Bio

Name-

My name is Ben Moore, 38 years old, from Garson, Ontario.

Recent Projects-

After spending a year as a consulting employee at a local painting company, then another 4 months completing a structural home renovation/complete cosmetic renovation on a family home, I have finally managed to successfully complete 2 very exciting audio electronic engineering projects; the Lowzee microphone pre-amplifier with proprietary discrete input-stage technology, and the Avid MBOX (9VDC,4A) regulated power-supply replacement project.

Engineering History-

My first endeavor in audio engineering was very much a happy accident. At the age of 12, a friend of mine brought an electric guitar that he had borrowed from our elementary school band over to my parents' house for me to see. In the case was a cool electric guitar, and a guitar cable, but we were absent an electric guitar amplifier. For some reason it occurred to me that the 1/4in guitar cable would fit nicely into the, then, 1/4in headphone jack on the front of the stereo receiver amp. It worked! Presumably, current was flowing through the guitar pickup, and when a voltage was induced, the negative-feedback loop of the amplifier was trying to correct for a moving ground voltage. However, the panning and EQ controls worked perfectly, so it must not have feedback to the power section. I don't remember the make or model of the amp, so I'll probably never know for sure why that worked so well.

Later, in the 10th grade, I again noticed that the 1/8in headphone input on my computer's SoundBlaster Live soundcard would match nicely with the 1/8in headphone output on the Digitech guitar processor that I had at the time. Recording software called Cool Edit Pro (now Adobe Audition) was available for free on the internet, and, bored with my Cisco certification cabling project, I spent class time going deep into message boards to get plug-in serial numbers. In the late 90's this sort of thing actually worked!!! In the end I was able to record and produce a piece of instrumental music about a girl who had held my interest at the time.

Years later, after I had stopped recording music altogether, a friend of mine invited me to help record a demo record for a local band called Life Blown Open. In the beginning we would simply guess at how the compressors and EQs worked, set the condenser mics based on where the LEDs were shining, then spent months learning the parametric EQ in the computer software simply trying to mitigate our horrid mistakes. The record came out, really, quite well. I have continued, on a somewhat sporadic basis, to work with these people. I even took that job at a painting company to help the lead musician with his endeavor.

In time, a desire to repair and modify guitar amplifiers turned into a desire to understand pro audio gear, then eventually to repair, modify, and ultimately build my own customized pro audio gear.

Renovations Career-

After high-school, I applied and was accepted to electronic engineering programs at Lakehead University in Thunder Bay, and both U of O and Carlton University in Ottawa. Coming from a very blue-collar upbringing, I didn't really know what an engineer did, and couldn't quite figure out what a capacitor did, so I passed on the opportunity. Another passion at the time was the culinary arts. I had been in contact with the national culinary institute and was as good as accepted to the program, but unable to get hired at any sort of reputable local restaurant to gain prep-experience I joined the Commerce and Administration program at our local university. By the time I got a call for a kitchen job from one of my culinary school resumes, I was already working in the construction industry.

I first started working for a property manager, then a services company, later working for individual homeowners, and eventually one day received a call from a local kitchen company where I then spent the bulk of 10 years renovating spaces to receive custom designed kitchens. The work started off cosmetic, then eventually turned into full-blown structural renovations requiring engineering consultants, city inspections, and logistical co-ordination. My innate need for continuous improvement proved to be rather cumbersome in the business of home renovations, and so a complete change of career path is needed.

George Brown Education-

At the end of my time contracting for the custom kitchen company, I decided that it was time to certify at something more interesting, and coincidentally at the time, George Brown college was advertising a distance-education electronics technician certification. I was quick to apply. Initially, my intention was to push through the curriculum as quickly as possible, but after a short time and a spelling error on the first test, I realized that the course model would allow me to use my university study experience and regained passion for the subject to achieve very high marks indeed. In the end I completed both the electronics technician and electromechanical technician certifications with an overall test score of

99.4%. After completing the courses, a telephone conversation with co-ordinator Angelo reassured me that the certification held great value, but I still felt the math was far too easy and my more in-depth questions on the subject matter were still being disregarded as outside the program material.

Future-

The future from here is very uncertain. The one thing that I can be certain of is that, at least in the near-term, my future will have to revolve around something that somebody is willing to pay me to do. I have exhausted all my earned time and resources for self-development and the time has come to seek employment. To follow is a description of my recent R&D, in hopes of informing the interested reader of my current proficiencies and experience. Certainly, I'm far from complete in my development, though my confidence is finally growing.

The Lowzee Microphone Preamplifier Project

I am fascinated by electronic signal distortion. In the past, all of my build projects centered around understanding and gaining the ability to develop tight control over the behaviour of various types of signal distortion. As an electric guitar player, amplifier distortion brings with it all kinds of lovely things such as much needed transient compression, attenuation of unwanted high-frequency harmonics, and in the very best vacuum-tube amplifiers, rich sub-harmonic content is brought forward. It is, however, very easy to use too much.

The past 14 years, whenever able, have been largely devoted to understanding signal transients. While on the subject of signal distortion, I would like to point out that in a well-designed audio system, it is the transducers themselves, and their physical inertia that create the worst of the distortion. On pg.407 of the Handbook for Sound Engineers (3rd Ed), Glen Ballou presents a graphical representation (fig 16-36) of the electrical output from a moving-coil dynamic microphone with respect to a pressure sine wave. It's atrocious! This, coupled with complaints from audio legends Steve Dove and Bill Whitlock about the inadequacies of solid-state inputs for low-impedance microphones due to improperly damped microphone termination impedance, and noise issues associated with a non-optimum source impedance for the transistors got me thinking. Alas! An idea for a low impedance, solid-state front-end microphone pre-amplifier that would function more like a transformer does. The Low-Impedance amp. The Lowzee.

