Fuzz Face Guitar Pedal Replica

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Physics 406 | Instructor: Prof. Steven Errede

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Introduction & Motivation

Fuzz as a guitar effect is a slight variation on what is typically referred to as distortion. It originated during the 1950's and 1960's as one of the first effects widely utilized by jazz and blues musicians as they began to desire warmer, grittier sounding electric guitars [3] . They started by simply running their amplifiers at higher-than-recommended volumes to create this effect and later, as the style began to spread, by creating pedals with circuits which mimicked the same outputs [3] . The sound was widely popularized by artists such as Jimi Hendrix, Keith Richards, and Paul McCartney (among many others) during the 1960's as fuzz and distortion pedals became more widely accessible [3] . Distortion effects have been extremely popular ever since, and are incorporated to some degree into a large fraction of songs which also feature electric guitar and/or bass [3] .

Distortion arises from the delinearization of outputs from a given source, a common example of which occurs when one plays music at too high a volume, causing it to sound rough and fuzzy [1] . To produce distortion intentionally, input signals are "clipped" to fit a specific waveform by adding overtones, which are higher frequencies with the same phase as the source [2] . The fuzz effect is created by taking the input and fitting it to a square waveform by adding numerous harmonic and odd-numbered overtones [2] . An illustration comparing an unmodified input signal with the same signal under soft clipping and hard clipping is illustrated in figure 1. The hard clipping most accurately depicts the fuzz effect.

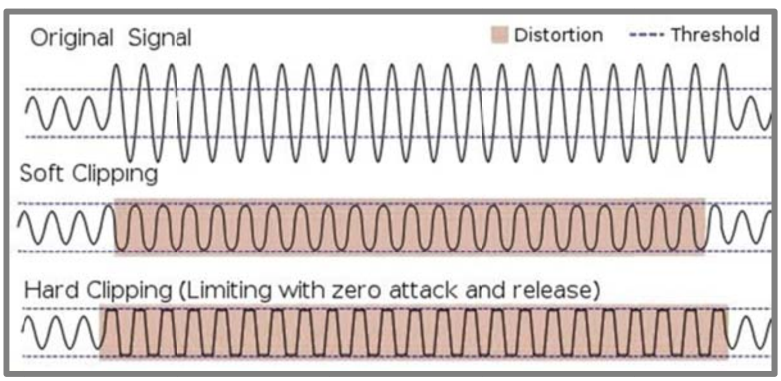


Figure 1: An example of the effect of clipping on a source waveform. Source: http://en.wikipedia.org/wiki/File:Clipping_waveform.jpg

The primary goal of this project was to build, analyze, and ultimately use a fuzz/distortion pedal for my electric jazz bass and electric guitar. I have played bass guitar and, to a much lesser degree, regular guitar for the last thirteen years, and a decent percentage of the music I play/am influenced by relies to some extent on effects, be it distortion or otherwise. Several years ago, I purchased a used Digitech Bass Overdrive distortion pedal which recently ceased to function, and, due to the presence of a multi-layered circuit board and DSP chip, was largely unfixable given my skill level. Through taking this course, I wanted to see if it was possible to build a functional replacement pedal of equal or greater quality than my own pedal, all at a fraction of the cost of similar pedals available through retailers. A secondary goal was to gain a basic understanding of circuit construction and design.

Design & Construction

The longest and most laborious phase of the project was the combination of design and construction of the pedal, which took well over half of the semester due to my woefully inadequate level of experience with creating and wiring circuits on a board. My initial plan was to teach myself basic principles pertaining to this, then find a fuzz circuit schematic online, design the circuit board, and assemble it from scratch. It quickly became apparent, however, that I was so far out of my depth in this endeavor that I would not only lose a non-negligible amount of capital in materials, but would likely not be able to produce a functional pedal by the end of the semester. Since those were the primary goals of the project, I decided to take an alternative route. General Guitar Gadgets, an online store which specializes in DIY guitar pedals and equipment, sells a replica of the Dallas Arbiter Fuzz Face pedal (one of the first/most famous fuzz pedals) for approximately half the cost of what such a pedal normally retails for. The kit included all necessary components for the fuzz pedal/circuit, including a predesigned circuit board tailored specifically for the pedal. It also included a full schematic (figure 2) and wiring diagram (figure 3). Excluding lab materials used, the final bill was ~$55, substantially less than the cost of most high quality fuzz pedals.

