Are IEC 60891 I-V characteristics correction methods suitable for I-V characteristics measured from PV modules under faulty conditions?

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Photovoltaic (PV) I-V characteristic (I-V curve) contains rich information about the status of the PV module or array; therefore, the I-V curve-based PV diagnosis has always been a popular issue [1]. Among this, the correction of I-V curves measured under various environmental conditions to an identical condition is usually a crucial step. However, there is no specific method dedicated to the correction of faulty I-V curves. Therefore, the correction procedures proposed in IEC 60891 standard [2] are commonly adopted, which, however, have only been validated for the correction of curves for healthy PV modules. Thus, this paper aims to evaluate the performance of the IEC 60891 single curve-based methods, i.e., procedure 1 (P1) and 2 (P2), for the correction of faulty I-V curves.

A PV array model with 6 sc-Si modules is developed under Simulink® to simulate PV array under healthy and 5 faulty conditions (as shown in Table 1): partial shading (PS), short circuit (SC), open circuit (OC), Rs and Rsh degradations. Irradiance (G) and module temperature (Tm) are selected based on field records of the modules used in the simulation. To evaluate the whole I-V curve correction performance, the curve error ($E_{I\text{-}V}$) is adopted as the metric:

$$E_{I-V} = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(I_i^c - I_i^{real}\right)^2} / I_{sc}^{real}$$

where, I_i^c and I_i^{real} are the current interpolated at V_i on the corrected and real curve; V_i is a voltage vector linearly interpolated in [0,120V]; I_{sc}^{real} refers to the I_{sc} extracted from the real curve.

Table 1. Parameter setting to set the different PV array conditions

Condition	GainPS	R_{SC} (Ω)	R_{OC} (Ω)	Rs (Ω)	Rsh (Ω)
Healthy (array)	1	10^6	10^{-6}	10^{-6}	10^6
PS (1 module)	**0.2**	10^6	10^{-6}	10^{-6}	10^6
SC (1 module)	1	$\mathbf{10^{-6}}$	10^{-6}	10^{-6}	10^6
OC (1 string)	1	10^6	$\mathbf{10^6}$	10^{-6}	10^6
Rs degradation (array)	1	10^6	10^{-6}	**1**	10^6
Rsh degradation (array)	1	10^6	10^{-6}	10^{-6}	**30**

Using P1 and P2, the I-V curves before and after correction are presented in Fig. 1.

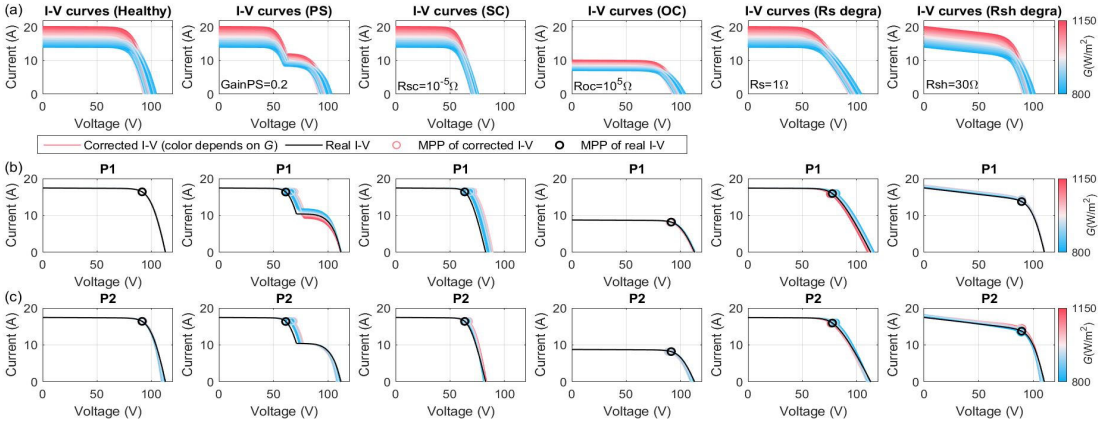

Fig. 1 Correction results (a): curves simulated for correction (b): corrected curves using P1, (c): corrected curves using P2

In this paper, based on the results in Fig. 1, the P1 and P2 will be compared and analysed. The impact of G and Tm on $E_{I\text{-}V}$ will also be evaluated. Finally, suggestions for the choice of correction methods will be given.

References

[1] Livera A, Theristis M, Makrides G, et al. Recent advances in failure diagnosis techniques based on performance data analysis for grid-connected photovoltaic systems. Renew Energy 2019; 133: 126–43.

[2] IEC 60891. Photovoltaic devices - Procedures for temperature and irradiance corrections to measured I-V characteristics. 2009.