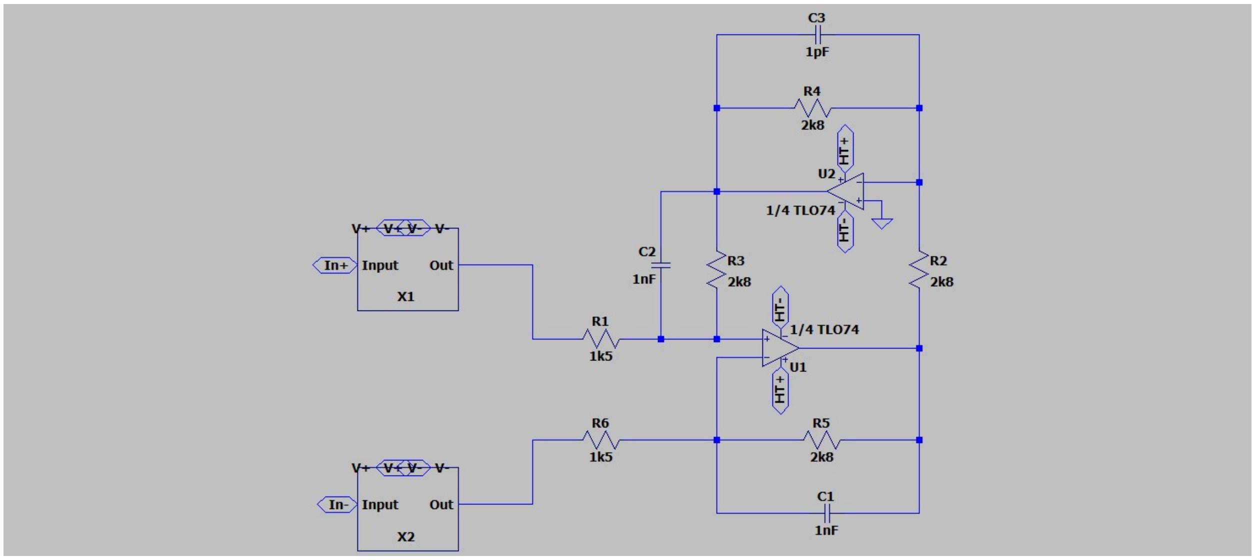
This is where things get a little crazy. I don't want to get too detailed about the front-end circuit operation, just in case this turns out to be some sort of useful technology, but a general description of the circuit function in certainly in order. I have read bits and pieces of descriptions of how some other engineers have tackled the issue of a solid-state front end. For example, transformer manufacturer Dean Jensen conceived of a circuit using radio inductors and multi-parallel inputs to address the problems. For my design, I decided to limit the useful input sources to moving-coil dynamic microphones, and perhaps ribbon-capacitor microphones as well. Off the list of design challenges for this project were high-output phantom-powered capacitor microphones. This allows for a max expected input voltage of about +3dBv, which, unfortunately, is a requirement in this circuit. Things do go a little non-linear around 0dBv, and the signal will clip the input before +6dBv.

Apart from my research into signal distortion, most of my learning regarding the clean and undistorted amplification of a voltage signal has come from the literature of engineer G. Randy Sloane. Thinking hard about all I have learned about operational amplifier design and construction, it occurred to me that if I were to balance a constant current source over a constant current sink, changing the voltage between the collectors would be very easy to do. Plus, the input impedance to that amplifier would be very high. This is what I would do, sort of. Essentially what we end up with is 4 parallel input amplifiers creating two complimentary pairs.

One mirror-image amplifier for is the In-Phase signal, and one mirror-image amplifier is for the Return signal. The microphone is terminated by a simple 1k8 resistor, then its voltage capacitively coupled to each of the 4 inputs. The input amplifier is in function, a common-base amplifier with active loads all around it.

This is the part where we start to think like a transformer might. Although the microphone sees a nearly purely resistive terminating load, and an instrumentation amplifier, the amplifier itself is trying to ignore the microphone the best that it can. The base of the sense transistor is pointed back into the amplifier circuitry and signal voltage is applied to its emitter. This disturbance to the balanced feedback loop creates a *di/dt* in the alpha-current of the sense transistor. It is the change in alpha-current that is actually being amplified! Proper biasing of the circuitry results in 2 half-wave class B signals being sent, in-phase to the inputs of a superbal decoder amp. In this case, it has been built from one half of a TLO74 biFet op-amp. One of the class B signals represents the positive half-cycles of the In-Phase conductor, the other class B signal represents the positive half-cycles of the Return conductor. Remembering that we're still working in the current domain, this is just fine. Of course, this means that an improperly balanced input will distort quite badly and represents yet another compromise from the performance of a real transformer. According to the design goals though, there should be never exist improperly balanced inputs.

