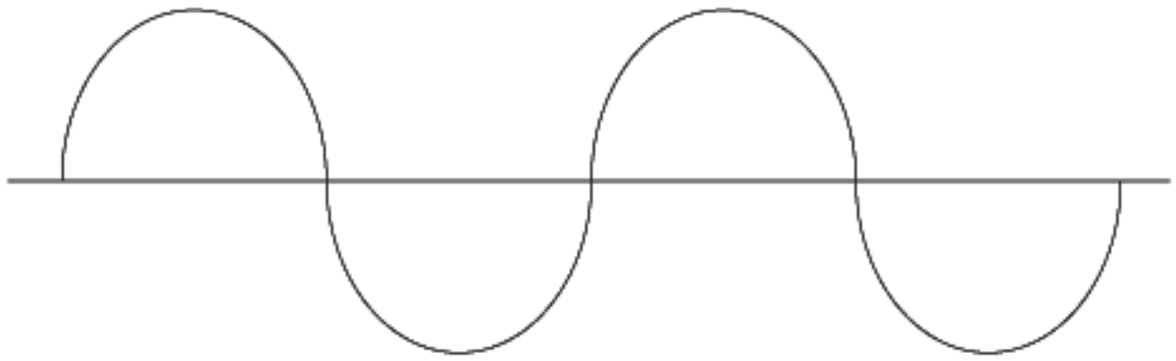
Lecture #2
Basic Electronics
Developer Platform

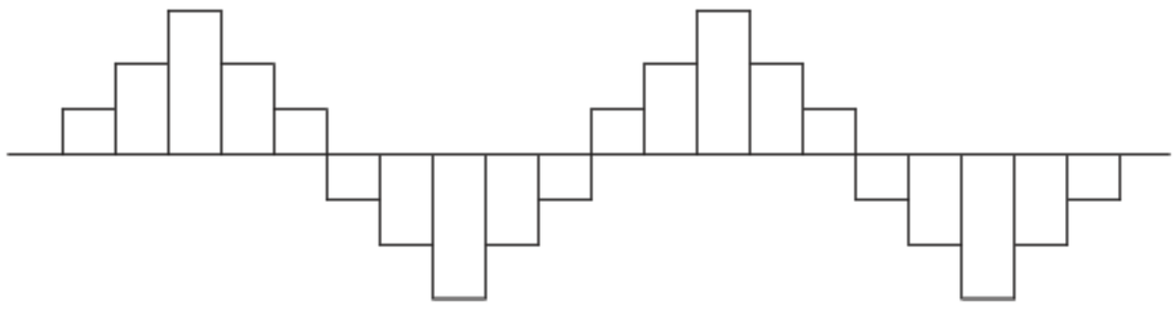
Android Things 2020

Signals

Analog



Digital



Analog and Digital

- We can store only digital signal.
  - We will convert everything that is analog to digital.
- When reading or writing digital signals we need to establish values for:
  - Bits per sample.
  - Sampling rate.

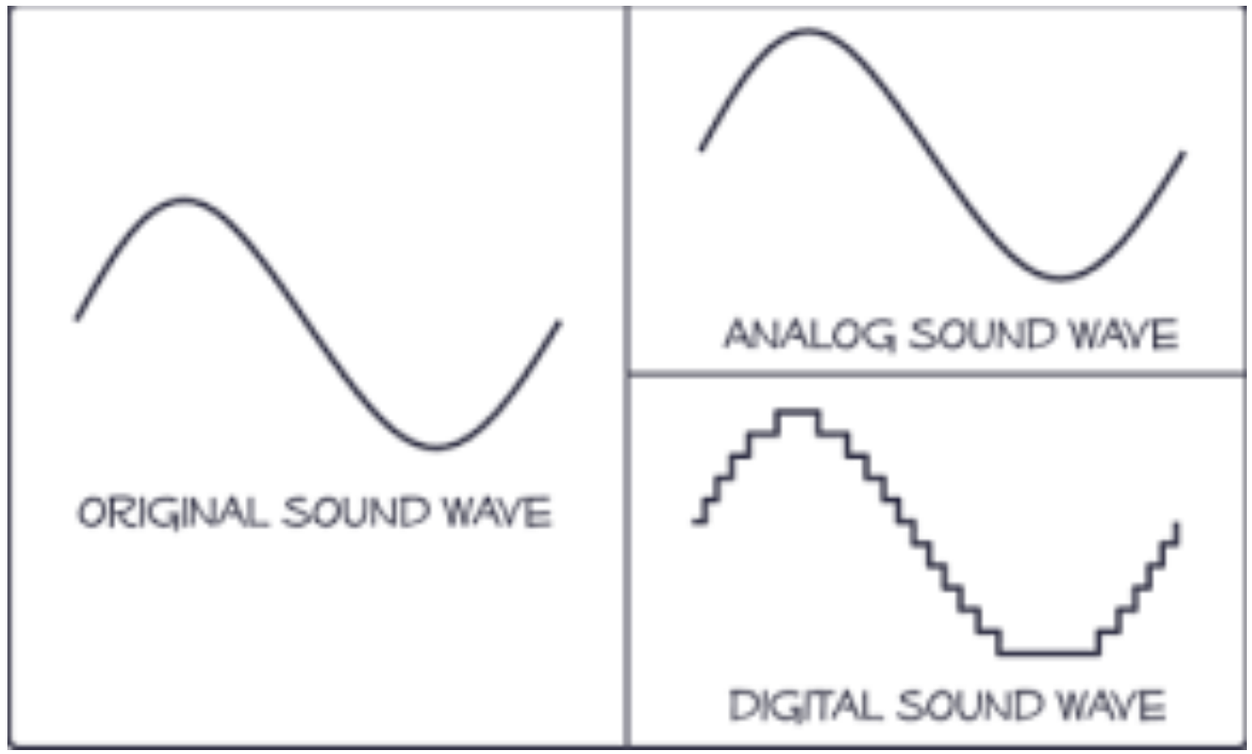
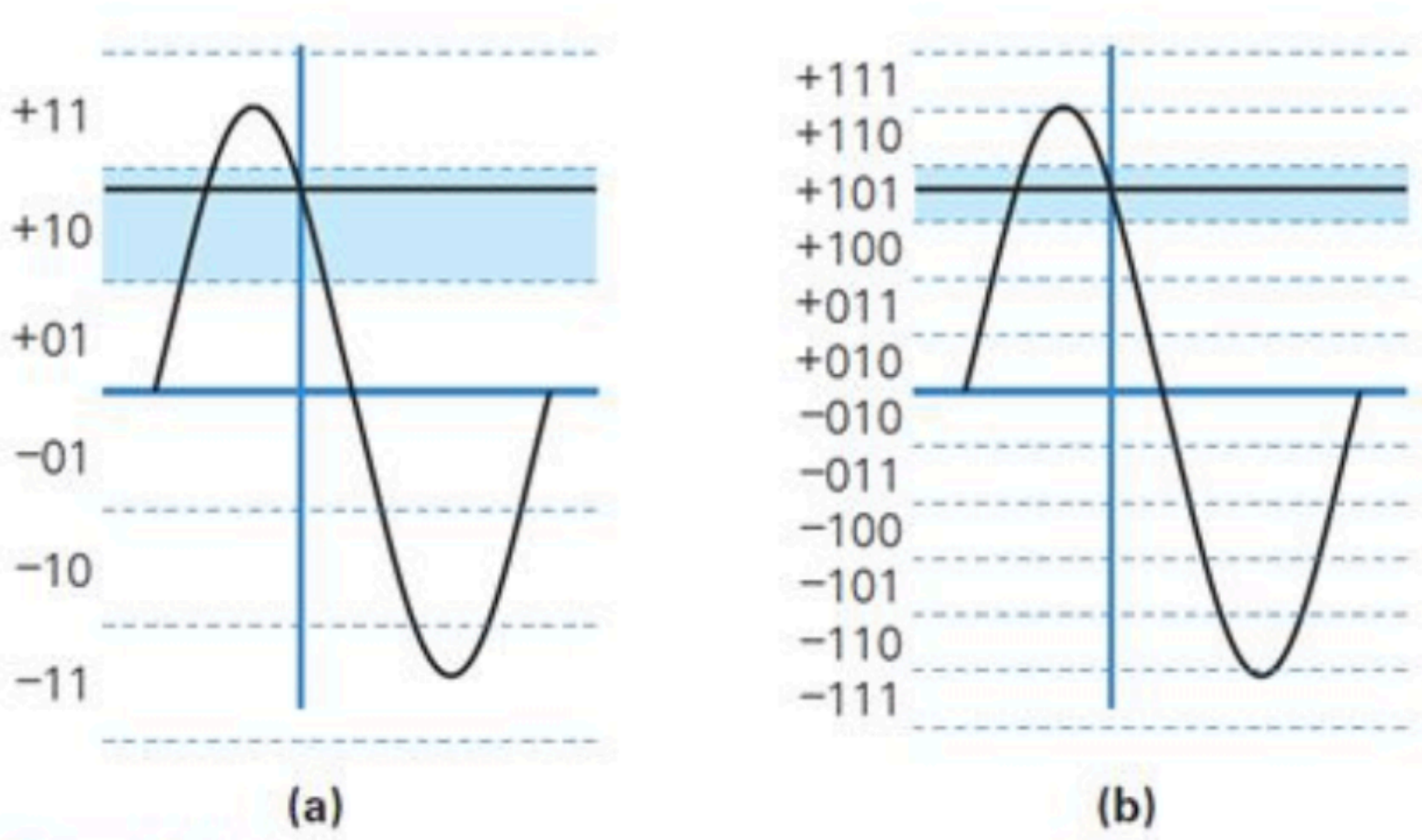


Image source: www.electronicproducts.com

Bits per sample

- How many bits are used to represent a value.

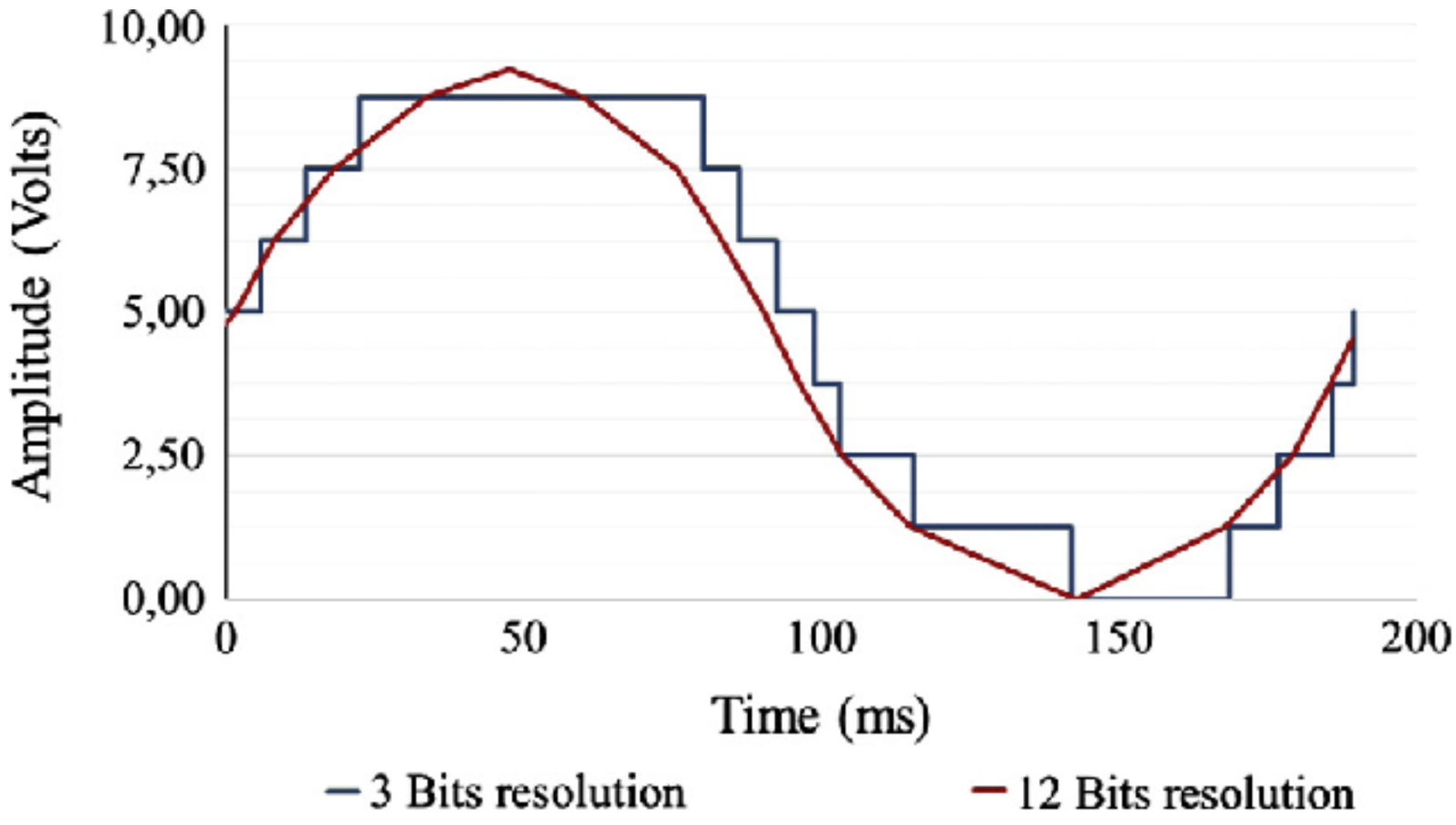


Bits per sample

- For **n** bits:
  - Values will range between 0 and 2^n - 1.
  - Eg. for 3 bits we will have:
    - 000 - 0
    - 001 - 1
    - 010 - 2
    - 011 - 3
    - 100 - 4
    - 101 - 5
    - 110 - 6
    - 111 - 7

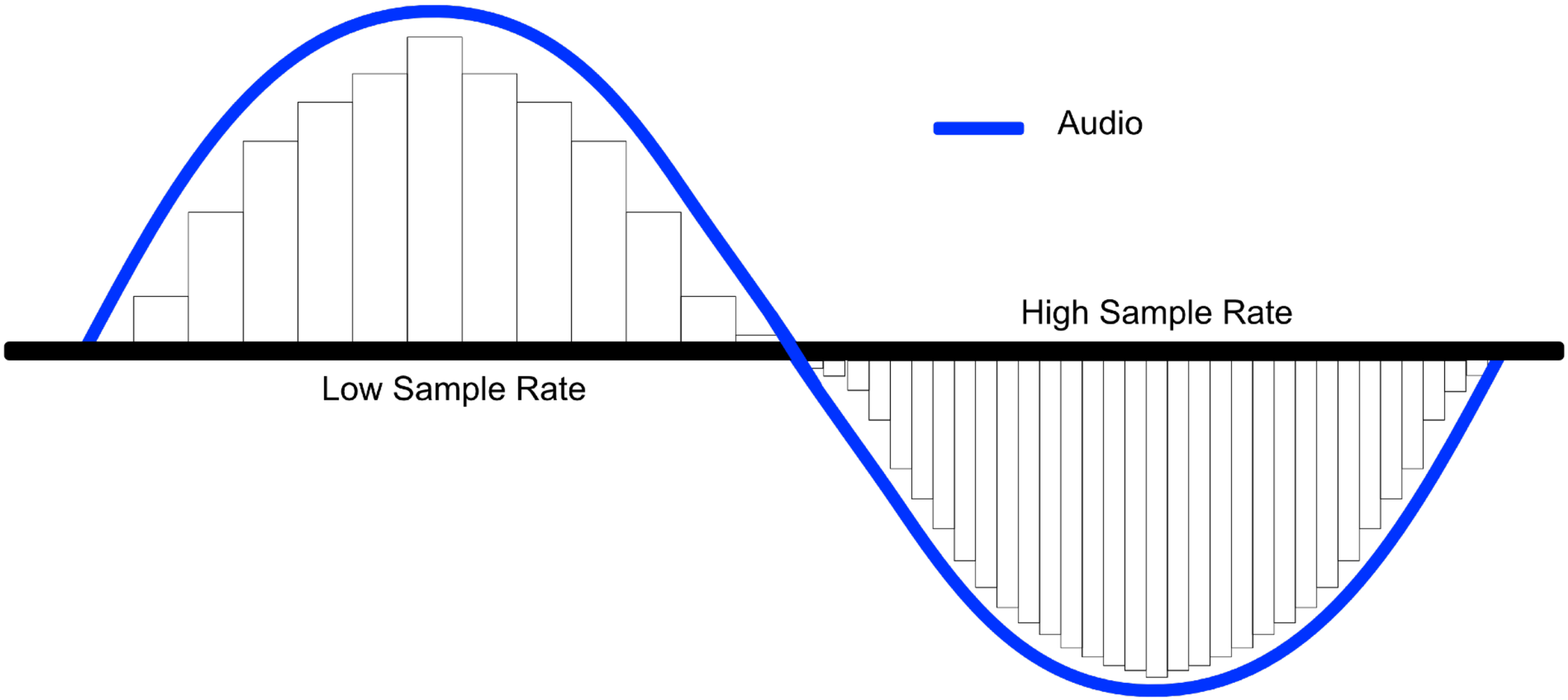
Source: etowns

Bits per sample

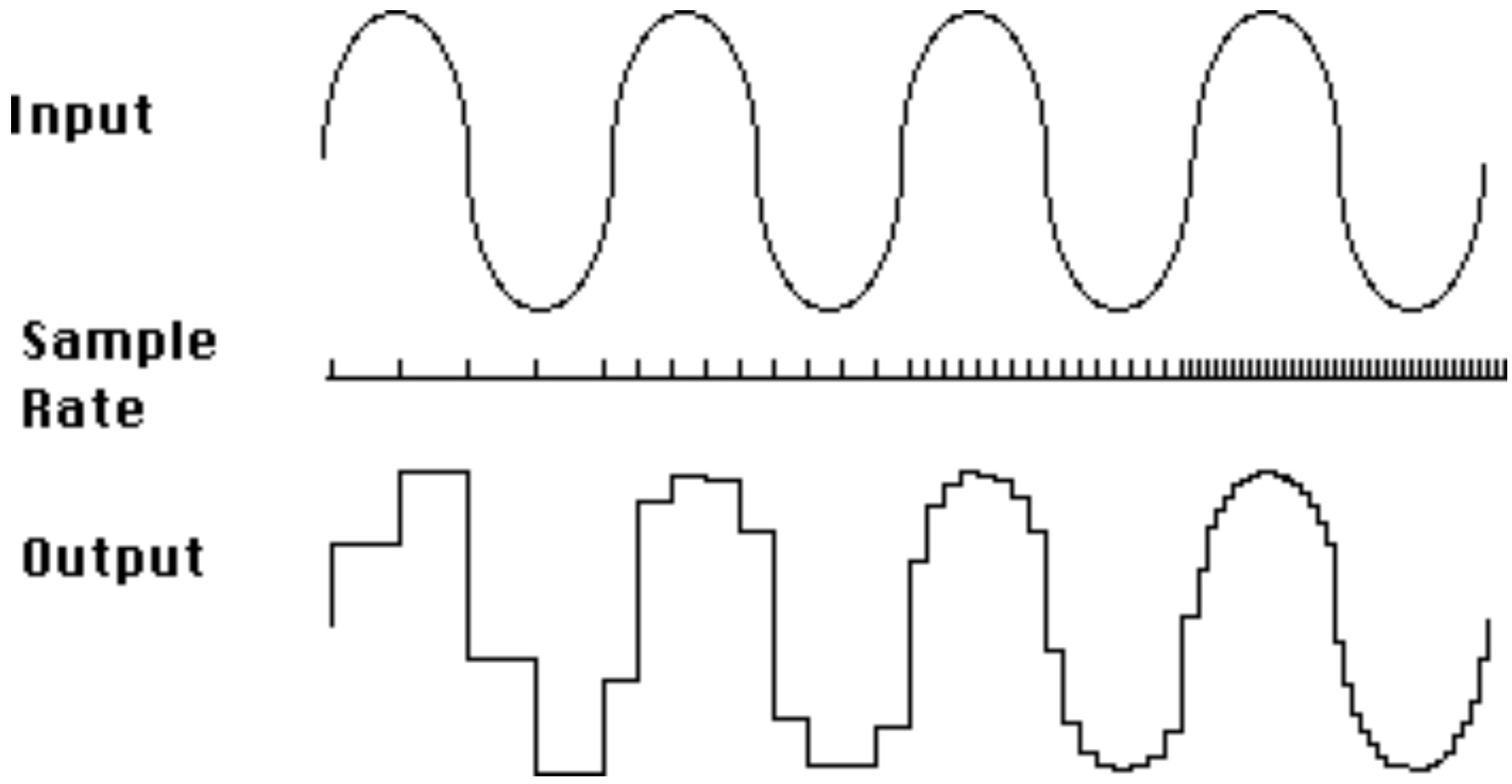


Sampling

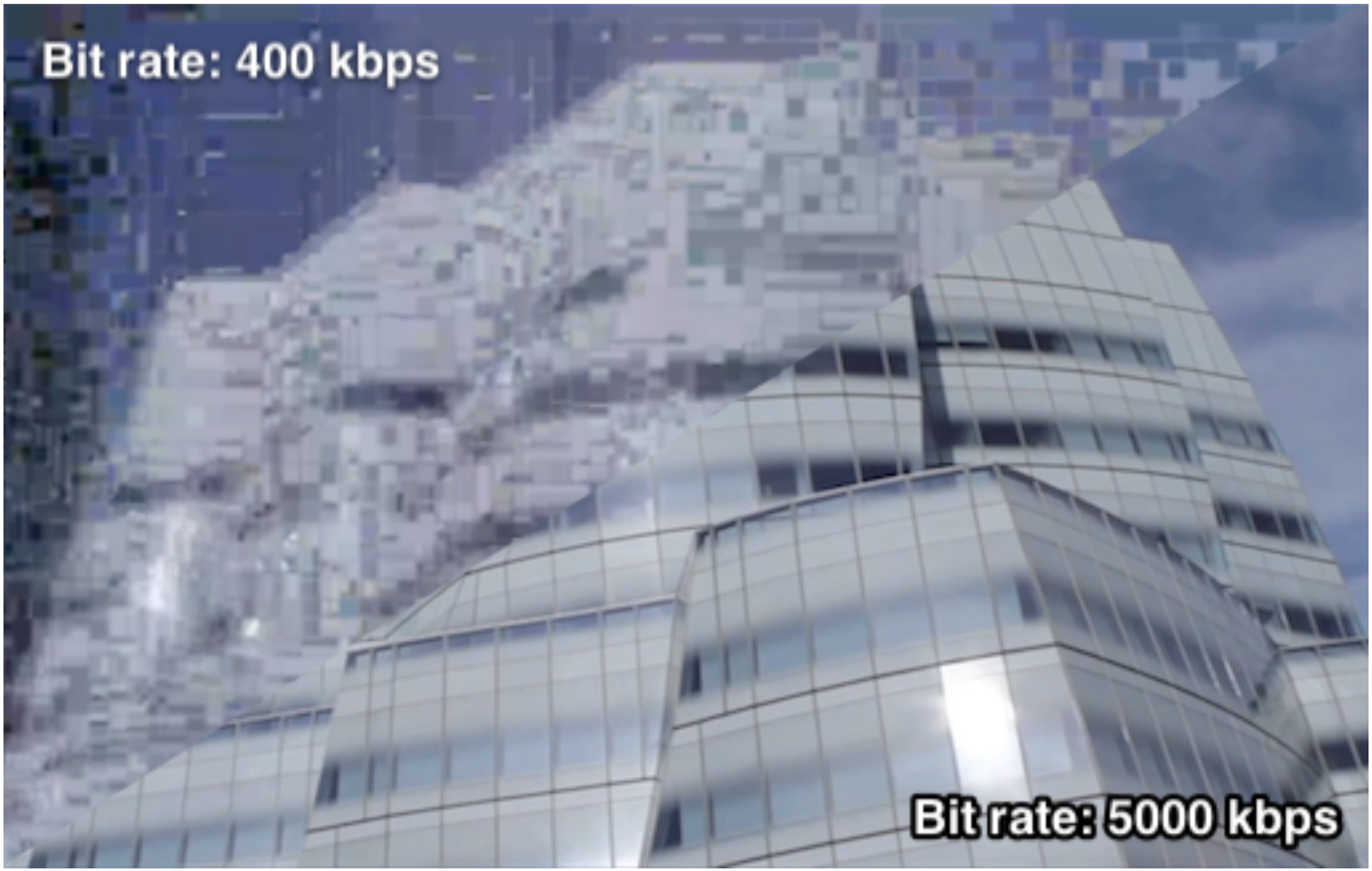
- Make measurements



Sampling



Sampling



Frequency

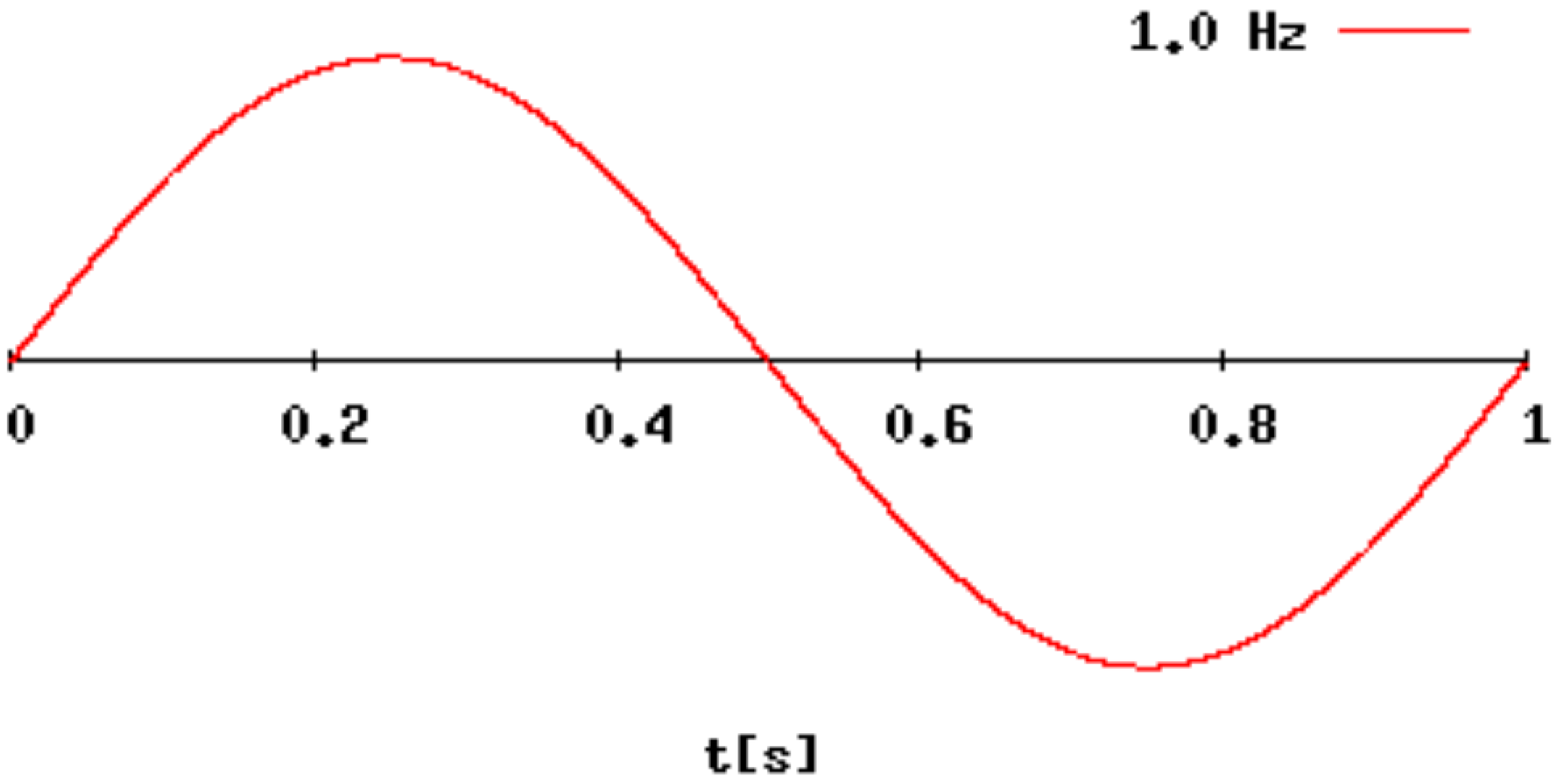
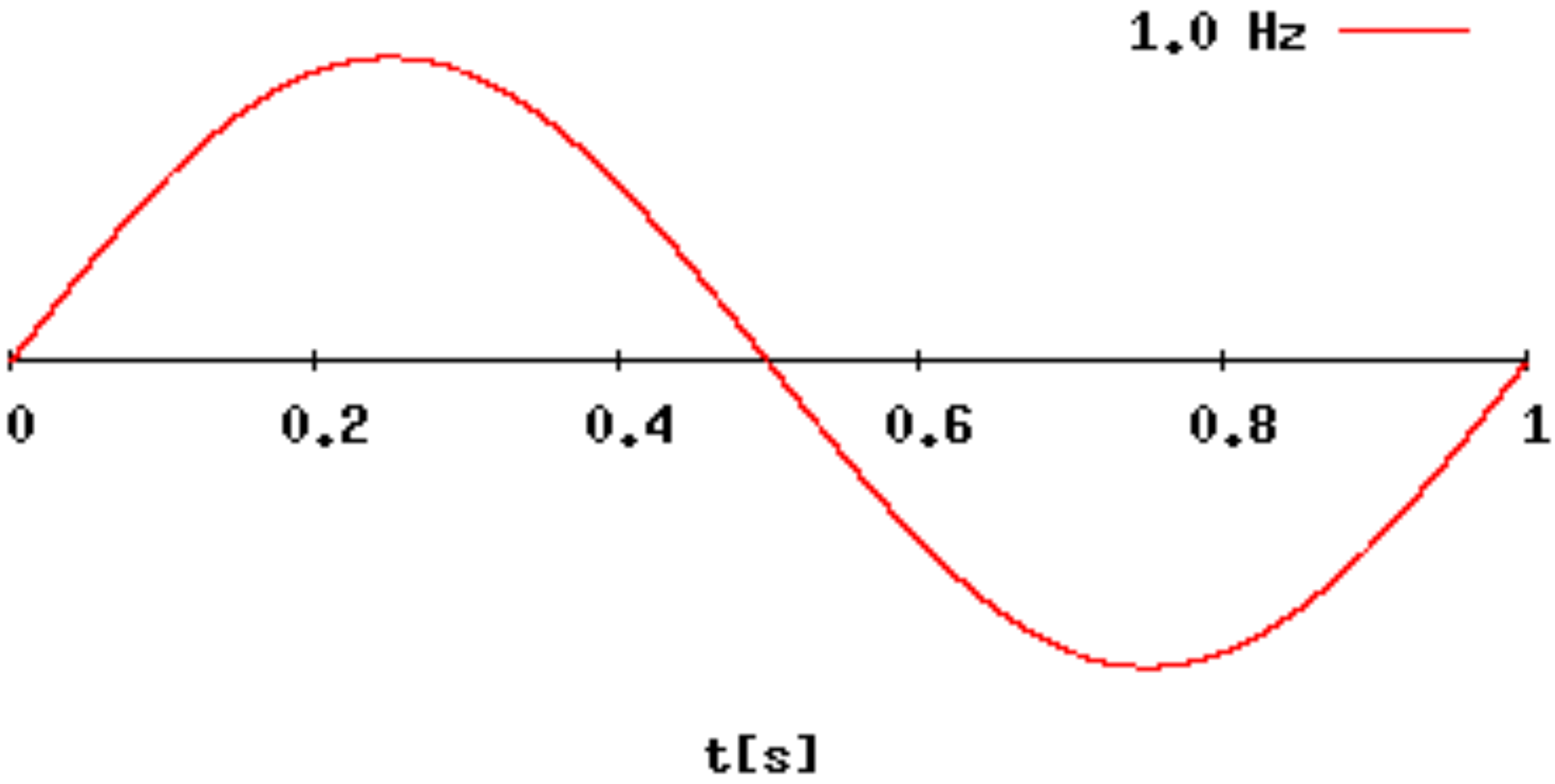


