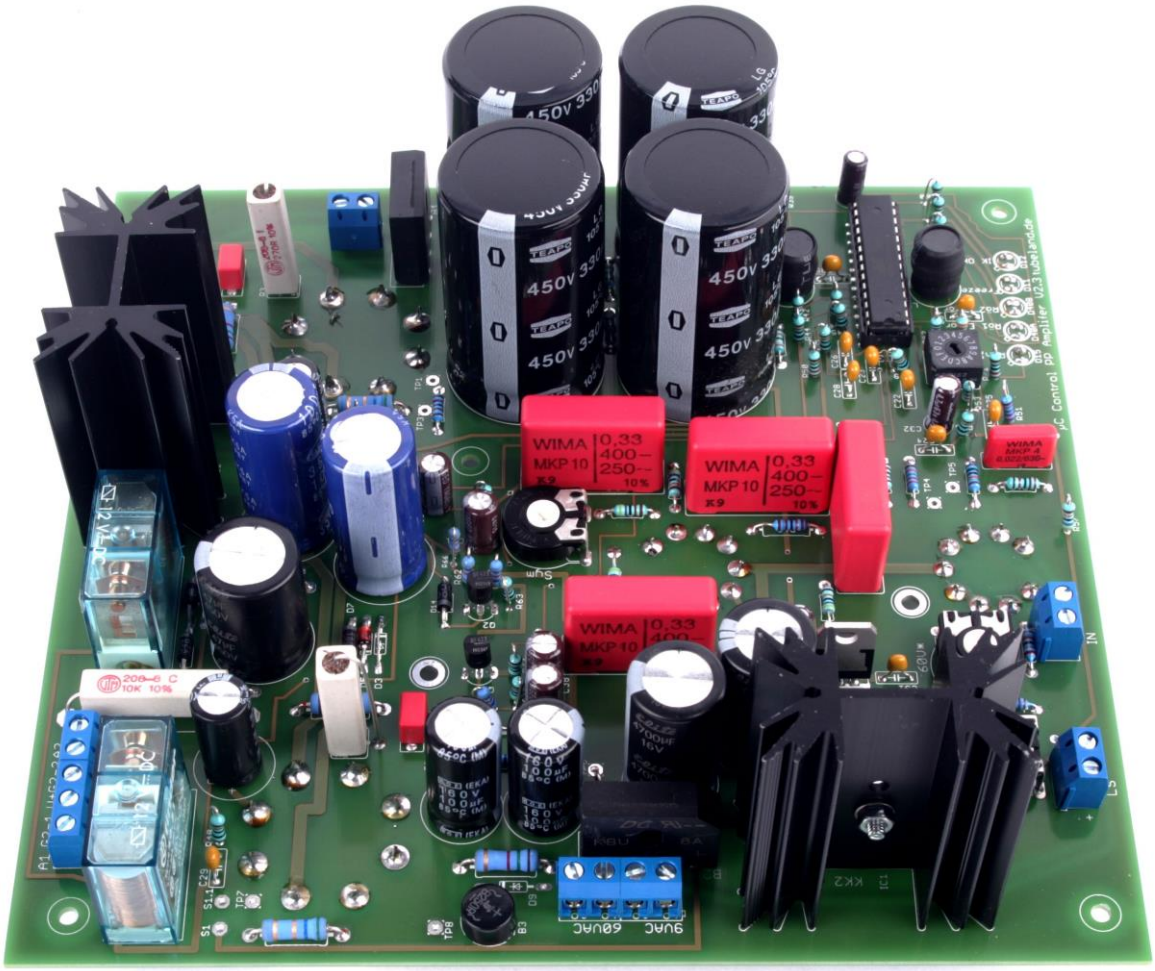
KT 88 Amp PP integrated with the Atmega 48 on board



- **New PCB design Dimensions and holes Identical to the previous version. The circuit board can easily be exchanged without much effort. 189x179mm**
- **µC Atmega48 controls the quiescent current. Adjustable in 16 levels**
- **No drifting away of the end tubes!**
- **LED status control (Run, IK ok, Freeze. Rö1 Err. Rö 2 Err)**
- **Uncomplicated switching between triode and pentode**
- **Can be used for: EL 34, KT66, KT88, KT120, KT150 etc. with the same pin assignment.**
- **Power supply on board.**
- **Double through-hole circuit board**
- **Symmetry and DC coupling can be adjusted**
- **Preamp tubes DC heating**

After the KT 88 board has been successfully in use for almost a decade, I decided to buy a new version with an integrated ATmega48 fully automatic bias control

design. Everyone who works with tubes knows that the KT88 is not protected from drifting away. Usually it is so that the quiescent current of the end tubes is checked at certain intervals and, if necessary, readjusted. And if you don't think about it anymore then it has already happened that an end tube has said goodbye. The following effort is even worse:

Not only that a new tube is now due. Most of the time the cathode resistors are over and have to be replaced. In the worst case, the circuit board is a bit scorched due to overheating. And if we take it very carefully, you don't mix old tubes with new ones because they have aged differently. Strictly speaking, it is now becoming expensive because you often swap all the power tubes together. The game starts all over again: adjust the tubes. 20-30 min waiting and checking. The same then after a day, a week, and if everything is still going well, maybe once a month?

It doesn't have to be. With the new design you can simply get started and never need to adjust against the power tubes. That’s history from now on.

Even tubes that have aged well, because the getter pill is rather milky, the regulator can still handle it! At the time when the KT120 was being developed, I got 4 prototypes that still run on the ATmega48 today. The getters are now giving up pills. The tubes are still running without a fault being displayed! And since then none of the tubes has broken to war. And that even though the electrostatic loudspeakers but also normal loudspeakers have tormented them for years. All of this speaks for a well-designed product.

In order to keep the effort even smaller, I decided to have a double through-hole printed circuit board manufactured. They are a little more expensive. However, this amount is still manageable.

Adjusting the assembly:

Once everything is installed and properly wired, we first start to check whether all voltages are present. Before all the negative grid bias is applied to pin 5 of the power tubes. You switch on the amp and measure on pin 5. (TP2 and TP6 against GND) immediately after switching on. You only have 45 seconds for this. time. Then the controller starts to work and regulates them down -UG! This is also normal if no KT (88 is plugged in! All voltages are available. If the preamp tubes are plugged in first.

