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Single Diode Parameter Extraction from In-Field Photovoltaic I-V Curves on a Single Board Computer

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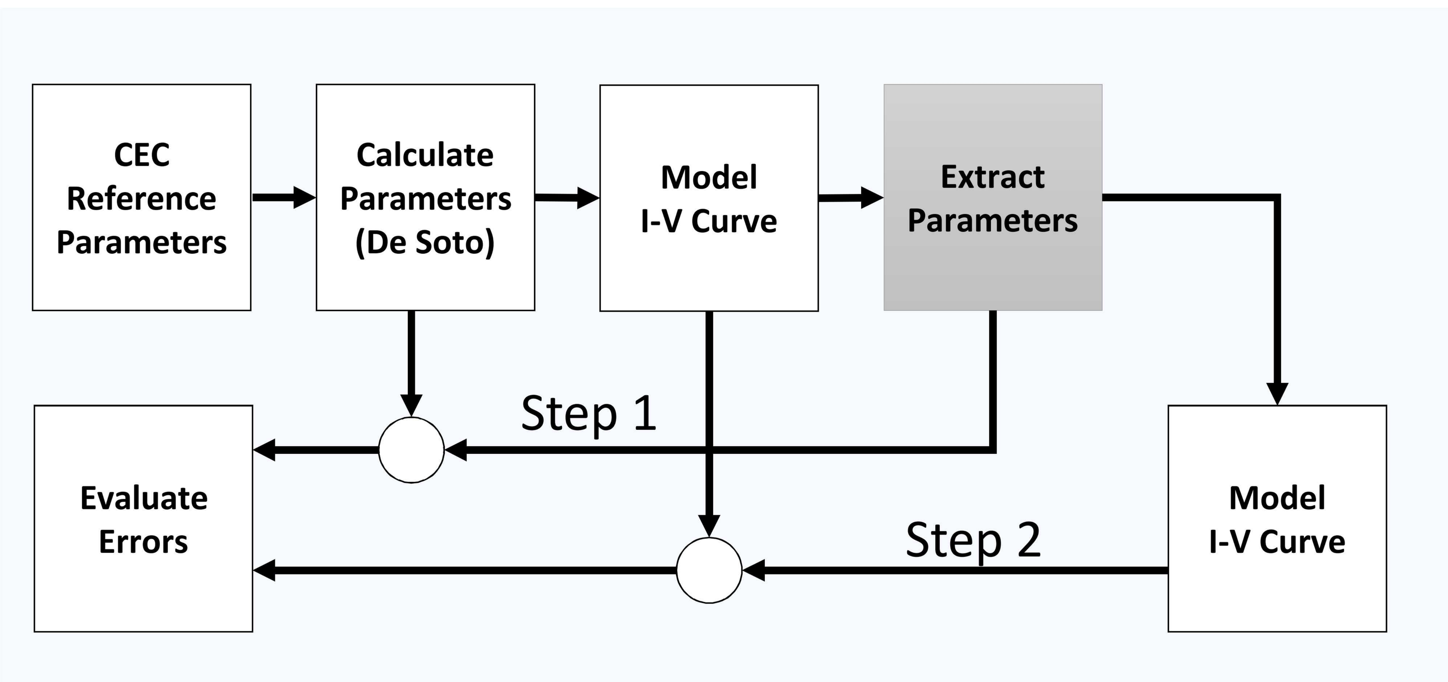
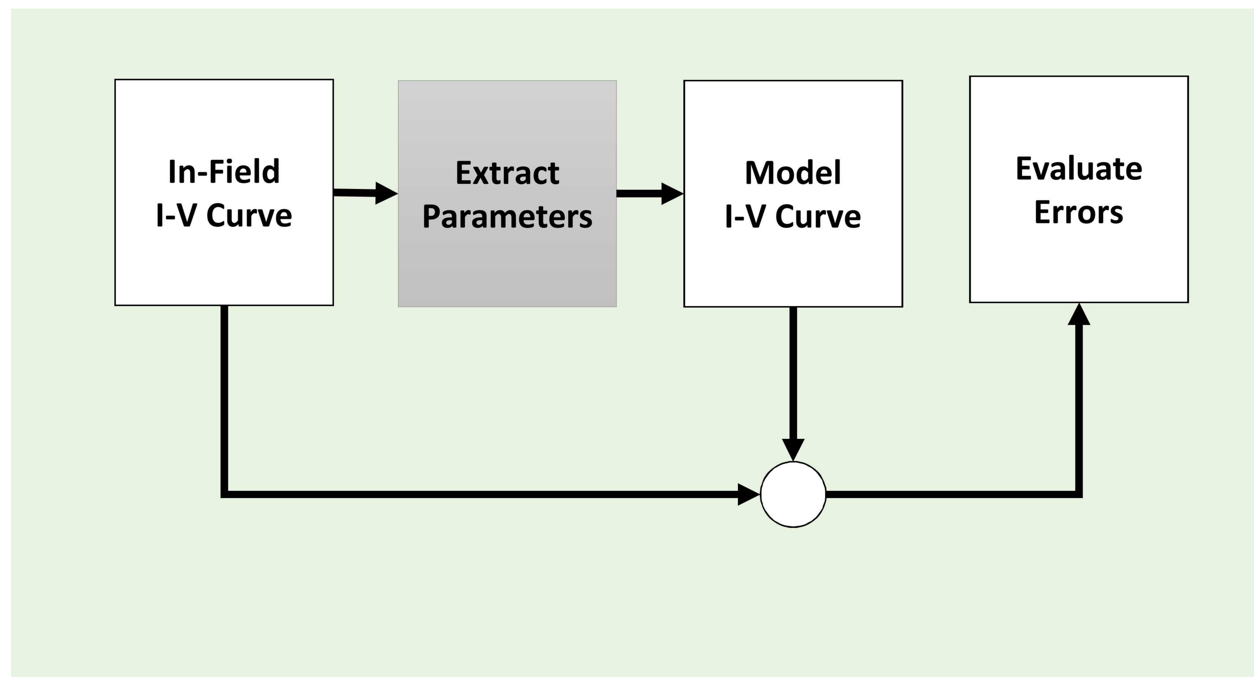
Introduction

