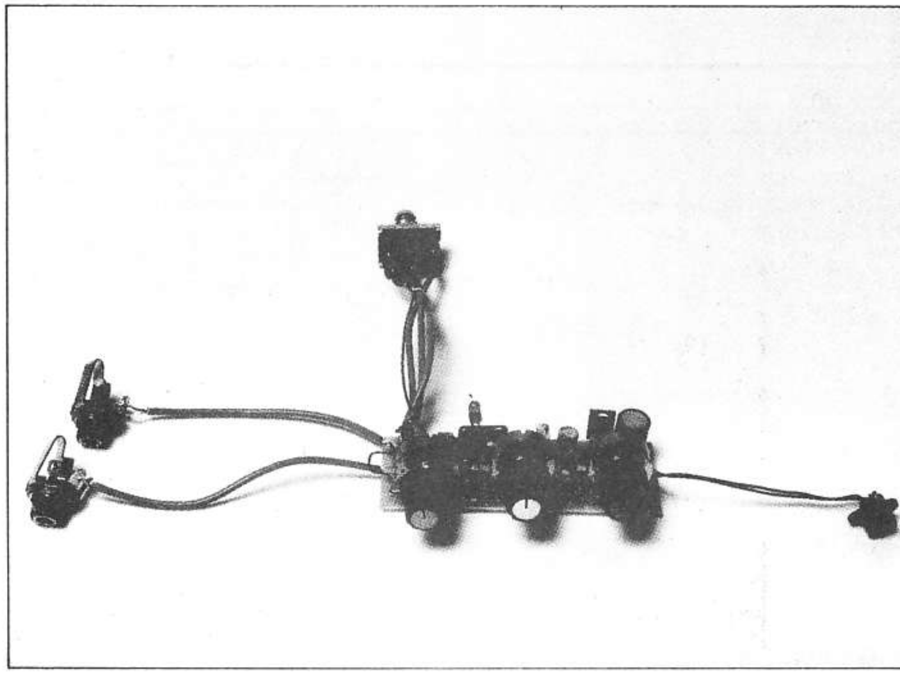
ELECTRONICS
ETI - 1429



ETI's Terry Kee shows how to get rid of crackle, pop and hum with this noise gate.

HUM AND HISS NO MORE

Eliminate annoying audio noises

Typical audio noises, such as hum and hiss, are most apparent and most annoying when there are pauses in the music. When music is present, the noise is masked by the music signal and is not as discernable to the listener, even though it is still there.

Ideally, noise problems in audio equipment should be located and rectified, but sometimes this is not practical. In situations like this, a noise gate is a must. The principle is quite simple. Any noise signal will generally be at a lower level than the average value of the signal, hence if the noise gate can be set to allow signals at high levels through but shut down at lower levels then the dynamics of the signal will largely be retained, but the hum will be reduced. When signal is not present the noise is effectively gated out.

The applications of the noise gate can be used to good effect in many situations. Musical instruments that use magnetic pick-ups are prone to pick up hum, particularly if they are located close to a magnetic field like a power supply in an amplifier, which is quite likely to occur in a live situation. The noise gate can also improve the quality of live recordings where audience noise, or sounds from instruments, spill over into adjacent microphones. Connecting a noise gate in each of the mic channels cleans up the sound by gating out the spill-over. Another use of the noise gate, common in recording studios, is to reduce the reverberation times of instruments, notably drum sounds, which already have added reverberation. In this context the noise gate acts as an envelope generator which shapes the envelope of the signal. The ETI-1429 can produce some envelope shaping by varying the threshold where the gating starts, so that lower signal levels are attenuated more sharply than the higher levels. The result is a shorter and punchier drum sound.

Internal workings

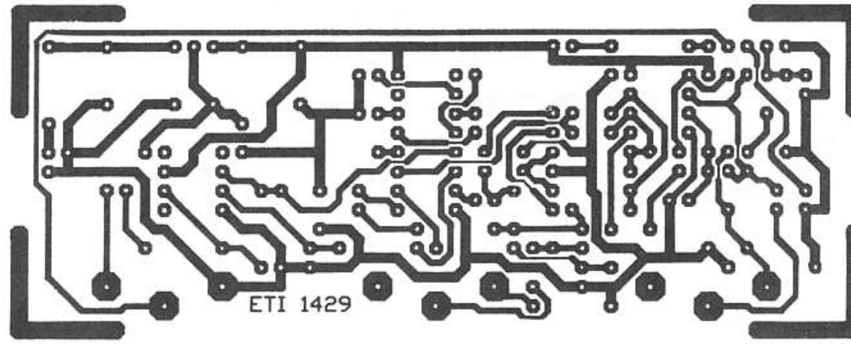
The ETI-1429 noise gate is configured around a compressor with low level mistracking and an expander based on the 572 companding chip. The signal is compressed in the compressor with a 2:1 ratio. This means that input signal level in dBs above a threshold level of −18 dBrn are reduced by 2:1 and levels below the threshold are increased by 2:1 (refer to the graph plotted in table 1). If the threshold level is referenced at O dB then an input level of −20 dB is increased to −10 dB and a 12 dB input level is reduced to 6 dBs.

