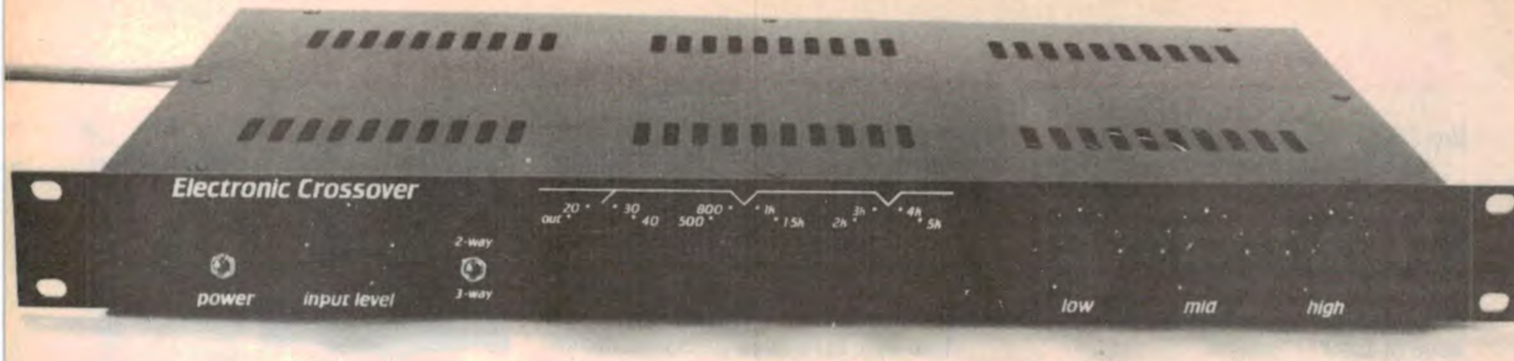


Active crossover for hifi systems

Build this electronic crossover for home hifi and sound reinforcement use. It features low noise and distortion, and provides plenty of flexibility in the selection of crossover frequencies.

by ANDREW LEVIDO design by JEFF SKEEN

Today's trend in professional sound reinforcement is toward high quality reproduction. Because of the superior sound and flexibility it affords, bi- and tri-amplification has all but completely replaced conventional speaker-amplifier systems using passive crossover networks.

In a bi-amplified system, the signal from the pre-amp or mixer is split into two frequency bands by an active crossover network. Each band is then amplified separately and fed to its particular loudspeaker. A tri-amped system is similar, except the incoming signal is split into three bands rather than two. The electronic crossover described here is designed to perform this frequency dividing function.

Because they use a separate power amplifier for each individual frequency range, bi- and tri-amplified systems make it possible to get much higher power output than is possible with conventional passive crossover networks. This is partly because a passive crossover network dissipates a considerable amount of the amplifier's power and also because the lower frequencies tend to "use up" most of the available amplifier power, leaving little for the higher frequencies.

The electronic crossover allows you to use separate amplifiers for each frequency band, so you can optimise the power supplied to each speaker. In addition, each band has an output level control, so the crossover is able to perform a primary equalisation function.

In the home situation, where high power levels are not of primary importance, other advantages of the bi- or tri-amplified system come to the fore. In particular, because there is no complex passive network between the amplifier output and the loudspeaker, the amplifier sees a less complex load impedance. This leads to improved damping, especially at low frequencies.

Another advantage of this type of system over the conventional set-up is the ability to match different loudspeakers. This is normally done using L-pad type attenuators which are very inefficient and can only be used at moderate power levels. The electronic crossover is able to perform this matching function before the power amplifiers, a much more satisfactory arrangement.

The crossover described here is ideally suited for both in-home and professional use. The signal to noise ratio of the prototype was better than 90dB referred to 1 volt, with all level controls set to maximum. Distortion was measured at below 0.003% on all settings. See the accompanying specification panel for further information on the performance of the prototype.

