



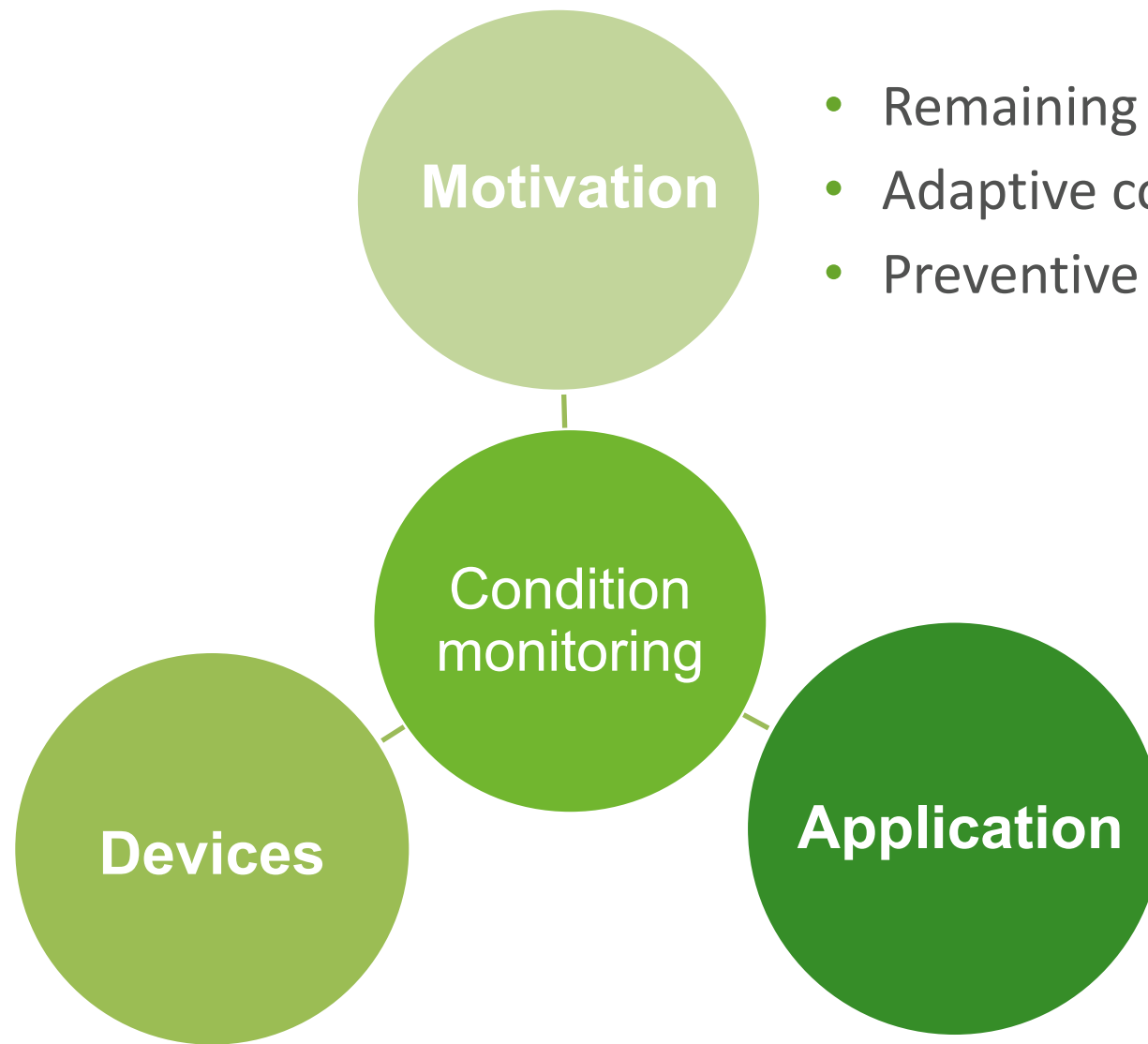
Real-Time TSEP and Model Based Condition Monitoring for PV Inverter Applications

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EnergyVille – A Flemish joint research center by KU Leuven, VITO, imec and UHasselt

- EnergyVille is a collaboration between four Belgian research partners in the fields of sustainable energy and intelligent energy systems.
- EnergyVille develops technology and knowledge to support public and private stakeholders in the transition to an energy efficient, decarbonised and sustainable urban environment.





