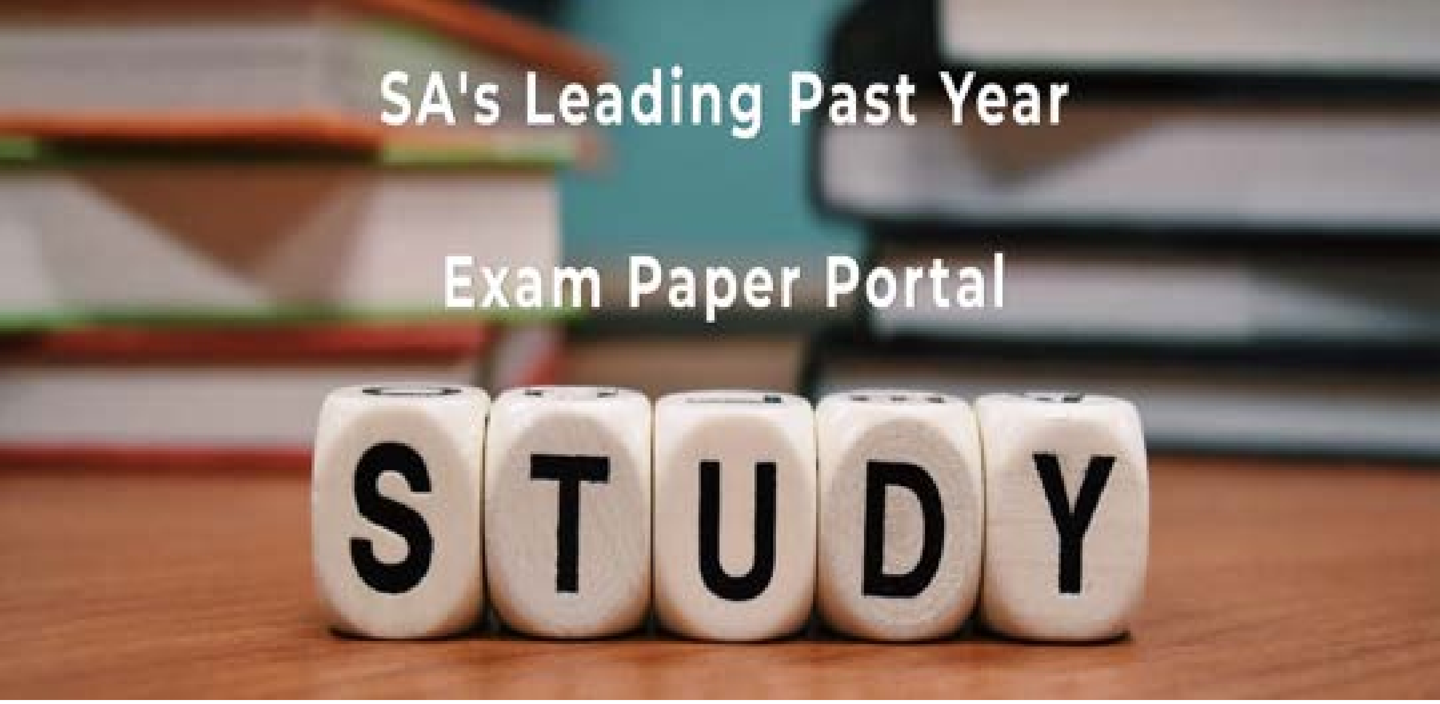
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GRADE 12

ELECTRICAL TECHNOLOGY: ELECTRONICS

NOVEMBER 2022

MARKS: 200

TIME: 3 hours

This question paper consists of 25 pages, a 1-page formula sheet and a 4-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 4.2.2 and 4.7.3
   QUESTIONS 5.2.4 and 5.3.4
   QUESTIONS 6.2.3 and 6.6.2

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 A/An … is an occurrence when a serious or unexpected dangerous situation occurs that requires immediate attention.

A evacuation procedure
B non-critical incident
C critical incident
D unsafe condition (1)

1.2 The total opposition against the flow of alternating current in an RLC circuit is the ...

A inductive reactance.
B impedance.
C capacitive reactance.
D inductance. (1)

1.3 When decreasing frequency to below resonance in a series RLC resonance circuit, the …

A impedance increases and the circuit becomes inductive.
B voltage drop across the inductor and capacitor increases.
C impedance decreases and the circuit becomes capacitive.
D impedance increases and the circuit becomes capacitive. (1)

1.4 The opposition to AC current flow caused by a capacitor will increase when the ...

A capacitance is decreased.
B frequency is increased.
C voltage is decreased.
D current is increased. (1)

1.5 If the emitter of the UJT is supplied with sufficient current, its operating point will continue falling until the ... is reached.

A cut-off voltage
B pinch-off voltage
C valley point voltage
D breakdown voltage (1)

1.6 A Darlington transistor amplifier develops a very low output impedance when used as common ...

A base.
B emitter.
C collector.
D drain. (1)

1.7 An op-amp circuit without any feedback has ... gain.

A closed-loop
B forward-loop
C reverse-loop
D open-loop (1)

1.8 The pin that sets the voltage at which the 555 will trigger is known as ...

A output.
B discharge.
C threshold.
D reset. (1)

1.9 A ... is used to eliminate switch bounce in electronics circuits.

A monostable multivibrator
B audio amplifier
C astable multivibrator
D oscillator (1)

1.10 A circuit used in an audio mixer to individually amplify or attenuate each input signal is the ...

A comparator
B Schmitt trigger
C summing amplifier
D inverting op amp (1)

1.11 A basic op-amp comparator circuit uses ...

A feedback.
B positive feedback.
C negative feedback.
D no feedback. (1)

1.12 A ... produces an output which is directly proportional to the rate of change of the input signal.

A passive RC integrator
B comparator
C passive RC differentiator
D non-inverting amplifier (1)

1.13 A circuit that passes a chosen range of frequencies and blocks frequencies higher and lower than that range is called a ...

A high pass filter.
B low pass filter.
C medium pass filter.
D band-pass filter. (1)

1.14 When a circuit experiences a loss of signal power between its input and output, it is called ...

A amplification.
B noise.
C attenuation.
D oscillation. (1)

1.15 The bandwidth of a common emitter RC amplifier falls between the ...

A upper frequencies.
B midrange frequencies at the -3 dB roll-off points.
C critical frequencies.
D input capacitance of the transistor. (1)
[15]

QUESTION 2: OCCUPATIONAL HEALTH AND SAFETY

2.1 State TWO human rights in the workplace that ensure that the dignity of the employer is not infringed. (2)

2.2 State TWO evacuation steps to be followed when an emergency alarm is sounded in a workshop. (2)

2.3 Explain why the misuse of equipment in a workshop could cause a health or safety threat. (2)

2.4 Refer to victimisation at the workplace and state TWO actions that are forbidden by the employer. (2)

2.5 State TWO types of risk analysis reports done by the health and safety representative. (2)
[10]

QUESTION 3: RLC CIRCUITS

3.1 Explain the term *inductance* with reference to RLC circuits connected to an AC supply. (2)

3.2 Draw the phasor diagrams for FIGURES 3.2.1 and 3.2.2 in the ANSWER BOOK.

3.2.1

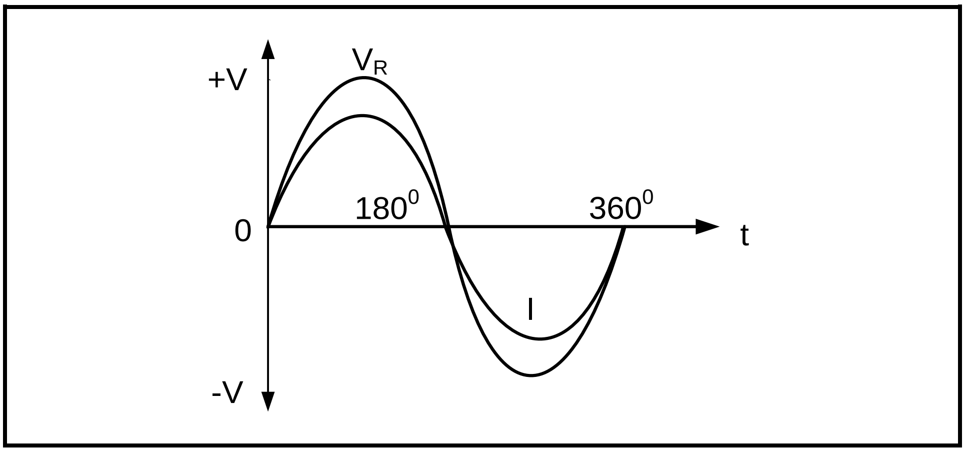

FIGURE 3.2.1: VOLTAGE AND CURRENT WAVEFORMS (2)

3.2.2

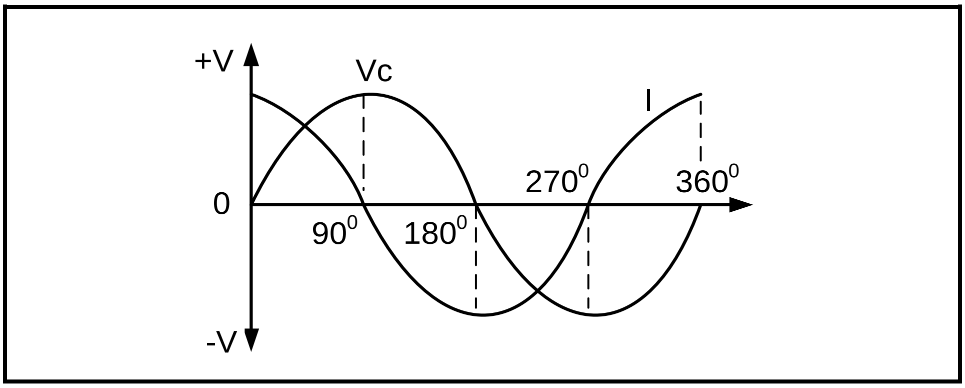

FIGURE 3.2.2: VOLTAGE AND CURRENT WAVEFORMS (2)

3.3 A series RLC circuit with a resistance of 25 Ω, an inductive reactance of 94 Ω and a capacitive reactance of 13 Ω is connected across a 150 V/60 Hz AC supply. Answer the questions that follow.

