Bootstrapping into Electronics

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www.ell-i.org

First, get the doc

- This set and some pieces of code are at:

  https://github.com/mlevlin/electronics-training

- Go get them!

Components

- Resistors
- LEDs
- FET transistors
- Condensators
- Potentiometers (adjustable resistors)
- Buttons
- DC jacks
- Lamps

Resistors
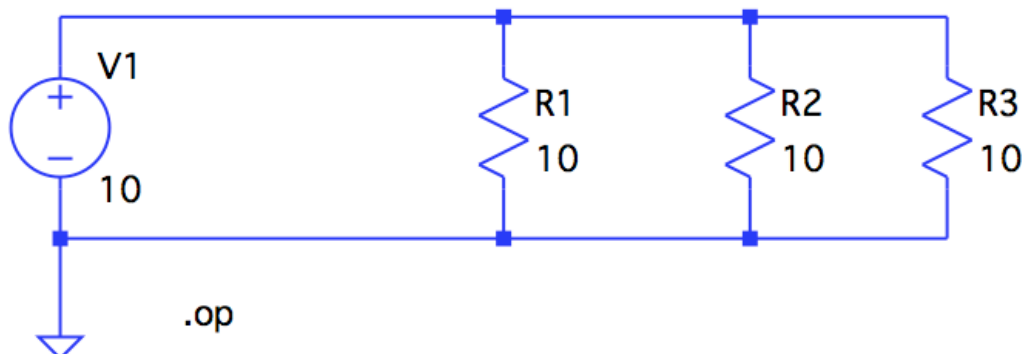
Resistor values

- Either measure, or look up from this:

Color	Significant figures	Multiplier	Tolerance
Black	0	$\times 10^0$	–
Brown	1	$\times 10^1$	±1%
Red	2	$\times 10^2$	±2%
Orange	3	$\times 10^3$	–
Yellow	4	$\times 10^4$	(±5%)
Green	5	$\times 10^5$	±0.5%
Blue	6	$\times 10^6$	±0.25%
Violet	7	$\times 10^7$	±0.1%
Gray	8	$\times 10^8$	±0.05% (±10%)
White	9	$\times 10^9$	–
Gold	–	$\times 10^{-1}$	±5%
Silver	–	$\times 10^{-2}$	±10%
None	–	–	±20%

