basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

ELECTRICAL TECHNOLOGY: ELECTRONICS

EXEMPLAR 2018

MARKS: 200

TIME: 3 hours

This question paper consists of 19 pages, a 1-page formula sheet and an answer sheet of 3 pages.

INSTRUCTIONS AND INFORMATION

1. This question paper consists of FIVE questions.
2. Answer ALL the questions.
3. Sketches and diagrams must be large, neat and fully labelled.
4. Show ALL calculations and round off answers correctly to TWO decimal places.
5. Number the answers correctly according to the numbering system used in this question paper
6. You may use a non-programmable calculator.
7. Show the units for ALL answers and calculations.
8. A formula sheet is provided at the end of this question paper.
9. Write neatly and legibly.
10. Use the ANSWER SHEET provided as per instruction.

QUESTION 1: OCCUPATIONAL HEALTH AND SAFETY (GENERIC)

1.1 Define the term *workplace* with reference to the Occupational Health and Safety Act, 1993 (Act 85 of 1993) (2)

1.2 Name TWO general duties for employees at the workplace. (2)

1.3 Explain why 'insufficient ventilation' is an unsafe condition in the workshop. (2)

1.4 State TWO functions of a health and safety representative. (2)

1.5 Explain *quantitative risk analysis*. (2)
[10]

QUESTION 2: RLC CIRCUITS (GENERIC)

2.1 Explain the phase relationship between current and voltage in the following AC circuits:

2.1.1 Resistive circuit (2)

2.1.2 Pure capacitive circuit (2)

2.1.3 Pure inductive circuit (2)

2.2 FIGURE 2.2 below shows a series RLC circuit, which consists of a 12 Ω resistor, a 30 mH inductor and a 150 μF capacitor, all connected across a 120 V/60 Hz supply.

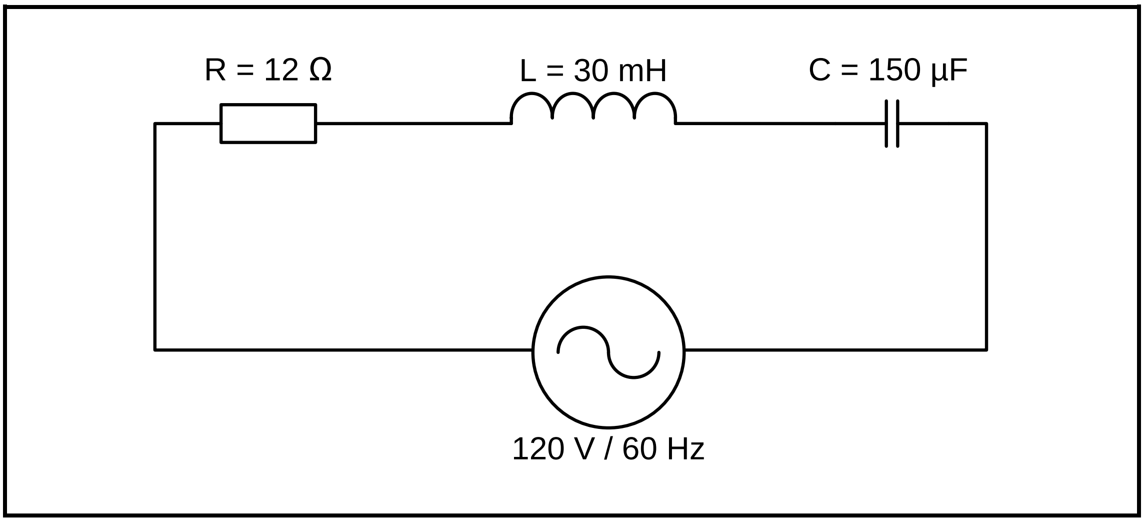

FIGURE 2.2: SERIES RLC CIRCUIT

Given:

R = 12 Ω
L = 30 mH
C = 150 µF
V_s = 120 V/60Hz
f = 50 Hz

Calculate the:

2.2.1 Inductive reactance (3)

2.2.2 Capacitive reactance (3)

2.2.3 Impedance (3)

2.2.4 Total current (3)

2.2.5 Power factor (3)

2.2.6 State whether the phase angle is leading or lagging. (1)

2.3 Refer to FIGURE 2.3 and answer the questions that follow.

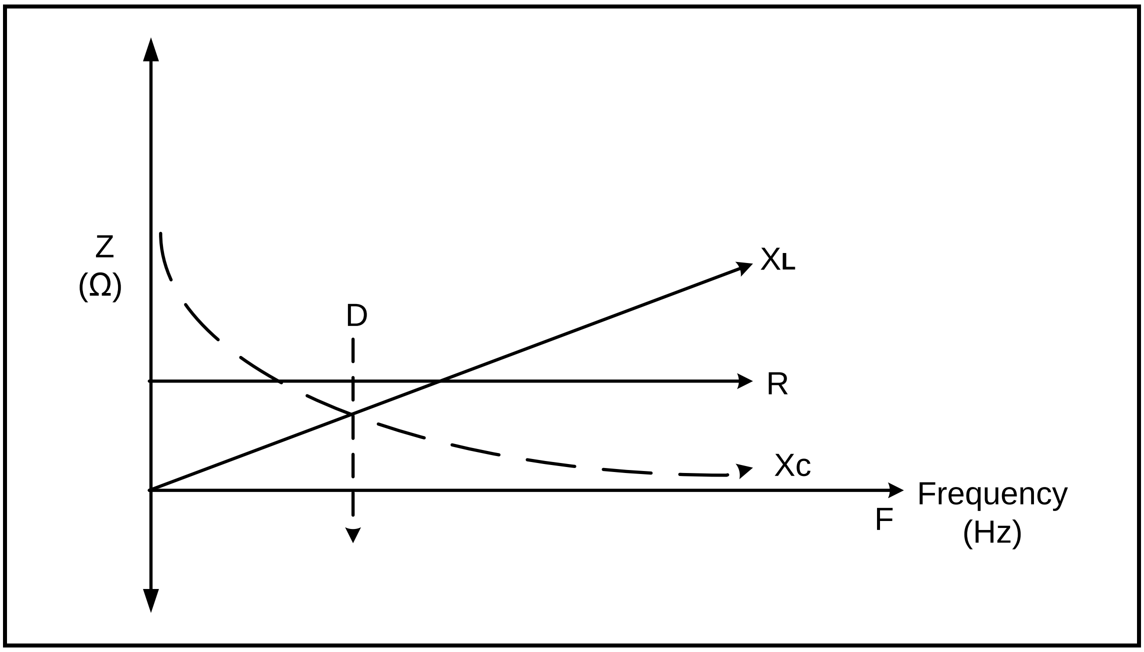

FIGURE 2.3 : FREQUENCY VERSUS IMPEDANCE

2.3.1 Describe how an increase in the frequency of the supply voltage will affect the:

(a) Inductive reactance (2)

(b) Capacitive reactance (2)

2.3.2 Explain why the response of line R is parallel to line F (2)

2.3.3 Name the electrical quantity that is equal to R at point D. (1)

2.4 A parallel RLC circuit consists of a 30 mH inductor, a 10 Ω resistor and a 120 µF capacitor connected across a 120 V alternating supply.

