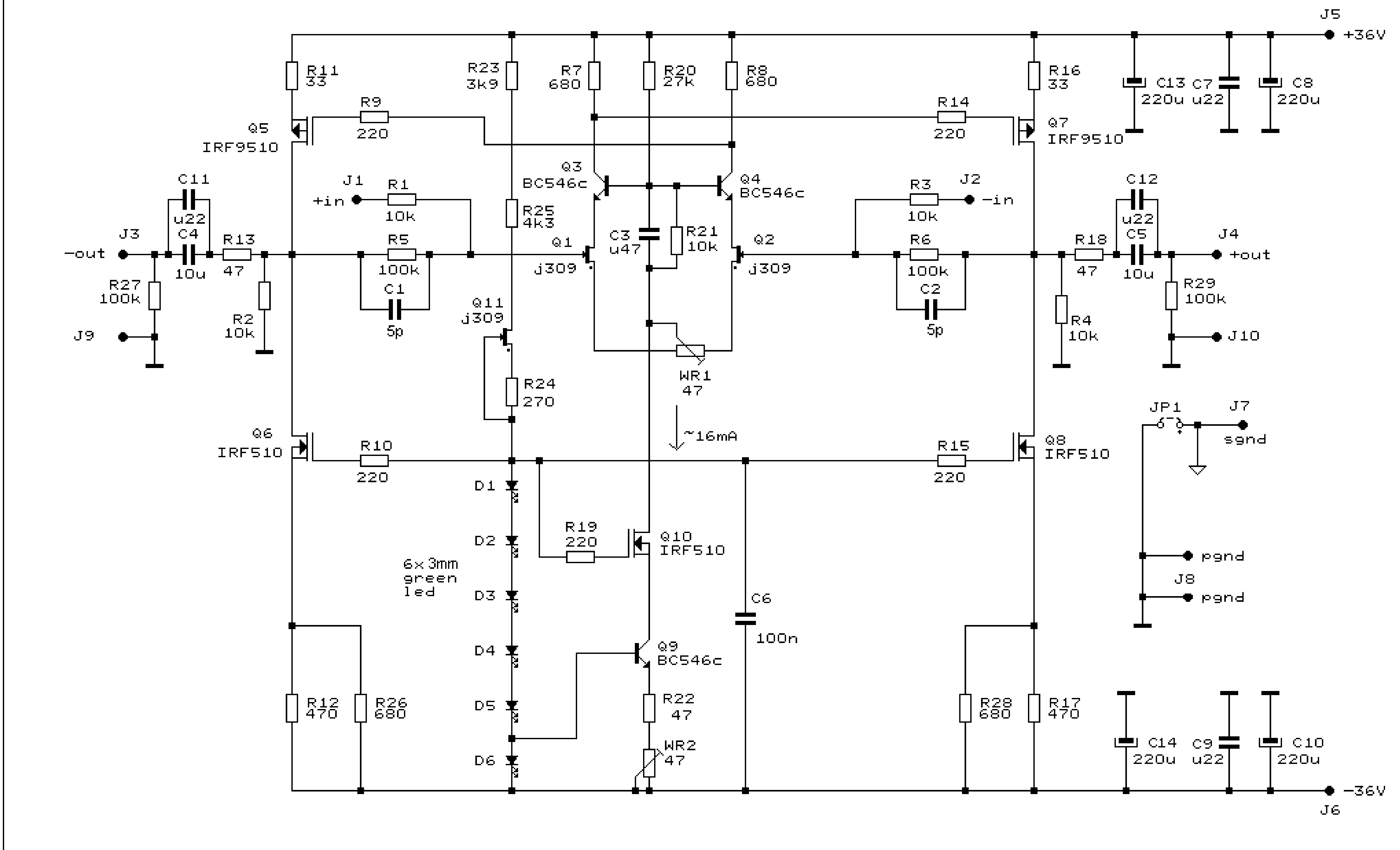
The Last Audio

The Pumpkin

Super Symmetric
Balanced Line Amplifier

2007.



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Size	Document Number	REV
A	The Pumpkin	1
Date: 2007	Sheet 1 of 1	

