

Hardware Hacking Village

Arduino From Art To Part

Morgan

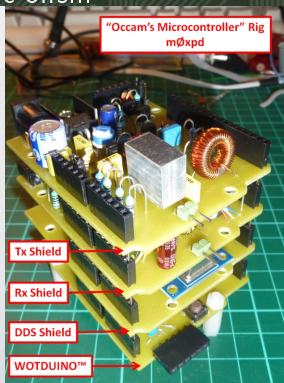
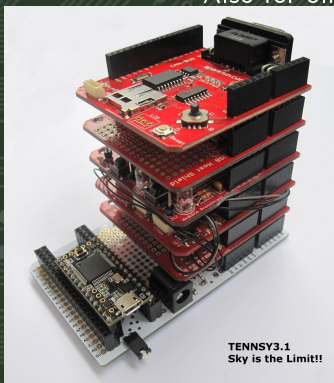
Ruxcon 2016

Overview

- 1 The Problem
- 2 The Solution
 - Isolation And Mapping
 - PCB Design
 - Fabrication
- 3 From Art To Part

Shields Are Great For Prototyping...

Also for one-offs...



Not So Much For Production...

- Bulky formfactor, difficult to package
- Extraneous connectors, add cost, complexity and points of failure
- Many incompatibilities between different shields requiring hacks or “go betweens” and such
- “Wasting” parts of the shields you’re not using
- Unnecessary duplication (shields frequently have their own power supply and such onboard)

Intro

The high level steps are as follows;

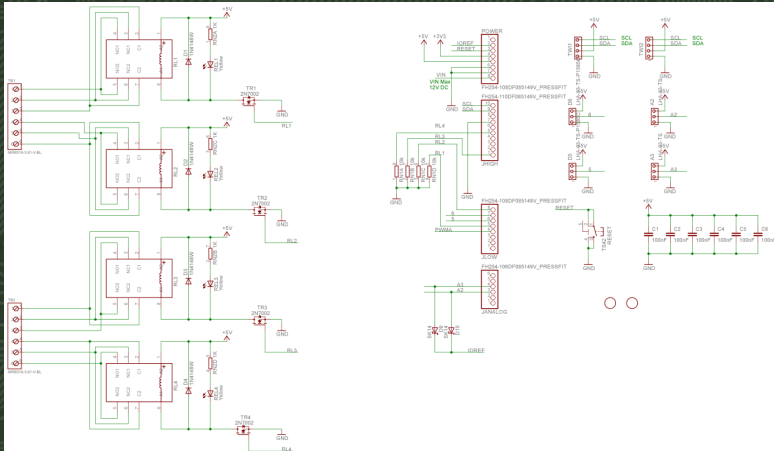
- Gather the schematics for the shields you're using
- Get the schematic for which ever 'duino you're using
- Isolate just the parts you need
- Map connections on the shields to physical pins on the micro
- Draw a schematic
- Create PCB Artwork
- Send to fab

Outline

- 1 The Problem
- 2 The Solution
 - Isolation And Mapping
 - PCB Design
 - Fabrication
- 3 From Art To Part

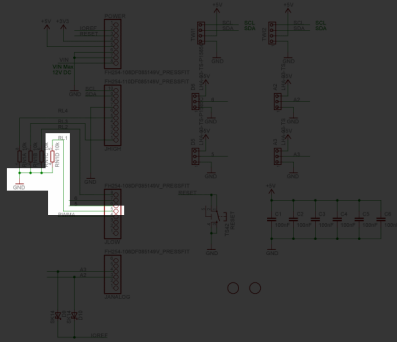
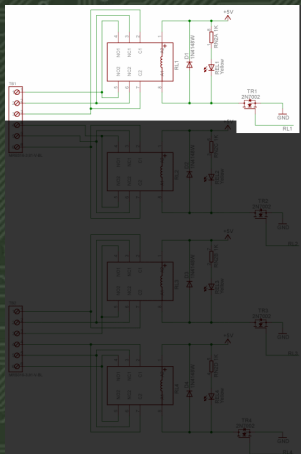
Shield Schematic

