Province of the
EASTERN CAPE
EDUCATION

NATIONAL SENIOR CERTIFICATE

GRADE 12

SEPTEMBER 2013

ELECTRICAL TECHNOLOGY

MARKS: **200**

TIME: **3 hours**

* E L C T D M *

This question paper consists of 12 pages, including a formula sheet.

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.

2. Sketches and diagrams must be large, neat and fully labelled.

3. ALL calculations must be shown and should be rounded off to TWO decimal places.

4. Number the answers correctly according to the numbering system used in this question paper.

5. A formula sheet is attached at the end of the question paper.

6. Non-programmable calculators may be used.

QUESTION 1: TECHNOLOGY, SOCIETY AND THE ENVIRONMENT

1.1 Designing, producing and marketing certain types of technological products require the manufacturer to exhibit entrepreneurial skills.

Name THREE entrepreneurial skills required. (3)

1.2 With reference to HIV/Aids, name ONE precaution that has to be taken when treating a person who has been injured. (1)

1.3 People use technologies and systems to meet their needs and desires. The use of technology has positive and negative impacts on society and the environment. Discuss briefly how the use of technologies can impact negatively on the following:

1.3.1 Air (2)

1.3.2 Water (2)

1.3.3 Land (2)

[10]

QUESTION 2: TECHNOLOGICAL PROCESS

2.1 The senior citizens of the Buqolo Retirement Village complained that the intercom system is not loud enough. The Electrical Technology learners have been asked to solve this problem.

Identify the problem experienced by the residents of the Buqolo Retirement Village. (2)

2.2 Physically disabled children need to practise how to control electrically powered wheelchairs in order to avoid accidents.

Develop a design brief to solve the above-mentioned problem. (5)

2.3 Research and investigation enable the designer to analyse existing products in order to understand and solve the problem better.

Describe THREE methods of collecting data regarding the design problem. (3)

[10]

QUESTION 3: OCCUPATIONAL HEALTH AND SAFETY

3.1 Name TWO precautions that must be taken when using a portable drilling machine. (2)

3.2 State TWO precautions that must be taken when measuring the current flow in a circuit with a digital multi-meter. (2)

3.3 Describe why it is important to have good ventilation in an electrical technology workshop. (2)

3.4 State TWO unsafe actions that can occur in an electrical technology workshop. (2)

3.5 Describe ONE precaution to be taken when stripping off the insulation of a conductor. (2)

[10]

QUESTION 4: THREE-PHASE AC GENERATION

4.1 State how the power factor of a *resistive inductive load* may be improved. (1)

4.2 Define the term *balanced load*. (2)

4.3 Describe ONE disadvantage of a three-phase motor that has a *poor lagging power factor*. (2)

4.4 A 2,5 kW balanced load is connected in delta to a 380 V supply. The load has a power factor of 0,85 and a rendement of 100%.

Calculate the kVA rating of the load at full load. (3)

4.5 Three loads, each having a resistance of 50 Ω, are connected in star formation to a 380 V, three-phase supply.

Determine the *phase voltage*. (2)

[10]

QUESTION 5: R, L AND C CIRCUITS

5.1 An alternating-current circuit consists of an inductor of 0,15 H, a capacitor of 150 µF and a resistor of 20 Ω, connected in parallel to a supply of 100 V, 50 Hz.

Calculate the following:

5.1.1 The current through the capacitor (3)

5.1.2 The current through the inductor (3)

5.1.3 The current through the resistor (3)

5.1.4 Total current flowing through the circuit (3)

5.1.5 Draw a neatly labelled *phasor diagram* of the circuit in QUESTION 5.1. (not to scale) (4)

5.2 An alternating-current circuit consists of a coil and a capacitor in series. The capacitor has a capacitance of 49 µF. The coil has an inductance of 0,14 H and a resistance of 40 Ω.