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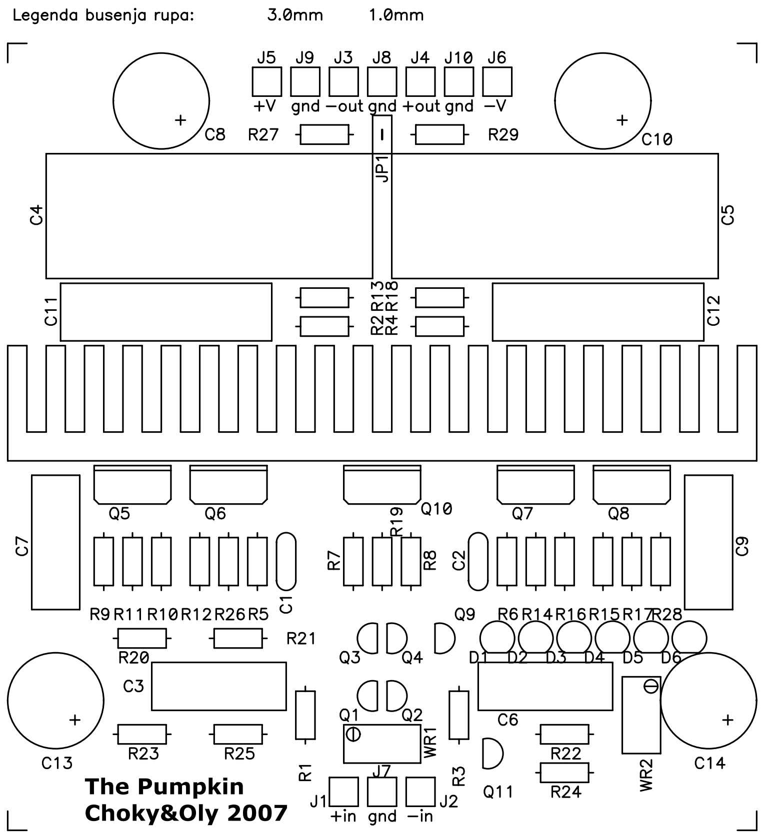


HOW PUMPKIN WORKS

Main part - in fact - engine of Pumpkin is differential pair (LTP - Long Tailed Pair) , made of Q1 and Q2 ; they are purposely chosen to be J309 or j310 - easy to find and with decent characteristics ;

Toob electronic is my main passion ; I learned with Toobz that you must have enough current through stage to achieve decent driving characteristics , in other words - that way you ensure that stage is capable enough to drive next stage .... same story here - I choose J310 as replacement for 2SK389V , or pair of 2SK170V - most current capable sane jfets ;)

I hope that I don't want to write how signal enters LTP and how's amplified ...... on both sides - at R7 and R8 as left and right loads ....

Both mentioned jfets in LTP are cascoded with plain vanila BC critters - probably most often used BC critters after BC109 and similar ones .... reason for cascoding is twofold - preserve tiny jfets from excessive voltage (thus dissipation also) and to fight with Herr Miller's ugly head (that's Herr connected with reflecting interelectrode capacitance of jfet via amplification factor ; when Uds is constant - we don't have variations in reflected (read- amplified) capacitance , also known as Miller's effect) .

LTP cascode is biased (base of both Q3 and Q4 is placed at desired voltage potential) via R20-R21 string ; possible variations are filtered with C3.

Current through entire LTP is set by CCS , formed of Q9 and Q10 ; I choose ~15mA , and that is ~ 7mA through left side of LTP,7mA through right side of LTP and ~1mA through cascode biasing string (look at schematic to see what's that ;))..

That CCS is biased (his own DC conditions) with D1 to D6 green led string ; each led have ~1,93V across it , at 5mA current , which is set with helper "micro" CCS , made of Q11+R24 . Led's are enough silent for that purpose .
Q10 is cascode of main CCS part (Q9) , augmenting Q9's dynamic resistance ; it's biased (read - open full throttle) with D1-D5 string , which is standing on D6 shoulders.

So - small info regarding Q9 current - Ube = 0,65V typical ; voltage across D6 is 1,93V ; so - voltage across R22+WR2 is 1,93-0,65 = 1V28 .... so - 1V28/17mA = 75ohms (don't try to connect TV antenna there .... hehe)

Same story goes for seting current through "micro" CCS - target is 5mA .... resistor is 270E - so - calculate what's Ugs ;)

Now - look at Q6 and Q8 ; they are nothing more and nothing less than output CCS-es , left and right ,respectively;

They are veeeery cleverly (ZM is also often known as Baldrick) biased along with Q10 – with same green LED string ;

so - 6 x Uled = 6x1V93 = 11V58 ; Ugs for these mosfets is in range of 4V ; now - we can calc what resistance we need in Q6 and Q8 sources to have ~ 30mA through each ..... 11V58-4V = 7V58/30mA = 252E , so I choose 470 and 680 ohms in parallel (think also about dissipation- so they are two) , giving ~277E ..... life is sometimes different than paper , and real mosfets are always different than paper ones ;) .... read - typical Ugs of 4V is often less than 4V .....

On top of each output CCS (Q6 and Q8) are placed real working output mosfets - Q5 and Q7 ;

They are biased (think again about magical number of 4V between G and S) with currents flowing through R7 (for Q5 biasing) and R8 (for Q7 biasing) ;

When your precious signal enter input LTP, current through these two resistors is going upand down , modulating gates of Q5 and Q7 ;

Important thing is - blabla - you often read about "common source , common drain , common gate" stages of mosfets;

Lookie,lookie-everything here is simple - just forget that outputs are in common source connection ; look at that this way - for each output mosfet's drain you have load - made of output CCS ; Q5's drain see Q6 CCS as load ; same- Q7's drain sees Q8 CCS as load ;
You must remember - when mosfet have load in drain, then that stage have gain , too ;
Just to mention - R16 and R11 are source degeneration resistors - popular way of slightly decreasing gain of stage and achieving slightly better .... everything ;) ; also observe - role of WR1 - it's there for slight source degeneration of input jfets and also for setting DC symmetry - when needed ....

huh ....