The EA Electronic Crossover is a stereo unit, with the front panel controls affecting both channels equally. It is assembled in an attractive black rack-mounting case measuring 430 x 254 x 44mm (W x D x H). The front panel of our prototype was screen printed, giving a professional-looking finish that would not look out of place in the home, or in an amplifier or effects rack.

The EA crossover provides for either two or three-band operation, with each of the crossover points being adjustable. Each output band is provided with a level control, and an input level control is provided. A mains power switch and an indicator LED are also included on the front panel. The rear panel accommodates the RCA type input and output connectors.

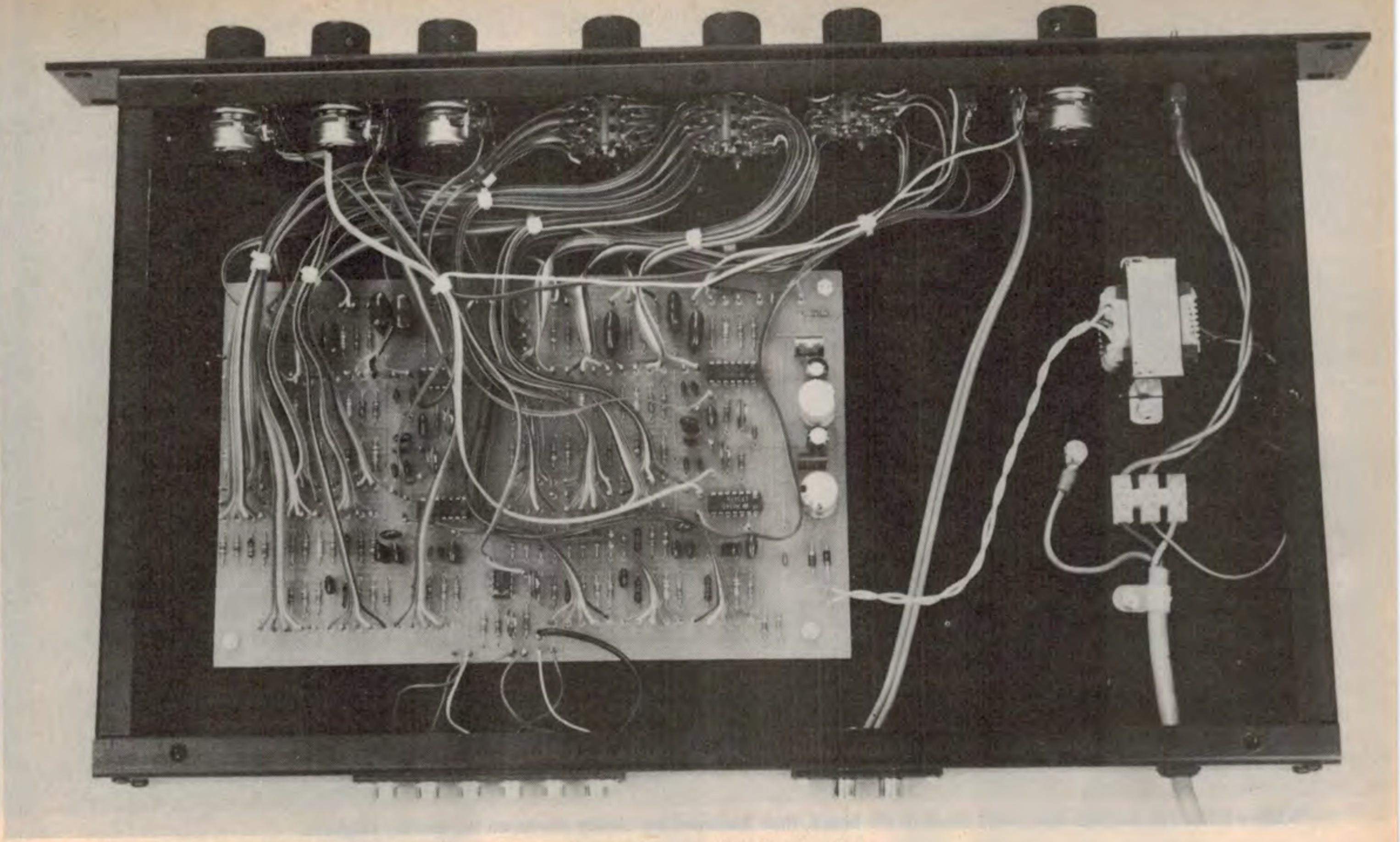
The left hand switch sets the lower cut-off frequency of the low frequency band. This cut-off can be set to either 40, 30 or 20Hz or switched out altogether, allowing flat response down to DC. The centre switch sets the crossover frequency between the low and the mid bands. The frequencies available are 500Hz, 800Hz, 1kHz and 1.5kHz.

