VALVE

the magazine of astounding sound

SIMPLEX Redux

by
Ari Polisois *©2002*

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

Resistors Explained

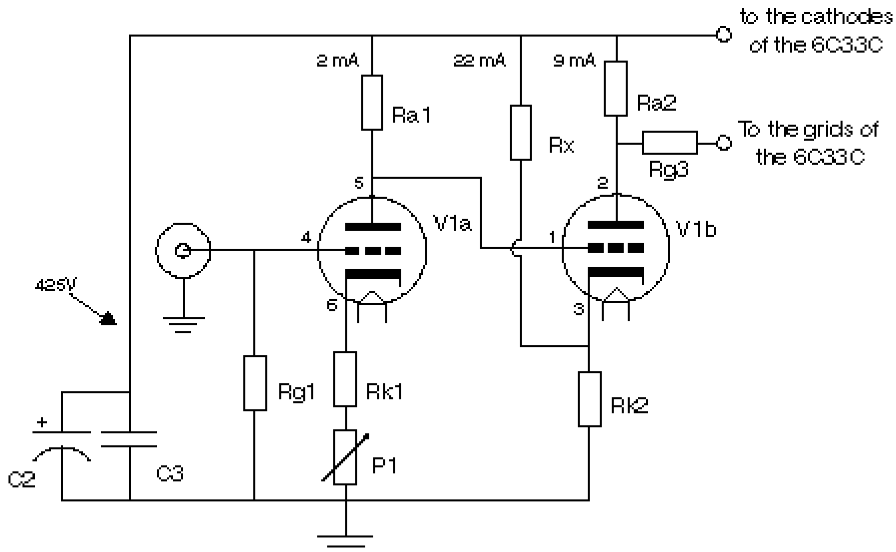
Starting from figure 1, the function of Rk1 and P1 has been already explained. Ultimately, they govern the plate current of the output valve 6C33C-B (see The Driver Section page from my article, The Simplex).

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.

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

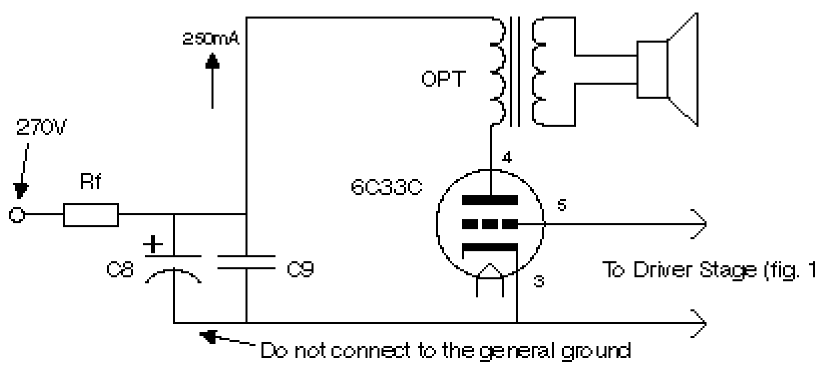
In addition to the increased gain (due to the improved ratio Ra2/Rk2), the amount of negative feed back caused by the V1b's plate current is reduced to a more acceptable value.

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 Rf, one for each channel.

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

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 µF/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 22mA+2mA+9mA, 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 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 Rsh=(Rrl*Ref)/(Rrl-Ref), where Rsh is the required shunting resistor; Rrl is the resistance of the relay coil, and Ref is the effective resistance we need to be crossed by the current. In our case:

Rsh=(500*303)/(500-303)=769 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