1. Insert the ECC 82 into the sockets
2. Set the measurement setup for pins 5 and 9 DC voltage to a good 6.3 V (R36)
3. Mute input. R13 Set Tp. 5 against GND to 80 V or at your own request, taking into account the anode power loss
4. R9 in the middle position. If necessary with a sine generator, adjust via TP 1 and 6 to GND
5. Plug in the power tubes and set the desired anode current to level 3 or level 4 using the DIP switch. This is how the quiescent current for the output tubes is set. See also the tables!

The following tables are used to determine the cathode resistance thought

RK in S ohm		RK in IK = A ohms		RK in ohm		RK in ohm	
	IK = A		IK = A		IK = A		IK = A
0 1		0.293 1.2	0.244	1.5	0.196	1.8	0.163
1 1		0.328 1.2	0.273	1.5	0.219	1.8	0.182
2 1		0.362 1.2	0.302	1.5	0.242	1.8	0,201
3 1		0.397 1.2	0.331	1.5	0.265	1.8	0.220
4 1		0.431 1.2	0.359	1.5	0.288	1.8	0.240
5 1		0.466 1.2	0.388	1.5	0.311	1.8	0.259
6 1		0.500 1.2	0.417	1.5	0.334	1.8	0.278
7 1		0.535 1.2	0.446	1.5	0.357	1.8	0.297
8 1		0.569 1.2	0.475	1.5	0.380	1.8	0.316
9 1		0.604 1.2	0.503	1.5	0.403	1.8	0.336
A 1		0.638 1.2	0.532	1.5	0.426	1.8	0.355
B 1		0.673 1.2	0.561	1.5	0.449	1.8	0.374
C 1		0.707 1.2	0.590	1.5	0.472	1.8	0.393
D 1		0.742 1.2	0.618	1.5	0.495	1.8	0.412
E 1		0.776 1.2	0.647	1.5	0.518	1.8	0.431
F 1		0.811 1.2	0.676	1.5	0.541	1.8	0.451

RK in S ohm		RK in IK = A ohms		RK in ohm		RK in ohm	
	IK = A		IK = A		IK = A		IK = A
0 2.2		0.133 2.7	0.109	3.3	0.089	4.7	0.062
1 2.2		0.149 2.7	0.121	3.3	0.099	4.7	0.070
2 2.2		0.165 2.7	0.134	3.3	0.110	4.7	0.077
3 2.2		0.180 2.7	0.147	3.3	0.120	4.7	0.084
4 2.2		0.196 2.7	0.160	3.3	0.131	4.7	0.092
5 2.2		0.212 2.7	0.173	3.3	0.141	4.7	0.099

6th	2.2	0.227	2.7	0.185	3.3	0.152	4.7	0.106
7th	2.2	0.243	2.7	0.198	3.3	0.162	4.7	0.114
8th	2.2	0.259	2.7	0.211	3.3	0.173	4.7	0.121
9	2.2	0.275	2.7	0.224	3.3	0.183	4.7	0.128
A.	2.2	0.290	2.7	0.236	3.3	0.193	4.7	0.136
B.	2.2	0.306	2.7	0.249	3.3	0.204	4.7	0.143
C.	2.2	0.322	2.7	0.262	3.3	0.214	4.7	0.151
D.	2.2	0.337	2.7	0.275	3.3	0.225	4.7	0.158
E.	2.2	0.353	2.7	0.288	3.3	0.235	4.7	0.165
F.	2.2	0.369	2.7	0.300	3.3	0.246	4.7	0.173

S.	**RK in ohm**	**IK = A**	**RK in ohms**	**IK = A**	**RK in ohm**	**IK = A**	**RK in ohm**	**IK = A**
0	5.6	0.052	6.8	0.043	10	0.029	12th	0.024
1	5.6	0.059	6.8	0.048	10	0.033	12th	0.027
2	5.6	0.065	6.8	0.053	10	0.036	12th	0.030
3	**5.6**	**0.071**	6.8	0.058	10	0.040	12th	0.033
4th	**5.6**	**0.077**	6.8	0.063	10	0.043	12th	0.036
5	5.6	0.083	6.8	0.069	10	0.047	12th	0.039
6th	5.6	0.089	6.8	0.074	10	0.050	12th	0.042
7th	5.6	0.096	6.8	0.079	10	0.053	12th	0.045
8th	5.6	0.102	6.8	0.084	10	0.057	12th	0.047
9	5.6	0.108	6.8	0.089	10	0.060	12th	0.050
A.	5.6	0.114	6.8	0.094	10	0.064	12th	0.053
B.	5.6	0.120	6.8	0.099	10	0.067	12th	0.056
C.	5.6	0.126	6.8	0.104	10	0.071	12th	0.059
D.	5.6	0.132	6.8	0.109	10	0.074	12th	0.062
E.	5.6	0.139	6.8	0.114	10	0.078	12th	0.065
F.	5.6	0.145	6.8	0.119	10	0.081	12th	0.068

In the table I have marked the appropriate place for the KT88 project!

Operating status display of the LED or controller function

The LEDs indicate the operating status as follows.
LED15 blue shows after approx. 45 sec. at which the controller starts to run. Before that, the heating phase of the power tubes begins. If the tubes are set to the quiescent current, the LED D12 lights up green and signals that the tubes are running on a set quiescent current.

As soon as the input signal reaches a certain level, the set value is frozen. Then the LED D11 lights up green.

LED D40A and / or D40B red light up for faults in the output tubes. If that is the case, something is wrong with the power amplifier tubes and may have to be replaced. This happens especially when the quiescent current apart from the specified quiescent current drifts despite all.

Port D7 is on after approx. 30-40 seconds 5V. This signals that the controller is ready to work.

