basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

SENIOR CERTIFICATE EXAMINATIONS/ NATIONAL SENIOR CERTIFICATE EXAMINATIONS

ELECTRICAL TECHNOLOGY: ELECTRONICS

MAY/JUNE 2025

MARKING GUIDELINES

MARKS: 200

These marking guidelines consist of 16 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. These marking guidelines 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 C ✓ (1)

1.2 B ✓ (1)

1.3 B ✓ (1)

1.4 A ✓ (1)

1.5 B ✓ (1)

1.6 B ✓ (1)

1.7 C ✓ (1)

1.8 D ✓ (1)

1.9 C ✓ (1)

1.10 D ✓ (1)

1.11 C ✓ (1)

1.12 B ✓ (1)

1.13 C ✓ (1)

1.14 A ✓ (1)

1.15 A ✓ (1)

[15]

QUESTION 2: OCCUPATIONAL HEALTH AND SAFETY

2.1 Health and safety equipment refer to any artefact which is manufactured, provided or installed ✓ in the interest of the health or safety of any person. ✓ (2)

2.2 Removing safety guards/covers from machinery before using it. ✓
Removing the earth pin from a 3-pin plug intended for use in a three-wire earth system. ✓
Removing an emergency stop button from a motor control circuit. (2)

2.3 The purpose of the act is to provide health and safety for people at work in general. ✓
To create a safe environment for those who work with machinery. ✓ (2)

2.4 Every employer is required by law ✓ to make employees conversant with the hazards to their health and the safety attached to any work that they perform. ✓ (2)

2.5 An employee/learner with good discipline stays focused and complete his/her tasks set out for the day. ✓
An employee/learner with good discipline will not fool around with or disturb others in the workshop in such a way that it might cause an accident. ✓ (2)
[10]

QUESTION 3: RLC

3.1 Reactance is the opposition offered ✓ against the flow of alternating current ✓ by the inductor.
Reactance is the ratio of voltage to current in an AC circuit when the voltage and current is 90º out of phase. (2)

3.2 3.2.1

$$X_C = \frac{1}{2\pi fC} \quad ✓$$
$$= \frac{1}{2\pi(60)(100 \times 10^{-6})} \quad ✓$$
$$= 26{,}53\ \Omega \quad ✓$$

(3)

3.2.2 Series $I_T = I_R = I_L = I_C$

$$I_T = \frac{V_R}{R} \quad ✓$$
$$= \frac{74{,}28}{12} \quad ✓$$
$$= 6{,}19\ A \quad ✓$$

$$Z = \sqrt{R^2 + (X_C - X_L)^2}$$
$$= \sqrt{12^2 + (26{,}53 - 11{,}31)^2}$$
$$= 19{,}38\ \Omega$$

$$I_T = \frac{V_T}{Z}$$
$$= \frac{120}{19{,}38}$$
$$= 6{,}19\ A$$

(3)

3.2.3 $V_L = I_T \times X_L$ ✓
$= 6{,}19 \times 11{,}31$ ✓
$= 70{,}01\ V$ ✓

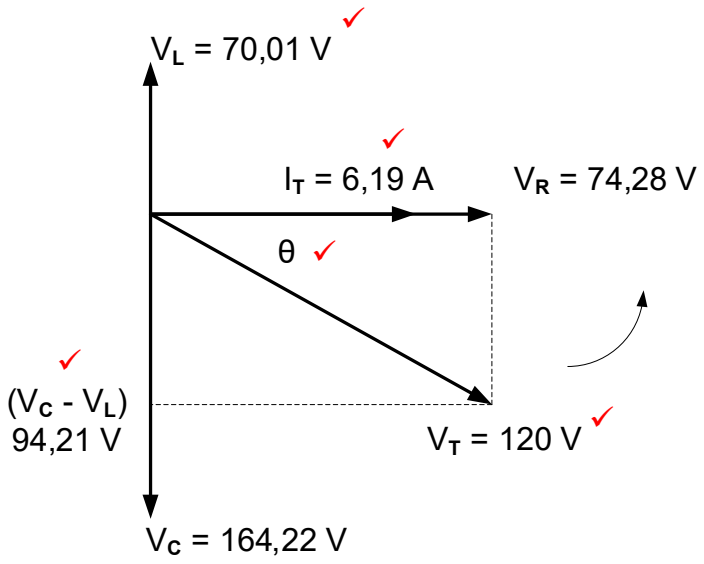
(3)

