Project	Plasma Speaker	**Designers**	**Page:** 1/6
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1 Project Overview

The goal of the project is to design a complete plasma tweeter which will be fully functional, safe and easy to use. The speaker can be powered by standard EU mains (240 Volts, 60 Hz) which is converted to 12V in a PSU and hence can be placed in any location of a household.

This document will have a detailed documentation of the circuit and design of the project in addition to the testing procedure used during the making of it. Many problems will be discussed and solutions to them will be provided for stable, consistent and safe operation.

2 Circuit Description

This section contains a detailed description of the electronic circuit of the entire project.

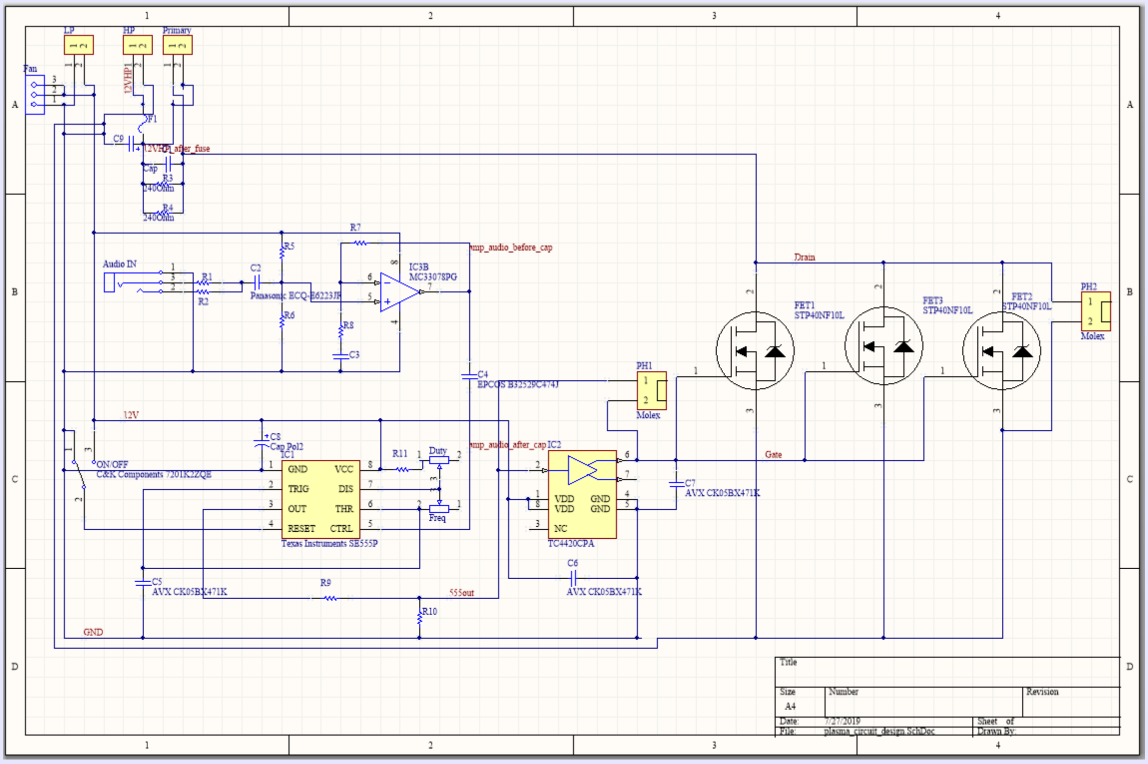

Figure 1: Plasma Tweeter Circuit

2.1 Low Power

Since the project operates with high power it is split into high and low power sections. This section will cover the low power section of our design. The significant active components in this section are the Texas Instruments SE555P, MC33078PG, TC4420CPA and a fan for cooling.

