Nutube Guitar OVERDRIVE and DISTORTION Pedal

by John Clarke

Do you long for that true "valve sound" in a guitar and distortion pedal? How about this one – it uses a unique low-voltage twin triode valve, so you know it's the real deal!

Electric guitars are almost always played (at least professionally) with some sort of effects in the loop. Acoustic guitars with electric pickup can also take advantage of an effects pedal.

Among the many effects pedals available, overdrive and distortion are probably the most popular. Some produce a harsh distortion (as in 'fuzz boxes'), while others provide a more gentle form of distortion.

Effects boxes commonly use circuitry with semiconductors such as JFETs for providing these effects, and sometimes silicon diodes for distortion.

But the 'Holy Grail' overdrive effect is produced by valves. While some solid-state overdrive pedals attempt to emulate the distortion effect produced by valves when overdriven, there is no substitute for the real thing.

To date, it has been difficult to incorporate valves into a small effect pedal. But that has all changed now that a compact low-voltage 6P1 dual triode is available from music instrument manufacturer Korg.

We introduced it only last January in our Valve Preamplifier (siliconchip.com.au/Article/12217)

This new project can be used as a distortion pedal, an overdrive pedal or a mixture of both. Two stages of distortion and/or overdrive are included, and the first stage can be used on its own or in conjunction with the second stage that's switched in by the boost pedal.

Overdrive versus distortion

The main difference between overdrive and distortion is in the type of distortion produced.

Overdrive is when an amplifier is driven with a high signal level, causing the output to be rounded off and eventually, limited or clipped. So at low signal levels, there is no or little distortion. The distortion rises as the signal level increases.

Once the signal becomes limited, the volume remains constant and does not increase significantly as the input signal level increases.

A side effect of excessive overdrive is that it tends to also act as a sustain effect, where the volume level remains constant for some time after the string is struck. The sustain effect continues until the signal from the guitar drops below the level required for limiting.

The type of overdrive distortion depends on how the signal is limited. With valves, the limiting is usually asymmetric, with one polarity of signal excursion more sharply clamped than the other.

A **distortion** effect is different, in that there is a deliberate attempt to distort the signal even at low levels, and the output level is not restricted as much as for overdrive. In other words, there is generally some distortion at all signal levels. We have provided some oscilloscope traces that show the differences between overdrive and distortion (Scope1-Scope8), later in the article.

Our Guitar Overdrive and Distortion Pedal can be set up for overdrive or distortion via its control knobs.

If the distortion controls are set for minimum distortion and the gain increased, the pedal acts as an overdrive, rounding off the higher signal levels. If the distortion controls are adjusted for more distortion, then it acts as a dis-

The Valve Guitar Overdrive and Distortion Pedal is housed in a sturdy diecast case, not only for hum minimisation but to ensure heavy-footed axemen (or women!) don't do any damage in the heat of the moment! It operates from 9-12V DC (yes, it is a genuine valve!) so you can use it with a plugpack supply or even a battery.

tortion pedal, with the gain level determining whether it is also producing an overdrive effect.

The distortion control in each stage can be set at the mid position for minimum distortion, or closer to either end for more distortion. When wound anti-clockwise, the negative half of the waveform is distorted, but the positive half is not as affected. Conversely, in a more clockwise position, the positive half of the waveform is distorted, but the negative portion of the waveform isn't as affected.

The Overdrive and Distortion Pedal has two stages that provide distortion, with both used when boost is selected. So if the first stage is set for positive distortion and the second stage set for negative distortion, both halves of the waveform will be distorted with boost activated. With the boost off, only the distortion provided by the first stage is in effect.

This difference is more noticeable if the signal level applied to the second stage is reduced in level to match that applied to the first stage. This can be achieved by adjusting a trimpot inside the Pedal.

A tone control is included that provides treble cut. The cut-off frequency is adjustable between about 2kHz and 23kHz. A lower cut-off frequency reduces the distortion harmonics to get the desired sound.

The output levels for when boost is in and out are also adjustable. How you set these depends on the effect you want. The level when boost is switched out is typically set to provide the same output level when bypass is enabled.

When the pedal is in bypass, the input signal is directly connected to the output. When not in bypass, the signal passes through the distortion and overdrive circuitry.

You could set the output level when boost is selected for a higher level, or at the same level as when boost is off. In general, the boosted output sounds louder anyway, due to the more squared waveform and added harmonics.

Presentation

The Pedal is housed in a rugged diecast aluminium case. It has two foot switches, six rotary controls and three indicator LEDs. Clear bezels are located over the two dual triode plates so that the grid bias setting can be

Features

- Two distortion stages
- High input impedance suits most pickups
- Gain, output level, distortion and tone controls
- True bypass and boost switches with LED indicators
- Housed in a rugged diecast enclosure
- No high voltages
- Uses a Nutube dual triode with no transformers
- Nutube plate glow is visible
- 30,000-hour Nutube life
- Low power consumption
- Battery or DC plugpack power
- Signal phase preserved from input to output
- Automatic and silent on/off switching
- Power supply reverse polarity protection

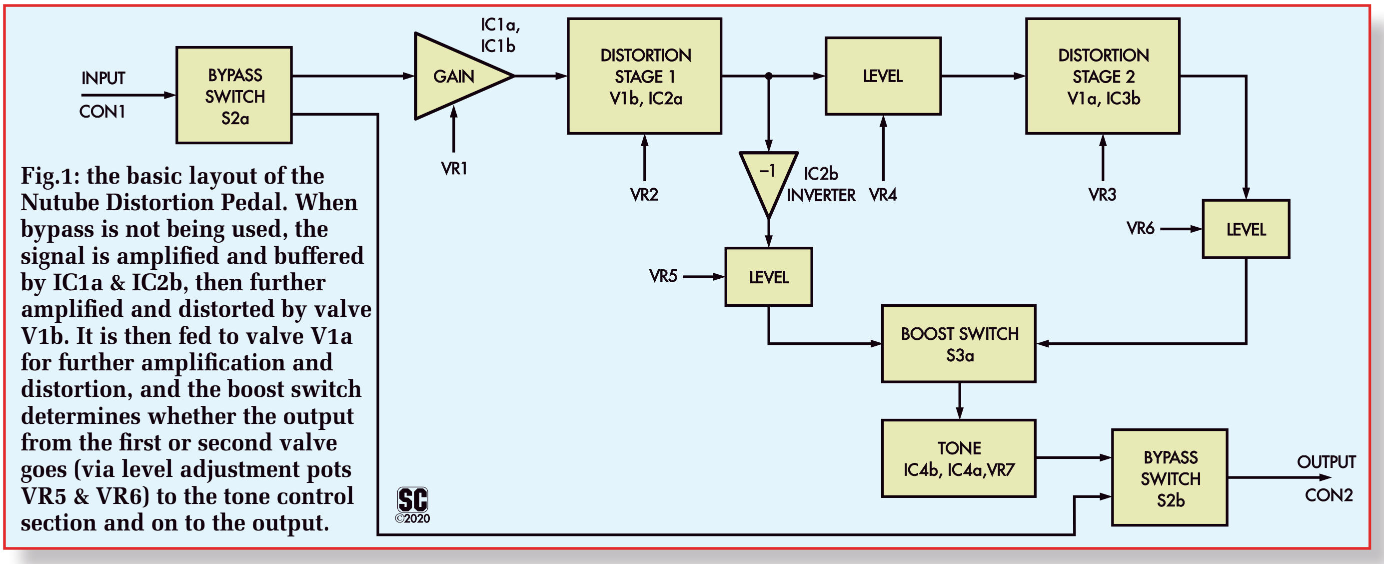


Fig.1: the basic layout of the Nutube Distortion Pedal. When bypass is not being used, the signal is amplified and buffered by IC1a & IC2b, then further amplified and distorted by valve V1b. It is then fed to valve V1a for further amplification and distortion, and the boost switch determines whether the output from the first or second valve goes (via level adjustment pots VR5 & VR6) to the tone control section and on to the output.

observed (more about this later) and so that everyone can see your magnificent valves glowing.

Two 6.35mm (1/4”) jack sockets at the rear provide signal input and output connections, with a DC socket to supply power. The unit can also be powered from an internal 9V battery. Power is automatically switched on when a plug is inserted into the output socket

Operation

Fig.1 shows a simplified block diagram of the Guitar Overdrive and Distortion Pedal. The signal from the guitar at CON1 can pass directly to the output at CON2 via the bypass switch (S2b). When bypass is not selected, the signal passes to the first gain stage instead. This comprises a high input impedance buffer stage (IC1a), an attenuator (potentiometer VR1) and an 11 times amplifier (IC1b).

The first distortion stage uses one of the Nutube Triodes (V1b) to provide amplification and distortion. The amount of distortion produced by this stage is adjustable via potentiometer VR2.

The output of V1b is buffered by op amp IC2a. As V1b inverts the signal, the output of IC1a is fed to an inverter (IC2b), restoring its original polarity. The output level from the inverter is adjusted by VR5, and the signal then goes to one side of the boost switch, S3a.

The output from before inverter IC2b is also applied to a level-adjustment trimpot (VR4) and then fed to the second distortion stage. This allows the second distortion and overdrive block to have the same input signal level as the first block. In that case, VR4 is adjusted to reduce the signal level from the first stage by about 15dB.

