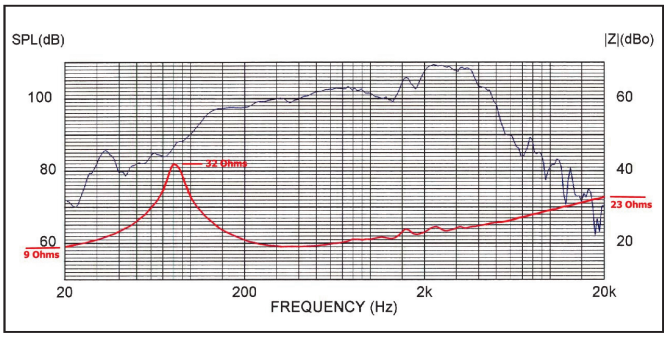
Why Does A Tube Amp Sound Different To A Solid State Version?

In order to fully appreciate why there is a difference in tone, the very first thing a musician must understand is the important role the guitar speaker and output transformer play in this outcome as far as a tube amp goes. For it is mainly their interaction that is the basis for the tonal difference associated, until recently, exclusively with tube amplifiers. It is vitally important that this fact is taken on board.

I don't intend to make this article a heavy technical document, but there is no escaping that a reasonable amount of technical jargon must be incorporated otherwise an explanation cannot be given. So I shall do my best to keep my tech chat as simple as possible.

In the graph of a typical Celestion 12" guitar speaker shown below, you will see two 'plots' - a black plot and a red one. The black plot simply shows the 'response' of the speaker, or what kind of tone it produces. However, we are only interested in the red plot for this article.



The red plot shows the speaker's impedance curve and proves that it varies according to the frequency of the signal being applied to its terminals.

Generally, a speaker is referred to as being a 16 Ohm, 8 Ohm or a 4 Ohm version, but that 'numeric value' is purely the speaker's 'NOMINAL' impedance. A value quoting the speaker's lowest impedance for the sake of convenience and simplicity.

Moving on… At approximately 80Hz, you will see a peak where the impedance rises to about 32 Ohms and that point is called 'The Resonant Frequency' (Rs). This is where the thin paper cone is easy to excite and produces lots of output for very little input power. I'm sure you can imagine that a paper cone is not a strong structure, so when it's being driven so hard, it's likely bend and buckle somewhat. During this process, the cone will even add distortions to the sound that are NOT produced by the amplifiers electronics at all! This does not only happen at around 80Hz, it also happens at other higher frequencies too. But for the moment we shall concentrate on the 80Hz region.

Tube Amp Warmth

It is near to this frequency that guitarists hear a warmth of tone that they call **'tube amp warmth'**. But really it has nothing to do with the amp's tubes at all! Tubes get the credit for this warmth simply because musicians can see that the 'warm' sounding amp has tubes in it; and the 'cold' sounding solid state amps quite obviously don't have tubes… so a conclusion is reached that the tubes must be the reason. Well, I have some bad news for you… that conclusion is completely and utterly WRONG! It is the speaker and tube amp's output transformer that are responsible for this extra warmth… absolutely NOT the tubes!

You most certainly do NOT need to employ tubes to create a warm sounding amp like a tube amp is alleged to be exclusively able to achieve!

Mechanically Generated Cone Harmonics

Just up a little from this 80Hz point at about 300Hz you may notice a long flattish portion of the plot, taking you right up into the 2kHz region which has an impedance of around 8 to 14 Ohms. This is where the speaker turns most of the amplifier's power into acoustic output via its cone. It is also in this mid frequency range where the speaker's cone, through being driven hard by a powerful amplifier, starts to behave badly. The thin paper cone, held in place by a rather simple and rudimentary suspension system, is allowed to buckle and jostle around in a somewhat semi-uncontrolled way. So, these unintended cone movements create distortions in the sound being produced. Yes, the sound is coming from the

amplifier, but there are also mechanically generated harmonics (or extra tones) being added by the unwanted cone movements. So now we have a sound that is a combination of the wanted sound from the amplifier's output and unwanted mechanically cone produced sounds. It is these 'unwanted' harmonic tones that make the speaker sound so good for electric guitar. Some call these tones 'cone cry.' They are truly 'defects' in the speaker, but good ones that we engineers exploit. Without them we would not know the guitar sounds we all take for granted… and mistakenly refer to as the 'tube amp tone.'

OK, so it is a tube amp that creates those tones we all love… but IT'S NOT THE TUBES CREATING THEM. IT'S THE SPEAKER AND OUTPUT TRANSFORMER!

Incidentally, the term used within our industry for the way a guitar speaker influences the 'guitar tone' is known as a BENEFICIAL DEFECT. That means: ***'A managed single or combination of known safe defects that is intentionally exploited to create a desirable outcome.'***

Looking at the higher frequencies, it is clear that the speaker's impedance has now risen to 23 Ohms. Similar effects are taking place at these higher frequencies too, but with slightly less audible impact. The upper frequencies are where the amp, or more accurately, the speaker produces a sparkle or 'chime' to the guitar's tone. Without this, the guitar would sound dull or lifeless. That sparkle is very important to the vitality of the final sound! Guitarists most definitely don't like guitar amps that don't have that quality. This is exactly what has been happening in most makes of solid state guitar amps over the years! Hence the cold flat tonality of many of them. However, NOT in post 2013 Session amps!

