

Hifisonix ax-Amp Assembly and Supplementary Data Presentation

60 Watt RMS class A Current Feedback Amplifier featuring AFEC and switchable class A, class AAB or class B operation

Read this presentation thoroughly before starting any assembly work

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Andrew C. Russell

www.Hifisonix.com

WARNING DISCLAIMER

This project is intended for experienced DIY constructors.

This project involves wiring up mains voltages.

Do NOT attempt this project unless you are completely aware of the dangers of mains voltages and fully understand mains voltage wiring safety practices and conventions.

A wiring mistake can be lethal. Do not take any risks.

Seek professional advice if you are not sure.

Always adhere strictly to the electrical regulations in your country.

WARNING DISCLAIMER

Never work on the amplifier wiring with power connected. When debugging with the top cover off, always unplug the amplifier from the mains

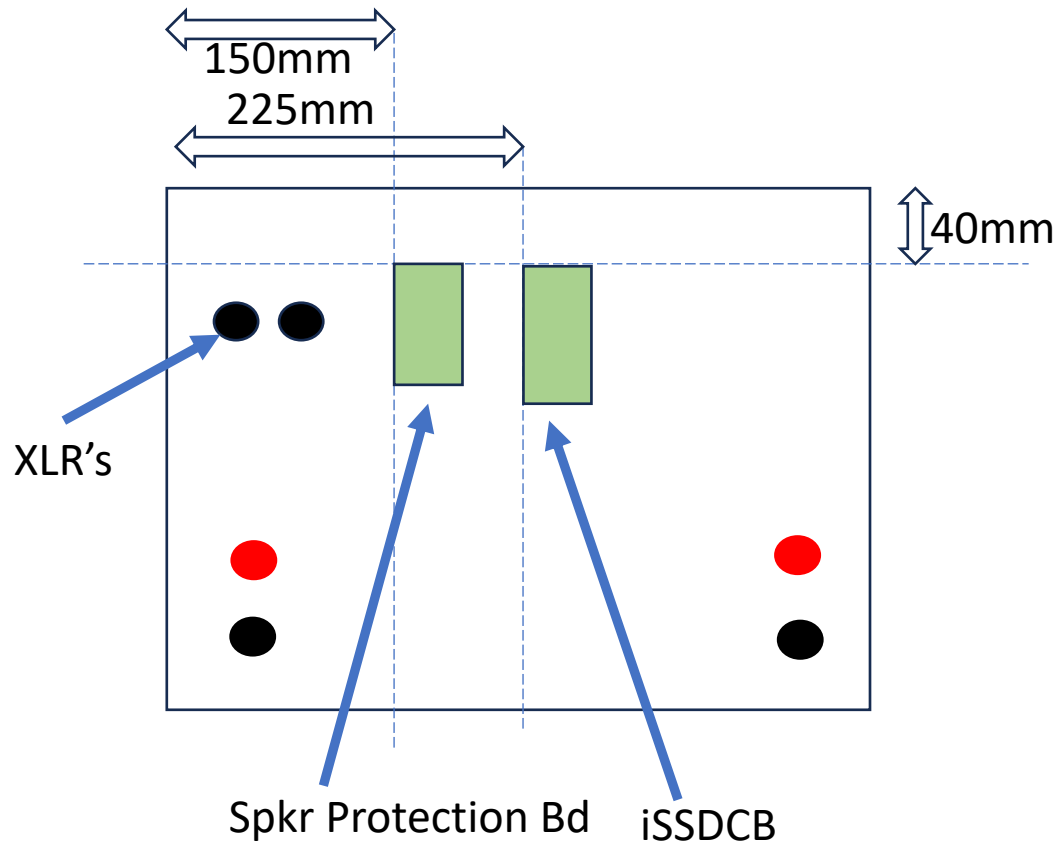
Get the chassis and PCB's ready

Do not assemble the chassis – you will need the heatsinks for amplifier module testing later in the process

- **Speaker protection board and the iSSDCB.** These are mounted on the chassis rear panel – see next page. Locate the corners of the PCBs per the dimensions shown and then mark off the associated mounting holes. Drill to 3.5mm and thoroughly deburr
- **Prepare the heatsinks.** Assemble the heatsinks onto the Modushop supplied steel brackets. The heatsinks as supplied may have a small ridge (0.1-0.2mm) around the edges of the transistor mounting holes. This prevents the OPS transistors from seating flat on the heatsink, leading to unstable operating currents higher than normal. Use a 10-12mm bit and make sure that all transistor mounting holes on the heatsink are countersunk to 0.2-0.3mm – i.e. *there is no ridge* around the OPS transistor mounting holes
- **Transformer Mounting.** I do not recommend a standard Modushop base plate for a big class A amplifier like this as it does restrict airflow. I used a custom 10mm thick Aluminium mounting bracket ordered from Modushop. If you go down this route, ask Gianluca at Modushop for part number 'Model 1721 Transformer Mounting Bracket'.
- **Assemble all PCB's.** Once the chassis is ready and all holes drilled and the PCB mounting holes confirmed to line up with the chassis holes, proceed to assemble the boards. Check components both against the PCB silkscreen and the BOM and circuit assignments during the build process. See notes on slide 3 on the power amplifier module OPS transistor mounting. **Note very carefully the orientation on the PCB-mounted heatsinks of Q11 And Q12**
- Do not fit R72 at this stage

Rear Panel Parts Location

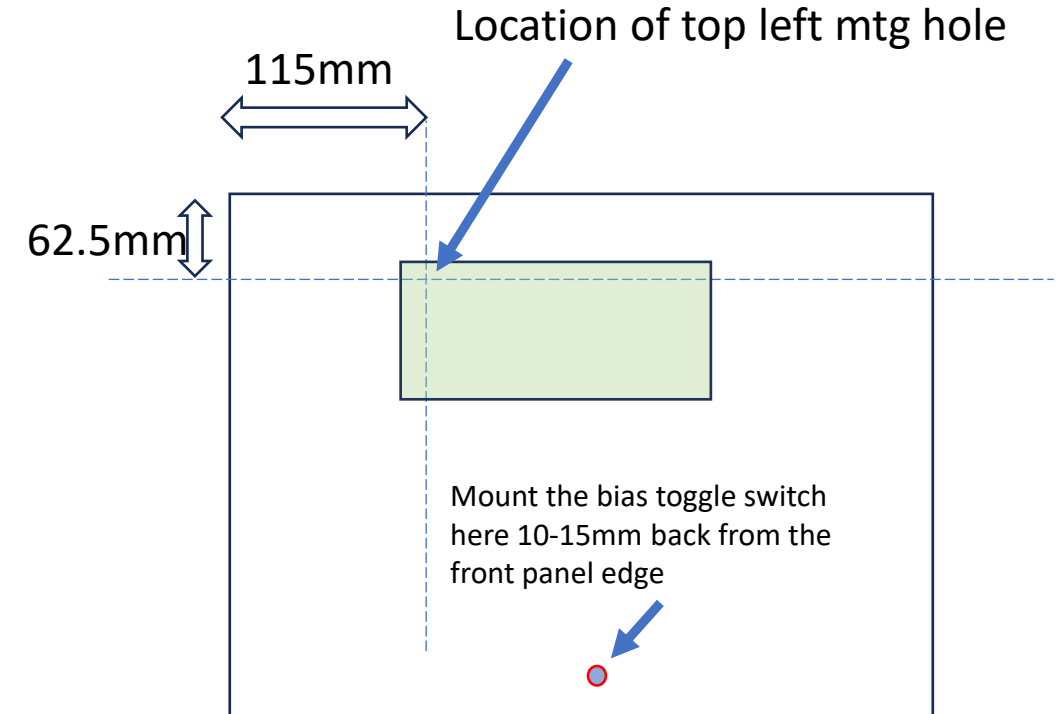
view looking from rear



The XLRs were mounted 75mm down from the top edge with centers from the LH edge at 75mm and 110mm. Mount speaker terminals on each side and towards the bottom as shown in keeping with the type of terminal you use

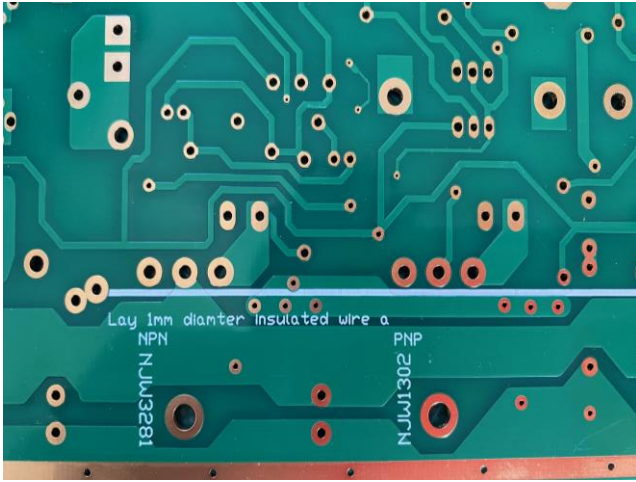
Bottom Panel PSU Board Location

view looking from bottom



Note: Some of the PSU mounting holes will locate in the slotted vents - this is correct. Use a round needle file to carefully open the holes up in the slots to 3.5mm. Drill the others to 3.5mm and deburr.

Drill the transformer mounting bolt hole after you have decided how you will mount it – see previous slide re mounting bracket option.



Bend the power transistor leads up at 90 degrees at the point where the lead thins. The bend must be up towards the front of the device and away from the heatsink tab.

Insert all of the devices into their respective mounting locations but do not solder them in place

Carefully turn the PCB over and locate it over the transistor mounting holes on the heatsink.

