The Hot Water Balloon

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Debian / Embedded Debian / Balloonboard.org / iEndian / Toby Churchill Ltd

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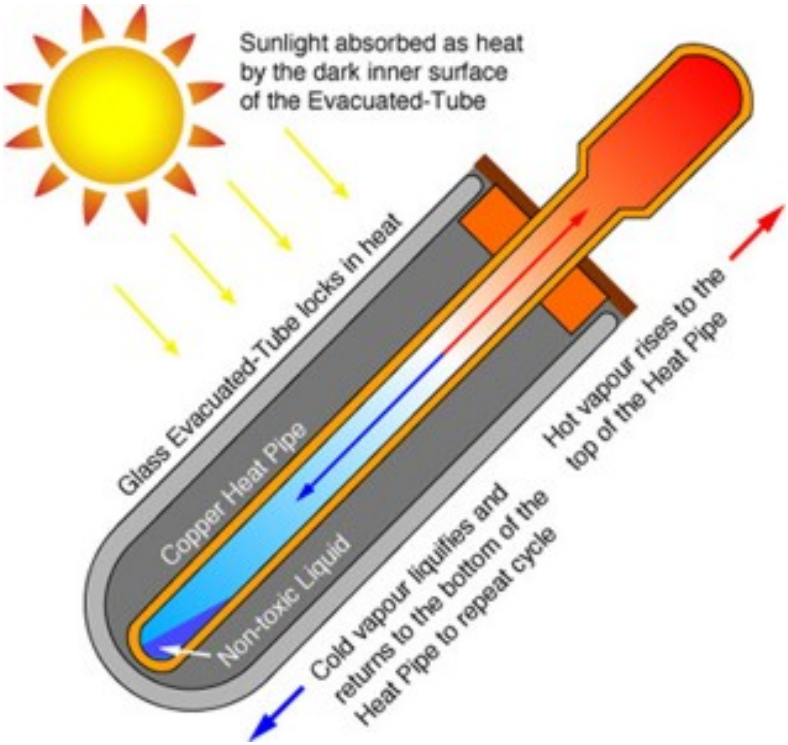
Ede

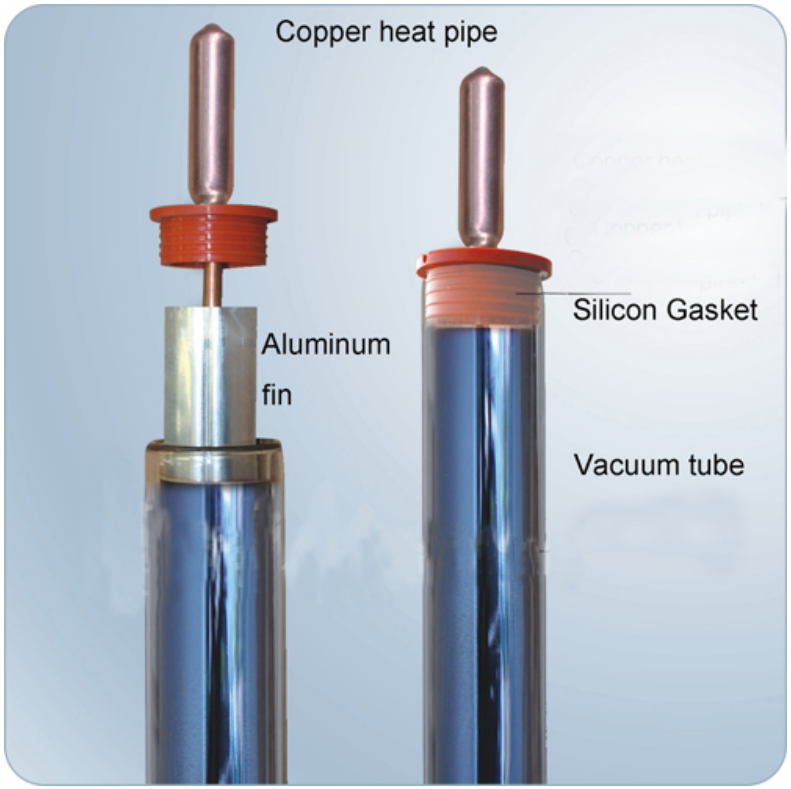
What is this talk about?

- Solar Thermal crash course
- Controllers
- 1-wire hackery how-to
- Results Analysis

Evacuated Tube

- Vacuum tube with heat-pipe





Solar Thermal System

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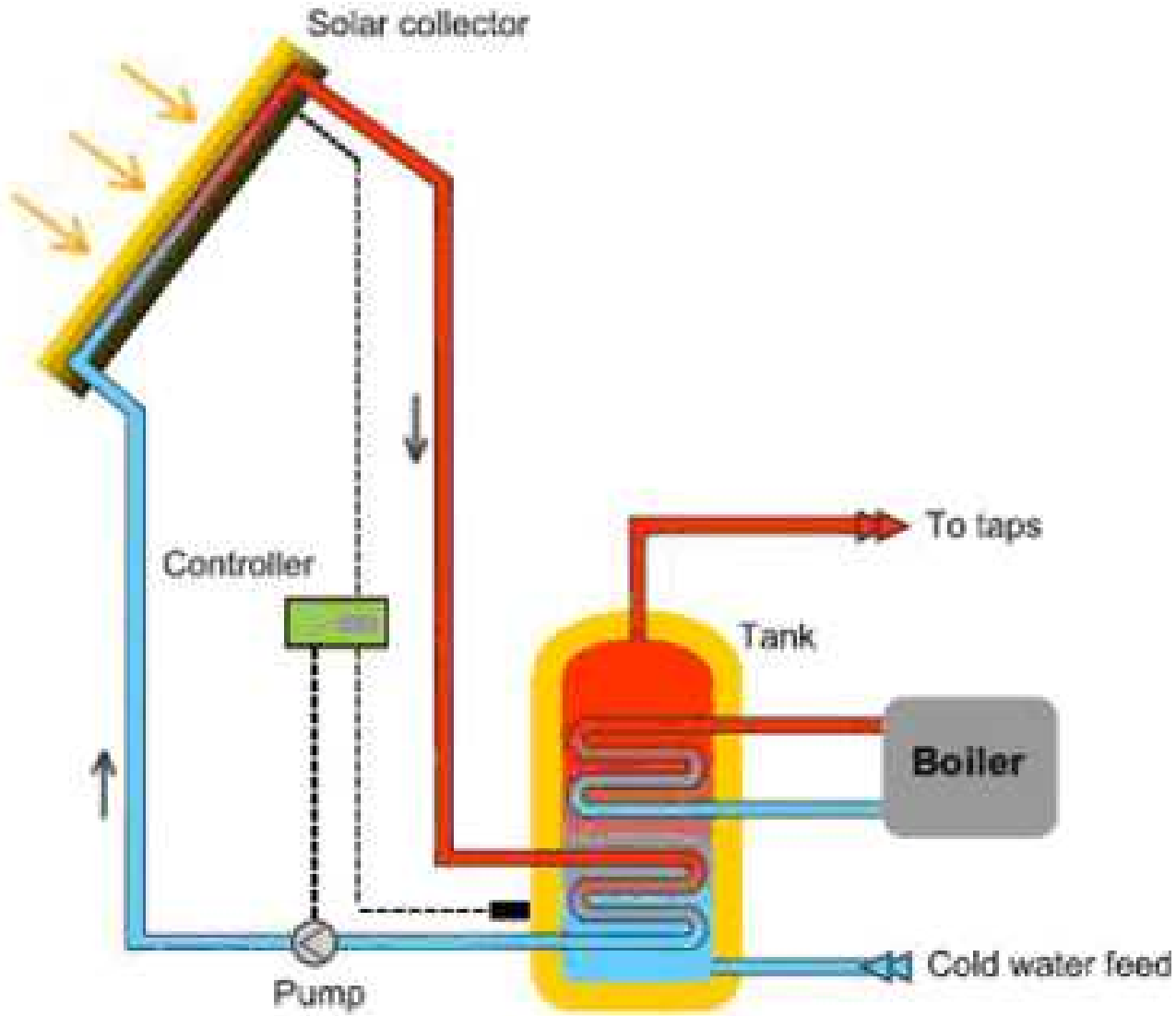
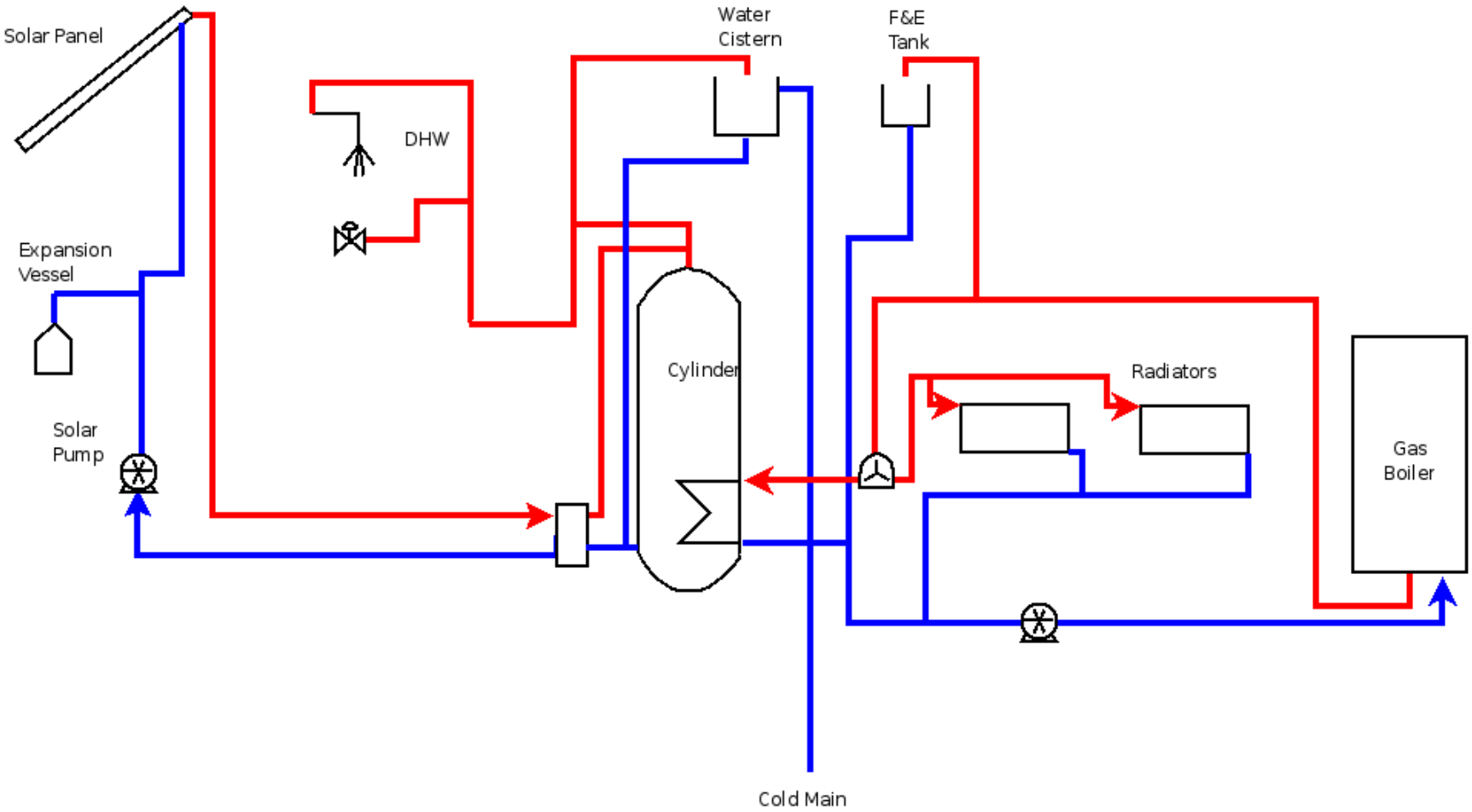