The righthand switch sets the crossover points between the mid and the high bands. The crossover frequencies available are 2kHz, 3kHz, 4kHz and 5kHz. If the electronic crossover is being used in the "2 way" mode this crossover point is bypassed, and the mid band extends beyond

We estimate the current cost of parts for this project to be

$200-$220

This includes sales tax.



Interior of the finished unit. Wiring data for the pots are given in the accompanying drawings.

20kHz. Thus, for two way operation, the two channels used are the mid and the low bands.

How it works

The basis of this design is an arrangement of high and low pass filters. Butterworth filters have been chosen for this application because of their flat amplitude characteristic in the passband. Third order filters have been used to provide an 18dB per octave rolloff. Using filters of this order is convenient since they can be implemented using only one op amp.

In our design the filter cut-off frequencies are made adjustable by switch selection of the resistors.

Now let's have a look at the complete circuit diagram. Only one channel is depicted although the equivalent ICs in the other channel are shown in brackets, within the op amp symbols. For example, the input buffers in each channel are IC1a and IC4a.

Low noise FET-input op amps are used throughout. The IC line-up consists of four quad op amps (LF347 or TL074) and one dual op amp (LF353 or TL072).

The input signal is buffered by IC1a and fed to each of the three filter channels. The low frequency channel consists of a high pass filter (IC1b) controlled by S3. This switch also has a bypass position which allows a response down to DC. This is followed by a low pass (IC1c) filter which defines the upper corner frequency of the low (bass) channel. The corner frequency IC1c is controlled by S4e, c and a.

The high pass filter (IC2c) which defines the lower corner of the mid band is also controlled by S4 and, because these filters are designed to have the same corner frequencies, changing the switch position is complementary and has the effect of moving the crossover frequency. IC2c is followed by a low-pass filter (IC2d) controlled by S5 (j, h and e). S2, the two/three-way switch, is connected so that when it is in the two-way position low-pass filter IC2d is bypassed.

The high frequency channel consists only of a high pass filter, IC2a, which is ganged with the low-pass filter in the mid band to provide the adjustment of the crossover point between these two bands.

Potentiometers VR2, VR4 and VR6 are each followed by an output buffer consisting of an op amp connected as a non inverting amplifier. Each of these output buffers has a trimpot to allow the gain to be adjusted. This adjustment is provided to compensate for any small differences in passband gain between the filters.

