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IDP

Introduction to Electronics

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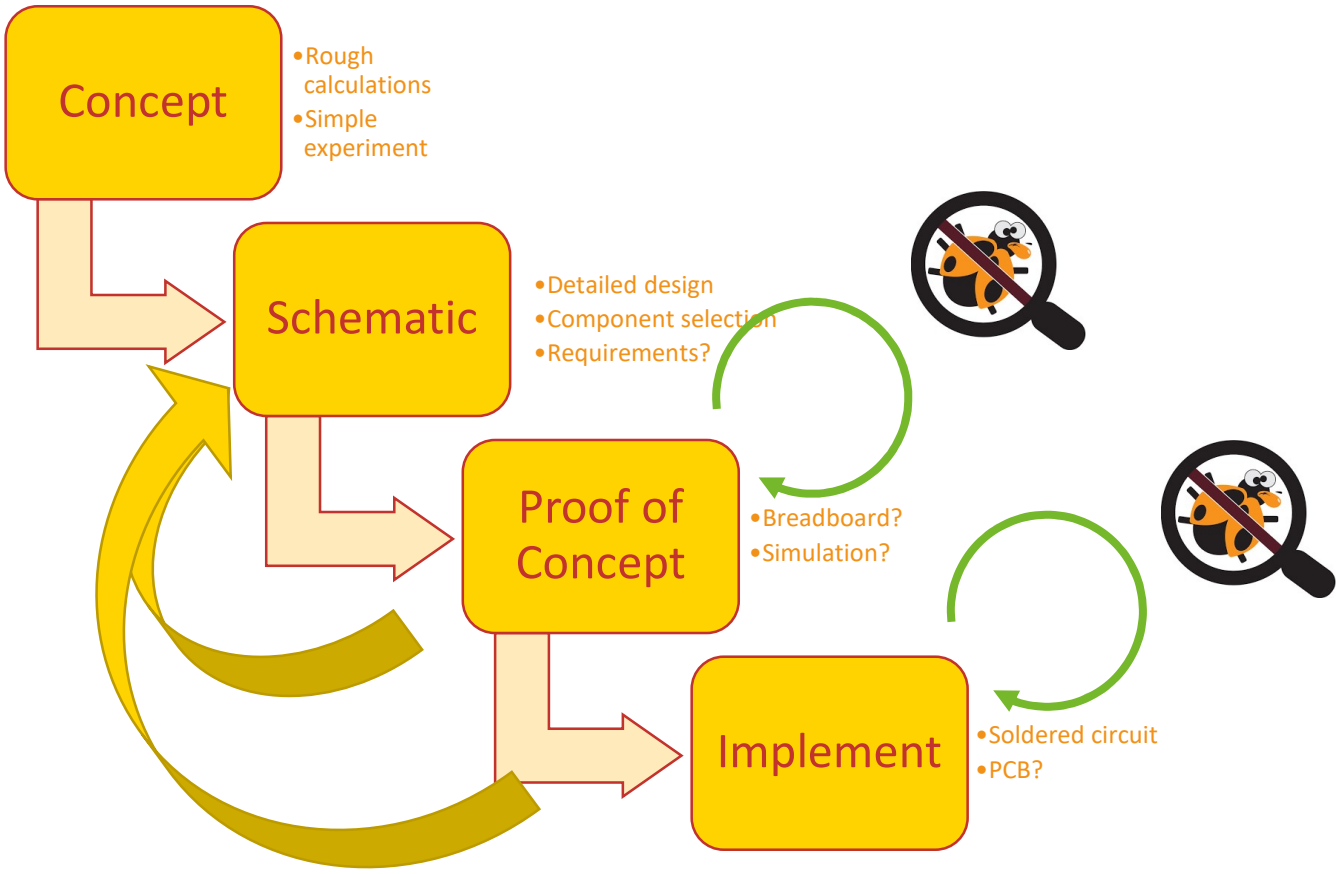
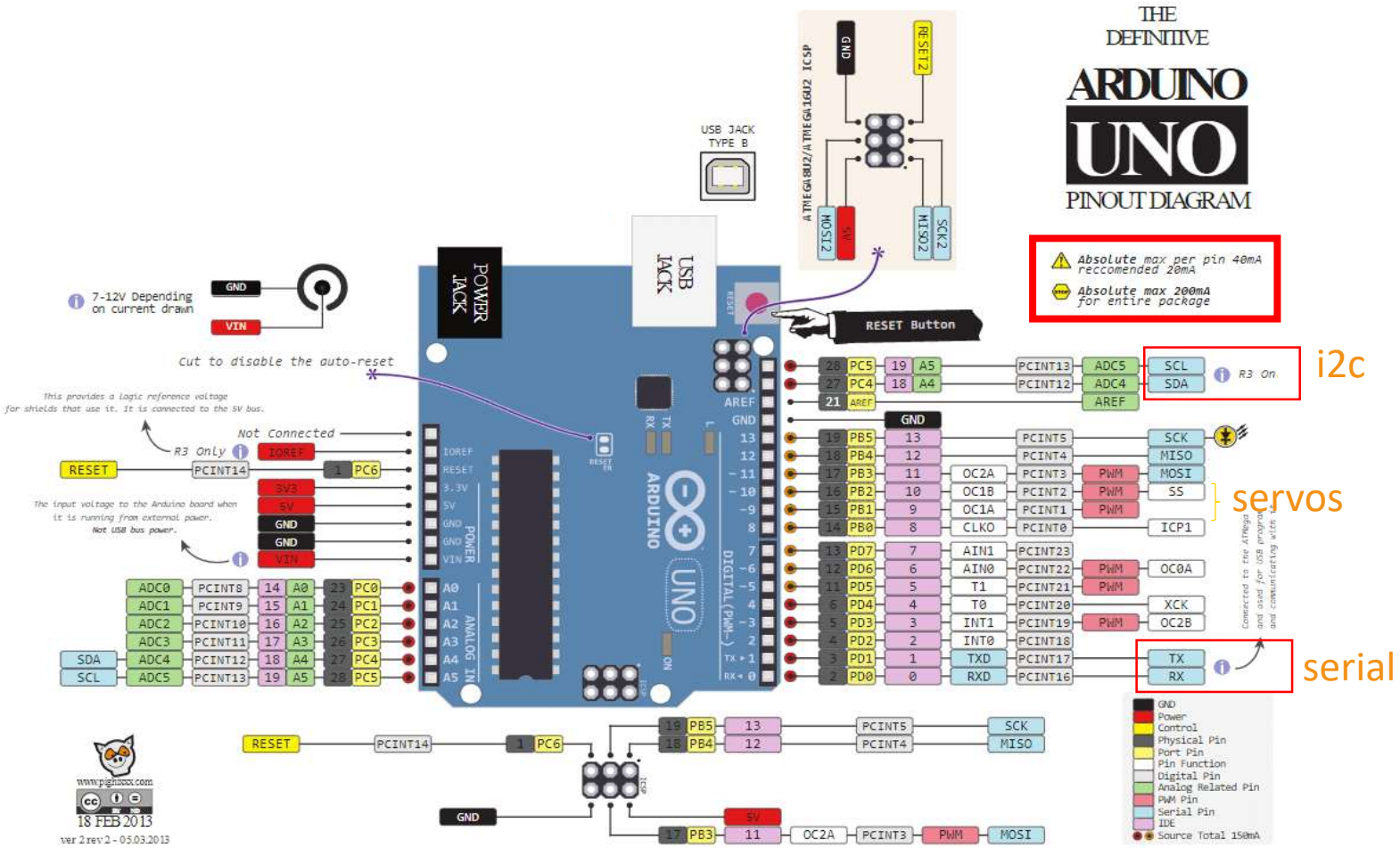
Electronics Design Process



