PART 1 - Making a Rev.2 swap board for the Yaqin MS-22B and MS-23

MS22B	MS23B
	

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Some History

Many years ago there was a British company called World Audio Design or WAD who manufactured various amplifiers as kits for home construction. Unfortunately they ceased trading leaving a legacy of many happy customers with high performance products using the highest quality components. The pricing was very good considering how much one has to pay for similar high end equipment today, maybe they under-priced themselves but their disappearance has been sadly lamented to this day.

Because their kits were no longer available, the Author built a copy of the WAD Phono Amplifier into a small die-cast box and this performed really well. Many solid state designs were tried later, some using the latest operational amplifiers but none came anywhere near to the quality of this simple little RIAA box.

The Author was keen to obtain and evaluate the Yaqin MS22B and one came his way as part of an amplifier deal. When he replaced his home made effort with this lovely looking piece of kit, he was very disappointed at the sound it produced. Visitors would plead with him to take it out of circuit and put his amp back into operation, was it that bad? Yes it really was!

So rather than put this amplifier away in a cupboard until its innards dried out, he decided to take a look at the circuit board with the idea of transplanting the WAD circuit into the much nicer looking enclosure. The WAD circuit uses three valves (called Tubes or Lamps in some other countries) yet the Yaqin only used two with a transistor acting as a buffer. Buffer? It is a name given to a stage that is designed to stop the effects of a following stage affecting the performance of the previous stage and also be able to drive external cables with minimum losses. A crude analogy would be using an oven glove as a buffer so you can pick up hot things without affecting your hand. Hope that is a bit clearer ☺ Anyway, Yaqin feed their RIAA circuitry from the same buffer circuit output that also feeds the signal to the output sockets. In theory therefor, different loading conditions could possibly affect the RIAA operation? Ideally the buffer should only feed signals out to the following amplifier and nowhere else and as stated, one of its properties is to be able to drive into the loads presented by the following equipment. Well the WAD circuit did not like the transistor at all, as expected the RIAA curves were all over the place so a MOSFET transistor was tried and it worked well but not as good as a third valve. So even though it means more effort in making a hole for a third valve, it is a worthwhile improvement and the only way to go, recommended by the author.

No experience?

The original idea was to modify the original circuit board, this required cutting tracks, drilling small 0.8mm holes and somehow getting all of the new circuit into the available board space.

It did work well and the instructions for doing this are here:-

http://www.g4cnh.com/public/Putting_'Life'_into_the_Yaqin_MS-22B.pdf

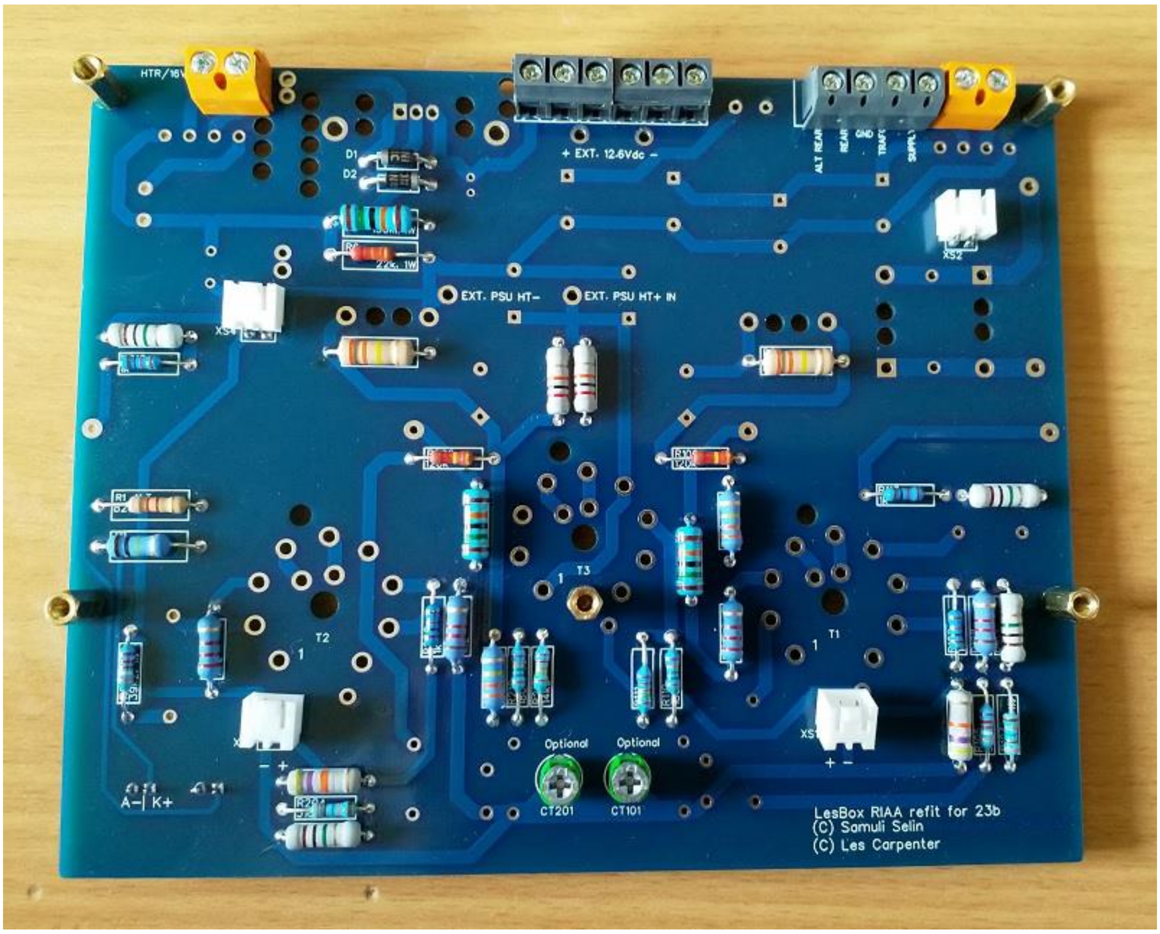
But there was a problem if you had no experience, no tools and had never soldered in your life, though many have tried and succeeded. So some sent the complete MS22 or MS23 to those who could do the work for them but again there were other problems. The mail services charged a high price for shipping and this had to be paid both ways! Also the Customs at the receiving countries

