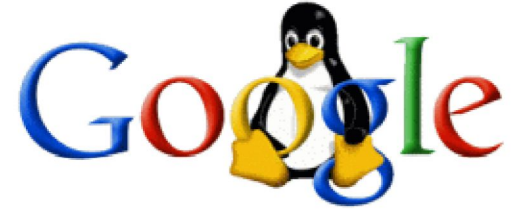# Linux.conf.au 2019

Using Open Hardware from my shirt
to OS testing for Google's Fuchsia

Slides: http://marc.merlins.org/linux/talks/Using_Open_Hardware/
Short link: https://goo.gl/4mWCE6

Marc MERLIN

merlin@google.com

Welcome to my compilation of rejected LCA talks since 2014 :)

- Introduction to arduino for the linux user <= rejected

- Tracking sleep apnea and sleep patterns with arduino and linux <= rejected
  http://marc.merlins.org/linux/talks/ArduinoSleepMonitoring/html/

- Learn from Tridge: how to hack hardware and software with Ardupilot <= rejected

- I'm sure it's not because the talks sucked, but because there are too many smart people here with even better talks :)

- Using Open Hardware from my shirt to OS testing for Google's Fuchsia <= you are here :)

Let's do them all, 4 talks... Over ~~150~~ 166 slides in 40mn

- Questions at the end/in the hall please

- 3.75 slides per minute

- Or 16 seconds per slide

- You can read that fast, right?

- Ready….

-

- Go!

This slide from Paul Fenwick makes talks go faster

Why this talk?

- I have nothing to sell to you

- No project to get you to use (actually that's a lie, please lok at FastLED::NeoMatrix and SmartMatrix::GFX)

- But really, it's about how you can do interesting hacking with minimal electronics knowledge

- What I've learned and what you can learn from the open hardware miniconf.

- And very blinky stuff you can do with microcontrollers

When I was a kid, I started learning electronics first

- We didn't have computers we could have at home yet (ZX-81 was just coming out).

- I got electronic kits where I could wire circuits that would do things, but I mostly didn't know why or how (I was 10 to 12)

- It's only may years later in university that I learned the theory behind circuits, which relied on differential equations.

- It was inconvenient and relatively expensive to have to walk and take the subway for over an hour to go buy electronic components I was missing or burnt

In Electronics, you make new friends

The magic blue smoke

I eventually gave up on electronics

- I finally got my first computer, Amstrad CPC 464 (8/16bit Z80 4.77Mhz, more RAM than an Arduino Uno but not faster). I was 12 then.

- It was much easier to continue on computers, the learning curve was easier, even if I eventually had to learn assembly on Z80.

- I still knew the basics from school, U = R x I and so forth. I did learn op amps and more in uni, but never really used them and forgot it all

- I spent all my time on computers for the next 20+ years

Don't listen to Jon Oxer, Electronics is hard and compile times are terrible :)

But there is basic electric stuff everyone can do

- Electronics is harder than microcontrollers (at least for me)

- But electricity is easier than both

- With a soldering iron and a multimeter you can do useful things

- Like the smallest thinkpad power supply I could find, reusing a 20V power supply I already carry for my Li-Ion battery pack

- My laptop backpack and wiring still weighs 15kg+ on a good day though

- "Fun" when flying in Oz or NZ with the 7kg limit

Thinkpad Power Supply Hacking

- I'm very happy with my Thinkpad P70, 4K 17" screen, 6TB of storage

- But it's a bit power hungry.

- It tries to speed charge the battery at over 5A/20A, which is over 100W

- Trips airplane power outlets, and >100W on 12V usually ends up being over 10A, so it trips 12V car cigarette ligher adapters too

- Thinkpad center pin tells the laptop if the power supply is 45W, 90W, 135W or 170W using a resistor value.

- Hack my own adapter to select the power I can safely use

- http://marc.merlins.org/perso/electronics/post_2016-02-29_Hacking-a-thinkpad-slim-tip-adapter-to-output-more-than-90W-_required-to-charge-a-Thinkpad-P70_.html
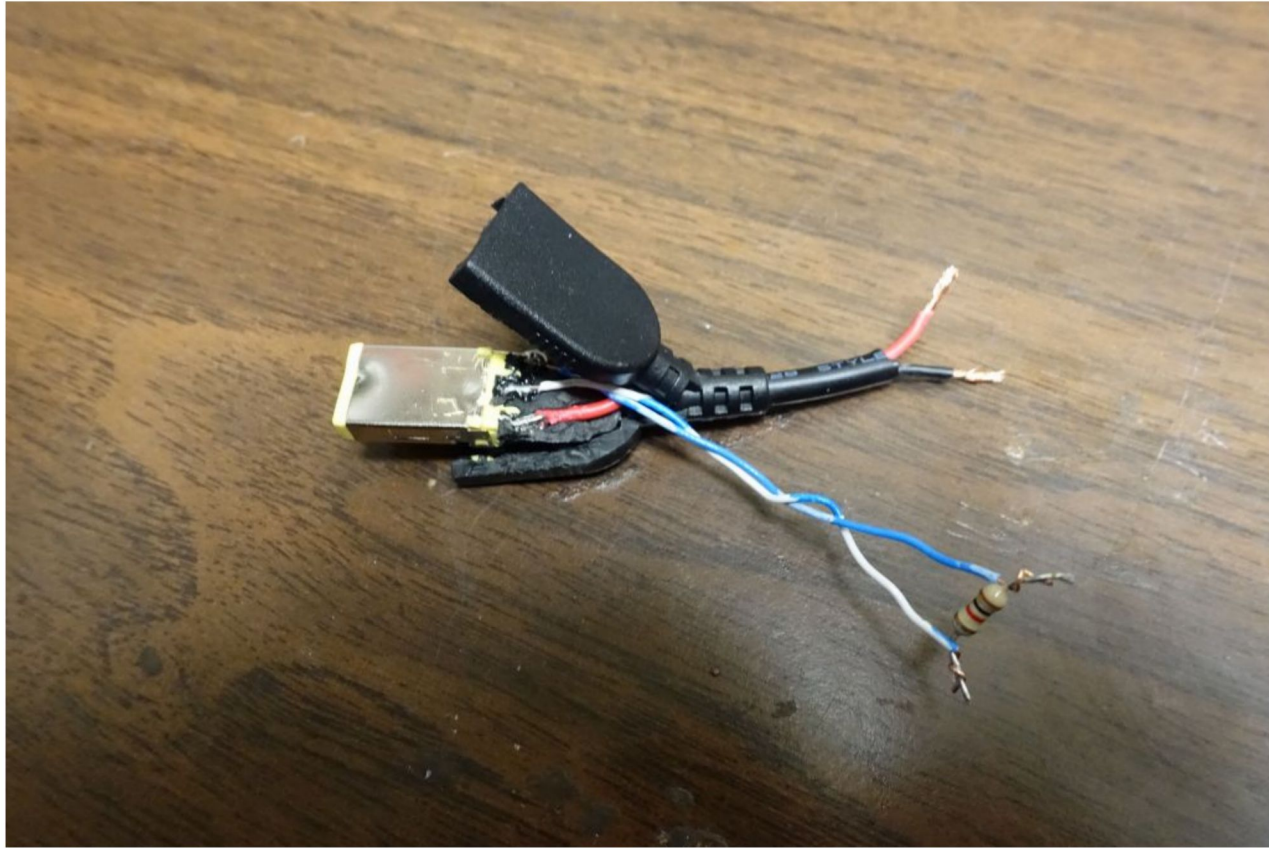
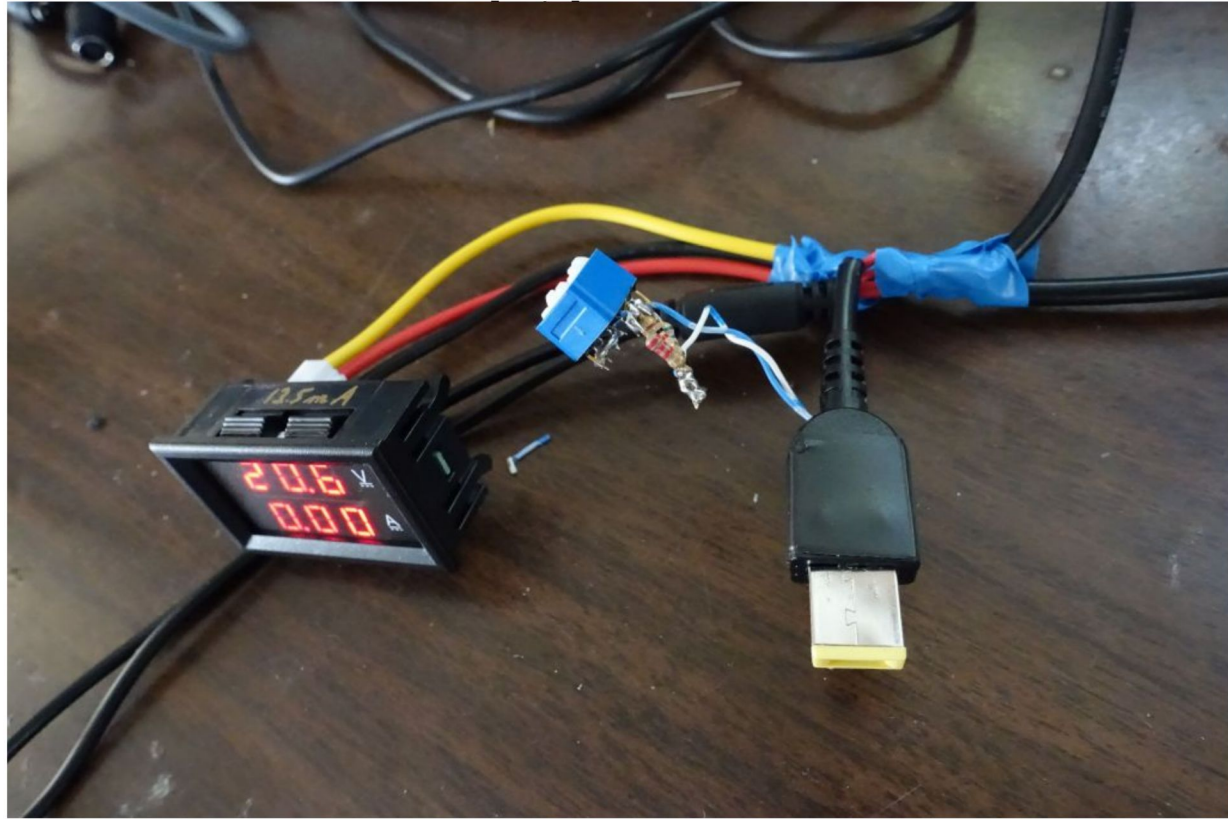# Reusing a small and light 20V power supply as emergency travel power supply

Roughing it up on the Routeburn Great Walk with my lighter power supply

Hacking the connector

Forcing 4 types of power supply amperages with resistor

# Successfully charging from a 110W 12V power

DC-DC power handling off the grid

- Be it from a car 12V power, or a marine/AGM battery with solar panels at ephemerisle or burning man, you don't want to convert 12V back to 110/220V and back down to 12V or 5V. You can even up-convert 12V DC to 20V DC more efficiently

- http://marc.merlins.org/perso/electronics/post_2018-06-30_DC-charging-with-DC-to-DC-conversions-when-off-the-grid.html

With minimal work, you can get this, no AC

Making my own thinkpad 12 to 20V power
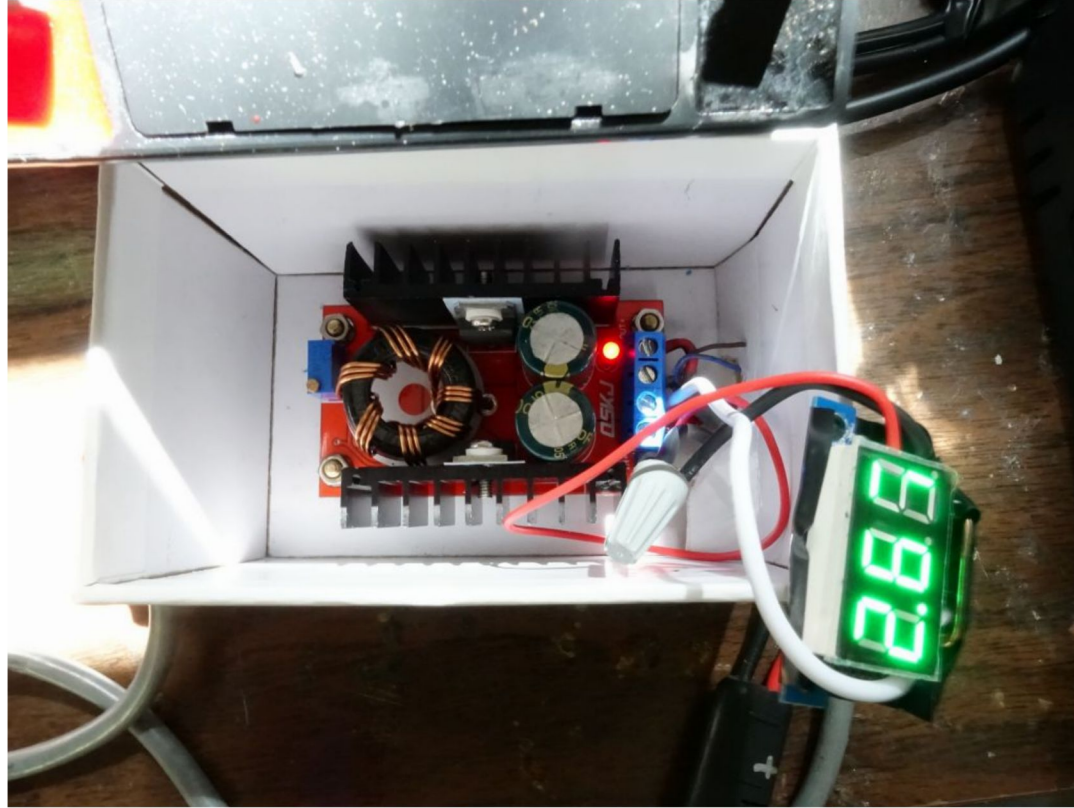
Simpler even: USB power monitoring

- USB is not that simple. Is it 5V, 9V, 12V, 20V?

- How many amps are going through?

- Why is my plugged in phone actually discharging overnight?

- Should I plug my phone into this unknown USB plug with a data cable?

  (spoiler alert: no, it could be using data to try and hack your phone)

Get a USB power monitor. This USB "charger" only provides 0.4A

My laptop can provide 5V/2A over USB and the adapter can charge 2 devices
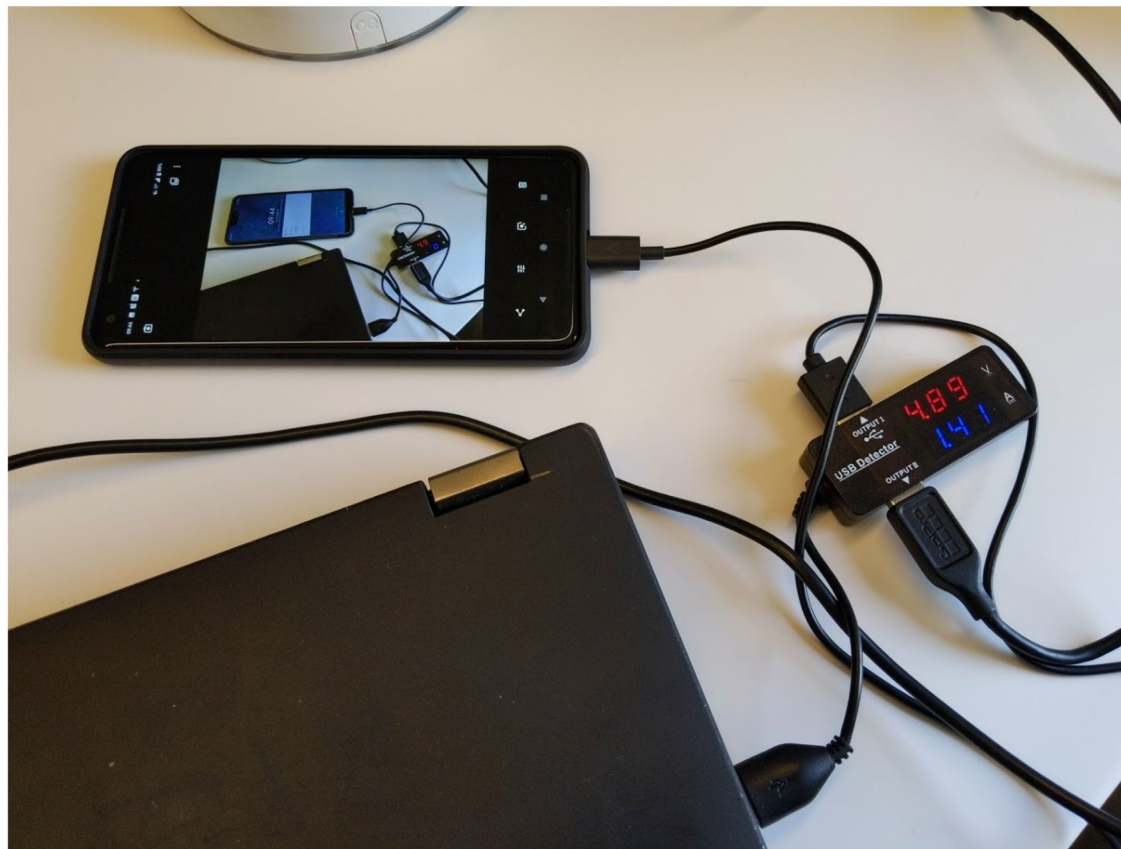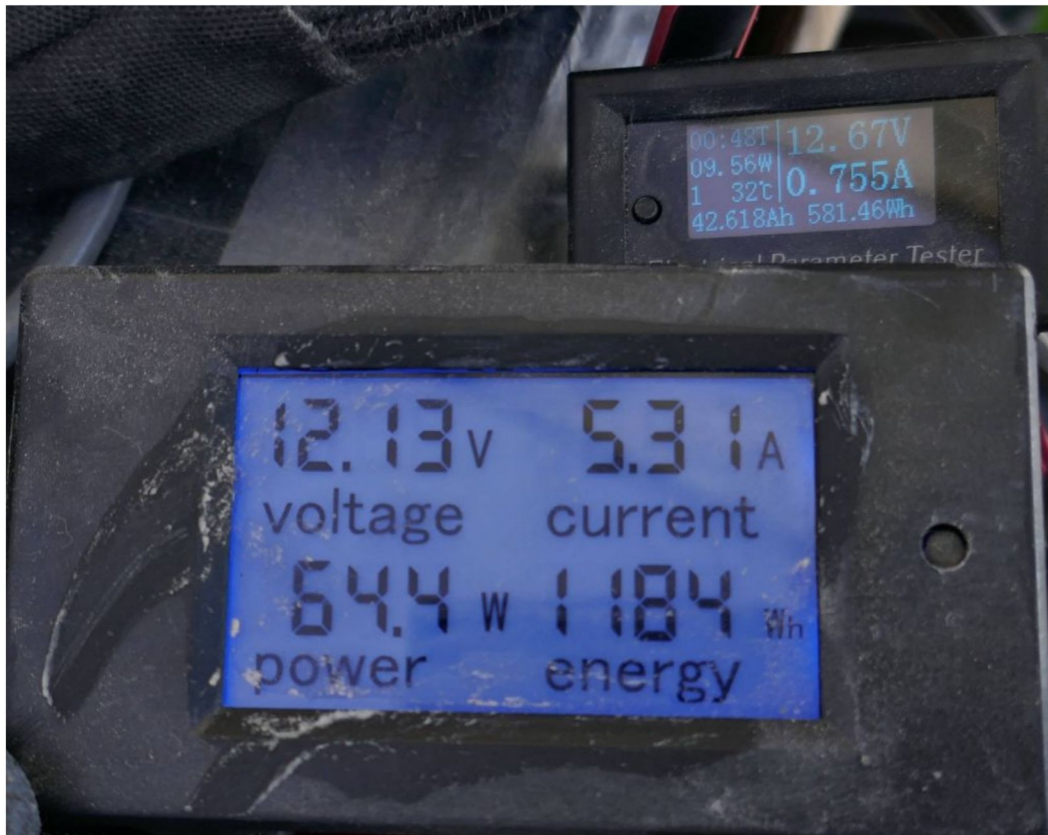
Making your own DC only solar charging system

20Wx2 was charging big deep cycle battery

Sadly I used twice as much power as I was making. Lots of things to charge

**But the big win: no need to deal with AC power (thanks again Paul)**

When Arduino came out

- Didn't really have time to look at it, or a need for it

- But it started getting momentum

- Up to when linux.conf.au added an arduino miniconf

  (now Open Hardware Mini Conf)

LCA 2010: Jon, Andy, Luke & all started the OHMC

- I missed the first OHMC at linux.conf.au 2010 (pebble v1)

- Although I was able to get it at LCA 2011 and had fun programming it
  http://marc.merlins.org/perso/arduino/post_2011-01-19_Pebble-Shield-from-Arduino-Miniconf-2010.html

- It had buttons (to practice button debouncing code)

- Potentiometer, Relays, Ldr (light detector)

