Province of the
EASTERN CAPE
EDUCATION

NATIONAL SENIOR CERTIFICATE

GRADE 12

SEPTEMBER 2023

ELECTRICAL TECHNOLOGY: ELECTRONICS

MARKS: **200**

TIME: **3 hours**

This question paper consists of 22 pages, including a 2-page formula sheet.

INSTRUCTIONS AND INFORMATION

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

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Various options are given 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, for example 1.16 D.

1.1. An attempt to numerically determine the probabilities of various adverse events and the likely extent of the losses if the event occurs is known as …

A risk analysis.
B quantitative risk analysis.
C qualitative risk analysis.
D dangerous practices. (1)

1.2 During resonance in a series RLC circuit …

A $Z = R$.
B $Z < R$.
C $Z > R$.
D Z is maximum. (1)

1.3 When increasing the frequency of a RLC circuit, the resistance will …

A also increase.
B decrease.
C remain the same.
D double its value. (1)

1.4 The power expended in a purely inductive or capacitive circuit is known as the … power.

A real
B true
C reactive
D apparent (1)

1.5 A bipolar junction transistor (BJT) is regarded as a(n) … device.

A current controlled
B drain-current (ID)
C voltage-controlled
D insulated-gate type (IGBT) (1)

1.6 The advantage of a field-effect transistor over a bipolar transistor is that it has a(n) …

A low amplification factor.
B high input current.
C extremely low input resistance.
D extremely high input resistance. (1)

1.7 The N-channel JFET will operate correctly when the …

A gate-to-source pn-junction is forward biased.
B gate-to-source pn-junction is reversed biased.
C drain is connected to ground.
D gate is connected to the source. (1)

1.8 To which input terminal of a 741-operational amplifier would a signal be connected if the output signal is in phase with the input signal?

A Terminal 2
B Terminal 3
C Terminal 1
D Terminal 4 (1)

1.9 When a square wave is applied to the input of an op-amp integrator circuit, the output will be a …

A sine waveform.
B constant DC voltage.
C triangular waveform.
D square waveform. (1)

1.10 A(n) … is a specialised op-amp circuit that compares two input voltages and produces an output that is always at either one of the two states.

A integrator
B differentiator
C comparator
D Schmitt trigger (1)

1.11 When the input voltage to a non-inverting Schmitt trigger is smaller than the reference voltage, the output is driven into …

A positive saturation.
B negative saturation.
C both negative and positive saturation.
D zero saturation. (1)

1.12 The frequency response range that occurs between the lower and upper frequencies in the frequency response curve of amplifiers is called …

A midrange frequency.
B critical frequency.
C distortion.
D decibel. (1)

1.13 Correct biasing method for a transistor amplifier requires the base-emitter junction to be … biased.

A reverse biased and the collector-base junction is forward
B forward biased and the collector-base junction is reverse
C reverse biased and collector-base junction is reverse
D forward biased and the collector-base junction is forward (1)

1.14 The RF amplifier will amplify …

A a single band of frequencies.
B all frequencies.
C DC signals.
D All of the above. (1)

1.15 Coupling capacitors …

A let through AC signals but block DC.
B let through DC signals but block AC.
C let through AC and DC signals.
D block AC and DC signals. (1)

[15]

QUESTION 2: OCCUPATIONAL HEALTH AND SAFETY (GENERIC)

2.1 State TWO factors needed to ensure a strong work ethic in a company. (2)

2.2 Define a *critical incident* in a workshop. (2)

2.3 Name ONE safety precaution you would observe when handling concentrated chemicals in a Printed Circuit Board (PCB) workstation. (1)

2.4 Differentiate between an *unsafe act* and a *calculated risk* in a workshop. (2)

2.5 Explain why you must protect yourself when helping a person who is being shocked by electricity. (1)

2.6 Explain why a person should not interfere with, or misuse, equipment in the workshop that is provided for health and safety. (2)

[10]

QUESTION 3: RLC CIRCUITS (GENERIC)

3.1 Define *inductive reactance* with reference to RLC circuits. (2)

3.2 Draw a full, labelled cycle of the waveforms representing the phasor diagram in FIGURE 3.2.

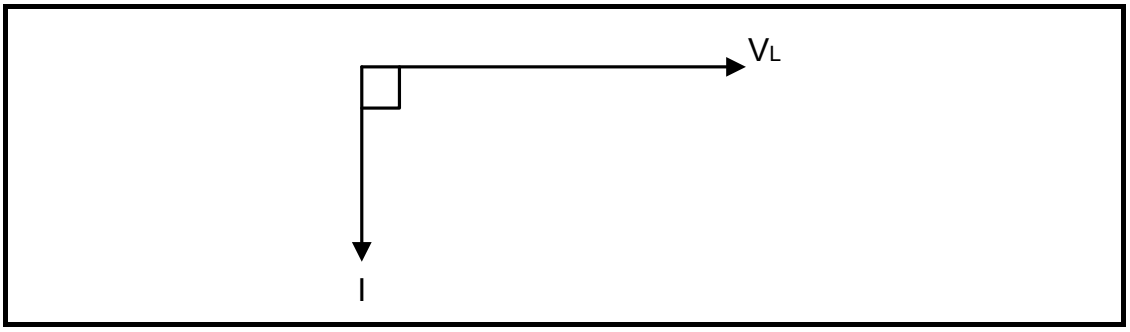

FIGURE 3.2: VOLTAGE AND CURRENT PHASOR DIAGRAM (3)

3.3 A series RLC circuit has a resistor of unknown value, a capacitor with a capacitance of 200 µF and an inductor with a reactance of 31,55 Ω connected to a 110 V/60 HZ AC supply. The impedance of the circuit is 101,65 Ω.

