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Objective



Main objective: increase the lifetime of PV panels to 40 years

- The National Academy of Engineering defined challenges, for the 21st century. One of these challenges is to “Make Solar Energy Economical”
- The 20-20-20 European Union climate and energy package suggests to increase the lifespan of the photovoltaic panels up to 40 years

- Introduction
- Faults
- Experimentation apparatus
- Fault diagnosis
- Conclusion

PV Panels lifespan increase - Bechara NEHME

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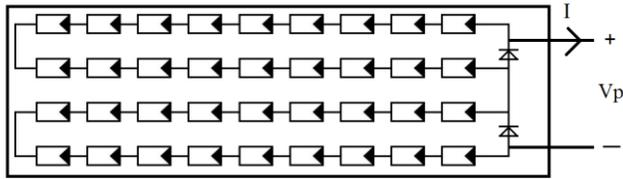
Problematic: The lifespan of PV panels is 20-25 years

- Efficiency decreases rapidly with ageing
- recent observations showed that PV faults and defaults may lead to undesirable conditions like fire
- faults may lead to increase fault effects or lead to other faults formation

Solution:

- We intend to propose a smart way of using PV panels
- Manly using diagnosis algorithm to detect faults in PV panels
- Model-based diagnosis methods

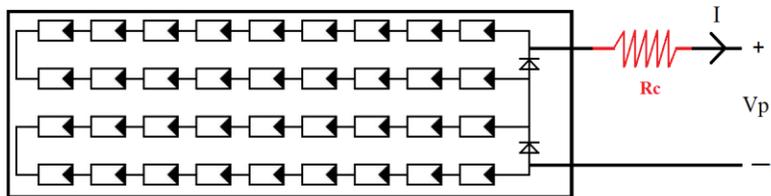
A residue is generated upon comparing the real value measured from the system and a simulated value generated from the system model



$$I = I_{sc} - I_{01} \left(\exp \left(\frac{q \left(\frac{V_{pv}}{N_s} + R_s I \right)}{KT} \right) - 1 \right) - I_{02} \left(\exp \left(\frac{q \left(\frac{V_{pv}}{N_s} + R_s I \right)}{2KT} \right) - 1 \right) - \frac{\left(\frac{V_{pv}}{N_s} + R_s I \right)}{(N_s) R_{sh}}$$

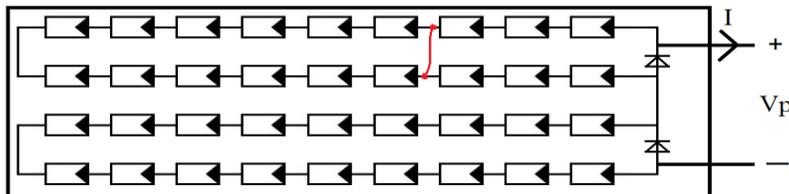


Interconnect and connection



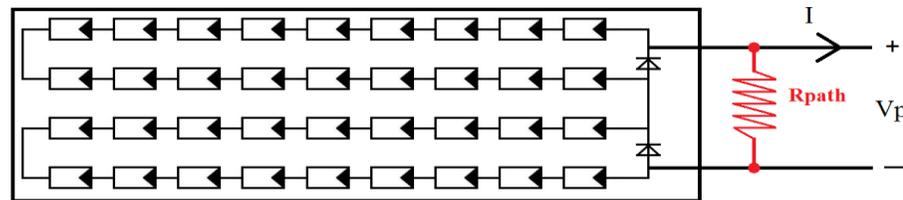
$$I = I_{sc} - I_{01} \left(\exp \left(\frac{q \left(\frac{V_{pv}}{N_s} + (R_s + R_c) I \right)}{KT} \right) - 1 \right) - I_{02} \left(\exp \left(\frac{q \left(\frac{V_{pv}}{N_s} + (R_s + R_c) I \right)}{2KT} \right) - 1 \right) - \frac{\left(\frac{V_{pv}}{N_s} + (R_s + R_c) I \right)}{(N_s) R_{sh}}$$

Bridge and earth



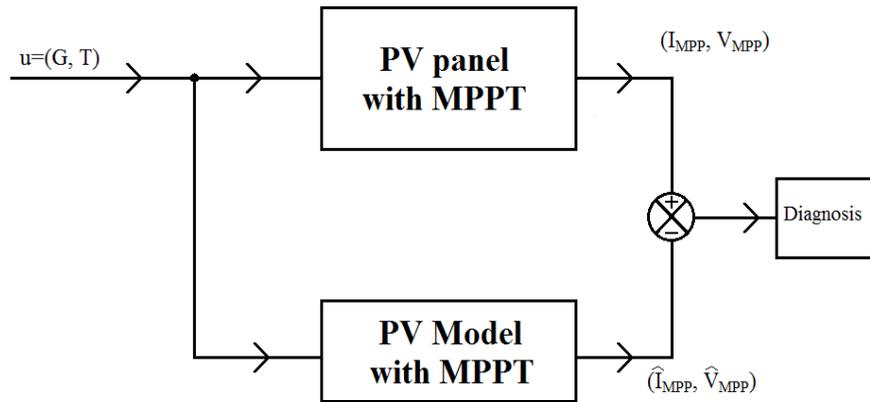
$$I = I_{sc} - I_{01} \left(\exp \left(\frac{q \left(\frac{V_{pv}}{N_s - n} + R_s I \right)}{KT} \right) - 1 \right) - I_{02} \left(\exp \left(\frac{q \left(\frac{V_{pv}}{N_s - n} + R_s I \right)}{2KT} \right) - 1 \right) - \frac{\left(\frac{V_{pv}}{N_s - n} + R_s I \right)}{(N_s - n) R_{sh}}$$

