basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

SENIOR CERTIFICATE EXAMINATIONS/ NATIONAL SENIOR CERTIFICATE EXAMINATIONS

ELECTRICAL TECHNOLOGY: ELECTRONICS

MAY/JUNE 2024

MARKING GUIDELINES

MARKS: 200

These marking guidelines consist of 14 pages.

INSTRUCTIONS TO THE MARKERS

1. All questions with multiple answers imply that any relevant, acceptable answer should be considered.

2. Calculations:

   2.1 All calculations must show the formulae.

   2.2 Substitution of values must be done correctly.

   2.3 All answers MUST contain the correct unit to be considered.

   2.4 Alternative methods must be considered, provided that the correct answer is obtained.

   2.5 Where an incorrect answer could be carried over to the next step, the first answer will be deemed incorrect. However, should the incorrect answer be carried over correctly, the marker has to re-calculate the values, using the incorrect answer from the first calculation. If correctly used, the candidate should receive the full marks for subsequent calculations.

3. This memorandum is only a guide with model answers. Alternative interpretations must be considered and marked on merit. However, this principle should be applied consistently throughout the marking session at ALL marking centres.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

1.1	D ✓	(1)
1.2	C ✓	(1)
1.3	C ✓	(1)
1.4	B ✓	(1)
1.5	B ✓	(1)
1.6	C ✓	(1)
1.7	C ✓	(1)
1.8	D ✓	(1)
1.9	A ✓	(1)
1.10	C ✓	(1)
1.11	B ✓	(1)
1.12	C ✓	(1)
1.13	B ✓	(1)
1.14	C ✓	(1)
1.15	D ✓	(1) **[15]**

QUESTION 2: OCCUPATIONAL HEALTH AND SAFETY

2.1 Failure to use safety equipment.✓
Tampering or misusing safety equipment. ✓
Wilfully or recklessly operating machinery that threatens the health of the user. (2)

2.2 Furnishing false information to the inspector. ✓
Failure to comply with any performance or safety requirements made by the inspector. ✓
Obstructing the inspector in the performance of his/her duties. (2)

2.3 Manufacturers who design and manufacture articles for the use in industry must ensure that the product is safe to use ✓ and the information and processes for the use of the artefact manufactured is clear ✓ and would assist with safe operation of the artefact. (2)

2.4 It is an event that is not expected ✓ that would not require calling for outside emergency assistance. ✓ (2)

2.5 It can cause the heart muscle to contract so strongly✓ leading to heart failure. ✓ (2)
[10]

QUESTION 3: RLC CIRCUITS

3.1 Reactance is the opposition offered to the flow of alternating current ✓by an inductor or capacitor ✓ in an AC circuit.
Reactance is the ratio of voltage to current in an alternating circuit when voltage and current are not in phase. (2)

3.2 3.2.1 The circuit is predominantly capacitive ✓ because V_C is greater than V_L. ✓ (2)

3.2.2

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

$$= \sqrt{18^2 + (15 - 10)^2}$$ ✓

$$= 18{,}68\ V$$ ✓ (3)

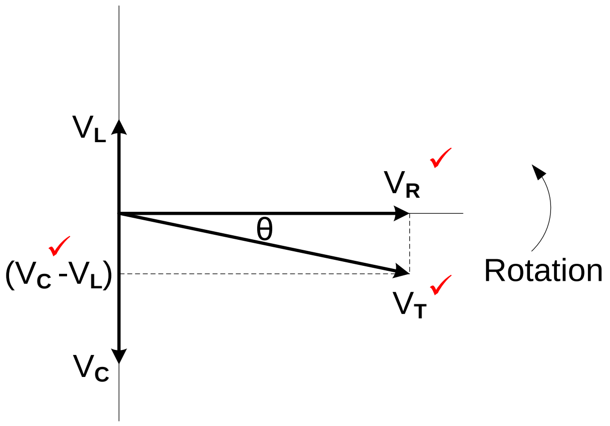
3.2.3

$$Cos\theta = \frac{V_R}{V_T}$$ ✓

$$\theta = Cos^{-1}\left(\frac{18}{18{,}68}\right)$$ ✓

$$= 15{,}51^{\circ}$$ ✓ (3)

