GAUTENG DEPARTMENT OF EDUCATION

SENIOR CERTIFICATE EXAMINATION

TECHNIKA (ELECTRICAL) HG

TIME: 3 hours

MARKS: 300

OCTOBER / NOVEMBER 2005
OKTOBER / NOVEMBER 2005

REQUIREMENTS:

- Drawing instruments and an approved calculator

INSTRUCTIONS:

- Answer ALL the questions.
- All the work including sketches and diagrams must be neat and clear.
- Formulae and calculations must, where applicable, be indicated.
- A list of formulae is provided on the last page of the question paper.

QUESTION 1
ELECTRICAL CURRENT THEORY

1.1 The following equation represents an alternating current circuit.

$V = 100 \sin 314\,t$ volt

$I = 50 \sin (314t - \frac{\pi}{3})$ ampere

Calculate the following:

1.1.1 The circuit impedance (3)

1.1.2 The frequency (3)

1.1.3 The power factor (2)

1.1.4 The power (3)

1.2 A circuit with a resistance of 12 ohms, an inductance of 0,15 henry and a capacitance of 100 microfarad is connected in series across a 100 V / 50 Hz supply.

Calculate the following:

1.2.1 The impedance (6)

1.2.2 The current flow (3)

1.2.3 The voltage across R, L and C (6)

1.2.4 The phase angle between the supply current and the supply voltage (2)

1.3

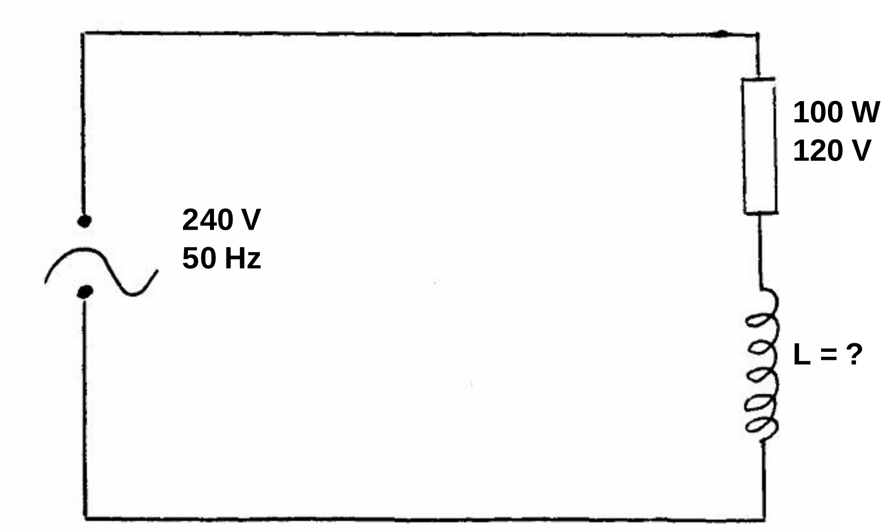

Figure 1

1.3.1 Calculate

(a) the current that is drawn from the supply. (3)

(b) the voltage drop across the inductor. (3)

(c) the value of the inductor in millihenrys. (4)

1.3.2 Draw a voltage phasor diagram of the circuit. (3)

1.4 A coil with a resistance of 10 ohms and an inductance of 50 millihenrys is connected in parallel with a capacitor of 200 microfarads across a supply voltage represented by the equation below.

$V = 100 \sin (628\,t + \frac{85}{180}$ volt)

Calculate

1.4.1 the resonant frequency of the circuit. (3)

1.4.2 the dynamic impedance of the circuit. (3)

1.4.3 the value of the circulating current. (3)
[50]

QUESTION 2
SINGLE-AND THREE-PHASE ALTERNATING-CURRENT SYSTEMS

2.1 In a balanced star-connected three-phase system the line voltage is $\sqrt{3}$ x phase voltage.

Use a phasor diagram to prove the theorem. Show all the calculations. (8)

2.2 The meter readings on an inductor single-phase unit show 250 V - 50 Hz respectively. The current that is been drawn is 4 A and the power is 0,75 kW.

2.2.1 Calculate the kVA capacity of the system. (3)

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

2.2.3 Show by means of a phasor diagram, using an appropriate scale, how the power factor can be improved to 0,9. (4)

2.2.4 Determine the following by using measurements from the phasor diagram:

(a) The active current components of the original and new power factor respectively (4)

(b) The reactive current components of the original and new power factor respectively (4)

(c) The current through the capacitor (2)

(d) The new ammeter reading (2)

2.3 Name THREE advantages of a three-phase alternating-current system over a single-phase alternating-current system. (3)

2.4 Briefly describe the meaning of **power factor improvement**. (3)
[36]

QUESTION 3
TRANSFORMERS

3.1 A delta-connected, three-phase-alternator with a phase voltage of 3,3 kV is connected to three identical single-phase transformers each having a turns ratio of 17 :1. The transformers are connected in star-delta.

