

"WOTS WHA-217 E2 edition" main amplifier.

PRESENTATION.

This is (and will be [never say never again]) my last elaboration on NHB-108 base. It is a dual-mono building. About the name: "WOTS" stays for "Warmth Of The Sound", "WHA" stays for "Will Hear Again" meaning you'll hear music every time you turn it on, while "NHB - Never Heard Before" doesn't sound that auspicious, "217" is double of "108" plus 1, "E2" could be "Enhanced version 2" or some other fancy meaning you can imagine; actually it is transposed from Roman slang, meaning "another one, the second"

The power of this amplifier is 200Wrms/8Ohms per channel with the capability to drive very low impedance loads. This performance is achieved by adding a follower to the original Diamond Buffer final stage, being this add-on made out of 15 paralleled couples. I gave this final stage the name of "Paragon Follower" being the simplest "DBT - Diamond Buffer Triplet" configuration. All stages work in "Class A" but the final pairs, working in "Class B".

The peculiar characteristic of this amplifier is to have no feedback from the speaker output, like the original base NHB-108.

PHILOSOPHY OF THE (MODIFICATION TO THE) PROJECT.

Music is emotion. If you listen to music and do not feel any emotion, something is wrong. Where is the emotion? It is trapped in the feedback loop!

All 3 last Hi-End amplifiers I built have no loop feedback. I will never step back building again any other amplifier with the feedback loop starting from the speaker end, unless I need it for a purpose other than the High End High Fidelity one. And, in that case, I would prefer the LJM L20 V9.2, which, with a little effort, becomes a true Hi-Fi main amp. But this is another story.

This project is the easiest way to build a Hi-End component with no feedback from the speaker end, because it is the only PCB I could find on the market with this feature. There are better projects sporting this feature for sure, but you have to design and make the PCB by yourself. Being no feedback from the speaker end, in order to achieve a good damping factor you have to use a lot of final pairs, at least six. The internal loop feedback, an evil that we cannot do less in a solid-state amplifier, is well insulated from the speaker reactions by the final stage "Paragon Follower".

KEY POINTS.

No feedback from speaker output.

0.1 resistors MUST be used in final pairs emitters.

Wired cabling of final pairs.

At least 6 final pairs in order to achieve a decent damping factor.

CONSTRAINT.

Final pairs MUST share the same heatsink with xVbe transistors, pre driver and driver transistor.

xVbe transistors MUST be placed AMONG final pairs transistors, in order to sense their heat.

Placement of pre-driver transistors should be close to some final pairs transistors in order to sense their heat.

HISTORY.

I have been working on this project for over a year, I posted it in DiyAudio some time ago. I don't remember the exact history, some proposed a Baxandall super couple (see T5/T8 and T6/T10 in my schematic), and some other attempts at improvement. I implemented them all on my "WHA-217 Cu Edition" because, from the tech side, they were valid. But I didn't like the result compared to the precedent build (circuitry on main board almost untouched), so I didn't replicate those mods on this "E2" version, and removed them from the Cu Edition.

RECOMMENDATIONS.

This is not a project for newbies, an advanced skill is required both in electronics and mechanics.

Anything conveniently improvable was improved, if you still see something improvable, ask yourself why I did not improve it, before asking me; this is a good test to check your skill: if you have the minimum required skill, you will find the answer by yourself. This is a tricky suggestion, If you can't, or have a doubt, do not go forward and do not hesitate to ask me.

The layout of what is on heat sinks is strictly part of the project and cannot be changed in its structure, constraints, and key points.

The voltage of 140V/160Vdc could be hazardous both for your health and the health of the components.

The main tools required for this project are:
a variac (mandatory);

a good soldering station;
a good de-soldering station, to repair your errors;
a couple of multimeter;
a drill press;
drill bits 2.5mm, 3mm, 3.5mm, 4mm, 4.5mm to drill holes;
suitable bits to deburr the holes;
threading tap M3 for through holes;
threading tap M3 for blind holes.

A function generator and an oscilloscope are required only in case you want to experiment yourself with the correct idle bias or play with the internal feedback loop. If you don't have them, follow the instructions.

CIRCUITRY.

