WAA-WAA EFFECTS PEDAL

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How to easily and inexpensively add expression to your playing.

THE waa-waa effect has been popular with guitarists for many years now, and one reason for this popularity is that it provides an easy means of adding great expression to your playing. It is also a relatively simple effect that can be implemented using inexpensive circuitry.

A waa-waa unit is basically just a tunable filter that boosts a narrow band of frequencies. As the pedal is operated, the operating frequency of the filter is moved up and down, giving the familiar "waa-waa" sound. The filtering boosts certain harmonics in the signal, and operating the pedal changes the harmonics that are affected.

For good results, it is essential that the processed signal contains reasonably strong harmonics, but an electric guitar is unlikely to be found lacking in this respect.

A waa-waa pedal represents an easy project for the home constructor as far as the electronics are concerned, but the mechanical side of construction can be problematic. The difficulty is that the effect is normally controlled by a pedal which operates a potentiometer. Producing a pedal mechanism that is genuinely reliable and will not let you down at the worst possible moment is more difficult than one might expect.

Most waa-waa units for the home constructor use some form of alternative approach that avoids the need for a pedal mechanism. The most simple of these alternatives is to use a low frequency oscillator to automatically operate the effect at a preset rate, but this gives rather "mechanical" results with no real opportunity for the player to add expression to the music.

The other alternative, and the one used here, is to have the effect controlled via a pushbutton switch. The switch is foot operated, and acts as a sort of pseudo foot-pedal. Operating the switch results in the effect being swept upwards in frequency, and releasing the switch results in the effect being swept back down again.

This is not quite as versatile as using a conventional foot-pedal mechanism, since the pushbutton switch does not give any control over the rate at which the effect is swept up and down.

However, these rates are individually adjustable via front panel controls and can be set at appropriate rates prior to

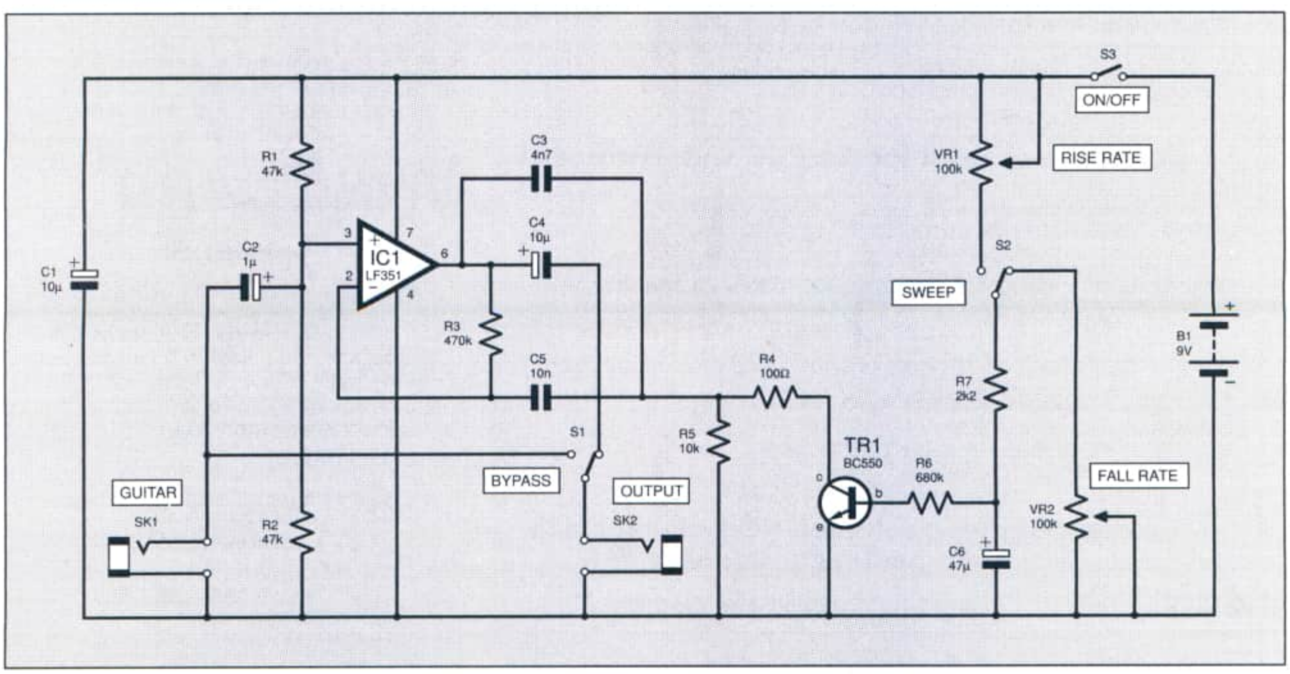


Fig.1. Complete circuit diagram for the Wah-Wah Effects Pedal.

commencing a piece. This gives the player much better control of the effect than simple automatic control, and does enable the effect to be used in an expressive fashion.

