STC-technology in general

***STC** should be read as the abbreviation of*

*"**S**tandard **T**ube **C**ircuitry",*

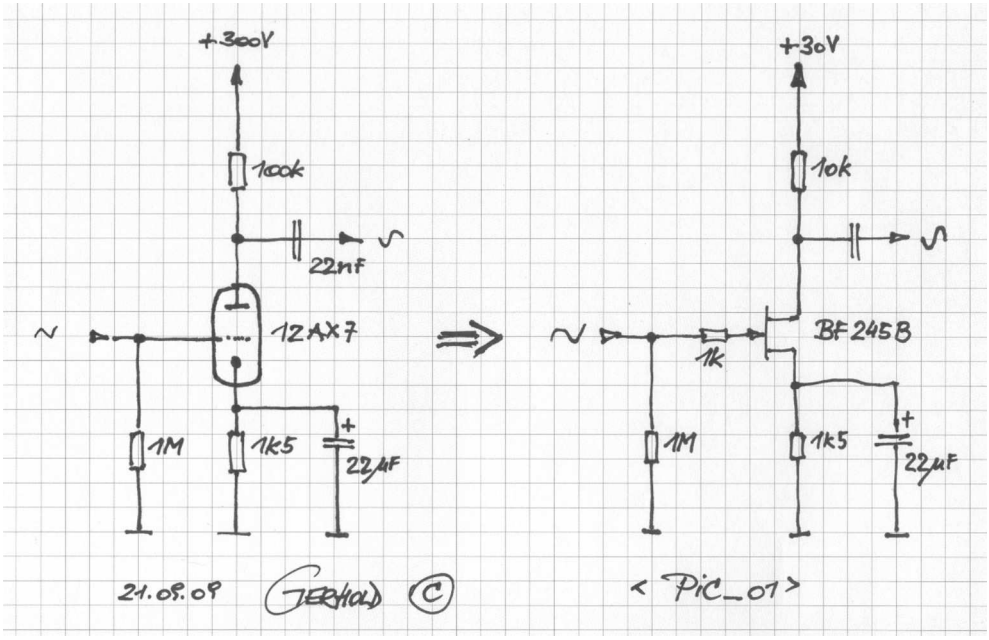
which in its meaning almost tells everything about…

In the entire very first, I have to say, that this article is no stuff for the beginner. You needed some experience in applied electronics to follow these explanations. You should also have some experience with the design of tube circuits, to understand this material. Please have a look for a skilled electronics tech, if you are not able to follow this material!

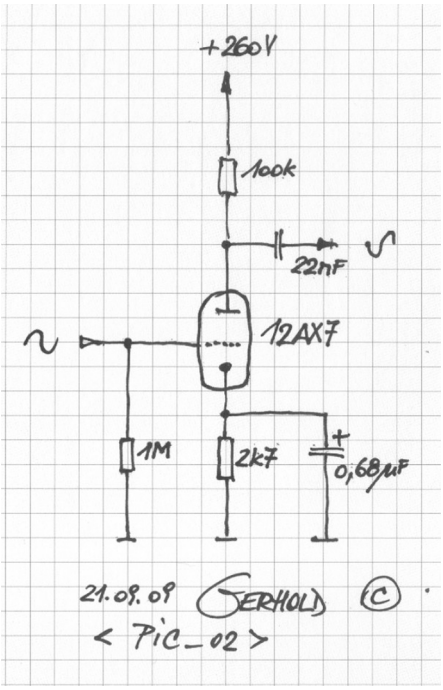
How STC started

I came to this technology, because I am playing electric jazz guitar and tried to find a way, to achieve this nasty triode tube-sound by the use of semiconductors. First all my attempts failed and I was close to the point to stop my research.

