STRATHMORE UNIVERSITY

SCHOOL OF COMPUTING AND ENGINEERING SCIENCES

MASTER OF SUSTAINABLE ENERGY TRANSITION

MSSET 8501: SOLAR PHOTOVOLTAIC SYSTEMS

DATE: 18th AUGUST 2023 **TIME: 2.5 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]

A dispensary in a rural village in Kisumu County has the following appliances whose power consumption when switched ON and OFF is given below;

Appliance	Qty	ON CONSUMPTION		OFF CONSUMPTION	
		Power	Hours	Power	Hours
Lights	20	5	10	0	14
Fans	10	10	8	0	16
Microscopes	3	20	1	3	23
Centrifuge	1	400	1	5	23
Phone Charging	1	10	4	0	20
Water Bath	1	400	1	5	23
Sterilizing Machine	1	600	2	5	22
Refrigerator	1	800	10	10	14
Radio	2	100	4	5	20

The solar insolation for Kisumu between the months of January and December is also provided as;

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Avg**
kWh/m^2	5.92	6.33	6.27	5.64	5.45	5.06	4.91	5.11	5.91	5.73	5.42.	5.76	**5.63**

Design a stand-alone solar PV system that can support the energy demand given. Your design should provide answers to these main questions:

a) What is the total daily energy demand of the dispensary? **[4 marks]**

b) What is the calculated PV array required and the number of panels required to meet this demand? **[2 marks]**

c) What is the recommended system voltage for this setup? **[2 marks]**

d) What is the battery capacity required assuming a 50% depth of discharge **[3 marks]**

e) What is the calculated inverter size required **[2 marks]**

f) What is the size of the charge controller required **[3 marks]**

g) Sketch out a single line diagram (SLD) showing connection of all the solar components, indicating their connections, quantities **[4 marks]**

The following additional information is also provided;

- Inverter efficiency of 95%
- Battery round-trip efficiency 85%
- PV loss factor of 75%
- Inverter oversizing factor of 25%
- Take one day of autonomy

The following are the available PV panels to select from;

ELECTRICAL PROPERTIES AT STC*

Model	Solinc EA280	Solinc EA285	Solinc EA345
Maximum power P_{max}	280 Wp	285 Wp	345 Wp
Current maximum power point I_{mpp}	8.83A DC	8.93A DC	8.96A DC
Voltage maximum power point V_{mpp}	31.7V DC	31.9V DC	38.5V DC
Open circuit voltage V_{oc} (STC)	38.5V DC	38.7V DC	46.8V DC
Short circuit current I_{sc}	9.54A DC	9.65A DC	9.68A DC
Module Efficiency (ηm)	17.21%	17.52%	17.78%
Maximum system voltage (V)	1000V DC		
Maximum series fuse rating(A)	15A		
Power tolerance	±5%		
Diode	6x10A		

QUESTION TWO [15 MARKS]

a) With relevant examples highlight and describe the features that differentiate Renewable energy from Non-conventional Energy Resources. **[4 marks]**

b) Using IV and PV curves illustrate the effect of high temperatures and shading on the outputs from a PV module. **[7 marks]**

c) Illustrate using a 12 V Gel type lead acid battery the different voltage levels during charging and discharging. **[4 marks]**

QUESTION THREE [15 MARKS]

a) Explain the factors that can lead to thermal runaway in lithium ion batteries **[6 marks]**

b) With illustrations show the different inverter configurations that can be applied in PV systems **[9 Marks]**

QUESTION FOUR [15 MARKS]

a) Briefly discuss the meaning and corresponding values of STC and how it differs from NOCT **[4 Marks]**

b) Explain any THREE different types of Solar PV panels in the market **[3 Marks]**

c) Draw a schematic diagram of a wind – solar hybrid system that has both DC and AC loads. **[4 Marks]**

d) Clearly illustrate the difference between irradiance and irradiation, hence or otherwise bring out the concept of peak sun hours (PSH) **[4 Marks]**