Arduino



Actual device in use is Arduino Uno Wifi Rev 2.

Functionally very similar to original Uno. (Actual uproc has more pins)

I/O pins

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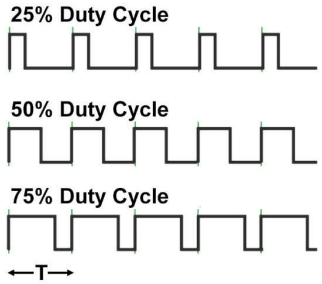
- Digital I/O pins
  - Can be set as inputs or outputs
- Analog inputs
  - Analogue voltage converted to a number between 0 and 255
- PWM outputs
  - Digital value between 0 and 255 output as a pulse with th duty cycle varying between 0% and 100%
  - Pseudo analogue – average value depends on digital val
  - Can filter…



- Check the current. Do not drive motors directly from Arduino.

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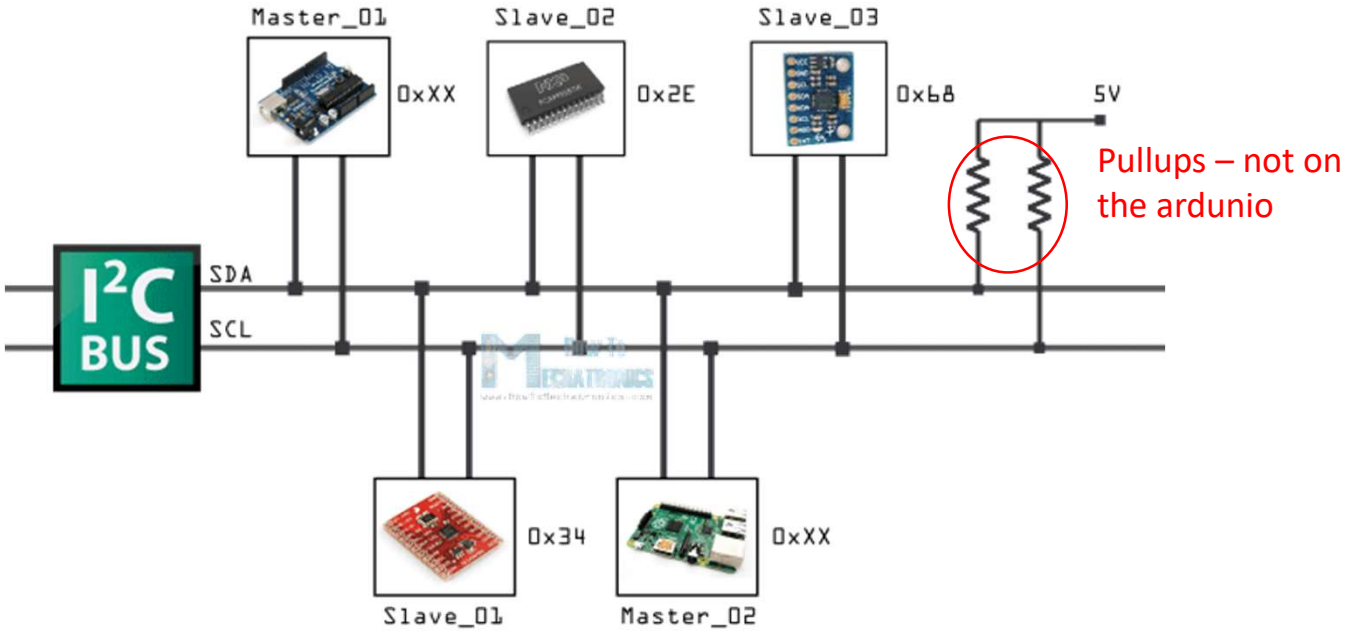
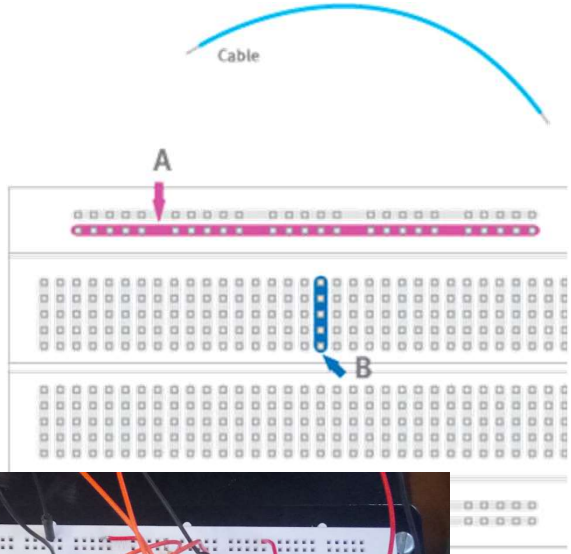
I2C communication

