Province of the
EASTERN CAPE
EDUCATION

NATIONAL
SENIOR CERTIFICATE

GRADE 11

NOVEMBER 2020



# ELECTRICAL TECHNOLOGY: DIGITAL ELECTRONICS (EXEMPLAR)

**MARKS: 200**

**TIME: 3 hours**

*IELTTE3*

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 and 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 legibly.



 

## 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: LOGICS

3.1 Refer to FIGURE 3.1 below and answer the questions that follow.

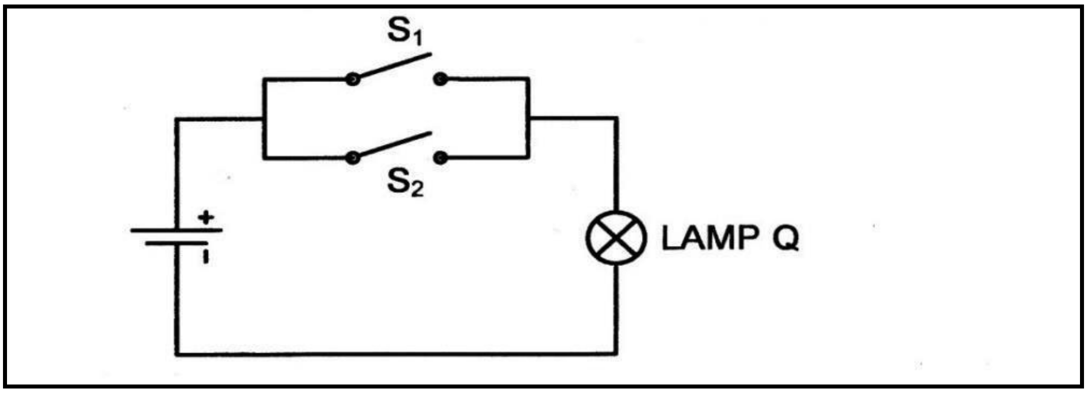


**FIGURE 3.1**

3.1.1 Identify the logic function of the circuit. (1)

3.1.2 Draw the logic symbol that is represented by the circuit. (2)

3.1.3 Draw the truth table of the gate. (4)

3.1.4 Write the Boolean expression for FIGURE 3.1. (2)

3.2 Using Boolean algebra, simplify the expression below:

Q = $\bar{A}B\bar{C} + AB\bar{C} + A\bar{B}\,\bar{C} + \bar{A}\bar{B}\,\bar{C}$ (7)

3.3 Use a Karnaugh map to simplify the expression below:

Q = $\bar{A}B\bar{C} + AB\bar{C} + A\bar{B}\,\bar{C} + \bar{A}\bar{B}\,\bar{C}$ (7)

3.4 Name TWO different states a logic probe can operate in. (2)

3.5 State TWO disadvantages of TTL. (2)

3.6 State TWO disadvantages of CMOS. (2)

3.7 Refer to FIGURE 3.7 below and answer the questions that follow.

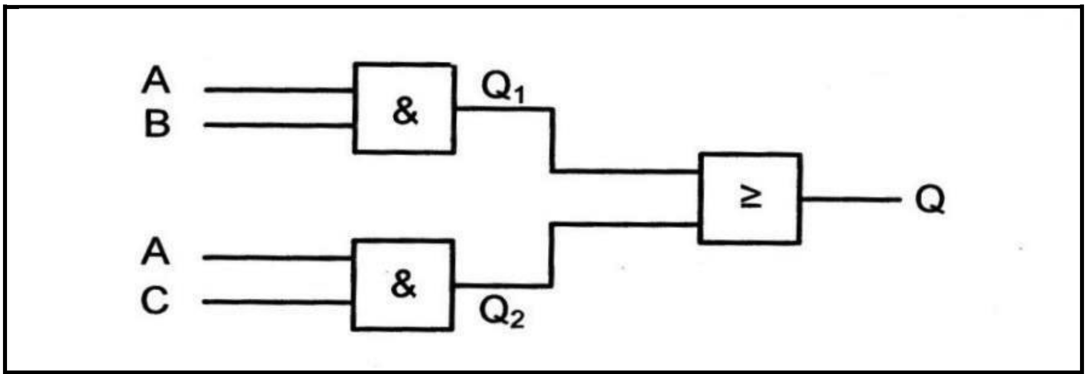


**FIGURE 3.7**

Give the Boolean expression at the following points:

3.7.1 $Q_1$ (2)

3.7.2 $Q_2$ (2)

3.7.3 Q (3)

3.8 Draw the truth table for a Half Adder. (4)

**[40]**

## QUESTION 4: COMMUNICATION SYSTEMS

4.1 Explain the term *resonance*. (2)

4.2 Name THREE types of oscillators (3)

4.3 Explain the purpose of the Wien bridge oscillator. (6)

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

4.5 Name the applications of a continuous wave transmitter. (2)

4.6 Explain the term *modulation*. (2)

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

4.8 Describe the purpose of frequency shift keying. (2)

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



5.3 Study FIGURE 5.3 below and answer the questions that follow.

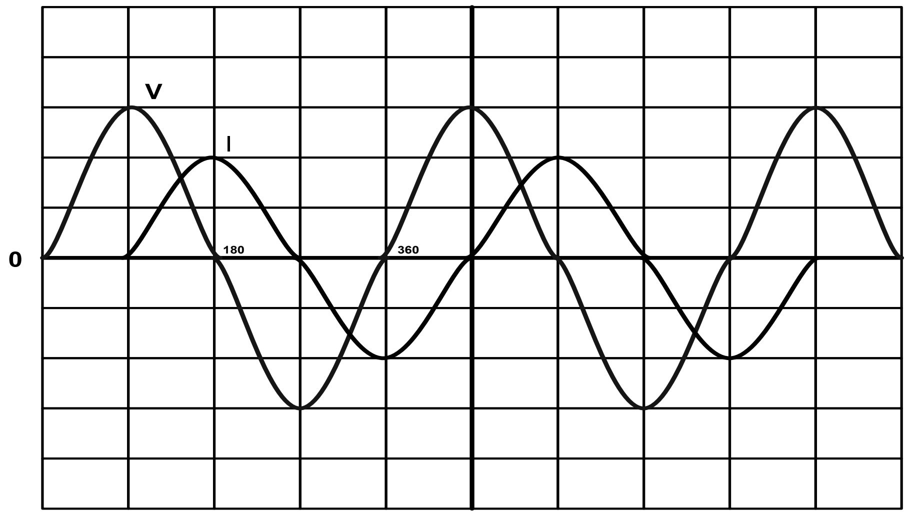


**FIGURE 5.3: RL CIRCUIT WAVEFORMS**

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

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

5.4 Refer to the circuit diagram in FIGURE 5.4 and answer the questions that follow.

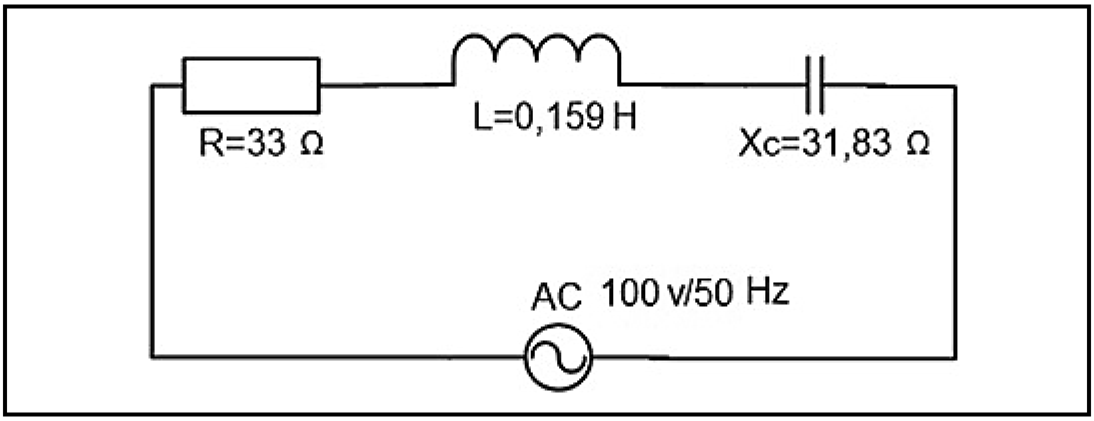


**FIGURE 5.4**

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

Calculate:

5.4.1 The inductive reactance of the coil (3)



5.4.2 The total impedance of the circuit (3)

5.4.3 The current flowing through the circuit (3)

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

5.5 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)

**[24]**

 

## QUESTION 6: WAVEFORMS

6.1 Identify the following waveforms as shown in FIGURES 6.1.1 to 6.1.4.

6.1.1

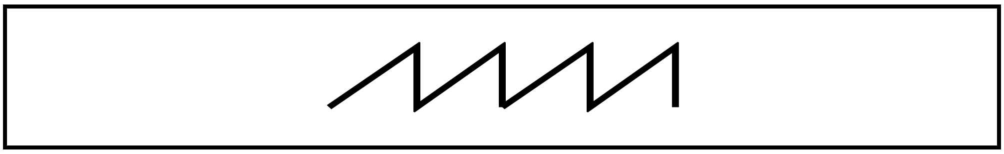

FIGURE 6.1.1 (1)

6.1.2

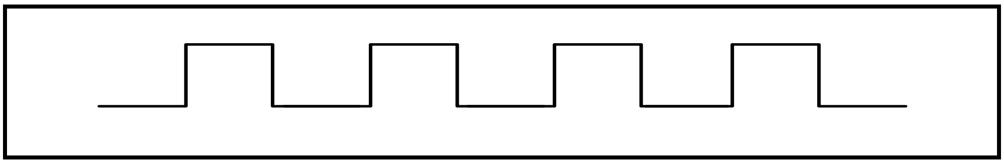

FIGURE 6.1.2 (1)

6.1.3

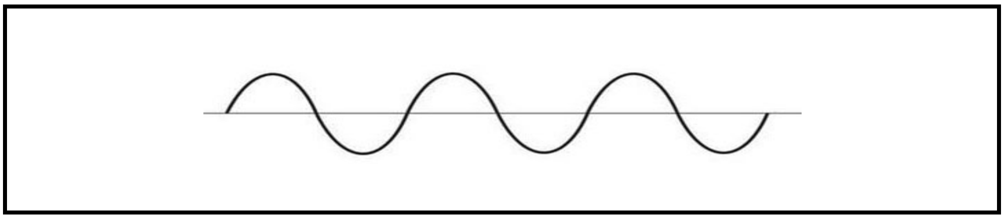

FIGURE 6.1.3 (1)

6.1.4

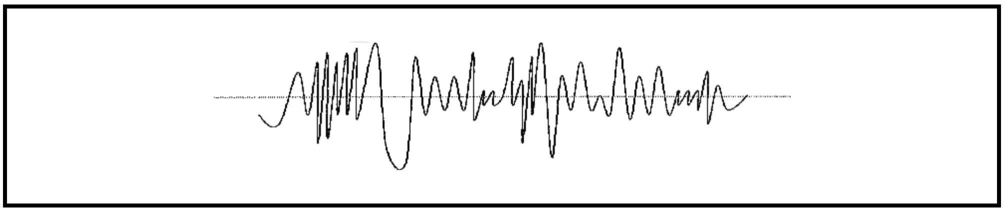

FIGURE 6.1.4 (1)

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

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

6.3.1 Pulse width (3)

6.3.2 Fall time (3)

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

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

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

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

**[26]**

 

