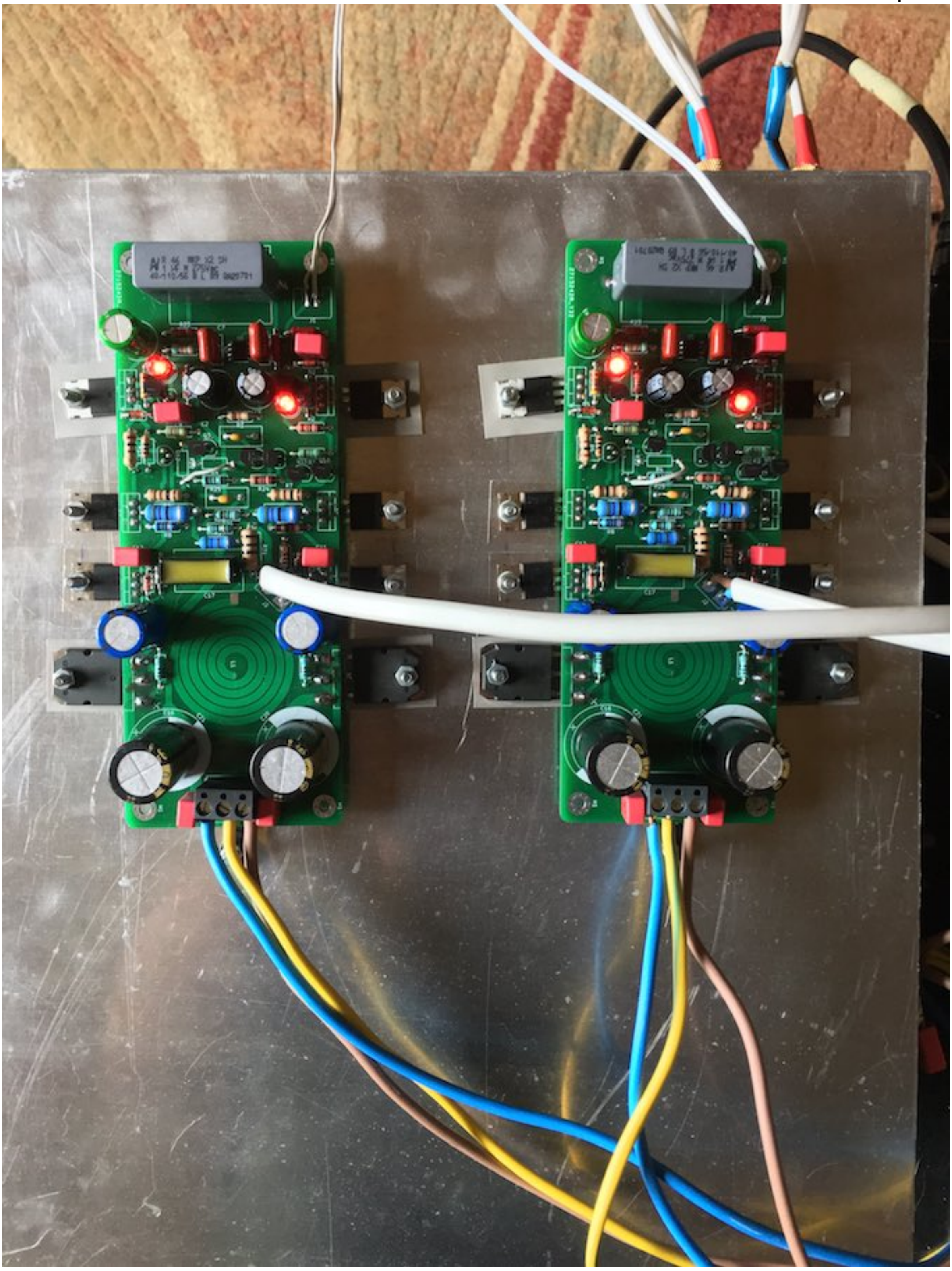
Q17 - a QUAD405 audiophile approach to perfect sound

Hard to prove statements:
I know what I saw ! Ufologist
I know what I hear ! Audiophile