CIRCUIT OPERATION

The circuit diagram for the Waa-Waa Effects Pedal is shown in Fig.1. IC1 is an operational amplifier which is used in the non-inverting mode, with input biasing provided by resistors R1 and R2. These set the input impedance at 11 kilohms.

The negative feedback circuit includes a simple *R-C* (resistor-capacitor) network that provides frequency selective feedback, and produces a bandpass filter action. The configuration used is almost the standard op.amp bandpass filter circuit, with the frequency selective negative feedback provided by capacitors C3, C5 and resistor R3, together with the series resistance of R4 and R5.

These components set the centre frequency of the circuit at a middle audio range, but in this application we need the filter frequency to be variable over middle to high audio frequencies.

It is possible to tune the filter by adding a variable resistance in parallel with resistor R5. This is the purpose of transistor TR1, which acts as a sort of crude voltage controlled resistor. The resistance across TR1's collector (c) and emitter (e) terminals depends on its base (b) input current, with higher currents giving reduced collector to emitter resistance.

Resistor R6 effectively converts TR1 from current to voltage operation, and also provides a boost in input resistance. There is a slight drawback in using an ordinary bipolar transistor as a voltage controlled resistor, which is simply that it does not provide pure resistance.

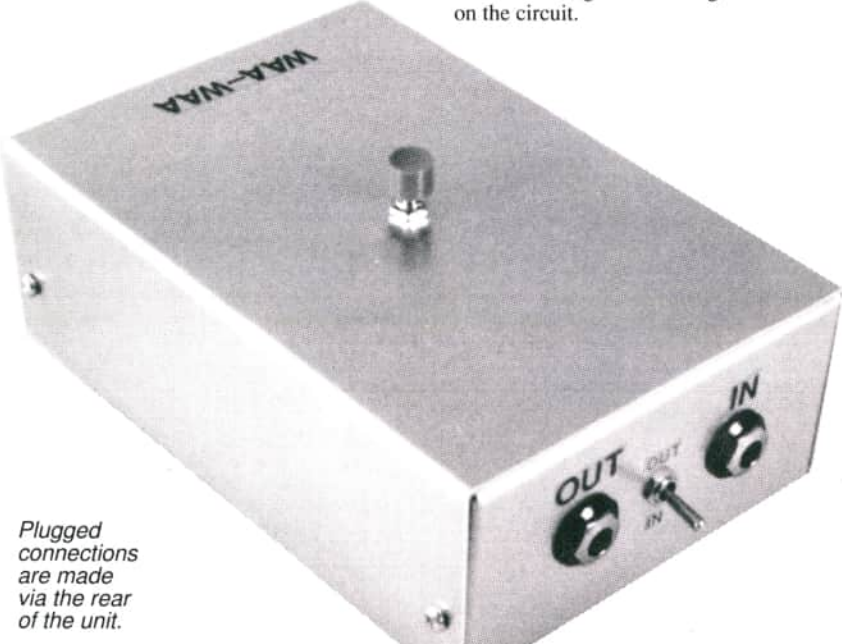
Changes in the signal voltage result in variations in the effective resistance provided by TR1, which in turn produce distortion on the output signal. Hi-fi performance is not really essential in this application, but the distortion will be reasonably low provided the circuit is not fed with an excessive input level.

Front view of the Waa-waa unit. The switch on the top is the sweep control, S2.

The "pedal" switch is notated as S2, and it is biased to the position shown in Fig.1. Under standby conditions, no current flows into the base of TR1, and the resistance provided by TR1 is, therefore, so high that it has no significant affect on the circuit.

Operating S2 results in capacitor C6 starting to charge via potentiometer VR1 and resistor R7. As the charge potential on C6 rises TR1 receives an increasing base bias current. This results in its collector to emitter resistance steadily reducing, and the centre frequency of the filter being swept upwards.

This continues until the charge voltage on C6 reaches almost the full supply potential, but the filter frequency then remains constant until S2 is released. C6 then starts to discharge via R7 and VR2, causing the resistance provided by TR1 to increase and the centre frequency of the filter to decrease. This action continues until the charge on C6 drops below about 0·7 volts, at which point TR1 becomes cut off and once again has no significant affect on the circuit.



