

Arduino LED Workshop

Arduino Platform - LEDs, LEDs and more
LEDs

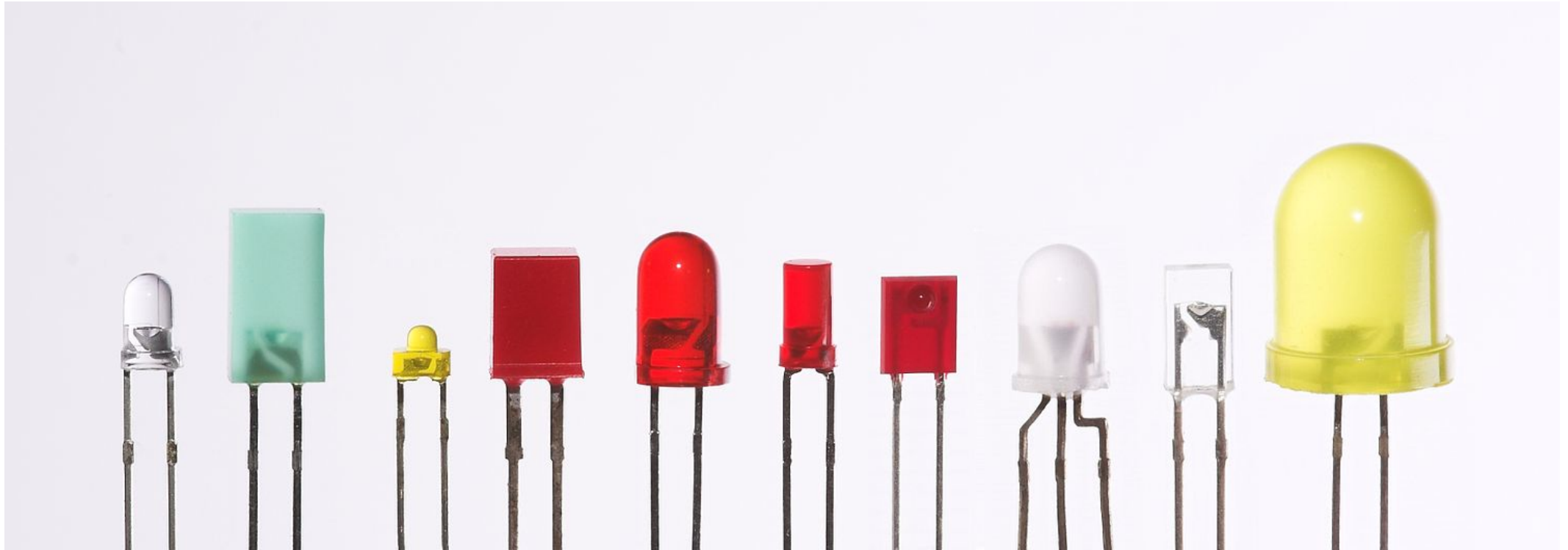
justin@classsoftware.com

LEDs

All you ever wanted to know about LEDs.

LEDs

- LED = Light Emitting Diode
- Many size and shapes and colours
- Moving towards SMD and module than through hole
- Low cost and low energy consumption
- Long life (25,000 to 100,000+) hours
- Fast on/off switching
- Red and green most efficient



