

There are digital converters available which are a credit to the CD format. They sound fantastic, milking every nuance of music from the stream of digital fed to them, and letting you forget the hi-fi in favour of the performance. Unfortunately for most of us, they tend to cost a lotta money and remain an aspirational product, such that the topics of 'buying one' and 'winning the lottery' are often heard in the same breath.

Having heard rumours that the inexpensive Cambridge Audio DACmagic II mk2 was worth a second listen, we secured a sample for closer examination. Sure enough, the sound quality heard when hooked up to even a budget integrated CD player's S/PDIF output showed that this DAC had real potential. And when Richer Sounds dropped the price another £20, to £99.95, we decided that this would be the ideal platform for a DIY upgrade project.

The basic design, though not cutting edge in technology, is a very good one. Designed by John Westlake, former electronics engineer at Pink Triangle, the DACmagic is hampered principally by those same low-cost electronic components that help keep the price competitive. This works to the advantage of any enthusiast handy with a soldering iron, as some simple substitution in key areas, from cheap mass-market components to audio-grade pieces, is often enough to

transform sound quality. Hence, an off-the-shelf DACmagic can be acquired, audio-grade components added, and performance lifted way out of its station, and all for less than £250.

Three entirely separate transformers supply the circuit board — one for digital processing, two and three individually powering left and right conversion/analogue channels. Power from their 15V secondaries is rectified by cheap silicon diodes, smoothed by banks of predominantly 3300µF electrolytic capacitors ('elcaps') and thence passed to a total of 23 voltage regulators around the board. The main thrust of the modification operation here was to focus on these components and associated decoupling capacitors.

Digital conversion itself is accomplished by a pair of Philips

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TDA1305 '18-bit' hybrid chips, surface-mounted on the underside of the board. This converter chip, last heard working to singularly good effect in the Naim CD3.5, is applied here in dual-differential mode, where each two-channel chip takes positive and negative phases. This provides a straightforward facility for a balanced audio output through the DAC's XLR sockets, although in the modified prototype the conventional RCAs were only ever used. Before the output socketry lies a pair of dual op-amps for output buffering — another area for easy upgrading, as the (already better-than-average) Analog Devices AD712s may be improved upon.

Within the constraints of a realistic parts budget (in this project, a nominal £100), the main areas addressed were rectification, smoothing and decoupling; later came attention to screening, output buffering and vibration damping.

SOLDERING IRON TIME

Remove the top cover's six screws on the side and rear to lift the lid. Inside can be seen the three transformers to the front, and circuit board at rear, the latter held in place by PCB-mounted socketry along one edge and two pillars on the opposing edge. The PCB will need to be lifted out to access the underside, but this need not mean totally extracting the board from the chassis; it can be left connected to the XLR outputs by their ribbons, unless you prefer to

This project started as an innocent exchange of a few capacitors.

The surprise was the transformation — from DACmagic to sublime sorcery

by **ANDREW HARRISON**

Magical Conversion



de-solder these from the unit (as with this example) to facilitate access. Other cabling from the transformers and to the front panel simply unclips.

The main reservoir caps exchanged are those responsible for the 5V and 12V digital sections and the DAC chips. The output stage caps were left as standard although this is an area for experimentation — see box. The bulk of the modification is replacement of cheap elcaps for quality OS-CONs and Elnas. The position and part numbers for these are shown in Figs 1 and 2. Substitution is simply a matter of desoldering an original cap (a desolder pump and/or braid makes this a cleaner and easier process) and installing a new one. This is best done one at a time in order that the correct polarity can be observed. When exchanging a non-polarised ceramic cap for polarised elcap, the correct orientation is essential. If, as is often the case, the ceramic was paralleled with a larger value elcap, then orientation should be obvious. Where it is less immediately apparent, the following guide should help. The negative (-ve) leg will face to one of four sides of the board, if viewed from above with the DACmagic's front panel towards you.

