Arduino Hardware

- Most of this talk will show circuit fragments that can be added to any microcontroller (PICs as well as AVRs)
- I'll show you enough to build a simple robot
- I WONT show you how …..

RECAP

- AVR chips have many uncommitted pins
- All can be digital input or outputs

  - make voltages at 3v (Vdd) or 0v (Gnd)

  - can sense voltages as being either Vdd or Gnd
- Some can be analog inputs too

  - can sense a range of voltages between Vdd and Gnd

Ways to use pins

- Pure digital input
  - pinMode(7, INPUT); digitalWrite(17, 0);
  - a = digitalRead(17);
- Digital input with pullup resistor
  - pinMode(7, INPUT); digitalWrite(17, 1);
  - a = digitalRead(17);
- Pure digital output
  - pinMode(7, OUTPUT);
  - digitalWrite(17, 1);

Proto boards

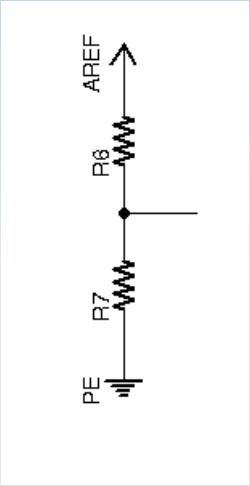
- Reusable ways to build and test circuits quickly without soldering
- Pins push through holes to make contacts
- Have long wires for power and ground
- Have short wires perpendicular to them for signals
- Badge can be adapted to plug into a proto board

Design Patterns

- Ways to think of circuits so that you can understand how they work without needing to know the mathematical details
- There are some simple patterns we'll look at today

Resistors

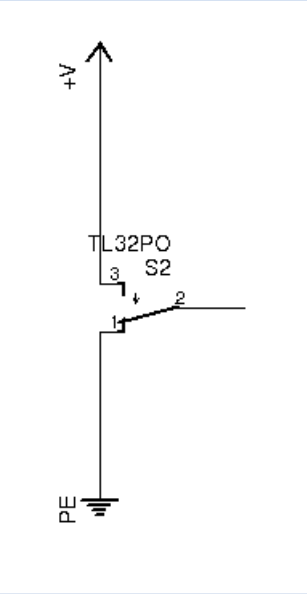
- Two resistors in series between power and ground



- What's the voltage in the middle?
- A ratio – R7/(R6+R7)
- What happens if R7 is 0? infinity? R6?

Resistors 2

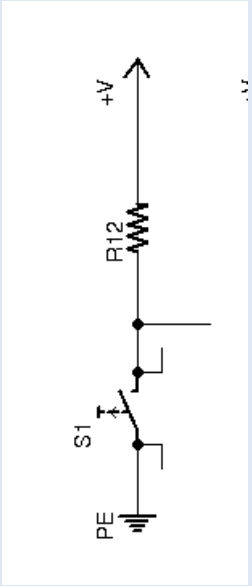
- What happens if R7 is 0? (0v) infinity? (V)
- What happens if R6 is 0? (V) infinity? (0v)



- Happens all the time – we call it a 'switch'

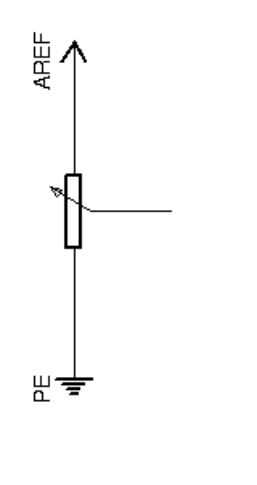
Resistors 3

- SPDT switches like that have a problem – as they switch there's a point where their output is undefined – better and cheaper to use a SPST switch and a resistor



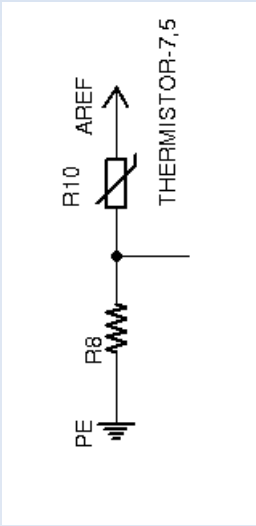
Resistors 4

- A 'pot' (variable resistor) will allow us to make a voltage anywhere between the two voltages



