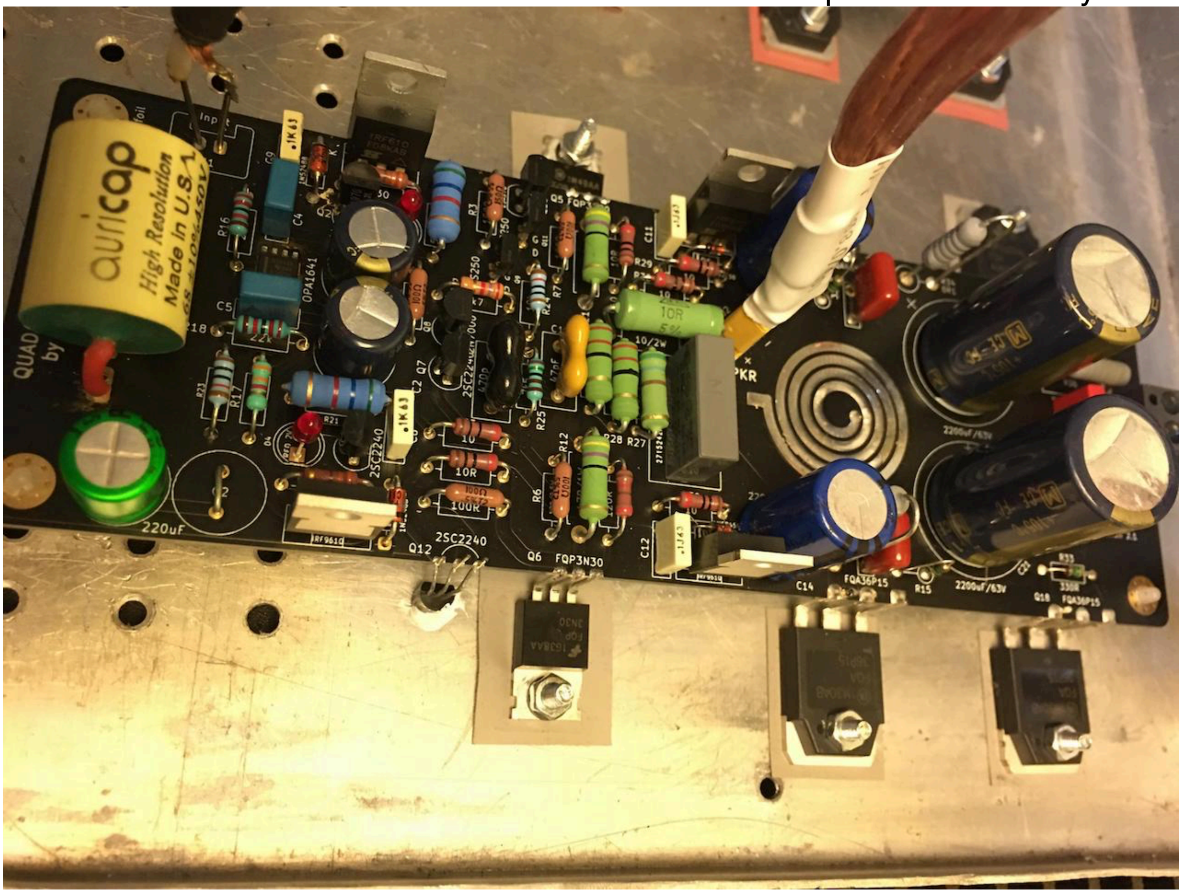
Q17 - audiophile approach to perfect sound

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

by audiophile Tiberiu Vicol & ChatGPT
This document was updated on 09.May.2023



Introduction:

Q17 is a class B amplifier based on the current dumping principle.

Initial technical requirements:

- Stable operation: The amplifier must remain stable under any operational condition, with no oscillation.
- Minimum 100W in 8ohm at 1kHz: This should be sufficient for audiophiles with "impossible to drive" speakers.
- Frequency response cutoff of 10Hz - 100kHz: This will allow for a decent slew rate.