Further :

Observe where is +input , where is -input, where is + output and where is - output ; look good where is each half gain contribution .... and also look at few more things :

Gain of entire stage is set with ratio of R1/R5 and R3/R6 ; you see that this approach is same as in so called - inverting Operational Amplifier stage .... one resistor inline with signal , one resistor taking signal back from output .....
(Pumpkin is tried with gain(s) set in range of ~ 2x up to 15x , working as expected .)

Specificum of this gadget is exactly where is taken drive for output stages - cross coupled !!
That's Super Symmetric Papa's thingie ...... think little about that ,and do not underestimate role of Tail in LTP ...... it's crucial for Super Symmetric effect , at least in Pumpkin .
I know that you'll have questions , so I will not even bother to write more about this thematic ....

The Pumpkin

Resistors : all - your favorite brand .... MF 0,25W /1% .....as example

POSITION	VALUE	pieces/channel	note
R1,R2,R3,R4,R21	10K	5pcs	
R5,R6,R27,R29	100K	4pcs	see 1.
R7,R8,R26,R28	680E	4pcs	
R9,R10,R14,R15,R19	150E to 240E	5pcs	
R11,R16	33E	2pcs	
R12,R17	470E	2pcs	
R13,R18,R22	47E	3pcs	
R20	27K	1pc	
R23	3K9	1pc	
R24	270	1pc	
R25	4K3	1pc	
WR1,WR2			

note 1 .

Ratio of R5/R1 and R6/3 sets gain of preamp ; In this case it's 10x ; you can alter values of both –R5 and R6 in range of 47K to 150 K and accordingly have gain in range of 4,7 to 15 .

Capacitors :

POSITION	VALUE	pieces/channel	raster mm	note
C1,C2	5p mica	2pcs	5	see 2.
C3	470n – 2u2 / 50V	1pc	5-15	
C4,C5	3u3 – 10u / 50V	2pcs	12,5 -38	
C6	100n – 220n / 50V	1pc	5-15	
C7,C9	220n – 2u2 / 50V	2pcs	5-15	
C11,C12	220n – 2u2 / 50V	2pcs	7,5 - 23	see 3.
C8,C10,C13,C14	220uF – 470uF /50V	4pcs	5	

note 2 . use mica if you find ; value must be scaled according to value of R5/R6 ; if you decrease/increase value of R5/R6 then increase/decrease value of C1/C2 to preserve approx. same RC ratio.

note 3. bypass caps for output caps C4/C5 ; use your fave ....

Semiconductors:

POSITION	type	pieces/channel	note
D1,D2,D3,D4,D5,D6	green led 3mm dia	6pcs	
Q1,Q2,Q11	J309 or J310	3pc	see 4.
Q3,Q4,Q9	BC546C (B)	3pcs	see 5.
Q5,Q7	IRF9510	2pc	see 6.
Q6,Q8,Q10	IRF510	3pcs	see 7.

