



Berner Fachhochschule  
Haute école spécialisée bernoise  
Bern University of Applied Sciences



# Ultrafast Multi-MPPT PV Inverter Test Bench

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▶ PV-Lab

# Topics

- ▶ Inverter Testing – What’s Important?
- ▶ Common Problems with PV Array Simulators
- ▶ PV Inverter Testing at Bern University of Applied Sciences
- ▶ The new Multi-MPPT PV Inverter Test Bench
- ▶ Conclusions and upcoming activities

Building “Tiergarten”, home of BFH-TI’s PV lab in Burgdorf, Switzerland.



# Inverter Testing – What's Important?

3 Things needed for Inverter Testing:

**Precise Measurement Equipment**

→ No Problem, if you got the Money.

**Good Quality PV Array Simulator**

→ **This one is trickier than one might think. Let's hear more about it!**

**Know-how & Experience**

→ This belongs into another presentation...

# Inverter Testing – What's Important?

## High Speed

Solar modules have a fast transient response. A good simulator should behave the same way.

## High Stability

Essential for reproducibility. Because of this, real PV arrays are not suitable for testing.

**Good Quality PV Array Simulator**

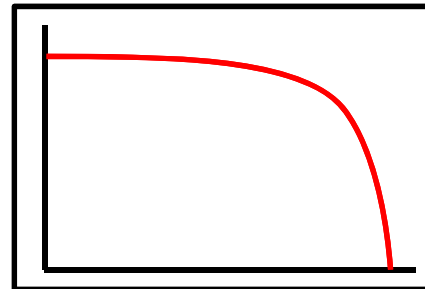
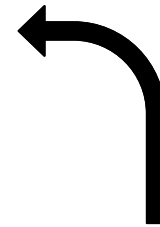
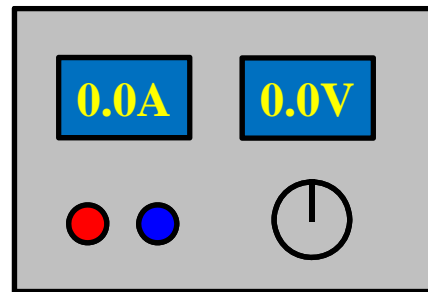
## Low Noise

The simulator should not affect the D.U.T. or the measurement equipment. Especially not, if you are measuring the D.U.T.'s electromagnetic interference.

# Common Problems with PV Array Simulators

**Most commercially available  
PV Simulators work like this:**

**Standard  
programmable  
power supply  
(switched mode)**

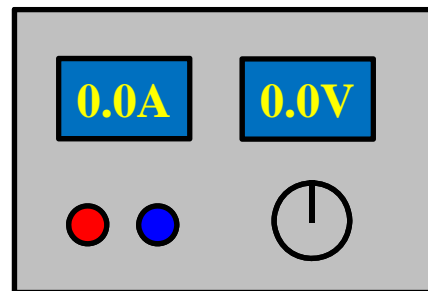


**IV curve generation  
by software option  
or additional control  
hardware**

# Common Problems with PV Array Simulators

**Most commercially available  
PV Simulators work like this:**

**Programmable  
power supply  
(switched mode)**



**Voltage Range**  
Many devices work up  
to only 600 volts.

**Switching Noise**  
Makes EMC measurements  
impossible.

**Filter Capacitor**  
Output capacitance  
makes the device slow.

# Common Problems with PV Array Simulators

**Many commercially available PV array simulators emulate the DC characteristics of a PV array very well.**

**Often there are major differences between the AC characteristics of these simulators and the characteristics of a real PV array. Also, such simulators often generate a considerable amount of switching noise which can compromise the measurement.**

## **Conclusion**

A cheap way for rudimentary tests of PV inverters.

Not suitable for a realistic & reproducible test environment.