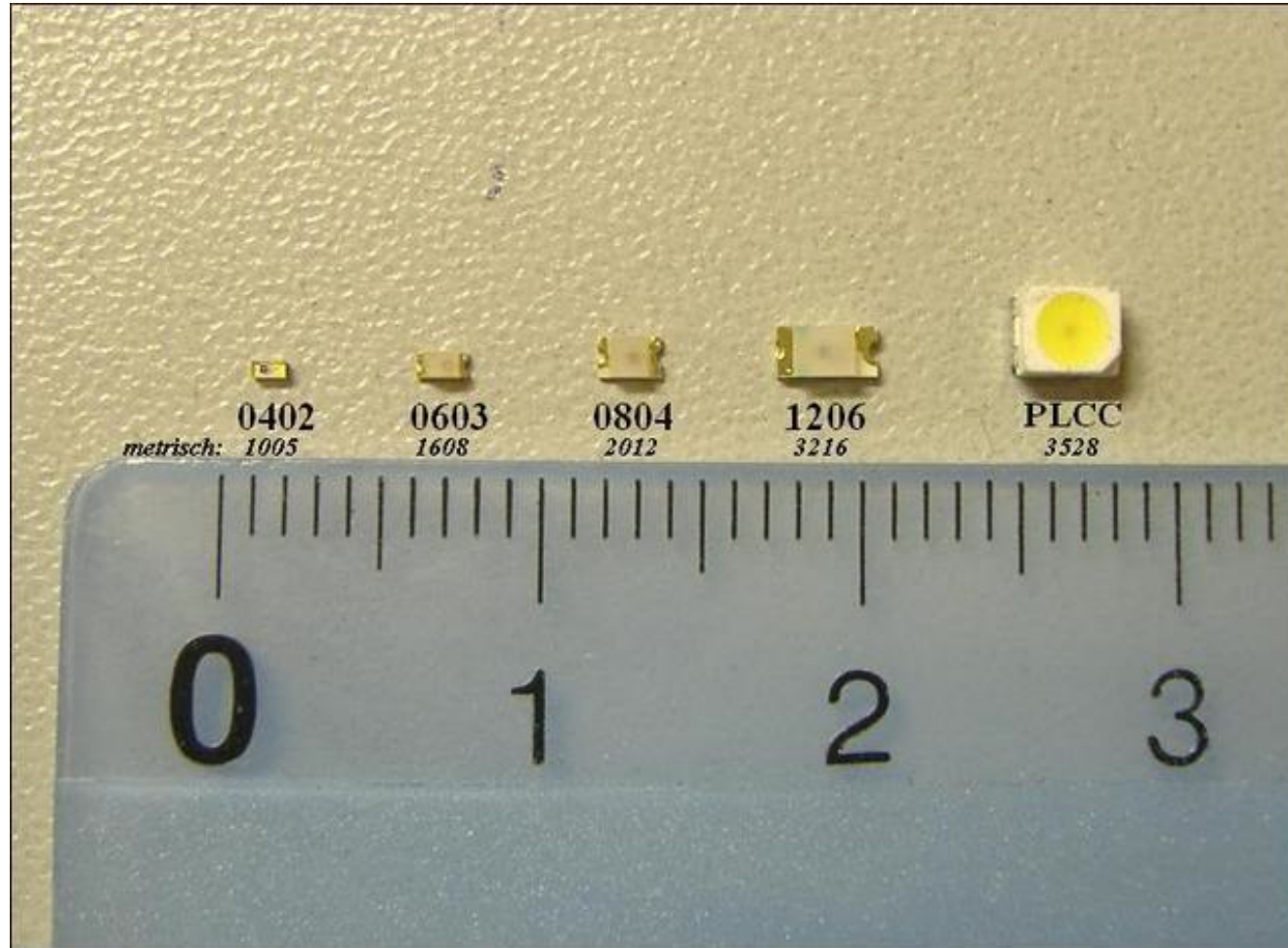
LED Types



SMD LED

Sizes

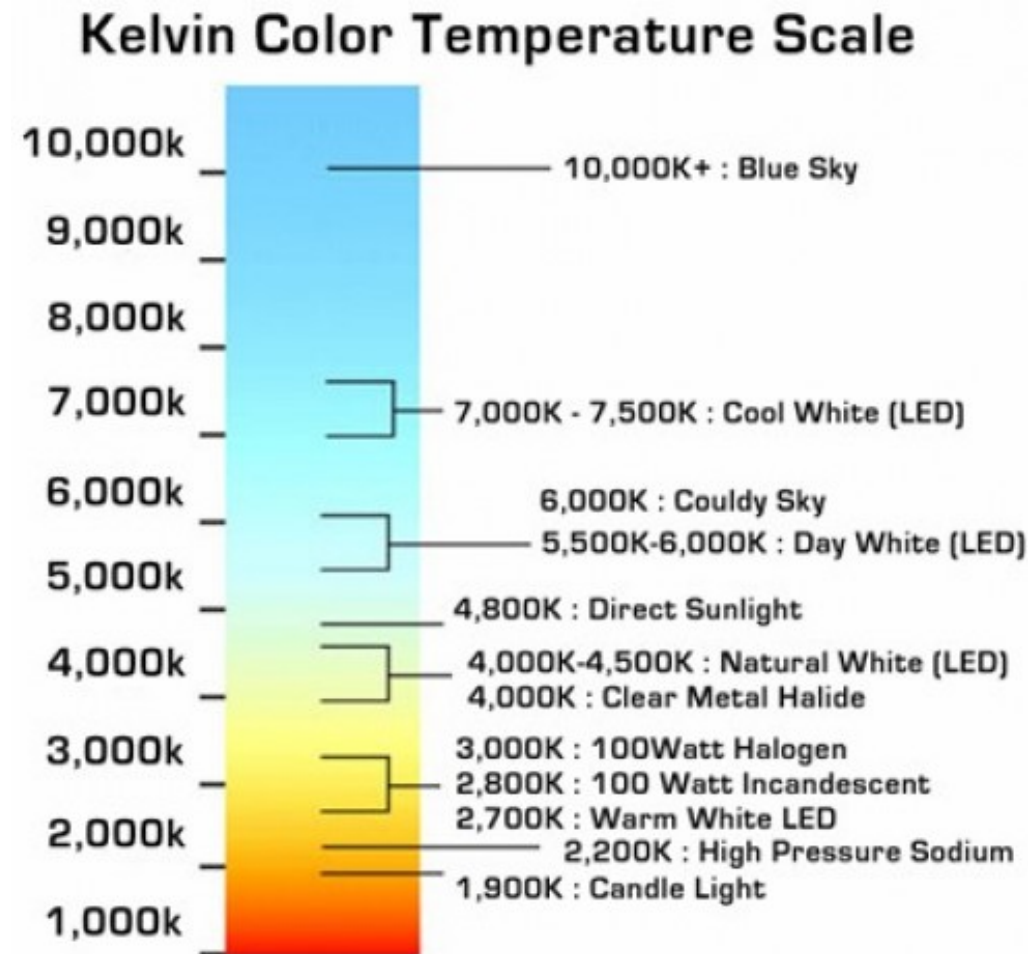
- Through hole
1.8 mm, T1 (3mm), T 1 3/4 (5mm), 10mm
- SMD
PLCC, 1206, 0804, 0603, 0402
- modules / hi power SMD come in many different sizes and form factors



SMD LEDs

Colours

- Red, green, yellow, orange, white, blue
- pink, purple, emerald
- IR and UV
- Can also get different shades e.g. true green vs green
- White comes in different colour temperatures
- RGB less have 3 LEDs inside them



White LED Temperature

Brightness

- Typically measured in mini candela and candela
- Very wide range of values from 1mcd to 10cd+
- High cd may also mean narrow angle
- Luminous flux also takes angle into account so give you a better idea of light output

DataSheets

- What's important?
- Forward voltage drop, typical current and maximum instantaneous current
- Brightness vs current curve
- Forward voltage curve
- Don't forget cost is a factor as well

Arduino and Power

- Digital pins max 40mA sink or source
- All pins max 200mA
- May run into these limit with lots of LEDs or high power LEDs

Looking at DataSheets

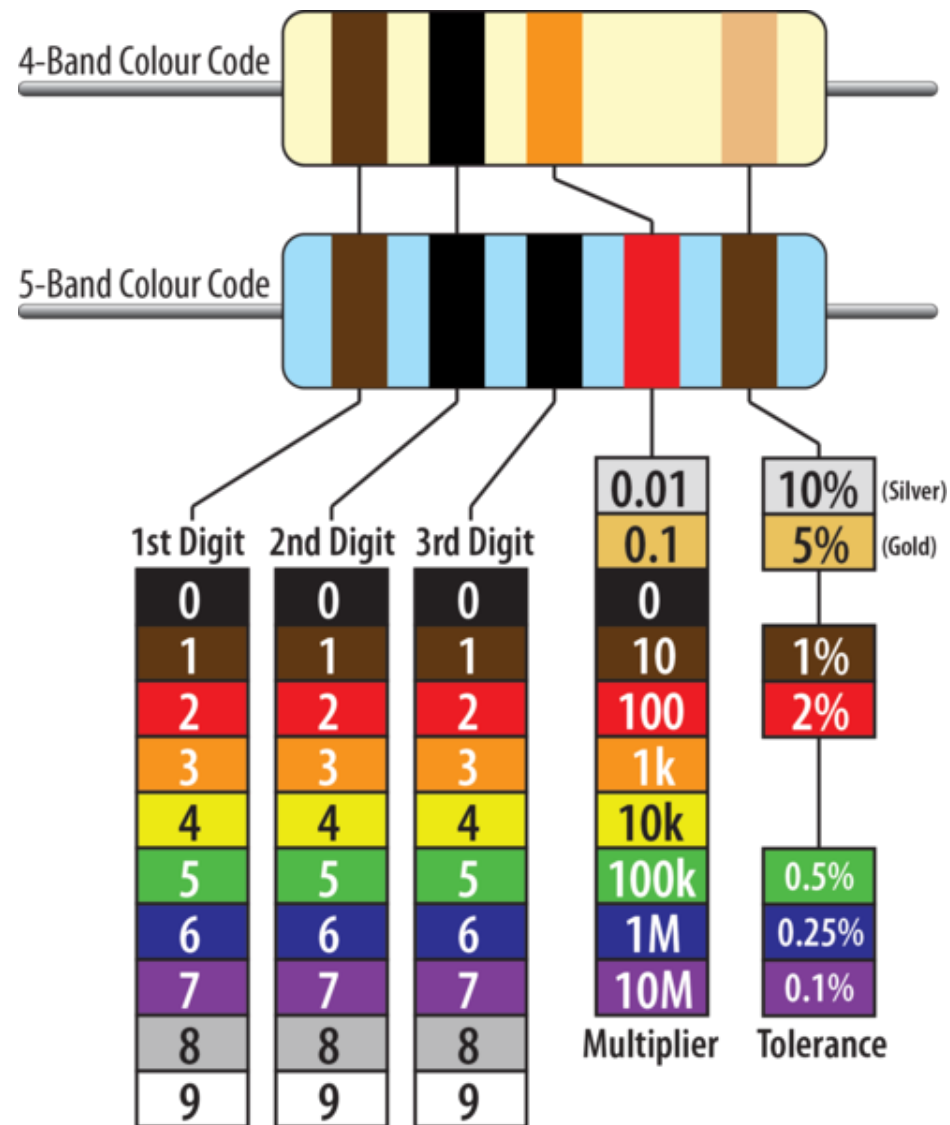
- Typical LED
- Bright LED
- Wide angle LED
- Wide current range LED
- Mid power LED
- High power LED

Ohms Law

- Ohms Law
 $V = IR$ or $R = V/I$ or $I = R/V$
- So typical LED 20ma with 5V supply
 $R = V/I = 5/0.020 = 250 \text{ Ohms}$
- But wrong, but will probably work OK, as LEDs don't follow Ohms Law

Resistors

- Batteries have some internal resistance so can get away without resistor with coin battery
- What resistor do I need if Ohms Law doesn't apply? Look at the data sheet!
 $R = (\text{supply} - \text{voltage drop}) / \text{current}$
- Typical LED 20mA 5V supply 2.2 voltage drop
 $R = (5 - 2.2) / 0.020 = 150 \text{ ohms (round up)}$
- Resistors come in standard values so round up
100, 110, 120, 130, 150, 160, 180, 200, 220, 240



Resistor Values

No DataSheet?

- Guess! Typical LEDs are 20ma and drop of 2.1 V for red, orange, yellow or (old style) green, 3.2 V for (new style) green, blue or white
- At 5V that gives roughly
150 Ohms for red, orange, yellow or green
100 Ohms for green, blue or white
- Measure voltage drop using multi-meter

Power

- Resistor are power rated
- Typically 1/8 Watt, 1/4 Watt or 1/2 Watt
- Standard LEDs with low voltage not an issue
- $P = I * I * R$
- Typical LED $P = 0.02 * 0.02 * 150 = 0.06$ Watts which is $< 1/8$ Watt - no issue
- Very bright led $P = 0.1 * 0.1 * 100 = 1$ Watt so need to be careful

Get it wrong?

