**NATIONAL
SENIOR CERTIFICATE**

GRADE 12

SEPTEMBER 2023

**ELECTRICAL TECHNOLOGY: ELECTRONICS
MARKING GUIDELINE**

MARKS: 200

This marking guideline consists of 13 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   B ✓   (1)

1.2   A ✓   (1)

1.3   C ✓   (1)

1.4   C ✓   (1)

1.5   D ✓   (1)

1.6   A ✓   (1)

1.7   D ✓   (1)

1.8   B ✓   (1)

1.9   C ✓   (1)

1.10   C ✓   (1)

1.11   A ✓   (1)

1.12   C ✓   (1)

1.13   B ✓   (1)

1.14   A ✓   (1)

1.15   A ✓   (1)

[15]

QUESTION 2: OCCUPATIONAL HEALTH AND SAFETY

2.1
- Integrity ✓
- Sense of responsibility ✓
- Emphasis on quality
- Discipline
- Sense of teamwork   (Any 2 x 1)   (2)

2.2   An event that causes grave or severe physical injury to a person, ✓ threatening their health and safety. ✓   (2)

2.3
- Avoid direct contact with any chemical ✓
- Always wear personal protective clothing
- Always read and be aware of the warning symbols on containers
                                                    (Any 1 x 1)   (1)

2.4   An unsafe act is the wilful performance of a task or activity in a manner that may threaten the health and safety of everyone. ✓
A calculated risk is the probability that injury or damage may occur while using dangerous equipment. ✓   (2)

2.5
- To prevent oneself from being electrocuted. ✓
- To prevent injury   (Any 1 x 1)   (1)

2.6   This could damage the equipment and render the equipment unsafe ✓ and compromise the safety of the user. ✓   (2)
                                                                     [10]

QUESTION 3: RLC CIRCUITS

3.1   It is the opposition offered to current flow by the reactive components of an inductor ✓ when it is connected to an AC supply. ✓   (2)

3.2
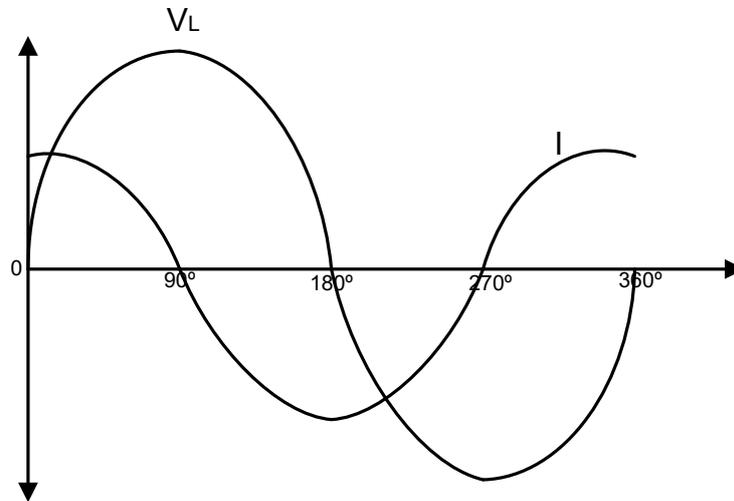
- Full cycles drawn correctly ✓
- Phase difference correct ✓
- Waveforms labelled correctly ✓   (3)

3.3   3.3.1 $X_C = \frac{1}{2\pi f C}$ ✓

$$= \frac{1}{2 \times \pi \times 60 \times 200 \times 10^{-6}} \checkmark$$

$$= 13{,}26 \,\Omega \checkmark \tag{3}$$

3.3.2 $I = \frac{V}{Z}$ ✓

$$= \frac{110}{101{,}65} \checkmark$$

$$= 1{,}08 \, A \checkmark \tag{3}$$

3.3.3 $Z = \sqrt{R^2 + (X_L - X_C)^2}$ ✓

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

$$= \sqrt{101{,}65^2 - (31{,}55 - 13{,}26)^2} \checkmark$$

$$= 100 \,\Omega \checkmark \tag{3}$$

3.3.4 $X_L = 2\pi f L$ ✓
$L = \frac{X_L}{2\pi f}$
$= \frac{31{,}55}{2 \times \pi \times 60}$ ✓
$= 0{,}084 \, H = 84 \, mH$ ✓   (3)

3.4 $f_r = \dfrac{1}{2\pi\sqrt{LC}}$ ✓

       $= \dfrac{1}{2 \times \pi \times \sqrt{50 \times 10^{-3} \times 60 \times 10^{-6}}}$ ✓

       $= 91{,}89 \text{ Hz}$ ✓   (3)

