Measure sound from 30 to 120dBA +

Sound Level Meter

Noise is one of the many pressures of today's often stressful lifestyle. To be able to combat noise in its many forms, you must first be able to measure it. Here is the means: a low-cost sound level meter which will measure sound levels of less than 30dB to more than 120dB with fast or slow response to the "A" weighting curve.

by JOHN CLARKE

Our Sound Level Meter measures sound pressure in nine ranges with fast or slow response.

As time goes on, noise will increasingly be regarded as an unnecessary byproduct of technology rather than an incidental and innocuous side-effect of progress. More and more, noise is being actively proscribed or prescribed by law: noise levels in factories, of vehicles, and even of your party after certain hours. At the same time, excessive noise is being recognised as injurious to hearing and health in general, so it is useful for the concerned individual to know just how loud are the noises to which he or she is exposed every day.

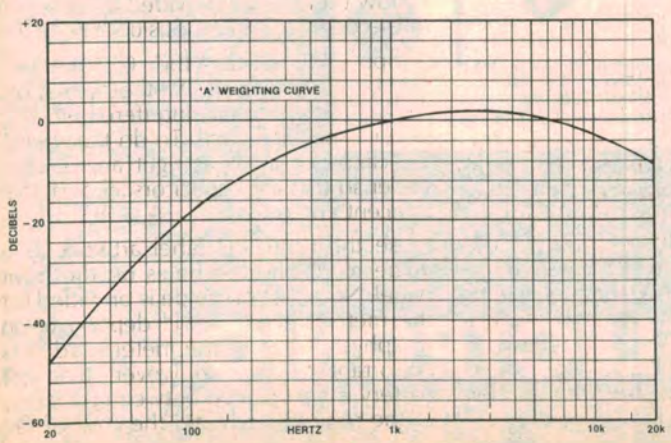
There is no question that many power tools and appliances found in the home produce noise at levels which are potentially harmful to hearing, to mention but a few: lawnmowers, food mixers and blenders, power drills, and routers, planers and circular saws. These dangerous levels can readily be identified with our Sound Level Meter.

At the same time, our Sound Level Meter may help you tolerate noises that really are not all that loud but seem to be insistently intruding upon your consciousness – your neighbour's radio giving the Saturday afternoon race commentary, passing traffic, planes flying overhead. Many of these noises can be very irritating but are really at a very low level in absolute terms – as our Sound Level Meter will readily confirm.

You can also use our Sound Level Meter to check your hifi sound reproduction levels – are you listening at realistic or excessive levels? Many people listen at excessively high levels, particularly when in their cars or when using headphones.

If you are involved with amateur theatre productions, discos or any other public activity where sound reinforcement is required you can also use this device to check sound distribution on a precise basis rather than simply by "ear".

Our Sound Level Meter uses the "A" weighted characteristic which is selected as a compromise compensation for the reduced sensitivity of the ear to high and low frequencies, as depicted by the Fletcher-Munson curves. It is also the characteristic referred to in any legislation which specifically mentions a noise level. For example, 85dBA refers to a sound level of 85dB using "A" weighting.



This graph shows the "A" weighting characteristic used for most sound level measurements and used by our Sound Level Meter.