3.2.4 At resonance $X_L = X_C$

$$X_C = \frac{1}{2\pi fC} \quad ✓$$
$$C = \frac{1}{2\pi f X_C}$$
$$= \frac{1}{2\pi(60)(11{,}31)} \quad ✓$$
$$= 234{,}53\ \mu F \quad ✓$$

(3)

3.3



(5)

3.4 3.4.1

$$I_T = \sqrt{{I_R}^2 + (I_C - I_L)^2} \quad ✓$$
$$= \sqrt{0{,}48^2 + (0{,}71 - 0{,}51)^2} \quad ✓$$
$$= 0{,}52\ A \quad ✓$$ (3)

3.4.2

$$Cos\theta = \frac{I_R}{I_T} \quad ✓$$
$$\theta = Cos^{-1}\left(\frac{0{,}48}{0{,}52}\right) \quad ✓$$
$$= 22{,}62° \quad ✓$$

$$Tan\theta = \frac{(I_C - I_L)}{I_R}$$
$$\theta = Tan^{-1}\left(\frac{0{,}71 - 0{,}51}{0{,}48}\right)$$
$$= 22{,}62°$$ (3)

3.4.3

$$X_L = \frac{V_T}{I_L} \quad ✓$$
$$= \frac{48}{0{,}51} \quad ✓$$
$$= 94{,}12\ \Omega \quad ✓$$ (3)

3.4.4

$$X_L = 2\pi f L \quad ✓$$
$$f = \frac{X_L}{2\pi L}$$
$$= \frac{94{,}12}{2\pi(0{,}3)} \quad ✓$$
$$= 49{,}93\ Hz \quad ✓$$ (3)

3.5 3.5.1 Curve Q_2 ✓ (1)

3.5.2

$$f_r = \frac{f_1 + f_2}{2} \quad ✓$$
$$= \frac{30\,000 + 90\,000}{2} \quad ✓$$
$$= 60\,000\ Hz \quad ✓$$
$$= 60\ kHz$$ (3)

[35]

QUESTION 4: SEMICONDUCTORS

4.1 A field-effect transistor (FET) is a device that relies on the creation of an electric field ✓ to control the current flow.✓ (2)

4.2 4.2.1 Substrate diffusion.✓ (1)

4.2.2 The FET's are regarded as unipolar because the current flow consists of only one type of charge carrier ✓ , i.e. electrons ✓ in N-channel FETs and holes ✓ in P-channel FETs. (3)

4.2.3
- When the gate voltage is increased negatively it repels electrons ✓ in the region of the gate and thus increases the size of the depletion layer. ✓
- This reduces the width of the channel, ✓ thus reducing its conductivity and less current flows. ✓ (4)

4.2.4 The pinch-off point is where the depletion region on either side of the junction increases to meet at the centre of the bar ✓ to reduce the conducting channel ✓ thus reducing the drain current. ✓ (3)

4.3 4.3.1 Depletion mode ✓ MOSFET. (1)

4.3.2 Silicon-dioxide insulation. ✓ (1)

4.3.3 Since the gate of the MOSFET is insulated from the channel, it can operate under forward/enhancement ✓ and reverse/depletion ✓ conditions.

No leakage current will flow between the gate and the conducting current due to layer of silicon-dioxide insulating the gate from the channel which is not the case for the JFET. (2)

4.3.4 When a negative potential is applied to the gate, it will result in the channel being depleted ✓ of majority carriers. The conductivity of the channel reduces ✓ and the drain current decreases. ✓ (3)

4.4 4.4.1 Switching circuits ✓ (1)

4.4.2 Touch sensor ✓ (1)

4.4.3 To protect/bias the transistor from being driven into saturation in case of accidental shorting out of contacts. ✓ (1)

4.4.4 As an emitter follower is often used as an interface between a circuit with a high output resistance ✓ and a low resistance load. ✓

It provides a very high input impedance as the base current is extremely small and a very low output impedance and thus prevents loading of the preceding stage and can drive a subsequent stage.