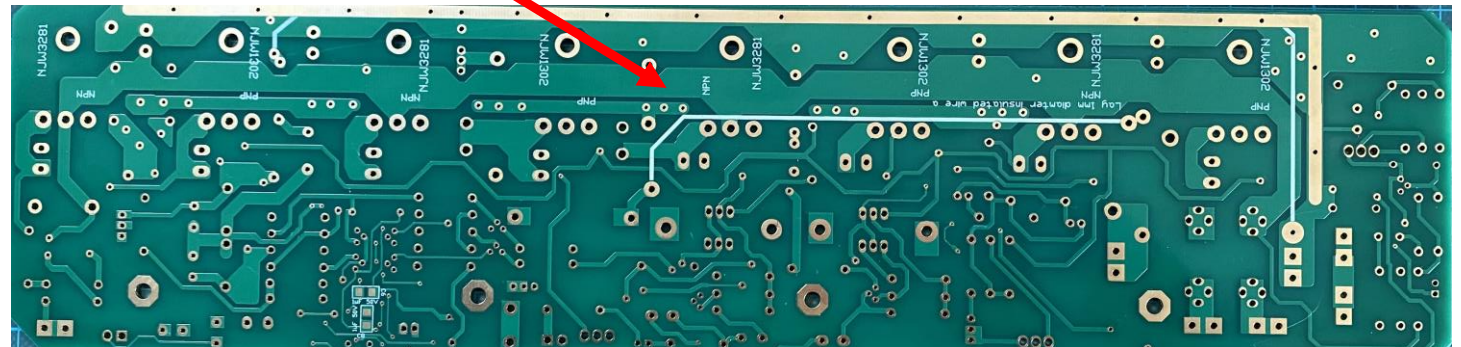
Screw the PCB in place with 8 off 12mm M3 machine screws, keeping the screws loose for the time being

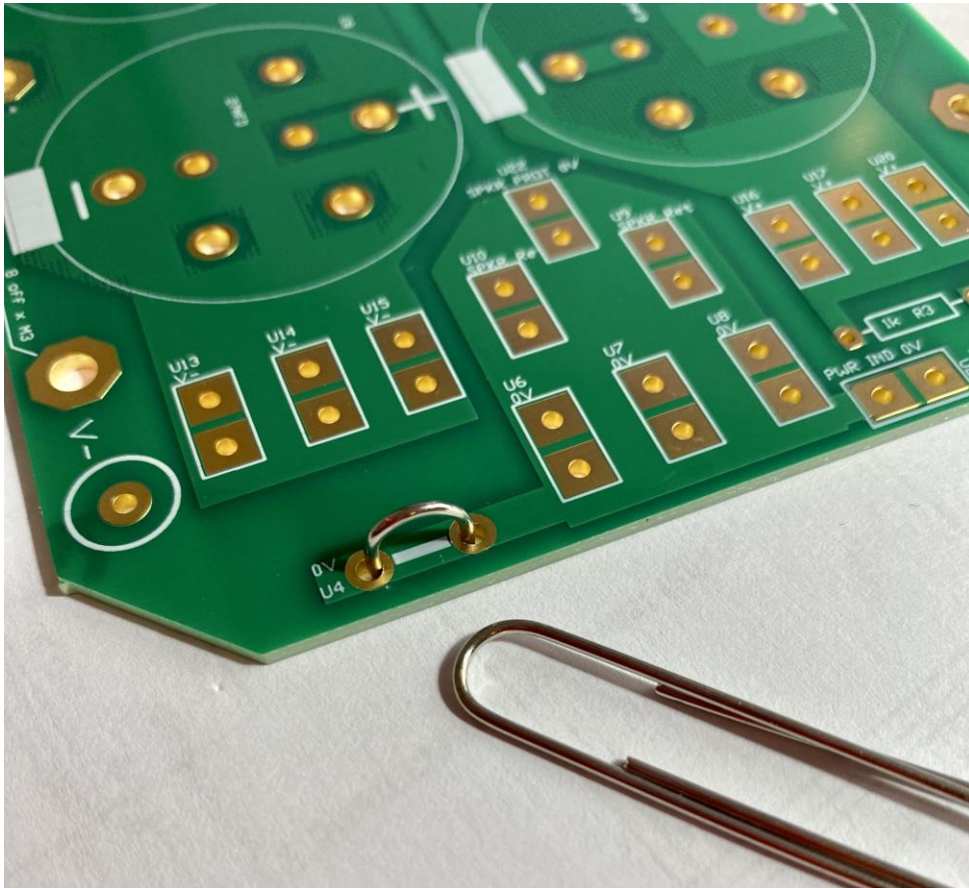
Check that the transistors are neatly lined up under the PCB and if so tighten the screws, starting from the center and tightening each side alternatively.

Once complete, solder the power transistor leads and clip off the excess lead protruding through on the component side of the PCB.

Next, remove the PCB from the heatsink, and using solid core 1mm diameter insulated wire, run the wire carefully along the white traces shown below. Hold the wire in place with some Sellotape and use a spot of superglue every 2cm (3/4") to secure it in position and on the corners where the wire bends. *The wire must be flat on the PCB.* For the shorter connection below, thread the wire between the OPS transistor legs and the device body.

Finally, on the component side, use a dab of heatsink grease to couple Q1 to the adjacent heatsink. This ensures *fast and flat* thermal response in class A mode. In class A mode, the ax-amplifier reaches 95% of nominal operating current within 3 minutes and does not deviate from this value by more than 2% from 25C to 57C (see Fig 4 Part 2)





- For the various monitoring straps around the amplifier e.g. Bias+ and Bias-, I use a good quality chromed paper clip as shown.
- You can get 3 monitoring straps per paper clip
- When using croc clips, the connection is secure and will not inadvertently come off, potentially causing problems or a short

Mount the amplifier modules to the heatsink in preparation for testing

- Use thermally conductive pads between the power transistors and the heatsink
- Use the same procedure as before, screwing the transistors in place from the center outwards alternatively. This ensures the board does not buckle and the transistors are making good thermal contact with the heatsink through the thermal pads
- The transistors should be tightly screwed down, but not overtightened as this could lead to the heatsink thread being stripped
- Use 4 off 5mm plastic spacers (suitable RS Pt# 136-4226) between the PCB and the heatsink on the 4 PCB mounting holes opposite the power transistors.
- On all screws, use an M3 serrated locking washer.

Test and set-up amplifier module PCB's (1)

1. Wire the transformer up to the PSU board. Wire the transformer mains side to a suitable cable and plug. Make sure the transformer primaries are connected as required for your local AC mains voltage i.e. 120 VAC or 240 VAC. Apply power and check the output voltage. It should read between 0 and +-40 VDC and +-41.5 VDC per rail. Disconnect the PSU and discharge the capacitors so the output voltages on both rails are close to 0V
2. Fit the amplifier module with 500mA T1 fuses in preparation for testing
3. Leave J5 initially OPEN; leave flash pads U13 and U14 (AFEC) OPEN
4. Connect the PSU to the amplifier module and apply power
5. Measure the voltage across Bias- and Bias+ on the module. It must measure 130 mV +-20 mV.
6. Check all the key voltages around the board using the annotated circuit diagram on slide £\$%^\$%^
7. Adjust R5 'Offset Adjust' for 0.00V at 'Speaker Out (U8)
8. Assuming all is OK at this stage, we can move to testing the amplifier in class A and class AAB mode
9. Power down and make sure the power rails are fully discharged.
10. Replace the 500mA fuses with 8A T1 devices
11. Connect a high power (50 W) 8 Ohm load to the amplifier module
12. With the module still powered on, short pin 2 to pin 3 on J5 'Bias'; insert shorting link across J6 'Test'. The amplifier will now operate in class A
13. Apply power
14. If all ok, measure the voltage drop across Bias- and Bias+ and adjust Class A Bias Trim (R2) for ~300 mV. Allow the heatsink to warm up fully to 55 to 60 C. Readjust R2 for 360 mV across Bias- and Bias+. Fine trim R5 OFFSET ADJ for 0.000V at SpkrOut (U8)
15. During this process you may have to tip the heatsink up its edge and raise it off the surface to ensure good airflow. The heatsink temp should not exceed 60C
16. Leave the amplifier on like this for a further 10~15 minutes and fine trim R2 for a 360 mV reading and R5 again

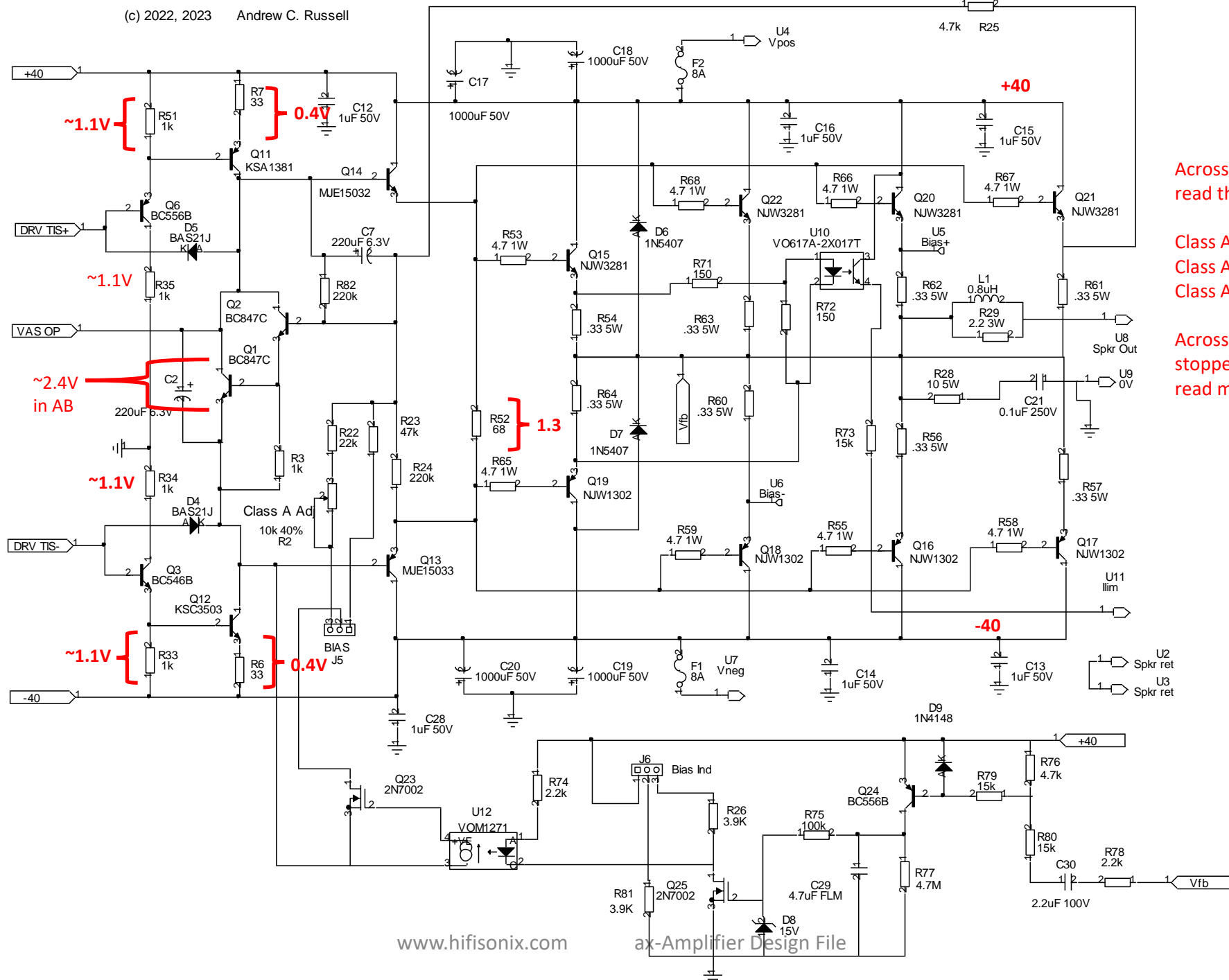
Test and set-up amplifier module PCB's (2)