- Slot for a wireless radio, Proto board

- http://www.openhardwareconf.org/wiki/AMC2010

Google

Pebble V1, LCA Arduino Miniconf 2010
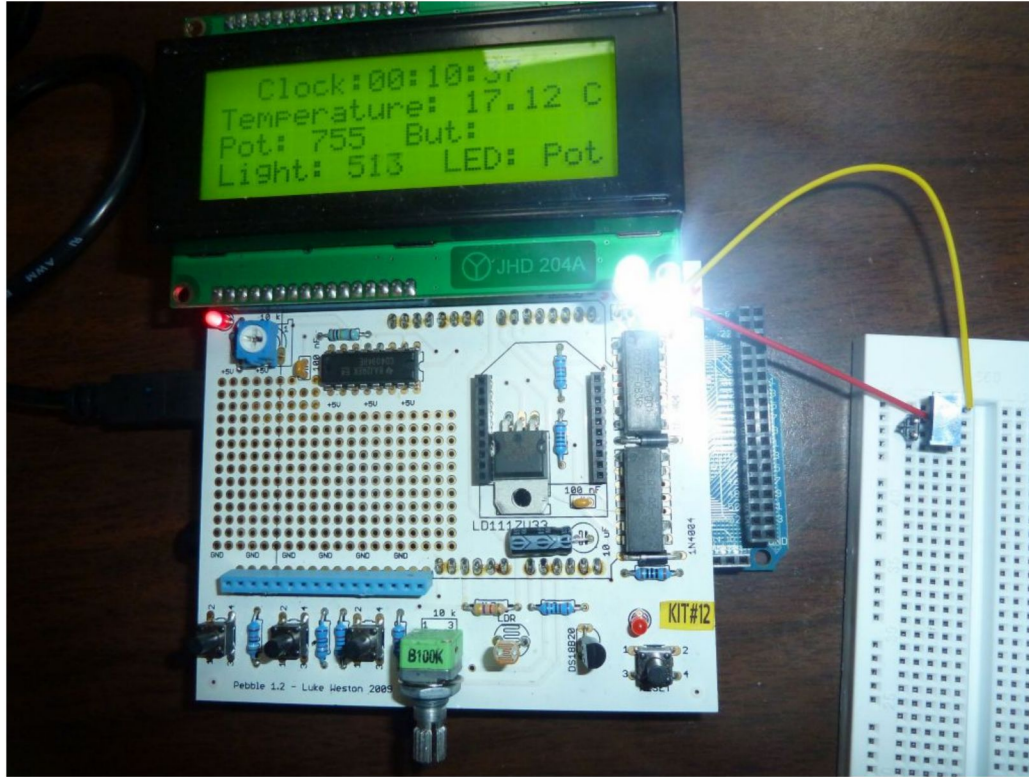
LCA 2011 OHMC: mobsendat, meant to go on a rocket

- Featuring the freetronics arduino 328p clone

- Another option, KitTen: www.freetronics.com/kitten

- It was a pretty compact and featureful arduino board for the time

- 2 wireless radios, GPS, Altimeter & accelerometer

- Sdcard to record data

- Meant to fly to "space" in a rocket built during the conference

- http://www.openhardwareconf.org/wiki/AMC2011

# Mobsendat, LCA Arduino Miniconf 2011
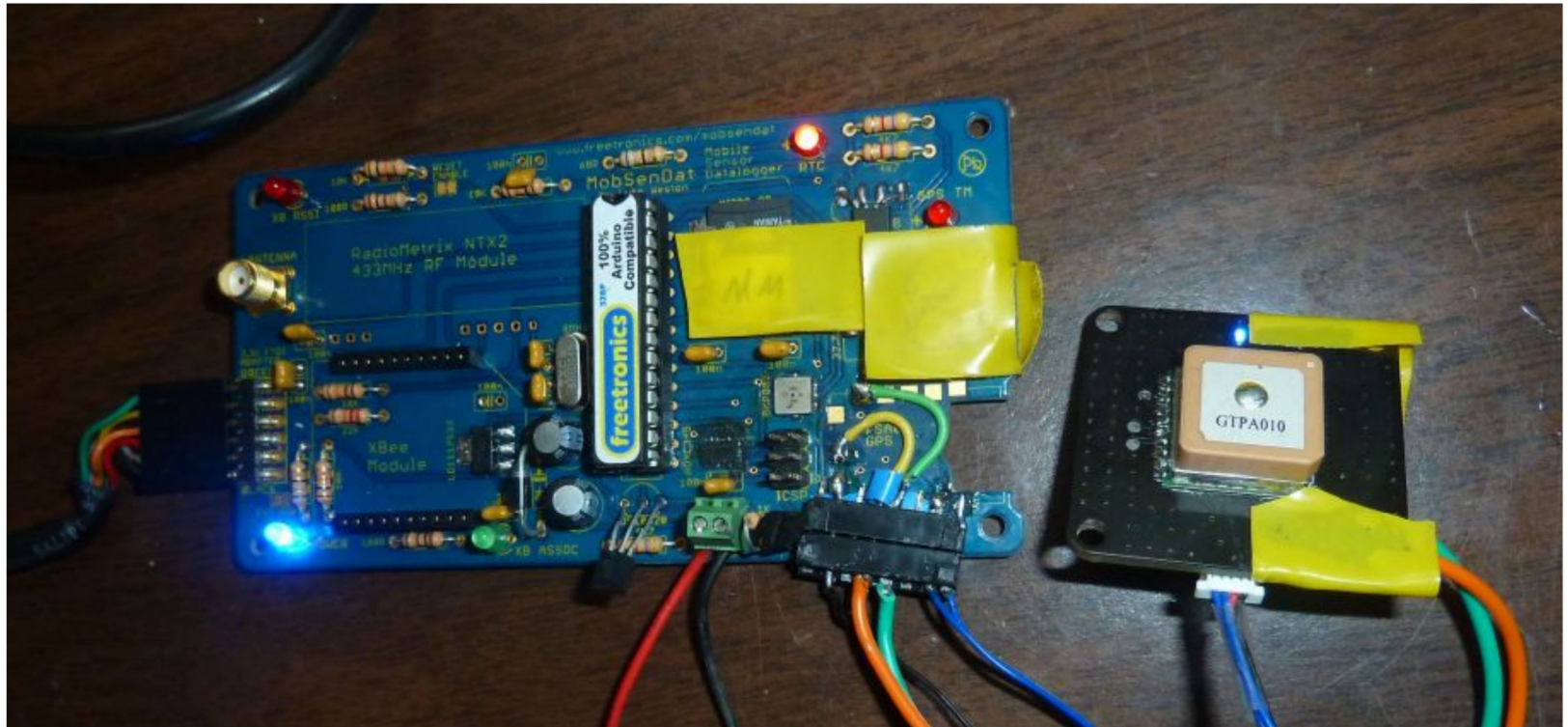
Mobsendat was built to go to space

https://www.freetronics.com.au/blogs/news/2651342-mobsendat-flies-to-the-edge-of-space

But my mobsendat never went to space

- I was interested in tracking my sleep

- How long I slept

- How long I stopped breathing if it happened (sleep apnea)

- Resulting drop on blood O2 saturation

- What was my sleep position (back sleeping is worse for apnea)

- http://marc.merlins.org/linux/talks/ArduinoSleepMonitoring/html/

Good luck having a normal night with this
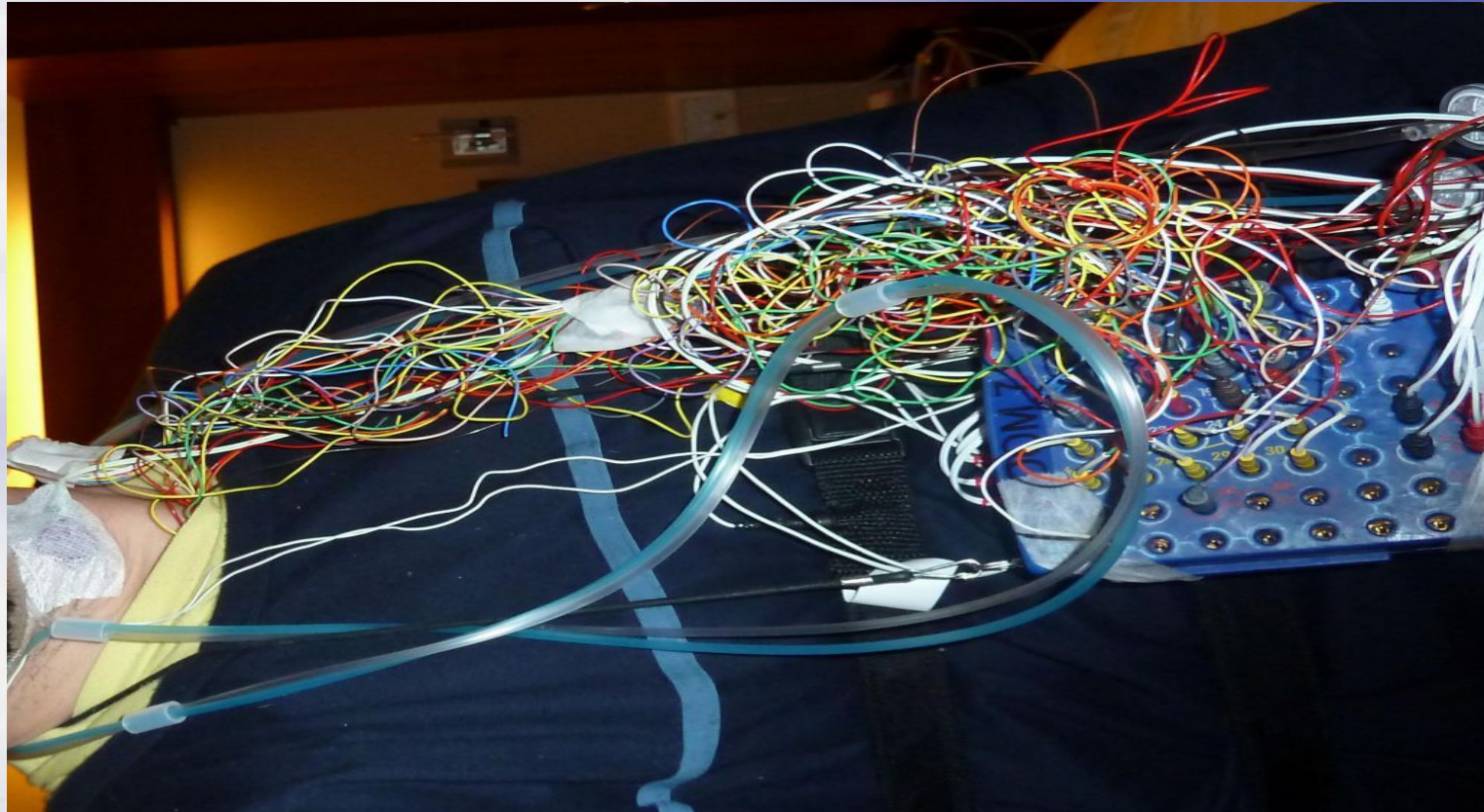
Watermark Medical Ares

- Looks well integrated, but not ideal for tummy sleepers.
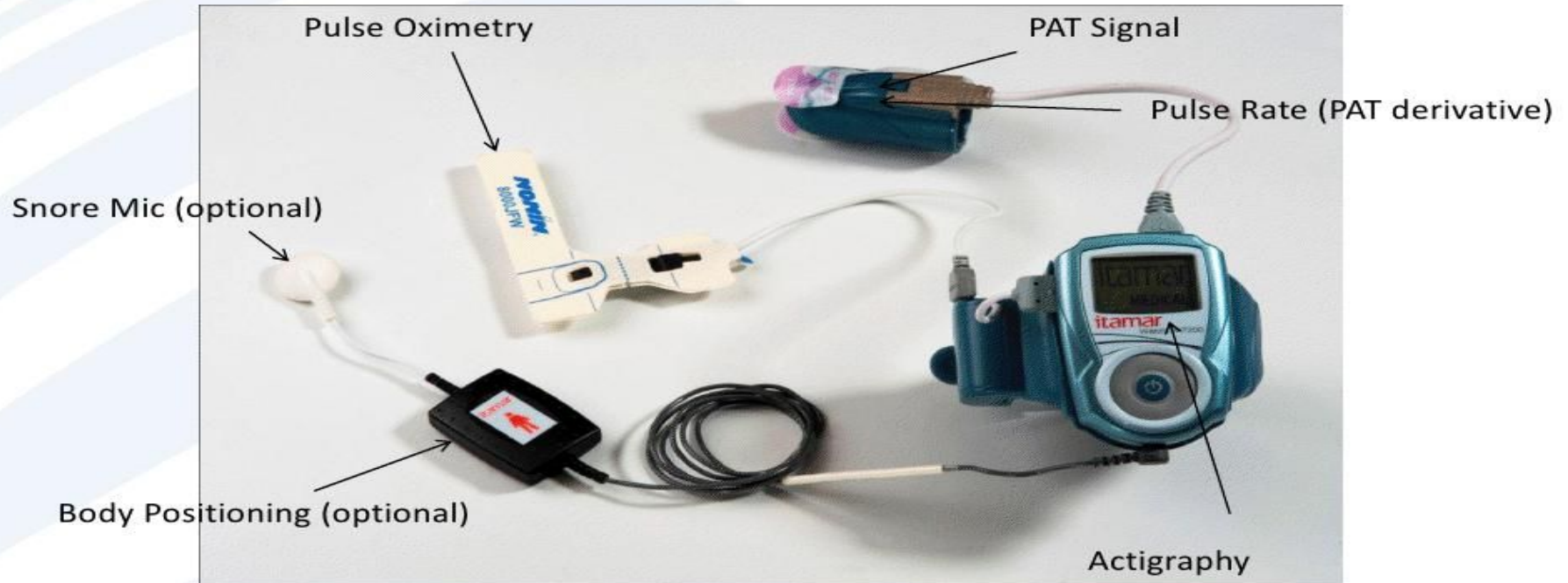- Too many ways it can slip off, so need to be tight and uncomfortable

Itamar Medical PAT 200

➤ Better integrated, nothing in your nose or on your head, but expensive one use throw away PAT monitor.
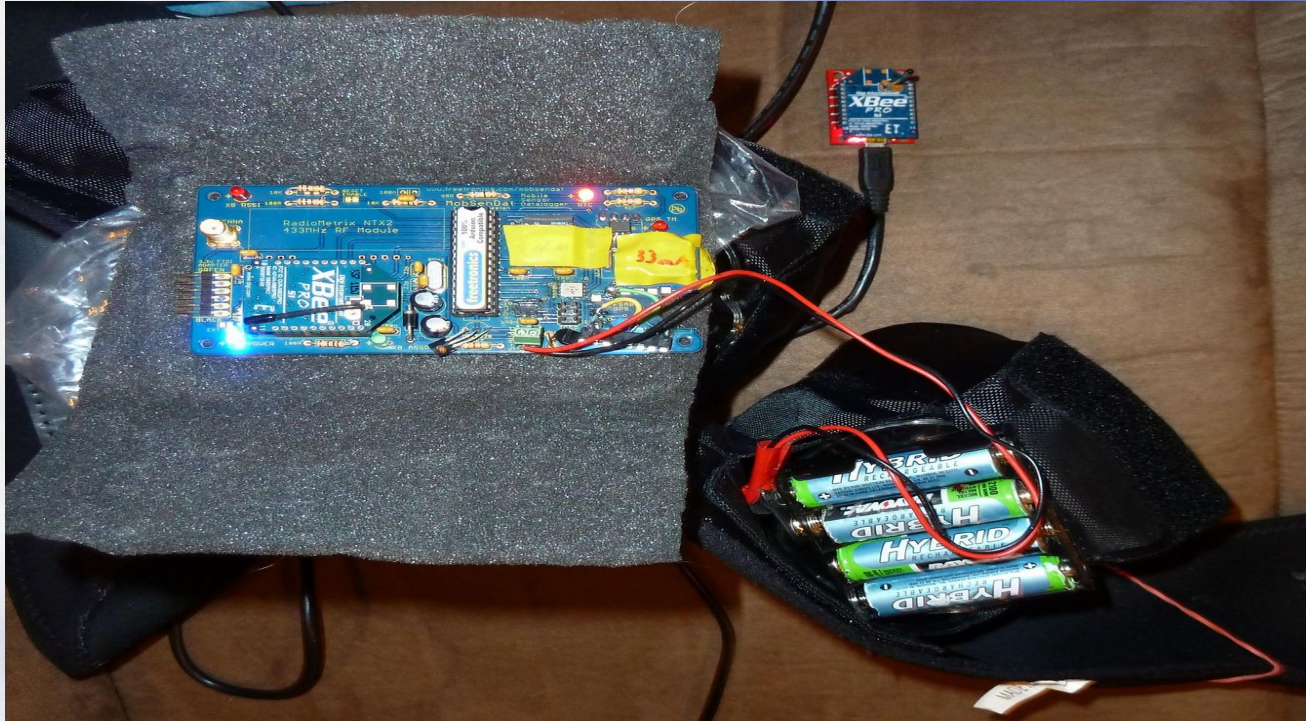
Sleep sensors

➢ Oximeter, airflow, body position, microphone, EEG for phases of sleep (light, REM, deep). Very expensive though.

When you have a hammer, everything looks like a nail

➢ Started by using the accelerometer and wireless radio

Arduino sleep position logs

[1] Using logfile 2012-08-18 23:56:05 instead of 2012/08/12 20:25:24 from arduino to compute epochoffset
[1] At 2012/08/12 20:31:37 (67), new position is now right (from unknown)
[1] At 2012/08/12 20:33:47 (93), new position is now down (from right)
[1] At 2012/08/12 23:33:13 (2021), new position is now left (from down)
[1] At 2012/08/12 23:55:33 (2289), new position is now down (from left)
[1] At 2012/08/13 00:31:58 (2726), new position is now left (from down)
[1] At 2012/08/13 00:49:08 (2932), new position is now right (from left)
[1] At 2012/08/13 00:54:58 (3002), new position is now down (from right)
[1] At 2012/08/13 01:43:28 (3584), new position is now left (from down)
[1] At 2012/08/13 01:55:48 (3732), new position is now down (from left)
[1] At 2012/08/13 02:06:58 (3866), new position is now left (from down)
[1] At 2012/08/13 02:58:28 (4484), new position is now right (from left)
[1] At 2012/08/13 03:03:43 (4547), new position is now down (from right)
[1] At 2012/08/13 03:13:28 (4664), new position is now left (from down)
[1] At 2012/08/13 03:28:38 (4846), new position is now down (from left)
[1] At 2012/08/13 03:49:43 (5099), new position is now left (from down)
[1] At 2012/08/13 04:09:33 (5335), new position is now right (from left)
[1] At 2012/08/13 04:34:13 (5631), new position is now down (from right)
[1] At 2012/08/13 04:52:58 (5854), new position is now right (from down)

up,   down, left, right,   unkwn,   hours sleep,   pos changes
00.1%,   63.1%,   28.2%,   07.6%,   01.1%,   8.2 H sleep,   18 pos chg

Modern Devices Wind Sensor

➤ The sensor is based on measuring temperature changes as affected by wind blowing through the sensor.
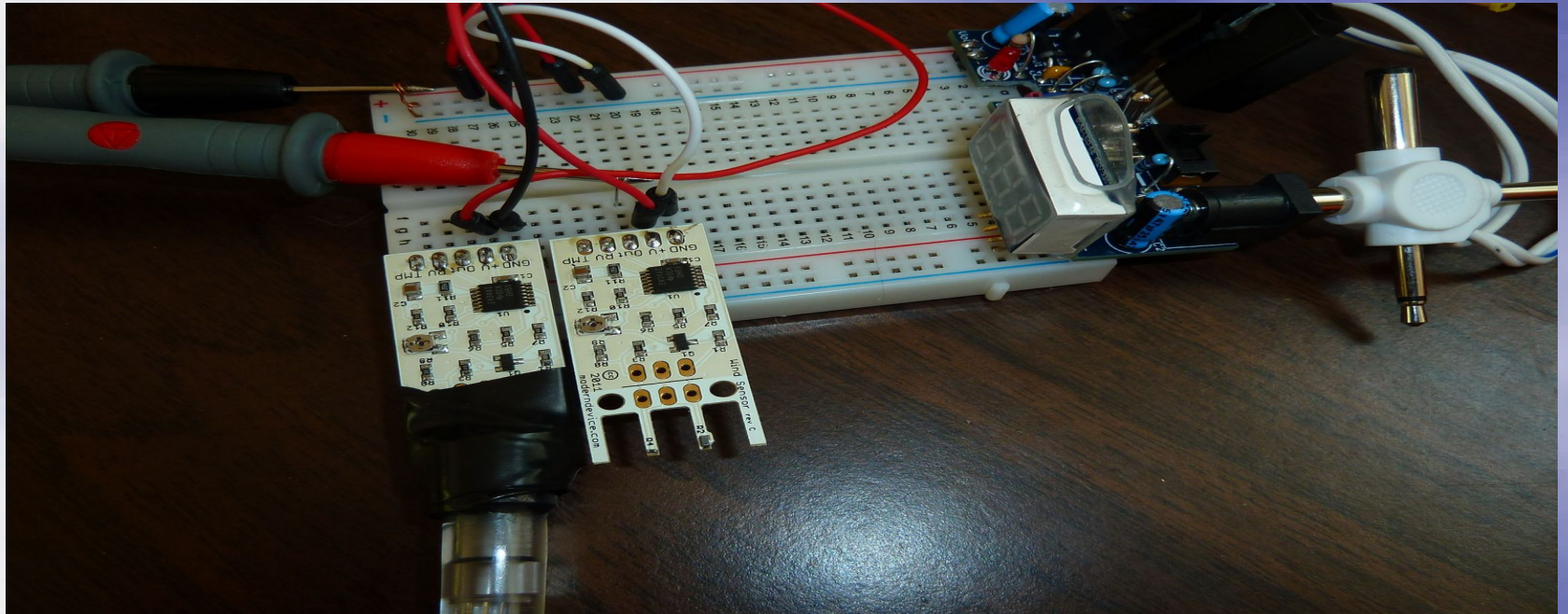
Ready for a "good" night :)

➢ Two different zeo probes taped so that they don't move off, and the cannula also needs to be pretty tight and taped so that it doesn't slip out of my nose at night.

