FIJI NATIONAL UNIVERSITY

COLLEGE OF ENGINEERING, SCIENCE AND TECHNOLOGY
SCHOOL OF ELECTRICAL AND ELECTRONIC ENGINEERING

TRADE/DIPLOMA in ELECTRICAL ENGINEERING PROGRAMME

EEE543 DIGITAL & ANALOGUE ELECTRONICS

FINAL EXAMINATION (TRIMESTER 1, 2018)

DATE/TIME/ROOM – Refer to Exam Timetable

INSTRUCTIONS TO CANDIDATES

1. You are allowed 10 minutes extra time during which you are not to write.
2. Write all your answers in the allocated Answer Booklet.
3. Begin each answer on a fresh new page and use both sides of the sheets.
4. Write your identification number on the top of each attached sheet.
5. Insert all written foolscaps, graph paper, drawing paper, etc in their correct sequence and secure with string provided.
6. For all sheets of paper in which has been done, cross it through and you must attach to your answer script.
7. Write clearly the number(s) of the question(s) attempted on the top of each sheet.
8. Numbering conversion systems calculators are prohibited.
9. All Sections are compulsory however in Section C; choose ***one*** out of three questions.

Section A: MULTIPLE CHOICE

(15 marks = 1 mark for each correct answer)

Instructions:

Write the corresponding question number for the correct alphabet in your answer booklet.

1. Analogue Electronics uses quantified values in electronic equipment which is(are) best described as:
   a) Discrete values.
   b) Continuous values.
   c) Any quantity varying with time.
   d) Both c) and d).

(1 mark)

2. The bipolar junction transistor has:
   a) Three p-n junctions.
   b) One p-n junction.
   c) Two p-n junctions.
   d) Four p-n junctions.

(1 mark)

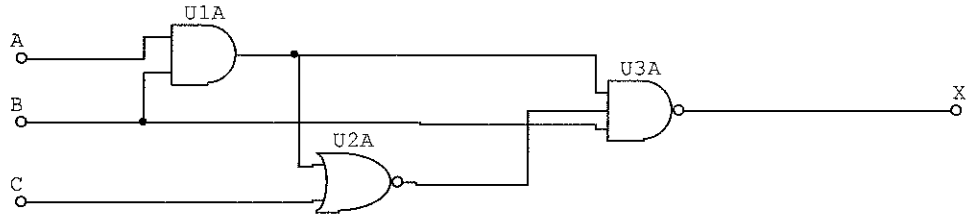
3. Analyse which fixed regulator IC would be suitable to give +12V output:
   a) 7912.
   b) 7712.
   c) 7112.
   d) 7812.

(1 mark)

4. Evaluate the appropriate flipflop which will perform the tasks of a toggle flipflop:
   a) SR NOR flipflop.
   b) D flipflop.
   c) JK flipflop.
   d) SR NAND flipflop.

(1 mark)

5. Which Boolean Equation bests describes the operation of the combinational logic diagram shown below:



   a) $X = \overline{(AB)(\overline{AB + C})B}$
   b) $X = \overline{(AB)(\overline{AB + C})B}$
   c) $X = \overline{\overline{(AB)(\overline{AB + C})B}}$
   d) All of the above.

(1 mark)

6. Name the semiconductor component that is used in the rectification stage of the DC power supply unit:
    a) Transistor
    b) Field effect transistor
    c) Light emitting diode
    d) Power diode

(1 mark)

7. Identify the "real world" electronic device:
    a) DAC
    b) ADC
    c) BCD Decoder
    d) Binary Comparator

(1 mark)

8. What is the operating voltage for a TTL IC?
    a) 3V
    b) 18V
    c) 12V
    d) 5V

(1 mark)

9. SR flipflops are commonly found in:
    a) Counter circuits.
    b) Register circuits
    c) Debounced circuits
    d) None of the above

(1 mark)

10. In the DC power supply; the rectification stage is to:
    a) Convert AC to AC.
    b) Convert DC to AC.
    c) Convert DC to DC.
    d) Convert AC to DC.

(1 mark)

11. The Boolean theorem known as De-Morgan's theorem $\overline{A + B}$ is equivalent to:
    a) $\bar{A} + B$
    b) $\bar{A} + \bar{B}$
    c) $\bar{A}.B$
    d) $\bar{A}.\bar{B}$

(1 mark)

12. The negative (-) input on a uA741 operational amplifier IC is used for:
    a) Non-inverting input
    b) Inverting input
    c) Ground potential
    d) Return part for the current flow

(1 mark)

13. When the J and K inputs are logic 0, the outputs condition will:
    a) Memorize the previous states.
    b) Toggle.
    c) Set.
    d) Reset.

