Subject: Tubes versus Transistors
Posted by Wayne Parham on Mon, 21 Feb 2022 16:24:01 GMT
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I enjoyed a little "garage find" this weekend. Not an equipment find - not even really a garage find - but a magazine squirreled away for decades.

I've been writing a series of online articles about old computers, mostly eight-bitters from the 1970s. I actually hoped to do one about every three months but I kinda went crazy on the first one - the Sym-1 - and so the second one was delayed. But I finally got around to writing this weekend, and uploaded an article on the RCA COSMAC ELF. In the months to come, I'll write articles on the Altair 8800 and the Inmos Transputer.

The ELF was a computer project described in an article written by Joseph Wesbecker, published in the August 1976 issue of Popular Electronics. A photo of the computer is shown on the cover of the magazine, and I reference that in my online article about the ELF.

So now to the point of why I wrote here. Go to the RCA COSMAC ELF page and find the image of the Popular Electronics August 1976 magazine. Click on that and you'll get a PDF file of the whole magazine. Then go to page 14.

It's an article about the differences between tubes and solid state. I had to post that here 'cause we still talk about the very same stuff, almost 50 years later!

Subject: Re: Tubes versus Transistors
Posted by Rusty on Mon, 21 Feb 2022 17:09:10 GMT
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Beats me but I sure dig my tube gear. But same with my ss gear. Just not as fondly. I didn't know that tube gear was as prevalent as it was in 1976. Like vinyl and phono it just couldn't be made extinct. Maybe because of us baby boomers, but like Pandora's box it's out there affecting younger generations. At the end of the article is an ad for a dot matrix printer. Damn thing looks like it's got a Briggs & Stratton motor on it. Digital really has come a long way from it's infancy.

P.S. Enjoyed looking at your "day job" work, You're on another level Wayne, what you do. And your family photo's.

Subject: Re: Tubes versus Transistors
Posted by gofar99 on Wed, 23 Feb 2022 02:20:05 GMT
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Hi, As long as there are tubes and solid state gear they will be talking about it. I have a considerable amount of each. In my main system there are 4 Oddblocks that provide the muscle

to the speakers. But there is no way I would replace the solid state electronic crossover that splits the sound to the amps. It would take 50 tubes and not be as good. Same thing on my main turntable. I can't even imagine trying to power the motor (an ex Dual 701 ESD1000) with tubes. The heat alone would require its own cooling system. The issue is not so simple in other parts of the system. I have tube and solid state phono preamps. The SS ones gather dust. FM is done by a really slick vintage Sony tuner. Tiny thing with only one sealed metal box in it. The thing made the "B" list for Stereophile. Incredible sensitivity, sound etc and OBTW gets HD FM. No way I would swap that for a tube unit. It would be a serious step down.

Now that we opened Pandora's box... the argument of discrete SS components vs IC ones. That is nearly equal in pros and cons. It includes the thoughts of some negative feed back, none or lots (as with ICs). Chomp on that one a while.

My overall take is that (one) there are many ways to do most things (two) each of us has to decide what works best for ourselves. :roll:

Subject: Re: Tubes versus Transistors
Posted by Wayne Parham on Wed, 23 Feb 2022 16:01:42 GMT
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I'm pretty sure that each of us (regulars) here on ART is in one-accord on this. But I was just surprised to find that amplifier article, long lost in my mind. I just had to mention it here, just for fun. It was as fun to read as the computer article I dug it up for.

Subject: Re: Tubes versus Transistors
Posted by positron on Tue, 21 Jun 2022 02:13:46 GMT
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Wayne, I was wondering if the subject is still open or if most just wish to close it now? Is there still interest in the inherent differences between tube and solid state pertaining to analog components/circuits, and associated parts? If there is still interest, there are still some inherent differences that affect sonic quality.

cheers

pos

Subject: Re: Tubes versus Transistors
Posted by Wayne Parham on Tue, 21 Jun 2022 13:53:09 GMT
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It's an ongoing discussion and I'm always interested.

I remember, when I was a teenager, thinking that vacuum tubes were an interesting historical oddity, firmly superseded by more modern technologies.

I was surprised to learn - much later - that modern vacuum tube amps weren't made purely for nostalgia. They were made for sound quality too.