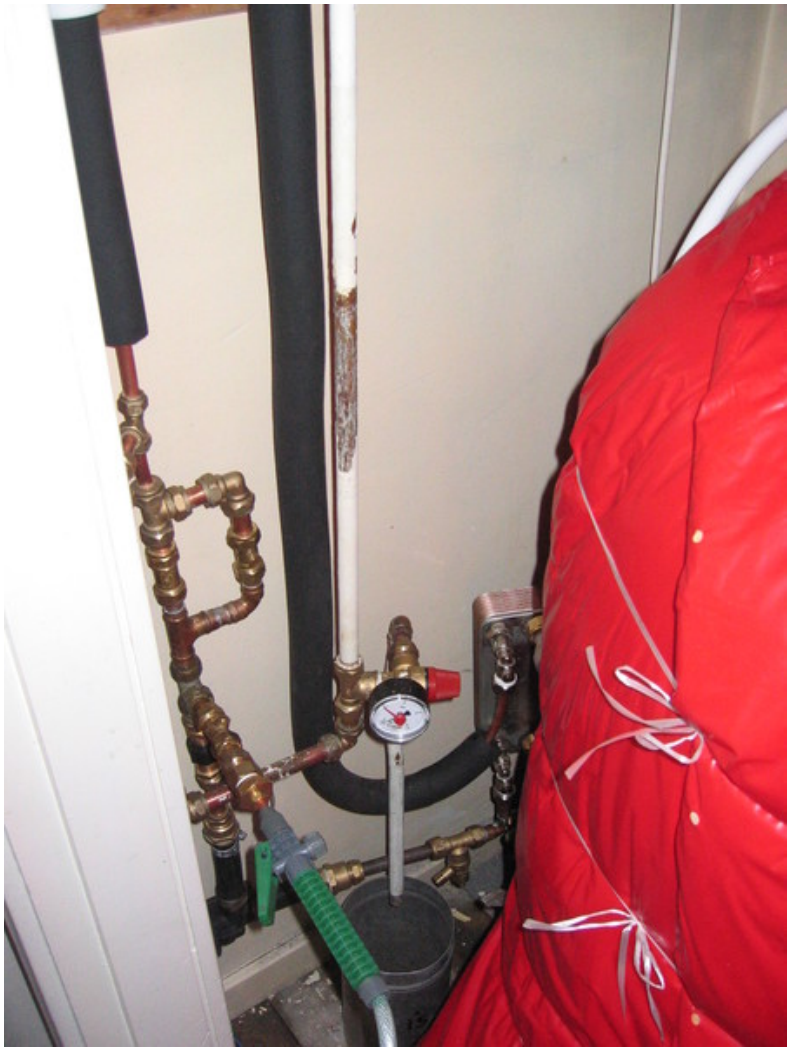
Wook's System

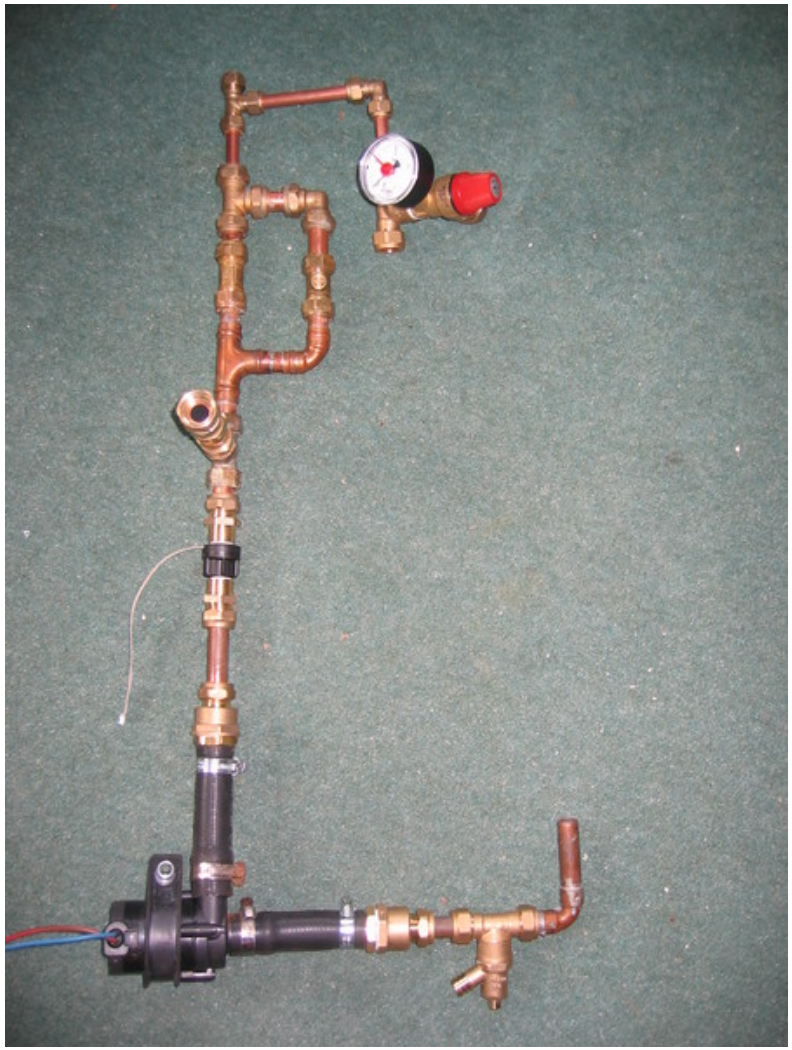
- plate heat exchanger (PHE) layout



Panel Fitting

Plumbing





Thermosiphon

- Existing Tank
- Thermosiphon
- Anti-siphon dip

Commercial Controllers

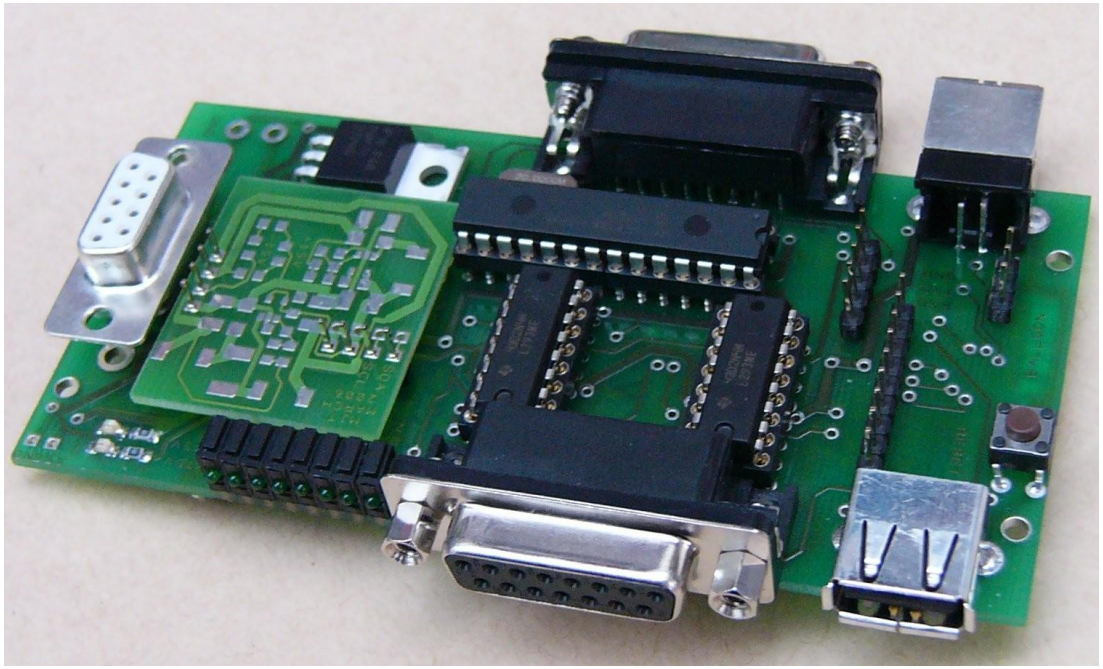
- Standard: 164€
- with Vbus: 230€
- Datalogger: 260€
- Remote Display: 68€
- 10 sensors, 7 outputs: 388€

- 3 sensors, 2 outputs: 162€
- Ethernet connection: 454€

Balloonboard

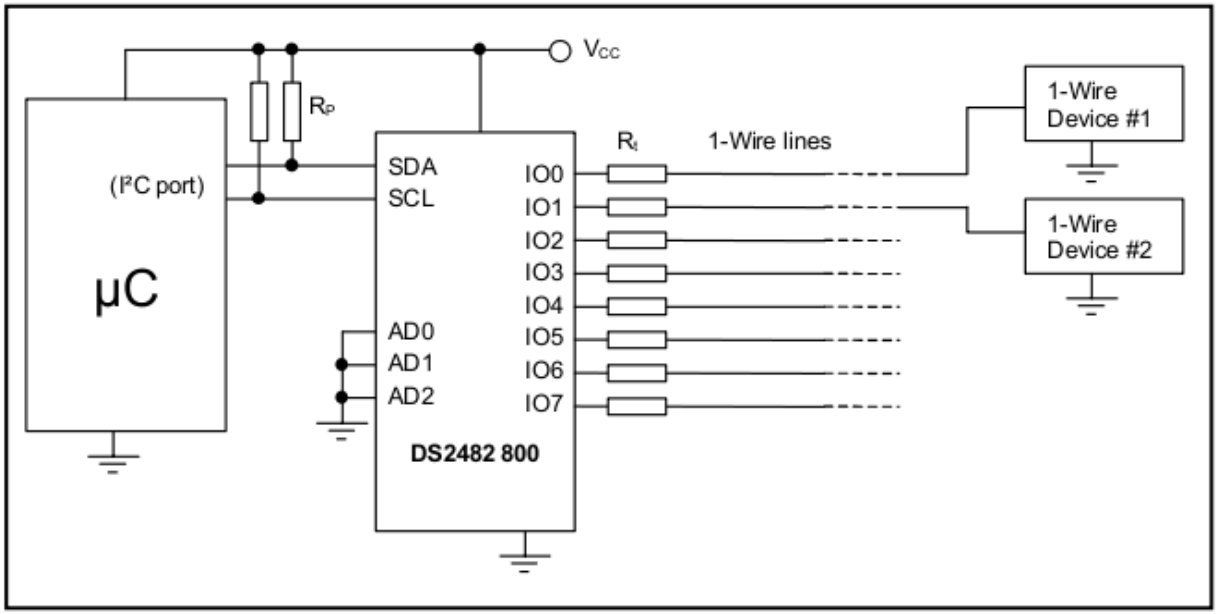
- PXA270, 1GB flash
- 384MB RAM, FPGA
- USB host, VGA display
- Open Hardware
- Distro choice, package management

CUED IO Espansion board



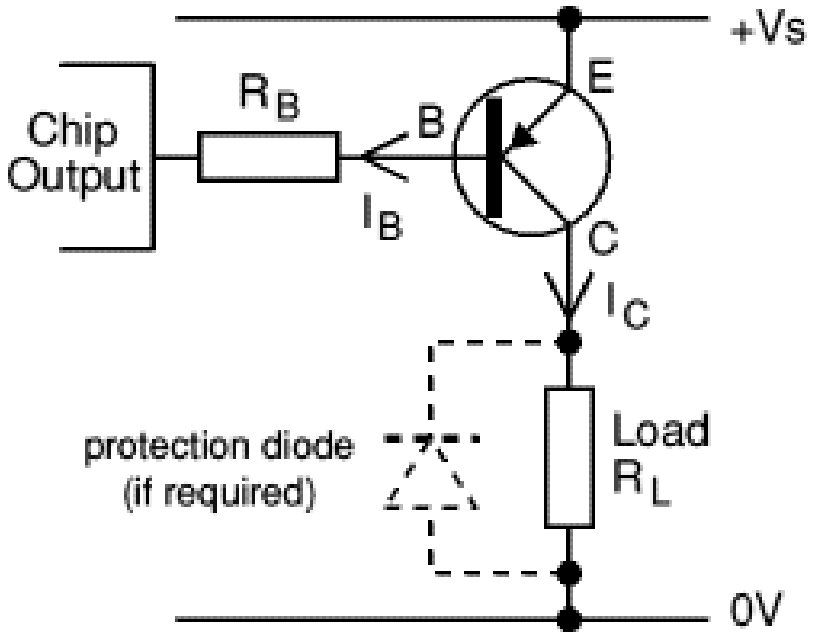
- I2C, 8 digital IO
- 6x 10bit ADC
- 15V/5V crowbarred supply
- USB host/slave
- PWM motor driver