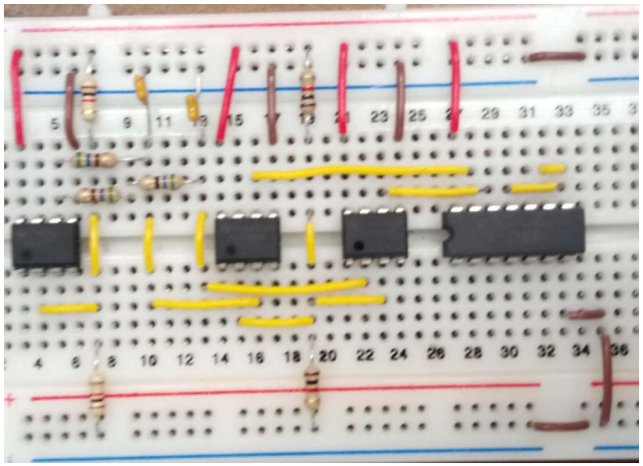
- Connect SDA (data) and SCL (clock) lines to all i2c devices
- Each sensor should have it's own I2C address
  - May be fixed or settable
  - Check datasheet
- Can talk to multiple sensors over one link
- One master (Arduino), multiple slaves

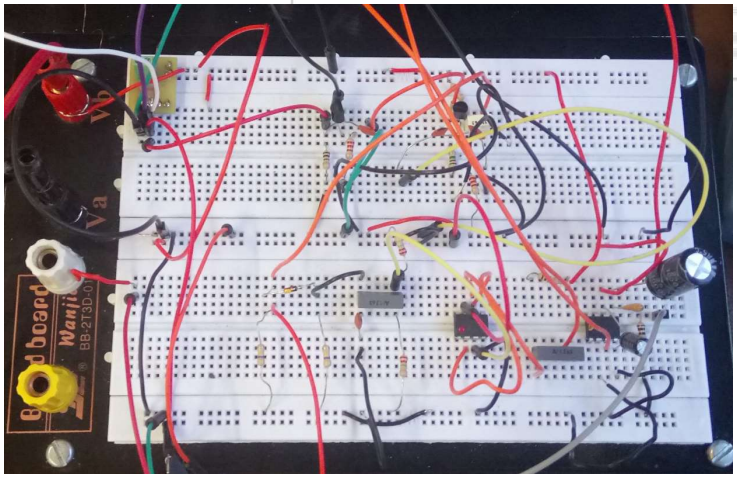


Breadboards

- You may remember these from IDP





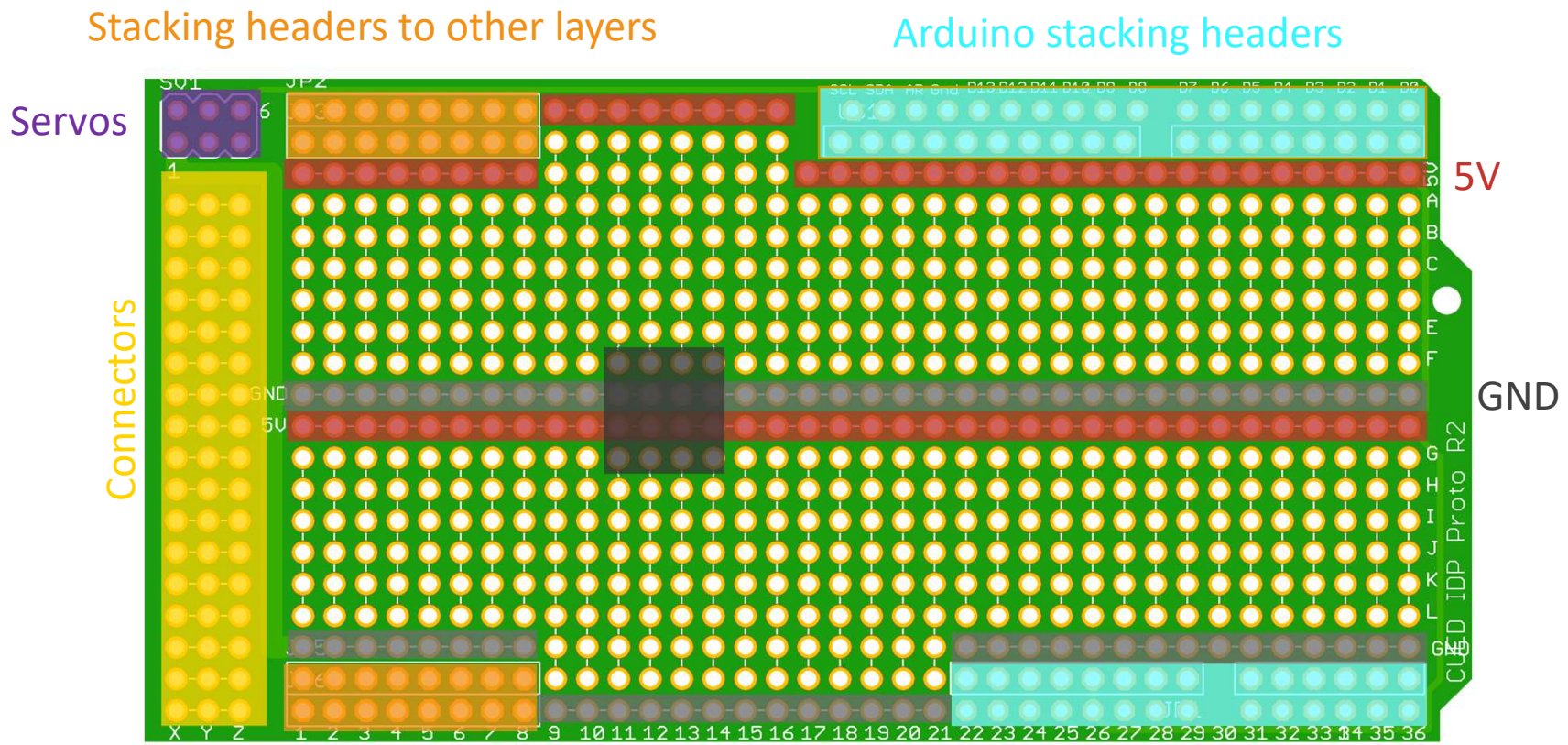


- Colour coded connections
  - Red – positive power
  - Black – ground
  - Signals, etc any other colour
- Neat layouts lead to fewer mistakes
- Neat is easy to debug

- Only use solid core wire
- Suitable for quick tests
- Not suitable for reliable use on robot

Prototyping board

- Final circuits must be soldered on the prototype shield (or stripboard)



Space is premium, compact layouts. But check fit of ICs before you solder

Use IC sockets

Unlike breadboard, tracks can be cut on back.

