STEREO SYNTHESISER
NORMAL
VCR
SYNTHESISER
TUNER
ON

Simple circuit gives pseudo stereo sound

Stereo synthesiser for tuners & VCRs

Enjoy the benefits of stereo sound from your video cassette recorder, TV or AM tuner with this Stereo Synthesiser. The circuit uses just four ICs and is easy to build.

By JEFF SKEEN and GREG SWAIN

Anyone who has ever directly compared mono to stereo sound will be well aware of the advantages of stereo reproduction. Stereo imparts a sense of dimension and realism to reproduced sound, thus providing greater listening pleasure. Now, with this simple device, you can synthesise realistic stereo sound from virtually any monophonic source, including VCRs, TV sets and AM radios.

In use, the Stereo Synthesiser is simply connected between the monophonic signal source and your stereo amplifier. Front panel toggle switches then let you choose between two signal sources, and between normal and synthesised stereo sound.

Synthesised stereo

Stereo reproduction relies on amplitude and phase differences between the two channels of a stereo system. To synthesise stereo from a monophonic signal, therefore, we need to have some means of artificially recreating these amplitude and phase differences. In practice, this involves dividing the mono signal into several components, and then distributing these components between the left and right channels.

So how is this done?

One technique involves passing the mono signal through a number of bandpass filters, and then mixing the outputs back with the original signal in the left and right channels. The frequencies passed by the bandpass filter increase in volume in the channel to which they are added and decrease in volume in the channel from which they are subtracted. By alternately adding to one channel and subtracting from the other, we can synthesise quite acceptable stereo sound.

In fact, this technique has been used by the recording industry for many years to process old monophonic readings into simulated stereo records.

The synthesiser described here uses an

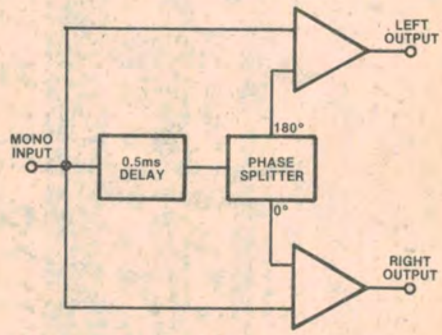
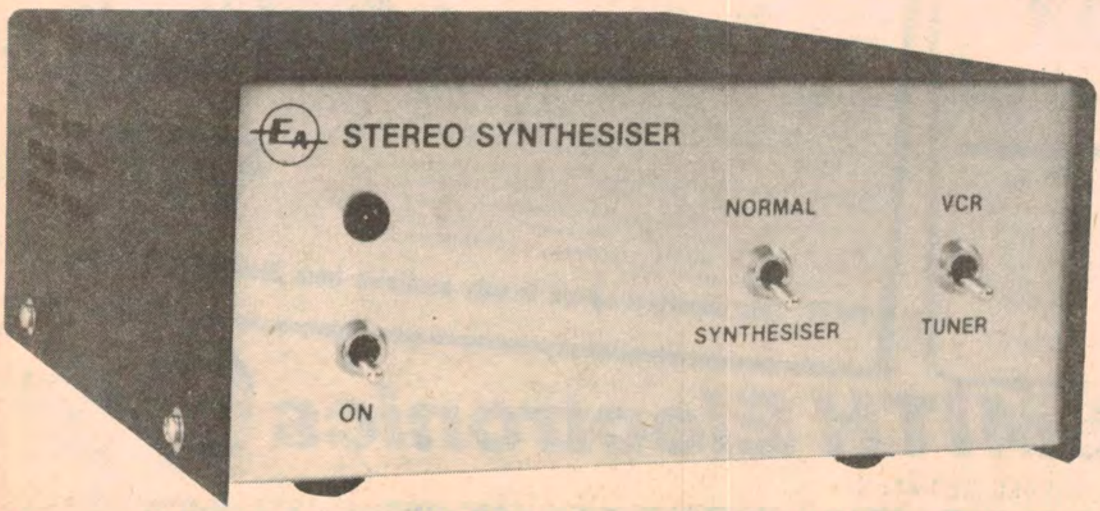


Fig. 1

even more effective, yet much simpler, add and subtract method to create stereo sound. It uses a comb filter technique, a term which we will explain further.

If a signal is delayed and then mixed back with the original signal, the frequency response of the system ends up as a series of peaks and troughs. This is because in-phase signals are added, while out-of-phase signals are subtracted. If there are enough peaks and troughs, the frequency response will resemble the teeth of a comb – hence the term "comb filter".

