



INTI
International College Penang

FINAL
Examination Paper

(COVER PAGE)

Session : August 2018

Programmes : Diploma in Electrical and Electronic Engineering (DEEI)

Course : EEE2112: Introduction to Power Electronics and Drives

Date of Examination : 13 December 2018 (Thursday)

Time : 11:00am – 1:00pm

Duration : 2 Hours Reading Time : Nil

Special Instructions :

This paper consists of SIX (6) questions. Answer any FOUR (4) questions in the answer booklet provided. All questions carry equal marks.

IMPORTANT NOTE : THIS PAPER SHOULD NOT BE TAKEN OUT OF THE EXAMINATION HALL BY THE STUDENTS.

Materials Permitted :
Non-programmable Scientific Calculator (e.g. Model fx570 Series)

Materials Provided :
1. Worksheet for Q4(b) (2 printed pages)
2. Linear Graph Paper (× 1)

Examiner(s) : Chan Tse Wei

Moderator : Dr. Ooi Beng Lee

This paper consists of 9 printed pages, including the cover page.

INTI INTERNATIONAL COLLEGE PENANG

DIPLOMA IN ELECTRICAL AND ELECTRONIC ENGINEERING PROGRAMME (DEEI)
 EEE2112: INTRODUCTION TO POWER ELECTRONICS AND DRIVES
 FINAL EXAMINATIONS: AUGUST 2018 SESSION

Instructions: This paper consists of **SIX (6)** questions. Answer any **FOUR (4)** questions in the answer booklet provided. All questions carry equal marks. The marks allocated to each sub-question are shown in square brackets at the right-hand margin. Present your answers neatly and clearly. The assessor reserves the rights to ignore your answers if they are ambiguous.

Question 1

- a. Define power electronics and explain the main reason power electronics adopt switching scheme in its applications. [5]
- b. Figure-Q1(b) shows a simple set up of a power control system adopting switching scheme to control power delivered from a DC voltage source to a resistive load through a voltage controlled solid-state switch.
- i. Explain the needed characteristics of the solid-state switch such that 100% power conversion efficiency is achieved. [5]
- ii. Explain the impact of switching duty cycle of the solid-state switch has on the amount of power delivered to R_{load} . [5]

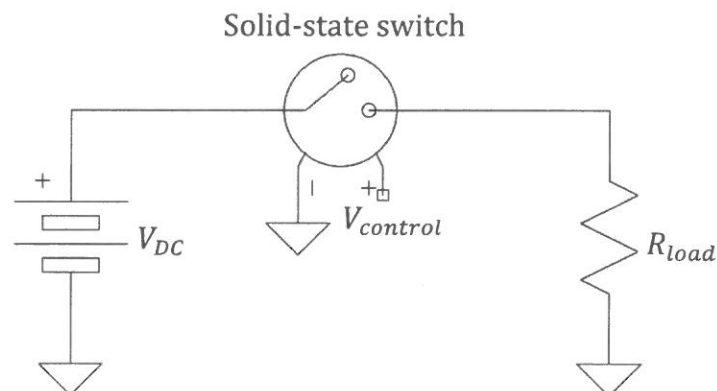


Figure-Q1(b)

- c. Figure-Q1(c) shows a basic topology of a chopper. Assume that the solid state switch has been open for a long time and diode D is ideal.

