Constructional Project

Sound Card Mixer

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Bring "Life" to your computerised live recordings!

HAVE you ever used your computer's sound card to make a live recording? Did you plug a microphone into the "microphone input" socket and were disappointed with the results? If so, read on!

The most common complaints from people doing this are of weak or distorted sound. One reason appears to be that there is no uniform standard set for this input. In many cases, it will have been designed for a computer microphone (say, for voice recognition purposes) rather than the general type used for music and voice recording. Even if the input is sufficiently sensitive to handle the very low signal from a good quality microphone, the on-board preamplifier is often of a low quality, resulting in distortion.

On the Level

Such problems may be overcome by using the sound card's Line input instead. This has more predictable characteristics and should be more or less the same for all makes and types of card. However, you cannot plug a microphone directly into this input and expect it to work properly. This is because it requires a signal of up to one volt to load it, rather than the few millivolts available from the microphone. A preamplifier is therefore necessary between the microphone and sound card to boost the signal.

One point worth noting is that the microphone input on a cheap sound card is sometimes a line level input anyway and the socket labelled "line input" appears to do nothing!

The Sound Card Mixer circuit described here provides the boost necessary to bring the microphone output to line level. However, while designing it, certain other issues were addressed to make it appeal to more readers. To this end, the finished device takes the form of a desktop unit which is connected to the sound card through a short length of cable. This avoids having to fumble behind the computer whenever connections need to be changed.

The new unit also provides additional inputs – for two stereo microphones (or four mono ones) plus a stereo line input. The latter allows a high-level device such as a CD player, tape deck or musical instrument to be connected. Of course not all the inputs need be used.

Six controls on the front panel allow the left and right channels of all inputs to be adjusted and mixed independently to provide a single pair of stereo outputs.

Extra Inputs

If the circuit is built in the specified case, there will be space for more sockets in addition to those described above. These could provide composite video input and output, for example, which might be used for video editing. These sockets would be connected directly to the computer, using their own cables – they would not really be part of the new circuit.

The unit is powered using an internal 9V battery pack consisting of six "AA" size alkaline cells. An On-Off switch and associated light-emitting diode (l.e.d.) "On" indicator are also fitted. The circuit draws some 40mA while operating, so the batteries may be expected to provide about 35 hours of service. Larger batteries could be used providing there is sufficient space inside the case to accommodate them (or you place them externally).

Another good method would be to use six nickel-cadmium or nickel metal hydride (rechargeable) batteries. Their 7·2V nominal output would be sufficient. It is not advisable to power the circuit from a mains-derived supply because there could be problems with mains induced hum.

Circuit Description

The full circuit diagram for the Sound Card Mixer is shown in Fig.1. IC1 to IC4 are identical low-noise dual operational amplifiers (op.amps). There are therefore eight op.amps altogether. All the "a" sections are associated with Right channels while the "b" ones are used for the Left.

Op. amps IC1a and IC1b are used for the first microphone input (MIC 1) while IC2 performs the same function for the other one (MIC 2). Op. amps IC3a and IC3b are associated with the Line Input. IC4a and IC4b are used as mixers which combine all the Right and all the Left signals obtained from IC1 to IC3.

The positive supply feed is via On/Off switch S1 and operates l.e.d. indicator D2

Completed Sound Card Mixer with author's mods (not described in this article).

COMPONENTS

Approx. Cost Guidance Only **£38** excl. case & batteries

Resistors

R1, R11, R21, R31	680Ω (4 off)
R2, R3, R6, R7, R12, R13, R16, R17, R22, R23, R32, R33, R42, R43, R52, R53	22k (16 off)
R4, R14, R24,R34	47k (4 off)
R5, R15, R25, R35, R41, R45, R51, R55	10k (8 off)
R8, R18, R44, R54	15k (4 off)
R9	560Ω

All 0.25W 5% carbon film or better.