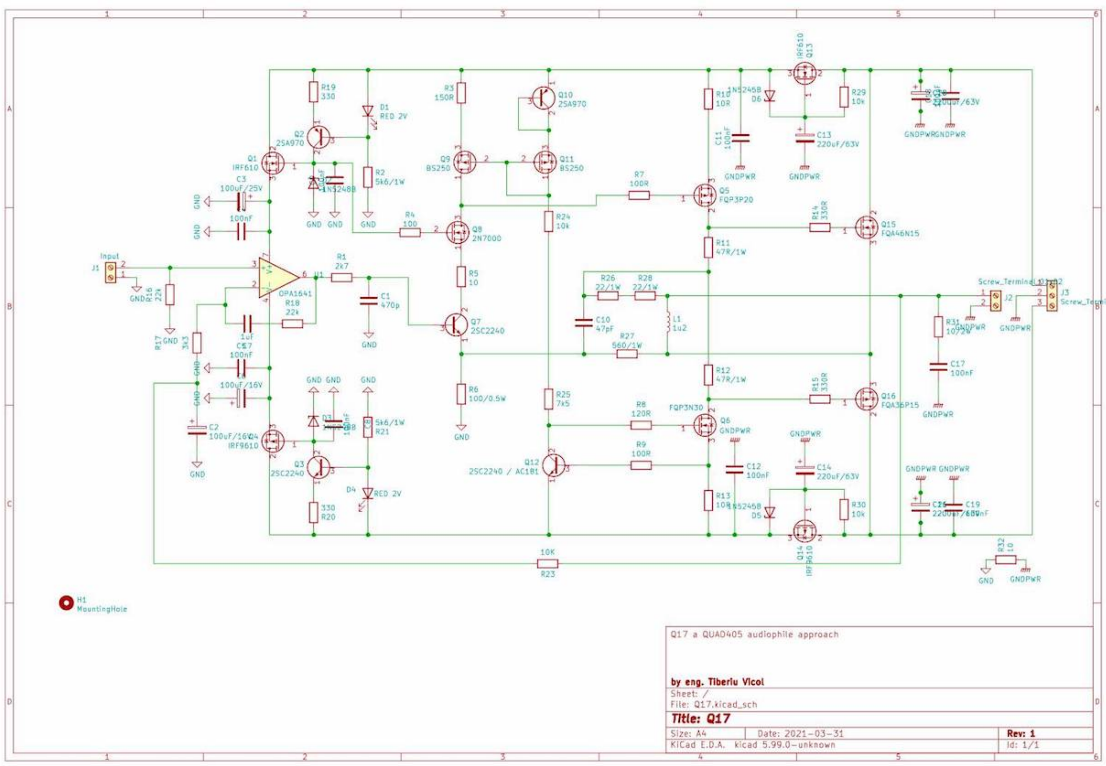
Introduction
Another QUAD405-maniak ? No, just an old one.
Yes, I must admit that, I am. I consider myself an audiophile too. You know … cables and other stuff … :-D
In the last 35 years I did a lot of modification based on this brilliant principle named Feed-Forward Error Correction.
Why ? because it works very well and the potential behind was barely exploited. Please, don't get me wrong. QUAD405 was an exceptionally designed amplifier, but highly limited by the parts available at the time.
With today technology and innovation in opamps, mosfets and power supply, the design can be pushed to sound fantastic, I mean really fantastic.
Usually I do not write so much, because I'm an engineer :-D. On other side, I also appreciate well documented projects. So, this is my effort to explain, in simple words and some basic arithmetics, amplifier topology, operation and some pellicular sonic decisions.

As I already mentioned, I have performed a lot of modifications over initial QUAD405 schematic. The result was a very revealing amplifier, with very low distortion. The sound was analytic, for some people too analytic. It was missing somehow the synergy, at low listening levels been somehow flat and boring. Otherwise, at high level, the amplifier was quite dynamic. Unfortunately this is same with original QUAD405 and even recent releases as QUAD606/707/909. Than I fall on the dark side of the audiophile force and started to change operational amplifiers. Some sound better than others, each have his own sound fingerprint, but they do not help too much.
Than I decided to go further and change the design completely, taking an audiophile approach. Don't put distortion as forefront rule and instead make it sound great. In fact there are so many amplifiers that measure 1% THD and sound amazingly good. This does not mean I do not base my decisions on simulation and measurement, it mean that I'll trust my ears more than my oscilloscope. :-D

Sound is paramount. It must sound very good, at any level. There must be no listening fatigue. Sound must be vivid, full body, plenty of harmonics with long decay. Resolution and clarity from top to bottom. Each instrument must sound natural, clearly separated and easy to locate in space even in large, big band orchestra.
Here are my initial technical requirements:
- stable operation. Amplifier must be stable in any operation condition. No oscillation at any frequency.
- 100W in 8ohm at 1kHz. This should be enough for an audiophile as long his "impossible to drive" speakers are moving.
- frequency response cutoff 10Hz - 100kHz. This will allow a decent slew-rate as well.
- IMD inter modulation distortion under 0.01%
- THD total harmonic distortion under 0.01% @ 1W&full power
- design must be affordable, with relatively easy to find components and equivalents THT or SMD.
- cost effective and easy to build. High-end audio must be affordable.
- open source. QUAD405 is a great design, who inspired people like me to learn and want more. Let's keep it that way and offer even more, schematic, simulation, source pcb files and bill of materials.

- designed by using LTspice simulation with final touch by extensive bench measurements and testing
- final design decision are always my platinum ears. ;-) This mean Q17 is designed by comparing different topologies and final decision is taken, not by measurement, by listening. Q17 is indeed designed by ear. :-D

And here are on-ear requirements:
- no hiss no buzz. Poor rectification and filtering may lead to unwanted noise.
- micro dynamic. Yea, this is the hard thing. My foot must beat the rhythm at any level. I do not want flat, compressed and dead sound. This is often collaborated with negative feedback - NFB. In my opinion it is partially true and highly depend on how you use NFB and other things. Good quality power supply filter capacitors may help as well.
- macro dynamic linearity. Amplifier must be able to go from low level to top power in an instant and to keep that high power level without distortion and compression. It must give the sensation of unlimited power. This is mainly related to power supply. If amplifier is capable to deliver, power supply must cope as well.
- resolution. I like an amplifier that offer resolution and full body instruments, without loosing harmonics and decay. Well designed SEDHT (single ended direct heated triodes) are able to do this and I want same from my amplifier too. I know is another hard one. :-) Inter modulation distortion have a word to say here. Low IMD always lead to top resolution, but sometimes musicality is lost.



Functional description

Today, OPA1641 is one of the best opamps on the market, probably. In fact is so good that a discrete circuitry will barely come close. OPA1641 is a JFET input operational that apart technical specifications, sound very good and is cost effective too. We are not driving a low impedance output and there are not thermal issues.

