GAUTENG DEPARTMENT OF EDUCATION

SENIOR CERTIFICATE EXAMINATION

FEB / MAR 2006

TECHNIKA (ELECTRICAL) HG

TIME: 3 hours

MARKS: 300

REQUIREMENTS:

- Drawing instruments and an approved calculator

INSTRUCTIONS:

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

QUESTION 1
ELECTRICAL CURRENT THEORY

1.1 Name ONE method of improving a low inductive power factor. (2)

1.2 Explain what is meant by **resonant frequency** by referring to series circuits. (3)

1.3 Define the following terms regarding alternating voltage:

1.3.1 Frequency (2)

1.3.2 Period (2)

1.4 What determines the value of the current in a resonant series circuit? (2)

1.5 A coil with a resistance of 10 ohms, an inductance of 200 millihenrys and a capacitor of 100 microfarads is connected in series to a 250 V 50 Hz supply.

Calculate the following:

1.5.1 Impedance of the circuit (9)

1.5.2 Power factor of the circuit (2)

1.5.3 Reactive component of the current (7)

1.6 The resistance component of a parallel resonant R, L and C circuit is 5 ohms. The circuit resonates at a frequency of 550 kHz if the capacitor is set at a capacitance of 500 pico-farads.

Calculate the following:

1.6.1 The Q factor of the circuit (5)

1.6.2 The current circulating between the coil and the capacitor if the supply current to the circuit is 50 micro-amperes. (4)

1.7 When a certain coil is connected to a 50 volt direct current supply, a current of 5 amperes is drawn and when the same coil is connected over a 140 volt - 60 Hz alternating current supply it draws a current of 7 amperes.

Calculate the following:

1.7.1 The value of the resistance of the coil (3)

1.7.2 The inductance of the coil (9)

[50]

QUESTION 2
SINGLE AND THREE-PHASE ALTERNATING-CURRENT SYSTEMS

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

2.2 Explain what is meant by **apparent power**. (2)

2.3 Why is electricity, distributed by means of transmission lines at high voltage for example, 80 kilovolts? (2)

2.4 In a certain balanced, star-connected three-phase circuit with an inductive load, the line-to-line voltmeter reading is 380 volts, the ammeter reading 10 amps and the wattmeter reading 3 kilowatt.

Calculate the following:

2.4.1 The phase voltage (3)

2.4.2 The phase current (3)

2.4.3 The power factor of the load (3)

2.4.4 The phase impedance (3)

2.4.5 The phase resistance (3)

2.5 A single-phase installation is connected to a 500 V 50 Hz supply. The current in the circuit is 100 amperes and the power factor is 0,7 lagging.

Calculate the

2.5.1 active component of the current. (3)

2.5.2 apparent power. (3)

2.5.3 reactive component of power. (4)

2.5.4 active component of power. (3)
[35]

QUESTION 3
TRANSFORMERS

3.1 Fully explain why the secondary windings of a current transformer may never be left open-circuited. (6)

3.2 Which TWO methods are generally used to cool transformers? (2)

3.3 Name ONE advantage of an auto transformer over that of a double-wound transformer. (2)

3.4 A star-connected three-phase alternator with a phase voltage of 6,6 kV is connected to a three-phase delta star transformer with a turns ratio of 50:1.

Calculate the

3.4.1 line voltage of the alternator. (3)

3.4.2 primary line voltage of the transformer. (3)

3.4.3 primary phase voltage of the transformer. (3)

3.4.4 secondary phase voltage of the transformer. (3)

3.4.5 secondary line voltage of the transformer. (3)
[25]

QUESTION 4
ALTERNATING CURRENT MOTORS

4.1 Name THREE factors that influence the speed of a squirrel-cage motor. (3)

4.2 Briefly describe TWO methods that are used in starters to limit the starting current of three-phase squirrel-cage motors. (4)

4.3 Describe fully the consequences of not including a NO-volt coil in a motor starter. (3)

4.4 Name the correct phase sequence for three-phase systems. (2)

4.5 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 4%.

