Overload Detector Circuit & Explanations

The circuit diagram is shown in Figure 1, and although shown with an LM358 opamp, you can use TL072, 1458, 4558 or any other common (cheap) dual opamp. While you can also use expensive high-performance opamps, there is no reason to do so - the circuit only lights an LED. The biggest advantage of the LM358 is that the output can swing to the negative supply rail, so there is no chance of the LED being on all the time. For other opamps, it will be necessary to reduce the value of the 10k resistor from base to emitter on Q1.

Where very high impedance is needed, the TL072 is suggested because its input bias current is very low, minimising errors caused by the input current. This is rarely necessary.

Despite the simplicity, the circuit works very well. If used with a mic preamp or similar, VR1 (trimpot) will allow you to set the peak voltage where the LED will come on. With VR1 at maximum, the detection voltage is about 10.7V, so there is almost no headroom before the signal clips. Normally, I'd expect VR1 to be set to roughly 1/2 resistance, which provides a detection threshold of ±8.3V. This is about the maximum you'd normally use for a circuit operating with ±15V supplies. Setting VR1 to lower resistance reduces the detection threshold voltage. At a 10% resistance setting (5k) the detection threshold is ±3V. If desired, a fixed resistor can be used instead of the trimpot.

U1A and U1B form what's known as a 'window comparator'. Provided the signal voltage remains within the boundary reference voltages at pins 2 and 5, the outputs remain at close to -15V. Should either pin 3 or pin 6 (which are joined) go above or below the reference voltage, the output of the corresponding opamp will swing high (close to +15V). C1 charges immediately via the diode, and the LED is turned on by Q1. After the transient has gone away, it takes time for C1 to discharge, so the LED remains on for long enough for you to see it. C1 cannot discharge back through the opamp outputs because of the diodes (typically 1N4148 or equivalent). The LED can be any colour you like, and the maximum LED current is about 6mA. This can be reduced by increasing the value of R6. Note that the circuit is mono - if you need to monitor a stereo signal you'll need two of them.

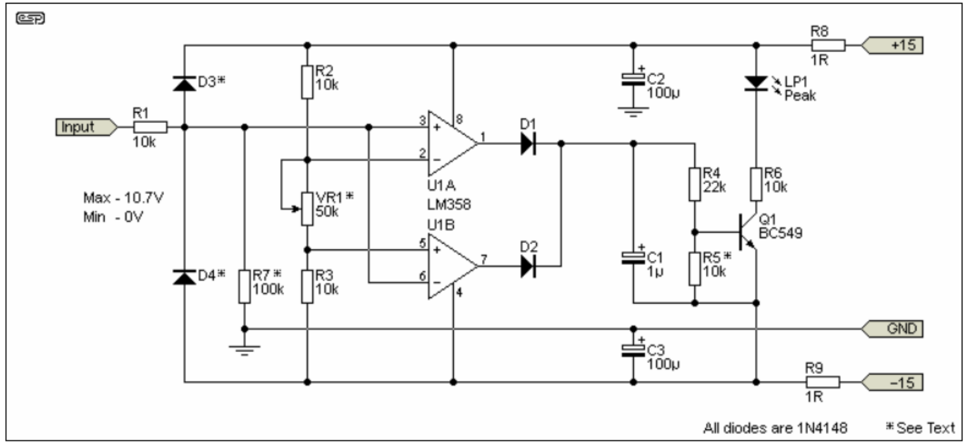

Figure 1 - Overload Indicator Schematic

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There's not a lot to the circuit, and it is very economical to build. The input has an earth/ ground reference set by R7. If the input is connected to the output of an opamp or the connected circuit has an earth reference then R7 can be omitted. If the monitored circuit is capacitively coupled or has no earth reference, then the input *must* be connected to earth via a suitable resistance for R7. 100k will be suitable for most circuits, but for high impedance circuits (such as valve equipment) R7 can be up to 1 megohm.

Note: The LM358 opamp should *not* be substituted. It's used because its output can get to the negative supply voltage (within a few millivolts). Some CMOS opamps can do the same, but none has the required supply voltage (30V) and they are only available in SMD packages. R5 is not necessary if you use the LM358, but if you use anything else (TL072, 1458, 4558, etc.) then it *must* be included or the LED will remain on. A value of 10k will usually be sufficient, but for some opamps it may need to be a lower value.

