basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

SENIOR CERTIFICATE EXAMINATIONS/
NATIONAL SENIOR CERTIFICATE EXAMINATIONS

ELECTRICAL TECHNOLOGY: ELECTRONICS

2023

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

QUESTION 2: OCCUPATIONAL HEALTH AND SAFETY

2.1 The purpose of the act is to provide good health and safety to all people at work ✓ especially when using machinery ✓ and for protection against the hazards arising out of activities of other ✓ people.
To establish an advisory council for occupational health and safety and related matters. (3)

2.2 An unsafe act may lead to an accident ✓ injuring an employee, this reduces the number of skilled personnel in the workplace ✓ therefore reducing the rate of productivity. (2)

2.3 Actions that will have serious consequences ✓ when they occur, but there is a low chance of these risks happening. ✓ (2)

2.4
- Apply direct pressure to the wound using a cloth or gauze. ✓
- Apply continual pressure to a pressure point to stop all circulation to that part of the body. ✓ (2)

2.5 Not to be in direct contact with blood due to the risk of HIV infection. ✓ (1)
[10]

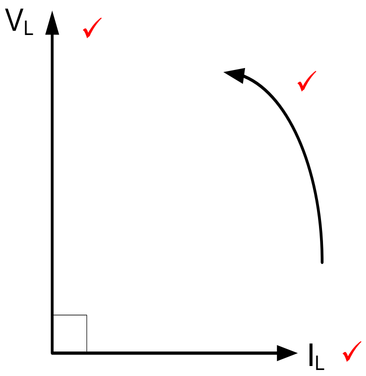
QUESTION 3: RLC CIRCUITS

3.1 When the voltage and current waveforms start at the same time, ✓ have the same frequency✓ resulting in a zero phase angle. ✓

OR

When any waveforms of electrical quantities start at the same time, reach their peak at the same time, pass through zero at the same time and end at the same time. (The two waves have the same frequency even though their amplitude may differ) (3)

3.2



(3)

3.3 Radio tuning circuits ✓
Television tuning circuits ✓ (2)

3.4 3.4.1 A - Impedance versus frequency. ✓
RLC parallel impedance response graph (1)

3.4.2 B - Current versus frequency. ✓
RLC parallel current response graph (1)

3.5 3.5.1

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

$$= \sqrt{30^2 + (60 - 20)^2} \quad ✓$$

$$= 50\ V \quad ✓$$

(3)

3.5.2

$$Tan\ \theta = \frac{V_L - V_C}{V_R} \quad ✓$$

$$\theta = Tan^{-1}\left(\frac{V_L - V_C}{V_R}\right)$$

$$= Tan^{-1}\left(\frac{60 - 20}{30}\right) \quad ✓$$

$$= 53{,}13° \quad ✓$$

OR

$$\theta = Cos^{-1}\left(\frac{V_R}{V_T}\right)$$

$$= Cos^{-1}\left(\frac{30}{50}\right)$$

$$= 53{,}13^0$$

(3)

3.5.3 Lagging. ✓
(Reason - The voltage across the inductor is greater than the voltage across the capacitor). (1)

3.6 3.6.1 At resonance $X_L = X_C = 113{,}12\ \Omega$

$$X_L = 2\pi f L \quad ✓$$

$$L = \frac{X_L}{2\pi f}$$

$$= \frac{113{,}12}{2\pi(3000)} \quad ✓$$

$$= 6\ \text{mH} \quad ✓$$

(3)

3.6.2

$$Q = \frac{X_C}{R} \quad ✓$$

$$= \frac{113{,}12}{100} \quad ✓$$

$$= 1{,}13 \quad ✓$$

(3)

3.6.3 $BW = \frac{f_r}{Q}$ ✓

$= \frac{3000}{1,13}$ ✓

$= 2654,87\ Hz$ ✓

(3)

3.6.4 The value of the current will be doubled. ✓ (1)

3.7 3.7.1 $I_L = \frac{V_T}{X_L}$ ✓

$= \frac{120}{300}$ ✓

$= 0,4\ A$ ✓

OR

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

$= \sqrt{1,22^2 - 1,2^2} + 0,2$

$= 0,42\ A$

(3)

3.7.2 $P = I^2R$ ✓

$= (1,2)^2 \times 100$ ✓

$= 144\ W$ ✓

(3)

