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PHYS 398: EMI

Term Project

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The "Reduced" Fender® Princeton

Project Goal

To realize a fully functioning reduced-size model of the Fender Princeton guitar amplifier, model 5F2-A. It is intended that the amplifier size be practical for "throwing into a backpack," as well as unique in its physical appearance. It is also desired that the design be accurate to an already existing version, still smaller, property of Prof. Steve Errede {n.b. pix of Prof. Errede's 5F2-A tweed μ-Princeton amp are available at the following URL: http://online.physics.uiuc.edu/courses/phys498pom/498pom_class_pix_spring01.html}. The goal also includes the application and integration of various distinct topics taught in the Physics 398 classroom.

The Process

The process of building the amplifier from scratch can be divided into different categories, as many parts are independent of the rest of production process, aside from the final integration of the finished components.

1. The cabinet
2. The chassis
3. The circuit
4. The speaker

A Closer Look: **The Cabinet**

Design

The cabinet is the first thing a person sees when looking at a guitar amplifier. The cabinet is the box that contains the speaker, amplifier circuit and user controls-it is the supporting structure, outer shell and for many, the first impression. The cabinet of this amplifier is explicitly not modeled after a traditional Fender Princeton amplifier. It is specifically modeled to match a 1955-1960 Fender Narrow-Panel Deluxe, on a smaller scale. The reason for this is one of convenience, having nothing to do with the design or aesthetic quality of a Princeton cabinet as compared to a Deluxe cabinet.

The way that the cabinet was originally modeled was by taking measurements of a Fender Deluxe amplifier that had been in the lab, belonging to Teaching Assistant Dan Finkenstadt. Upon taking these measurements, the immediate goal was to build an amplifier exactly half the size of the original measured model. The only exceptions made were the thickness of the wood used, and minimal internal design discrepancies, such as how the speaker panel is mounted.

The shape of the amplifier resembles a box. Differing from a box, instead of having a rectangular side-plate of wood, the shape of the side panels is that of a trapezoid. Still, the amplifier can be considered to be a box. Therefore, neglecting any deviation from a box shape, the dimensions of the amplifier are 10" × 4 ¾" × 8 ¼". Hand-drawn measurements/plans have been attached for reference.

Build

The cabinet is made of ½" thick red oak wood. Any panels were made using ¼" red oak. The main cabinet wood was purchased as a single board, cut into sections with a jigsaw, carved with a coping saw to design the top piece and create hand-made dovetails, sanded down, and finally glued together to create what is the simple cabinet. The bottom of the amplifier has four pegs, or "feet," on which the amplifier stands and is kept level.

Aesthetics

The cabinet was stained with an American Cherry tint and coated with polyurethane high-gloss finish for the look and feel of a new piece of furniture. It was desired that the amplifier have this specific look and feel because this particular style is not widely seen among today's most common guitar amplifier cabinets. The intent was for the cabinet to be pleasing to the eye, and unique, but still recognizable as a guitar amplifier.

A Closer Look: **The Chassis**

Design

The chassis for this amplifier is merely a C-channel shaped plate of aluminum. It is roughly $^{3}/_{64}$" thick, and its dimensions are roughly 7" × 5". The chassis is yet unpainted and there haven't been any plans to paint it at this point.

This piece that is the chassis was not originally intended to be the chassis. Originally, the chassis was to be a piece of aluminum, the same shape, except the C-shape was in the other direction. This piece came from a receiver system for a cordless microphone. Half of it was used as a chassis by my peer, Tim Patterson, and the other half was going to be my chassis. I took this piece up to the workshop on the 4th floor of Loomis Lab, to get it bent to a more suitable shape for a chassis. What ended up happening was a different story. Instead of modifying this piece of aluminum so that it could be a suitable chassis, an entirely different plate of aluminum was chosen and manipulated to fit together with the original piece of aluminum, to create a closed chassis. After much thought, however, it was decided that the original piece of aluminum could be scrapped and that the second piece of aluminum, originally a complement to the first, would be used as the chassis for this amplifier.

Holes were punched into the chassis using a drill press and then adjusted on a more precise scale using a reamer, and in the case of the light, a chassis punch. There were holes drilled for the on/off switch, fuse, light, tone pot, volume pot, two inputs, speaker output, and the two vacuum tubes. Most of these holes were different sizes in diameter. Other holes were drilled for mounting of such objects as the output transformer, two circuit boards, power transformer, and star ground. A schematic has been attached, showing the layout and design of the chassis.

A Closer Look: **The Circuit**

Design

The circuit design was fairly straightforward in this project because schematics had been provided, suggesting the optimal logistical layout of the circuit. There also had been a circuit diagram provided. These schematics have been redrawn and attached, for reference.

