



MACHAKOS UNIVERSITY

University Examinations for 2021/2022

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

FIFTH YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (ELECTRICAL & ELECTRONICS ENGINEERING)

EEE 505: SWITCHGEAR AND PROTECTION

DATE: 10/12/2021

TIME: 2.00-4.00 PM

INSTRUCTIONS: This examination paper contains five questions. Answer **Question ONE** and any other **TWO Questions**. Question ONE carries 30 Marks and ALL the other questions carry 20 Marks each.

QUESTION ONE (COMPULSORY) (30 MARKS)

- a) Explain two different types of distance type relays as used in protection. (3 marks)
- b) List and explain four inherent problems encountered in differential protection scheme. (3 marks)
- c) Define the following terms as used in relays. (4 marks)
 - i) Pick up current
 - ii) Current setting
 - iii) Plug-setting multiplier
 - iv) Time setting multiplier
- d) What are some of the advantages of a fuse. (3 marks)
- e) List four desirable characteristics of a fuse. (3 marks)
- f) Define the following terms as used in the analysis of a fuse, (3 marks)
 - i) Current rating of fuse element
 - ii) Fusing current
 - iii) Fusing factor

- g) A 13.2kV, 3-phase, 100MW at 0.8pf lag alternator has a reactance of 0.2p.u. If it is equipped with a circulating current differential protection set to operate at least 500A fault current, determine the magnitude of the neutral grounding resistance that leaves the 10% of the winding unprotected. (10 marks)
- h) A 3-phase transformer having line-voltage ratio of 0.4kV/11kV is connected in star-delta and protective transformers on the 400V side have a current ratio of 500/5. What must be the ratio of the protective transformer on the 11kV side? (5 marks)

QUESTION TWO (20 MARKS)

- a) What are some of the important characteristics/ratings that must be possessed by every high voltage AC circuit breaker arc? (3 marks)
- b) A generator connected through a 5 cycle CB to a transformer is rated 8000kVA with the reactances of $X_d'' = 10\%$, $X_d' = 16\%$ and $X_d = 100\%$. it is operating at no load and rated voltage when 3-phase short circuit occurs between breaker and transformer. Find;
- Sustained short circuit in breaker, (1 mark)
 - The initial symmetrical rms current in breaker. (3 marks)
 - Maximum possible DC. component of short circuit in breaker. (1 mark)
 - The momentary current rating of the breaker. (1 mark)
 - Current to be interrupted by the breaker. (1 mark)
 - The interrupting kVA. (1 mark)
- c) In a short circuit test on a 3-pole, 132kV circuit breaker, the following observations are made p.f. of fault 0.4, recovery voltage 0.9 times full line value, the breaking current symmetrical, frequency of restriking voltage 16kHz. Assume neutral is ground and fault is not grounded. Determine average RRRV (10 marks)

QUESTION THREE (20 MARKS)

- a) Explain the principle of operation of the following types of relays (6 marks)
- Attracted armature type relay
 - Solenoid type relay
 - Balanced beam type relay
- b) A 50MVA, 3-phase, 33kV synchronous generator is protected by the Merz-Price protection using 1000/5 ratio CTs. It's provided with restricted earth fault protection with the earthing resistance of 7.5Ω . Calculate the percentage of winding unprotected in each phase against earth faults if the minimum operating current of relay is 0.5A.

(6 marks)

- c) A synchronous generator rated at 20kV protected by circulating current system having neutral grounded through a resistance of $15\ \Omega$. The differential protective relay is set to operate when there is an out of balance of 3A. the CTs have a ratio of 1000/5A. Determine: (8 marks)

- i) The % of winding remains unprotected
- ii) The value of earth resistant to achieve 75% protection of winding

QUESTION FOUR (20 MARKS)

- a) Show that the current carrying capacity of a fuse element is directly proportional to its diameter (3 marks)
- b) A fuse wire of circular cross section has a radius of 0.8mm. The wire blows off at a current of 8A. Calculate the radius of the wire that will blow off at a current of 1A. (3 marks)
- c) A three-phase transformer having line voltage ratio of 0.4kV/11kV is connected in star-delta and protective transformers on the 400V side have a current ratio of 500/5. What must be the ratio of the protective transformer on the 11kV side? (6 marks)
- d) A 10 MVA, 6.6 kV, 3-phase star-connected alternator is protected by Merz-Price circulating current system. If the ratio of the current transformers is 1000/5, the minimum operating current for the relay is 0.75 A and the neutral point earthing resistance is 6Ω , Calculate:
- i) The percentage of each of the stator windings which is unprotected against earth faults when the machine is operating at normal voltage (5 marks)
 - ii) The minimum resistance to provide protection for 90% of the stator winding (4 marks)

QUESTION FIVE (20 MARKS)

- a) The figure Q5(a) below shows a part of typical power system. If for the discrimination, the time grading margin between the relays is 0.6sec, calculate the time of operation of relay 1 and time setting multiplier for relay 2. The time current characteristics of relay is shown by fig Q5(ai) and the time setting multiplier of relay 1 is 0.3: (10 marks)

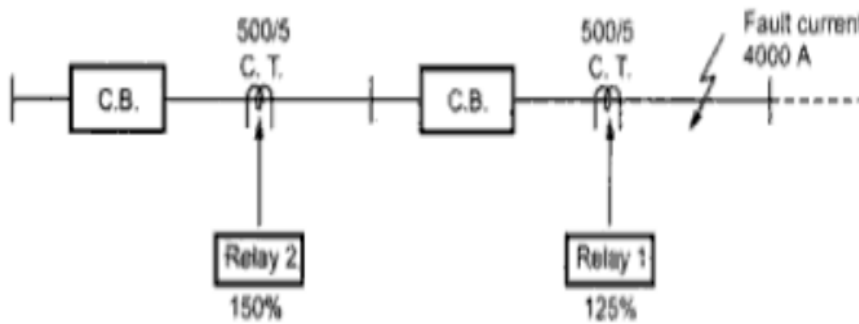


Fig Q5(a)

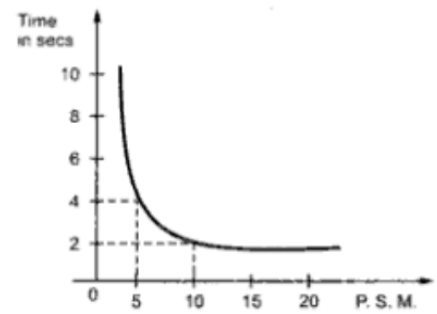


Fig Q5(ai)

- b) A star connected 3 phase, 12MVA, 11kV alternator has a phase reactance of 10%. It is protected by Merz-Price circulating current scheme which is set for a fault current not less than 200A. Calculate the value of earthing resistance to be provided in-order to ensure that only 15% of the alternator winding remains unprotected. (10 marks)