Province of the
EASTERN CAPE
EDUCATION

NATIONAL SENIOR CERTIFICATE

GRADE 11

NOVEMBER 2020

ELECTRICAL TECHNOLOGY: ELECTRONICS (EXEMPLAR)

MARKS: **200**

TIME: **3 hours**

IELTTE2

This question paper consists of 11 pages, including a 1-page formula sheet.

INSTRUCTIONS AND INFORMATION

1. This question paper consists of NINE questions.
2. Sketches and diagrams must be large, neat and fully labelled.
3. Show ALL calculations and round off answers to TWO decimal places. Show the units for ALL answers of calculations.
4. Number the answers correctly according to the numbering system used in this question paper.
5. You may use a non-programmable calculator.
6. A formula sheet is provided at the end of this question paper.
7. Write neatly and legible.

QUESTION 1: OCCUPATIONAL HEALTH AND SAFETY

1.1 Name TWO instances where the user is not required to supply an earth to roofs, gutters, downpipes and wastepipes, on a premises to which electrical energy is supplied. (2)

1.2 Explain how the following environmental factors could impact negatively on a worker in the workshop:

1.2.1 Lack of space (1)

1.2.2 Lighting (1)

1.3 Describe the term *anthropometrics*. (2)
[6]

QUESTION 2: TOOLS AND MEASURING INSTRUMENTS

2.1 What is the purpose of a crimping lug? (1)

2.2 Explain the advantage of a clamp meter over a digital multimeter when measuring current. (2)

2.3 Why is it important to stand aside to allow the grinder wheel to run up to full speed before using it? (2)

2.4 Explain the purpose of a time-base generator in an oscilloscope. (1)
[6]

QUESTION 3: COMMUNICATION SYSTEMS

3.1 Explain the term *resonance*. (2)

3.2 Name THREE types of oscillators. (3)

3.3 Explain the purpose of a Wien bridge oscillator. (6)

3.4 Explain the purpose of a variable frequency oscillator. (3)

3.5 Name the applications of continuous wave transmitter. (2)

3.6 Explain the term *demodulation*. (2)

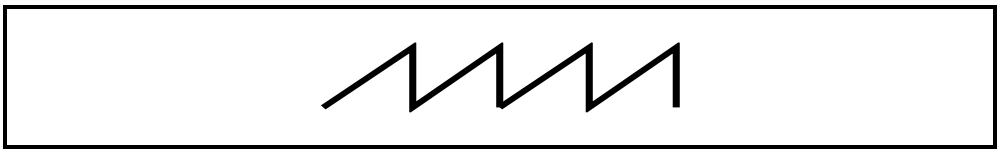
3.7 Draw a block diagram of an AM receiver. (6)

3.8 Describe the purpose of frequency shift keying. (2)
[26]

QUESTION 4: WAVEFORMS

4.1 Identify the following waveforms as shown in FIGURES 4.1.1 to 4.1.4.

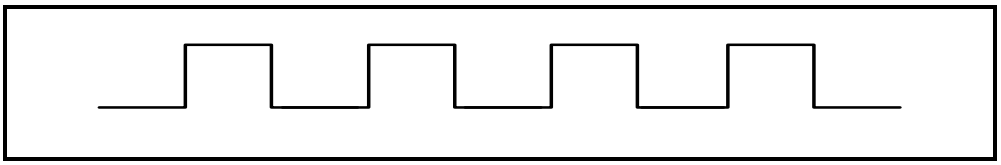
4.1.1



(1)

FIGURE 4.1.1

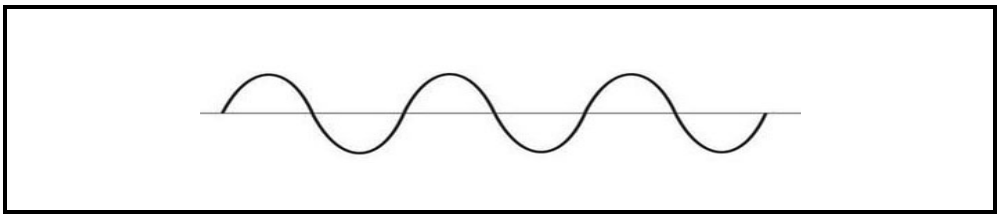
4.1.2



(1)

FIGURE 4.1.2

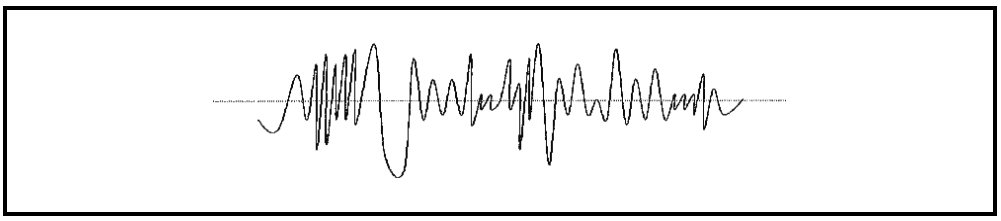
4.1.3



(1)

FIGURE 4.1.3

4.1.4



(1)

FIGURE 4.1.4

4.2 Define the term *period* with reference to a wave form. (3)

4.3 For a digital pulse waveform, explain the following terms:

4.3.1 Pulse width (3)

4.3.2 Fall time (3)

4.4 An AC supply has an rms voltage of 9 V. Determine its peak voltage. (3)

4.5 Determine the periodic time of a wave with a frequency of 500 Hz. (3)

4.6 Describe the concept of *clamping* in electronics. (4)

4.7 Mention THREE applications of a radio wave. (3)

[26]