Zeo Bedside Sleep Manager

➤ Zeo made a headband that picks up electrical signals from the brain and computes what sleep status you're in (Light, REM, deep, or awake).

# Graphing Airflow Overlayed With Sleep Stage

Arduino + Zeo output:
2012-08-26 05:07:43: AF|
17825341:989798989697949696969696969797999A9B9A9A9A9998979898979595989A9C9D9E9F9F9E9D9C9C9B9A9A9A99999898
2012-08-26 05:07:43: POS|17830189:"2012/08/25 17:53:53",,X:0.10,Y:-
1.00,Z:0.10,V:5.27,left,rssi:901(DC:0),assoc:838(avg:502|ANS)
2012-08-26 05:07:48: AF|
17830264:9496969797969695969596979A9B9B9B9B99989897959596959597999B9B9E9E9F9D9D9B9D9D9D9D9C9C9D9D9C9C9C9C
2012-08-26 05:07:53: POS|17835046:"2012/08/25 17:53:58",,X:0.11,Y:-
1.01,Z:0.09,V:5.27,left,rssi:901(DC:0),assoc:838(avg:670|ANS)
2012-08-26 00:00:00: AF|
17835124:989A9A9A9A999797989B9D9E9E9E9C9B9B9B9A999897979A9C9E9F9F9F9F9F9F9F9E9E9C9C9B9B9B9C9C9C9D9D9D9C9C9C
2012-08-26 05:07:53: POS|17840050:"2012/08/25 17:54:03",,X:0.11,Y:-
1.00,Z:0.09,V:5.29,left,rssi:901(DC:0),assoc:837(avg:670|ANS)
2012-08-26 05:07:58: AF|
17840197:9A9A9C9B9A9A9A9A9A9C9D9F9F9F9E9E9D9D9B9A9B9D9FA0A0A0A1A09E9E9E9E9D9D9C9C9C9B9B9C9E9FA09E9E9D9E9E9D
2012-08-26 05:07:58: POS|17845049:"2012/08/25 17:54:08",,X:0.10,Y:-
1.00,Z:0.08,V:5.26,left,rssi:901(DC:0),assoc:838(avg:670|ANS)
2012-08-26 05:08:03: AF|
17845125:999A999A9C9E9E9FA0A0A0A09FA0A1A1A1A1A1A0A09F9F9E9E9F9E9E9E9E9E9E9D9C9C9D9EA09F9D9D9B9C9D9D9C9B9A98
2012-08-26 05:08:03: POS|17850050:"2012/08/25 17:54:13",,X:0.09,Y:-
1.01,Z:0.09,V:5.31,left,rssi:901(DC:0),assoc:0(avg:670|ANS)
2012-08-26 05:08:08: AF|
17850195:9A9C9D9E9E9F9E9D9E9E9E9F9E9E9D9D9C9C9C9C9B9B9B9C9C9C9C9B9A9A9A9A9A9C9E9E9D9B9B9C9B9A9B9A989897989B
2012-08-26 05:08:08: POS|17855047:"2012/08/25 17:54:18",,X:0.10,Y:-
1.00,Z:0.09,V:5.26,left,rssi:901(DC:0),assoc:0(avg:502|ANS)
2012-08-26 05:08:10: Zeo Sleep state: REM

Nose Canula graphs

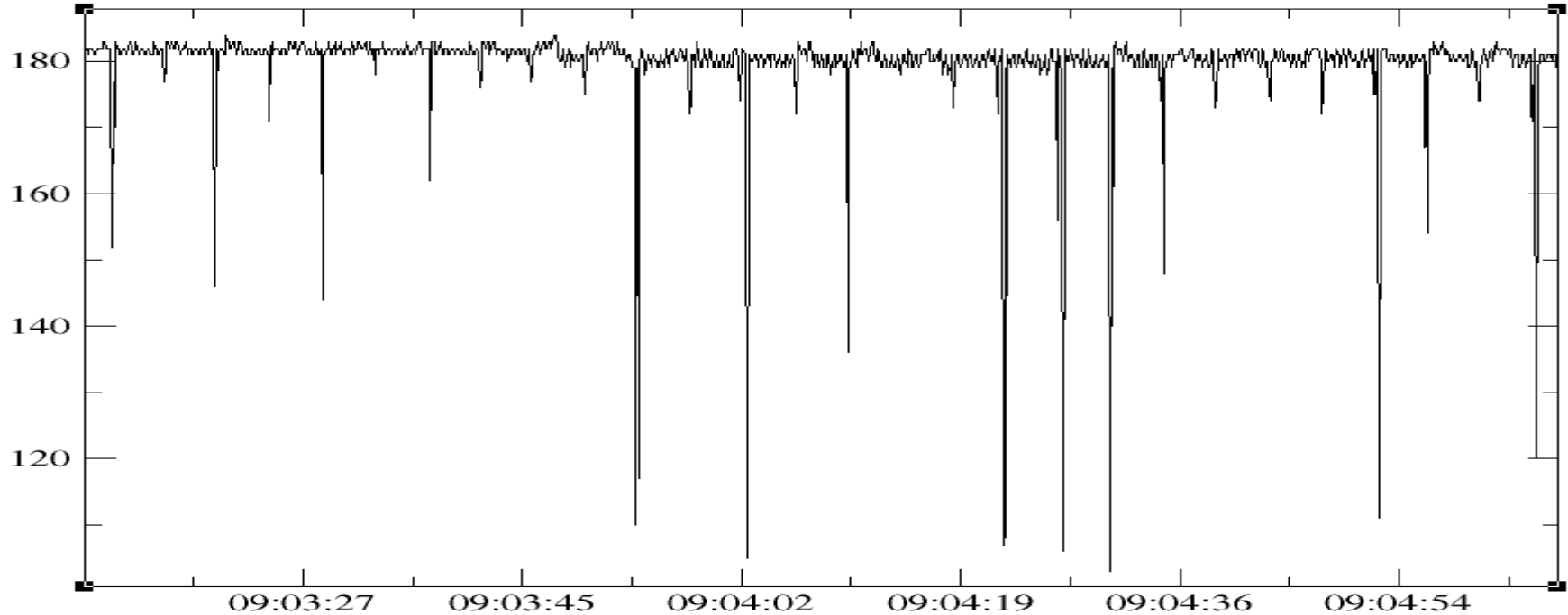> I move a lot and I could block the tubes, showing no breathing when in fact I didn't stop breathing for 2.5mn.
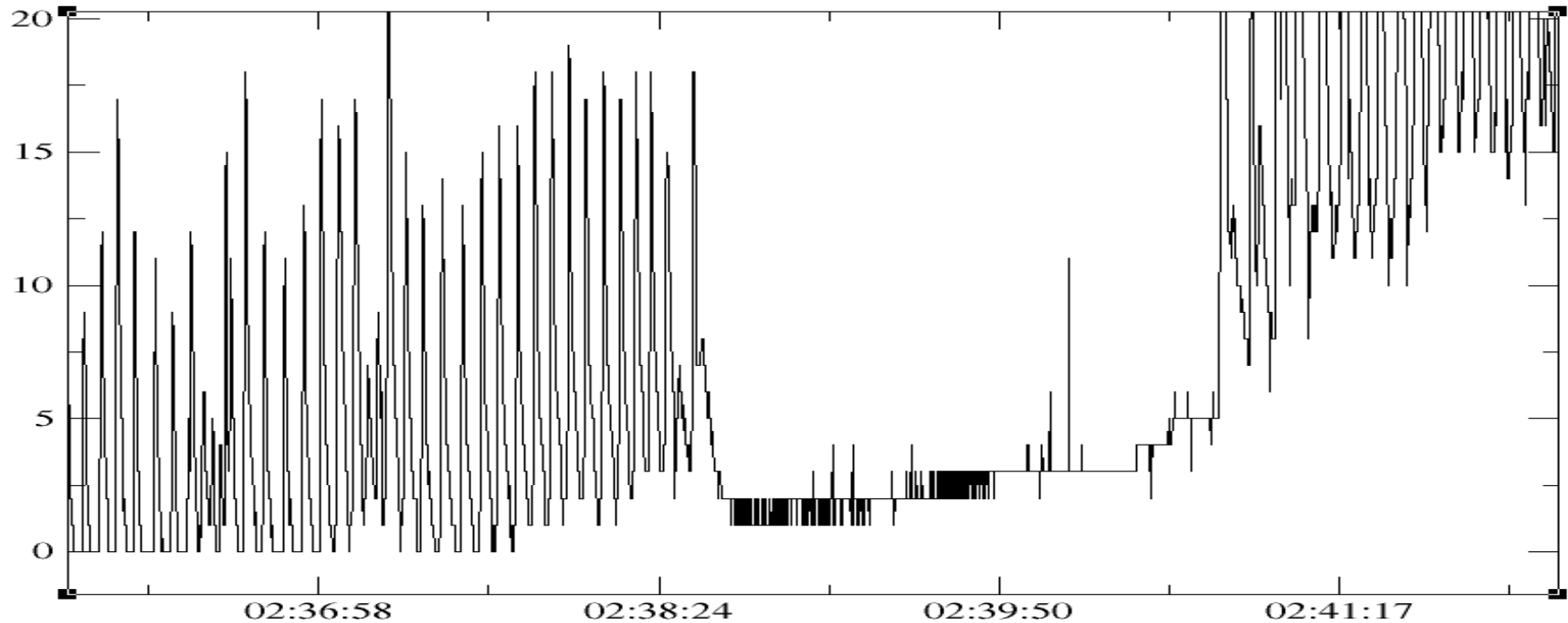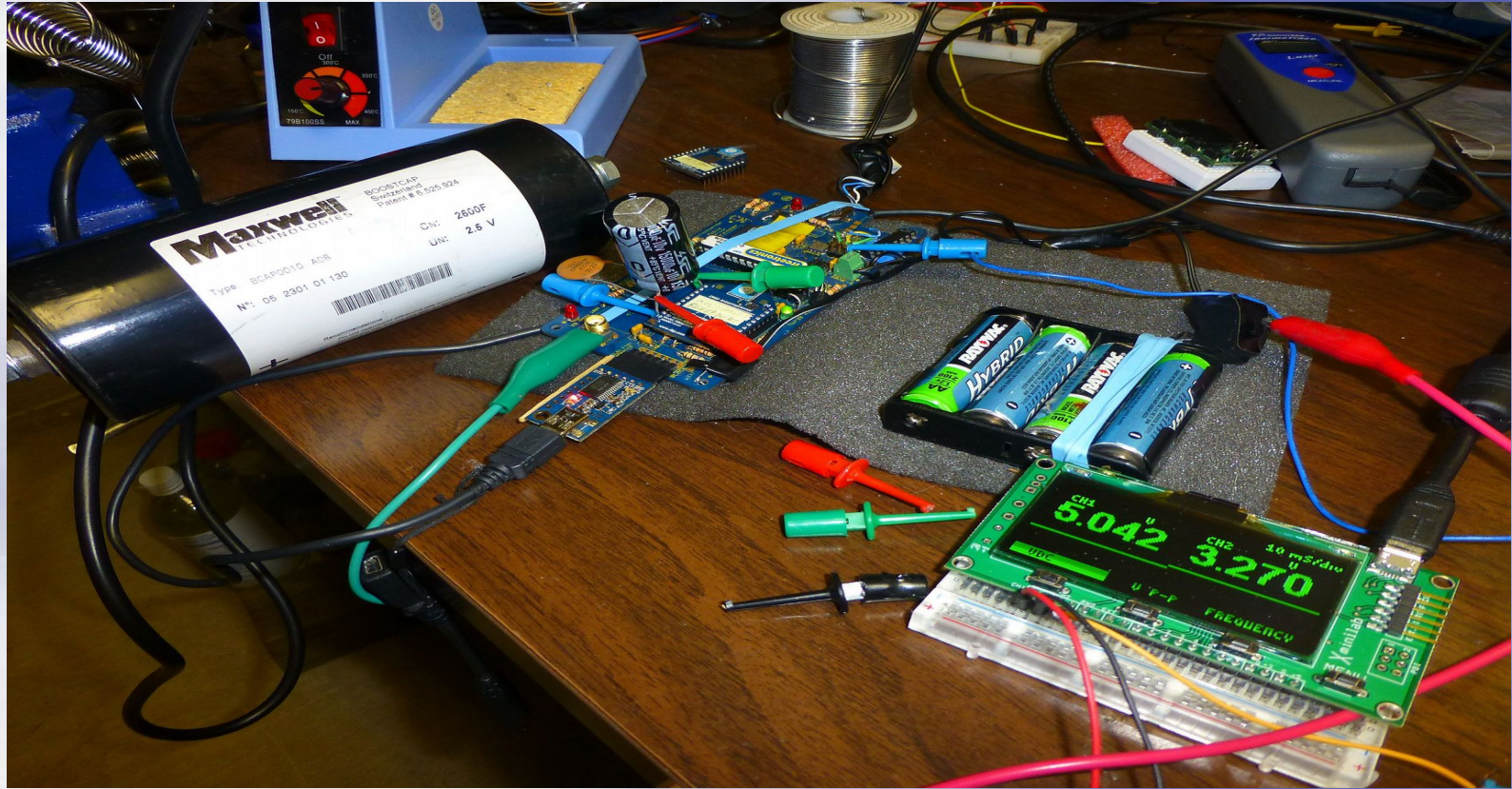
Trying again with stretch fabric
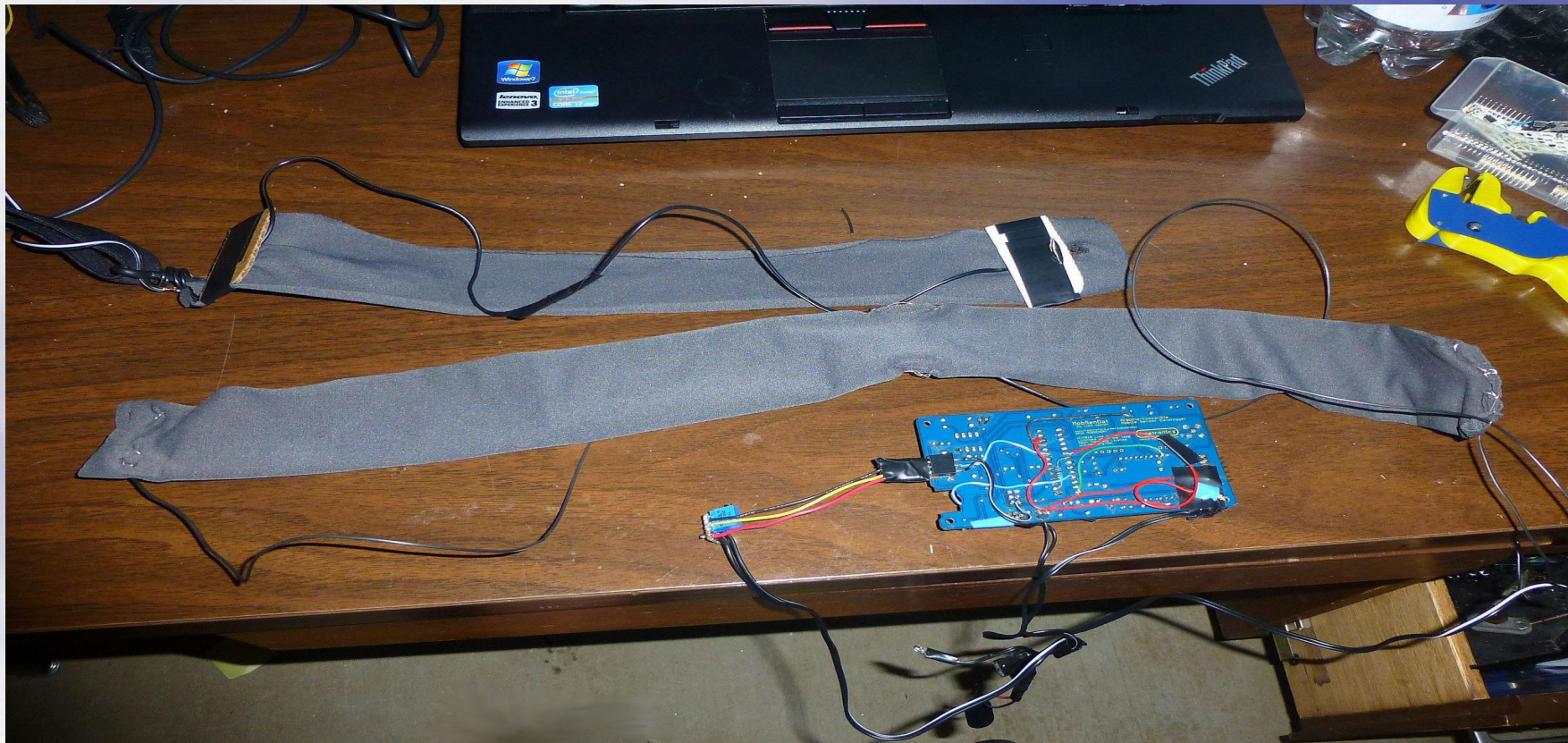
Electronics:why things never fully work

➢ Things did get better, but then I got this:

Killing the noise: you just need a bigger cap :)

Killing noise, continued

- I started looking into this sampling noise and found out it was worse with an xbee pro than a regular xbee.

- I tried to protect my Vcc from fluctuations by adding more capacitors, but that didn't help.

- Eventually, I found it happened more when the batteries weren't full, and that the voltage out of the regulator was dipping below 3.1V instead of 3.3V.

- Then I realized that the diode that protects the input of my voltage regulator dropped about 0.7V and was enough to turn the 5V out of my batteries into 4.3V, which was too marginal for the voltage regulator under load.

- Solution was simple, short circuit the diode.

Peak Detection (2)

➤ Low amplitude when on my tummy and moving body also make things more interesting.

Current logs:

```
[1] At 2012/08/25 13:13:34 (127), new position is now down (from unknown)
[1] At 2012/08/25 14:42:55 (1199), new position is now left (from down)
[1] At 2012/08/25 15:34:00 (1812), new position is now down (from left)
[1] At 2012/08/25 15:53:25 (2045), new position is now left (from down)
[1] At 2012/08/25 16:01:45 (2145), new position is now down (from left)
[1] At 2012/08/25 16:10:25 (2249), new position is now left (from down)
[1] At 2012/08/25 17:00:40 (2852), new position is now down (from left)
[1] At 2012/08/25 17:15:25 (3029), new position is now up (from down)
[1] At 2012/08/25 17:21:25 (3101), new position is now left (from up)
[1] At 2012/08/25 17:38:50 (3310), new position is now down (from left)
[1] At 2012/08/25 19:05:45 (4353), new position is now left (from down)
[1] At 2012/08/25 19:20:00 (4524), new position is now down (from left)
[1] At 2012/08/25 20:18:15 (5223), new position is now left (from down)
[1] At 2012/08/25 20:19:40 (5240), new position is now unknown (from left)
up,   down, left, right,     unkwn,       hours sleep,    pos changes
01.4%,    63.1%,    32.5%,     00.2%,     02.8%,      7.3 H sleep,    14 pos chg
Number of breaths: 6365
Breaths with the longest delay:
8.1 -> 2012/08/25 20:17:47
7.7 -> 2012/08/25 17:14:43
7.5 -> 2012/08/25 15:52:37
7.5 -> 2012/08/25 16:09:24
7.4 -> 2012/08/25 13:13:25
```

This is where I gave up

- I spent a lot of effort over several months

- I realized getting the last 5-10% right might take 90% of the effort

- Inaccurate data would make the whole effort mostly pointless

- A sleep monitor without SPO2 monitoring isn't that useful

- And building or interfacing with SPO2 at the time, was too hard

- So I gave up that project

Google

LCA 2012 OHMC: Pebble v2

- http://www.openhardwareconf.org/wiki/AMC2012

- Still freetronics 328p based

- Nicer 4 row LCD, Tricolor analog LED

- I was able to port the NewLiquidCrystal library to the 3 wire shift register setup from that board

- My first time mostly writing a device driver, using the datasheet. Exciting!

