Province of the
EASTERN CAPE
EDUCATION

NATIONAL SENIOR CERTIFICATE

GRADE 12

SEPTEMBER 2018

ELECTRICAL TECHNOLOGY POWER SYSTEMS MARKING GUIDELINE

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 recalculate 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 guidelines, depending on how and where in the calculation rounding off was used.

3. This marking guideline is only a guide with model answers. Alternative interpretations must be considered and marked on merit. However, this principle should be applied consistently.

QUESTION 1: OCCUPATIONAL HEALTH AND SAFETY

1.1 The purpose of the Occupational Health and Safety Act is: to provide for the health and safety of persons at work and the health and safety of persons in connection with the use of plant and machinery; ✓ the protection of persons other than persons at work against hazards to health and safety arising out of or in connection with the activities of persons at work. ✓ (2)

1.2 Alternating current (AC) such as from the main supply, causes the muscles in the body to contract✓ and if the current is high enough one would not be able to 'let go' of the live wire causing the electric shock. ✓Typical 'let go' current is about 0,007 ampere (7 milli-amp). (2)

1.3
- Faulty tools or equipment ✓
- Poor ventilation
- Poor quality or missing machine guards
- Excessive noise
- Lack of knowledge of emergency procedures

(Any relevant answer) ✓ (1)

1.4
- Horseplay
- Running in the workshop
- Throwing things around
- Leaving bags, stools or material in walkway
- Spilling a liquid or oil without cleaning

(Any relevant answer) ✓ (1)

1.5
- Keep the person lying down ✓
- Cover the person to maintain body heat ✓
- Don't move the person in case of neck or spine injuries. Get medical assistance immediately
- If unconscious, put them on their side (recovery position)
- Keep a close watch on the patient's colour, raising the head or legs to manage blood flow into the paler areas

(Any TWO relevant answers) (2)

[8]

QUESTION 2: RLC

2.1 2.1.1 $Z = \sqrt{R^2 + (X_L - X_C)^2}$ ✓

$= \sqrt{12^2 + (24 - 18)^2}$ ✓

$= 13,42\ \Omega$ ✓ (3)

2.1.2 $I_T = \frac{V_T}{Z}$ ✓

$= \frac{30}{13,42}$ ✓

$= 2,24\ A$ ✓ (3)

2.1.3 $V_R = I_T \times R$
$= 2{,}24 \times 12$ ✓
$= 26{,}88\ V$ ✓
$V_L = I_T \times X_L$
$= 2{,}24 \times 24$ ✓
$= 53{,}76\ V$ ✓
$V_C = I_T \times X_C$
$= 2{,}24 \times 18$ ✓
$= 40{,}32\ V$ ✓ (6)

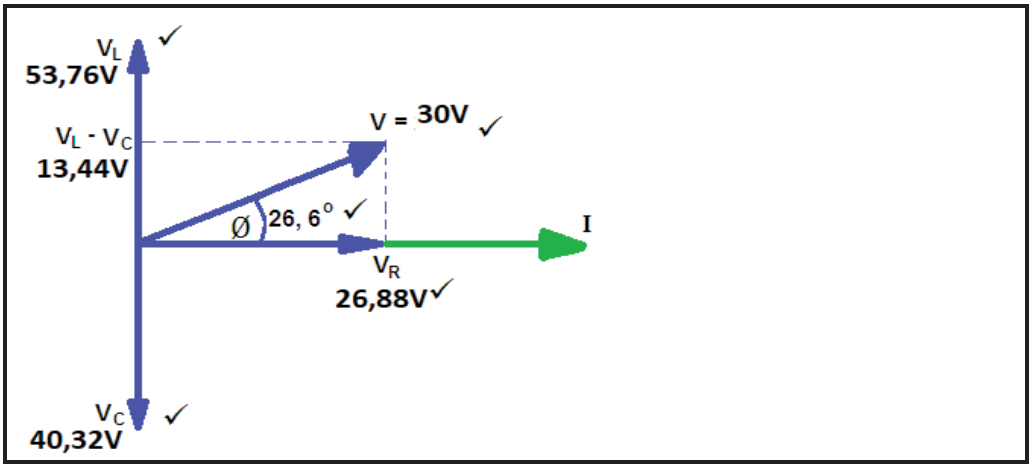
2.1.4 $\cos\theta = \frac{R}{Z}$
$\theta = \cos^{-1}\frac{R}{Z}$✓

