

AUDIO PHASER

THERE AREN'T MANY ELECTRONIC music accessories that we haven't published as projects in ETI and this project will make the list even shorter.

Most musicians will know what a phaser sounds like and it is going to be very difficult for us to describe the effect to readers who don't know the sound. It really has to be heard to be appreciated.

The most dramatic effect, and the easiest to describe, is that caused by feeding white noise through a phaser. The sound is similar to the sound of surf, an 'atmospheric' whooshing sound. On recordings phaser effects can be heard on electric guitars, drums, electric piano, and other instruments.

Technically the phaser acts as a filter — it phases out certain frequencies in the audio spectrum and over a period of a second or two these minima in the response curve sweep up and down the audio band. The response of the ETI phaser can be seen in figure 1. Frequencies between 10 Hz and 4 kHz are present in varying proportions between 0 and 100% of the input signal level. As the values of the components in the phase-shift network change, the proportions of these frequencies will change as the response curve moves up and down the audio spectrum.

The unit we have designed is a six-stage phaser (there are six phase-shift networks in the phase-change path) which gives three minima in its response curve. It is built into a die-cast box so it can be used on stage by a guitarist. The only external control adjusts the speed, except for the foot-operated switch which puts the phaser in or out of circuit. The power is switched on by plugging the jack plugs into their sockets.

CONSTRUCTION

Apart from the PCB the box contains one pot, two jack sockets and a foot-operated switch, so construction is unlikely to be any problem. Use our design for the PCB pattern and insert the components according to the overlay drawing. IC sockets do not have to be used but a socket would spare

Specification

Phase-shift stages:

Six stages providing a maximum 1080 degrees phase-shift, and consequently three minima (see graph).

Frequency range:

With 10n and 100k networks, minima at 40 Hz, 160 Hz, and 600 Hz.

With 10n and 56k networks, minima at 70 Hz, 270 Hz and 1 kHz (as shown in Figure 3).

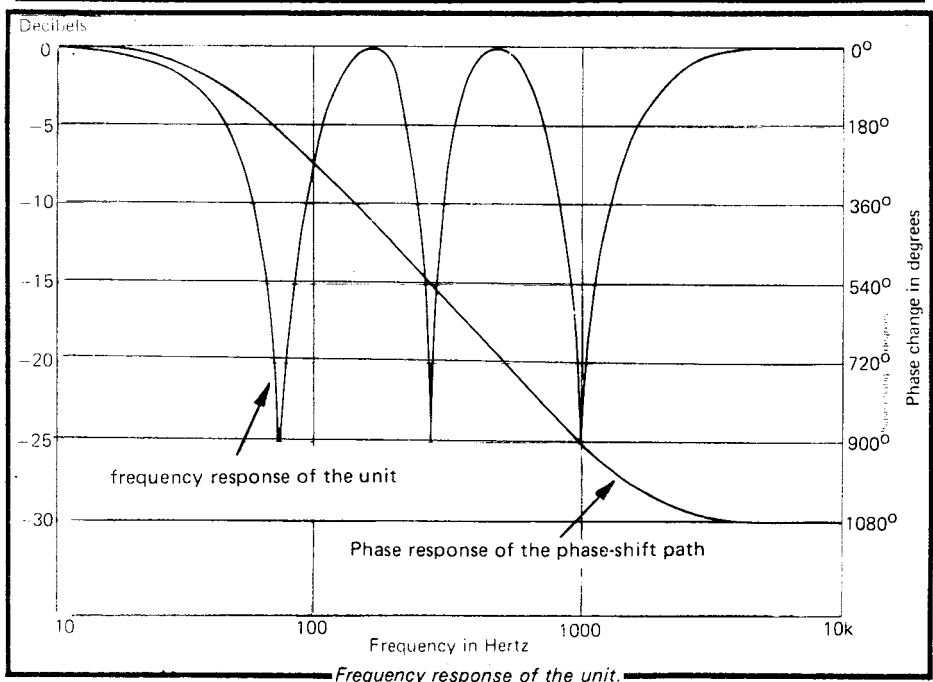
With 10n and 10k networks, minima at 400 Hz, 1600 Hz and 60 kHz.