Subject: Re: Tubes versus Transistors
Posted by Rusty on Tue, 21 Jun 2022 14:25:53 GMT
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A/D in the year 1965. What the vacuum tube could accomplish then wasn't any slacker. The end of the video sums it up best. Good engineering is what can be done with what you got. Bell Labs it seems was one of the most productive and innovative engineering works in our countries history.

https://hackaday.com/2022/06/08/retrotechtacular-the-forgotten-vacuum-tube-a-d-converters-of-1965/

Subject: Re: Tubes versus Transistors
Posted by positron on Wed, 22 Jun 2022 03:08:46 GMT
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Wayne Parham wrote on Tue, 21 June 2022 08:53
It's an ongoing discussion and I'm always interested.

I remember, when I was a teenager, thinking that vacuum tubes were an interesting historical oddity, firmly superseded by more modern technologies.

I was surprised to learn - much later - that modern vacuum tube amps weren't made purely for nostalgia. They were made for sound quality too.

Don't worry, many over the years have also thought tubes were somewhat an oddity, including my professors. Fortunately, being older I grew up with tubes, and worked on amps and radios since I was 7 or so. (Am I really fortunate??)

Anyway, with the advent of solid state, I had the opportunity of comparing tube amps vs the newly marketed solid state amps of the 60s on. The sonic difference was clear back then. Fortunately, both tube and SS have improved.

As far as inherent differences I will list some, but this will not be an exhaustive list. Some items will be quite elementary, but I mention them for the general public's benefit.

1. Both tubes and transistors have internal capacitances. Triodes have plate to grid, plate to cathode, cathode to grid. Transistors have collector/drain to base/gate, collector/drain to emitter/source, emitter/source to base/gate. (Corresponding to bipolar, fets, hexfrets etc.)

A capacitor consists of two conductive plates/foils and an insulating material/dielectric. The insulating material has dielectric absorption (DA), and foils a series equivalent resistance (ESR). As the musical signal voltage changes, the DA holds on to electrons when it should not. ESR tends to prevent the capacitor from fully discharging when it should. Both are bad.

A. Tubes use a vacuum, thus with basically zero DA.

B. Transistors use a "solid state" material(s) with a much much higher dielectric absorption figure (DA); maybe 500 or more times higher.

2. Tubes have extremely low impedance/resistance terminations to the leads/pins, so the ESR of the internal capacitances are near zero. Solid state has much higher internal termination impedances/resistances, thus a much much higher ESR.

3. Both have Miller capacitance, the gain of stage times the plate to grid capacitance (drain/collector to gate/base capacitance).
Miller capacitance = Av x Cpg.

A. For triodes, the Miller capacitance can amount to up to 150pf, maybe higher in a common cathode gain stage. This capacitance remains relatively constant.

B. Hexfets are a different story. They have their Cdg changing from quite small pf (pico farads) to 1000pf or more for power output Hexfets, depending upon the Vcc drain voltage to source. Even a three amp drain rating has quite high capacitance but fortunately output types are generally source followers with gain of less than one. Bi-polars are much better in this respect.

There are ways to minimize the junction capacitance problem, but that usually means more transistors, thus more associated parts in the circuitry.

4. Number of stages can vary. Generally, I see many more stages, with associated parts, with SS than with tubes. However, I have recently seen a SS amp with just two total stages, the same as some tube amps. (Tube amplifiers can also have several stages, with more associated parts.)

5. Power supply differences.

A. A solid state amplifier works at relatively low voltages and high currents. This means that the power supply filter capacitance has to be huge, generally in the 10s of 1,000s of uf. Large electrolytic capacitors create huge problems with high DA, ESR, higher internal inductance, and lower resonant frequency.
(See article "Picking Capacitors" by Walter Jung and Richard Marsh" for more information.)

B. A tube amplifier works with much higher voltages and much less current. This means that the power supply filter capacitance is a factor less than SS amplifiers. The DA is just as large, but the ESR and inductance is generally much less, as there is much less foil to deal with. The resonant

frequency is generally higher.

6. Output to speaker.

A. A tube amplifier generally has an output transformer (OPT). A transformer converts a large musical signal (hundreds of volts) to a smaller signal (like SS outputs produce), and a small musical current (couple of hundreds of milliamps) to a large musical signal (like SS outputs produce) to maximize output power to the speaker. These transformers need to handle a wide range of frequencies in a balanced way, and deal with high voltages. This is not easy but can and has been accomplished.

