SOLUTION TO IMPROVE THE FAULT TOLERANCE OF SOLAR ARRAYS

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Introduction

The latest thin-film and crystalline silicon on glass (CSG) solar panel technologies can be modelled as individual 'sub-cells' interconnected with a resistance \( R \) as shown, right. This model was invented by Dr. Paul Basore at Pacific Solar. Dr. Basore’s idea was that \( R \) could be used to deal with short-circuit (s/c) and open-circuit (o/c) faults.

For an o/c, \( R \) should be small to allow the current to detour around the fault as shown below:

For a s/c, \( R \) should be large to prevent the current being ‘drained’ into the fault as shown below:

The problems

Mission 1:

In the future it may be possible for a larger variety of \( R \) values to be manufactured. Given a known expected density of s/c and o/c faults, what is the optimal value for \( R \) to maximise the power?

Mission 2:

Modern day thin-film and CSG manufacturers can implement up to three possible values for \( R \): 1 ohm, 100 ohms and removing \( R \) altogether (\( R = \)), the latter of which is a bit more expensive. The panels are more susceptible to s/c faults than o/c faults but it is unknown by how much. Which value for \( R \) should they implement?

The computer model

Java programs control the different types of simulations required. This involves rewriting and saving text files, implementing algorithms, randomly selecting fault positions and calling Matlab and Star-HSpice in batch mode.

The results

Mission 2:

Contour plots for each \( R \) value show the percentage of power lost at various densities of s/c and o/c faults in the array:

- \( R = 1 \)
- \( R = 100 \)

In the comparison graph above, it’s Blue where \( R = 100 \) is better and Red where No R is better. However, when the extra cost of No R is considered, \( R = 100 \) is always better.

Since there is likely to be higher s/c densities, \( R = 1 \) is eliminated. Too much draining of the current occurs in the s/c faults as shown with the ridges below left in a graph of the individual sub-cell power.

The graph above right shows that at \( R = 100 \), the draining is kept to the vicinity of the s/c sub-cells and not along the row.

The conclusion

It has been quantified how an interconnecting resistance \( R \) can be used to minimise the power lost due to faults in thin-film and CSG solar panels.

If the likely densities for s/c and o/c faults are known, an optimum value for \( R \) can be looked up in the graph on left.

When there are more s/c faults than o/c faults, the highest power is obtained from using \( R = 100 \) instead of \( R = 1 \) or removing \( R \) altogether and factoring in extra cost.