## QUESTION 7: POWER SUPPLIES

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

7.2 Refer to the circuit diagram in FIGURE 7.2 below and answer the questions that follow.

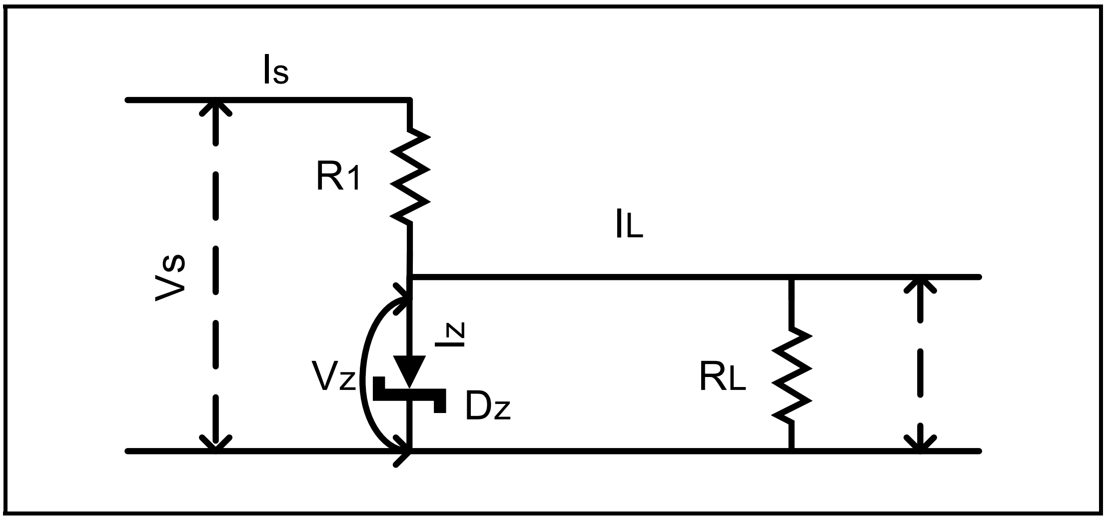


**FIGURE 7.2**

Given:

Pz = 2 W
Vs = 12 V
Vz = 5 V
RL = 1 kΩ



Calculate:

7.2.1 The maximum current flowing through the Zener diode ($I_Z$). (3)

7.2.2 The minimum value of the series resistor, $R_S$. (3)

7.2.3 The load current IL if a load resistor of 1 kΩ is connected across the Zener diode. (3)

**[12]**

## QUESTION 8: SEMICONDUCTOR DEVICES

8.1 Describe the term *semiconductor*. (3)

8.2 What is the Q-point of a diode? (3)

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

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

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

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

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

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

8.6 Draw fully labelled circuit symbols of the following:

8.6.1 SCR (3)

8.6.2 TRIAC (3)



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

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

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

8.10 Explain how a Zener diode differs from other diodes. (3)

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

8.11.1 Forward biased? (2)

8.11.2 Reverse biased? (2)

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

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

**[48]**

## QUESTION 9: SENSORS AND TRANSDUCERS

9.1 Define the term '*sensor*' with reference to sensors and transducers. (2)

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

9.3 List TWO types of humidity sensors. (2)

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

**TOTAL: 200**

## FORMULA SHEET

### WAVE FORMS

Frequency

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

Maximum value

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

RMS Value

$$V_{RMS} = V_{MAX} \times 0{,}707$$

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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# ELECTRICAL TECHNOLOGY: DIGITAL ELECTRONICS
# MARKING GUIDELINE
# (EXEMPLAR)

**MARKS: 200**

This marking guideline consists of 13 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)

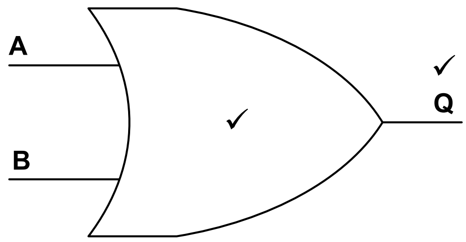
2.3 This is the time the bonding of the wheel is liable to disengage and break apart. ✓ Therefore, it is not safe to be standing in the direct path of any pieces that may be thrown out by centrifugal force. ✓ (2)

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

## QUESTION 3: LOGICS

3.1 3.1.1 OR gate ✓ (1)