Given:

$R = 25\ \Omega$
$X_C = 13\ \Omega$
$X_L = 94\ \Omega$
$V_T = 150\ V$
$f = 60\ Hz$

3.3.1 Calculate the impedance of the circuit. (3)

3.3.2 Calculate the phase angle of the circuit. (3)

3.3.3 Calculate the value of the inductor. (3)

3.3.4 Explain what is meant by a *lagging power factor*. (1)

3.3.5 Explain why the current and the voltage waveforms are in phase in a series RLC resonance circuit. (2)

3.4 Refer to FIGURE 3.4 and answer the questions that follow.

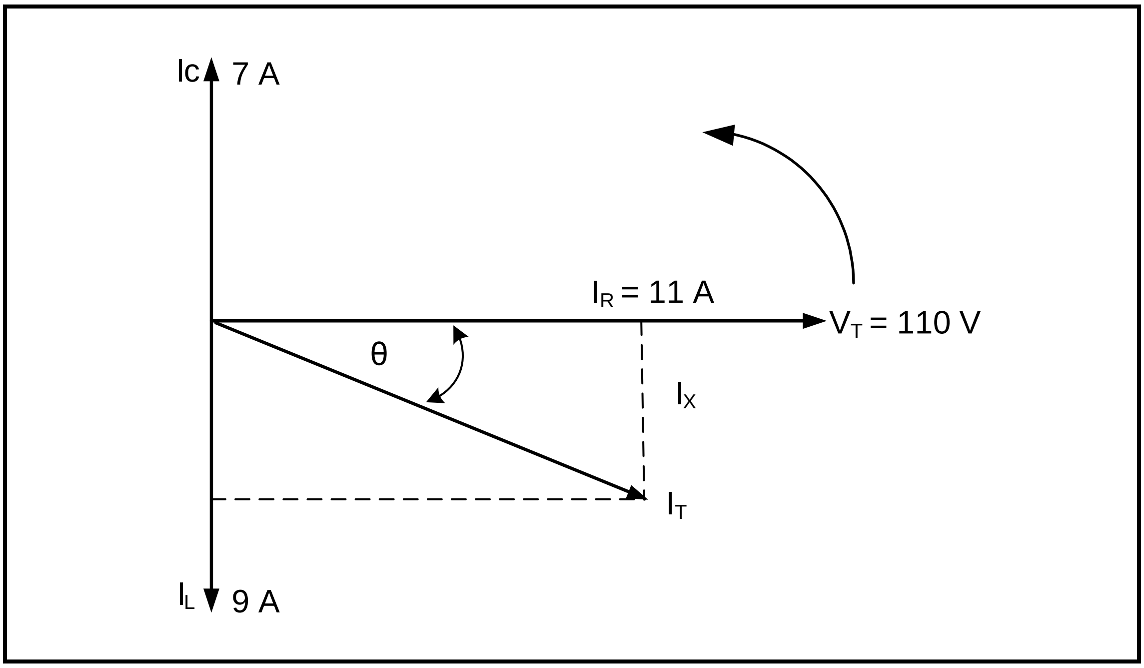

FIGURE 3.4: PARALLEL RLC PHASOR DIAGRAM

Given:

I_L = 9 A
I_C = 7 A
I_R = 11 A
V_T = 110 V

3.4.1 Calculate the total current. (3)

3.4.2 Calculate the power factor. (3)

3.4.3 Calculate the total power. (3)

3.4.4 State, with a reason, whether the circuit has a leading or lagging power factor. (2)

3.5 Refer to FIGURE 3.5 and answer the questions that follow.

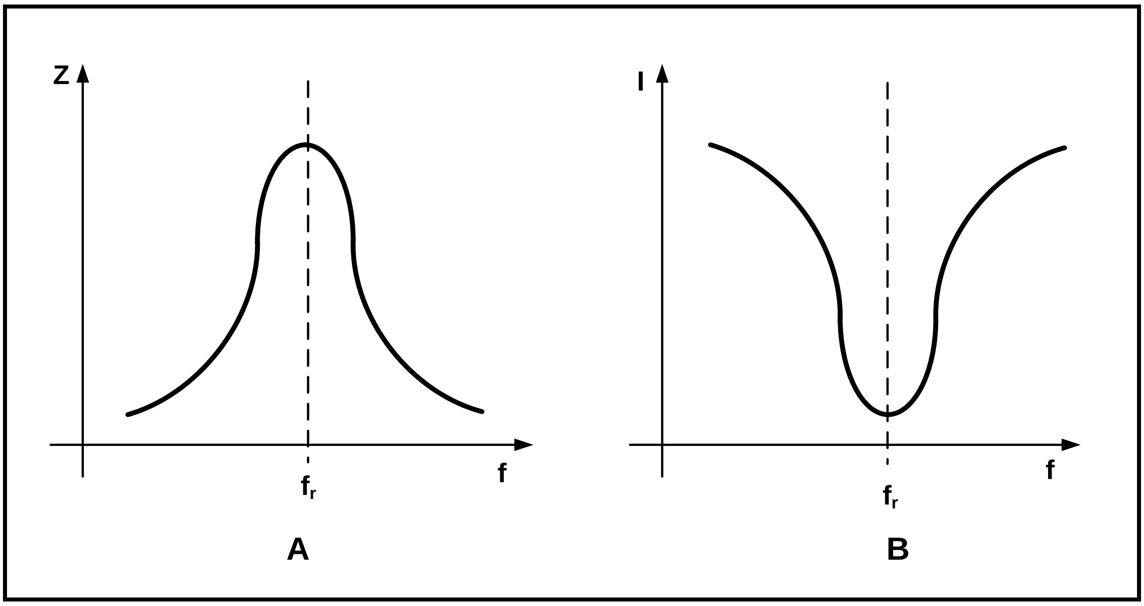

FIGURE 3.5: IMPEDANCE AND CURRENT RESPONSE CURVES

3.5.1 Name the circuit that produces the response at **A** and **B** in FIGURE 3.5. (2)

3.5.2 Discuss the difference between the *impedance* and *current* at resonant frequency. (2)

3.5.3 Describe what happens to impedance when the frequency increases in FIGURE 3.5 **A**. (2)
[35]

QUESTION 4: SEMICONDUCTOR DEVICES

4.1 Refer to FIGURE 4.1 and answer the questions that follow.

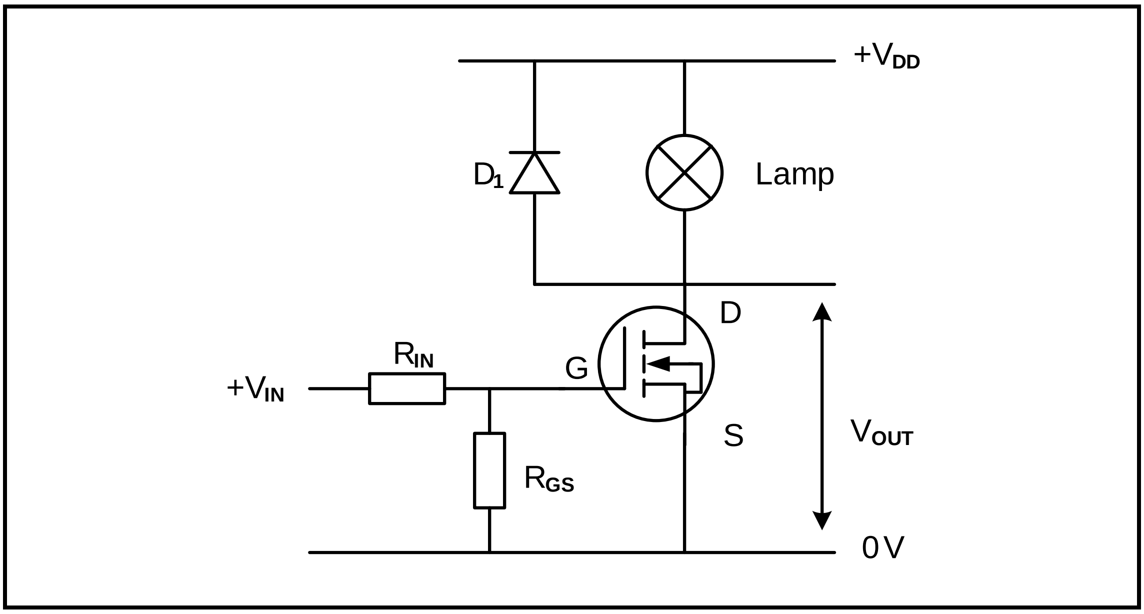

FIGURE 4.1: MOSFET AS A SWITCH

4.1.1 Identify the type of MOSFET used in this circuit. (1)

4.1.2 Explain how an increase in V_{GS} would affect the MOSFET in the circuit. (3)

4.2 Refer to FIGURE 4.2 and answer the questions that follow.

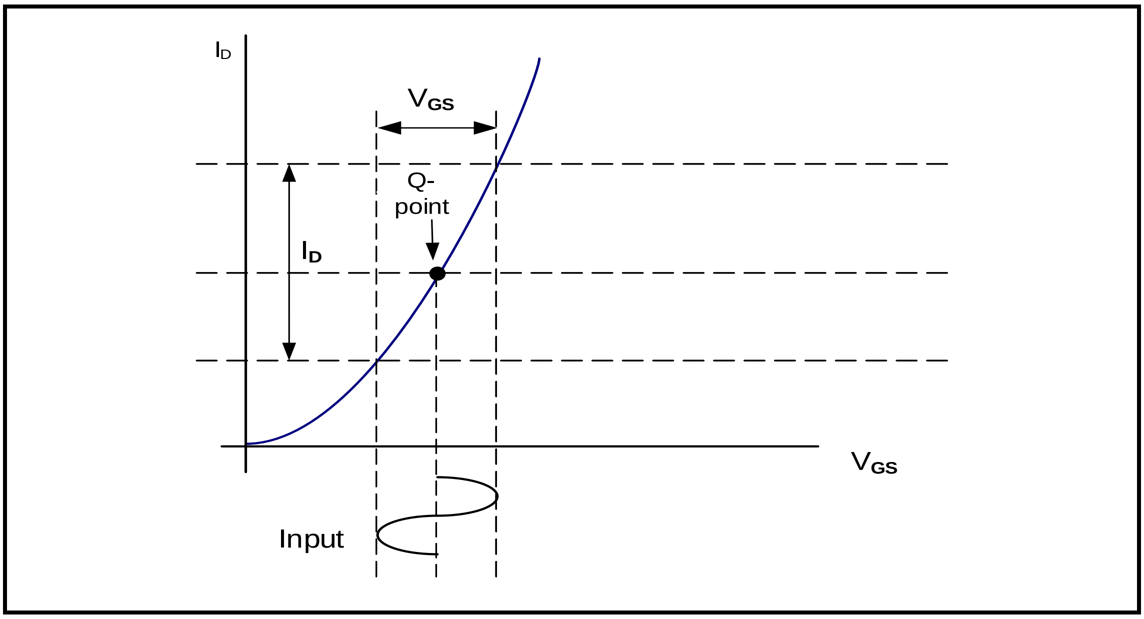

FIGURE 4.2: CHARACTERISTIC CURVE

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

4.2.2 Draw the output waveform on the ANSWER SHEET for QUESTION 4.2.2. (3)

4.3 Refer to FIGURE 4.3 and answer the questions that follow.

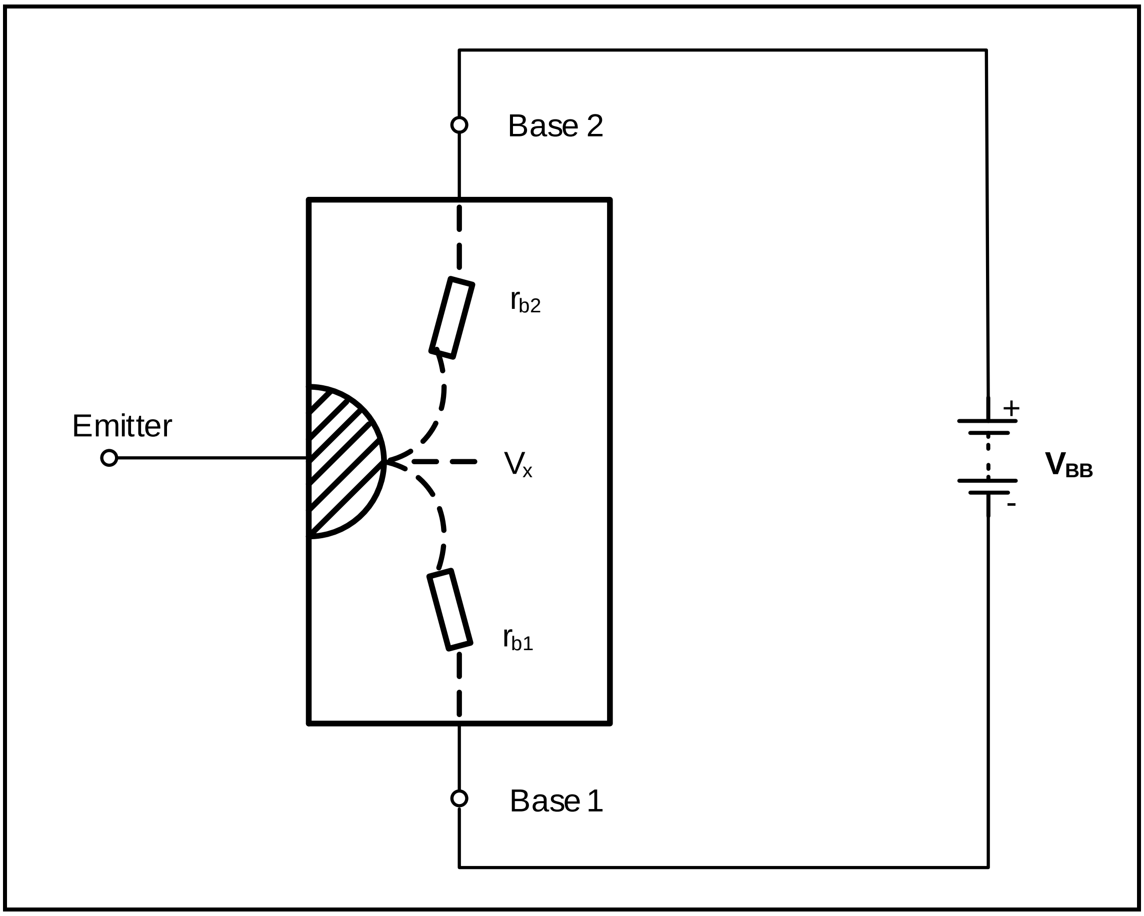

FIGURE 4.3: OPERATIONAL REPRESENTATION OF THE UJT

4.3.1 State ONE application of the UJT. (1)

4.3.2 Explain what happens when the external voltage (V_{BB}) is applied to the base terminals of the UJT. (2)

4.3.3 A UJT characteristic curve shows three main regions of operation, namely cut-off, negative resistance and saturation.

Describe the operation of the UJT in the negative resistance region. (3)

4.4 Refer to FIGURE 4.4 and answer the questions that follow.

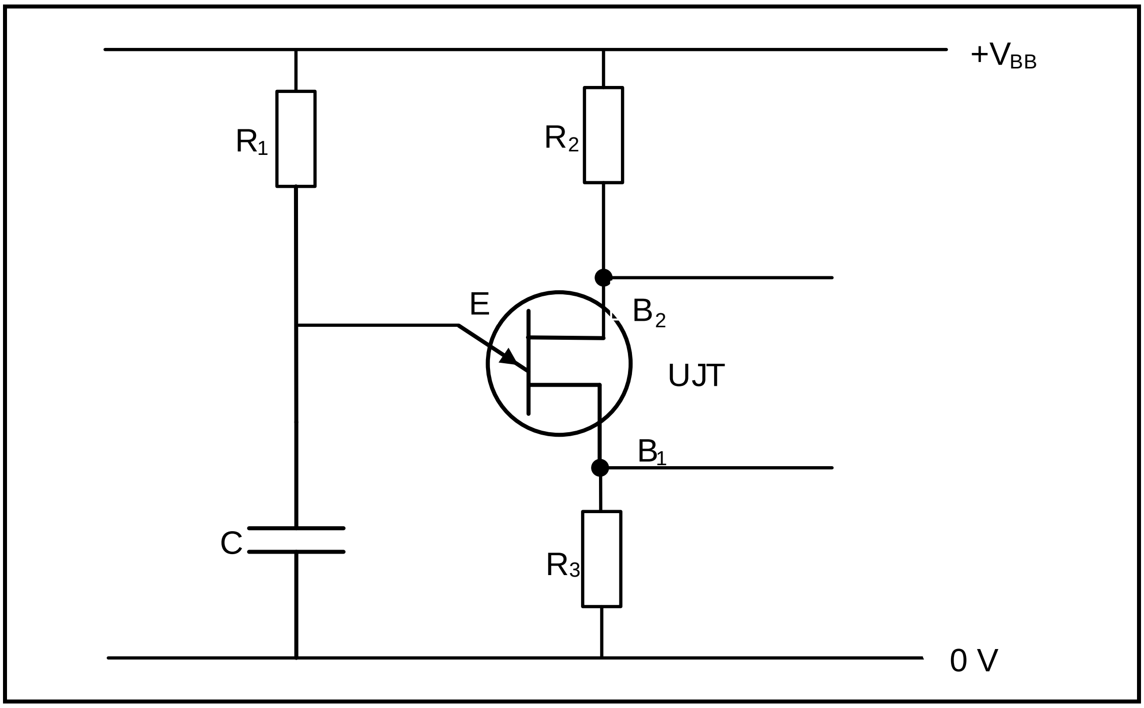

FIGURE 4.4

4.4.1 Identify the circuit diagram in FIGURE 4.4. (1)

4.4.2 Discuss the operation of the circuit in FIGURE 4.4. (4)

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

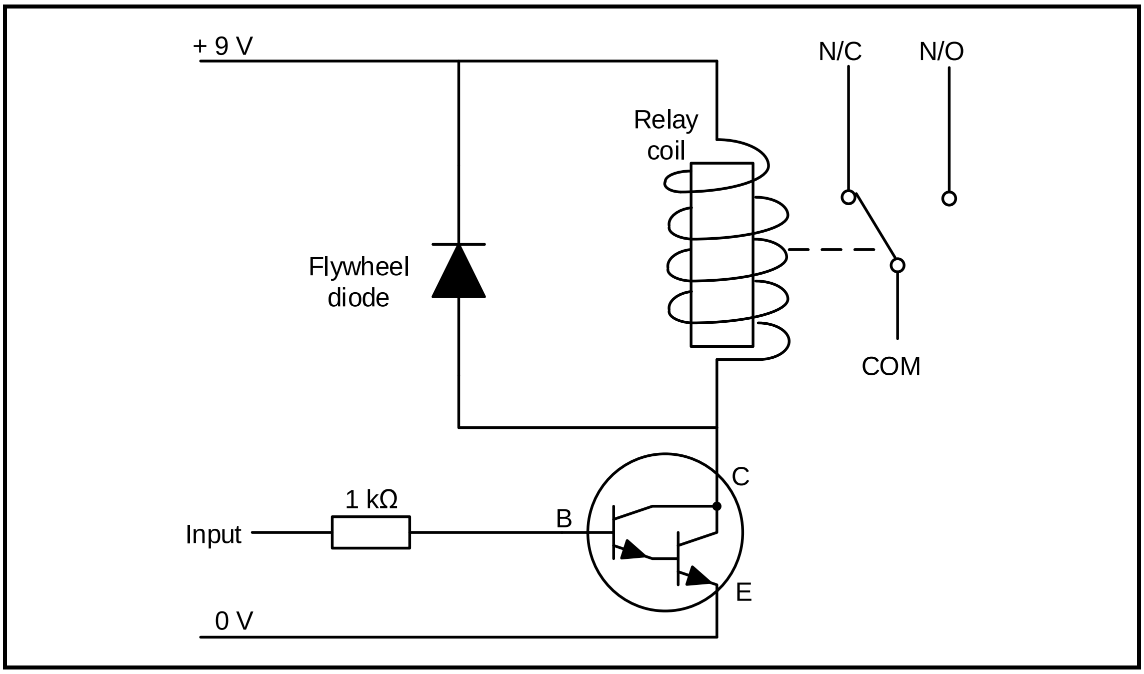

FIGURE 4.5: DARLINGTON TRANSISTOR CIRCUIT

4.5.1 State the application of the circuit in FIGURE 4.5. (1)

4.5.2 State the function of the flywheel diode in the circuit diagram. (1)

4.5.3 Describe why the N/O contact will close when a supply is connected to the circuit. (3)

4.6 Refer to FIGURE 4.6 and answer the questions that follow.

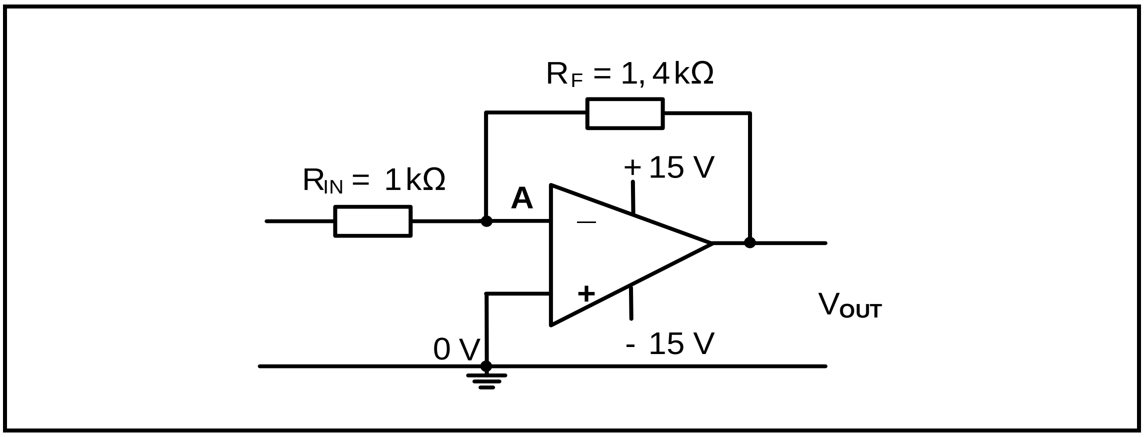

FIGURE 4.6: INVERTING OPERATIONAL AMPLIFIER

4.6.1 State the voltage at point **A**. (1)

4.6.2 Calculate the gain of the op amp. (3)

4.6.3 State the phase relationship between the input and the output signal when an AC signal is applied to the input. (1)

