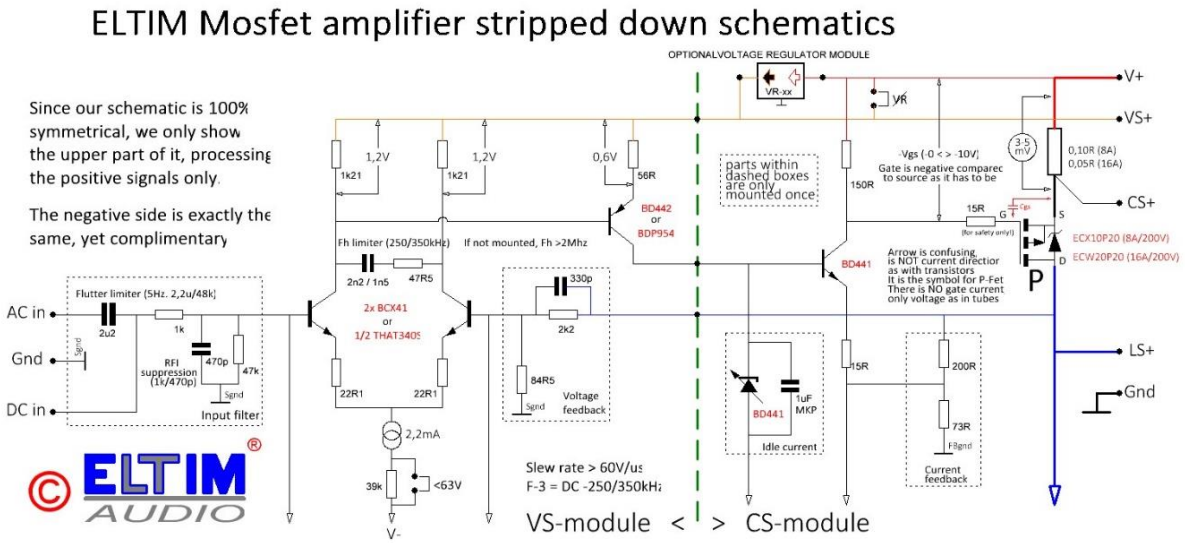
Alignment procedure ELTIM Mosfet amplifier modules.

Updated 12-10-2021

Introduction.

Besides our work in electronics for over 40 years, we at ELTIM audio are also DIY'ers ourselves. As a matter of fact, we made our hobby our work in the end. The idea about our modules setup we had in mind in 1996 already.
We like to share our ideas with others where not everybody has the same skills and knowledge (yet). Therefore we made documentation for all our modules with quite some text explaining all we did. Know it already (for sure)? Skip it!
Mostly building our modules works fine, but there are some cases known where DIY'ers didn't follow the procedures below and/or did (not) things not to be meant to do. So, we urge DIY'ers to read our documentation and understand our amplifier principle before starting to build.



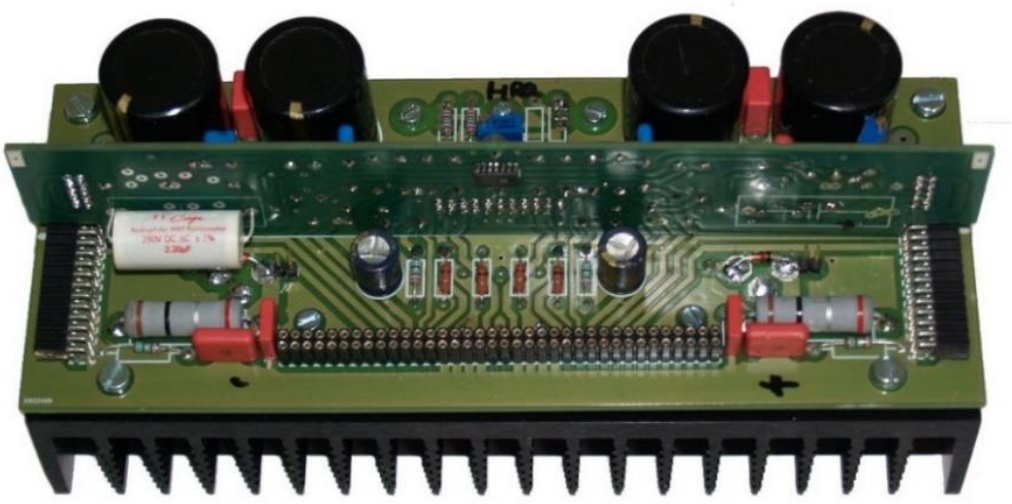
NOTE: if you always worked with power transistor based amplifiers, the function and connection of Mosfets can be confusing.
Some even believe that the P-Fet should be mounted below and N-Fet on top as about everybody else does. To explain that we did it correctly, yet different, we made this minimised schematic. A P-Fet starts conducting if the Gate is at a lower voltage than the Source (0 - -20V)
In our design this will happen and -Vgs falls over the 150R resistor, caused by a current flowing through the BD441. An N-Fet here would never conduct!
Perhaps, the arrow in the symbol is confusing. Unlike transistors it is NOT pointing a gate current direction! It's just the symbol of a P-Fet, see datasheets.
In the Gate there is NO current flowing as in transistors. As with tubes, only applying a voltage to it will start conducting from Source to Drain.