(1 mark)

14. The low pass filter is found in which stage of the DC power supply?
    a) Rectifier.
    b) Regulator.
    c) Filter.
    d) Transformer.

(1 mark)

15. A MINTERM in a Boolean equation represents a:
    a) Logic 0
    b) Logic 1
    c) Logic 2
    d) None of the above

(1 mark)

Section B: Short & long answers

(15 marks)

Instructions:

Write the appropriate answers in your answer booklet.

1. Describe the terms indicated below: (show a diagram where necessary)
    a) Truthtable

(2 marks)

    b) Gate

(1 mark)

    c) Forward bias of a diode

(2 marks)

    d) Reverse bias of a diode

(2 marks)

    e) Inverting amplifier using an op-amp

(2 marks)

2. Illustrate the representation of ladder logic in relations to the given Boolean equations:
    a) $Y = \bar{A}B + \bar{B}A$

(2 marks)

    b) $Y = B.C$

(2 marks)

    c) $Y = B + A$

(2 marks)

Section C: Design of digital and analogue electronics circuits
(45 marks)

Instructions:

- *Choose **one** design question by clearly writing the question number and its appropriate answers in your answer booklet.*
- *You may use the component datasheet and formulas to supplement your analysis in the questions.*
- *Ensure that your answers in your answer booklet appear in a logical numbering pattern than being too scattered.*

1. You as a design engineer were assigned to develop a system to fill the water tank from the fifth to sixteenth levels. The design specifications was aimed at to exclude the four top levels of a 16-levels, however the next 12-levels indicates when the water pump is turned on. The first level is zero which is at the top of the tank and these first four levels indicate that the pump shall turn off.
    a) Design the minimized logic diagram to ensure that the pump turns on the fifth level to the minimum at the sixteenth level. (Include some assumptions, conditions, analysis and process flow to satisfy the design objectives)

    (29 marks)

    b) The logic gates used in your design should be efficient and sustainable to ensure that the system is resilience in maintaining the steady voltage and the power supply used is a DC source. In this case, you are to use the TTL ICs beside the CMOS ICs; the requirements are:
        i. Illustrate and label the block diagram of the regulated d.c. power supply which should facilitate this steady voltage required by the circuit.

        (4 marks)

        ii. Design the circuit diagram by drawing it and labeling all component reference designators.

        (4 marks)

        iii. Analyse regulator specifications on the "Headroom" and "Dropout voltage" with the aid of the regulator circuit diagram. Describe "headroom" and "dropout voltage" in relations to the regulator.

        (8 marks)

2. The Manager Engineering has given you a task to design a system for the Renewable Energy Sustainability Control Management to contain and sustain the availability and energy efficiency to maintain a constant voltage level to power the systems of a 12-star resort. In your design, renewable energy generation was identified as a suitable answer to the mains source. This redundancy plan was to use a pico-hydro, wind turbines, and solar. You are to use 4 voltage sensors to control the switching circuit so that you establish and maintain the voltage levels.
    a) Design this minimized combinational logic circuit by using NAND gates. (Include some assumptions, conditions, analysis and process flow to satisfy the design objectives)

    (25 marks)
    b) The output of the NAND gates as in question a) must drive a switching analogue electronic circuit to switch the AC motor for the cooling system in the resort.
        i. Design the adjoining analogue electronic block diagram of this switching system.

        (4 marks)
        ii. Design by illustrating the circuit diagram of this transistor switching system. (Assume *hfe* = 200; V_{cc} = 12V; I_b = 20 μA; & digital gates used are TTL IC. Show the working for the calculation for the value for I_c and R_b)

        (8 marks)

    c) The digital electronic system uses $+5V_{d.c}$ and the analogue electronic system uses $+12V_{d.c}$; design and draw a circuit diagram of the power supply to facilitate and maintain the voltages to these systems. (Include all analysis)

    (8 marks)

3. You were given a task as an electrical engineer to design, distinguish, analyse and discuss an electronic system comprising of digital and analogue electronics. This system is used to summarize the total voltage of a system and to count up the number of times the voltages are summarized of a maximum of 12 counts
    a) Distinguish the two differences of the summing operational amplifier to that of a differential operational amplifier if you decide to use the operational amplifier circuits.

    (4 marks)
    b) Discuss the ideal specifications of an operational amplifier.

    (4 marks)
    c) Your design circuit must include some delay in the up-count process and the appropriate counter would be an asynchronous counter. The summing amplifier was chosen from the characteristics as in part a) to be the appropriate circuit to sum the voltage. The digital circuitry includes the asynchronous up counter uses $+5V_{dc}$ and the analogue electronic circuitry

comprises of the summing operational amplifier uses +15 V_{dc} and -15V_{dc}. The other interfacing opto-coupler circuit that will interface the digital and analogue circuits uses +12V_{dc}.

i. Design by illustrating and labeling the block diagram of the dc power supply unit to facilitate the voltages to this circuit. Using the fixed regulator IC, convey the fixed regulator ICs to have the above voltages.

