Simple circuit uses three low-cost ICs

# Stereo simulator for tuners & VCRs

**Built around three low-cost op amp ICs, this simple circuit can produce simulated stereo sound from virtually any monophonic source. It can be built as a self-contained unit or installed inside an existing piece of equipment.**

**by COLIN DAWSON**

Anyone who has built the Playmaster wide-band AM tuner (Dec, 1982 – March, 1983) will be aware that the quality of transmitted AM programs is much higher than generally accepted. In fact, it quite often approaches that of FM transmissions. But, after the initial euphoria of this discovery has subsided, the listener's satisfaction may be dampened by the inherent limitations of mono sound which, by comparison with stereo, can sound a little dull.

Our new Stereo Simulator was designed expressly to overcome this limitation, although it can also be used with other monophonic signal sources such as VCRs and TV sets. In fact, we made up two versions of the unit, and installed one permanently in the chassis of the AM tuner. The other version was fitted inside a small plastic case to serve as a self-contained unit, and features optional mono/stereo switching.

Actually it was only last September that we presented a stereo synthesizer using a bucket brigade device. Is this previous design superseded already? No. The new design has the attraction of much lower cost but it does not offer quite the same even stereo spread of the September 1982 BBD design. Even so, the effect is very worthwhile and certainly should contribute to your listening pleasure.

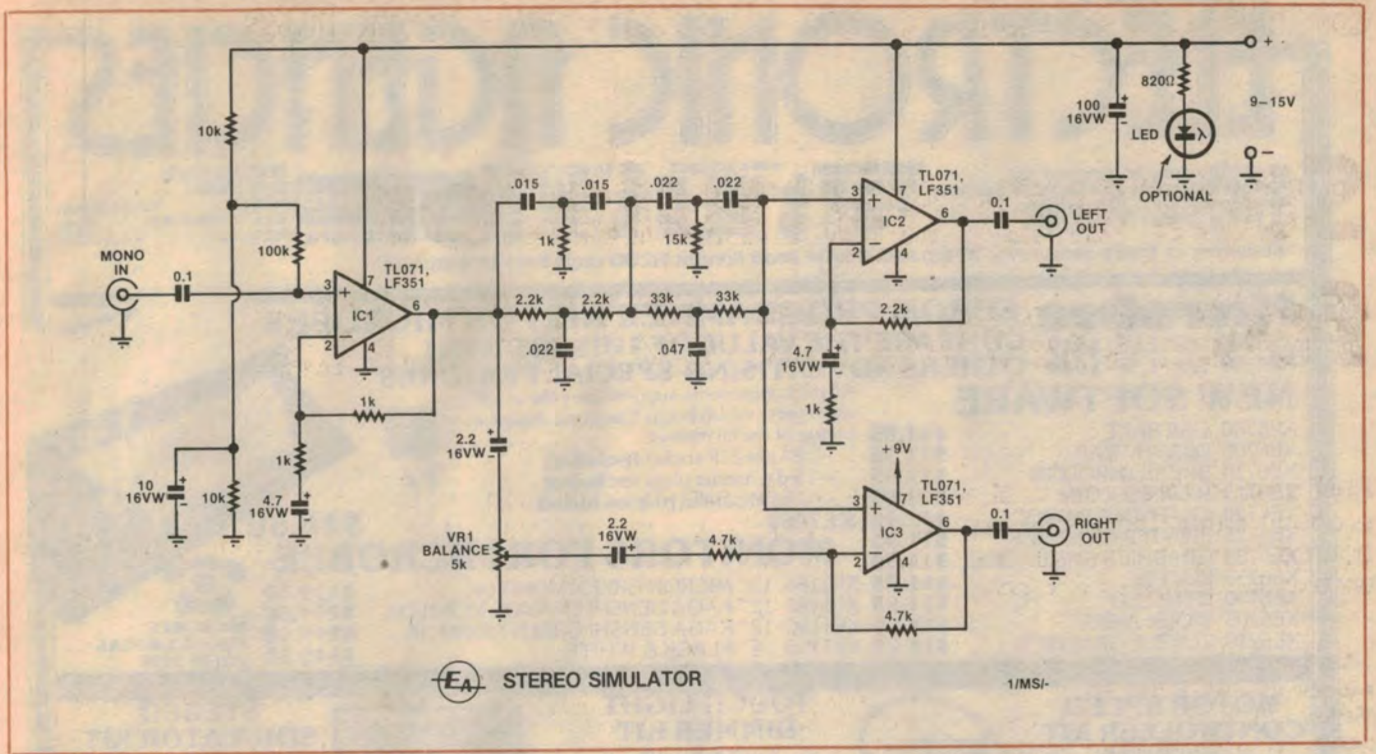
Another advantage of this particular unit is its small size which generally allows it to fit inside existing equipment (including the Playmaster AM Tuner).

