Expanding the RTL2832u SDR Dongle

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Deep Space Exploration Society

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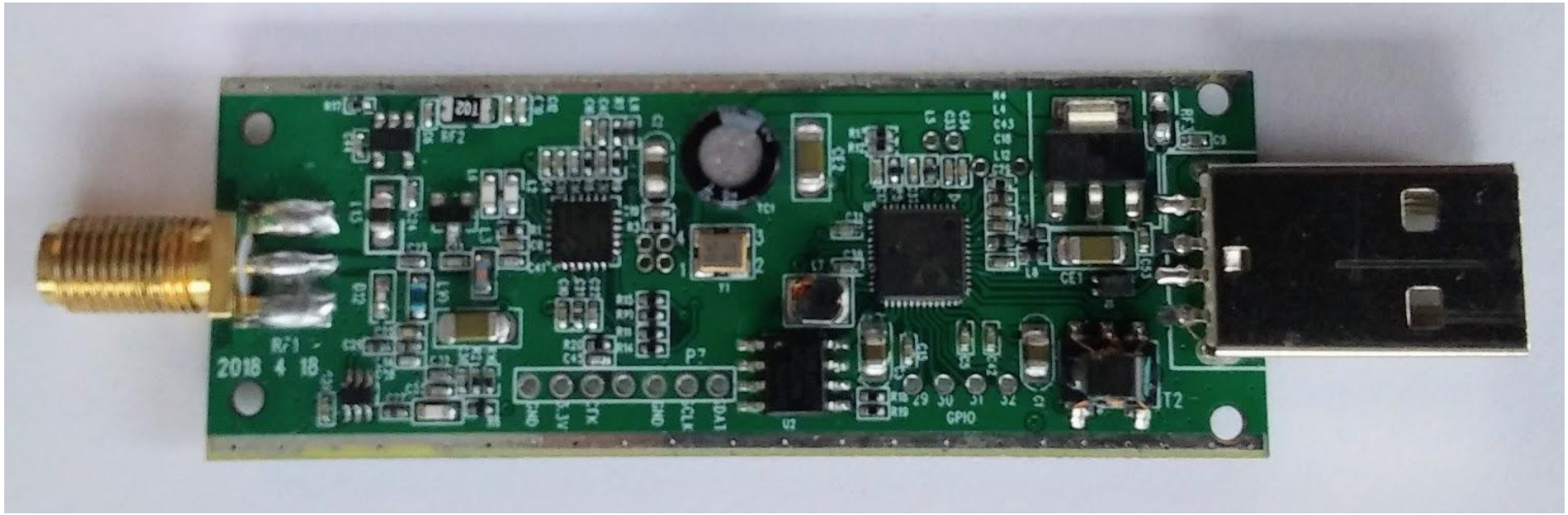




The RTL-SDR

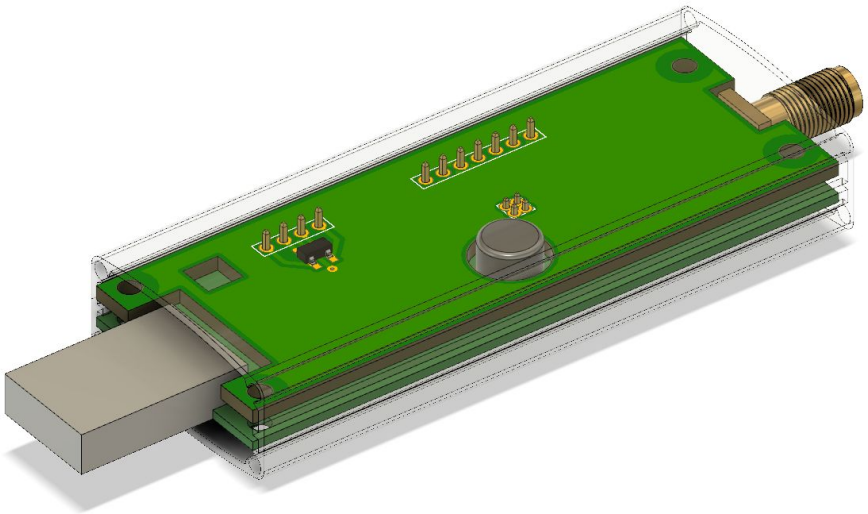
- USB SDR Dongle from DVB-T TV tuners
- Advantages
  - Low Cost
  - Ease of use
  - Versatility
- Disadvantages
  - Limited hardware
  - Limited bandwidth
  - Requires external hardware for radio astronomy

RTL-SDR Blog V3



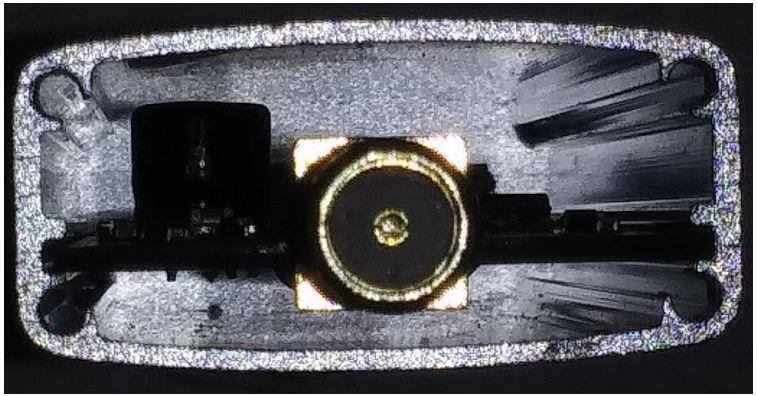
- RTL2832u and R820T2 Tuner
- Optimized for SDR
- Temperature Controlled Oscillator
- Expansion options

