

# Calorimetric Efficiency Measurement

# Typical power analyzers have 1% deviation for current and voltage measurement

which means

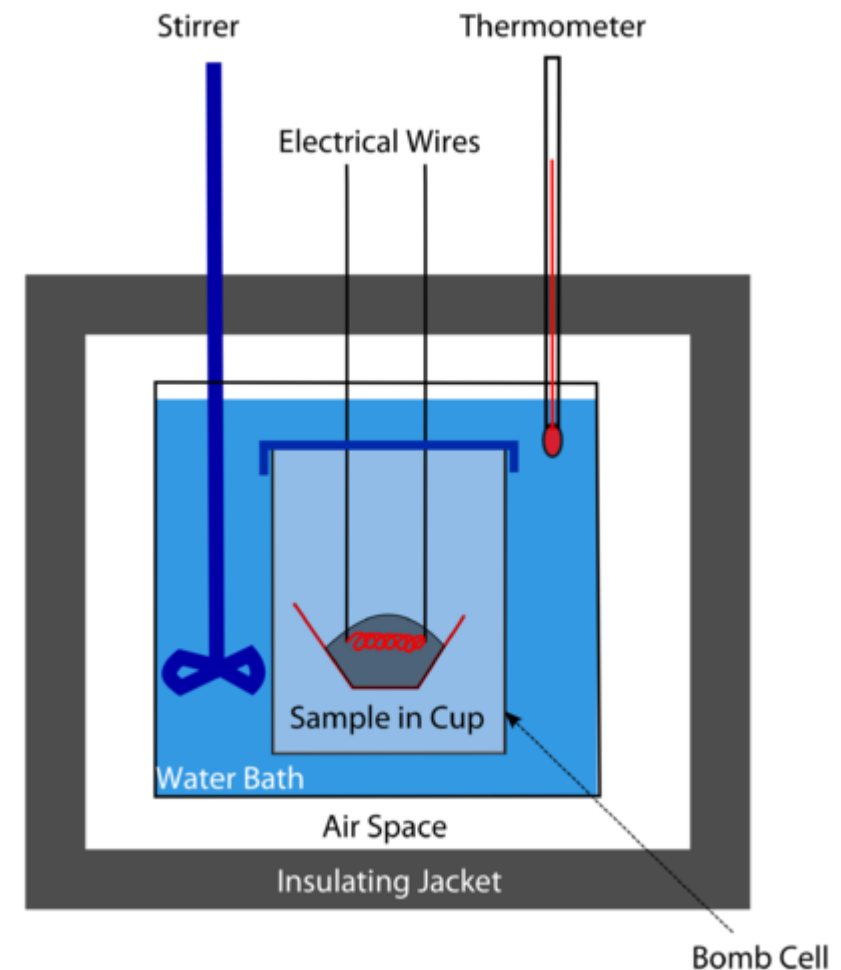
For a 10A, 300V system → Power deviates between 2940W to 3060W → Efficiency varies between 102% to %98

Measurement is not accurate!