QUESTION 5: RLC-CIRCUITS

5.1 Mention ONE factor that directly affects the capacitive reactance of an AC circuit with RC components. (1)

5.2 Name TWO methods of finding the combined impedance of a series connected circuit. (2)

5.3 Draw a neatly labelled graph showing the relationship between the inductive reactance and the frequency in an RLC series circuit. (3)

5.4 Study FIGURE 5.4 below and answer the questions that follow.

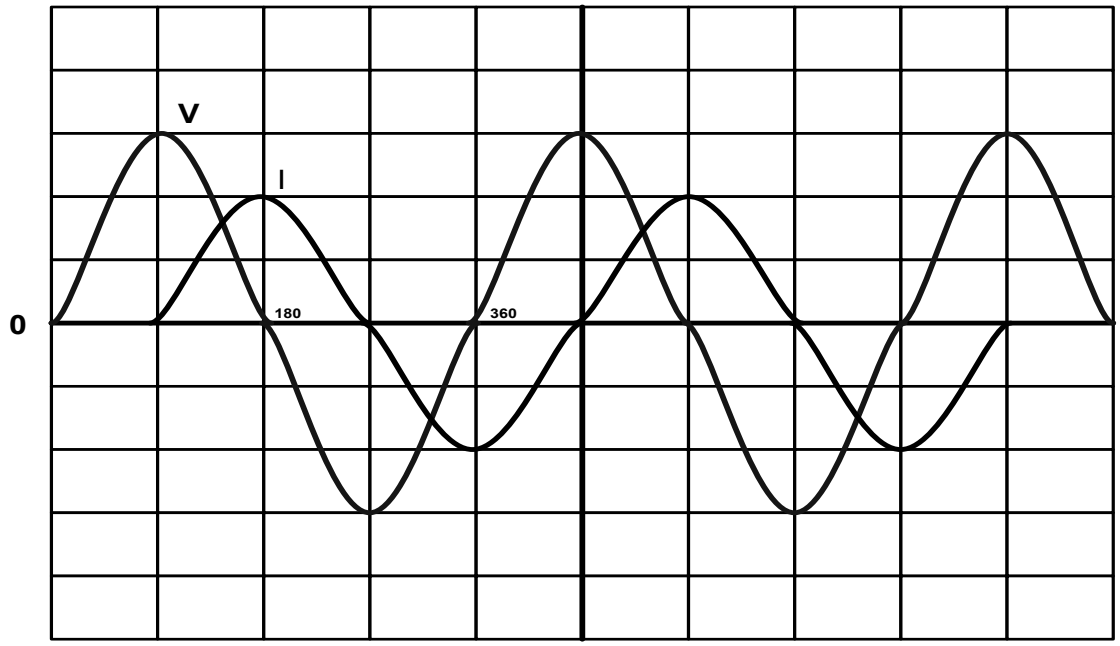


FIGURE 5.4: RL CIRCUIT WAVEFORMS

5.4.1 Describe the relationship between the voltage and the current waveforms. (1)

5.4.2 Explain how an increase in frequency would affect the current waveform. (3)

5.5 Refer to the circuit diagram in FIGURE 5.5 and answer the questions that follow.

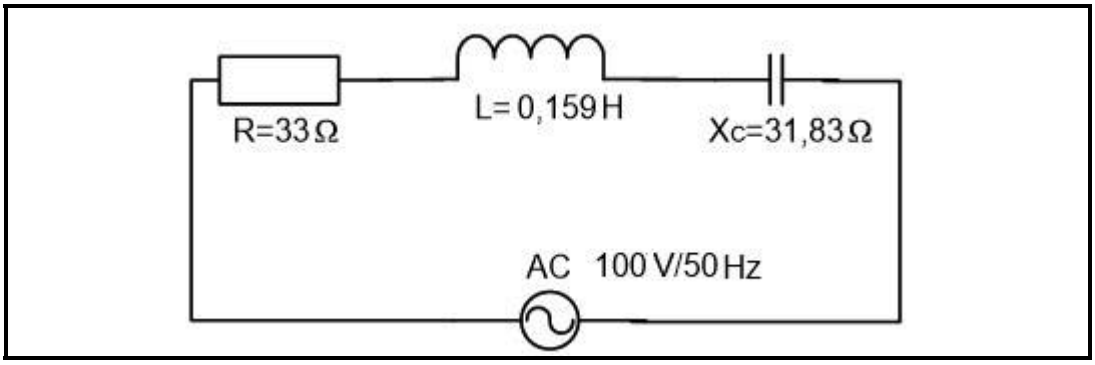


FIGURE 5.5

Given: $R = 33\ \Omega$
$L = 0{,}159\ H$
$X_C = 31{,}83\ \Omega$
$V = 100\ V$
$f = 50\ Hz$

Calculate:

5.5.1 The inductive reactance of the coil (3)

5.5.2 The total impedance of the circuit (3)

5.5.3 The current flowing through the circuit (3)

5.5.4 The value of the capacitor in the circuit (3)

5.6 Given a series circuit with a 600 Ω resistor, an inductive reactance of 37,7 Ω and a capacitive reactance of 665 Ω. Describe what occurs to the impedance of a series circuit when it reaches the point of resonance. (4)
[26]

QUESTION 6: SEMICONDUCTOR DEVICES

6.1 Describe the term *semiconductor*. (2)

6.2 What is the Q-point of a diode? (2)

6.3 Briefly explain the term *majority carriers* in a P-type silicon semiconductor. (2)

6.4 Draw a fully labelled characteristic curve of a TRIAC. (4)

6.5 Semiconductors are mass produced and are often small in physical size. Manufactures supply component data sheets. Answer the following questions with reference to component data sheets.

