

VALVE

the magazine of astounding sound



The Simplex

by
Ari Polisois ©2001,
2002
*The Simplex Single-ended Audio
Amplifier*

The Idea

After having built several audio amplifiers (single-ended and push-pull) and compared, first their theoretical qualities, then the practical side (complexity, matching of the valves and need of adjustments) and, last but not least, the sound, I decided in favor of the single-ended. I was much inspired by the wonderful article written by Scott Frankland on the Dec. 96 and Jan-Feb. 97 issues of *Stereophile*.

There was another reason for me to choose this layout:

single ended amplifiers are less expensive to build, in terms of cost of components and time spent to assemble them. My plan was to design an amplifier as simple as possible, still keeping the quality high. The latest one I completed a week ago has an incredibly pure sound, by far the best, compared to the others I had so far built, that were considered, until then, by all people who listened to them, of having an impressive good sound.

My wish is that someone else decides to build its twin and share his impressions with me. Surely, with different speaker systems and listening rooms, etc...the comparison will be questionable, but, nevertheless, some character should show up.

I gave the amp the name Simplex, as it is to me: Simple and excellent. At first sight it is not so simple, due to the fact that it contains some novel solutions and, undoubtedly, everything new implies effort to be fully understood. But once you have accepted them, I bet you will use them as an alternative to the traditional and too often repeated circuits, most of which polluted by compromises that reduce the sound quality. I am aware that what I am saying seems quite arrogant. Take it as an invitation to prove the opposite.

I decided to use the bulky but generous 6C33C, driven by the evergreen 6SN7, for the following reasons:

- the 6C33C has a lot of potential as it can deliver a substantial amount of power
- it works at quite a low plate voltage
- it has a wide filament/heater surface
- its price is affordable.

On the other hand, it requires a high driving swing, in the range of 85-100V peak. It took me some time to obtain this swing from a 6SN7, but this beautiful valve succeeded, with an acceptable distortion figure, an unbelievably extended frequency range (from few Hertz to over 150 kHz) and, consequently, with a respectable linearity.

The simulations suggested a biasing voltage of -90 for the 6C33C, a B+ of 270V and an idle plate current of 250 mA. The plate load was set at 800 ohms, with a ratio of 10:1 on an 8 ohm load.

Raw Power requirements

At first I will refrain to spend much time and space on

For 110V Mains
 F1 - 1A Time Delay
 F2 - 3.16A Time Delay
 F3 - 3.16A Time Delay

For 220/230V Mains
 F1 - 1A Time Delay
 F2 - 2A Time Delay
 F3 - 2A Time Delay

R1 - 470 - 600 ohms 25W w/heatsink
 R2 - 470 ohms 50W w/heatsink
 C1 - 100uF 500V
 C2 - 470uF 450V
 C3 - 470nF 100V MKT
 C4 - 220uF 450V
 C5 - 1000uF 385V
 C6 - 470nF 1000V MKT
 C7 - 1000uF 385V
 B1 - 4 pairs of 1N4007 shunted by 4700pF 1000V caps
 B2 - 4 - 1N5408 shunted by 4700pF 1000V caps
 CH1 - 5H 600mA Choke
 SW1 - 250V 3A DPST (the second section can be used for a pilot lamp showing that PS2 is powered on)
 SW2 - 250V 6A SPST
 SW3 - 250V 6A SPST

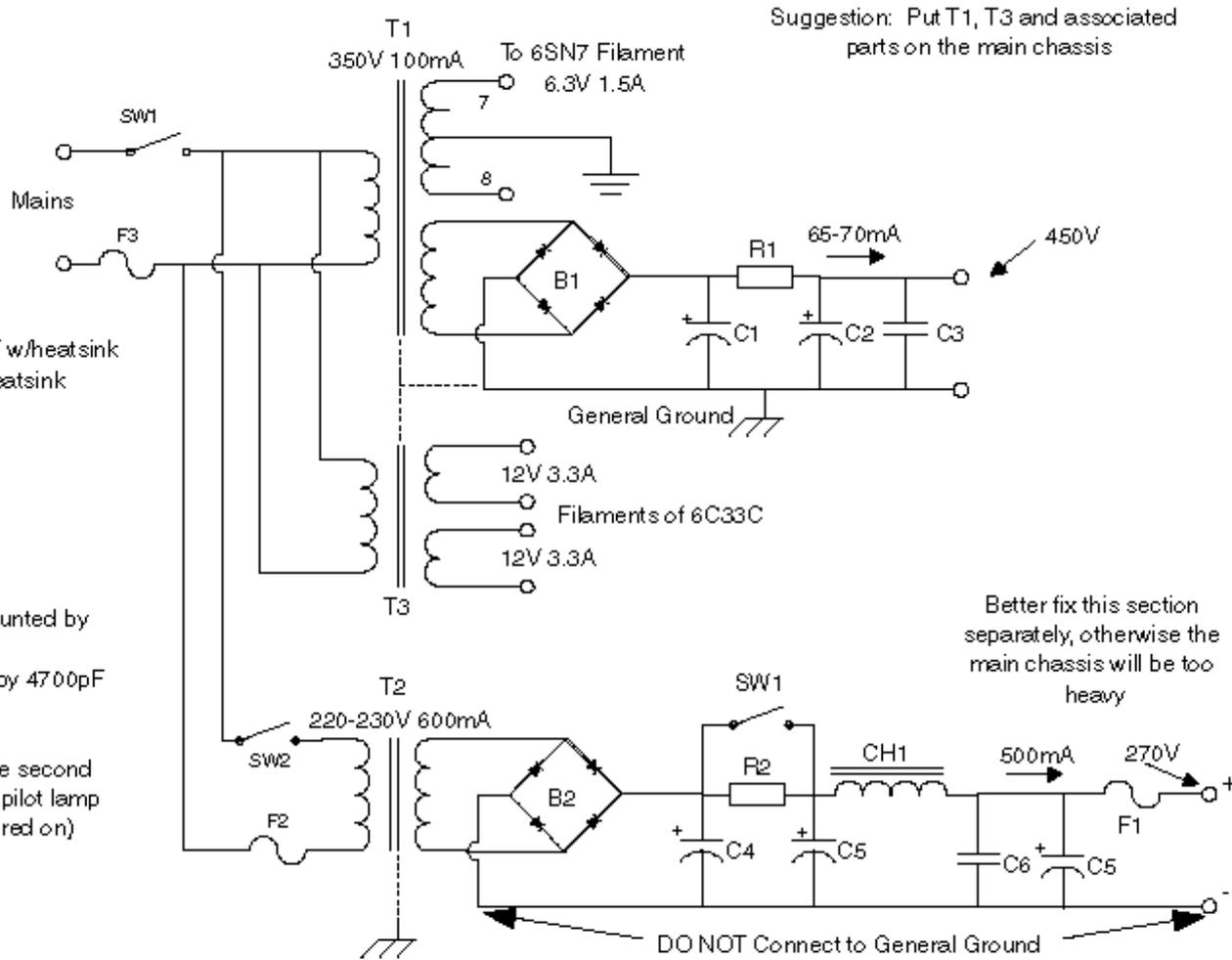
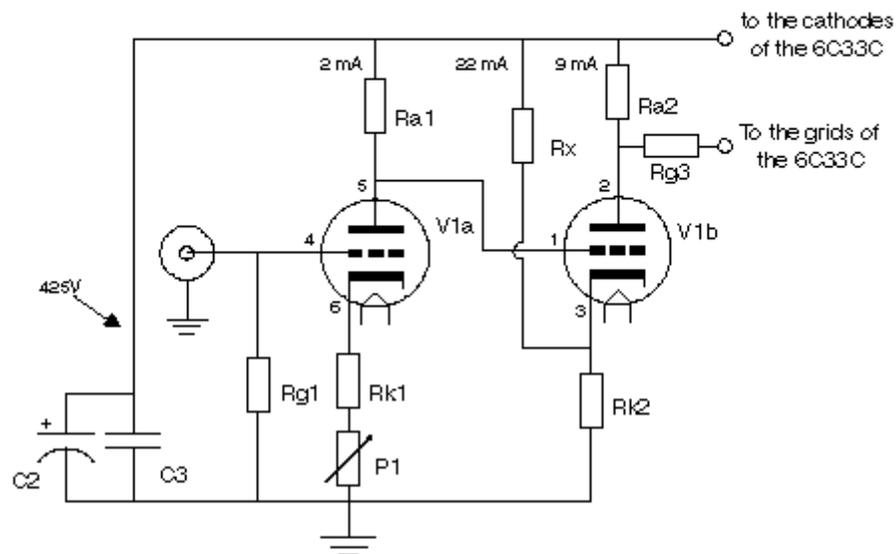


Figure 5. Power Supply Section (both channels)

Figure 1. Driver Stage (one channel)



- C2 - 470µF 450V (see Fig. 5)
- C3 - 470nF 1000V (see Fig. 5)
- Rg1 - 330K 1/4W
- Ra1 - 180K 2W
- Rk1 - 330 or 390 1/4W
- P1 - 470 variable
- Rx - 16K 20W (2 x 33K 10W in parallel, outside chassis in a well ventilated box)
- Ra2 - 10K 2W
- Rk2 - 2350 4W (2 x 4K7 2W in parallel)
- Rg3 - 2K2 - 2K7 1/4W
- V1 - 6SN7GTA/GTB

the power supplies, considering that this subject is recurrent in almost every description of an audio amplifier. As per Fig. #5, you need TWO, different ones. Why will be explained later in the text. The first, intended for the driver sections, must be able to deliver 425V at about 100 mA (actually each driver requires approx. 32 mA) and the second, for the 6C33Cs, 270V at 500-600 mA idle (in total, that is, for both power tubes). I decided to use one transformer (T1) just for the driver section, another (T3) for the 6C33C filaments, requiring (each valve) 12.6 V at 3.3 A.

