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…