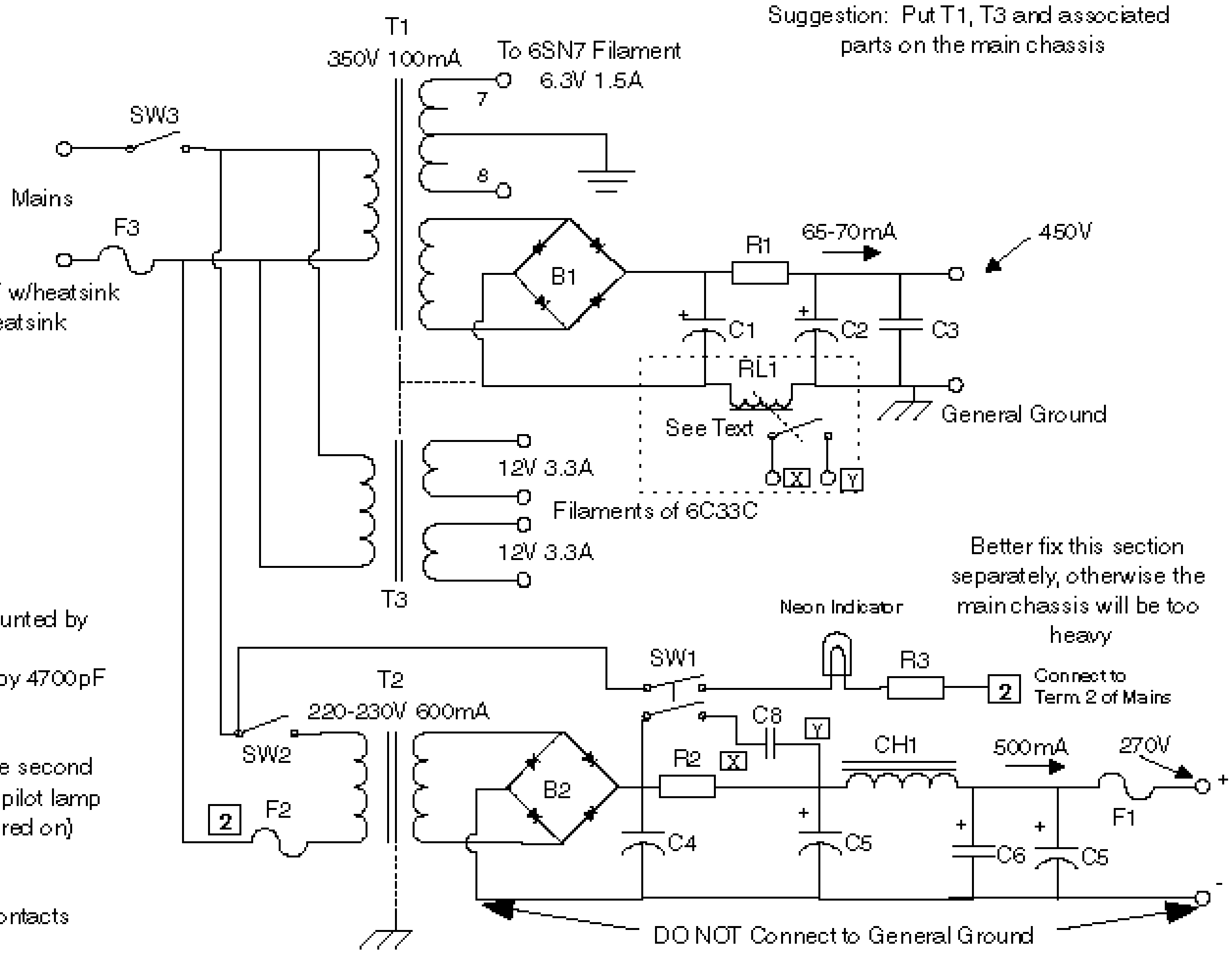


Figure 5B. Power Supply Section (for both channels) same formula above, we will find the new effective resistance crossed by the addition of the above resistor in parallel:

Ref= (Rrl*Rsh)/(Rrl+Rsh)=(500*810)/(500+810)=309 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.