Hardware 1-wire



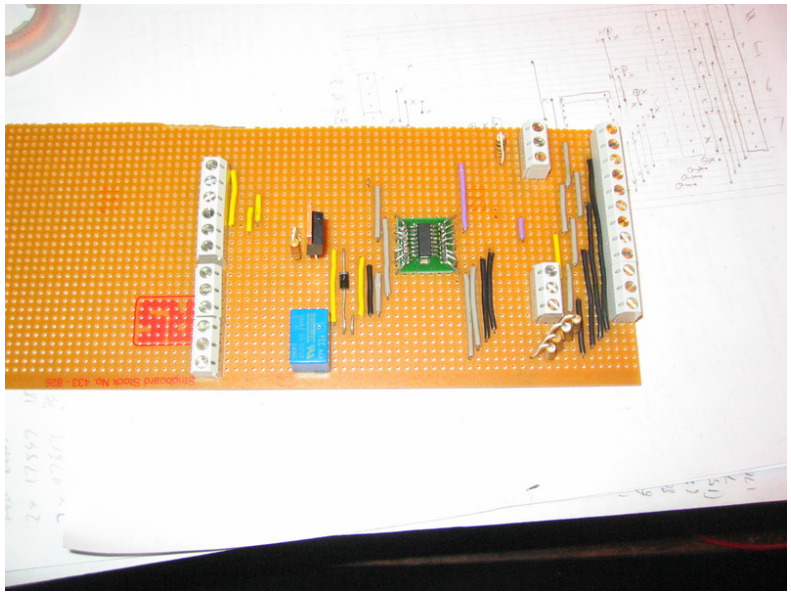
- 8 multiplexed 1-wire buses
- Data: 14Kbit/s max
- Scan: 13 devices/second
- Measurement: 94-750ms
- I2C 400Kbit/s

Hardware - Switching



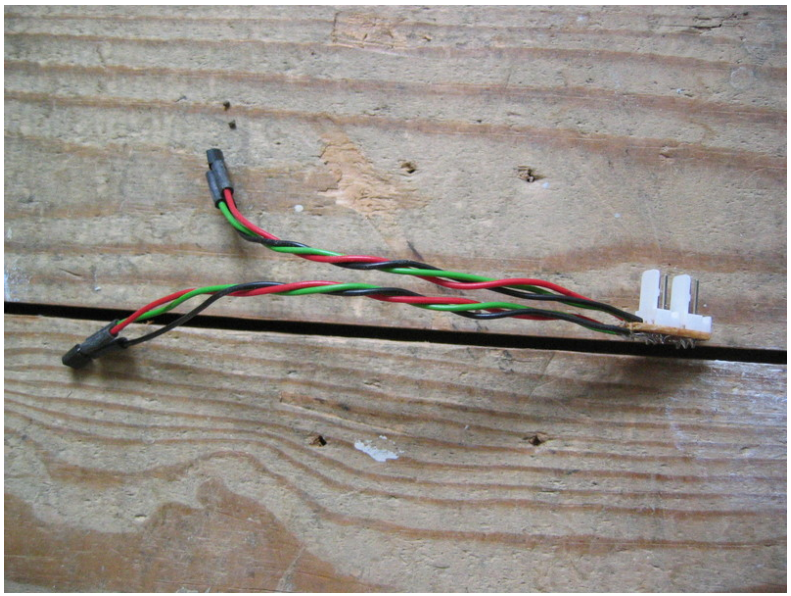
- PCF8574a
- 8 channel IO
- I2C interface
- ‘On’ pulls pin low - PNP
- Relay needed for 12V
- puts out 45mA max

