Subject: 300B SE Project, Part 8 - Common cathode 6SN7 triode driver
Posted by Damir on Sun, 05 Mar 2006 15:08:41 GMT
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The 6SN7 «family» of tubes is known for it`s linearity (low distortion, mostly k2) and wide use in audio. It`s a «medium-mu» triode (μ~20) in various «shapes» (single and duo-triodes), bases (octal, loctal, even noval), versions (GTA, GTB, WGT…), and various heater voltages. It`s a very common tube, but the «most popular», quality NOS 6SN7 examples can be expensive now.Looking on the plate curves, it seems that the best linearity is in the 7-10mA / 200-250V «area». For the moment, we`ll use (factory) reccomendable OP – Uak=250V, Ia=9mA, Ugk=-8V. Anode resistance is 7,7 kOhms, μ=20, and gm=2,6mA/V in this operating point.I tried the simple circuit shown in Fig. 1 – common cathode voltage amplifier, resistive load.The results aren`t good enough for the 300B driver. Amplification of the circuit is only about 15, output resistance is rp//Ra = 7,7 // 22 k = 5,7 kOhms, the sound is too «warm» (distortion), soft and rolled off on both frequency extremes.We have only Ra : rp ratio of about 3 – for minimizing distortion we need much larger Ra (R3), but it`s «connected» to impractically high B+.There`re many other circuits that use 6SN7 for the 300B driver (SRPP, Mu-Follower…), and probably the most known is «cascaded» direct coupled triodes, Fig. 2.There are many problems with this arrangement – we need rel. high B+, but because of «loses» of voltage in direct coupling, both tubes work with rel. small Uak (86,7V & 177V) and small currents (3,4 & 4,3mA). R6 (anode load for V2) is rel. low and output resistance is rel. high, 10 // 39 = 8 kOhms. Tubes don`t work in the most linear area, and cascading have the cosequence that distortion is relatively high, with bad harmonics «profile» , see for example measurements by Pete Millett. Amplification and input sensitivity are too high, A=A1*A2, or A~260 times with R8=220k load, or grid-leak resistor of the next stage.Yet, many people found this «warm» sounding circuit simple and «good enough»…Using active, CCS load with low impedance output, the «picture» drastically changes – distortion vanished, «punch» returns, details…In the begining, I used resistive cathode bias, like in Fig. 1. But, in the listening test I heard some coloration, probably the effect of electrolytic capacitor bypass. I tried many combinations of «plastic» and electrolytic caps, even just many 15μF MKS caps in parallel, but I still heard some «warm» mid-bass coloration.We have Ugk=-8V bias, it`s hard to get with LEDs and batteries «under» cathode. Then I «borrow» this from M. Jones book – simple 8,2V Zener diode… Yes, it can be noisy and it has a little resistance that isn`t linear resistor, but we have rel. large input and output AC voltages through the tube, and possible «bad effects» are minimal, at least, I can`t hear it. With Zener diode bias we have a little bit «brighter» sound, and «more linear» (mid)bass area, «tighter» then in Rk+Ck example. This is very subjective, and the potential builder can easy try what works best for him. For Ia=9mA use Rk=910 Ohms, and for the 8mA use Rk=1k. Although «math» said that with active load we need just >22μ bypass, I liked 220μ electrolytic bypassed with 15μ MKS more. Easy to try both, as I said before… IMO – Zener bias «sounds» better, but YMMV.We have a little «safety issue» with this bias arrangement – «self adjusting» action of the cathode resistor (in some limits) is now lost, it is a practically fixed-bias scheme, and if (for some reason – say, shorted CCS) the whole B+ is present on the anode, triode would «pull» very large current and would «burn out». For some protection, we can solder 3k3/0,5W metal film (or other non-flamable resistor) between the CCS and tube anode. This resistor can limit the current and act like the «slow-blow» fuse. In «normal» work with 9mA current we have about 30V voltage «drop» through the resistor (not very important with large B+=440V and CCS, IME), and dissipation in it is 0,267W. If Ia rises over

