1997 A/L

1) In the circuits shown D is a silicon unction diode.

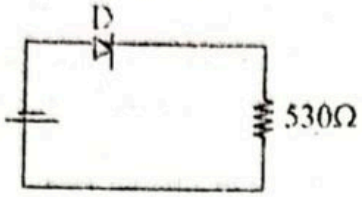


Figure (1)

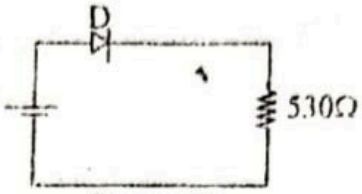
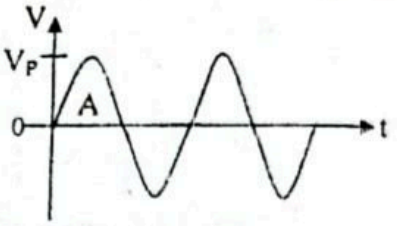


Figure (2)

(i) Identify the circuit in which the diode id forward biased. If a current of 10 mA flows in that circuit by considering the potential drops across components, estimate the voltage of the cell.

(ii) Suppose you are provided with four silicon rectifier diodes, a smoothing capacitor C and a load resistor R_L . Draw a circuit diagram of a bridge rectifier including the C and R_L

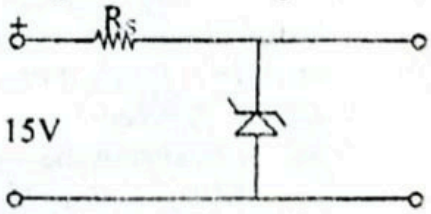
(iii) The voltage V applied at the input of the rectifier is shown in the figure. Peak voltage, V_p = 12 V. Indicate the path of the current in the circuit drawn in (ii) during the first half cycle A of the input using arrows.



(iv) Draw the output voltage waveform of the rectifier circuit including C and R_L and estimate the peak value of the output voltage.

(iv) The circuit shown is provided to obtain a 10V regulated dc voltage from an unregulated voltage of 15 V .

If the maximum current that can be sent through the zener diode is 200 A, and the zener voltage is 10 V estimate a minimum value for R_S



1998 A/L

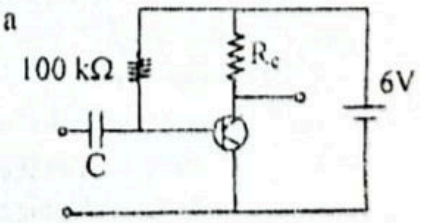
2) (i) The circuit shown below uses a silicon transistor and a 6V battery. The collector potential is set at 3V.

(a) Show that in this circuit the transistor is biased in the active mode.

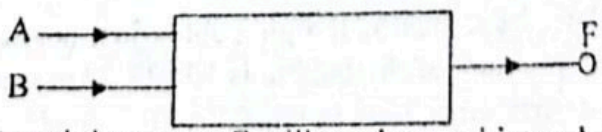
(b) Find the base current in the circuit.

(c) If $\beta = 50$ find the value of R_C.

(d) What is the purpose of having a capacitor C at the input?



(ii) Block diagram of a circuit used to detect the binary numbers corresponding to the decimal numbers 2 or 3 in a string of binary numbers is shown below.

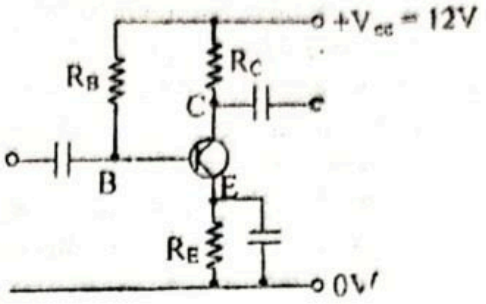


AB is the binary input, and the output F will produce a binary 1 whenever a proper detection is made. Design a circuit using logic gates for this purpose. State all the design steps clearly.

1999 A/L

3) With the aid of a clear labeled diagram show the structure of a junction transistor.

What are the configurations in which a transistor can be used in electronic circuits? Illustrate these configurations with simple circuits. Which of these is commonly used in amplifier circuits? Give the reasons for this



In the amplifier circuit shown, it is desired to have $I_C = 2$ mA. $V_{CE} = 6$ V and $V_E = 1.2$ V. If $\beta = 100$ and $V_{BE} = 0.6$ V. Find suitable values for R_E, R_C and R_B. What are the values of V_B and V_C?

If a small sinusoidal voltage is connected to the input of the amplifier, sketch the input and output voltage on the same time scale. V_{CE} is usually chosen to be around $\frac{V_{CC}}{2}$ explain why .

2000 A/L

4) Draw the circuit symbol of an operational amplifier, clearly identifying the non inverting input (v_1) inverting input (v_2) and the output (v_0)

If A is the open loop gain of the operational amplifier, write down an expression relating the inputs v_1, v_2 and the output v_0

(i) A 741 operational amplifier has an open loop gain of 10^5 and it is powered with supply voltages of ±15V. If voltages $v_1 = -3$ mV and $v_2 = -5$ mV are applied to the operational amplifier inputs, what would be the polarity and the approximate magnitude of the expected of the expected output voltage v_0?

(ii)(a) You are provided with two resistors R_1 and R_2. Draw a circuit diagram of a non inverting amplifier, clearly showing its input and output.

(b) In an experiment the voltages produced by a thermocouple in the range of 0 - 10 mV are to be measured with a voltmeter having a full scale deflection of 1 V. Draw a circuit diagram to show how the non inverting amplifier given in (ii) (a) is inserted between the thermocouple and the voltmeter in order to obtain a full scale deflection from the voltmeter for 10 mV thermocouple output.

(c) Of the two resistors R_1 and R_2 if the smaller resistor has the value 1 kΩ. What should be the value of the other resistor in order to achieve the full scale deflection in (ii) (b)?

(iii) If you are provided with another resistor R_3 and a two – way key, how would you modify the circuit given in (ii) (b) so that it can be used to measure voltages in two ranges 0-10 mV and 0 - 100mV separately with the same voltmeter giving full scale deflections in either range the two – way key is used to select the required range. Find a suitable value for R_3.

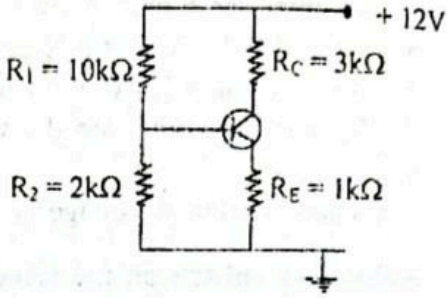
2001 A/L

5) (i) Draw I – V characteristics of a junction diode. How would you use these characteristics to identify Si and Ge diodes.

(ii) Give the circuit diagram of a half wave rectifier and draw input and output waveforms.

(iii) An a.c. voltage of peak value 25 V is connected in series with a silicon diode and a load resistance 600 Ω. If the forward bias resistance of the diode is 40 Ω, find the peak current through the diode and the peak output voltage .

(iv) A silicon transistor is connected as shown in the circuit diagram. The circuit is designed such that the base current I_B is 20 times smaller than the current through the voltage divider. Find the base current I_B, the emitter current I_E and the collector emitter voltage V_{CE} for the circuit.



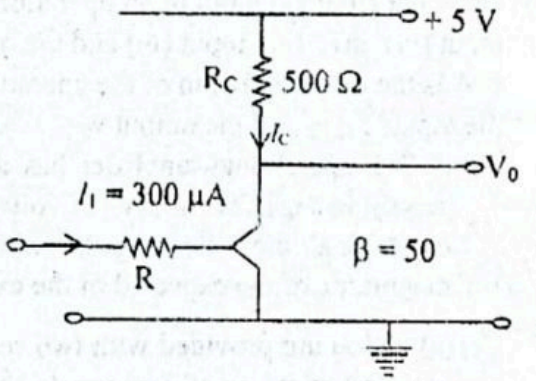
2002 A/L

6) (i) Draw the output characteristic (I_C VS V_{CE}) of an transistor operating in the common emitter configuration, and clearly label the saturation and cut-off regions.