Resistors 5

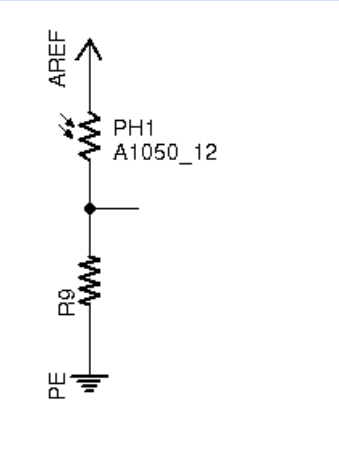
- Some components change their resistance depending on some outside factor – we can use them as sensors if we put them with a fixed resistor:

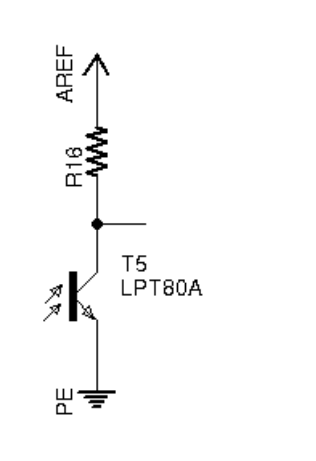


- A Thermistor changes resistance depending on temperature

Resistors 6

- A 'Light Dependant Resistor' (LDR) aka a 'Cadmium Cell' changes resistance with light





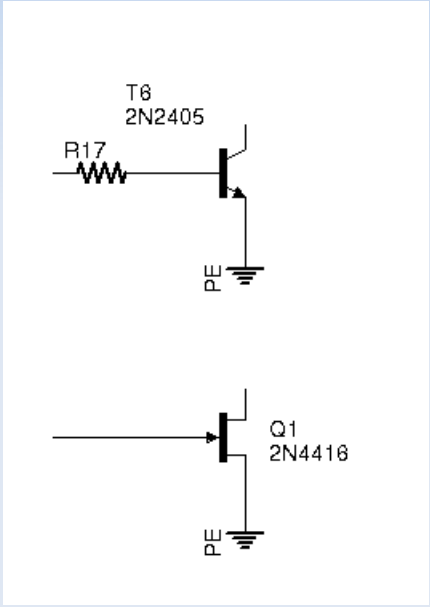
- So does a 'photo transistor'

Resistors 7

- All along here I haven't told you how to calculate the value of the other resistor
- There's no right value, generally higher is better (below say 1Mohm)
- For a digital input we often use 1-10kohm – it usually doesn't matter
- For analog inputs it depends on the sensor – you want to maximise dynamic range – have a play, try a range of values on your protoboard, use a multimeter to measure the voltage

Transistors

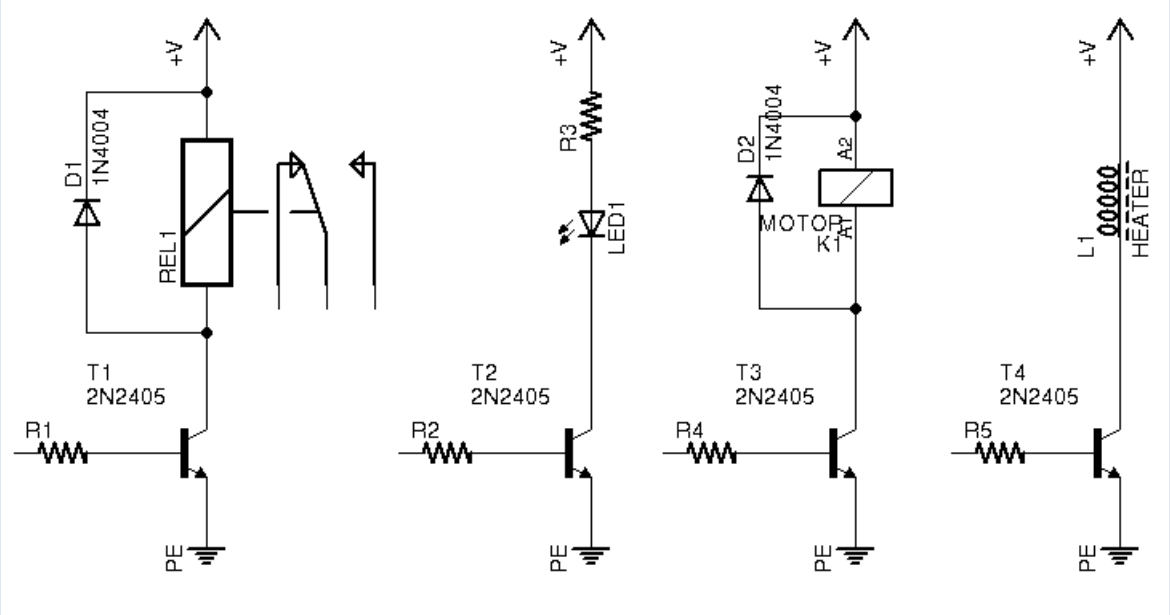
- Transistors work in 2 modes – we only care about their 'saturated' – in this mode they work as current switches