> *'Another use is to reduce the reverberation times of instruments'*

The output of the compressor is fed into an expander circuit which provides a complementary action to the compressor. It expands signal levels above and reduces signals below the threshold with a 1:2 ratio. The result is a unity gain signal i.e. a 1:1 ratio. A graph of the companding system levels of the 572 is shown in Table 1. The noise gate action is introduced at the compressor by mistracking the compression ratio at low levels. This means that at high levels the signal undergoes a 2:1 compression whereas low levels tends towards a 1:1 ratio.

At the output of the expander the applied signal undergoes the nominal 1:2 expansion, which reconstructs the top half of the signal so that it follows the input signal. But due to the low level mistracking of the compressor the bottom half signal is expanded down by a factor of 2.

The threshold where low level mistracking of the compressor occurs is made variable. The graph plotted in Table 2 shows the effect of varying the threshold. The response of the noise gate has to be compared to the 1:1 graph where the input equals the output. With the threshold set to minimum, signal levels below about −50 dBm start to detract from the nominal 1:1 curve. When the threshold is set to maximum it is raised to around 5 dBm. The thresholds of −40 dB, −30 dB and −20 dB are also shown in table 2.



NE 572 companding chip

The 572 is a dual channel gain control circuit where one channel is configured as the compressor and the other as the expander. Each channel has a full-wave rectifier that detects the average value of the applied signal, a variable gain cell and a time constant buffer. This buffer allows separate control of the attack and recovery time constants. This feature reduces the low frequency ripple that controls the gain cell and reduces the distortion at these frequencies. The attack time of the noise gate is set fairly fast to 3.3 mS via C12 and C16 and the release time by C11 and C15 to 47 mS (see the circuit diagram). These time constants work well with sharp percussive drum sounds and guitar. Note that C12 must equal C16 in value (ditto for C11 and C15) if you want to experiment with different time constants. Reducing the release time will increase the low frequency ripple and thus worsen the low frequency distortion.