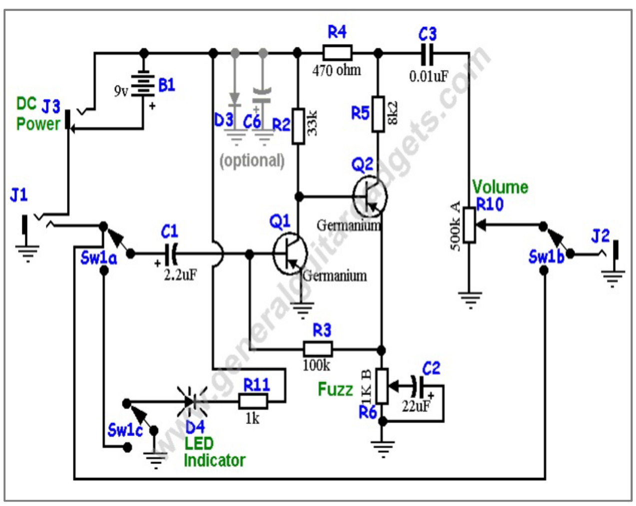


Figure 2: Full schematic as provided by General Guitar Gadgets.

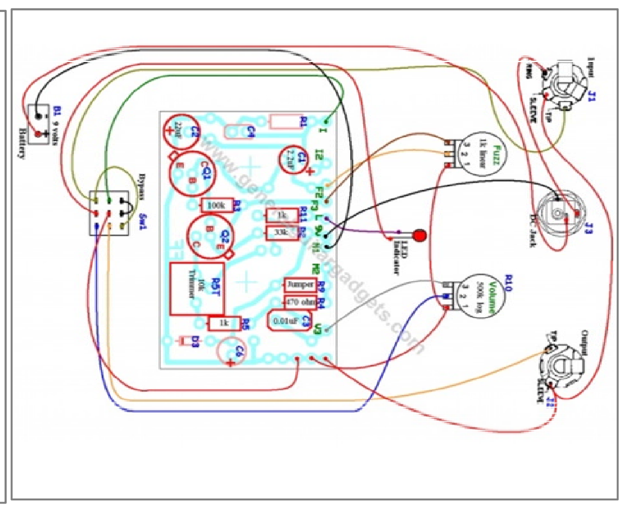
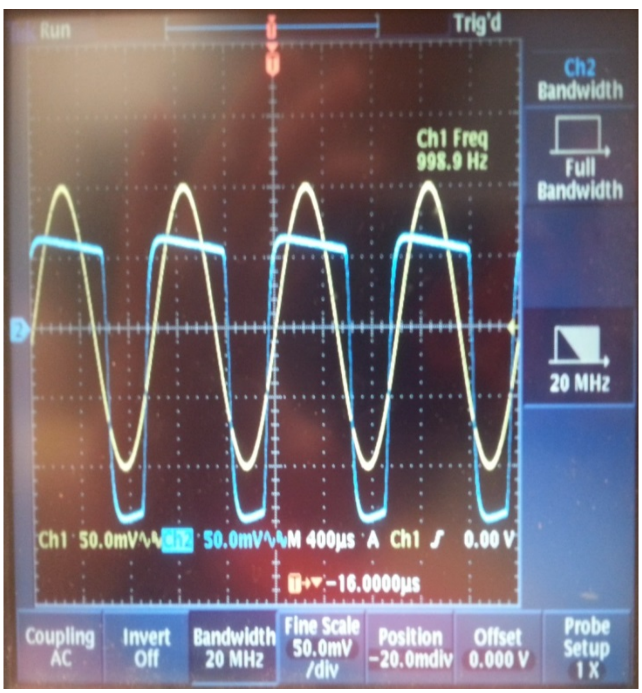


Figure 3: Full wiring diagram as provided by General Guitar Gadgets.

