Subject: Practical limit to tube based phono preamps
Posted by gofar99 on Tue, 20 Dec 2022 02:12:33 GMT
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Hi, (this could go in either this forum or the tube one) In my never ending quest to get rid of hum and noise I seem to have hit an end point in tube based phono preamps that do not use global NFB. There seems to be what is essentially a practical limit to what can be done without going to extremes. The current preamps are in the -85 to -90dbv range for MM/MI use. That is really quiet BTW. Well below the noise level of a really good and clean LP. Depending on what study you check that value is in the -65 to -75dbv range. With a preamp 15 to 25 db quieter than the best you can get off a LP that is really quite sufficient. I however, am a fanatic about hum and noise. If I can hear it or measure it then it is too much. The limits of my test gear is right around -105dbv. I can get solid state phono preamps close to that but they use NFB. So getting to the limits...I removed everything that had AC on it and all power supply filtering from one preamp and made it into a two box design. I figured that it ought to be quieter...nope. When I compared it to one that is a single chassis I use in my main system the differences were really slight. Under a single db for noise and nearly identical for signal related 60HZ hum. Power supply hum and its harmonics were in both cases within a db of each other. Even with getting selected low noise tubes I have apparently reached the limit in this sort of application. (for those who are interested in this the difference between standard JJ tubes and three different selected low noise ones was only about 1.5db) So what I concluded was that the tubes and passive components were the remaining factors and cause for the wide band low level residual hiss. As I indicated in the beginning none of this is audible. My system has a digital (passive) preamp and the usual listening level is at about -40db according to the display. I have to go to -3 or -4 to hear anything right at the speakers. This level of gain would greatly exceed the ability of the amps to deliver. For now I will have to be satisfied and sit back and enjoy the music.

Subject: Re: Practical limit to tube based phono preamps
Posted by Wayne Parham on Tue, 20 Dec 2022 19:39:56 GMT
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Dude, that's so cool. One of the most useful explorations in tube audio - getting noise down.

Assuming full audio bandwidth as highest priority, reducing noise is only superseded in importance to reducing distortion, and I'm not even sure they're in that order. Once harmonic distortion is under 3% or so - provided its spectral distribution naturally descends in orders - this small amount of distortion isn't really all that unpalatable.

Getting a low noise floor is definitely one of the holy grails in tube audio.

So from what you said, none of the noise - or very little - is related to your amplifier's power supply. To me, that's huge because I find power supply hum to be most annoying. Hiss is less distracting, especially if it is at a very low level. And I'm not sure it can be cured because it's part of the package, being an issue of colliding electrons. It's not like power supply ripple or a ground loop, it's inherent in any circuit with resistance.

At some point, white noise can't be reduced. It's not a qualitative thing - better components won't help here - the only way to reduce it is to reduce bandwidth or reduce circuit impedance or both. And since bandwidth is a sort of a constant (20kHz for audio), we are limited in what can be done at that most fundamental level.

Subject: Re: Practical limit to tube based phono preamps
Posted by gofar99 on Wed, 21 Dec 2022 01:50:12 GMT
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Hi Wayne, indeed since my very first project I have tried to reduce hum and noise. All my projects now are low distortion typically in the 1% range except for power amps at full output which can get to about 4% just before going tilt. (they flat line because of the CCS) The line stages, phono preamps and headphone amps are in the 1% range. All are wide band as well. The phono preamps are nearly ruler flat on a RIAA curve and extend to about 35K. The line stages can get to 75K with good tubes and capacitors. The power amps are within 0.5db of flat from (depending on the actual size amp) 10-15 HZ to roughly 35K. With the minor bit of NFB off (it is there to prevent resonances above the audio band in the power amps) they typically will reach 65K at only 2-3 db down. BTW I use the NFB in place to insure stability with my electrostatics as they look like huge capacitors and drop to 1 ohm at 20K. Never heard and issue...but just to be safe. This does remind me of my first attempt at a phono preamp in 2009. Fairly similar to the topology of the present ones. It could detect a hum source from 5 feet away. I went through about 5 different variations then and finally got something in the -60 to -65db range. OK, but not good enough. It took about 5 years to get something I liked. Even then it was only about -70. Those extra db in the newest ones took a lot of trial and error. A lot of things matter but grounding and component placement are the top two. I don't recommend folks design their own phono preamps unless they have a lot of experience and patience. I nearly gave up.

Subject: Re: Practical limit to tube based phono preamps
Posted by positron on Wed, 11 Jan 2023 23:47:52 GMT
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A few thoughts for the newbies out there.

1. Tubes produces internal noise from a variety of reasons.

2. The resistors associated with said tube also produce noise.

   A. The cathode resistor noise will be amplified by the tube's gain.

   B. The grid resistor noise will also be amplified by the tube's gain.
      This resistor is generally much larger than the cathode resistor and
      will generate more noise.

   C. The "stopper" resistor will produce noise that will be amplified by

the tube's gain.

D. The source, itself, will generate noise which is fed into the tube and will be amplified by the tube's gain.

E. From my understanding, the Vishay naked resistors produce the lowest noise. After that a good wire wound (non inductive for audio)is preferred. Both are expensive, but reduce noise.

3. Concerning 120hz AC hum, I prefer at least 4 stages of filtering, 5 is even better. My preamplifier and phono stage have 6 stages. I never use an inductor anywhere as it causes non-linearities due to 2 factors. (If I did, it would be only in the early stages of filtering.)