Calculate

3.1.1 the secondary line voltage. (8)

3.1.2 the secondary phase current when the combined transformer delivers 30 kW to a load having a power factor of 0,7 if the efficiency of the transformer is 0,98. (6)

3.2 Sketch a circuit diagram of a voltmeter connected in a circuit using an instrument transformer. (3)

3.3 Describe in detail why the secondary windings of a current transformer may never be left open-circuited. (5)

3.4 Name and describe the major disadvantages of an auto-transformer. (3)

3.5 Sketch a labelled circuit diagram of an auto-transformer. (6)

[31]

QUESTION 4
ALTERNATING-CURRENT MOTORS

4.1 Describe, by using current-wave curves and simple sketches, how a rotating magnetic field is obtained in a three-phase induction motor. (9)

4.2 A four-pole squirrel-cage induction motor is connected to a 380 V alternating current supply with a periodic time of 0,02 seconds. The motor slip is calculated to be 0,05.

Calculate the following:

4.2.1 The supply frequency (3)

4.2.2 The rotor speed (6)

4.3 Explain by using a sketch of a capacitor-start motor how the direction of rotation can be changed. Also explain how this has been done. (7)

4.4 Briefly describe TWO methods which can be used in starters to limit the starting current of three-phase squirrel-cage motors. (4)

4.5 Name the TWO safety mechanisms in a motor starter and describe the operation of each one briefly. (6)

[35]

QUESTION 5
SEMICONDUCTORS

5.1 Study **Figure 2** and answer the questions that follow.

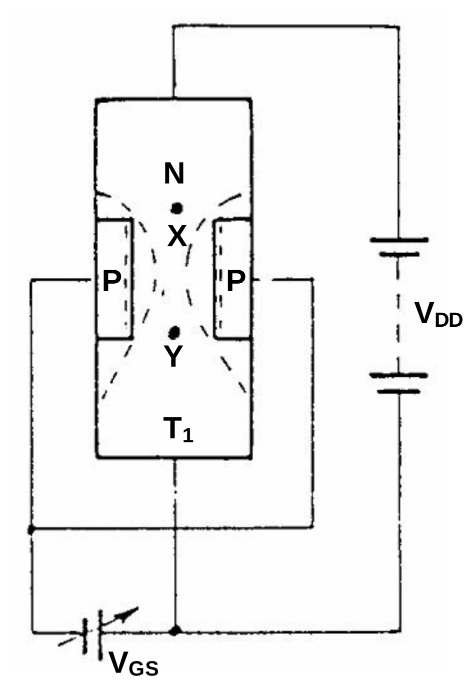

Figure 2

5.1.1 Identify the above circuit. (2)

5.1.2 Identify **T_1**. (2)

5.1.3 What is the function of areas **X** and **Y**? (2)

5.1.4 Is the gate voltage in this transistor forward or reverse-biased and what is controlled by this voltage? (2)

5.2 Draw the symbol of the following semiconductors and identify the terminals.

5.2.1 Triac (2)

5.2.2 Diac (2)

5.2.3 SCR (2)

5.2.4 Transistor (2)

5.3 Show by means of a circuit diagram using two transistors the working of an SCR. (3)
[19]

QUESTION 6
AMPLIFIERS

6.1 Sketch neatly labelled frequency response curves to compare an RC-coupled amplifier with a mutually coupled amplifier (transformer coupled). (6)

6.2 The power obtained from an amplifier is 100 mW at a frequency of 10 kHz. When the frequency is increased to 20 kHz, the power decreases to 50 mW. Calculate the power loss in decibels. (4)

6.3 A common-emitter-amplifier is connected to a 4 kO load resistor and a 12 V-supply.

6.3.1 Calculate the co-ordinates of the load line of the amplifier. (4)

6.3.2 Sketch typical in- and output characteristics of an amplifier on the same axis as the loadline. The amplifier is an A-class amplifier with a sine wave input. (6)