Given:

$C = 200\ \mu F$
$X_L = 31{,}55\ \Omega$
$V_S = 110\ V$
$f = 60\ Hz$
$Z = 101{,}65\ \Omega$

Calculate:

3.3.1 The capacitive reactance (3)

3.3.2 The current flowing through the circuit (3)

3.3.3 The value of the resistor in the circuit (3)

3.3.4 The inductance of the inductor (3)

3.4 A coil with a negligible resistance has an inductance of 50 mH and is connected in series with a 60 µF capacitor and a 100 Ω resistor. The circuit is connected to a 220 V supply with a variable frequency.
Calculate the resonant frequency of the circuit. (3)

Given:

$L = 50\ mH$
$C = 60\ \mu F$
$V_S = 220\ V$

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

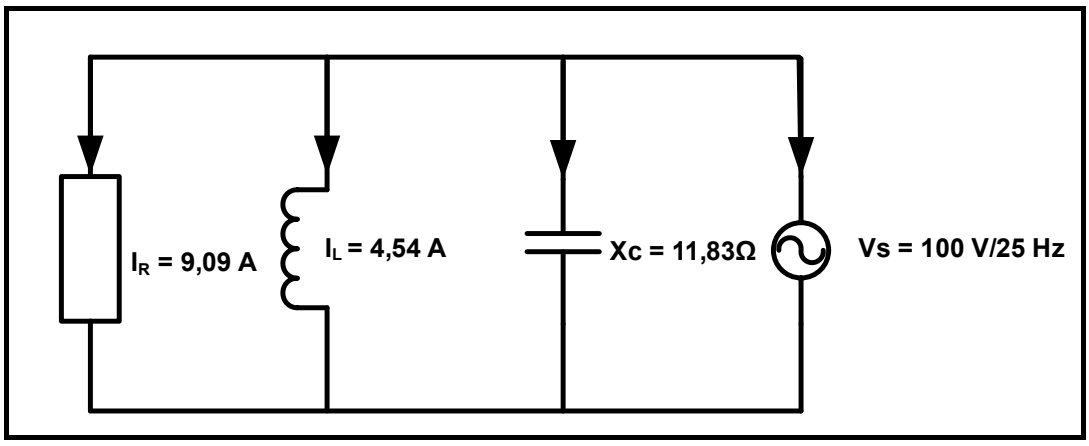

FIGURE 3.5: PARALLEL RLC CIRCUIT

Given:

I_R = 9,09 A
I_L = 4,54 A
X_C = 11,83 Ω
V_S = 100 V
f = 25 Hz

Calculate:

3.5.1 The current flowing through the capacitor (3)

3.5.2 The total current flowing through the circuit (3)

3.5.3 The power factor (3)

3.5.4 State, with a reason, whether the current is leading or lagging the voltage (2)

3.6 Define *selectivity* of a resonant circuit. (2)

3.7 Name TWO factors that determine the *quality factor(Q)* of a resonant circuit. (2)

[35]

QUESTION 4: SEMICONDUCTOR DEVICES (SPECIFIC)

4.1 Draw a neatly labelled symbol of an N-channel JFET. (3)

4.2 FIGURE 4.2 below shows a cross-section of the construction of an enhancement mode MOSFET. Answer the questions that follow.