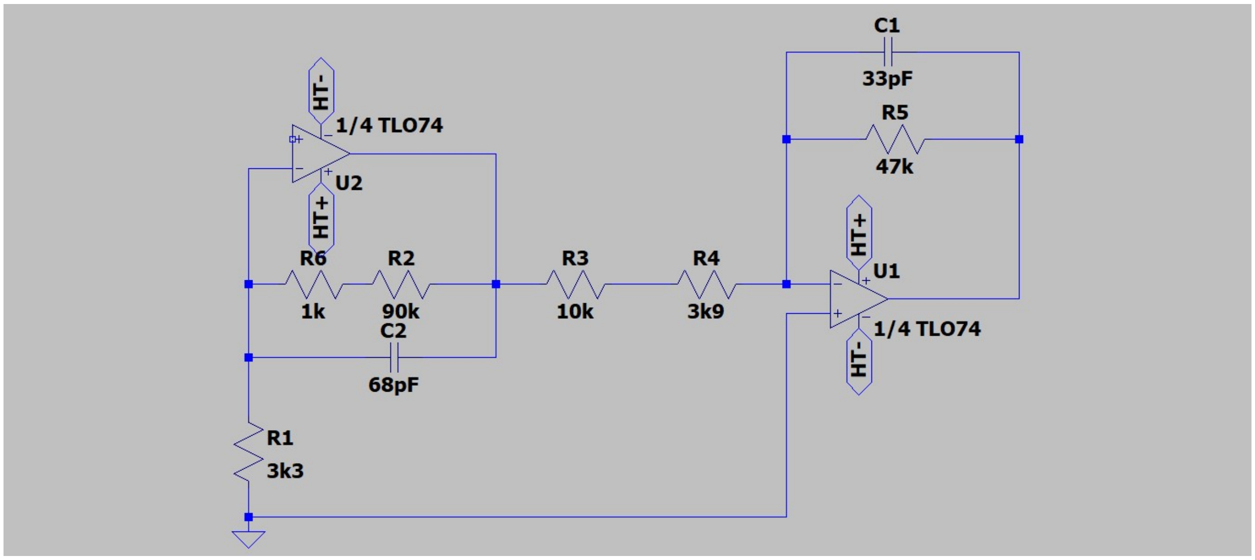
Input Detail



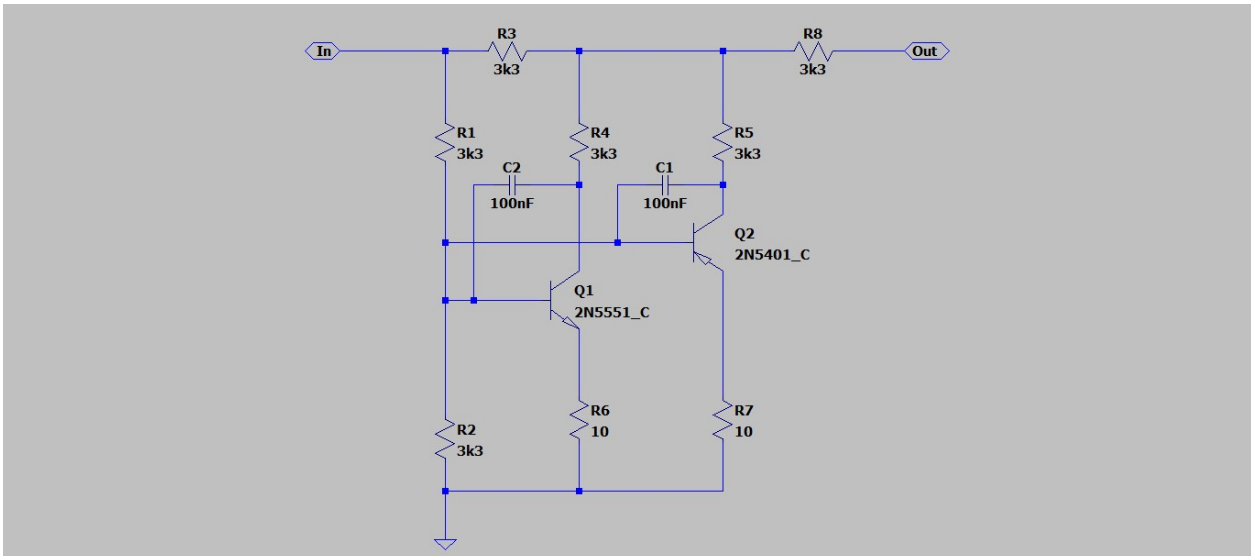
In the diagram above, R1 and R6 play the roll of the magnetic flux, not only bringing energy to our 'secondary winding' but also facilitating a voltage rail increase. On the input block side of the circuit, the rails are set to +/- 4.5VDC, and they have to be in order to protect the b-e junction of the input transistors. Conversely, the rail voltage on the voltage amplifier side of the circuit should be much higher in order to give us headroom to properly amplify the voltage transients before we start to purposely crush them back off again. It is the bias impedance of the input blocks combined with the gain factor of the superbal that gives us our 'turns ratio'. A better engineer than I could conceivably achieve almost any turns ratio, limited only by thermals. The input impedance is set by a single terminating resistor. The output impedance will always be near zero, or whatever your op-amp output is capable of.

To finish up with the operation of the input stage, our two class B signals are seen as current disturbances by the superbal circuitry, and as it works to maintain ground potential at its main inputs, the current impulses are stitched back together and complimentarily pulled through 0V by each other, delivering a very nice signal at the output, in a rather unique way.

Much of the rest of the circuit is fairly generic, at least by pro-audio standards. Voltage gain is achieved through a dual-amp shared-gain arrangement. I was hoping for 80dB of gain, but inadequate noise-floor work limited the actual gear to about 61.7dBv. Not too bad for a first go, I guess.