(ii) When plotting the curves in (i), one parameter is kept constant for each curve, What is it?

(iii) Considering the current (I) – voltage (V) characteristics for open and closed mechanical switches. Show that an npn transistor can be operated as a switch.

(iv) Assume that the transistor in the circuit given above operates in the saturation mode. What are the output voltage (V_0) and the collector current (I_C) of the circuit?

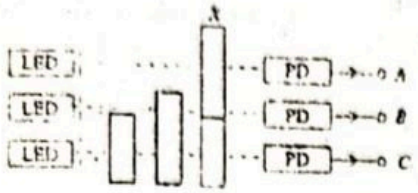


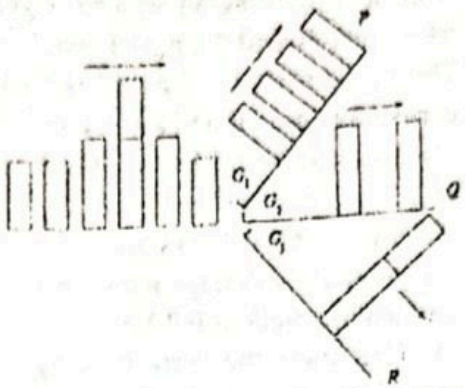
(v) Also using the data given, verify that $I_C < \beta I_B$ for the above transistor which is operating in the saturation mode ($\beta = 50$)

(vi) What is the relationship between I_C and I_B if a transistor operates in the active mode? If I_B in the above circuit is maintained at 300 μA and the R_C value is reduced to 200 Ω, show that the operation mode of the transistor is shifted from saturation to active mode.

(vii) Three LED – photodiode circuit (PD) combinations are to be used to sort out two types of metal cans coming down a production line according to their heights and put them in two different lines P and Q by opening mechanical gates G_1 and G_2 . See the figure. Rare occurrences of sitting one can on top of the other, such as X in the diagram shown have to be detected and put them into the third line R by opening the gate G_3

The arrangement is shown below,





Assuming that PD circuit outputs A, B and C produce voltage signals corresponding to binary '1' when light beams emitted from LED s are interrupted by cans, propose three logic circuits which provide binary '1' output signals to open the mechanical gates G_1, G_2, and G_3 at appropriate occasions.

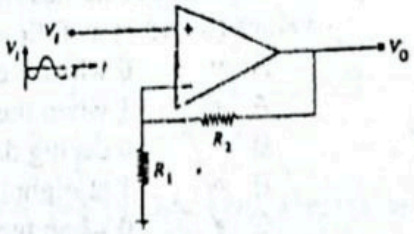
2003 A/L

7) (i) (a) State two advantages of integrated circuits (IC) over electronic circuits constructed of discrete elements.

(b) Top view of an operational amplifier IC is shown below

Copy the diagram onto your answer script in a suitable manner and number the pins

(ii) (a) Identify the above circuit and write down an expression relating V_0 and V_1 in terms of R_1 and R_2

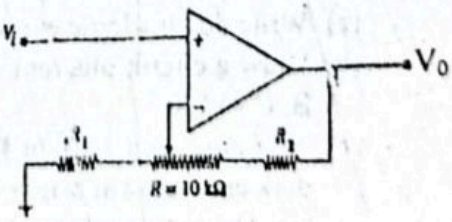


(b) Draw a rough sketch of the output waveform for the output waveform for the input waveform shown in figure.

(c) What will be the voltage gain of the circuit when R_1 is made very large relative to R_2?

(iii) The circuit in (ii) above is modified as shown below to form an amplifier with a variable voltage gain.

R_1 and R_2 are fixed resistors and R is a variable resistor. The operational amplifier operates with two voltage supplies of +15 V and -15V.



(a) Calculate suitable values for R_1 and R_2 in order to obtain a variable voltage gain between 10 and 100.

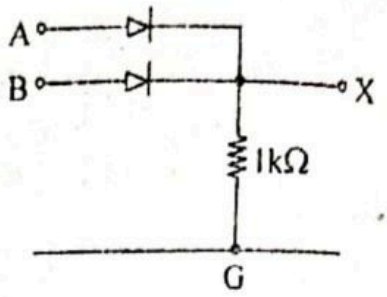
(b) What would be the range of input voltages (V_1) that can be amplified properly with this amplifier?

(c) What is the gain of the amplifier when R_1 is disconnected from the ground?

2004 A/L

8) (i) Draw a circuit diagram of a NOT gate built using a single npn transistor, indicating its input, output, and the power supply connection

(ii) The circuit shown in figure 1 is made using two germanium diodes and a 1 kΩ resistor.



The table under (a) below shows combinations of voltages connected to the inputs A and B of the circuit. All voltages are indicated relative to the point G. (Voltage across a forward biased germanium diode is 0.2 V)

(a) Determine the corresponding output voltages at X and complete the following table. (Important : Copy table on to your answer script)

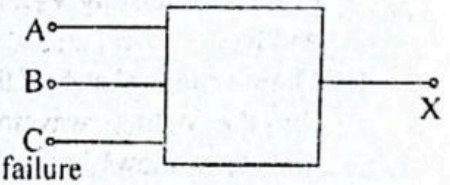
A (volts)	B (volts)	X (volts)
0.0	0.0	
0.0	5.0	
5.0	0.0	
5.0	5.0	

(b) Hence identify the gate and write down its truth table

(iii) A student wants to design a digital circuit to turn on a battery powered lamp automatically when there is a mains electricity failure at night. In addition, the circuit must have a facility for it to be turned on at any time by pressing a button.

A block diagram of his circuit, having three inputs and one output, is shown in figure 2. assume that he has the means to generate the three inputs A, B and C with logic values (0 and 1) as follows.

A = 0 when the button is not pressed
A = 1 when the button is pressed
B = 0 during day time
B = 1 at night
C = 0 when there is a mains electricity failure
C = 1 when mains electricity is available



The circuit is to be designed so that the lamp will be on when X = 1 and off when X = 0.

(a) Write down a logic expression for X in terms of A , B and C

(b) Draw a circuit diagram for your expression, using basic logic gates, and label A, B, C and X

(c) You are given a Light Dependent Resistor (LDR) having a resistance 10 MΩ at dark and 100Ω at bright light a 5 V battery and an additional 100kΩ resistor.

(1) Using these items draw a suitable circuit diagram to generate the logic values for the input B

(2) Calculate the voltage provided by this circuit, for B when dark.

(d) Will the lamp function properly if the circuit is installed in a place where the light dependent resistor is exposed to the lamp itself? Briefly explain your answer.

2005 A/L

9) (i) It has become necessary to operate a certain electronic device that requires a precise 10V supply voltage, by a 12V battery. A circuit suitable for this purpose, which can reduce a 12 V supply to 10 V, is shown in figure (i).

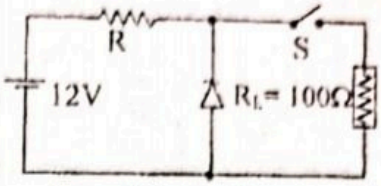


Figure (1)

In this circuit, the load resistance of the electronic device is represented by R_L. The break down voltage of the Zener diode is 10 V.

(a) Assuming that the battery has no internal resistance, calculate the value of R that will allow a 10 mA current through the Zener diode, when the switch S is closed.