3.2.4



NOTE: If I_T is indicated in the place of V_R, a mark will be awarded.
If the phase angle is correctly indicated in the place of (V_C-V_L) a mark will be awarded. (3)

3.2.5 The supply current (I_T) and the voltage across the resistance (V_R) are always in-phase ✓ and V_R is leading V_T, ✓ therefore it is safe to assume that I_T is also leading V_T by the same angle.
In a capacitive circuit the supply current will always lead the supply voltage. (1 mark) (2)

3.3 3.3.1

$$I_L = \frac{V_T}{X_L}$$ ✓

$$= \frac{230}{62,83}$$ ✓

$$= 3,66\ A$$ ✓

(3)

3.3.2

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

$$= \sqrt{1,15^2 + (3,66 - 1,59)^2}$$ ✓ ✓

$$= 2,37\ A$$

(3)

3.3.3

$$Cos\theta = pf$$

$$Cos\theta = \frac{I_R}{I_T}$$ ✓

$$= \frac{1,15}{2,37}$$ ✓

$$= 0,49$$ ✓

(3)

3.3.4 At resonance X_L=X_C, Therefore ✓

$$X_C = \frac{1}{2\pi f C}$$ ✓

$$C = \frac{1}{2\pi f X_C}$$

$$= \frac{1}{2\pi(50)(62,83)}$$ ✓

$$= 50,66\ \mu F$$ ✓

(4)

3.4 3.4.1 A decrease in resistance increases the Q factor. ✓ (1)

3.4.2

$$Q = \frac{X_L}{R}$$ ✓

$$= \frac{2000}{50}$$ ✓

$$= 40$$ ✓

(3)

3.4.3

$$f_r = \frac{f_1 + f_2}{2}$$ ✓

$$= \frac{1200 + 2100}{2}$$ ✓

$$= 1650\ Hz$$ ✓

(3)
[35]

QUESTION 4: SEMICONDUCTOR DEVICES

4.1 P-channel ✓ JFET ✓ transistor. (2)

4.2 4.2.1 Depletion regions.✓ (1)

4.2.2 When the gate-source voltage increases, the depletion regions on either side of the conducting channel widens ✓ to meet at the centre of the bar, pinching off (clamping) the current flow, ✓ resulting in the reduction of current. ✓ (3)

4.2.3 During the operation, the conductive channel is depleted ✓ of charge carriers. ✓ (2)

4.2.4 It makes use of one type of current charge carrier ✓ at a time. ✓ (2)

4.3 4.3.1 Enhancement ✓ mode (1)

4.3.2 A - Silicon dioxide insulation.✓
B - Enhanced channel.✓ (2)

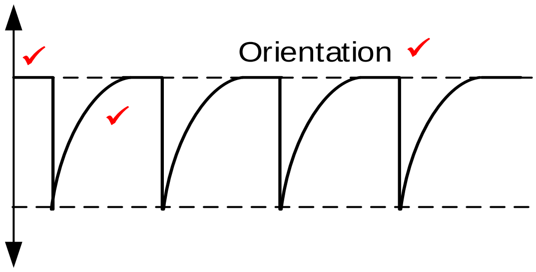
4.3.3 When positive voltage is applied to the gate terminal, negative charge carriers will be attracted from the source and drain regions ✓ creating a conductive channel between the source and the drain ✓ through which current can flow. ✓ (3)

4.4 Junction Field Effect Transistor (JFET) operates in depleted mode ✓ whilst the Metal Oxide Semiconductor Field Effect Transistor (MOSFET) operates in either depleted ✓ or enhancement mode.✓ (3)

4.5 4.5.1 R_1 protects the UJT by limiting the discharge current to a safe value. ✓
R_1 also produces a voltage spike across itself each time the UJT fires (1)

4.5.2 When a negative pulse is applied to the emitter, the pn junction is reverse biased ✓and the emitter current is cut off and the UJT is said to be in the OFF state.✓ (2)

4.5.3



(3)

4.6 4.6.1 Positive. ✓
In-phase (1)

4.6.2 Zero. ✓ (1)

4.7 4.7.1 Op-amps are not frequenctly used in an open loop mode because of their very high gain ✓ which creates poor stability of the output voltage. ✓ (2)

