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**NATIONAL
SENIOR CERTIFICATE**

GRADE 12

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**ELECTRICAL TECHNOLOGY
MARKING GUIDELINE**

MARKS: 200

This marking guideline consists of 11 pages.

QUESTION 1: OCCUPATIONAL HEALTH AND SAFETY

- 1.1 No person may enter or remain in a workplace under the influence of drugs as he may place himself ✓ and other persons in danger while operating machinery. ✓ (2)
- 1.2
- Earth-leakage system ✓
 - Overload circuit breakers ✓
 - No-volt coil prevents automatic restarting after power interruption.
 - Fuses
 - Emergency stop switch
- (ANY TWO) (2)
- 1.3 If Aids is not brought under control:
- it can affect productivity in that employees with skills may become ill or die ✓
 - person may not function well, may take time off work, ✓
 - Colleagues may be unwilling to work with a person having HIV due to the stigma associated with HIV.
- (ANY TWO RELEVANT ANSWERS) (2)
- 1.4
- Safety is the responsibility of any person who enters or works in an electrical technology workshop. ✓
 - Each person has a responsibility to himself and others around him. ✓
 - It only takes one person to ignore safety procedures to cause serious problems for all in the electrical technology workshop. ✓
- (ANY SOUND MOTIVATED RESPONSE MUST BE CONSIDERED) (3)
- 1.5
- Wet floors ✓
 - Wet work areas
 - Bare conductors
- (ANY OTHER RELEVANT ANSWERS) (1)
- [10]**

QUESTION 2: THREE-PHASE AC GENERATION

2.1 2.1.1 $P = \sqrt{3} V_L I_L \cos \theta \checkmark$ But $I_L = \sqrt{3} I_{ph}$ $P = 3 V_{PH} I_{PH} \cos \theta \checkmark$
 $= \sqrt{3} \times 380 \times 20,78 \cos 25^\circ \checkmark$ $= \sqrt{3} \times 12$ OR $= 3.380.12. \cos 25^\circ \checkmark$
 $= 12,40 \text{ kW} \checkmark$ $= 20,78 \text{ A}$ $= 12,40 \text{ kW} \checkmark$ (3)

2.1.2 $S = \sqrt{3} V_L I_L \checkmark$ $S = \frac{P}{\cos \theta} \checkmark$
 $= \sqrt{3} \times 380 \times 20,78 \checkmark$ or $= \frac{12,40}{\cos 25} \checkmark$
 $= 13,68 \text{ kVA} \checkmark$ $= 13,68 \text{ kVA} \checkmark$ (3)

2.2 $V_L = \sqrt{3} V_{ph} \checkmark$
 $= \sqrt{3} \times 220 \checkmark$
 $= 381,05 \text{ V} \checkmark$ (3)

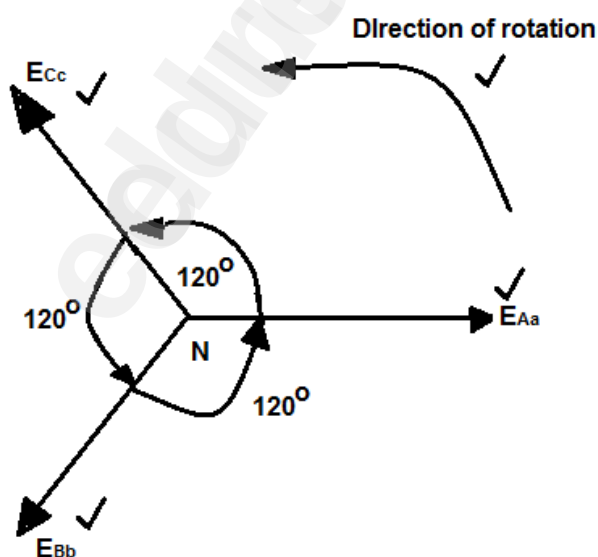
- 2.3
- For high power generation the three-phase system is functional and efficient. $\checkmark$
 - The voltages between all phases (i.e. line voltages) are the same
 - The direction of rotation of three-phase machines can be easily changed
 - Transmission and distribution are fairly simple
- (ANY ONE) (1)

