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VCR Sound Processor

Stereo simulator, plus 5-band graphic equaliser plus noise filtering

- What to do if your project doesn't work
- Flight simulators — the grand illusion
- Forum: when you can't find a job
- Phase Linear compact disc player reviewed
- Building the new LCR Bridge
- Li'l Pokey — an electronic poker machine
- High-power load box for amplifiers
- Op amps explained, Pt 2

VCR Sound

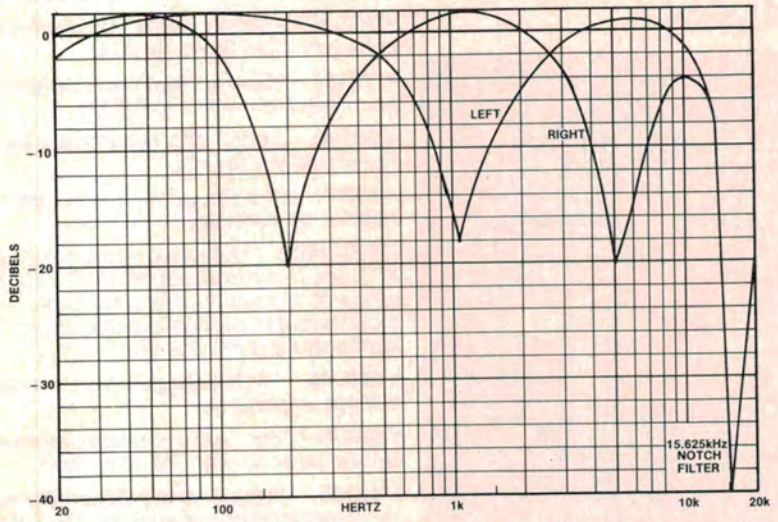
Give the sound from your VCR a lift with this new VCR Sound Processor. Main features include an effective stereo simulator circuit, a 5-band graphic equaliser, and noise filtering.

by JOHN CLARKE and GREG SWAIN

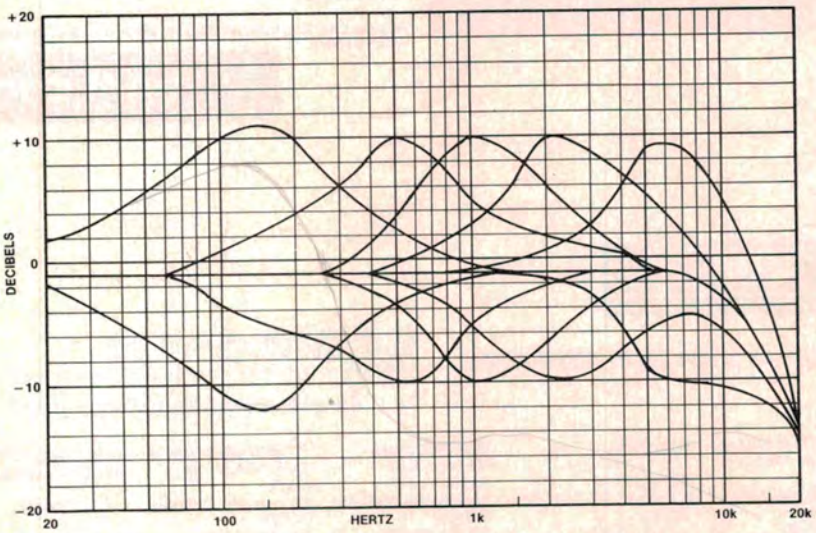
There's no denying that the sound produced by most VCRs is barely adequate for the job. By the time the sound signal is extracted from the tape, modulated along with the video signal onto a spare TV channel, and fed to a typically modest TV-set speaker, any pretence to high-fidelity has been well and truly lost.

In an effort to overcome this problem, most VCR manufacturers include an audio output socket on the rear panel. The user simply turns down the volume on the TV set and feeds the audio direct to a high-quality stereo system. Because hifi loudspeakers are used instead of the TV set's internal speaker, the improvement in sound quality is often quite dramatic.

But this approach does have drawbacks. The sound is mono only and there is usually a fair amount of good old-fashioned tape hiss to boot. On top of that, it's possible for the 15.625kHz TV line frequency to find its way into the audio chain, resulting in a low-level whistle from the tweeters. When added to the 15.625kHz "garbage" already radiated by the TV set, this whistle can be very annoying for those with keen ears.



Graph 1: left and right channel response with equaliser controls set flat.



Graph 2: frequency response curves for the 5-band graphic equaliser.

Part of the answer to improved TV sound lies with the new stereo VCRs now on the market. But while these provide an extra dimension if the soundtrack is in stereo, most current VCR tapes are only recorded in mono. In addition, they generally have a poorer signal-to-noise ratio than comparable mono VCRs since each channel occupies only half the audio track width.

It was with these thoughts in mind that we recently decided to develop an add-on sound enhancer. The result is this new VCR Sound Processor. It is designed for use with an existing stereo system and boasts a 5-band graphic equaliser, an effective stereo simulator, and in-built noise reduction circuitry.

To use the unit, all you have to do is feed the VCR audio to the input socket and connect the left and right channel outputs to the auxiliary inputs of your stereo amplifier. After that, it's just a matter of adjusting the various controls and enjoying the vastly improved sound quality. No longer will you have to put up with tape hiss or boring mono sound. And with the 5-band equaliser, you can tailor the sound to your personal tastes.

For example, the midrange controls of the equaliser can be adjusted to enhance dialogue or to reduce harshness in a particular voice. Or you can roll off the high frequency response even further if you wish, or perhaps boost the bass. The controls provide up to 10dB of boost or cut at nominal centre frequencies of 150Hz, 500Hz, 1kHz, 2kHz and 5kHz.