could apply more charges and in fact the overall cost would easily exceed the cost of the new parts and modification work.
So with the amazing talents of Samuli Selin in Finland, a **Swap Board** was created such that anyone could fit the new board without soldering. The Power connections would be by screw terminal blocks, the audio connectors would be compatible and options provided to cater for differences in the MS22's or MS23's, notably the number of front panel LEDs employed.

You still have to drill a 28mm hole in the chassis top but it is easy to make a template from thin cardboard to assist in locating this.
See **PART 2** for template details, drilling the 28mm hole and fitting the completed board which will of course be the starting point for those buying a ready built and tested swap board.

This **PART 1** contains the instructions for those capable of building a Rev.2 Swap Board.
The actual fitting is described in Part 2

The latest Rev.2 Circuit Board. (This is the Bottom side prior to the top side being built and heater lines added).



This side is recommended to be built first as otherwise the top side components make soldering difficult. The parts quoted are those that the Author uses and the constructor is free to choose alternatives.

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Start by fitting:-

D1 & D2 – 1N4007 (https://www.cricklewoodelectronics.com).
(Polarised component - Observe that the small oblong in silk screen is the Grey band end)

R1 – There are two, one is a 100k 0.5W (for single LED), Cricklewood H100K and is fitted just above the position for R205 (39k2) fitted later.
The other is a R1 ALT, 820 ohms, Cricklewood H820R or RS 148-483 and is fitted above R1 for powering multi-LED illuminated front panels.
R3, R4, R109 & R209 – 330k 1W, Farnell 3547096 or RS 214-1478
R5, R112 and R212 – 150k 1W Farnell 1973226
R6 – 22k 1W Farnell 3541753 or RS 214-1311
R101 & R201 – 47k 1W Farnell 3547099 or RS 214-1355
R102, R202, R113 and R213 – 1k 1W Farnell 1738587
R103, R203, R114 and R214– 1M 1W Farnell 1563897
R104 & R204 – 316k 0.5W Farnell 9467238
R105 & R205 – 39k2 0.5W Farnell 9467726 or RS 754-5673
R106 & R206 – 120k 1W Farnell 3619373
R107 & R207 – 2k2 1W Farnell 1738591
R108 & R208 – 1k2 1W Farnell 1738588
R110 & R210 – 180k 1W, can be replaced with 165k 0.6W Farnell 9464786 or RS 755-0971, 0.25W, 1%. (165k is alleged to be better at 50 kHz).
R111 & R211 – 14k3 (RS 755-0903) – 0.5W
R116 & R216 – 20k 1W Farnell 3619381 or 0.5W RS 187-0890.
CT101 & CT201 – 50pF Trimmers, fit the correct way around with Ground tag to the lower pad closest to board edge.
These are OPTIONAL but recommended; the Green ALPS perform best if you can find them.