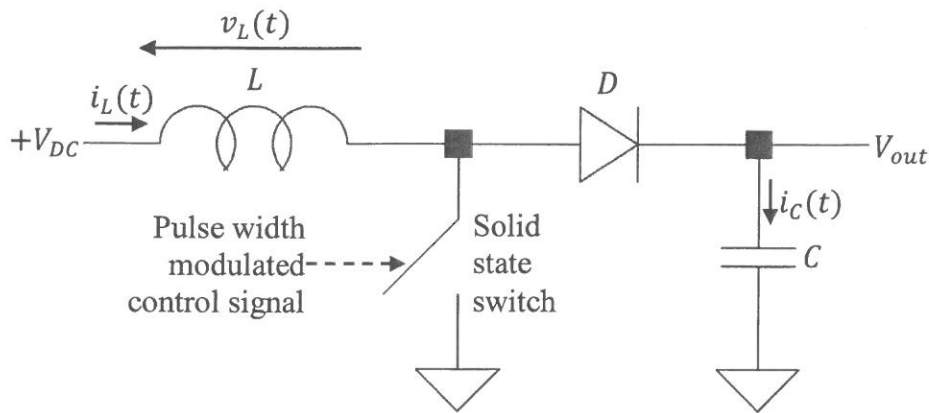


Figure-Q1(c)

- State the output voltage expression right before the solid-state switch is closed. [2]
- Clearly sketch the timing diagram of the current flowing through the inductor, $i_L(t)$ after the solid-state switch is closed for Δt_1 moment. Assume piecewise linear operation. [3]
- The solid-state switch is reopened after Δt_1 for Δt_2 moment. State the output voltage expression the moment the switch is reopened. [2]
- Assume that the duration of Δt_2 provides continuous inductor current condition, clearly sketch the timing diagram of the current flowing through the capacitor, $i_C(t)$ for the duration of $\Delta t_1 + \Delta t_2$. [3]

Question 2

- State three examples of semiconductor devices that are used as switches in power electronics circuits. [3]
- Figure-Q2(b) shows the symbol of an n -channel MOSFET used in power electronic circuits. Explain the electrical principle of operation of the device and the type of power losses that it exhibits. [5]

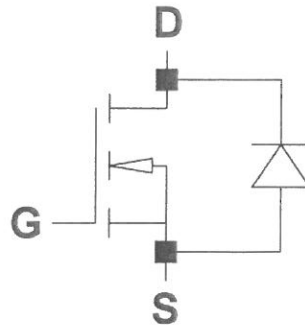


Figure-Q2(b)

c. Figure-Q2(c) shows the experimented turnoff recovery characteristic of a fast recovery diode current, $i_D(t)$.

- i. Identify the peak reverse current magnitude of the diode. [2]
- ii. Determine the reverse recovery time of the diode. [2]
- iii. Calculate the recovered charge of the diode. [3]

