Solutions to Chapter 9

Exercise 9.1: Radiation Sensors

a) Secondary Standard; accuracy: ± 2 %

b) 1) Pyranometer with shade ball
2) Pyranometer with shade ring

c) No, the pyranometer is too slowly for this. Instead, solar cells of photo diodes are used in this case.

Exercise 9.2: Peak Power Measurement at Site

See Figure 9.6.

Exercise 8.3: Thermographic Measuring Technology

a) Bright thermography: Detection of bad cells, cabling errors.
Dark thermography: Control of contact resistances, detection of inactive cells or cell parts.

b) $P = \sigma \cdot \varepsilon_{\text{Correct}} \cdot T_{\text{Correct}}^4 = \sigma \cdot \varepsilon_{\text{Device\_adjusted}} \cdot T_{\text{Device\_shown}}^4 \Rightarrow \varepsilon_{\text{Correct}} \cdot T_{\text{Correct}}^4 = \varepsilon_{\text{Device\_adjusted}} \cdot T_{\text{Device\_shown}}^4$

$$\Rightarrow T_{\text{Correct}} = T_{\text{Device\_shown}}^4 \cdot \sqrt[4]{\frac{\varepsilon_{\text{Device\_adjusted}}}{\varepsilon_{\text{Correct}}}} = 314.74\ \text{K} \Rightarrow \vartheta_{\text{Correct}} = \underline{41.6\ °\text{C}}$$

Exercise 9.4: Electroluminescence Measuring Technology

a) Silicon emits light just above its bandgap wavelength of 1107 nm. As CCD sensors also consist of silicon this light is at the absorption limit and therefore only weakly detectable. Furthermore, many CCD contain a filter against infrared radiation.

b) Micro cracks, screen-printing errors, local shunts.

c) Advantages:
High resolution, detailed analysis of the defect, photo can be well taken also under oblique angle.

Disadvantages:
Not feasible at full daylight, modules have to be energized by a power supply.

Aufgabe 9.5: PID-Effekt

a) Local shunting (PID-Shunting) of the p-n junction caused by migration of sodium ions into the cells base.

b) Application of a voltage of -1000 V at the module cables with respect to the frame together with the aluminum foil laying on the glass pane for 7 days. Measurement of the module power at begin and end of that period.

c) High EL-brightness at the positive side of the string, which is getting darker more and more in the direction of the negative string end (this polarity holds for p-type cells). The affected modules mostly show EL-pictures of cells with strongly different brightness.