A third, separate transformer of 150-200VA was meant for the B+ supply of the 6C33Cs. A 110-220V to 220V mains insulating transformer would do, because you need to have 220V across the rectifying bridge (I used four 1N5408 diodes, rated 1000V 3 Amps, followed by a 220 μ F 350V good quality electrolytic). From my experience, it is better to build, at first, the driver section and its power supply on one chassis, on which you fitted, at the same time, the 6C33C's sockets. No output transformers, for the time being, to have the chassis lighter for tests and measurements.

The dimensions recommended for this chassis (not including the Power supply for the 6C33Cs - see next paragraph) are no less than 12" x 16" (30 x 40 cm.). This accommodates both channels, with their OPTs. Also, an advisable solution is to have the power supply for the Power Tubes physically separated, in a metal box and connected to the main chassis with a three-wire cord (+270V, Null and control wire, if necessary).

The Driver Section

One of the classic circuits I admire is the direct coupling used by Williamson in his famous amplifier: the first triode's plate connected directly, that is, without any blocking condenser, to the grid of the second triode. The potential of the cathode must be higher, to ensure the necessary bias (between - 7 and - 9 V, depending on the actual characteristics of the tube used). In the Williamson, the second triode is also a phase inverter. We do not need it here, because of the single-ended topology.

Let us have a look at Fig. #1. V1a is the first section of the 6SN7 (pins 4, 5, 6 preferably). Its plate (pin #5) is connected directly to pin #1 (grid of the second triode). You will notice the usual grid resistor Rg1, connecting the input "i" to ground, as well as Rk1 and P1, both acting to provide the cathode bias to V1a. The purpose of P1 is to vary the bias of V1a as required, within certain limits. We will see

later why, but we can state immediately that the adjustment of P1 also varies the potential level of the anode of V1a (which is directly connected to the grid of V1b), with respect to the cathode (pin #3). The consequence is that also the bias of V1b changes, modifying the plate current. The plate load of V1b, the resistor Ra2, catches a different voltage, depending on the setting of P1. In other words, P1 controls the voltage drop across Ra2.

What is the purpose of Rx? This hi-wattage resistor supplies an extra current to Rk2, adding to V1b's idle anode current. This layout has two main effects:

a) the local negative feed-back, taking place because of the absence of a by-pass condenser across Rk2, improves the performance of V1b (in fact I measured a drop of 75% in THD) at the expense, of course, of a reduction of gain by almost the same proportion;

b) The extra 22 mA current supplied by Rx, reduces the need of a higher value resistor Rk2, still providing for the voltage level to counter-act V1a's plate voltage (remember that the bias of V1b is the difference between the Voltage at pin 5 and pin 3). The advantage is that the ratio Ra2/Rk2 is improved and because the gain of V1b depends on this ratio, the amplification jumps from 1 to 4, approximately.

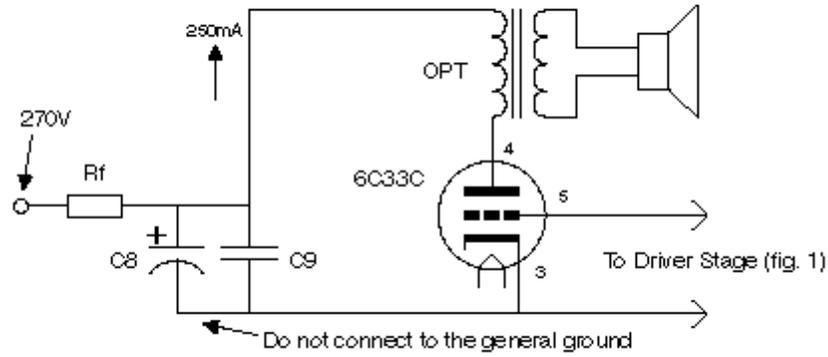
Just a word on Rg3. It has become a habit to fit a small (few kilo-ohms) resistor, before the output tube's grids, to avoid any parasitic oscillation.

The Output Stage

Now, how is the driver connected to the power tube? Very simple: plate to grids, because the 6C33 has 2 grids (pin #5), without any blocking condenser (just Rg3, as explained above) and B+ terminal to cathodes (Pin #3). This is made possible by the fact that there are TWO dedicated power supplies, one for the driver and one for the output tubes and they do not have their negative terminals connected together. In fact, the Power stage's B- is, instead, connected to the Driver stage's B+. Fig. #2 illustrates the power section. The polarity of the voltage across Ra2 suits the bias requirement (minus to grid and plus to cathode).

Now, please do not tell me that this is a complication. What difference does it make to have two smaller transformers instead of a single but bulky and heavy one with a lot of outgoing wires? It is true that you need two different filtering sets, and this is quite expensive, but, in

Figure 2. Power Stage (one channel, simplified)



Rf - 10 - 15 2W (filtering and measuring resistor)

C8 - 1000uF 385V

C9 - 470nF 1000V MKT

OPT - Must be the following:

Z = 800 ohms

Turns Ratio 10:1

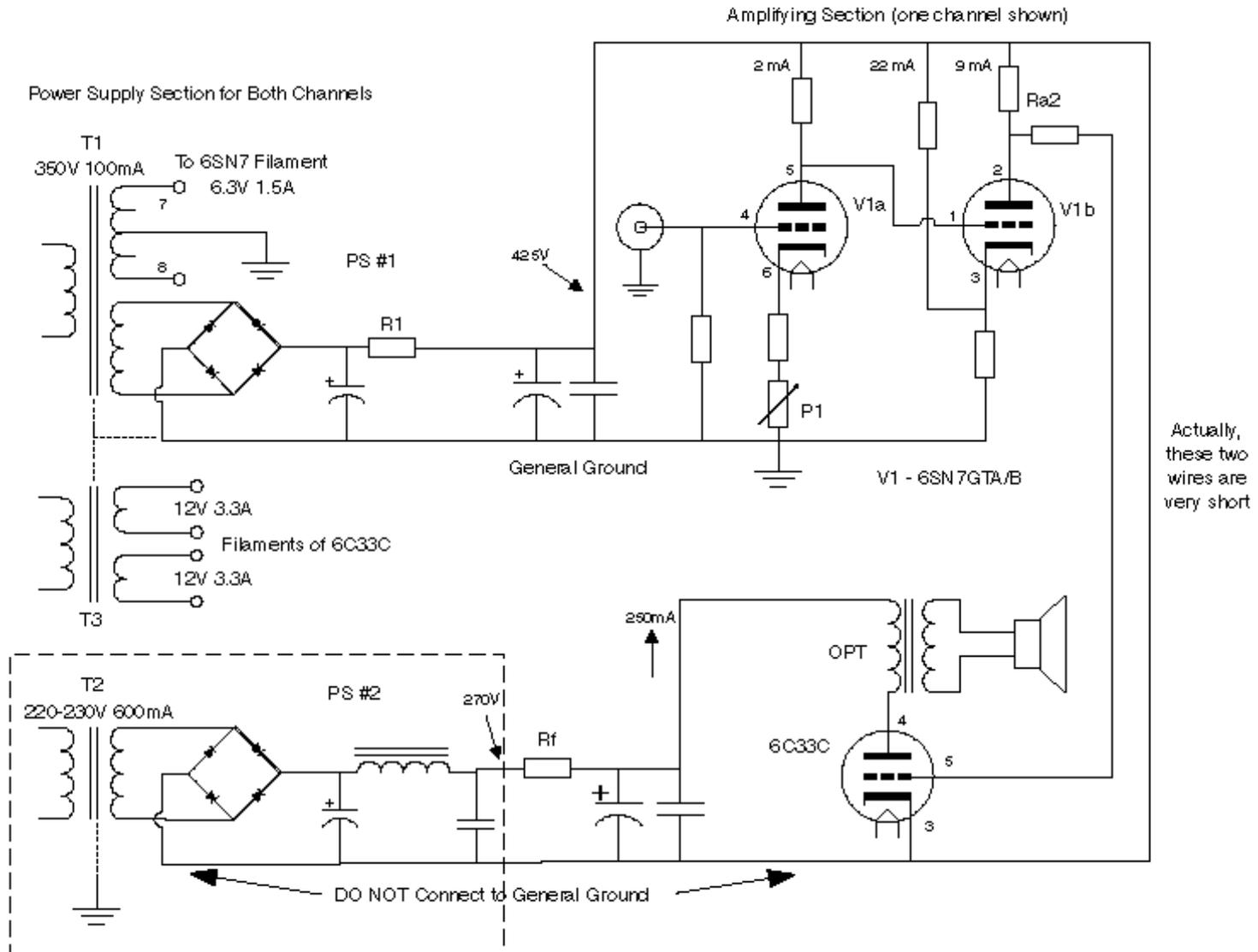
Nominal Power > 20W

Max. Current 500mA

Frequency Range 20Hz to 40KHz

Primary Resistance < 80 ohms

Figure 3. General Layout



Actually, these two wires are very short

any case, you always have to separate the output stage power positive voltage source and the driver source with some kind of resistor/choke plus condenser combinations.

