Constructional Project

ACOUSTIC PROBE by ROBERT PENFOLD

An audio "telescope" or stethoscope to investigate distant or low-level sound.

This project could be regarded as the audio equivalent of a telescope. Its basic function is to pick up sounds via a microphone, greatly amplify the resultant signal, and then feed it to a pair of headphones. This gives users a sort of "larger than life" version of what they would normally hear, permitting them to detect sounds that would otherwise be inaudible. A sort of hearing aid for those who do not have a hearing defect.

Apart from making sounds louder, it is often possible to place the microphone very close to the sound source, or even actually touching it, so that otherwise inaudible sounds can be monitored. When used in this way the unit acts as a sort of electronic stethoscope, and the barely audible sound from a watch can be made to sound more like a shipyard in full production. It is even possible to place the microphone underwater, perhaps to monitor the wildlife in a pond, provided, of course, the microphone is given adequate waterproofing.

The unit is small and self-contained, although a separate microphone can be used if preferred. An electret type is used whether the microphone is built-in or external to the main unit. A low cost insert will suffice if an internal microphone is used, and should provide excellent audio quality.

The output signal is monitored using headphones or an earphone rather than a loudspeaker, because the latter gives problems with acoustic feedback. This feedback produces the whistling and howling sounds that dog so many PA systems. These are largely avoided using headphones, and are totally eliminated using an earphone.

CIRCUIT OPERATION

The full circuit diagram for the *Acoustic Probe* is shown in Fig.1. The input circuit may look a little unusual, but it has to be borne in mind that an electret microphone insert has an integral buffer amplifier. Furthermore, the load resistor for the JFET (junction gate field-effect transistor) used in the buffer amplifier is usually absent, and must be included in the main circuit. Resistor R1 and capacitor C2 provide a well-decoupled supply to the microphone insert, and also drop the supply voltage to a more suitable level. R2 is the load resistor for the JFET in the microphone insert (MIC1).

Resistors R1, R2, and capacitor C2 should be omitted if the unit is used with an external electret microphone having a built-in battery supply for the preamplifier. Apart from the fact they would be superfluous they could also prevent the microphone from working properly.

HIGH GAIN

It is essential for the circuit to have very high voltage gain due to the low output level from the microphone. When dealing with faint sounds the output voltage from the microphone is likely to be microvolts rather than millivolts.

A two-stage amplifier is therefore used, employing IC1

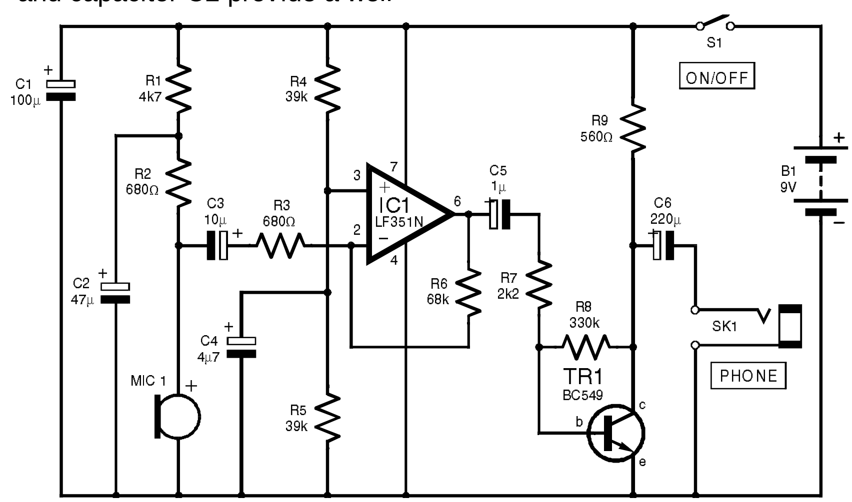


Fig.1. Complete circuit diagram for the Acoustic Probe.

to provide the initial amplification. The input stage is a standard inverting mode type having its voltage gain set at 40dB (100 times) by negative feedback resistors R3 and R6.

Resistors R4 and R5 form a potential divider that supplies the usual mid-supply bias potential to the non-inverting input of IC1. Capacitor C5 couples the output of IC1 to a simple common emitter amplifier based on transistor TR1. This provides a similar level of voltage gain to the input stage, giving an overall voltage gain of about 80dB (10,000 times) or so.