The Elna elcaps in the main reservoir bank are easy to fit, but

make sure the polarity of the additional bypass OS-CONs on the underside tally with those above. The other capacitor changes are an additional by-pass 0.1µF OS-CON, mounted on the underside in parallel with C120, (cleans the +5V rail to IC34, SN74HC157 input logic chip). The final capacitor change was the initial coupling cap (C115) on the 'CD' input, a 0.1µF ceramic. This was exchanged with a 0.1µF Audyn KP polypropylene and 0.01µF MIT MultiCap in parallel. This configuration has been tried on other DACs to good effect, although the effect here was not clearly discernible. It was kept in place since switching between standard 'DAT' and modified 'CD' inputs remained an easy option for comparison.

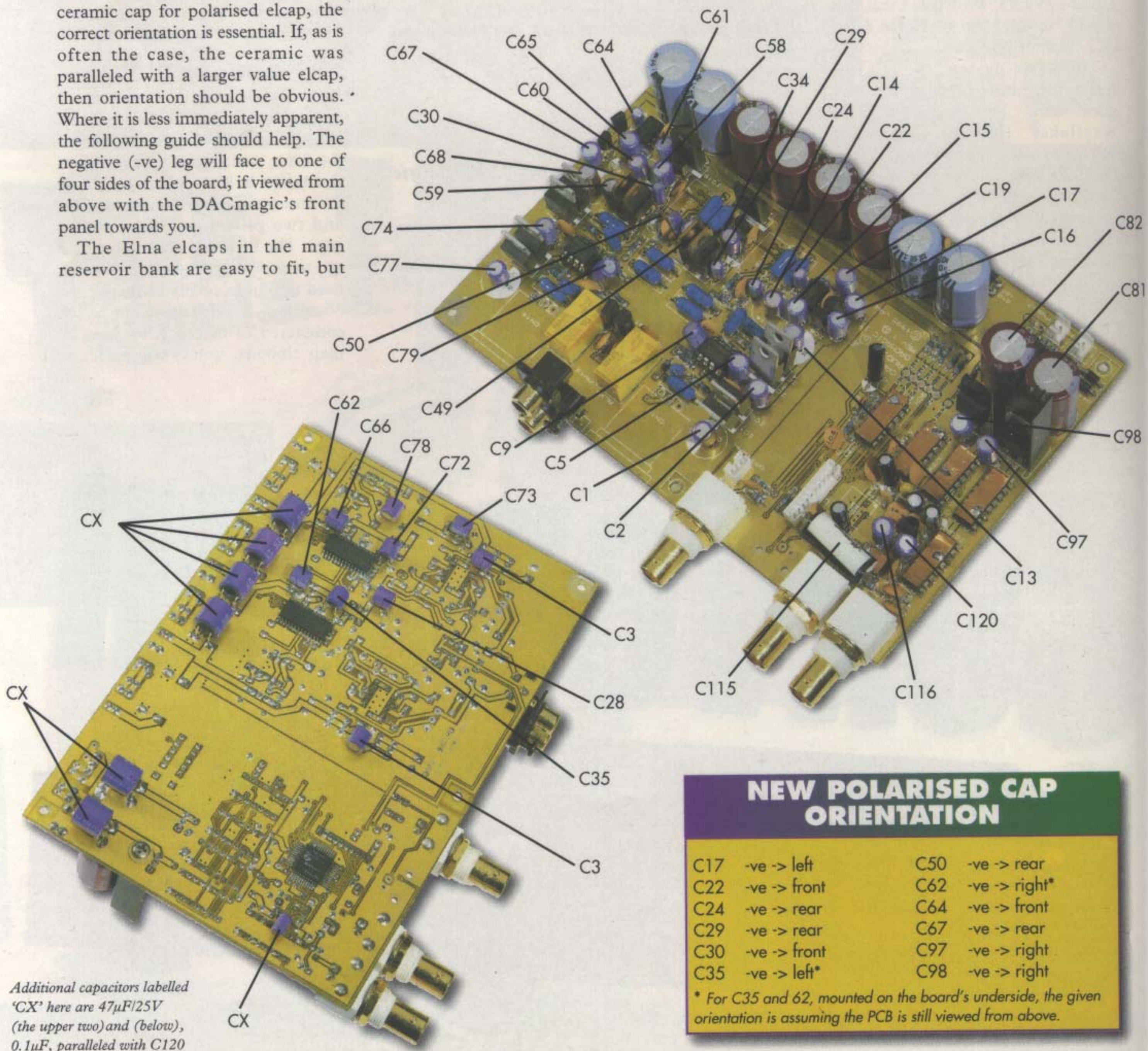
The output op-amps were substituted to Burr-Brown OPA

