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PV Safety, Arcing & Fusing

- PV Arcs & their properties

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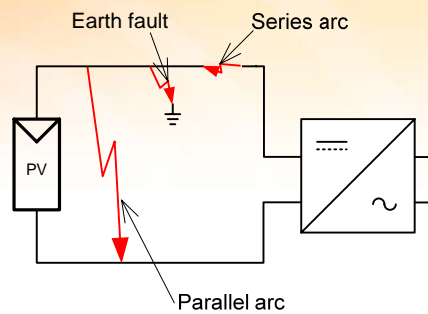
www.ceem.unsw.edu.au



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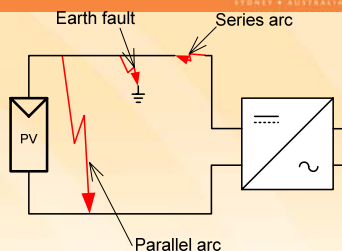


DC Arcs in PV arrays What types of situations?





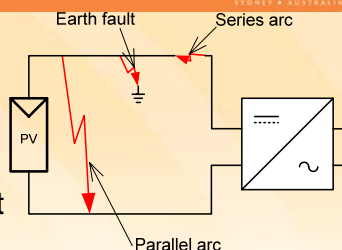
DC Arcs in PV arrays What types of situations?



- **Parallel fault** due to breakdown in insulation between + and – due to eg mechanical damage, aging or rodent damage.
- **Earth fault** in systems that are earth referenced or have a transformerless inverter
- **Series arc** due to a bad connection or a break in the wiring



Parallel Fault

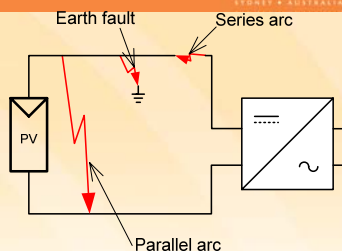


- **Parallel fault** is obviously the most dangerous as the entire array could feed the fault. Maximum voltage and maximum current available.



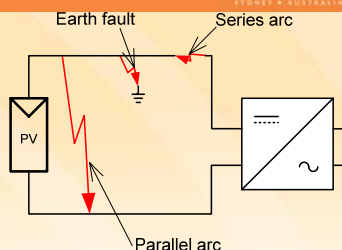
Earth Fault

- **Earth fault** is also very dangerous depending on the array configuration and the actual situation the entire array could feed the fault. Maximum voltage and maximum current could be available.



Series Fault (break)

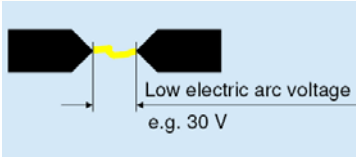
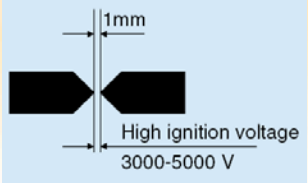
- **Series arc** –Generally less energy available to it than the parallel arc but:
- A **Series arc** is a much higher probability event due to the number of connections in an array.
 - If an arc develops in only one string the consequences are less than if it were in the array output cable connections



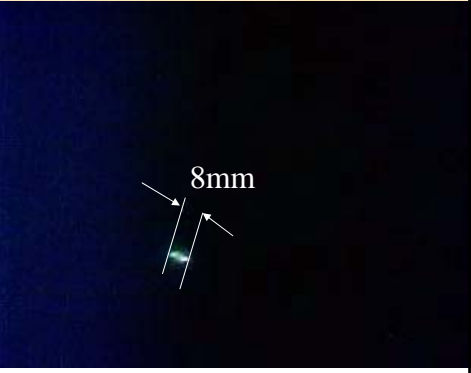

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ARCS

- Small gap with no breakdown will support a high voltage
- Once struck an arc will burn with relatively low voltage drop.