New advancements in I-V curve tracing systems enable in situ scans of strings and modules within production PV arrays. Many systems, on the market today, use single board computers to store and assess data. The on-board assessment reports common I-V features included Isc, Voc, Rs, and Rsh. A more detailed understanding of system health can be achieved by comparing I-V curves with an equivalent circuit mode. Therefore, this poster presents a light-weight algorithm that can extract parameters for the single diode equivalent circuit model from individual I-V curves on a single board computer that is located at the point of measurement.

Accuracy Evaluation



Performance Evaluation



Extraction Procedure

(1) The single diode equation is simplified by eliminating the -1, which has negligible impact on the I-V curve shape.

$$I = I_L - I_0\left[\exp\left[\frac{V+IR_s}{nN_sV_t}\right]\right] - \frac{V+IR_s}{R_{SH}}$$

(2) Eqn. 2 is rearranged into a linear and exponential component. The R_{SH} is replaced by the shunt conductance $G_p = 1/R_{SH}$.

$$I \approx \frac{I_L}{1+G_pR_s} - \frac{G_pV}{1+G_pR_s} - \frac{I_0}{1+G_pR_s}\exp\left[\frac{V+IR_s}{nN_sV_{th}}\right]$$

(3) Then, the two coefficients in the linear component are estimated using linear least-squares regression over a portion of the I-V curve ($0 \le V \le V_L$).

$$I \approx \frac{I_L}{1+G_pR_s} - \frac{G_p}{1+G_pR_s}V = \beta_0 + \beta_1 V$$

(4) The right side of Eqn. 3 is substituted into Eqn. 2 and then rearranged.