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

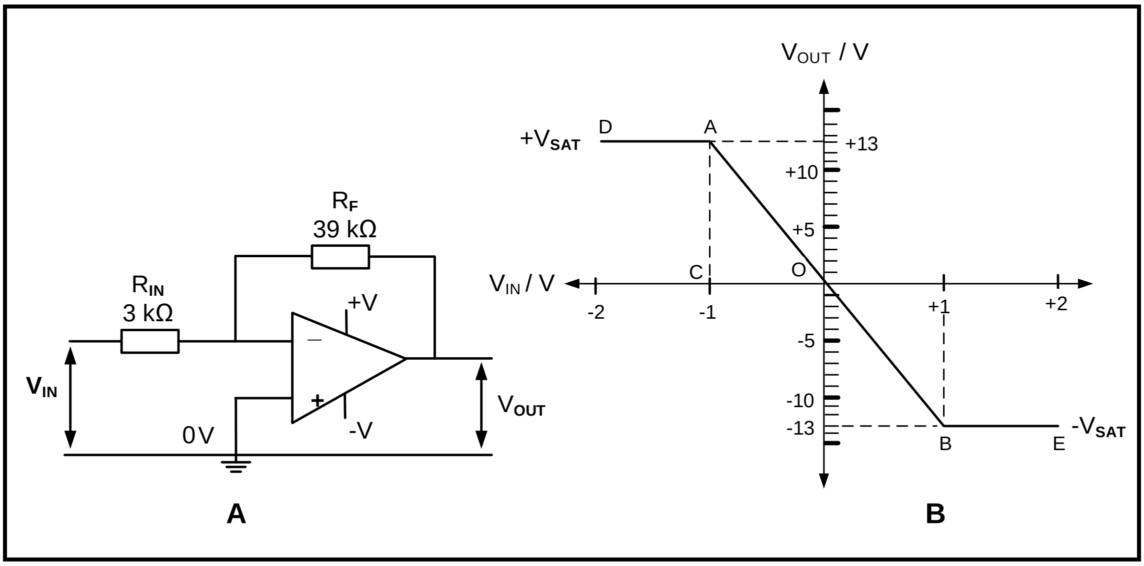

FIGURE 4.7: INVERTING OPERATIONAL AMPLIFIER

4.7.1 Identify the saturation regions in FIGURE 4.7 **B**. (2)

4.7.2 Calculate the gain by using the voltage values on FIGURE 4.7 **B**. (3)

4.7.3 Draw the output waveform on the ANSWER SHEET for QUESTION 4.7.3 when the op amp is saturated.

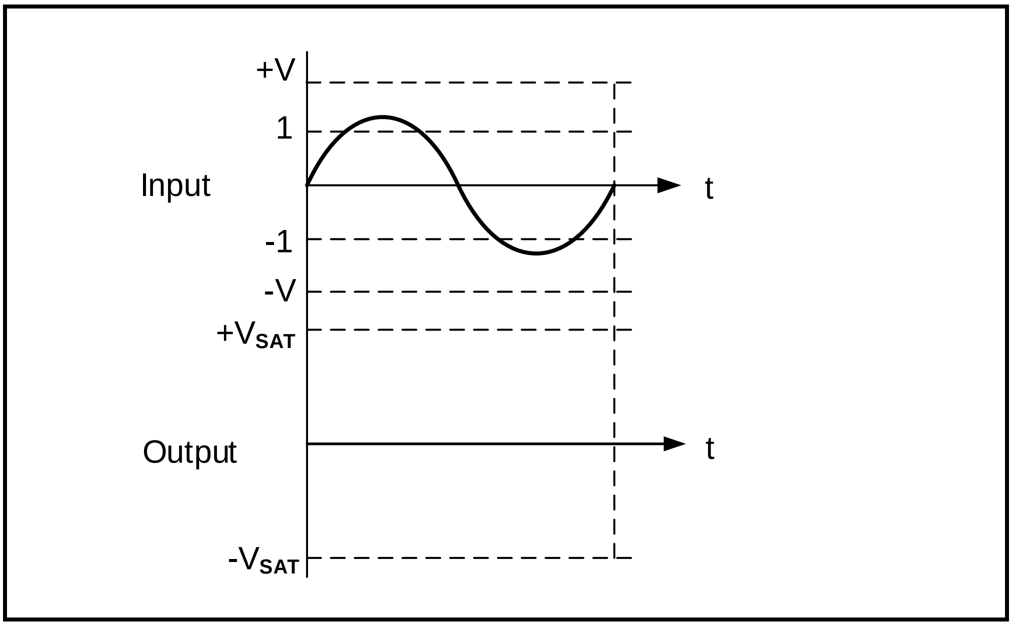

FIGURE 4.7.3 (3)

4.7.4 State THREE advantages of increasing the value of R_F. (3)

4.8 Refer to FIGURE 4.8 and answer the questions that follow

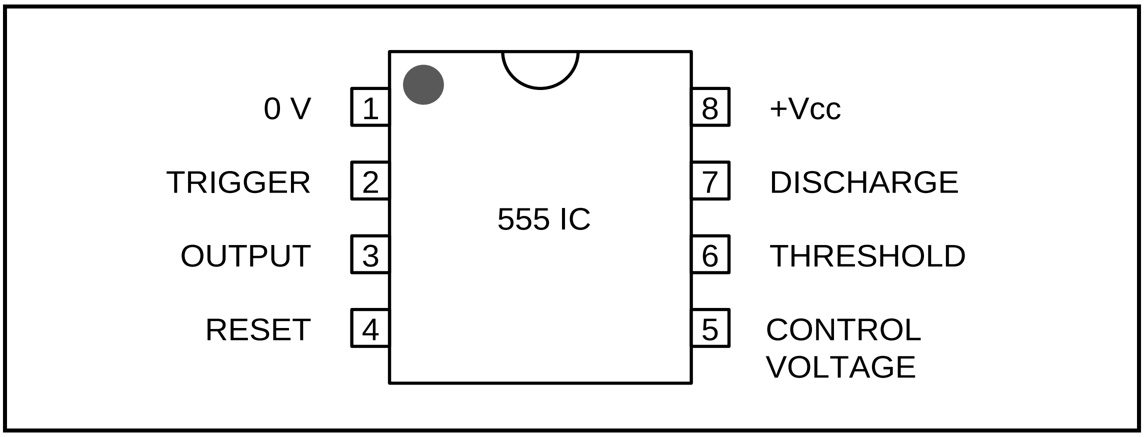

FIGURE 4.8: 555 IC PIN LAYOUT

4.8.1 State the function of pin 7. (1)

4.8.2 Describe how the 555 IC is triggered with reference to pin 2. (4)
[45]

QUESTION 5: SWITCHING CIRCUITS

5.1 State the difference between a *monostable multivibrator* and an *astable multivibrator* with reference to their output states. (2)

5.2 FIGURE 5.2 shows a bistable multivibrator using a 555 IC. Answer the questions that follow.

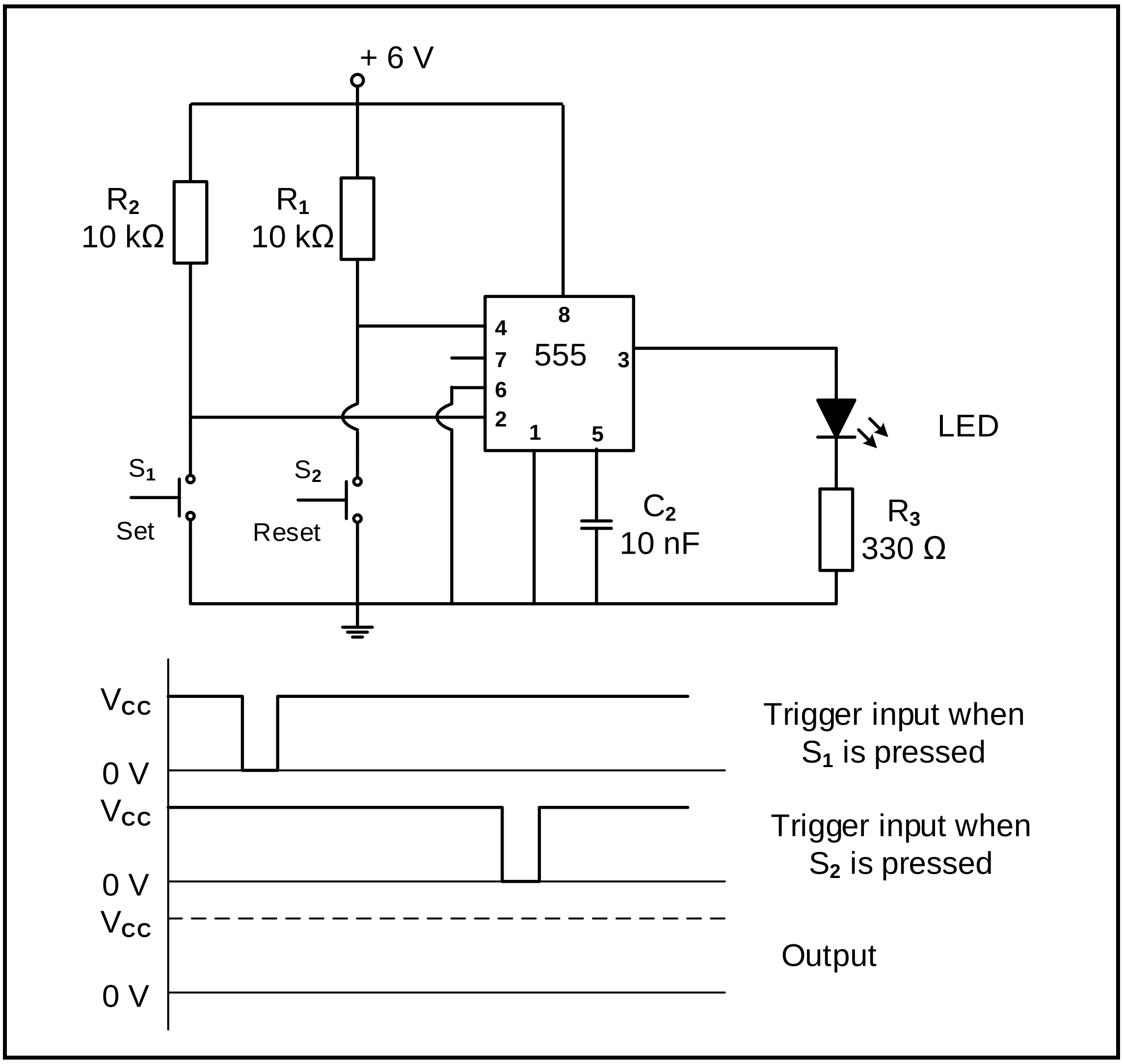

FIGURE 5.2: BISTABLE MULTIVIBRATOR

5.2.1 State ONE application of a bistable multivibrator. (1)

5.2.2 Explain why threshold pin 6 is connected directly to ground. (3)

5.2.3 Explain what will happen to the input voltage on pin 2 if resistor R_2 is disconnected from the supply leaving it as an open circuit. (2)

5.2.4 Draw the output waveform on the ANSWER SHEET for QUESTION 5.2.4. (3)

5.3 FIGURE 5.3 shows a 741 monostable multivibrator circuit in its natural resting condition. Answer the questions that follow.

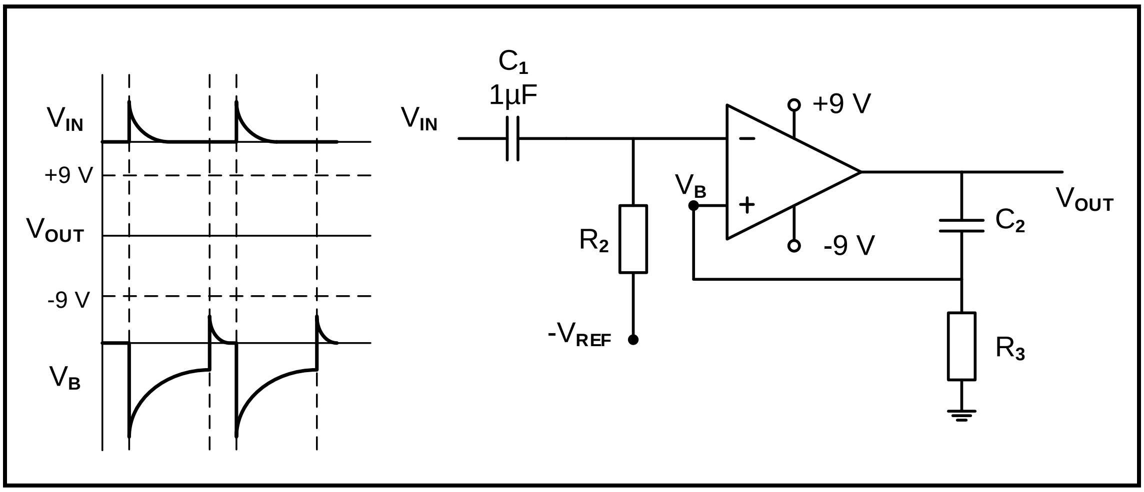

FIGURE 5.3: 741 IC MONOSTABLE MULTIVIBRATOR

5.3.1 State the purpose of C_2 and R_3. (2)

5.3.2 Determine the voltage at the non-inverting input (V_B) when capacitor C_2 is fully charged to the saturation voltage of 9 V and no current flows through R_3. (1)