You can now examine the general architecture of the amplifier in Fig. #3. Note how few are the components of the amplifying/power stages. The root "simple", of the word SIMPLEX is thus explained.

With regard to the power supplies, unfortunately there is nothing I can do to reduce their size nor the number of components. The more they are generously furnished, the better the amplifier's performance, within certain limits, of course. Just one additional word on the subject: T3 (Fig. #3) is better located on the main chassis, not too far from the 6C33C sockets, because of the high current flowing in the wires. Fig. #4 shows the area reserved for the driver section as well as for T3 (approx. 8 x 16 inches). The output transformers find their place on the back corners, thus requiring an extension of the above basic area to 12 x 16" ; however, in the topology I have chosen, the 6C33Cs are in the front row and the OPTs on the sides. If the amplifier is at reach of inexperienced persons, make a provision to surround at least the output tubes with a protection against burns.

Testing the Driver Section

Going back to Fig. 1, you will notice the expected currents in the three branches (V1a anode, V1b anode and through Rx), but this is just orientative. Assuming the PS voltage is close to 425 Volts (if not, you can replace R1 - Fig. 5, by a suitable resistor), you should measure about 65V at pin 5 (same as pin 1) of the 6SN7, with respect to ground.

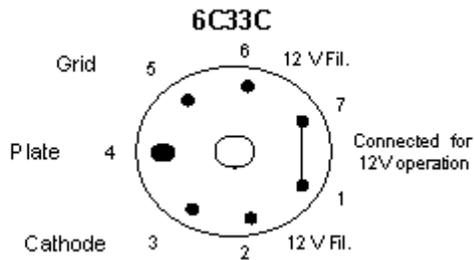
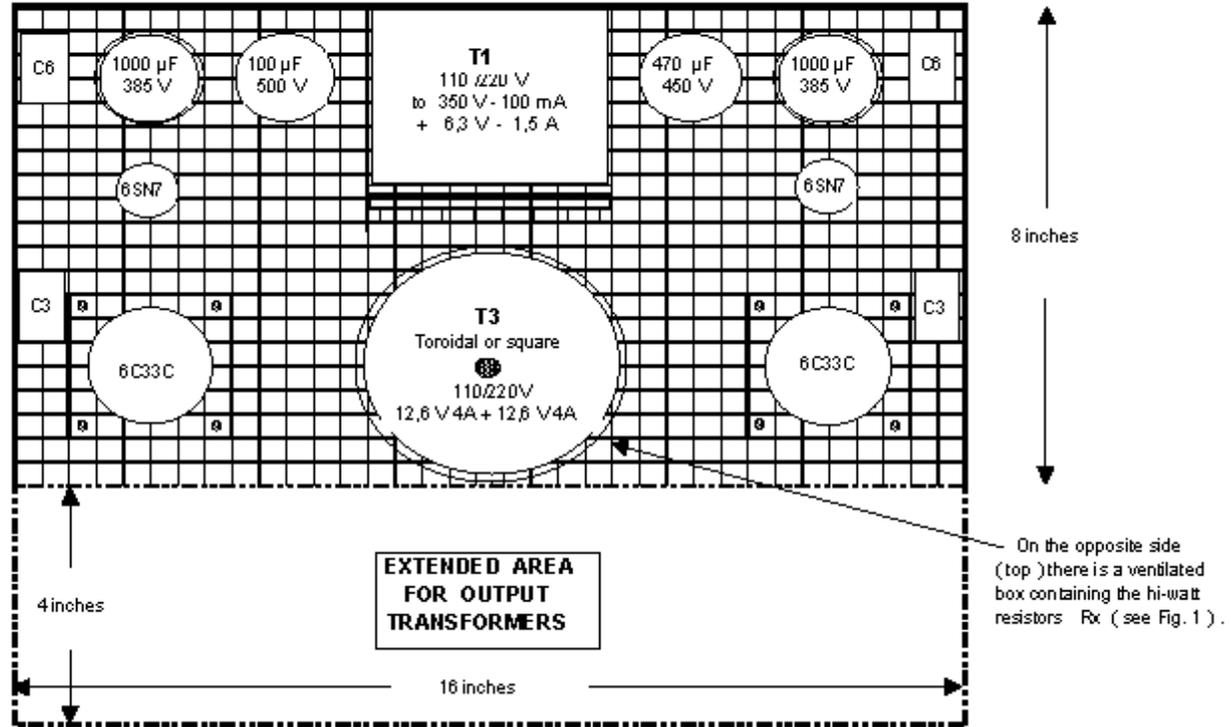
The opponent voltage present at pin 3 should be higher, but by less than 10 Volts (say 73V to 74V with respect to ground. Any difference is due to the tolerances of the components, including tubes. What matters is the anode current of V1b. By adjusting P1 you should be able to have a drop of 90V across Ra2 (Fig. 1). If the drop is lower even at P1's limit, set P1 in the middle position and find a suitable shunting resistor (normally 33K 2W should do) to reduce Rk2's value. The plate current of V1b should increase and so the drop across Ra2. When both 6SN7 are checked, your driver's channels are ready.

Testing the Power Section

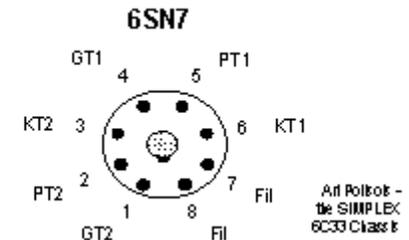
The DC power is supplied to the output tubes through a

4

THE MAIN CHASSIS
(View from inside).



MAX. RATINGS	
	6C33 6SN7GTAB
Plate voltage	400 450 V
Cathode current	600 20 mA
Plate dissipation	60 3.75 W
Filaments	2 x 6.3 6.3 V
Current	2 x 3.3 0.6 A



low ohm resistor (10 to 15 Ohms 2W). I have fitted two 13 ohm 3W resistors (available), one in each channel path. This addition serves three purposes:

- it allows measuring the anode currents of each power tube (these should be 250 mA each but, actually can be substantially different, even with the same bias level)
- it adds another filtering section to the common one included in the 270V power supply box (as mentioned, this power supply is kept far from the main chassis and OPTs)
- It reduces the interference of one channel with respect to the other.

