Improve the sound from your VCR with this

Dynamic Noise Reduction System

Give the sound from your mono VCR a lift with this Dynamic Noise Reduction (DNR) System which reduces hiss and adds simulated stereo. The circuit uses the standard DNR chip from National Semiconductor.

by GREG SWAIN

Anyone who owns a mono VCR knows that the sound quality, as it finally emerges from the TV set, is pretty lousy. In fact, it's worse than from a mono cassette recorder without Dolby noise reduction.

But it needn't be so. Most VCRs include an audio output socket which allows the sound to be routed to a stereo amplifier. That's the first step to improving sound quality.

The second step is to build and interpose this Dynamic Noise Reduction System into the signal line between the VCR and the amplifier. Depending upon the circumstances, it is capable of providing a very worthwhile 18dB (maximum) improvement in the signal-to-noise ratio.

While this figure might not mean too much to many readers, your ears will certainly appreciate the difference. Less hiss adds up to much greater enjoyment of the audio sound track. As a bonus, the circuit processes the mono soundtrack to give a realistic stereo effect and provides notch filtering of the TV line frequency (15.625kHz).

Although mainly designed for use with VCRs, the Dynamic Noise Reduction System could also be used with other audio sources where noise is a problem. For this reason, the circuit is capable of accepting both mono and stereo line level inputs. No provision has been made for line frequency extraction from stereo sources, however.

So, if you want to get the best possible sound from your VCR, this project is a must. It's easy to assemble and the setting up procedure is a snack.

Noise reduction systems

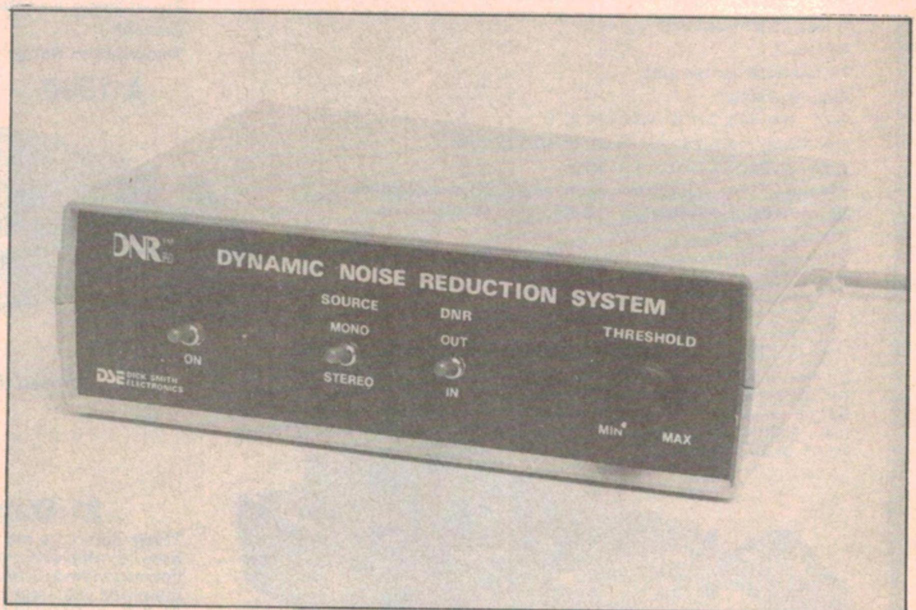
Audio noise reduction systems fall into two broad categories: complementary and non-complementary. In a complementary system, such as the Dolby and dbx systems, the signal is compressed during recording and then expanded in complementary fashion during playback. This effectively reduces the noise in the playback signal — hopefully to a level below the threshold of hearing.

In a non-complementary system, on the other hand, noise reduction takes place in the playback mode only. This is the technique used in the DNR System described here. It's main advantage is that it can be used with almost any audio source since no signal processing is required during recording.