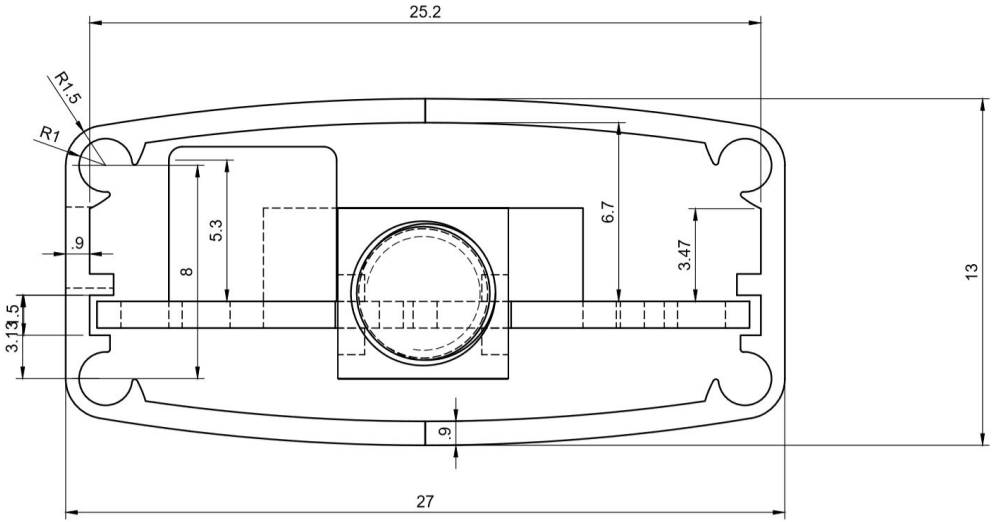
The RTL-SDR Expansion Board



- Fits on top of the V3 PCB
- Allows the user to add additional circuitry to the RTL-SDR
  - Filters
  - Cooling
  - Amplifiers
  - Buffered outputs
- Includes:
  - GPIO pins
  - Clock Pins
  - Expansion header
  - Optional ufl and sma connectors for rerouting signal

The Available Space

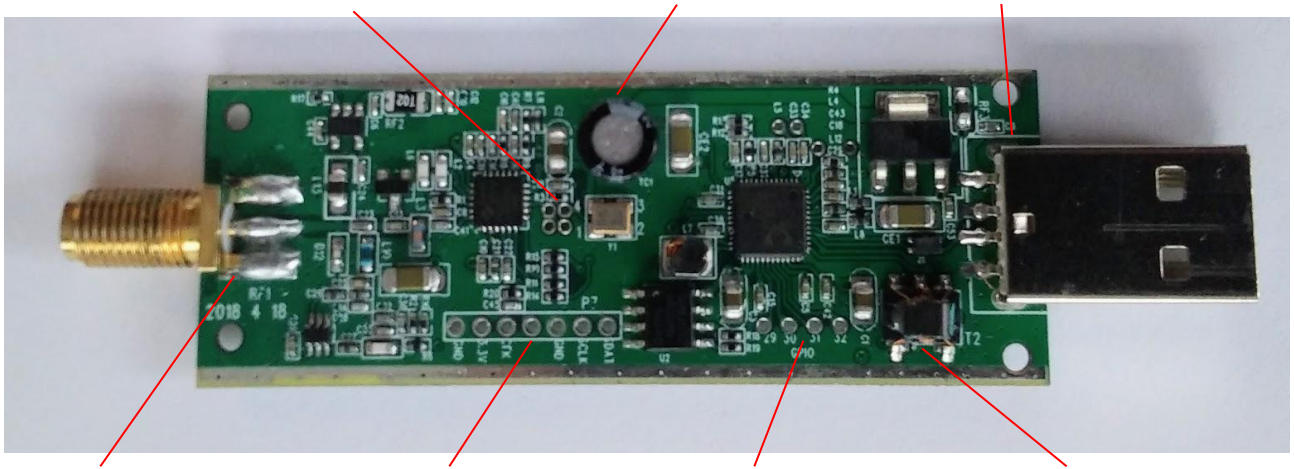




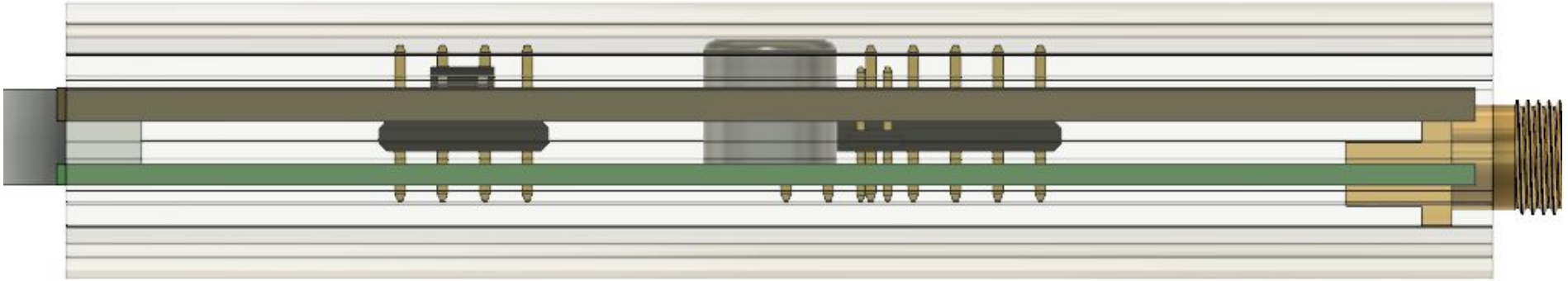
- It is ideal to fit the expansion board into the aluminum case (25 x 11.2 mm)
- Case built to fit TC1, SMA and USB
- 3.5 mm of clearance
- Electronics must be low profile (no room for through hole components)

Expansion

- RTL2832 GPIO pins
- Clock options
- T2, TC1, USB and SMA protrude into available space
- Non-standard pitch for header connectors
- Little space for rerouting signal



