Open Source Low Cost Power Meter

Building on Seed Eco-Home PV System
Shane's Work Log
Shane's Blog

Power Monitoring - Requirements

- Tentative Paper:
  - Open Source Low Cost Power Measurement System for Solar Energy
- Low cost
- Simple
- Measures power - voltage + current
- Use CAT5 for connections
  - Use M-M cable for connection - these could be made to any length
- Wired sensors, located on the PV control panel
- Use Arduino brain
- Make it extensible - extensible in units of 12 data channels
- Dump to SD card
- Measurements every 15 minutes
- Use non-invasive current sensor. Not any more
- Include AC&DC clamps to measure loads outside of control panel
- Consider doing an open source inverter later?
- Most common ranges:
  - DC 0-1- parasitic loads
  - DC 1/2A-15A - typical DC loads
  - Hight range DC = 1kW power tool - 50A DC @24v, or max 8kW welder - 400A
  - AC - phone charger AC comparing DC draw from battery to AC draw on small device

Documentation Output Requests

- KiCAD 101
- Circuit Mill Instructional
- Design Rationale for the Board
-

27JAN2017 Meeting Overview

- Present and discuss design so far
  - Modify and take notes as we go
- Answer all outstanding questions
- Discuss plan moving forward
  - Come up with parts to order list, and discuss size of trial runs
  - Pick intermediate deadline

Project Goals as Defined by Dr. Pearce

- Meet all requirements using only **OS** electronics + software.
- Tech part of paper OSH model
  - - Design blocks
  - BOM - KiCAD
  - Schematics - KiCAD
  - Modeling - simulations using SPICE-based platform
  - Software - Arduine Environment - IDE
  - Proof of concept -> validation
- Big intro on overall design of house - include building electronic schematic
  - -BIPV (Building integrated Photovoltaic) mech drawing, etc
- Target - OS Hardware journal UNLESS we get lots of data from them

Appropedia Links

Where I will have to keep track of progress as well for Dr. Pearce

- Open Source Low Cost Power Measurement System for Solar Energy
- Literature Review

Initial Implementation Ideas

Two wire interface

TWI

(Mostly) Universal Sensor Node:

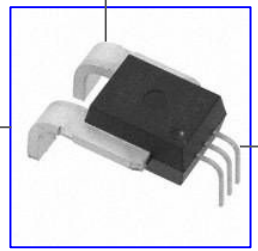
Adjust for different ranges with different resistors

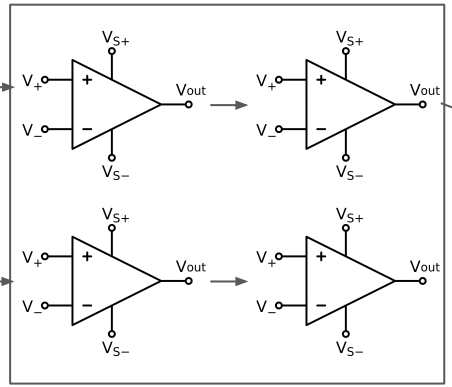
Communicate via ~~I2C~~, for single bus connection, up to 256 sensors (8 bit address)

Amplify and Offset

10 bit ADC PDIP

Voltage Tap





AT Tiny

RJ45 Conn

May need signal boosters

It may be a good idea to go with socket-able components for ease of maintenance (no soldering to replace parts)