17. Assuming all steps up to 16 are okay, apply a 0.5V 1 kHz square wave to the amplifier from a generator and check that the output is a clean square wave at 20V.
18. Next, power the amplifier down, ensuring the power rails are fully discharged.
19. Disconnect the input source.
20. Now flash U14 and U13 closed. AFEC is now enabled
21. Re-power up the amplifier
22. Check that the class A bias current is correct at 360 mV across Bias- and Bias+
23. The output offset must not exceed 20mV (it may be higher than the reading taken when AFEC was disabled – this is correct)
24. Redo step 17, ensuring there is a clean output square wave.
25. Next, connect the generator to the input and set the amplifier output to c 200mV pk to pk at 1 kHz. Connect a scope to
26. Adjust R4 for a dip in signal at pin 7 of U1 (OPA1642). This trims the amplifier gain to that of the main feedback resistor pair tolerance – worst case c. 2% between channels
27. This completes amplifier module testing and set-up



Ax-Amplifier Test Voltages

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Across Bias+ and Bias-,
read the following:-

Class A 360mV
Class AAB 250mV
Class AB 130mV

Across the 4.7 Ohm base
stoppers you should not
read more than 2-3mV

Soft Start DC Blocker Test

1. Measure between U2 (AC Neut IN) and U8 (AC Neut OUT) terminals with your meter set to 'diode test' mode. The reading will ramp from close to 0 to up to 0.9 to 1.2 indicating 2 diode drops
2. Repeat the measurement with the leads reversed. The reading will ramp down to 0 and then back up to 0.9 to 1.2
3. Measure from U7 (AC Live_Hot In) to U2 (AC Neut IN) with your meter set to Ohms, making sure it measures an open circuit and there are no shorts
4. Measure from U7 (AC Live_Hot In) to U3 (Hot to TXFMR) and make sure it is an open circuit and there are no shorts
5. Measure from U3 (Hot to TXFMR) to U8 (Neut to TXFMR), making sure it is an open circuit and there are no shorts

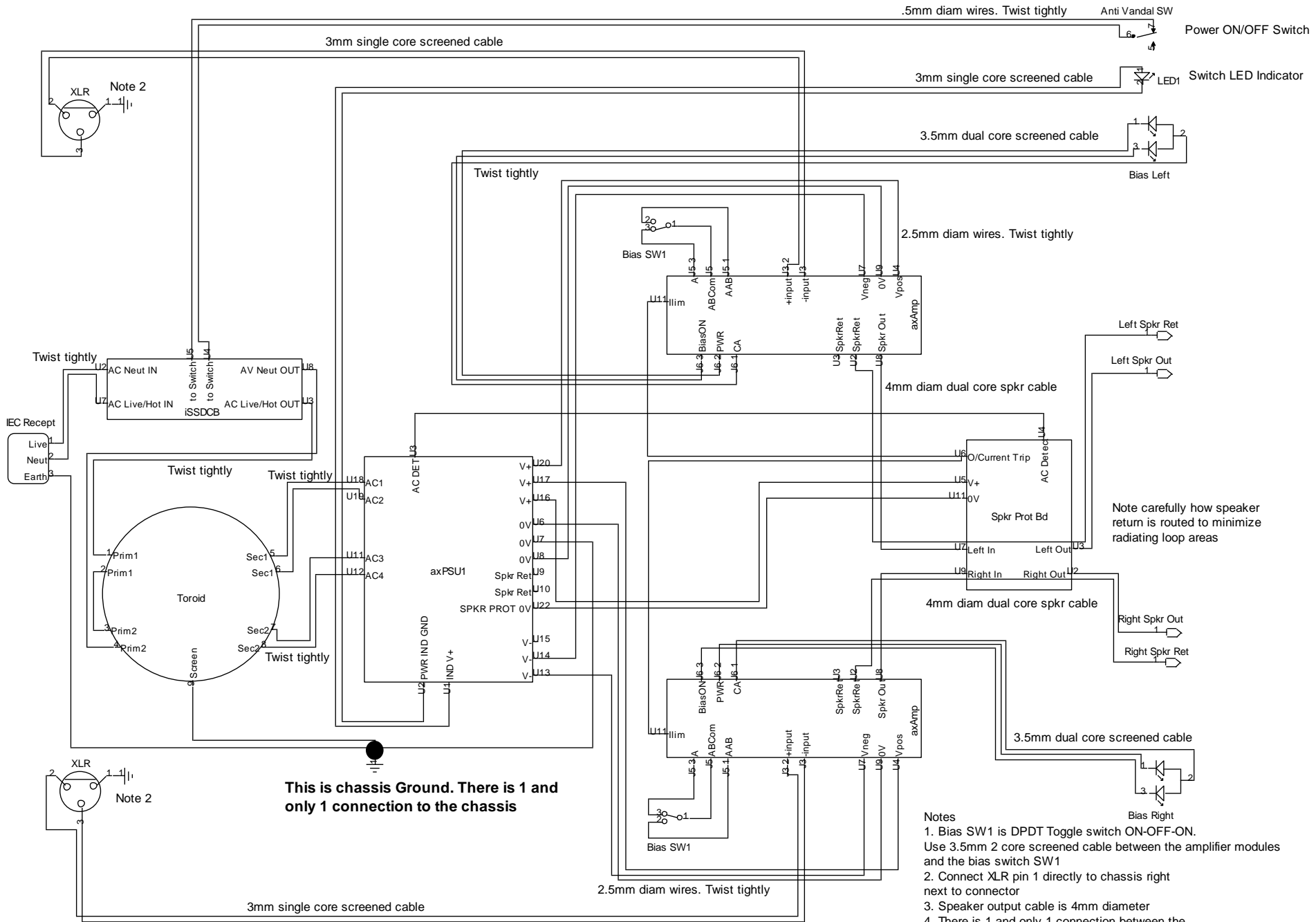
If all of the above measures ok, the SSDCB is ready for use.

Before progressing, place Gorilla tape over the exposed capacitor cans. When installed, the capacitor cans are at mains potential. For this reason, always unplug the amplifier when debugging or working on the wiring.

Chassis assembly and wiring

1. The amplifier modules must be mounted to the heatsinks before you assemble the chassis.
2. Once the chassis is assembled, mount the SSDCB and the Speaker protection board
3. Mount the transformer. I placed mine centrally and slightly to the back of the chassis using the aforementioned 'Model 1721 Mounting Bracket' from Modushop.
4. Mount the anti-vandal ON/OFF switch on the front panel and the bias switch to the base plate
5. Be very careful when wiring up the amplifier as the 1000uF capacitors on the amp module PCB protrude quite far out and it is easy to bump these and rip the capacitor body from the leads
6. Use the diagram on Slide 15 (print it out on A3) to wire the amplifier up, keeping to the guidelines shown on Slide 16 as to how the cables should be routed and dressed. The basic rules are to ensure cable pairs and triplets are tightly twisted or plaited and then cable tied every 2-3 cm to ensure loop areas are kept as small as possible
7. Slide 22 gives some hints about consumables that can be purchased off Amazon for the wiring-up process

