

Electronics and Microcontrollers in 20 mins

Physical Computing and Rapid Prototyping for Artists

New Talents Ruhr, 2024 · Day 01 · Johannes Bereiter-Payr

Electronics and Mirrors

Physical Computing
New Talent+

NO MATHS

REQUIRED!

Prototyping in 15 mins

with Johannes Bereiter-Payr

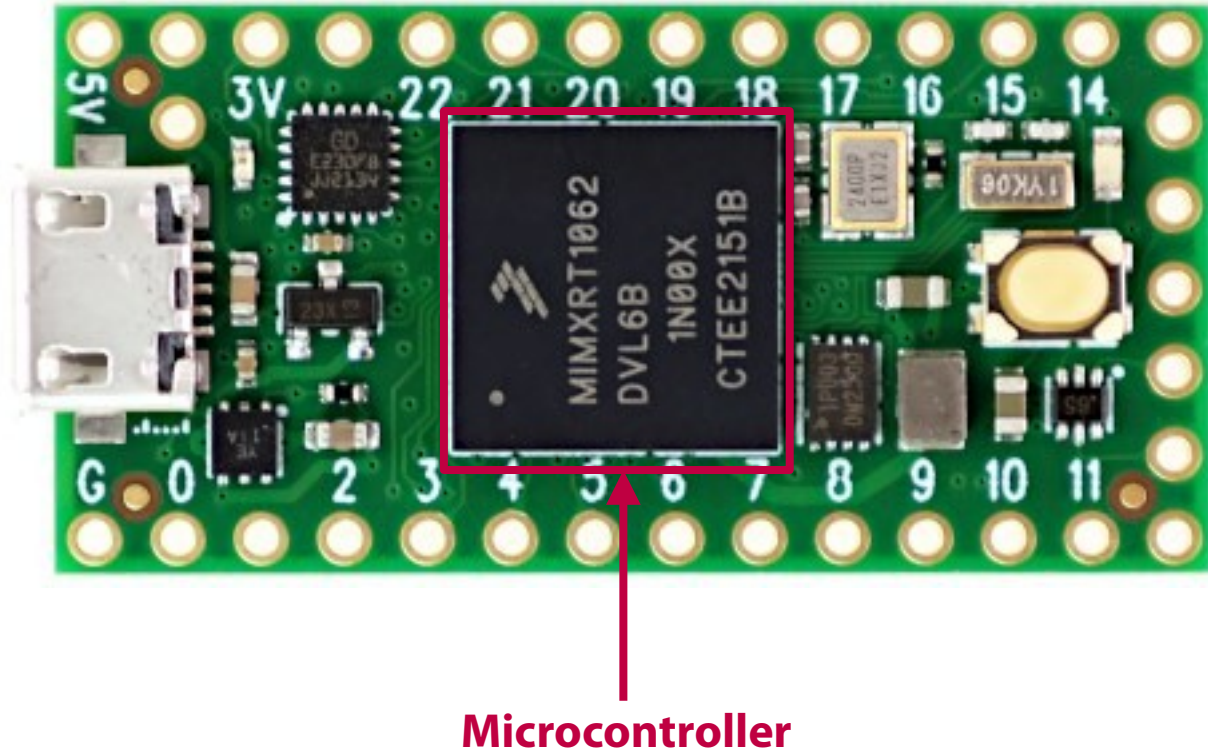
What is a microcontroller, dev board?



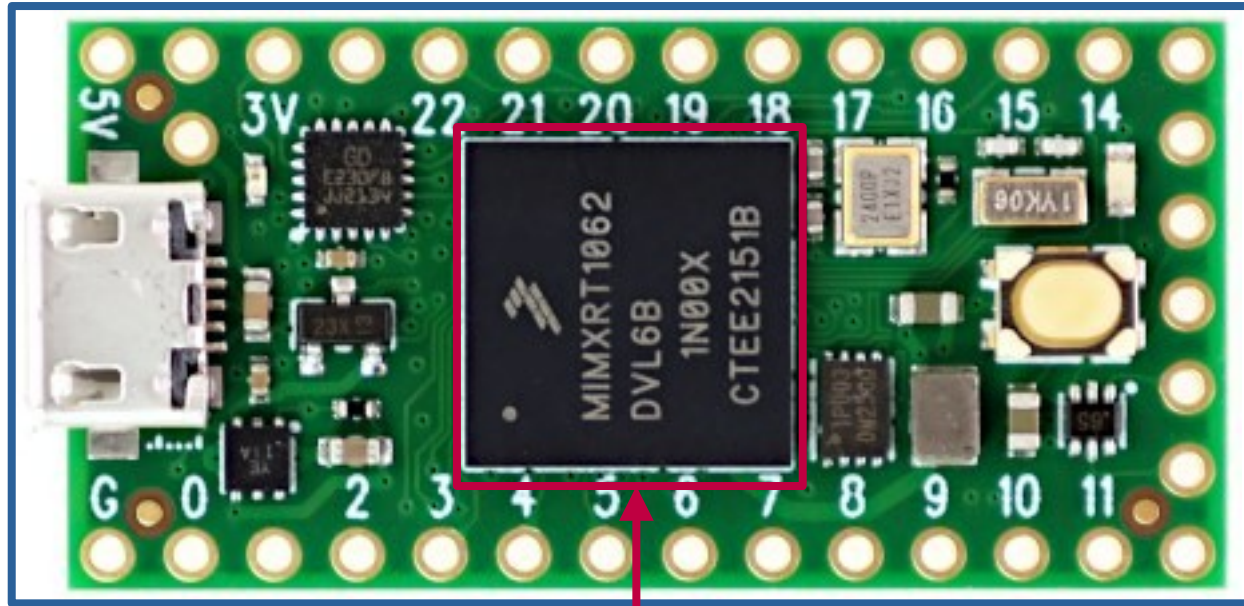
Anatomy of a dev board



Anatomy of a dev board



Anatomy of a dev board



Dev Board

Microcontroller

Anatomy of a dev board



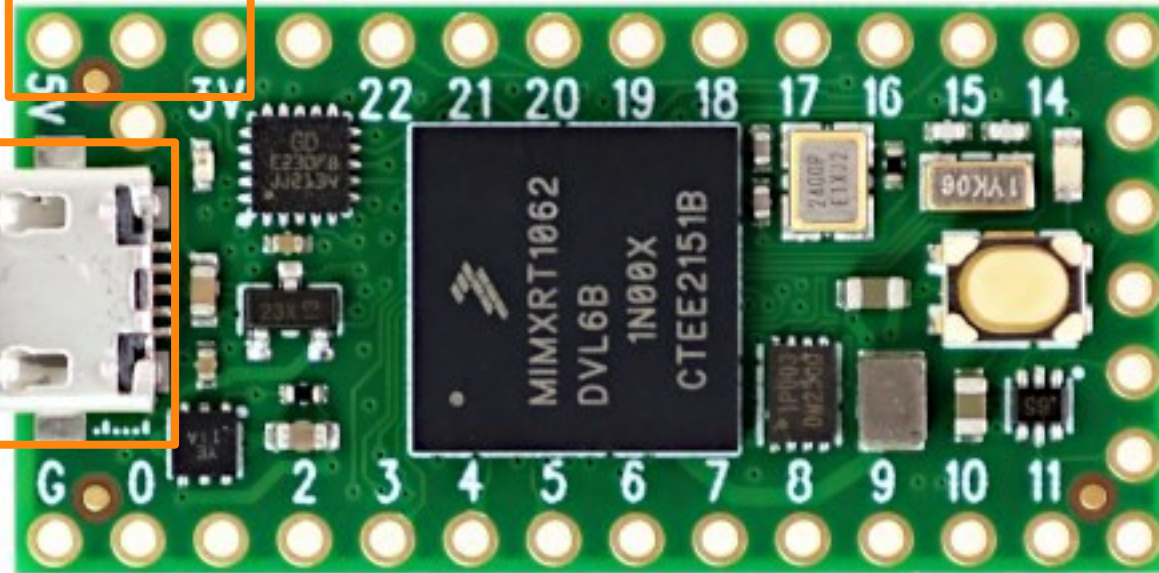
USB Connector
(Power and Com)

Anatomy of a dev board

Power In/Out
(Production Mode)