4.7.2 The bandwidth refers to the band of frequencies ✓ where an op amp is able to amplify an input signal without distortion. ✓

OR

It means the range of input signal frequencies the device can operate on without the output waveform being distorted. (2)

4.7.3

$$V_{out} = V_{IN} \times (-\frac{R_F}{R_{IN}})$$ ✓

$$= 60 \times 10^{-3} \times \left(-\frac{10 \times 10^3}{1 \times 10^3}\right)$$ ✓

$$= -0{,}6V$$ ✓

$$= -600\ mV$$ (3)

4.8

$$R_f = R_{IN}\left(\frac{Vout}{V_{in}} - 1\right)$$ ✓

$$= 2 \times 10^3 \left(\frac{4}{0{,}5}\right) - 1$$ ✓

$$= 15\,999\,\Omega$$

$$= 16\ k\Omega$$ ✓ (3)

4.9 4.9.1 Discharge pin.✓ (1)

4.9.2
- Pulsewidth modulator✓
- Linear ramp generator (1)

4.9.3 Pin 4 is the reset input for the flip-flop and as soon as the reset pin is 0 V, the 555 IC will discharge through the transistor, ✓ and the output pin 3 will be low ✓

OR

(The reset pin 4 is used to reset the IC i.e it causes the output to return to zero volts if it is connected to zero volts). (2)

4.9.4
- Monostable ✓
- Bistable ✓
- Astable Mode (2)

4.9.5 The pin sets the voltage at which a 555 IC will trigger. ✓ It is used to maintain the voltage across the timing capacitor ✓ which is discharged with the help of pin 7. (2)

[45]

QUESTION 5: SWITCHING CIRCUITS

5.1 In electronic circuits, the pulses created by switch bouncing will be interpreted as information which may give a wrong output. ✓ (1)

5.2 5.2.1 Feedback is when a fraction of the output voltage ✓ is fed from the voltage divider R_2 and R_3 to the non-inverting input. ✓ (2)

5.2.2 When a positive trigger pulse is applied to the input, both plates ✓ of the capacitor immediately rise to the applied voltage.✓ (2)

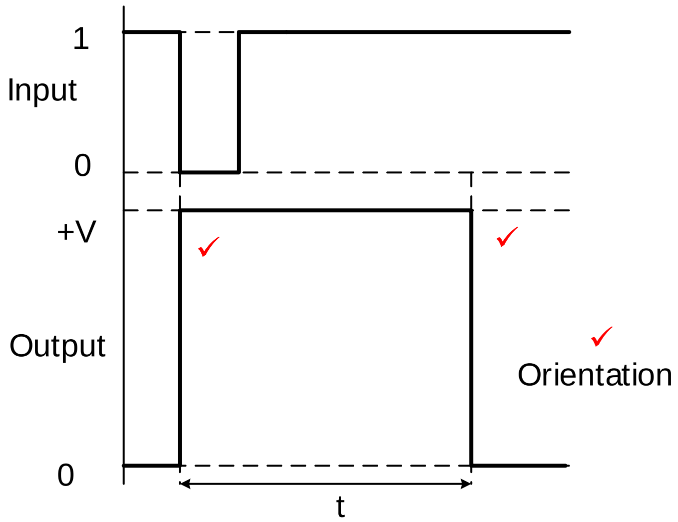
5.2.3 When a negative trigger (reset) pulse is applied to the input, the op-amp compares the two voltages at its two input terminals. ✓ When the voltage on the inverting input becomes more negative ✓ than the voltage on the non-inverting input the output goes high ($+V_{SAT}$) where it will remain.✓ (3)

5.2.4 Trigger pulse 2 is positive, ✓ and the voltage on the non-inverting input is negative. ✓ The circuit will only change state when a voltage which is more negative ✓ than the voltage present on the non-inverting input is applied to the inverting input. (3)

5.3 5.3.1 Monostable multivibrator.✓ (1)

5.3.2 Resistor R_2 keeps pin 2 high ✓ keeping the monostable circuit in its steady state.✓ (2)

5.3.3



(3)

5.3.4 6 V, ✓ the circuit will return to its resting state when capacitor C_1 charges up to ⅔ V_{CC}.✓ (2)

