ArduPower v2

Open and Modular Power Measurement for HPC Components

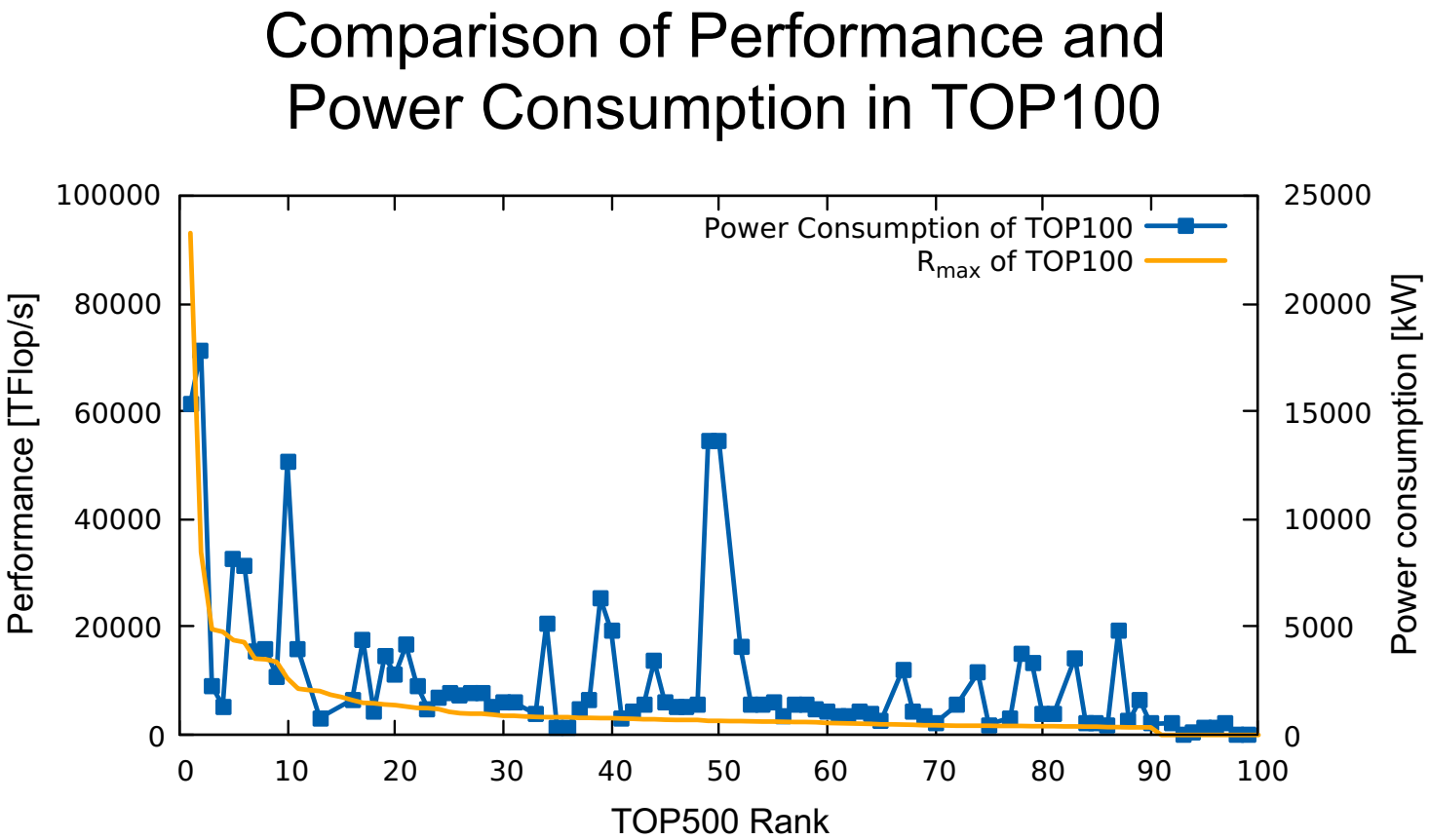
Daniel Bremer, Michael Kuhn, Mohammad Reza Heidari

[daniel.bremer, michael.kuhn, heidari]@informatik.uni-hamburg.de

Power Consumption in HPC

- "GreenIT" $\rightarrow$ Green500
- Computation/simulation is essential design step
- Power consumption $\neq$ Computational power
- ArduPower aims to
  - Raise awareness for energy consumption
  - Offer cost optimization utilities
  - Allow performance evaluation

