education

Department:
Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

ELECTRICAL TECHNOLOGY

NOVEMBER 2009

MARKS: 200

TIME: 3 hours

This question paper consists of 12 pages and 1 formula sheet.

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.

2. Read ALL the questions carefully.

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

4. All calculations must be shown, and should be rounded off correctly to TWO decimal places.

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

6. A formula sheet is provided at the end of the question paper.

7. Non-programmable calculators may be used.

8. Write neatly and legibly.

QUESTION 1: TECHNOLOGY, SOCIETY AND THE ENVIRONMENT

1.1 The development of technology has an effect on the environment.

Name and describe TWO negative impacts that electrical technology may have on the environment. (4)

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

State THREE skills that successful entrepreneurs possess. (3)

1.3 Female learners and physically disabled learners should receive equal treatment in an Electrical Technology class.

Write down THREE principles that will ensure equal treatment for all the learners in an Electrical Technology class. (3)

[10]

QUESTION 2: TECHNOLOGICAL PROCESS

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

2.1.1 Identify the problem experienced by the residents of Mazweni retirement village. (2)

2.1.2 Draw a flow diagram of the chosen solution. (6)

2.1.3 Describe any TWO specifications of the solution. (2)

[10]

QUESTION 3: OCCUPATIONAL HEALTH AND SAFETY

3.1 State ONE precaution that must be taken when working with a soldering iron, AND describe why this precaution must be taken. (2)

3.2 State ONE precaution that must be taken when using chemicals to etch a PC board AND describe why this precaution must be taken. (2)

3.3 Name TWO inspections that must be done before using a portable drilling machine. (2)

3.4 Name TWO unsafe acts that may lead to an electric shock when working in an Electrical Technology workshop. (2)

3.5 State TWO precautions that must be taken when using a multimeter to measure the voltage in a circuit. (2)

[10]

QUESTION 4: THREE-PHASE AC GENERATION

4.1 Name ONE advantage that a three-phase distribution system has over a single-phase distribution system. (1)

4.2 Name the type of power factor that a three-phase generator has, and explain why it has such a type of power factor. (3)

4.3 In a balanced three-phase delta-connected circuit, the phase voltage is 380 V and the phase current is 12 A. If the phase angle is 25°, calculate the following:

4.3.1 The true power (3)

4.3.2 The apparent power (3)

[10]

QUESTION 5: R, L AND C CIRCUITS

5.1 Write down the SI symbols of the following electrical quantities:

5.1.1 Impedance (1)

5.1.2 Capacitive reactance (1)

5.1.3 Inductance (1)

5.2 The circuit in FIGURE 5.1 below shows an inductor connected in series with a resistor. The voltage across the inductor (V_L) is 40 V and the voltage across the resistor (V_R) is 30 V. If the current flow is 3 A, answer the following questions.

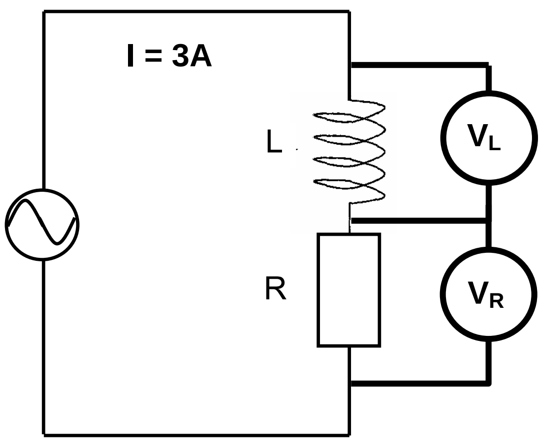


FIGURE 5.1: R AND L CIRCUIT

5.2.1 Calculate the total voltage across the circuit. (3)

5.2.2 Calculate the phase angle between the total voltage and the total current. (3)

5.2.3 Calculate the impedance of the circuit. (3)

5.2.4 Draw the phasor diagram of the circuit. (6)

5.3 An alternating-current circuit consists of a 0,1 H inductor, a 150 μF capacitor and a 20 Ω resistor, all connected in parallel to a 100 V, 50 Hz supply. If the current through the capacitor is 4,71 A, calculate the following:

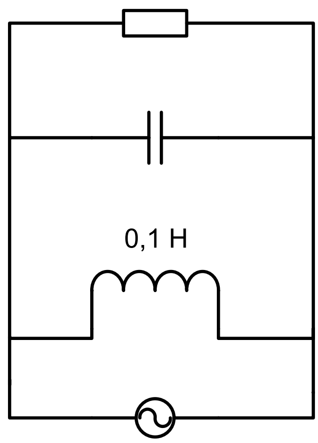


FIGURE 5.2: RLC circuit

5.3.1 The current through the inductor (6)

5.3.2 The current through the resistor (3)

5.3.3 The total current (3)
[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 Draw the circuit symbols of the following electronic components:

6.3.1 The DIAC (2)

6.3.2 The TRIAC (3)

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

6.5 Explain why the firing angle controlled by the RC network, can only be controlled up to 90° if the capacitor in FIGURE 6.1 below was replaced with a resistor.

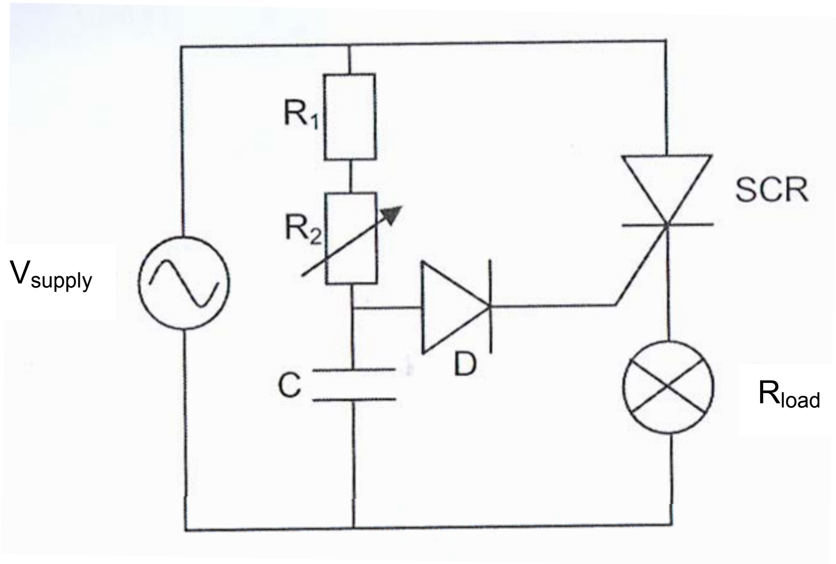


FIGURE 6.1: LAMP DIMMING CIRCUIT (4)

6.6 Name TWO advantages that a TRIAC and an SCR have over resistive methods of power control. (2)

6.7 Name ONE advantage that a TRIAC has over an SCR in power control. (1)
[25]

QUESTION 7: AMPLIFIERS

7.1 Explain the term *positive feedback.* (3)

7.2 Expain the term *natural oscillation frequency* and draw THREE complete cycles to demonstrate natural oscillation frequency. (6)

7.3 Consider the frequency response curves shown in FIGURE 7.1 below and answer the following questions:

7.3.1 State FOUR main changes in the response curves between gain with negative feedback and gain without negative feedback. (4)