Plugged connections are made via the rear of the unit.

The required action is therefore obtained, with the filter frequency being swept upwards when S2 is operated, and swept back down again when it is released. VR1 controls the rate at which the filter frequency rises, and VR2 controls the rate at which the filter frequency falls. In both cases the rate of change is very rapid at minimum resistance, but takes several seconds for a full sweep at maximum resistance.

This type of voltage controlled bandpass filter is very simple, but it is slightly flawed in that the *Q* (quality) value of the filter rises as the operating frequency is increased. This results in a narrower response and higher maximum gain at high frequencies, and a broader response with lower maximum gain at low operating frequencies.

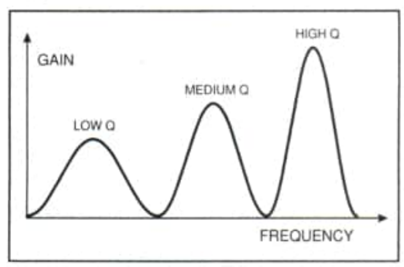


Fig.2. Filtered frequency response.

In Fig.2 is shown the general way in which the response changes as the filter frequency is altered. In practice, this does not seem to have a detrimental affect on results, and the effect obtained is perfectly acceptable. In fact, it is probably better to have things this way, as it avoids having a high level of boost on the fundamental signal, which could easily cause overloading.

Switch S1 enables the circuit to be bypassed when the waa-waa effect is not required.

The circuit is powered from a small 9V battery, and this should have a very long operating life as the current consumption of the circuit is typically just under two milliamps.

COMPONENTS

See SHOP TALK Page

Resistors

R1, R2	47k (2 off)
R3	470k
R4	100Ω
R5	10k
R6	680k
R7	2k2

All 0.25W 5% carbon film

Potentiometers

VR1, VR2	100k rotary carbon lin. (2 off)

Capacitors

C1, C4	10µ radial elect. 25V (2 off)
C2	1µ radial elect. 50V
C3	4n7 mylar
C5	10n mylar
C6	47µ radial elect. 16V

Semiconductors

TR1	BC550 *npn* transistor
IC1	LF351N bifet op.amp

Miscellaneous

S1	s.p.d.t. min. toggle switch (see text)
S2	s.p.d.t. pushbutton switch (see text)
S3	s.p.s.t. min. toggle switch
SK1, SK2	standard mono jack socket (2 off)
B1	9V battery (PP3 size)

Printed circuit board, available from the *EPE PCB Service*, code 932; metal case (see text); control knob (2 off); battery connector; 8-pin d.i.l. socket; wire; solder; nuts and bolts, etc.

