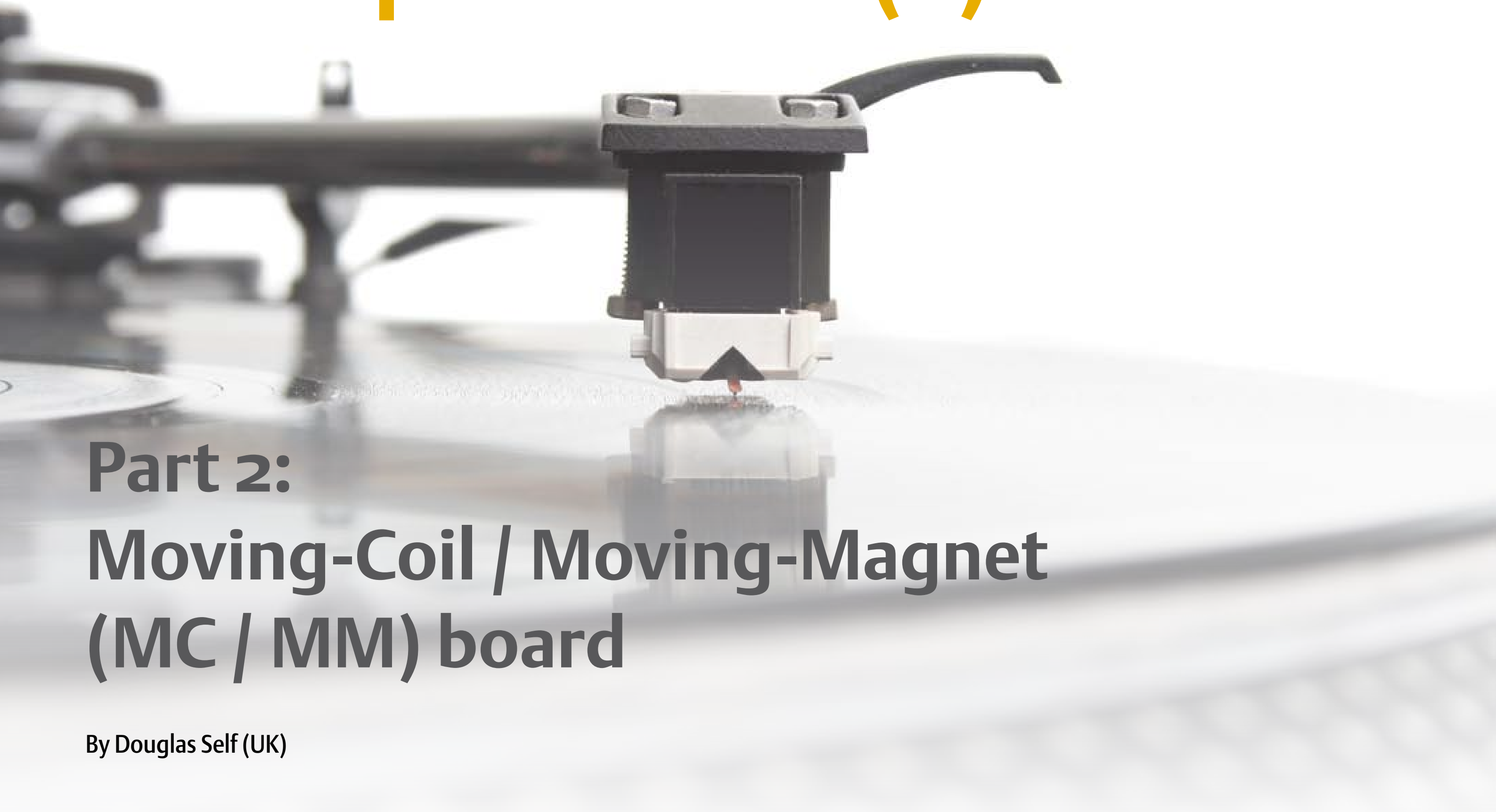
Preamplifier 2012 (2)



Part 2: Moving-Coil / Moving-Magnet (MC / MM) board

By Douglas Self (UK)

Just in case you didn't know, vinyl records are making a comeback and there are even under-25 musicians releasing new material on CD cheerfully along with vinyl, preferably of the 180-gram variety. Also, high-end turntables are available at extragalactic prices but none of this makes any sense if you do not have a preamplifier to match your MC or MD cartridge optimally and that's exactly what the present design does — rather successfully.