- LED not bright enough - may not be a issue
- Worse case let out magic smoke = dead LED
- Can shorten lifespan - but then perhaps 10,000 hours is fine for your application?
- Colour shift - can be temporary or permanent

LED Displays

- 7 segments
- Alphanumeric
- Matrix

Common Anode vs Cathode

- Common Anode means connect common pin to 5V
- Common Cathode means connect common pin to ground

Shift Registers

- Serial data in parallel data out
- Good for driving 7 segment display and matrixes

Current Drivers

- LED need current not voltage
- Current drivers give exact current
- Fewer components usually no resistors

Multiplexing

- Turning LEDs on/off rapidly in sequence
- Too fast for human eye to see
- Uses less digital outputs

Bit Banging

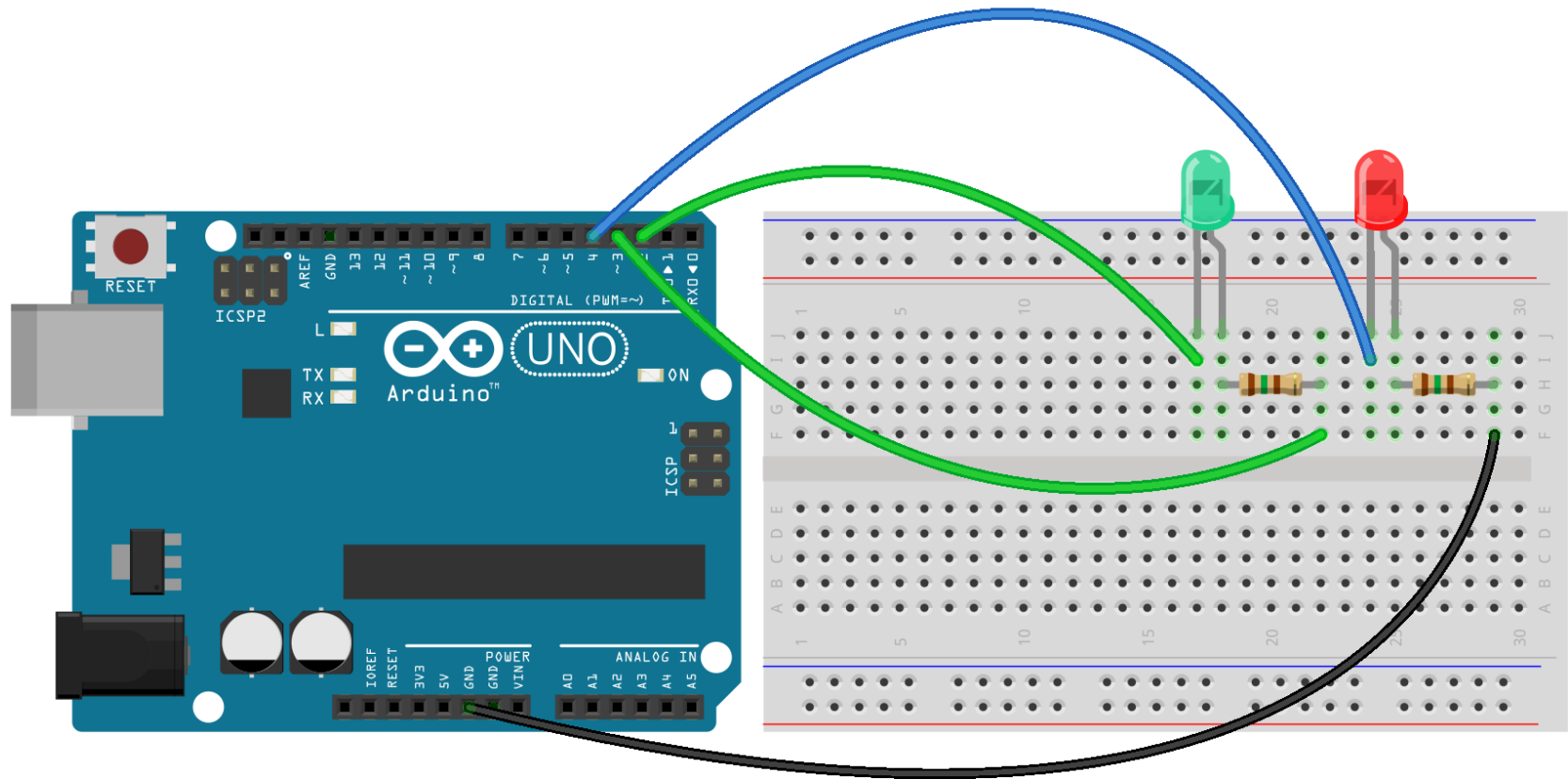
- Emulate a protocol by manual turing digital output on and off
- May have timing issues but usually solvable with delay
- Look at data sheet

LED Sensor

Using a LED as a sensor

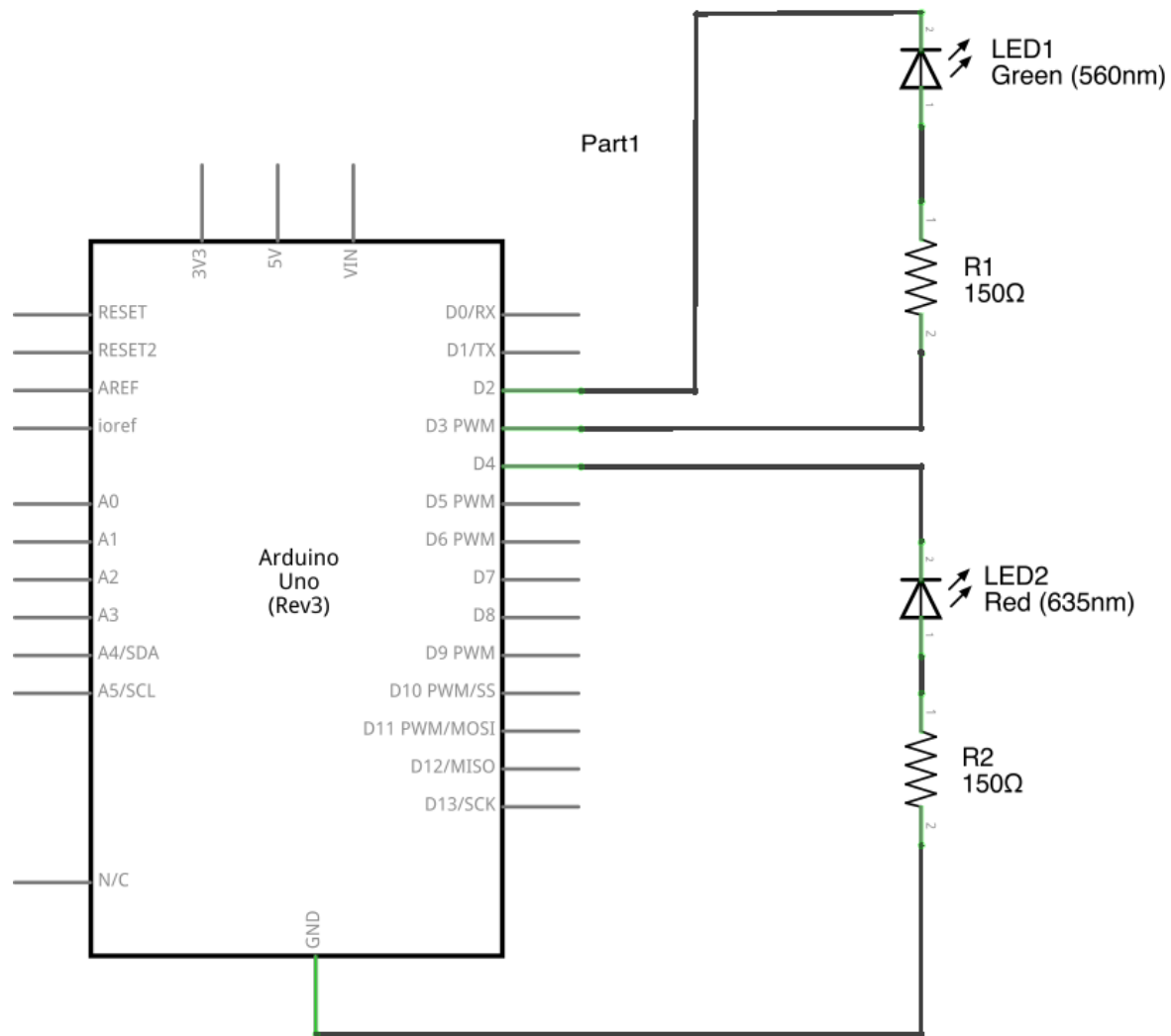
LED sensor circuit

- Hook up a LED to two digital pins
- Make one an output, one an input
- Hook up LED to ground and another pin



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LED Breadboard



LED Circuit

LED sensor code

- Turn LED on
- Small delay
- Turn LED off, swap input and output
- Measure (roughly) how long input it takes to be zero

Experiment

- What colour LED works best?
- Play about with the delay. Does it matter how long you have the LED on for?

