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Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

ELECTRICAL TECHNOLOGY: ELECTRONICS

NOVEMBER 2023

MARKS: 200

TIME: 3 hours

**This question paper consists of 25 pages, a 1-page formula sheet
and a 6-page answer sheet.**

INSTRUCTIONS AND INFORMATION

1. This question paper consists of SIX questions.
2. Answer ALL the questions.
3. Answer the following questions on the attached ANSWER SHEETS:

QUESTIONS 5.2.5, 5.4.3, 5.5.3 and 5.7
QUESTIONS 6.4.3, 6.5.2 and 6.7.3
4. Write your centre number and examination number on every ANSWER SHEET and hand them in with your ANSWER BOOK, whether you have used them or not.
5. Sketches and diagrams must be large, neat and FULLY LABELLED.
6. Show ALL calculations and round off answers correctly to TWO decimal places.
7. Number the answers correctly according to the numbering system used in this question paper.
8. You may use a non-programmable calculator.
9. Calculations must include:
 - 9.1 Formulae and manipulations where needed
 - 9.2 Correct replacement of values
 - 9.3 Correct answer and relevant units where applicable
10. A formula sheet is attached at the end of this question paper.
11. Write neatly and legibly.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Various options are provided as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question numbers (1.1 to 1.15) in the ANSWER BOOK, e.g. 1.16 D.

- 1.1 The following can be considered as dangerous practices:
- A The use (or misuse) of power tools
 - B The incorrect use and handling of hand tools
 - C The etching of printed circuit boards
 - D All the above-mentioned (1)
- 1.2 ... is the reference quantity in a parallel RLC circuit.
- A Current
 - B Resistance
 - C Reactance
 - D Voltage (1)
- 1.3 The reactance of a ... must be equal for a circuit to resonate.
- A resistor and an inductor
 - B resistor and a capacitor
 - C capacitor and an inductor
 - D transducer and a capacitor (1)
- 1.4 The following condition is common to both series and parallel resonance:
- A The impedance is minimum.
 - B The current is maximum.
 - C The bandwidth is affected by its quality factor.
 - D The Q-factor depends on voltage amplification. (1)
- 1.5 ONE of the advantages of the field-effect transistor is its extremely ...
- A low input resistance.
 - B low input and output resistance.
 - C high output resistance.
 - D high input resistance. (1)
- 1.6 The ratio of the internal resistances of a UJT is called ...
- A negative resistance ratio.
 - B common-mode rejection ratio.
 - C intrinsic standoff ratio.
 - D extrinsic standoff ratio. (1)

- 1.7 A ... circuit is used to eliminate switch bounce in switching circuits.
- A comparator
 - B bistable multivibrator
 - C monostable multivibrator
 - D differentiator
- (1)
- 1.8 When negative feedback is used in an op amp, the bandwidth ...
- A increases.
 - B decreases.
 - C is equal to zero.
 - D stays the same.
- (1)
- 1.9 The ... is a switching circuit with two inputs that is able to store one bit of data at a time.
- A bistable multivibrator
 - B monostable multivibrator
 - C astable multivibrator
 - D passive integrator
- (1)
- 1.10 An op-amp application that uses positive feedback is the ...
- A comparator.
 - B summing amplifier.
 - C Schmitt trigger.
 - D differentiator.
- (1)
- 1.11 The op-amp comparator is an extremely sensitive circuit because ...
- A it is the only op-amp application that uses closed loop gain.
 - B there is no feedback connection between the output and the input.
 - C it makes use of the virtual ground concept.
 - D the supply voltage is connected to it.
- (1)
- 1.12 ONE of the key operating principles in an op-amp integrator circuit:
- A When a constant current is fed to the capacitor, it will charge at a constant fixed rate rather than exponentially.
 - B The two input terminals of the op amp have different voltages at all times.
 - C The inputs of the op amp draw maximum current so that any input current is blocked by the feedback circuit.
 - D The current fed to the capacitor causes it to charge exponentially.
- (1)

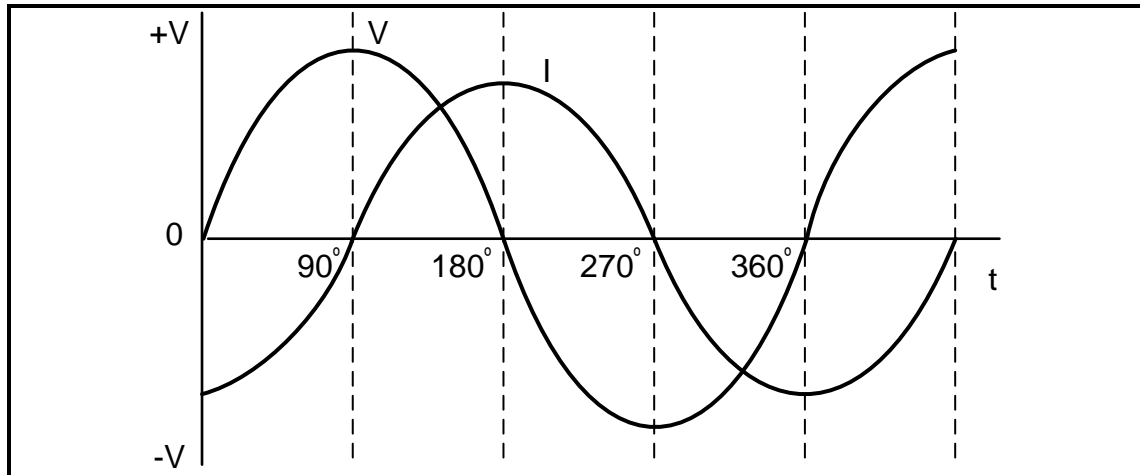
- 1.13 The efficiency of a class C amplifier is ...
- A less than the efficiency of a class A amplifier.
 - B less than the efficiency of a class B amplifier.
 - C less than the efficiency of a class AB amplifier.
 - D greater than the efficiency of a class A, B or AB amplifier. (1)
- 1.14 A bipolar junction class B push-pull amplifier with no transformer coupling uses ...
- A two NPN transistors.
 - B two PNP transistors.
 - C complementary transistors.
 - D none of the above-mentioned. (1)
- 1.15 A/An ... is a circuit that produces an output waveform without an internal signal source.
- A bistable multivibrator
 - B amplifier
 - C Schmitt trigger
 - D oscillator (1)
- [15]**

QUESTION 2: OCCUPATIONAL HEALTH AND SAFETY

- 2.1 Name TWO incidents arising out of activities of people at the workplace that must be reported to the health and safety inspector. (2)
- 2.2 Define the term *danger* with reference to the Occupational Health and Safety Act, 1993 (Act 85 of 1993). (2)
- 2.3 Explain why the location of the emergency master switch is important for safety in and around the workshop. (2)
- 2.4 State TWO effects a third-degree burn has on a person's body. (2)
- 2.5 Name TWO first-aid steps to take after a person has been shocked by an electric current. (2)
- [10]**

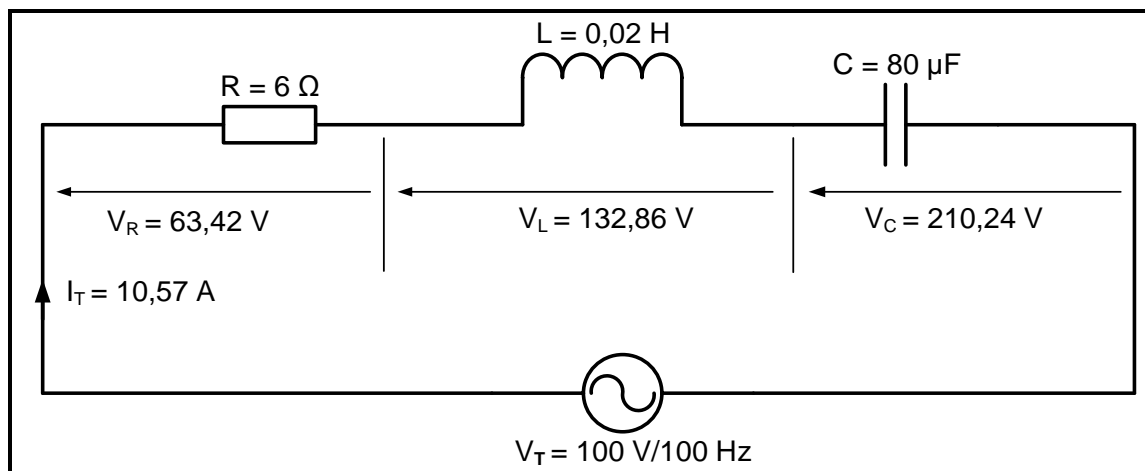
QUESTION 3: RLC CIRCUITS

- 3.1 State the relationship between inductive reactance and frequency. (1)
- 3.2 Refer to FIGURE 3.2 below and state the phase relationship between the current and voltage waveforms.

**FIGURE 3.2: CURRENT AND VOLTAGE WAVEFORMS**

(1)

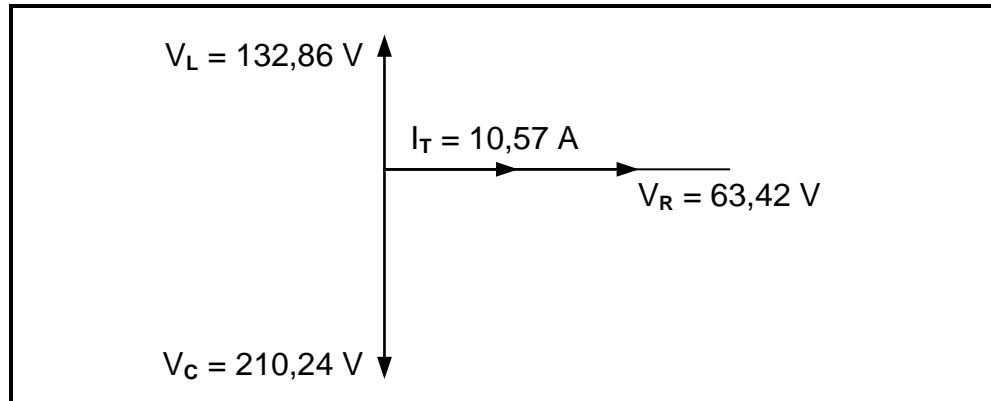
- 3.3 FIGURE 3.3 below shows an RLC series circuit which consists of a resistor with a resistance of $6\ \Omega$, an inductor with an inductance of $0,02\ \text{H}$ and a capacitor with a capacitance of $80\ \mu\text{F}$ which are all connected across an alternating supply of $100\ \text{V}/100\ \text{Hz}$.

**FIGURE 3.3: RLC SERIES CIRCUIT**

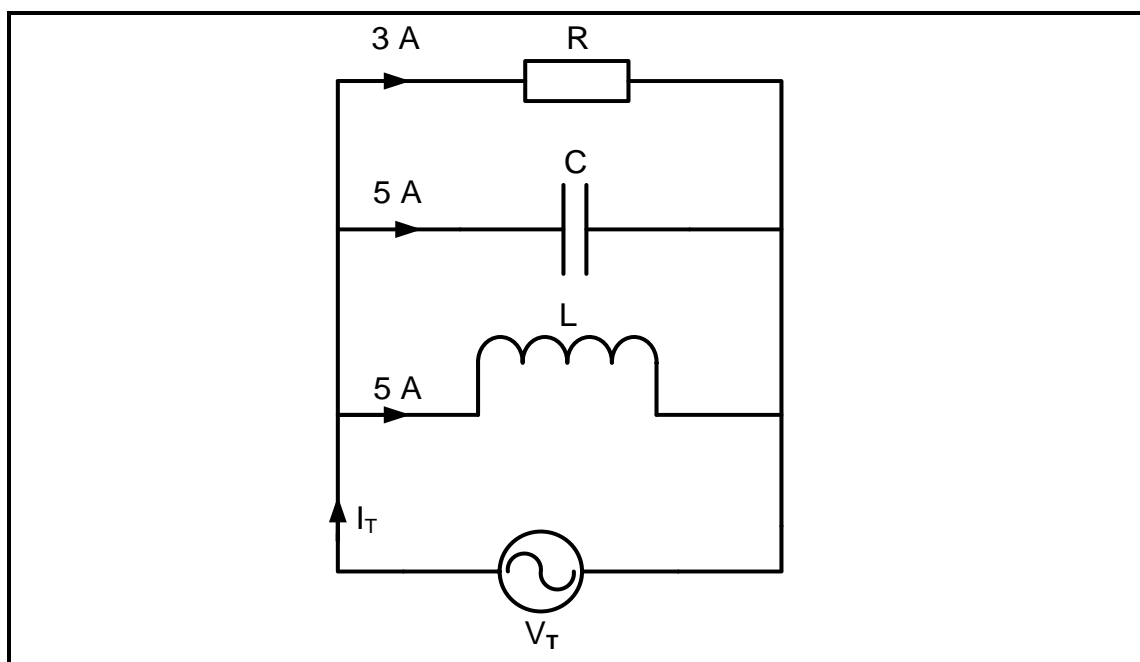
Given:

$$\begin{aligned}
 R &= 6\ \Omega \\
 L &= 0,02\ \text{H} \\
 C &= 80\ \mu\text{F} \\
 V_R &= 63,42\ \text{V} \\
 V_C &= 210,24\ \text{V} \\
 V_L &= 132,86\ \text{V} \\
 V_T &= 100\ \text{V} \\
 I_T &= 10,57\ \text{A} \\
 f &= 100\ \text{Hz}
 \end{aligned}$$

- 3.3.1 State whether the supply current is leading or lagging the supply voltage. Motivate your answer. (2)
- 3.3.2 Redraw and complete the phasor diagram of the circuit diagram in FIGURE 3.3 in the ANSWER BOOK.