Given:

L = 30 mH
C = 120 µF
R = 10 Ω
V = 120 V

Calculate the:

2.4.1 Resonant frequency (3)

2.4.2 Q-factor (5)

2.4.3 Bandwidth (3)
[40]

QUESTION 3: SEMICONDUCTOR DEVICES (SPECIFIC)

3.1 State whether the JFET is a current-controlled or a voltage-controlled device. (1)

3.2 Draw a fully labelled symbol of a P-channel JFET. (3)

3.3 Refer to FIGURE 3.3 below and explain what will happen to the drain current, I_{DS}, if the variable voltage supply, V_{GS}, is increased.

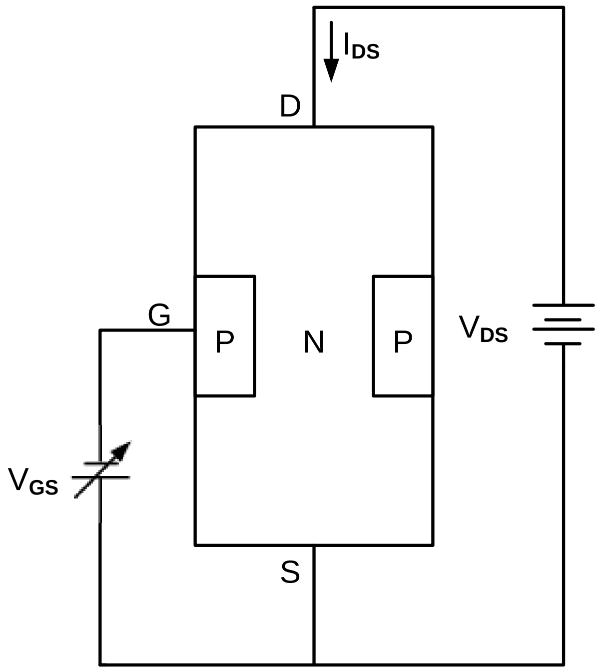

FIGURE 3.3: CONSTRUCTION OF N-CHANNEL JFET (3)

3.4 State what MOSFET stands for, with reference to field-effect transistors. (1)

3.5 Name the mode in which the MOSFET operates when V_{GS} exceeds 0 V. (1)

3.6 State TWO applications of a UJT. (2)

3.7 Draw a fully labelled symbol of a Darlington pair transistor. (3)

3.8 Refer to FIGURE 3.8 below and answer the questions that follow.

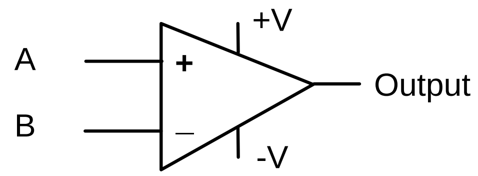

FIGURE 3.8: OP-AMP SYMBOL

3.8.1 Label inputs **A** and **B**. (2)

3.8.2 Explain why an op amp uses a dual voltage supply. (2)

3.9 Refer to FIGURE 3.9 below and answer the questions that follow.

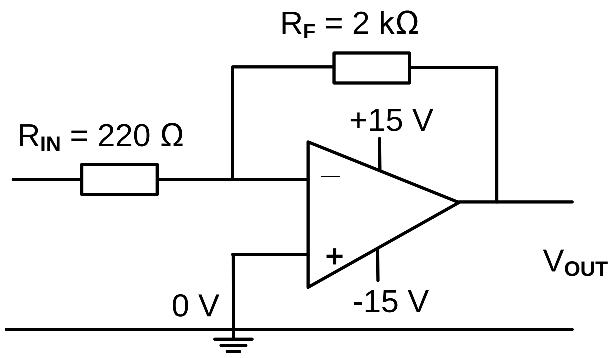

FIGURE 3.9: INVERTING OP AMP

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

3.9.2 Calculate the output voltage if a 0,55 V signal is applied to the input. (3)

3.9.3 Describe what will happen to the output voltage if the value of the feedback resistor is increased to 20 kΩ. (2)

3.10 State TWO uses of the 555 IC. (2)

3.11 FIGURE 3.11 below shows the 555 IC. Explain the function of pin 6.

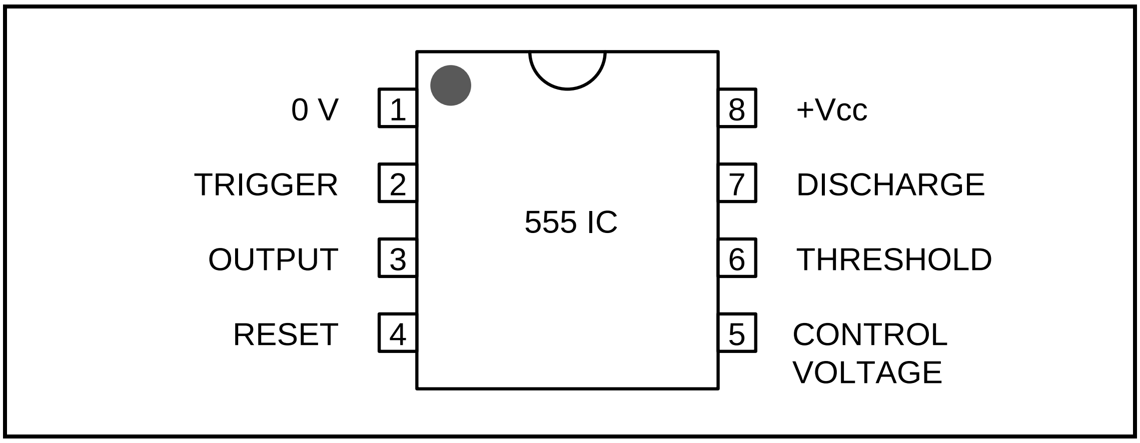

FIGURE 3.11: 555 IC (2)

[30]

QUESTION 4: SWITCHING CIRCUITS (SPECIFIC)

4.1 Draw the output signal of an astable multivibrator on the ANSWER SHEET provided. (3)

4.2 Define the term *bi-stable multivibrator*. (3)

4.3 FIGURE 4.3 below shows the input signals of a bi-stable multivibrator using a 555 IC. Draw the output on the ANSWER SHEET provided.