Green500 Top List

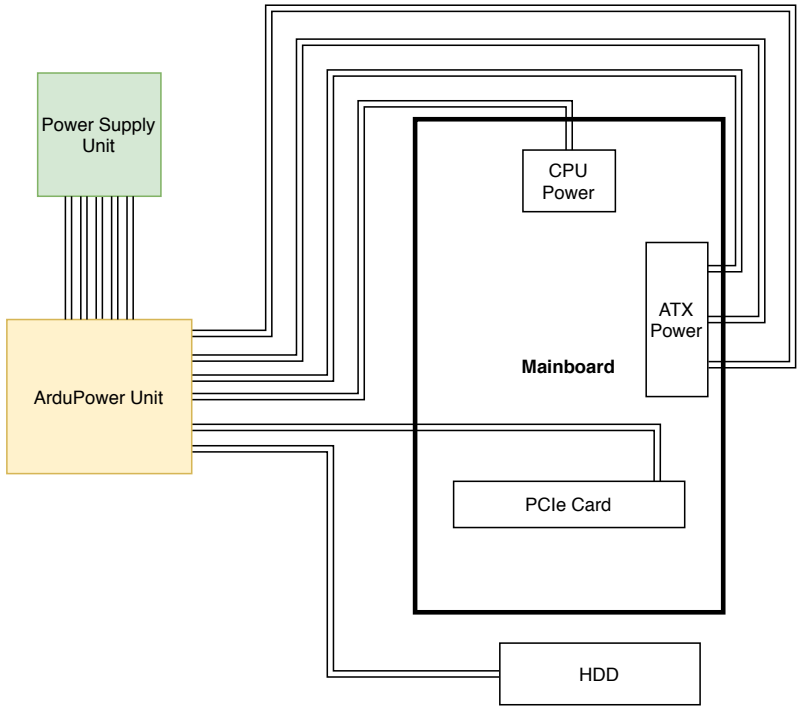


Preface

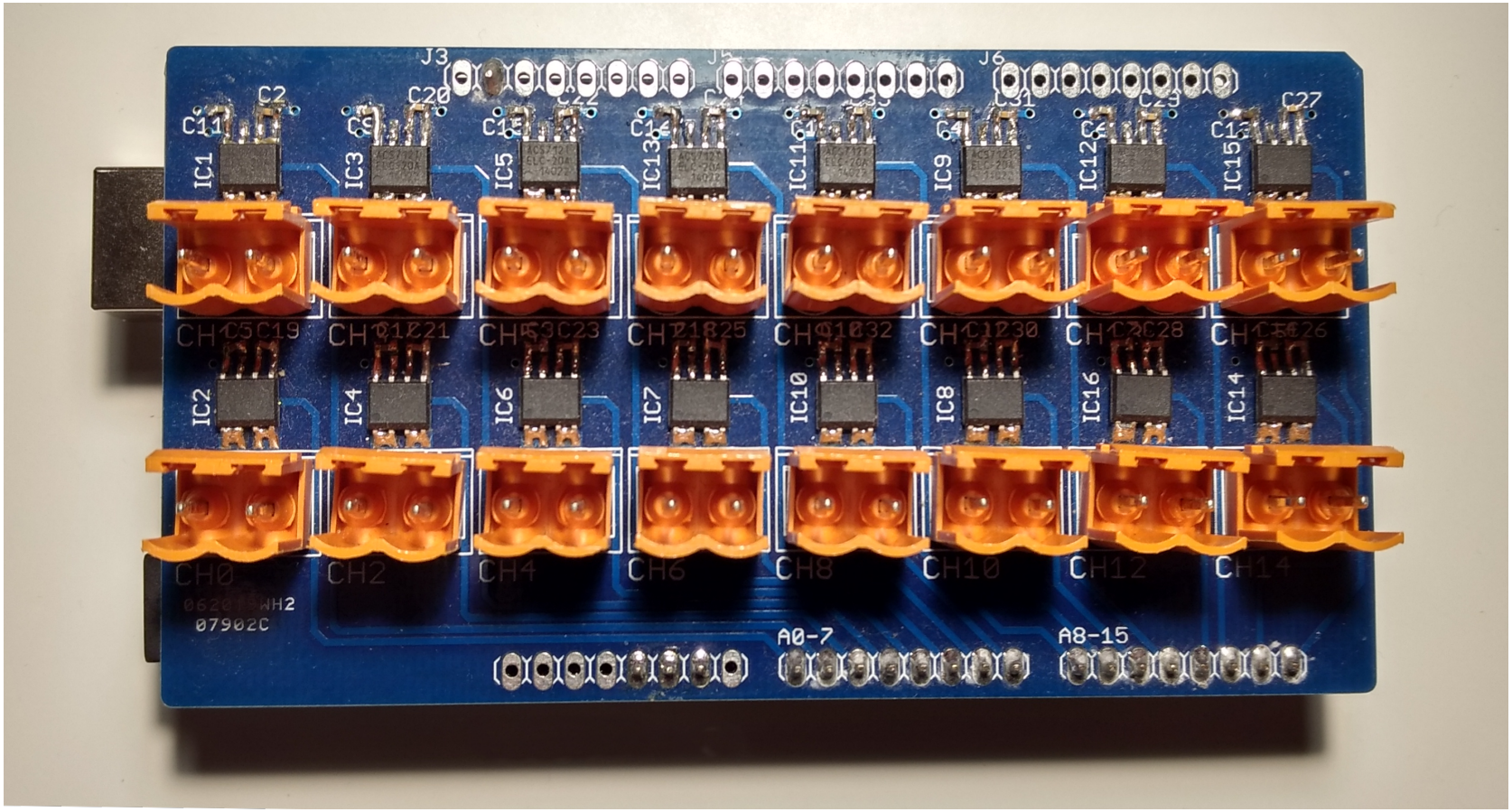
- Electrical Power = Voltage · Current
  - Voltages from ATX Specification
- External Wattmeter
  - Power between wall and PSU
- Internal Wattmeter
  - Power between PSU and component
- Arduino
  - Arduino Mega 2560
  - Flashable microcontroller

ArduPower Version 1

- Shield for the Arduino Mega
- Up to 16 channels
- Calibration process for sensors
- Central hub design
- No wiring harness given
  - destructive installation

