Hardware platforms

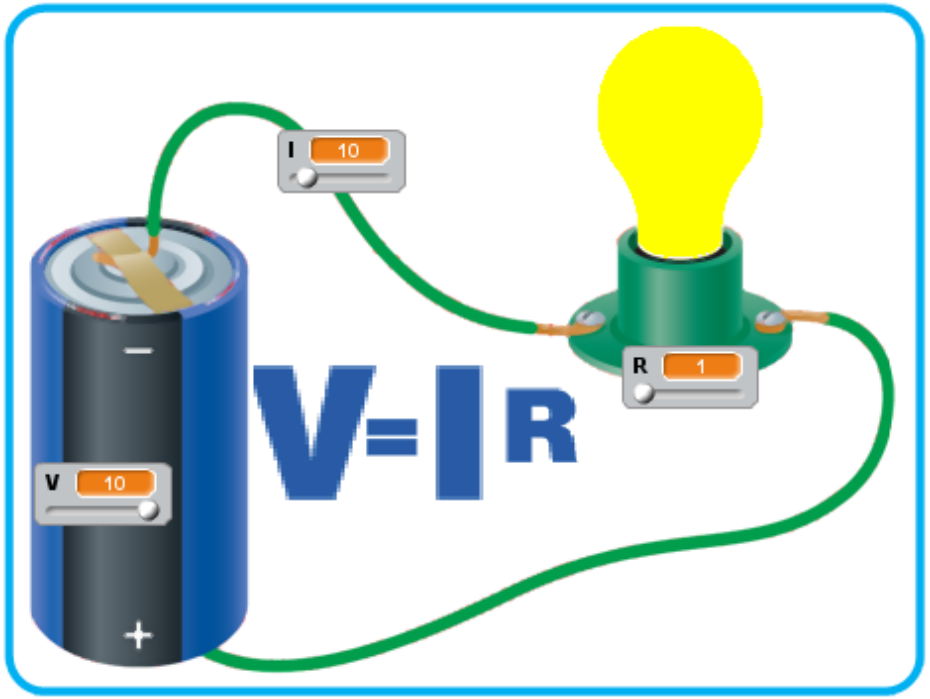
Overview and ESP8266

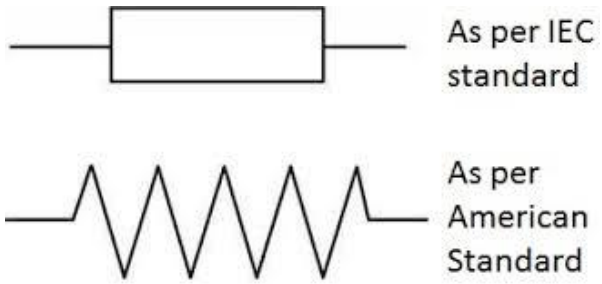
Some circuit theory

- Ohm’s law: voltage, current and resistance
- A word about capacitors and inductors
- Switch (e.g. button)
- LED

Ohm's law

- Key concept: **resistance** (R)
- **I = V / R**
  - **More** voltage -> **more** current
  - **Less** resistance -> **more** current
- Useful analogy: **water & pipes**
  - Pressure <-> Voltage
  - Flow <-> Current
  - Pipe diameter <-> Resistance
- Resistor element