Well, sometimes only good luck helps. A musician from my neighborhood asked me to help with his solid state combo-amp, which he wanted to use with his acoustic guitar. The built-in piezo pickup had too high impedance for the amps input. He had tried by himself with an OP-amp as a preamp, but failed. It did not sound like he wanted. I gave him a JFET high impedance frontend – and he was happy. Some days later he came in again and meant, if we could not mount this JFET stage into his guitar. Now we had the additional problem that it should use only as little battery power as possible. So I defined during tests that about 1mA were the least possible. He again came back some days later, a smile in his face, asking what I had really done. He meant that now his guitar produces on stage the sweetest tone he ever heard. So I again went into research after I had proven the sound by myself. This was the point, were STC really started. All in all I can tell today, that I was misled before by data books, application notes, tech articles and so on. The only real way is to use a tube schematic, search for a JFET with similar characteristics substituting the tube and use exactly the same operating point and idling current. Easy – if we know…



Have a look at the above schematic: Do you dig what I mean? This little schematic shows the typical input stage of a Fender® tube amp. Translated to STC it sounds the same and works the same. You could translate for example also a typical Marshall® input stage (below). It again will sound the same as the tube thing!



The formulas for the translation:

The JFET

It needs to be chosen in a way, that its gate-source voltage is nearly the same as the grid-cathode voltage of the tube at the same anode current. In our above schematic, the 12AX7 has an Ugc of about -2V, so we choose a BF245B, which will show nearly the same value.

JFETs should be bought in larger quantities and selected afterwards. I always buy them in bulk of 100# and select each type to several characteristics. The selection process is described in behind. Please be patient.

The supply voltage

It has to carried out as about 10% of the original tube schematic. For example: If the tube circuit had a supply voltage of 250VDC, you should use 25VDC.

"Resistor ladders" between several JFET stages should be kept at 10% of the tube circuit values for to get same operation (e.g. if the voltage drop ahead a frontend tube is 10V => 10k at 1mA, we use 1k at the same current value to get 1V drop).

The caps in the supply circuit

As we use only 10% of the supply voltage, caps have to be 10 times bigger in value, than in the tube circuit. If the original tube circuit says 10µF we have to use 100µF.

The source resistor

If you have chosen the right JFET, it will have the same value as the cathode resistor in the tube circuit.

The drain resistor

Look at the tube circuit and use 10% of the value of the anode resistor from the tube circuit.

The operating point, the idling current

It will settle at compared the same value of the tube circuit. For example: If the operating point was 50% of +Ub in the tube circuit, it will again be 50% of +Ub in the JFET circuit.

Well, and the sound will also stay the same! Easy – if we know…

Some typical, frequently asked questions and their answers

- How would you define the sound of such a STC-circuit?

  Very, very tube-like. Maybe the sound will be a little crispier than the original tube sound. Here a small cap with only some …pF across a drain resistor or against ground can help. If you use a hard coupled MOSFET (see schematic of the STC Line-Preamp) as a drain follower, this is not necessary, because it has its own gate capacitance. Some people told me, they associate the JFET-sound a little with a pentode in triode mode, anyhow…

- If the supply voltage of the tube circuit is bigger than 300V, we have to manage. The maximum value of a BF245 is 30V.

  We could use only 30VDC and make the drain resistor a little smaller.

  We could use a source resistor with a little bigger value (which would make drain current a little smaller concurrently) and leave the drain resistor to is formulated value.

  We could use another type of JFET (not so easy, because only a few types are really suited for STC).

- What – if the anode current is bigger than the chosen JFET can deliver?

  We have to couple a small signal MOSFET (e.g. BS170). See schematic STC-Line-Preamp.

- Will the transition frequency be high enough?

  Yes – BF245 reach 700MHz, truly enough for audio.

- Will the gate impedance be high enough?

  Yes – it is higher than the grid impedance of a tube.

- Is a JFET as rugged as a tube?

  No – but this problem can be handled easily. Max. power and voltage limits must not to be exceeded. Also see next point.

- Are JFETs also due to oscillations like tubes?

  Yes – and the same preparing will help. At inputs or outputs to connected items always use series resistors (gate/grid-stoppers). Zener or Schottky barriers are used to protect against static discharge and couplings to other equipment (e.g. tube circuits). Proper grounding should be regarded.

