This is a very useful expression. As we shall see, the values of all the parameters on the right-hand side are easily obtained allowing immediate application of the expression. An inconsistency arises in the sense that $I(V = 0) \neq I_{SC}$. Nevertheless, in all solar cells of practical use, we find that $V_{OC} \gg IR_S \Rightarrow I(V = 0) \approx I_{SC}$, which therefore makes this objection irrelevant. The expression can be inconvenient to use in the sense that I is implicit (it appears on both sides of the equation), theoretically making it necessary to solve the equation iteratively. However, for voltages close to the maximum-power point, a reasonably accurate solution can be obtained with only one iteration by setting $I = 0.9 \times I_{SC}$ in the second term.

The calculation of the maximum power can, in principle, be carried out by considering that the power is given by the product $P = VI$. The values of I_M and V_M, defining the maximum-power operation point, can be obtained from the usual condition for a maximum, $\mathrm{d}P/\mathrm{d}V = 0$. However, the implicit nature of the resulting expression makes it very cumbersome to use. It would be better to look for a simpler method, based on the existing relationship between the fill factor and the open-circuit voltage. According to M.A. Green [54] an empirical expression describing this relation is

$$FF = \frac{V_M I_M}{V_{OC} I_{SC}} = \frac{P_M}{V_{OC} I_{SC}} = FF_0(1 - r_s) \tag{20.63}$$

where

$$FF_0 = \frac{v_{OC} - \ln(v_{OC} + 0.72)}{v_{OC} + 1} \tag{20.64}$$

and $v_{OC} = V_{OC}/V_t$ and $r_s = R_S/(V_{OC}/I_{SC})$ are defined as the normalised voltage and the normalised resistance, respectively. It is interesting to note that the series resistance at STC can be deduced from the manufacturer's data by the expression

$$R_S = \left(1 - \frac{FF}{FF_0}\right) \frac{V_{OC}}{I_{SC}} \tag{20.65}$$

The values of V_M and I_M are in turn given by [55]

$$\frac{V_M}{V_{OC}} = 1 - \frac{b}{v_{OC}} \ln a - r_s(1 - a^{-b}) \text{ and } \frac{I_M}{I_{SC}} = 1 - a^{-b} \tag{20.66}$$

where:

$$a = v_{OC} + 1 - 2v_{OC} r_s \text{ and } b = \frac{a}{1 + a} \tag{20.67}$$

This set of expressions is valid for $v_{OC} > 15$ and $r_s < 0.4$. The typical accuracy is better than 1%. Their application to a photovoltaic generator is immediate, if all their cells are supposed to be identical, and if the voltage drops in the conductors connecting the modules are negligible.

Now, for the prediction of the I–V curve of a PV generator operating on arbitrary conditions of irradiance and temperature, a good balance between simplicity and exactness is obtained through the following additional assumptions.