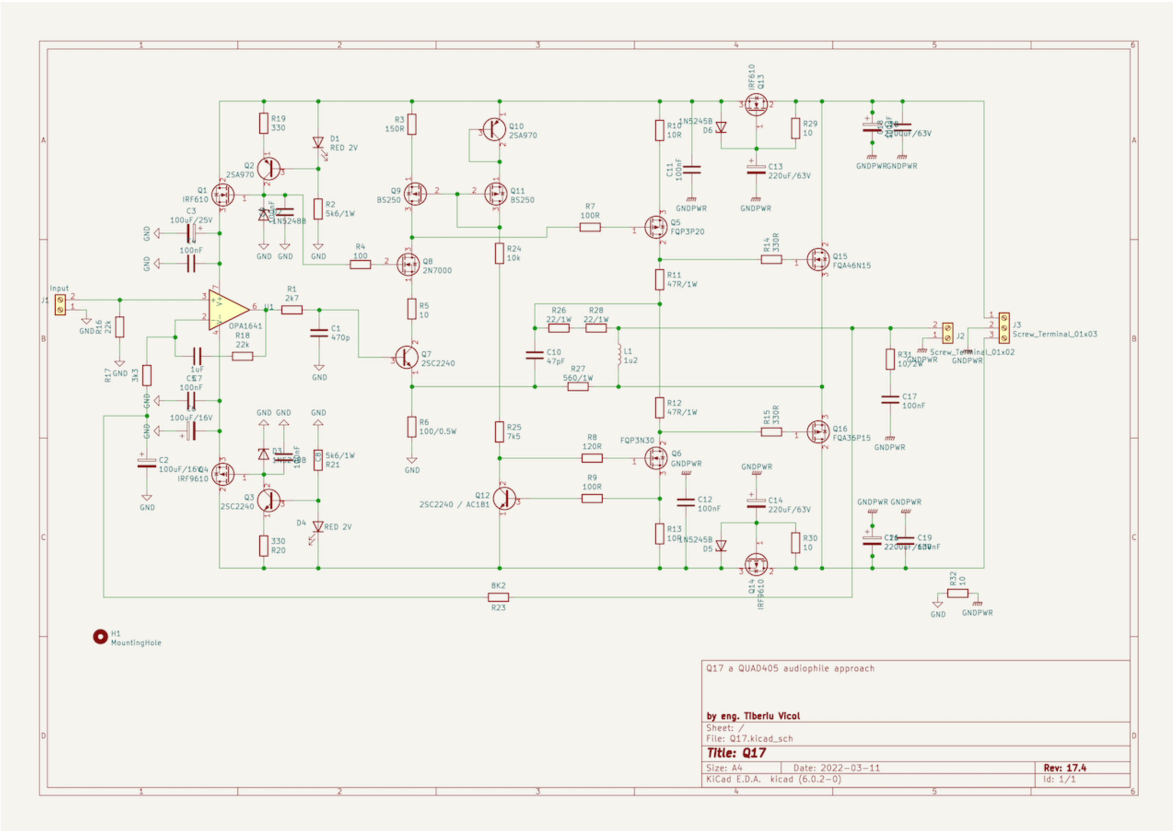
- IMD (Inter-Modulation Distortion) under 0.01%
- THD (Total Harmonic Distortion) under 0.01% at 1W and full power
- Design must be affordable, using readily available THT or SMD components or equivalents.
- Cost-effective and easy to build: High-end audio must be affordable.
- Open source: Let's offer everything - schematic, simulation, source PCB files, and bill of materials.
- Designed using LTspice simulation with final touch by extensive bench measurements and testing. Starting with KiCad 6.0.2, ngspice simulation is possible, and files have been made available by Holger Vogt: https://forum.kicad.info/t/simulation-examples-for-icad-eeschema-ngspice/34443
- Final design decisions are always made using my platinum ears. ;-) This means that Q17 is designed by comparing different topologies, and the final decision is taken not by measurement, but by listening. Q17 is indeed designed by ear. :-D

And here are the on-ear requirements:

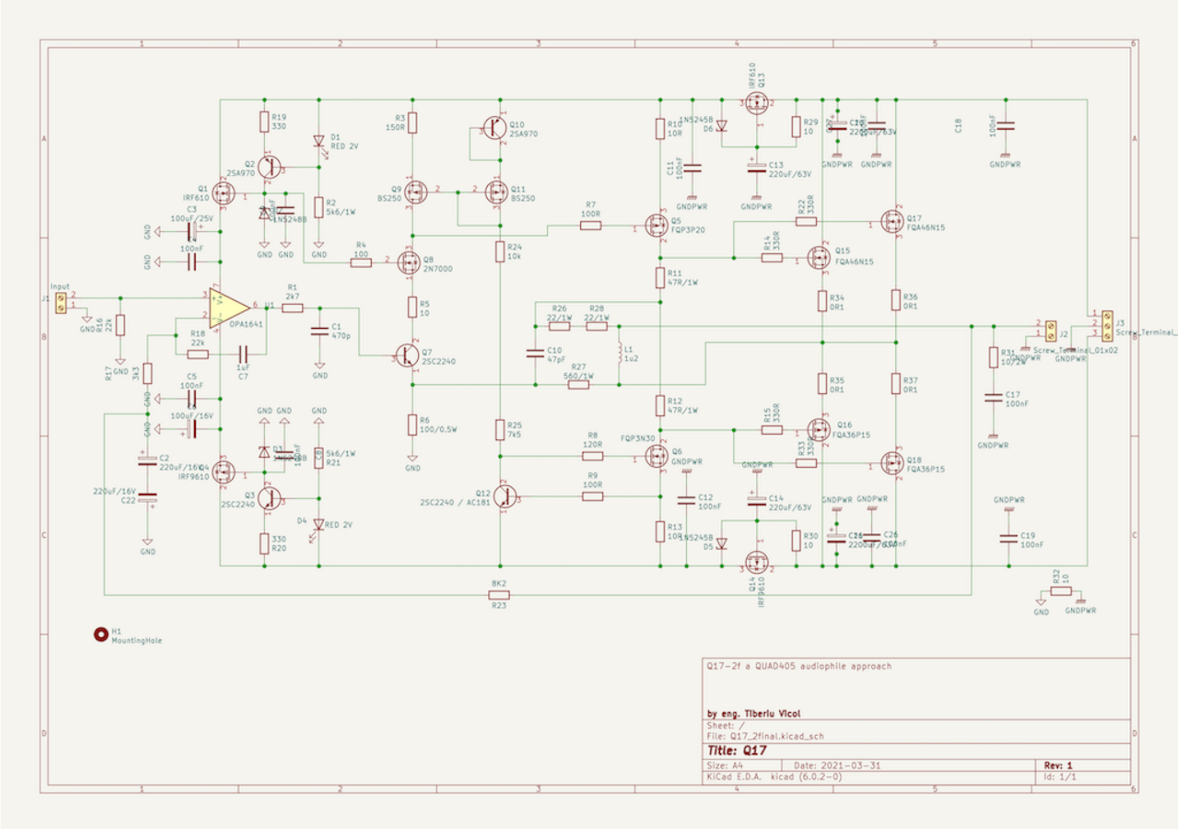
Sound quality is of paramount importance. The amplifier must sound excellent at any level, without causing listening fatigue. The sound must be vivid, with a full body and plenty of harmonics with long decay, while maintaining resolution and clarity from top to bottom. Each instrument must sound natural, clearly separated, and easy to locate in space, even in large orchestras.

- No hiss or buzz: Poor rectification and filtering may result in unwanted noise.
- Microdynamic: This is challenging. The rhythm must be clear and distinct at any volume. I don't want flat, compressed, or lifeless sound. This is often related to negative feedback (NFB). In my opinion, NFB is only partially true, and it largely depends on how it is used along with other factors. High-quality power supply filter capacitors may also help.
- Macrodynamic linearity: The amplifier must be capable of going from low to high power levels instantly, without distortion or compression. It must provide the feeling of unlimited power. This is mainly related to the power supply. If the amplifier is capable of delivering power, the power supply must be able to handle it as well.

- Resolution: I prefer an amplifier that offers both resolution and full-bodied instruments, without losing harmonics and decay. Well-designed single-ended direct-heated triodes (SEDHT) are capable of achieving this, and I want the same from my amplifier. I know this is another challenging requirement. Intermodulation distortion plays a role here. Low IMD always leads to top resolution, but sometimes musicality can be lost.



Q17 with output single pair of Fairchild's



Q17 with output double pair of Fairchild’s

Functional Description:

Q17 is designed to deliver music at the highest audio performance, and this design does not follow the "amplifier design book." Intentionally, the input is DC coupled, it has no input LPF, and does not make use of diodes or Vbs multiplier for thermal compensation. Q17 will run in class B, even though the output devices are MOSFETs with a very high Vgs threshold. As far as I know, this has never been attempted before. Please correct me if I'm wrong. Q17 is divided into two separate sections, which we will call Section One and Section Two.