2.1.1 MC33078PG

This module is used as a summing amplifier to combine the *Left* and *Right* components of the music signal. The summed signal is passed as input to the SE555P Timer

2.1.2 SE555P Timer

The 555 timer is operating on a astable oscillating mode. The frequency of the oscillation can be adjusted with the *Duty* and *Freq* potentiometer. This will modulate the music signal from the MC33078PG summing amplifier. Low oscillation frequencies will decrease music quality and high frequencies result in increased heat dissipation across the power MOSFETS. From tests conducted the optimal frequency is around 40-50 kHz. The output is passed as input to the 4420CPA MOSFET driver.

2.1.3 TC4420CPA MOSFET Driver

Since the SE555P's current output is below the requirement for stable operation, a MOSFET driver has to be used in order to switch the power MOSFETS quickly and hence minimise power dissipation.

2.2 High Power

While the high power section of the circuit is significantly smaller, it has many problems which need to be solved for stable operation. The components of this section are three STP40NF10L power MOSFETS, a snubber cicuit and a flyback transformer. A 40A fuse is used to prevent excessive currents from causing damage to the components.

The MOSFETS are put in parallel in order to share the input current and hence decrease power dissipation across them. The specific model was selected as a low gate charge time and power dissipation are required for fast switching and to prevent overheating. Additionally they are attached to a heat sink and have a fan for active cooling. The drain is passed as input to the primary of the flyback transformer. A snubber circuit is placed between *Vcc* and the MOSF bET drain in order to suppress voltage spikes caused by the parasitic inductance. Two resistors are used in parallel in order to share the current and prevent overheating and component failure. The number of windings on the inductor will be varied to maximise current input while avoiding component failure. The method for determining that will be covered in the *Testing* section. All the components are embedded in a 50A rated PCB and the windings on the flyback transformer are done using a 50A rated cable.