**FIGURE 3.3.2: PHASOR DIAGRAM**

- 3.3.3 Prove that the resultant of V_R , V_L and V_C equals the supply voltage. (3)
- 3.3.4 Calculate the frequency at which the circuit will resonate. (3)
- 3.4 Refer to FIGURE 3.4 below and answer the questions that follow.

**FIGURE 3.4: CIRCUIT DIAGRAM**

- 3.4.1 Calculate the total current of the circuit. (3)
- 3.4.2 Calculate the phase angle. (3)
- 3.4.3 Draw a fully labelled phasor diagram for the circuit in FIGURE 3.4 above in the ANSWER BOOK. (4)

- 3.5 A series circuit consists of a resistor with a resistance of 30 ohms, an inductor with an inductance of 10 mH and a capacitor with a capacitive reactance of 300 ohms. This combination is connected across an alternating supply of 30 V and resonates at a frequency of 4,77 kHz.

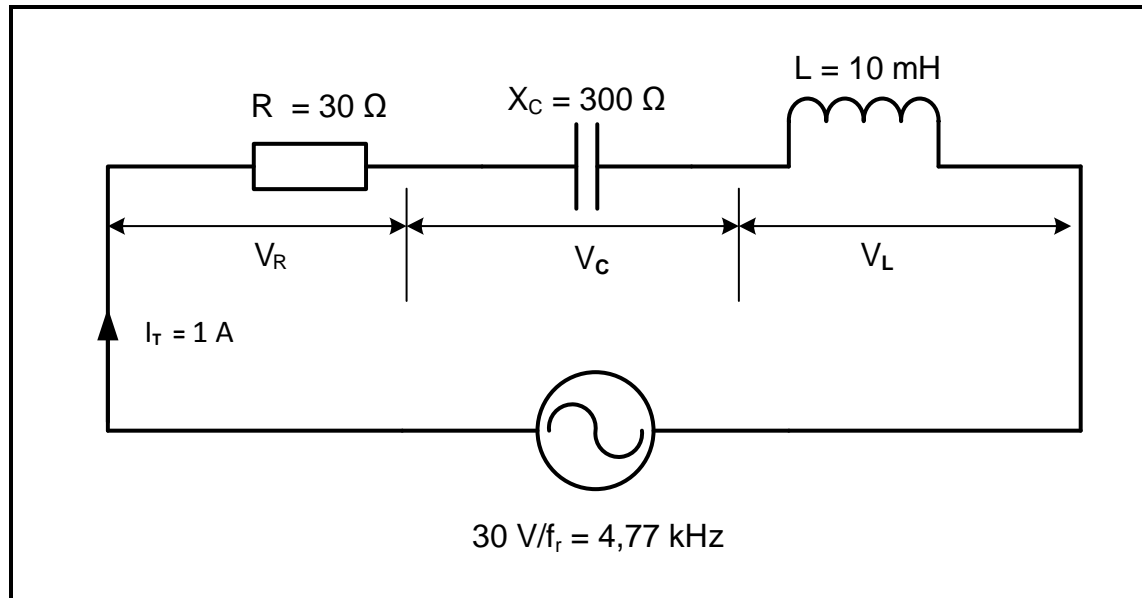


FIGURE 3.5: RESONANCE RLC SERIES CIRCUIT

Given:

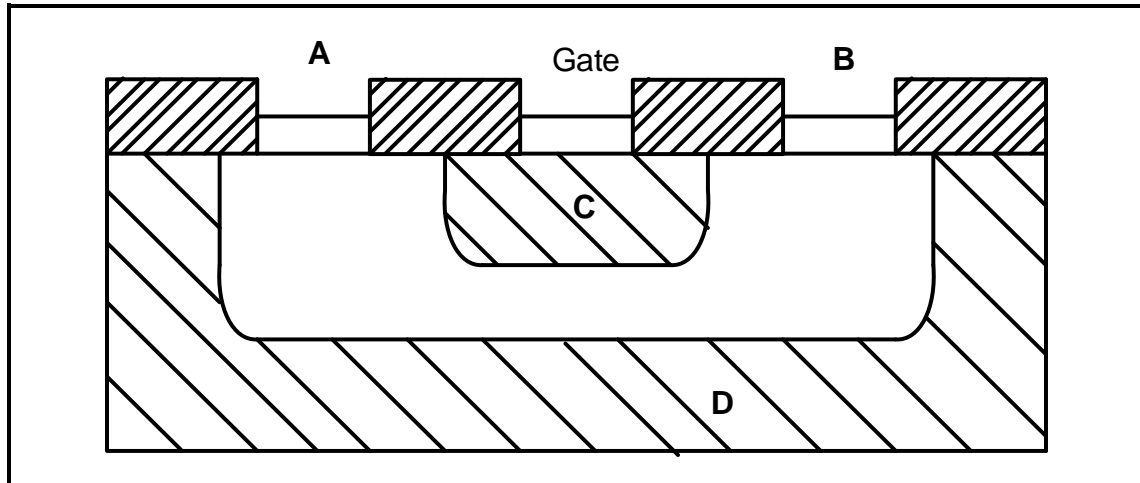
$$\begin{aligned}
 R &= 30\ \Omega \\
 X_C &= 300\ \Omega \\
 L &= 10\ \text{mH} \\
 V_T &= 30\ \text{V} \\
 f_r &= 4,77\ \text{kHz} \\
 I_T &= 1\ \text{A}
 \end{aligned}$$

- 3.5.1 Calculate the Q-factor of the circuit. (3)
- 3.5.2 Calculate the bandwidth of the circuit. (3)
- 3.5.3 Calculate the voltage drop across the inductor. (3)
- 3.5.4 Explain why the voltage across the inductor is greater than the value of the supply voltage. (2)

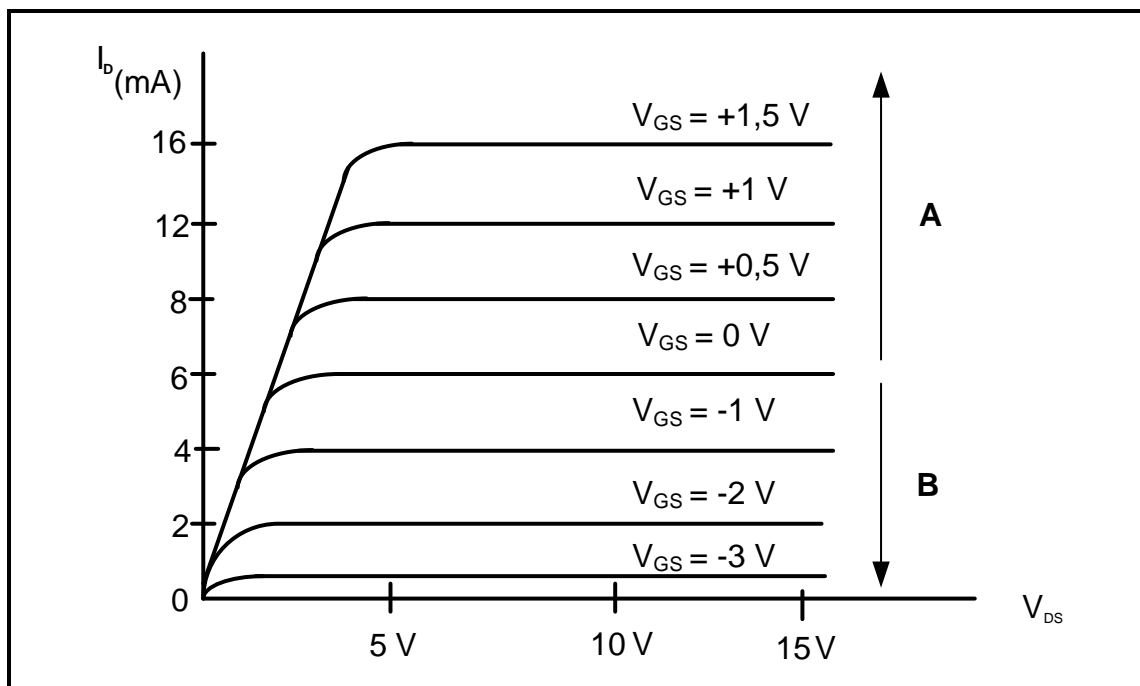
[35]

QUESTION 4: SEMICONDUCTOR DEVICES

- 4.1 Refer to FIGURE 4.1 below of the construction of a JFET and answer the questions that follow.

**FIGURE 4.1: CONSTRUCTION OF A JFET**

- 4.1.1 Label **A** and **B**. (2)
- 4.1.2 Briefly describe the construction of the junction field-effect transistor (JFET). (2)
- 4.1.3 Describe how the flow of current is restricted in the JFET when the value of the V_{GS} is increased. (3)
- 4.2 Refer to FIGURE 4.2 of a characteristic curve below and answer the questions that follow.