In this circuit, the delay for the comb filter effect is generated by a bucket



Front panel switches let you choose between normal and synthesised stereo sound, and between two different monophonic signal sources. Unit is housed in a standard metal case.

brigade device (BBD). The delay time is set to approximately 0.5ms, and this has the effect of evenly dividing the audio spectrum into 1kHz "chunks" – about optimum for effective stereo simulation.

How it works

Block diagram Fig. 1 shows the general circuit concept. The input signal is fed direct to the 0.5ms delay line which in turn drives a phase splitter network. The 0° and 180° phase-shifted (and delayed) outputs are then fed to left and right channel mixer circuits, where they are mixed with the original mono signal.

At very low frequencies, the 0.5ms delay time is short relative to wavelength. Thus, the delayed signal reinforces the signal in the right channel and tends to cancel the signal in the left. As a result, low bass is 6dB louder in the right channel, and almost totally absent in the left. At 1kHz, however, a 0.5ms delay represents one-half of the wavelength, so the two phases are effectively reversed. We now get a 6dB reinforcement in the left channel and signal cancellation in the right.

This addition and subtraction effect is repeated for each 1kHz interval (actually slightly less in the prototype) across the audio spectrum, with maxima and minima occurring at each 1kHz "marker". This is depicted in Fig. 2 which plots the frequency response of the two output channels. Note that when the output on one channel is at a maximum, the other channel is at a minimum.

Circuit description

The circuit is based on a design that appeared in the June 1982 edition of the American magazine "Popular Electronics". However, while our circuit uses the same general principle, it has been extensively modified to improve the performance and make use of locally available components.

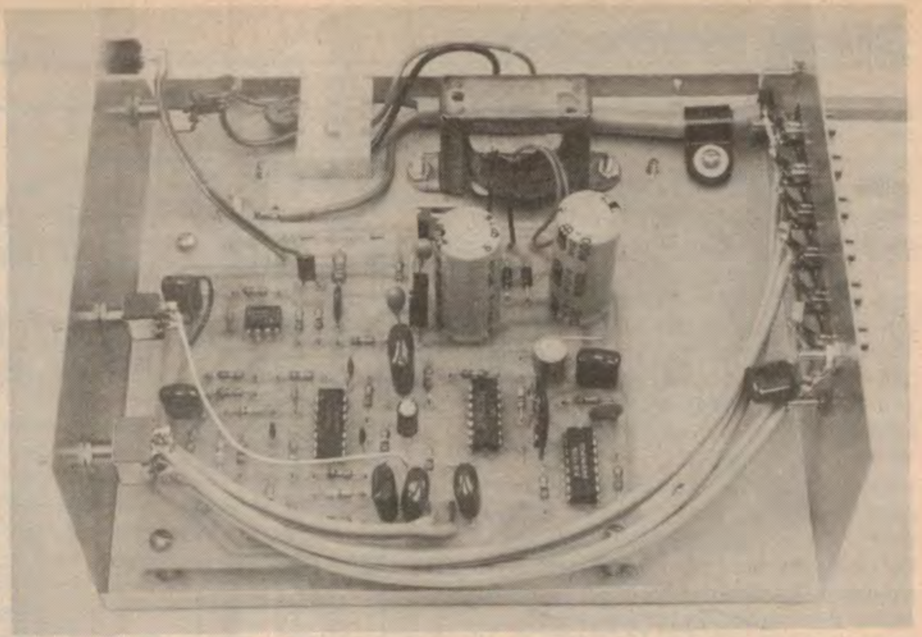
Input signals to the stereo synthesiser are fed in via two pairs of RCA input sockets. One pair of input sockets is wired in parallel and accept a mono input signal, eg from a VCR or a TV set. The other pair are isolated from each other and can accept either a stereo input signal – as from an FM tuner – or a paralleled mono input signal.

Switch S1a,b selects between the two source inputs and passes each channel through a subsonic filter formed by a 0.1μF capacitor and two 47kΩ (or 1 x 100kΩ) resistors. The left input signal is then fed to the input of mixer/buffer amplifier IC1a, while the right input signal goes to IC1c. IC1a and IC1c both function as inverting amplifiers with gain set to unity by 100kΩ feedback resistors.

A 56pF capacitor is included in the feedback loop of each amplifier to roll off the response above 30kHz. This is a precautionary measure, designed to filter out any noise from the bucket brigade device when the unit is operating in the synthesiser mode.

Delay line driver IC1b functions as a non-inverting unity gain buffer stage. Its input signal is derived from the left channel, at the junction of the two 47kΩ input resistors, and will be half the amplitude of the original signal due to the voltage divider action of these resistors. Since IC1b has unity gain, its output is also one half the left input signal, and this ensures that signal peaks within the delay line are well below maximum.

