UNIVERSITY OF JOHANNESBURG

PROGRAM : BACHELOR OF ENGINEERING TECHNOLOGY [**BEng Tech**] IN ELECTRICAL ENGINEERING. B6ELEQ

MODULE : **POWER TECHNOLOGY 3B**

CODE : **POWELB3**

DATE : SUMMER **SUPPLEMENTARY** EXAMINATION NOVEMBER 2019

DURATION : 3 HOURS

CALCULATION CRITERIA : 40 [SEMESTER]: 60 [EXAM]

NQF : 7

TOTAL MARKS :100

EXAMINER : DR W. DOORSAMY

MODERATOR : DR L. MASISI

NUMBER OF PAGES : 5 PAGES

INSTRUCTIONS : QUESTION PAPERS MUST BE HANDED IN.

REQUIREMENTS : POCKET CALCULATORS ARE PERMITTED.

INSTRUCTIONS TO CANDIDATES:

1. 100 MARKS = 100%.
2. ATTEMPT ALL QUESTIONS.
3. ANSWER QUESTIONS CONSIDERING THE MARK ALLOCATION.
4. QUESTIONS MAY NOT BE ANSWERED IN ANY ORDER AND **ALL PARTS OF A QUESTION MUST BE KEPT TOGETHER**.
5. ALL DIAGRAMS AND SKETCHES MUST BE DRAWN NEATLY AND LABELED CLEARLY.
6. ALL WORK DONE IN PENCIL EXCEPT DIAGRAMS AND SKETCHES WILL BE CONSIDERED AS ROUGH WORK.
7. **MARKS WILL BE DEDUCTED** FOR WORK WHICH IS POORLY PRESENTED.
8. ANSWER ALL THE QUESTIONS.

QUESTION 1

1.1 Answer true or false. When the answer is false, justify your answer by giving a brief explanation or a mathematical proof.

1.1.1 At turn on, diode current reverses for reverse recovery time (t_{rr}) which is required to sweep excess carriers and block positive polarity voltage. (2)

1.1.2 Fast recovery diodes are useful for application in high-frequency circuits because they are designed with a small reverse recovery time (t_{rr}). (2)

1.1.3 Switching a MOSFET requires continuous application of gate-source voltage. (2)

1.1.4 IGBTs can be designed to block negative voltages. (2)

1.1.5 The reverse voltage across a thyristor should be removed during turn-off time interval t_q to avoid risk of premature turn-on. (2)

[10]

QUESTION 2

1.2 According to the datasheet of a switching device, switching corresponds to linearised characteristics shown in figure 1a for clamped-inductive switching:

t_{ri} = 100 ns; t_{fv} = 50 ns; t_{rv}=100 ns; t_{fi} = 200 ns;

Solve for and plot the switching power loss as a function of frequency in a range of 25-100 kHz, assuming V_d = 300 V and I_o = 4A in figure 1b.