The accompanying specifications panel shows the performance of our prototype unit. Note that these figures were obtained with the unit powered from an unregulated 9V plugpack supply. Both the signal-to-noise ratio and distortion figures are improved slightly when a regulated supply is used. Even so, the performance is quite satisfactory and the distortion figure of 0.1% can generally be regarded as conservative – at most frequencies it is only about .05%

Some readers may think it strange that the signal-to-noise ratio is different in the left and right channels, but this is simply a result of our having taken the measurements with respect to a 1kHz signal. At this frequency (and in fact at most frequencies), the left and right channels have different gain and hence different noise levels.

We can't claim to have derived genuine stereo from a mono recording – it is simply not possible to recover spatial information that was not recorded in the first place. In this respect, the term "stereo" is something of a misnomer since the simulator does not provide a signal with any directional information. What it does do is diffuse the "point source" effect of normal mono, creating a certain amount of artificial separation


*This self-contained version of the Stereo Simulator includes the LED power indicator and optional mono/stereo switching. It can be powered from a 9V plugpack or any convenient 9-15V DC supply.*




*The circuit consists of an op amp buffer (IC1), a twin-T filter network, and output amplifiers IC2 and IC3.*

or spread. The result is a signal which sounds as though it could be stereo — hence the term "stereo simulator."

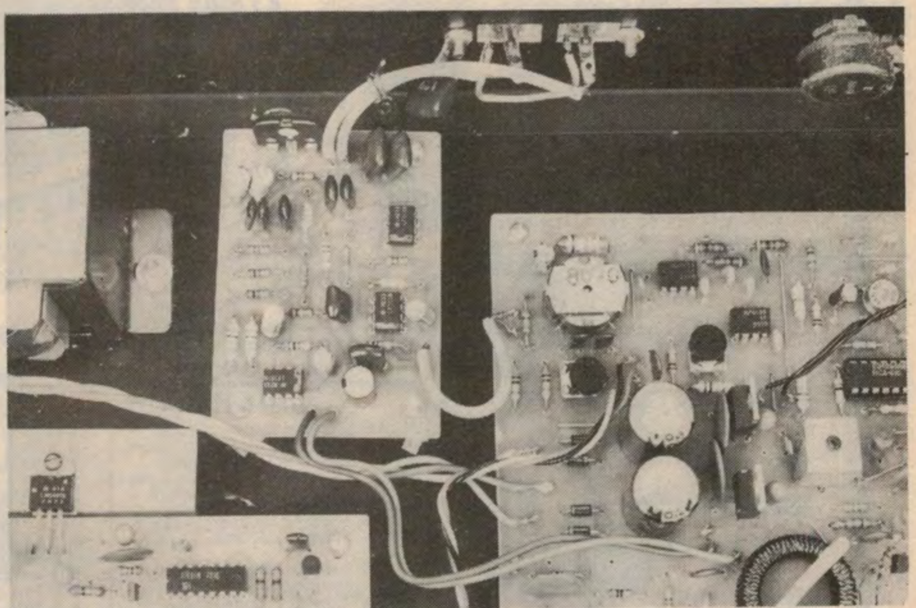
## How it works

The simulator creates "left" and "right" channels from the original mono signal by means of filters. This method has been used in many circuits over the years and in its crudest form is comparable to siting the tweeter of a speaker system on one side of the room and the woofer on the other.