5.3.3 Explain what happens to the output voltage the moment a positive input pulse is applied to the inverting input. (3)

5.3.4 Draw the output waveform on the ANSWER SHEET for QUESTION 5.3.4. (4)

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

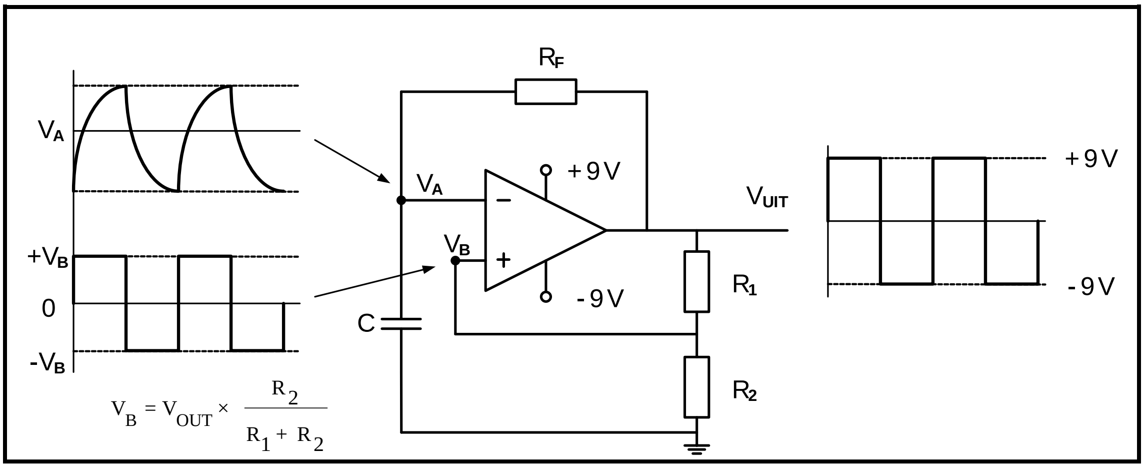

FIGURE 5.4: 741 IC ASTABLE MULTIVIBRATOR

5.4.1 Determine the polarity of V_B when the output is positive. (1)

5.4.2 Refer to V_A and V_B and state when the output changes from +9 V to –9 V. (1)

5.4.3 Describe how an increase in the value of R_F affects the operation of the circuit. (3)

5.5 Refer to FIGURE 5.5 and answer the questions that follow.

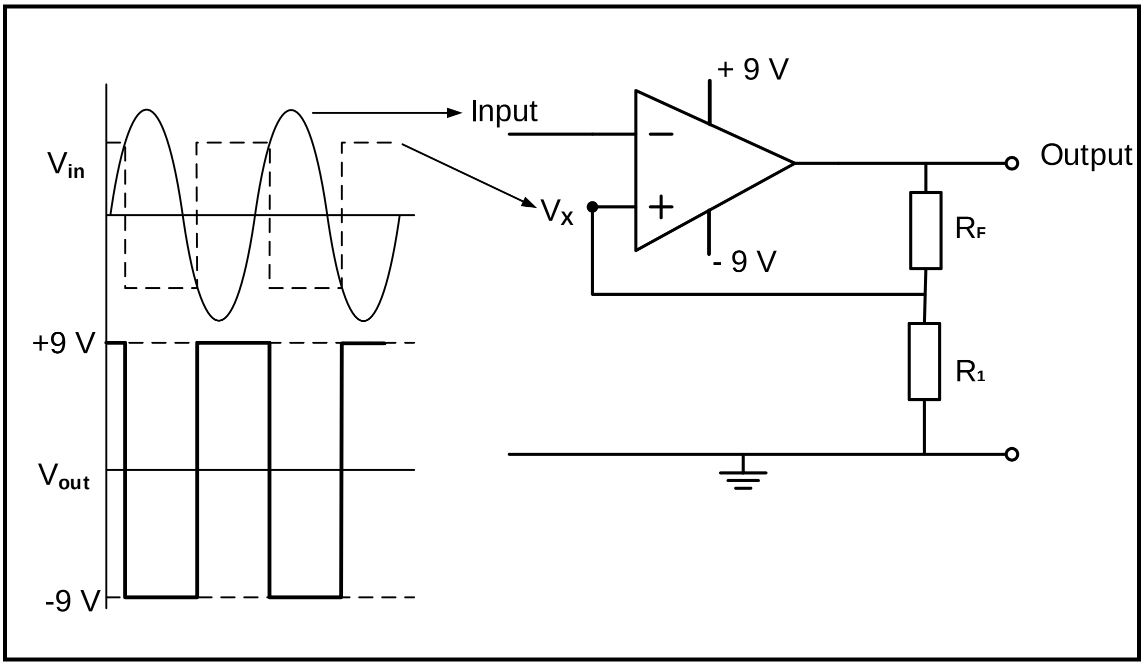

FIGURE 5.5: SCHMITT TRIGGER

5.5.1 Determine the saturation voltages of the Schmitt trigger. (1)

5.5.2 Explain the purpose of R_F and R_1 in the circuit. (2)

5.5.3 State when the output changes from high to low. (2)

5.6 Explain the operation of the circuit in FIGURE 5.6.

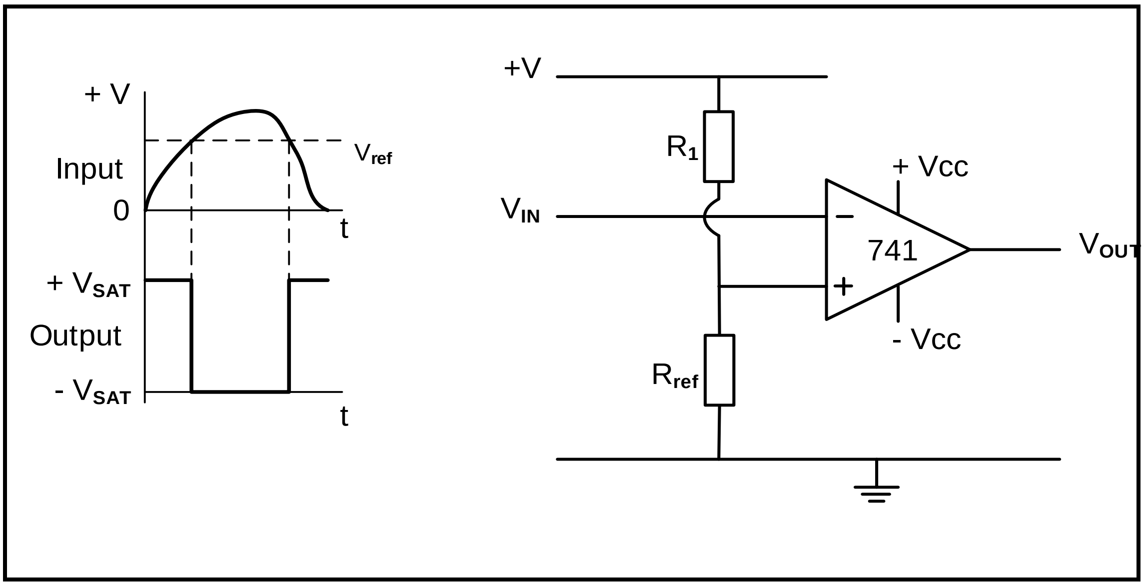

FIGURE 5.6: OP-AMP COMPARATOR (3)

5.7 Refer to FIGURE 5.7 and answer the questions that follow.

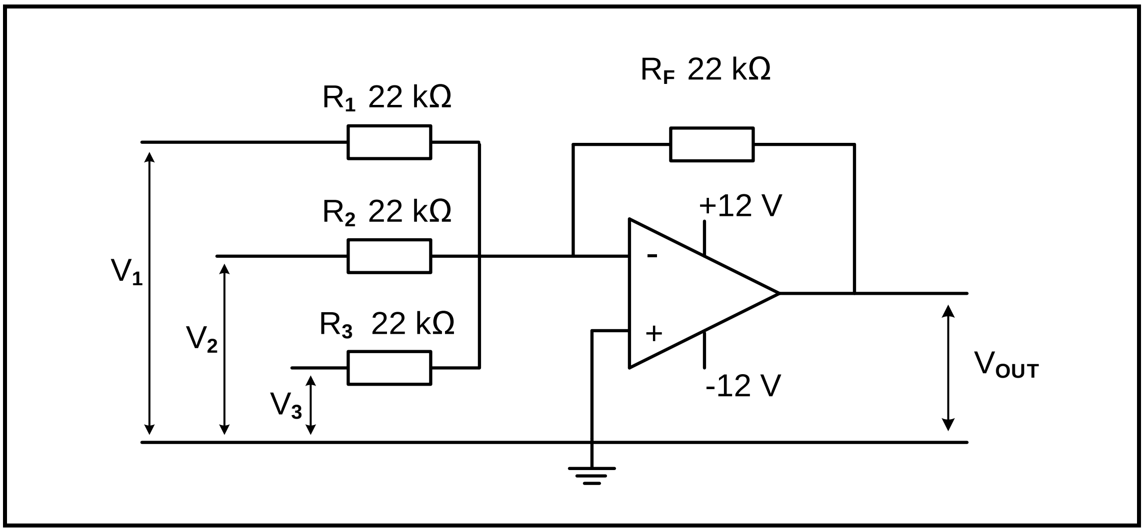

FIGURE 5.7: OP-AMP CIRCUIT

Given:

$R_1 = R_2 = R_3 = R_F$ = 22 kΩ
V_s = +12 V/-12 V
V_1 = 0,9 V
V_2 = 1,2 V
V_3 = 2,1 V

5.7.1 Identify the op-amp circuit in FIGURE 5.7. (1)

5.7.2 Determine the gain of the amplifier. Motivate your answer. (2)

5.7.3 Calculate the output voltage. (3)

5.7.4 Explain the effects of increasing the value of the feedback resistor. (2)

5.8 Refer to FIGURE 5.8 and answer the questions that follow.

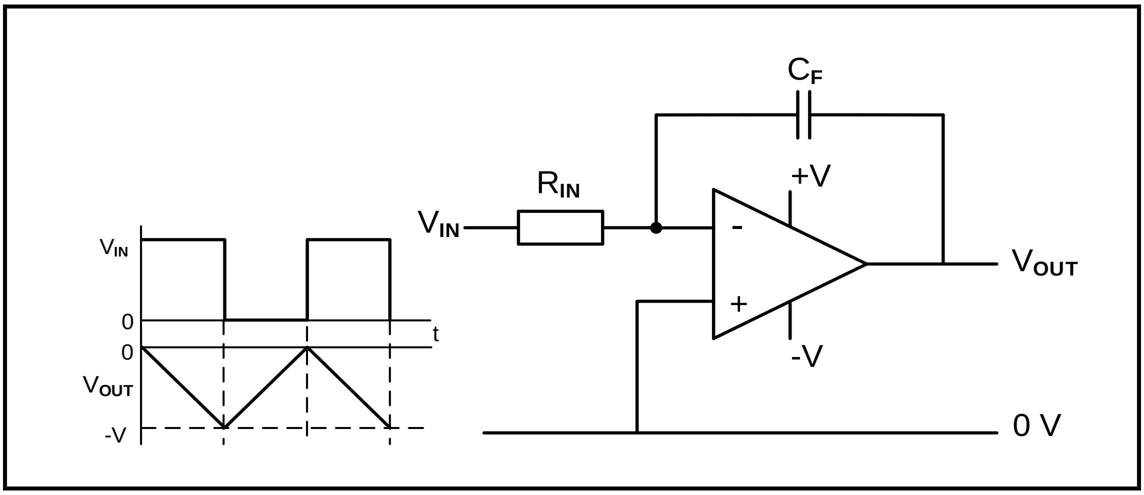

FIGURE 5.8: OP-AMP INTEGRATOR

5.8.1 State TWO factors that determine the output voltage of the circuit at any time. (2)

5.8.2 Explain why capacitor C_F charges at a fixed linear rate towards –V when a positive square wave is fed to the input. (4)