3.1.2




(2)

3.1.3

| S1 | S2 | Output (Q) |
|---|---|---|
| 0 | 0 | 0 ✓ |
| 0 | 1 | 1 ✓ |
| 1 | 0 | 1 ✓ |
| 1 | 1 | 1 ✓ |

(4)

3.1.4 Q=$A+B$ ✓✓ (2)

3.2 $X = \bar{A}B\bar{C} + AB\bar{C} + A\bar{B}\,\bar{C} + \bar{A}\bar{B}\,\bar{C}$

$= (\bar{A}B\bar{C} + A\checkmark B\bar{C}) + (A\bar{B}\,\bar{C} + \checkmark\bar{A}\bar{B}\,\bar{C})$

$= B\bar{C}(\bar{A} + \checkmark A) + \bar{B}\,\bar{C}(A + \checkmark\bar{A})$



$= B\bar{C} + \bar{B}\,\bar{C}$ ✓

$= \bar{C}(B + \bar{B})$ ✓

$= \bar{C}$ ✓ (7)

3.3 C ✓ AB ✓

| | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 0 | 1 ✓ | 1 ✓ | 1 ✓ | 1 ✓ |
| 1 ✓ | | | | |

(7)

3.4 Logic high ✓
Logic low ✓ (2)

3.5 Simple, compatible with CMOS if the applied voltage is the same, can be constructed using discrete components. ✓
They have a low current drain. ✓ (2)

3.6 Slow switching speed ✓
They can be easily destroyed by static electricity ✓ (2)

3.7 3.7.1 Q1 ✓ = A.B ✓ (2)

3.7.2 Q2 = A ✓.C ✓ (2)

3.7.3 Q = (A.B) ✓ + ✓ (A.C) ✓ (3)

3.8

| Inputs | | Outputs | |
|---|---|---|---|
| A | B | Sum | Carry |
| 0 | 0 | 0 | 0 ✓ |
| 0 | 1 | 1 | 0 ✓ |
| 1 | 0 | 1 | 0 ✓ |
| 1 | 1 | 0 | 1 ✓ |

(4)

**[40]**

## QUESTION 4: COMMUNICATION SYSTEMS

4.1 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)

4.2
- The basic LC resonant oscillator ✓
- Hartley oscillator ✓
- Colpitts oscillator ✓
- The RC phase shift oscillator
- The Wien bridge oscillator (3)

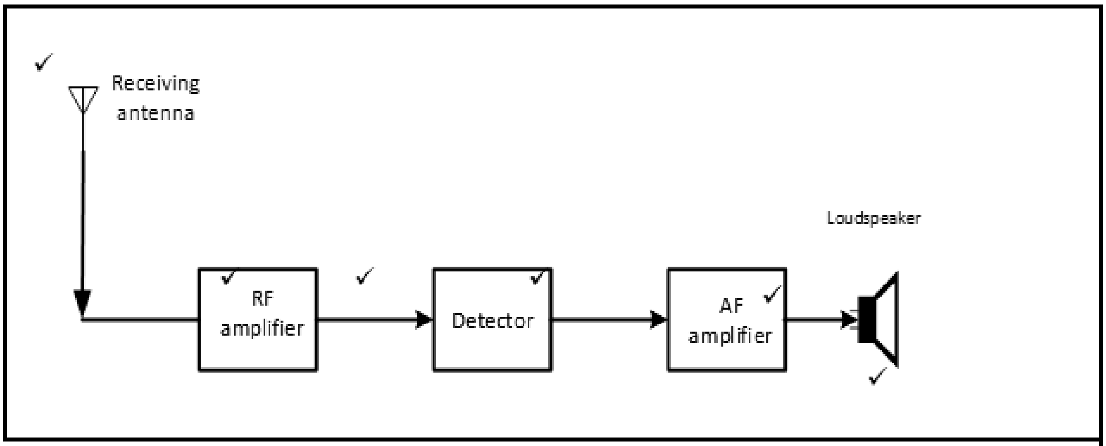
4.3 The Wien bridge oscillator is among the simplest sine wave oscillators which uses an RC network, ✓ rather than a tuned LC tank circuit. ✓
It is based on the frequency selective form of a wheatstone bridge circuit. ✓
It uses feedback from two RC circuits, a series RC circuit connected with a parallel 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)