Image source: https://commons.wikimedia.org/wiki/File:Wave_frequency.gif

Frequency



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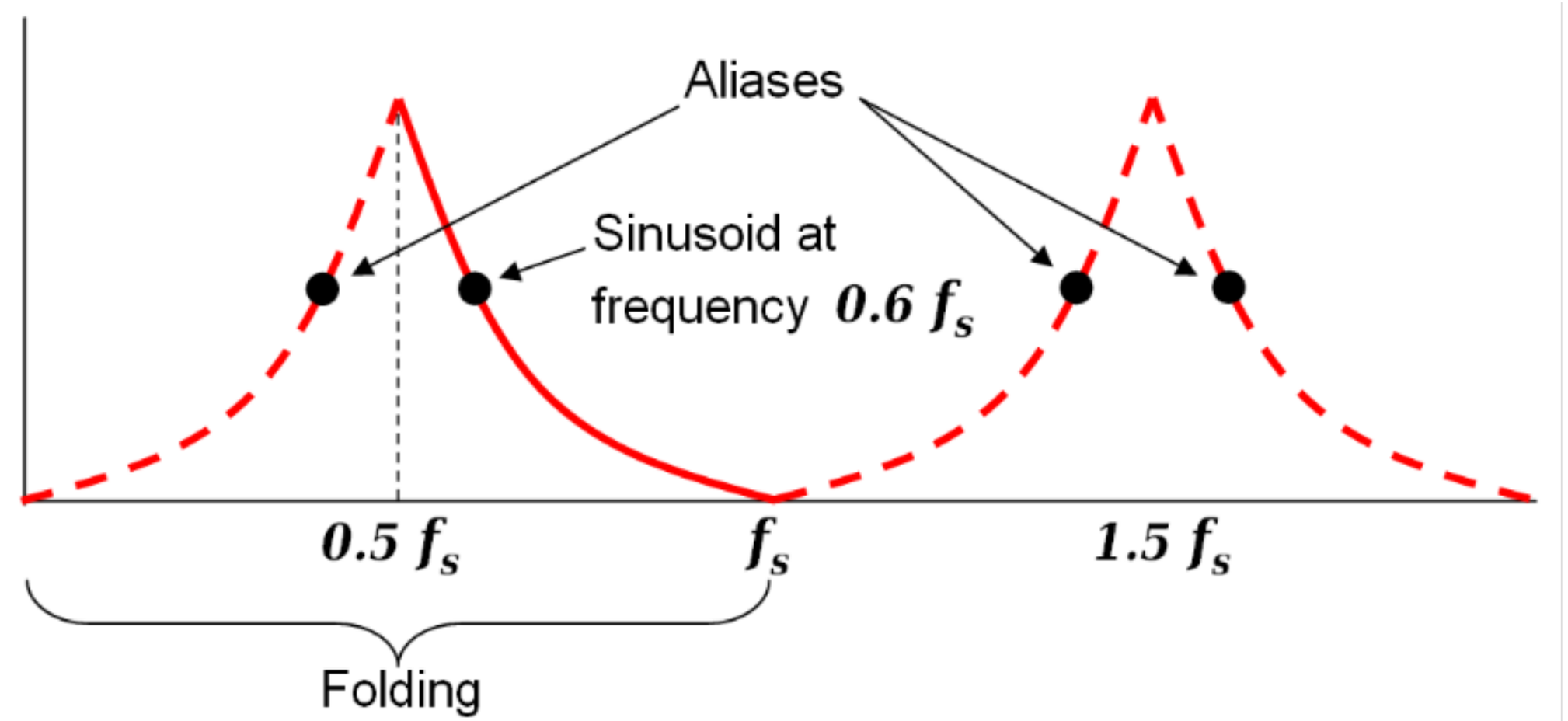
Sampling Rate

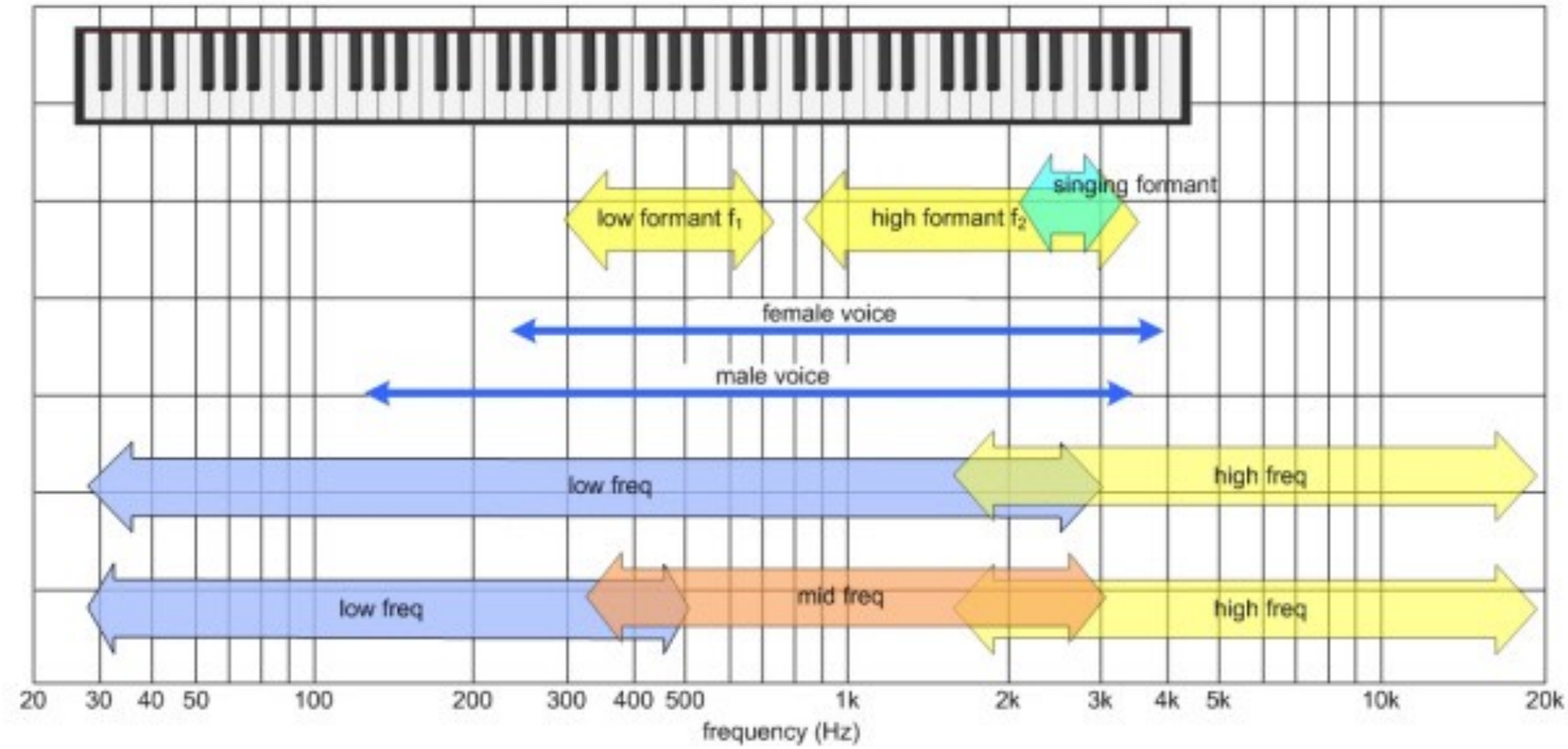
- Nyquist Theorem: Sampling rate >= 2*max frequency



https://whatis.techtarget.com/definition/Nyquist-Theorem

Voice Frequency

- Human audible range:
  - 20 Hz to 20KHz.



Titze, I.R. (1994). Principles of Voice Production, Prentice Hall (pp. 188), ISBN 978-0-13-717893-3.

Voice Frequency

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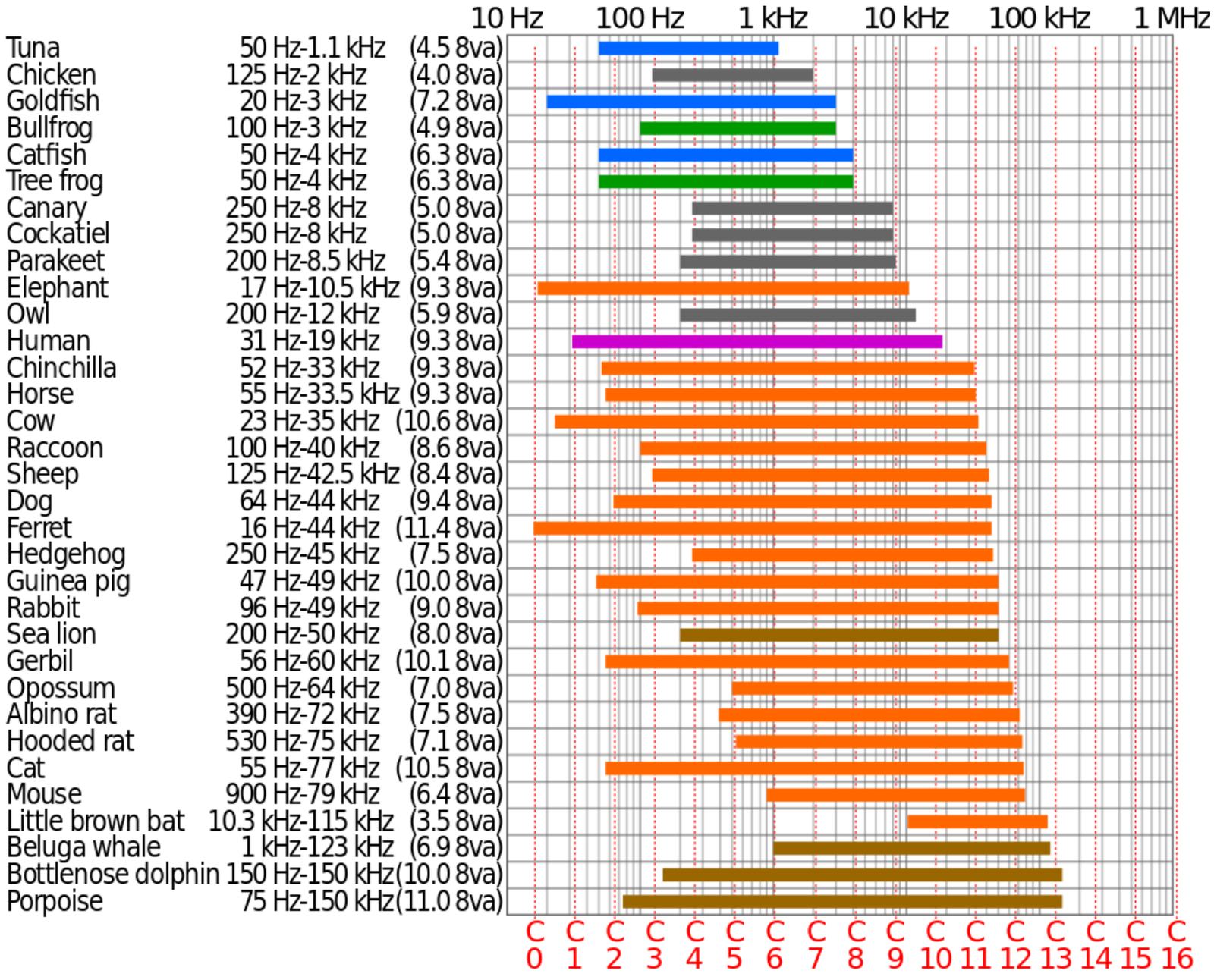

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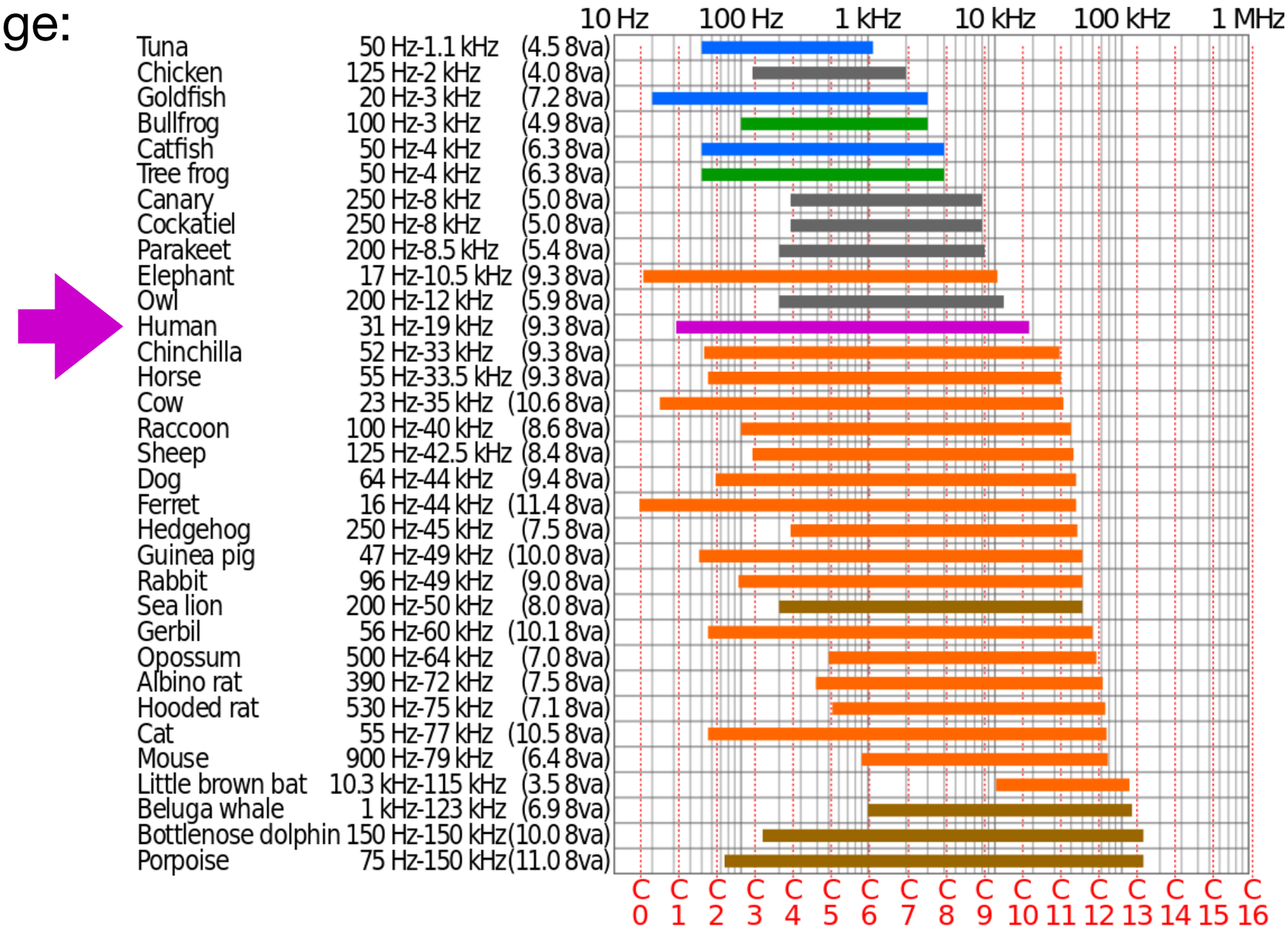

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Voice Frequency

Image source: www.proav.de/audio/speech-level.html

Voice Frequency

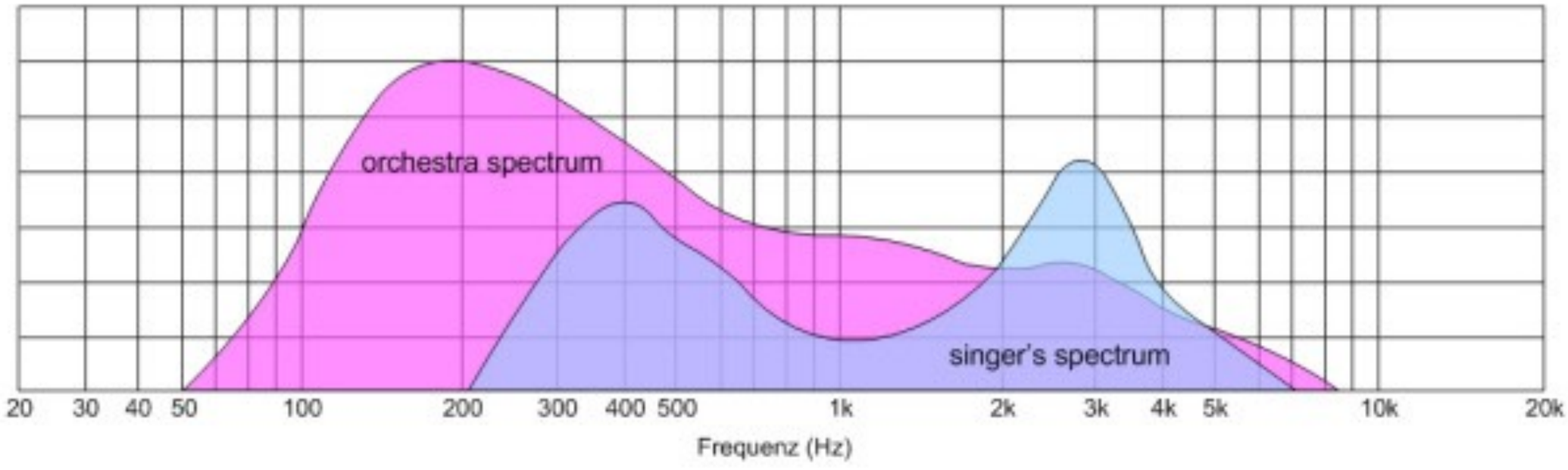

Image source: www.proav.de/audio/speech-level.html

Source: https://www.youtube.com/watch?v=qf97H6cV5QQ

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Voice Frequency

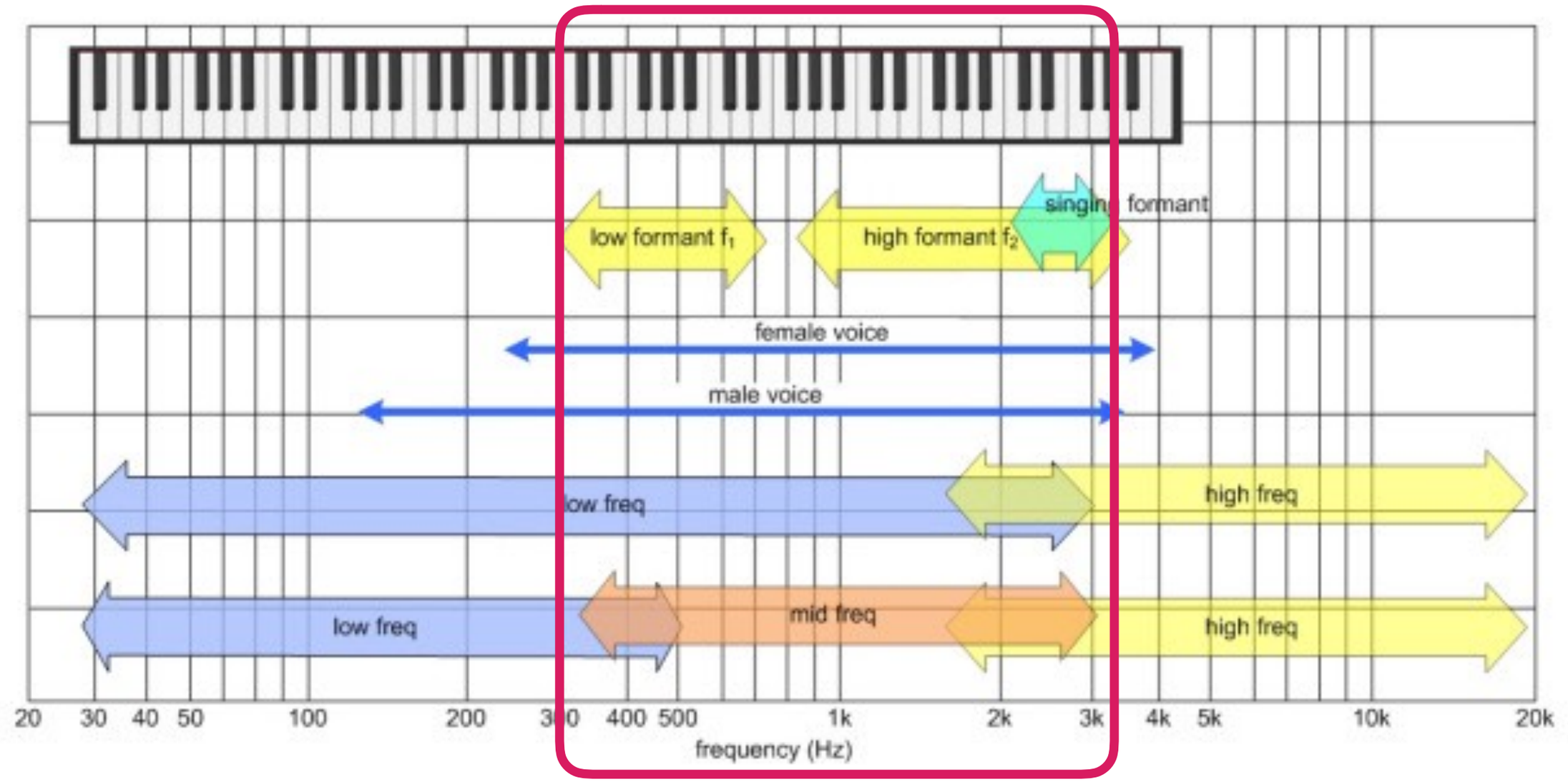

Image source: www.proav.de/audio/speech-level.html

Telephony, voice frequency range: 300Hz to 3400Hz.

Ohm Law

$$I = \frac{V}{R}$$

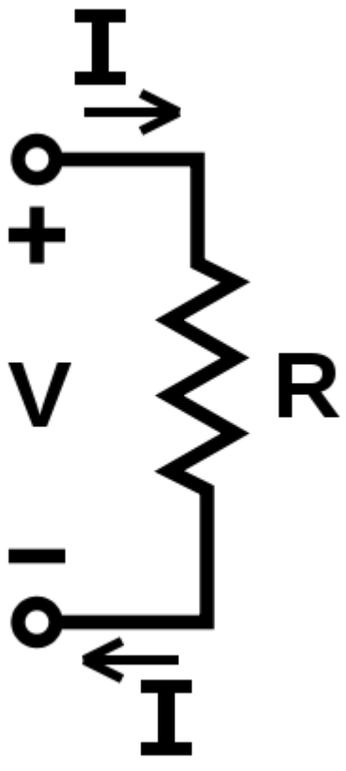

Image source: http://stat.case.edu/~pillar/genealogy/ohm.gif

Ohm Law

Ohm's Law Calculator

*Voltage (V) = Current (I) * Resistance (R)*
*Power (P) = Voltage (V) * Current (I)*

Enter any two known values and press "Calculate" to solve for the others.

Voltage (V)	3.3	Volts (V)
Current (I)	16.5	milliamps (mA)
Resistance (R)	200	ohms (Ω)
Power (P)	0.05445	Watts (W)

Calculate

Click "Calculate" to update the fields with orange borders.

http://www.ohmslawcalculator.com/ohms-law-calculator

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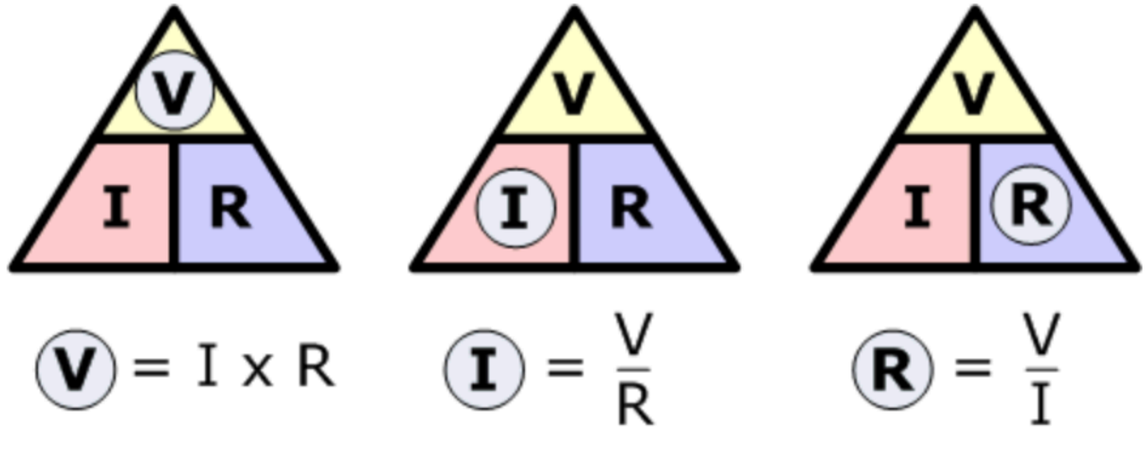
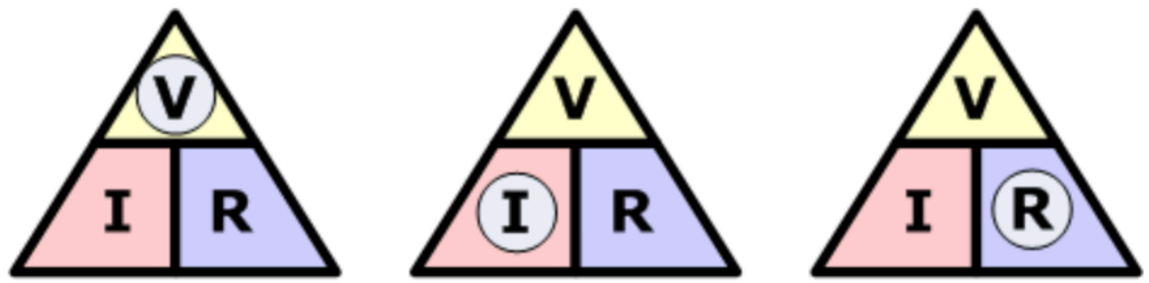


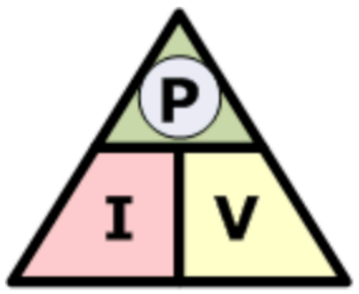
Ohm Law



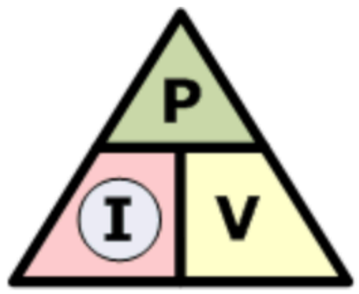
$V = I \times R$

$I = \frac{V}{R}$

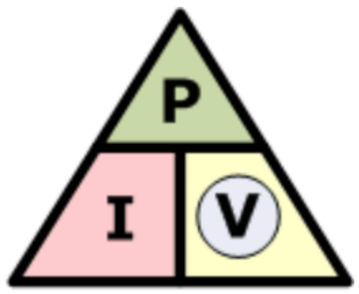
$R = \frac{V}{I}$



$P = I \times V$

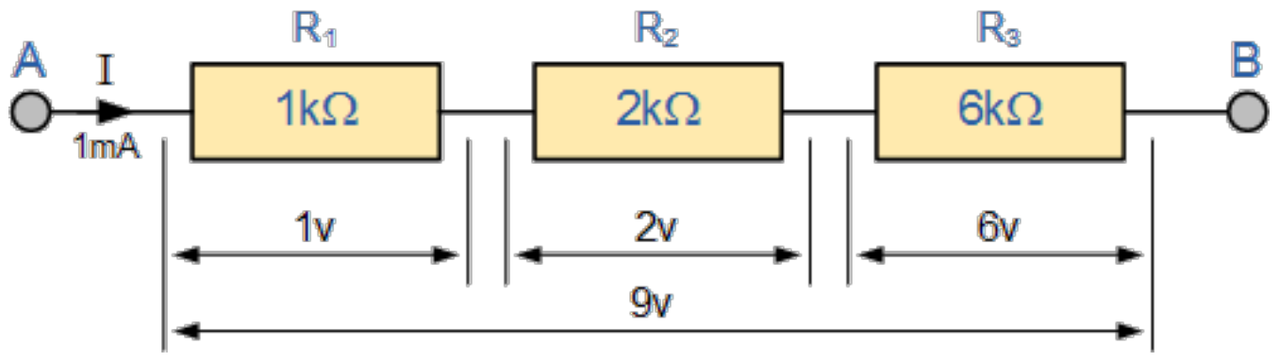


$I = \frac{P}{V}$



$V = \frac{P}{I}$

Resistors in Series

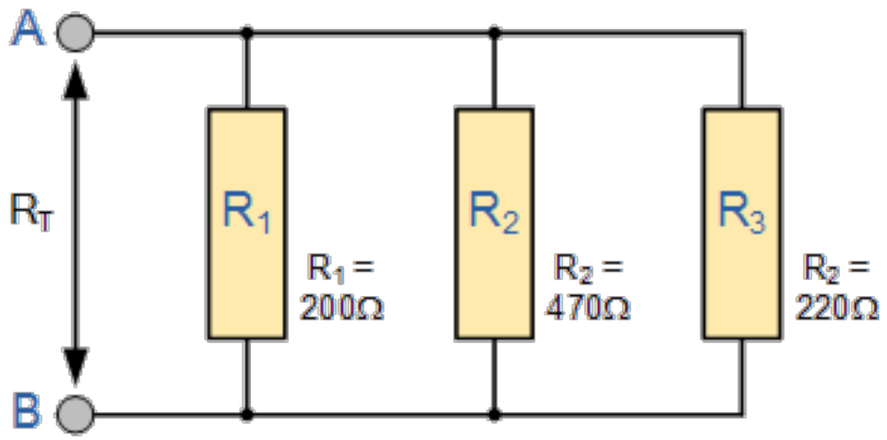


$$R_T = R_1 + R_2 + R_3$$

$R_{EQ} = R_1 + R_2 + R_3 = 1k\Omega + 2k\Omega + 6k\Omega = 9k\Omega$

https://www.electronics-tutorials.ws/resistor/res_3.html

Resistors in Parallel



$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \ldots\ldots + \frac{1}{R_n} \text{ etc}$$