5.8.3 Explain the effect of a long RC time constant on the output. (2)

[50]

QUESTION 6: AMPLIFIERS

6.1 State TWO categories of amplifiers. (2)

6.2 Refer to FIGURE 6.2 and answer the questions that follow.

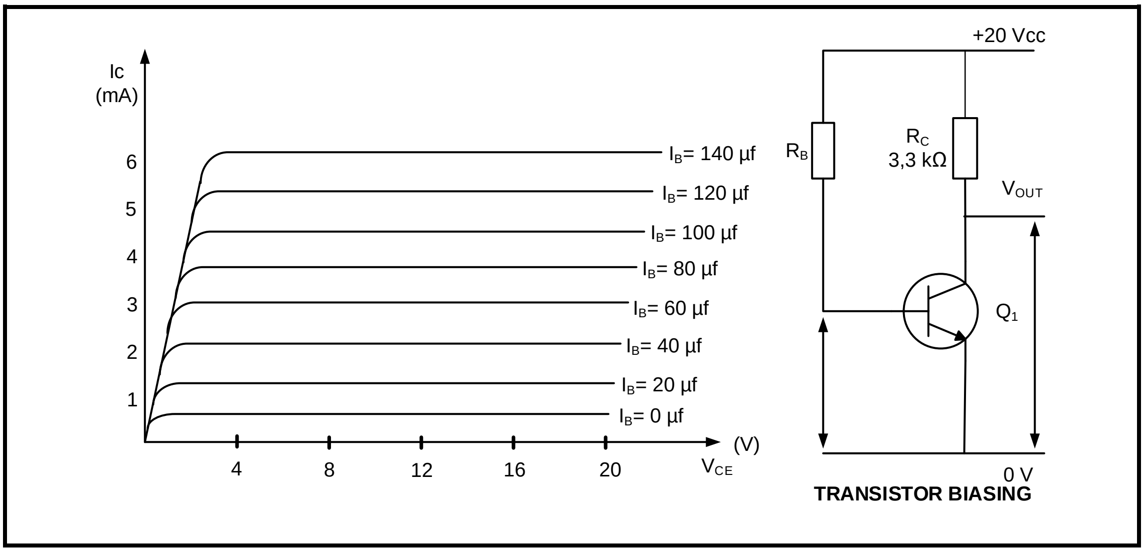

FIGURE 6.2: CHARACTERISTIC CURVE OF A TRANSISTOR CIRCUIT

6.2.1 Determine the maximum voltage across the collector emitter terminal of the transistor. (1)

6.2.2 Calculate the maximum collector current in FIGURE 6.2. (3)

6.2.3 Draw the load line for the amplifier in FIGURE 6.2 on ANSWER SHEET 6.2.3. (2)

6.2.4 Indicate the bias point on the load line on ANSWER SHEET 6.2.3 when the amplifier in FIGURE 6.2 is biased as a Class A amplifier. (1)