7.3.2 Analyse the bandwidth and state, with a reason, if it would be suitable as a high-quality audio amplifier. (2)

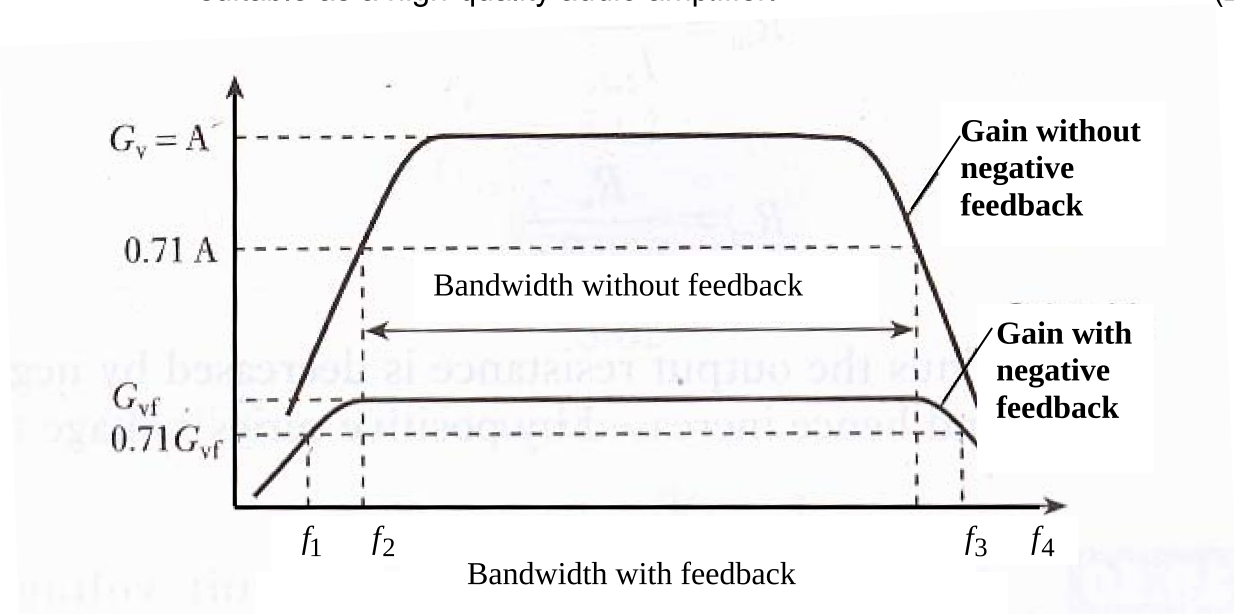


FIGURE 7.1: FREQUENCY RESPONSE CURVES

7.4 With reference to an operational amplifier, do the following:

7.4.1 Draw the operational amplifier in a configuration which will enable it to act as a summing amplifier with THREE inputs. (3)

7.4.2 Calculate V_{out} (RMS) if the following in-phase voltages are applied to the inputs:

- $V_1 = 0,5\ V_{RMS}$
- $V_2 = 1\ V_{RMS}$
- $V_3 = 1,5\ V_{RMS}$ (3)

7.4.3 Draw the THREE input wave forms and the resulting output wave form. (4)

[25]

QUESTION 8: THREE-PHASE TRANSFORMERS

8.1 Name TWO types of losses that occur in transformers. (2)

8.2 Draw a fully labelled diagram to show how three identical single-phase transformers may be connected to operate as a three-phase delta-star unit. (4)

8.3 The delta-connected primary winding of a three-phase transformer is supplied with 11 kV. The secondary winding is star-connected and supplies 400 V to a balanced star-connected load of 10 kW with a power factor of 0,8. Calculate the following at full load:

8.3.1 The total kVA of the load (3)

8.3.2 The secondary line current (3)

8.3.3 The secondary phase current (3)

[15]

QUESTION 9: LOGIC CONCEPTS AND PLC'S

9.1 Name TWO types of counters used in logic systems. (2)

9.2 Sequential logic systems are combination systems where some of the outputs are fed back as inputs. The multivibrator range is acknowledged as a sequential logic system. List the THREE possible mutivibrators that will form part of sequential logic systems. (3)

9.3 Logic systems can be divided into two types, depending on the value of the voltages representing logic 1 and 0. Identify the TWO types. (2)

9.4 Explain why the maintenance of a PLC system (soft-wired system) should be less than that of a relay system (hard-wired system). (1)

9.5 Draw the logic gate diagram that will have the same output as the logic ladder diagram shown in FIGURE 9.1 below.

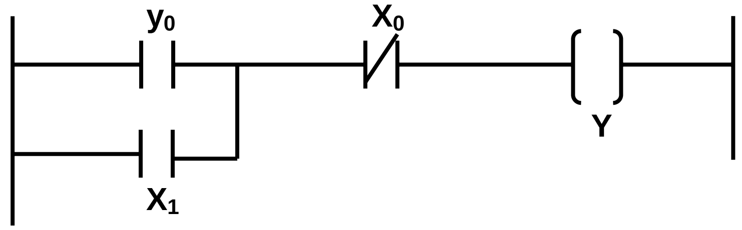


FIGURE 9.1: LOGIC LADDER DIAGRAM (4)

9.6 A digital control system uses three positional sensing devices on a conveyor belt in a bottling plant. Each sensing device produces an output of 1 when the position is confirmed. These devices are to be used in conjunction with a logic network of AND and OR gates.