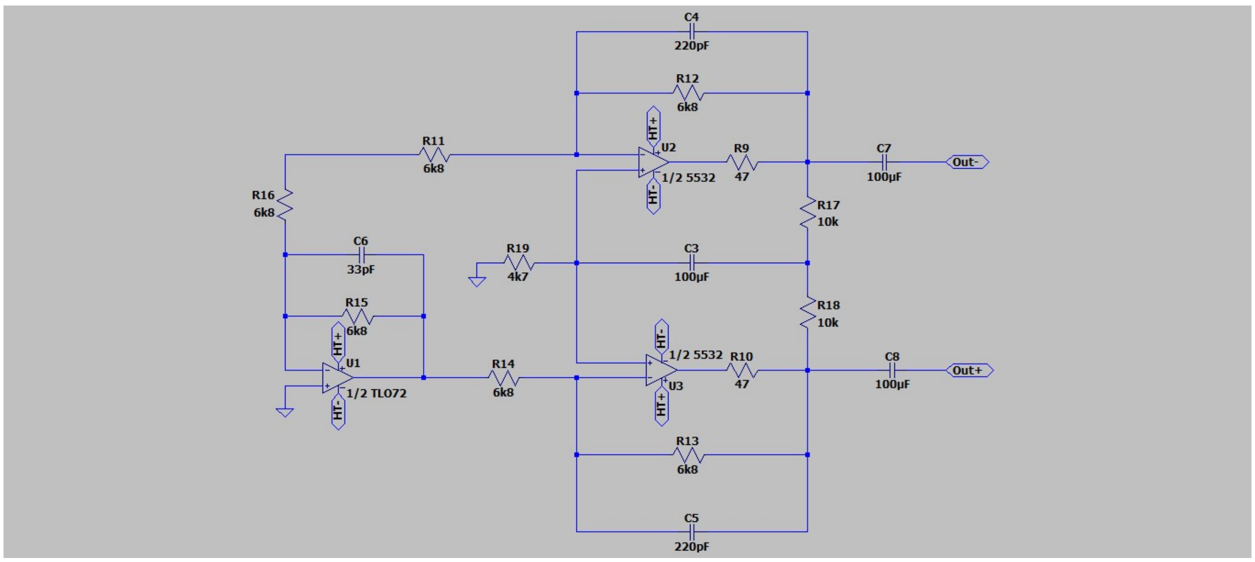


The auto-compression circuit is quite fun. It relies on balanced impedance, and the growing signal actually drives itself down, according to the response curves of the 2N5551 and 2N5401 dump transistors. This presses down those nasty transients, with no sharp edges until you bump the rails. By the time you are bumping into the rails, a string of 3 1N4148 diodes in a clamp are already holding your output at a hard +6dB.



The circuit is tuned to only start drawing current when the signal voltage reaches 0dBv, allowing for undistorted amplification of the main audio information, while controlling the unnecessarily huge *di/dt* of the transient events. An aggressive indicator circuit fires a red LED with a long release constant on the front panel as soon as the compression starts drawing current, long before it is perceptible. This gives a nice, simple roadmap to where the signal is in the gain-staging. Basically, it's just the 0dBv LED from a peak program meter.

For the output to the amplifier; a circuit taken straight from the article by Steve Dove. It's a capacitively coupled, inverter driven, true floating output circuit. As I understand it, this and one other circuit architecture designed for electronic outputs took many engineers, many years, and a great number of failed designs to settle on as circuits most likely to succeed. I simply used it.



The Noise Problem

Not only was this the first project where I designed are ordered real circuit boards instead of simply making them from discarded telephone wire, but it was the first build in which I had the privilege of using an oscilloscope to see what I was doing. Building these types of circuits with only a Klein DMM is somewhat painful, and usually fails on only minutiae. This time I could monitor my own progress, and in the case of the input biasing, the reality of the cirsuit was so far from the theory that I'd have never gotten it figured out without my trusty Rigol. In fact, it took me 3 days to figure out!

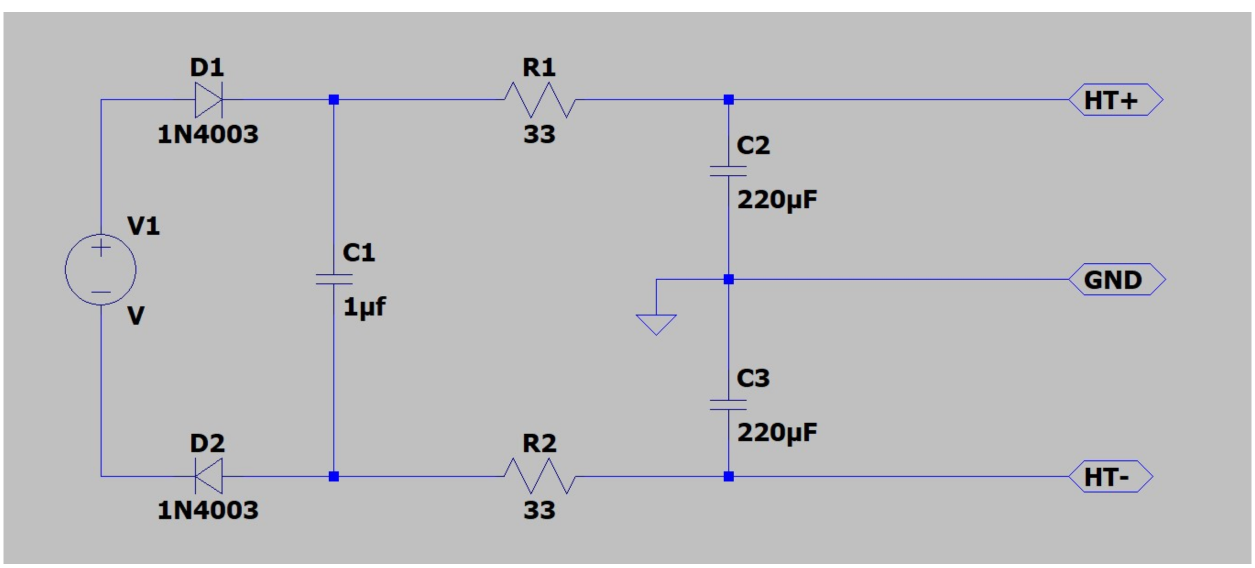
As most good stories begin,

'…then…when we first tried to put real audio through it…'

