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I remember, when I was a teenager, thinking that vacuum tubes were an interesting historical oddity, firmly superseded by more modern technologies.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