

The Breadboard Power Supply & Custom Bluetooth Speaker

Ignite Their Future 2024

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Course Description

Get ready to embark on an exciting journey into the world of electronics. Hands-on activities will teach you how to prototype electronic circuits and construct two innovative projects: a Breadboard Power Supply and a Class D, battery-powered Bluetooth speaker. These projects will teach you about voltage regulation and audio amplification and introduce you to essential skills such as circuit breadboarding, troubleshooting, and soldering. By the end of the camp, you will have gained practical hands-on experience and a sense of accomplishment in creating your own functional and personalized electronic devices.

Keywords:

Electronics, Test Equipment, Breadboard, Bluetooth, Amplifier Design and Development, Soldering.

Welcome

Welcome, esteemed students, to the "Custom 3D Printed Bluetooth Speaker Project"!

We're thrilled to have you join us on this electrifying journey into the dynamic realm of electronics. Whether you're a seasoned veteran or just starting your adventure in electronics, this course promises to invigorate your passion and expand your knowledge to new heights.

Led by an experienced instructor with nearly three decades of expertise in electronics, including a decade of teaching at Idaho State University, this course is designed to provide a comprehensive understanding of breadboard prototyping and the breadboard power supply. Together, we'll explore the intricacies of amplifiers, circuits, and hands-on learning experiences, culminating in the creation of your very own custom Bluetooth speaker.

This course will focus on project-based learning. Project-based learning offers invaluable opportunities for students to actively engage in their education, fostering deep understanding and long-term retention of concepts. By immersing students in real-world, hands-on projects, they develop critical thinking, problem-solving, and collaboration skills essential for success in both academic and professional settings. Moreover, project-based learning promotes creativity and autonomy, empowering students to take ownership of their learning journey and cultivate a lifelong love for learning.

So, get ready to rock the classroom as we embark on this exciting journey. Welcome aboard, and let's dive into the world of electronics together!

- **Project 1** will dive into circuit design and development of a Breadboard Power Supply.
- **Project 2** will explore the creation of a Class D 3D-printed battery-powered Bluetooth speaker using readily available parts.

The Breadboard Power Supply

Introduction

Although the power supply aspect of electronic projects may not initially captivate your attention, it stands as a crucial and foundational element. Inadequate power supply implementation or design can lead to intermittent circuit problems, premature circuit failures, and overall frustration.

Understanding RMS & Peak Voltage

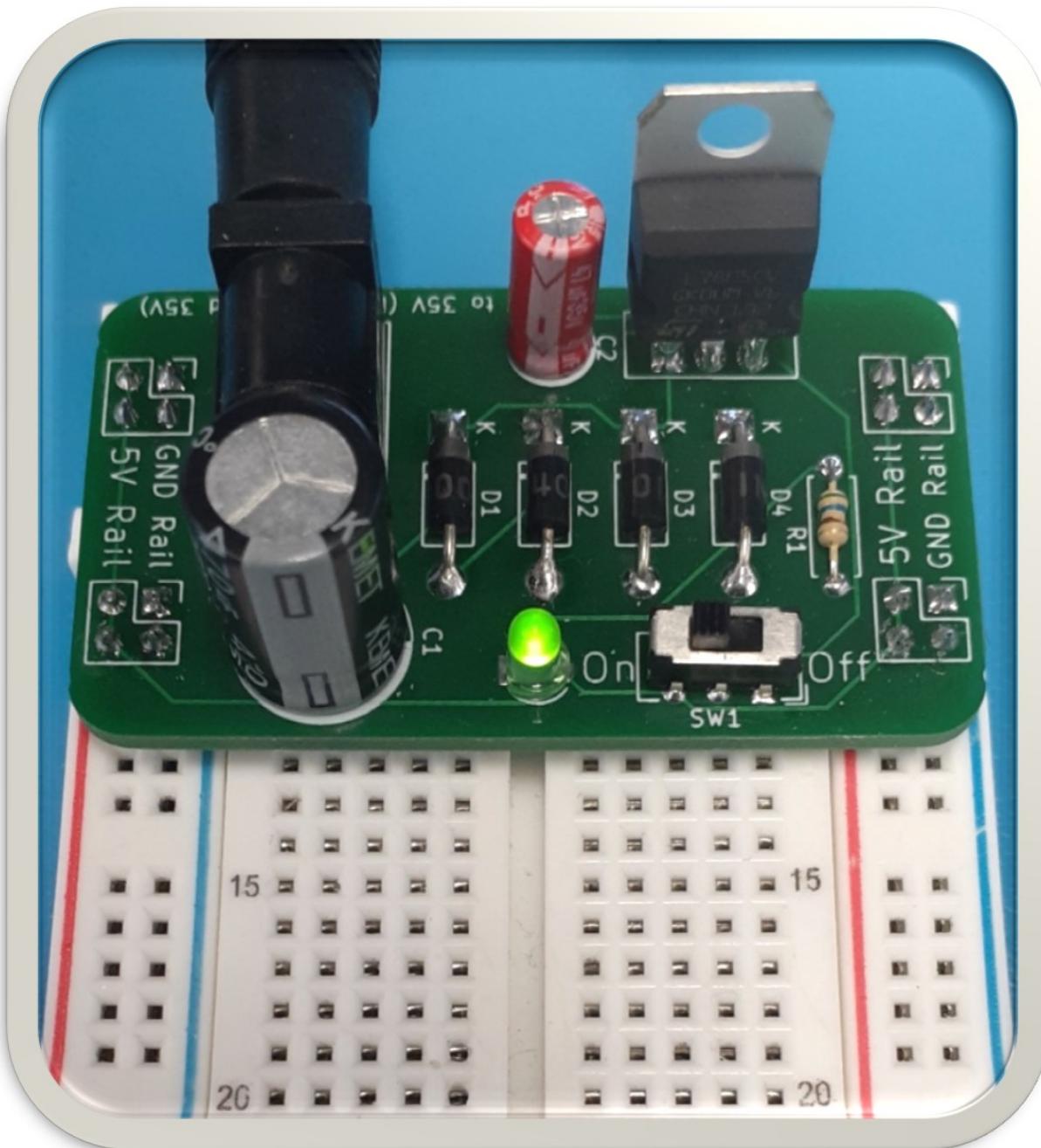
The wall outlet in your house typically operates at 120 volts rms. While this may seem innocuous, 120 volts rms can be perilous. Circuit breakers, acting as safety switches, typically have a maximum current rating of 15 or 20 amps. It's important to note that death can occur from currents as low as 100mA or 0.1A. The primary function of the circuit breaker isn't to protect against electrical shock but rather to prevent wiring overheating and potential fire hazards. It's crucial not to underestimate the dangers associated with 120-volt wall power – it has the potential to be lethal. For further safety information, refer to OSHA's Basic Electrical Safety guidelines.

Differentiating between AC and DC

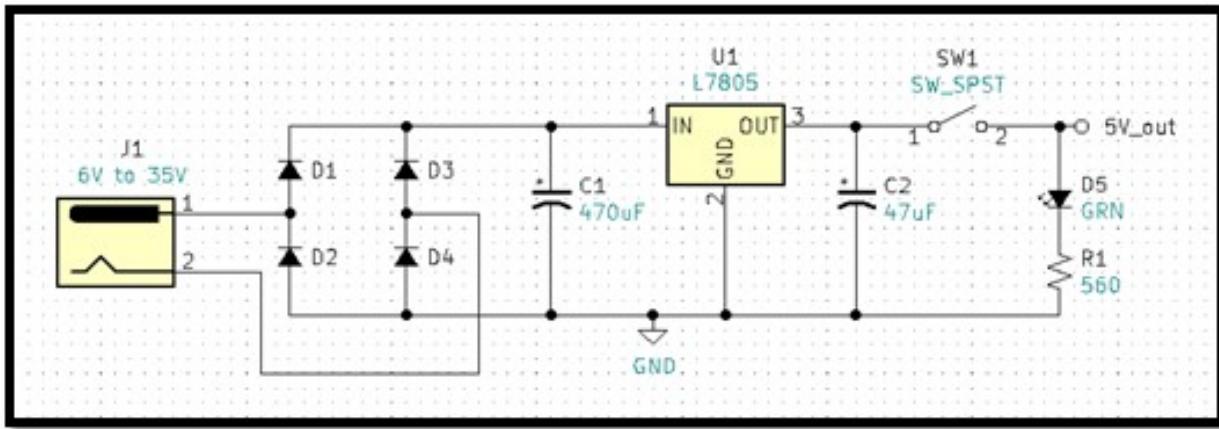
Wall voltage is categorized as AC (Alternating Current), while much of what we encounter in electronics operates on DC (Direct Current). Devices like computers, cell phones, Arduinos, Raspberry Pis, and battery-powered devices operate on DC. For example, the motor in your RC car is a DC motor. Some motors are versatile enough to operate using either single-phase AC or industrial three-phase AC.