3.5   3.5.1 $I_C = \dfrac{V}{X_C}$ ✓

            $= \dfrac{100}{11{,}83}$ ✓

            $= 8{,}45 \text{ A}$ ✓   (3)

   3.5.2 $I_T = \sqrt{I_R{}^2 + (I_C - I_L)^2}$ ✓

            $= \sqrt{9{,}09^2 + (8{,}45 - 4{,}54)^2}$ ✓

             $= 9{,}9 \text{ A}$ ✓   (3)

   3.5.3 $\cos\theta = \dfrac{I_R}{I_T}$ ✓

            $= \dfrac{9{,}09}{9{,}9}$ ✓

             $= 0{,}918$ ✓   (3)

   3.5.4   Leading, ✓ because I_c is larger than I_L ✓   (2)

3.6   Selectivity is a measure of how well a resonant circuit responds to a range of frequencies. ✓ and separates other frequencies. ✓   (2)

3.7
- The value of the series resistor ✓
- The LC ratio ✓   (2)

                                                      [35]

QUESTION 4: SEMICONDUCTOR DEVICES

4.1

GATE (G) ✓   DRAIN (D) ✓
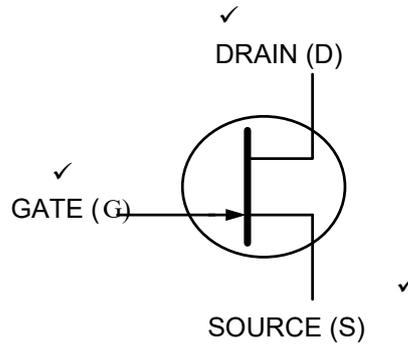
SOURCE (S) ✓   (3)

4.2   4.2.1   1 – Source ✓
              2 – Gain ✓
              3 – Drain ✓
              4 – Enhanced channel ✓   (4)

       4.2.2   N-type material ✓   (1)

4.3   Cut off: with zero on the emitter the pn junction is reverse biased and a small reverse leakage current flows. ✓ By increasing the emitter voltage, the reverse leakage current falls until a point is reached where the emitter voltage equals the voltage in the bar point. ✓ No current flows either direction. ✓ If the emitter voltage rises until the pn junction is on the point of becoming forward biased, forward current begins to flow at the cut off region. ✓   (4)

4.4
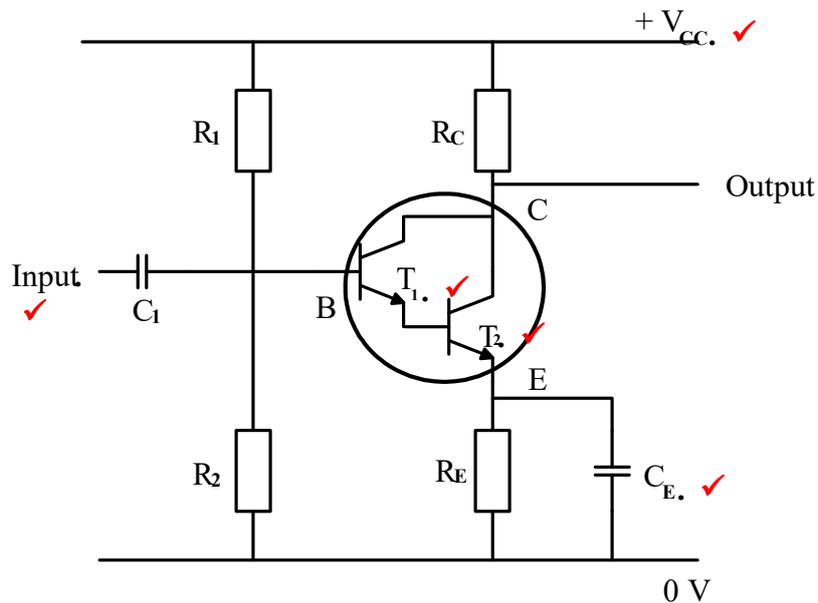
                                                      (5)

4.5   4.5.1   A = Non inverting op-amp ✓
                 B = Inverting op-amp ✓
                 C = Output ✓   (3)

       4.5.2   The Op-amp is ideal for amplifying AC voltages because of its dual voltage supply ✓ which allows the output terminal to rise and fall above and below zero volts. ✓   (2)

4.6   4.6.1   Inverting amplifier. ✓   (1)

       4.6.2

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

$$R_F = \frac{V_{OUT} \times R_{IN}}{V_{IN}}$$

$$R_F = \left(\frac{8 \times 1,8 \times 10^3}{0,4}\right) \checkmark$$

$$= 36\ 000\ \Omega \checkmark$$

(3)