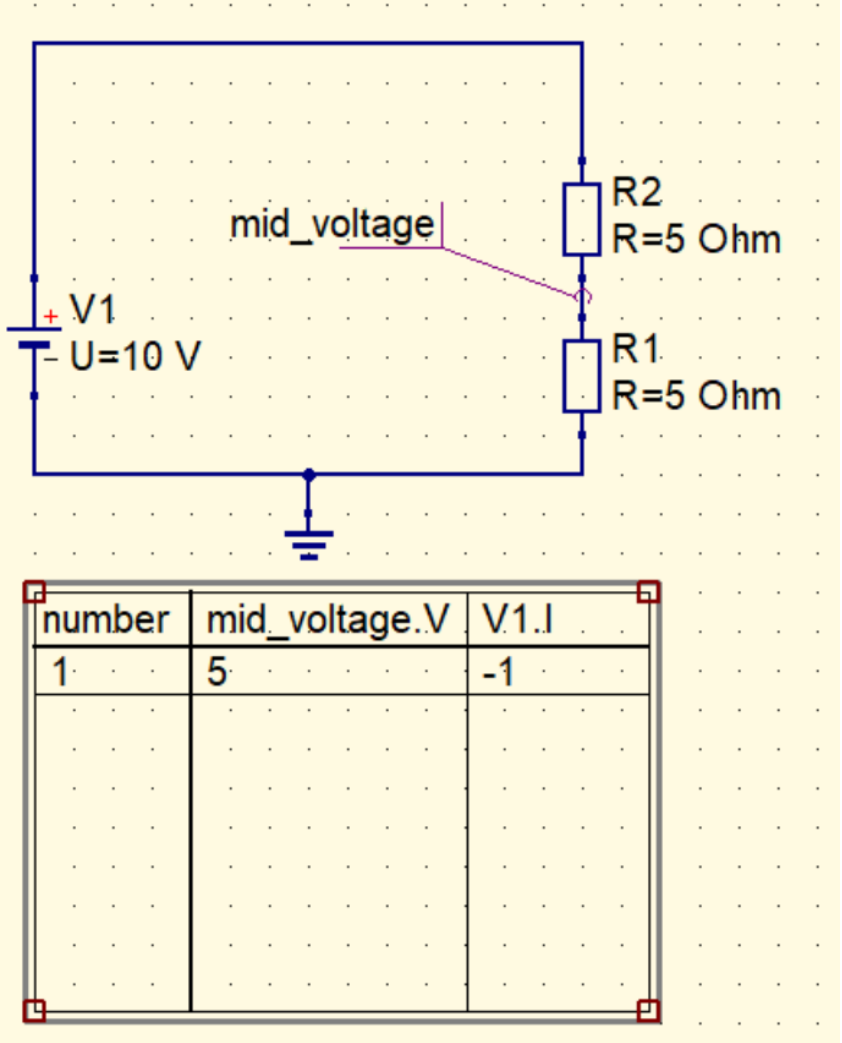




https://scratch.mit.edu/projects/17822395/

Circuit theory

- Ohm’s law on steroids
- Circuits can be more complex …
- But we can simulate them
  - DC steady state & sweep
  - AC linear (frequency domain)
  - Transient
  - …

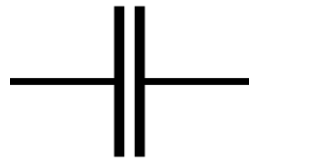


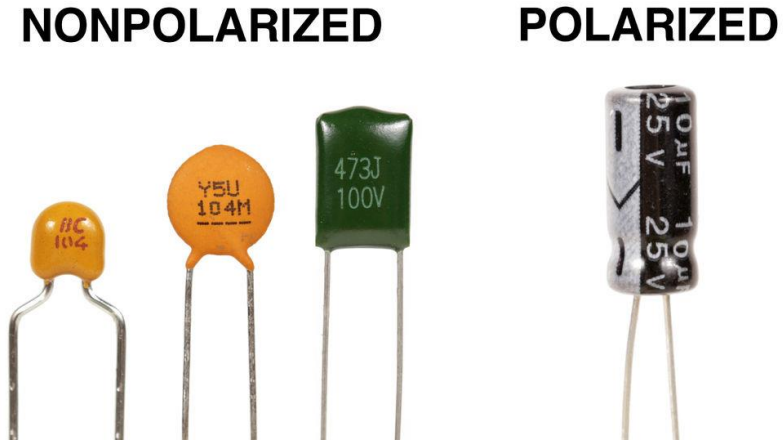
number	mid_voltage.V	V1.I
1	5	-1

http://qucs.sourceforge.net/docs/tutorial/getstarted.pdf

Capacitors & Inductors

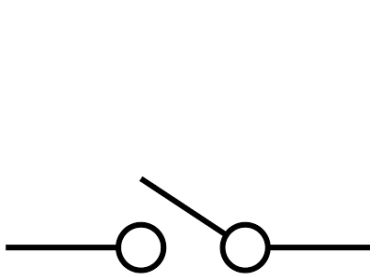
- Concept: Energy builds up in time
- Capacitor
  - builds up voltage
  - May be **polarized**
- Inductor
  - builds up current
  - non-polarized
- Common uses:
  - Filter
  - Energy buffer/store



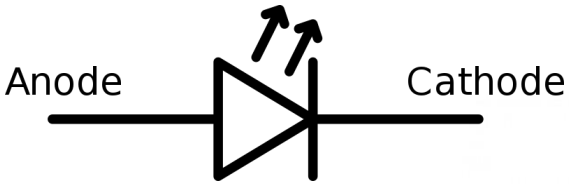


Switch & LED

- Switch
  - Turns electricity on/off
  - May come in many physical forms
  - Normally open (NO) vs Normally closed (NC)