The Breadboard Power Supply

The Breadboard Power Supply offers a fixed regulated 5V output, ideal for prototyping and developing various electronic circuits.



Breadboard Power Supply



Breadboard Power Supply Schematic

Schematic Component Overview

J1 is a power jack 2X5.5MM connector which allows for a 6V to 35V DC input.

D1-D4 Some power bricks are center pin positive and some are center pin negative. Diodes D1 through D4 are used to make sure the regulator receives the correct voltage polarity regardless of the center pin polarity.

C1 and C2 are filter capacitors used to minimize any ripple voltage in the circuit.

U1 is the L7805, a 5V fixed linear regulator with internal current limiting and built-in temperature protection. The L7805 is part of the L78 series of linear regulators. The L78 series can be purchased as 5V, 6V, 8V, 8.5V, 9V, 12V, 15V, 18V, and 24V regulators. One point to understand is linear regulators can only regulate down, they cannot regulate up. For the L7805 5V regulator, the input voltage can be a minimum of 6V to an absolute maximum voltage of 35V.

SW1 was added to provide switchable 5V output. The logical position for this SW1 would have been at the input. However, this project has a small size or form factor, and the micro switch used is rated at 6V, so the problem with putting the switch in series with J1 is that it

would be out of specification due to overvoltage. The problem with SW1's current position is the quiescent current of the L7805. Linear regulators are inefficient when compared to switch-mode power supplies. The inefficiency of the L7805 is because the regulator requires a certain amount of current to operate even if there is no load at the output. This current is called quiescent current and the typical quiescent current, per the datasheet, for an L7805 is 3.2mA. If you are using a 9V battery and a barrel adapter to power your breadboard power supply circuit you will need to unplug the barrel jack after use to ensure the battery does not drain down. The typical 9V battery is rated at 500mAh, meaning if you run the battery at 500mAs, it will be drained in exactly one hour. So, if our linear regulator requires 3.2mAs and we have no load (no current) at the output, how long will it take to drain the 9V battery?

$$500mA = 1hr, 3.2mA = x hrs?$$

$$x = \frac{500mA \times 1hour}{3.2mA} = 156.25hrs$$

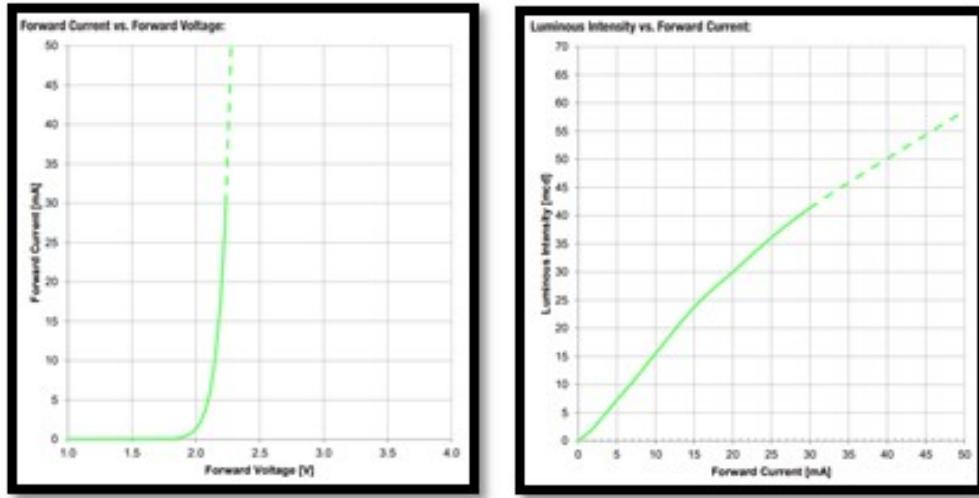
If you leave a 9V battery plugged into the breadboard power supply with no load at the output and the SW1 in the off position, you will have a dead battery after 156 hours. I considered not having a switch at all, making the circuit even simpler, and forcing the operator plug and unplug the barrel jack. However, I like having the ability to switch on and off the 5V GND rails on the breadboard and one of the goals of this project was to use salvaged barrel jack ACDC wall adapters.

D5 and R1 - The green LED D5 provides on/off output indication. The maximum current rating for the LED is 30mA. The forward voltage for this green LED is approximately 2V. This leaves us with 3V across the current limiting resistor R1. What is the minimum resistance that R1 can be without exceeding the diodes 30mA max current?

$$R1_{min} = 3V / 30mA = 100W$$

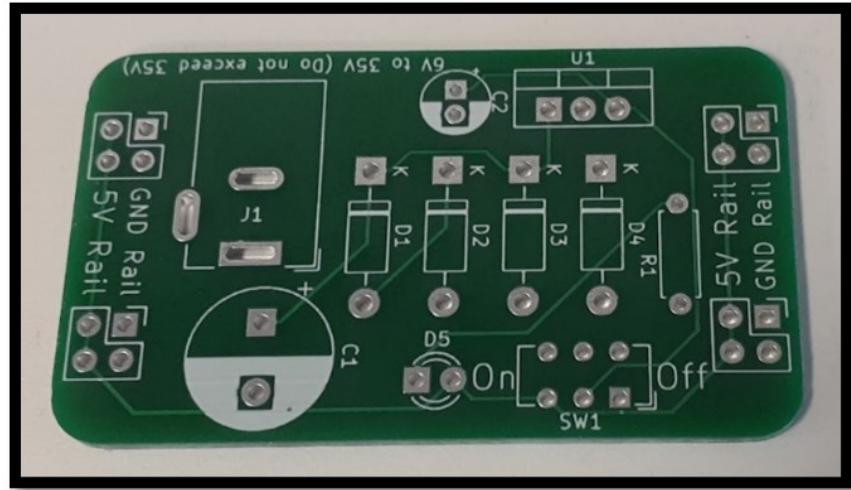
As R1's resistance value is increased, the LEDs forward current will decrease, and the

LEDs luminous intensity will decrease. Bench testing found that a 560Ω resistor provides a minimum current with adequate LED illumination.



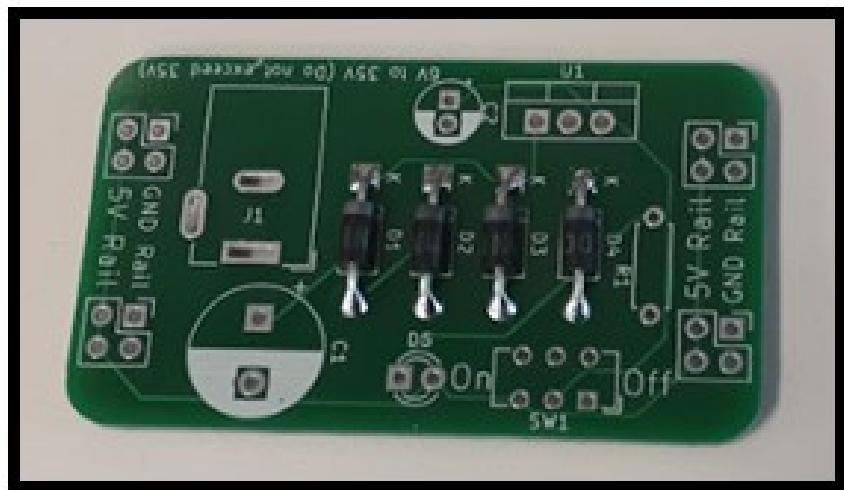
LED Forward Current vs. Forward Voltage and LED Intensity vs. Forward Current

