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NATIONAL SENIOR CERTIFICATE

GRADE 12

SEPTEMBER 2024

ELECTRICAL TECHNOLOGY: ELECTRONICS MARKING GUIDELINE

MARKS: 200

This marking guideline consists of 13 pages.



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INSTRUCTIONS TO MARKERS

1. All calculations 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.
 - 2.6 Markers should consider that learners answers may deviate slightly from the marking guideline depending on how and where in the calculation rounding off was used.
3. These marking guidelines are only a guide with model answers.
4. 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 | A ✓ | (1) |
| 1.2 | C ✓ | (1) |
| 1.3 | C ✓ | (1) |
| 1.4 | B ✓ | (1) |
| 1.5 | A ✓ | (1) |
| 1.6 | C ✓ | (1) |
| 1.7 | B ✓ | (1) |
| 1.8 | A ✓ | (1) |
| 1.9 | C ✓ | (1) |
| 1.10 | C ✓ | (1) |
| 1.11 | B ✓ | (1) |
| 1.12 | D ✓ | (1) |
| 1.13 | C ✓ | (1) |
| 1.14 | A ✓ | (1) |
| 1.15 | B ✓ | (1) |
- [15]**

QUESTION 2: OCCUPATIONAL HEALTH AND SAFETY

- 2.1 Teamwork helps a team to meet its goals and deliver quality work. ✓
Employees who are good in teamwork, respect their peers and help where they can, making collaborations go smoother. ✓ (2)
- 2.2 When a learner is involved in horseplay in a workshop, the learner is intentionally conducting an unsafe act, ✓ which could lead to the injury or death of someone, as well as the possibility of damage to machinery and/or equipment. ✓ (2)
- 2.3
- Poor ventilation. ✓
 - Poor lighting.
 - Faulty tools or equipment.
 - Poor housekeeping. (Any 1 x 1) (1)
- 2.4
- Your right to earn a living wage. ✓
 - Your right to work reasonable hours.
 - Your right to fair labour practices.
 - Your right to belong to a trade union.
 - Your right not to be discriminated against because of your sex, religion language, disability, or race. (Any 1 x 1) (1)
- 2.5
- The use (or misuse) of power tools. ✓
 - The incorrect use and handling of hand tools. ✓
 - The etching of printed circuit boards. (Any 2 x 1) (2)
- 2.6 In quantitative risk analysis, an attempt is made to numerically determine the probabilities of various adverse events ✓ and the likely extent of the losses if a particular event takes place. ✓ (2)

[10]

QUESTION 3: RLC CIRCUITS

3.1 3.1.1 The shift in phase between the supply voltage and the circuit current
✓ within a complex circuit with reactances and resistances. ✓ (2)

3.1.2 The increase in amplitude of an oscillation in a mechanical or electrical system, ✓ under the influence of an external periodic impulse of similar frequency to the original vibration. ✓ (2)

3.2 • The frequency. ✓
• The capacitance of the capacitor. ✓ (2)

3.3 The resistance will remain constant ✓, therefore the current and voltage will remain in phase, regardless of the change of frequency. ✓ (2)

3.4 $X_L = X_C$. ✓
 I_T is at a maximum. ✓
 $Z = R$. ✓
Phase angle is 0° . (3)

3.5 3.5.1 $f_r = \frac{1}{2 \times \pi \times \sqrt{L \times C}}$ Hz ✓
 $f_r = \frac{1}{2 \times \pi \times \sqrt{80 \times 10^{-3} \times 33 \times 10^{-6}}}$ Hz ✓
 $f_r = 97,95$ Hz ✓ (3)

3.5.2 $I = \frac{V_T}{Z}$ ($Z = R$ at resonance) ✓
 $I = \frac{120}{30}$ A ✓
 $I = 4$ A ✓ (3)

3.5.3 $V_L = I \times X_L \times V$ ✓
 $V_L = 4 \times 49,24$ V ✓
 $V_L = 196,94$ V ✓ (3)

3.6 3.6.1 $X_L = \frac{V_S}{I_L}$ Ω ✓
 $X_L = \frac{100}{2}$ Ω ✓
 $X_L = 50$ Ω ✓ (3)

