DC Servo for Aleph-X

Here´s a way to reduce the absolute dc-offset of an Aleph-X to nearly 0V independent of temperature and mains voltage.

Normally in an Aleph-X the absolute dc offset starts at around 5-8V (from both outputs to ground) from cold and then goes to around zero when the amp has warmed up (and the voltage was adjusted at this temperature).
There are two main causes for the change of the absolute dc-offset:

1. Temperature dependency of V_{gs} of the current source Fet for the diff pair. In my case an IRF9610 ($Q6_a$) which changes V_{gs} from 3,78V (cold) to 3,62V (warm). Since the voltage over $D1_a$ barely changes (in my case 3x 3,3V Zener = 9,9V) the voltage over R24, R26 and VR2 will go up with temperature and the current will rise. this causes the gate voltage of Q2/11 to go up and the absolute output voltage to go more negative. How much depends a bit on the value of the McMillan resistors R46/47, the higher this is the more change in voltage.
2. Changes in mains voltage. If this goes up absolute dc-offset gets more negative. Where I live voltage varies between 225V and 335V which is quite a lot and for me in combination with high values for the McMillan resistors too much

Point 1 can be dealt with a PTC (for example KTY81-1) connected to the case near Q6a in series with R26 (the values of R26 and R24 need to be changed). I did this before I put in the servo and it worked well for warmup.

For point 2 I couldn't think of something simple so I´ve used a dc servo. The schematic was often published in Elektor/Elektuur magazine. It feeds of the amps power supply through two voltage regulators (7815/7915). Input is from one output side of the amp through a lowpass filter and the output is connected via a resistor to the connection point of R26 and R24. Here it can feed a little bit of extra current and can take away a lot more (the output can go a lot more negative as positive referenced to this point). To keep the action of the servo as small as possible I´ve kept the PTC in but this can probably be deleted without a problem.
The only thing important is that the amp should be set so the output voltage of the servo is a bit below 17,2V (23,5V-9,9V+3,62V) wenn warm and with mains at a „normal“ value (225V). I´ve set it at around 16V. This way it will keep the output at 0V up until 240V mains.
Testing from cold and with a variac is probably a good idea. I also tried a few different servo output filters (low-pass), some oscillated…..

The following schematics refer to my amp with around 23,5V rails, 910R drain resistors (R23/25), 33k for R46/47 and 2SJ74 input jfets with around 10mA of bias for the pair.

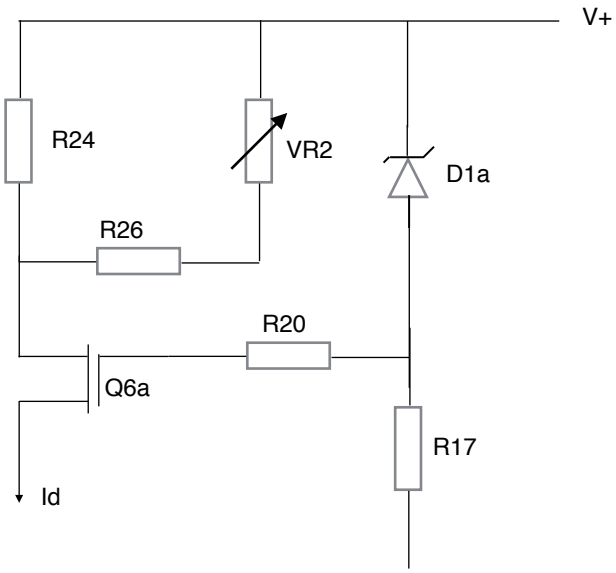
Here are the values as used in my amps:

Current source:

	R24	R26	VR2	V+	Id	Vgs	zener
Standard cold	2700	690	200(111)	23,5V	9,9mA	3,78	3x 3V3
Standard warm	2700	690	200(111)	23,5V	10,16mA	3,62	3x 3V3
PTC (1k@25°C)	820	750	200(111)	23,5V		3,62	3x 3V3
PTC + Servo	820	750	200(111)	23,5V		3,62	3x 3V3

