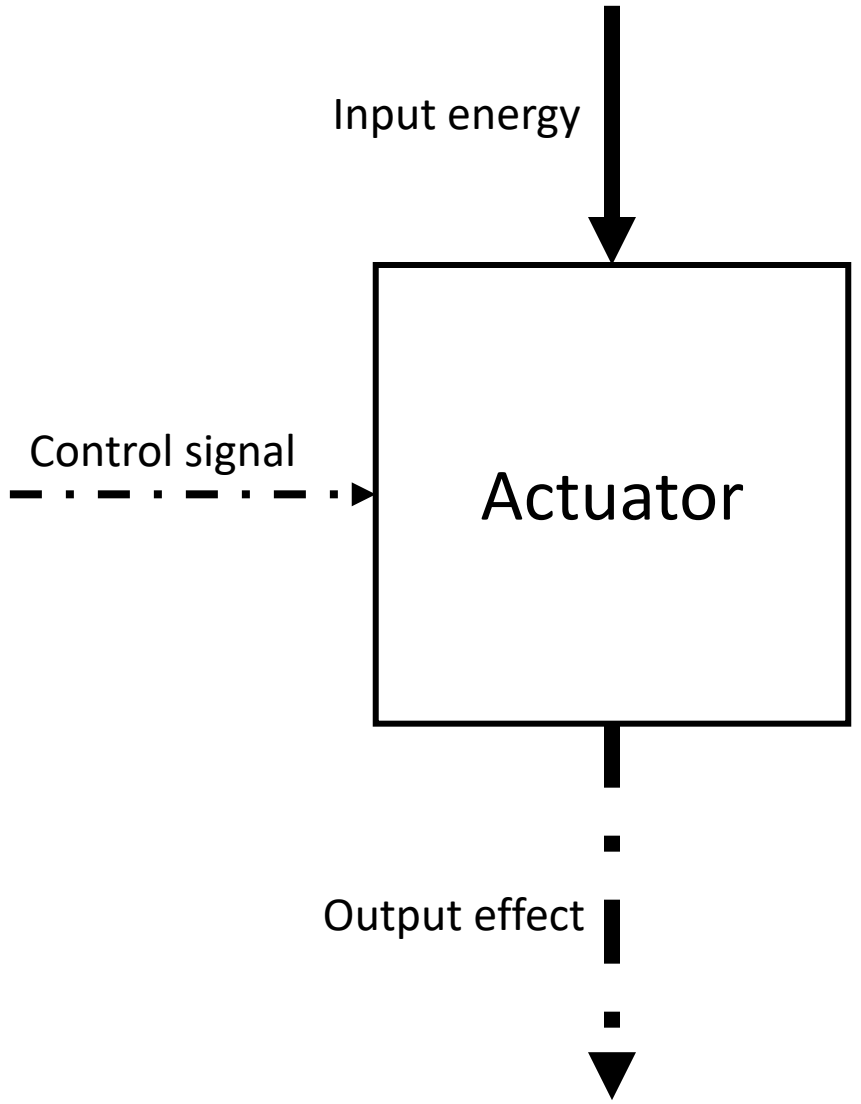
Displays & Actuators

Some theory

What is an actuator?

- Uses energy
  - Electricity, pressure, heat, light …
- Produces an effect
  - Movement, heat, light, radio waves …
- Controlled by a signal
  - Low power
  - Coming from a controller (e.g. ESP32)

