Introduction to Arduino IDE and getting started with the ESP32 microcontroller

Part 3: Summary of the different pins on the microcontroller

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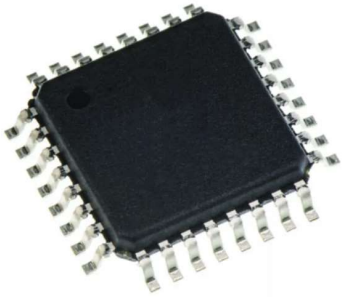
Introduction

- Summary of the different pins on the microcontroller:
  - Power supply, digital GPIO, analogue I/O, UART/USART, SPI, I^2C,)
  - … and their uses:



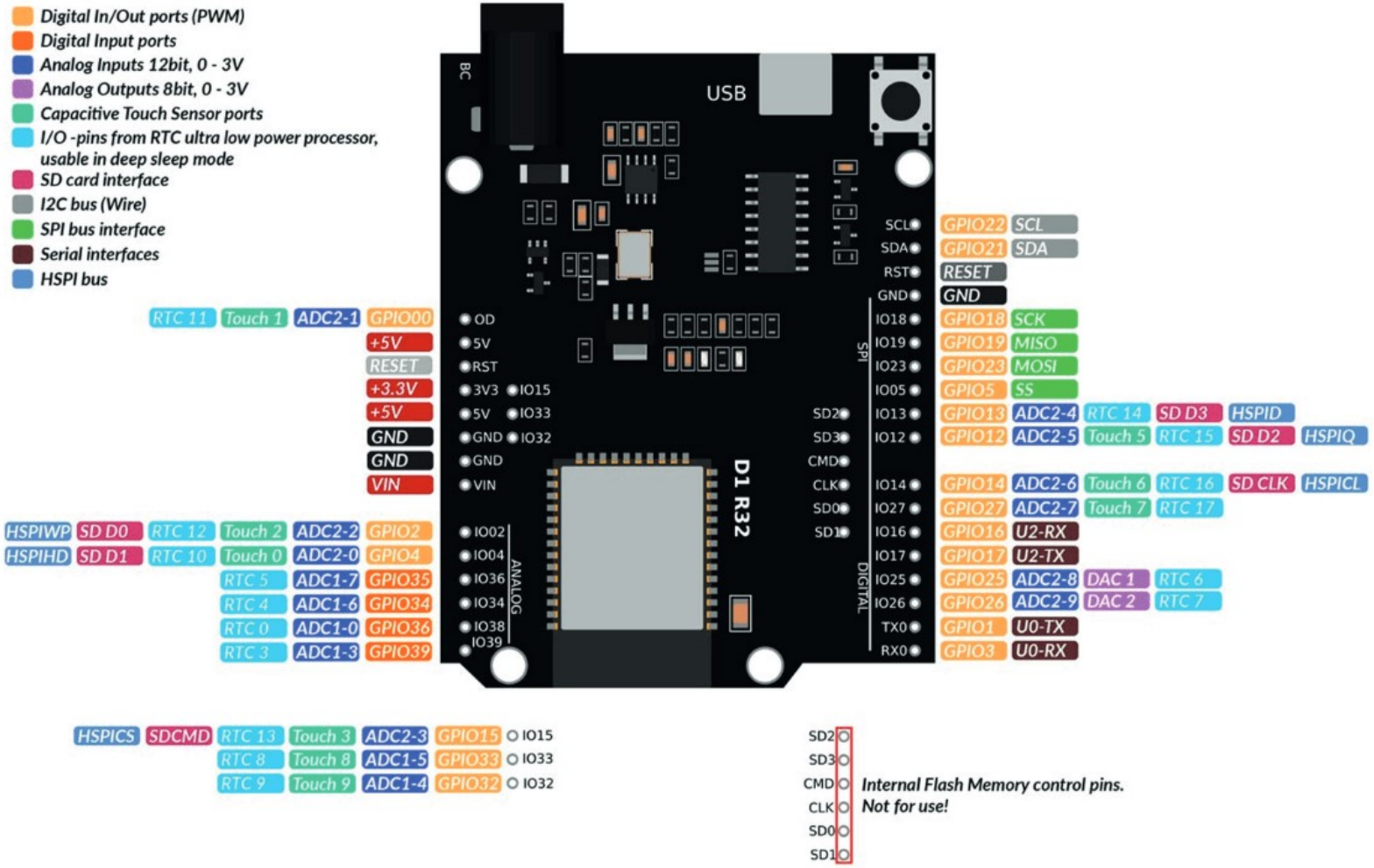
1. Connecting the microcontroller to external peripherals:
   1. Power supply.
   2. Digital GPIO (General Purpose I/O).
   3. Analogue I/O.
   4. UART (Universal asynchronous receiver/transmitter) / USART (Universal Synchronous/Asynchronous Receiver/Transmitter).
   5. SPI (Serial Peripheral Interface).
   6. I^2C (Inter-Integrated Circuit (IC)).