If the supply voltage is 220 V/50 Hz, calculate the following:

5.2.1 Inductive reactance (3)

5.2.2 Capacitive reactance (3)

5.2.3 The impedance of the circuit (3)

5.2.4 The current flowing through the circuit (3)

5.3 Name the type of reactance offered to the flow of electric current in the following:

5.3.1 Pure inductive circuit (1)

5.3.2 Pure capacitive circuit (1)

[30]

QUESTION 6: SWITCHING AND CONTROL CIRCUITS

6.1 Explain the functional operation of a DIAC. (4)

6.2 Draw a neat, fully labelled characteristic curve of a TRIAC. (5)

6.3 Explain how an SCR is switched on AND how it is switched off. (4)

6.4 Draw the circuit symbols of the following electronic components:

6.4.1 The TRIAC (3)

6.4.2 The DIAC (2)

6.5 Explain why the firing angle controlled by the RC network, can only be controlled up to 90° if the capacitor in FIGURE 6.5 below was replaced with a resistor. (4)

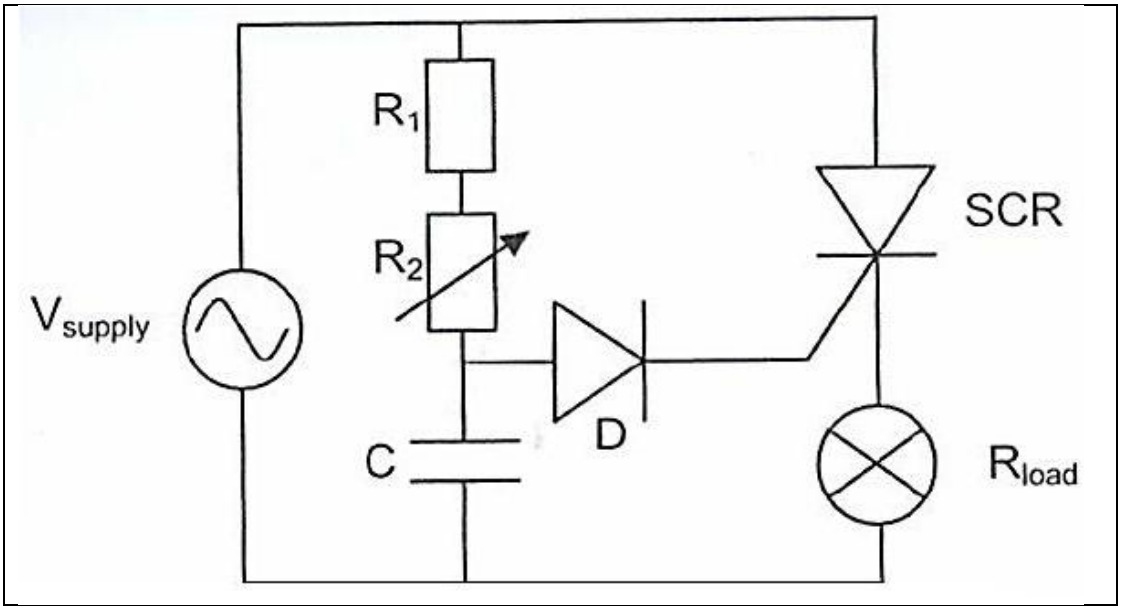


FIGURE 6.5: LAMP DIMMING CIRCUIT

6.6 Name THREE advantages that a TRIAC and an SCR have over resistive methods of power control. (3)

[25]