See SHOP TALK page

Potentiometers

VR1, VR11, VR21, VR31	220k enclosed carbon preset, horiz. (4 off)
VR2, VR12, VR22, VR32,VR42, VR52	10k single-turn conductive plastic, 12mm square p.c.b. mounting (2·5mm pin spacing), log. or lin. (6 off)
VR3, VR13	10k enclosed carbon preset, horiz. (2 off)

Capacitors

C1, C11, C21,C31, C41, C51	4µ7 min. radial elect. 35V (6 off)
C2, C6, C12, C16,C22, C32, C42, C52	47µ radial elect. 16V (8 off)
C3, C7, C13, C17, C23, C33,C43, C53	22p ceramic disc, 5mm pitch (8 off)
C4, C5, C8, C9, C14, C15, C18, C19, C24, C25, C34, C35,C44, C45, C54, C55	10µ radial elect. 16V (16 off)
C20	220µ radial elect. 16V
Cx	220n ceramic disc, 5mm pitch (see text) (4 off)

Semiconductors

D1	1N4001 50V 1A rect. diode
D2	red l.e.d. indicator
IC1 to IC4	NE5532 dual low-noise op.amp (4 off)

Miscellaneous

S1	s.p.d.t. toggle switch
SK1 to SK4	3·5mm mono jack socket (4 off)
SK5, SK6	non-insulated phono sockets (see text) (2 off)

Printed circuit board, available from the *EPE PCB Service*, code 489; metal instrument case, 220mm x 170mm x 35mm (min. height) x 80mm (max. height); control knobs (6 off); rubber grommet; AA alkaline cells (6 off); PP3-type battery connector; materials for battery bracket; 8-pin d.i.l. sockets (4 off); small fixings; stereo screened cable; 3.5mm stereo jack plug; plastic p.c.b. spacers (see text); cable tie; connecting wire; solder etc.

via current-limiting resistor R9. Current also flows through diode D1 to charge capacitor C20. The capacitor provides a reserve of charge and maintains any momentary peaks of current which will be useful when the battery is nearing the end of its life.

The diode also provides reverse-polarity protection – if the supply were to be connected the wrong way round, the diode would fail to conduct and nothing would happen. This prevents damage to the other semiconductor devices. Note, however, that the l.e.d. indicator is not protected in this way.

Since the circuits based on IC1a/b and IC2a/b are identical, only a description of that centred around IC1a is required. The Right microphone input is connected to IC1a inverting input, pin 6, via capacitor C1 and input resistor R1 (the equivalent resistor in IC1b is labelled "R11" while in IC2a it is labelled "R21" and so on).

Capacitor C1 allows the a.c. signal to pass while blocking the d.c. path. The resistance of the microphone itself, therefore, does not affect the circuit following it.

Boost

The combined value of fixed resistor R4 and preset potentiometer VR1 in series (the feedback network) divided by that of R1 determines the gain (amplifying factor) of this section. In fact, this is *negative* (since it is configured as an inverting amplifier) but this does not affect the practical result.

With the values specified, the minimum gain is therefore −70 times and the maximum, −400 times approximately, depending on VR1 adjustment. This will be set at the end to match the sensitivity of the microphone used.

Low-value capacitor C3, connected in parallel with R4/VR1, has negligible effect at audio frequencies. This is because its impedance will be high compared with that of the resistors.

However, at frequencies higher than the audio range, its impedance becomes significant and this reduces the overall value of the feedback loop. The gain therefore "rolls off" and prevents any high frequency instability which might otherwise occur.

Bias

The non-inverting input (pin 5) of IC1a is connected to the potential divider consisting of equal-value resistors R2 and R3. This biases it to one-half of the supply voltage (nominally 4·5V). It allows processing of both the positive and negative parts of the input signal by allowing them to swing above and below this level.

However, as far as a.c. is concerned, capacitor C2 maintains the non-inverting input at 0V because it has a very low impedance at audio frequencies and effectively reduces the value of the lower "arm" of the potential divider.

The output signal appears at pin 7 and the a.c. (audio) signal flows, via capacitor C4 and the track of potentiometer VR2, to 0V. Potentiometer VR2 is one of the six panel-mounted mixer controls and it allows a fraction of the output voltage to be "tapped off" by the sliding wiper contact. This is fed, via capacitor C5 and resistor R5, to the Right channel mixer section based on IC4 and which will be described presently.