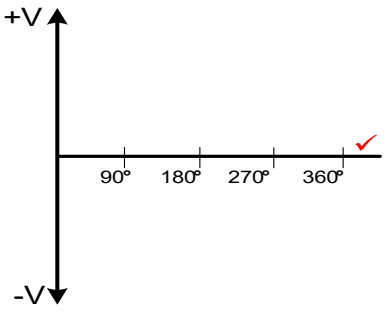
(A Darlington pair has high input resistance and does not load the preceding stage, this acts as a buffer when coupling the stages) (2)

4.5 4.5.1 The amplitude of the output waveform will be reduced. ✓ (1)

4.5.2
- The gain of the amplifier can be controlled ✓
- The amplifier will be stable ✓
- The output signal distortion is reduced
- The range of frequencies that can be amplified is increased (2)

4.6 4.6.1 An ideal op-amp is not dependant on frequency ✓ and would be able to amplify all frequencies from 0 Hz to infinite. (1)

4.6.2



(1)

4.6.3
- Operational amplifiers are high-gain amplifiers that has the ability of amplifying signals from 0 Hz (DC) to MHz range. ✓
- It can be used to perform many mathematical operations. ✓ (2)

4.7 4.7.1 The circuit will become an open loop whereby the output waveform will be saturated and the voltage gain will be infinite. ✓ (1)

4.7.2 Virtual Ground ✓ (1)

4.7.3
$$V_{OUT} = V_{IN}\left(-\frac{R_F}{R_{IN}}\right)$$ ✓

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

$$= 15 \times 10^3 \times \left(-\frac{-12}{1}\right)$$

$$= 180\,000\ \Omega$$ ✓ (3)

4.8 4.8.1 The comparator's output controls the state of the flip-flop.✓ (1)

4.8.2 T_2 will be activated when the reset pin 4 is connected to ground/0 V✓ (1)

4.8.3 When the trigger voltage goes below ⅓V_{cc}, the flip-flop sets ✓ and the output Pin 3 goes to a high level. ✓ (2)

4.8.4
- Pin 6 sets the voltage at which the 555 IC will trigger. ✓
- It is used to maintain the voltage across the timing capacitor ✓ which is discharged with the help of Pin7. (2)

4.8.5 Temperature measurements. ✓
Controlling the positioning of a servo device. ✓ (2)
[45]

QUESTION 5: SWITCHING CIRCUITS

5.1 Astable refers to a circuit that changes its output continuously between two states ✓ without the need of an external trigger input.✓ (2)

5.2 5.2.1 The input circuit has two trigger inputs.✓ (1)

5.2.2 R_1&R_2 divides the output voltage ✓ to a value which is fed back to the non-inverting input.✓ (2)

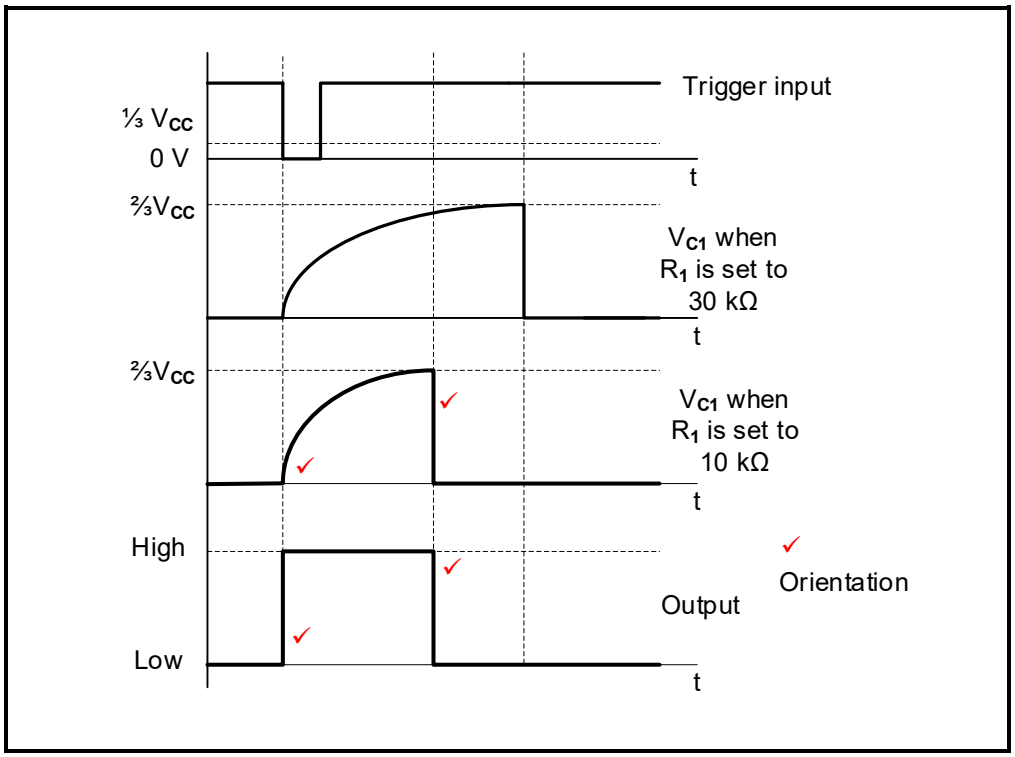
5.2.3
- When PB_1 is pressed it connects the inverting input of the op-amp through C_1 and R_3 to the positive supply connecting a positive voltage (signal) to the inverting input. ✓
- The moment this input signal is higher than the positive voltage present on the non-inverting terminal. ✓
- The output swings to negative saturation ✓ which changes the voltage on the non-inverting terminal to a negative value. ✓ (4)