There is one very important point that you must be aware of. Because the opamp comparators are fairly fast and there is a LED being switched on and off, the circuit can introduce noise via the supply lines (±15V). The LED and switching does not connect to the earth/ ground bus to minimise ground noise. For this reason, it is very important that ***all*** power wiring is returned directly to the power supply, and not daisy-chained from the supplies used for preamps. Supply decoupling is also desirable, as shown in the circuit diagram (R8, C2 and R9, C3). This keeps most of the noise within the circuit. I've shown R8 & R9 as 1 ohm, but you can increase this a little if necessary. More than 2.7 ohms may cause erratic operation. The other option is to use a separate zener regulated supply - it won't be perfect, but the circuit is only an indicator, and extreme accuracy isn't necessary.

If a large number of these circuits is used (in a multi-channel mixer for example), there's a lot to be said for including a secondary power supply to power all 'noisy' electronics. These include overload detectors (like this one) and metering amplifiers. If this is done, the power rail decoupling becomes less of an issue as long as all noisy supply busses are kept separated from other circuitry.

Note that the inputs *must* be protected from voltages outside the opamp supply rails. The optional diodes (D3 & D4) aren't needed if the circuit is monitoring audio circuitry operating from the same supply voltages, but are essential for anything else (valve equipment, power amplifiers, etc.). Where the input level will normally be (perhaps significantly) higher than the supply rails, the input should be provided via a pot (to allow adjustment) or a voltage divider. If a pot is used for the input signal, VR1 can be a fixed resistance.

For use with a fixed resistor, I suggest that VR1 is replaced by a resistor of 10k, which is quite suitable for many applications. With ±15V supplies, this sets the detection threshold to ±5V which is very convenient. The detection voltage for any value of resistor is determined by the following ...

$V = Vcc / (R2 / (0.5 \times R) + 1)$ ... so for example ...
$V = 15 / (10k / (0.5 \times 10k) + 1)$
$V = 15 / 3 = 5V$

Vcc is the supply voltage, V is the detection threshold voltage (positive and negative) and R is the resistance used in place of VR1. In all cases, R2 and R3 are identical values, and there's no good reason to change from the 10k suggested. I leave it to the reader to determine how to reverse the formula so a resistance can be calculated from the desired threshold voltage.

To use the detector as a power amp clipping detector is simple enough, but be aware that unlike Project 23, it cannot compensate for supply rails that collapse with sustained high power. Therefore, it would normally be adjusted so that any signal greater than ~75% of the nominal supply voltage will cause the LED to come on. This is pessimistic, and in normal use it will be ok for the LED to flash occasionally. For an amplifier using ±35V supplies, you might want the detector to operate with any transient signal above 26V peak.

The input attenuator (between the power amp and clipping detector) could use the standard 10k resistor from the output, with a 2.2k resistor to earth (as shown below). This gives a threshold voltage of 27.7V - a little higher than the 75% suggested, but uses standard value resistors and will be quite satisfactory for normal use.

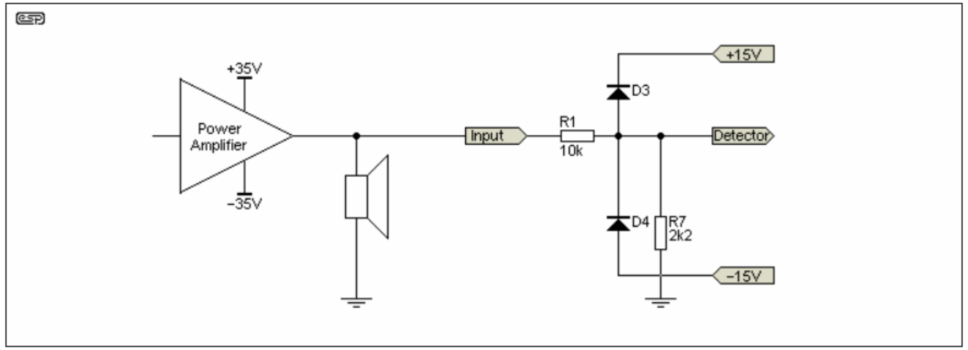

Figure 2 - Power Amplifier Attenuator Example

The above assumes that VR1 is replaced by a 10k fixed resistor, and as discussed, the detection threshold is ±27.7V (28V close enough). It will be quite alright if the LED flashes every so often - typically no more than once per second. This depends on the programme material of course. The occasional flash of the LED indicates that the amp is close to clipping, but there is still *some* headroom (about 1.5dB, which is the bare minimum).