The Interface

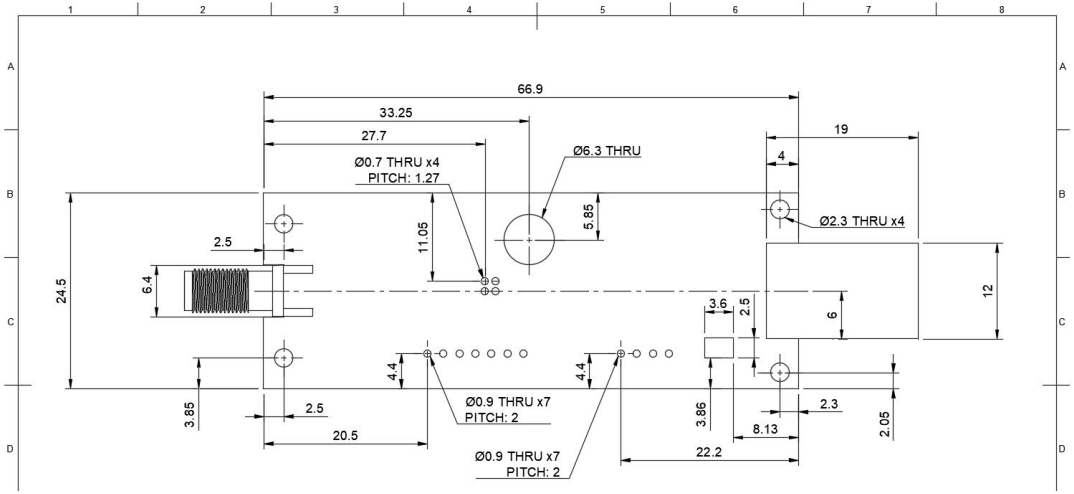


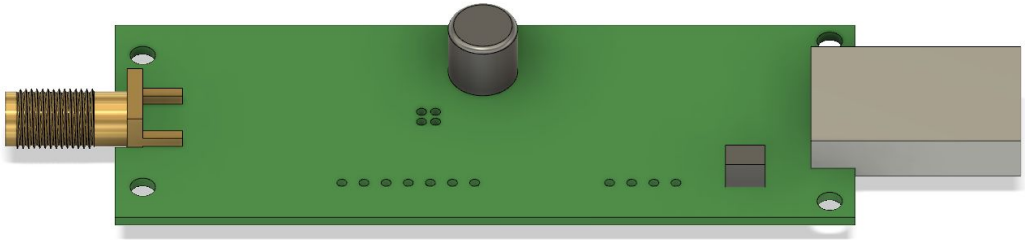


- Headers for connecting PCBs
  - Semi-permanent
  - Low profile
- Board to board UFL for rerouting signal
  - Low profile, correct impedance

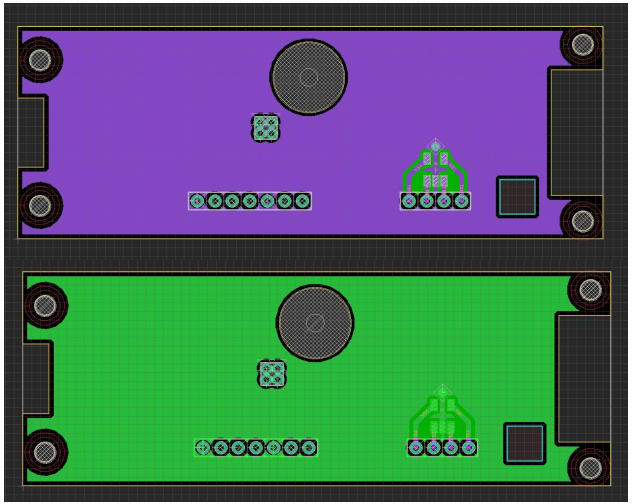
Measuring The V3 PCB

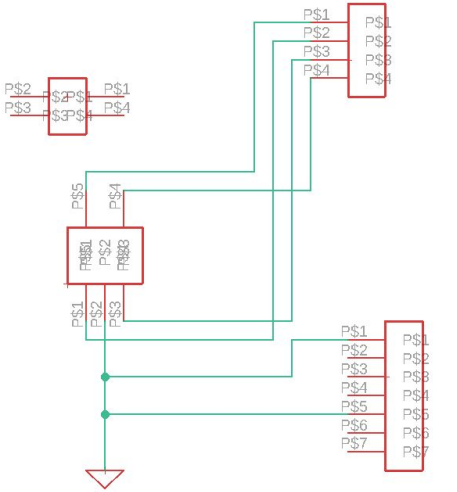
- No public designs for the V3
- The measured distances are compared with a design traced over an enlarged picture of the V3
- Placement of features confirmed using printoutn

