TECHNICAL UNIVERSITY OF MOMBASA

Faculty of Engineering and Technology

DEPARTMENT OF ELECTRICAL & ELECTRONIC ENGINEERING

UNIVERSITY **SUPPLEMENTARY/SPECIAL** EXAMINATIONS FOR THE DEGREE OF BACHELOR OF SCIENCE IN ELECTRICAL & ELECTRONIC ENGINEERING

EEE 2510: POWER SYSTEM PROTECTION

TIME: 2 HOURS SERIES: SEPTEMBER, 2018

INSTRUCTIONS TO CANDIDATES

1. You are required to have the following for this examination;
   - Answer Booklet
   - A Non- Programmable Scientific Calculator

2. This paper consists of **FIVE** Questions.
3. Answer Question **ONE** (**COMPULSORY)** and any other **TWO** Questions
4. This paper consists of **FIVE** printed pages.

QUESTION ONE [20 MARKS]

(a) Explain any FOUR desirable features of busbar protection

(4 marks)

(b) Using the torque equation derive the following characteristics and draw for EACH relay its characteristic and indicate clearly the zones of operation and no operation.

(i) Impedance relay
(ii) Reactance relay
(iii) Mho relay

(12 marks)

(c) Draw the "Merz Price circulating current protection scheme" for the protection of alternator against stator faults (phase- to – phase and phase – to – ground) and explain the operation.

(8 marks)

(d) Explain why 100% winding of alternator cannot be protected using the method with earthing resistance to limit the fault current.

(6 marks)

QUESTION TWO [20 MARKS]

(a) (i) With the aid of a diagram explain a biased differential protection scheme applied to a three phase transformer

(ii) Tabulate the different types of CT connections used for different types of transformer primary and secondary winding connections.

(12 marks)

(b) With the aid of a block diagram describe the carrier system of protection.

(8 marks)

(c) A three phase transformer having a line voltage ratio of 400V/33,000V is connected in star-delta. The CTs on the 400V side have a current ratio of 1000/5. Determine the ratio of CTs on the 33,000V side. **(4 marks)**

QUESTION THREE [20 MARKS]

(a) With the aid of sketches(s) and relevant equations, Explain the problems associated with interruption in circuit breakers resulting from the following;

(i) Rate of Rise of Re-striking Voltage (RRRV).
(ii) Current Chopping
(iii) Capacitive current Breaking.

(9 marks)

(b) Explain FOUR ways used for arc extinction while using High resistance methods

(4 marks)

(c) A 50Hz, 11kv, three–phase alternator with earthed neutral has a reactance of 5Ω per phase, and is connected to busbar through a circuit breaker. The capacitance to earth between the alternator and the circuit breaker is 0.02μF per phase. Assuming the

resistances of the generator to be negligible. Determine the following;

(i) Maximum voltage across the contacts of the circuit breaker
(ii) Frequency of oscillations.
(iii) The average rate of rise of Restriking voltage up to the first peak

(7 marks)

QUESTION FOUR [20 MARKS]

a) Explain FOUR ways used for arc extinction while using High resistance methods **(4 marks)**

b) With the aid of a circuit, current and voltage waveform and a Laplace equivalent circuit derive Re-striking Voltage. **(10 marks)**

c) A circuit breaker interrupts a magnetizing current of 100MVA transformer at 220kV the magnetizing current of transformer is 5% of the full load current. Determine the maximum voltage that may appear across the gap of the breaker. When magnetizing current is interrupted at 53% of its peak value. The stray capacitance is 2500 micro farad. The inductance is 30H. **(6 marks)**

QUESTION FIVE [20 MARKS]

(a) With the aid of sketches(s)/block diagram describe two categories of faults in a synchronous generators, stating in EACH case how the fault can be mitigated.

(12 marks)

(b) A 3- phase 20MVA, 11KV star connected alternator has a synchronous reactance of 2.5Ω/phase and resistance of 0.75Ω/phase. It is being protected by a Merz-price balanced current system. Determine what portion of the winding remains unprotected and if the neutral of the alternator is earthed through a resistor 5Ω. Assume that the relay operates, when the out of balance current exceeds 25% of the load current.

(9 marks)