**FIGURE 4.2: CHARACTERISTIC CURVE**

4.2.1 Identify the characteristic curve in FIGURE 4.2. (1)

4.2.2 Label **A** and **B**. (2)

4.3 Refer to MOSFETs and answer the questions that follow.

4.3.1 Name TWO electronic devices that use metal-oxide-semiconductor field-effect transistors (MOSFETs). (2)

4.3.2 Briefly describe, with reference to the gate, how the MOSFET differs from the JFET. (2)

4.4 FIGURE 4.4 below shows a UJT speed-control circuit diagram. Answer the questions that follow.

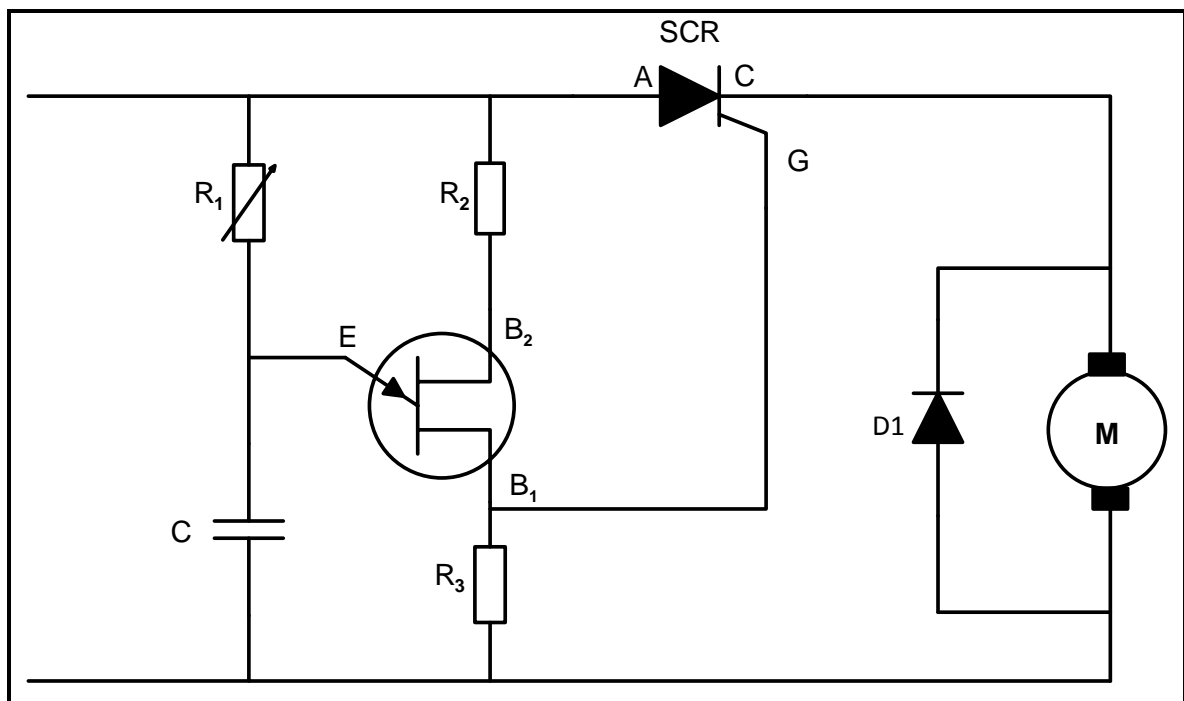


FIGURE 4.4: UJT SPEED-CONTROL CIRCUIT DIAGRAM

4.4.1 Explain how the value of R_1 affects the rate at which the capacitor will charge. (2)

4.4.2 Discuss how the UJT, together with the SCR, control the speed of the motor in FIGURE 4.4. (3)

4.5 Refer to FIGURE 4.5 below and answer the questions that follow.

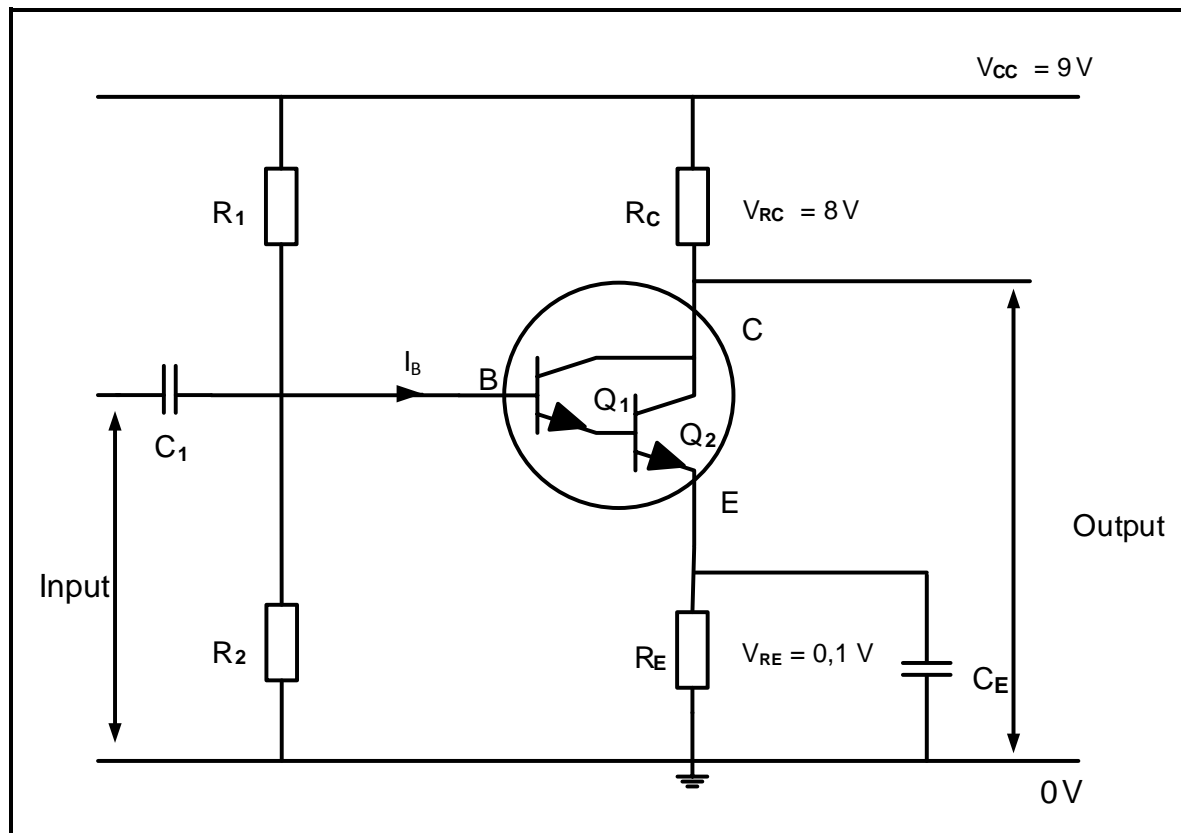


FIGURE 4.5: DARLINGTON CIRCUIT

- 4.5.1 State TWO advantages of a Darlington transistor pair. (2)
- 4.5.2 Refer to the circuit and determine the collector emitter voltage in the circuit. (1)
- 4.5.3 Explain how the input base current receives double amplification in a Darlington transistor. (3)

- 4.6 Refer to FIGURE 4.6 below of an inverting operational amplifier and answer the questions that follow.

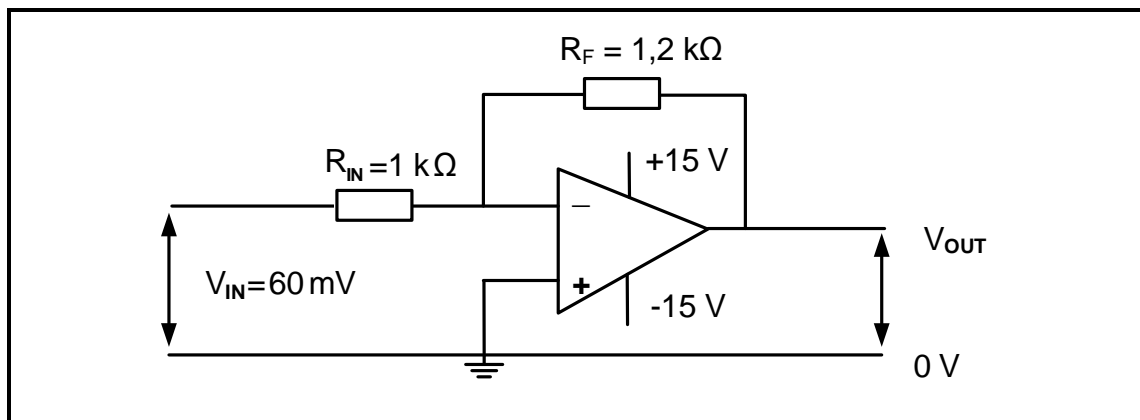


FIGURE 4.6: INVERTING OPERATIONAL AMPLIFIER

- 4.6.1 State the purpose of the feedback resistor (R_F). (1)
- 4.6.2 Explain why op amps are seldom used in open-loop mode. (2)
- 4.6.3 Calculate the voltage gain of the circuit. (3)

- 4.7 Refer to FIGURE 4.7 below and answer the questions that follow.

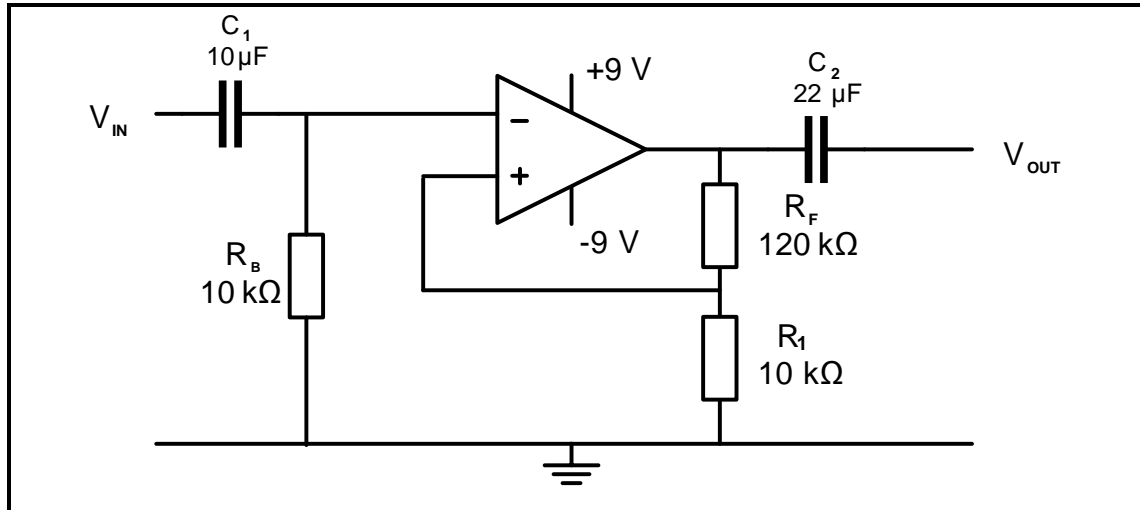


FIGURE 4.7: NON-INVERTING OP AMP

- 4.7.1 State TWO functions of resistor R_B in FIGURE 4.7. (2)
- 4.7.2 Calculate the voltage gain of the circuit in FIGURE 4.7. (3)