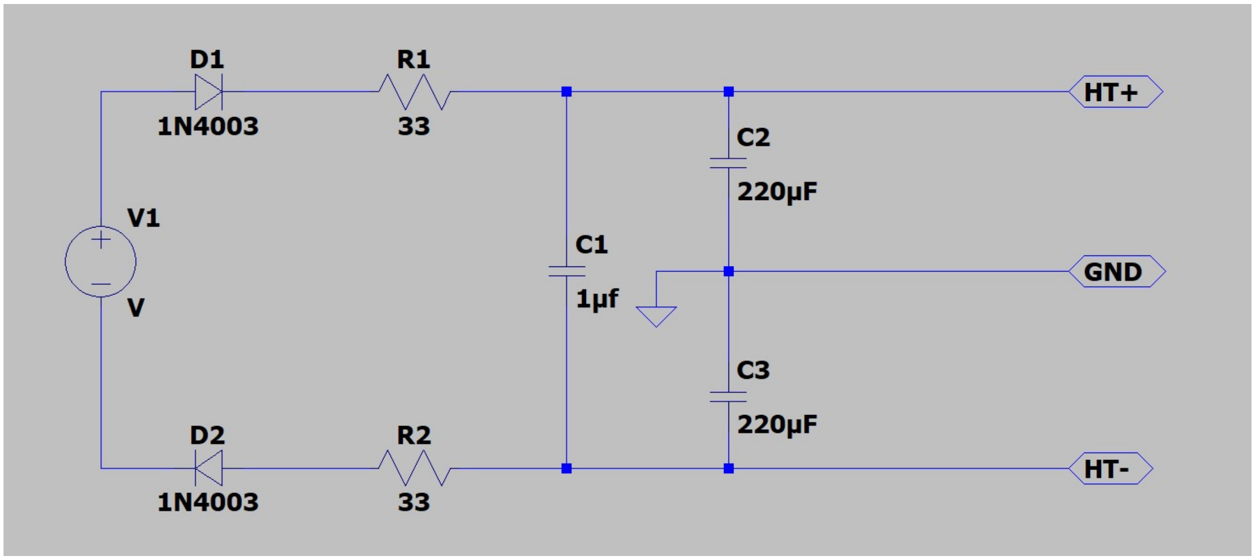
The noise was horrific! It didn't look THAT bad on the scope, but the sound was truly obnoxious. Switch-mode Power Supply noise, making through to my circuitry. Oh on! My custom enclosure was already complete and was a month of headaches in and of itself, but the amplifier was completely unusable much above unity gain!

I tried a couple of different designs for simple voltage regulators, after all, 20dB from 10mV should be easy. Right? My first circuit failed. The voltage reference for the regulator looked good, but it was a single 1N4148, and the diode drop had to be amplified. At the end of it all, the rails looked identical to no regulator at all. Hmm, must have reduced the ripple, then amplified it right back. That was dumb! I re-made the voltage reference portion of the circuit. This time, a constant current source was voltage referenced from the rail, then a resistive load referenced to ground. The op-amp was now set for unity gain too. This'll work for sure! The voltage reference looked great, but again, the output to the amp was identical to having no regulator at all. The noise was going right into the supply pins of my op-amps, and right through their regulating circuitry too!

Discouraged, and nearly ready to give up, it was time to try a simple balanced line filter. At some point I realized that a big part of the reason that power supply noise is so perverse is that the back EMF from the output filter is actually sucking charge right back off the filter tank. More rectification was needed. A couple of 1N4003 diodes worked nicely, but the *dv/dt* at switch shutoff is so massive that its apparent frequency sees the PN junction capacitance as an open door. The idea, from op-amp theory, was to look back into the power supply and slug the dominant pole. This is what I came up with.



It worked great for a bit, but when it was unplugged from the mains for too long, the tank caps lost too much charge and the power supply wouldn't even turn on anymore. Short-circuit protection from the Recom SMPS was kicking in. The 1N4003s were too fast, and the 1uF was too deep I suppose. Moving the dropping resistors solved the issue, and there was no real change in the noise volume or character as a result of going from a 2-pole filter to a singe pole. The 1uF becomes a great big speed-up cap, and the mic pre is done!



At the end of the project, I got a 2-channel microphone pre-amp with just over 60dB of gain, a noise-floor around -70dB, and the automatic compression sounds great! The detail in the reproduction is fantastic as well, being the first amp that I have ever used to show a distinct difference in sound character between my Shure SM57 and my Neumann BCM705.

My careful front-end design work to reduce noise was completely swamped by the rail noise, and so remains unproven.

That's that, I suppose.

The MBox Power Supply Replacement Project

Years ago, for one of the Life Blown Open recording projects, I purchased a portable recording interface called the Avid MBox Pro. It's a very nice piece of recording gear, and runs off a 9VDC, 4A SMPS. Not long after that first project, the world of renovations came down on me like a ton of bricks and I lost track of all my music and recording gear. Several years ago, when a friend wanted to use my MBox to do some systems testing at his home studio, I tried to find said power supply but could not. I remembered the part about 4A, but totally forgot that I required 9V. One day I found an HP Laptop supply rated 19.6V, 4.74A and I thought I had found the correct unit, but the barrel connector was wrong and so was the voltage. The original power supply has never been seen again.

Now that I have a working pre-amplifier, I would like to record something with it. I spent some time on Digikey and found a nice medical rated power supply for $28, but having just quite literally exhausted all of my resources putting together the time to design and build the Lowzee, I really can't afford even that. My attention was drawn to the opened cardboard boxes from Digikey, just sitting in the corner of my apartment. They are all full of amplifier components that I have purchased, but for one reason or another I have not been able to get around to building with.