QUESTION 7: AMPLIFIERS

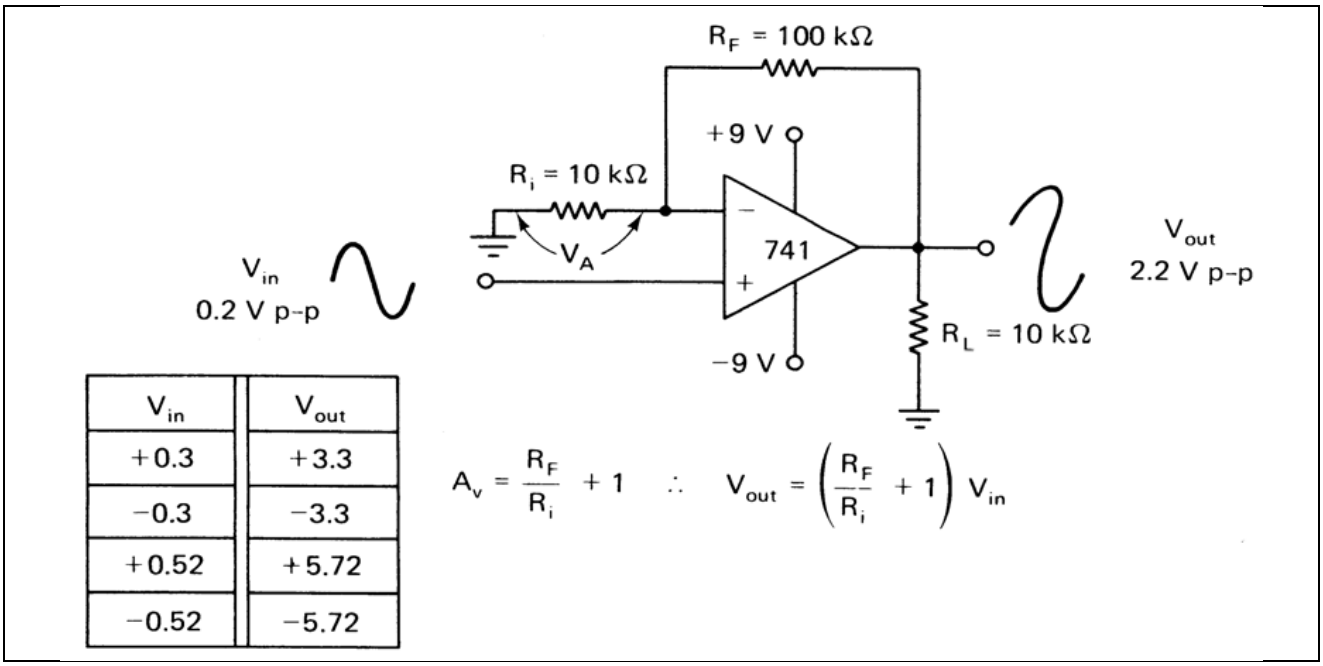
7.1 Name FOUR characteristics of an ideal operational amplifier. (4)

7.2 Operational amplifiers may be configured to have a single input/single output, a differential input/differential output or a differential input/single output.

Explain the term *differential*, with specific reference to operational amplifiers. (2)

7.3 Explain the difference between positive and negative feedback, with reference to amplifiers, giving an example of each. (4)

7.4 The operational amplifier in FIGURE 7.4 has been coupled in a certain way.



V_{in}	V_{out}
+0.3	+3.3
−0.3	−3.3
+0.52	+5.72
−0.52	−5.72

FIGURE 7.4: OPERATIONAL AMPLIFIER CIRCUIT

Make use of your knowledge of operational amplifiers to determine the following:

7.4.1 In which mode is the operational amplifier coupled? (1)

7.4.2 Would this be a good or bad amplifier to use for audio applications, when referring to the input and output wave forms? Motivate your answer accordingly. (2)

7.4.3 Determine the gain at which the amplifier is set, making use of the information provided in the circuit in FIGURE 7.4. (2)

7.4.4 Explain what you would do to increase the gain of this amplifier. Also explain the nature of the adjustment you would make. (3)

7.5 Negative feedback holds certain advantages when applied in amplifier circuits. State THREE useful advantages of negative feedback in amplifiers. (3)