Questions

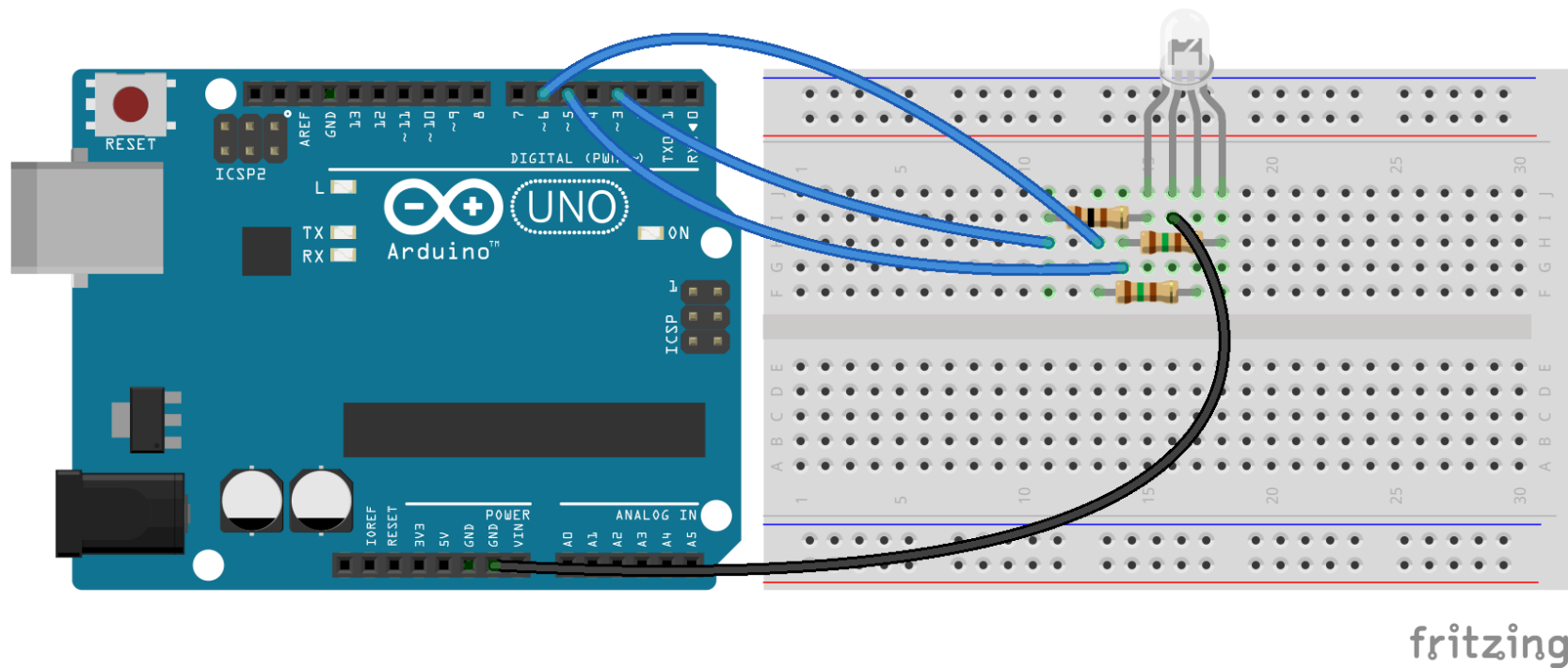
- Why not use an analogue input?
- Why measure via a tight loop?
- You don't have to always use components as intended. Any problems with this?
- See any other issues with this approach?

RGB LEDs

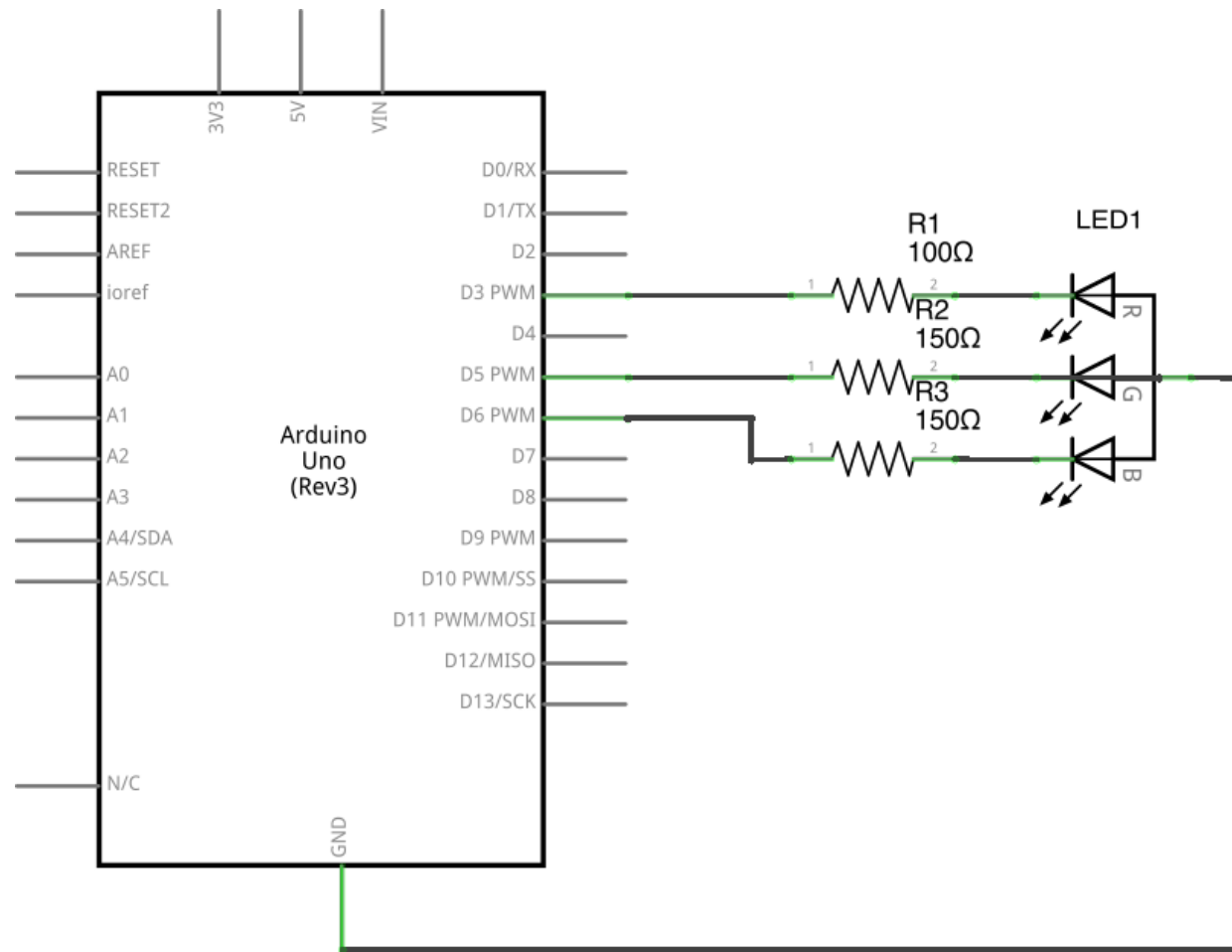
Colour mixing

RGB LEDs

- Selecting correct resistors
- Match each channel maximum brightness
- Human vision is more sensitivity to green, then red then blue



RGB Circuit



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RGB Circuit

LED RGB code

- Look at the data sheet
- Double check resistor values!
- Factor each PWM by how bright each of the individual LEDs are
- Also factor in current

Experiment

- Is RGB the best combination for making white light?
- What if you change the resistors to put 30ma through Red and Blue?

Questions

- How white is your white?
- How many colours can you make?
- Can RGB make any colour?