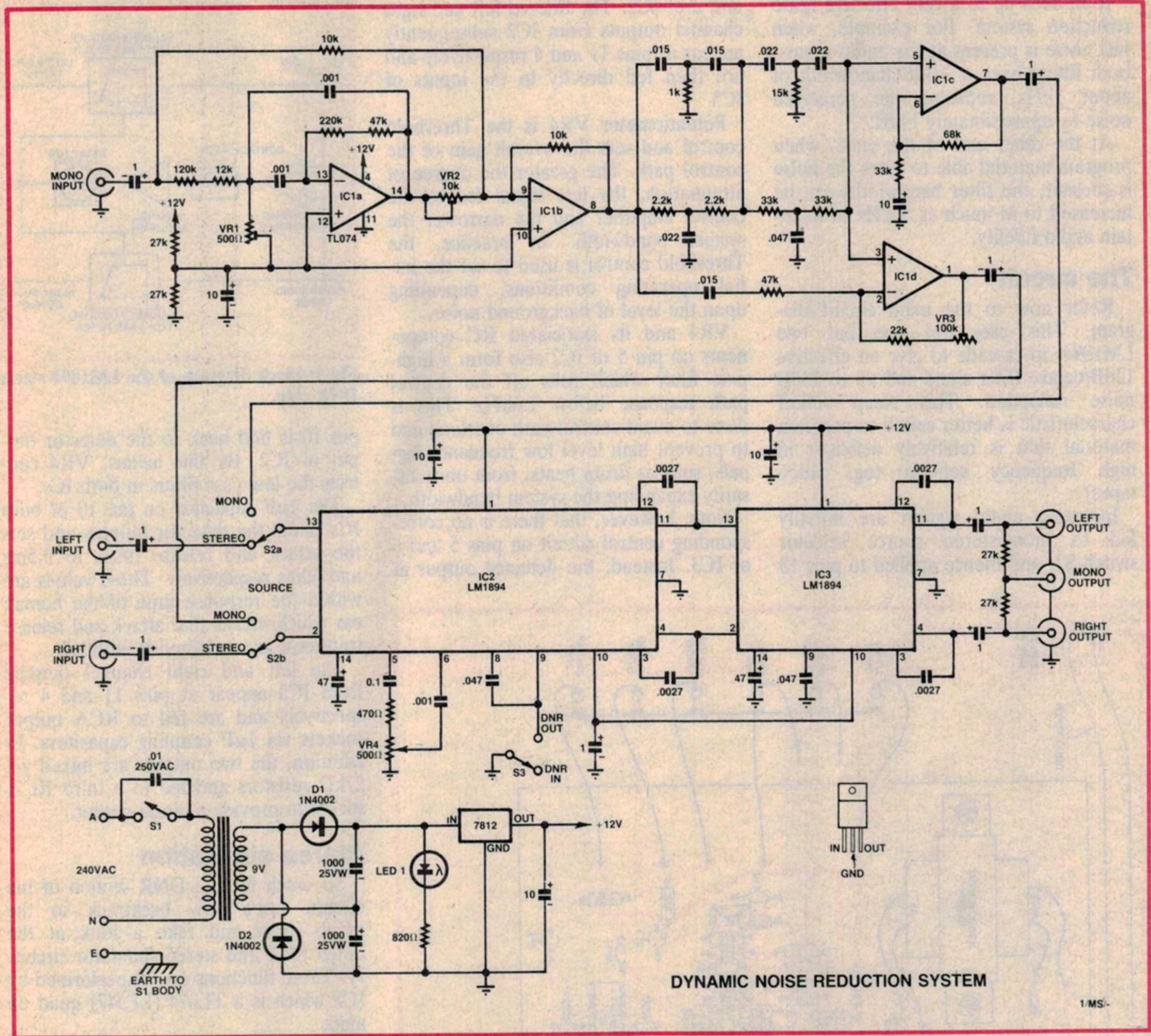
How it works

At the heart of the circuit is the LM1894 stereo DNR chip from National Semiconductor. The operation of this chip depends on two principles: (1) in any playback system, the audible noise is proportional to the bandwidth; and (2) desired signals above a certain level are capable of masking the background noise.