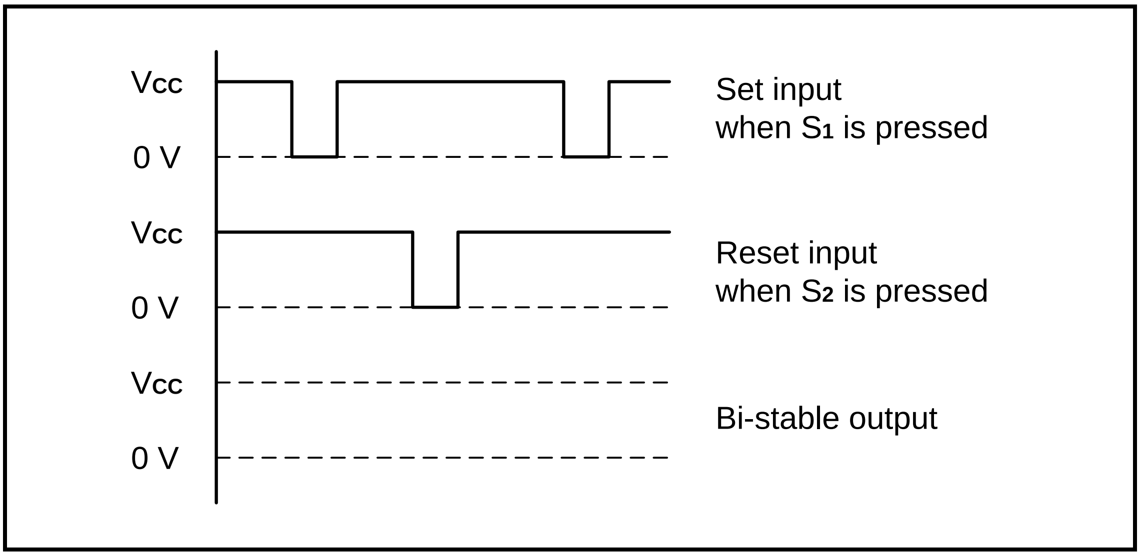

FIGURE 4.3: INPUT SIGNALS OF A BI-STABLE MULTIVIBRATOR (3)

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

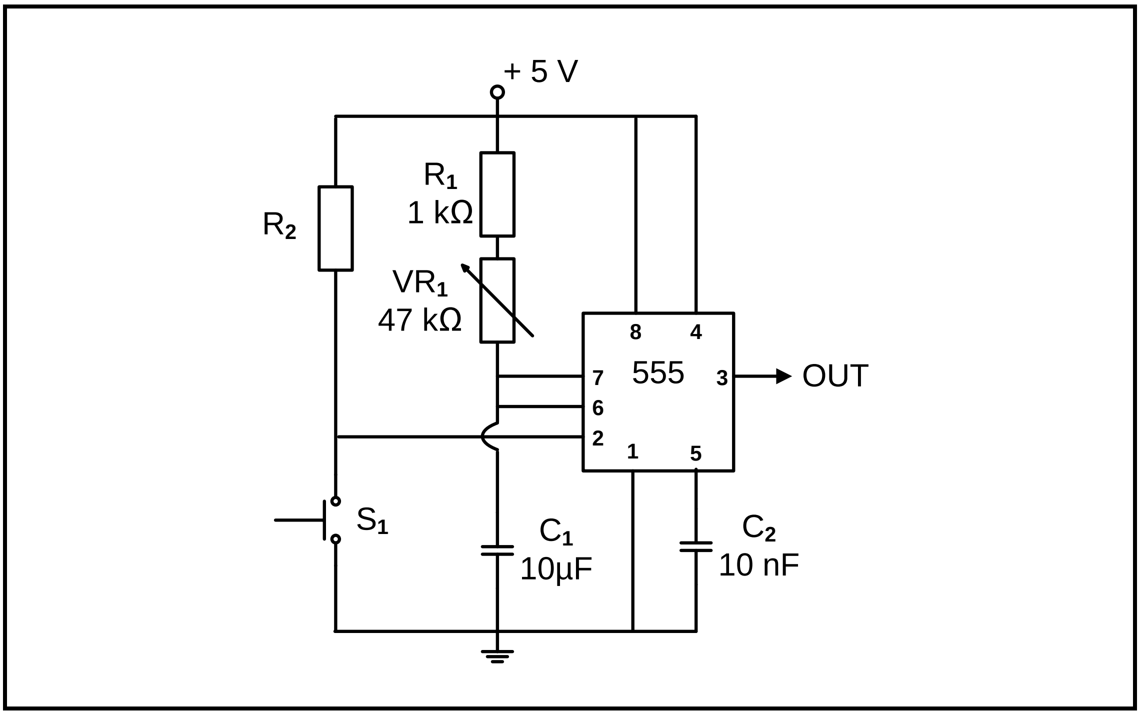

FIGURE 4.4: MONOSTABLE MULTIVIBRATOR

4.4.1 State ONE application of the monostable multivibrator. (1)

4.4.2 Explain why resistor R_1 is necessary in the circuit. (3)

4.4.3 Explain how an increase in the value of capacitor C_1 will affect the circuit. (2)

4.4.4 Describe what will happen in the circuit when switch S_1 is pressed. (5)

4.5 State TWO applications other than a temperature sensitive switch of a Schmitt trigger. (2)

4.6 Explain the basic operation of a Schmitt trigger with reference to FIGURE 4.6 below.

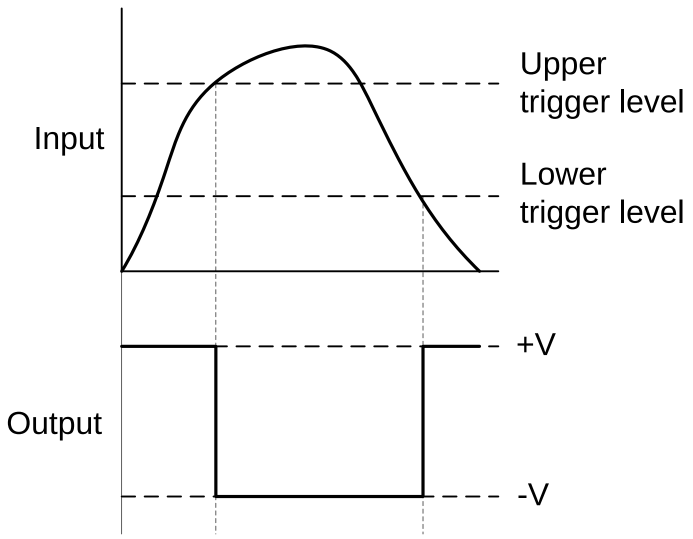

FIGURE 4.6: INPUT AND OUPUT OF AN INVERTING SCHMITT TRIGGER (3)