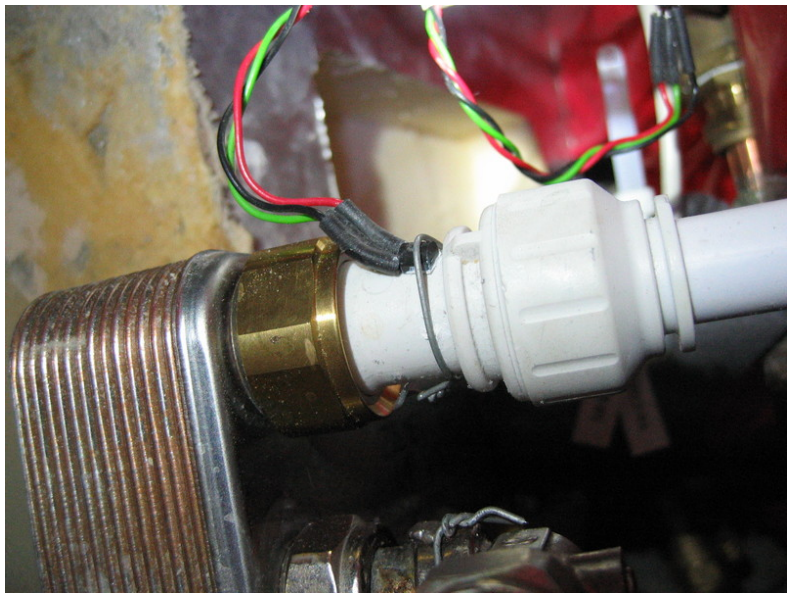
Hardware - Building



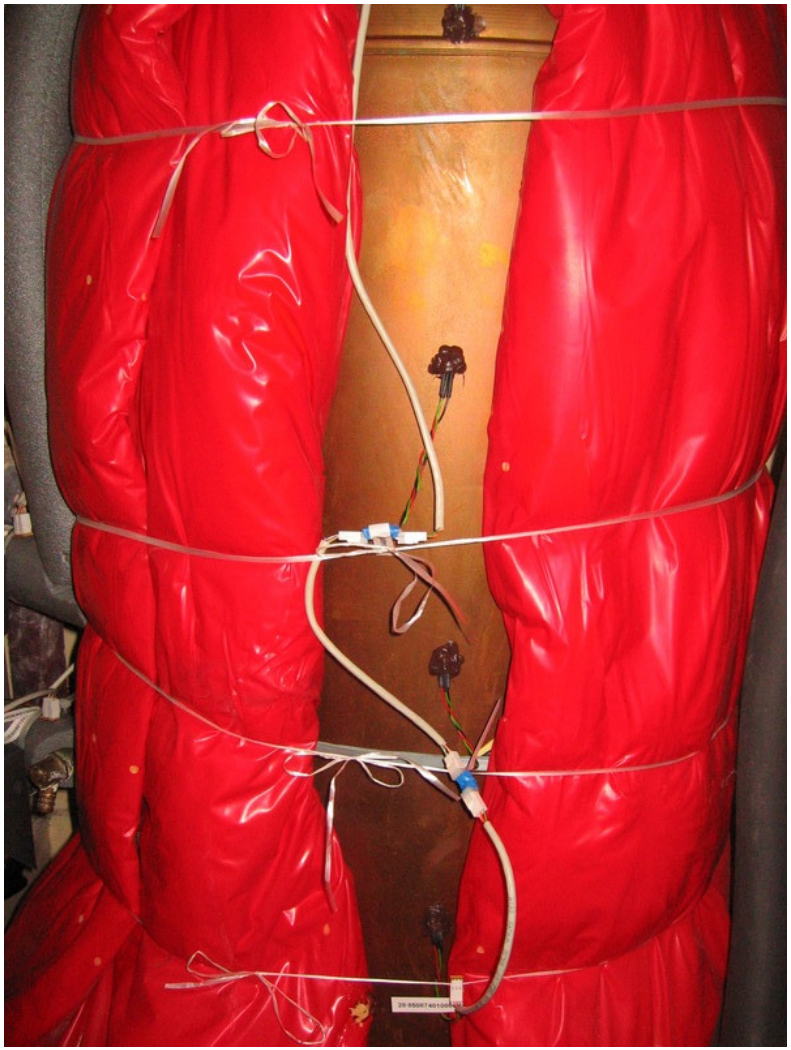
- 4 wires - I2CData, I2CClk, GND, +5V

1-wire Sensors



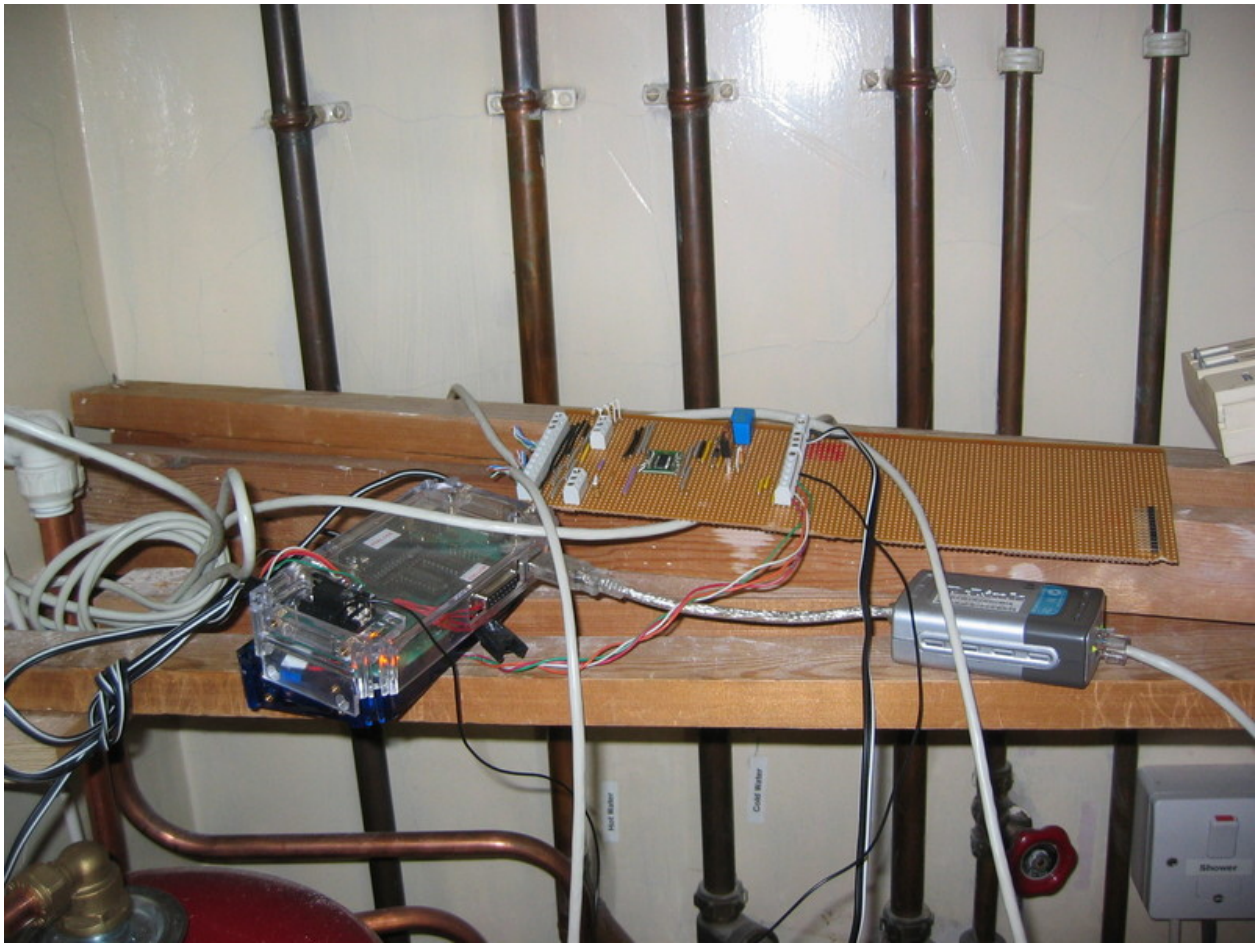


Fitting Sensors



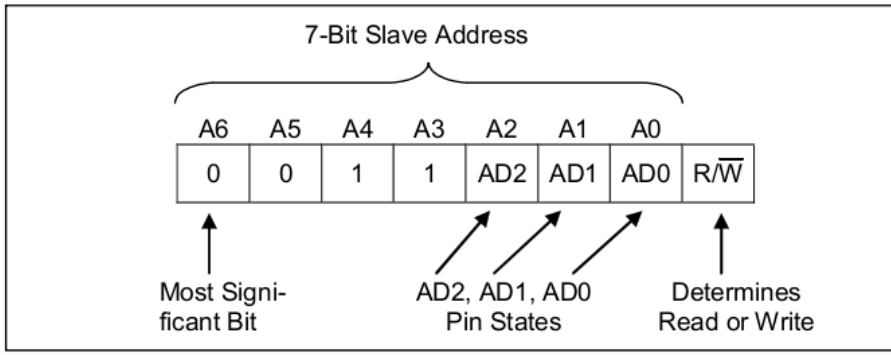
Wook's tidy airing cupboard

- Balloon, extra IO board, USB ethernet adaptor



Software - I2C modules and adressing

- modprobe i2c-pxa
- modprobe i2c-dev
- /dev/i2c-0 /dev/i2c-1
- bus 0 is general, bus 1 is power
- I2C addresses fixed.
- 7bit - bottom bit is r/w
- on DS2482 Address is 0011nnn
- 0x18-0x1F
- pull all three pins low to get 0x18



Software - I2C access

- i2cdump 0 0x18

```
     0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f     0123456789abcdef
00: XX XX XX XX XX XX XX XX XX XX XX XX XX XX XX b5     XXXXXXXXXXXXXXX?
10: XX XX XX XX XX XX XX XX XX XX XX XX XX XX b5 XX     XXXXXXXXXXXXXX?X
20: XX XX XX XX XX XX XX XX XX XX XX XX XX b5 XX XX     XXXXXXXXXXXXX?XX
30: XX XX XX XX XX XX XX XX XX XX XX XX b5 XX XX XX     XXXXXXXXXXXX?XXX
{\ldots}
e0: XX 00 XX XX XX XX XX XX XX XX XX XX XX XX XX XX     X.XXXXXXXXXXXXXX
f0: 18 XX XX XX XX XX XX XX XX XX XX XX XX XX XX XX     ?XXXXXXXXXXXXXXX
```

- pcf8574a on 0x38
- i2cdump from lm-sensors or i2c-tools
- On: echo “0” > /sys/bus/i2c/devices/0-0038/write
- Off: echo “255” > /sys/bus/i2c/devices/0-0038/write

Software - OWFS

- FUSE filesystem