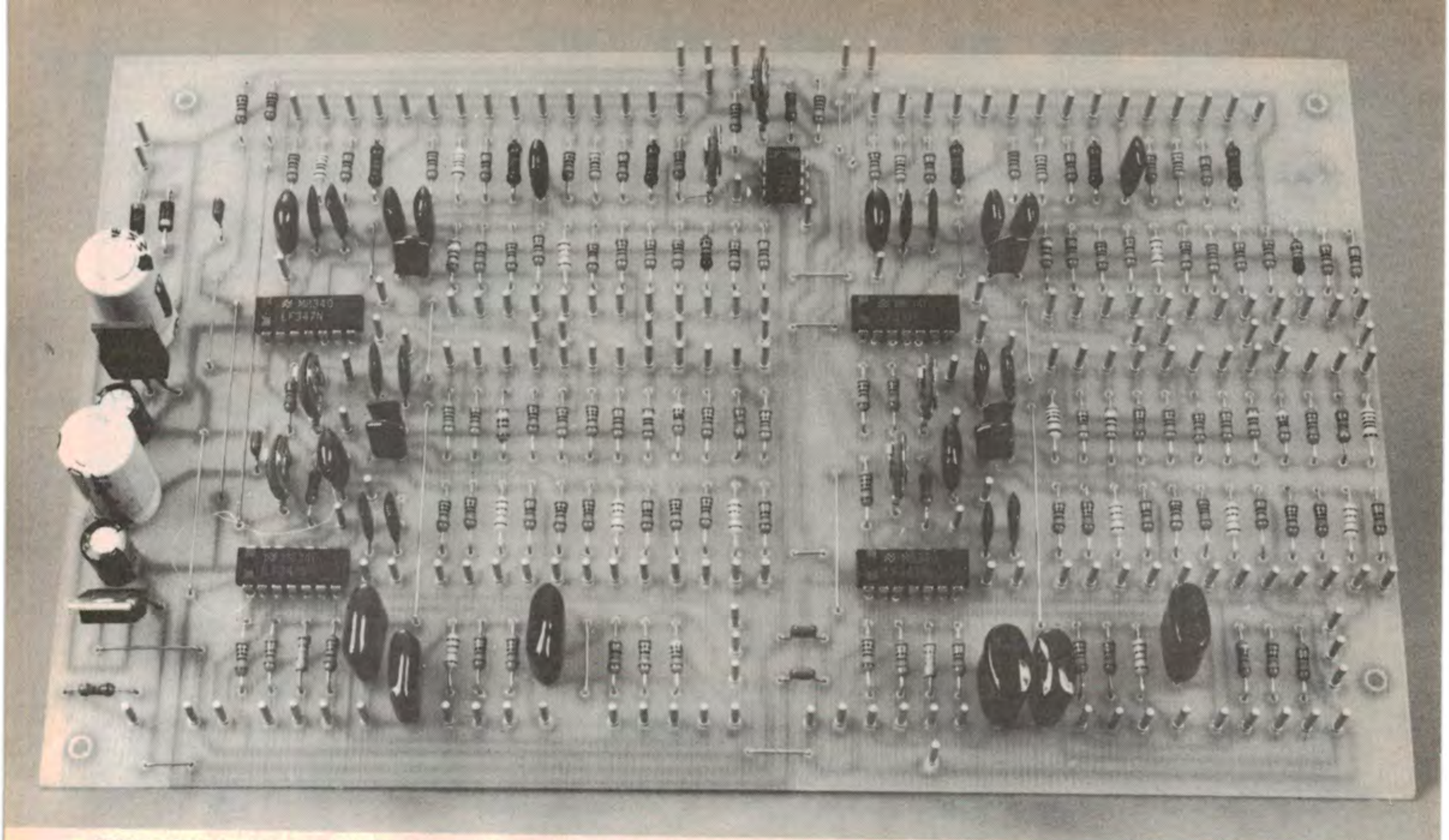
The power supply is a fairly conventional design using two half-wave rectifiers to derive a positive and a negative supply rail from a single secondary winding. These rails are filtered, and regulated by 7812 and 7912 3-terminal regulators. The power indicator LED is run from the negative supply via a 1.2kΩ resistor. The supply rails are decoupled by 0.1μF capacitors at a number of places throughout the circuit.