The in-built noise reduction circuitry consists of a fixed 10kHz low pass filter. This is effective in reducing tape hiss and other unwanted high frequency noise but has little effect on the wanted sound. Also provided is an optional 15.625kHz

Processor

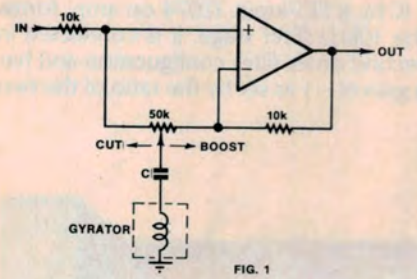


FIG. 1

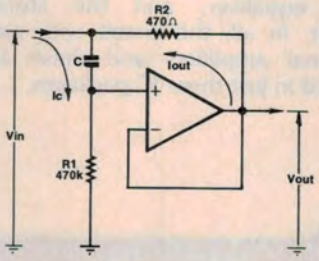
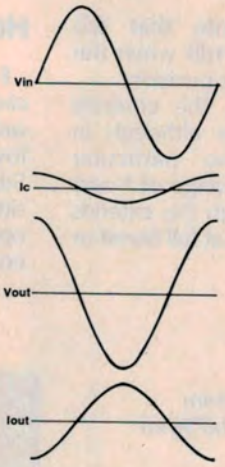


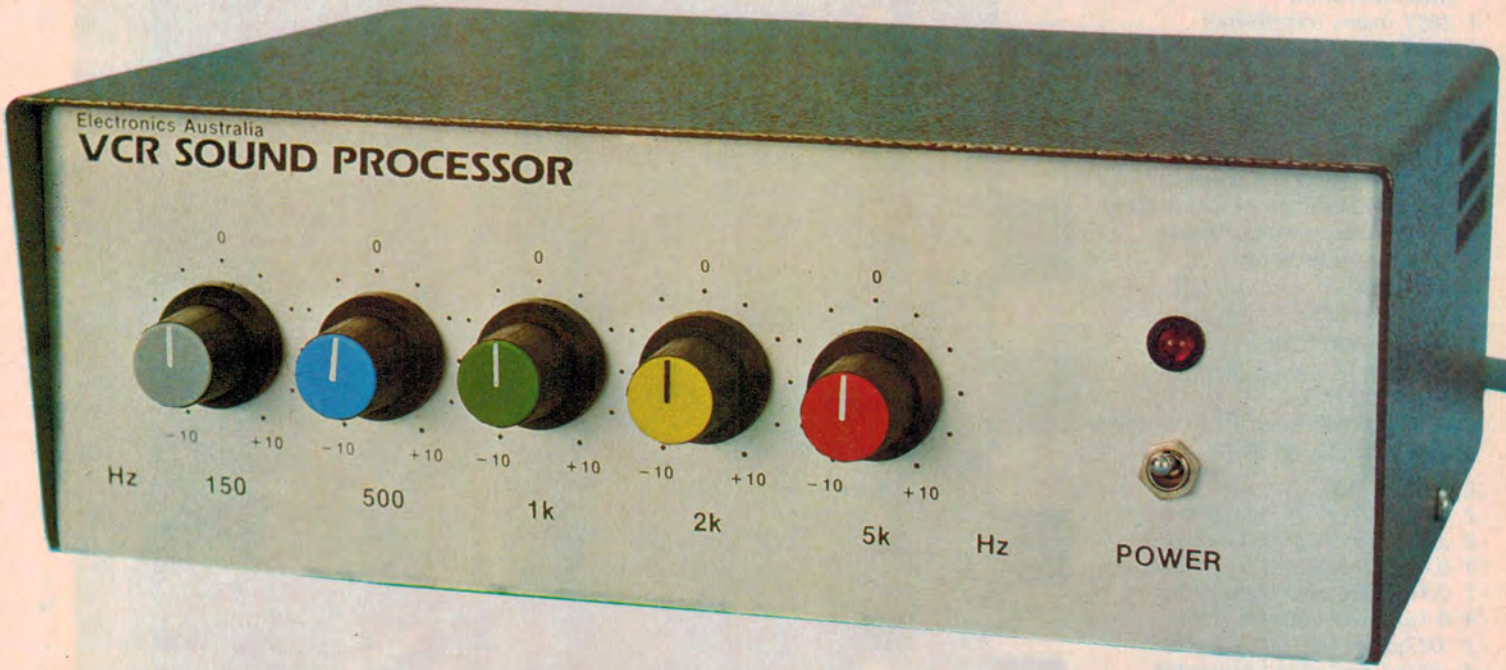
FIG. 2



We estimate that the cost of parts for this project is approximately

$57

This includes sales tax, but not the optional whistle filter circuit.



notch filter circuit which can be added if the TV line frequency proves troublesome.

Stereo simulator

One particularly attractive feature of the unit is the stereo simulator. This processes the mono signal into separate left and right channels, although it must be realised that it is incapable of producing genuine stereo. What it does do is create a certain amount of artificial separation between the left and right channels, thus diffusing the "point source".

The result is a much more interesting signal which sounds as though it could be stereo – hence the term "stereo simulator".

The way in which the simulator circuit works is both interesting and straightforward. Two twin-T filters are used to create notches in the frequency response at 200Hz and 5Hz and this filtered signal forms the right channel. The left channel then becomes the difference between the right channel and the mono input.

This is a fairly effective approach since the sum of the two outputs gives the original mono signal, yet the left and right channel signals are quite different.

