the scheme in details. Is there any particular feature that is required for transient stability of the drive? Which block takes care of the same? Explain with appropriate logic. Draw the graph of the E-f and V-f characteristics of the machine with correct numerical values.

(12+11)

4 a) Draw the schematic of a BLDC drive both under open-loop and closed loop. Draw the idealized waveforms of phase and line emfs and the phase currents. Explain the importance of position feedback for the operation of the BLDC. Indicate how the resultant mmf space vector jumps at each switching. What is sensor angle and what should be its value to give dc motor like characteristics? What should be the conduction mode of the 3-phase inverter connected to the stator? Derive an idealized expression for the net armature power developed by the motor.

b) Develop from basics of abc to dq transformation model of 3-phase machines the d-q domain equations of voltage and torque of a 3-phase BLDC motor fed from a $120^0$ conduction mode inverter. Thereafter develop tables of $v_d$ and $v_q$ during the different switching intervals of the inverter. Utilise the same to develop simple expressions for torque under steady state both at low and high speeds. Correlate the concepts of initial lag angle of the rotor or sensor angle ($\sigma$) and the conventional load angle ($\delta$) and derive values of the same at low and high speeds.

(10+13)

## Group C

5. (a) What is the effect of discontinuous conduction or the dynamic response of a motor? Explain with appropriate equations.

(b) What is the controlled variable in 'field weakening' control of a dc motor? Draw the schematic diagram for a circuit that implements this type of control.

(c) Why is the ratio X / R important in a power utility grid? How can we predict the over-voltage across a pf-correcting capacitor with the help of this ratio?

(d) What is the percentage increase in armature loss for a dc motor when it is driven at a speed of 1000 rpm at half load from a three phase converter with firing angle $60^0$? The motor specifications are as given below:

220 V, 40 hp, 1500 rpm, $R_a = 0.066$ W, $L_a = 6.5$ mH, $J = 25$ kgm$^2$, $B = 0.4$ Nm/rad/sec.

The converter operates from a 230 V, 50 Hz. ac main.

(5 + 5 + 6 + 7)

6. (a) For a transistorized four-quadrant dc chopper driving a dc motor draw the (i) load voltage (ii) load current (iii) supply current waveforms, in the forward motoring and forward regeneration modes.

(b) Find out the four quadrant chopper switch ratings for a dc drive drawing maximum 30A from a 100V supply. The range of duty cycle is 10% - 90%.

(c) Why is an 'anti-windup' circuit necessary for speed controllers in chopper drives? Give the block schematic of such a circuit and briefly explain its operation.

(d) A chopper-controlled dc motor has the following parameters:

100 hp, 500 V, 1500 rpm, $R_a = 0.4\ \Omega$, $L_a = 12$ mH, $K_b = 1.86$ V/rad/sec, $J = 1$ kg-m$^2$,

$B = 0.162$ N-m/rad/sec, $f_c = 600$ Hz., $V_s = 650$ V

Find the duty cycle at half load and 500 rpm (use average analysis).

(e) What are the popular methods of 'sensorless' control? Briefly describe any one of them.

(6 + 4 + 4 + 5 + 4)