Hall Effect Current sensor

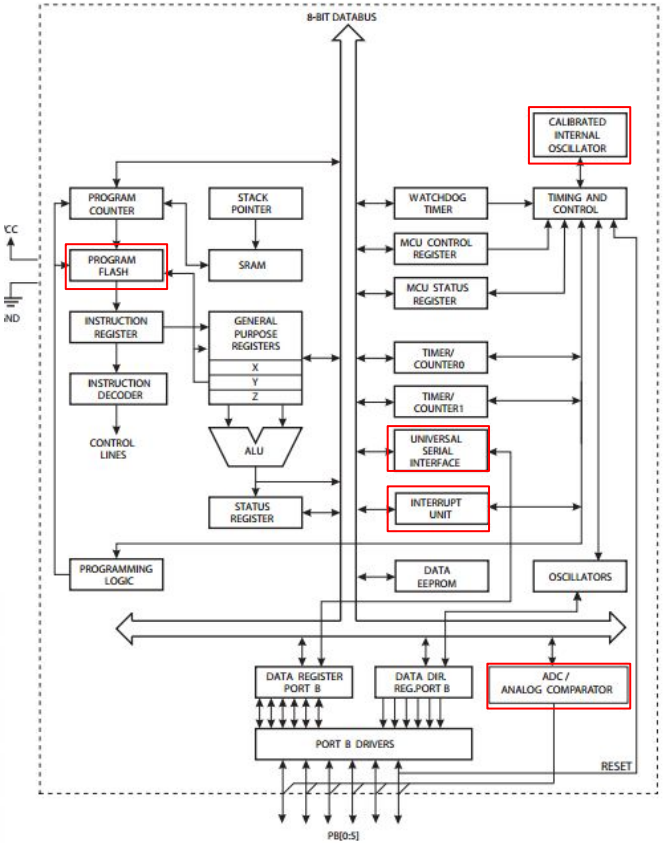
- Good for 100A
- 100 micro-ohm resistance
- Thermal compensation

Quad Op-Amp

At a peak current, power consumption is
100^2*0.0001= 1 watt
At Half current: 0.25 watt

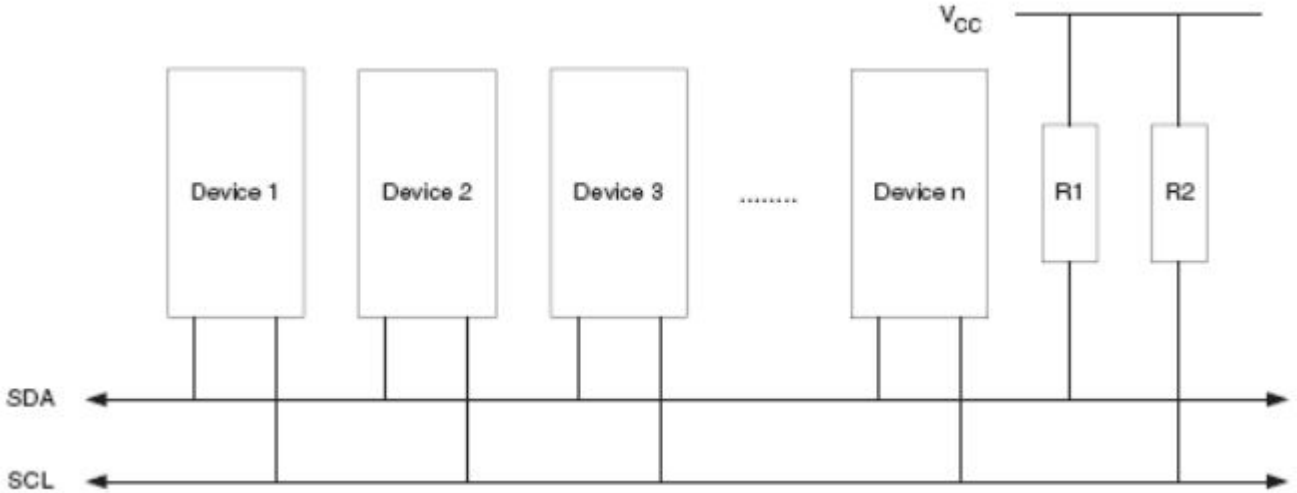
Selected Microcontroller Notes

- [AVR AVR® ATtiny Microcontroller IC 8-Bit 20MHz 8KB (4K x 16) FLASH 8-PDIP]
- Capable of Two Wire Interface (TWI). Not exactly I2C, but that's okay
  - Read as - Lots of devices
- Internal Oscillator, to reduce parts. We don't need super - high speed for this application
- 10 bit ADC with 4 single ended channels (or 2 differential)
  - Differential won't be necessary due to preceding op-amps
  - Should probably plan to range higher than expected V
- Universal serial unit has "start condition detector"
  - Controller can be woken up via serial
    - Read as - low power when not measuring
- Cost: $1.24 (lower price with bulk discounts)
- Internal clock is 8 MHz



Why have seperate microcontrollers?