- configure in /etc/default/owfs
  - `SERVER_OPTS="-d /dev/i2c-0"`
  - `CLIENT_OPTS="-s localhost:4304"`
- run with /etc/init.d/owfs start
- New on lenny (on etch needs older python, swig, libfuse)
- apt-get install owfs libowfs26 libfuse

Software - OWFS

- Discover: owdir -s 430 `/28.D23974010000`
- Read: owread -s 4304 /28.D23974010000/temperature
  `34.25`

Manual rrdtool - create database

- Create Round Robin Database
- Filled in with rrdupdate

```
sudo rrdtool create /var/log/solar.rrd -s 10\
   DS:panel:GAUGE:40:-20:125\
   DS:tanktop:GAUGE:40:-20:125\
   DS:tankbott:GAUGE:40:-20:125 \
   DS:pump:GAUGE:40:0:1 RRA:AVERAGE:0.5:1:20160\
   RRA:LAST:0.5:1:20160 RRA:MAX:0.5:60:1120
```

- Should be 9 days, actually 2.5

Manual rrdtool - generate graph

```
sudo rrdtool graph --end 18:00d --start 06:00d /tmp
    /solardetail.png -M -i\
  -t ''Wook's solar system'' -v ''Temp (C)'' -h 200
      -w 800\
  DEF:pump=/var/log/solar.rrd:pump:LAST TICK:pump#
      000000:0.05:''Solar Pump on'' \
  DEF:panel=/var/log/solar.rrd:panel:LAST LINE2:
      panel#FF0000:''Panel Temp'' \
  DEF:tanktop=/var/log/solar.rrd:tanktop:LAST LINE2
      :tanktop#00FF00:''Top of Tank'' \
  DEF:tankbott=/var/log/solar.rrd:tankbott:LAST
      LINE2:tankbott#00ffff '':Bottom of Tank''
```

Munin

- local and remote munin setups
- hides rrdtool details
- Easy plugin scripts
- Munin-graph uses 85% of cpu
- Munin broken on arm