6.4

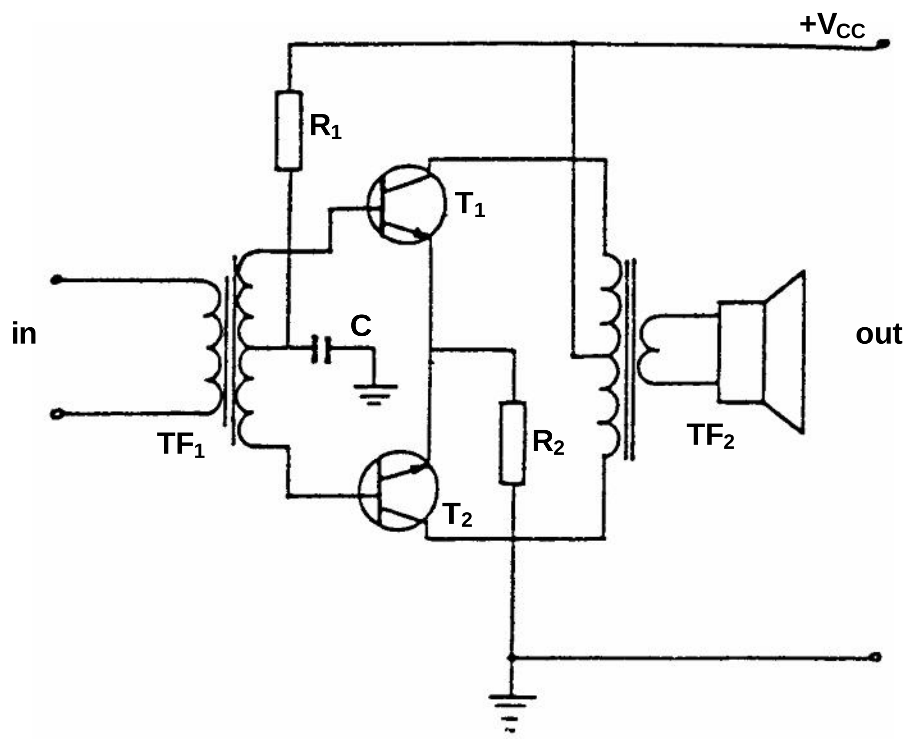

Figure 3

6.4.1 Identify the circuit illustrated in **Figure 3**. (2)

6.4.2 Where is this type of amplifier commonly used? (2)

6.4.3 What is the function of TF_1? (2)

6.4.4 What is the function of TF_2? (2)

[28]

QUESTION 7
SWITCHING AND CONTROL CIRCUITS

7.1

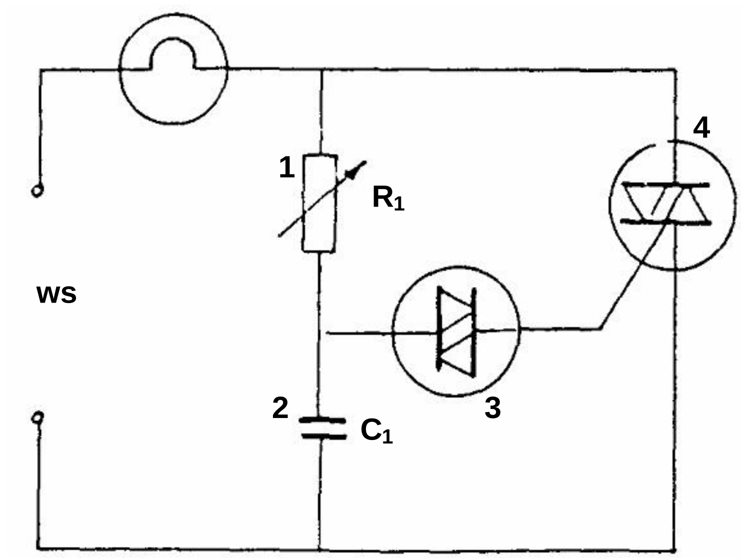

Figure 4

7.1.1 Identify the circuit in **Figure 4**. (2)

7.1.2 Give the name and function of each of the components marked **1** to **4**. (8)

7.2 Draw a circuit diagram of a series regulator that can be used to keep the output voltage of a power supply constant. (8)

7.3 Draw a circuit diagram to show how a transistor can be used to switch a light on and off. (4)

[22]

