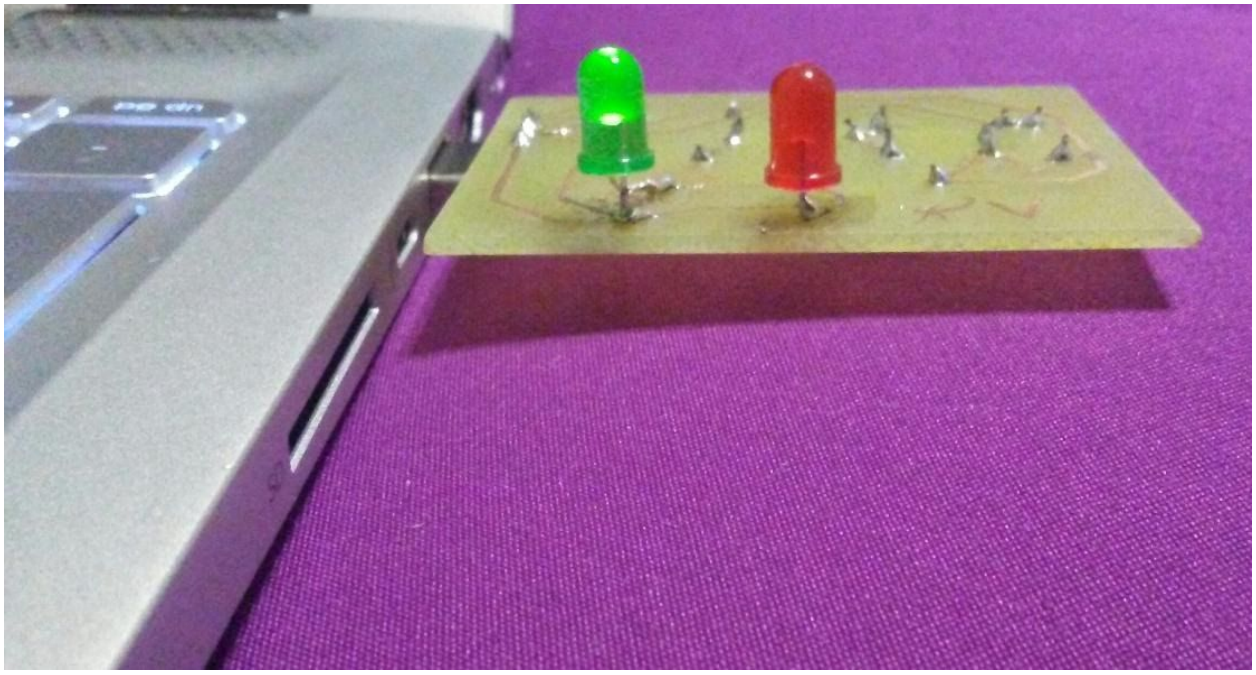
**P 1.2.7 PCB Design-- USB Port Tester**



DE 2019-2020
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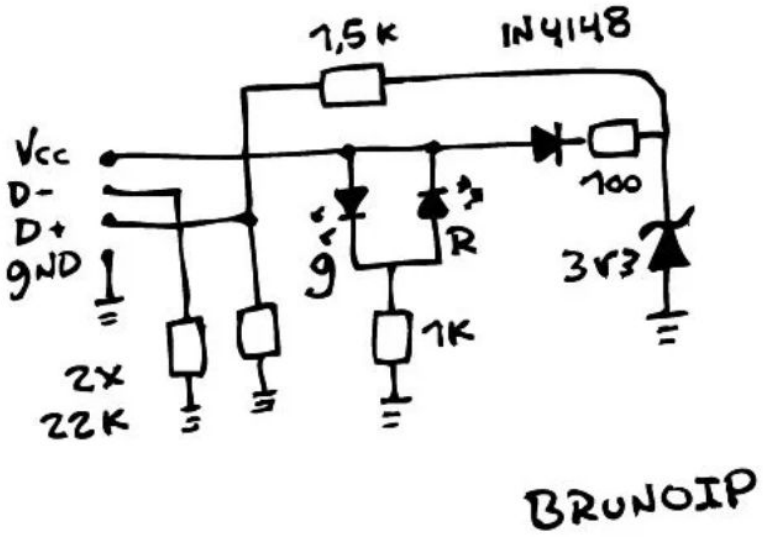
**Circuit Description**