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

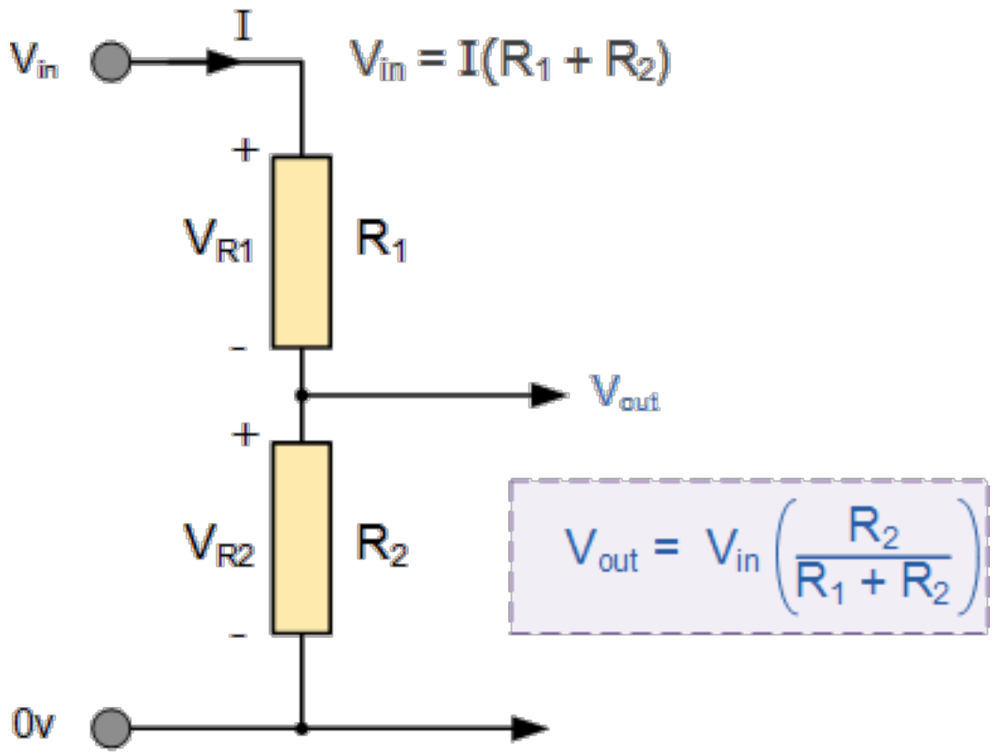
$$= \frac{1}{200} + \frac{1}{470} + \frac{1}{220} = 0.0117$$

$$\text{therefore: } R_T = \frac{1}{0.0117} = 85.67\Omega$$

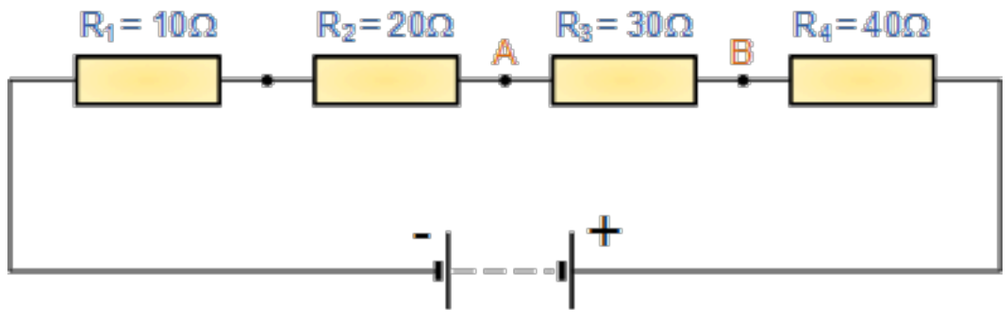
https://www.electronics-tutorials.ws/resistor/res_4.html

Voltage Divider Network

Kirchhoff's Voltage Law:
"the supply voltage in a closed circuit is equal to the sum of all the voltage drops (I*R) around the circuit"



Voltage Divider Network

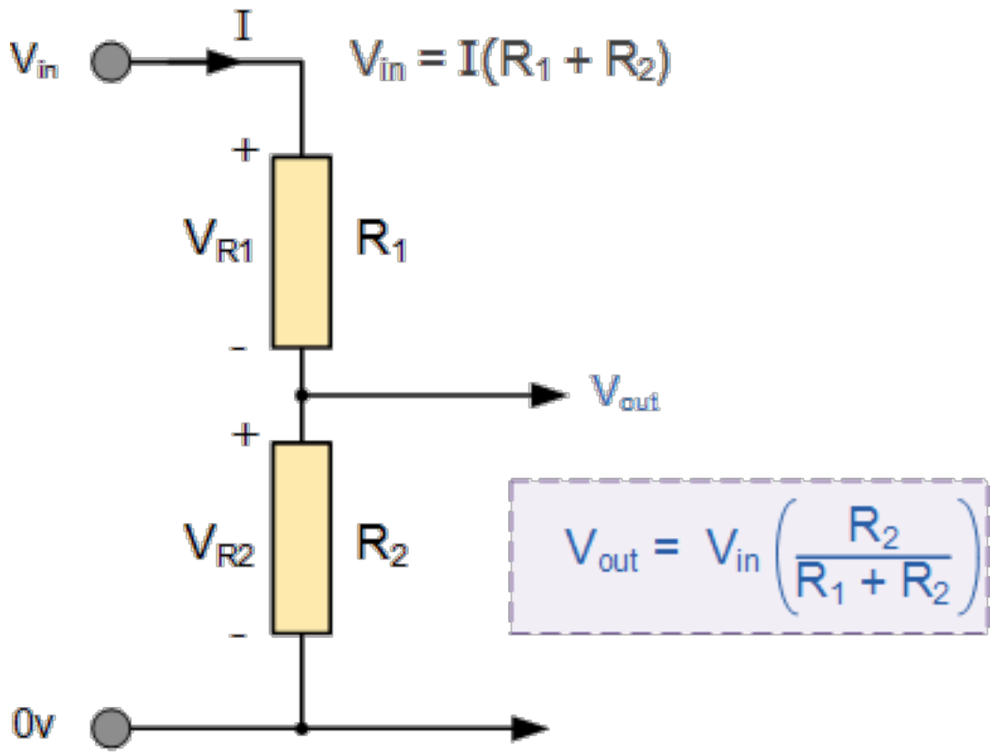


$$V_{AB} = V_{R3} = V_S \times \frac{R3}{R1+R2+R3+R4}$$

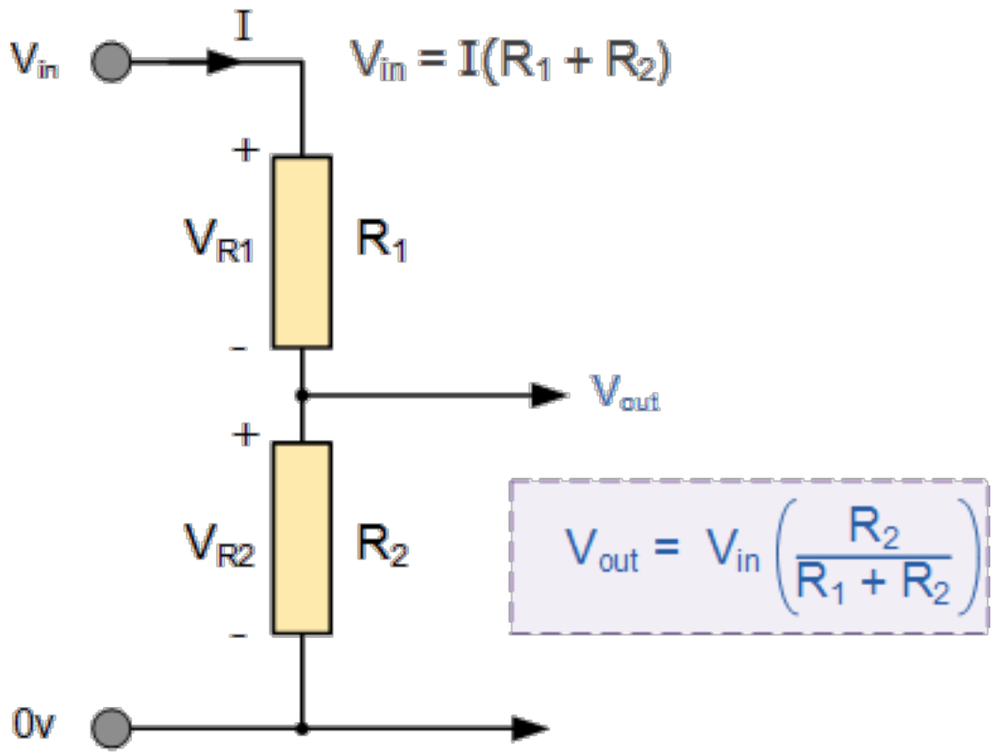
$$V_{AB} = 10 \times \frac{30}{10+20+30+40} = 10 \times 0.3 = 3V$$

https://www.electronics-tutorials.ws/resistor/res_3.html

Voltage Divider Network

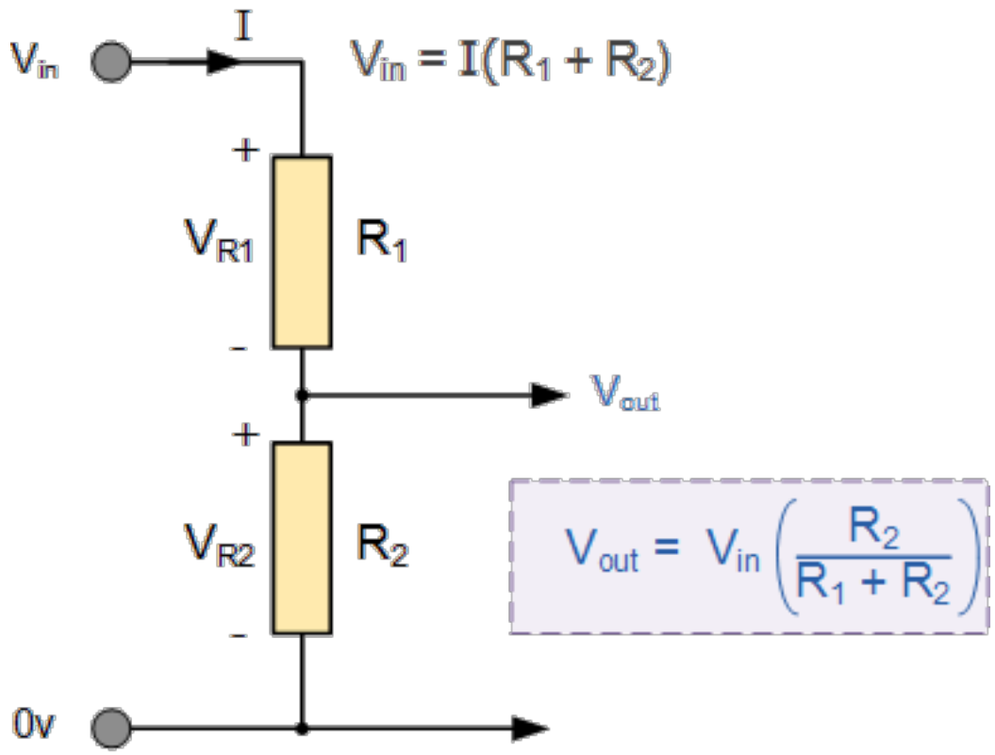


Voltage Divider Network



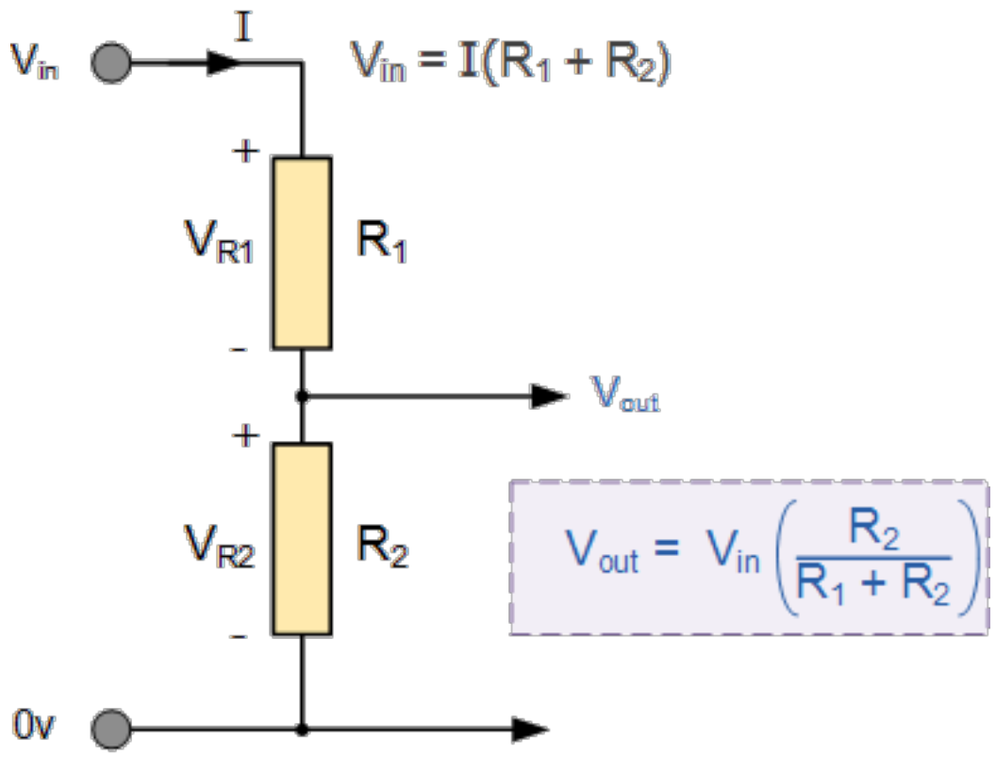
R1 = 0
Vout = ?

Voltage Divider Network



R1 = 0
Vout = Vin

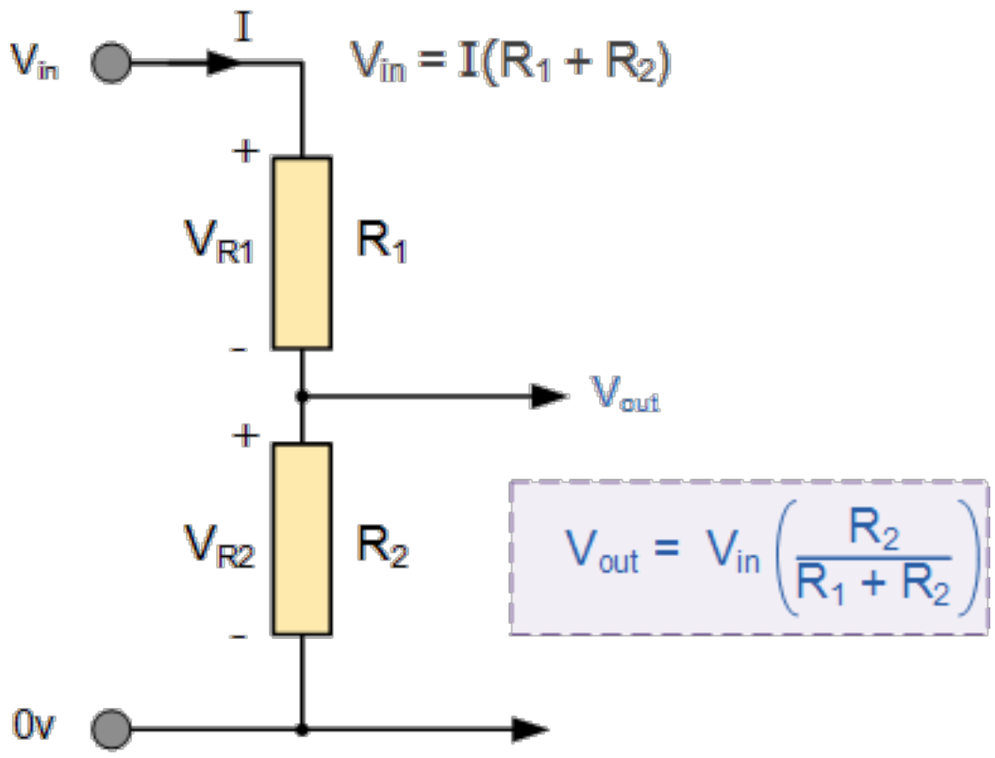
Voltage Divider Network



R1 = 0
Vout = Vin

R2 = 0
Vout = ?

Voltage Divider Network



R1 = 0
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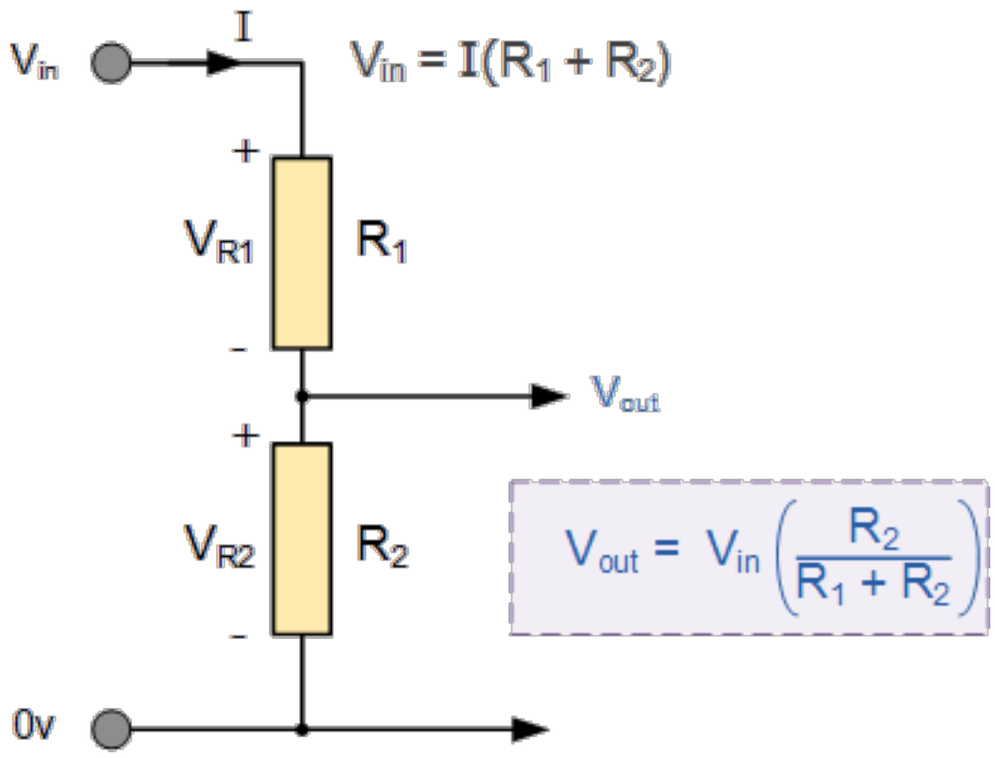
R2 = 0
Vout = 0

Voltage Divider Network

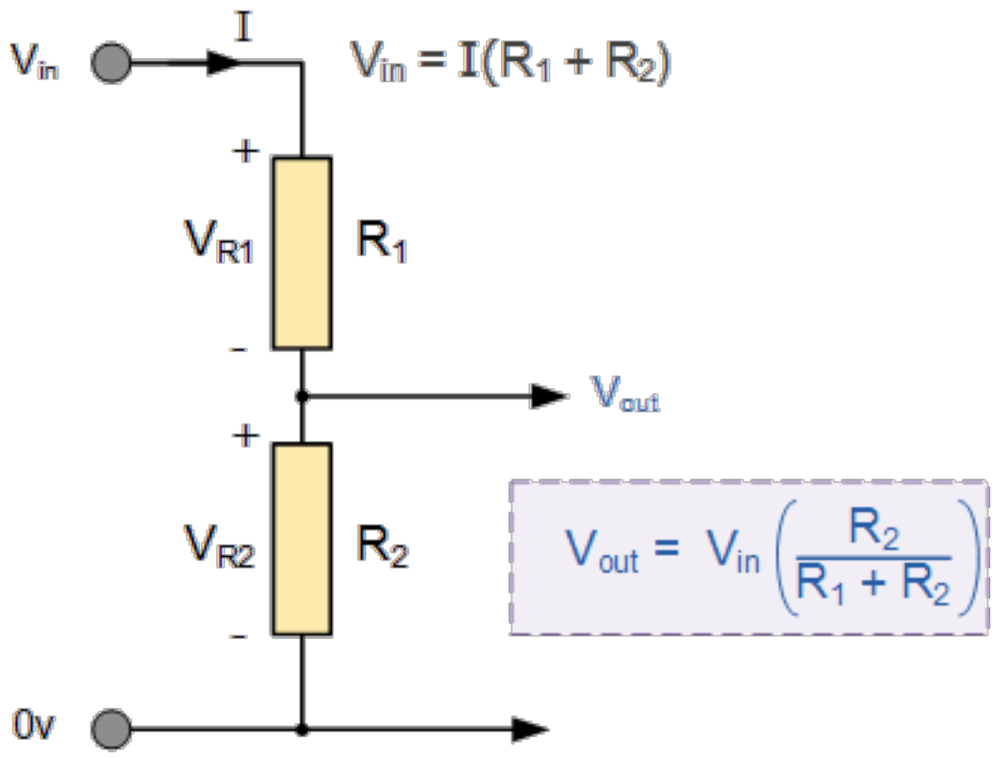


R1 = 0
Vout = Vin

R2 = 0
Vout = 0

R2 = infinit
Vout = ?

Voltage Divider Network



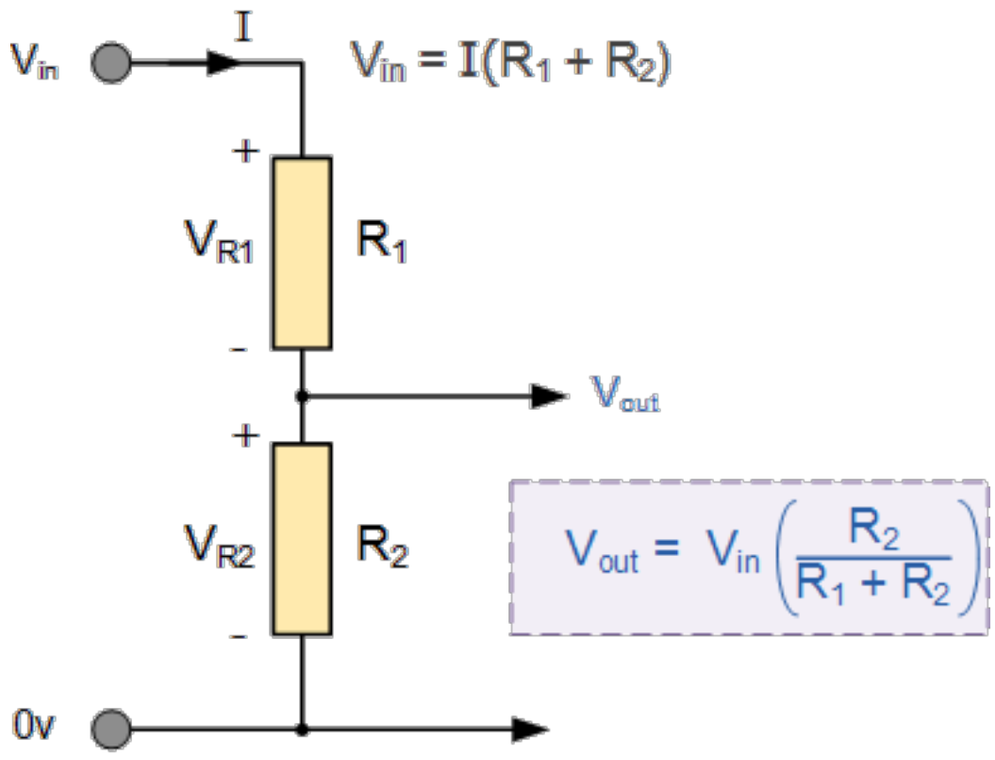
R1 = 0
Vout = Vin

R2 = 0
Vout = 0

R1 = 0
R2 = 0
Vout = ?

R2 = infinit
Vout = Vin

Voltage Divider Network



R1 = 0
Vout = Vin

R2 = 0
Vout = 0

R1 = 0
R2 = 0
Vout = ?