Those who do not like JFET sound, may try LME49990. This sound great as well. Original Quad405 has inverted signal phase, this mean the input signal will get phase negated at the output. Some are not able to hear phase difference, therefore this does not matter much. but IMHO phase accurate it is very important, therefore Q17 is not-inverted and will preserve original phase of the signal.

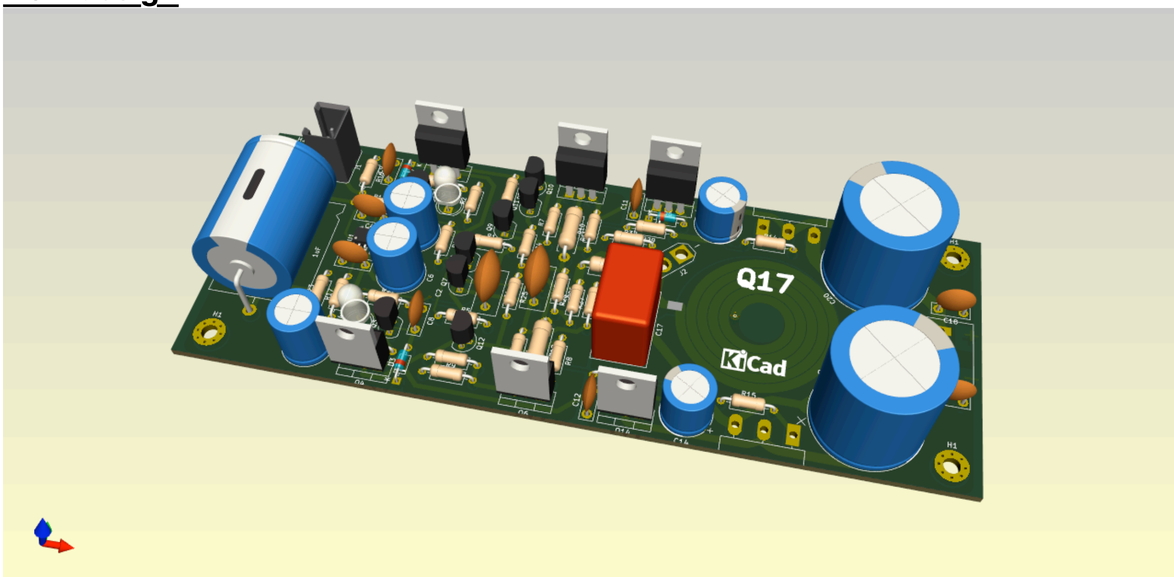
Like QUAD405, Q17 is divided in two separate sections. Let's called section one and two.
Section one is made with operational amplifier. Input impedance is given by R16 = 22K. This is a good trade between high impedance and thermal resistor noise. You wanna higher input impedance? You can go as high as 47K. Use here a good metal foil resistor and should be enough.
R17 and R18 are part of operational negative reaction will set the gain to (R17+R18)/R17=7,6. Many operational amplifiers will not be stable at low gain and the stability limit is usually at gain higher than 5. 7,6 will offer good sensibility and we are on the safe side, away from any oscillation.
Trough R30, R25 and C3 input operational will have a second role acting as DC servo. C3 may be bipolar, however a normal polarised electrolytic will work just fine. Use low voltage electrolytic 6,3V - 10Vdc.
R1C1 form a low pass filter with cut off frequency at 125kHz. Together This RC filter is the main load for the operational and will also limit whole amplifier full bandwidth. C1 must be silver-mica or polystyrene.
Operational is feed by two "reasonable low noise" regulators.
Operational will not draw more than 10mA per raw, but his sonic performance is highly dependent on the quality of these regulators, so I have invested some time and parts to get the best topology for sound vs price compromise.
Here is how it works.
There is a 18V Zener, D2 and D3, which feed a constant current at around 4mA. Q7,D1,R19 and R2 (respectively Q8,D4,R20 and R21, for negative rail) form a simple current source. D1 and D4 are red LED with Vf=2V. It is well known that LED is a reliable low noise voltage reference. Current trough zener diode will be (LedVf-Q7Vbe)/R19=(2-0,6)/330=4,2mA. This reference voltage is used by two mosfet Q1 respectively Q4 to deliver current to OPA1641. IRF610/IRF9610 are a bit overkill here, but are easy available and cheap enough. These will run warm, but do not heed a heatsink.
Here is one of my first observations. MOSFET regulators sound better than bipolar. Do not measure better, sound better.

Section two start with a cascode formed by Q7 and Q8. This stage offer high gain, high output impedance and high open loop bandwidth and may be a challenge to keep it out of oscillation. For this reason R5 is there. This will lower the gain and increase stability at the cost of some distortion. In place of Q7 some inexpensive transistors BC8xx can be used ,as maxVce> 45V is the only restriction. From sonic point of view, some cascodes may kill the "soul of music", in other words, offer a less vivid sound. Things are going far better if you use a mosfet as top active device. This will preserve dynamics at any level.
Cascode- Q7&Q8 - stage have high output impedance, therefore is feed by a constant current source made by Q10 and R3 at aprox. 4,5mA. Q10 can be any low cost, high beta pnp bjt. Yes, any pnp, no constraints.
The CCS current is mirrored to Q12 by Q9&Q11 trough R24&R25. In fact the heart of