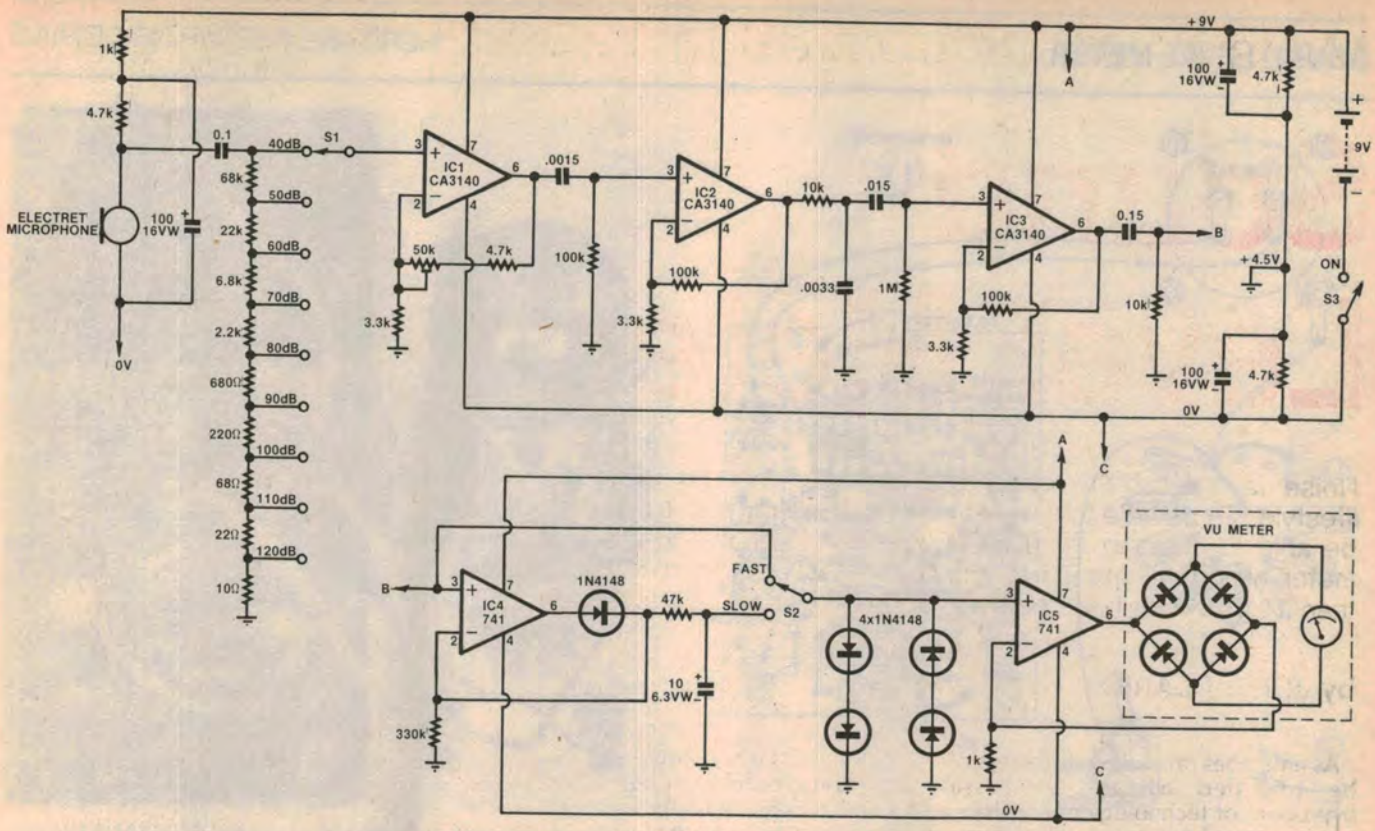
Our Sound Level Meter also features fast and slow response times. The fast response is used when you wish to monitor sounds of a percusive or transient nature while the slow response can be used to ignore the effect of an occasional transient upon the general noise level.

Overall measurement range is from less than 30dBA to slightly more than 120dBA – more than 90dB overall. 30dBA is the sort of level you would expect to (and wish to) find in an average domestic bedroom in the dead of night (discounting snores and possums in the roof). At the other end of the scale, 120dBA is unspeakably and painfully loud – to be avoided at all costs, since even brief exposure to these levels can cause permanent hearing damage.

THE CIRCUIT

The key component of the Sound Level Meter is a low-cost electret microphone insert which has excellent performance in spite of its low cost.

Because electret microphones deliver



SOUND LEVEL METER

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Five op amps provide the requisite voltage gain for the Sound Level Meter while passive single-pole filters provide the "A" weighting characteristic.

very small signals, relative to conventional high impedance dynamic microphones and because of the need to measure a very large range of sound levels, the circuit requires enormous gain. This is provided by five op amps. Three of these are the CA3140T Mosfet-input type while the other two are 741 op amps. Now let us refer to the circuit.

The electret microphone insert has an integral FET buffer stage which requires a DC supply of 1.5 milliamps. This is supplied by a 4.7kΩ resistor from a decoupling network consisting of a 1kΩ resistor and 100μF capacitor. The signal output from the electret microphone is fed via a 0.1μF capacitor to a nine-step attenuator and thence to the first CA3140T op amp stage. This is wired as a non-inverting amplifier with the gain variable by a 50kΩ trimpot.