Section One is made with the operational amplifier OPA1641. Today, OPA1641 is one of the best opamps on the market. In fact, it is so good that a discrete circuitry will barely come close. OPA1641 is a JFET input operational amplifier that, apart from technical specifications, sounds very good and is cost-effective too. We are not driving a low impedance output, and there are no thermal issues. Those who do not like JFET sound may try LME49990. This sounds great as well.

In my humble opinion, phase accuracy is very important. Therefore, Q17 is not inverted and will preserve the original phase of the signal. The input impedance is given by R16 = 22K. This is a good trade between high impedance and thermal resistor noise. You want higher input impedance? You can go as high as 47K. Use a good metal foil resistor here, and it should be enough. R17 and R18 are part of operational negative feedback and 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 a gain higher than 5. 7.6 will offer good sensitivity, and we are on the safe side, away from any oscillation. Through R30, R25, and C3, the input operational will have a second role, acting as a DC servo. C3 must be bipolar, and I recommend using a good one like Nichicon MUSE. However, two normal polarized electrolytics connected in series will work just fine. For this use, low-voltage electrolytics in the range of 6.3V-10VDC.

R1C1 forms a low-pass filter with a cutoff frequency of 125kHz. This RC filter is the main load for the operational and will also limit the whole amplifier's full bandwidth. C1 must be silver-mica or polystyrene.

The operational is fed by two "reasonably low noise" regulators. The operational will not draw more than 10mA per raw, but its 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 versus price compromise.

Here is how it works. Regulation is ensured by 18V zeners D2 and D3, which are fed by a constant current source at around 4.2mA. Q2, D1, R19, and R2 (respectively Q3, D4, R20, and R21 for the negative rail) form a simple current source. D1 and D4 are red LEDs with Vf~2V. It is well-known that an LED is a reliable low-noise voltage reference. The current through the zener diode will be (LedVf-Q7Vbe)/R19 = (2-0.6)/330 = 4.2mA. This reference voltage is used by two MOSFETs, Q1 and Q4, respectively, to deliver higher current to OPA1641. IRF610/IRF9610 are a bit overkill here but are easy to find and cheap enough. These will run warm but do not need a heatsink.

Here is one of my first audiophile observations: MOSFET regulators sound better than bipolar regulators. They do not measure better, but they sound better.

Section two starts with a cascode formed by Q7 and Q8. This stage offers 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 BC5xx/BC8xx can be used, as maxVce > 45V is the only restriction. From a 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 the top active device. This will preserve dynamics at any level.

The cascode - Q7 & Q8 - stage has a high output impedance, therefore it is fed by a constant current source made by Q10 and R3 at approx. 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 through R24 & R25. In fact, the heart of Q17 is around this CCS+ current mirror. A current mirror that can be made with high-beta PNP transistors or P-channel MOSFET. You may need to pair these transistors to have same Vbe or Vgs at ˜5mA.

I tried both. BJT mirror is very precise and offers a lush sound. For MOSFET, I used BS250P, and in this case, sound is deeper with a better midrange. Micro-dynamics seem to be higher too. After extensive listening sessions and some burn-in, I can confidently say that I will stay with MOSFET mirror. Take care of BS250P numbering termination as this is different for manufacturers - see Vishay and Diodes.

Instead of R24 & R25, you may use a single 1W resistor. This was split in two to distribute power dissipated.

Next is a class A stage. Here a single modern high-transconductance MOSFET will do an excellent job, at the cost of some input capacitance. MOSFETs create more even-order harmonics compared to bipolar's too. As I care more about harmonic content than THD, here is my preference for MOSFET.
The quality of these MOSFETs may dramatically influence the amplifier's sonic signature, and these have been chosen after long listening sessions.

The P-channel MOSFET Q5 is a class-A active device, and from my observation, the P-channel FQP3P20 is slightly more linear than the N-channel FQP3N30. However, at the current time (2021), we do not have too many options. Toshiba's lateral MOSFETs (2SJ76, 2SJ77, 2SJ78, 2SJ79, and 2SK213, 2SK214, 2SK215, 2SK216) have long been obsolete. If you can source them, use them, but don't set your expectations too high. These will not sonically exceed the FQP's. However, if you do use them, some capacitor compensation may be needed to keep them from oscillating.