Referring back to the block diagram of the Preamplifier 2012 shown in part 1 of the article [1], this month we discuss the blocks identified as 'MC preamp', 'Load synth', MM preamp', Bandwidth definition filter' and 'Switched gain'. Note that the switch drawn with Switched gain' block is actually an on-PCB jumper block. All units are comprised on a single circuit board, the second of a total of seven that make up our very high end audio control amplifier. Let's see how it all works by taking a tour of the circuit diagram in **Figure 1**.

Moving-Coil (MC) stage

This stage built around transistors T1-T4 and opamps IC1A and IC2A gives very low noise with the low impedances of moving-coil cartridges. It provides a fixed gain to its output of +30 dB. Gain switching to cope with the very wide range of MC cartridge sensitivities is done later in the switched-gain stage. There are no compromises on noise or headroom with this architecture, and no necessity to switch the gain of the MC stage, which simplifies things considerably.

The total gain of the stage is actually +45 dB, to allow a sensibly high value of feedback resistance defined by R8 and R9. Only part of this gain is used, tapped off via C7. The extra 15 dB of gain causes no headroom problems as the following MM stage will always clip long before the MC stage.

The DC conditions for the 2SA1085 input transistors are set by R3 and R4. The DC conditions for the opamp IC1A are set independently by the DC integrator servo IC2A, which enforces exactly 0 V at the output.

This MC stage design gives a 1 dB improvement in noise performance (for 3.3 Ω and 10 Ω source resistances) compared with earlier versions of this circuit. This results from using four paralleled 2SA1085 pnp transistors, which should be easier to obtain than the obsolete 2SB737; the latter can however be used if you have them.

Component positions R1 and C1 are provided so the cartridge loading can be modified. This has only a marginal effect on MC cartridge response in most cases because the cartridge impedance is so low. However, if you want to experiment then the appropriate range for R1 is 10 Ω- 1 kΩ, and for C1 0 – 10 nF.

Moving-Magnet (MM) stage

This is a relatively conventional stage, except that it uses multiple polystyrene capacitors to obtain the required value

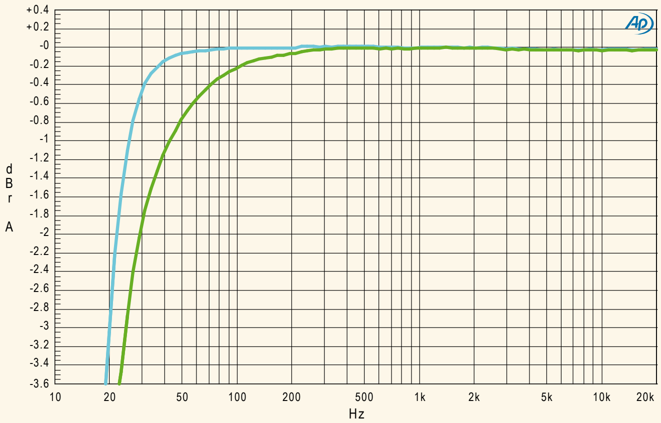
Performance graph

MC/MM board # 110650-2 only.

Test equipment: Audio Precision Two Cascade Plus 2722 Dual Domain (@Elektor Labs).

Here we have the AP-2 supplying an amplitude corrected signal according to RIAA pre-equalisation curve. This allows the deviation from the ideal RIAA curve (amplitude error) to be visualised conveniently. The curve with the higher roll-off point was plotted with the IEC Amendment relay energised. The error at 20 kHz is less than 0.06 dB, measured on the left-channel MC input. Measurements on the right-channel MD input gave practically identical results, the curves matching extremely closely.