Example:
100k resistor,
5% tolerance

https://en.wikipedia.org/wiki/Electronic_color_code

Parallel circuit

Series circuit

Series and parallel

Rtot = 1/(1/R1 + 1/R2) + R3

.op

Potentiometer

R1
R
ANALOG1
R2
R
V1
V
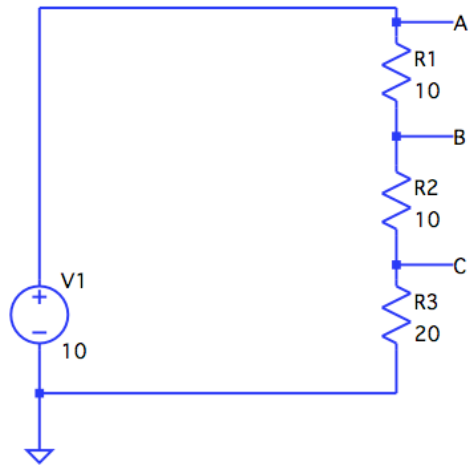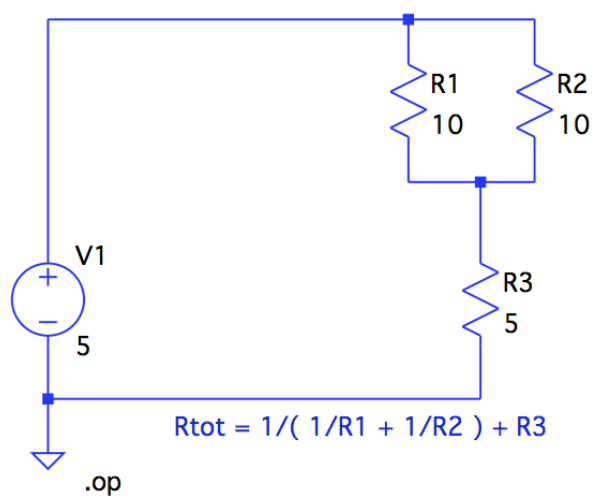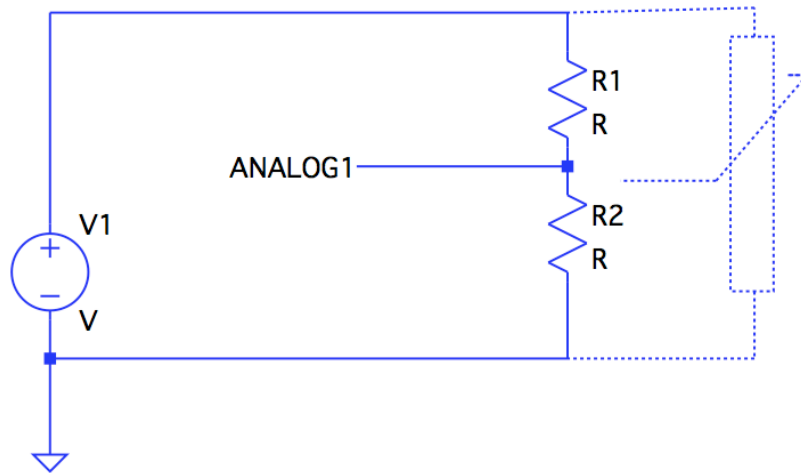
Pull up and pull down resistors

S1
SW
INPUT1
R1 PULL DOWN
R   RESISTOR
V1
V
R2 PULL UP
R   RESISTOR
S2
SW
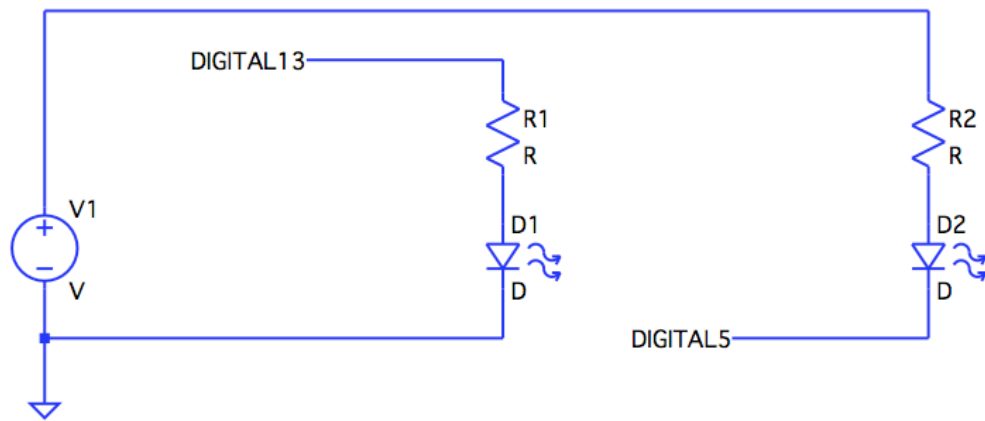INPUT2
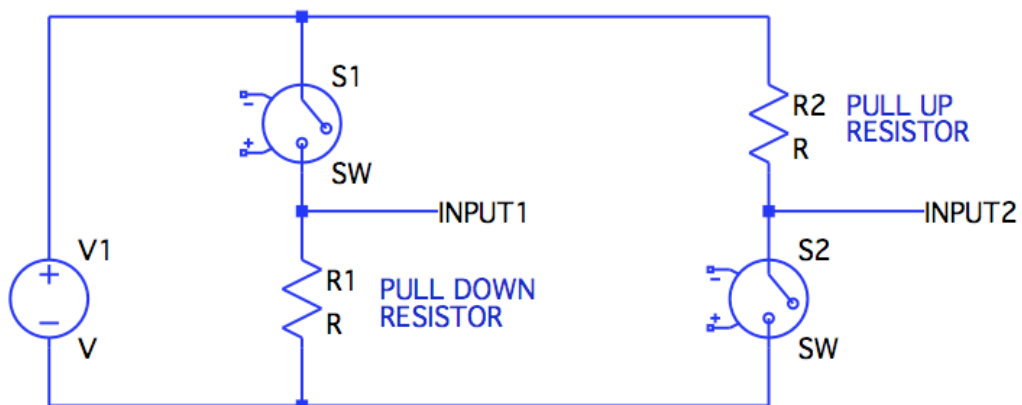
LEDs