Breadboard Power Supply Assembly



BBPS Raw PCB

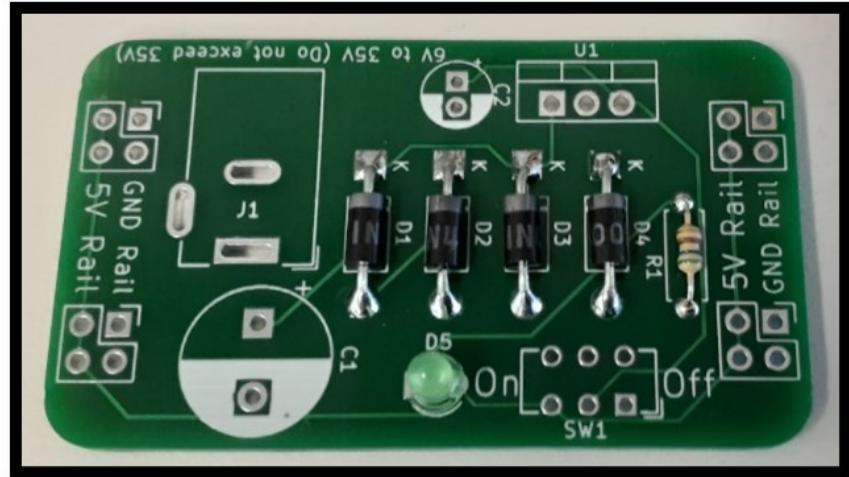
- Solder diodes D1 – D4. Make sure the orientation is correct, the silver band is the cathode and goes toward the K.



BBPS Diodes D1-D4

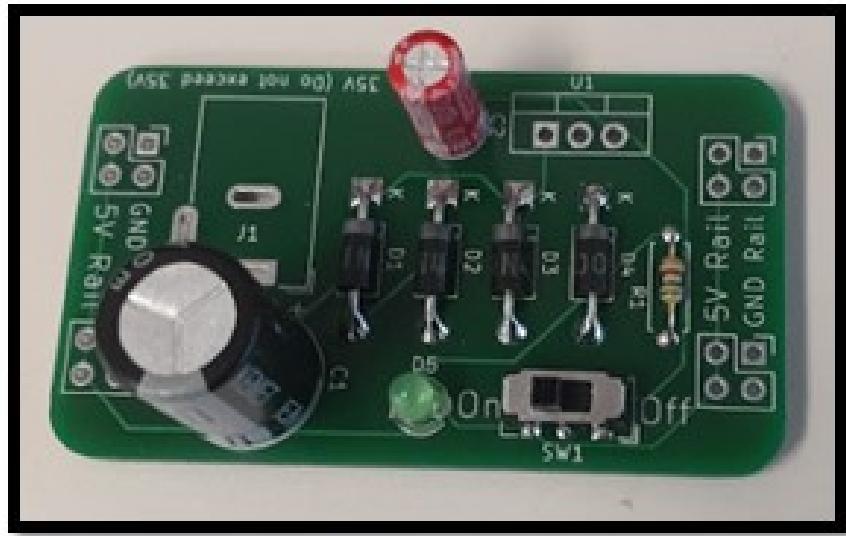
- Solder R1 and D5; R1's orientation is not important. D5 the LED must be soldered with the proper orientation. There is a flat side on the collar of the LED, this flat side should be

associated with the short lead. The short lead and flat side collar should be soldered to the square pad. The long lead of the LED goes to the round pad, toward SW1.



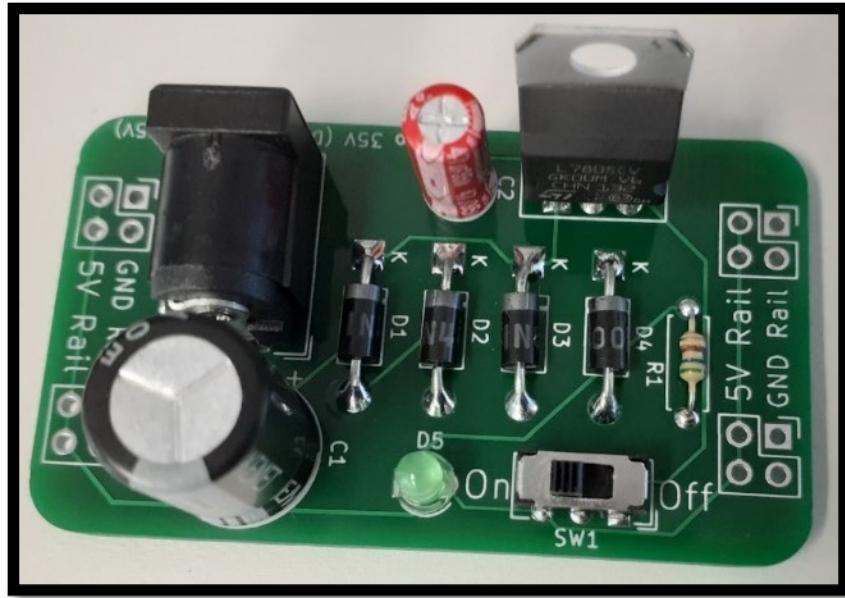
BBPS LED D5 and R1

- The electrolytic capacitors are polarity-sensitive and must be installed correctly. Solder the negative pins to the round pad with the white silkscreen and the positive pin to the square pad.



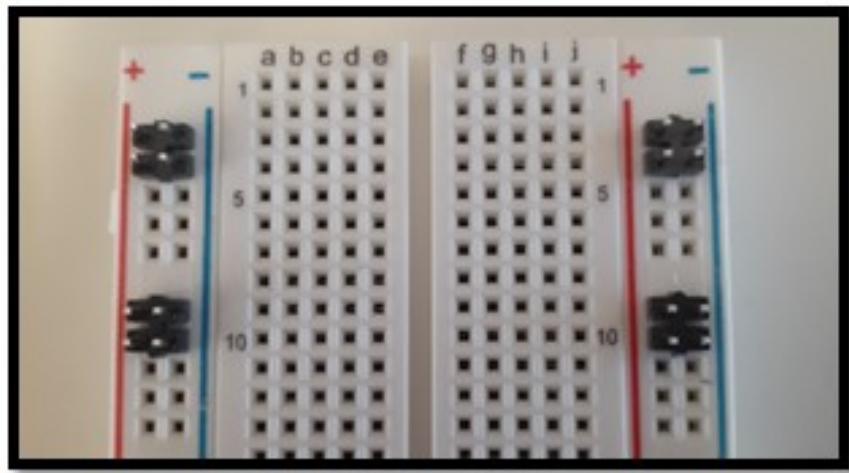
BBPS Capacitors C1 and C2

- The barrel jack input connector has kinked pins. At first, this part can be a little difficult to get into position. Make sure to align the pins and then press hard and it should snap into place. Orient the L7805 as seen in the picture, front to the circuit and back to open space.



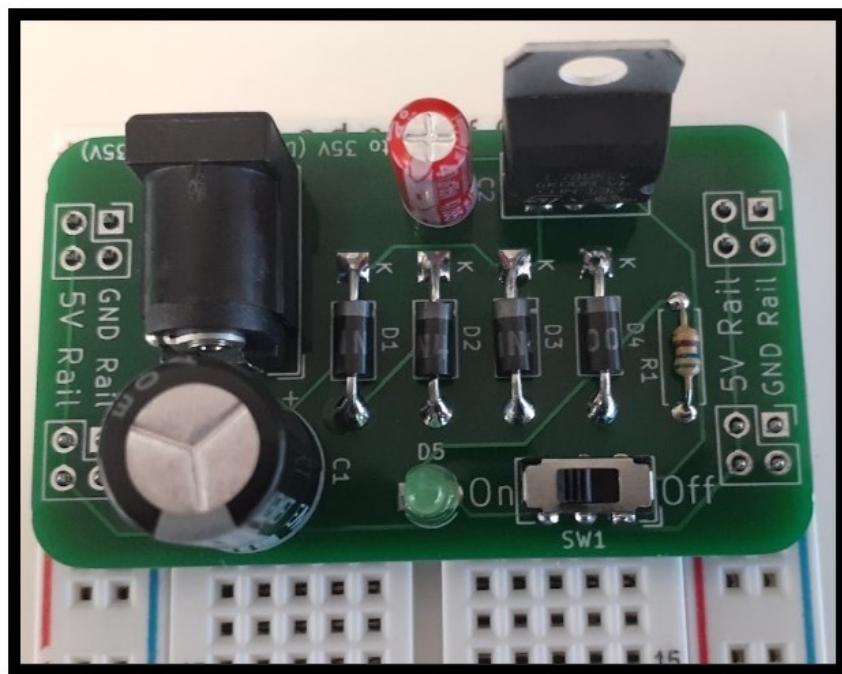
BBPS J1 Barrel Jack Connector and U1 L7805

- Snap off the header pins in 2x2 groups. The easiest way to do this is to use two needle nose pliers. On the breadboard, there are five pin groups down the power rails. Orientate the header pins, as seen in the picture, in the first position of two adjoining five-pin groups. Notice the snap-off tabs are all oriented in the same direction.