3.6.2 $X_C = \frac{V_S}{I_C}$ Ω ✓
 $X_C = \frac{100}{6}$ Ω ✓
 $X_C = 16,67$ Ω ✓ (3)

3.6.3 $I_T = \sqrt{I_R^2 + (I_C - I_L)^2}$ A ✓
 $I_T = \sqrt{5^2 + (6 - 2)^2}$ A ✓
 $I_T = 6,4$ A ✓ (3)

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$$3.7 \quad 3.7.1 \quad I_T = \sqrt{I_R^2 + (I_C - I_L)^2} \text{ A} \quad \checkmark$$

$$I_T = \sqrt{6^2 + (3 - 4)^2} \text{ A} \quad \checkmark$$

$$I_T = 6,083 \text{ A} \quad \checkmark$$

(3)

$$3.7.2 \quad \cos \theta = \frac{I_R}{I_T} \quad \checkmark$$

$$\theta = \cos^{-1} \frac{I_R}{I_T}$$

$$\theta = \cos^{-1} \frac{6}{6,083} \quad \checkmark$$

$$\theta = 9,59^\circ \quad \checkmark$$

(3)
[35]

QUESTION 4: SEMICONDUCTOR DEVICES

- 4.1 Field Effect Transistor ✓ (1)
- 4.2 For its operation it makes use of only one charge carrier at a time, ✓ either electrons or holes, but not both. ✓ (2)
- 4.3 4.3.1 Source ✓ (1)
- 4.3.2 Gate ✓ (1)
- 4.3.3 Output ✓ (1)
- 4.3.4 Channel ✓ (1)
- 4.4 MOSFET ✓ (1)
- 4.5 An op-amp requires both a positive as well as a negative supply voltage to operate. ✓ A split power supply, or double-polarity voltage supply, provides a positive supply ✓ and a negative supply ✓ with relation to 0 V. ✓ (4)
- 4.6 $V_{out} = V_{in} \left(-\frac{R_f}{R_{in}} \right) V$ ✓
 $8,5 = 10 \text{ mV} \left(-\frac{R_f}{180\Omega} \right)$ ✓
 $R_f = 153 \text{ k}\Omega$ ✓
- NOTE:** The negative sign can be omitted as it is resistance. (3)
- 4.7 4.7.1 Non-inverting op-amp. ✓ (1)
- 4.7.2 $V_{out} = V_{in} \left(1 + \frac{R_f}{R_{in}} \right) V$ ✓
 $4,275 \text{ V} = 150 \text{ mV} \left(1 + \frac{33 \text{ k}\Omega}{R_{in}} \right)$ ✓
 $R_{in} = 1\text{k}2$ ✓ (3)
- 4.8
- The output of an op-amp is proportional to the difference of the inputs. ✓
 - When the inputs are identical the output voltage is zero. ✓
 - This is known as a common-mode signal. ✓
 - The ability of an op-amp to suppress these signals are known as its common-mode rejection ratio. ✓ (4)
- 4.9
- The output is fed back 100% to the inverting input. ✓
 - This cancels out all the gain of the op-amp and leaves it with a gain of 1 (unit). ✓
 - This makes this circuit ideal to be used as a coupling stage (buffer) between two unevenly matched stages, without them been directly connected to each other. ✓ (3)

- 4.10
- It is an active low trigger. ✓
 - When the voltage on Pin 2 is less than $\frac{1}{3}$ of the supply voltage, the output goes high. ✓
 - When the voltage on Pin 2 is larger than $\frac{2}{3}$ of the supply voltage, the output will immediately go low. ✓
- (3)
- 4.11
- This circuit compares the voltages at its inputs. ✓
 - Depending on the difference between the input voltages, the output will either go high or low. ✓
 - If the non-inverting (+) terminal voltage is higher, the output will remain high. ✓
 - If the inverting (-) terminal voltage is higher, the output will change to low. ✓
- (4)
- 4.12
- The three 5 kΩ resistors form a voltage divider network between the supply pin and ground. ✓
 - The first 5 kΩ resistor will give a voltage drop of $\frac{2}{3}$ of the supply voltage to the first comparator ✓, which compares this input to the threshold voltage and to trigger the 555 as the charging voltage reaches $\frac{2}{3}$ of the supply. ✓
 - The lower voltage is compared against the trigger voltage by the second comparator. ✓
- (4)
- 4.13
- When the unijunction transistor is connected to a voltage supply, a voltage drop will develop across the length of the component. ✓
 - Two voltage drops are distinguished, namely the voltage drop across base 1 and the emitter, and the voltage drop across the emitter and base 2. ✓
 - The voltage drops across the emitter and base 2 is known as the specific voltage. ✓
 - When an external voltage that exceeds the specific voltage is applied to the component's emitter. ✓
 - The internal resistance of the component will drop very quickly. ✓
 - The component will start conducting between base 1 and base 2. ✓
 - When the emitter voltage is removed, the internal resistance of the component will increase very quickly. ✓
 - The component will react like an open switch. ✓
- (8)