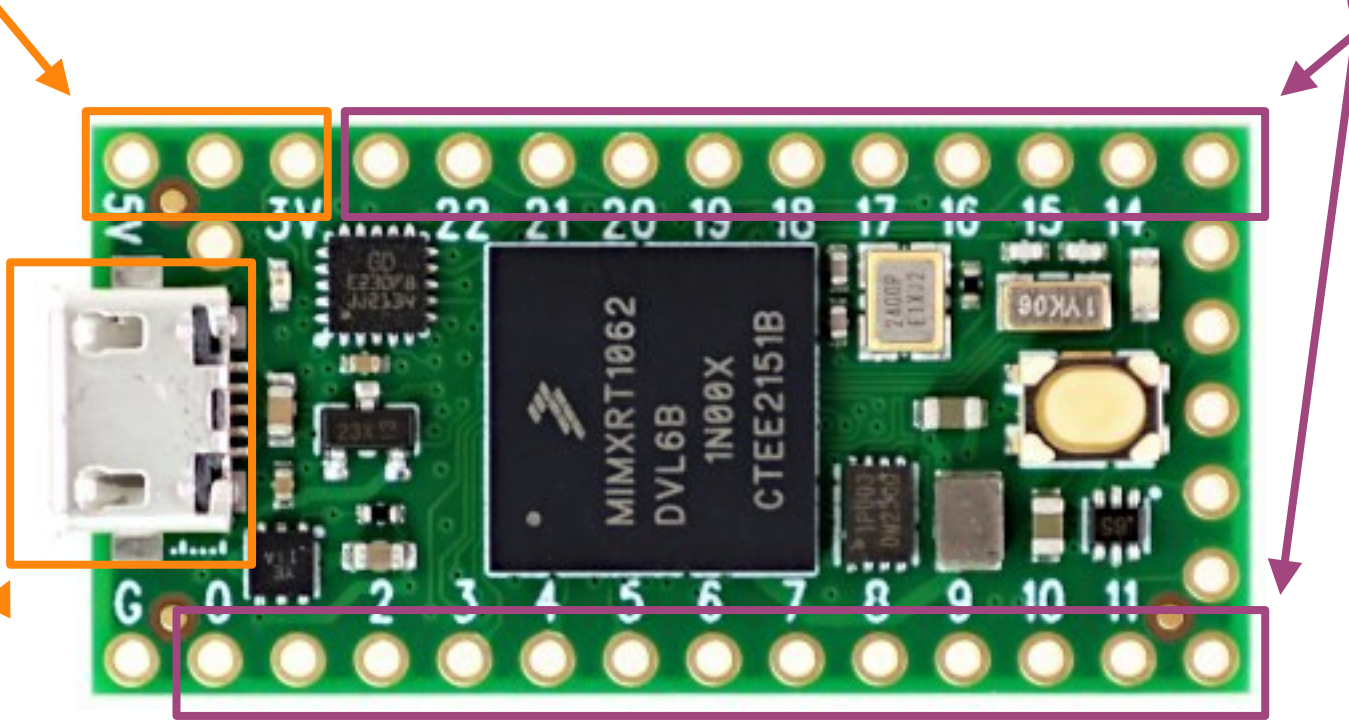
USB Connector
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Anatomy of a dev board

Power In/Out
(Production Mode)

General Purpose
Input/Output
(GPIO)



USB Connector
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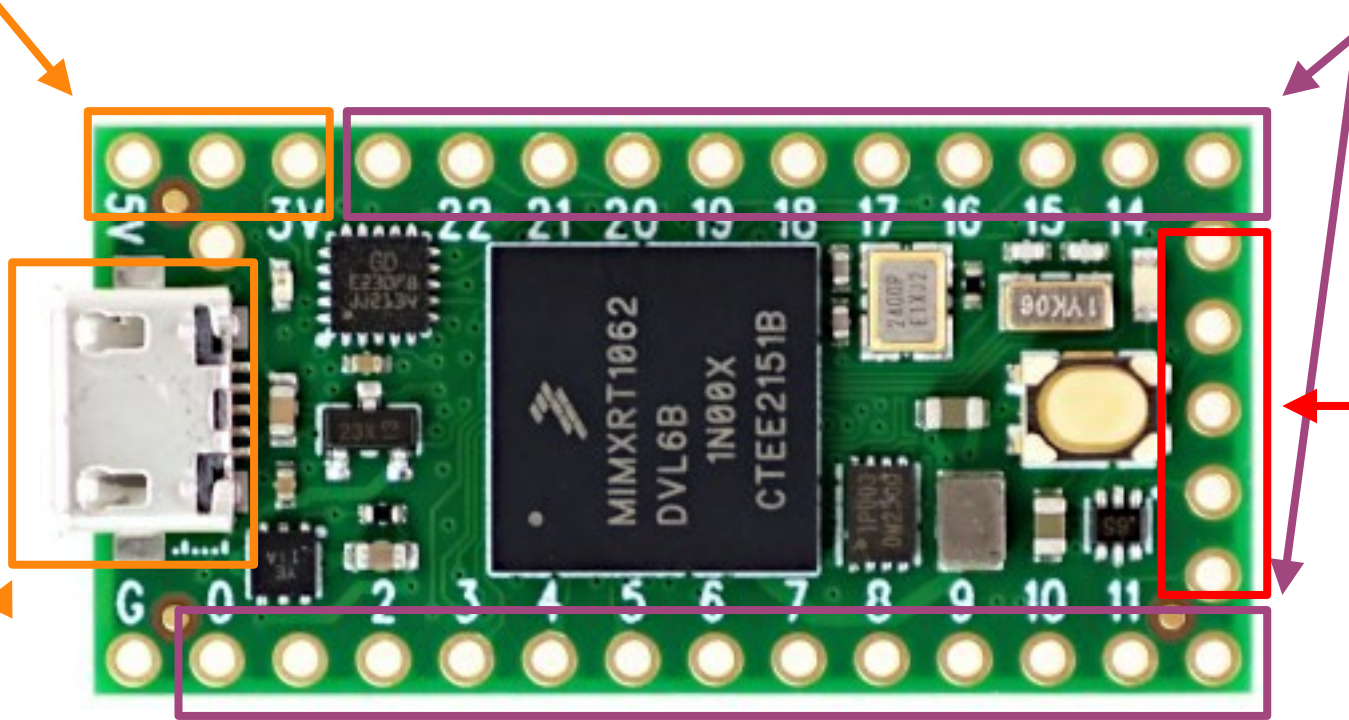
Anatomy of a dev board

Power In/Out
(Production Mode)

General Purpose
Input/Output
(GPIO)

Auxilliary Pins
(Advanced)

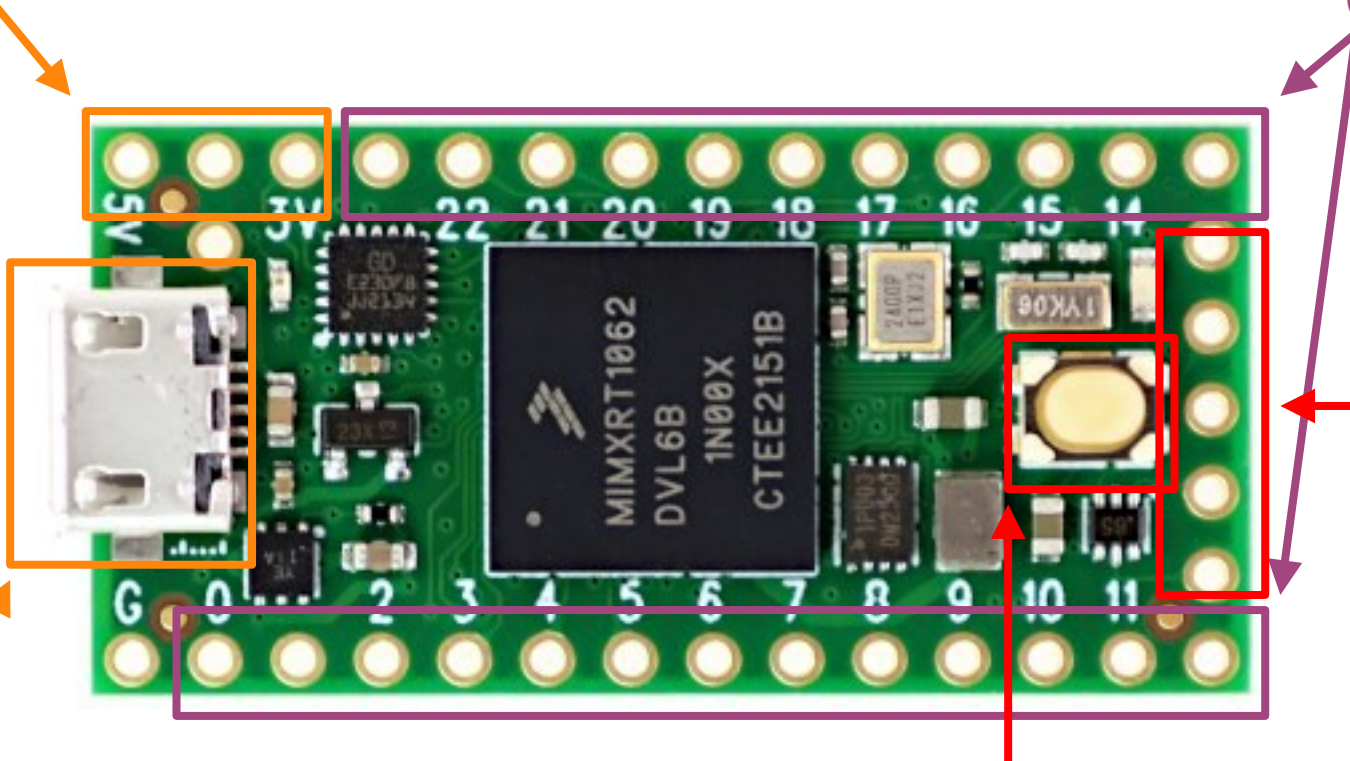
USB Connector
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Anatomy of a dev board