Each of the following CA3140T op amp stages is also a non-inverting amplifier with a fixed gain of 30dB. Note that we specifically recommend the CA3140T for this application. The "T" suffix refers to the low cost "minidip" package. Other Fet-input op amps, such as LF351 or TL071, are not suitable in this application as their minimum gain-bandwidth product is inadequate.

Two high-pass filters and one low-pass filter combine to provide the A-weighting characteristic. Between IC1 and IC2, the .0015μF capacitor and 100kΩ resistor constitute a 1kHz high-pass filter. Following IC2, the 10kΩ resistor and .0033μF capacitor forms a 5kHz low-pass filter while the 0.15μF capacitor and 10kΩ resistor following IC3 form a 100Hz high-pass filter. The additional .015μF capacitor between IC2 and IC3 is not required for the A-weighting characteristic but to provide AC-coupling to prevent DC offset problems.

We estimate that the current cost of parts for this project is approximately

$35

This includes sales tax and battery.

Amplifier signal from IC3 is directed along two paths, one to the fast/slow response switch, S2, and the other to IC4 which half-wave rectifies the signal and averages it in the filter consisting of a 47kΩ resistor and 10μF capacitor. The 330kΩ resistor discharges the filter capacitor. So IC4 provides the slow response function.

IC5 functions as a current driver for the VU meter movement which has an internal bridge rectifier. Since the meter is inside the feedback loop, the non-linearity and voltage drop of the diode network are effectively cancelled. Meter overdrive is prevented by the four diodes shunting the input to IC5.

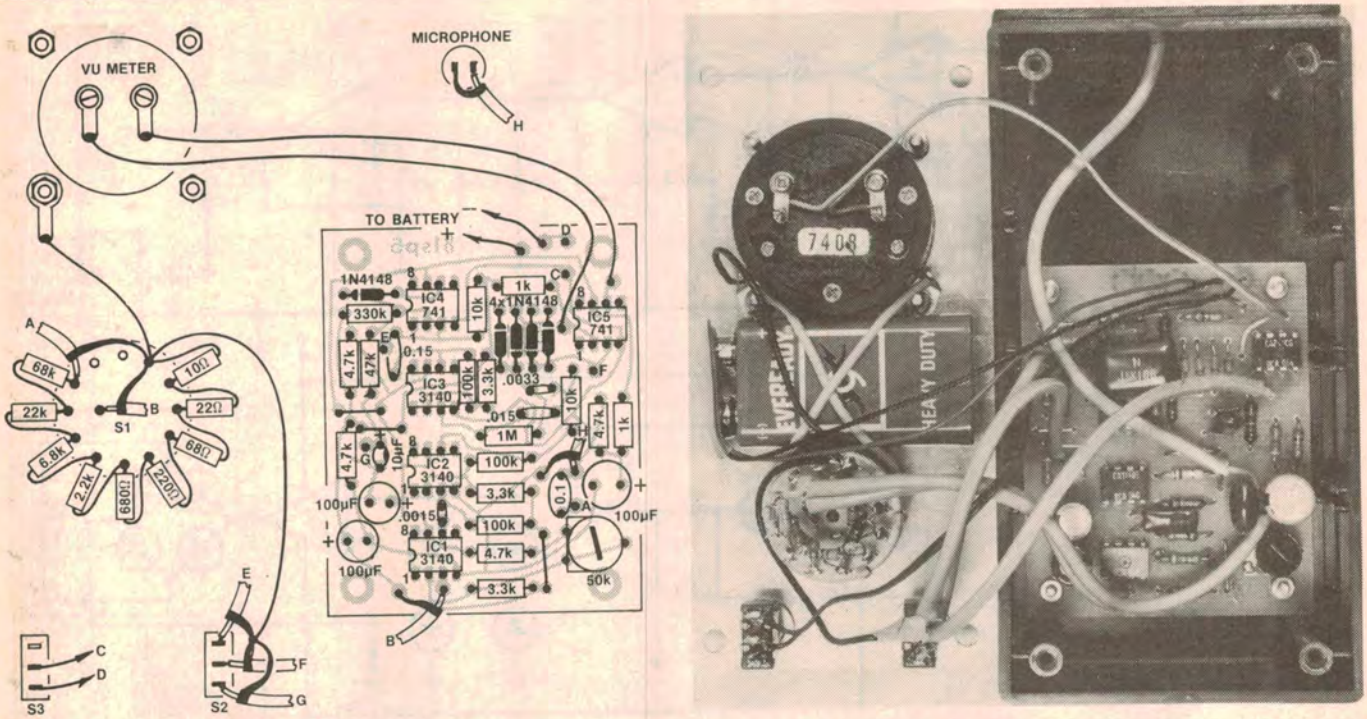
A single 9V battery powers the circuit. Two 4.7kΩ resistors and two 100μF capacitors provide a half-supply voltage reference for the op amps and the use of the two capacitors avoids a large turn-on offset and resulting meter overload.