A. One is inductance which is frequency sensitive. It would appear as a straight diagonal line in the circuit below.

B. The other factor is dc resistance, which is not frequency sensitive. Attached is a simple circuit. The choke/inductor has 200 ohms winding dc resistance. Notice the curve where dc resistance becomes dominant.

C. Me and another music lover have experimented between choke/inductor and resistor and the sonic change is quite substantial.

Distortion being defined as the altering of sound in any way.

With speaker crossovers, dc resistance tends to be minimized.

cheers

pos

File Attachments

1) Inductor nonlinear.jpg, downloaded 222 times

Subject: Re: Practical limit to tube based phono preamps
Posted by Wayne Parham on Thu, 12 Jan 2023 00:02:25 GMT
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Interesting stuff. To me, that's the "holy grail" of tube amps. Rare indeed is the tube amp that is dead black quiet between musical passages.

Subject: Re: Practical limit to tube based phono preamps
Posted by positron on Fri, 13 Jan 2023 03:45:54 GMT
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Wayne Parham wrote on Wed, 11 January 2023 18:02
Interesting stuff. To me, that's the "holy grail" of tube amps.
Rare indeed is the tube amp that is dead black quiet between musical passages.

I thought I would do a little more research that might help..

The Vishay Z, S102, tx2352 resistors have approximately
10 nano-volts/volt across the resistor, current noise.
Another figure given is -40db. Expensive.

Mills non-inductive wire wounds equal or pretty close. Expensive

Metal films seem to Max out at 200 nanovolts/volt (0,2 microvolts/volt)
I do not know the averge for all metal films. Based on 0,2, that would
be approximately -14db.
Inexpensive.

Metal oxide inexpensive and
finally carbon types inexpensive. I saw figures of 10 microvolts/volt
for carbons.

cheers

pos

Subject: Re: Practical limit to tube based phono preamps
Posted by Wayne Parham on Fri, 13 Jan 2023 04:11:31 GMT
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Amazing how much noisier the metal film resistors are.

I wonder how much difference one might see in various tubes. I haven't noticed much difference in the amps I run, until the tubes get close to end-of-life. And then the noise they begin to make isn't white noise, but rather intermittent whistles and pops. Some start drawing more current too.

So but I'm not considering what the tube does as its sunsetting. I'm more interested in what it is doing when it is working properly.

Subject: Re: Practical limit to tube based phono preamps
Posted by positron on Fri, 13 Jan 2023 22:37:48 GMT
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From my understanding, ragged edges, rough wire surface, impurities in the material/copper cause eddy currents and is one source of noise. I can't remember which resistor company discussed this aspect though.

A couple of decades ago, the finite number of NOS vacuum tubes and prices worried me. So I searched, tested and found the small signal JJs not only had the lowest harmonic distortion I had ever measured, -79db below the fundamental, but the sound quality was the most accurate/natural.
I have gobs of Bugleboys,PQs, and others, but the JJs won out with visitors as well.

(I am not affiliated with JJ in any way, shape, or form. I am also retired for some 10 years from designing, but still tinker.)

I am not saying harmonic distortion is the only criteria, but it sure helps. Sovteks, EH and others are ok, but they are not NOS and not JJs.

Turned out the harmonic distortion of the JJ E88cc (prob others as well) was some 1/10th (-19db) that of any other tube I have ever tested.
The materials used are also excellent.

Still, dealing with such small signals as the OP, one has to deal with the noise and hum. For me, it is by far the noise over hum.

Tubes with high Rp and RL (plate resistances and plate resistors) tend to have the highest noise levels as well.

I know, kind of a diatribe. Thoughts just run together sometimes.

pos

Subject: Re: Practical limit to tube based phono preamps

Posted by Wayne Parham on Fri, 13 Jan 2023 23:18:19 GMT
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I'm with you there. The most annoying noise to me - by far - is power supply hum. If a tube amp keeps that down below audibility, it's a big deal to me. That's so rare. This is especially true when you stack all tube phono stage, preamp and power amps, and drive high-efficiency speakers. That combination is tough to get dead-black quiet, but it's so important.

Subject: Re: Practical limit to tube based phono preamps
Posted by positron on Mon, 16 Jan 2023 04:13:42 GMT
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Wayne Parham wrote on Fri, 13 January 2023 17:18
I'm with you there. The most annoying noise to me - by far - is power supply hum. If a tube amp keeps that down below audibility, it's a big deal to me. That's so rare. This is especially true when you stack all tube phono stage, preamp and power amps, and drive high-efficiency speakers. That combination is tough to get dead-black quiet, but it's so important.

So true. I personally designed at least 4 stages of filtering in my amps pre output stage, and I went from 5 to 6 stages of power supply filtering for my preamplifier. I use 2 chassis design, and 6 stages of filtering in my phono stage as well.

Cheers

pos

Subject: Re: Practical limit to tube based phono preamps
Posted by gofar99 on Tue, 24 Jan 2023 02:17:23 GMT
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Hi, Good stuff. I nearly always use JJ small signal tubes. As you noted they are quiet and accurate. I like simple designs with as few stages as necessary with as few components as needed to do the job. It is possible to achieve really excellent results with non-expensive components. Careful attention to layout especially grounding is essential for a quiet build. The subject of grounding is not intuitive and requires a really good understanding of micro current voltages induced into the ground conductors and swamping noise etc from higher power stage ground currents into lower power stages. IMO the more filtering in the power supply the better. I do not like chokes for the reasons given. But I will use active filtering. Likely LR8XX or FET capacitive multipliers. 6 sections seem about typical for my builds, but I have gone as far as 9 in phono preamps. I am fanatical about getting rid of hum and noise.