Next up are the terminal blocks, the colours you use are optional.

Terminal Blocks:- 2 way Orange RS 408-7871 (2 off), 4 way Black RS 494-8978 and two 3 way Black RS 494-8962 coupled together to make a 6 way. Alternatively three 2 way Black RS 408-7871 can be coupled together to make a 6 way.
Fit the miniature terminal blocks as shown in the previous photograph.
The author likes to fit a 4 way Black terminal block for the Ground wires, Two 3-way Black RS 494-8962 or three 2-way Black RS 408-7871 can be joined together to make a 6-way for Heater supply and an Orange for High and low AC Voltage supply. Make sure they are mounted the right way around with the holes for the wires located around the board edge except the Heater ones, which face inboard ready for the three pairs of wires, added later, that will be coming from the valve sockets.
Fit the miniature 2-Pin plugs; these can be reclaimed from the old board. Take careful note of their orientations. They all mount with pins uppermost as shown in the previous photograph. The LED plugs are mounted on the other side of the board but facing downwards towards the board edge,

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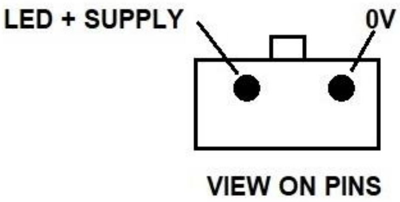


Slightly lift plug XS1 as this will allow access to the solder pad of V1 ground pillar when this valve base is fitted.
Once this joint has been made later, the plug can be carefully placed back against the board.

Note that there are extra pads located at the ends of where R2 is located.
First fit a sleeved 24SWG tinned copper wire between the innermost pads, this will act as a shorting wire across the 6R8 5W resistor R2 when this is fitted on the other side of the board using the outermost pads

Why the shorting link.

In cases where the Heater regulator is being fed with too much voltage from the power transformer, the excessive dissipation causes shut down of the valves heaters.
In these circumstances, the link wire can be easily cut to introduce the resistor and thus prevent shut down.

Due to V3 socket, it is important that you now fit the central 13mm stand-off pillar.

You can also fit the four 10mm stand-off pillars to the four board edge mounting locations.

These stand-off pillars can be obtained from the old board along with their securing screws.
The heater wiring is added later, this keeps the solder pads clear for soldering the top (upper) side board components.
At this stage the Author likes to wash the flux residues from the completed bottom side of the board with Isopropyl Alcohol and then put aside to dry whilst preparing some of the hardware for the top side of the board.

The Regulator U3 has to be mounted to the heat sink and will require a 6mm long M3 screw, shake proof washer and nut. It is also required to be treated with a thin film of heat sink thermal compound so that its metal tab makes a good thermal bond with the heat sink. There may be enough by re-using the old regulator and salvaging what's left remaining on the old heat sink.
The new heat sink is a Stonecold SHS29-25S available from Banzai Music in Germany. https://www.banzaimusic.com/Heat-Sink-SHS29-25S.html SKU 26184

The skirted valve holders are special and have integral grounding pillar, you need to add a 7mm M3 spacer and a 4mm M3 screw on each flange to provide the same support distance.
Holders are Belton VT9-ST-C and available from various sources including these.
https://www.banzaimusic.com/Micalex-Socket-Noval-PC-Mount-shielded-base.html
SKU 18443
https://www.tubeampdoctor.com/en/vt9-st-c-belton-noval-socket-pc-mount-with-skirt
S9CSK-PC-BT

PART 1 - Making a Rev.2 swap board for the Yaqin MS-22B and MS-23

Construction of the top side of the board should start with;-

a) D3 & D4 – Bridge rectifiers. Polarity is important!
b) 7812 Regulator U3 – Fit complete with its heatsink.
c) Valve holders – For mounting the Belton VT9-ST-C micalex valve holders, fit to the board and secure with another 4mm M3 screw. Check the holder is square to the board, holding the assembly if required. The Author uses a long 3mm screw threaded through the top side of the holder and secured with a fixing nut. With its position now securely held, you can fully tighten the 4mm screws and solder all nine pins of the holder and the Grounding stand-off lug. Remove the long M3 screw and repeat for the other two sockets.