CONSTRUCTION

We built our sound level meter in a plastic utility box measuring 130 x 68 x 41mm (W x H x D) and constructed the circuit on a printed circuit board measuring 57 x 71mm and coded 81sp5.

Start construction by making sure the PC board will fit snuggly within the box. If not, some filing of the PC board edges may be necessary to achieve this. Next, all the resistors, diodes, links and ICs can be placed and soldered in position. Follow the overlay provided to help you in the orientation and positioning of the components. Install the 0.15μF and .0015μF capacitors so that they lie flat on the board and do not interfere with the meter or range switch. To do this, bend the capacitor leads at right angles and solder so that the capacitors lie over the adjacent components.

Use the Scotchcal label artwork as a guide to drilling the holes on the front panel. Note that no guide is provided for the meter since this will depend upon the physical size of the meter used. It is important to note, however, that the battery is best placed between the body of the rotary switch and the case of the



The wiring diagram and inside photograph show the wiring details. The battery is secured with hookup wire as noted in the text.

meter. So the meter should be located for a close fit between the battery and switch.

The attenuating resistors can now be soldered around the 12-position rotary switch. These should be wired in a compact way and the resistor body should be inward from the switch lugs so that the effective diameter of the switch body is not increased by the resistors. The 68kΩ resistor should be between position one and two on the switch, the 22kΩ between positions two and three following through until the 10Ω resistor is terminated at the tenth position (even though this position is unused).

Use screened cable for the wiring to the microphone, fast/slow switch (S2) and the rotary switch (S1), as this prevents unwanted signals interfering with the sensitive amplifier circuitry. It is important to use the same earthing arrangement shown in the wiring diagram. Hookup wire can be used for the on/off switch and the wiring to the meter.

The microphone is mounted in a tapered piece of wood, which is screwed to the end of the box. This tapering ensures that little sound is reflected to interfere with the operation of the microphone output. A diagram shows the actual dimensions of the microphone holder which should be made of fine-grained wood to prevent splitting.

CALIBRATION

Calibration of the sound level meter involves either of several methods dependent upon the equipment accessible to you and the type of microphone used. Before any calibration is done, however, the zero adjust on the meter should be adjusted until the pointer reads zero with the power off. It should be noted that even at the 120dB range setting the meter will show a small reading under quiet conditions. This is due to the electronic noise within the circuit of the instrument.

The best calibration method is by using another known accurate commercial sound level meter. The two meters should be held such that the microphones are in line with a sound source and the trimpot adjusted until the same readings are obtained. Some sound level meters may not incorporate the A-weighted curve and misleading results can occur if this is not taken into account. The "safest" calibration is therefore done from a 1kHz sound source where both meters should read the same.

PARTS LIST

1 Printed Circuit Board coded 81sp5, 71 x 57mm
1 electret microphone insert, Dick Smith Cat C1160
1 Scotchcal front panel
1 Plastic Utility Box measuring 130 x 68 x 41mm
1 VU meter with internal bridge rectifier
2 SPDT miniature toggle switches
1 single-pole 12-way rotary switch
1 9V 216 Battery and clip leads
1 knob

SEMICONDUCTORS
3 CA3140T operational amplifiers
2 741 operational amplifiers
5 1N4148 signal diodes

RESISTORS (¼W 5%)
1 x 1MΩ, 1 x 330kΩ, 3 x 100kΩ, 1 x 68kΩ, 1 x 47kΩ, 1 x 22kΩ, 2 x 10kΩ, 1 x 6.8kΩ, 4 x 4.7kΩ, 3 x 3.3kΩ, 1 x 2.2kΩ, 2 x 1kΩ, 1 x 680Ω, 1 x 220Ω, 1 x 68Ω, 1 x 22Ω, 1 x 10Ω, 1 x 50kΩ horizontal mount trimpot.