Q17 is around this CCS+ current mirror. Current mirror that can be made with high beta pnp transistors, or p channel mosfet.
I tried both. BJT mirror is very precise and offer a lush sound. For mosfet I used BS250P and in this case sound is dipper with a better midrange. Micro-dynamics seems to be higher too. After extensive listening sessions and some burn-in, I can confidently say that I will stay with mosfet mirror.
Instead R24&R25 you may use a single 1W resistor. This was split in two in order to distribute power dissipated.
Next is class A stage. In original Quad405 a Darlington triplet was used in order to increase input impedance. Here a single mosfet will do a far better job, at the cost of some input capacitance. Mosfet's do create more even order harmonics compared to bipolar's too. As I care more about harmonics content than THD, here is my preference for mosfet.
P channel MOS Q5 is class A active device and from my observation, P channel FQP3P20 (IRF9610), is slightly more linear than N channel FQP3N30 (IRF610). Anyhow, at current time - 2021 - we do not have too many options. Toshiba's lateral mosfet's (2SJ76, 2SJ77, 2SJ78, 2SJ79 respectively 2SK213, 2SK214, 2SK215, 2SK216) are long time obsolete. If you can source them, use them. If you do, some capacitor compensation it may be needed, in order to keep them out of any oscillation. Q5 is feed by a 60mA CCS formed by Q12 and Q6. Q12 Vbe is the main reference in this CCS and can be used as thermal compensation for final stage, too. Again, no constraints for Q12. Can be any high beta, low voltage, npn bjt. CCS current can be calculated by Q12Vbe/R13 and would be around 60mA. This will push Q5 operation in class A and offer enough juice to drive final dumper stage. Q5 and Q6 will dissipate 3W and must be mounted on heatsink.
Q12 must be mounted on heatsink too, as it will be used to compensate final stage thermal run away.
Changing R13 to 2ohm, a germanium AC181 can be used here as a better temperature compensation. I must mention that this mod will not bring "germanium sound" into this amplifier. Sorry, germanium lovers !
R9 is there as base stopper and to avoid any possible oscillation. R7 and R8 are gate stoppers too.
Choosing final pair Q15 & Q16.
I'm a big fan of lateral mosfets made by Semelab-Semefab-Exicon-Magnatec, whatever company is behind. This Scottish company is one of the last to make very good high power lateral mosfets. I proudly used them in many Quasar amplifiers and they sound exceptional. The main goal of Q17 is to be affordable and these laterals, as many other good things, are not so cheap. They are very rugged and allow high level of "torture" and make things sometimes easy, but … there is a "but". They have small transconductance. You need to use double die and parallel few of them to get some decent transconductance, because audiophile speakers make use of complicated crossovers who like lot of current in the most unexpected frequencies.
Fairchild, now ON-Semiconductor, was a great company and one of their legacy is FQA46N15 and FQA36P15. If you think these are P/N pairs, you are wrong. There is no such P/N perfect match in real world, but we can choose the most closed ones. These are marketed as: "Fairchild Semiconductor's proprietary planar stripe and DMOS technology.", with a small remark that these may be suitable for "audio amplifier" as well.
FQA46N15 have a regular transconductance of 36 Siemens while Exicon duble die ECW20N20 have a maximum of 4 Siemens. This is equivalent of 9 double die

laterals. Yes, very impressive !
FQA36P15 have a regular transconductance of 19.5 Siemens while Exicon duble die ECW20P20 have a maximum of 4 Siemens. This is equivalent of 4 double die laterals.
In the “darkside” of Mouser are living some beasts that may leave these Fairchild’s in dust. These are made by IXYS and a pair could be IXFK220N20X3 and IXTK120P20T. These exhibit over 120 Siemens transconductance and are able to transform your amplifier into a real welding machine. No joke at all. If your speakers have never been moved before, use a pair of these and shake your world, your walls, your neighbour …
Trough R11 and R12 will bias these devices near to class A operation. Both, FQA46N15 & FQA36P15 Vgs - threshold voltage between 3V and 4V. I found that P channel FQA36P15 will open around 3V, while the FQA46N15 will need 100mV-300mV more. (To have both running at same level R11 may be increased to 51ohm or more.)
Obviously Q15 and Q16 must be mounted on a large heatsink.
R31C17 is the well known Zobel filter. C17 quality is important. Use a good propylene here, or a polystyrene one. My preference is polystyrene Multicap RTX series. If you do not wanna invest too much go for Arcotronix.
R26,R27.R28,C10,L1 form current dumping bridge. R27&R6 are part of section 2 negative feedback. This set entire amplifier gain to [(R17+R18)/R17]x[{R27+R6)/R6]=45,6, enough for amplifier to reach 100W/8ohm at 0.7V input.
Q13 and Q14 are capacitor multipliers and are there to reduce power supply ripple. (These are not needed if you use synchronous rectification - see below.) During power on, the gate to source voltage on Q13 and Q14 may easily exceed 10V and may damage these mosfets, for this reason D5 and D6 are there to protect.
You may noticed that there are R4,R7,R8,R9,R14,R15 as gate or base stoppers. I always prefer gate stoppers than compensating with capacitors.
R32 will separate signal ground plane from power ground plane. No special requirements for this one.