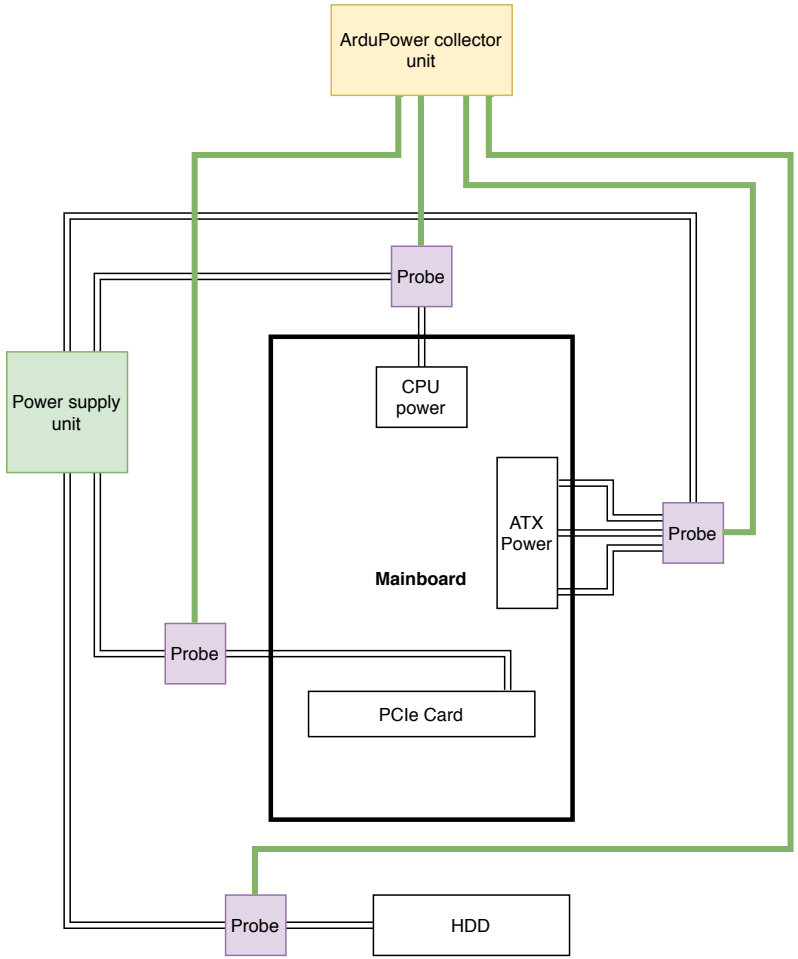


Central Hub approach. Rewiring of whole node needed.


J3
J5
J6
C2
C20
C27
IC1
IC3
IC5
IC9
IC12
IC15
IC2
IC4
IC6
IC7
IC10
IC8
IC16
IC14
CH0
CH2
CH4
CH6
CH8
CH10
CH12
CH14
A0-7
A8-15

ArduPower Version 2

- Shield for the Arduino Mega and probes
- Up to 15 channels
- Modular, expandable design
- Plug-and-play installation
- Automatic Configuration
- Improved Protocol
- Flexible use cases



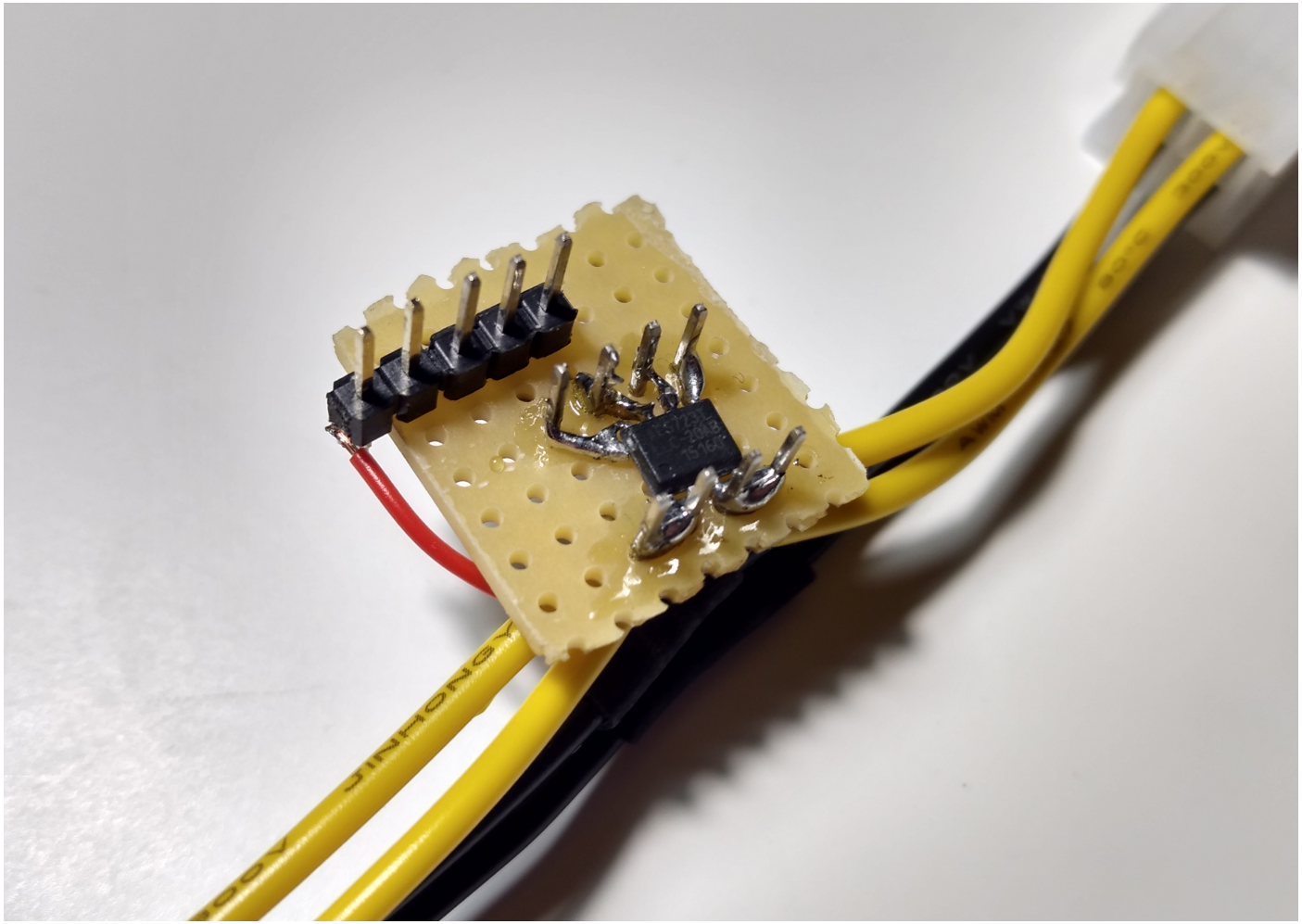
Wiring harness fitted with probes.