Calculate the

4.5.1 supply frequency. (2)

4.5.2 rotor speed. (4)

4.6 A single-phase motor draws a current of 15 amperes with a power factor of 0,85 from a 380 volt supply.

Calculate the

4.6.1 power of the motor. (3)

4.6.2 active component of the current. (3)

4.6.3 reactive component of the current. (4)

[28]

QUESTION 5
SEMICONDUCTORS

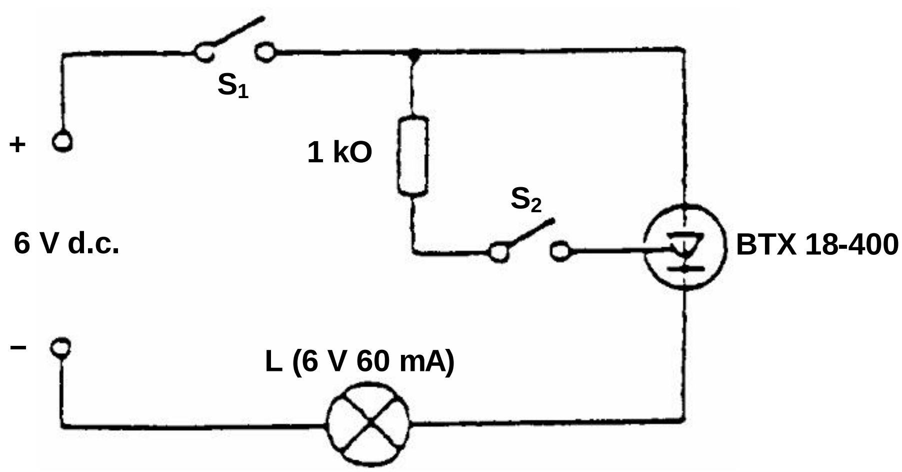

Figure 1

5.1 From the above circuit diagram explain, with reasons, what happens to the lamp when the following switching sequence takes place:

5.1.1 S_1 is closed, S_2 remains open, then (3)

5.1.2 S_1 remains closed and S_2 is closed, then (3)

5.1.3 S_1 remains closed and S_2 is opened. (3)

5.2 Draw the symbol and label the following electronic components:

5.2.1 PNP-Transistor (2)

5.2.2 Triac (2)

5.3 Under which basic conditions can an PNP-transistor be switched on? Draw a diagram to prove your answer. (4)

5.4 Name TWO important forward-biased conditions for an SCR to function adequately. (4)

5.5 What is the difference between a **triac** and an **SCR**? (2)
[23]

QUESTION 6
AMPLIFIERS

6.1 Study the following circuit and answer the questions that follow.

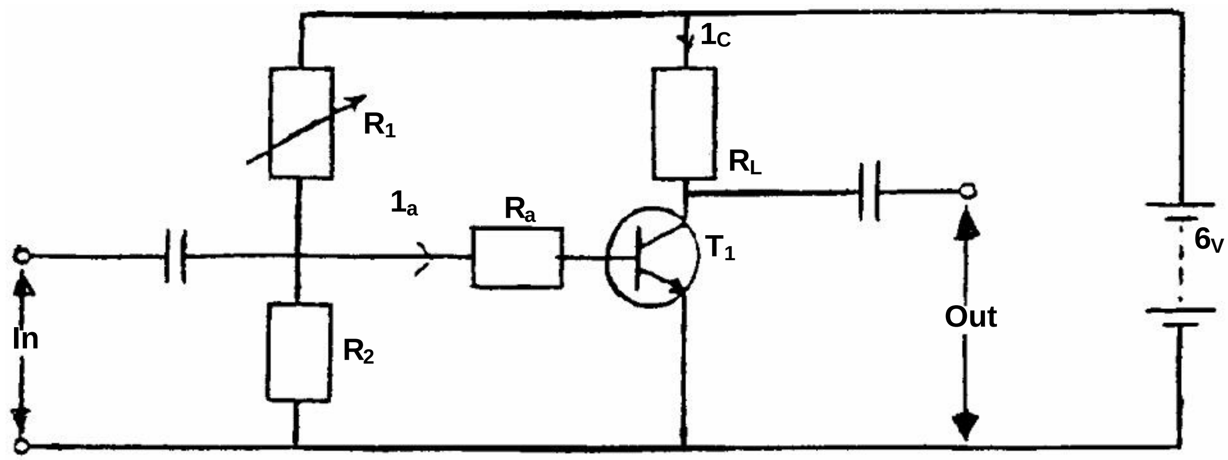

Figure 2

6.1.1 What is the voltage across

(a) RL and (2)

(b) T_1 when the transistor is off? (2)

6.1.2 (a) RL and (2)