6.5.1 State ONE source where such data sheets may be found. (1)

6.5.2 Working temperature may be displayed on the sheet. Explain why this information is important. (3)

6.5.3 Other than working temperature, state TWO types of information given on data sheets. (2)

6.6 Draw fully labelled circuit symbols of the following:

6.6.1 SCR (3)

6.6.2 TRIAC (3)

6.7 Explain the difference between *conventional* current flow and *electron* flow. (4)

6.8 Describe the term *solid state*, with reference to semiconductors. (2)

6.9 Describe how N-type material is formed. (5)

6.10 How does a zener diode differ from other diodes? (3)

6.11 For the normal operation of a transistor as a switch, which junction should always be:

6.11.1 Forward biased? (2)

6.11.2 Reverse biased? (2)

6.12 Briefly explain TWO ways of switching on the SCR. (4)

6.13 Name any TWO impurities which are added to pure silicon to create P-type material. (2)

[46]

QUESTION 7: POWER SUPPLIES

7.1 Explain the purpose of a transformer. (3)

7.2 Draw a circuit diagram for a half wave rectifier. (5)

7.3 Draw the block diagram of the series voltage regulator. (3)

7.4 Refer to the circuit diagram in FIGURE 7.4 below and answer the questions that follow.

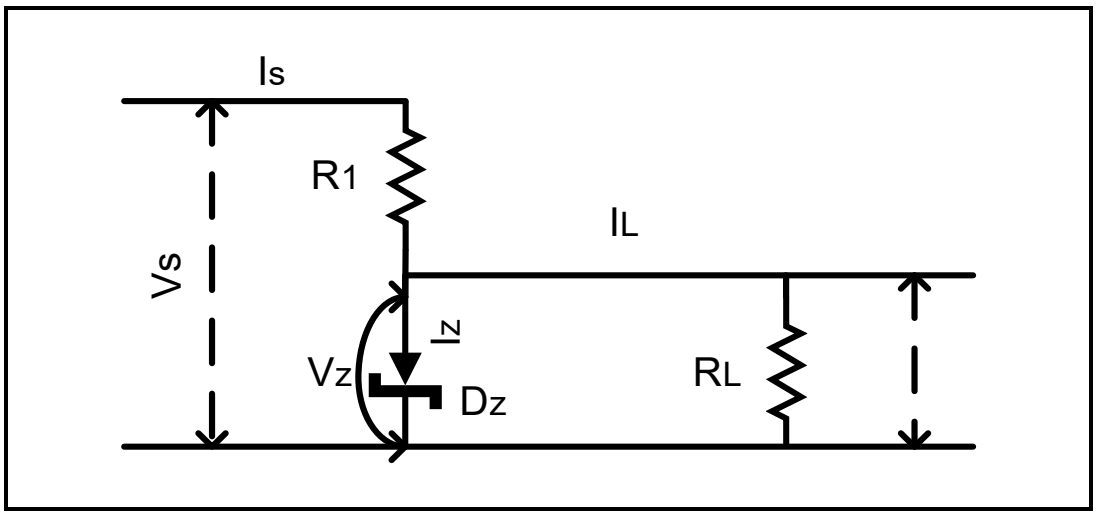


FIGURE 7.4

Given:

Pz = 2 W
Vs = 12 V
Vz = 5 V
RL = 1 kΩ

Calculate:

7.4.1 The maximum current flowing through the Zener diode (I_Z) (3)

7.4.2 The minimum value of the series resistor, R_S (3)

7.4.3 The load current (IL) if a load resistor of 1 kΩ is connected across the zener diode (3)

[20]