Probe Design

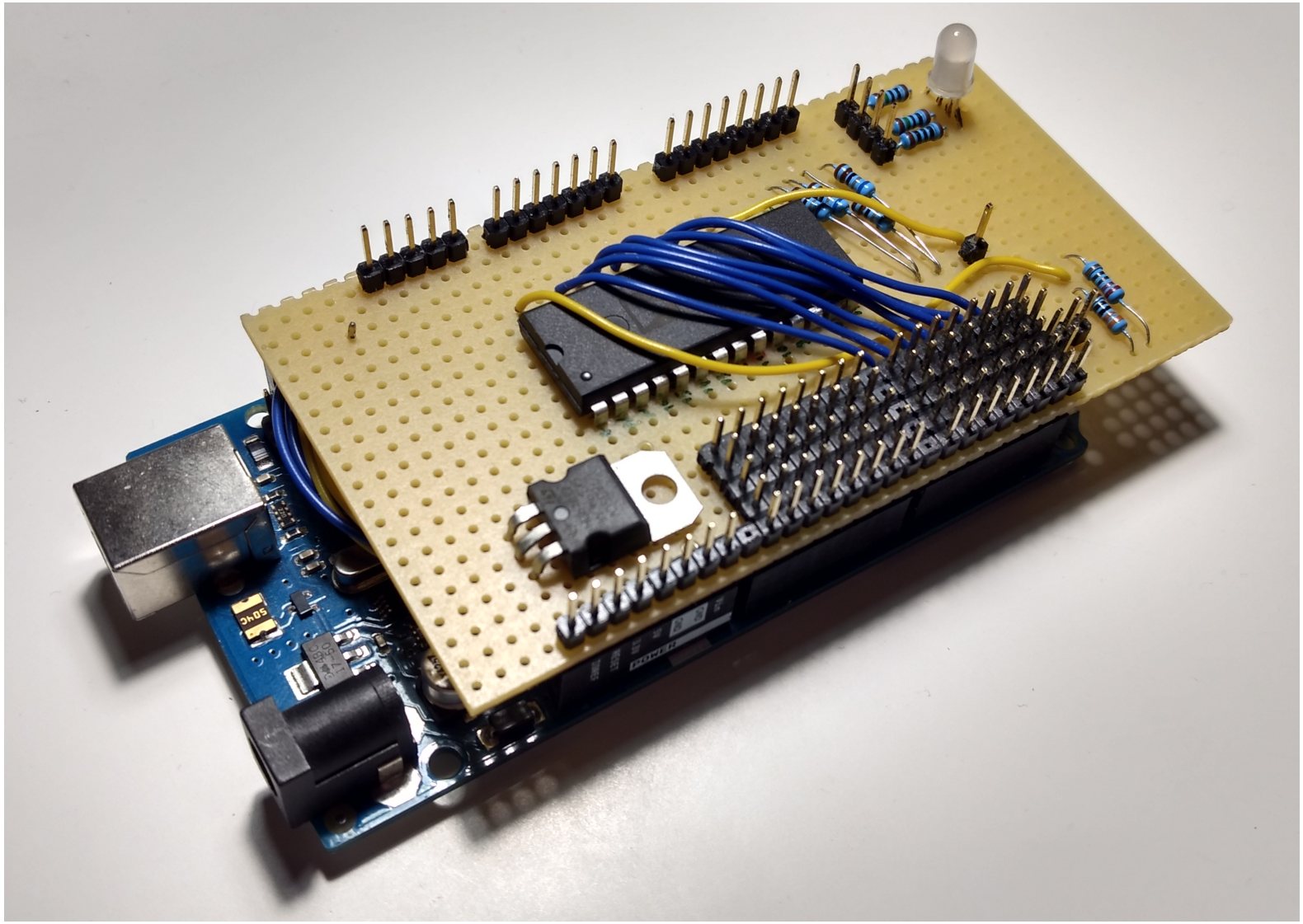
- Individual probes for all power lines
- Shield only is used for pin mapping and Automatic Configuration