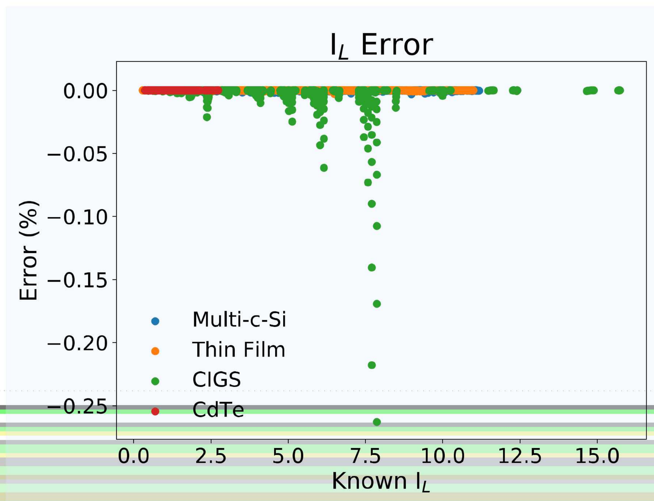
$$\log(\beta_0 - \beta_1 V - I) = \log\left[\frac{I_0}{1+G_pR_s}\right] + \frac{1}{a}V + \frac{R_s}{a}I = \beta_2 + \beta_3 V + \beta_4 I$$

(5) For $I \ge 0.1I_{SC}$ values for β_2, β_3, β_4 are obtained by least-squares regression, and four of the single diode parameters are calculated sequentially from the regression coefficients.

$$R_S = \frac{\beta_4}{\beta_3} \qquad G_p = \frac{\beta_1}{1 - R_S\beta_1}$$

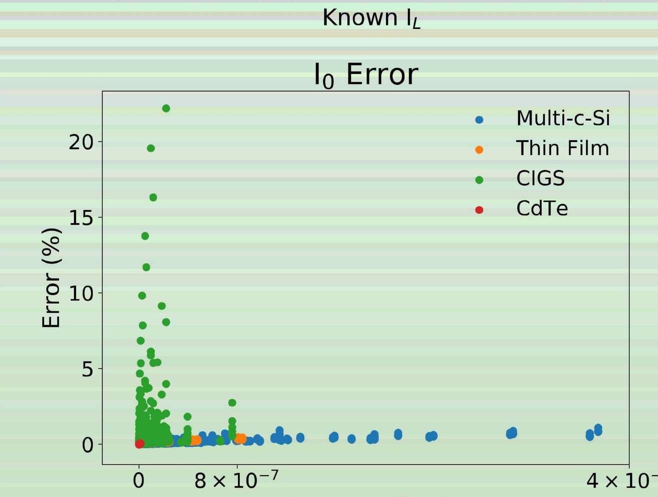
$$R_{SH} = \frac{1}{G_p} \qquad I_L = (1 + G_pR_S)\beta_0$$