A disadvantage of a Mosfet is its Gate capacity. The lower this is, the faster the amp will be. Paralleling Mosfets will increase this value > slower amp.
However, with former versions of power Mosfets, the Safe Operation Area (SOA) would be passed and so mutiple pairs required. Not with us.
We designed our amps mechanically that different and clever, that a single pair of 8A Mosfets can fill your living room with music way louder than you like.
Even then, the amp will become only handwarm actually. Setting it in "old school" class A makes no sense, since with 50mA it is working linear already.

Also: since all mentioned Fets can handle huge peak currents, there is NO output coil required and so, not mounted > faster transient response..

This electronics can handle up to ±100Vdc, yet limited by the type of Mosfets, the supply capacitors voltage, speaker current and the dissipation rate of the cooling surfaces. If one or more of these factors are restricted, lower the supply voltage accordingly: ± 25 - (50)100Vdc, see the graphs in our info bulletins.

If you bought a DIY kit, please read the info bulletins and just mount all parts as printed on the PCB's and it will work as many other modules already do.



Only a combination of a VS-, and a Cs-module form a power amplifier as you are used to. So, you need both!

Jumpers
The electronics of our VS-modules normally can handle ±63V max. We added two jumpers on the modules making it possible to use it up to ±100V. Remove the jumpers if you use > ±60Vdc, then VS-xx can take ±100Vmax.

On our CS-modules there is also a pair of jumpers or diodes on the new models. They are close to the long power header connector (jumpers) or VS-connector (diodes) and connect the VS-module supply rails to the CS-module supply rails. Only in case a Voltage Regulator (VR) board is used, remove these jumpers/diodes. The VR-module takes over then and supplies regulated voltages to the VS-module supply rails, resulting in even better sound.

Mechanical preparations
During the alignment procedure and of course afterwards, mechanically connect the Power Mosfets to a heat conducting surface. If something is wrong, they could become hot and maybe overheated! If mounted to a single heatsink, mount the insulating pads between them. Unlike most other Mosfet based amp designs, the cooling area of EXICON's in combination with our uncommon setup (P-Fet on top, N-Fet at bottom!) are connected to V+ resp. V- !
No plates will cause a massive shortcut between V+ and V-. Perhaps the current sense resistors will burn then.

Some people experienced severe problems, caused by bad mechanical work. After drilling holes in the heatsinks for the transistors/Mosfets you need to flatten the surface by turning a large size drill by hand some turns. Feel if it is flat.
If you don't do this, the Mosfets won't touch the surface properly and get overheated or even mechanically overloaded. Over time or immediately a shortcut could occur as well due to damaged insulation pads or even mech. broken Mosfets!

Alignment procedure reason
On our amplifiers, both the idle current and the output dc offset must be trimmed for a correct functioning.
With this alignment procedure the DC output voltage of the amplifier is set to 0Vdc. If there would be a dc offset, the woofer would be off centred as well and worse, in the end this permanent magnetic field could affect its quality.
Also, the idle current through the power stage, required for a correct and distortion free operation has to be set.