Alternatively, VR4 can be set to provide the full signal level to the second distortion block, to maximise limiting and overdrive.

The second distortion block circuitry is the same as the first, only it uses triode V1a and buffer IC3b. Potentiometer VR3 sets the distortion level while the output level is adjusted with potentiometer VR6. The resulting signal is applied to the other side of the boost switch, S3b.

So the boost can select between the signals from the first or second distortion stages. The selected signal goes to the tone control with adjustable high-frequency cut, as set by potentiometer VR7.

The output from the tone control then goes to one side of the bypass switch, S2b. The bypass switch selects between this signal or the input signal at CON1 (when in bypass).

The Nutube twin triode

One of the things that makes the Nutube so special is that it can run at a very low voltage. Traditional valves require a high anode voltage (above 100V). The Nutube 6P1 was developed by Korg and Noritake Itron of Japan. While it is a directly-heated triode with a filament, grid and plate, it is made in a way that more resembles a vacuum fluorescent display (VFD) than a traditional valve (or tube).

The Nutube has rectangular glass encapsulation, and each triode comprises a single-pixel VFD. Its internal construction has the heater filament as a fine-gauge wire running across the front, with the metal mesh grid located below that. Behind the grid is the plate (or anode), which is phosphor-coated and glows when the filament is heated.

The filament wire is held taut, so it can vibrate similarly to a guitar string. (The Nutube is, after all, sold by a musical instrument manufacturer). This vibration is not necessarily a wanted feature as it can be the source of microphonics, where an external sound can couple to the filament and alter (or modulate) the audio signal being amplified. As a result, this vibration is heard in the sound.

Careful construction methods can minimise microphonics. This includes protecting the Nutube from surrounding air vibrations, by using flexible wiring, and a vibration-damped mounting method.

In operation, the Nutube draws minimal current, with each filament requiring just 17mA. The grid and plate currents total around 38µA. The Nutube is best operated with a plate voltage of 5-30V. The load-line curves show that within this voltage range, the grid voltage needs to be above the cathode filament voltage.

This is different from the traditional triode, where plate voltages are much higher, and the grid voltage is usually negative with respect to the cathode. Nutube distortion can be adjusted by varying its grid bias voltage.

Circuit details

The circuit is shown in Fig.2. You can see the two halves of the Nutube near the upper middle, with both connected

Specifications

- *Supply: 9-12V DC @ 47mA with bypass and boost LEDs off (+6mA for each LED)*
- *Gain: 32dB maximum with boost off; up to 43dB with boost on*
- *Frequency response: -0.6dB at 20Hz. Upper frequency response is dependent on the tone setting.*
- *Tone control: 20dB/decade high-cut filter, -3db point varies from 2.12kHz to 23.4kHz with tone control*
- *Maximum input and output swing: 2.3V RMS for 9V supply; 3.3V RMS for 12V supply*
- *Minimum signal level for overdrive limiting: 55mV without boost, 15.5mV with boost*
- *Signal to noise ratio: 82dB with respect to 55mV in and 55mV out*

as common-cathode amplifiers; the cathode filaments are connected to ground at pin F3. Signals are applied to the grids (G2 & G1), and the resulting amplified signal appears at the anodes (or plates), A2 and A1. The anodes have resistive loads to the positive supply, Vaa.

The Nutube triodes have a relatively low grid input impedance and high output impedances at the anodes. Therefore, buffers are used; one to provide a low-impedance drive for the grid of each triode, and others to keep the anode load impedances high.

These op amps (OPA1662A) have very low noise and distortion, of around 0.00006% at 1kHz, 3V RMS and unity gain. So the op amps do not affect the sound of the signal in any way. Any noise or distortion they might introduce is dominated by that from the triodes.

The signal path is as follows. When the bypass switch (S2a) is in the non-bypass position, the signal passes through ferrite bead FB1 and a 100Ω stopper resistor. These, in conjunction with the 100pF capacitor, stop RF signals from entering the circuit, which may result in unwanted radio frequency detection and reception. The 100pF capacitor also provides loading for piezo guitar string pickups.

The signal is AC-coupled to pin 3 of op amp IC1a and biased to half supply (Vaa/2) via a 1MΩ resistor. The Pedal's input impedance is therefore high at 1MΩ , making it suitable for a piezo guitar pickup.

The half-supply rail (Vaa/2) is derived by two 10kΩ resistors in series across the Vaa supply. It is bypassed with a 100µF capacitor to remove supply noise, and buffered by unity gain amplifier IC3a.

The output of IC1a is AC-coupled to the level control, VR1, which then feeds IC1b. IC1b provides 11 times gain. So when VR1 is at maximum, the output signal from IC1a is directly applied to the IC1b amplifier for an overall gain of 11.

With reduced settings for VR1, there is less overall gain from input to the output of IC1b.

The signal from the output of IC1b drives the grid (G2) of Nutube V1b via a 10µF coupling capacitor. This grid is DC-biased via a 33kΩ resistor connected to the wiper of potentiometer VR2. VR2 is adjusted to set the operating point and hence, distortion produced by V1b.

VR2's wiper voltage range is restricted to 1.27-3.3V by 8.2kΩ and 6.2kΩ padder resistors. This provides a good range of distortion variation. The resistor values were chosen so that the centre position for VR2 provides the lowest distortion for V1b.

The amplified signal appears at the plate of V1b (A2). This has a 330kΩ load to Vaa via a 150Ω decoupling resistor. The supply is bypassed using a 100µF capacitor to remove supply ripple.

The high-impedance anode signal is again AC-coupled to another op amp buffer (IC2a) via a 100nF capacitor, biased to half supply with a 1MΩ resistor. This resistor loads the anode and so reduces the signal swing by about 25%. This is unavoidable in such a high-impedance circuit.

The output signal from IC2a goes to IC2b, a unity-gain inverter, which inverts the signal to compensate for the inversion by V1b. It also goes to the grid of V1a via trimpot VR4. The trimpot allows the signal to be attenuated (if desired) before being applied to the grid. V1a's grid bias is adjusted by potentiometer VR3 from 1.96-3.48V. These voltages are higher than for V1b for reasons explained below.

The output signal from the anode (A1) of V1a is buffered by IC3b, similarly to how IC2a buffers the output of V1b. The signals from both IC2b and IC3b drive level adjustment potentiometers VR5 and VR6, respectively. The wipers of these potentiometers connect to either side of the boost switch, S3a. S3a therefore selects between the outputs of the first and second distortion stages.

Note that in the second stage, triode V1a inverts the signal in the same way that op amp IC2b does. So both signals applied to S3a have the same phase. The signal selected by the boost switch is applied to buffer IC4b, ensuring that neither VR5 nor VR6 is unduly loaded. This buffer also provides a low impedance drive for the following tone control circuitry.

This comprises a simple low-pass filter with a corner frequency controlled by potentiometer VR7. The tone control provides a 20dB per decade (6dB/octave) roll-off of high frequencies. The roll-off (-3dB point) starts at about 23kHz when VR7 is fully anti-clockwise, so the tone control essentially does nothing.

The roll-off frequency drops to about 2kHz when VR7 is wound fully clockwise. The resistance of VR7 and the 1kΩ fixed series resistor sets the RC time constant of the filter. The -3dB point can be calculated as $1/(2 \pi RC)$, where C is 6.8nF, and R varies from 1-11kΩ .

IC4a buffers the output of the tone control RC network. The signal from IC4a is then AC-coupled with a 100µF capacitor to remove the DC bias and fed to bypass switch S2b, then through RLY1 and to output connector CON2. The output signal goes through a 100Ω isolation resistor to stop IC4a from oscillating should long (capacitive) leads be connected.

When S2 is set to the bypass position, the input signal at CON1 bypasses the distortion/overdrive circuitry, and the input to IC1a is tied to ground. This prevents switching noise when not bypassing, by keeping the 100nF capacitor at IC1a's input charged.

To prevent any audio noise when power is switched on and off, the output signal passes through the contact of relay RLY1, which is open when power is off. At power-on, the relay contact only closes after a delay, to allow time for the voltages in the circuit to stabilise. More on this later.

Filament current

Like most thermionic valves, the Nutube has heater filaments. There is one for each triode, between the pins labelled F1 and F2 for V1a and between F2 and F3 for V1b. These filaments are connected in series, with F2 being the junction.

There are two ways of driving these filaments. Current can be supplied to F1 and F3 via separate resistors with F2 tied to ground. In this case, 17mA flows through each filament for a total of 34mA. Or, like in our circuit, F1 or F3 can be connected to ground and current is supplied to the opposite end of the pair of filaments, so the same 17mA flows through both, halving the total current requirement.

The latter method is more efficient and enhances battery life. In our circuit, F3 is tied to ground, F2 is effectively open (with just a bypass capacitor connected) and current supplied via a 200Ω resistor from 5V to F1. F1 is also bypassed with 10µF capacitor, which forms an RC low-pass filter with the 200Ω resistor. These two capacitors reduce noise in the circuit.