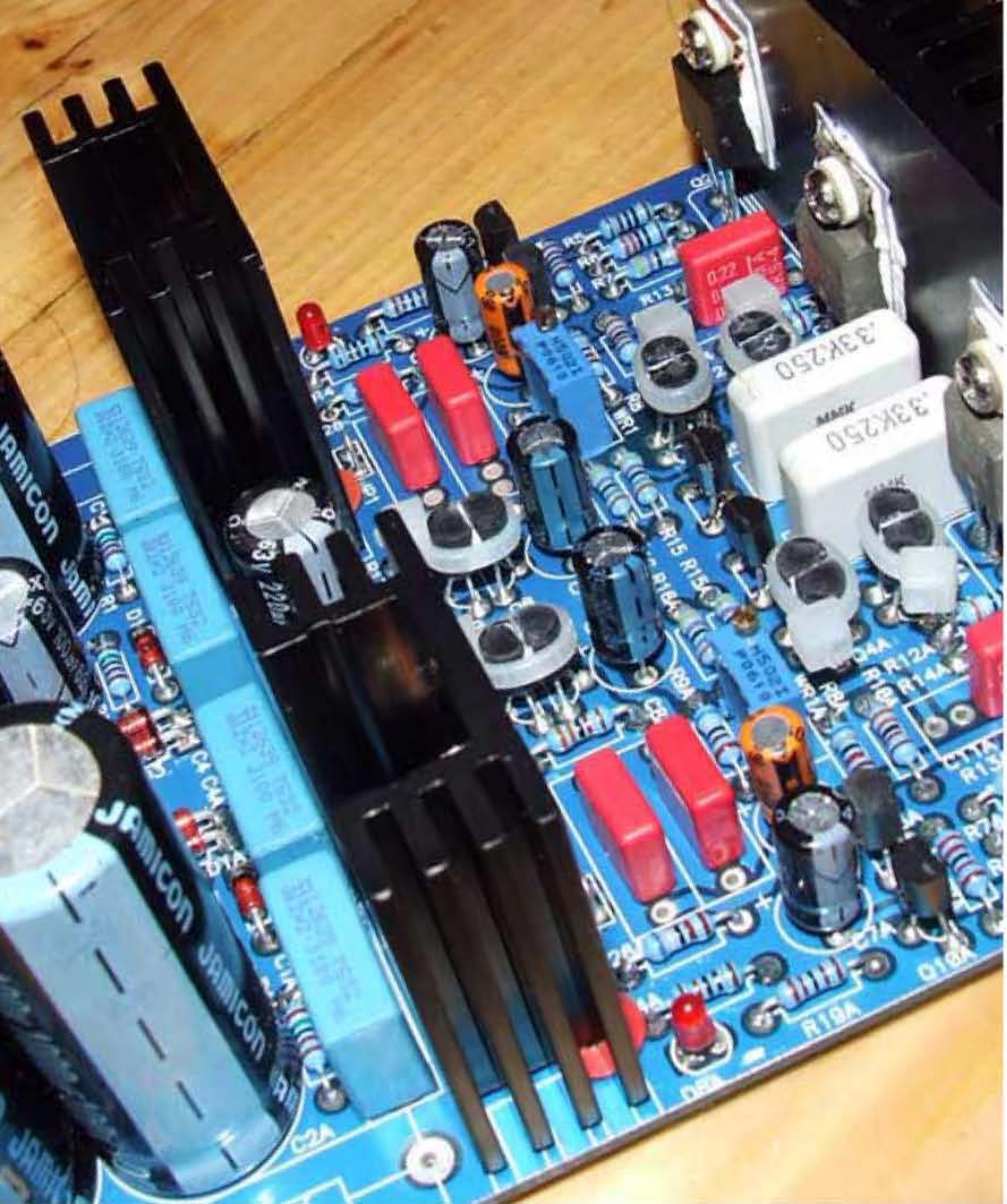
note 4. Q1/Q2 matched pair

note 5. Q3/Q4 matched pair ; you can also use BC550C , or any other decent low noise NPN little jobbie with similar U/I/P .

note 6. matched pair ; you can also use IRF9520, IRF9610 , IRF9620 , with somewhat different character in upper register .

note 7. Q6/Q8 matched pair ; you can also use IRF520 , IRF610 , IRF620 without any harm ; they are just CCS-es .

Heatsink - anything around 5C/W or better .... until it burn your fingers everything is OK ; there is just slightly more than 5W dissipation per channel .
You need one heatsink /channel .... hehe .