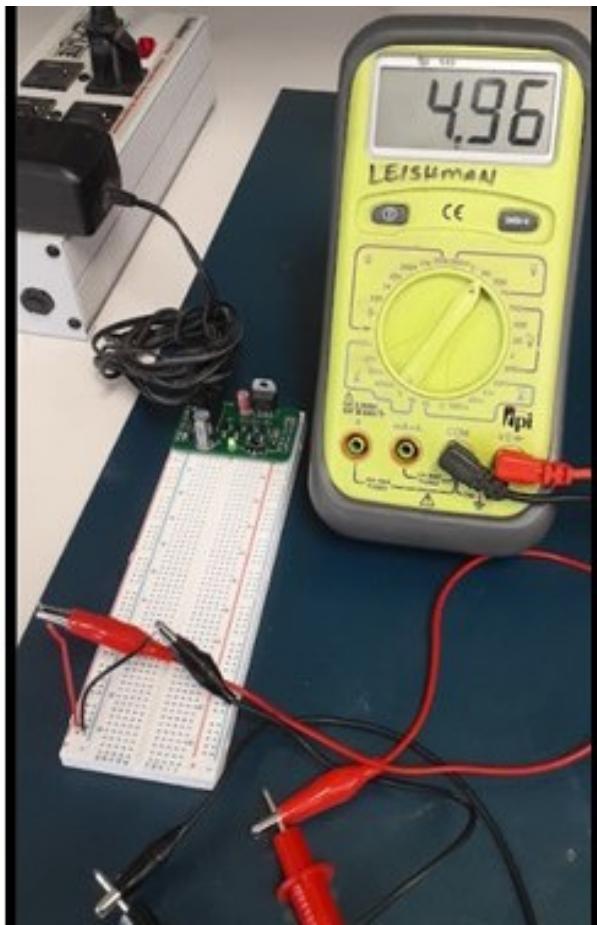
BBPS Pin Alignment

- Place the PCB on the header pins and press firmly to make sure all the header pins are square and flush to the breadboard. Solder the header pins in place, from the top of the PCB.



BBPS Pin Solder

- Plug in your ACDC wall adapter. Test that the green led turns on and off with SW1 and verify that both power rails have 5VDC.



BBPS Verify 5VDC on both rails

Conclusion

I hope you enjoyed this lesson on linear regulated power supplies. Now put your new breadboard power supply to work and develop cool electronic projects. If you are interested in a career in electronics, consider taking your skills to the next level by studying with me at Idaho State University's Robotics and Communications Systems Engineering Technology program. We are happy to give program tours! So, come check us out. Please contact: (208) 282-2622 or ctech@isu.edu

Middle School and High School STEM teachers please connect with me and consider purchasing the Breadboard Power Supply kits from the Idaho State University Electronics Club. The proceeds earned from the Breadboard Power Supply kits will help support students at the

Skills USA competition and other club events. Please contact me at leistimo@isu.edu.



Battery Powered Bluetooth Speaker

Battery Power Bluetooth Amplifier (The Benny Amp)

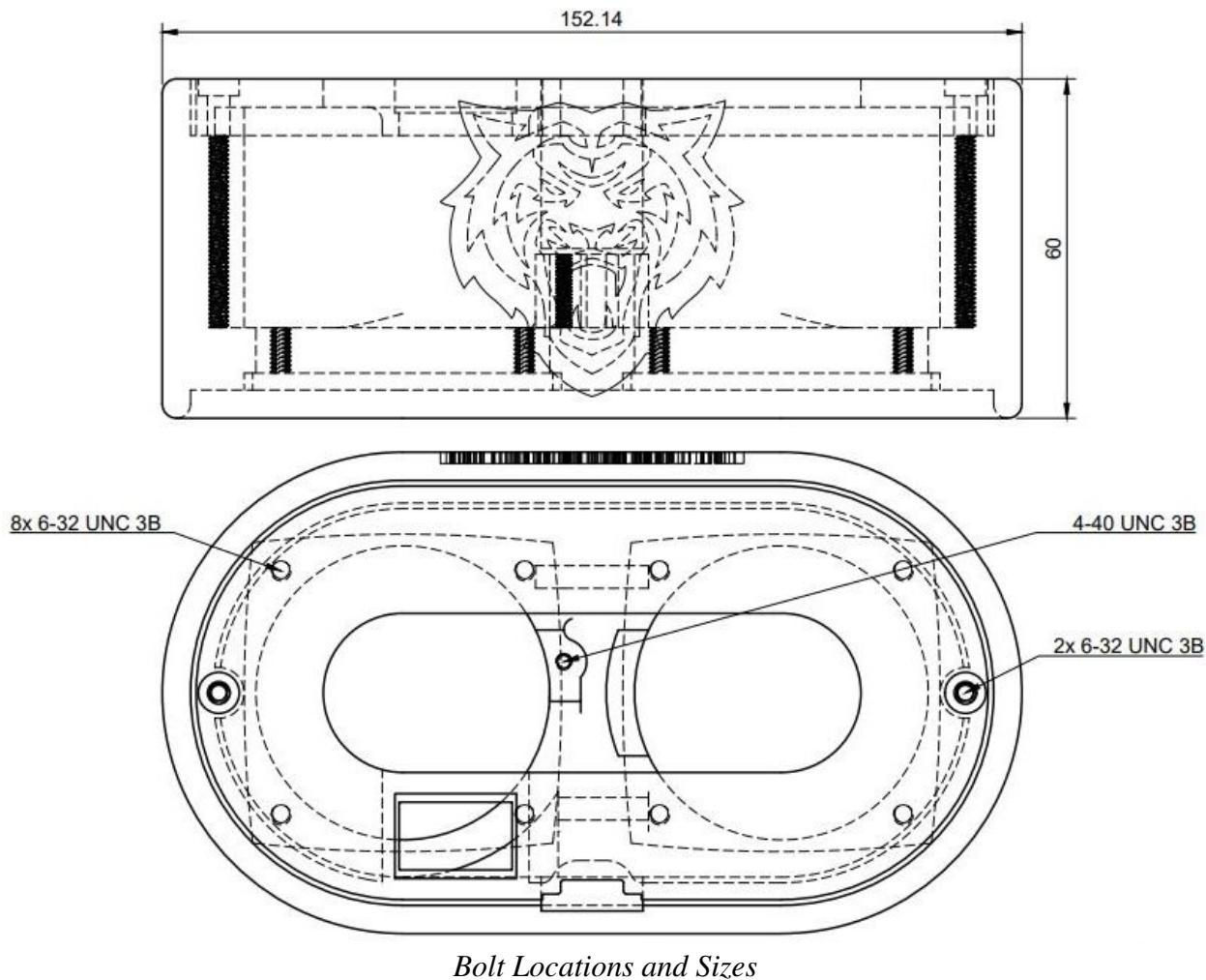
Downloadable parts list

- https://github.com/leistimo/2.1in_5watt_Bluetooth_Amp/raw/main/Parts.xlsx

3D printed parts

- https://github.com/leistimo/2.1in_5watt_Bluetooth_Amp/raw/main/2.1_Body.3mf
- https://github.com/leistimo/2.1in_5watt_Bluetooth_Amp/raw/main/2.1BackPlate.3mf

3D Printed Parts Prep



On the front of the 3D-printed body, there are eight 6-32 bolt holes that hold the speakers in place. On the back of the 3D-printed body there are two 6-32 bolt holes that hold the back plate on and one 4-40 bolt hole that will hold the Bluetooth module in place. All of the holes will need to be tapped to the proper size.



Clean up the eight front speaker holes with a 6-32 Tap.