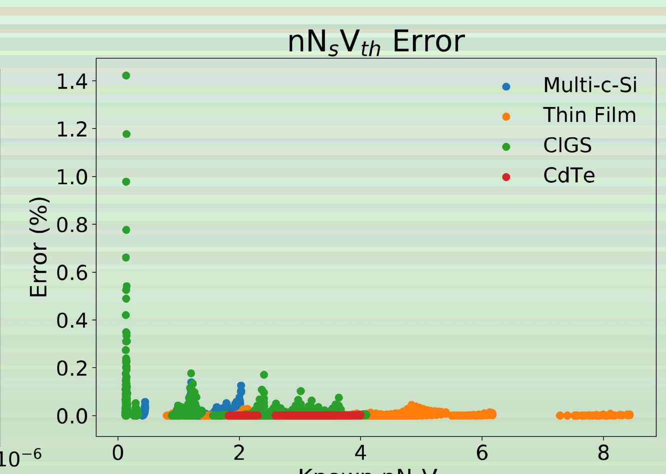
Accuracy Results

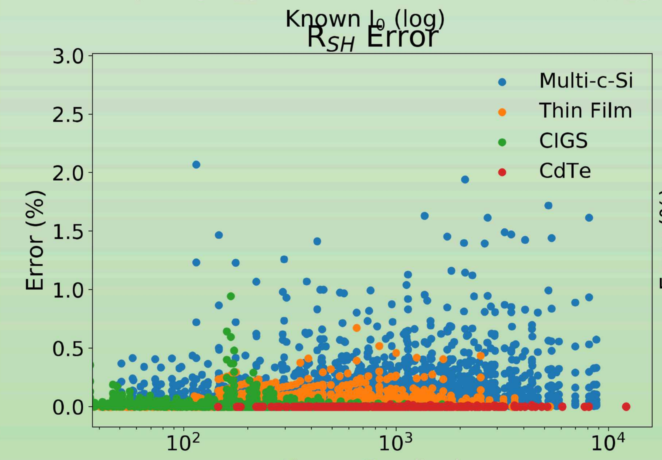


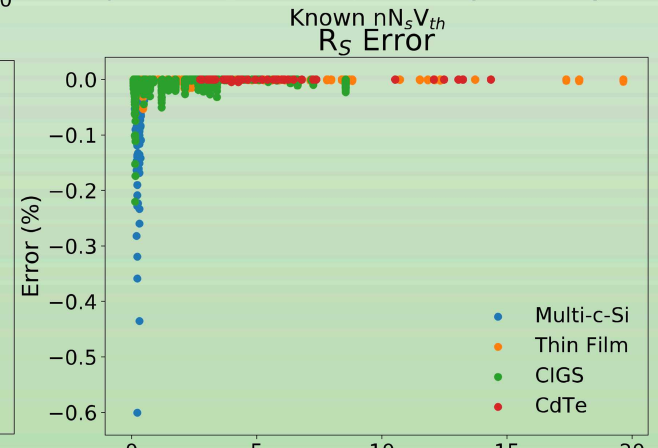
Step 1:

The differences between the known and extracted single diode parameters are small for four module types (Multi-c-Si, Thin Film, CIGS, CdTe). The CIGS modules tended to have the highest errors and the R_{SH} was largest for the Multi-c-Si modules.



