MURANG'A UNIVERSITY OF TECHNOLOGY

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

UNIVERSITY POSTGRADUATE EXAMINATION

2018/2019 ACADEMIC YEAR

FIRST YEAR **SECOND** SEMESTER EXAMINATION FOR MASTER OF TECHNOLOGY IN ELECTRICAL AND ELECTRONICS ENGINEERING

EET 620 – PHOTOVOLTAIC SYSTEMS

DURATION: 3 HOURS

DATE: 18/4/2019

TIME: 2-5 P.M.

Instructions to candidates:

1. Answer ANY FOUR questions.
2. Mobile phones are not allowed in the examination room.
3. You are not allowed to write on this examination question paper.

QUESTION ONE (25 MARKS)

a) Differentiate using appropriate diagrams the two types of charge controllers used in PV systems. (4 marks)

b) With the aid of an appropriate time plot explain the battery voltage profile during charging and discharging. (6 marks)

c) With the aid of an appropriate circuit diagram sketch the basic configuration of an IV curve of a solar cell. (7 marks)

d) Sketch the extended IV curve of 18 cells with and without the bypass diode and thus explain the purpose of the bypass diode. (8 marks)

QUESTION TWO (25 MARKS)

a) With the aid of appropriate IV and PV curves explain the effect of irradiance of PV modules and illustrate its effect on the total power output. (10 marks)

b) A PV system is designed of 2 strings in parallel of 5 modules each. The IV curve of one module at $55^{o}C$ is given in figure 2. Assuming the total battery bank voltage to be 67.4v and the barrier voltage of the bypass diodes and blocking diodes to be 0.6v.

   i. Draw the layout of the system.

   ii. Determine the current per string, voltage across each module and the total current to battery bank when all the modules are in good working condition.

   iii. Determine the current per string, voltage across each module and the total current to battery bank when one module in one of the strings is dead

   iv. Determine the current per string, voltage across each module, and the total current to the battery bank when two modules in one of the strings are dead. (15 marks)

QUESTION THREE (25 MARKS)

a) Figure 3 is the IV curve of a PV module, extracted at the following standard conditions: $25^{0}C$, $1KW/m^{2}$ and an air mass of 1.5. Draw the corresponding PV curve and hence estimate the rating of the module. On the PV curve sketch the result of increasing the module temperature. Using the PV curve illustrate and explain whether you may draw or not maximum power if this module is connected to a standard battery for domestic use.

(10 marks)

b) The Kenyan government intends to power 30 laptops per rural primary school of capacity 37 mH each in the Laptop-per-Child policy. Assume an efficiency of 90% for the AC/DC laptop charger and an efficiency of 90% for the DC/AC inverter.

i. Determine the total energy to be drawn from the Battery.

ii. The battery capacity in WH assuming a 20% depth of discharge.

iii. Capacity of the PV module in WH and W assuming 80% efficiency of battery and an average isolation of Kenya to be 5.6kwh/$m^{2.}$

iv. Based on (iv) above determine the batteries VA and sketch the layout if 100W panels are used in the design. (15 marks

QUESTION FOUR (25 MARKS)

a) With the aid of appropriate diagrams explain how solar energy is harnessed using photovoltaic cells. (8 marks)

b) Explain the following status of the system in figure 4.1 as per the measured data. Indicate if the data was taken at daytime on night time, type of and charge controller status, the batteries state-of-charge, the load power and the PV power? Is the system working well? (6 marks)

c) The system shown in figure 4.2 is to be designed to supply 100wh load per day. The efficiency of the inverter is 90%. Assume the battery efficiency to be 80%.

The voltage drop allowance between battery and charge controller is 0.1v for 12v and 0.2v for 24v-system. The peak hours are 5.6 with a maximum irradiance of 1.2 kw/m^2. The PV module derating is estimated at 80%.

Determine:

i. The rating of the module from the given IV curve in figure 4.3, and hence calculate the number of panels required to supply the load.

ii. If the panels are connected in parallel, estimate the rating of the charge controller.

iii. Determine the kWh rating of the battery assuming a 20% depth of discharge.

(11 marks

QUESTION FIVE (25 MARKS)

a) What is feed-in tariff and what are its objectives. (5 marks)

b) Explain the factors affecting the life cycle of a battery. (5 marks)

c) The following data is measured for a PV module.

No	Temp. (^{0}C)	Voc (V)	Irradiance (kw/m^2)
1	18.3	14.55	120.1
2	20.5	21.80	845.3
3	23.4	21.14	823.1
4	27.2	21.22	836.2
5	32.6	20.53	840.4
6	34.2	18.20	560.7
7	38.1	19.84	812.2
8	41.2	19.21	814.1
9	45.6	19.83	810.2
10	52.3	18.32	830.3
11	58.7	17.50	820.9
12	61.4	17.45	810.2

i. Eliminate data that may not be representative of the actual measurements done.

ii. Plot the measured data and draw the average line.

iii. Calculate the temperature coefficient of the PV module. (5 marks)

d) With the aid of a time plot, explain the normal operation of a battery in 24h schedule. (7 marks)

e) Explain the difference between batteries A, B, and C in table 5, each having the same Ampere hour rating. (3 marks)