



INTI
International College Penang

FINAL
Examination Paper

(COVER PAGE)

Session : April 2018

Programmes : Diploma in Electrical and Electronic Engineering (DEEI)

Course : EEE2112: Introduction to Power Electronics and Drives

Date of Examination : 27 July 2018 (Friday)

Time : 2:00pm – 4:00pm

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 :
Laplace Transform Table
Linear Graph Paper (× 2)

Examiner(s) : Chan Tse Wei

Moderator : Dr. Ooi Beng Lee

This paper consists of 8 printed pages, including the cover page.

DIPLOMA IN ELECTRICAL AND ELECTRONIC ENGINEERING PROGRAMME (DEEI)
 EEE2112: INTRODUCTION TO POWER ELECTRONICS AND DRIVES
 FINAL EXAMINATIONS: APRIL 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. List five (5) ideal characteristics of a power electronic switch. [5]
- b. Figure-Q1(b) shows a simple set up of a power control system utilizing switching scheme to control power delivered from a 20 V DC voltage source to a 20 Ω load through a voltage controlled solid-state switch.
- Find the average power delivered to the load if the solid-state switch is,
- closed, [2]
 - opened, [2]
 - open 40% of the time, and [3]
 - closed 20% of the time. [3]

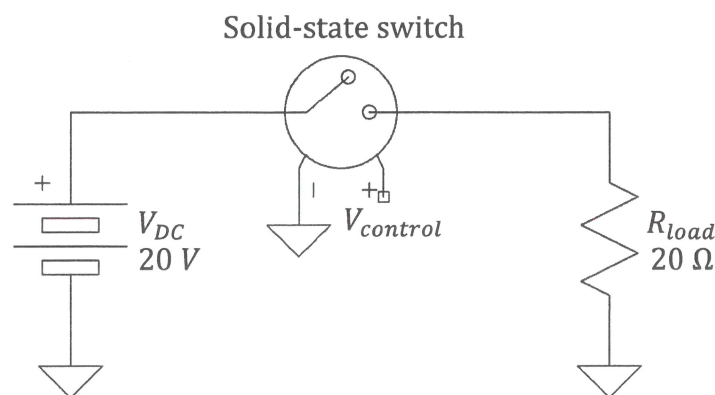


Figure-Q1(b)

- c. Figure-Q1(c) shows a basic buck-boost chopper circuit. The pulse width modulator (PWM) generates a fixed 10 kHz signal with varying duty cycle to operate the solid-state switch. The duty cycle of the PWM depends on the value of the output voltage, V_{out} .

R_v represents a varying resistive load ranging from $90\ \Omega$ to $2.25\ \text{k}\Omega$. The variation of the load resistance should not affect the load power which is to be maintained at 10 W. The chopper circuit need to regulate the DC output voltage in order to sustain the 10 W load power delivered to the varying R_v .

Calculate the minimum inductance value for inductor L , if the circuit is to be operated in a continuous-conduction mode. [10]

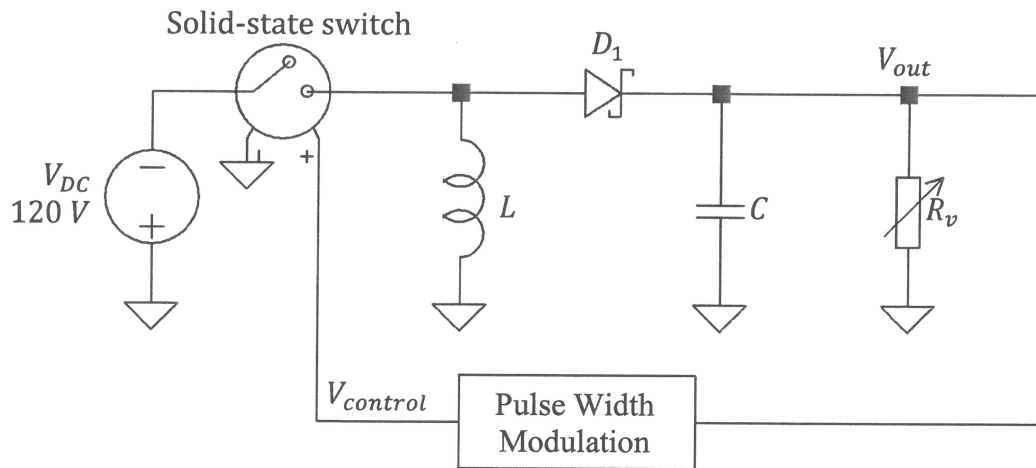


Figure-Q1(c)