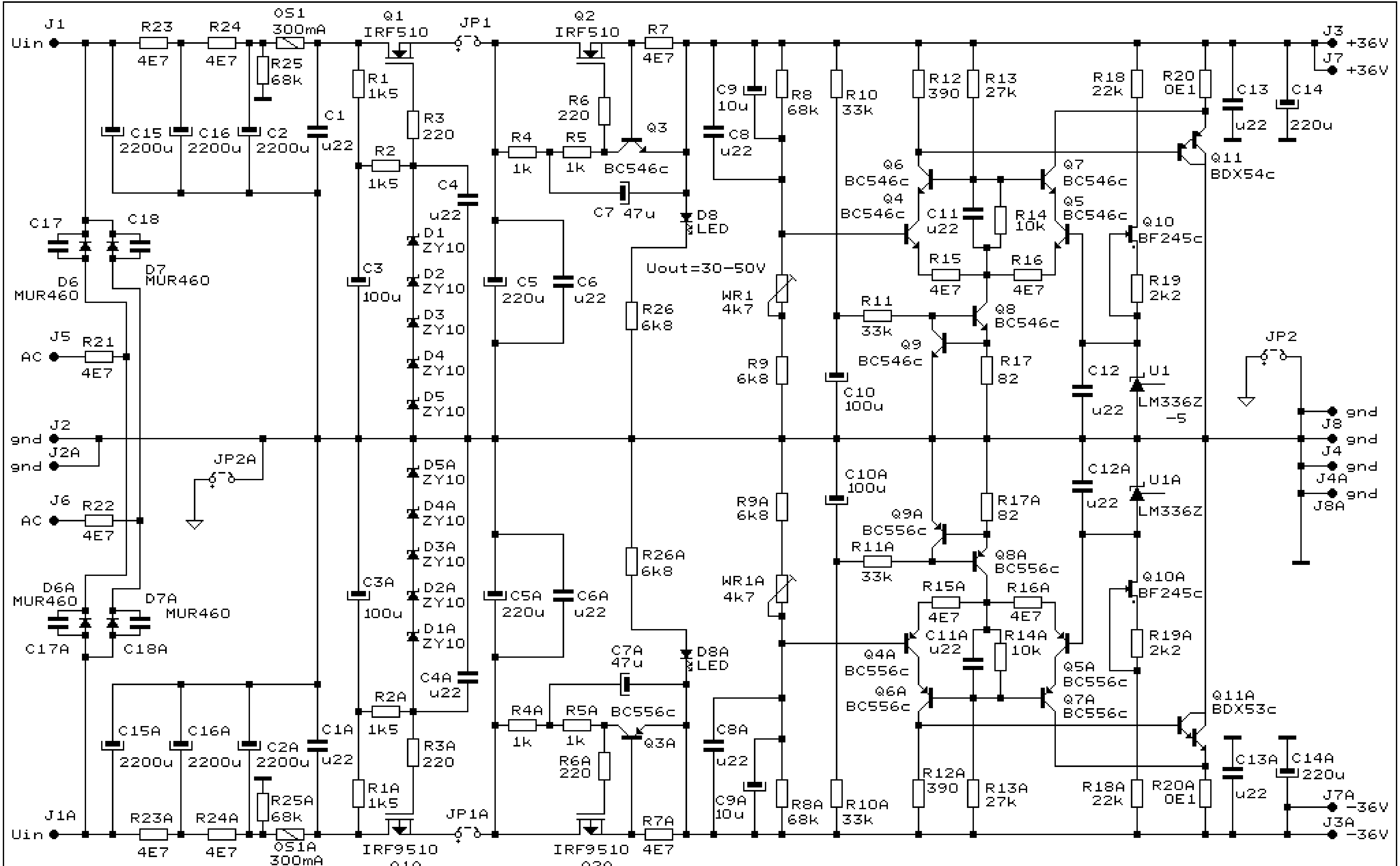


The Last Audio

The Shunty

Low Noise Serial/Parallel
Voltage Regulator

2007.



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Size A	Document Number The Shunty	REV 1
Date: October 7, 2007	Sheet 1 of 1	

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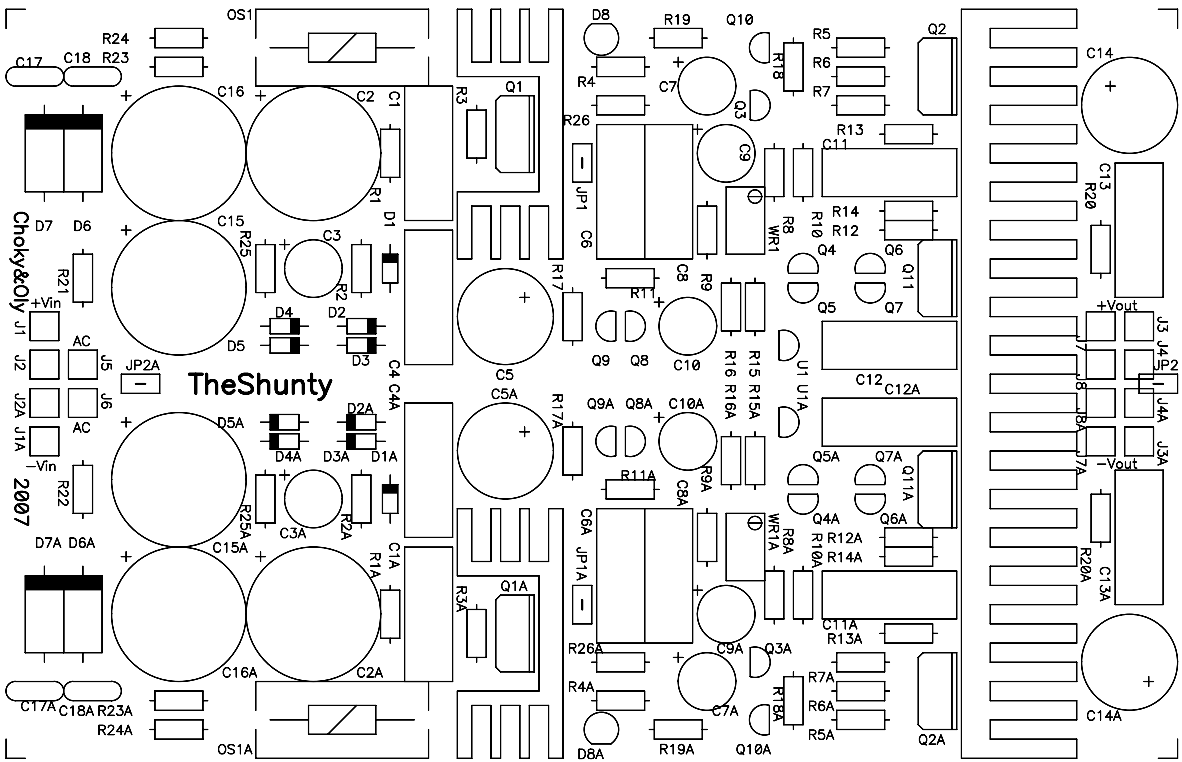


HOW SHUNTY WORKS

I use to think about regs in "class" boundaries ...... series reg is B class and shunt reg is A class - same as in amp classes ; A class is always willing to release energy , and that is certainly more naturall , than .... blah blah ..

Anyway - Shunty ; look at schematic , and just cover lower half with sheet of paper ; upper an lower halves are symmetric , and you really don't need to look at all this mess to understand how it works ....

Depending of Shunty's purpose and use - you'll have either xformer in front of it , or you'll have ready DC voltage (from main amp PSU perhaps) , but in any case you can use input Graetz , made of D6,,D7,D6a,D7a ; after Graetz - you see multiple CRCRC bank..... purpose of that is obvious ;

After that - you see plain vannila series reg , made of Q1 and surrounding parts ; it's regulating voltage is set with D1-D5 zenner string .... 5 x 10V - 4V (remember Ugs ?) = 46 V .