In operation the resistive element of the phase-shift networks varies continuously and these minima sweep across the spectrum.

Input impedance: 500k.

Input sensitivity: 3 mV to 1 V.

Overall gain: Unity.



the CMOS IC from the dangers of direct soldering.

First solder the low-profile components to the board, then the other components. When the case-mounted parts have been installed, wire up the board to these using sufficiently long leads to enable easy fault-finding, should this be necessary.

For stage use, the phaser needs properly protecting against physical 'shocks' so we strongly recommend you use a die-cast box and wrap the PCB in foam sheeting rather than screwing it to the case. If the phaser is to be built into a mixer or an effects unit then housing is obviously less important.

SETTING UP

The best way to set up the phaser is to use a white noise source and then

adjust the bias preset to give a continuous whooshing sound. If the bias is incorrectly set the sound will be interrupted, it will not whoosh continuously.

If you do not have a white noise source use a signal high in harmonic content: electric guitar, crowd noise, FM hiss, etc.

We cannot teach you how to use the phaser, it is a special effect offered as an aid to creative musicians. It can produce weird effects with almost any audio source (it can, for example, simulate long-distance phonecalls or radio stations) and it is necessary to play certain styles of electric guitar and electric piano.

The phaser can be plugged into the echo send and echo return sockets of the ETI Master Mixer for use on any channel as desired.

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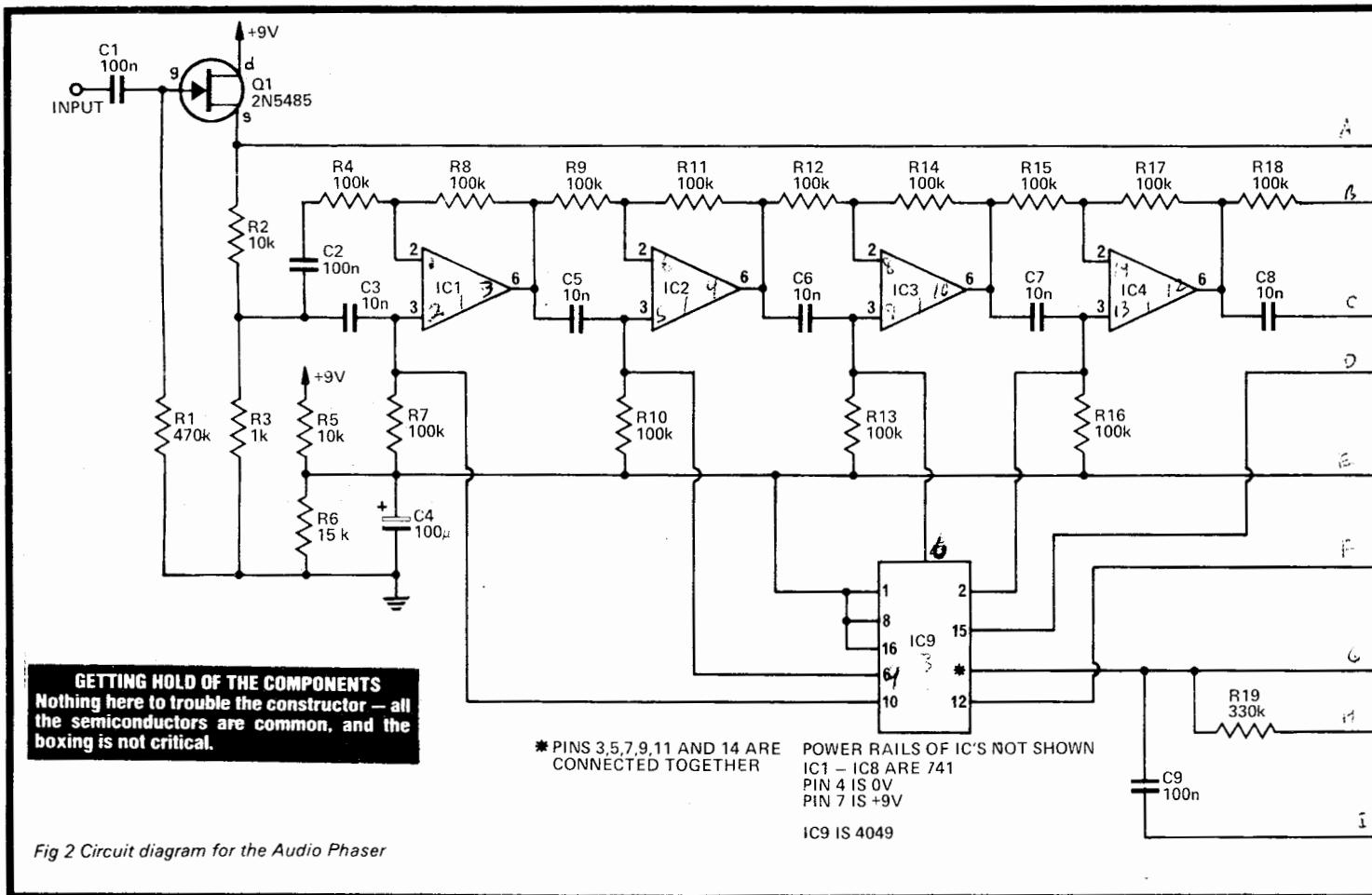


