Department of Electrical Engineering
Indian Institute of Technology, Kharagpur

Power Electronics(EE31011) Date: 27th Sept, 2012 AN
3rd Year EE Exam Halls: V1 & V2 100 students
Time: **2 hours.** Autumn Mid Semester Exam. 2012-2013 Full Marks: **80**

Instructions: Attempt **All** the questions. Intermediate calculation steps must be shown.

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1. (a) A 3-phase fully controlled bridge converter is supplied from a source having inductance L per phase as detailed in Figure 1. Assuming the output current to be constant at I, explain the operation of the bridge at firing angle α and derive expressions for the overlap angle and the output average voltage. Sketch the output voltage indicating which supply voltage appears across the load in different time intervals. Mathematical steps should be clearly explained while deriving the formula. [12]

   (b) A 3-phase fully controlled ac to dc converter is supplied from 420 V (line to line), 50 Hz main with per phase source inductance of 0.1 mH. If the output current is constant at 100 A, calculate the over lap angle and the average output voltage for the firing angle $\alpha = 60°$ [8]

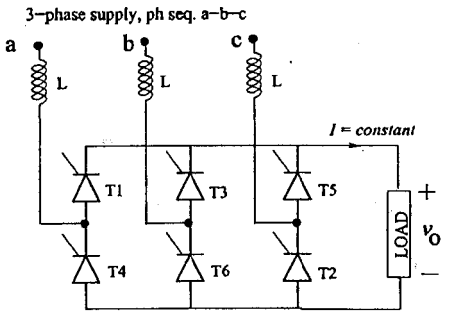

Figure 1: Pertaining to Q1(a)

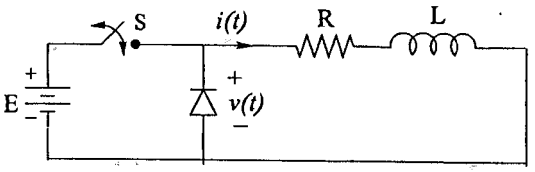

Figure 2: Pertaining to Q2(a)

2. (a) For the circuit shown in Figure 2, assume the switch was initially OFF and the current in $R-L$ load was zero. Now the switch is made ON and OFF repeatedly such that ON time is T_{ON} and OFF time is T_{OFF}. If the load current $i(t)$ is continuous, sketch the current against time from the instant when the switch was closed for the first time. Show that the circuit will reach a steady state condition and derive expressions for the I_{max} and I_{min} at steady state condition.[8]

   (b) The switch S of the circuit shown in Figure 3 is closed at $t = 0$ for 10 ms and then made off permanently. Sketch to scale the the waveforms for $v_1(t)$, $i_1(t)$, $v_2(t)$, $i_2(t)$, $v_D(t)$ and $v_s(t)$. The ratio of turns of the two tightly coupled coils is $N_1 : N_2 = 1 : 2$ and inductance L_1 of the first coil is 10 mH. Calculate the amount of energy transferred to the 5 V battery from the 10 V battery. [12]

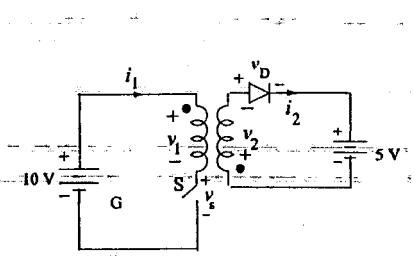

Figure 3: Pertaining to Q2(b)

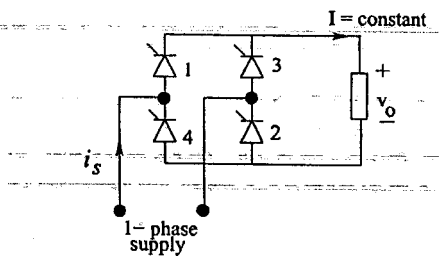

Figure 4: Pertaining to Q3(a)

Please turn over

3. (a) A single phase fully controlled converter supplies a constant current I to the output load and operates at a firing angle α as shown in Figure 4. (i) Sketch the input supply voltage, input current and output voltage. Obtain expression for output voltage, power factor and total harmonic distortion (ii) Repeat part (i) if a FD is connected at the output terminal. [10]

(b) A single phase fully controlled bridge feeds a $R-L-E$ load with $R = 3\,\Omega$, $L = 200$ mH and $E = 150\,\text{V}$. The bridge is supplied from a 1-phase, 220 V, 50 Hz source. The trigger angle is adjusted to $\alpha = 60°$.

(i) What is the minimum value of α for which the bridge will operate?

(ii) Write down the expression for the output current.

(iii) Decide whether the current is continuous or not.

(iv) If the current is discontinuous, form an equation from which the current extinction angle β can be determined.

(v) Also form an equation from which the instant at which the peak current occurs , can be determined. [10]

4. (a) For the 3-phase ac controller shown in Figure 5, goal is to obtain the voltage waveform v_{AO} across the load R. Draw the relevant supply wave forms and gate signals to the SCRs and sketch v_{AO}. Assume the firing angle α to be 90°. Also assume the duration of gate signal to each SCR to be 120°. [10]

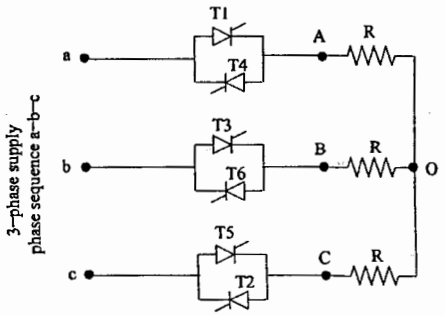

Figure 5: Pertaining to Q4(a)

(b) Draw and explain the operation of a *dual converter* (circulating current type). What is the relationship between the trigger angles of the two converters. Sketch relevant waveforms corresponding to $\alpha_1 = 30°$ in order to obtain the voltage waveform across the inductor. If the load is the armature of a separately excited d.c motor, explain how regenerative braking can be implemented. [10]

Note: Use graph papers to sketch wave forms correctly and quickly.

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