For amplifiers with different supply rails (and therefore different power ratings), R7 can be adjusted to suit. This still assumes that VR1 is replaced by a fixed 10k resistor, so the detector will light the LED with any transient exceeding ±5V. Based on this, suitable values might be as follows ...

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Amp Power (8Ω)	Supply Voltage	R7 Value	Detect Voltage
10 W	±13 V	12k	9.2 V
20 W	±18 V	5.9k	13.5 V
50 W	±29 V	3.0k	21.7 V
70 W	±35 V	2.3k	26.7 V
100 W	±40 V	2.0k	30.0 V
150 W	±50 V	1.5k	38.3 V
200 W	±58 V	1.3k	43.5 V
300 W	±70 V	1.1k	50.5 V
500 W	±90 V	800R	67.5 V

The resistor values are rounded to one decimal point, and there is some variation from the ideal. However, since the peak voltage was mainly based on 75% of the nominal supply voltage there is room for small errors without it causing a problem. Some of the values are not standard, and you may decide that using a trimpot in place of R7 is more appropriate. If you do this, select a pot that's around double the resistor value listed. For example, for a 100W/ 8 ohm amplifier, a 5k trimpot would be suitable. For a 300W amp, use a 2k trimpot. With amps above 150W I recommend using a 1W resistor for R1 so that it is not stressed at all.

Setup And Usage

Overload detectors such as the one shown here can be a blessing or a curse. If you often use your system turned up pretty loud, then you'll likely be horrified to see that the clipping indicator LED is on much of the time. It's not at all uncommon for amplifiers to be clipping on transients, and most of the time the clipping is entirely inaudible. An overload indicator makes it very easy to see that's what is happening, and you could easily discover that when operated below clipping at all times, the amp isn't loud enough.