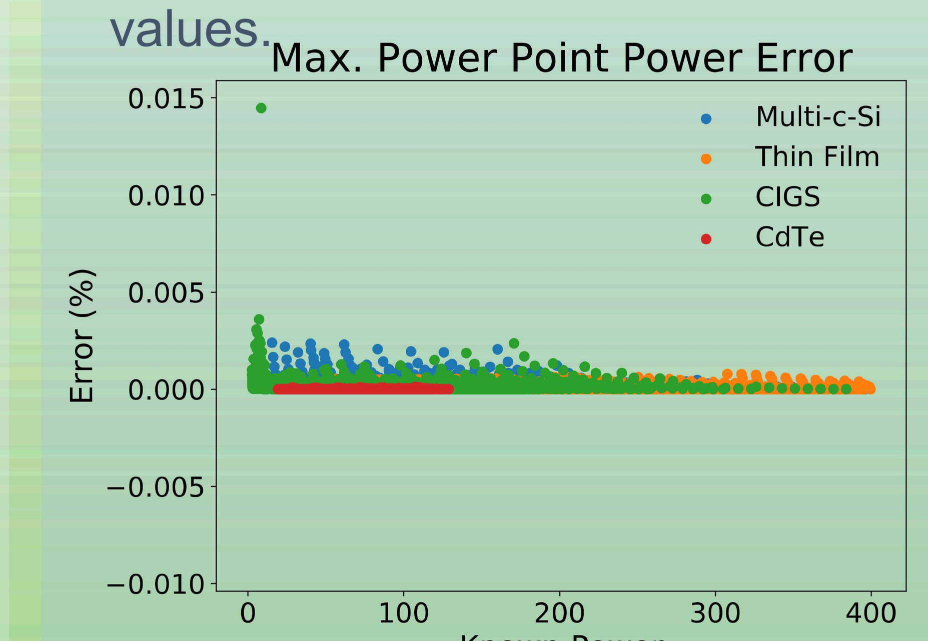




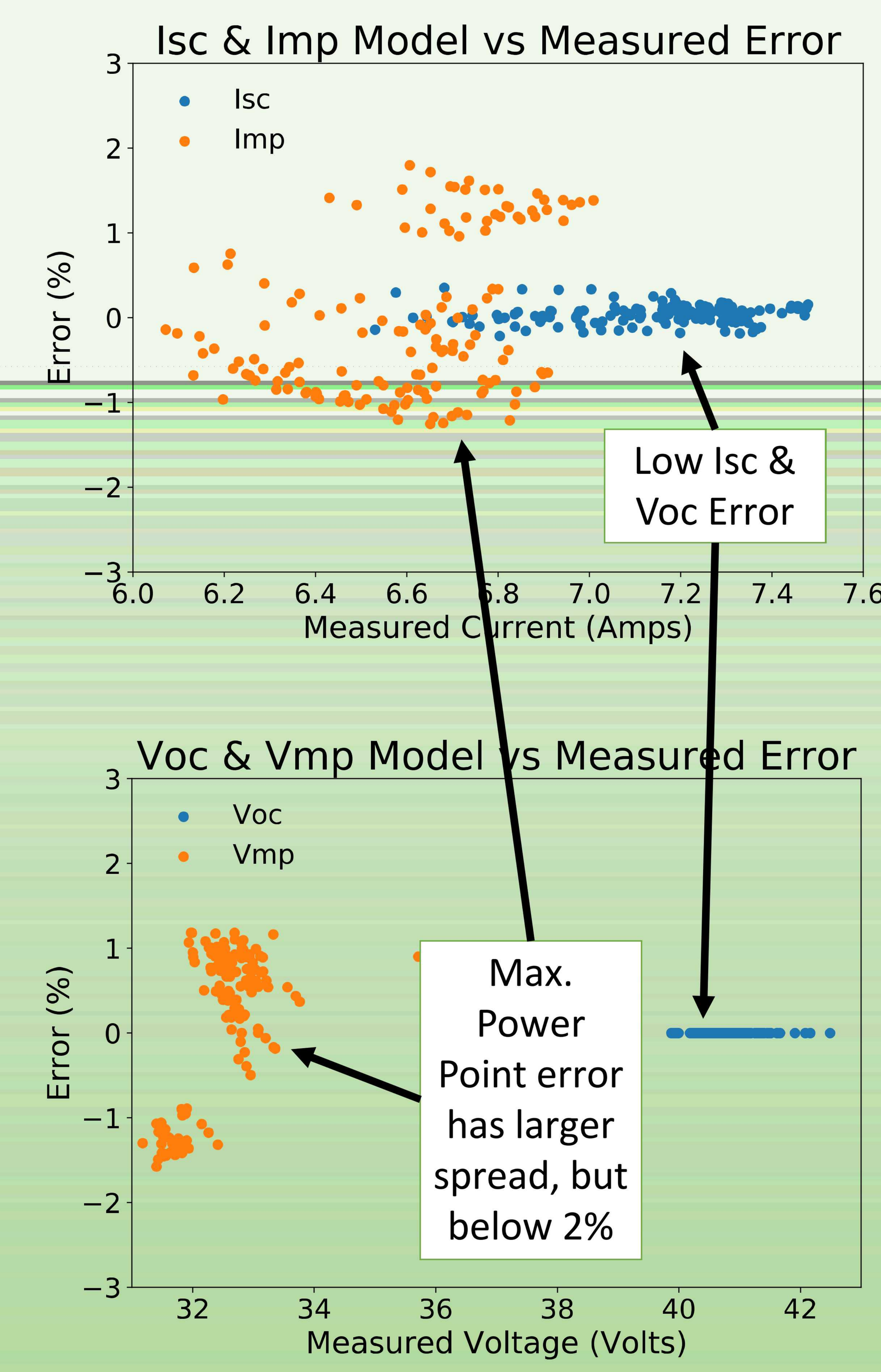


Step 2:

Reconstructed I-V curves from extracted parameters had low errors when compared with the known values.