5.2.4 The circuit has already been triggered at trigger pulse 1 ✓ and will remain in this state until a negative trigger pulse is applied. ✓ (2)

5.3 5.3.1 R_2 is a pull-up resistor ✓ keeping the voltage at pin 2 high and the 555 timer in a stable state. ✓ (2)

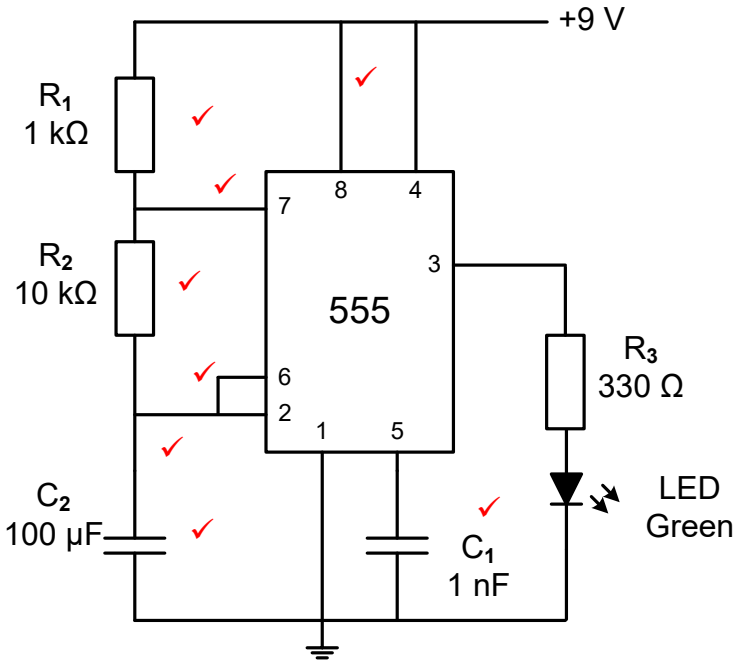
5.3.2 A 1 kΩ resistor must be inserted in series with VR_1 ✓ and the supply ✓ to protect pin 6 and pin 7 from being connected directly to the supply. (2)

5.3.3



(5)