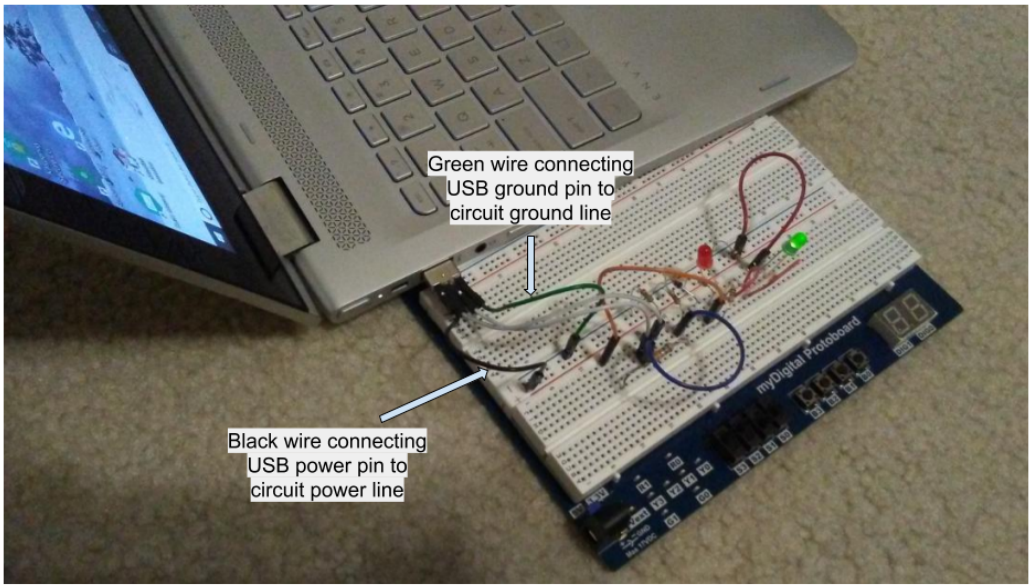
My circuit is a USB port tester. When plugged into any USB port there are three possible results. One, the red LED glows; two, the green LED glows; or three, neither LED glows. These three cases indicate three indicate three different things. The red LED lighting up indicates that the USB port's polarity is reversed. In a reverse polarity USB port, the computer's internal wiring switches power and ground. It delivers power to the USB ground pin and grounds the USB power pin. This phenomenon can occur if a USB port is damaged, and it will undoubtedly damage any USB that is plugged into this port as well. The red light glowing will warn the user not to plug their USB into this port. However, if the green LED on the port tester glows, then the USB port's polarity is correct. It shouldn't do any damage to a USB that is plugged in. If neither LED glows, it means that the USB port is not activated. Nothing will plugged into the port will be able to connect with the computer. I got this circuit off of Instructables. I used this schematic off of the website to construct my prototype breadboard circuit:



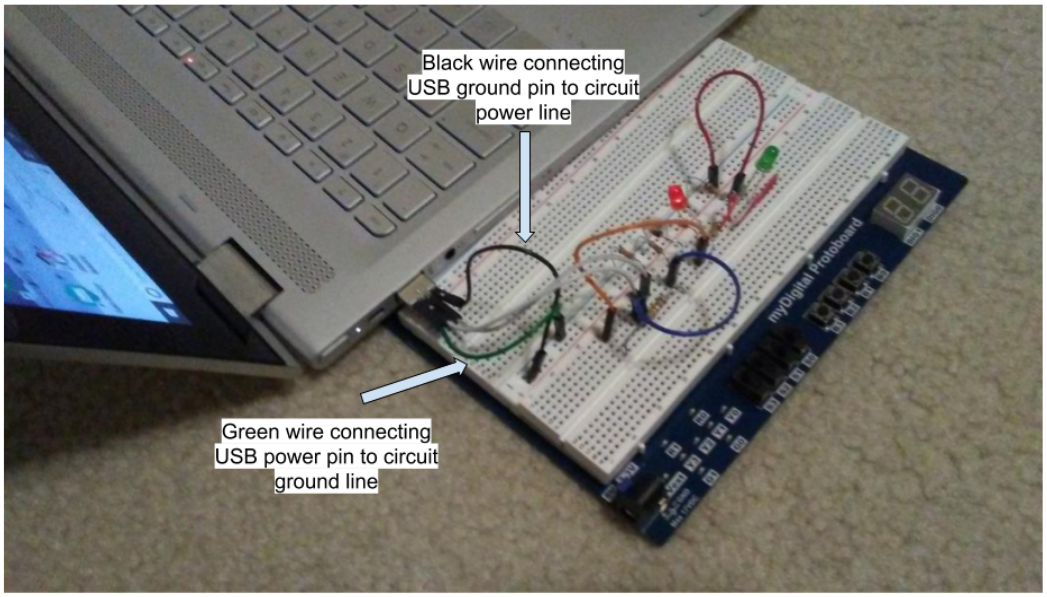

The three major components of this circuit are the USB head, the red LED, and the green LED. When the VCC (power) pin of the USB is powered and its ground pin is grounded, current flows through the green diode and 1k ohm resistor to ground. However, when the ground pin is supplied with power and the power pin is grounded (reverse polarity situation), current flows up from the ground pin, through the 1k ohm resistor and the red diode, to the power pin (which is grounded). The reason only one LED lights up at a time is because they are diodes with opposite directions. The green diode will only allow current to flow through it from the power pin, while the red diode will only direct current that comes from the ground pin (in the case of a reverse polarity USB port).

My completed, functioning breadboard looked like this in the three use cases.

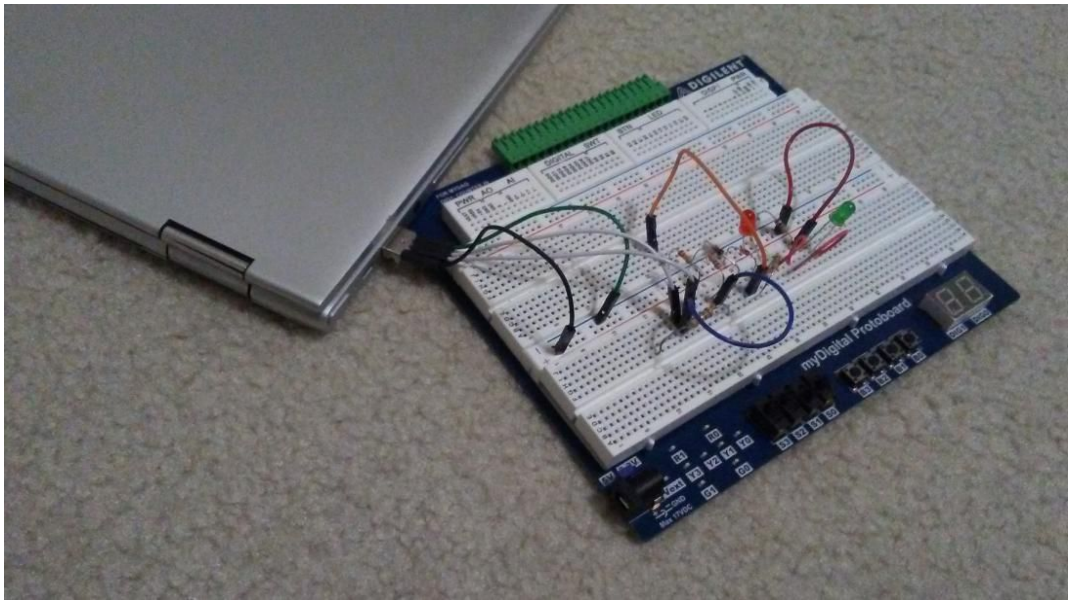
1. This occurs when the polarity is correct. The computer sends power to the USB power pin and grounds the USB ground pin.