As an aside, most background noise (hiss) occurs at frequencies above 1kHz. This means that the noise can be considerably reduced by filtering out these high frequencies (ie, by reducing the bandwidth). The DNR system does this in such a way as to leave the program



The front panel controls include mono/stereo source switching, DNR IN/OUT, and threshold.



DYNAMIC NOISE REDUCTION SYSTEM

content largely unaffected.

In essence, the LM1894 monitors the incoming audio signal and continuously adjusts the system bandwidth in response to the signal amplitude and frequency content. This means that, when low-level or low-frequency signals are present, the bandwidth is deliberately restricted to filter out the unwanted high-frequency noise.

Conversely, when high-level or high-frequency signals are present, the noise is masked and the bandwidth is correspondingly expanded to pass the wanted program content.

Fig.1 is a block diagram of the LM1894 chip. In each channel is a variable cut-off low pass filter. These filters have a flat frequency response below the cut-off frequency, and a smoothly decreasing (−6dB/octave) response above the cut-off frequency.

The cut-off frequency is continuously adjusted by means of a control voltage derived from a weighted filter-cum-detector network. This so-called 'control path' provides summing of the audio input, while the weighted filter prevents high level low frequency signals from activating the detector.

Specifications

Gain	0dB; stereo input (note 1)
Frequency response	10Hz-20kHz; stereo input (note 1)
Crosstalk	−54dB; Vin = 775mV
Maximum input level	3.2V stereo; 2.2V mono @ 1kHz
Signal-to-noise ratio	75dB; stereo, unweighted, ref. 775mV
S/N ratio improvement	18dB maximum (note 2)

Note 1: Due to the effects of the stereo simulator circuitry, it is difficult to specify gain and frequency response figures for mono operation. Mono gain is approximately −6dB.

Note 2: the signal-to-noise ratio improvement is dependent upon noise content and spectral distribution of the source material.

It all adds up to a very effective noise reduction system. For example, when just noise is present at the audio inputs, both filters have a −3dB bandwidth of about 1kHz, reducing the perceived noise by approximately 14dB.

At the other end of the scale, when program material able to mask the noise is present, the filter bandwidths can be increased to as much as 30kHz to maintain audio fidelity.

The circuit

Refer now to the main circuit diagram. This uses not one but two LM1894s in cascade to give an effective 12dB/octave filter slope and up to 18dB noise reduction. This steep rolloff characteristic is better suited to program material that is relatively deficient in high frequency content (eg, video tapes).

Incoming audio signals are initially fed to mono/stereo source selector switch S2, and thence applied to pins 13 and 2 of IC2. The filtered left and right channel outputs from IC2 subsequently appear at pins 11 and 4 respectively and are then fed directly to the inputs of IC3.

Potentiometer VR4 is the Threshold control and sets the overall gain of the control path. The greater the degree of attenuation, the less signal fed to the control amplifier and the narrower the system bandwidth. In practice, the Threshold control is used to set the initial operating conditions, depending upon the level of background noise.

VR4 and its associated RC components on pin 5 of IC2 also form a high-pass filter which rolls off the control path response below 1.6kHz. This is done to avoid control path overload and to prevent high level low frequency signals, such as drum beats, from unnecessarily expanding the system bandwidth.

Note, however, that there is no corresponding control circuit on pins 5 and 6 of IC3. Instead, the detector output at pin 10 is tied back to the detector output of IC2. By this means, VR4 controls the low pass filters in both ICs.