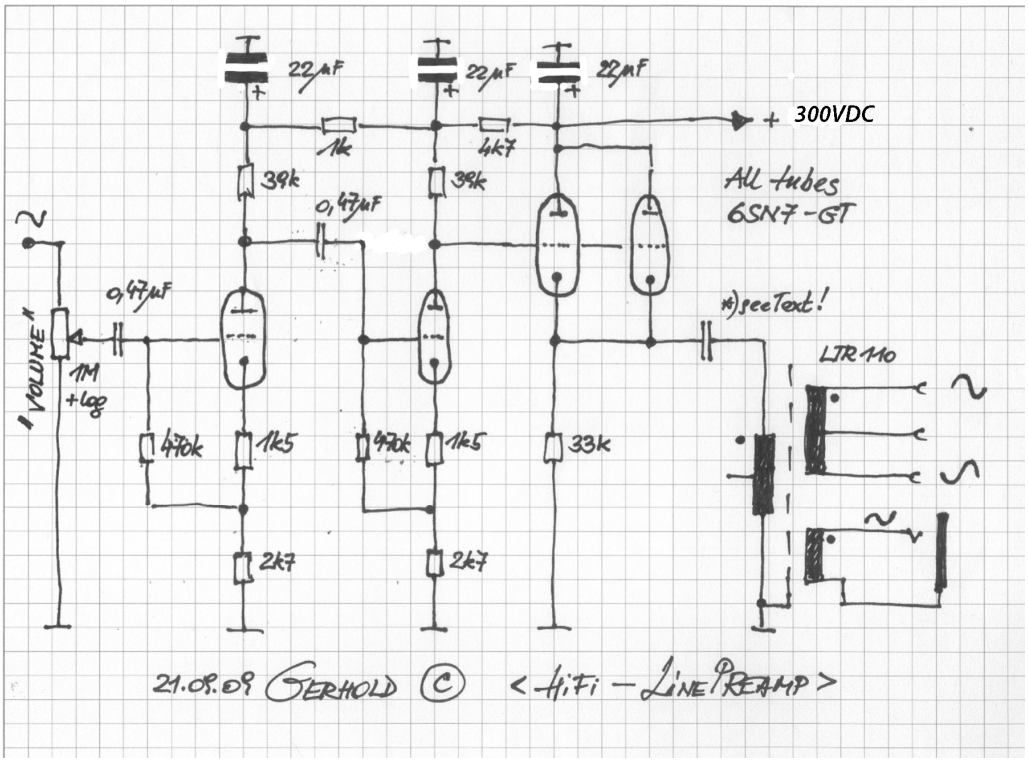
Now have a look at HiFi-Design

I pointed out a well respected and also well known circuit of a Tube Line-Preamp, to let you see, what is today's "State of the Art" in HiEnd tube tech. The following circuit's schematic has a total amplification of about 50x, a very high impedance input – only determined by the volume pot – and a balanced output (+6dBm) together with an isolated but unbalanced output (0dBm). The output transformer could also be omitted; if you do not need resp. fear the dual groundings of the preamp and the power amp. The sound is overwhelming and noise rejection is at its best, because the only real amplifying tube stages (the two in front) act the same but phase reversed.