B. A solid state amplifier generally has no need for an output transformer. They are usually directly coupled to the speaker, thus a possible headache avoided.

7. Longevity concerns.

A. Tubes require a filament and cathode.

B. SS is generally immune, although I have seen a transistor's characteristics change over the years.

8. Integrated circuits (ICs) have a couple of problems.

A. A common voltage source, so frequency dependent signal feedback through the power supply.

B. With so many transistors in a close space, transmission of audio signals from one to another, just like an antenna.

C. The associated internal parts, such as resistors etc, are of questionable quality.

With this information presented, I hope the public has a better knowledge base.

Cheers

pos

ps. I have updated this post so one may wish to re-read it again.

Subject: Re: Tubes versus Transistors
Posted by positron on Tue, 26 Jul 2022 21:48:50 GMT
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For your convenience, here is a link to the article "Picking Capacitors" by Walter Jung and Richard Marsh, Audio Magazine, Feb 1980.

https://milbert.com/Files/articles/Picking_Capacitors_1.pdf

Open the .pdf for the article.

Notice graph B4, the X axis is frequency rising with the arrow pointed right.
The Y axis is Z, the impedance is rising with the arrow pointing up.

From left to right, the line Xc is the capacitive reactance (let's call
it ac resistance). Notice the real capacitor's resistance is
dropping/sloping down until it touches the X axis, zero ac resistance and stays zero resistance to infinity frequency.
That is a perfect capacitor.

However, a real world capacitor is not perfect.
Notice at Rs, the line is curving and then rising, now called XL.
At Rs, the capacitor is actually becoming an inductor/choke, with inductive
reactance (ac resistance) becoming prominent. (However, there is no dc current flowing.)

Now let's go to figure 7. This shows a few electrolytic capacitors and the
Rs frequency. Notice how the line for each capacitor starts to curve at
"Rs" and then rises.

Notice most curvature starts below 1,000 cycles per second, less
than 1khz and all by 10khz. Of course that is well within the audible
range. This is the value of capacitors used in solid state and some tube designs.

Newer capacitors are still quite poor compared to poly type
capacitors. Of course, a very small electrolytic capacitor will not
come close to matching any poly capacitors in figures 9A-D.

I hope this helps in understanding why electrolytic capacitors are not
desirable in any analog electronic components, except well away from the direct musical signal path. This especially includes the decoupling
capacitor next to the plate resistor.

cheers

pos

Subject: Re: Tubes versus Transistors
Posted by Madison on Mon, 10 Jul 2023 04:06:54 GMT
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You really seem to know your stuff, Wayne. Your blog entry about the Sym-1 is incredibly

detailed. I especially enjoyed how you set the scene, so we can put the computer in the context of the time. Very interesting!

Subject: Re: Tubes versus Transistors
Posted by Wayne Parham on Mon, 10 Jul 2023 14:27:11 GMT
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Thanks for the kind words. We are blessed with the company of a lot of smart guys on this board.

If you liked the Sym-1 write-up, be sure to check out the others too.

As an example, I wrote a version of CP/M for the Altair that supports IDE hard drives and compact flash. The development and debugging in assembly language is recorded there as well. In some ways, it's boring but in others, well, you can see what assembly language debugging was like in the 1970s. High-tech for its day - using an early debugger - just past the time when you single-stepped using the front-panel.

Subject: Re: Tubes versus Transistors
Posted by positron on Wed, 11 Sep 2024 01:57:10 GMT
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I have obtained a little more information from the
RCA Radiotron Designers Handbook, 1960, by 26 engineers.
Attached are the dynamics characteristics of a triode vs
pentode vs straight line, and the second is the IMD
characteristics of a triode vs Pentode. (See figure 2
in the article to compare.)

The second has to do with the article statement:

"Reportedly, his manipulations were so
successful that not one of his challengers
could consistently distinguish his
solid-state amplifier from their own
specially designed tube equipment,
nor could they say definitely which
sounded better in the long run.

Notice the words "consistently"and "in the long run",
which infers multiple A and Bs, back and forths.
No conditions or methods are mentioned.
As such, they were just asking for a false conclusion.

Any time one suggests just listening multiple times, the listening session is not scientific in any way, shape, or form.

