

1. [28 Marks]

- (a) Draw a block diagram of power system and state the transmission and distribution voltages used in Eswatini. [5]
- (b) The objective of a smart grid is to provide reliable, high-quality electric power to digital societies in an environmentally friendly and sustainable manner.
 - i. Discuss four differences between the smart grid and the traditional grid. [4]
 - ii. Discuss two smart grid technologies in Eswatini? [4]
- (c) State any five major power system protection equipment. State the function of each equipment. [5]
- (d) Describe the operation of a lightning arrestor under normal and fault conditions. [5]
- (e) Explain
 - i. the skin effect [2]
 - ii. the corona effect and state two factors affecting it. [3]

2. [15 Marks]

Draw the per unit impedance diagram for the network shown in Figure Q2 below. Choose 100 MVA and 33 kV bases. [15]

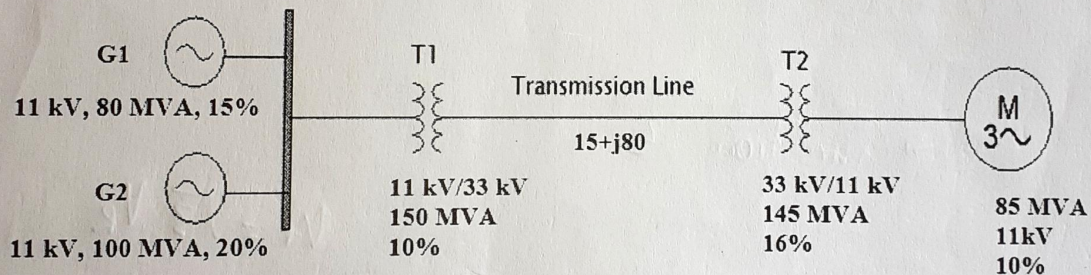


Figure Q2

3. [18 Marks]

A 3Φ 30 kVA, 415 V, four pole, 50 Hz, star connected synchronous machine has negligible stator winding resistance and a synchronous reactance of 1.5 Ohms per phase at the rated voltage.

- (a) Determine the speed of the rotor? [2]
- (b) Draw the per phase equivalent circuit of this generator. [3]
- (c) Determine the excitation voltage and angle when the machine is delivering 41A at 0.7 power factor lagging. [7]
- (d) Draw the phasor diagram of this condition. [6]

4. [17 Marks]

A 480-V, 200-kVA, 0.8-power-factor-lagging 60-Hz two-pole Y-connected synchronous generator has a synchronous reactance of 0.25Ω and an armature resistance of 0.03Ω . At 60 Hz, its friction and windage losses are 6 kW, and its core losses are 4 kW. The field circuit has a dc voltage of 200 V, and the maximum field current I_F is 10 A. The resistance of the field circuit is adjustable over the range from 20 to 200 Ω . The OCC of this generator is shown in Figure Q4.

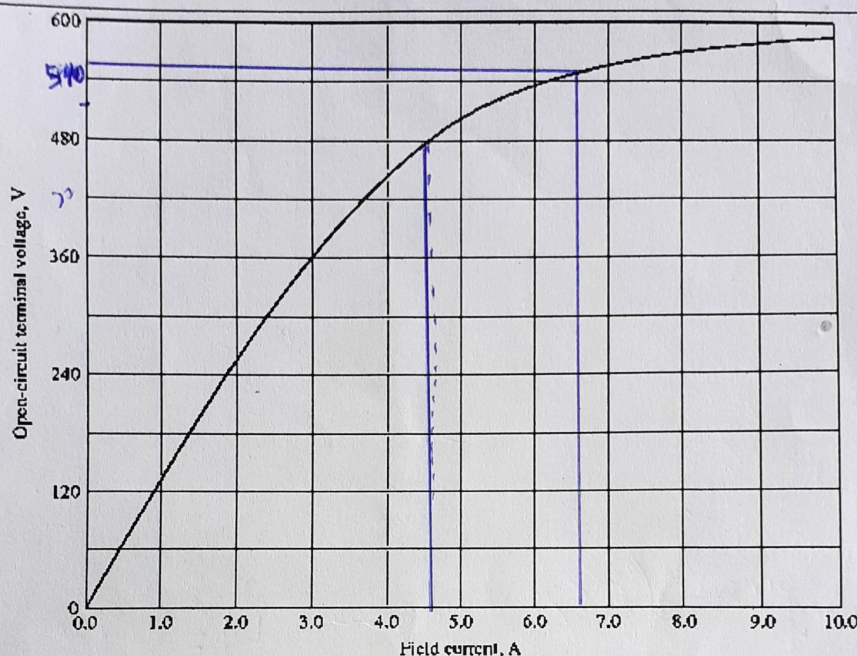


Figure Q4

- How much field current is required to make V_T equal to 480 V when the generator is running at no load? [2]
- What is the internal generated voltage of this machine at rated conditions? [5]
- How much field current is required to make V_T equal to 480 V when the generator is running at rated conditions? [2]
- How much power and torque must the generator's prime mover be capable of supplying? [8]

5. [22 Marks]

- A 200km, 230 kV, 60 Hz three phase line has a positive sequence series impedance $z=0.08 + j0.48 \Omega/\text{km}$ and a positive sequence shunt admittance $y = j3.33 \times 10^{-6} \text{ S}/\text{km}$. At full load, the line delivers 250 MW at 0.99 p.f. lagging and at 220 kV. Using the nominal π circuit, calculate:

- the ABCD parameters, [5]
- the sending end voltage and current [6]
- the percent voltage regulation, and [3]
- Transmission line efficiency [3]

- With an aid of a simple sketch, discuss the radial distribution system, state advantages and disadvantages. [5]

$$P = S \cos \theta$$

$$T_r =$$

$$p = 250 \text{ MW}$$

$$p.f. = 0.99$$