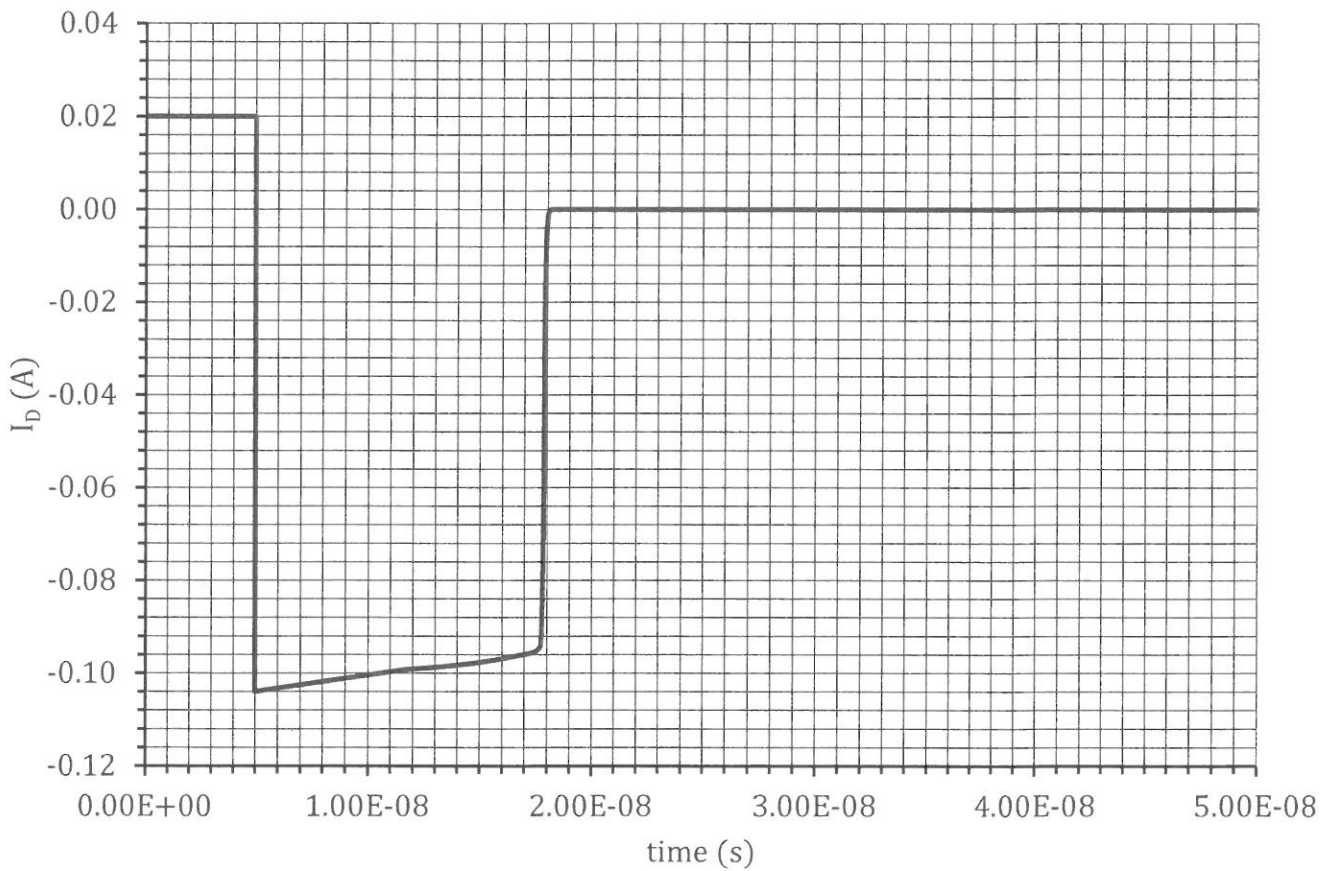


Figure-Q2(c)

d. Diode D in Figure-Q2(d)(i) has the following characteristics:

- Peak inverse voltage, $PIV = 100\text{ V}$
- Equal t_a and t_b (refer to Figure-Q2(d)(ii))
- $|di_D/dt| = 50\text{ A}/\mu\text{s}$ during reverse recovery
- Forward biased voltage, $V_F = 0.7\text{ V}$

Switch SW in Figure-Q2(d)(i) has been left open for a relatively long time. Both the input voltage, V_{in} and the current I are DC sources.

If switch SW is turned on until steady-state condition is achieved, determine if the diode is suitable to be implemented in the circuit. Justify your answer by sketching the timing diagram of the voltage across the diode, $v_D(t)$. [10]

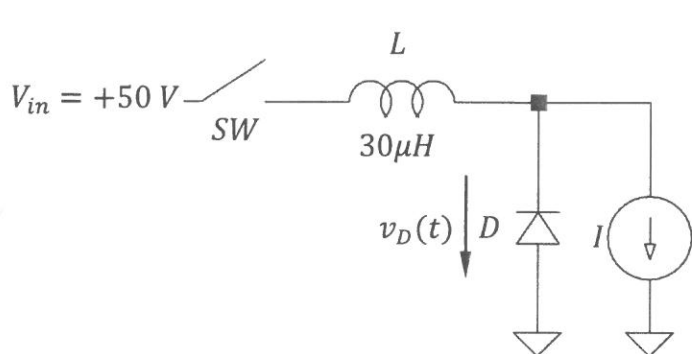


Figure-Q2(d)(i)

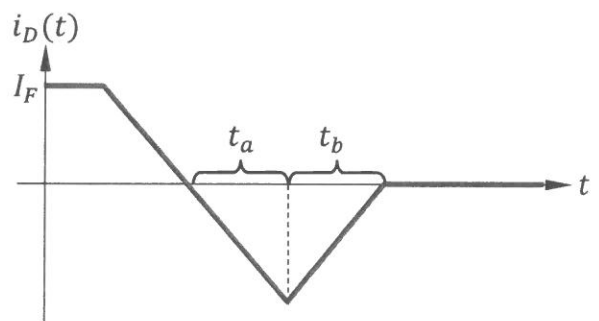


Figure-Q2(d)(ii)