Take care with shorts. Wires passing over other holes must be insulated.

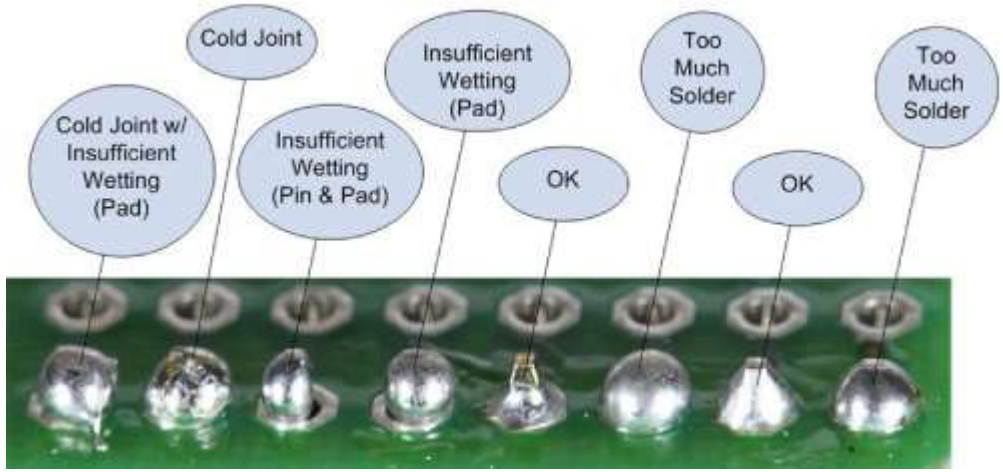
Vin and 3.3V supplies aren't available, only 5V and GND

Soldering

- A clean iron works much better than one covered in gunk
  - Make sure the sponge is wet, and wipe the iron regularly
- Hotter does not make soldering any better
  - Aim for 275C-300C (lead free solder melts around 217C, to hot and the flux burns too quick)

1. Melt a little bit of solder onto the iron, and place the iron on the joint you want to solder
2. Add some solder
3. Wait about 2 seconds – both parts must get hot!
4. Remove the iron
   - You should have a clean, shiny pyramid shaped joint
   - If not, clean the iron, place it back on the joint, add a little bit more solder then remove the iron

- Ask a demonstrator for a quick demo.
- Use IC socket in case ICs need replacement