2. I/O pins on the ESP32:
   1. The available I/O pins.
   2. Serial communications: using the UART.

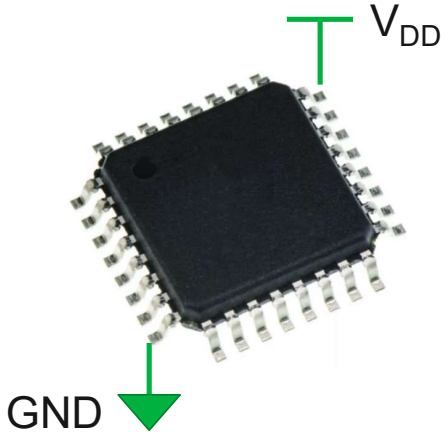
ESP32 D1 R32 Board Pinout

Image source:

https://bpb-ap-se2.wpmucdn.com/blogs.auckland.ac.nz/dist/9/698/files/2021/08/2_Pinout_D1_R32.png



Power supply



- Always required for an IC to work!
- Most microcontrollers will operate on a standard power supply voltage:
  - +5 V
  - +3.3 V
- Some microcontrollers will operate on a power supply voltage of less than 3.3 V.
- The ESP32 operates on a +3.3 V power supply.
- It is essential to operate the microcontroller on the correct power supply voltage and to connect peripheral devices to the microcontroller pins that operate on the same voltage levels.
- Some ICs have separate power supplies for digital and analogue circuitry.

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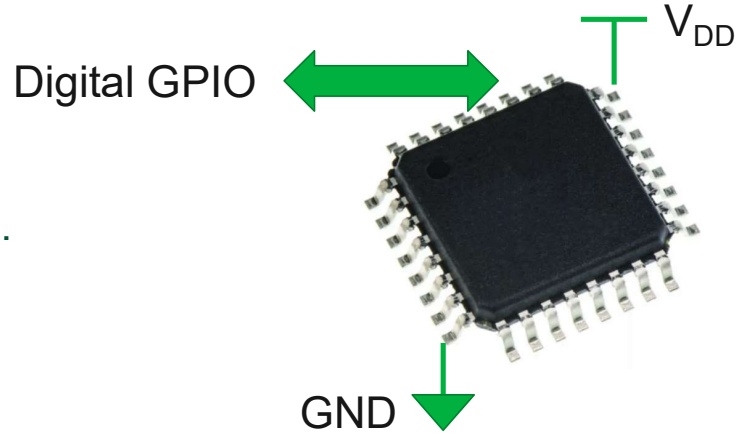
Digital GPIO

- Digital pins for general use (general purpose.
- Can be input or output (IO) … or bidirectional (both input and output).
- Creates two logic level outputs:
    - Logic 0 = GND (or 0 V).
    - Logic 1 = V_{DD} (positive power supply, typically +3.3 V or +5 V).
- In Arduino terminology:
    - Logic 0 = LOW.
    - Logic 1 = HIGH.



