ArduPower v2
Open and Modular Power Measurement for HPC Components

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Purpose of this Project

Power Consumption in HPC

- "GreenIT" → Green500
- Computation/simulation is essential design step
- Power consumption ≠ Computational power
- ArduPower aims to
  - Raise awareness for energy consumption
  - Offer cost optimization utilities
  - Allow performance evaluation
Green500 Top List

Comparison of Performance and Power Consumption in TOP100
Preface

- Electrical Power = Voltage \cdot 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.
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.
Overview

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
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

Measurement of HPL with ArduPower v2
High Performance Linpack II
High Performance Conjugate Gradients

![HPCG Graph]

Powerdraw [W]
Datapoint
HPCG
EPS1
EPS2
Combined CPU

Data points range from 0 to 5000, with power draw values ranging from 60 to 220 W.
Sampling Rates

Samples per Second in comparison to probes on ArduPower v2

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