Q5 is fed 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 the final stage too. Again, there are no constraints for Q12. It can be any high-beta, low-voltage, NPN BJT. The CCS current can be calculated by Q12Vbe/R13 and would be around 60mA. This will push Q5's operation in class A and offer enough juice to drive the final dumper stage. Q5 and Q6 will dissipate 3W and must be mounted on a heatsink.

Q12 must also be mounted on a heatsink as it will be used to compensate for final stage thermal runaway.

Changing R13 to 2 ohms, a germanium AC181 can be used here as better temperature compensation. I must mention that this mod will not bring "germanium sound" into this amplifier. Sorry, germanium lovers!

R9 is there as a base stopper and to avoid any possible oscillation. R7 and R8 are gate stoppers too.

The Q17 amplifier runs in class B. There is no bias needed, and the Q17 amplifier may accept a very wide range of output MOSFET transistors.

Choosing the 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 amplifiers, and they sound exceptional. The main goal of Q17 is to be affordable, and these laterals, like many other good things, are not so cheap. They are very rugged and allow a high level of "torture" and make things sometimes easy. No protections are needed. But... there is a "but." They have a small transconductance. You need to use double die and parallel a few of them to get some decent transconductance because audiophile speakers make use of

complicated crossovers that like a lot of current in the most unexpected frequencies.
Fairchild, now ON Semiconductor, was a great company and one of their legacies is FQA46N15 and FQA36P15. If you think these are P/N pairs, you are wrong. There is no such P/N perfect match in the real world, but we can choose the closest ones. These are marketed as "Fairchild Semiconductor's proprietary planar stripe and DMOS technology," with a small remark that they may be suitable for audio amplifiers as well.

FQA46N15 has a regular transconductance of 36 Siemens, while Exicon double die ECW20N20 has a maximum of 4 Siemens. This is equivalent to 9 double die laterals. Yes, very impressive! FQA36P15 has a regular transconductance of 19.5 Siemens, while Exicon double die ECW20P20 has a maximum of 4 Siemens. This is equivalent to 4 double die laterals.

In the "dark side" of Mouser, some beasts may leave these Fairchild's in the dust. These are made by IXYS, and a pair could be IXFK220N20X3 and IXTK120P20T. These exhibit over 120 Siemens of transconductance and are capable of transforming 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 neighbor...

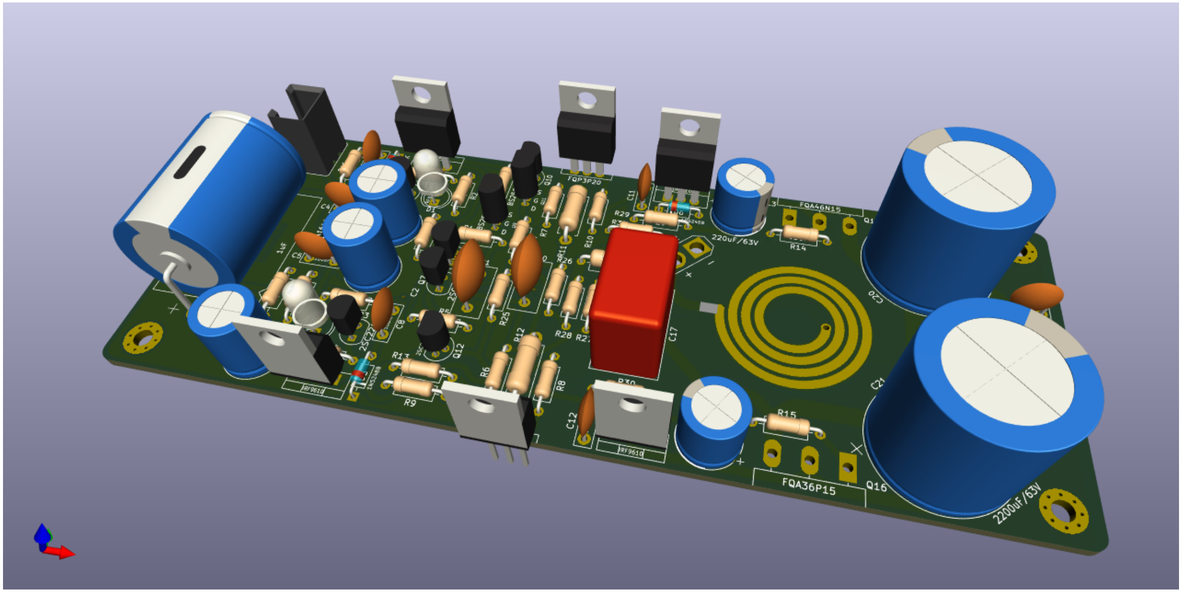
Through R11 and R12, these devices will be biased near class A operation. Both FQA46N15 and FQA36P15 have a Vgs - threshold voltage between 3V and 4V. I found that the P channel FQA36P15 will open around 3V, while the FQA46N15 will need 100mV-300mV more. (To have both running at the same level, R11 may 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 or polystyrene capacitor here. My preference is polystyrene Multicap RTX series. If you do not want to invest too much, go for Arcotronix.