Fig 2 Circuit diagram for the Audio Phaser

How it works

The input impedance of the phaser has to be high to prevent damping of the strings when used with an electric guitar. Loading caused by a low input impedance would stop the notes from sustaining properly. In the ETI phaser this is achieved by the high impedance buffer, Q1.

After the input buffer the signal is split along two paths, and the two parts do not meet again until they are mixed back together again at the junction of R26 and R27. One part of the signal undergoes phase-shift, via ICs 1 to 6, and the other part follows a direct path. Q2 amplifies the output to give an overall gain of unity.

The phase-shift is achieved in six identical RC networks; the overall shift being the sum of the shifts at each stage. IC9 varies the value of resistance in each stage, but we will first look at the operation with a fixed value, say 56 k.

In this case each stage puts a 10nF capacitor and 56k resistor across the signal. The waveform at the junction of these two components has to be of such phasing as to reconcile the perpendicular phasing of the waveforms across each component.

The signal fed into the op-amp undergoes a phase-shift, but the phase-shift is not the same for all frequencies. In the one stage the signal undergoes a change of 180 degrees at high frequencies and a negligible

change at low frequencies. The curve of Figure 1 shows that there is little shift at 10 Hz and 1080° at 4 kHz (that is 180° at each stage: a total of 1080° from all six stages).

When all six stages are taken into account, frequencies from 10 Hz to 4 kHz have a continuous range of phase-shifts from 0 to 1080°.

Figure 1 also shows what happens when equal amplitudes of the two signals (from the direct and phase-shift paths) are mixed.

Because frequencies outside the range 10 Hz to 4 kHz are in phase the response is flat. In-Phase mixing also occurs within this range at two places. These are at phase differences of 360° and 720°, in this case at 160 Hz and at 460 Hz.

The holes in the response are caused by out-of-phase mixing, as occurs when the phase differences are 180°, 540°, and 900°. With 10nF and 56k in the phase-shift networks these minima occur at 70 Hz, 270 Hz, and 1 kHz.

The number of minima in the response is directly related to the number of phase-shift stages. Four stages would give a maximum phase shift of 720° and minima would then only occur at 180° and 540°. If you use eight stages another minimum will occur at 1260°, giving four in all.