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Soldering Arduino Stacking Headers

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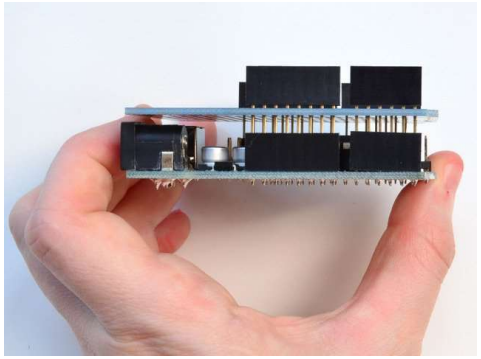
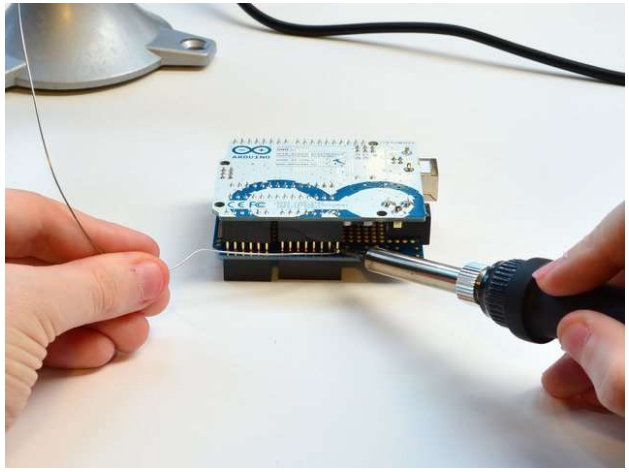


Insert headers through board and partially insert into another shield.
Make sure your board is right way up (track side down)

Turn over so Arduino is on top and your board is on bottom



Solder end pins of each header.

Now you can remove the Arduino and solder remaining pins normally.

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https://learn.adafruit.com/adafruit-proto-shield-arduino/solder-it

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Types of wire

Single strand

- Stiff
- Good for link wires or jumpers on breadboard or circuit boards
- Easy to strip won't create shorts

Multi strand

- More flexible
- Won't break with repeated movement

Connections

Good

- Hellerman sleeves (or heatshrink) over component legs
- OK to cut metal legs shorter if sleeves won't cover all metal
- 'Short' adjacent pads on back of board with offcut.

Bad

- Exposed metal
- Can short easily

IDP Power System

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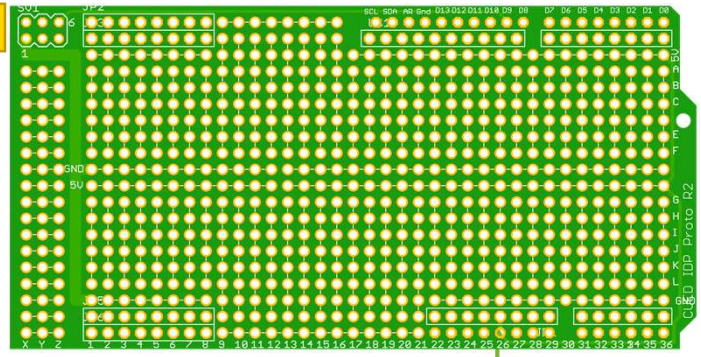
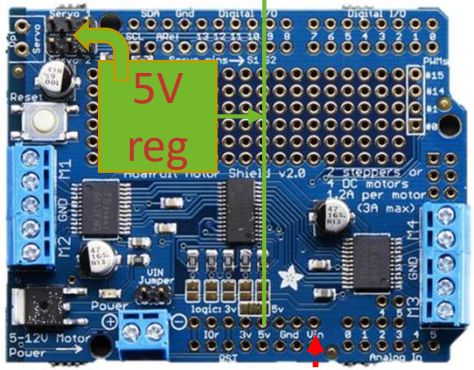


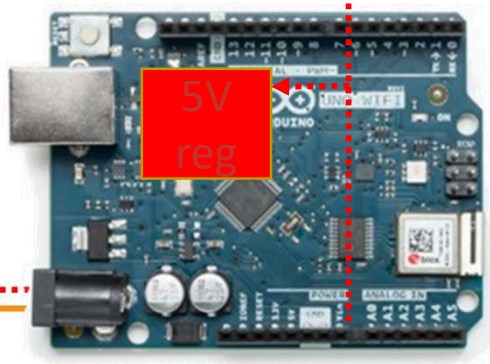
Protoboard covers servo connector.
Replicated on protoboard.

5V supply – from motor shield if present, otherwise arduino



High current 12V Motor PWM
Watch for shorts!!
Do not plug or unplug while powered

Do not try to disassemble Arduino/Motor shield.



12V Battery / PSU

Arduino falls back to USB power if no external source connected. 5V line won't work in this case.