SUPPLIER

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2134PA, mounted in 8-pin DIL sockets. Using such sockets (high quality turned pin, RS 813-115) makes experimentation easy, as other chips can be evaluated quickly without the fiddly job of chip desoldering; in our modified sample, the old AD712s were actually destroyed in the removal process. Using a de-solder wick is essential here — put iron tip to chip pin termination on the board's underside with the braid between pin and tip. Applying gentle iron pressure wicks away enough solder to allow the chip to come free.

Rectification diodes were swapped from cheap 1N4004 to Schottky 11DQ10 for all rectification stages. Careful orientation should again be observed, with the 'banded' diode end corresponding to the 'line' (cathode) side marked in circuit



Additional capacitors labelled 'CX' here are 47µF/25V (the upper two) and (below), 0.1µF, paralleled with C120

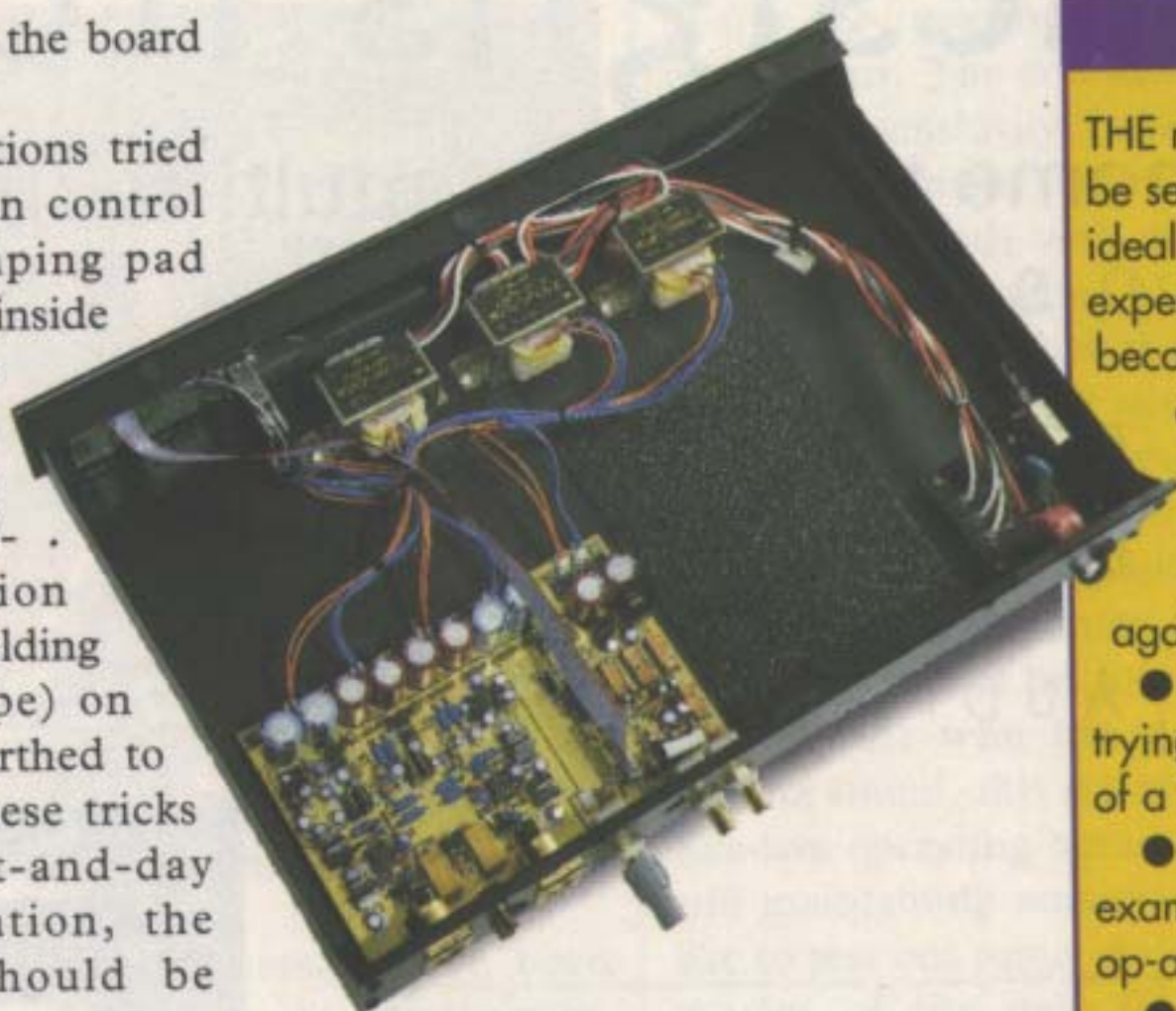
NEW POLARISED CAP ORIENTATION

C17	-ve -> left	C50	-ve -> rear
C22	-ve -> front	C62	-ve -> right*
C24	-ve -> rear	C64	-ve -> front
C29	-ve -> rear	C67	-ve -> rear
C30	-ve -> front	C97	-ve -> right
C35	-ve -> left*	C98	-ve -> right

* For C35 and 62, mounted on the board's underside, the given orientation is assuming the PCB is still viewed from above.

diagrams (and printed on the board itself).

Some further modifications tried on our sample: vibration control with bitumen-type damping pad stuck to chassis base and inside of top cover (available from car repair shops); ferrite ring around power cable inside unit, for RF-noise attenuation (AudioQuest); copper shielding (CHO-FOIL copper tape) on data processing chips, earthed to ground. While any of these tricks may not give night-and-day improvements in isolation, the compounded effect should be beneficial.



THE QUALITY OF SOUND

A DACmagic II mk2, from the box, is a good-sounding converter, a valid upgrade in itself for budget to mid-priced CD players. Its faults (when compared to much pricier machines) include an edgy, hard sound, and what could be described as a detailed but pushy sound.

We kept an unmodified DACmagic as a reference, showing the abyss that separated the two as upgrades were made.