12,3mA max. dissipation of the resistor is exceeded and it`d burn – protecting the tube and PS. I tried it , and didn`t hear the sound difference, see Fig. 4: I tried 10 various tubes from a little collection I have – 6J5, 6SN7, 7N7 and 12SN7, mostly Sylvania and RCA. I built the test rig with three sockets (octal for 6SN7 and 12SN7, octal for 6J5, and loctal for 7N7) and two heater supplies – 6,3V and 12,6V – AC.In double triodes (6SN7, 12SN7, 7N7) I tested just one triode, leaving other unconnected, although it`s probably better to ground unused pins (anode, cathode and grid of unused triode). By the datasheets, we can use the section 1 (pins 4,5,6) – little less interelectrode capacitance. But it is a minor point, and we can use this little «trick» - on the L tube, use section 1, and on the R- section 2. After some time, swap the tubes – you have (almost) new driver tubes. Or use one triode for the L and another for the R channell – one (double triode) 6SN7 stereo driver?! I tried parallel connection of both triodes – both cathodes tied together, the same with grids and anodes. In this case, anode resistance of «compound» device is halved, gm is doubled and μ stays the same in respect with each triode. But, input capacitance is now about doubled, and it partly explains the «thicker, darker» sound I get. It gets a little «punchier», but somehow looses «fine nuances», and I returned to the single triode – more transparent. I ran it with 16 mA of current.We mentioned the input capacitance – it can be a serious problem in this (common cathode) arrangement. Total input capacitance is:Cin = (A+1)*Cag + Cgk + Cstrays , where (A+1)*Cag is so-called «Miller» capacitance.If we put some numbers from the datasheets (Cag=4pF, Cgk=3pF), we can see that input capacitance is at least 100 pF, probably more. If we use the «standard» 100 k volume pot before the driver, than in middle position our pot has 100/4=25 k max. output resistance. With 100 pF capacitance it forms a low-pass filter, with –3 dB point 1/(2Pi*R*C) = 63,6 kHz. Too much HF «losses» ot the input of our amp. It`s better to use lower value volume pot (depends of the source), 50 k and lower.Most of the tests are done with Ia=9mA, although I tried 8 mA also. Very subtle difference, maybe higher current «sounds» a little more «punchier» - try it for yourself. Some tubes (6J5) have max. anode dissipation of only 2,5 W (or even less – 5692) and with 9 mA/250 V we are almost «on the edge» - it is «wise» to lower the Ia to 8mA in those cases.It`s interesting that I measured A = μ > 21 in most of the samples I tried. But, unfortunately - it isn`t enough amplification for our «standard» input of 2Vrms. We need (at least) 52 Vrms on the 300 B grid for the max. power in class A1, and we can get only 42Vrms, or we are 20log52/42 = 1,86 dB «short» here. We need at least 52/21=2,5Vrms input, and that means preamp, or CD player with larger output voltage then 2Vrms maximum.In theory, with –73,5 V bias, and Ugk=73,5Vp=52Vrms input on 300B grid we can get:Ua=(Ugk*μ)/(1+rp/Ra) = (52*3,85)/(1+700/3000) = 162Vrms , and on the 3k primary we have U^2/Ra = 162^2/3000 = 8,75W theoretically, not counting the losses in OPT, etc.With only 2Vrms max. CD player we can get 42Vrms from our driver, and «just» 131Vrms on the anode of 300B – it means «just» 5,73 W on the primary. Expressed in dB it is not much, but it`s best to have «proper» 2,5Vrms input in our driver if we want every Watt we can get. Listening test: I tried 10 samples, and they all have similar «family» sound – soft, warm and clean. But, every tube I tried sounded a little different. Some sound more in a compressed, warm, rounded, rolled-off, unfocused way I didn`t like. I remembered (expensive) tube preamp/EQ/compressor I had in my home-studio a few years ago – vocals sound warm and nice, but you can`t get a decent sound with drums, bass, guitars. It somehow «dulls» the attack of the note, «smears», and «softens» the sound. The similar sound I get with metal 6J5 and gray glass 12SN7, both RCA. The six other tubes I can put in «so-so» category, they are good in some things, and not-so in others (say dynamic and highs/lows). Those are two 7N7 examples, 6J5GT, 6SN7GTB and 12SN7 – all Sylvania. 6SN7GTB GE isn`t bad - it can be usable, but two tubes are far above the others in details, dynamics, highs, «wide and deep» category. RCA `50s wide black ribbed plates is sweet and detailed in my test, and «tall bottle, silver top, triangle smooth black anodes» Sylvania 12SN7 – dynamics, highs, huge sound.You can notice that I didn`t have too much samples (many more existed), I tried them in my system (YMMV), and I really can`t (based on one sample listening test) predict the sound of some «families, vintages, manufacturers». Internet is full of confessions of «tube rollers», and some search for «best 6SN7» can give you other people`s opinions. The conclusion from this (very long) test of some tubes from 6SN7 family can be that differences exist, and some «tube swapping» is necessary to find the best examples in concrete system.I listened for a long time for differences between the sound of CCS-ed 6C45Pi-E and various 6SN7. In short – 6SN7 isn`t agressive, 6C45Pi is «focused» on high-mid / high frequencies. 6SN7 is «sweeter» and (with better samples) has «larger» sound. Bass and highs are a little soft and «rounded», 6C45Pi has more «punch» here.But, 6SN7 has so sweet, clean, detailed and nice sound that you can listen to the music all day long. It excels in vocals, solo-instruments (sax, strings…). But maybe it isn`t accurate enough for all kinds of music – for example, I listened to the Ramones, and guitar is a little bit soft and «laid-back», but you can hear every word of the vocal(s), ha. On the other hand, 6C45Pi has «razor-sharp, chainsaw» quality, more bass and treble, but not that vocal… Those differences are not night/day, but subtle, and we must remember that the driver is just the part of the 300B amp, coupled to the speakers…and that those listening test results are subjective.CONCLUSION: 6SN7 common cathode with CCS load with Mu - output is a very good 300B driver. Not agressive, but on the sweet, smooth, clean, soft, detailed and «intimate» side. Amplification is only 21 times, and we need 2,5Vrms input source. There is some difference in sound between the various versions/manufacturers. But finding the «right» sounding pair isn`t too hard…and very nice «triode» amp sound results...

Subject: Re: Excuse me; I didn't mean to post over your post
Posted by Manualblock on Sun, 05 Mar 2006 21:02:06 GMT
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I just threw this post on because i saw where Douglas has re-designed his pre-amp with resistive loading and eliminated the CCS and I wanted to find out what he did.Sorry man; If I could re-position my post I would. My Bad.

Subject: ??? :-)
Posted by Damir on Sun, 05 Mar 2006 21:46:24 GMT
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Hey, I can`t say that I understand what`s going on, but never mind. No need for excuses.

Subject: Re: 300B SE Project, Part 8 - Common cathode 6SN7 triode driver
Posted by Adrien on Sat, 21 Oct 2006 18:25:00 GMT
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I would very much like to see the example circuits which for some reason do not display. Only the first 2 display. Are these still available?Thanks

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Subject: Fig. 3 & Fig. 4
Posted by Damir on Thu, 26 Oct 2006 16:58:59 GMT
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I noticed that many pictures I hosted with "Image Shack" weren`t there after some time. Fortunately, I have these "low-res" copies...