The largest challenge I faced in building the pedal, even with the help of the kit, was soldering the whole thing together. Prior to this project, I had never assembled more than the most basic of circuits ala physics 212, so I spent the majority of the project learning how to solder (with the help of Prof. Errede), soldering the board together, and subsequently learning how to desolder so as to fix the errors I made in soldering. The diagrams shown represent the circuit I constructed using PNP germanium transistors. The kits also came equipped with the materials to build the pedal using NPN silicon transistors along with associated diagrams. It had been my intent to use silicon transistors, as they are believed by some to give the fuzz a better, more “classic” sound. Due to a clerical error on my part, however, I accidentally built the entire pedal using the above wiring diagram, which led to several weeks of frustrated troubleshooting by professor Errede and myself trying to fix the circuit, which in reality only required a simple swapping of transistors. After this exchange was made, the pedal worked sufficiently to continue on to the next stage of the project.

Analysis, Results, & Conclusions

The next stage of the project was to run an analysis of the fuzz pedal so as to view the effect it had on an arbitrary input signal. In order to do this, the pedal input was hooked up to the Agilent Function Generator running a 1 kHz sine wave at approximately 1mA. The pedal the output was then simultaneously hooked up back into the same function generator as well as an HP-5362A Dynamic Signal Analyzer. This setup was made so as to show the output of the pedal both in the time domain (in the function generator) and the frequency domain (in the signal analyzer. Data were taken for three separate setups. The volume knob on the pedal was left at ~50% the maximum volume, while the tone knob, which alters the degree of clipping, was switched from completely off, to halfway on, to completely on for the three data collecting runs respectively. The data collected are shown below.



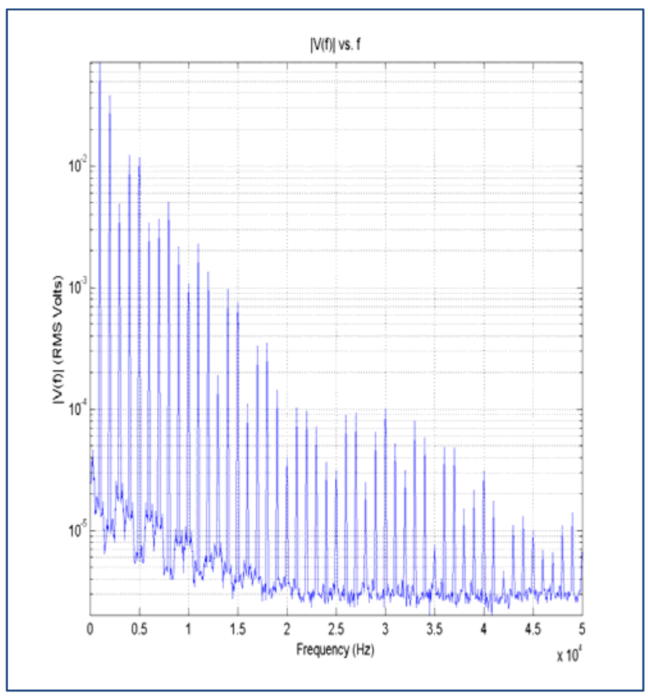


Figure 3: The figure above shows data gathered for the system run at the minimum fuzz setting on the tone knob. The graph on the left was taken from the function generator while that on the right from the signal analyzer.