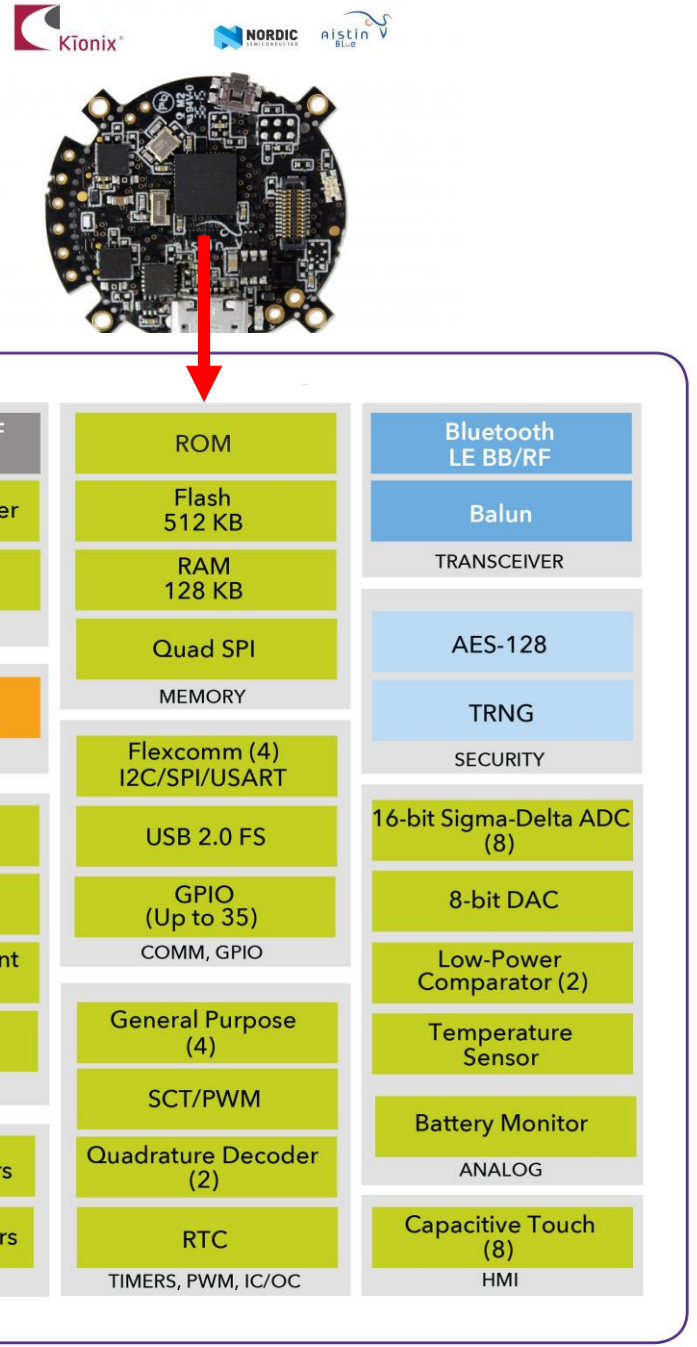


- LED = Light Emitting Diode
  - Like a bulb, but **polarity matters**
  - Different colors and sizes
  - Sometimes more than one in a single package



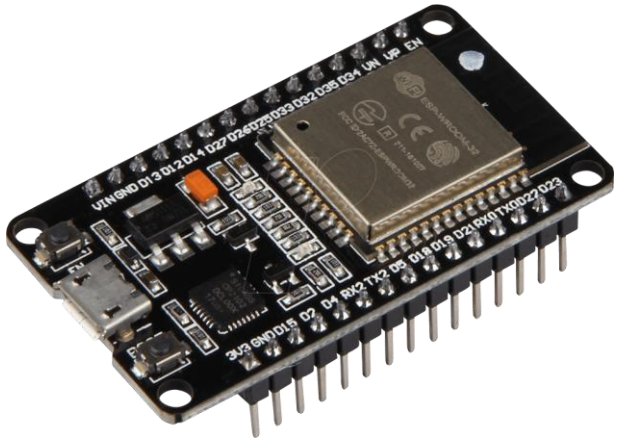
Programmable systems

- Common names
  - System on Chip (SoC)
  - System on module (SoM)
  - Microcontroller (MCU)
- SoC = CPU + supplementary HW/FW
  - Power on reset (POR)
  - Brown out detection (BOD)
  - Over the air update (OTA)
  - Watchdog timer (WDT) …