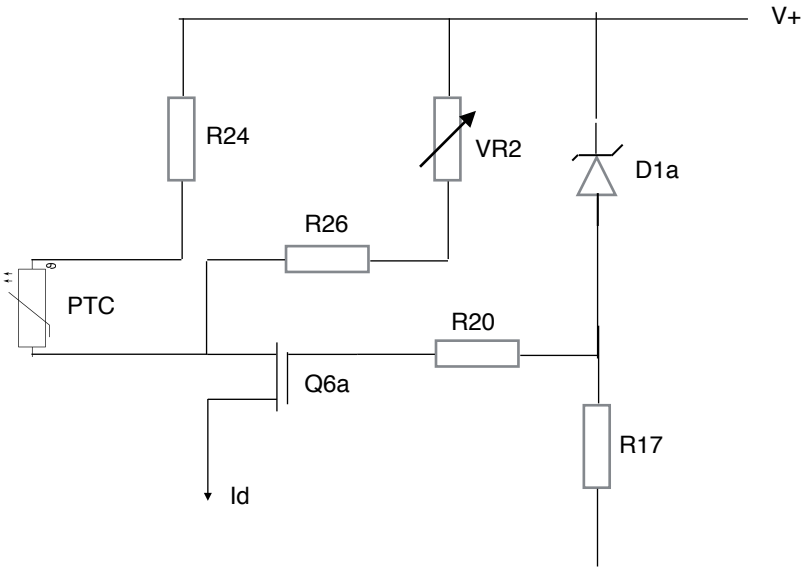
With Id = 10,16mA and V+ at 23,5V absolute dc-offset is around zero.

Here is the standard configuration:

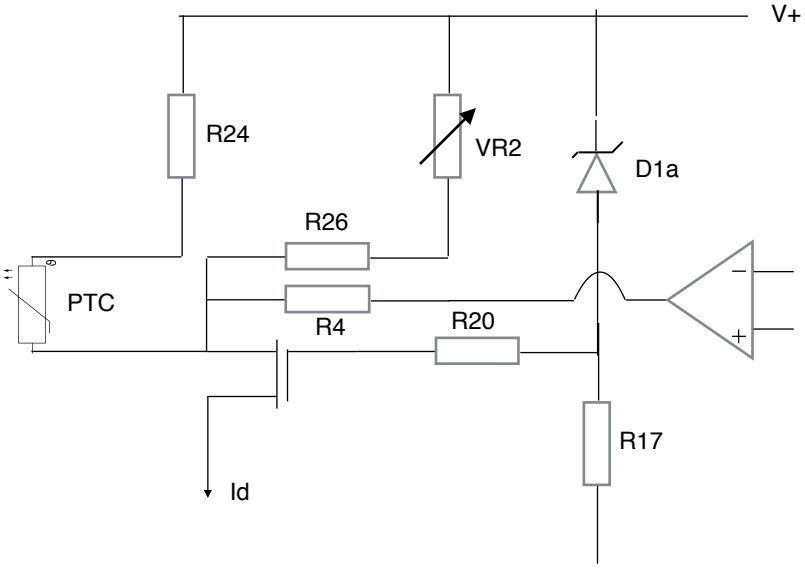


Here with the PTC (KTY81-1).
This is placed in direct contact with Q6a (see pics). The change in total resistance (Rt) of R24, R26, VR2 and PTC should compensate for the change in Vgs.