4.7 Draw a fully labelled circuit diagram of a 741 op amp connected as an inverting Schmitt trigger. (5)

4.8 FIGURE 4.8 below shows a 741 op amp as a comparator. Answer the questions that follow.

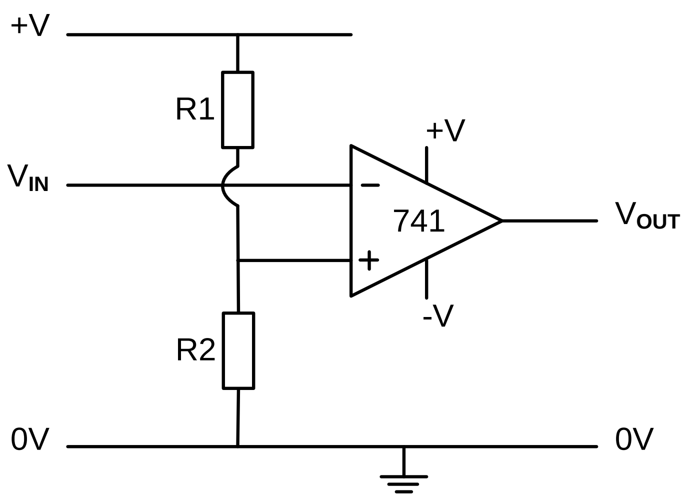

FIGURE 4.8: COMPARATOR

4.8.1 State the function of R_2 in the circuit. (1)

4.8.2 Describe the operation of the comparator. (6)

4.8.3 State how the circuit can be modified to adjust the reference voltage. (1)

4.9 Refer to FIGURE 4.9 below and answer the questions that follow.

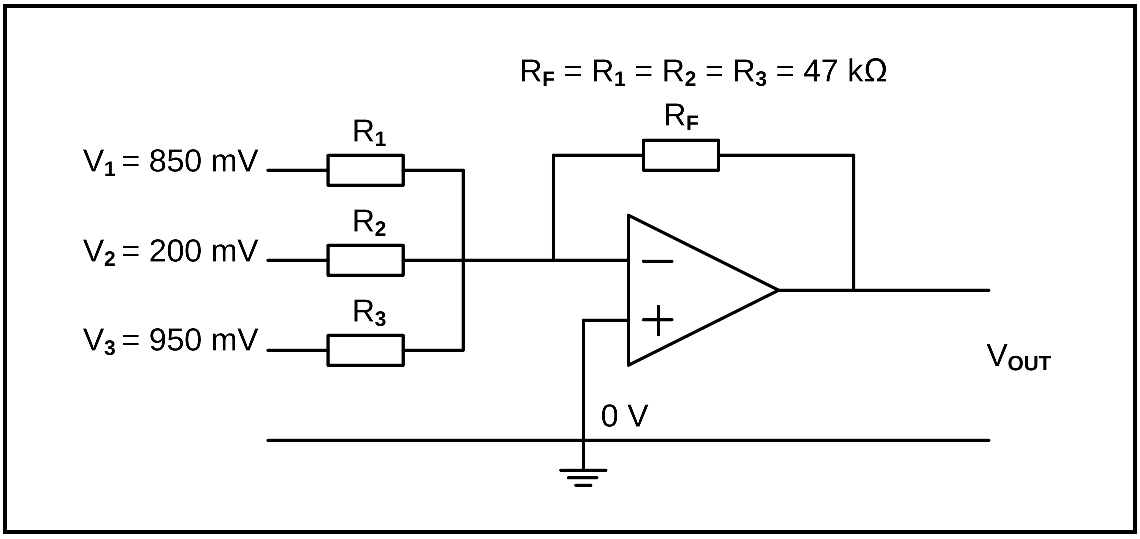

FIGURE 4.9: AMPLIFIER

4.9.1 Identify the amplifier in FIGURE 4.9. (2)

4.9.2 Name the type of feedback provided by R_F. (1)

4.9.3 Explain how the gain of this amplifier is determined. (3)

4.9.4 Calculate the output voltage of the amplifier. (3)

4.10 Explain the basic function of a differentiator. (2)

4.11 FIGURE 4.11 below shows the circuit of a basic passive RC differentiator with its input signal. Answer the questions that follow.

