Loughborough University

Advanced Photovoltaics

23WSP640 (DL)

Semester 2 In-Person Exam paper

This examination is to take place in-person at a central University venue under exam conditions. The standard length of time for this paper is **2 hours**.

You will not be able to leave the exam hall for the first 30 or final 15 minutes of your exam. Your invigilator will collect your exam paper when you have finished.

Help during the exam

Invigilators are not able to answer queries about the content of your exam paper. Instead, please make a note of your query in your answer script to be considered during the marking process.

If you feel unwell, please raise your hand so that an invigilator can assist you.

Answer **ALL THREE** questions.

All questions carry equal marks.

Use a **SEPARATE** answer book for **EACH** question.

Use of a calculator is permitted - It must comply with the University's Calculator Policy for In-Person exams, in particular that it must not be able to transmit or receive information (e.g. mobile devices and smart watches are not allowed).

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1. PV Devices

a) What are the 3 basic processes which happen within a solar cell to enable electrons to be extracted from its terminals? [3 marks]

b) Give the names of each of the 4 sets of equations which are used to derive and calculate the solar cell equation. Explain what each equation describes. You **do not** need to write down the individual equations. [8 marks]

c) When improving solar cell performance, is it more important to improve the majority carrier lifetime, or the minority carrier lifetime? Explain your answer. [4 marks]

d) What determines the generation rate of e-h pairs in a solar cell and how would you maximise its value? [5 marks]

2. Thin film solar cells

a) Name 5 potential advantages of thin film photovoltaics over conventional crystalline silicon photovoltaics. [5 marks]

b) Draw a cross section diagram of the most common configuration CIGS solar cell, indicating the material used in each layer and the typical thicknesses of each layer. [6 marks]

c) CIGS solar cells have a tuneable band gap. Explain how this can be achieved, and why the best performance is usually found at a band gap of about 1.2 eV. [4 marks]

d) Draw a typical external quantum efficiency (EQE) curve of a high performance CIGS solar cell with a band gap of 1.2eV, indicating where the band gap of the TCO, CdS buffer layer and absorber are. [5 marks]

3. PV Systems & Modelling

a) Describe the equipment and method required to determine the temperature coefficient of maximum power for a PV module in a laboratory. [5 marks]

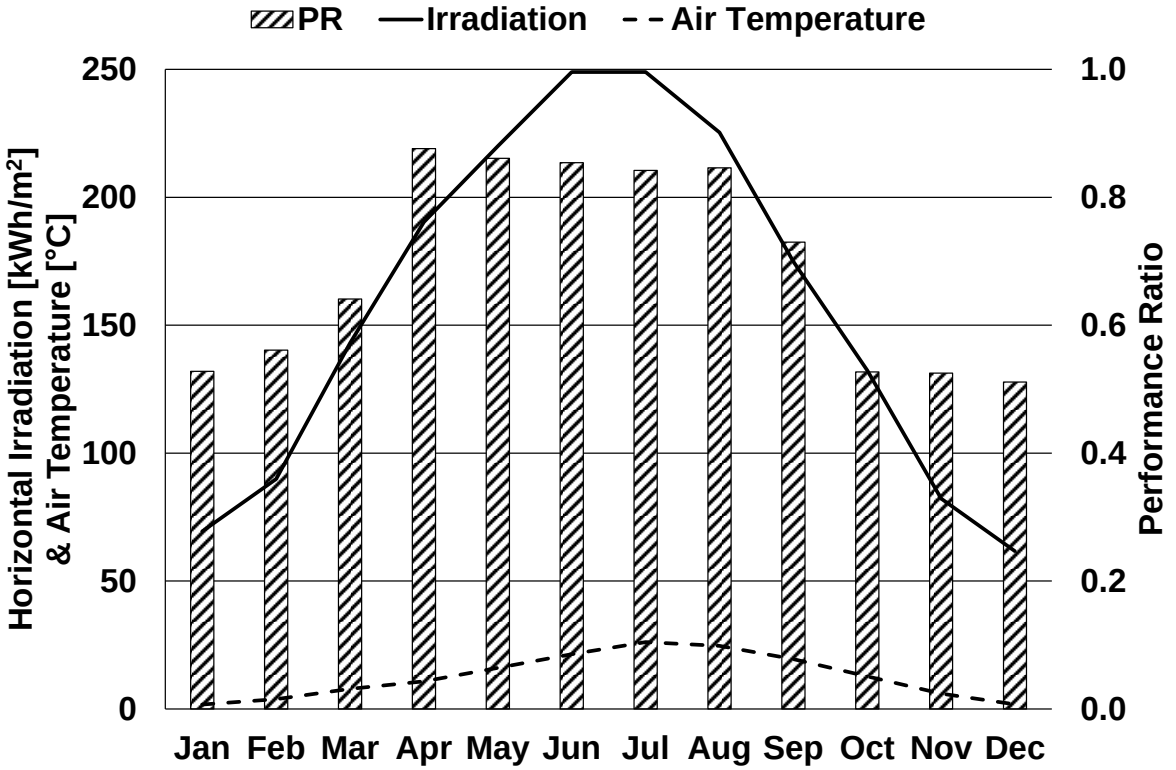
b) How would you make use of the temperature coefficient to improve the accuracy of modelled electrical output from a PV system? (Consider and describe what other data and models it would be combined with). [5 marks]

c) The figure below shows data from a site and PV system located in Reno, Nevada, USA (latitude 39.5°N).

The system is a multi-megawatt, ground-mounted installation, with no notable buildings or obstructions nearby. It comprises approximately 50 rows of identical mounting frames at a 30° tilt angle.

There are no electrical faults (such as inverter failure), and the system is not subject to curtailment of the output.

Based on the information provided, explain likely causes of any variations in the monthly performance ratio you can see, and causes that you can exclude. Where possible, make suggestions that may improve the system performance. [10 marks]



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