$\theta = \cos^{-1}\frac{12}{13{,}42}$✓

$\theta = 26{,}6^o$✓ (3)

2.1.5 $V_T = \sqrt{V_R^2 + (V_L - V_C)^2}$✓
$= \sqrt{26{,}88^2 + (53{,}76 - 40{,}32)^2}$✓
$= 30\ V$ ✓ (3)

2.1.6



(5)

2.2 2.1.2 $I_T = \sqrt{I_R^2 + (I_L - I_C)^2}$✓
$= \sqrt{15^2 + (15 - 10)^2}$✓
$= 15{,}81\ A$✓ (3)

2.2.2 $X_L = \frac{V_T}{I_L}$✓

$= \frac{240}{15}$✓

$= 16\ \Omega$✓ (3)

2.2.3 $X_L = 2\pi\ fL$

$L = \frac{X_L}{2\pi f}$✓

$L = \frac{16}{2\pi \times 50}$✓

$L = 0{,}05\ H$ or $50\ mH$✓ (3)

2.3 2.3.1 Resonance in an RLC circuit is a condition at a specific frequency where $X_L = X_C$. ✓ This results in the current and voltage to be in phase therefore a phase angle of 0^o. ✓ (2)

2.3.2 Q-factor in a parallel circuit is the relationship between the resistance ✓ and the reactance of the circuit.✓ (2)

2.4 2.4.1 $C = \frac{1}{2\pi f X_C}$✓

$C = \frac{1}{2\pi \times 50 \times 157}$✓

$C = 20,27\ \mu F$✓ (3)

2.4.2 $Q = \frac{X_L}{R}$✓

$Q = \frac{157}{4}$✓

$Q = 39,25$✓ (3)

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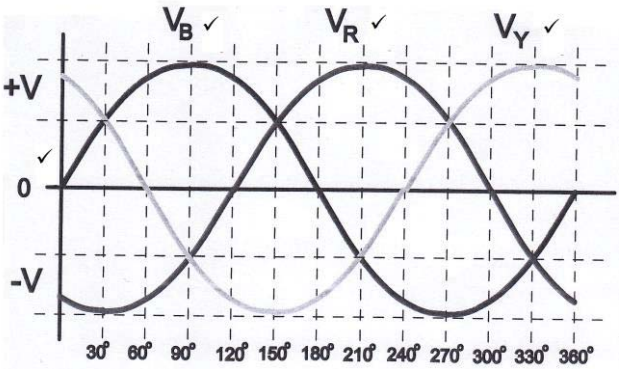
QUESTION 3: THREE-PHASE AC GENERATION

3.1



(4)

3.2 Apparent power is the product of the current and voltage of the circuit. ✓ Due to energy stored in the load and returned to the source, ✓ the apparent power will be greater than the real power.✓ (3)

3.3 3.3.1 $P_{app} = \sqrt{3}V_L I_L$

$V_L = \frac{P_{app}}{\sqrt{3}I_L}$✓

$= \frac{40\ 000}{\sqrt{3}\times 25}$✓

$= 923,76\ V$✓ (3)

3.3.2 $V_{ph} = \frac{V_L}{\sqrt{3}}$✓

$= \frac{923,76}{\sqrt{3}}$✓

$= 533,33\ A$✓ (3)

3.3.3 $P_r = \sqrt{3}\, V_L I_L \sin\theta$ But $Cos\ \theta = 0,87$

$= \sqrt{3} \times 923,76 \times 25 \times \sin 29,54^o$ $= \cos^{-1} 0,87$✓

$= 19,72\ k\ VA_r$✓ $= 29,54^o$ ✓ (4)

3.4 The power factor of an AC electrical system is defined as the ratio of the real power ✓ flowing to the load to the apparent power in the circuit, ✓ so the power factor of large industries is important because the power factor determines how efficient the electric power is used. ✓ (3)

3.5 3.5.1 $V_L = \sqrt{3}\, V_{ph}$

$$V_{ph} = \frac{V_L}{\sqrt{3}}$$

$$= \frac{415}{\sqrt{3}} ✓$$

$$= 239{,}6\ V ✓$$

$$I_{ph} = \frac{V_{ph}}{R_{ph}}$$

$$= \frac{239{,}6}{45} ✓$$

$$= 5{,}32\ \text{A} ✓$$ (4)