In conclusion it is safe to say that the investment in a large number of relatively costly polystyrene capacitors in this section of the Preamplifier 2012 is justified.



(polyester capacitors have worse tolerance and introduce non-linear distortion) and to improve RIAA accuracy (because random errors in the capacitor values tend to cancel). Multiple RIAA resistors R22-R23 and R24-R25 are used to improve accuracy in the same way. The value of C12 is large as the IEC amendment is not implemented in this stage.

The HF RIAA characteristic is corrected for the relatively low gain of the stage by R26, R27, and C22. Once again two resistors are used to improve accuracy, and C22 is polystyrene.

Note that an NE5534A is used here for IC3 as it is quieter than half an NE5532, and considerably quieter than an LM4562 with its higher current noise. The high inductance of an MM cartridge makes low current noise important. Cartridge loading, and capacitance in particular, has a much greater effect on MM cartridges. Component positions R13 and C8 are provided so it can be modified. The appropriate range for C8 is 0–330 pF. Adding extra loading resistance is rarely advocated; if used here it will partly undo the noise reduction given by the load synthesiser. The lowest recommended value for R13 is 220 kΩ.

The load synthesiser

A load-synthesis circuit around IC4 is used to make an electronic version of the required 47 kΩ loading resistor from the 1 MΩ resistor R16. The Johnson noise of the resistor is however not emulated and so noise due to the rising impedance of the MM cartridge inductance is eliminated. R16 is made to appear as 47 kΩ by driving its bottom end in anti-phase to the signal at the top. IC4B shows a high impedance to the MM input while IC4A is an inverting

MM/MC Board Performance

Test conditions: supply voltage ±17.6 V, B = 80 kHz; measured at Volume/Balance/Tone control board output (# 110650-1); volume set to 1 V out.

Test equipment: Audio Precision Two Cascade Plus 2722 Dual Domain (@Elektor Labs)

MD: 5 mV in, 1 kHz, JP1/2 = 15 dB (source 750 Ω)	THD+N S/N S/N S/N (input shorted)	0.008 % 82 dB 86 dBA 88 dBA
MC: 0.2 mV in, 1 kHz, JP1/2 =15 dB (source 1 Ω)	THD+N S/N S/N	0.016 % 76 dB 79.5 dBA
MC stage gain		29.8 dB

Low roll-off (–3 dB)	19.8 Hz (L) 20 Hz (R) 23.3 Hz (L, IEC Amendment on) 24.8 Hz (R, IEC Amendment on)
Deviation from straight line:	–0.06 dB (100 Hz to 20 kHz)

Gain definitions on JP1/JP2 (dB)	L	R
0	0	0
5	5.22	5.23
10	10.95	10.97
15	14.71	14.72
20	19.52	19.51