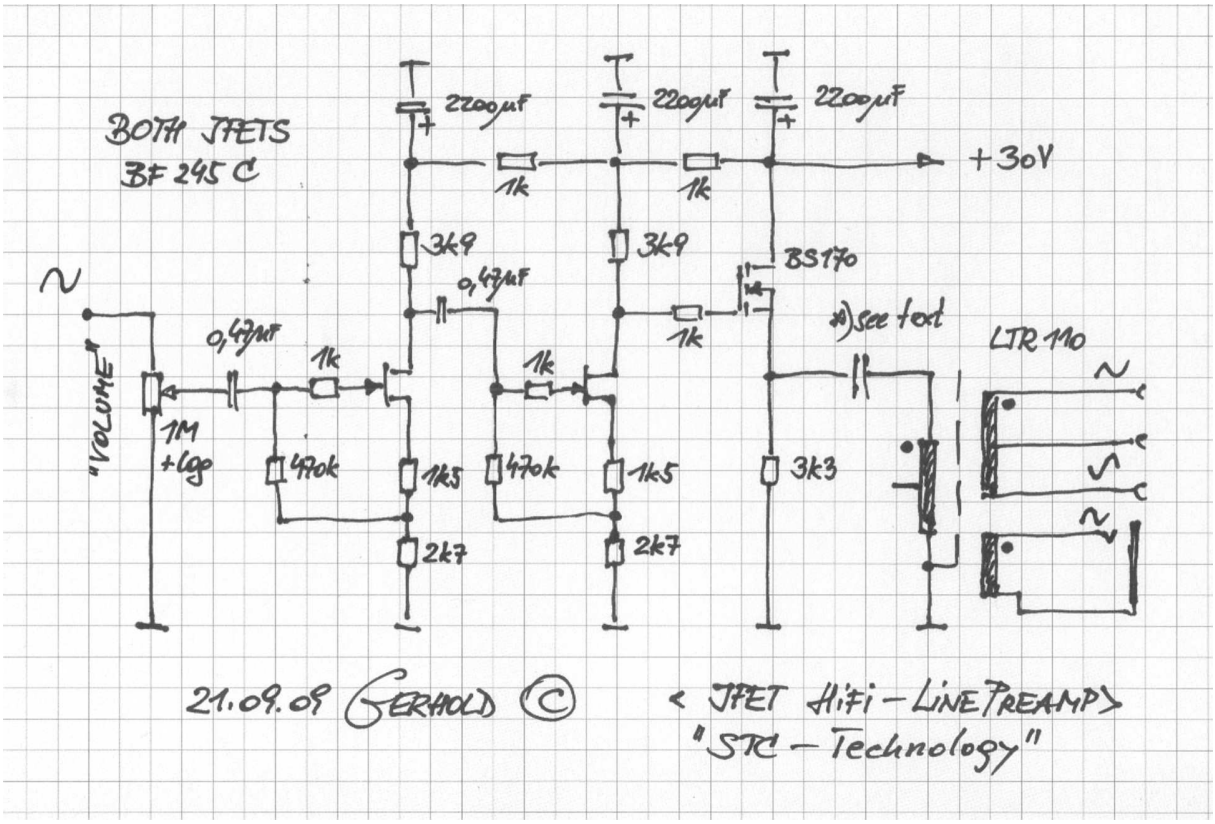
The Tube Line-Preamp shows no overall feedback, so no cancelling of any harmonic content will occur. But also no harmonic content of the original music material will be cancelled, so the sound will stay bright, rich and blooming. Only current-feedback resistors are added to the ground wires of the two front-tubes. They manage to force each tube stage to a very, very low distortion figure.

Some similar tube schematics show current-feedback resistors as big as 10k instead of the shown 2k7. This lowers the total amplification factor. You should determine by yourself, how much this factor should be. I prefer to keep the total amplification to a lower value because I do not like volume pots that show only a useful action in the lowest degrees of the turning angle. A volume pot should be at half way (12 o'clock) at a medium listening level in my opinion. If you use an audio taper pot this means it is at -20dB or 1/10 input voltage. Higher values of the current-feedback resistors also increase the 3D imaging. Please try by yourself!

All this behavior now should be able to be translated to STC. But first we need the original tube schematic, which is shown next page:



Now let us see, how we can copy its very good behavior by STC:



As you can see, all parameters of the STC circuit are the same – except the drain resistors and the supply chain. They are altered according to the formulas given in the above chapter. The sound is also the same.

Easy - if we know …

Some words about the parts needed

Tube circuit

Caps should be of good make (450VDC, MKP). Because I am from Europe I normally use WIMA, a very good brand at a payable price.

The cap ahead the output transformer is a mix of 33µF MKP and a 0.22µF FKP in parallel. The 33µF MKP cap can be obtained from speaker dealers (speaker divider networks!). Please use a reliable and good make. You could also use a good electrolytic cap, paralleling it with 1µF MKP and 0.22µF FKP.

The output transformer is a LTR-110 from MONACOR (www.monacor.com), a widely used part in studio equipment - again at a payable price.

I used tubes from SOVTEK (www.sovtek.com) because of their bright and blooming sound.