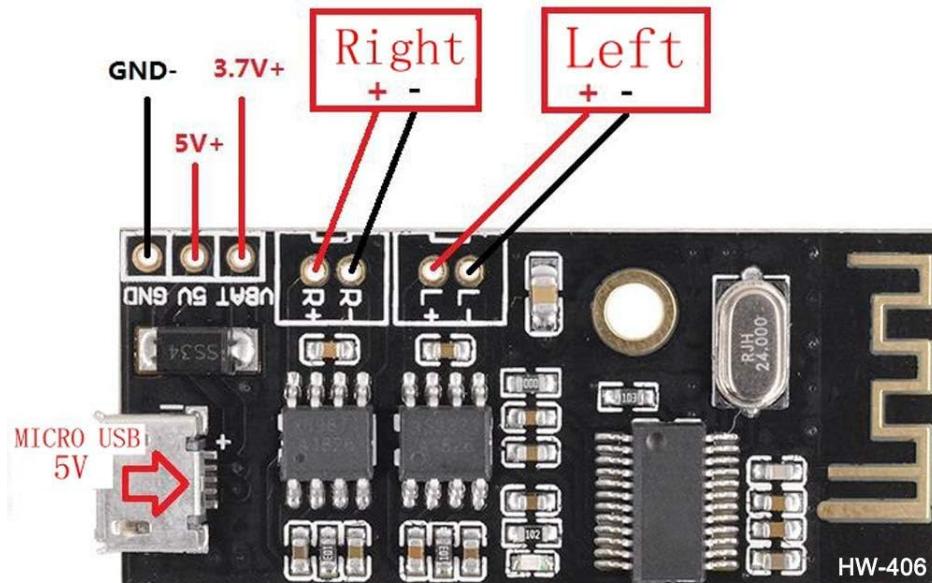
The center hole is 4-40, and the outer two back-plate holes are 6-32.

- Tap the ten 6-32 holes approximately 5/8" deep.
- Tap the single 4-40 hole approximately 5/8" deep.
- Clean up the two holes on the rear back plate.

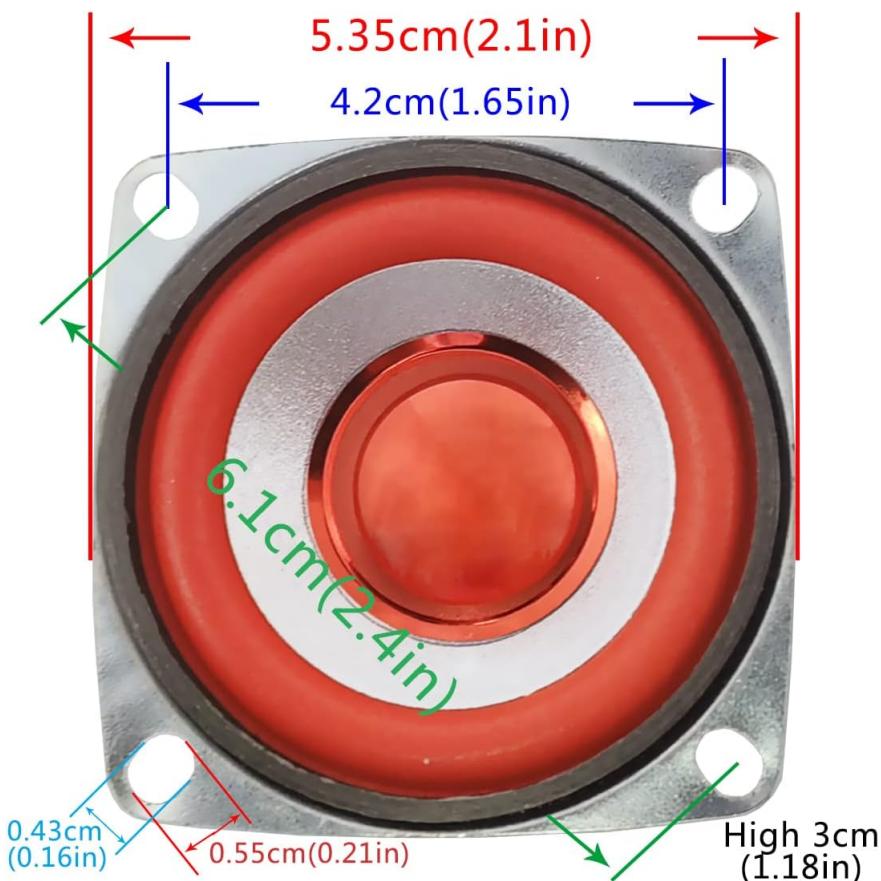
HiLetgo M38 Bluetooth Module Review

	M18	M28	M38
MICRO USB (power supply)	✗	✓	✓
Audio headphone jack	✗	✓	✗
Built-in amplifier	✗	✗	✓ (5W+5W)
Lithium battery powered	✓	✓	✓
Support USB sound card(free drive)	✗	✗	✓
Volume memory/adjustment	✓	✗	✗
MUTE interface	✓	✗	✗
Button extension	✓	✗	✗
Bluetooth version			Bluetooch V4.2
Support Bluetooth protocol		HFPV1.7, A2DPV1.2, AVRCPV1.5, AVCTPV1.2, AVDTPV1.2	
Format support		WAV/WMA/FLAC/APE/MP3 lossless decoding, stereo dual channel output	
Operating Voltage			5V/3.7V-4.2V
Not connected broadcast status			5.5mA
Connection work status			20mA
Deep sleeping			3UA
Transmission distance			20M (MAX)
Operating temperature			-40°C-+85°C
Sensitivity			-87dbm

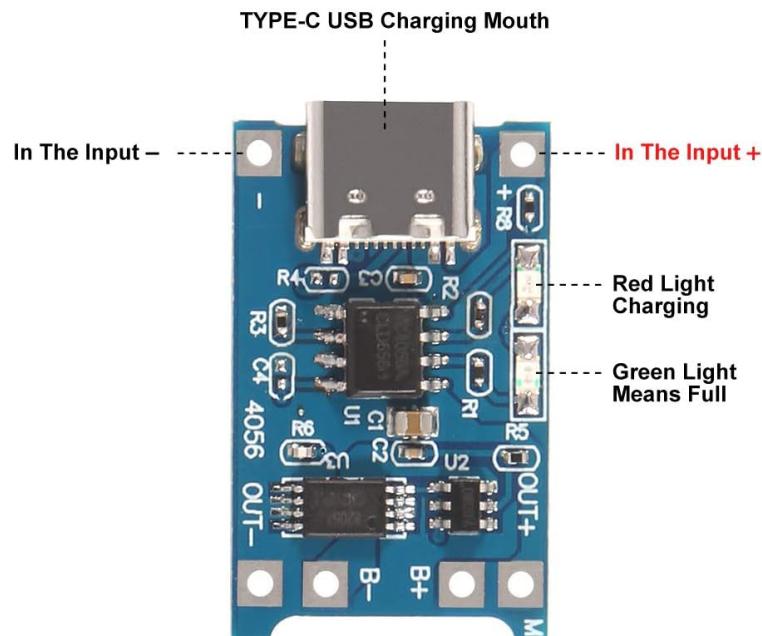
The M38 has built-in 5watt amplifiers.