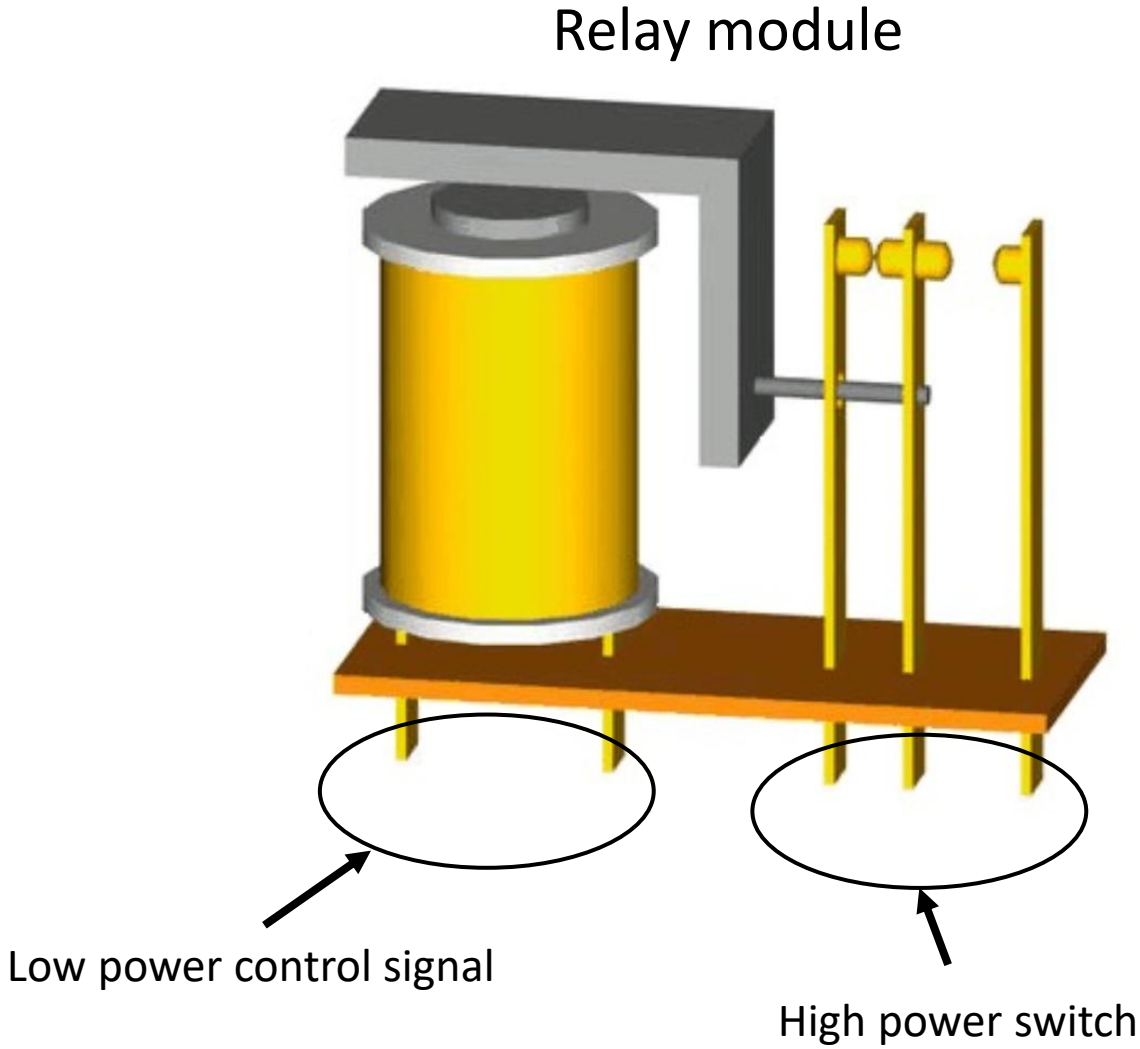


Energy sources and effects

- Sources
  - electricity, pressure, light
  - ESP32 GPIO: 40mA / 0.13W
  - USB: 500mA / 2.5W
- Effects
  - Movement, light, heat
  - Pressure, flow, sound, vibration
- Example
  - Source: electric energy
  - Effect: water flow

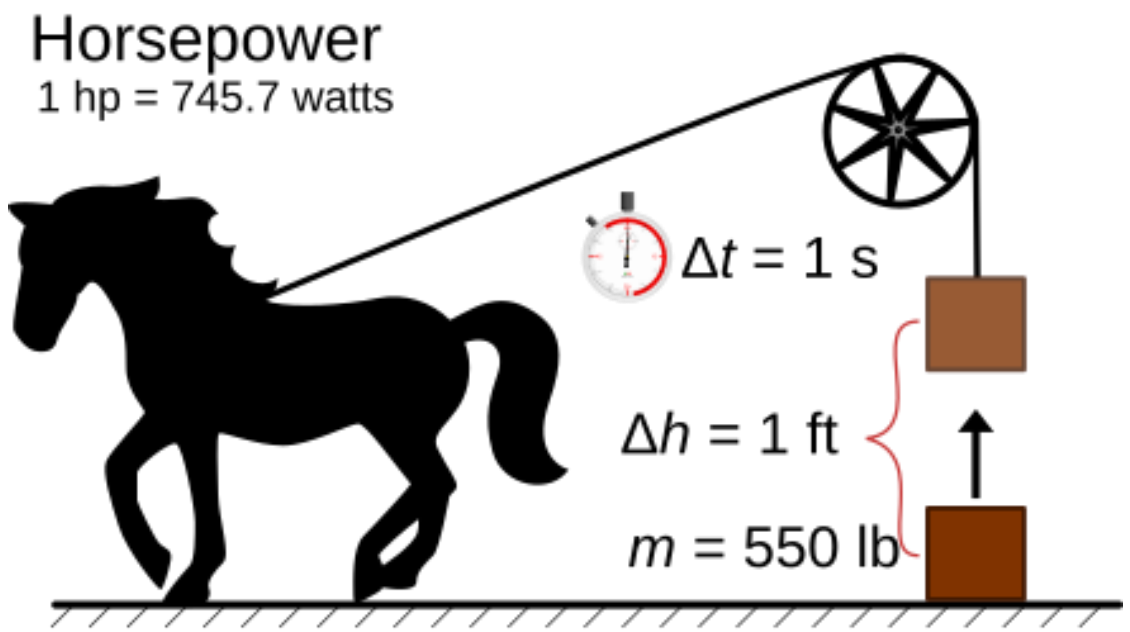
Control signals

- Analog
  - GPIO (on/off)
  - PWM (pulse width modulator)
  - Stepper motor signals
- Digital
  - I2C, SPI, UART
  - Custom
- Bit banging



