



Strathmore
UNIVERSITY

SCHOOL OF COMPUTING AND ENGINEERING SCIENCES

MASTER OF SUSTAINABLE ENERGY TRANSITION

END OF SEMESTER EXAMINATION

MSSET 8501: SOLAR PHOTOVOLTAIC SYSTEMS

DATE: 23rd AUGUST 2023

TIME: 18:00-20:30 HOURS

INSTRUCTIONS

1. This examination contains **FOUR** questions.
2. Attempt **Question ONE (COMPULSORY)** and any other **TWO** questions
3. All workings should be shown clearly.

QUESTION ONE [20 MARKS]

You have been requested to design an off-grid solar PV system to supply energy to a village in remote parts of the country. The details of the loads to be supplied in the village is as given below.

No	Appliances	Qty	Appliance rating (W)	Operating Time (Hours/day)
1	Lights	80	10	5
2	TV	6	60	12
3	Kinyozi (Barber Shop)	6	20	8
4	Salon (Hair Dryer)	1	1500	5
5	Security Flood Lights	2	100	12
6	Deep freezer (300Ltrs)	1	115	15
7	Others (Mobile, laptops, computers)	1	1000	3

Perform a complete design of the PV system by determining the following;

- a) Calculate the total power and energy consumption per day. **[4 marks]**
- b) Number of batteries required to provide 2 days of autonomy considering
 - i) Lithium ion battery option (200 Ah, 48 V, efficiency = 99%, DOD = 80 %)
 - ii) Lead acid AGM battery option (200 Ah, 12 V, efficiency = 85%, DOD = 60 %)**[6 marks]**
- c) The size of the Solar PV System considering a combined de-rating factor of 15 % when using an MPPT charge controller assuming a PSH of 5 hours. **[3 marks]**
- d) The size of the inverter considering efficiency of 90% and a safety factor of 1.5 **[2 marks]**
- e) Draw a single line diagram showing connection of all the components, indicating their connections and quantities. **[5 marks]**

QUESTION TWO [15MARKS]

- a) Briefly discuss with the help of an I-V and power curves of a solar photovoltaic cell the major current, voltage and power points. **[8 marks]**
- b) Using a 100 AH battery as a reference illustrate how battery capacity can vary depending of the rate of discharging **[7 marks]**

QUESTION THREE [15 MARKS]

- a) State and explain factors that would influence the selection of a site to build a grid connected Solar PV power plant. **[6 marks]**
- b) Using a 12 V battery to illustrate, explain the difference in battery voltages during charging and when charging stops. Show that the state of charge could be different even with same voltage readings. **[6 marks]**
- c) Explain how by-pass diodes are used in solar PV systems **[3 Marks]**

QUESTION FOUR [15 MARKS]

- a) Highlight some of the challenges faced by the solar PV technology even as it plays a leading role in the current sustainable energy transition space **[5 marks]**

b) A solar PV system was installed in an area having an annual daytime temperature range between $-10\text{ }^{\circ}\text{C}$ and $45\text{ }^{\circ}\text{C}$. The solar module has the following other characteristics

- a V_{oc} of 43.24 V at STC ($25\text{ }^{\circ}\text{C}$),
- a V_{mpp} of 35.35 V at STC, and
- a temperature coefficient (TC) of $-0.168636\text{ V/ }^{\circ}\text{C}$ of V_{oc}

Find the;

- Maximum V_{oc} and V_{mpp} produced by the module
 - Minimum V_{oc} and V_{mpp} produced by the module **[5 marks]**
- c) Distinguish between sulphation and stratification and describe how each of these is handled in lead acid batteries used in solar PV system **[5 marks]**