OR

$Cos\ \theta = \frac{I_R}{I_T}$

$P = VI\left(\frac{I_R}{I_T}\right)$

$= 120 \times 1,22 \times \frac{1,2}{1,22}$

$= 144\ W$

3.7.3 The circuit is inductive ✓ because the inductive current is greater than the capacitive current. ✓ (2)

[35]

QUESTION 4: SEMICONDUCTORS

4.1 4.1.1 N - channel ✓ enhancement MOSFET ✓ (2)

4.1.2 P - channel ✓ depletion MOSFET. ✓ (2)

4.2
- The MOSFET is created with no direct channel existing between Source and Drain. ✓
- The N regions below both Source and Drain terminals are heavily doped. ✓
- The entire surface of the device with an exception of the two connections for source and drain is covered with an extremely thin layer of metal oxide to form the insulation for the insulated Gate. ✓
- A metallic conductive contact is added to the top of the metal dioxide film to form the Gate contact. ✓ (4)

4.3 4.3.1 R_1 and R_2 serves as potential dividers ✓ to bias the MOSFET. (1)

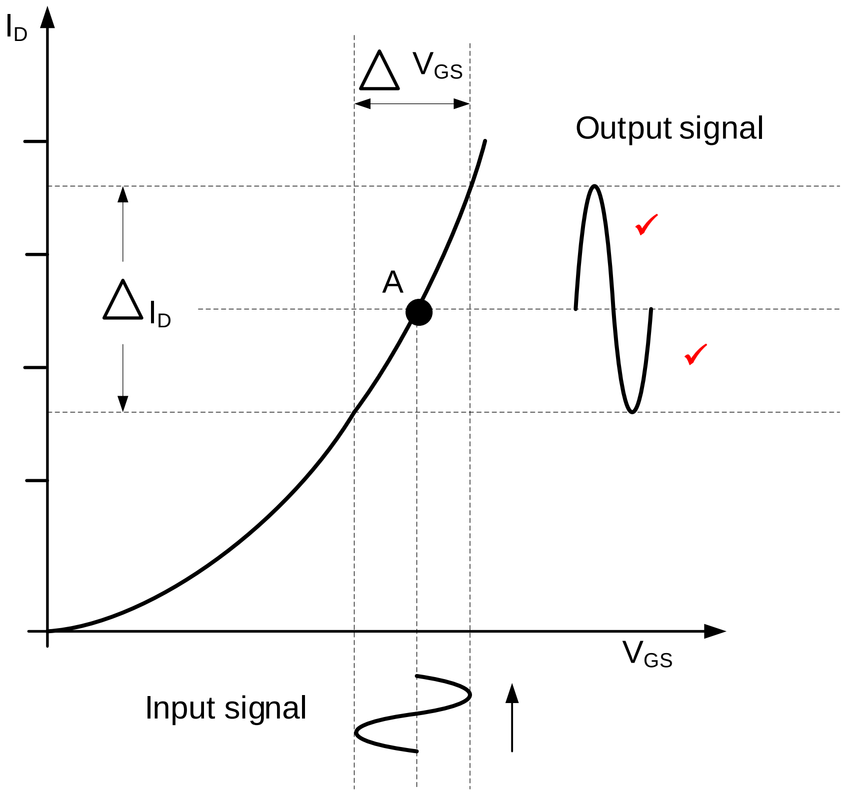
4.3.2 The MOSFET can be operated as a linear amplifier by selecting the correct biasing resistors ✓ to set its operating point ✓ in the centre of the transfer characteristic. ✓ (3)

4.3.3 During the first 90º of the input signal, the voltage across the gate-source terminals (V_{GS}) rises ✓ turning the transistor more ON. This causes the voltage across the drain-source terminals (V_{DS}) to decrease ✓ and the I_D will increase. ✓ (3)

4.4 4.4.1 Enhancement mode MOSFET. ✓ (1)