The above description applies not only to the other microphone channels but also to the line inputs. However, there are certain small differences.

Looking at IC3a (right line channel), the gain is fixed at 1·5 times by the ratio R44/R41. This is much less than the gain of the microphone channels because the signal is already at a high level. A small amount of boost is applied so that a suitable gain will be obtained when the sliding contact of mixer control VR42 is at some intermediate setting.

Mixing It

The right-hand channel signals (two microphone and one line) pass via capacitors C5, C25 and C45 and resistors R5, R25 and R45 respectively to IC4a inverting input, pin 6 (the right channel mixer input). The non-inverting input (pin 5) is biased using resistors R6 and R7 in the same way as for IC1/IC2/IC3.

The gain is the same for all channels and is set by the resistance of R8 divided by that of one of the input resistors (R5, R25 and R45) giving 1·5 times. Capacitor C7 rolls off the gain at high frequencies and promotes stability in the same way as with the previous sections.

The combined right-hand signal passes via capacitor C8 through the track of preset potentiometer VR3, whose sliding contact then "taps off" a fraction of this and the final output appears via capacitor C9. Mixing of the left-hand channels is carried out by IC4b in exactly the same way.

Preset VR3 and VR13 will be adjusted at the end to match the gain to the output requirements of the sound card, also to remove any imbalance that might exist between the right and left channels.