R26, R27, R28, C10, and L1 form the current dumping bridge. R27 and R6 are part of section 2 negative feedback. This sets the entire amplifier gain to [(R17+R18)/R17]x[{R27+R6)/R6]=45.6, enough for the 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 have noticed that there are R4, R7, R8, R9, R14, and R15 as gate or base stoppers. I always prefer gate stoppers to compensate with capacitors. R32 will separate the signal ground plane from the power ground plane. There are no special requirements for this one. Please note that R32 is 0ohm and not 10ohm as in presented schematic.



PCB design

During the COVID-19 lockdown, I had enough time to learn KiCad. KiCad runs on any operating system and is open source. This offers flexibility, scalability, and security. KiCad is a great tool.
I have designed this project in KiCad 5.99-nightly. To open the files, you need at least 5.99. This is already compatible with the 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. For the best noise reduction, small signal GND makes use of top and bottom ground planes.
The PCB embeds an L1 inductor that is part of the 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 the PCB will help lazy people like me a lot, but what I said earlier is still valid. A PCB coil is better. In a separate document, I have detailed how to create and embed inductors in KiCad.
The PCB offers the option to install several C7 types. Use propylene at any voltage > 50V. C17 must be propylene, preferably FKP, or polystyrene at a voltage > 100V.
OPA1641 is the single SMD part, and the PCB does not offer the option to install a THT one. But as long as 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
Q7,12 - 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
Q2,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
Q1,13 - IRF610 - https://ro.mouser.com/ProductDetail/Vishay-Siliconix/IRF610PBF-BE3?qs=%2Fha2pyFadugbZUitPAu%252BTEPjT5SopLZ8qDnf9IMIvY8%3D
Q4,14 - IRF9610 - https://ro.mouser.com/ProductDetail/Vishay-Semiconductors/IRF9610PBF?qs=cval6ThkwxtWoLkQbU%2FdsA%3D%3D
Q5 - FQP3P20 - https://ro.mouser.com/ProductDetail/onsemi-Fairchild/FQP3P20?qs=mdiO5HdF0Ki1WoTNCOatYg%3D%3D
Q6 - FQP3N30 - https://ro.mouser.com/ProductDetail/onsemi-Fairchild/FQP3N30?qs=FOlmdCx%252BAA1dVHDhvU%252BUcw%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
R24 - 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
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
R14,15,19,20,22 - 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
R23 - 8K2 - https://ro.mouser.com/ProductDetail/Vishay-Dale/CCF078K20GKE36?qs=QKEOZdL6EQrGlLmaSP0G2w%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 - https://www.hz-profishop.com/product_info.php?info=p701_mks-1651-6-0-202-s18--schwarz-.html
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=Mv7BduZupUgRMrlfdnWHCQ%3D%3D

Extra parts for Q17-2f (Q17 amplifier with two output pairs)
R22, R33 - 330ohm https://ro.mouser.com/ProductDetail/Vishay-Dale/CCF07330RJKE36?qs=pkalMaiJWwv10%252BO%252BONxDWg%3D%3D
R34,35,36,37 - 0.1ohm/3W https://ro.mouser.com/ProductDetail/TE-Connectivity-Holsworthy/ROX3SJR10?qs=sGAEpiMZZMsPqMdJzcrNwtkiCP%2FuZm62WDIB0kikdgI%3D
Q17 - FQA46N15 - https://ro.mouser.com/ProductDetail/ON-Semiconductor-Fairchild/FQA46N15?qs=%2Fha2pyFaduimCeOyuw0xouriGUKJcVVjoz%2FqQ0BKQtc%3D
Q18 - FQA36P15 - https://ro.mouser.com/ProductDetail/ON-Semiconductor-Fairchild/FQA36P15?qs=%2Fha2pyFadugPFcM3hvKrsP2cJsnMpKcpv1XDSGf5JCo%3D