The output of the network (F) is to be 1 when two or more of the sensing devices [Sensor 1(A), 2(B) and 3(C)] are producing signals of 1.

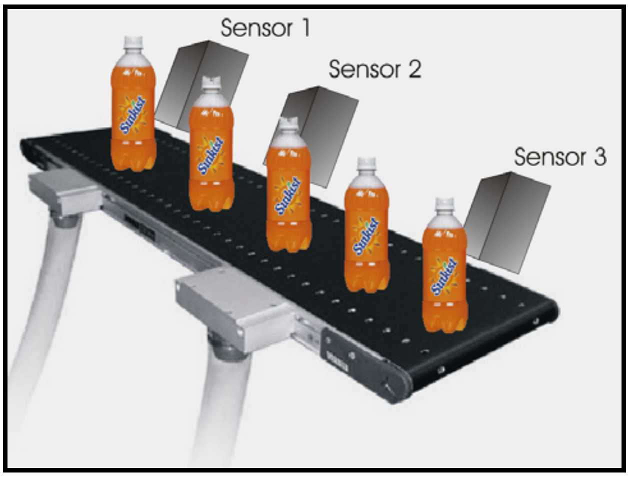


FIGURE 9.2: CONVEYOR-BELT SYSTEM

9.6.1 Write down the Boolean equation of the control system. (4)

9.6.2 Simplify the equation using a Karnaugh map. (5)

9.6.3 Draw the gate network of the simplified system. (5)

9.7 Draw a simple diagram of a bistable multivibrator making use of NAND gates only. It must not be possiblee to apply a logic 1 simultaneously at the set and reset inputs. (5)

9.8 Draw the output-timing diagram of the J-K flip-flop in FIGURE 9.3 below if the following inputs are applied to J and K. Draw the output below the inputs to show the output in relation to the input. Note the state of the enabling clock pulse.

Disregard the zero indicators at the gates, as this indicates an idle state.