4.4 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)

4.5
- Correction of radio controlled communication ✓
- Radio control ✓ (2)

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

4.7




(6)

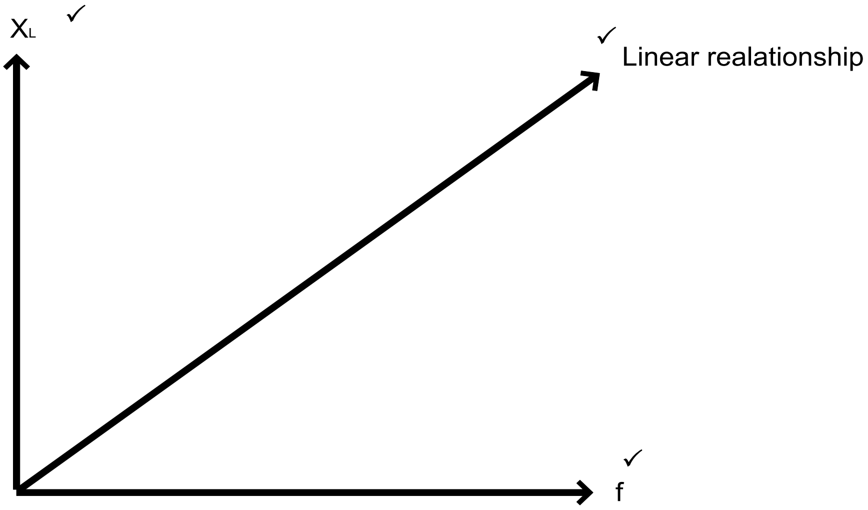
4.8 Frequency-shift keying is a method of being able to transmit a digital pulse signal ✓ using traditional radio transmitting and receiving methods. ✓ (2)

**[26]**

## QUESTION 5: RLC-CIRCUITS

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

5.2




(3)

5.3 5.3.1 The current lags the voltage by 90 degrees. ✓ (1)

5.3.2 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)

5.4 5.4.1

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

5.4.2

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

5.4.3

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

5.4.4

$X_C = \frac{1}{2\pi fC}$
$C = \frac{1}{2\pi fC}$ ✓
$= \frac{1}{2 \times \pi \times 50 \times 31{,}83}$ ✓
$= 1 \times 10^{-4}F = 100\ \mu F$ ✓ (3)

5.5 At the resonant frequency point the two reactance are identical in size ✓ but exactly opposite to each other in direction making $X_L - X_C = 0$ or $X_L = X_C$. ✓ 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 resistance. ✓ (4)

**[24]**

## QUESTION 6: WAVEFORMS

6.1 6.1.1 Saw tooth wave ✓ (1)

6.1.2 Square wave ✓ (1)

6.1.3 Sine wave ✓ (1)

6.1.4 Audio wave ✓ (1)

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

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

6.3.2 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)

6.4
$$V_{rms} = V_{pk} \times 0{,}707\ V$$
$$V_{pk} = \frac{V_{rms}}{0{,}707}\ V \checkmark$$
$$= \frac{9}{0{,}707}\ V \checkmark$$
$$= 12{,}73\ V \checkmark$$
(3)



6.5
$$T = \frac{1}{f}\ s \checkmark$$
$$= \frac{1}{500}\ s \checkmark$$
$$= 0{,}002\ \sec\ or\ 2\ ms \checkmark$$
(3)

6.6 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)