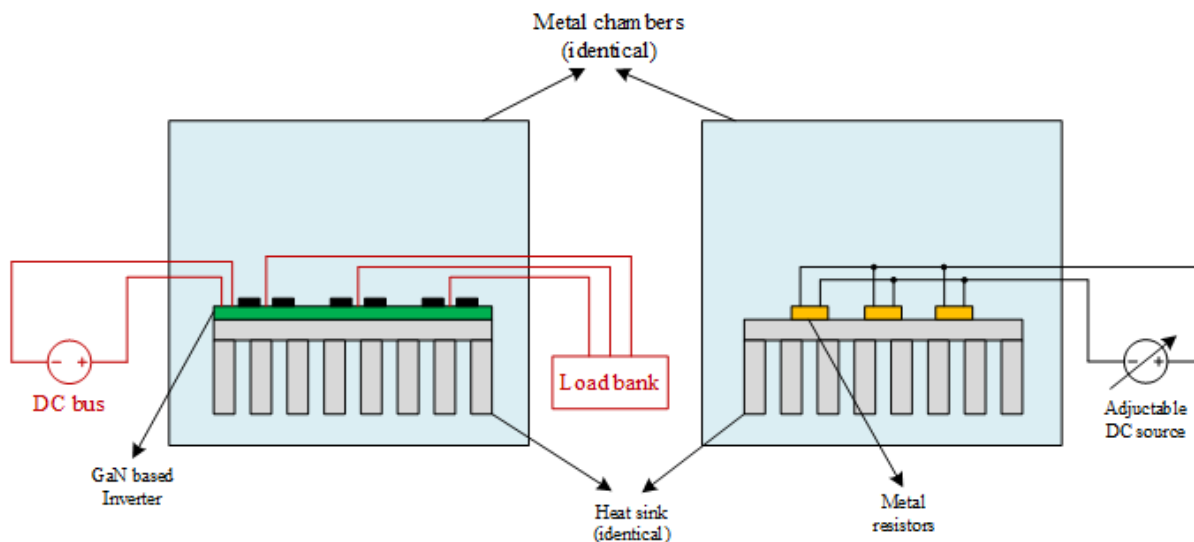
# Calorimetric Efficiency Measurement

- Aims to measure power loss, so percent deviation is far lower
- Works based on comparison of two loss sources or heat capacity of a flowing element (water)
- Highly preferred for high efficiency power converter applications





# Loss Comparison


- Two black boxes are compared thermally
- There is a DUT(Device-under-test) inside one of the box and a resistor in other box
- Certain loss is applied on resistors and after the boxes reaching thermal steady state, their temperatures are compared. If one of them is hotter than other one, there is more loss production inside that box.
- The loss on the resistor is changed over time to obtain the same temperature with DUT box.




## Loss Comparison - Challenges

- Temperature measurement accuracy 
  - Human error
  - Measurement tool error

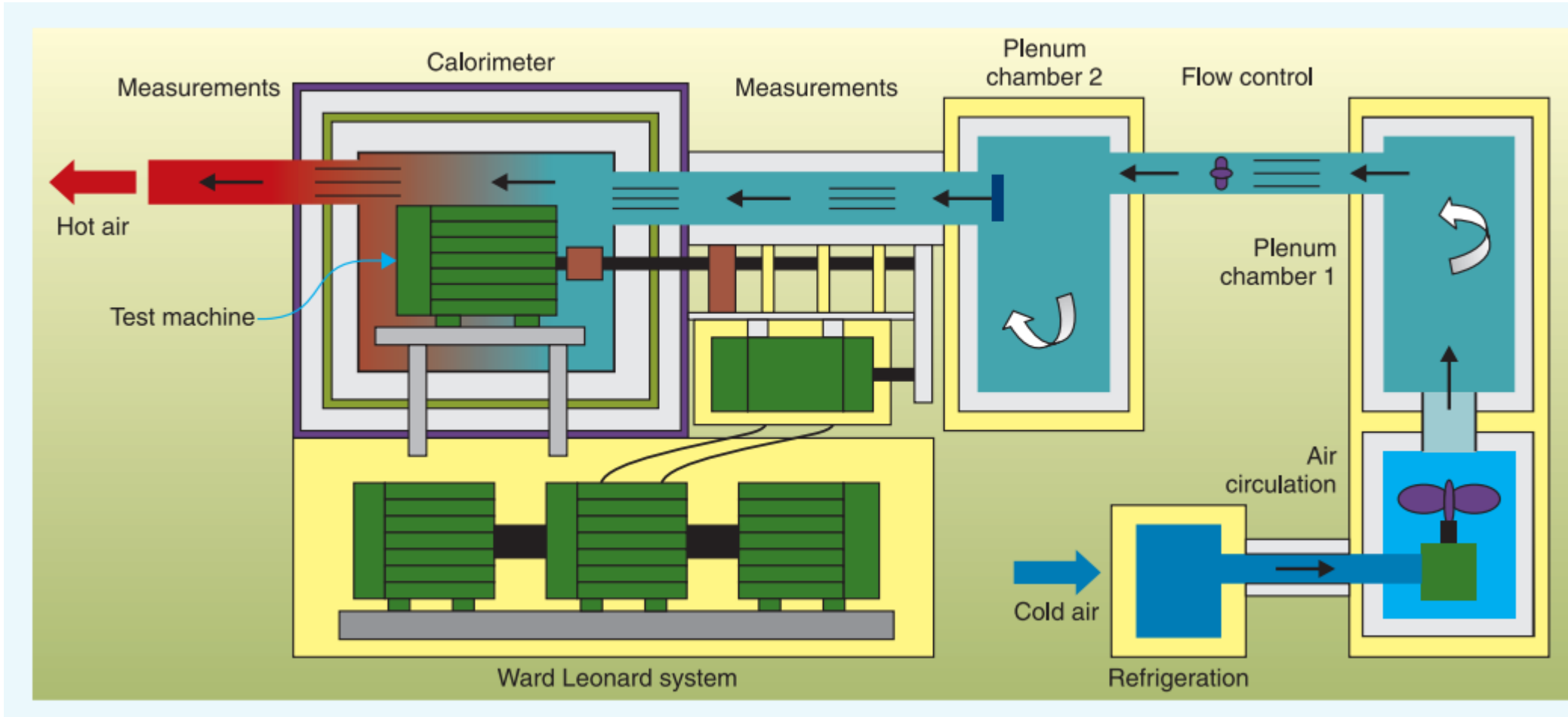
Several measurement sensors placed for multiple measurement points
- Long times before reaching the steady-state 