STC circuit

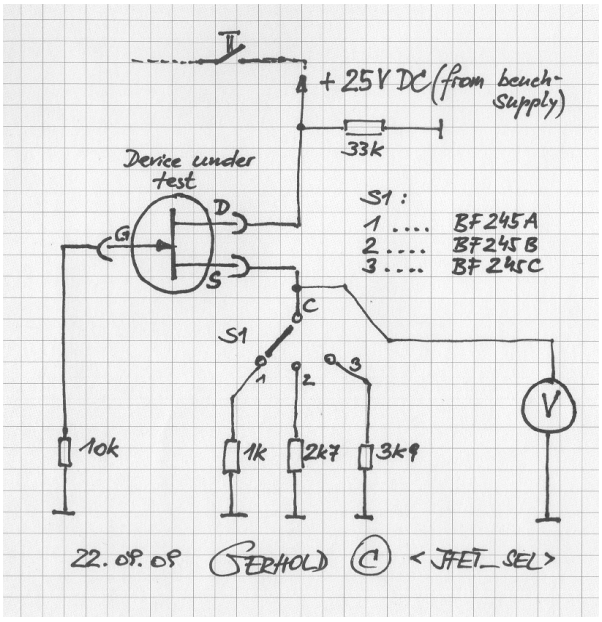
Caps should be of good make (>63VDC, MKP). I normally again use WIMA.

The output transformer and the cap ahead of it are the same as well as the same mix from the tube circuit.

I used BF245 JFETs from a local parts-store. Mostly they are of Siemens or Philips brand.

The JFET selection process

Have a look at the beneath schematic:



I made up a small PCB, containing all the parts: 3-pole transistor socket, selector-switch, measuring resistors and DVM.

The measuring resistors are chosen in a way, that at nominal values a drain-current of 1mA would flow.

The how-to do:

If I select a bulk of BF245B - for instance,

1. I switch to ***position 2***.
2. ***Put in the JFET*** under test into the transistor socket,
3. ***switch-on*** the power (+25VDC) and
4. ***read the DVM***.
5. Then I ***switch-off*** the power and
6. ***add the JFET*** to the assigned compartment in my small parts selector box.

I defined the following classes for JFETs.

TYPE	Gate-source voltage	CLASS	Useable for acc. tube (e.g.)	Application (e.g.)
BF245A	0.7V - 1V	**A<1**	6SL7	Mike preamp
	1V - 1,3V	**A>1**	12AX7, 6SL7	Mike preamp, guitar input
BF245B	2,1V – 2,5V	**B_2,3**	12AX7, 6SL7	guitar input, HiFi-RIAA stage
	2,5V – 2,9V	**B_2,7**	12AX7, 6SL7	guitar input, HiFi-RIAA stage
	2,9V – 3,3V	**B_3,1**	12AX7, 6SL7	guitar input, HiFi-RIAA stage
BF245C	3V – 3,5V	**C_3,3**	6SN7, 12AT7	HiFi-Line preamp, driver apps
	3,5V – 4V	**C_3.8**	6SN7, 12AT7	HiFi-Line preamp, driver apps
	4V – 4,5V	**C_4,3**	6SN7, 12AT7	HiFi-Line preamp, driver apps

JFETS with differing values are labeled and marked with their corresponding gate-source voltage in clear writing and gathered for special applications. These drop-outs should not be too much, as my classes cover mostly all values. Keep them for further use.

An example for choosing a JFET:

The Marshall® pre-stage from our second schematic will show a cathode voltage of about +1,6VDC at +260VDC supply voltage. As the closest part we take a BF245A -> class < A>1> or a drop-out JFET with nearly exactly the needed value (-Ugs=1,6V). Maybe also a BF245B with low Ugs will fit this application.

If the drain current (about 0,6mA) at a supply voltage of +26VDC is too big with a source resistor of 2k7, we make the source resistor a little bigger -> 2k8 (2x 5k6 in parallel). If it is too small, we operate inverse -> 2k59 (2k2 + 390 Ohms). You could also change the JFET to get the needed Ugs with corresponding Ud. The voltage across the JFET and the drain resistor should nearly be equal to the broken-down voltages from the tube schematic, to give the same harmonic content and therefore the same sound. In our example the anode voltage is shown as +200VDC, so we should get around +20VDC.

Normally these voltages are chosen in a way that the DC-voltages across the tube and the plate resistor are almost equal. This is necessary to achieve a good clean tone.

For HiFi use, these voltages should be as equal as possible - if not defined to another value in the original tube schematic!

If you should wish to design a tube-like overdrive, you could go the inverse way to get crunch-sound. You will be adding mostly k2 - first harmonic with twice the frequency of the basic wave - to the input signal, (also "Aural Exciters" operate this way!).

Now make your own decisions and translations from tube => STC and you also will benefit from this new technology. Easy – if we know …

If you have further questions, please have a look at the FAQ page or contact me via support@tubeclinic.com.