PCB design



During “covid-19 lockdown” I had enough time to learn and use KiCad. KiCad run on any operating system and is open source. This is a great tool.
I have designed this project in KiCad 5.99-nightly. To open files, you need at least

5.99. The advantage of this is that This is a great tool.already compatible with upcoming KiCad 6, which is a huge step forward.
I opted for separate small and high signal ground planes. Ground planes are a good solution to avoid ground loops and offer excellent EMI reduction.
PCB embeds L1 inductor that is part of error correction bridge. This will ensure good tolerance and optimal geometric design. Yes, a PCB inductor will have the right shape for a near to ideal inductor. The truth is that I'm lazy to wire-wind coils. Having this embedded in PCB will help lazy people like me a lot, but what I said earlier is valid. PCB coil is better. In a separate document I have detailed on how to create and embed inductors in KiCad.
PCB offer the option to install several C7 types. Use propylene at any voltage > 50V. C17 must be propylene or polystyrene at voltage > 100V.
OPA1641 is the single SMD part and PCB do not offer the option to install a THT one, but as long I offer the source files for this project, you are invited to modify and redesign as you wish.

Bill of materials for Q17
D1,4 - LED RED 2V - https://ro.mouser.com/ProductDetail/Vishay-Semiconductors/TLHR5200?qs=GMckgg3bfZPthGr1cDR0RA%3D%3D
D2,3 - 1N5248B - https://ro.mouser.com/ProductDetail/ON-Semiconductor-Fairchild/1N5248B?qs=G5AQjGfRJcJY58VFTX%252BkdQ%3D%3D
D5,6 - 1N5245 - https://ro.mouser.com/ProductDetail/ON-Semiconductor-Fairchild/1N5245BTR?qs=jumAldekxNAufOthuRVeGQ%3D%3D
Q2,7,12 - KSC1845 - https://ro.mouser.com/ProductDetail/ON-Semiconductor-Fairchild/KSC1845FTA?qs=UMEuL5FsraDCmxWozTypUA%3D%3D
Q8 - 2N7000 - https://ro.mouser.com/ProductDetail/ON-Semiconductor-Fairchild/2N7000TA?qs=iN0KuJO79KZfCWVKA48bEg%3D%3D
Q10 - KSA992 - https://ro.mouser.com/ProductDetail/ON-Semiconductor-Fairchild/KSA992FBTA?qs=BiJXFBt7cx0C7PSFUPmr1w%3D%3D
Q9,11 - BS250P - https://ro.mouser.com/ProductDetail/Diodes-Incorporated/BS250P?qs=OlC7AqGiEDnRUFCQhRDfhA%3D%3D
Q1,6,13 - IRF610 - https://ro.mouser.com/ProductDetail/Vishay-Siliconix/IRF610PBF-BE3?qs=%2Fha2pyFadugbZUitPAu%252BTEPjT5SopLZ8qDnf9IMIvY8%3D
Q4,5,14 - IRF9610 - https://ro.mouser.com/ProductDetail/Vishay-Semiconductors/IRF9610PBF?qs=cval6ThkwxtWoLkQbU%2FdsA%3D%3D
Q15 - FQA46N15 - https://ro.mouser.com/ProductDetail/ON-Semiconductor-Fairchild/FQA46N15?qs=%2Fha2pyFaduimCeOyuw0xouriGUKJcVVjoz%2FqQ0BKQtc%3D
Q16 - FQA36P15 - https://ro.mouser.com/ProductDetail/ON-Semiconductor-Fairchild/FQA36P15?qs=%2Fha2pyFadugPFcM3hvKrsP2cJsnMpKcpv1XDSGf5JCo%3D
U1 - OPA1641 - https://ro.mouser.com/ProductDetail/Texas-Instruments/OPA1641AIDR?qs=sGAEpiMZZMutXGli8Ay4kFRPeV04IrZfqfNgaiEGnmE%3D

C17 - 100nF - https://ro.mouser.com/ProductDetail/KEMET/R76MI31005050J?qs=pUKx8fyJudAaVipAdJ8Rqw%3D%3D
C4,5,8,9,11,12,18,19 - 100nF - https://ro.mouser.com/ProductDetail/KEMET/PHE426DJ6100JR05?qs=PoZJcSwa6DzVkLIswxOBtw%3D%3D
C10 - 47pF - https://ro.mouser.com/ProductDetail/Cornell-Dubilier-CDE/