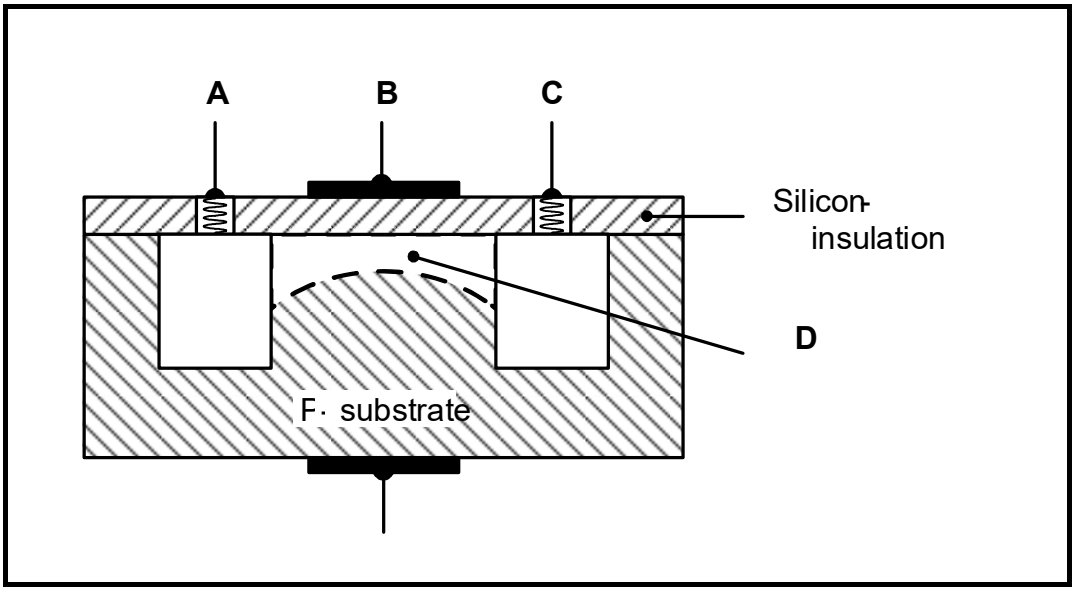

FIGURE 4.2: ENHANCEMENT MODE MOSFET

4.2.1 Label **A**, **B**, **C** and **D**. (4)

4.2.2 Indicate whether the enhanced channel consists of P-type or N-type material. (1)

4.3 Refer to the UJT and explain the term *cut off*. (4)

4.4 Draw a fully labelled circuit diagram of the Darlington pair. (5)

4.5 Refer to FIGURE 4.5 of an ideal op-amp below and answer the questions that follow.

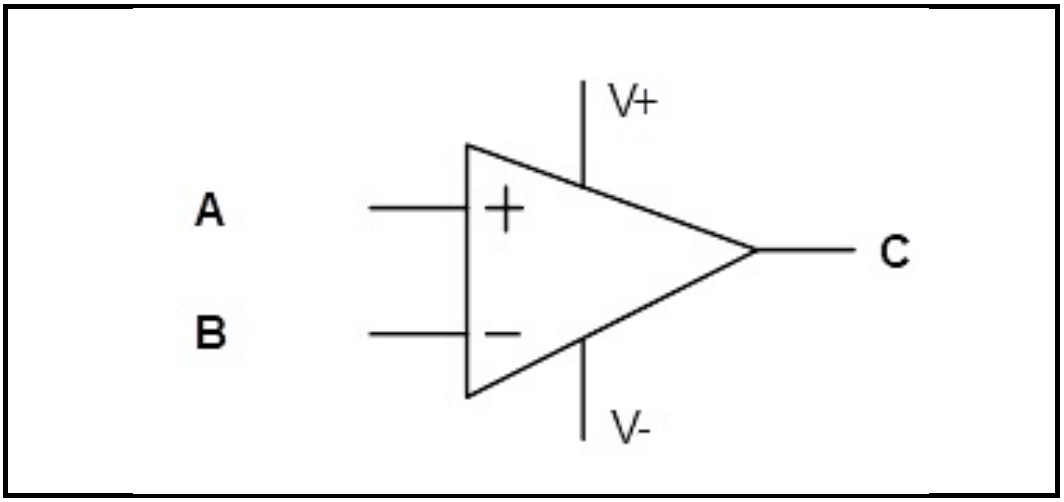

FIGURE 4.5: OP-AMP

4.5.1 Label points **A**, **B** and **C**. (3)

4.5.2 Explain what makes the op-amp ideal to amplify alternating voltages. (2)

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

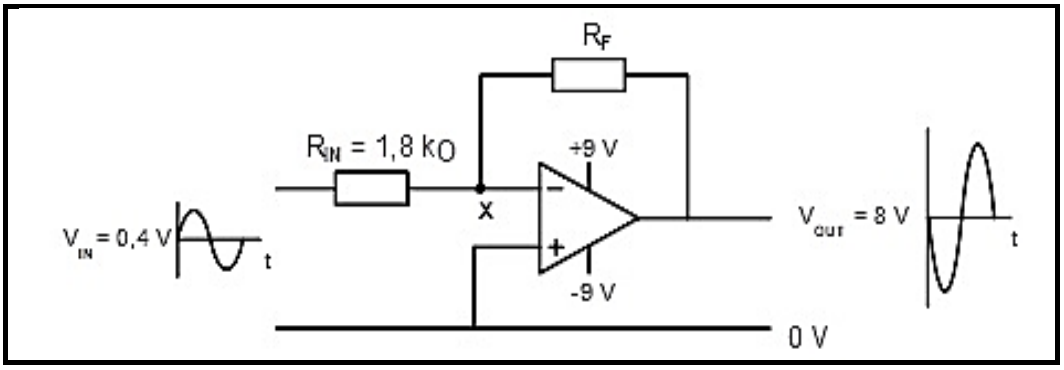

FIGURE 4.6: OP-AMP

4.6.1 Identify the above circuit diagram. (1)

4.6.2 Calculate the value of feedback resistor R_F. (3)

4.7 Explain how a 100 mV sine wave signal would react if the gain of the circuit is 10 and the signal is connected to the ...

4.7.1 inverting input of the component. (3)

4.7.2 non-inverting input of the component. (3)

4.8 Describe the advantages of using negative feedback in an op-amp. (4)

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

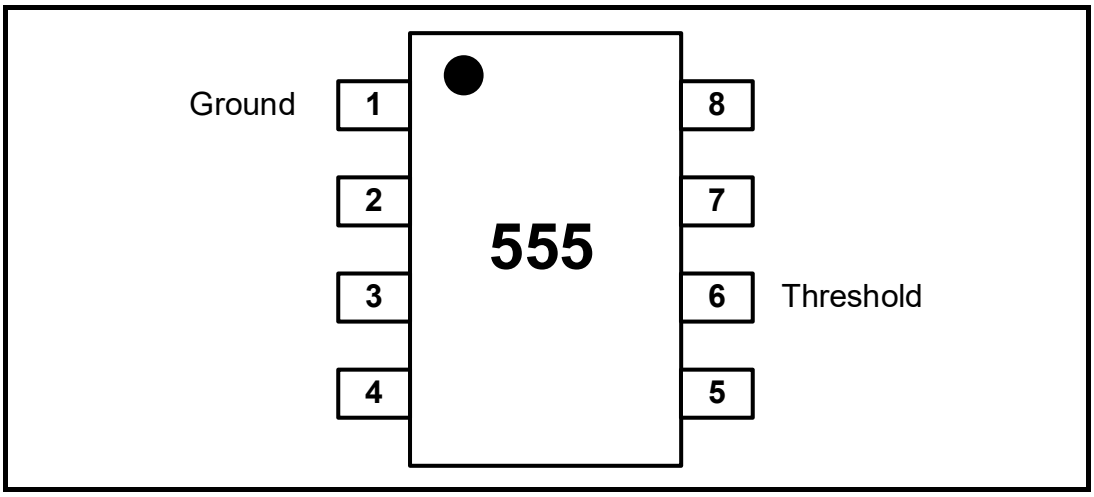

FIGURE 4.9

4.9.1 Label pins **2**, **3**, **5** and **8**. (4)

4.9.2 Explain the function of pin 6. (3)

4.9.3 State the supply voltage range at which the 555 IC operates. (2)

[45]