Performance

No apologies need to be made for the performance of the unit. As the specification panel shows, the signal-to-noise ratio is a very good 65dB or more while the distortion is comparable with that of a good stereo amplifier, even with the equaliser controls at full boost. Maximum input signal before clipping is 4V RMS, which is more than adequate.

The accompanying graphs show the frequency response curves for various circuit stages. Graph 1 shows the left and right channel response with the equaliser controls set flat. Note that the 10kHz filter rolls off the response at 40dB/decade while the notch filter has a deep null of 40dB at 15.625kHz. Also shown are 20dB notches in the right channel response at 200Hz and 5kHz, and the complementary notch at 1kHz in the left channel.

The second graph depicts the equaliser response. For clarity this shows the response of the equaliser and 10kHz low pass filter only (the left and right channel and notch filter responses would only

VCR Sound Processor

confuse the result). Note that the equaliser has a gain of −1dB when the controls are set to the flat position.

As with all equalisers, the controls interact to some degree although in practice this is of no particular importance. The normal range of boost and cut is ±10dB, although this extends to ±12dB with all controls at full boost or cut.

How it works

Four distinct sections make up the circuit of the VCR Sound Processor. In order of signal flow these are: the 10kHz low pass filter, 15.625kHz notch filter, 5-band equaliser, and the stereo simulator. In all, the circuit uses nine operational amplifiers and these are contained in just three IC packages.

Note that both the filter and equaliser stages go before the stereo simulator. If they had been placed after the stereo simulator we would have had to double up on much of the circuitry. And that would have been expensive.

IC1a, a FET-input TL074 op amp, forms the 10kHz filter stage. It is connected in second order filter configuration and has a gain of −1 as set by the ratio of the two

PARTS LIST

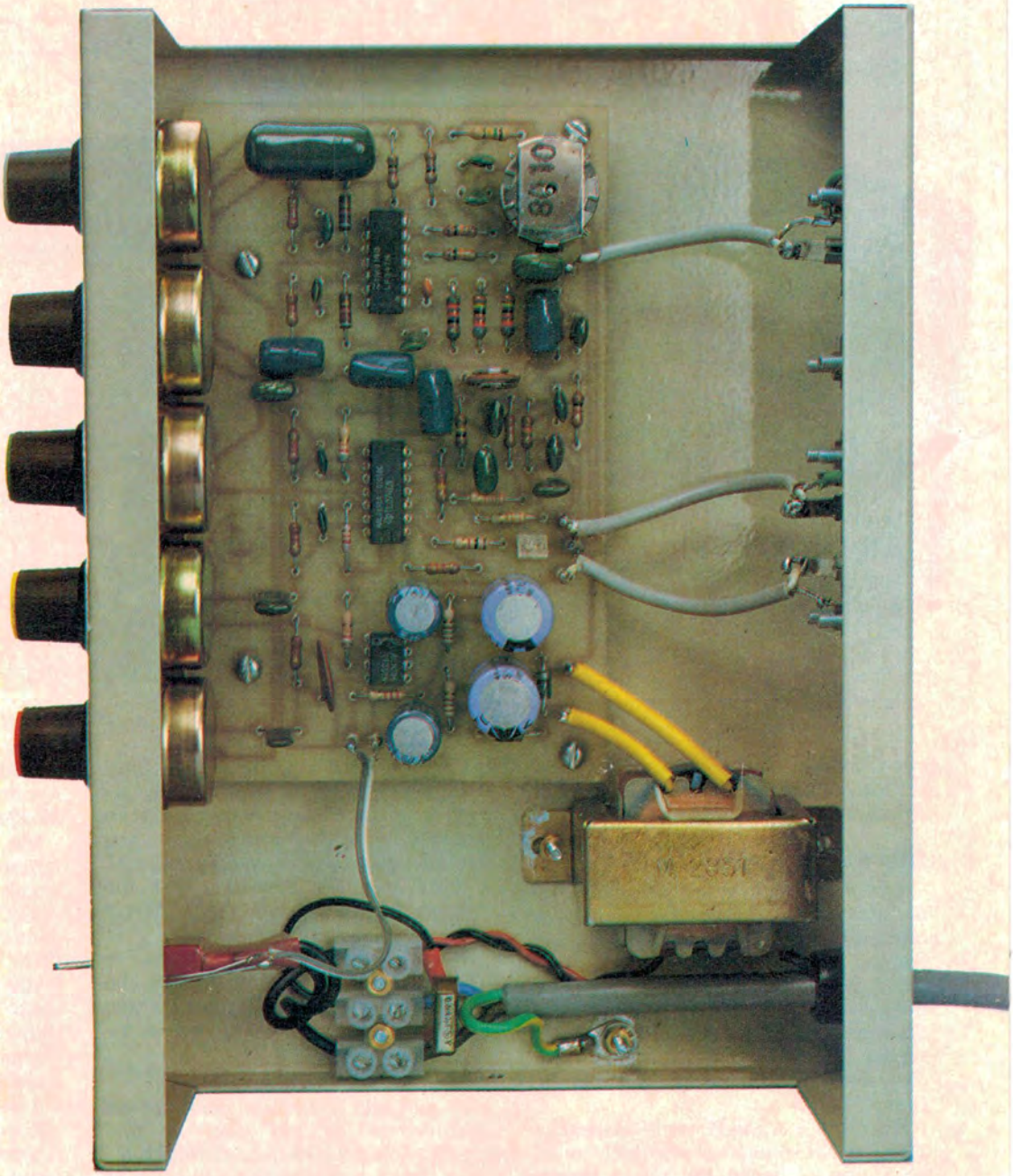
1 PCB, code 84sp3, 80x130mm
1 Scotchcal front panel, 201x79mm
1 Betacom case, E-IC2/2, 200x140x70mm
1 2851 mains transformer
1 SPDT mains switch
5 knobs
1 mains cord and plug
1 Jabel 8010 whistle filter coil (optional, see text)
1 stereo RCA socket panel
1 mono RCA insulated socket panel
1 3-way mains terminal block
1 mains cord grommet
1 earth lug
4 9mm spacers