2. To model a reverse polarity USB port (since my port is functional) I switched the wires connecting the USB to the breadboard. As a result, the red LED lit up.

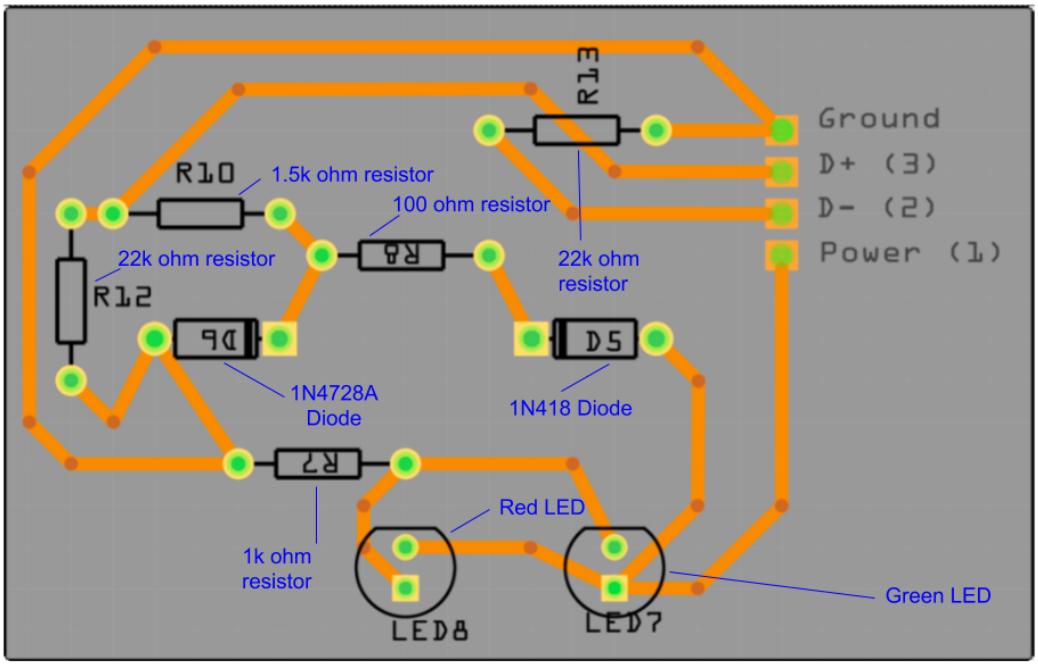