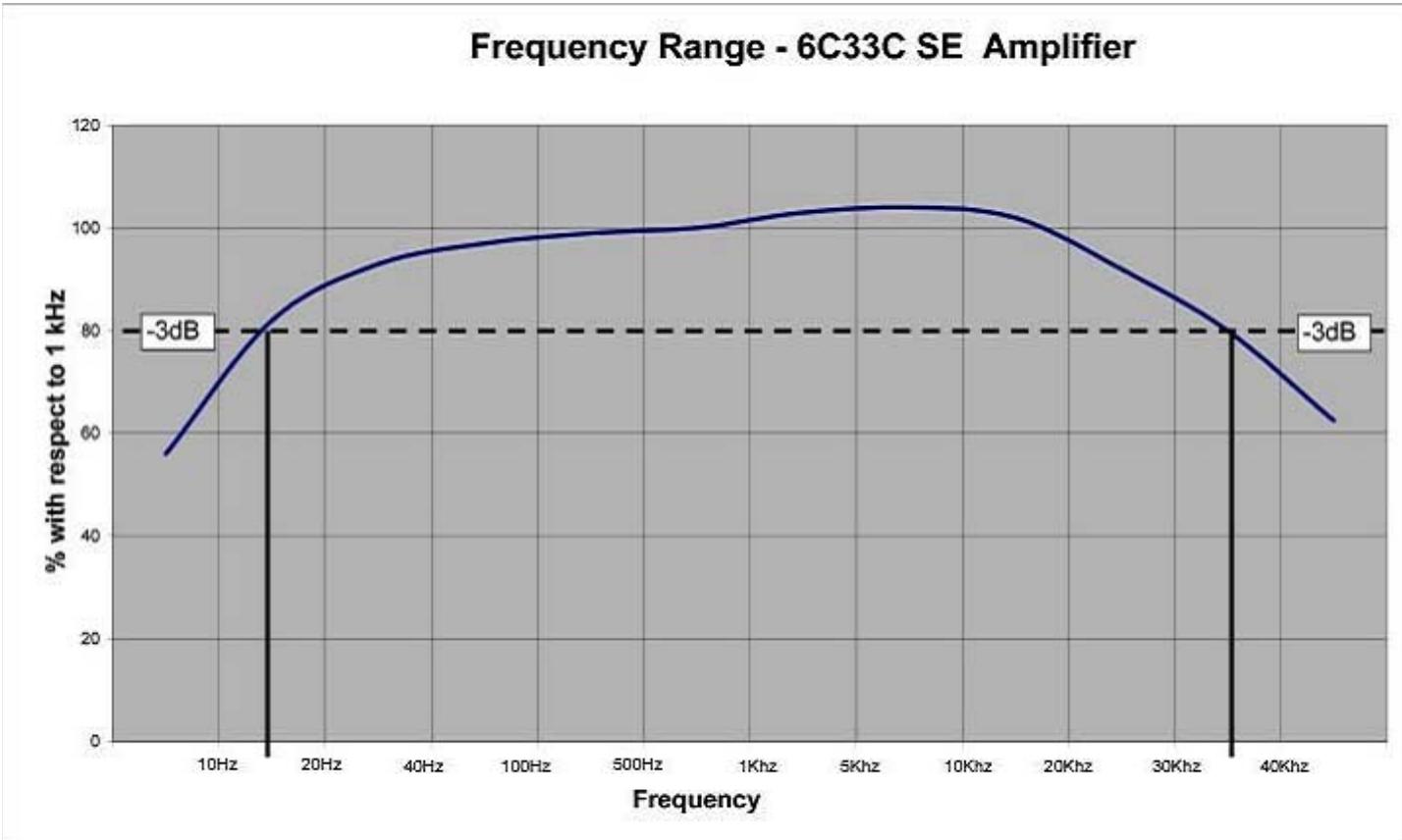
Now here comes a good question, with regard to A. What if, having adjusted the bias of the 6C33C at -90V, we find a higher or lower plate current? Well, if it is lower, we can try first another 6C33C, to replace the "weak" one or, we can reduce the bias, say to -85V, until we get a plate current of about 250 mA. But if it is higher, we better not exceed 270-280 mA (playing with the bias level) or we might damage the OPT (not the 6C33C, because it withstands higher currents). In any case, we must watch not to exceed the rated admissible power dissipation, of 60W, by more than 10%. Usually, with a regular tube, this case remains theoretical.

Lowering or increasing the bias level, I found, does not change noticeably the overall performance of the amplifier. I tried with a bias of -85 V up to -100 V. The anode current consumption varied a lot and probably, with the lower bias tests, the life of the 6C33C was somewhat shortened, but I cannot tell, at present, by how much.

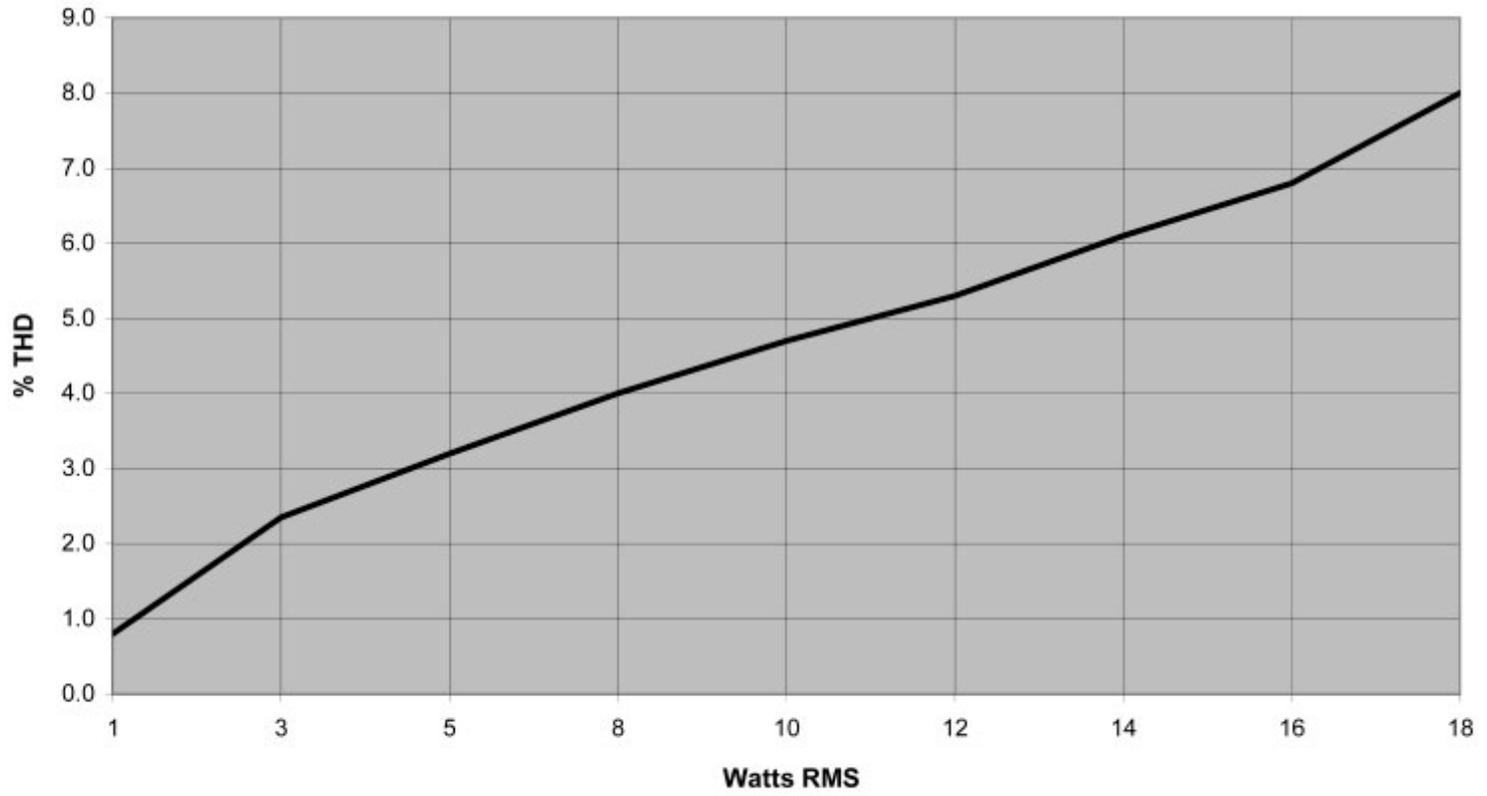
The presence of high capacity filtering condensers has suggested to insert R2 after the reservoir capacitor C4. This relatively high value (and wattage) resistor allows a slower charge of C5 and C7. Within a minute or so, SW1 can be manually operated to short-circuit R2 and allow the full amount of current to flow. This could also be done with a relay, operated from the main chassis, using the third wire connecting the latter to the PS Box.

The Output Transformers

Fig. 2 gives a general indication of their characteristics. The OPTs I used are custom made and work fine, as can be seen in the graph of frequency range and output power vs. THD. No other measurements have been made



6C33C SE Amplifier - Output Power vs THD



so far. If you can find a suitable transformer from a commercial source, make sure its primary can withstand at least 400 mA. The ratio 10:1 allows a good power transfer. 7:1 can give more power but also more distortion. I hope to be able to give more details on this subject in a coming article.

WARNING: the amplifier is super up to the OPT connection. If you use a low grade output transformer, you loose a lot of brilliancy.

Questions

This chapter, I presume, should have been located at the beginning and not at the end of the text. I refer to the main question many of you have in mind: "Why not use a regular blocking condenser, instead of a direct coupling between the driver and the output tube, requiring two power supplies?"

Let me ask you: Are you aware of the damages to the sound, made by this cap? And also: Only if you listen to the SimpleX you will be fully convinced, because of its Excellent sound. If you don't believe what I say, you have two main choices: forget this amplifier or build it and check.

Should you have other questions, I suggest to contact me by e-mail and I'll do my best to answer.

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SIMPLEX Redux

Resistors Explained

Starting from figure 1, the function of Rk1 and P1 has been already explained. Ultimately, they govern the plate current of the output valve 6C33C-B (see The Driver Section page from my article, The Simplex).

A recommended upgrade is to bypass the 470 ohm pot with a 1K 1/4W fixed resistor, moreover, use a good quality pot, for instance a Cermet, which has the reputation to last much longer, and to not produce scratchy noises. The natural tendency is to adjust this pot too often. Just wait until the 6C33s are warm enough and their anode current settle at their normal operation level.