More and more (mostly non-technicians) believe that a class A/B and class-A phrase is a quality level one. It is not !
It is just telling in what area the power stage is set, or on other words how much idle current it takes. As with our amps is the case, a modern class A/B amp could perform better than regular transistor based class-A amplifiers.
If you want to know more about it read our special document we made to explain this classes thing.

We use a technical A/B setting, meaning that the Mosfets are just running in the linear part of their working area. Unlike all other transistors and Mosfets we are aware of EXICON Mosfets as we use are extremely linear from that point on, so there is no need and makes no sense to set them at higher idle currents (200-400mA) as most other types require. This also means that setting them in "class-A" with even more idle current really makes no sense at all. Doing so is only causing extra heat without any significant sound quality improvement as with most other power transistors or Mosfets!
±30-100mA is really sufficient. 8A versions we set at 50mA, 16A types at 100mA ourselves.
This also means that our amps are about the same efficient as Class-D amps are in daily use: 15-20W (1 pair of Mosfets).
If there are more than one pair of Mosfets installed, you only need to measure one. Due to their negative temperature coefficient, they will stabilise at the same value by themselves in minutes. This measuring is done by measuring the voltage over just one of the series resistors in the Source lines of a Mosfet.
We prefer 8A EXICONS > 50mA (5mV measured over 0,10ohms), 16A's > 100mA (5mV measured over 0,05ohms). If you decided not to use these current sensing resistors measure with a mA-meter before mounting the wire bridge.
Unlike other designs, we don't need these resistors for a stable functioning of the amp, they are only used for measuring the source current in each (max 8) Mosfets. These signals only go to our possible mounted Protection module.

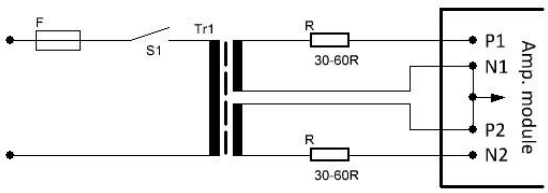
While setting the idle current, the output dc voltage could change as well, caused by the slightly and inevitable difference behaviour of P- and N-channel Mosfets. So, after every idle current trim, the output offset must be retrimmed as well.

We checked and aligned ready modules at +/- 31,5Vdc, the max. voltage we can make with our laboratory equipment.
While using significant other supply voltages you need to **realign** the modules, don't forget this!

UPDATE 8 October 2021: So far, we delivered our amps with a 1k idle current trimmer. With that value it can happen that the trimmers are in a start position where the Mosfets take severe currents, causing a lot of heat or even blowing fuses. You also could believe then that you did something wrong. We know what to do then quickly, but if you align an ELTIM amp for the first time it could end up in disaster.
We did some fine tuning in the idle current network (the same for all our CS-modules), with the result that with the trimmer you can set the harmless idle current range of 0 – 400mA and at the same time way more smoothly.
By altering the resistors and trimmer values in the idle current circuit (at centre back) you can easily modify your (excisting) CS-module: ~~1k0~~ > 2k7, ~~2k2~~ > 1k5 trimmer ~~1k0~~ > 500R. On newer boards this will be listed/mounted already.
While doing so, the max idle current is way lower, and you can trim it much nicer.

Preparations for DIY'ers

If you assembled our modules yourself, you could have done something wrong, causing huge currents to flow.
Best is to connect it to a symmetrical laboratory power supply with lowered max. current settings first.
If you don't have that you connect a transformer or power supply with the possibility that a lot of current flows if you something wrong. To prevent massive currents at first connection, best is to connect our modules as shown at right.



A low value primary fuse will do as well > blows if something is wrong. Remember that the supply capacitors load with a large current and the transformer has a large inrush current, which both could cause the fuse to blow. This is no failure.

Alignment procedure

After firing up and all seems to stay alive, we can proceed with aligning the modules before using them.
First thing to do is setting the central trimmer on the CS-module at about the centre position, avoiding large idle currents.
Measure the runner to an end value, must be around 500ohm. If a (see update above) 500R is placed, make it 250R.
Then measure the resistance between V+/GND and V-/GND, should be about equal. If not, check for shortcuts.
Switch on the power supply. Check if the supply voltages and their polarity are correct and about the same.
If not, immediately power down to prevent blown Mosfets and/or electrolytic capacitors.