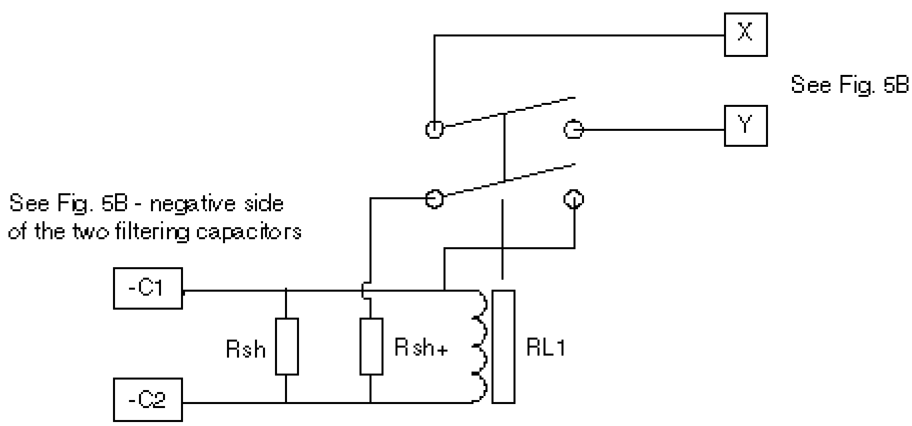


Figure 6. Power Supply Relay Detail

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 Rsh+, that can now replace the potentiometer. Better round the value 5-10% higher, and fit a 22 or 47µF (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 Rx, 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.

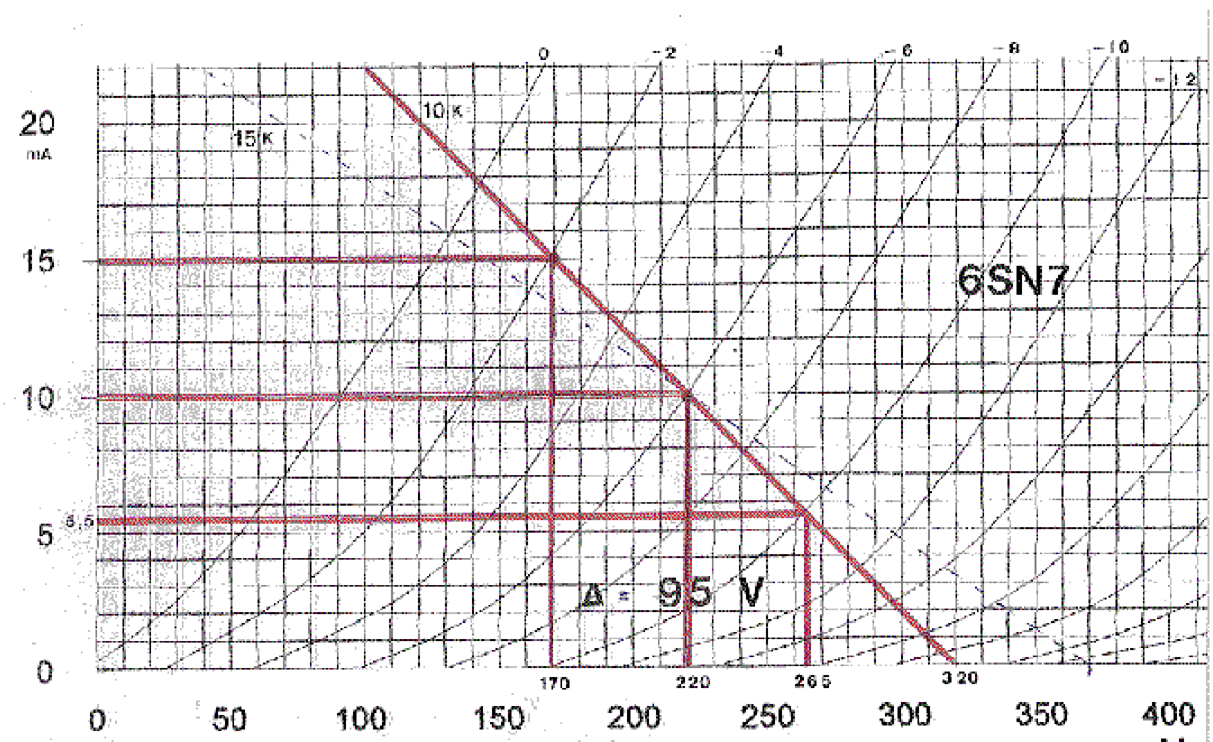


Figure 7. 6SN7 Load Line - 10K Plate Load

Working Conditions of the Driver

When a high power output is needed, a wide swing must be applied to the 6C33s grids. This means to go from almost zero bias to the maximum negative limit. As you know, this is a crowded area, meaning a higher distortion (see figure 7). This graph shows the load line of a 10K anode load (plain line). The graph is based, for simplicity, on a swing of-2V to -10V on the grid of V1b, with an idle current of 10mA, corresponding to a no signal condition bias of minus 6 Volts.