In fact, the way comparisons are suggested/performed means the conclusions are skewed 100% of the time towards no sonic difference. That is worse than a simple normal sighted listening comparison.

This includes allowing one to perform the test anyway one wants; a guarantee one will Not perform the listening session/dbt correctly, thus skewed.

The problem lies in the fact that virtually No confound variables are addressed, except sight. But how is one to know they are being taken for a ride? I doubt if the author, himself, even knows.

In previous posts in this string, I have mentioned differences between transistors and tube characteristics and surrounding parts. Each component, even parts make a sonic difference when specialized listening tests are performed correctly.

How is that important? In my lab designs (now home) after performing specialized listening tests of each component, ics, parts etc, and found accurate in absolute terms, my friends can perceive sonic changes as low as -132db from the fundamental (using 20log equation).
Not surprising that components with the "same specs" sound different.

Unfortunately the article's performance is an uneducated attempt to explain sonic differences between transistors and tubes. However, it is all the parts, and design that are involved in producing the music we hear.

It is not surprising why Audio excellence has stagnated, and the audio field has been in decline for decades.

pos

File Attachments

1) Triode vs Pentode vs Straight Line.pdf, downloaded 251 times
2) Triode vs Pentode IMD.pdf, downloaded 254 times

Subject: Re: Tubes versus Transistors
Posted by gofar99 on Sat, 21 Sep 2024 02:45:19 GMT
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Hi Pos, Humm. I don't believe I have seem any gear with -132db fundamentals. The noise floor of the best gear I have is about -120 so the fundamental would not be audible. What gear were you using?

Subject: Re: Tubes versus Transistors
Posted by OutOfSpace on Mon, 28 Oct 2024 14:32:45 GMT
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A bit late to the party, but I ran across this article some time ago about the Bob Carver challenge from Stereophile:

https://www.stereophile.com/content/carver-challenge

Pretty interesting how he went about matching the amps.

Chris

Subject: Re: Tubes versus Transistors
Posted by Wayne Parham on Mon, 28 Oct 2024 15:07:22 GMT
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That's a very interesting article.

Thanks for the link!

Subject: Re: Tubes versus Transistors
Posted by positron on Tue, 04 Feb 2025 06:19:09 GMT
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gofar99 wrote on Fri, 20 September 2024 21:45Hi Pos, Humm. I don't believe I have seem any gear with -132db fundamentals. The noise floor of the best gear I have is about -120 so the fundamental would not be audible. What gear were you using?

Sorry for the late reply 99.

I refer to altering the frequency response and using the typical 20log equations,
which are generally the standard for frequency response deviations and other specs.

There are various ways of checking. The ear is extremely sensitive to fr variations.

I started my venture to help a friend back in 1980, when I was 30 years old. I have since designed every piece of gear from scratch, including ics, preamps, monoblock amps, and for the last 13 years my two way speakers. It started in my lab, I then retired at home (my apt is my lab now). I was in manufacturing as SAS Audio Labs, retiring in 2012.

I just kinda finished my venture by ordering Jenalabs 6N copper wire and installing parallel "strands". It will optimize at some number of parallel "strands", probably different than typical 3N copper, which was 11 "strands" of 18 gauge, ~7 feet long.

Right now, I am altering the sonics a couple of ways. The first is by bending one lead of each inductor's wire slightly, one inductor for the bass and the other for the treble response.

The second method is by using a 2 ohm Mills resistor in series with the wide band driver. This is the reference for sound.

I am by parallel the 2 ohm resistor with either no resistor (reference), or 8 megohms, 4 megohms, 2 megohms, or ~1.333 megohms. I may yet use another value.

There are other ways of checking ear sensitivity but I shall end my diatribe. :)

cheers

pos

Subject: Re: Tubes versus Transistors
Posted by positron on Tue, 04 Feb 2025 06:25:50 GMT
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OutOfSpace wrote on Mon, 28 October 2024 09:32A bit late to the party, but I ran across this article some time ago about the Bob Carver challenge from Stereophile:

https://www.stereophile.com/content/carver-challenge

Pretty interesting how he went about matching the amps.

Chris

Pertaining to the article, one must realize that electrolytic capacitors, by themselves will mask inner detail, which negatively affects perceived sonic differences.