Power In/Out
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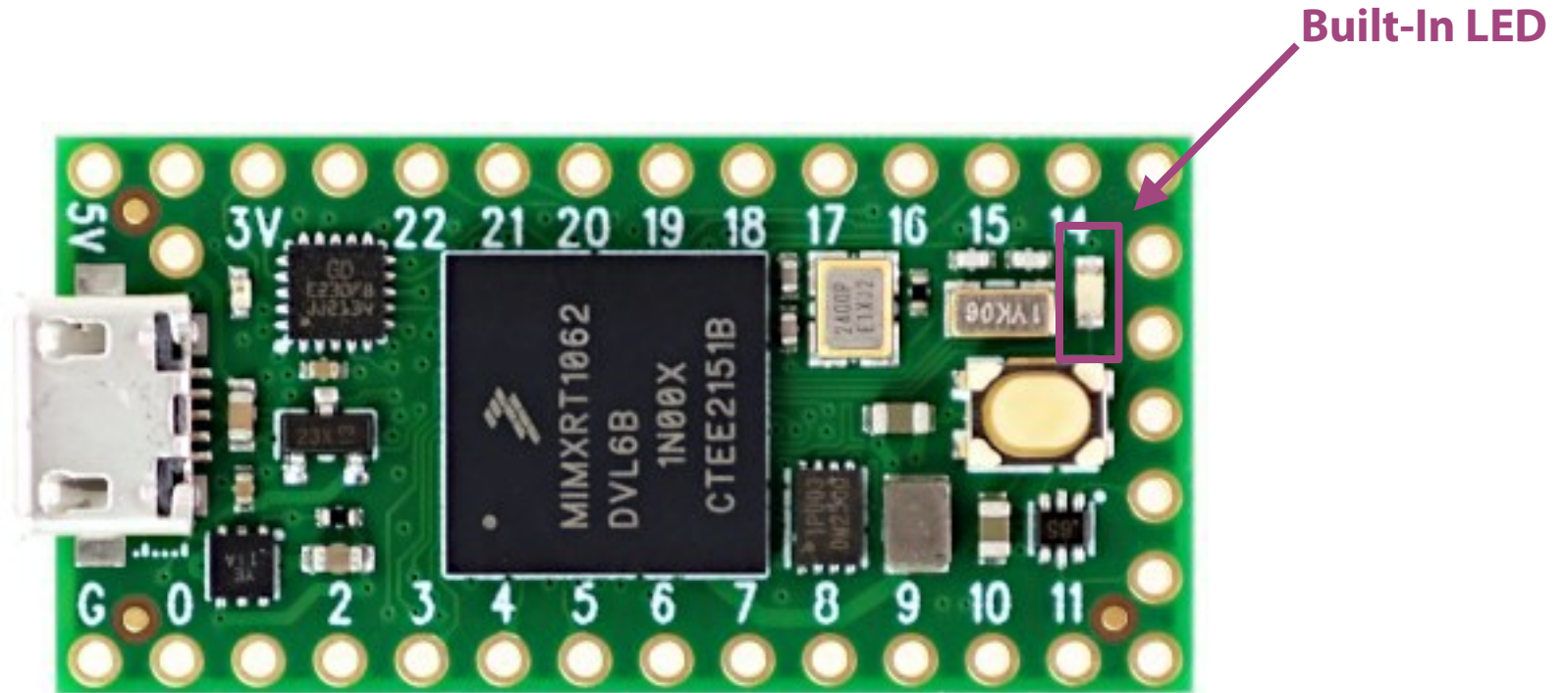


USB Connector
(Power and Com)

Auxilliary Pins
(Advanced)

Recovery Button/
Programming Mode

Anatomy of a dev board



Aside: The full story...

Welcome to Teensy® 4.0

32 Bit Arduino-Compatible Microcontroller

To begin using Teensy, please visit the website & click [Getting Started](http://www.pjrc.com/teensy).

www.pjrc.com/teensy

The diagram shows the Teensy 4.0 microcontroller board with pins numbered 0 to 12. The pins are color-coded and labeled with their functions and library references. The board is shown from a top-down perspective, with the microcontroller chip in the center. The pins are arranged in two rows: pins 0-12 on the left and pins 13-23 on the right. The board is green with gold-colored pins. The microcontroller chip is labeled 'MK66FT1802' and 'C17A1010B'. The board also features a USB connector, a 3.3V regulator, and various other components.

Pin	Function	Library
0	Digital Read/Write	digitalRead, digitalWrite, pinMode
1	Digital Read/Write	digitalRead, digitalWrite, pinMode
2	Digital Read/Write	digitalRead, digitalWrite, pinMode
3	Digital Read/Write	digitalRead, digitalWrite, pinMode
4	Digital Read/Write	digitalRead, digitalWrite, pinMode
5	Digital Read/Write	digitalRead, digitalWrite, pinMode
6	Digital Read/Write	digitalRead, digitalWrite, pinMode
7	Digital Read/Write	digitalRead, digitalWrite, pinMode
8	Digital Read/Write	digitalRead, digitalWrite, pinMode
9	Digital Read/Write	digitalRead, digitalWrite, pinMode
10	Digital Read/Write	digitalRead, digitalWrite, pinMode
11	Digital Read/Write	digitalRead, digitalWrite, pinMode
12	Digital Read/Write	digitalRead, digitalWrite, pinMode
13	Digital Read/Write	digitalRead, digitalWrite, pinMode
14	Digital Read/Write	digitalRead, digitalWrite, pinMode
15	Digital Read/Write	digitalRead, digitalWrite, pinMode
16	Digital Read/Write	digitalRead, digitalWrite, pinMode
17	Digital Read/Write	digitalRead, digitalWrite, pinMode
18	Digital Read/Write	digitalRead, digitalWrite, pinMode
19	Digital Read/Write	digitalRead, digitalWrite, pinMode
20	Digital Read/Write	digitalRead, digitalWrite, pinMode
21	Digital Read/Write	digitalRead, digitalWrite, pinMode
22	Digital Read/Write	digitalRead, digitalWrite, pinMode
23	Digital Read/Write	digitalRead, digitalWrite, pinMode
24	Digital Read/Write	digitalRead, digitalWrite, pinMode
25	Digital Read/Write	digitalRead, digitalWrite, pinMode
26	Digital Read/Write	digitalRead, digitalWrite, pinMode
27	Digital Read/Write	digitalRead, digitalWrite, pinMode
28	Digital Read/Write	digitalRead, digitalWrite, pinMode
29	Digital Read/Write	digitalRead, digitalWrite, pinMode
30	Digital Read/Write	digitalRead, digitalWrite, pinMode
31	Digital Read/Write	digitalRead, digitalWrite, pinMode
32	Digital Read/Write	digitalRead, digitalWrite, pinMode
33	Digital Read/Write	digitalRead, digitalWrite, pinMode
34	Digital Read/Write	digitalRead, digitalWrite, pinMode
35	Digital Read/Write	digitalRead, digitalWrite, pinMode
36	Digital Read/Write	digitalRead, digitalWrite, pinMode
37	Digital Read/Write	digitalRead, digitalWrite, pinMode
38	Digital Read/Write	digitalRead, digitalWrite, pinMode
39	Digital Read/Write	digitalRead, digitalWrite, pinMode
40	Digital Read/Write	digitalRead, digitalWrite, pinMode
41	Digital Read/Write	digitalRead, digitalWrite, pinMode
42	Digital Read/Write	digitalRead, digitalWrite, pinMode
43	Digital Read/Write	digitalRead, digitalWrite, pinMode
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97	Digital Read/Write	digitalRead, digitalWrite, pinMode
98	Digital Read/Write	digitalRead, digitalWrite, pinMode
99	Digital Read/Write	digitalRead, digitalWrite, pinMode
100	Digital Read/Write	digitalRead, digitalWrite, pinMode
101	D	