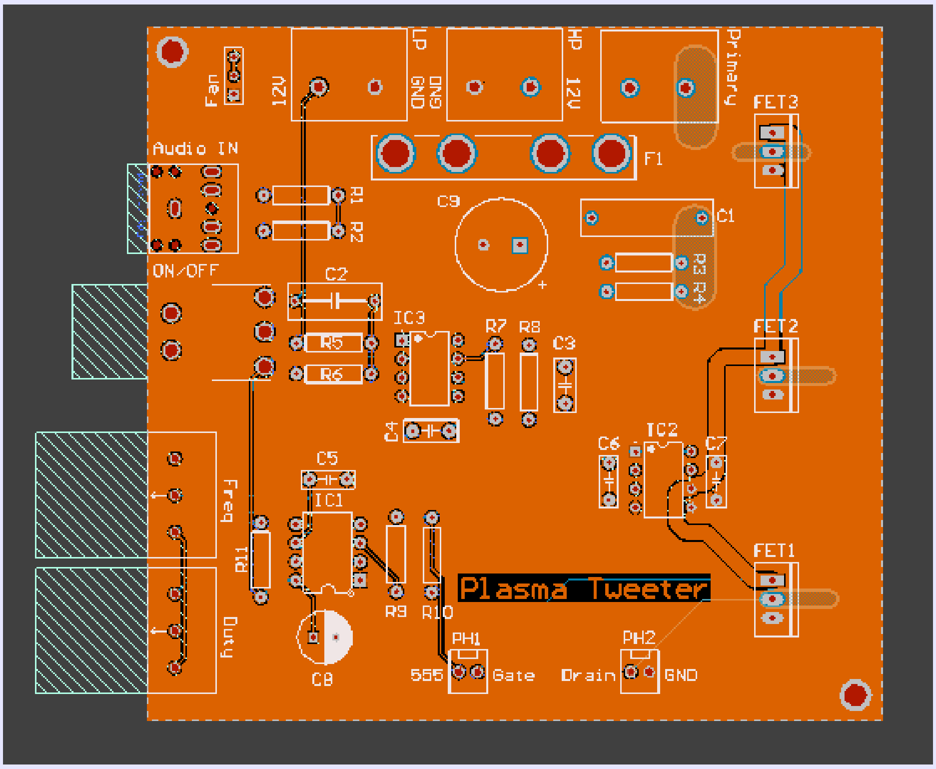

Figure 2: PCB design 1

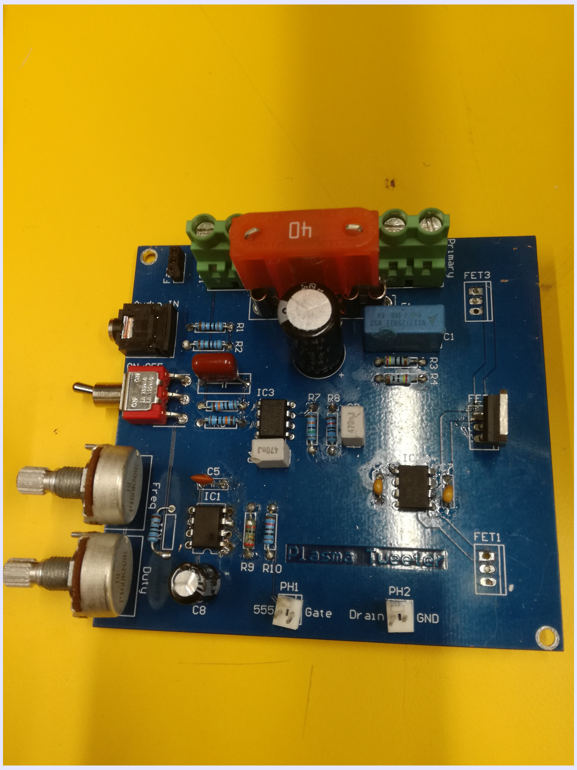

Figure 3: PCB design 2

3 Design Description

This section contains pictures and a shirt description of the reasoning behind the physical design used for the project.

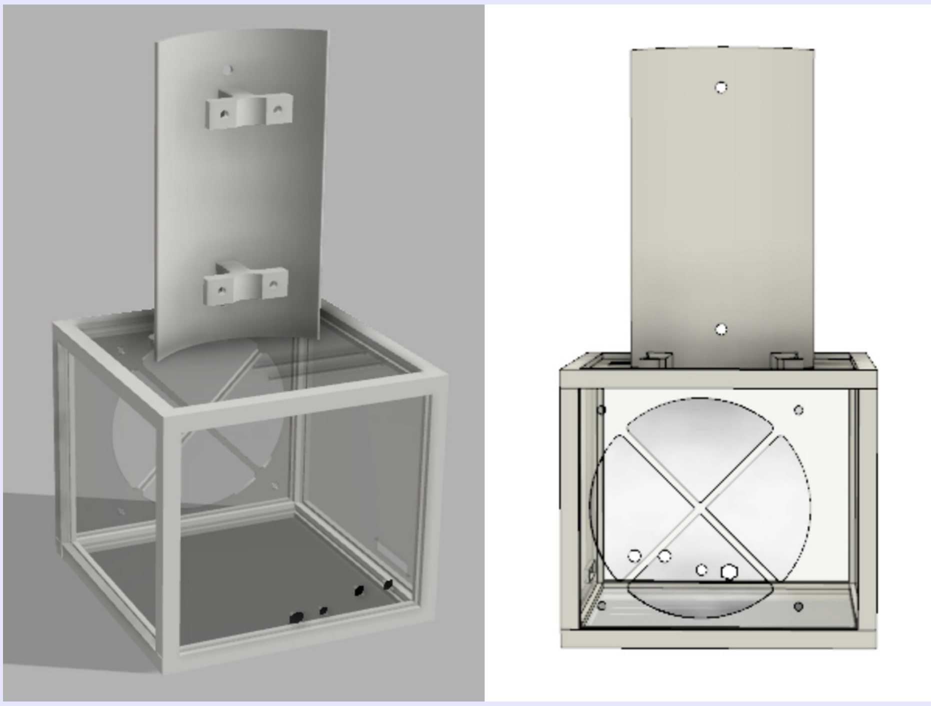

Figure 4: PCB design 2

3.1 Speaker Frame

The box is made up of a frame which contains slots for the acrylic panes. It is preferable to use ABS due to its properties being toughness and low cost. The frames can be put together with any adhesive and optionally one of the acrylic panes can be omitted during the testing process and added after the completion of the design.