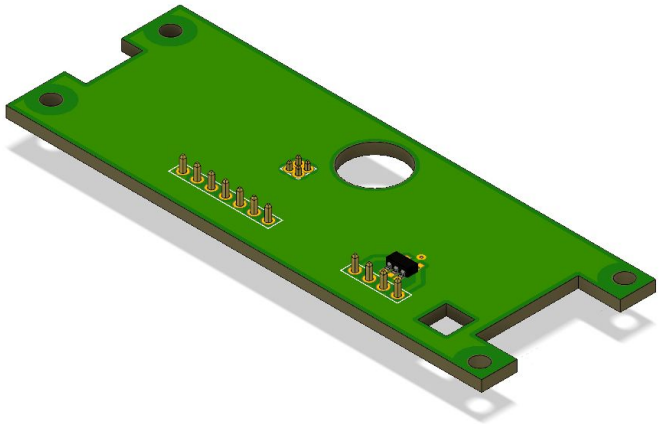




The Expansion PCB

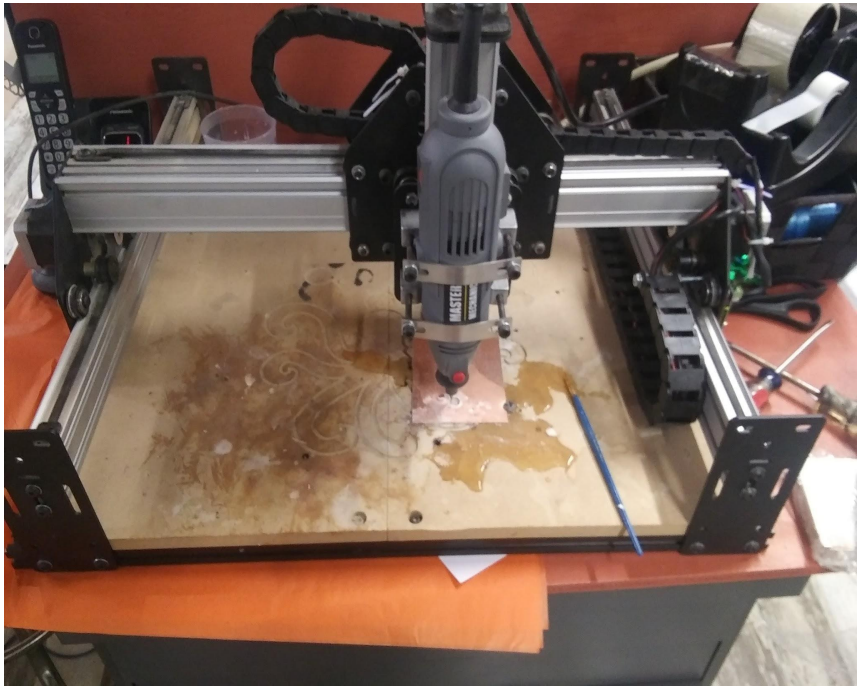




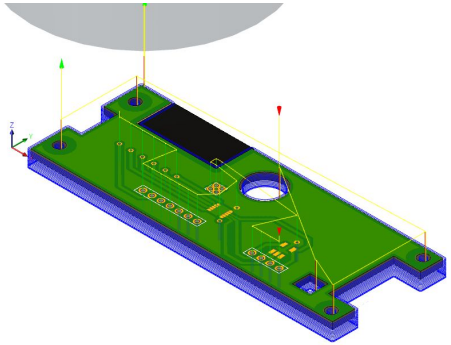


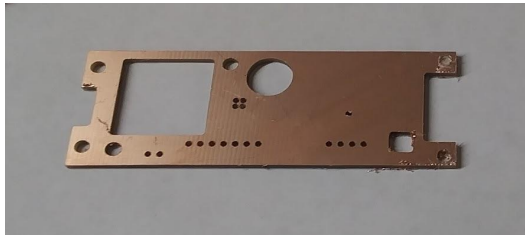
- Design created in Autodesk Eagle
- Provides ESD protection for GPIO pins
- Includes expansion features and holes for external mounting