The rest of the circuitry in the phaser is used to vary the resistance in the phase-

shift networks to move the response curve of the phaser up and down the frequency axis. IC9 is effectively six sets of complementary FETs and the resistance of each can be controlled by applying a voltage onto its gate. Varying the gate voltage of IC9 causes the effective resistance of R7 to be shunted from 100k down to a few kilohms.

IC7 is an integrator and IC8 is a Schmitt trigger, together they make a triangle-wave oscillator. This triangle waveform gives a rising and falling voltage to the gates in IC9. The waveform has to be correctly biased to give the desired resistance change in each phase-shift stage. The bias voltage is set by RV1.

RV2 controls the speed of the triangle-wave oscillator to give periods ranging from a few seconds down to a tenth of a second or so.

The zero reference voltage for the op-amps is taken from the junction of R5 and R6, which is at half the supply voltage. This does away with the need for a split supply — a single 9V battery is sufficient. The power is switched on and off by the jack socket. The foot-switch switches the phaser in and out of circuit.

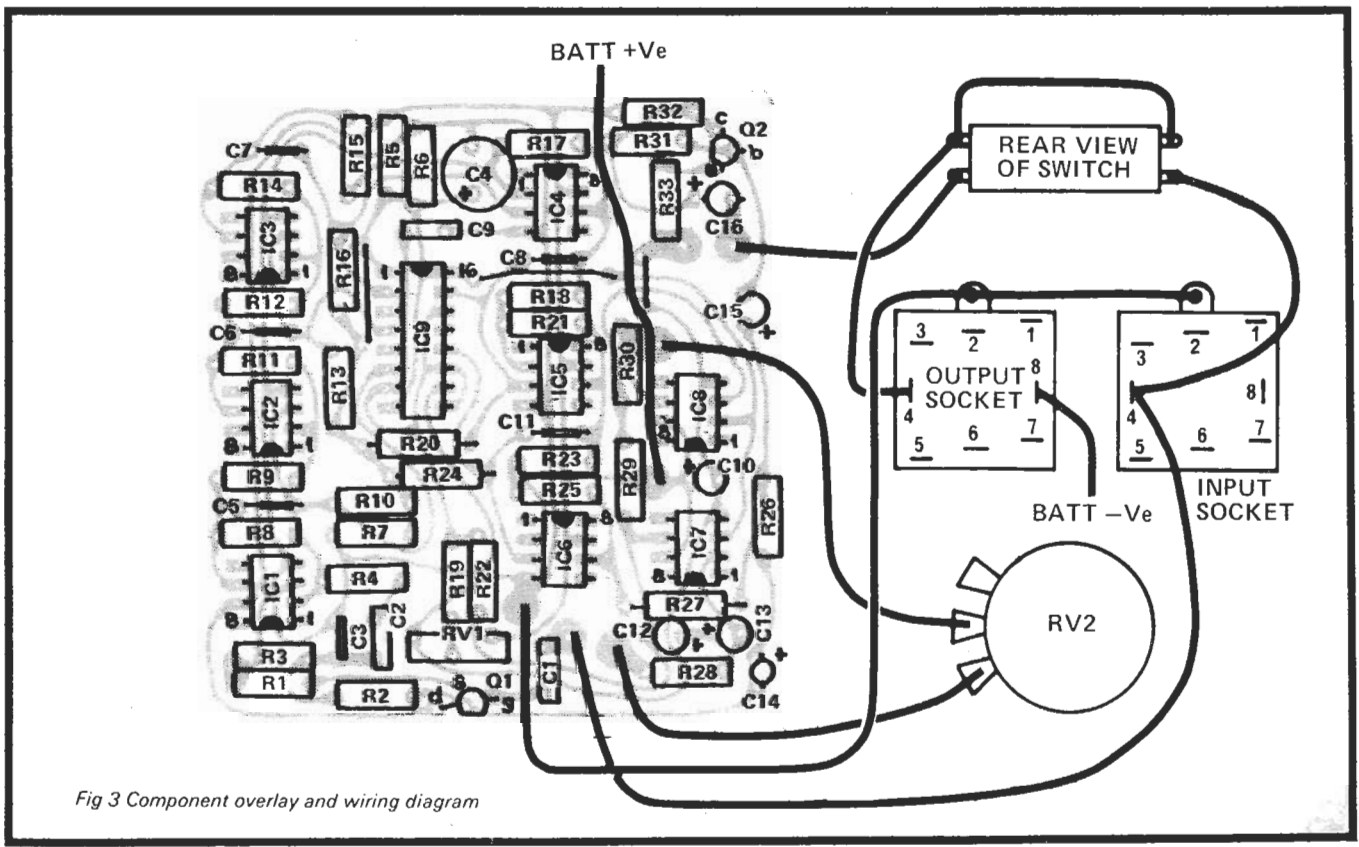
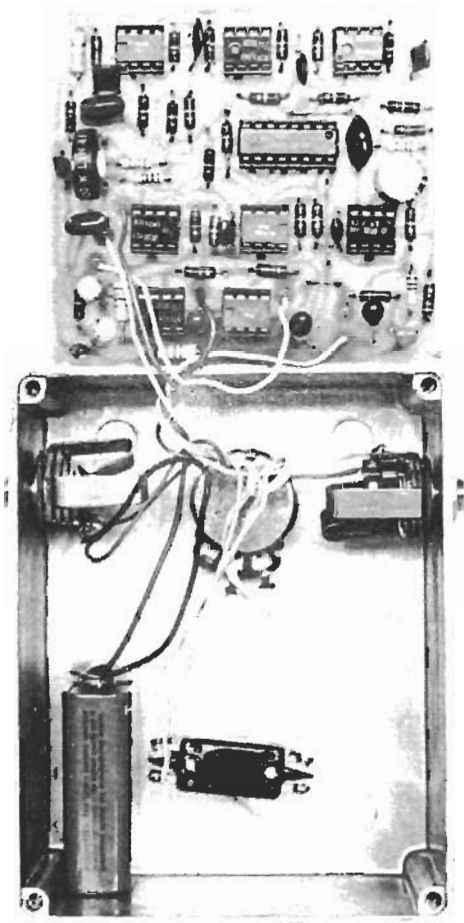
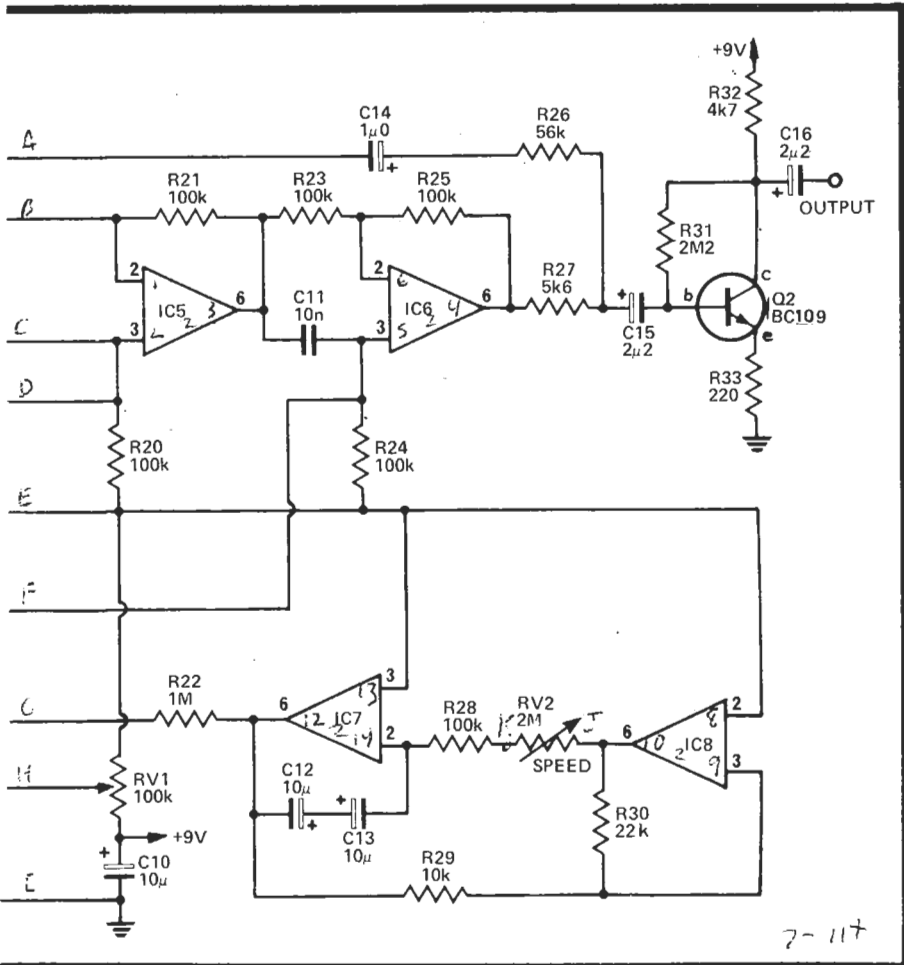