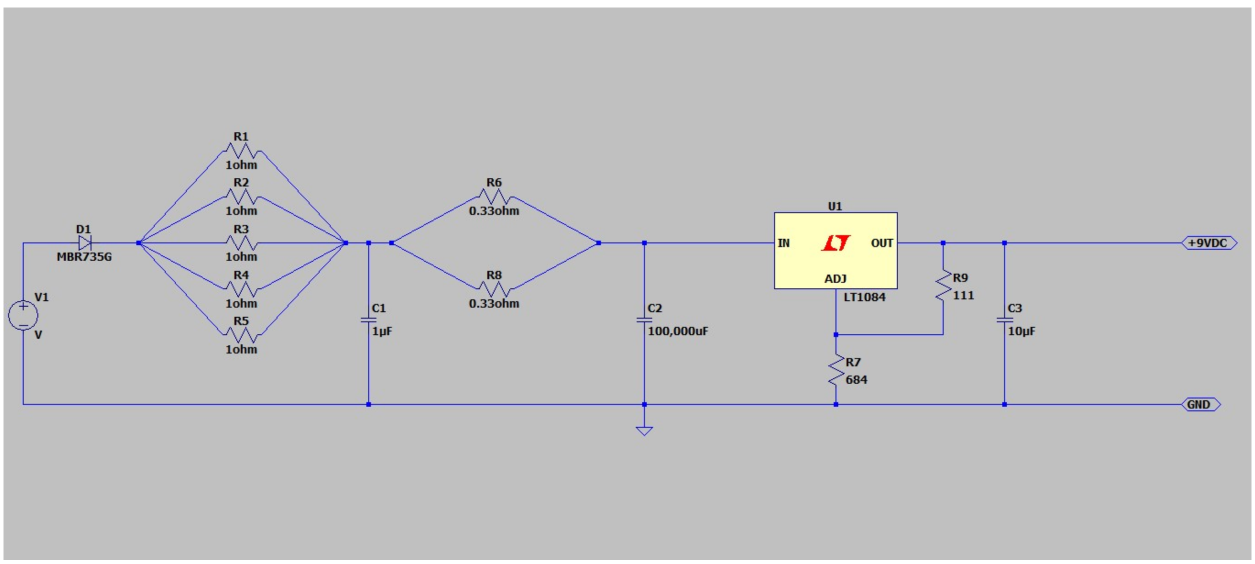
I had already found a small package of LT1084 voltage regulators during the Lowzee noise-floor crisis. Cutting edge when I bought them, a search for the datasheets showed that the parts are now obsolete and no longer available for purchase. Might as well use one. I had a nice 35V, 7.5A Schottky diode too, and a nice heatsink from an old TV for it. Also in the box, a heatsink that I cast from melted beer cans and gutter pipe several years ago, during my thermal research phase. It was already flat black, had mounting holes, plus it has already been extensively tested to deliver about 0.8*C/W dissipation. And there was a beautiful 100,000uF, 25V Nichicon filter tank sitting there too!

I found a barrel connector that would fit into the MBox, then swapped it for the one on the shielded #16AWG cable that came with the HP supply. The heavier wire got soldered directly to the solder points on the barrel, then a new molding was made from simple PC-7 Epoxy and heat shrink tube. Probing around to check the grounding of the SMPS, I found that the earth ground pin was shorted to the output ground pin as well as to the RF shield itself so the ground wire on the output of the SMPS has been removed, and all circuitry is grounded to STAR at the base of the 100,000uF tank.

Series dropping resistors were going to be a problem for me because they were going to need to burn some power, without eating up too much voltage at 4A. Power resistors are not something that I have a lot of on hand, but there were two 5W, 0.33R resistors waiting to be used as current sense devices in an EF power amp that I had in a box somewhere. In the world of vacuum-tube amplifiers, a 5W,1R resistor makes a convenient ammeter when soldered into the circuit, so I happened to have a bag of those as well.

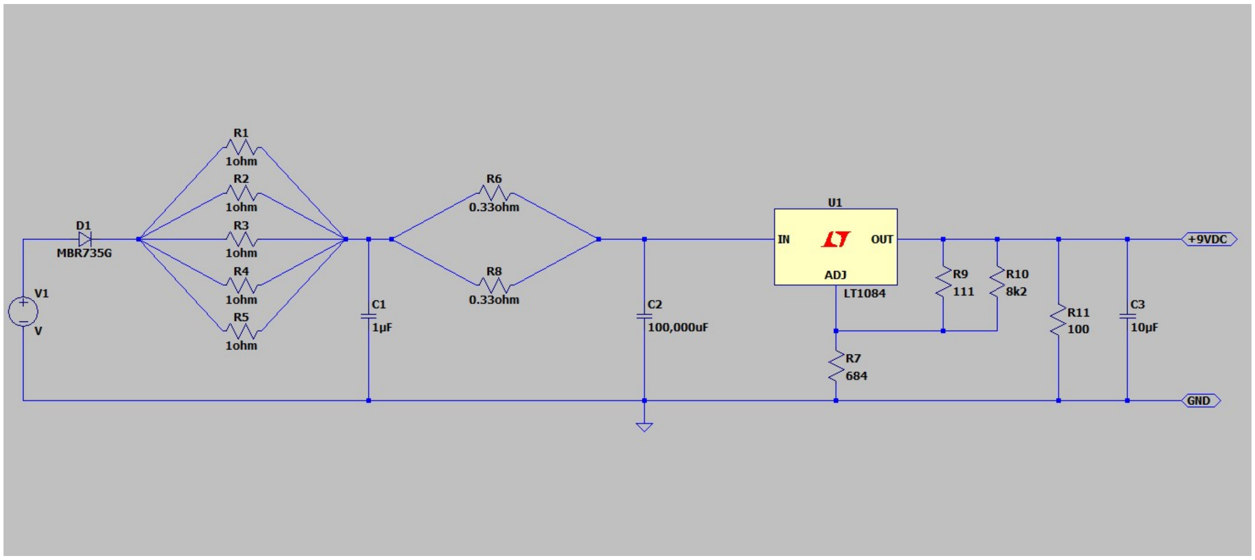
As far as I'm concerned, 19.6V is uncomfortably close to the 25V dielectric rating of my big 'ol filter tank, and the charge rate of the voltage spikes above 19.6V make me even more uncomfortable, so a two-pole filter is a must in this application. Again, there's not much selection in film caps around, but I had taken the bulk discount on some 1uF caps, and there was one left in a bag. 0.2R into 1uF, with a slope as steep as the one I was looking at seemed to be about right. After all, I just want to reduce the charge velocity before the big tank capacitor. As far as the tank capacitor is concerned, 0.365R into 100,000uF at 5 tau works out to 21.8Hz. Perfect.