ax-Amplifier wiring diagram October 2023



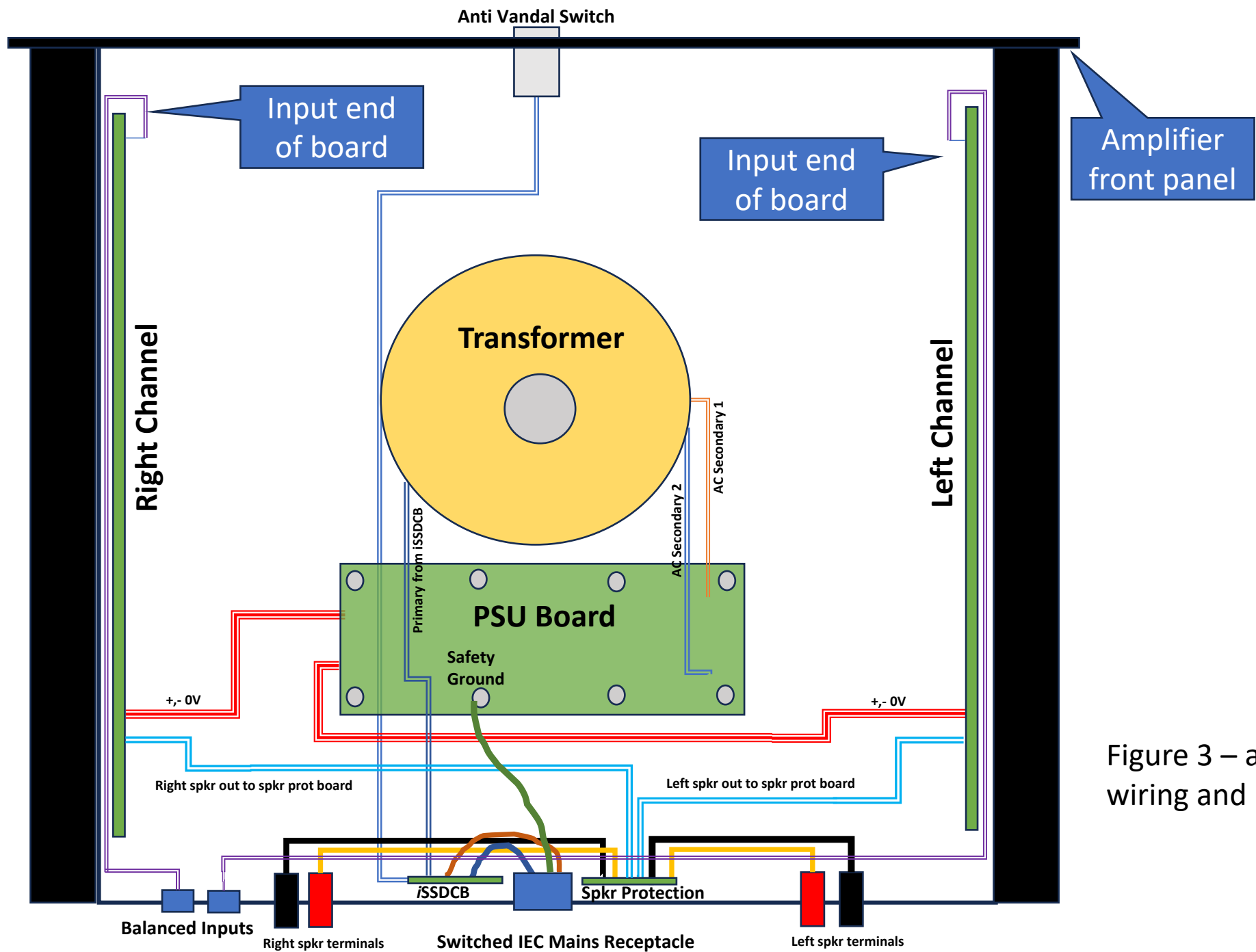
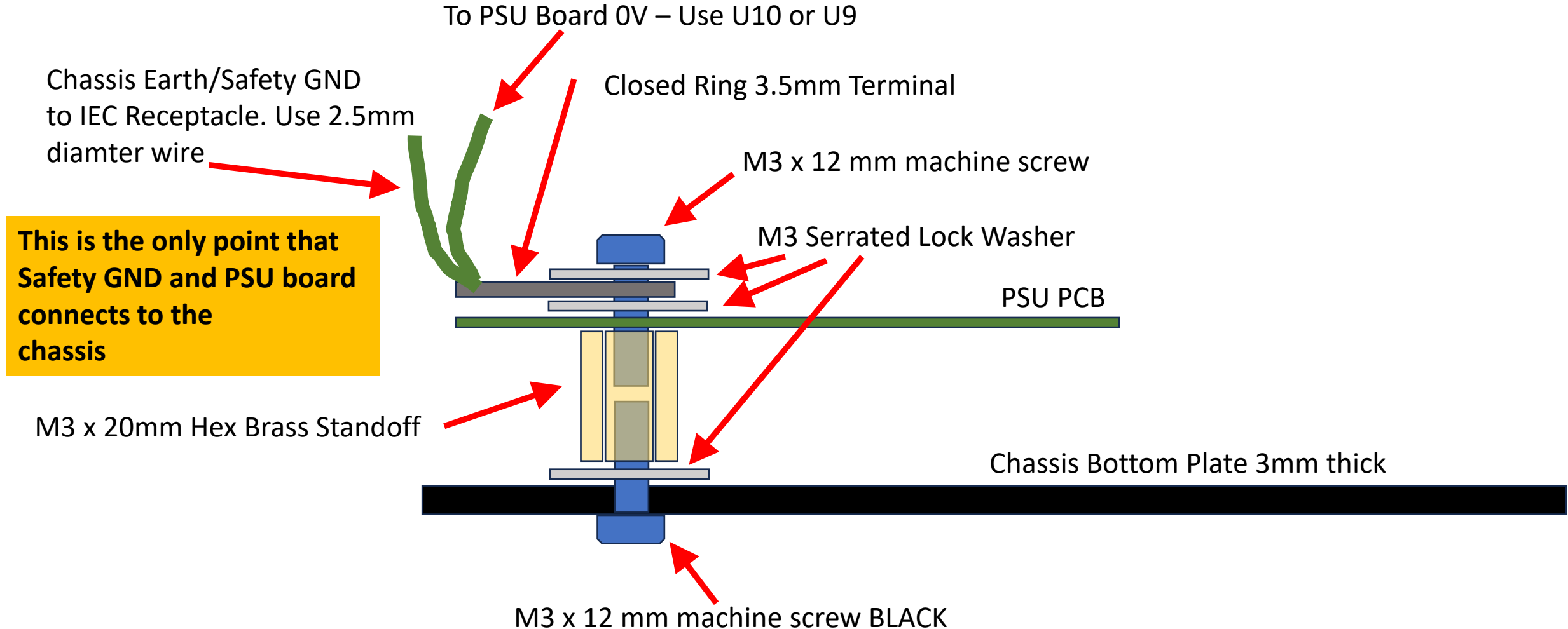


Figure 3 – ax-Amplifier wiring and layout

How to mount the PSU board for good safety ground connection



System Check and Test (1)

1. Once the amplifier is wired up, basic checks have to be made to ensure it is safe to power up
2. Make sure the amplifier is unplugged from the mains and with no input stimulus. Remove the 8A fuses from the amplifier modules
3. Fit the appropriate Mains fuse in the IEC fuse draw receptacle (only use T1 type fuses)
4. With the IEC switch in the ON position, measure from AC HOT (Live) to AC neutral on the IEC receptacle pins. You should measure an open circuit
5. Measure from AC Hot to the chassis and AC Neutral to the chassis. You must measure an open circuit
6. Measure from the IEC receptacle safety ground (earth) to every part of the chassis – you must measure 0 Ohms
7. Measure from IEC safety ground to the PSU 0V – you must measure 0 Ohms
8. Measure Ohms from V+ and V- on both the amplifier modules before the fuses to the chassis – you should measure a low value that slowly increases – this is because the PSU caps are charging up
9. Measure from the amplifier output (U8) to chassis on both channels – you must measure an open circuit
10. If all of the above is okay, replace the 8A module fuses
11. Power up the amplifier. If all is good, we can move on to the next tests

System Check and Test (2)

1. The final test is to make sure the speaker over-current protection is working correctly.
2. Important note: If you are using the Hifisonix speaker protection board, the loudspeaker switching mosfets will be damaged if the amplifier runs continuously into 2 Ohms. When doing this test, keep the test duration to 10-15 secs max and then stop and let the mosfets cool down. I used 7.8 mOhm Rdson mosfets so the total power dissipation into 2 Ohms on the switches was 3W each
3. Let the amplifier run in Class A into an 8 Ohm load so that it is hot
4. Connect a 1 to 1.5 Ohm load to the amplifier (50-100W) and connect your scope to the amplifier output. Apply a 1 KHz triangular wave, starting at a low value. Increase the input slowly monitoring the output signal level until the LED on the speaker protection board extinguishes.
5. Calculate the peak current the amplifier was delivering from V_{opk}/R_L . You should get a value of between 26 Amp and 32 Amps peak output current
6. If your calculated peak current is much less than this, you will need to fit resistor R72. The best way to determine the correct value is to wire a 25-turn 5k potentiometer (*make sure it is set to maximum i.e. 5K*) across R72 terminals.
7. Power the amplifier up, let it get hot (class A into 8 Ohms), and then set the input to give the correct peak output voltage so the amplifier can deliver slightly more than 26A peak into the load
8. Adjust the potentiometer so that the LED on the speaker board just extinguishes – this means the amplifier is delivering 26A peak into the load.
9. Remove the potentiometer, measure it, and then insert the next highest E24 value resistor into R72. You can use the same value for both channels

Additional General Notes

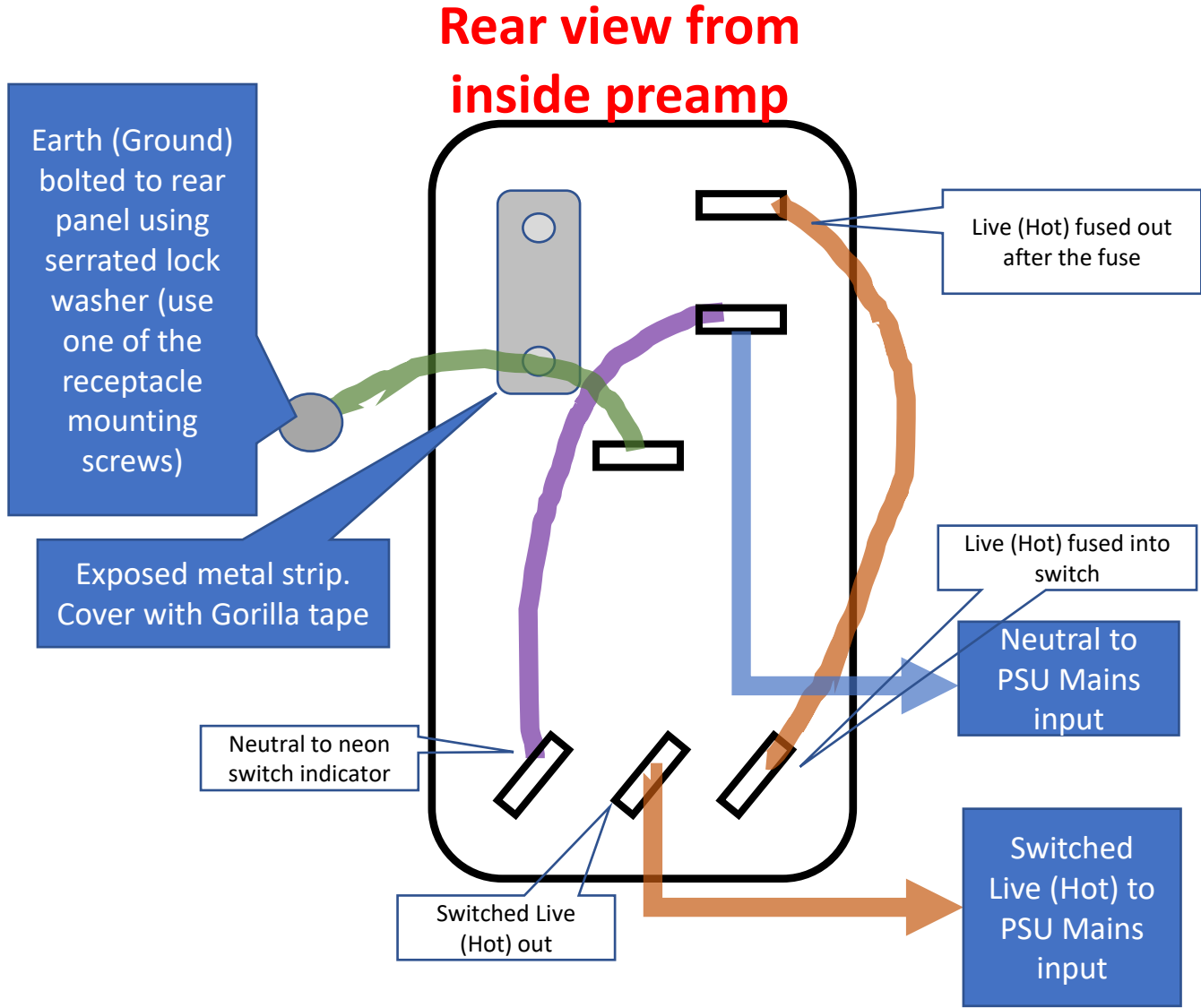
- It is not recommended that you trim the output offset once AFEC is connected. Trim the output offset without AFEC enabled.
- The output offset with AFEC enabled will be between 10 and 20 mV provided the amplifier offset was well nulled before activating AFEC
- When disabling AFEC, *BOTH* U13 and U14 flashpads must be opened
- The ax-Amplifier accepts balanced Inputs only. Using an unbalanced to balanced adaptor cable will result in serious frequency response errors and measurement anomalies because of the differential input filter used.