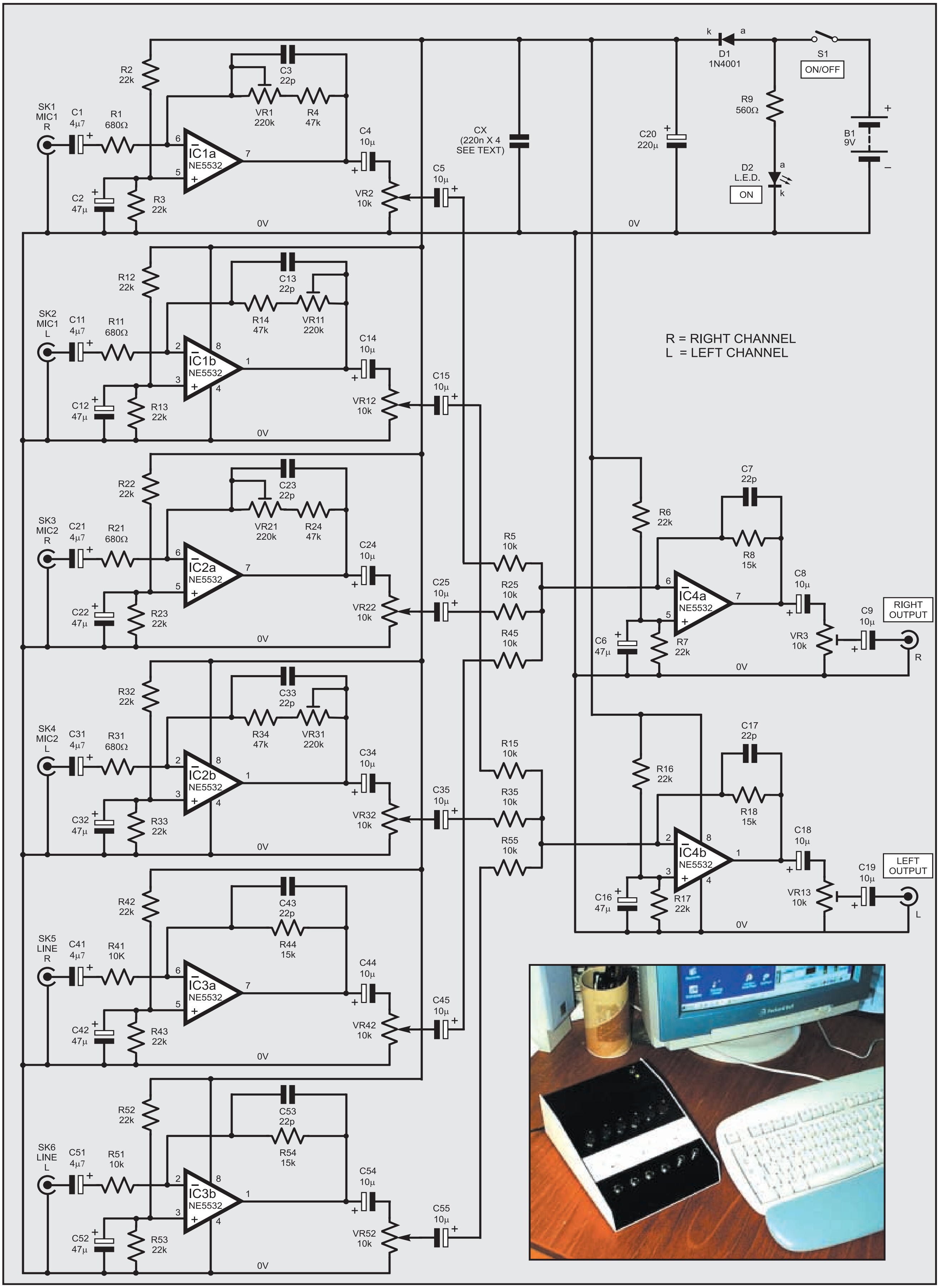


Fig.1. Complete circuit diagram for the Sound Card Mixer. Note that the author used jack sockets for the MIC inputs and un-insulated phono sockets for the Line inputs.

Construction

Construction of the Sound Card Mixer circuit is based on a single-sided printed circuit board (p.c.b.). This board is available from the *EPE PCB Service*, code 489. The component layout, interwiring and actual size copper foil master track pattern are shown in Fig.2.

Drill the five p.c.b. mounting holes in the positions indicated (they might not be needed but it is better to drill them at this stage just in case). Drill small holes in the positions indicated at the centre of each preset VR1, VR11, VR21 and VR31 position. This allows them to be adjusted through the p.c.b. when this is in position.

Solder the four 8-pin i.c. sockets and the link wire (near IC4) in place. Follow with all resistors (including the six presets) but not the mixer controls (VR2, VR12, VR22, VR32, VR42 and VR52). Add diode D1, taking care over its orientation. Next, solder the capacitors in position. Most of these are electrolytic types and must be soldered with the polarity as indicated.

Capacitor C20 should be mounted flat on the circuit board to present a low profile. There are four decoupling capacitors (all labelled Cx) – one across the supply rails of each i.c. Only one of these capacitors is shown in the circuit diagram but all four appear on the p.c.b. layout.

Next, solder the mixer potentiometers in place. It would be better if they were of the logarithmic type since these give a better physiological response (angle of rotation against perceived change in volume) but, in fact, ordinary linear controls would be perfectly adequate. The potentiometers are mounted flat on the circuit board so that the spindles point vertically upwards.

However, those used in the prototype were really intended for vertical mounting. If the units used are of this type, the connecting pins will need to be bent through right angles. Additional support should then be given to each potentiometer by a wire loop passing round the bush and soldered to the unconnected pad below its position.

Going Loopy

Prepare these loops using bare connecting wire (strip the insulation from ordinary single-strand wire). Using a suitable mandrel (say, the shank of a 10mm drill bit) twist the wire to make a loop at one end and solder the joint. Pass a loop over each bush, pull the wires tight and solder the ends to the free pads.

Adjust all six preset sliding contacts to approximately mid-track position. Check that the tops of all on-board components fall below the level of the potentiometer bushes and make any adjustments as necessary to make this so.