Question 2

- a. State three examples of semiconductor devices that are used as switches in power electronics circuits. [3]
- b. Explain the principle of operation of an SCR as a solid-state switch. [5]
- c. Figure-Q2(c) shows the experimented turnoff recovery characteristic of a fast recovery diode current, $i_D(t)$. Interpret the experiment result and solve for the,
- reverse recovery time, [2]
 - peak reverse current, and [2]
 - recovered charge. [3]

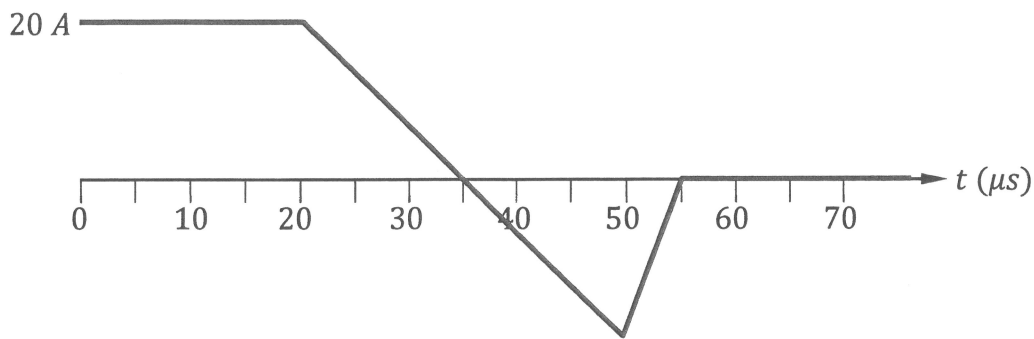


Figure-Q2(c)

d. Table-Q2(d) shows the results of an experiment conducted on a power diode. V_D and I_D are respectively the static voltage across the power diode and static current flowing through it. Next to Table-Q2(d) is the sign convention of the diode measured parameters.

V_D (V)	-50	-40	-30	-20	-10	-5	-1	0
I_D (A)	-2.0μ	-1.9μ	-1.4μ	-0.9μ	-0.4μ	-0.2μ	$-52n$	0.0

V_D (V)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
I_D (A)	0	0	0	0	5m	10m	0.2	1.7

V_D (V)	0.9	1.0	1.1	1.2	1.4	1.6	1.8	2.0
I_D (A)	4.0	10.0	15.0	28.0	55.0	80.0	100.0	135.0

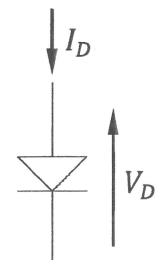


Table-Q2(d)

From the experiment results, model the diode using the model shown in Figure-Q2(d). D_1 and D_2 in the shown model are ideal diodes. R_f and R_r are respectively, the piecewise linear forward biased and reverse biased resistances. V_f is the diode's forward biased barrier voltage.

Hint: You need linear graph papers to attempt to this question.

[10]

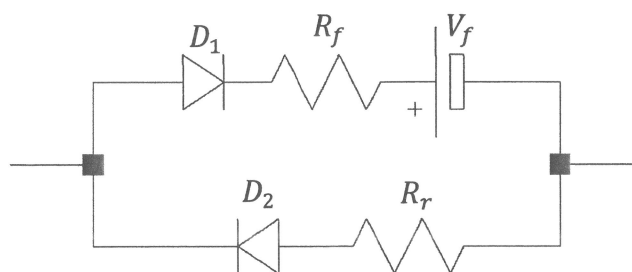


Figure-Q2(d)

Question 3

a. Explain phase-controlled rectifier and the two reasons that makes SCR a unique power switch to be used in this type of power converter. [5]

b. Figure-Q3(b) shows a rectifier circuit, controlling power delivered to a heating element represented as R_H in the figure. The switch triggering circuit produces a stream of trigger pulses to the gate terminal of SCR D_1 at every 8 ms after the supply voltage, V_S crosses the 0 V level from its negative cycle to positive.