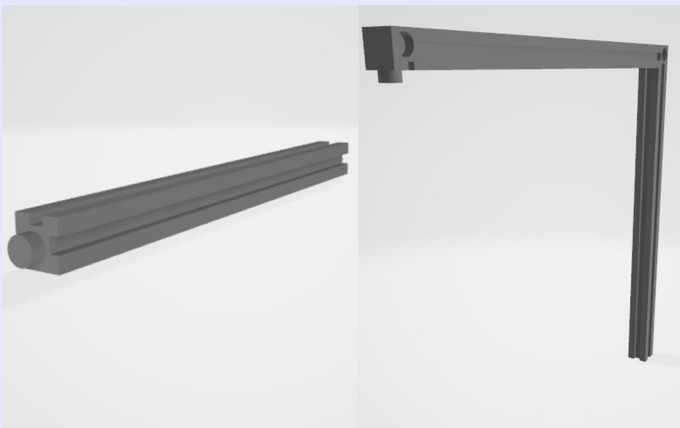

Figure 5: Box Frame

3.2 Speaker Panes

The panes used for enclosing the electronic components are to be laser cut out of 3mm thick acrylic and put together in the right order. The front pane contains four holes which are required for the *Duty* / *Freq* potentiometers, 3.5mm jack and switch. The back pane contains an opening for airflow and hence better cooling of the device. The right pane contains an opening for the input power cables. The top pane has slots for the arc holder and holes for improved airflow. The left and bottom panes are left unchanged.

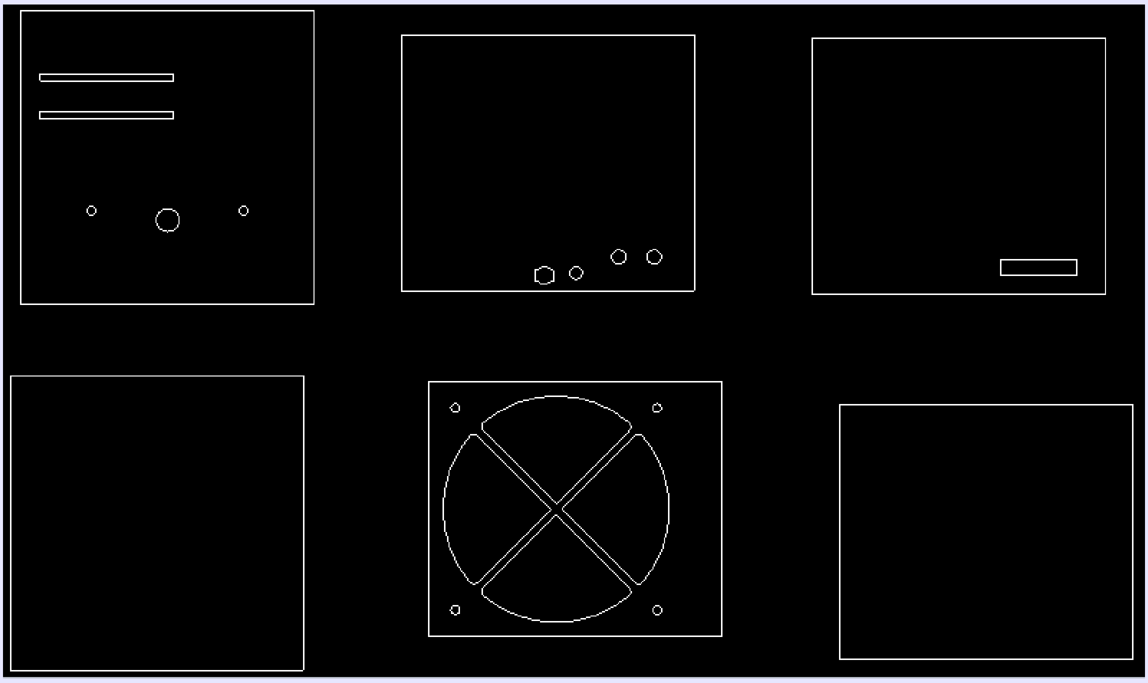

Figure 6: Speaker Panes

3.3 Arc Holder

This part is where the arc is produced from the flyback transformer secondary. Voltages of up to 20kV can occur here depending on the input current. This is located above the box and two Arc Holders are used to hold the electrodes at an adjustable vertical distance from each other. This can either be left open for better visibility of the arc and improved sound quality or sealed of for safety.