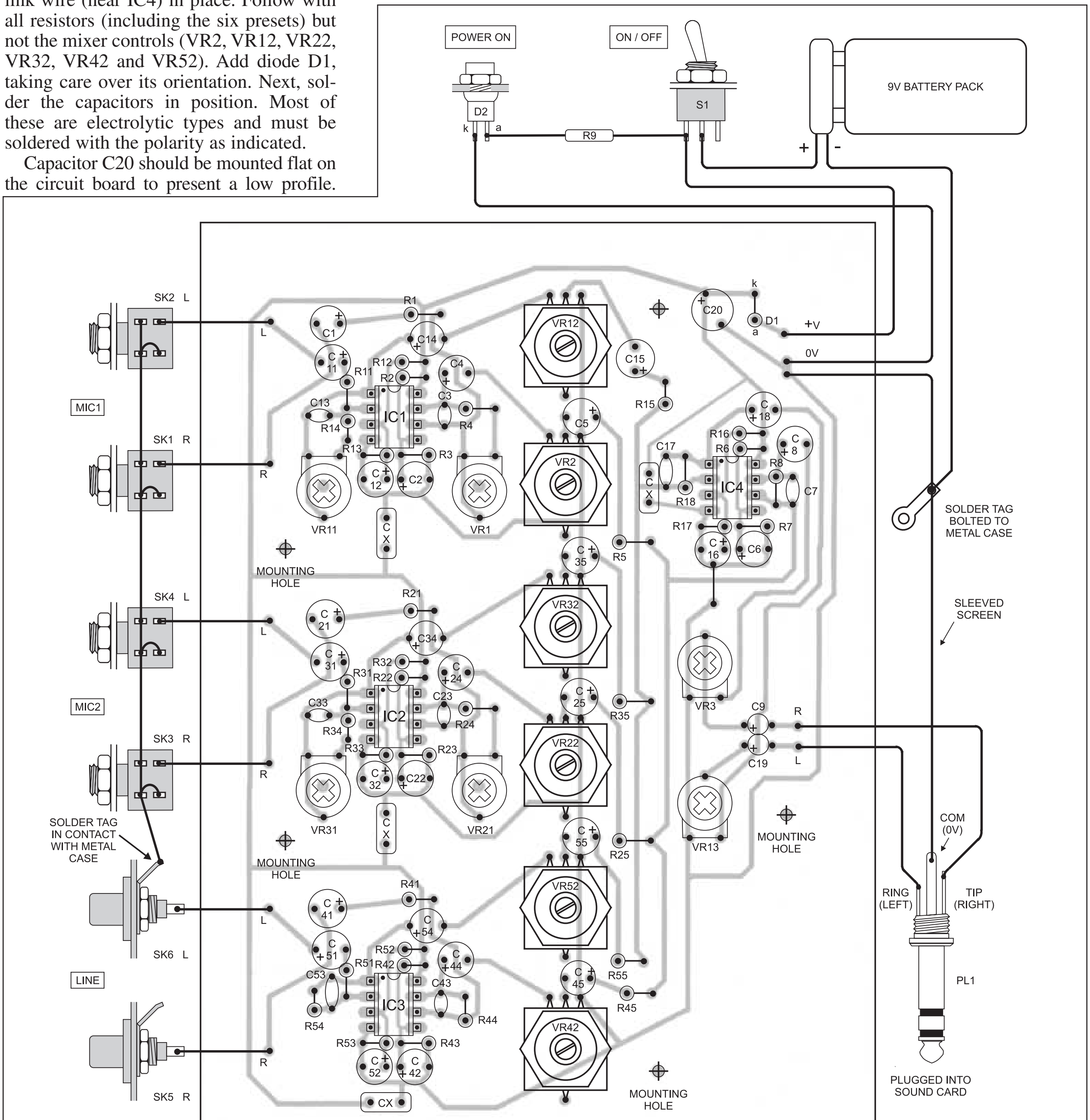


Fig.2. Sound Card Mixer printed circuit board component layout and interwiring. The full-size underside copper foil master is shown on the opposite page. The right and left outputs have been hard-wired to a stereo jack plug. Connections will, of course, have to match your own sound card set-up.