4.4.2 Quiescent point. ✓ (1)

4.4.3

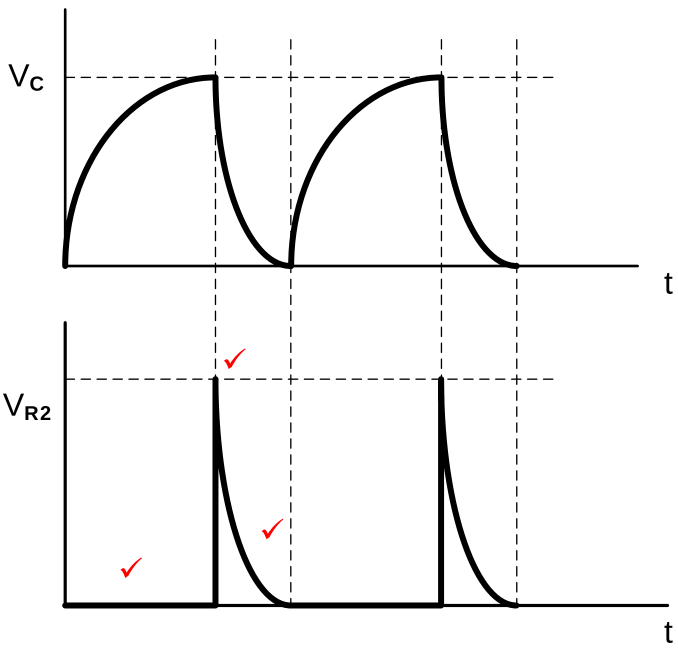


(2)

4.5 4.5.1 Multi-shot. ✓ (Continuous switching) (1)

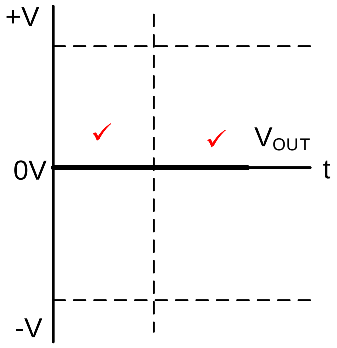
4.5.2 The purpose of R_3 is to limit the discharge current ✓ of the capacitor ✓ through the UJT to a safe value. It develops a large potential across itself for a short time when the high discharge current is flowing from the capacitor. (2)

4.5.3



(3)

4.6



(2)

4.7 4.7.1 Non-inverting amplifier. ✓ (1)

4.7.2 It means that the operational amplifier can operate within an infinite range of frequencies ✓ with the same amount of amplification or gain.✓ (2)

4.7.3

$$A_V = \left(1 + \frac{R_F}{R_{IN}}\right) \checkmark$$

$$= \left(1 + \frac{47 \times 10^3}{10 \times 10^3}\right) \checkmark$$

$$= 5{,}7 \checkmark$$

(3)

4.7.4

$$A_V = \frac{V_{OUT}}{V_{IN}} \checkmark$$

$$V_{OUT} = A_V \times V_{IN} \checkmark$$

$$= 5{,}7 \times 100 \times 10^{-3}$$

$$= 0{,}57\,V/570\,mV \checkmark$$

(3)

4.8 4.8.1 A = Control voltage ✓
B = Trigger ✓ (2)

4.8.2 The discharge pin provides the discharge path ✓ for the timing capacitor and the timing resistor. ✓ (2)

4.8.3 Comparator 1 compares the threshold voltage on pin 6 ✓ to 2/3rd of the supply voltage on the non-inverting input ✓ and provides a relevant output ✓ which is fed to the RS flip-flop. (3)

4.8.4
- Basic timing functions, like turning a light on (or off) for a certain length of time. ✓
- Pulse, oscillation and waveform generation ✓
- Digital logic probes
- To produce musical notes of a particular frequency
- In industrial applications
- Creating a warning light that flashes on and off (2)

[45]

QUESTION 5: SWITCHING CIRCUITS

5.1 5.1.1 Bistable Multivibrator ✓ (1)

5.1.2 Monostable Multivibrator ✓ (1)

5.1.3 Astable Multivibrator ✓ (1)

5.2 5.2.1 The purpose of variable resistor R_2 is to adjust the frequency ✓ of the output ✓ by changing the time constant of Capacitor C_1. (2)

5.2.2 As soon as the output goes high, the LED becomes forward biased ✓ and without a series resistor it would damage the LED✓ because of the excessive current flowing through the LED. ✓

OR

As soon as the output goes high, the current flowing through the LED will be too high without the series resistor and this may lead to damage to the LED. (3)

5.2.3 This circuit operates as an astable multivibrator because trigger pin 2 and threshold pin 6 ✓ are connected to capacitor C_1 ✓ causing the circuit output to trigger and change state ✓ as the capacitor charges to ⅔ and discharges to ⅓ of the supply voltage.✓ (4)

5.2.4 Capacitor C_1 will discharge through resistor R_2 to pin 7 and pin 1 down to ground. ✓ (1)

5.3 5.3.1 Because R_1=R_2, the voltage on pin 2 (inverting input) is half the supply voltage ✓ = 3 V✓

$$V_2 = \frac{6}{2} = 3\ V$$
(2)