The output from the delay-line driver passes to the pin 3 input or IC2, an MN3001 dual 512-stage bucket brigade device that operates as an analog shift register. Input bias voltage from the BBD



A single printed circuit board accommodates most of the components. Keep mains wiring neat and tidy to avoid the possibility of electric shock.

PARTS LIST

1 metal case, 160 x 184 x 70mm
1 Scotchcal front panel, 160 x 75mm
1 printed circuit board, code 82/ms/8, 121 x 99mm
1 six-way RCA socket panel
2 SPDT toggle switches
1 DPDT toggle switch
1 28V, or 36V CT transformer, Ferguson PF3786, PF3787 or equivalent
1 mains cord and plug
1 mains cord clamp
1 three-way terminal block
1 rubber grommet
2 solder lugs
4 12mm tapped brass standoffs

CAPACITORS
2 1000uF/25VW PC electrolytic
1 47uF/16VW PC electrolytic
2 10uF/16VW tantalum
1 10uF/16VW PC electrolytic
1 0.22uF metallised polyster (greencap)
7 0.1uF greencap
1 .0015uF greencap
1 .0012uF greencap
1 470pF 2kV disc ceramic
1 150pF disc ceramic
1 120pF disc ceramic
4 56pF disc ceramic

SEMICONDUCTORS
1 LF347 quad BiFET op amp
1 MN3001 dual n-channel BBD
1 4049 hex inverter
1 TL071, LF351, Fet-input op amp
1 7815 +15V 3-terminal regulator
1 7915 −15V 3-terminal regulator
1 4.7V 400mW zener diode
4 1N4001 1A silicon diodes
2 1N4148 silicon diodes
1 red LED and bezel

RESISTORS (¼W, 5% unless stated)
3 x 120kΩ, 8 x 100kΩ, 2 x 47kΩ, 3 x 27kΩ, 1 x 22kΩ, 5 x 10kΩ, 1 x 5.6kΩ, 1 x 2.7kΩ ½W, 1 x 1.5kΩ, 1 x 1kΩ, 2 x 390Ω, 1 x 10kΩ large vertical trimpot.

MISCELLANEOUS
Machine screws and nuts, 1 metre of shielded audio cable, 200mm of rainbow cable, solder, etc.

is set by trimpot VR1, and this is blocked from the output of IC1b by a 10μF capacitor. Switch S2 bypasses the stereo synthesiser function by grounding the output of IC1b, thereby removing by signal from the delay line.

We won't delve into the internal operation of the BBD here. Suffice to say that if an audio signal is fed to its input, a delayed version of this signal appears at the output. Note that in this circuit only one-half of the MN3001 BBD is used. The unused pins of the other half are tied either high or low.

Clock signals for the BBD are derived from a two-phase clock oscillator formed by IC3, a 4049 hex inverter IC. IC3a, 3b and 3c form a standard CMOS oscillator, while inverters IC3d and IC3e buffer the out-of-phase clock signals to pins 2 and 12 of IC2. The nominal clock frequency is 550kHz.

The delay time through IC2 is 465μs (512 divided by twice the clock frequency). Its output signal appears at pins 13 and 14 and is AC-coupled to a low pass filter which uses a single Fet-input op amp (IC4) and three RC networks.

This combination active/passive filter gives a Butterworth response (maximally flat in the passband) and a −3dB point at 20kHz. Gain in the passband is unity, while the ultimate slope of the filter is 18dB/octave above the corner frequency (−3dB point).

IC4 and IC1d effectively operate to produce two buffered outputs, one 180° out of phase with the other. In other words, we have the phase splitter referred to in Fig. 1. The in-phase delayed signal appears at the output of IC1d and is fed into the right channel mixer amplifier (IC1c) via a 27kΩ resistor. The out-of-phase delayed signal appears at the output of IC4 and is fed into the left channel mixer amplifier (IC1a), again via a 27kΩ resistor.

Thus, when the delayed signal is exactly in phase with the original, the output from the right channel increases by about 6dB and the left channel output decreases to about −20dB (or less). This situation is reversed when the delayed signal is exactly out of phase with the original.

The power supply is conventional and consists of a 30V centre-tapped transformer driving a bridge rectifier, with filtering provided by two 1000μF 25VW electrolytic capacitors. Regulated ±15V supplies are derived using positive and negative 3-terminal regulators, while zener diode D3 provides the +4.7V rail. The remaining −13.8V rail is derived using diodes D1 and D2.