The finished upgraded model seen here has a relatively natural and inviting sound, that, while not as sharp and airy as some, nonetheless really does let the music flow quite effortlessly. The following comments are made with respect to using the S/PDIF coaxial input with Audiolab

and TAG McLaren disc transports. Digital cables tried include Kimber DV-30, DV-75, vdH The First and Ecosse Digital.

The soundstage is very wide and diffuse — there is no strict cut-off at the speakers' perimeter. Vocal images hold fast in space and invite listening with little sense of constraint or limiting. Tonally, the top end is detailed and sharp enough to convey nuances of, say, close-miked cymbal strikes but never falls prey to undue sibilance are synthetic-sounding glare. Midrange is equally natural and relatively uncolored, but the most incredible surprise was in bass drive.

There is an organic warmth and velvety-ness in the low octaves that brings to mind sub-chassised

NEXT STEPS

THE modifications carried out for this project should not be seen as final and authoritative. They are, instead, an ideal launching pad for further 'tweaks' and experimentation, the commencement of which can become an all-consuming obsession. To anyone already afflicted this is old news. To the rest — you have been warned!

Here are some pointers for more fun:

- Upgrade the reservoir caps in the output stage, again supplemented by low-capacitance bypass caps.
 - Look at the many voltage regulators themselves, trying for example, Linear Technology LT323AT in place of a 7805.
 - Output op-amps can be substituted with, for example, Burr Brown OPA 2132AP. Be aware that some op-amps don't like operation with unity gain, though.
 - Voltage reference to the TDA1305 is critical. Try improving the NE5534 op-amp to, say, Burr Brown OPA132P. Also look to uprate C14 and C60 which smooth power before the V REF input.
 - All resistors can be investigated and exchanged with, for example Holco or Vishay, exploiting their associated better temperature co-efficients, lower noise and reduced inductance.
 - Those three transformers could also be replaced with high quality toroids, perhaps even mounted in an outboard box.
 - The box itself, while very sturdy for the money, is made from pressed steel. This could be exchanged for something non-ferrous.
- Remember to make changes in gradual steps if you're looking to make subjective evaluation of any particular mod. In the event of a breakdown, it also becomes easier to spot a fault.

