Province of the
EASTERN CAPE
EDUCATION

NATIONAL SENIOR CERTIFICATE

GRADE 12

SEPTEMBER 2017

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 $P = \sqrt{3}\, V_L I_L \cos\theta$ ✓ But $I_L = \sqrt{3}\, I_{ph}$ $P = 3V_{PH}I_{PH}\cos\theta$ ✓

$= \sqrt{3} \times 380 \times 20{,}78 \cos 25°$ ✓ $= \sqrt{3} \times 12$ OR $= 3.380.12.\cos 25°$ ✓

$= 12{,}40$ kW ✓ $= 20{,}78$ A $= 12{,}40\ kW$ ✓ (3)

2.1.2 $S = \sqrt{3}\, V_L I_L$ ✓ $S = \frac{P}{\cos\theta}$ ✓

$= \sqrt{3} \times 380 \times 20{,}78$ ✓ or $= \frac{12{,}40}{\cos 25}$ ✓

$= 13{,}68$ kVA ✓ $= 13{,}68 kVA$ ✓ (3)

2.2 $V_L = \sqrt{3}\, V_{ph}$ ✓

$= \sqrt{3} \times 220$ ✓

$= 381{,}05$ V ✓ (3)

2.3
- For high power generation the three-phase system is functional and efficient. ✓
- 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

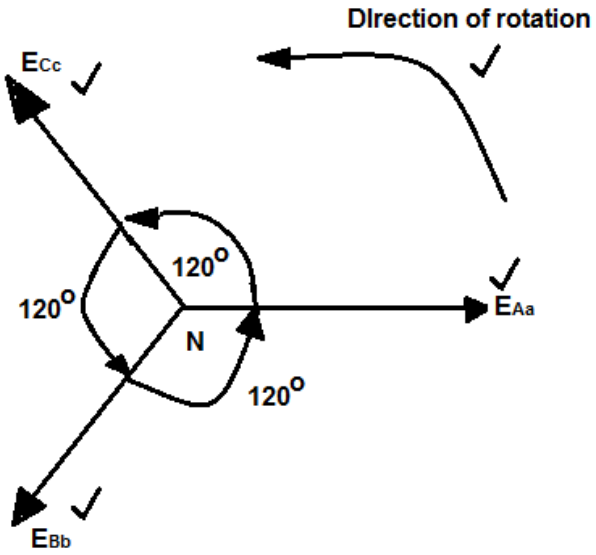
(ANY ONE) (1)

2.4 A generator has a lagging power factor ✓ as it consists of coils which are inductive. ✓ Current through an inductor connected to an AC supply lags the applied voltage. ✓ (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). ✓ (1)

2.6 120 degrees (1)

2.7



(4)

2.8 Effective value or rms value ✓ (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 $I_{ph(s)} = I_{L(s)}$ ✓
= 18,04 A✓ (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

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

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

$$= 25,32 \text{ A} \checkmark$$

(3)

4.4.2

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

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

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

$$= 16,67 \text{ kVA} \checkmark$$

(3)

4.4.3

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

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

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

$$= 14,43A \checkmark$$

(3)

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

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

$= 105,88$ kVA (2)

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

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

$= 152,83$ 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)

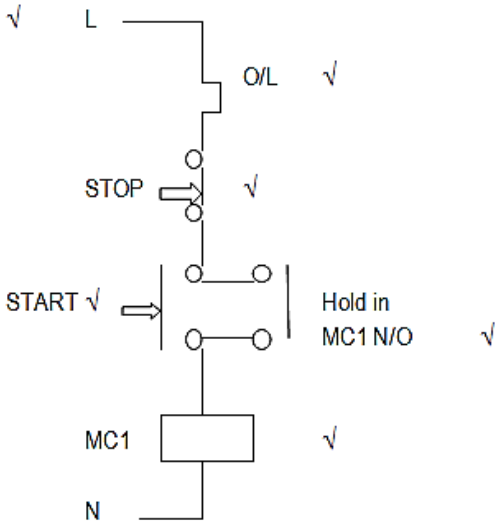
4.8 The motor will keep on operating, but to maintain the same output power ✓ the current on the other two phases will increase. ✓ If the protection is set correctly, it will engage, protecting the motor from permanent damage. ✓ (CONSIDER RELEVANT MOTIVATED ANSWERS) (3)