Then you see CCS part of shunt reg , made with Q2,Q3 and few surrounding parts ; same as with main CCS in Pumpkin -current is set with Ube voltage of Q3/ R7 , and that's 0V65/4E7 = ~140mA .... so - that CCS is trying all the time to push 140mA through everything after him ,and that's nothing else than Pumpkin's positive halve , in paralel with shunt part of shunt reg ;

In all shunt reg- load combos , most natural way of current sharing is when you have same currents through load and shunt element of reg .... it be that element is active , or passive , or combination of both .

After Q2 CCS , you can see - going right - one little all bipolar Pumpkin ; so - that's again LTP, cascoded too , just because benefits of cascoding aren't limited on jfets/mosfets only , but on other active sorts too.....
CCS for LTP is made of Q8/Q9 ; current through it is set by R17 ; base current for Q8 is delivered via R10/R11 string , and C10 is there just for little filtering .cascode is , obviously , biased via R3/R14 string .

Far right (sensing side - base of Q5) side of LTP is clamped to +5V via U1 , and that's voltage reference for 5V , eeny weeny 3-legged chip, which is like reference zenner in fact ;

Current through U1 is held constant with "micro" CCS , made with Q10/R19 combo .

LTP is trying to always preserve same conditions on both sides ; so - when base of Q4 feels (via voltage divider made of R8/WR1+R9) something different than 5V , it is trying to null that difference yoyo-ing current through halves ....

Yoyo-ing current through Q5 is routed via R12 , and that current is resulting in adequate amount for gentle opening and closing Q11 ;

That critter (Q11) is nothing else than good old BJT Darlington ; it needs ~1V3 of Ub1e2 voltage for full throttle opening ; just imagine it as rheostat , and you'll understand his role and work here .... when LTP feels that voltage is greater than 36V (set by tweedling with WR1) , it conducts more current through R12, thus more opening Q11 , which then eats more current ....

Simple - isn't it .

There are few tricks more , but I can't remember right now what they exactly are ...... I'm pretty sure that you'll

Ask what you must ask ...... so no simple stone will be left unturned ;)

The Shunty

<u>Resistors</u> : all - your favorite brand .... MF 0,25W /1% .....as example

POSITION	VALUE	pieces/pcb	note
R1,R1a,R2,R2a	1K5	4pcs	
R3,R3a,R6,R6a	150E to 240E	4pcs	
R4,R4a,R5,R5a	1K	4pcs	
R7,R7a,R15,R15a,R16,R16a,R21,R22, R23,R23a,R24,R24a	4E7	12pcs	see 1.
R8,R8a,R25,R25a	68K	4pcs	
R9,R9a,R26,R26a	6K8	4pcs	
R10,R10a,R11,R11a	33K	4pcs	
R12,R12a	390E	2pcs	
R13,R13a	27K	2pcs	
R14,R14a	10K	2pcs	
R17,R17a	82E	2pcs	
R18,R18a	22K	2pcs	
R19,R19a	2K2	2pcs	
R20,R20a	0 to 0E1	2pcs	
WR1,WR1a	4K7 multiturn	2pcs	screw on top

<u>note 1 .</u>

R7 (R7a) set(s) current through main CCS(s) (made with Q2+Q3 (Q2a+Q3a) ;
Iccs=Ube/R ; here 0v65/4E7 ~ 140mA .

<u>Capacitors :</u>

POSITION	VALUE	pieces/channel	raster mm	note
C1,C1a,C4,C4a,C6, C6a,C8,C8a,C11, C11a,C12,C12a,C13, C13a	u22 – 2u2 / 63V	14pcs	all 5 - 15 mm,except C1(a),C4(a), C12(a) only 15mm	
C2,C2a,C15,C15a, C16,C16a	1000 to 2200 uF	6pcs	5 - 8	see 2.
C3,C3a,C10,C10a	100uF	4pcs	5	see 3.
C5,C5a,C14,C14a	220uF / 63V	4pcs	5	
C7,C7a	47 – 100uF / 25V	2pcs	5	
C9,C9a	10uF / 50V	2pcs	5	
C17,C17a,C18,C18a	10n ceramic	4pcs	5	

note 2 . depending of DC voltage you have after Graetz bridge , you'll put caps of 63V or even more ; say that you are safe with 63V caps if voltage on them is max 60V under load , and you use good quality caps.

note 3. C3(a) voltage must be at least 63V ; C10 voltage perfect even just 16V .