turntables. This comes as a welcome break from many a CD player that sounds too top- or mid-focused, and arguably contributes to this budget bargain's listenability. A critical part of my conscience started to wonder if the emphasis was too far in favour of the bass spectrum. Euphony there may be due to low-frequency jitter effects finding themselves accentuated in a reduced field of HF jitter, though without measurement this remains speculation.

One thing worth pointing out is that the optical Toslink connection, often shunned as sounding too 'glary', works very well on this DAC and should not be instantly overlooked.

With a few notable exceptions, digital-to-analogue converters are easily the most boring-looking pieces of equipment in a hi-fi system. With these modifications you may agree that at least music need not be as grey to listen to. †

Acknowledgments

With thanks to Mark Bartlett, John Cheadle and John Westlake for assistance in this project.

A kit of components to upgrade the DACmagic can be supplied, at a special 10% reduction for HFN/RR readers, by AudioCom (UK) Ltd. For less confident DIYers, Audiocom is also able to carry out all the necessary fitting work. Contact 01834 842803 for more details.

COMPONENT CHANGES

Part No:	Original spec	New part	Part No:	Original spec	New part
C1	2200µF/16V	22µF/20V	C87	3300µF/25V	2200µF/25V
C2	10µF/25V	10µF/25V			ELNA R20
C5	47µF/16V	10µF/16V			+ 47µF/25V
C77	2200µF/16V	22µF/20V	C88	3300µF/25V	2200µF/25V
C73	47µF/16V	10µF/16V			ELNA R20
C3	10µF/25V	10µF/25V			+ 47µF/25V
C13	2200µF/16V	22µF/20V	D20,21,22,23	1N4004	11DQ10 x 4
C9	47µF/16V	10µF/16V	C95	100nF	Discard
C72	10µF/25V	10µF/25V	C35	100nF	10µF/16V
C68	2200µF/16V	22µF/20V	C62	100nF	10µF/16V
C79	47µF/16V	10µF/16V	C47	10µF/25V	10µF/16V
C15	100µF/10V	10µF/16V	C29	100nF	10µF/25V
C16	10µF/25V	10µF/16V	C28	100µF/10V	10µF/16V
C17	100nF	10µF/25V	C59	10µF/25V	10µF/16V
C22	100nF	0.1µF/25V	C30	100nF	10µF/25V
C65	100µF/10V	10µF/16V	C78	100µF/10V	10µF/16V
C66	10µF/25V	10µF/16V	C81	2200µF/25V	2200µF/25V
C67	100nF	10µF/25V			ELNA R20
C64	100nF	0.1µF/25V			+ 47µF/25V
C19	100µF/10V	10µF/16V	D4,5,6,7	1N4004	11DQ10 x 4
C14	2200µF/16V	22µF/20V	C97	100nF	10µF/25V
C24	100nF	0.1µF/25V	C82	2200µF/25V	2200µF/25V
C61	100µF/10V	10µF/16V			ELNA R20
C60	2200µF/16V	22µF/20V			+ 47µF/25V
C50	100nF	0.1µF/25V	D8,9,10,11	1N4004 x 4	11DQ10 x 4
C34	100µF/10V	10µF/16V	C98	100nF	10µF/25V
C58	100µF/10V	10µF/16V	C91	100nF	discard
C85	3300µF/25V	2200µF/25V	C120	100µF/10V	22µF/20V
		ELNA R20			+ 0.1µF/
		+ 47µF/25V	C115	100nF	0.1µF/250V
C86	3300µF/25V	2200µF/25V			Audyn Cap KP
		ELNA R20			+ 0.01µF
		+ 47µF/25V	C116	100µF/10V	MITMultiCap
D16,17,18,19	1N4004	11DQ10 x 4			10µF/16V
C94	100nF	Discard			

All capacitors are Sanyo OS-CON SC unless otherwise stated