- 2.4 A generator has a lagging power factor $\checkmark$ as it consists of coils which are inductive. $\checkmark$ Current through an inductor connected to an AC supply lags the applied voltage. $\checkmark$ (3)

- 2.5 The function of a kWh meter is to measure the amount of power consumed by a consumer over a period of time (energy). $\checkmark$ (1)

- 2.6 120 degrees (1)

- 2.7



- 2.8 Effective value or rms value $\checkmark$ (1)

[20]

QUESTION 3: THREE-PHASE TRANSFORMERS

- 3.1
- **Copper losses** ✓ losses due to the resistance of the copper wires used ✓
 - **Stray losses** ✓ occurs when some of the magnetic field does not cut the secondary winding ✓
 - **Iron losses** ✓ heat losses due to hysteresis of the core ✓
 - **Dielectric losses** ✓ occurs when insulation of windings is damaged, causing leakage currents ✓
- (4)

3.2 3.2.1

$$S = \frac{P}{\cos\theta} \checkmark$$

$$= \frac{10000}{0,8} \checkmark$$

$$= 12,5 \text{ kW} \checkmark$$

(3)

3.2.2

$$I_{L(s)} = \frac{P}{\sqrt{3}V_{L(s)} \cos\theta} \checkmark$$

$$= \frac{10000}{\sqrt{3} \times 400 \times 0,8} \checkmark$$

$$= 18,04 \text{ A} \checkmark$$

(3)

3.2.3

$$I_{ph(s)} = I_{L(s)} \checkmark$$

$$= 18,04 \text{ A} \checkmark$$

(2)

- 3.3 To create a three-phase four-wire system ✓ so that a transformer can supply both single-phase ✓ and three-phase. (To distribute power to both domestic and industrial installations.) ✓
- (3)

- 3.4
- Losses and current flow in transformers causes heat build-up ✓
 - Overloading ✓
 - Poor Cooling ✓
 - Lack of Ventilation
 - Poor Connections / Hot connections
 - Excessive vibration due to poor mechanical construction
- (ANY RELEVANT ANSWERS)
- (3)

- 3.5 The primary phase current will also be doubled ✓ as it is directly proportional to the load. ✓
- (2)

[20]

QUESTION 4: THREE-PHASE MOTORS AND STARTERS

4.1 The purpose of using a starter to start a three-phase motor is to safely control the motor, ✓ protect electrical equipment and the user of the motor. ✓ (2)

4.2

- Stator ✓
- Rotor ✓
- End plates ✓
- Fan
- Terminal box
- Bearings

(ANY THREE) (3)

4.3 To reduce the voltage at start-up. ✓ This in turn reduces the starting current. ✓
Reduced starting current leads to fewer nuisance tripping problems at start **or**
to less heat build-up and decreases the chance of burn-out of the motor. ✓ (3)

4.4 4.4.1

$$I_L = \frac{P}{\sqrt{3} \times V_L \cos \theta} \checkmark$$

$$= \frac{15000}{\sqrt{3} \times 380 \times 0,9} \checkmark$$

$$= 25,32 \text{ A} \checkmark \quad (3)$$

4.4.2

$$P_{app} = \frac{P}{\cos \theta} \checkmark$$

$$= \frac{15000}{0,9} \checkmark$$

$$= \frac{25}{\sqrt{3}} \checkmark$$

$$= 16,67 \text{ kVA} \checkmark \quad (3)$$

4.4.3

$$I_L = \sqrt{3} \times I_{ph} \checkmark$$

$$I_{ph} = \frac{I_L}{\sqrt{3}} \checkmark$$

$$= \frac{25}{\sqrt{3}} \checkmark$$

$$= 14,43 \text{ A} \checkmark \quad (3)$$

4.5 4.5.1
$$S = \frac{P}{\cos \theta}$$

$$= \frac{90\,000}{0,85}$$

$$= 105,88 \text{ kVA}$$
 (2)

4.5.2
$$I_L = \frac{P}{\sqrt{3}V_L \cos \theta}$$

$$= \frac{90\,000}{\sqrt{3} \times 400 \times 0,85}$$

$$= 152,83 \text{ A}$$
 (3)