- Remaining useful lifetime
- Adaptive control
- Preventive maintenance

- **Switching devices**
- Capacitors
- PCB, connections, etc...

- Constant mission profile
- **Highly variable mission profile**

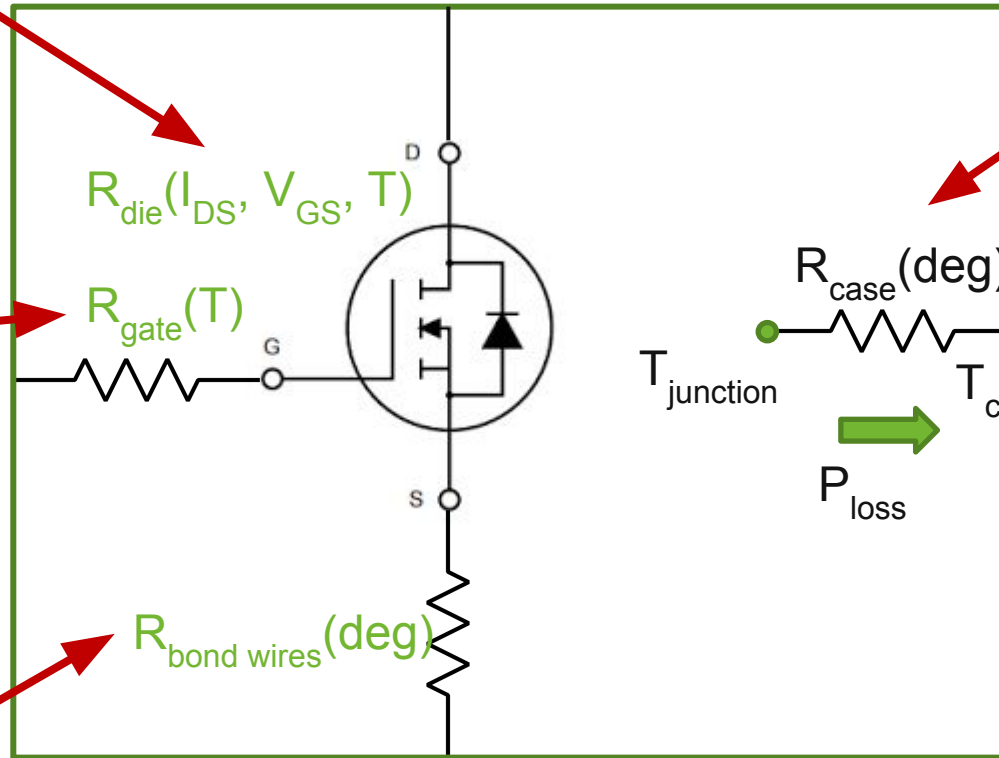
[1, 2]

Condition monitoring of switching devices

Die resistance only dependent on temperature, current and voltage
(no chip level degradation)

Gate resistance only temperature dependent
(no gate oxide degradation)

Resistance increases with bond wire degradation (cracking and lift-off)