Our circuit employs two twin T filters which cause notches in the frequency response at 200Hz and 5kHz in one channel. This is quite effective, but strictly conventional. The interesting aspect of this circuit is how the signal for the other channel is derived. Usually, this would simply be the unfiltered input signal, but in this circuit is the difference between the input signal and filtered signal. This is a far more realistic approach since the sum of the two outputs gives the original signal, yet the left and right channel signals are quite different.

Fig. 1 shows the response of the two channels, with the notches at 200Hz and 5kHz appearing in the left channel. The right channel response features a single 25dB notch centred on 1kHz.

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 cancellation at its centre frequency. Actually, the



*This photograph shows the assembled PCB mounted inside the chassis of the Playmaster AM Tuner. Power for the simulator is derived from the main tuner PCB at right.*

## SPECIFICATIONS

**SIGNAL-TO-NOISE RATIO** . . . 60dB (left channel); 56dB (right channel)

**DISTORTION (both channels)** . . . 0.1%

**GAIN** . . . (see graph)

**CURRENT DRAIN** . . . 6.5mA without LED, 17mA with LED

Measurements were taken with respect to 100mV output at 1kHz using an unregulated 9V plugpack supply. Signal-to-noise ratio and distortion figures can be expected to improve slightly with a regulated supply.

values used in our filter networks are not selected critically and this has resulted in notches of about 20dB. Although this could be improved by choosing "ideal" components, the degree of cancellation is already sufficient and any further improvement would be purely academic.

In fact, if the notches were made very deep and very narrow, the left channel would sound almost identical to the original mono input. On the other hand, we would get very little sound from the right channel since it would consist of just two very narrow bands of signal centred on 200Hz and 5kHz. This is clearly not what we want.

The response of the filters has also been modified to a certain extent by the interaction between stages, since the two filters are directly coupled. We have minimised this interaction, however, 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. While interaction between the filters could have been completely eliminated by an op-amp buffer stage, the improvement would again be of only academic interest. And, as we've already seen, we don't want the filters to have a really sharp response.

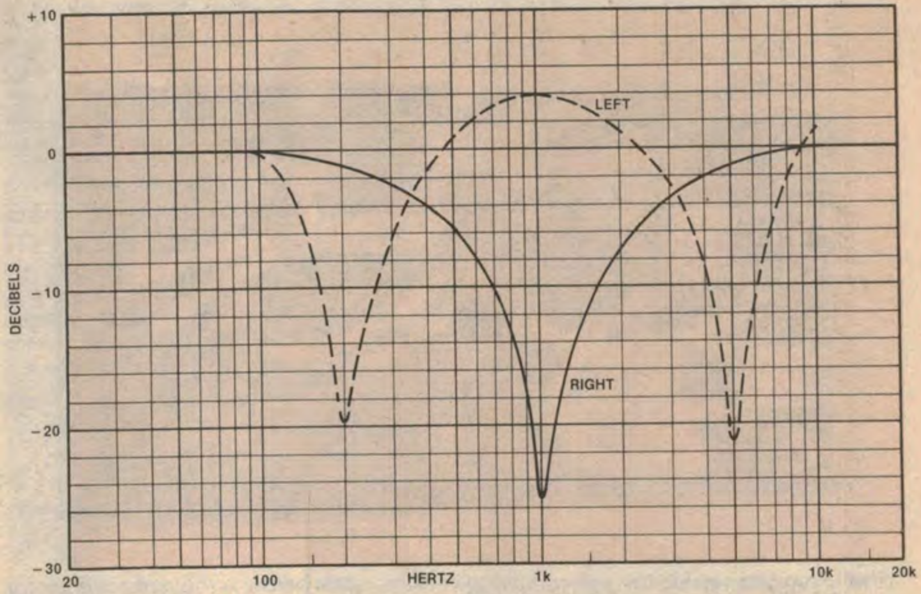
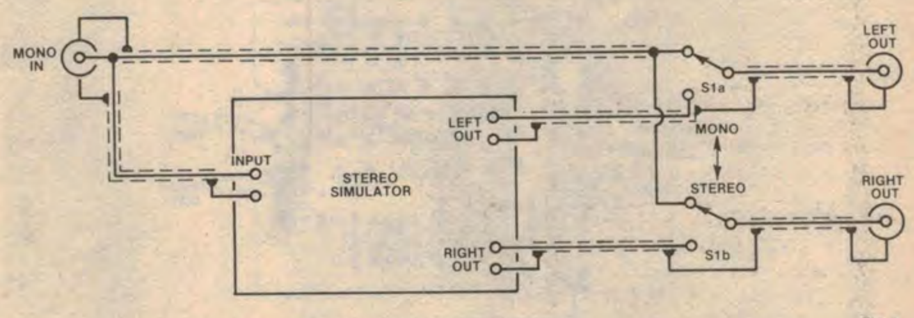