Decoupling of the regulator outputs is provided by two 10μF tantalum capacitors, while a LED connected in series with a 2.7kΩ resistor across the ±15V rails provides power on/off indication. The 470pF capacitor across the mains switch (S3) is included to minimise switch-on transients.

Readers should also note the 0.1uF capacitor between the circuit earth and chassis. This capacitor AC-couples the 0V rail to chassis to suppress mains-borne interference, while at the same time avoiding the hum loop problem that a direct connection would cause.

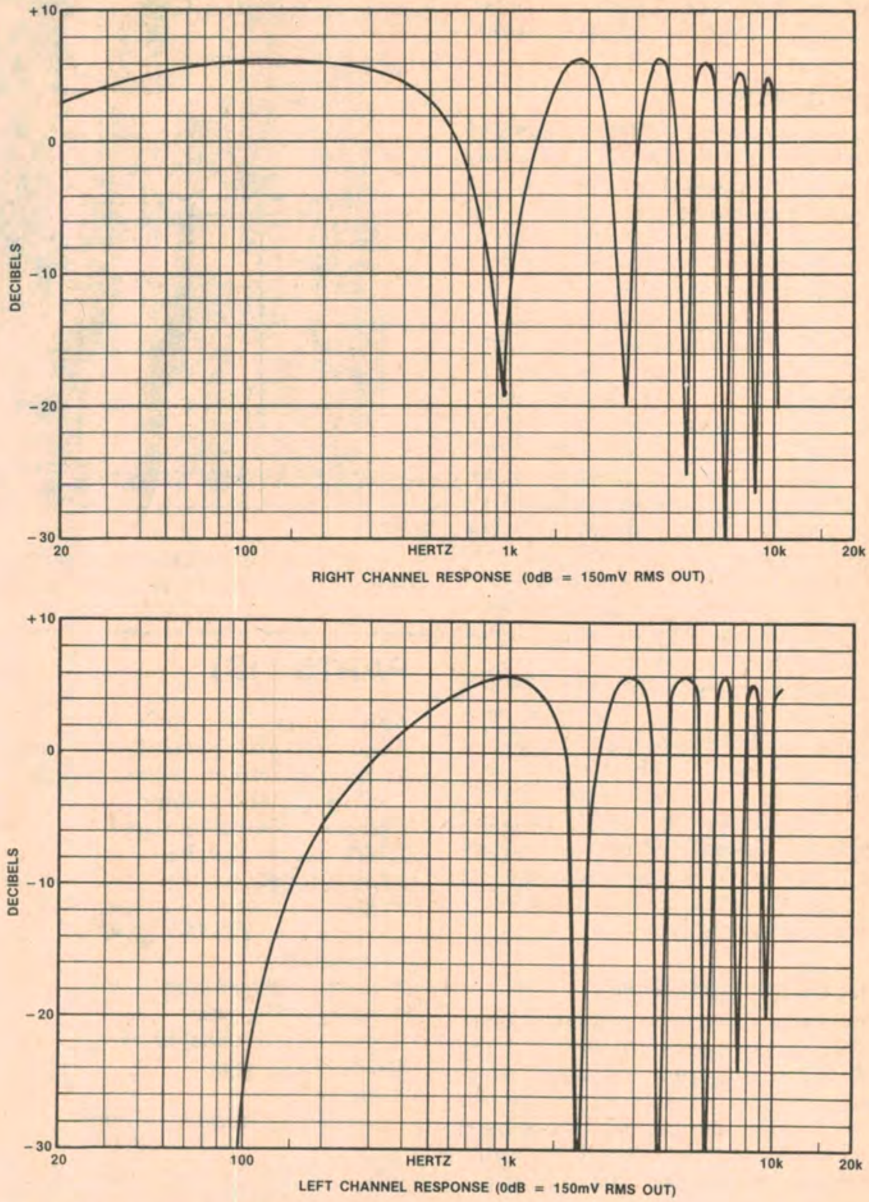


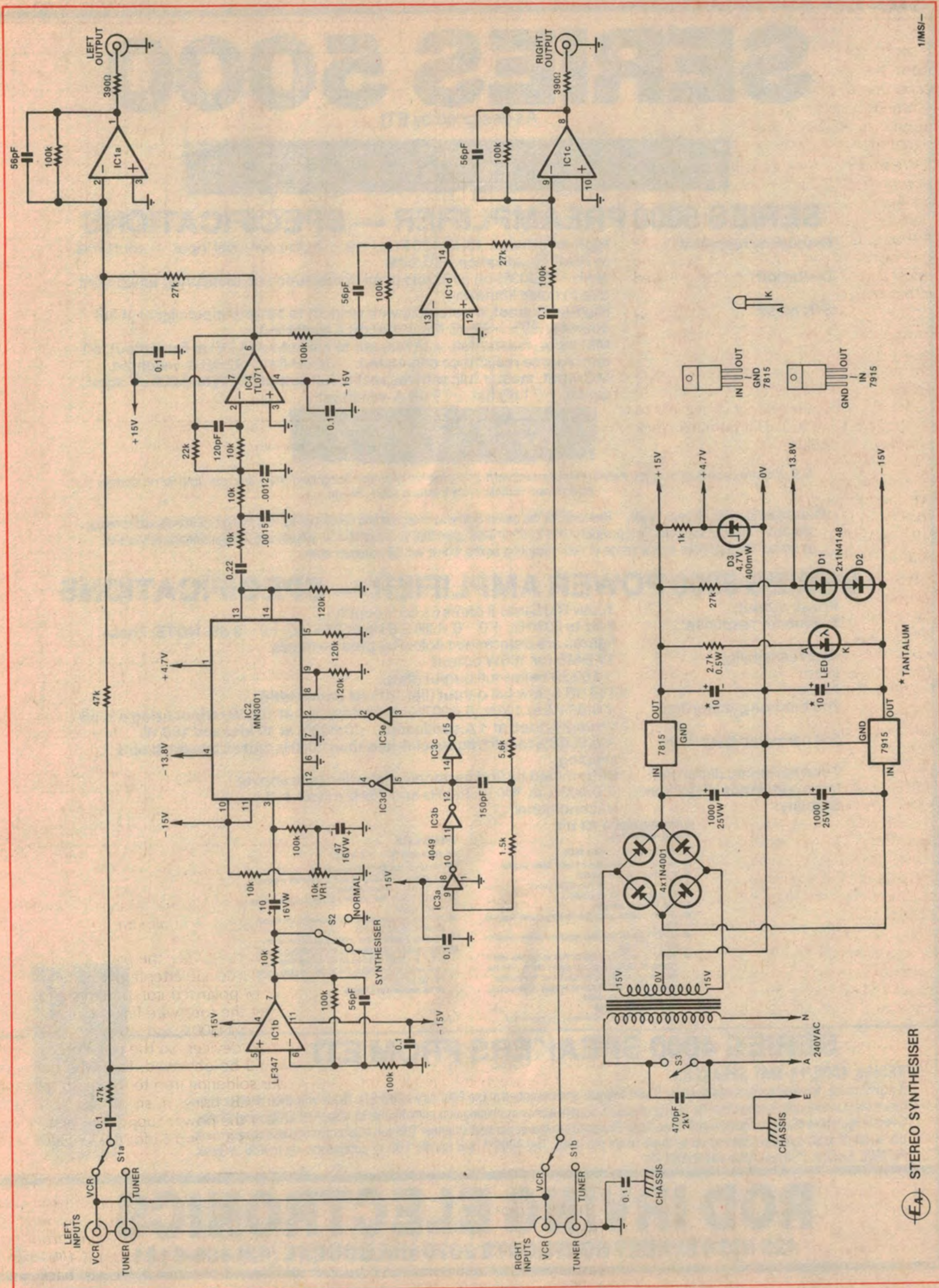
Fig. 2: frequency response curves for the right and left output channels. Note that when one channel is at maximum output, the other is at minimum.

Construction

The circuit is built on a small printed circuit board (PCB) coded 82ms8 and measuring 121 x 99mm. Assemble the PCB according to the parts layout diagram, leaving the four ICs until last. Pay particular attention to the orientation of polarised components and don't forget the four wire links.