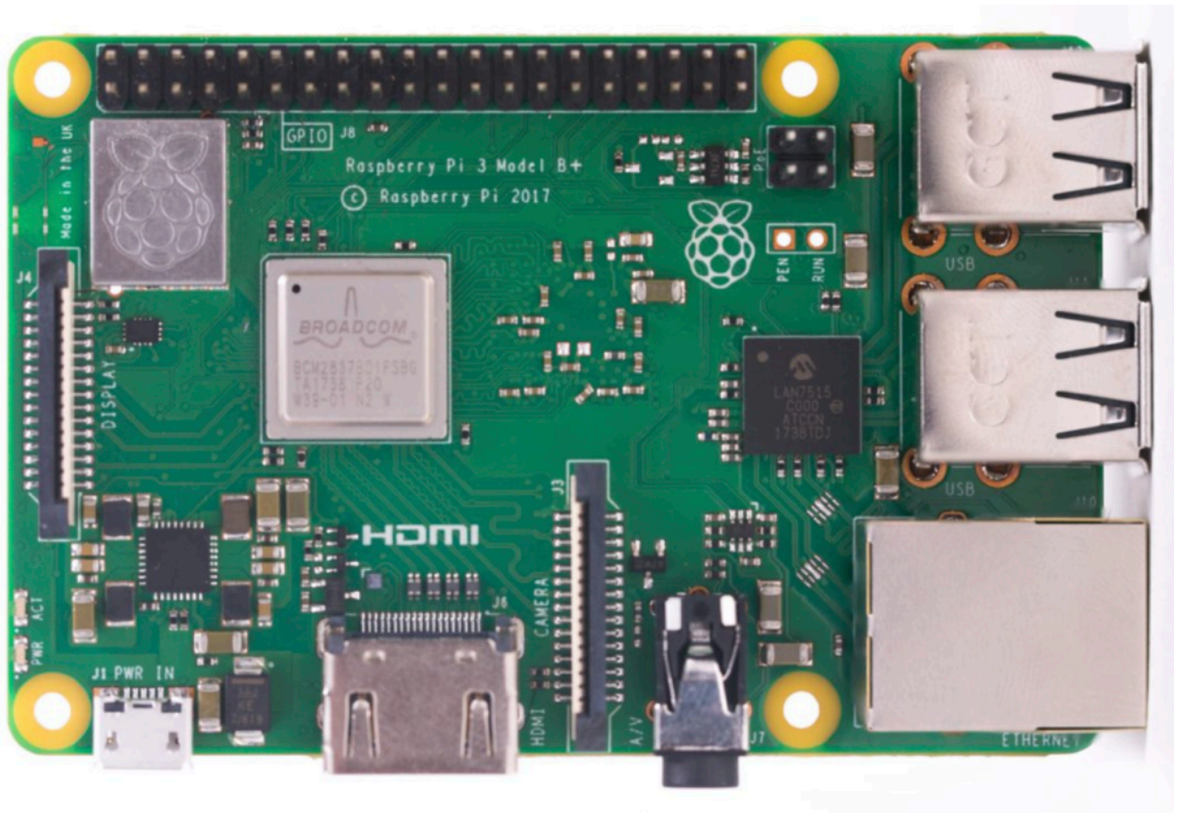
Short circuit

R2 = infinit
Vout = Vin

Peripheral I/O

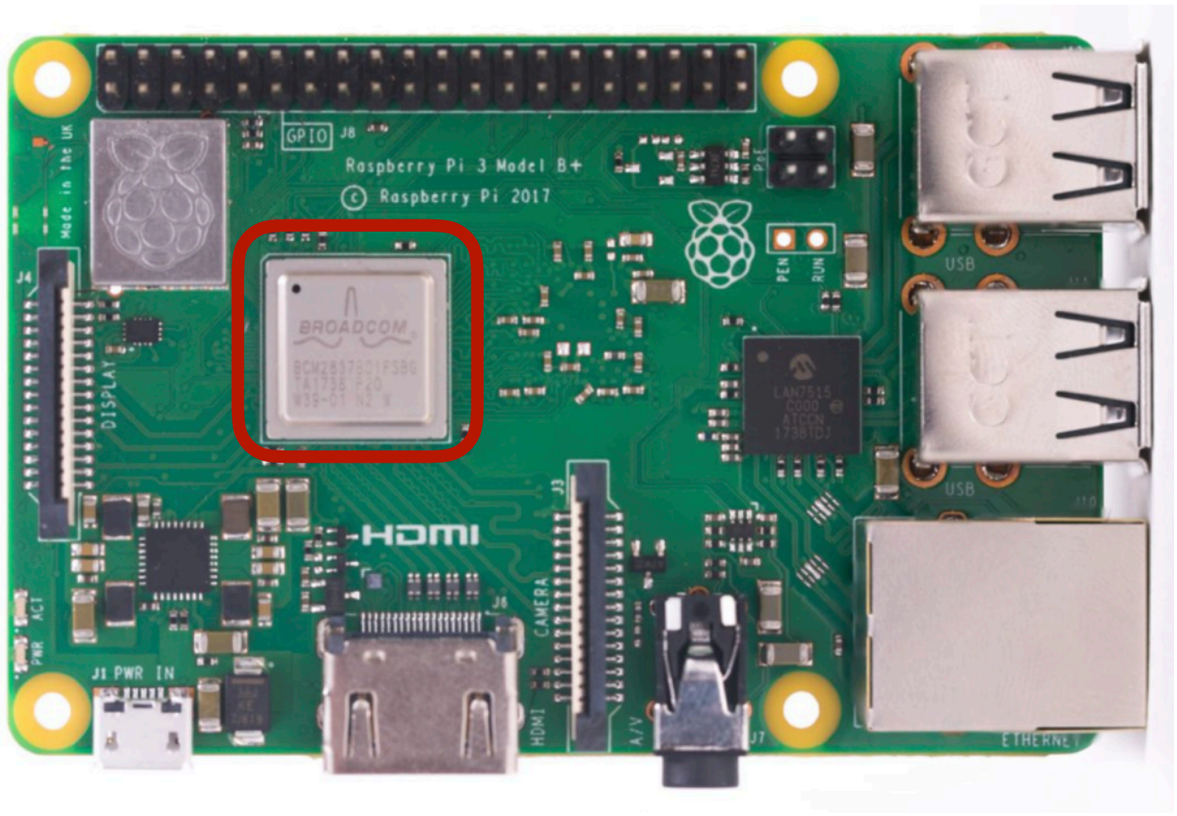
- General Purpose Input/Output (GPIO)
- Pulse Width Modulation (PWM)
- Serial Communication

Raspberry Pi 3 Model B



https://developer.android.com/things/hardware/raspberrypi.html

Raspberry Pi 3 Model B



Quad-core 64-bit ARM Cortex-A53

1.2GHz

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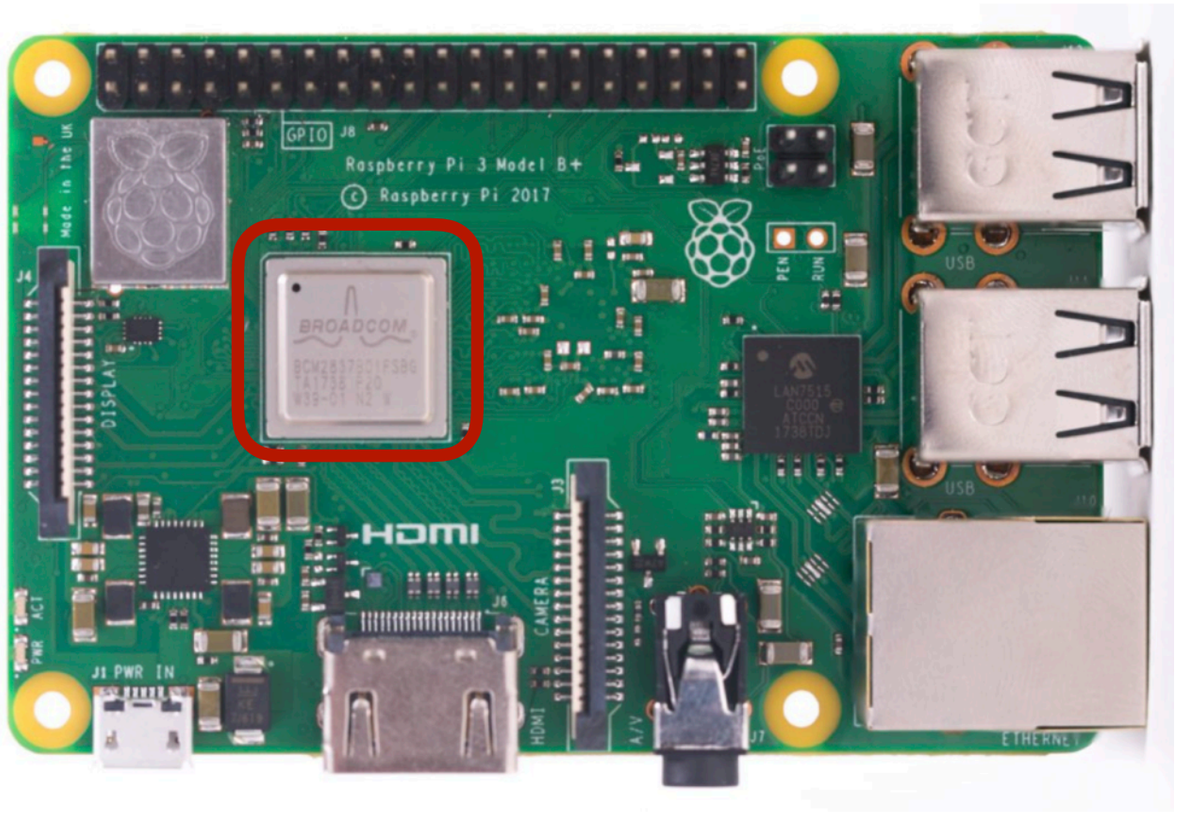
Raspberry Pi 3 Model B



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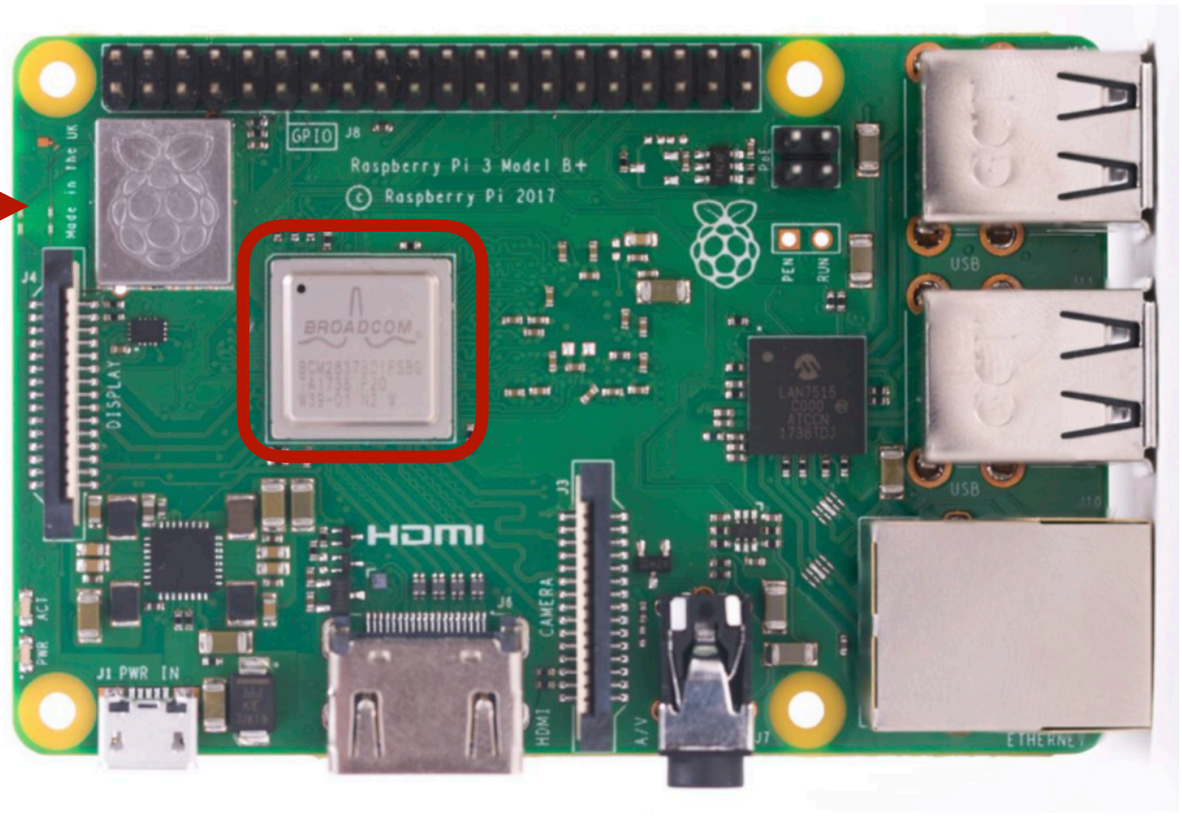

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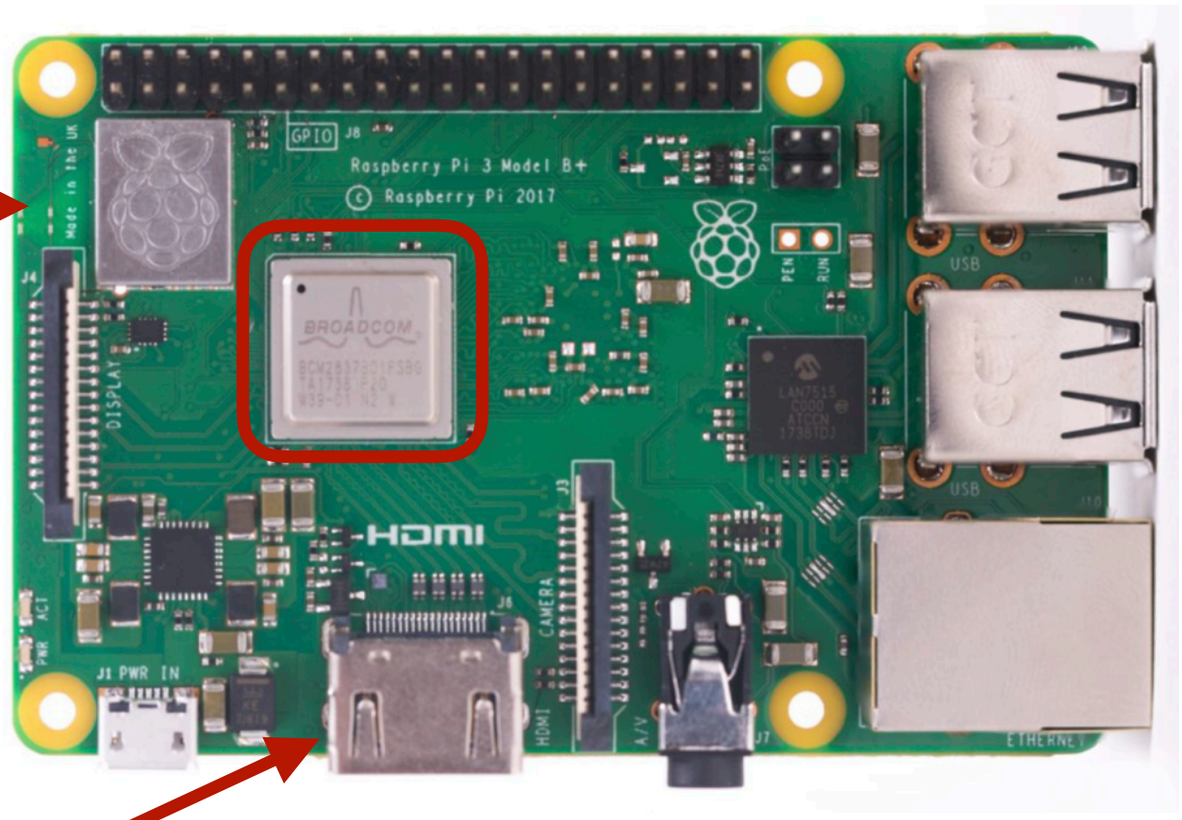

Wireless Networking

Four USB Ports

Wired Networking

HDMI

Quad-core 64-bit ARM Cortex-A53

1.2GHz

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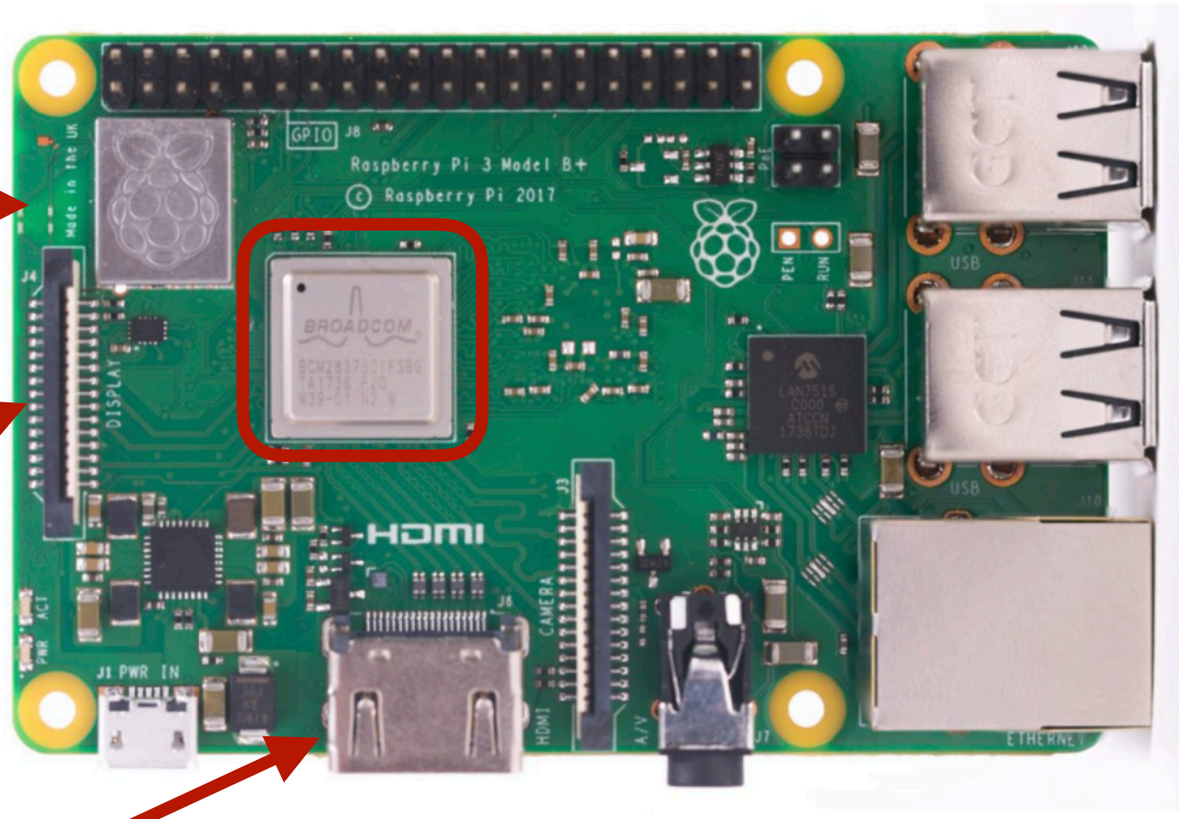
Raspberry Pi 3 Model B



Wireless Networking

Four USB Ports

Composite Video

Wired Networking

HDMI

Quad-core 64-bit ARM Cortex-A53

1.2GHz

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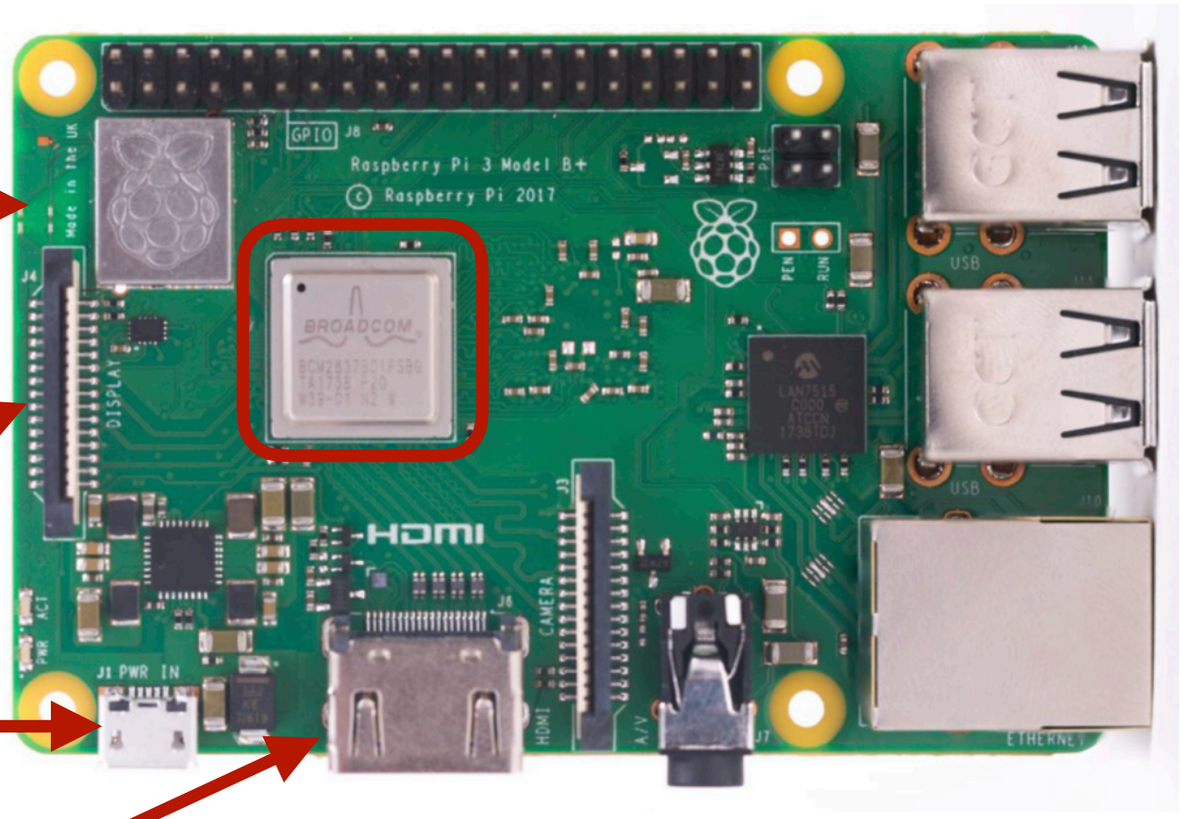
Raspberry Pi 3 Model B



Wireless Networking

Four USB Ports

Composite Video

Wired Networking

Power

HDMI

Quad-core 64-bit ARM Cortex-A53

1.2GHz

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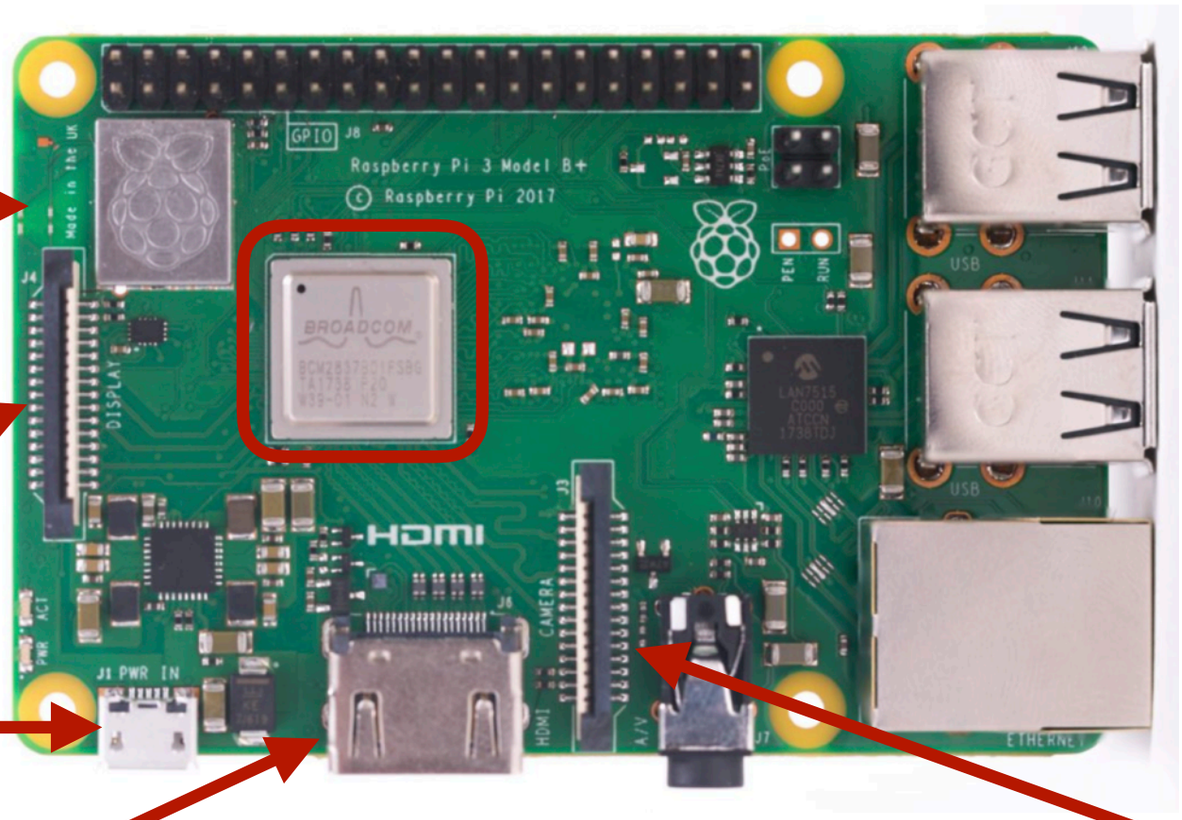
Raspberry Pi 3 Model B



Wireless Networking

Four USB Ports

Composite Video

Wired Networking

Power

Camera connection

HDMI

Quad-core 64-bit ARM Cortex-A53

1.2GHz

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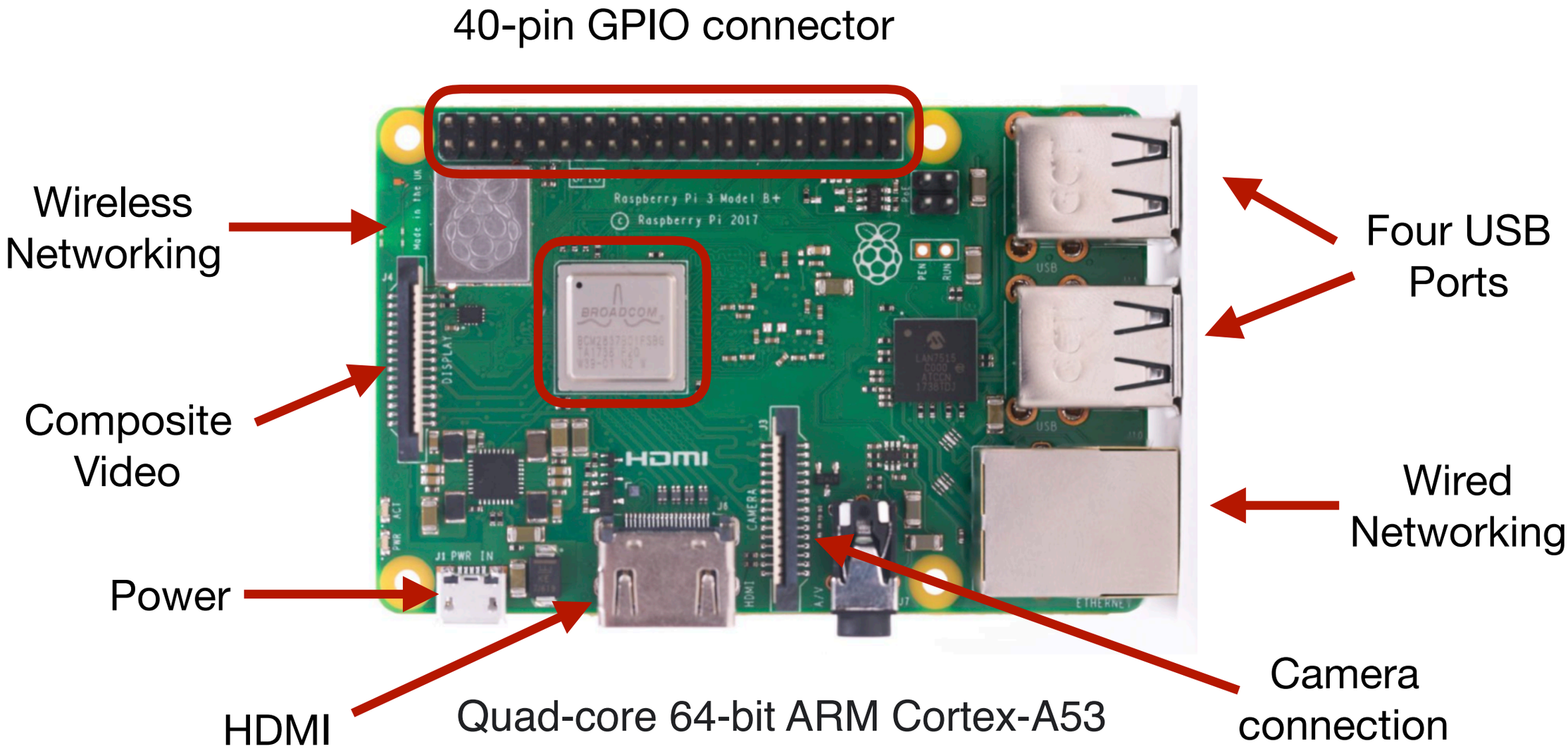
Raspberry Pi 3 Model B



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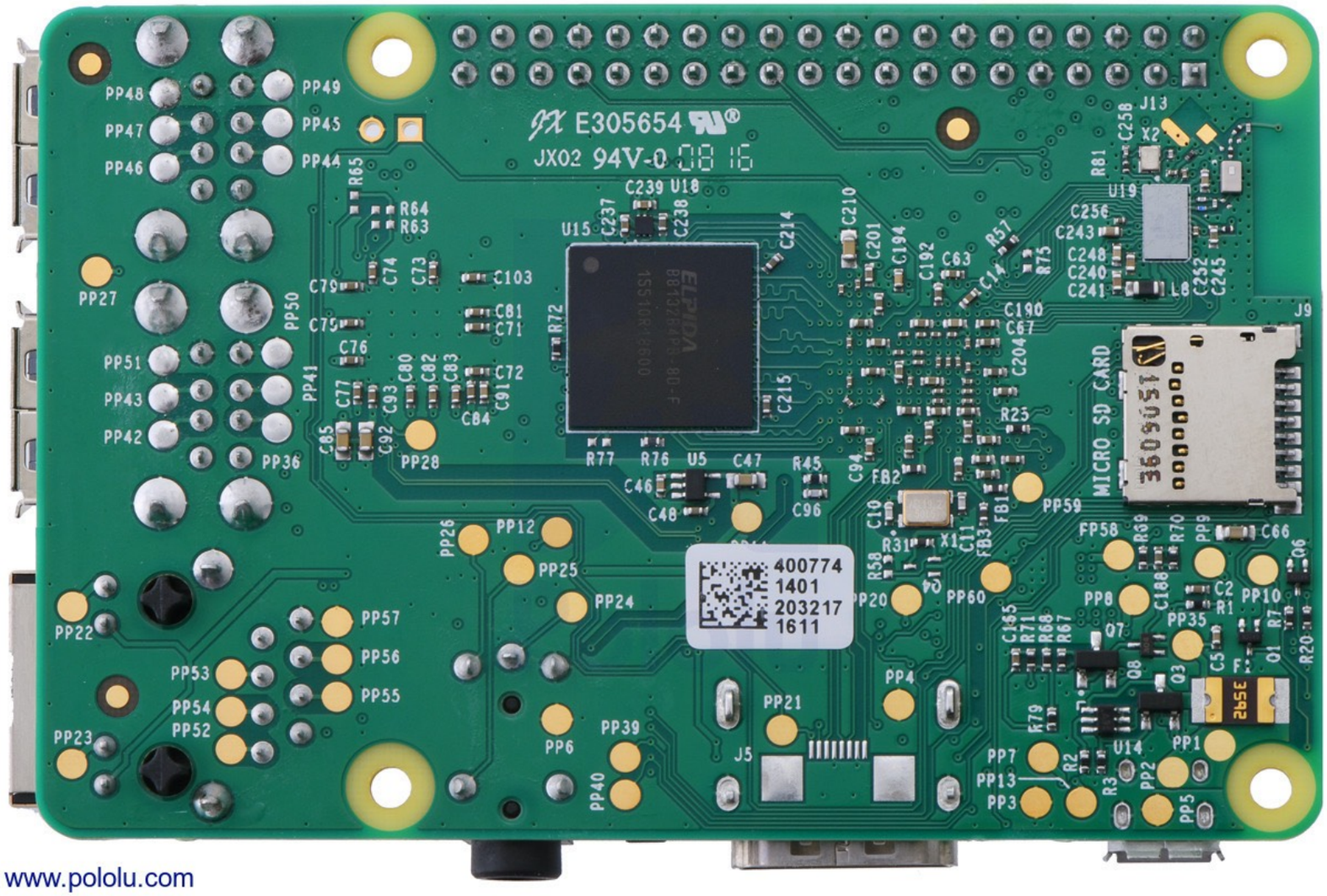
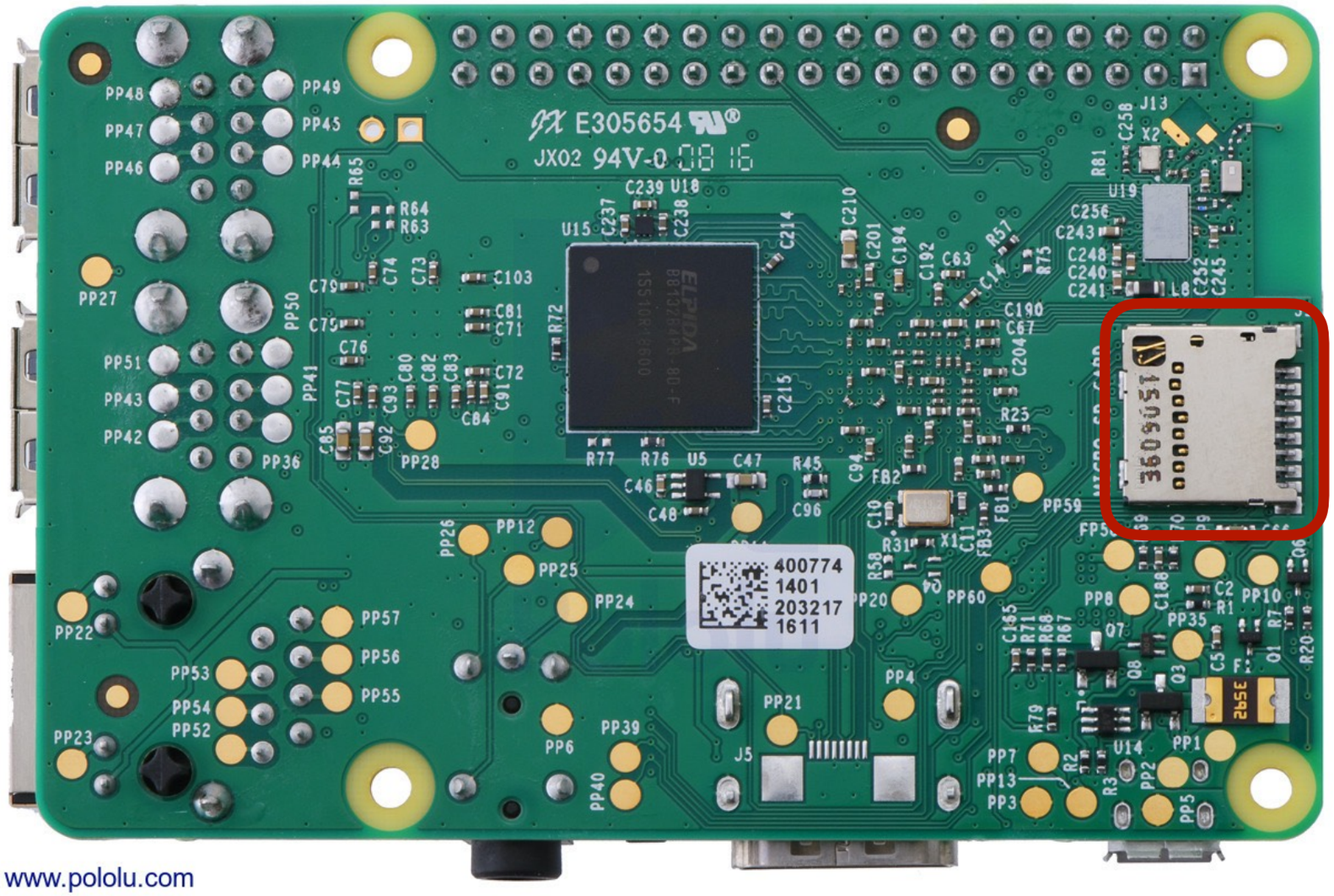