# Inverter Testing at Bern University of Applied Sciences

- ▶ The pv lab of BFH-TI has more than 20 years experience in testing of PV inverters.
- ▶ As there were no simulators available in the early nineties, first tests were performed with real PV arrays.
- ▶ After having made bad experiences with an industrial simulator, the pv lab developed its own PV array simulator (25 kW) in 1999.
- ▶ In 2001, an improved simulator of 20 kW became operational.
- ▶ In 2009 the construction of our PV array simulator of 100kW was finished. At this time, this was probably the most powerful simulator in the world.

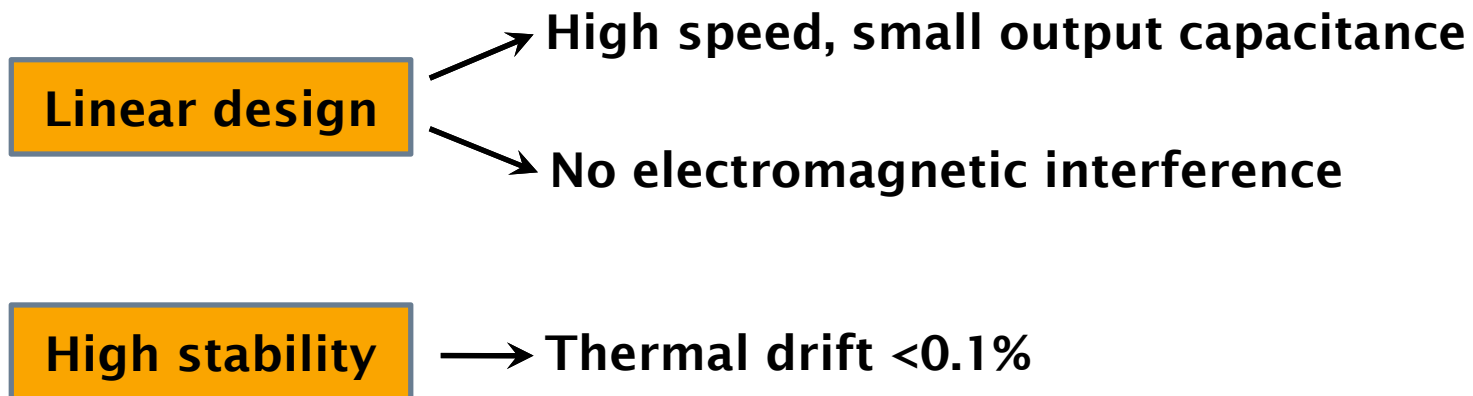




**BFH-TI's 100 kW PV array simulator shortly  
before it became operational in 2009**

# Inverter Testing at Bern University of Applied Sciences

**What makes our simulators special?**



# The new Multi-MPPT PV Inverter Test Bench

- ▶ In summer 2013, construction of a PV array simulator for testing of multi-MPPT inverters began.
- ▶ The design is inspired by our existing simulators. All the same, it is a complete redesign.

## Projected technical data

Topology: 3 linear, individually programmable, liquid cooled sub array simulators