LED

- The usual 1-color LED

- RGB LED, three leds in one package
  - One end of the leds connected together

- Different LEDs need different voltages
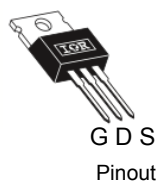 - Red: typically ~1.8V
  - White: typically ~3V
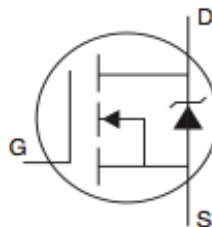
Lighting a LED

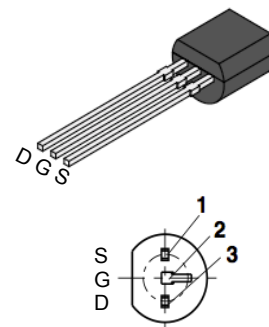DIGITAL13

V1
V

R1
R

R2
R

D1
D

D2
D

DIGITAL5

FETs

IRL530N
in TO220 package

BS107
in TO92 package

Symbol

G D S
Pinout

D

G

S

D G S

1
2
3
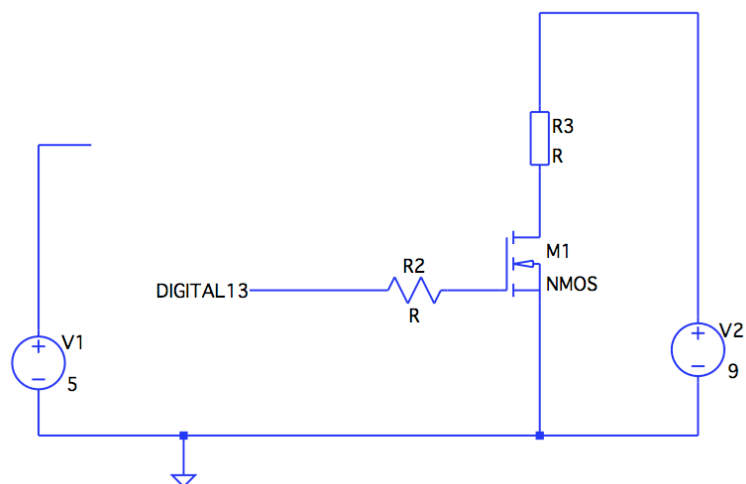
S
G
D

Using a FET
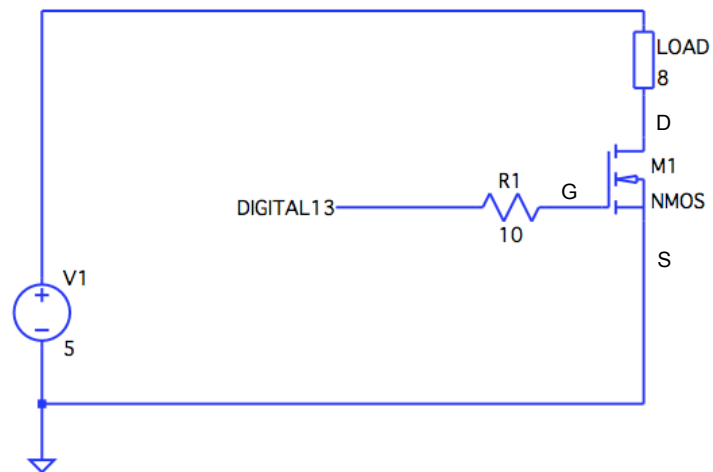
Typical use of a FET switch – dual voltage

Capacitors
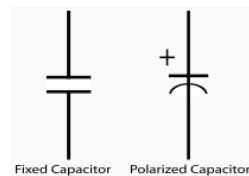
Capacitors

- Capacitors store energy!
- Connect
  - A led and 1k resistor in series, led to – line
  - 1000 µF capacitor between – line and resistor (+ end to resistor!)
  - Switch between + line and resistor/cap joint
  - DC jack to + and – lines
- Press switch and see your energy storage problems solved!