Fig. 1

*This graph plots the response of the left and right channels.*




OPTIONAL MONO-STEREO SWITCHING Fig. 2

*Wiring details for optional mono/stereo switching. Note use of shielded cable for all input and output connections to the PCB and switch.*

## Circuit details

The filter network is driven by a Fet-input op amp buffer (IC1) which isolates it from the line output of the tuner or VCR, etc. A voltage divider consisting of two 10kΩ resistors sets the bias to the non-inverting input to half supply so that the op amp can function from a single supply rail. This bias is applied to IC1 via a 100kΩ resistor, with decoupling provided by a 10μF capacitor.

IC1 is configured as a non-inverting amplifier with unity gain and frequency roll-off below 40Hz set by the 4.7μF feedback capacitor. The mono input signal is AC-coupled to the non-inverting input (pin 3), while the output (pin 6) feeds directly into the twin T filter network and also, via a 2.2μF capacitor, to one side of a 5kΩ trimpot (VR1). The other side of the trimpot is grounded and the signal available on its wiper used to drive the following right channel output stage.

The left and right channel output stages consist of two more non-inverting amplifiers, again using Fet-input op amps (IC2 and IC3). The filtered signal from the twin T network is applied to the non-inverting input in each case. IC2 applies a gain of around two to this signal which subsequently becomes available as the left channel output. Note that since there is a DC path through the filter network, it is not necessary to provide biasing for IC2 and IC3.

IC3 is wired as a differential amplifier and functions rather differently to IC1 and IC2. In this case, different signals are applied to the non-inverting and inverting inputs – the signal from the twin T filter network appears on the non-inverting input, while the signal on the inverting input is derived from VR1 and is a buffered version of the original mono input. The output of IC3 represents the difference between these two signals.

Thus, when the signals on pins 2 and 3 of IC3 are common (ie, they have the same phase and amplitude), they are cancelled and IC3 has no output. When the signals are no longer common, only partial (or nil) cancellation occurs depending upon the relative phase and amplitude differences between them.

Note that the gain of IC2 (as set by the ratio of the 2.2kΩ and 1kΩ feedback resistors) compensates for the inherently "lossy" nature of the twin T filter network, at least as far as the left channel is concerned. Trimpot VR1 adjusts the gain of IC3 in the right channel, and functions as both a "depth of stereo" control and a balance control. In fact, the actual setting of VR1 tends to be a compromise between these two functions.