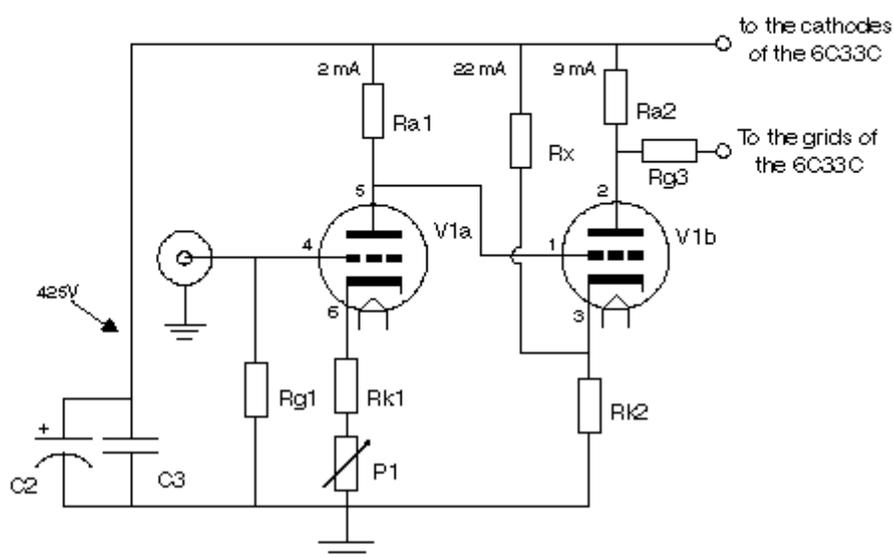
The value of Rk1 might need to be changed to a higher value, say 470 ohms, should the voltage measured across Ra2 be lower than the one required (between 85 and 95V when P1 is half way).

Paul Joppa defined the pair of resistors Rx and Rk2 a voltage divider. This is actually a better definition than mine. I had considered Rx an auxiliary source of current for Rk2, to raise its potential with respect to ground. A voltage divider gives the idea of a more stable voltage setting and, in fact, in the DCMB driver circuit described, the variations of the anode current of V1b being a small fraction of the current supplied through Rx, the V-level set by Rx-Rk2 does not change significantly.

by
Ari Polisois ©2002

Focus on the novel performance of the Simplex 18W SE Amp, published last issue, and making some improvements

Figure 1. Driver Stage (one channel)



- C2 - 470uF 450V (see Fig. 5)
- C3 - 470nF 1000V (see Fig. 5)
- Rg1 - 330K 1/4W
- Ra1 - 180K 2W
- Rk1 - 330 or 390 1/4W
- P1 - 470 variable
- Rx - 16K 20W (2 x 33K 10W in parallel, outside chassis in a well ventilated box)
- Ra2 - 10K 2W
- Rk2 - 2350 4W (2 x 4K7 2W in parallel)
- Rg3 - 2K2 - 2K7 1/4W

V1 - 6SN7GTA/GTB

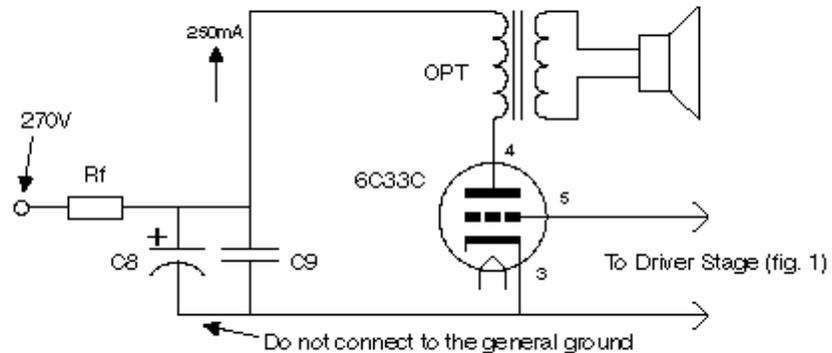
In addition to the increased gain (due to the improved ratio $Ra2/Rk2$), the amount of negative feedback caused by the V1b's plate current is reduced to a more acceptable value.

Rg1 left and right channel can be replaced by a twin volume control, such as an ALPS or similar, audio-taper 20K or 50K. I found this necessary when connecting the amp directly to a CD source, because some CDs are recorded at loud levels. With this direct connection, you gain much in quality, unless you have a perfect preamp.

Power stage

It is convenient to have a stable voltmeter connected to R_f , one for each channel.

Figure 2. Power Stage (one channel, simplified)



R_f - 10 - 15 2W (filtering and measuring resistor)

C_8 - 1000 μ F 385V

C_9 - 470nF 1000V MKT

OPT - Must be the following:

$Z = 800 \text{ ohms}$

Turns Ratio 10:1

Nominal Power > 20W

Max. Current 500mA

Frequency Range 20Hz to 40KHz

Primary Resistance < 80 ohms

You get, at first glance upon closing SW1 (shown in Figure 5 of the original article), an idea of the anode current flowing in each 6C33, from the start until when they are hot. My experience shows that it is always more or less the same at the beginning and later. However, when the 6C33 tubes age, this stability might be upset, therefore you will get an indication of what is happening just by looking at the meter. Remember one of the points I had in mind when designing this amp is a "user friendly dialogue", simplifying the diagnosis in case of problems. These two voltmeters are good witnesses of the 6C33s health.

On the other hand, P1 corrects, to a certain extent, the aging consequences of V1. When it fails, the 6SN7GTA/GTB is to be replaced with a suitable one (of same characteristics as regards plate current capability).

Power supply

As explained, the switch SW1, manually operated few minutes after turning the amplifier on, allows a smoother charge of the "heavy" 1000 μ F/385V electrolytics.

However, in spite of a red "warning" pilot lamp, connected as per figure 5B, I happened to forget SW1 closed, losing all the benefits of its inclusion in the circuit. A good way to automate the operation is to insert a pair of relay contacts, as shown in the same figure. I would not remove SW1, operated manually, but use it in conjunction with the automation provided by relay.

Figure 5B shows the relay RL1. There exists quite a wide voltage difference between the on and off conditions of a relay. This depends upon the resistance offered by the moving armature to the attraction of the coil, which in turn depends on the distance between the latter, as well as on the strength of the spring. In our case, we need this relay to be very sensitive to a change in current.

It should be in the on state when the correct current is flowing in its coil. This is typically twice $22\text{mA} + 2\text{mA} + 9\text{mA}$, where 22mA is the current flowing through Rx, and 2mA and 9mA being the anode currents of each 6SN7 section. Therefore, a 66mA current will actuate this relay. Suppose we choose a 24VDC operated relay (nominal):

A) First we have to measure at which effective voltage (surely below 24V) this relay will work. Suppose we find 18 V, but decide to consider 20V, to have some tolerance. The formula $R=V/I$ will give us the effective resistance that we need to operate the relay with the chosen current, in our case 66mA. We obtain:

$$R=20/0.066= 303 \text{ ohms.}$$

Suppose our relay has an resistance of 500 ohms instead. We need to reduce this value to 303 ohms, with the help of a shunting resistor. The formula to be used is $R_{sh}=(R_{rl} * R_{ref}) / (R_{rl} - R_{ref})$, where R_{sh} is the required shunting resistor; R_{rl} is the resistance of the relay coil, and R_{ref} is the effective resistance we need to be crossed by the current. In our case:

$$R_{sh}=(500 * 303) / (500 - 303) = 769 \text{ ohms.}$$

We will use a somewhat larger standard value, say 810 ohms, to cope with a slightly lower current. With the

For 110V Mains
 F1 - 1A Time Delay
 F2 - 3.16A Time Delay
 F3 - 3.16A Time Delay

For 220/230V Mains
 F1 - 1A Time Delay
 F2 - 2A Time Delay
 F3 - 2A Time Delay
 R1 - 470 - 600 ohms 25W w/ heatsink
 R2 - 470 ohms 50W w/ heatsink
 R3 - 150K 1/4W
 C1 - 100uF 500V
 C2 - 470uF 450V
 C3 - 470nF 100V MKT
 C4 - 220uF 450V
 C5 - 1000uF 385V
 C6 - 470nF 1000V MKT
 C7 - 1000uF 385V
 C8 - .1uF 400V
 B1 - 4 pairs of 1N4007 shunted by 4700pF 1000V caps
 B2 - 4 - 1N5408 shunted by 4700pF 1000V caps
 CH1 - 5H 600mA Choke
 SW1 - 250V 3A DPST (the second section can be used for a pilot lamp showing that PS2 is powered on)
 SW2 - 250V 6A SPST
 SW3 - 250V 6A SPST
 RL1 - 12V 60mA Relay, contacts 250V @ 2A - See Text