5.3.2 6 V ✓, because the capacitor is fully charged. (1)

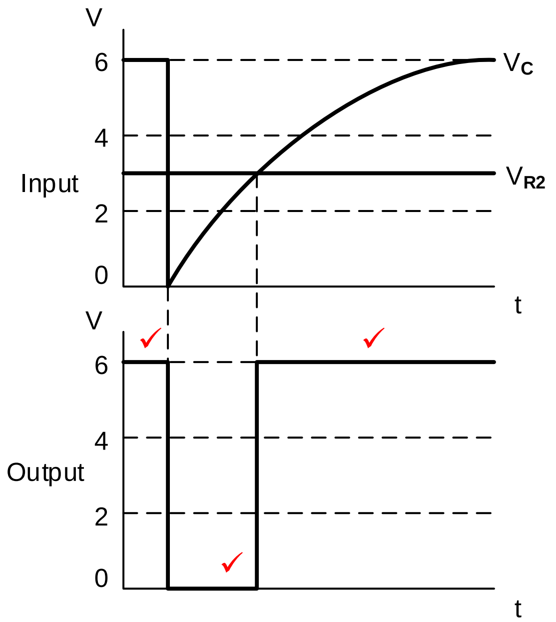
5.3.3 The output is high (6 V), ✓ because the voltage on the non-inverting input is higher than the voltage on the inverting input. ✓ (2)

5.3.4 0 V ✓, the switch connects pin 3 to 0 V ✓ and the capacitor will instantaneously discharge to 0 V. (2)

5.3.5
- The moment the switch is pressed, both plates of the capacitor and the voltage on the non-inverting input will be 0 V. ✓
- Because the voltage is higher on the inverting input (3 V), the output will be low (0 V). ✓
- The capacitor starts to charge and while the capacitor is charging the output remains low until the voltage across the capacitor reaches 3 V. ✓
- The moment the voltage across the capacitor exceeds 3 V, ✓ the output swings to high (6 V) ✓ where it will remain until the switch is pressed.

(5)

5.3.6

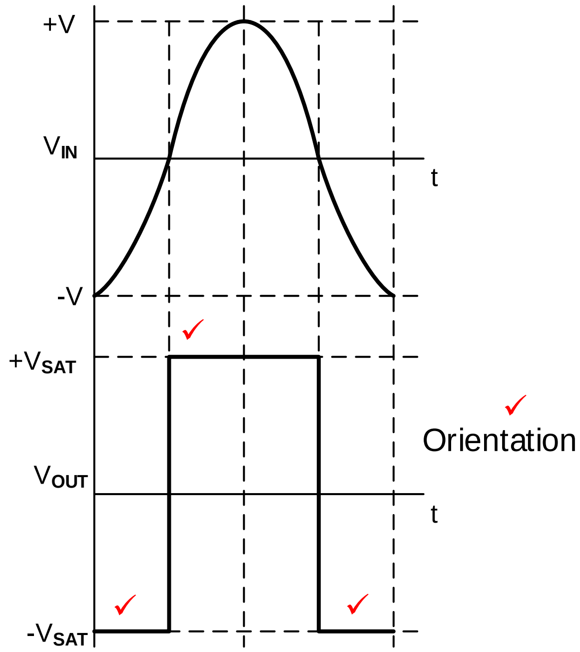


(3)

5.4 5.4.1 0 V. ✓ The inverting terminal is connected to ground. ✓ (2)

5.4.2 A Schmitt trigger is used to clean up distorted signals in radio receivers. ✓
A Schmitt trigger is used to convert analogue signals to digital signals. ✓ (2)

5.4.3



(4)

5.5 5.5.1 Because the gain is -1; $R_F = R_{IN} = 10\ k\Omega$, ✓ (1)

5.5.2

$$A_V = -\frac{R_F}{R_{IN}} \checkmark \qquad \textbf{OR} \qquad A_V = \frac{V_{OUT}}{V_1 + V_2 + V_3}$$

$$= -\frac{100 \times 10^3}{10 \times 10^3} \checkmark \qquad\qquad = \frac{-10}{0{,}3 + 0{,}4 + 0{,}3}$$

$$= -10 \checkmark \qquad\qquad = -10$$

(3)

