FIJI NATIONAL UNIVERSITY

COLLEGE OF ENGINEERING, SCIENCE AND TECHNOLOGY

School of Electrical & Electronics Engineering

Bachelor of Engineering (Electronics & Instrumentation)

EEB701 – Industrial Electronics

FINAL EXAMINATION (Supplementary)

Semester 1, 2019

Date: As per Exam Time Table

Time: As per Exam Time Table

Venue: As per Exam Timetable

Duration of Exam: 3 Hours 10 Minutes
Total Number of Pages: 4

Instructions to Students

1. You are allowed an extra ten (10) minutes of reading time during which you are NOT allowed to write.
2. Attempt all questions.
3. Write your answers in the answer booklet provided.
4. Write your Student ID number on each page used.
5. Begin each Section on a fresh page and use both sides of the answer sheet.
6. You may use calculators provided they are non-programmable.
7. Clearly number the questions in your answer paper in their correct sequence and write legibly. Show all working.
8. Attach any extra sheets used to your answer booklet securely with the string provided.

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Question 1 (30 marks)

i) Sketch the volt-ampere (V-I) characteristic curve of the thyristor (SCR) and describe its operation. ***(4 marks)***

ii) Name and describe the three basic characteristics important to understand the process control system. ***(4 marks)***

iii) Compare switching regulator with series and shunt regulators. ***(4 marks)***

iv) Outline the requirements of rectifier circuit design and list any two important parameters which are used to measure the performance of rectifier circuits. ***(3 marks)***

v) Define process control and outline its important components. ***(4 marks)***

vi) Analyze the on-off control mode and illustrate the concept using an example of temperature control using op-amp based on-off controller. ***(4 marks)***

vii) Outline the principle of operation of three-phase induction motors. ***(4 marks)***

viii) Discuss and describe the features of transducers that need to be considered when selecting a transducer. ***(3 marks)***

Question 2 (25 marks)

i) Design a series voltage regulator using an operational amplifier and a 5.1 V zener diode to maintain a regulated output of 15 V. Assume that the unregulated input varies between 10 V and 30 V and that the current through the zener diode must be at least 30mA to keep it in its break down region. ***(10 marks)***

ii) Design a battery charger circuit using half-wave rectifier circuit to charge a battery of 20V. The average charging current should be 5A. The primary input voltage is 120V, 60 Hz and the transformer turns ratio is 2:1. ***(10 marks)***

iii) Using an aid of a circuit diagram, outline the principles of either regenerative braking or rheostatic braking of a dc-dc converter-fed dc motor drives. ***(5 marks)***

Question 3 (25 marks)

i) Design a PUT based firing circuit which could be used to trigger an SCR. PUT parameters are $V_s = 25V$, $I_G = 1.8mA$. The frequency of oscillation is $f = 1.2kHz$. The triggering pulse width is $t_g = 30\mu s$ and the peak voltage of the triggering pulse is equal to 6V. Use $C = 0.5\mu F$. ***(10 marks)***

ii) For a single-phase bridge voltage source inverter (VSI), draw the circuit diagram and output waveforms with a resistive load of R and explain its operation. ***(10 marks)***

iii) With an aid of a circuit diagram, describe the operating modes of dc motors in variable-speed application. ***(5 marks)***

Please Turn Over

Question 4 (20 marks)

i) Design an op-amp based circuit for implementing a PI-controller with transfer function:

$$G_c(s) = -2\left(1 + \frac{1}{0.30s}\right)$$

Draw the required op-amp based circuit and select suitable component values. Assume that a 0.3μF capacitor is to be used. ***(10 marks)***

ii) For industrial application, a variable voltage can be obtained by varying the input dc voltage and maintaining the gain of the inverter constant. On the other hand, if the dc input voltage is fixed, then variable output voltage can be obtained by varying the gain of the inverter. Outline and explain one of the method to control the gain. ***(5 marks)***

iii) Explain proportional, integral and derivative control methods and its effect on system response. ***(5 marks)***

THE END

ALL THE BEST FOR THE EXAMINATION

Formula Sheet

- Period of oscillation using UJTs and PUTs

$$T = RC \ln\left(\frac{1}{1-\eta}\right)$$

- PUT gate current and resistance:

$$I_G = (1-\eta)\frac{V_s}{R_G}$$

$$R_1 = \frac{R_G}{\eta}$$

$$R_2 = \frac{R_G}{1-\eta}$$

- Average and RMS voltage calculations

$$V_{dc} = \frac{1}{T}\int_0^T v_L(t)\,dt$$

$$V_{rms} = \left(\frac{1}{T}\int_0^T {v_L}^2(t)\,dt\right)^{1/2}$$

- DC motor equations

$$e_g = K_v w i_f$$

$$T_d = K_t i_f i_a$$

$$T_d = J\frac{dw}{dt} + Bw + T_L$$

- AC motor equations

$$w_s = \frac{2w}{p}$$

$$s = \frac{w_s - w_m}{w_s}$$

$$w_m = w_s\left(1 - \frac{s_m}{2T_{mm}}T_d\right)$$