M38 Module

5-watt Speakers*Gikfun 5-watt speakers**Gikfun 5-watt speaker Dimensions*

Power Management

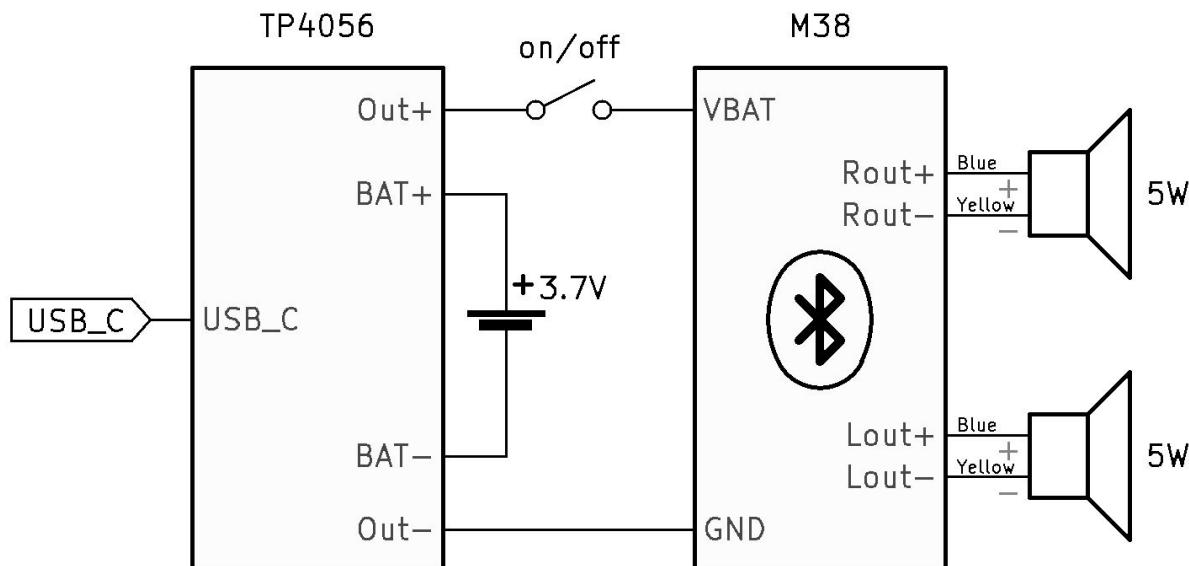


USBC Power Management 4056



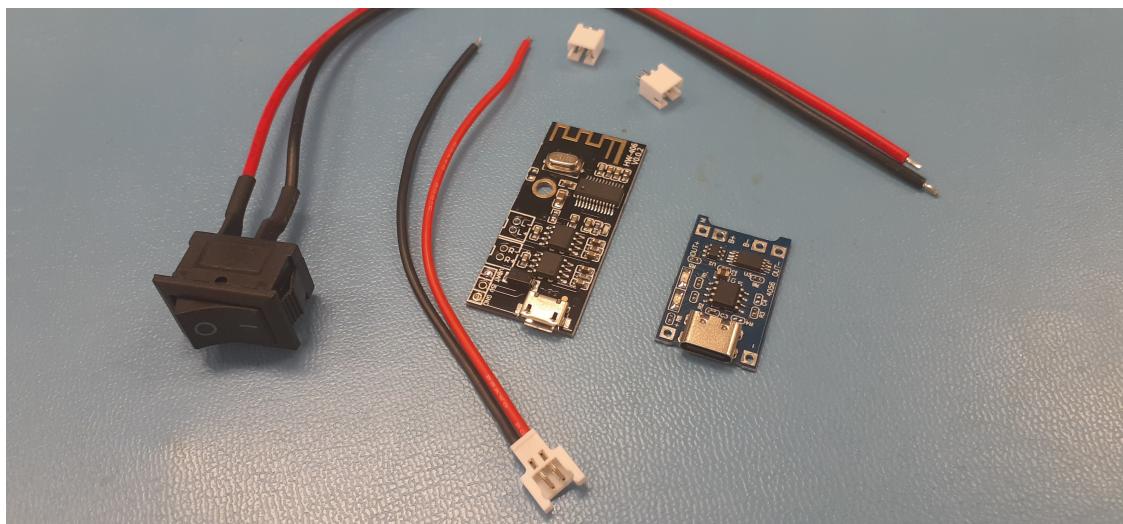
Lithium polymer battery

Final Schematic

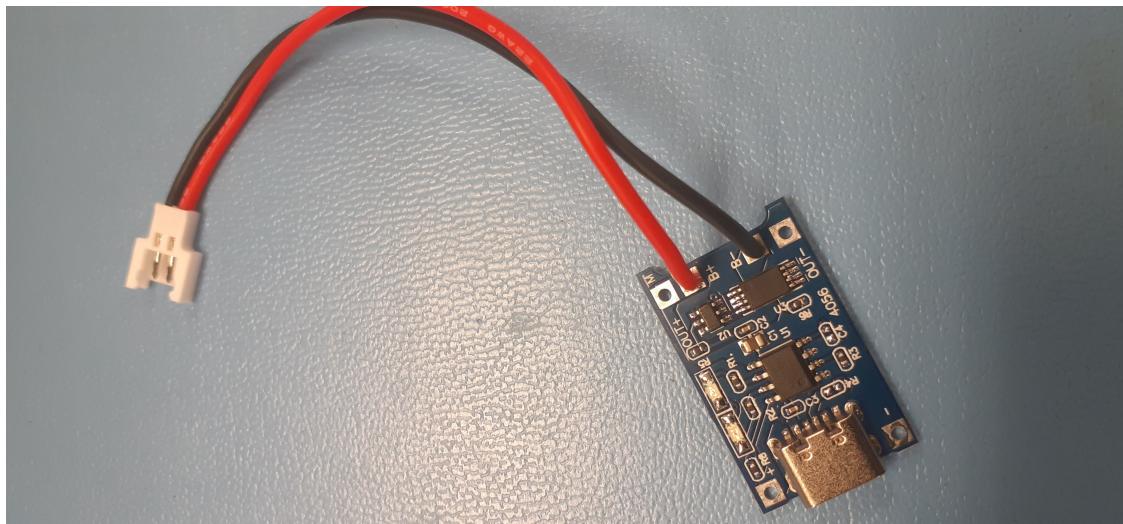


Benny Bluetooth Schematic

Parts Assembly

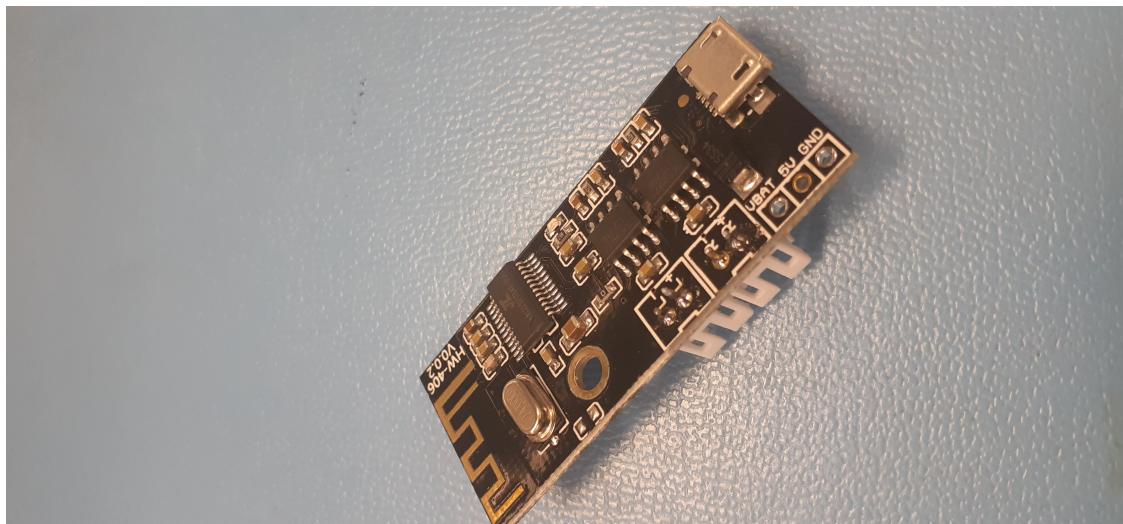


Electronic Parts



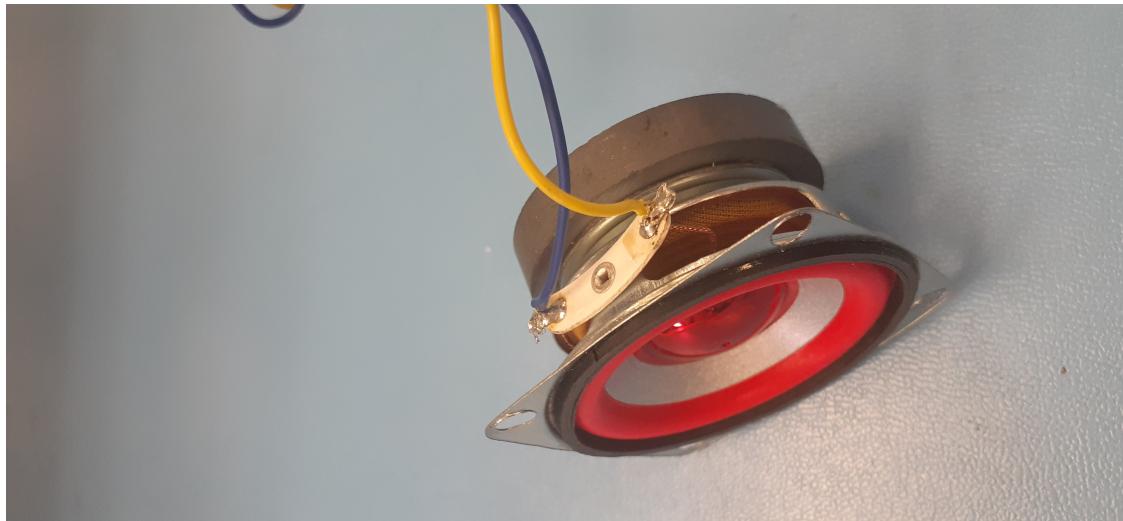
Solder the battery connector to the USBC 4056

- Solder the red wire of the battery connector to B+ of the USBC 4056 module.
- Solder the black wire of the battery connector to the B- of the USBC 4056 module.