Shunt path development



$$I = I_{sc} - I_{01} \left(\exp \left(\frac{q \left(\frac{V_{pv}}{N_s} + R_s I \right)}{KT} \right) - 1 \right) - I_{02} \left(\exp \left(\frac{q \left(\frac{V_{pv}}{N_s} + R_s I \right)}{2KT} \right) - 1 \right) - \frac{\left(\frac{V_{pv}}{N_s} + R_s I \right)}{N_s R_{sh}} - \frac{V_{pv}}{R_{path}}$$

Residue Model



Connection and interconnect fault

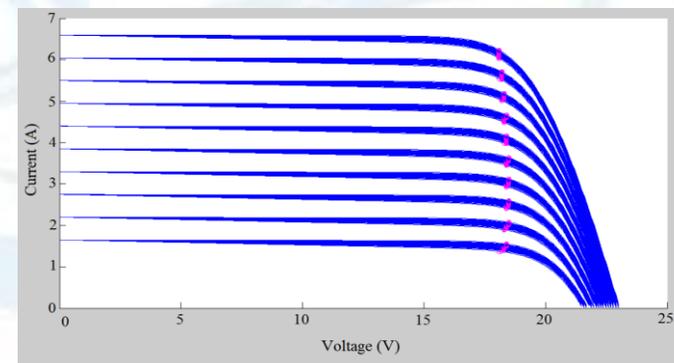
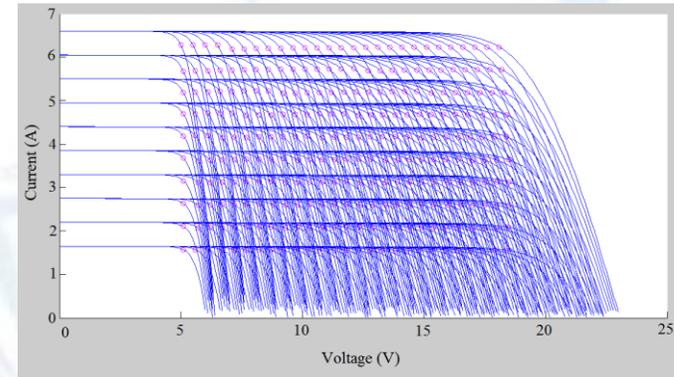
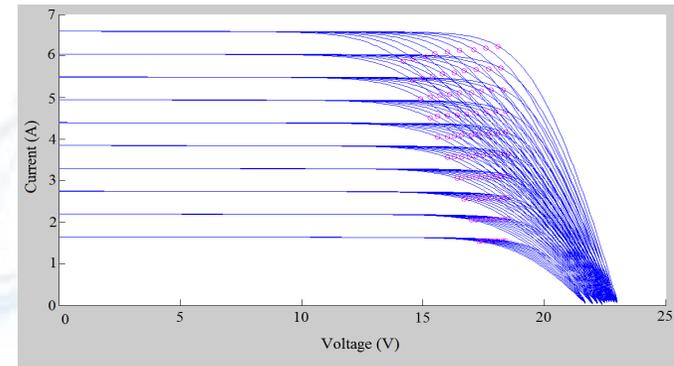
$$I = f(R_c)$$

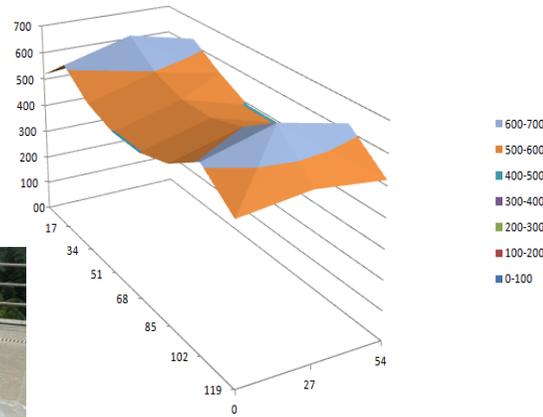
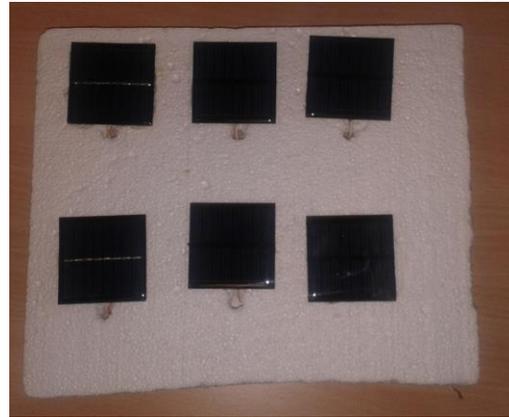
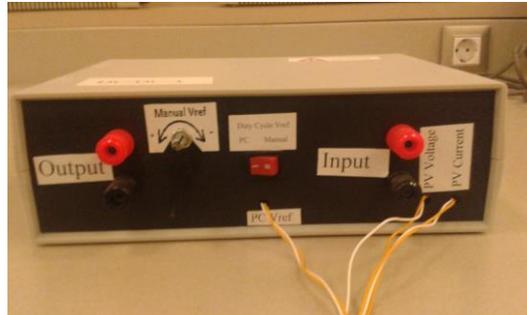
Bridge and earth fault

$$I = f(n)$$

Shunt path development

$$I = f(R_{path})$$





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$$\% \Delta I = \frac{\widehat{I_{MPP}} - I_{MPP}}{\widehat{I_{MPP}}}$$