This is the circuit that I came up with



Initial testing showed that the LT1084 was nowhere close to regulation with the load disconnected. I didn't think it would be a problem during design, because the load would always be connected. In reality, the MBox doesn't present a load until it is switched on, plus it takes the regulator a pretty long time to correct once the load starts drawing current. Seemingly, the simple solution would be to decrease the resistances in the voltage divider, but on my handmade board with all of the heatsinks and wires mounted already, that solution was not so simple. I had one 1/2W, 100-ohm resistor from Radio-Shack left in an old kit box, and that would work.

The power burn is way too high for a 1/2W resistor, but I would be soldering it to the top of the board less than 1cm from that big 0.8*C/W heatsink, so I bent the leads and epoxied the resistor to the heatsink. The resistor stays nice and cool, and the amp maintains regulation. Progress was being made! My 9V wasn't quite 9V, so an 8k2 was paralleled with the 111 just bring it up a tiny bit.



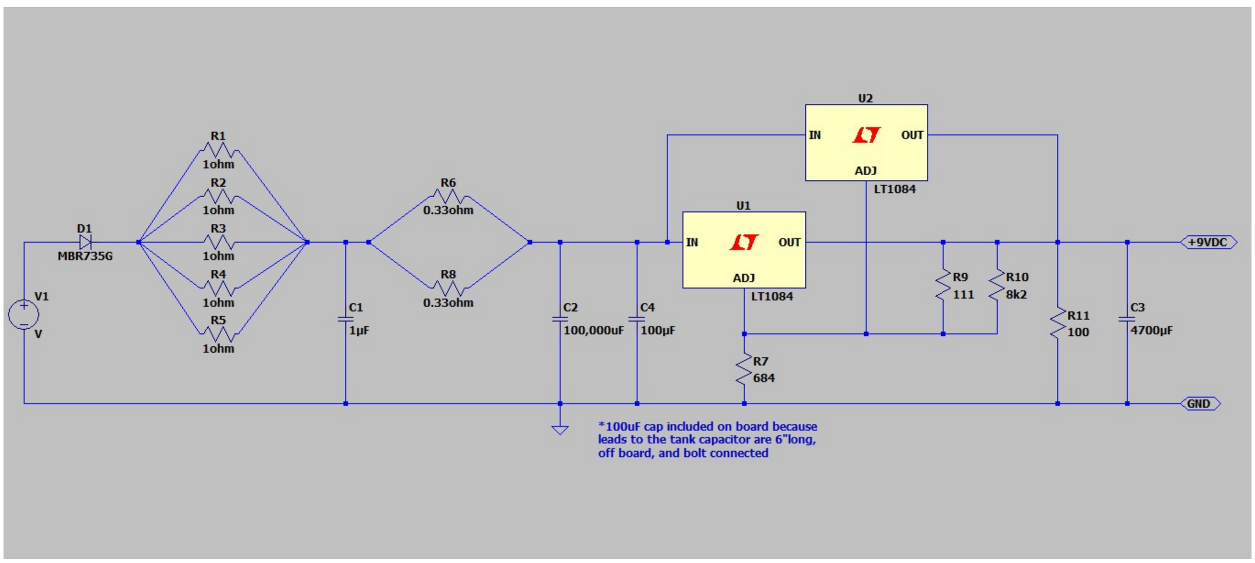
Scope testing showed that I have successfully built my 9VDC,4A power supply. Time to hook up the gear. Turns on, success! Turns off, failure! What happened, I wonder fearfully?! The rails are rock-solid, then after about a minute of simply being powered on, the MBox interface would suddenly shut off, and the rail would bounce wildly from ground to about 1V and back again. Turning off the MBox did not help but powering the supply down until the tank cap discharged then powering back up seemed to reset the unit.

A finger held to the case of the 1084 during power up quickly revealed the problem. The MBox would shut off the instant the case became too hot to touch, and the temp rose very quickly after switching the unit on. THERMALS! In my inexperience, I had neglected to include the resistances of the grease and pad. The heat was being trapped between a screaming hot case and an icy-cold heatsink! I looked again at the datasheet and sure enough 60*C case temp at 40W with my part no. suffix was the absolute maximum. Luckily my very expensive LT1084 just kept shutting itself down before burning up.

Devastated by my mistake, I went looking through the datasheet for some sort of high-current regulator option. Paralleling LM138 regulators is quite a pain, so I was worried enough to consider just putting a potentiometer on the rig and calling it an adjustable 3A bench supply. Then, a miracle. The LT108345 family of regulators can be directly paralleled. Short each of the 3 pins together. No other circuit modifications necessary. A couple scraps of wire and some more PC-7 epoxy, and I managed to get it going without even needing to disassemble.