The disadvantage of connecting the filaments in series is that, due to the voltage drop across the filaments, the cathode of one triode will sit at 0.7V rather than 0V. This means that the two triodes need 0.7V different grid bias voltages to operate in the same manner. This is the reason for the different grid voltage adjustment ranges for potentiometers VR2 and VR3, due to their different padder resistors.

Indicators LED1-LED3 are powered from the 5V supply via 510Ω resistors. LED1 is the power indicator, and it runs off the 5V rail. The bypass (LED2) and boost (LED3) LEDs are only powered when the bypass and boost switches are on.

Power supply

The circuit powers up when microswitch S1 is activated by a jack plug being inserted into CON2. The plug pushes on the ground pin in CON2, and this lifts the microswitch actuator to power the circuit. This is a slightly unconventional method of switching power, but it works reliably.

We decided to do it this way, rather than using a PCB-

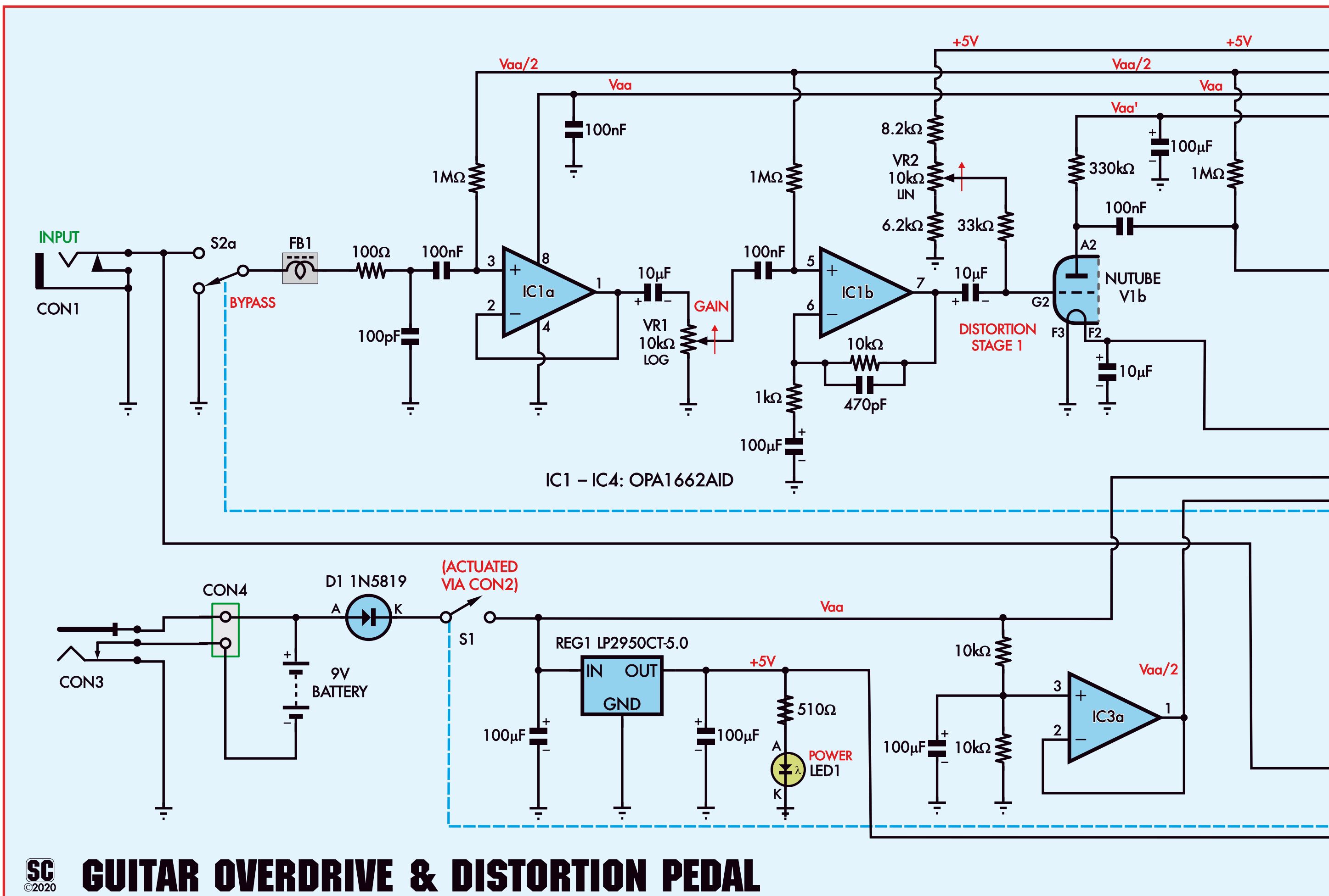


Fig.2: the circuit diagram of the Distortion Pedal. Potentiometers VR2 and VR3 set the grid bias voltages for valves V1b and V1a, and in doing so, determine the amount and nature of distortion that they introduce. The signal from the output of V1b to the input of V1a (via buffer IC2a and attenuator VR4) also goes to pin 6 of IC2b, which acts as an inverter, so that the non-boosted and boosted signals on either side of switch S3a are in-phase.

mount jack socket with an isolated internal switch or a panel-mount wired socket, mainly because those socket types are not universally available, while the type we are using is.

When there is no DC plug inserted, the DC socket (CON3) connects the negative end of the battery to ground, so the circuit will be powered from the battery when S1 is closed. When a power plug is inserted, the battery negative is disconnected, and the unit runs from the DC power supplied to CON3. In either case, schottky diode D1 prevents damage if the battery or DC power plug polarity is incorrect.

REG1 is a low-dropout, low quiescent current 5V linear regulator. Its main purpose is to maintain a constant grid voltage for the Nutube triodes and a constant voltage for the filaments. It also supplies power to 5V relay RLY1. A 100µF capacitor bypasses the input supply to REG1, and its output voltage is filtered similarly.

Relay delay

As mentioned, RLY1 switches on after a delay when power is first applied. IC5, a CMOS version of the 555 timer, provides this delay. When power is first applied, the 10µF capacitor at its trigger input (pin 2) and threshold input (pin 6) is discharged. The pin 3 output is at 5V, which drives the bottom end of the relay. There is no voltage across the relay coil, so it is off.

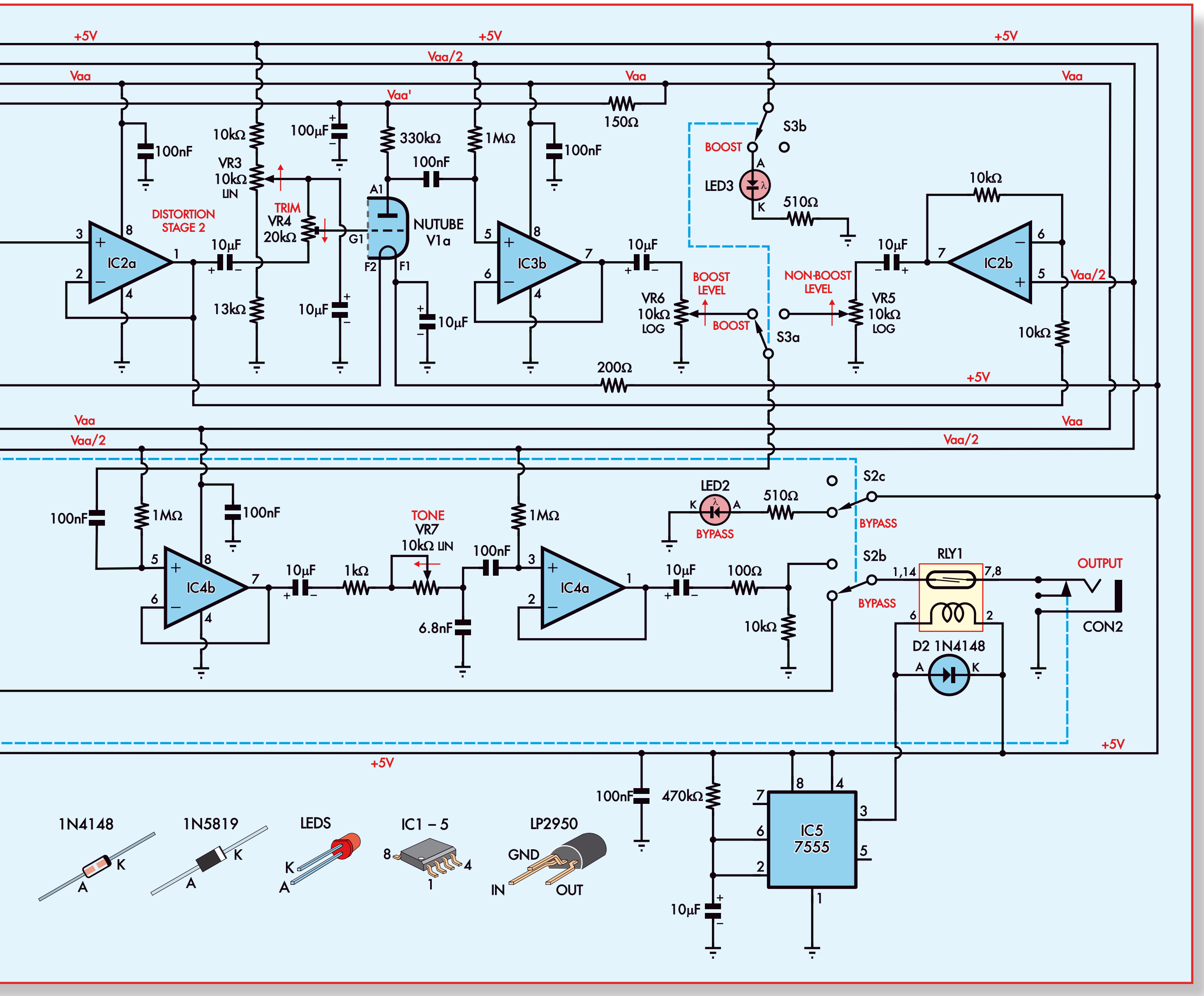
When the 10µF capacitor charges to 66% of the 5V supply (3.33V), the threshold voltage is reached and the pin 3 output goes low, energising the relay coil.