A note on units

- Power vs Energy
  - 1 W = 1 J/s
  - Power is energy per unit time
  - kW is **power**, kWh is **energy**
- How much is a W, kW, MW?
  - LED: 0.05 - 3W
  - Domestic appliances: ~2 kW
  - Car (Tesla model 3): 366 kW
- Other power units
  - Horsepower (hp, bhp, PS) = ~746W
  - BTU/h = 0.293 W,
  - ton (refrigeration) = 12000 BTU

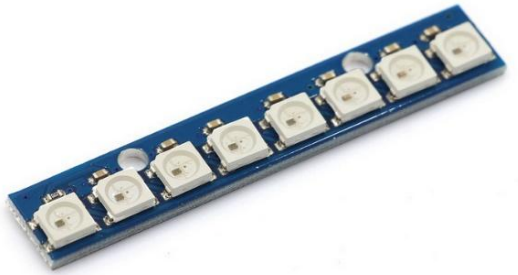


https://en.wikipedia.org/wiki/Horsepower

Examples

LED modules

- RGB (WS2812b)
- Consumes 0-60 ma
- Control 500+ leds with a single GPIO

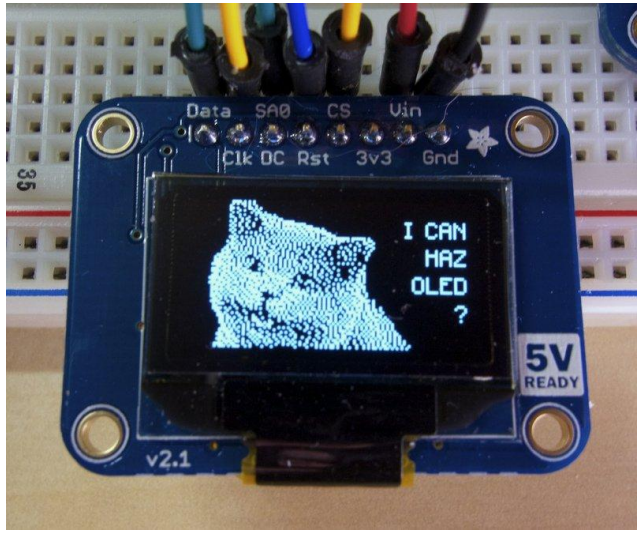


Character Display

- LCD Display
  - Only Characters / no Graphics
- Sizes: 1x8, 2x10, 2x16, 2x20, 4x40, 2x20
- Control
  - I2C to send characters
  - Backlight on/off

OLED B/W

- Protocol: I2C or SPI
- Types: 128x64, 128x32, 64x32
- Black/White, Black/Blue, Black/Yellow/Blue