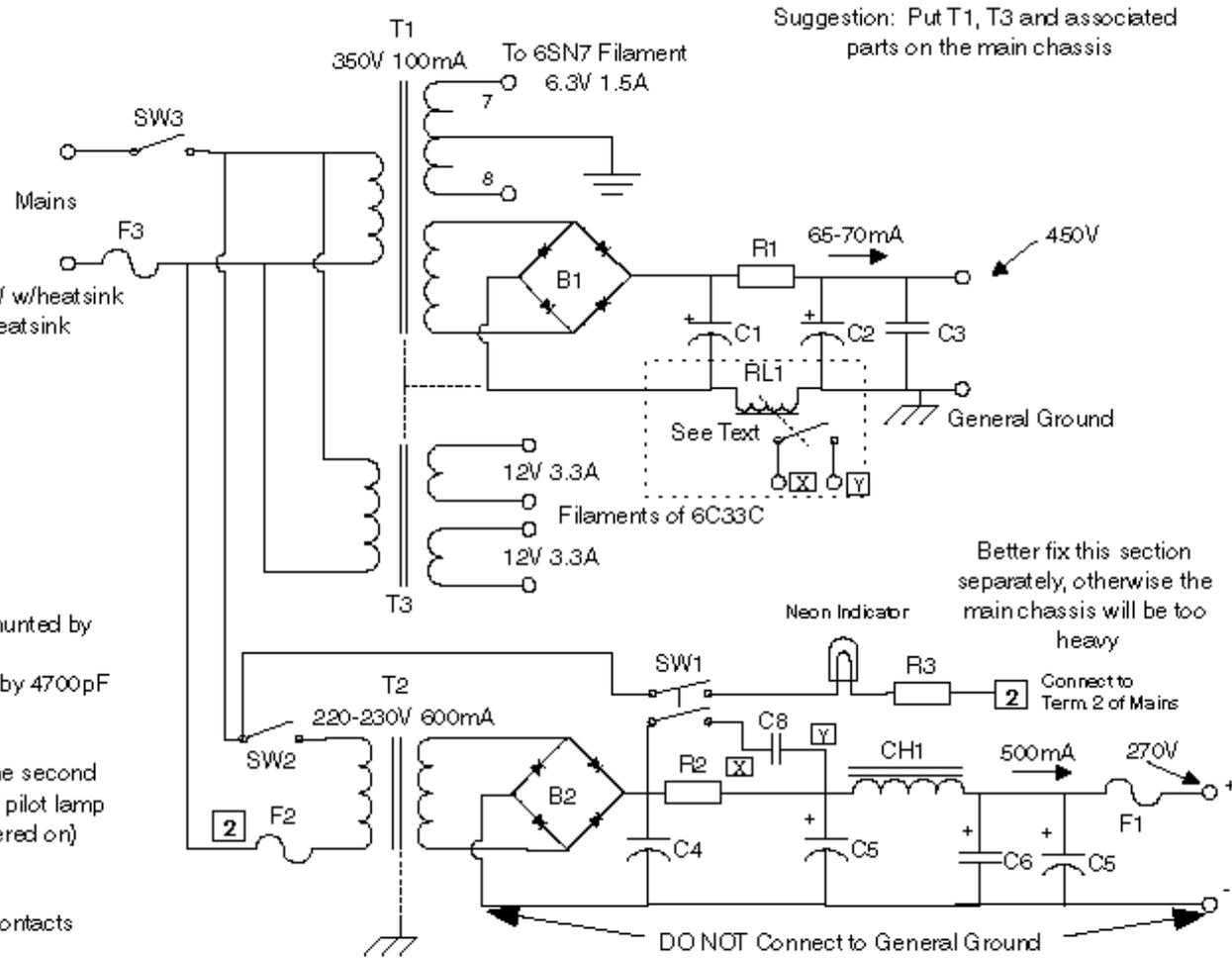


Figure 5B. Power Supply Section (for both channels)

same formula above, we will find the new effective resistance crossed by the addition of the above resistor in parallel:

$$R_{ef} = (R_l * R_{sh}) / (R_l + R_{sh}) = (500 * 810) / (500 + 810) = 309 \text{ ohms.}$$

The 20V level required to actuate the relay will then be reached with a lower current. This is given by the formula $I = V/R$, which equates to $20/309 = 0.0647$, or 0.065mA. If we need to increase the tolerance, we can fit a shunting resistor of approximately 1K. In such case, 60mA will suffice to actuate the relay.

NOTE: The adjustment of the relay sensitivity needs to be performed without any connection to the amplifier.

B) Now comes the more delicate step: to make sure that the relay will go OFF, with the smallest (but reasonable) drop of current level. We can size this drop to pretty close the current drawn by just one of the driver tubes (9+2mA), for instance 8mA, so that, in case the tube failed, for any reason, the relay contacts would open, making the output tubes power supply quiescent.

We could use an IC, or just a transistor operated system, but here is what I consider the simplest.

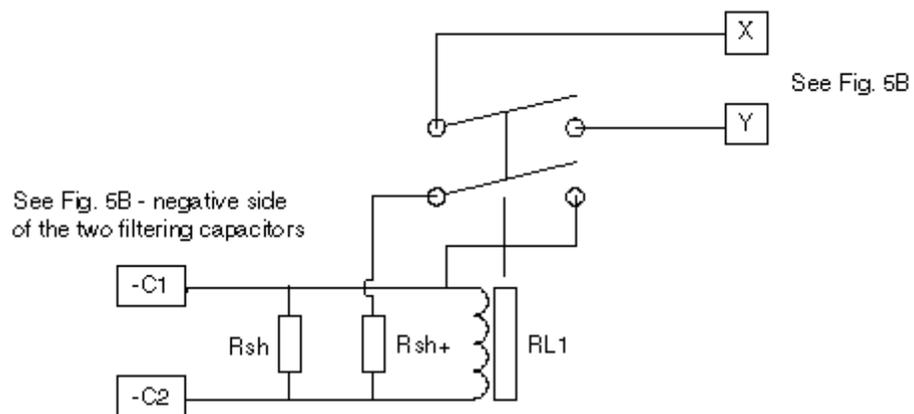


Figure 6. Power Supply Relay Detail

In Figure 6, we have TWO shunting resistors close to the relay. Rsh- is always connected, and the other, Rsh+ will connect as soon as relay RL1 is actuated. When shunted by a second shunting resistor, the coil gets closer to the voltage below which it fails to be ON. In other words, the threshold value at which the armature is released.

The value of Rsh+ must be calculated in such a way that, when the current flowing in the coil of RL1 drops by just about 8mA, the relay contacts open. We could calculate this value theoretically, but, instead, let us proceed by trial and error. We will need to connect a potentiometer instead of Rsh+. An approximate value for this pot, full scale, could be three or four times the resistance of the relay coil.

The relay coil is already shunted with the resistor Rsh that allows the armature to be attracted at the specified current (in our case 66mA). We now need to find the value of a the second shunting resistor (Rsh+) that will reduce the attraction of the armature to the point that, if just 8mA were missing, the armature would be released. The procedure requires an adjustable DC source of, preferably, at least four times the voltage that operates the coil. Therefore, if the coil operates, nominally at 24 Volts, the source should be 100V.

Moreover, we need to insert a milliammeter, to monitor the threshold current setting. Its range must be selected close to the relay operating current. Below are the steps:

- Before turning the voltage source ON, set the potentiometer to its maximum value.
- Set the DC source to a low value.
- Connect the DC source (in series with the mA) to terminals -C1 and -C2 and turn it ON.
- Increase the voltage applied to the relay, until the armature is attracted and the contacts close (this should happen at 66mA, if Rsh is 810 ohms).
- Reduce the source voltage until the milliammeter shows a drop of 8mA (58mA in our case). The armature should still remain attracted.
- Turn the potentiometer to reduce its resistance in ohms.
- When the relay releases the armature do not

change the setting, but disconnect everything and measure the actual value of the potentiometer resistance.

- Said value corresponds to the fixed resistor R_{sh+} , that can now replace the potentiometer. Better round the value 5-10% higher, and fit a 22 or 47 μ F (63V or greater) electrolytic capacitor in parallel with the relay coil. Both these measures will improve the relay stability. Recheck the operation to be sure it works as desired.

After this work, you can fit the relay as in Figure 5B: The specified drop in the current consumption of the driver due to a malfunction of the tubes or the resistors R_x , will cut the supply of anode current to the 6C33s.

This safety measure is not compulsory, but it ensures a safer amplifier life. In practice, however, the fuse F1 should be enough.