7.6 Refer to the circuit below to answer the question that follows.

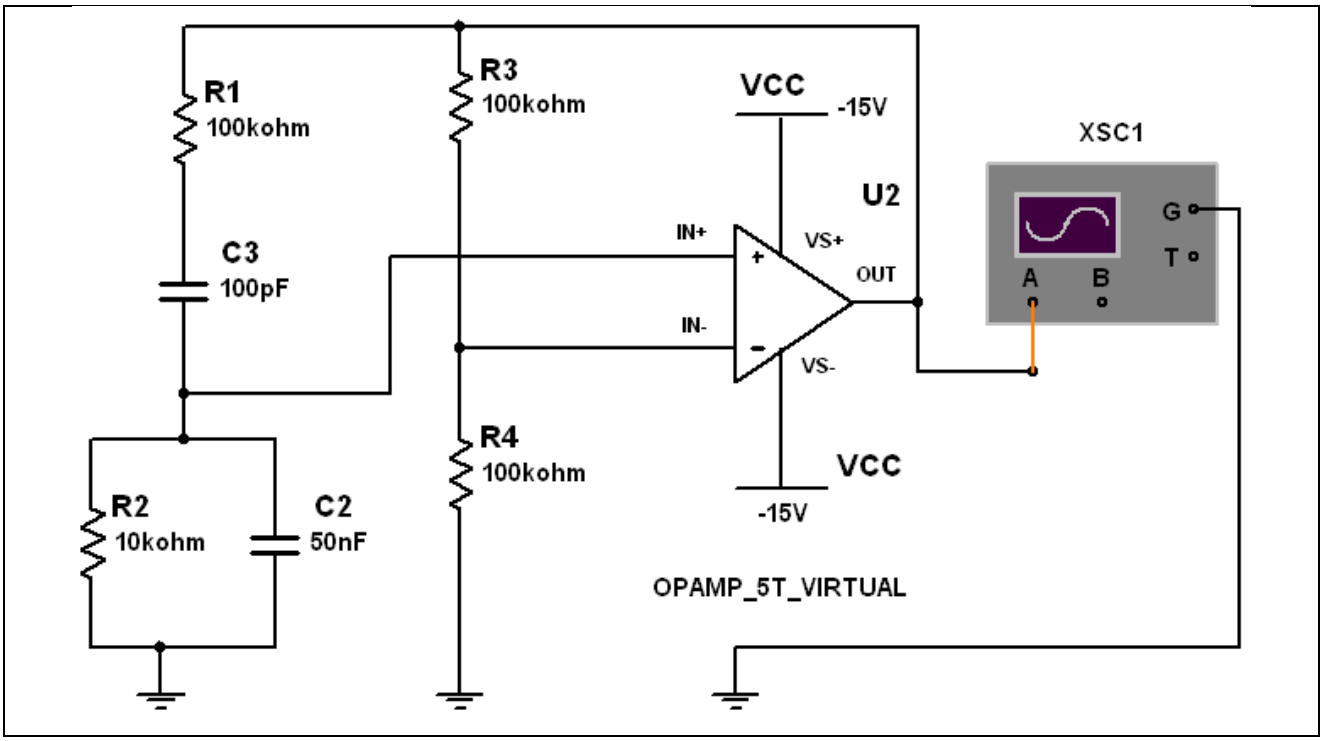


FIGURE 7.6: WIEN BRIDGE OSCILLATOR

Calculate the resonant frequency of the Wien bridge oscillator shown in FIGURE 7.6 above. (3)

7.7 Name ONE method of biasing a common emitter amplifier. (1)

[25]

QUESTION 8: THREE-PHASE TRANSFORMERS

8.1 Name TWO methods that may be used to reduce the magnetic leakage flux of a transformer. (2)

8.2 A 30 kVA transformer with a winding ratio of 50:1 is connected in delta-star formation to supply a farm with a line voltage of 380 V. Calculate the following:

8.2.1 Secondary phase voltage (2)

8.2.2 Primary line voltage (3)

8.2.3 Power delivered at full-load at a power factor of 0,85 lagging (4)

8.3 Give FOUR losses that occur in transformers. (4)

[15]

QUESTION 9: LOGIC CONCEPTS AND PLCs

9.1 What is implied by the expression *programmable logic controller* (PLC) or *programmable integrated circuit* (PIC) within the digital environment? (2)

9.2 Describe the main difference between a *hard-wired system* and a PLC or *soft wired system*. (4)

9.3 A PLC scans the programme when it executes the commands in the RUN mode. This is done in three main steps, then the process is repeated.

9.3.1 Briefly explain the meaning of the statement above, with relation to the operation of programmable logic controllers. (2)