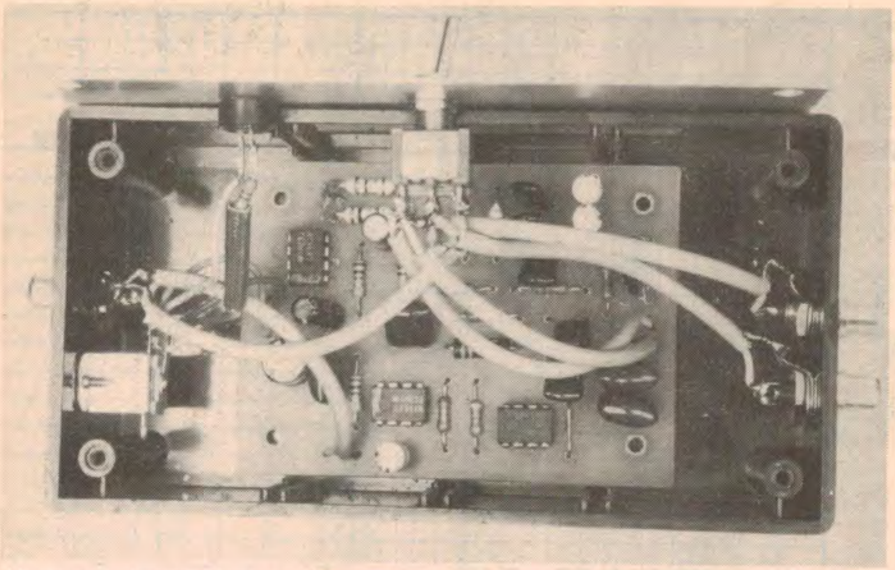
The response curves accompanying this article (Fig. 1) indicate that the output of IC3 has a very deep null at 1kHz. The depth of this null depends on the setting of VR1 and the results indicated are for what is considered an optimum adjustment.

Power for the circuit can be derived

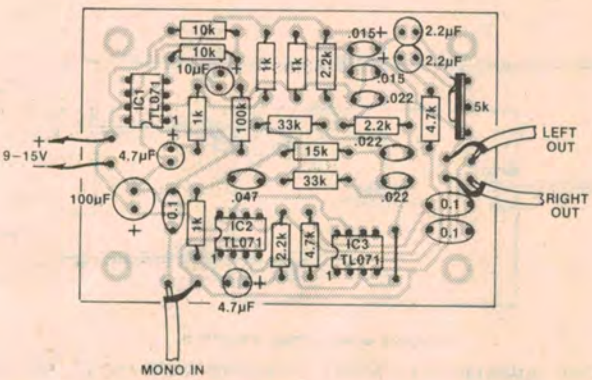
We estimate that the current cost of parts for this project is approximately

**$12**

for the PCB version The self-contained version will cost about $20 (does not include the plugpack supply). These prices include sales tax.



*Above is a view inside the self-contained version, while below is the parts overlay for the PCB. Be sure to mount all polarised components the right way round.*




from any convenient 9-15V DC supply, eg a 9V plugpack, a 9V battery, or a 9-15V supply rail inside existing equipment. A 100µF electrolytic capacitor decouples the supply, while power indication is provided by a LED wired in series with an 820Ω current limiting resistor across the supply rails. This indicator LED is optional and can be included if the circuit is to be built as a self-contained unit.

Finally, it is possible to include optional mono-stereo switching using a single DPDT toggle switch. Fig 2. shows the circuit details. In the stereo position, switch S1 selects the left and right outputs of the Stereo Simulator. In the mono position, the simulator is bypassed and S1 selects the mono input signal line.

## Construction

The simulator is built on a small printed circuit board (PCB) measuring 80 x 57mm and coded 83ms4. Mount the parts on the PCB according to the parts overlay diagram, beginning with the resistors and then moving on to the capacitors and ICs. Don't forget the wire link adjacent to IC3, and make sure that you install the ICs and electrolytic capacitors the right way round.

We recommend that you use PC stakes for all external connections to the PCB – they make the job of wiring that much easier.