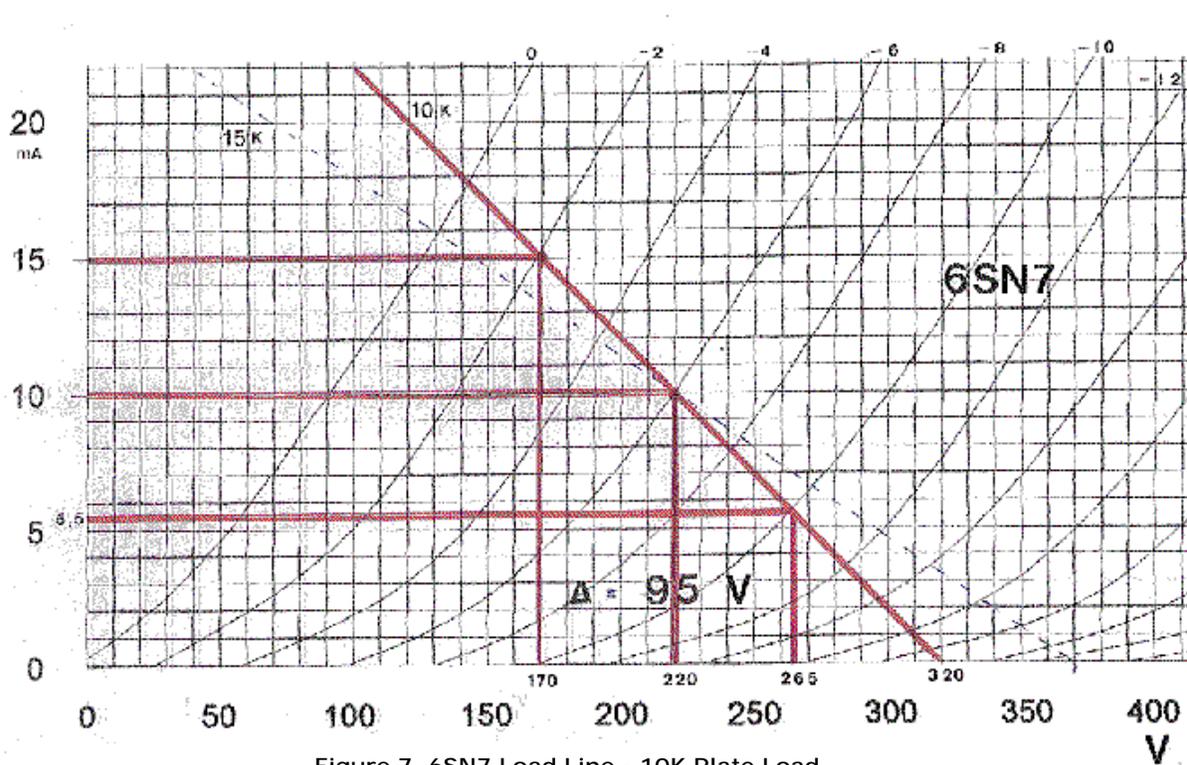


Figure 7. 6SN7 Load Line - 10K Plate Load

One way to resolve these conflicting situations is represented in figure 9 (attached). The circuit shown explains how, with the addition of an extra high-wattage high-voltage resistor (preferably two series-connected resistors), we can obtain the reduction of the voltage drop across R_{a2} , with or without some local negative feed back.

Finally, figure 10 (attached) deals with the merits of DCMB with respect to frequency discrimination, slew rate, etc.

Please do not hesitate to write for more details or explanations.

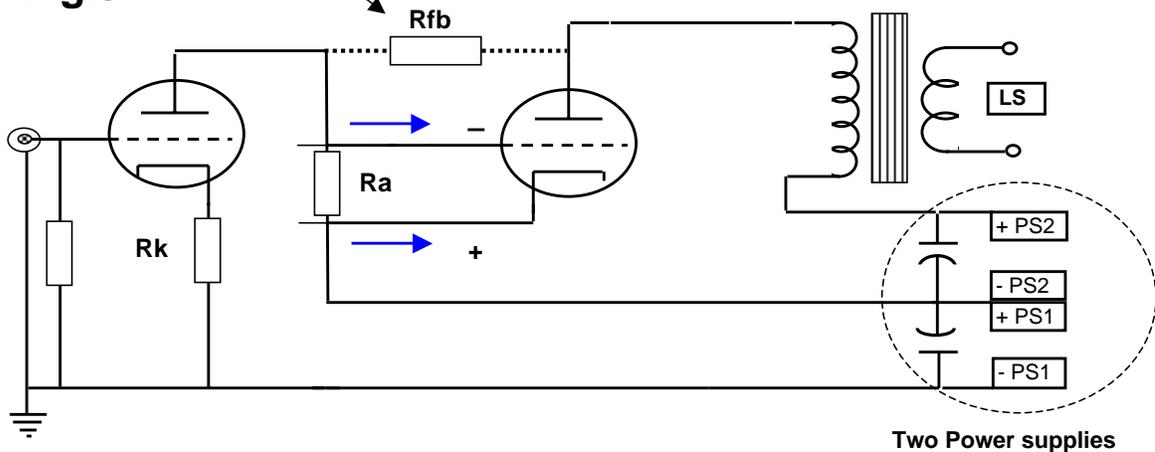
Ari Polisois
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ABSOLUTE NEGATIVE FEED BACK IN DCMB

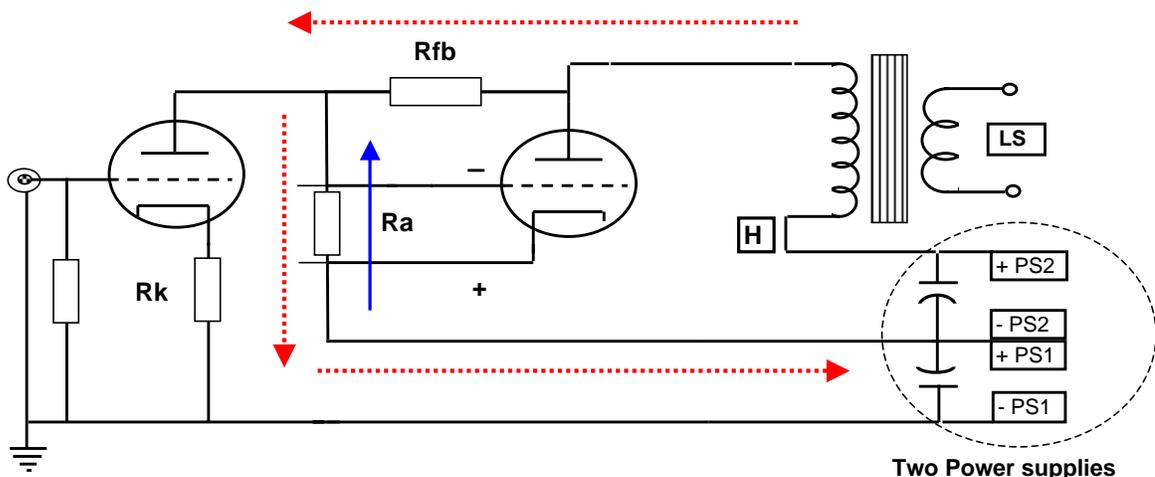
You can reduce the THD , in the DCMB layout , just

by fitting a resistor of suitable value between the output tube's anode and the driver's anode.

Fig.9



Here is what happens



PS2 supplies the load resistance (R_a) with a current (dotted line - red) , in opposition to the anode current of the driver's tube (plain - blue) .
 The result is that a negative feed-back takes place , similar in effect to the operation of a classic feed-back network , but with an important advantage : a straightforward action , controlled by the value of R_{fb} (which is generally in the range of 50 - 100 k-ohms , depending on the voltage of PS2 and the value of the load resistor , as well as the amount of the feed-back needed) .
 A subsequent article will give the formula to calculate R_{fb} 's value .

LOSS OF GAIN .

Applying feed-back results in a loss of gain . In a DCMB layout , from a direct current point of view , the effect of the opposed current supplied by R_{fb} causes the potential across the load resistor (R_a) to drop below the original level that was set to match the power tube bias requirement .

To restore this level we can increase the value of R_a , until we get again the necessary bias .
 As a result , we improve , at the same time , the ratio R_a / R_k , thus improving the gain of the driver stage and off-setting partially or totally , the loss of gain produced by the negative feed-back .

WHAT IF YOU DO NOT WANT ANY NEGATIVE FEED-BACK ?

Just connect the driver's anode , through R_{fb} , to the other side of the OPT , point H or B+ of PS2 .

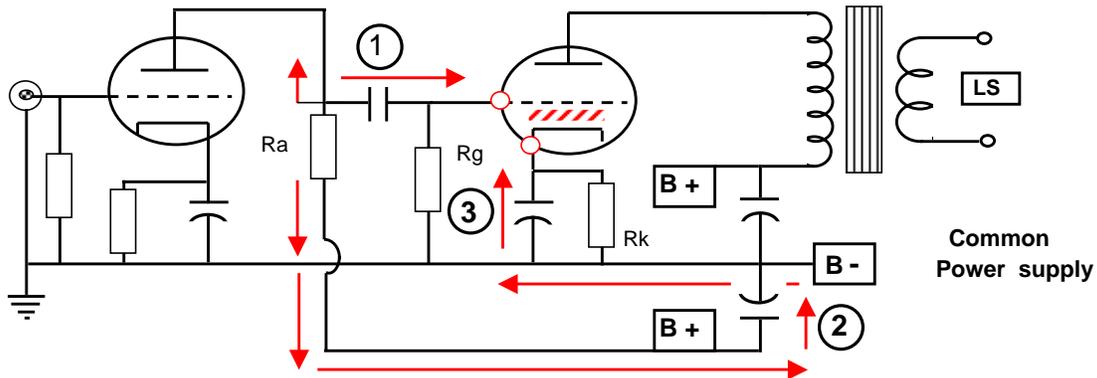
Practically , it is better to start with this solution and , after getting the correct bias , switch to the negative feed-back layout .