Assume that the SCR is ideal, verify that this circuit set up delivers approximately 6 W of power to the heating element. [5]

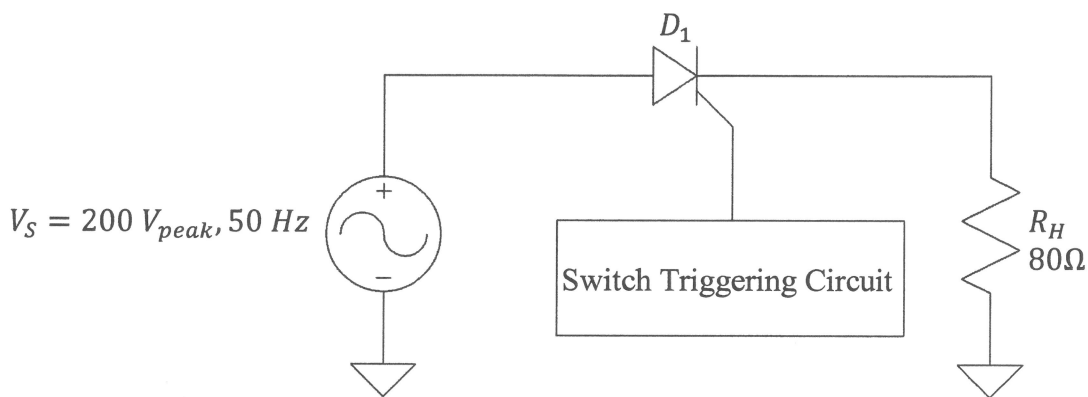


Figure-Q3(b)

c. Figure-Q3(c)(i) shows a rectifier circuit with inductive load, while Figure-Q3(c)(ii) shows the timing diagrams of $V_S(t)$ and $V_R(t)$ measured with an oscilloscope.

Determine the expression of the instantaneous value of $V_R(t)$ and verify the accuracy of the expression respectively at $t = \{2 \text{ ms}, 8 \text{ ms}, 12.45 \text{ ms}\}$ [15]

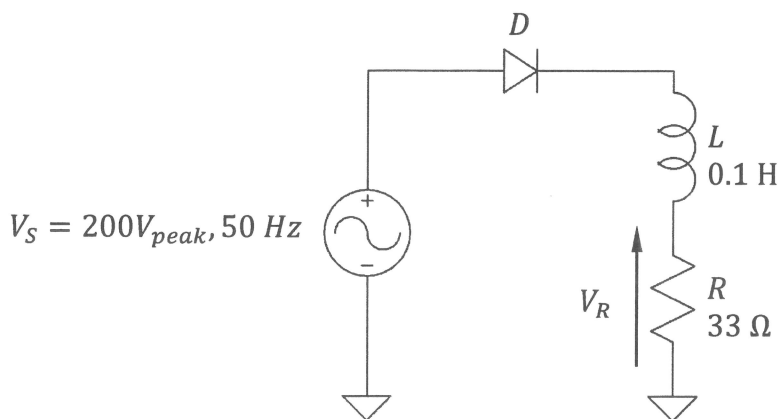


Figure-Q3(c)(i)