Active power supply

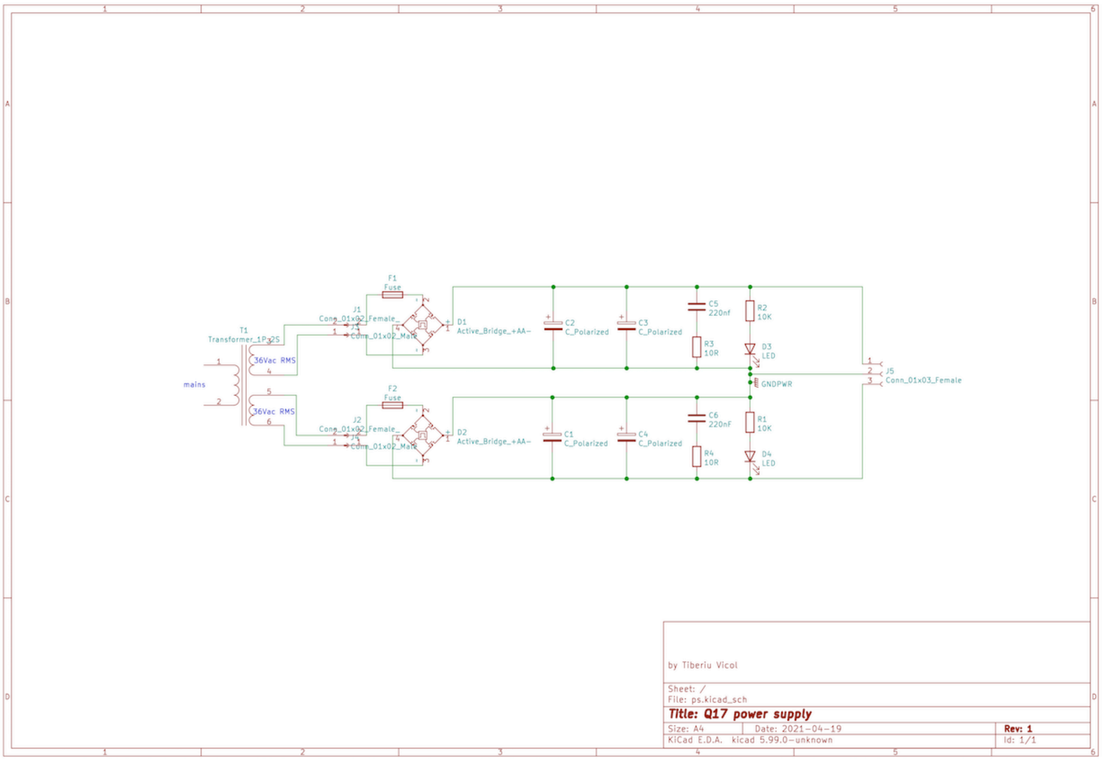
A good amplifier needs an exceptional power supply. All design efforts will be lost if we do not excel in this area too.

A diode is far from being a perfect device. There are no better devices, only better solutions.

Synchronous, or active rectification, has been available for a long time in professional appliances. The very first synchronous rectifier (mechanical rectifier) was used in the 1950s for high power and high voltage applications.

Its limited usage in consumer electronics was due to complexity and the very high cost involved. In recent years, thanks to green power requirements and electric vehicles, several dedicated chips have appeared in the consumer market. These mainly target PoE (power over Ethernet), but by choosing the right parts, the application can be extended to high-end audio as well.

A synchronous rectifier is a diode-less bridge employing modern MOSFET transistors that replace the four diodes in a full-wave bridge rectifier with a milliohm Rdson MOSFET, drastically reducing power dissipation, heat generation, voltage loss, and diode on/off switching noise. There is no P-N junction involved; only a low milliohm conductive channel is inserted in the power path. This allows for 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.