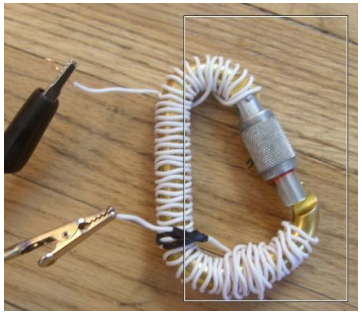
- If voltages were sent directly to measurement unit, there is a higher chance for noise and losses
- Easier to multiplex serial stuff (in fact, not muxing will be required for this setup) then it would be for handling analog voltages directly
- Greatly improves scalability (up to 256 devices)
- Allows for future enhancements to be programmed later



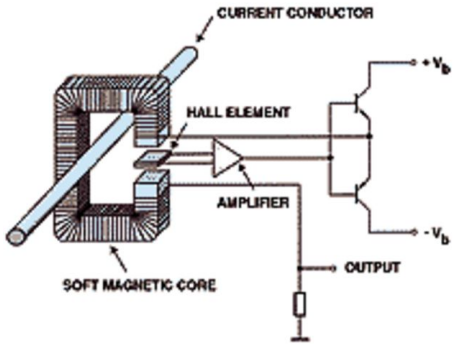
Current Sensor Choices (Continued)

- Purchase Sensors
  - For AC loads, consider purchasing from this $6 list
  - For a more general sensor (capable of AC and DC)
    - Same series: 100 A, 200 A, 400 A, 50 A, 300 A
      - Needs +-15V supply
    - Or if it is necessary for environmental seals, consider this one
      - 5V Supply (This is more favorable)
      - Starts to get up there in price ($20)
  - If you are okay with the sensor being invasive (wire must be cut and wired through It, consider this one $8

Current Sensor Choices



- DIY Current Sensors
  - $2 Carabiner AC amp sensor
    - This is cheap and REALLY easy to make. But it only works with AC. Also it may need a burden resistor to stabilize. This means there will be a power loss.
  - DIY current sensor (hall effect)
    - Capable of DC and AC. Possibility of saturation, must be biased properly
  - Both of these can be adjusted for any expected current range
  - My approach would be Ferrite beads and magnet wire



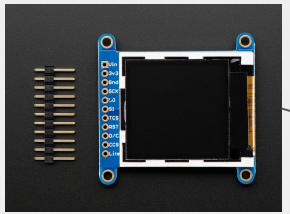
The issue with this is the potential for the wire to break. Need some sort of strain relief