Approx Cost Guidance Only £20 excluding batteries

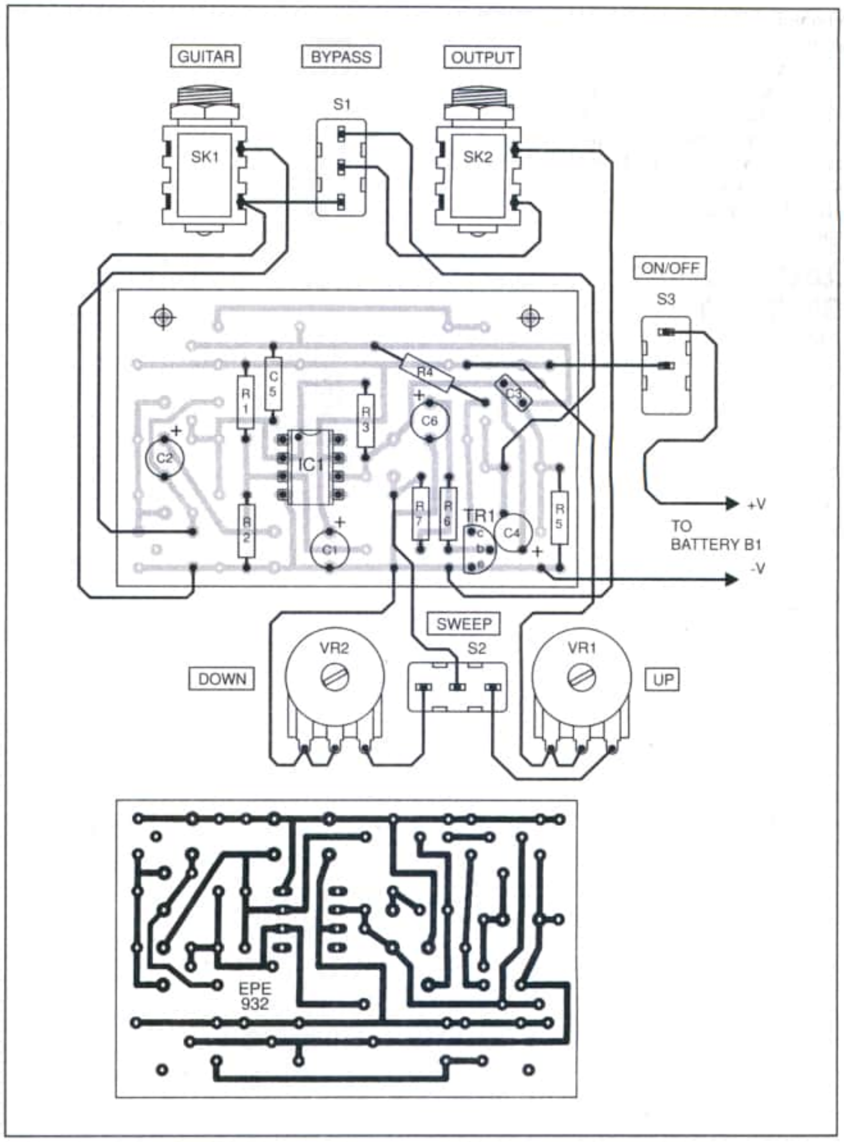
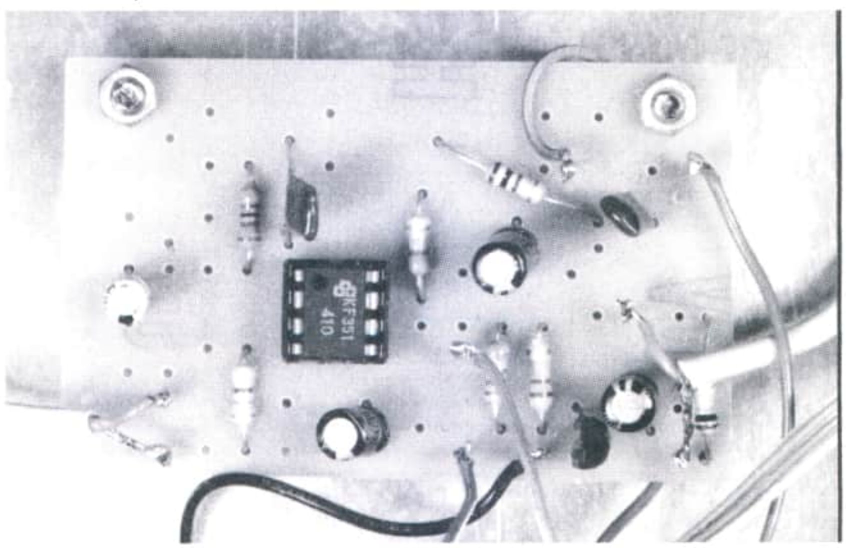


Fig.3. Printed circuit board component layout and full size underside copper foil track master pattern for the Waa-Waa Effects Pedal.



CONSTRUCTION

The Waa-Waa Effects Pedal is built using the *EPE* multi-project printed circuit board. This board is available from the *EPE PCB Service*, code 932.

Construction of this board is mainly straightforward, but the usual warning has to be given. This is not a custom printed circuit board in the conventional sense, and many of the holes in the board are left unused. Consequently, it is relatively easy to get a component fitted in the wrong place and extra care, therefore, has to be exercised when fitting the components.

The board's component overlay, master track pattern and hard wiring details are shown in Fig.3.

IC1 is not a static sensitive device, but it is a good idea to use a holder for any d.i.l. integrated circuit. Be careful to fit IC1 and the electrolytic capacitors with the correct orientation. From the electrical point of view, C3 and C5 can be any form of plastic foil capacitor, but mylar capacitors are the easiest type to fit into this layout.

Fit single-sided solder pins to the board at the points where connections will be made to the controls and sockets. "Tin" the tops of the pins with plenty of solder, but do not make any connections to them at this stage.

As this project will be controlled by foot, it is clearly essential for it to be housed in a tough case that will not crush or crack easily. It is also a good idea to use a metal case as this will provide the circuit with good screening from mains "hum" and other electrical noise.

A diecast aluminium box is ideal, but might prove to be rather expensive. A case of folded aluminium construction is just about strong enough, and represents a good low-cost alternative. It is possible to fit everything into quite a small case, but the use of a medium size box is recommended as this will be more stable in use. It also provides more panel space for the controls and sockets.