Analogue I/O

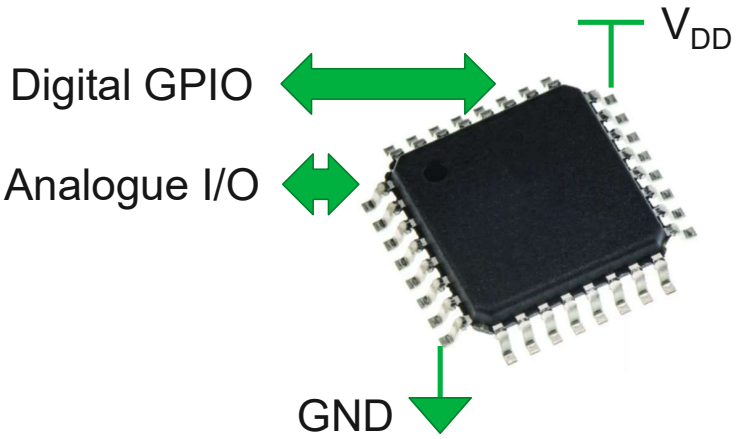
- Provide an analogue voltage output from the microcontroller.

- Analogue voltage output from a microcontroller can be created using:

    1. An in-built Digital to Analogue Converter (DAC) … within the microcontroller if available.

    2. An external DAC connected to digital pins on the microcontroller.

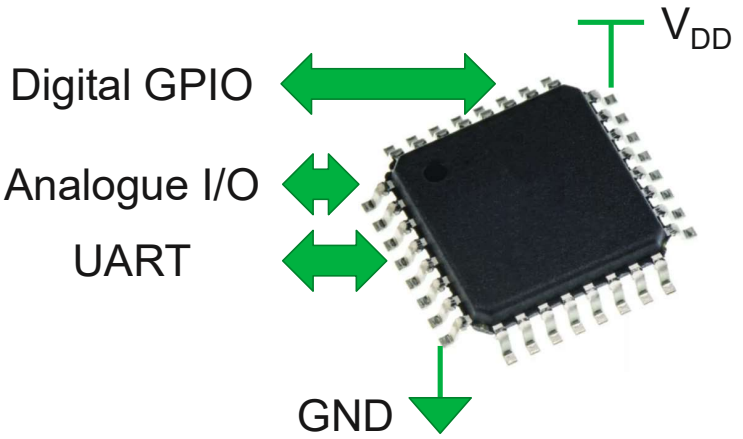
    3. Using a PWM (Pulse Width Modulation) digital output that is then low-pass filtered using an analogue low-pass filter.

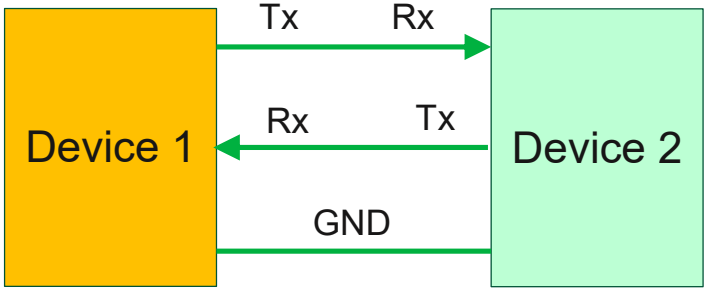


UART

- UART (Universal asynchronous receiver/transmitter):
  - Hardware device.
  - Used for asynchronous serial communications.
  - Microcontrollers will typically incorporate one or possibly two UARTs.
  - The two devices communicating with a UART will need to use the same communications data transmission/reception speed (the Baud rate) based on an internal clock frequency.
  - In older computers, the UART would have been used to connect to a RS-232 port (with voltage level translation between the microcontroller and the computer RS-232 port).
  - In computers used today, USB communications is required and the UART would be connected to the computer USB port using a UART-to-USB converter IC.

- USART (Universal Synchronous/Asynchronous Receiver/Transmitter):
  - Hardware device.
  - Used for synchronous serial communications.
  - The data transmission/reception clock frequency is embedded within the signal.