QUESTION 8
OSCILLATORS

8.1

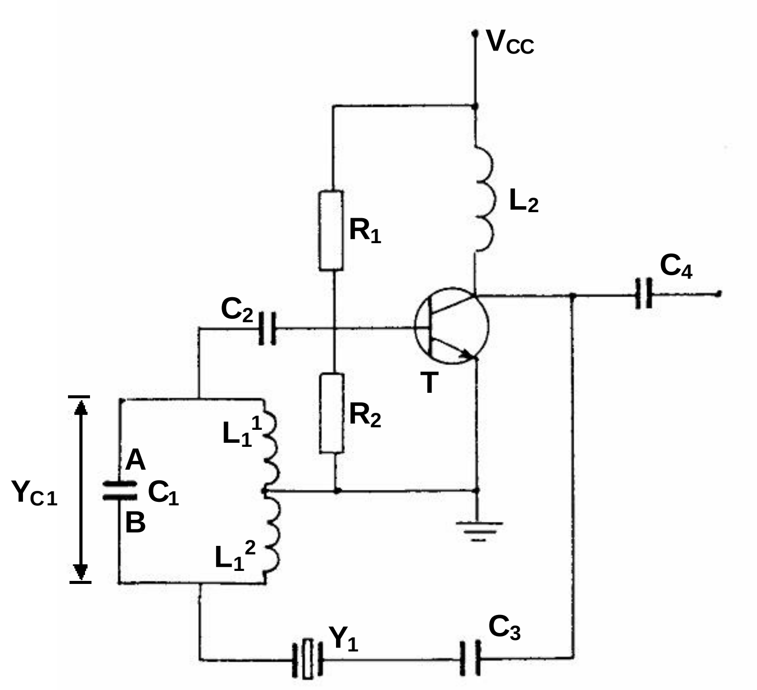

Figure 5

8.1.1 Identify the circuit in **Figure 5**. (2)

8.1.2 Give the name and function of each of the following components in **Figure 5**:

(a) L_2 (2)

(b) C_3 (2)

(c) C_2 (2)

(d) L_1 with C_1 (2)

(e) R_1 and R_2 (2)

[12]

QUESTION 9
OPERATIONAL AMPLIFIERS

9.1 Show, with the aid of a diagram, how an operational amplifier can be connected to operate as a bistable multivibrator. (5)

9.2 Give the output curves of the diagram in Question 9.1. (2)

9.3 Name the characteristics of an ideal operational amplifier. (3)

[10]

QUESTION 10
COMPUTER PRINCIPLES

10.1 Design a logic circuit by using two 2-input NOR-gates and 2 input AND-gates to switch OFF the electrical supply to a lift under the following circumstances:

- When the lift (H) is too heavy (H = 1) and the door is open (D = 1)

ALSO WHEN (OR)

- When the lift moves (B = 1) and the door is open (D = 1)

10.1.1 Sketch the logic circuit. (6)

10.1.2 Draw the truth table. (4)

10.1.3 Give the Boolean equation for this circuit. (2)

10.2 Draw the logic circuit of a clocked RS latch consisting of NAND-gates. (4)

10.3 Draw a logic circuit for a half-adder by using only TWO logic gates. (4)

10.4 Give the symbols and truth tables for the following logic gates:

10.4.1 NAND-gate

10.4.2 Exclusive OR-gate (4)

[24]

QUESTION 11
MEASURING INSTRUMENTS

11.1 Complete the open spaces in the following block diagram of the digital capacitance meter. Write the letters **A** to **E** in your answer book and the appropriate label next to each.

