

In Fig. 1 we can see the «typical» SE DHT output stage. The purpose of pot, P1 (50 Ohms/2W typical) is to provide the way to «nulling» the hum. In Fig. 2 a,b,c, we can see other ways of connecting the filaments to cathode resistor  $R_k$ . We want potentiometer, to have some AC hum control, `cos we`ll use «traditional» 5V AC heating. I doesn`t have a multi-turn (precision) 50 Ohms/2W pot, and I used the circuit on Fig. 2c. It has some advantage that current flows mostly through  $R_1$  and  $R_2$ , and not through (possible problematic) center-wiper contact. We have «fine» adjustment, Fig. 2d. Now we can calculate the cathode resistor. With  $U_{ak} = 350V$  and  $I_a = I_k = 80mA$ , we have about  $U_{gk} = -70V$ . Then, by Ohm`s Law:  $R_k = U_k / I_k = 70 / 0,08 = 875$  Ohms. Not a standard value, but we can use the combination, I used 820 Ohms/25W Al-clad chasis mounted resistor and 56 Ohms/1W in a series. If necessary, lower value = higher current, and opposite. Dissipation in  $R_k$  is  $P_{rk} = I_k^2 * R_k = U_k * I_k = U_k^2 * I_k = 5,6W$  – we must use at least 10W resistor here. Calculating the cathode bypass capacitor  $C_k$ : We want  $C_k$  to «bypass» all AC frequencies of interest, intuitively – we need f-3dB at about 1-2 Hz. But:- Power bandwidth f-3dB of our OPT is about 20Hz, and there is not much sense in amplifying the subsonic frequencies that can saturate the core- We need not too large RC time constant here – quick bias «recovering» from overloads- For say, 2Hz –3dB high pass frequency we`d need large and expensive film cap, or electrolytic (hmmm...) Then, I choose low-cut frequency around 5-10 Hz. Let`s see: Our  $C_k$  «see» the cathode impedance  $Z_k = (r_p + R_a) / (\mu + 1)$  in parallel with cathode resistor  $R_k$ , or  $R_{cath} = Z_k // R_k$ . The formula for  $C_k = 1 / (2\pi * f * R_{cath})$ , and when we put those equations together, we get the final formula for cathode capacitor:  $C_k = [(\mu + 1) / (r_p + R_a) + 1 / R_k] / 2\pi * f$ , or obviously f-3dB is:  $f-3 = [(\mu + 1) / (r_p + R_a) + 1 / R_k] / 2\pi * C_k$  When we put some numbers in it, and use the standard 47µF/100V MKP cap here, we get f-3dB about 8,4 Hz:  $f-3 = [(3,85 + 1) / (650 + 3000) + 1 / 875] / 2 * 3,141 * 47 * 10^{-6} = 8,4$  Hz Note that we use  $R_a = 3000$  Ohms, like constant resistance value, but our OPT is far from that, we neglected  $L_p$ ,  $R_w$ , etc. But, possible mistake is small, and can be neglected for our purposes. The quality of  $C_k$  is critical, and it`s recommended that we use quality film cap here. And not just that, see Fig. 3 – SE stage «redrawn» to include PS capacitor(s). We can see that both  $C_k$  and  $C_{ps}$  are inside the output signal current loop, and that both caps are practically in a series. Then, quality of  $C_{ps}$  is also critical, and it can also be MKP or MKV types. In Fig. 4 we can see the final SE stage, with all the values. I choose the «safe» value for grid-stop resistor  $R_{gs} = 1k$ , non-inductive type (say, carbon-comp), mounted close to the tube pin. For grid resistor  $R_g$ , we need small value from the output tube standpoint, and large value from the driver tube standpoint. Some people put grid-choke here (rel. small DC resistance and large AC impedance), but we`ll use «standard» 220k here, somewhat smaller than max. recommended 250k from 300B data. I choose 0,22µF for coupling capacitor  $C_i$  (between the driver tube and output stage). We have the first order high-pass filter here, 6dB/octave. Again, we need «low enough» -3dB high pass point, but not too large RC time constant, because of possible «blocking» effect. Again, the quality of this capacitor is critical. Combination of 220k/0,22µ gives:  $f-3 = 1 / (2\pi * R_g * C_i) = 1 / (2 * 3,141 * 220000 * 0,22 * 10^{-6}) = 3,3$  Hz. The formula for  $C_i = 1 / (2\pi * f * R_g)$ , obviously :-). We have another «unpleasant» effect with our output stage, the input capacitance:  $C_{in} = C_{miller} + C_{gf} + C_{strays} = (A + 1) * C_{ag} + C_{gf} + C_{strays}$ . From Parts 1&2 we know that amplification of our output stage is output AC signal swing divided with input AC signal swing, or  $A = U_a / U_{gk} = 3$ . Then

we have:  $C_{in} = (3+1)*15 + 9 + 11 = 80\text{pF}$ . Values for  $C_{ga}$  and  $C_{gf}$  we have in 300B data, and value for  $C_{str}$  we estimated. Now, with 80pF of input capacitance and at least 100kHz driver bandwidth, our output resistance  $R_{out}$  from the driver can be the maximum  $R_{out} = 1/(2\pi*f*C_{in}) = 1/(2*3,141*100000*80*10^{-12}) = 19,9\text{k}\Omega$ . Although for «driving»  $Z_{cin} = 1 / 2*\pi*f*C_{in} = 99,5\text{ k}\Omega$  on 20 kHz with full input signal of 49,5Vrms requires just  $I=U_{gk}/Z_{cin}= 0,5\text{mA}$  of AC driver signal current, we need driver that «works» with at least a few times that current, to avoid so called «slewing» distortion. In Fig. 5 we can see the possible wiring of our output stage.  $C_k$  can't be too close to the hot  $R_k$ . Of course, the designing methods here are «shortened» and simplified, and some designing choices are subjective. But, I hope that DIY-ers can have some «basis» in above, for understanding and experimenting with SE stages...

---