Examples of sheathed, insulated spade connector



Push on spade connector is fully insulated/shrouded. **DO NOT** use uninsulated spade connectors

How to wire up the switched, fused IEC Bulgin Mains Receptacle (Bulgin Pt# BVA01/Z0000/02)



Examples of consumables required for wiring up the ax-Amplifier from Amazon.

Attention: only use fully insulated spade connectors!

HIGHLY RATED

Sponsored | Based on star rating and number of customer ratings



Crimping Tool for Insulated Electrical Connectors - Ratcheting Wire Crimper - Crimping Pliers - Ratchet Terminal Crimper - Wire Crimp Tool...

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6.3mm Male Female Insulated Spade Crimp Terminal Connectors Wire Cable Electrical (6.3mm Female Insulated) (Pack of 100), Blue)

Brand: Switch Electronics
★★★★☆ ~ 74 ratings

£5.45 (£0.05 / count)

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FREE Returns

Spread the cost of your purchase over £100.

Select Instalments by Barclays at checkout. Subject to financial status. Amazon is the credit broker.

Representative example: Credit limit £1200, Annual interest rate 12.2% variable, Representative APR 12.2% variable

Learn more about Instalments by Barclays

Note: This item is eligible for **FREE Click and Collect** without a minimum order subject to availability. Details

Size Name: 100 x Female Insulated

100 x Female 100 x Female Insulated 100 x Male

Colour Name: Blue



Colour Blue
Gauge 16.0
Stud size 6.3 mm

Delivery Pick-up

£5.45 (£0.05 / count)

prime One-Day

FREE Returns

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Spread the cost of your purchase over £100.

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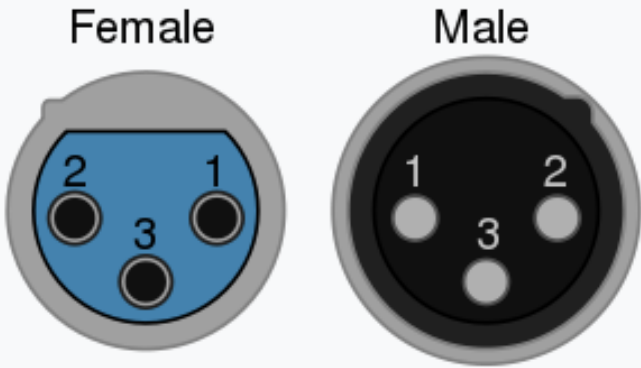
Representative example: Credit limit £1200, Annual interest rate 12.2% variable, Representative APR 12.2% variable

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Note: This item is eligible for **FREE Click and Collect** without a minimum order subject to availability. Details

Colour Name: Multicolored





Pin	Function
1	Chassis ground (cable shield)
2	Positive polarity terminal for balanced audio circuits (aka "hot")
3	Negative polarity terminal for balanced circuits (aka "cold") ^[20]

These are the pin designations looking from the FRONT of the connector. Use single-core screened cable for each channel from the ax-Amplifier module to the XLR receptacle. The screen (cold) goes to pin 3, the core goes to pin 2 (hot). Note how the input cables are tracked in slide 16. Connect pin 1 directly to the chassis right next to the connector. This ensures the source, the interconnect cable, and the ax-Amplifier chassis are one enclosure at RF

Additional ax-Amplifier Measurements

1st Oct 2023

FFT: 128k
Avg: 36 of 50
Res: 1.46 Hz
Fs: 192 KHz
Win: Hann
Weight: None

Meas Start: 20.0 Hz
Meas Stop: 20.0 KHz
RMS L: 0.0 dBr
RMS R: 0.0 dBr

Peak L: 0.00 dBr
Peak R: 0.04 dBr
Peak L: 61.7 W (8.0 Ω)
Peak R: 62.2 W (8.0 Ω)

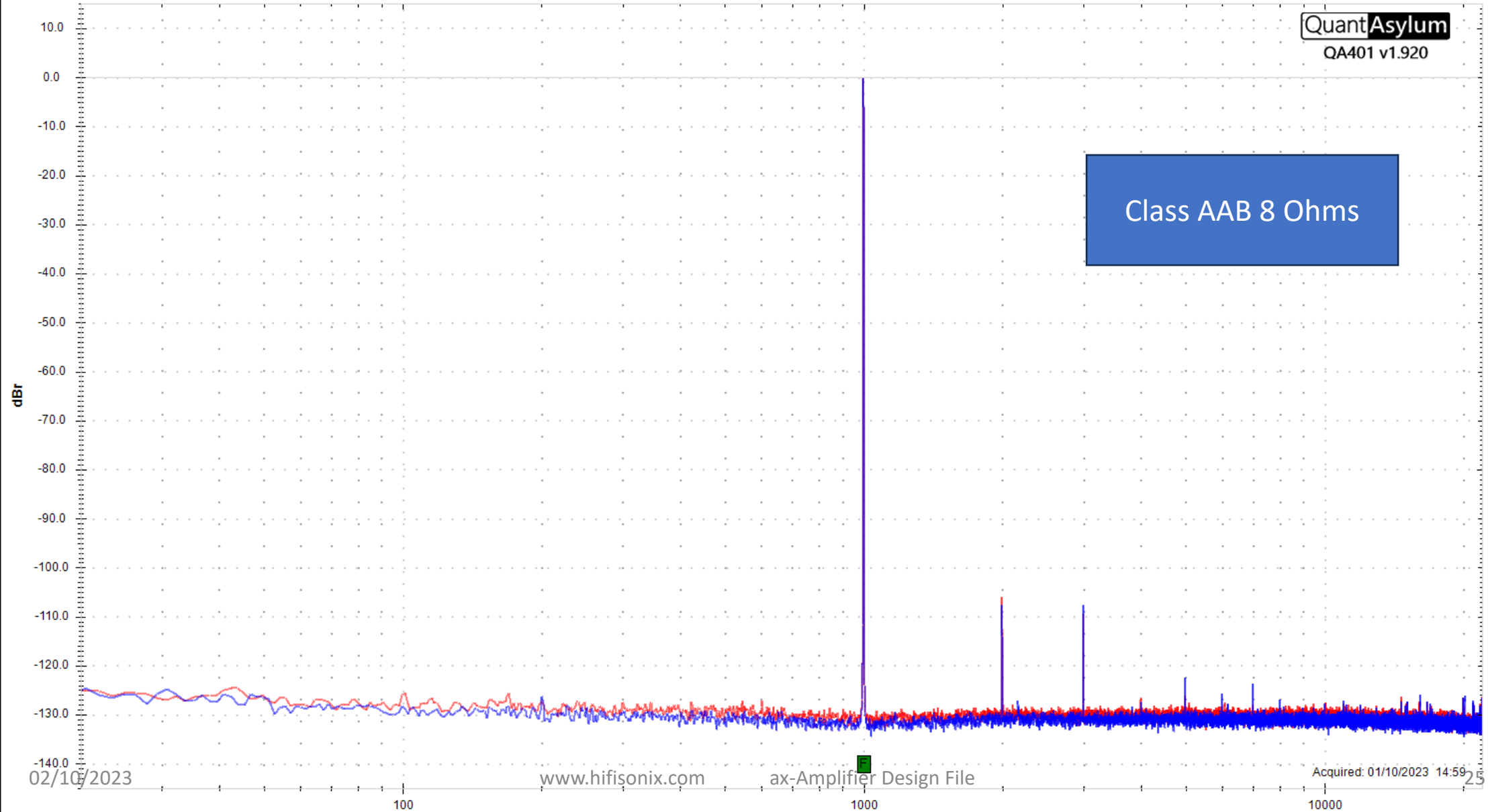
THD L: -104.3 dB/ 0.00061%
THD R: -104.3 dB/ 0.00061%
THD+N L: -91.5 dB/ 0.00266%
THD+N R: -90.8 dB/ 0.00289%