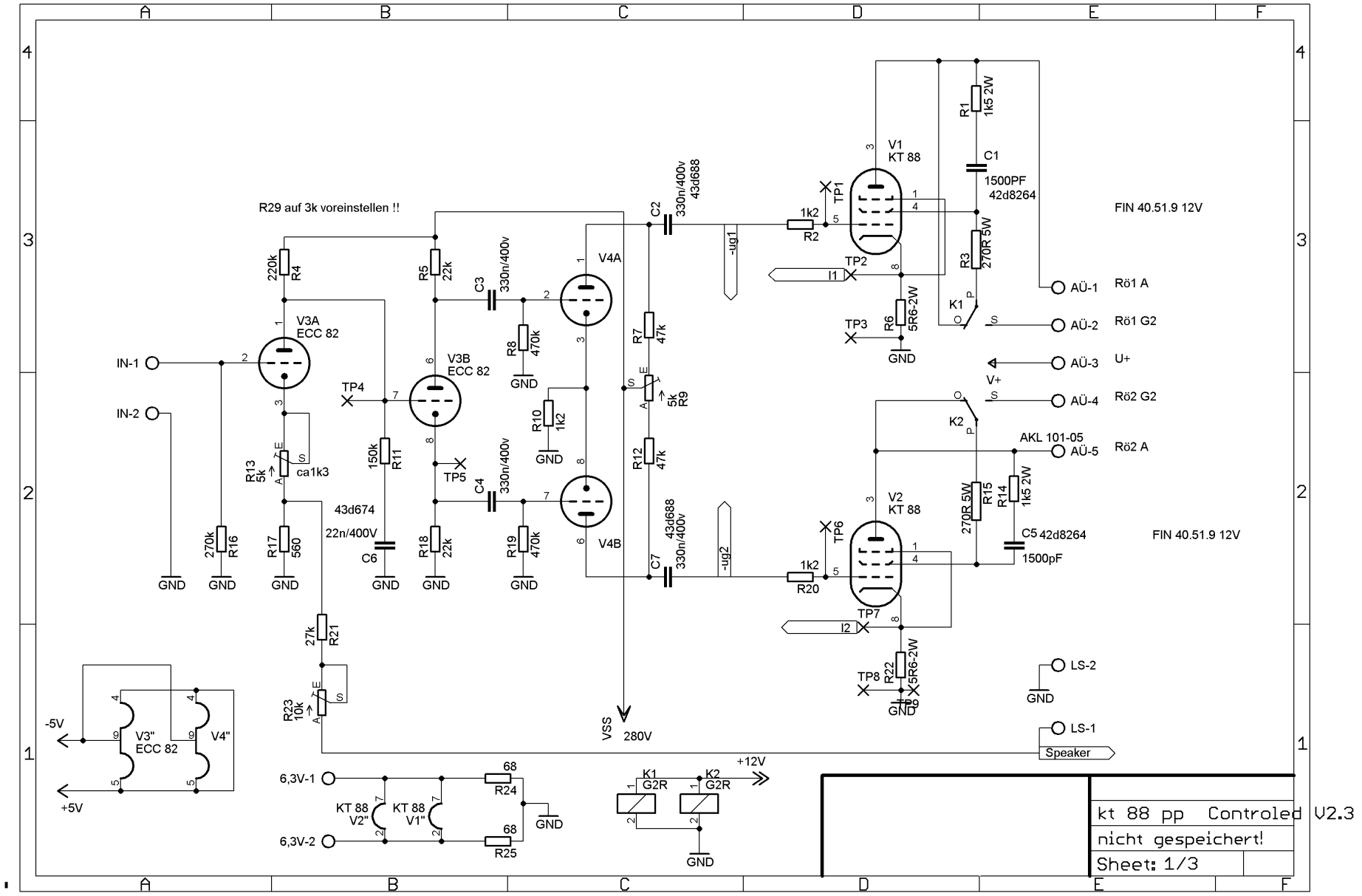
The controller needs the following conditions to start running:
1) the time (~ 30 - 45s) must have expired since switching on - this can be checked by measuring at PortD.7 whether 1-5V is present. 2) the voltage at the speaker input must be higher than 0.28V (mind you. After the divider resistors) Otherwise -Ug will not be frozen and the controller will adjust the operating point undesirably. That shouldn't be! 3) the voltage at the operating voltage input must be at least 0.47V (even ... after the divider resisted) if this is not the case, all LEDs remain dark and the controller maintains the maximum -Ug voltage! Depending on how high the anode voltage is, the voltage divider would have to be adjusted accordingly.
If everything is fulfilled, the controller starts to run. If nothing else is connected to the measurement inputs for the cathode currents, the controller has to run into the limit at some point and the associated LEDs should come on (PortB.4PortB.7). If the inputs are really open and not pulled to 0V by a measuring resistor, this can also be done at different times. PortB.0 only goes to "High" if the speaker input is more than 0.28V. Depending on the input voltage, the voltage divider can be adjusted.