USB Isolation

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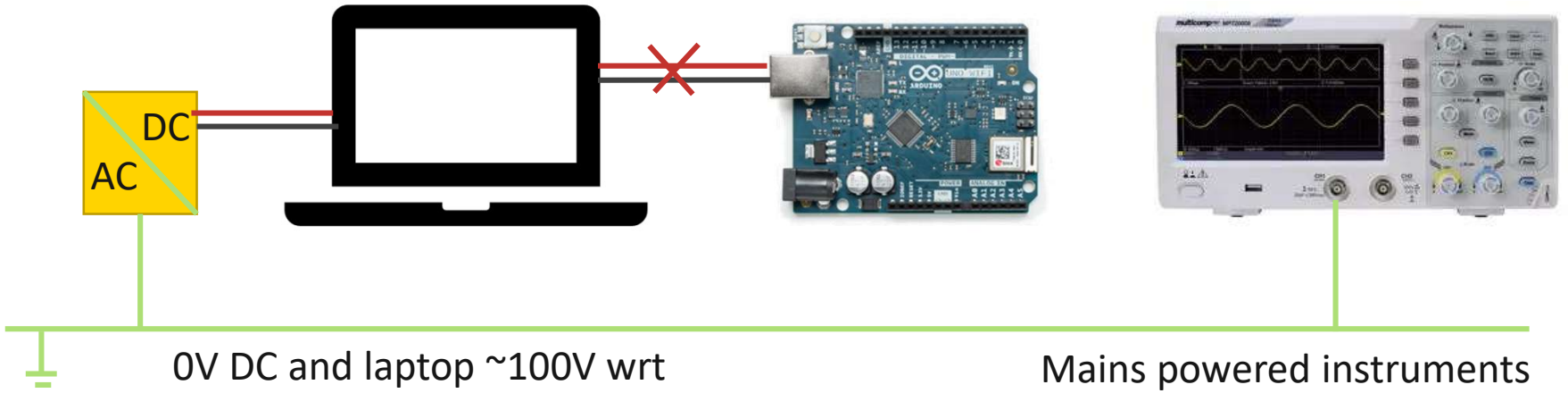

0V DC and laptop ~100V wrt to mains GND!
No problem, everything floats
Low capacitance, low current you don't feel a thing

Mains powered instruments – exposed connectors must be grounded for safety. Can get >100V PD on connection with your circuit.
Damage to Arduino and your circuit.

Isolator protects PC and your circuits. Use whenever an external PSU, battery or instrument is used

Cable management

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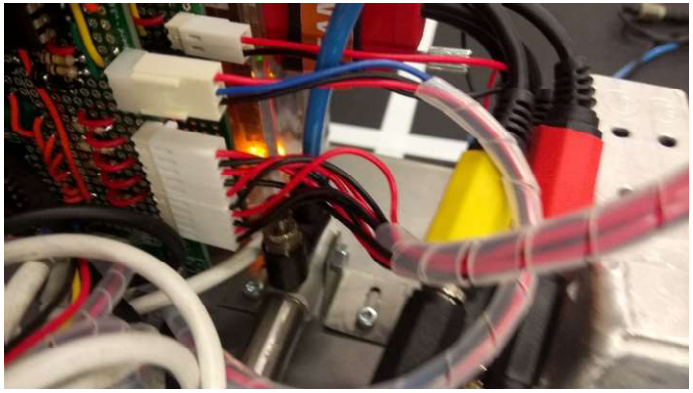
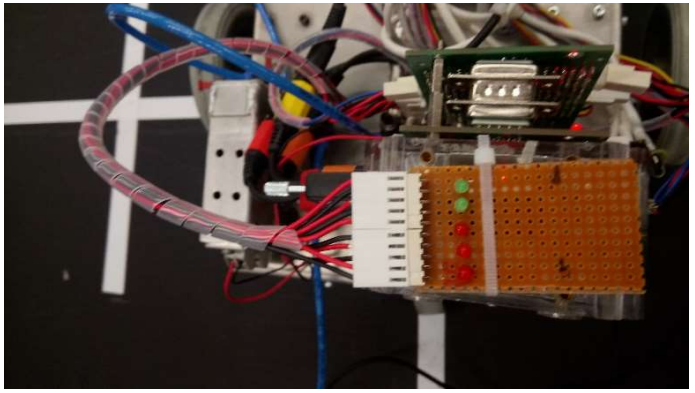
- Messy cables look bad, get caught, and are tricky to debug
- Anything going off board should have a connector (and use flexible wire)
- Twist (or plat) wires going to the same place together
  - Or use cable guides
- If you know how long you want a wire to be, make it that length
  - If you don't know… Find out





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Crimping

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- Tutorial videos online (youtube)
- Bad crimp joints will fail
- Can solder if you want (but should be unnecessary)
- A failed crimp on a sensor wire can ruin a perfectly good robot! Take your time.