TOPOLOGY OF THE GAIN STAGE - The topology of the gain stage is almost untouched, compared to the NHB-108: the midpoint trimmer and associated components were removed (a lot of hum from that circuit), the feedback loop is slightly changed in order to have a single input point for the feedback, instead of two. This also avoids altering, even minimally, the polarization of T3, T4, which would happen (in the original circuitry) in consequence of having inserted a xV_{be} . I removed the input capacitor because I know how my preamplifiers are equipped (capacitor and short circuit at output with 100 seconds delay), so the input capacitor, for me, would have been one more useless capacitor in the signal path. For best result in midpoint stability, T1, T2, T3, T4 transistors must be thermally coupled (see pictures).

COMPONENTS TO BE NOTICED - Some transistors are replaced with respect to the original, avoiding the MJE15032/MJE15033 pair, because of their huge difference in NPN/PNP h_{FE} . T5/T6 pair are Toshiba TTC004B/TTA004B (but can be 2N5401/2N5551), no need to be put on the heat sink; T8/T10 pair are Sanken 2SA1859A/2SC4883A. Some transistors I used are obsolete, if you cannot find them, download their data-sheets and search for similar ones.

XVBE - A xV_{be} was implemented, for the bias setting and the temperature tracking. It is made out of a Sziklai couple, to allow a low impedance, a low sensitivity to the voltage variations, a good tracking capability, highly needed, because very low 0.1Ohm emitter resistors are used in the final pairs, and we don't want a thermal runaway. The xV_{be} board is to be housed among the final

pairs, in order to sense their heat. Another help controlling the temperature is from the pre-driver stage, whose transistors are to be put close to the final pairs. Going deeper on very low R_e 's on final pairs concept: the R_e is the local feedback of the connected transistor. The R_e is able, with its feedback action, to help compensate the h_{FE} effect of the transistor when it increases its temperature (higher temperature=higher h_{FE} =higher conduction=higher temperature=thermal runaway). The lower the R_e value, the lower the ability to compensate. A 0.22Ohm R_e is the most used value, that, in association with the usual xV_{be} , made out by only one transistor, allows sufficient thermal tracking. Lowering the R_e to 0.1Ohm, the compensation effect decreases so we have to use a better thermal tracker in order to avoid a thermal runaway. The good is that, with 0.1Ohm resistors, the idle bias can be lowered and the distortion shows a better trend. A better-designed xV_{be} will prevent any thermal runaway and, if needed, its temperature coefficient can be increased. Here is used a Sziklay configuration with its natural temperature coefficient. It shows a low impedance and low sensitivity to voltage variations. This xV_{be} , in association with the pre-driver effect (higher temperature=lower bias on the final pairs), will be enough to avoid the thermal runaway.

FINAL STAGE - The final stage is the said "Paragon Follower" with CCS's made out of Depletion Mosfets, delivering 12.5mA each. Taking advantage of the fact that all final transistors have a very close h_{FE} , and according to D.Self, 0.1Ohm resistors were chosen as R_e 's, in order to keep the bias as low as possible and minimize the distortion. The pair TTA1943/TTC5200, surely over sized, has been chosen as a driver because of its low C_{ob} and high current feature, but it is not critical to exactly use this couple.

POWER SUPPLY UNIT: it is the classical simple one with 10x 6.8mF/100V capacitors/rail/channel = 40x 6.8mF/100V for the high current section "Paragon Follower", and 1x 4.7mF/100V capacitor/rail/channel = 4x 4.7mF/100V for the low current gain stage section VAS. I implemented a simple solution that allows the voltage on the VAS to be almost constant, by decoupling its power lines by a diode couple. I bought the bare PCBs on eBay, 6 boards (for stereo) able to hold 8 x 35mm capacitors each.

SERVO: Since the internal feedback loop is partialized even in DC (no decoupling capacitor is present), and since the feedback is the current type, in order to

maintain the midpoint at zero, a non-inverting servo circuit is highly advisable, better than a capacitor.

You can design the servo PCB by yourself following the schematic you find here, using an OPA277 single precision OpAmp taking in account of the different pinout.

If you buy the servo from eBay, as I did, you get a double channel one, because it was designed for NHB-108 double feedback loop. You have to modify it (super simple to do) in order to obtain a single channel servo as the one needed here.

The servo sold in eBay (both old and new 2020.05 editions) has two main issues. First about components: extremely cheap film capacitors are used, while they must be high quality and (very important) low tolerance ones, and the OpAmp must be a precision one (OPA2277). Second: even with the best OpAmp, it will be impossible to have exactly the same offset tracking on both outputs. But, in our case, this is not a real issue because only one section of the servo will be used lowering its Routput to 16600Ohm, not really critical, a 15-:-18KOhm resistor will be OK. Otherwise, since everything is already in place, one can decide to use both sections with outputs paralleled, as I did. Other improvements are possible (2020.05 edition): the two electrolytic capacitors were substituted with two 1mF 25V ones, and the removed ones were put in parallel with the 12KOhm resistors, according to the best practice for the TL413A shunt regulator. There will be no way that this upgraded servo can spoil the sound quality.