QUESTION 8: SENSORS AND TRANSDUCERS

8.1 Define the term '*sensor*' as used in sensors and transducers. (2)

8.2 Describe the basic operation of a dynamic microphone. (4)

8.3 List TWO types of humidity sensors. (2)

8.4 Explain the principle of operation of a *Light Dependant Resistor (LDR).* (4)
[12]

QUESTION 9: AMPLIFIERS

9.1 Describe how class C amplification is obtained. (2)

9.2 Name ONE use of class AB amplifiers. (1)

9.3 List THREE common types of transistor configurations. (3)

9.4 Give TWO types of biasing as used in amplifier design. (2)

9.5 Refer to FIGURE 9.5 below and answer the questions that follow.

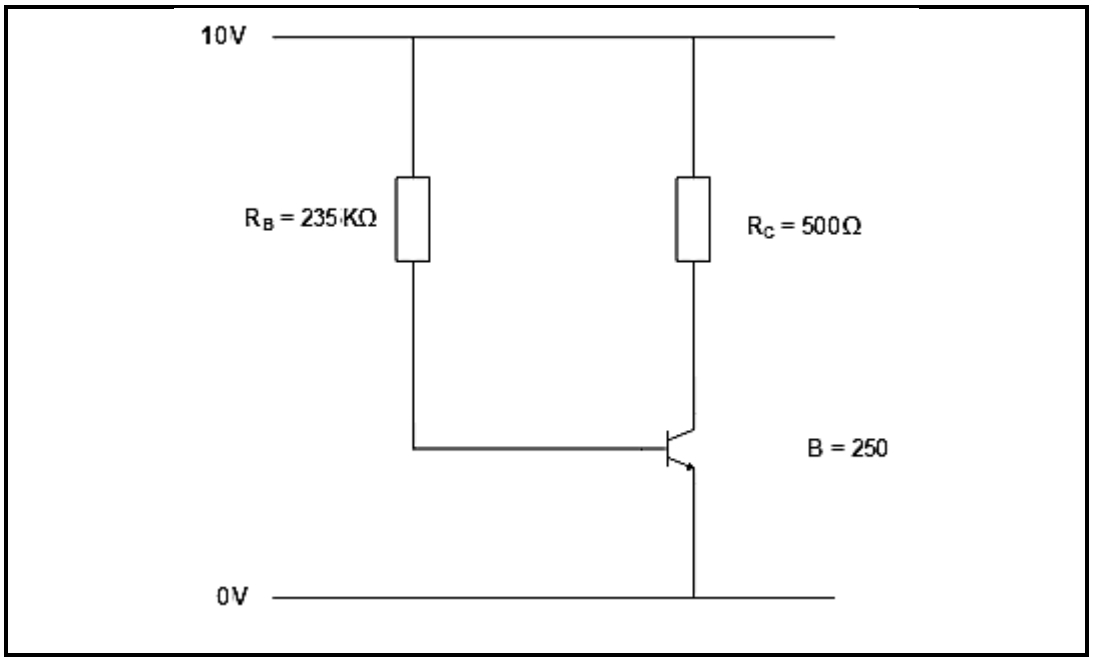


FIGURE 9.5

Calculate:

9.5.1 The quiescent base current (3)

9.5.2 The quiescent collector current (3)

9.5.3 The quiescent collector-emitter voltage (3)

9.6 Name TWO advantages of negative feedback. (2)

9.7 Draw a block diagram of negative feedback. (5)

9.8 List THREE types of transistor operation regions. (3)

9.9 With reference to a basic amplifier. Explain the purpose of following:

9.9.1 The voltage amplifier (3)

9.9.2 The current amplifier (2)

[32]

TOTAL: 200

FORMULA SHEET

WAVE FORMS

Frequency

$$f = \frac{1}{T}$$

Maximum value

$$V_{MAX=}\ V_{RMS}\ \times 1{,}414\ (V)$$

RMS Value

$$V_{RMS}\ =\ V_{MAX}\ \text{x } 0{,}707$$

Average value

$$V_{ave}\ =\ V_{max}\ \times 0{,}637$$

POWER SUPPLIES

$$Vave = Vpk - \frac{1}{2}\ V_{RIP\ P-P}$$

$$V_{OUT}\ = V_Z$$

$$Vo = V_Z - V_{BE}$$

$$I_L\ = I_E\ (\beta\ + 1) I_B$$

RLC CIRCUITS

Inductive reactance

$$X_L\ = 2\pi Fl$$

Capacitive reactance

$$X_C\ = \frac{1}{2\pi fc}$$

Impendence

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

Power factor

$$COS\ \theta = \frac{R}{Z}$$

$$COS\ \theta = \frac{VR}{VZ}$$

AMPLIFIERS

$$V_{CE\ max} = V_{VCC}$$

$$V_{CC} = V_{CE}\ +\ I_C\ R_C$$

$$I_C\ =\ \beta I_B$$

$$A_V\ = \frac{Output\ voltage}{input\ voltage}$$

$$A_I = \frac{output\ current}{input\ current}$$

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NOVEMBER 2020

ELECTRICAL TECHNOLOGY: ELECTRONICS MARKING GUIDELINE (EXEMPLAR)

MARKS: 200

This marking guideline consists of 12 pages.

INSTRUCTIONS TO 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.

   2.6 Markers should consider that candidates' 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.

QUESTION 1: OCCUPATIONAL HEALTH AND SAFETY

1.1 Where the operating voltage does not exceed 50 V. ✓
Roofs, gutters, downpipes, and wastepipes made of non-conductive material.
On premises which receive electricity by means of underground service connections. ✓
All metallic parts that are not part of the electrical circuit, that can become live, but have an insulated covering. (2)

1.2 1.2.1 Lack of space can lead to chances of mistakes or even injury. ✓ (1)

1.2.2 Incorrect lighting can lead to eye strain. ✓ (1)

1.3 It is the study of the human body ✓ and its movement. ✓ (2)
[6]

QUESTION 2: TOOLS AND MEASURING INSTRUMENTS

2.1 A crimping lug offers a quick and permanent solution of terminating a cable. ✓ (1)

2.2 The clamp meter is safer and easier to use, ✓ because there is no need to connect to the circuit to make measurements. ✓ (2)

2.3 This is the time the bonding of the wheel is liable to disengage and break apart. ✓ Therefore, it is not safe to be standing in the direct path of any pieces that may be thrown out by centrifugal force. ✓ (2)

2.4 The time base generator generates the internal saw tooth waveform to control the horizontal sweep of the trace. ✓ (1)
[6]

QUESTION 3: COMMUNICATION SYSTEMS

3.1 Resonance is the increase in amplitude of an oscillation in mechanical or electrical systems ✓ under the influence of an external periodic impulse of similar frequency to the original vibration. ✓ (2)

3.2
- The basic LC resonant oscillator ✓
- Hartley oscillator ✓
- Colpitts oscillator ✓
- The RC phase shift oscillator
- The Wien bridge oscillator

(3)

3.3 The Wien bridge oscillator is among the most simple sine wave oscillator which uses an RC network ✓ rather than a tuned LC tank circuit. ✓
It is based on the frequency selective form of a wheatstone bridge circuit. ✓
It uses feedback from two RC circuits, a series RC circuit connected with a parallel RC which together are very frequency selective. ✓
They combine to cause a phase shift of exactly 0° for only the chosen resonant frequencies', ✓ while all higher or lower frequencies are shifted in phase resulting in them not being able to drive the circuit into oscillation. ✓ (6)