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48V nominal 2 strings 48V nominal 1 string

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Arc Characteristics

(a) Cathode, Region A, Region B positive column, Electrons, Positive ions, Anode +

Electrons emitted in great number thermionically or from cathode spot

(b) Voltage, Region A, Region B

3000 °C - 7000 °C

Source: www.arcadvisor.com/faq/dc_direct_current_arc.html

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Arc Characteristic Curves

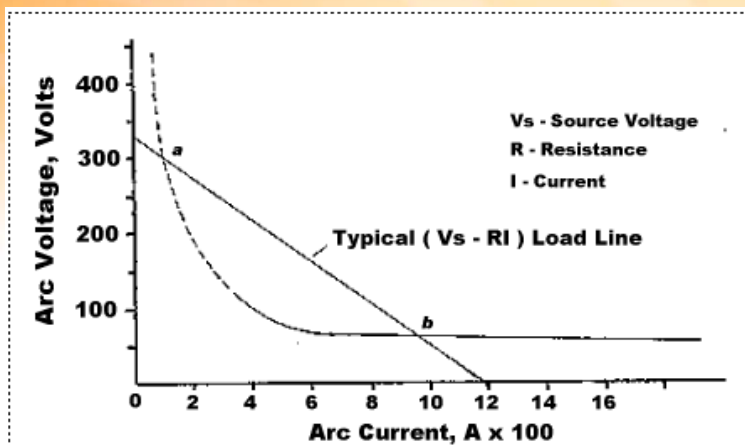
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Arc Operating Point