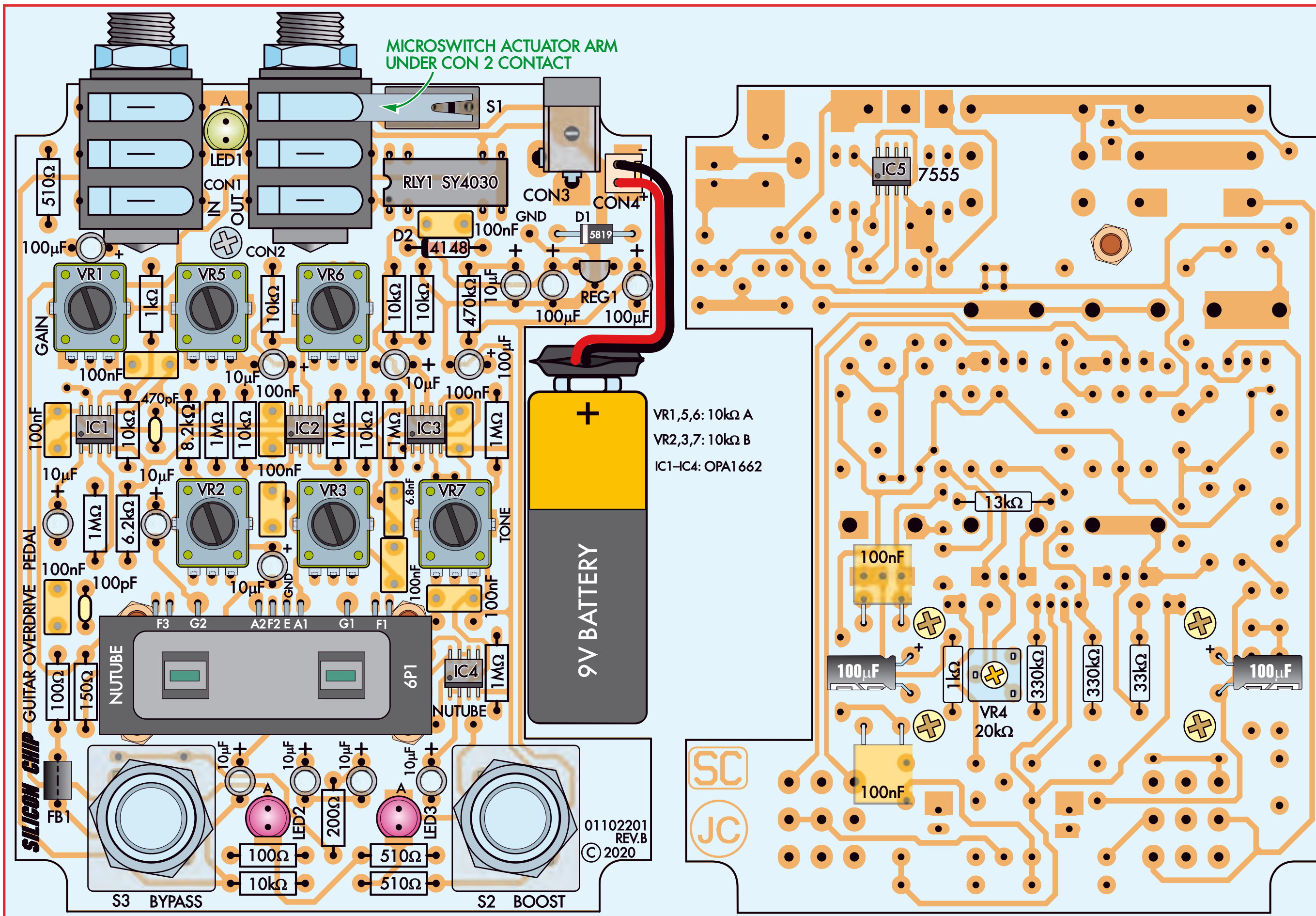
RLY1 is a reed relay with a meagre 10mA coil current requirement, so IC5 can drive the coil directly. Diode D2 shunts the back-EMF voltage from the coil when RLY1 is switched off.

Note that RLY1 prevents a bypass signal from getting to the output when the Pedal is powered off. But since power is switched on automatically when a plug is inserted into output connector CON2, and you can't get a signal from the unit without anything plugged into CON2, this is not a major problem.

Construction

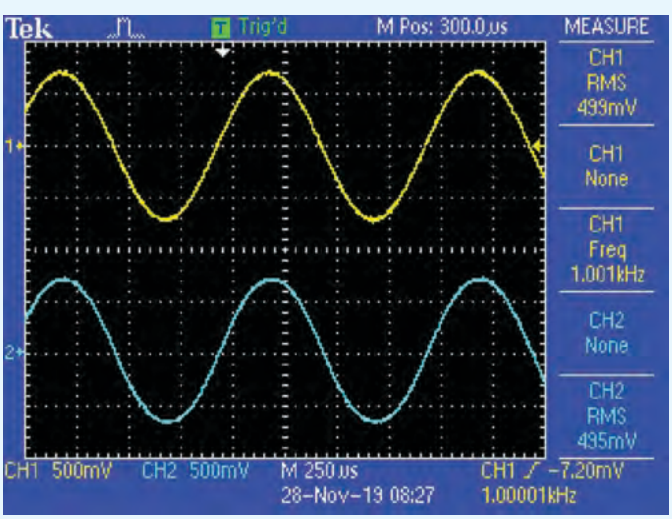
The Guitar Overdrive and Distortion Pedal is built using a double-sided PCB coded 01102201 and measuring 86 x 112mm. It is housed in a diecast enclosure measuring 119



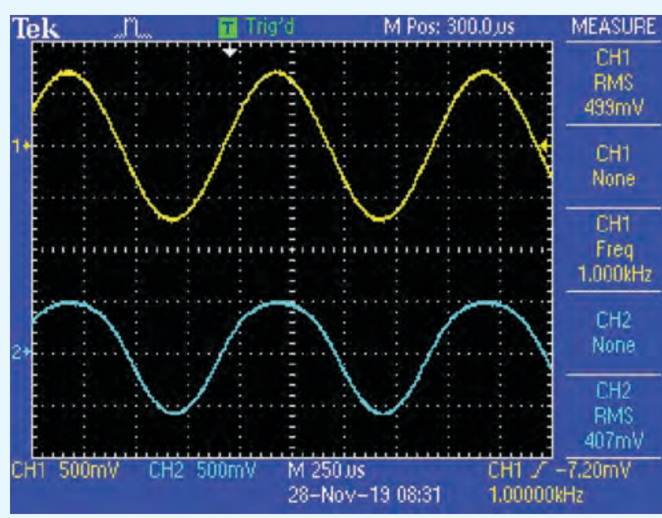


(TOP OF PCB) (UNDERSIDE OF PCB)