4.7   4.7.1   The signal will be 10 × greater than the input signal / ✓the output will be 1 V ✓ and the output signal will be 180° out of phase with the input signal. ✓   (3)

       4.7.2   The signal will be 11 × greater than the input signal / ✓the output will be 1,1 V ✓ and the output signal will be in phase with the input signal.   (3)

4.8
- The amplifier circuits gain will be reduced. ✓
- The amplifier becomes much more stabilised. ✓
- Distortion of the output signal is reduced. ✓
- The range of frequencies which can be amplified is increased. ✓   (4)

4.9   4.9.1   2 – Trigger ✓
                 3 – Output ✓
                 5 – Control voltage ✓
                 8 – Power supply ✓   (4)

       4.9.2   It provides the discharge path ✓ for the timing capacitor ✓ and timing resistor ✓   (3)

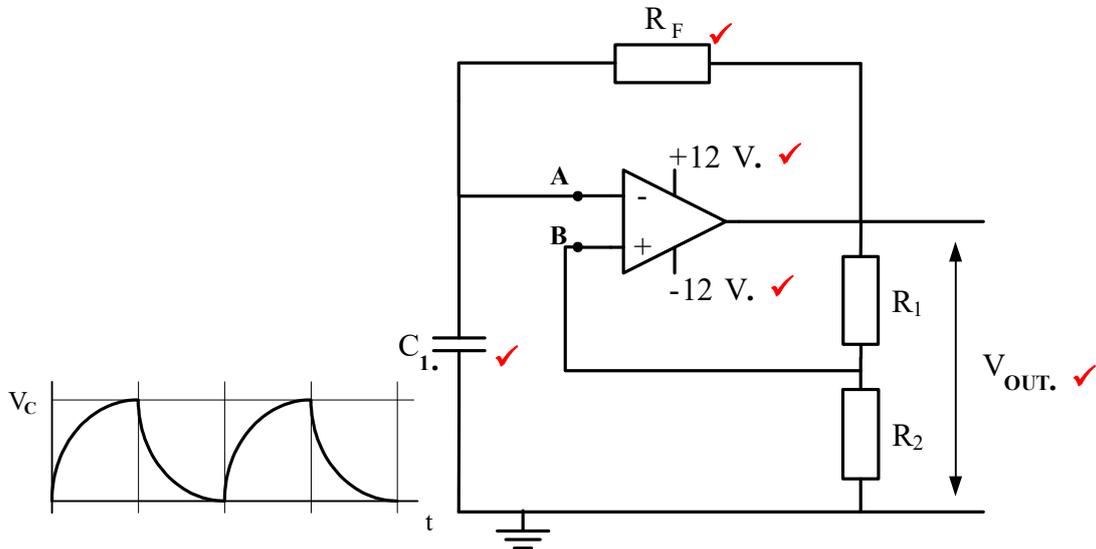   4.9.3   The 555 IC can only operate at power supply voltages between +5 V ✓ to +18 V. ✓   (2)

[45]

QUESTION 5: SWITCHING CIRCUITS

5.1   5.1.1   Monostable multivibrator ✓   (1)

       5.1.2   Bistable multivibrator ✓   (1)

5.2

(5)

5.3   5.3.1   Bistable ✓multivibrator ✓   (2)

       5.3.2   Resistor R_1 and R_2 are pull-up ✓ resistors ✓   (2)

       5.3.3   When set is pressed, it pulls pin 2 'low' ✓ (0 V) and cause the output to go 'high'. ✓ turning the LED on. ✓   (3)

       5.3.4   Threshold pin 6 is purposefully held at 0 V ✓causing the IC not to reset, ✓ keeping the output high ✓ when S1 is pressed.   (3)

5.4   5.4.1   The output signal represents an inverting Schmitt trigger ✓ because the output signal is inverted ✓ with reference to the input signal. ✓   (3)

       5.4.2
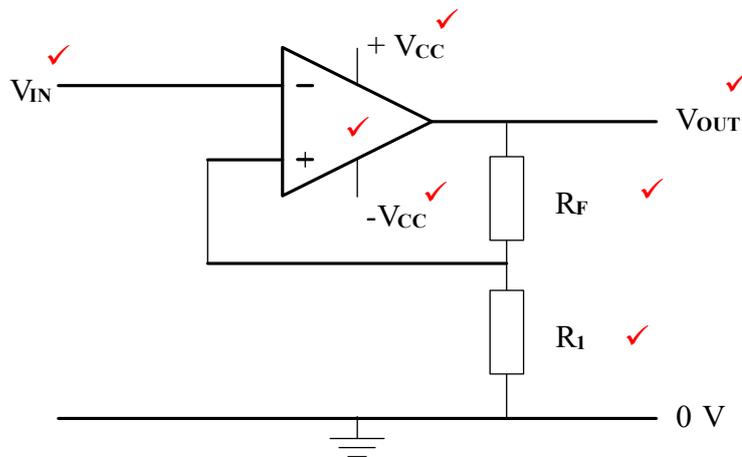
(7)