6.2.5 Determine the value of the collector current at the class A bias point. (1)

6.3 Refer to FIGURE 6.3 and answer the questions that follow.

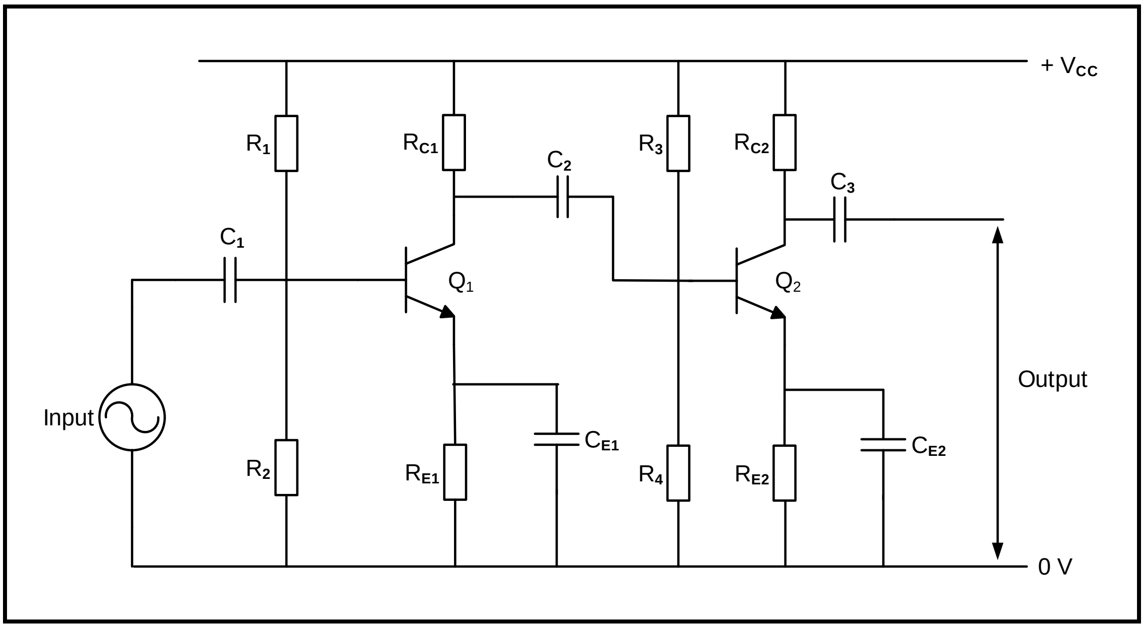

FIGURE 6.3: TWO-STAGE RC-COUPLED AMPLIFIER

6.3.1 State the function of R_1 and R_2. (2)

6.3.2 Explain why the values of the coupling capacitors are purposely selected to be as large as possible. (1)

6.3.3 State the purpose of $R_{E.}$ (2)

6.3.4 Describe the function of the RC coupling. (2)

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

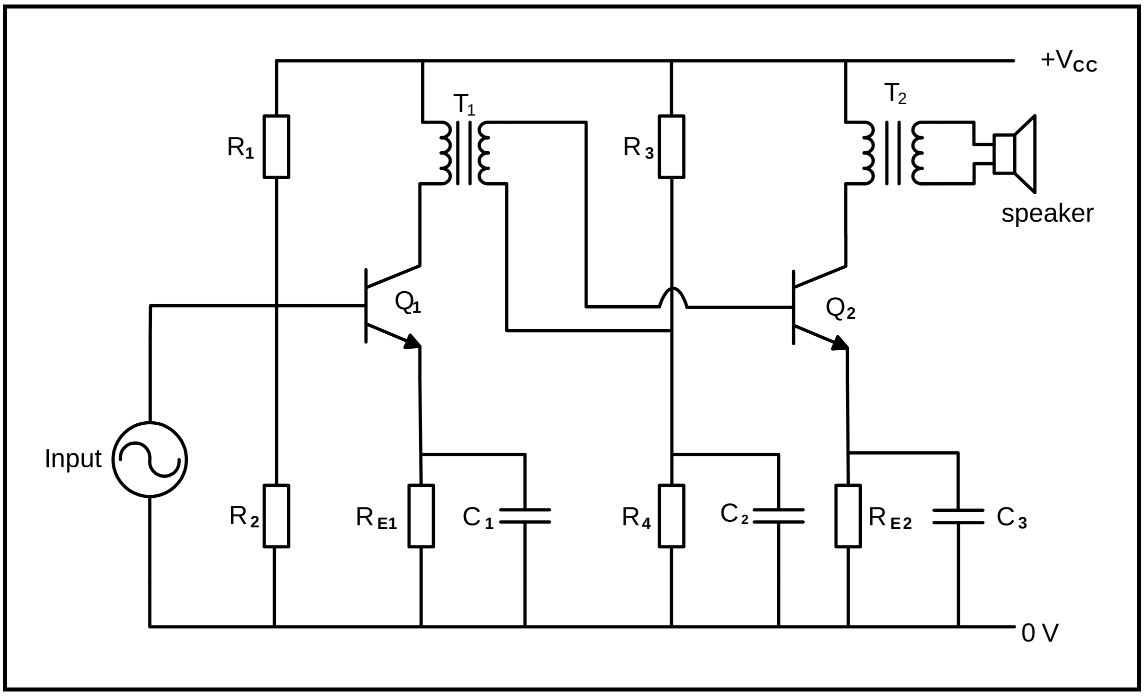

FIGURE 6.4: TWO-STAGE TRANSFORMER-COUPLED AMPLIFIER

6.4.1 State ONE application of the transformer-coupled amplifier. (1)

6.4.2 State TWO advantages of the circuit in FIGURE 6.4. (2)

6.4.3 Name TWO devices, apart from the speaker, that can be connected across the terminals of transformer T_2. (2)

6.5 FIGURE 6.5 below represent the radio-frequency amplifier. Answer the questions that follow.

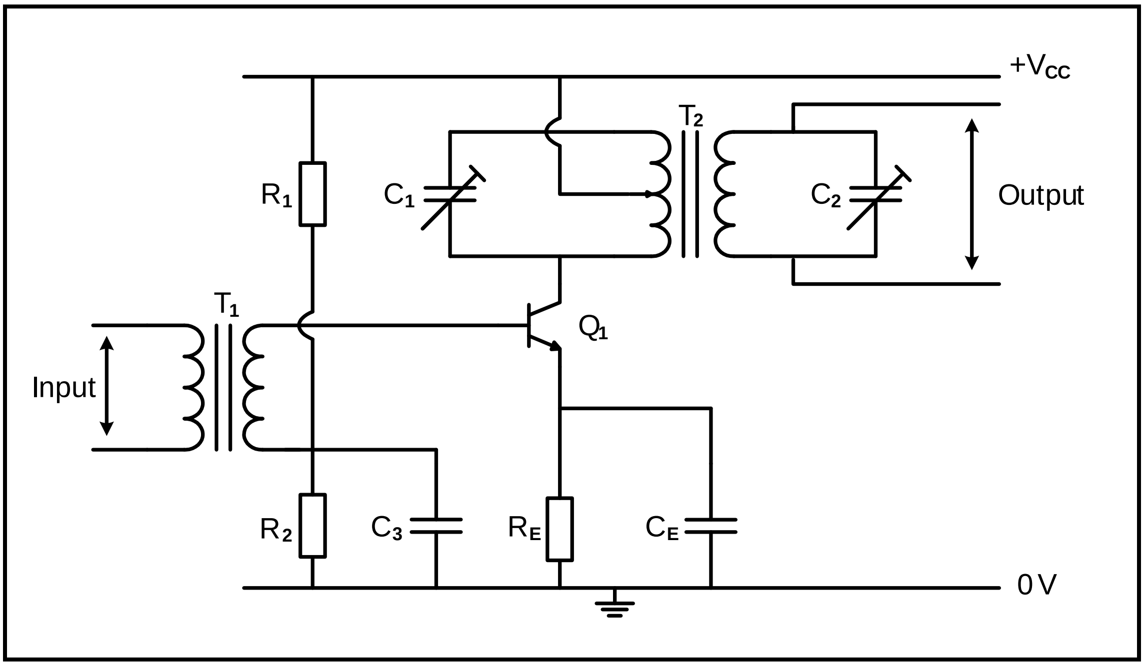

FIGURE 6.5: RADIO-FREQUENCY AMPLIFIER

6.5.1 State ONE purpose of $C_{E.}$ (1)

6.5.2 Describe the functions of the radio-frequency amplifier. (2)

6.5.3 Explain why variable pre-set capacitors C_1 and C_2 have been used with transformer T_2. (2)

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

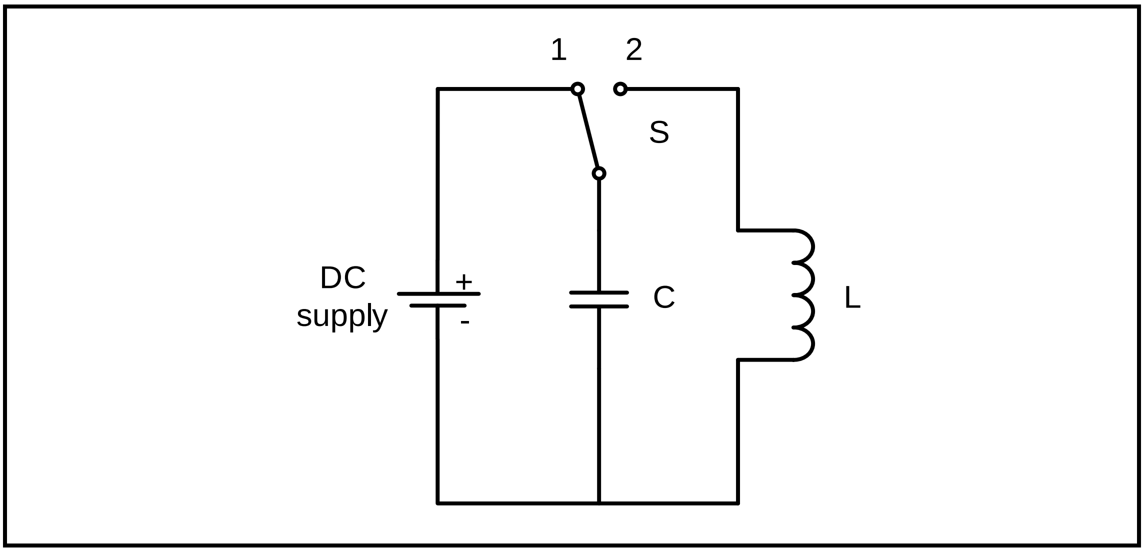

FIGURE 6.6: TANK CIRCUIT

6.6.1 Describe what would occur when switch S is moved to position 2. (2)

6.6.2 Draw the voltage waveform across the capacitor on the ANSWER SHEET for QUESTION 6.6.2 after the switch is moved to position 2. (3)

6.6.3 State how the frequency of this tank circuit can be increased. (1)

6.7 Study FIGURE 6.7 and answer the questions that follow.

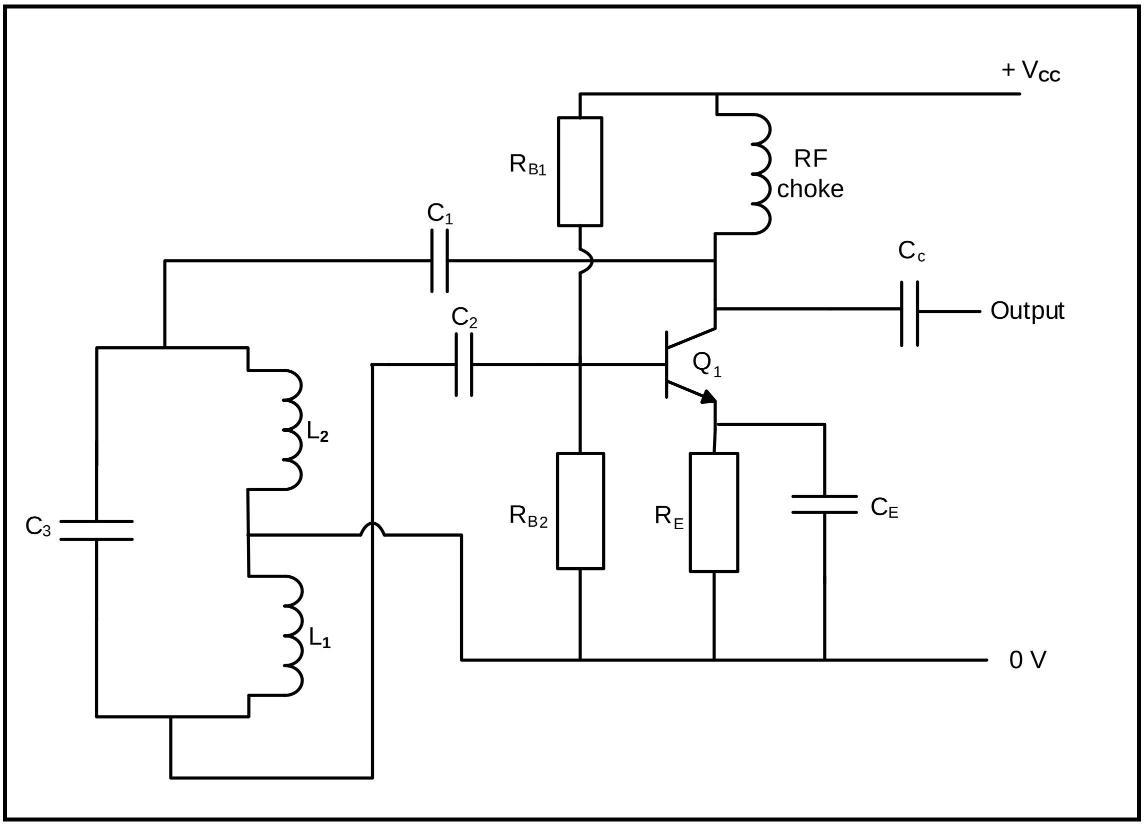

FIGURE 6.7: HARTLEY OSCILLATOR CIRCUIT DIAGRAM

6.7.1	State ONE application of the Hartley oscillator.	(1)
6.7.2	State the function of C_1 and C_2.	(2)
6.7.3	Describe how the state of oscillation can be maintained.	(2)

6.8 Refer to FIGURE 6.8 and answer the questions that follow.

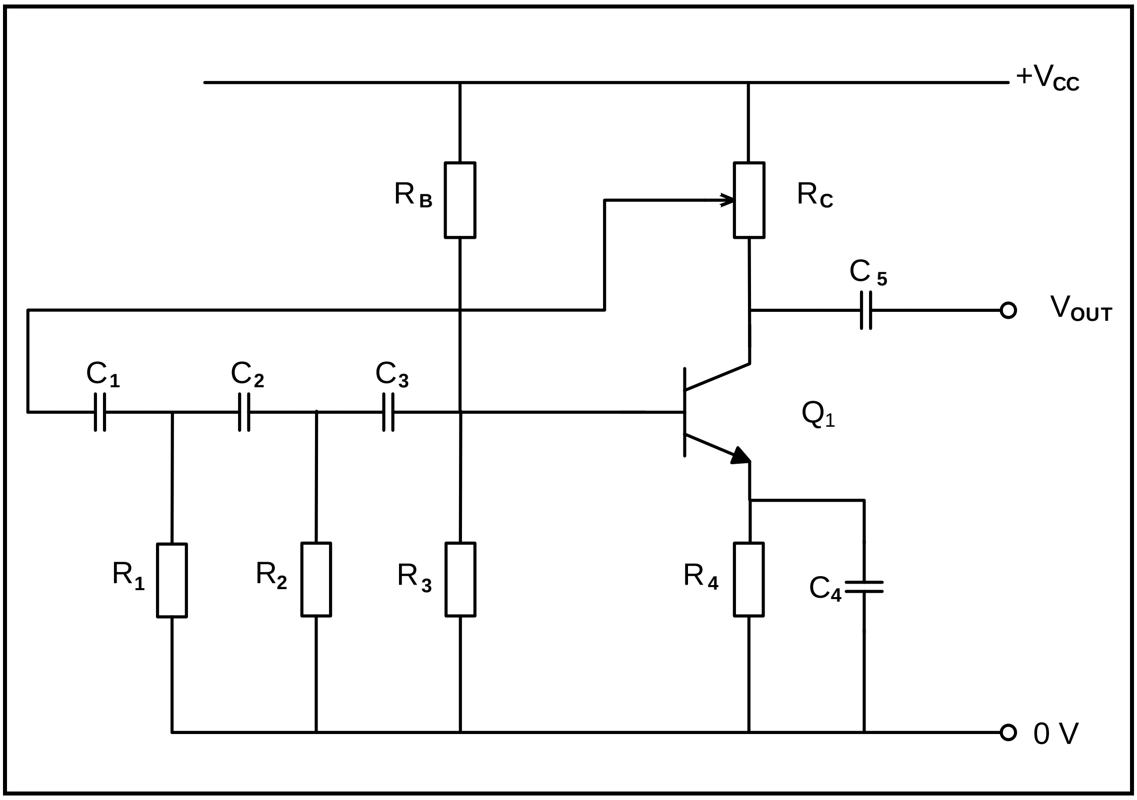

FIGURE 6.8: RC PHASE-SHIFT OSCILLATOR

6.8.1 State ONE function of transistor Q_1. (1)

6.8.2 Describe how the frequency of the oscillator in FIGURE 6.8 can be adjusted if the value of the resistors are kept the same. (2)

6.8.3 Compare the feedback used in transistor amplifiers to oscillator circuits. (2)

6.9 State the difference between *LC* and *RC oscillators* with reference to frequency. (2)
[45]

TOTAL: 200

FORMULA SHEET

RLC CIRCUITS

$$P = V \times I \times \cos\theta$$

$$X_L = 2\pi fL$$

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

$$f_r = \frac{1}{2\pi\sqrt{LC}} \quad \textbf{OR} \quad f_r = \frac{f_2 + f_1}{2}$$

$$BW = \frac{f_r}{Q} \quad \textbf{OR} \quad BW = f_2 - f_1$$

Series

$$V_R = IR$$

$$V_L = I X_L$$

$$V_C = I X_C$$

$$I_T = \frac{V_T}{Z} \quad \textbf{OR} \quad I_T = I_R = I_C = I_L$$

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

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

$$\text{Cos}\,\theta = \frac{R}{Z} \quad \textbf{OR} \quad \text{Cos}\,\theta = \frac{V_R}{V_T}$$

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

Parallel

$$V_T = V_R = V_L = V_C$$

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

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

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

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

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

$$\text{Cos}\,\theta = \frac{I_R}{I_T}$$

$$Q = \frac{R}{X_L} = \frac{R}{X_C} = \frac{I_L}{I_T} = \frac{I_C}{I_T}$$

SEMICONDUCTOR DEVICES

$$\text{Gain } A_V = \frac{V_{OUT}}{V_{IN}} = -\frac{R_F}{R_{IN}} \qquad A_V = 1 + \frac{R_F}{R_{IN}}$$

