KENYATTA UNIVERSITY

UNIVERSITY EXAMINATIONS 2011/2012

SECOND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN ENERGY ENGINEERING

SET 536 : PHOTOVOLTAIC TECHNOLOGY

DATE: MONDAY 18TH APRIL 2012 **TIME: 2.00 P.M. – 4.00 P.M.**

INSTRUCTIONS

a) This paper contains five questions
b) Attempt any three questions
c) All questions carry equal marks
d) State assumptions made and define all symbols used

Question 1

a) Using appropriate illustrations, describe the basic principles of a working solar photovoltaic cell. (6 marks)

b) A photovoltaic system for supplying drinking water is installed in a village in Marsabit in North Eastern province of Kenya. The water is pumped from a borehole, from a well of depth of 48 m. The solar cells are made form single crystal silicon and the array consists of 24 modules. It is given that the inverter efficiency is 85% and the pump and motor set at 45%. Calculate the water discharge rate at noon when the global solar radiation incident normally on the cells is 945 W/sq-m. (14 marks

V module specifications:

Module size: 100 cm + 50 cm; Cell size: 10.4 cm x 10.4 cm; Number of cells : 36; Maximum output: 50 W; Maximum voltage: 17.1 V ; Maximum current: 2.92 A; Open circuit voltage: 21.6 V ; Short circuit current: 3.22; and Conversion efficiency: 12.8%

Question 2

a) Describe step by step how you will go about design a solar photovoltaic system for domestic application in your homestead. As much as possible use illustrations and guiding design theory to maximize energy conversion efficiency.

(10 marks)

b) You are given the following data for Kenya as follows:

An average energy burn rate of 3.5 x 1013 kWh yr^{-1}) as projected in Kenya in terms of energy consumption including waste heat; an average solar radiation received per day 6 $kWhm^{-2}$; an average power production by PV arrays per day in Kenya equals 7 $kWhm^{-2}$;

The PV system energy conversion efficiency is about 12% including all system losses. Determine the total land required to sustain the PV power production capacity. (10 marks)

Question 3

a) What are the basic components of a stand alone photovoltaic system and describe their basic functions as used in solar PV powered homes. (10 marks)

b) A photovoltaic module with 108 cells is connected in series and an area of 1.281 sq-m has the following measured characteristics at the following reference conditions: Short circuit current is 8.7 Amps, open circuit voltage is 60 volts, maximum power is produced when current is 8 Amps and 48 Volts. Other data include temperature coefficient of the short circuit are 1.325 x 10^{-3} a/k and -0.0775 v/k, respectively

i) Determine the values of Saturation and load current (5 marks)

ii) Determine the series resistance and maximum power generated

(5 marks)

Question 4

a) A farmer in a rural countryside wants to use solar energy lighting his homestead and powering domestic appliances. The following are his requirements:

4 bed-room house, sitting room, corridor, kitchen, bathroom, toilet and two security lights. The appliances include 1 black and white television set rated at 35W, DC and one radio rated 5W, DC. Use the following information: solar panel is rated 60W, DC, current output = 3 A, Average sunshine hours = 6 hours, battery size = 100 Ah, lights are 10W, overall system efficiency = 70%. All lights are used for one hour each. TV and radio are used for 3 hours. Describe how you would go about sizing his system. Use illustrations where possible. (10 marks)

b) A small household lighting system is powered by from 8V storage battery having a 30 Ah supply when fully charged. The lighting is used for 4 hours each night at 3 Amps. As an energy engineering graduate from Kenyatta University, you are asked to design a suitable photovoltaic system that will charge the battery form an arrangement of silicon cells.

i) How will you arrange the cells? (5 marks)

ii) How will the circuit connected? (5 marks)

Question 5

a) Describe step by step how one can enhance stand alone photovoltaic system using energy storage technology technologies. (6 marks)

b) Describe how dye sensitized photovoltaic cells can be constructed using locally available materials. (6 marks)

c) Solar powered photovoltaic system with energy conversion efficiency of 12% is to be installed at Kenyatta University for street lighting. Assuming the average yearly solar resource is 2192 $kWh/m^{-2}yr^{-1}$ and expected streetlights average burn rate is $3.5 \times 10^{-13}\ kWyr^{-1}$ determine the total land area required to enable installation of the photovoltaic generator. (8 marks)