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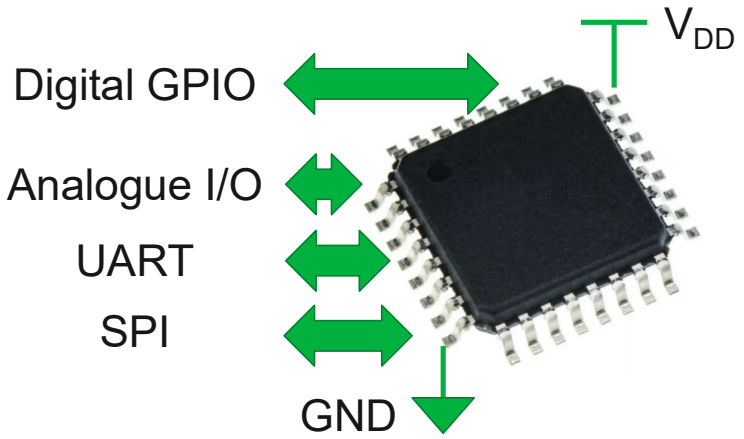
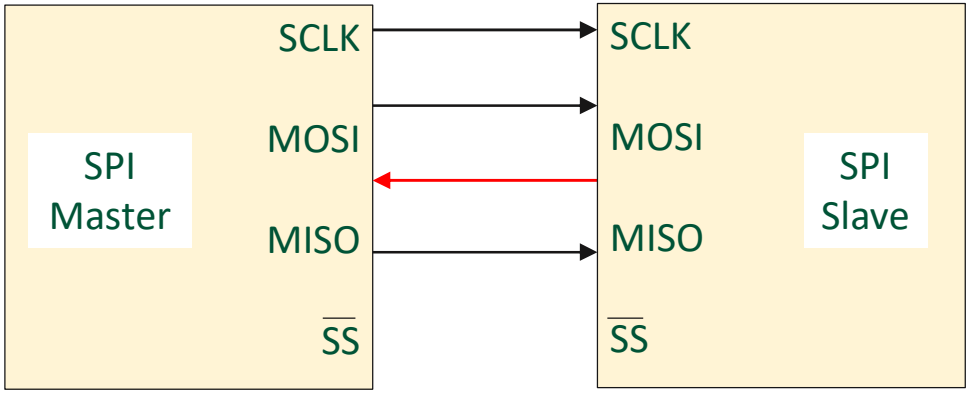
SPI

- Serial Peripheral Interface (SPI) is an interface bus commonly used to communicate data and instructions between microcontrollers and small peripheral devices (Integrated Circuits (ICs)) in embedded systems.
- A synchronous serial communication interface specification used for short-distance communication, primarily in embedded systems.
- The interface has a master device and one or more slave devices. Four signals involved:
  - SCLK
    - Serial Clock (output from the master).
  - MOSI
    - Master Out Slave In (data output from the master).
  - MISO
    - Master In Slave Out (data output from the slave).
  - SS
    - Slave Select (often active low, output from the master).





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I²C (1)

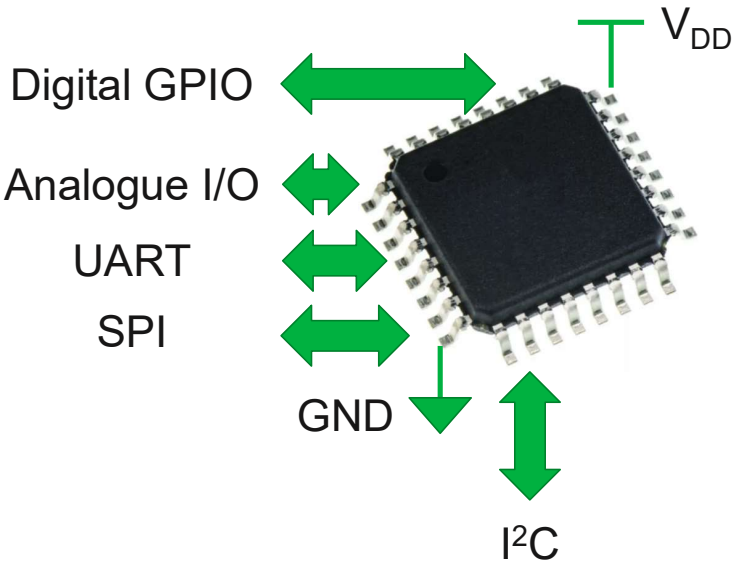
- I²C stands for Inter-IC bus. Developed by Philips.
- IC – integrated circuit.