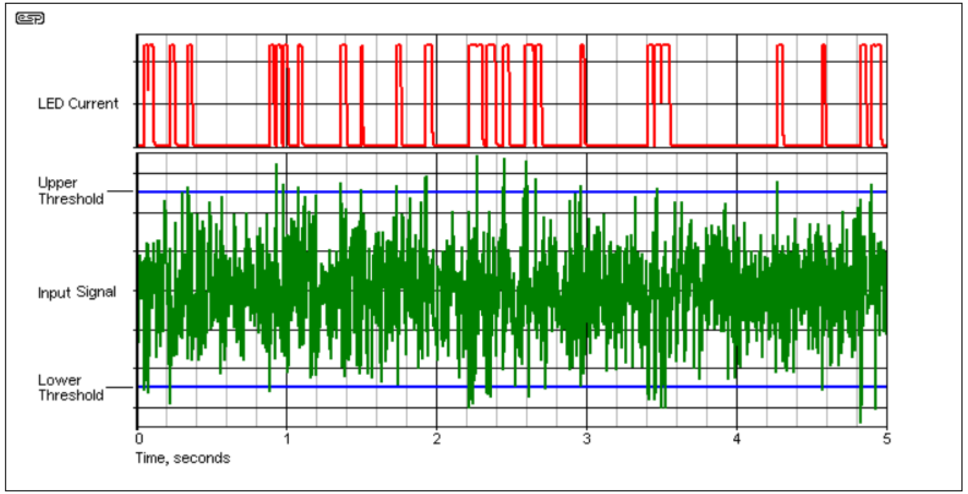
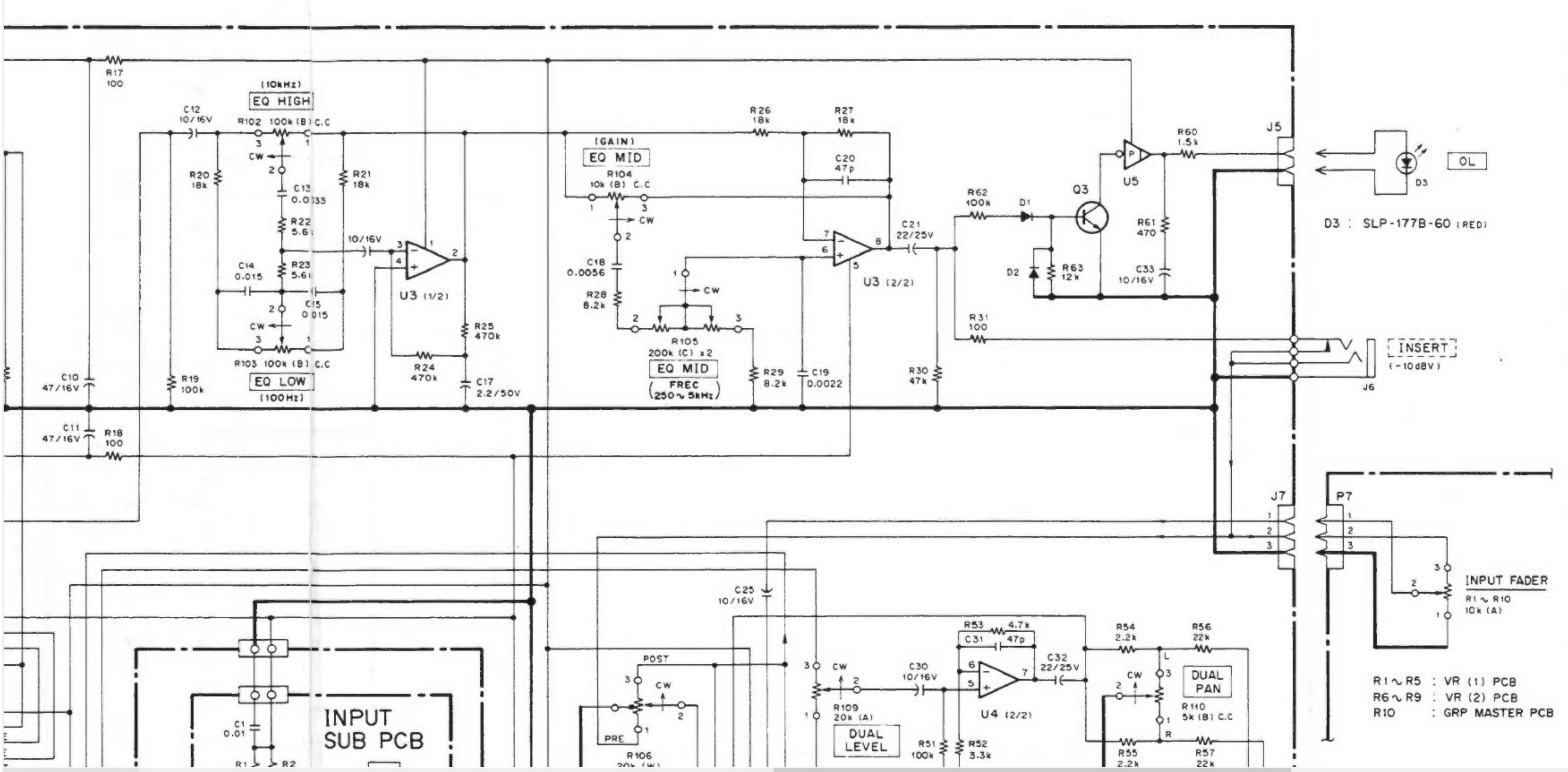