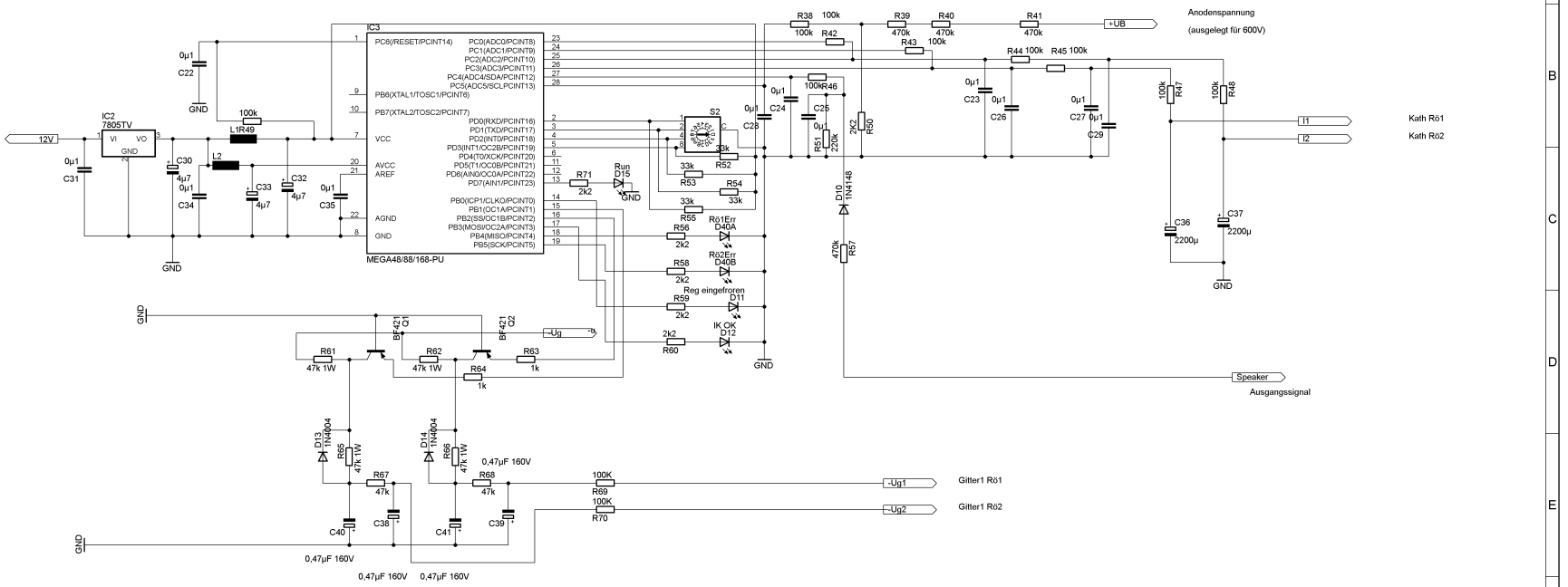
The capacitors can also be exchanged for larger ones (1uF) if desired (100nF). But it's a matter of taste. PortB.3 goes high if all (measured) cathode currents are in a very small range around the target current.

The series resistors have to be adapted depending on the LED type. As a standard I used 2K2 Ohm resistors. These are for LEDs with a current consumption of approx. 20 mA. For low energy LEDs approx. 2 mA, the resistances should be around 2K2 ohms. Note the data sheet of the LED used!

In general, a maximum load of 20 mA may be connected to the port outputs of the Atmega xx.

Ug Should be chosen a little higher than required!


R29 auf 3k voreinstellen !!
V3A ECC 82
V3B ECC 82
V4A
V4B
V1 KT 88
V2 KT 88
V3" ECC 82
V4"
KT 88 V2"
KT 88 V1"
IN-1
IN-2
TP1
TP2
TP3
TP4
TP5
TP6
TP7
TP8
TP9
I1
I2
R1 1k5 2W
R2 1k2
R3 270R 5W
R4 220k
R5 22k
R6 5R6-2W
R7 47k
R8 470k
R9 5k
R10 1k2
R11 150k
R12 47k
R13 5k ca1k3
R14 1k5 2W
R15 270R 5W
R16 270k
R17 560
R18 22k
R19 470k
R20 1k2
R21 27k
R22 5R6-2W
R23 10k
R24 68
R25 68
C1 1500PF 42d8264
C2 330n/400v 43d688
C3 330n/400v
C4 330n/400v
C5 42d8264 1500pF
C6 43d674 22n/400V
C7 43d688 330n/400v
K1 G2R
K2 G2R
K1
K2
AKL 101-05
AÜ-1 Rö1 A
AÜ-2 Rö1 G2
AÜ-3 U+
AÜ-4 Rö2 G2
AÜ-5 Rö2 A
V+
FIN 40.51.9 12V
FIN 40.51.9 12V
LS-1 Speaker
LS-2
-ug1
-ug2
VSS 280V
+12V
-5V
+5V
6,3V-1
6,3V-2
GND
kt 88 pp Controled V2.3
nicht gespeichert!
Sheet: 1/3



Tubeland	
kt 88 pp Controled V2.3 TITLE:	
REV: 0.93	Document Number: 0001
3/3 Sheet:	nicht gespeichert! Date:

To the power supply:

Here, too, a small number of sensible changes were made. R27 was exchanged for a 22K 2W resistor (formerly 8K2) that has the advantage that the R26 doesn't get quite as warm anymore. D3 Is usually not equipped and is replaced by a wire bridge! Also D9 is usually not populated! If necessary, it serves to limit stress.