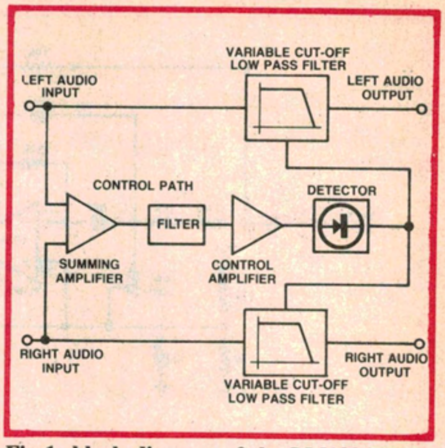
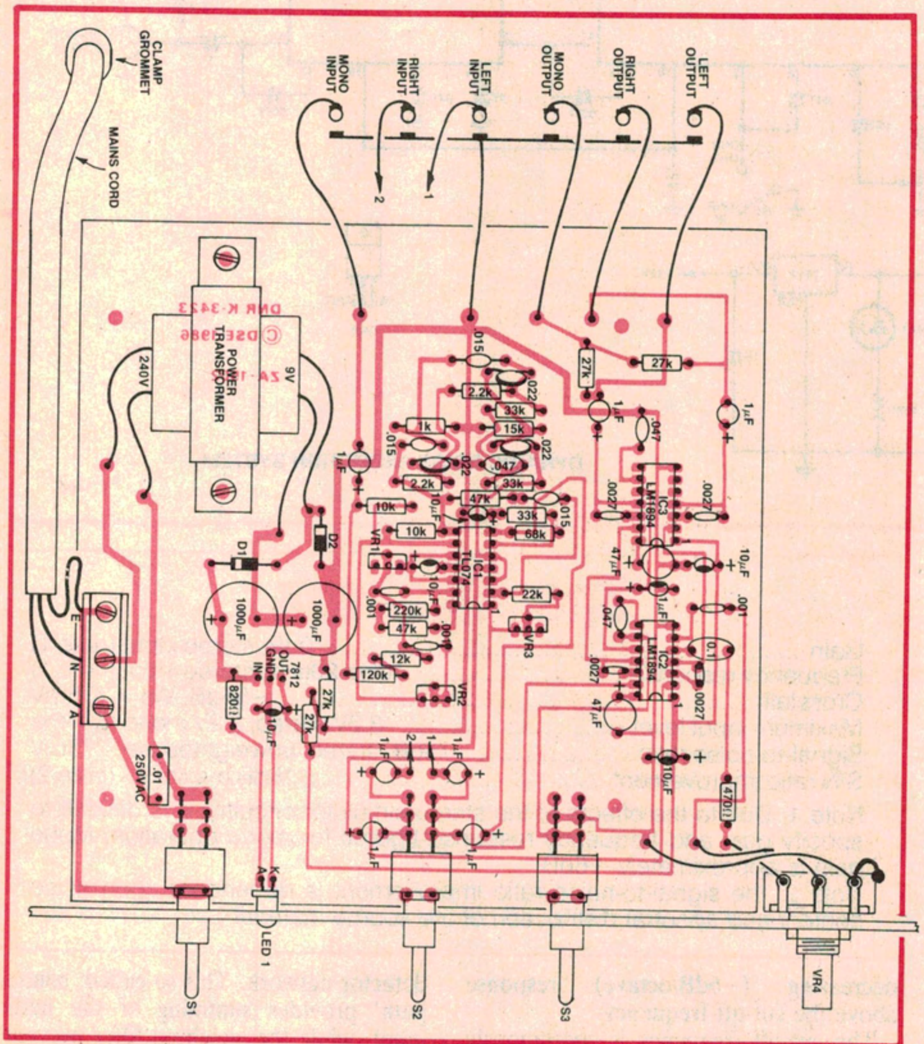


Fig.1: block diagram of the LM1894 stereo DNR chip.

The 1μF capacitor on pin 10 of both ICs filters the detector outputs and sets the attack and release times to 0.5ms and 60ms respectively. These values are within the response time of the human ear which means that attack and release transients are rendered inaudible.

The left and right channel outputs from IC3 appear at pins 11 and 4 respectively and are fed to RCA output sockets via 1μF coupling capacitors. In addition, the two outputs are mixed via 27kΩ resistors and fed to a third RCA socket to provide a mono output.



Above: parts layout diagram for the Dynamic Noise Reduction System. Note that mains voltages are present on the PCB.