3.5.2 P $= \sqrt{3} V_L . I_L . Cos\theta ✓$

$$= \sqrt{3} \times 415 \times 5{,}32 \times 0.85 ✓$$
$$= 3{,}25\ kW ✓$$ (3)

3.5.3 S $= \sqrt{3}.\ V_L . I_L ✓$

$$= \sqrt{3} \times 415 \times 5{,}32 ✓$$
$$= 3{,}82\ kVA ✓$$ (3)

3.6 $\tan\theta = \sqrt{3}[\frac{W_{blue} - W_{red}}{W_{red} + W_{blue}}]$ ✓

$$= \sqrt{3}\,[\frac{8{,}5-3}{3+8{,}5}]$$ ✓

$$= 0{,}83 ✓$$ (3)

3.7 The real power is the capacity of the circuit for performing work in a particular time.✓ (1)

[34]

QUESTION 4: THREE-PHASE TRANSFORMERS

4.1 The main function of a transformer is to step up ✓ or step down the voltage ✓ (2)

4.2 Size ✓
Frequency ✓
Windings ratio ✓
Voltage
Power factor (3)

4.3 The transfer of mmf through a transformer is constant. ✓ An increase in load will increase the mmf of the secondary side. ✓ The mmf on the primary side will increase by the same amount. ✓As the voltage is fixed by the supplier, only the primary current can increase. ✓ (4)

4.4 Since the oil is a dielectric, a non–conductor of electricity, ✓ it improves the electrical insulation between the windings and the case. ✓
It also helps to provide cooling ✓and prevents the formation of moisture on the windings. ✓ (4)

4.5 Copper losses ✓
Iron losses ✓
Eddy current losses ✓
Hysteresis (3)

4.6 4.6.1 $I_L = \frac{P}{\sqrt{3}\, V_L\, Cos\, \theta}$ ✓

$= \frac{85\,000}{\sqrt{3}\times 450 \times 0.8}$ ✓

$= 136{,}32\ A$ ✓ (3)

4.6.2 $S = \sqrt{3}.\ V_L.I_L$

$= \sqrt{3} \times 450 \times 136{,}32$ ✓

$= 106{,}25\ kVA$ ✓ (2)

4.6.3 $V_{ph} = \frac{V_L}{\sqrt{3}}$

$= \frac{450}{\sqrt{3}}$ ✓

$= 259{,}81\ V$ ✓

$I_p = \frac{V_p \times I_s}{V_S}$ ✓

$= \frac{13\,800 \times 136{,}32}{259{,}81}$ ✓

$= 7\,240{,}74\ A$ ✓ (5)

[26]

QUESTION 5: THREE PHASE MOTORS AND STARTERS

5.1 Squirrel cage induction motors are very popular, because they are rugged dependable and economical ✓
They are cheaper ✓
Require less care and maintenance ✓
They have high starting torque
Easy to change direction of rotation
They have a better cooling system (3)

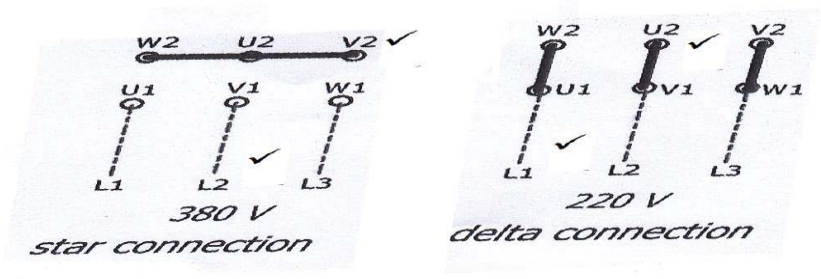
5.2 An induction motor can be used as an induction generator ✓
Fans and water pump ✓
It can be unrolled to form a linear induction motor which can directly generate linear motion (2)

5.3 $n_s = \frac{60 \times f}{p}$ ✓

$\frac{48\ poles}{3\ phase} = 16\ poles\ per\ phase = 8\ pole\ pairs\ per\ phase$ ✓

$n_s = \frac{60 \times 50}{8}$ ✓
$= 375\ r.p.m$ ✓ (4)

5.4



(4)