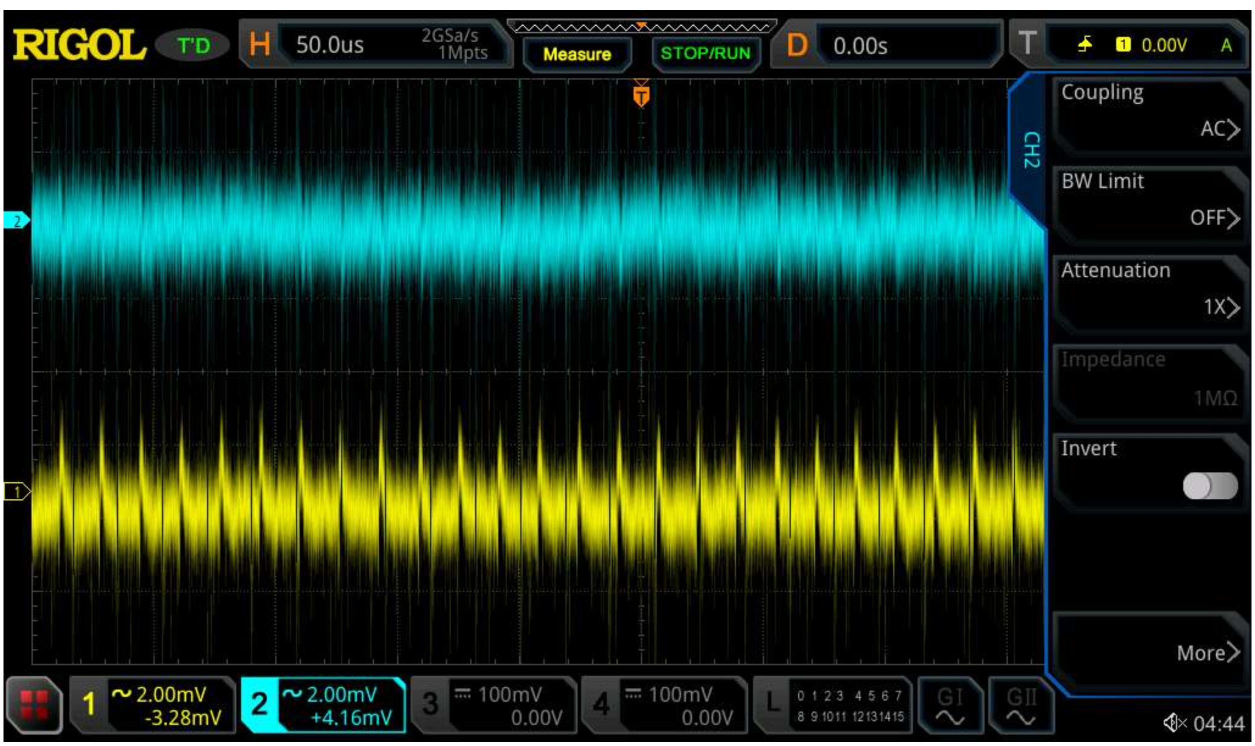
Now with the power burden being shared between 2 TO-220 packages, the case temps maintain their safe operating region easily. The heatsink itself will take a lot more power than this machine will ever deliver to it.

And so, the final regulator circuit, plus a few scope screenshots. In the end, this power-supply is fairly wasteful of power, and would run just fine on a 12VDC SMPS, but what is engineering if not using what is available at hand at the time?



Tank AC vs. SMPS AC

Output AC vs. Tank AC



Engineering Goals

At some unfathomably young age, when I was first starting to learn to print letters, I decided that I would try and take some of the letters that I had learned already and try writing them beside each other. After some effort, I turned to my mother and my aunt and asked, 'Is that a word?'. To the shock of everyone, myself included, it actually was! I had written out, in order, the letters v o l t. This is my earliest memory.

My very first memory of doing electronics comes, this time from a forgivably young age, which I do not remember. I somehow managed to connect a small DC motor from a broken children's toy and run it from the Bell Canada DC bias current. It turns out they noticed!

Since then, I have learned a little bit, but it would seem there is still infinitely more left to go. As previously mentioned, more than the past decade has been dedicated to the study of signal voltage, transient behaviour, and signal distortion. I am now ready to explore more of the detailed and difficult concepts in electronics.

My ultimate goal is the complete acoustic and electronic design and build of a world class recoding space. Included in that process are the joyful tasks of calculating isolate and reverberant spaces, their mechanical and architectural design, and their ultimate construction, plus the ultimate challenge of the recording console itself.

It will make sense then, that my learning and practical goals in the near future include:

-Amplified ground, and supply rails at -110dBv

-Full understanding and ability to correctly and accurately calculate and predict transformer behaviour

-Basic programming abilities, plus the ability to delegate more complex programming projects for Microchip controlled circuits

-Proficiency in fibre-optics, especially laser diode drive/sense circuitry

-Attain some level of radio certification, whether it be Amateur/Advanced, or some sort of professional certification

Career Aspirations

There has long been a lot of talk that the modern electronics technician's job is now limited to testing and replacing circuit boards, or basic cabling work, and after years of drywall and painting, that would be OK too. In the interests of having a rich and fulfilling career, my ambitions reach a little bit higher than that. I hear that there are no jobs, but that certainly can not mean that there is no work to be done.

I understand the lack of need or demand for a high-level audio engineer in our current environment, but many of the aspects of audio that excite me are certainly present in all current and functional aspects of electronics as well. To limit the list to 3 categories…

Analog aspects of Digital Electronics

This is by far the most exciting field in my opinion. Ideas for study and practice that come to mind.

-Transmission line effects, even on short conductors at high frequencies

-Capacitance to ground and slew-rate limiting effects

-Inductance of conductors

-Ground Planes

-Wave Guides

Battery Technology

After reading about the seminal work of Alessandro Volta in my George Brown education, I spent some time experimenting with bi-metal current generation. Fun stuff.

-Cell Chemistry

-Internal resistance, current, thermals

Analog or RF Communications

Back in my university days, I spent a summer working on the floor in a foundry facility. I would look up from my grinding station at the Allen-Bradley control boxes and think that I would prefer to work on those than what I was doing. Again, that would be OK too, but I've spent a lot of time in the dirt and noise in my life already, and the field of communications seems preferable to me. If I'm honest, I find digital electronics and computer software to be quite boring. Analog electronics and computer logic however, are among the most exciting things that I can imagine. With digital signals becoming so very fast and reactively limited as they are, I really imagine there should be plenty of analog work to go around.

If you made it all the way through, thanks for reading, Ben.