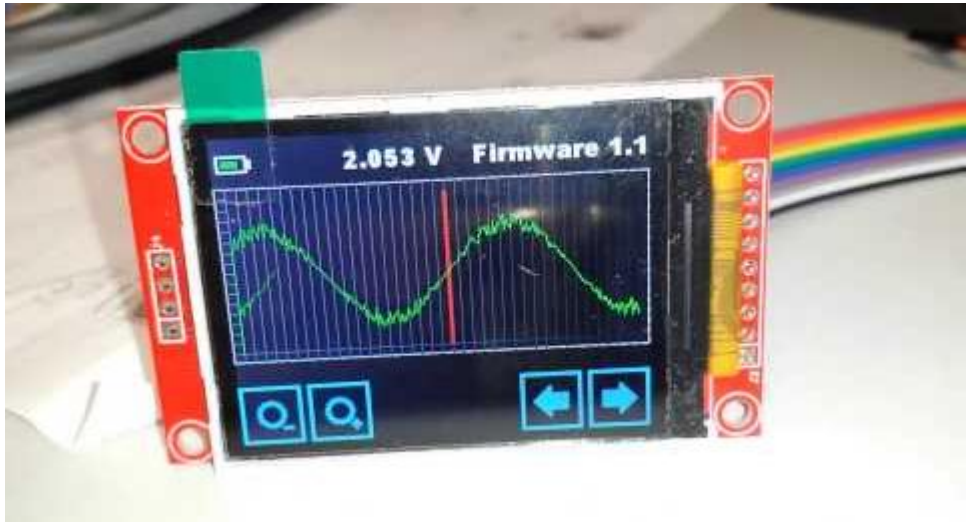
Nokia 5110

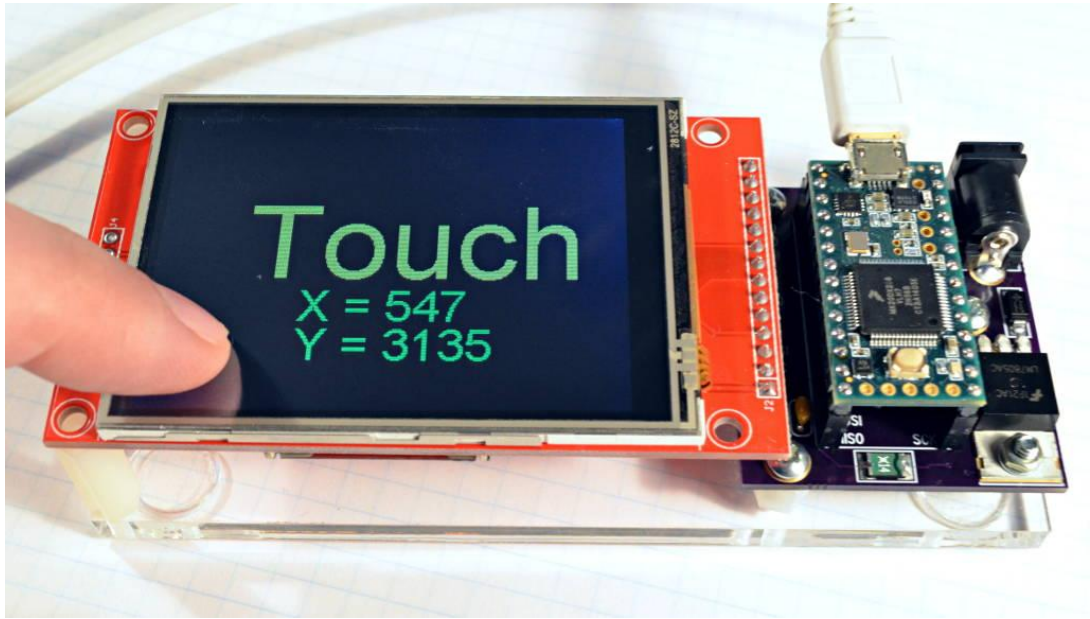
- Resolution: 84x84
- Very Low Power
- Custom Driver

https://botland.de/alphanumerische-und-grafische-anzeigen/2650-grafisches-lcd-display-84x48px-nokia-5110-blau-5904422309299.html

TFT Display (ILI9341)

- 320x240 px, 15/16 bit color, 2.2” – 3.2”
- SPI (5+ wires communication)
- Resistive Touch support (on some models)
- Library: https://github.com/Bodmer/TFT_eSPI



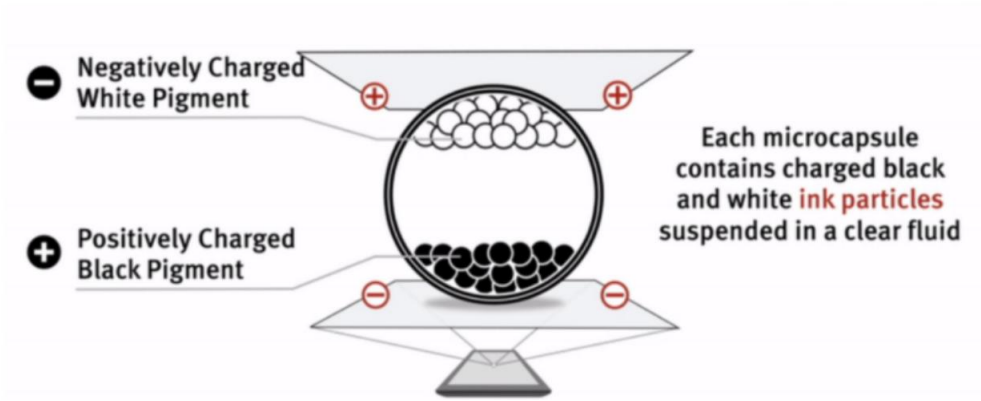


Nextion Displays

- Integrated 48–108Mhz CPU
- Protocol: Custom 2 wires
- Size: 2.4”, 2.8”, 3.5”
- IDE for visual design

