ETI-1425 GUITAR NOTE EXTENDER

If you want your guitar notes to keep on hanging on cleanly, then the ETI-1425 may be just for you.

Terry Kee

THE INFAMOUS "fuzz box" or distortion box has long been the electric guitar player's most used effect pedal. One of the reasons responsible for this is that the distortion allows the player to sustain the notes much longer than normal and the other is due to the harmonic change generated by the clipping or bending of the guitar signal. It is often difficult to achieve a guitar sound with heaps of sustain and without it being buried in distorted grunge.

The ETI-1425 solves the problem and provides the sustain without the distortion. Using the Note Extender as the first pedal in the effects chain, and there are usually many, can accentuate the effect of other ones, as an example, using it with a distortion unit set to give just a hint of "edge" can fire that guitar solo into life.

The 1425 has a Bypass LED indicator which tells us when the effect is switched in or out. The Input Drive knob is used to set the input gain so as not to overload the unit and it also determines the amount of sustain required. The output level can be varied by the volume knob. The unit is powered by a 9V battery. There is also a dc socket to accept a 9V battery eliminator. The power to the unit is switched on when a jack plug is inserted into the output socket, thus eliminating an on/off switch.

Design Considerations

The Note Extender works on the same principles as the familiar Automatic Level Control circuit found in radio receivers. The heart of such a device is a Voltage Control Amplifier (VCA) and a rectifier that converts the ac signal into an appropriate dc level to control the VCA and keep the level constant. The time constant of the rectifier filter plays an important role in determining the overall performance of the unit. The attack time has to be fast enough to bring down the gain quickly to stop the transient portion of the guitar signal from being amplified excessively.

Remember that once the guitar note has decayed the system gain will be at its maximum thus making the speed of the attack time even more accute. The decay time has to be fairly long to smooth out the low frequency that can effectively modulate the VCA and manifest itself as distortion at these frequencies. Furthermore the decay time has to be short enough to follow the envelope of the signal. In a simple RC filter network the fast attack and slow decay requirements are conflicting as the time constants are determined by a single capacitor.

After some experimentation with different time constants and plucking endless guitar notes, I came to the conclusion that a dual time constant rectifier circuit was essential. The compromise between low distortion and a fast response became too critical. Furthermore the results that were obtained were too dependent on guitar playing styles.

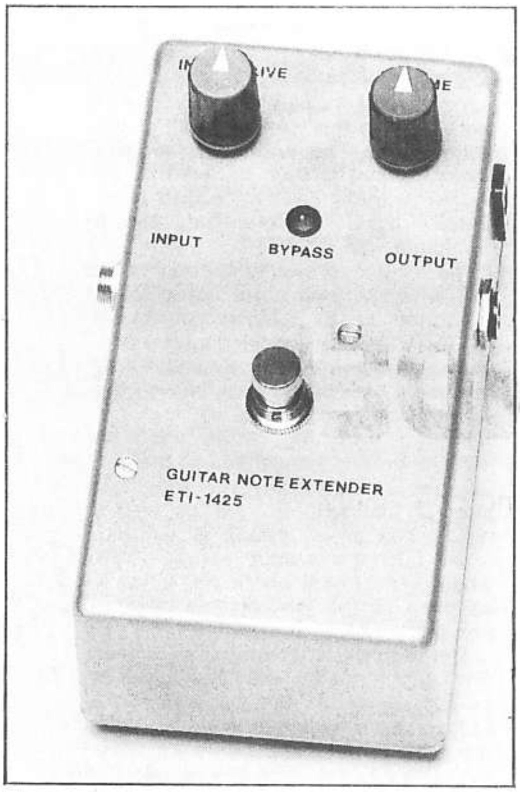
Occasionally plucking a note hard and fast allowed a nasty click through to the output as the sytem was too slow to respond to it. My attention was then drawn to the 572 companding chip which has a separate attack and decay time constant built into the rectifier filter network. The 572 can be configured as a compressor or an expander circuit hence the name, companding. In the Note Extender the 572 is configured as an Automatic Level Controller (ALC) with the signal input connected to the rectifier input rather than the signal output, which is the compressor configuration. This makes the gain inversely proportional to the input level so a decaying signal level will produce a proportional increase in gain to keep the level constant.