5.5 By swopping any two supply lines, the direction of rotation can be reversed ✓✓ (2)

5.6 Voltage ✓
Current
Frequency
Phase (1)

5.7 At starting, the induced emf in the rotor bars, being short-circuited will be very high due to the full rated supply line voltage applied to the motor windings. ✓ The peak starting current can be up to six times the full load current. ✓ The motor windings can be damaged by the high current. ✓ Starters therefore reduce the starting voltages across the windings to protect them. ✓ (4)

5.8 Such a low reading indicates a short circuit between the U and W coils. ✓ The reading should not be less than 1 MΩ. ✓ The motor should not be activated.✓ (3)

5.9 The reading must be very high up - to infinity ✓ but not less than 1 MΩ for a motor in good condition. ✓ (2)

5.10 $Slip = \frac{n_s - n_r}{n_r} \times 100\%$✓

$= \frac{3\,600 - 3\,384}{3\,600} \times 100\%$✓

$= 6\%$✓ (3)

5.11 $Efficiency(\eta) = \frac{input - losses}{input} \times 100\%$✓

$= \frac{25\,000 - 2\,200}{25\,000} \times 100\%$✓

$= 91{,}2\%$✓ (3)

5.12 $P = \sqrt{3} V_L I_L \cos\theta\eta$ ✓
$= \sqrt{3} \times 415 \times 20 \times 0{,}8 \times 0{,}9$ ✓
$= 10{,}35\ kW$ ✓ (3)

[34]

QUESTION 6: PROGRAMMABLE LOGIC CONTROLLERS

6.1 Mechanical relay ✓ (1)

6.2
- They need regular maintenance ✓
- Fault-finding was long and tedious ✓ (2)

6.3
- Flexibility ✓
- Simplicity ✓
- Cost ✓
- Space (3)

6.4
- Make sure that the PLC has a single point of ground to improve electrical noise protection. ✓
- Use the wires of an adequate current carrying size to avoid the risk of fire. ✓
- All contactors should be wired correctly and securely fitted. ✓ (3)

6.5 First the analogue signal is converted to a standardised digital form ✓ by converting the real world physical variable into a low-level electrical current or voltage. ✓The standard being 0 – 20 mA. This current signal is then converted into 0 – 5 V voltage signal using a very accurate 1% tolerance 250 Ω resistor. ✓ The PLC then receives a 0 – 5 V DC voltage which represents the real world situation. ✓ (4)

6.6 Binary Coded Decimal (BCD) is a binary code which converts each decimal number in a number sequence, ✓ into its own four-bit binary code. ✓ Then each of these four-bit coded numbers are generated together to form the eventual binary representation of that decimal number. ✓ (3)

6.7 6.7.1 0110 0011 0100 0111

6 3 4 7✓

$6\ 347_{10}$✓ (2)