Now we add the remaining components, there are a number of electrolytic capacitors which MUST be placed onto the board the correct way round.
The White segments in their respective circles are where the Negative (-) wire has to go and the larger electrolytic capacitors have their Positive (+) wires indicated by a square solder pad rather than a round one. Critical part sizes are shown in **Bold.**

C1 – 1000uF 25V **Body Height 21mm Width 12.8mm** (RS 711-1148)
C2 – 100uF 25V **Body Height 11.5mm Width 5.3mm** (RS 519-4059)
C3 – 47uF 350V **Body Height 21- 25mm Width 16.3mm** (FARNELL 1673481)
C4 – 47uF 350V Body as for C3
C5 – 47uF 350V Body as for C3
C6 – 47uF 350V Body as for C3
C7 – 47uF 350V Body as for C3
C8 – 47uF 350V Body as for C3
C9 – 47uF 100V **Body Height 13mm Width 11mm** (RS 365-4509)
C101 & C201 – 68uF 350V **Body Height 26mm Width 16.2mm** (RS 526-2231)
C102 & C202 – 100nF 400V (RS 755-4472)
C103 & C203 – 8200pF Silver Mica (Best sourced on the Internet)
Note that 300V Polystyrene capacitors have been used to good effect.
C104 & C204 –180pF Silver Mica where Trimmers CT101 and CT201 are fitted.
(Tests on boards without Trimmers appear to show that a 220 pF 1% will do the job but on some boards a 200 pF with a 10pF fitted in parallel at the extra pads provided gave better results).

R2 – 6R8 5W or 7W wire wound, example RS 144-3042.
This resistor is normally shorted by the wire link on the underside of the board.
In situations where the link has to be cut to prevent regulator shut down, the resistor generates quite a lot of heat and the Author likes to stand the resistor away from the circuit board.

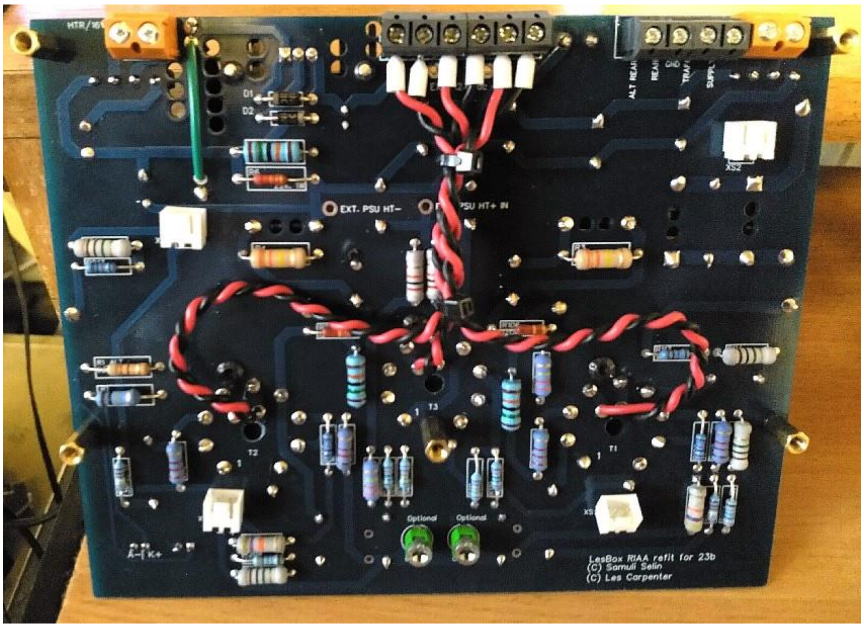
C105 & C205 – 3.3uF 400V (Audyn M4)
R9 – 10k 5W radial wire wound resistor. (RS 199-7898)

The Optional Ground Lift components (if required) should now be fitted:-
R7 – 10 Ohm 5W resistor (RS 762-9175)
D5 & D6 – 6A Diodes SF63G (RS 688-2195)
C10 – 100nF 400V Capacitor (RS 755-4472)

The Optional Zener stabiliser diodes (if required) should now be fitted:-
Z101 & Z201 – 190V 5W 1N5387B

Make up three lengths of twisted wire suitable for the heater supplies, one length to be 85mm and the other two 120mm each.
Connect one 120mm length between the first two terminal block positions and the heater pads of V2.
Connect the 85mm length between the next two (central) terminal block positions and the heater pads of V3.
Finally connect the remaining 120mm length between the last two terminal block positions and the heater pads of V1.
The wiring can be held in place by one or two small zip ties, the Author also prefers to use bootlace ferrules for connecting to the heater terminal block.
Note how the link (covered in Green sleeving) is fitted across R2 as mentioned on Page 6.