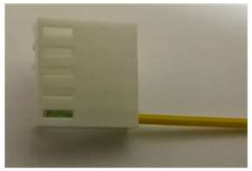
Use stranded cable stripped as shown

Place cable in KK crimp

Use crimpers

Prepare to crimp wire conductor, repeat for insulation

The finished product



Insert finished product into the required header socket, in this case a 5 way

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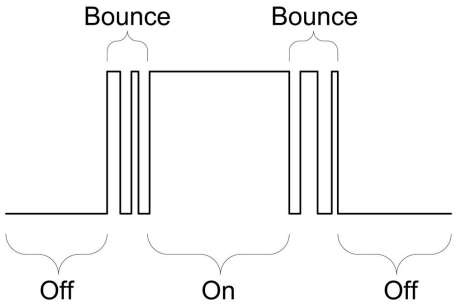
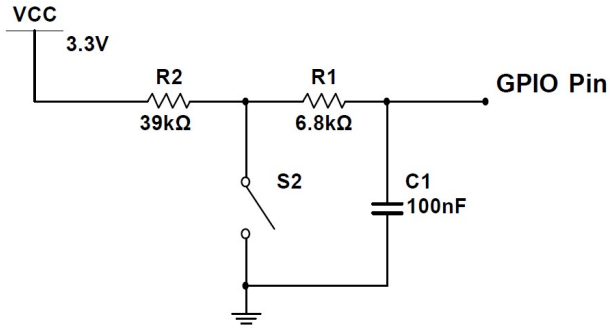
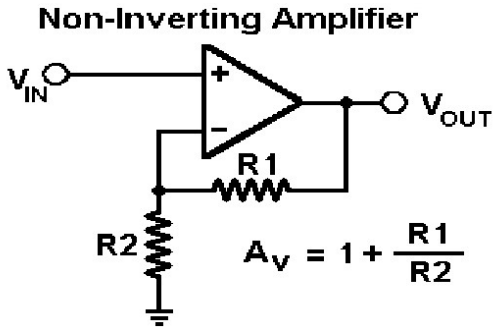
Some circuit building blocks

- Switch debouncing

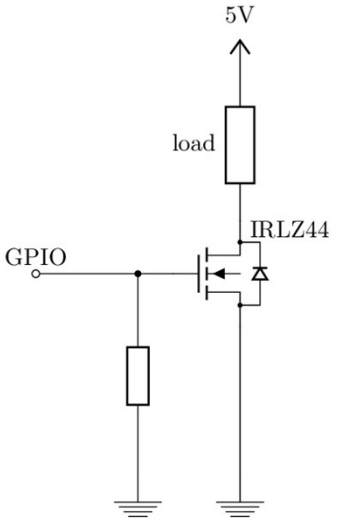




- Amplifier



- High current output
  - Arduino 20mA max.



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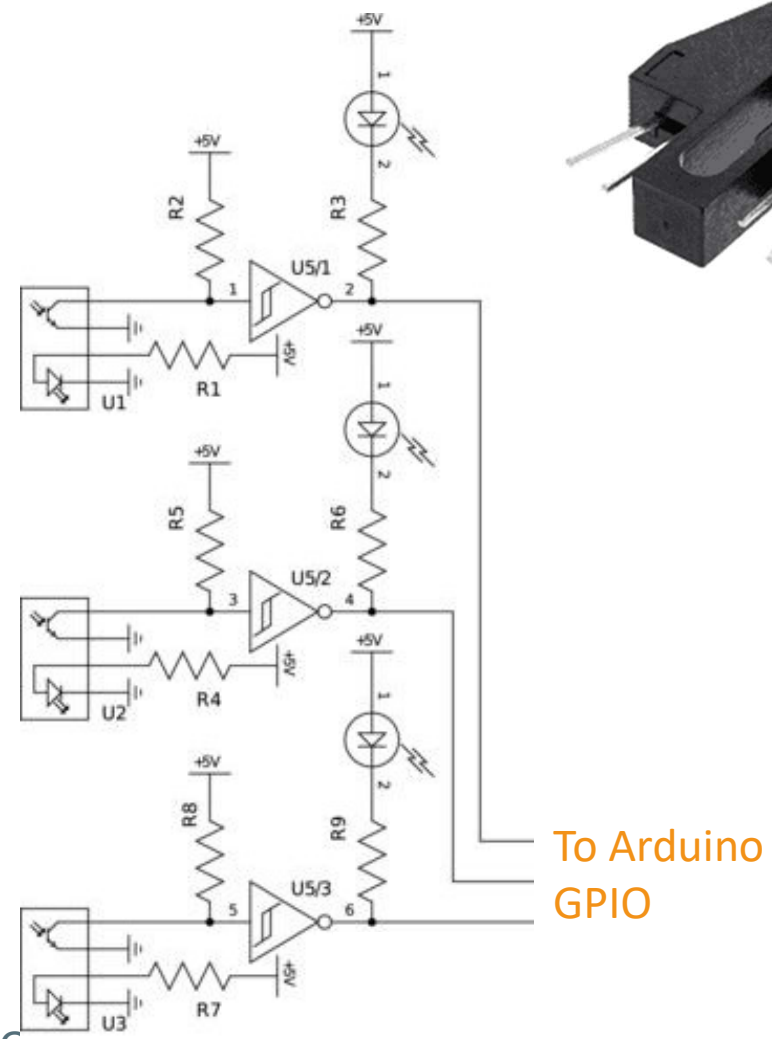
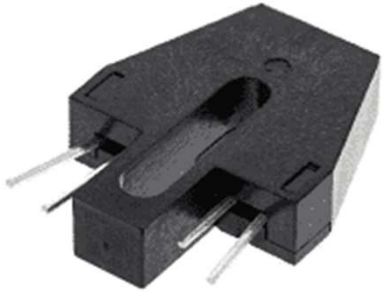
Line Follower





OPB704 integrates IR LED and phototransistor

Phototransistor, allow current to pass in response to light. R2 gives the voltage swing.

Schmitt Trigger- hysteresis for clean transition, also buffer to provide current for indicator LED.