Fig 3 Component overlay and wiring diagram

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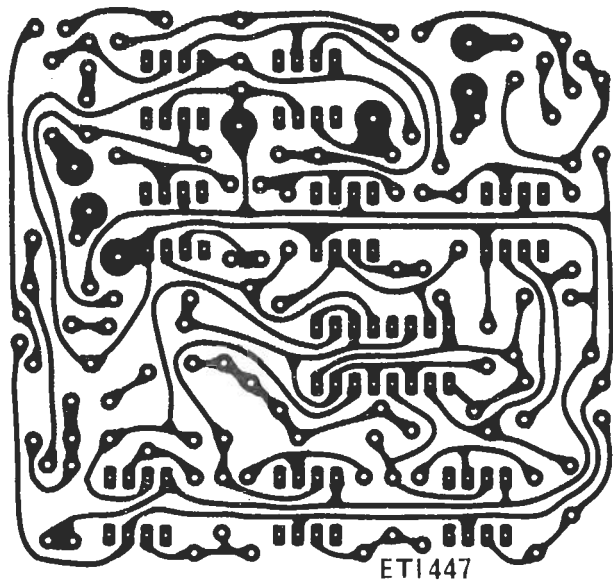


Fig 4 Printed-Circuit Layout. Full Size 81 x 76 mm.

Parts List

Resistors all 1/2 W 5%

R1 470 k
R2 10 k
R3 1 k
R4 100 k
R5 10 k

R6 15 k
R7-R18 100 k
R19 330 k
R20,21 100 k
R22 1 M

R23-R25 100 k
R26 56 k
R27 5 k6
R28 100 k
R29 10 k

R30 22 k
R31 2 M2
R32 4 k7
R33 220

Potentiometers

RV1 100 k trim type
RV2 2 M log rotary

Capacitors

C1,2 100 n polyester
C3 10 n "
C4 100 μ F 6 V
C5-C8 10 n polyester
C9 100 n "

C10 10 μ F 25 V
C11 10 n polyester
C12,13 10 μ F 25 V
C14 1 μ F 25 V
C15,16 2 μ F 25 V

Semiconductors

Q1 2N5485 or similar
Q2 BC109 or similar
IC1-IC8 μ A741 op-amp
IC9 4049 CMOS

Miscellaneous

PC Board ET1 447
Two stereo phone sockets
Switch — push on push off
push button
Case to suit
9 V battery
Knob