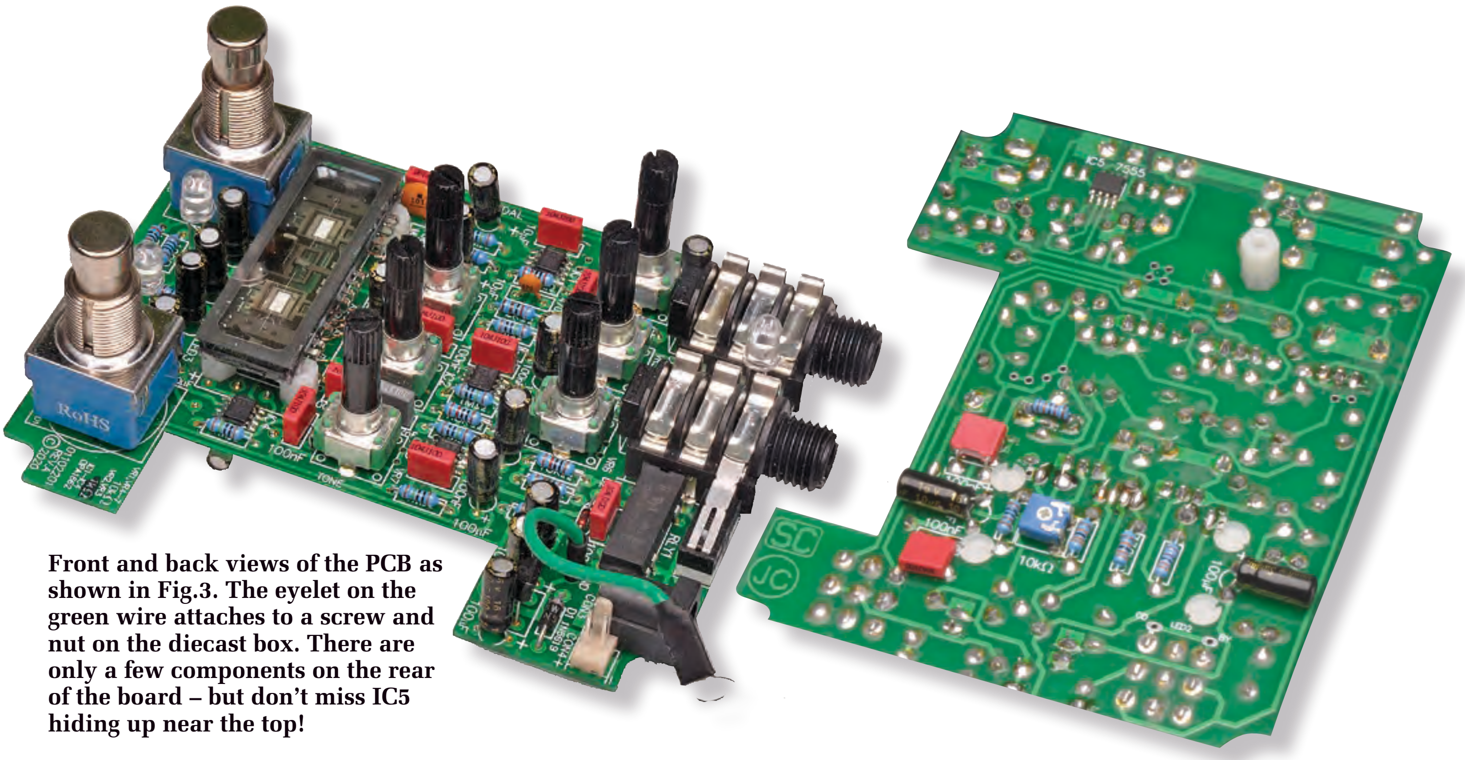
Fig.3: these PCB overlay diagrams show where all the parts go on both sides of the board. Note how the lever of microswitch S1 is touching jack socket CON2 (also see photos). And while potentiometers VR1-VR3 and VR5-VR7 look identical, and are all 10kΩ pots, some are linear and some are logarithmic, as described adjacent to the board. Be sure to orientate the ICs, diodes, LEDs, electrolytic capacitors and RLY1 as shown here.



Scope1: the input signal is shown at the top and the output signal at the bottom. Here the first distortion control is set for minimum distortion (mid-position), with the gain control set so that there is no overdrive. Therefore, the output waveform is similar to the input.



Scope2: using the same settings as in Scope1, except that the first distortion control is rotated fully clockwise. The lower trace shows flat-topping of the sinewave for the positive portion of the waveform, giving significant distortion.



Front and back views of the PCB as shown in Fig.3. The eyelet on the green wire attaches to a screw and nut on the diecast box. There are only a few components on the rear of the board – but don't miss IC5 hiding up near the top!

x 94 x 34mm. Fig.3 shows the PCB assembly details.

Begin by fitting the surface-mounting parts on the top side of the PCB, ie, IC1-IC4, followed by IC5 on the underside. These are not difficult to solder using a fine-tipped soldering iron.

Good close-up vision is necessary; you may need to use a magnifying lens or glasses to see well enough.

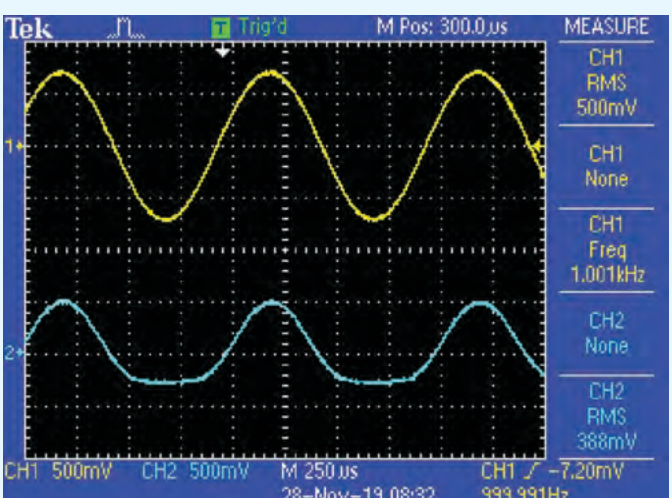
Make sure that these components are oriented correctly before soldering in place. Also, check that IC5 is the 7555 timer. For each device, solder one pad first and check its alignment.

Adjust the component position by reheating the solder joint if necessary before soldering the remaining pins. If any of the pins are bridged by solder, use solder wick to remove it.

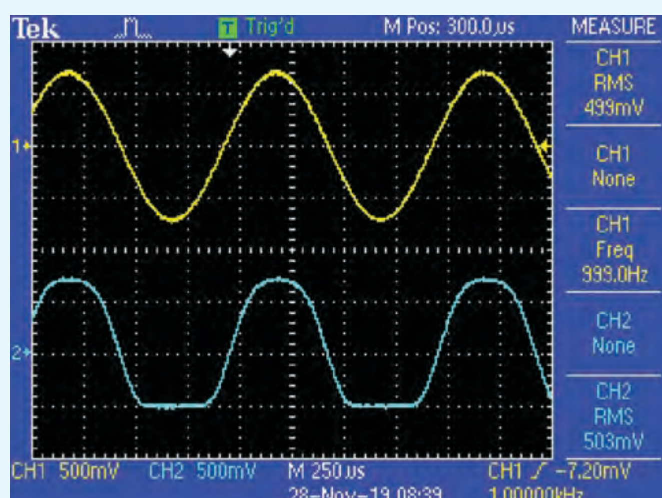
Note that adjacent pins 1 & 2 of IC1, IC2, and IC4 and pins 6 & 7 of both IC3 and IC4 connect together on the PCB, so a solder bridge between these pins is acceptable.

Continue construction by mounting the resistors on the top side of the PCB (use your DMM to check the values), followed by the ferrite bead (FB1). Feed a resistor lead off-cut through the bead and bend the lead to fit the PCB pads. Push the bead lead down so that it sits flush against the PCB before soldering its leads.

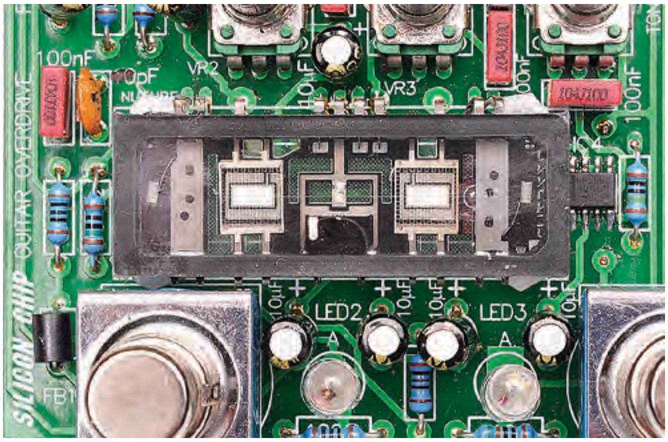
The resistors that mount on the underside of the PCB can be installed now. Solder these from the top side of the

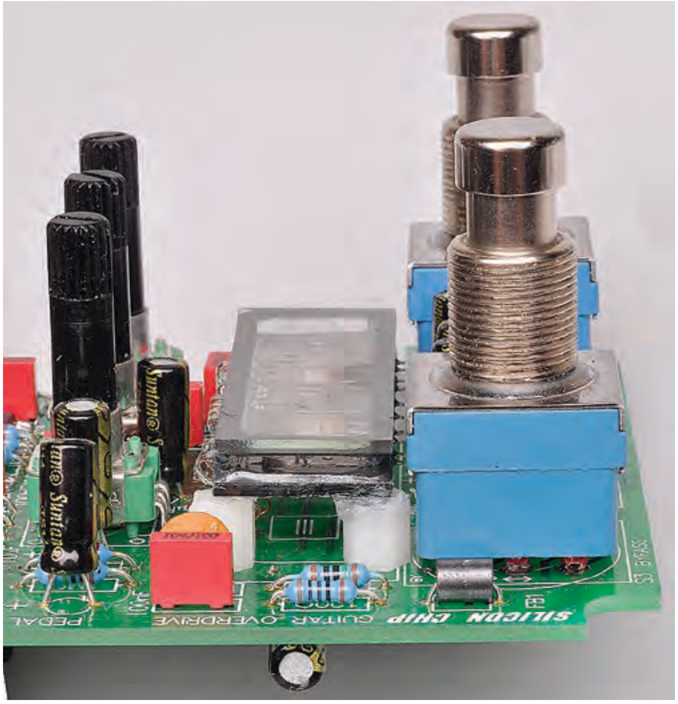


Scope3: the first stage distortion control is now set fully-anticlockwise. The top trace is the input signal, while the lower trace shows the flat topping (or is that bottoming?) of the sinewave on negative excursions.



