



MACHAKOS UNIVERSITY

University Examinations 2017/2018

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

FIFTH YEAR SECOND SEMESTER EXAMINATIONS FOR BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONIC ENGINEERING

EEE 505: SWITCHGEAR AND PROTECTION

DATE: 14/12/2017

TIME: 8.30-10.30 AM

INSTRUCTIONS

Answer Question One and Any Other Two Questions

QUESTION ONE (COMPULSORY) (30 MARKS)

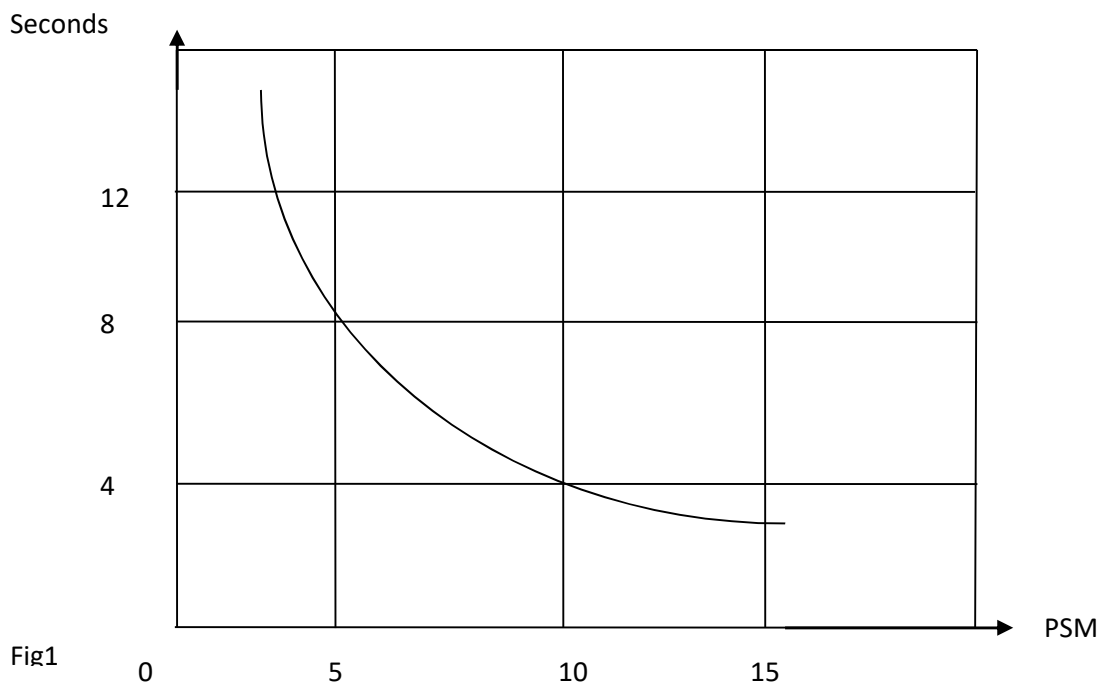
- a) State any two advantages of vacuum circuit breakers. (2 marks)
- b) Derive the expression of the restriking voltage across a circuit breaker. (8 marks)
- c) A 3-phase 40 MVA, 10KV star connected alternator is protected by Merz Price circulating current system. The star point is earthed through a resistance of 6 Ohms. If the current transformers have a ratio of 1000/10 and the relay is set to operate when there is an out of balance current of 2.0 ampere, calculate:
 - i. The percentage of each phase of the stator winding which is unprotected.
 - ii. The minimum value of earthing resistance to protect 90% of the winding.(10 marks)
- d) With aid of diagram differentiate between axial-blast, cross-blast and radial-blast types of circuit breakers. (6 marks)
- e) Describe distance protection scheme for the protection of feeders. (4 marks)

QUESTION TWO (20 MARKS)

- a) Explain the functional properties of SF₆ as an arc quenching medium. (2 marks)
- b) With aid of a labeled diagram describe the operation of graded time protection for four substations connected in radial and having a common generator. (8 marks)
- c) A 50Hz, 11 KV, three phase alternator with earthed neutral has a reactance of 5 ohms per phase and is connected to the bus bars through a circuit breaker. The capacitance to earth between the alternator and the circuit breaker is 0.02μF per phase. Assuming the resistance of the generator to be negligible, calculate:
- Frequency of oscillations
 - Maximum voltage across the contacts of the circuit breaker.
 - The average rate of rise of restriking voltage up to the first peak. (10 marks)

QUESTION THREE (20 MARKS)

- a) Mention any two areas to be checked during maintenance inspection of oil circuit breakers. (2 marks)
- b) With aid of labeled diagrams explain the following types of induction relays:
- Shaded pole
 - Wattmeter (4 marks)
- c) A 4 ampere 3 second over current relay having a current setting of 150% and a time multiplier of 0.8 is connected to a circuit through a 500/6 ampere current transformer. If a fault occurs and a current of 5000 amperes flows through the circuit, determine the operating time of the relay. Use curve shown in fig.1. (10 marks)



- d) With aid of diagram describe how parallel feeders are protected. (4 marks)

QUESTION FOUR (20 MARKS)

- a) With aid of diagrams describe the operation of the following relays:
- i. Balanced beam relay
 - ii. Circulating current relay (4 marks)
- b) Define the following terms as used in protection:
- i. Reliability
 - ii. Sensitivity
 - iii. Pick up current (6 marks)
- c) A three phase 33/11KV star-delta connected transformer is protected by Merz Price circulating current system. If the current transformers on the lower voltage side have a ratio of 600/10, determine the ratio of current transformers on the higher voltage side. (10 marks)

QUESTION FIVE (20 MARKS)

- a) With aid of a labeled diagram define the following terms with respect to the circuit breakers:
- i. Arc voltage
 - ii. Restriking voltage
 - iii. Recovery voltage (6 marks)
- b) With aid of a diagram describe the arc quenching mechanism when circuit breaker contacts opens in presence of oil as the arc quenching medium. (4 marks)
- c) A three phase 11KV alternator having a per unit X of 0.25 at 30MVA is connected to the primary of a three phase transformer having per unit X of 0.1 at 40 MVA. Calculate the primary current and short circuit MVA when a three phase symmetrical short circuit occurs on the secondary of the transformer:
- i. Using a 30 MVA base
 - ii. Using a 40 MVA base (10 marks)