

Fine Tuning Vacuum Tube Amplifiers.

9/7/2021

I can not tell you how many times before going to sleep at night laying in bed I have come up with a question wondering if something would do what I predict it will or not regarding the sonic performance of a vacuum tube amplifier. Often I need to get out of bed and write it in my journal that I keep while developing amplifier designs. Journals are so ever important, they prevent you from designing in circles, they help you understand what happened a long the way, and they also tells you later when reading them why you did that thing three months ago. Of course Journals are only helpful if you got back and read them, otherwise you might find yourself redesigning something you already had figured out.

The first objective of designing an amplifier is its basic operation characteristics, what are called the operating points based on information in the data sheet for any given tube. For years I have been deciphering the information portrayed by charts in data sheets, there is a great deal of information not overtly stated in those charts of tubes characteristics. Keeping an open mind and maintaining a humble attitude that you don't know anything for certain constantly causes you to question your assumptions or past findings, so I put them to the test over and over. What happens though is you use parts on hand to cobble together an operating amp, often on a breadboard, based on what your knowledge base is. After getting it up and running you listen to it, then you write down how the amp sounds in that specific operating condition. At that point you start investigating a tube further by altering various aspects of its operation. It is the constant question of what if, "What would it sound like if..." I like to explore the extremes in every aspect of a tubes operation. This often leads to some amazing discoveries, some good, and some bad. Once I found that using a lower cathode heater voltage in one tube gives it a very very smooth and mellow sound, but unfortunately the tube after several weeks suffered from cathode poisoning and started not to work very well. But then I discovered that if I put a much higher voltage on the cathodes heater for a very short period of time this would return the tube back to normal operation. It is interesting to try things like this and see what happens.

It is at a certain point that you become very familiar with the character of the tube, what are its strengths and weaknesses, and when and if it doesn't work very well in a specific situation operationally. Also you discover if there is anything special about a specific tube, some tubes sound dynamic but lack bass, other tubes are not nearly as dynamic but sound very easy going, relaxed and effortless in their sound. And to be honest some tubes are just turds and I don't like how they sound no matter what I do. I have spent way too many hours, days, weeks, and months polishing turds only to come to the conclusion I will never get what I want from a specific tube or circuit. Two such examples of this in my case are the 6N1P-EV Russian tube, and the 6CL6 power Pentode. Don't get me wrong both are decent tubes and make music, and in some circuits are remarkable as well, but they will never make the sound I like and want in my music system used in specific fashions. That said I will say I have never heard a tube sound as amazing as the 6N1P in a cathode follower circuit, so it is my go to when I use that circuit. You just have to be brutally honest when it comes to things like this and your own palate when it comes to music and sound. I am totally aware that some people would be in heaven living with things I can not tolerate.

So at this point you know how a tube operates and how to get it to operate in an area that is practical for the tube and you. You also have come to know its character, and what effects various aspects of its

operation with regard to how it sounds. Now comes the point of refining things, and the first thing I try to refine is the power supply.

Power supplies are so critical to how an audio amplifier sounds, how they cause distortion in an amplifiers I read about 20yrs ago in an article by Douglas Self. One thing I have learned is that with single ended designs, Triode and Pentode operation the power supplies need to be very different. This is mostly because a Triode is a constant voltage device, and a Pentode is a constant current device. I am a minimalist designer, meaning my belief is anything should not have any more parts than is absolutely necessary for its operation, also a system itself should be as simple as possible. So you start simple, and add more and more complexity, until adding more doesn't yeild any further benefits toward your end functional goal. Also connections and signal paths should be kept as short as is feasibly possible. This is one reason I make integrated amplifiers, the synergy between the pre-amp and power amp is too important to leave to chance, and all the extra connections are not necessary. Of course mono-block amplifiers need a common pre-amplifer, so there is a good example of where more complexity is needed to accomplish the goal of mono-block operation.

Therefore as a minimalist, I don't like special circuits in a tube amplifier that create specific conditions that could be done in a simpler way. I also don't like some things in power supplies using tubes that are suppose to clean up the noise in the power supplies DC or regulate voltage, often they detract from the end goal of clean DC power. Some of these look cool but in the end do nothing for the music, or actually degrade the sound. I also believe that if you have a good power supply it can compensate for noisy or poor voltage from the mains, so I do not like AC power conditioners or re-generators, and DO NOT recommend them. I do like complex power supplies in that the more you can separate the sections that power each gain stage the better, to me the dual mono approach is good in the same chassis but don't sacrifice the integrated amp condition for this by making mono-block amplifiers.

I also do not like tube rectifiers as they are way too inconsistent, from tube to tube and from brand to brand, one will make an amp sound wonderful and another will sound horrible. But solid state rectifiers like Cree schottky rectifiers are very consistent and very low noise, to my ears they sound as good if not better than some of the best very expensive NOS tube rectifiers I have used. I also like switch mode power supplies, they can sound wonderful, and if they produce noise it is easy to filter out, but I like them for their very low impedance, as well as work with anything from 85v to 240v AC so compensate for how ever your AC source is behaving. Not to mention I have had wonderful experience using them in many applications not just tube amplification. People that don't like them haven't used them or given them a fair chance, just like linear power supplies some are good and some are NOT. You really have to know how to use them and implement them, because they can sound bad if you do not.

How do I refine an amp, being a minimalist? Well by careful parts selection after carefully selecting the operating points of everything, with a project on a budget that means making some compromises, but where there is only a few dollars difference perhaps several things only adding \$10 dollars to the cost of an entire design, then I will bite the bullet and just use more expensive parts. Sometimes this comes down to flavors or preferences, so I used what I like what sounds best to me. But this is also an advantage as some parts can solve an issue perhaps your having in an amp. For example Mundorf Silver Supreme caps sound very smooth and liquid to me, they in the coupling cap position take grain away, and make an amp sound more relaxed. Orange drop caps sound very articulate, for some designs too much so. V-caps are super clean and neutral, high frequencies sound so articulate with them. Many of the Russian NOS caps can give an amp a wonderful character that sounds warm and natural.