Scope4: the gain is increased to set up an overdrive situation with the first distortion control set for minimum distortion (mid-way). The output level control is adjusted down to reduce the output signal level, compensating for the high gain at the input. Note how flat the negative portion of the waveform is; more signal would increase this and also begin to flatten the positive portion.





The 6P1 valve mounts on four 6.3mm Nylon standoffs, as shown in these photos. This helps minimise microphonics which could otherwise be a problem.

PCB and trim the leads close to the PCB. Diodes D1 and D2 can then be mounted – note they are different types. Take care to orientate them correctly.

Now fit the MKT and two ceramic capacitors, followed by the electrolytic capacitors, which are polarised. Their longer leads go to the pads marked with a + on the PCB. The two 100nF and two 100µF capacitors that mount on the underside of the PCB need to lie on their sides.

Next, install trimpot VR4 on the underside, soldering its pads on the top side. VR4 might be marked as 203 rather than 20kΩ.

Follow with potentiometers VR1-VR3 and VR5-VR7, noting that VR1, VR5, and VR6 are logarithmic types (marked A) and VR2, VR3 and VR7 are linear types (marked B). These pots may be labelled as 103 instead of 10kΩ.

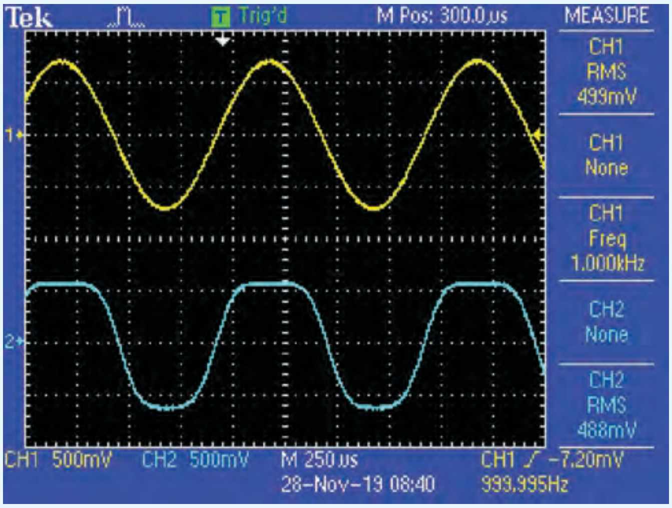
The next step is to fit REG1 by splaying its leads slightly to fit the hole arrangement on the PCB. Also, install the PC stake at the GND test point. The locking header for the battery lead can be fitted now, then RLY1, the two jack sockets and the DC socket.

Switch S1 is mounted so that the lever is captured under the front sleeve contact of the CON2 jack socket. We have provided slotted holes so the switch can be inserted and slid, so the lever enters under the contact.

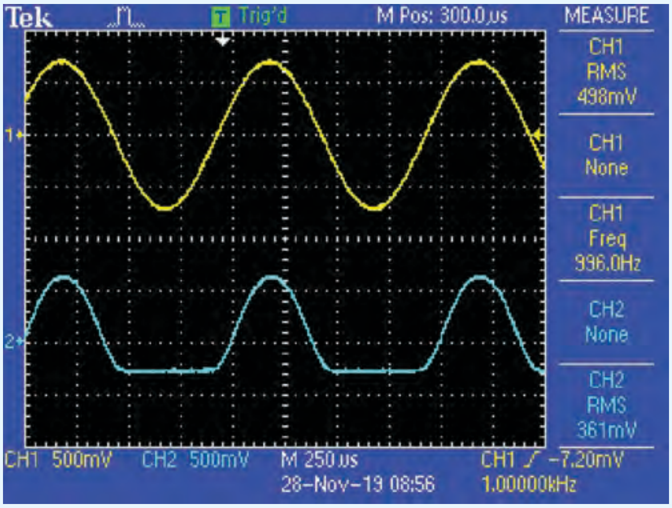
Check that the switch is open circuit, between the two outside pins, when there is no jack plug inserted. There must be continuity between the two outside pins when a jack plug is inserted.

You may need to bend S1's lever a little so that the switch works reliably.

Mount foot switches S2 and S3 now. Make sure these are perfectly vertical before soldering their pins. The LEDs

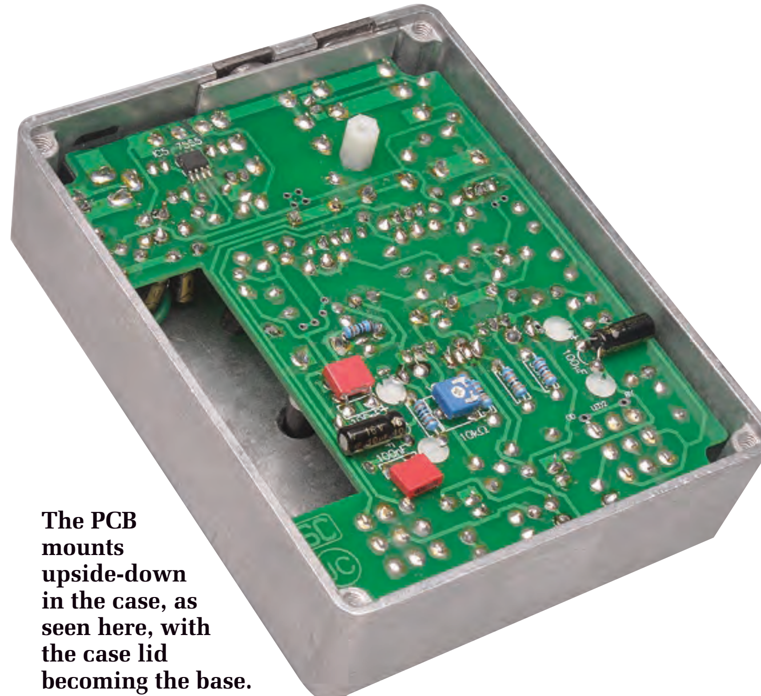


Scope5: the settings as the same as in Scope4, but with the Stage1 distortion control set fully clockwise. This produces a more square form of overdrive; the incoming sinewave is being converted into a sort of rounded square wave.



Scope6: the same settings as in Scope4 and Scope5, but with the first distortion stage control set fully anti-clockwise. The output waveform is now very flat on negative excursions but mostly undistorted on positive excursions.

14 holes and two slots are drilled/cut in the diecast case. Note these holes are in the bottom and end of the case. (See dimensioned drilling diagram on page 36).



The PCB mounts upside-down in the case, as seen here, with the case lid becoming the base. All controls emerge through what was the base – which is now the front panel! Five bezels in the panel show the status of the LEDs and 6P1 Twin Triode.

are mounted later when the PCB is installed in its case.

Wiring

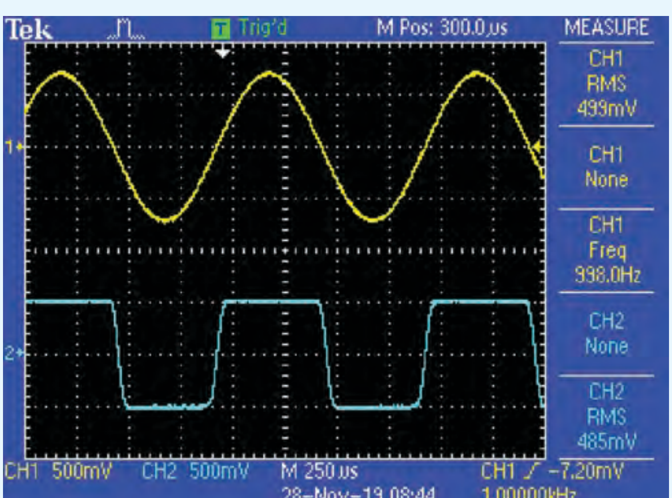
The Nutube is mounted with its envelope parallel to the PCB. Its leads are soldered to the pads on top of the PCB using short lengths of enamelled copper wire. This wire helps prevent microphonics in the Nutube, by giving a flexible connection.

Bend the Nutube leads back under the body and solder 20mm lengths of the 0.25mm enamelled copper wire to each Nutube lead. Molten solder held over the end of the wire will burn off the enamel so that the wire can be soldered.

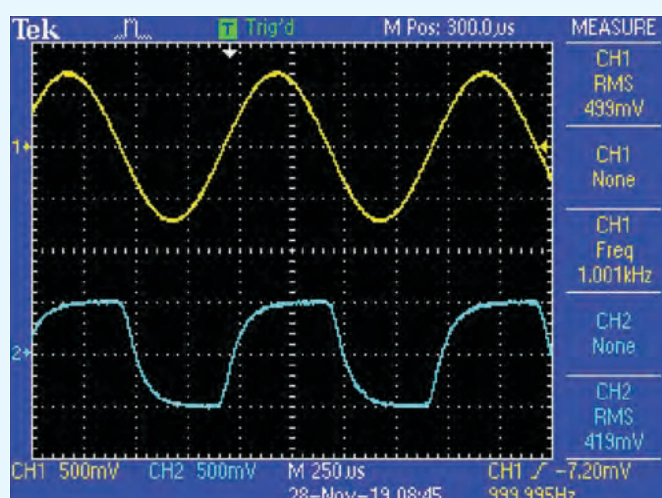
There are two leads for F1 and two leads for F3 at each end of the Nutube. The two leads are connected together, so only one wire is needed to connect each pair to the PCB.