Board Bottom



Board Top

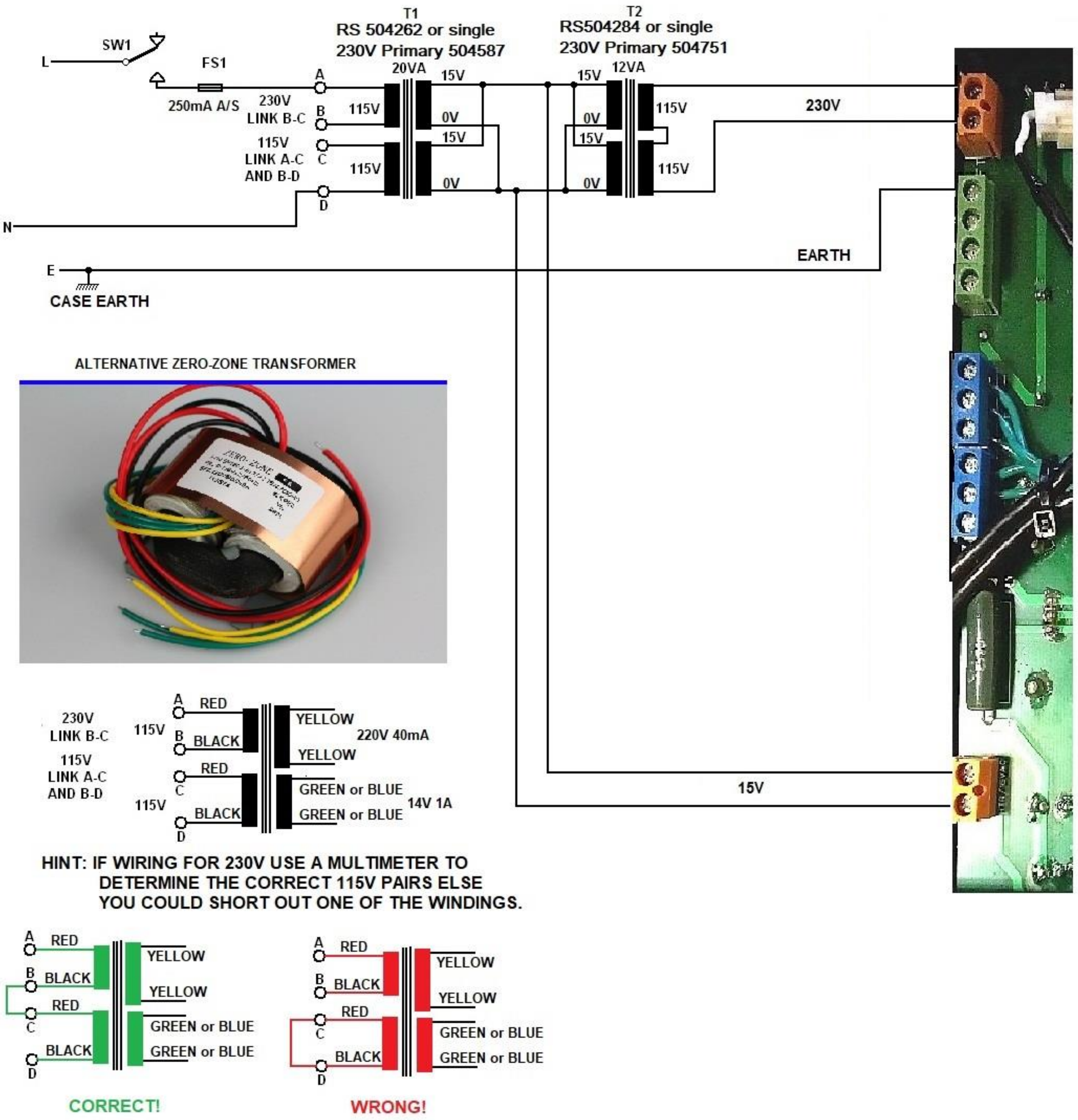
There should be no need to do point to point resistance checks like the re-used stock board. The check list is not valid on the swap boards anyway due to reassignment of valve pins.

The following is for those who want to test their boards in isolation

For testing in isolation, a power transformer giving 230V AC and 15V AC is required such as the Zero-Zone R-Core 30VA30W https://www.ebay.co.uk/itm/384552651826?hash=item59891fcc32:g:IssAAOSwf8lhpxW2.

An alternative and perhaps safer with its double split bobbin isolation, is to use two standard back to back power transformers.
These MUST be placed in a well-insulated enclosure of course.
First one is 20VA 15V and the second is 12VA 15V. If you use types with twin secondary's like below, then make sure the windings are paralleled correctly, 0 to 0 and 15V to 15V.

The picture gives an idea of how the transformers can be interfaced.