- Developed to connect microprocessors and other ICs on a PCB (printed circuit board).

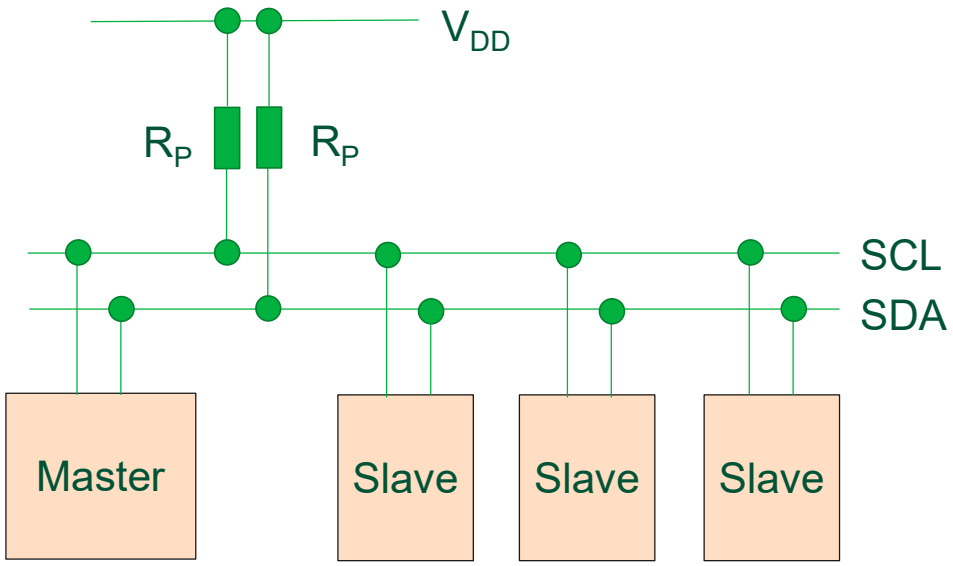
- Serial communications that connects devices with two wires that would otherwise have been connected using parallel communications -> saves on device pins, interconnects, and PCB area.

- Requires two wires:
  1. SDA – Serial Data.
  2. SCL – Serial Clock.

- All devices share these two wires. Each device has an exclusive, unique address.



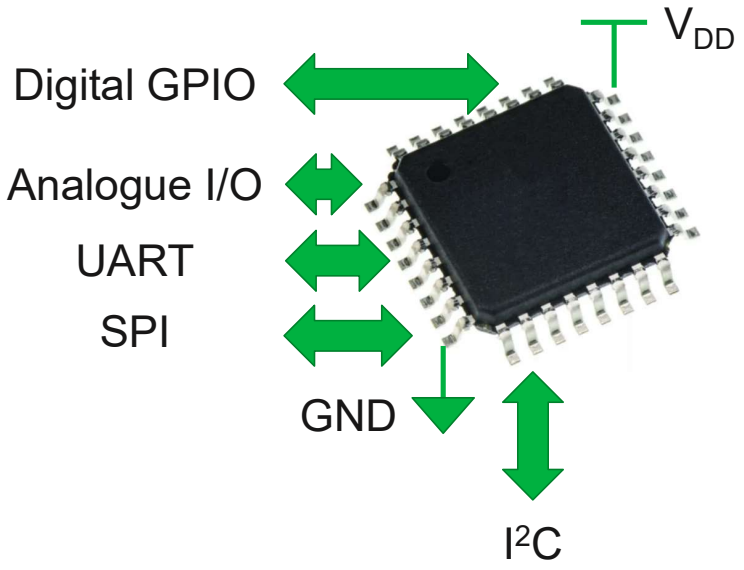
I²C (2)



- Simple to use.
- There can be more than one master.
- Each device has a 7-bit address, so a single I²C network can theoretically support up to 128 devices.
- Only an upper bus speed is defined.
- Only two wires with pull-up resistors are required to connect the I²C devices on an I²C network.