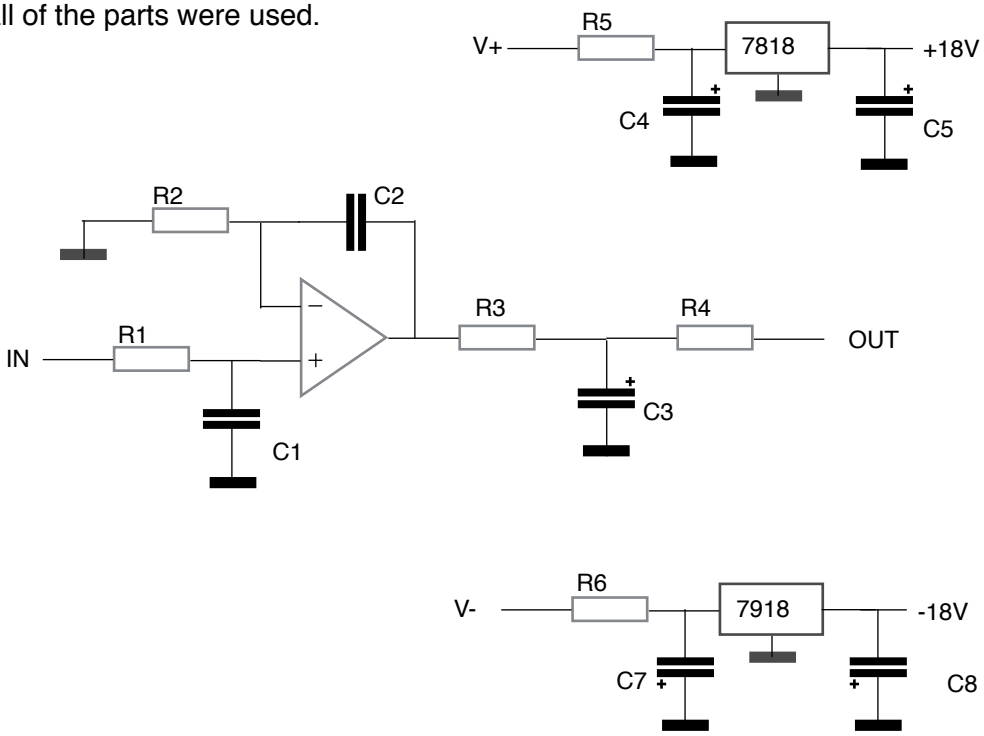
So if warm (50°C), Vgs = 3,62V, the voltage over Rt = 6,28V and Rt = 618R for Id=10,16mA
You can calculate that Rt at 20°C should be 602R for a Vgs of 3,78V and the same Id of 10,16mA.
With this you can calculate the values for R24 and R26.



And here with the dc-servo connected as used in my amps. It is certainly possible to leave out the PTC and even R24. I haven´t tried this (yet) but it would make everything simpler.



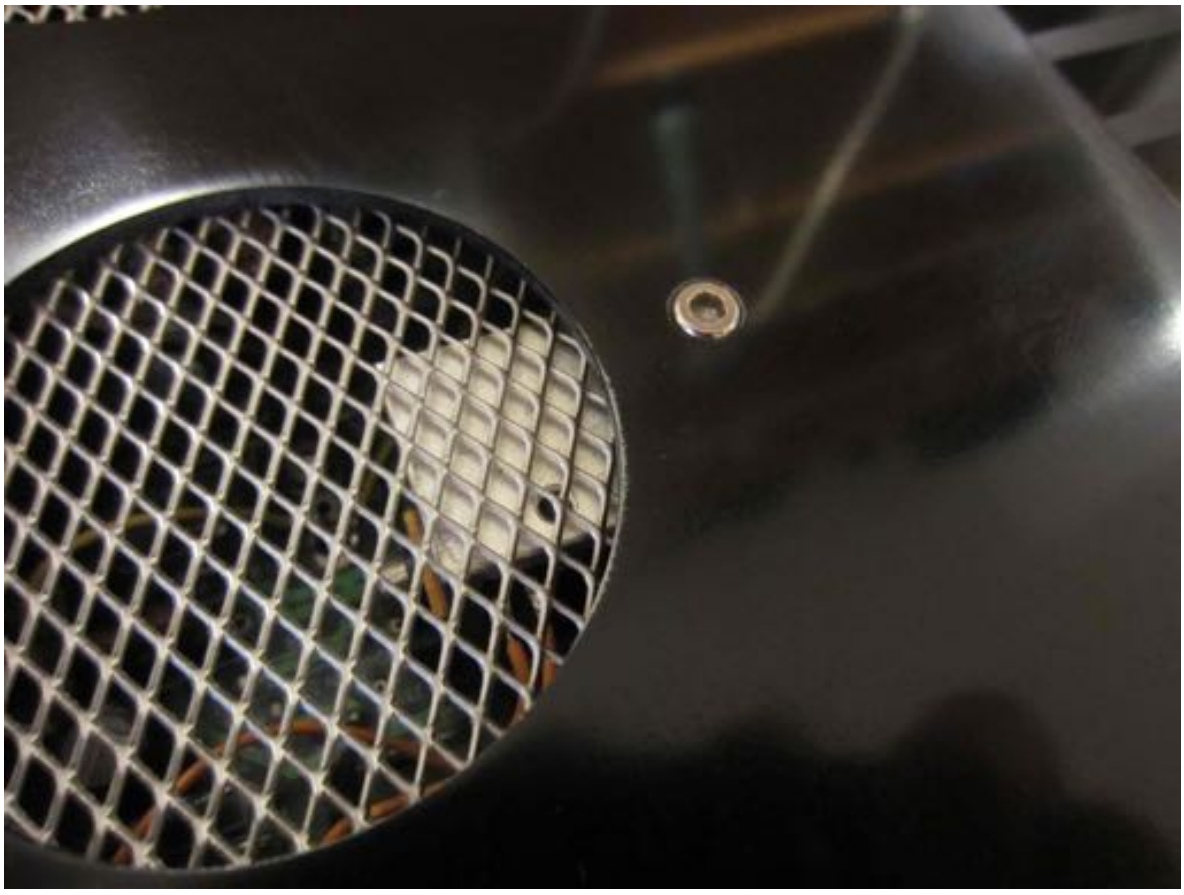
This is the schematic of the dc-servo.
Not all of the parts were used.