[45]

QUESTION 5: SWITCHING CIRCUITS

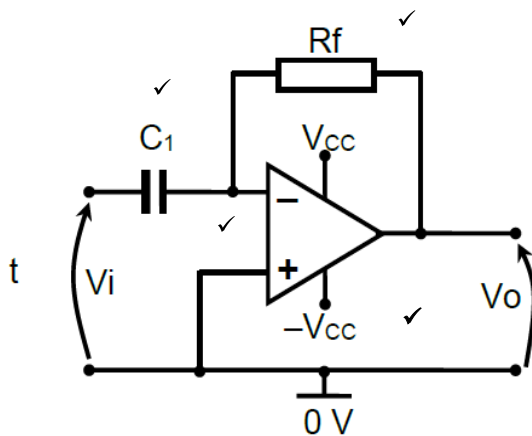
- 5.1 5.1.1 It has TWO ✓ external inputs and TWO ✓ stable states. (2)
- 5.1.2 It has ONE ✓ external input and ONE ✓ stable state. (2)
- 5.1.3 It has NO ✓ external inputs and NO ✓ stable states. (2)
- 5.2 It is used to eliminate switch bounce. ✓ (1)
- 5.3 When a switch is closed, the contacts never simply connect cleanly. ✓
Instead, it will be gently springing up and down until it finally settles. ✓ (2)
- 5.4 It will be a continuous train of square waves. ✓ (1)
- 5.5 The time lag ✓ between cause and effect. ✓ (2)
- 5.6
- It is widely used in the first stages of radio receivers ✓, where it is used to 'clean up' a signal which was distorted during transmission. ✓
 - It is used in digital circuitry, ✓ where noise is often introduced to the circuit by switch bounce which can cause a number of unwanted voltage spikes, to eliminate these spikes. ✓
 - It is used to change the input waveform, ✓ for instance, a sine wave can be changed to a square or rectangular wave. ✓
 - It is used to recover severely distorted signals ✓ and in the process eliminate high level spikes. ✓ (8)
- 5.7 5.7.1 Inverting summing amplifier. ✓
Marker's Note: If learner only writes summing amplifier, 1 point is also awarded. (1)
- 5.7.2 By adding an additional resistor in parallel to the current resistors. ✓ (1)
- 5.7.3
$$V_{\text{out}} = - \left(V_1 \frac{R_f}{R_1} + V_2 \frac{R_f}{R_2} + V_3 \frac{R_f}{R_3} \right) V \checkmark$$

$$V_{\text{out}} = - \left(50 \text{ mV} \frac{100 \text{ k}\Omega}{5 \text{ k}\Omega} + 150 \text{ mV} \frac{100 \text{ k}\Omega}{10 \text{ k}\Omega} + 300 \text{ mV} \frac{100 \text{ k}\Omega}{15 \text{ k}\Omega} \right) V \checkmark$$

$$V_{\text{out}} = - (1 + 1,5 + 2) V$$

$$V_{\text{out}} = - 4,5 V \checkmark$$
 (3)
- 5.7.4
- The input resistors are connected to the negative input terminal of the op-amp. ✓
 - This is the inverting input and will render a negative answer. ✓ (2)

5.8



Marker's Note:

One mark for Feedback resistor.