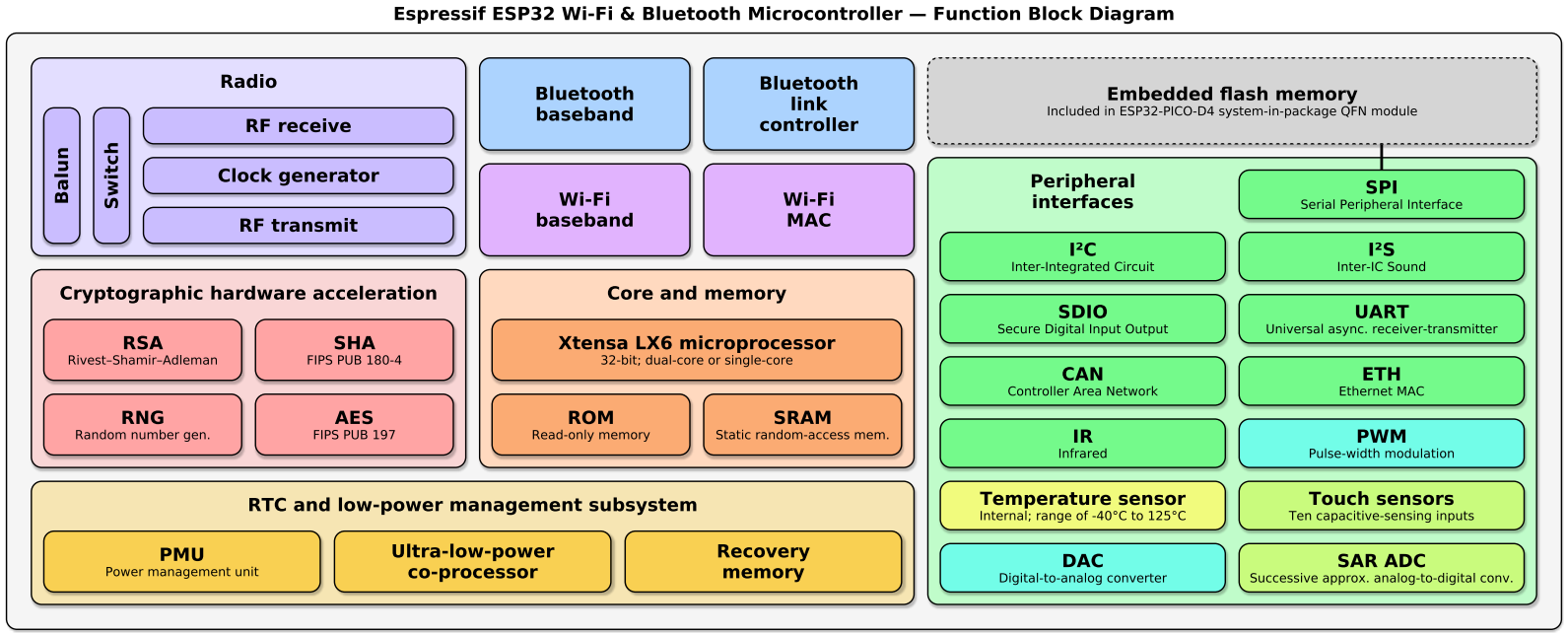


https://www.nxp.com/products/wireless-connectivity/bluetooth-low-energy-ble/a-highly-extensible-platform-for-application-development-of-qn908x:QN9080DK