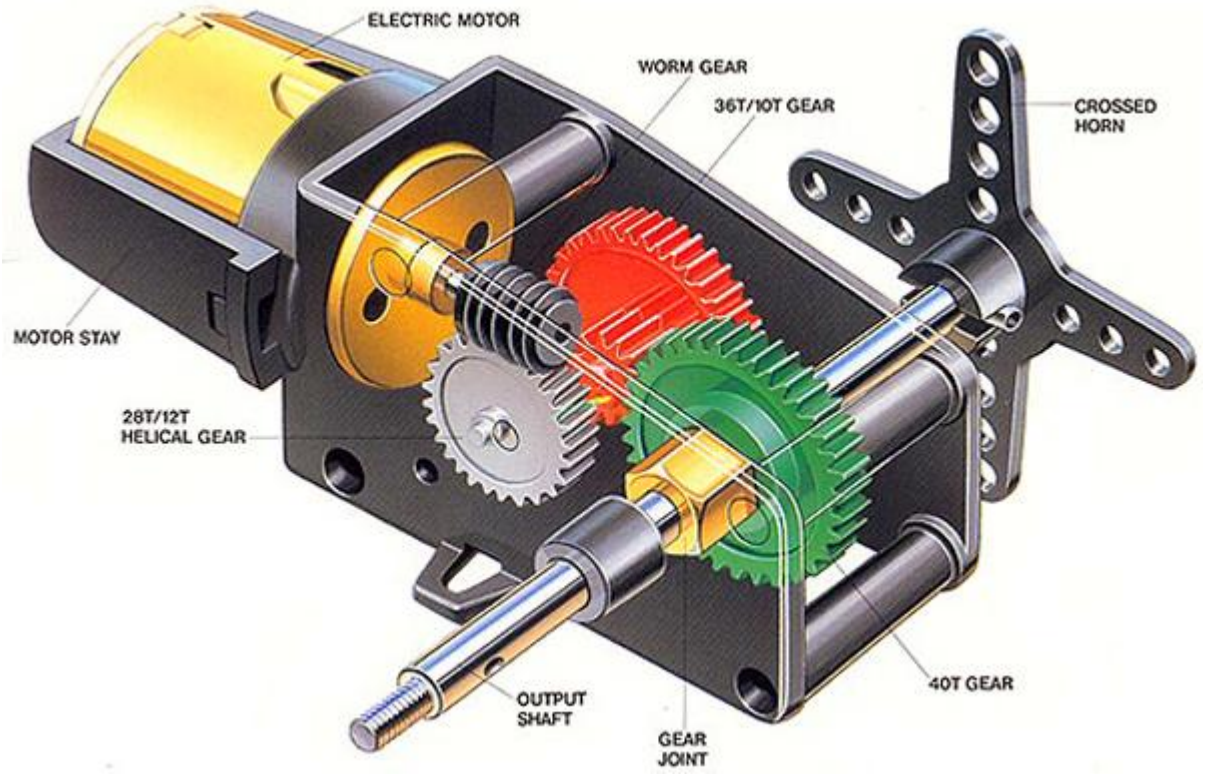
E-Ink / E-Paper Displays

- Resolution: 296x128
- Power supply: **3,3V**
- Refresh current: 85mA
- Standby power: 0,017mW
- Interface: SPI
- Full refresh: 2 s
- Price: 20$



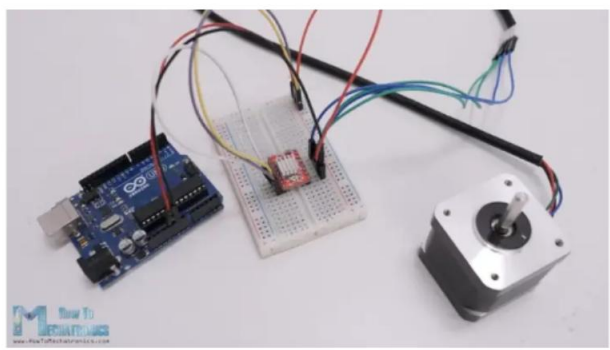
Servo motor

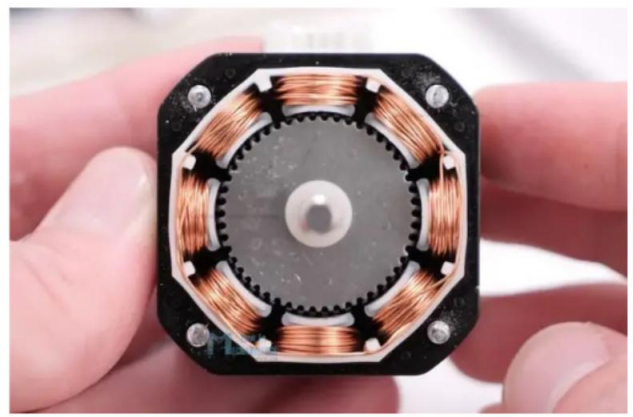
- Rotates and holds
  - +/- 90/180/360 degrees of rotation
- Various torque/power levels
- Control
  - 3 wires (+,- and PWM)
  - PWM width to angle
  - Built it feedback sensor