The advantage of using synchronous rectification is huge. While a normal diode has at least a 600mV drop at 1A, a low Rdson MOSFET will have as little as 3mV, or less, at the 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 to synchronous rectifiers having negligible on/off noise. Each bridge MOSFET is acting like a soft on/off switch. The entire medium to top audio spectrum is cleaner. Voices are soft and cymbals full of harmonics. Another effect is better dynamics. The sound is more vivid because no power is lost in rectification or modulated by diode pn junctions, and the single current limiter is the intrinsic transformer resistance.

We make use of two Saligny Standard synchronous rectifiers made by Evotronix SRL. These are operated at 36Vac each, from a 300VA R-Core transformer. C1, C2, C3, C4 = 10000uF/63V are the 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

Selecting alternative parts

With current component shortage, it may happen that some parts listed in BOM to be unavailable, here are few alternative recommendations:
R16 - use a metal film resistor
C7 - use a good polypropylene made by Mundorf, Epcos, Vishay, CDC,
U1 - following opamps can be used and will offer different sonic signatures: LME49710, LME49990, OPA604, OPA134, NE5534. Do not use TL071, TL081, LM301, LM741.
Q2 and Q3 - use transistors with Vce >= 65V & hFE>=100 : 2N5401 / 2N5551
Q7 and Q12 - other transistors that may be used are: KSC1845, 2N4401, BC546 / BC547 / BC548 / BC549 / BC550 - use the one with A termination for

Q7 and C termination for Q12.
C1 - this must be silver-mica or at least polystyrene.
Q1- KSA992, 2N4403, BC556C, BC557C, BC558C, BC559C, and BC560C
C10 - silver-mica or ceramic NP0
R26, R27, R28 - these must be non-inductive resistors. MILLS make some good ones.
C17 - in this order: polystyrene, teflon, foil polypropilene, metalised polypropylene.
Q5 and Q6 - following pairs may be used with excellent performance: FQP3P50/FQP4N80; FQP4P40/FQP5N60
Q5 and Q6 - following pairs may be used with modest performance: IRF610/IRF9610; IRF640/IRF9640; 2SJ76, 2SJ77, 2SJ78, 2SJ79 respectively 2SK213, 2SK214, 2SK215, 2SK216.
Q15,Q16,Q17,Q18 - following pairs can be used with modest performance IRFP9240/IRFP240; 2SJ201/2SK1530; 2SJ118/2SK413; 2SJ119/2SK414.
Q9 and Q11 - Instead BS250 you may use

Exicon ECW20N20 and ECW20P20 lateral MOSFET's can NOT be used on this PCB. PCB need to be redesigned to accommodate lateral mosfet pinout.

Q17 Construction

Keep input shorted before any dc or static amplifier measurements. Static mean you only measure voltages in various places.
Start by installing operational and regulator with Q1-Q2-Q3-Q4. Next add Q13 and Q14 capacitor multipliers. Power up at and measure voltages before and after regulators. Before regulators you should measure +45Vdc/-46Vdc. After regulators you may expect around +13.5Vdc and -14Vdc
The two red LED, D1 and D4 must light on.
Mount the rest of parts, short input, power up and measure DC output. This must be under ~40mV.
Voltage across R3 and R13 must be between 500mV and 700mV.
Voltage across R11 and R12 ~3V, a bit higher on R12.
If above measurements are OK, then you may connect Q17 amplifier to a preamplifier, potentiometer or volume controller. Connect output speakers trough a speaker protection module or a 3A fast fuse.
Take care and do not short the amplifier output. There is no protection, unless you have installed a separate one.
In some cases, a soft-start module is needed.

Building active power supply

For proper performance Q17 need a min.300VA transformer. There are E+I, C-core, R-core, Toroidal transformers. Any of them will work, but people ask which is the best. The best is the one that is the best constructed, using

proper materials and well executed. However, from theoretical point of view, R-core exhibit lowest EM loss. A well executed R-core can be the best.
Transformer must have dual separate secondary, 2 x 36Vac at min 5A.
Do not measure Saligny rectifiers without filter capacitors. Install all parts and measure when all is in place. Compared to any diode rectifier, Saligny rectifiers do not have voltage loss and you should get 36Vac x √2 = 50.9Vdc at active
Power supply output on each rail.

Measurements

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 powered 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. Exceptional midrange with crystal clear top response. Instrument separation localisation in deep 3D.
Enjoy & Thank you !

References and acknowledgements:

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