Performance

With the values shown in the circuit a THD of

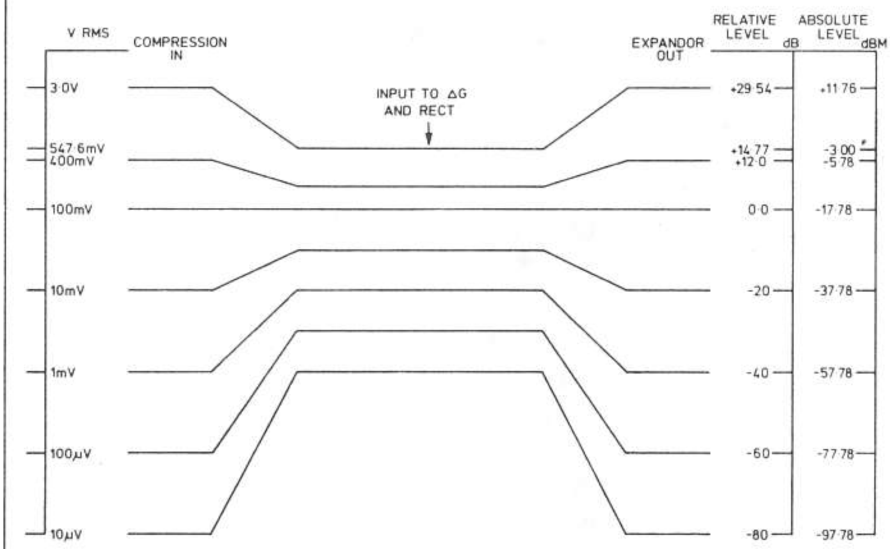
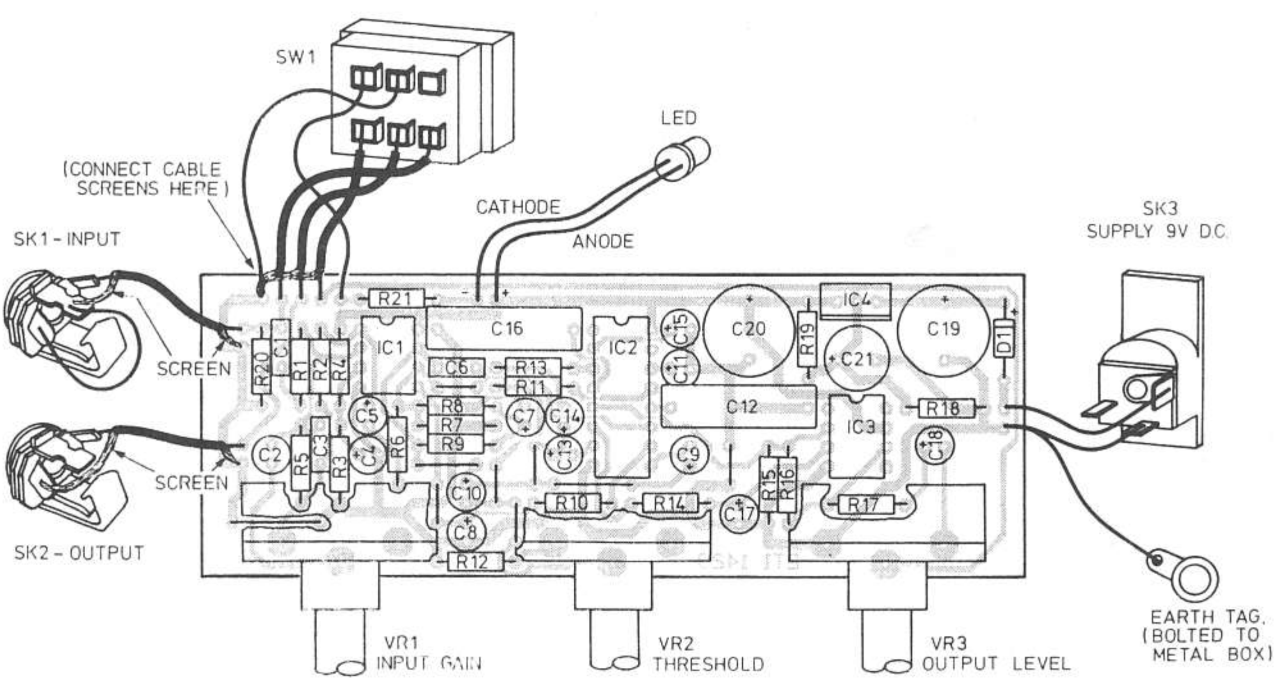


TABLE 1. NE572 SYSTEM LEVEL



0.6% at 100 Hz and 0.08% at 1 kHz was measured at a 0 dBm level. The noise floor of the unit sits at about −84 dBm with the input shorted to ground and signals starts to clip at about 8 dBm (1.9 V rms). The bandwidth (−3 dB points) occurs between 8 Hz to 40 kHz.

Signal levels

Due to the companding process, the operation of the noise gate is dependent on the applied signal level, threshold level setting and input gain. Optimum signal levels are between −10 dBm (245 mV rms) and 0 dBm (775 mV rms) which are typical line levels so a good place to insert the unit would be between the pre-amp and the power amp or at the effects send and return of a mixing stage. The noise gate also incorporates an input amplifier that boosts signals over a variable 0 to 18 dB range to give some control on the input levels. The output level control can then be used to attenuate the output to compensate for the additional gain set at the input amplifier. In practice this is done by switching over the bypass switch and adjusting the output control until the levels are equal.

Parts List — ETI-1429

Resistors: – all 1/4 W, 5% unless stated otherwise.

