

## EE.REE.310, Solar Power Systems

Examination, 5.5.2023

1.
  - a) Extra-terrestrial solar irradiance on the Earth varies annually from 1322 to 1414 W/m<sup>2</sup>. Why does it vary?
  - b) How and why does the solar irradiance on a plane perpendicular to the coming irradiance at the ground level vary on a sunny day?
  - c) How can you estimate (calculate) the solar irradiance on the earth surface during a clear sky day?
  
2.
  - a) What are the valence and conduction band structures in commercially available semiconductor based solar PV cells (Si and thin film cells)?
  - b) How is the energy of solar radiation converted into electrical energy in these solar PV cells?
  - c) How does the absorption probability of photons behave in these solar PV cells as a function of photon energy?
  
3.
  - a) Explain the lightning sphere method and how it is used in the design of solar PV power plants.
  - b) A solar PV power plant is to be installed on the roof of a single-family house with a gable roof in a place where lightning protection is needed against the effects of displacement current induced in solar generator wires by distant and nearby lightning strikes, as well as direct lightning strikes (there is an open area around the house). What kind of lightning protection system is needed for the solar PV power plant?
  
4. PV module has 80 series connected identical silicon PV cells and four bypass diodes each protecting 20 series connected PV cells. Each PV cell has a short circuit current of 8 A and an open circuit voltage of 600 mV in standard test conditions (STC).
  - a) Draw current and power of the PV module as a function of voltage in STC conditions.
  - b) Draw current and power of the PV module as a function of voltage in STC temperature when eight of the PV cells protected by one bypass diode are partially shaded receiving an irradiance of 125 W/m<sup>2</sup> and the rest of the cells receive clear sky irradiance of 500 W/m<sup>2</sup>.
  - c) Draw current and power of the PV module as a function of voltage in case b), when two of the bypass diodes are broken and fully nonconductive.
  
5.
  - a) How are single and polycrystalline silicon PV cells made from molten pure silicon raw material?
  - b) What are the main electrical characteristics of solar PV modules and how are they determined for modules under different operating conditions?