https://developer.android.com/things/hardware/raspberrypi.html

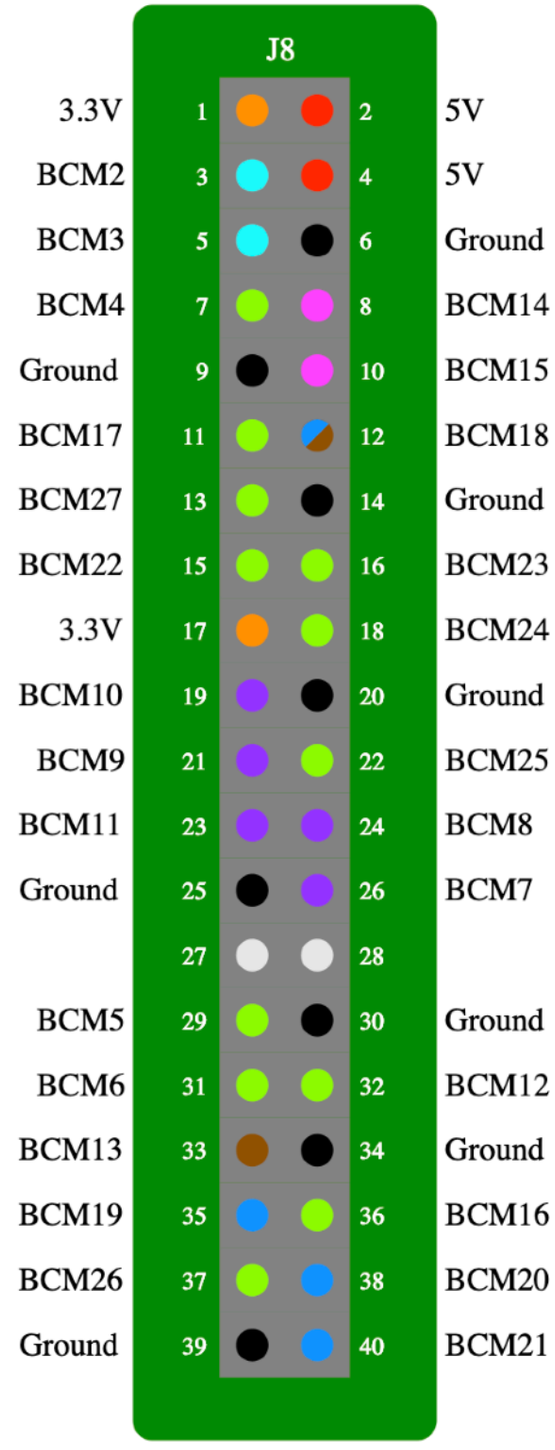
Raspberry Pi 3 Model B

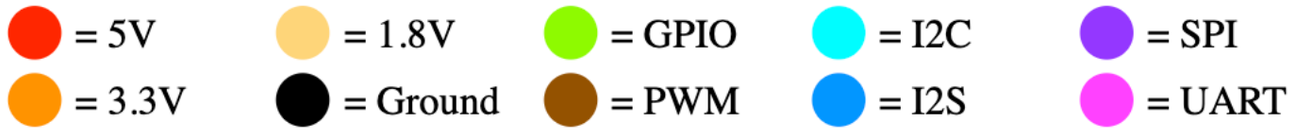


https://developer.android.com/things/hardware/raspberrypi.html

I/O Pinouts

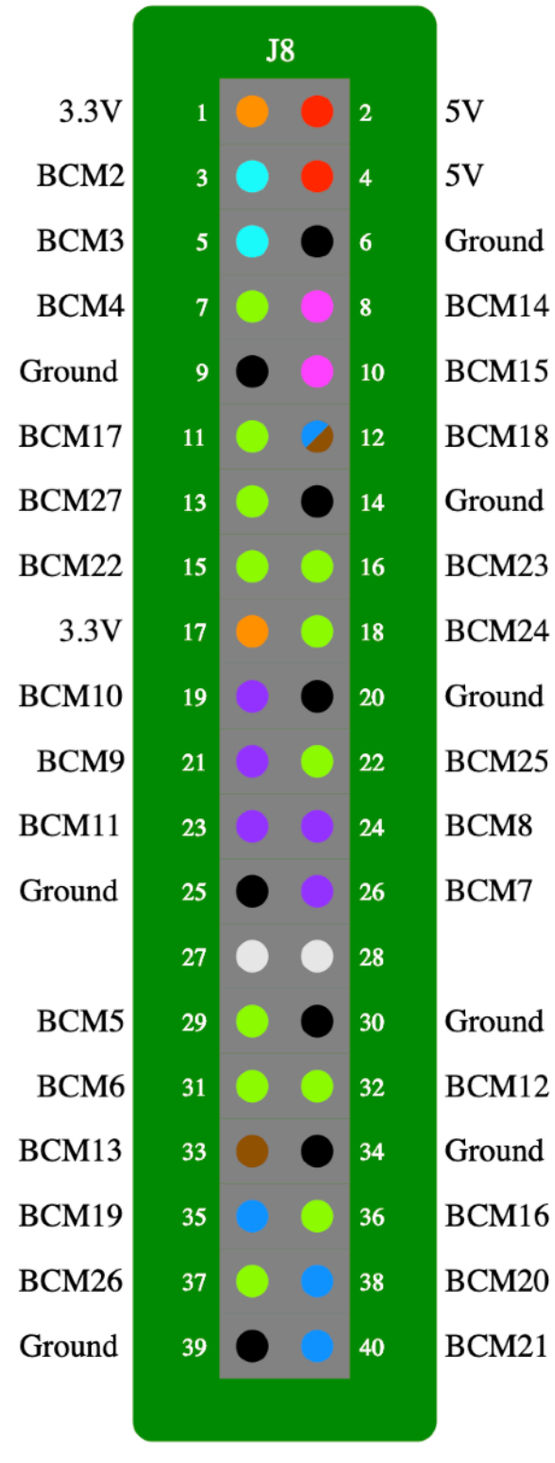
GPIO Signal	Alternate Functions	
BCM2	I2C1 (SDA)	
BCM3	I2C1 (SCL)	
BCM7	SPI0 (SS1)	
BCM8	SPI0 (SS0)	
BCM9	SPI0 (MISO)	
BCM10	SPI0 (MOSI)	
BCM11	SPI0 (SCLK)	
BCM13	PWM1	
BCM14	UART0 (TXD)	MINIUART (TXD)
BCM15	UART0 (RXD)	MINIUART (RXD)
BCM18	I2S1 (BCLK)	PWM0
BCM19	I2S1 (LRCLK)	
BCM20	I2S1 (SDIN)	
BCM21	I2S1 (SDOUT)	



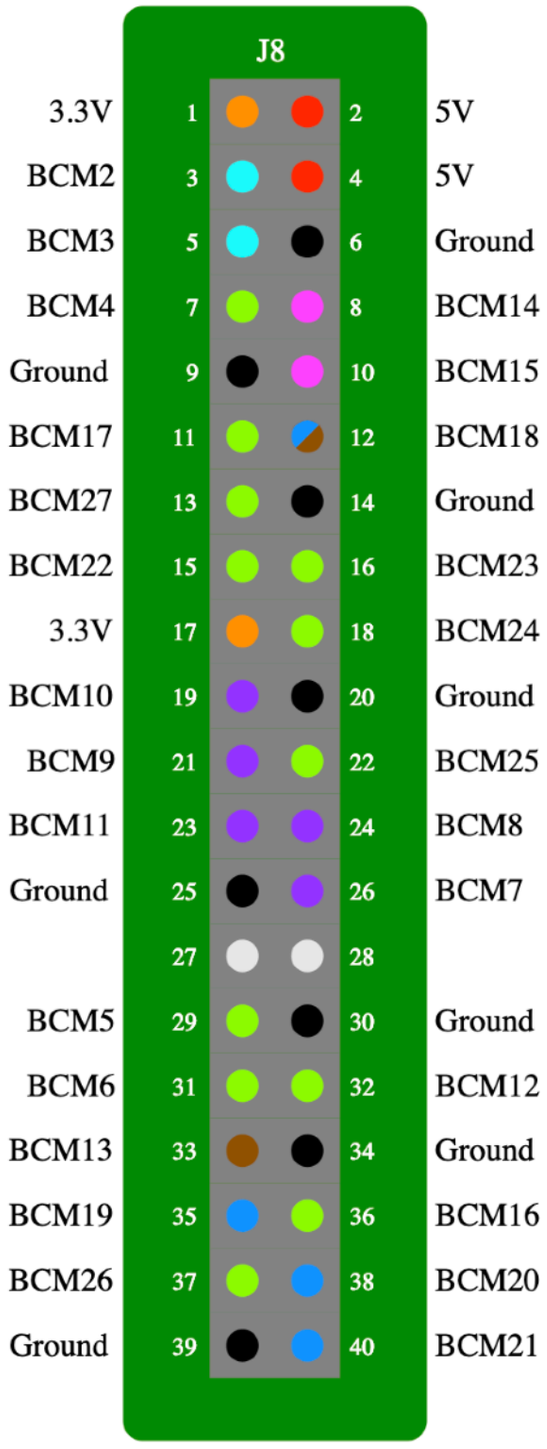


Output and Input

- Digital Pins
  - Two values:
    - Low (0)
    - High (1)
- Acts either:
  - Battery (OUTPUT)
  - Voltage meter (INPUT)

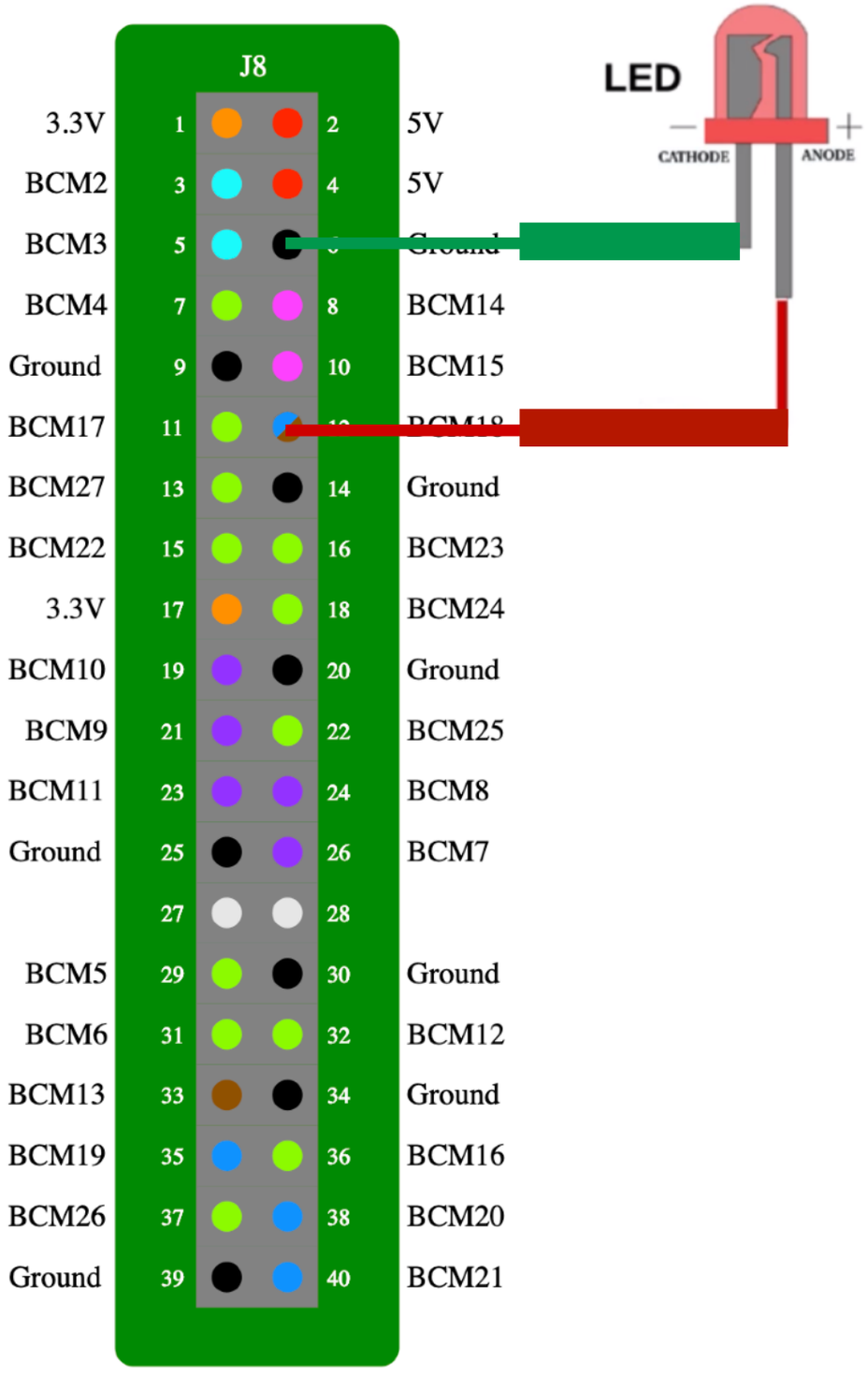


Output



- Pin 12 can act like a battery (OUTPUT)
  - LOW - 0V
  - HIGH - 5V, 3.3V or 1.8V

Output



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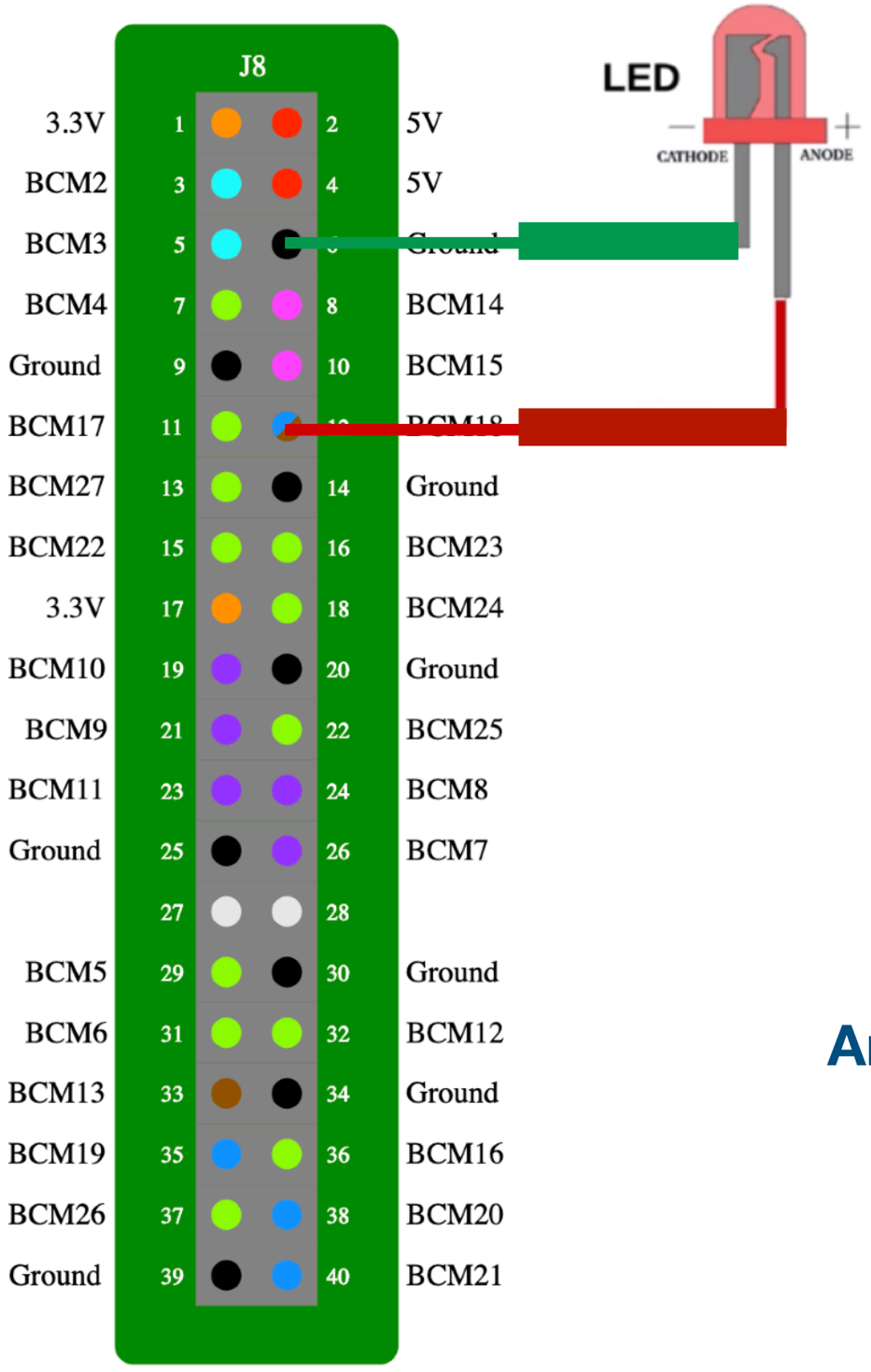

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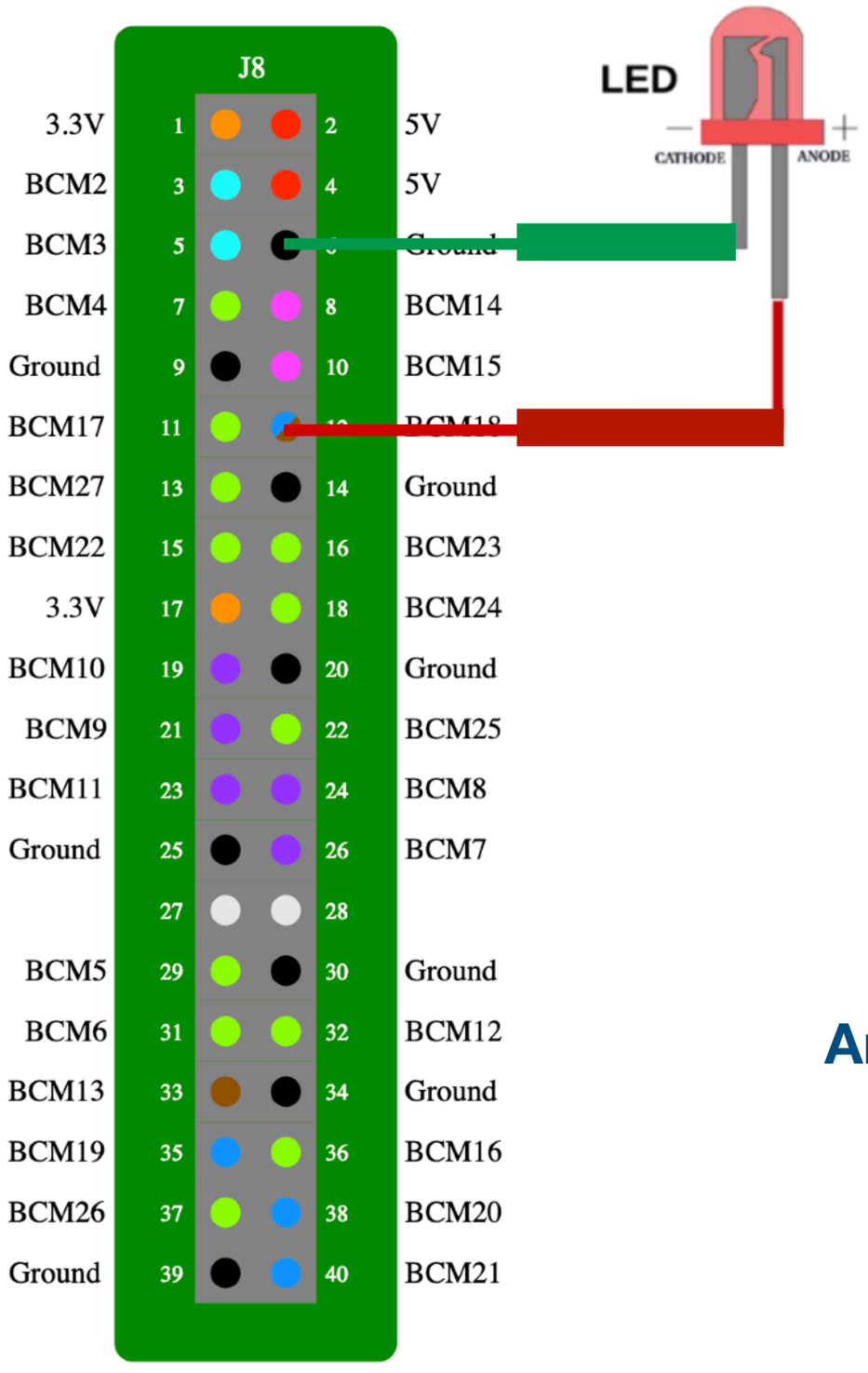
Arduino

Output



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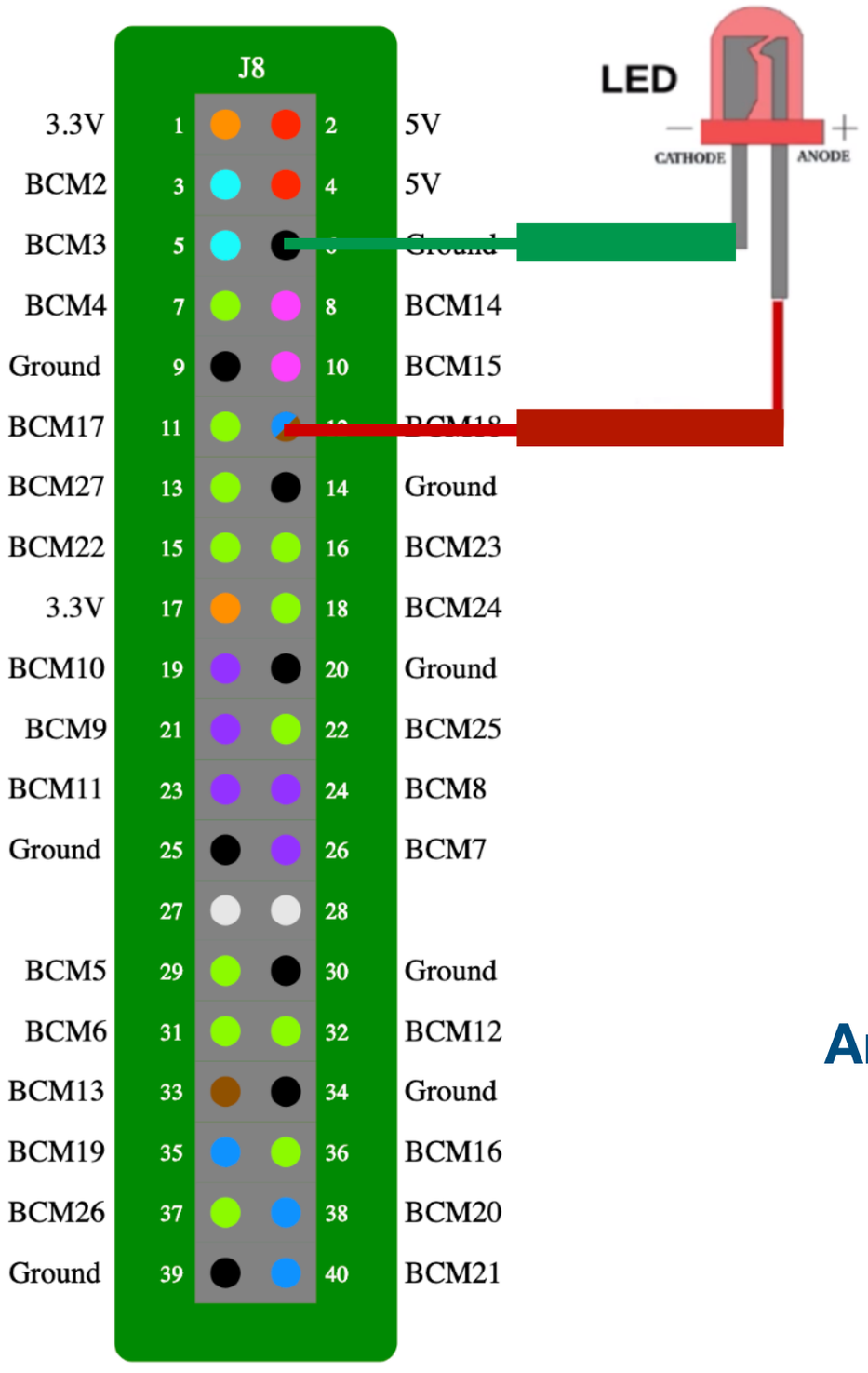
Arduino

Raspberry Pi

Output



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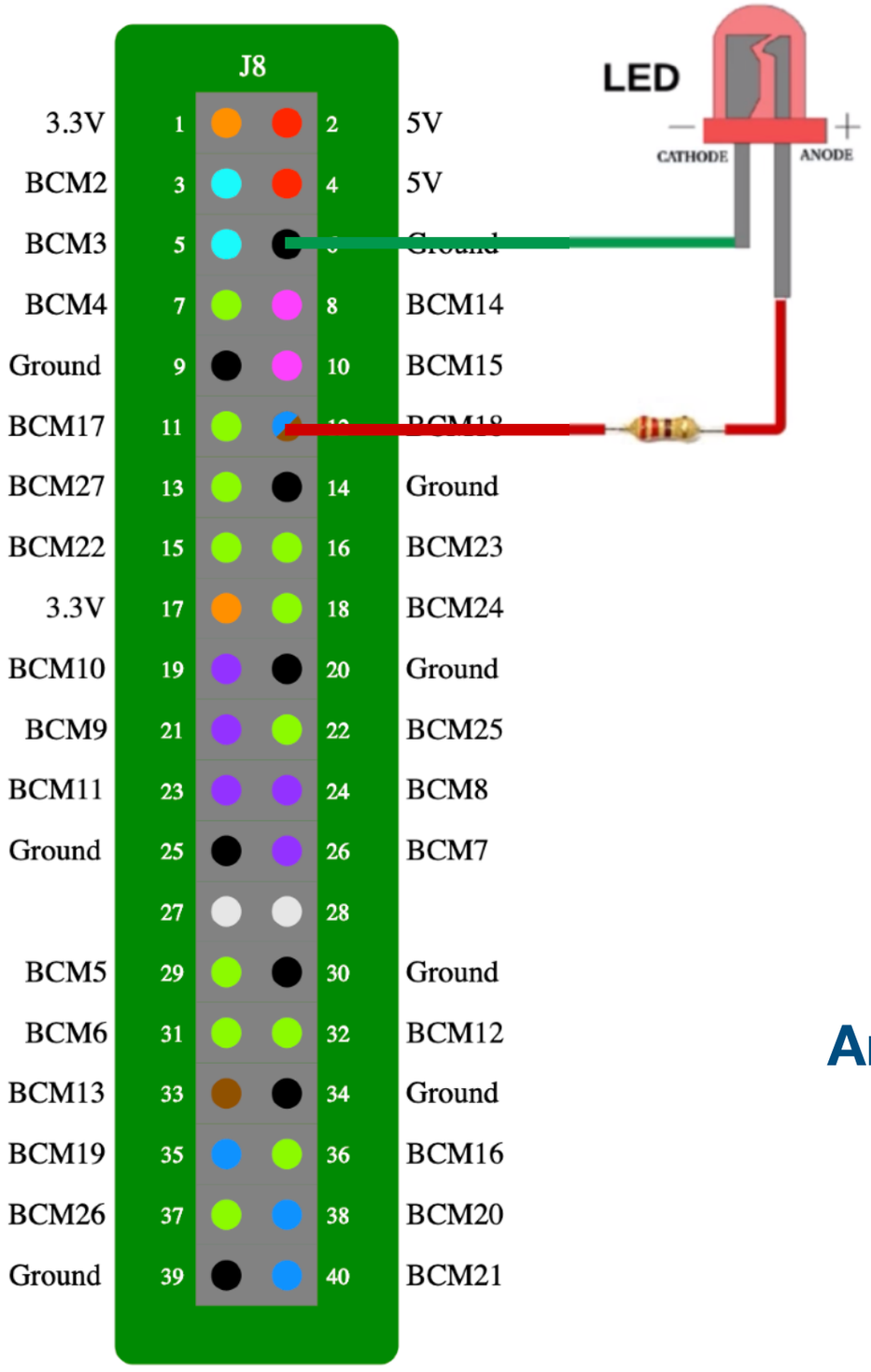
Arduino

Raspberry Pi

Others

Output



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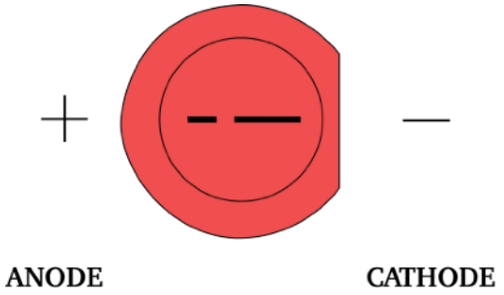
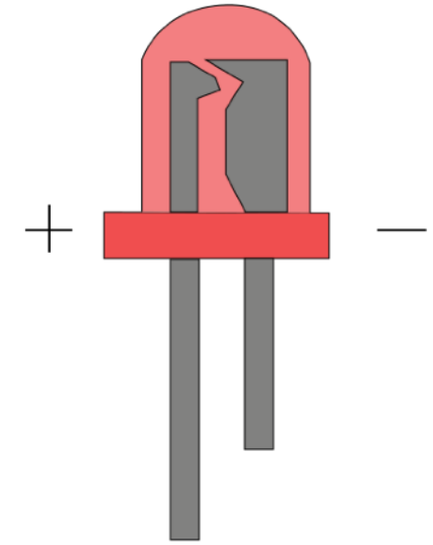
Arduino

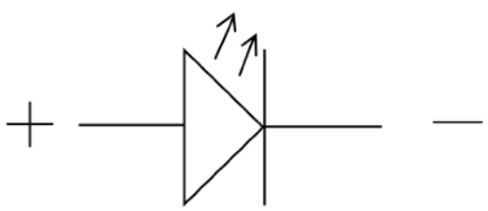
Raspberry Pi

Others

What resistor to use?