If we're using only RL1 on this Arduino Relay Shield;



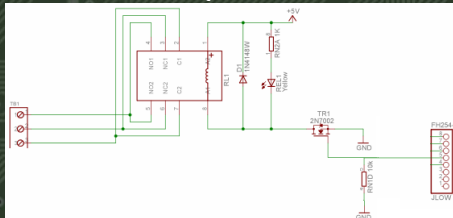
Isolating Required Parts

These are the only parts we'd actually need;



Redraw For Reference

Re-draw only what we need;



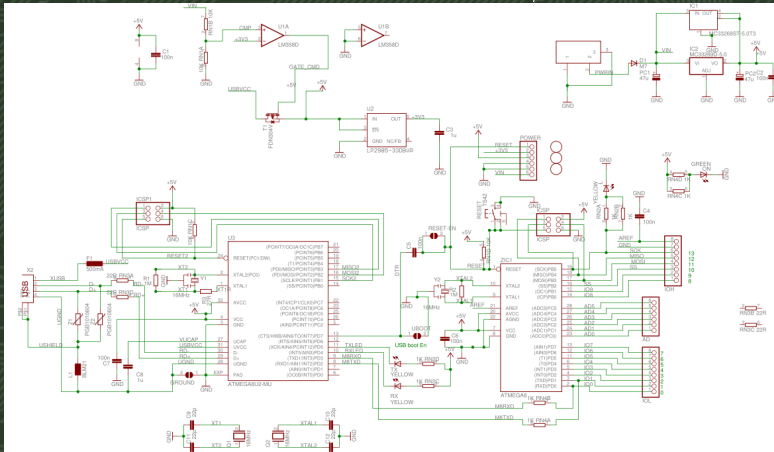
- Repeat the process for all the shields in your design
- Be aware that if your shield has ICs on it, they should have “bypass” capacitors, ensure you don't omit those

Arduino Programming Options

- How are we going to program the 'duino?
 - Using the Arduino bootloader
 - Directly via AVR-ISP (can still use Arduino IDE to write code)
- The above decision will dictate what parts of the 'duino are and are not necessary
 - AVR-ISP - USB->UART parts can be eliminated
 - Bootloader - Can still eliminate USB->UART, but need "standard" FTDI header
 - Breakout AVR-ISP pins anyway

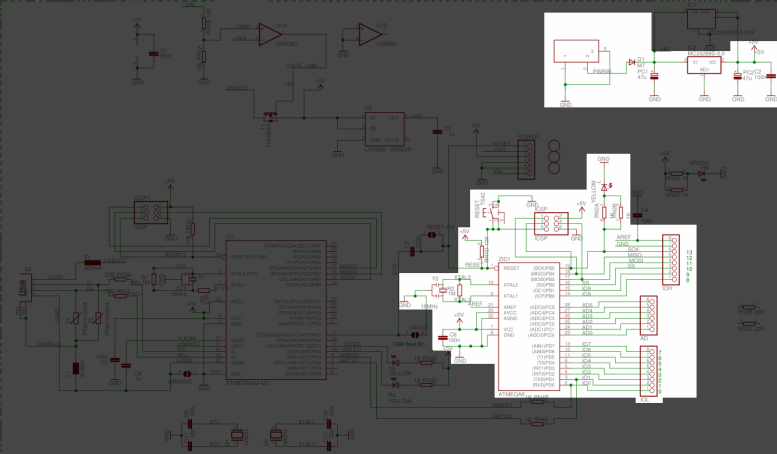
Arduino Schematic

Arduino Uno Schematic;