Need to think about installability

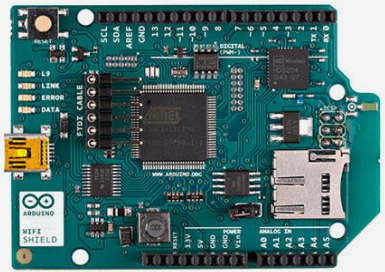
Measurement Hub

Note: Actual connection should be in star topology, not daisy-chain

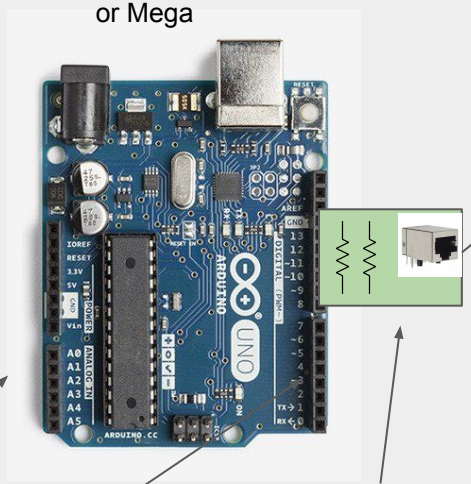
LCD and uSD card

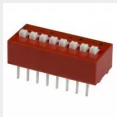


Wifi Shield



Arduino UNO
or Mega





Serial Pullup BOB

Set # of nodes

Supply In

10 Port Supply Hub

Supply In

10 Port Supply Hub

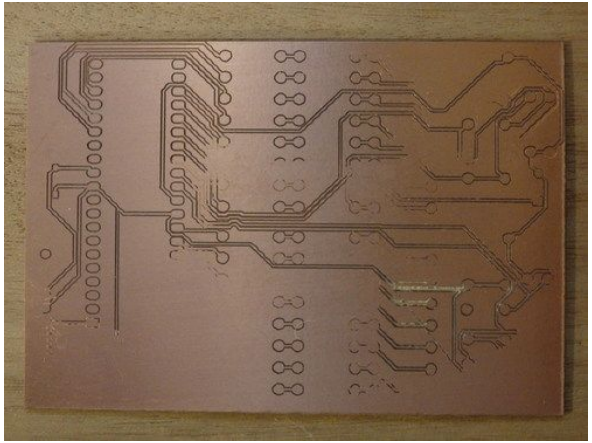
Supply In

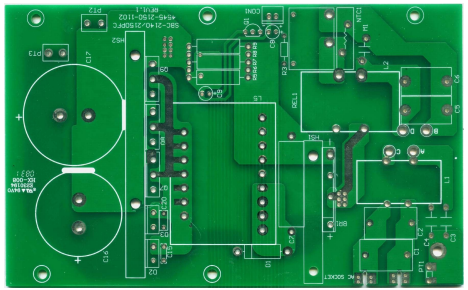
10 Port Supply Hub

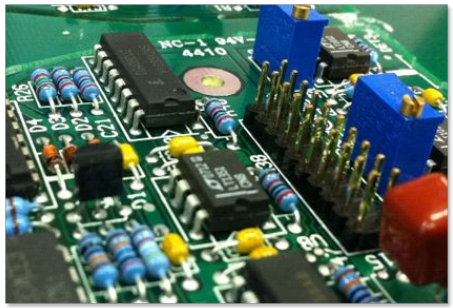
Up to 256 ports -> 32 Hubs

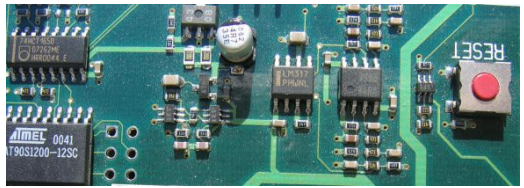
Board Construction

- PCB Mill
  - I have this mill
  - Currently trying to fix leveling issues, I'm close.
- Board House
  - I've used EasyEDA in the past
  - Good quality cheap boards (Maybe 6 bucks a board for our application
  - Made in China and probably not very sustainable
- Maintnanceability
  - Should I use through hole or surface mount?









Please add probing procedure documentation (what you have already)