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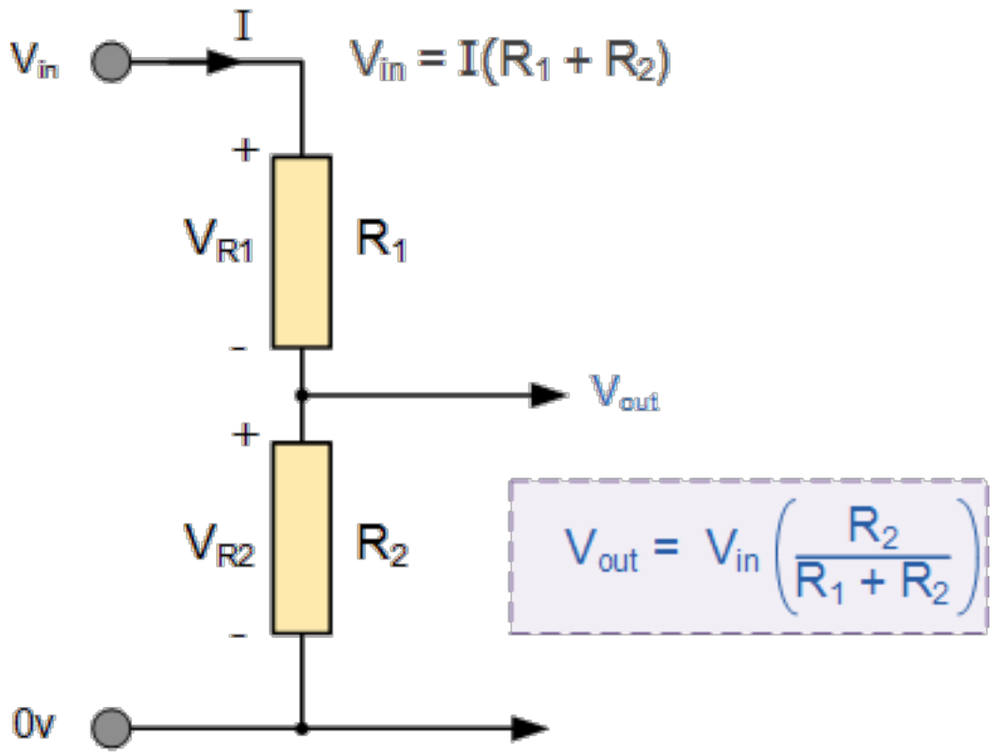

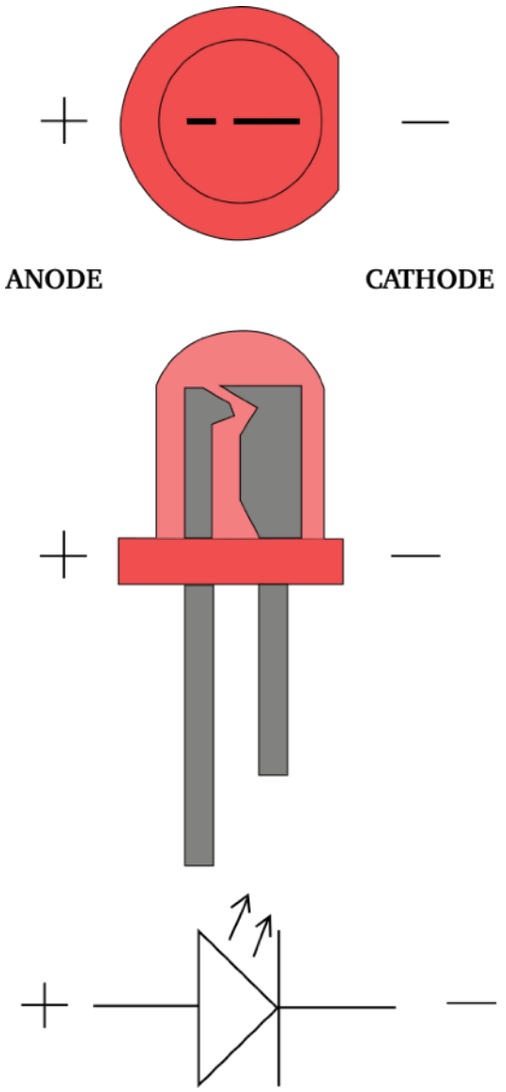

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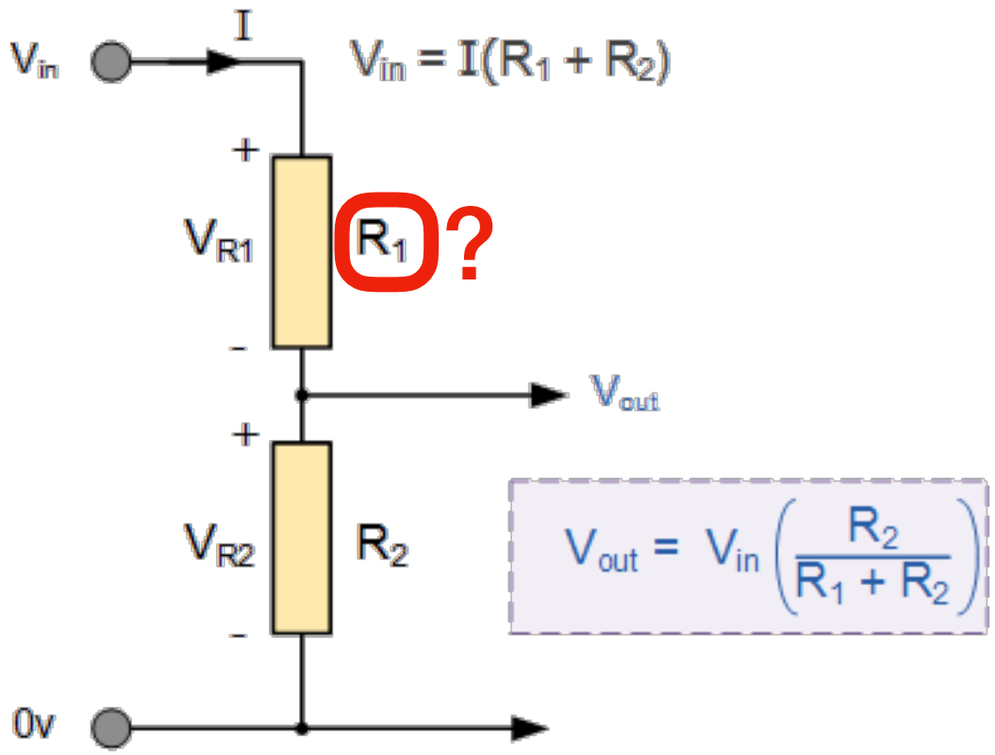

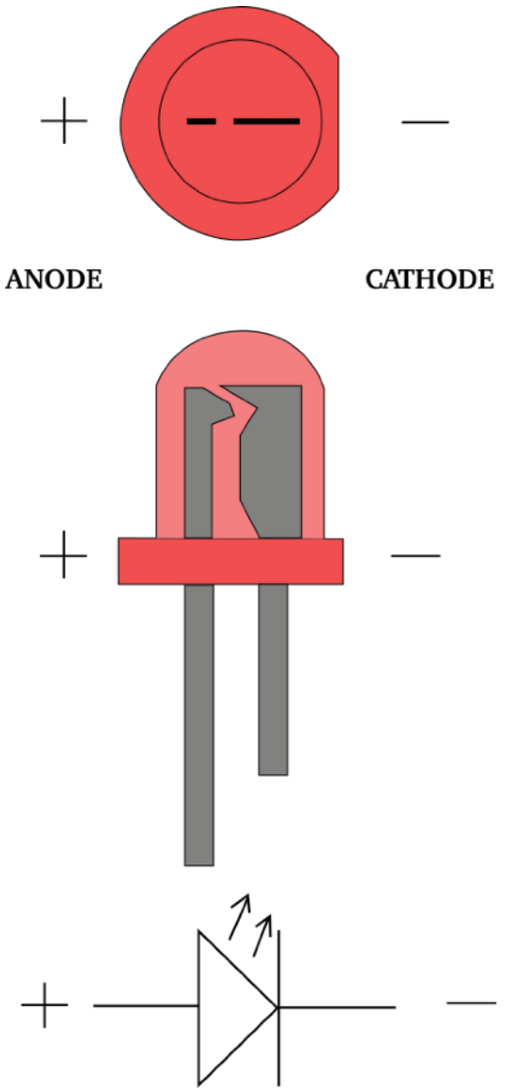

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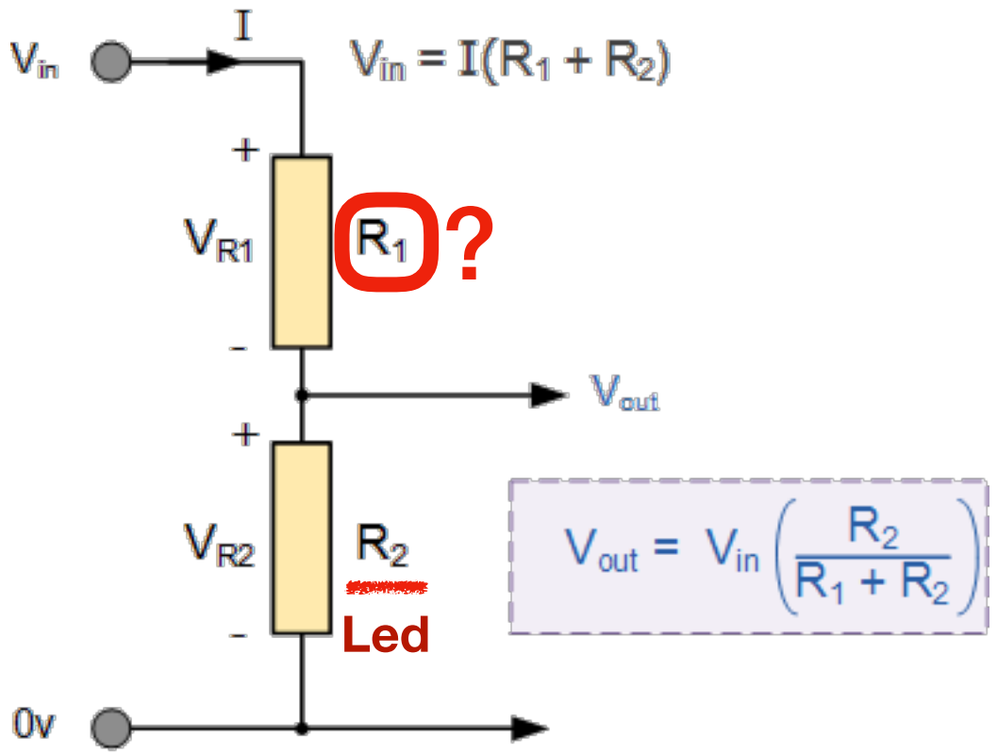

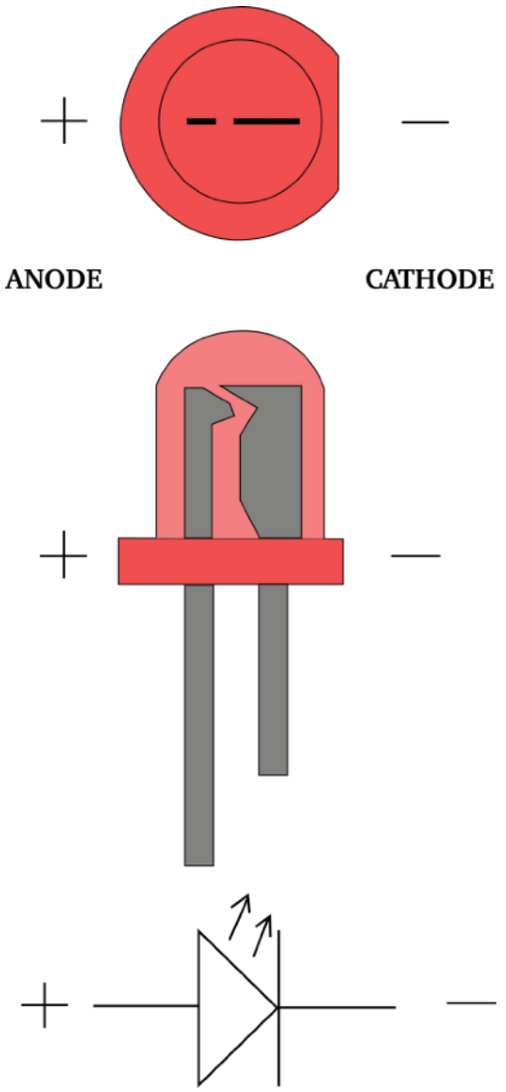

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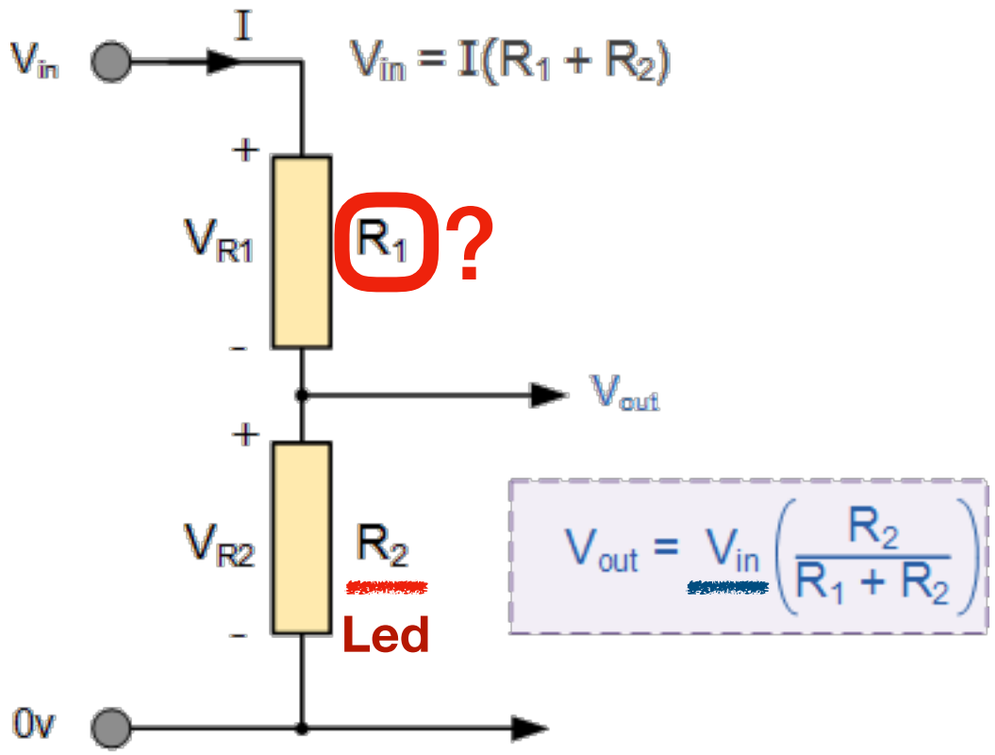

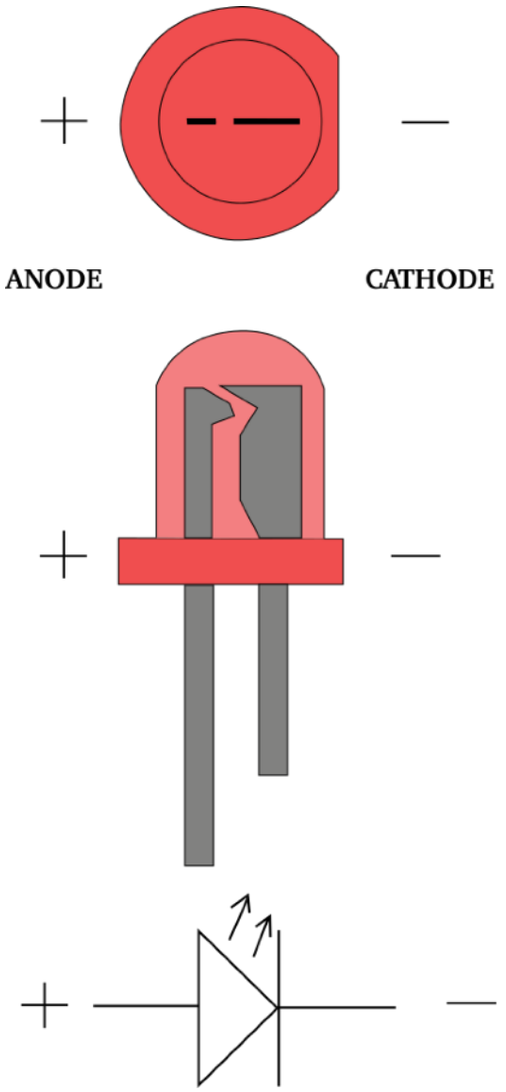

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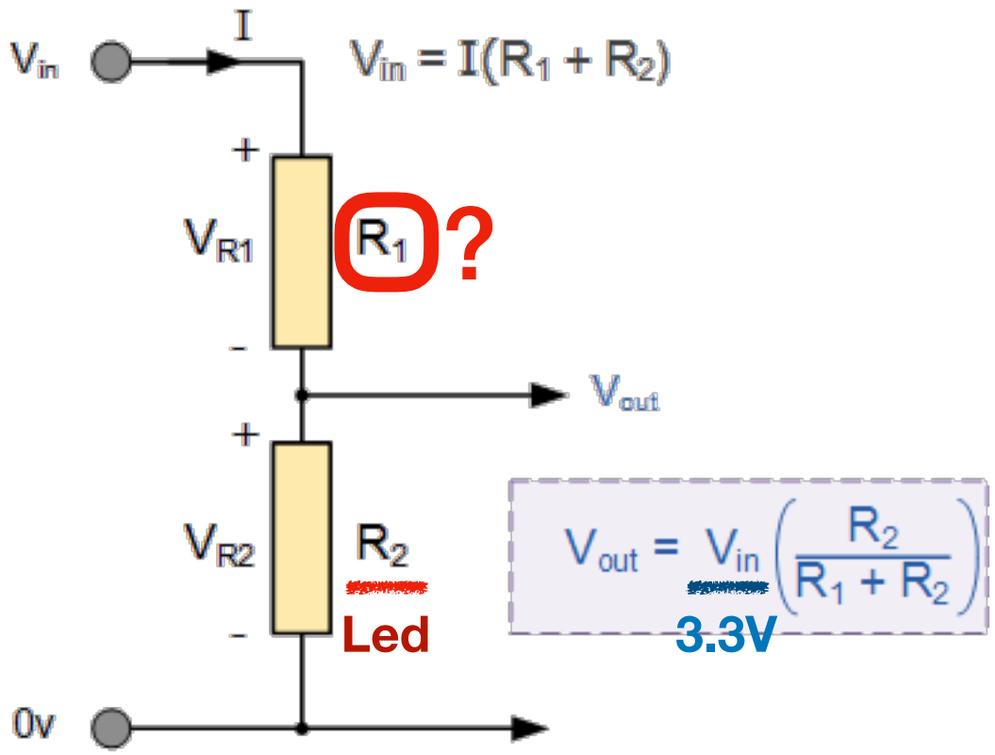

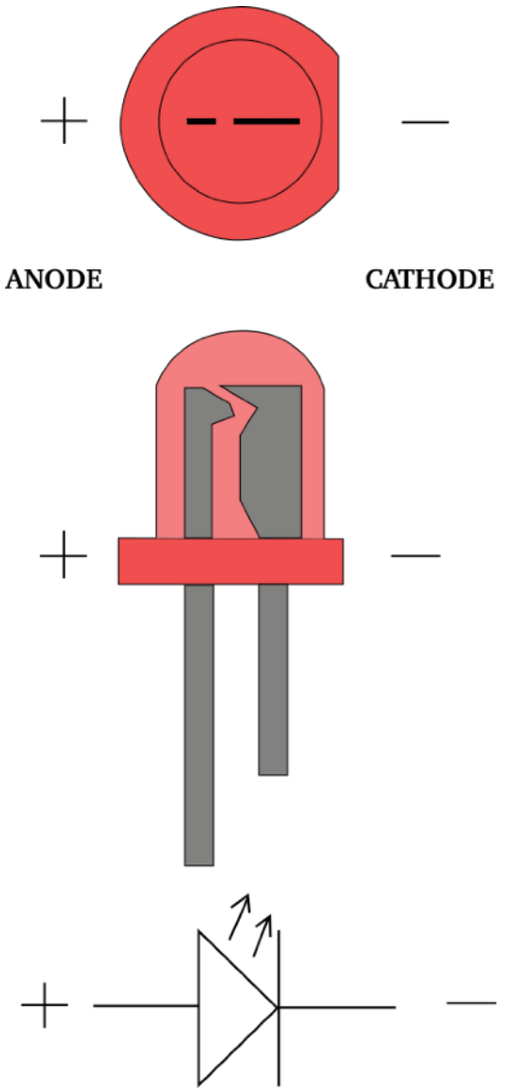

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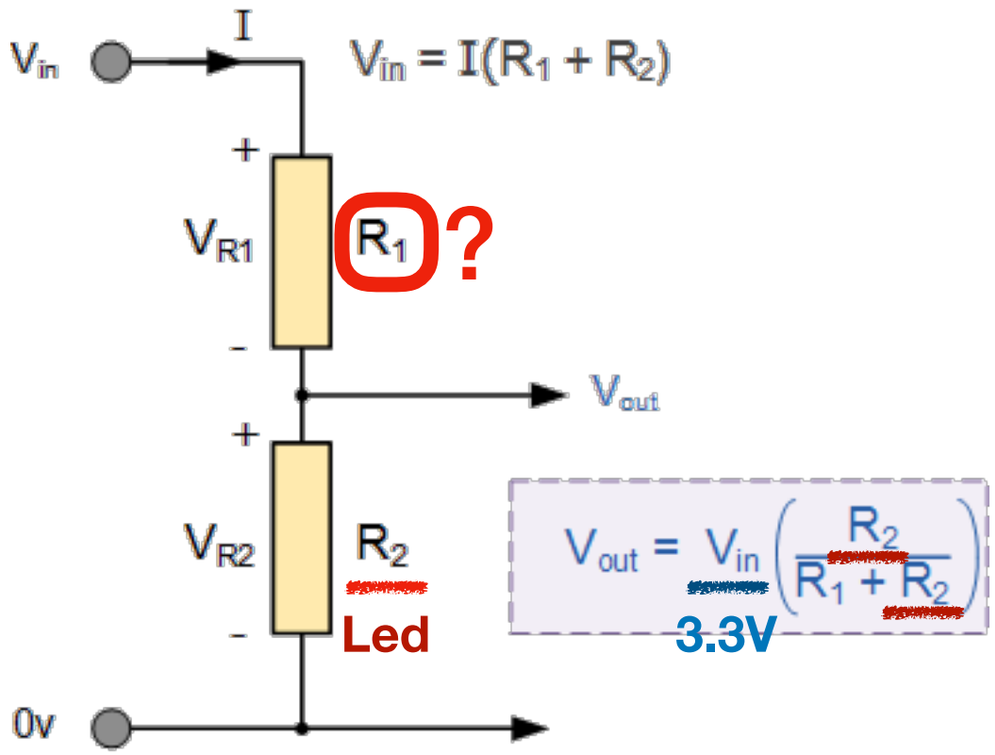

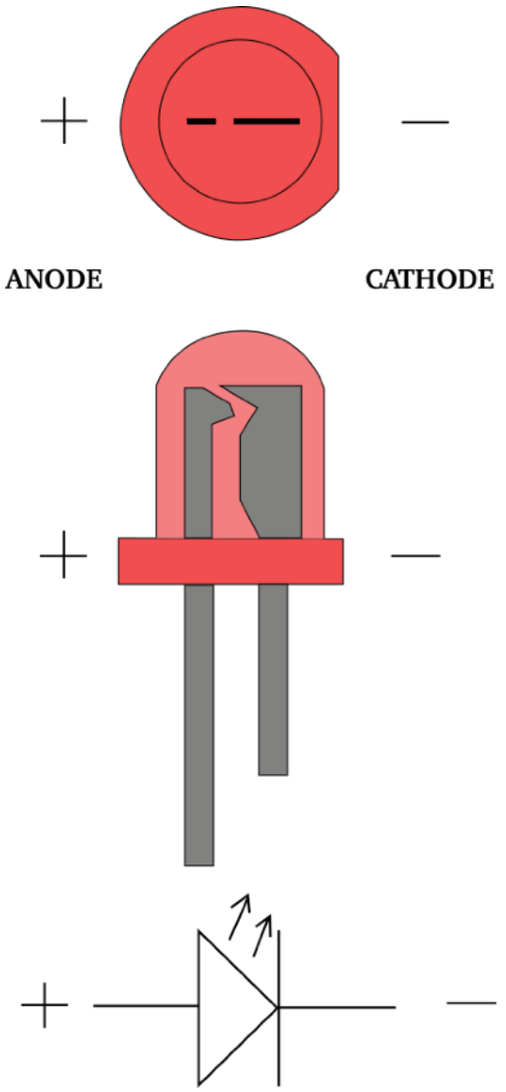

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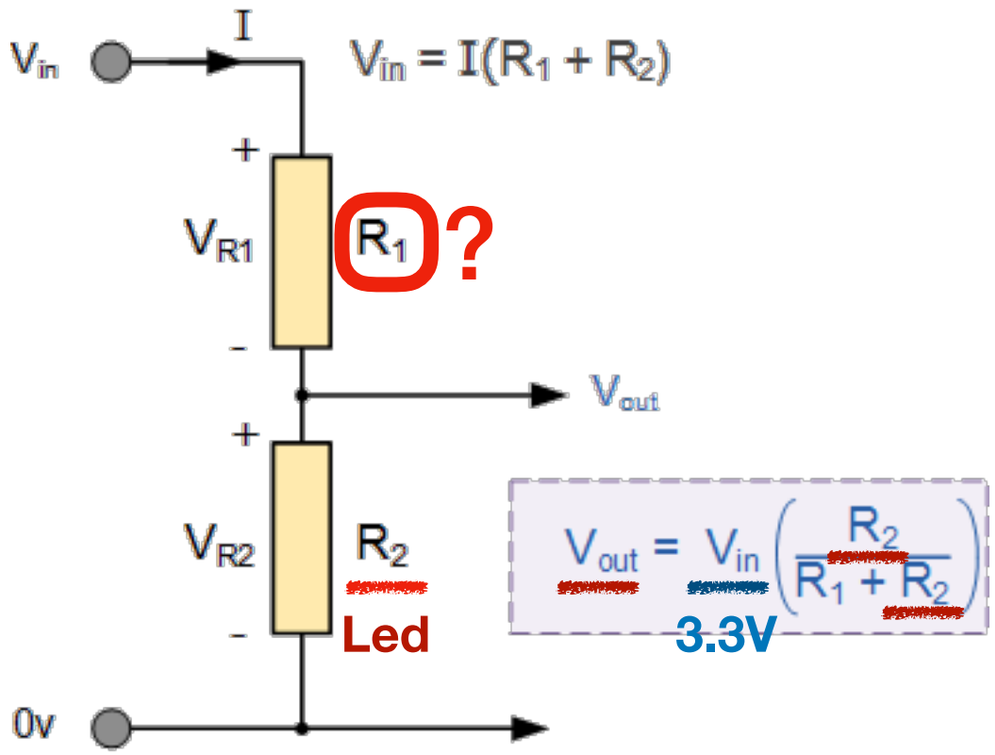

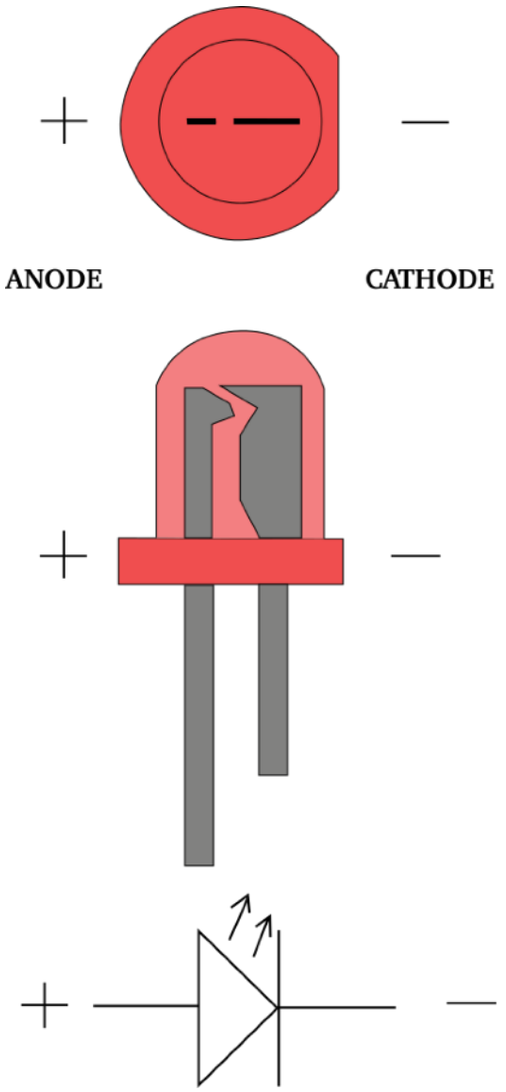

Led

LED - Basic Red 5mm

COM-09590 ROHS

$0.35

Volume sales pricing

- 1 +

ADD TO CART

Quantity discounts available

DESCRIPTION FEATURES DOCUMENTS

LEDs - those blinky things. A must have for power indication, pin status, opto-electronic sensors, and fun blinky displays.