4.8 Refer to FIGURE 4.8 below and answer the questions that follow.

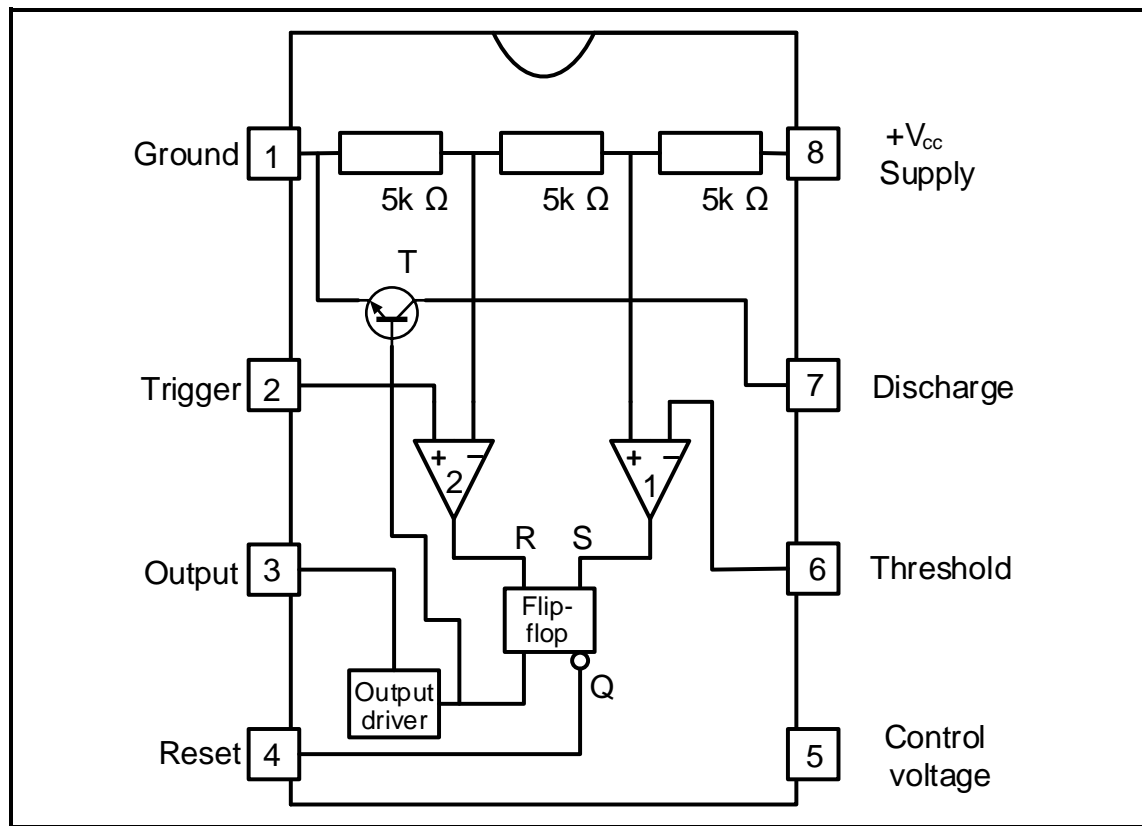


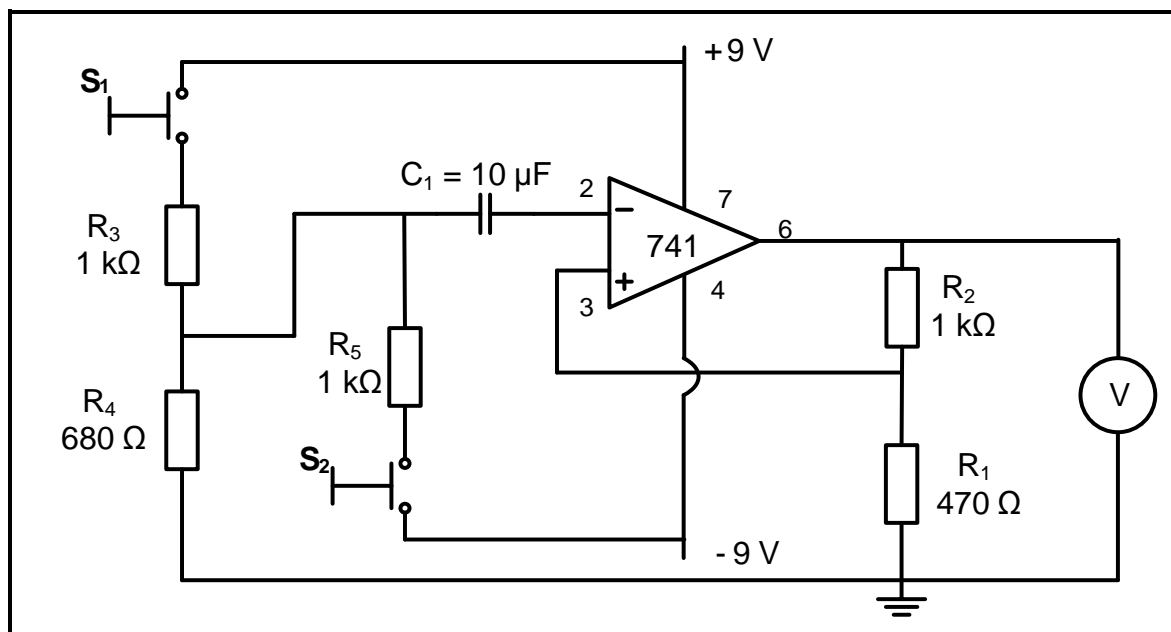
FIGURE 4.8: 555 IC PIN LAYOUT

- 4.8.1 Name TWO applications of the 555 IC. (2)
- 4.8.2 State TWO disadvantages of the 555 IC. (2)
- 4.8.3 Describe the function of pin 4. (3)
- 4.8.4 State the functions of the following components in FIGURE 4.8 above:
- (a) NPN transistor (1)
 - (b) Comparator 2 (1)

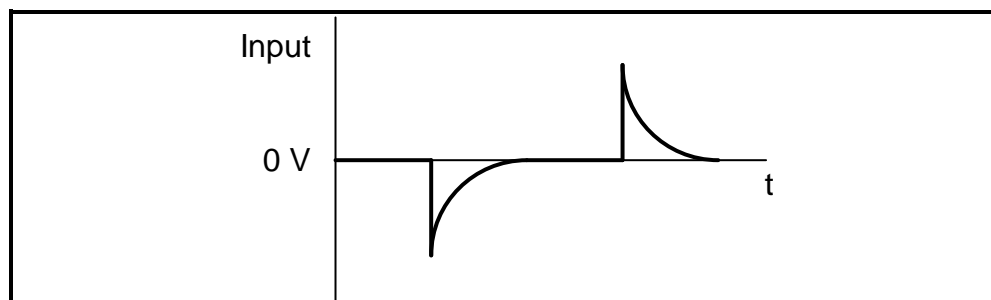
[45]

QUESTION 5: SWITCHING CIRCUITS

- 5.1 Differentiate between *bistable multivibrators* and *astable multivibrators* with reference to the output states. (2)
- 5.2 FIGURE 5.2 below shows the circuit of an op amp as a bi-stable multivibrator. Answer the questions that follow.

**FIGURE 5.2: BISTABLE MULTIVIBRATOR**

- 5.2.1 Explain the function of R_1 and R_2 . (2)
- 5.2.2 State the polarity of the output when S_2 is pressed. (1)
- 5.2.3 Explain the operation of the circuit when S_1 is pressed. (1)
- 5.2.4 Deduce the value of the output voltage when S_1 is pressed. (3)
- 5.2.5 Refer to the input in FIGURE 5.2.5 below and draw the output waveform on the ANSWER SHEET for QUESTION 5.2.5.

**FIGURE 5.2.5: INPUT PULSES**

5.3 Refer to FIGURE 5.3 below and answer the questions that follow.

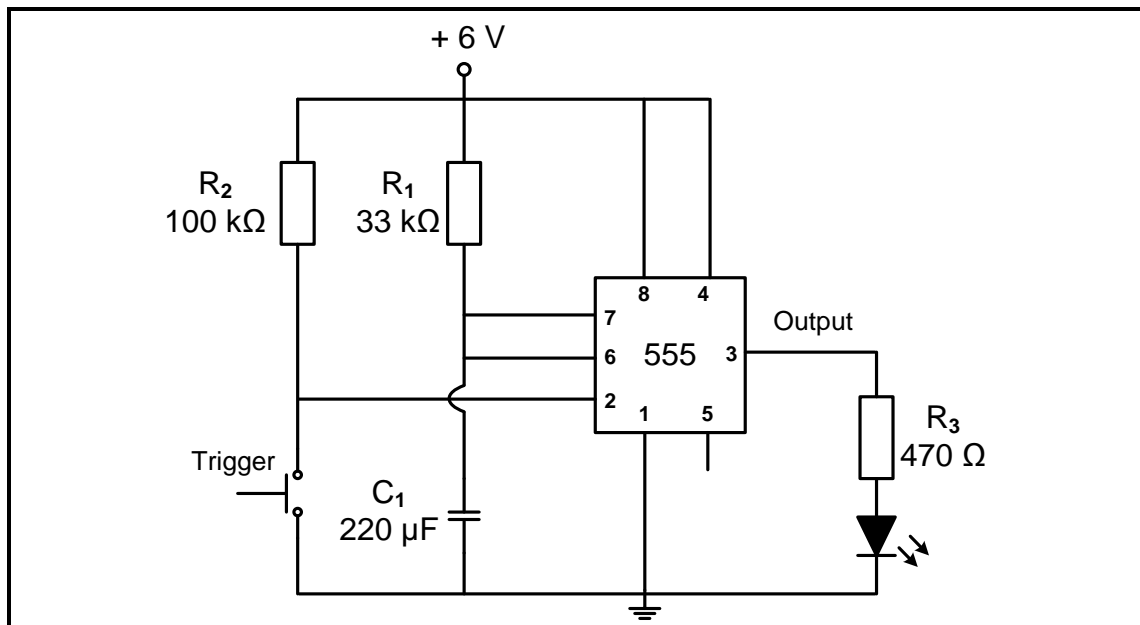


FIGURE 5.3: MONOSTABLE MULTIVIBRATOR

- 5.3.1 State whether this circuit uses an active high trigger or an active low trigger to set the output. (1)
- 5.3.2 Determine the threshold voltage of the circuit. (1)
- 5.3.3 Explain the operation of the circuit when the trigger is pressed. (5)
- 5.3.4 State how you would eliminate any unwanted noise from the supply that might affect the timing of the circuit. (2)

5.4 Refer to FIGURE 5.4 below and answer the questions that follow.

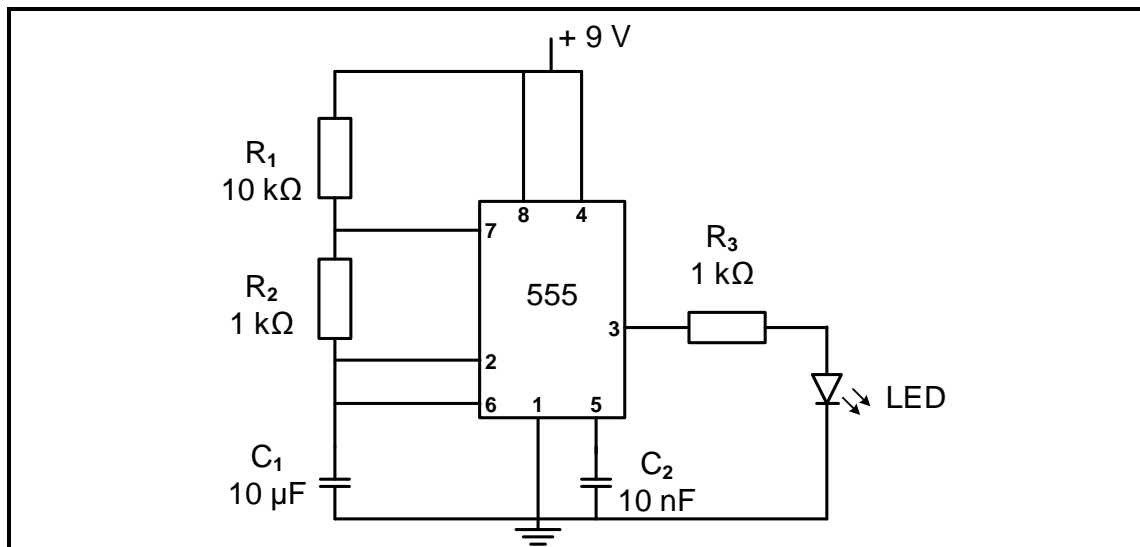


FIGURE 5.4: ASTABLE MULTIVIBRATOR

5.4.1 Explain the term *duty cycle* with reference to multivibrator outputs. (2)

5.4.2 State whether the charging time of the capacitor or the discharging time of the capacitor is longer. Motivate your answer. (3)

5.4.3 Draw the voltage waveform that appears across capacitor C_1 for ONE full cycle on the ANSWER SHEET for QUESTION 5.4.3. (4)

5.5 FIGURE 5.5 below shows the circuit of an inverting Schmitt trigger.

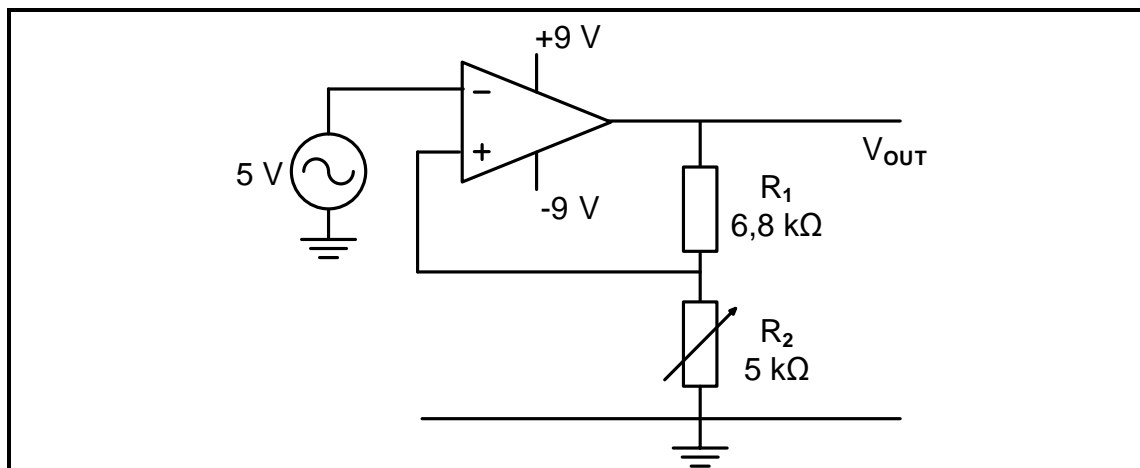


FIGURE 5.5: INVERTING SCHMITT TRIGGER

5.5.1 State the advantage of making R_2 variable. (1)

5.5.2 Calculate the value of the trigger voltage if R_2 is set to 2,2 kΩ. (3)

5.5.3 Draw ONE cycle of the input and output waveforms for the circuit on the ANSWER SHEET for QUESTION 5.5.3 when R_2 is set to 2,2 kΩ and the input waveform is sinusoidal. (6)