SEMICONDUCTORS
2 1N4002 1A silicon diodes
1 5mm red LED
2 TL074, LF347 quad JFET op amps
1 TL071, LF351 op amp

CAPACITORS
2 470µF/16VW PC electrolytic
2 220µF/25VW PC electrolytic
1 0.47µF metallised polyester
1 0.12µF metallised polyester
4 0.1µF metallised polyester
2 .047µF metallised polyester
4 .022µF metallised polyester
2 .015µF metallised polyester
1 .012µF metallised polyester
1 .0068µF metallised polyester
1 .0047µF metallised polyester
1 .0047µF 250VAC polyester
3 .0022µF metallised polyester
1 .0018µF metallised polyester
1 .001µF metallised polyester
1 560pF ceramic
1 470pF ceramic

RESISTORS (¼W, 5%)
1x220kΩ, 1x150kΩ, 1x100kΩ, 5x82kΩ, 2x33kΩ, 2x22kΩ 1x15kΩ, 1x12kΩ, 2x10kΩ, 9x2.2kΩ, 2x1kΩ, 2x180Ω, 2x100Ω, 1x100kΩ large vertical trimpot, 5x47kΩ linear potentiometers.

MISCELLANEOUS
Screws, nuts, solder, shielded audio cable, hook up wire, mains wire, insulated sleeving etc.



View inside the prototype VCR Sound Processor.

22kΩ resistors. The response of this stage is 3dB down at 10kHz and the rolloff above this frequency is at the rate of 12dB per octave.

The 0.12μF capacitor at the input provides low frequency rolloff below 20Hz.

Following the 10kHz filter stage is the notch filter. This consists of an 8010 whistle filter coil connected in a bridged-T network. As used here, the bridged-T network is essentially a parallel-tuned circuit. At resonance, the parallel-tuned circuit is a very high impedance and this results in a deep null in the response at 15.625kHz.

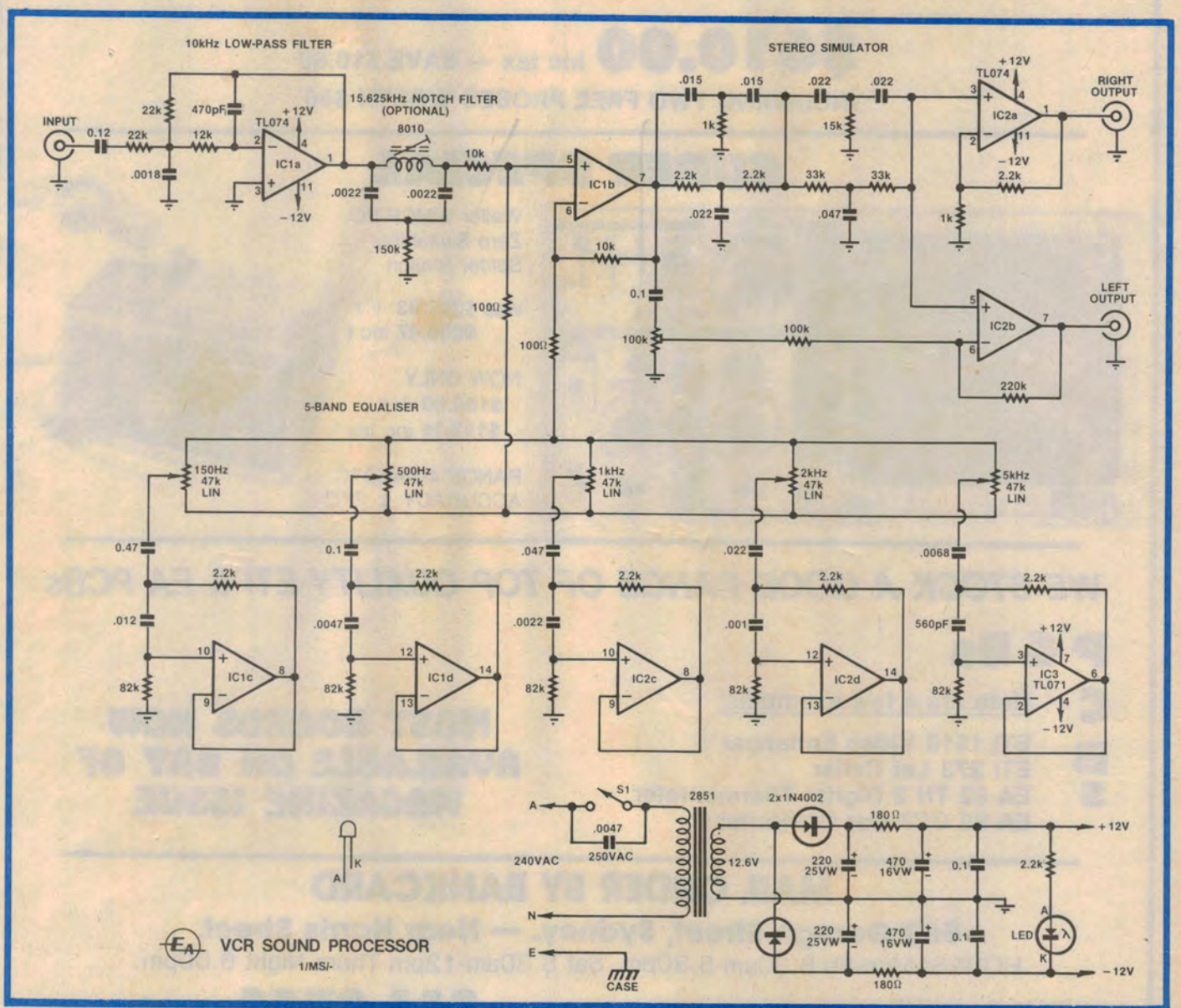
The inductor has a nominal inductance of 100mH and is adjusted to give resonance at precisely 15.625kHz by rotating the top section of the potcore. This has the effect of adjusting the air gap between the core sections, and thus adjusts the inductance. Since the null is very sharp, the adjustment is quite critical.

