THE KENYA POLYTECHNIC UNIVERSITY

COLLEGE

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

HIGHER DIPLOMA IN ELECTRICAL ENGINEERING

END OF YEAR II EXAMINATIONS

NOVEMBER 2007

POWER SYSTEMS

3 HOURS

INSTRUCTIONS TO CANDIDATES:

You should have the following for this examination:

Answer booklet

Non-programmable calculator/ New Mathematical tables

Answer any FIVE of the following EIGHT questions.

All questions carry equal marks and the maximum marks for each part of a question are as shown.

This paper consists of **5** printed pages.

1. (a) Derive form first principles the sending-end voltage and current for a long transmission line. (13 marks)

   (b) A long transmission line delivers a load of 60MVA at 154kV 50Hz at 0.8p.f lagging. If the line constants have been evaluated to be:

   A = D = $0.986\angle 0.32^0$

   B = $70.3\angle 69.2^0$

   C = $4.44\times 10^{-4}\angle 90^0$

   Determine the:

   (i) Sending-end voltage and current

   (ii) Power factor at the sending end. (7 marks)

2. (a) With the aid of a circuit and phasor diagrams, explain the construction and operation of "the induction type directional over current relay". (10 marks)

   (b) (i) Draw the schematic arrangement for differential protection of a 3-phase alternator windings.

   (ii) A star-connected 3-phase, 12MVA, 6.6kV alternator has a per phase reactance of 15%. It is protected by the current differential protection method which is set to operate for fault currents not less than 200A. Calculate the value of earthing resistance to be provided in order to ensure that only 10% of the alternator winding remains unprotected. (10 marks)

3. (a) (i) Describe the main design feature incorporated into rotating exciters in order to secure a high rate of response. (5 marks)

   (ii) With the aid of a diagram, explain the operation of the indirect-acting rheostat excitation system. (8 marks)

   (b) An 11kV 3-phase, star-connected alternator delivers 200A at unity power factor. Determine the armature current and p.f at which the machine works when the excitation is raised by 20%, the power input remaining

unchanged. (Assume the efficiency is constant and the armature resistance is 0.5Ω/phase and the synchronous reactance is 6Ω/phase.) (7 marks)

4. (a) Describe the phenomenon of Arc extinction in HV circuit breakers. (6 marks)

   (b) With the aid of diagrams, explain the operation of the Arc control oil circuit breaker, stating the distinction between self blast and forced blast breakers. (6 marks)

   (c) A 50Hz, 11kV, 3-phase generator with earthed neutral has a reactance of 4Ω/phase and is connected to a bus-bar through a circuit breaker. The distributed capacitance up to the circuit breaker between phase and neutral is 0.01μF. Determine the:

   (i) Peak restricting voltage across the contacts of the breaker.

   (ii) Frequency of oscillations

   (iii) Average rate of rise of re-striking voltage up to the first peak. (8 marks)

5. (a) Explain any SIX conditions that may give rise to transients in transmission lines. (6 marks)

   (b) Derive the expression for surge characteristic impedance of a transmission line. (3 marks)

   (c) (i) Show that maximum power transfer occurs when the line is terminated with a load that is equal to the characteristic impedance.

   (ii) A surge of 100kV is initiated in a line with inductance of 14.4mH and capacitance of 0.04μF/m. The line is connected to two other lines at a junction. The inductance and capacitance of the two lines are 4.8mH and 0.12μF and 38.4mH and 0.06μF respectively. Find the surge voltage, current and power transmitted into each of the branch lines at the junction. (8 marks)

6. (a) With the aid of a circuit diagram and phasor diagrams, describe the Schering bridge method of determining cable loss angle. (14 marks)

(b) A 19.1kV, 50Hz single core lead sheathed paper insulated cable is 1.61km. The conductor diameter is 2cm while the internal diameter of the lead sheath is 5cm. The insulation used is uniform throughout and has a resistivity of 1.4×10^8MΩ-cm and relative permittivity of 3.5. The long angle at the rated voltage and frequency is 0.0017 radians. Calculate the:

(i) Insulation resistance

(ii) Capacitance

(iii) Power loss due to leakage current flowing through the insulation resistance.

(iv) Total dielectric loss

(v) Dielectric hysteresis loss

(vi) Maximum dielectric stress occurring in the dielectric. (6 marks)

7. (a) Describe the operation of the following as a means of protecting overhead lines against over voltages:

(i) The horn gap (ii) The Peterson coil (10 marks)

(b) A 3-phase, 110kV, 50Hz delivers 150MVA at 0.9p.f lagging. The line has total resistance of 40Ω, capacitance of 1.36μF and inductance of 0.217H per phase. Calculate the:

(i) Sending end voltage, current and power factor

(ii) The efficiency of transmission.

Neglect leakage and use nominal $\pi-$method. (10 marks)

8. (a) Describe any TWO disadvantages of series connected generator reactors. (6 marks)

(b) (i) Describe the corona phenomenon and explain how it occurs.

(ii) Explain any THREE methods that can be employed to reduce corona losses. (6 marks)

(c) A generating station has two alternators of 300kVA and 4500kVA and percentage reactances of 7% and 8% respectively. The circuit breakers have a rupturing capacity of 150MVA. It is desired to expand the system

by a supply from the grid via a transformer of 7500kVA and 7.5% reactance. Determine the reactance of the reactor to be added in the bus-bar section to prevent the circuit breaker being overloaded if a symmetrical short circuit occurs on an outgoing feeder. The bus-bar voltage is 6600v.