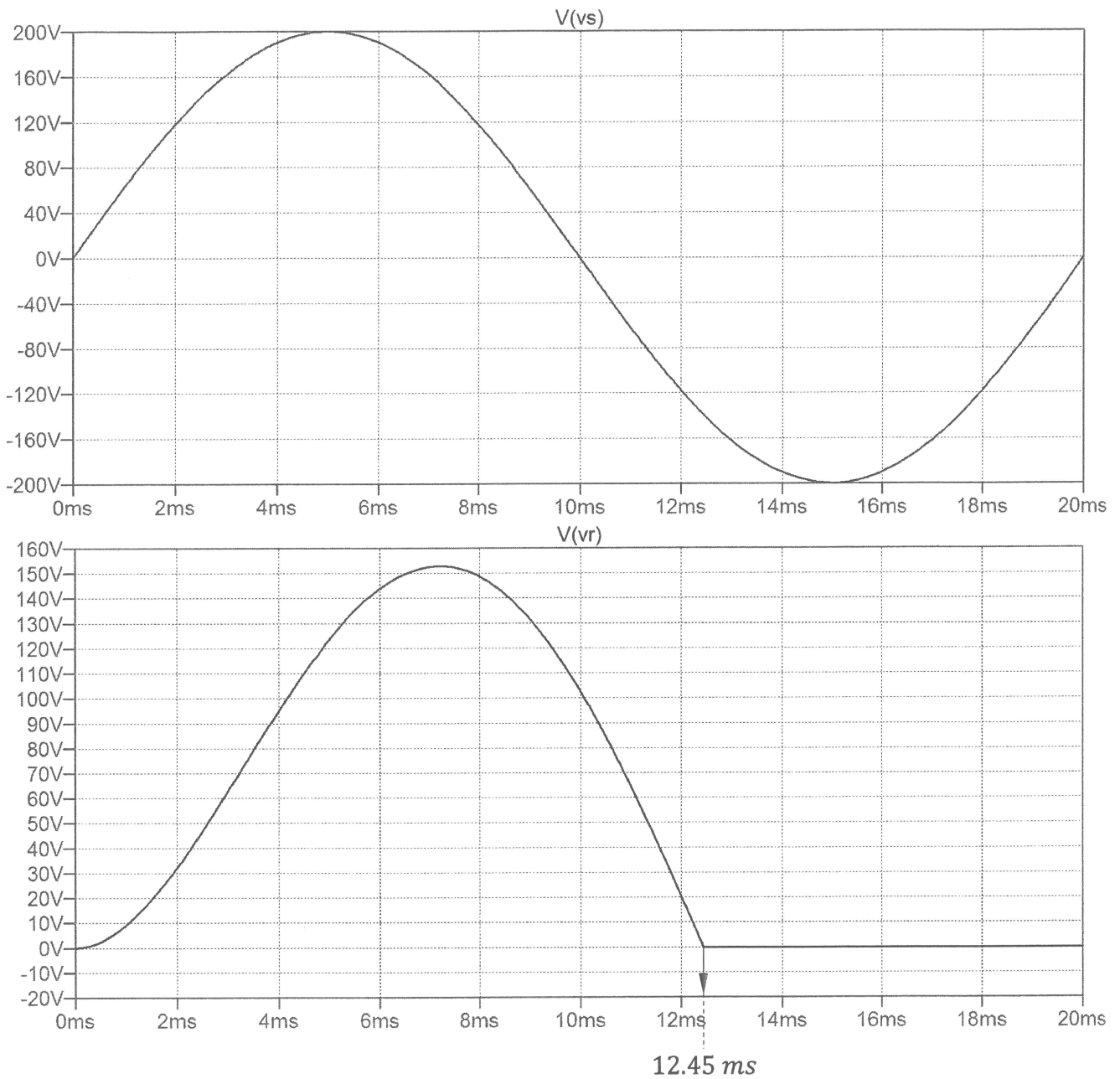


Figure-Q3(c)(ii)

Question 4

- a. Distinguish between a single phase half-bridge inverter and a single phase bridge inverter by showing their respective schematic diagram and explain their respective principle of operation.

[10]

- b. The square-wave inverter in Figure-Q4(b) produces an output frequency of 50 Hz. The saturated voltage of each opto-coupler in the bridge configuration is 1.5 V and the rest of its operation is considered ideal.

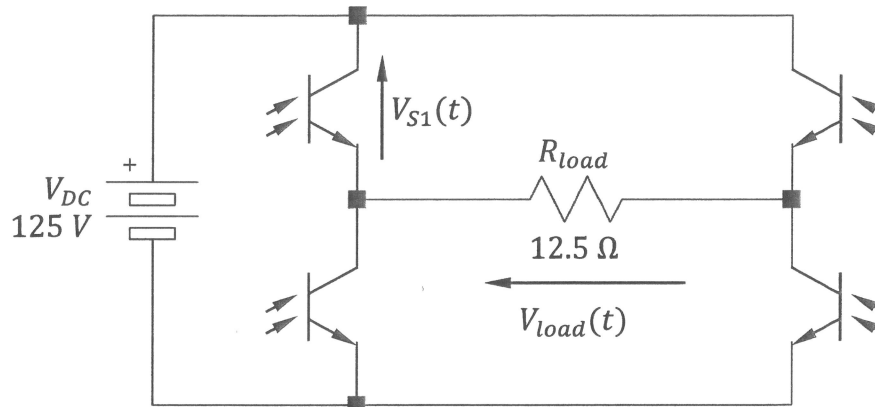


Figure-Q4(b)

- i. Sketch the synchronized timing diagrams for $V_{load}(t)$ and $V_{S1}(t)$ respectively. [5]
- ii. Calculate the minimum power rating requirement for the resistive load. [4]
- iii. Analyze if an opto-coupler having a maximum rms output current of 5 A is suitable for such application. [6]