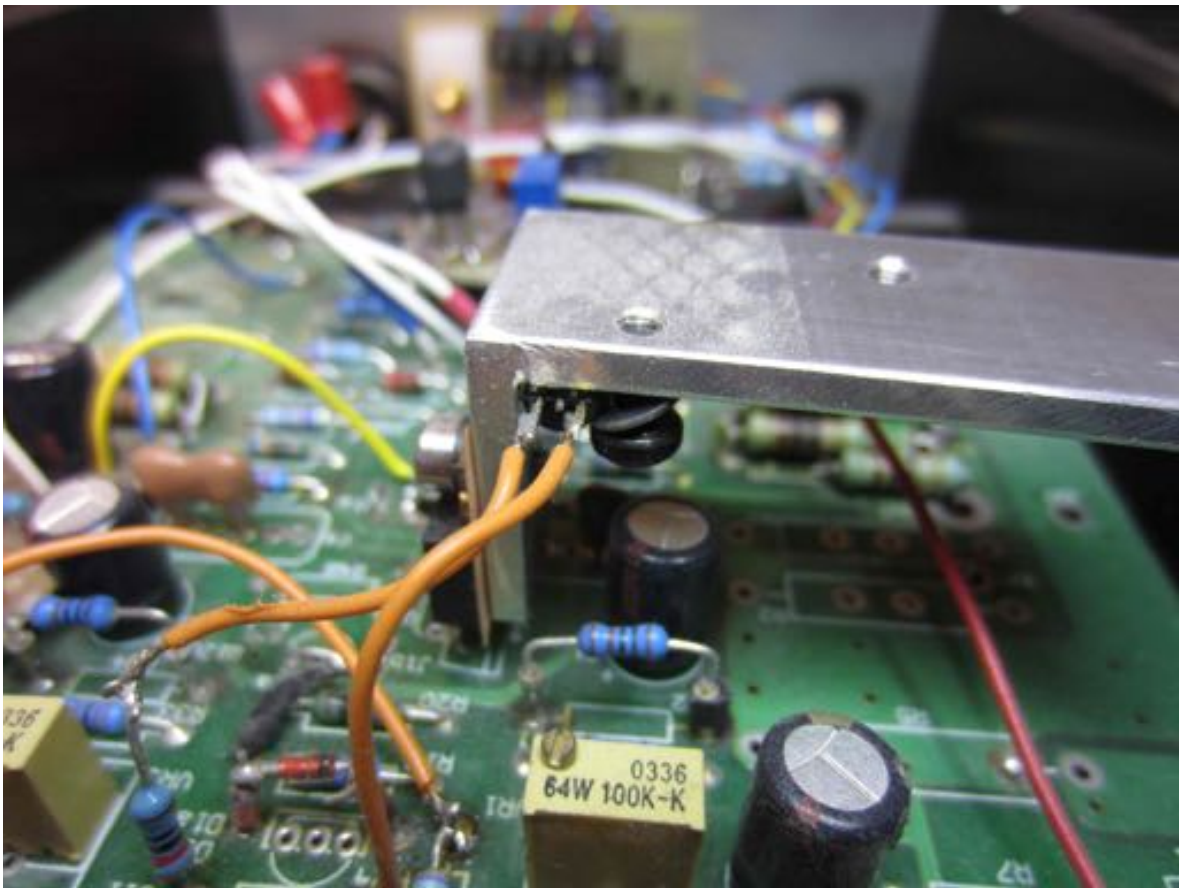


Part	**Value**	
opamp	OP77G	
R1, R2	680k	
R3	1k	
R4	470R	
R5, R6	470R	-3dB@10Hz