- Bipolar transistors saturate with enough input current
- FETs saturate with a high enough input voltage
- Saturated their outputs switch from a high resistance to almost none

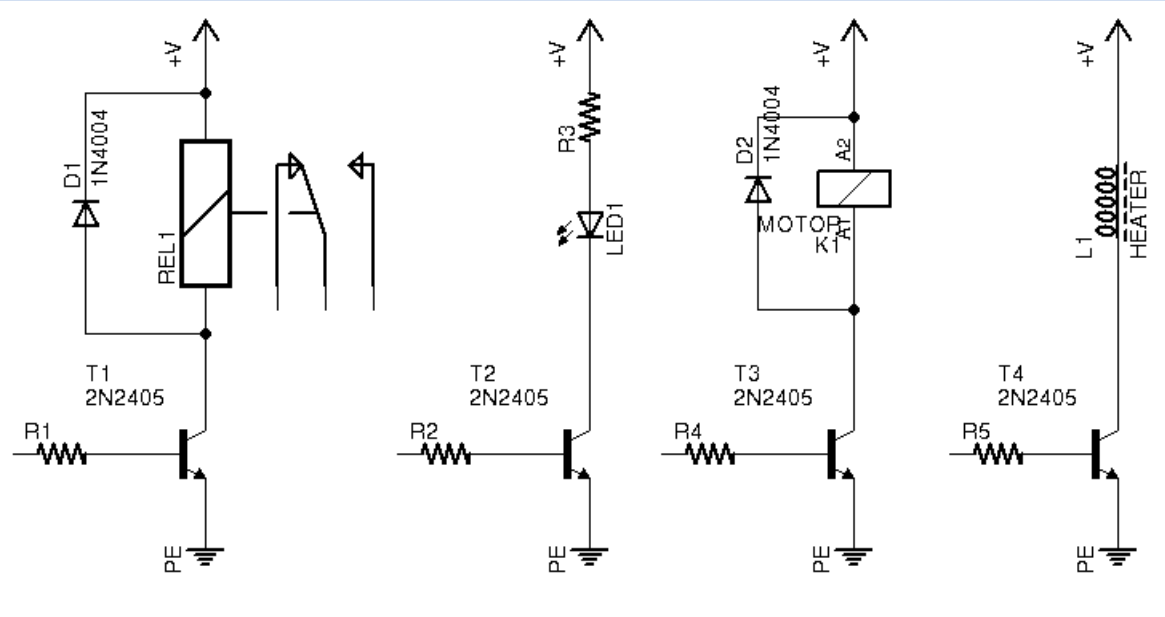
Transistors 2

- AVR digital outputs only provide a small amount of drive (current) enough for a small LED
- Use a beefier transistor to drive high current outputs:



Transistors 3

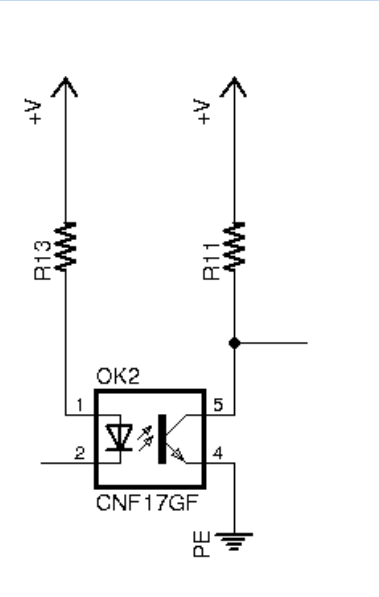
- Careful about current – choose a transistor with a rating higher than the current you need



- Protect your transistor against inductive loads with a protection diode

A bit of both

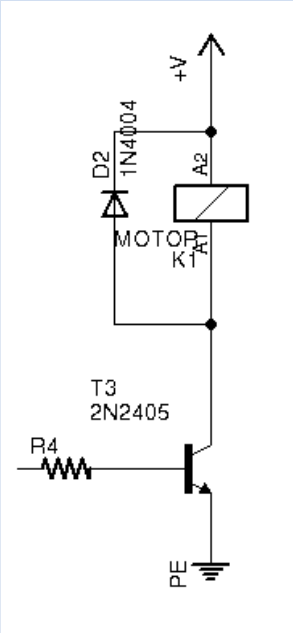
- A photo-interrupter – detects a light beam being broken