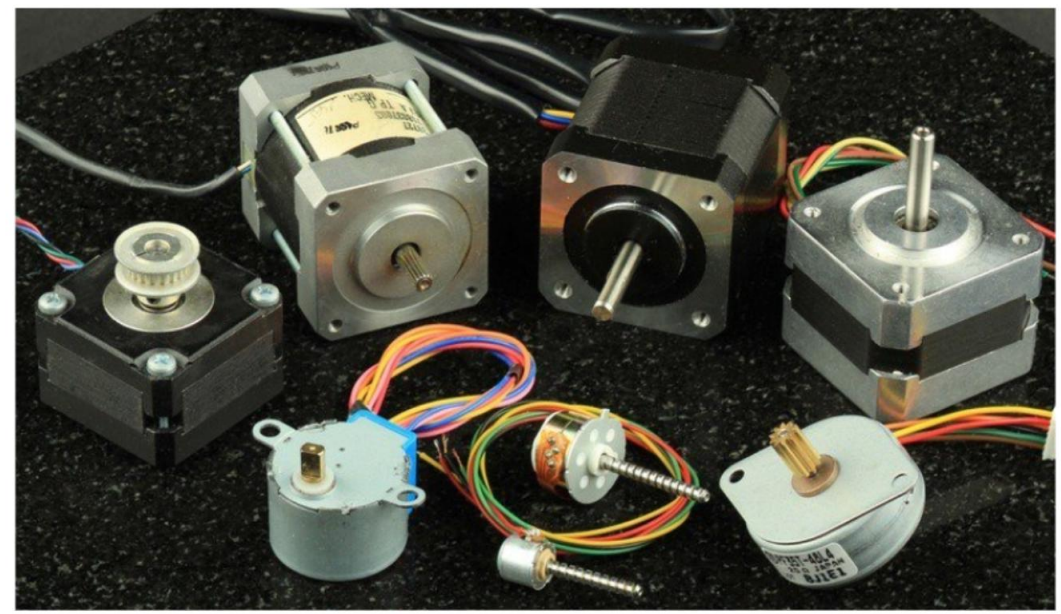


Stepper (стъпков) Мотор

- Може да се контролира колко точно стъпки да се завърти, например 10 градуса, 20, 30, не се връща сам обратно
- Обичайни стъпки на завъртане 0.9°, 1.8°, 3.6° и 4.5°, най-разпространени 1.8°
- Контролер на стъпков мотор

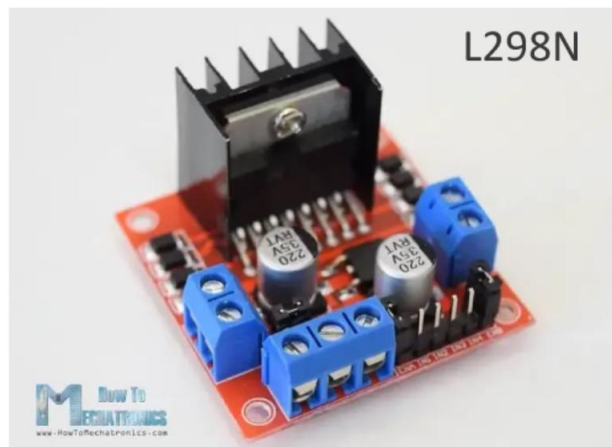


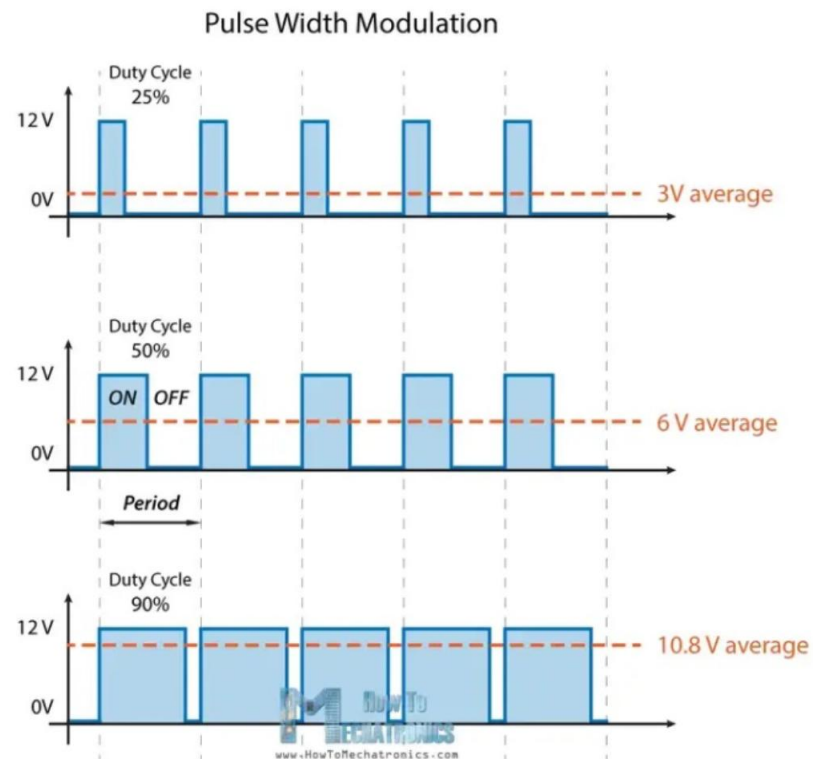




DC Motor

- Controlled by PWM and ESC (Electronic Speed Control)