Thermal resistance junction to case increases with solder layer delamination

nonlinearities due to radiation and convection

Condition monitoring of switching devices

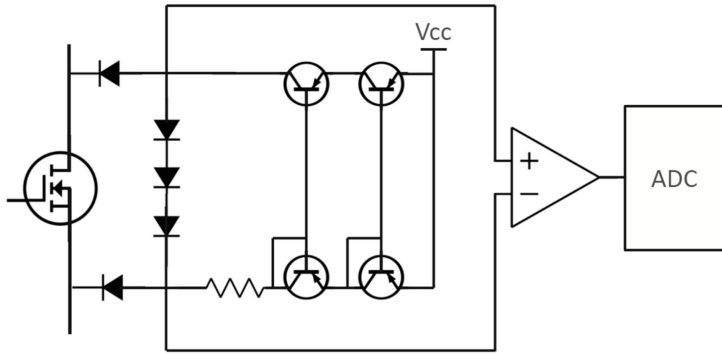
$R_{DS(on)}$ as main condition monitoring parameter

- Under complex mission profiles the $R_{DS(on)}$ measurement alone cannot distinguish between normal temperature fluctuations and actual damage to **bond wires** and **die attach solder layer**
- Two solutions
 1. **Implement an additional measurement only sensitive to temperature**
 2. **Compare the measured results with a digital twin**

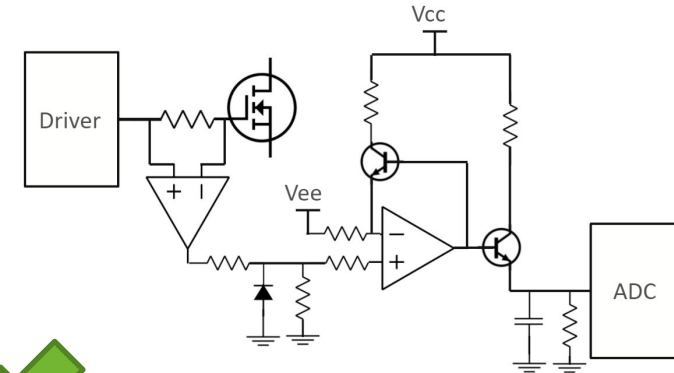


Measurements implementations

$R_{DS(on)}$ measurement

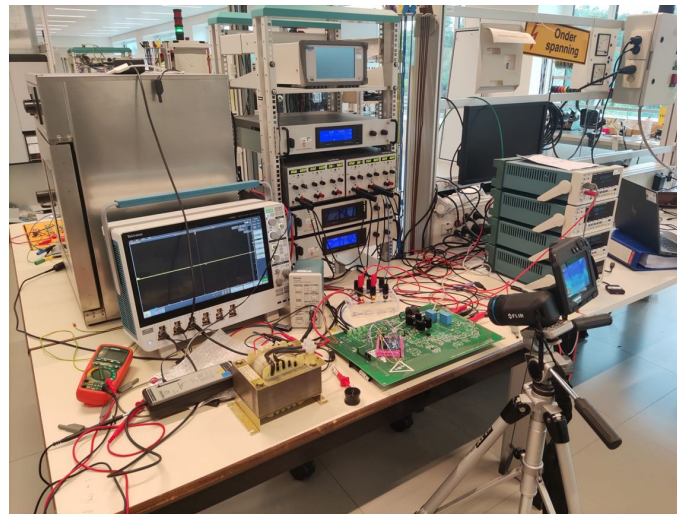
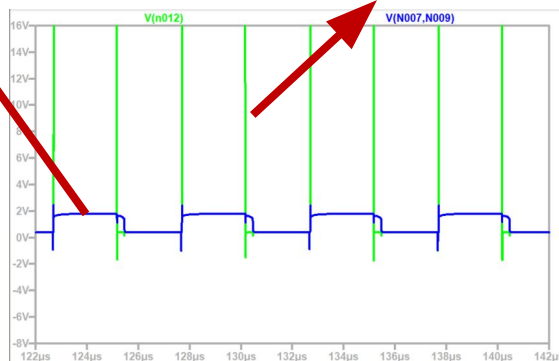