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 basic single phase AC voltage controller with a resistive load. SCR S_1 and S_2 are alternatively triggered at a delay angle of α radian after each of them are being forward-biased. Show that the r.m.s. voltage across the load resistor R can be expressed as,

$$V_{R(rms)} = \frac{V_{ac(peak)}}{\sqrt{2}} \sqrt{1 - \frac{\alpha}{\pi} + \frac{\sin(2\alpha)}{2\pi}} \quad [10]$$

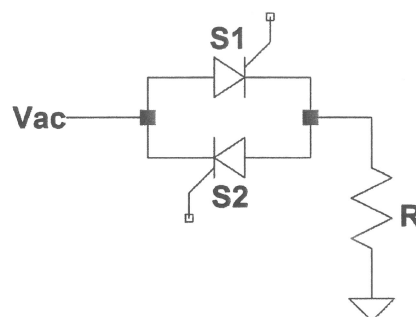


Figure-Q5(b)

- c. If the single-phase AC voltage controller in Figure-Q5(b) has a 240 V rms, 50 Hz source, and the load resistance is 20Ω , calculate
- the delay angle required to deliver 500 W of power to the load [4]
 - the rms source current [3]
 - the rms current flowing through each SCR. [3]

Question 6

- State the function of snubber circuits used in association with transistor switching. [5]
- Define thermal resistance of an electronic device. [5]
- 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]

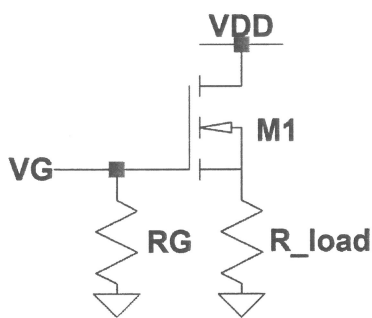


Figure-Q6(i)

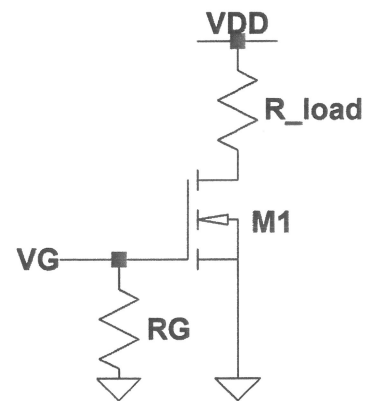


Figure-Q6(ii)

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

~ The End ~

THE LAPLACE TRANSFORM TABLE

Definition	$f(t)$ from $t > 0$	$F(s) = \mathcal{L}[f(t)] = \int_0^{\infty} f(t)e^{-st} dt$
2. First Derivative	$\frac{d}{dt}[f(t)]$	$sF(s) - f(0)$
3. n^{th} Derivative	$\frac{d^n}{dt^n}[f(t)]$	$s^n F(s) - s^{n-1}f(0) - s^{n-2}f'(0) \dots f^{(n-1)}(0)$
4. Definite Integral	$\int_0^t f(u)du$	$\frac{F(s)}{s}$
6. Exponential multiplier	$e^{-at}f(t)$	$F(s + a)$
10. Unit impulse at $t = 0$	$\delta(t)$	1
12. Unit step	$u(t)$	$\frac{1}{s}$
15. Unit ramp	$r(t) = t$	$\frac{1}{s^2}$
17. n^{th} order ramp	t^n	$\frac{n!}{s^{n+1}}$
18. Exponential decay	e^{-at}	$\frac{1}{s + a}$
19. Exponential growth	$1 - e^{-at}$	$\frac{a}{s(s + a)}$
20. Exponential $\times t$	te^{-at}	$\frac{1}{(s + a)^2}$
21. Exponential $\times t^n$	$t^n e^{-at}$	$\frac{n!}{(s + a)^{n+1}}$
22. Difference of exponentials	$e^{-at} - e^{-bt}$	$\frac{b - a}{(s + a)(s + b)}$
23. Difference of exponentials	$\frac{1}{b - a}(be^{-bt} - ae^{-at})$	$\frac{s}{(s + a)(s + b)}$
24. Sine	$\sin(\omega t)$	$\frac{\omega}{s^2 + \omega^2}$
27. Exponentially decaying sine	$e^{-at}\sin(\omega t)$	$\frac{\omega}{(s + a)^2 + \omega^2}$
28. Cosine	$\cos(\omega t)$	$\frac{s}{s^2 + \omega^2}$
31. Exponentially decaying cosine	$e^{-at}\cos(\omega t)$	$\frac{s + a}{(s + a)^2 + \omega^2}$