Before powering up you will of course need to plug in 12AX7 valves to each of the three sockets. If you have a Variac or lamp limiter, it may be a good idea to initially use this so that the chance of a fault will be spotted before a lot of damage is done. If you otherwise feel confident, then apply the AC power supplies and do a basic check for DC Voltages on the board.

DC Voltage checks.

1) Check for HT (B+) between the Ground terminal block and either pin 1 or pin 6 of V3, typically 198V to 201V. You could alternatively check for voltage at the ends of the 20k resistors closest to V3 as this will also check the Zener diodes.
Look for an approximate voltage of 190V here as Zener diodes have quite a wide tolerance.

2) Check across two adjacent screws of the Heater Terminal Block, for approximately 12.6V.

3) Check Heater Lift between the Ground terminal block and one of the screws of the Heater Terminal Block. Depending on the screw being measured you should get approximately 29V or 42V.

Signal Testing

For signal testing you will need a low distortion sine wave generator with a **levelled output spanning 20 Hz to 20 kHz**. The author uses a HP 209A with an in-line 40dB attenuator. Measurements should be taken using a wide frequency range RMS voltmeter.
The author uses a HP400EL with enlarged decibel scale, it is most important to set up a signal path loop with the cables and attenuator you intend to use, sweeping from 20 Hz to 20 kHz and checking for flatness on the RMS Voltmeter.

Unless you are testing in the MS22/23 chassis, you will need to interface the board under test with your test equipment. The authors test equipment is linked by BNC connectors so four interface cables were made by cutting two 2 metre BNC-BNC cables in half. Each cable was then fitted with mating pre-wired two pin sockets, bought from eBay.
Remember that Yaqin reversed the pins on the Left Channel Input XS1 for reasons unknown so best to mark this connector in some way, else you may accidentally ground one of the outputs XS2, XS4 or the Right Channel Input XS3.
Preliminary tests can be made using an oscilloscope as follows; no actual measurement value needs to be taken with the oscilloscope.

Preliminary basic operation test (optional)

A BNC ‘T’ piece is fitted to the output of the 40dB attenuator so that two cables, one wired for the infamous Left Channel XS1, can be connected to the swap board Inputs XS1 and XS3.
Connect oscilloscope to XS2 and XS4 or just XS2 if your oscilloscope is single channel.
Inject 1 kHz into the swap board and set oscilloscope for a display of say four vertical divisions on Left Output XS2.
Then set signal generator to 20Hz and note that the oscilloscope display has increased such as to be off the screen.
Set the signal generator to 20 kHz and not that the oscilloscope display has decreased to a very small deflection.
Having proved this occurs on the Left channel; connect the Oscilloscope to Right Output XS4 and check for similar results at the same check frequencies of 1 kHz, 20 Hz and 20 kHz.

RIAA Plotting Right Channel

Now we know that basic channel operation of both Left and Right channels has been proven, the Author prefers to do a preliminary setting up of the trimmers starting with CT201 while the Right channel is connected.

Transfer the BNC from the Oscilloscope to the RMS Voltmeter set to 1V (0dB) scale.
Inject a 1 kHz sine wave to XS3 and monitor output on XS4, set constant output sine wave generator to give 0dB output on the RMS Voltmeter.
Switch sine wave generator to 15 kHz and adjust CT201 to give -17.2dB on the RMS Voltmeter.
Note: If trimmer range is insufficient it may be necessary to alter the value of C204 using the additional pads on the board for adding, for example, a 10pF Mica capacitor.

Recheck at 1 kHz for 0dB and adjust sine wave generator if necessary.
Check for -17.2dB at 15 kHz and again adjust CT201 if necessary.

Keeping the Right Channel connected, the RIAA can now be plotted, starting at 1 kHz with 0dB on the RMS Voltmeter, first go up in steps to 20 kHz, recording the output on the RMS Voltmeter at each step. Then recheck 0dB at 1 kHz as this may have moved slightly especially if the trimmer CT201 was re-adjusted.

Then go down in steps to 20 Hz, recording the output on the RMS Voltmeter at each step.

FREQ (Hz)	RIAA (dB)	LEFT (dB)	RIGHT (dB)
20	19.3		
30	18.6		
40	17.8		
50	17.0		
60	16.1		
80	14.5		
100	13.1		
150	10.3		
200	8.2		
300	5.5		
400	3.8		
500	2.6		
800	0.7		
1000	0.0		
1500	-1.4		
2000	-2.6		
3000	-4.8		
4000	-6.6		
5000	-8.2		
6000	-9.6		
8000	-11.9		
10000	-13.7		
15000	-17.2		
20000	-19.6		

RIAA Plotting Left Channel

Repeat the same procedure, injecting the 1 kHz signal into XS1 and checking XS2 first for 0dB at 1 kHz before switching to 15 kHz and adjusting CT101 for -17.2dB on the output. Once again, if trimmer range is insufficient it may be necessary to alter the value of C104 and add, for example, a 10pF Mica capacitor.