Gen 1: 1.000488 KHz @ 1.8 dBr
Gen 2: 19.99951 KHz @ -3.4 dBr

Phase L: 179.79 deg
Delay L: 510 uSec
Delay R: 510 uSec
Gain L: 38.34 dB
Gain R: 38.38 dB

ax-Amplifier

QuantAsylum
QA401 v1.920



Class AAB 8 Ohms

02/10/2023

www.hifisonix.com

ax-Amplifier Design File

Acquired: 01/10/2023 14:59:25

FFT: 128k
Avg: 43 of 50
Res: 1.46 Hz
Fs: 192 KHz
Win: Hann
Weight: None

Meas Start: 20.0 Hz
Meas Stop: 20.0 KHz
RMS L: -0.1 dBr
RMS R: 0.0 dBr

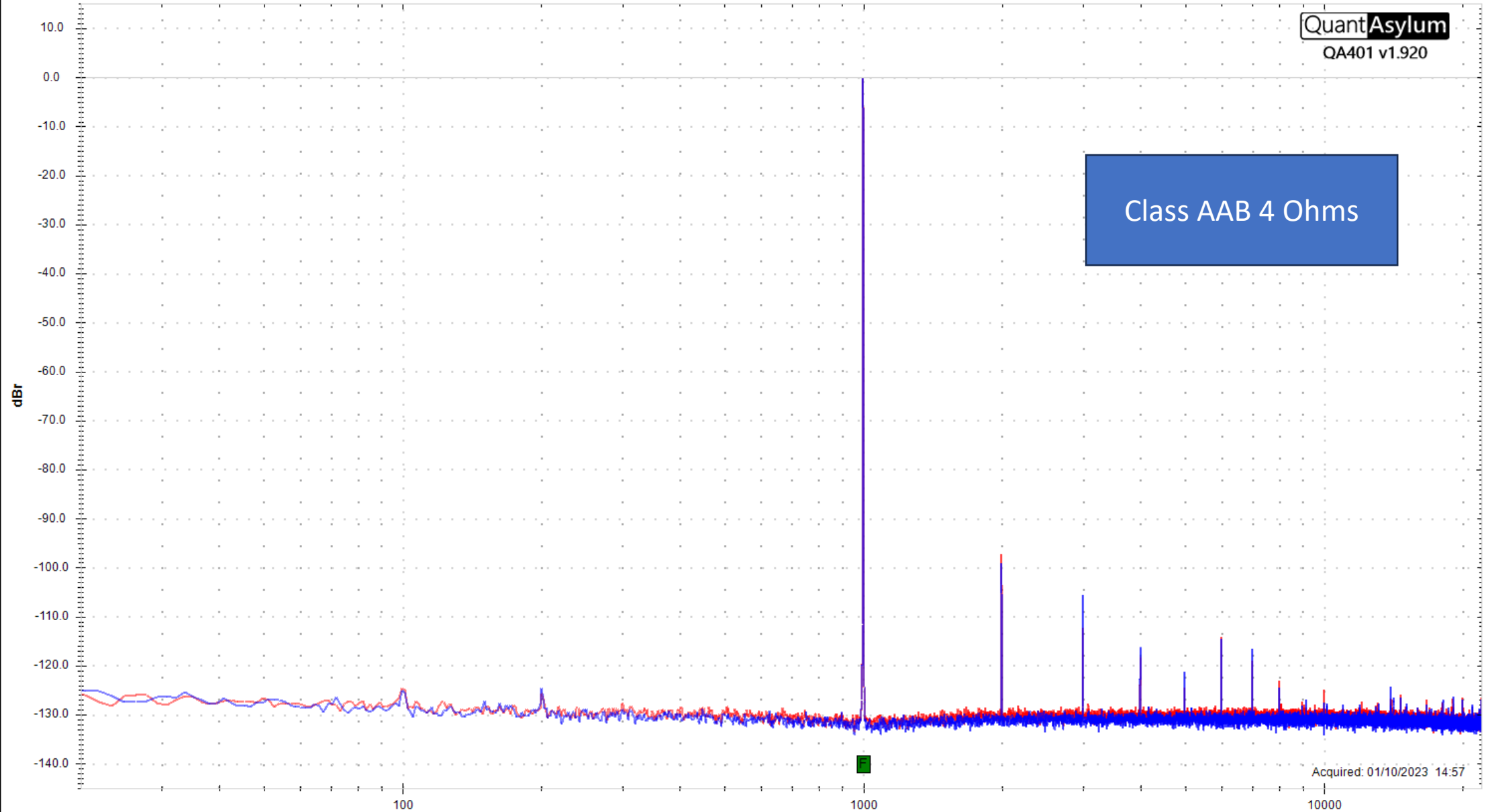
Peak L: -0.05 dBr
Peak R: -0.02 dBr
Peak L: 121 W (4.0 Ω)
Peak R: 122 W (4.0 Ω)
THD L: -98.0 dBr/ 0.00125%
THD R: -97.0 dBr/ 0.00141%

Gen 1: 1.000488 KHz @ 1.8 dBr
Gen 2: 19.99951 KHz @ -3.4 dBr
THD+N L: -90.7 dBr/ 0.00290%
THD+N R: -90.0 dBr/ 0.00316%

Phase L: 179.69 deg
Phase R: 179.70 deg
Delay L: 510 uSec
Delay R: 510 uSec
Gain L: 38.29 dB
Gain R: 38.33 dB

ax-Amplifier

QuantAsylum
QA401 v1.920



FFT: 128k
Avg: 35 of 50
Res: 1.46 Hz
Fs: 192 KHz
Win: Hann
Weight: None

Meas Start: 20.0 Hz
Meas Stop: 20.0 KHz
RMS L: 0.0 dBr
RMS R: 0.0 dBr

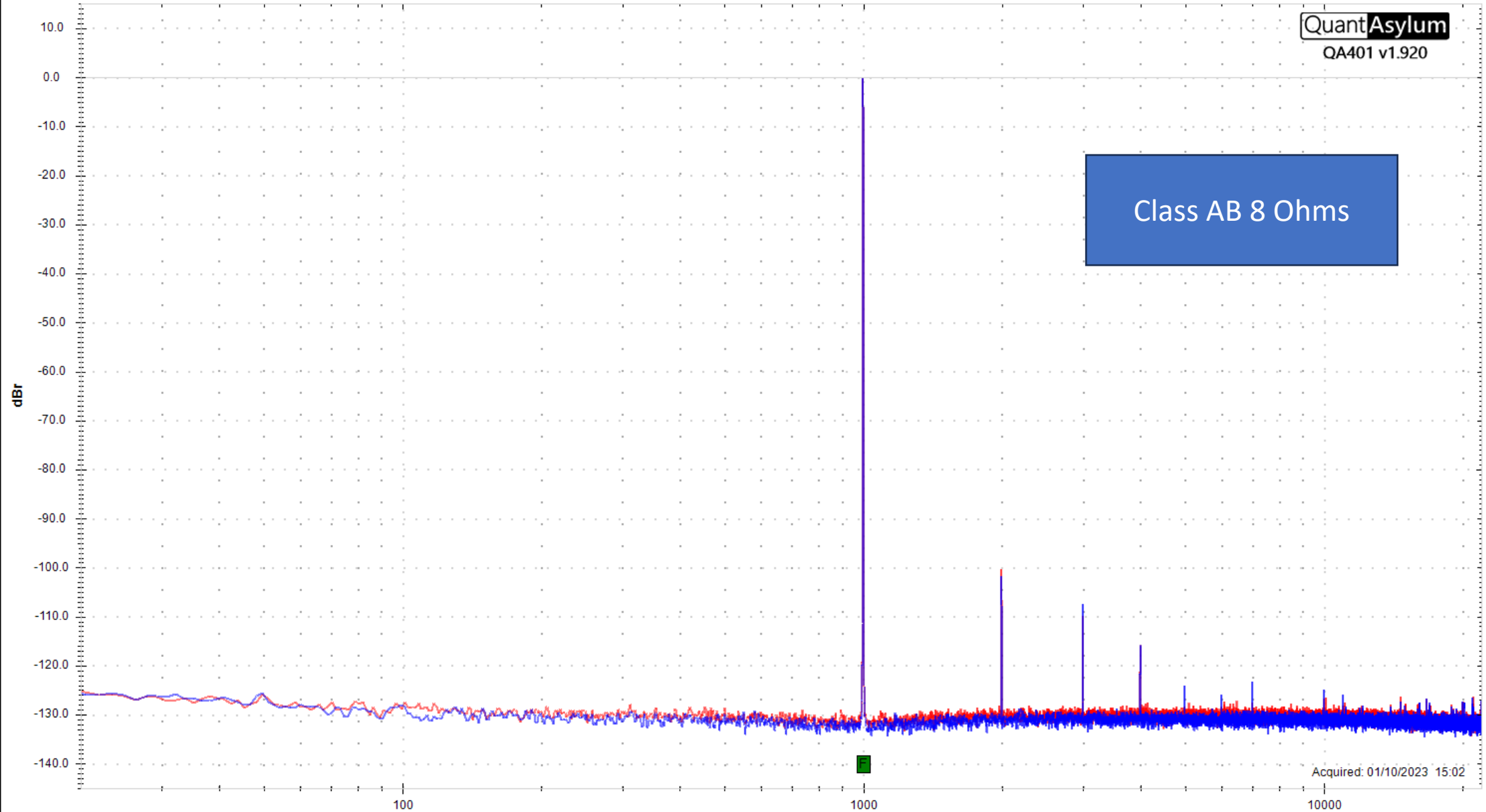
Peak L: 0.00 dBr
Peak R: 0.03 dBr
Peak L: 61.6 W (8.0 Ω)
Peak R: 62.1 W (8.0 Ω)
THD L: -100.4 dB/ 0.00095%
THD R: -99.8 dB/ 0.00103%

Gen 1: 1.000488 KHz @ 1.8 dBr
Gen 2: 19.99951 KHz @ -3.4 dBr
THD+N L: -91.2 dB/ 0.00275%
THD+N R: -90.5 dB/ 0.00299%

