Province of the
EASTERN CAPE
EDUCATION

NATIONAL
SENIOR CERTIFICATE

GRADE 12

SEPTEMBER 2022

ELECTRICAL TECHNOLOGY: ELECTRONICS
MARKING GUIDELINE

MARKS: 200

This marking guideline consists of 11 pages.

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

QUESTION 2: OCCUPATIONAL HEALTH AND SAFETY

2.1 An occurrence of catastrophic proportions, ✓ resulting from the use of machinery, or activities at work. ✓ (2)

2.2 The learner does not know safe practices. ✓
The learner knows better but intentionally conducts the act. (1)

2.3 2.3.1 Running could cause you to trip or collide with another learner. ✓ This could result in you injuring yourself with nearby equipment or machinery. ✓ (2)

2.3.2 This could cause the outlet to exceed its rated current ✓and could lead to short circuits, fires or damaged appliances. ✓ (2)

2.4 First, I would define all the various threats to safety in the workshop. ✓
Secondly, I would determine the extent of all the vulnerabilities in the workshop. ✓
Finally, I would devise countermeasures should a risk occur. ✓ (3)

[10]

QUESTION 3: RLC CIRCUITS

3.1 3.1.1 It would remain the same. ✓ (1)

3.1.2 $X_L = 31{,}83\ \Omega$ ✓ (1)

3.1.3 (a) $X_L = 2\pi fL$ ✓
$= 2 \times \pi \times 50 \times 0{,}5$ ✓
$= 157{,}08\ \Omega$ ✓ (3)

(b) $Z = \sqrt{R^2 + (X_L - X_C)^2}$ ✓
$= \sqrt{120^2 + (157{,}08 - 31{,}83)^2}$ ✓
$= 173{,}46\ \text{A}$ ✓ (3)

(c) $V_c = I \times X_C$ ✓
$= 1{,}38 \times 31{,}83$ ✓
$= 43{,}93\ \text{V}$ ✓ (3)

(d) $X_C = \frac{1}{2\pi fC}$
$C = \frac{1}{2\pi fX_C}$ ✓
$= \frac{1}{2 \times \pi \times 50 \times 42{,}44}$ ✓
$= 0{,}000075\ \text{F} = 75\ \mu\text{F}$ ✓ (3)

(e) $I = \frac{V_R}{R}$ ✓
$= \frac{240}{120}$ ✓
$= 2\ \text{A}$ ✓ (3)

3.2 0 A ✓ (1)

3.3 The small band of frequencies ✓ centred around the resonant frequency. ✓
The frequencies between the upper cut-off frequency and the lower cut-off frequency, centred around the resonant frequency. (2)

3.4 Z is maximum ✓
I is minimum ✓
$X_L = X_C$ (2)

3.5 3.5.1 $I_T = \sqrt{{I_R}^2 + (I_C - I_L)^2}$ ✓
$= \sqrt{0{,}83^2 + (0{,}63 - 0{,}5)^2}$ ✓
$= 0{,}84\ \text{A}$ ✓ (3)

3.5.2 $I = \frac{V}{R}$
$V = I.R$ ✓
$= 0{,}83 \times 120{,}487$ ✓
$= 100\ \text{V}$ ✓ (3)

3.5.3 $Z = \frac{V}{I_T}$ ✓

$= \frac{100}{0,84}$ ✓

$= 119,05\ \Omega$ ✓ (3)

3.5.4 $\cos\theta = \frac{I_R}{I_T}$

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

$= \cos^{-1}\frac{0,83}{0,84}$ ✓

$= 8,85°$ ✓

leading ✓ (4)

[35]

QUESTION 4: SEMICONDUCTOR DEVICES

4.1 Junction field effect transistor ✓ (1)

4.2 N-channel JFET or NFET ✓
P-Channel JFET or PFET ✓ (2)

4.3 To overcome leakage current between the gate terminal and drain-source channel, the gate terminal was electrically isolated from the channel ✓ by means of an extremely narrow layer of metal-oxide-silicon. ✓ (2)

4.4 4.4.1 Enhancement-mode ✓ N-channel ✓ MOSFET (2)

4.4.2 The lamp will switch ON as soon as the gate voltage V_{GS} is raised ✓ to a sufficient level which will forward bias the internal channel of the MOSFET. ✓ (2)

4.4.3 If R_{GS} is short circuited, it will cause the internal conductive channel of the MOSFET to disperse, ✓ cutting the current flow ✓ and switching the lamp OFF. ✓ (3)

4.5 4.5.1 **A** – Cut off region ✓
D – Saturation region ✓ (2)