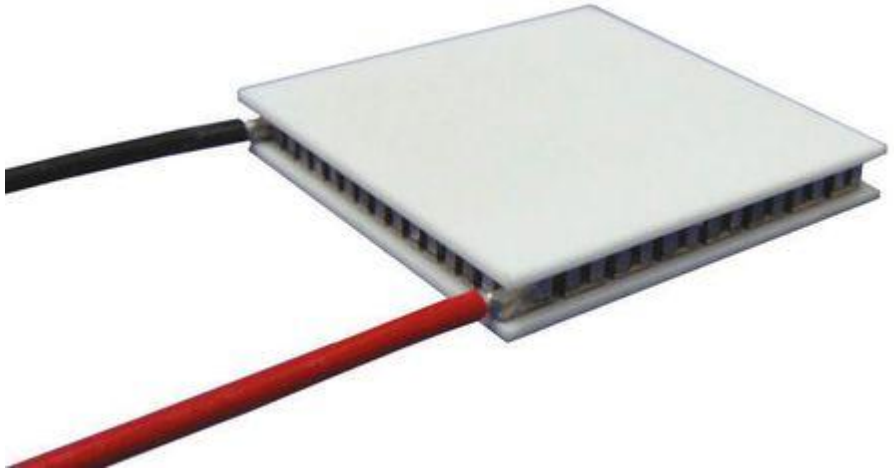


Linear Actuator

- Motor + gearing
- Position sensors vs Overload tolerant

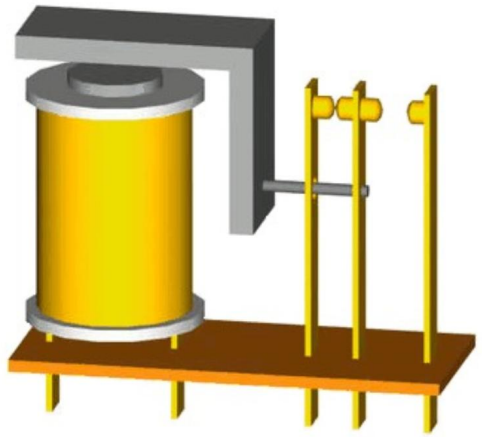
Peltier Module

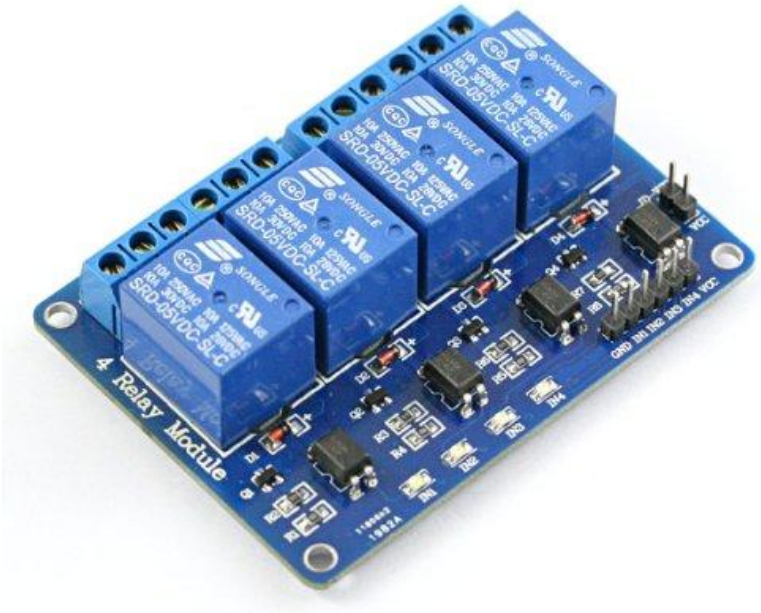
- Solid state, active cooling
- One side gets cold and the other gets hot
- Low efficiency, but still useful for temperature control



