# UNIVERSITY OF RUHUNA

## Faculty of Engineering

End-Semester 3 Examination in Engineering: August 2018

**Module Number: EE3301** **Module Name: Analog Electronics**

**[Three Hours]**

[Answer **all questions,** each question carries **10 marks]**

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All notations have their usual meanings.

Q1 a) Figure Q1 a) shows the monolithic IC construction of two electronic components. Name the components.

[1 Mark]

b) The conventional discrete bias circuit in Integrated Circuit design using the voltage divider method is shown in Figure Q1 b). Show that this circuit is equivalent to a constant current source in series with a load by deriving an expression for the current.

[3 Marks]

c) i) Reproduce the circuit of an ideal differential amplifier that has collector bias resistors of 7 kΩ, a supply voltage of +18 V, a constant current source of 2 mA and designate the input and output terminals.

ii) Calculate the internal emitter resistance of the transistors for this ideal differential amplifier.

iii) When the input 2 of the ideal differential amplifier circuit is grounded and a sinusoidal signal is applied to the input 1, calculate the magnitude and phase of the voltages at the

I) emitters of the transistors.

II) output 1.

iv) When the signals ± 15 sin (ωt) mV are applied simultaneously to inputs 1 and 2, by inference determine the magnitude and phase of the two output voltages.

[6 Marks]

Q2 a) List five (05) important characteristics of an operational amplifier (Op-Amp).

[2 Marks]

b) Figure Q2 b) shows the packaging and pin configurations for a Texas Instruments μ741 Op-Amp. The pin identification and related functions are

| | |
|---|---|
| 1 – Offset Null | 5 – Offset Null |
| 2 – IN- | 6 – OUT |
| 3 – IN+ | 7 – Vcc+ |
| 4 – Vcc- | 8 - NC |

Match the pin identifications to Figure Q2 b) and state the meaning of each function.

[2 Marks]

c) For an Op-Amp define the
   i) frequency response,
   ii) gain bandwidth product (GBP) and
   iii) slew rate.

[1.5 Marks]

d) The output offset voltages of an Op-Amp are due to the input bias or offset currents and input offset voltages.
Using Figure Q2 d), perform an analysis to calculate a value for the compensating resistor $R_c$ that minimizes the output offset voltage only due to the input offset currents.

[4.5 Marks]

Q3 a) Synthesize a circuit using two operational amplifiers to obtain the difference between two voltages without restrictions.
[Hint : Invert one input and add to the other input]

[2 Marks]

b) i) Describe an ideal operational amplifier circuit to integrate a sinusoidal input signal $v_{in}$ = E sin (ωt) and derive expressions for the output voltage and its frequency.
   ii) Explain modifications to the circuit in practice and the reasons for it.
   iii) Sketch the frequency response of a practical operational amplifier integrator and identify the integration region.

[4 Marks]

c) i) Filters are classified according to their order. State the relevance of the order to the filter response and its fall off.
   ii) Filters are also classified according to their specific design. State the two most common design types.
   iii) Describe the difference between these two types in part (ii) by considering their response characteristics.

[4 Marks]

Q4 a) State the difference between an oscillator and a multivibrator.

[1 Mark]

b) State the Berkhausen criterion for a system to oscillate.

[1.5 Marks]

c) Figure Q4 c) shows the circuit of a Wien Bridge oscillator. $Z_1$ is a network with a capacitor $C_1$ in series with a resistor $R_1$ and $Z_2$ is a network with a capacitor $C_2$ in parallel with a resistor $R_2$. Calculate the
   i) feedback ratio β.
   ii) oscillator frequency ω.
   iii) required amplifier gain, if the resistors and capacitors have the same value.

[4 Marks]

d) Figure Q4 d) shows the circuit of an astable multivibrator using an operational amplifier as a comparator. Assume that the output voltages of the comparator are equal in magnitude and opposite in polarity $\pm V_{max}$. Assume also that the output is at $+V_{max}$.

i) State a value for the feedback ratio $\beta$.
ii) Explain the charge characteristics for the capacitor with a graph.
iii) Using the graph in part ii), find the output of the circuit.