4.5.2 At point C the UJT triggers ON. As the UJT is triggered, its internal resistance and voltage ✓ will decrease ✓ while current increases. ✓ This is contrary to Ohm's law and is called negative resistance. At point D if the emitter is supplied with sufficient current the UJT operating point will continue falling until a valley point is reached (D), UJT goes into its permanent ON condition called saturation region. (3)

4.6 4.6.1 Darlington pair ✓ (1)

4.6.2 Very high current gain ✓
Improved input impedance ✓
When used in common collector pair it develops a very low output. (2)

4.7
- Infinite gain ✓
- Infinite input impedance ✓
- Zero output impedance ✓
- Infinite bandwidth ✓
- Infinite common mode rejection ratio
- Unconditional stability (4)

4.8 4.8.1

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

$$A_V = 1 + \frac{50\ 000}{10\ 000} \checkmark$$

$$A_V = 6 \checkmark$$ (3)

4.8.2

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

$$V_{OUT} = 1{,}5 \times \left(1 + \frac{50\ 000}{10\ 000}\right) V \checkmark$$

$$V_{OUT} = 9\ V \checkmark$$ (3)

4.8.3 If the value of the feedback resistor is decreased the gain of the amplifier will decrease ✓ causing the output voltage to decrease. ✓ (2)

4.9 4.9.1 This pin sets the voltage at which the 555 IC will trigger. It is used to maintain ✓ the voltage across the timing capacitor ✓ which is discharged through pin 7. ✓ (3)

4.9.2 The 555 IC can operate from power supply voltages of between +5 V ✓ and +18 V. ✓ (2)

4.9.3 In this mode the 555 timer is astable ('free running'), therefore its output will continuously toggle between high and low ✓ thus generating a continuous train of square-wave pulses. ✓ (2)

4.9.4 The pin closest to the dot. ✓
The pin to the left of the notch. (1)

4.10 Open loop gain is the gain of an op amp without any from the output to the input. ✓

Closed loop gain is the of an op amp with feedback from the output to the input. ✓ (2)

4.11 Basic timing functions like turning a light on or off ✓
Pulse, oscillation and waveforms generation ✓
Digital logic probes ✓
Creating a warning light that flashes on and off
Produce musical notes of a particular frequency (3)

[45]

QUESTION 5: SWITCHING CIRCUITS

5.1 5.1.1 Two external inputs ✓
Two stable states ✓ (2)

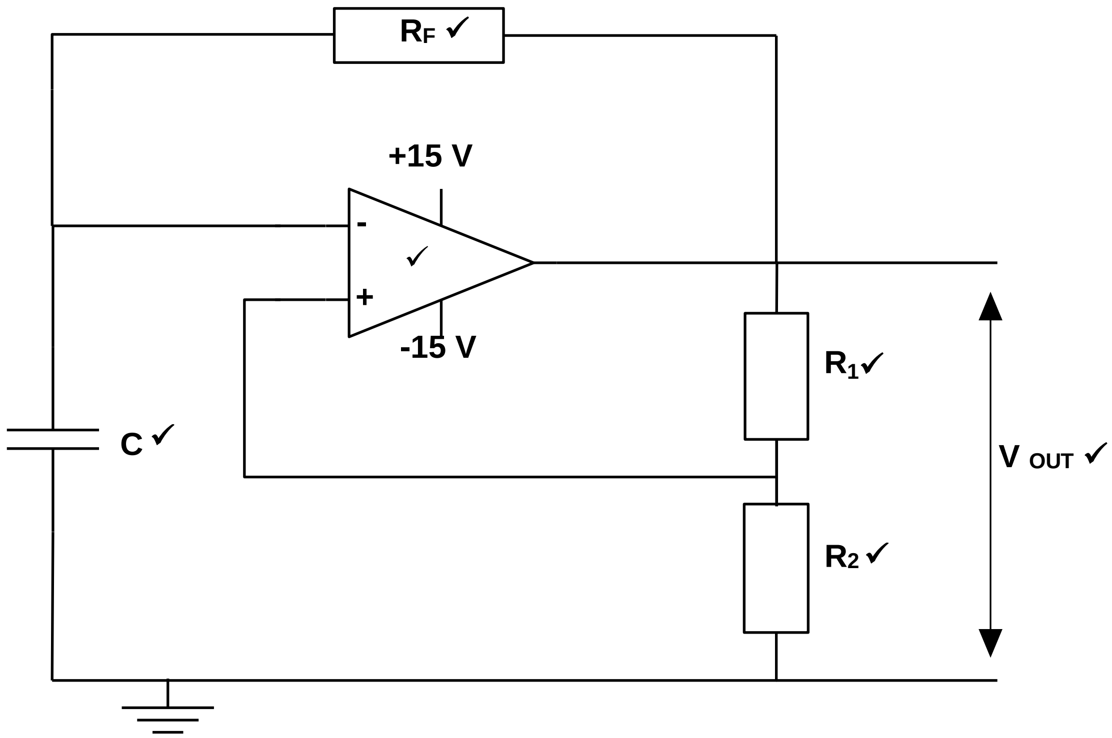
5.1.2 The LED will be destroyed. ✓ (1)

