

Save Your Ears

'Hello... HELLO! Are you deaf? Do you have disco ears?' If people ask you this and you're still well below 80, you may be suffering from hearing loss, which can come from (prolonged) listening to very loud music. You won't notice how bad it is until it's too late, and after that you won't be able to hear your favourite music the way it really is – so an expensive sound system is no longer a sound investment. To avoid all this, use the i-trixx sound meter to save your ears (and your neighbours' ears!).



Noise meter

With just a handful of components, you can build a simple but effective sound level meter for your sound system. This sort of circuit is also called a VU meter. The abbreviation 'VU' stands for 'volume unit', which is used to express the average value of a music signal over a short time. The VU meter described here is what is called a 'passive' type. This means it does not need a separate power supply, since the power is provided by the input signal. This makes it easy to use: just connect it to the loudspeaker terminals (the polarity doesn't matter) and you're all set. The more LEDs that light up while the music is playing, the more you should be asking yourself how well you are treating your ears (and your neighbours' ears).

Of course, this isn't an accurately calibrated meter. The circuit design is too simple (and too inexpensive) for that. However, you can have a non-disco type (or your neighbours) tell you when the music is really too loud, and the maximum number of LED lit up at that time can serve you as a good reference for the maximum tolerable sound level.

Although this is a passive VU meter, it contains active components in the form of two transistors and six FETs. Seven LEDs light up in steps to show how much power is being pumped into the loudspeaker. The steps correspond to the power levels shown in the schematic for a sine-wave signal into an 8-ohm load.

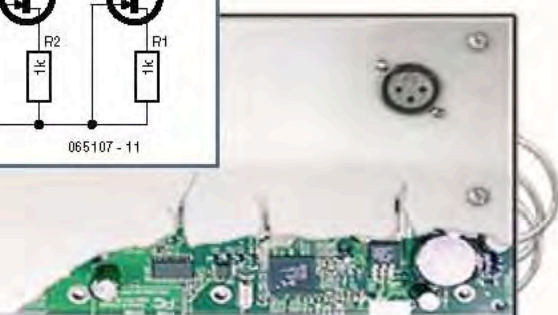
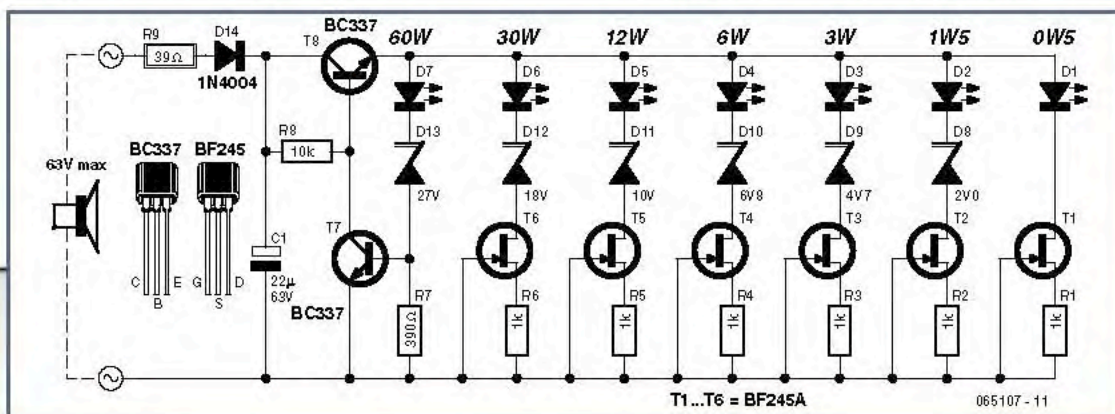
LED D1 lights up first at low loudspeaker voltages. As the music power increases, the following LEDs (D2, D3, and so on) light up as well. The LEDs thus dance to the rhythm of the music (especially the bass notes).

This circuit can easily be assembled on a small piece of prototyping board. Use low-current types for the LEDs. They have a low forward voltage and are fairly bright at current levels as low as 1 mA. Connect the VU meter to the loudspeaker you want to monitor. If LED D2 never lights up (it remains dark even when LED D3 lights up), reverse the polarity of diode D8 (we have more to say about this later on). In addition, bear in mind that the sound from the speaker will have to be fairly loud before the LEDs will start lighting up.