Teensy® 4.0 Back Side

Additional pins and features available on the back side

The diagram illustrates the back side of the Teensy 4.0 microcontroller board, showing various pin headers and their functions. The pins are numbered 24 through 33, and the board features several functional blocks and connectors.

Pin Headers and Functions:

- 24:** PWM
- 25:** SCL2
- 26:** TX6
- 27:** A10
- 28:** MOSI1
- 29:** A12
- 30:** RX7
- 31:** CRX3
- 32:** OUT1B
- 33:** CTX3
- 34:** MCLK2
- 35:** SCK1
- 36:** PWM
- 37:** PWM
- 38:** PWM
- 39:** PWM

Other Features and Connectors:

- On/Off Program GND 3.3V VBat:** Buttons for power control.
- USB:** USB Type-C connector.
- D- D+:** USB data pins.
- Use 3V coin cell for Date & Time and power management features:** A coin cell battery holder.
- SD Card (4 bit SDIO):** SD Library, `SD.begin(BUILTIN_SD_CARD)`.
- USB Host:** USBHost_v36 Library.
- Teensy 4.0 signal pins are not 5V tolerant. Do not apply more than 3.3 volts to any pin, except VIN or VUSB.**

Pin Header Details:

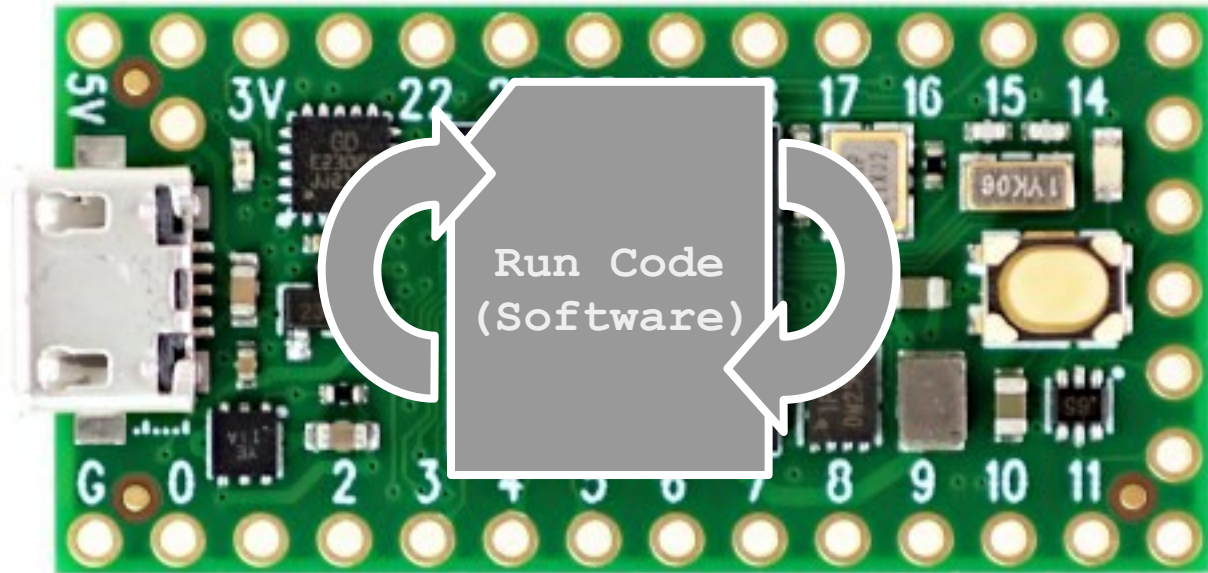
- 24-33:** 24, 25, 26, 27, 28, 29, 30, 31, 32, 33
- 34-39:** 34, 35, 36, 37, 38, 39
- 40-45:** 40, 41, 42, 43, 44, 45
- 46-51:** 46, 47, 48, 49, 50, 51
- 52-57:** 52, 53, 54, 55, 56, 57
- 58-63:** 58, 59, 60, 61, 62, 63
- 64-69:** 64, 65, 66, 67, 68, 69
- 70-75:** 70, 71, 72, 73, 74, 75
- 76-81:** 76, 77, 78, 79, 80, 81
- 82-87:** 82, 83, 84, 85, 86, 87
- 88-93:** 88, 89, 90, 91, 92, 93
- 94-99:** 94, 95, 96, 97, 98, 99
- 100-105:** 100, 101, 102, 103, 104, 105
- 106-111:** 106, 107, 108, 109, 110, 111
- 112-117:** 112, 113, 114, 115, 116, 117
- 118-123:** 118, 119, 120, 121, 122, 123
- 124-129:** 124, 125, 126, 127, 128, 129
- 130-135:** 130, 131, 132, 133, 134, 135
- 136-141:** 136, 137, 138, 139, 140, 141
- 142-147:** 142, 143, 144, 145, 146, 147
- 148-153:** 148, 149, 150, 151, 152, 153
- 154-159:** 154, 155, 156, 157, 158, 159
- 160-165:** 160, 161, 162, 163, 164, 165
- 166-171:** 166, 167, 168, 169, 170, 171
- 172-177:** 172, 173, 174, 175, 176, 177
- 178-183:** 178, 179, 180, 181, 182, 183
- 184-189:** 184, 185, 186, 187, 188, 189
- 190-195:** 190, 191, 192, 193, 194, 195
- 196-201:** 196, 197, 198, 199, 200, 201
- 202-207:** 202, 203, 204, 205, 206, 207
- 208-213:** 208, 209, 210, 211, 212, 213
- 214-219:** 214, 215, 216, 217, 218, 219
- 220-225:** 220, 221, 222, 223, 224, 225
- 226-231:** 226, 227, 228, 229, 230, 231
- 232-237:** 232, 233, 234, 235, 236, 237
- 238-243:** 238, 239, 240, 241, 242, 243
- 244-249:** 244, 245, 246, 247, 248, 249
- 250-255:** 250, 251, 252, 253, 254, 255
- 256-261:** 256, 257, 258, 259, 260, 261
- 262-267:** 262, 263, 264, 265, 266, 267
- 268-273:** 268, 269, 270, 271, 272, 273
- 274-279:** 274, 275, 276, 277, 278, 279
- 280-285:** 280, 281, 282, 283, 284, 285
- 286-291:** 286, 287, 288, 289, 290, 291
- 292-297:** 292, 293, 294, 295, 296, 297
- 298-303:** 298, 299, 300, 301, 302, 303
- 304-309:** 304, 305, 306, 307, 308, 309
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- 448-453:** 448, 449, 450, 451, 452, 453
- 454-459:** 454, 455, 456, 457, 458, 459
- 460-465:** 460, 461, 462, 463, 464, 465
- 466-471:** 466, 467, 468, 469, 470, 471
- 472-4**