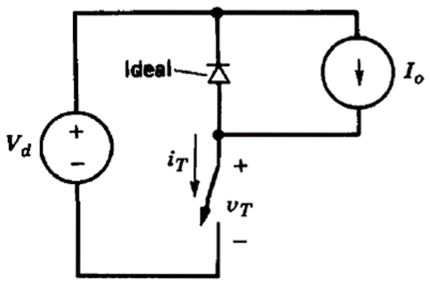

FIGURE 1a

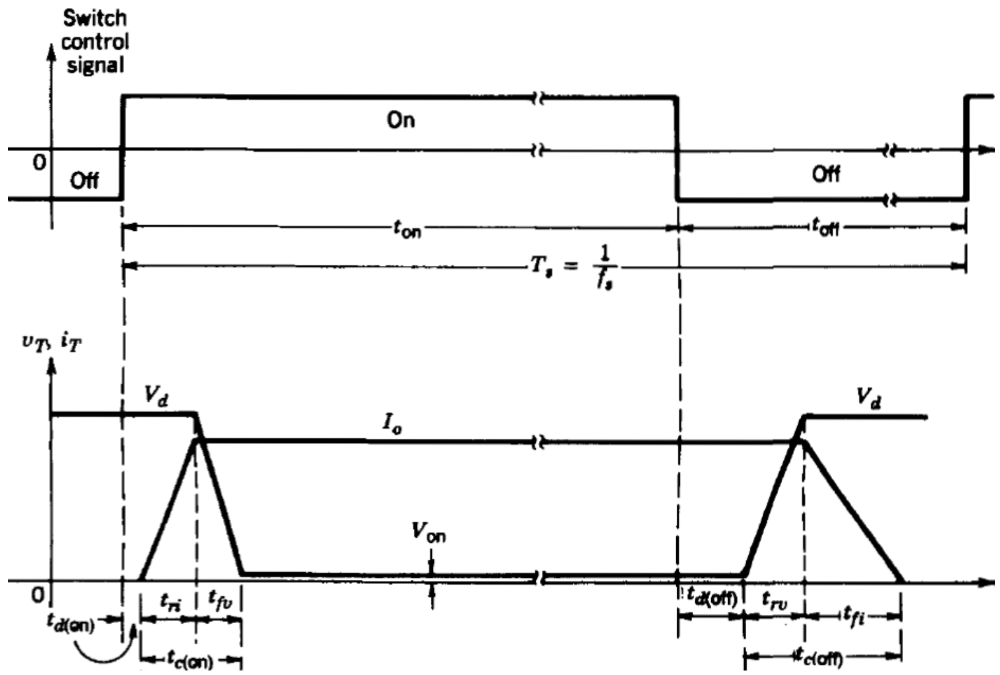

FIGURE 1b

[10]

QUESTION 3

The repetitive input voltage waveform given in figure 2 is filtered and then applied across the load resistance. Consider it to be in steady state. Given that L = 100 µH and P_{Load} = 250 W:

3.1 Solve for the average voltage output V_O. (2)

3.2 Assuming C→∞ so that $v_O(t) \approx V_O$, determine the rms value of the the load current. (5)

3.3 Illustrate the waveforms of V_L and I_L. (8)

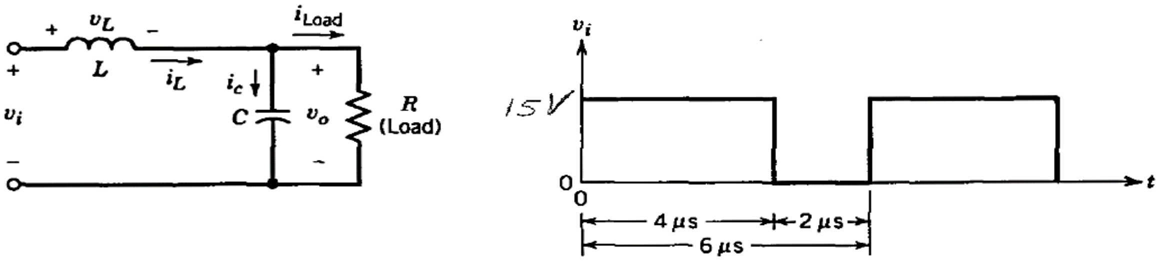

FIGURE 2

[15]

QUESTION 4

4.1 Derive the efficiency of a single-phase half-wave rectifier. (5)

4.2 Solve for the average current supplied to a 200 Ω load when it supplied by using a single phase bridge rectifier and single-phase alternating supply voltage of 220 V rms. (3)

4.3 A 3-phase full-wave diode rectifier is required to feed a 100 Ω resistive load from a 3-phase 220 V (line, rms), 50Hz delta connected supply. Determine the load current (rms). (7)

[15]

QUESTION 5

Derive the state equations for the buck converter from first principles, using the state-space averaging technique.

Express your final formulation in canonical form.

[20]

QUESTION 6

6.1 Explain with the aid of a simple graph the concept of PWM voltage control through varying the amplitude modulation ratio. (5)

6.2 Figure 3 gives a single-phase full bridge inverter, operating in a square-wave mode. The dc-voltage is 444V and the output voltage frequency supplying the motor is 57 Hz. Inductance L = 200 mH. Solve for the peak value of the ripple current in the output. (10)

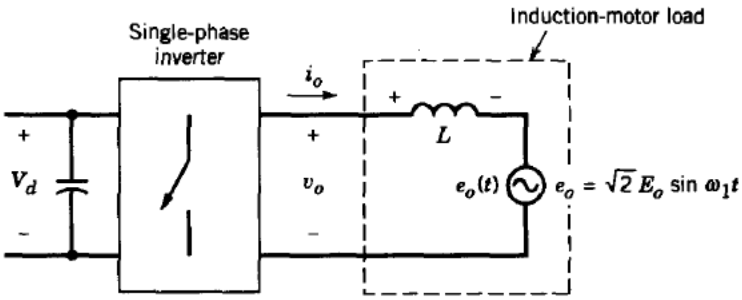

FIGURE 3

[15]

QUESTION 7

7.1 A 10Ω resistor with a suitable power rating is mounted on a heat sink and connected to a 20V dc-power supply. The ambient temperature is 25˚C and after one hour the temperature of the heat sink is 55˚C. Calculate the thermal resistance of the heat sink. (5)

7.2 With the aid of a neat and clearly labelled circuit illustration, give a detailed discussion of an inrush-current protection scheme. (10)

[15]

TOTAL : 100