(b) For the value of R obtained in (a) above, calculate the power dissipation of the Zener diode when,

1) the switch S is closed and
2) the switch S is opened.

Hence state the minimum power rating of the Zener diode required for the proper operating of the circuit.

(ii) A better circuit that can be used for the purpose of obtaining 10 V is shown in figure (2)

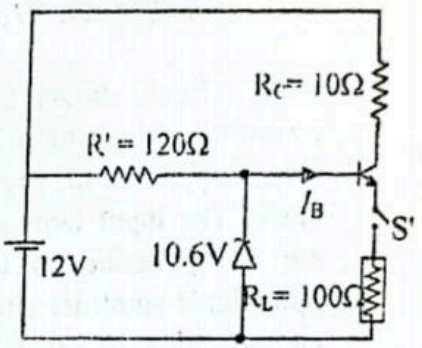


Figure (2)

(a) If the transistor used in this circuit is a silicon transistor, show that the electronic device receives the correct supply, voltage (Assume that the potential difference across a forward biased silicon diode is 0.6 V)

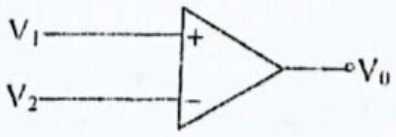
(b) If the current gain (β) of the transistor is 99, calculate the base I_B when the switch S' is closed.

(c) Calculate the maximum power dissipation of the zener diode and determine whether a zener diode of $\frac{1}{4}$ W power rating will be sufficient for the proper operation of the circuit.

(d) What is the advantage of this circuit, compared to the circuit used is part (i) above ?

2006 A/L

10) (i) If A is the open loop gain of the operational amplifier shown, write down an expression for V_0 in terms of V_1, V_2 and A.



(ii) If the saturation voltage of the output of the above operational amplifier is ± 5 V, and $A = 10^5$, find the minimum value of the input voltage difference, $(V_1 - V_2)$, that is necessary to saturate the output.

(iii) Output saturation voltage of the operational amplifier shown in the circuit (see figure 1) is ± 5 V.

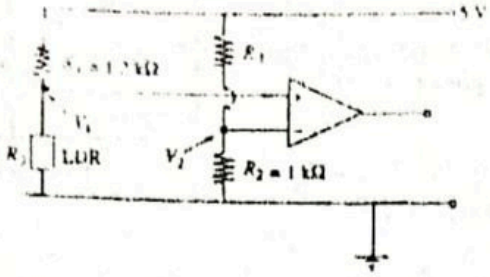


Figure 1

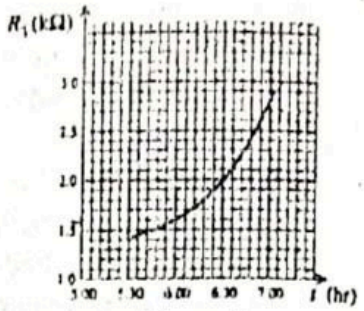
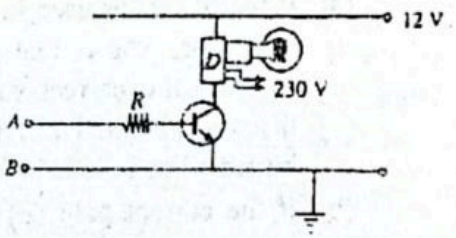


Figure 2

(a) If $R_2 = 1$ kΩ, calculate the value of R_1 which makes $V_2 = +3$ V. Assume that no current flows into the input terminals of the operational amplifier.

(b) R_3 is the value of a light dependent resistor (LDR) whose resistance varies with the time *(t)* of day according to the curve shown in figure 2. Show that the output voltage of the operational amplifier is –5 V at 6.00 p.m. and +5 V at 6.30 p.m.

(iv) In the circuit shown the device D has the capability of lighting a 230 V lamp when the transistor is set to operate in the saturation mode. The input terminals AB of this circuit are to be connected to the output of the operational amplifier circuit shown in figure 1 above to light the 230 V bulb when dark (i.e at 6.30 p.m.)



(a) If the base current needed to operate the transistor in the saturation mode is 100 μA, calculate a suitable value for *R*. ($V_{BE} = 0.7$ V)

(b) If the effective collector resistance due to device D is 600 Ω, find the collector current through the transistor when the lamp is lit.

2007 A/L

11) Draw the I-V characteristics of an ideal diode and a real diode.

In answering the following questions assume that the voltage across the diodes, when conducting, is 0.7 V.

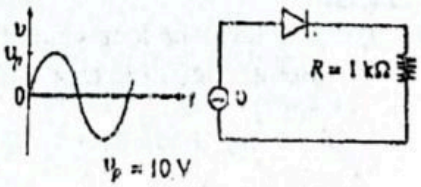


Figure (a)

Figure (b)

(i) Input signal (*v*) to the circuit given in figure (*b*) is shown in figure (*a*). Calculate the values of positive and negative peak currents in the circuit.

(ii)

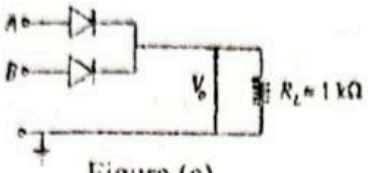


Figure (c)

V_A(V)	V_B(V)	V_o(V)	logic level
0	0		
0	5		
5	0		
5	5		

In the given table V_A and V_B are voltages applied to inputs *A* and *B* of the circuit shown in figure (*c*). Inputs A and B are connected to combinations of 0 and 5 V as shown in the table. Copy the table on to your answer script and fill in the columns for the output voltage V_0 and the corresponding logic levels (1 or 0)

(iii) In the circuit shown in figure (c) above if $V_A = 5$ V and $V_B = 3$ V, calculate the current through R_L

(iv) full wave rectifier and voltage regulator

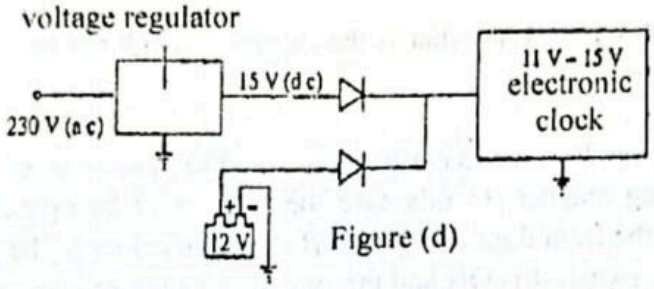


Figure (d)

Figure (d) shows the power connection to an electronic clock which needs a de (direct current) voltage in the range 11 V – 15 V for proper operation.

(1) Describe the operation of the circuit when
  (a) ac (alternating current) power is present.
  (b) ac power fails.

(2) What is the current drawn from the 12 V battery when the ac power is present?

(v) Draw a suitable circuit for the full wave rectifier and voltage regulator shown in figure (*d*) above.

2008 A/L

12)(a) Show by drawing a circuit diagram how you would construct a NAND gate using a NOT gate and an-input AND gate.

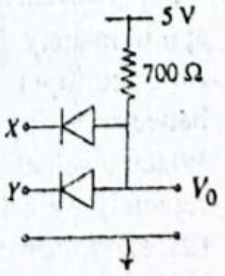


Figure 1

(b) Considering voltages, prove that the circuit shown in figure 1 operates as an AND gate. (Assume that the voltage across a forward bias diode is 0.7 V.)

(c) Figure 2 shows a circuit diagram of a transistor circuit whose input *B* can be connected either to 5 V or 0 V. (Assume that when forward biased V_{BE} of the transistor is 0.7 V.)

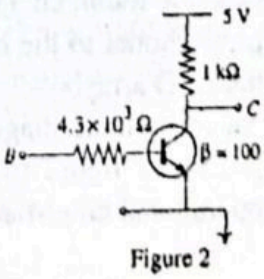


Figure 2

(i) If the current gain (β) of the transistor is 100 show that it is operating in the saturation mode when the input voltage is 5 V.