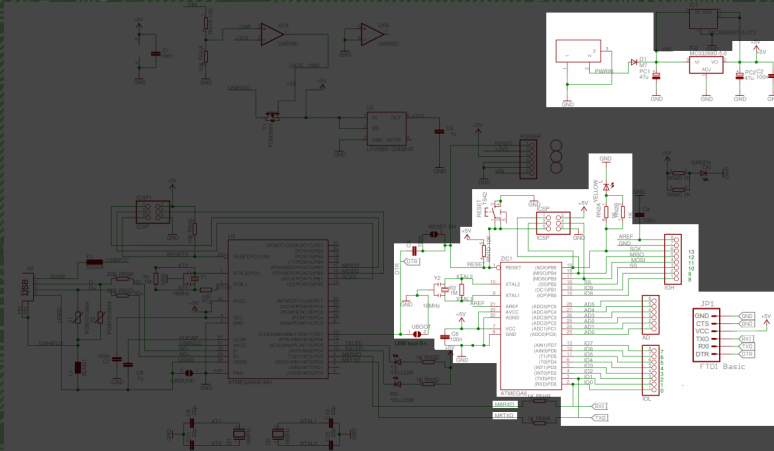
Arduino Decisions

We'll take the "Bootloader/FTDI" approach;

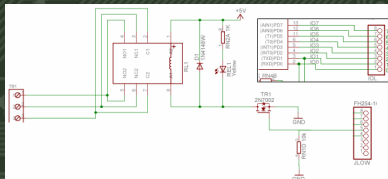


Arduino Decisions cont'd

But there's no FTDI Header on that schematic!



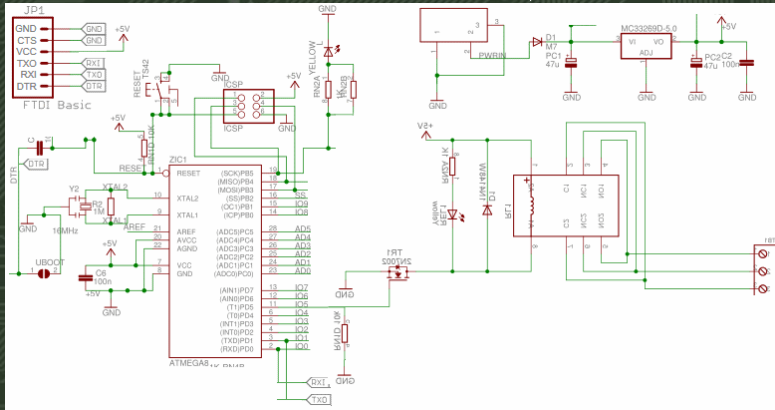
Mapping Shields to Pins



- JLOW on the Relay shield corresponds to IOL on the 'duino
- Drive MOSFET connects to pin 5 on JLOW
- Pin 5 on IOL goes to the pin designated PD5 on the micro
- We can eliminate both connectors and directly connect PD5 of the micro to the gate of TR1
- Connect +5V and GND as well

Combine Schematic Fragments

Now we take the two (or however many) chunks of schematic and combine them into one;



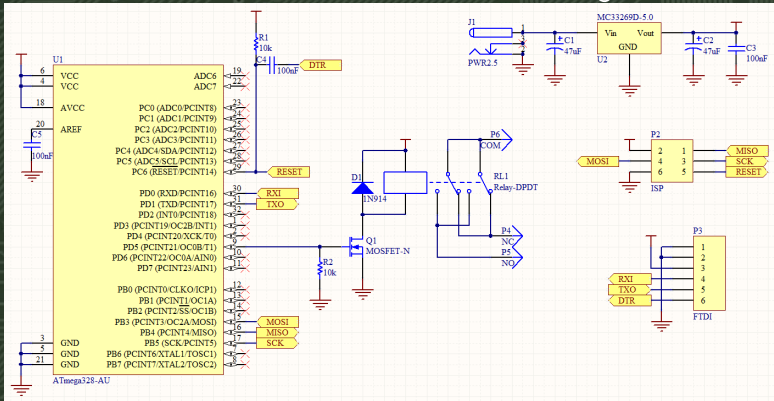
Schematic Capture

Now to draw a “proper” schematic;

- CadSoft (now Autodesk) Eagle
- KiCAD
- gEDA
- Autotrax
- Altium Designer/Circuit Maker