By increasing the anode load to 15K, the load line slope is modified, as per Figure 8. You will notice that, with the same signal amplitude (from -2V to -10V), the peak to peak ac voltage across Ra2 increases to about 110 Volts, instead of 95V with a 10K load (More information is available in the RCA Receiving Tube Manual, page 13 onwards). However, with the same anode current of 10mA, the voltage drop across Ra2 increases from 100V to 150V.

The B+ to the driver must be increased somewhat, in order to restore the potential at V2b's anode to the same level. It is very important that I remind you that this drop corresponds to the bias applied to the 6C33 and that this value is in excess of the requirements.

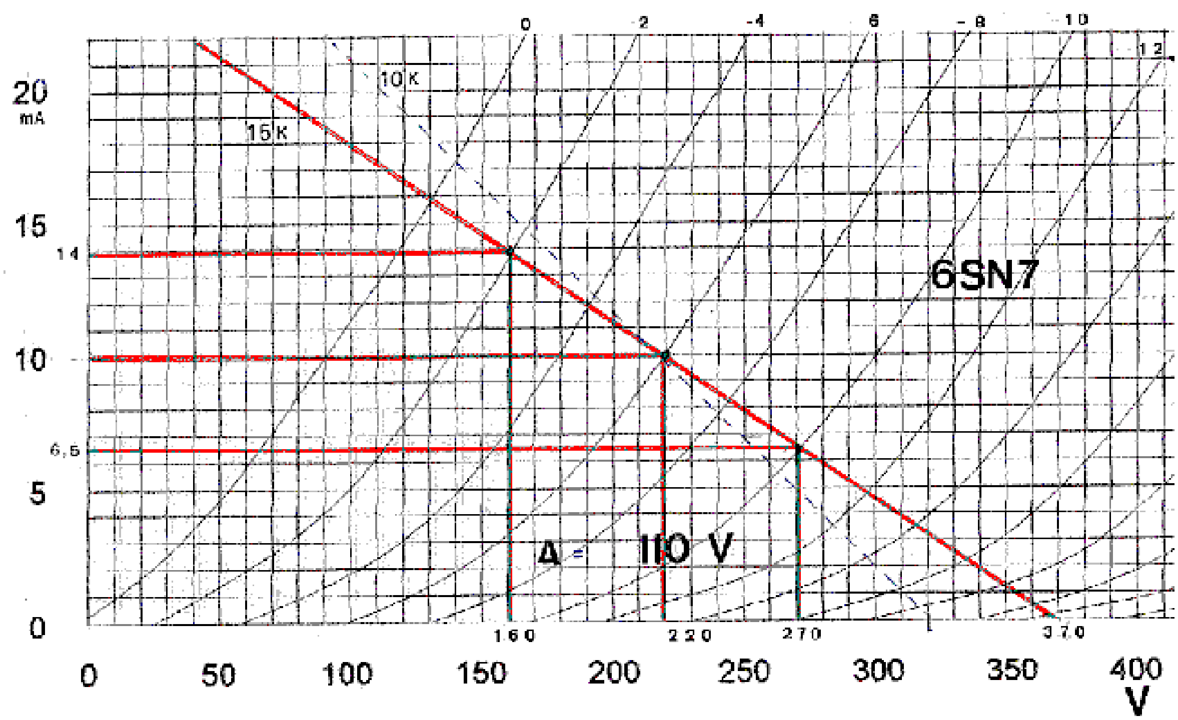


Figure 8. 6SN7 Load Line - 15K Plate Load

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 Ra2, 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.