I_{gate} peak measurement



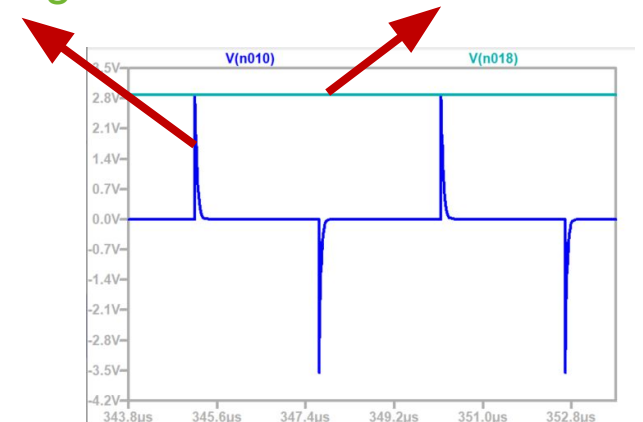
Clipped voltage

Drain to source voltage

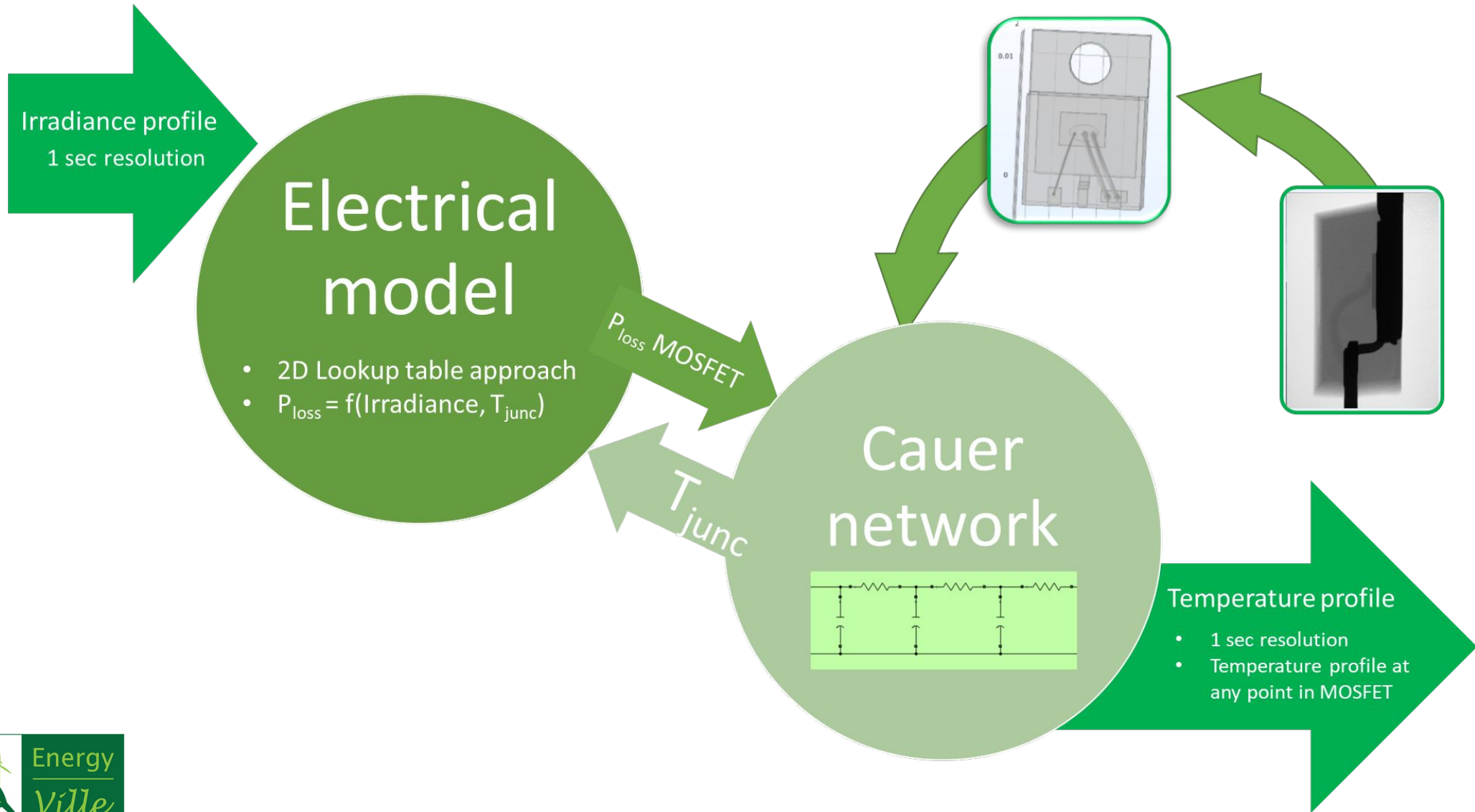