C1, C2	1μF	
C4, C7	220μF	
C5, C8	33μF	C8 not used
C3		not used

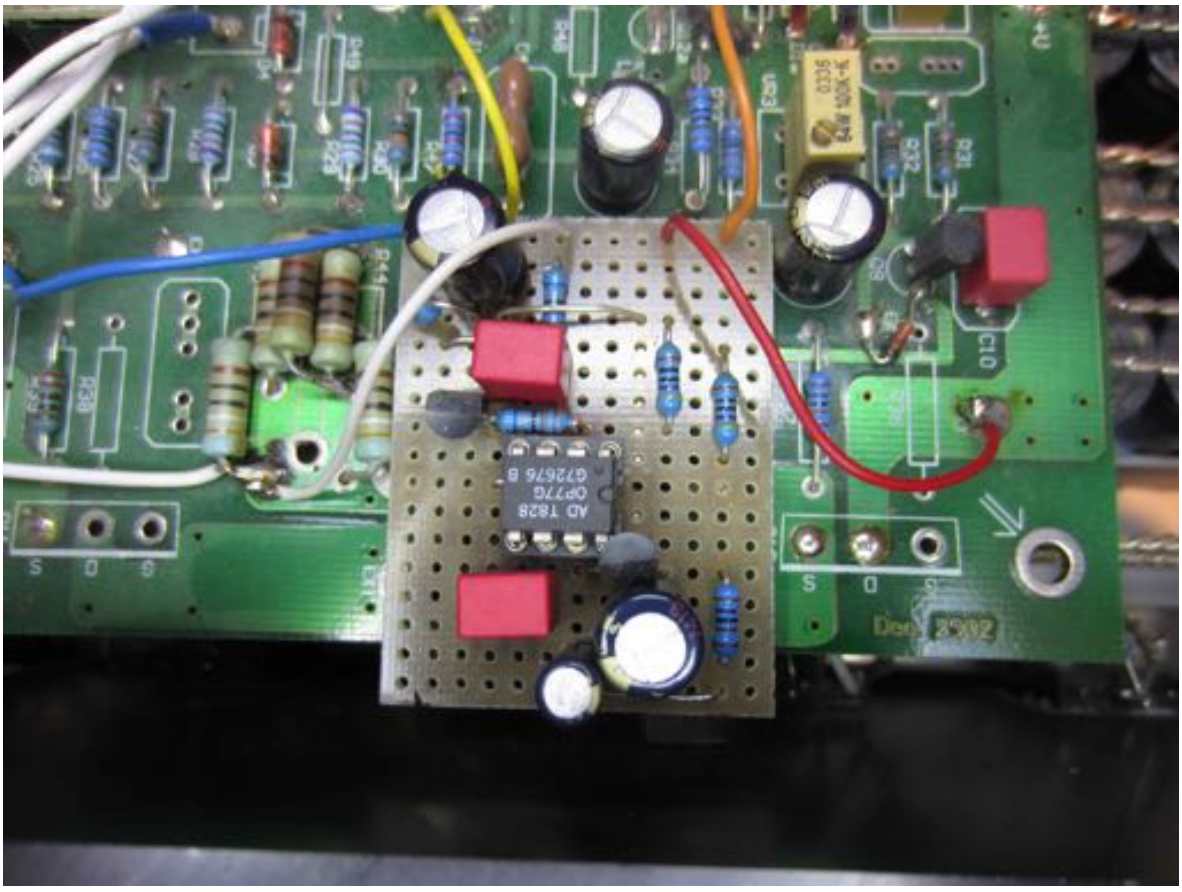
And finally some pics.