R1, R2	100k
R3, R4	100k 1%
R5	4M7
R6, R12	18k
R7	22k
R8, R9	10k
R10, R14	1k
R11, R21	3k3
R13	2k2
R15	15k
R16	12k
R17	82R
R18	150R
R19	220R
R20	2M7
VR1, VR2	1M log pc mount pot, 24 mm diameter
VR3	5k log pc mount pot, 24 mm diameter

Capacitors

C1	82n greencap
C2	10 u/25V bipolar electro
C3	100p ceramic
C4, C7, C13, C14, C5, C8, C9, C10	10 u/25V electro
C17, C18	2u2/25V electro
C11, C15	4u7/25V electro
C6	390p ceramic
C12, C16	330n greencap
C19	1000u/25V electro
C20	100u/25V electro
C21	33u/25V electro

Semiconductors

IC1	TL072 dual op-amp
IC2	NE 572 companding ic.
IC3	TL071 op-amp
IC4	7805 5V regulator
D1	1N4004
LED	any 5 mm led will suffice

Miscellaneous

SK1, SK2	6.5 mm Jack socket (contacts open when plug is inserted).
SK3	dc plug pack socket
SW1	DPDT switch (can be toggle or footswitch type).

ETI-1429 pc board, 9V dc plugpack at 200mA, suitable metal box, 3 off knobs to fit ports.

Construction

The construction is fairly straightforward as all the electronic components, except for the sockets and switch, are contained on the pc board with dimensions 110 mm × 40 mm. The pc board is designed to accept pc mount pots which simplifies the wiring and the board can be mounted directly to the panel of the box with the pot nuts bolting the pc board down. The choice of box is left to the reader so no enclosure details are given here. However a metal one is preferred for screening purposes. If the noise gate is to be floor mounted then a diecast box is recommended. The unit will have to endure quite a bit of foot bashing, so a heavy duty footswitch should be used for the bypass switch. Otherwise a standard DPDT toggle switch should suffice.

Start by inspecting the pc board for any unetched or broken tracks as some are quite thin and run close together. A finely tipped soldering iron will make life easier. Mount and solder in the links (use some hook-up wire) resistors and capacitors. Take note of the polarity of the electrolytics. Refer to the component overlay.

Next, insert and solder the pc mount pots making sure they sit parallel to the board. Solder in the op-amps, 572, D1 and the 5 V regulator, taking careful note of their correct orientation. The pc board soldering is now finished and all that remains to be done is to wire in the switch, LED and sockets.

Drop the board inside the box and measure and drill out the holes for the 3 pots, sockets, switch and LED. Refer to the overlay and commence with the wiring. It would be easier to mount all the hardware into the box so that the length of the wires can be measured out accurately. Use screened audio cable for the input, output and switch connections and hook-up wire for the dc socket and LED connections. Note that the ground screen is cut off at the switch (SW1) end but joined together and soldered to ground at the pc board. The metal chassis of the box has to be connected to ground and this can be done by bolting a tag to the chassis and soldering a ground connection to the tag. Insulate any exposed contacts if there is any possibility of shorting.

Testing

Before you apply power, sit back and carefully check the pc board for solder splashes across tracks and bad solder joints.

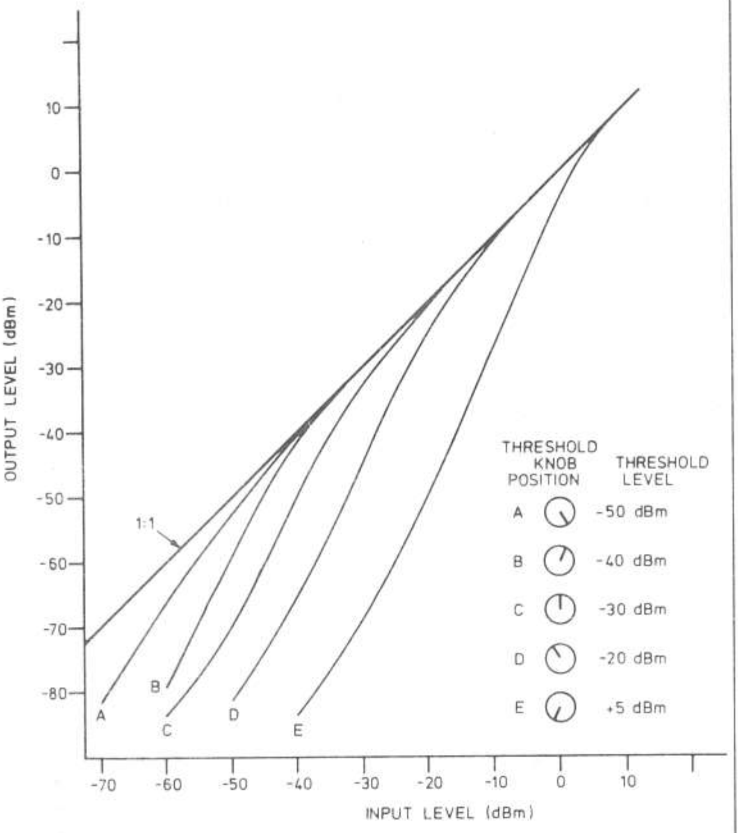
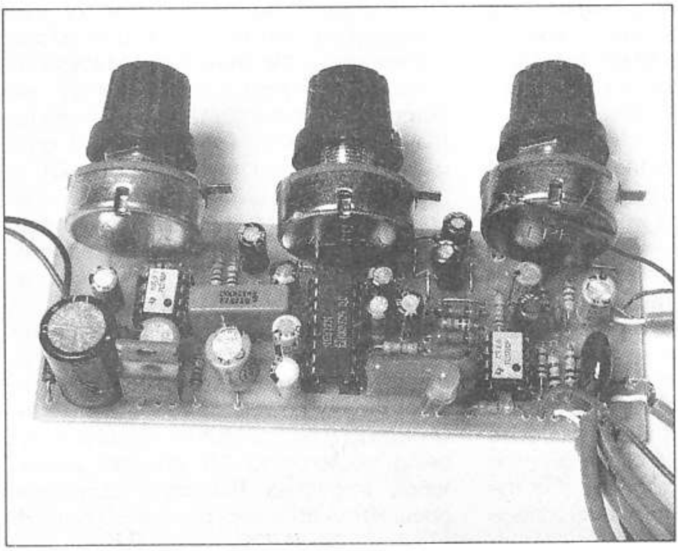