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

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

SWITCHING CIRCUITS

$$V_{OUT} = -\left(V_1\frac{R_F}{R_1} + V_2\frac{R_F}{R_2} + \ldots V_N\frac{R_F}{R_N}\right)$$

$$\text{Gain } A_V = \frac{V_{OUT}}{V_{IN}} = \frac{V_{OUT}}{(V_1 + V_2 + \ldots V_N)}$$

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

AMPLIFIERS

$$I_C = \frac{V_C}{R_C} \qquad V_{CC} = V_{CE} + I_C R_C$$

$$V_B = V_{BE} + V_{RE}$$

$$A_V = \frac{V_{OUT}}{V_{IN}}$$

$$A_I = \frac{I_{OUT}}{I_{IN}} \quad \textbf{OR} \quad \beta = \frac{I_C}{I_B}$$

$$A_P = \frac{P_{OUT}}{P_{IN}} \quad \textbf{OR} \quad A_P = A_V \times A_I$$

$$A = \beta_1 \times \beta_2 \quad \textbf{OR} \quad A_V = A_{V1} \times A_{V2} \times A_{V3}$$

$$P_{IN} = I^2 \times Z_{IN} \quad \textbf{AND} \quad P_{OUT} = I^2 \times Z_{OUT}$$

Oscillation frequency

$$f_o = \frac{1}{2 \times \pi\sqrt{LC}} \quad \textbf{OR} \quad f_o = \frac{1}{2 \times \pi\sqrt{6}RC}$$

GAIN IN DECIBELS

$$A_I = 20\log_{10}\frac{I_{OUT}}{I_{IN}}$$

$$A_V = 20\log_{10}\frac{V_{OUT}}{V_{IN}}$$

$$A_P = 10\log_{10}\frac{P_{OUT}}{P_{IN}}$$

CENTRE NUMBER:							

EXAMINATION NUMBER:													

ANSWER SHEET

QUESTION 4: SEMICONDUCTOR DEVICES

4.2.2

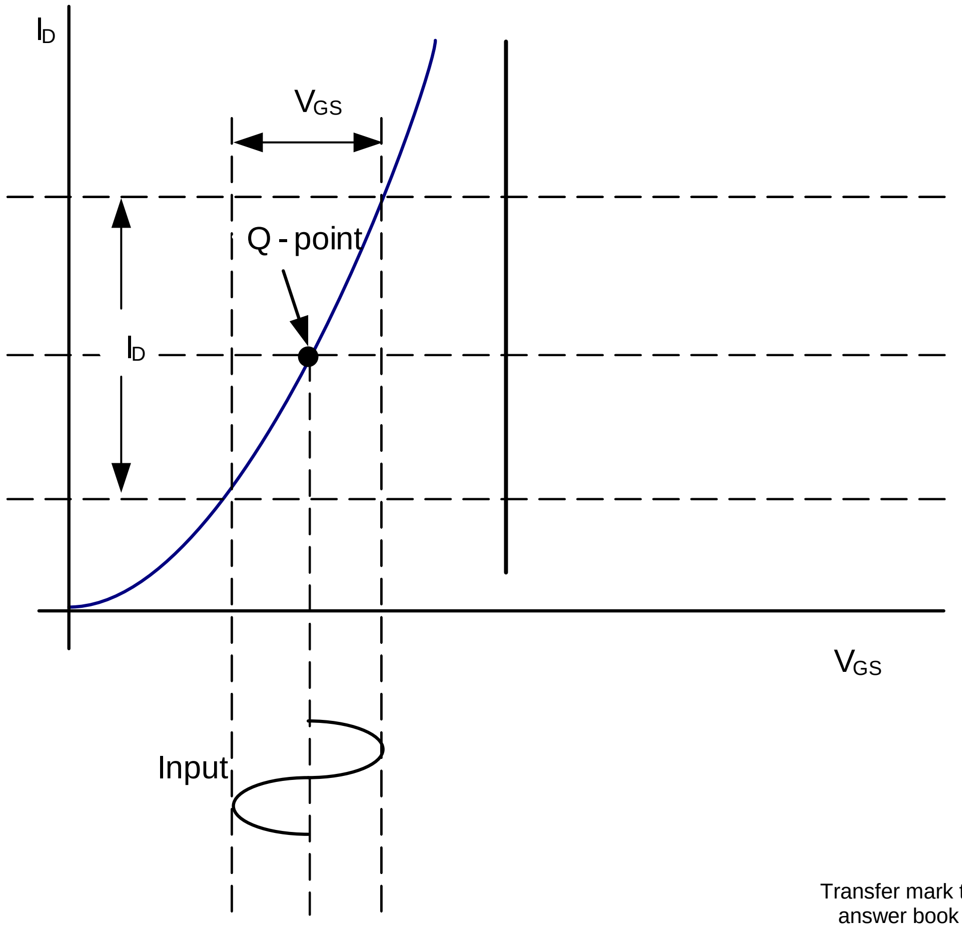

FIGURE 4.2.2

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(3)

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EXAMINATION NUMBER:													

ANSWER SHEET

4.7.3

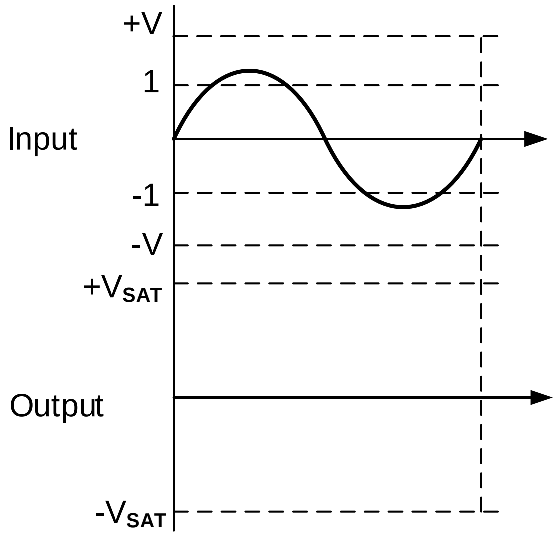

FIGURE 4.7.3

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(3)

CENTRE NUMBER:							

EXAMINATION NUMBER:													

ANSWER SHEET

QUESTION 5: SWITCHING CIRCUITS

5.2.4

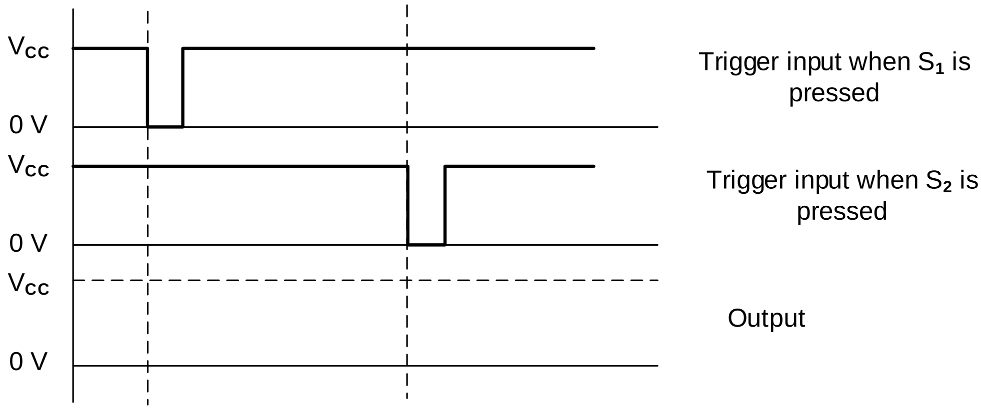

FIGURE 5.2.4

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5.3.4

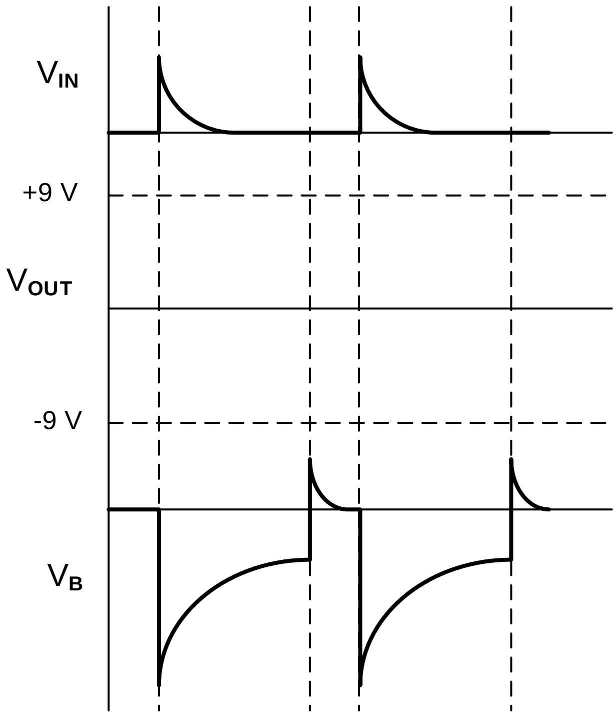

FIGURE 5.3.4

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EXAMINATION NUMBER:													

ANSWER SHEET

QUESTION 6: AMPLIFIERS

6.2.3

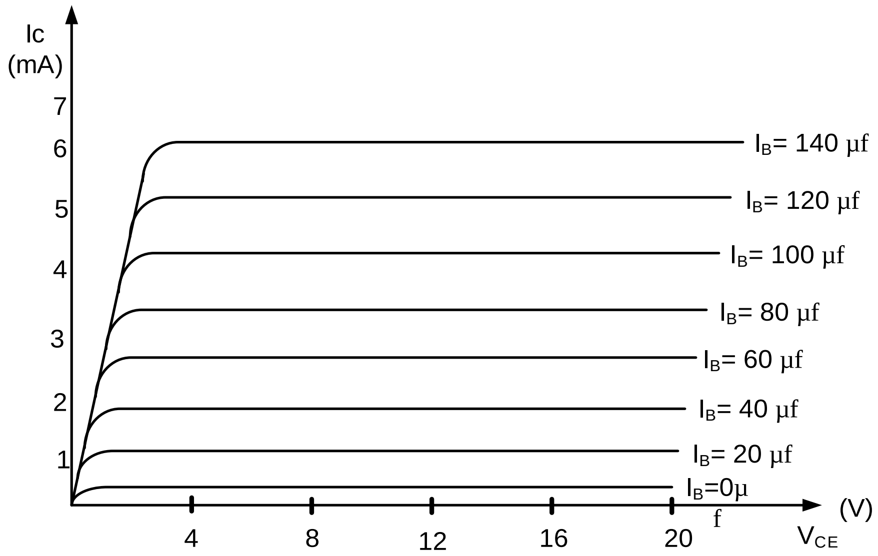

FIGURE 6.2.3

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6.6.2

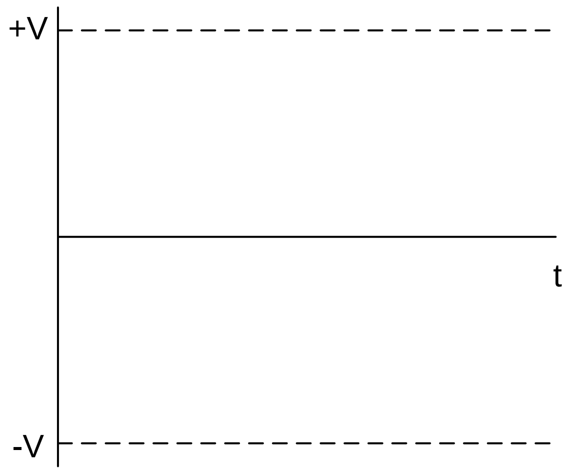

FIGURE 6.6.2

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(3)