From here, the construction procedure depends on where you are mounting the board. Before mounting the unit inside an existing piece of equipment, check that it can be installed so that doesn't foul controls or cover ventilation slots, and that a 9-15V DC supply rail is available. You should also check that there is space on the rear panel to mount the extra output socket. In most cases, this will be an RCA socket but should, of course, match the existing socket.

In the case of the Playmaster AM tuner, the PCB is mounted towards the rear of the chassis between the power transformer and the main tuner board. The rear panel already has stereo output sockets, and it is a simple matter to rewire these for stereo. First, drill four mounting holes in the bottom of the cabinet, and install the PCB on 19mm stand-offs. The tuner output now becomes the input to the simulator, while the simulator's outputs are connected to the RCA sockets on the back panel of the tuner.

Power is derived from the main tuner board. This board has a +15V output which is used to power the alignment module during the alignment procedure. Once alignment is complete, this output is normally unused and thus provides a convenient point from which to derive the positive supply. The negative (earth) side of the simulator supply should be connected to the nearby "G" (ground) terminal on the tuner PCB.

If you wish to include the optional mono-stereo switching, we suggest that you mount the switch on the rear panel. Note that all signal connections to and from the simulator should be run in shielded cable to avoid hum pick-up. The indicator LED and its series 820Ω resistor are not needed in this application.

For the self-contained version, we mounted the PCB in a plastic utility box

## PARTS LIST

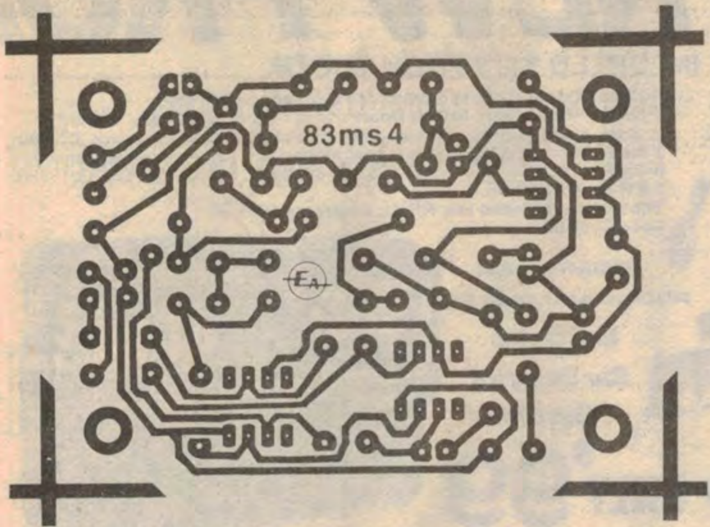
*1 printed circuit board, code 83ms4, 80 x 57mm*
*4 19mm standoffs*
*3 TL071, LF351 Fet-input op amps*