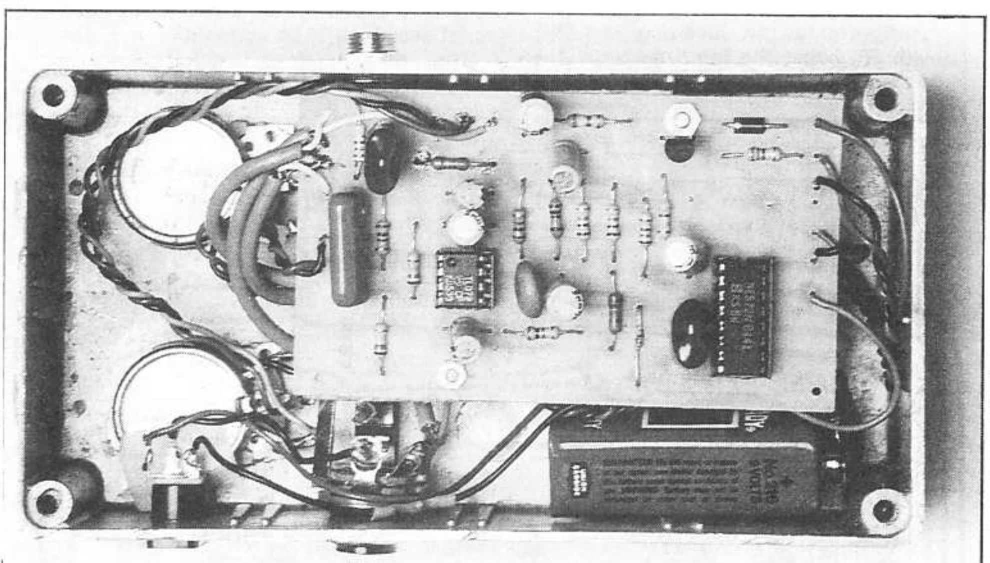
The amplification of the lower levels of the guitar signal does present us with a problem as the level becomes comparable to the guitar pick-up noise and that dreaded hum!

Unfortunately the envelope of a plucked guitar string decays fairly quickly so low level amplification is important to the amount of sustain perceived by the ear. However, there has to be a compromise between the amount of sustain and acceptable noise levels. This compromise is also a function of the type of guitar pick-up to be used with the 1425. The single-coil pick-up as found on Fender Strats are renowned for their ability to pick up hum and to generate noise of their own.

The humbucker is a twin coiled pick-up which cancels out any picked up hum (hence the name). These pick-ups have their own characteristic sound and both are widely used.

Furthermore some guitars are not properly screened which makes them a perfect aerial for hum! To accommodate different types of pick-ups and to obtain the best performance with your guitar a Select On Test resistor is included in the design. A measured SNR of −80dB was obtained





with the input short circuited so most of the noise will be generated by the pick-ups.

Circuit Description

The input amplifier IC1a serves to provide a high input impedance of around 90k ohms so as not to load the guitar pick-ups and to provide amplification for those lack-lustre pick-ups. The gain is made variable via the Input Drive pot from 0 dB to a maximum of 20 dBs.

A bass cut is also built into the input amplifier to attenuate low frequency noise and hum. The mid to high frequencies are thus accentuated by the ALC action and this makes the sustain effect more noticeable. The signal is then applied to the heart of the Note Extender which is the gain control section consisting of the 572 Companding ic. The gain cell contained in the 572 is placed in the feedback loop of an op-amp with the input signal connected to the rectifier input.