Specifications

Signal to noise ratio (at 1V)	
High (10kHz)	93dB
Mid (1kHz)	93dB
Low (800Hz)	93dB
Distortion (at 1V)	
High (10kHz)	<.003%
Mid (1kHz)	<.003%
Low (100Hz)	<.003%
Crosstalk (referred to 1V)	
High (10kHz)	−56dB
Mid (1kHz)	−65dB
Low (100Hz)	−91dB

Construction

Although this project is not complicated in terms of the electronics, the construction involves a large amount of wiring and is very time-consuming. The first step in construction is to drill the holes in the metalwork if this is not already done. The front panel artwork gives the location of the holes for the pots and switches, and the blank circuit board can be used as a template for



While a lot of components have to be fitted to the board, their locations are clearly shown on the overlay diagram.

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marking out its own mounting holes. The locations of the other holes are not critical, and can be determined from the photographs.

PARTS LIST

- 1 PCB, code 84ac11, 141 x 231mm
- 1 rack mounting case 430 x 254 x 44mm (W x D x H)
- 1 mains transformer, 12V at 150mA, 2851 or equivalent
- 1 SPDT miniature toggle switch
- 1 DPDT miniature toggle switch
- 3 Lorlin RA series rotory switch bodies
- 8 Lorlin RA series 4 pole 4 position switch wafers
- 7 knobs
- 1 mains cord and plug
- 1 cable clamp
- 1 grommet
- 1 3-way barrier strip
- 180 PC stakes
- 3 metres 10-way rainbow cable
- 1 6-way RCA socket panel
- 1 2-way RCA socket panel

Semiconductors

- 4 LF347, TL074 quad op amp
- 1 LF353, TL072 dual op amp
- 1 7812 positive 3-terminal regulator
- 1 7912 negative 3-terminal regulator
- 1 3mm red LED

Capacitors

- 2 1000µF 25VW PC electrolytic
- 2 100µF 16VW PC electrolytic
- 6 0.22µF polyester
- 4 0.1µF monolithic
- 4 .056µF polyester
- 10 .022µF polyester
- 6 .01µF polyester
- 4 .002µF polyester
- 4 .001µF polyester

Resistors (¼W, 1% tolerance)

2 x 180kΩ, 2 x 120kΩ, 2 x 91kΩ, 2 x 75kΩ, 2 x 43kΩ, 2 x 39kΩ, 2 x 36kΩ, 4 x 27kΩ, 2 x 24kΩ, 8 x 20kΩ, 2 x 18kΩ, 2 x 16kΩ, 2 x 13kΩ, 6 x 12kΩ, 10 x 10kΩ, 8 x 6.8kΩ, 2 x 6.2kΩ, 2 x 5.6kΩ, 10 x 5.1kΩ, 4 x 3.9kΩ, 2 x 3.6kΩ, 6 x 3.3kΩ, 2 x 3kΩ, 2 x 2.7kΩ, 8 x 2.4kΩ, 4 x 2.2kΩ, 8 x 2kΩ, 2 x 1.5kΩ, 2 x 1.3kΩ, 2 x 1.1kΩ, 2 x 910Ω

Resistors (¼W, 5%)