5.5.3

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

$$= -\left(1 \frac{20 \times 10^3}{10 \times 10^3} + 0{,}5 \frac{20 \times 10^3}{10 \times 10^3} + 0{,}5 \frac{20 \times 10^3}{10 \times 10^3}\right) \checkmark$$

$$= -4\ \text{V} \checkmark$$

(3)

OR

$$V_{OUT} = A_V(V_1 + V_2 + V_3)$$

$$= -2(1 + 0{,}5 + 0{,}5)$$

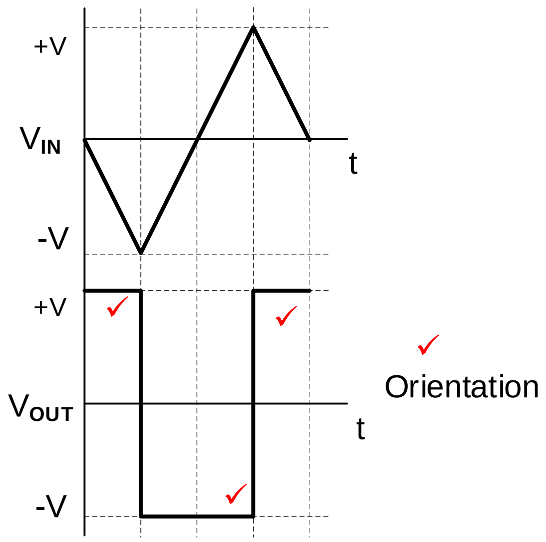
$$= -4\ V$$

5.5.4 An increase in R_F increases the gain ✓ of the summing amplifier.

OR

R_F is directly proportional to the gain (1)

5.6 5.6.1



(4)

5.6.2 The polarity of the output depends on whether the input voltage increases in value ✓ or decreases in value. ✓ (2)

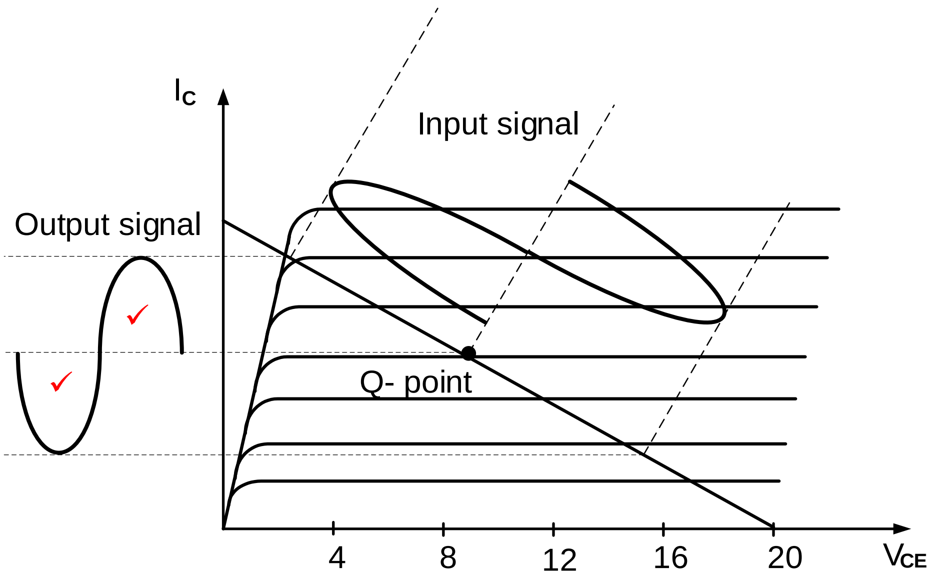
[50]

QUESTION 6: AMPLIFIERS

6.1 Stability is the measure of how well an amplifier maintains its design parameters ✓ over changes in temperature. ✓ (2)

6.2. 6.2.1 Class A amplification.✓ (1)

6.2.2



(2)

6.3 6.3.1 C - Saturation region ✓ (1)

6.3.2

$$Rc = \frac{Vcc}{Ic} \quad ✓$$

$$= \frac{20}{(4 \times 10^{-3})} \quad ✓$$

$$= 5\,000\,\Omega \quad ✓$$

$$= 5\,k\Omega$$

(3)

6.3.3 Load line B had its load resistance value increased ✓ causing the collector current to decrease ✓ while the value of V_{CE} remained constant. (2)

6.4 6.4.1 4,5 V ✓ (Half of the supply voltage) (1)