The World Of Constant Current Amplification

OK, so how does all this have any relevance to the difference in tone of tube and solid state amplifiers? Well, quite simply, it's all down to one simple fact. A tube amp's **output transformer** (OPTX) enables all of these 'beneficial defects' to take place in a tube amp!

The OPTX has a lot of copper wire used in its construction and, to cut a very long story short, this copper has an impedance of its own… often totalling about 4 Ohms. That 'impedance' is in series with the speaker, so as the impedance of the speaker varies with the changing frequency of the signal driving the it, the current flow through the speaker changes in sympathy. The transformer's internal impedance forms what is known as a 'potential divider' with the speaker's impedance and, as such, causes the voltage across the speaker to change with frequency in reaction.

In short, as the speaker's impedance rises, the current through the speaker falls. This then causes the AC voltage across the speaker to rise due to the decreased current flowing through the OPTX's internal impedance. The increased AC voltage across the speaker means that there will be a rise in the current through the speaker and it is this action that prevents the power of the amplifier and speaker as a system from falling. They are all inter-dependant and the resultant benefit is called **'Constant Current Drive'** and is a common feature of all tube power amps.

In solid state amplifiers, since the early nineteen-sixties, there has been no need for an OPTX. Therefore, this self regulating 'constant current' output power cannot take place. So, as the current falls through the speaker's rising impedance, so will the overall output power being generated by the amplifier and speaker. Now, because the impedance changes taking place when the speaker is mainly at around 80 Hz and towards the higher frequencies, those are the areas where the power output of the system will be most attenuated… giving rise to the so called 'cold' tone of 'old school' solid state amplifiers.

Why Not Equip Solid State Power Amps With Constant Current Ability?

Yes, why not? They don't have an OPTX, but we can use another method. Happily, it is very simple to provide solid state amps with a 'constant current' power amps that will behave exactly like a tube power amp! It amounts to just four extra components in the power amp circuit. These components detect the current flow through the speaker and apply a control signal to the main power amp circuitry to dynamically control the gain of the power amp. The solid state power amp then behaves exactly like it had an output transformer. Eureka! So now, the solid state power amp follows precisely how the tube power amp

works. It really was that simple all along! So all SESSION amps are equipped with it and we even have conversion services to give all our old 1980s Sessionette:75 amps a nice 'constant current' power amp upgrade, called RetroTone. In our new amps, the power amps are designated 'ConCur™' as a simple 'handle' to let customers know what advancements our amps have and that they won't sound cold like the 'old school' solid state amps of yesteryear!

It was a long journey!

This problem has been staring solid state amplifier designers in the face for around fifty years and no one actually noticed… apart from a handful back in the early nineteen-seventies, HH being the most well known. HH amps did the job really well, but unfortunately their pre-amp designs did not really produce that 'classic American character' that everyone was, and still is, accustomed too!

A few amp makers had produced amps with various combinations of solid state and tube technology, but none could find that illusive 'sound' using purely solid state technology. The one combination that truly did work was when they hung a solid state preamp onto a tube power amp - like Musicman and Marshall did. Surely, that was like waving a huge red flag in front of their projects trying to give them a bloody great nudge as to where they were going wrong? No, it appears not!

Until that time, apart from HH, it was only tube power amps that were able to deliver the REQUIRED constant current drive that made guitar sound great! HH knew how to do it! That's why the brand was so successful. Their solid state power amps behaved just like a tube power amp! You only have to listen to early Wilko Johnson to understand this!

All the makers of solid state amps that had reverb facilities built in, were already using constant current power amps in their reverb driver circuits! But never thought of using the idea to drive their amp's speakers too! Isn't it plain stupid? But really, no one knew it was that important… except for the rather clever designers at HH! Well done lads… it was there in the public domain, but it slipped by completely unnoticed by their competitors for all those years! Or perhaps, not unnoticed but more to the point, was viewed with disinterest because they were 'only' solid state amps… and of course, no one wants those! It is very true that most amp makers, even now, don't have much regard for solid state amplifiers, so don't even bother to put any development into the type.

We have to say, when even the most adamant 'it must be tube' players try one of our BluesBaby 'ConCur™ equipped combos, 99% are knocked out by them! Once they have tried them, the tube amp reliability and tube replacement cost issues start to play on their minds. Most players also want the excessive weight of their tube amps to vaporise as well! We thinks it's just a matter of time now, before tube amps take a back seat to ConCur™ equipped lightweight solid state guitar amps.

Who will be the first of our competitors to launch a BluesBaby-like combo based on the techniques we have pioneered? We are expecting it!

Summary

It is my bet that if HH HAD produced solid state amps that DID produce that classic American tonal character, tube amps would have certainly been consigned to the history books along with tube radio sets and TVs long before now!

Could this be the end of the 'flat earth' attitude to solid state amps? After all, the customer always decides in any market place. We have given players the tone they want, the lightweight product they want and low ongoing running costs. What more can a player really ask for… it's all there now!

Guitar amp designer since 1967

P.S: The funny thing here is that constant current tube amps don't work with Hi-Fi speaker cabinets that have built in passive cross-over circuits. The highly inductive loads that they present is the problem. Damage to the amp can be the end result! This begs the question: Why do Hi-Fi shops sell tube Hi-Fi amps to people with modern cross-over equipped speakers? Hmmm!