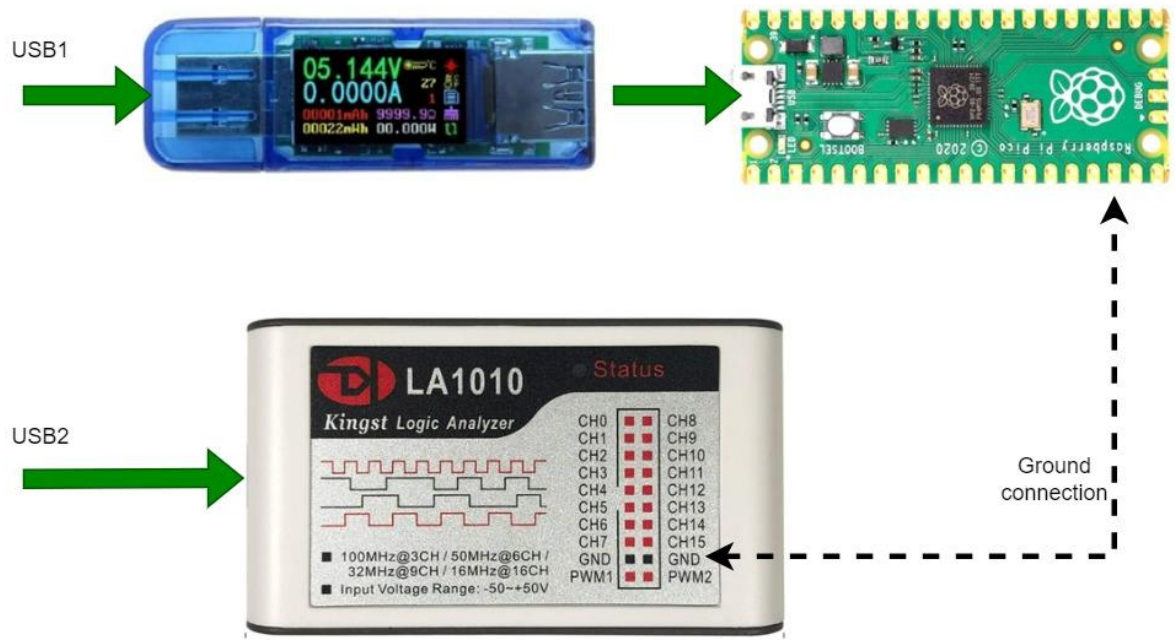
Return current path with multiple connected USB devices.

The question of the return path for the current when using several USB-powered devices arose when I was building a bench test for an embedded system course.

My setup was the following :

- A Raspberry Pi Pico.
- An USB tester (voltage and current monitor).
- An USB Logic analyser.



My purpose was to test my new instruments by running some code in Python on the Pico.

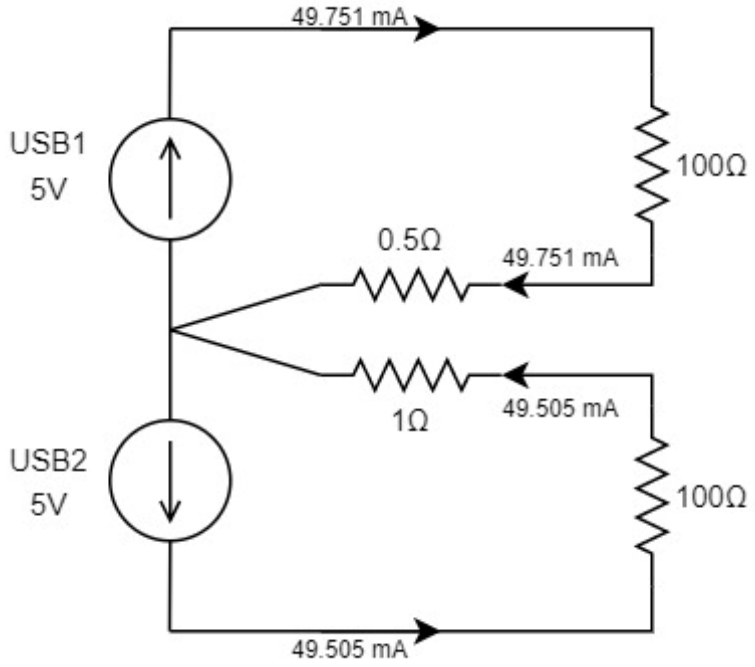
First, I didn't connect the logic analyser, and I monitored the current when blinking the on-board LED (18,6 mA when off, 20,5 mA when on).

Then I connected the logic analyser and put a wire between analyser GND and Pico GND (no other wire connected). At that moment the current ramped up to **39 mA** (when the LED is on). Therefore an increase of **18.5 mA**.

What happened ?

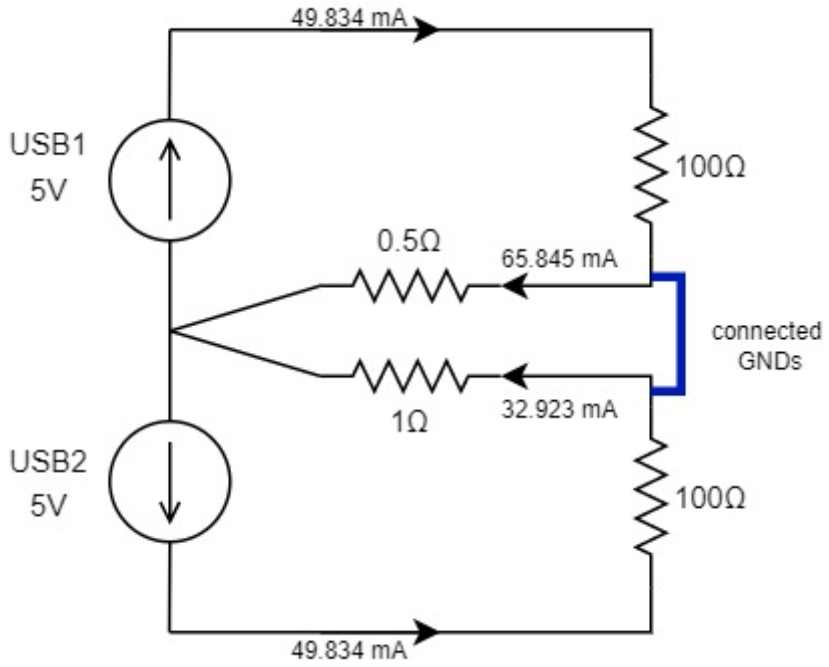
To understand the problem, doing some math on a model is useful.

For this model, I choose two loads of 100 Ω, and I add two different resistors (simulating wire resistances) in the ground (GND) return path (ground stands here for the 0 V connection).



For each device, the return current is the same as the corresponding supply current.

In the following schematic, I have connected the two ground wires on the load side together.



We notice that the return current in the 0.5 Ω ground wire is twice the one in the 1 Ω ground wire.

But the supply currents (+5V) are hardly affected by this connection. In other word supply current don't vary but distribution of ground currents are very different.

So, why is the current shown by the USB tester different?

The answer lies in the fact that the current sensor in the tester is made of a resistor shunt in series with the current path. But instead of putting it in the power connection (+5V), it turns out that, in this device, it is wired in the ground connection…

Even if the ground wire resistance is low, this phenomenon will occur unless the resistances of both connections are the same.

Links.

USB tester : https://amz.run/5nRm
USB logic analyser : https://amz.run/5nRn