- The same circuit is in an 'opto-isolator" used to pass signals across voltage domains

A bi-directional motor

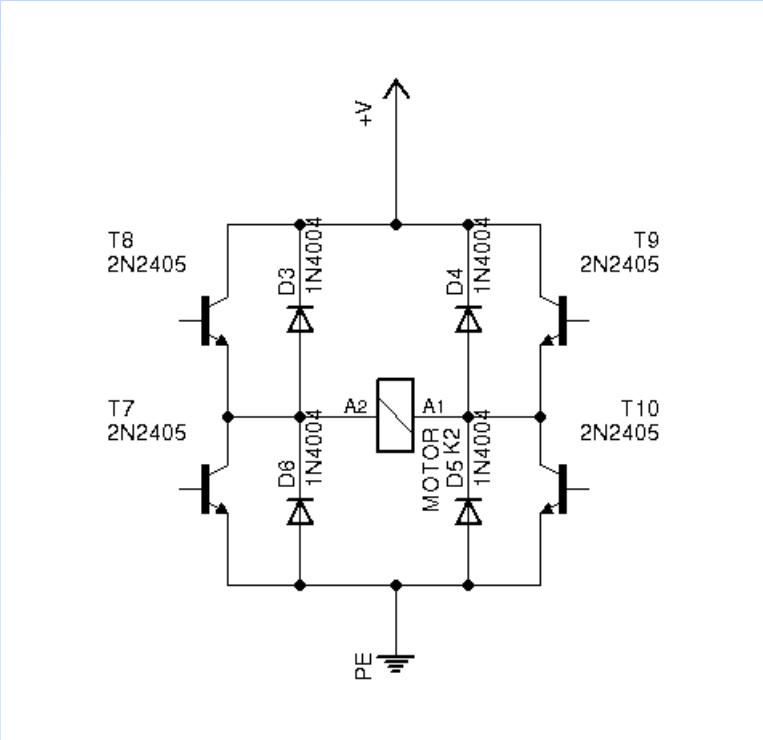
- We saw this circuit before to drive a DC motor:



- Problem is it only goes one way …..

H-Bridge

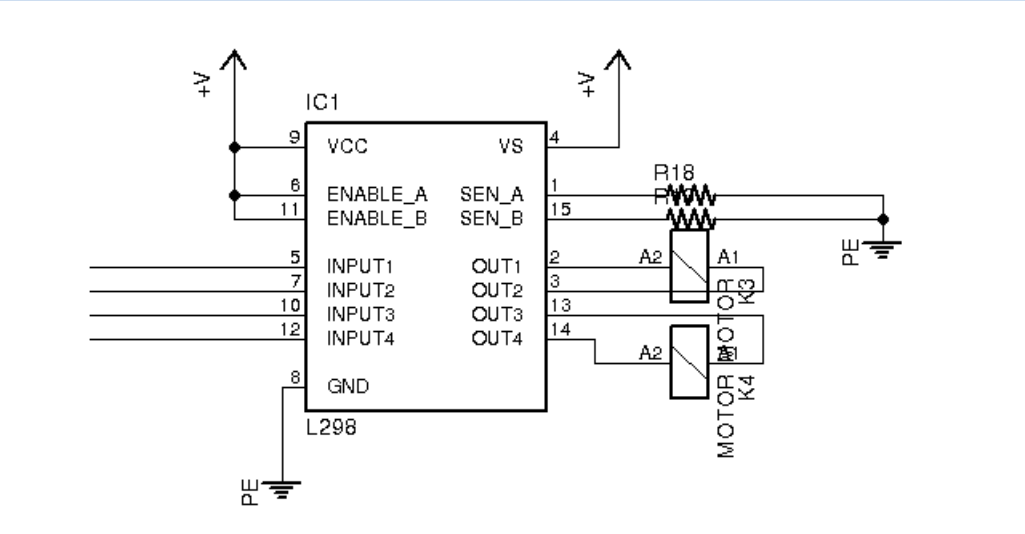
- An “H-bridge” is a circuit that will drive a motor in both directions



- T8 on, T7 Off A2 = +V, T9 off, T10 on A1 = Gnd
- T8 off, T7 on A2 = Gnd, T9 on, T10 off, A1 = +V