(6 marks)

ii. Discuss the operation of this power supply operation in relations to the block diagram.

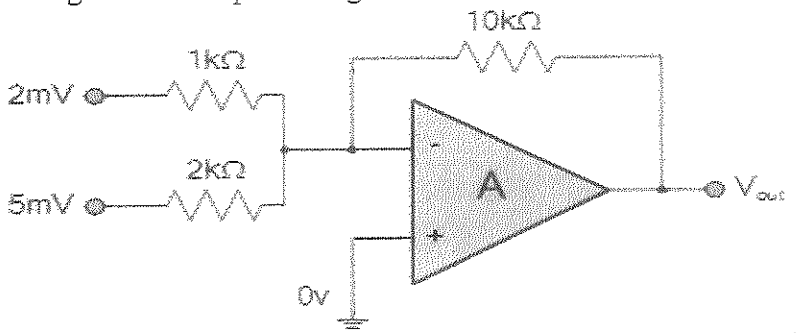
(6 marks)

iii. Using the fixed regulator IC datasheet, convey the appropriate specifications of the regulator stage with the aid of a diagram; and discuss the main parameter; the terminology "headroom".

(6 marks)

d) Evaluate the design of the summing amplifier by calculating the following parameters:

i. The gain at the input voltage of 2 mV and 5 mV.



(1.5 marks)

ii. V_{out} if the given circuit is:

(3.5 marks)

e) Since you are designing the count up to 12 using the asynchronous up-counter;

i. Analyse the type of Modulus used by developing the state diagram and state table.

(8.5 marks)

ii. Design the circuit for this asynchronous up-counter at the counter of 12.

(5.5 marks)

Section D: Evaluations, analysis and calculations of numbering systems, power supply system, and transistor circuits (25 marks)

Instructions:

- *Choose any two design questions by clearly writing the question number and its appropriate answers in your answer booklet.*
- *You may use the formulas to supplement your analysis in the questions.*
- *Ensure that your answers in your answer booklet appear in a logical numbering pattern than being too scattered.*

1. Evaluate the conversion equivalent of the given numbering systems by showing all workings:

   $2FB4_{16}$ = _____$_8$ = _____$_{10}$ = _____$_2$

   (6 marks)

2. Apply the binary addition method and evaluate the answer:

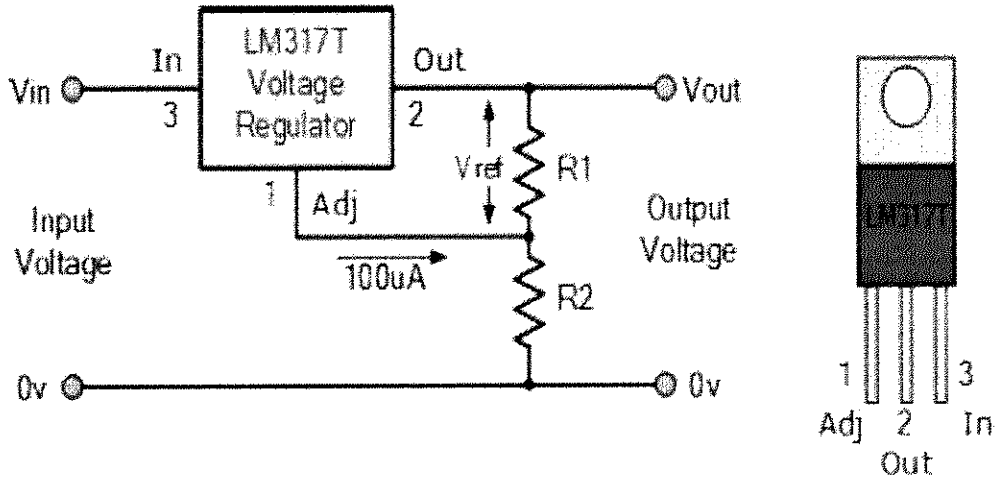
   $192_{10} + 134_8$ = _____ $_2$

   (3marks)

3. An NPN transistor has a DC current gain, (β) value of 200. Calculate the base current I_B required to switch a resistive load of 4 mA.

   (2 marks)

4. The circuit of the LM317T variable voltage regulator is given below:



   Calculate the output voltage, V_{OUT}; if R_1 = 100 kΩ and R_2 = 270 kΩ.