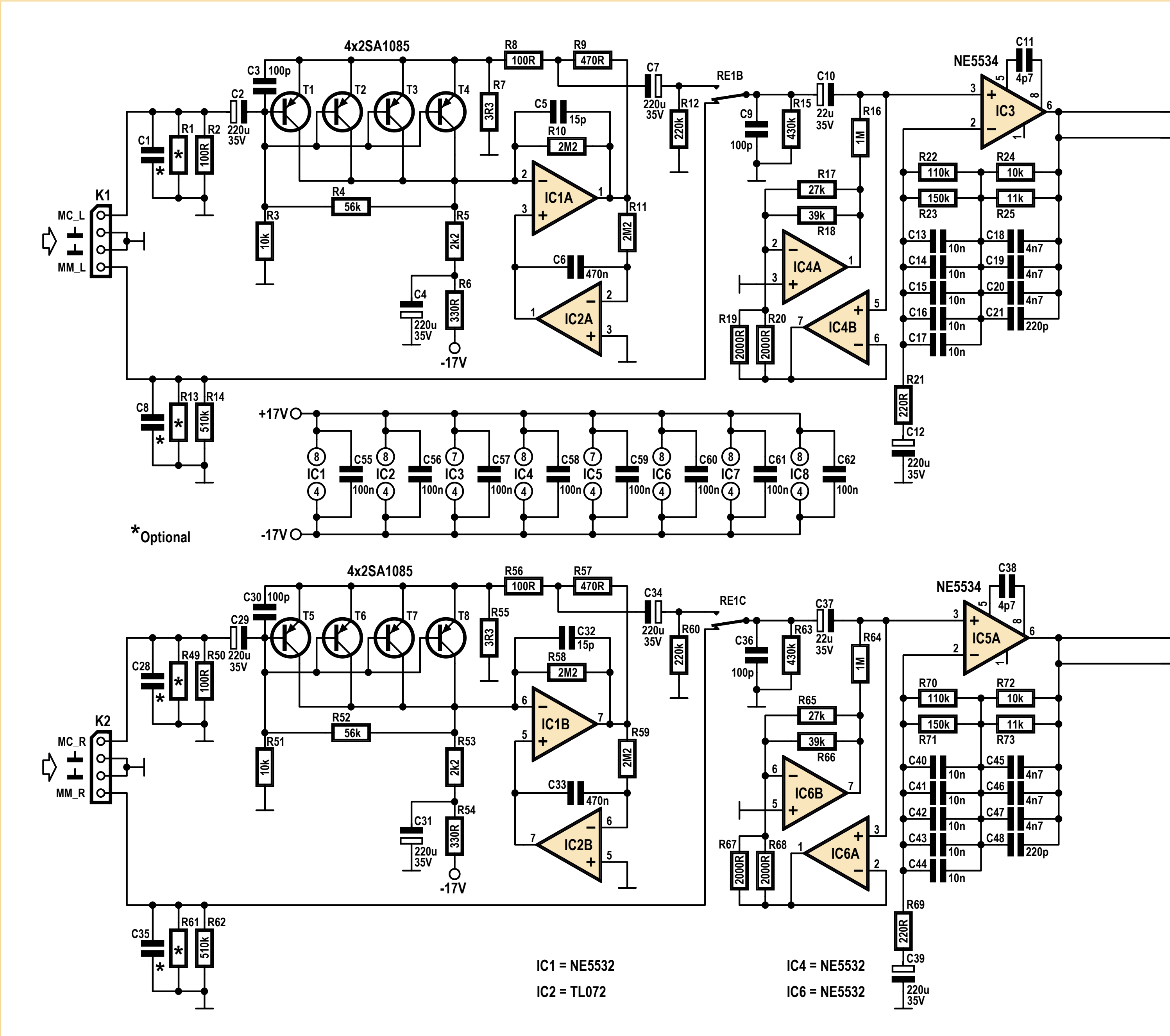