The output from the notch filter is fed to the non-inverting input of IC1b which, together with IC1c, IC1d, IC2c, IC2d and IC3, forms the 5-band graphic equaliser. Notice that the filter circuits IC1c-IC3 are connected in parallel between the inverting and non-inverting inputs of IC1b.

Fig. 1 illustrates the basic circuit principle. This shows an operational amplifier connected in the non-inverting mode, with negative feedback to the inverting input. The circuit is considerably simplified in that it shows only one of the five potentiometer controls.

The circuitry connected to each pot acts like a series tuned circuit, so that is how it is shown in Fig. 1. With the slider control centred, the op amp provides unity gain and the tuned LC circuit has negligible effect. When the slider pot is set to the boost end, the negative feedback signal tends to be shunted to ground by the tuned LC circuit which increases the gain at the resonant frequency. With the slider set to the cut end, the negative feedback is at a maximum and the gain is at a minimum at the resonant frequency.

But instead of using inductors the circuit employs gyrators. As used here,



VCR Sound Processor

the word "gyrator" refers to an op amp circuit which effectively transforms a capacitor into an inductor. This is illustrated in Fig. 2.

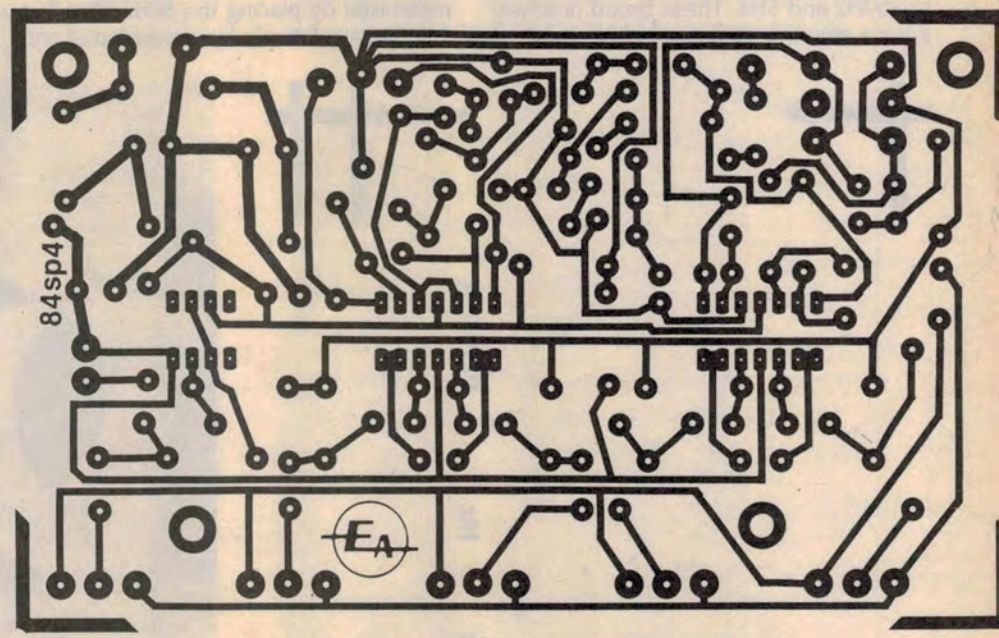
Consider an AC voltage source, Vi, connected to the op amp circuit of Fig. 2. This forces a current Ic through the capacitor, which develops a proportional voltage across R1. The voltage across R1 is reproduced at the output of the op amp. The voltage across R2 is equal to the difference between Vi and Vo and this causes current Io to flow through R2 and into the input voltage source!

An analysis of the phases of these currents and voltages will show that while Ic leads the voltage Vi, as would be expected for a capacitive circuit, the net input current, which is the vector sum of Ic and Io, actually lags the voltage Vi. So, in effect, capacitor C has been transformed into an inductor by the op amp. The inductance is given by the formula:

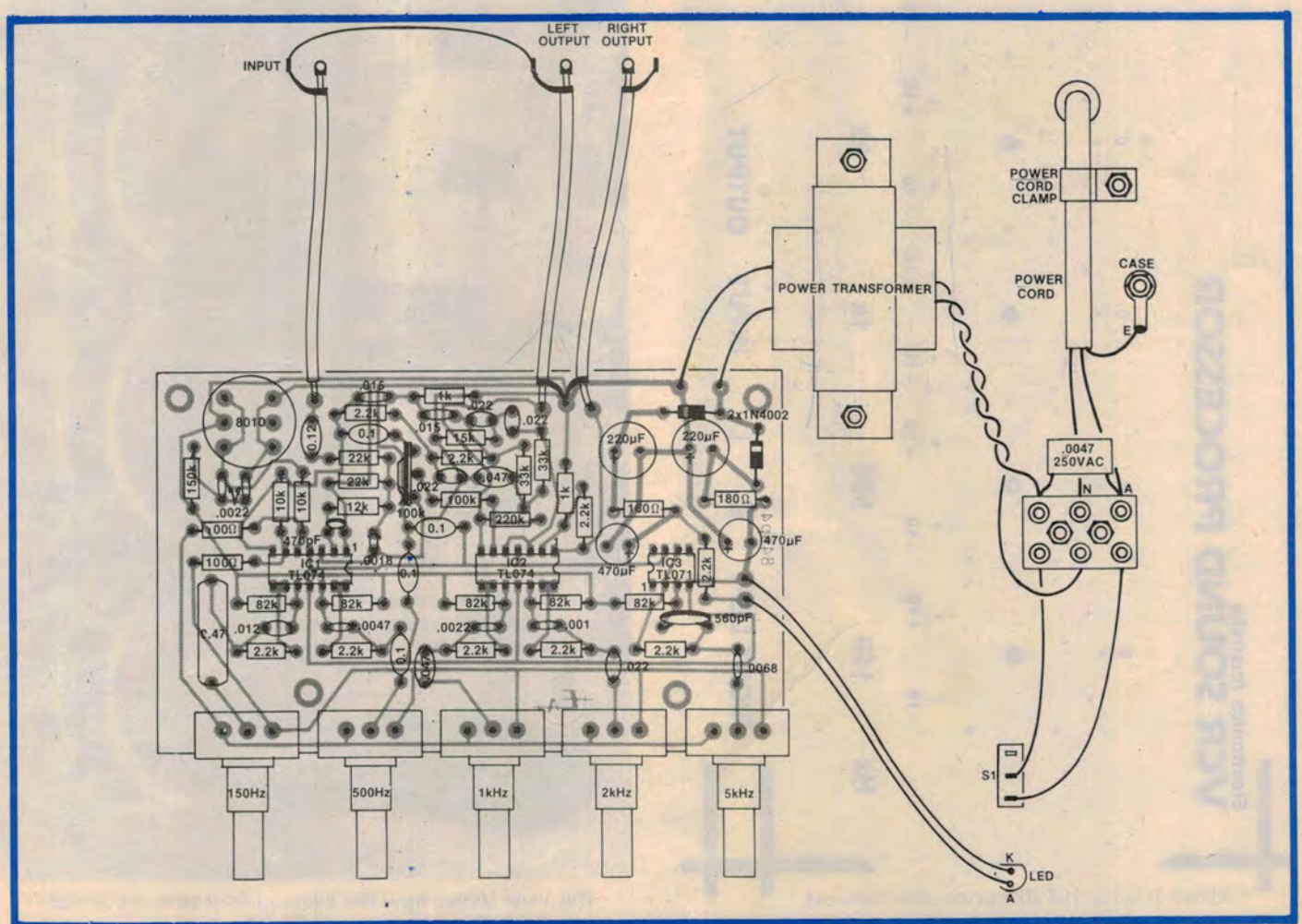
$$L = R1 \times R2 \times C$$

where C is in Farads, R is in ohms and L is in Henries.

We now come to the stereo simulator circuit which consists of op amp IC2a and IC2b and two twin-T filter networks. Twin-T filters are so named because they consist of two T sections. One section uses an R, 2C network and the other an R/2, C network. When the values are chosen precisely, the filter gives a narrow notch with almost total



Here is actual size artwork for the printed circuit board.