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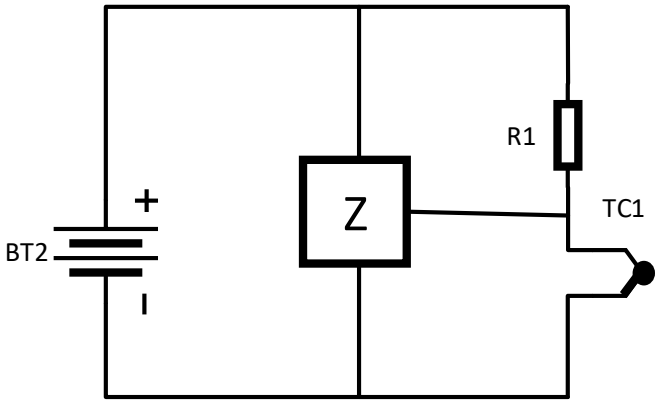
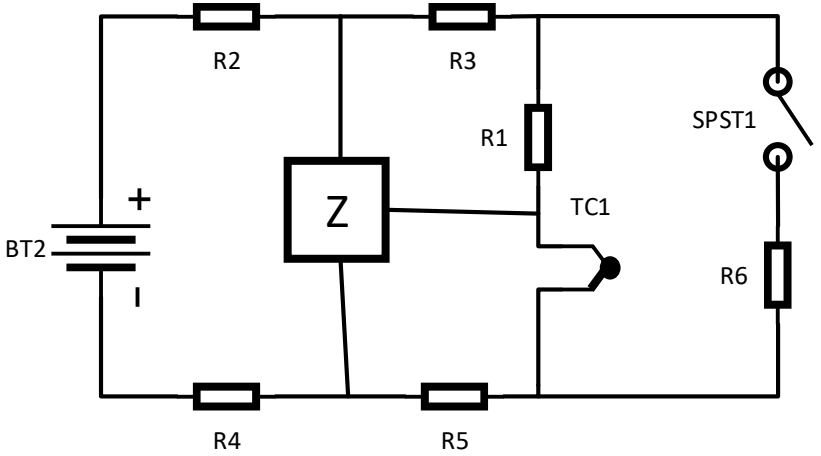
Decoupling Capacitors

What you think the circuit looks like:



Reality

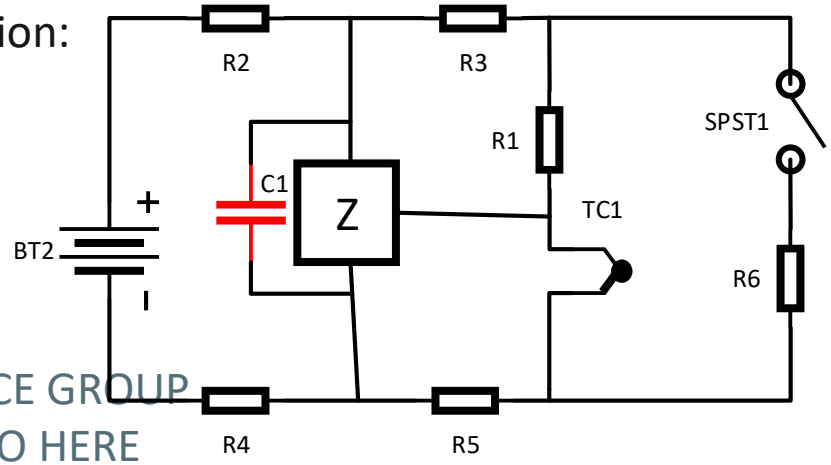


Finite resistance in all tracks and wires, including power supplies

Many components (particularly digital logic) have a variable current requirement

Change in current in resistor -> Change in voltage, spurious sensor readings, odd behaviour

Solution:



Decoupling cap as close as possible to IC supplies.

Smooths out any noise already on power lines, provides short term current pulses without drawing from lines.

How much?

Check datasheet try 10nF

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Other Things to think about…

- Reliability is key – simple but effective is a good approach
- Walls are useful as they don't move – you could use to align, or ensure the robot is straight or physically track along
- Sensing think outside the box:
  - Encoders to detect distance moved
  - Touch/limit switches to detect walls/obstacles/objects
  - Position of sensors is key!!!!
  - Redundancy/diversity is good
  - Test and try different approaches, don't stick with the first which happens to work
- LED location – off board connectors?
- Only change one thing at a time
- Take time and care with implementation so much easier to replace a wire when building than find a dodgy connection later.
- Test, test, test, test and test again.

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Eagle / E-Cad

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See detailed walk through on moodle.

Problems? – Get in touch

Alternatives:

Fritzing (now paid for), other free schematic programs…

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Circuit Diagrams & Layouts

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• **Circuit diagrams.** Produce circuits to show all the electronics and the interface between the sensors and the Arduino.

- Pin numbers / lables
- Passive component Values.
- IC Part numbers (if you are use multiple ICs of the same type these should be labelled appropriately)
- Power lines/connectors (labelled)
- Off board parts – connectors, label all pins and where it goes
- Make sure off board parts are in your BOM
- Consider what is connected as a digital/analog input. If it is a digital input ensure it is a digital signal

• **Layout diagrams.** The layout and connections between any sensors and the Arduino must be shown. All connectors should be shown

- Power rails should be labelled (if non standard)
- Location of headers should be shown
- Location of all Parts
- Location where tracks should be cut
- Location of any jumper wires required

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Parts

- Electrical parts most are in you kits, spares or other parts post in the moodle forum
- The parts list can be found online on Moodle

Final Development

- You are given a motor shield – which must be connected and wired up
- You have a prototyping board for final circuit layout
- You have access to headers + vero board for custom circuits (they can be stacked)

Getting Started

- Make sure you read and complete the getting started activities: https://www.vle.cam.ac.uk/mod/page/view.php?id=10953951

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Final piece of advice

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Ask the demonstrators

We are here to help!

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