$$\% \Delta V = \frac{\widehat{V_{MPP}} - V_{MPP}}{\widehat{V_{MPP}}}$$

- H0: Normal Situation

%DV=0 and %DI=0

- H1: Interconnect and connection fault

%DV≠0 and %DI≠0

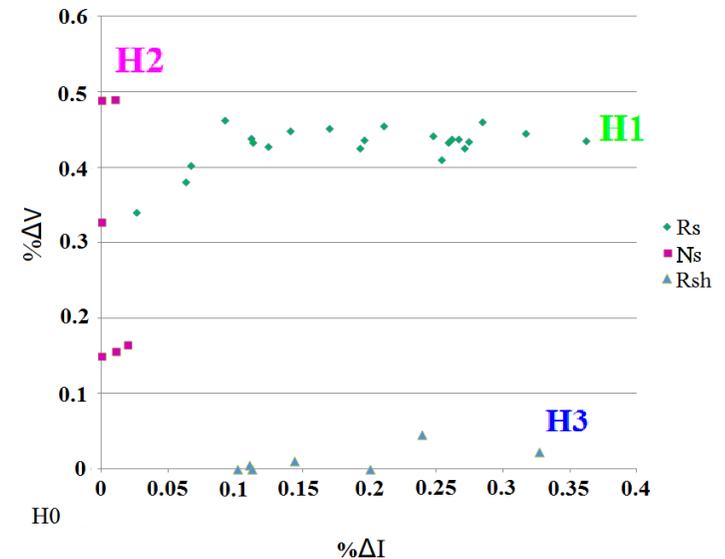
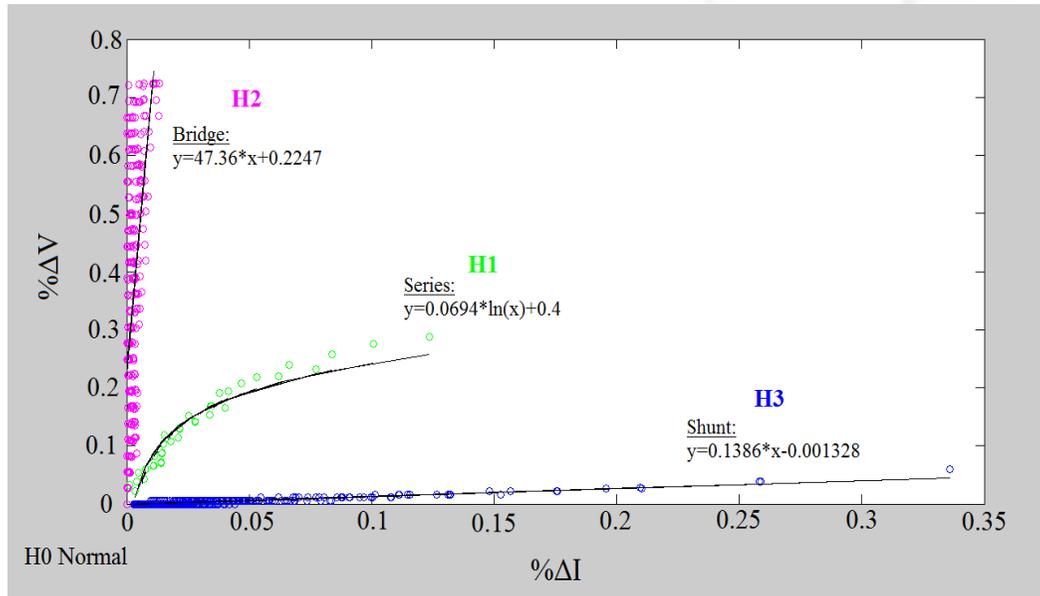
- H2: Bridge and earth fault