The MN3001 and 4049 ICs are both CMOS devices, so the usual precautions should be observed. Earth the barrel of your soldering iron to the earth track on the PCB using a small clip lead and solder the power supply pins first. These are pins 1, 4 and 11 for the MN3001, and

A two-phase clock (IC3) driving a bucket brigade device (IC2) forms the heart of the circuit. The delayed signal from the BBD is fed to phase splitter IC4/IC1d and the resulting signal mixed back with the original. ▶



STEREO SYNTHESISER
LEFT OUTPUT
RIGHT OUTPUT
LEFT INPUTS
RIGHT INPUTS
VCR
TUNER
S1a
S1b
S2
S3
NORMAL
SYNTHESISER
IC1a
IC1b
IC1c
IC1d
LF347
IC2
MN3001
IC4
TL071
IC3a
IC3b
IC3c
IC3d
IC3e
4049
VR1
7815
7915
4x1N4001
2x1N4148
D1
D2
D3
4.7V
400mW
LED
TANTALUM
1000 25VW
240VAC
470pF 2kV
CHASSIS
+15V
+4.7V
0V
−13.8V
−15V
1/MSI/–

pins 1 and 8 for the 4049. No special precautions are required for the LF347 and TL071 devices, but you should make sure that all ICs are inserted the right way round.