Manufacturing-1

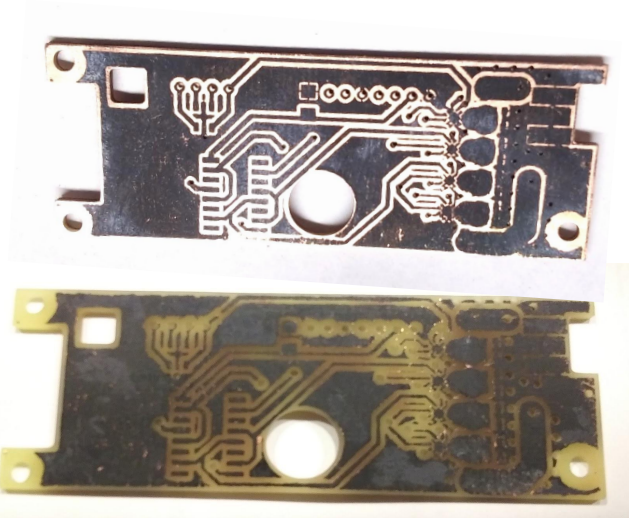


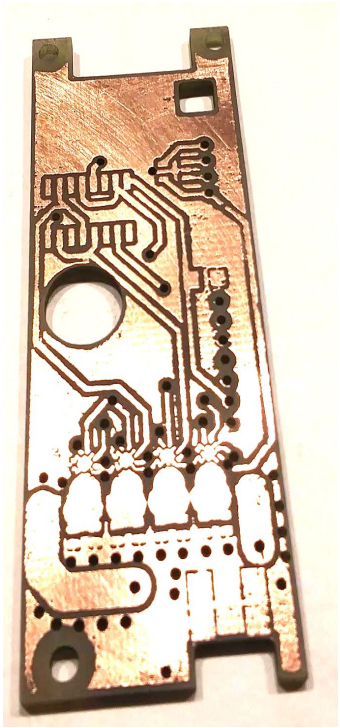


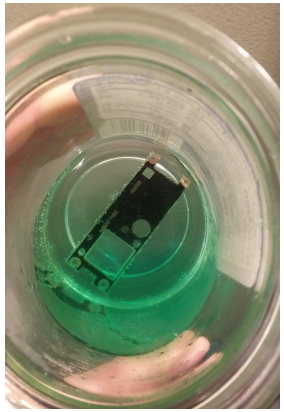


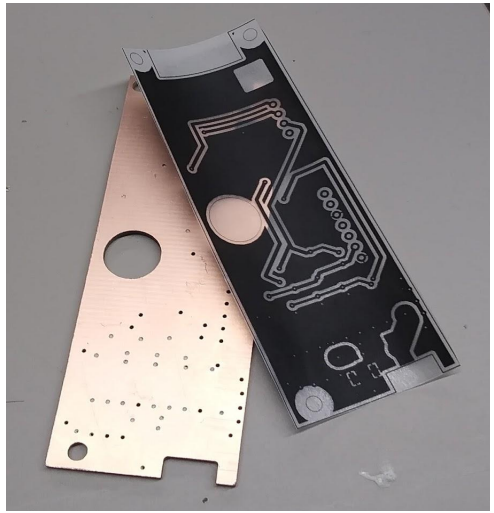


Manufacturing-2



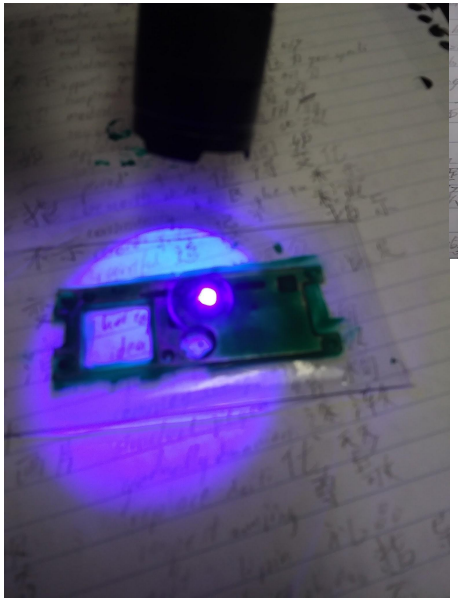


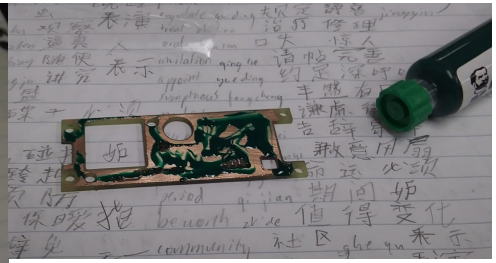


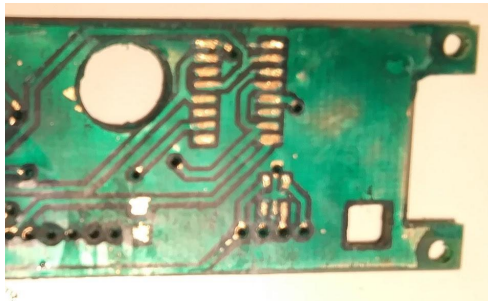




Manufacturing-3



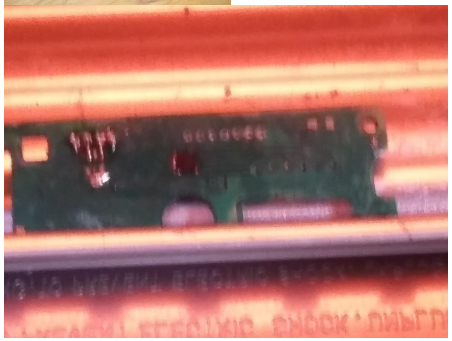


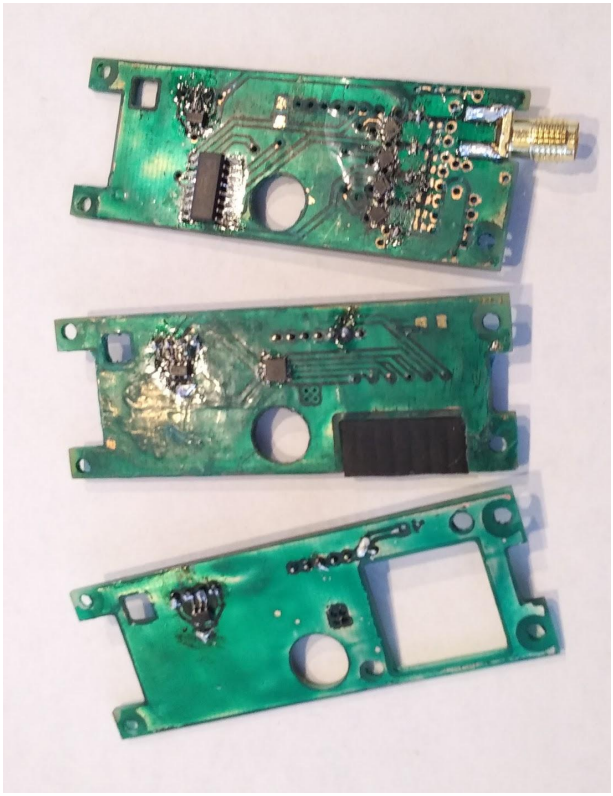


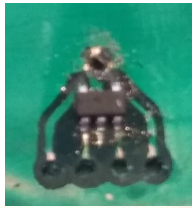


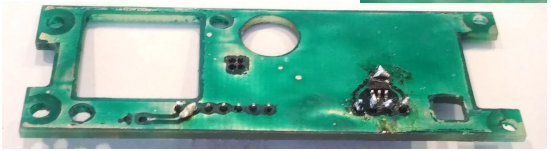
Manufacturing-4

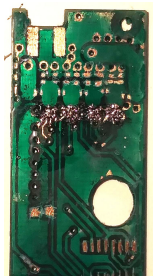


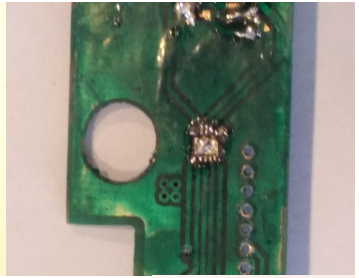


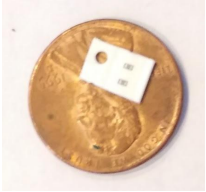










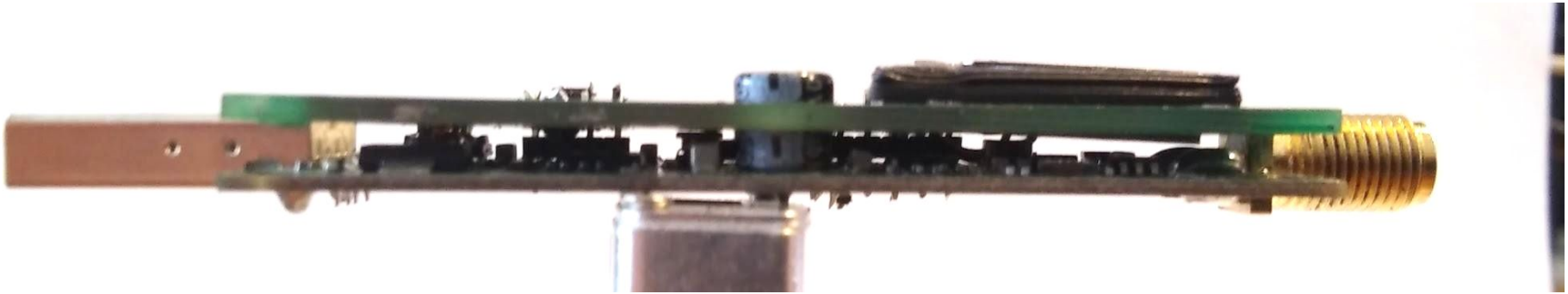


The Fit

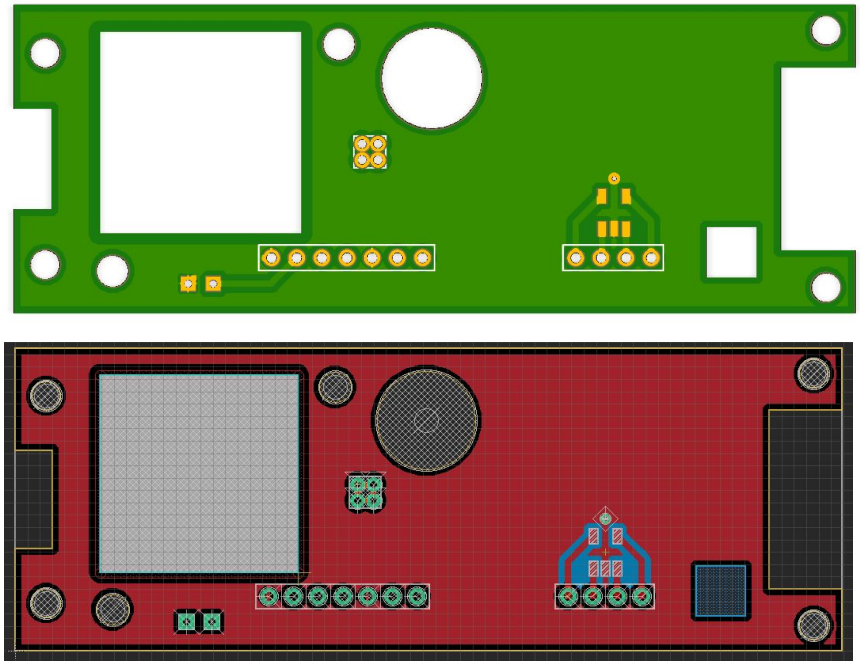
- 2.7 mm clearance
- Max 3 mm space for components
- Slides into case