9.3.2 Name and describe the THREE main steps that a PLC takes in order to perform its function. (6)

9.4 FIGURE 9.4 shows a simple AND-gate simulation using two switches to activate a coil.

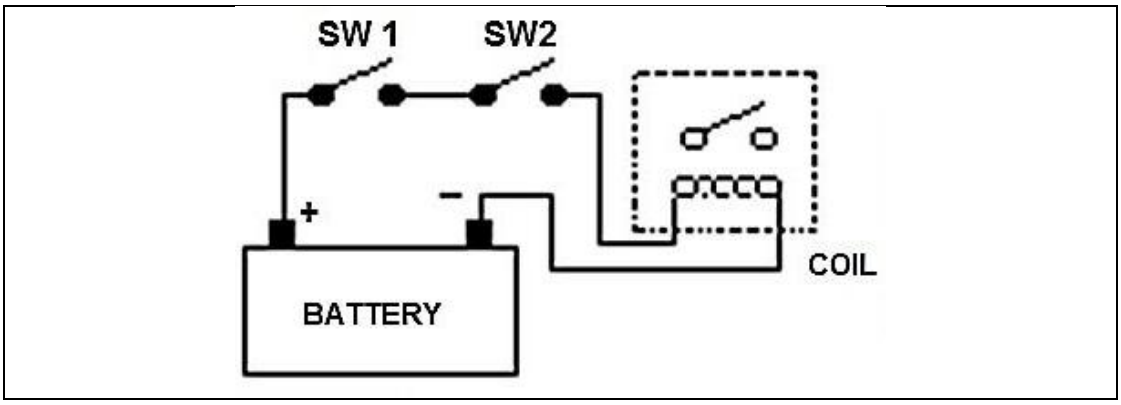


FIGURE 9.4: AND GATE USING SWITCHES

9.4.1 Translate this Boolean equation of A.B = X into a logic ladder diagram for use in a PLC. (4)

9.5 FIGURE 9.5 shows a PLC connected to an oil tank.

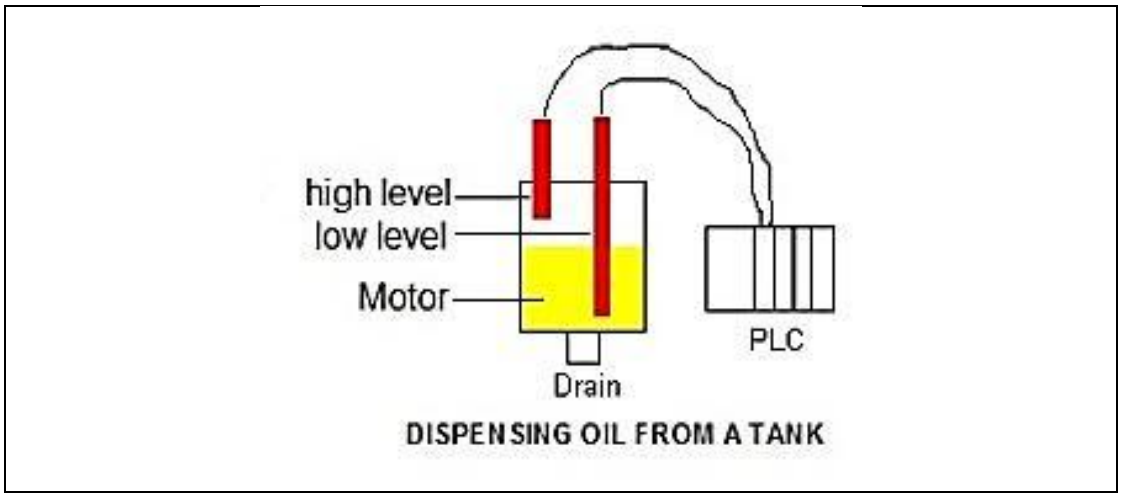


FIGURE 9.5: Applying a PLC in practice

Problem Statement

- You are controlling lubricating oil being dispensed from a tank in a factory. The tank is draining continuously.
- It is necessary for the motor to pump lubricating oil into the tank until the high-level sensor turns on.
- At that point the motor should be switched off until the level falls below the low-level sensor. Thereafter the motor should be turned on and the process repeated.

Information

- Control is made possible using two sensors. One is put near the bottom and one near the top.
- There is a need for three I/Os (in other words – inputs/outputs). Two are inputs (the sensors) and one is an output (the motor).
- Both of the inputs will be NC (normally closed) fibre optic level sensors. When they are NOT immersed in liquid, they will be ON. When they are immersed in liquid, they will be OFF.
- Each input and output device will have an address. This lets the PLC know where the devices are physically connected. The addresses are shown below.

INPUTS	ADDRESS	OUTPUT	ADDRESS	INTERNAL UTILITY RELAY
Low input relay	0000	Motor	0500	1000
High input relay	0001			

9.5.1 Determine whether the following Boolean expression will satisfy the above problem statement:
A.B + AB = X (2)

9.5.2 Make use of the information provided in the problem statement and derive the logic ladder diagram that will programme the PLC to perform the function satisfactorily. (7)

9.5.3 Each of the inputs and outputs has been assigned an address. Explain why this is done with reference to PLC devices. (2)

