

# Hardware Setup / Protection Guide

## Pico 2W RGB LED Ring Controller

Gemini CLI Agent

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## 1 Power Consumption Analysis

Understanding the current draw is critical to preventing brownouts or overheating. The WS2812B LEDs draw specific amounts of current depending on their color and brightness.

### Theoretical Maximums (100% Brightness)

- **Single LED (White):**  $\approx 60 \text{ mA}$
- **16-LED Ring (White):**  $16 \times 60 \text{ mA} = 960 \text{ mA} \approx 1 \text{ A}$

### Operational Realities

Most USB 2.0 ports on computers are limited to  $500 \text{ mA}$ . The Raspberry Pi Pico 2W itself consumes  $\approx 50 - 100 \text{ mA}$  (more with WiFi active).

- **Available for LEDs:**  $\approx 400 \text{ mA}$
- **Safe Brightness Limit:**  $400 \text{ mA}/960 \text{ mA} \approx 40\%$

**Recommendation:** Keep the software brightness limiter (in ‘controller.py’) at or below 0.4 (40%) when powering directly from a computer USB port.

## 2 Circuit Protection

To ensure longevity of the hardware, the following components are recommended:

1. **Data Line Resistor ( $330\Omega - 470\Omega$ ):** Placed between the Pico’s GPIO pin and the LED Data Input. This dampens signal reflections and protects the first pixel from voltage spikes.
2. **Bypass Capacitor ( $1000\mu\text{F}$ ):** Placed across the  $+5\text{V}$  and GND terminals of the LED ring. This buffers sudden changes in current draw, preventing voltage dips that could reset the Pico.
3. **Logic Levels:** The Pico uses 3.3V logic. WS2812s expect 5V logic. While it often works directly, if you experience flickering, use a Logic Level Shifter (74AHCT125 or similar).

### 3 Wiring Diagram

The following schematic illustrates the recommended connection for the Pico 2W and the 16-element Ring. Note that VBUS outputs the 5V from the USB connector.

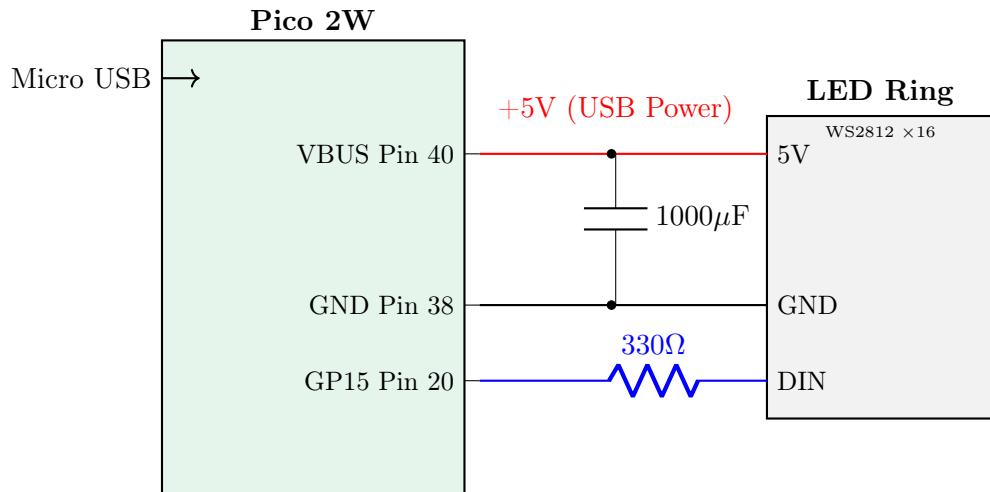


Figure 1: Connection Diagram with protection components