QUESTION 5: SWITCHING CIRCUITS

5.1 Name the type of the multivibrator that:

5.1.1 Produces one pulse cycle of 'high' and low' when a trigger pulse is applied (1)

5.1.2 Changes state when a trigger pulse is applied and remains in that state (1)

5.2 Draw a circuit diagram of an astable multivibrator. (5)

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

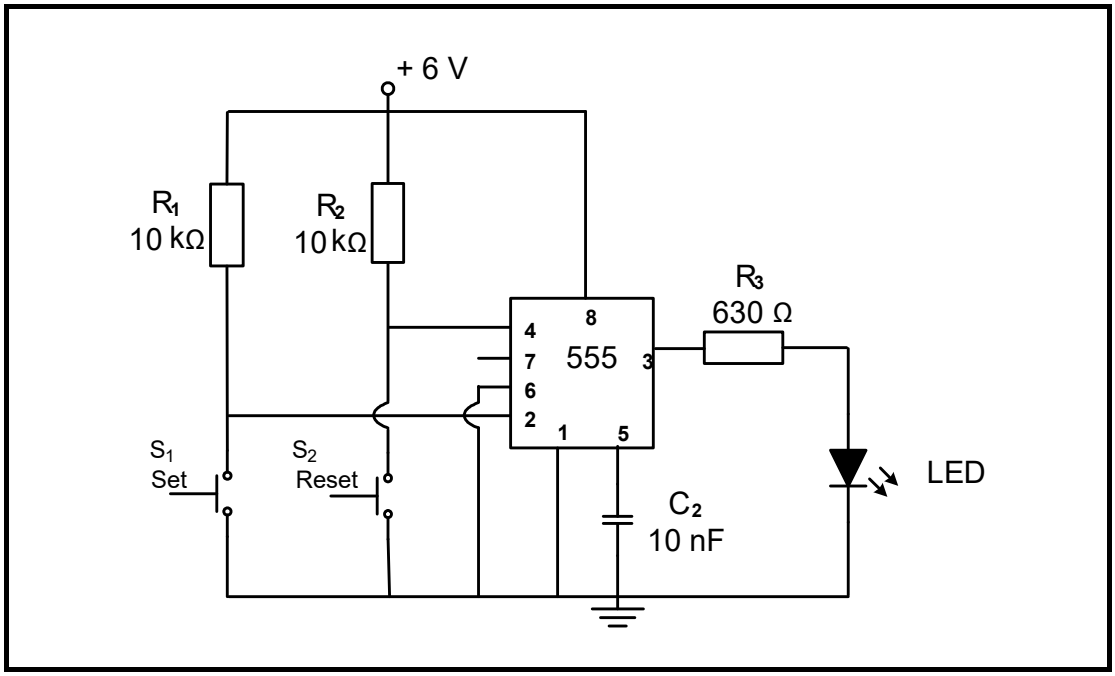

FIGURE 5.3: MULTIVIBRATOR

5.3.1 Identify the above multivibrator. (2)

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

5.3.3 Describe what happens when the set switch, S_1, is pressed. (3)

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

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

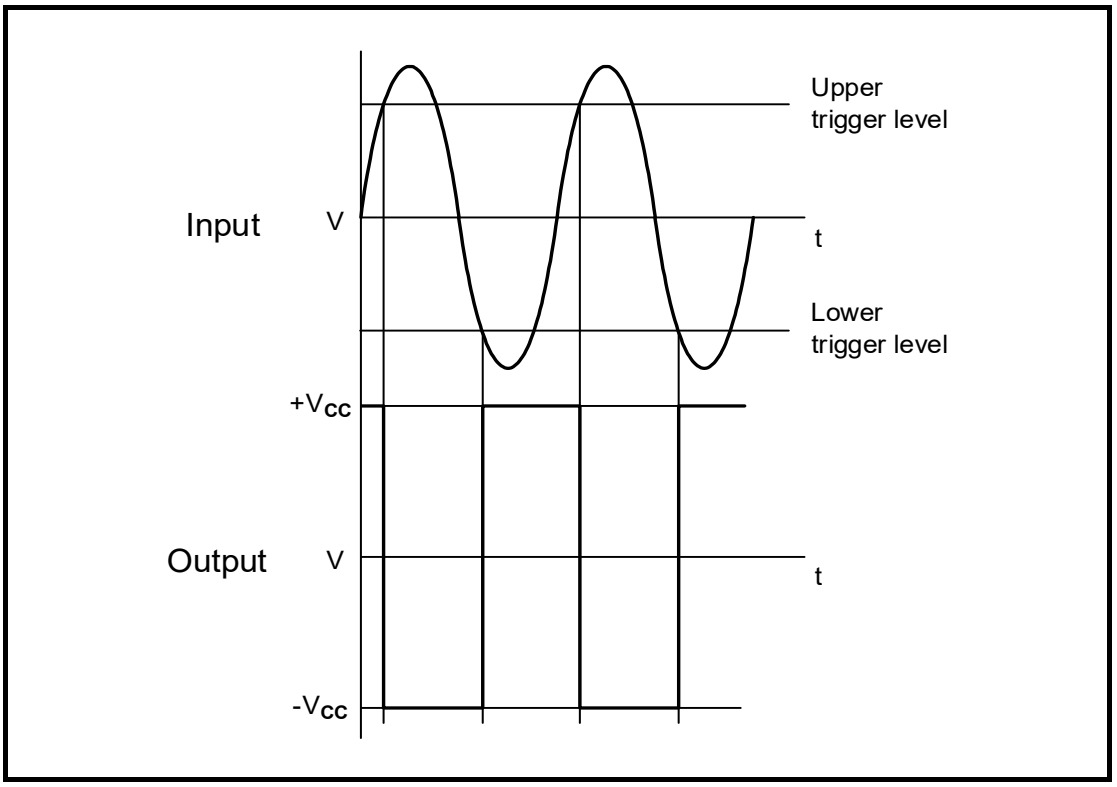

FIGURE 5.4: SCHMITT TRIGGER INPUT AND OUTPUT

5.4.1 State whether the output signal represents an inverting or a non-inverting Schmitt trigger. Motivate your answer. (3)

5.4.2 Draw the circuit diagram of the Schmitt trigger consisting of two resistors and a 741 op-amp that will produce the output signal in FIGURE 5.4. (7)