[3.5 Marks]

Q5 a) i) State two differences between a JFET (Junction Field Effect Transistor) and a BJT (Bipolar Junction Transistor).
ii) Sketch the structure of a N-channel JFET showing the DC biasing for active mode operation in common source configuration (Clearly indicate the terminals, the depletion region and the channel of conduction).
iii) Reproduce the N-channel depletion type MOSFET (Metal Oxide Semiconductor FET)drain characteristics clearly indicating the different regions of the curve.

[3 Marks]

b) i) Reproduce the transfer characteristic curve for a N-channel JFET.
ii) Show that the transconductance ( $g_m$) for a JFET is given by,

$$g_m = \frac{2I_{DSS}}{|V_P|}\sqrt{\frac{I_D}{I_{DSS}}} \qquad \text{Seimens}$$

[Hint: Use the transfer characteristic curve produced in part b) i).

[2 Marks]

c) The JFET in the common source amplifier circuit shown in Figure Q5 c) has $I_{DSS} = 12$ mA, $V_P = (-4)$V and $r_d = 100$ kΩ.

i) Find the Q point values of $I_D$ and $V_{DS}$ and confirm that the Q point is in the active region.
ii) Find the value of transconductance ( gm).
iii) Draw the small signal ac equivalent circuit for the common source amplifier and find the voltage gain.

[5 Marks]

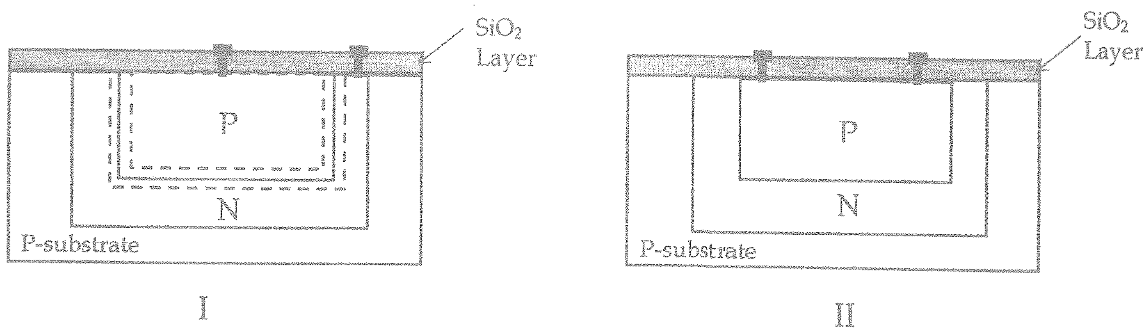


Figure Q1 a)

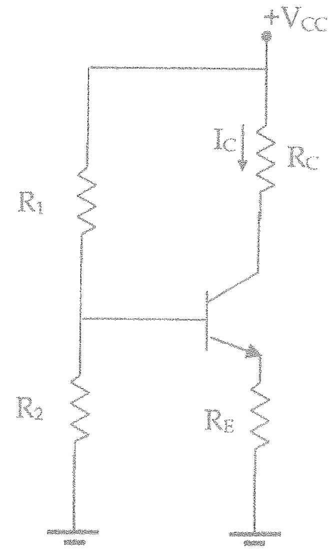


Figure Q1 b)

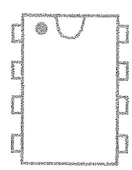

Figure Q2 b)

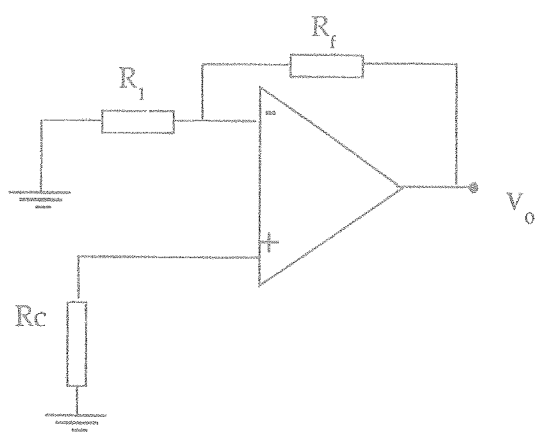


Figure Q2 d)