(ii) Considering voltages, prove that it operates as a NOT gat.

(d) The circuit in figure 3 is constructed by connecting the two circuits given in figure 1 and 2 together.

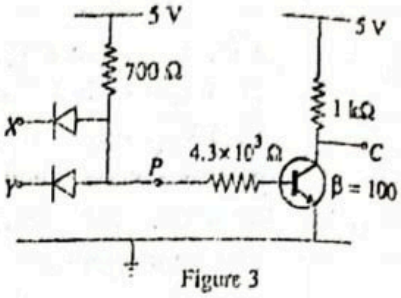


Figure 3

(i) Considering the logic levels at P, show that the circuit shown in figure 3 operates as a NAND gate (Note : This type of Diode Transistor Logic (DTL) gates are no longer in used and they are now replaced with TTL gates.)

(ii) When $X = Y = 5$ V, what is the current through the base-emitter junction of the transistor?

(e) Logic gates can be used to construct a circuit to operate an electric lamp in a room in the following manner. In this case the lamp is to be operated from two switches; switch A at the front door and switch B at the back door to the room. The lamp is to be lit when the switch A is ON and the switch B is OFF or when the switch A is OFF and the switch B is ON. The lamps is to be OFF it both switches are OFF or ON. Using the same symbols A and B is to represent corresponding logic variables of the switches.

(i) Write down a logic expression for the output (F) of the circuit which satisfies the above requirements.

(ii) Draw the logic circuit using gates which performs the above functions.

2009 A/L

13) b) Write down an expression relating the voltages V_0, V_1, V_2 and the open loop again A of the operational amplifier shown in figure (1).

b) Input resistance of a 741 operational amplifier is approximately 2 MΩ. Give a rough estimate of the expected input current when a voltage of 5 V is applied between the inputs.

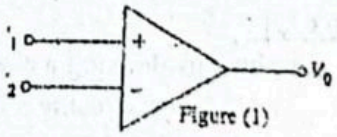


Figure (1)

c) Water level of a water tank is to be monitored and displayed remotely by a linear vertical array of LED^S as shown in figure (2). Height of the water level in the tank is to be proportional to the number of LED^S that glows from the bottom. A water level detector mounted in the tank will provide a voltage, which is proportional to the height of the water level, and is used to light the LED array.

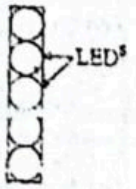


Figure (2)

An incomplete diagram of a circuit designed for this purpose in shown in figure (3). Positive saturation voltage of 5 V from operational amplifier outputs are used to light the LED array.

i) Copy the figure (3) onto your answer sheet and complete the circuit by,
(1) connecting the other input terminals of the operational amplifiers to the appropriate points in the circuit.
(2) clearly indicating the non – inverting and inverting inputs of the operational amplifiers with + and – signs according to the circuit requirements.

ii) Values of the resistors (R) should be determined so that they draw only 1 mA from the power supply. Calculate a suitable value for resistors R. Assure that the currents drawn by operational amplifier inputs are negligible.

iii) The current – voltage requirement for proper operation of the LED in the array is 20 mA – 2.8 V.

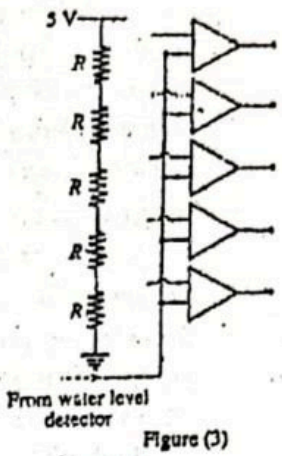


Figure (3)

As the operational amplifiers used in the circuit above are unable to provide this current the circuit shown in figure (4) is used to light LED^S. The diode D creates a potential drop of 0.7 V when forward biased, and the current gain of the transistor is 100. Assume that the transistor operates just at the saturation level and the collector current I_c can still be given by $I_c = \beta I_B$

(1) Calculate a suitable value for R_c

(2) If V_{BE} = 0.7 V and V_0 = 5 V calculate a suitable value for R_B

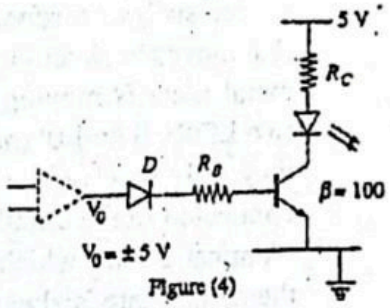


Figure (4)

2010 A/L

14) a) In the circuit shown in figure 1, A and B are two identical light depended resistance (LDR). The resistance of each LDR at complete darkness is 50 MΩ. The operational amplifier has saturation voltages of ±5V and an open loop voltage gain of 10^5.

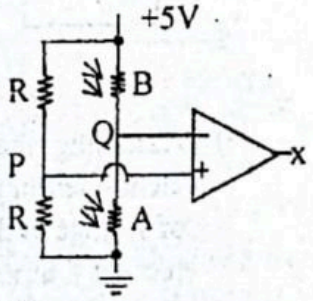


Figure 1

i) Calculate the minimum voltage difference between P and Q that would saturate the operational amplifier at +5V.

ii) What would be the voltage V_X at X when both LDRs are at complete darkness ?

iii) When both LDRs are in a place, where the ambient light level causes the resistance of each LDR to drop to 200 Ω. what would be the value of V_X ?

iv) When both LDR s are kept in the place mentioned in (iii) above, light from a small light source is allowed to fall on A only. This reduces the resistance of A to 50Ω. Calculate the new V_X value.

v) If this circuit is used for detecting an external light source, is there an advantage of using an LDR for B. without using of a fixed resistor ? Explain the reason for your answer.

b) Figure 2 shows there different positions of an opaque piece of cardboard with a hole, placed near the two LDRs. S is a light source. The cardboard is moved slowly at a constant speed starting from position (1) until it reaches position (3) via position (2). The resistance of A when it receives light through the hole is 50Ω. At other positions, due to ambient light its resistance is 200 Ω. Resistance of B remains at 200 Ω in all positions.

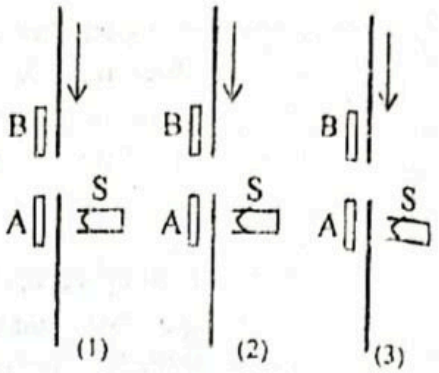


Figure 2

i) Sketch the variation of V_X with time (t), when the cardboard is moving.

ii) Sketch the variation of the V_X with time (t), when the speed of the cardboard is doubled.

c) As 'optical encoder' which is used to determine the position of a moving part of a device such as a robot is based on the above principle. Figure 3 shows a robot arm that moves back and forth and a metal plate with two rows of holes, attached to it. The metal plate is moving between light sources and LDRs as shown in the figure. The two LDRs B and B' (not shown in the figure) are kept away from the light sources and they only receive the same ambient light as A and A'. The two LDRs A and B are connected to the circuit shown in figure 1 while LDRs A' and B' connected to another identical circuit which has output Y. Assume that one of the four section (1 – 4) of the metal plate is always between the LDR s and the light sources.