TABLE 2 RESPONSE WITH VARYING THRESHOLDS

Check the wiring as well. Once you are satisfied with your handywork connect in the 9 Vdc plugpack and check that 9 Vdc is present on the power rails with a multimeter. If not then disconnect the power and check that the polarity of the plugpack plug corresponds to the socket. Once the 9 V has been established check that it appears on pin 8 of IC1, pin 16 of IC2 and pin 7 of IC3.



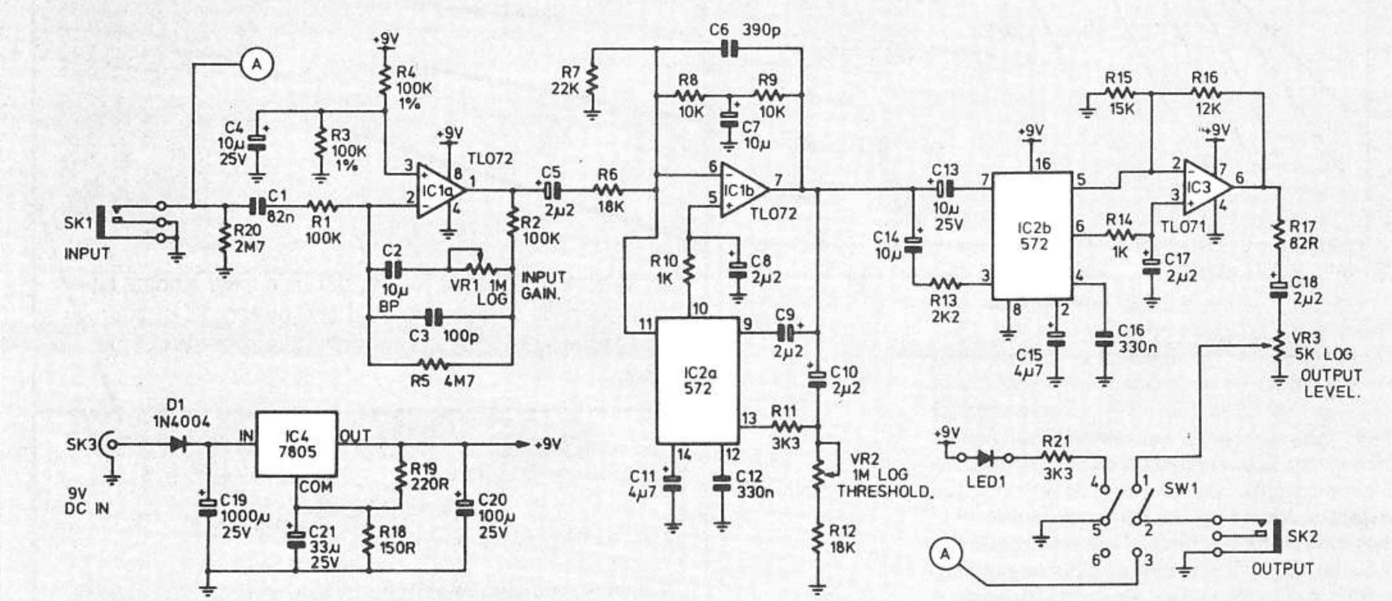
Switch over the bypass switch and the LED should light up in one position. If not, then the legs of the LED are possibly reversed. If the circuit is tested outside the box, connect the metal case of the input control pot and the footswitch to ground, to avoid inducing hum into the audio circuits.