Question 3

a. Draw a single phase full-wave uncontrolled rectifier circuit with RL load, and explain its principle of operation. [5]

b. Figure-Q3(b) shows a controlled rectifier circuit, controlling power to a $50\ \Omega$ resistive load represented as R_{load} in the figure. Calculate the power dissipated in R_{load} if SCR_1 is triggered to conduct current at the moment the supply voltage, V_s reaches its positive peak value. State any assumption made in your calculation. [5]

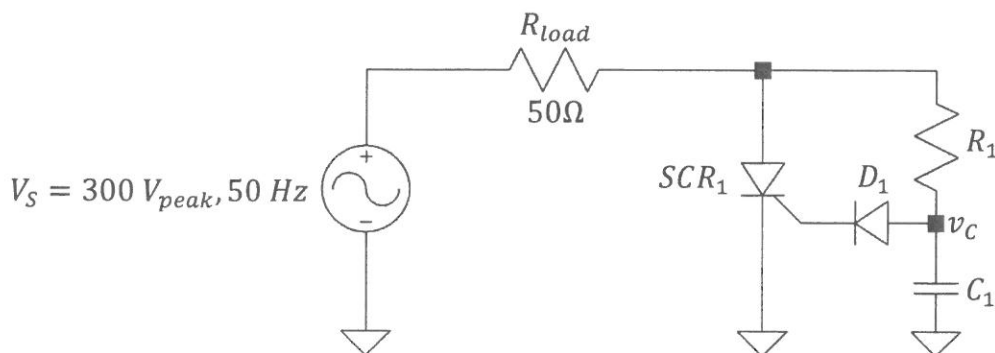


Figure-Q3(b)

c. The circuit in Figure-Q3(b) has the following requirements and set ups:

- $v_C = 2 V$ to initiate SCR_1 into conduction mode.
- $R_1 = 10 k\Omega$
- $C_1 = 300 nF$
- SCR on resistance, $R_{ON} \approx 0\Omega$
- SCR off resistance, $R_{OFF} \approx \infty \Omega$

Identify the firing moment of SCR_1 and the power delivered to R_{load} .

[15]

Question 4

a. Explain the switching DC regulator and the reason for using it. Illustrate three of its basic topologies.

[10]

b. Figure-Q4(b)(i) shows an inverter circuit. Consider its operation is ideal. Figure-Q4(b)(ii) shows the timing diagrams of $I_{load}(t)$, $V_{ctrl1}(t)$ and $V_{ctrl2}(t)$ during steady state condition.

i. Determine the output frequency of the inverter.

[3]

ii. Complete "Worksheet for Q4(b)" by sketching the relevant waveform on each of the given timing diagram.

[12]