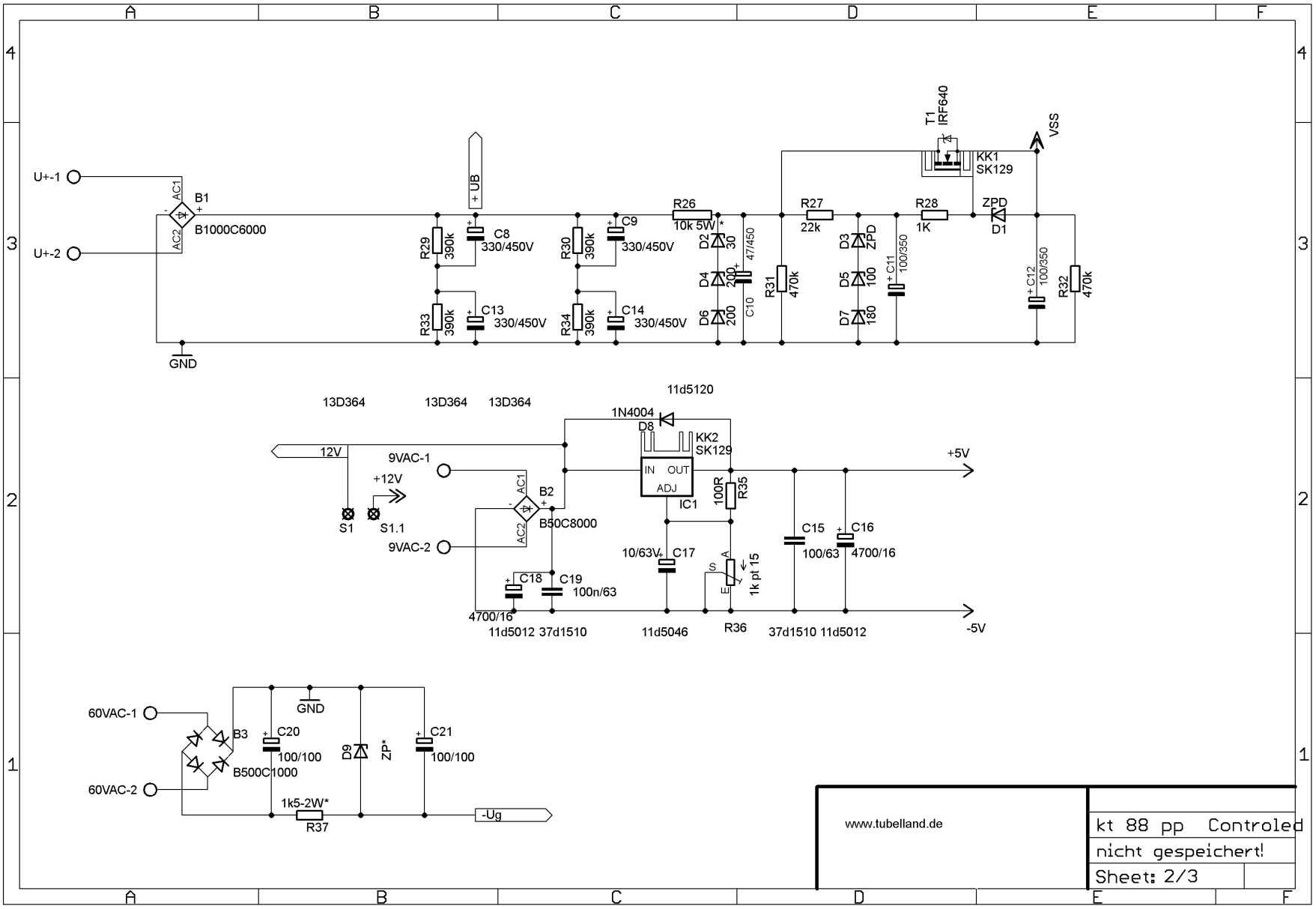
The power supply has also been simplified a bit.

The charging capacitors are connected in series and have discharge resistors. **DANGER!** The on-board voltage is life threatening! ! ! Please make sure that the anode voltage is almost reduced when handling. So that they don't get hurt! !

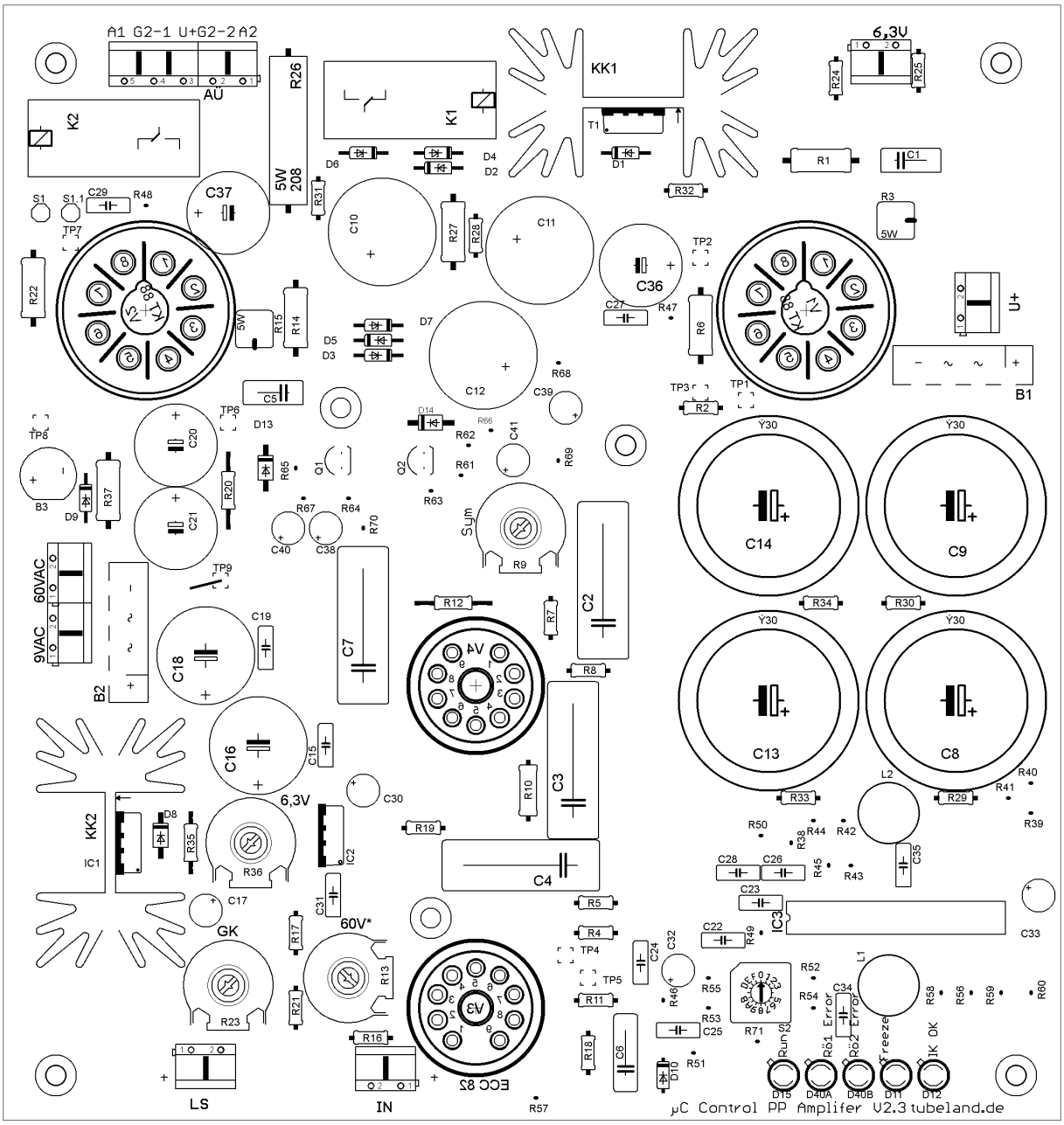
The picture shows again the DIP switch position for the KT88 Amp level 3-4 is correct here!