%DV≠0 and %DI=0

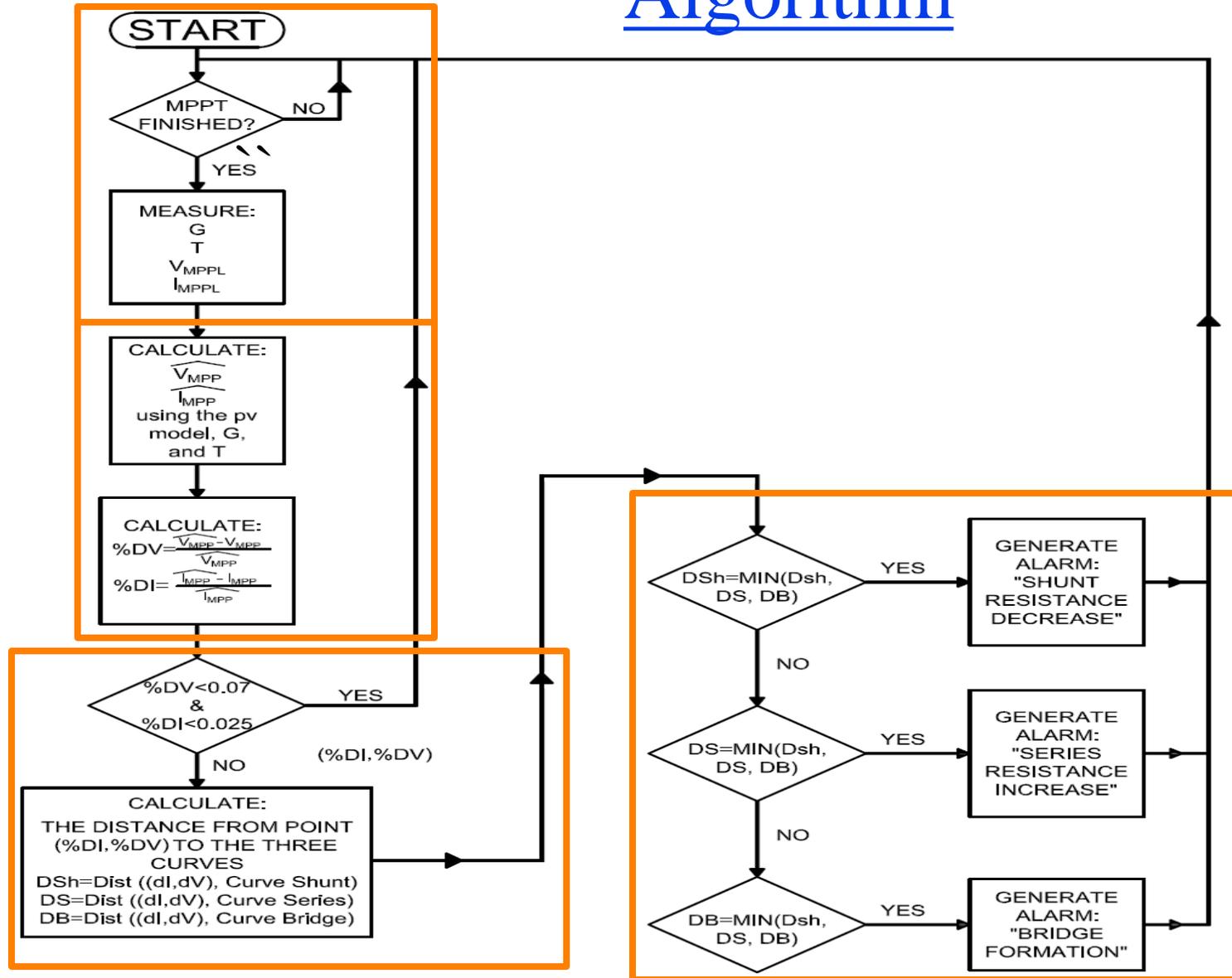
- H3: Shunt path development fault

%DV=0 and %DI≠0

Faults Validation



Algorithm



Conclusion



- ✓ Characterization of faults
- ✓ Validated each fault signature
- ✓ Contributed to their detection

Short term perspectives

- Validate our algorithm using real hardware apparatus
- Extend the algorithm to other faults

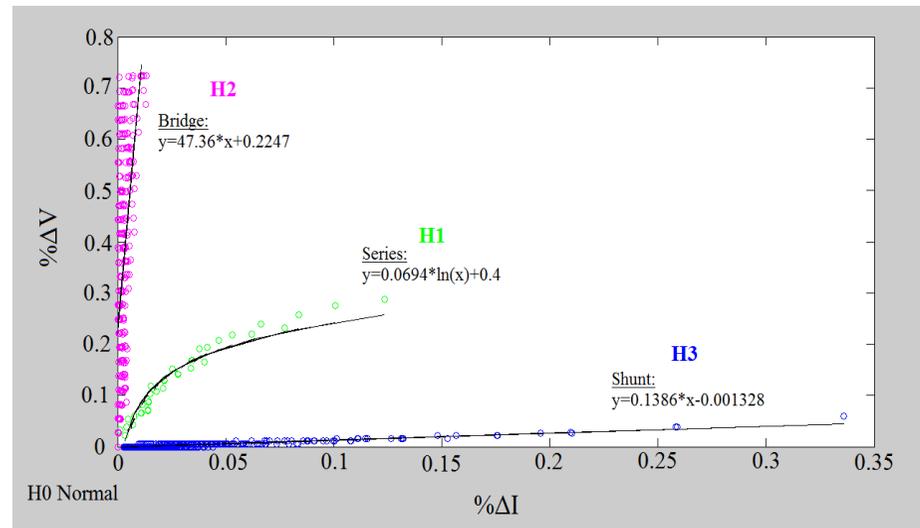
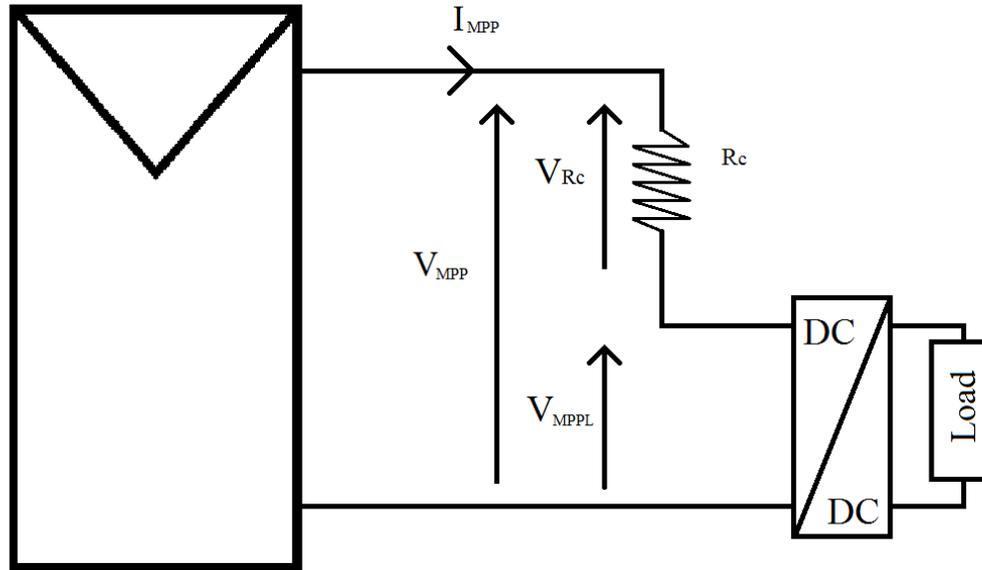
Long term perspectives