This is a very basic 5mm LED with a red lens. It has a typical forward voltage of 2.0V and a rated forward current of 20mA.

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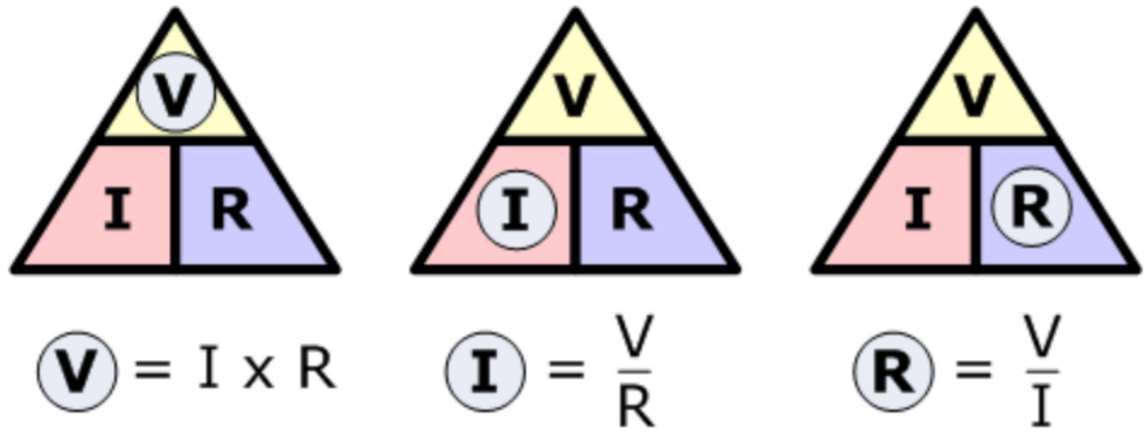

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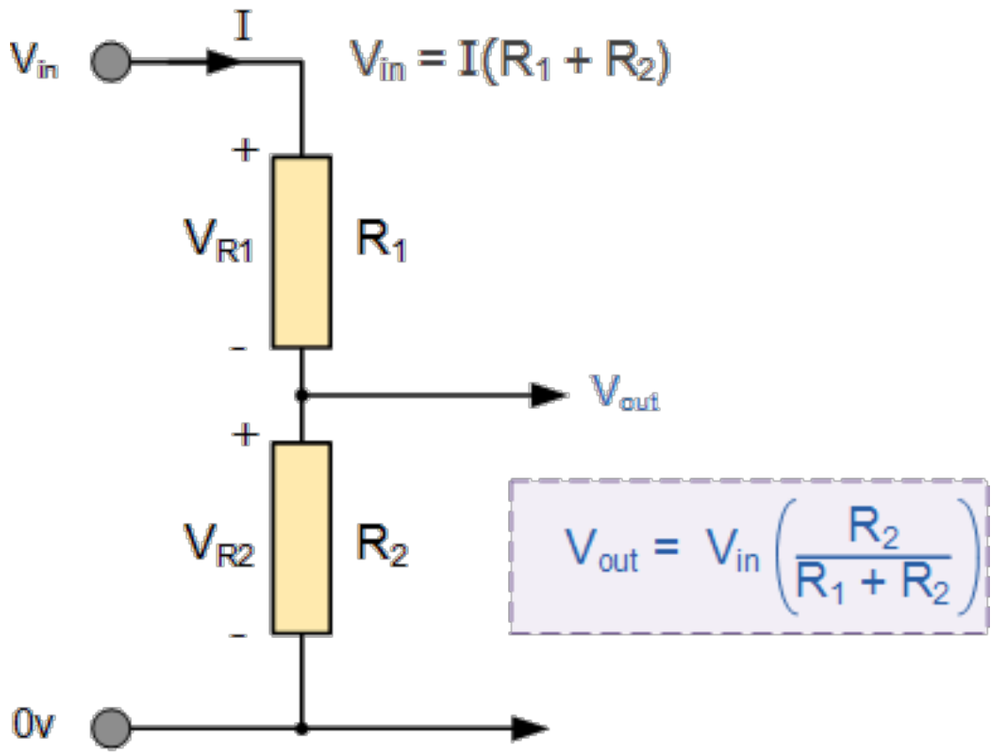
Compute R1


V_{in}
I
$V_{in} = I(R_1 + R_2)$
+
V_{R1}
R_1
-
V_{out}
+
V_{R2}
R_2
-
0v
$V_{out} = V_{in}\left(\frac{R_2}{R_1 + R_2}\right)$

Compute R1

$$V_{out} = V_{in}(\frac{R_2}{R_1 + R_2})$$

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$$R_2 V_{in} = R_1 V_{out} + R_2 V_{out}$$

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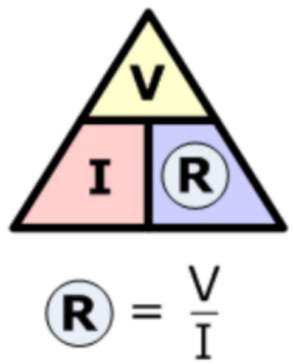

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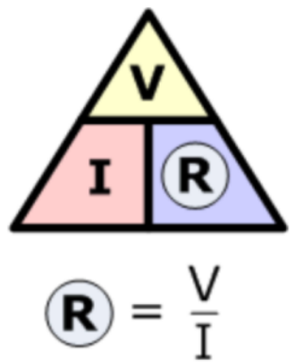

Compute R1

$$R_1 = \frac{V_{in} - V_{out}}{I_{out}}$$

Compute R1

LED - Basic Red 5mm

COM-09590 ROHS ✔

$0.35

Volume sales pricing

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COM-09590 ROHS ✔

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Volume sales pricing

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$$R_1 = \frac{V_{in} - V_{out}}{I_{out}} = \frac{3.3V - 2V}{0.020A} = 65\Omega$$

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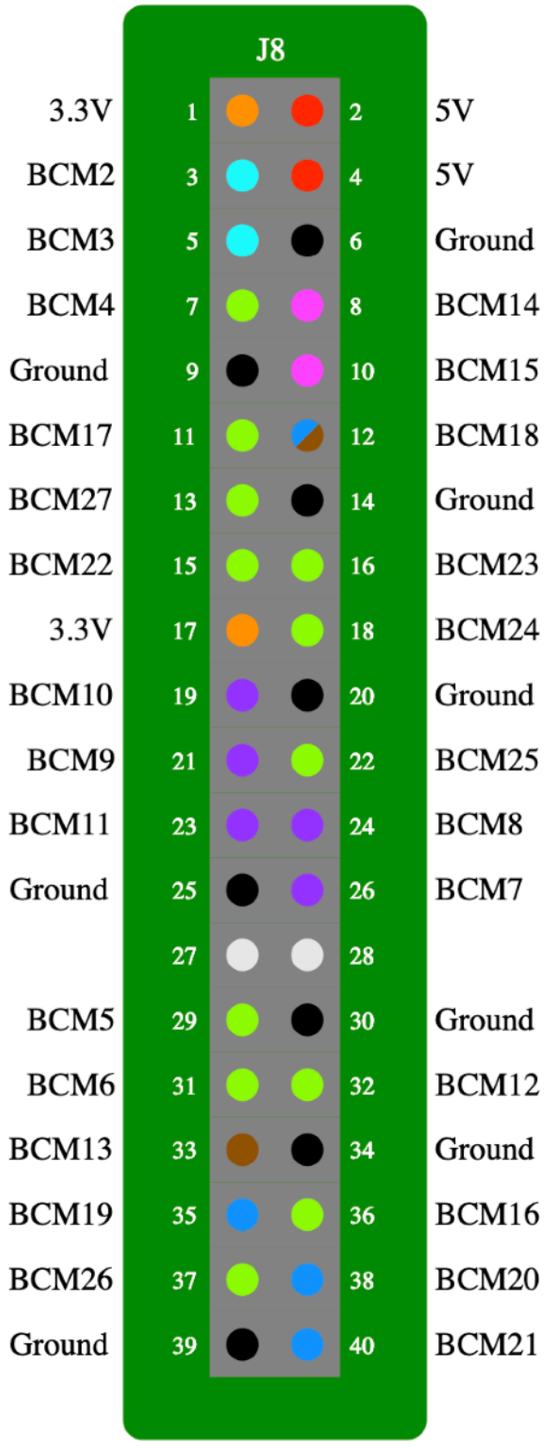
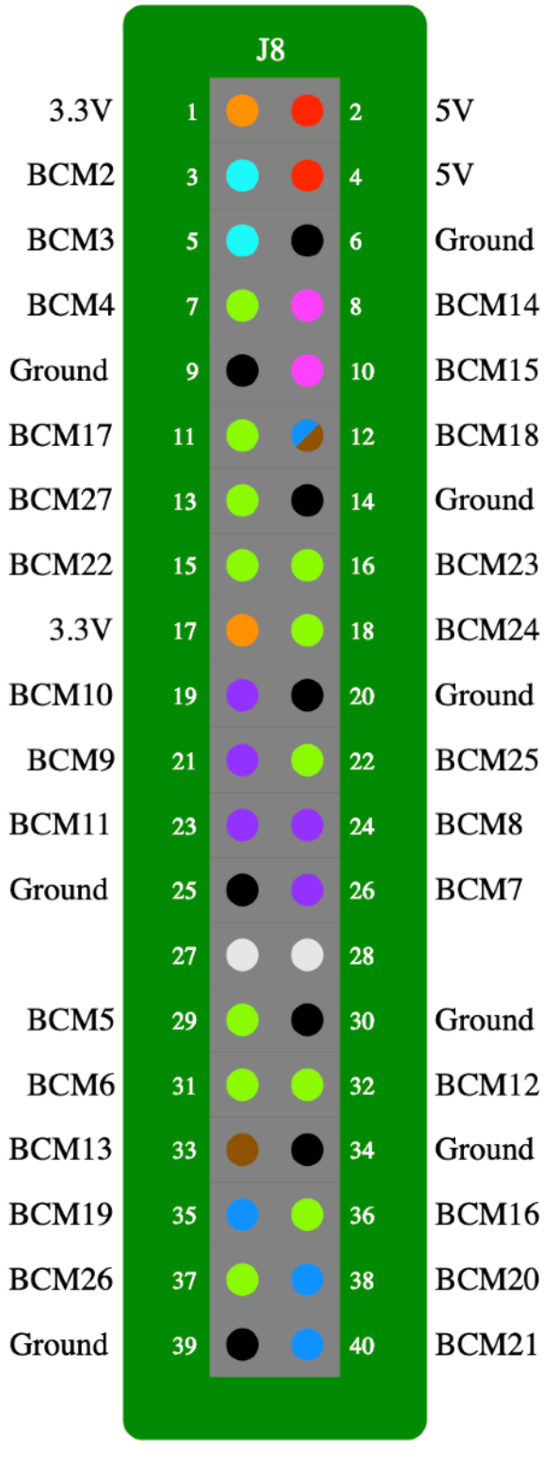
http://www.ohmslawcalculator.com/led-resistor-calculator

Input



- In this case we are measuring V_{out}
- Represented on one bit.

Input



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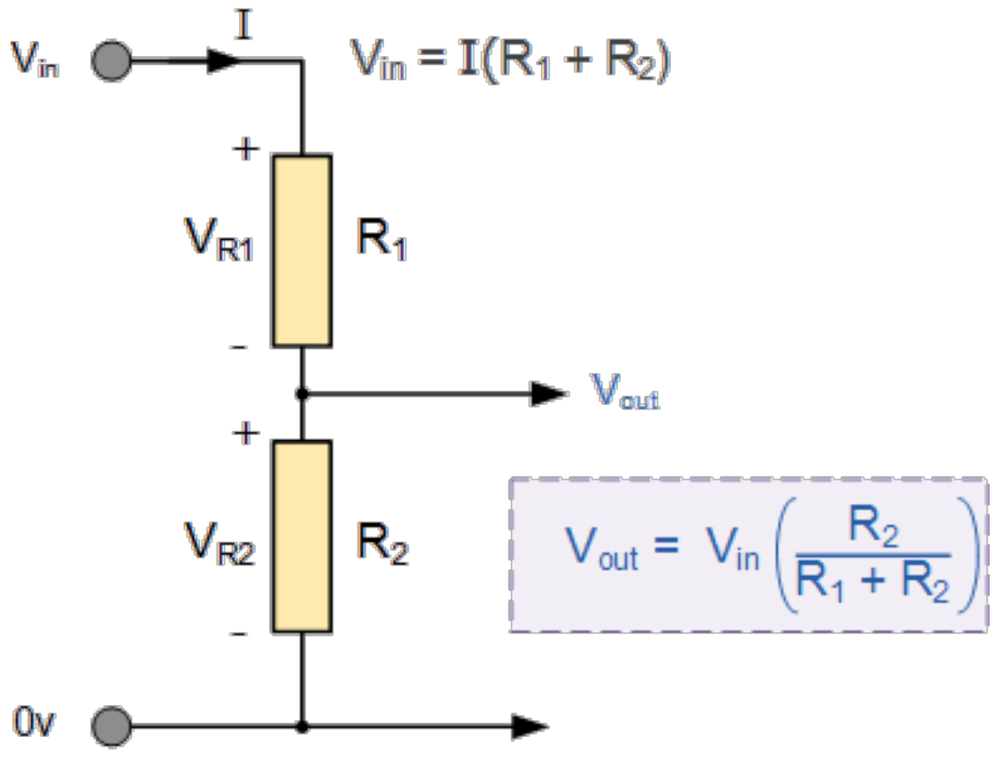
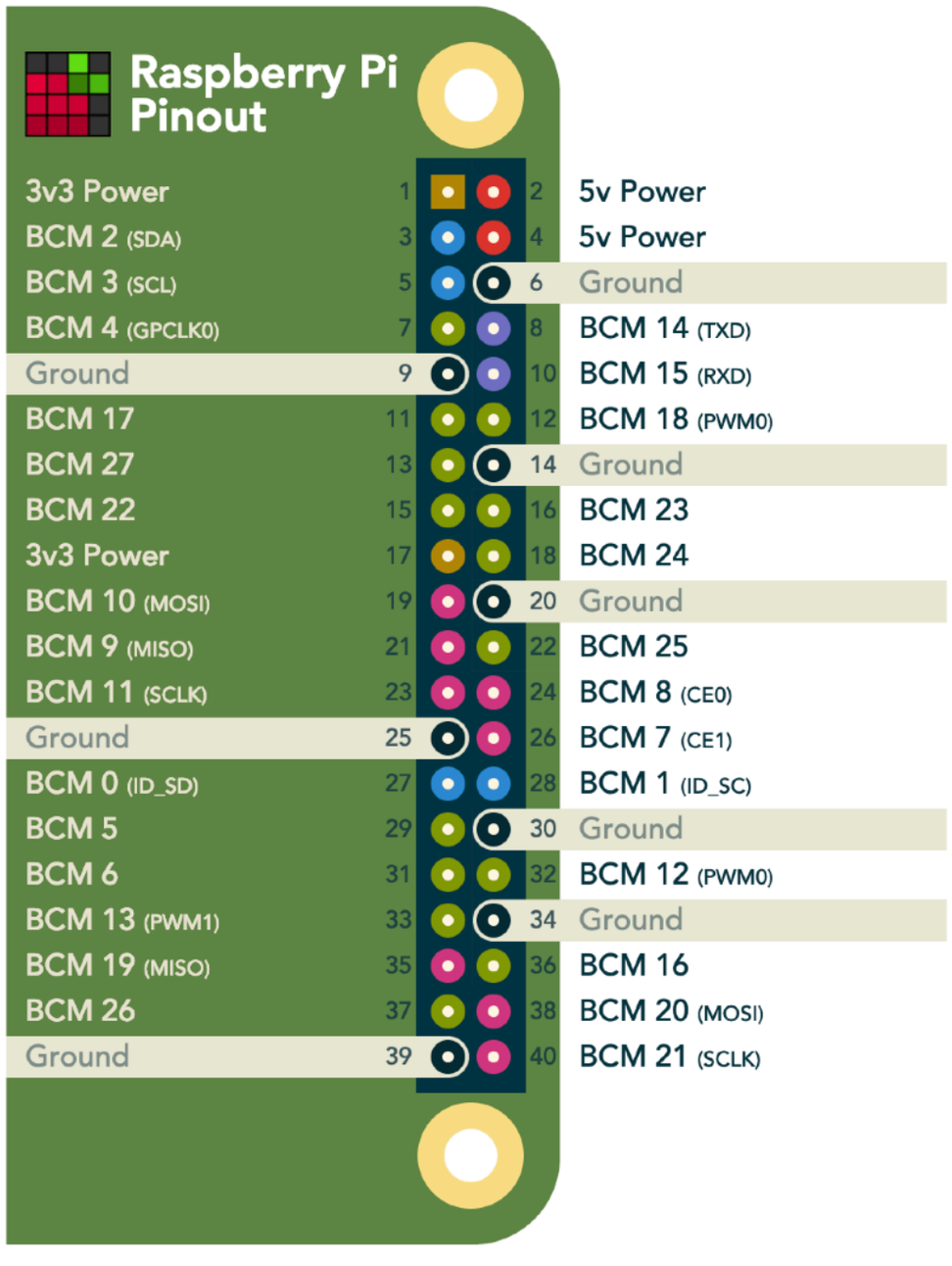


I/O Pinouts



Ground | DPI | GPCLK | JTAG | 1-WIRE | PCM | SDIO | I2C | SPI | UART | WiringPi

Browse more HATs, pHATs and add-ons »

Arcade Bonnet
Connect joystick, buttons and speakers to your Pi

MotoZero
Control 4 motors from your Raspberry Pi

XBee Shield
Use XBee modules with the Raspberry Pi

Score:Zero
A super-simple and stylish soldering kit - makes an NES-style games controller when assembled.

Ground

The Ground pins on the Raspberry Pi are all electrically connected, so it doesn't matter which one you use if you're wiring up a voltage supply.

Generally the one that's most convenient or closest to the rest of your connections is tidier and easier, or alternatively the one closest to the supply pin that you use.

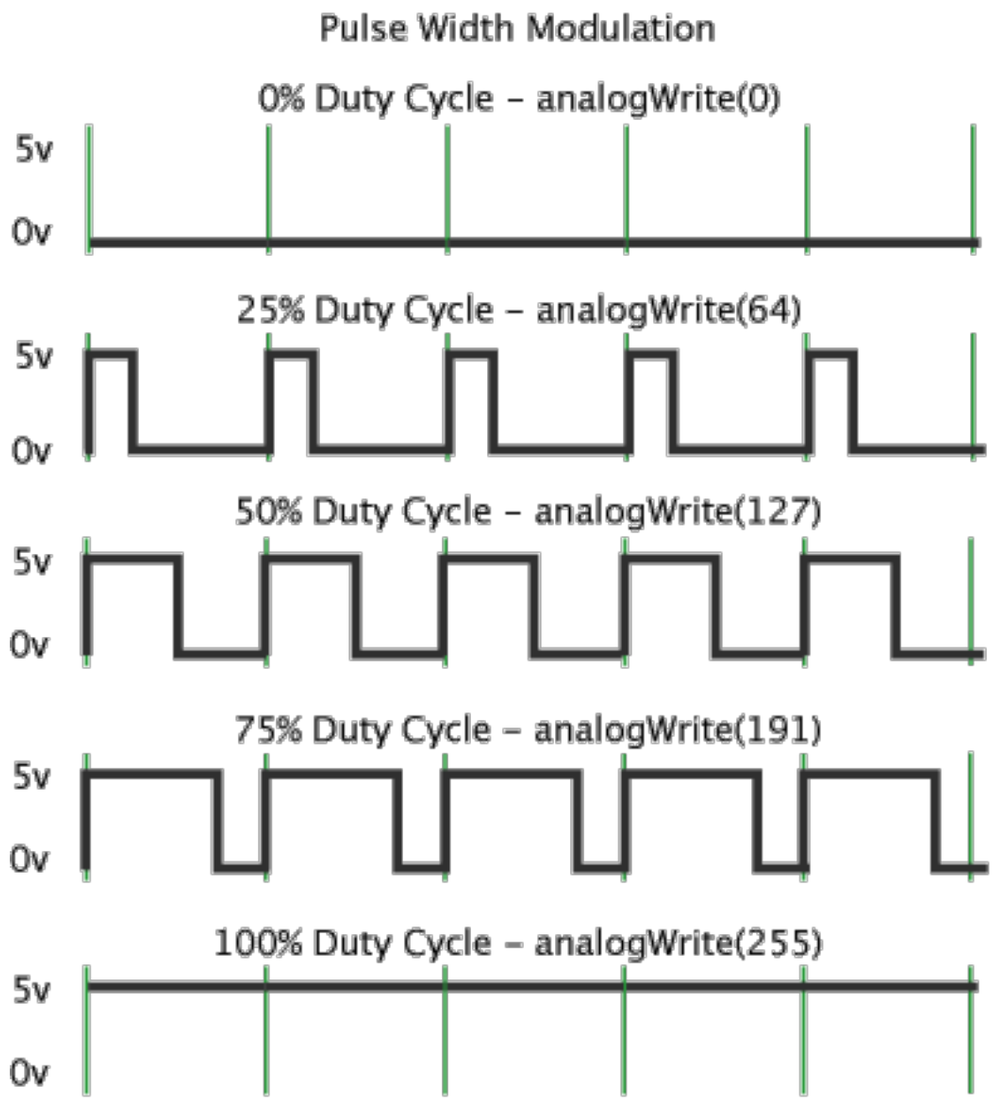
For example, it's a good idea to use Physical Pin 17 for 3v3 and Physical Pin 25 for ground when using the SPI connections, as these are right next to the important pins for SPI0.

Details

- 1 pin header
- Uses 8 GPIO pins

https://pinout.xyz

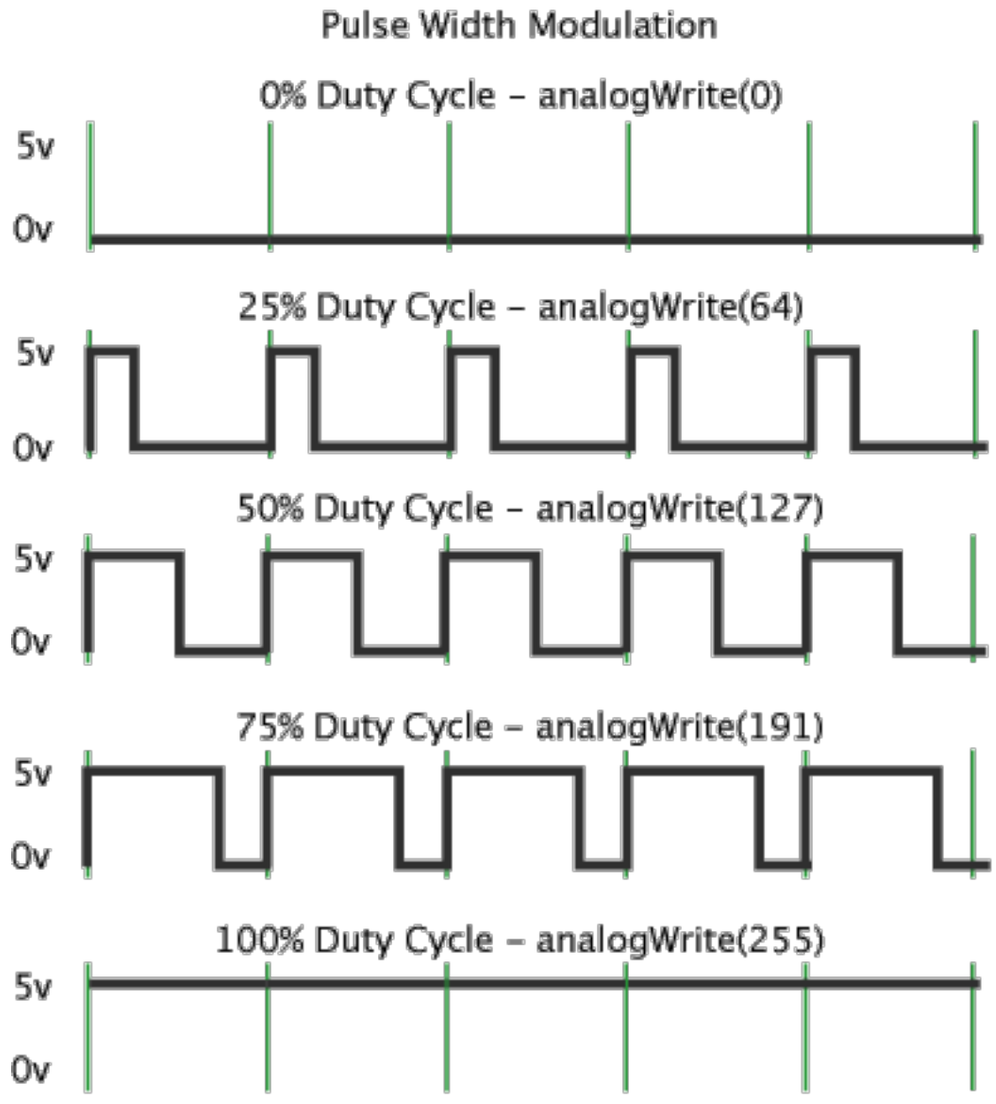
Pulse Width Modulation
PWM



https://www.arduino.cc/en/Tutorial/PWM

Pulse Width Modulation
PWM

- PWM Pins
  - Capable to generate square wave signals.
- We control the % of the duty cycle:
  - 0 - 0%
  - 255 - 100% (check hardware specs)
- Possible usage:
  - Led dimming.
  - Control a servo motor.