5.1.3 The current flowing through the LED will not be limited. ✓ This will cause the LED to draw more current than what it is able to handle.✓ (2)

5.1.4 Pressing the SET button will pull Pin 2 "low" ✓ and cause the IC output to switch to "high". ✓ As Pin 6 is deliberately held "low" the IC cannot reset itself thus staying "high". ✓ (3)

5.1.5 These resistors are known as "pull up" resistors. ✓ When both SET and RESET buttons are open, the pull up resistors keep the voltage on the input high. ✓ (2)

5.2



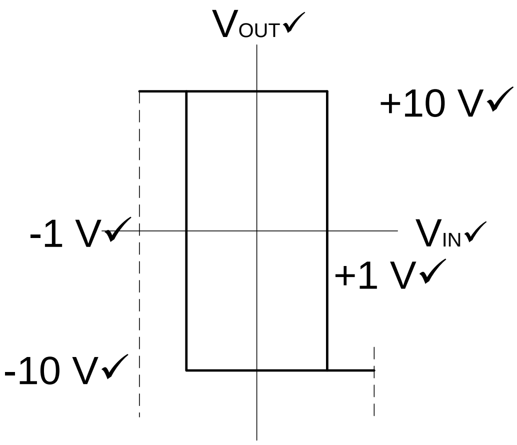
(6)

5.3 The feedback resistor is connected from the output ✓ of the op amp to the inverting input. ✓ This allows a part of the output to flow back to the inverting input. ✓ (3)

5.4 It is used to eliminate switch bounce. ✓ (1)

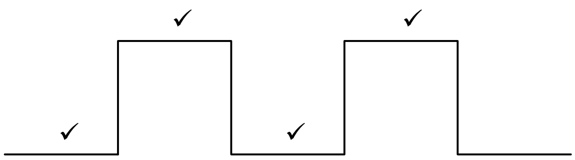
5.5
- A light dependent resistor (LDR) and a100 kΩ resistor is connected in series. This forms a voltage divider. ✓
- The voltage divider feeds the non-inverting input of the op amp. ✓
- The inverting input is fed by a 100 kΩ variable resistor. ✓
- Less light on the LDR, the resistance rises and in turn the voltage on the non-inverting also rises. ✓
- When the voltage level increases to a level higher than the level set by the variable resistor, the op amp output will go high immediately. ✓
- This will switch the transistor on, and the alarm will be energized. ✓ (6)

5.6



(6)

5.7



(4)

5.8 5.8.1 A summing amplifier is used to add two or more different input signals ✓ to create one amplified output signal. ✓ (2)

5.8.2

$$V_{OUT} = -(V_1 + V_2 + V_3) \checkmark$$
$$= -(0{,}5 + 1{,}2 + 0{,}9) \checkmark$$
$$= -2{,}6 \text{ V} \checkmark$$

OR

$$V_{OUT} = -\left(V_1 \frac{R_F}{R_1} + V_2 \frac{R_F}{R_2} + V_3 \frac{R_F}{R_3}\right) V \checkmark$$
$$V_{OUT} = -(0{,}5 \frac{20\,000}{20\,000} + 1{,}2 \frac{20\,000}{20000} + 0{,}9 \frac{20\,000}{20\,000} V \checkmark$$
$$V_{OUT} = -2{,}6\, V \checkmark$$ (3)

5.8.3

$$V_{OUT} = -\left(V_1 \frac{R_F}{R_1} + V_2 \frac{R_F}{R_2} + V_3 \frac{R_F}{R_3}\right) V \checkmark$$
$$V_{OUT} = -(0{,}5 \frac{40\,000}{5\,000} + 1{,}2 \frac{40\,000}{10\,000} + 0{,}9 \frac{40\,000}{20\,000} V \checkmark$$
$$V_{OUT} = -10{,}6\, V \checkmark$$

(3)

