

GPIO: READING AND DRIVING PINS

How a GPIO pin drives a line high or low or reads a button or sensor, why a floating input misbehaves, and what a pull-up resistor does. With ESP32 3.3 V examples.

ONE THOUSAND DRONES ENGINEERING TEAM · VERIFIED 2026-07

A GPIO pin, for general-purpose input/output, is a microcontroller's connection to the outside world. Set it as an output to drive a wire high or low and light an LED or switch something on. Set it as an input to read a button or a sensor line. You pick the direction, then you read or write.

OUTPUT: DRIVING A PIN HIGH OR LOW

As an output, the pin connects internally either to the chip's supply, **3.3 V**, for a high, or to ground, **0 V**, for a low. That is enough to light an LED, switch a transistor, or send a signal to another chip. But each pin can only source or sink a limited current, on the order of tens of milliamps, so drive small loads directly and put a transistor between the pin and anything larger. Over-draw a pin and you damage it.

INPUT: READING A LEVEL

As an input, the pin reports whether the voltage on it sits above or below a threshold, returning a high or a low. The catch is a pin connected to nothing: it floats, picking up stray noise, and reads high and low at random. So any input that is not always driven by something needs a resistor to hold it at a known level when idle.

PULL-UPS AND PULL-DOWNS

A pull resistor ties an undriven input to a default level. A pull-up connects the pin to **3.3 V**, so it reads high until something actively pulls it low. A pull-down connects it to ground, so it reads low until something pulls it high. A button wired to ground with a pull-up is the classic input: high when released, low when pressed. The ESP32 has internal pull-ups and pull-downs you switch on in firmware, so you often need no external resistor at all.

$$I = V_{\text{pull}} / R$$

That current matters: a **10 kΩ** pull-up on a **3.3 V** rail passes about **0.33 mA** while the line is held low, which is why a weak (larger) pull-up saves power and a strong (smaller) one resists noise better. It is Ohm's law on the pull resistor.

DEEP DIVE · 3.3 V LOGIC, AND WHY 5 V CAN KILL A PIN

The ESP32's pins are 3.3 V logic and are not 5 V tolerant. Feed a 5 V signal straight into an input and you can damage the pin, because it drives current into the chip's internal protection. If you need to read a 5 V line, level-shift it, or divide it down with a voltage divider first, so the pin never sees more than about 3.3 V. Outputs, in turn, only ever swing between 0 V and 3.3 V, which is worth remembering when driving a part that expects a taller 5 V logic high.

CALCULATOR · LED SERIES RESISTOR CALCULATOR (Ω FROM SUPPLY, VF, CURRENT)

Size an LED's current-limiting resistor from supply voltage, forward voltage, and target current. Gives the nearest E24 standard value and the power it burns.

Interactive calculator: academy.onethousanddrones.com/tools/led-series-resistor

SIZE THE SERIES RESISTOR WHEN A 3.3 V GPIO DRIVES AN LED.

ONE PIN, TWO DIRECTIONS: DRIVING AN LED AS AN OUTPUT, READING A BUTTON AS AN INPUT.

- Espressif. ESP-IDF Programming Guide: GPIO (input/output, internal pull-ups and pull-downs). docs.espressif.com
- SparkFun. Pull-up Resistors tutorial (why a floating input needs a pull). learn.sparkfun.com

On a One Thousand Drones L1.01 board a GPIO drives the on-board LED through a resistor, and the BOOT button pulls a pin to ground, exactly the output and input patterns above.

CHECKPOINT**1. Before you read or drive a GPIO pin, what must you set?**

- a. Its fixed output voltage
- b. Its resistance in ohms
- c. Its direction: input or output

ANSWER · C

A GPIO is general-purpose; you configure it as an input or an output first, then read or write it. You do not dial in a voltage or a resistance.

2. Why does a floating input pin (connected to nothing) misbehave?

- a. It picks up stray noise and reads an unpredictable level
- b. It always draws too much current
- c. It can never be reconfigured as an output

ANSWER · A

With nothing driving it, the pin floats and reads high or low at random; a pull resistor fixes it.

3. What does an internal pull-up resistor do to an input pin?

- a. Increases the pin's output current
- b. Holds it at a known high level until something pulls it low
- c. Converts the pin to an analog input

ANSWER · B

A pull-up ties the idle pin to 3.3 V so it reads high until a button or line pulls it low.

- Prerequisite: diodes and LEDs

- Calculate it: the LED series resistor calculator
- Next: the ADC, reading an analog voltage