9.6 FIGURE 9.6 below shows the gate network of a logic circuit.

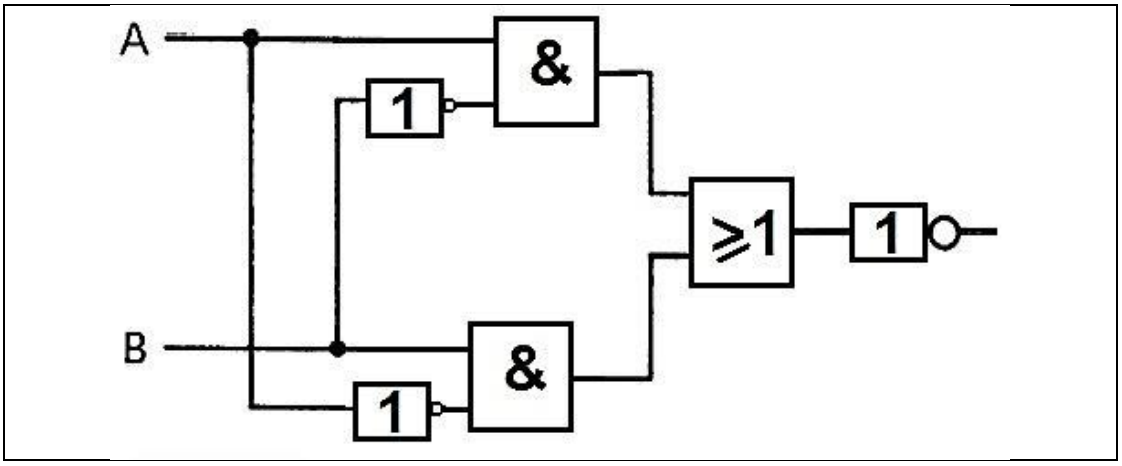


FIGURE 9.6: LOGIC CIRCUIT

9.6.1 Determine the simplified Boolean expression for the logic circuit AND draw the equivalent logic circuit for your answer. (6)

[35]

QUESTION 10: THREE-PHASE MOTORS AND CONTROL

10.1 A three-phase motor operating off a 380 V system develops 8 kW. The motor has a power factor of 0,8 and an efficiency rating of 100%. If the motor is started by a star-delta starter, calculate the following at full load:

10.1.1 Line current and phase current (5)

10.1.2 Input in kVA (3)

10.2 Why is a star-delta starter used to start three-phase motors? (3)

10.3 Explain the term *no-volt protection* with reference to motor starters. (3)

10.4 Explain the term *normally closed* with reference to motor starters. (2)

10.5 Why must the casing of a three-phase motor be earthed? (3)

10.6 How can the rotation direction of a three-phase motor be reversed? (2)

10.7 Electrical motors have internal losses. Name and describe THREE of the losses. (6)

10.8 Before a motor is started, after it has been installed, basic mechanical and electrical inspections should take place. Name ONE basic mechanical AND TWO basic electrical inspections that must take place before the commissioning of the motor. (3)

[30]

TOTAL: 200

ELECTRICAL TECHNOLOGY/ELEKTRIESE TEGNOLOGIE

FORMULA SHEET/FORMULEBLAD

$$X_L = 2\pi FL$$

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

$$Z = \sqrt{\mathrm{R}^2 + (\mathrm{X}_L \cong X_C)^2}$$

$$Z = \sqrt{(R^2 + (X_L \cong I_C)^2}$$

$$I_T = \sqrt{I_R^2 + (I_C \cong I_L)^2}$$

$$V_T = \sqrt{V_R^2 + (V_C \cong V_L)^2}$$

$$V_R = IR$$

$$V_L = IX_L$$

$$V_C = IX_C$$

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

$$Q = \frac{X_L}{R} = \frac{V_L}{V}$$

$$cos\Theta = \frac{I_R}{I_T}$$

$$\Theta = cos^{-1}\frac{I_R}{I_T}$$

$$cos\Theta = \frac{R}{Z}$$

$$tan\Theta = \frac{X_C}{R}$$

$$\Theta = tan^{-1}\frac{X_C}{R}$$

Single phase/Enkel fase:

$$P = VIcos\Theta$$

$$S = VI$$

$$Q = VIsin\Theta$$

Three-phase/Drie-fase:

$$P = \sqrt{3}V_L I_L Cos\Theta$$

$$P = 3V_{ph} I_{ph} Cos\Theta$$

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

$$Q = \sqrt{3}V_L I_L Sin\Theta$$

Delta:

$$V_L = V_{ph}$$

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

Star/Ster:

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

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

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

$$\frac{V_{ph(P)}}{V_{ph(S)}} = \frac{N_P}{N_S} = \frac{I_{ph(P)}}{I_{ph(S)}}$$

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