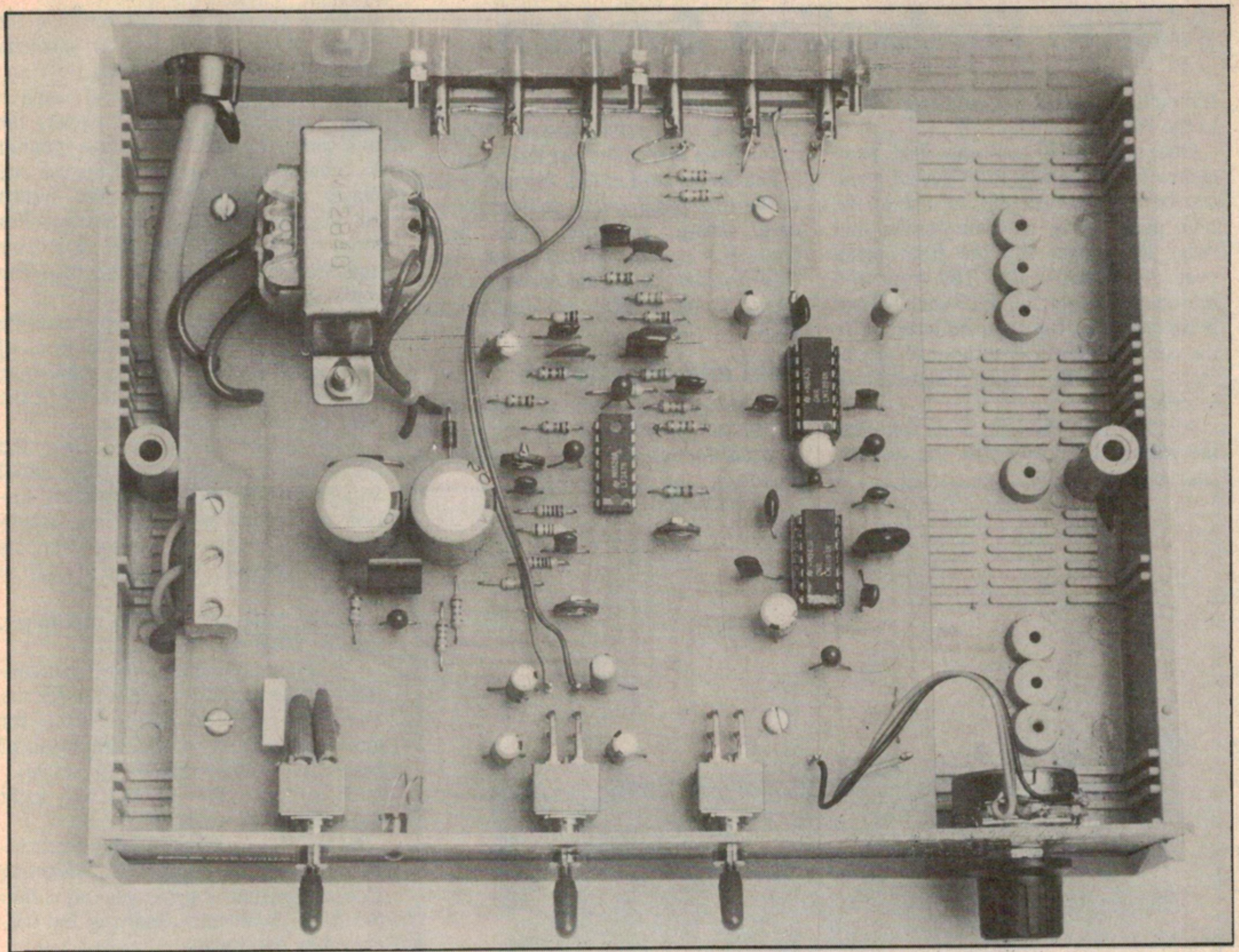
Stereo simulation

So much for the DNR section of the circuit. Let's now backtrack to the mono input and take a look at the notch filter and stereo simulator circuitry. These functions are all performed by IC1 which is a TL074 (LF347) quad op amp.

IC1a and IC1b together form the 15.625kHz notch filter circuit. Note that the bias for the non-inverting inputs of the two op amps is derived from a voltage divider consisting of two 27kΩ resistors strung across the supply rail. Trimpot VR1 sets the notch centre frequency while VR2 sets the null.