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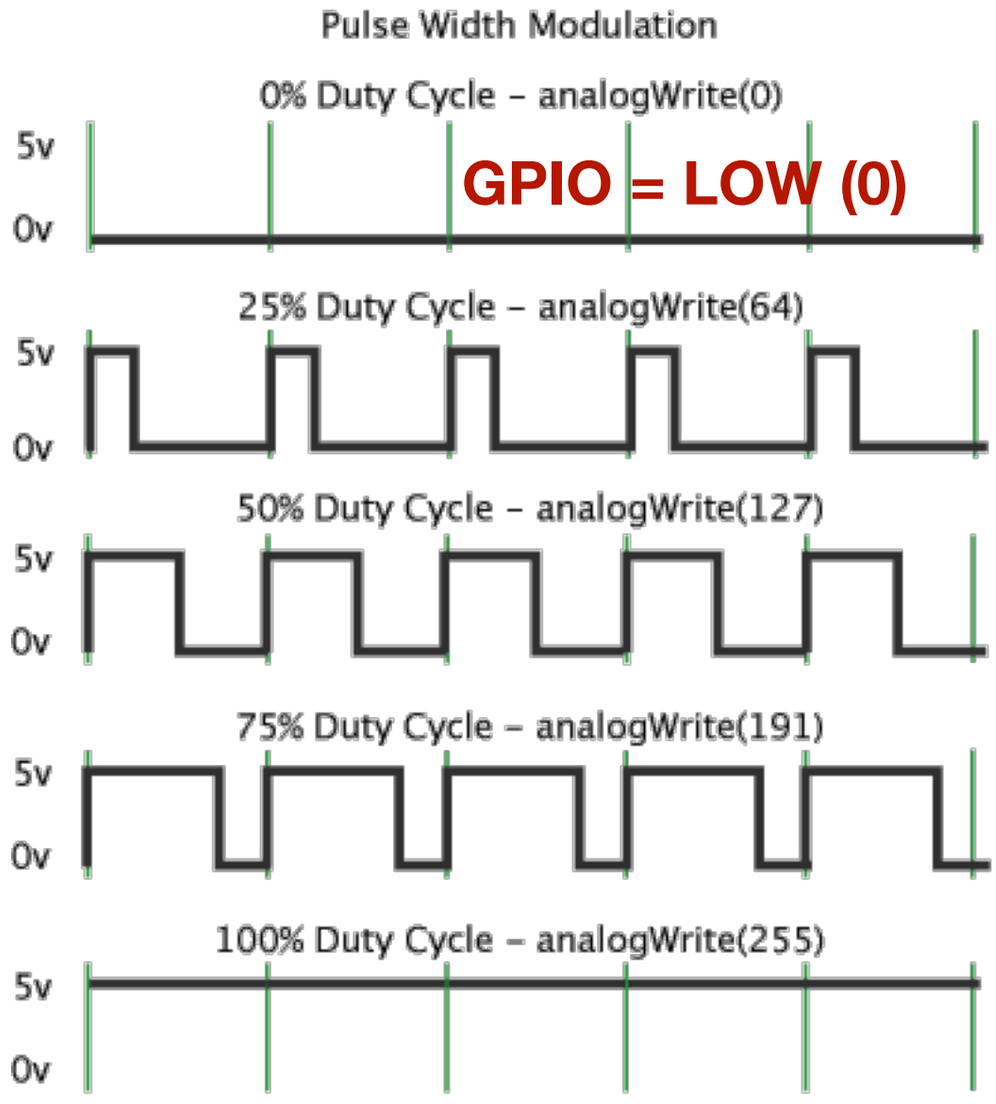

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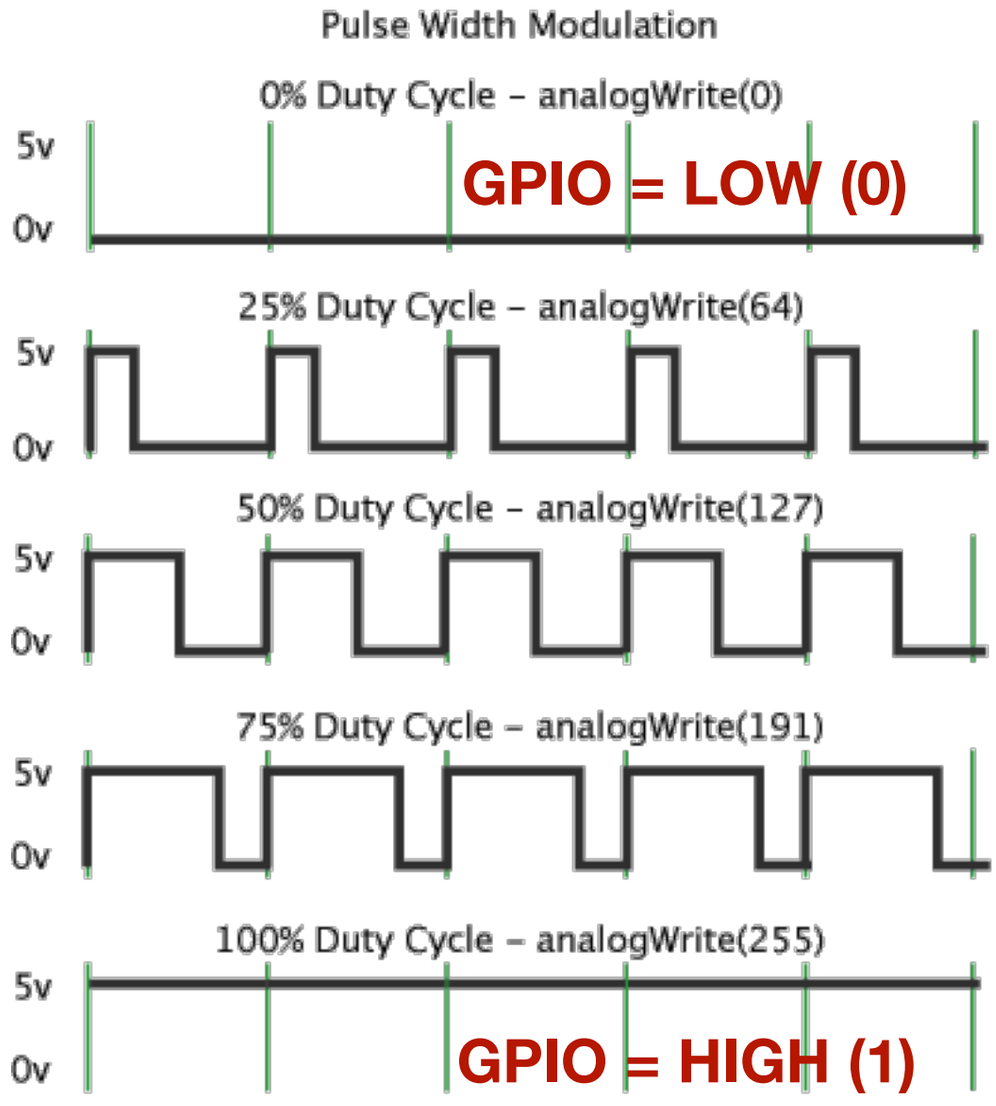

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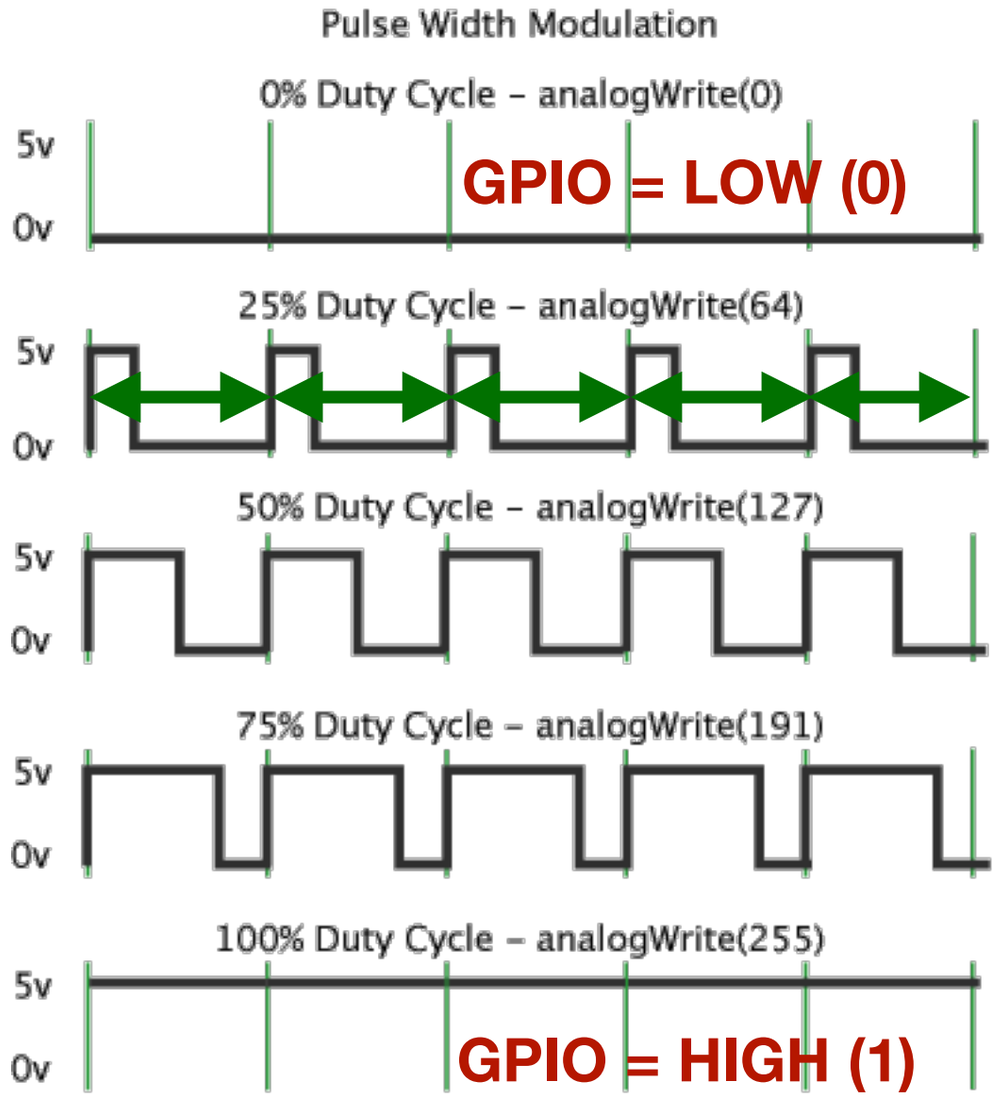
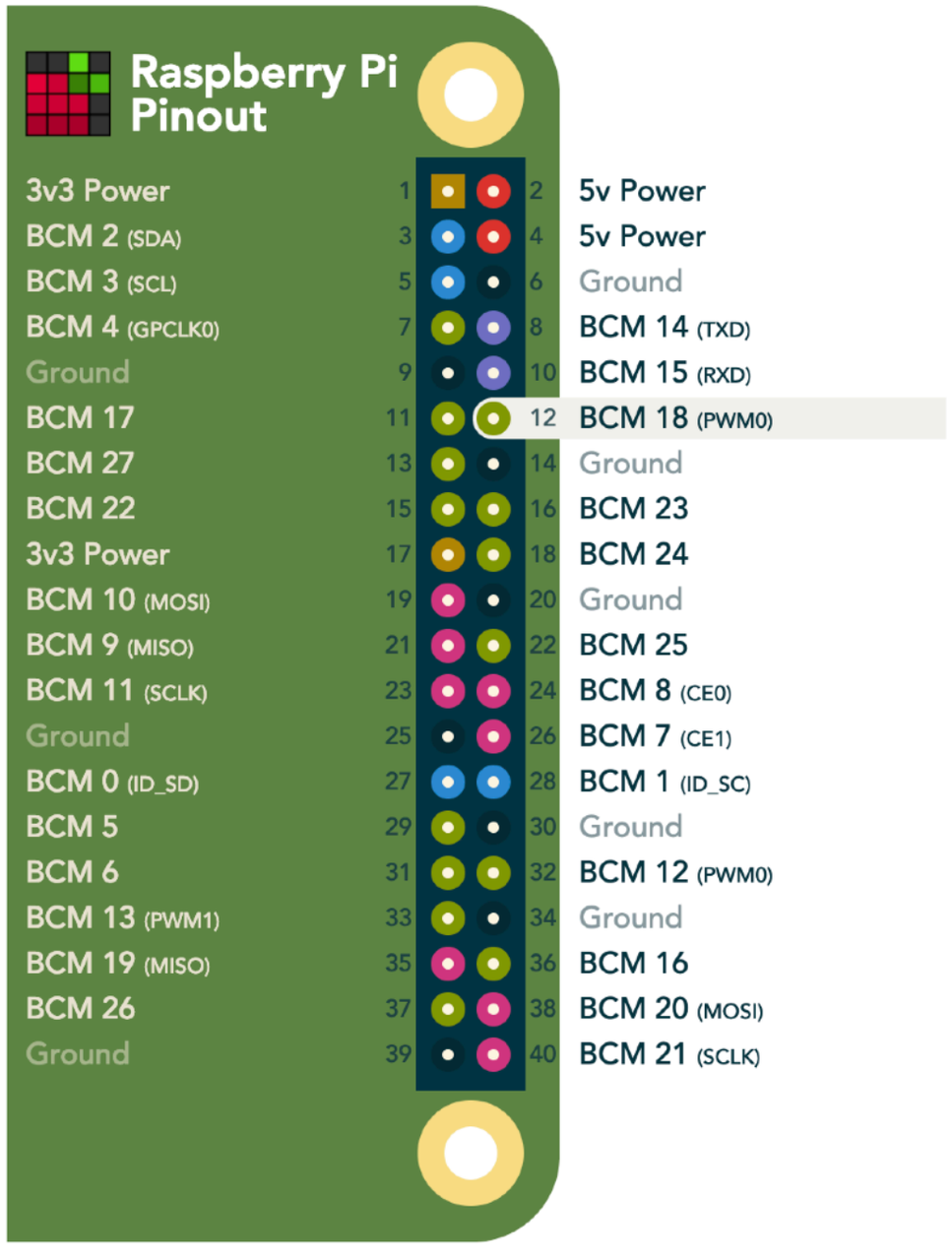
  - 0 - 0%
  - 255 - 100% (check hardware specs)
- Possible usage:
  - Led dimming.
  - Control a servo motor.

Between 1.1Hz and 19MHz



https://www.arduino.cc/en/Tutorial/PWM

Analog to Digital Convertors



Ground | DPI | GPCLK | JTAG | 1-WIRE | PCM | SDIO | I2C | SPI | UART | WiringPi

Browse more HATs, pHATs and add-ons »

Arcade Bonnet
Connect joystick, buttons and speakers to your Pi

MotoZero
Control 4 motors from your Raspberry Pi

XBee Shield
Use XBee modules with the Raspberry Pi

Score:Zero
A super-simple and stylish soldering kit - makes an NES-style games controller when assembled.

BCM 18 (PWM0)

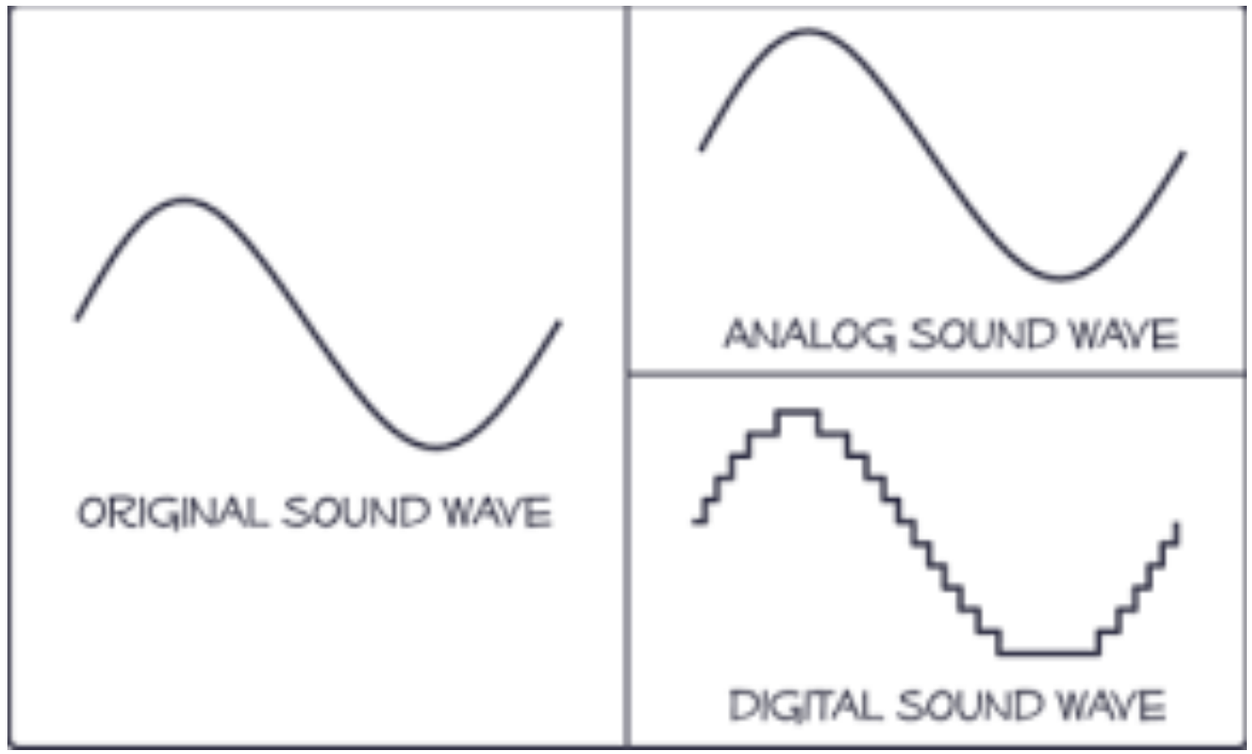
Alt0	Alt1	Alt2	Alt3	Alt4	Alt5
PCM CLK	SMI SD10	DPI D14	I2CSL SDA / MOSI	SPI1 CE0	PWM0

- Physical pin 12
- BCM pin 18
- Wiring Pi pin 1

The PWM0 output of BCM 18 is particularly useful, in combination with some fast, direct memory access trickery, for driving tricky devices with very specific timings. The WS2812 LEDs on the Unicorn HAT are a good example of this in action.

Analog to Digital Convertors

- When reading or writing digital signals we need to establish values for:
    - Bits per sample.
        - 1 bit - GPIO Input.
        - n bits - 0..2^n - 1
- Sampling rate.



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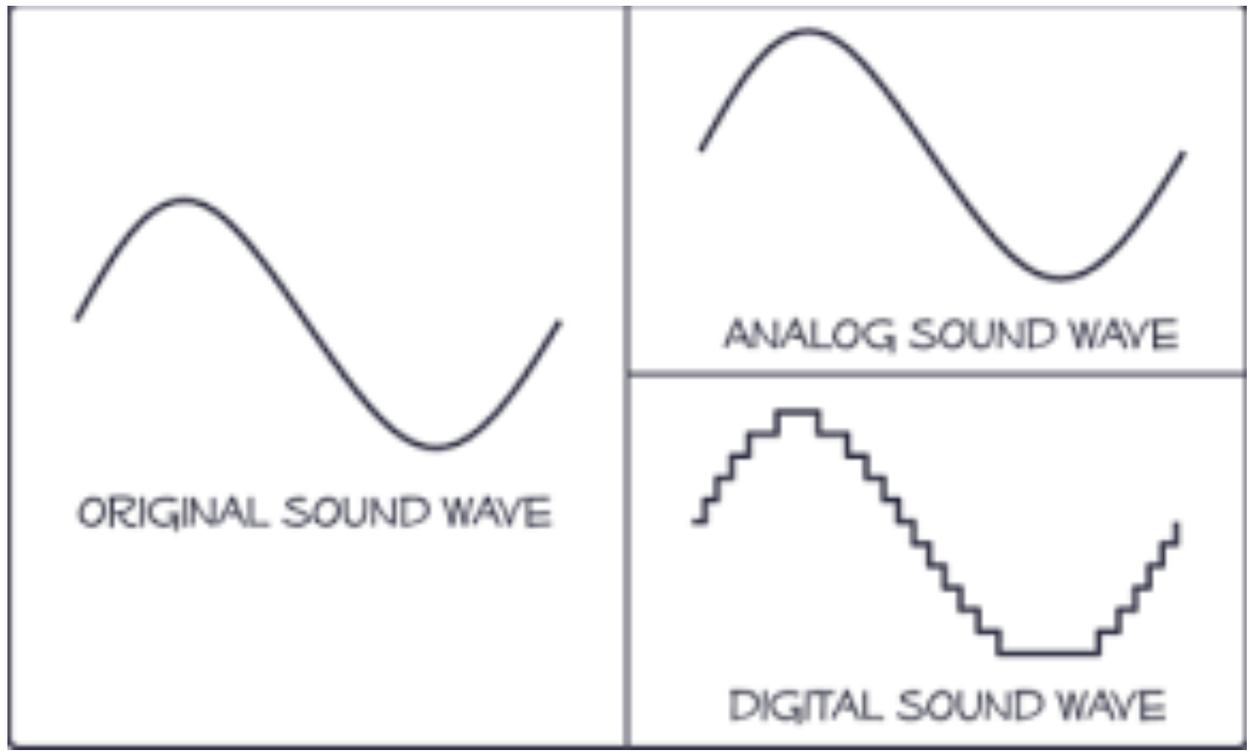
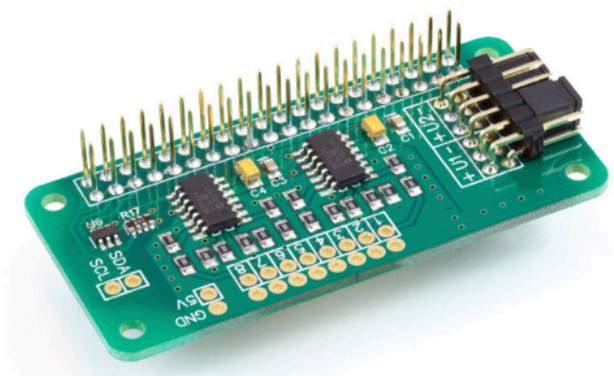


ADC Pi



Analog to Digital Convertors

Features

- 8 x 17-bit 0 to 5V Single Ended Inputs
- Control via the Raspberry Pi I2C port
- Stack up to 4 ADC Pi boards on a single Raspberry Pi
- ...

https://www.abelectronics.co.uk/p/69/adc-pi-raspberry-pi-analogue-to-digital-converter

Analog to Digital Convertors

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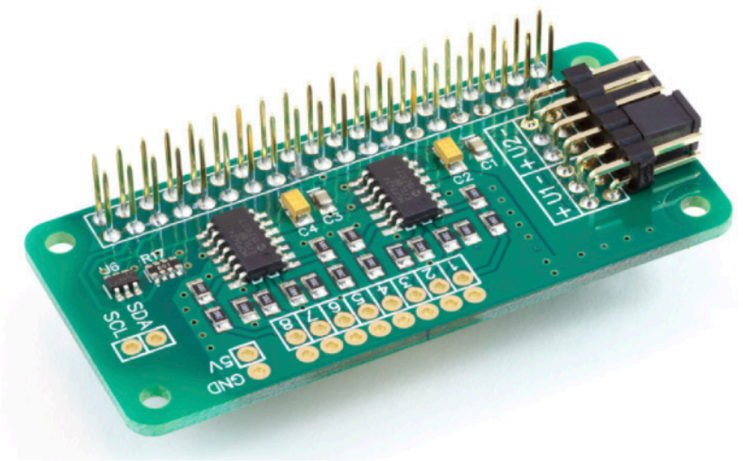
ADC Pi



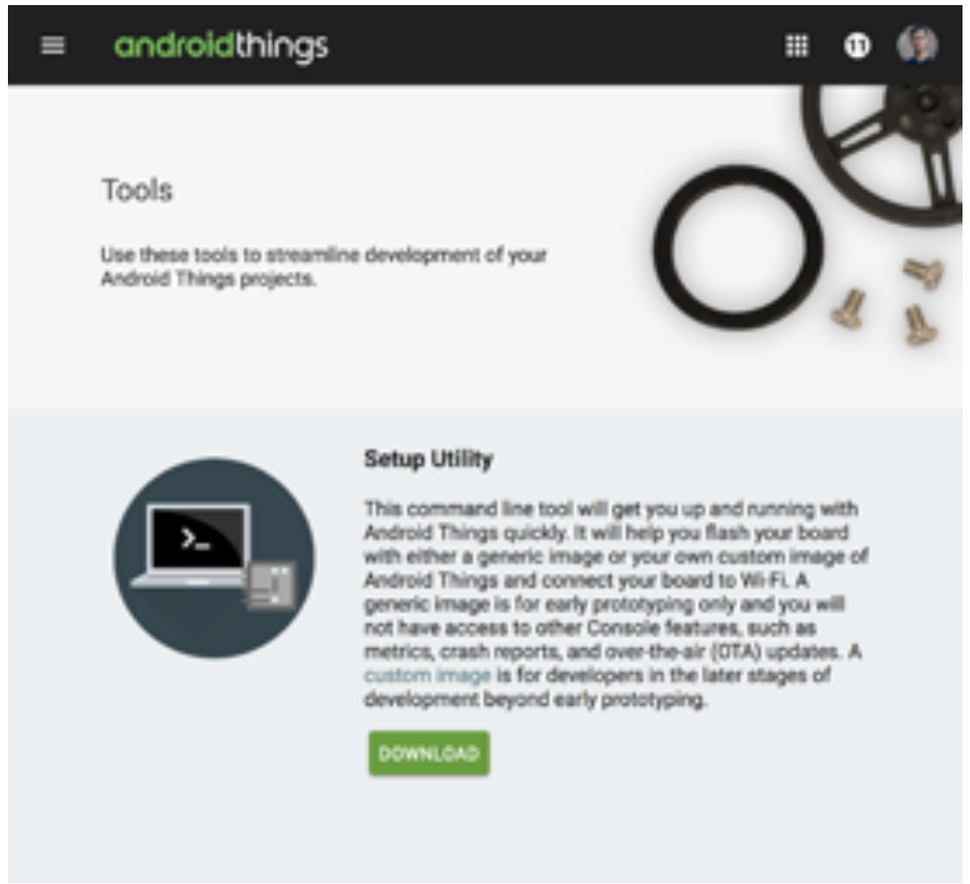
https://www.abelectronics.co.uk/p/69/adc-pi-raspberry-pi-analogue-to-digital-converter

Setup

Image source: https://rehhoff.me

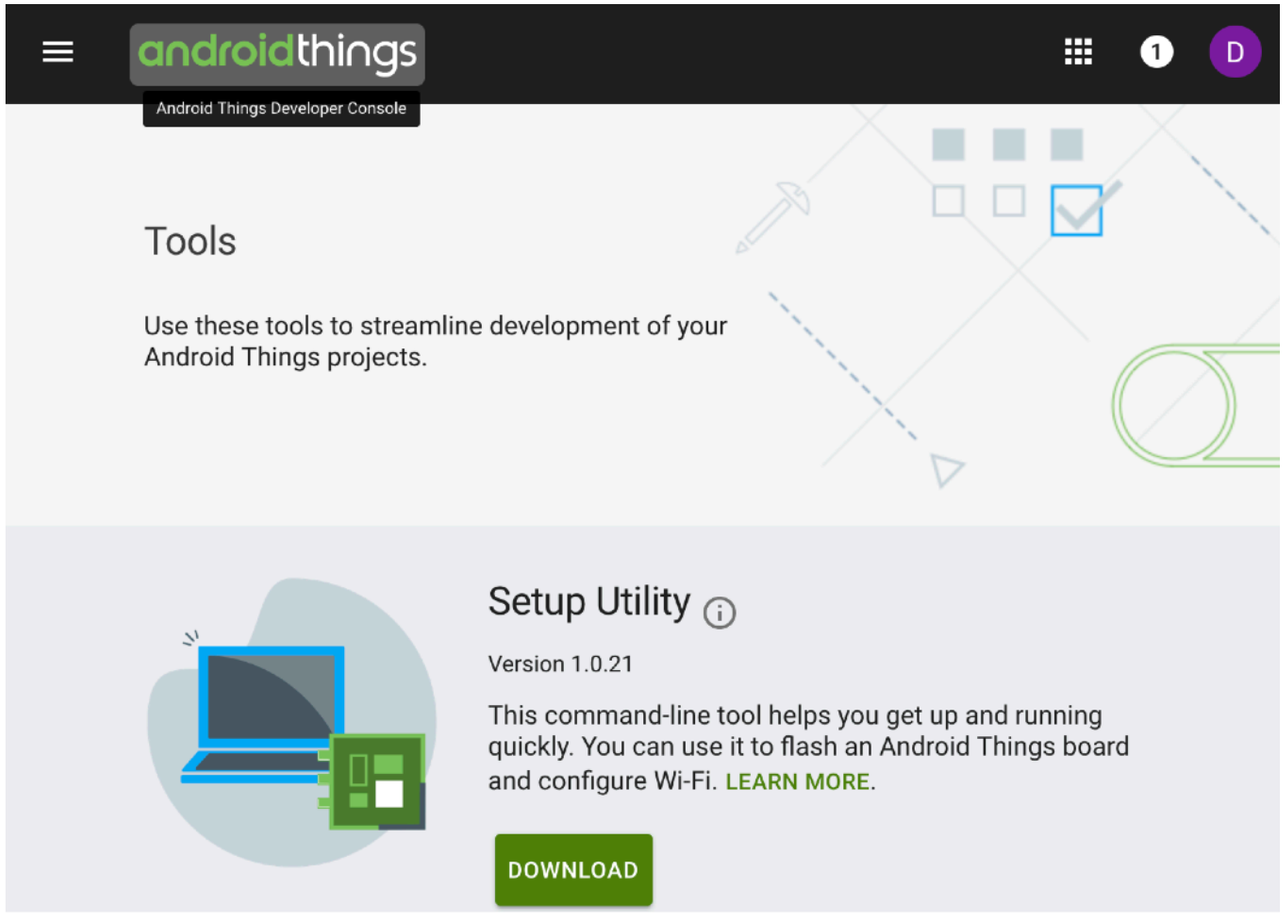
Flashing the Image

- Prerequisite:
  - Micro-USB cable.
  - Ethernet cable.
  - MicroSD card reader.
  - 8GB or larger microSD card.
  - Optional items:
    - HDMI cable.
    - HDMI-enabled display.



Step 1

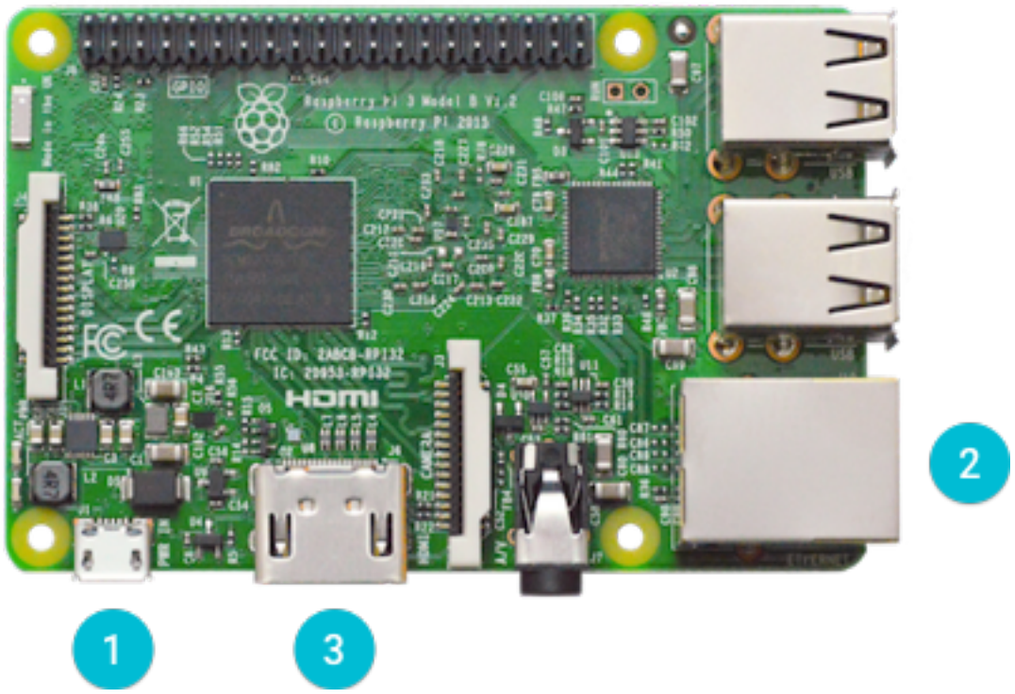
- Download the Android Things Setup Utility.
  - https://partner.android.com/things/console/#/tools
- Using the setup utility:
  - Select the option to install Android Things and optionally set up Wi-Fi.
  - Insert the microSD card into the microSD slot on the underside of the Raspberry Pi.



Step 2

- Connect a USB cable to J1 for power.
- Connect an Ethernet cable to your local network.
- (Optional) Connect an HDMI cable to an external display.
- Verify that Android is running on the device.
  - Connect to the IP address using the adb tool:
    - adb connect <ip-address>

      connected to <ip-address>:5555



Lecture outcomes

- Understand how to establish the needed components.
- How to establish the hardware characteristics for the needed components.
- How to use the available pins for input and output.
- Setup the development platform.