6 x 5.6kΩ, 6 x 1.2kΩ, 6 x 100Ω

Potentiometers

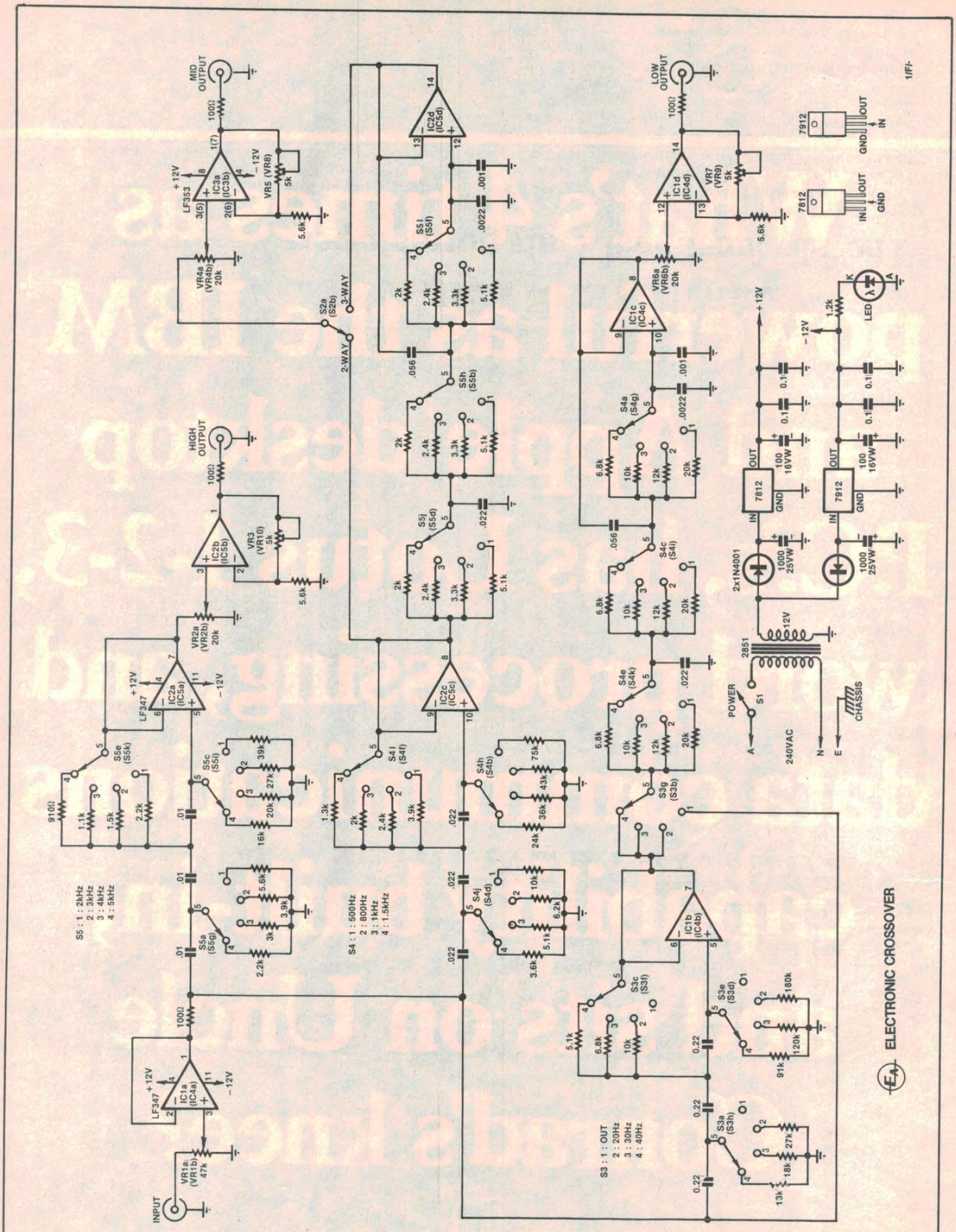
6 x 5kΩ miniature vertical trimpots
3 x 20kΩ log dual ganged pots
1 x 47kΩ log dual ganged pot

It is necessary to cut slots in the rear of the case for the RCA connector panels. These are best made by drilling a series of holes and filing out the unwanted metal. When all this has been done the RCA panels can be mounted, as can the power transformer, mains switch and terminal block. Wire the mains cable and switch according to the wiring diagram. Do not install the pots or switches at this stage.

The next task is the assembly of the printed circuit board. PC stakes are a necessity in this project, and they should be mounted first. After this is done assemble the board in the normal way. Be careful reading the colour codes on the 1% resistors; it is easy to make mistakes. When the board is assembled and checked it can be mounted in the case. We mounted the prototype PCB using 6mm spacers.