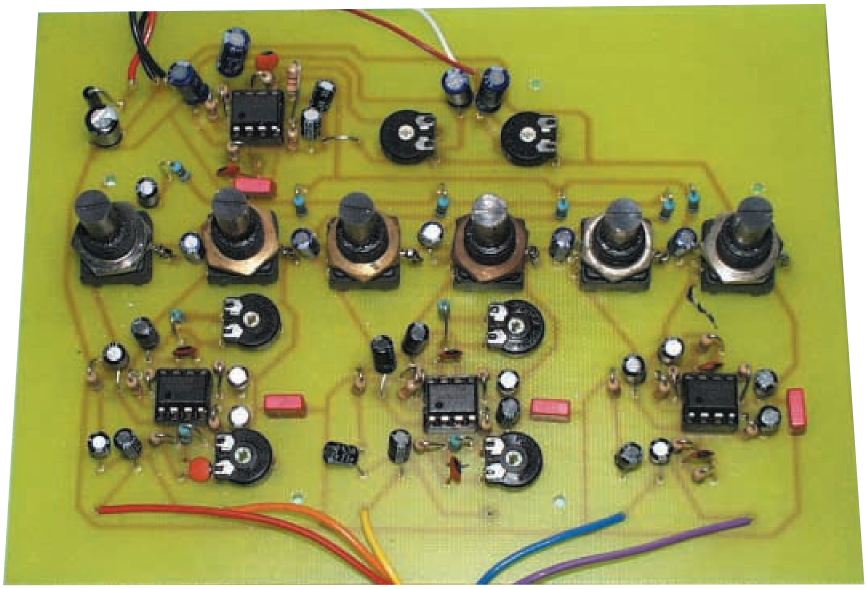
Boxing Up

An all metal box must be used for this project. This screens the circuit against possible hum pick-up which might otherwise be apparent in the final sound. The box should be large enough to accommodate all components and allow for any anticipated expansion with sockets for special purposes, etc.

Plan the layout of the front panel. This involves marking the positions of the potentiometer bushes, l.e.d. indicator, on-off switch and input sockets. Drill these holes through. In the prototype, 3·5mm mono jack sockets were used for the microphone inputs. In some cases, stereo sockets would be appropriate.

If the microphones have 6·35mm jack plugs fitted, adaptors are available to enable them to be plugged into 3·5mm sockets. Otherwise fit 6·35mm sockets if space permits. Whatever sockets are used, they should have switch contacts that open when a plug is inserted. These will be used to connect the "tip" to 0V ("earth") when a channel is left "open". This technique prevents hum that might be introduced by an unconnected input.

The Line inputs are made to a pair of phono sockets (SK5 and SK6). Mark out and drill a hole in the rear of the unit for the rubber grommet which will carry the output cable.



Component layout on the completed circuit board

Supply Arrangements

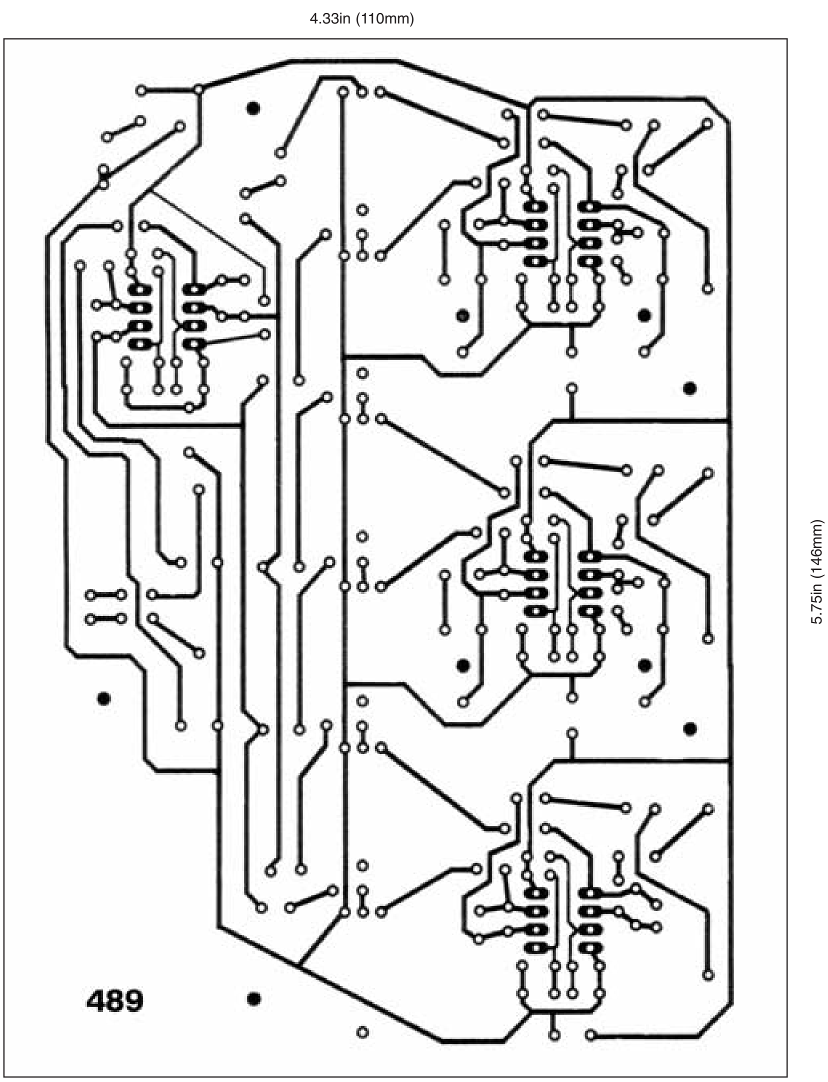
Decide where the battery pack is to be mounted and make a bracket to hold it. Drill the necessary attachment holes and a further one for a solder tag near the battery position. Fit these parts. Make sure the solder tag makes good electrical connection with the case by scraping off the paint around it.

