FINAL EXAM

Smart Energy Management Systems

Please carefully read the following instructions:

1. Exam duration: 3 hours.
2. Answer all questions.
3. Please write your name and surname below (signature as well).
4. Use of non-programmable calculator is allowed.

I have read and understood all instructions:

(Name/Surname)	(ID number)	(Signature)

		Grade
Question 1.	(10)	
Question 2.	(10)	
Question 3.	(10)	
Question 4.	(10)	
Question 5.	(20)	
Question 6.	(10)	
Question 7.	(10)	
Question 8.	(10)	
Question 9.	(10)	
Total	(100)	

Question 1

a) Explain the concept of a microgrid and Smart Grid. How are these different from a classical Grid? (2)
b) During the module we have learned the importance of renewables integration in Smart Power Grids. What is their role, and what are the possible risks we undertake by this action? (3)
c) Draw and describe the basic (DC and AC) architecture of a microgrid with renewables distributed generation system. (5)

[10]

Question 2

a) Please name and analyze 4 communication technologies that are being used today. (4)
b) Explain the LAN network topology, how it works and the three categories of data transmission (4)
c) What is a Smart Meter? What functions does it serve? Explain their significance in Smart power grids. (2)

[10]

Question 3

a) What is a load flow? Mention the three classical methodologies for studying load flow (3)
b) A three - phase feeder is connected through two cables with equal impedance of $4 + j15\ \Omega$ in series to 2 three-phase loads. The first load is a Y connected load rated 440 V, 8 KVA, p.f. = 0.9 (lagging) and the second load is a Δ connected motor load rated 440 V, 6 KVA, p.f. = 0.85 (lagging). The motor requires a load voltage of 440 V at the end of the line on the Δ-connected loads. Perform the following:
   i) Give the one - line diagram
   ii) Find the required feeder voltage (3)
c) A three - phase generator rated 440 V, 20 kVA is connected by one cable with impedance of $1+ j0.012\Omega$ to a motor load rated 440 V, 15 kVA, 0.9 p.f. lagging. Assume the load voltage to be set at 5% above its rated value. Perform the following:
   i) Give the three- phase circuit if the load is Y connected
   ii) Give the three- phase circuit if the load Δ connected
   iii) Compute the generator voltage (4)

[10]

Question 4

a) Explain how a PV cell works. Analyze the meaning of open circuit voltage, short circuit current and maximum power point. How does an inverter know how to extract the maximum power possible? (5)
b) Why do we prefer the serial PV panel connection and not the parallel connection (remember that topology does not alter the output power!) (1)
c) Design a PV system to process 500 kW of power at 460 V, 60 Hz, three phase AC, and using PV data below. Determine the following: i) Number of modules in a string and number of strings in an array ii) Inverter and boost specification iii) The output voltage as a function and total harmonic distortion iv) The one - line diagram of this system (4)

Power (max)	300 W
Maximum voltage, P_{MPP}	
Voltage at maximum power point (MPP), V_{MPP}	50.6 V
Current at MPP, I_{MPP}	5.9 A
V_{oc} (open-circuit voltage)	63.2 V
I_{sc} (short-circuit current)	6.5 A

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Question 5

Design a microgrid with the load of 1000 kW rated at 460 V AC and connected to the local power grid at 13.2 kV using a transformer rated 2 MVA, 460 V/13.2 kV and 10% reactance. To support the emergency loads, the microgrid needs a 200 kWh storage system to be used for 8 hours a day. Data for a three-phase inverter and the PV system are given in the following slides. Determine the following:

i) The ratings of PV arrays, converters, inverters, storage systems and a single-line diagram of this design based on the minimum surface area. Also, compute the cost, weight, and square feet area of each PV type and give the results in a table. (15)
ii) Per unit model for the design (5)

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Question 6

a) What do we mean by mentioning “interoperability”? Please explain. How is it important to the design and implementation of a Smart Grid? (5)
b) Explain the concept of Cyber security and possible threats for the Smart Grid. (5)

[10]

Question 7

a) What is a SCADA system's main function? Explain. (4)
b) Analyze the components of a SCADA system and draw a representative SCADA architecture. (4)
c) Discuss the basic features of fuel cells. Are they indeed better than batteries? (2)

[10]

Question 8

a) How is load forecasting needed for the implementation of a Smart Grid? Explain. (2)
b) Briefly mention three medium and long-term forecast models. What is the accuracy of each one? (4)
c) Briefly mention three short-term forecast models. What is the accuracy of each one? (4)

[10]

Question 9

a) What do we mean by the term IoT (Internet of Things)? What is its role in Smart Grids? (5)
b) Give a detailed comparion between the classical grid and a smart grid, focusing on the IoT component and how it helps realizing this transformation in the future. (5)

[10]