If mounted, now align VS+ and VS– supply of the VR-Voltage Regulator board at the same value, ±25 - 35Vdc works best.
This voltage is fed to the VS-board and needs to be symmetrical. If not set exact equal, following procedure will fail!

Check the speaker output (DC) voltage and roughly align it to around **±100mVdc** with the trimmer on the VS-module.
You need to retune a few times later in the process, so no exact setting required at this point.

Check the voltage over one of the power resistors (mV-mark) on the CS-board (or CD-board if used) and align it to **3-10mVdc** (=30-100mA) with the trimmer on the CS-board. You could also measure this from supply (pin 16,17,18) to S1 (14) of the side connector. While doing so, you measure the idle current (I=U/R). We use these Sense1-4 for our Protection module current measuring b.t.w. Measure between V+ (upper three pins) and Sense 1 then.
If wire bridges are mounted instead, replace one by a mA-meter for the alignment.

Since the value of this measuring resistor (used in the same way by our Protection Module) differs with the type of Power Mosfet used, this aprox. 5mV counts, regardless the type of Mosfets used. Resistors used: 0,10ohm/8A, 0,05ohm/16A.
We set them at 5mV (=50mA idle current for 8A Mosfets, 100mA for 16A types) ourselves.
More than 10mV (= 100/200mA) makes NO sense at all due to the extremely linear behaviour of the Mosfets we use!
Monoblock versions, set at 10mV then for most optimal sound quality results.
There is NO need for higher idle current, check our explanation regarding class A/B versus class-A (and class-D).
Unlike other solid-state designs, the power Mosfets we use require only very low idle currents for FULL linear operation, even better than conventional transistors operating in class-A mode as recognised by some class-A adepts!
Transistors need 250-400mA/pair, mostly multiple pairs required; with us only one pair, 30-100mA > cool amp. (35-40ºC).
This results in immediate listening (about no heat up time) and a way longer lifespan (we expect >20 years).
Our amps work more efficient than class-D amps in regular living room use, fact. 15-20W without a signal, stereo.

Wait for a few minutes, the power stage is warming up a bit (should be no more than hand warm) which causes drifting of the settings. Feel if it becomes hot to make sure. If so, there is something wrong, f.e. way to high idle current or a shortcut.
Unlike transistor-based designs with a positive temperature coefficient, the negative temperature coefficient of the power Mosfets result in a self-stabilising effect, even when multiple pairs are used. This is one of the reasons why we can build our amplifiers with way less components as seen in many commercial designs. We don't need parts to compensate.
With us no thermal runaway effects, less non-perfect behaving parts and way wider PCB-tracks instead.
Although not necessary, best is to connect a load now, preferably an old surplus speaker. Then you can also hear and see (woofer cone movement) if something goes wrong. Our eyes, ears and senses are the best instruments available!
If all works as we say, you and we obviously did it right, so take a cup of coffee, tea, or a beer now and relax a bit -)

If all could be trimmed within the correct range and in a smooth and stable way, you now can remove the precaution resistors and connect the transformer directly. Then, realign both trimmers on the VS- and CS-board to the desired values (0Vdc at the output and 3-10mV over the power resistor) and wait a moment again. Realign both a few times this way. After 3-5 times, they will reach the required point and stay stable. If it is not possible and/or not going smoothly, you better start doubting if all is correct, especially if your measurements/alignment differs a lot from above! Aligning should work nice and smooth. If you have a scope, check for oscillations (caused by bad supply, wrong/incomplete wiring, etc., not caused by our design!). If you did all as you should do, there should be no oscillation whatsoever.
If all went well, you can use your amp now for at least coming 10-15 years.

