

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 $U_{gk} > -3V$, if possible. The 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 $1\mu F$ value gives $f_{-3} = 1/(2\pi \cdot R_s \cdot C_6) = 1,4$ Hz, where $R_s = R_3 // R_4 = 113,71k\Omega$. This is somewhat "modified" cascode, with resistor $R_5 = 33k/5W$. "Ordinary" cascode with the same B+ and same R_a and $I_a \sim 10mA$ (for about equal voltage "drops" of 150V through R_a and 150V through V2) yield amplification of about 22-25 times, not enough. Like in pentode, amplification of our "compound" device consists of V1 and V2 is $A = g_m \cdot R_L$ - where g_m is transconductance of the device, and R_L load resistance, consists of R_a in parallel with R_g , then $R_L = 15 // 220 = 14k$. It can be approximated like $A \sim g_{m1} \cdot R_L$, where g_{m1} is transconductance of V1. More current through V1 = larger transconductance, up to the point. We can have $I_{a2} = 10mA$ through upper tube, and additional 10mA through R5 for lower tube, then $I_{a1} = 20mA$. On 5687 $I_a/U_a/U_g$ graph we can read for: V1 - 20mA/105V - $g_{m1} \sim 7,5mA/V$ and $\mu \sim 17,5$, then $r_{p1} \sim \mu/g_{m1} \sim 17,5/7,5 \sim 2,33k\Omega$. But, we prefer unbypassed R_k here (better distortion characteristics), and we actually have: $r_{p1}' = r_{p1} + (\mu+1)R_k = 2,33 + (17,5+1) \cdot 0,150 = 5,1k\Omega$, and $g_{m1}' = 17,5/5,1 = 3,4mA/V$. V2 - 10mA/150V - $g_{m2} \sim 5,5mA/V$, $\mu \sim 17,5$, $r_{p2} \sim 17,5/5,5 \sim 3,18k\Omega$, then $r_{p2}' = 3,18 + 18,5 \cdot 0,15 = 5,95k\Omega$, and $g_{m2}' = 17,5/5,95 = 2,94mA/V$. Amplification of our cascode stage is $A \sim g_{m1}' \cdot R_L \sim 3,4 \cdot 14 \sim 47,6$ times, IME is always an "optimistic" value, and more detailed calculation (formulae in M. Jones book) gives $A=40$. $A = 1/[1/g_{m1}' \cdot R_L + (r_{p2}' + R_L)/R_L \cdot 1/\mu_1(\mu_2+1)]$. Simulations with two different 5687 models gave $A=41$ and 43 times. Output resistance that R_g in parallel with input capacitance of our output stage "sees" from the driver is R_a in parallel with internal resistance of the cascode (much larger than R_a), and it is about R_a , like in the pentode case. $R_{out} = R_{casc} // R_a$, $R_{casc} = (\mu+2)r_{p1}' = 99,55k$, and then $R_{out} = 99,5 // 15k = 13k\Omega$. On 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 $U_{in} = 50/41 = 1,22V_{rms}$ gives max. output needed. In practice, it means that if we use 2Vrms max. input device, then we must attenuate it by $20 \log_2 2/1,22 = 4,3dB$ if we don't want to drive our tube "in red" by peaks which approach 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 surprise. 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...