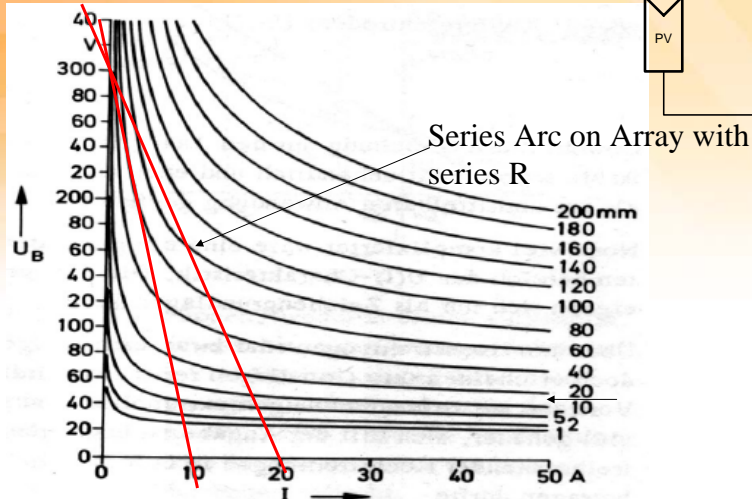
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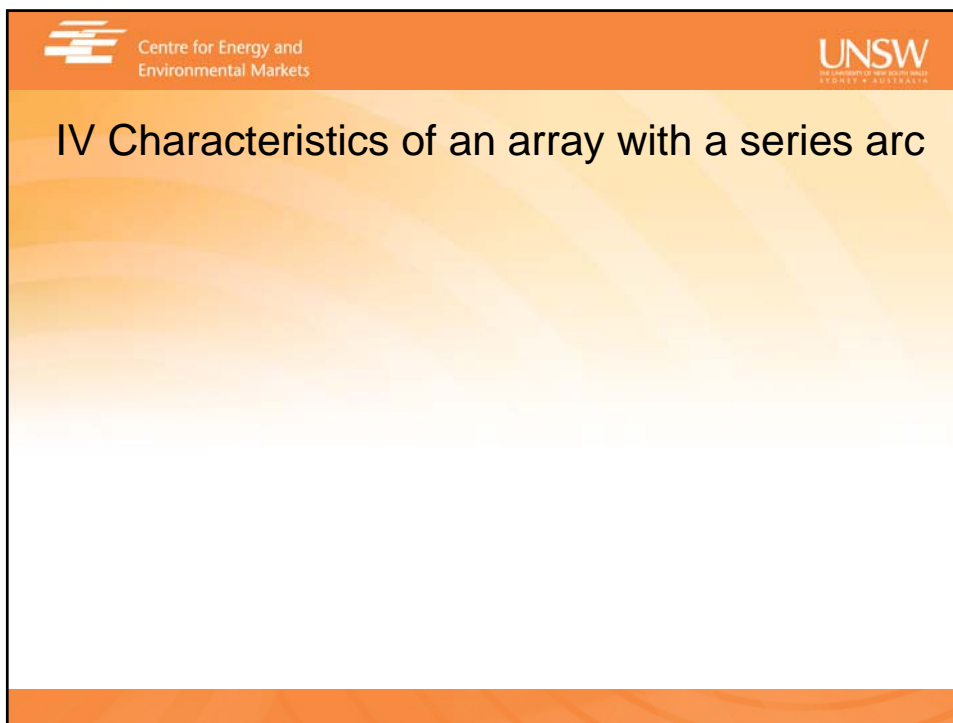
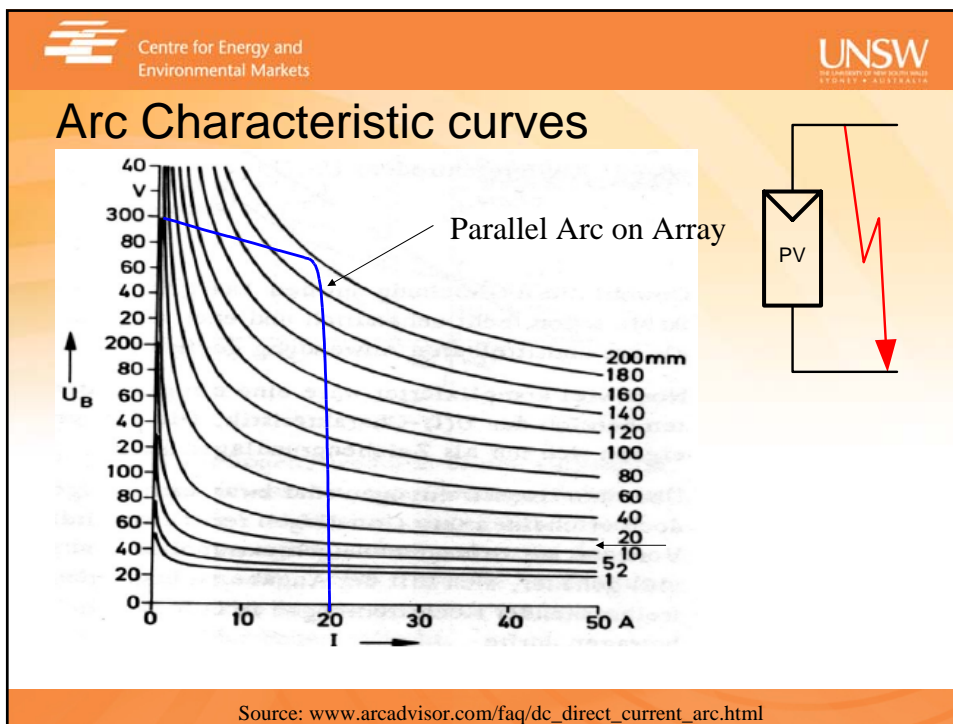