See also: <https://www.pjrc.com/store/teensy40.html>

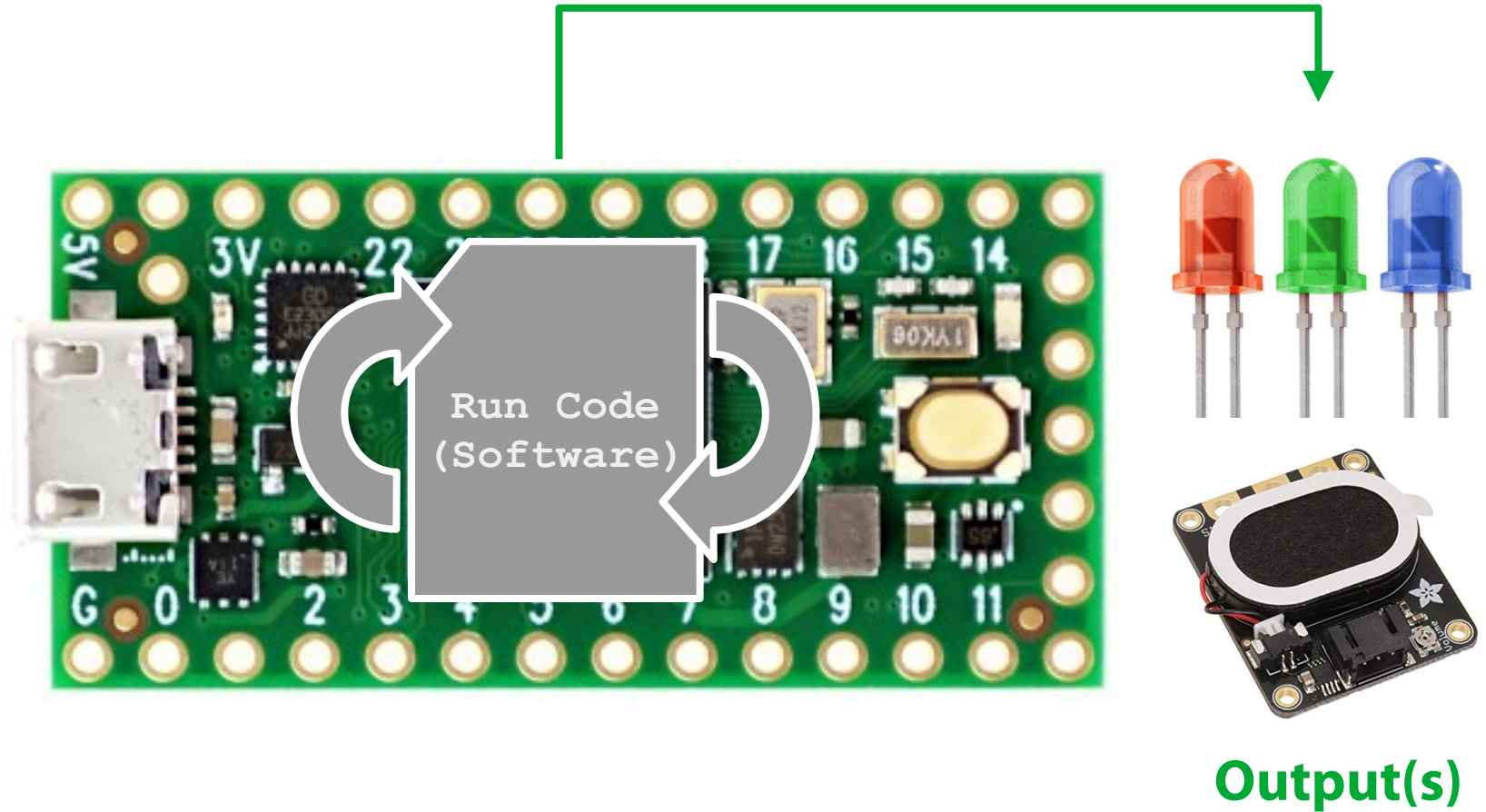
What is it good for?



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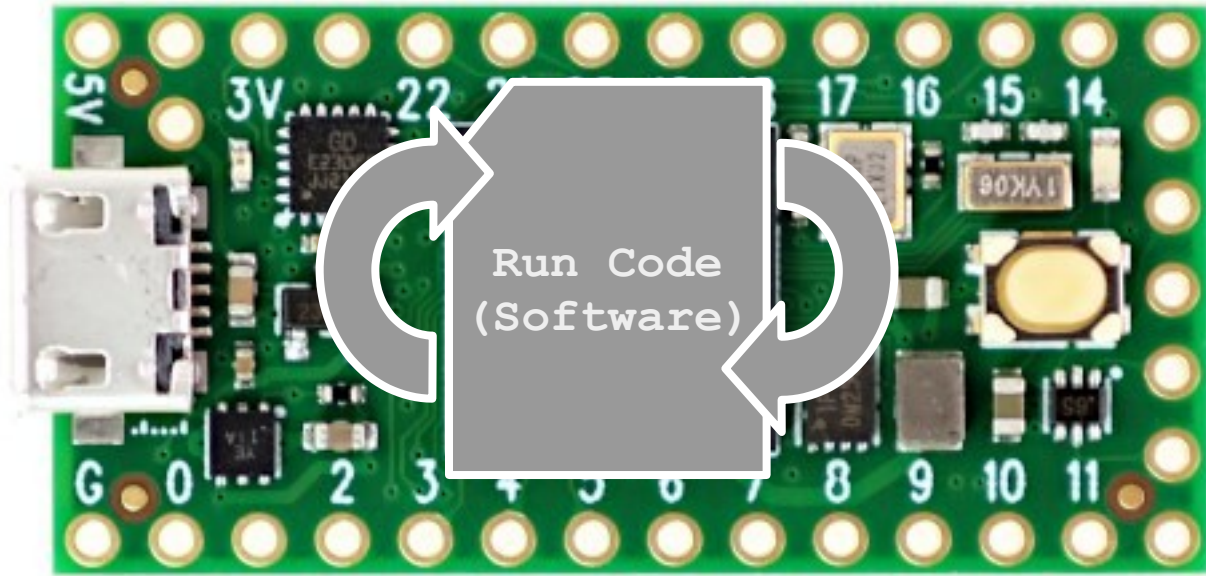


What is it good for?



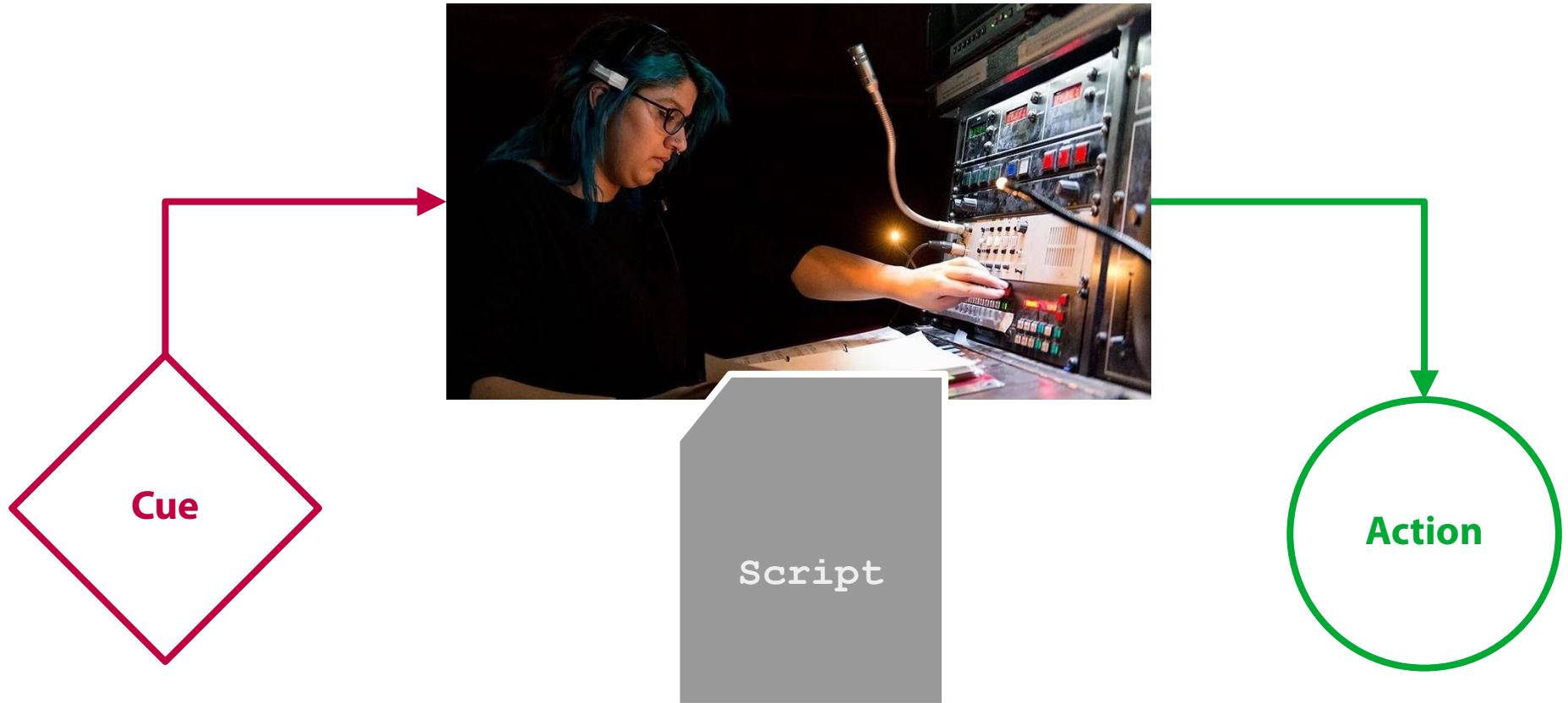
What is it good for?