The exact layout used is not critical, but it is advisable to have switch S1 mounted close to the input and output sockets. On the prototype, S1 and the sockets are mounted on one end panel, with controls VR1, VR2 and S3 fitted on the other end panel.

JACKS AND SWITCHES

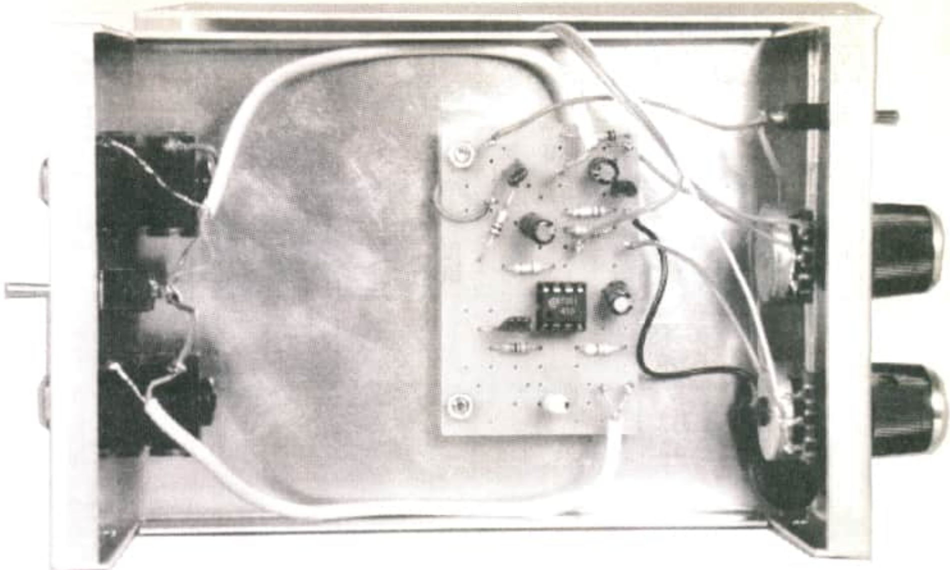
In Fig.3, the input and output sockets are shown as insulated jacks, which are the type favoured by many guitarists. These are often fitted with switch contacts, and then have two extra tags which are left unused in this application. Open style jack sockets can of course be used if preferred.

Switch S2 is a pushbutton type that must be mounted on the top panel of the case so that it can be operated by foot. It has single-pole changeover contacts, and it must be of the non-locking variety. Ideally, S2 would be a heavy duty switch, but a suitable component seems to be unobtainable. An ordinary type should be adequate provided it is of good quality.

Switch S1 could also be a pushbutton type mounted on the top panel of the case so that it can be operated by foot. This enables the effect to be totally eliminated while playing the guitar. Totally switching out the effect is not essential though, as the unit has little effect if the filter is left at its minimum frequency and is not swept.

The printed circuit board is mounted on the base panel of the case using either plastic stand-offs or metric M3 bolts. If you use mounting bolts it is essential to include spacers about 6mm or more in length to hold the connections on the underside of the circuit board well clear of the metal case.

It is not essential to use screened leads for any of the connections, but try to keep the wiring reasonably short and direct. The wires to S2 must be quite long as this switch is mounted on the removable lid of the case, but long wires here should not compromise performance.



TESTING AND USE

Standard screened jack leads are used to connect the guitar to SK1, and SK2 to the input of the guitar amplifier. With the unit switched on, the signal should be coupled straight through to the amplifier with S1 set to the bypass position.

With S1 switched to the other position, the waa-waa effect should be obtained when S2 is operated. If the filter is swept downwards when S2 is pressed, and upwards when it is released, reverse the connections to the outer two tags of S2.

It is worth experimenting with the settings of VR1 and VR2 to obtain the control characteristic that you like best. Remember that you do not have to use the same settings all the time and that, if necessary, different settings can be used for each piece that you play.

If you intend to use many different settings it might be worthwhile using control knobs having "0" to "9" calibrated skirts. These make it easy to note down each pair of settings, and quickly dial them up when they are required again.

As pointed out previously, the circuit will only provide low distortion if it is used with a fairly low input level. When using the unit with a high output guitar pick-up it will almost certainly be necessary to back-off the volume control on the guitar, and advance the volume control on the guitar amplifier. Otherwise quite severe distortion may occur at some filter frequencies.

With low and medium output pick-ups there should be no problems with distortion, even if the guitar is set for maximum volume. □