5.4 5.4.1 The output of the circuit changes state continually because both trigger pin 2 ✓ and threshold pin 6 ✓ are connected to the top of the timing capacitor. This allows the circuit to repeatedly reset and trigger ✓ as the capacitor charges and discharges to ⅔ and ⅓ of the supply voltage ✓ producing a continual stream of high and low pulses at its output. (4)

5.4.2 Pulse t_1 and t_2 are not equal because the capacitor charges through $R_1 + R_2$ ✓ to the threshold voltage and only discharges through R_1. ✓ (2)

5.4.3

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

$$= \frac{1}{(70 \times 10^{-3} + 69{,}3 \times 10^{-3})} \checkmark$$

$$= 7{,}18\ Hz \checkmark$$

(3)

5.5 5.5.1 $V_{ref} = 4{,}5$ V ✓

Note: $V_{CC} = V_S - V_{R1}$

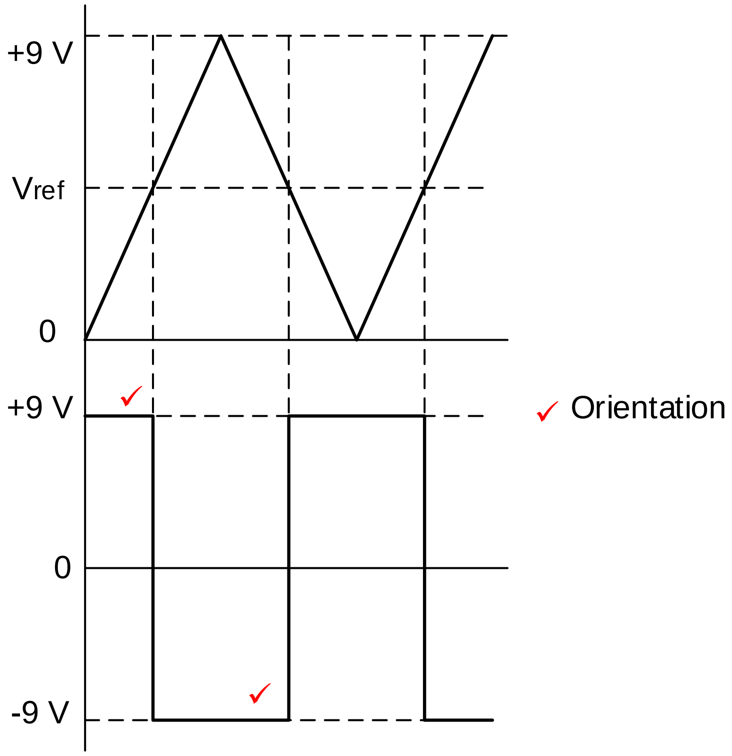
$V_{CC} = 9 - 4{,}5$

$= 4{,}5$ V

(1)

5.5.2 The voltage across R_2 is half of the supply voltage. ✓ For this to happen, $R_1 = R_2 = 2\ 200\ \Omega$. ✓ (2)

5.5.3



(3)

5.5.4 An increase in the value of R_1 means that $R_1 > R_2$ ✓ and will cause the voltage across R_2 to decrease. ✓ (2)

5.6 5.6.1 A summing amplifier makes it possible to feed a number of different signal voltages ✓ into a circuit and provide one output signal ✓ consisting of the sum of all the input signals.✓ (3)

5.6.2

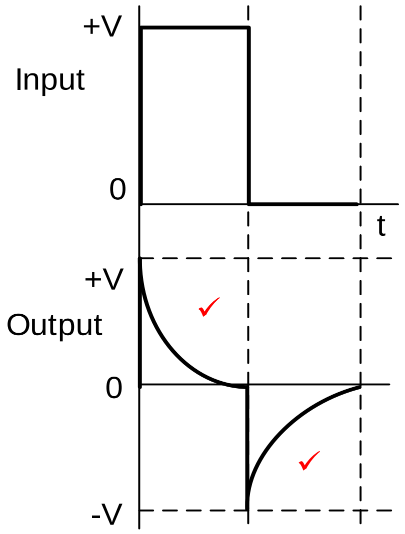
$$V_{OUT} = -\left(V_1\frac{R_F}{R_1} + V_2\frac{R_F}{R_2} + V_3\frac{R_F}{R_3}\right) ✓$$

$$= -\left(0{,}1 \times \frac{33000}{2200} + 0{,}2 \times \frac{33000}{2200} + 0{,}3 \times \frac{33000}{2200}\right) ✓$$

$$= -9\ V ✓$$ (3)