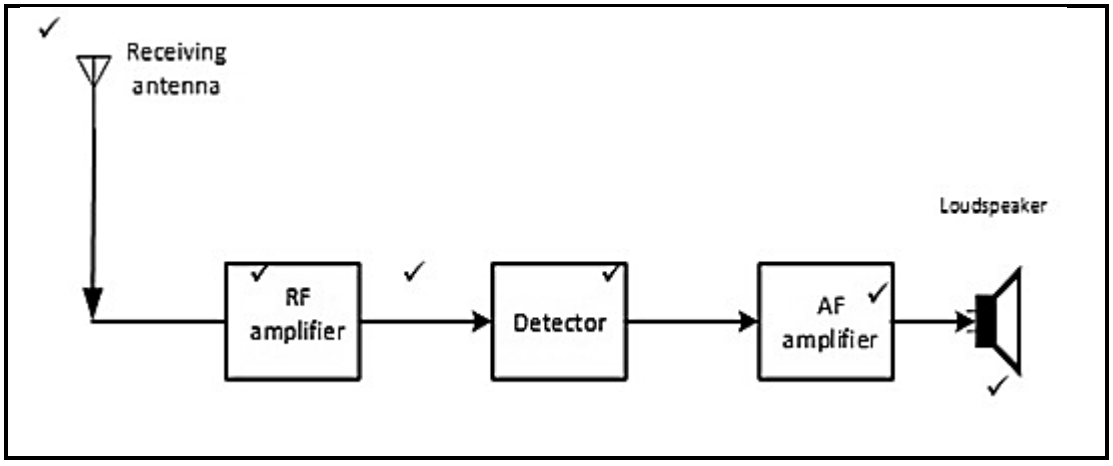
3.4 A variable frequency oscillator is an oscillator circuit which has one of its oscillating components that is adjustable. ✓ It is a widely used component in all tunable radio receivers and transmitters ✓that work using the superheterodyne principle. ✓ (3)

3.5
- Correction of radio controlled communication ✓
- Radio control ✓

(2)

3.6 Modulation refers to the changing of a high frequency signal ✓ in a way that is able to carry information. ✓ (2)

3.7



(6)

3.8 Frequency-shift keying is a method of being able to transmit digital pulse signals, ✓ using traditional radio transmitting and receiving methods. ✓ (2)

[26]

QUESTION 4: WAVEFORMS

4.1 4.1.1 Saw tooth wave ✓ (1)

4.1.2 Square wave ✓ (1)

4.1.3 Sine wave ✓ (1)

4.1.4 Audio wave ✓ (1)

4.2 The period is the time taken ✓ to complete one ✓ full cycle. ✓ (3)

4.3 4.3.1 This is the time between the 50% ✓ amplitude points on both the rising ✓ and the falling edges of the pulse. ✓ (3)

4.3.2 Fall time, this is the time a falling pulse takes to make a change from the higher state 'on' ✓ to the lower state 'off'. ✓ It is measured between the 10% and 90% points of the completed pulse. ✓ (3)

4.4 $V_{rms} = V_{pk} \times 0{,}707\ V$

$V_{pk} = \frac{V_{rms}}{0{,}707}\ V$ ✓

$= \frac{9}{0{,}707}\ V$ ✓

$= 12{,}73\ V$ ✓ (3)

4.5 $T = \frac{1}{f}\ s$ ✓

$= \frac{1}{500}\ s$ ✓

$= 0{,}002 \sec or\ 2\ ms$ ✓ (3)

4.6 The clamping circuit actually binds the upper or lower ✓ extremes of a waveform to a fixed DC voltage level. ✓ When unbiased, clamping circuits will fix ✓ the voltage lower limit ✓ (or upper limit, in the case of negative clampers) to 0 volt. (4)

4.7
- Communication ✓
- Broadcasting ✓
- Computer network ✓ (3)

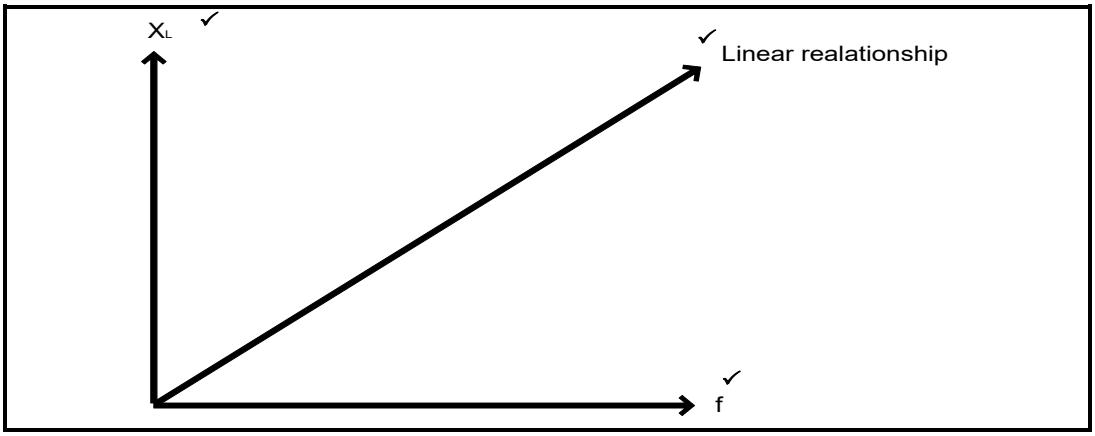
[26]

QUESTION 5: RLC-CIRCUITS

5.1
- The capacitance of the capacitor ✓
- The frequency of the supply (1)