6.4.2 The circuit in FIGURE 6.4 must be an audio amplifier because its input and output signals ✓ fall within the audio frequency range ✓ due to the microphone on the input and earphones on the output.✓ (3)

6.4.3 To provide the low resistance path for AC signals ✓ to ground✓ (2)

6.5 6.5.1 The emitter by-pass capacitors (C_1 and C_3)
- offers a low reactance path to the AC signal.✓
- Provides emitter stabilisation. ✓ (2)

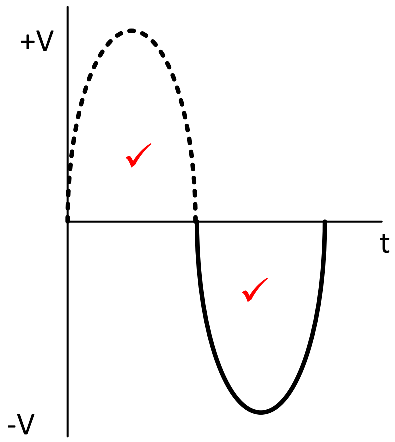
6.5.2
- Impedance matching is possible due to the transformer. ✓
- High efficiency.
- offers a low reactance path to the AC signal. (1)

6.5.3 The coupling Transformer T_1
- is used to feed the output ✓ of the first stage to the input ✓ of the second stage.
- Ensuring correct bandwidth is maintained through all stages. ✓
- Used for Coupling of the stages. (3)

6.6 6.6.1 It introduces cross-over distortion into the sound system.✓ (1)

6.6.2 The capacitor C_2 is coupling the circuit with the speaker ✓ and acts as a short term power source for the PNP transistor during the negative half cycle.✓ (2)

6.6.3



(2)

6.7 6.7.1 RF amplifiers are used to amplify a single high frequency ✓ (above100 kHz) and suppress all others.✓ (2)

6.7.2 Noise ✓ (1)

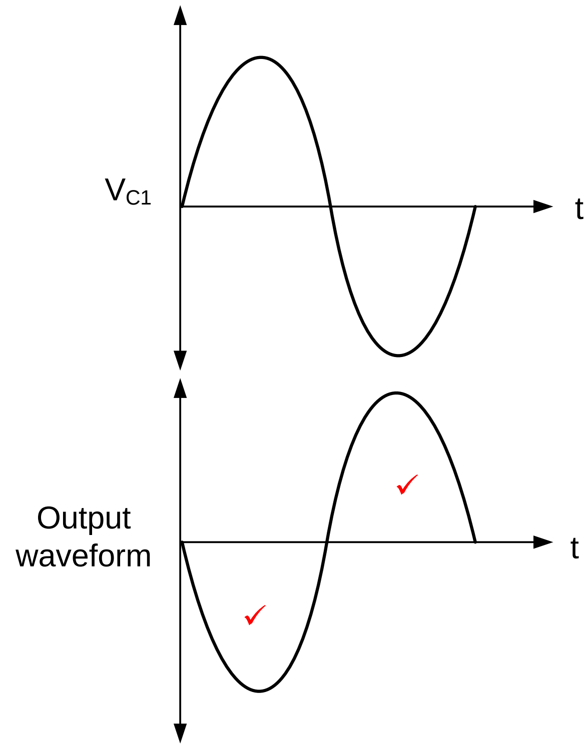
6.7.3 To make the circuit more frequency selective.✓ (1)

6.7.4 To enable the RF amplifier to be tuned to a range of frequencies, making the circuit tuneable. ✓ (1)

6.8 6.8.1 Used in radio receivers.✓ (1)

6.8.2 The purpose of the transistor (Q_1) is to replace the energy that is lost ✓ during each cycle so that the oscillation frequency can be sustained. ✓ (2)

6.8.3



(2)

6.9 6.9.1 R_C controls the collector current ✓ in order to protect the transistor.✓ (2)

6.9.2

$$f_O = \frac{1}{2\pi\sqrt{6}\,RC} \quad ✓$$

$$C = \frac{1}{2\pi\sqrt{6}\,Rf_O}$$

$$= \frac{1}{2\,\pi\sqrt{6}\,(10000)(64{,}98)} \quad ✓$$

$$= 9{,}99 \text{ X } 10^{-8}\text{ F} \quad ✓$$

$$= 100\text{ nF}$$

(3)

6.9.3 The oscillation frequency will increase ✓ because the value of the capacitor is indirectly proportional to the oscillation frequency. ✓ (2)

[45]

TOTAL: 200