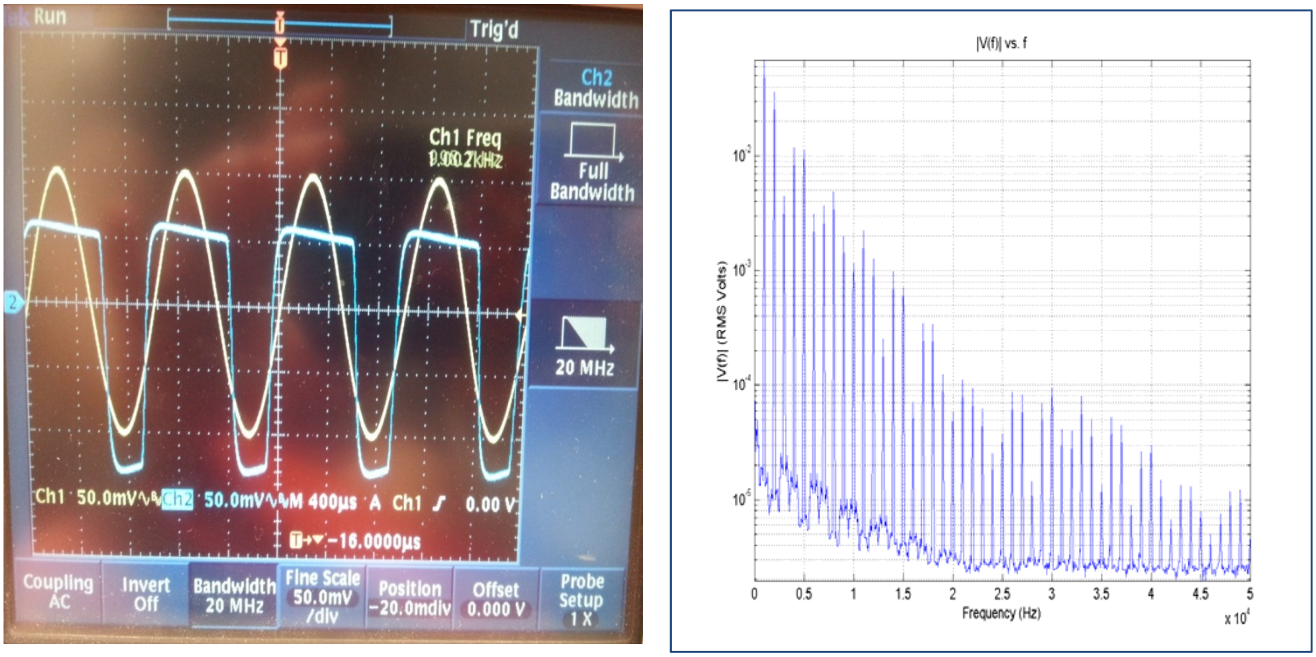


Figure 4: The same setup as in figure 3 except the tone knob is set to half the maximum fuzz.