5.2
- Graphical using the impedance triangle ✓
- By calculations using Pythagoras theorem ✓ (2)

5.3



(3)

5.4 5.4.1 The current lags the voltage by 90 degrees. ✓ (1)

5.4.2 An increase in frequency causes the inductive reactance to increase. ✓ This will cause the impedance to increase ✓and the maximum value of the current waveform to decrease. ✓ (3)

5.5 5.5.1
$$X_L = 2\pi fL \checkmark$$
$$= 2 \times \pi \times 50 \times 0{,}159 \checkmark$$
$$= 49{,}95\ \Omega \quad \checkmark$$ (3)

5.5.2
$$Z = \sqrt{R^2 + (X_L - X_C)^2} \checkmark$$
$$= \sqrt{33^2 + (49{,}95 - 31{,}83)^2} \checkmark$$
$$= 37{,}65\ \Omega \checkmark$$ (3)

5.5.3
$$I = \frac{V}{Z} \checkmark$$
$$= \frac{100}{37{,}65} \checkmark$$
$$= 2{,}66\ A \checkmark$$ (3)

5.5.4
$$X_C = \frac{1}{2\pi fC}$$
$$C = \frac{1}{2\pi fC} \checkmark$$
$$= \frac{1}{2\times\pi\times50\times31{,}83} \checkmark$$
$$= 1 \times 10^{-4} F = 100\ \mu F \checkmark$$ (3)

5.6 At the resonant frequency point the two reactance are identical in size ✓ but exactly opposite to each other in direction making $X_L - X_C = O$. ✓ At this point they cancel each other's effect and the only resistance left in the circuit is the resistance of the resistor R, ✓ where the component impedance will be equal to the resistance. ✓ (4)

[26]

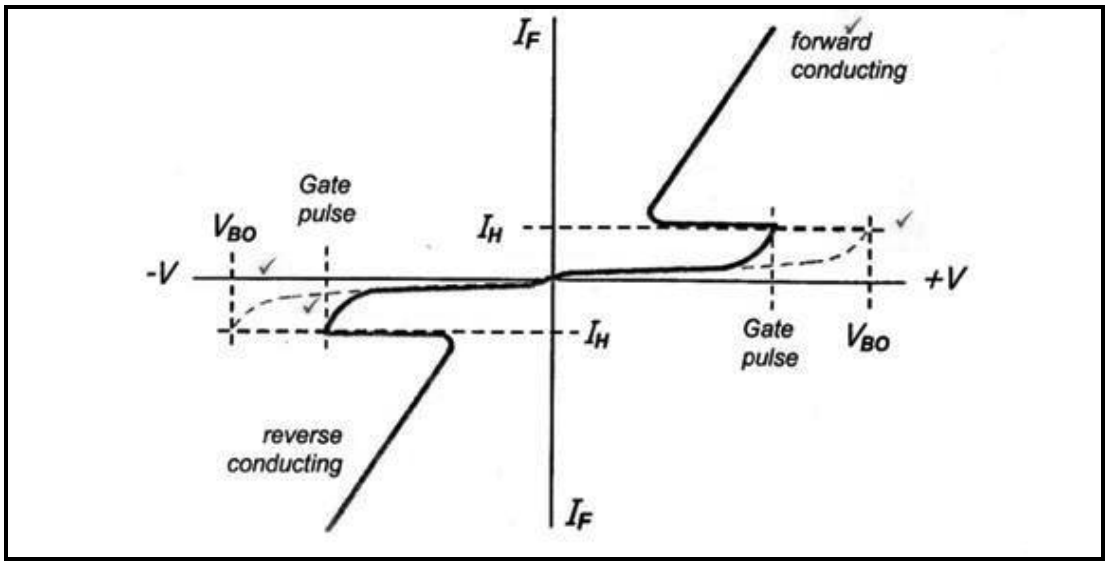
QUESTION 6: SEMICONDUCTOR DEVICES

6.1 A semiconductor is a material of which the conductivity ✓ lies between that of a conductor and an insulator. ✓
Semiconductor devices are electronic components that are made from materials like silicon that have four valance electrons and their conduction can be controlled. (2)

6.2 It is the point of intersection between the diode's characteristic ✓ and the circuit's load line. ✓ (2)

6.3 The majority carriers in P-type silicon are holes ✓ formed when adding impurities. ✓ (2)

6.4



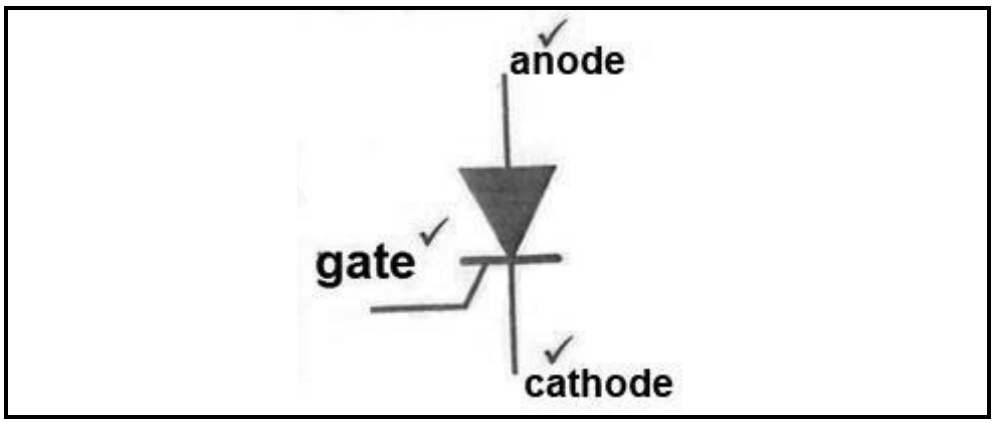
(4)