Input(s)

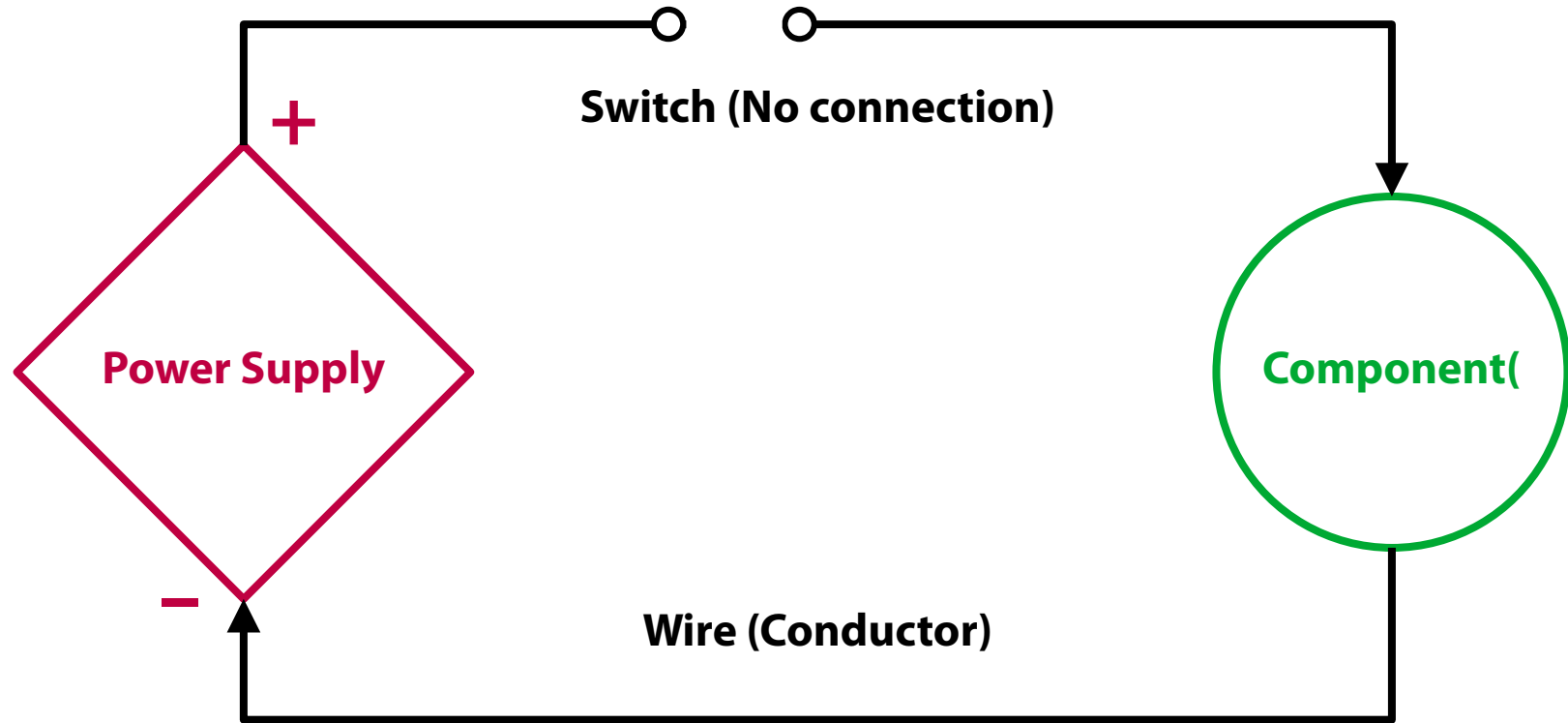


Output(s)

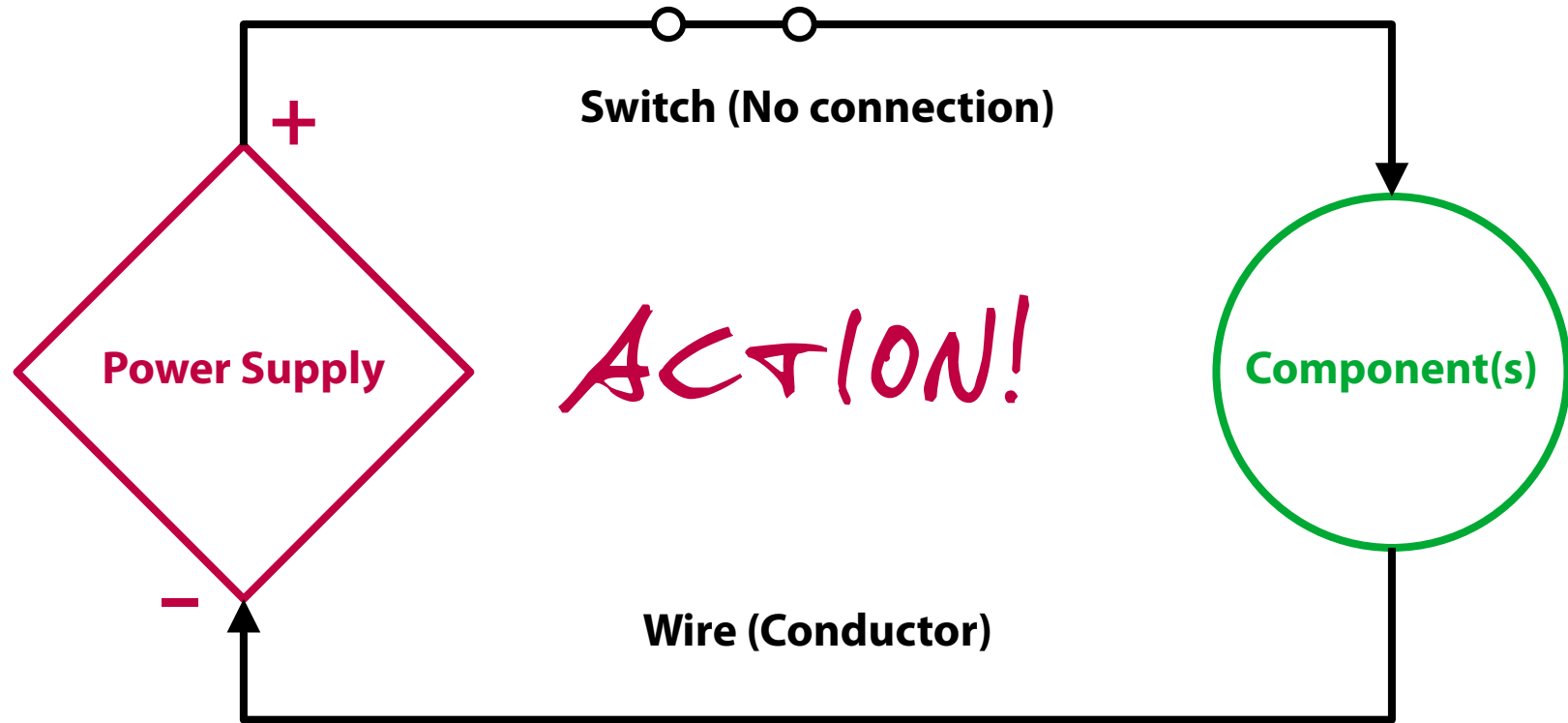
Imagine it as an electronic stage manager