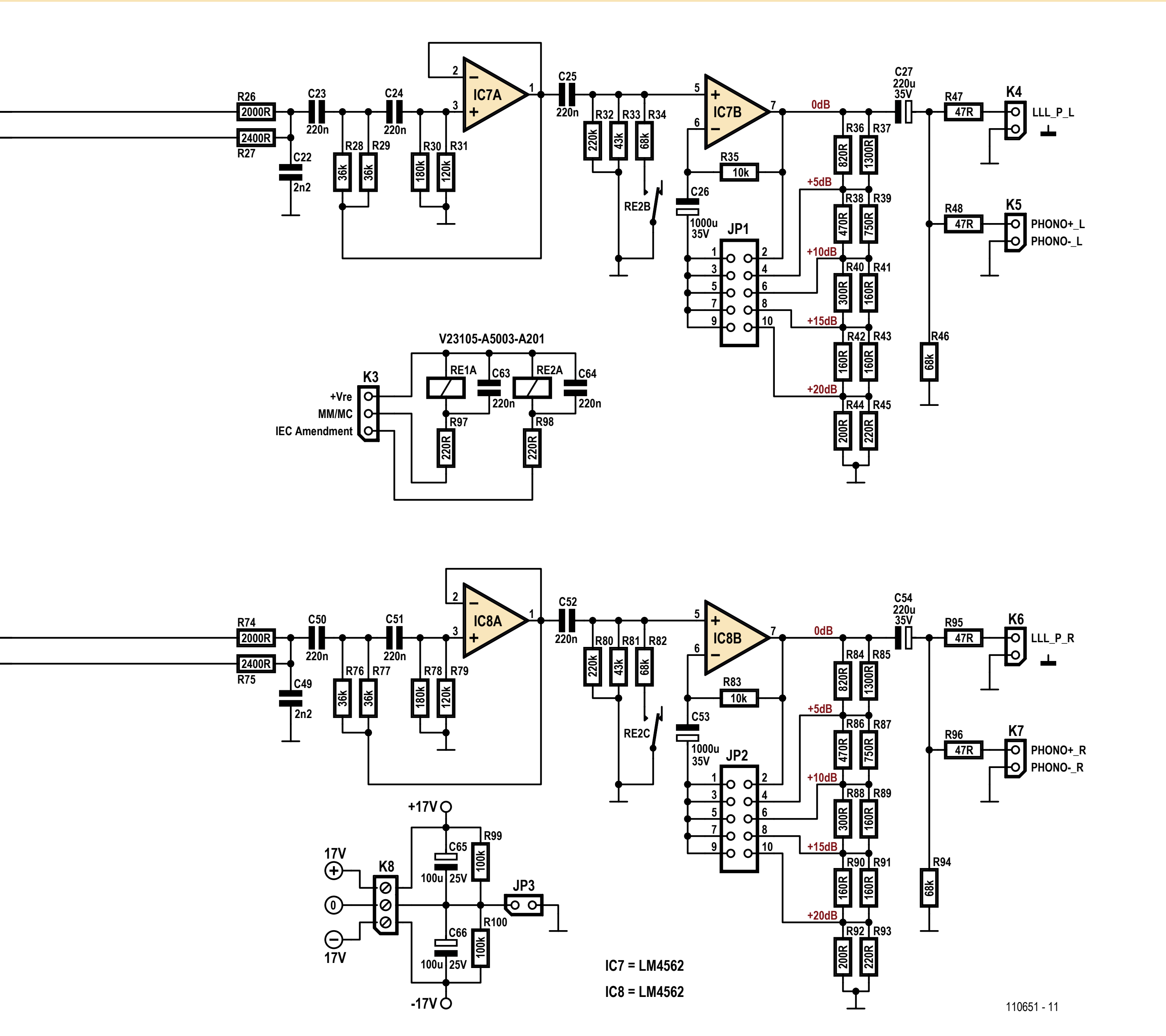