Figure 3 - Typical Operation With Noise Input

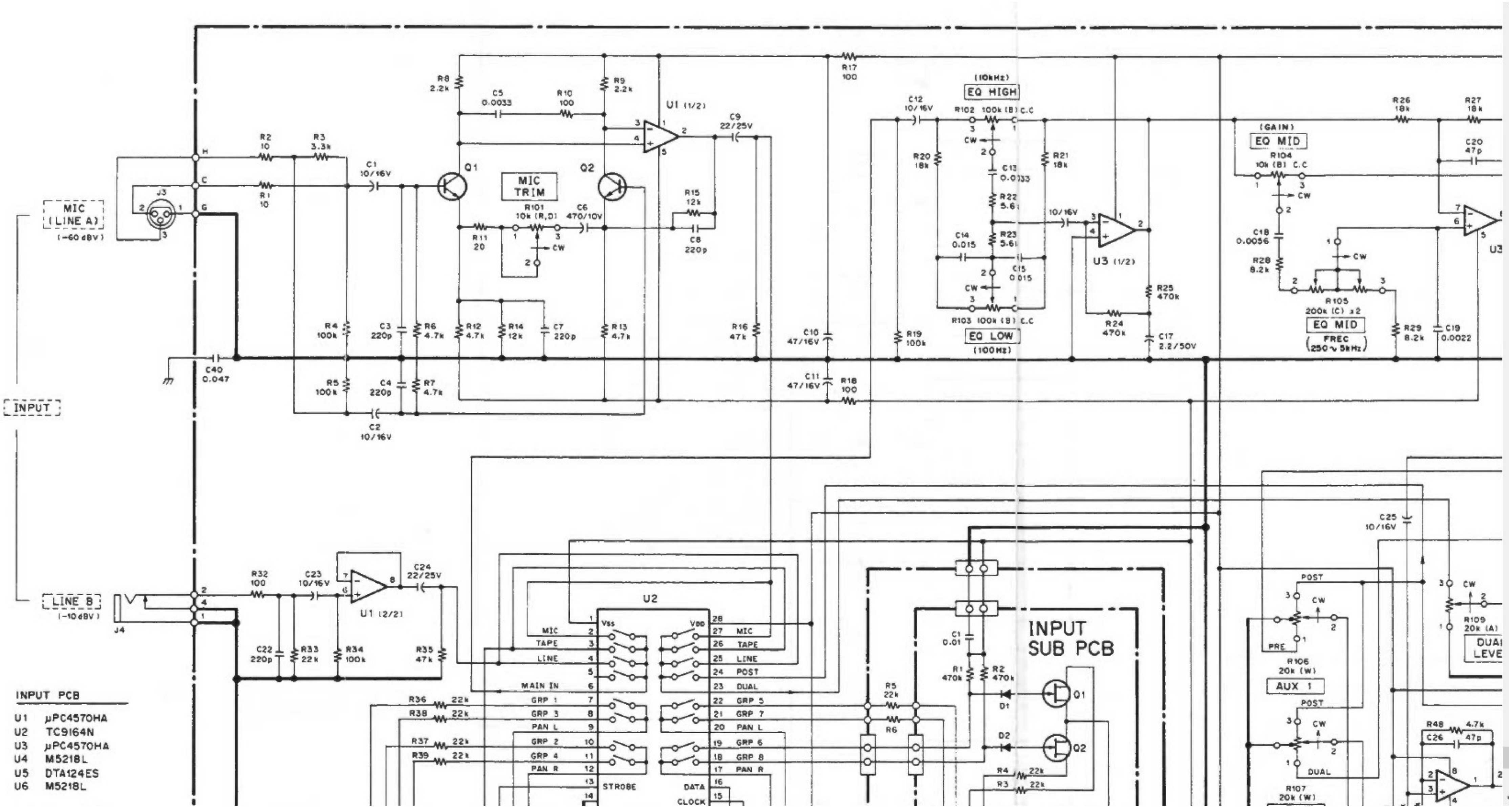
Figure 3 shows the simulated output (LED current in red), the noise signal in green, along with the upper and lower threshold voltages. Any time the input exceeds either threshold, the LED is turned on. This example is deliberately set so that there is plenty of activity. Although the diagram is a simulation, the waveforms are no different on an oscilloscope.

If you look *very* carefully, you will see that there are some excursions just on the thresholds that don't cause the LED to light. This is normal - the signal voltage needs to be at least a few millivolts greater than the threshold. While we might assume that 'fast' musical transients have a large high frequency component, this is usually not the case at all. The most common cause of amp overload is bass and midrange, especially when there is additional transient information 'riding' the bass or midrange waveform. The energy in music rolls off naturally above ~1.5-2kHz, and a super-fast detector serves no useful purpose.

All circuitry shown in this project is operated with an unbalanced input. Since it's intended to be used within a preamp or mixer case that's not a problem. It can also be used as an external unit, and will work fine even with balanced circuits. Because the input impedance is very high (when R7 is omitted), the circuit can monitor one of the two signal lines of a balanced interconnect, and because both usually have exactly the same voltage (just the polarity is reversed) if one line is close to clipping, then so is the other.



17.00 x 11.00 in



INPUT PCB

U1	µPC4570HA
U2	TC9164N
U3	µPC4570HA
U4	M5218L
U5	DTA124ES
U6	M5218L