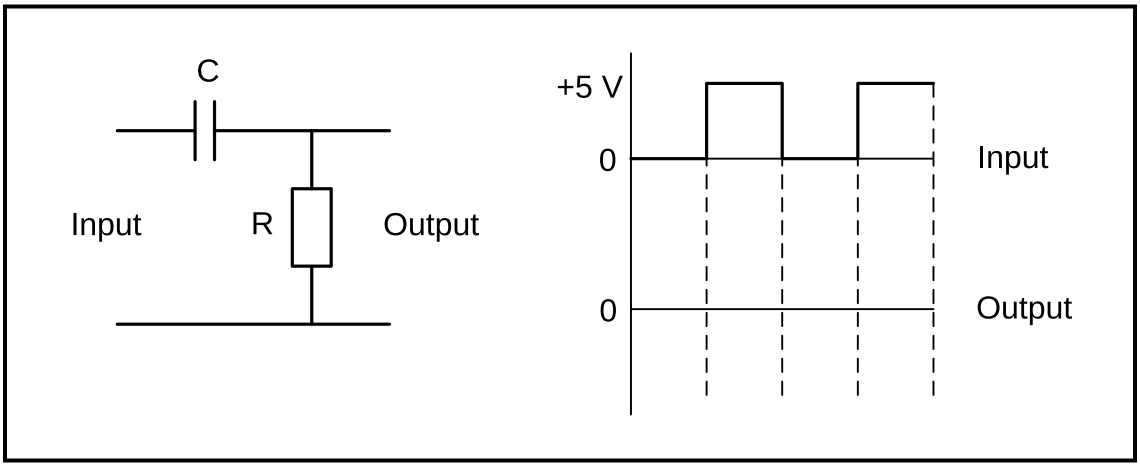

FIGURE 4.11: RC DIFFERENTIATOR

4.11.1 Draw the output with reference to the input signal on the addendum provided. (3)

4.11.2 Explain how a long-time constant will influence the output signal. (2)

4.12 Refer to FIGURE 4.12 below and answer the questions that follow.

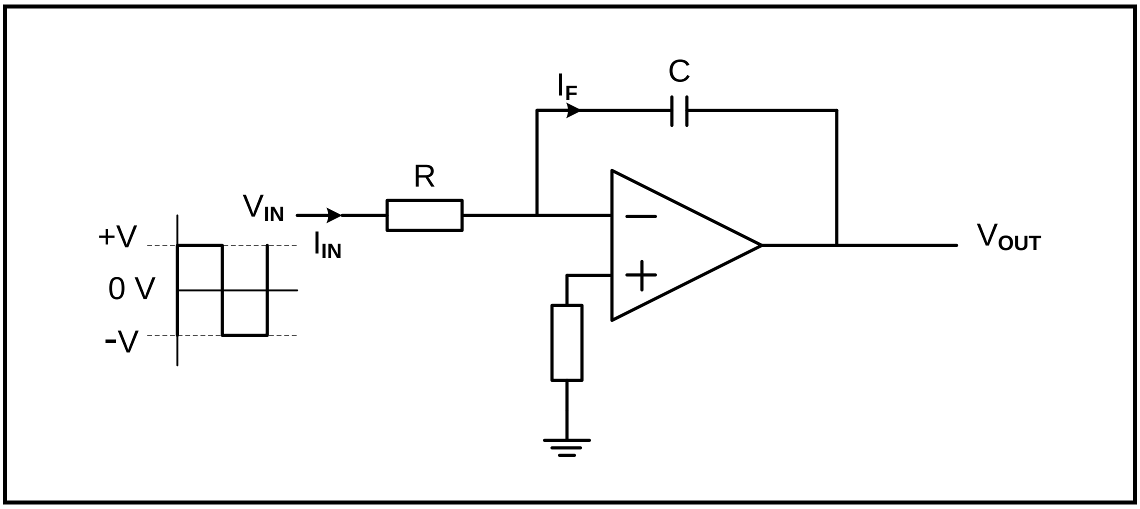

FIGURE 4.12: OP AMP

4.12.1 Identify the amplifier. (2)

4.12.2 Draw the output signal, on the addendum provided, with reference to the input in FIGURE 4.12. (2)

4.12.3 Explain how a higher input frequency will affect the output of an integrator. (2)
[60]

QUESTION 5: AMPLIFIERS

5.1 Explain Class B amplification with reference to output collector current. (2)

5.2 Refer to FIGURE 5.2 below and answer the questions that follow.

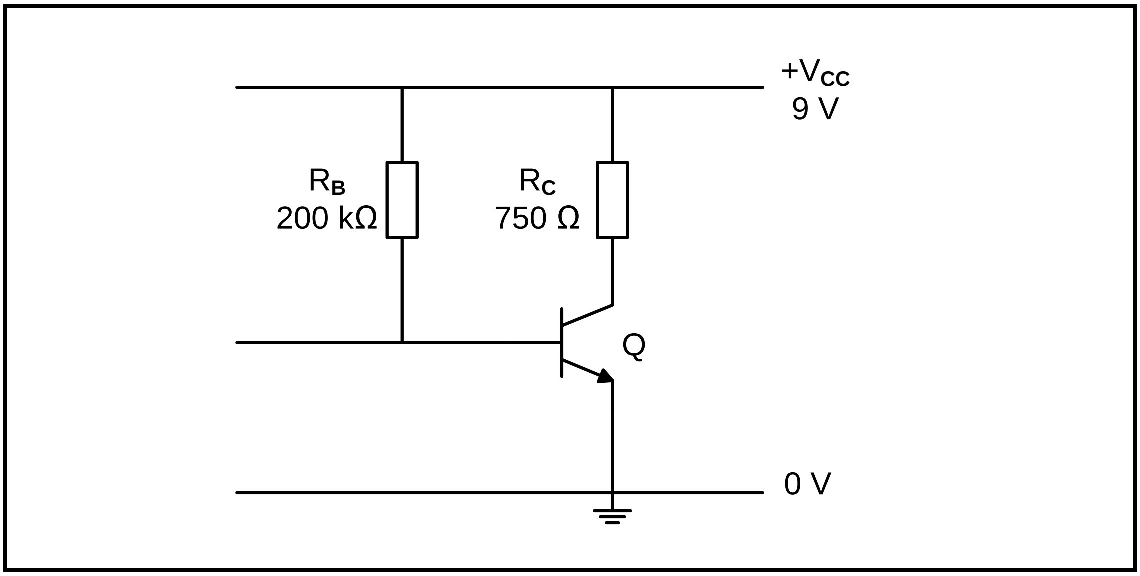

FIGURE 5.2: CLASS A FIXED-BIAS TRANSISTOR AMPLIFIER

5.2.1 Determine the maximum collector emitter voltage. (2)

5.2.2 Calculate the maximum collector current. (3)

5.2.3 Draw the load line of the circuit on the ANSWER SHEET provided. (3)

5.2.4 State how the value of the collector current will be affected if the load resistance increases. (1)

5.3 Describe how an increase in the supply voltage will affect the Q-point on a load line of the characteristic curve of a bipolar junction amplifier. (2)

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

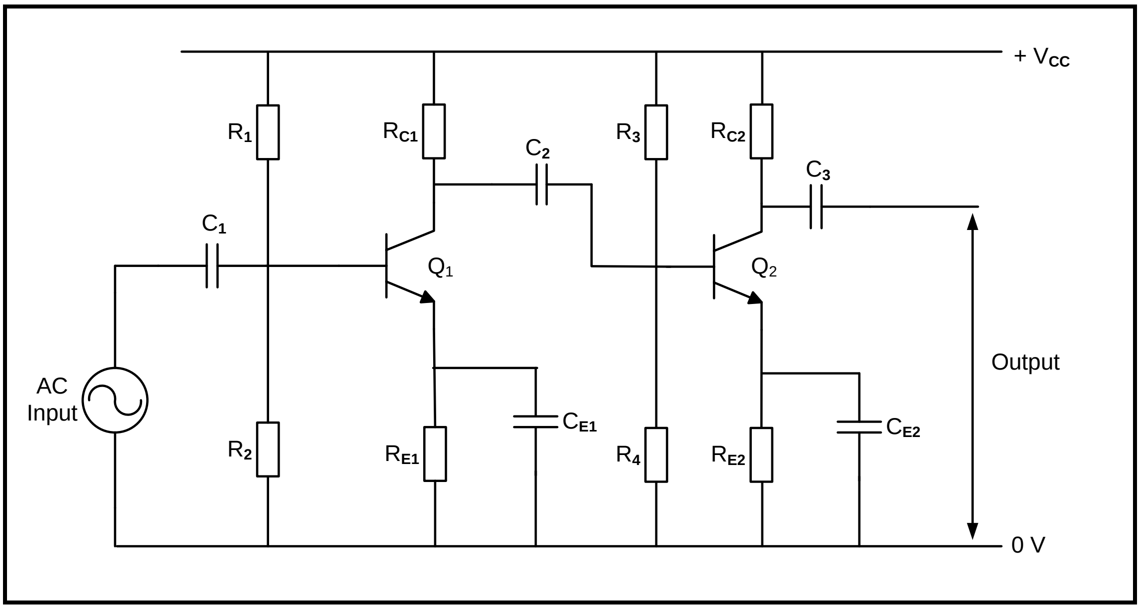

FIGURE 5.4: RC-COUPLED AMPLIFIER

5.4.1 State the purpose of the RC coupling. (2)

5.4.2 Determine the combined gain of the amplifier circuit. (1)

5.4.3 Explain how the amplification of the input signal to the RC-coupled amplifier is affected by increasing the frequency to a very high value. (3)