The 572 thus acts as a varying impedance in the feedback loop that is controlled by the input signal and in turn, varies the voltage gain of the op-amp. When the input amplitude decreases below the cross-over point which is around −30 dBm, the overall system gain increases proportionally to hold the output at a constant amplitude of −30 dBm.

As the input level increases above the cross-over point, the system gain decreases proportionally again holding the output amplitude constant. The amount of ALC action is thus level dependent and the Input Drive control ensures that the input level can be varied to an amplitude comparable to the cross-over point.

The rectifier in the 572 consists of a full-wave circuit and a buffer amplifier that implements the separate attack and decay filter network. Capacitor C6 and a 10k internal resistor determines the attack time.

In the Note Extender an attack time of 1.5mS was found to be suitable only after extensive plucking of guitar notes and listening carefully to the transient response at the output. The decay time is determined by C7 and another internal 10k resistor.

A time constant of 68 mS was suitable and produced about 1% distortion at 100 Hz. Note that the 572 is a dual channel device, however only one channel is used.

To reduce the gain at very low levels, R15 supplies an extra current to the rectifier which raises the voltage applied to the gain cell and effectively reduces compression at low levels. The ALC action is further reduced at low input levels by R5 which limits the maximum gain of the circuit.

Unfortunately limiting the low level gain by these methods also affects the amount of gain availble at the cross-over point. Hence the trade-off is acceptable noise generated by your particular guitar pick-ups and sustain. I used a Stratocaster guitar with single-coil pick-ups to set up the values of R15 and R5 experimentally.

The procedure to set up the 1425 to work best for your individual guitar is described in the Testing section.

The input jack socket is wired to short out the input when no plug is inserted. The output socket has a switched connection that disconnects the ground connection from the battery or dc power source. The footswitch allows the output to be switched between the output of the Note Extender or the input signal. A LED is also switched on when the unit is in use.

The unit can accept a maximum input level of 10 dBm with the Input Drive set to minimum before clipping commences at an output level of −6 dBm.

Construction

The circuit board is built on a single-sided pc board measuring 90 x 53 mm. Once the pc board is etched and the holes are drilled then start by mounting and soldering in the resistors, capacitors, link and ic sockets (if you have decided to use them). Check the polarity orientation of the electrolytic capacitors by referring to the overlay. Note that C10 is a 470μ/25V capacitor and if you find that the component height is too high to fit in the box, then solder the cap on the solder side. Solder in the diode and transistor, noting again their correct orientation.

The next step before the wiring can commence, is to decide on the type of box you want to use. Since the unit is to be floor mounted, it needs to be rugged and made of metal for screening purposes. I used an aluminium diecast box measuring 150 x 50 x 80 mm, commonly available from electronics stores. The holes on the box need to be marked and drilled out. I did not use a Scotchcal panel as they tend to scratch quite easily and would not survive all that foot pounding! Measure out the holes by dropping in the hardware and checking that everything fits. Do not forget about the 9V battery! Ensure that the marks are neatly aligned before the holes are drilled. I managed to fit everything in the diecast box although it was a tight squeeze.

The pc board was mounted on top of the footswitch and input jack socket and tightened down to the top panel via 2 bolts and spacers. The footswitch contacts were bent down so that the pc board could fit inside the box.

Next comes the spray painting, if you want the unit to look really professional. I coated the box with a metallic blue spray, available from your local car accessory store. Smooth the surface of the box with a small piece of fine wet and dry sandpaper. Wipe it clean and allow it to dry. Spray the box with three light coats of paint, allowing each coat to dry fully. Use some Letraset or something similar to letter the knobs and sockets. Spray the lettering with a clear protective coat to avoid the lettering from being rubbed off.

Once that is done it is time to commence with the wiring. Use screened audio cable for the connections to the jack sockets and footswitch. Note that the connections to the footswitch have the screen cut at the switch end but soldered to ground on the pc board. Sleeve the connection at the switch end to prevent any short circuits to ground. Use hook-up wire for the rest of the wiring keeping the connections to the two pots as short as possible to minimise stray pick-up. Insert the ics into their respective sockets if you have not soldered them in already. Take note of their polarity.