- Female-Male extension cord with integrated ACS723 sensor
- Probes carry analog "type" voltage
  - Used to identify sensor variant
- Power line voltage is forwarded to Arduino
  - Voltage divider
  - Automatic voltage determination
- Current measurement is analog voltage

Product



Product



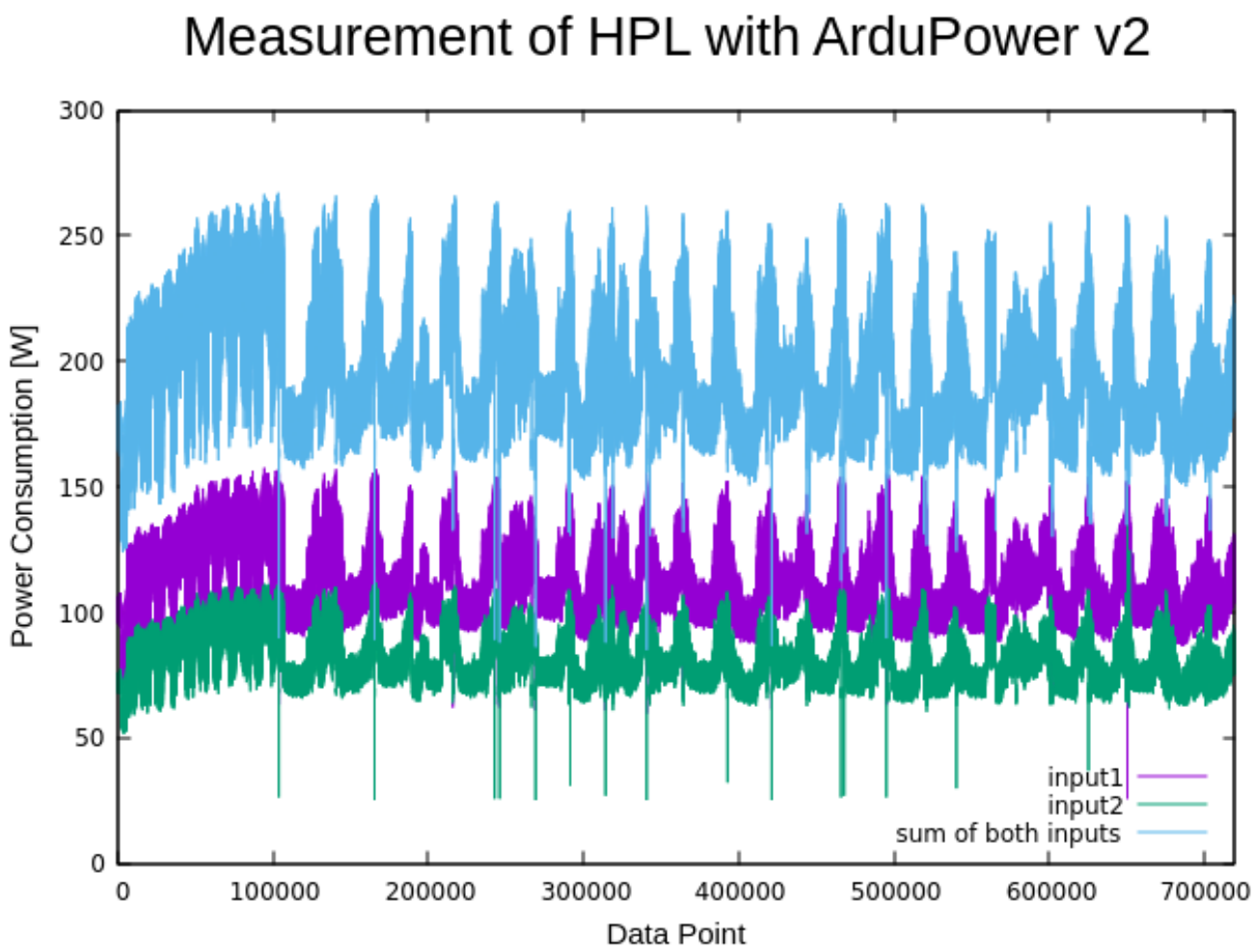
Automatic Configuration

- Eliminate need for manual configuration of ArduPower
- Sense connected probes and voltages of lines
- Optimize reading loop
- Implemented by multiplexing analog inputs