Munin plugins

- Any language
- Called with config: prints variables
- Called normally: prints values

sudo munin-run panels

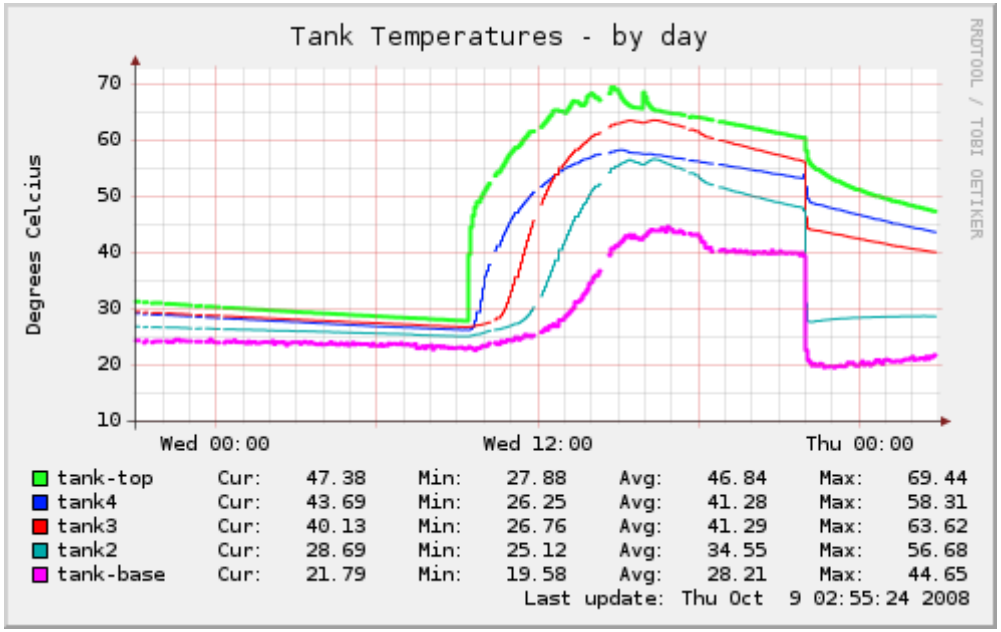
```
panelin.value        10.875
panel1.value         9.5625
panel2.value         10.4
pump.value           0
```

Munin plugin for panel

sudo munin-run panels config

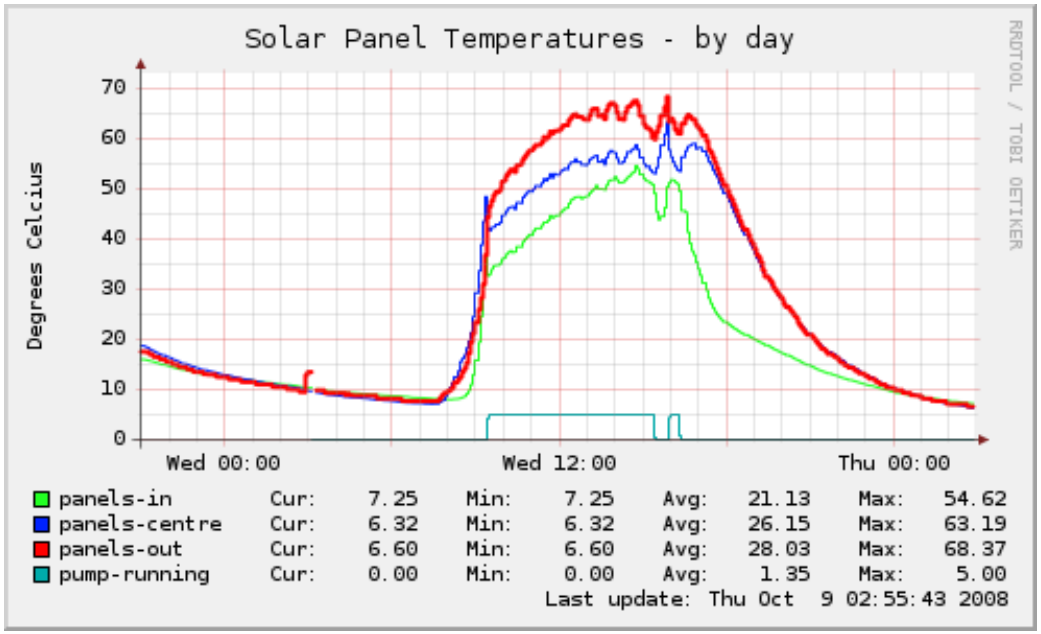
```
graph_title Solar Panel Temperatures
graph_order panelin panel1 panel2 pump
graph_vlabel Degrees Celcius
graph_info This graph shows solar panel temperature
graph_period minute
panelin.label panels-in
panelin.draw LINE1
panelin.max 126
panelin.min -2
panelin.type GAUGE
panelin.info Temp flow into solar panels
```

What did I discover



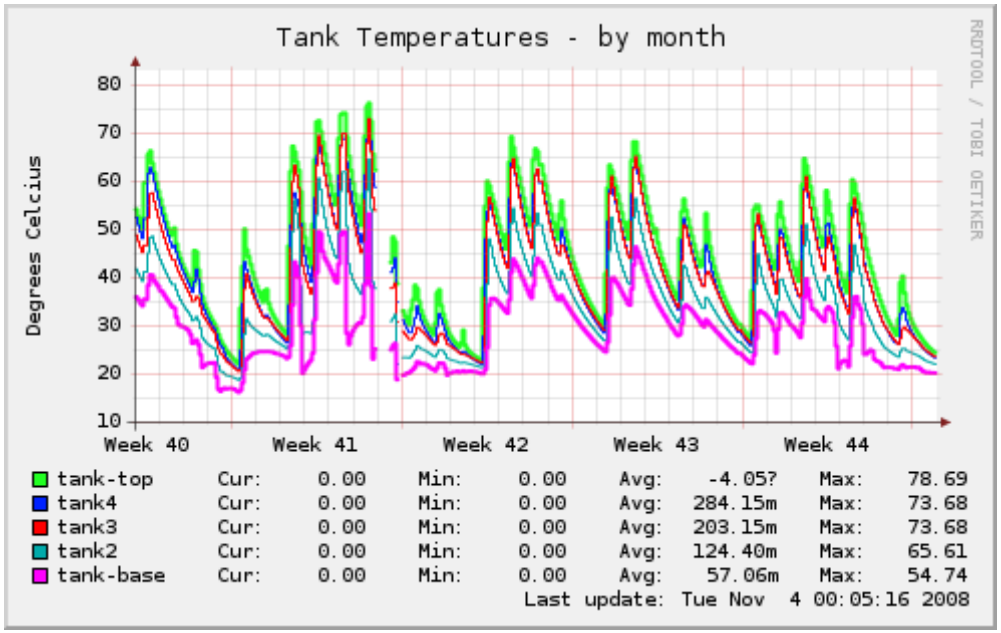
- It works!
- Thermosiphon reacts very quickly (<30 seconds)
- Control is interesting question