Recheck at 1 kHz for 0dB and adjust sine wave generator if necessary.
Check for -17.2dB at 15 kHz and again adjust CT101 if necessary.

The Left Channel RIAA can now be plotted, starting at 1 kHz with 0dB on the RMS Voltmeter, first go up in steps to 20 kHz, recording the output on the RMS Voltmeter at each step. Then recheck 0dB at 1 kHz as this may have moved slightly especially if the trimmer CT101 was re-adjusted.

Then go down in steps to 20 Hz, recording the output on the RMS Voltmeter at each step.

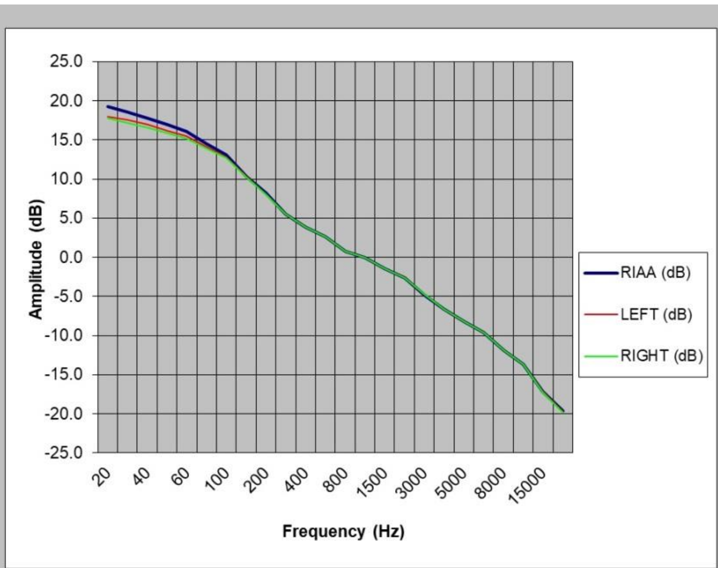
Plotting RIAA Graph on Excel.

Now you can enter the results into an Excel sheet that can do the Math and draw a set of graphs to compare against the ideal RIAA Curve.
Here is a link to the Xcel spreadsheet that the Author uses; he has kept a set of typical results on the GRAPH PLOT Sheet, simply enter over them with your results (Yellow Boxes).
You can paste them if you use the figures recorded on the RESULTS sheet. This sheet is provided so that you can enter data while you test perhaps a number of boards. Then later you can paste the results one at a time into the GRAPH sheet.
The third sheet is for HP3400 owners, it helps interpret the meter readings against the range switch, most useful for after midnight testing when the brain waves are getting weak!
☺