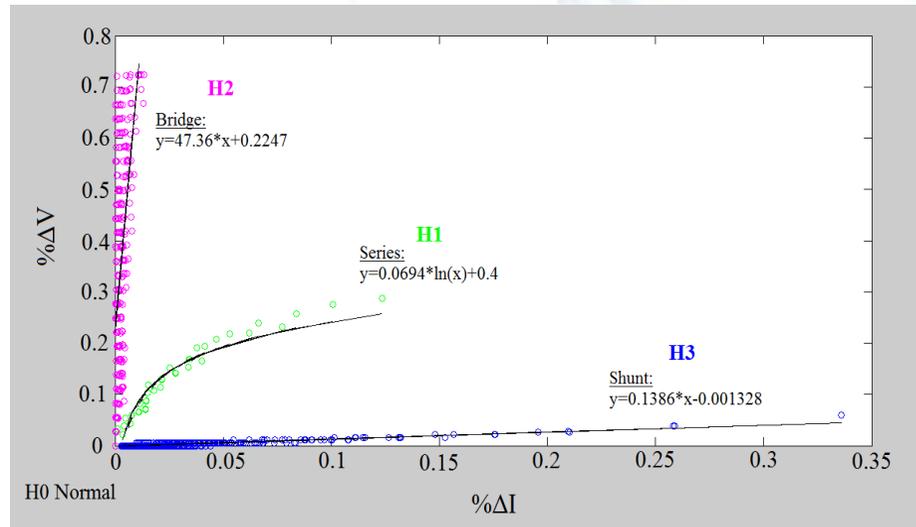
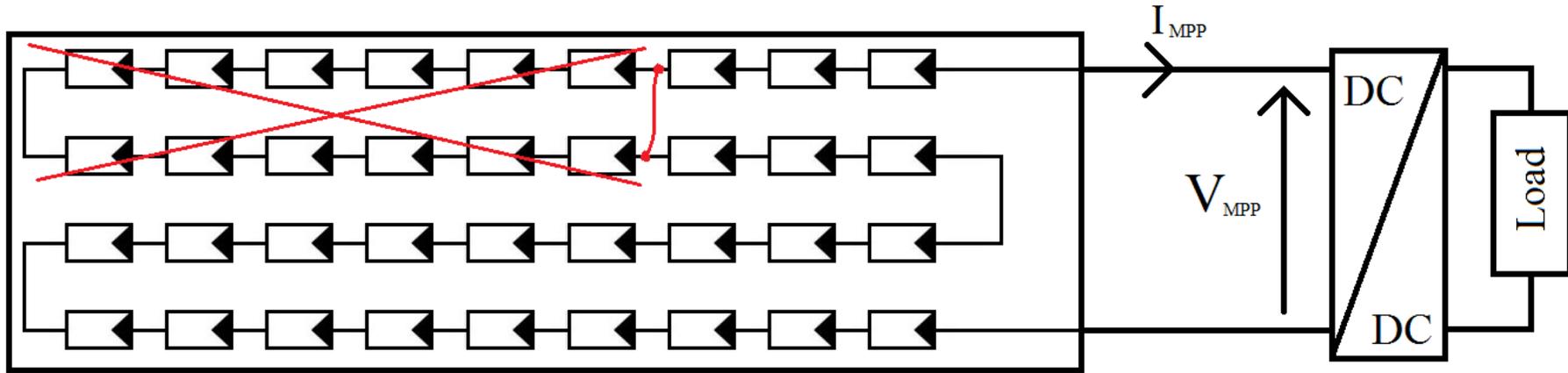
- Extend our approach to RES (Wind turbines, batteries)
- How to integrate faults detection in EMS (energy management systems)

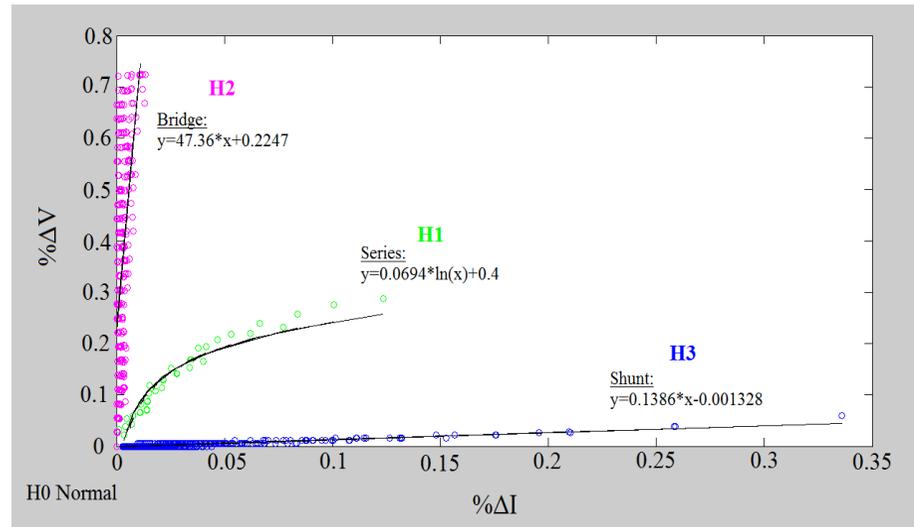
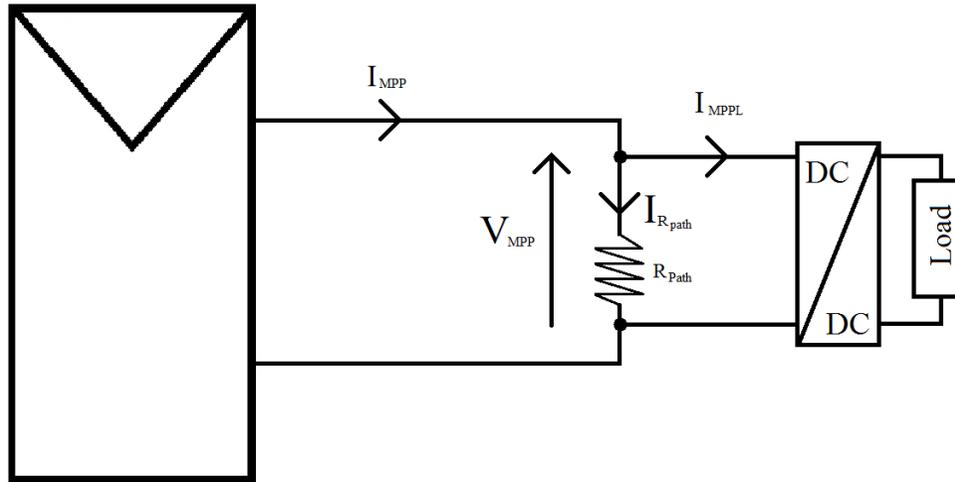