5.6.3 When R_F is set to 2200 Ω the gain of the amplifier is 1 ✓ and the output voltage is the sum of the input voltages. (1)

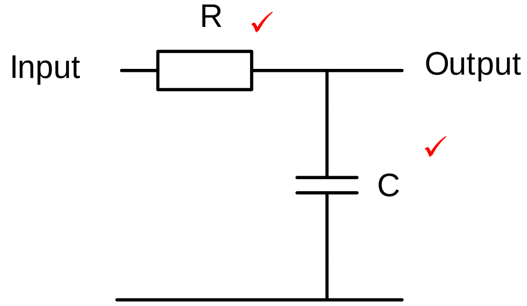
5.7 5.7.1



(2)

5.7.2 When a square wave is applied to the input, both plates of the capacitor immediately charges up to the potential of the input. ✓ The left hand plate of the capacitor is kept at that potential for as long as the square wave is high. ✓ The right hand plate of the capacitor will discharge through the resistor to 0 V ✓ at a rate determined by the RC time constant of the circuit. (3)

5.7.3



(2)
[50]

QUESTION 6: AMPLIFIERS

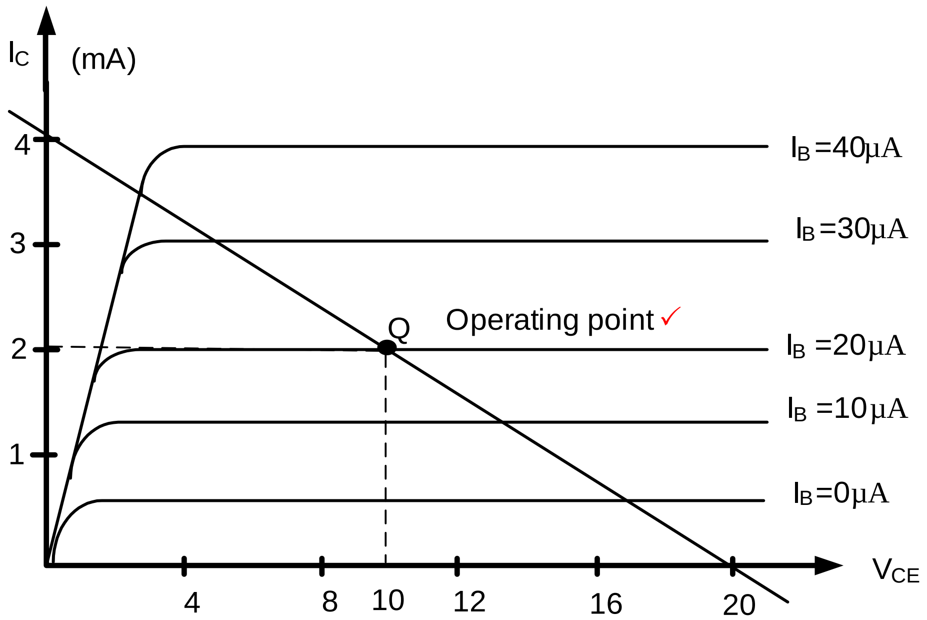
6.1 Stabilisation is the process of making the operating point of the transistor independent of temperature changes ✓ or variations in the transistor parameters. ✓ (2)

6.2 Cross-over distortion is reduced. ✓
Each half circuit is able to amplify the input signal to double its previous size. (1)

6.3 6.3.1 2 mA ✓ (1)

6.3.2 10 V ✓ (1)

6.3.3



(1)