5.5.4 State how the value of the trigger voltage can be decreased. (1)

5.6 Refer to FIGURE 5.6 below and answer the questions that follow.

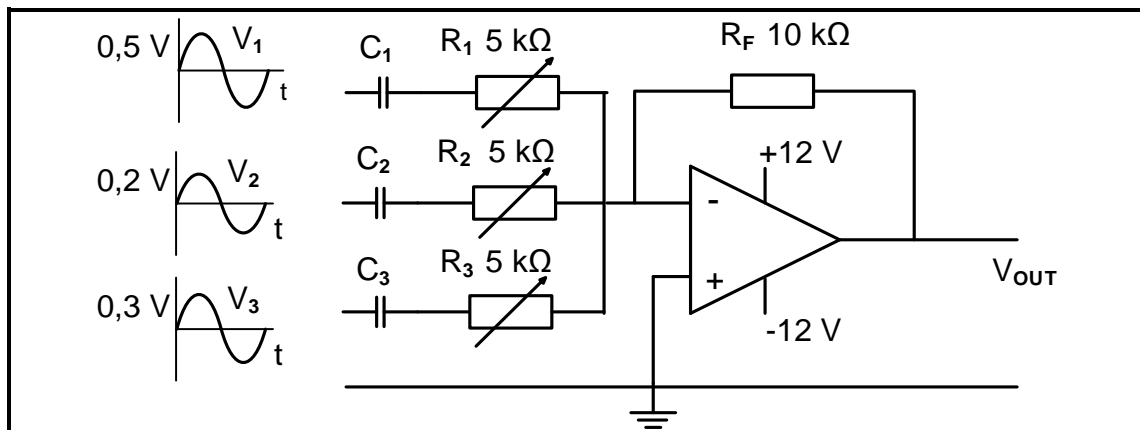


FIGURE 5.6: INVERTING SUMMING AMPLIFIER

- 5.6.1 State the purpose of the capacitors in series with the input resistors. (1)
- 5.6.2 Explain the advantage of using variable resistors instead of fixed-value resistors on the input of the amplifier. (2)
- 5.6.3 Calculate the output of the amplifier if all input resistors are set to 2 kΩ. (3)

5.7 FIGURE 5.7 below shows the op amp as differentiator with its input signal. Draw the output waveform on the ANSWER SHEET for QUESTION 5.7.

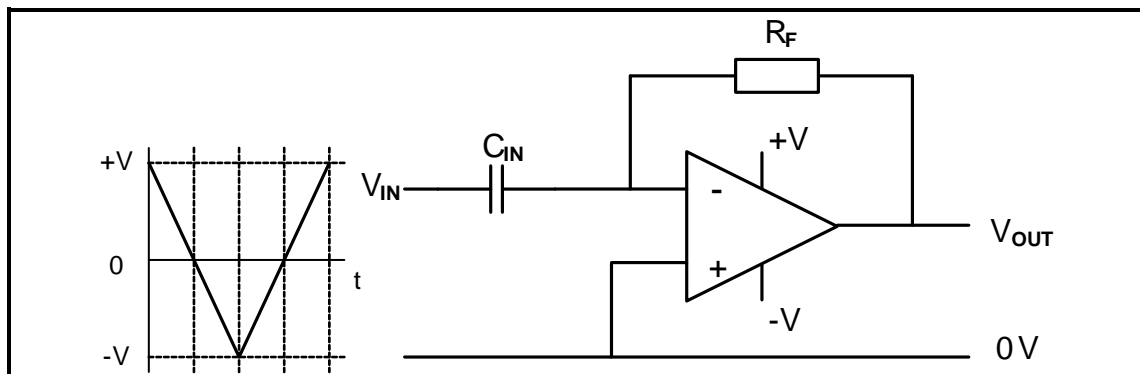
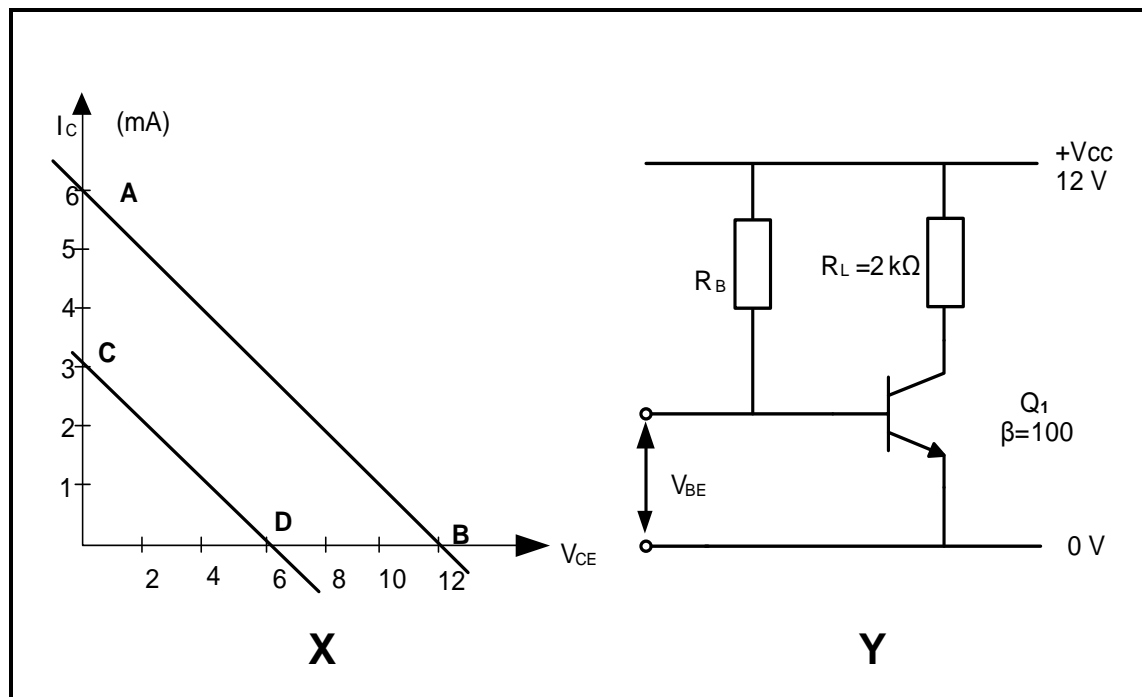


FIGURE 5.7: OP AMP AS DIFFERENTIATOR

(3)
[50]

QUESTION 6: AMPLIFIERS

- 6.1 Describe the term *positive feedback* with reference to oscillators. (2)
- 6.2 Compare a basic class A amplifier to a class B push-pull amplifier with reference to their sound reproduction. (2)
- 6.3 Refer to FIGURE 6.3 below and answer the questions that follow.

**FIGURE 6.3: DC LOAD AND TRANSISTOR BIASING**

- 6.3.1 Determine the value of V_{RL} in FIGURE 6.3 Y above when the transistor is ON. (1)
- 6.3.2 If the load line in FIGURE 6.3 X above is changed to CD, describe what changes were made to the circuit to effect this. (2)

6.4 Refer to FIGURE 6.4 below and answer the questions that follow.

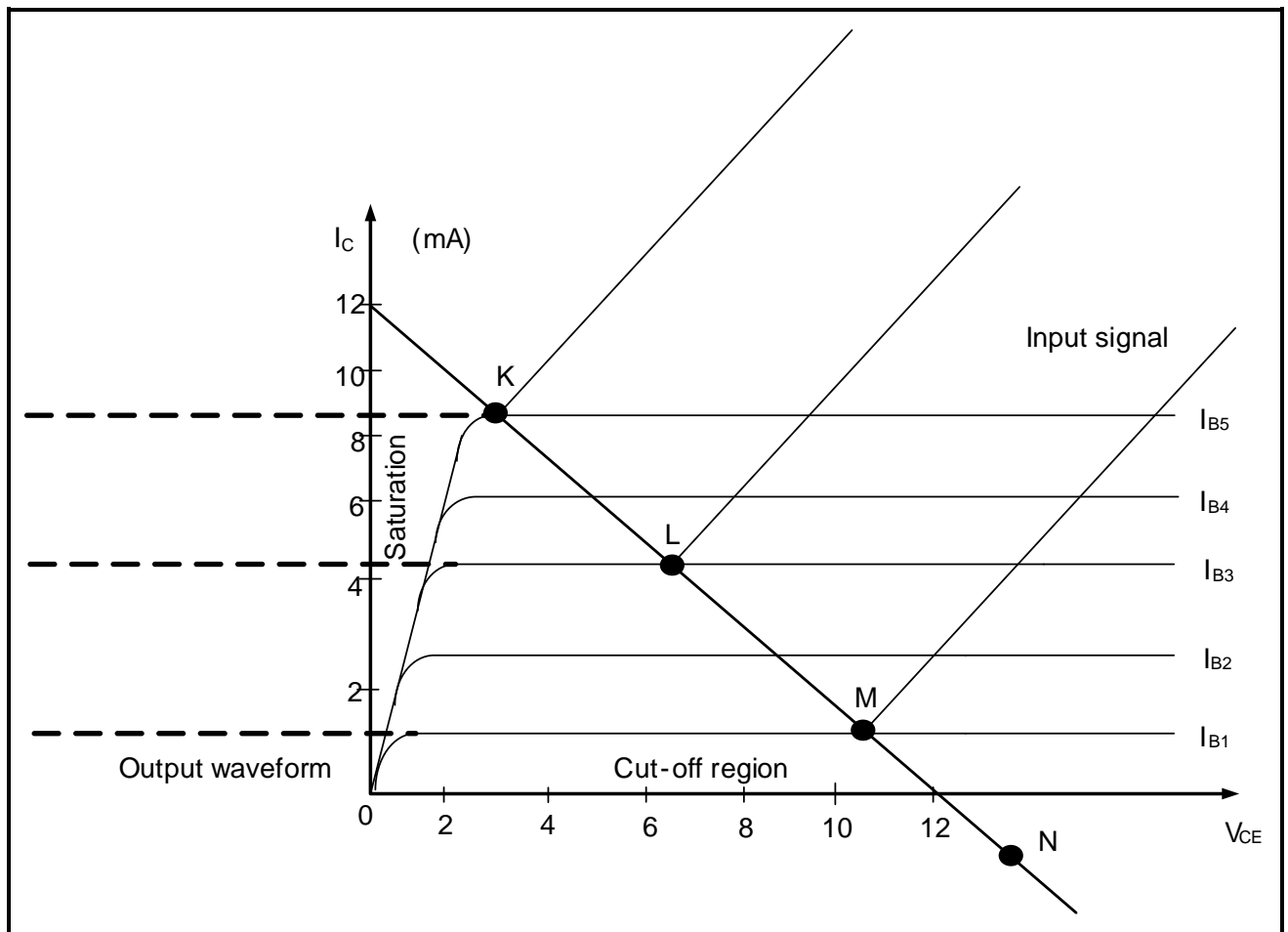


FIGURE 6.4: TRANSISTOR OUTPUT CHARACTERISTIC CURVE

- 6.4.1 Identify the region between K and M on the characteristic curve. (1)
- 6.4.2 Name ONE factor that influences the bias stability in a transistor amplifier. (1)
- 6.4.3 Draw the output waveform and input signal on the ANSWER SHEET for QUESTION 6.4.3 (NOT to scale) when the circuit in FIGURE 6.4 above is biased in class B. (4)