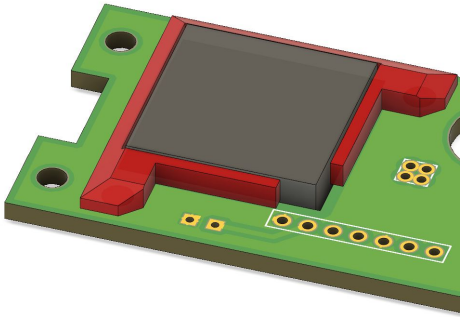


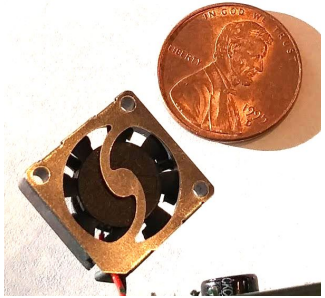




Example Implementation - Cooling-1





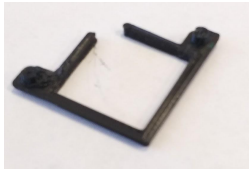


- 15 x 15 x 4mm
- The original inspiration for this project
- Can be run continuously or controlled by GPIO pin

Example Implementation - Cooling-2

- Low profile 3d printed clip holds fan in place
- 0.42 mA
  - (from amazon page at https://www.amazon.com/gp/product/B07CVCWYKD/ref=ppx_yo_dt_b_asin_title_o00_s01?ie=UTF8&psc=1)
- Add 1 mm of height to the PCB stack
- Still includes ESD protection
  - Featured in base design