Capacitor C6 couples the output signal to the earphone or headphones. Good results are obtained using either a crystal earphone or medium impedance headphones of the type sold as replacements for use with personal stereo units. The unit is unlikely to give worthwhile results with a low impedance earphone or any other type of headphones. The current consumption of the circuit is about eight milliamps.

VOLUME AND NOISE

The high gain of the unit produces a potential problem with excessive volume from sounds at medium to high levels, or if the microphone is accidentally knocked. There are two ways around this, which are limiting and an automatic gain control circuit. Limiting is the method used here, and it is the more simple of the two. It simply entails limiting the maximum drive level from the output stage so that excessive volume levels cannot be produced. This has the advantage of being instant in operation, and the unit will operate normally as soon as a high input level has dropped back within normal operating conditions.

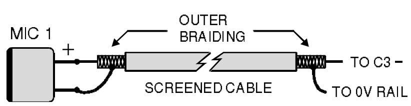


Fig.3. Screened microphone cable must be used if it is more than a few centimeters long.

The drawback of limiting is that quite severe distortion is produced on high level signals. This is not really a major drawback, since the unit is only intended for investigating sounds at low levels. The limiting is provided by using a simple output stage that is unable to drive the earphone or headphones at very high volumes, and effectively has built-in limiting.

On the face of it, the higher the gain of the circuit the better it will perform. Unfortunately, it is not practical to use ultra-high gains in order to enable extremely quiet signals to be detected.

The lowest sound level that can be detected is mainly governed by the signal-to-noise ratio of the amplifier's input stage.

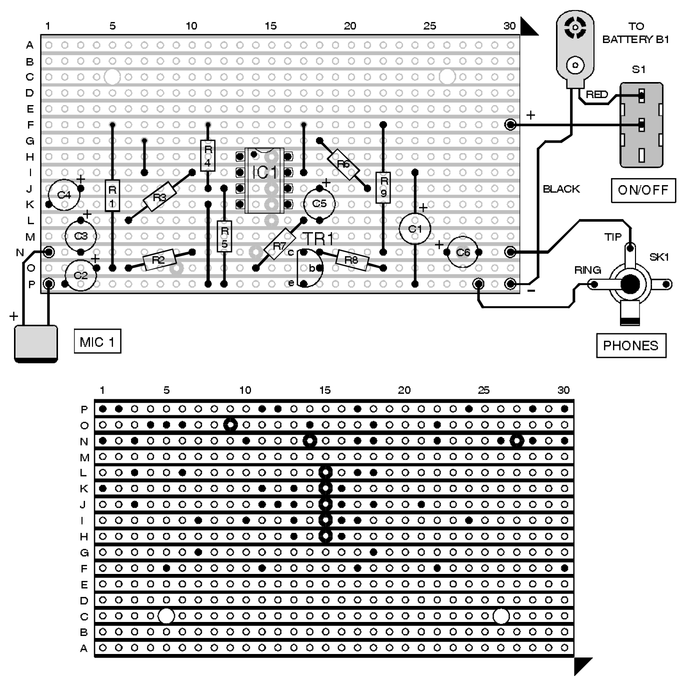
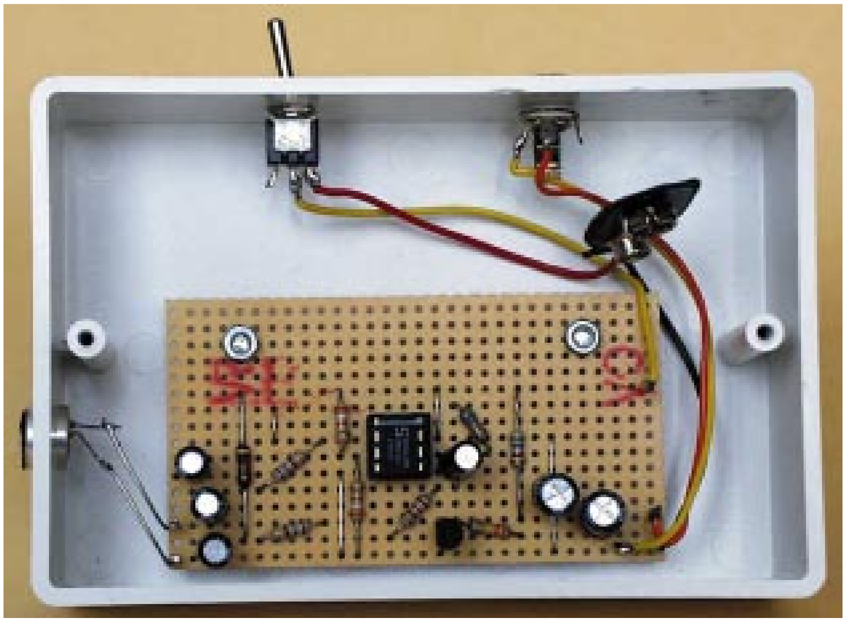