6.5 Refer to FIGURE 6.5 below and answer the questions that follow.

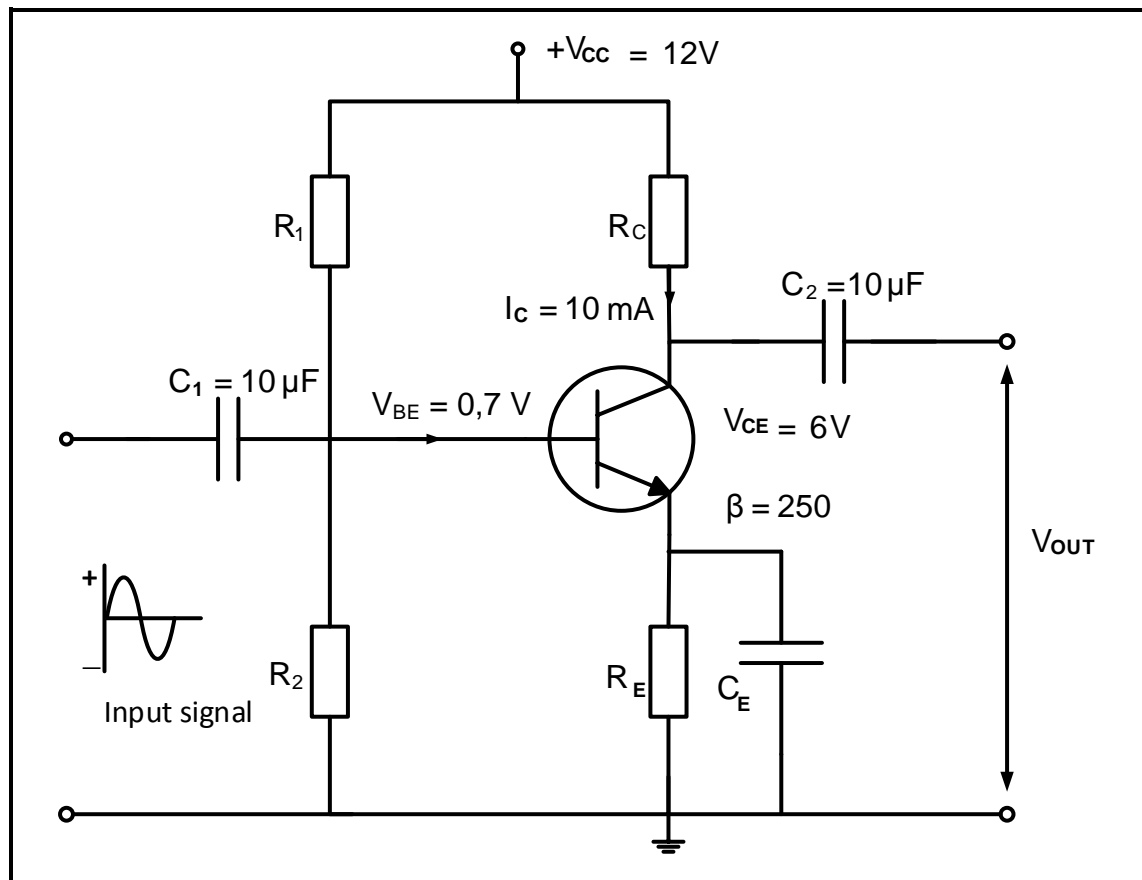


FIGURE 6.5: RC-COUPLED AMPLIFIER

- 6.5.1 Discuss the operation of the circuit in the negative half-cycle of the input signal. (3)
- 6.5.2 Draw, on the ANSWER SHEET for QUESTION 6.5.2, a full cycle of the output waveform when the transistor is driven into saturation. (3)

6.6 Refer to FIGURE 6.6 below and answer the questions that follow.

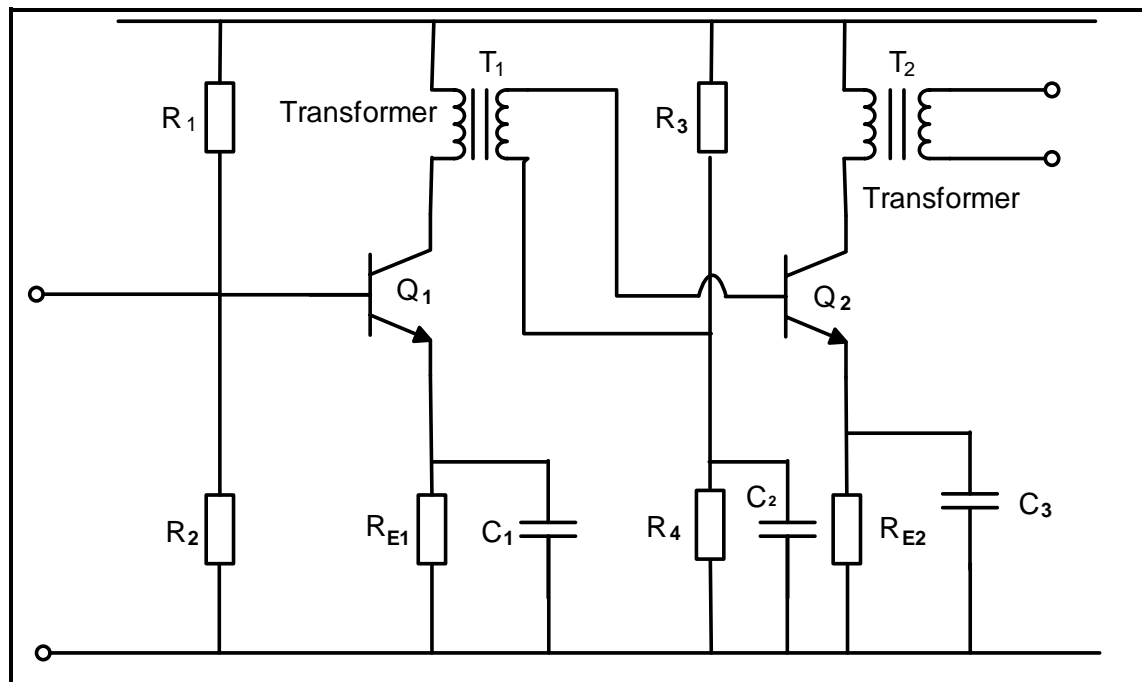


FIGURE 6.6: TWO-STAGE TRANSFORMER-COUPLED AMPLIFIER

- 6.6.1 State the function of transformer (T_2) in FIGURE 6.6 above. (1)
- 6.6.2 Explain why transformer-coupled amplifiers are more efficient than RC coupled amplifiers. (2)
- 6.6.3 Describe how the output impedance of the first stage can be matched to the input impedance of the second stage. (2)

6.7 Refer to FIGURE 6.7 below and answer the questions that follow.

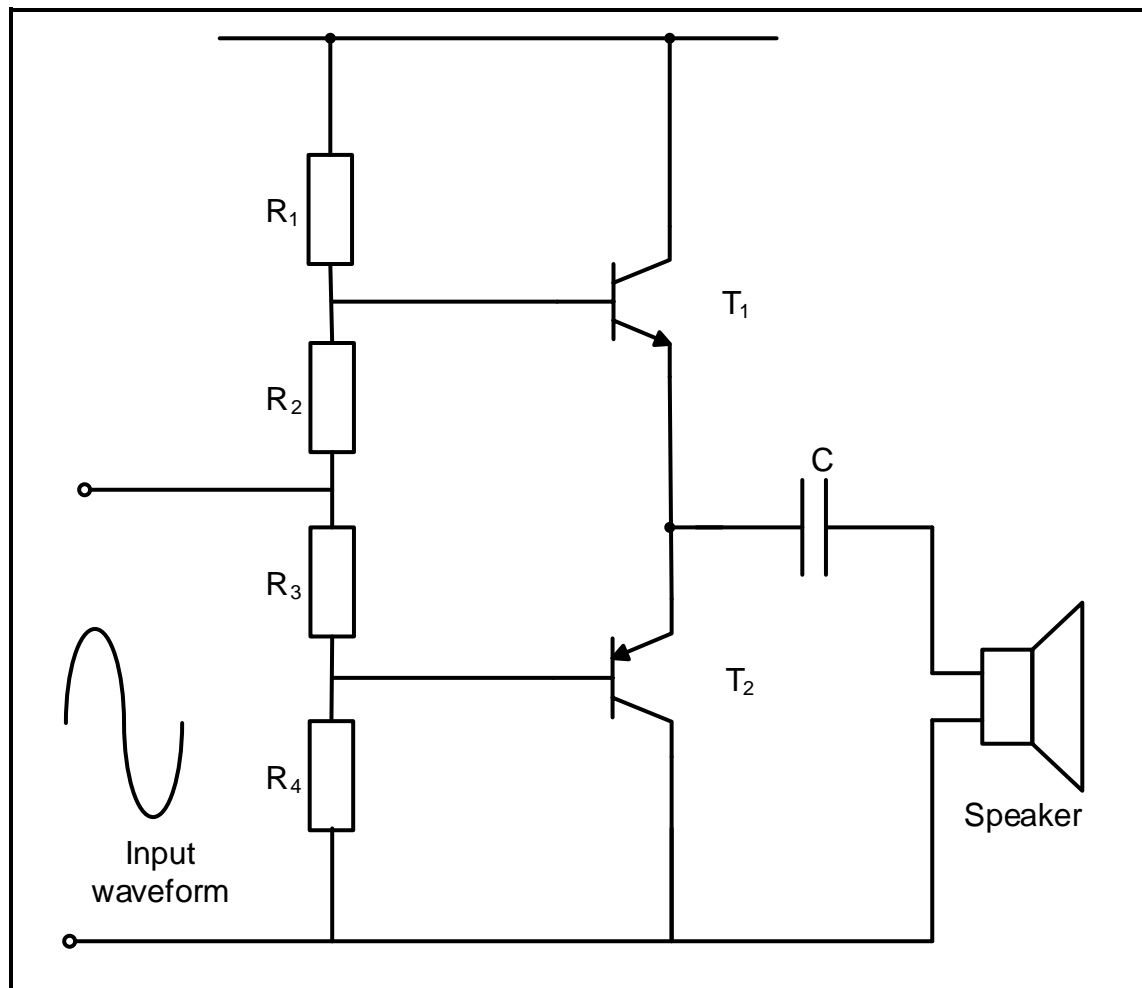


FIGURE 6.7: COMPLEMENTARY PUSH-PULL AMPLIFIER CIRCUIT

- 6.7.1 Name the class of amplification used in FIGURE 6.7 above. (1)
- 6.7.2 Explain how the circuit in FIGURE 6.7 above overcomes the problem of cross-over distortion. (2)
- 6.7.3 Draw the output waveform on the ANSWER SHEET for QUESTION 6.7.3. (3)

6.8 Refer to FIGURE 6.8 below and answer the questions that follow:

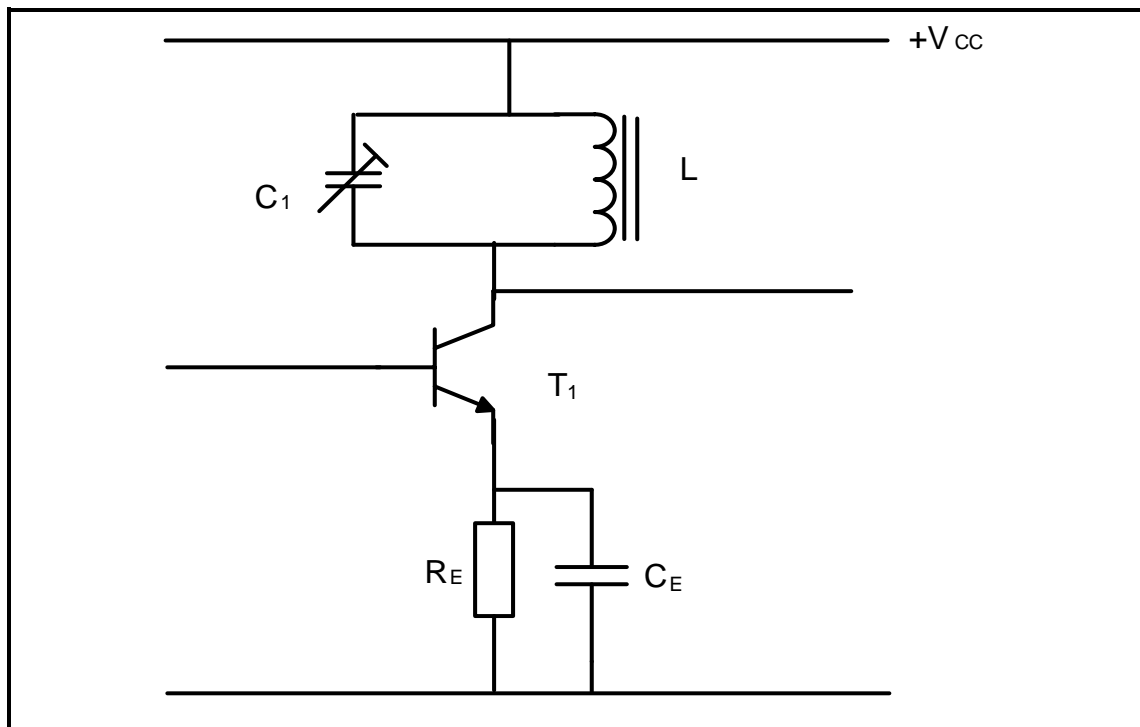


FIGURE 6.8: LC-RESONANT CIRCUIT

- 6.8.1 Identify the function of C_E in FIGURE 6.8 above. (1)
- 6.8.2 Describe the basic function of the LC tank circuit in FIGURE 6.8 above. (3)
- 6.8.3 Explain the purpose of the radio frequency amplifier when used in radio circuits. (3)