(b) T_1 when the transistor is switched on fully? (2)

6.2 Name ONE advantage of negative feedback as applied to amplifiers. (2)

6.3 Sketch labelled frequency characteristic curves of a mutually coupled amplifier and a RC coupled amplifier in order to make a comparison between the two. (4)

6.4 Draw a diagram of a Darlington-pair amplifier with two NPN transistors. (4)

[18]

QUESTION 7
SWITCHING AND CONTROL CIRCUITS

7.1 Explain the term **regulated power supply**. (2)

7.2 With the aid of a diagram, explain the operation of a transistor series regulator when the input voltage shows a sudden increase. (10)

7.3 Explain, with the aid of a circuit diagram, how lamp dimming can be obtained in an AC circuit through the use of a triac. (6)
[18]

QUESTION 8
OSCILLATORS

8.1 What is the function of the crystal in the crystal-controlled Hartley oscillator circuit? (2)

8.2 What is **piëzo-electricity**? (2)

8.3

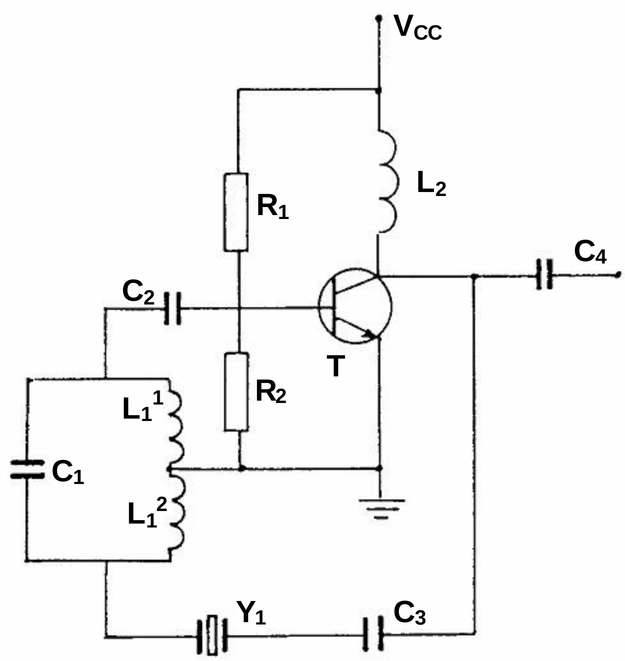

Figure 3

8.3.1 Identify the above circuit. (2)

8.3.2 Describe the function of R_1 and R_2 in the circuit. (4)

8.3.3 Identify the components which form the tank circuit. (2)

8.3.4 Identify Y_1. (2)

8.3.5 Describe how the value of Y_1 is selected. (2)
[16]

QUESTION 9
OPERATIONAL AMPLIFIERS

9.1 Sketch a diagram of a comparator circuit using an operational amplifier. Sketch typical output wave forms if the input is sinusoidal. (6)

9.2 Show, with the aid of a diagram, how an operational amplifier can be connected to operate as an a-stable multivibrator. (6)

[12]

QUESTION 10
COMPUTER PRINCIPLES

10.1 Prove with the aid of truth tables that

$$A + B = A . B$$ (6)

10.2 Simplify the following Boolean equation:

X = (A . B . C) + (A . B) (5)

10.3 Sketch a block diagram of a full adder by using two half adders and an OR gate. Give the Boolean equation after each component. (8)

10.4 Draw a logic circuit of a clocked RS latch using NAND gates. (7)

10.5 The Technika (Electrical) educator is asked to design a lock for the school's pedestrian gate. This gate must only open under the following conditions:

- It must be daylight (morning) A = 1
- <u>and</u> at least ONE of the following people must be present:

B = 1 The headmaster of the school
C = 1 The deputy headmaster
D = 1 One of the heads of department

10.5.1 Draw a truth table to show all the possibilities. (6)

10.5.2 Give the Boolean equation from the truth table that will allow access to the school. (3)

10.5.3 Draw the logic circuit of this system. (5)

[40]

QUESTION 11
MEASURING INSTRUMENTS

11.1 Label the following block diagram of a capacitance measuring instrument. Write the letters **A** to **E** in your answer book and the appropriate label next to each.