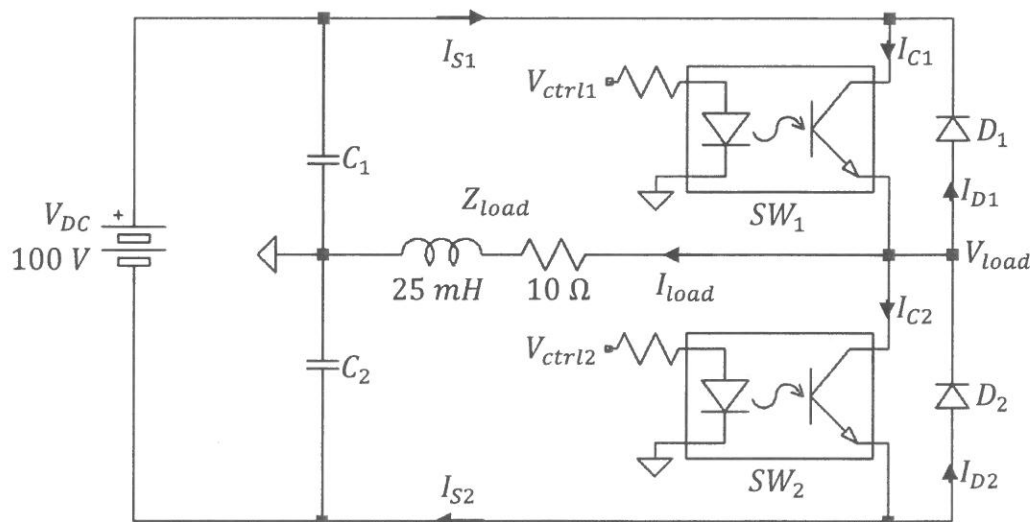


Figure-Q4(b)(i)

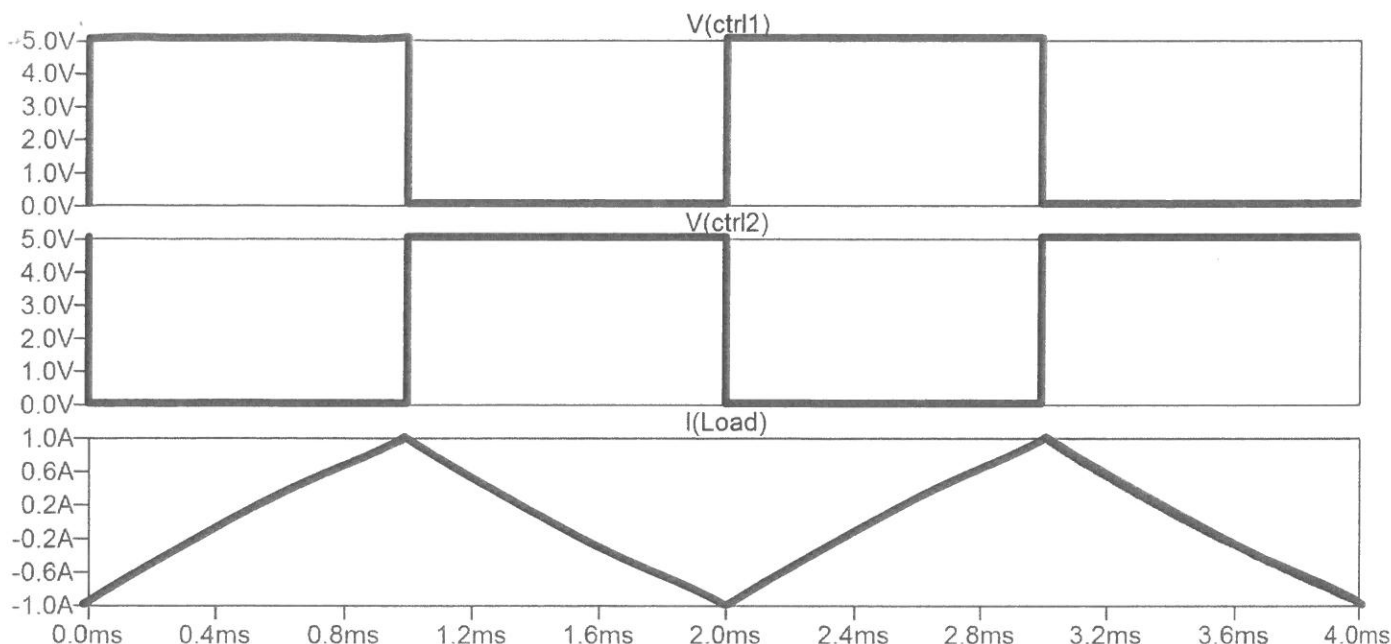


Figure-Q4(b)(ii)

Question 5

a. Explain the function of an AC-to-AC converter and give two application examples of such converters. [5]

b. Figure-Q5(b) shows a chopper circuit. Switch S_1 is driven to turn on and off at a frequency of 5 kHz so that R_{load} receives 150 V drop across it. Assume all the components are ideal.