If you want to know more about the technical details of this VU meter, keep on reading.

Each LED is driven by its own current source so it will not be overloaded with too much current when the input voltage increases. The current sources also ensure that the final amplifier is not loaded any more than necessary. The current sources for LEDs D1–D6 are formed by FET circuits. A FET can be made to supply a fixed current by simply connecting a resistor to the source lead (resistors R1–R6 in this case). With a resistance of 1 kΩ, the current is theoretically limited to 1 mA. However, in practice FETs have a especially broad tolerance range. The actual current level with our prototype ranged from 0.65 mA to 0.98 mA.

To ensure that each LED only lights up starting at a defined voltage, a Zener diode (D8–D13) is connected in series with each LED starting with D2. The Zener voltage must be approximately 3 V less than the voltage necessary for the indicated power level. The 3-V offset is a consequence of the voltage losses resulting from the LED, the FET, the rectifier, and the overvoltage protection. The overvoltage protection



is combined with the current source for LED D7. One problem with using FETs as current sources is that the maximum rated drain-source voltage of the types used here is only 30 V. If you want to use the circuit with an especially powerful final amplifier, a maximum input level of slightly more than 30 V is much too low. We thus decided to double the limit. This job is handled by T7 and T8. If the amplitude of the applied signal is less than 30 V, T8 buffers the rectified voltage on C1. This means that when only the first LED is lit, the additional voltage drop of the overvoltage protection circuit is primarily determined by the base-emitter voltage of T8. The maximum worst-case voltage drop across R8 is 0.7 V when all the LEDs are on, but it has increasingly less effect as the input voltage rises. R8 is necessary so the base voltage can be regulated. R7 is fitted in series with LED D7 and Zener diode D13, and the voltage drop across R7 is used to cause transistor T7 to conduct. This voltage may be around 0.3 V at very low current levels, but with a current of a few milliampères it can be assumed to be 0.6 V. Transistor T7 starts conducting if the input voltage rises above the threshold voltage of D7 and D13, and this reduces the voltage on the base of T8. This negative feedback stabilises the supply voltage for the LEDs at a level of around 30 V. With a value of 390 Ω for R7, the current through LED D7 will be slightly more than 1 mA. This has been done intentionally so D7 will be a bit brighter than the other LEDs when the signal level is above 30 V. When the voltage is higher than 30 V, the circuit draws additional current due to the voltage drop across R8. The AC voltage on the loudspeaker terminals is half-wave rectified by diode D14. This standard diode can handle 1 A at 400 V. The peak current level can be considerably higher, but don't forget that the current still has to be provided by the final amplifier. Resistor R9 is included in series with the input to keep the additional load on the final amplifier within safe bounds and limit the interference or distortion that may result from this load. The peak current can never exceed 1.5 A (the charging current of C1), even when the circuit is connected directly to an AC voltage with an amplitude of 60 V. C1 also determines how long the LEDs stay lit. This brings us to an important aspect of the circuit, which you may wish to experiment with in combination with the current through the LEDs. An important consideration in the circuit design is to keep the load on the final amplifier to a minimum. However, the combination of R9 and C1 causes an averaging of the complex music signal. The peak signal levels in the music are higher (or even much higher) than the average value. Tests made under actual conditions show that the applied peak power can easily be a factor of 2 to 4 greater than what is indicated by this

VU meter. This amounts to 240 W or more with an 8- Ω loudspeaker. You can reduce the value of C1 to make the circuit respond more quickly (and thus more accurately) to peak signal levels.

Now a few comments on D8. You may receive a stabistor (for example, from the Philips BZV86 series or the like) for D8. Unlike a Zener diode, a stabistor must be connected in the forward-biased direction. A stabistor actually consists of a set of PN junctions in series (or ordinary forward-biased diodes). Check this carefully: if D2 does not light up when D8 is fitted as a normal Zener diode, then D8 quite likely a stabistor, so you should fit it the other way round.