6.5 6.5.1
- Internet ✓
- Manufacturers' technical support material (1)

6.5.2 Semiconductors are very sensitive to temperature. ✓ It is crucial to know the operating temperature of the device ✓ so that it is not destroyed or its operating conditions changed. ✓ (3)

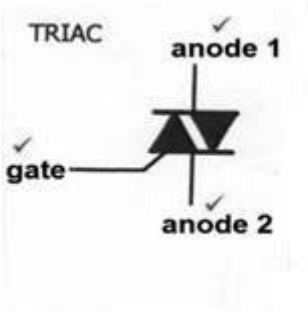
6.5.3
- Electrical characteristics ✓
- Equivalent values ✓ (2)

6.6 6.6.1



(3)

6.6.2



(3)

6.7 Electron flow is the movement of electrons ✓ through material, from a negative potential to a positive potential. ✓
Conventional current flow is the flow of current, ✓ from a positive potential to a negative potential. ✓ (4)

6.8 Solid-state devices are devices that are built entirely from solid materials, ✓ and in which the electrons or other charge carriers are confined entirely within the solid material. ✓ (2)

6.9 N type material is formed when a semiconductor (silicon), which has four valence electrons, ✓ is doped with a material that has five valence electrons. ✓
Four valance electrons from the semiconductor and from the impurity combine and form covalent bonds. ✓
The fifth electron remains unbonded. ✓
This creates an excess of electrons that can be broken away from their atoms and become part of conduction. ✓ (5)

6.10 A zener diode has a unique reverse biased operating characteristic ✓ in that it blocks any flow of current when under low reverse voltage ✓ but as soon as the voltage rises to reach its 'zener breakdown', it breaks down and allows a current to flow in the reverse direction without any damage to itself. ✓ (3)

6.11 6.11.1 Emitter ✓base ✓ – junction needs to be forward biased. (2)

6.11.2 Collector ✓ base ✓– junction should be reverse biased. (2)

6.12 The usual method of turning an SCR on is by forward biasing the anode-cathode ✓ terminals and applying a positive voltage to the gate terminal. ✓
By raising the anode-cathode forward biasing voltage ✓ to a large positive level which will force the one reverse biased PN junction to break down. ✓ (4)

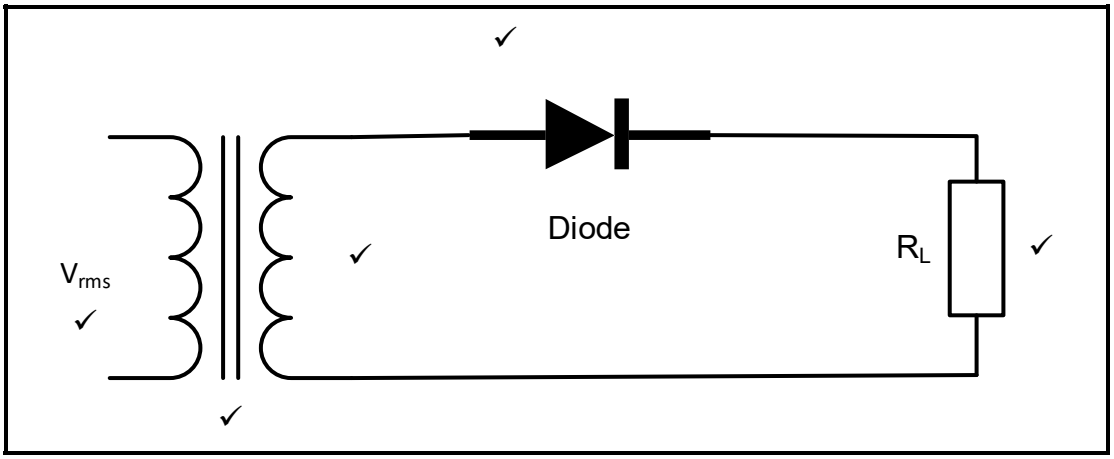
6.13
- Boron ✓
- Gallium ✓
- Indium (2)

[46]

QUESTION 7: POWER SUPPLIES

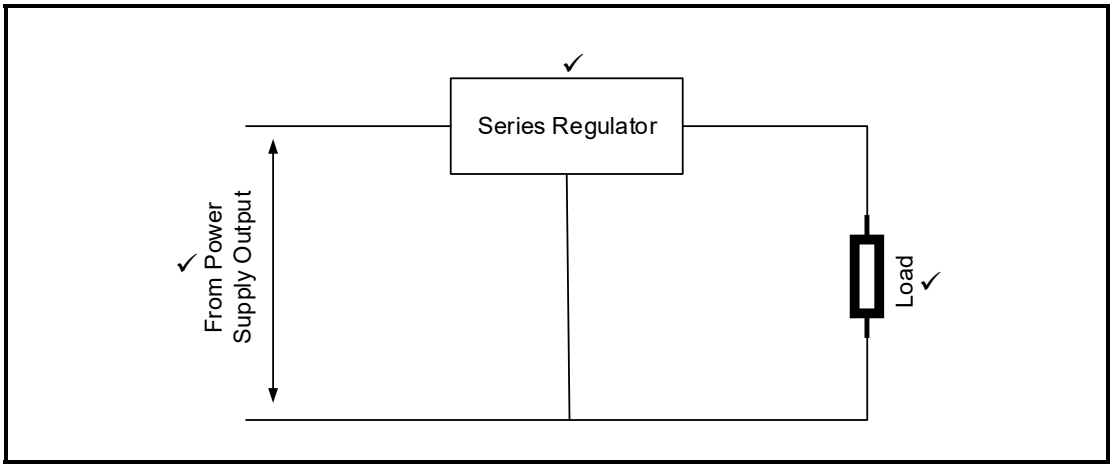
7.1 A transformer is the primary device used to couple ✓ the AC input voltage ✓ from the source to the rest of the power supply. ✓ (3)