The final stage is to cut a piece of cardboard to insulate the solder side of the pc board from the footswitch and input jack socket. Tighten the nut of the input socket SK1 firmly as it also acts as the ground connection to the metal box.

HOW IT WORKS — ETI 1425

IC1a is configured as a non-inverting amplifier with the gain set by RV1 and R4 to a maximum of 20 dB. R2 and R1 establish the biasing point 4.5V for the op-amp to operate with a 9V supply and sets the input impedance to 90k. The signal is then ac coupled via C3 and C4 to IC1b and the rectifier input of the 572 (IC2). C6 determines the attack time with an internal 10k resistor and sets it to 1.5 mS; C7 sets the decay time to 68mS.

The resistor R5 limits the maximum gain of the circuit to reduce the ALC action at very low input levels. Reducing the value of this resistor reduces the gain and increasing it, increases the ALC action. R15 is connected between pin 2 to 9 V to reduce the gain even further at very low levels.

Resistor R9 is used to bias the output halfway between the supply and ground to obtain the maximum headroom. A value of 22k sets pin 7 of IC1b to 4.5 Vdc feedback is provided by R10 and R11 and C8 ensures that no ac signal is present in this path.

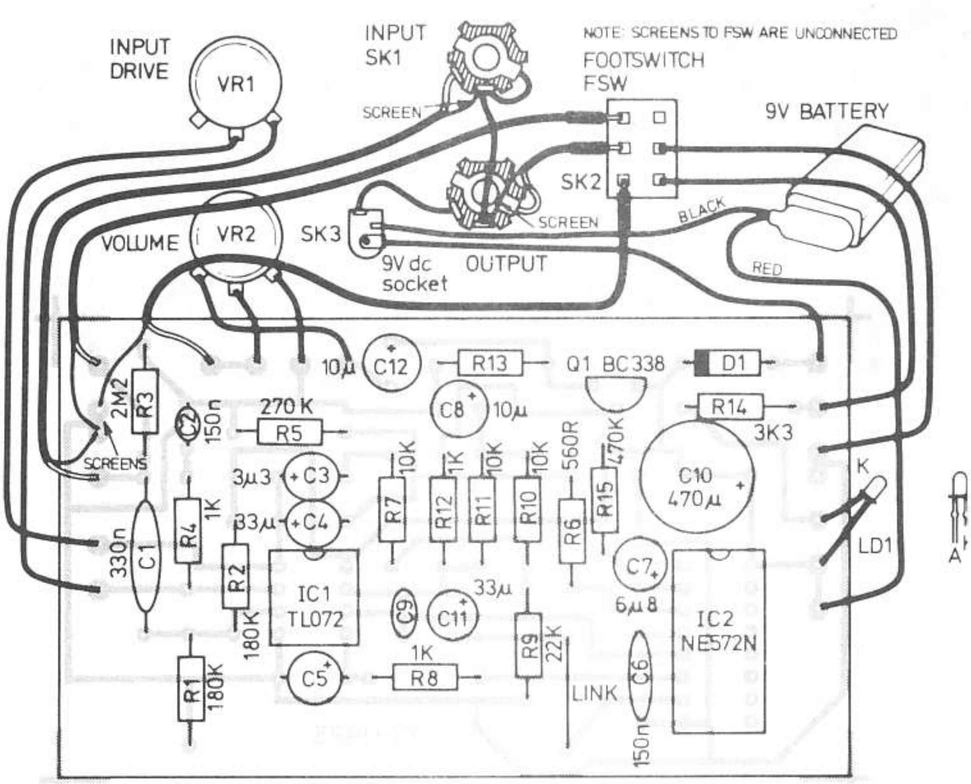
The 572 is placed in the negative feedback loop of IC1b with the output ac coupled via C11 into the input of the gain cell (pin 7). The gain circuit is configured as an inverting amplifier with R7 being the input resistor. The non-inverting input of the op-amp (IC1b) derives its dc bias from pin 6 of the 572. Note that only one half of the 572 is used. The output of the gain control circuit is then buffered by an emitter follower Q1. The output is ac coupled by C12 before being fed to the volume pot (VR2).