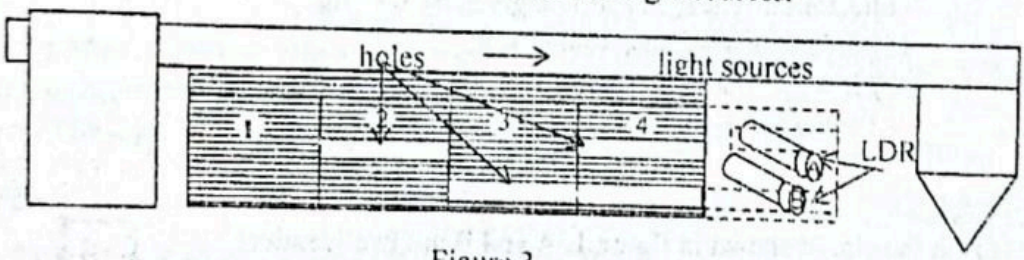


Figure 3

i) Assuming that the light levels received by the LDR s are identical to those mentioned in part (b) above, draw a rough sketch of a graph to show the variations of voltage at the output X and Y with time (t) when the metal plate is moving from section 4 to section 1 at a constant speed past A and A'. Draw the variations of Y underneath that of X on the same time axis.

ii) If the outputs of X and Y interpreted as logic signals, write down the binary numbers obtained from X and Y, when each of the four sections of the metal plate are facing A and A'.

2011 A/L

15) (a) Figure 1 shows the I – V characteristics of a light emitting diode (LED) for two different temperature.

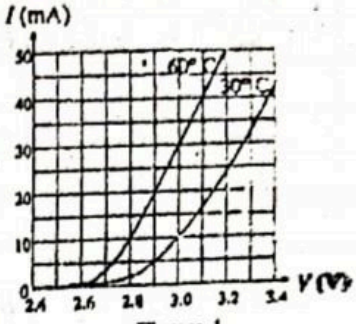


Figure 1

(i) Suppose the LED at 30°C room temperature is connected to a 3V battery as shown in figure 2. According to the I – V characteristics, it will draw a 10mA current. After some time, if the LED reaches a temperature of 60°C due to its heat dissipation, what will be the current through the LED ?

(ii) Why would a current through a semiconductor device depend on the temperature ?

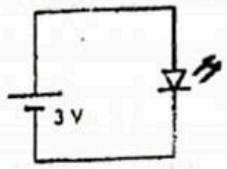


Figure 2

(iii) It is possible to control the current through the LED by connecting a resistor to series. Calculate the value of the resistor that would limit the current through the LED (at 30°C) to 10mA, when connected to a 9V battery.

(iv) With a resistor having the value calculated in part (iii) above, suppose the temperature of the LED goes above 30°C and the current through the LED reaches 10.3 mA . Calculate the voltages across the resistor and the LED under this condition. When this happens, will be power dissipated in the LED increase or decrease ? Justify your answer. If the current further increases due to higher LED temperature, what will happen to the voltage drops across the resistor and the LED ?

(b) Figure 3 shows a circuit commonly used for providing a constant current to a device such as an LED (marked as D in the figure)

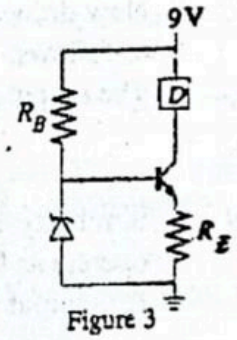


Figure 3

(i) If the value of R_B is 3000Ω and the voltage drop across the Zener diode is 3V, calculate the current through the Zener diode. (Assume that the base current is negligible)

(ii) If the voltage across the base – emitter junction of the transistor is 0.7V, calculate the value of R_B that will make the collector current 10mA. (Assume that the emitter current is equal to the collector current)

(iii) If the LED in part (a) above is used as the device D, calculate the voltage across the collector and emitter terminals of the transistor (V_{CE}) (Assume that the LED temperature is 30°C)

(iv) Assume that the graph in figure (4) represents the I_C – V_{CE} curve for the transistor for the relevant I_B value. Copy this graph to your answer script and mark the operating point (V_{CE} I_C) as point A.

(v) If the LED temperature now increases, indicate on the graph with an arrow which way the operating point will move.

(vi) Now suppose two identical LEDs connected in series, are used as the device D. Calculate the new V_{CE} value and indicate the operating point of the transistor in the graph as point B.

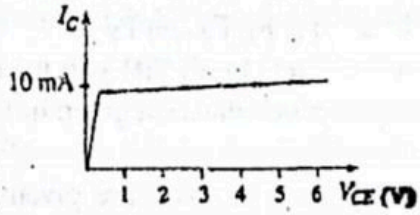


Figure 4

2012 A/L

16) a) Write down the truth table for a 2 - input AND gate. Use symbols A and B for inputs and F for output.

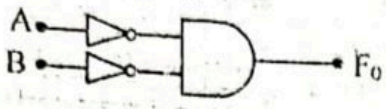


Figure (1)

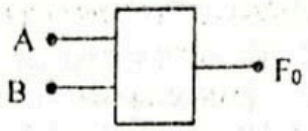


Figure (2)

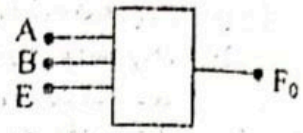


Figure (3)

b) The block diagram of the circuit shown in figure (1) is given in figure (2)

i) Write down the truth table for the circuit shown in figure (1)

ii) Hence, show that the circuit shows in figure (1) operates as follows

$F_0 = 1$ only, when $A = 0$ and $B = 0$

and $F_0 = 0$ otherwise

A	B	E	F_0
0	0	1	
0	1	1	
1	0	1	
1	1	1	

A	B	E	F_0
0	0	0	
0	1	0	
1	0	0	
1	1	0	

c) Suppose now you use a 3 input AND gate in the circuit shown in figure (1) above instead of a 2 – input AND gate. Let the third input be E. Then the block diagram will take the form shown in figure (3)

i) Draw the circuit diagram corresponding to the block diagram in figure (3)

ii) By filling the two truth tables shown, show that the circuit will operate similar to the circuit given in figure (1) when $E = 1$, and the output $F_0 = 0$ when $E = 0$ irrespective of the values of A and B

d) Now draw a circuit diagram using a 3-input AND gate and one NOT gate to operate as follows.

The output $F_1 = 1$ only when $A = 0$, $B = 1$ and $E = 1$

$F_1 = 0$ when $E = 0$

e) Similarity draw two separate circuits using 3-input AND gates and NOT gates to operate as follows.

i) Output $F_2 = 1$ only when $A = 1$ and $B = 0$ and $E = 1$

$F_2 = 0$ when $E = 0$

ii) Output $F_3 = 1$ only when $A = 1$ and $B = 1$ and $E = 1$

$F_3 = 0$ when $E = 0$.

f) Now combine all four circuits drawn under (c)(i), d), (e)(i) and (e)(ii) and draw a single circuit so that it will have only 3 common inputs A, B and E and four outputs F_0, F_1, F_2 and F_3.

The circuit that you have drawn should conform with the block diagram given in figure (4)

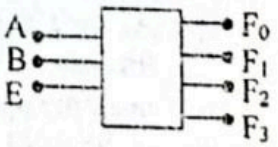


figure (4)

g) Suppose you are given four devices, an electric fan, an electric heater, an electric kettle and an electric motor which can be switched ON or OFF with logic signals 1 or 0 respectively.

i) Draw a block diagram to show how you would connect the devices shown in figure (5) to the block diagram given in figure (4) so that any one of them can be selected and operated one at a time.
Write down the combination of appropriate logic signals that you would apply to the inputs A and B to select each device.

ii) How would you keep all the devices in non operative condition using logic signals ?