It would be better if the batteries were attached to the lid section of the case rather than being placed on the bottom. This is because the wires will not be put under any strain when the lid is removed.

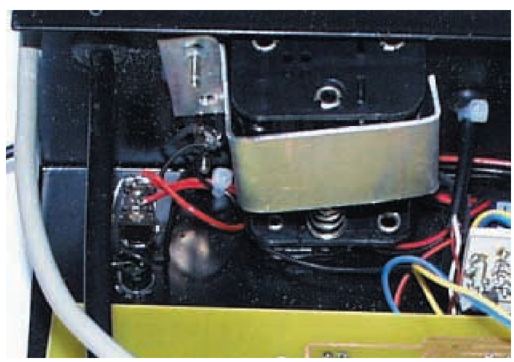
Check the fit of the p.c.b. Use washers (or spare nuts) on the potentiometer bushes so that as little as possible of them will protrude on the outside. This will provide a better fit for the control knobs (but do not attach these yet). With the arrangement used in the prototype, the potentiometer fixing nuts alone were sufficient to hold the panel securely – check this point.

If necessary, mark the positions of the p.c.b. mounting holes on the box, remove the p.c.b. and drill some or all of them through. Additional support may then be given by using thin bolts through these holes. If doing this, use stand-off insulators on the bolt shanks cut to the correct length. Mount the p.c.b. temporarily making sure that no on-board components are bent out of position or put under strain when the potentiometer nuts and any other fixings are tightened.

Mount the input sockets. If the phono sockets are of the "single hole fixing" non-insulated type as specified, scrape away the paint around the holes so that the "sleeve" connections make good metallic



Full-size underside p.c.b. copper foil master pattern.



Battery holder (6 cell) clamped to the side wall of the case.

contact with the case. Also, fit a solder tag (supplied with this type of phono connector) to the one nearest the microphone jack sockets. This is used as an "earth" (0V) point for all the jack socket sleeve and switch connections. If the phono sockets used do not make an automatic connection between the "sleeve" and the metalwork, a separate solder tag making good electrical contact with the case will be needed to do this.

Well Connected

Remove the p.c.b. again. Using pieces of stranded wire, make the connections to the input pads. Make similar connections to the supply and "solder tag" position. Using some form of colour code will help to avoid wiring errors. Fit the l.e.d. indicator (D2) and On/Off switch (S1).

Referring to Fig.2, complete the internal wiring. Note how resistor R9 is hard-wired in series with the l.e.d. The connections appropriate to the jack sockets used in the prototype are shown. Check that these are correct for the sockets used.

For the output cable, use twin (stereo) screened wire having a 3·5mm stereo jack plug on the end (or as appropriate for the sound card). This wire should be no longer than necessary, to avoid hum pick-up. Fit a rubber grommet in the hole drilled in the rear panel, pass the wire through it and solder the ends to the output copper pads on the p.c.b.