Schematic

Our schematic redrawn in Altium Designer



Outline

- 1 The Problem
- 2 The Solution
 - Isolation And Mapping
 - PCB Design
 - Fabrication
- 3 From Art To Part

Footprints

A few notes on “Footprints”

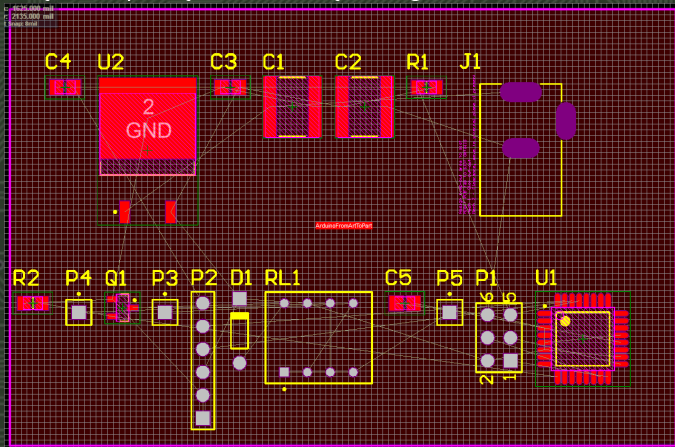
- Parts regularly come in different packages
- Different “footprints” for different packages
- Various considerations in choice of package;
 - Ease of assembly
 - Availability of parts
 - Overall envelope fitment
- Generally selected during “Schematic Capture”
- Different packages frequently have different pinouts

From Schematic to PCB

- “Netlist” generated by “Schematic Capture” imported into “PCB Design”
- Board definition (physical dimensions, etc)
- Design constraints (track width/spacing, etc)
- Typically track width/spacing and other dimensions are specified in Imperial
- Laying out parts
- Routing of tracks

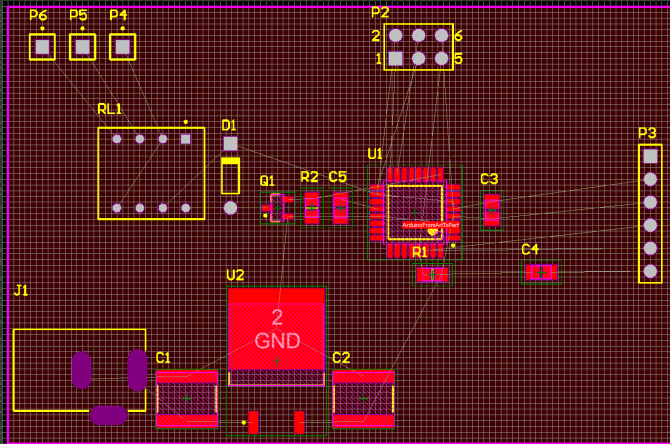
Ratsnest

After you import your Netlist you'll go into "Ratsnest" mode;



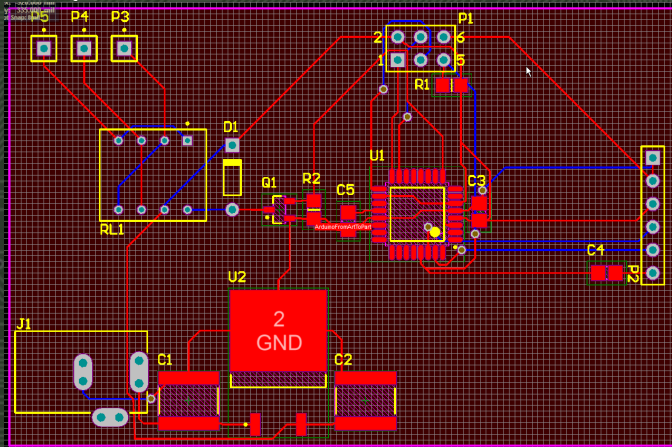
Arrange Parts

Next arrange parts sensibly, trying to minimise crossovers;