Semiconductors: general note – pinouts for european types

POSITION	type	pieces/channel	note
D1 – D5 , D1a – D5a	ZF10	10pcs	0,4W & up
D6,D6a,D7,D7a	anything 1A/100V	4pc	
Q1,Q2	IRF510,520,610,620	2pcs	
Q3,Q4,Q5,Q6,Q7,Q8, Q9	BC546C(B) ,BC550C any decent N bjt	7pc	see 4.
Q10,Q10a	BF245C	2pcs	
Q11	BDX54C	1pc	see 5.
Q1a,Q2a	IRF9510,9520,9610, 9620	2pcs	
Q3a,Q4a,Q5a,Q6a, Q7a,Q8a,Q9a	BC556C(B),BC560C any decent P bjt	7pcs	see 6.
Q11a	BDX53C	1pc	see 7.
U1,U1a	LM336Z-5	2pcs	

note 4. Q4/Q5 , Q6/Q7 matched pairs ,if possible

note 5. any decent 60V/10W/1A PNP darlington ;

note 6. Q4a/Q5a , Q6a/Q7a matched pairs ,if possible

note 7. any decent 60V/10W/1A NPN darlington ;

Heatsinks - little ones – 12C/W or better – two pcs per pcb ; larger one 3,5C/W or better – one piece per pcb

Various :

fuse holder – raster 23mm – 2pcs per pcb

Xformer – EI preferable , 82 to 100Vct / 300mA per channel (one Shunty) minimum .

see again ***NOTE 2. !!!***

this child drawing of bird intentionaly placed here ;)

The Pumpkin assembly

You can see in Pumpkin BOM what is most important ;
Regarding parts – pick your poison , or use favorite brands of parts, but stay with noted voltage ratings for caps (as minimum values) , use multiturn trim-pots (it's somewhat easier to set with them , than with dreky non multiturns) , use whatever type of isolators between IRF mosfets and heatsinks .... etc .

Heatsink thermal conductivity is noted in BOM , too , but I presume that you can also use convenient size of Al or Cu sheet ; Say that sheet length must be as pcb width , at least 2mm thick and 35mm high . You'll have ~ 5W of dissipation across that heatsink .

Top ground plane is connected to ground via JP1 . Just solder shortie in these two holes .

During soldering of resistors , use some 0,5mm thick spacer between pcb and resistor body , to ensure that resistors have same clearance from pcb ; Even if pcb have top blue silk and voltages in Pumpkin aren't sky high , you don't wanna risk that somehow scratched resistor body have contact with somehow scratched top GND plane .

Check twice polarity of electrolitycs ;

When you solder everything - , check trice for nasty shorties , use your DMM and check that both trimpots are in mid position ; You wanna see ~22E from both sides to wiper .

If you soldered everything , give it a rest , and go to Shunty ; When both (Pumpkin and Shunty) are assembled , just then is time for setting ....

The Shunty assembly

Pretty much same things written above are applicable for Shunty ;
Top GND plane is connected via JP2 or JP2a ; Somewhat is more convenient to use JP2 ; Just solder shortie through these two holes .

When we are at shorties – don't forget to put ones in place of JP1 and JP1a ;
JP1 and JP1a are here if you want to include some nice fave wodoo part , as common mode choke or whatever ..... piece of Silver wire wound around your Grand Pa Tobacco Pipe .... Obviously – in case of that , do not solder shorties ;)

Well – D8 and D8a somehow slipped from Shunty BOM ; they're nothing else than plain 3mm leds – your fave color , and their role is nothing else than visual sign that you have (some) voltage at outputs of reg .

Solder everything ; Heatsink characteristics are written in Shunty BOM .
If you are cheapskate (as I am) use Al or Cu sheets, pretty same as for Pumpkin – for larger heatsink , and for solo IRF's heatsinks use something substantial,too .
Few pictures you can see in P & S building thread on DiyA will feed your eyes and tell to your brain what's probably enough . Each little heatsink must cool down around 2,5W , and biggie must cool down around 5W .

You don't need any isolation between small heatsinks and their mosfets ;
Put your fave thermal goo between them ,and be sure that they aren't in physical contact with pcb . Use nylon or thick paper spacers between ALL heatsinks and pcb.
Same applicable (spacers) for both – Pumpkin and Shunty .

When you soldered everything , triple checked (on Pumpkin too) that IRFs and darlington are well isolated from heatsink , time is for preliminary setting of Shunty voltage .
You need two 470E/5W resistors for that as load , instead of (impatiently waiting) Pumpkin boards . Wire xformer secondary wires where is needed, solder one biggie resistor to positive Shunty output and gnd, second biggie resistor to negative Shunty output and gnd ; Fire it up , and with WR1 set that you have 36V on positive output , and with WR1a set that you have -36V on negative output .
Desolder biggie resistors (after powering off) , solder them to second Shunty board and repeat procedure .

<u>Final setting procedure</u>

Presuming that you placed both (precisely – all 4 boards) in some sort of box and that you wired everything – including selector , pot (yes – pot is also your choice ;)) , all wires between both Pumpkins and Shuntys , you can power it up .
If nothing smoked , you can now leave for cup of coffee , leaving your new preamp to cook a little .
After 10 mins (it's not good for nerves to drink cup of coffee faster) , you can go back to cooking gadget ;

Pick one channel ; I didn't tell you that you place fuses in both Shunty boards . Just one is perfectly good for start ;) .
Place probes of one of your Voltmeters between GND and any output before output cap . Good point for that is "inside in circuit" pin of any output cap : C4 or C5 . See on enclosed picture – use TP0 and any of TP1 or TP2 .
Place probes of second voltmeter between positive and negative output ,also before output caps ; good points for that are same as for previous : both "inside in circuit" pins of C4 and C5 . Again – see picture and use TP1 and TP2 .
Turn volume all the way down . Now look at voltages ; Between outputs is completely normal that you see few volts , and it's completely normal to see that you

have between one output and GND almost full side of PSU ..... don’t worry – just tweedle WR2 until you see that offset is coming down .