The screening should be sleeved to prevent short-circuits and connected to the rear solder tag (the one near the battery position). Three wires need to be soldered here. Twist them all together and make the joint in one operation. Check that this work is sound. Apply some form of strain relief to the output wire (for example, by using a tight cable tie on the inside of the box) so that it cannot be pulled free in use.

Mount the circuit panel and tighten the potentiometer nuts. Do not do this too tightly because you may wish to remove the p.c.b. again later. Make sure no wires are trapped or left under strain. Insert the i.c.s into their sockets and fit the batteries.

Completed Sound Card Mixer. The knob on the top/back of the case is the Volume control for next month's Stereo Headphone Monitor.

Testing

If headphone monitoring is not already possible, you might like to construct the add-on Stereo Headphone Monitor (next month) before making any accurate tests.

Connect the output to the sound card's Line input (as stated previously, this might be the microphone socket!). Turn the Mixer controls to minimum and switch on the unit. The l.e.d. should glow.

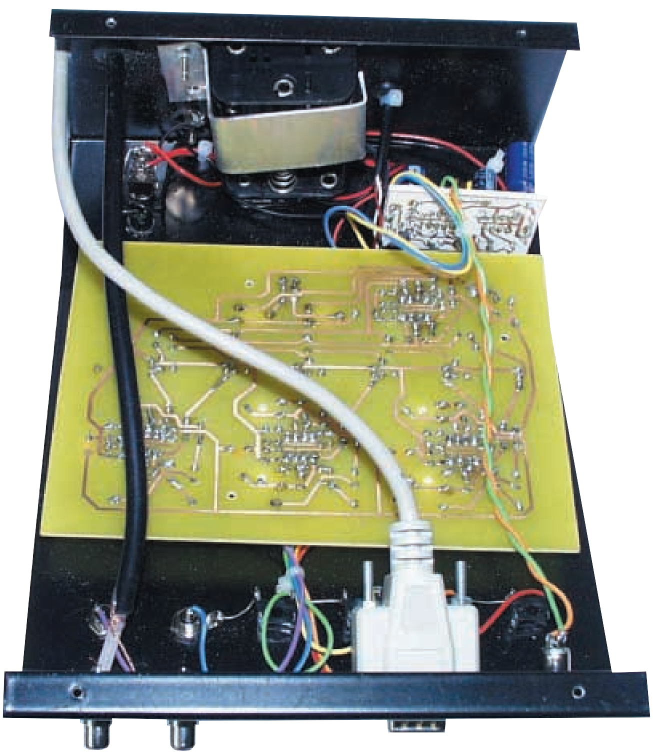
It is best to test the line inputs first. For this, you will need a device having a line-level output, such as a tape deck or the audio output from a camcorder. Make test recordings using both Left and Right channels. You will probably find that presets VR3/VR13 provide a satisfactory output level when left at mid-track adjustment.

If you do have to adjust them, the p.c.b. will need to be removed to allow this (unless you drilled the access holes in the p.c.b. as mentioned earlier). If one channel is louder than the other, adjust VR3/VR13 slightly to restore the balance.

Now, plug a microphone into each channel in turn and speak into it while slowly advancing the corresponding mixer control. The sound should be recorded clearly. Adjust the microphone gain presets (VR1, VR11, etc) to obtain a good level and a satisfactory balance between the microphone and line channels.

If the final level is much too high or too low despite adjusting VR3/VR13, you will need to alter the gain of the mixer. If it needs to be increased, raise the value of resistors R8 and R18 equally. Conversely, if it needs to be reduced, lower the values.

It only remains to tighten the potentiometer nuts, fit the control knobs, make a label and attach self-adhesive plastic feet to the base of the box. During operation, you will know when the batteries will need to be replaced when the "power on" l.e.d. indicator becomes dim and the sound quality deteriorates. □



Layout of components mounted on the inside of the metal case cover. The sockets on the front edge are the author's additions plus the stereo socket (front right) for next month's Stereo Headset Monitor.

Next Month: Build an add-on or stand-alone Stereo Headphone Monitor