Figure 1. The circuit diagram of the moving coil / moving magnet preamplifier section of our Preamplifier 2012. Everything is designed with low noise in mind, as well as perfect adaptability to a wide variety of MC or MD cartridges out there.

stage. Multiple resistors R19-R20 and R17-R18 are used to improve gain accuracy and therefore the accuracy of the synthesised impedance.

Subsonic filter

This is a two-stage 3rd-order Butterworth highpass filter that is –3 dB at 20 Hz. Multiple resistors R28-R29 and R30-R31 are again used to improve accuracy. My previous preamp designs have used a single-stage version of this, but I have found the two-stage configuration is preferred when seeking the best possible distortion performance [2]. An LM4562 is used here (IC7A) as



Check the figures in the Performance inset to see if we've been anywhere near successful.

it significantly reduces distortion.

Switchable IEC amendment

The IEC amendment is an extra LF roll-off that was added to the RIAA spec at a later date. Most people regard it as unwelcome, so it is often omitted. Here it can be switched in by placing an extra resistance R34 across the subsonic filter resistances R32-R33. This is something of an approximation, but saves an opamp stage and is accurate to ±0.1 dB down to 29 Hz. Below this the subsonic filter roll-off begins and the accuracy is irrelevant.

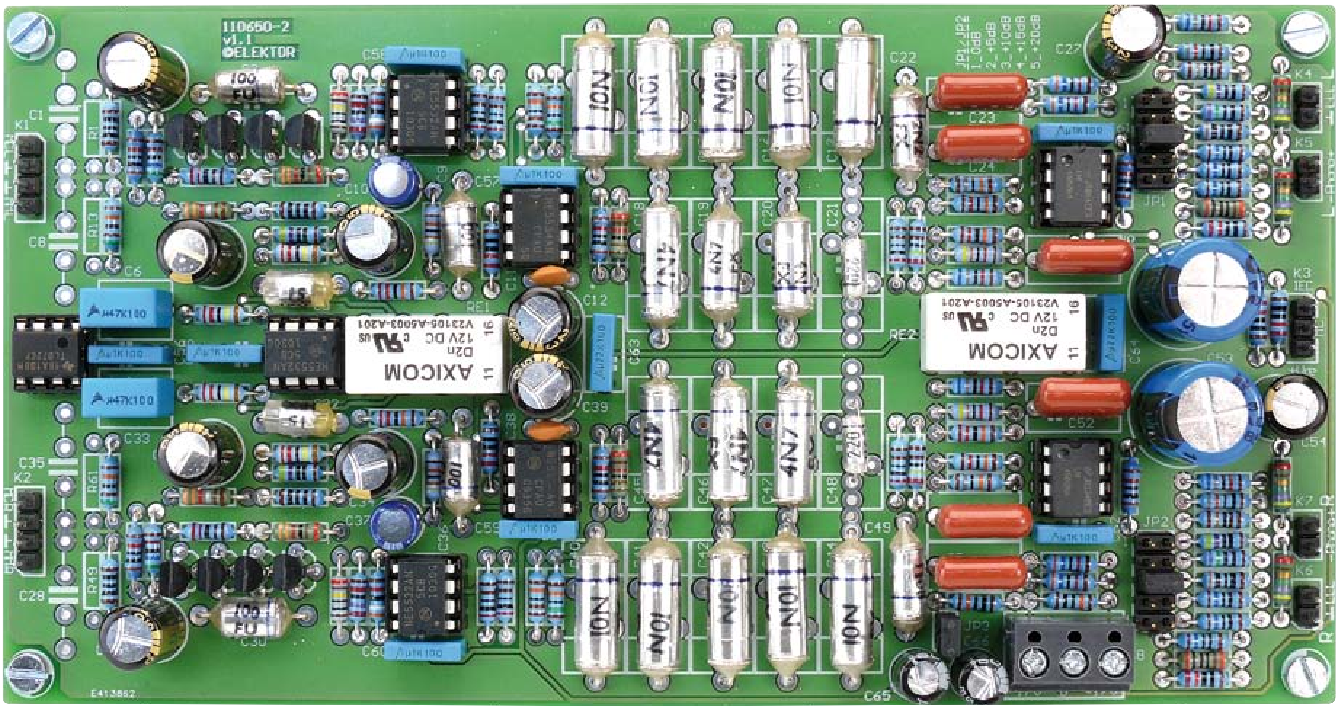


Figure 3. Fully assembled and tested MM/MD board "escaped from the Elektor Labs".

The switched-gain stage

This stage around IC7B allows every individual MC and MM cartridge on the market to receive the amount of gain required for optimal noise and headroom. The gain is varied in 5 dB steps by a jumper on jumper block JP1 selecting the desired tap on the negative-feedback divider R36–R45. Each divider step is made with two paralleled resistors to get the exact value required, and improve accuracy. R35 provides continuity of DC feedback when the switch is altered.

The drive signal to the Log-Law Level LED stage (LLLL) is tapped off via R47 and appears on connector K4. The LLLL circuit and circuit board will be discussed next month.

Construction

The circuit is constructed on double-sided through-plated printed circuit board # 110650-2 (note number) of which the silkscreen (component overlay) is shown in **Figure 2**. As with the board we discussed in the previous instalment, assembly is largely a routine matter since only through-hole parts and conventional soldering are involved. For assembly we again recommend the use of a grill or the even better a flip-over type of PCB assembly jig. Assuming you have positively identified each and every part using the components list, the flip-over jig enables the parts leads to be inserted first. Next, the parts are held securely in place at the top side of the board by a thick layer of packaging foam and a clamp-on panel. The board then gets flipped over allowing the wires to be soldered one by one without the parts (now at the underside) dropping or dislocating. Experienced users do the low-profile parts first for obvious reasons.