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

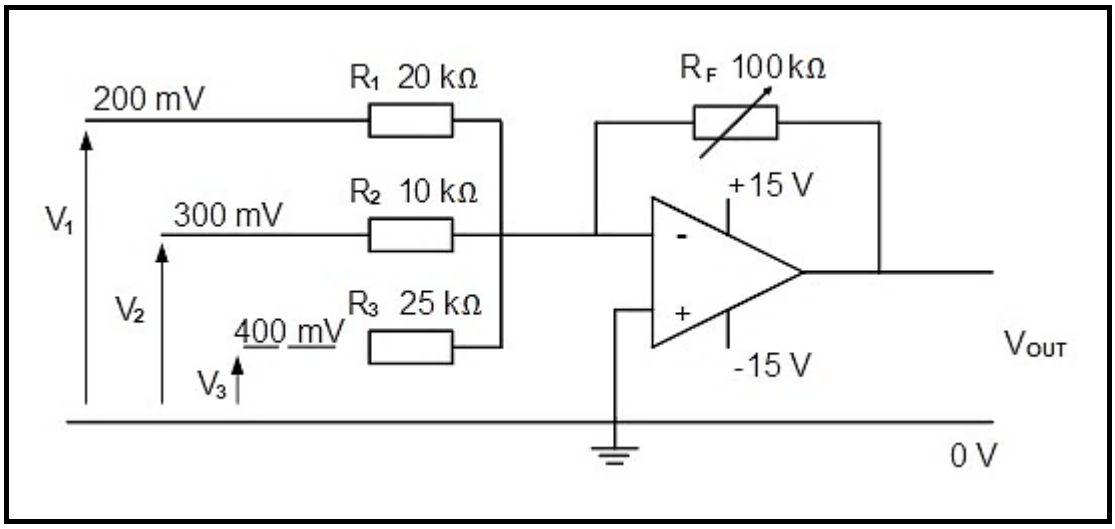

FIGURE 5.5: INVERTING SUMMING AMPLIFIER

Given:

V_1 = 200 mV
V_2 = 300 mV
V_3 = 400 mV
R_F = 100 kΩ
R_1 = 20 kΩ
R_2 = 10 kΩ
R_3 = 25 kΩ