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

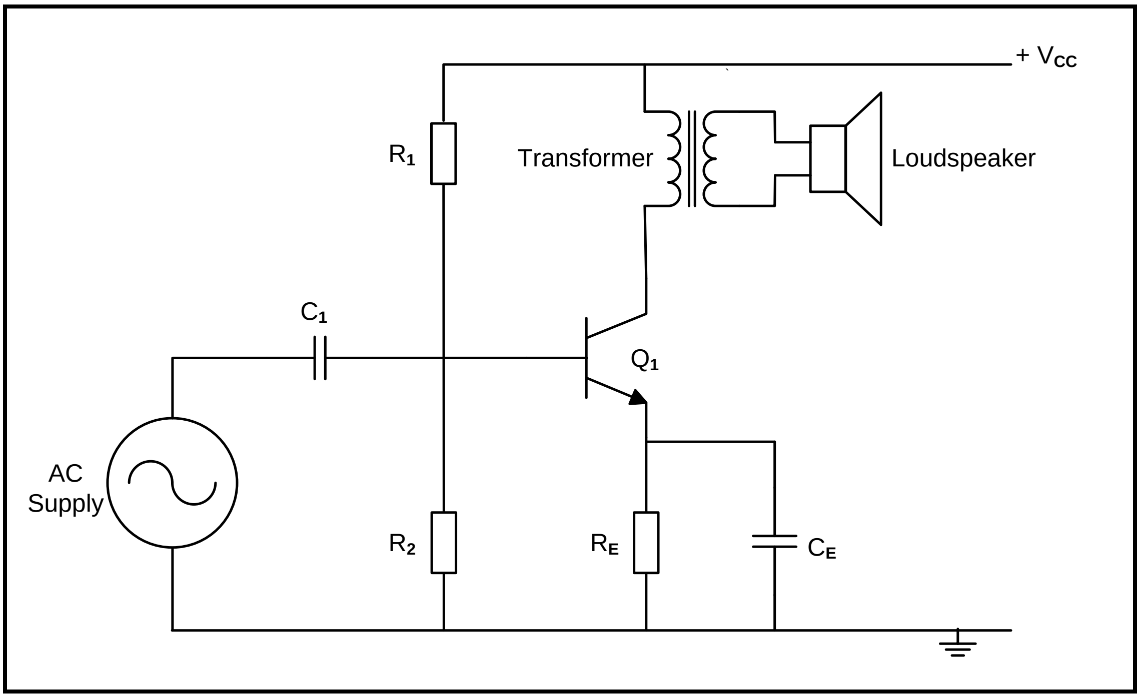

FIGURE 5.5: TRANSFORMER-COUPLED AMPLIFIER

5.5.1 State TWO disadvantages of a transformer-coupled amplifier. (2)

5.5.2 State how the circuit must be modified if the loudspeaker is changed to a lower-impedance loudspeaker. (3)

5.6 FIGURE 5.6 below shows a push-pull amplifier using two NPN transistors. Answer the questions that follow:

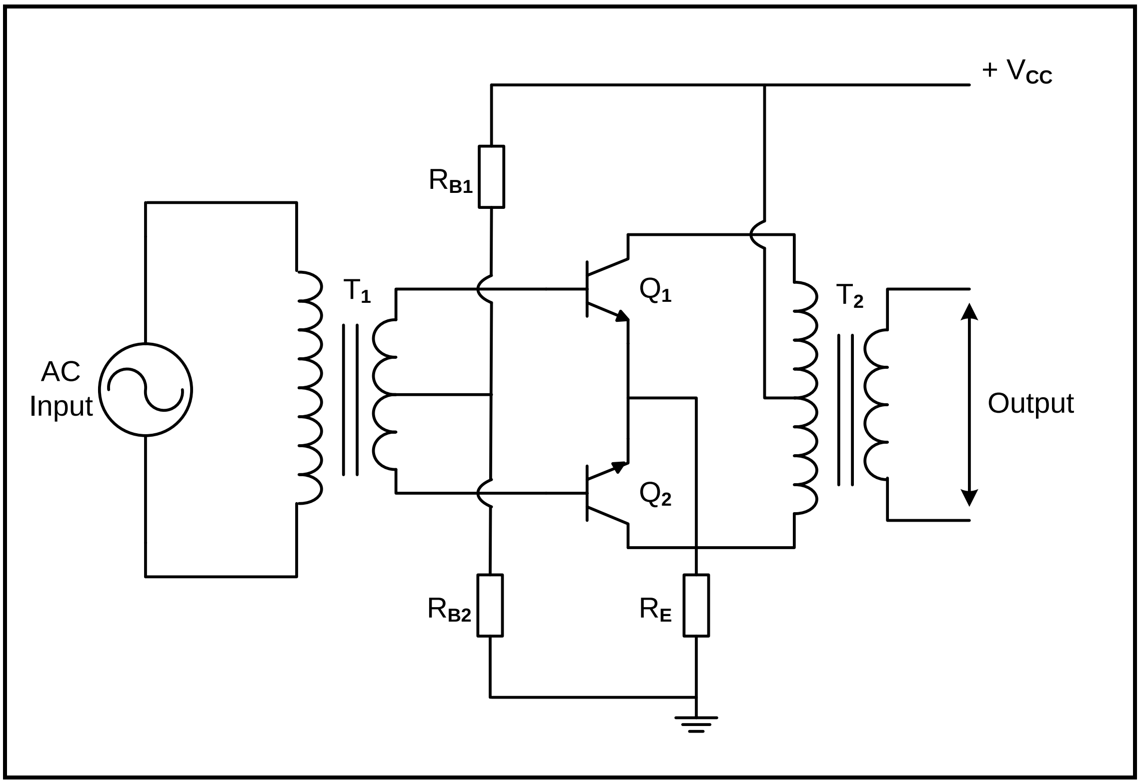

FIGURE 5.6: PUSH-PULL AMPLIFIER USING NPN TRANSISTORS

5.6.1 Describe how cross-over distortion occurs. (2)

5.6.2 Draw a fully labelled diagram of the cross-over distortion in the amplifier on the ANSWER SHEET provided. (3)

5.6.3 Calculate the current gain in dB by using the following specifications:

Input power	= 3,5 watts
Output power	= 100 watts
Input current	= 200 amperes
Input voltage	= 200 volts
Output impedance	= 20 ohms

(6)

5.7 FIGURE 5.7 below represents the radio-frequency amplifier. Answer the questions that follow:

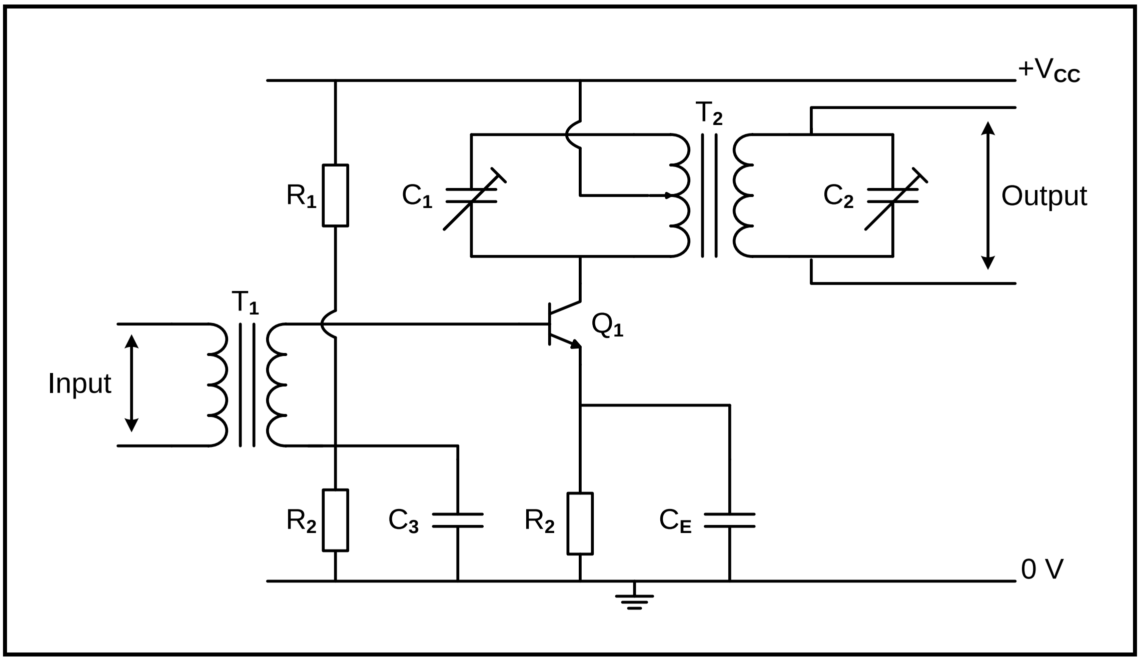

FIGURE 5.7: RADIO-FREQUENCY AMPLIFIER

5.7.1 Explain how a radio-frequency amplifier differs from other amplifiers with reference to frequency. (2)

5.7.2 Discuss the function of the tuned circuit formed by the second transformer (T_2) and capacitors (C_1 and C_2). (3)

5.7.3 Describe how the radio-frequency amplifier circuit can be made so that it can be tuned to handle a range of frequencies instead of passing a single frequency (3)