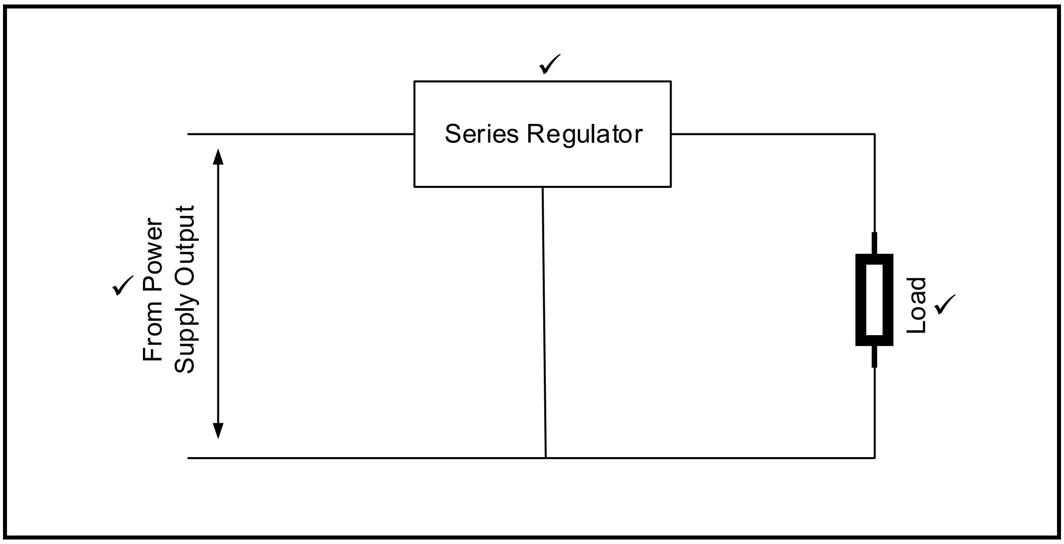
6.7
- Communication ✓
- Broadcasting ✓
- Computer network ✓

(3)

**[26]**

## QUESTION 7: POWER SUPPLIES

7.1




(3)

7.2 7.2.1 $P_Z = V_Z \times I_Z$

$I_Z = \frac{P_Z}{V_Z}\ A$ ✓

$= \frac{2}{5}\ A$ ✓

$= 400\ mA$ ✓ (3)

7.2.2 $R_S = \frac{V_S - V_Z}{I_Z}\ \Omega$ ✓

$= \frac{12 - 5}{0{,}4}\ \Omega$ ✓

$= 17{,}5\ \Omega$ ✓ (3)

7.2.3 $I_L = \frac{V_Z}{R_L}\ A$ ✓

$= \frac{5}{1000}\ A$ ✓

$= 5\ mA$ ✓ (3)