The supply voltage is possible via the T1018 or via the T2419.

The anode voltage is to be selected for the KT88 353V -UG = 60V. The amp can be switched between triode and pentode during operation via S1 and S1.1.


U+-1
U+-2
B1
B1000C6000
AC1
AC2
+ UB
GND
R29 390k
R30 390k
R33 390k
R34 390k
C8 330/450V
C9 330/450V
C13 330/450V
C14 330/450V
R26 10k 5W*
D2 30
D4 200
D6 200
C10 47/450
R31 470k
R27 22k
D3 ZPD
D5 100
D7 180
C11 100/350
R28 1K
ZPD D1
T1 IRF640
KK1 SK129
VSS
C12 100/350
R32 470k
13D364
13D364
13D364
11d5120
1N4004
D8
KK2 SK129
12V
9VAC-1
9VAC-2
+12V
S1
S1.1
B2
B50C8000
IN OUT ADJ
IC1
100R R35
+5V
-5V
C15 100/63
C16 4700/16
10/63V C17
C18 4700/16
C19 100n/63
1k pt 15
R36
11d5012 37d1510
11d5046
37d1510 11d5012
60VAC-1
60VAC-2
B3
B500C1000
C20 100/100
C21 100/100
D9 ZP*
1k5-2W*
R37
-Ug
www.tubelland.de
kt 88 pp Controled V2.3
nicht gespeichert!
Sheet: 2/3

On the assembly print you can see a small wire bridge over TP9! This must be set and connects the DC heater to GND! All TP (Test Point) are used to test the board voltage or adjustment. Here the measuring tips can simply be placed on the pad.



Basically, the assembly is done according to the assembly plan!

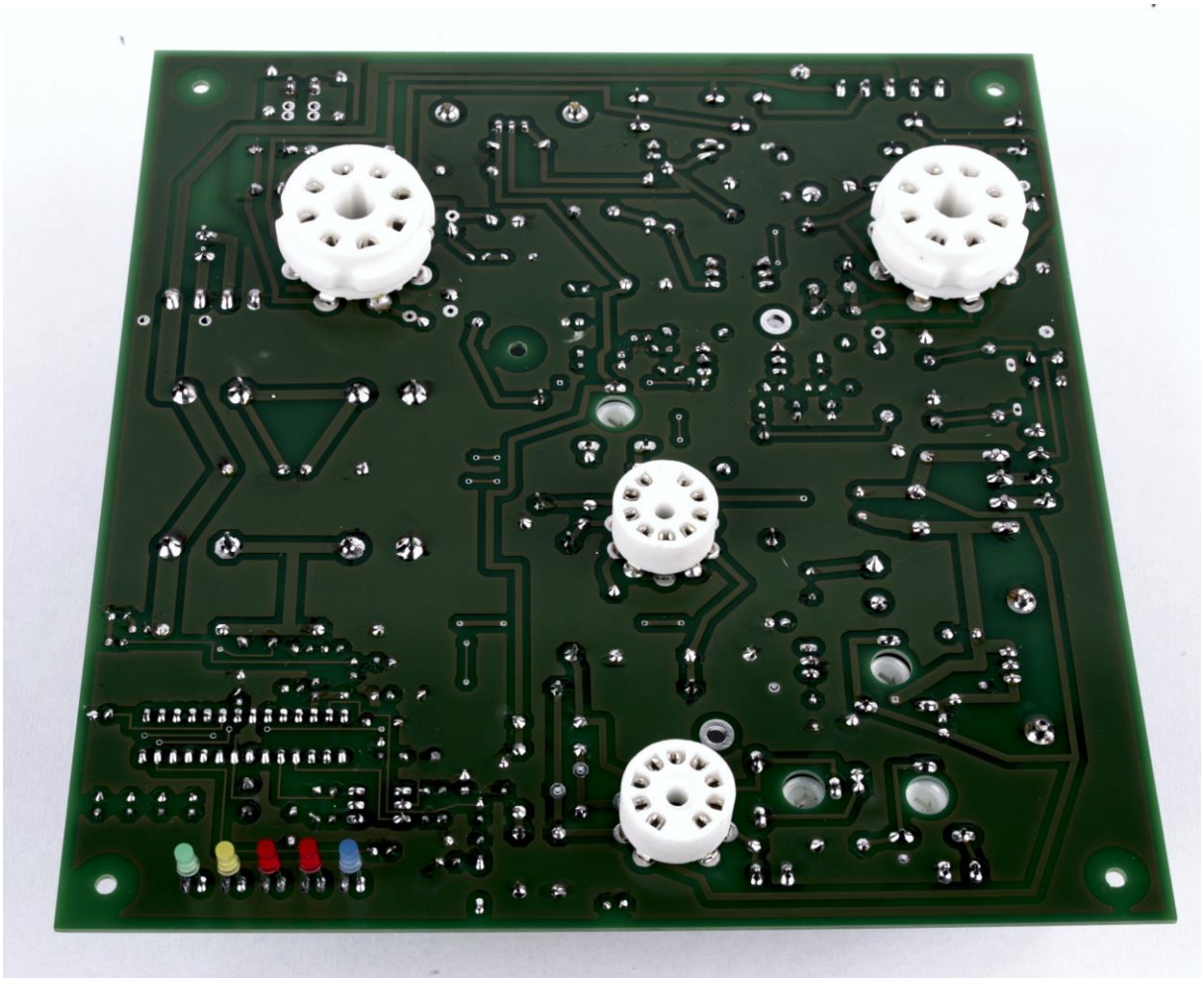
If you want to modify the amp!