Fig.2. Stripboard component layout, off-board hard wiring, and underside view showing breaks required in the copper tracks.



Layout and wiring of components inside the small plastic case, keep the leads to the mic. And 'phone socket well apart.

Increasing the gain of the circuit simply results in proportionately more "hiss" type noise from the headphones, with low level signals being lost in this noise.

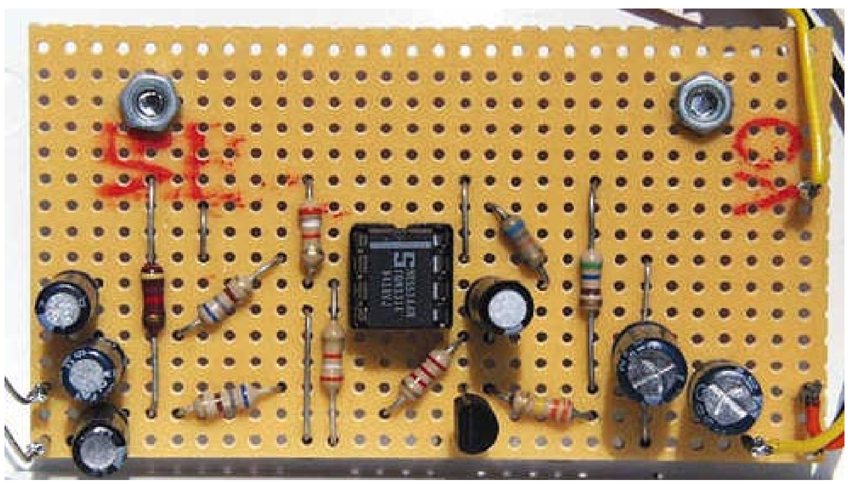
Regardless of the amount of gain used, signals below a certain level will be too far below the noise level to be detectable. The LF351N specified for IC1 is an inexpensive device that gives quite good noise performance. However, a high quality audio operational amplifier such as the NE5534AN will provide a significantly lower signal to noise ratio and extend the capabilities of the unit.

CONSTRUCTION

The circuit board is based on a piece of stripboard that has 30 holes, by 16 copper strips. Details of the component layout and wiring, together with the breaks in the copper strips are shown in Fig.2. The high gain of this circuit make it vulnerable to problems with instability due to stray feedback, so unless you know what you are doing it is best to copy the layout shown here rather than experimenting with your own design.

Construction of the board follows along the normal lines, and starts with a board being trimmed to size using a hacksaw. The rows of holes are very close together so cut along rows rather than trying to cut between them. There will inevitably be some rough edges and corners, but the board is easily filed to a neat finish.

Next drill the two 3·3mm diameter mounting holes and



COMPONENTS

Resistors
- R1 4k7
- R2, R3 680 ohms (2 off)
- R4, R5 39k (2 off)
- R6 68k
- R7 2k2
- R8 330k
- R9 560 ohms

All 0.25W 5% carbon film

Capacitors
- C1 100u radial electrolytic, 10V
- C2 47u radial electrolytic, 16V
- C3 10u radial electrolytic, 25V
- C4 4u7 radial electrolytic, 50V
- C5 1u radial electrolytic, 50V
- C6 220u radial electrolytic, 10V

Semiconductors
- TR1 BC549 *npn* transistor
- IC1 LF351N opamp (see text)

Miscellaneous
- MIC1 electret microphone insert (see text)
- B1 9V battery (PP3 size)
- SK1 3.5mm jack socket (see text)
- S1 s.p.s.t. miniature toggle switch

Small plastic or metal box, approx 100mm x 75mm x 40mm; 0.1 inch matrix stripboard, measuring 30 holes by 16 strips; 8-pin DIL socket; battery connector, multistrand connecting wire, solder, etc.