SPEAKER PROTECTION: I really would like to avoid this function and related hardware. But, at the same time, I don't want to take any risk of burning my speakers, and don't like to use fuses in audio lines. So I gave myself the mandatory rule to use a relay to interrupt the speaker connection in case of failure. Will the relay affect the sound? Perhaps yes but I prefer this "perhaps" to the other "perhaps" about burning my speakers. So I tried to minimize the negative affect of the relay in the audio line.

I bought two stereo boards from eBay, each made of two big and good 30A relays that I paralleled. Rectification and delay capacitors were substituted with 1mF 25V/220uF 6.3V ones in order to achieve a higher Vdc and a longer 20 seconds delay time; moreover, the 220uF capacitors among the two relays were substituted by another with the same value but uncut long leads, assembled upside down, in order to connect a fan socket to its leads; then the fan socket was glued among the two relays. Since each board will be used for one channel, the contacts of the relays must be paralleled.

FANS: they are not strictly mandatory but it would be better to move the air inside the cabinet, where all things are going to generate some heat. The fans will rotate at a low speed without making any noise. I used two Noctua NF-B9 Redux 3 pin; a 50 -:- 150Ohm resistor is needed for each fan, in order to reduce its speed and keep it silent. The fans get the power from the speaker protection boards.

SOFT START: I bought a board on eBay with a 100A (!) relay. This board has an original delay time too fast to work correctly with 0.3F total capacity. Also, it uses 4 NTCs that are not suitable to handle correctly the power needed when a longer delay time is configured. But this board is the best you can find at an affordable price. So, some and simple modifications are needed: remove all NTCs and use a halogen bulb as a damper load; change the timing capacitor with a 220uF 25V that will configure about 8 seconds of delay, reinforce the high current tracks by melting some tin on them.

PLACING FINAL PAIRS - In my layout it is better to put the transistors with higher hFE on the first heatsink, the one holding the main board.

All bundled picture refer to this [E2 edition but 2](#). These are:
[Electronics 06 Mainboard 18 \(CuE\) Particulars Positive Side and](#)
[Electronics 06 Mainboard 19 \(CuE\) Particulars Negative Side](#)
referring to the CuE Edition.

[I forgot to take these pictures while assembling the E2 edition; what I intend to show is the feedback node, made by the components you see put vertical on the PCB; ignore any other particular.](#)

FIRING UP.

Mandatory: use a bench power supply with LOW-VALUE CAPACITORS and a VARIAC. Put together the "VAS" and "Paragon Follower" power rails. Do not be worried about the hum you will hear, it will disappear once you connect the real power supply. The hum is very welcome in this phase, it allows you to understand the amp is alive and if it is drawing too much current (by the tune of the hum).

Connect the speaker with an anti-series of two capacitors to the output and the mass (to avoid any possible DC to flow to the speaker, in case of errors).

Insert a 10Ohm resistor in one collector's rail of the final pairs (any, + or - makes no difference) and connect the millivoltmeter across this resistor. Connect the

heatsink to the mass (do not leave it floating) with a double alligator cable, and fire it up now rising the variac to obtain 10Vdc (5+5Vdc) on power rails.

Use your finger as a function generator touching the input. If you don't hear any noise, something is wrong: stop here, disconnect all and search for errors. If you hear the characteristic grid noise, it means that the amplifier is alive.

Read the millivoltmeter; lower the reading to its minimum possible using the bias trimmer. When done, start rising the voltage by the variac while using the function generator (finger): the current drawing will decrease a lot. If no explosion nor smoke is detected, reach gradually the 140Vdc, read the millivoltmeter and adjust the bias until it shows 65mV which, on 10hm, are 65mA.

FINAL ASSEMBLING.

Now you are ready to assemble everything together and connect the real power supply. Remember to connect together the two mass connections of the input pin jacks RCA otherwise auto oscillation can occur with very unpleasant consequences. That's true for me, having the field generated by the Acoustat 1+1 in my whole house. Moreover, I think it is better to close the unavoidable mass and signal loop outside the amplifier. If you do not short the input masses directly on RCA pin jacks, the mass loop would close with the GND coupler, that is to say inside the amplifier. If your speakers are electrostatic ones, it is even worse because the mass loop closes also with the speakers' connection to the power outlets, picking up the disturbance generated by the speakers. Catastrophic!