The multipole switches have to be assembled before they can be wired. Switch three has eight poles (two wafers) and switches four and five have 12 poles (three wafers). The wafers are stacked up on one another and the whole lot are secured to the switch body with the threaded rods and nuts provided with the switches.

Begin the switch wiring with switch five. Split the ribbon cable down the centre, and cut each strip into six equal lengths. Connect one end of each length



ELECTRONIC CROSSOVER

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to one of the poles of the switch. You should end up with 12 pieces of five-way ribbon cable connected to the switch. Mount this switch in the front panel, and begin to connect the wires to the appropriate PC stakes, according to the wiring diagram. You will need to cut the pieces of ribbon cable to a sensible length as you go.

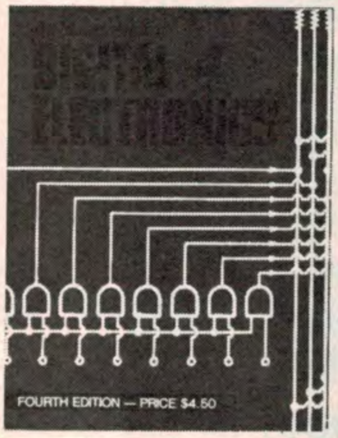
Once this is completed, move on to wire up switch four in exactly the same manner. Switch three is connected differently to the other two in that not all of its pins are used. There are also some wire links soldered between some of the switch lugs. Use lengths of four- and three-way ribbon cable to make these connections. This switch can then be mounted in the case and the connections made to the circuit board in the same way as the other two.

The pots and the two-way/three-way switch can now be mounted and wired as shown in the diagram. Lastly, wire the output sockets, the input sockets and the transformer secondary. Don't forget to install the front panel LED. When all the wiring has been completed it should be neatly tied up using a few cable ties. This completes construction of the crossover, and all that is left to do is to test it and set up the trimpots on the board.

To test and set up the crossover you will need to use a signal generator and an oscilloscope. Feed a signal into one input of the crossover and check each output in turn with the oscilloscope. Check each crossover point by using an appropriate input frequency range to confirm that the output tapers as it should. Make sure that a response is obtained which is similar to that shown in the accompanying graph. If you find any major differences between the performance of your unit and the expected results, recheck the construction, particularly the switch wiring. Repeat for the other channel.

Set up the output level by feeding in a signal in the centre of each band, and adjusting each output level trimpot for the same output signal amplitude. Make sure that for this test the front panel pots are all set to maximum. Suggested frequencies are: low band, 100Hz; mid band, 2kHz; high band, 10kHz. Note that the crossover frequency switches should be set so that the band being measured is as wide as possible.

Start with the high frequency band. Feed in a signal of the appropriate frequency and note the output level with VR3 in the mid position. Next, feed in a signal of the same amplitude as before, but of the mid band frequency. Adjust VR5 for the same output level as before. Similarly, adjust VR7 for the same out-



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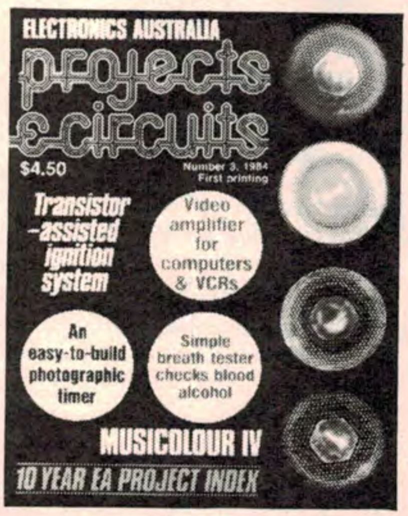