5.5   5.5.1   The gain of the amplifier is determined by the ratio ✓ of the feedback resistance ✓ to the input resistance of each. ✓   (3)
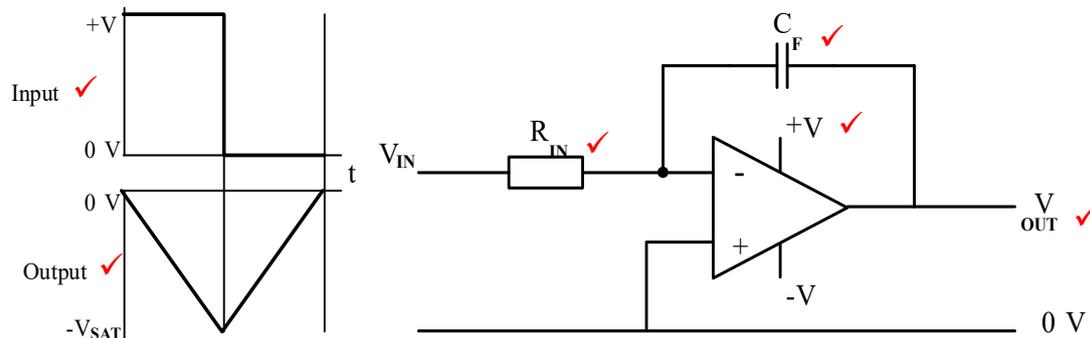
5.5.2 $V_{OUT} = -\left(V_1\frac{Rf}{R1} + V_2\frac{Rf}{R2} + V_3\frac{Rf}{R3}\right)$ ✓

$= -\left(200\ mV\frac{100\ k\Omega}{20\ K\Omega} + 300\ mV\frac{100\ k\Omega}{10\ K\Omega} + 400\ mV\frac{100\ k\Omega}{25\ k\Omega}\right)$ ✓

$= -(200\ mV \times 5) + (300\ mV \times 10) + (400\ mV \times 4)$ ✓
$= -5.6\ V$ ✓   (4)

5.5.3 $V_{OUT} = V_{IN} \times Gain$

Gain $A_V = \frac{V_{OUT}}{V_{IN}}$ ✓

$= \frac{5,6}{0,2 + 0,3 + 0,4}$ ✓

$= 6,2\ V$ ✓   (3)

5.5.4   With a variable resistor in the feedback loop, the gain ✓ of the amplifier can be varied / controlled. ✓   (2)

5.5.5   If R_2 is changed to 5 kΩ, the gain for V_2 will increase ✓ causing the total output voltage to increase. ✓   (2)

5.6

(6)

5.7   •   The inputs draw zero current. ✓
•   The two inputs will always have the same voltage. ✓
•   The capacitor will charge at a constant rate when a constant current is supplied. ✓   (3)

[50]

QUESTION 6: AMPLIFIERS

6.1   6.1.1 $V_{ce} = V_{cc}$ ✓   (1)

     6.1.2 $I_{Cmax} = \dfrac{Vcc}{Rc}$ ✓

            $= \dfrac{12\,V}{600\,\Omega}$ ✓

            $= 2\,mA$ ✓   (3)

6.2   6.2.1   • RC coupled amplifier. ✓
            • Common emitter amplifier.   (Any 1 x 1)   (1)

     6.2.2   The emitter-base junction (EB) must be forward biased above the cut-off region, ✓ and below the saturation region. ✓ The collector-base junction (CB) must be reversed biased ✓ for the transistor to operate in the active region for amplification to take place. ✓   (4)