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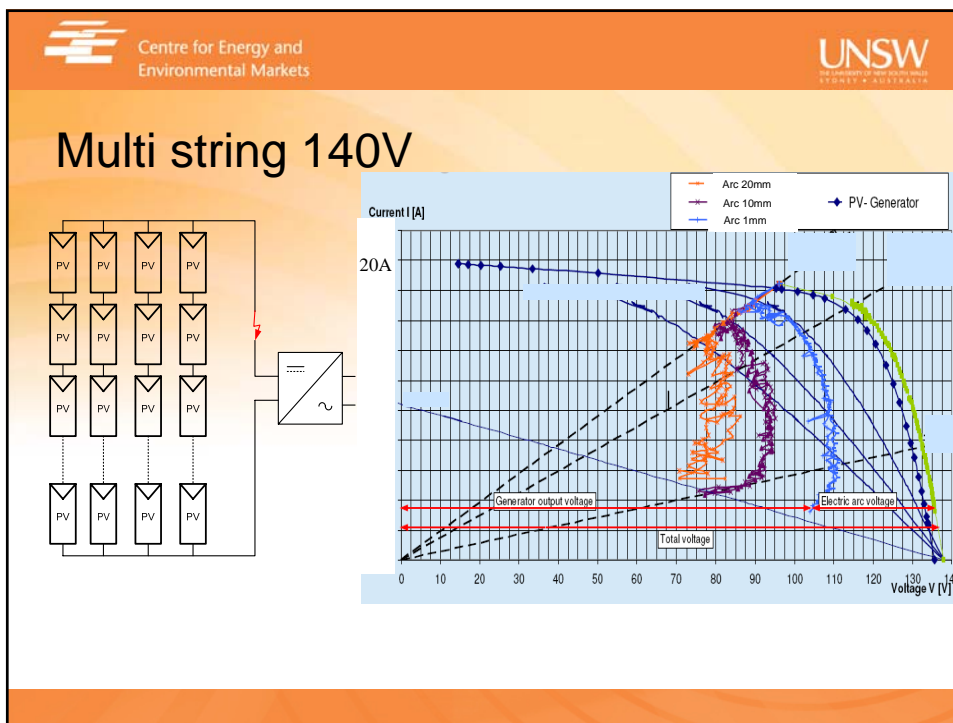
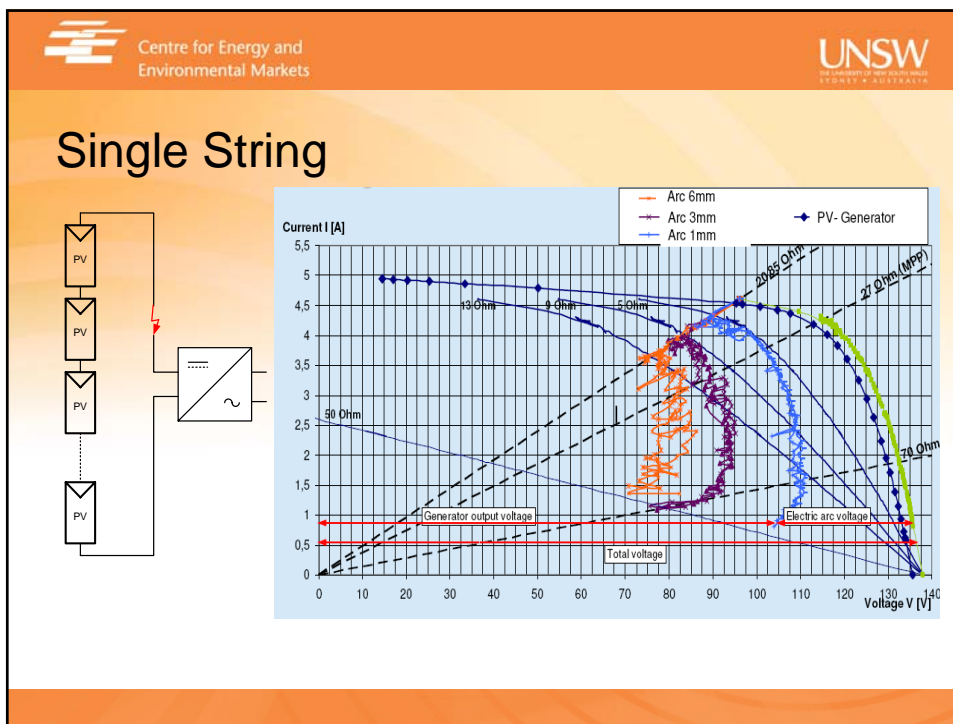