Phase L: 179.78 deg
Phase R: 179.79 deg
Delay L: 510 uSec
Delay R: 510 uSec
Gain L: 38.34 dB
Gain R: 38.38 dB

ax-Amplifier

QuantAsylum
QA401 v1.920



FFT: 128k
Avg: 38 of 50
Res: 1.46 Hz
Fs: 192 KHz
Win: Hann
Weight: None

Meas Start: 20.0 Hz
Meas Stop: 20.0 KHz
RMS L: -0.1 dBr
RMS R: 0.0 dBr

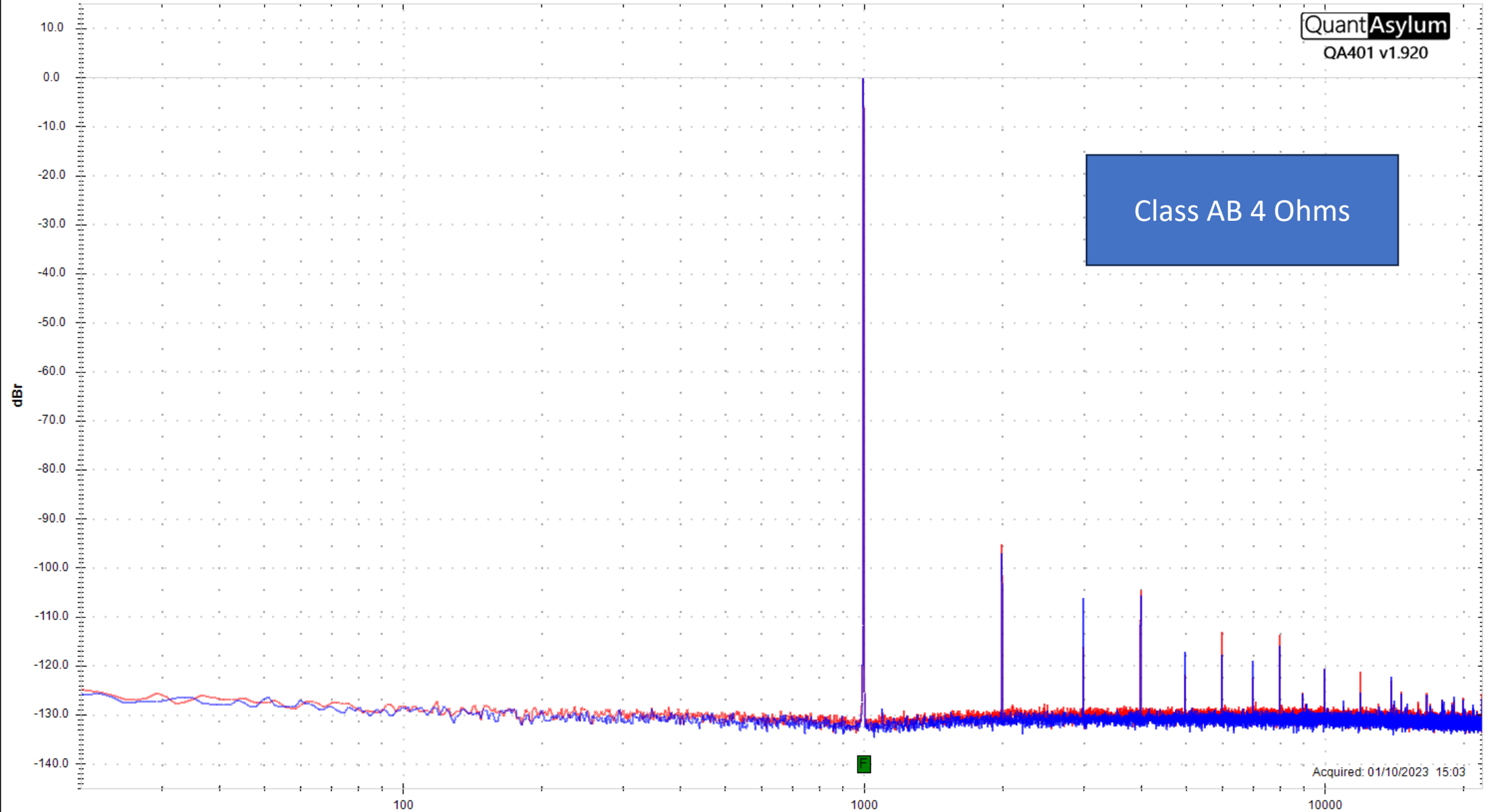
Peak L: -0.05 dBr
Peak R: -0.02 dBr
Peak L: 121 W (4.0 Ω)
Peak R: 122 W (4.0 Ω)
THD L: -95.9 dB/ 0.00161%
THD R: -94.7 dB/ 0.00184%

Gen 1: 1.000488 KHz @ 1.8 dBr
Gen 2: 19.99951 KHz @ -3.4 dBr
THD+N L: -90.3 dB/ 0.00307%
THD+N R: -89.4 dB/ 0.00338%

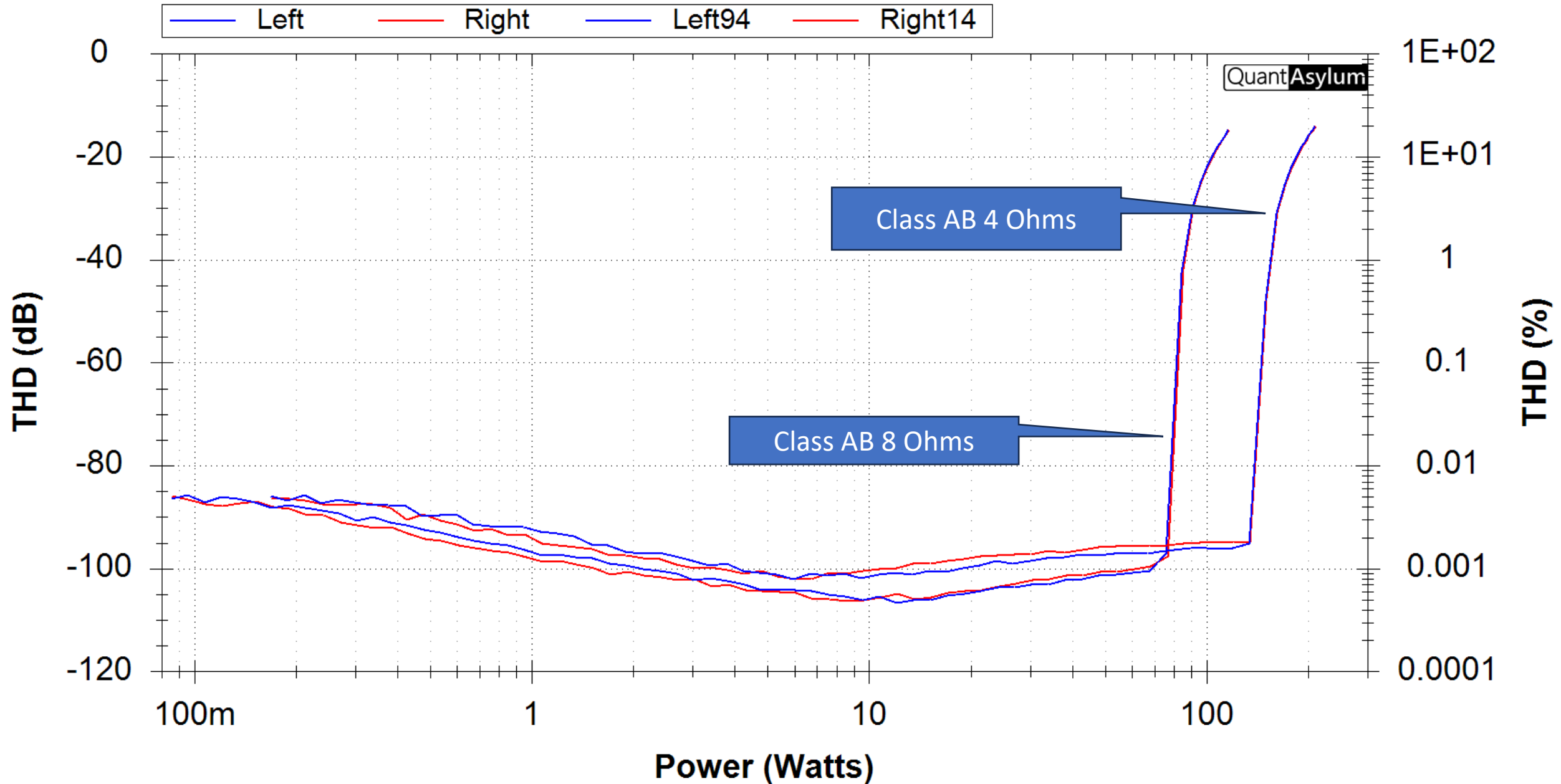
Phase L: 179.69 deg
Phase R: 179.70 deg
Delay L: 510 uSec
Delay R: 510 uSec
Gain L: 38.29 dB
Gain R: 38.33 dB