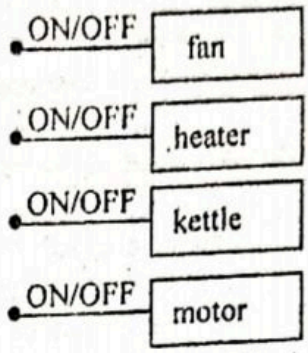


figure (5)

2013 A/L

17) A step-down transformer produces an output voltage of 18 V (peak value) from a 240 V, 50 Hz ac mains voltage.

a) Draw a circuit diagram of a bridge rectifier connected to the appropriate terminals of the above transformer.

b) Draw the voltage waveforms formed across a resistor connected across the outputs at the following output stages. Label the axes of the graphs and clearly mark the peak values of the voltage (in volts) and the period of the waveforms (in seconds). Assume that the silicon rectifier diodes used in the rectifier have a forward bias voltage of 1 V.
   i) Transformer output.
   ii) Rectifier output (without smoothing capacitor)
   iii) Rectifier output with the smoothing capacitor. Show the capacitor connection in the circuit. that you have drawn under (a).
   iv) Output after connecting a zener diode to regulate the voltage. Show the zener diode connection in the circuit that you have drawn under (a).

c) i) What is the advantage of choosing a large capacitance value for the smoothing capacitor than a small value?
   ii) When the smoothing capacitor is in place what is the maximum reverse-bias voltage that can appear across a diode?

d) If the zener diode used in (b) (iv) above has following specifications, calculate the value of the safety resistor that has to be used in order to safeguard the zener diode.
   Zener voltage = 10 V
   Maximum permissible current through the zener diode = 200 mA
   (Use the relevant peak values for your calculations)

e) A student has decided to use the rectifier circuit with the smoothing capacitor (but without zener regulation) as the dc power supply which is necessary to operate a common emitter amplifier.
   i) Draw a circuit diagram of a common emitter amplifier.
   ii) State changes that you would expect in voltages at the base and at the output of the amplifier due to the voltage variation (ripple voltage) of the power supply.

2014 A/L

18) a) Draw the input-output voltage characteristic for a 741 operational amplifier and label the linear and saturation regions.

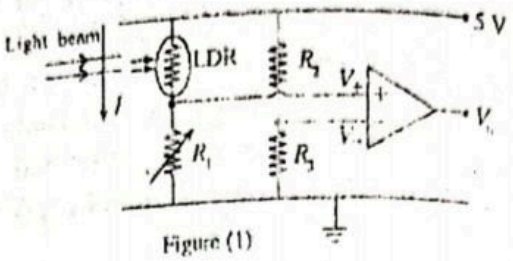


Figure (1)

b) A circuit is to be designed to detect an intruder *I* entering a premises at night. A part of a circuit that can be used for this purpose is shown in figure (1).
A narrow beam of light is set to incident continously on the Light dependent Resistor (LDR) as shown in figure (1). The operational amplifier is to operate with V_0 at its saturation voltages of ±10 V.

(i) If the voltage at the inverting input (V_-) is set up 3.5 V, calculate the value of R_2. Take the value of R_3 as 7000 Ω.

(ii) When light falls continously on the LDR, it is decided to maintain a voltage difference of 0.5 V between the inverting input (V_-) and the non inverting input (V_+). What should be the value of R_1 in order to achieve a value of +10 V at the output V_0 under this condition? Assume that the resistance of the LDR when light falls on it is 500 Ω.

(iii) If the light beam gets obstructed due to the movement of the intruder, what will be the value of V_0 during the period of interruption? Give reasons to your answer. Take the resistance of the LDR under this condition as $10^5\Omega$.

c) Suppose the output of the circuit given in figure (1) is now connected to the circuit shown in figure (2)

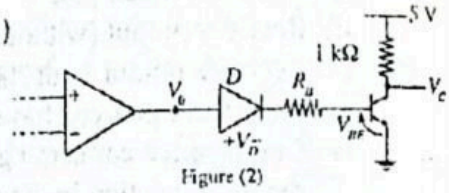


Figure (2)

(i) When $V_0 = +10V$. Calculate a suitable value for R_B to provide a base current of 50 μA. Take $V_D = V_{BE} = 0.7$ V.

(ii) If the current gain of the transistor is 100 find the value of the collector voltage V_C under the situation given in (c) (i).

(iii) When $V_0 = -10$ V,

(1) what will be the potential difference across the diode? (Assume that the reverse breakdown voltage of the diode is 25 V)

(2) what will be the collector voltage V_C under this condition?

d) i) If the transistor output V_C is connected to a S – R flip-flop as shown in figure (3), write down the input logic levels of S and R when light falls on the LDR, and when the intruder crosses the light beam.

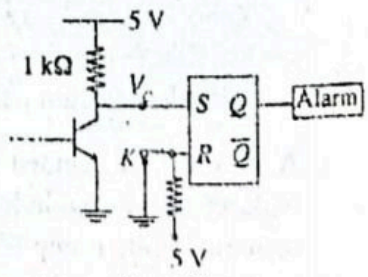


Figure (3)

ii) If the alarm operates when Q = 1, state whether the alarm sounds continously even after the intruder has crossed the light beam and moved away. Explain your answer. (K is a grounded switch)

2015 A/L

19) a) Draw current (I) – voltage (V) characteristic for a silicon diode, indicating its forward bias voltage of 0.7 V on the voltage axis.

b) Instead of the characteristic you have drawn under (a), hypothetical diode characteristic given in figure (1) is also used frequently in the analysis and design of circuits with silicon diodes. According to the figure (1), current through the diode is zero until its voltage becomes 0.7 V at which the current increases sharply parallel to the I – axis.

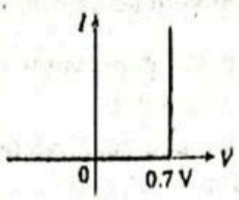


Figure (1)

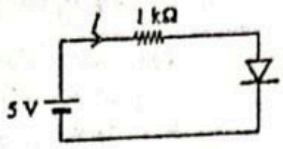


Figure (2)

Use the I – V characteristic given in figure (1) and calculate the current I in the circuit shown in figure (2).

Also use the characteristic given in figure (1) above to answer all the following questions.

c) In the figure (3) shown D_1 and D_2 are silicon diodes and the input voltages A and B can have either 5V or 0V.

i) Find the voltage (V_F) at the output F for various combinations of the input voltage and fill in the following table (Copy the table onto your answer script for this purpose)

A(V)	B(V)	V_F(V)
0	0	
5	0	
0	5	
5	5	

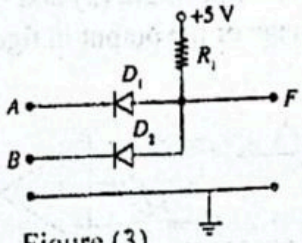


Figure (3)

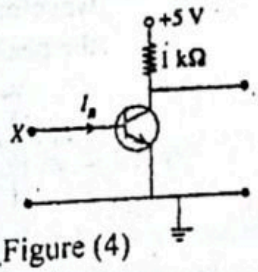


Figure (4)

ii) As far as F output is considered, if 0.7 V represents binary 0 and 5V represents binary 1, identify the gate corresponding to the circuit given in figure (3) and write down its truth table.

iii) Calculate a suitable value for R_1 which will limit the sum of the currents through both diodes to 0.5 mA.

d) Suppose the terminal X of the circuit shown in figure (4) is now connected to the output F of the circuit shown in figure (3).

i) When the inputs A and B represent binary 1, what is the base current I_B?

ii) Show that the transistor operates as a closed switch under the input conditions given in (d)(i) above. Assume that the current gain β of the transistor in 50.

iii) Show that the transistor, however, does not operate as a open switch when F in figure (3) represents binary 0.

iv) With the aid of a circuit diagram show how you would convert the composite circuit consisting of circuits given in figure (3) and (4) to perform as a NAND gate by inserting another silicon diode at an appropriate place in the circuit given in figure (4) above.