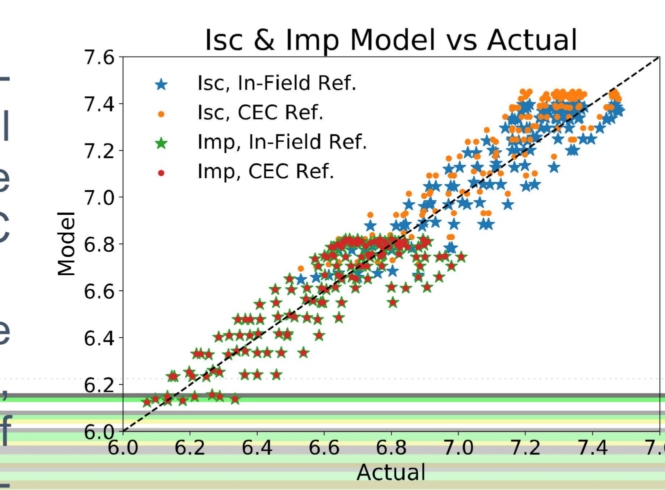


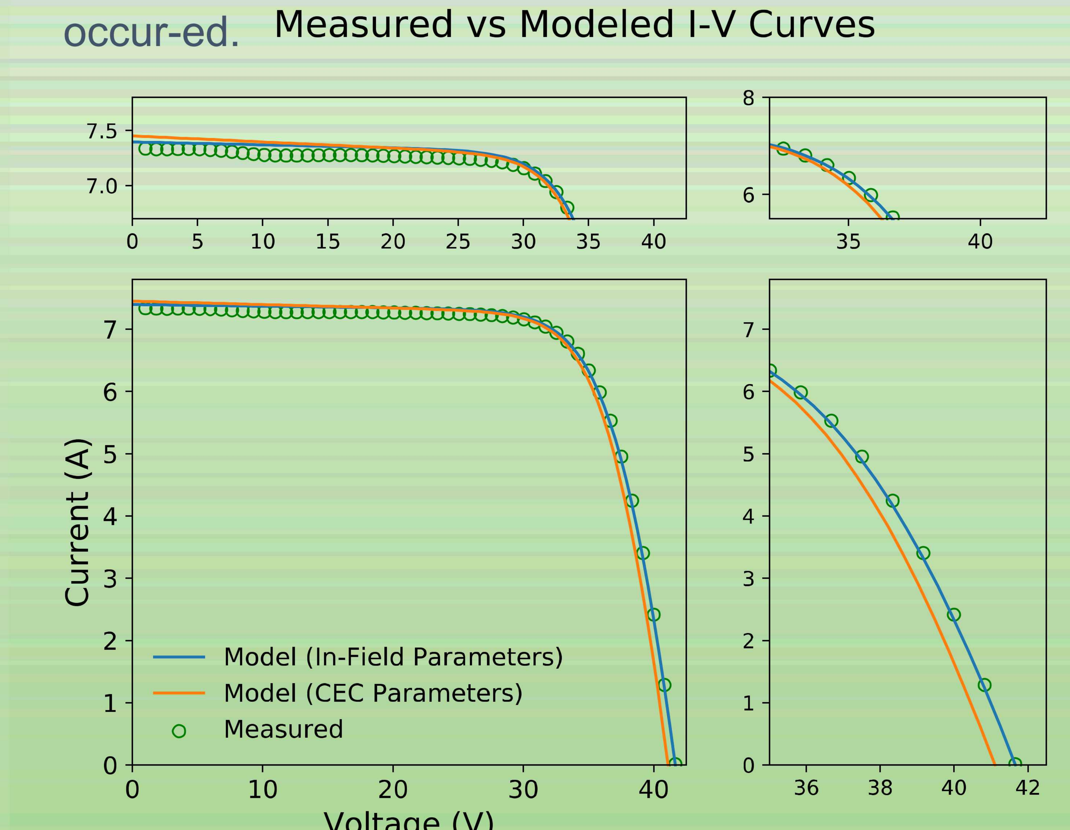
Performance Results



Model Results

Extracted parameters can model the PV module when the CEC database parameters are not available, inaccurate, or if significant degradation has occur-ed.





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