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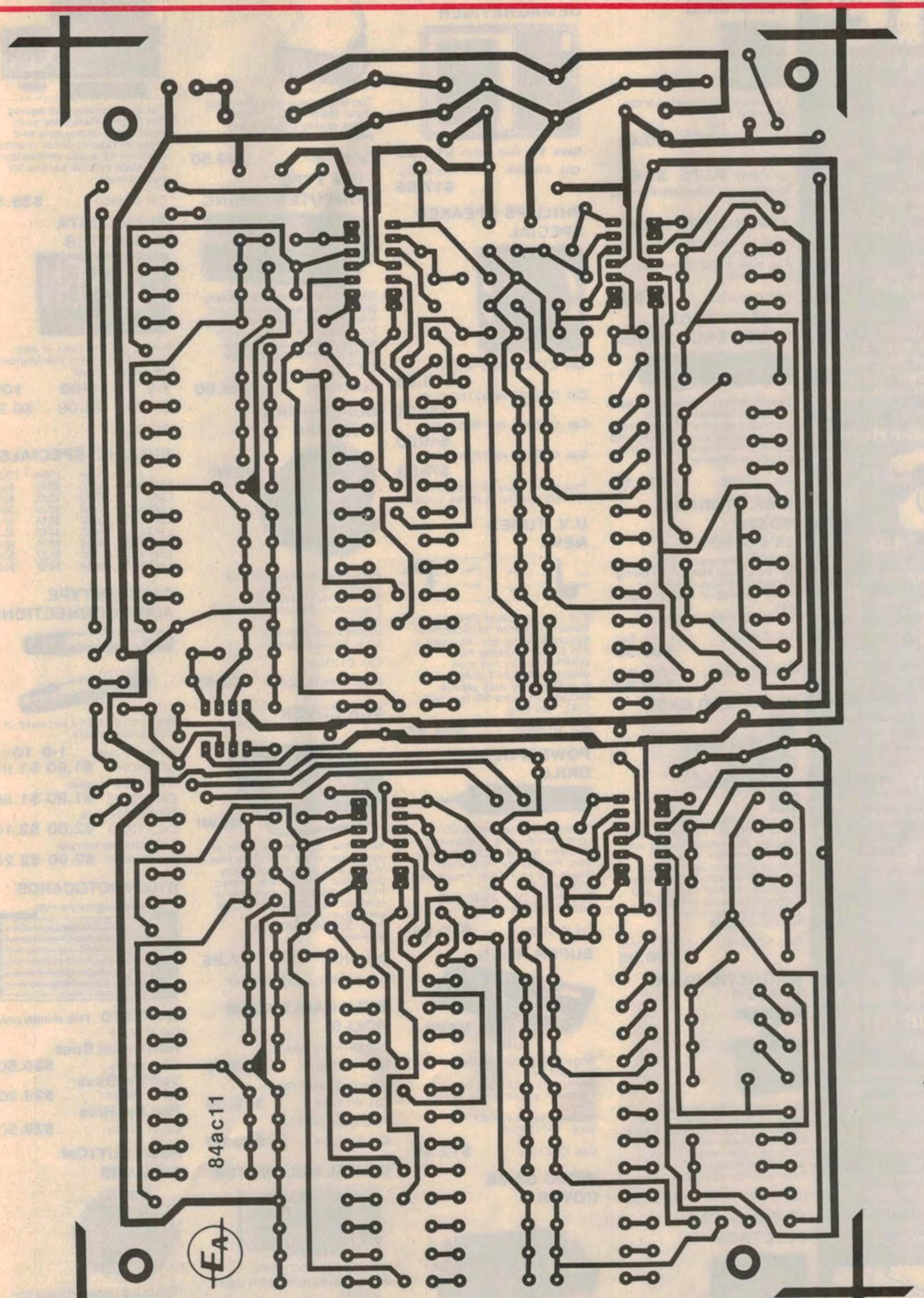

The printed board, shown actual size.

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put level with the high frequency signal. Repeat for the other channel (VR10, VR11, VR12 respectively). This completes the setting up procedure, so the lid can now be screwed down, and the crossover is ready to use.