OR , you can use a 2T switch , to choose at will between both .

More effects will be explained later in the text .

Figure 10. FREQUENCY DISCRIMINATION

In standard circuits, signals usually cross three capacitors



The signal built up in the driver's load resistor R_a cross at point 1 from the upper side, to reach the grid on the output valve. From the lower side, they have to reach the cathode of the power tube, so they first cross at point 2 and then, if using self-biasing circuits, also at point 3.

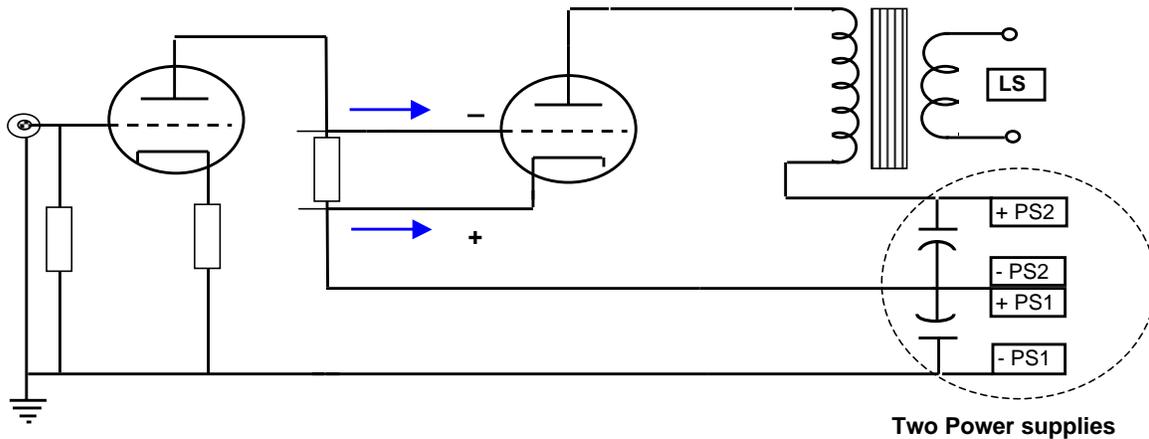
This is quite a long and stressing trip. The capacitors oppose the AC a different resistance (reactance) depending on the frequency, according to the formula :

$$Z = 1/(2 \cdot 3.14 \cdot f \cdot C)$$

where Z is in ohms; f in Hertz, C in Farads.

As an example, if capacitor #1 has a value of $0.22 \mu\text{F}$, its reactance is $1/(2 \cdot 3.14 \cdot f \cdot 0.00022) = 36,190 \text{ Ohms}$ at 20Hz , and only 36.2 ohms at 20KHz . If R_g has a value of $100,000 \text{ ohms}$, the 20Hz signal is reduced by a third, across the output tube's grid/cathode terminals, whereas the $20,000$ cycle signal is received in its full amplitude.

With D.C.M.B (DIRECT COUPLING MODULATED BIAS), This Does Not Happen



The absolute direct connection between the driver's load resistor and the grid/cathode of the following valve means no difference between Low and Hi frequencies. Every slightest variation of the signal is transmitted without loss, in Class A (*). The voltage drop across the driver's load resistor is also providing for the necessary bias to the output valve and is set to the correct polarity (minus to grid and plus to cathode).

DCBM requires two distinct power supplies but, in return, has better sonic properties. The whole amplifier is drastically simplified and the number of components, especially the capacitors, reduced. Removing the capacitors equals to reducing phase shifts (*). In a following chapter I will deal with the DCMB behaviour when there is a grid current.

THE FIRST STEP: DCMB

By Ari Polisois ©

DCMB stands for *Direct Coupling Modulated Bias*. It is a novel coupling system between valves, with many advantages that will be explained in detail. As every novel circuit, it requires some extra brain work to be fully understood, and it requires personal listening experience to convince.

WHY D.C.M.B. ?

For over half a century, designers adopted, in most of their audio amplifier circuits, the capacitor/resistor coupling between one stage and the following. This was made necessary because DC voltage present at the driving tube's anode had to be blocked. Otherwise, the same DC voltage would rush into the grid of the driven tube and cause damage. The blocking cap was sized to allow an acceptable range of frequencies to pass through it. This range, until some time ago and often even now, was set between 20 and 20,000 cycles.

Not long ago, researchers demonstrated that a wider amplified range was beneficial to the quality of reproduction, especially at the high end. For some reason, and opinions differ on the subject, frequencies beyond the human hearing threshold, when included, actively participate to shape the sonic personality of an audio reproduction device, giving it more brilliance and life. Experiments have given more credibility to this belief. Although apparently of a different nature, the following experiment has something to do with it.

An amplifier was set to reproduce a low fundamental frequency, 40 Hertz, as well as several of its harmonics (80Hz, 120Hz, 160Hz, etc...) The 40Hz fundamental was removed and, although the spectrum analyser confirmed the absence from the output signal to the speakers, the human ear still could notice its presence. In other words, the harmonics "testified" to the hearing sense that somewhere their fundamental frequency existed.

With the same logic, we can accept the fact that the inaudible sounds contribute to the timbre of the musical message. Well, maybe yes, maybe no, but, why amputate the original stream, if we can avoid this questionable operation?

Going back to our blocking caps, they really do us a favour with their "harmless" connection, in blocking DC, but they really cost a lot in terms of quality of sound. Our beloved musical message passes through it, and how do they treat him? They squeeze him and modify his personality. With the frequency discrimination they cause, the low frequencies life becomes hard. Let us see how.

On the output side of these caps you regularly find the so-called grid leak resistor, whose value is chosen, usually, between 50K to 500k. The cap has an internal resistance to AC, named reactance, determined by the formula: $X_c = 1/(2 \times 3.14fC)$, where X_c in ohms, f is Hertz, and C is in Farads.

Example: If we use a 0.22 μ F blocking cap, the calculated reactance is 36.2K at 20Hz, and just 36 Ohms at 20,000 cycles.

Supposing we have, at the exit end, a grid leak resistor of 100K, the consequences are: At 20 Hz, over one third of the signal's amplitude is "eaten" by the cap and the grid leak resistor gets only 73%. At the high end of the spectrum, the signal crosses undisturbed.

The voltage amplitude measured across the grid leak resistor is what the output tube gets as driving signal. The unfair behaviour of a cap with respect to low frequencies becomes obvious. The caps can be of excellent quality, still, they all have some kinds of internal vices that disturb the purity of the musical message (foil, dielectric, etc...) Many authors state that even the most expensive, hi-quality, cap is worse than no cap at all.

THE FIRST STEP: DCMB

By Ari Polisois ©

DCMB belongs to the well known DC coupling family, honest and straightforward, but it has some properties that make it the farthest step in the field. Consider the main dilemmas we have to face:

1. We want to hand over, to the following tube's grid and cathode, the voltage swing that the driver's gain has built across its anode load, and we want to do that instantly and without any kind of fee.
2. We want to prevent the DC, present at this load resistor's terminals, to force its way through the grid of the next tube, damaging it.
3. We do not want any capacitor's interference, such as discrimination between frequencies and generation of phase shifts.

DCMB matches the above three requirements, without unbearable compromises.

The enclosed schematics and text will illustrate how this result is achieved. With this novel layout we are going to buy a better quality, paying for it just the price it deserves. Someone could find beforehand the statement of better quality questionable. I would be surprised if this attitude still remained after self experience in building or listening. As stated above, we will have to give something in return and admit that the blocking condenser system is quite safe and handy.

No doubt many of the readers are happy with the simple and efficient RC coupling, and prefer to stick to it. I respect their choice. However, I am sure that some others seek quality improvements. Their ambitions will materialize with DCMB. Equal gain on a wider frequency band, faster handling of transients (dynamics), much lower phase shift, are promises that will be kept, provided design and construction respect the rules.

Some additional positive points will be discovered, amongst which:

- Improved damping effect in the output tube's operation, mainly because DCMB eliminates the need for a fixed bias resistor that burns, in addition, a lot of energy.
- Versatility, because it can be adapted to many output tubes, with minor adjustments.
- Economy, considering the cost of hi-quality caps, worth a bottle of Champagne each.

I will not neglect to mention, to be fair, the negative points I am aware of, and I will give the solutions I found to neutralize them, based on my 5 year experience on the subject, encompassing dozens of drivers of this kind and over ten completed amplifiers (PP, SE and SEPP). Better solutions than the ones I used must exist, as well as other undiscovered drawbacks. **DCMB is at its early age.** The more numerous we are to look at it, the faster this novel system will improve and expand, helping other friends to enjoy their favourite melodies.

Ari Polisois
April 2002

(*) not surprising that the formula of the phase angle includes capacity and resistance, namely:
Phase angle = $\tan^{-1}(Xc/R)$, when the cap and the resistor are in series, predominantly our case.

VALVE

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