Bright LEDs

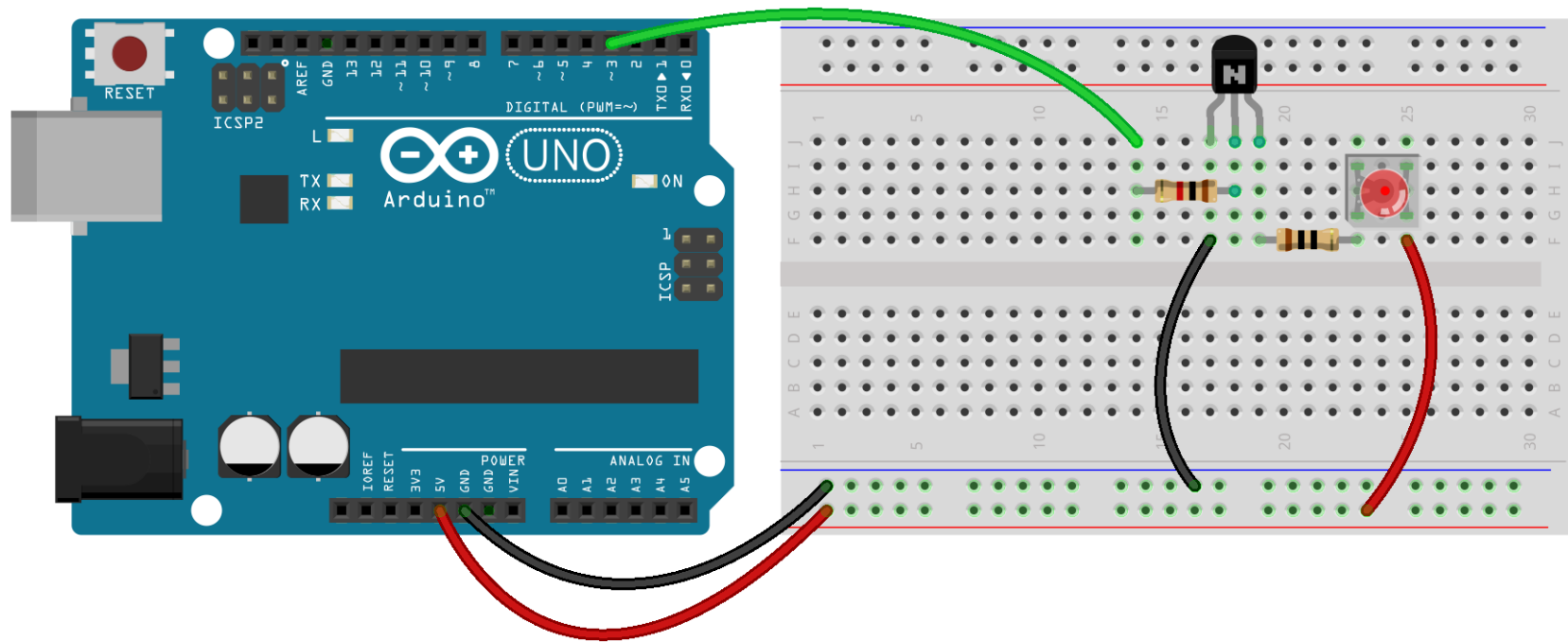
Switching higher current LEDs

Bright LEDs

- Can be 20ma or a lot more
- Some LEDs take several amps!
- Look at bright LEDs (20ma)
- Look at super flux LED (70ma)

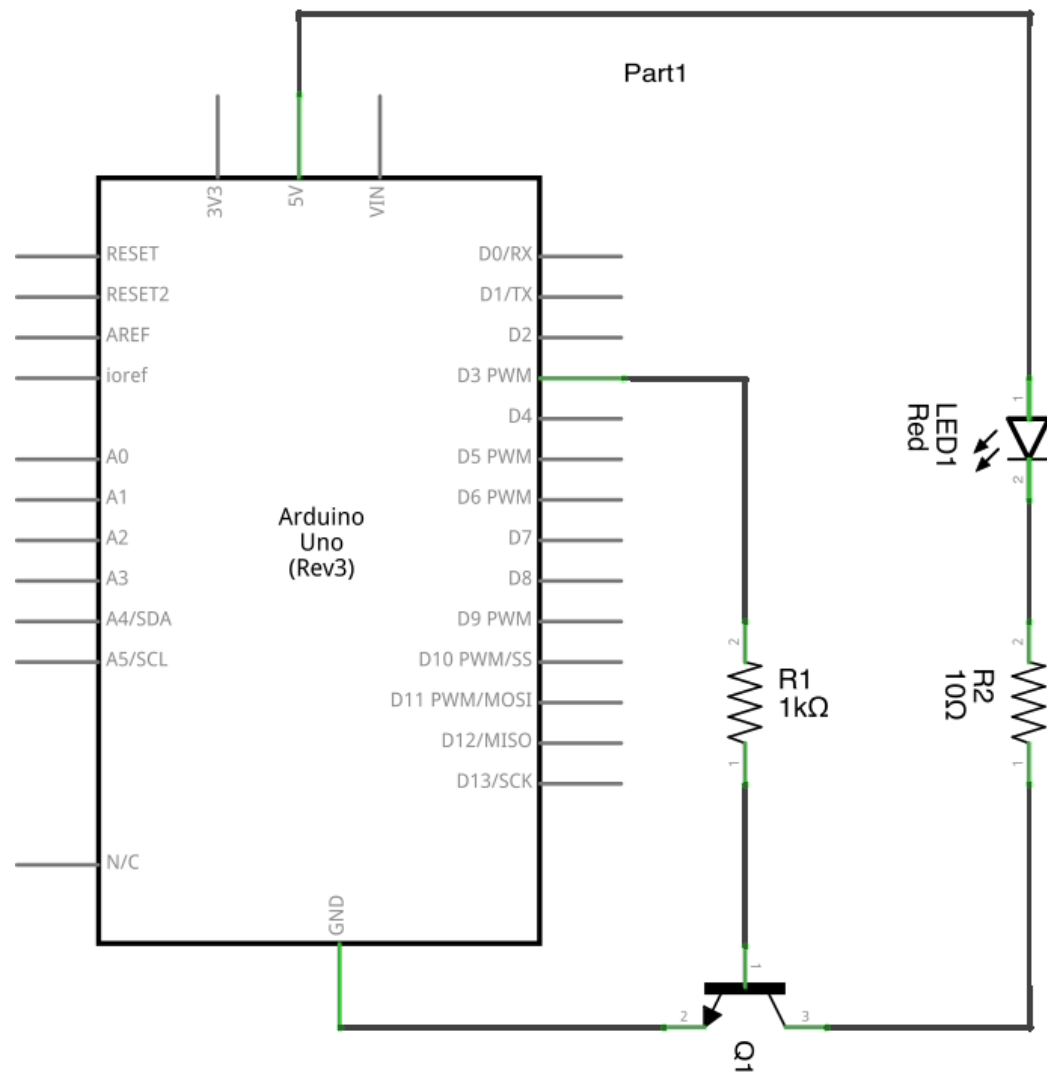
Using Transistors as a Switch

- Arduino pin max 40ma
- 70ma LED how do we run at full power?
- Use a transistor to switch a higher current
- Remember resistors may need to be higher wattage