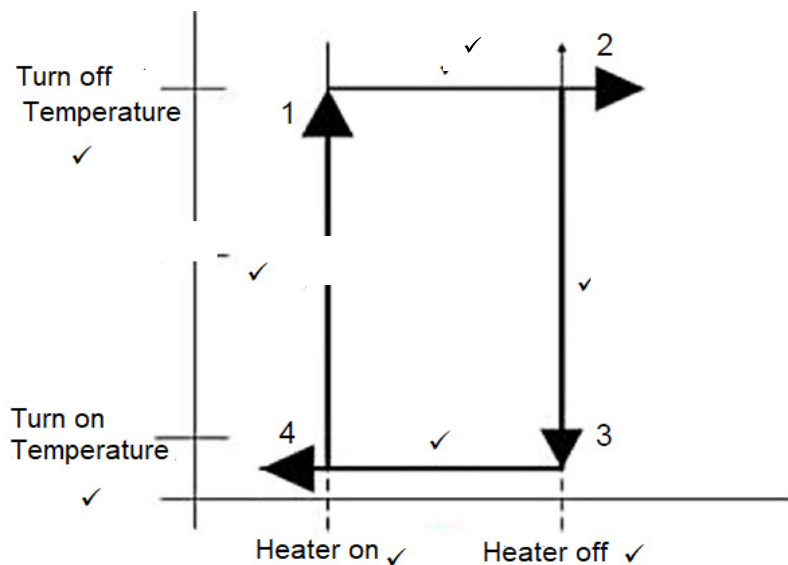
One mark for input capacitor on correct input.

One mark for op-amp symbol correct.

One mark for both supply voltages correct and connected correctly.

(4)

5.9



(8)

5.10 Change the value of the timing resistor. ✓

Change the value of the timing capacitor. ✓

Change the value of both, the timing resistor and the timing capacitor. ✓

(3)

- 5.11
- A light dependant resistor (LDR) ✓ is connected in series with a 100 kΩ resistor. ✓
 - This forms a voltage divider feeding the non-inverting input of the
 - op-amp. ✓
 - The inverting input is fed by a 100 kΩ variable resistor. ✓
 - As the intensity of the light lowers, the LDR resistance increases. ✓
 - This will cause the voltage on the non-inverting input also to rise. ✓
 - When the voltage on the non-inverting input rises to a level set higher than the reference voltage on the inverting input by the 100 kΩ variable
 - resistor, ✓ the op-amp output immediately goes high, activating the transistor which then energises the alarm. ✓