4.6 By reversing the connections of any two of the three supply lines to the stator. ✓ (1)

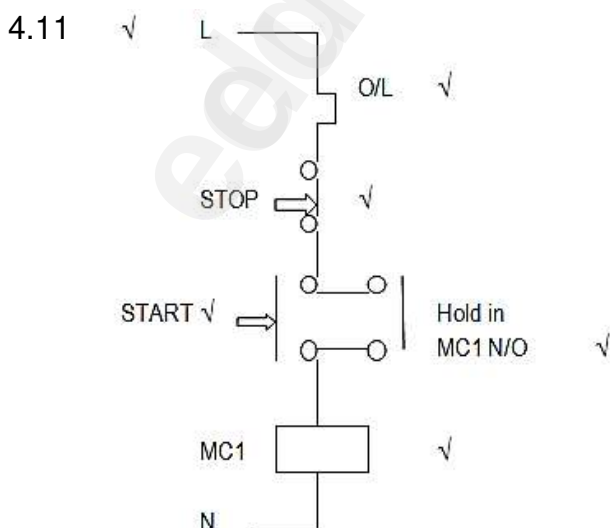
4.7 To protect electrical equipment from damage ✓ during faulty operating conditions and protecting the operator of the equipment. ✓ (2)

4.8 The motor will keep on operating, but to maintain the same output power ✓ the current on the other two phases will increase. ✓ If the protection is set correctly, it will engage, protecting the motor from permanent damage. ✓ (CONSIDER RELEVANT MOTIVATED ANSWERS) (3)

4.9 4.9.1 The function of a star-delta starter is to reduce the starting current of a motor at start as a motor draws 3 to 4 times full-load current at start. ✓ (1)

4.9.2 The motor is connected in star at start. ✓ This reduces the voltage across the motor windings which in turn reduces the current in the windings. ✓ Once the starting current has reduced, the motor windings are changed over to delta, restoring full-line voltage across the windings, therefore full current. ✓ (3)

4.10 The overload relay is designed to protect the motor ✓ and motor wiring against current fault conditions. ✓ It will open and cut power to the motor. ✓ (4)

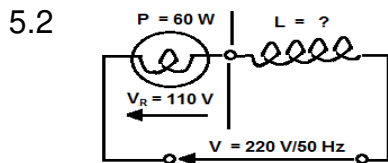


(4)
[40]

QUESTION 5: RCL CIRCUITS

$$\begin{aligned}
 5.1 \quad 5.1.1 \quad Z &= \sqrt{R^2 + (X_L - X_C)^2} \checkmark \\
 &= \sqrt{500^2 + (300 - 250)^2} \checkmark \\
 &= 502,49 \, \Omega \checkmark
 \end{aligned}
 \tag{3}$$

$$\begin{aligned}
 5.1.2 \quad \cos \theta &= \frac{R}{Z} \checkmark \\
 &= \frac{500}{502,49} \checkmark \\
 &= 0,995 \checkmark \text{ Lagging} \checkmark
 \end{aligned}
 \tag{4}$$



$$\begin{aligned}
 5.2.1 \quad R &= \frac{V^2}{P} \checkmark \\
 &= \frac{110^2}{60} \checkmark \\
 &= 201,67 \, \Omega \checkmark
 \end{aligned}
 \tag{3}$$

$$\begin{aligned}
 5.2.2 \quad I &= \frac{P}{V_R} \checkmark \\
 &= \frac{60}{110} \checkmark \\
 &= 0,55 \, \text{A} \checkmark
 \end{aligned}
 \tag{3}$$

$$\begin{aligned}
 5.2.3 \quad Z &= \frac{V}{I} \checkmark \\
 &= \frac{220}{0,55} \checkmark \\
 &= 400 \, \Omega \checkmark
 \end{aligned}
 \tag{3}$$

$$\begin{aligned}
 5.2.4 \quad X_L &= \sqrt{Z^2 - R^2} \\
 2\pi fL &= \sqrt{Z^2 - R^2} \checkmark \\
 L &= \frac{\sqrt{Z^2 - R^2}}{2\pi f} \checkmark \\
 &= \frac{\sqrt{400^2 - 201,67^2}}{2\pi \cdot 50} \checkmark \\
 &= 1,1 \, \text{H} \checkmark
 \end{aligned}
 \tag{4}$$