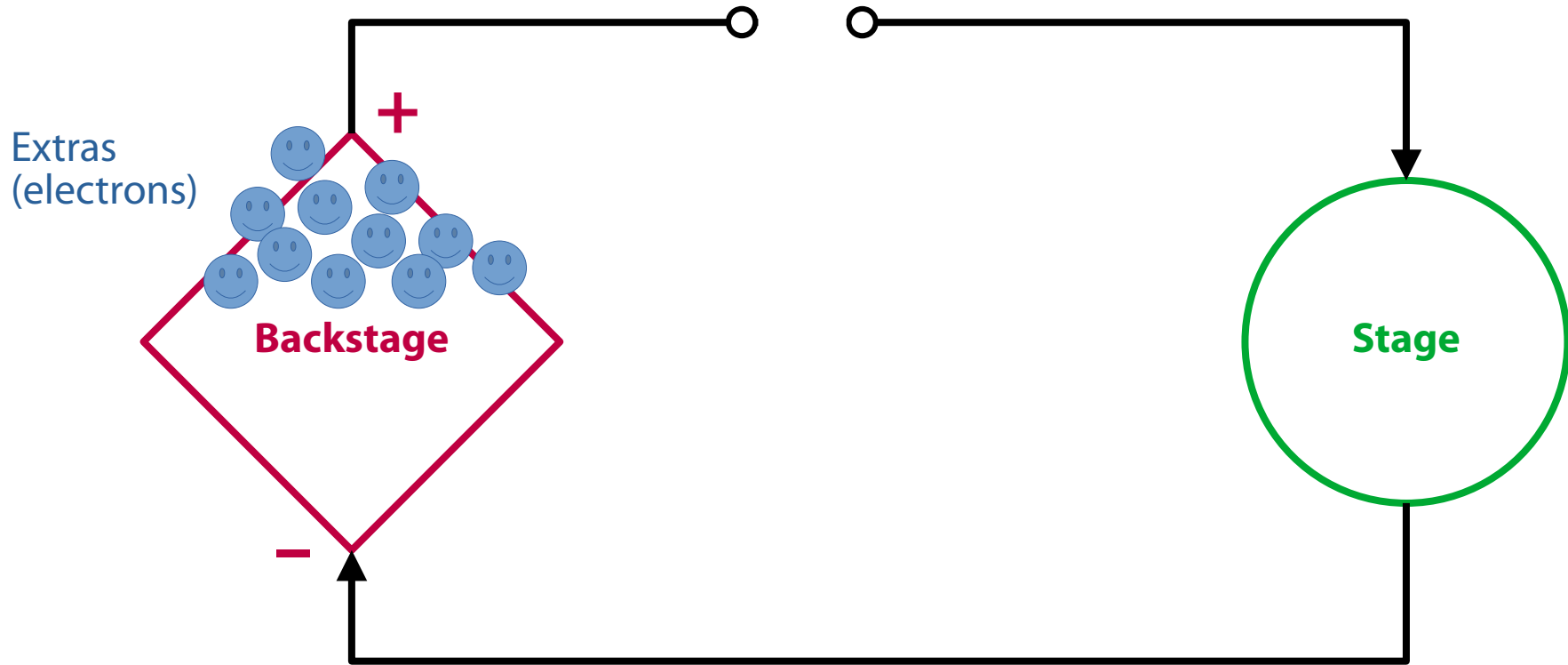
Basics: electronics in 30 seconds



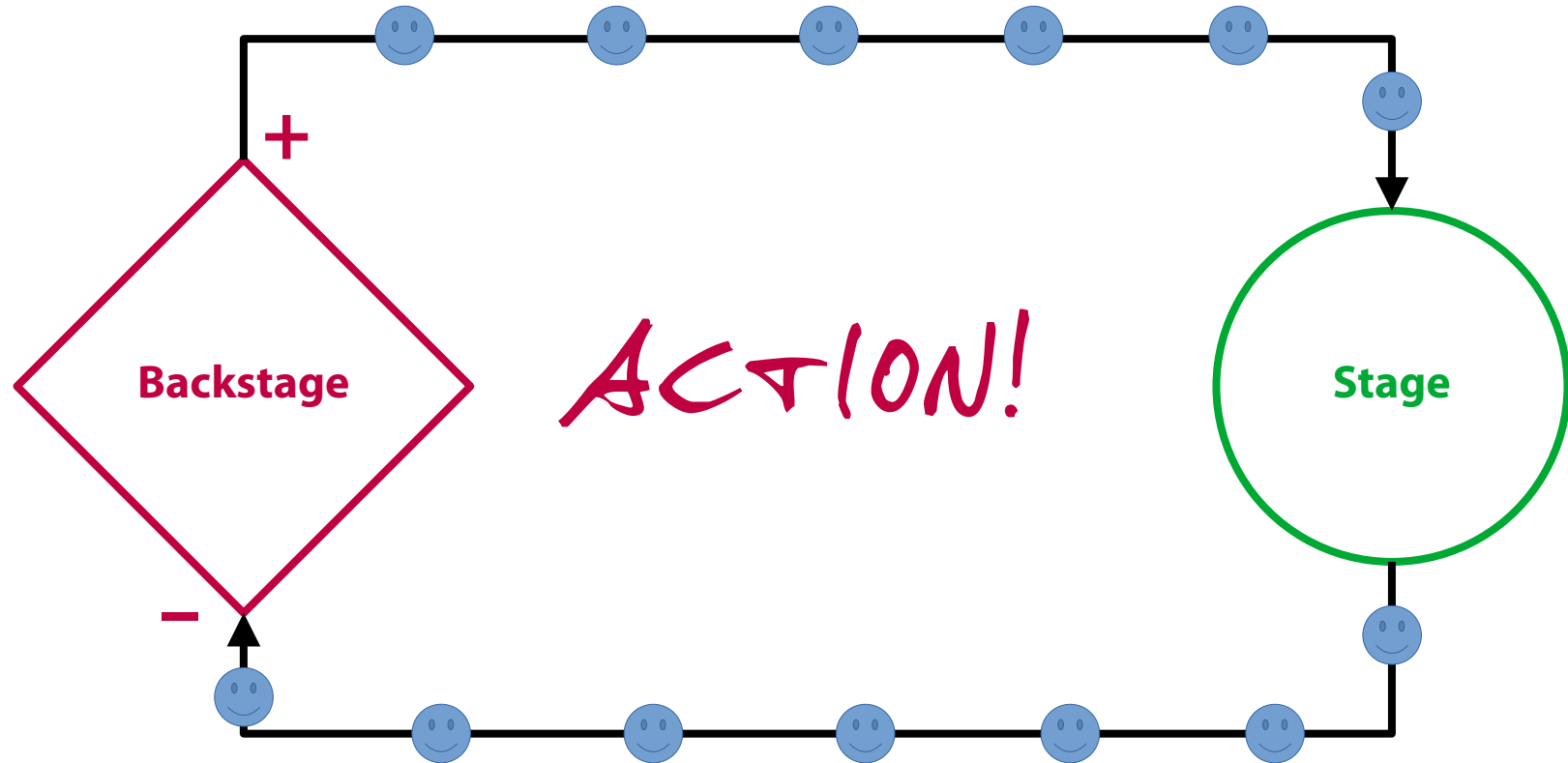
Basics: electronics in 30 seconds



Basics: electronics in 30 seconds



Basics: electronics in 30 seconds



Absolute basics – (almost) all you need to know

- electrons:
 - Want to get to their final destination as fast as possible (final destination = – (minus), ground, etc.)
 - Provide power to components (if they lie between source and ground)
- Voltage:
 - Max. amount of electrons which could move through the wire (e.g. potential)
- Current:
 - How many electrons are moving through a given point

STAGE MAGIC

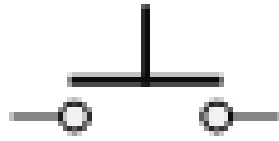
- EXTRAS
 - Want to get to the end of their shift as fast as possible
 - Move stuff around if it happens to be on their way
- PAYROLL
 - Max. number of extras the production can pay for
- POWER OF THE MASSES
 - How many extras are moving through a given tight spot

Circuits: stages for electrons

- Electrons always take the path of least resistance
- They move with the speed of light (i.e. when the curtain opens, they are all on their places)
- Energy is transferred to the components by electrons

Common components

- Resistors
- LEDs – light emitting diodes
- Buttons and switches
- capacitors
- Transistors (MOSFETs)
- Magnets, speakers and motors



Buttons, switches



- Opens / Closes the wire
- Usage:
 - As Input
 - Turning stuff on (and off)
- Good to know:
 - High currents can cause flying sparks (fire hazard)
 - Button contacts can bounce when pressed, microcontrollers may count multiple presses – use de-bounce to mitigate





Resistor



- Limits current (electron choke point)
- Usage:
 - Protect components (LEDs)
 - Heating things
 - Reduce voltage
- Good to know:
 - Power creates heat, resistors may get hot!