ESP32: our SoC



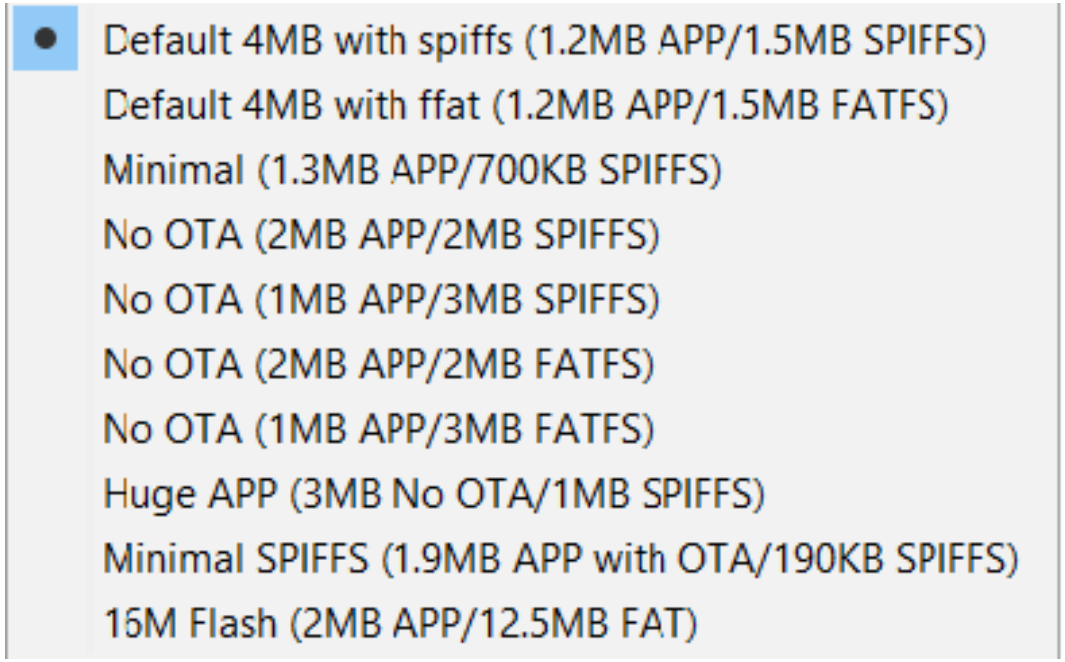
- **CPU**: 32 bit (2 core), 240 MHz
- **RAM**: 520k
- **Network**
  - WiFi (WPA2, STA/AP, WiFi direct) + TCP/IP
  - BT 4.2 / BLE
- **Flash**: 4 – 16 MB*
- **OTP:** 768 bytes
- **ULP** features
- **Crypto**
- -40 to 125 ºC



https://www.espressif.com/sites/default/files/documentation/esp32_technical_reference_manual_en.pdf

ESP32: Memory & Flash

- **Memory**
  - 32 bit address space
  - Code stored in flash
  - Flash mapped into address space
    - Caches
  - HW mapped into address space
- **Flash layouts**
  - OTA vs No OTA
  - App vs FS memory
  - SPIFFS vs FATFS

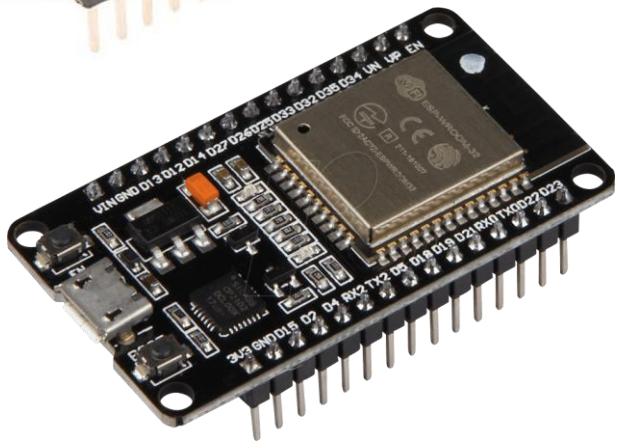


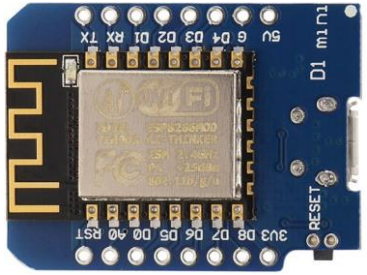
ESP8266: our old SoC

- **CPU**: 32 bit, 80/160 MHz
- **RAM**: ~36k
- **Network**
  - WiFi, (WPA/WPA2, STA/AP/STA+AP)
  - TCP/IP (+ HTTP, MQTT etc libs)
- **Flash**: 4MB (shared, different layouts possible)
- **Low Power features**
- -40 to 125 ^{o}C

What’s on the SoC

- Micro USB connector
  - Power 3.3V (2.5 to 3.6)
  - Upload code (Arduino or ESP-IDF/FreeRTOS)
- Buttons
  - Restart
  - User button
- LEDs
- Pins
  - GPIOs (3.3V tolerant)
  - I2C, PWM …





Exercises

1. Print “Hello world”
2. Blink an LED
3. Read a button
4. Interrupts
5. Advanced (find the docs yourself)
   - Watchdog
   - Flash (EEPROM, SPIFFS)
   - Additional guidelines