L298

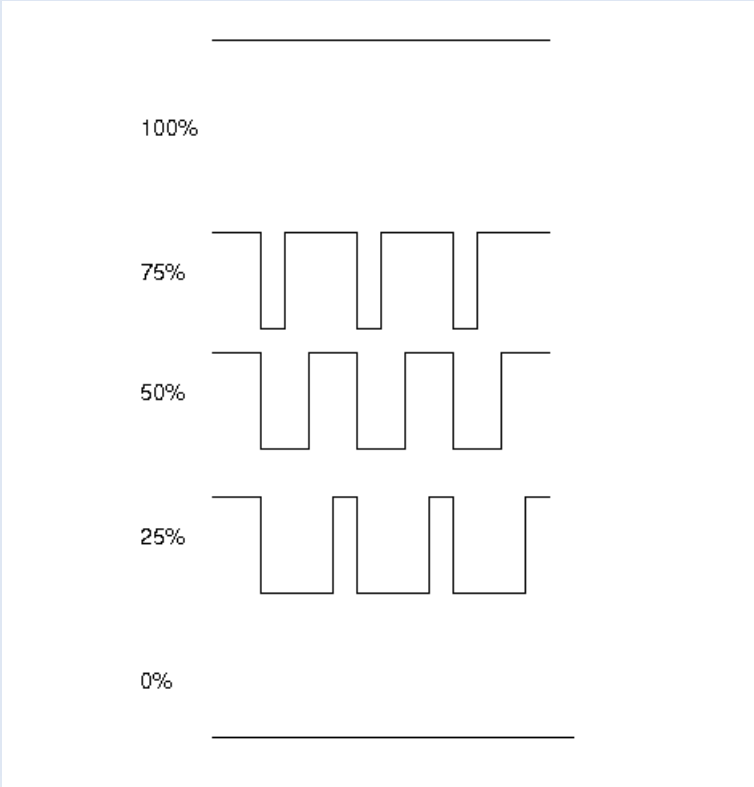
- Don't build one, buy one – an L298 contains 2 H bridges



- Input1 H, Input2 L – OUT1/2 forward
- Input1 L, Input2 H – OUT1/2 reverse
- Input1 L, Input2 L – OUT1/2 brake

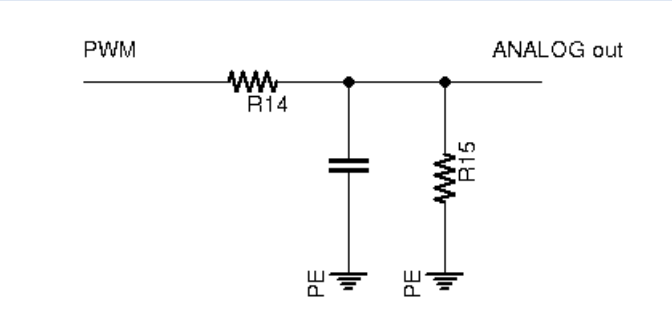
Analog outputs

- So far we've looked at analog and digital inputs and digital outputs – our chips have no built in circuits to make analog outputs – but it's not hard
- Pulse Width Modulation (PWM) makes a digital signal which can be averaged over time to make an analog one



PWM

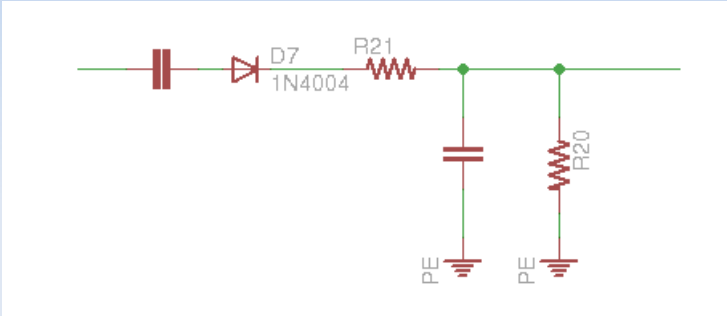
- LEDs are fast enough, and our eyes slow enough, that we can 'dim' leds by switching them on and off quickly enough (30kHz)
- We can convert explicitly using a low pass filter:



- The AVR has hardware PWM circuits for us

Audio Levels

- Finally something fun:



- Here's a circuit that converts an audio signal into a level – it's another low pass filter preceded by a diode to convert an AC signal into a voltage
- Added to a badge you can make a sound level meter