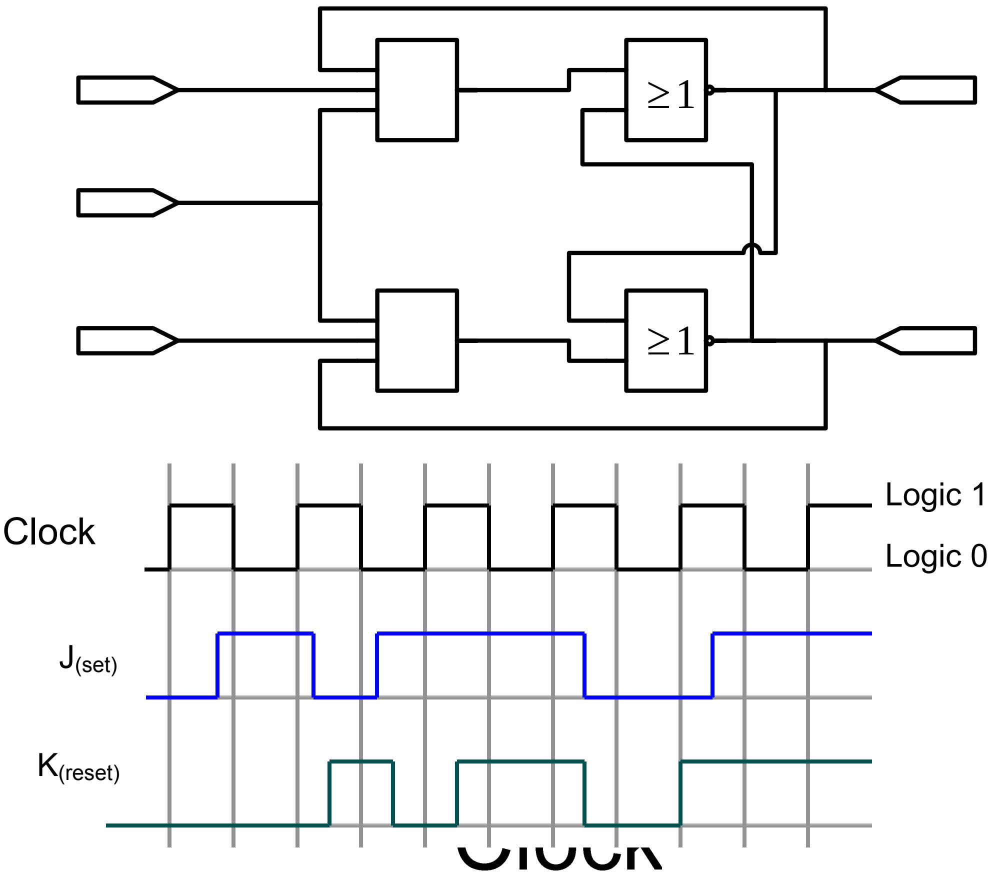


FIGURE 9.3: J-K FLIP-FLOP WITH INPUTS AND CLOCK PULSE (4)
[35]

0
0 & 0
0

J

0
0 & 0
0

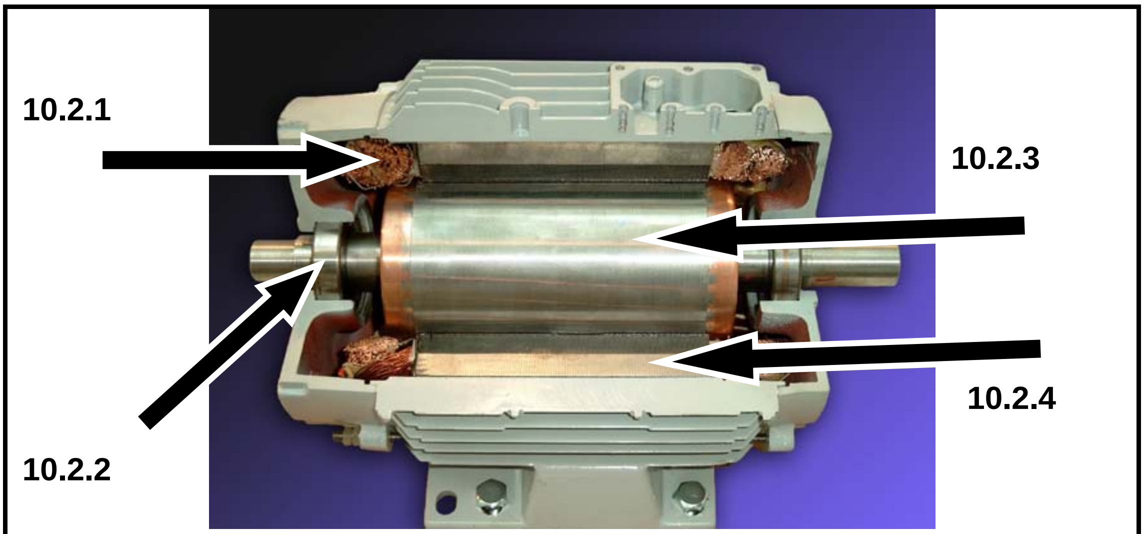
QUESTION 10: THREE-PHASE MOTORS AND CONTROL

10.1 After a motor has been installed, basic electrical and mechanical inspections should be carried out on it, before the motor is started.