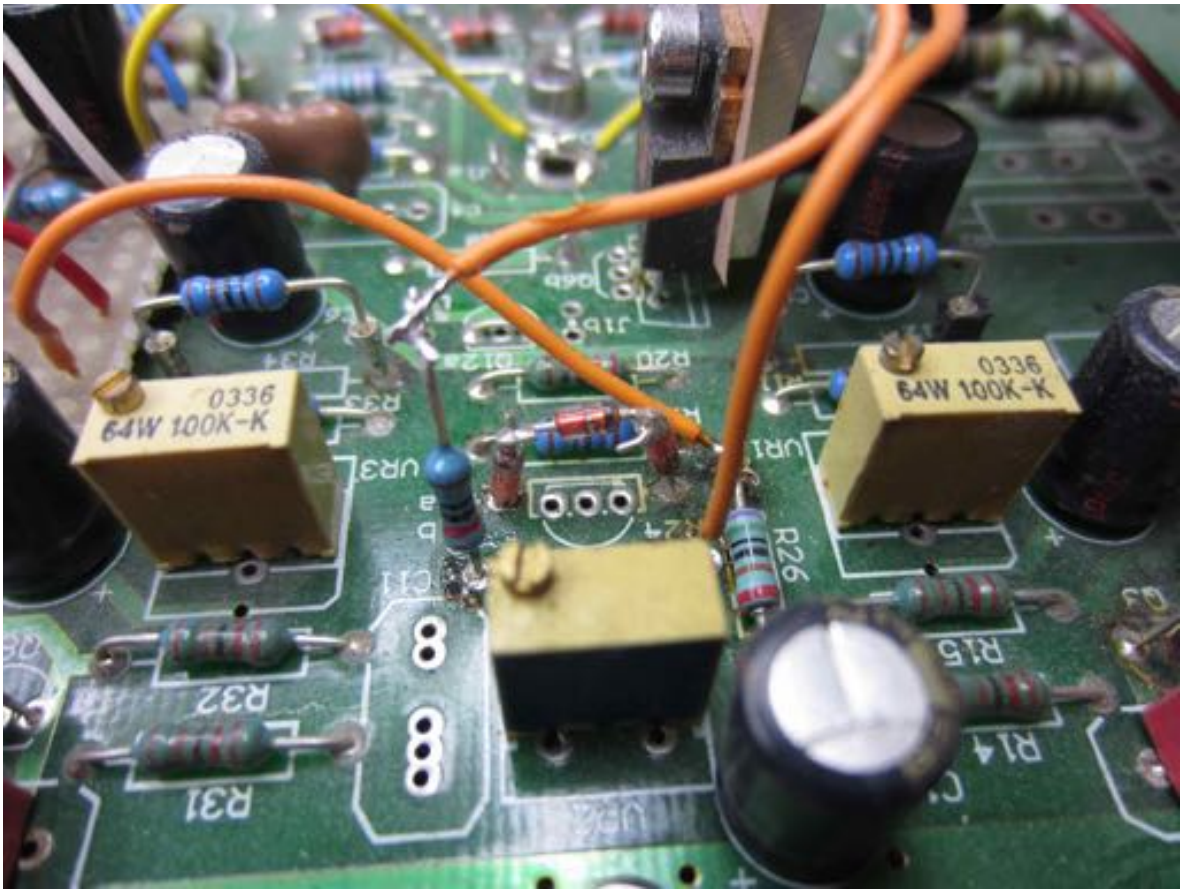
One amp with the lid on. The lower pic shows the small aluminium angle that connects the IRF9610 to the case (this also helped to reduce the absolute offset from cold)





Here´s the angle with the mounted PTC.
Below you can see the dc-servo board sitting on top of the original Hifizen board.





Here´s the somewhat messy current source.
Below an overview of the board.