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)

4.11



(4)

[40]

QUESTION 5: RCL CIRCUITS

5.1 5.1.1 $Z = \sqrt{R^2 + (X_L - X_C)^2}$ ✓

$= \sqrt{500^2 + (300 - 250)^2}$ ✓

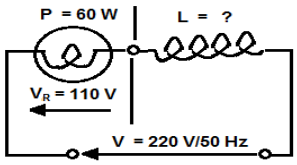
= 502,49 Ω ✓ (3)

5.1.2 $Cos\theta = \frac{R}{Z}$ ✓

$= \frac{500}{502,49}$ ✓

0,995 ✓ Lagging✓ (4)

5.2



5.2.1 $R = \frac{V^2}{P}$ ✓

$= \frac{110^2}{60}$ ✓

$= 201,67\ \Omega$✓ (3)

5.2.2 $I = \frac{P}{V_R}$ ✓

$= \frac{60}{110}$ ✓

$= 0,55$ A ✓ (3)

5.2.3 $Z = \frac{V}{I}$ ✓

$= \frac{220}{0,55}$ ✓

$= 400$ A ✓ (3)

5.2.4 $X_L = \sqrt{Z^2 - R^2}$

$2\pi fL = \sqrt{Z^2 - R^2}$ ✓

$L = \frac{\sqrt{Z^2 - R^2}}{2\pi f}$ ✓

$= \frac{\sqrt{400^2 - 201,67^2}}{2.\pi.50}$ ✓

$= 1,1$ H ✓ (4)

[20]

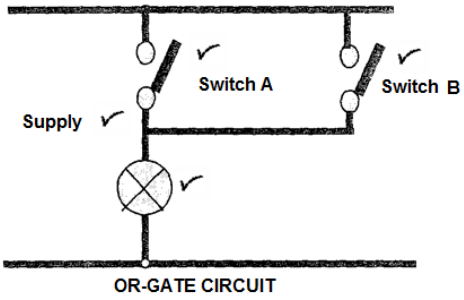
QUESTION 6: LOGIC

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)

6.4 6.4.1



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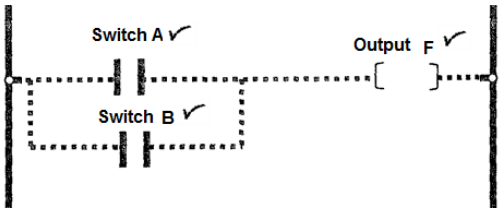
6.4.2



(3)

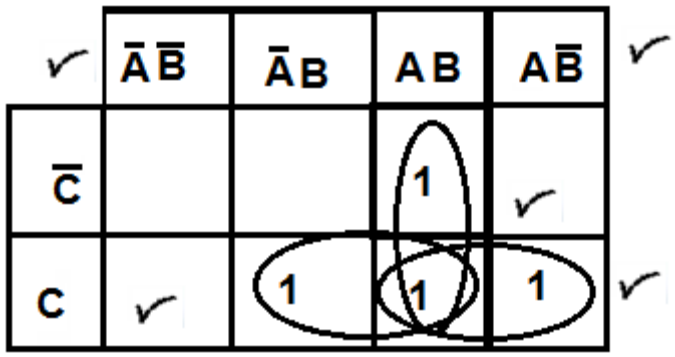
6.5 Ladder logic (LL). ✓
Instruction list (IL). ✓
Logic block diagram (LBD). ✓
Function Block Diagram (FBD)
Structured Text Sequential Flow / Function Chart
(ANY THREE) (3)

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 $\bar{A}.B.C + A.\bar{B}.C + A.B.\bar{C} + A.B.C$ (4)