- http://marc.merlins.org/perso/arduino/post_2012-01-24_Much-Improved-Pebble-v2-Aiko-Demo-Code.html

Pebble V2, LCA Arduino Miniconf 2012

LCA 2013 OHMC: HackCNC

- http://www.openhardwareconf.org/wiki/AMC2013

- http://marc.merlins.org/perso/linux/post_2013-01-28_Linux_conf_au-2013.html

- Biggest OHMC kit so far, fun to fit in your luggage for the flight back :)

- It took gcode and was able to draw 2D figures on paper

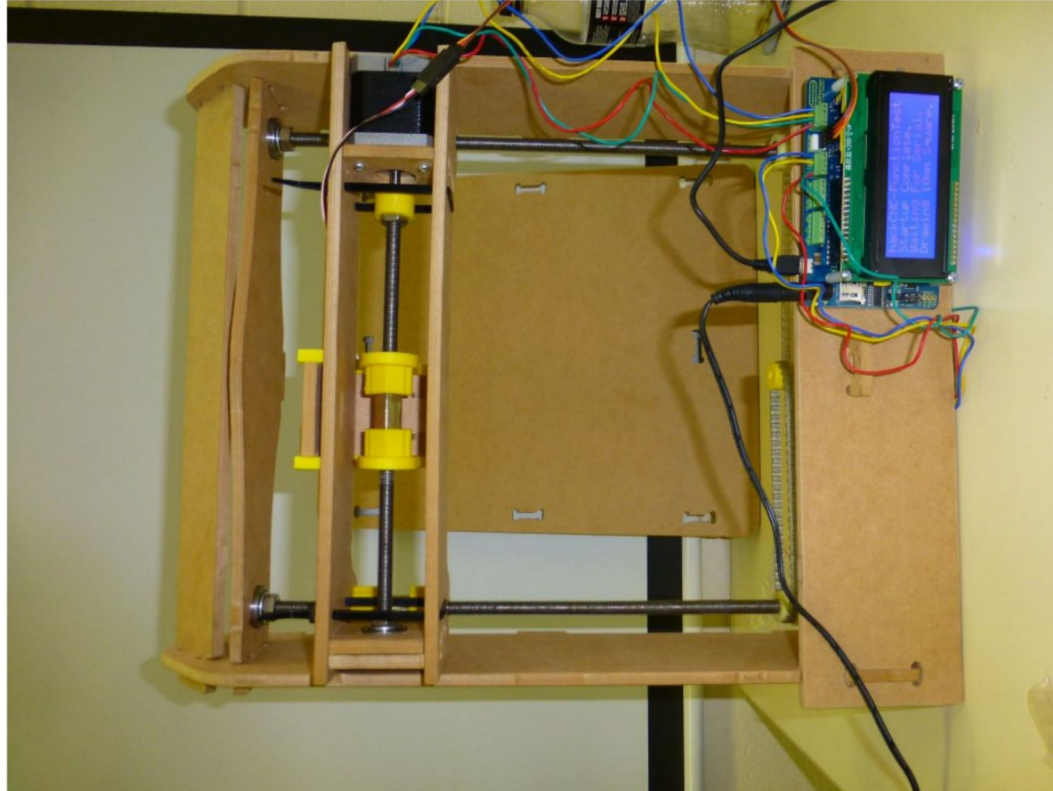- Sadly I never did further work with it, but it was my first introduction to 3D printing

# HackCNC, before

HackCNC, during

HackCNC, after

2013/09: Getting a taste of Adafruit::GFX API

- I was able to join an introduction to arduino course at work. Good excuse to hack on arduino hardware.
  http://marc.merlins.org/perso/arduino/post_2013-09-14_Arduino-Training-and-Hacking-at-Google.html

- It included an adafruit I2C controlled 8x8 matrix

- Sadly the built in controller only allowed for red and green to be on or off, and give orange if you mixed them together.

- But GFX gave cool drawing primitives, which I learned

- https://github.com/adafruit/Adafruit-GFX-Library

Adafruit bi-color LED Matrix with GFX
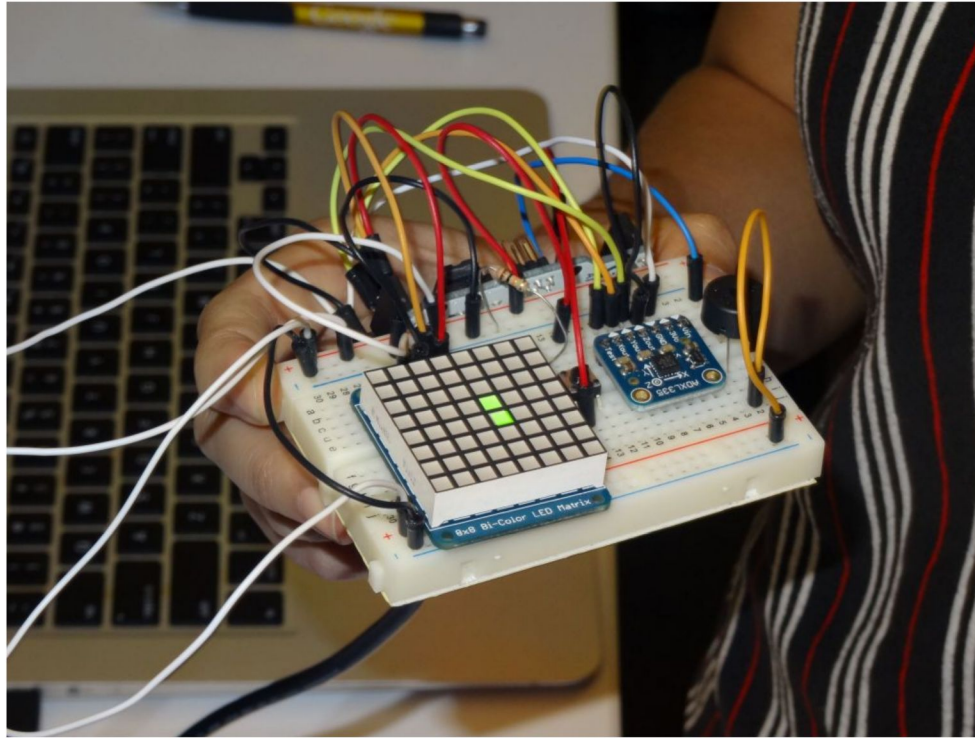
# 2014/12: Bi Color RGB Matrix: 24 pins
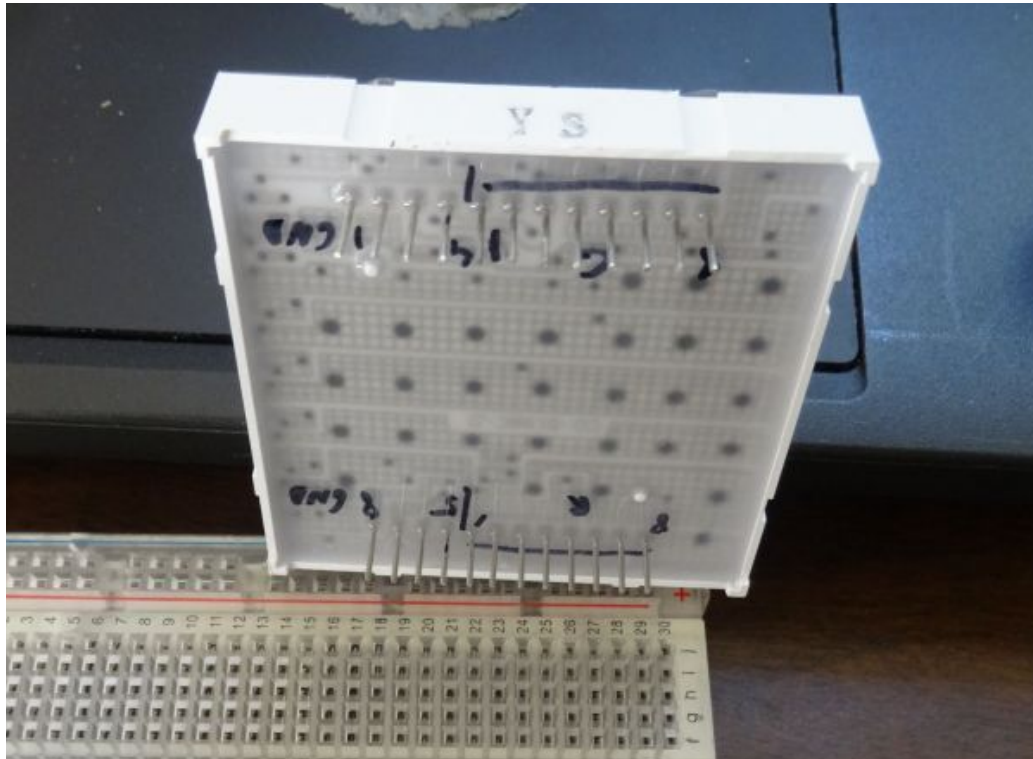
My first real driver: Row Scanned RGB Matrix

- The Adafruit panel only supported 3 colors, no way to do PWM to mix colors

- I got some super cheap 8x8 matrices that supported RGB

- How hard would it be to write a generic driver that supported single, bi and tri color LEDs with direct driving or shift registers with proper PWM color mixing?

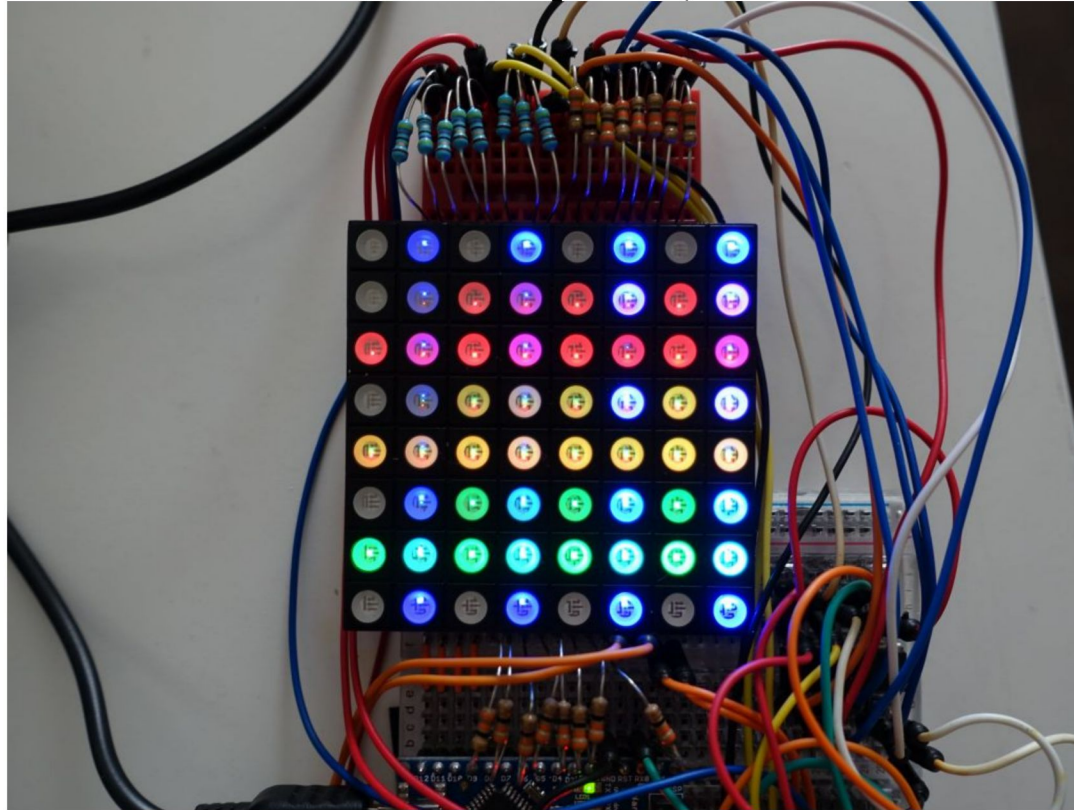- Famous last words :) 3-4 weeks of work later:

  https://github.com/marcmerlin/LED-Matrix/

  http://marc.merlins.org/perso/arduino/post_2015-01-06_Driver-for-direct-driving-single-to-3-color-LED-Matrices-with-software-PWM.html

Bi Color RGB Matrix PWM color mixing
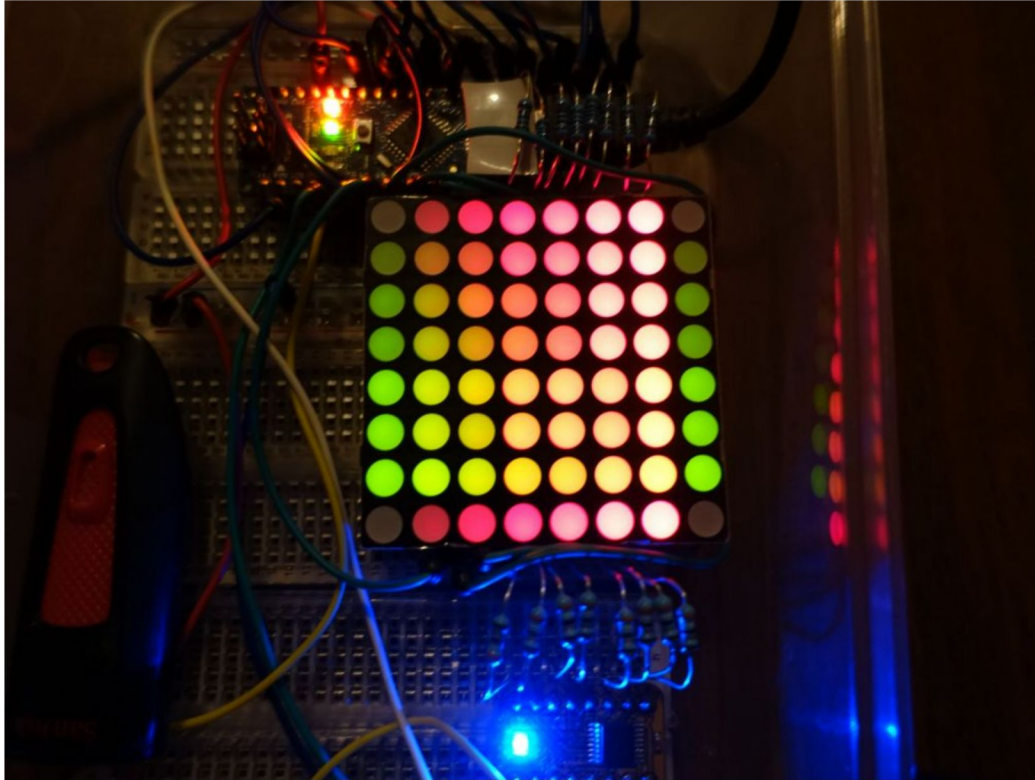
Tri Color RGB Matrix: 32 pins, needs shift registers

Writing a Adafruit::GFX compatible Row Scanning Driver

- My driver had to scan the rows one by one, and select the right colums to light up for each row

- For 2 or 3 RGB components, they could be lit up at the same time

- When scanning quickly enough the image looked continuous

- But to get more than 7 color mixes, I had to do PWM to change the intensity of each color component

- 4 bits per color gave 15 levels of intensity and 4096 color mixes

Row Scanning Driver Details

- I learned how to write an ISR

- Cannot use Serial.printf in ISR, and must be fast. Debugging is not easy.

- Need to use volatile to share a global between ISR and main code.

- Instead of firing 16 interrupts and light up a color 0 to 15 times, there is a technique called BCM

- Binary Code Modulation changes the interrupt frequency to fire only 4 times instead of 16, but with intervals 8t, 4t, 2t, and t.

LCA 2014 OHMC: Arduphone

- http://www.openhardwareconf.org/wiki/AMC2014

- http://marc.merlins.org/perso/linux/post_2014-01-06_Linux_conf_au-2014-in-Perth.html

- How many levels of cool is this? Your own arduino GSM phone

Does your arduino make phone calls?

# Looked very stylish, probably worked to enter the matrix :)

Arduphone, aftermath

- Sadly some of them, including mine, had unexplained speaker/sound issues

- Jon tried to fix mine months after the conf and eventually sent me another one.

- By then, unfortunately, 2G which was the only thing supported by the GSM chip, was turned off

- So I was never able to really use it :(

LCA 2015 OHMC: SimpleBot

- http://www.openhardwareconf.org/wiki/OHC2015

- http://marc.merlins.org/perso/linux/post_2015-01-12_Linux_conf_au-2015-in-Auckland.html

- First Raspberry Pi project

- Minimalistic robot with cardboard wheels

- Used javascript. Good for people not great with C++

- Not great for me, I suck at JS and never really spent the time to learn it

Simplebot
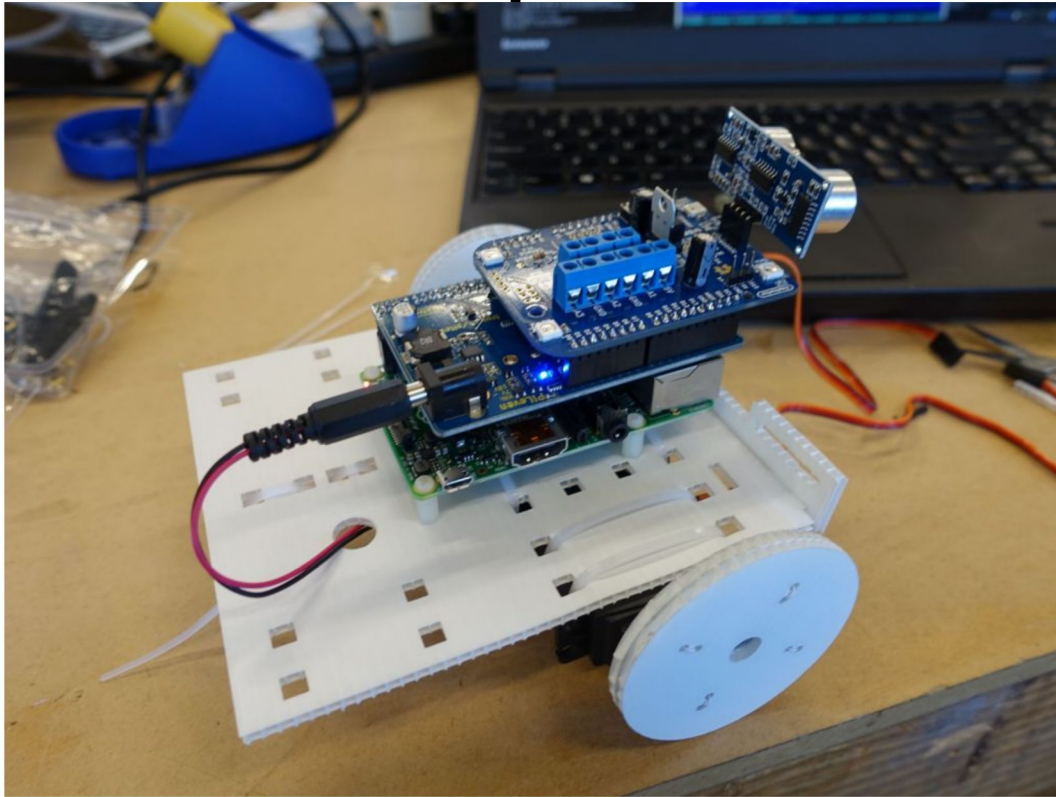
# Get into RC Tridge said, it'll be fun!