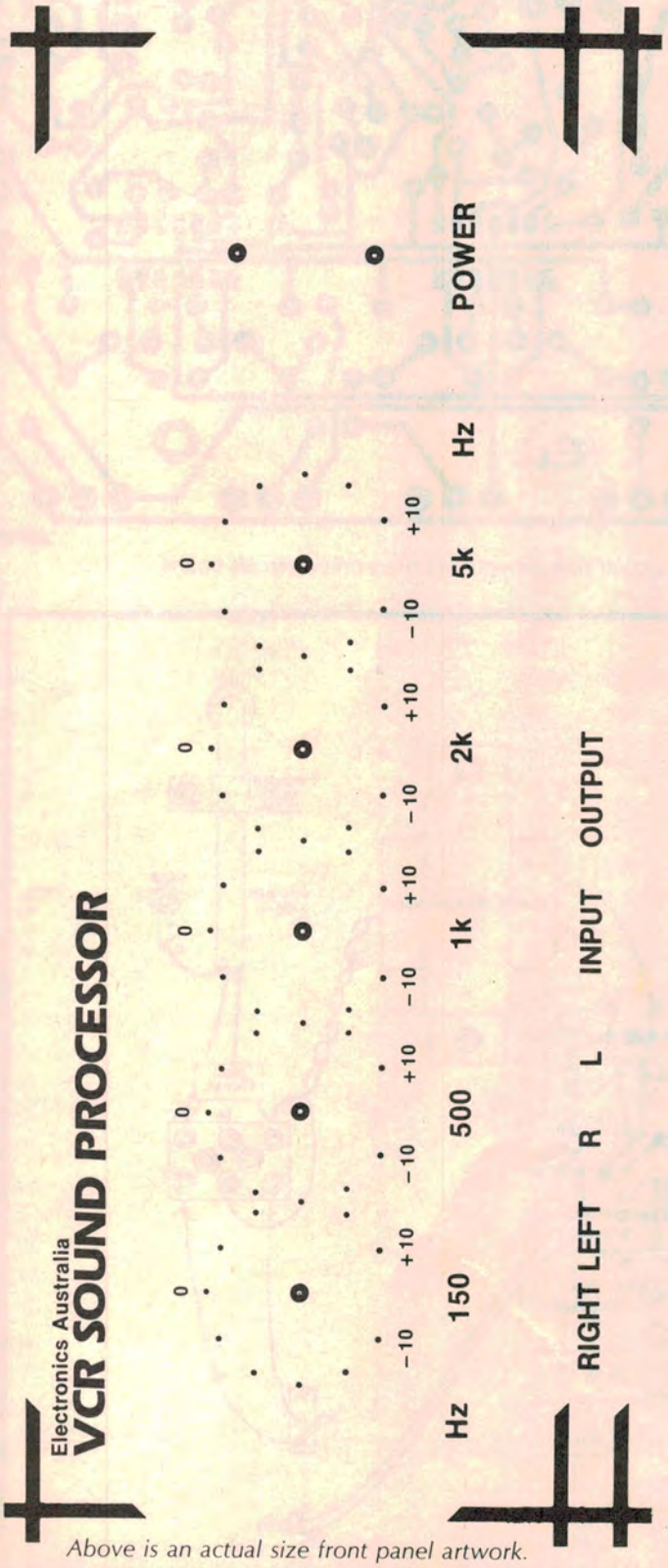
VCR Sound Processor

cancellation at its centre frequency.

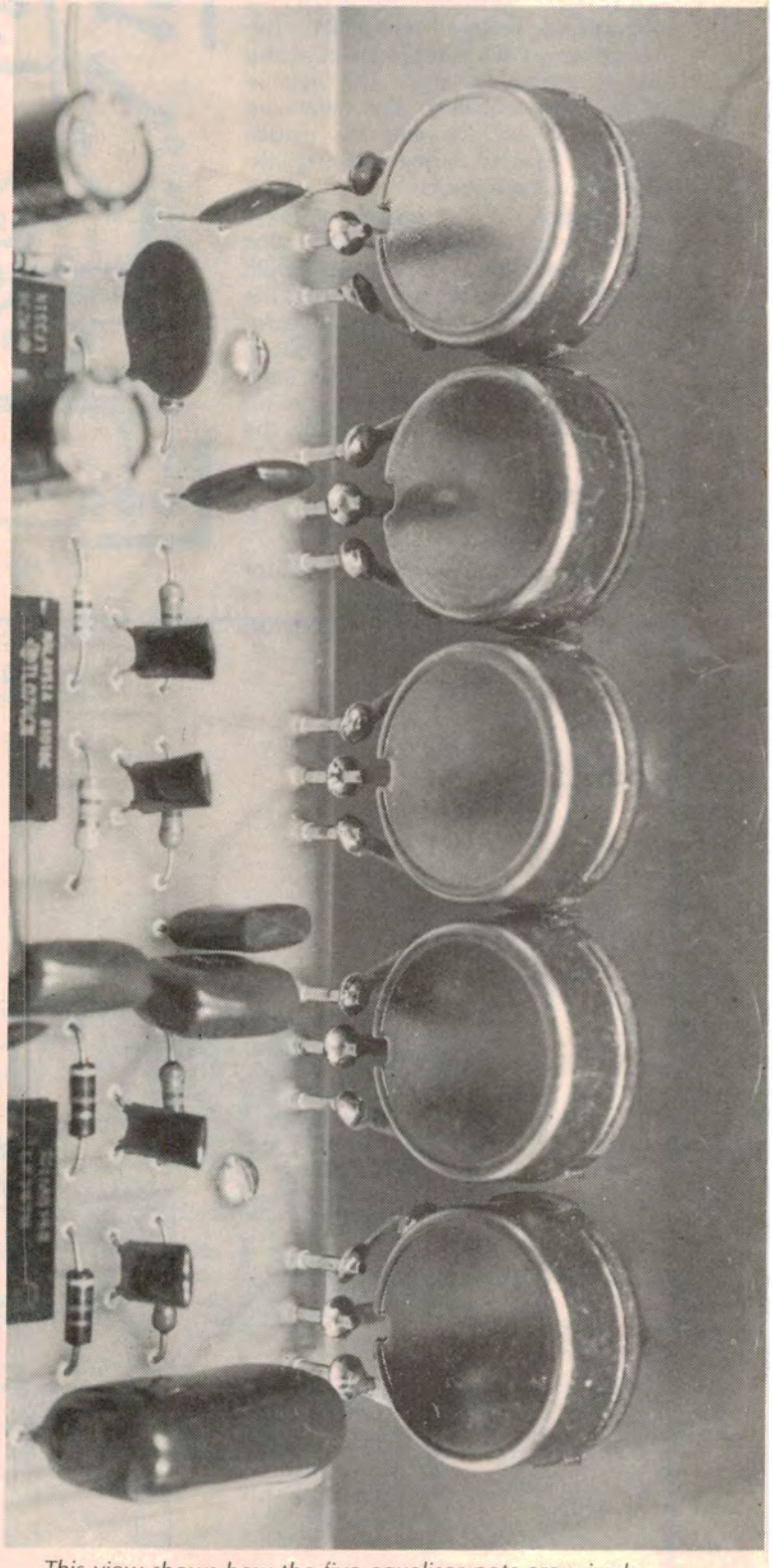
In this circuit, however, the values used are deliberately off value and this has resulted in broad notches of about 20dB at 200Hz and 5Hz. These broad notches ensure effective stereo simulation.

The response of the filters has also been modified by interaction between the two stages since they are direct coupled. This interaction has been minimised by placing the 5kHz filter first – it has a relatively low impedance and is thus not unduly loaded by the higher impedance of the following 200Hz filter.

As we have seen, IC1b forms part of the equaliser circuitry. Its output feeds directly into the twin T filter network and also, via a 0.1μF capacitor, to one side of



Above is an actual size front panel artwork.



