Subject: 300B Project - Part 5 : cascode driver
Posted by Damir on Wed, 16 Nov 2005 13:16:40 GMT
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Our driver stage must provide about 50Vrms (70Vp=140Vpp) on the 300B grid for max. power (class A1), and if we have CD player with 2Vrms (2,828Vp=5,656Vpp) max. output, then we need amplification of A=50/2=25 times. But, ideally, we need some "reserve", for "quiet" CDs (or other sources), say about 3-6 dB. Then we need amplification of about 35-50 times.Some of the other driver requirements:-good distortion characteristics (low overall distortion with "falling" harmonics profile and with a negligible portion of higher-order harmonics, quick overload recovery, etc.:-))-low output impedance, and "high enough" working current (subjective, ha) for driving input capacitance of our output 300B SE stage-input "biased" to accept full 2Vrms signal without large grid current/distortion, say Ugk>-3V, if possibleThe schematic shows 5687 cascode driver. It has some good characteristics, like low Miller capacitance, input-output isolation, etc. It can be considered as a series amplifier, with V1 like common cathode amplifier, and on top of it grounded-grid amplifier. The stage is similar to the pentode voltage amplifier, but with advantage that "upper" grid doesn`t draw any current from its supply (R3, R4, C6 and grid stopper R6). It is just "voltage reference", or bias for upper tube V2. Capacitor C6 provide ground reference for "upper" grid, and 1µF value gives f-3 = 1/(2Pi*Rs*C6)= 1,4 Hz, where Rs= R3//R4 = 113,71kOhms.This is somewhat "modified" cascode, with resistor R5=33k/5W. "Ordinary" cascode with the same B+and same Ra and Ia~10mA (for about equal voltage "drops" of 150V through Ra and 150V through V2) yield amplification of about 22-25 times, not enough.Like in pentode, amplification of our "compound" device constists of V1 and V2 isA = gm * RL– where gm is transconductance of the device, and RL load resistance, consists of Ra in parallel with Rg, then RL=15//220=14k.It can be aproximated like A ~ gm1 * RL , where gm1 is transconductance of V1. More current through V1 = larger transconductance, up to the point. We can have Ia2=10mA through upper tube, and additional 10mA through R5 for lower tube, then Ia1=20mA.On 5687 Ia/Ua/Ug graph we can read for:V1 – 20mA/105V – gm1~7,5mA/V and µ~17,5 , then rp1~µ/gm1~17,5/7,5~2,33 kOhmsBut, we prefer unbypassed Rk here (better distortion characteristics), and we actually have:rp1`= rp1+(µ+1)Rk = 2,33+(17,5+1)*0,150 = 5,1kOhms, and gm1`=17,5/5,1 = 3,4mA/VV2 – 10mA/150V – gm2~5,5mA/V, µ~17,5, rp2~17,5/5,5~3,18kOhms, thenrp2`=3,18+18,5*0,15=5,95kOhms, and gm2`=17,5/5,95=2,94mA/VAmplification of our cascode stage is A~gm1`* RL ~ 3,4*14 ~ 47,6 times, IME is always an "optimistic" value, and more detailed calculation (formulae in M. Jones book) gives A=40.A=1/[1/gm1`*RL + (rp2`+RL)/RL * 1/µ1(µ2+1)]Simulations with two different 5687 models gave A=41 and 43 times.Output resistance that Rg in parallel with input capacitance of our output stage "sees" from the driver is Ra in parallel with internal resistance of the cascode (much larger then Ra), and it is about Ra, like in the pentode case. Rout = Rcasc // Ra, Rcasc=(µ+2)rp1` = 99,55k, and then Rout = 99,5 // 15k = 13kOhmsOn the schematic we can see the actual measured values, little difference in comparison with calculated/simulated. V2 "draws" about 9,9mA, and V1 through R5 "additional" 9,6mA, about 19,5mA total. The measured amplification of the stage is 41 times. It means that input of Uin=50/41=1,22Vrms gives max. output needed. In practice, it means that if we use 2Vrms max. input device, then we must attenuate it by 20log2/1,22 = 4,3dB if we don`t want to drive our tube "in red" by peaks which aproach 2Vrms. In listening test, I attenuated the CD output by 4-6 dB. The full CD player output (2Vrms) with this driver gives noticeably more distorted and compressed sound, not a suprise The