A standard metal case 160 x 184 x 70mm (W x D x H) is used to house the PCB. Using the photographs as a guide, mount the six-way RCA socket panel and drill mounting holes for the PCB, mains transformer, terminal block, cord clamp and earth solder lug. The mains cord entry hole should also be drilled at this stage, and fitted with a rubber grommet.

Next, spray the Scotchcal front panel with a hard-setting lacquer (eg, "Estapol") to prevent scratches and carefully affix it to the front panel. Install the front panel switches and LED and mount the various hardware items in the case. The internal wiring can now be completed according to the diagram.

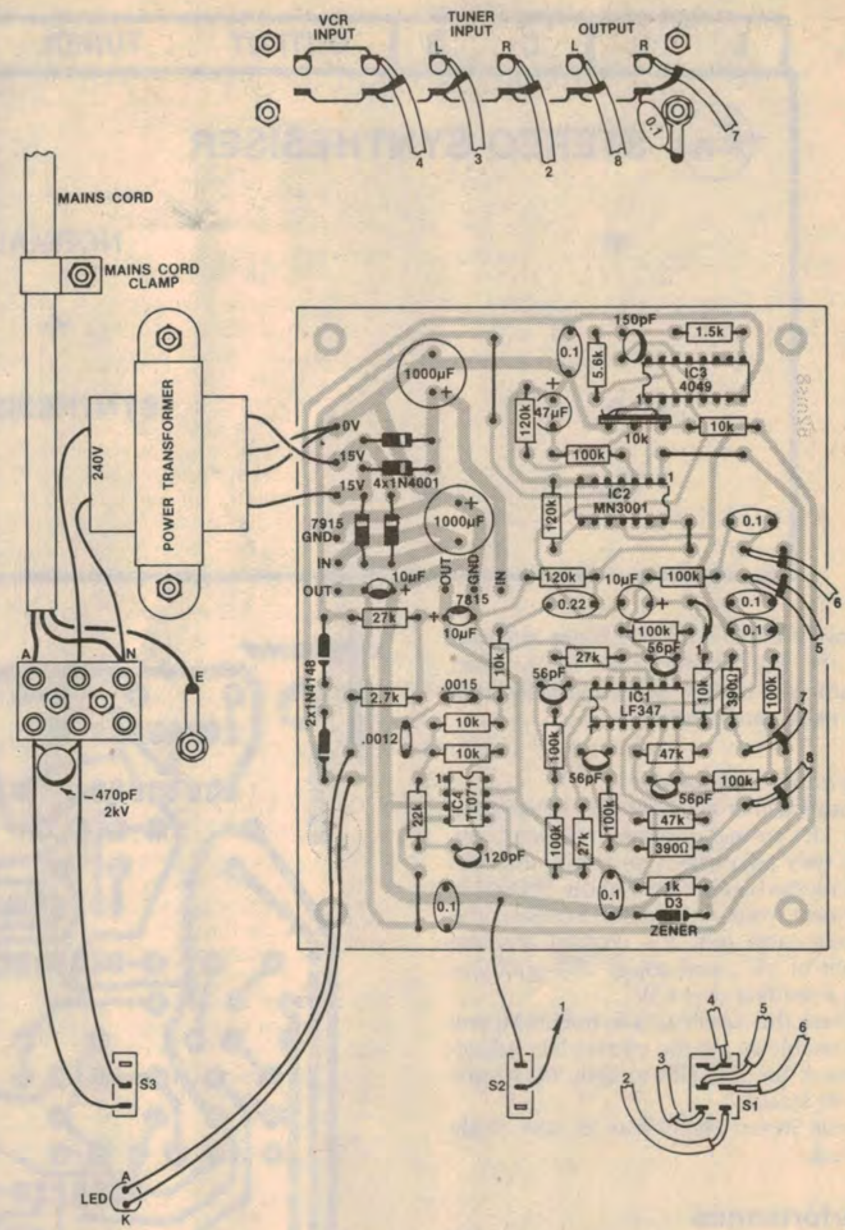
Pass the mains cord through the grommeted entry hole and anchor it securely with the cord clamp. The active (brown) and neutral (blue) leads are connected to

the insulated terminal block, while the earth lead (green/yellow) goes to a solder lug bolted to the chassis. Complete the mains wiring to switch S3 and the transformer primary using 250VAC rated hook-up wire.