6.8.2



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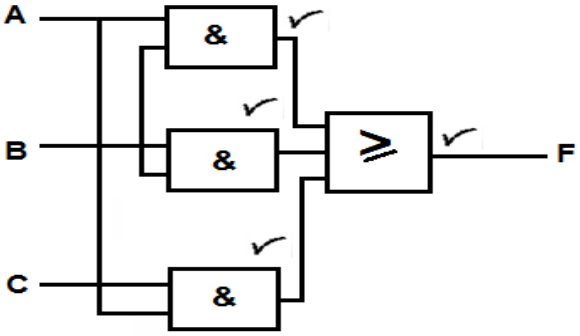
6.8.3



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[40]

QUESTION 7: AMPLIFIERS

7.1
- Linear amplifiers √
- Pulse amplifiers √
- Buffer circuits Integrating √
- Differentiating
- Summing amplifiers

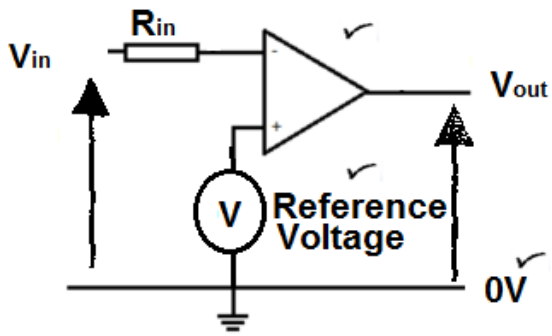
(ANY THREE) (3)

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)

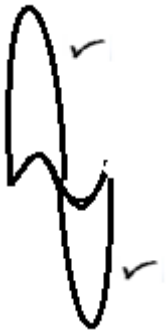
7.5 A portion of the output signal is fed back to the input signal ✓ and is in phase with the input signal (2)

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



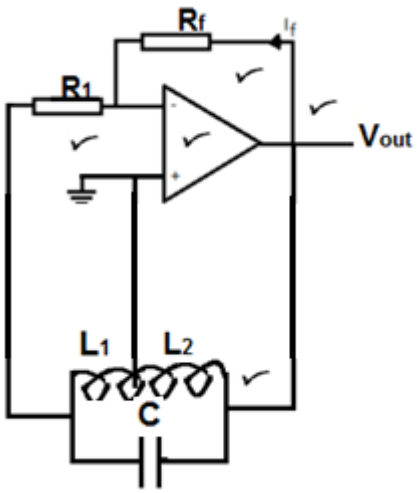
same frequency ✓ amplification ✓ non- inverting ✓ (2)

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

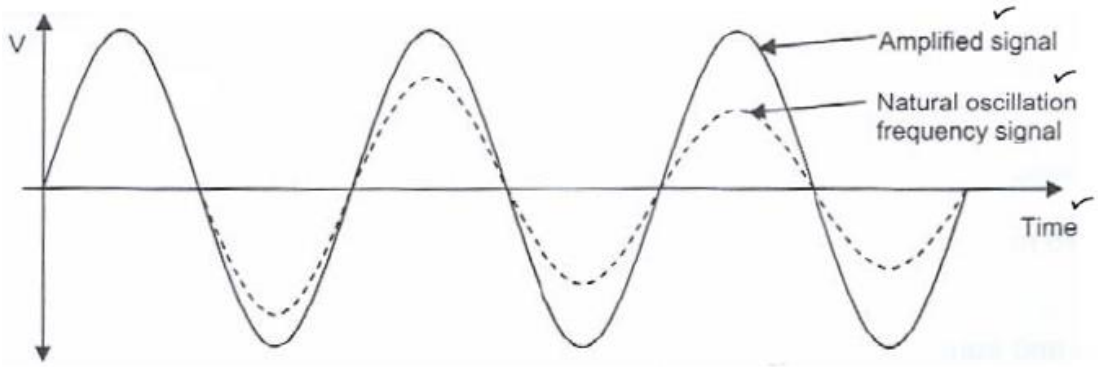


(5)

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