Secure the four 6.3mm Nylon spacers to the PCB under where the Nutube mounts, using Nylon or polycarbonate screws.

Place small dobs of neutral-cure silicone sealant on top of each spacer, then sit the Nutube on top. There should



Scope7: with boost on, the waveform is now so overdriven and limited that the output waveform is almost square.



Scope8: this shows the effect of the tone control when set for maximum high-cut. The settings are the same as in Scope7, except for the tone control. Note the difference between the squared waveform in Scope7 and the rounded off surf-wave like effect here, due to the operation of the tone control.

Parts list – Nutube Guitar Effects Pedal

1 double-sided PCB coded 01102201, measuring 86 x 112mm
1 panel label
1 119 x 94 x 34mm diecast enclosure [Jaycar HB5067]
1 Korg Nutube 6P1 double triode thermionic valve (V1) [RS Components 144-9016]
2 6.35mm PCB jack sockets (CON1,CON2) [Jaycar PS0190]
1 2-pin PCB-mount header with 2.54mm spacing (CON4)
  [Jaycar HM3412, Altronics P5492]
1 PCB-mount DC power socket (CON3) [Jaycar PS0520, Altronics P0621A]
1 2-pin polarised header plug [Jaycar HM3402, Altronics P5472 + 2 x P5470A]
1 C&K ZMA03A150L30PC microswitch or equivalent (S1) [eg, Jaycar SM1036]
2 3PDT footswitches (S2,S3) [Jaycar SP0766, Altronics S1155]
1 5V DIL reed relay (RLY1) [Jaycar SY4030, Altronics S4100]
6 11.5mm diameter 6mm tall 18-tooth spline knobs
  [RS Components 299-4783] (see text)
1 4mm OD, 5mm-long ferrite bead (FB1) [Altronics L5250A, Jaycar LF1250]
5 5mm clear LED bezels [RS Components 171-1931]
1 6.3mm mono jack plug or jack plug lead (to test power switching)
1 9V battery
1 9V battery clip lead
1 9 x 45mm piece of 1-1.5mm thick aluminium sheet
1 PC stake (GND)
1 solder lug (for grounding enclosure)
4 stick-on rubber feet OR
4 M4 x 10mm Nylon screws – see text
4 6.3mm-long M3 tapped Nylon spacers (to go under Nutube)
4 M3 x 6mm Nylon or polycarbonate screws (for Nutube spacers)
1 9mm-long M3 tapped Nylon spacer (support for PCB)
2 M3 x 6mm screws (for solder lug and 9mm spacer)
1 M3 nut and star washer (for solder lug)
1 160mm length of 0.25mm diameter enamel copper wire
1 50mm length of green medium duty hookup wire
2 100mm cable ties

Semiconductors
4 OPA1662AID dual op amps, SOIC-8 (IC1-IC4) [RS Components 825-8424]
1 ICM7555CBA CMOS timer, SOIC-8 (IC5)
1 1N5819 1A schottky diode (D1)
1 1N4148 small signal diode (D2)
1 LP2950CT-5.0 5V LDO regulator (REG1)
3 5mm high-intensity LEDs (one green and two red recommended)

Capacitors
6 100µF 16V PC electrolytic
10 10µF 16V PC electrolytic
11 100nF MKT polyester
1 6.8nF MKT polyester
1 470pF ceramic
1 100pF ceramic

Resistors (all 0.25W, 1% metal film)

6 1MΩ	1 470kΩ	2 330kΩ	1 33kΩ	1 13kΩ	7 10kΩ	
1 8.2kΩ	1 6.2kΩ	1 1kΩ	3 510Ω	1 200Ω	1 150Ω	2 100Ω

1 20kΩ miniature horizontal trimpot (VR4) [Altronics R2481B, Jaycar RT4362]
3 10kΩ vertical 9mm log (A) pots (VR1,VR5 & VR6) [Altronics R1958]
3 10kΩ vertical 9mm linear (B) pots (VR2,VR3 & VR7) [Altronics R1946]

Miscellaneous
Solder, solder wick, clear neutral-cure silicone sealant (eg, roof and gutter silicone)

The infill piece we made to cover the slots (as seen opposite). Fig.4 (below) shows the dimensions.

be a 1mm silicone bead between each spacer and the underside of the Nutube envelope. Ensure the Nutube is correctly positioned and wait for the silicone to cure.

The next step is to cut the battery wires to 60mm long, then crimp or solder them to the polarised plug pins. Insert these terminals into the plug shell, making sure you get the red and black wires in the correct position for polarity: + to red and – to black.

A grounding wire is required to connect the case to the GND terminal on the PCB. This prevents hum injection to the circuit via the enclosure. Solder the wire to the lug at one end and the GND terminal at the other.

Heatshrink tubing can be used over the lug terminal and the GND PC stake. When assembled, the solder lug is secured to the case using M3 x 6mm screw, star washer and M3 nut.

Powering up and testing

If you are planning to use a battery, connect it now. Alternatively, plug in a 9-12V DC supply to CON3. Insert a jack plug into CON2 to switch on the power.

Set your multimeter to read DC volts, connect the negative probe to the GND terminal and measure the regulator input and output voltages. The input should be about 0.3V below the DC supply. The regulator output should be between 4.95V and 5.05V.

Also, check that RLY1 switches on

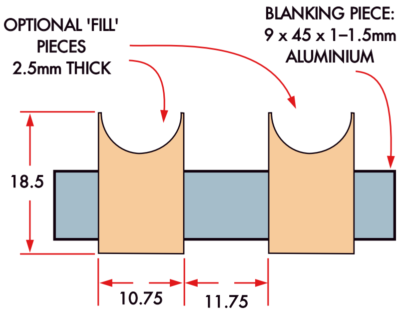


Fig.4: cut a piece of aluminium as shown to partially cover the slots, with the two optional plastic pieces glued to it to fully cover those spaces.

The 6.35mm input/output sockets need to be slid into place which necessitates slots, rather than holes (as can be seen in the drilling photo on page 33). We fashioned an infill piece from scrap aluminium (seen opposite) the same size as the slots, held in place by the sockets themselves and their washers/nuts.

(Right): rather than glue feet on the lid of the case (which becomes the base!) we used four M4 Nylon pan-head screws which act as pretty robust feet, their heads being slightly proud of the surface. We reasoned that glue-on feet probably wouldn't last long in use but the screws should last.

after about five seconds. You should hear a quiet click.

Centre VR2 so that the left-hand plate of the Nutube lights up at its brightest. Similarly, adjust VR3 so the right-hand plate of the Nutube glows brightest. Note that when the signal passes through the unit, the plate glow will dim a bit. Set VR4 fully clockwise for now.

Housing it

We use the lid of the diecast enclosure as the base, and the main body becomes the top. The drilling diagram (Fig.5) shows where holes are made in the base and side of the case, and can also be used as a template. Holes are required for the potentiometer shafts, LED bezels, Nutube viewing holes and the footswitches on the main panel area.

Cut-out slots are also required for the two jack sockets and DC power inlet, at the end of the box. Slots, rather than holes, are required so that the jack sockets can be manoeuvered into place.

To stop dirt and other gunk from entering the case we made a 45mm x 9mm blanking piece from a sheet of 1-1.5mm thick aluminium. This covers the slots from the inside, after the jack sockets have been inserted. We also added some shaped plastic pieces to fill the slots to the same level as the outside of the enclosure.

This is optional; the fill pieces can be glued to the backing piece, as shown in the drawing and photograph.

It's a good idea to add rubber feet so it won't move during use. While you could apply stick-on rubber feet to the lid, we weren't convinced they would stay stuck on during the rough and tumble of use.