   (2 marks)

5. Assuming a single-phase bridge rectifier has an AC secondary voltage of 24V at 50Hz, and a load resistance of 1000 Ω, determine the following parameters:
   a) Load voltage, V_L

      (2 marks)

   b) Load current, I_L

      (2 marks)

   c) The PIV across the diode, PIV

      (2 marks)

   d) The ripple voltage, V_{Ripple}

      (2 marks)

   e) Ripple frequency, f_R

      (2 marks)

6. If the circuit parameters of a transistor switching circuit is:
   - $\beta = 200$
   - $I_C = 4$ mA
   - $I_B = 200$ μA

   Determine the value of the base resistor (R_B) required switching the load "ON" when the input terminal voltage exceeds 2.5V.

   (2 marks)

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Datasheet References:

- **78xx datasheet:**

National Semiconductor

February 1995

LM78XX Series Voltage Regulators

General Description

The LM78XX series of three terminal regulators is available with several fixed output voltages making them useful in a wide range of applications. One of these is local on card regulation, eliminating the distribution problems associated with single point regulation. The voltages available allow these regulators to be used in logic systems, instrumentation, HiFi, and other solid state electronic equipment. Although designed primarily as fixed voltage regulators these devices can be used with external components to obtain adjustable voltages and currents.

The LM78XX series is available in an aluminum TO-3 package which will allow over 1.0A load current if adequate heat sinking is provided. Current limiting is included to limit the peak output current to a safe value. Safe area protection for the output transistor is provided to limit internal power dissipation. If internal power dissipation becomes too high for the heat sinking provided, the thermal shutdown circuit takes over preventing the IC from overheating.

Considerable effort was expanded to make the LM78XX series of regulators easy to use and minimize the number of external components. It is not necessary to bypass the output, although this does improve transient response. Input bypassing is needed only if the regulator is located far from the filter capacitor of the power supply.

For output voltage other than 5V, 12V and 15V the LM117 series provides an output voltage range from 1.2V to 57V.

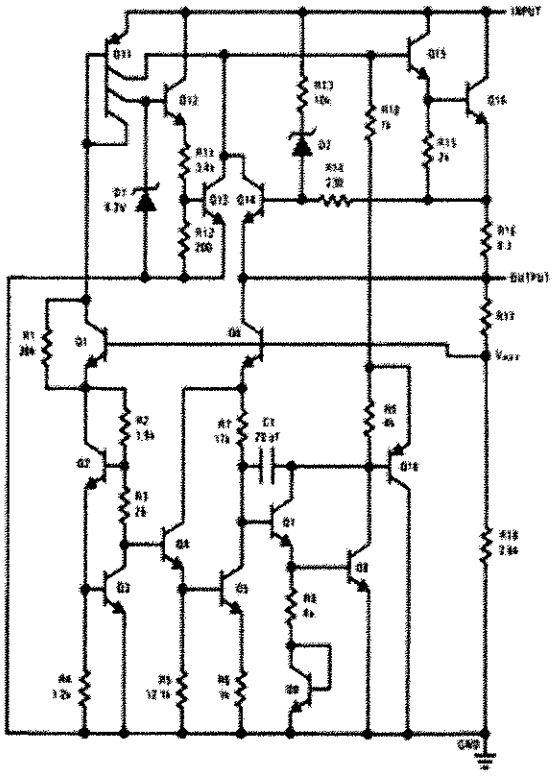
Features

- Output current in excess of 1A
- Internal thermal overload protection
- No external components required
- Output transistor safe area protection
- Internal short circuit current limit
- Available in the aluminum TO-3 package

Voltage Range

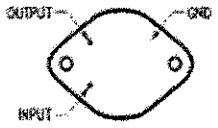
LM7805C	5V
LM7812C	12V
LM7815C	15V

Schematic and Connection Diagrams



TL/H/7746–1

Metal Can Package
TO-3 (K)
Aluminum

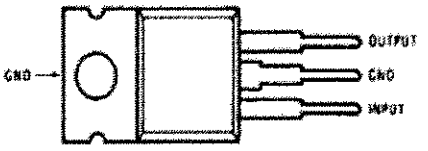


TL/H/7746–2

Bottom View

Order Number LM7805CK, LM7812CK or LM7815CK
See NS Package Number KC02A

Plastic Package
TO-220 (T)



TL/H/7746–3

Top View

Order Number LM7805CT, LM7812CT or LM7815CT
See NS Package Number T03B

RRD-B30M115/Printed in U. S. A.

Formulas:

- $f_R = 2f$
- $V_L = V_{DC}$
- $I_L = \frac{V_L}{R_L}$
- $R_B = \frac{V_{in} - V_{BE}}{I_B}$
- $PIV = \sqrt{2} \times V_{AC}$
- $f_R = f$
- $f_R = 2f$