6.7.2 1001 0010 0100 1000

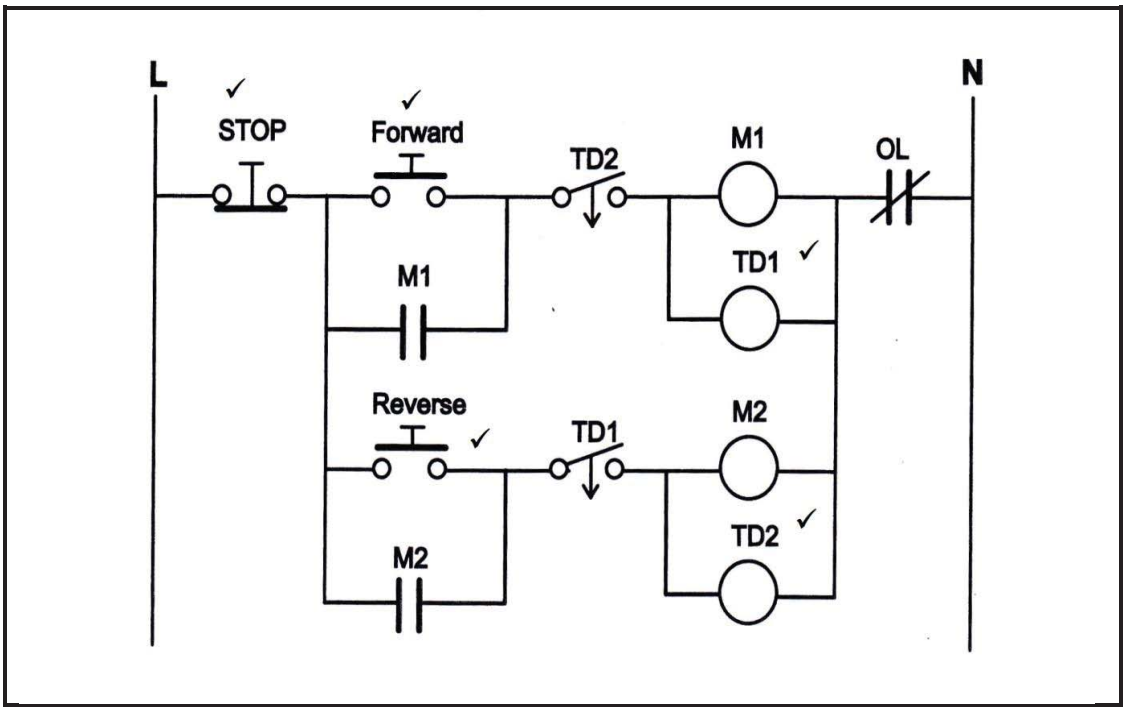
9 2 4 8✓

$9\ 248_{10}$✓ (2)

6.8 An opto-isolator uses light to transfer an electrical signal between circuits, ✓ while keeping them electrically isolated from each other. ✓ Therefore when used in a PLC circuit they isolate the PLC from any electrical overload damage. ✓ (3)

6.9 Proximity sensors ✓ : used to detect the presence of object using light, sound and electromagnetic field ✓
Temperature sensors ✓: used to measure temperature by sensing some change in a material's physical state ✓
Light sensors ✓ : used to detect the amount of light ✓
Level sensors ✓ : used to monitor levels of liquid ✓
Overload sensors ✓ : used to sense the force of the load ✓ (10)

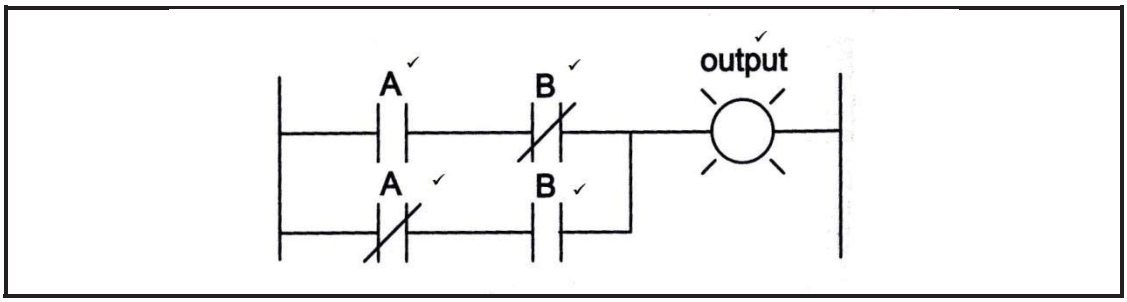
6.10



(5)

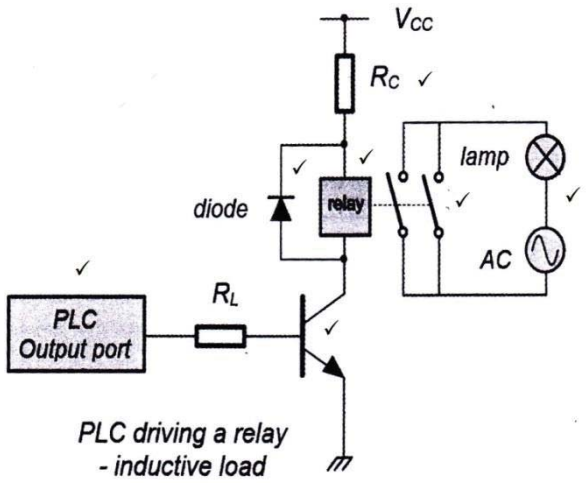
6.11 A variable speed drive (VSD) controls the speed of an AC motor by ✓ varying the frequency supplied to the motor ✓ (2)

6.12



(5)

6.13



(7)

6.14 Voltage and frequency control (V/Hz drive) ✓
Vector drives ✓ (2)

6.15 The system using this type of braking is able to 'self-generate' power ✓ which it uses to slow the system down under braking ✓ (2)

[56]

TOTAL: 200