ELL363: Power Engineering-II
Minor Exam Odd Semester, 2022-2023
Department of Electrical Engineering, IIT Delhi

Total marks- 30 Duration- 60 minutes

1. Two synchronous generators G1 and G2 of 100 MVA rating are operating in parallel to deliver power to the grid at nominal frequency of 50 Hz. An industrial frequency-sensitive load is also operating in parallel with the generators, which changes its load by 0.28 pu due to 0.1 pu frequency deviation at the generator bus.
   A. If the governor-droop constants of G1 and G2 are 0.01 pu and 0.02 pu respectively, how much frequency-independent load change (in MW) would occur for which the frequency at the generator bus is deviated to 49.95 Hz?
   B. For the same frequency-independent load change, what would be the frequency at the generator bus if there is no governor action of the generators?

   (3+3=6 marks)

2. The unit of inertia constant (H) of a synchronous generator is _____. Justify the answer. (0.5+2=2.5 marks)

3. To increase active power reserve at constant power angle of a synchronous generator, the operating field current has to reduce. True/False.
   Justify the answer. (0.5+2=2.5 marks)

4. Considering a fixed DC capacitor and an unchanged upper limit of modulation index, the reactive power limit of a voltage source converter is increased with the higher voltage at the grid side terminal. True/False.
   Justify the answer. (0.5+2=2.5 marks)

5. A 3-unit based generator station supplies power with sufficient reserve at every generator. The fuel cost of unit-1, unit-2 and unit-3 are 1 $/MBtu, 1.2 $/MBtu, and 1.4 $/MBtu, respectively. The cost functions of the generators are expressed below.

Unit 1:	$510+7.2P_1+0.00142P_1^2$ MBtu/hour
Unit 2:	$310+6P_1+0.00118P_2^2$ MBtu/hour
Unit 3:	$78+5.14P_1+0.00101P_3^2$ MBtu/hour

   To increase generation of 150 MW from the station, calculate the contribution of each generator unit (in MW) with a minimum cost of operation. Neglect active power loss in the generators.

   (3 marks)

6. A person has purchased 12 PV panels and a 1-phase string inverter to setup a roof-top solar infrastructure. The voltage and current of each panel at maximum power point are 42.15 V and 9.74 A, respectively. The open circuit voltage and short circuit current of each panel are 48.23 V and 10.22 A, respectively. The rated capacity and rated DC bus voltage of the inverter are 6 KVA and 150 V. What should be the possible number of strings among the following options?
   (i) 6 (ii) 4 (iii) 3 (iv) 2
   Justify the answer. (0.5+2=2.5 marks)

7. In Figure 1B, the equivalent circuit of a synchronous generator is represented, where E_t is the terminal voltage and X_s is the synchronous reactance of the generator. Considering angle stability margin, find the possible operating point(s) among A, B, and C in Figure 1A, at which

the generator can deliver P MW of active power. Justify the answer which must define the reason of possibility/not possibility of each operating point separately.

(0.5+3=3.5 marks)

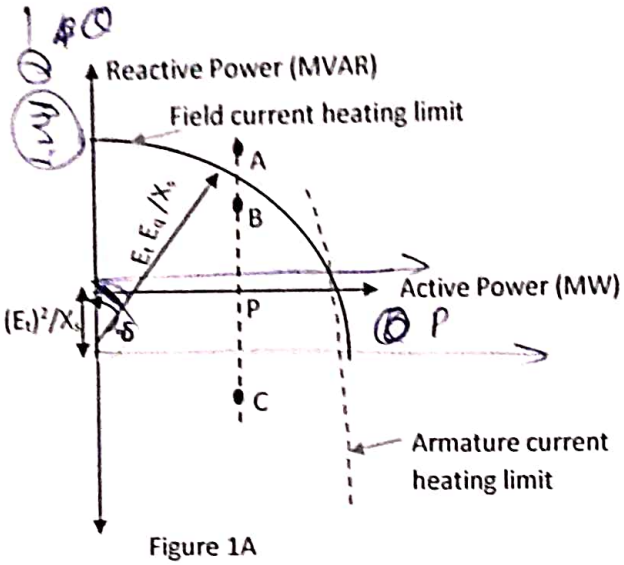

Figure 1A

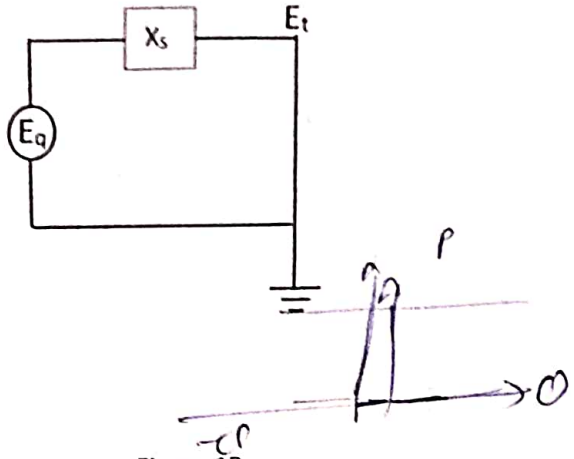

Figure 1B

8. The I-V characteristic of a photovoltaic (PV) module behaves more like a _____ (current/voltage) source at maximum power point.
Justify the answer. (3 marks)

9. The power vs. voltage characteristic of a typical PV array is shown in Figure 2. To operate the array at 10% derated condition at the insolation of 1000 W/m^2, the DC bus voltage across the PV array should be,

(i) <700 V (ii) > 700 V (iii) equal to 700 V (iii) cannot be determined

Justify the answer. (0.5+1=1.5 mark)

Power Vs Voltage curve of PV array at different irradiation

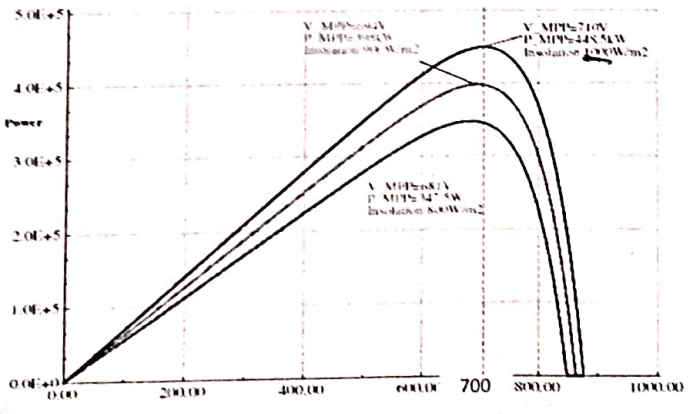

Figure 2

10. What is meant by rated wind speed, cut-in wind speed, and cut-out wind speed of a wind turbine? (1+1+1=3 marks)