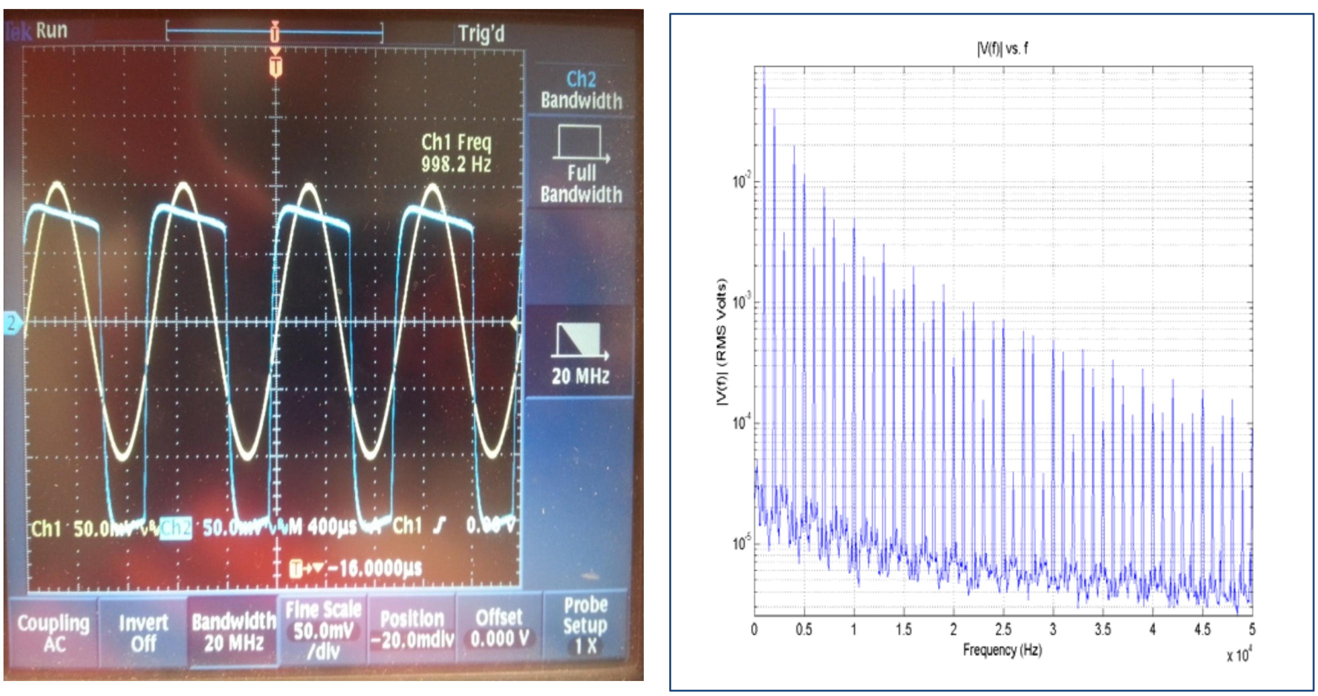


Figure 5: The final setup, showing data with the tone knob set to maximum fuzz.

The graphs provide visualization for the fuzz effects as described previously. On the left-hand graphs, the input signal is shown in yellow and the output is shown in blue. On the right-hand graphs, the output is the only signal provided. In the time domain, it is quite easy to see the general effect the fuzz pedal has, as the standard sine wave is clipped into a nearly square waveform. One may note that there is little detectable change between the minimum and half fuzz settings, but as the tone is turned up to the maximum setting, the output signal is amplified slightly, while simultaneously producing a slightly sharper square wave. In the frequency domain (as shown on the right-hand graphs), one can immediately see the spikes in voltage response as a function of frequency, V(f), in RMS volts that correspond to the additional harmonic and odd-numbered overtones. As in the time domain, there is little change in the outputs between the first two graphs corresponding to the minimum and half-fuzz tone settings. For the maximum fuzz setting there is a sharp increase in all voltage responses above ~1.5 kHz. The outward effect of this is a much dirtier, darker sounding fuzz effect when compared to the other two settings tested.

Generally, the fuzz pedal worked rather well, but from the data it is apparent that there is little response from the tone control when compared to most commercial pedals. This result could be due in part to the circuit design as provided by General Guitar Gadgets, and would be a subject for further study in improving the performance of the pedal. Considering that this was my first attempt at building a pedal, however, this is a relatively small issue. The primary goals going into the project, to build a functioning pedal at a fraction of the cost to purchasing one, were accomplished to a standard I had not anticipated going in, so the issue with the tonal control, while slightly annoying, is not cause to call the project a failure. Going forward, I may attempt to resolve the issue with the tonal control if it is within my ability, but judging from the state of the circuit board after the last round of soldering and desoldering this might not be a wise move. The project did show, however, that in spite of my general lack of knowledge pertaining to circuits, building guitar pedals on a budget is both doable and wholly enjoyable, so I definitely plan to continue adding to my homemade effects pedal collection in the future.

Figure 6: The finished pedal.

References

[1] Errede, S. (2000). *Theory of distortion I*. Retrieved from http://courses.physics.illinois.edu/phys406/Lecture_Notes/Distortion/PDF_FIles/Theory_of_Distortion1.pdf

[2] Trivedi, Y. (2011, May 20). *Htg explains: How do guitar distortion and overdrive work?*. Retrieved from http://www.howtogeek.com/64096/htg-explains-how-do-guitar-distortion-and-overdrive-work/

[3] (2013, November 27). *Distortion (Music) – History.* Retrieved from http://en.wikipedia.org/wiki/Distortion_(music)#History