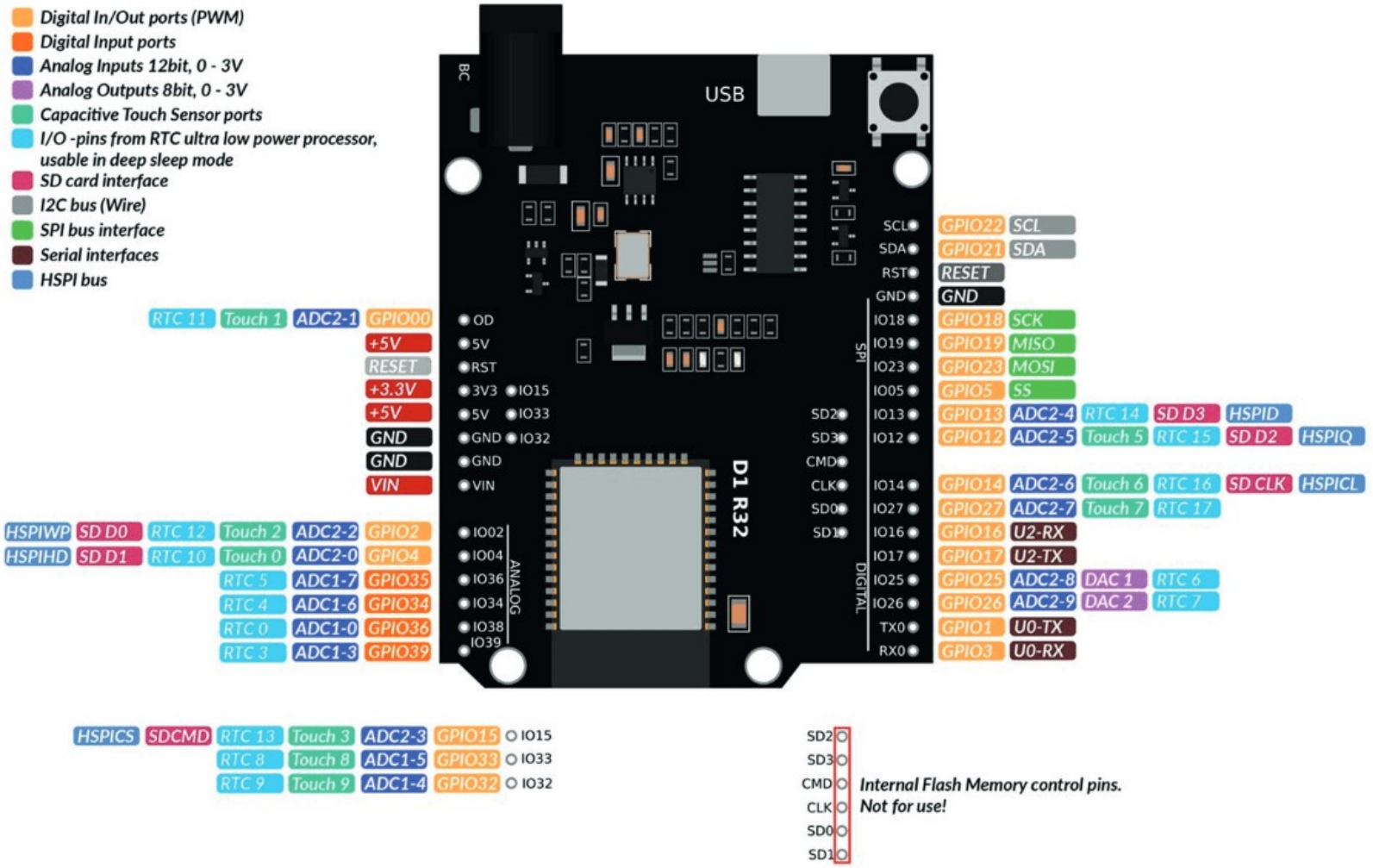
Pins with multiple possible uses

- The pins on the microcontroller used for digital and analogue I/O can be:
    - Dedicated to a single use.
    - Programmable so that the pin can be used for one of two or more possible uses.



D1 R32 Board Pinout

ESP32



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Any questions?

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