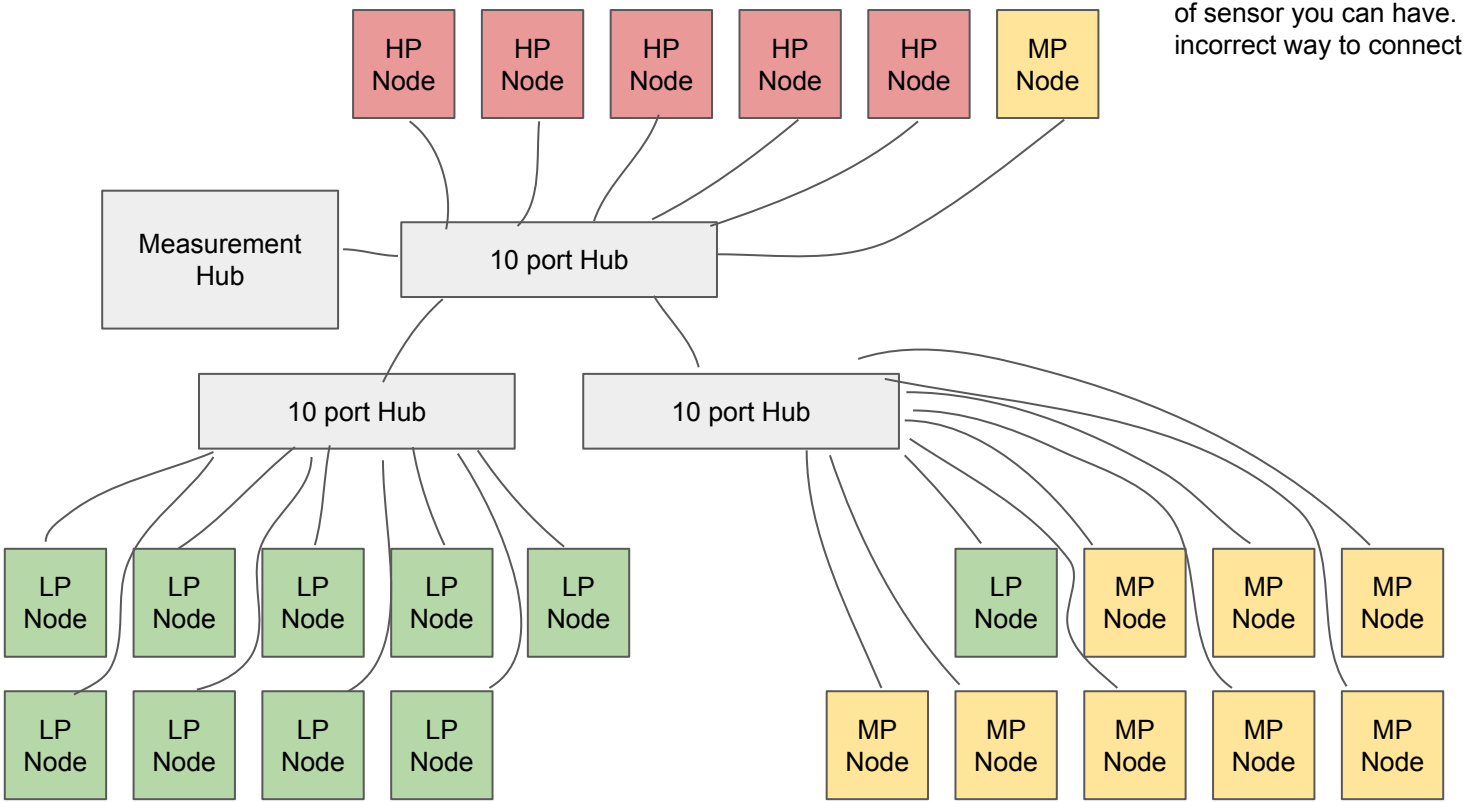
- Materials - copper-clad fiberboard

Enclosures

- 3D Printed (I’m assuming this one)
- Purchased
  - Something like this
- Enclosures for everything?

