UNIVERSITY OF KWAZULU-NATAL

School of Engineering

Power Electronics 3

ENEL4PBH2

EXAMINATIONS – October 2016

Main

Duration	: 2H00
Max.Marks	: 50
Number of Questions	: 5
Number of pages	: 5

Examiner	: Dr.C.Venugopal
Moderator	: Dr J Van Coller

Instructions:

- Answer either Part A or Part B from each question
- No notes of any form are allowed into the examinations
- Scientific calculator is allowed

QUESTION 1

Part A: External Commutation Methods

The circuit shown in Fig.1a is employing resonance commutation. The commutating capacitance is 20μF and inductance is 5μH. Initial voltage across the capacitor is 230V. For a constant load current of 300A, calculate

a. Conduction time of the auxiliary thyristor TA (2 Marks)
b. Voltage across the main thyristor T1 when it gets commutated and (6 Marks)
c. The circuit turn-off time of the main thyristor T1 (2 Marks)

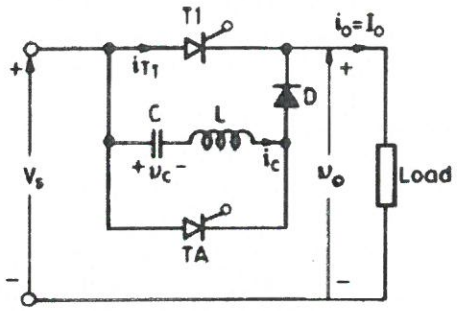

Fig. 1a

Part B: Cycloconverter Drives

The input voltage to the cycloconverter shown in Fig. 1b is 230V(rms), 50Hz. The load resistance is 5Ω and the load inductance is 40mH. The frequency of the output voltage is 16.67Hz. If the converters are operated as semiconverters such that $0 \le \alpha \le \pi$ and the delay angle is α_p is $2\pi/3$. Determine

a. The rms value of output voltage V_o (2 Marks)
b. The rms current of each thyristor I_R (6 Marks)
c. The input power factor (2 Marks)

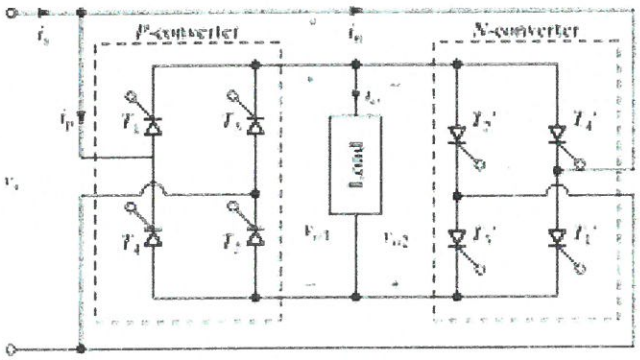

Fig.1b

QUESTION 2

Part A: Thyristor Heating, Cooling and Mounting Techniques

A power semiconductor switch has a specified thermal resistance of 0.8°C/W from junction to casing. It is mounted on a heat sink whose thermal resistance is 0.3°C/W. The thermal resistance from heat sink surface to ambient is 0.2°C/W. The switch is operating with a total power dissipation of 50W. The ambient temperature inside the cabinet in which the equipment is housed is 45°C. Determine

a. The junction temperature (4 Marks)
b. The temperatures of the casing and heat sink surfaces (4 Marks)
c. The increased allowable power loss in the thyristor-sink combination if the heat sink temperature is brought down to 40°C by forced cooling. (2 Marks)

Part B: Dual Converters and Snubber Circuits

1. A single phase dual converter is operated from a 220V, 50Hz supply. The load resistance is 15Ω. The circulating inductance is 100mH and the delay angle (α_1)of the converter 1 is 60° and delay angle (α_2) of the converter 2 is 130°. Calculate the
   a. Peak circulating current (1 Mark)
   b. Peak load current (1 Mark)
   c. Peak current of converter 1 (1 Mark)

2. A transistor is operated as a chopper switch as shown in fig.2 at a frequency f_s of 10kHz. The dc voltage of the chopper (V_s) is 220V and the load current I_L is 100A. The $V_{CE(Sat)}$ is 0V for the switching times t_d of 0, t_r of 3μsec and t_f of 1.2μsec, determine
   a. The values of L_s, C_s and R_s for the critically damped condition. (3 Marks)
   b. The value of R_s if the peak discharge current is limited to 10% of load current (2 Marks)
   c. The power loss in the RC snubber circuit neglecting the effect of inductor L_s on the voltage of the snubber capacitor C_s and the loss in diode D_s. (2 Marks)

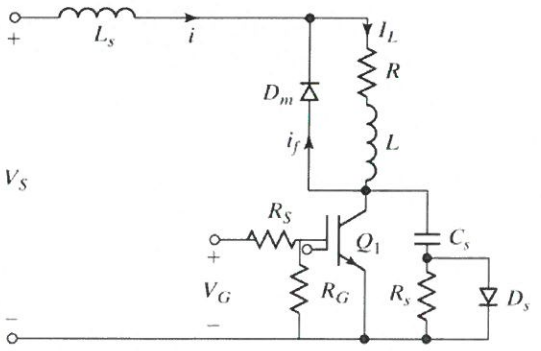

Fig.2

QUESTION 3

Part A: Multilevel Inverter

A single-phase diode-clamped multilevel inverter has 5 levels. If V_{dc} is 4kV and I_o is $50\sin(\theta-\pi/3)$. Find the

a. Peak switch voltages (1 Mark)
b. Peak branch diode voltages (3 Marks)
c. Current ratings of diodes (6 Marks)

Part B: Inverter Harmonics

A single-phase full bridge inverter employing transistors is fed from a 220V dc supply and connected to a RLC load with R = 6Ω, L = 30mH and C = 180μF. The output frequency is 50Hz. Calculate

a. The peak value of load current (6 Marks)
b. THD of output current (4 Marks)

QUESTION 4

Part A: Synchronous Motors

A 3 phase, 5kW, 440V, 50Hz, 4 pole, Y connected synchronous motor has a stator winding resistance of 0.2Ω, synchronous reactance of 8 Ω and a rated field current of 1A when operating at full load with unity power factor.

a. Calculate the torque angle when operating at full load (7 Marks)
b. Calculate the pull-out torque and power at pull-out torque (3 Marks)

Part B: Slip Power Controlled Drives

A 3 phase, 440V, 6 pole, 970 rpm, 50Hz, Y-connected induction motor has the following parameters referred to the stator

$R_s = 0.2\Omega$, $R_r' = 0.15\Omega$, $X_s = X_r' = 0.4\ \Omega$, $R_d = 0.01\ \Omega$

The stator to rotor turns ratio is 3.5

The motor speed is controlled by the static Scherbius drive. The drive is designed for a speed range of 30% below the synchronous speed. The maximum value of firing angle is 170°. Determine the

a. Turns ratio of the transformer (2 Marks)
b. Torque for a speed of 750rpm and $\alpha = 140°$ (8 Marks)

QUESTION 5

PART A: Hybrid Solar and Wind Power Systems

Explain the design of hybrid solar and wind power systems with neat sketches (10 Marks)

PART B: Space Vector Modulation

Generate a reference vector, Vref, that can be used by a SVPWM controlled three phase inverter to generate a three phase voltage at 65Hz with a peak voltage of 50 V. The reference vector must be generated at 3.42msecs. In what sector does the vector lie? (10 Marks)