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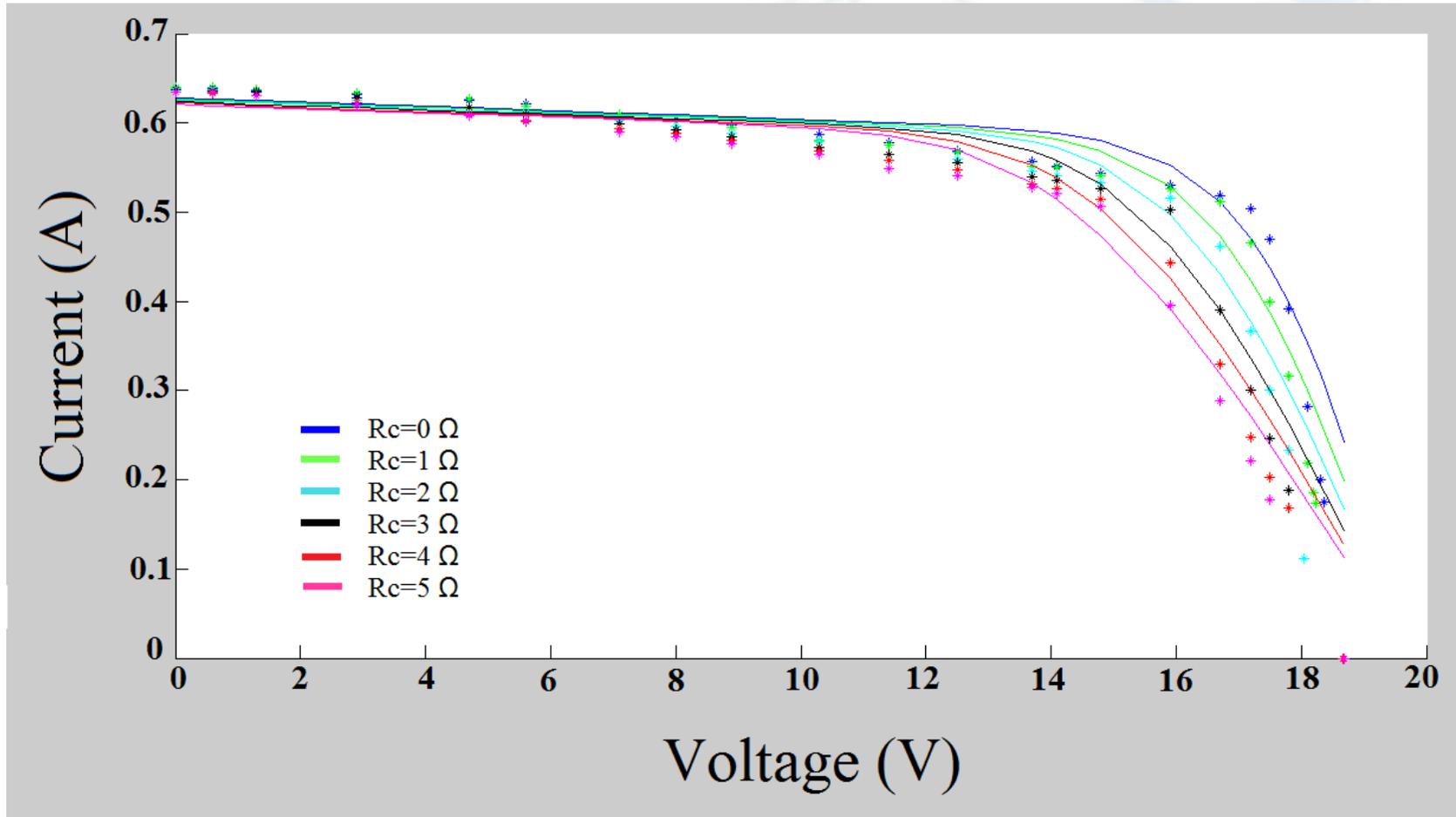
Additional Slides