Shunt resistor voltage

Peak detector output

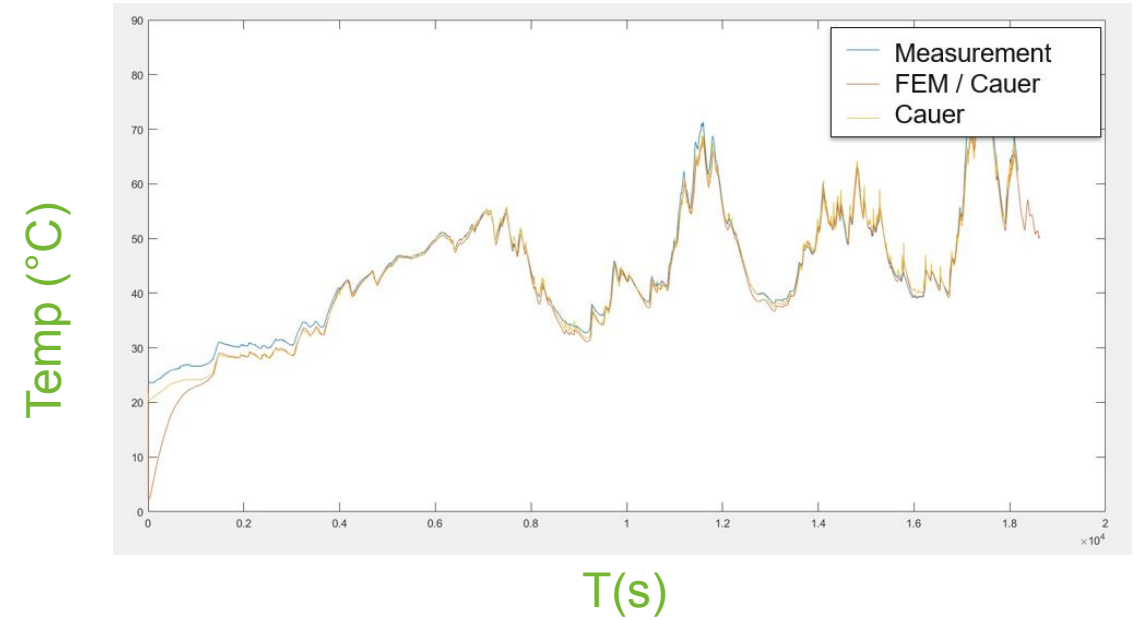
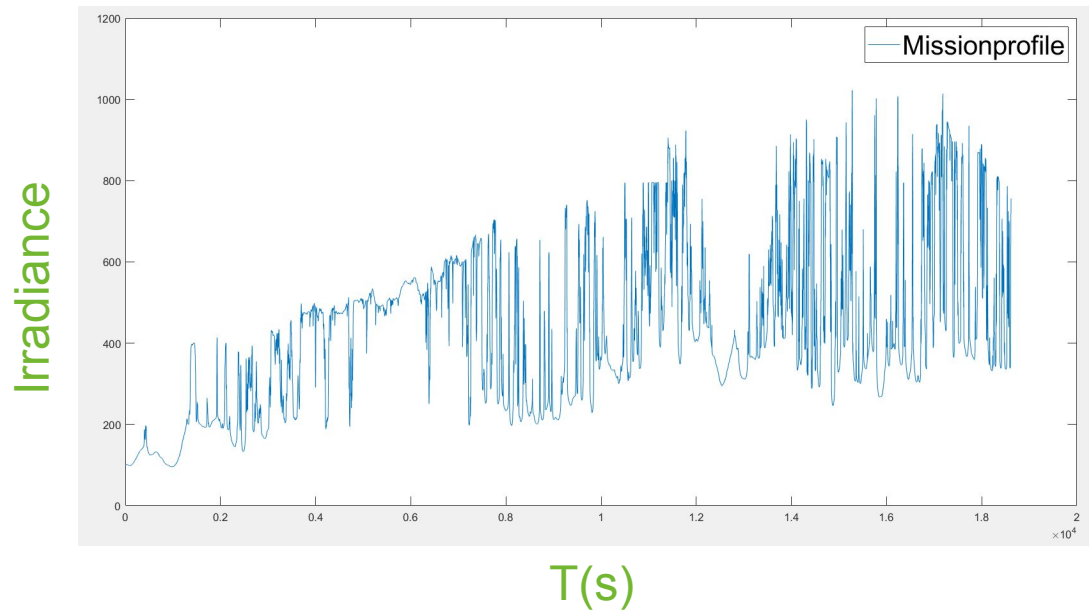