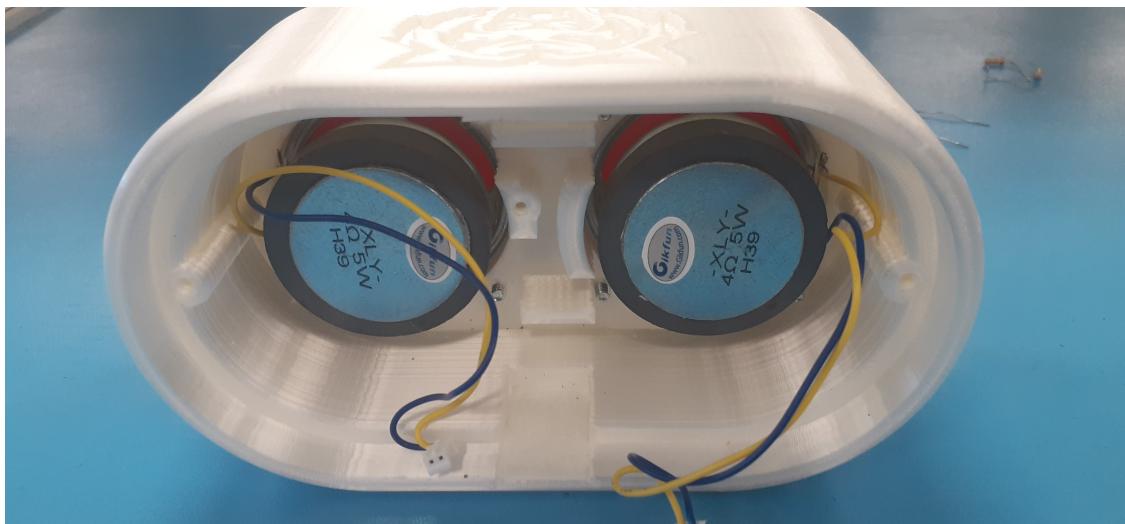
Solder the speaker connectors on the M38

- Solder the white speaker connectors onto the M38 board as seen above.



Solder the speaker wires to speakers

- Solder the blue and yellow wires to both speakers as shown in the image.



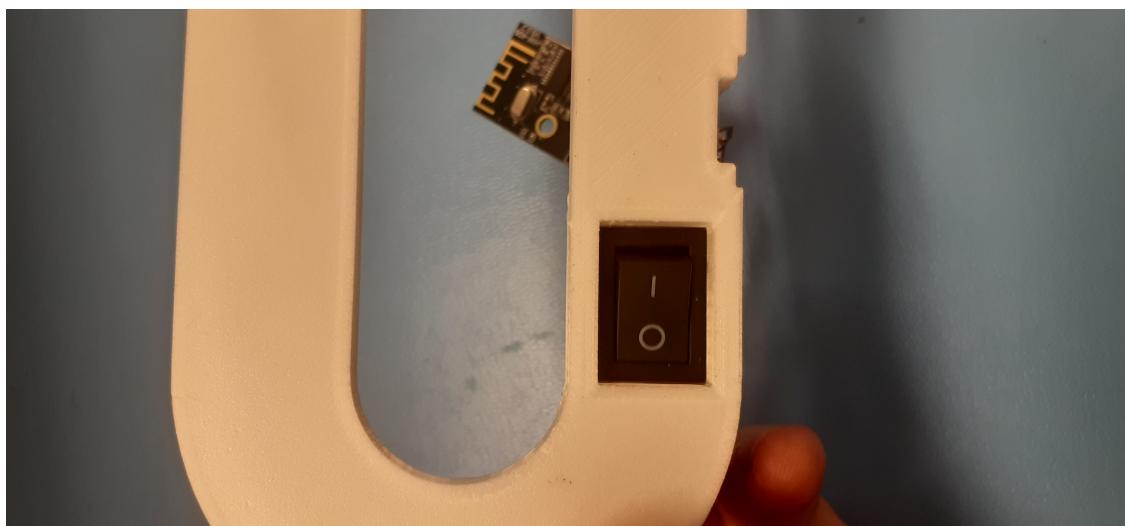
Speaker mounting

- Orient the speakers so the wires are opposite the center.



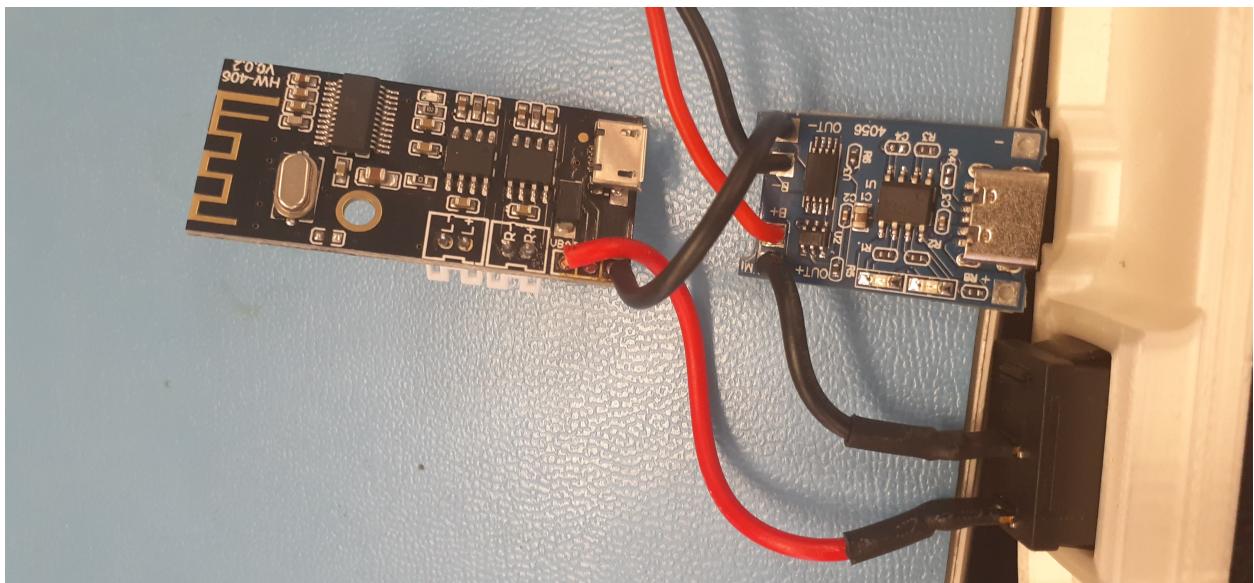
Speaker mounting front view

- Use eight 6/32 screws to secure the speakers from the front (**Do Not overtighten the screws!**).