The notch filter output appears at pin 8 of IC1b and is applied to the stereo simulator circuit. This circuit is based on one that appeared in *Electronics Australia* in April 1983. It consists of op amps IC1c, IC1d 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 exact values are chosen, the filter gives a narrow notch with almost total cancel-



Virtually all the parts are mounted on a single PCB. Take care with mains wiring.

lation at its centre frequency.

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

The filtered signal from the twin-T networks is applied to the non-inverting inputs of IC1c and IC1d. IC1c applies a gain of about two to this signal, as set by the ratio of the 68kΩ and 33kΩ feedback resistors.

Unlike IC1c, IC1d is wired as a differential amplifier. Note that the output of the twin T filter network is applied to the non-inverting input, while the signal on the inverting input is derived from the output of IC1b via a 0.015μF capacitor and 47kΩ resistor. The output from IC1d represents the difference between these two input signals.

Thus, when the signals on pins 2 and 3 are common (ie, they have the same phase and amplitude), they are cancelled and IC1d 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.

Trimpot VR3 allows the gain of IC1d to be adjusted so that its output level matches that of IC1c. The outputs of IC1c and IC1d become the left and right channels respectively and are AC-coupled to S2 via 1μF capacitors.

Power for the circuit is derived from a 9V power transformer which drives a voltage doubler circuit consisting of D1 and D2 and the two 1000μF capacitors. The output from the voltage doubler is then applied to a 3-terminal regulator which provides a +12V rail. A red LED wired in series with an 820Ω resistor across the regulator input provides power on/off indication.

Construction

The Dynamic Noise Reduction System is available as a complete kit of parts from Dick Smith Electronics. Construction mainly involves assembly of a single PCB which is coded ZA-1502. This is housed in a plastic instrument case measuring 200 x 160 x 65mm (W x D x H).

No special procedure need be followed when wiring up the PCB although we suggest that the smaller components be installed first. The main thing to watch here is the orientation of polarised components. These include the electrolytic capacitors, the 3-terminal regulator and the ICs.

The three toggle switches are all PC-mounting types and are soldered directly to the PCB. Push them down onto the board as far as they will go before soldering. Note that S1 switches the mains — its terminals should be sleeved with plastic tubing to prevent accidental contact while the unit is being worked on.

PC stakes are used to terminate external connections to VR4 and the RCA sockets. Twelve PC stakes are required in all. The transformer leads should be trimmed to length and soldered direct to the PCB.

Once the PCB assembly has been completed, the 6-way RCA socket panel can be mounted on the outside of the rear panel using machine screws and nuts. This done, slip the front panel over the switch shafts. The front and rear panels, with the PCB sandwiched between them, can then be installed in the case and the PCB secured to the integral standoffs using self-tapping screws.

All that remains now is to complete the wiring. Take care with the orientation of the LED and note that the metal backshell of potentiometer VR4 is earthed via one of the pot terminals.

The mains cord enters through a hole in the rear panel and is secured using a cord clamp grommet. The active (brown), neutral (blue) and earth (green/yellow) leads are connected to a mains terminal block installed on the PCB.

Test and adjustment

To test the unit, connect it into your hifi system, switch on and check that all controls operate correctly. All you have to do is connect the unit between the output of your VCR and the auxiliary inputs to your stereo amplifier.

Alternatively, if you intend using it with a non-Dolby cassette player, the unit can be installed in the tape monitor loop between the outputs of the cassette player and the amplifier. The system can also be installed in the tape monitor loop if it is to be used with a graphic equaliser, or used with more than one signal source.

Note that the DNR system should be installed in the signal path in front of the graphic equaliser (or any other tone control system), since adjustment of the equaliser alters the noise floor.

Both the 15.625kHz notch filter and the stereo simulator require some initial adjustment. These adjustments are carried out under actual listening conditions and involve tweaking trimpots VR1, VR2 and VR3. Here's what to do:

(1) Set VR1 and VR2 to mid-range, and the DNR switch to out.