5.5.1 Describe how the gain of this amplifier can be determined. (3)

5.5.2 Calculate the output voltage of the amplifier. (4)

5.5.3 Calculate the gain of the amplifier using voltage values. (3)

5.5.4 Explain the advantage of using a variable resistor in the feedback loop instead of a fixed resistor. (2)

5.5.5 What will happen to the output voltage if the value of R_2 is changed to 5 kΩ? (2)

5.6 Draw a circuit diagram of an op-amp integrator with input and output signals. (6)

5.7 Name THREE key operating points of the op-amp integrator circuit. (3)
[50]

QUESTION 6: AMPLIFIERS

6.1 Refer to FIGURE 6.1 below and answer the questions that follow.

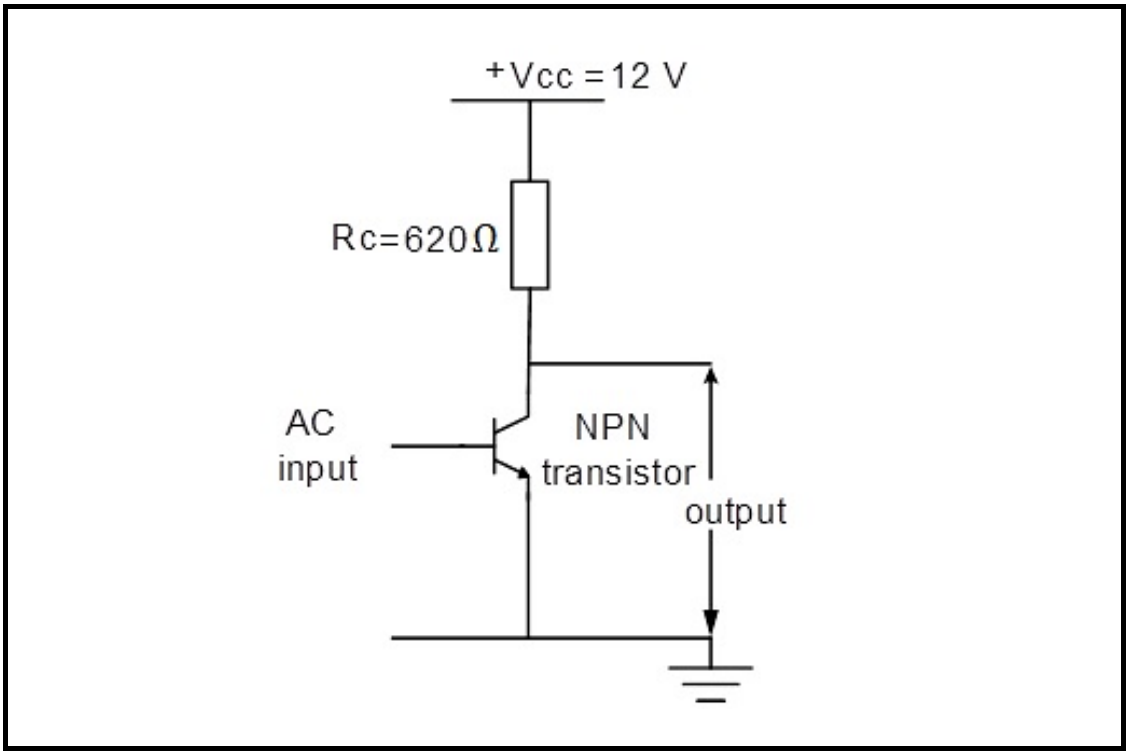

FIGURE 6.1: BIASED NPN TRANSISTOR

6.1.1 Determine V_{ce} for the circuit when it is at rest. (1)

6.1.2 Calculate the maximum collector current that can flow in the circuit. (3)

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

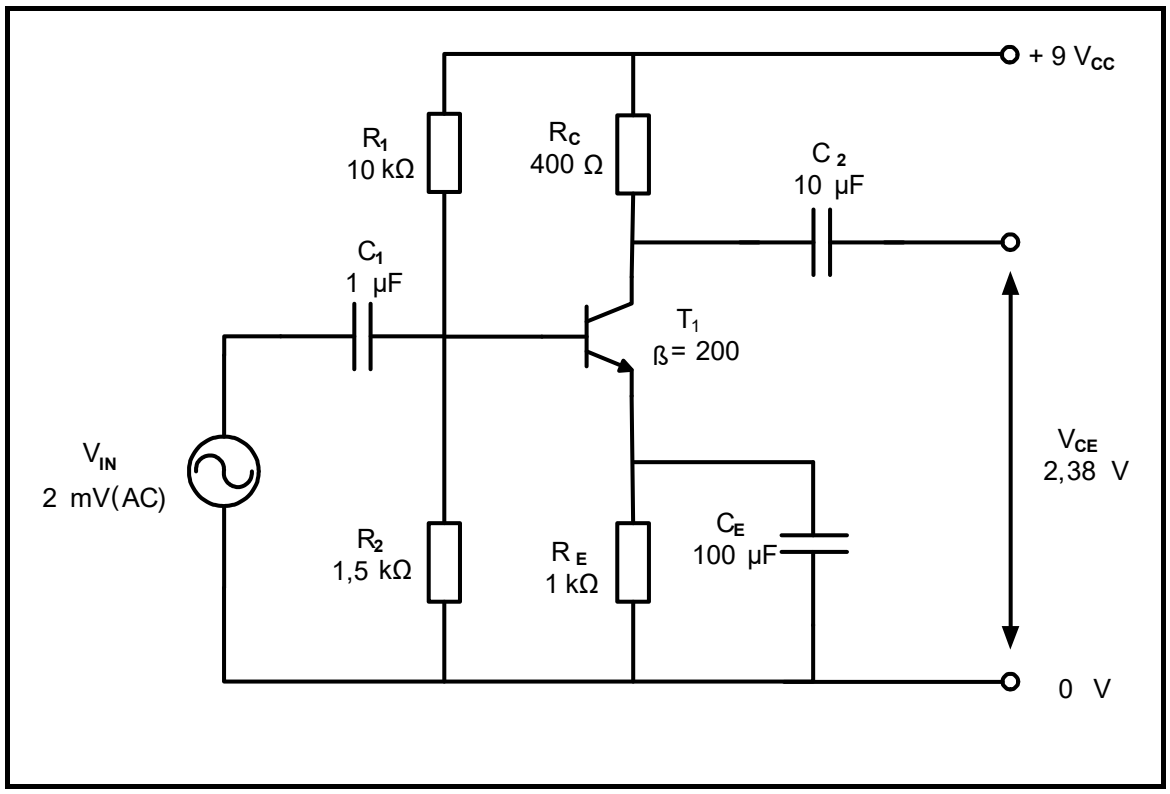

FIGURE 6.2: AMPLIFIER CIRCUIT DIAGRAM

6.2.1 Identify the amplifier in FIGURE 6.2. (1)

6.2.2 Describe the biasing method for Class A amplification. (4)

6.2.3 Determine the voltage drop across R_c. (3)

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

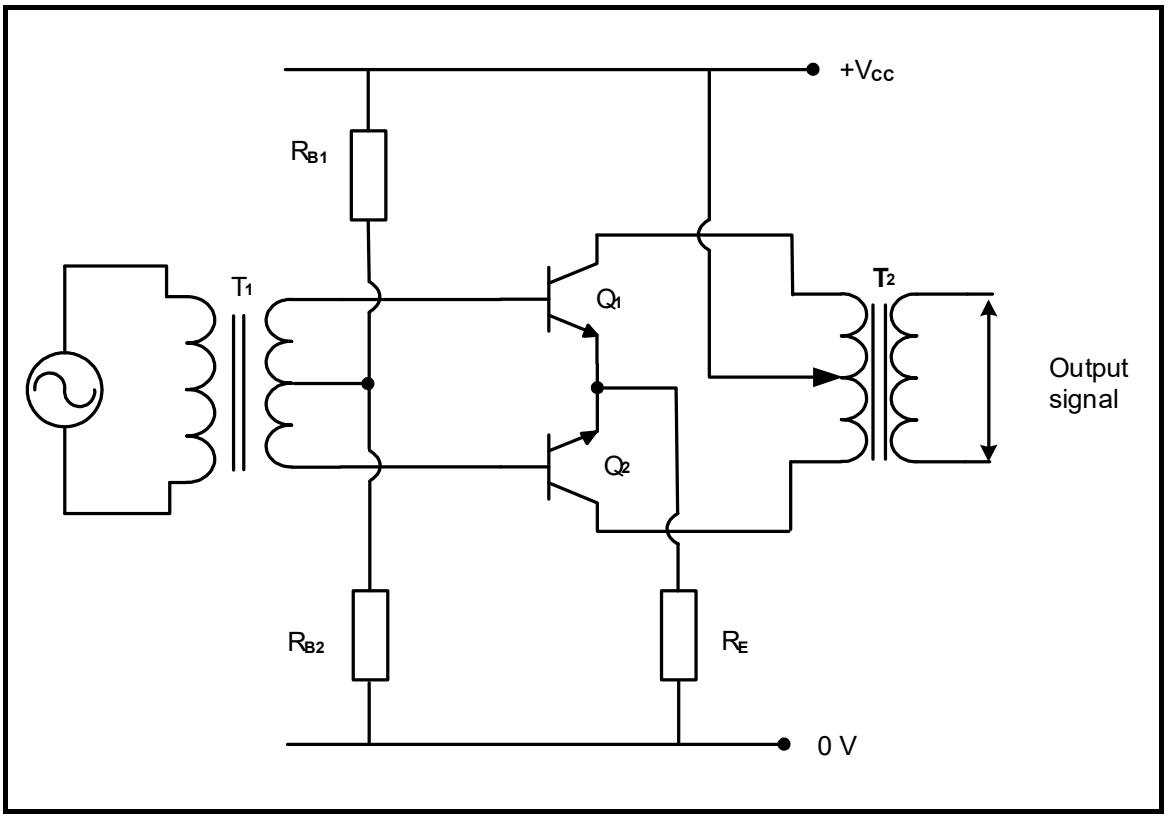

FIGURE 6.3: AMPLIFIER CIRCUIT DIAGRAM

6.3.1 Identify the amplifier circuit in FIGURE 6.3. (1)

6.3.2 Name the type of transistor used in the circuit. (1)

6.4 A push-pull amplifier circuit has the following information:

Given:

Input power = 750 mW
Output power = 28 W
Input voltage = 230 V
Output voltage = 219 V
Input current = 3,6 mA
Output current = 15,3 mA
Output impedance = 40 Ω

Calculate the following:

6.4.1 Current gain in dB (3)

6.4.2 Voltage gain in dB (3)

6.4.3 Power gain in dB (3)

6.5 Draw a circuit diagram of a complementary push-pull pair amplifier. (5)

6.6 Refer to FIGURE 6.6 below of a radio-frequency amplifier.

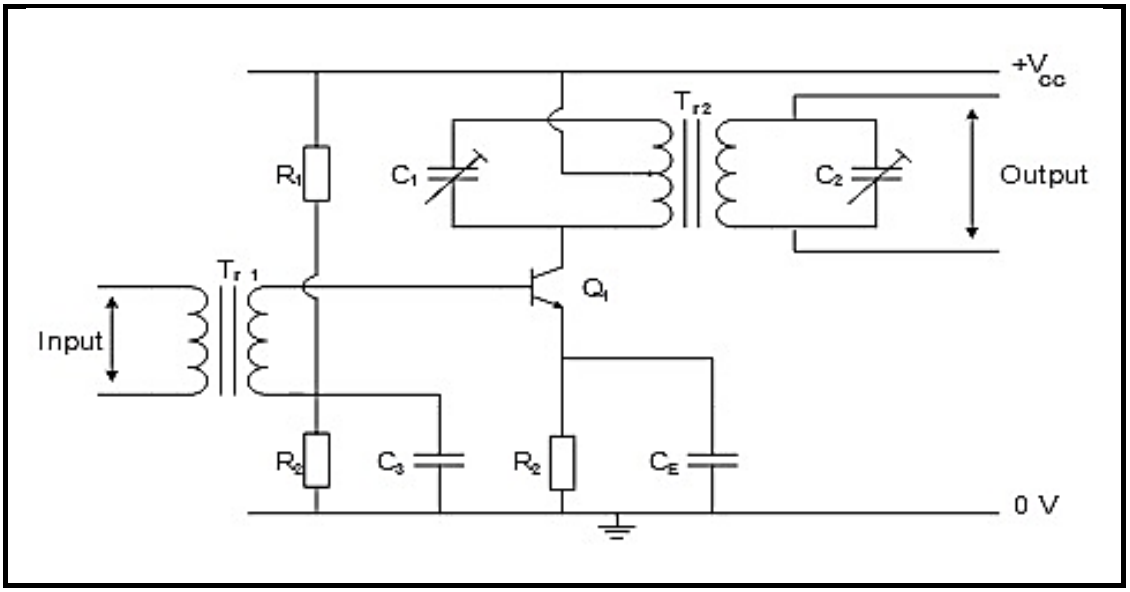

FIGURE 6.6: RADIO-FREQUENCY AMPLIFIER

Draw a fully labelled frequency response curve of the RF-coupled amplifier. (4)