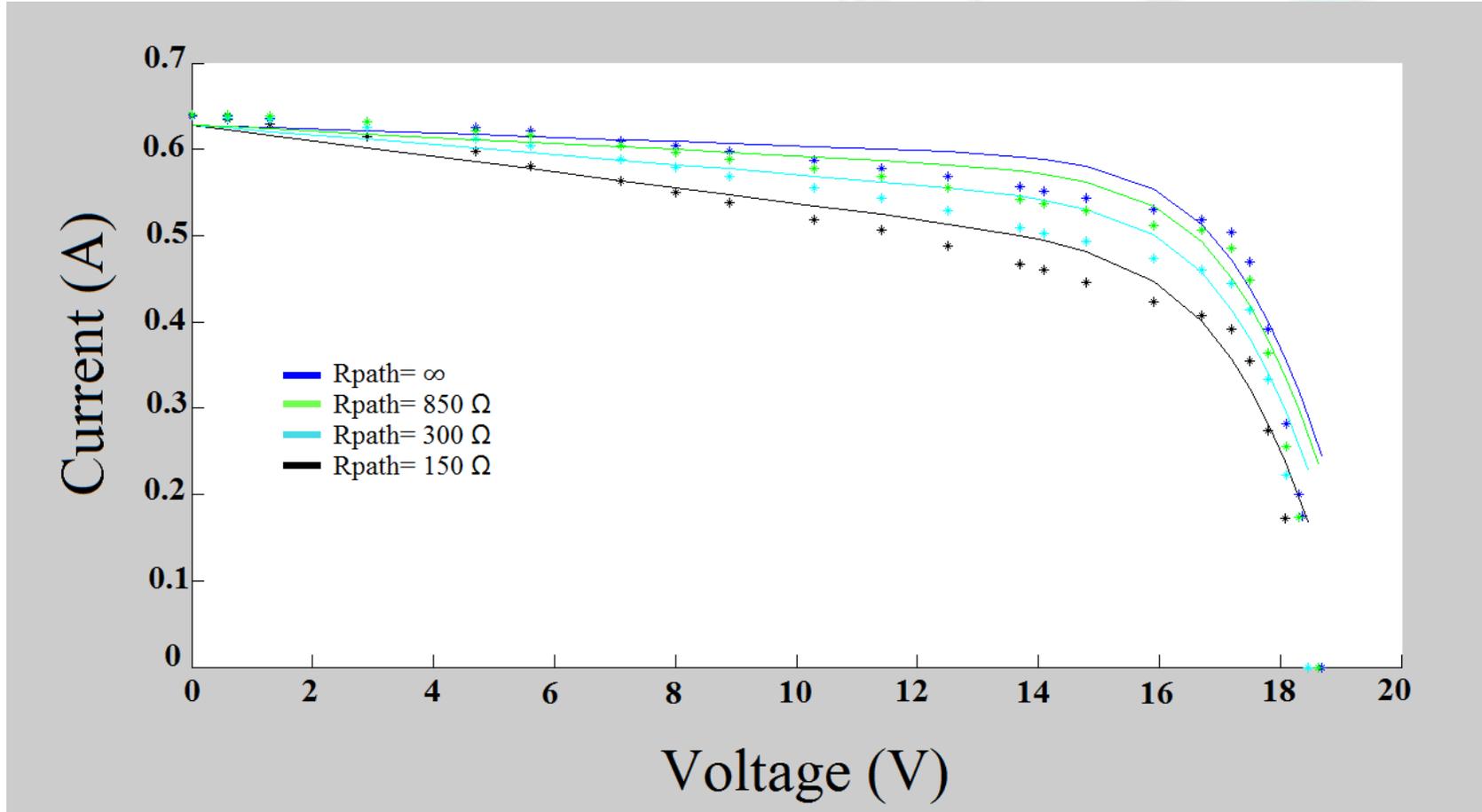
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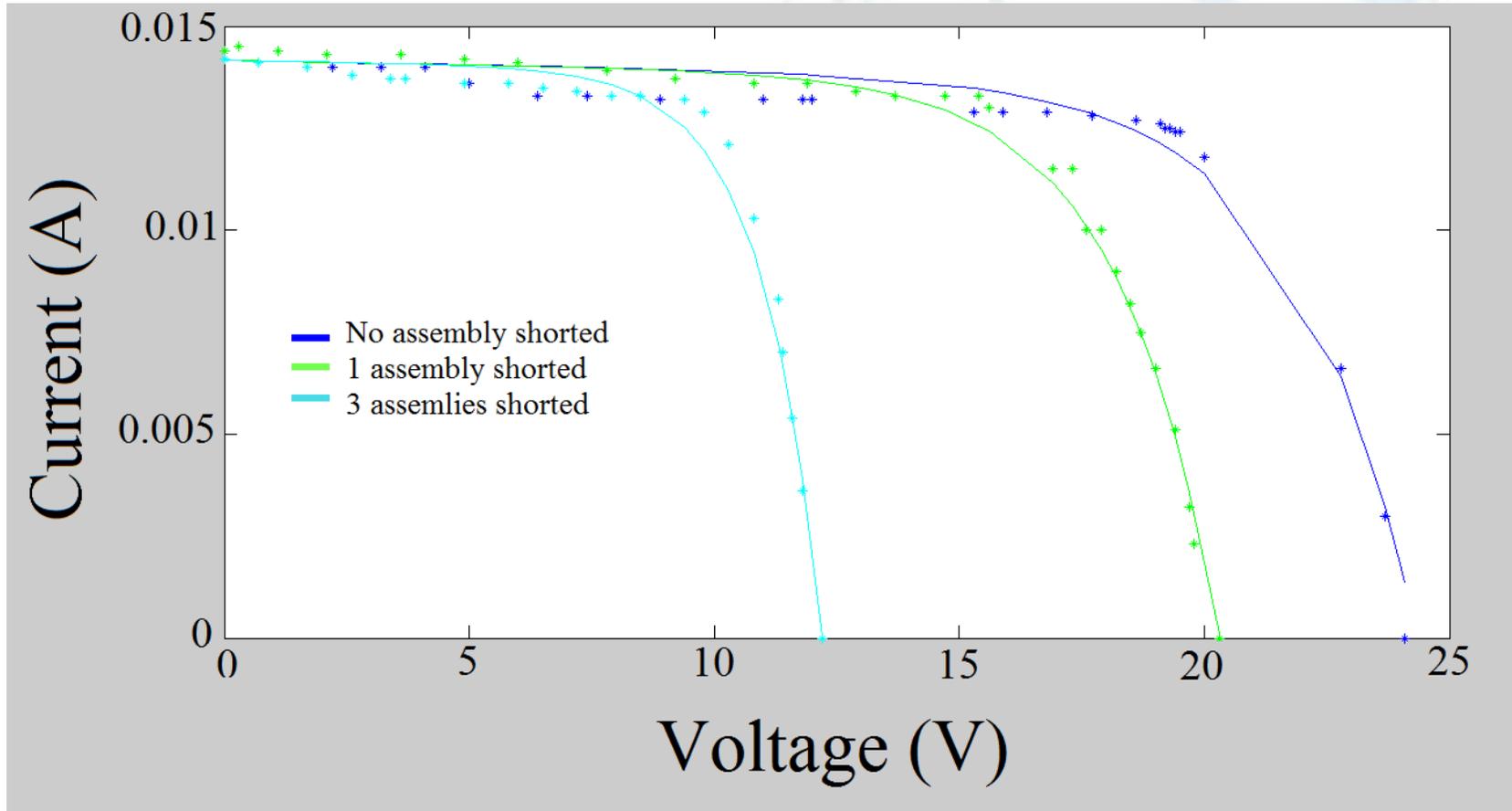
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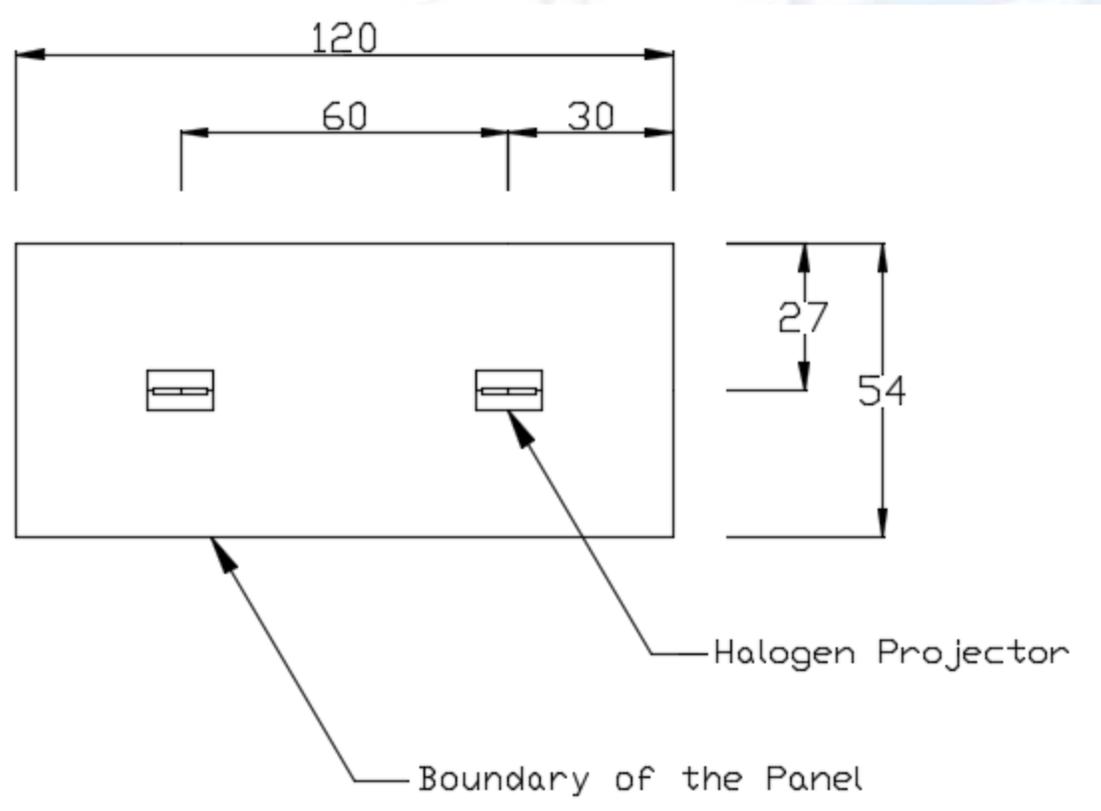
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Fault	Effect on I-V curve	Effect on Equivalent circuit
Interconnect and connection faults	Decrease of the slope near Increase in R_s V_{oc} , Power decrease	Increase in R_s
Bridge and earth fault	Voltage decrease	Decreases in N_s
Shunt path development	Increase of the slope near I_{sc}	Decrease in R_{sh}