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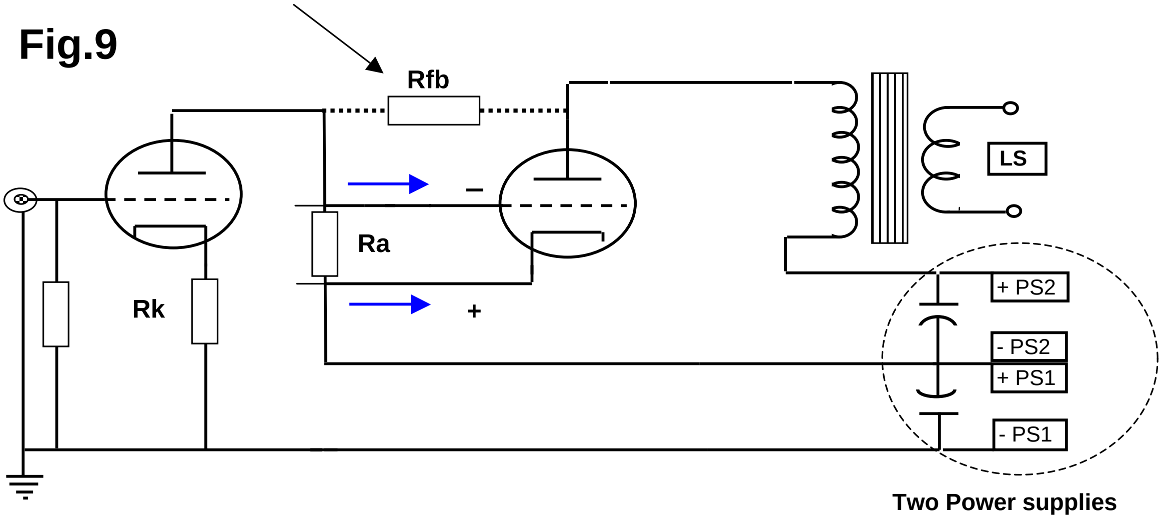
ABSOLUTE NEGATIVE FEED BACK IN DCMB

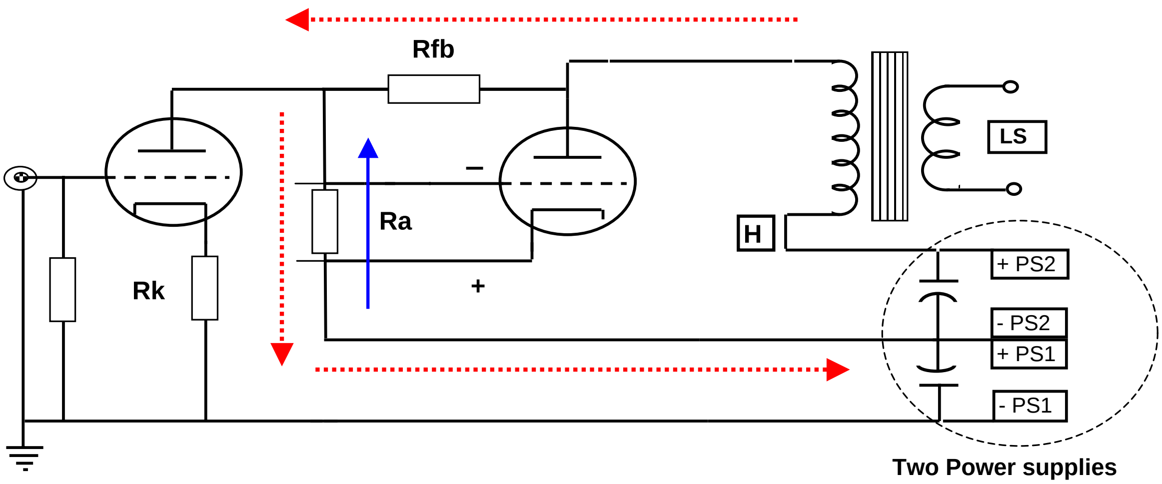
You can reduce the THD , in the DCMB layout , just

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 (Ra) 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 Rfb (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 Rfb'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 Rfb causes the potential across the load resistor (Ra) 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 Ra , until we get again the necessary bias .
As a result , we improve , at the same time , the ratio Ra / Rk , 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 ?