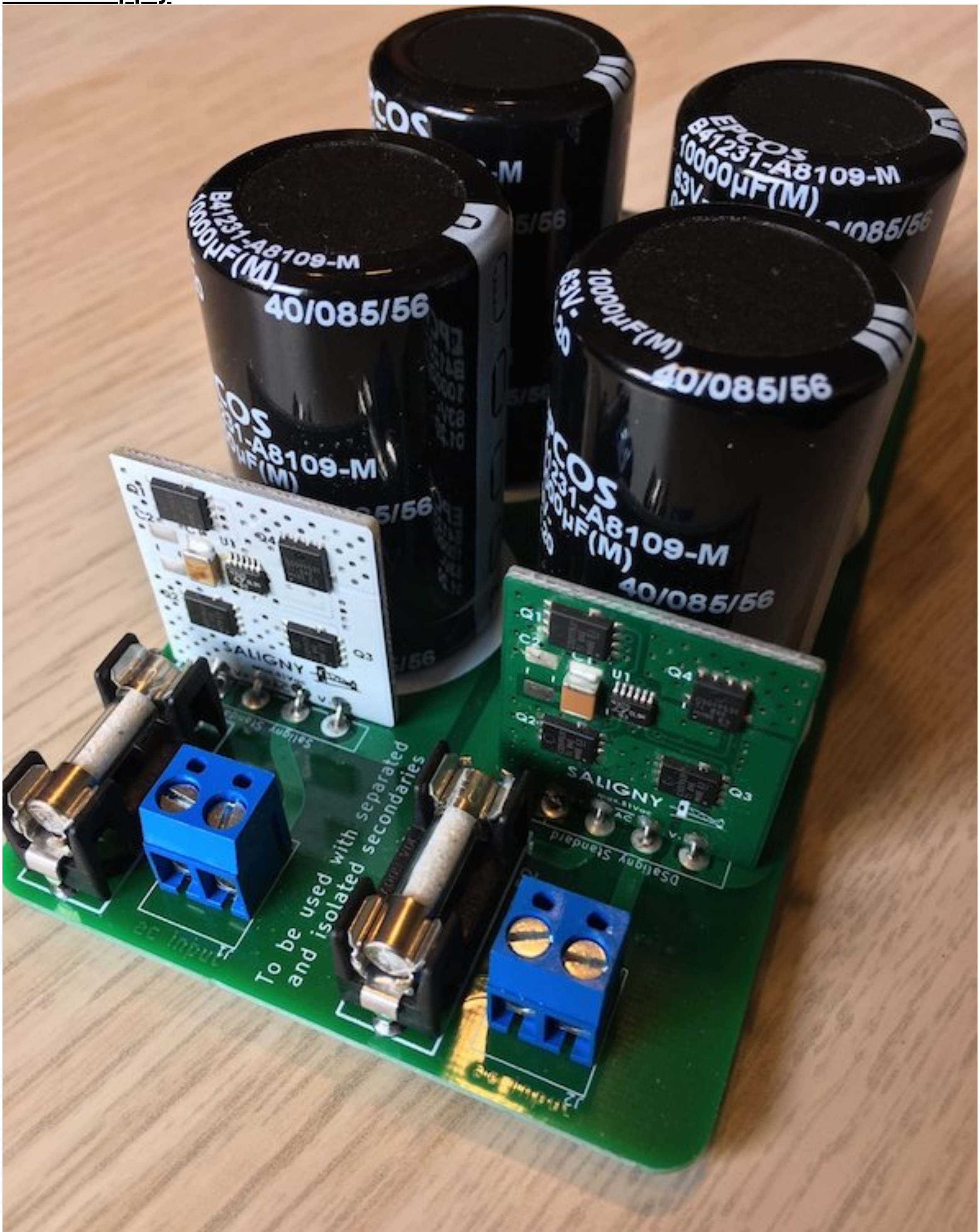
CD15ED470JO3?qs=JlSiUoO6twmzsCndHIj%2FhA%3D%3D
C7 - 1uF - https://ro.mouser.com/ProductDetail/Cornell-Dubilier-CDE/930C1W1K-F?qs=oi6qnwyrdkzUKQFAck35kQ%3D%3D
C1 - 470pF - https://ro.mouser.com/ProductDetail/Cornell-Dubilier-CDE/CD15FD471JO3F?qs=FKrQhPEeH%252B6Y%2FhdJiMfeDw%3D%3D
C2 - 100uF BP - https://ro.mouser.com/ProductDetail/Nichicon/UES1C101MPM1TD?qs=JgOBn5pVFoqelxyCFlUB6Q%3D%3D
C3,6 - 100uF/25V - https://ro.mouser.com/ProductDetail/Vishay-Sprague/510DX107M025CC2D?qs=j9BvaggtyN3XWy0%2FfD7iig%3D%3D
C13,14 - 220uF/63V - https://ro.mouser.com/ProductDetail/Vishay-BC-Components/MAL215058221E3?qs=sGAEpiMZZMvwFf0viD3Y3Yd5qvTVv7orMyRFoicAYcg%3D
C15,16,20,21 - 2200uF/63V - https://ro.mouser.com/ProductDetail/Nichicon/UPW1J222MHD?qs=sGAEpiMZZMvwFf0viD3Y3V%252BktQc2dZjNU8%252BcKz5%2FjOU%3D