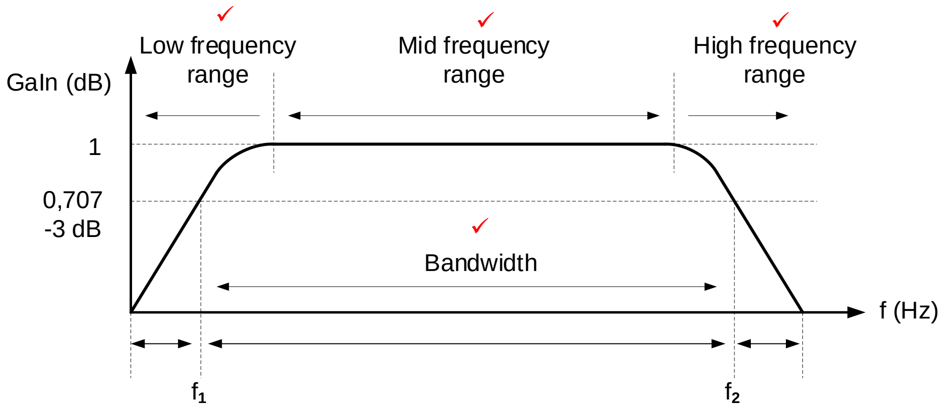
6.3.4 Distortion of the output wavefom will result.✓
Transistor will be damaged due to thermal runaway.✓ (2)

6.4 6.4.1 Unsuitable for low frequency amplification.✓
Low voltage and power gain as the effective load resistance is reduced. (1)

6.4.2 When the temperature increases, more leakage current caused by the flow of the minority charge carriers in the reverse biased base-collector junction will result in thermal runaway, ✓ which will destroy the transistor in time. ✓ (2)

6.4.3 The RC-coupled network blocks DC (low frequency) ✓ while allowing higher frequencies to pass ✓ and can be regarded as a low frequency filter. (2)

6.4.4



(4)

6.5 6.5.1
- Poor frequency response.✓
- Tend to saturate at high audio frequencies.
- Low frequencies receive less amplification than high frequencies. (1)

6.5.2 For maximum power transfer to the speaker.✓ (1)

6.5.3 C_1 allows ac signal to pass through ✓ and blocks DC signals. ✓ (2)

6.5.4 The transistor has been connected in common emitter mode ✓ and because of the impedance matching of the transformer, maximum power is transferred to the speaker. ✓ (2)

6.6 6.6.1
- It produces a much larger output signal than a single Class A biased transistor amplifier.✓
- Efficiency between 70% and 75% can be achieved. (1)

6.6.2 By biasing the two push-pull transistors into class AB mode.✓ (1)

6.6.3 During the negative half cycle of the input signal, transistor Q_1 is off and ✓ transistor Q_2 is turned ON, ✓providing a discharge path for the capacitor to send a current pulse anti-clockwise Q_2 and up through the speaker. ✓ (3)

6.7 6.7.1 Radio-frequency amplifier. ✓ (1)

6.7.2 A bandpass filter is a circuit which passes a band of frequencies✓ and blocks those outside a chosen range, lower than f_1 and higher than f_2. ✓ (2)

6.7.3 The resonant frequency can be changed by varying the value of the capacitor or the inductor ✓ in the tank circuit. ✓ (2)

6.8 6.8.1 Receivers of Radio/television. ✓
Transmitters of Radio/television. (1)

6.8.2 The tank circuit determines the frequency of oscillations.✓ (1)

6.8.3
$$f_o = \frac{1}{2\pi\sqrt{LC_T}} \quad ✓$$
$$= \frac{1}{2\pi\sqrt{200 \times 10^{-3} \times 150 \times 10^{-6}}} \quad ✓$$
$$= 29{,}06\ Hz \quad ✓$$
(3)

6.9 6.9.1 Positive feedback. ✓ (1)

6.9.2 Each RC combination produces a phase shift of 60°. ✓ (1)

6.9.3
$$f_o = \frac{1}{2\pi\sqrt{6RC}} \quad ✓$$
$$= \frac{1}{2\pi\sqrt{6(10 \times 10^3)(0{,}001 \times 10^{-6})}} \quad ✓$$
$$= 20{,}54\ Hz \quad ✓$$
(3)

6.9.4 The attenuation is when the output voltage becomes smaller ✓ than the input voltage. ✓

OR

(When a circuit causes a loss of signal power between its input and output it is said to have attenuated) (2)
[45]

TOTAL: 200