Small boxes or estimating final temperature from the heating curve
- Increased ambient temperature 




Large boxes or cooling inside of the boxes down
- Local heating in a box 

Heat should be distributed homogeneously inside the box

# Using Heat Capacity of a Flowing Element

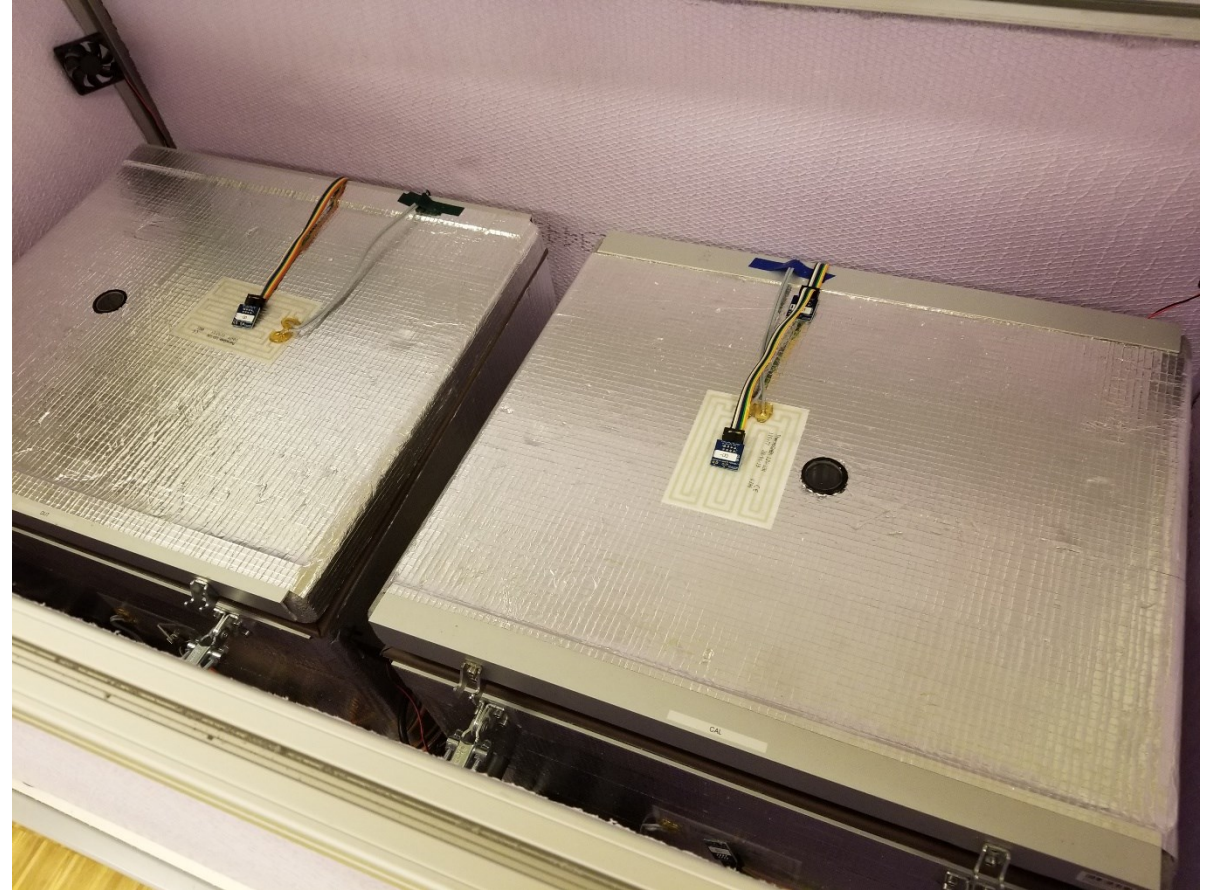


## Using Heat Capacity of a Flowing Element - Challenges

- Homogene distribution of the flow element  Airflow or water flow damper
- Multiple connectivity especially for water coolant  Requires creative ideas
- Isolating the box from outside  Thick borders