ax-Amplifier

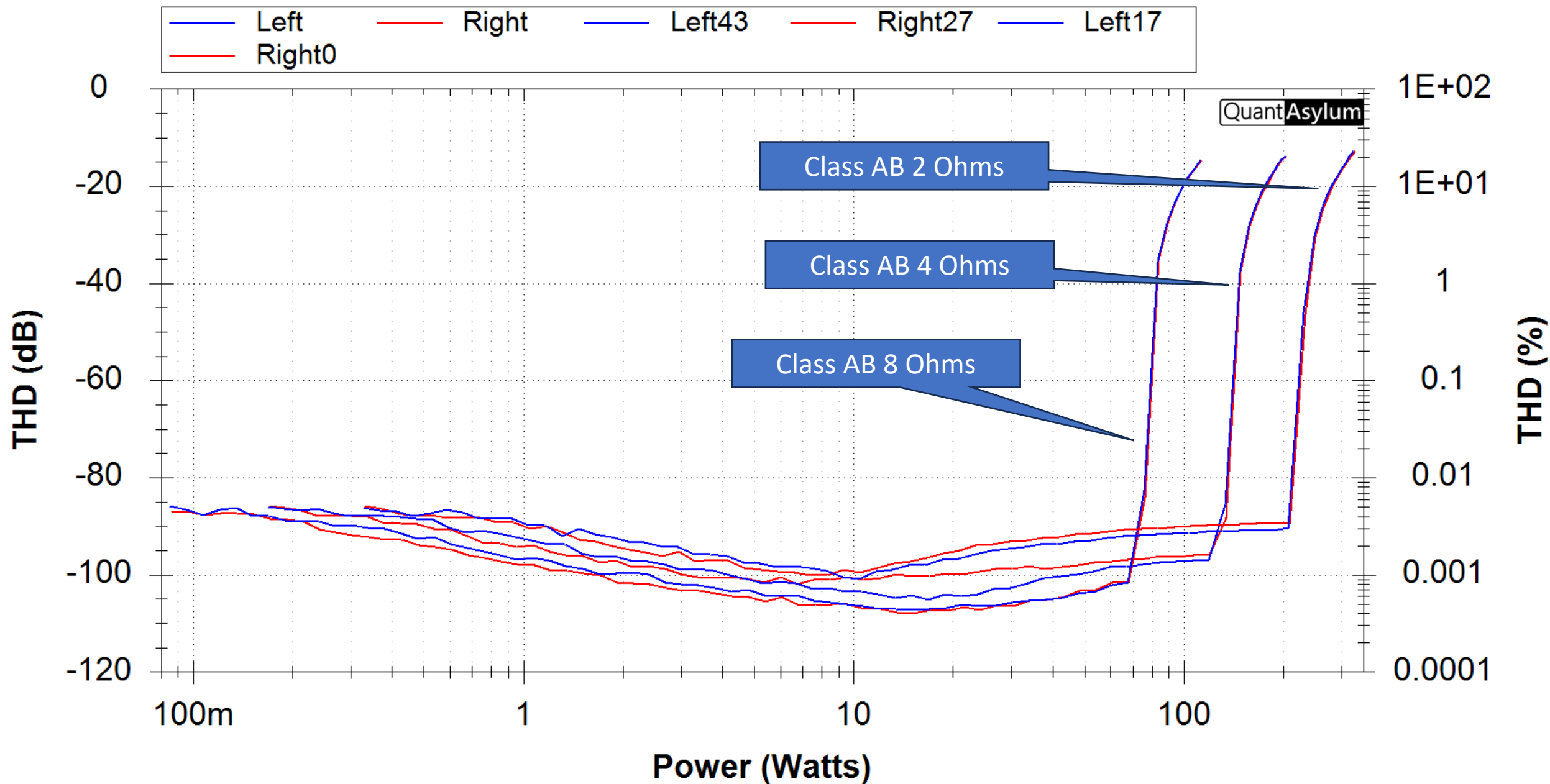
QuantAsylum
QA401 v1.920



ax-Amplifier class AB THD vs Power

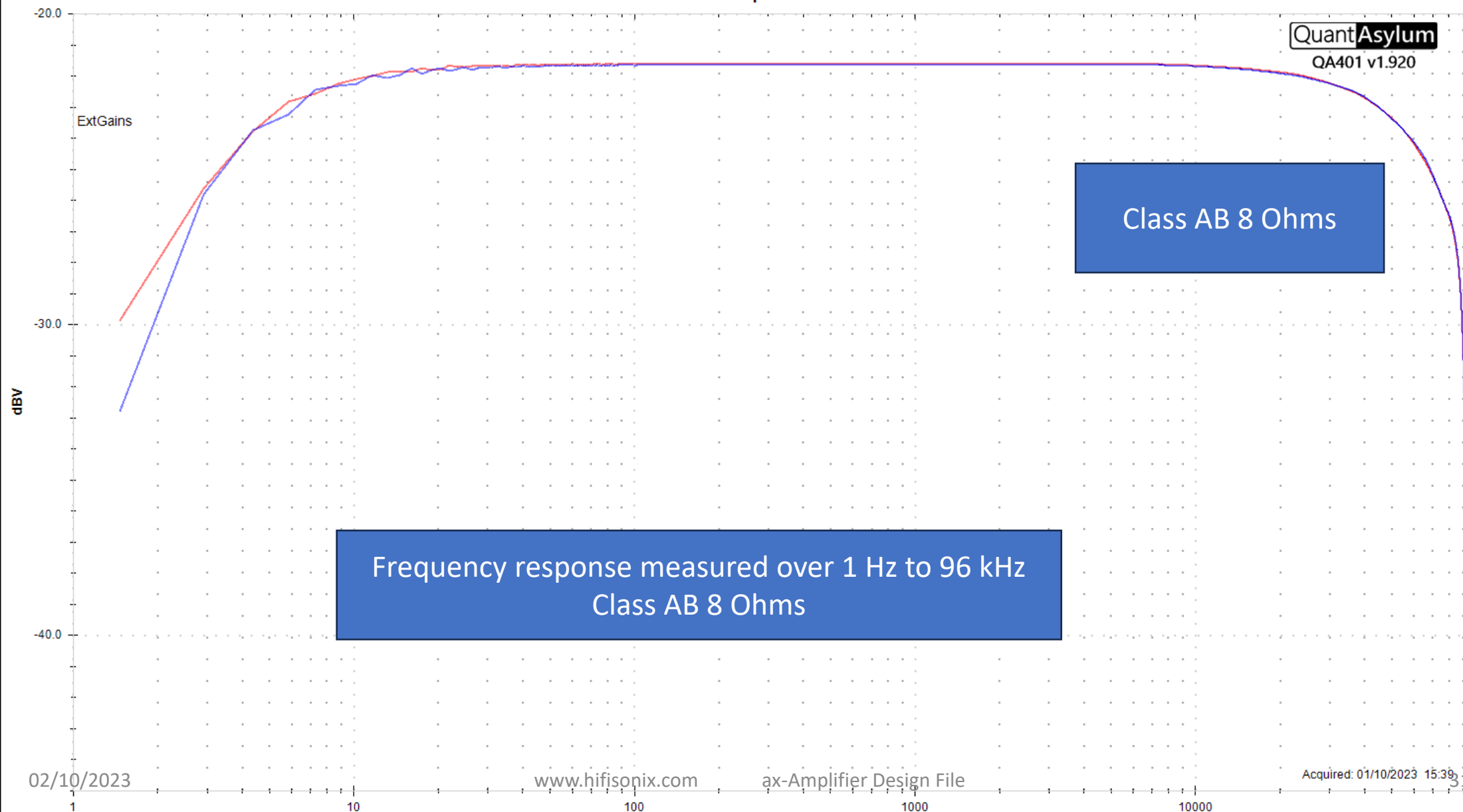


ax-Amplifier Class A THD vs Power



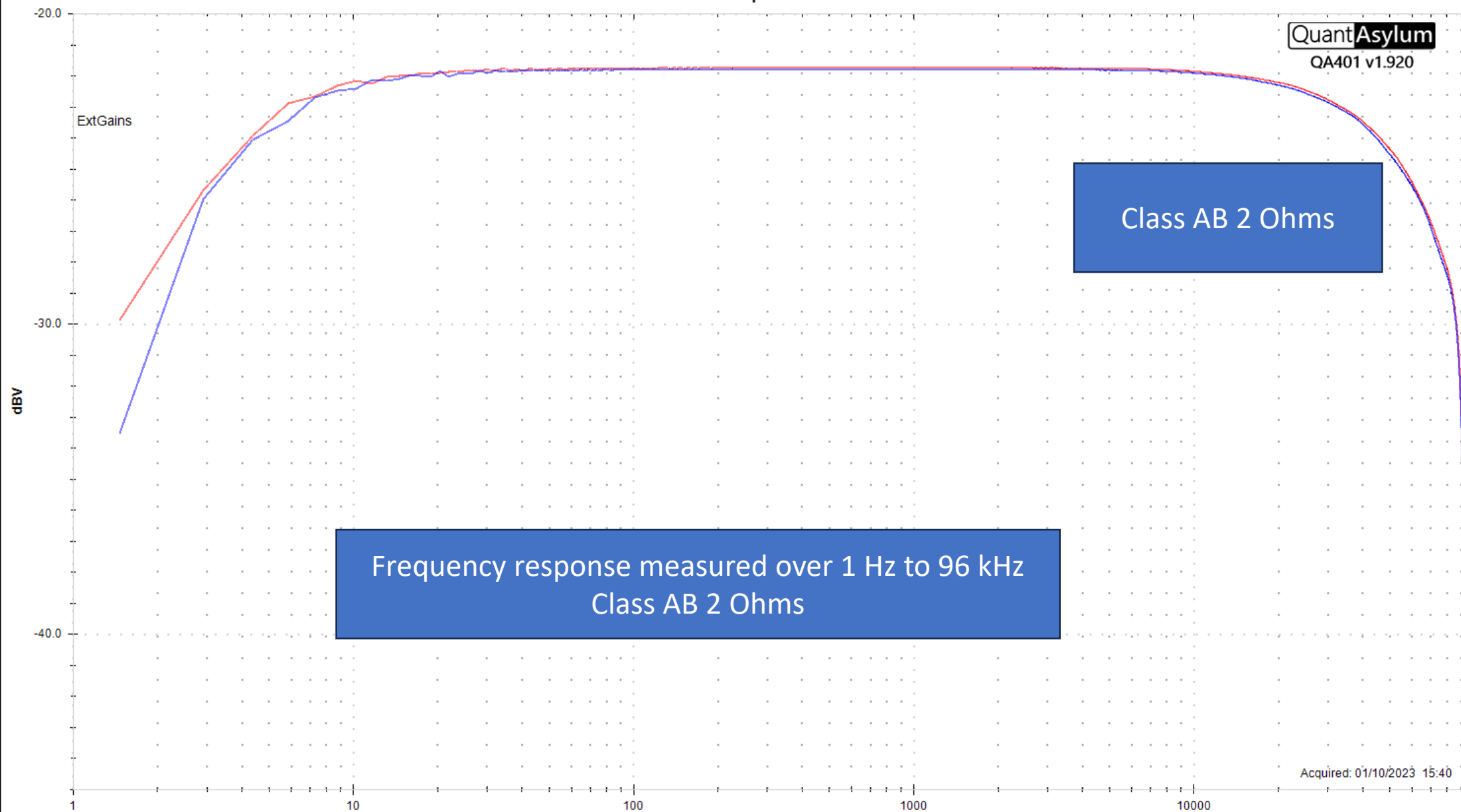
FFT: 128k Meas Start: 20.0 Hz Peak L: -21.65 dBV FR Gen: -60.0 dBV
Avg: — Meas Stop: 20.0 KHz Peak R: -21.61 dBV
Res: 1.46 Hz Peak L: 855 uW (8.0 Ω)
Fs: 192 KHz Peak R: 862 uW (8.0 Ω)
Win: Hann FR Window: None
Weight: None FR Smoothing: 1/96 Oct

ax-Amplifier



FFT: 128k Meas Start: 20.0 Hz Peak L: -21.80 dBV FR Gen: -60.0 dBV
Avg: — Meas Stop: 20.0 KHz Peak R: -21.75 dBV
Res: 1.46 Hz Peak L: 3.30 mW (2.0 Ω)
Fs: 192 KHz Peak R: 3.34 mW (2.0 Ω)
Win: Hann FR Window: None
Weight: None FR Smoothing: 1/96 Oct

ax-Amplifier



ax-Amplifier Output Impedance 4 and 8 Ohms