6.9 Refer to FIGURE 6.9 below and answer the questions that follow.

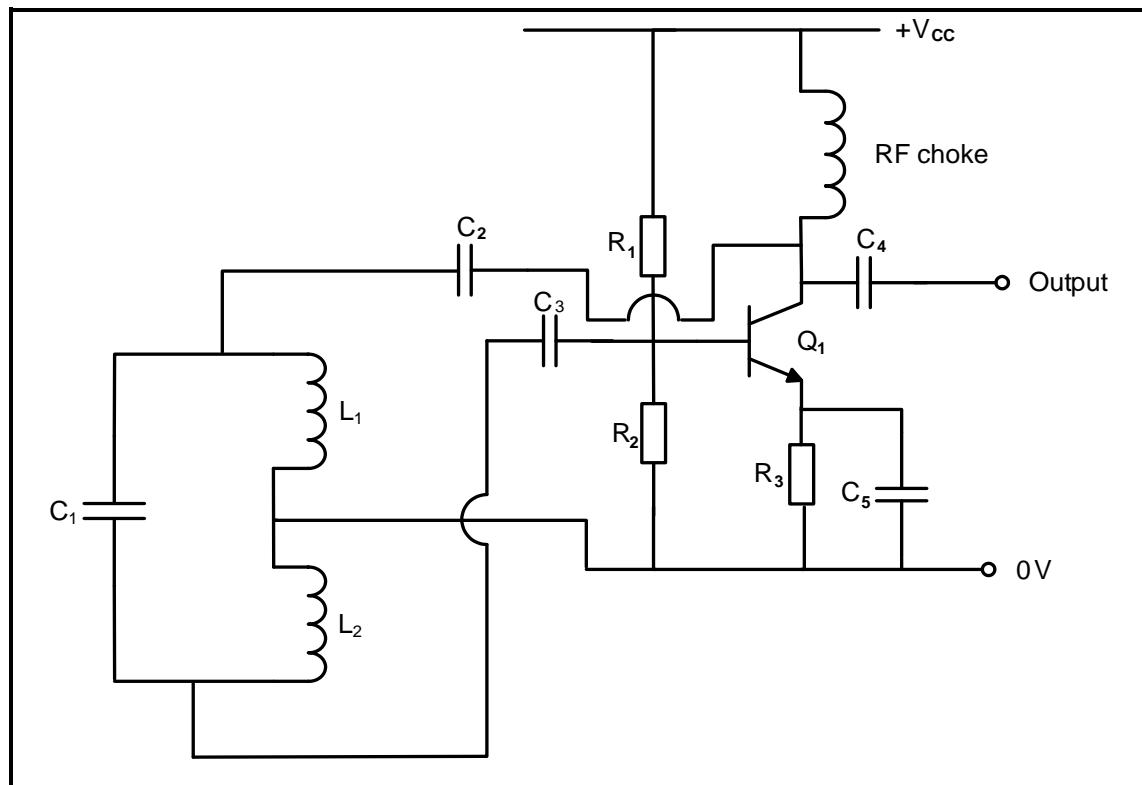


FIGURE 6.9: HARTLEY OSCILLATOR

- 6.9.1 Identify the function of C_2 and C_3 . (1)
- 6.9.2 Name TWO factors that can influence the stability of the frequency of oscillations. (2)

6.10 Refer to FIGURE 6.10 below and answer the questions that follow.

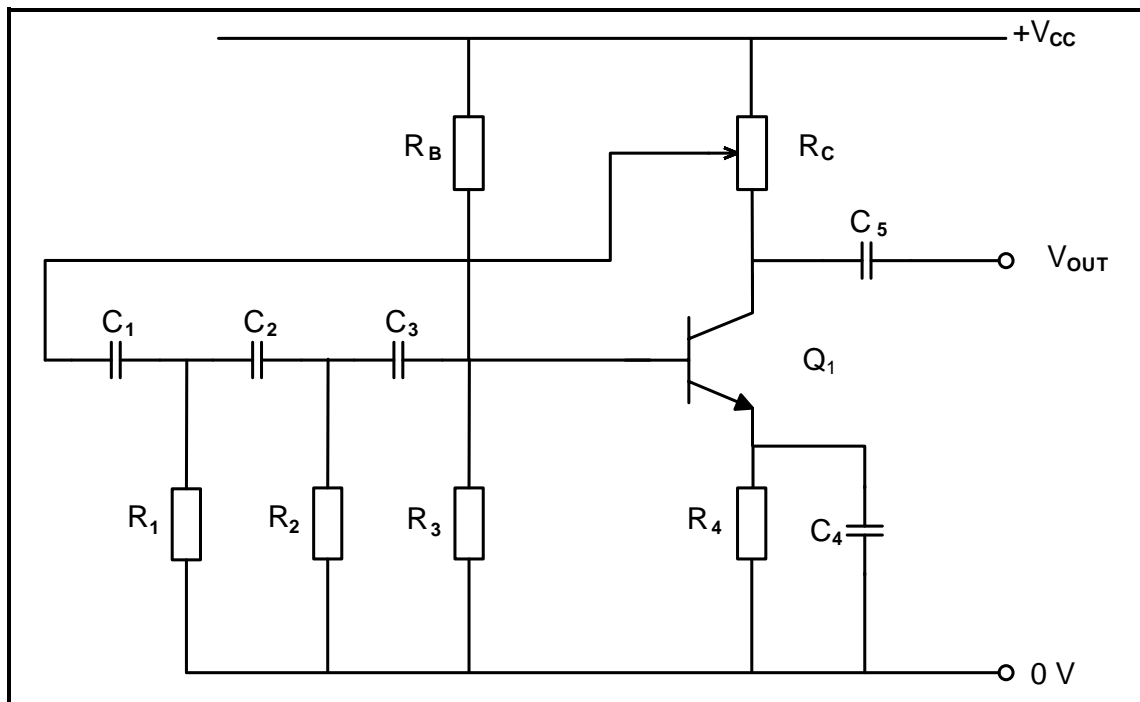


FIGURE 6.10: RC PHASE-SHIFT OSCILLATOR

- 6.10.1 Explain what determines the phase difference between the current and the applied voltage in the circuit diagram. (2)
- 6.10.2 Explain how the circuit achieves sufficient current gain to initiate its oscillation. (2)
- 6.10.3 State the application of the RC phase-shift oscillator. (1)
- [45]**

TOTAL: 200

FORMULA SHEET**RLC CIRCUITS**

$$X_C = \frac{1}{2\pi fC}$$

$$X_L = 2\pi fL$$

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

SERIES

$$I_T = \frac{V_T}{Z}$$

$$V_L = I X_L$$

$$V_C = I X_C$$

$$V_T = I Z$$

$$Q = \frac{X_L}{Z} = \frac{X_C}{Z} = \frac{V_L}{V_T} = \frac{V_C}{V_T} = \frac{1}{R} \sqrt{\frac{L}{C}}$$

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

$$V_T = \sqrt{V_R^2 + (V_L - V_C)^2}$$

$$\cos \theta = \frac{R}{Z}$$

$$\cos \theta = \frac{V_R}{V_T}$$

PARALLEL

$$\cos \theta = \frac{I_R}{I_T}$$

$$I_T = \sqrt{I_R^2 + (I_L - I_C)^2}$$

$$I_R = \frac{V_R}{R}$$

$$I_C = \frac{V_C}{X_C}$$

$$I_L = \frac{V_L}{X_L}$$

$$Q = \frac{R}{X_L} = \frac{R}{X_C}$$

$$BW = \frac{f_r}{Q}$$

SEMICONDUCTOR DEVICES

$$\text{Gain } A_V = \frac{V_{OUT}}{V_{IN}} = - \left(\frac{R_F}{R_{IN}} \right)$$

$$V_{OUT} = V_{IN} \times \left(- \frac{R_F}{R_{IN}} \right)$$

$$V_{OUT} = V_{IN} \times \left(1 + \frac{R_F}{R_{IN}} \right)$$

SWITCHING CIRCUITS

$$V_{OUT} = - \left(V_1 \frac{R_F}{R_1} + V_2 \frac{R_F}{R_2} + V_3 \frac{R_F}{R_3} \right)$$

$$V_{OUT} = - (V_1 + V_2 + V_3 + \dots + V_N)$$

$$V_{FB} = V_{SAT} \times \frac{R_2}{R_1 + R_2}$$

$$T = 1,1 \times R_1 C_1$$

$$f = \frac{1}{T}$$

$$V_{TRIG} = V_{OUT} \times \frac{R_2}{R_1 + R_2}$$

AMPLIFIERS

$$I_C = \frac{V_C}{R_C} \quad \text{AND} \quad V_{CC} = V_{CE} + I_C R_C$$

$$A_i = 20 \log \frac{I_o}{I_i}$$

$$A_V = 20 \log \frac{V_o}{V_i}$$

$$P_O = I^2 \times Z_O$$

$$A_P = 10 \log \frac{P_O}{P_i}$$

$$A_{v(dB)} = 20 \log A_V$$

$$\text{Gain } A_V = \frac{V_{OUT}}{V_{IN}} = - \left(\frac{R_F}{R_{IN}} \right)$$

$$f_o = \frac{1}{2\pi\sqrt{LC_T}}$$

$$f_o = \frac{1}{2\pi\sqrt{6}RC}$$

$$f_o = \frac{1}{2\pi\sqrt{L_T C}}$$

CENTRE NUMBER:

EXAMINATION NUMBER:

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QUESTION 5: SWITCHING CIRCUITS

5.2.5

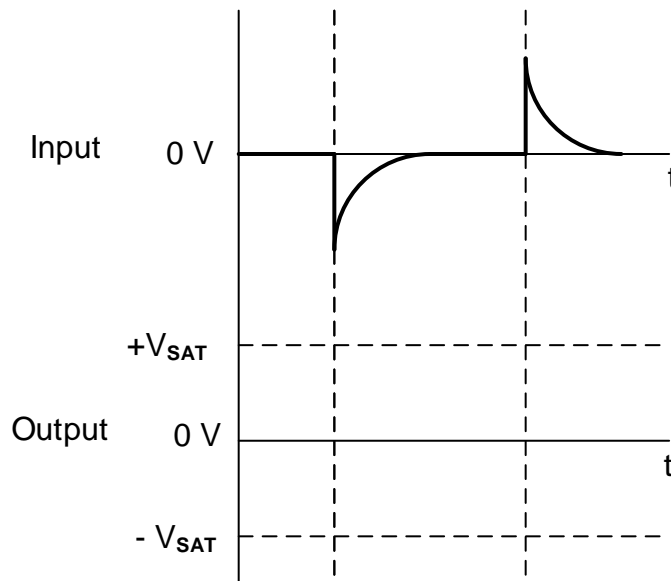


FIGURE 5.2.5

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MOD

(3)