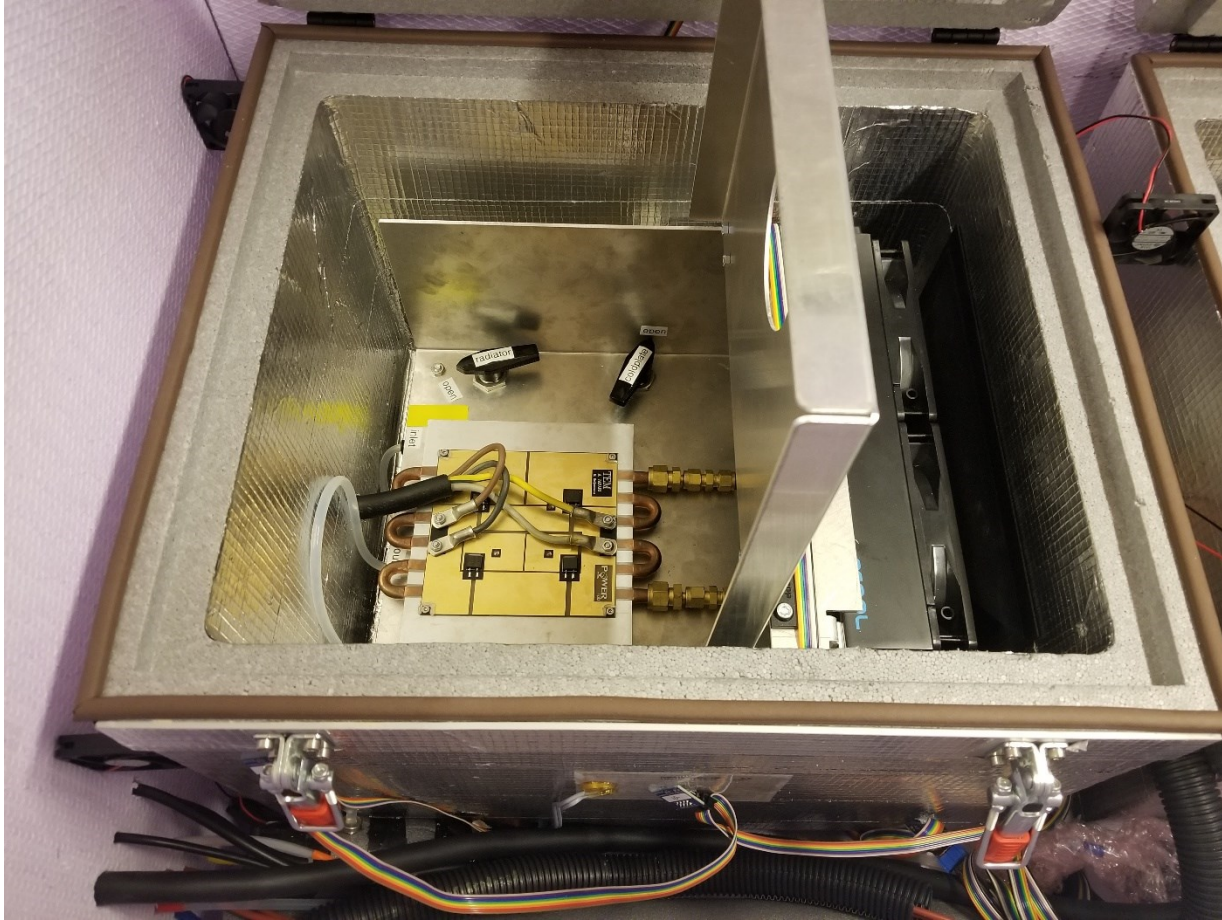


## A solution from PowerLab, EPFL



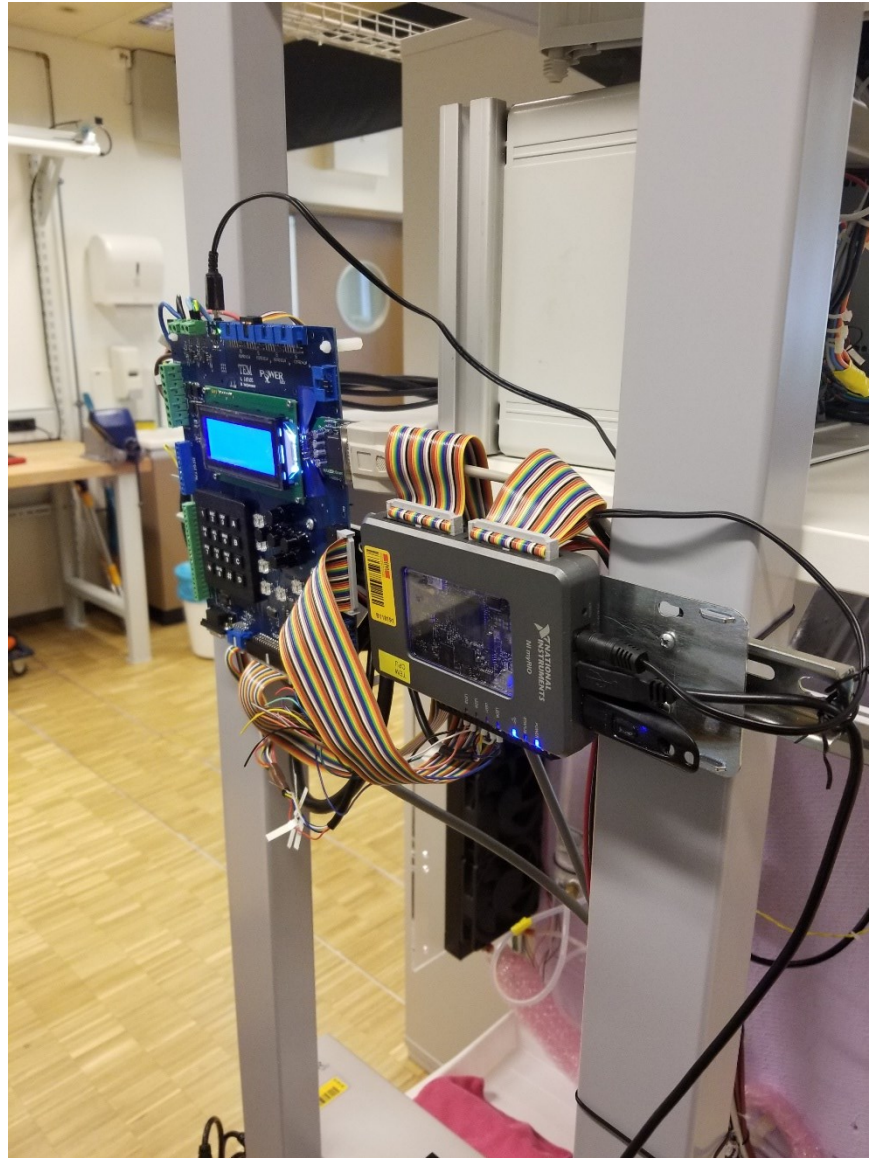


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## References

- 1) High-Power Solar Inverter Efficiency Measurements by Calorimetric and Electric Methods, Lassi Aarniovuori, Antti Kosonen, Pekka Sillanpää, and Markku Niemela
- 2) Development of a High-Precision Calorimeter for Measuring Power Loss in Electrical Machines, Wenping Cao
- 3) A REVIEW OF CALORIMETRIC APPLICATION FOR ACCURATE POWER LOSS MEASUREMENT, W. Cao