2015-2016: Ardupilot RC planes with Custom Electronics

- Mix of simple electronics and arduino programming

- Tridge was right, having your code flying, is cool

- Built simple electronics for custom control needs
  http://marc.merlins.org/perso/rc/post_2015-10-29_Controlling-5-and-12V-swtiching-with-SmartFPV-RCCCv2-Video-Switching-Board.html

- After losing a plane to an undected motor death, wrote code to detect future failures (arduino 328p programming)

  http://marc.merlins.org/perso/rc/post_2017-10-30_Hacking-Night-Ghost-MinimOSD-to-do-what-I-needed-thanks-to-OSS_-Mode-Rotation-with-Channel-Toggle_-and-Motor-Death-Detection.html

RC: what you are hoping for
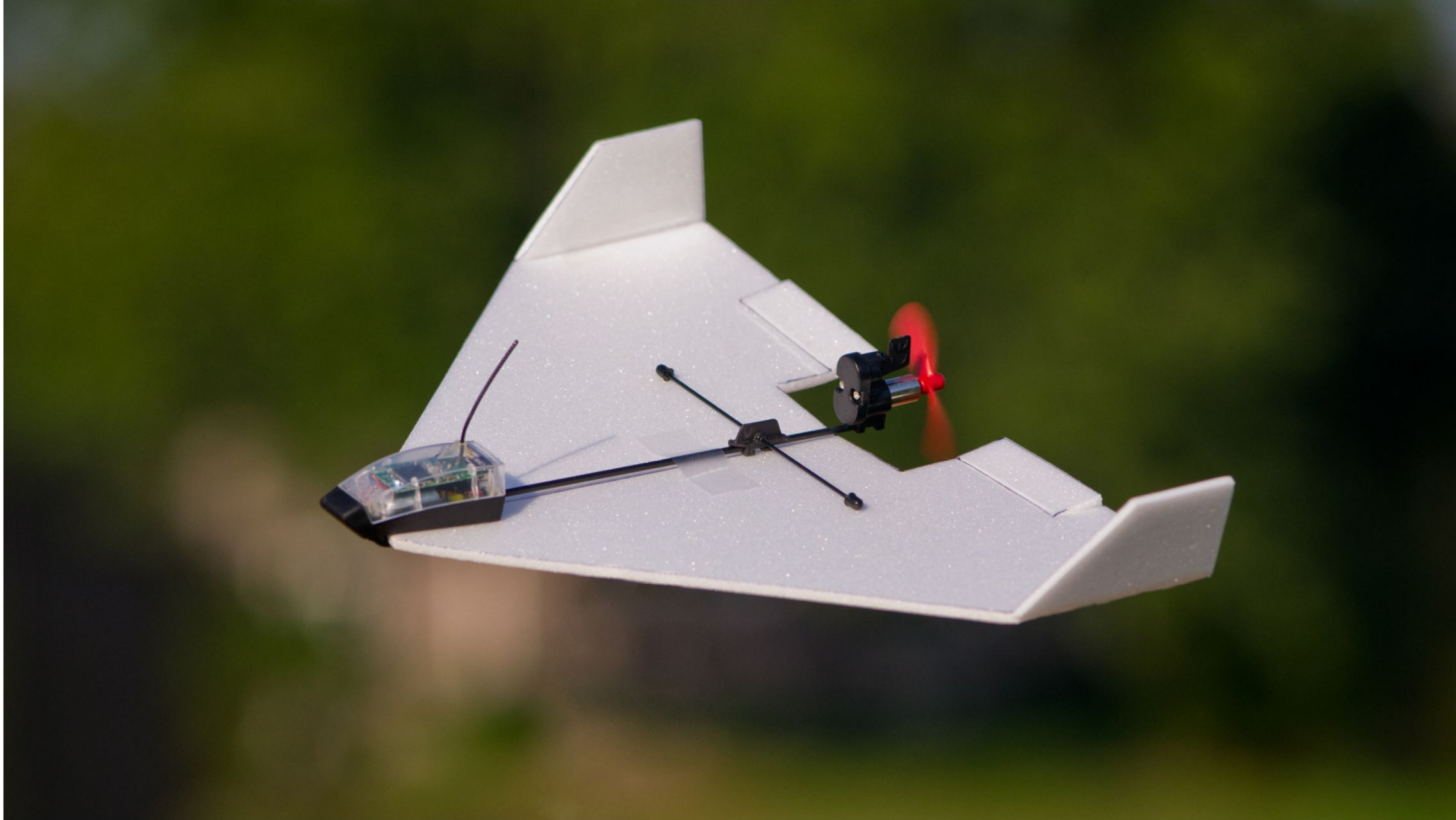
RC: what it really is: a more efficient way to turn money into sometimes flying things than making paper airplanes with $100 bills

Pilot error: crash into a light pole, 10mn delayed lipo fire

Hardware bug: tail unglued in flight during maiden flight

Sdcards didn't like the crash, one was cut the other one shorted inside

Lipo somehow didn't catch fire, but didn't work as well afterwards :)

Another hardware bug, wings detached in flight during speed test

Lipo somehow didn't catch fire either.
I was able to reuse 3 cells from the battery

2015/08: My first Ardupilot flights over Burning Man

2x 2K cameras (front and rear)

The 2015 Man

Ardupilot and FPV with OSD makes night flying possible

On Screen Display + Autopilot Makes Night Flying Possible

2016/08: Round #2: Better and Faster with 4K Video

- My 2015 plane and flight were a good start, but could be improved

- 2016 edition had rear prop for better front video view

- Lighter and faster plane (prop optimized for speed, not takeoff trust)

- Better electronics, switchable night lights, more that doesn't fit in this talk

- http://marc.merlins.org/perso/rc/post_2016-08-29_RC-Flights-over-Burning-Man_-2016-edition.html

- http://marc.merlins.org/perso/rc/post_2016-08-05_120kph-Capable-HK-Sky-Eye-FPV-build-with-Pixhawk-Ardupilot-3_5.html

Smaller Plane, Still Good Motor Glider

4K Video = More Better

4K Video = More Better

The Magic Hour Around Sunset

LCA 2016 OHMC: ESPlant

- http://www.openhardwareconf.org/wiki/OHC2016

- http://marc.merlins.org/perso/linux/post_2016-02-01_ESPlant_-Arduino-Miniconf-at-Linux_Conf_AU-2016.html

- First non arduino microcontroller

- ESP8266 programmed arduino-like, but 32bits with Wifi

- Soil and humidity sensor with solar panel

- And neopixel ring, because Bling!

- I spent more time programming the neopixel LED patterns than the rest of the device :)

ESPlant: Monitor Plants and Light up Neopixels!

LCA 2017 OHMC: IoTuz, ESP32 and ILI9341

- The friendly looking OHMC team gave us the hardest and coolest board they ever made

- New, beta quality ESP32 chip, ~~many~~ most drivers missing

- Only "mostly" arduino compatible

- Spent over 100 hours porting drivers and demo code to it.

- https://github.com/marcmerlin/IoTuz

I got conned by friendly looking OHMC people

Drivers, drivers, drivers >100H of work the next months

- TFT ILI9341 (hw SPI)
- Touchscreen (hw SPI)
- Replacement touchscreen support
- Rotary Encoder via pin interrupt driven driver
- Support for A and B buttons "hidden" behind the I2C IO multiplexer
- Joystick (needs to be calibrated to play breakout or tetris)
- 2 Color LEDs (NeoPixels, a long slippery slope for me)
- Accelerometer
- BME280 (temperature, humidity, pressure)
- IO expander (pcf8574)
- Infrared receiver

Touch screen + LCD driver, could be a great video console
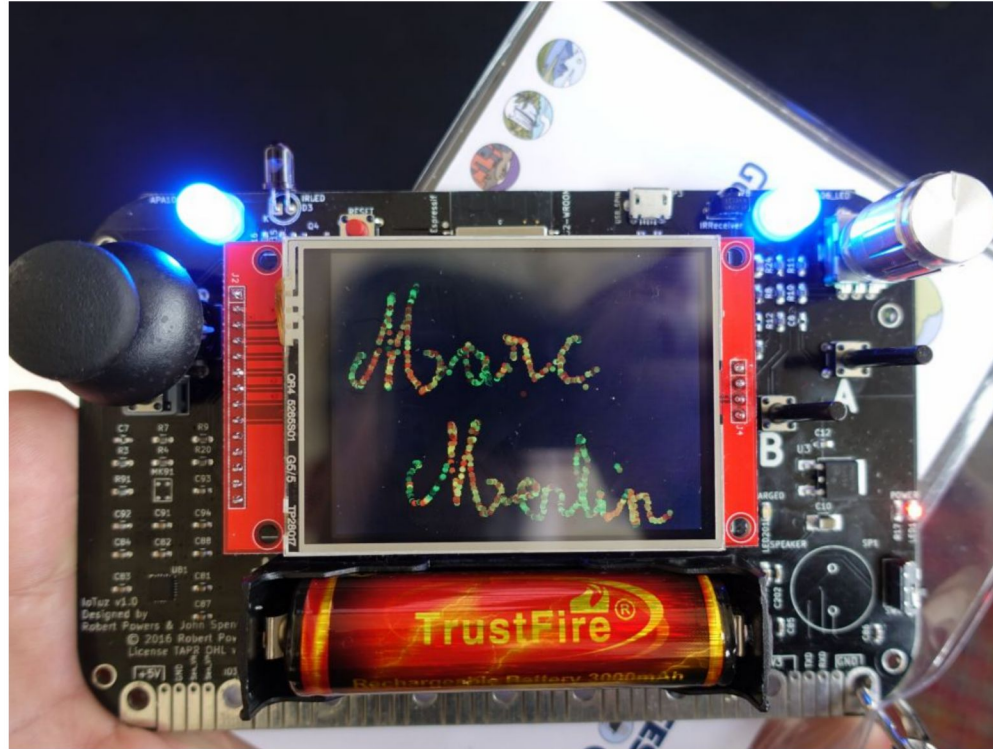
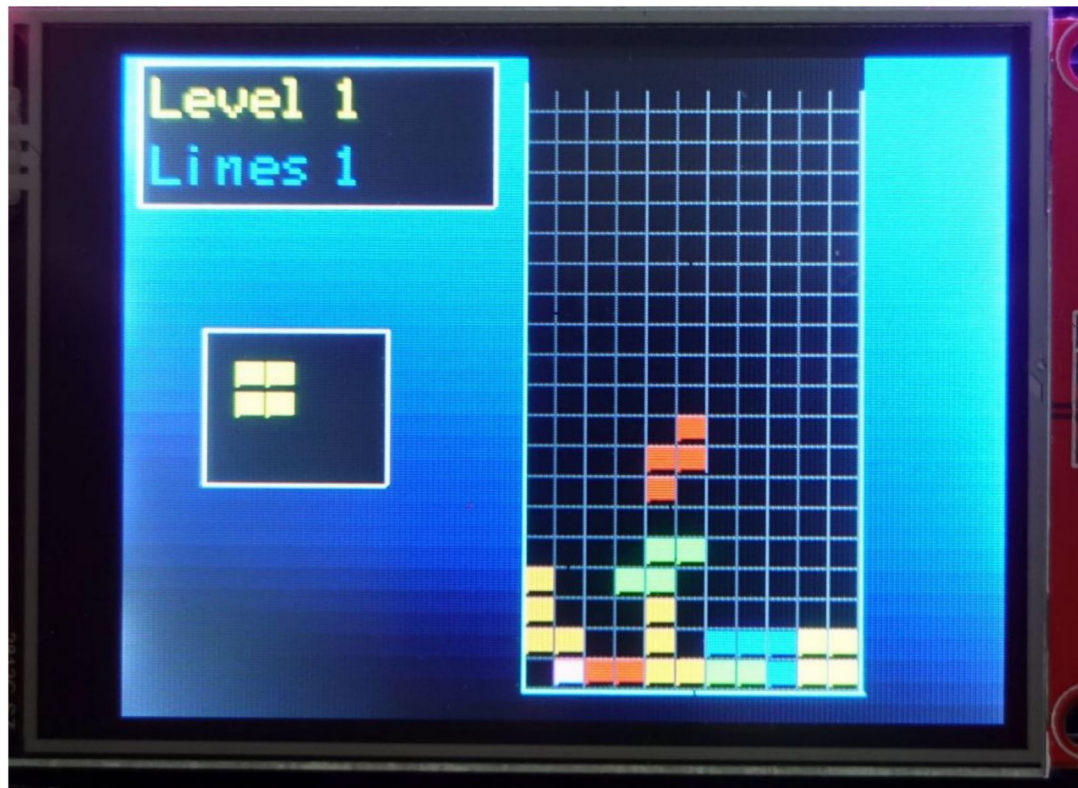# Wrote Adafruit::GFX based demo touch screen menu system
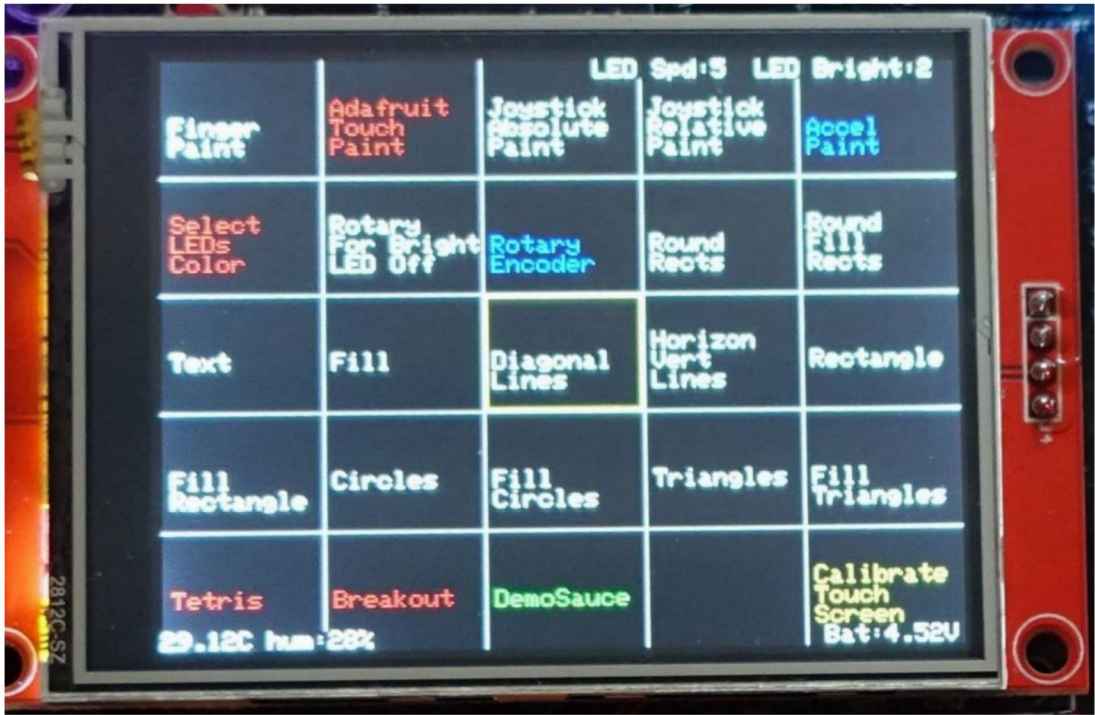
Accelerometer Paint
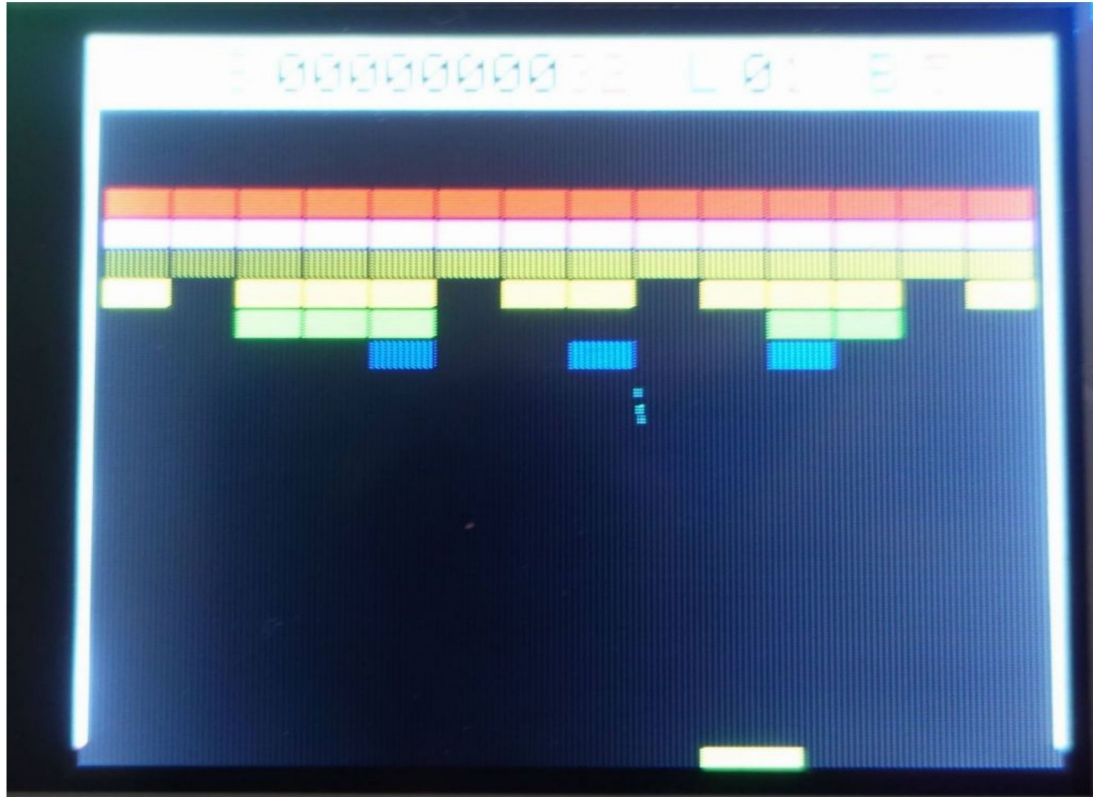
Stylus Paint (originally from Adafruit)

Used my contributed Adafruit_GFX::drawRGBBitmap
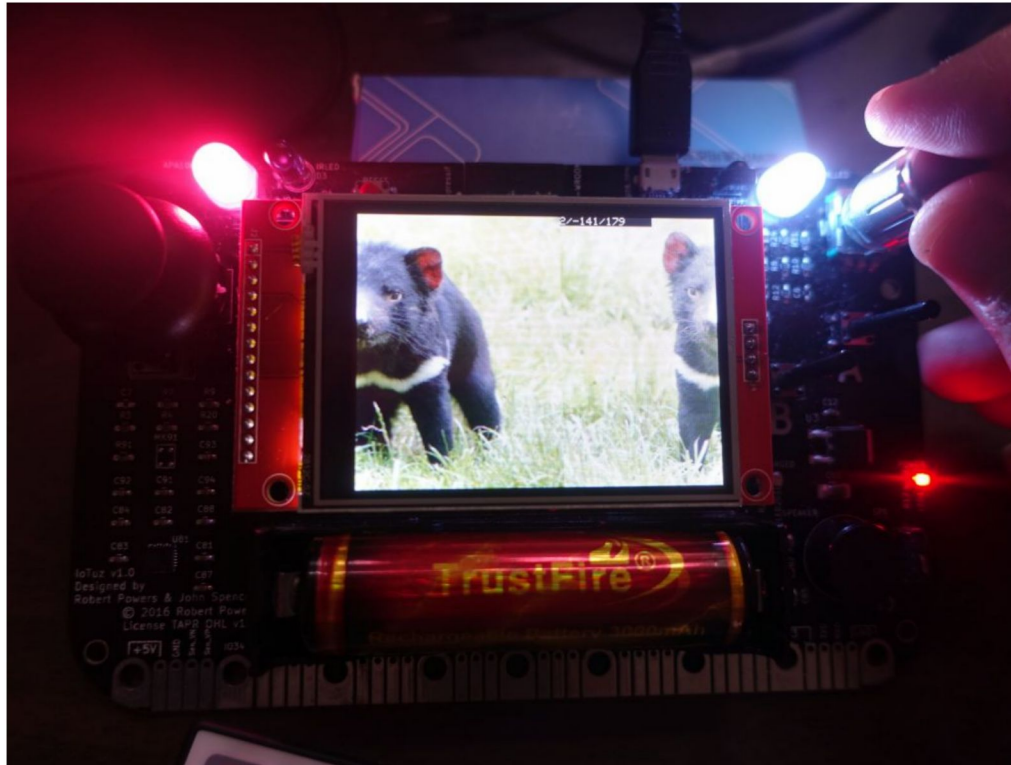
Great programmers program

Better ones, steal :)

IOTuz library after 100h+ of work

- The worst part was the many days lost to a compiler code alignment bug in the early esp32-arduino suite, but eventually I finished:

- https://github.com/marcmerlin/IoTuz

- http://marc.merlins.org/perso/arduino/post_2017-01-16_IoTuz-Driver-for-our-ESP32-board-built-at-Open-Hardware-Miniconf-at-Linux_Conf_au-2017.html

- Sadly all this work was only ever useful to a few LCA users, so I ported it to expressif's Wrover board

- http://marc.merlins.org/perso/arduino/post_2017-04-16_IoTuz-Driver-ported-to-Expressif-ESP32-WROVER-board.html

Emulating IoTuz with Expressif Wrover.
People did ask me where they could buy the IoTuz board
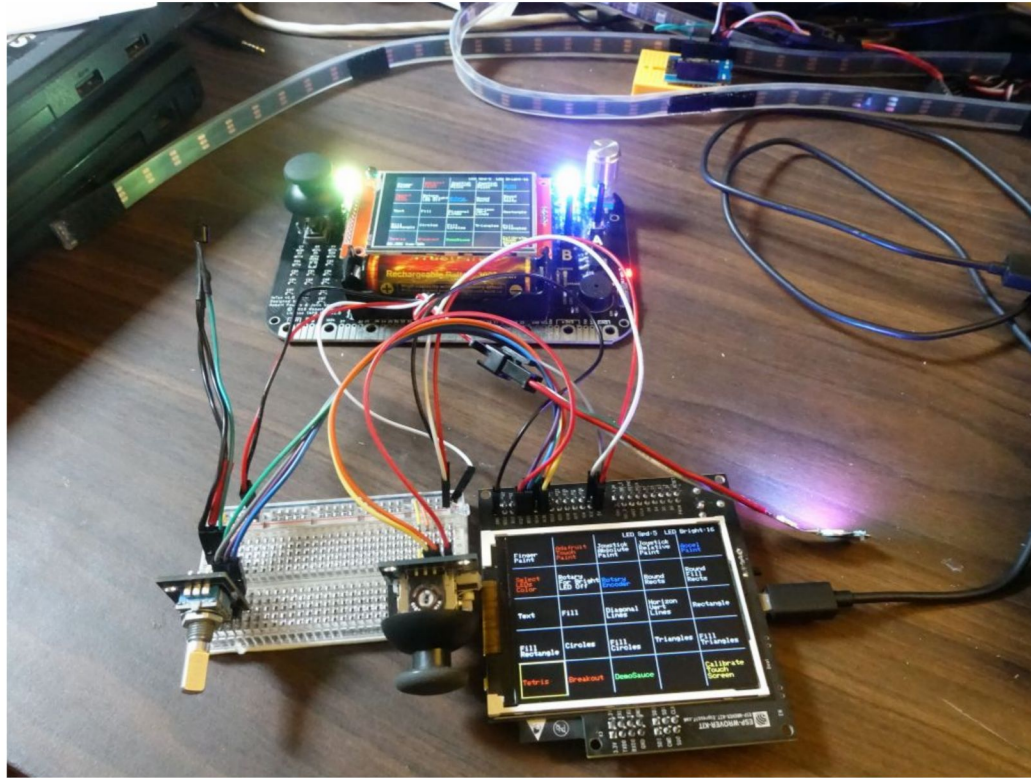
2017/04: Bitten by the NeoPixel bug, More Adafruit::GFX

