Cell-to-module conversion loss simulation for shingled-cell concept

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Abstract

The “shingled interconnection concept” applied to c-Si solar cells has been investigated since more than 26 years [1]; nonetheless little information about its implementation on module level is available in literature. The present work focuses on module design and cell-to-module conversion loss for embedding commercial 6-inch c-Si solar cells, with adapted metallization layout, into a module made out of cell stripes interconnected by the shingle concept. Results show an acceptable cell-to-module calculation accuracy, with an active area efficiency up to 3%rel higher than a module made of traditional front-to-back cell-to-cell interconnection. The S 1/5 concept improves efficiency up to 3% rel higher than a module interconnected by the shingle concept. The S 1/5 concept improves module design and cell-to-module interconnection. The S 1/5 concept improves efficiency up to 3% rel higher than a module connected by the shingle concept.

Approach

1.- Shingled-cell concept: full size area solar cell reduced in area by laser cutting next to the busbar (red dashes lines in Fig 1), resulting in stripes (pcs). 2.- The power loss for cell-to-stripe conversion is calculated by adapting equations for ohmic loss explained in [6]. 3.- Shingle string: stripes in series interconnected by overlapping the back of one stripe to the front side connection of the next one (Fig 2). Electrical conductive adhesive (ECA) is employed to ensure mechanical and electrical interconnection. 4.- Modules are manufactured by using 3.2 mm textured glass, EVA and transparent backsheet.

Simulation

Target: PPeak = 300 W, VMPP = 42 V

* Experimental: fit of 3-cell module experimental data extrapolated to 300Wp module or equivalent compared to its simulation

No significant gain or loss in power have been measured, yet the efficiency over active area increases with the numbers of pcs per wafer. Simulation results are in accordance with experimental data. Nevertheless, the medium needs to be improved by incorporating module geometry in the power loss and total area efficiency calculations. Reliability is needed to be tested for long “shingle-strings”. TC and DH pre-liminary tests (not showed in this poster) reveal that it’s possible to achieve power loss less than 5% by choosing an adequate ECA.

Summary

Improvement of FF at module level, specially for 1/5 shingle concept (2%abs higher), mainly due to low ohmnic power loss (R_{ohm})

Experimental results

Manufactured modules are 1-cell equivalent power

<table>
<thead>
<tr>
<th>Module group</th>
<th>S 1/4 REF</th>
<th>S 1/5 REF</th>
<th>S 1/5</th>
</tr>
</thead>
<tbody>
<tr>
<td>N: 4</td>
<td>4 busbars overlapped N: 3</td>
<td>5 busbars overlapped N: 5</td>
<td>5 busbars overlapped N: 5</td>
</tr>
<tr>
<td>Overlap (mm)</td>
<td>2.0</td>
<td>1.5</td>
<td>1.5</td>
</tr>
</tbody>
</table>

- High C2M J_{mpp} drop for S1/5 and 2.0 mm overlap (Fig 5).

Fig 3. Example of manufactured modules, a) S 1/4 REF, b) S 1/5, c) S 1/5

High FF at module level (Fig 4, 5) mainly due to a better V_{mpp} to V_{oc} ratio (Fig 6)

- High C2M J_{mpp} drop for S1/5 and 2.0 mm overlap (Fig 5).

Fig 5. C2M change in FF, J_{mpp}, V_{mpp} and V_{oc}

High FF deviation in stripes measurements due to contacting problems and cell homogeneity

Fig 6. FF change along module manufacture process

Fig 7. Cell-to-stripe-to-module change of P_{peak} and active area efficiency

Fig 8. Comparison of MPP current density over active area

Relative difference between simulation and experimental are in the range of error measurement (±1%). Nevertheless, the trend of simulation fits for shingled strings only.

References


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Approach

Fig 2. Lateral view of a so-called shingle string. ECA in green

For detailed stripe analysis check poster 2CV.2.44

Fig 1. Cell-to-shingle scheme