i. Calculate the duty cycle of the switch S_1 . [2]

ii. Calculate the maximum and minimum current drawn from the 20 V supply voltage. [6]

iii. Calculate the lowest inductance value to maintain continuous current flow from the supply voltage. [2]

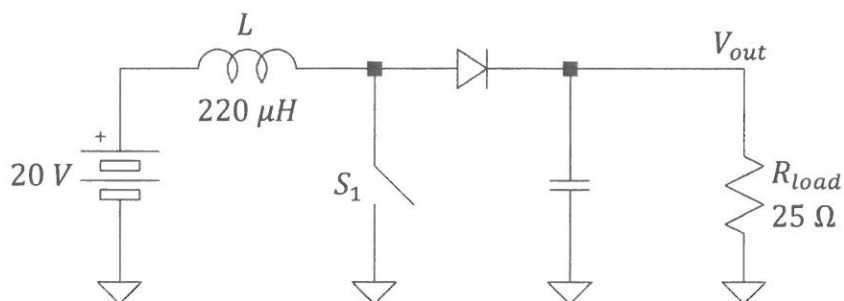


Figure-Q5(b)

- c. Figure-Q5(c) shows a single-phase AC-AC voltage converter. V_{AC} has a frequency of 50 Hz. Plot, using the provided linear graph paper, the graph of the circuit's power factor against the gate firing moments at {0 s, 1 ms, 2 ms, 3 ms, 4ms, 5 ms, 6ms, 7 ms and 8 ms} after every 0 V crossing of the AC voltage, V_{AC} .

Comment on the converter circuit performance.

[10]

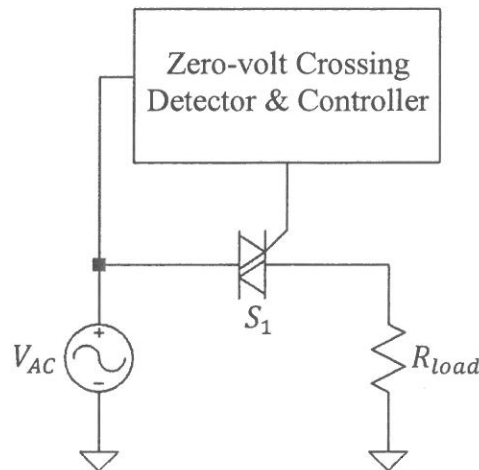


Figure-Q5(c)

Question 6

- a. State the function of snubber circuits used in association with transistor switching. [5]
- b. Define thermal resistance of an electronic device. [5]
- c. Figure-Q6(i) and (ii) show two different switching circuits utilizing power MOSFETs. Distinguish the requirement of the respective gate drive voltage, V_G to deliver power to the respective loads. [5]

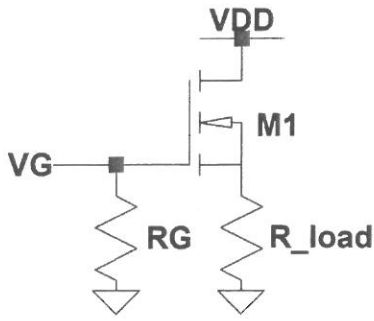


Figure-Q6(i)

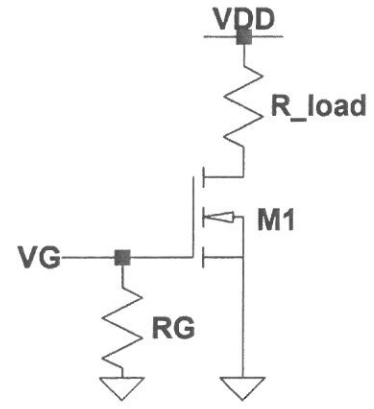


Figure-Q6(ii)

- d. Explain the principle operation of an RC snubber circuit to protect an SCR. [5]
- e. Explain the electric circuit analogy for steady-state thermal power flow of an electronic device with heat-sink. [5]

~ The End ~