Arc Characteristic curves



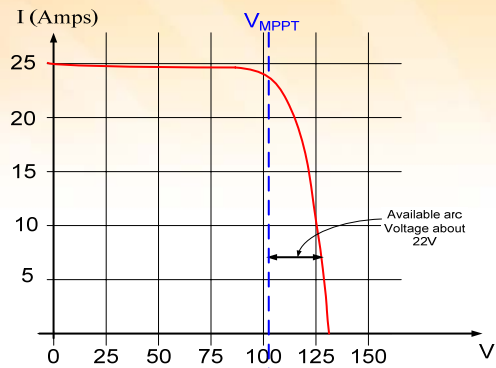
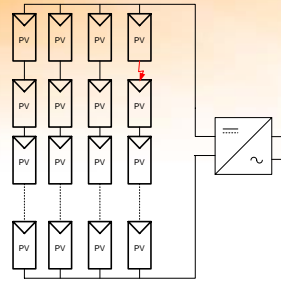
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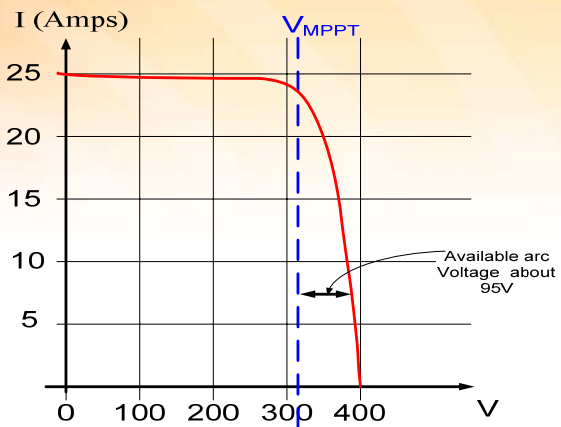
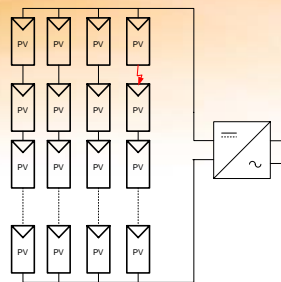


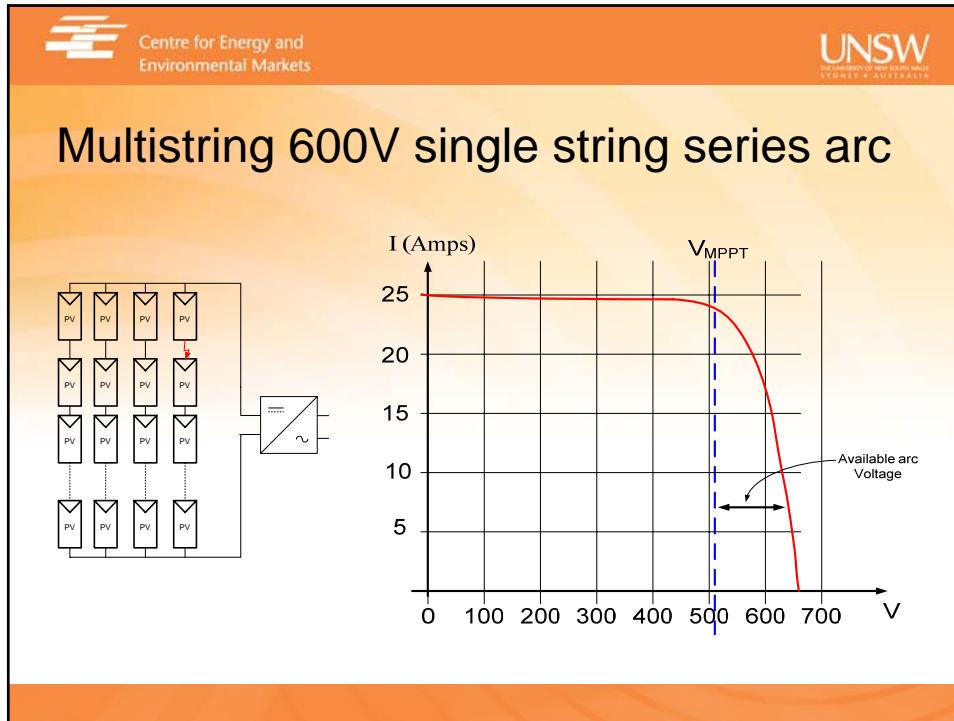


Multistring 140V single string series arc



Multistring 400V single string series arc





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- Arc Conclusions**
- Arcs of any type are a real problem
 - Series arcs are the most probable
 - Earth faults and parallel faults very dangerous if they occur.
 - Severity of arc related to:
 - location in array
 - Voltage and current available