Column1	Column2	Column3	Column4
quantity	value	Device	Components
2	5R6-2W	2W metal	R6, R22
2	68R	1/4 W metal	R24, R25

1	100R	1/4 W metal	R35
1	560R	1/4 W metal	R17
2	270R 5W	RKH208-8R	R3, R15
3	1k	1/4 W metal	R28, R63, R64
3	1k2	1/4 W metal	R2, R10, R20
2	1k5 2W	2W metal	R1, R14
1	1k5-2W *	2W metal	R37
6th	2k2	1/4 W metal	R50, R56, R58, R59, R60, R71
1	10k	TRIM_EU-LI15	R23
1	10k 5W *	RKH208-8	R26
2	22k	1/4 W metal	R5, R18
1	22k 2W	2W metal	R27
1	27k	1/4 W metal	R21
4th	33k	1/4 W metal	R52, R53, R54, R55
8th	47k 1W	1W metal	R7, R12, R61, R62, R65, R66, R67, R68
11	100k	1/4 W metal	R38, R42, R43, R44, R45, R46, R47, R48, R49, R69, R70
1	150k	1/4 W metal	R11
1	220k	1/4 W metal	R4, R51
1	270k	1/4 W metal	R16
4th	390k	1/4 W metal	R29, R30, R33, R34
8th	470k	1/4 W metal	R8, R19, R31, R32, R39, R40, R41, R57
1	1k pt 15	TRIM_EU-LI15	R36
2	5k	TRIM_EU-LI15	R9, R13
2	1500PF	C-EU075-042X103 C1, C5	
1	22n / 400V	C-EU102-043X133 C6	
13th	0µ1	C-EU050-025X075	C15, C19, C22, C23, C24, C25, C26, C27, C28, C29, C31, C34, C35
4th	330n / 400v	C-EU225-087X268 C2, C3, C4, C7	
4th	0.47µF 160V	CPOL-EUE2.5-6 C38, C39, C40, C41	
3	4µ7	CPOL-EUE2.5-6 C30, C32, C33	
1	10µF / 63V	CPOL-EUE2.5-6 C17	
1	47µF / 450V	E7.5-18 C10	
2	100µF / 100V	CPOL-EUE5-13 C20, C21	
2	100µF / 350V	E7,5-18 C11, C12	
4th	330µF / 400V	CPOL-EUE10-30 C8, C9, C13, C14	
2	2200µF / 16V	CPOL-EUE5-13 C36, C37	
2	4700µF / 16V	CPOL-EUE7.5-16 C16, C18	
3	1N4004	1N4004	D8, D13, D14
1	1N4148	1N4148DO35-7	D10
1	13V	ZPD	D1
1	30V	ZPD	D2

1	100V	ZPD	D5
1	180V	ZPD	D7
2	200V	ZPD	D4, D6
1	7805TV	7805TV	IC2
1	B50C8000	KBU8A	B2
1	B500C1000	RB1A	B3
1	B1000C6000	KBU	B1
2	BF421 or BF423	BF421	Q1, Q2
1	IRF640	IRF640	T1
1	MEGA48PU	MEGA48PU	IC3
1	LM350T	LM350T	IC1
1	IK OK LED GREEN	SFH482	D12
1	Rö1Err LED RED	SFH482	D40A
1	Rö2Err LED RED	SFH482	D40B
1	Reg frozen, LED YELLOW	SFH482	D11
1	Run LED blue	SFH482	D15
1	KDR16 HEX DIP		S2
7th	AKL 101-02	AK500 / 2	
1	AKL 101-03	AK500 / 3	
1	Socket DIP28		
2	SK129	SK129	KK1, KK2
2	4.7mH	BS11	L1, L2
2	ECC82	ECC82	V3, V4
2	KT 88	EL34-P	V1, V2
2	Noval version		
2	Octal version		
2	G2R relay 12V 1xUM	G2R	K1, K2
1	Circuit board 189x179mm		

When equipping, the socket is mounted on the botten side! Make sure that the octal socket is soldered in correctly as shown in the photo! Point your nose backwards!



Enclosed in Appendix N in which the data can be found.

The list can be expanded or changed. The latest version can be found on www.tubeland.de

Appendix N

Tube	output power	circuit	AT impedance	U +	I.	R16 / R18	G1 -U
EL 34	36 W.	Pentode	3k8	350V	35 mA	470R	- 32
EL 34	44 W.	Pentode	2k8	375V	35 mA	470R	- 32
EL 34	45 W.	Pentode	4k	400V	30 mA	1K	- 38
EL 34	55 W.	Pentode	3k4	425V	30 mA	1K	- 38
EL 34	58 W.	Pentode	5k	475V	30 mA	750 R	- 36
EL 34	70 W	Pentode	4k	500V	30 mA	750 R	- 36
EL 34	90 W.	Pentode	11k	750V	25 mA	750 R	- 39
EL 34	100 W.	Pentode	11k	800V	25 mA	750 R	- 39
EL 34	15.5 W.	Triode	5 K	375 V			
6L6	14.5 W	Pentode	5K	250V	60 mA		- 16
6L6	26.5 W	Pentode	6K6	360V	44 mA		- 22.5
6L6	47 W.	Pentode	3k8	360V			- 22.5
6L6	55 W	Pentode	5k6	450V			- 37
6L6	1.4 W	Triode	5K	250V	40 mA		- 20th
6550	77 W	Pentode	3K5	450V			- 29.5
6550	100 W	Pentode	5K	600V			- 32.5
KT 66	4.5 W.	Triode	2k5	270V			- 19th
KT 66	14.5 W.	Triode	5k	440V			- 38
KT 66	50 W.	Pentode	8K	525V	35 mA		- 67
KT 66	50 W.	Pentode	5k	475V			- 80
KT 77	34 W.	Pentode	6k	430V		22R	
KT 77	45 W.	Pentode	4k5	400V		22R	- 31
KT 77	67 W.	Pentode	5k5	500V		22R	- 43
KT 77	72 W.	Pentode	9k	600V		22R	- 56
KT 77	18 W.	Triode	5K	430V		22R	- 30
KT 88	50 W.	Pentode	6k	500V		270R	- 50
KT 88	100 W.	Pentode	4k5	560V		270R	- 80
KT 88	15 W.	Triode	4k	400V		270R	- 38
KT 88	37 W.	Triode	4k	485V		270R	- 48
KT 88	30 W.	Pentode	5K	375V		270R	- 35
KT 88	70W	Pentode	4K	485V		270R	- 59

KT 90 Unfortunately no data are available at the moment

KT Unfortunately no data are available at the moment

As you can see there are a few possibilities I decided on the KT 120 485V DC under load and an AÜ with 4K for the EL 34 50W from my program. Who did his service well. Basically, my AÜ'ś are over-demensored so that I can also use the EL34 AÜ for the KT120. Quiescent current is on pos 4. I am satisfied with it. In which mode you want to run the power amplifier you can freely choose.