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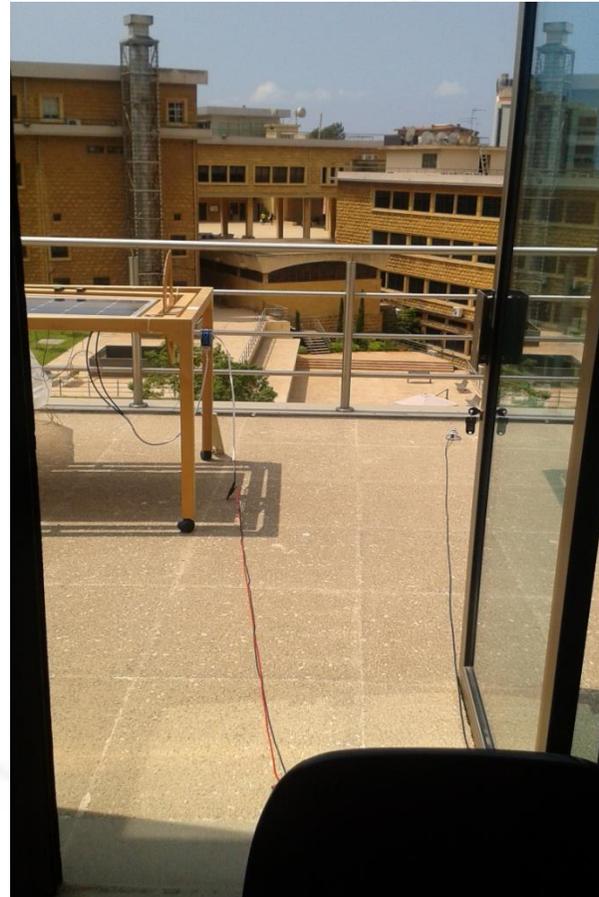
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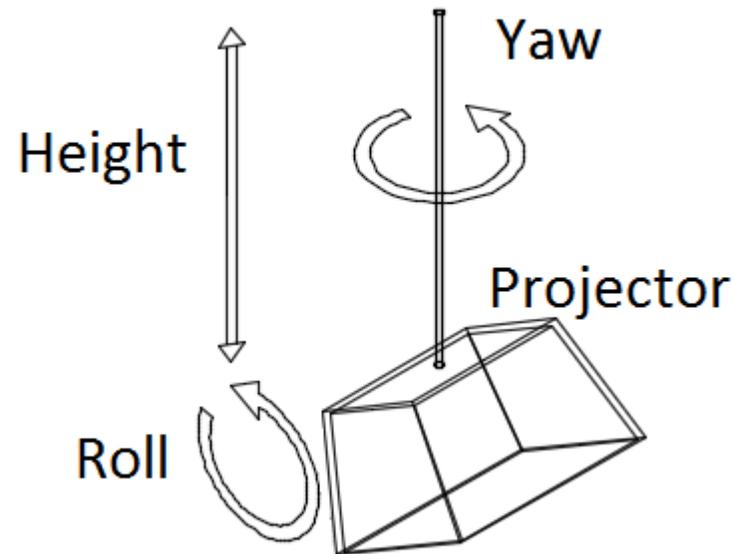


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