The end result should be a board that's as thoughtfully built as the circuit was designed — check your personal effort against our prototype pictured in **Figure 3**.

(110651)

References

[1] Preamplifier 2012 part 1, Elektor March 2012; www.elektor.com/110650.

[2] Peter Billam 'Harmonic Distortion in a Class of Linear Active Filter Networks', *Journal of the Audio Engineering Society* June 1978 Volume 26, No. 6, p426.

COMPONENT LIST

Resistors

(1% tolerance, metal film, 0.25W)
R1,R13,R49,R61 = optional, see text
R2,R8,R50,R56 = 100Ω
R3,R24,R35,R51,R72,R83 = 10kΩ
R4,R52 = 56kΩ
R5,R53 = 2.2kΩ
R6,R54 = 330Ω
R7,R55 = 3.3Ω
R9,R38,R57,R86 = 470Ω
R10,R11,R58,R59 = 2.2MΩ
R12,R32,R60,R80 = 220kΩ
R14,R62 = 510kΩ
R15,R63 = 430kΩ
R16,R64 = 1MΩ
R17,R65 = 27kΩ
R18,R66 = 39kΩ
R19,R20,R26,R67,R68,R74 = 2.00kΩ
R21,R45,R69,R93,R97,R98 = 220Ω
R22,R70 = 110kΩ
R23,R71 = 150kΩ
R25,R73 = 11kΩ
R27,R75 = 2.4kΩ
R28,R29,R76,R77 = 36kΩ
R30,R78 = 180kΩ
R31,R79 = 120kΩ
R33,R81 = 43kΩ
R34,R46,R82,R94 = 68kΩ
R36,R84 = 820Ω
R37,R85 = 1.3kΩ
R39,R87 = 750Ω
R40,R88 = 300Ω
R41,R42,R43,R89,R90,R91 = 160Ω
R44,R92 = 200Ω
R47,R48,R95,R96 = 47Ω
R99,R100 = 100kΩ

Capacitors

C1,C8,C28,C35 = optional, see text
C2,C4,C7,C12,C27,C29,C31,C34,C39,C54 = 220µF 35V, 20%, diam. 8mm, lead spacing 3.5mm
C3,C9,C30,C36 = 100pF 630V, 1%, polystyrene, axial
C5,C32 = 15pF ±1pF 160V, polystyrene, axial
C6,C33 = 470nF 100V, 10%
C10,C37 = 22µF 35V, 20%, diam. 6.3mm, lead spacing 2.5mm
C11,C38 = 4.7pF ±0.25pF 100V, lead spacing 5mm
C13-C17,C40-C44 = 10nF 63V, 1%, polystyrene, axial
C18,C19,C20,C45,C46,C47 = 4.7nF 160V, 1%, polystyrene, axial
C21,C48 = 220pF 630V, 1%, polystyrene, axial
C22,C49 = 2.2nF 160V, 1%, polystyrene, axial
C23,C24,C25,C50,C51,C52 = 220nF 250V, 5%, polypropylene, lead spacing 10mm
C26,C53 = 1000µF 35V, 20%, diam. 13mm, lead spacing 5mm
C55-C62 = 100nF 100V, 10%, lead spacing 7.5mm
C63,C64 = 220nF 100 V, 10 %, lead spacing 7.5 mm
C65,C66 = 100µF 25V, 20%, diam. 6.3mm, lead spacing 2.5mm

Semiconductors

T1-T8 = 2SA1085, Hitachi, e.g. Reichelt.de # SA 1085; RS Components # 197-9834
IC1,IC4,IC6 = NE5532, e.g. ON Semiconductor type NE5532ANG
IC2 = TL072
IC3,IC5 = NE5534, e.g. ON Semiconductor type NE5534ANG
IC7,IC8 = LM4562, e.g. National Semiconductor type LM4562NA/NOPB