2016 A/L

20) Figure (1) shows the circuit symbol of an operational amplifier having open loop voltage gain A.

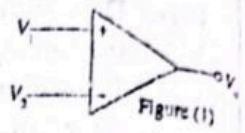


Figure (1)

a) Write down the expression for the output voltage V_0 in terms of V_1, V_2 and A.

b) If the positive and negative output saturation voltage of the operational amplifier are $\pm$ 15 V and $A = 10^5$, calculate the minimum input voltage difference which will drive its output into saturation.

c) i) Draw the output voltage waveform when the given triangular voltage signal of peak amplitude 5 V is applied to the + input of the circuit as shown in figure (2) and label its peak voltage values.

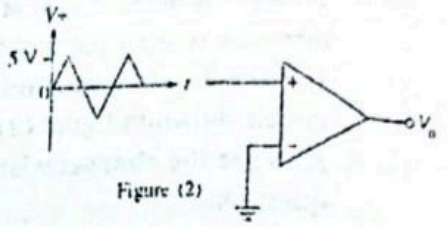


Figure (2)

ii) The circuit in figure (2) is now modified as shown in figure (3). When S_1 is closed and S_2 is open the circuit will produce the output waveform shown in the figure (3) for the input triangular signal. Considering the actions of circuit elements in figure (3), explain the reasons for differences, if any, between the output voltage waveform shown in figure (3) and the waveform drawn by you in (*c*) (*i*). What is the peak voltage of the output in figure (3)?

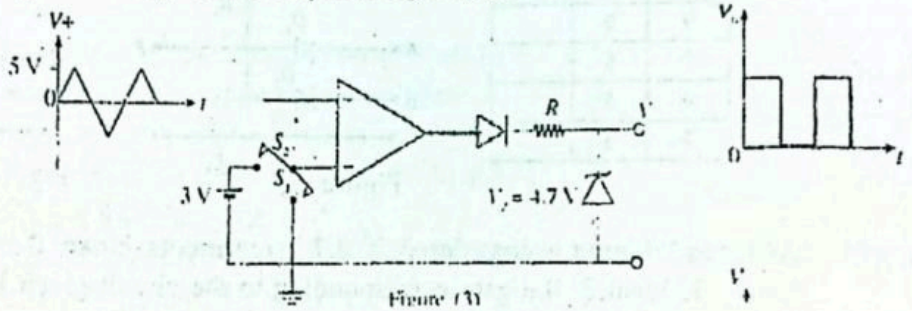


Figure (3)

iii) Now a voltage of +3V is applied to the - input of the operational amplifier in figure (3) by opening S_1 and closing S_2. When a hypothetical voltage waveform shown in figure (4) is applied to the + input of the operational amplifier, draw the output waveform expected from the circuit and label the magnitude of the output voltage.

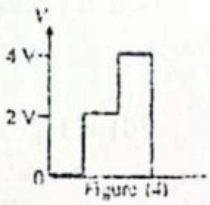


Figure (4)

d) A certain blood cell counting system operated as follows. The blood is diluted by a known proportion in a proper type of solution and allowed to flow through a small aperture X of the order of 50 μm diameter placed in between two electrodes S and T as shown in the figure (5). Blood cell counting is based on the fact that the electricity resistiv9ity of blood cells is higher than the electrical resistively of the solution.

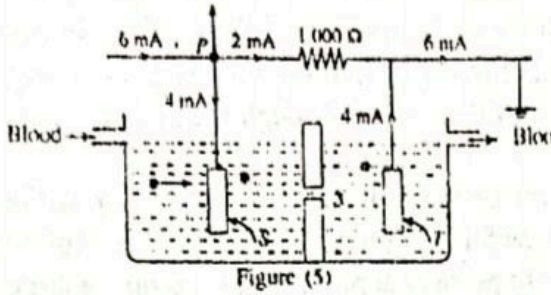


Figure (5)

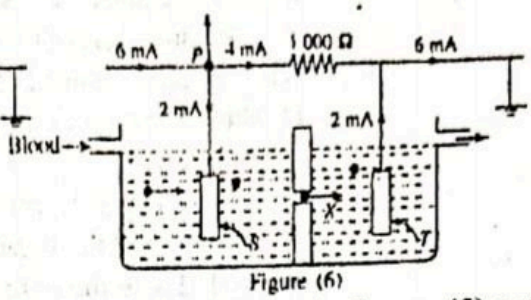


Figure (6)

A constant current of 6 *mA* is passed through the system as shown in figures (5) and (6). Currents through 1000Ω resistor and the electrodes when the solution passes through the aperture *X* is shown in figure (5). Figure (6) shows the currents through 1000Ω resistor and the electrodes when a blood cell is going through the aperture *X*. The point *P* of the circuits shown in figures (5) and (6) is connected to + terminal of the operational amplifier in the circuit shown in figure (3) with S_1 open and S_2 closed. The output *V* is connected to a pulse counter. (Not shown in the figure)

i) What are the voltage at point P in figures (5) and (6)?

ii) If the situation in figure (5) occurs before (6), draw the voltage waveform at *P* for such situations.

iii) Draw the output voltage waveform of the circuit in figure (3) relevant to (ii) above.

iv) What does the counter output balance of a diluted blood stream is allowed to flow through the aperture X?

2017 A/L

21) a) Write down the expression for the relationship among I_C, I_E and I_B, of an *npn* transistor. All symbols have their usual meaning.

b) The *npn* transistor connected as shown in figure (*1*), is operating in the active mode. Assume that the current gain of the transistor is 100, and when it is forward biased, the voltage across the base and the emitter, $V_{BE} = 0.7\ V$.

i) Calculate the base current I_B necessary to produce a collector voltage of 5 *V*.

ii) Calculate the value of R_2, if R_1 = 12 kΩ. (Assume I_B is negligible for this calculation).

iii) Modify the given circuit shown in figure (1) so that it could be operated with a negative power supply voltage of -10 *V*. Correctly re-label, the modified circuit using R_1, R_2, 10 *k*Ω, and the labels *A* and *B* given for the points in the **appropriate** manner. Indicate the direction of the collector current. and the direction of the current through R_1 and R_2 with arrows.

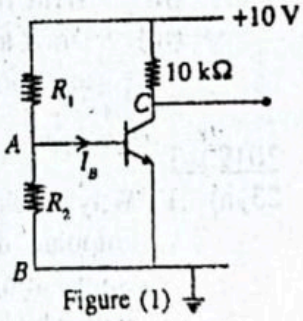


Figure (1)

c) A photodiode is to be connected across the base and the emitter of the transistor in the **modified circuit** that you have drawn under (*b*) (*iii*).

i) When connecting a photodiode to a circuit, it is done in such a way that the photodiode is reverse biased. Using the circuit symbol of the photodiode show how you would connect it correctly across the base and the emitter of the transistor in the **modified circuit.**

ii) When the photodiode is connected to the modified circuit correctly, will it alter the resistance across base and emitter appreciably? Explain your answer.

iii) When a rectangular light pulse of short duration is incident on the photodiode,
1) show the direction of the current through the photodiode in the circuit using an arrow.
2) draw the waveform of the **voltage** pulse appearing at the base relative to emitter, and the waveform of the **voltage** pulse at the collector relative to the earth due to the light pulse at appropriate places on the circuit.

2018 A/L

22) a) The circuit shown in figure (1) is constructed using a silicon transistor of current gain 100. Assume that 0.7 V is needed to forward bias the base emitter junction of the transistor.

(i) Calculate the maximum current possible through the collector resistor.

(ii) Calculate the maximum value for R_B which ensures the condition stated in (i) above, for $V_B = 5$ V.