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Super Flux Circuit



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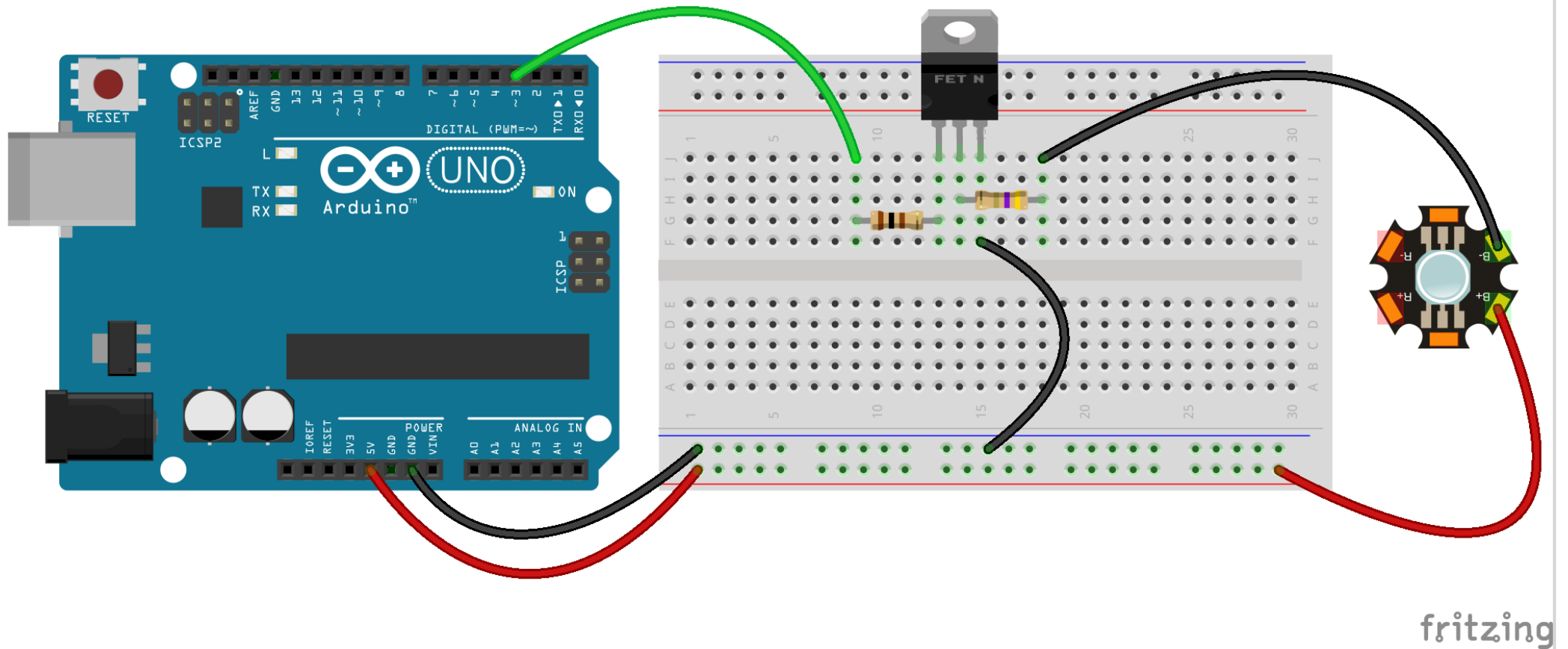
Super Flux Circuit

Blink code

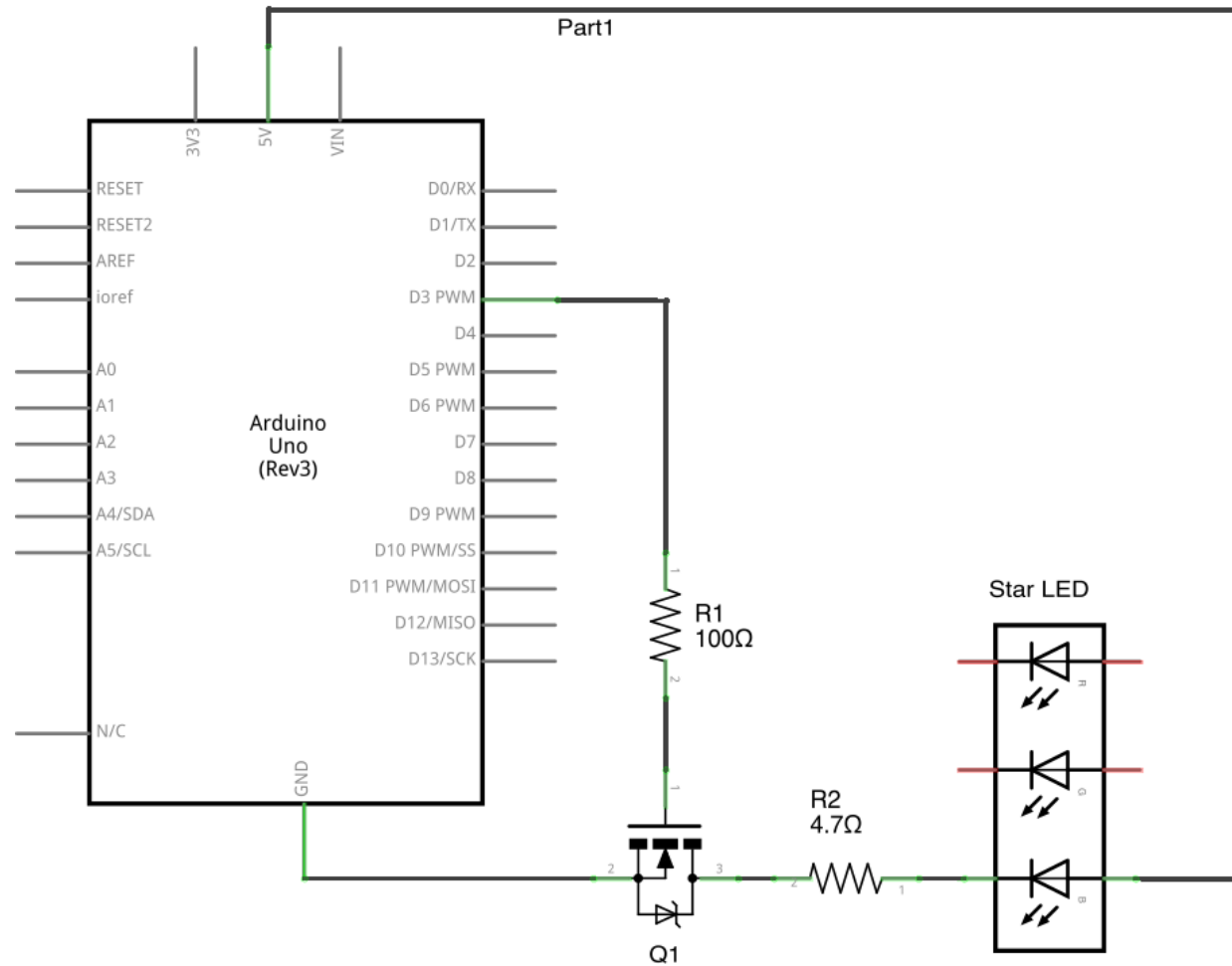
- Nothing new here!

Using Mosfet as a Switch

- 30 amps of switching power!
- May need a heat sink if running > 5 amps
- PWM is possible



Mosfet Circuit



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Mosfet Circuit

Questions

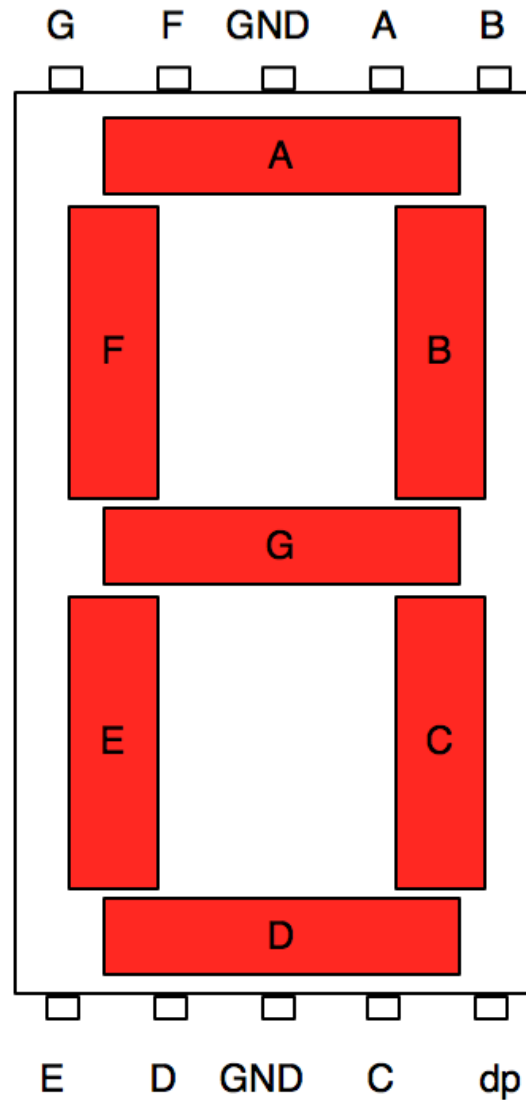
- How much current can you get out of the Arduino 5V pin?
- Can you use the arduino to switch a different power supply?