- LCA 2017's Iotuz featured two NeoPixels

- Which were not supported in ESP32 yet, so I ported the Adafruit driver

- Then, a friend gave me some left over strips he had from another project

- The rest was "history" aka, multiple hundred hours down the drain :)

- I started with self built NeoPixel matrices to recreate a low res display like the one in my IoTuz, which also supported Adafruit::GFX
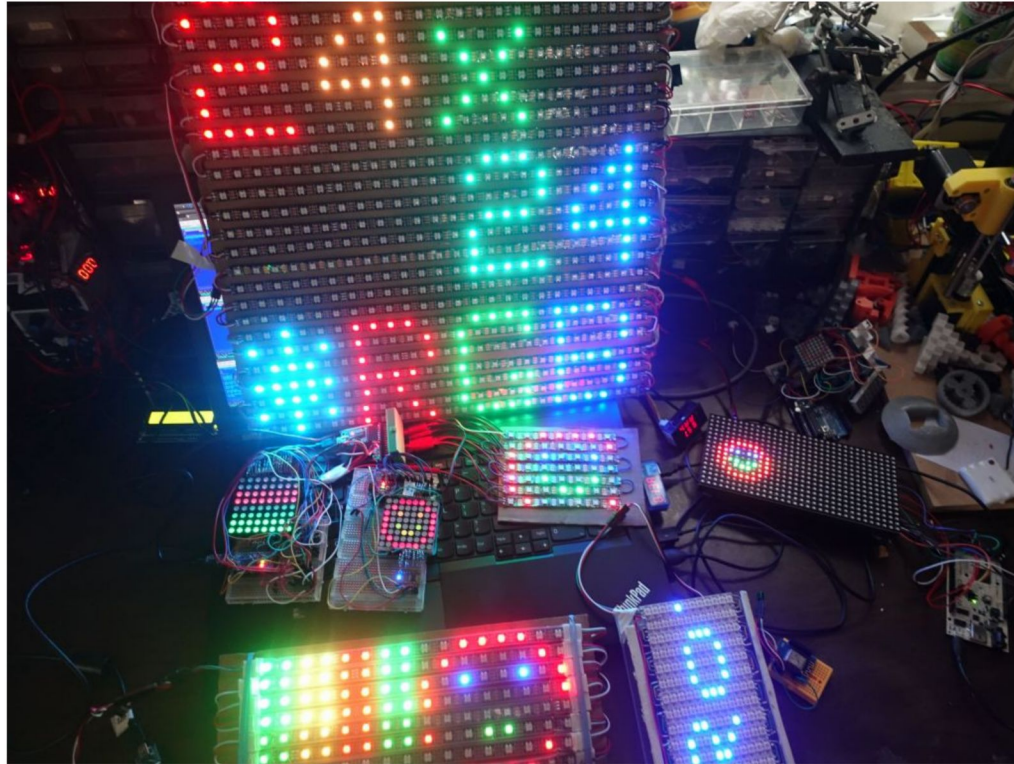
2017/04: Adafruit::NeoMatrix & RGB-Panel

Adafruit::NeoMatrix, 24x24 build, almost a day of build
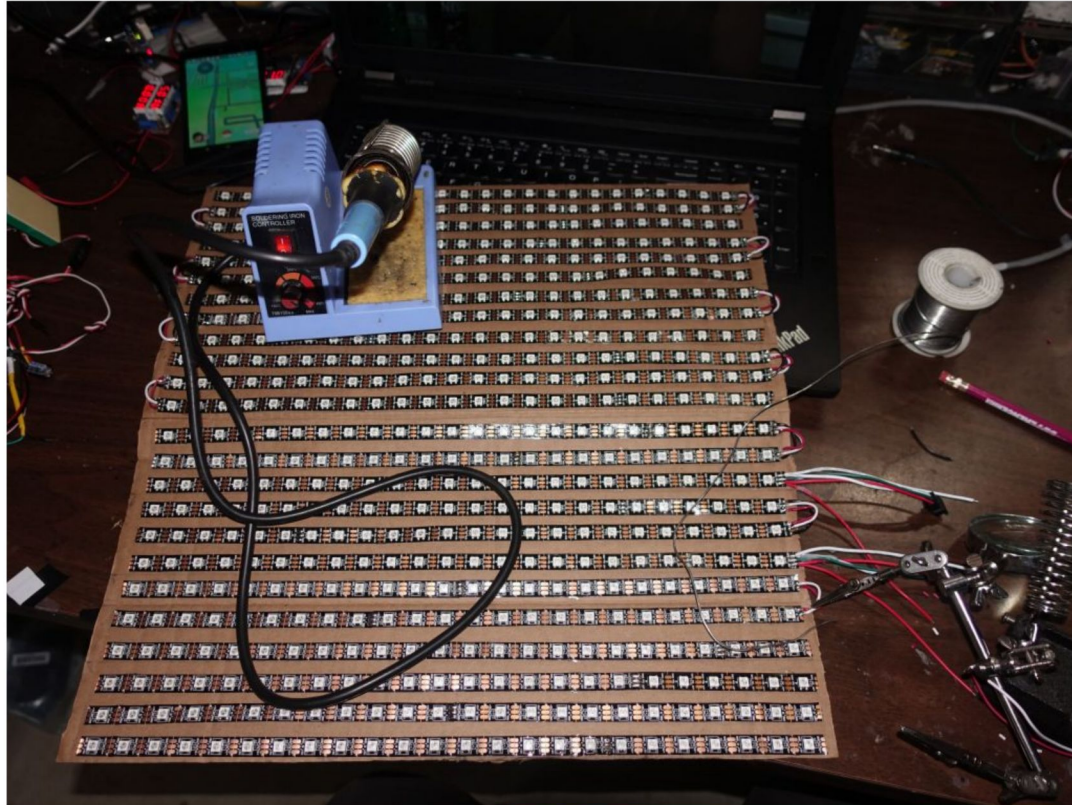
Adafruit::NeoMatrix, 24x24 demo

Adafruit RGB-matrix-Panel

- RGB Panels have higher pixel density than neopixels

- But pixels have no local processing, panel requires constant refresh

- Only 4 bits per RGB, 12 bpp when GFX supports 16bpp

- Originally written by Adafruit for 32x16 panels

- Supports 32x32, 64x32 on some CPUs, but not above

- Was able to port my GFX demo and run the same code on NeoMatrix and RGB Panels

RGB Panel GFX Demo 32x16

Used my contributed Adafruit_GFX::drawRGBBitmap again
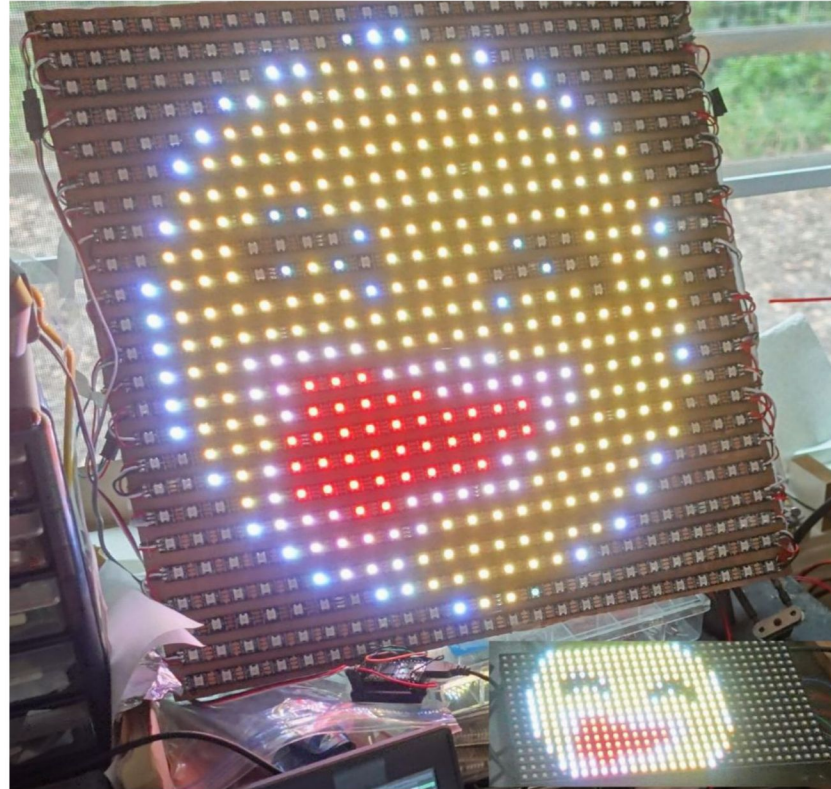
2017/06: Neopixel Shirt and Pants in time for EDC 2017

- I'm a bit insecure and shy

- I don't have many friends

- I go to events where being lit up is a good thing

- http://marc.merlins.org/perso/arduino/post_2017-06-02_LED-Pants-and-Shirt-Programmed-With-Arduino-on-ESP8266.html
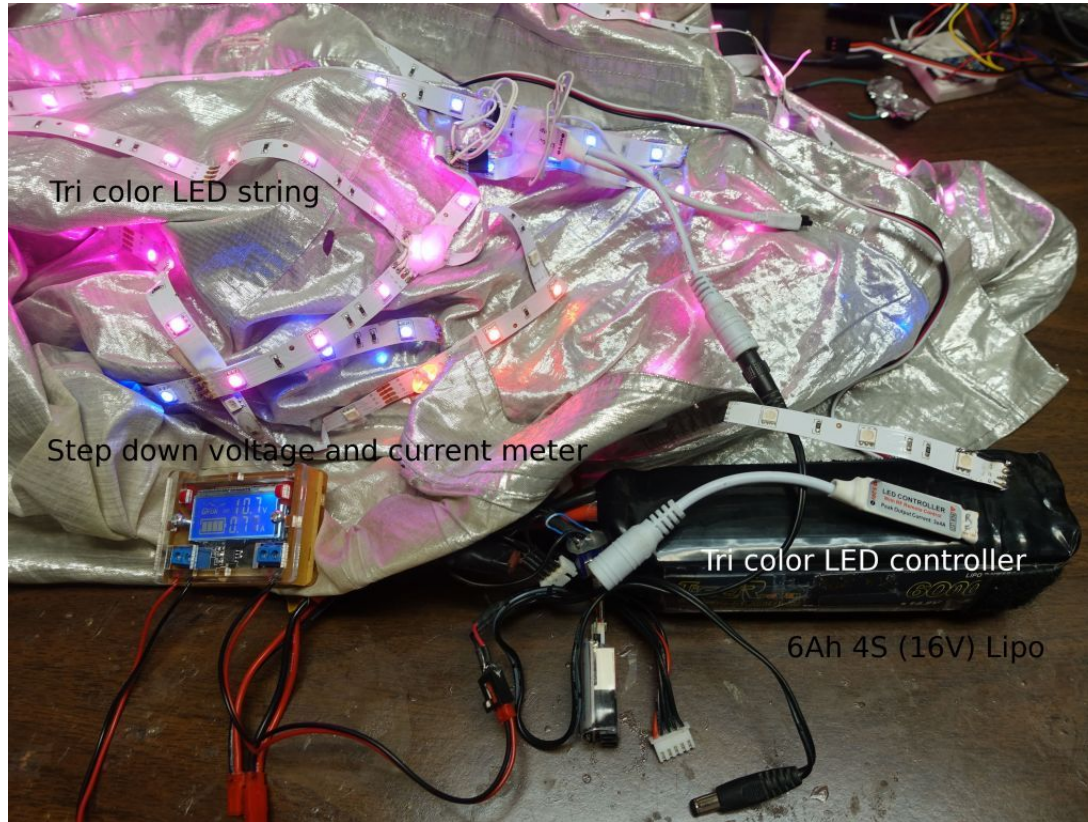
Not this kind of lit up

This kind

Tri color LED strip with power converter for brightness and 16V lipo

Tri color LED string

Step down voltage and current meter

Tri color LED controller

6Ah 4S (16V) Lipo

Let's do better. ESP8266 driven Neopixels with patterns on harms and legs

Like moth to a flame? :)

Not the only one wearing lights, but the only one with addressable pixels

Doing Neopixels with constant updates and IR is not simple

- While I had contributed the ESP32 Neopixel driver to Adafruit

- The Adafruit driver prevents IR from working since it disables interrupts

- FastLED is a much better driver for lots of pixel types and CPUs

- On 32bit chips, it re-enables interrupts between each pixel update

- This allows the IR interrupt handler to run in between 2 pixels

- If the ISR takes too long, FastLED is smart enough to cancel updating the rest of the strip and avoid corrupted display due to mistmatched timings http://marc.merlins.org/perso/arduino/post_2017-04-03_Arduino-328P-Uno-Teensy3_1-ESP8266-ESP32-IR-and-Neopixels.html

NeoPixel + IR only works on 32bit CPUs
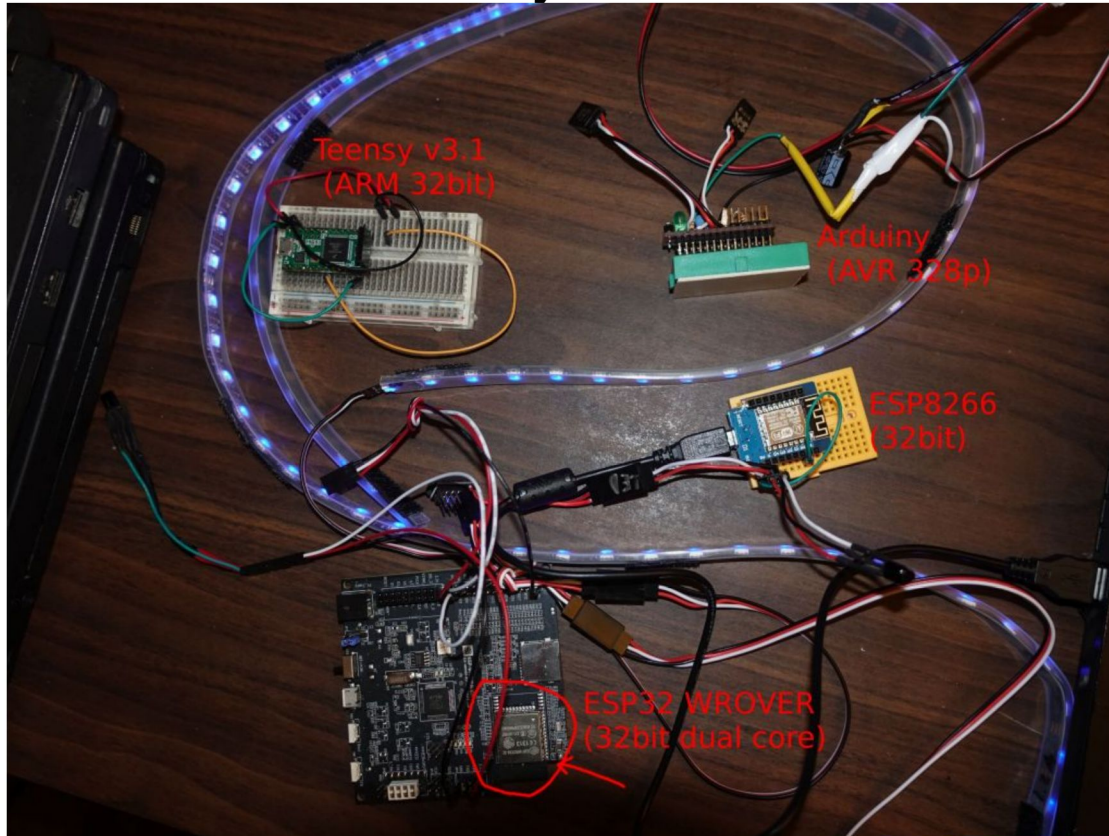
Extra points: Neopixel DMA

- Some pixels strips like APA102 have a clock line, WS2812B (neopixels) don't, and need exact timing.

- Either you do precise bit banging with interrupts

- Or some chips allow you to do DMA with a coprocessor while the main CPU is free to do other work

- Teensy can use its versatile serial port driver to do DMA
  https://www.pjrc.com/non-blocking-ws2812-led-library/

- ESP8266 can use DMA by abusing its I2S driver
  https://github.com/JoDaNl/esp8266_ws2812_i2s/

- ESP32 has an 8 channel RMT driver to do general IO like IR or Neopixels

- With DMA output, doing IR with interrupts is a non issue.

- https://github.com/marcmerlin/Neopixel-IR is a multi-driver example

LCA 2018 OHMC: Lolibot

- http://www.openhardwareconf.org/wiki/OHMC2018

- http://marc.merlins.org/perso/linux/post_2018-01-22_Lolibot_-FPGA-Primer_-MicroPython-for-ESP8266-ESP32-and-Protocol-Analysis-at-Open-Hardware-Miniconf-at-Linux_Conf_au-2018.html

- Much nicer robot than SimpleBot

- Also ESP32 based, but running micropython

- Better than JS for sure, but didn't have much time to program it

- Distracted by next project…

Google

Lolibot, ping pong playing robot

Neopixels Shirt:
A sane person would have been content at this point

- But, but, but, what if someone else builds a shirt with the info and code I posted? Can't have someone else wear the same outfit as me :)

- Big flaw of my Shirt v2, the RGB strips were glued on the shirt, making it unwashable.

- Yes, I'm French, but there is only so much cologne you can put on a shirt :)

- Taking the shirt to Burning Man made washing it a priority (playa dust). I rebuilt it once, and then looked for a new better design

- Next target: EDC 2018

What if I put a Neopixel Matrix on my shirt?

- Because "More pixelz = More better! :)"

- However, making matrices with strips is pain

- You can use smaller pre-made matrices (8x32 or 16x16) and piece them together

- However mapping X/Y coordinate to LED number in the chain is now a pain

- This is where Adafruit::NeoMatrix comes in. It does all the work of mapping coordinates while offering an array you can write to with Adafruit::GFX functions

Need FastLED::NeoMatrix

- NeoMatrix is great, but the Adafruit::NeoPixel backend it's based on, does not work with DMA or other Interrupts

- FastLED does, but there is no NeoMatrix for it

- Well, there was no NeoMatrix before I wrote one :)

- https://github.com/marcmerlin/FastLED_NeoMatrix

- http://marc.merlins.org/perso/arduino/post_2018-04-23_FastLED_NeoMatrix-library_-how-to-do-Matrices-with-FastLED-and-Adafruit_GFX.html