Set it to 0 volts and wait a little ; Then set –with WR1 – 0 Volts between outputs . You are almost finished with that channel .

Now – power it down for moment , put fuses in second channel , power it up and you can go again to kiss your better half and ask for more coffee .

When you’re back – move both voltmeters to second channel , and repeat procedure .

When you are finished , put top lid on , and wait 1 hour .

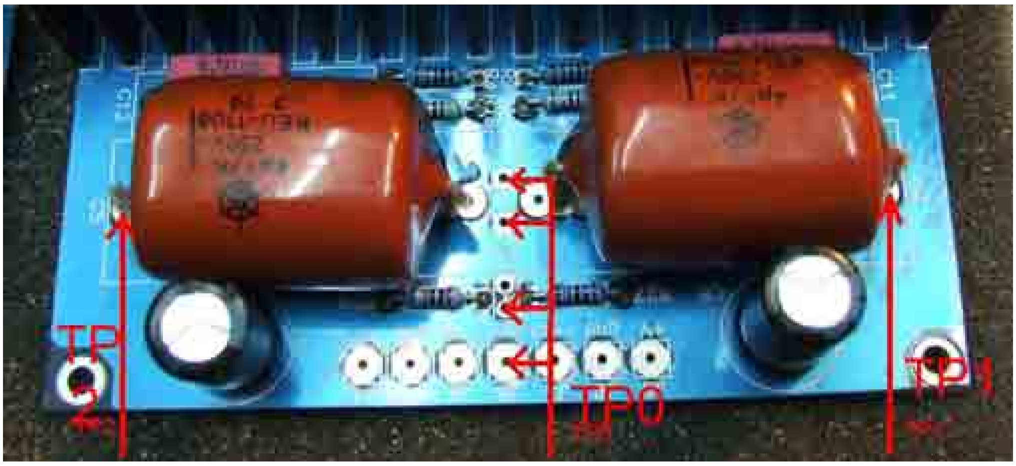
Put top lid off- recheck offset on one channel ,set it again and put lid again on .

Wait 10 mins , put lid off and recheck other channel ; put lid on .

After few hours – repeat “lid off – check – lid on “ procedure for both channels , and then you can be pretty sure that entire gadget reached temperature equilibrium ,and it will be stable with these settings .

OK- that’s it ; it’s done – you can now enjoy in your new FI FI gadget , and plan what to do with your , now obviously, crappy amp ....

Cheers!



ADDITIONAL NOTES :

HEATSINKS :

Fischer
SK81-50 SA
SK75-50 OR

Austerlitz
KS100.3-50
KS32.1-50E

CONNECTION :

You can connect Pumpkin inputs and outputs in all combinations you can imagine ;
My advice can be – use balanced pot(s) for inputs (either one 4-deck , or two independent stereo pots) in any value you choose – from 5K to 50K , log off course .

Then use XLR chassis connectors for all inputs and outputs .

That's certainly most convenient if you choose balanced input – balanced output configuration .

If you choose to use unbalanced either input or output (or both unbalanced) , again use XLR cable jack even for unbalanced ,and just tie (solder) pins 1&3 inside that cable jack .

So – these combinations are possible :

- bal in : bal out
- unbal in : bal out
- unbal in : unbal out
- bal in : unbal out

In every "unbal" case – you must tie 1&3 pins in XLR ;

It's also possible special situation – where you use bal out and unbal out in same time, but (naturally) WITHOUT tying 1&3 pins of output XLR (just because tying those pins you are just killing balanced out entirely) , where you as "unbal" out are using in fact just half of balanced signal .... where HOT is from pin 2 (+ output) and gnd is from gnd , what else ;) ; That's useful for biamping purpose , where one power amp is balanced and other is not .... and 6db difference between balanced and unbalanced is something that suits your needs ....

Also important notes :

- For Shunty : Resistors R21 ,R22 , R23, R24 , R23a , R24a need to be either plain carbon 0,5W ones , or decrease them to 1E8 or 2E2 , if you insist to use metal films of 0,25W variety . Few clever Shunty builders pointed that these resistors are prone to burning , if you use low ESR biggie electrolytics in input side of Shunty .

- My mistake was that I wrote ZY10 zenners in Shunty (D1 to D5, D1ato D5a)
; all you need is ZF , which are just generic 400mW ones ; now corrected in parts table .

- In case that you are fluffy with setting absolute offset (DC voltage between plus and minus outputs of Pumpkin) , you'll have replicated DC on both INPUTS of Pumpkin .... exactly divided by ratio of feedback net .
That will result in screechy noise during volume pot turning .....
cure is simple - Papa-like .... just include 2u2 good cap on each input leg (both + and -) between pot and inputs ; that will block DC to reach pot .
Hehe - that cure is certainly less evil than using any kind of Servo .