Modifications

Because this amplifier is intended to be a low-power amplifier, because of its small size, there had to be some adjustments made to the suggested circuit for the Fender Princeton 5F2-A. One change involves the rectifier tube. In the Reduced Princeton, there is no rectifier vacuum tube.

All that is used to rectify the input is two 1N-4007 silicon diodes. This was cost effective and simplifying for the circuit. Another change is in the pilot light. For purely aesthetic purposes, a large AC pilot light was chosen for the amplifier, as opposed to a traditional LED. This changed the circuitry of the amplifier, but not dramatically. One extreme adjustment made is one involving the vacuum tubes. There were different vacuum tubes used for this model of the amplifier than those used for the original Princeton. The original Princeton used a 6V6GT power tube and 12AX7 preamp tube, whereas this model uses a miniature Raytheon 6112 pentode power tube and 5902 dual-triode preamp tube. These miniature vacuum tubes are sometimes affectionately termed "pencil tubes." Not only was there a change in the types of tubes, but also therein follows an entirely different way to wire the tubes up. Additional changes include allowing lower-power resistors and capacitors in the circuit, changing 22kΩ & 10kΩ resistors to 4.7kΩ & 1.0kΩ resistors, respectively, and slightly tweaking some capacitance values. One last notable change is in the power transformer. The heating filaments of the tubes generally demand a 6.3 V source, whereas the only available source for the pencil tubes, using the particular power transformer specified, was one of 5.6 V. Luckily, this slight change in voltage does not create a difference in performance or functionality.

Difficulties/Problems

There were many difficulties and problems in putting this circuit together. One of the difficulties was soldering the vacuum tube sockets to the rest of the circuit. This was very difficult because of how small and close together the tube sockets are. Soldering these joints was an incredible challenge. Another difficulty was creating a star ground terminal. This was difficult because it is connected to the chassis, under a multitude of wires. It was hard to get in and solder something else onto it.

Of problems, there is one that sticks out more than any others do. The problem is that when I first started, I was working with the wrong circuit schematic! I was working on the Fender Princeton 5E2. This was wrong because the 5E2 includes a "choke" for the circuit, which is something that wasn't readily accessible to this circuit. This problem wasn't discovered until a week before the project due date. After the problem was discovered, there was left about three times as much work on the circuit as previously anticipated. After a great deal of overtime work, however, the circuit was eventually transformed from a Reduced Fender Princeton 5E2 to a Reduced Fender Princeton 5F2-A.

A Closer Look: **The Speaker**

The only consistent information that can be given regarding the speaker is that it must have an impedance of 8 Ω. The amplifier system and output transformer is laid out so that the speaker should have this particular impedance. The output transformer, however, is an all-purpose output transformer, and therefore can have a variable required load impedance. This indicates that it might be possible to tweak the configuration of the

output transformer to adapt to a lower or higher impedance speaker layout. This is a very positive point in the amplifier: its output flexibility.

A ¼" jack has been installed in the chassis and connected appropriately so that a speaker must merely be plugged into the circuit through this jack. This means the speaker will not be hard-wired and can be changed as is seen fit.

The current speaker being used is one that came from a Chrysler automobile. The speaker exhibits an impedance of 8 Ω and measures 4" in diameter. It is recommended that any speaker introduced into the cabinet be no more than 4-5" in diameter, because of space limitations.

Problems/Recent Modifications

As a conclusion, the amplifier works! There were several problems involved with its functionality, however. These are the following:

I. The pilot light.

Upon close examination, it was found that the pilot light had a faulty bulb installed. However, upon installation of a new bulb, it was found that a green light would not shine very brightly because the (neon) bulb glowed with an orange tint. Therefore the green light cover was replaced with an orange light cover.

II. Circuit instability when tone or volume is turned to maximum.

It was found that when the volume or tone knob was turned to its maximum value, the circuit became audibly unstable. The grid offset voltages would climb from 0 VDC to values of magnitude up to -2 VDC. The solution for this problem involved several different measures:

A. Shielding of wires.

It was decided to use coaxial cables in the preamp section of the circuit, for shielding measures. This amplifier circuit is extremely prone to shielding and electromagnetic coupling problems because of its compact size and the proximity of various different circuit elements.

B. Filtering irrelevant/undesired frequencies.

It was found that some very high (>100 kHz range) frequencies were disturbing the circuit's functionality. The solution for this problem was to introduce into the circuit a small mica capacitor to block these frequencies, while still passing relevant frequencies. The audible frequency of the human ear is generally below 20 KHz, and any higher frequencies can therefore be ignored or eliminated.

Notes

A million thanks to Prof. Steve Errede for his assistance, guidance, and provision regarding this project.

Thanks to Harold Scott from the 4th floor High Energy Physics Electronics Shop for helping with the construction of the chassis.

A circuit schematic and layout drawing for this amp also accompanies this report – please see the following file.