Miscellaneous

K1,K2 = 4-pin straight pinheader, pitch 0.1'' (2.54mm)
Socket headers for K1,K2
K3 = 3-pin straight pinheader, pitch 0.1'' (2.54mm)
Socket header for K3
K4-K7,JP3 = 2-pin straight pinheader, pitch 0.1'' (2.54mm)
Socket header for K4-K7
Jumper for JP1,JP2,JP3
JP1,JP2 = 10-pin (2x5) pinheader, pitch 0.1'' (2.54mm)
K8 = 3-pin screw terminal block, lead pitch 5mm
RE1,RE2 = relay, DPDT, 12V/960Ω, 230V/3A, PCB mount, TE Connectivity/Axicom type V23105-A5003-A201
PCB # 110650-2 (www.elektorpcbservice.com)

Note: parts available from Farnell (but not exclusively), except T1–T8 and PCB 110650-2.

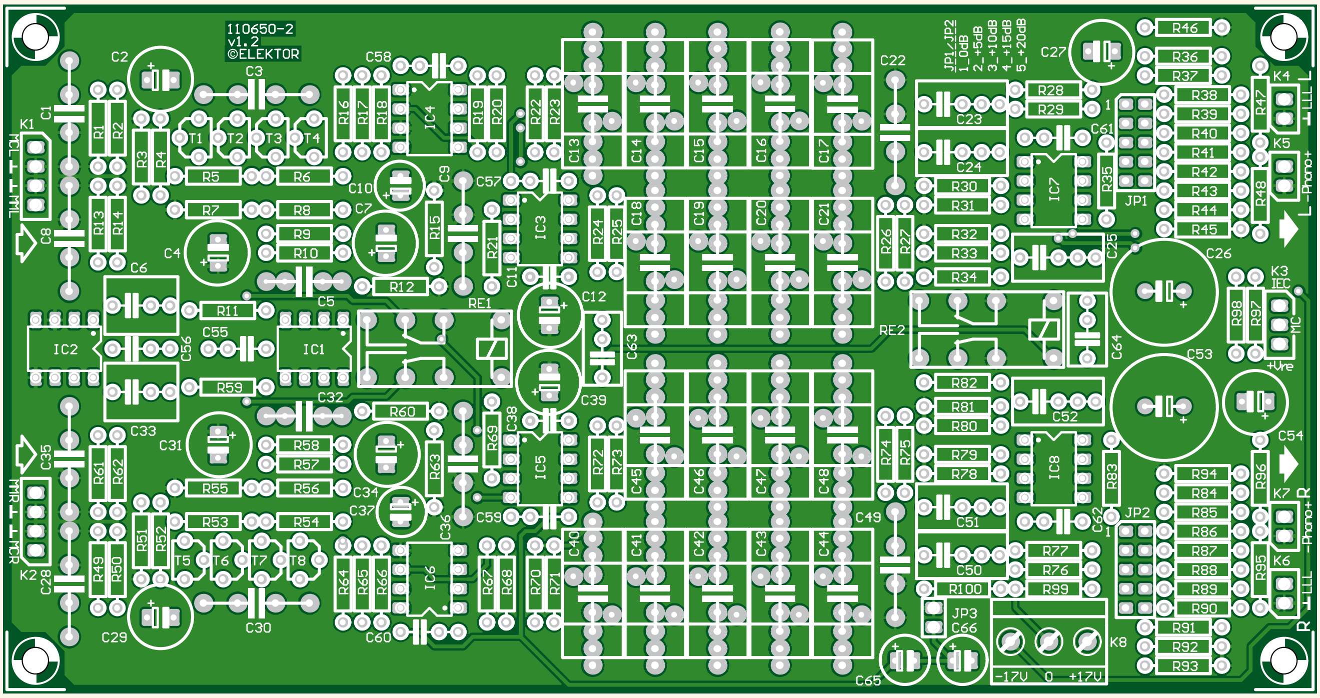


Figure 2. Component overlay of the MM/MC board. The high quality ready-made board is available from ElektorPCBservice.com.