System Overview

(Example configuration)
No limit to how many of each kind of sensor you can have. No incorrect way to connect them



Outstanding Questions

- Which Current sensor?
  - Is invasive okay? yes
  - Power losses
  - How to install?
- SMD or TH - Hybr. Throughhole where necessary, SMD for low cost.
- Units & storage? Both voltage and current and time and sensor ID
- (environmental exposure?) Interior
- Real time clock OR MAYBE? Yes
- Serial okay? Yes
- Can initial prototypes be from board house if Issues arise? Yes
  - Still cheap
- Should I adjust gains to fit full range, or only around expected (Increase resolution) Is 10 bit ADC okay? Provide a table for apropriate range
- Screw Terminals or connectors only? Use Screw Terminals
- Auto assign address, or programed in? Programmed in will be MUCH easier
  - Each sensor could also have its name programmed on it? IE: PUMP1? Program is Okay

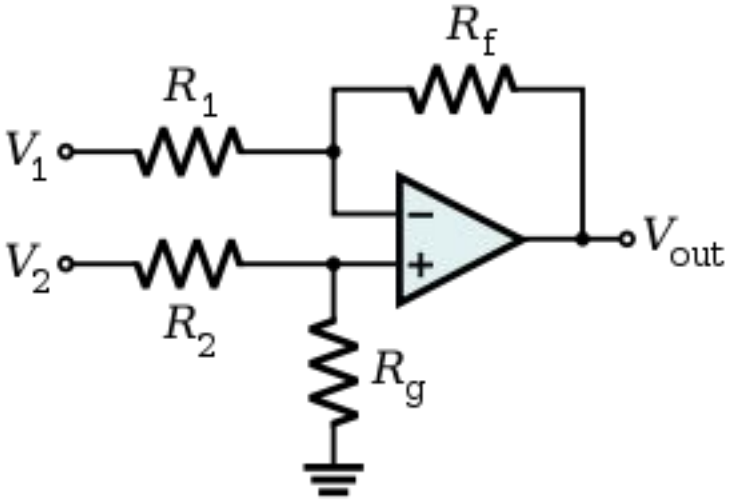
Resistor as Current Sensor

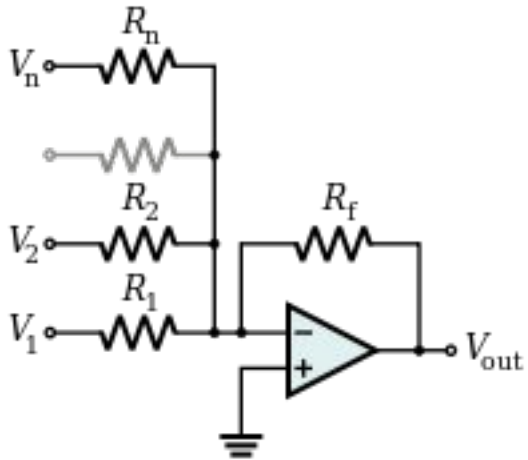
- 0.0002 Ohm ±1% 12W Chip Resistor 3920 (1052 Metric) Current Sense, Moisture Resistant Metal Element

Product Attributes		Select All
Categories	Resistors Chip Resistor - Surface Mount	
Manufacturer	Bourns Inc.	
Series	CSS2H-3920	
Packaging	Cut Tape (CT)	
Part Status	Active	
Resistance (Ohms)	0.0002	
Tolerance	±1%	
Power (Watts)	12W	
Composition	Metal Element	
Features	Current Sense, Moisture Resistant	
Temperature Coefficient	50ppm/°C	
Operating Temperature	-55°C ~ 170°C	
Package / Case	3920 (1052 Metric)	
Supplier Device Package	3920	
Size / Dimension	0.394" L x 0.205" W (10.00mm x 5.20mm)	
Height - Seated (Max)	0.051" (1.30mm)	
Number of Terminations	2	
Failure Rate	-	

Signal Conditioning

- General Purpose Amplifier 2 Circuit Rail-to-Rail 8-PDIP





High current connections:

- http://www.digikey.com/products/en?FV=fff40016.fff803bc&k=screw%20terminal
  - Good for 20A
- http://www.digikey.com/product-detail/en/molex-llc/0389690002/WM7469-ND/3044567
  - Good for 50A
  - Cost just as much as above, might as well use only these

Future Work

- Killawatt Meter like operation where you plug in the load into a 3 prong plug