MURANG'A UNIVERSITY OF TECHNOLOGY

SCHOOL OF ENGINEERING & TECHNOLOGY

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

UNIVERSITY POSTGRADUATE EXAMINATION

2018/2019 ACADEMIC YEAR

FIRST YEAR **SECOND** SEMESTER EXAMINATION FOR MASTER OF TECHNOLOGY

EET 623 – ADVANCED POWER SYSTEMS PROTECTION

DURATION: 3 HOURS

DATE: 14/5/19

TIME: 2-5 P.M.

Instructions to candidates:

1. Answer **Any Four** questions.
2. Mobile phones are not allowed in the examination room.
3. You are not allowed to write on this examination question paper.

QUESTION ONE

(a) An alternator rated at 10kv protected by the balanced circulating current system has its neutral grounded through a resistance of 10ohms. The protective relay is set to operate when there is an out-of-balance current of 1.8A in the pilot wires, which are connected to secondary windings of 1000/5 ratio current transformers. Determine the:

i. The percentage winding which remains unprotected. (4marks)

ii. The maximum value of the earthing resistance required to protect 80% of the winding. (4marks)

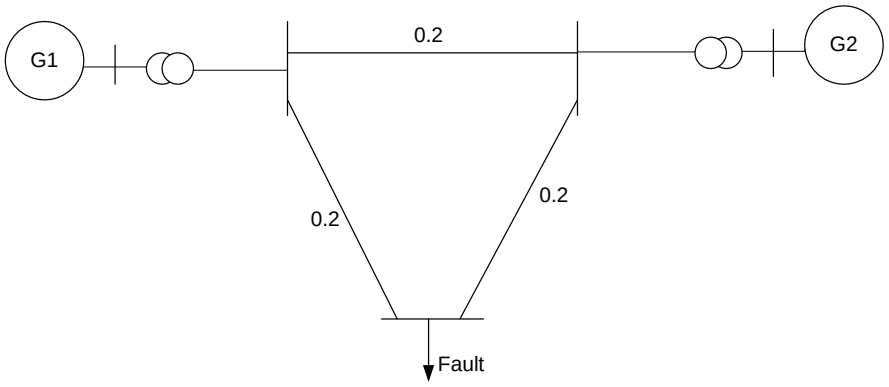
(b) The line-to-ground voltages on the high voltage side of a step- up transformer are 100kV, 33kV and 38kV on phase a, b and c respectively. The voltage of phase 'a' leads that of phase 'b' by 100^0 and lags that of phase 'c' by 176.5^0. Determine analytically the symmetrical components of voltage. (6marks)

(c) Show that for a simulation of a solidly grounded, unloaded alternator under line-to-ground fault, all the three sequence networks are required and must be connected in series. (10marks)

(d) A small generating station has a bus bar divided into three sections. Each section is connected to a tie-bar with reactors each rated at 5MVA and 0.1p.u reactance. A generator of 8MVA rating and 0.15p.u reactance is connected to each section of the busbar. Determine the short-circuit capacity of the breaker if a 3-phase fault takes place on one of the sections of the bus bar. (6marks)

QUESTION TWO

Figure Q2 shows a sample power system network:



a) Draw the thevenin passive network for this system (4marks)

b) Develop the Z_{bus} matrix. (8marks)

c) For a solid three phase fault current, V_{1f} and V_{2f} and fault current in line 1-2. (8marks)

QUESTION THREE

A 50MVA, 11kV, synchronous generator has sub-transient reactance of 20%. The generator supplies two motors over a transmission line with transformers at both ends as shown in fig Q3. The motors have rated inputs of 30 and 15MVA, both 10kV, with 25% sub-transient reactance. The three-phase transformers are both rated 60MVA, 10.8/121 kV, with leakage reactance of 10% each. Assume zero sequence reactance for the generator and motors of 6% each. Current limiting reactors of 2.5 ohms each are connected in the neutral of the generator and motor No 2.

The zero sequence reactance of the transmission line is 300 ohms. The series reactance of the line is 100 ohms. Draw the:

a) Positive sequence network. (8marks)
b) Negative sequence network. (6marks)
c) Zero sequence network. (6marks)

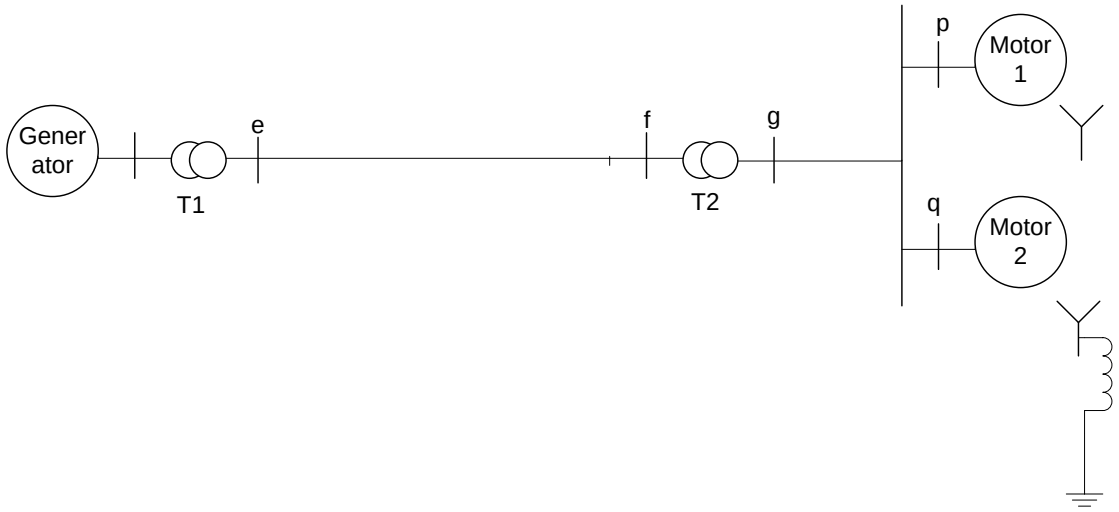


Fig Q3

QUESTION FOUR

A 30MVA, 13.2 kV synchronous generator has a solidly grounded neutral. The positive, negative and zero sequence impedances are 0.30, 0.40 and 0.05pu respectively. Determine the following:

a) The value of reactance that must be placed in the generator neutral so that the fault current for a line-to-ground fault of zero fault impedance shall not exceed the rated line current. (3marks)

b) The value of the resistance in the neutral that will serve the same purpose as in (a) above. (3marks)

c) The value of reactance that must be placed in the neutral of the generator to restrict the fault current to the ground to rated line current for a double line to ground fault. (6marks)

d) Determine the magnitude of the line currents when the ground current is restricted as in (c) above. (5marks)

e) As the reactance in the neutral is indefinitely increased, determine the values of limiting line currents. (3marks)

QUESTION FIVE

a) Explain the essential qualities of a protective system. (5marks)

b) Explain with the aid of sketches the four tripping characteristics of a relay. (6marks)

c) Considering the power system network shown in fig Q5,

i. Determine the direction of flow of power between bus 1 and bus 2. (3marks)

ii. Locate the position of load impedance onto the R-jX plane. (3marks)

iii. Calculate the maximum load ability of a distance relay with mho characteristics for zone3 (3marks)