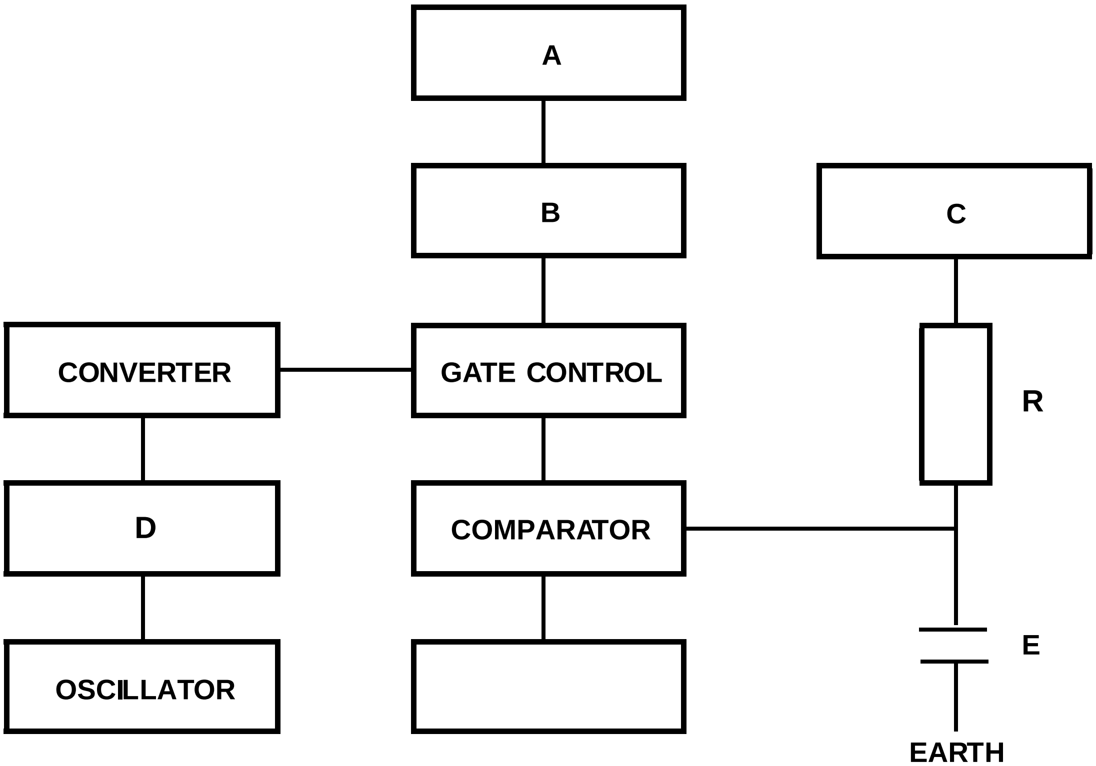

Figure 4 (5)

11.2 Draw a labelled circuit diagram to show how one wattmeter can be connected to measure the power in a balanced, star-connected load. (6)

11.3 Name TWO uses of an ossilloscope. (2)
[13]

QUESTION 12
OCCUPATIONAL SAFETY

12.1 Who is responsible for the prevention of occupational accidents? (2)

12.2 Your friend's hand is cut in the work centre. Describe what you will do to stop the bleeding, keeping the HI-virus in mind. (6)

[8]

QUESTION 13
PRACTICAL

13.1 Design a power supply that transforms 220 V alternating current to a stable 12 V direct current so that it can be used as a battery charger. Sketch the circuit diagram and show the following components. (N.B. Not a block diagram)

- Transformer
- Main switch
- Fuse
- Diode Bridge
- Filter Capacitor
- Zener diode (10)

13.2 Show, by means of a sketch, how a diode can be tested with a multimeter. (4)

[14]

TOTAL: 300

FORMULES / FORMULAE

$X_L = 2\pi LF$

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

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

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

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

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

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

$t = R.C$

$V_R = IR$

$V_L = I.X_L$

$V_C = I.X_C$

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

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

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

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

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

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

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

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

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

$P = I \times V$

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

$kVA = I \times V$

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

Ster/Star

$V_L = V_P . \sqrt{3}$

$I_L = I_P$

Delta

$I_L = I_P . \sqrt{3}$

$V_L = V_P$

$Ir = I \sin\Theta$

$Ia = I \cos\Theta$

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

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

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

$N_r = N_s - S$

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

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

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

$I_E = I_B + I_C$

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

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

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

$N = 10 \text{ Log } \frac{P_2}{P_1}$

END