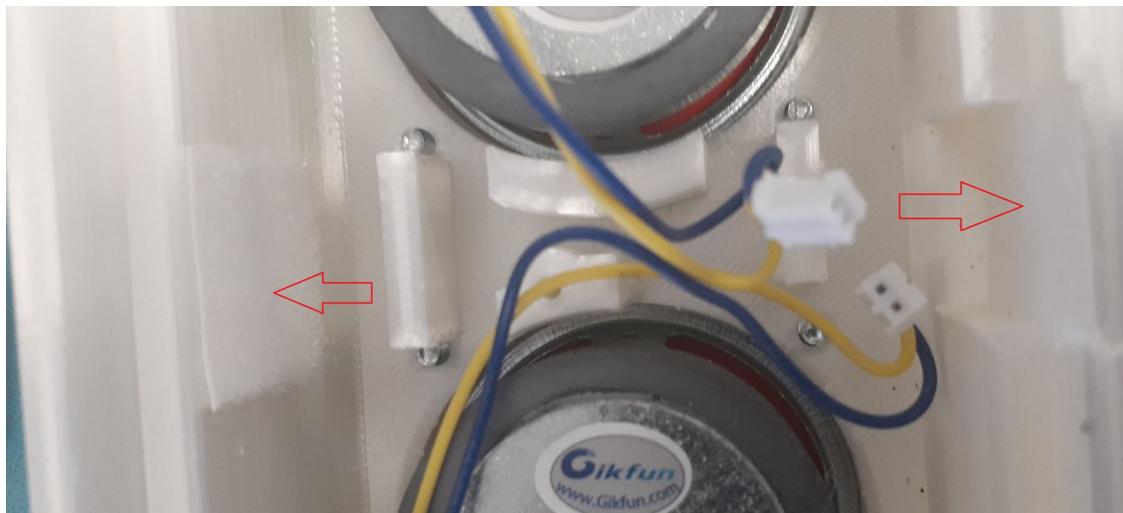
Power switch installation

- Press-fit the switch into the back plate.

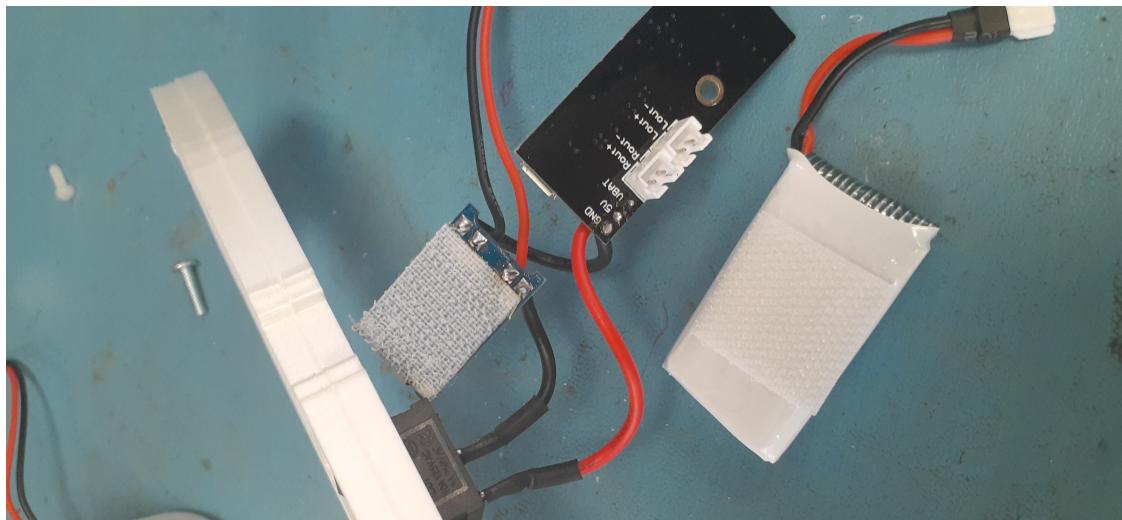


Switch solder connections

- Solder a 2-inch wire from one side of the switch to OUT+ of the 4056 module.
- Solder a 2-inch wire from the other side of the switch to VBAT of the M38.
- Solder a 2-inch wire from OUT- of the TP4056 to GND of the M38.

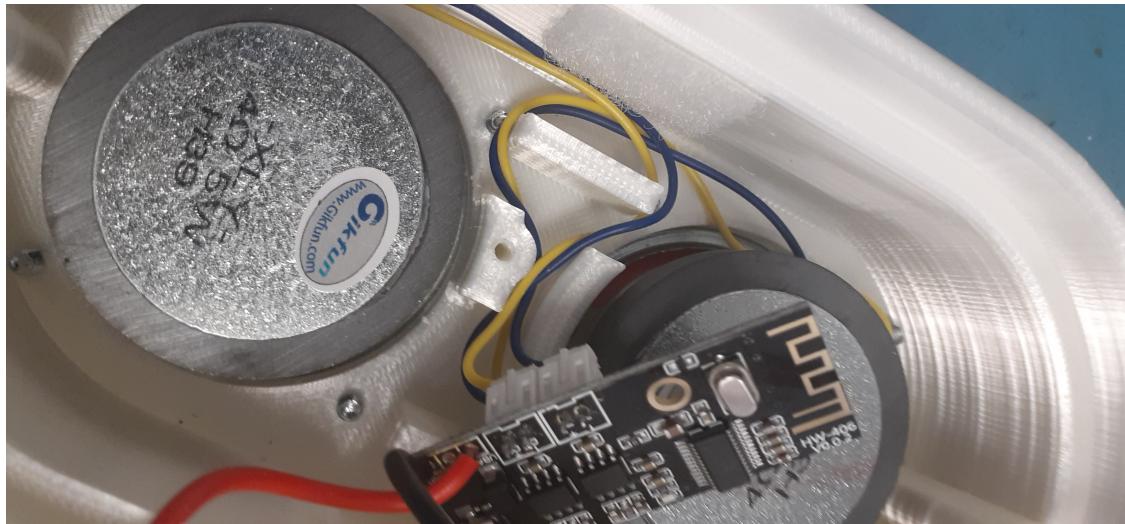


Attach Velcro soft-side squares to the inside of the body



Attach Velcro hard-side to the Battery and the USBC module

- Attach Velcro pieces as seen above. The Velcro must be trimmed to size for the USBC 4056 module.



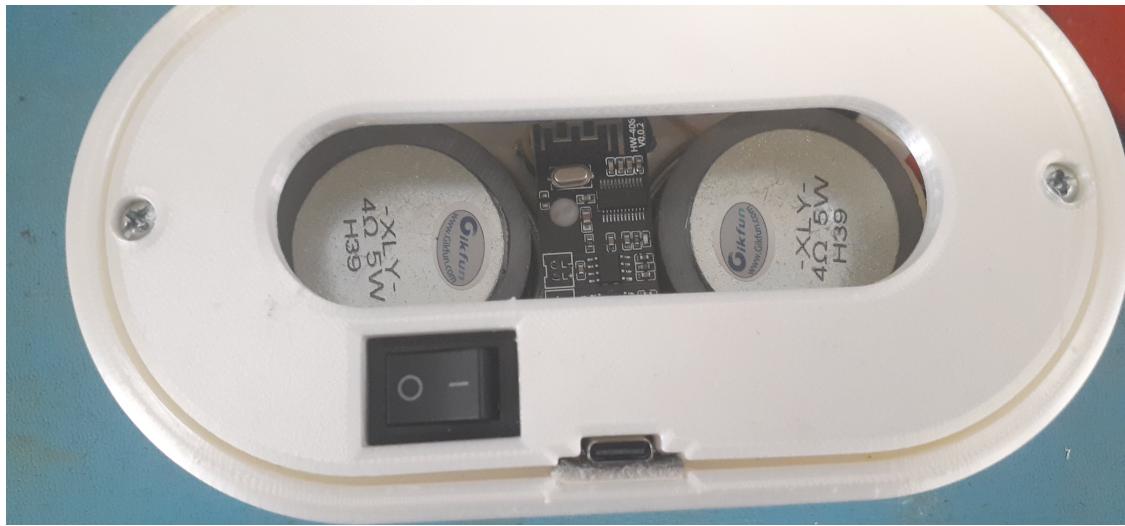
Speaker Connection and Wire Routing

- Connect the Left and Right speakers to the M38 PCB.
- Route and tuck wire down out of the way.



M38 and Battery Mount

- Gently use a nylon 4-40 screw to secure the M38 module.
- Ensuring the power switch is off (O position), connect the battery wire connector and secure the battery in place using the Velcro. Route the battery wires by tucking them down and around the speaker.



Back Plate

- Place the back plate into position, while lightly pressing the back plate into the USBC and Velcro, tighten the two 6-32 bolts to secure the back plate into the proper position. The gap between the back plate and the body should be uniform.

- Turn on and test. A blue LED should light and be visible on the M28 board and an audible "Bluetooth Mode" should be heard from the speakers. Pair with and test the Bluetooth audio using your phone.