CAPACITORS
3 100µF/16VW PC electrolytics
1 10µF/6.3VW PC electrolytic
1 0.15µF metallised polyester
1 0.1µF metallised polyester
1 .015µF metallised polyester
1 .0033µF metallised polyester
1 .0015µF metallised polyester

MISCELLANEOUS
Shielded cable, hook-up wire, mounting screws and nuts.

NOTE: The components specified are those used in our prototype. Higher rated components may generally be used providing they are physically compatible.

Alternatively, a less accurate method is to apply a signal to the microphone input with the microphone removed and adjust the trimpot until a certain reading on the meter is obtained. If the DSE microphone insert is used and a signal generator is available, then a 1kHz sine wave source at 25mV RMS is necessary to give a reading on the sound level meter of 100dB.

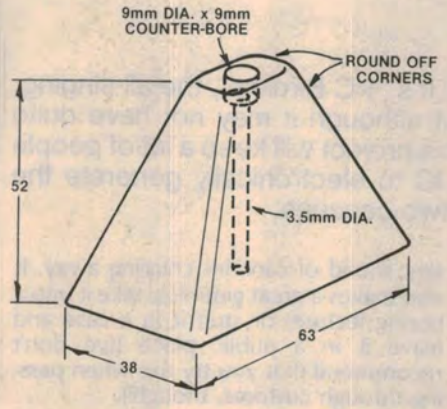
With the microphone out of circuit, apply the signal from the generator to the microphone input. The attenuator on the sound level meter should be set to the 100dB scale. The 50kΩ trimpot is then adjusted until the meter reads 0VU on the meter scale. That completes the calibration. Reconnect the microphone to the circuit and the sound level meter is ready to be used.

We arrived at this calibration figure by taking the mean signal sensitivity of a small sample of the DSE microphone inserts. With this calibration method it is expected that an accuracy of ±3dB can be obtained.

Alternatively, if no signal generator is available, a signal from a low voltage transformer can be used with an attenuator to reduce the signal level. Since the signal is not 1kHz but 50Hz, the signal will need to be 32dB greater than that of the 1kHz signal due to the A-weighting of the meter. Consequently the signal will need to be 1V RMS for a reading of 100dB on the meter.

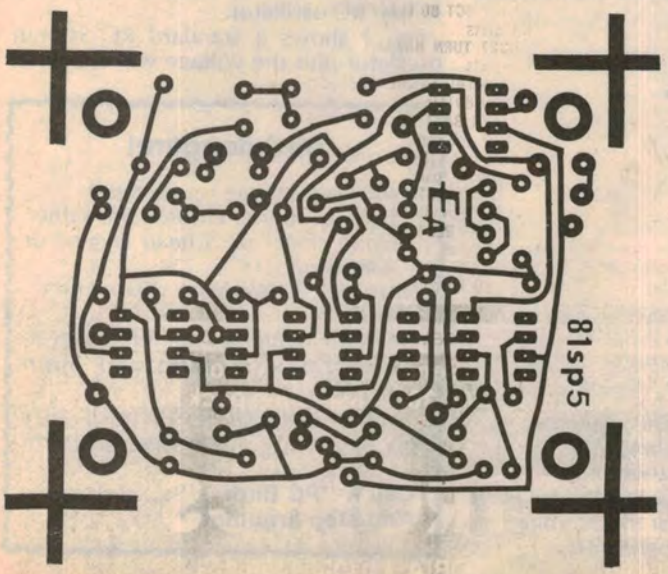
If a different electret microphone is used, the sensitivity will be different and new calibration figures will need to be calculated. For instance, we will calculate the calibration figure required for a microphone with a sensitivity of −65dB. This is with respect to 0dB at one microbar, which is defined as 1 volt and 74dB sound pressure level. So 65dB down from 1 volt is .562mV at 74dB. A 94dB sound pressure level gives 5.62mV and at 100dB, 11.2mV. The sensitivity of the microphone used can be calculated in a similar manner.

Operation of the sound level meter is straightforward. The readings are more accurate when the needle is indicating more than half scale deflection and consequently choosing the best range is important.



DIMENSIONS IN MILLIMETRES

At left is a view of the Sound Level Meter showing how the microphone insert is recessed into the nose cone, which is shown in perspective view in the diagram above. Also shown on this page is the full-size artwork for the PC board and front panel.



EA SOUND PRESSURE METER