Let's make some noise
After a successful alignment and testing we can make some noise.
If you have a scope, set it at small times and also higher sensitivity, checking for oscillations. Our amps normally don't but there was a case where bad wiring i.c.w. a bad power supply caused some.
If not ok, check all what you did so far. Used ALL supply pins f.e.? We don't use so many just for fun, it's required!
F.e. Powerlines use 2x6 pins * 3A = 36A of current possible. There are people connecting only two pins 6A…..
Then not to mention the resistance/impedance/induction (> oscillation) these insufficient contacts can cause!
If you use your own power supply, use our PS-0 module, making all the contacts required in the correct way.
Please **do not use** cheap N.O.S. surplus elco's, since after about 10 years of age they rapidly degrade, even while stored! They are sold cheap for a reason……

If a speaker is connected (as well) check the movement of the cone. Visibly checking works very well, look from aside.
If there is a proper undistorted hum noticeable, apply a signal (10-100mV/ f.e. 1kHz) or some music to the input and check what happens. The output signal should be a way larger copy (+28dB) of the input signal.
While using a scope and signal generator: our amps should run over 500kHz (-3dB point/half size) without problems.
Our amps run that high because of our symmetrical and different PCB design and thanks to a lot of experience.
Also check the square wave response, the flanks should rise/fall with **> 50V/us**. A quality opamp "does" <20V/us….
If you can make a Bode plot (as in the video), the phase error should be < -3º, being the time delay between in- and output. Due to this small and constant phase error, the staging of our amps is phenomenal. Check others…..
Take away the power and wait for the supply capacitors to discharge properly before starting to mount it all in a cabinet. Especially MUNDORF MLGO(+) capacitors take serious time to discharge completely, due to their very low leakage!

If you recognise our text above in aligning your DIY project, tuning and responding nice, you can now proceed mounting it.
If it is not the case, you will have to face the most difficult in DIY: finding a fault(s) ! Most of you don't have experience in that and (have to) start to learn more about finding errors in electronic circuits.
Do us and yourself a favour and don't climb into some forum. They don't know our designs and as we experienced unfortunately; these "experts" will bring you only further away from a solution!

If you can't find the error you can send it to us and we'll repair it at a charge of € 80,-/ hour.

Mounting
So, obviously all went well while reading this, and the next phase arrived.
Mount the modules in the cabinet by your way, connect transformer and input/output connectors.
The 3 BD's mounted on CS-35/40/60(ps), won't get hot with low supply voltages ((<40V), so then you don't need heatsink actually! Mounting them to the heatsink though is safer and gives a more solid construction.
On older versions CS-80/120/165, these 3 BD-s are mounted at the back of the PCB. Don't forget to use all FIVE grey SILPAD400 insulation pads, otherwise there is a shortcut between V+ and V- (and GND)!
An aluminium bar is supplied, mounted behind the three BD's in order to get the same thickness as the Mosfets. Depending on the insulation pads used, it's probably a bit too thick and you need to file off a bit.
On most recent PCB's CS-75/100/150/200/300/400, the BD's or TTA/C's are screwed onto the board, acting as a cooling device. For that reason, we also made a lot of extra holes in our PCB's actually. Cooling air flows through it.
After final mounting check again, also if there is no shortcut over the power lines (mostly due to wrong/not mounted insulation pads).

After mounting it all in the cabinet and checked all fire it up and check/correct the settings again after a few minutes.
If OK, connect a sound source (signal generator or music source) and preferably an old or inexpensive speaker to the output and listen to the sound. It should be undistorted. With your fine ears and senses, you can detect failures way faster and better than with a stack of measuring equipment. Only use those for development, final check and fault finding said the man who made and repaired hundreds of speakers/amps and also repaired and modified a lot of other electronics !
If it's all OK, hook up your true gear and

ENJOY the MUSIC by an amplifier you built by yourself -)

After listening with it for some weeks,

tell us about your experiences in building and listening please.

Then we will share this with others on our special page.

Troubleshooting
If the alignment is not working smooth, the amp becomes hot or whatever irregularities, it could be that the amp is oscillating due to some mishap somewhere, f.e. a missing soldering or a shortcut. If you have a scope, check it.
Normally, the amp will never oscillate nor producing strange sounds, not even while putting a calling cellphone on top of it! NO dut du dut, etc. It should be always totally silent. Nice and clean. It also should never become hot.
Check alignment, wiring, supply, shortcuts, mechanical bad work (Mosfets flat to the heatsinks?), etc. then.
Some are not able to find the fault(s), f.e. due to misplaced parts, overheated (broken) transistors/mosfets, bad/shortcut solderings, incomplete wiring, bad power supply, etc., etc. In that case you can send it to us for repair.
NOTE that the power Mosfets are ESD-sensitive devices, meaning that if you don't follow the rules for that the Mosfets could die, even before you soldered them on the PCB.