R1 - 2k7 - https://ro.mouser.com/ProductDetail/Vishay-Dale/CCF072K70JKE36?qs=QKEOZdL6EQrf8lXj1m%2FHqg%3D%3D
R2,21 - 5k6 - https://ro.mouser.com/ProductDetail/Vishay-BC-Components/PR01000105601JR500?qs=LCMWAU1DZcyMK8Yz0ZAhmQ%3D%3D
R23,24 - 10k - https://ro.mouser.com/ProductDetail/Vishay-Beyschlag/MBB02070C1002FRP00?qs=Jr4%2Ft4s12JUmAfKOFUNhig%3D%3D
R3 - 150ohm - https://ro.mouser.com/ProductDetail/Vishay-Dale/CCF07150RJKE36?qs=Ad%252BIW%2FmDqmUeNbXSTmV5ZQ%3D%3D
R5,10,13, 29,30,32 - 10ohm - https://ro.mouser.com/ProductDetail/Vishay-Dale/CCF0710R0GKE36?qs=QKEOZdL6EQpP4bkfADZzbQ%3D%3D
R4,6,7,9 - 100ohm - https://ro.mouser.com/ProductDetail/Vishay-Dale/CCF07100RJKE36?qs=NQWA6AwZmkMW4Ul%252BG32rNg%3D%3D
R8 - 120ohm - https://ro.mouser.com/ProductDetail/Vishay-Dale/CCF07120RGKE36?qs=QKEOZdL6EQrffKbi7vq1lg%3D%3D
R11,12 - 47ohm/2W - https://ro.mouser.com/ProductDetail/Vishay-Dale/CCF0247R0JKE36?qs=QKEOZdL6EQqc7KTqtOG%2FUA%3D%3D
R14,15 - 390ohm - https://ro.mouser.com/ProductDetail/Vishay-Dale/CCF07330RJKE36?qs=pkalMaiJWwv10%252BO%252BONxDWg%3D%3D
R16,18 - 22k - https://ro.mouser.com/ProductDetail/Vishay-Dale/CCF0722K0JKE36?qs=Ad%252BIW%2FmDqmUs0WVMJaSusw%3D%3D
R17 - 3K3 - https://ro.mouser.com/ProductDetail/Vishay-Dale/CCF073K30GKE36?qs=QKEOZdL6EQqcBZBx6GnZnQ%3D%3D
R19,20,22 - 330ohm - https://ro.mouser.com/ProductDetail/Vishay-Dale/CCF07330RJKE36?qs=pkalMaiJWwv10%252BO%252BONxDWg%3D%3D
R25 - 7K5 - https://ro.mouser.com/ProductDetail/Vishay-Dale/CCF077K50GKE36?qs=QKEOZdL6EQqRpabQIgr10Q%3D%3D
R31 - 10ohm/2W - https://ro.mouser.com/ProductDetail/TE-Connectivity-Neohm/RR02J10RTB?qs=s1WWODT2SXW%252BZIrISq22ow%3D%3D
R26,28 - 22ohm - https://ro.mouser.com/ProductDetail/Vishay-Beyschlag/MBB02070C2209FCT00?qs=sGAEpiMZZMsPqMdJzcrNwkfQgWkDJ%252BE2Mwj0n7JK2mo%3D
R27 - 560ohm/1W - https://ro.mouser.com/ProductDetail/Ohmite/OM5615E-R58?qs=sGAEpiMZZMukHu%252BjC5l7YREnR%2FWY87i1xVQq21Ltfa0%3D

J1 - input connector -

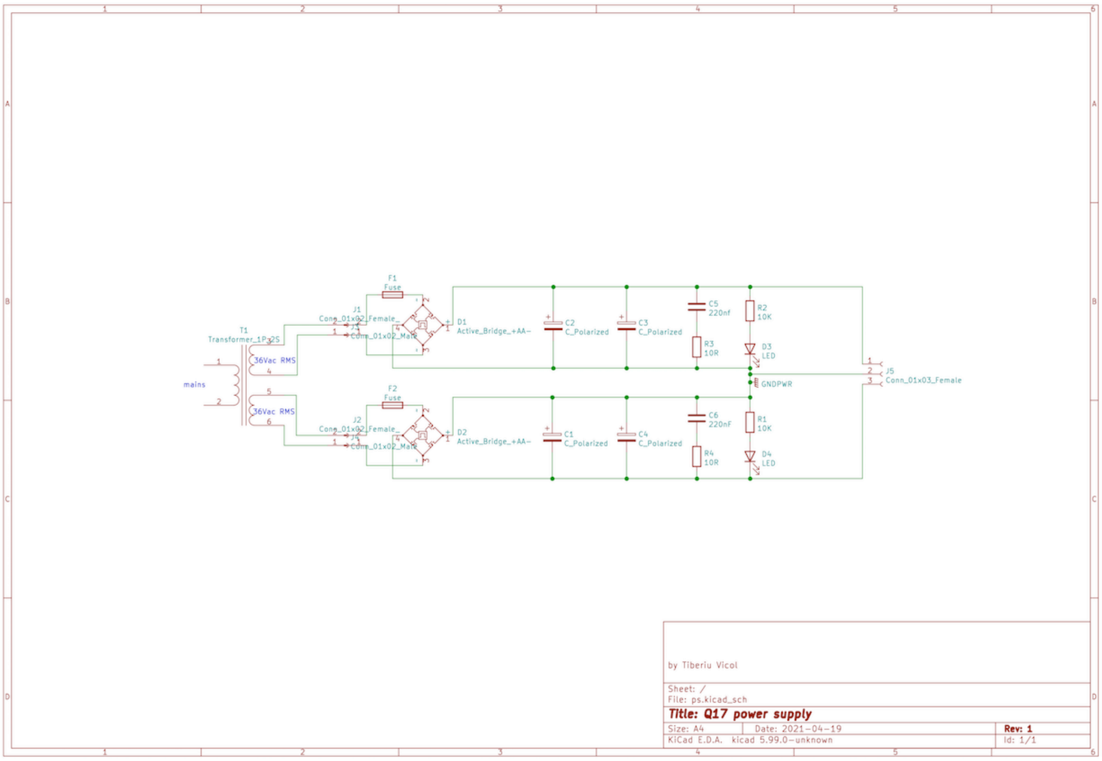
J2 - speaker output connector- https://ro.mouser.com/ProductDetail/DFRobot/FIT0586?qs=w%2Fv1CP2dgqouWR8IxqIK1w%3D%3D
J3 - terminal block x 3 - https://ro.mouser.com/ProductDetail/Amphenol/TC0303620000G?qs=Mv7BduZupUgRMrIfdnWHCQ%3D%3D

Power supply



A good amplifier need an exceptional power supply. All design effort will be lost if we

do not excel in this area too.
Diode is far for being a perfect device. There are not better devices but better solutions.
Synchronous, or active rectification was long time available in professional appliances. The very first synchronous rectifier (mechanical rectifier) had been used in 1950’s in high power and high voltage applications.
His limited usage in consumer was due complexity and very high cost involved. In the last years, thanks to green power requirements and electric vehicles, several dedicated chips appeared in consumer market. These manly target PoE - power over ethernet, but by choosing right parts around the application can be extended to high-end audio as well.