The listening testing method is also quite suspect since virtually no confound variables are addressed, except sight, or spl level.
The tests are skewed toward no sonic difference virtually every single time.

cheers

pos

Subject: Re: Tubes versus Transistors
Posted by positron on Tue, 04 Feb 2025 16:08:07 GMT
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To explain a little further on #117, I am sure our friends have heard more inner detail when one purposely leans their system, or even brightening the top end frequency response. On a good system, one can hear the effects down through the lowest bass regions. One is removing masking by leaning the bass, or due to over bassing, or masking caused by electrolytic capacitor(s) DA, or even other parts.
Of course, one can teetor/totter and over lean one's system and lose naturalness.

Ok, so let's install polypropylene capacitors in place of electrolytic capacitors in the entire system, removing the masking caused by electrolytic capacitors. This will allow us to perceive the smallest frequency response and inner detail changes, easily past -120 db. (Although not reliably, we have tested FR down to 1 part in 11,000,000, or approx. -140 db change). -120 db actually becomes the limiting factor in inner detail retrieval in my system. We have to remember though that this is a lab system, not a typical system.

DA, 7% of the music is lost to non musical nonsense in each electrolytic capacitor used. Compare that figure with 0,02% for a polypropylene capacitor. We actually hear more inner detail while improving the naturalness of the music (assuming an accurate polypropylene cap is used.) The difference in naturalness, and sensitivity is profound.

Specs sheets do not mean much when comparing components.

Virtually all audio components use multiple electrolytic capacitors. (My lab designs do not except for the high voltage output which is bypassed with poly caps.)

Any small change, such as bending an inductor lead, or bypassing a 2 ohm resistor with megohms, the response and inner detail change is perceived.

Cheers

pos

Subject: Re: Tubes versus Transistors
Posted by Wayne Parham on Tue, 04 Feb 2025 21:17:44 GMT
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I'm totally with you there. Electrolytics are convenient for where super large size capacitors are needed, but best used where their inherent non-linearity isn't a problem. That pretty much rules them out for any kind of analog audio circuit.

And I also agree with you about polypropylene capacitors. These days, poly caps are available in fairly large sizes. Anywhere I see 1uF to 100uF electrolytic caps in older gear that I care about, I immediately swap them with polypropylene capacitors.

Subject: Re: Tubes versus Transistors
Posted by positron on Wed, 05 Feb 2025 00:24:38 GMT
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Wayne Parham wrote on Tue, 04 February 2025 15:17I'm totally with you there. Electrolytics are convenient for where super large size capacitors are needed, but best used where their inherent non-linearity isn't a problem. That pretty much rules them out for any kind of analog audio circuit.

And I also agree with you about polypropylene capacitors. These days, poly caps are available in fairly large sizes. Anywhere I see 1uF to 100uF electrolytic caps in older gear that I care about, I immediately swap them with polypropylene capacitors.

I think you are one of the very few who understands this Wayne. I don't remember finding any in other forums (not this website) doing this upgrade. My audiophile buddy has exchanged a couple of electrolytics in his AR and Luxman components that helped.

For the solid state guys out there, the signal stages could be helped, but replacing 20,000uf and up electrolytics with poly caps would be quite expensive, and I could not rule out other sonic problems?

cheers

pos

Subject: Re: Tubes versus Transistors
Posted by gofar99 on Wed, 05 Feb 2025 01:44:26 GMT
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Hi, The above is why with only one exception I use only polys in my gear and specify them in my projects. Any elecrolytics are only in power supplies and are bypassed with polys. In one of my latest phono preamps I even use polys in the latter stages of the power supply. So I am in agreement with you. Further if there is a way to eliminate a capacitor in a design (like between stages) I do that as well as long as the omission doesn't cause additional issues.

Subject: Re: Tubes versus Transistors
Posted by positron on Thu, 13 Feb 2025 19:48:55 GMT
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Something I should mention is that I try to have at least the "decoupling" capacitor and previous capacitor as all polypropylene.

Another is that although there are some sonic differences between electrolytic capacitors, I find a quite wide sonic differences between polypropylene capacitors, so one needs to be careful to obtain the correct ones.

Sonic differences are caused by:

1. Dielectric materials used
2. Type of conductive "plate" material used
3. Thickness of the "plate" material
4. Termination techniques
5. Type of lead material used
6. Size of lead material used
7. Combination of materials combined, whether "plate", termination, or lead

There may be more upon in depth reflection.

cheers

pos