Other tips, tricks, and remarks.
NOTE: Our amp modules themselves have no speaker protection as most amplifiers haven't. If there is a relay on board it only "masks" the on/off irregularities, seen as massive woofer movements. We don't need that, is not happening.

Many amps are running for a few years now, all working without any problem. We use several amps ourselves in our office (f.e. former demo amp) and in our living room (CS-40ps Monoblocks) for some years now without any problem at all.
However, if it makes you feel more comfortable (can imaging when very expensive speakers are connected) you could use one of our Protection modules or something of your own.
Unlike most other Mosfet based designs, the power Mosfets we use won't break down if a proper fuse is mounted.
They can handle 10x more peak current as listed normal values, so the fuse will blow first.

But, since it are DIY designs where we cannot check if you did all as you should do, **ELTIM audio BV cannot be held accountable for any defect, failure or any other event or damage caused by the use of any of our modules.**
If you do not agree to that, send back the product(s) while unused and in original packing within 14 days after purchase and we will refund your money. DIY kits cannot be returned nor refunded of course after building them up.

Before start building, we strongly recommend reading the corresponding info bulletins.
In a long document we explain all what can be explained and tell you why/how we did it different than others do.
DIY is not only mounting some parts and save (a lot) money; sometimes you have to locate a fault and be able to correct it !
While finding faults you learn more about electronics in general, another nice thing in DIY.
That's also how we started over 40 years ago, followed by several professional electronics jobs in adjustment, testing and repair of all kinds of electronics.
In all cases where an error occurs: please don't doubt our designs, there are a lot of them working already.
If you can't find the fault, please contact us instead of some "wise guys" on fora. Mostly they give wrong tips and/or give their opinions only in how an amp should have been made! Our question: why don't you design yourself as we did?
While there are lot of amps out there already, some even state f.e. that we "switched" Mosfet locations "so our amps can't work"???!!!. Yes, we did switch them indeed compared to a lot of other Mosfet based designs, but (of course) our schematics differs as well, didn't you notice? One of the reasons they measure and also sound different.

Please note that the texts you write on the internet somewhere can be found on internet for ever. There are some to read already where customers had some troubles and wrote about it instead of asking us. Afterwards it always appears that the customer did things wrong. The texts taken out of context (by Google search) however are harming us and the good name of our products! One of these guys apologised, but his texts stay…. CONTACT US
As counteraction we receive a growing number of reactions from reviewers, dealers, builders, users and even colleagues.

English reactions **Deutsche Reaktionen** **Nederlandse reacties**

Documentation of all our modules can be found on our website and extra info is on the PCB's themselves.

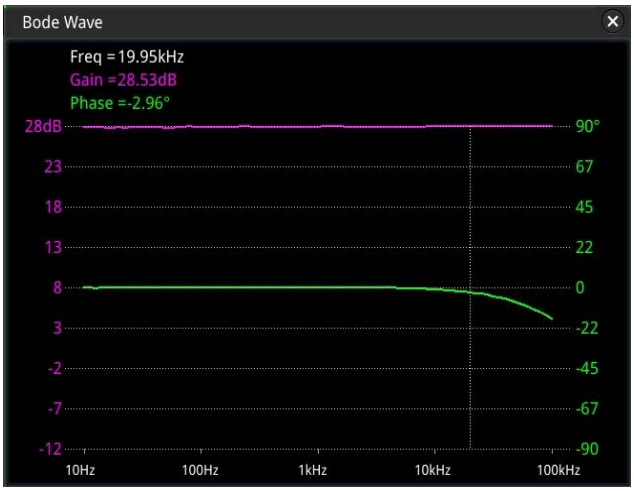
ELTIM audio BV, Louis Timmers
HAM radio callsign: PE1LTM

Measuring data.