5.4.3

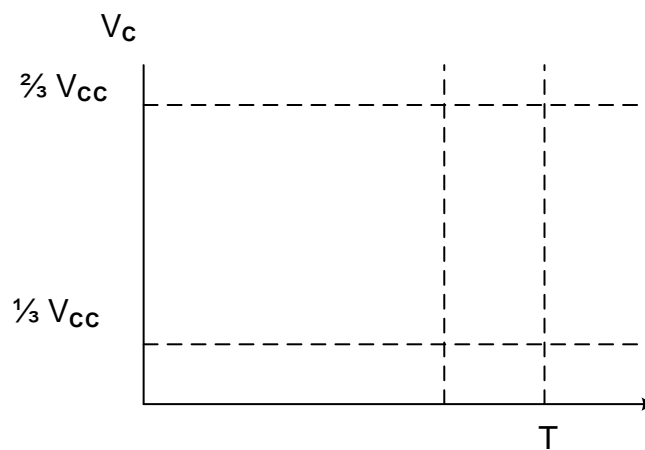


FIGURE 5.4.3

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answer book

MOD

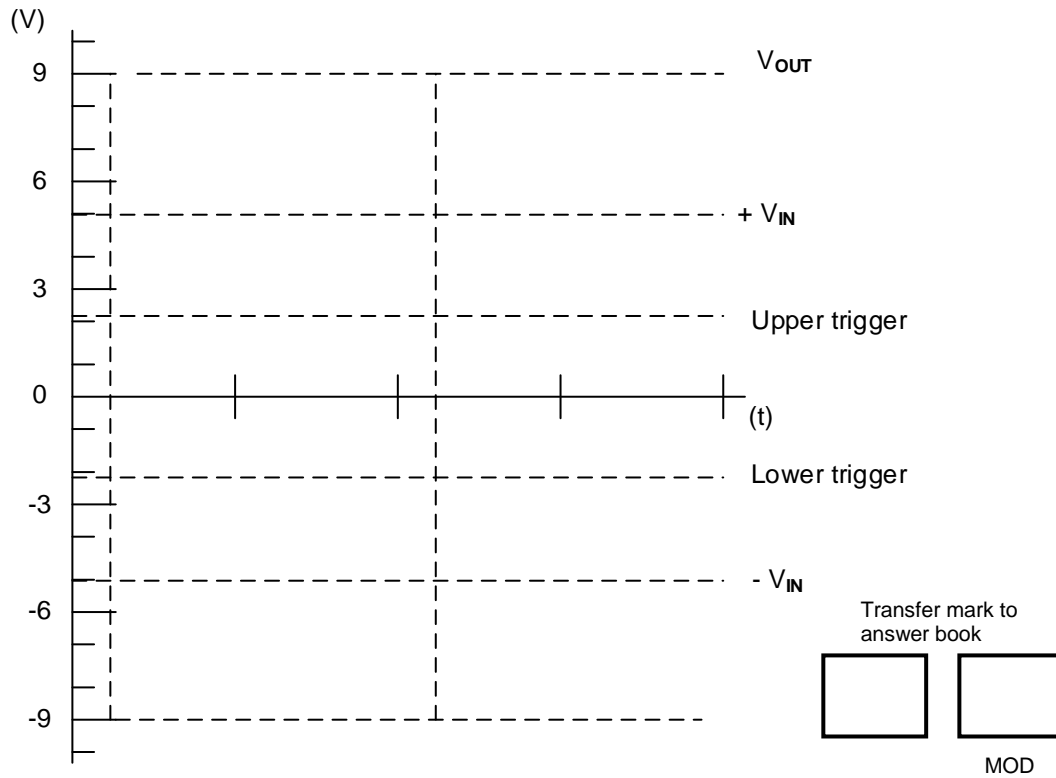
(4)

CENTRE NUMBER:							
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EXAMINATION NUMBER:												
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ANSWER SHEET

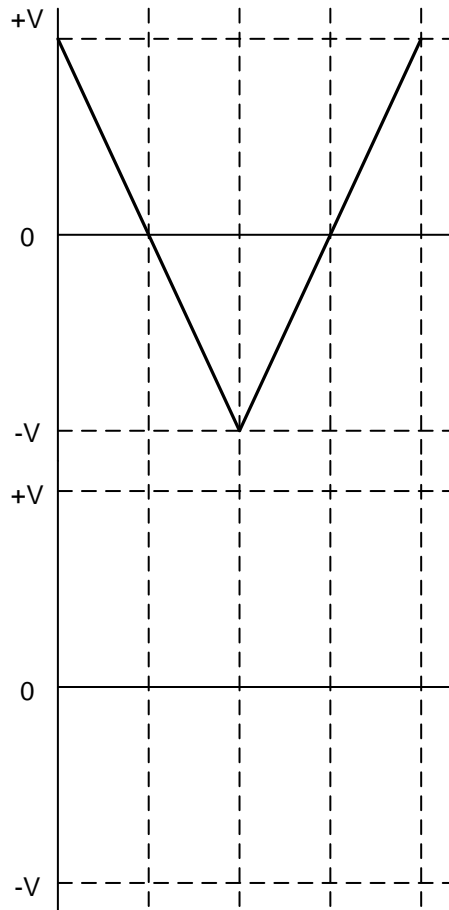
5.5.3

**FIGURE 5.5.3**

(6)

CENTRE NUMBER:**EXAMINATION NUMBER:****ANSWER SHEET**

5.7

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FIGURE 5.7**(3)**

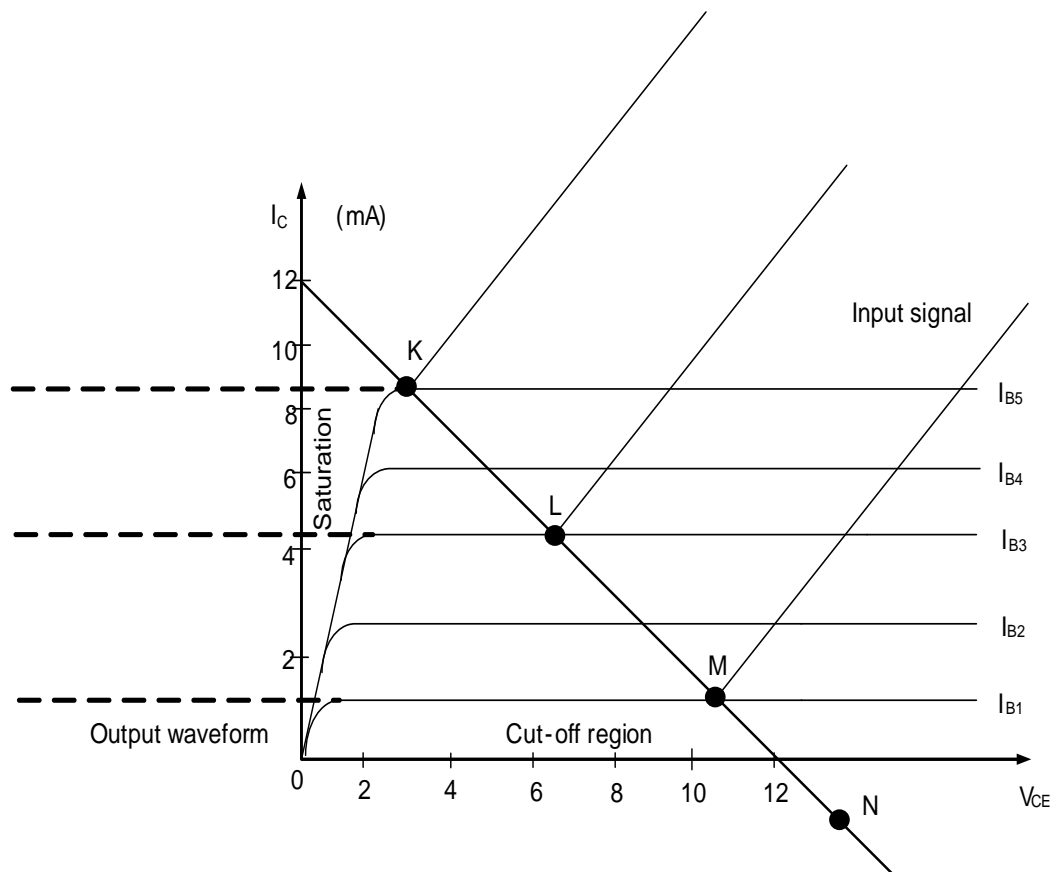
CENTRE NUMBER:

EXAMINATION NUMBER:

ANSWER SHEET

QUESTION 6: AMPLIFIERS

6.4.3

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FIGURE 6.4.3

(4)

CENTRE NUMBER:

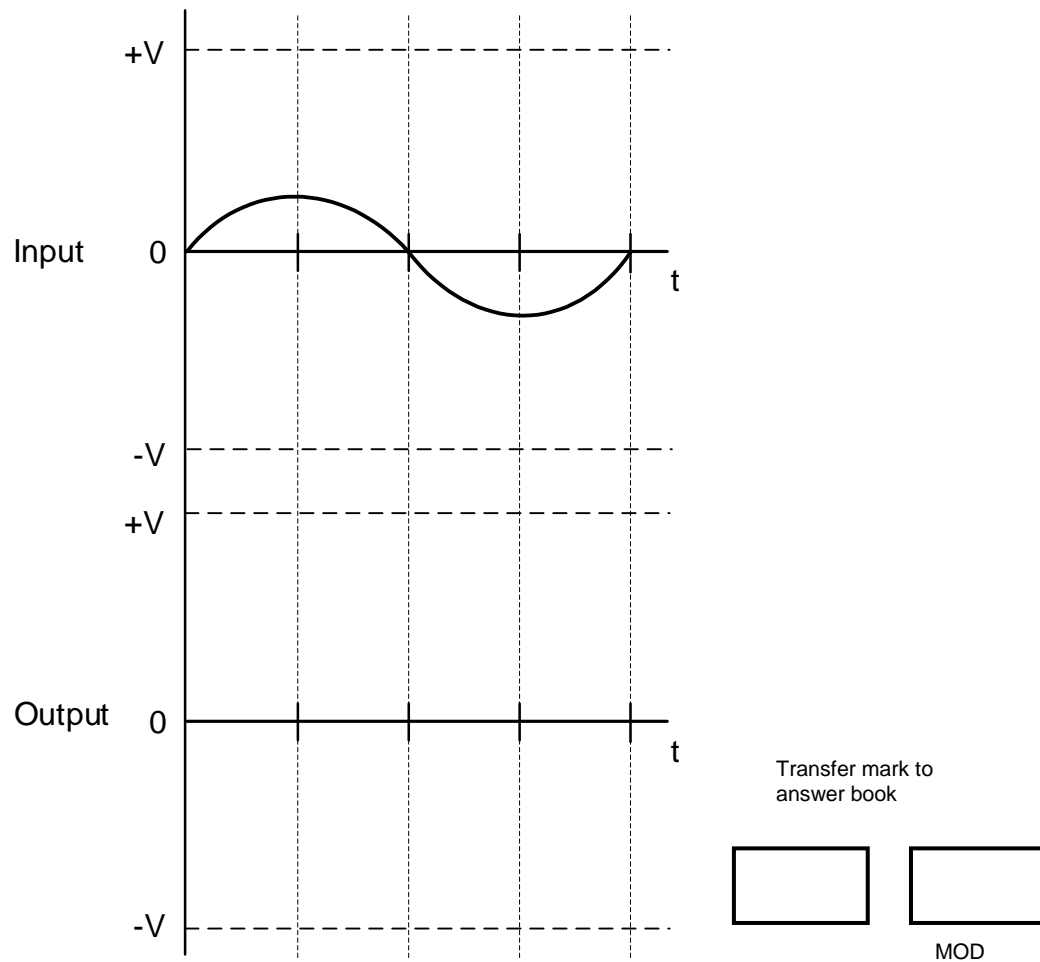
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EXAMINATION NUMBER:

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ANSWER SHEET

6.5.2

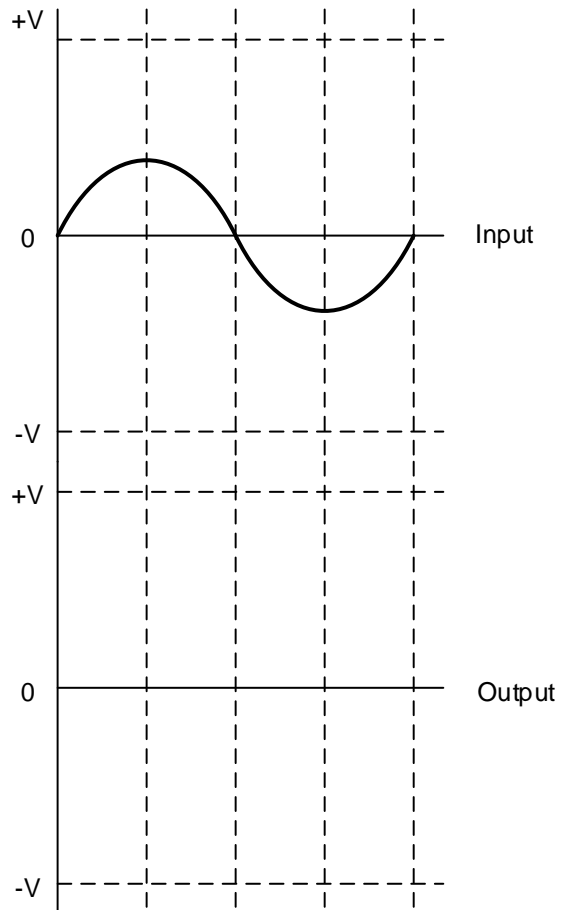
**FIGURE 6.5.2****(3)**

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EXAMINATION NUMBER:													
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ANSWER SHEET

6.7.3

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answer book

MOD

FIGURE 6.7.3**(3)**