# Done, and Done: 4x8x32 matrices = 32x32

Now, I can do the Neopixel shirt

- Existing Neopixel matrices are P10, i.e. 1cm between each pixel

- For my body size, I can only reasonably have 32 high, 24 across

- Found helpful 8x32 panels for about US$30 each

- 768 pixels in the front, and added a 768 pixels mirror in the back

- Full power on white is a total of 60A at 5V, but it's way too blinding

- Typical usage is only 2A

# WS2812 are a chain, if one dies the rest stops working (WS2813 fixes this)
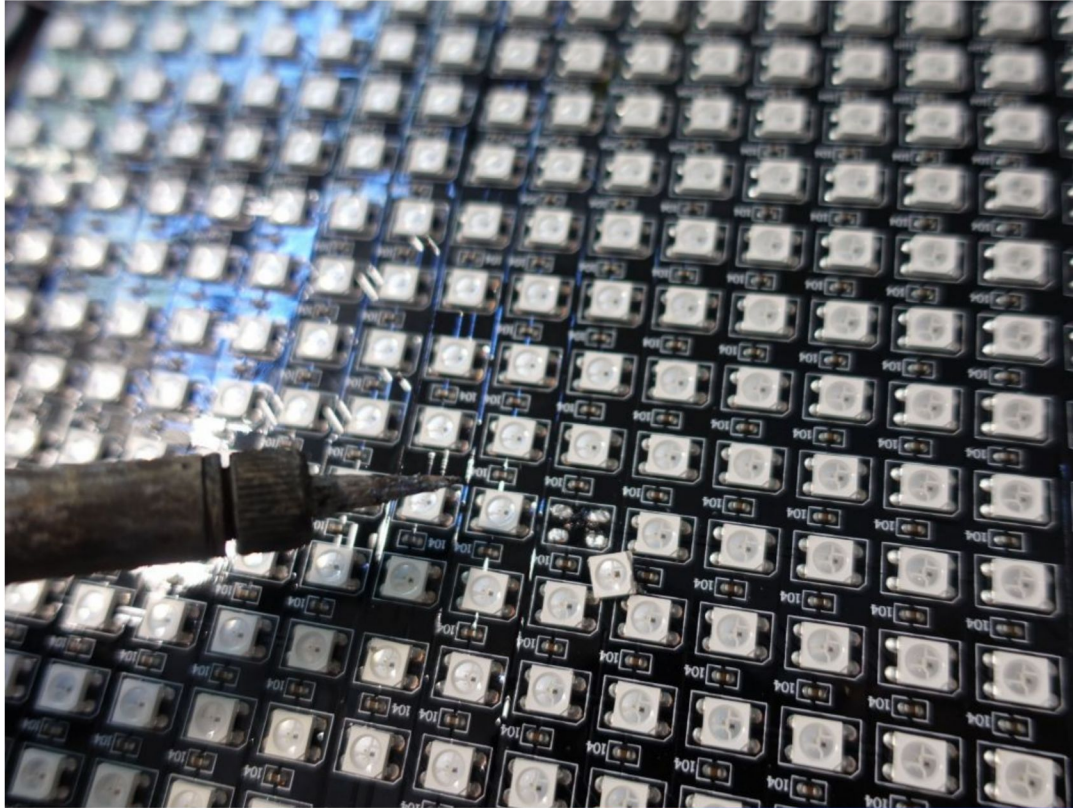
To avoid brownouts, power is injected in 9 places (3 per panel)
**Cat-5 is used to send 3 data lines without crosstalk**
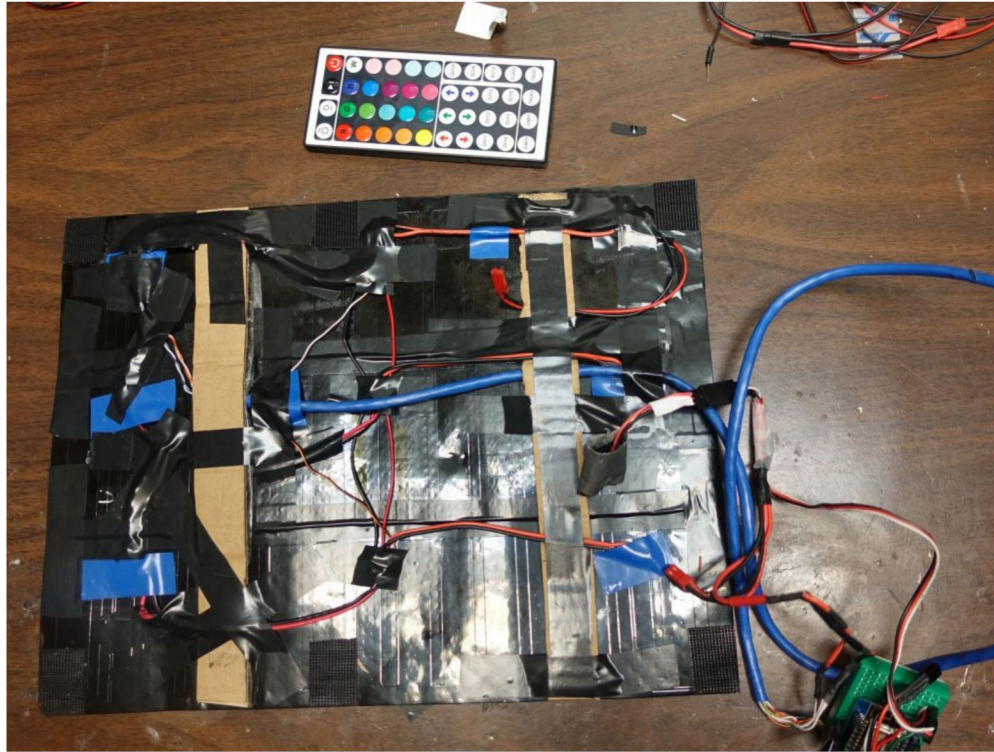
Power: Neopixels are hungry

- A very big USB battery pack is 99Wh (limited by airlines) and they only give 2-3A at 5V

- I fly RC, so I had lipos. 2X 4S (16V) 5Ah = 160Wh. Around 10-12H of runtime. But it's 2x 80Wh, so under the 100Wh limit. Auckland airport checked my carry on lithium limit :-/ (and stole my superglue because it's "flammable")

- Lipos can deliver 200A peak at 16V, or over 500A when converted to 5V. Probably overkill enough :)

- 3A at 5V = 1A at 16V or 10h for 10Ah of batteries.

- Tobsun 10A step down converter for Neopixels

- 2nd lossy voltage regulator to 3.3V to replace El Wire glasses batteries

Power system, ESP8266 on the left from Alastair's tutorial a few years back
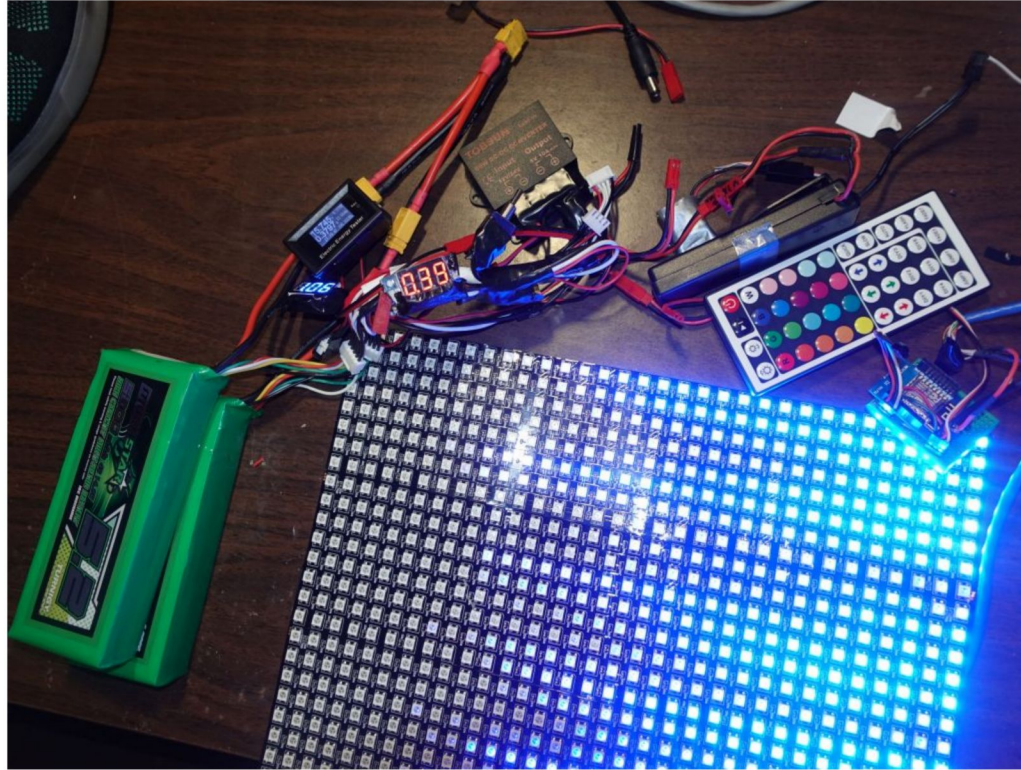
Power Monitoring. Had to explain to a cop it was not a bomb timer.
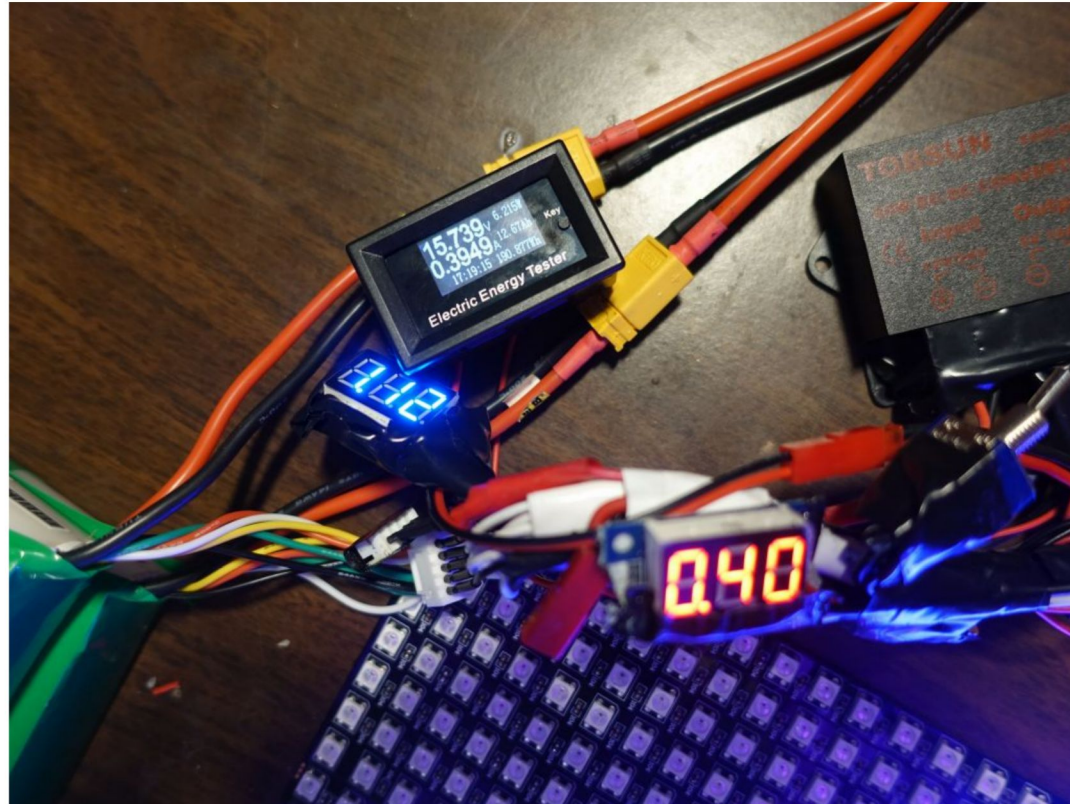
Rear Panel is inside the shirt to use the shirt as a diffuser

Front panels are velcro'ed on shirt

EDC Vegas 2018 was a success

Like Moth to a flame :)

Top Questions at EDM shows

- OMG, I must have this? Where did you buy it? => I didn't

- This is cool. Can I have one? => only if you build it yourself

- You should sell this => don't need the money, don't have the time, don't want to deal with the tech support, and don't want you to wear the same outfit as me, unless you earned it by building it :)

- How much did it cost (time/money) => several months of software and hardware work, about $400 in materials

- Is it hot? => thankfully, no. Barely warm to the touch (little energy wasted to heat)

So, you're done now, right?

- Outside of the week/months of coding to write and port demos to run on the panels

- Ported demos from incompatible SmartMatrix panels, and LEDMatrix library

- Ported AnimatedGifs library to Neomatrix and ESP8266 flash FS (SPIFFS)

- http://marc.merlins.org/perso/arduino/post_2018-07-13_AnimatedGIFs-for-SmartMatrix-or-NeoMatrix-_Neopixel-WS2812B_-from-SDcard-or-SPIFFS_-on-Teensy-3_x_-ESP8266_-or-ESP32.html

# Animated Gifs added a lot of animations for "free"
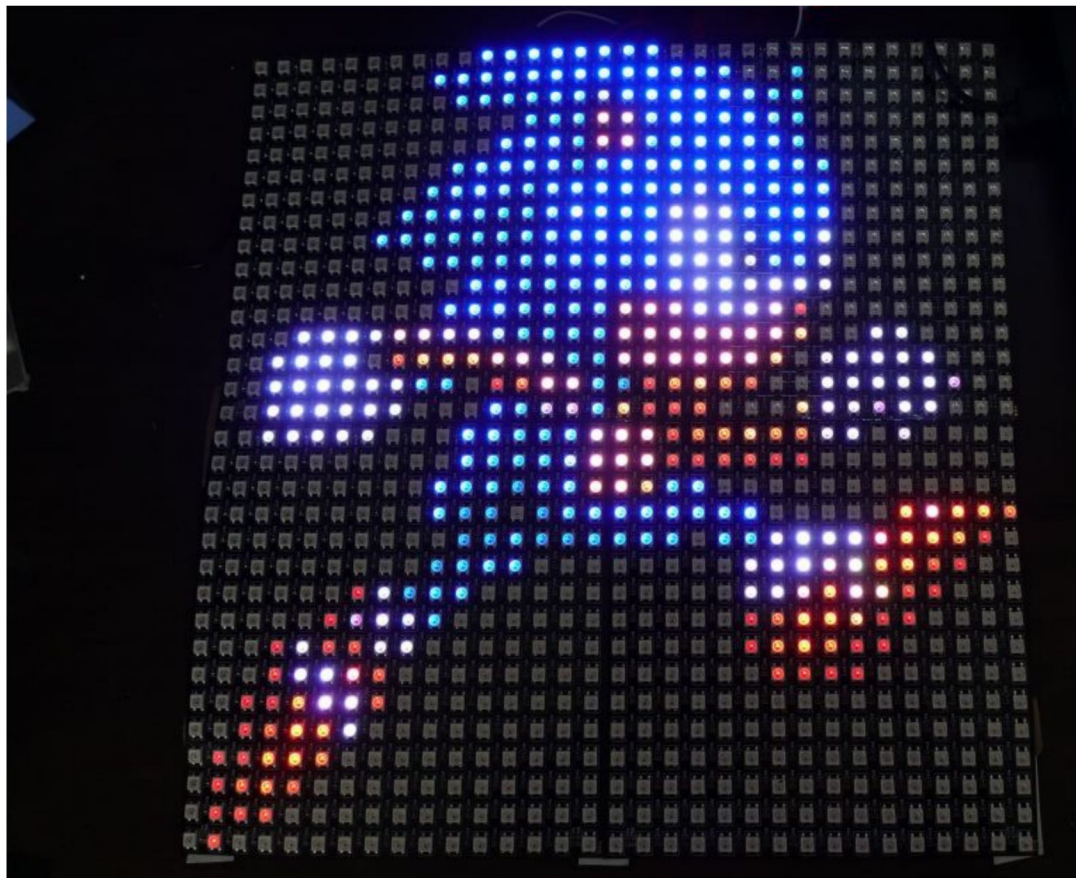
Mission Accomplished?

Over 4000 free WS2812B LEDs, an expensive gift :)

- One of my coworkers gave me a bit over 4096 pixels he wasn't using anymore, 1.66cm pitch.

- 64 LEDs is over 1m across

- It was hard to resist

- So I didn't :)

- And it cost me another 2 weeks of solid work

- http://marc.merlins.org/perso/arduino/post_2018-07-30_Building-a-64x64-Neopixel-Neomatrix-_4096-pixels_-running-NeoMatrix-FastLED-IR.html
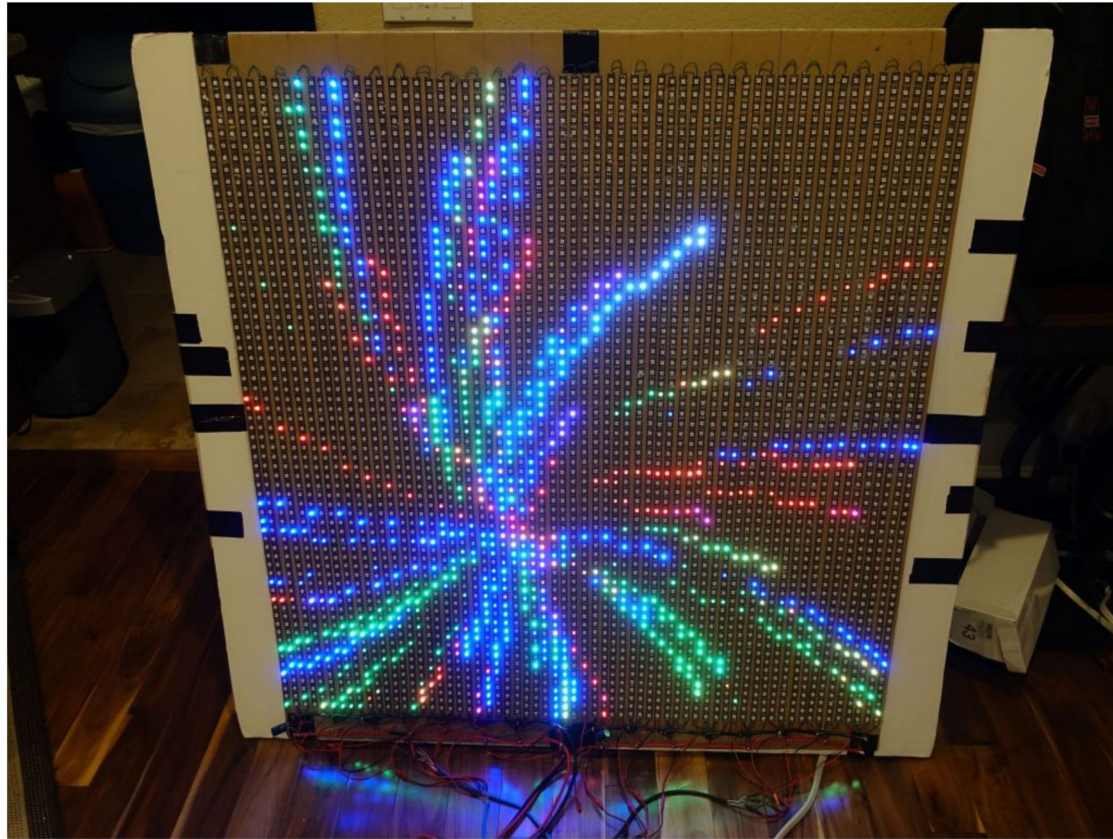
Took forever to lay out the strips and solder them
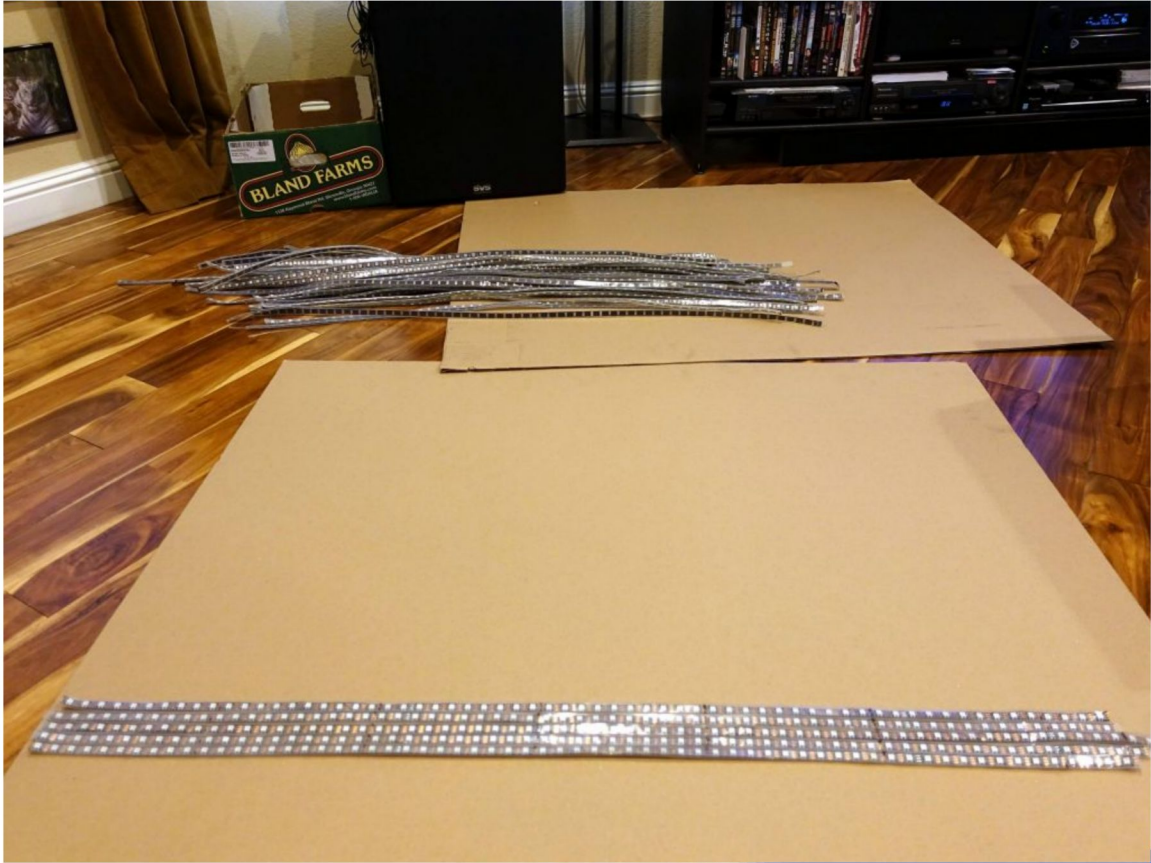
2 halves of 80 amps each, thick wire for power bus
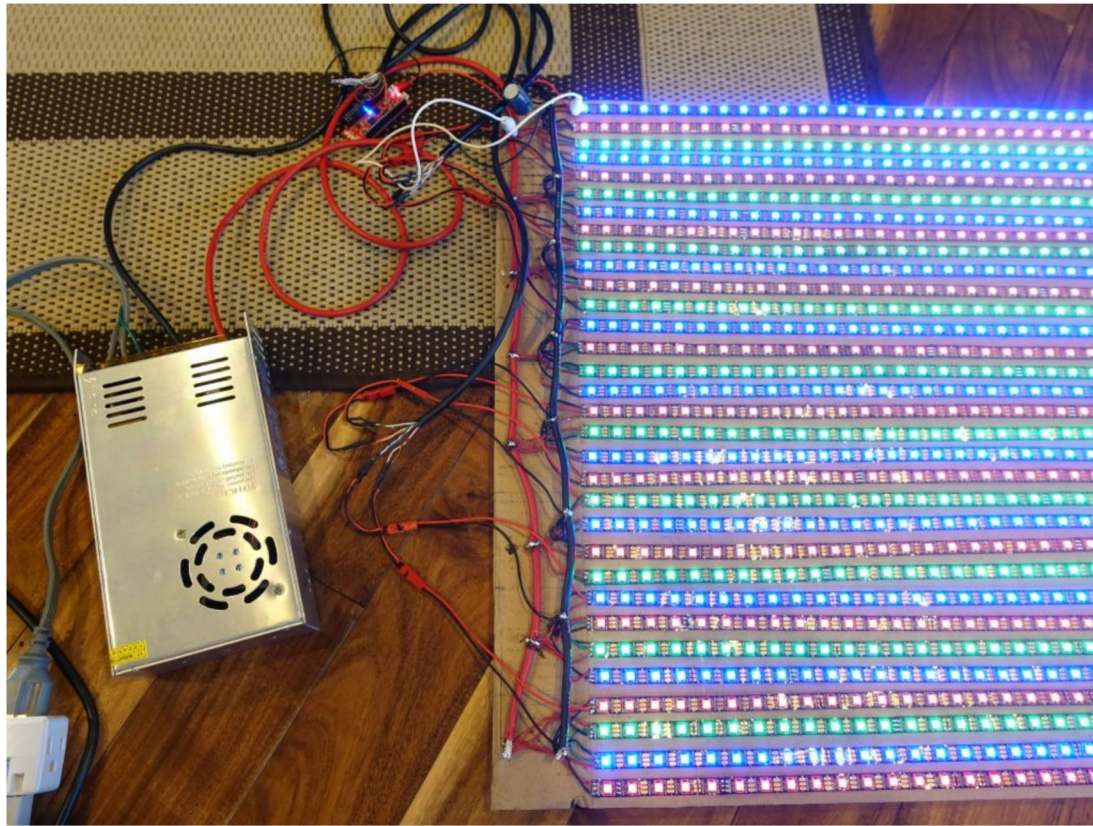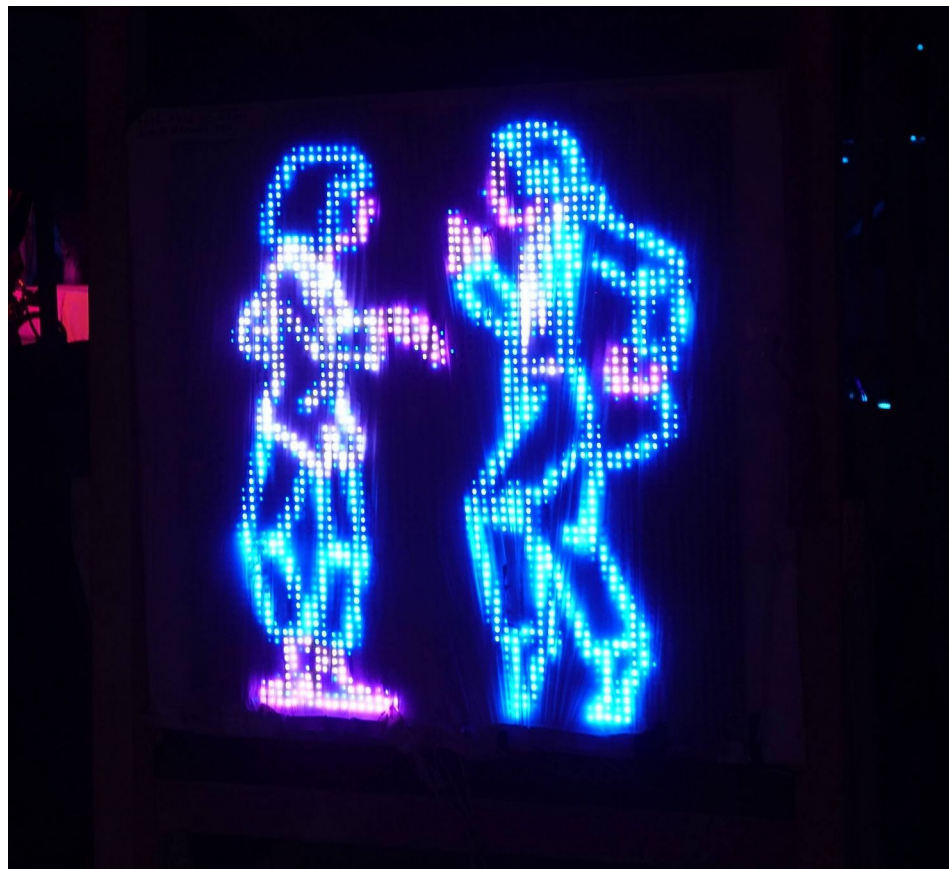
Power Testing, Bright as a small Sun :)