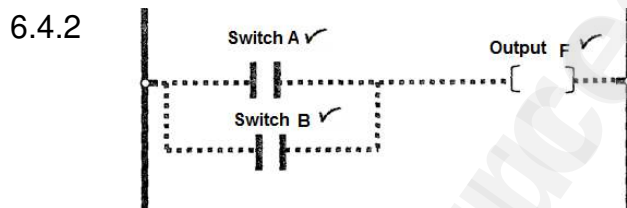
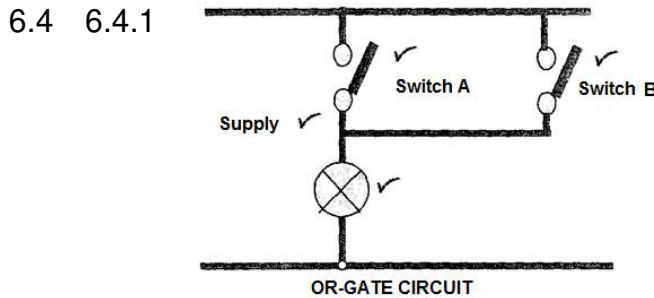
[20]

QUESTION 6: LOGIC

6.1 A series of instructions ✓ written in a language ✓ that a PLC can recognise and interpret into an output. ✓ (3)

6.2 Programmable Logic Controller ✓ (1)

6.3 • User interface (On the PLC Unit – Screen & Buttons). ✓
• Computer or laptop with interface cable. ✓
• Handheld programming device. ✓ (3)



6.5 Ladder logic (LL). ✓
Instruction list (IL). ✓
Logic block diagram (LBD). ✓
Function Block Diagram (FBD)
Structured Text Sequential Flow / Function Chart
(ANY THREE) (3)

6.6 $\bar{A}B\bar{C} + AB\bar{C} + \bar{A}BC + ABC$
 $= B\bar{C}(\bar{A} + A) + BC(\bar{A} + A)$ ✓✓
 $= B\bar{C} + BC$ ✓
 $= B(\bar{C} + C)$ ✓
 $= B$ ✓ (5)

6.7 Fewer components such as contactors are subject to wear because less of these items are used. ✓ Additionally units have built-in diagnostic functions. ✓ (2)

6.8 6.8.1

$$\bar{A}.B.C \checkmark + A.\bar{B}.C \checkmark + A.B.\bar{C} \checkmark + A.B.C \checkmark$$

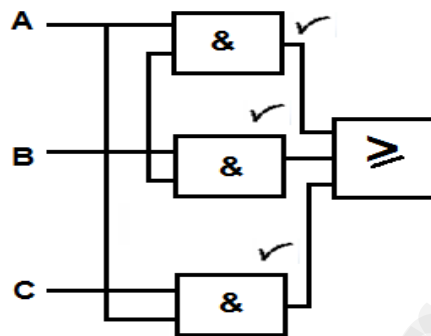
(4)

6.8.2

	$\bar{A}\bar{B}$	$\bar{A}B$	AB	$A\bar{B}$
$\bar{C}$			1	
C	✓	1	1	1

(8)

6.8.3



(4)

[40]

QUESTION 7: AMPLIFIERS

7.1

- Linear amplifiers ✓
 - Pulse amplifiers ✓
 - Buffer circuits Integrating ✓
 - Differentiating
 - Summing amplifiers
- (ANY THREE)

(3)

7.2

- Input draws no current ✓
 - The voltage drop between the input terminals is zero ✓
 - The open-loop voltage gain is infinite ✓
 - Output impedance is zero. Input impedance is infinite
 - Frequency Response is infinite
- (ANY THREE)

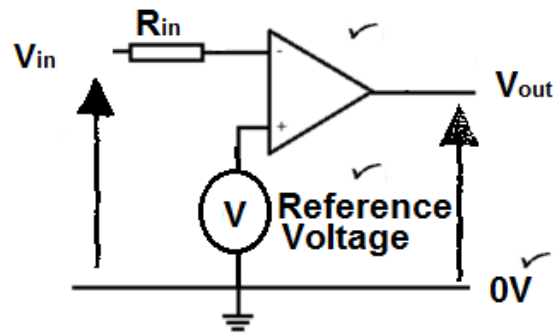
(3)