10.1.1 Describe TWO electrical inspections. (2)

10.1.2 Describe TWO mechanical inspections. (2)

10.2 Identify the parts of the squirrel-cage motor shown in FIGURE 10.1 below.



[Source: http://www.copper.org/about/pressreleases/2006/images/motor_rotor_hi.jpg]

FIGURE 10.1: THE SQUIRREL-CAGE MOTOR (4)

10.3 Describe the functional operation of a three-phase induction motor (squirrel-cage motor). (7)

10.4 A 4 kW motor is connected in delta to a 380 V supply. If the motor has a power factor of 0,8, calculate the following at full load:

10.4.1 The current drawn from the supply (4)

10.4.2 The current flowing in each phase (3)

10.4.3 The reactive power of the motor (4)

10.5 FIGURE 10.2 below shows both the main circuit and control circuit of a three-phase direct-on-line motor starter.

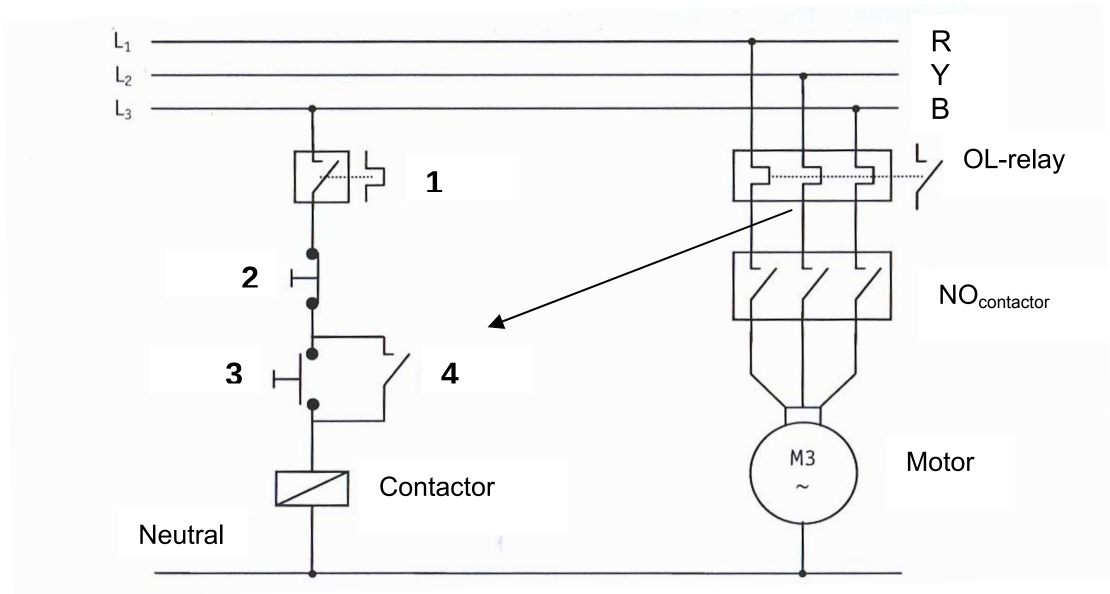


FIGURE 10.2: DIRECT-ON-LINE MOTOR STARTER

List the parts numbered 1 to 4. (4)
[30]

TOTAL: 200

FORMULA SHEET

RLC

$$X_L = 2\pi FL$$

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

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

$$I_T = \sqrt{I_R^2 + \left(I_C - I_L\right)^2}$$

$$V_T = \sqrt{V_R^2 + \left(V_C - V_L\right)^2}$$

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

$$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$

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

$$Cos\theta = \frac{I_R}{I_T}$$

$$Cos\theta = \frac{R}{Z}$$

Amplifiers

$$Av = \frac{R_f}{R_{in}} + 1$$

$$\beta = \frac{I_c}{I_b}$$

$$I_b = I_e - I_c$$

$$P_G = 10\log\frac{P_0}{P_i}$$

Alternating Current, Transformers and Motors

Single Φ

$$P = VI\cos\theta$$

$$S = VI$$

$$Q = VI\sin\theta$$

Three Φ

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

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

$$Q = \sqrt{3}\, V_L I_L \sin\theta$$

$I_L = \sqrt{3} I_{PH}$ for Δ

$V_L = V_{Ph}$ for Δ

$V_L = \sqrt{3}\, V_{Ph}$ for Y

$I_L = I_{Ph}$ for Y

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

$$\frac{V_1}{V_2} = \frac{N_1}{N_2} = \frac{I_2}{I_1}$$

$$\eta = \frac{P_O}{P_I}$$