Converter modeling

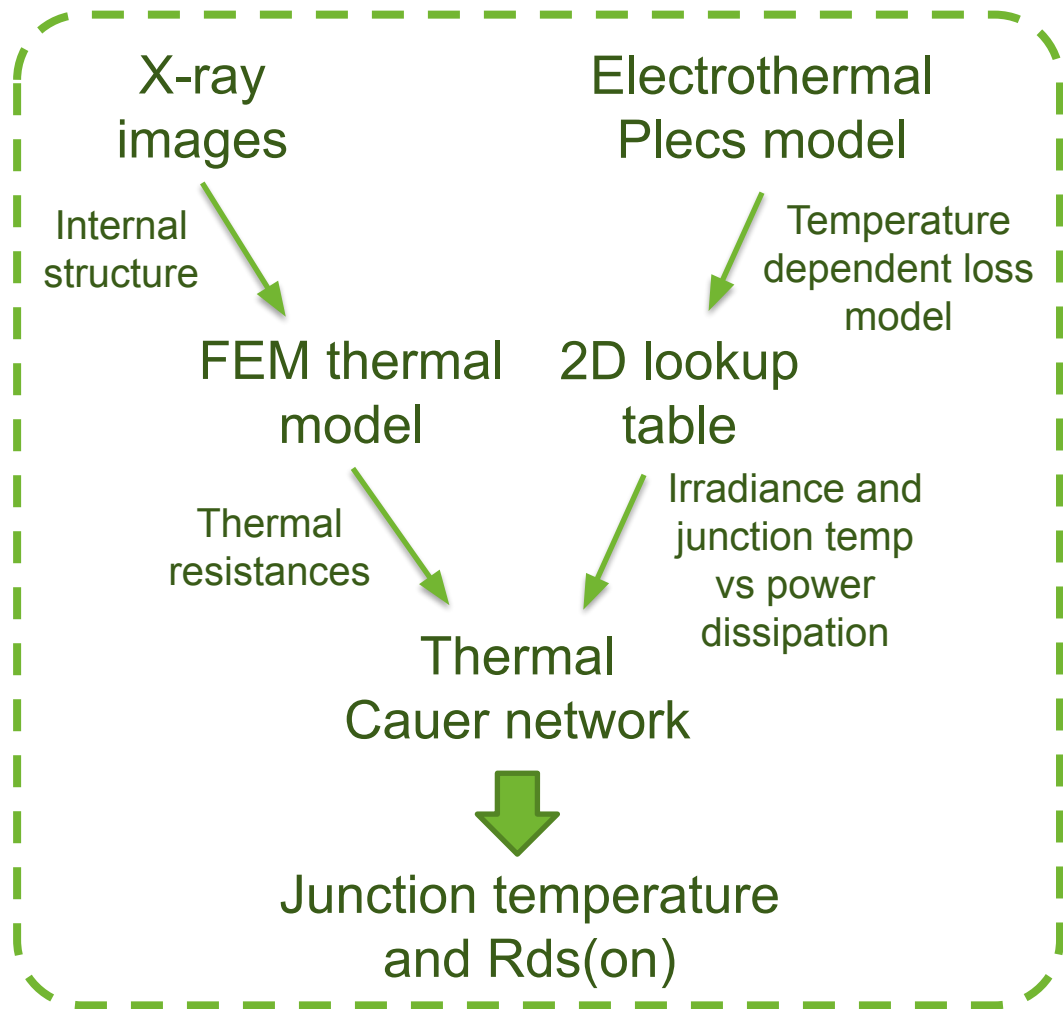


Converter modeling

- 1 sec resolution
- ~5h duration



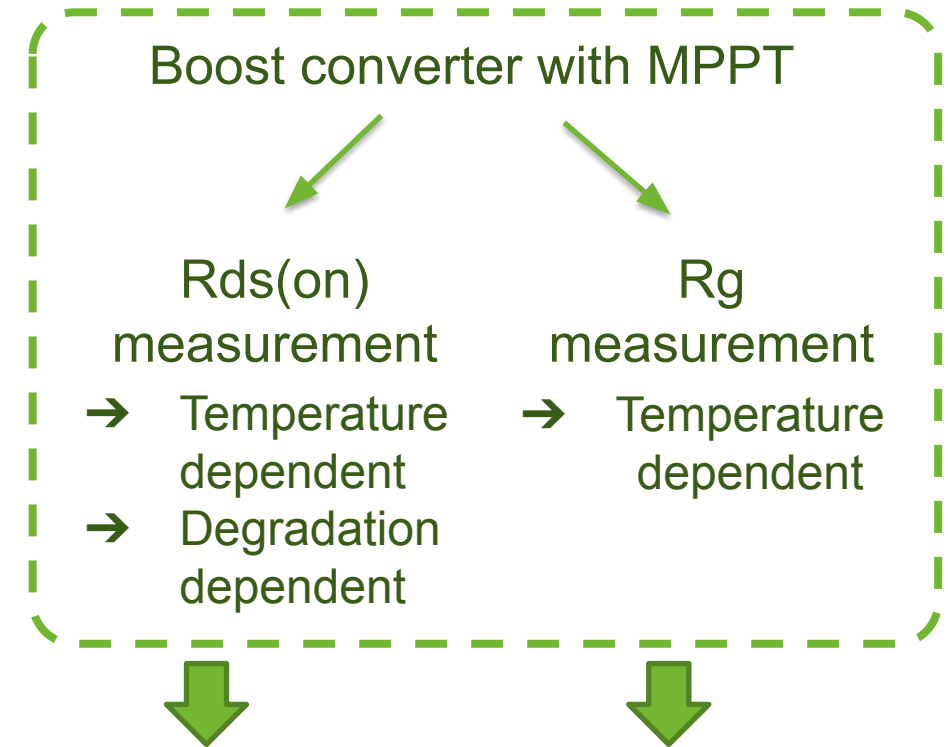
Summary condition monitoring



Digital twin



Real time measurements



Case temp validation

Junction temp validation

Model and single measurement based degradation detection

Dual measurement based degradation detection

References

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