Displaying Numbers

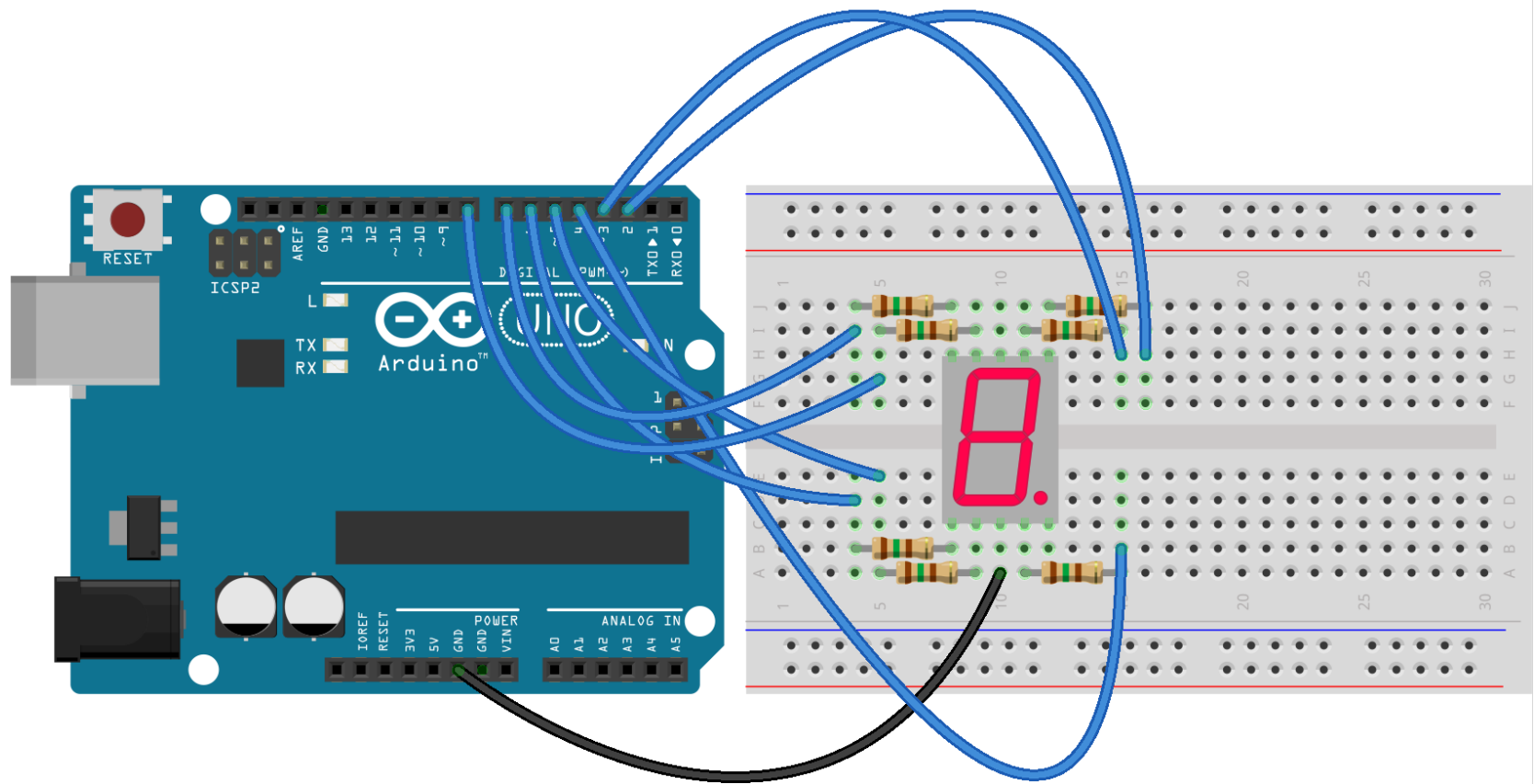
7 segment displays

7 Segment LEDs

- 7 led in a display arranged in a figure 8
- Can display number 1-9 and 0 by turning on/off segments
- Many ways to drive them
- Common cathode (common ground) vs common anode (common +5V)



7 Segment LED



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7 segment display

7 Segment code

- Arrays - in C start from zero
- Bits and binary operations

Experiment

- Display something other than digits try to display an “E” for error or the blinking “0”

Questions

- Is this an effective use of digital outputs?
- Can we dim the LED? How? Is that effective?
- Have we exceeded any specs here?

Shift Registers

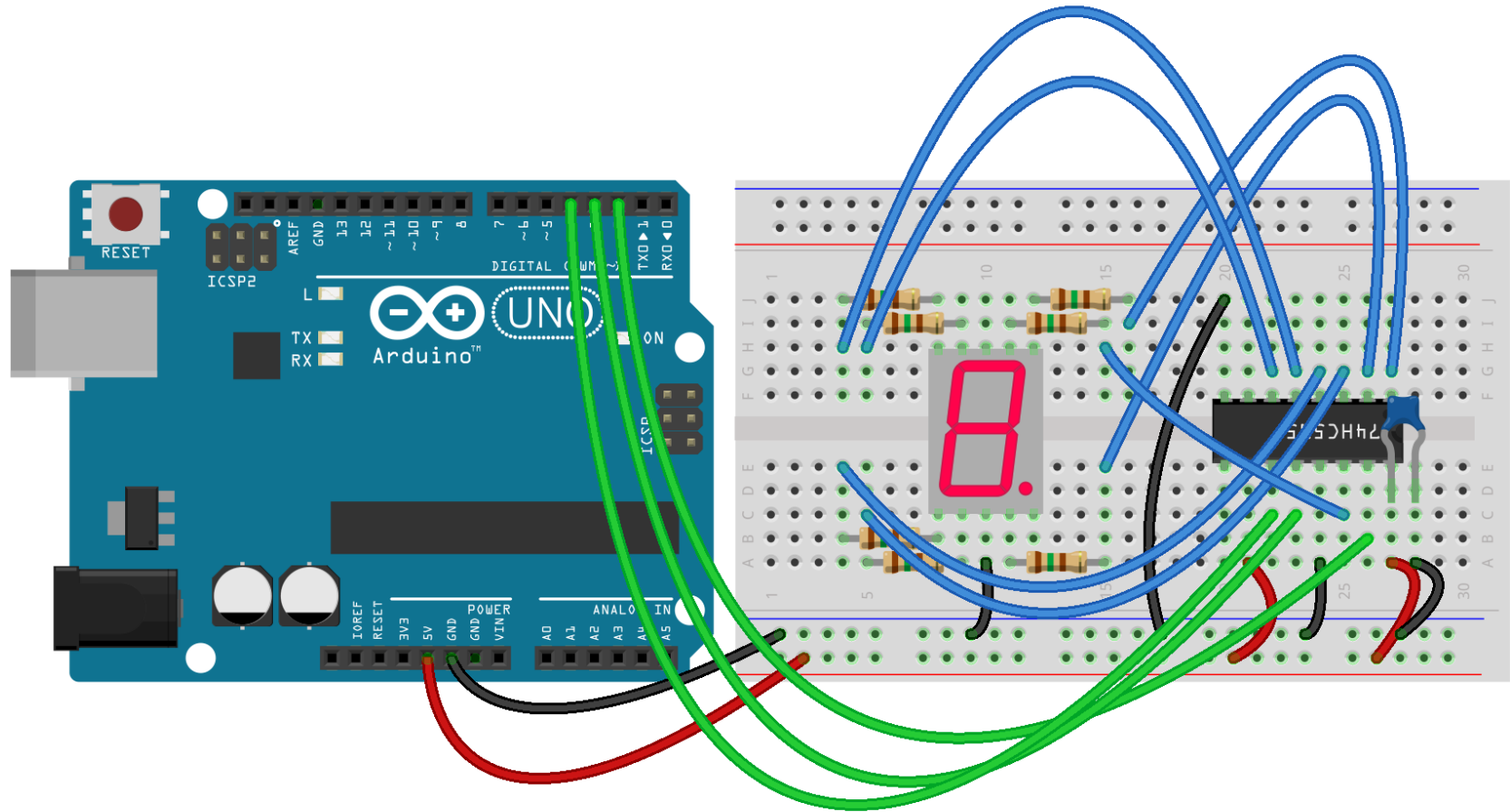
- Simple serial to parallel interface
- 3 pins to control
- Clock, data and latch pins
- Can drive via bit banging or use inbuilt shiftOut function
- Other way is to drive led segments is a BCD chip (4 inputs required per segment)
- Chain-able

ICs and Breadboards

- May need to straighten pins by pushing gently side of IC onto hard flat surface

Decoupling capacitors

- 0.1 uF capacitor
- Connect from power pin to ground
- May be useful on other pins e.g. latch
- Not always needed but cheap and you never know when you do