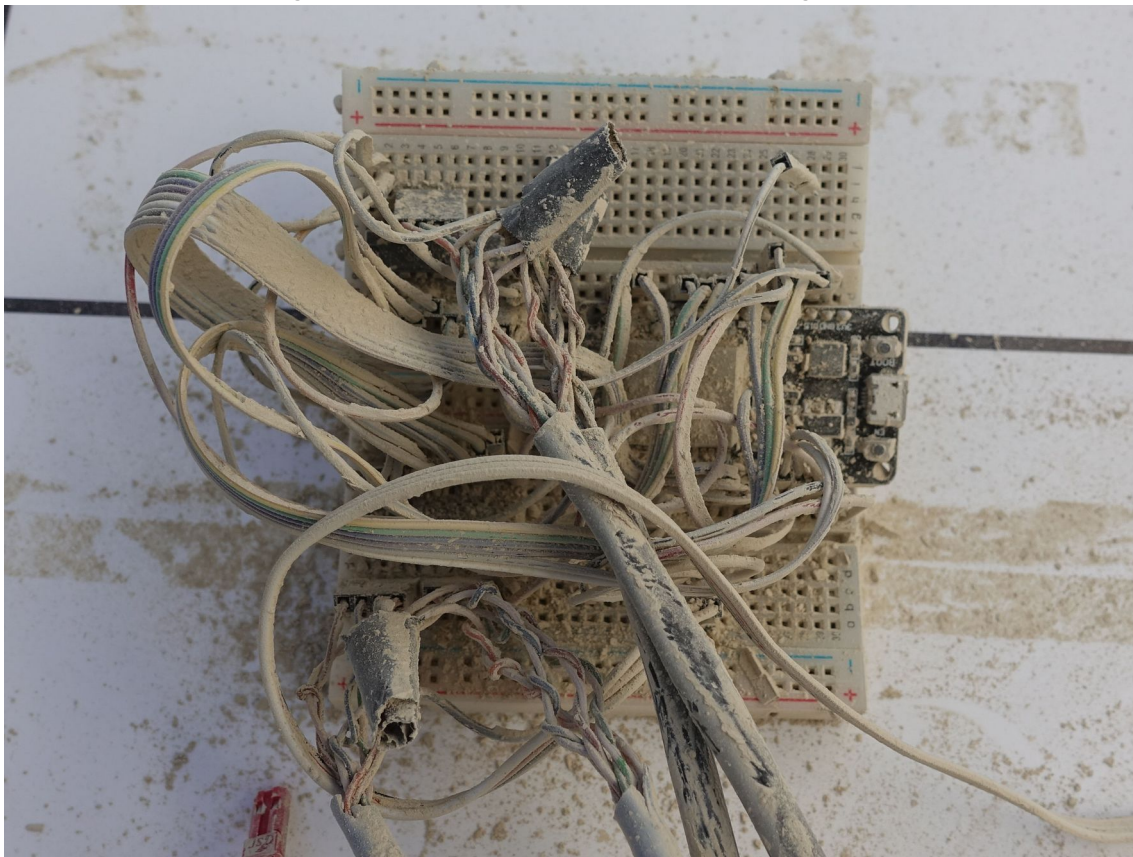# Switched to ESP32 for 16 way parallel output (256 LEDs each)

Ready for Burning Man

Worked Great At Night

ESP32 survived the playa dust, and so did my "permaprotoboard" :)

And I wasn't the only one with a lit shirt

But the only one with a real LED Matrix

# This one was really cool though, I'm shiny but I don't have wings

The end?

- Hard to get smaller pitch LEDs in neopixels (6.6mm or 5mm possible, but no panels for sale).

- Switch to RGB Panels that go down as far as P2 (2mm)

- No smarts, needs constant refresh and PWM/BCM for colors

- SmartMatrix does the work with teensy 3.6 or ESP32

- Not compatible with GFX or my FastLED demos

SmartMatrix::GFX, my new glue driver

- NeoMatrix code not compatible with SmartMatrix, so I wrote http://github.com/marcmerlin/SmartMatrix_GFX

- Now all my demos work both with NeoMatrix and SmartMatrix backends:
  https://github.com/marcmerlin/FastLED_NeoMatrix_SmartMatrix_LEDMatrix_GFX_Demos

- Now I can re-use all my existing code and demos and they just work on SmartMatrix: Adafruit::GFX, FastLED, NeoMatrix, and LEDMatrix.

- I ported some SmartMatrix code down to NeoMatrix (SmartMatrix API is more complex and unused by demo code I've found)

- New Shirt should be ready for EDC 2019 and Burning Man 2019

Now I can run NeoMatrix code from my 1m^2 panel on a tiny SmartMatrix one
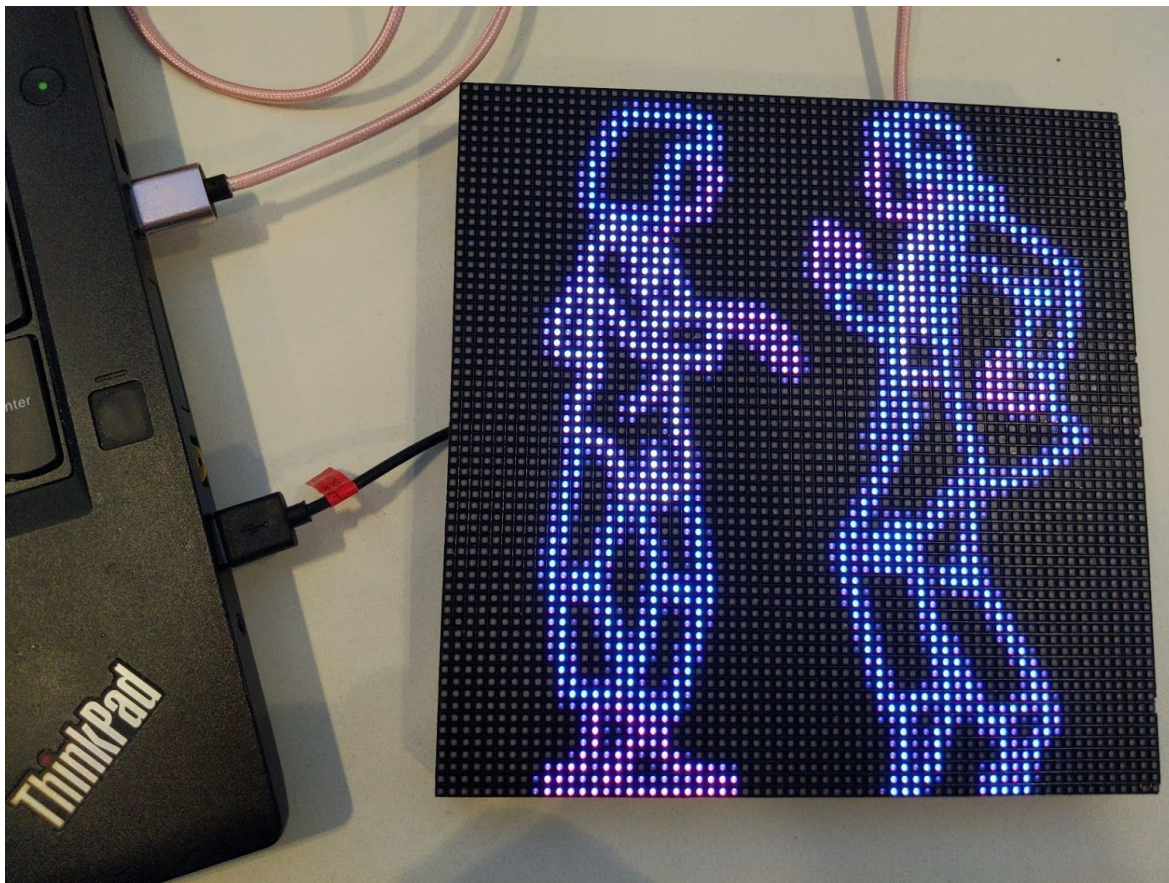
LEDMatrix code ported to NeoMatrix now also works on SmartMatrix
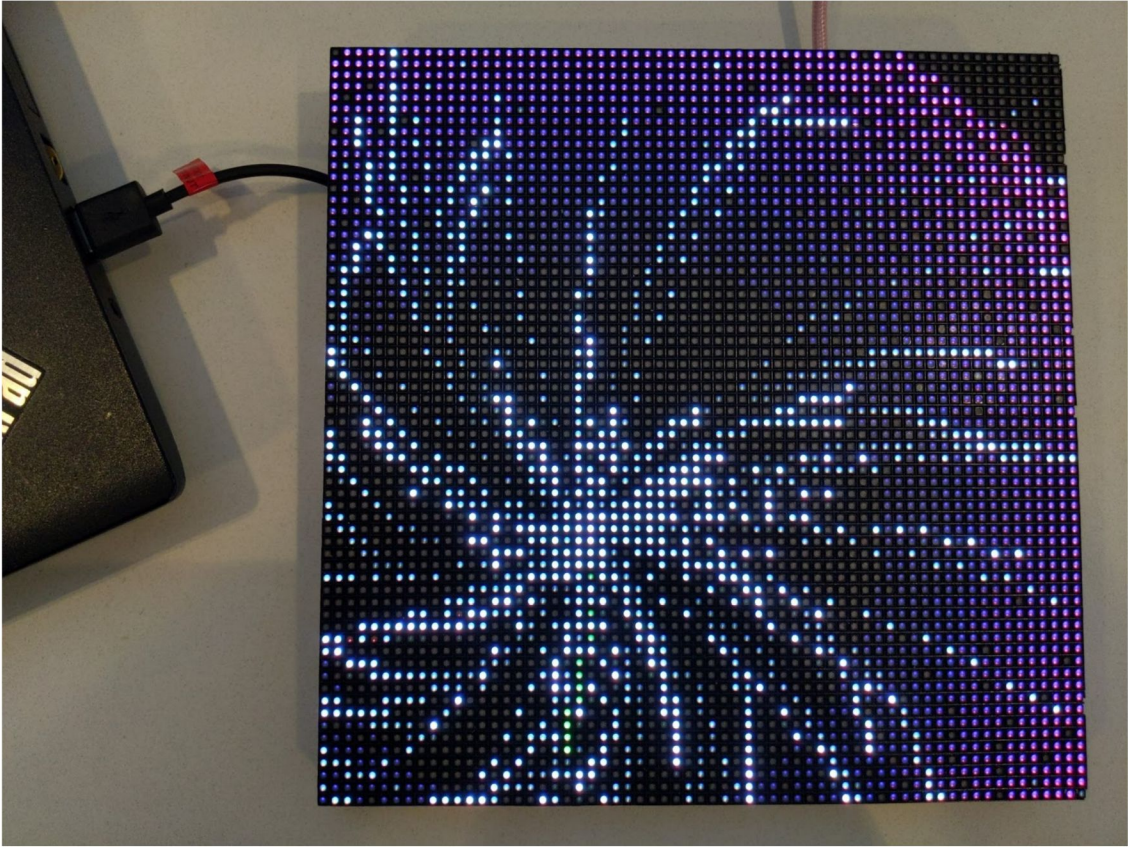
Real work: testing fuchsia on hikey960

- The relatively limited electronics/arduino knowledge I learned was at least used for work a bit

- Google's Fuchsia, outside of being a color that's hard to spell :) , supports arm64 architectures. The first platform I had to support was hikey960.

- Dual powered 12V and 5V USB

Fuchsia OS testing on hikey960

- Need to reboot a crashed board

- There is a daughter board that supports serial console

- It also supports a special raw USB command to power cycle the board

- Sadly the broken method it uses crashes the ttyUSB device, causing loss of early boot messages.

- Instead, easier to toggle 12V power

Arduino to the rescue: cheap PDU

- 12 devices meant 12 power bricks

- Instead of used a big 12V power supply and spliced its output

- I then cut the cables and had them go through a relay

- Simple 16 relay board with pins going to an arduino nanov3

- Trivial program that takes 2 character serial input and toggles relays

- 11 => turn '1' on, 10 => turn it off

- Voilà: Server PDU for $30 instead of $300 and a single power supply instead of 15 power supplies (12 devices, 2 USB hubs, one switch)

Craftsmanship worth sharing :) (need a longer tray)

Fuchsia OS testing on khadas vim2

- Hikey960 was a terrible board to support due to lack of programming specs

- We switched to khadas vim2, a nice $100 onboard arm board

- Khadas was a true pleasure to work with and implemented a WOL reboot feature when I asked them how to remotely reboot crashed boards

- As a result, a tray build was a lot easier, I only needed to support the wiring for fastboot USB/power and USB serial console

Vim2 rack tray setup, no fancy electronics needed

- Used a full length rack tray instead of a baby one

- Single shared 12V power supply for the 2 USB hubs which act as 5V power converter and the ethernet switch

- Onboard ethernet switch to avoid all the ethernet cables coming out

- Only 3 wires coming out: USB, ethernet and single power cord.

Khadas vim2 rack with single power supply
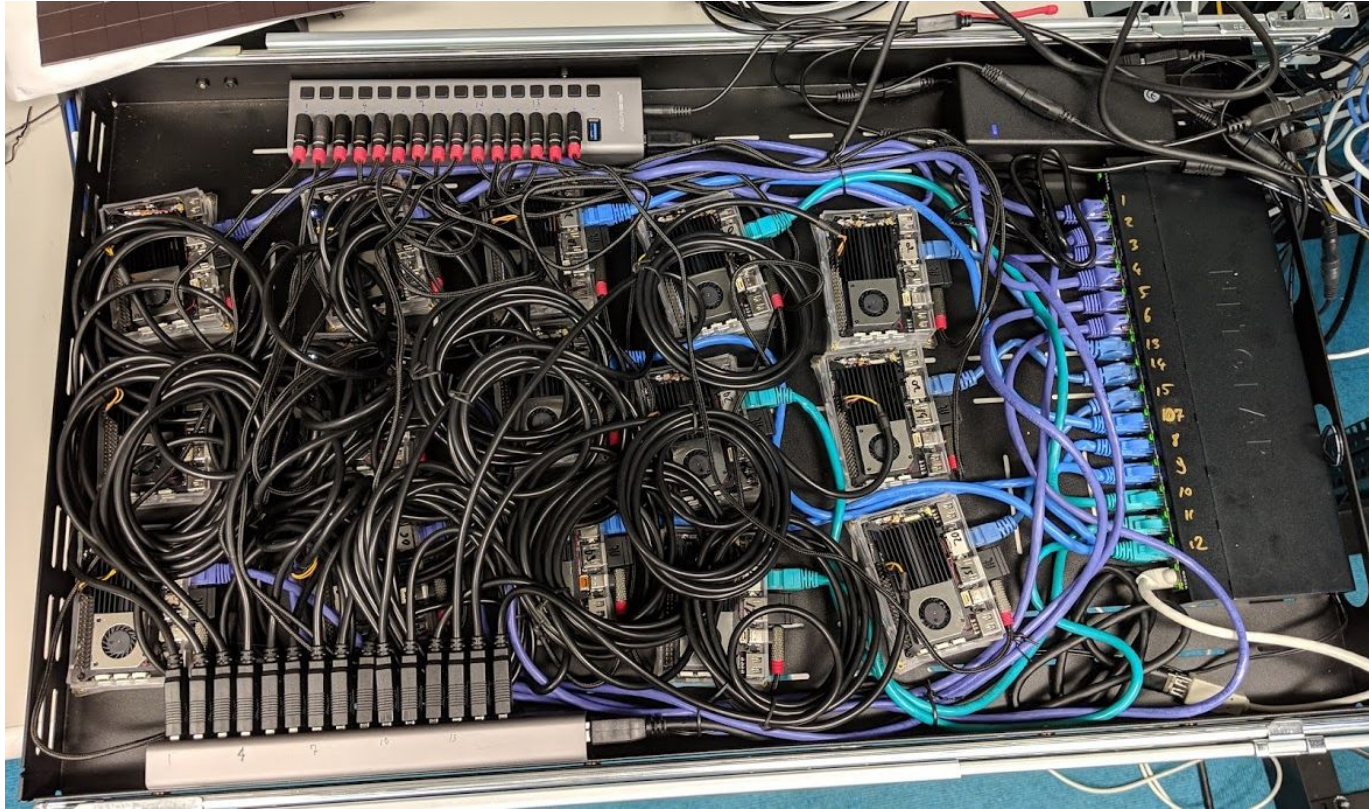
Conclusions

- Microcontroller programming is fun

- Some basic knowledge can be useful at work, even if you're not as smart as Jon Oxner and his crew and your stuff won't go to space :)

- Basic electronics knowledge does come in handy, at least, volts, amps, and voltage dividers

- Analog electronics gets messy. Avoid that if you can :)

- Sadly sometimes you do hit analog limits (wire length, cross talk, etc…)

- Build something, have fun!

Q&A

Marc Merlin
merlin@google.com

Slides:
http://marc.merlins.org/linux/talks/Using_Open_Hardware/

Short link: https://goo.gl/4mWCE6

Burning Man:
http://marc.merlins.org/perso/bm/2018/