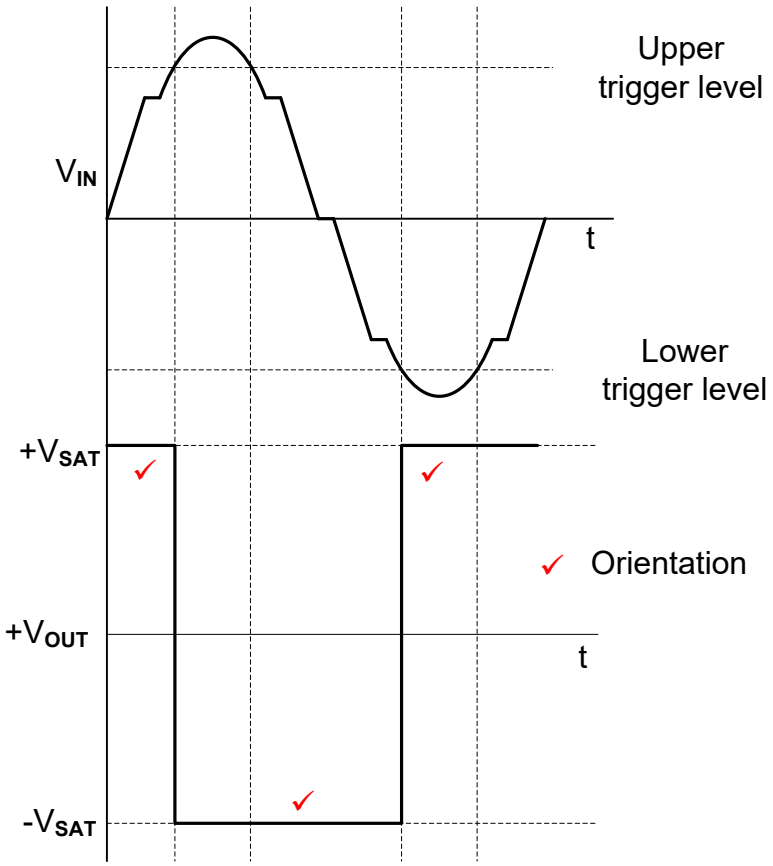
5.4



(8)

5.5 5.5.1 Signal recovery in communication systems. ✓
Converting analogue to digital signals. ✓ (2)

5.5.2



(4)

5.6 The comparator:

- The comparator compares an input voltage to a single reference voltage value ✓ and
- saturates at the slightest difference where it stays until the input rises above or falls below the reference again. ✓
- No feedback takes place and it operates in open loop mode. ✓

The Schmitt trigger:

- The Schmitt trigger compares the input voltage to two different voltage values ✓
- These values are determined by the feedback voltage from the voltage divider on the output. ✓
- As soon as the input rises above the upper trigger level, the output saturates where it remains until the input voltage falls below the lower trigger voltage level. ✓ (6)

5.7 5.7.1 10 kΩ ✓ (1)

5.7.2 -1 ✓ (1)

5.7.3
$$V_{OUT} = -\left(V_1\frac{R_F}{R_1} + V_2\frac{R_F}{R_2} + V_3\frac{R_F}{R_3}\right) \quad ✓$$
$$= -\left(0{,}2\frac{100\,000}{33\,000} + 0{,}9\frac{100\,000}{33\,000} + 0{,}7\frac{100\,000}{33\,000}\right) \quad ✓$$
$$= -5{,}45\ V \quad ✓$$
(3)

5.7.4
$$A_V = -\frac{R_F}{R_{IN}} \quad ✓$$
$$= -\frac{100\,000}{20\,000} \quad ✓$$
$$= -5 \quad ✓$$
(3)

5.8 When a constant current is fed to the capacitor, it charges at a constant rate. ✓
The op-amp's input draws zero current. ✓
The op-amp's two input terminals always possess the same voltage. (2)
[50]

QUESTION 6: AMPLIFIERS

6.1 A linear amplifier provides amplification of a signal without any distortion ✓ so that the output signal is an exact amplified replica of the input signal.✓ (2)

6.2 6.2.1 Saturation region.✓ (1)

6.2.2 The value of the collector current at point B will be zero.✓ (1)

6.3 Class C ✓ (1)

6.4 $$N = 10\log_{10}\frac{P_0}{P_i}$$ ✓

$$= 10\log_{10}\frac{12}{0{,}5}$$ ✓

$$= 13{,}802\,\text{dB}$$ ✓ (3)

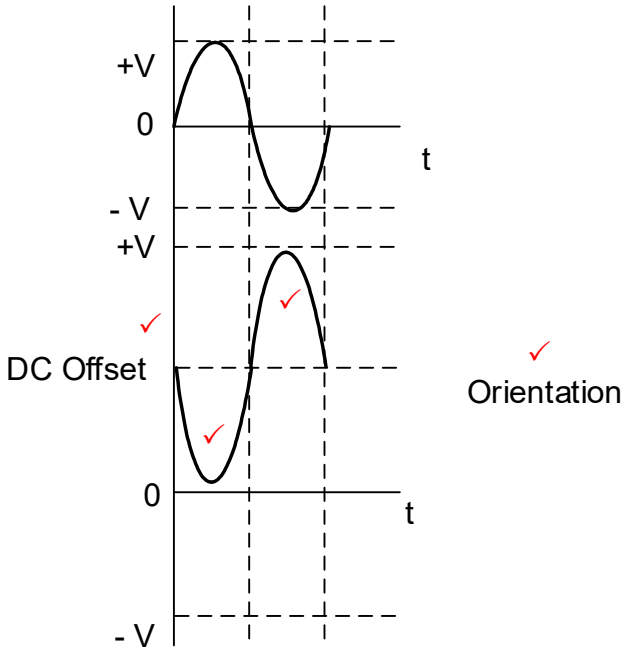
6.5 6.5.1 C_1 and C_3 allows AC signals to pass through✓ and blocks the DC.✓ (2)