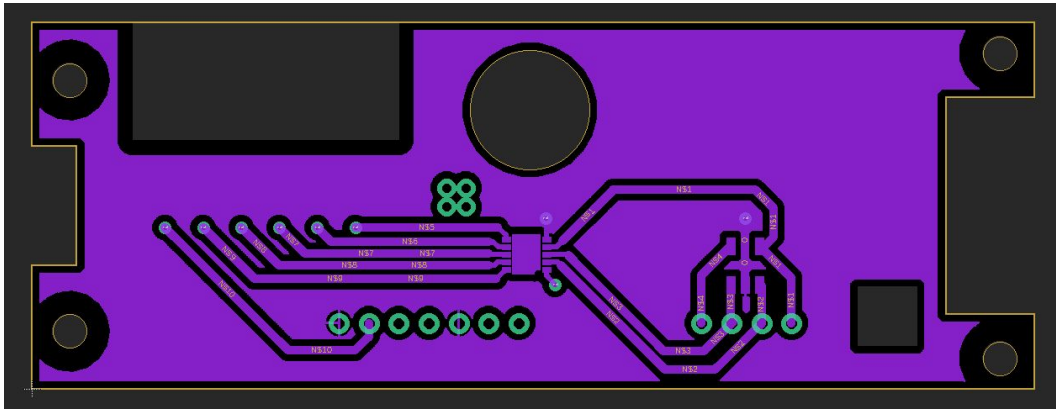


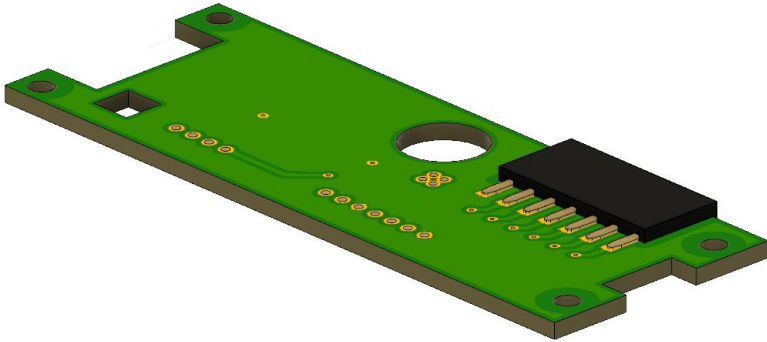






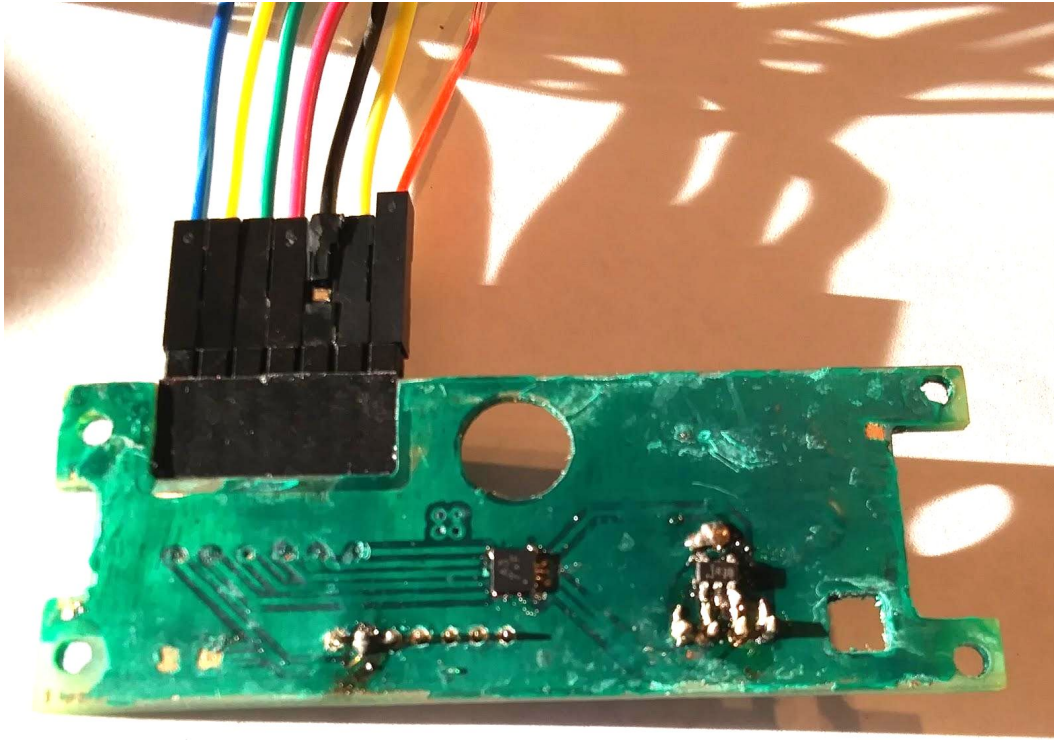
Example Implementation - GPIO Outputs-1



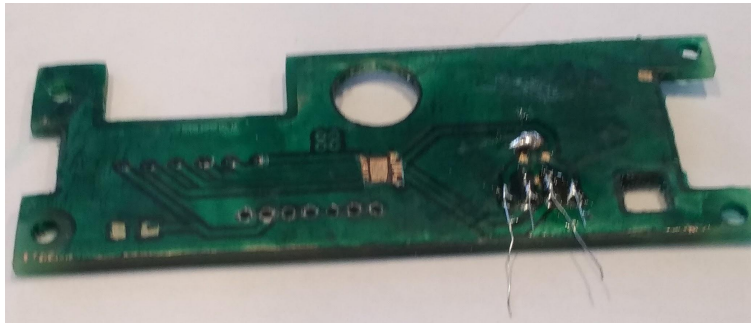


- GPIO pins can be used for driving external hardware
  - No clear way to route signals out of case
  - USB cannot drive large loads
  - Limited to 3.3V
- GPIO outputs buffered with 16V darlington IC
  - User can select voltage
- Signals routed to 2.54 mm header
  - Requires milled slot in case

Example Implementation - GPIO Outputs-2

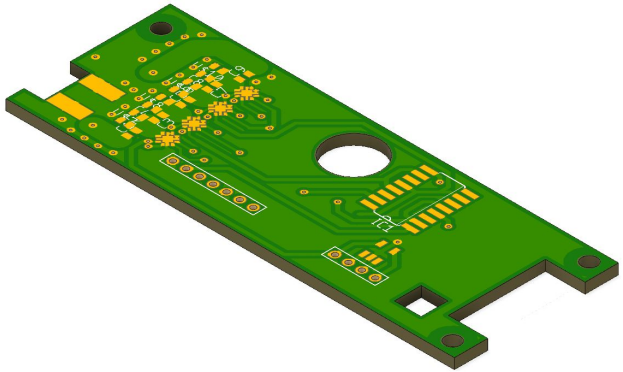


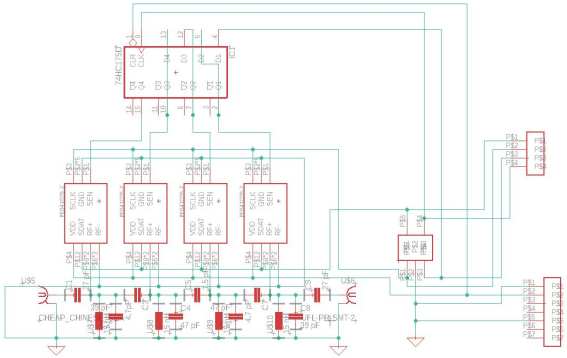
- Terrible results from solder mask
  - Varying thickness made DFN package soldering difficult
- Header fits into V3 case

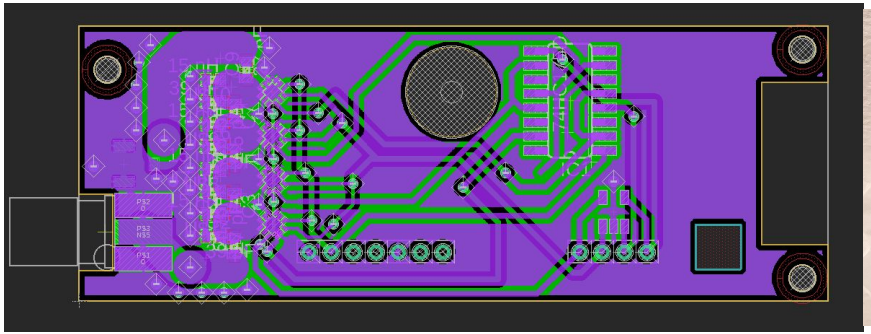


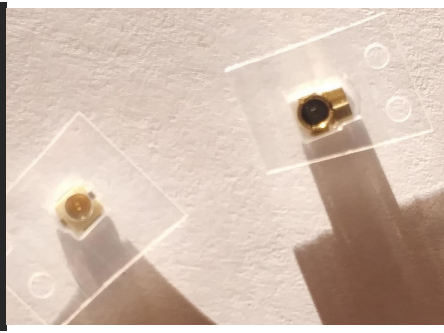
Example Implementation - Filter-1

- Digitally tunable filter first described by Enclides Chuma (ARRL)
- Reroutes signal through filter before reaching RTL-SDR
  - UFL board to board connectors





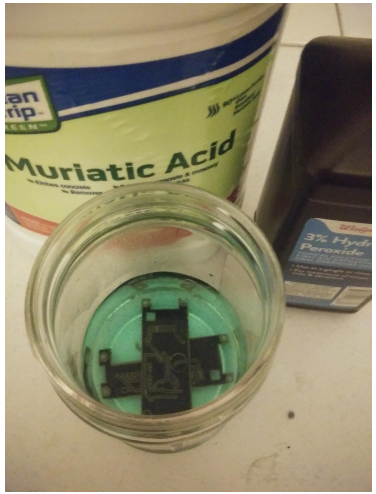


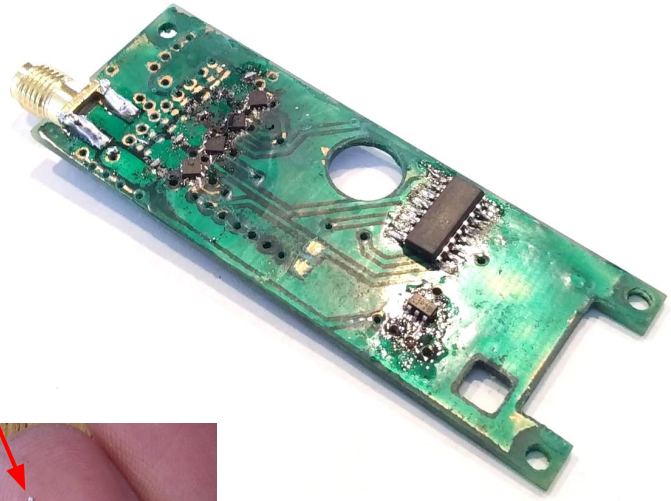


Example Implementation - Filter-2

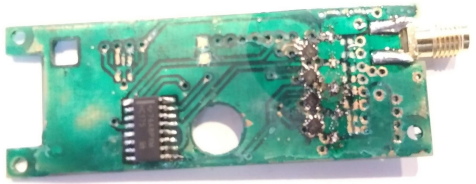












- 0402 Components too small to solder
- Currently redesigning for professional manufacture