(iii) If the transistor in the above circuit has been replaced later by a similar transistor but having a current gain of 50, keeping R_B at the value calculated in (ii) above.
(1) Calculate the voltage at the output F for $V_B = 5$ V.
(2) What is the new mode of operation of the transistor?

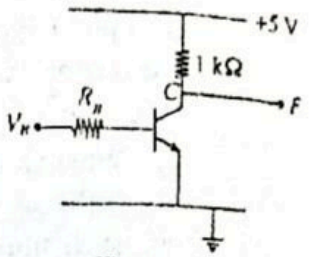


Figure (1)

(b) The digital circuit whose block diagram is shown in figure (2) operates as follows. Each of the inputs A and B accepts binary 1 or 0. F_1, F_2 and F_3 are outputs, where

$F_1 = 1$ only when $A < B$, otherwise $F_1 = 9$
$F_2 = 1$ only when $A = B$, otherwise $F_2 = 0$
$F_3 = 1$ only when $A > B$, otherwise $F_3 = 0$

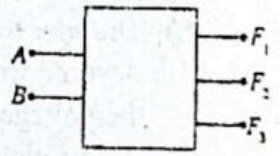


Figure (2)

(i) Prepare a truth table with A and B as inputs and F_1, F_2 and F_3 as outputs.

(ii) Write down Boolean expressions for F_1, F_2 and F_3.

(iii) Draw a logic circuit which operates according to the conditions given above, using logic gates.

2019 A/L

23) a) i) Why Field Effect Transistors (FET) are called unipolar devices? What are the charge carriers contributing to the operation of FETs?

ii) State why FETs are also known as voltage-controlled devices.

iii) Calculate the drain current I_D and the Gate-Source voltage V_{GS} for the circuit shown in figure (1), assuming $V_D = 5$ V.

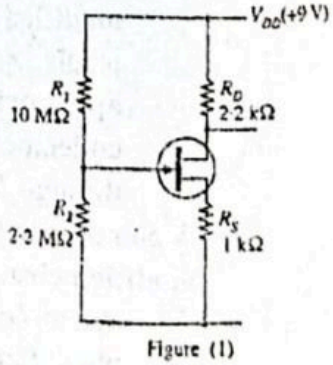


Figure (1)

b) In the Op-amp circuit shown in figure (2), each electromechanical switch S_i (i = 0, 1, 2, 3) is operated by applying an electrical signal D_i (i = 0, 1, 2, 3) which can be 'High' (5V) or 'Low' (0V). When D_i is 'High' the respective switch S_i will be closed and otherwise, it will be open.

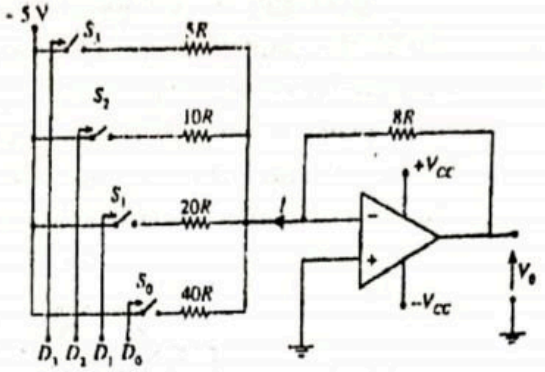


Figure (2)

(i) When D_2 is 'High', find the current through the resistor 10R in terms of R.

(ii) If a set of voltages (5V, 0V, 5V, 5V) is applied simultaneously to operate the switches S_3, S_2, S_1, S_0, respectively, calculate the current I indicated in figure (2) in terms of R.

(iii) Calculate the output voltage V_0 when a set of voltages (5V, 5V, 5V, 5V) is applied simultaneously to operate the switches S_3, S_2, S_1, S_0 respectively

(c) A cash operated snack dispenser will provide a pack of 'Marie' or 'Chocolate Crearn' biscuits under the following conditions.

- The correct amount of cash is inserted (I)
- 'Marie' (M) or 'Chocolate Cream' (C) is selected
- If 'Marie' is selected, 'Availability of Marie' in the dispenser (X)
- If 'Chocolate Cream' is selected, 'Availability of Chocolate Cream' in the dispenser (Y)

(i) Obtain the logic expression for the conditions under which a pack of biscuits may be obtained.

(ii) Show how this may be implemented using logic gates.

2020 A/L

24) a) Write down the "golden rules" applicable to an ideal operational amplifier (op-amp) when it operates in negative feedback mode.

b) The op-amp circuit shown in figure (1) is known as a "Differential amplifier" since it amplifies the difference between the two input voltages V_2 and V_1. The voltages at the non – investing input and inverting input of the op - amp circuit are V_+ and V_- respectively and V_0 is the output voltage of the op-amp.

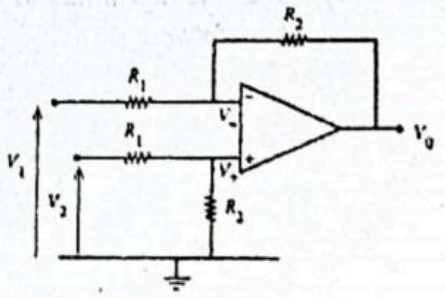


Figure (1)

i) Write down an expression for V_+ in terms if V_2, R_1 and R_2.

ii) Write down an expression for V_- in terms f V_2, R_1 and R_2.

iii) Write down an expression for V_0 in terms of V_1, V_2, R_1 and R_2.

iv) Deduce an expression for V_0, if $R_1 = R_2 = R$.

c) The above circuit in figure (1) can be modified to activate a burglar alarm. The modified circuit is shown in figure (2). The right arm of the bridge circuit has two equal resistors of resistance R_1 and the left arm consists of a 50 Ω resistor and a light dependent resistor (LDR) which is sensitive to infra-red (IR) light. A narrow beam of IR light is allowed to fall on to the LDR continuously. When a burglar (B) enters the building he blocks the IR beam falling on to the LDR.

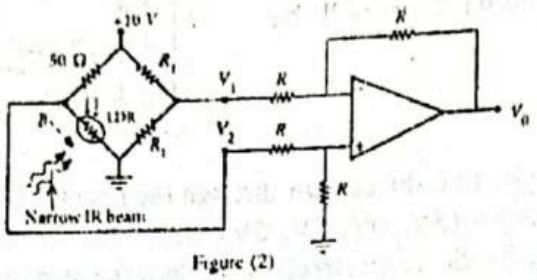


Figure (2)

i) When the IR beam falls on to the LDR its resistance is equal to 50Ω. Determine the corresponding values of V_1, V_2 and V_0.

ii) When the burglar crosses the IR beam the resistance of the LDR increases to 10^6 Ω. Determine the corresponding values of V_1, V_2 and V_0 in this situation.

d) i) Now the output V_0 of the op-amp is connected to the S input of an S-R flip-flop as shown in figure (3). The R input is grounded via a two – way switch. The alarm should sound when Q = 1. Write down the input logic levels of S and R for the following two situations.

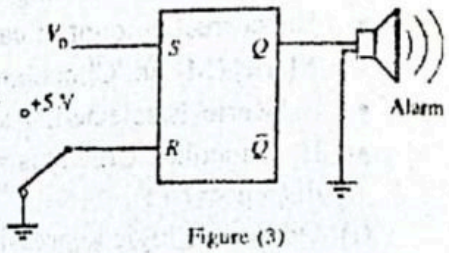


Figure (3)

1) When the IR beam is incident on the LDR.
2) When the burglar crosses the IR beam.

ii) Write down the truth table of an S-R flip-flop.

iii) Show that the alarm will sound when the burglar crosses the IR beam.

iv) Explain why is it desirable to use a flip-flop in this situation?

v) Later the alarm has to be stopped. How could this be achieved? Give reasons for your answer.