5.8.4

$$V_{OUT} = -\left(V_1 \frac{R_F}{R_1} + V_2 \frac{R_F}{R_2} + V_3 \frac{R_F}{R_3}\right) V \checkmark$$
$$R_F = \frac{-V_{OUT}}{\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}}$$
$$R_F = \frac{-10{,}4}{\frac{0{,}5}{20\,000} + \frac{1{,}2}{20\,000} + \frac{0{,}9}{20\,000}} \checkmark$$
$$R_F = 80\ k\Omega \checkmark$$

OR

$$A_V = -\frac{R_F}{R_{IN}}$$
$$R_F = A_V \times R_{IN} \Omega$$
$$R_F = 4 \times 20\,000\ \Omega$$
$$R_F = 80\,000\ \Omega$$
$$R_F = 80\ k\Omega$$

(3)

5.8.5

$$A_V = -\left(\frac{V_{OUT}}{V_{IN}}\right)$$
$$= -\left(\frac{V_{OUT}}{V_1 + V_2 + V_3}\right) \checkmark$$
$$= -\left(\frac{5{,}2}{0{,}5 + 1{,}2 + 0{,}9}\right) \checkmark$$
$$= -2 \checkmark$$

(3)
[50]

QUESTION 6: AMPLIFIERS

6.1 Class A – the transistor is biased with the Q-point on the midpoint ✓ of the load line, allowing for the full signal (360°) to be amplified. ✓ (2)

6.2 6.2.1 C_2 serves as the AC coupling component between the two stages. ✓ C_2 also blocks or decouples the DC component of the signal. ✓ (2)

6.2.2
- 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 (Q_1). ✓
- An alternating voltage will develop across the collector resistor (R_{C1}). ✓
- The developed alternating voltage across the R_{C1} will be transferred through capacitor C_2 ✓ to the base of the transistor (Q_2) in the amplifier's second stage (stage 2). ✓
- The process will be repeated and the amplified output will measured between C_3 and 0 V. ✓ (6)

6.2.3
- Impedance matching ✓
- DC isolation ✓
- Correct frequency response (Any 2 x 1) (2)

6.3 6.3.1 A – Low frequencies ✓
B – Middle frequencies ✓
C – High frequencies ✓
D – Voltage gain✓ (4)

6.3.2 Frequency response is the ability of the circuit ✓ to respond to a range of frequencies applied to the transistor. ✓ (2)

6.3.3 At lower frequencies the reactances of the decoupling capacitors across the emitter resistors rises. ✓
These reactances each combine with the resistance of their emitter resistors, causing the total impedance to rise ✓ limiting the stage gain. ✓ (3)

6.4 6.4.1 Impedance matching can be achieved by selecting a transformer ✓ with the required number of turns ✓ that will coincide with the impedances of the respective stages. (2)

6.4.2 The reason for using a transformer is that the relatively high output impedance of the second stage ✓ is connected to the relatively low impedance of the speaker ✓ thus matching the output impedance ✓ of the amplifier to the load. (3)

6.4.3 Poor frequency response – gain is constant over only a small range of frequencies ✓
Coupling transformers are bulky and expensive at audio frequencies✓
Low frequencies receive less amplification than high frequencies
Tends to introduce hum in the output
Increased cost (2)

6.5 6.5.1 An oscillator is a device which generates an AC output signal ✓ without any externally applied input signal. ✓ (2)

6.5.2 The RF coil resistance against the change in the collector current ✓and causes the collector voltage Vc to decrease. ✓ (2)

6.5.3 The resistors R_1 and R_2 form a voltage divider ✓ to bias the base of the transistor. ✓ (2)

6.5.4 The Colpitts oscillator uses TWO capacitors and an inductor in the tank circuit. ✓
The Hartley oscillator uses TWO inductors and a capacitor in the tank circuit. ✓ (2)

6.5.5 When first switched ON, the collector voltage rises and allows the capacitor in the tank circuit to charge. ✓
The voltage drop across the inductors is in an inverted form, driving the transistor's base in the opposite direction thereby switching it OFF. ✓
The capacitor will discharge through the inductors and push the tank circuit into oscillation. ✓
During oscillation the voltages at each end of the tank circuit are 180° out of phase with each other, relative to their 0 V common centre tap point. ✓
This ensures that the collector voltage is 180° out of phase with the base voltage. ✓
The freewheeling effect of the tank circuit's operation then begins to drive the transistor alternately ON and OFF which in turn continually re-charges the tank circuit keeping it oscillating at a constant ✓ amplitude. (6)

6.5.6 $F_0 = \frac{1}{2\pi\sqrt{L \times C}}$ ✓

$L_T = L_1 + L_2$ ✓ (2)

[45]

TOTAL: 200