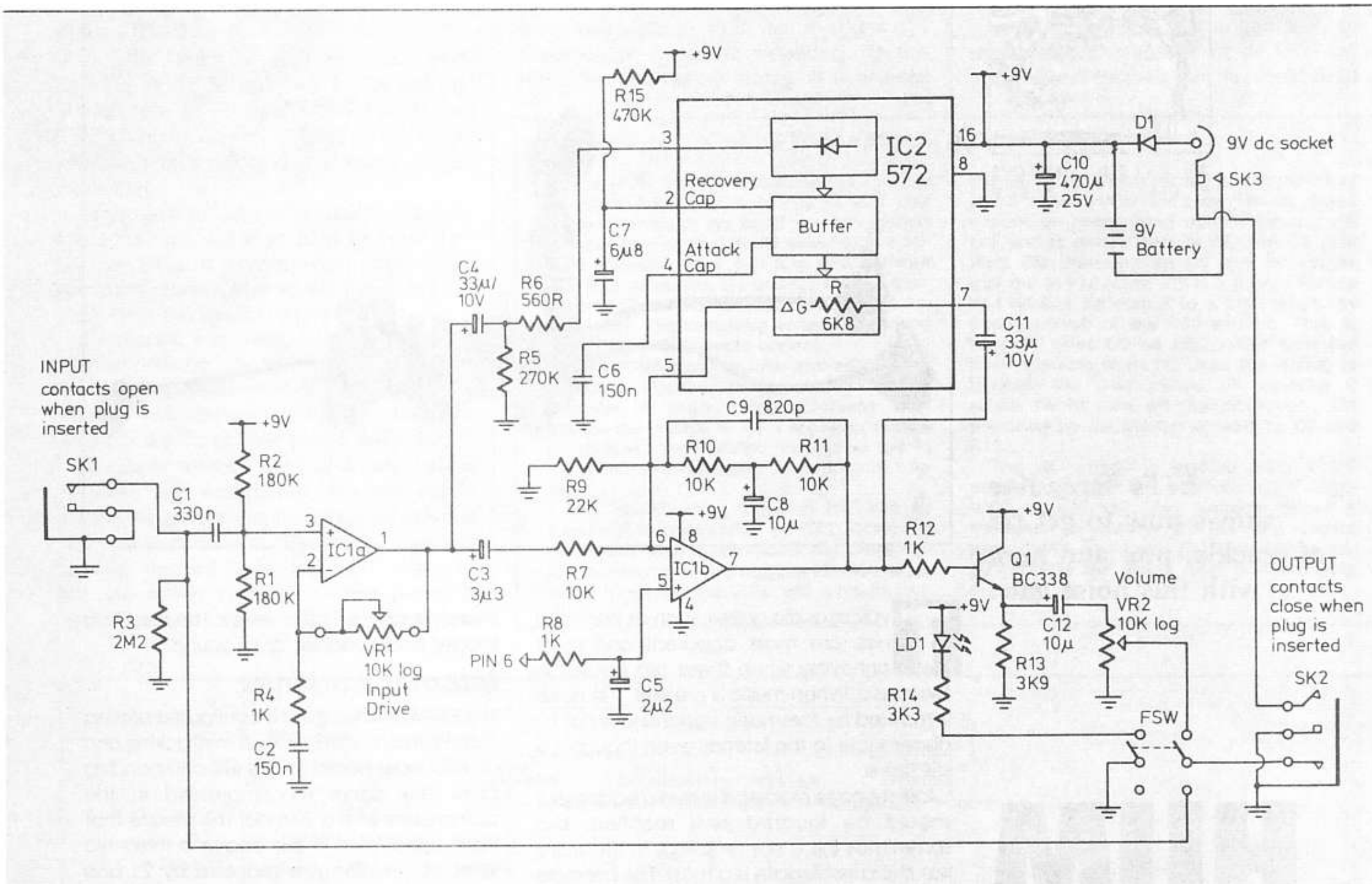
The 9V rail is heavily decoupled by C10 which smooths out the glitches generated by the gain control circuitry. The diode D1 provides circuit protection for incorrect supply polarity by becoming reversed bias when the wrong polarity is applied.