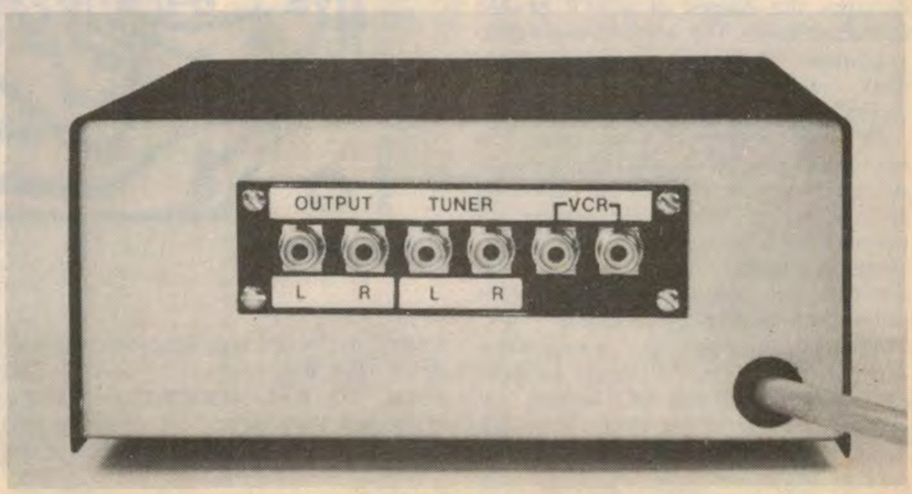
The 470pF 2kV mains suppression capacitor is connected directly to the terminal block. Keep the leads to this capacitor reasonably short to prevent them from contacting the chassis (or the user).

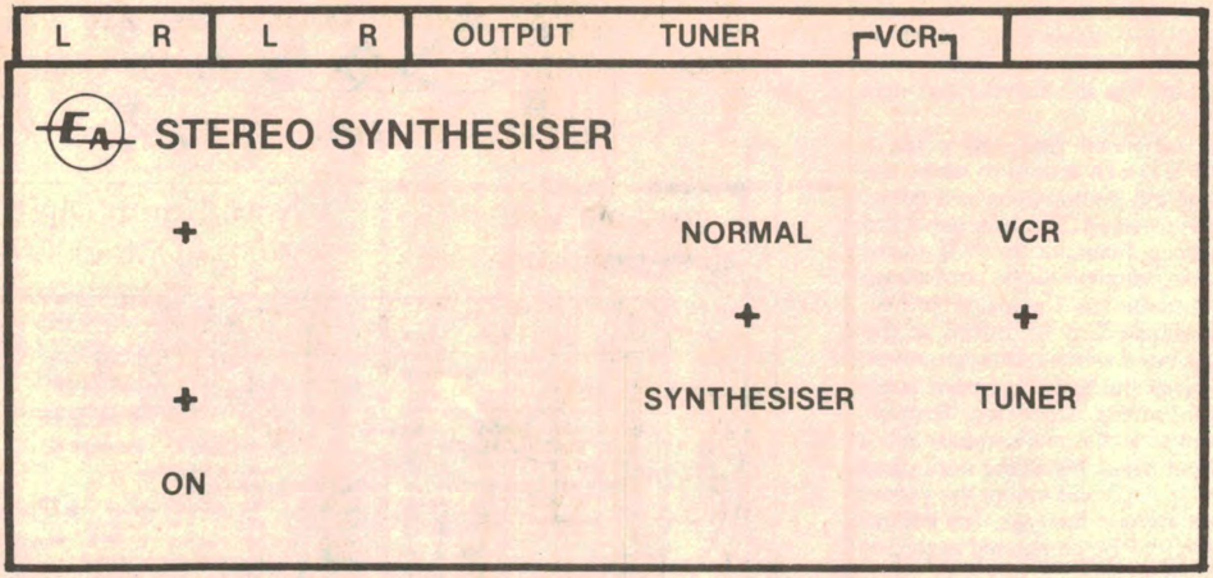
Connections to the LED and switch S2 can be run in rainbow cable, but you must use shielded audio cable for all connections to the RCA sockets. Don't forget the 0.1uF capacitor between the circuit earth and chassis, and note the wire link between the active terminals on the VCR input sockets. Do not make a direct connection between the circuit earth and chassis.