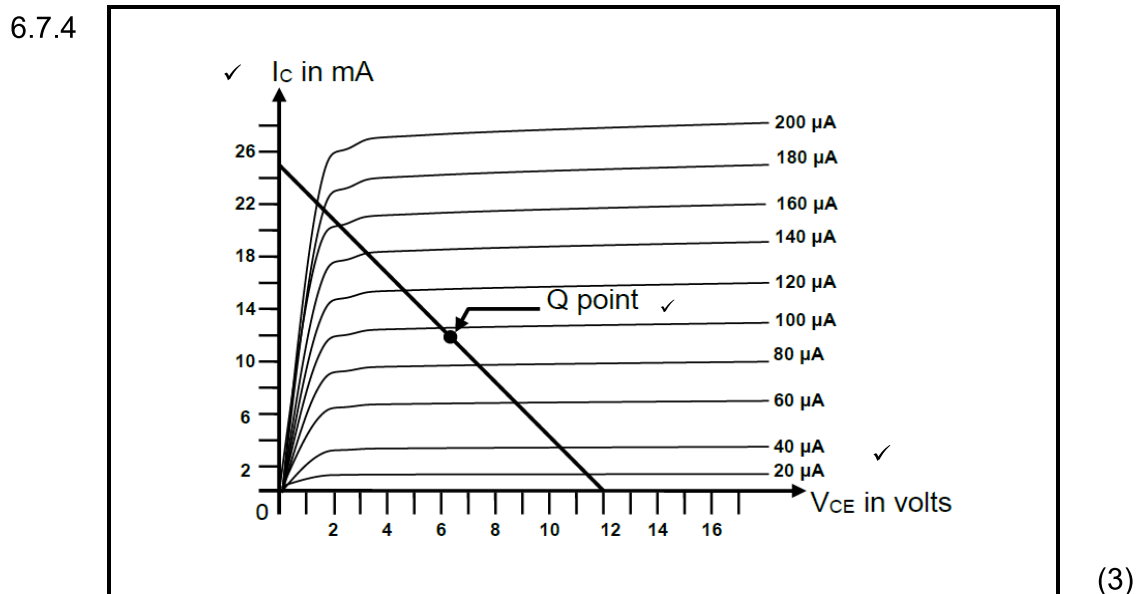
(8)
[50]**QUESTION 6: AMPLIFIERS**

- 6.1
- 6.1.1
- Q point Class A amplifier – the Q point is in the middle of the DC load line. ✓
 - Q point Class B amplifier – the Q point is on the cut-off of the DC load line. ✓
- (2)
- 6.1.2
- Efficiency Class A amplifier – it has low efficiency, therefore, it has less output power. ✓
 - Class A amplifier – 25%.
 - Class B amplifier – it has higher efficiency, therefore, produces more output power. ✓
 - Class B amplifier – 50%.
- (2)
- 6.2
- Increases the input and output impedances of the circuit. ✓
 - Improves the gain stability of the circuit. ✓
 - Reduces noise and distortion of the output wave. ✓
 - Increases the bandwidth of the circuit. (Any 3 x 1)
- (3)
- 6.3
- A small signal amplifier is used to enlarge a very low level of signal voltage or current to a more manageable size. ✓
 - This amplification must be done without introducing ✓ any distortion or noise into the circuit. ✓
 - This is managed by only amplifying the signal small amounts at a time. ✓
- (4)
- 6.4
- A transistor is said to be biased when its surrounding circuit sets up the correct, ✓ pre-chosen voltages at its terminals ✓ which in turn causes controlled and selected currents to flow through the circuit. ✓
- (3)
- 6.5
- Cut off region. ✓
 - Saturation region. ✓
 - Active operating region. ✓
- (3)
- 6.6
- Transistors are classified based on the position of their Q point on the load line. ✓
- (1)

6.7 6.7.1 $I_{Cmax} = \frac{V_{CC}}{R_C} \text{ A} \checkmark$
 $I_{Cmax} = \frac{12}{470 \text{ k}} \checkmark$
 $I_{Cmax} = 25,53 \mu\text{A} \checkmark$ (3)

6.7.2 When $I_C = 0 \text{ A}$
 $V_{CE} = V_{CC} \checkmark$
 $V_{CE} = 12 \text{ V} \checkmark$ (2)

6.7.3 $I_B = \frac{V_{CC} - V_{BE}}{R_B} \text{ A} \checkmark$
 $I_B = \frac{12 \text{ V} - 0,7 \text{ V}}{120 \text{ k}} \text{ A} \checkmark$
 $I_B = 94,17 \mu\text{A} \checkmark$ (3)



6.8 $A_v = 20 \log \frac{V_{out}}{V_{in}} \text{ dB} \checkmark \checkmark$

$A_v = 20 \log \frac{3,5 \text{ V}}{250 \text{ mV}} \text{ dB} \checkmark$

$A_v = 22,932 \text{ dB} \checkmark$ (4)

- 6.9
- At the point of transmission, the signal was immediately amplified to make it large enough to carry down the transmission lines for the greatest distance. \checkmark
 - As the signal travels down the lines, it would be attenuated (reduced in size) by the natural resistance of the transmission lines itself. \checkmark
 - To overcome this problem, the signal was amplified along the lines several times. \checkmark
 - To calculate the total gain of the signal in a linear numeric method would produce very large and unwieldy values. \checkmark
- (4)

- 6.10
- When an AC voltage is applied to the input of the first amplifier stage, ✓ an alternating current will flow in the collector circuit of transistor (Q1). ✓
 - An alternating voltage ✓ will develop across the collector resistor (RC1). ✓
 - The alternating voltage across the RC1 will be transferred through capacitor C2 ✓ to the base of the transistor (Q2) in the amplifiers second stage. ✓
 - The proses will be repeated ✓ and the amplified output can be measured between C3 and 0 V. ✓

(8)
[45]

TOTAL: 200