author dares to detail here a rather simple methodology that allows the estimation of the $I-V$ curve of c-Si PV modules operating in any prevailing environmental condition, exclusively using as input the values of I^*_{SC}, V^*_{OC} and P^*_M. In principle, such methodology can be extended to other-than-c-Si materials, and additional comments to do this are also included in the text that follows. However, the reader should be advised that the much less available experience with these materials encompasses significant increase in uncertainty.

20.10.1 The Selected Methodology

In a previous chapter (see Chapter 3), it has been shown that the characteristic $I-V$ of a solar cell can be expressed with sufficient accuracy by

$$I = I_L - I_0\left(\exp\frac{V + IR_S}{V_t} - 1\right) - \frac{V + IR_S}{R_P} \tag{20.58}$$

where I_L, I_0, R_S and R_P are the photo-generated current, the dark current, the series resistance and the parallel resistance, respectively. The voltage V_t equals *mkT/e* (we recall that for $m = 1$, $V_t \approx 25$ mV at 300 K). This expression gives an adequate representation of the intrinsic behaviour of a typical c-Si solar cell. Nonetheless, it cannot be used directly to obtain the required predictions, because some parameters, I_L and I_O in particular, cannot be established from the usually available information, often restricted to the values of I^*_{SC}, V^*_{OC}, and P^*_M, which are always included on the manufacturers' data sheets.

This difficulty is effectively overcome when the following assumptions, which are generally valid for c-Si PV cells and modules, are made:

- The effect of parallel resistance is negligible.
- The photo-generated current and the short-circuit current are equal.
- $\exp((V + IR_S)/V_t) \gg 1$ under all working conditions.

This allows equation (20.58) to be written as

$$I = I_{SC} - I_O \exp\left(\frac{V + IR_S}{V_t}\right) \tag{20.59}$$

which, with $I = 0$, leads to the following expression for the open-circuit voltage:

$$V_{OC} = V_t \ln\left(\frac{I_{SC}}{I_O}\right) \tag{20.60}$$

whence

$$I_O = I_{SC} \exp\left(-\frac{V_{OC}}{V_t}\right) \tag{20.61}$$

Substituting equation (20.61) in (20.59), we arrive at

$$I = I_{SC}\left[1 - \exp\left(\frac{V - V_{OC} + IR_S}{V_t}\right)\right] \tag{20.62}$$