Panels



- 15°C rise across panels
- 68°C in October

Monthly summary

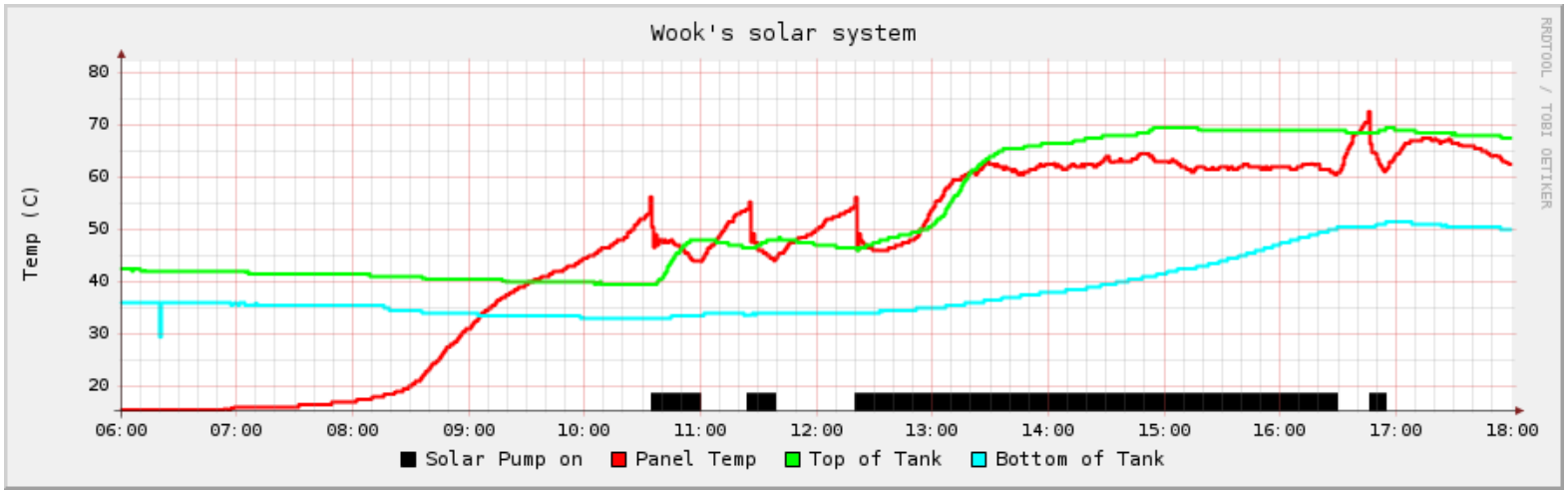


- Provided hot water about 23 days of 31

Control

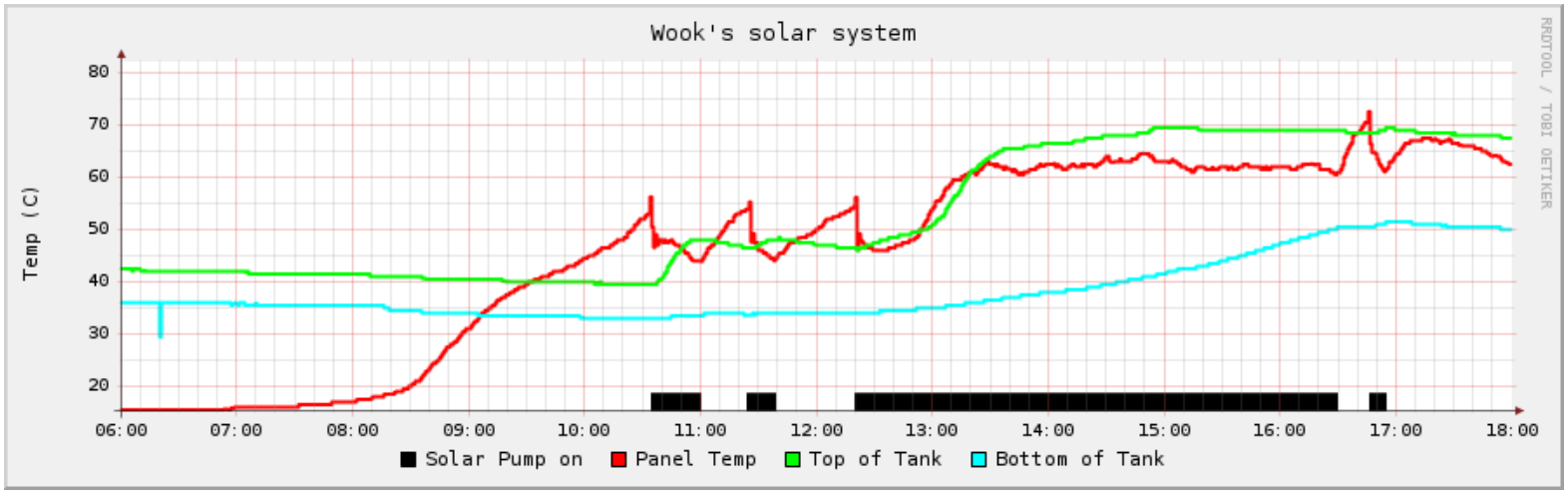
- if panel >tank_bot + 20 or panel >tank_top + 4 : pump on
- if panel <tank_bot + 10 : pump off
- if tank_top >80 : pump off
- Horrible shell script
- Decimal temp readings - bc
- DIYzoning. . . PID control

Stratification



- Tank stays stratified during loading
- Tank hotter than panel!?

Stratification



- Tank stays stratified during loading
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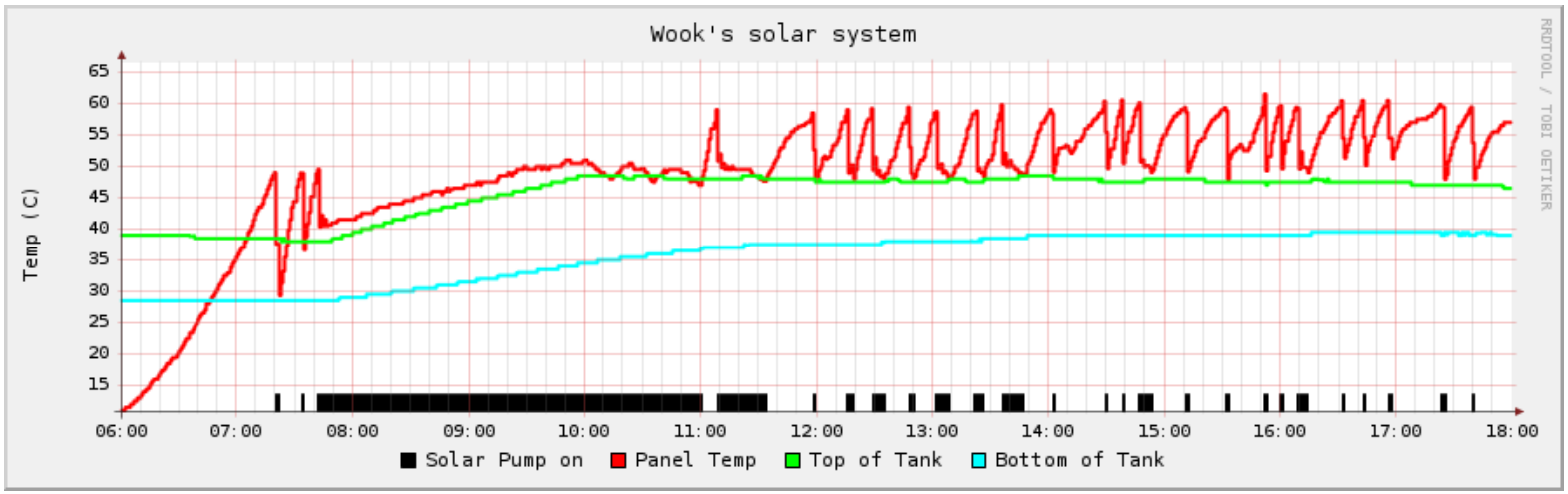
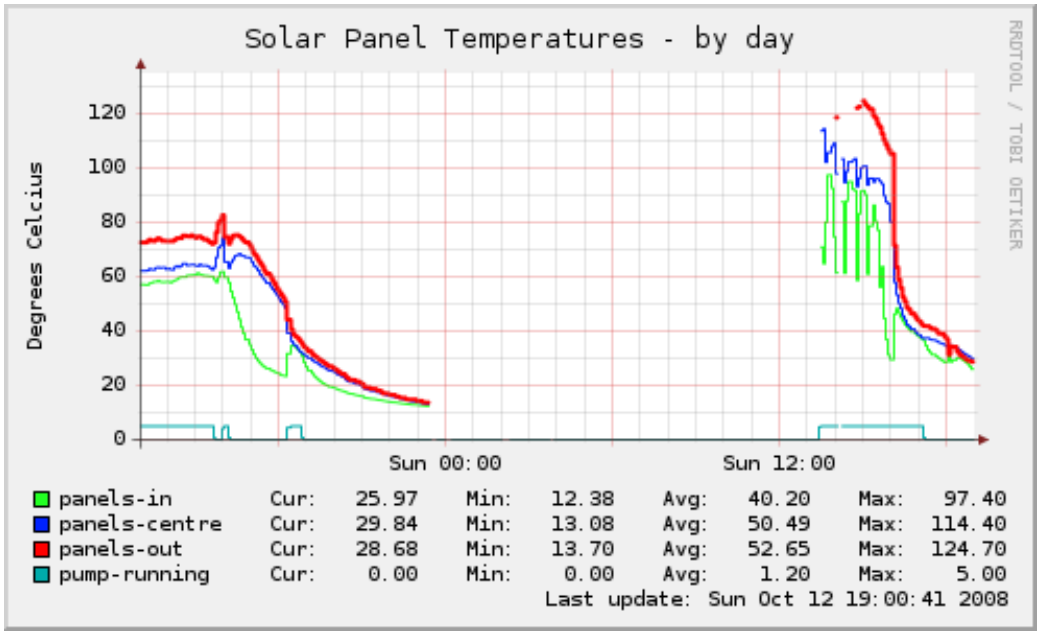
Medium day