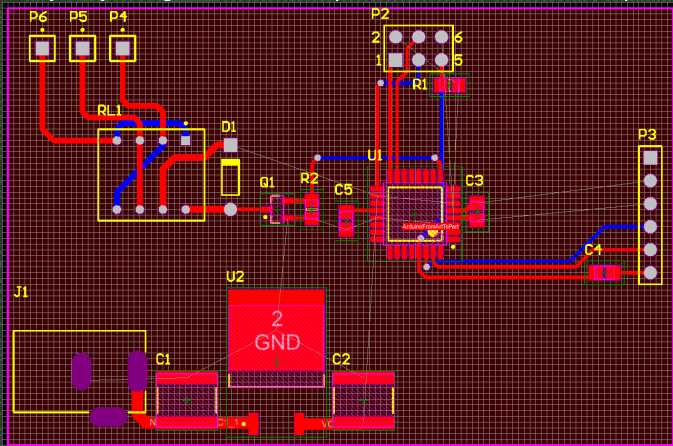
DO NOT Use "Auto Route All"

Probably the best result I've seen from an "Auto Route All";



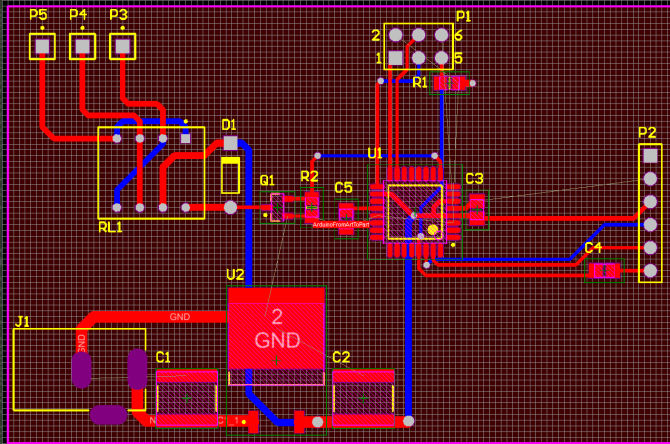
Route All "Signals"

Basically anything that's NOT power to individual components;



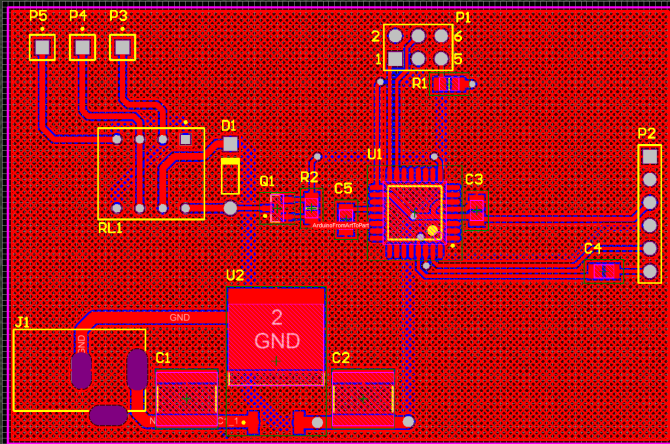
Route "Special" Power

Anything that is particularly sensitive, power hungry or noisy;



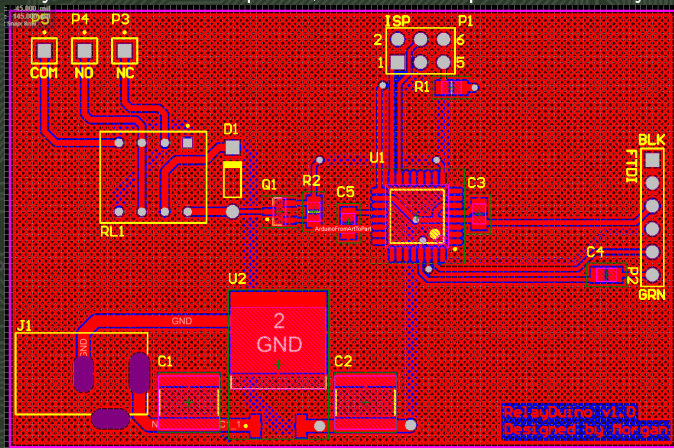
Pour Power Planes

Take care of any other power by pouring planes for GND and VCC;