**[12]**

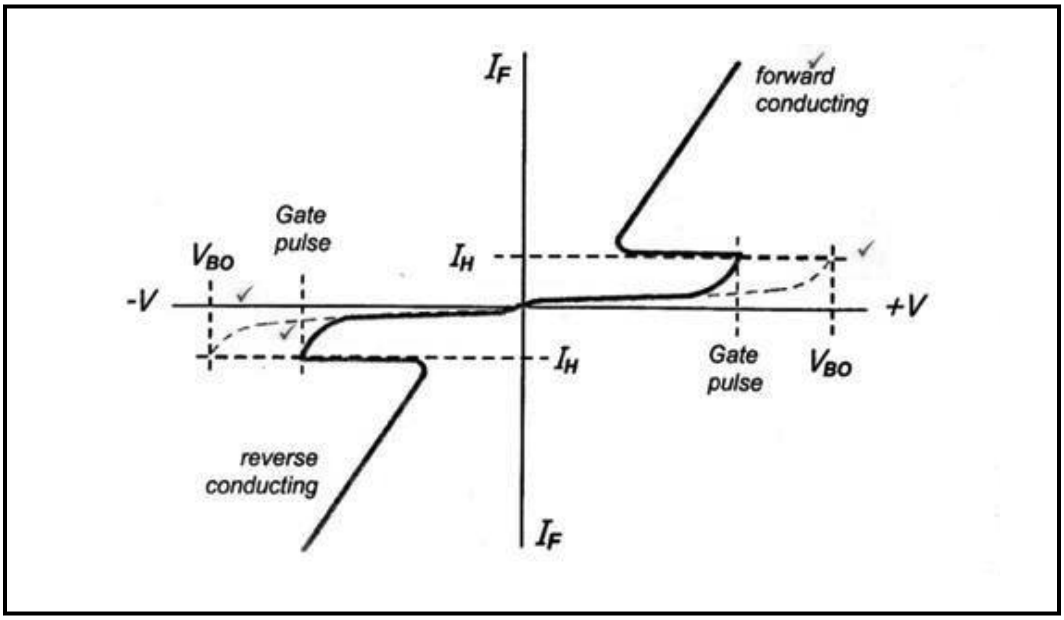
## QUESTION 8: SEMI-CONDUCTOR DEVICES

8.1 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. (3)

8.2 It is the point of intersection ✓between the diode's characteristic ✓ and the circuits' load line. ✓ (3)

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

8.4




(4)

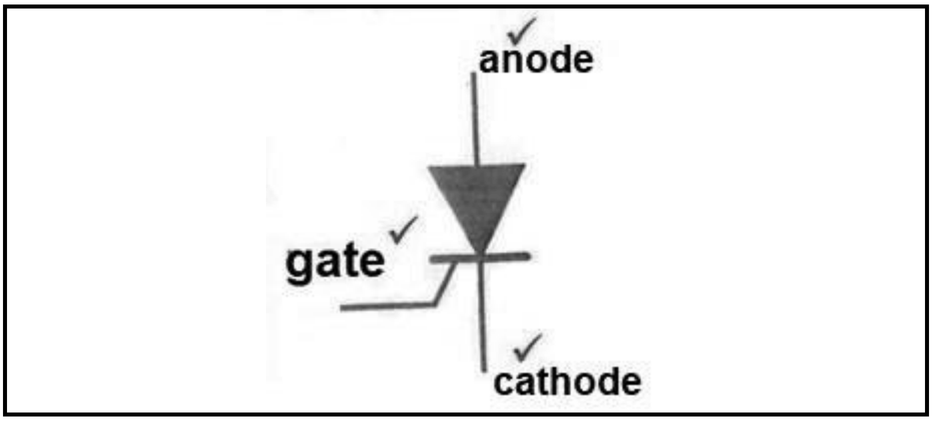
8.5.1
- Internet ✓
- Manufacturers' technical support material (1)

8.5.2 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)

8.5.3
- Electrical characteristics ✓
- Equivalent values ✓ (2)

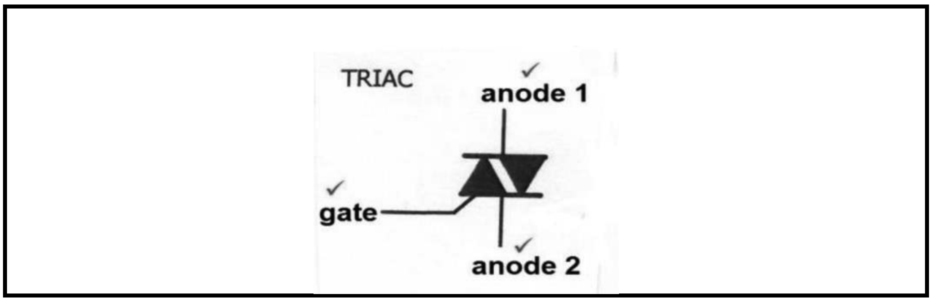
 

8.6.1




(3)

8.6.2




(3)

8.7 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)

8.8 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)

8.9 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)

8.10 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)

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

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

8.12 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)

8.13
- Boron ✓
- Gallium ✓
- Indium (2)

**[48]**

## QUESTION 9: SENSORS AND TRANSDUCERS

9.1 A sensor is a device that detects or senses an 'input-function', reacts to it and executes it. ✓ It also involves measuring physical quantities. ✓ (2)

9.2 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)

9.3
- Capacitive humidity sensor ✓
- Resistive humidity sensor ✓
- Thermal conductivity sensor (2)

9.4 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]**

**TOTAL: 200**