This view shows how the five equaliser pots are wired.

VCR Sound Processor

a 100kΩ trimpot. The other side of the trimpot is grounded and the signal available on its wiper used to drive the following left channel output stage.

Op amps IC2a and IC2b form the output stages. The filtered signal from the twin T network is applied to the non-inverting input in each case. IC2a applies a gain of about two to this signal which subsequently becomes available as the right channel output.

IC2b is wired as a differential amplifier and functions somewhat differently to IC2a. In this case, different signals are applied to the non-inverting and inverting inputs – the output from the twin-T filter network appears at the non-inverting input, while the signal on the inverting input is derived from the 100kΩ trimpot. The output of IC2b represents the difference between these two signals.

Thus, when the signals on pins 5 and 6 of IC2b are common (ie, have the same phase and amplitude), they are cancelled and IC2b has no output. When the signals are no longer common (as at the twin T notch frequencies), only partial (or nil) cancellation occurs depending upon the relative phase and amplitude differences between them.

Note that the gain of IC2a compensates for the "lossy" nature of the twin-T filter network, at least as far as the right channel is concerned. The 100kΩ trimpot adjusts the gain of IC2b in the left channel and functions as both a depth of stereo control and a balance control. In practice, the actual setting tends to be a compromise between these two functions.

Readers who built the stereo simulator described in our April 1983 issue will note the similarity of the present circuit to the earlier version.

Power for the circuit is derived from a 12.6V transformer, the output of which is half-wave rectified and filtered to provide ±12V supply rails. The 0.1μF capacitors across each rail improve supply line rejection while the .0047μF capacitor across switch S1 minimises switching transients. A red LED wired in series with a 2.2kΩ resistor across the supply provides power on/off indication.

Construction

Most of the parts are mounted on a printed circuit board (PCB) coded 84sp4 and measuring 80 x 130mm. Begin construction by installing the parts according to the overlay diagram, taking care to ensure correct orientation of the ICs, diodes and electrolytic capacitors. PC stakes are used to terminate all external wiring connections and these should also be installed at this stage.

You will need 23 PC stakes in all, of which 15 eventually provide direct connections to the terminals of the five equaliser control pots.

The 15.625kHz filter can be considered optional, as not all VCRs will have a problem in this regard. We suggest that you initially purchase the kit without the notch filter components and only install them later if the 15.625kHz whistle proves a problem. For the time being, the whistle filter coil should be replaced by a wire link.

The remaining notch filter components (2 x .0022μF and 1 x 150kΩ) are simply left off the board.

Once the PCB assembly has been completed, attention can be turned to the metalwork. The circuitry is housed in a Betacom metal case measuring 200 x 140 x 70cm (W x D x H) and coded E-IC2/2. A Scotchcal front panel gives the unit a professional finish.

The Betacom IC2/2 case is part of an attractive new range of cases recently made available in Australia. Of New Zealand manufacture, it features a folded aluminium base finished in beige enamel and fitted with small rubber feet. The wraparound cover has a contrasting dark brown crinkle finish and is secured to the base by two self-tapping screws.

Spray the Scotchal front panel with a hard-setting clear lacquer (eg, "Estapol"), then carefully affix it to the front panel and drill mounting holes for the front panel hardware. You will also have to drill holes in the rear panel to accept the RCA socket panels and mains cord, and in the base to accept the power transformer and other hardware items (see wiring diagram).

Note that the PCB must be positioned so that the PC stakes along the front edge of the board line up directly beneath the pot lugs. It is secured on 9mm spacers using machine screws and nuts.

All that remains now is completion of the internal wiring. The mains cord passes through a grommeted hole in the rear panel and is anchored with a cord clamp. Terminate the mains active (brown) and neutral (blue) leads to the insulated terminal block and solder the earth lead (green/yellow) to a solder lug bolted to chassis.

Make sure that you scrape away the paint under the solder lug, otherwise you will not get a good chassis connection.

The wiring to switch S1 must be mains-rated. Before you actually solder the switch connections, slip a short length of heatshrink tubing over the two wires. Then, when the switch wiring is completed, the heatshrink tubing can be slipped over it to shroud the mains terminations.

Use the barrel of your soldering iron as a heat source for the heatshrink tubing.

Connections between the PCB and the RCA sockets are run using shielded audio cable, while light-duty hook-up wire is used for the LED connections. It is important that you make all connections exactly as shown in the wiring diagram, otherwise you could get a hum loop. Note that there is no connection between the circuit earth and chassis.

Testing

Testing the unit involves little more than connecting it up and trying it out. Connect the unit between your VCR and stereo amplifier, switch on and try adjusting each of the equaliser controls in turn. If you strike problems, switch off immediately and check for wiring errors.

Now adjust the 100kΩ trimpot for the best compromise between overall balance and stereo spread. A half-way setting should be about right.

Finally, check for the presence of 15.625kHz whistle. If this proves to be a problem, the whistle filter components will have to be installed and the filter adjusted for a null by rotating the top section of the coil potcore.

SPECIFICATIONS

SIGNAL-TO-NOISE RATIO
66dB (left channel); 65dB (right channel) unweighted with respect to 100mV at 1kHz.

DISTORTION
.035% (left channel); .05% (right channel) at 1kHz and 100mV;
.03% (left channel); .04% (right channel) at 10kHz and 100mV;
.06% (right channel) at 1kHz with full equaliser boost.

MAXIMUM SIGNAL INPUT
4V RMS before clipping with maximum equaliser boost.

FREQUENCY RESPONSE (see graph).

EQUALISER
Cut and boost of ± 10dB for each band: 150Hz, 500Hz, 1kHz, 2kHz, 5kHz.