Arduino
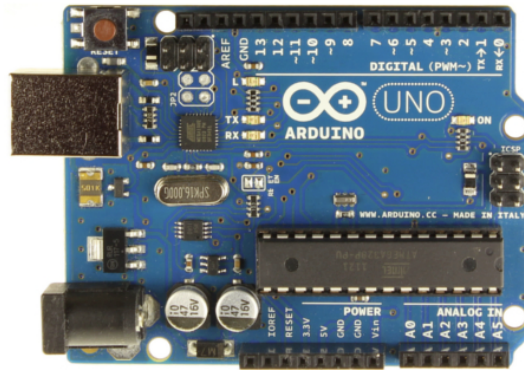
Arduino

- Smallest computer you have ever coded for
  - 32 kB flash
  - 2 kB RAM
  - 16 MHz
- Perfect for hardware I/O
  - 14 digital I/O pins, of which 6 can do PWM
  - 6 analog input pins
- Arduino IDE supports the Arduino language, based on C/C++
  - See http://arduino.cc/en/Reference/HomePage

Arduino: setting up

- Fetch and install IDE from arduino.cc
  - Version 1.0.5
- Fetch and install USB drivers from http://www.ftdichip.com/FTDrivers.htm
- Settings in Arduino IDE:
  - Tools/Board: select Arduino Uno
  - Tools/Serial board: select /dev/tty.usbmodemXXX or similar

Hello World

- Blinking a led on the Arduino board
- Load example "Blink": File/Examples/01.Basics/Blink
- Compile & upload

  … and the led should blink!

- Play with the code, adjust blink periods, etc

Hello World with external led

- <u>Always disconnect Arduino before adjusting connections!</u>
- Connect a led and 1k resistor in series
- From the resistor, one jumper to pin 13 on Arduino
- From the led, one jumper to pin GND on Arduino
- Connect USB back: the led should blink

Fading a LED

- Connect a led and 1k resistor in series, then to pin 9 on Arduino
  - and to GND on the other end
- Load File/Examples/01.basics/Fade
- Compile & upload

How does it work?

- Pulse Width Modulation, PWM!
  - See reference on analogWrite()
- Arduino generates pulses at a fixed frequency
  - about 500 Hz
- Length of the pulses is adjusted
  - Short pulses: dim
  - Long pulses: bright

Measurement

- Control fading with a potentiometer!
- Connect a led and 1k resistor in series, then to pin 9 on Arduino
  - and to GND on the other end
- Connect a potentiometer:
  - Ends to + and – lines
  - Middle to A0 input in Arduino
- Fetch https://github.com/mlevlin/electronics-training /Arduino/FadeControl
  - Open in IDE, compile & upload
- Adjust the potentiometer and see brightness change

Filtering with capacitors

- Complete & test circuit as in "Measurement"
- Replace led & resistor with:
  - 1 kohm resistor from pin 9 to 10 µF capacitor
  - Other end of cap to – line
  - 10 kohm resistor in parallel to cap
- Measure DC voltage over capacitor while adjusting the pot
  - Should see a voltage from 0 to 4.5 V

Playing with RGB colors

- RGB led: longest wire to GND
- Other wires to 1k (or 470 ohm) resistors
- Wires from resistors to pins 3,5,6 of Arduino
- Get code from

  https://github.com/mlevlin/electronics-training
  /Arduino/RGB_with_sines
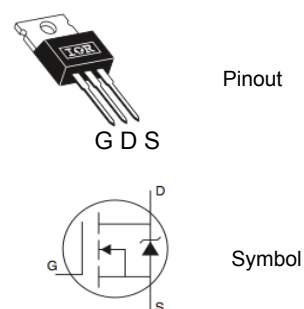- Open in IDE, compile & upload