5.8 Study the FIGURE 5.8 below and answer the questions that follow.

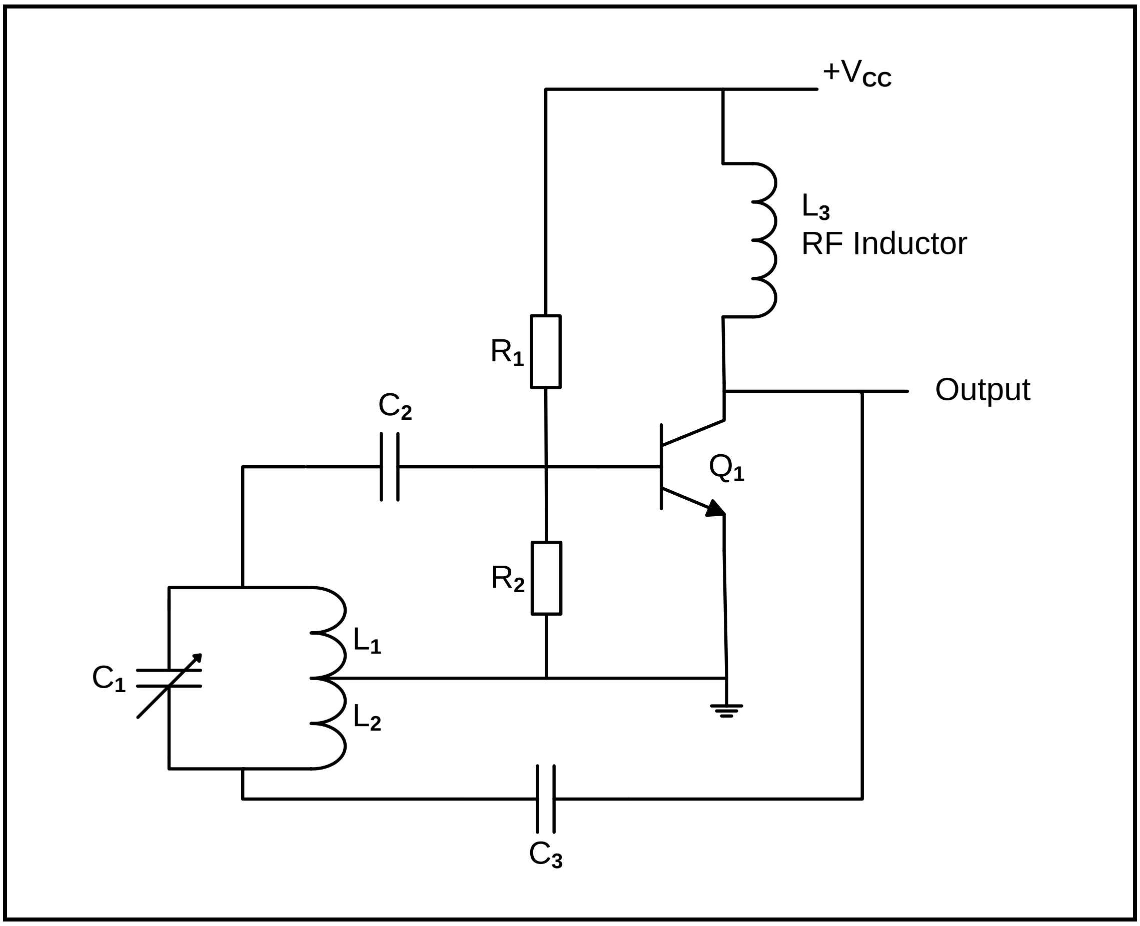

FIGURE 5.8: HARTLEY OSCILLATOR

5.8.1 Describe the function of the RF coil in the oscillator circuit. (2)

5.8.2 State the purpose of the tank circuits in the Hartley oscillators. (2)

5.8.3 Draw the output waveform of the Hartley oscillator on the ANSWER SHEET provided. (2)

5.8.4 Differentiate between the *Hartley oscillator* and the *Colpitts oscillator* with reference to their tank circuits. (2)

5.9 Refer to FIGURE 5.9 below which shows an RC-phase oscillator using FET, and answer the questions that follow.

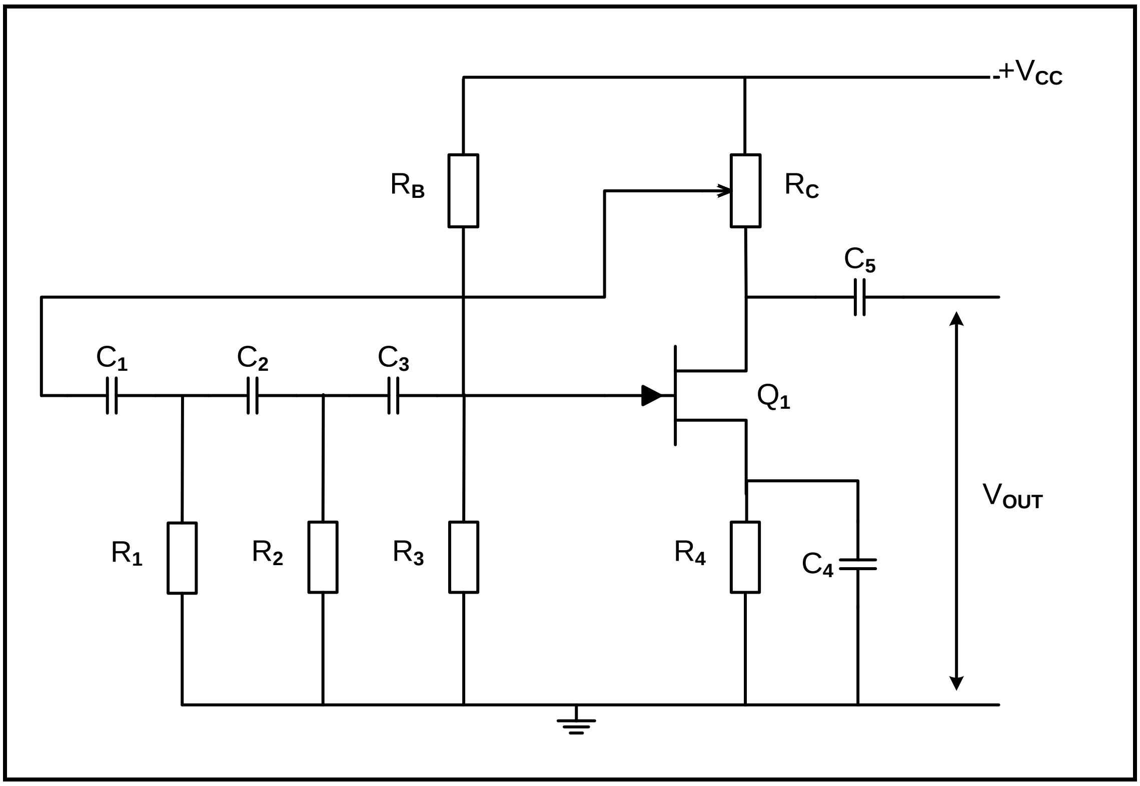

FIGURE 5.9: FET OSCILLATOR

5.9.1 State TWO functions of the RC network. (2)

5.9.2 Define the *type of feedback* used by the circuit in FIGURE 5.9. (3)

5.9.3 State TWO conditions for positive feedback to take place. (2)

5.9.4 Explain why field-effect transistors are preferred over bipolar junction transistors in oscillator circuits. (2)
[60]