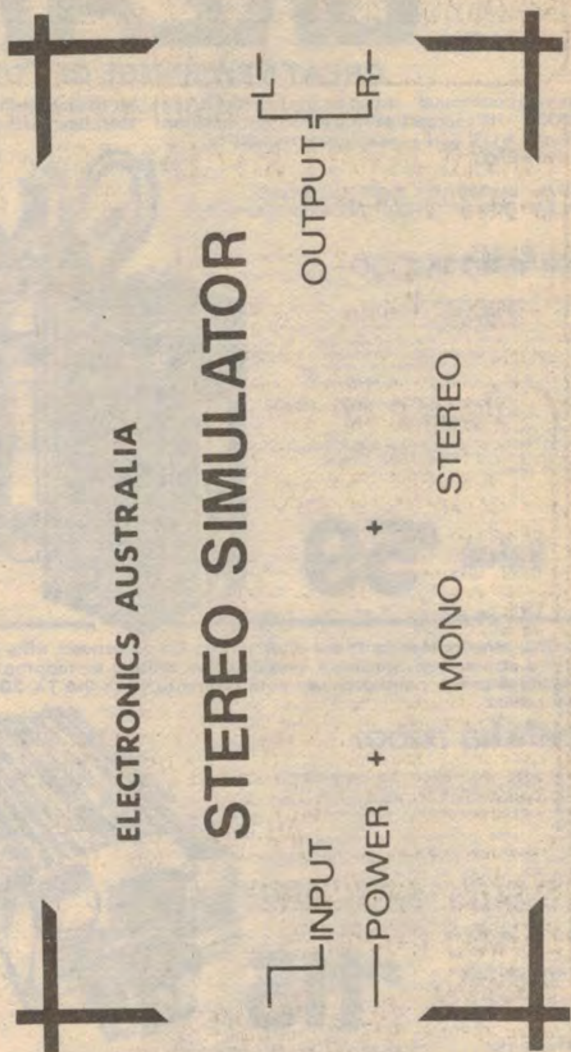
*CAPACITORS*
*1 100µF/16VW electrolytic*
*1 10µF/16VW electrolytic*
*2 4.7µF/16VW electrolytic*
*2 2.2µF/16VW electrolytic*
*3 0.1µF greencap (metallised polyester)*
*1 .047µF greencap*
*3 .022µF greencap*
*2 .015µF greencap*

*RESISTORS (¼W, 5%)*
*1 x 100kΩ, 2 x 33kΩ, 1 x 15kΩ, 2 x 10kΩ, 2 x 4.7kΩ, 3 x 2.2kΩ, 4 x 1kΩ, 1 x 5kΩ 10mm vertical trimpot*

*ADDITIONAL PARTS FOR SELF-CONTAINED VERSION*
*1 plastic utility box, 130 x 67 x 40mm*
*1 Scotchcal front panel, 125 x 63mm*
*3 RCA sockets (screw-mound)*
*1 DPDT toggle switch*
*1 socket to suit plugpack supply*
*1 red LED and bezel*
*1 820Ω resistor (¼W, 5%)*

*MISCELLANEOUS*
*Machine screws and nuts, shielded cable, hook-up wire solder etc.*




*Here are actual size artworks for the PCB and front panel.*

measuring 130 x 65 x 40mm. This is fitted with RCA input/output sockets and a power socket, together with the LED indicator and optional mono-stereo switching. A front panel made from self-adhesive Scotchcal material provides an attractive finish to the unit.

The first job is to affix the Scotchcal label to the lid of the box, and drill mounting holes for the switch and indicator LED. This done, mounting holes may be drilled in the box for the RCA sockets, power socket and PCB. As shown in the photograph, the RCA input socket and the power socket are mounted on the left hand side of the box, while the two RCA output sockets are mounted on the right hand side.

The various items of hardware may now be mounted in position and the wiring completed. As before, all input and output connections (including those to the switch) should be run in shielded cable. Connections to the power socket and LED can be run using multistrand hook-up wire. Don't forget to solder the 820Ω resistor in series with the LED.

It is a good idea to check the polarity of the power socket terminals with a multimeter before making the connections to the PCB. You will almost certainly damage the ICs if power is applied with reversed polarity.

To test the unit, first apply power and check that the LED illuminates. If all is well, disconnect the plugpack and connect the simulator into circuit. The mono input accepts the signal from the program source, while the left and right outputs go to the amplifier line inputs. If you have an integrated tuner/amplifier, the tuner signal will be available at the "Tape Out" outputs. The simulator outputs should then be connected to the "Tape Monitor" inputs on the amplifier.

Apply power and check that everything functions normally with switch S1 in the "mono" position. Finally, switch to "stereo" and adjust VR1 for the most satisfying sound. Your "Stereo Simulator" is now ready for use.

As explained earlier, this device will not endow the music with any directional information. For example, you will not be able to positively identify the lead guitarist as being right of centre. Nevertheless, the simulator has a satisfying "spread" effect and you will certainly know when it is working.