sound of 5687 cascode+300B is (if I can say it:-)) "typical" 300B – warm, clean, little on the soft side, detailed, articulated – in short- good and very "promising". The only downside of this driver I didn`t like is rel. high output resistance. More experiments are in order soon, CCS modifications…to be continued:-).And yes, I "elevated" heater supply (6,3V AC) to about 45V above ground…

Subject: Re: 300B Project - Part 5 : cascode driver
Posted by Wayne Parham on Wed, 16 Nov 2005 14:24:14 GMT
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Wow, great work! This is really shaping up nicely, isn't it? What shall thee call it?

Subject: Re: 300B Project - Part 5 : cascode driver
Posted by Damir on Wed, 16 Nov 2005 17:52:22 GMT
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Haha, still too early for the names, but thanks...Huh, I`m slow The plan is a few parts about drivers with some other "usual suspects" (triodes and pentodes), then final building and final schematic...

Subject: Re: 300B Project - Part 5 : cascode driver
Posted by Wayne Parham on Wed, 16 Nov 2005 18:00:42 GMT
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Cool, sounds good.Sorry for using old English. Your use of English is so good sometimes I forget it's your second language. Kind of funny how you know all the cultural references used by people around you, things like names of places and movies and events of your culture, so you forget that other parts of the world never heard of them.

Subject: Re: 300B Project - Part 5 : cascode driver
Posted by 2wo on Thu, 17 Nov 2005 00:41:53 GMT
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Hi Damir,Nice work. I always look forward to the next part.Have you considered the Russian 6n6~ (still don't know what that last letter is)I have a one in the Guinnivere and in a linestage to be

named later.I like them a lot, not as dry as the 5687, other then the pin out it spec's pretty close...John

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Subject: Re: 300B Project - Part 5 : cascode driver
Posted by Damir on Thu, 17 Nov 2005 11:58:13 GMT
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Hey, thanks. Unfortunately, I don`t have any 6H6Pi, 6H30Pi, ECC99, etc. - usable here. I have a few E182CC and I`ll try them next time...
http://www.klausmobile.narod.ru/testerfiles/index.htm

Subject: Encore!!!!! Encore!!!!
Posted by PakProtector on Fri, 18 Nov 2005 01:11:38 GMT
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Hey-Hey!!!,That was excellent. I would make a suggestion:The voltage divider resistor, R4 should be attached to the cathode150R node. I have found the cascode works better this way. As in the pentode, g2 should be referenced to the cathode. Other than that, keep the upper end of the load line running through g1=0 V before it starts deviating from the pentode-ish behaviour with its flat plate "curves".Since the bottom triode is important for its gm, a triode strapped pentode might be useful. At 15 mA/V the 12BY7 and EF184 look nice. A step further would lead towards the 12GN7 at an advertised 36 mA/V and probably realizeable to 25 mA/V w/o the additional current source of the 25k resistor.Looking forward to Chapter 6.cheers,Douglas

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Subject: Re: Encore!!!!! Encore!!!!
Posted by Damir on Fri, 18 Nov 2005 17:23:03 GMT
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Haha, thanks for the support and tips, especially R4 reference to cathode. I`ll try it when I change the burned PT I have a few D3a, E280F and EF184 that I planned to try like "straight" pentode and triode connected drivers. Using those tubes (triode connected) for lower device in cascode (high gm), and some linear single triode for the upper, say 6J5GT, can work with rel. low current, and have the advantage that we can use two heater supply, one "normal" for V1, and other "elevated" for V2 (V2 has its cathode on about 108V above ground). But, I have only about 420V supply, with only Uak=100-120V for the lower tube, and bias Ugk could be only about -1V or so with those tubes (without "tricks") I didn`t decide yet, but for now I prefer here one tube, easy to implement and find. More suggestions are welcome!