The run down of various parts is that capacitors add distortion, and better quality means less distortion but some boutique audio caps often add some types of distortion which is not always bad. Resistors create noise, in its extreme the noise is there the more the current changes flowing through them. Resistors add more noise than the tubes ever do, so people searching for low noise tubes then using noisy resistors are cutting off their nose in spite of their face. The amp at idle not playing music will not necessarily manifest resistor noise, but you can hear it if you know what your looking for during music play. Things simply will not sound as clear, the background won't sound as dark, and instruments won't be as separate when using resistors with lots of noise. Although some folks like high noise resistors because they solve some problems, like harsh treble can be tamed, they can make the music seem more intimate, they also help prevent oscillation when used in some locations, so they have their place sometimes. I though like to use metal film resistors whenever possible, because they have low noise values, and I like to use some boutique and precision resistors because they also have lower amounts of noise and add flavor. Parts are likes herbs and spices in cooking, they help add to the major flavors, but make it taste(sound) unique and add ever so much.

In the end knowing a tubes character, knowing its strengths and weaknesses, and knowing the qualities parts can give you in various positions in a circuit, are all things that during the refinement phase of an amplifier design can come together to make a sonic signature that you enjoy. But you have to have a clear view of what you want. When A/B-ing two of my amplifier designs I am often amazed at how similar they sound with two completely different sets of vacuum tubes, and I think it comes down to the sonic signature I like, and my knowledge base of how things will effect how a circuits sounds in the end. Knowing where in the circuit specifically certain aspects of the final sounds orginate, goes a long way in tailoring the sonic signature of an amplifier.

The thousands of hours it takes to refine an amplifier design is impossible to quantify, because it happens a few minutes here, and a few minutes there, over MONTHS. Then any given set of tubes will alter it slightly. And that is one reason why I like to design an amplifier so that a given set of tubes will last YEARS rather than months. I have gotten ten years out of a set of tubes in an amplifier used almost every day. I have used one tube amp everyday for years as background music while I work in my shop with the same set of tubes. Now don't get me wrong, once in a while I pop in a new set of tubes, while I test the old ones in my tube tester to see if the old set needs replaced about once a year. But if they don't then there is no point to replacing them.

In some tube amplifiers I own, replacing tubes with NOS or a different brand will make a large difference in how it sounds. I like to design so that for the tubes I design around this doesn't happen. I think that is because I usually try to stay in the center of the design parameters. With each tube there seems to be a sweet spot where almost any tube will sound good with very little difference. One tube amplifier not design by me, the tubes literally make or break the amp. There is only one combination that gives me the sound I like from it, anything else does not sound good. Unfortunately to retube that amp cost a LOT of money as well, almost as much as the amplifier is worth, and the NOS tube combination I like are getting harder and harder to find, but I have enough tubes that I should be good for at least the next 20 years. I keep this amplifier around mostly as a touchstone.

That last thought brings up another good point. If you don't have an amplifier that you use as an anchor or touchstone by which you go back and do A/B comparisons, you can sometimes be designing or refining in circles. It is like exploring unknown terrain without a map, you got to know where you came from to know where your going, and if you have made any real progress. Taking notes helps with this, that is why I keep a journal of everything I try with everything. My only regret is that I didn't start doing that early on, and so I often have to relearn things I figured out before.

In the end parts selection is completely based on the sonic signature your trying to create. Sometimes I make an amp for someone and they mention something they don't like about my amp, but other things are such that they don't want to send an amplifier back. Almost always I can take the amp and switch out a few key components and create the sonic signature they want. Not everyone likes the same thing and that is ok. Parts, and operating points are tools and a means to an end, and that is how you make an amplifier sound a way to create a musical experience. I want to share my experience with as many people as possible before I die or can no longer do so. I like to interview potential buyers if possible, because this way I can get to know what music they like, what is it they listen to in the music, are they a musician, are they a vocalist and are pitch perfect, what is it emotionally they get from music, why do they listen to music? Sometimes this starts because we live on separate sides of the world with them buying a less expensive amp I offer and then telling me what they like and what they don't, and I know my amplifiers better than anyone, so I know if I can alter an amp simply to get them where they want to be, or if in reality my amplifiers aren't for them.

So what do I like from tube amplification. Well in my designs I design for a few things, primarily clean dynamics, both micro and macro, the more dynamics the more lively and exciting the music sounds. Micro dynamics resides mostly in the treble range, it has to be as clean as possible, having a fast power supply, low noise resistors and lower 3rd order harmonic distortion are key elements to achieving this. My personal philosophy is that most instruments have treble information accompanying them. Such as plucks of the strings on a bass, or the thump of a bass drum, all instruments have high frequency content that can either be there or not. A key component is the output transformer made for a circuit that obtains the most dynamics from the tube. Essentially I think my job as a designer is to get everything out of the way of the tube that could prevent it from doing its job, nothing should hinder it with regard to the hierarchy of my priorities. I have been known to sacrifice bass response for dynamics, then add a sub amp and woofer to compensate, my experience is this produces tighter more dynamic bass response, so it is a win win.

No matter who you are the thing to remember is, "If it sounds good, it is good." Like a much older friend of mine once said, "in the mid 20th century musical listeners/philosophers conjured up ways of wiggling the air in a very please way with electronic inventions, we have been chasing after this and improving on it ever since."

Happy listening.