3. In this picture, the USB port is not activated because the computer is off. As a result, neither LED glows.

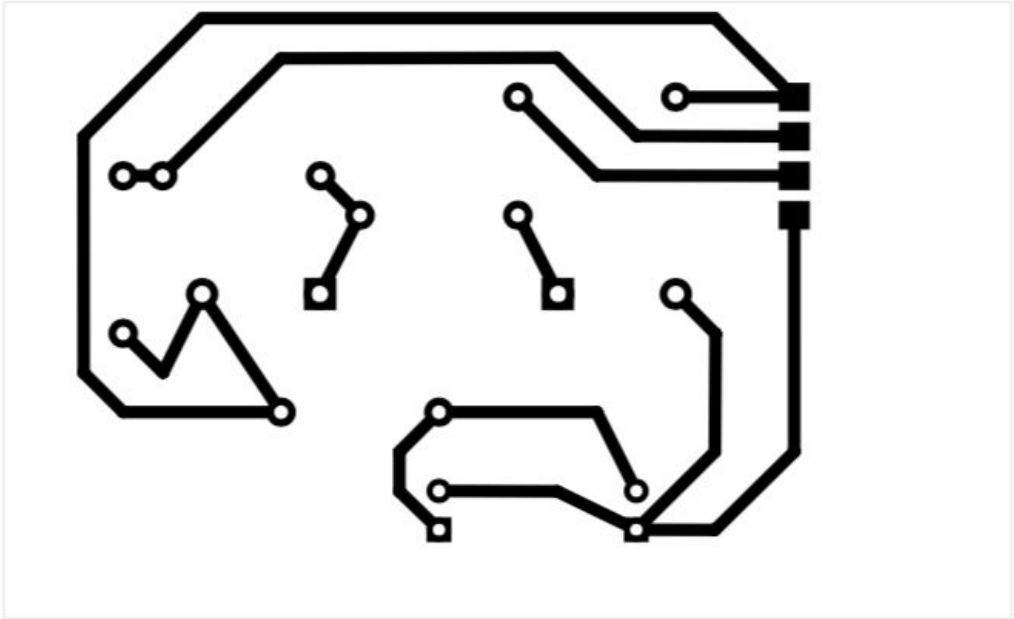

DIGILENT
myDigital Protoboard

## Fabrication Design

PCB Layout:

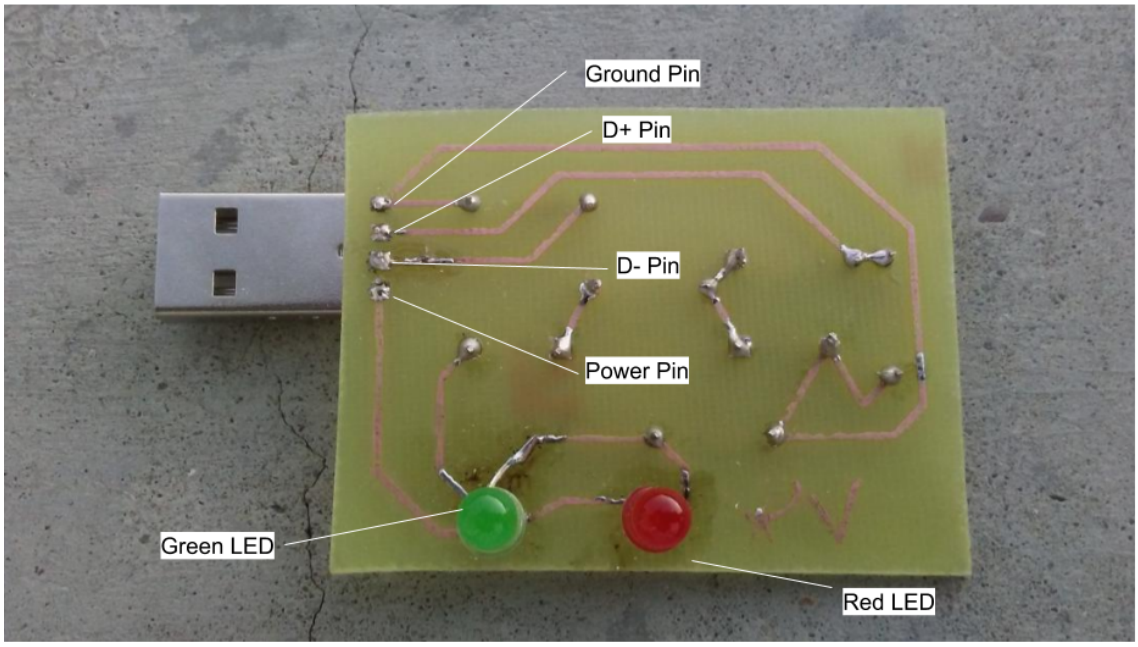



Copper Mask:

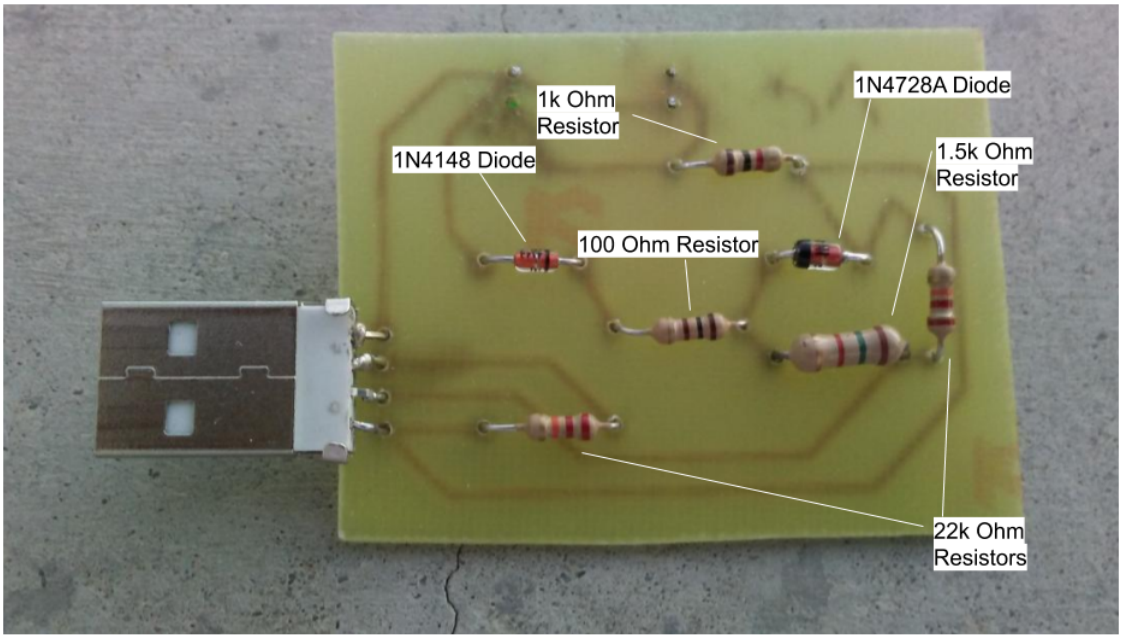


## Final Circuit Design

Final PCB Front View:




Final PCB Back View:



I began my design process of this project by researching various breadboard/PCB projects online. The USB port tester on Instructables was the most appealing idea to me because it seemed genuinely useful. It also involved powering my PCB through a USB port, something that added a sense of novelty to the already intriguing concept. All of the other circuit designs that I had come across were powered by batteries.

After settling with this idea, I cut a USB head out of old wire that I found at home. Then, I breadboarded the design based off of the provided schematic (displayed in the Circuit Description section). I tested to ensure that the circuit produced the desired result in each of the three use cases (as detailed in the Circuit Description section). Once I proved that the schematic worked, I began transferring the layout of my breadboard onto Fritzing. I added everything to the breadboard view except for the four wires leading to the four pins of the USB. These I manually added to the PCB mode as wires leading to empty patches. My goal was then to detangle the wires and ensure that the four patches were in order of the pins on a USB (power, D-, D+, and then ground). I knew this would make soldering the USB on my PCB significantly easier.

After I finished my PCB layout, I printed it on glossy paper. I ironed this print-out onto a provided copper board. The ink from the print out transferred onto the metal due to the applied heat. Thus, my copper mask was produced. I then allowed it to soak in an acid bath for about two hours. In a process called etching, the bath stripped away all of the copper except for what was sealed beneath the ink. I then scraped the ink off, exposing the remaining copper. These were the wires of my circuit. My next step was to drill holes at the solder points of components. After this was completed, I soldered all of the resistors, diodes, and LEDs (a type of diode) in. The final component that I soldered was my USB head. I elongated the wires coming out of the head by soldering small pieces of wire to them. I then soldered each elongated pin onto their corresponding spot on the PCB.

My final step was to test to ensure that my USB port tester worked. I plugged my device into a computer. The green LED lit up, as it should have. Since I did not have an actual reverse polarity USB port, I simulated it by using a 9V battery. I touched the power (red) wire of the battery to the USB head's ground pin and the ground (black) wire of the battery to the USB head's power pin. The red LED lit up. Here are videos of these two tests:

| Computer Test | Reverse Polarity Test |
| --- | --- |
|  *Double Click this Image to Open Video |  *Double Click this Image to Open Video |