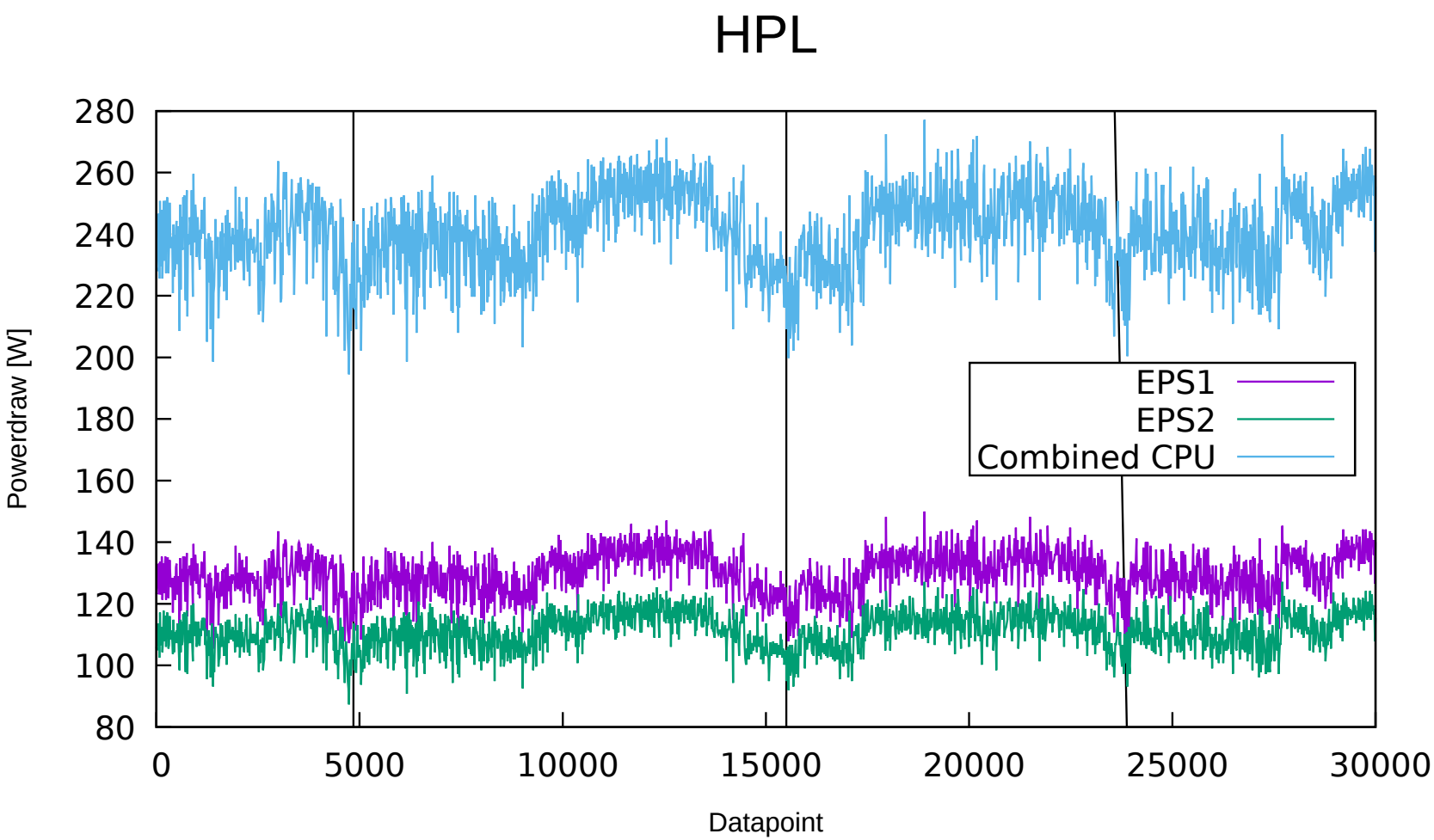
Downside

- No calibration
  - 2% error of ACS723

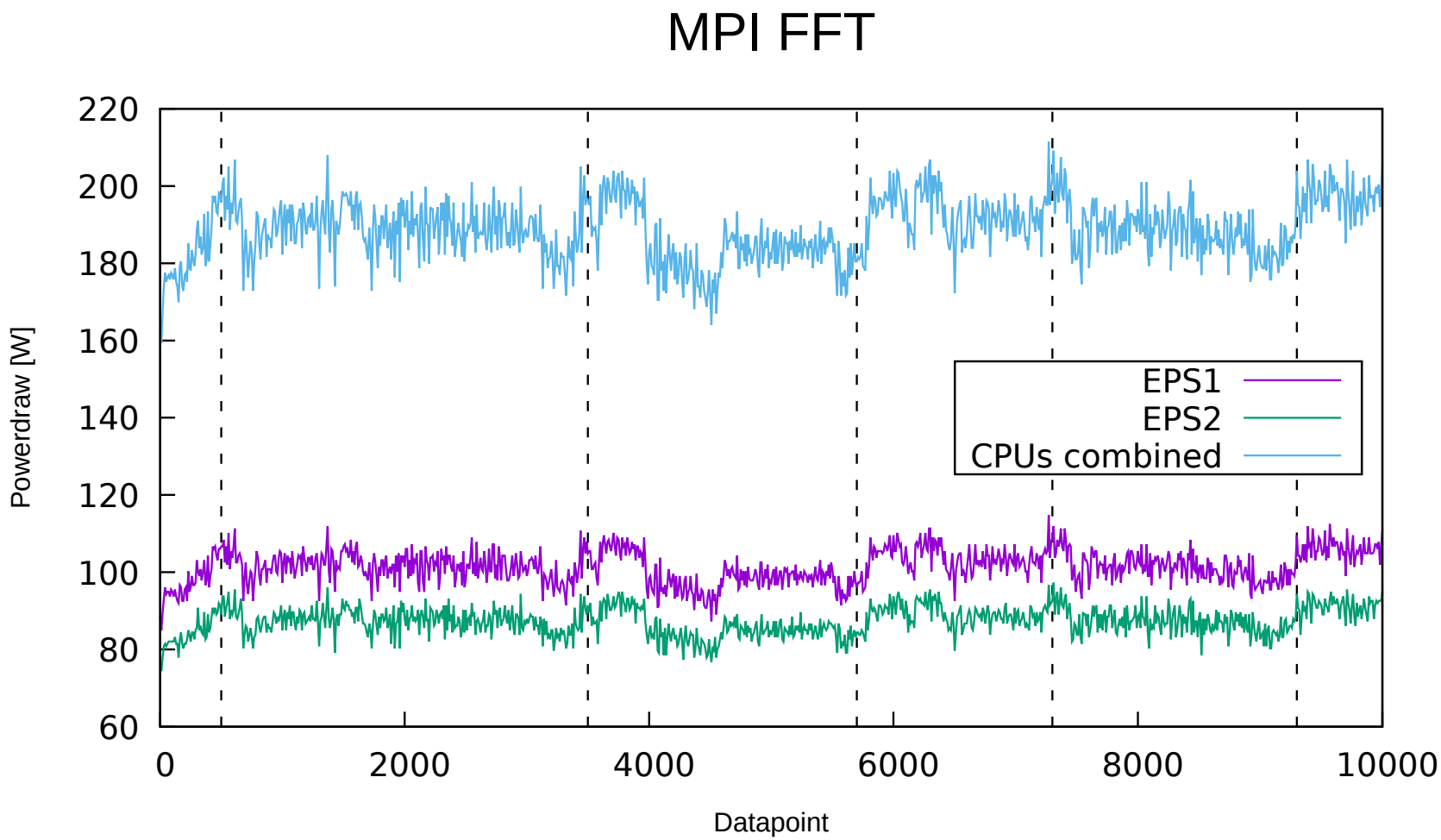
High Performance Linpack



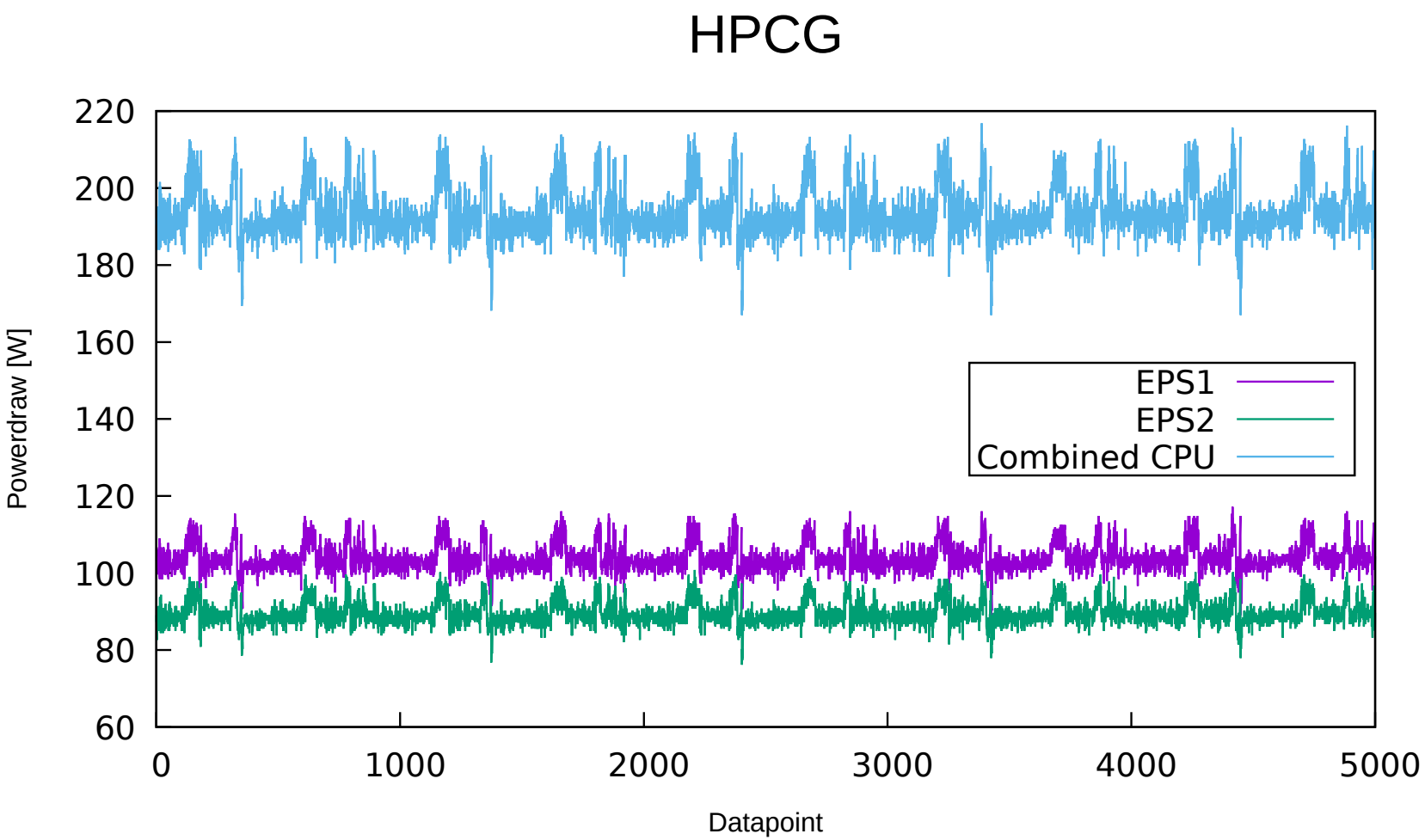
High Performance Linpack II



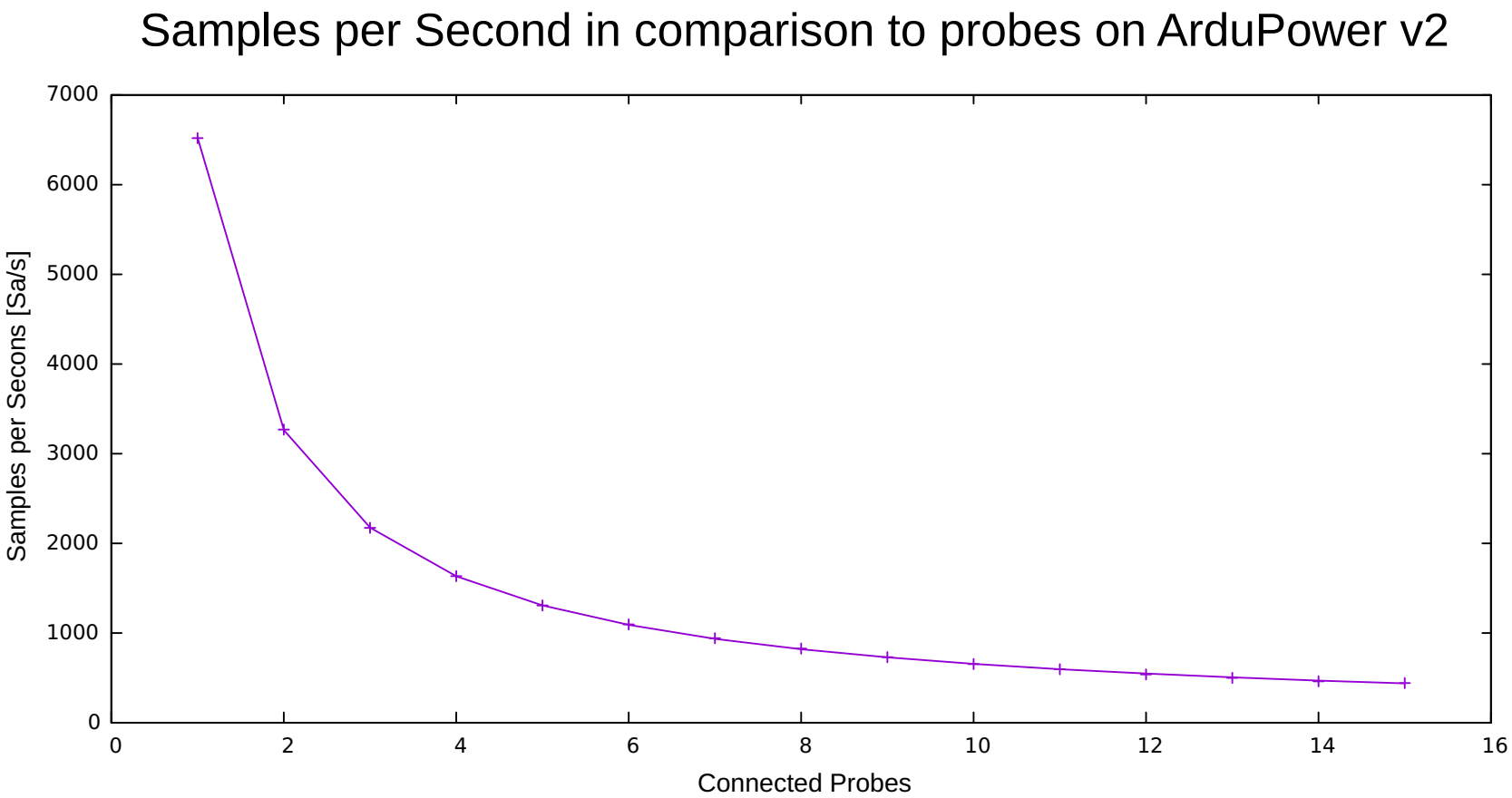
MPI FFT


MPI FFT
Powerdraw [W]
Datapoint
220
200
180
160
140
120
100
80
60
0
2000
4000
6000
8000
10000
EPS1
EPS2
CPUs combined

High Performance Conjugate Gradients



Sampling Rates



Rate 1 probe: 6517 Sa/s

Rate 15 probes: 433 Sa/s

Future Works

- Probe for 230 V/110 V lines
  - Implementation via software, ACS723 is capable
- Further probes?
  - ATX12VO
  - PCI-e
  - U.2
  - M.2
  - RAM socket
  - Thermal
  - Airflow

Conclusion

Initial goals

- Achieved high modularity and easy usage
  - Extensible design allows for modifications in the future
- Automatic Configuration eliminates need for configuration
- Reduces Protocol overhead

Conclusion II

Further achievements

- High frequency sampling
- Precise measurements
- Over 10 times higher sampling speed

Thank you

https://github.com/wr-hamburg/energy2020-ardupower