7.2



(5)

7.3



(3)

7.4 7.4.1

$$P_Z = V_Z \times I_Z$$
$$I_Z = \frac{P_Z}{V_Z}\ A \checkmark$$
$$= \frac{2}{5}\ A \checkmark$$
$$= 400\ mA \checkmark$$

(3)

7.4.2

$$R_S = \frac{V_S - V_Z}{I_Z}\ \Omega \checkmark$$
$$= \frac{12 - 5}{0{,}4}\ \Omega \checkmark$$
$$= 17{,}5\ \Omega \checkmark$$

(3)

7.4.3

$$I_L = \frac{V_Z}{R_L}\ A \checkmark$$
$$= \frac{5}{1\,000}\ A \checkmark$$
$$= 5\ mA \checkmark$$

(3)

[20]

QUESTION 8: SENSORS AND TRANSDUCERS

8.1 A sensor is a device that detects or senses an 'input' function and reacts to it and executes it. ✓ It also measures physical quantities. ✓ (2)

8.2 The dynamic microphone has a small movable induction coil attached to a diaphragm placed in a magnetic field created by a permanent magnet. ✓
The sound waves from a voice create air pressure variations that make the diaphragm vibrate. ✓
The vibrating diaphragm attached to the coil produces an induced varying current. ✓
In this way sound energy will be converted to electrical energy. ✓ (4)

8.3
- Capacitive humidity sensor ✓
- Resistive humidity sensor ✓
- Thermal conductivity sensor (2)

8.4 If the light on the surface of the LDR increases, ✓ the resistance will decrease. ✓
If the light on the surface of the LDR decreases, ✓ the resistance will increase. ✓ (4)
[12]

QUESTION 9: AMPLIFIERS

9.1 Class C amplifiers are biased, ✓ so that their transistors will only conduct for less than one half of a cycle of the input signal. ✓ (2)

9.2 Push pull amplifier in audio systems ✓ (1)

9.3
- Common base ✓
- Common emitter ✓
- Common collector ✓ (3)

9.4 Fixed base biasing ✓
The role of the collector resistor ✓ (2)

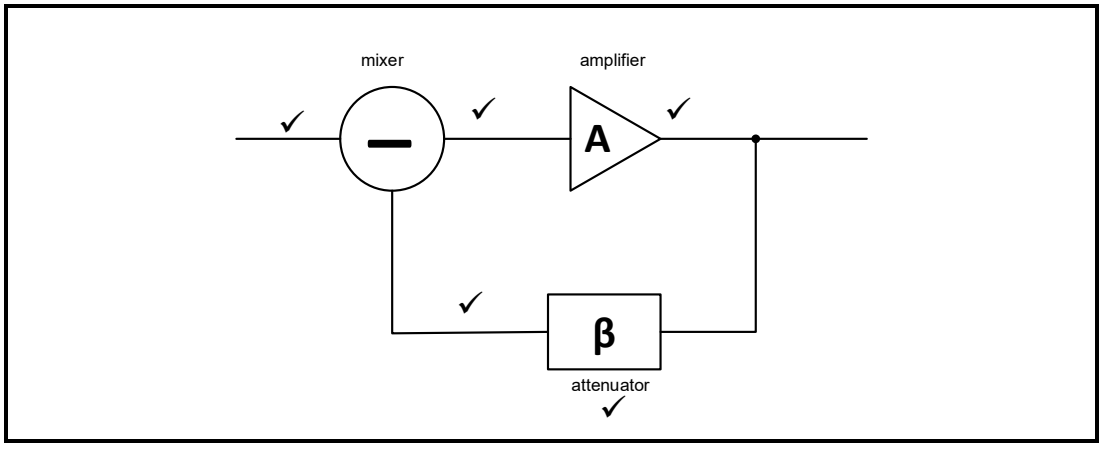
9.5 9.5.1
$$I_B = \frac{V_{cc} - V_{be}}{R_b} \checkmark$$
$$= \frac{10 - 0{,}6}{235\,000} \checkmark$$
$$= 40\ \mu A \checkmark$$ (3)

9.5.2
$$I_C = \beta\, Ib \checkmark$$
$$I_C = 250 \times 40\mu \checkmark$$
$$= 10\ mA \checkmark$$ (3)

9.5.3
$$R_S = \frac{V_S - V_Z}{I_Z}\ \Omega \checkmark$$
$$= \frac{12 - 5}{0{,}4}\ \Omega \checkmark$$
$$= 17{,}5\ \Omega \checkmark$$ (3)

9.6
- Improve stability against changes of temperature ✓
- More reliable and constant voltage gain ✓
- Decrease distortion of the signal as it passes through the amplifier. The output signed is clear with no distortion
- Increased bandwidth (2)

9.7



(5)

9.8
- Active region ✓
- Saturation region ✓
- Cut-off region ✓ (3)

9.9 9.9.1 Stretches voltage shape of input signal. ✓ It may change a shape of the current waveform, but the voltage ✓delivered by the voltage amplifier always remain a replica of input voltage. ✓ (3)

9.9.2 'Boosts' the input current ✓ to a far higher output level. ✓ (2)

[32]

TOTAL: 200