Laboratory of Photovoltaics and Optoelectronics

Accuracy of Outdoor PV Module Temperature Monitoring Applications

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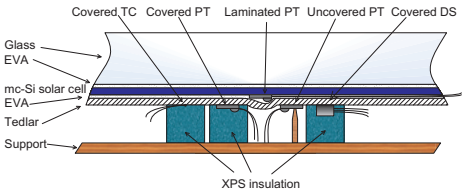
Objectives

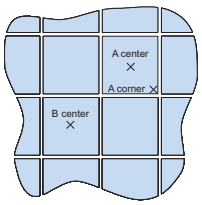
- To evaluate and compare different types of temperature sensors for long term outdoor monitoring of PV modules.
- To evaluate the difference between temperature measurement at the backsheet of PV module, back surface of cells and calculation from V_{OC} (EN60904-5)
- To evaluate the feasability of digital temperature sensors DS18B20 for long term PV temperature monitoring .

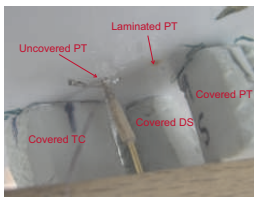
Experiment



Sensor	Type	Class	Uncertainty T = [0, 85 °C]
PT	Pt1000	1/3 B+	± 0.25 °C (k = 2)
TC	K-thermocouple	2	± 3.2 °C (k = 2)
DS	DS18B20	-	± 0.5 °C (k = 3)

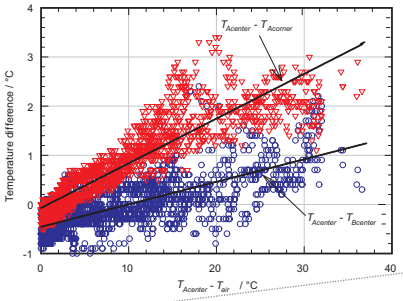
- Locations of laminated PT sensors behind two cells in the middle area of the PV module and a photo of temperature sensors arrangement at the back side of PV module.



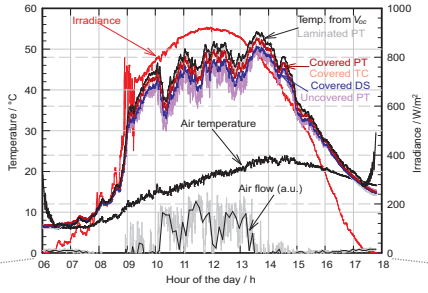


Results

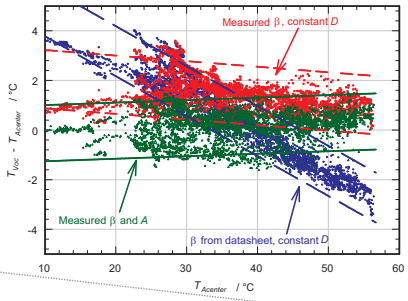
- Additional heating of cells due to isolation at the back of cell A is less than 1 °C.

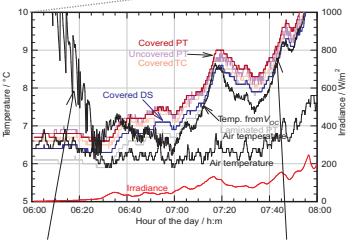


- Temperature, irradiance and wind data for a typical clear sky day.



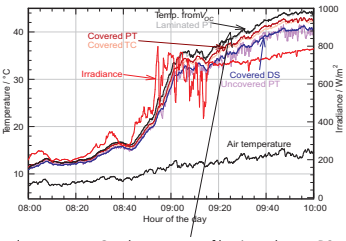
- Temperature from V_{oc} (EN 60904-5) compared to laminated PT in center of cell A.



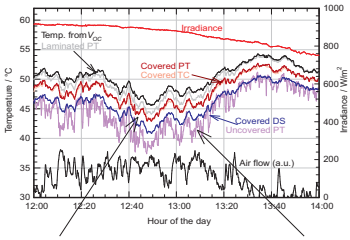


V_{oc} method has low accuracy at low irradiances.

Temperatures of all sensors are close at low irradiance and low air temperature.

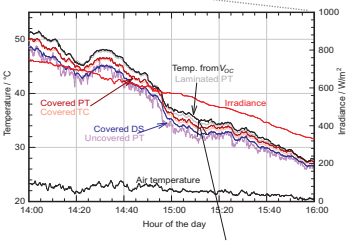


Good agreement of laminated PT and V_{oc} method.



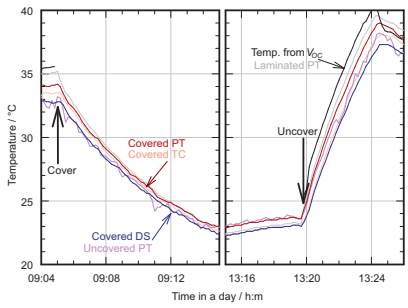
DS sensor exhibits lowest temperature despite insulation.

High temperature noise of uncovered PT due to air flow at the back side.

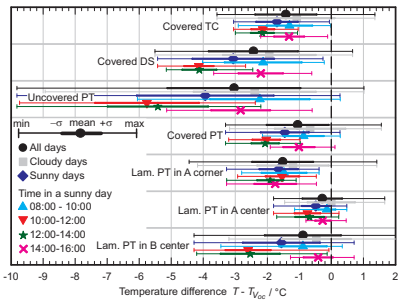


Covered PT and TC deliver almost identical results, but lower than laminated PT.

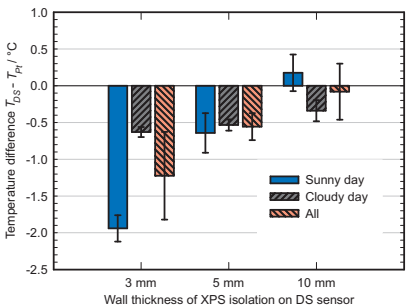
- Test by shading the PV module shows adeqate time response of all sensors.



- Temperature deviations of each sensor according to temperature from V_{oc}.



- DS sensor with different XPS isolations compared to covered PT at the back side.



Conclusion

- Temperature calcualted from V_{oc} give very accurate results at irradiances above 200 W/m^2 if parameters of PV module at STC conditions are known.
- Among sensors attached at the back side, covered PT and TC sensors delivers the best results in range of 1-2 °C of lower temperature in average.
- DS sensors exhibit similar results to PT if they are properly isolated and are more suitable for simultaneous temperature acquisition at many locations.
- XPS insulation of sensors at the back side cause a slight temperature raise of the cell area around, however less than 1 °C in average.

[M. Jankovec and M. Topic, "Intercomparison of Temperature Sensors for Outdoor Monitoring of PV Modules", Journal of Solar Energy Engineering, in print, 2013.]

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