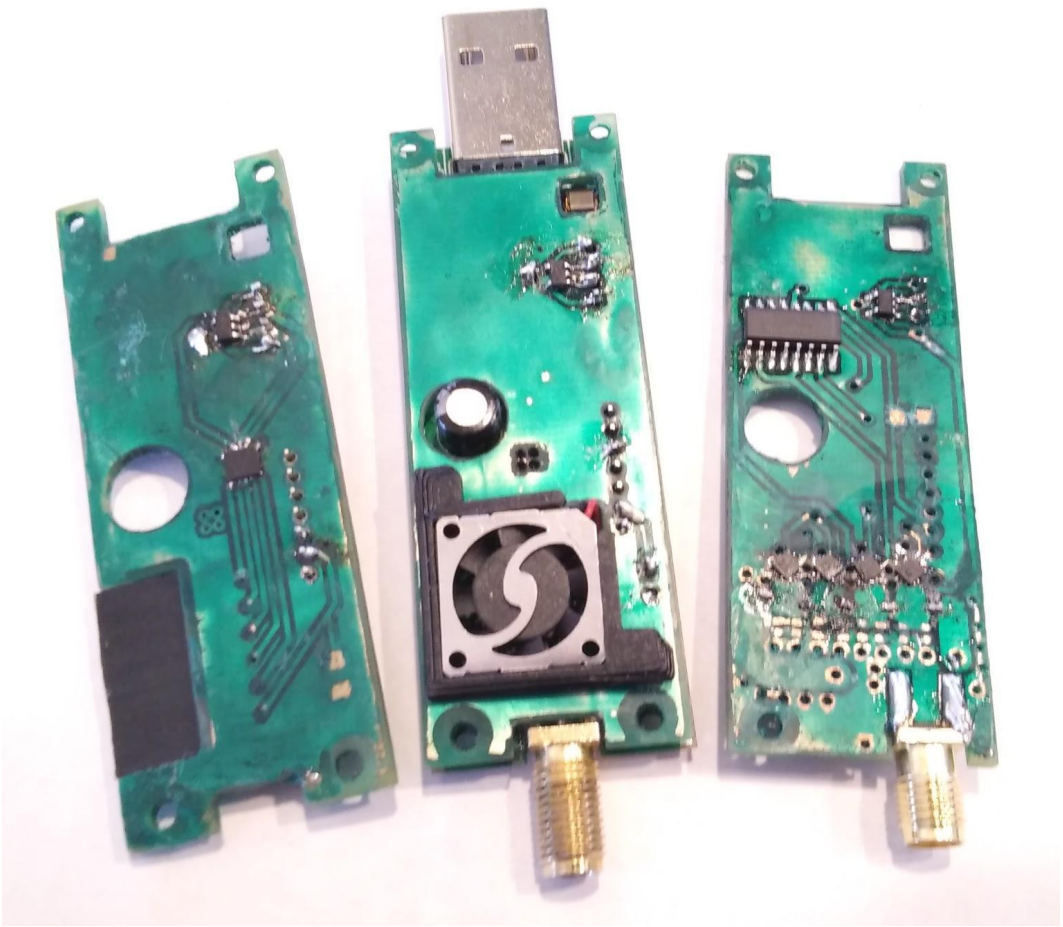
Regarding Software

- Currently modifying Osmocom RTL-SDR library for more general GPIO access
  - Done by Devon Rutledge and Alexander Schor
  - Will allow access to GPIO expansion through other software
    - GNURadio
    - Linux Terminal
- Building on work by Marko Čebokli
  - http://lea.hamradio.si/~s57uuu/mischam/rtlsdr/ports.html

```
557 void rtlsdr_set_gpio_bit(rtlsdr_dev_t *dev, uint8_t gpio, int val)
558 {
559   uint16_t r;
560
561   gpio = 1 << gpio;
562   r = rtlsdr_read_reg(dev, SYSB, GPO, 1);
563   r = val ? (r | gpio) : (r & ~gpio);
564   rtlsdr_write_reg(dev, SYSB, GPO, r, 1);
565 }
566
567 void rtlsdr_set_gpio_output(rtlsdr_dev_t *dev, uint8_t gpio)
568 {
569   int r;
570   gpio = 1 << gpio;
571
572   r = rtlsdr_read_reg(dev, SYSB, GPD, 1);
573   rtlsdr_write_reg(dev, SYSB, GPD, r & ~gpio, 1); // CARL: Changed from rtlsdr_write_reg(
574   r = rtlsdr_read_reg(dev, SYSB, GPOE, 1);
575   rtlsdr_write_reg(dev, SYSB, GPOE, r | gpio, 1);
576 }
577
578 void rtlsdr_set_i2c_repeater(rtlsdr_dev_t *dev, int on)
579 {
580   if (on == dev->i2c_repeater_on)
581     return;
582   on = !!on; /* values +2 to force on */
583   dev->i2c_repeater_on = on;
584   rtlsdr_demod_write_reg(dev, 1, 0x01, on ? 0x18 : 0x10, 1);
585 }
586
587 int rtlsdr_set_fir(rtlsdr_dev_t *dev)
588 {
589   uint8_t fir[20];
590
```

Next Steps

- Have filter built professionally, or redesign for in house manufacture
- Better Prepreg
  - FR-4 has high Dk (~4.6)
- Evaluation
  - Functionality
  - Interference
- New dongles?
  - LNBC
  - Buffered inputs
  - Interferometry



Conclusion

- Certainly still a work in progress
  - Testing, rebuilding PCBs
- Needs to be expanded to other RTL-SDR dongles
  - Not all SDR dongles provide expansion ports
- Custom manufacturing is not always feasible
  - Requires CNC machine
- I hope others will improve on these designs, and use them for their own projects



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