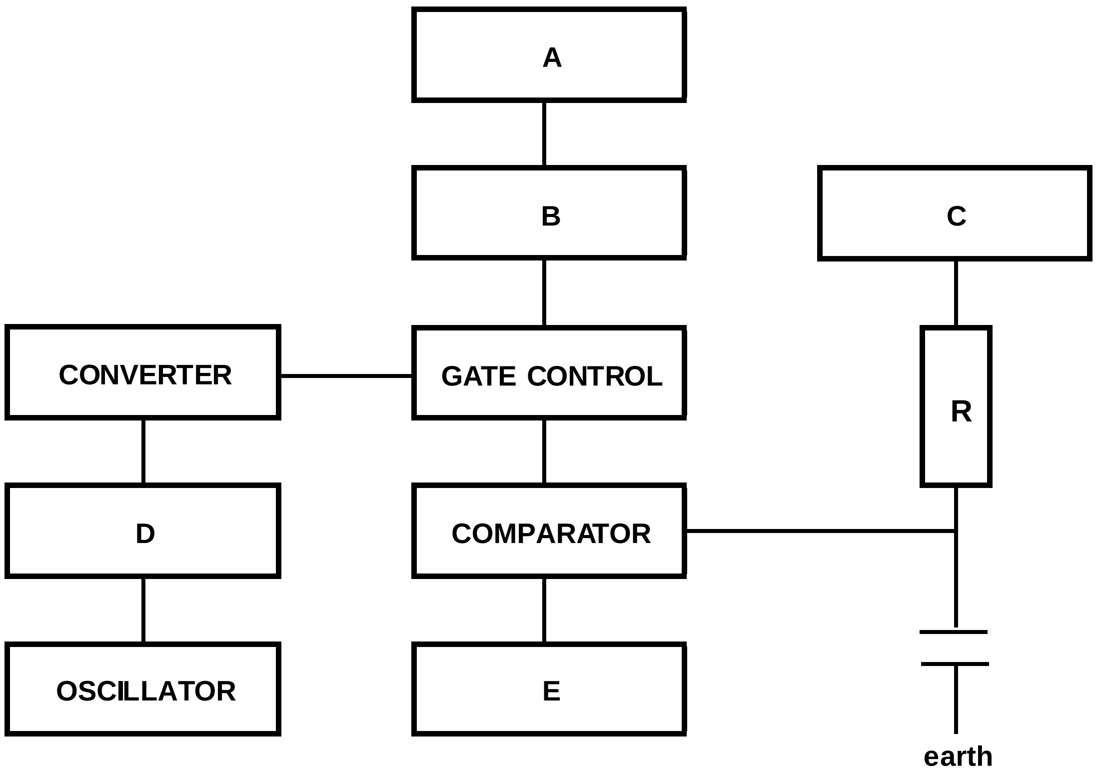

Figure 6 (5)

11.2 Study the circuit below and answer the questions that follow:

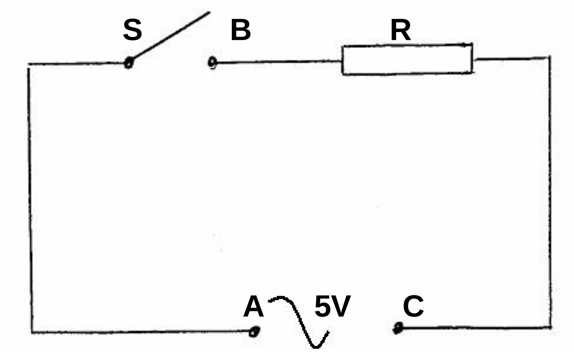

Figure 7

11.2.1 What is the voltage between **A** and **B** when **S** is open? (2)

11.2.2 What is the voltage between **B** and **C** when **S** is closed? (2)

11.2.3 What is the voltage between **A** and **C** when **S** is open? (2)

11.2.4 What is the voltage between **A** and **B** when **S** is closed? (2)
[13]

QUESTION 12
OCCUPATIONAL SAFETY

12.1 A register must be kept by the person who is responsible for safety in the workplace. Name FIVE things that he must look out for and report. (5)

12.2 Name FOUR safety precautions to prevent HIV. (4)

12.3 What is the name of the illness you can develop after you have been infected with the HI-virus? (1)
[10]

QUESTION 13
PRACTICAL

13.1 Design a battery charger using the following components:

- Transformer
- Main switch
- Fuse
- Diode bridge
- Filter capacitor

NOTE: (Not a block diagram but a circuit diagram) **[10]**

TOTAL: 300

FORMULES / FORMULAE

$X_L = 2\pi LF$

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

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

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

$F_R = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$

$I_C = V . \sqrt{\frac{C}{L}}$

$f = \frac{W}{2\pi}$

$t = R.C$

$V_R = IR$

$V_L = I.X_L$

$V_C = I.X_C$

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

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

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

$I = \frac{V}{Z}$

$Z = \frac{L}{C.R}$

$Z = \frac{V}{I}$

$P = I \times V \times \cos\theta$

$Iwgk = Imax \times 0{,}707$

$Q = \cos^{-1}\frac{VR}{VT}$

$P = I \times V$

$Vt^2 = V_R^2 + V_L^2$

$kVA = I \times V$

$Ns = \frac{f}{p}$

Ster/Star

$V_L = V_P . \sqrt{3}$

$I_L = I_P$

Delta

$I_L = I_P . \sqrt{3}$

$V_L = V_P$

$Ir = I \sin\theta$

$Ia = I \cos\theta$

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

$\cos\theta = \frac{P}{P_{Skynbaar/Apparent}}$

$\frac{N_P}{N_S} = \frac{V_P}{V_S} = \frac{I_S}{I_P}$

$N_r = N_s - S$

$\text{Rendement/Efficiency} = \frac{\text{Uitset/Output}}{\text{Inset/Input}}$

$S = \frac{N_s - N_r}{N_s}$

$Ns = \frac{f}{P}$

$\frac{N_P}{N_S} = \sqrt{\frac{Z_P}{Z_S}}$

$\beta = \frac{I_C}{I_B}$

$I_E = I_B + I_C$

$I = \frac{Vcc}{R_L}$

$N = 10 \log \frac{P_2}{P_1}$

END / *EINDE*