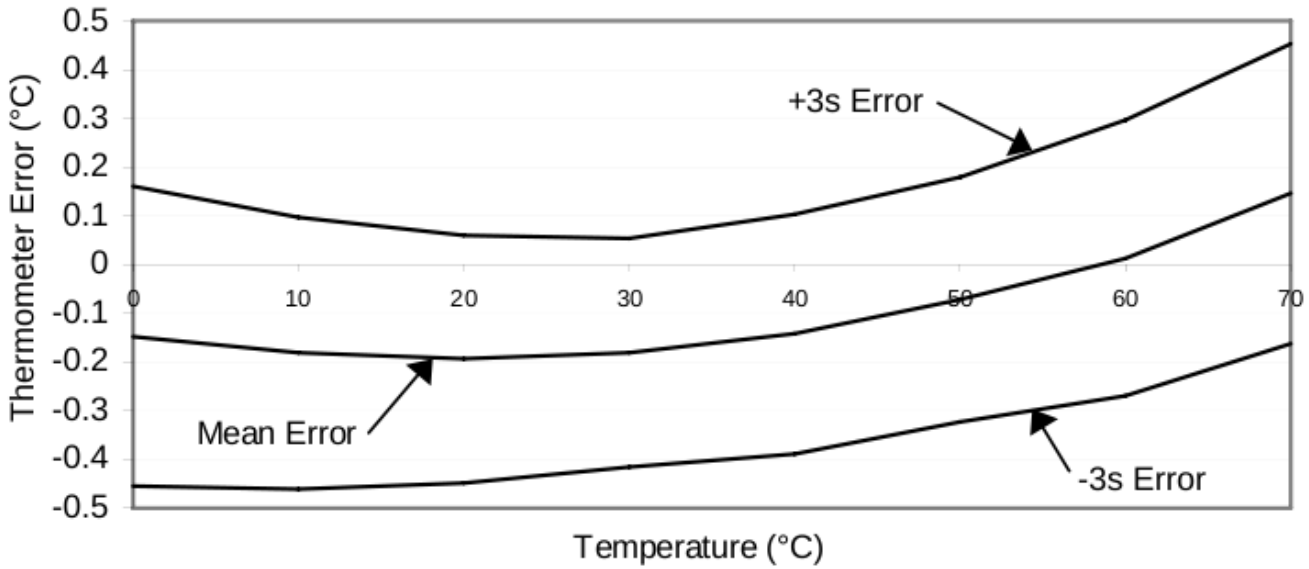
- Hysteresis between +10°C and +20°C

Reliability



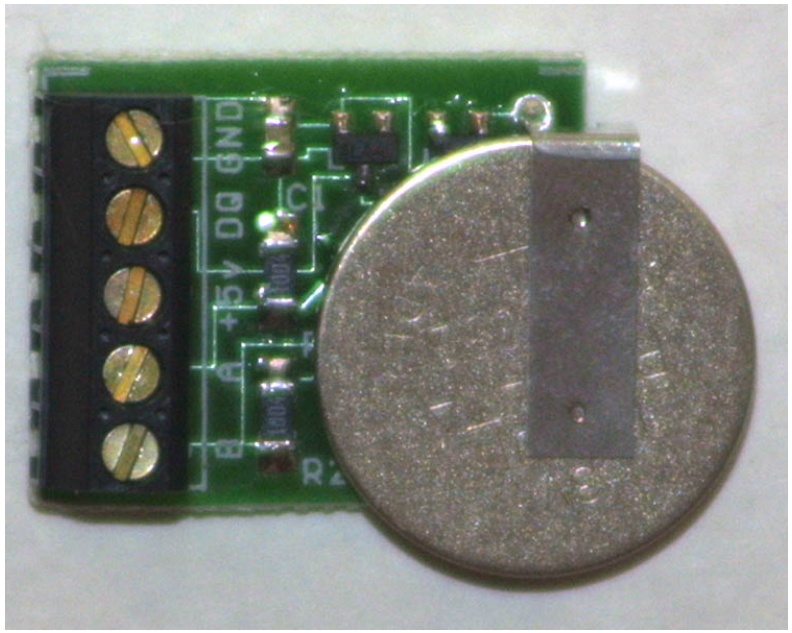
- Uptime: 87 days load average: 1.02
- owserver crashed once in 5 months
- Some 1-wire glitches
- Disk full survived

Temp accuracy



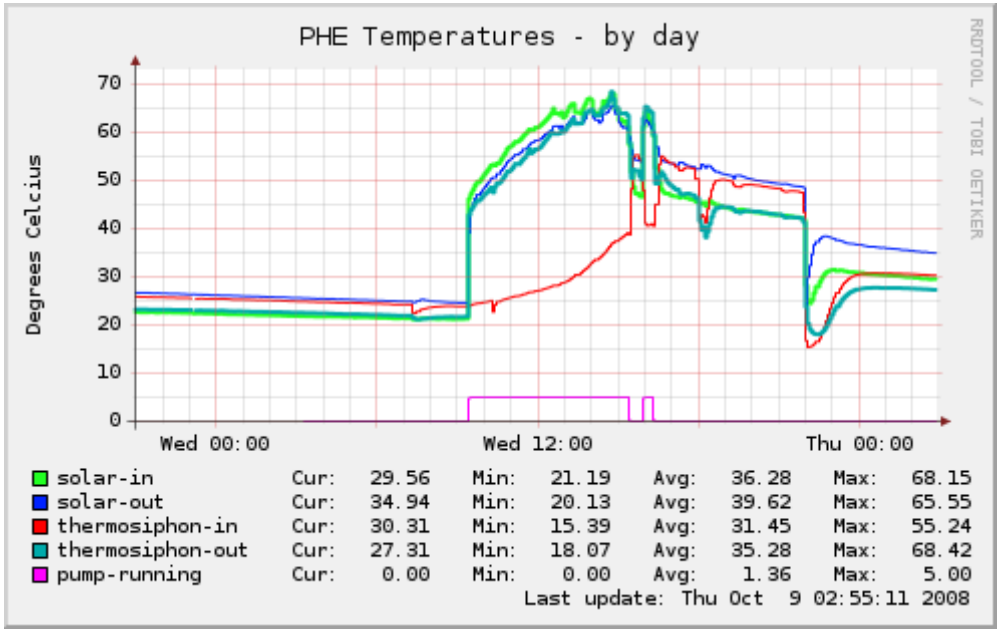
- Nominal 0.5°C accuracy (0-55°C)
- 2°C accuracy (below 0°C, above 55°C)
- 3.8°C difference
- Stuck at 85°C, and 10% low

Flowmeter



- Swissflow SF800 - optical sensor
- Battery-backed Counter board

Flowmeter



- 1.3 million pulses
- 4°C temp drop
- 6100 pulse/litre
- 1.6 l/min
- $Specific_heat(kWh/KgC * Mass(Kg) * Temp_diff(C) = Energy(Kwh)$
- $0.00116 * 1327532/6100 * 4 = 1kWh$

What's missing/Future?

- power-fail proofing
- Local User Interface
- Solar: Display tank temp, Bath status, Energy gain
- House: Room temps, Active zones
- Inputs: 'Make a bath' button, Leaving house, +1hr
- Configuration: Sensor allocation, Rule adding/adjusting
- How?: Browser, GTK, Misterhouse, Glade
- MythTV plugin, SMS
- Interfaces: xAP, wireless sensors, moon on stick
- Upload data for comparison, to AMEE

Conclusions

- Solar Thermal is great
- 1-wire is great
- UI is harder - needs work
- I have a very tolerant wife