6.7 Refer to FIGURE 6.7 below of an RC-phase shift oscillator using FET and answer the questions that follow.

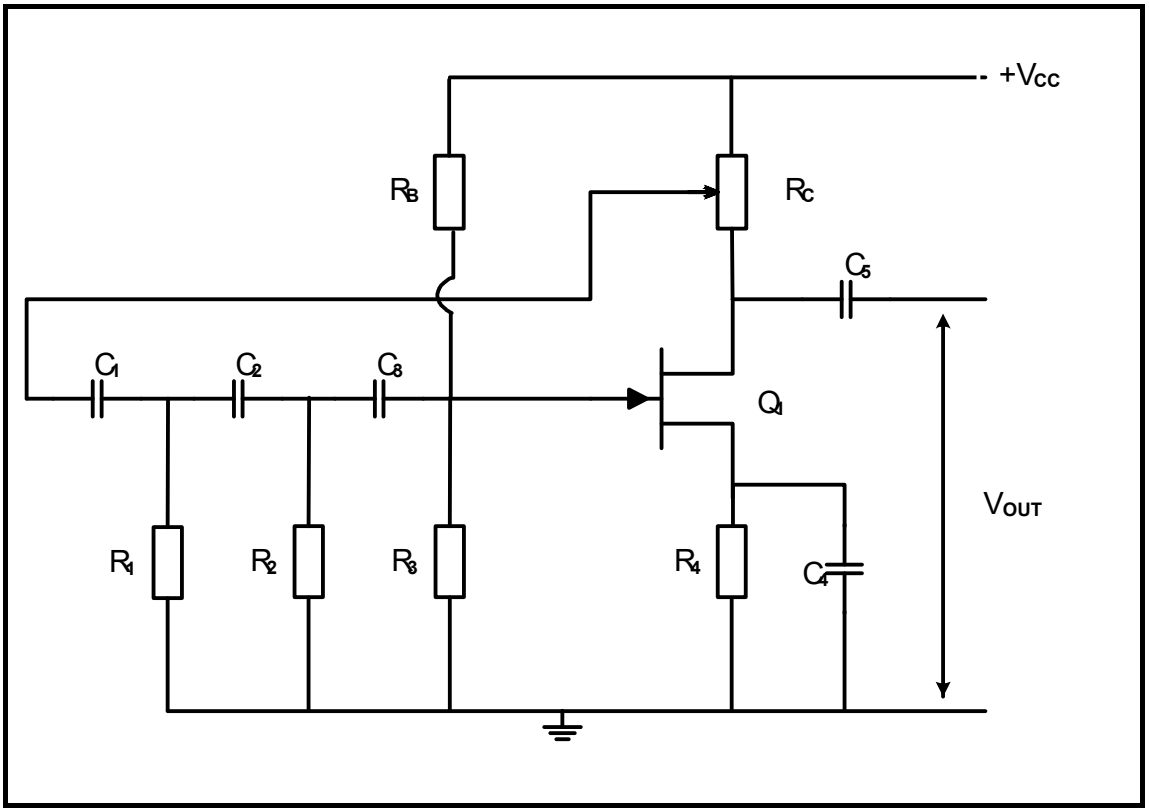

FIGURE 6.7: RC-PHASE SHIFT OSCILLATOR

6.7.1 Define the term *oscillator*. (2)

6.7.2 Describe how the RC-phase shift oscillator achieves its phase shift of 360° during its operation. (4)

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

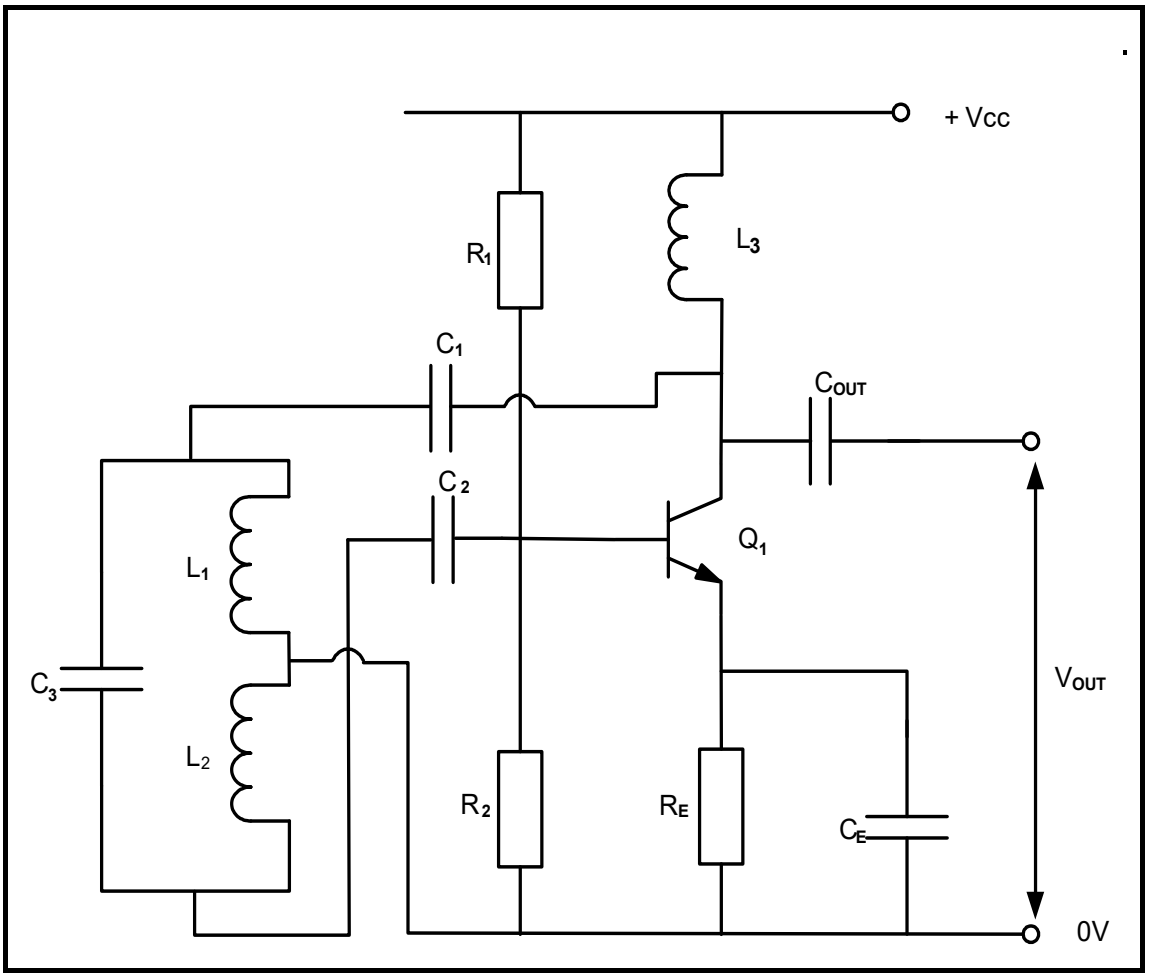

FIGURE 6.8: OSCILLATOR CIRCUIT DIAGRAM

6.8.1 Identify the oscillator in FIGURE 6.8. (1)

6.8.2 Discuss how oscillation is achieved in this circuit. (6)

[45]

TOTAL: 200

FORMULA SHEET

RLC CIRCUIT

$$XL = 2\pi FL \; and \; XC = \frac{1}{2\pi FC}$$

SERIES

$I_T = I_R = I_C = I_L$

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

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

$VL = IX_L$ and $Vc = IX_C$ and $V_T = IZ$

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

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

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

PARALLEL

1. $VT = V_R = V_L = V_C$
2. $I_R = \frac{V}{R} = and \; I_L = \frac{V}{X_L} = I_C = \frac{V}{X_C}$
3. $I_T = \sqrt{I_R{}^2 + (I_L - I_C)^2}$
4. $COS\theta = \frac{I_R}{I_T}$
5. $Q = \frac{X_L}{Z} = \frac{X_C}{Z} = \frac{V_L}{V_S} = \frac{1}{R} = \sqrt{\frac{L}{C}}$

SEMI-CONDUCTORS DEVICES

$A_V = \frac{Vout}{Vin} = \frac{R_F}{R_{IN}}$

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

$A_V = 1 + \frac{R_F}{R_{IN}}$

$V_{OUT} = V_{IN}\,(1 + \frac{R_F}{R_{IN}})$

$\beta_{super} = \beta_1 \times \beta_2$

AMPLIFIERS

$V_{CE} = V_{CC}$

$I_{Cmax} = \frac{V_{CC}}{R_C}$

$A' = \frac{A}{1+\beta A}$

$$Power\ Gain\ \ A_P = log_{10}\left(\frac{P_{out}}{P_{in}}\right)$$

$A_V = 20\ log_{10}\frac{E_{out}}{E_{in}}$ dB

$A_I = 20\ log_{10}\frac{I_{out}}{I_{in}}$

$F_0 = \frac{1}{2\pi\sqrt{L_T C}}$

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

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

SWITCHING CIRCUITS

1. $\text{Gain A}_V = \frac{V_{OUT}}{V_{IN}} = -\left(\frac{R_f}{R_{in}}\right)$ inverting operational amplifier

2. $\text{Gain A}_V = \frac{V_{OUT}}{V_{IN}} = 1 + \left(\frac{R_f}{R_{in}}\right)$ non-inverting operational amplifier

3. $V_{OUT} = V_{IN} \times \left(-\frac{R_f}{R_{in}}\right)$ inverting amplifier

4. $V_{OUT} = -(V_1 + V_2 + V_3)$ summing up op-amp

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

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