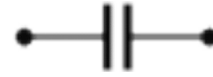


(Light emitting) diode

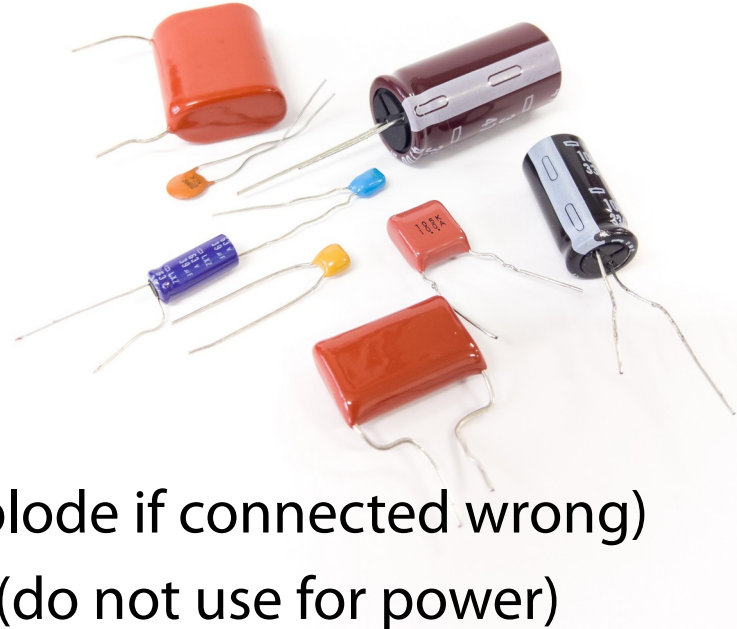
- All diodes are one way streets for electrons
- LEDs make light
- Usage:
 - Protect from wrong polarity
 - As light source, indicators (LEDs)
- Good to know:
 - LEDs can only take a limited current (need resistors)
 - Diodes cause voltage drop (usually $\sim 0.7V$)

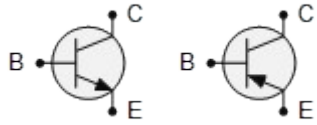


Capacitor

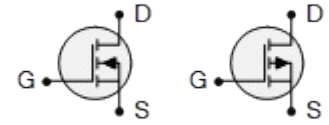


- (Very small) voltage storage
- Usage:
 - Smooth over voltage peaks
 - Frequency filters
- Good to know:
 - Electrolytic capacitors have a polarity (explode if connected wrong)
 - Discharge is not linear, voltage drops fast (do not use for power)
 - Exception: High capacity gold caps (not part of this course)

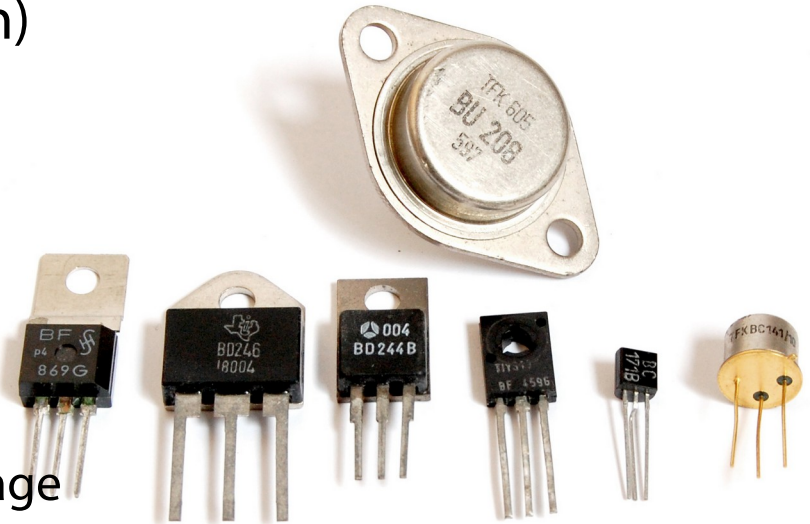




Transistors, MOSFETs



- Electronically controlled resistor (or switch)
- Usage:
 - As amplifier
 - As switch
 - For power drivers
- Good to know:
 - There are many types, depending on the usage
 - Very common component in chips (ie. Integrated circuits) like microcontrollers, processors, amps etc.
 - Use as discrete component mainly as power driver (MOSFET) and in audio applications (Synths, Amps etc.)



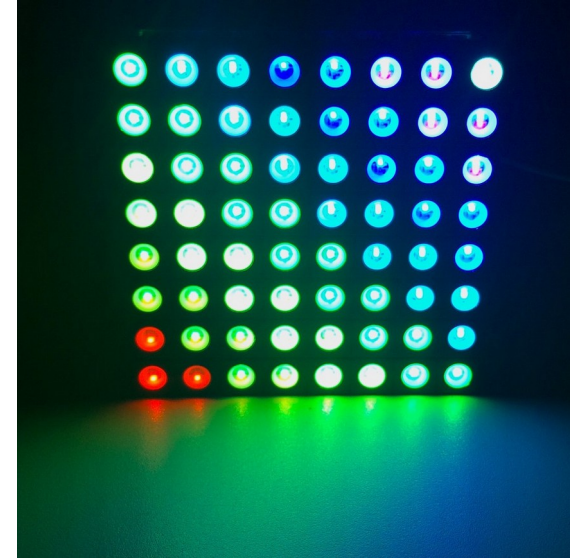
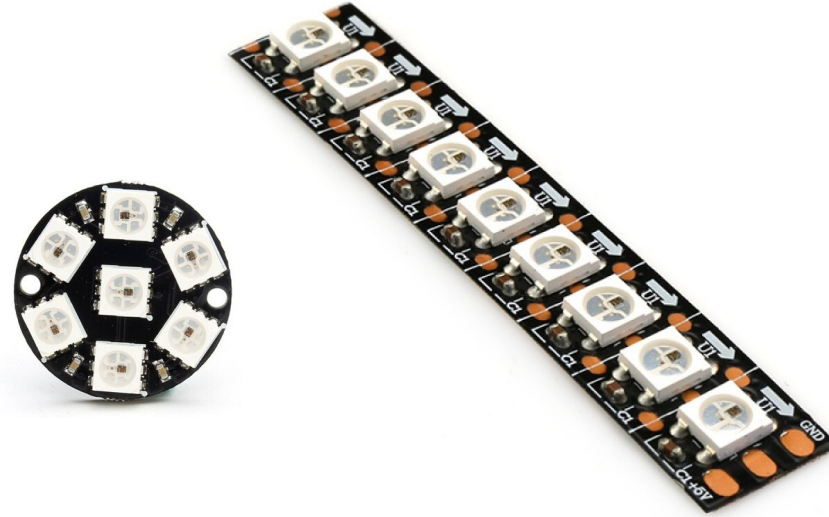
Magnets, speakers, relais, motors

- Move stuff, switch stuff, make a noise
- Usage:
 - Many
- Good to know:
 - Motors (and magnets in general) can generate electricity – need protective circuit
 - Electromagnets are basically very long wires, ie. resistors. They may use a lot of power.
 - Always use power drivers for electromagnetic components. Microcontrollers can't handle the power requirements!



Programmable RGB(W)-LEDs

- Fast changing colored lights
- Usage:
 - Many
- Good to know:
 - Actually 3-4 LEDs and a controller in one package
 - Many boards, matrices and flexible coils available
 - Only need one line for communication
 - Can be daisy-chained – one microcontroller pin can control hundreds of LEDs



We'll be back after the break!