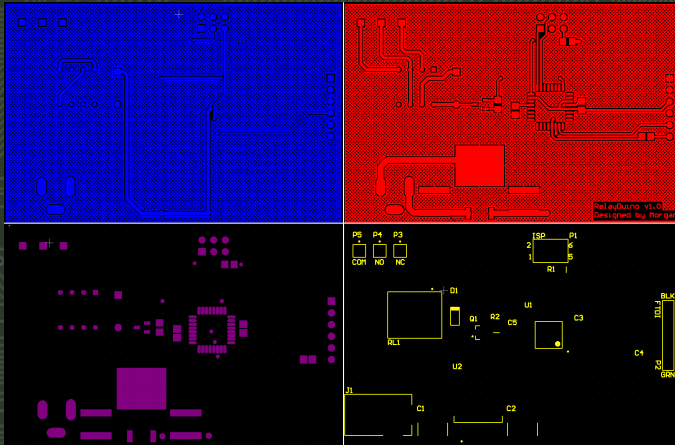
Annotate And Clean Up

Add any annotations required, and clean up other overlay items;



Gerbers

Now you're ready to send to fab;



Outline

- 1 The Problem
- 2 The Solution
 - Isolation And Mapping
 - PCB Design
 - Fabrication
- 3 From Art To Part

Fabrication

Why go to a fab?

- Mass producing PCBs at home sucks (in fact, producing PCBs at home in general sucks)
- Can't really do solder mask/overlays at home (or you can but it requires a lot of work and equipment)
- It's dirt cheap these days
- Plated through holes!
- Solder paste stencils
- They can do it better than you can
- Did I mention it's dirt cheap?

Suggested Fabs

The two fabs I've worked with most recently;

- Hackvana - Mitch, the guy who runs the show is pretty awesome and will bend over backwards to help you out
- DirtyPCBs - Part of Dangerous Prototypes, less personal service, but it is a bit cheaper, the HHV project PCBs came from Dirty PCBs

Basically conduits to cheap Chinese board houses;

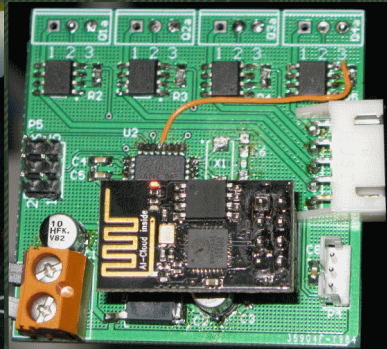
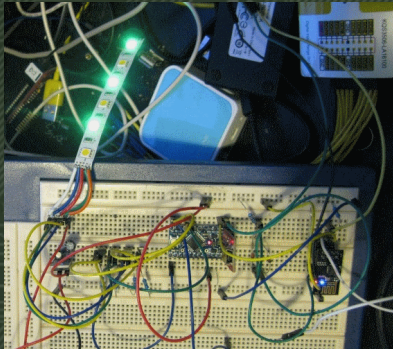
- If you're concerned about your IP, perhaps go elsewhere
- Standard shipping can be slow, expedited options are available for a bit of extra coin

Some More Notes On Fabs

- Make sure you check your fab's limitations;
- Track width/spacing - Standard service is 6/6mil these days, 4/4mil for a bit extra
- Minimum hole size
- Silkscreen stroke thickness - usually the same as track width/spacing but best to check
- 2 Layer boards are "standard", but you can get 4/6/8/whatever layer for a bit more
- Most fabs will happily route boards of any shape you want (also isolation slots and such), but v-grooving is hit and miss

Arduino From Art To Part

Art... to Part



Links

- <http://www.hackvana.com> - Hackvana; PCB Fab and also assorted other bits and pieces
- <http://www.dirtypcbs.com> - What it says on the box
- <http://www.arduino.cc> - Most 'duino schematics can be found here