7.3

Means that there is no feedback (neither negative nor positive) ✓ from the output back to the input. ✓ The gain of the circuit is at a maximum. ✓

(3)

7.4



(3)

7.5 A portion of the output signal is fed back to the input signal ✓ and is in phase with the input signal (2)

7.6 This will reduce the loading effect on the previous circuit. ✓ In so doing, no current will be drawn ✓ from that circuit. Therefore, the voltage appearing ✓ at its output terminals ✓ will be passed on to the op amp with little or no loss. (4)

- 7.7
- Audio oscillators ✓
 - Electronic organ ✓
 - GPS units ✓

(3)

7.8 7.8.1



same frequency ✓ amplification ✓ non-inverting ✓

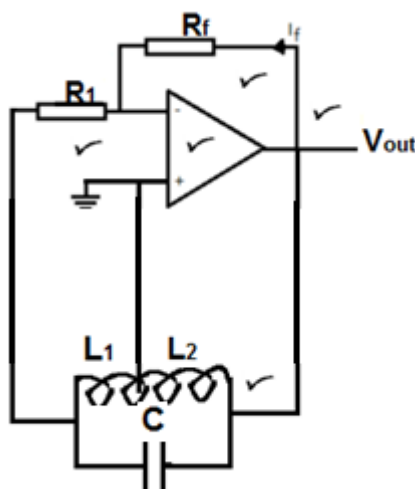
(2)

7.8.2 Output signal ✓ is fed back to the inverting input ✓ through feedback resistor R_f . ✓ (3)

7.8.3 If the resistance of R_f is decreased V_{rf} will decrease ✓ this is feedback on the inverting input of the op-amp ✓ increasing the overall gain of the circuit. ✓ (3)

7.8.4 R_{in} allows further control ✓ of the op-amp circuit gain. ✓ Setting R_{in} at a high value compared to R_f creates a voltage-follower circuit. ✓ (3)

7.9



(5)

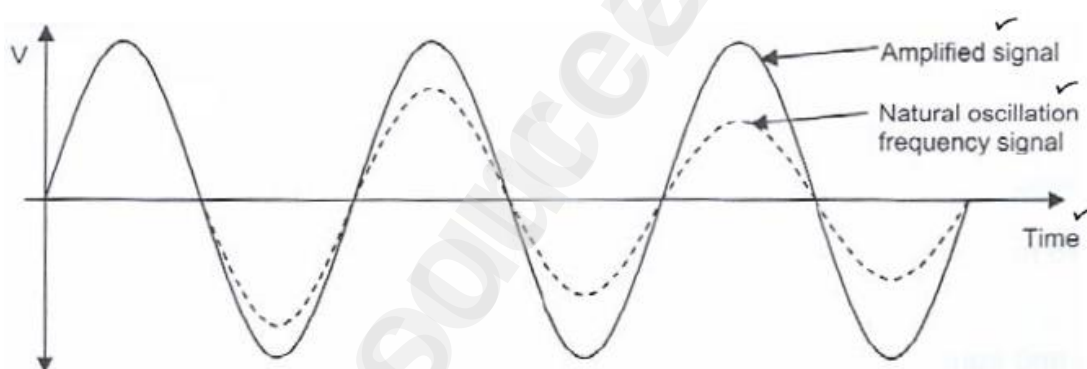
7.10 The output of the comparator will be zero. ✓ This is due to a comparator only amplifying the difference between the input signals. ✓

(2)

7.11 The frequency of the wave form remains unchanged. ✓

(1)

7.12



The electrical signal that the oscillator produces is called the natural oscillation frequency. ✓ Natural oscillation diminishes in amplitude and disappears due to a lack of positive feedback. ✓

(6)

7.13 When an op-amp is utilised between stages it is used as a buffer amplifier to adapt/match the impedance between the stages. ✓✓

(2)

7.14 Any application where a phase shift is not required, ✓ such as: audio amplifiers. ✓

(2)

[50]

TOTAL: 200