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Shift Register

Shift Register Code

- ShiftOut function
- Can use any pins

Experiment

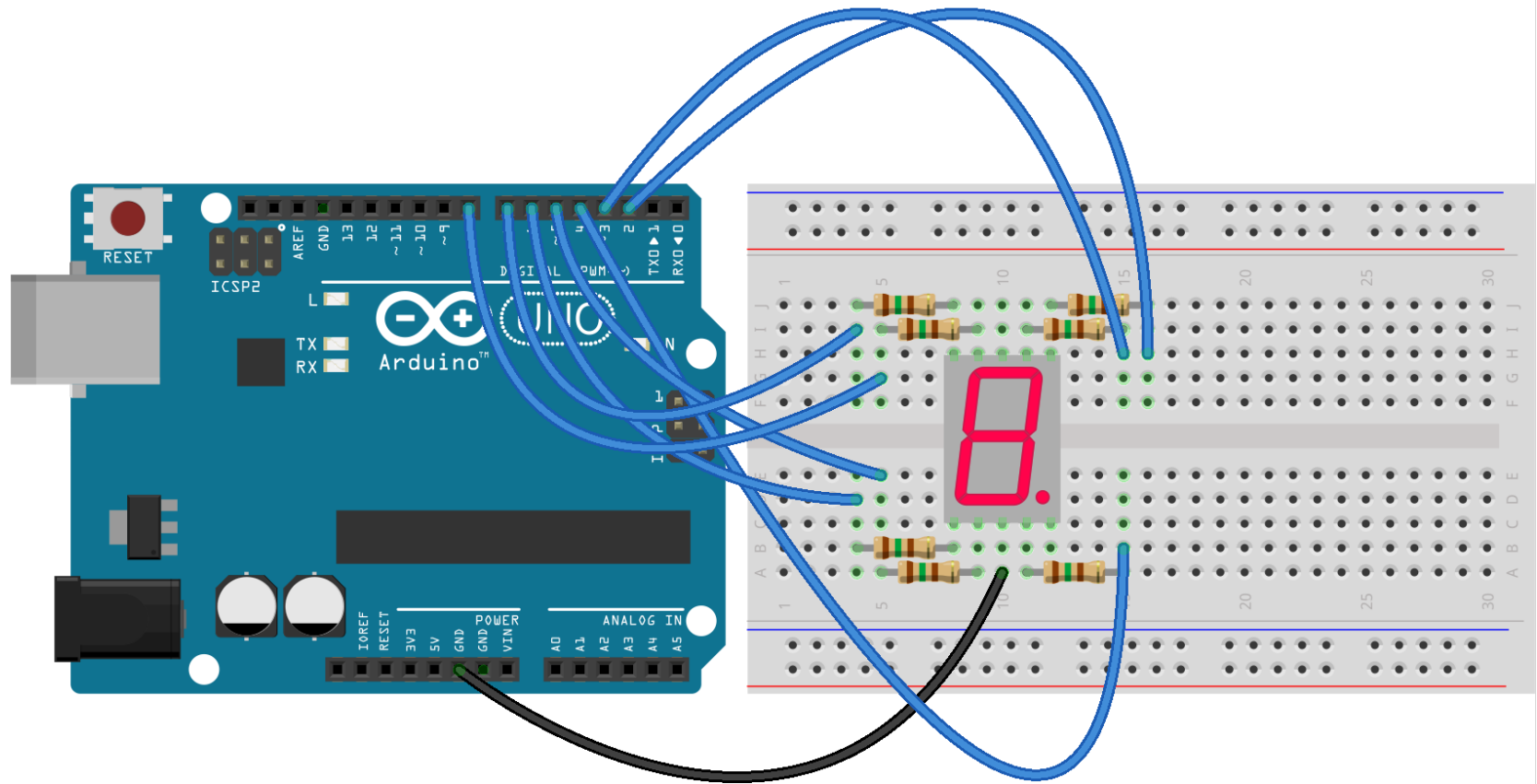
- Does it work without the capacitor?
- Make the 7 segment display do something else

Questions

- Can we dim the LED?
- What else could you use shift register for?
- Is this slower than using more digital outputs?
Does it matter?
- Can you use either common anode or common cathode LEDs?
- Have we exceeded any specs here?

TI Driver Chip

- Similar to a shift register
- Can drive as fast or slow as you want (very similar to SPI)
- Chain-able
- Common Cathode (+5V) only!
- Can control brightness as well
- Look at the data sheet!



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LED driver

Questions

- Similar to a shift register
- Can drive as fast or slow as you want (very similar to SPI)
- Chain-able
- Common Cathode (+5V) only!
- Can control brightness as well
- Look at the data sheet!

Experiment

- What happens if you leave enable set to LOW?
- Make the 7 segment display do something else

Bit Banging Code

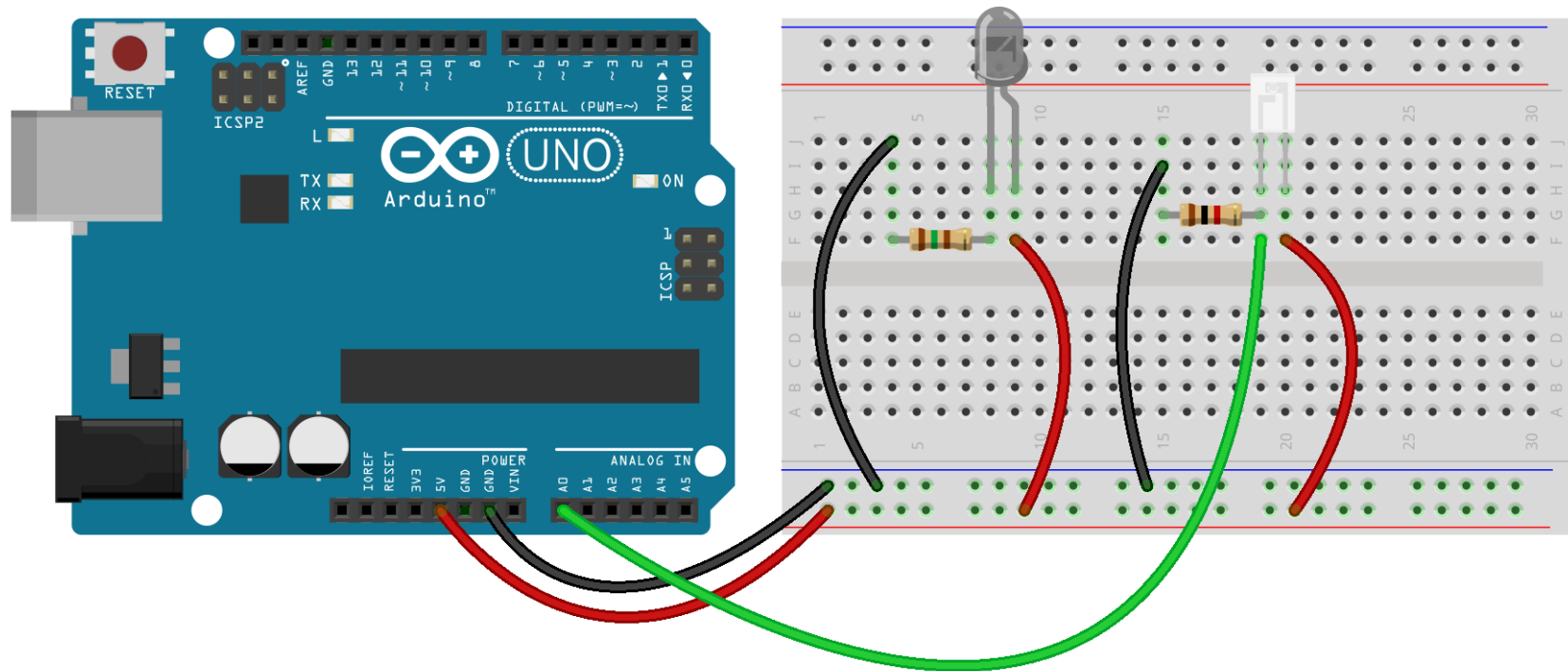
- Use bit banging rather than `shiftOut` to change brightness

Remote Control

Using IR LEDs

IR LEDs

- Invisible to the naked eye
- Can use as a distance sensor
- Can use to transmit data



Distance Circuit

Experiment

- What happens if you change the value of the photodiode resistor?
- Change the angle of the LEDs?

LED Matrix

LED matrix

LED Matrixes

- Driver row or column at a time
- Multiplex
- Need row x column digital inputs

Displaying Characters

Alpha-numeric displays

Alphanumeric Displays

- Just like 7 segment displays but with more segments
- Some (expensive) displays have controller chips/decoders built in

LED Bars

LED bars

LED Bars

- Several LED in a single component
- Usually use to display value of analogue input
- Driver chip