Dimming a lamp

- FET: IRL530N
- Connect:
  - DC jack to + and – lines (red == +)
  - G of FET through 1k resistor to pin 9
  - S of FET to – line
  - D of FET to lamp
  - Other wire of lamp to + line
  - GND of Arduino to – line
- Load File/Examples/01.Basics/Fade, compile & upload

Pinout

G D S

Symbol

D

G

S
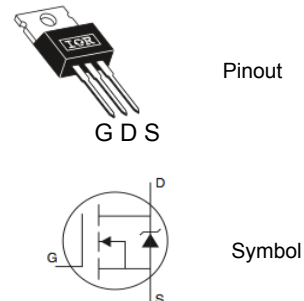
Sound

- FET: IRL530N
- Connect:
  - DC jack to + and – lines (red == +)
  - G of FET through 1k resistor to pin 8
  - S of FET to – line
  - D of FET to loudspeaker
  - Other wire of loudspeaker to 100 ohm resistor
  - Other end of resistor to + line
  - GND of Arduino to – line
- Load File/Examples/02.Digital/toneMelody, compile & upload
- Press Reset switch to play
- Move code from setup() to loop() to annoy everyone

Pinout

G D S

Symbol

D

G

S

Combine measurement & sound!

- Connect as previously in "Sound"
- Connect a potentiometer:
  - Ends to + and – lines
  - Middle to A0 input in Arduino
- Fetch https://github.com/mlevlin/electronics-training /Arduino/followTone
  - Open in IDE, compile & upload
- Adjust the potentiometer and annoy your brains out

Basic display, 1/2

- These 2x16 character displays are a standard (keyword: "HD44780" compatible)
  - Cheap
  - Common sizes from 1x16 to 4x40
- Controlled using
  - 4 I/O lines for data
  - 2 I/O lines for control
  - Input for contrast control
  - Connections for backlight LED

Basic display, 2/2

- Connect:
  - Arduino 5V to + line, GND to – line
  - Arduino 12 to LCD 4
  - Arduino 11 to LCD 6
  - Arduino 5 to LCD 11
  - Arduino 4 to LCD 12
  - Arduino 3 to LCD 13
  - Arduino 2 to LCD 14
  - LCD 5 to – line (GND)
  - LCD 16 to – line (GND)
  - LCD 15 to 1k resistor to + line (5V)
  - LCD 1 to – line, LCD 2 to + line
  - Potentiometer: ends to – and +, middle to LCD 3
- Load File/Examples/LiquidCrystal/HelloWorld, compile & upload
- Adjust potentiometer until you see text
- Play with other pieces in File/Examples/LiquidCrystal/*

1 … … … 16
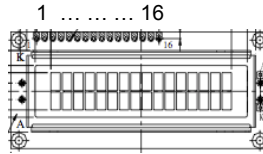
PIN NO.	SYMBOL
1	Vss
2	Vdd
3	Vo
4	RS
5	R/$\overline{\text{W}}$
6	E
7	DB0
8	DB1
9	DB2
10	DB3
11	DB4
12	DB5
13	DB6
14	DB7
15	A
16	K

Measure & Display

- Connect and test display as in "Basic display"
- Connect a second potentiometer:
  - Ends to + and – lines
  - Middle to A0 input in Arduino
- Fetch https://github.com/mlevlin/electronics-training /Arduino/DisplayInput
  - Open in IDE, compile & upload
- Adjust the second potentiometer and see readings change

Develop something!

- Combine these examples,
   modify,
      experiment,
         play around!

Need more toys?

- Local suppliers in Helsinki:
   - Www.bebek.fi, Hakaniemi
   - Www.partco.biz, Metsälä
   - Www.yeoy.fi, Olari
- From the web:
   - Sparkfun.com
   - Adafruit.com
   - Zillions of others...

Want to learn more?

- Arduino reference: arduino.cc
- Good introductory learning material:
  - Learn.adafruit.com
  - Learn.sparkfun.com/tutorials