(2) Switch on, wind up the treble control of your amplifier, and listen for the 15.625kHz whistle. Adjust VR1 for minimum level, then VR2 (rejection of better than −40dB should be possible).

(3) Adjust VR3 for left and right stereo balance.

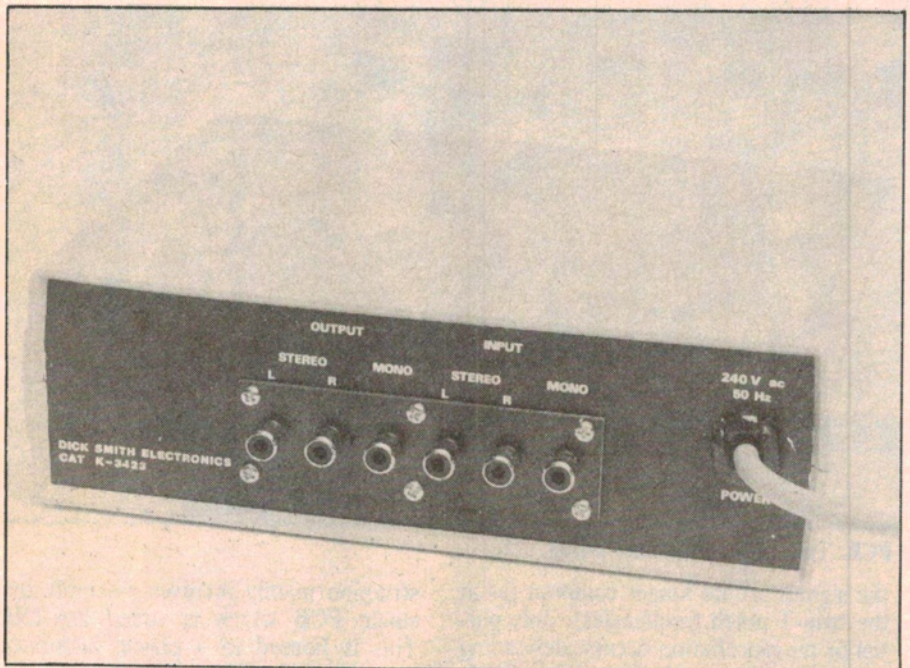
Note: VR1 and VR2 in the notch filter can also be adjusted by injecting 15.625kHz from a signal generator into the mono input and observing the output on an oscilloscope.

Using the DNR System

Careful adjustment of the Threshold control is required if you are to get the best possible sound when using DNR. The procedure is really very easy: apply tape noise to the input (ie, no program material) and adjust the Threshold control to a point slightly below where the noise comes up. This will ensure that the filters achieve optimum bandwidth when program material is present.

Note that the Threshold setting will have to be altered for different sources, depending upon the noise level. You can compare the subjective improvement by switching the DNR unit between IN and OUT. The DNR action should be most apparent between tracks and during soft passages, when it should remove nearly all of the hiss.

Finally, do not wind the Threshold control back too far. The high frequency response of program material will be noticeably restricted if you do. With just a little practice, you'll soon learn to accurately set the Threshold control by ear.



The rear panel carries the 6-way RCA socket panel.

Where to buy the kit

This project was developed in the Research and Development Department at Dick Smith Electronics Pty Ltd. It is available as a kit of parts only, and can be purchased by mail order or from your nearest Dick Smith Electronics store.

The kit comes complete and includes a pre-drilled fibreglass PCB, a plastic case, pre-punched panels with screened lettering, and a construction manual. The cost is $99.00 plus postage and packing charges where applicable.

Mail orders should be addressed to: Dick Smith Electronics Pty Ltd, PO Box 321, North Sydney, NSW 2113. Phone (02) 888 2105.

Note 1: PCB artwork copyright Dick Smith Electronics Pty Ltd.

Note 2: The word "DNR" and the symbol used on the front panel of this project are registered trade marks of National Semiconductor Corporation, USA. Under the terms of the licencing agreement with National Semiconductor, the LM1894 cannot be purchased separately, either from Dick Smith Electronics or from any other source (except as a replacement item).