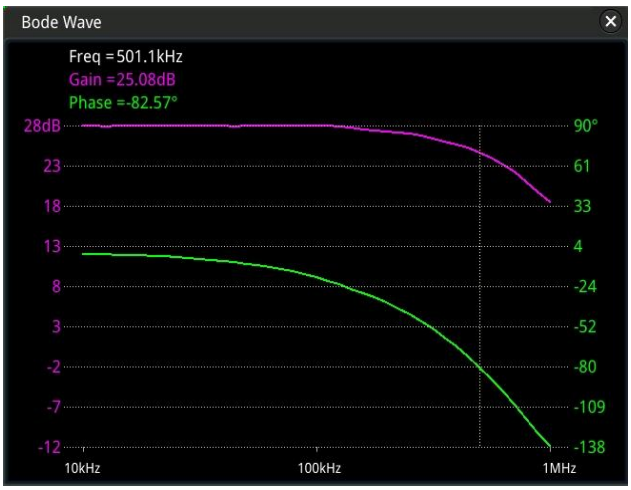
We ourselves prefer listening over measuring, since our ears and senses are way better instruments than any other equipment. However, a lot of DIY'ers want to see graphs/data (acknowledging our senses) instead. Try to listen! !

If you have a nice electronics shop and can do some measurements as we can ourselves, you can do some controlling measurements now to be sure all works correct. With those you can check if your amp works as it should.

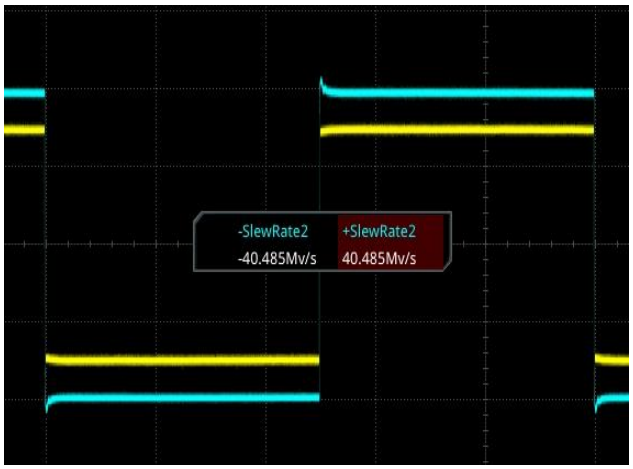
All our CS-current stages run way over 1MHz and so the VS-input modules (except for the output power and "punch") define the sound character and frequency range for the largest part.
So, the graphs below are valid, regardless of CS-module used and only differ a bit based on the VS-module type:



Wide audio bandwidth graph 10-100.000Hz with the marker set at 20kHz. Freq. graph straight as a ruler ±0,2dB. At this 20kHz the input to output phase error is at a minor -3º, meaning that the 3D staging (= phase!) is phenomenal, since the phase behaviour of an amplifier (and speaker) defines the 3D staging it shows. Linear (flat) = most optimal.
VS-20 i.c.w. >VS-75 -3º is around 25kHz…..



Extended bandwidth graph 10kHz – 1MHz with the marker at the -3dB point. Nice and clean roll offs.
This -3dB point as mostly given is just over 500kHz here.
Also often listed -10dB point is over 800kHz actually.
VS-20 i.c.w. >VS-75 -3dB is around 550kHz…..



1kHz square wave signal without any significant irregularities.
Ye-in, Bl=out. It also shows a slew rate of >40V/us in this setup.
VS-20 can do >65V/us with higher supply and signal.
The higher quality CS-module used, the lower the overshoot.
VS-20 i.c.w. >VS-75 there is about no overshoot.

Frequency domain (50kHz wide). Harmonics < -65dB (13+53).
The irritating 3rd harmonics is at a low level of -66,7dB.
Even more irritating 5th is below the scale actually.
Depending on the type of VS/CS module used this can differ a bit.

Measurement setup:
VS-20 (dc input used) + CS-35 LEX08 (cheapest, and idle current set at 50mA) output stage
with CADDOCK MP725 resistors in feedback and INTERTECHNIK Q6-1,0uF over the power lines.
Supply voltage ±30Vdc, load 8ohms dummy. Measurement date: 11 august 2021.

Measuring/test signal equipment: RIGOL MSO5074 all in one instrument, all available options included.