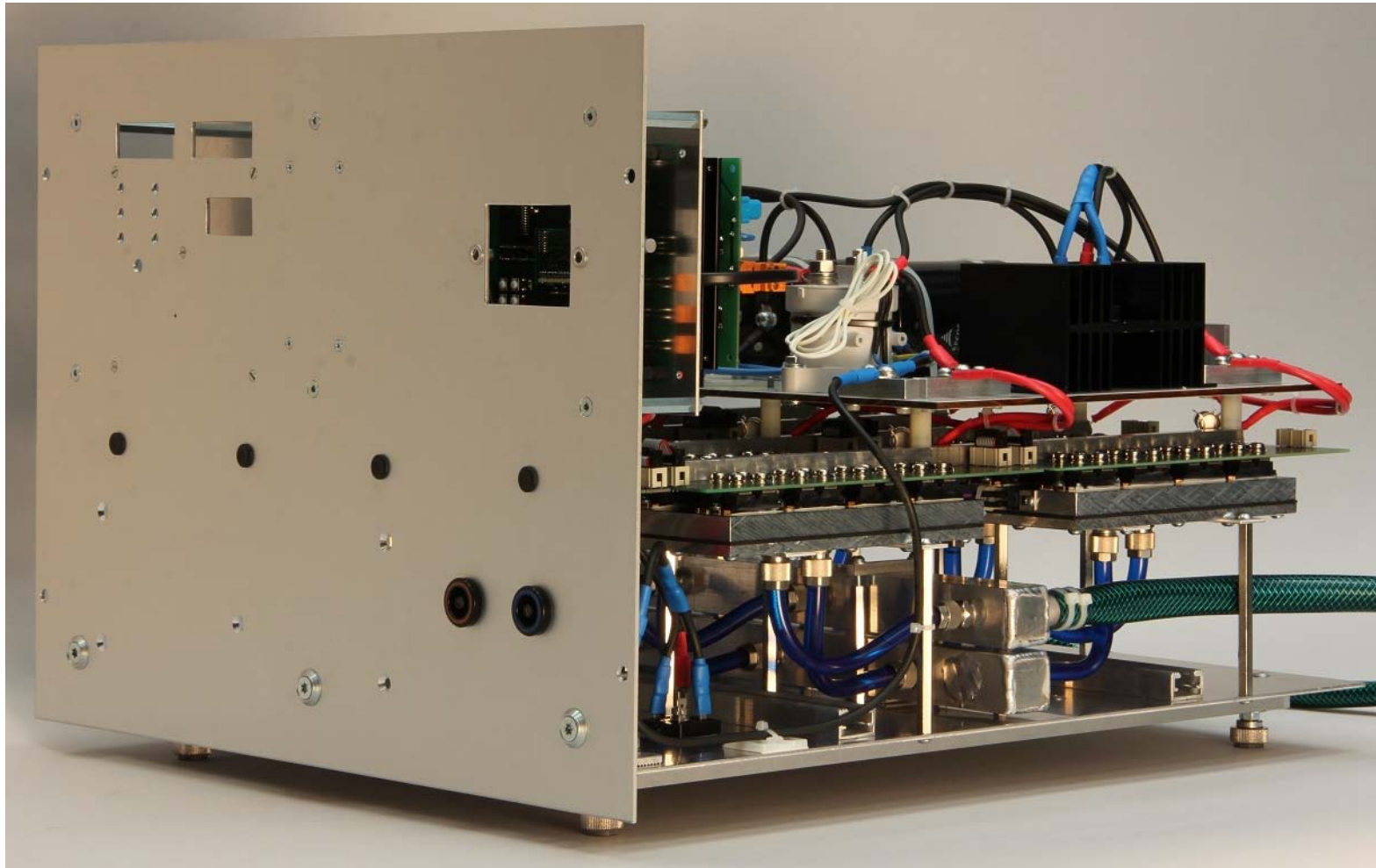
Voltage range: 0...1000VDC

Output Power: 3 x 11.52kW (FF = 72%)  
3 x 12.8kW (FF = 80%)

Thermal Drift: < 0.1%

Settling Time: < 100μs

# The new Multi-MPPT PV Inverter Test Bench



Prototype of a sub array simulator (under construction)

# The new Multi-MPPT PV Inverter Test Bench

## Challenges of a 1'000V linear Design

- ▶ Only very few high voltage linear semiconductors are available
- ▶ Most don't have a 1'000V rating
- ▶ Peak power dissipation of 16kW per sub array simulator
- ▶ Liquid cooling required



Liquid cooled heatsink for the multistring-simulator

## Conclusions

- ▶ The construction of a good quality PV array simulator is an often underestimated problem.
- ▶ Most commercially available simulators have unrealistic AC characteristics and can cause EMC problems.
- ▶ BFH-TI's PV array simulators have a linear design, resulting in very good AC and DC behaviour with no switching noise.

## Upcoming activities

- ▶ The new multi-MPPT PV inverter test bench will be operational by Spring 2015.
- ▶ Accreditation of the existing 100 kW and the new multi-MPPT test bench, making BFH-TI's PV lab to Switzerland's only test institute able to carry out certified tests on PV inverters.
- ▶ You are welcome to test your PV inverters and/or MPPT charge controllers at BFH-TI's PV lab!

**Thank you for your time!**