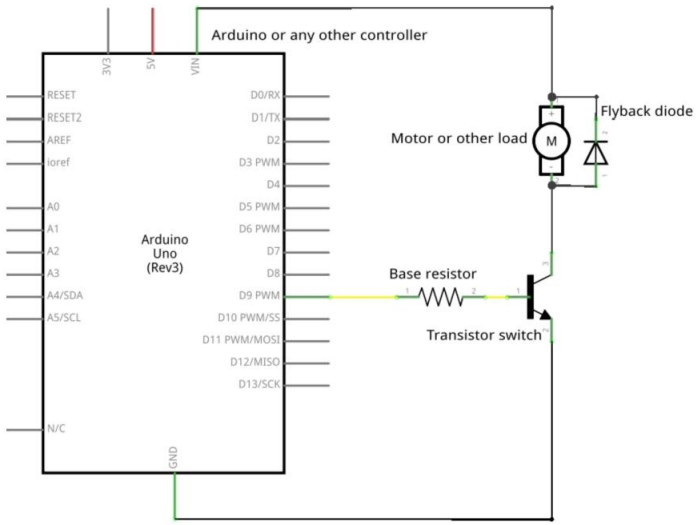
Relay modules

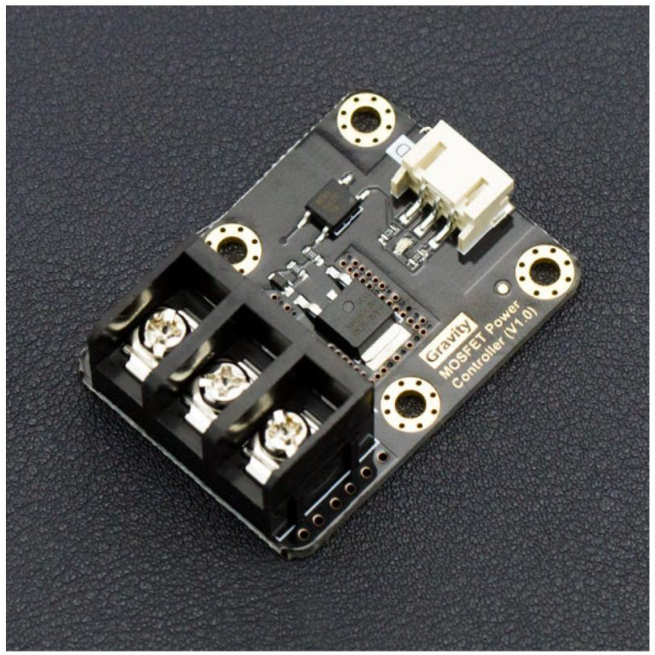
- Control circuit
  - Rated voltage: 3.3, 5, 12, 220V…
  - Low current/power
- Operating circuit
  - Rated current: 1, 5, 10A …
  - Rated voltage: 12V, 220V …
  - AC vs DC (arcing, impedance …)

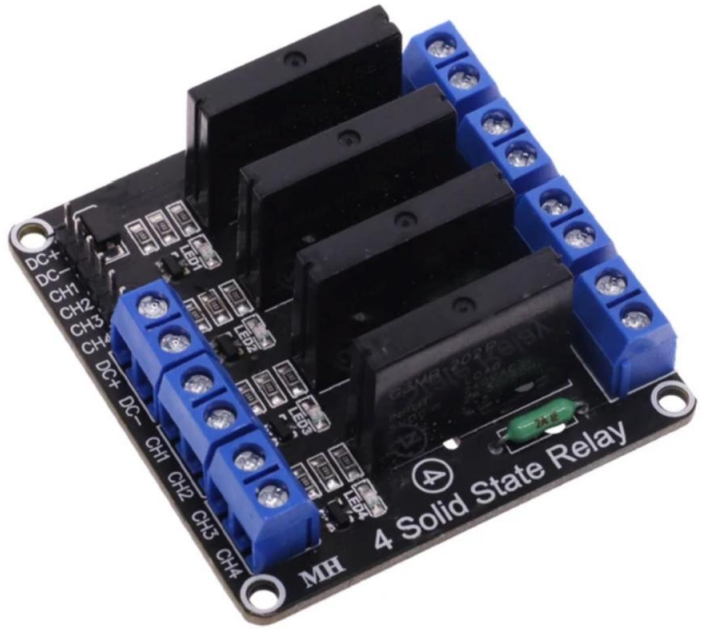




Електронни ключове / Solid State Relay







Push/pull solenoid actuators

- On/off position actuator
- Use cases
  - Valve
  - Electric lock
  - Fuel injectors
  - Gearboxes
  - Production lines

Vibration actuators

- Motor or “speaker”
  - Eccentric Rotating Mass (ERM)
  - Linear Resonant Actuators (LRA)
  - Voice Coil (VCA/VCM)
  - Piezoelectric (PA)
- Use cases
  - Haptic feedback to the user
  - Ultrasonic washing
  - Industrial processing
- Controlled by PWM

Exercises