Battery switching is arranged so that the ground connection of the battery becomes disconnected when a dc plug is inserted into the dc socket (SK3). The on/off switch is incorporated into the output socket (SK2) where the ground continuity is made as soon as the jack plug is inserted into the socket.

The footswitch is configured to feed the output socket with the input or output signal. At the same time the LED circuit is switched in via the limiting resistor R14 and lights up when the output is selected. The resistor R3 discharges the voltage on any capacitors in preceeding units and enables quiet switching to be achieved.

The unit consumes about 9 mA dc current when the unit is switched in.





Testing

Check the pc board for solder bridges across pads and track for broken tracks, before it is fastened down to the box.

Connect in a 9V battery and insert a jack plug into the output socket to switch on the power. Measure the dc voltage across the power rails with a multimeter and check that it is indeed around 9V. If the voltage falls to 0V then disconnect the battery and check your soldering for a short circuit across the power rails. If you are using one of the commercial 9V battery eliminator then ensure that the polarity of the dc power plug has the positive terminal at the centre of the plug. Note that the unit needs a regulated 9 Vdc supply so it will not operate satisfactorily with a plug pack. Switching the footswitch should light up the bypass LED.

Once that has been ascertained, plug in your guitar and connect the output to an amplifier. Rotate the input and output controls to maximum and listen to the output. Compare the difference by plucking a note, the open G string is a good one to use. Switch in the unit and you should hear the note hanging on much longer than the straight through version. If the output is distorted then the input level is too large. Back off the Input Drive controls until the distortion disappears. Note that decreasing the input drive will also reduce any extraneous pick-up noise.

If your guitar pick-ups are excessively noisy then experimenting with the value of R5 should help enormously. Reducing the value will decrease the gain; a value of 220k would be a good starting point. Conversely if your pick-ups are particularly clean then increasing the value of R5 will extend the sustain. Happy Plucking. ●

ETI-1425 PARTS LIST

Resistors................all ¼W, 5%

- R1, R2 .... 180k
- R3.......................... 2M2
- R4, R8, R12........... 1k
- R5.......................... 270k
- R6.......................... 560R
- R7, R10, R11......... 10k
- R9.......................... 22k
- R13........................ 3k9
- R14........................ 3k3
- R15........................ 470k
- RV1, RV2 .... 10k log pot

Capacitors

- C1.......................... 330n greencap
- C2, C6 .... 150n greencap
- C3.......................... 3µ3/25V pc mount electro
- C4, C11 .... 33µ/10V pc mount electro
- C5.......................... 2µ2/25V pc mount electro
- C7.......................... 6µ8/25V pc mount electro
- C8, C12 .... 10µ/25V pc mount electro
- C9.......................... 820p ceramic
- C10........................ 470µ/25V pc mount electro

Semiconductors

- D1.......................... 1N4001
- Q1.......................... BC338
- IC1......................... TL072
- IC2......................... NE572
- LD1........................ Yellow LED

Sockets and Switches

- SK1 .... 6.5mm Switched Jack Socket (contacts open when plug is inserted).
- SK2 .... 6.5mm Insulated Mono Jack Socket (contacts close when plug is inserted).
- SK3 .... Insulated Switched dc socket (contacts open when plug is inserted)
- FSW .... Heavy Duty Footswitch DPDT

Miscellaneous

9V battery holder, 1 off 8 pin ic socket, 1 off 16 pin ic socket, diecast box (150 x 50 x 80 mm), 2 knobs, automotive paint spray