The advantage of using synchronous rectification is huge. Synchronous rectifier is a diode-less bridge employing modern mosfet transistors, that replaces the four diodes in a full-wave bridge rectifier with a mili-ohm Rdson MOSFET, to drastically reduce power dissipation, heat generation, voltage loss and diode on/off switching noise. There is no P-N junction involved, only a low miliohm conductive channel get inserted in power path. This allow big current capability, better power management, less power loss, less dynamic impedance change versus load current and better circuit performance than any available junction rectifier solution.
While a normal diode have at least 600mV drop at 1A, a low Rdson MOSFET will have as little as 3mV, or less, at same 1A. This is 200 times better than a PN diode and at least 100 times better than a Schottky diode.
But how is this translated in audio ? The most sensible difference is noise, due synchronous rectifier have less ripple and on/off noise. Each bridge mosfet is acting like a soft on/off switch. Entire medium to top spectrum is cleaner. Voices are soft and cymbals full of harmonics. Another effect is better dynamic. The sound is more

vivid due no power is loss in rectifier, or modulated by diode pn junction and the single current limiter is intrinsic transformer resistance.
We make use of two Saligny Standard syncronous rectifiers, made by Evotronix SRL. (Yea, I'm involved in this.) These are operated at 36Vac, each, from a 300VA R-Core transformer. C1,C2,C3,C4=10000uF/63V are main capacitor filters. There is a snubber formed with R3C5 and R4C6. This is needed only when normal diode bridge rectifiers are used, in our case with Saligny rectifiers you may skip these parts. R2D3 and R1D4 are rail power indicators. A single power supply may be used for both Q17 modules, or two in case of a dual mono approach.

Bill of materials for power supply

J1,2 - terminal block x 2 - https://ro.mouser.com/ProductDetail/Amphenol/TC0203620000G?qs=%2Fha2pyFaduhbuFfD6OHbCYxDpT0ma2Hwq0r2vPcUv6eC%2FIlp4URn7Q%3D%3D
J5,6 - terminal block x 3 - https://ro.mouser.com/ProductDetail/Amphenol/TC0303620000G?qs=Mv7BduZupUgRMrlfdnWHCQ%3D%3D
C1,2,3,4 - 10.000uF/63V - https://ro.mouser.com/ProductDetail/EPCOS-TDK/B41231A8109M000?qs=f4aWRLuQiuxqY40YlReJiQ%3D%3D
C5,6 - 220nF MKP - https://ro.mouser.com/ProductDetail/CDE-Illinois-Capacitor/MPX224K305E?qs=HXFqYaX1Q2wK3o1vUzHyKw%3D%3D
D1,2 - Synchronous Bridge - Saligny Standard - evotronix.eu
D3 - Red LED - https://ro.mouser.com/ProductDetail/Vishay-Semiconductors/TLHR5200?qs=GMckgg3bfZPthGr1cDR0RA%3D%3D
D4 - Green LED - https://ro.mouser.com/ProductDetail/Vishay-Semiconductors/TLHG5200?qs=%2Fha2pyFadujruHm0H%252By%2FYe3hostfbxme%2F774XrUw9tU%3D
R1,2 - - 10K/0,5W - https://ro.mouser.com/ProductDetail/Vishay-BC-Components/SFR16S0001002JA500?qs=H30XFsNYD%2FGypwPt5jX7ew%3D%3D
R3,4 - - 0 ohm - strap these if you use Saligny Standard
F1,2 - fuse holder - https://ro.mouser.com/ProductDetail/Littelfuse/0PTF0078P?qs=Co4VkB5J4%2Fsczy6gG8s%2FsA%3D%3D
Transformer - *primary 2 x 115Vac region dependant* - secondary 36Vac + 36Vac at 5A

Final note

Amplifier do not need specific adjustments and should work from the beginning.
Please allow at least 48h for burn-in. Electrolytic capacitors are the most sensible at burn-in and some need 200h or more.
Mosfet transistors also need burn-in. My personal observation is that after 48h these are ok to go.
In order to perform burn-in, leave your amplifier ON. A musical program at low level will help as well.
What you should expect from this amplifier ?
Exceptional dynamics with superb harmonic extension. Strong and round bass.
Crystal clear top response. Instrument separation localisation in deep 3D.
Enjoy & Thank you !

by audiophile Tiberiu Vicol

References:

Current Dumping Audio Amplifier - PJ Walker - Wireless World, December 1975
Feedforward Error Correction in Power Amplifiers - Vanderkooy-Lipshitz
Current dumping does it really work ? Theory and practice by J. Vanderkooy and S. P. Lipshitz University of Waterloo, Ontario
Current dumping analysis Class B amplifiers without crossover distorsion by H, S. Malvar, M. Sc. University of Brasilia
Test reports QUAD405 Current Dumping Amplifier by Gordon J. King
Sources 101: Audio Current Regulator Tests for High Performance - Full Article by Walt Jung