So we replaced the original lid securing screws with Nylon M4 panhead screws instead. The heads are proud of

Resistor Colour Codes

	Qty.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	6	1MΩ	brown black green brown	brown black black yellow brown
❑	1	470kΩ	yellow violet yellow brown	yellow violet black orange brown
❑	2	330kΩ	orange orange yellow brown	orange orange black orange brown
❑	1	33kΩ	orange orange orange brown	orange orange black red brown
❑	1	13kΩ	brown orange orange brown	brown orange black red brown
❑	7	10kΩ	brown black orange brown	brown black black red brown
❑	1	8.2kΩ	grey red red brown	grey red black brown brown
❑	1	6.2kΩ	blue red red brown	blue red black brown brown
❑	1	1kΩ	brown black red brown	brown black black brown brown
❑	3	510Ω	green brown brown brown	green brown black black brown
❑	1	200Ω	red black brown brown	red black black black brown
❑	1	150Ω	brown green brown brown	brown green black black brown
❑	2	100Ω	brown black brown brown	brown black black black brown

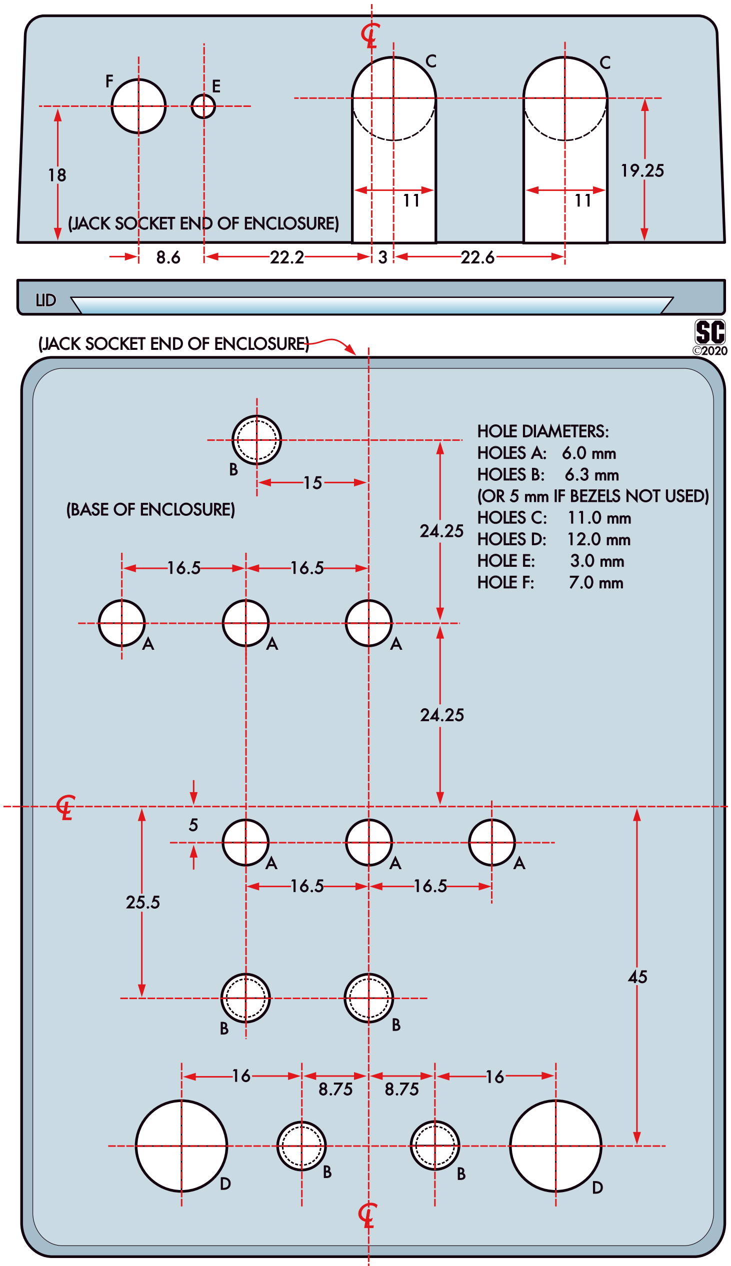


Fig.5: drill the holes in the enclosure base and side as shown. Two of the holes in the side need to be slotted so that the sockets can slide down into place. The only hole required in the lid is optional, to access VR4; use the PCB to locate this hole if you've decided to drill it.

the surface by a couple of millimetres and hence act as the feet. However, to allow this, the holes in the enclosure for the original mounting screws had to be drilled out to 3.5mm then tapped using an M4 tap.

Fig.6 shows the lid panel artwork we have prepared for the Pedal. It can be copied from this diagram, or downloaded from the Silicon Chip website and printed out (the download also includes the drilling templates).

To help protect it, you can print the label onto overhead projector film as a mirror image, so the ink will be between the enclosure and film when affixed. Use projector film that is suitable for your printer (either inkjet or laser) and affix using clear neutral-cure silicone sealant. Squeegee out the lumps and air bubbles before the silicone cures. Once cured, cut out the holes through the film with a hobby or craft knife.

For more detail on making labels see www.siliconchip.com.au/Help/FrontPanels

Mounting the PCB

Attach the 9mm M3 tapped spacer to the rear of the PCB using an M3 screw through the top. The hole is located between CON1 and CON2. This spacer keeps the PCB in place by resting on the lid when the case is assembled.

If you haven't already done so, solder the ground to the GND PC stake on the top of the PCB and shrink a short length of heatshrink tubing over the stake. The ground lug mounting position is adjacent to the DC socket. Secure this using an M3 screw, star washer and nut before the PCB is inserted into the case.

Orientate the solder lug so that the wire is closest to the base of the enclosure, so it does not foul any components on the PCB.

Insert the LED bezels from the outside of the case. The Nutube viewing holes also require bezels to stop dirt and dust from getting in. They can be held in place with small cables ties, pressing them against the inside of the enclosure, then glued in place with silicone sealant.

Before putting the PCB into the enclosure, insert the LEDs into the PCB holes. The longer anode leads must go into the holes marked "A" on the PCB. Place the Nylon washers for the footswitches onto each switch shaft, then fit the PCB into the enclosure. Push the LEDs into position in their bezels to capture them, then solder the LED leads from the rear of the PCB.

The battery compartment is made from a rectangular cut-out on the PCB. The battery can be prevented from moving by packing some of the foam packaging supplied with the Nutube around it.

Insert this between the end of the battery and the edge of the PCB. If you are not using a battery, unplug the battery clip from CON3 and remove it to prevent the contacts from shorting against the board.

Knobs

Since the potentiometer shafts do not protrude much more than 9mm above the lid, you can't use standard knobs with a skirt. The skirts are intended to cover the potentiometer securing nut but there is no nut here, resulting in insufficient internal fluting to secure the knobs to the shafts.

There are two ways around this; either use knobs without a skirt, or cut the skirts off. The knobs mentioned in the parts list don't have skirts.

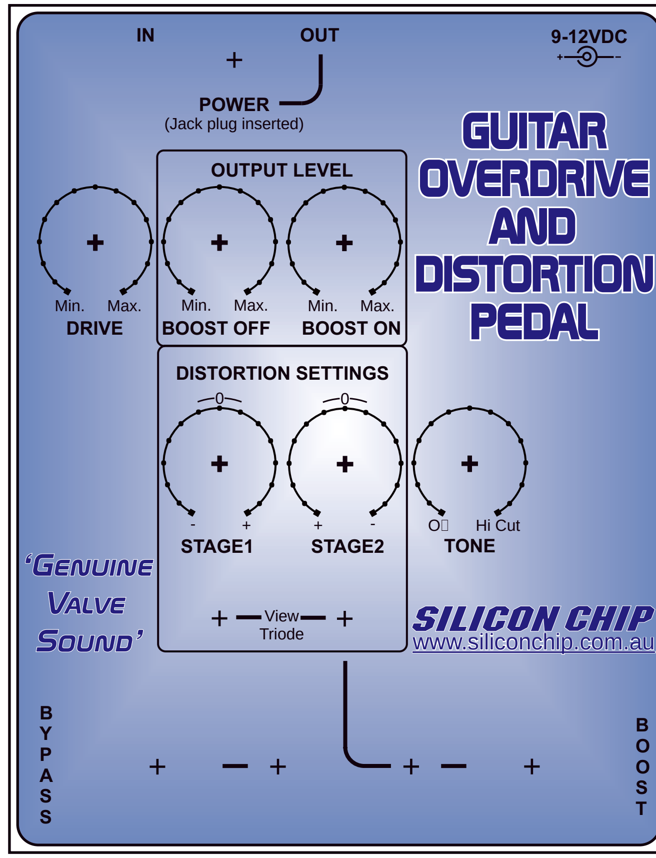
If you can't get those for some reason, you can purchase Jaycar knobs in the HK7730-7734 range (we recommend Cat HK7733 blue) and cut the lower skirt flange off with a hacksaw.

Finally, secure the lid in place using either the original screws or Nylon M4 screws, as mentioned previously. Attach the rubber feet to the base using their sticky-back adhesive if you are not using the Nylon screws as feet.

Removing the knobs

The knobs may be difficult to remove by pulling; you may need to lever them off. Insert a sheet of thin plastic between the lever (eg, a flat-bladed screwdriver) and the case to prevent damage to the panel.

Fig.6 (right): same-size front panel artwork which fits on the bottom of the diecast case (which of course becomes the top!) It's easiest to cut the holes once the panel has been glued in position. Note our comments re longevity of this panel – it's likely to suffer some pretty rough treatment!



Using it

It's basically just a matter of twiddling the controls until you get the sound you want. The only control which is not externally accessible is trimpot VR4, so it's a good idea to figure out what you want to do with this before you close the case. But note that the Pedal is designed so that you can drill a hole in the base to externally adjust VR4 with a screwdriver.

We prefer to leave VR4 fully clockwise so that there is a substantial limiting action when in boost. But you might want to adjust VR4 so that the second distortion stage has a similar effect to the first, and they combine more evenly with the distortion control adjustments. It is a matter of personal preference.

Many amplifiers for musical instruments have an Earth loop switch which allows the common shield connection of the jack lead to either be Earthed or floating. When used with a guitar that has piezo pickups, you should get less hum when it is connected to Earth.

Oscilloscope screen grabs Scope1-Scope8 show how the output waveform varies with a range of different control settings. See those screen grabs for more details. SC