See also the SHOP TALK Page!

Approx. Cost Guidance Only (Excluding headphones) **$15**

make the eight cuts in the copper strips. The cuts can be made using the special tool or a hand-held twist drill bit of about 5mm in diameter. Make sure that the copper strips are cut across their full width.

The stripboard is then ready for the components to be fitted. Start with the resistors and link wires. Only three links are required and they are quite short, so trimmings from the resistor leadouts should suffice for these. Then fit the capacitors, making sure that each one has the correct polarity.

Now fit transistor TR1 and an 8-pin DIL holder for IC1. The LF351N used for IC1 is not a static-sensitive device, but it is still a good idea to mount it on the board via a holder.

Use single-sided solder pins at the points where the board will connect to MIC1, S1, SK1, and the battery; it is one millimeter diameter pins that are required. A tool for fitting them to the board is available, but they can usually be pushed into place quite easily.

CASE

There is potentially some advantage in using a metal case for a sensitive audio project such as this one, because it can help to screen the circuit from stray pickup of electrical noise such as mains "hum". However, a small plastic box should be perfectly all right unless the unit is likely to be used in an electrically "noisy" environment.

The component panel is bolted in place using metric M3 or 6BA bolts, and it is advisable to use short spacers or some extra nuts between the board and the case. This prevents the board from distorting and possibly cracking when it is bolted in position. The exact layout of the unit is not critical, but try to keep the wiring to MIC1 and SK1 well separated.

The construction diagram Fig.2 shows SK1 as the usual open style 3·5mm jack socket. This is the correct type of socket for use with a crystal earphone, but a 3·5mm stereo jack socket is needed for medium impedance stereo headphones. The two phones must be connected in series, which means that the earth tag is ignored and the connections are made to the other two tags of the socket (either way round).

MICROPHONE MOUNTING

The best way of dealing with the microphone depends on the manner in which the unit will be used. In most instances it can simply be mounted at one end of the case. Probably the easiest way of mounting it is to drill a hole in the case of the same diameter as the insert, and to then glue the insert in this hole. An alternative approach is to mount the microphone insert at the end of a piece of plastic tubing and to mount this tube on the case. An advantage of this method is that it makes it easy to maneuver the microphone into awkward places, but it is difficult to produce a strong assembly that will not keep breaking apart. It is probably more practical to have the microphone insert separate from the main unit and connected to it via a screened lead about 0·5 to 2 meters long. The screen of the cable carries the earth connection, and the inner conductor carries the connection to capacitor C3, as shown in Fig.3.

The microphone insert will only work properly if it is connected with the right polarity. If the polarity is not marked on the unit itself the manufacturers or retailer's literature should provide connection information.

Usually one terminal connects to the metal case of the insert, and this should be the "–" lead that connects to the 0V rail of the circuit. Getting the polarity wrong is unlikely to damage the insert, so if all else fails trial and error can be used to determine the correct method of connection.

SEPARATE MICROPHONE

If a separate microphone is used it is possible to use a "proper" electret type, complete with built-in battery supply. As pointed out previously, R1, R2, and C2 must be omitted if a microphone of this type is used. A "proper" electret microphone should be fitted with a screened lead and a plug. The plug will normally be a 3·5mm or standard (6·35mm) jack plug.

The connections to the circuit board are made via a socket of the appropriate type fitted on the front panel of the case. The unit will not work properly unless this socket is connected the right way round. If there are major problems with stray pickup of mains "hum", etc. the socket is connected the wrong way round.

TESTING

With the headphones or earphone connected and the finished unit switched on it should be obvious if the unit is working correctly. If all is well there will be a noticeable "hissing" sound from the headphones or earphone, and sounds in the room should be heard loud and clear.

If there is a "hissing" sound but no sound pickup whatever, try reversing the connections to the microphone insert. If you are using headphones, maintain a reasonable distance between the microphone and the headphones or there could be problems with acoustic feedback.

Go to next section