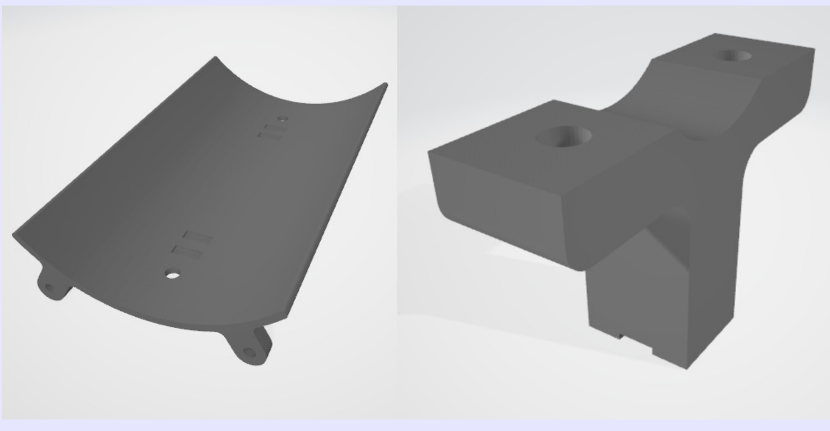

Figure 7: Arc Shield and Arc Holder

3.4 Electrodes

The electrodes chosen for this project are made out of stainless steel due to its high melting point and conductivity. Other possible alternatives are any metals with similar properties such as tungsten. A certain amount of thickness is required in order to avoid the electrodes from reaching their melting point.

4 Testing and Thoughts

Due to the nature of the project of having high and low power compartments it is also beneficial to split up the testing procedures similarly. This section of the report will discuss the testing methodology used for the project and important details and observation regarding it.

4.1 Low Power

The maximum current used by the components in this compartment of the circuit do not exceed 500mA. Hence this part could be prototyped easily using a breadboard. The *Duty* and *Freq* potentiometers were chosen to keep their respective factors of the modulating signal variable in order to allow for optimisation at any point of the design and after it's completion. Once it has been confirmed that the summing amplifier is able to correctly combine the input sound, then is correctly modulated and finally reaches the MOSFET and is able to turn it on and off it has been confirmed that it works as intended. It can then be ported to a more stable PCB to harshly decrease chance of failure and consistency.

4.2 High Power

Unlike the other compartment of the circuit, this is largely more complicated to test and gather data on. Since the current in this section can exceed 20A, breadboards and thin wires will melt and hence cannot be used. A perf board can be used for initial tests however a PCB and high current rated wires will need to be used eventually for later stages of testing. Preferably, the container for all the electronics should be used for late testing stages as the flyback transformer will increase the voltage level to dangerous levels. All MOSFETS need to be equipped with heat sinks and active cooling should be present. For initial low current tests, not all three MOSFETS are required and in the case of consistent operation the third MOSFET can be omitted if it is not beneficial. The current which is drawn from this compartment is decided by the *Duty* / *Freq* potentiometers and the transformer windings. Initially testing should commence at a large number of additional primary windings (8-9) and the potentiometers should be adjusted to compromise between maximum sound quality and minimum power consumption. By decreasing the transformer windings the current draw can be increased resulting in a higher output volume, arc length and heat generated in the MOSFETS. Another important factor which can cause harm to components are the voltage spikes caused by the parasitic inductance. If these exceed the MOSFET's maximum voltage, it can result in component failure. The voltage spikes can be decreased by carefully adjusting the snubber circuit.