ABOUT THE IDLE BIAS.

Studying Douglas Self books, you will learn that the transition Class-A/Class-B generates distortion. So it would be better to keep this transition at the lowest possible level, going towards Class-B as much as possible, stopping before incurring in cross-over distortion.

In this main amplifier 65mA, a surprisingly low bias for 15 final pairs, is enough to avoid cross-over distortion and have a good sound. This is due to the very low value of the Emitter Resistor, 100mOhm (again from D.Self).

Going over 65mA is surely possible, according to your preferences. Dick Olsher and Nelson Pass say that the 1st Watt will reveal the sound of the amplifier. So, if you agree with this statement, 180mA is the right value to have the 1st Watt in Class-A on 8 Ohm, while 250mA is suitable for 4 Ohm.

But just have in mind to keep the Class-A as low as possible.

AT PRESENT.

The amplifier has been playing continuously since its birth, it only stays off when I sleep. Its bias is set @180mA. It is barely warm while listening at low and normal volume. After ½ hour delivering 25Vrms on my “Martin Logan Source” it becomes a little warmer (without barely). The sound is very precise and warm. It took some days to deliver the good sound, do not expect to power up the amplifier for the first time and have a good sound, the capacitors must acknowledge that they are working after a long rest on some shelf! I can state, without any doubt, that no listening fatigue occurs at all, having the music as a background while doing other things. I also am enjoying its sound with movies and music... What can I say... Very good! Perhaps under "La Regola dello Scarrafone" (you have to google for it).

MECHANICAL NOTES.

I chose the HiFi2000's Dissipante 5U/500mm with its internal base. The front panel remained untouched, the rear panel holds the two fans, the input pin jacks, the speaker's binding posts, the IEC C20 socket, and a fuse holder. The internal base was adapted with some drilling, to hold the "castle" of capacitors and all the rest.

The biggest work was the drilling of the heat sinks in order to hold the main boards and the final pairs: 104 threaded holes in total. You need to use good taps. With mine mounted on the tap wrench, I was able to thread with two fingers, applying a very low torque while using a tap able to expel chips from the other end of the hole. All holes are through-hole but 4, in order to thread these 4 holes a different tap and a stronger torque are needed, together with some ability. To make the tap as perpendicular as possible, use the drill-press as a guide (see pictures). While treading use the turpentine as a lubricant. Once all threading work has finished, use a brake cleaner spray to clean away the turpentine, allowing the use of a thread lock. Once you put in place all studs with the thread lock fluid, tension them by using a nut and a spacer (see pictures); do not put in place the nut without a spacer because the thread lock will lock the nut on the stud.

My friend Paolo, building the thing at the same time, resolved the hosting of the two transformers close to the front panel. I made them removable so, when I have to move the amplifier I don't have to lift 130 lbs or more at once. He convinced me to thread the holes of the final pairs and taught me how to do, what I would have never suspected to be that easy and precise!

The leads of the final pairs must be bent in the way described in the picture. In order to bend them correctly, I used a prying tool 4mm thick.

CONCLUDING.

The "lay6" file contains, instead of PCB designs, the drilling masks needed in order to drill the holes. It opens with Sprint Layout 6.0.

The "spl7" file contains all schematics of the project, you can obtain all BOMs from it. It opens with Splan 7.0.

Should some be interested, I have all the BOM and pictures taken during assembling my WHA-217 E2, just let me know in a PM.

PLEASE, for the both of us.

Do not send me any re-drawn schematic to approve, the schematic is the one you find in the binder of all documents. Do yourself a favor: buy the bare PCB of the chinese clone of the Dartzeel NHB-108 from eBay or Aliexpress, do not challenge yourself designing a new PCB. In any case do not send me any design of PCB to approve, your skill is the right one to understand if you did a good job.

Send me, for approval, the layout of transistors on the heat sink, that is really critical.

Do not have any concern about long cabling, for example, from the main board to the daughter board where xVbe is, look at my pictures.

Avoid buying fake transistors and fake capacitor from eBay, when you see something attractive, as Nippon Chemicon capacitors 10mF/80V or even 10mF/100V in the same small can, at a cheap price: go first to their official catalog online, and search for that capacitor, there are good probabilities you will not be able to find it, meaning it is a fake! I got fake capacitors, fake transistors, fake Burson OpAmps! Be on your guard.