Setting up

The performance of the unit depends on the level of the applied input signal and the settings of the input gain, threshold and output level controls. Because the three controls interact with one another it would be best to follow a sequence to set it up. Start the procedure with the input gain control turned fully anti-clockwise (i.e. unity gain), the threshold turned fully clockwise (i.e. maximum threshold) and the output level control set fully clockwise (i.e. maximum volume). Use this setting as the starting reference point because the output of the noise gate closely follows the input except at input levels below about −50 dBm. The response follows curve A in the graph plotted in table 2. Apply a signal to the input and connect the output to an amplifier. Activate the bypass switch and the levels should be similar; incidentally the LED lights up when the output of the noise gate is selected.

The threshold level should be reduced by rotating the knob slowly anti-clockwise until the hum or hiss is gated out. Test that the main signal is still present and adjust the input and output controls for equal level if it is required. The unit is designed to operate at levels higher than about −10 dBm (245 mV rms) so connect the noise gate at the output of a pre-amplifier or at the end of a chain of effect pedals if the input level is insufficient.

Increasing the input gain should be complemented by reducing the output level control, because the signal including the hum and hiss is boosted by the input amplifier. Be careful with the gain control set to boost input signals and switching between input and output as there can be heaps of gain difference between them; certainly enough to give one's ears quite a fright not to mention overloading power amps and speakers! Avoid just twiddling the knobs and hoping for the best. Always start from the reference setting and work from there. For envelope shaping the threshold level needs to be set fairly high to produce maximum attenuation and thus the most noticeable effect. Happy gating.



How it works

IC1a is connected as an inverting amplifier with a gain range of 0 dB to 18 dB, made variable by VR1. The gain resistors R2 and VR1 are ac coupled by C2 to reduce pot noise due to dc currents in the feedback path. Resistor R5 provides the necessary dc feedback. Input impedance is set to 100 k by R1 and is ac coupled by C1. R4 and R5 biases the non-inverting input to 4.5 Volts.

IC1b and IC2a comprise the compressor with the variable gain cell of the 572 placed in the feedback path of the op-amp. Pin 7 of the op-amp also feeds the output of the compressor to the rectifier input of the 572 via pin 13. The resistor network VR2 and R12 sets the threshold where the compressor deviates to a 1:1 compression ratio. The attack and release time is determined by C12 and C11 together with internal 10 k resistors and are set to 3.3 mS and 47 mS respectively. Resistors R8 and R9 introduce dc feedback and C7 provides a low impedance path for ac. The non-inverting input (pin 5) of IC1b is biased to 2.5 V which is derived from an internal reference voltage. R7 sets the output dc level of the op-amp to 4.5 V for maximum swing.

The expander circuit consists of IC2b and IC3. The variable gain cell of the 572 is placed in the inverting input of the op-amp and acts as a variable input resistor which varies the gain depending on the input signal. The rectifier provides the control signal and derives its input from the output of the compressor via C14 and R13. The resistor R16 and the op-amp IC3 converts the output current of the gain cell to the output voltage. The non-inverting input (pin 3) of the op-amp (IC3) is biased at the internal reference voltage of 2.5 V via pin 6 of the 572. The resistor R15 sets the dc output level of the pre-amp to 4.5V to allow maximum voltage swing.

The attack and release time of the expander is set to 3.3 mS and 47 mS respectively by C16 and C15 and internal 10 k resistors. The output is attenuated by the output level control (RV3) before it is fed to the bypass switch. The bypass LED and associated current limiting resistor R21 is switched into circuit and lights up when the noise gate is selected. R20 discharges any floating voltages on C1 and reduces switching noise when the bypass switch is activated.

A 9V regulated power rail is derived from the 7805 regulator (IC4) and R19 and R18 biases the common terminal to 4 V which raises the output voltage to 9 V. The diode D1 protects the circuit from incorrect polarity being applied and C19 provides power supply smoothing. The circuit consumes about 10 mA dc current plus the LED current.