6.5.2 When the input signal goes positive, the transistor switches on ✓ resulting in V_{CE} going to zero volts. ✓ This results in an inversion of the output signal. (2)

6.5.3 The current will increase, leading to thermal run away, ✓ which could destroy the transistor. ✓

The output signal may be clipped or it may saturate leading to distortion of the amplified signal. (2)

6.5.4



1 mark for each ½ cycle = 2
1 mark for orientation = 1
1 mark for DC offset = 1 (4)

6.6 6.6.1 Transformer coupled amplifier frequency response curve. ✓ (1)

6.6.2 Transformer. ✓ (1)

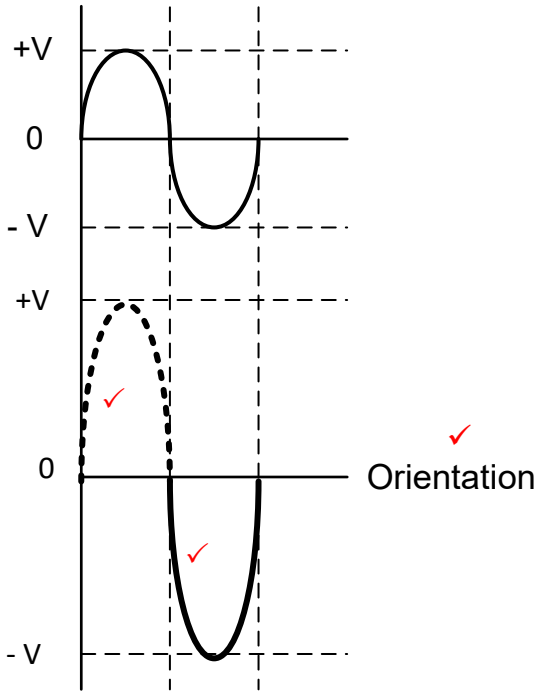
6.6.3 At higher frequencies the transformer winding and its built-in parasitic capacitance begin resonating ✓ causing the short and sharp increase in the gain affected by the q-factor ✓ resulting in a change in roll-off. (2)

6.7 6.7.1 Crystal earpiece. ✓ (1)

6.7.2 Used in dc motor amplifier. ✓
Audio-amplifier (1)

6.7.3 It is not suitable for an audio amplifier because of cross-over ✓ distortion that causes noise in the output. ✓ (2)

6.7.4



1 mark for each ½ cycle = 2
1 mark for the orientation = 1 (3)

6.8
- Transformer coupling ✓
- Resistance – capacitance coupling. ✓
- Direct coupling (2)

6.9 6.9.1 Radio-frequency amplifier ✓ (1)

6.9.2 C_2 is connected in the secondary winding of second transformer to:
- create a second LC tuned circuit ✓
- make the circuit more frequency selective. ✓ (2)

6.9.3

$$A_p = 10\log\frac{P_{out}}{P_{in}} \quad ✓$$

$$26\text{ dB} = 10\log\frac{P_{out}}{27\text{ m W}} \quad ✓$$

$$\frac{26}{10} = \log\frac{P_{out}}{27 \times 10^{-3}}$$

$$398{,}11 = \frac{P_{out}}{27 \times 10^{-3}}$$

$$P_{out} = 398{,}11 \times 27 \times 10^{-3}$$

$$= 10{,}75\text{ W} \quad ✓$$

(3)

6.10 6.10.1
- The phase-shift around the positive feedback loop must be 360°/0°. ✓
- The gain around the loop must be equal to unity. (1)

6.10.2 C_2 and C_3 blocks DC current ✓ from passing through and allows only Radio Frequency signals to pass from the amplifier to the tank circuit. ✓ (2)

6.11 6.11.1 RC phase Shift Oscillator.✓ (1)

6.11.2 A - RC network ✓
B - Amplifier. ✓ (2)

6.11.3 The RC-network provides a 180º phase shift ✓ and the transistor amplifier provides a further 180º phase shift which results in a 360º phase shift for the circuit. ✓ (2)
[45]

TOTAL: 200