I have collected the data from tables and have written a guarantee of correctness here, despite careful revision.

And another thing. I would definitely allow the circuit to have a switch-on delay! Otherwise, the machine could fly out when the amp is switched on. In addition, the fuses would not optimally protect the transformer

Circuit board for switch-on delay is treated separately.

Negative feedback:

To make sure that it is really coupled against. Use the following test:

First let the power amplifier run WITHOUT negative feedback.

A sine wave signal or something from a CD can serve as the audio source.

The speakers are connected. Setting the output level to room volume is sufficient. The GK is switched on during operation.

Pay attention to the difference in volume.

Is the music quieter now than before? Was the GK wired correctly. The amp would then be ready.

Should the music playback not be quieter, but louder. Then let's talk about positive feedback!

In our case, the positive feedback is not desired.

Countermeasures:

Then swap output 11 and 17 on the AÜ.

The counter is now coupled as desired.

GND is always LS - and the soldering lug that is also used for the GK is LS +

Basically the amp has to be earthed. To prevent a ground loop, the ground can be grounded to the cinch input or to the DC heating bridge.

Technical specifications:

Anode voltage under load 485V

Tubes used: 2 * ECC 82 JJ **2 * KT 88 EH**

Transformer 2 * EL 34 4K 8R

Triode operation:

Power 36W

Input sensitivity 0.931V at full scale

F gang measured at 20 watts 12.5 Hz 0 db, 35 kHz 0 db 54 kHz - 3 db

Gain factor 25.2 db

Pentode operation:

Power 70 W

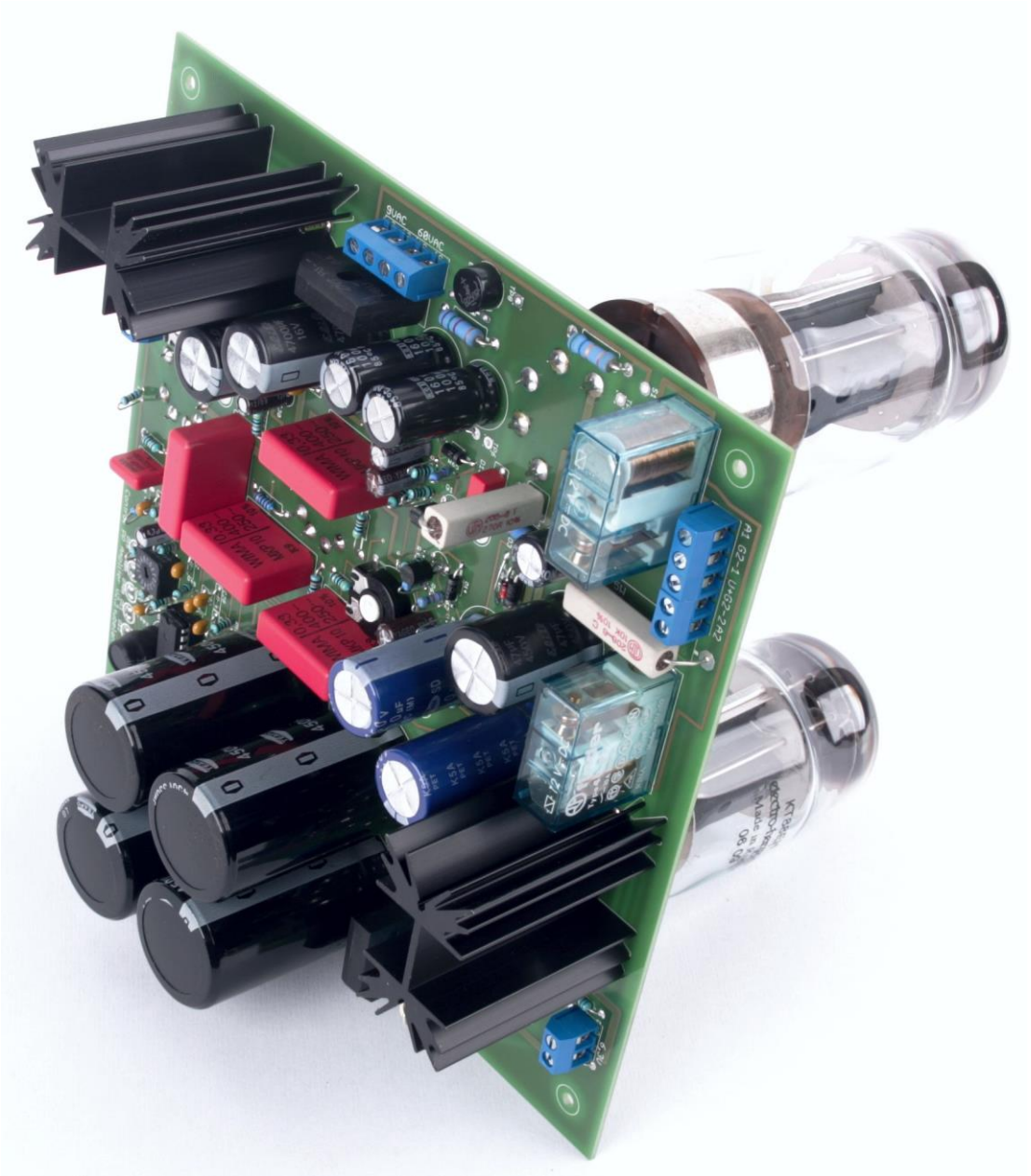
Input sensitivity 0.947 V at full level

F gang at 35 watts Measured 15 Hz - 0.2 db, 35 kHz 0db, 45 - 3db

F output at 70 watts Measured 15 Hz - 1.6 db, 20 Hz - 0.4 db, 25 kHz - 3db

Gain factor 28 db

Interference voltage 0.9mV at 8 ohms


5UAC
5BUAC