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

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

$$V_L = I\,X_L$$

$$V_C = I\,X_C$$

$$V_T = I\,Z$$

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

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

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

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

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

Parallel

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

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

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

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

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

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

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

$$V_{OUT} = V_{IN}1 \times \left(-\frac{R_F}{R_1}\right) + V_{IN}2 \times \left(-\frac{R_F}{R_2}\right) + \dots .V_{IN}N \times \left(-\frac{R_F}{R_N}\right)$$

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

AMPLIFIERS

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

$$V_{CC} = V_{CE} + I_C R_C$$

$$A = \beta_1 \times \beta_2$$

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

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

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

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

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

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

$$f_O = \frac{1}{2\pi\sqrt{L_T C}}$$ Hartley oscillator

$$f_O = \frac{1}{2\pi\sqrt{LC_T}}$$ Colpitts oscillator

$$f_O = \frac{1}{2\pi\sqrt{6RC}}$$ RC phase-shift oscillator

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ANSWER SHEETS FOR ELECTRICAL TECHNOLOGY: ELECTRONICS

QUESTION 4: SWITCHING CIRCUITS

4.1

(3)

4.3

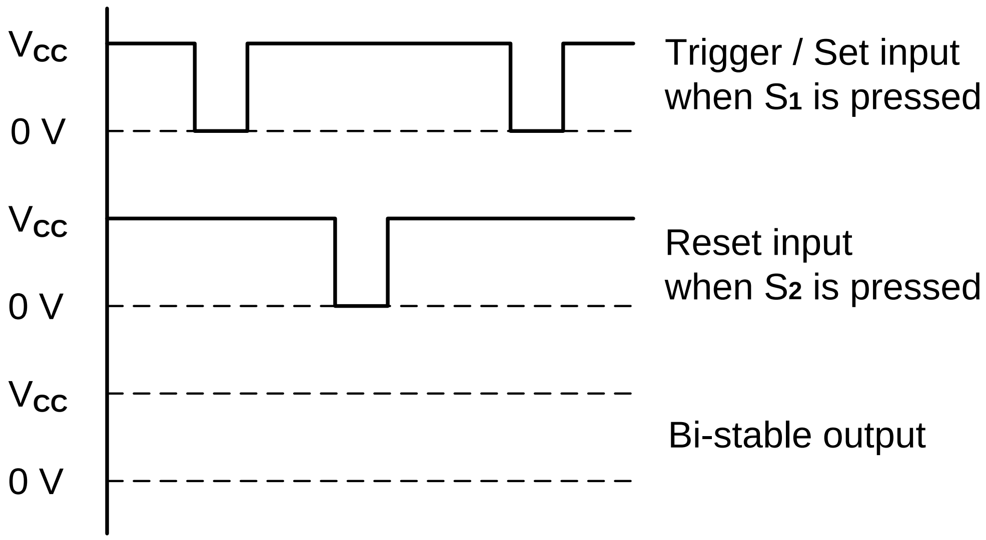

FIGURE 4.3: INPUT SIGNALS OF A BI-STABLE MULTIVIBRATOR (3)

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4.11.1

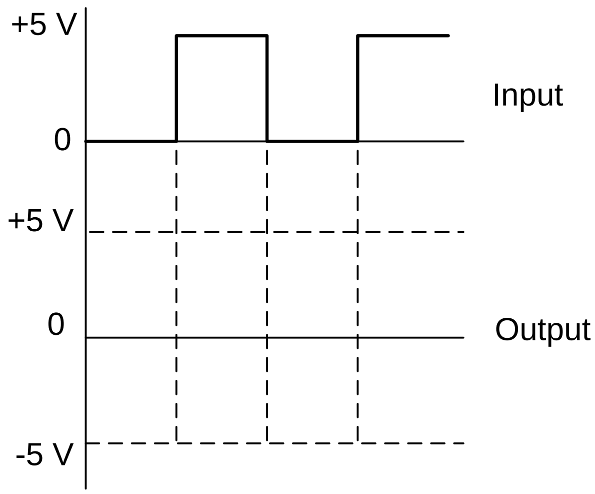

FIGURE 4.11: RC DIFFERENTIATOR (3)

4.12.2

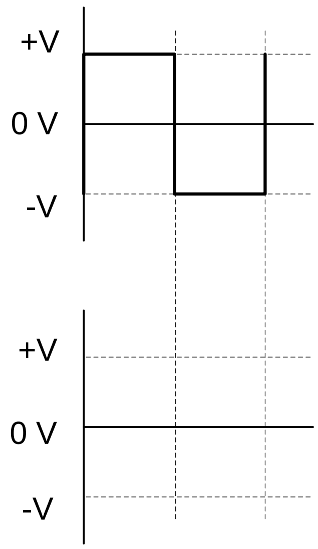

FIGURE 4.12: OP AMP (2)

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QUESTION 5: AMPLIFIERS

5.2 5.2.3

FIGURE 5.2: CLASS A FIXED-BIAS TRANSISTOR AMPLIFIER (3)

5.6 5.6.2

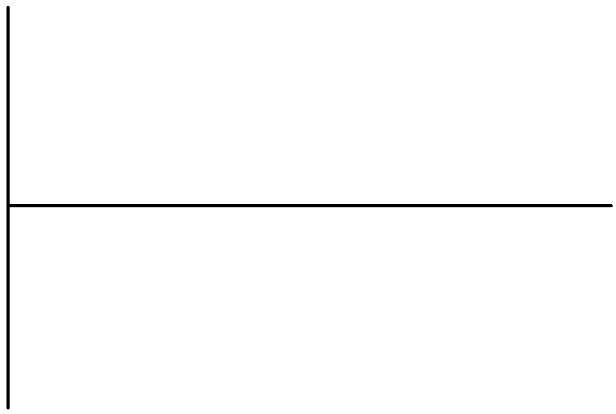

FIGURE 5.6: PUSH-PULL AMPLIFIER USING NPN TRANSISTORS (3)

5.8 5.8.3

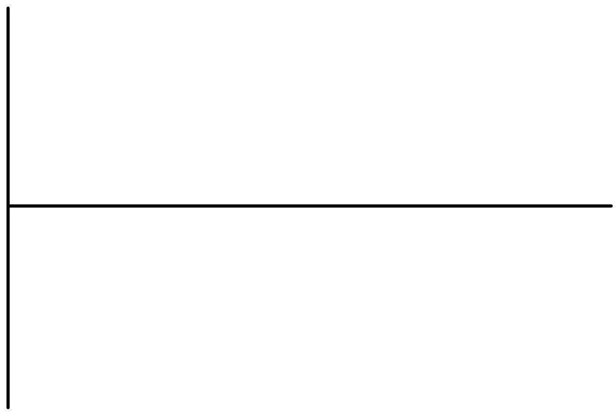

FIGURE 5.8: HARTLEY OSCILLATOR (2)