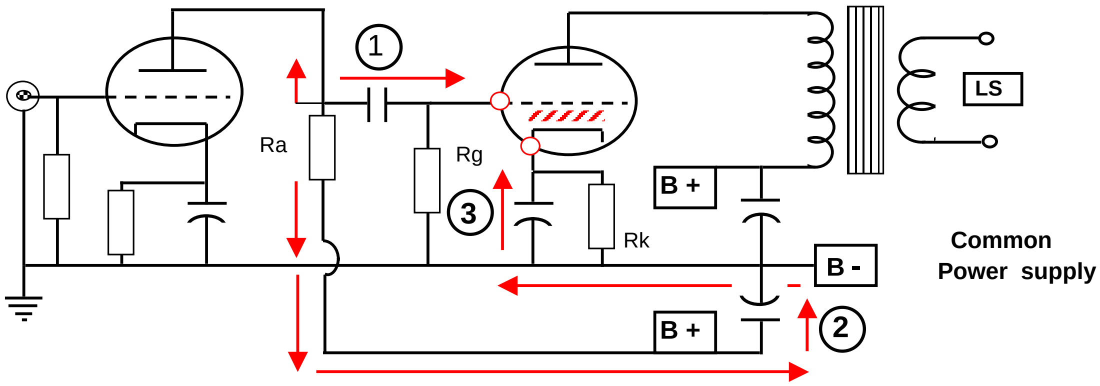
Just connect the driver's anode , through Rfb , to the other side of the OPT , point H or B+ of PS2 .
Practically , it is better to start with this solution and , after getting the correct bias , switch to the negative feed-back layout .

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 Ra 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.

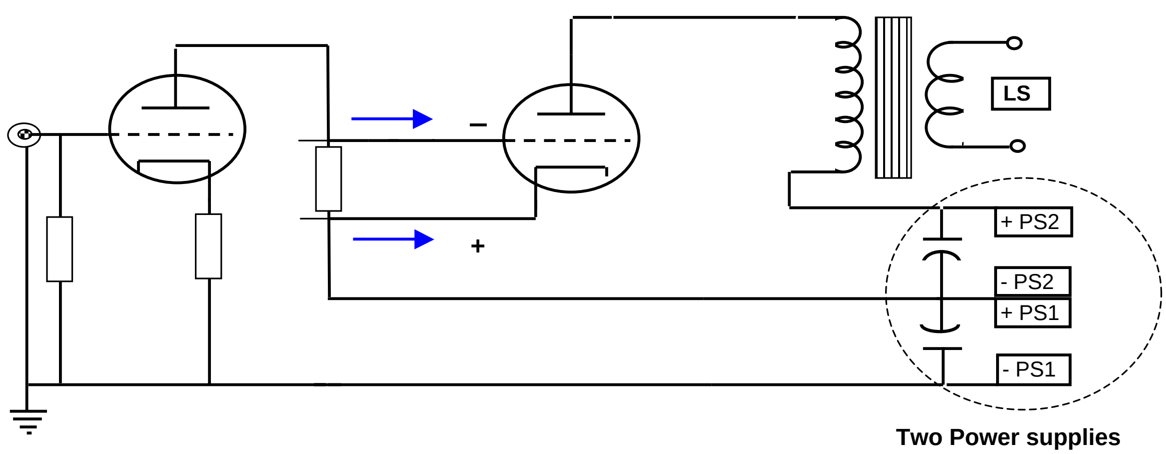
This is quite a long and stressing trip. The capacitors oppose the AC a different resistance (reactance) depending on the frequency , according to the formula :

Z = 1/(2*3.14fC)

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

As an example , if capacitor #1 has a value of 0.22 µF, its reactance is 1/(2*3.14*f*.00022) = 36,190 Ohms at 20Hz, and only 36.2 ohms at 20KHz. If Rg has a value of 100,000 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 Xc in ohms, *f* is Hertz, and C is in Farads.

Example: If we use a 0.22µF 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
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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.

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