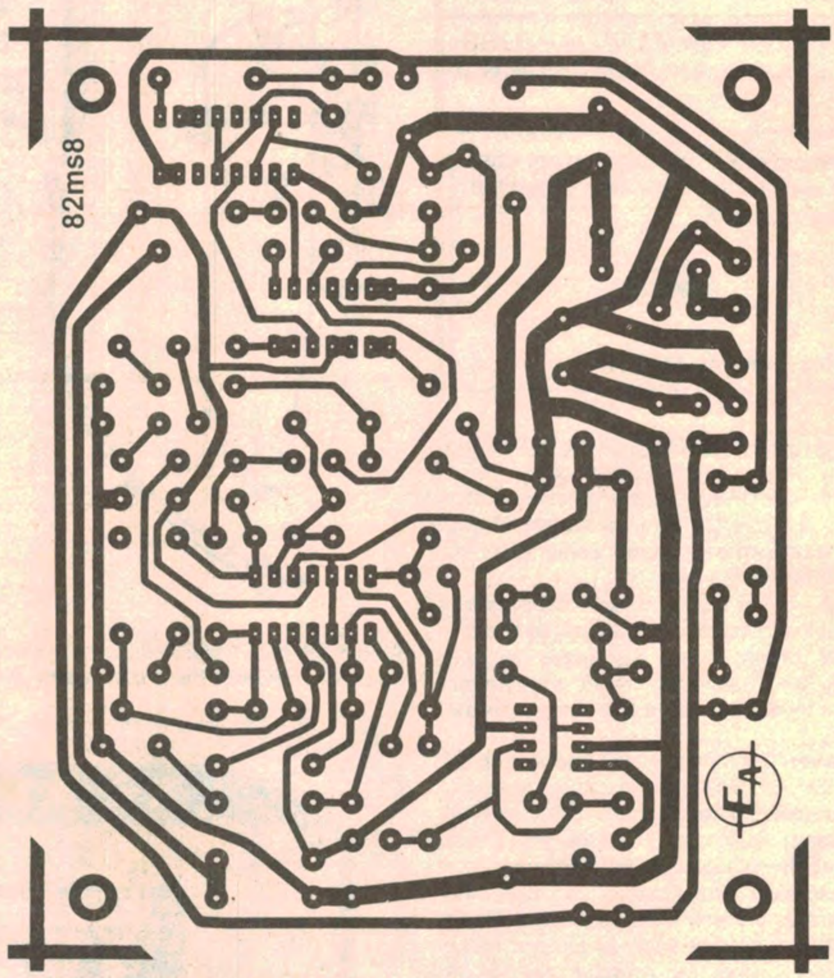
The PCB can now be mounted in position using 12mm brass standoffs and machine screws and washers. Check your work carefully before switching on – a few minutes checking here can save you a lot of hassles later on if you've made some silly wiring error like inser-



Make sure that polarised components are correctly oriented and note the 0.1μF capacitor between the circuit earth and chassis. Below is the rear panel.







Above and right are actual size artworks for the front panel and PCB. Finished boards and panels will be available from the usual retail outlets.

ting an IC back-to-front.

Satisfied that all is correct, rotate trimpot √R1 to mid-position and switch on. The only adjustment necessary involves setting the bias on pin 3 of the BBD (IC2). Connect your multimeter between the circuit earth (not the chassis) and the wiper of VR1, and adjust VR1 until you get a reading of −4.5V.

Check the supply rails to the BBD if you are unable to get the correct bias adjustment. If the LED fails to light, try reversing its leads.

Your Stereo Synthesiser is now ready for use.

Performance

Because of limitations in the BBD device, the unit does not meet hifi specifications but is entirely adequate to enhance the output of a VCR or AM broadcast tuner. The signal-to-noise ratio is around −47dB with respect to 150mV RMS, while harmonic distortion is typically 0.4% at the same output level.

Although labelled VCR and tuner, the two inputs may be coupled to any mono or stereo source capable of delivering 100mV to 1V. The easiest method of connection is simply to interpose the synthesiser between the source and the amplifier, but you could also connect it in the tape loop of the amplifier.

Whatever your source, if it only has a single mono output it should be connected to one of the VCR inputs – it doesn't matter which one. A source capable of either stereo or mono output, such as an AM/FM tuner, should be connected to the left and right tuner inputs. Note that the synthesiser inverts the phase of both channels by 180°, regardless of whether S2 is set to normal (ie, synthesiser bypassed) or synthesiser.

We do not recommend that you connect the synthesiser to your TV unless it has an audio output socket. Many modern receivers have a live (240V AC) chassis, and it's best that you stay well clear unless you know precisely what you are doing!