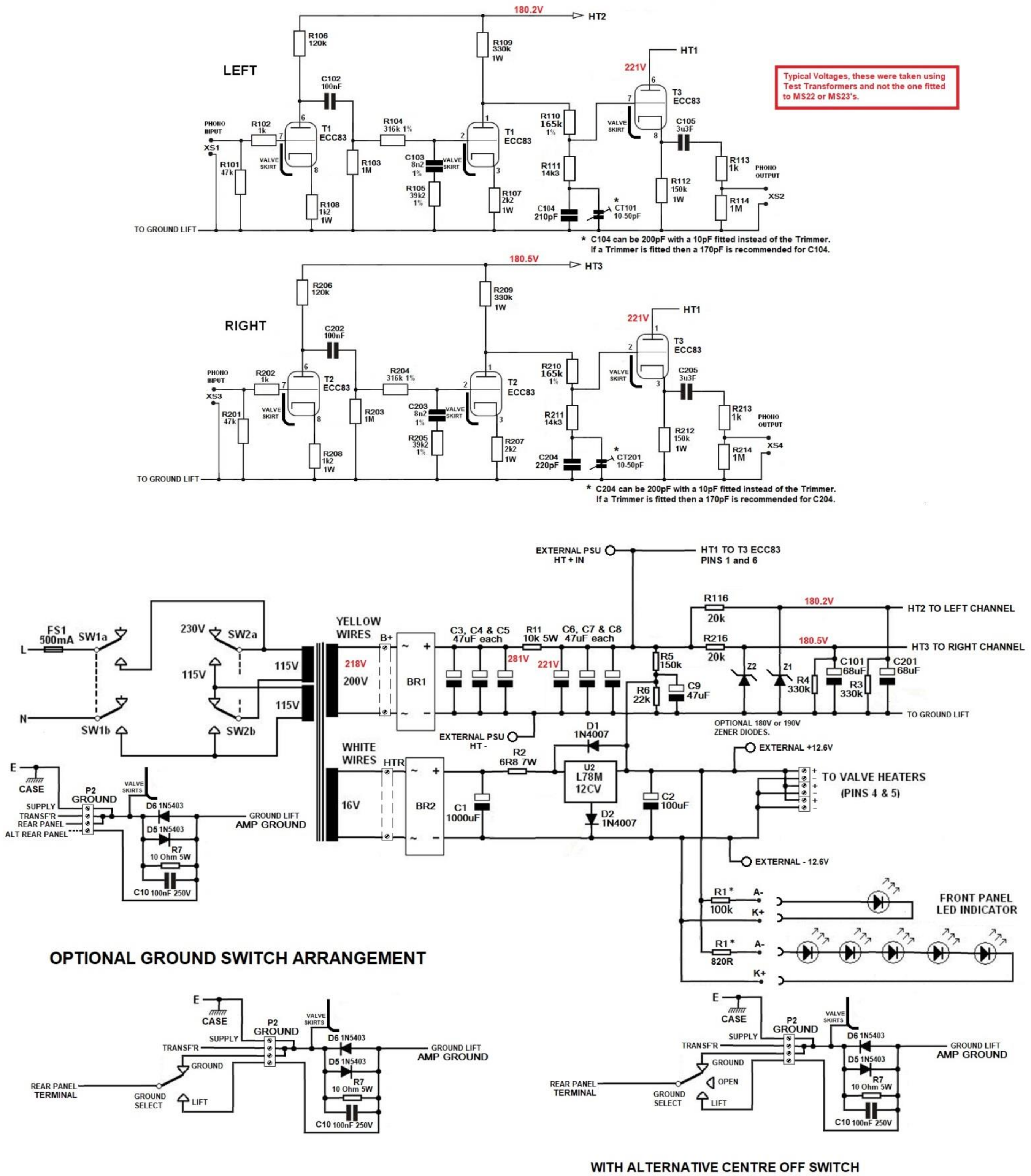
http://www.g4cnh.com/public/Internet%20RIAA%20chart.xlsx

The Plot obtained on the above Xcel link.

FREQ (Hz)	RIAA (dB)	LEFT (dB)	RIGHT (dB)	left error	right error	chan dev
20	19.3	18.0	17.8	1.30	1.50	0.20
30	18.6	17.6	17.2	1.00	1.40	0.40
40	17.8	17.0	16.6	0.80	1.20	0.40
50	17.0	16.2	15.9	0.80	1.10	0.30
60	16.1	15.5	15.2	0.60	0.90	0.30
80	14.5	14.1	13.9	0.40	0.60	0.20
100	13.1	12.8	12.7	0.30	0.40	0.10
150	10.3	10.3	10.2	0.00	0.10	0.10
200	8.2	8.0	8.0	0.20	0.20	0.00
300	5.5	5.5	5.5	0.00	0.00	0.00
400	3.8	3.8	3.8	0.00	0.00	0.00
500	2.6	2.6	2.6	0.00	0.00	0.00
800	0.7	0.7	0.7	0.00	0.00	0.00
1000	0.0	0.0	0.0	0.00	0.00	0.00
1500	-1.4	-1.4	-1.4	0.00	0.00	0.00
2000	-2.6	-2.6	-2.6	0.00	0.00	0.00
3000	-4.8	-4.7	-4.7	-0.10	-0.10	0.00
4000	-6.6	-6.6	-6.6	0.00	0.00	0.00
5000	-8.2	-8.2	-8.2	0.00	0.00	0.00
6000	-9.6	-9.6	-9.6	0.00	0.00	0.00
8000	-11.9	-11.9	-11.9	0.00	0.00	0.00
10000	-13.7	-13.7	-13.7	0.00	0.00	0.00
15000	-17.2	-17.2	-17.3	0.00	0.10	0.10
20000	-19.6	-19.7	-19.8	0.10	0.20	0.10



Circuit Diagram



Please note that if the External Supply inputs are used then the Regulator U3 and its protection diode D1 MUST be removed. The external 12.6V supply should also be floating from Ground as in the original power circuit; this enables the Heater Lift circuit to operate correctly.