     6.2.3 $V_{RC} = V_{CC} - V_{CE}$ ✓
            $= 8 - 2,38$ ✓
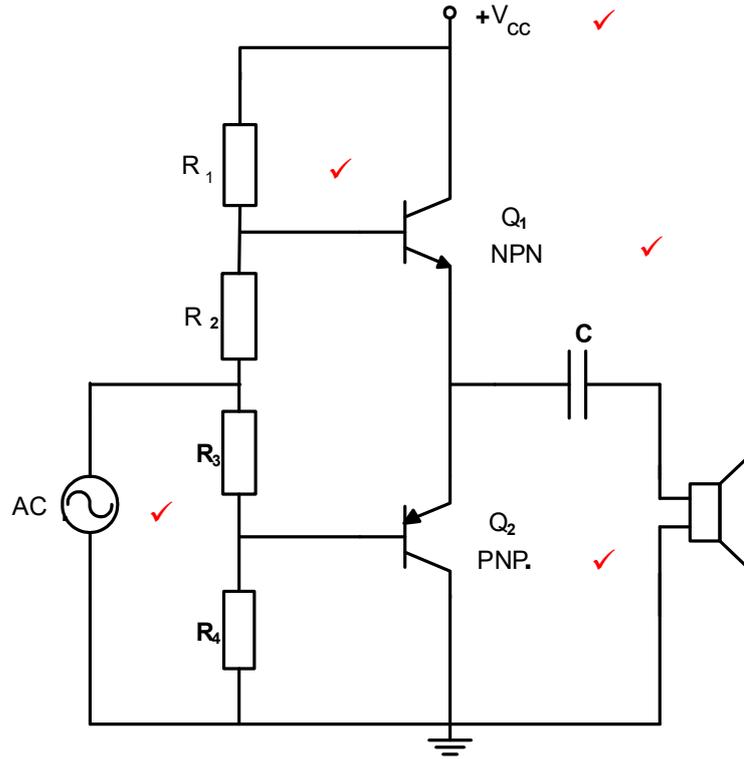 $= 5,62\,V$ ✓   (3)

6.3   6.3.1   Push-Pull amplifier ✓   (1)

     6.3.2   NPN transistor ✓   (1)

6.4   6.4.1 $A_I = 20log_{10}\dfrac{I_{OUT}}{I_{IN}}$ ✓

           $= 20log_{10}\dfrac{15,3\,mA}{3,6\,mA}$ ✓

           $= 20 \times 4,25$

           $= 85\,dB$ ✓   (3)

     6.4.2 $A_P = 10log_{10}\dfrac{P_{IN}}{P_{OUT}}$ ✓

          $= 10\,log_{10}\dfrac{750 \times 10^{-3}A}{28}$ ✓

          $= 10 \times 0,026$

          $= 0,268\,dB$ ✓   (3)

     6.4.3 $A_V = 20log_{10}\dfrac{V_{OUT}}{V_{IN}}$ ✓
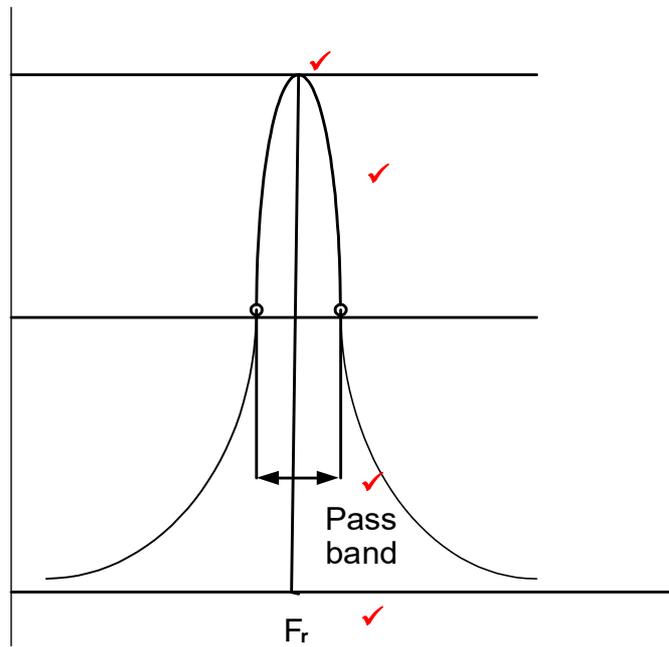
          $= 20log_{10}\dfrac{219}{230}$ ✓

          $= 19\,dB$ ✓   (3)

6.5

(5)

6.6

(4)

6.7   6.7.1   An oscillator is a device which generates an AC output signal, ✓without any externally applied input signal. ✓   (2)

6.7.2 • The RC-phase-shift oscillator uses three sets of RC combinations ✓ to create a phase-shift of 180° of the output waveform from the amplifier ✓ and attenuates it.
  • Together with the 180º phase-shift between the base voltage and collector voltage of the amplifier, ✓ the output signal with a phase-shift of 360º is achieved and amplified before supplying it to the RC-network. ✓
  • The cycle repeats itself.   (4)

6.8   6.8.1   Hartley Oscillator ✓   (1)

6.8.2 • 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)
                                                                     [45]

                                                      TOTAL: 200